Newmont™

Brucejack Mine
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January 4, 2024

RE: Newmont Brucejack – 4950 tpd Joint M-243 / PE-107835 Amendments Application

To whom it may concern,

Please find attached the following documents in support of the joint application to amend *Mines Act* Permit M-243 and *Environmental Management Act* Effluent Permit 107835 (PE-107835) to increase the Brucejack Mine average ore production rate from 3800 tpd to 4950 tpd:

1. Environmental Protection Notice
2. Brucejack Mine 4950 tpd Joint M-243 / PE-107835 Amendments Application (4950 tpd Joint Application)

The 4950 tpd Joint Application is an application by Pretium Resources Inc. (Pretium), now operating under Newmont Corporation (Newmont), to increase the Brucejack Mine average ore production rate to 1,806,750 tonnes per year (tpy) (4950 tpd) from the current authorized average rate of 1,387,000 tpy (3800 tpd). There is no proposed change to the Brucejack Mine Environmental Assessment Certificate M15-01 life-of-mine ore limit of 18.5 Mt and no change to the *Mines Act* Permit M-243 WRTSF waste rock deposition limit of 11.9 Mt. The proposed increased ore production rate would reduce the mine life by 3 years from current, with mining projected to cease at the end of 2029 rather than 2032.

Please do not hesitate to contact the undersigned if you require further information and/or clarification on this application. Communications regarding the 4950 tpd Joint Amendments Application should be directed to:

Sylvia Van Zalingen
Manager, Permitting, Brucejack Mine
PO Box 10, 2965 Tatlow Road
Smithers, BC, Canada, V0J2N0
Sylvia.VanZalingen@newmont.com
1-778-653-8049

Sincerely,

Sylvia VanZalingen

Sylvia Van Zalingen
Manager, Permitting, Brucejack Mine

cc: Sean Masse, Torence Sandhals, Stephanie Thibeault, Greg Norton, Newmont

ENVIRONMENTAL PROTECTION NOTICE

Application for a Permit Amendment Under the Provisions of the *Environmental Management Act*

We, Pretium Resources Inc. (Pretium), operating under Newmont Corporation, PO Box 10, 2965 Tatlow Road, Smithers, BC, V0J 2N0, have submitted an application to the Director to amend the *Environmental Management Act* (EMA) effluent Permit PE-107835, issued August 31, 2015 (last amended August 21, 2023), which authorizes discharge of effluent from the Brucejack Mine. The amendment application requests changes to the permit to support a proposed increase in the average ore production rate from 3800 tonnes per day (tpd) to 4950 tpd.

The land upon which the facility is situated, and the discharge occurs, is Mining Lease Tenure Number 1038598, located at 56.47N and 130.19W, approximately 65 km north-northwest of Stewart BC within the Regional District of Kitimat Stikine.

The amendment application requests under existing PE-107835 Condition 1.1.1 that the characteristics of the mine effluent being discharged at the Waste Rock and Tailings Storage Facility (WRTSF) outlet (BJ 3.10) be changed to:

Parameter or Contaminant Name	EXISTING Authorized Limit and Units	AMENDMENT REQUESTED Limit and Units
Total Arsenic	10 µg/L	26 µg/L
Nitrate	11.5 mg/L as N	20 mg/L as N
Dissolved Copper	-	0.9 µg/L
Total Selenium	-	6.2 µg/L

The amendment application requests an amendment to permit Condition 1.5.3 to increase the number of authorized Filterbox C75 domestic wastewater treatment units from three to four.

A copy of the permit application, including supporting documentation, is available electronically at https://operations.newmont.com/north-america/brucejack-canada in the Reports and Documents section. Any person who may be adversely affected by the proposed amendment and wishes to provide relevant information may, within 30 days after the last date of posting, publishing, service or display, send written comments via post or email to the applicant, with a copy to Rosanna Breiddal, Senior Project Lead, Major Mines Office, Ministry of Energy, Mines and Low Carbon Innovation, PO Box 9320 Stn Prov Govt, Victoria, BC, V8W 9N3, (Rosanna.Breidall@gov.bc.ca). The identity of any respondents and the contents of anything submitted in relation to this application will become part of the public record.

Dated this 4 day of January 2024.

Sylvia VanZalingen

Contact person: Sylvia Van Zalingen
Email address: sylvia.vanzalingen@newmont.com
Phone: 1.778.653.8049

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

4950 tpd Joint *M-243* / *PE-107835*

Amendments Application

November 2023

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

4950 tpd Joint *M-243 / PE-107835* Amendments Application

Prepared by

Pretium Resources Inc.

November 2023

EXECUTIVE SUMMARY

Introduction

This report is the 4950 tpd Joint M-243/PE-107835 Amendments Application (4950 tpd Joint Application) by Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies, to increase the Brucejack Mine average ore production rate from the currently M-243 authorized average of 1.387 Mtpa to 1.807 Mtpa (equivalent average 3800 tpd to 4950 tpd). The report provides the technical and other information required by the approved Joint Information Requirements (JIRT) for this application.

Specifically, Pretium is applying to amend Brucejack Mine *Mines Act* Permit M-243 and *Environmental Management Act* Effluent Permit 107835 as required to authorize the production rate increase. Pretium's overall approach to the proposed production rate increase is to minimize changes aside from increasing the ore production rate. The increased production rate will not result in any changes to the Environmental Assessment (EA) Certificate M15-01 life-of-mine (LOM) ore limit (18.5 Mt) or Certified Project Description (CPD), or the M-243 current Waste Rock and Tailings Storage Facility (WRTSF) waste rock deposition limit (7.8 Mt).

Brucejack Mine is an underground gold mine located in northwest British Columbia, approximately 950 km northwest of Vancouver and 65 km north-northwest of Stewart. Ground access is via the 73 km Brucejack Access Road (BJAR) which originates at Hwy 37 km 215. The mine's mining, processing and other primary infrastructure is located at an elevation of approximately 1365 masl at the headwaters of Brucejack Creek, a westerly draining non-fish bearing tributary of the Unuk River via Sulphurets Creek. Construction of the mine began in September 2015, with commercial production commencing in July 2017. The Brucejack Mine, the BJAR and the Brucejack transmission line lie within the asserted traditional territory of the Tsetsaut Skii km Lax Ha, and portions lie within the Nass Area of the Nisga'a Nation as defined in the Nisga'a Final Agreement, and the asserted territory of the Tahltan Nation.

This 4950 tpd Joint Application has been prepared with reference to the Joint Application Information Requirements (MEMPR & ENV 2019), and includes the following chapters:

1. Introduction and Project Overview
2. Baseline
3. Mine Plan
4. Reclamation and Closure
5. Modelling, Mitigation and Discharges
6. Environmental Assessment Predictions
7. Environmental Monitoring
8. Health and Safety
9. Management Plans

Mine Plan Update

The 4950 tpd mine plan presented in this 4950 tpd Joint Application has been updated based on the mine plan presented in the 2019 National Instrument 43-101 Technical Report dated March 9th, 2020 (Tetra Tech 2020). The production rate increase from 3800 tpd to 4950 tpd would result in a shortened mine life from the 16 years spanning 2017 through 2032 presented in the 2020 mine plan, to 13 years spanning 2017 through 2029.

Established mine site facilities within the mining leases include:

- Four underground vent air raises;
- VOK and WZ underground mine portals;
- WZ pad, within which surface support infrastructure for the underground mine is located. This includes the old heavy shop, staging areas for waste rock, offices, covered storage, propane storage for mine air heater, and fuel storage and dispensing stations;
- Diesel power station (DPS) pad, including diesel generators and fuel storage serving as a back-up electrical generation facility;
- Mill building housing ore processing equipment, smelting furnace, WTP, paste backfill plant, assay laboratory, core processing area and related facilities;
- Lower and upper camps with kitchen, recreation, laundry, mine and mill dry facilities, medical clinic, fire hall, administration/offices, potable water well distribution and treatment system, STP, and solid waste management systems;
- Surface heavy duty shop to service surface vehicles and mobile equipment;
- Cement binder storage silo for pasting operations;
- Avalanche cap and powder magazines;
- Warehouse, coverall storage and equipment laydown areas;
- Heli-pad;
- Solid waste sorting and handling facilities, incinerator, waste oil burners, and burn pits;
- Contact and non-contact water management facilities, including mine dewatering, freshwater diversion channels, surface contact water collection system and a contact water storage pond (CWP);
- Overburden stockpile;
- The WRTSF containing five subaqueous tailings discharge pipelines, a treated WTP/STP effluent discharge pipeline, an emergency discharge pipeline from the CWP, and the WRD platform and associated temporary waste rock stockpile (WP1) that facilitates subaqueous waste rock deposition;
- A low-level weir (LLW) at the WRTSF outlet (site BJ 3.10) housing flow monitoring instrumentation and water reclaim equipment. The LLW facilitates continuous from the WRTSF to Brucejack Creek and houses a reclaim water pumping system that provides fresh water for to the mill;

- NPAG quarry (km 72 NPAG quarry) that provides NPAG material for surface and underground mine development and road maintenance;
- Site roads to connect mine area facilities, including the BJAR section between the km 72 NPAG quarry and the mine site; and
- Communication, monitoring, and control systems, including wireless local area network receivers, underground fiber optic network, radio base stations, programmable logic controllers, and video cameras.

The following infrastructure upgrades and equipment changes have been identified to facilitate the production increase from 3800 tpd to 4950 tpd:

- Increasing the haul truck fleet size from eight to 11 (at minimum) 50 t BEVs and addition of an electric load-haul-dump (LHD) vehicle;
- Additional Knelson concentrator within the mill, and equipment upgrades to the gravity and floatation circuits;
- A fourth C75 domestic wastewater treatment unit;
- Increasing the mine's power supply delivered by the existing 138 kV and 69 kV lines to 35 MVA, for which both lines are adequately rated; and
- Additional underground emulsion bay.

A second waste rock dump (East WRD), temporary surface waste rock stockpile(s) (WP2) and supporting haul road are being evaluated as a potential contingency management option to be developed east of the WRTSF and will be addressed via separate applications. These proposed upgrades to the existing waste rock management infrastructure are intended to provide contingency to the mine's waste rock management strategy, irrespective of the production rate increase.

Similarly, a fifth vent raise (VR5) and four new tailings discharge lines to the WRTSF are being considered for installation between 2023 and 2026, regardless of production rate. The new tailings lines are intended to replace existing and future tailings lines through LOM.

The Brucejack Mine produces gold and silver from the VOK and WZ deposits. The vertical and horizontal extents of the underground mine development for the 4950 tpd Joint Application mine plan remain similar to those presented in the 3800 tpd Amendment Application as per Permits M-243 and PE-107835 (Pretium 2018b) and the 2020 Mine Plan and Reclamation Program Update (Pretium 2020b). Mine plan changes in the 4950 tpd Joint Application compared to these previous submissions include updates to a subsection of the VOK called the North Block, and additional underground exploration development to the east, west and south.

Small portions of the updated exploration development extend beyond the current M-243 Permitted Mine Area (PMA) extents. In September 2022, Pretium submitted an M-243 permit amendment application to extend the mine's current PMA to the existing mining lease boundaries (M-243 Amendment #9). If approved, exploration development currently outside of the PMA will be inside it.

All waste rock at the mine is managed as PAG and is either deposited subaqueously within the WRTSF at the mine's WRD, or backfilled in mined out areas in the underground mine below the predicted closure flooding elevation. Mine tailings are co-mingled with sludge from the mine's WTP and deposited subaqueously in the WRTSF. Total Life-of-Mine (LOM) waste rock deposition to the

WRTSF remains within the 7.8 Mt currently authorized under M-243, and total tailings deposition to the WRTSF remains below the authorized 11.9 Mt.

The underground mine has been designed to extract ore through a combination of transverse long hole open stoping (LHOS) and longitudinal LHOS in a traditional primary/secondary sequence. Primary stopes are backfilled with cemented paste tailings and secondary stopes are backfilled with cemented paste tailings or waste rock. The mine utilizes a combination of conventional bulk sulphide flotation and gravity concentration to produce gold-silver floatation concentrate and doré from the on-site smelter. Both products are transported offsite for additional processing and refinement.

The increased mining rate from 3800 tpd to 4950 tpd will be sustained by expanding the battery electric vehicle (BEV) fleet and increased rates of drilling and development. No changes from the mining methods presented in the 2020 Mine Plan and Reclamation Program Update (Pretium 2020b) are required to achieve the production increase. Unrelated to the proposed production rate increase, Pretium is continuing to expand the Brucejack Mine battery electric vehicle fleet.

Reclamation Program Update

The Reclamation and Closure Plan addresses mine infrastructure components and site disturbance authorized under M-243, including mine development within the PMA portion of the mining leases and the portion of the mine's transmission line extending south from the mining leases to Pretium's Mineral Claim #1026976. Permit M-243 authorizes the northernmost 19.5 km of the transmission line; the 37.5 km segment located south of that is authorized under Statutory ROW #6408729.

There is no new surface disturbance associated with the proposed production rate increase, and therefore the Reclamation and Closure Plan does not include changes specific to the 4950 tpd Joint Application with the exception of infrastructure timing shown on the reclamation progression figures (e.g. WRTSF related mine wastes extents and mine closure in 2029). The Reclamation and Closure Plan has however, been updated to reflect surface infrastructure changes since the 2020 update (Pretium, 2020b) and for planned or proposed changes that are required for the existing mine operation irrespective of the proposed production rate increase.

Brucejack Mine surface disturbance areas are limited in extent due primarily to it being an underground mine. The M-243 approved PMA is 659.3 ha, with approximately 195 ha covering a 100 m corridor along the northernmost 19.5 km of the transmission line, and the remaining approximately 464 ha being located within the mining leases. Actual disturbance at end of 2022 was calculated at 278 ha; however, the historical exploration buffer areas are minimally disturbed and have been partially reclaimed. The terrestrial disturbance area total for the mine site primary infrastructure area is 55 ha which includes mine site infrastructure and related disturbance areas.

The end land use objective remains the same as required by M-243: wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot on the mine site and high elevation sections of the transmission line, and moose and grizzly bear habitat at lower elevations of the transmission line. The mine and its operations have been planned and designed to limit the terrestrial development footprint and to prevent significant adverse effects on the downstream aquatic receiving environment, including both water quality and aquatic biota. The general approach to reclamation and closure planning continues to be creation of post-mine topography and conditions that will achieve the matrix habitat end land use and support passive natural revegetation to the extent feasible. The post-closure

mine site will have low vegetation cover, consistent with its pre-mine condition and with surrounding areas, as most of the adjacent landscape is comprised of unvegetated bedrock exposures.

Mine closure activities are planned for implementation in a sequential manner such that infrastructure needed to the end of mine closure remains in place and all other reclamation activities occur in a logical progression. Underground mine reclamation, including removal of underground mobile equipment and completion of other pre-flooding preparatory measures, and flooding will begin immediately following closure. Removal of surface equipment, buildings and infrastructure not required for water treatment and ongoing reclamation activities will occur during the first summer season of the closure phase. Surface reclamation will then be conducted as described below, including recontouring to prevent barriers or hazards to wildlife, establishment of stable post-closure surface drainage, and decompaction as appropriate.

Mine flooding is estimated to be complete within seven months based on accelerated flooding accomplished by water withdrawal from the WRTSF. The withdrawal rate will be to the current licensed rate during the winter low flow period, and at accelerated rates during the freshet high flow period. Water treatment of the underground mine pool will occur throughout the active flooding period, and is predicted will occur for an additional eight months after flooding is completed (total 15 months). Watertight plugs will be installed in the WZ and VOK portals, and in the raise planned north of Brucejack Creek, during the first year of the closure phase to allow underground mine flooding to its ultimate flooding elevation. Remaining surface reclamation will be completed once active water treatment is no longer required, along with removal of remaining surface infrastructure and equipment, including the water treatment plant and transmission line.

Based on the 4950 tpd mine plan (refer to Chapter 3), the remaining mine life is approximately 7 years, with operations ceasing at the end of 2029. This will be followed by a closure phase estimated at three years that includes two years of closure and reclamation within the M-243 area, and a third year of reclaiming off-site mine related infrastructure (i.e. the BJAR and adjacent infrastructure below Knipple Glacier and extending to the Highway 37 intersection, and the Statutory ROW authorized portion of the transmission line). A post-closure monitoring period of ten years is planned for the M-243 area following mine closure. Post-closure monitoring and reporting will include surface water quality, sediment quality, aquatic resources, groundwater quality and levels, structural integrity of portals and raise watertight plugs, geotechnical, and reclamation success.

Modelling, Mitigation and Discharges

The existing groundwater model, water balance model, and water quality model for the 3800 tpd production rate were updated to include the changes to the mine plan associated with the proposed increase to a daily average ore production rate of 4950 tpd. Updates to these models also included refinement of model inputs using recent monitoring data and test results. Results of the water quality model were screened to identify parameters of concern. A best achievable technology (BAT) assessment was carried out to evaluate treatment options for the parameters of concern, associated costs, and feasibility of implementation. An effects assessment was conducted to assess potential risk to aquatic life in the receiving environment from the modelled water quality, without the implementation of the technology identified by the BAT assessment. Considering the results of the BAT assessment and the effects assessment, Pretium is proposing to amend PE-107835 to increase current discharge limits for nitrate and total arsenic (T-As), and to request the addition of discharge limits for dissolved copper (D-Cu) and total selenium (T-Se). The proposed discharge limits were assessed to have low risk to aquatic life in the receiving environment and to avoid adverse effects of

treatment at the WRTSF outlet which include high energy demand, generation of by-products, and high costs.

MODELLING

The updated 4590 tpd groundwater model predicts increased inflow rates over LOM, but less overall groundwater extraction as compared to the 3800 tpd model. The increased flows to the underground mine will be managed effectively by the mine's current water collection and treatment system. Predicted changes in baseflow reporting to Brucejack Creek for the 4950 tpd production rate are similar to those predicted for the 3800 tpd production rate. Contact groundwater flow rates to Brucejack Creek at closure are predicted to be higher than those predicted for the 3800 tpd mine plan on account of the slightly deeper and broader mine development.

The updated water balance model incorporates anticipated changes to mine site and receiving stream flows based on the increased mining rate for a Base Case scenario, representing average climate conditions. This model forms the basis for the updated water quality predictions. Additional water balance model runs were carried out to assess the model's sensitivity to variable tailings solids content, variable climate conditions, and climate change.

The water quality model was revised to account for the increased ore production rate and the associated mine plan. Revisions to the model include the incorporation of revised flows from the updated groundwater model and water balance model, changes to the mine waste schedules, and updates to geochemical source terms based on new data and trends observed in the monitoring data sets. The water quality model incorporates loadings from mine sources and background flows to generate Base Case and Upper Case water quality predictions at two sites in Brucejack Creek: BJ 3.10, the mine's regulated discharge point, located at the outlet to the WRTSF; and BJ 2.62, a downstream monitoring location in Brucejack Creek. The Base Case is considered to represent the expected water quality and the Upper Case incorporates the combined effects of Upper Case geochemical source terms for all mine-related inputs.

The water quality model results were evaluated to identify parameters that are likely to have concentrations at BJ 3.10 or BJ 2.62 that exceed current discharge limits, or concentrations that are greater than BC water quality guidelines for protection of aquatic life for parameters that don't have discharge limits, during the life of mine. This process identified nitrate, nitrite (during closure only), arsenic, copper, and selenium as parameters of concern (POCs) that will require additional mitigation to meet current conditions in PE-107835 or revisions to discharge limits in PE-107835.

The water quality model report evaluated the potential for the modelled water quality to cause adverse effects to aquatic life in the receiving environment. Brucejack Creek provides habitat for benthic invertebrates and periphyton, but is not fish habitat. The closest fish-bearing waters are more than 20 km downstream of Brucejack Creek, below a barrier to fish migration near the mouth of the Sulphurets River. The effects assessment concluded that there is low risk to aquatic life in Brucejack Creek from the modelled water quality during all mine phases, except for the Upper Case model results for selenium during closure, which was categorized as having a moderate risk of causing adverse effects.

MITIGATION

Source control is a primary method that is used to maintain acceptable effluent quality at the outlet of the WRTSF (BJ 3.10). Source control procedures developed for the mine are described in environmental management plans, including the ML/ARD Management Plan, Nitrogen Management Plan, Chromium Management Plan, the WRTSF OMS Manual, and the Water Management Plan OMS Manual. Treatment of mine contact water by the water treatment plant (WTP), and treatment of sewage by the sewage treatment plants (STPs), prior to discharge to the WRTSF, are also primary mitigation methods. Monitoring of the various sources of contaminant loadings to the WRTSF, and monitoring of WRTSF effluent at BJ 3.10, show that the source control measures implemented have been effective in maintaining acceptable discharge quality. It is anticipated that these measures will continue to be effective for a production rate of 4950 tpd.

A best achievable technology (BAT) assessment was conducted to evaluate options for water treatment at the outlet of the WRTSF to meet current discharge limits and applicable water quality guidelines at BJ 3.10 during the operations phase, under the proposed increased production rate scenario. It was determined that treatment at the WRTSF outlet would be required to meet discharge criteria (effluent limits or water quality guidelines) for POCs identified by the water quality model because a significant proportion of total loadings of these POCs occurs in the WRTSF, downstream of existing mitigations. The BAT assessment was conducted in accordance with the step-by-step process described in the ENV guidance document titled *Best Achievable Technology Assessment to Inform Waste Discharge Standards Handout*, published in October 2021. Treatment technologies for POCs were identified and evaluated for feasibility, reliability, control-effectiveness, and cost-effectiveness.

The BAT assessment concluded that the low effluent limits for T-Se and D-Cu require the use of reverse osmosis (RO) technology. Reverse osmosis is a robust treatment solution for NO_3 and T-As as well. Therefore, RO is considered best achievable technology to meet the current discharge criteria for all POCs during the operations phase, based on the flows and water quality predicted for WRTSF discharge under the proposed increased production scenario. Based on the selected BAT (i.e., an RO-based system), treatment of the high flow rates expected at the WRTSF outlet would require an impractically large footprint and high energy demand. Further, the RO process generates a waste stream concentrated in contaminants which will require management and additional treatment, resulting in additional operational complexity and cost. The estimated capital and operating costs of a WRTSF treatment system (with the capacity to treat approximately 50% of predicted peak flows) are approximately $73,000,000 CAD and $27,500,000 CAD/year, respectively. Based on these negative aspects of constructing and operating a RO treatment plant at the outlet of the WRTSF, coupled with the conclusions of the effects assessment that there is low risk to aquatic life in the receiving environment from the proposed limits (refer to next section), treatment of the WRTSF is considered impractical and uneconomical. In lieu of treatment at the WRTSF outlet, new or increased BJ 3.10 discharge limits for POCs are proposed.

PROPOSED DISCHARGE LIMITS

PE-107835 specifies conditions required for effluent discharged from the WRTSF to Brucejack Creek, including the maximum concentration of several parameters. Parameters without specified discharge limits are expected to meet BC water quality guidelines for the protection of aquatic life, because WRTSF discharge is the headwaters of Brucejack Creek which does not allow for an initial dilution zone. The 4950 tpd water quality model results indicate that concentrations of nitrate and T-As in

Brucejack Creek will likely exceed current discharge limits, and concentrations of D-Cu and T-Se will likely increase to values greater than BC long-term water quality guidelines. Pretium is applying to increase the discharge limit for nitrate to 20 mg-N/L and to increase the discharge limit for T-As to 26 µg/L. Pretium is also applying to add a discharge limits to PE-107835 of 0.9 µg/L for D-Cu and of 6.2 µg/L for T-Se. These discharge concentrations are set at the maximum Upper Case modelled concentration at BJ 3.10 during operations. The decision to apply for these discharge limits considers the conclusions of the effects assessment that there is low risk to aquatic life in the receiving environment from the proposed limits, and negative effects of constructing and operating an RO treatment plant at the WRTSF outlet which include the generation of a waste stream that requires additional treatment, the high energy requirements for the plant, and the high expenses required to build and operate an RO plant at the WRTSF outlet.

Environmental Monitoring

Pretium implements an extensive environmental monitoring program at the Brucejack Mine site and its vicinity, in accordance with the monitoring requirements of the mine's authorizations and its management plans. Groundwater is monitored at 31 groundwater wells, according to conditions in PE-107835 which require measurement of groundwater levels at all wells and groundwater quality at 28 of the wells. Inflows to the underground mine are computed daily using the underground dewatering rates measured from water pumped to the water treatment plant. Mine water flows are monitored at the WTP, STPs, the discharge from the contact water pond, and tailings discharge to the WRTSF. Stream flows are continuously monitored at two sites in Brucejack Creek (BJ 3.10 and BJ 1.74) and in upper Sulphurets Creek just downstream of Sulphurets Lake (SC-1).

Surface water quality is measured at locations within the mine site (WTP influent and effluent, tailings supernatant, and STP effluent), in the receiving environment (three locations on Brucejack Creek and one location in upper Sulphurets Creek), in the Camp Creek tributary to Brucejack Creek, and at a reference stream 20 km northwest of the WRTSF at the frequencies required by PE-107835. Water quality samples are analyzed for general parameters, major ions and nutrients, total and dissolved metals, and total organic carbon.

Monitoring programs have also been developed to assess the impact of disturbances and waste products associated with the various mine facilities including the NPAG Quarry, the mine site, the underground mine, the process plant and the WTP. Monitoring programs include collection of solid samples (waste rock, quarry rock, tailings, WTP sludge), as well as leachate (NPAG Quarry, mine site runoff, paste backfill drainage) and water quality (tailings supernatant, underground mine sumps and seeps) samples at frequencies prescribed the mine's ML/ARD management plan. Various kinetic test programs have also been developed to evaluate the long-term behaviour of mine site materials and to inform the geochemical source terms applied to the mine's water quality model.

Effluent quality from the WRTSF is measured weekly at BJ 3.10. Toxicity testing of BJ 3.10 water is conducted using a *Daphnia magna* acute lethality test, an algae growth inhibition test, and a survival and growth test of the freshwater invertebrate *Chironomus dilutus*. Toxicity testing is also conducted to meet the requirements of the federal Metal and Diamond Mine Effluent Regulations, which require a rainbow trout acute lethality test and a *Ceriodaphnia dubia* reproduction and survival test, in addition to the *Daphnia magna* acute lethality test.

Sediment quality, periphyton community characteristics, and benthic invertebrate community characteristics are sampled in Brucejack Creek, upper Sulphurets Creek, and reference site L3-OF according to the requirements of PE-107835.

No additional environmental monitoring is proposed for the 4950 tpd mine plan, since the increase to the ore production rate will not produce additional surface disturbance, and the existing monitoring programs meet environmental monitoring needs.

Health & Safety

Existing Brucejack Mine Health and Safety related management plans and associated procedures will remain in effect with the proposed production rate increase; no changes are necessary specific to the change in production rate.

Management Plans

Established management plans will continue to be applied throughout the operations and closure phases. Current versions of all 21 component management plans required under Schedule B of EAC M15-01 and 10 additional management plans required through other BC provincial authorizations (mainly permit M-243, PE-107835 and PA-107025) which comprise the Brucejack Mine Environmental Management System (EMS) are included in this application. Consistent with previous applications and reviews, any required updates to management plans for the proposed production increase will be completed post-review to incorporate changes resulting from the review. Pretium currently anticipates that the following management plans and OMS manuals may require revisions following the 4950 tpd Joint Application review process: Metal Leaching/Acid Rock Drainage (ML/ARD) Management Plan, Nitrogen Management Plan, Subaqueous Waste Rock and Tailings Deposition Management OMS Manual, Closure and Underground Water Quality Adaptive Management Plan, Backfill Management Plan, and Ventilation Management Plan.

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LIST OF ACRONYMS AND ABBREVIATIONS

Terminology used in this document is defined where it is first used in each chapter. The following list will assist readers who may choose to review only portions of the document.

2020 Update	2020 Mine Plan and Reclamation Program Update
4950 tpd Joint Application	4950 tpd Joint M-243 / PE-107835 Amendments Application
ABA	acid base accounting
ACP	Advanced Care Paramedic
AEMP	Aquatic Effects Monitoring Plan
Annual Report	Annual Report for *Mines Act* Permit M-243 and *Environmental Management Act* Permits PE-107835 and PA-107025
Assessment Report	2015 Brucejack Gold Mine Project Assessment Report (EAO 2015)
ASX	Australian Securities Exchange
AQTS	Aquarius Time-Series
BAT	Best Achievable Technology
BC	British Columbia
BEC	Biogeoclimatic Ecosystem Classification
BEV	Battery Electric Vehicle
BJAR	Brucejack Access Road
BJT	Brucejack Terminal Station
CABIN	Canadian Aquatic Biomonitoring Network
CEAA	*Canadian Environmental Assessment Act*, 2012
CMAun	CMAun – Coastal Mountain-heather Alpine (undifferentiated)
Code	Health, Safety and Reclamation Code for Mines in British Columbia
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWP	Contact Water Pond
DPS	Diesel power station
EA	Environmental Assessment
EAC	Environmental Assessment Certificate (EAC #15-01)
EAC/EIS Application	Brucejack Gold Mine Project: Application for an Environmental Assessment Certificate/Environmental Impact Statement (2014)
EAO	BC Environmental Assessment Office
East Diversion	Johnson Creek Diversion Channel

EC	Environment Canada
ECCC	Environment and Climate Change Canada
EEM	Environmental Effects Monitoring
EIS	Environmental Impact Statement
EMA	BC *Environmental Management Act*
EMLI	Ministry of Energy, Mines and Low Carbon Innovation
EMP	Environmental Monitoring Program
EMS	Environmental Management System
ENV	BC Ministry of Environment and Climate Change Strategy
EOM	End-of-Mine
EWRD	East waste rock dump
FLNRORD	BC Ministry of Forests, Lands, Natural Resources Operations, and Rural Development
FWAL	Freshwater Aquatic Life
GCMP	Ground Control Management Plan
Granduc	Granduc Mines Ltd.
ha	Hectares
HDPE	High-density polyethylene
IC	Inhibiting concentration
LHD	Load-haul-dump
LHOS	Long hole open stoping
LLW	Low-level weir
LNL	Long Lake generating station
LNT	Stewart substation
LOM	Life-of-Mine
LOO	License of Occupation
M-243	*Mines Act* permit M-243 for the Brucejack Mine
M15-01	Environmental Assessment Certificate #M15-01 for the Brucejack Mine
MA	BC *Mines Act*
MA/EMA	BC *Mines Act/Environmental Management Act*
***MA/EMA* Permits Application**	Applications for Mines Act and Environmental Management Act Permits (2015)
masl	metres above sea level

MDMER	Metal and Diamond Mining Effluent Regulations
MECCS	BC Ministry of Environment and Climate Change Strategy
MEMPR	BC Ministry of Energy, Mines and Petroleum Resources
MERS	Mine Effluent Reporting System
The Mine	Brucejack Mine
Mine Site	Primary mine infrastructure area within Brucejack Mine mining leases
ML/ARD	Metal Leaching and Acid Rock Drainage
Mm^3	Million cubic metres
MOE	BC Ministry of Environment and Climate Change Strategy
MSO	Mineable shape optimize
Mt	Million tonnes
Mtpa	Million tonnes per annum
MW	Megawatt
Newcana	Newhawk Gold Mines Ltd. and Lacana Mining Corp., 60%
Newcrest	Newcrest Mining Limited
NFA	Nisga'a Final Agreement
NLG	Nisga'a Lisims Government
nonel	Non-electric
NPAG	Non-Potentially Acid Generating
NPR	Neutralization potential ratio
OMS	Operations, maintenance and surveillance
PA-107025	Air Permit 107025, issued under EMA for the Brucejack Mine
P.Ag.	Professional Agrologist
PAG	Potentially Acid Generating
PCP	Primary Care Paramedic
PE-107835	Effluent Permit 107835, issued under EMA for the Brucejack Mine
P.Eng.	Professional Engineer
P.Geo.	Professional Geoscientist
PMA	Permitted Mine Area
PNG	Papua New Guinea
PNGX	Papua New Guinea Exchange Markets
POC	Parameter of concern

POPC	Parameter of potential concern
Pretium	Pretium Resources Inc.
PVC	Polyvinyl chloride
QA/QC	Quality Assurance and Quality Control
QPO	Quantifiable Performance Objective
RN	Registered Nurse
ROM	Run-of-mine
ROW	Right-of-Way
SAG	Semi-autogenous grinding
sQ	shifted quarter
STP	Sewage Treatment Plant
SUP	Special Use Permit
SWIM	Single Window Information Manager
t	tonne (1,000 kg) (metric ton)
TCG	Tahltan Central Government
TOC	Total organic carbon
tpd	Metric tonnes per day
tpa	tonnes per annum
TRP	Trigger Response Plan
TSS	Total suspended solids
TSS	Total Suspended Solids
UG	Underground
VFD	Variable frequency drive
VOK	Valley of the Kings Zone
VR	Vent raise
VSF	Volcanic Sedimentary Facies
West Diversion	Camp Creek Diversion Channel
WHMIS	Workplace Hazardous Materials Information Systems
WP1	Temporary waste rock stockpile 1
WP2	Temporary waste rock stockpile(s) 2
WQG	Water Quality Guidelines
WRD	waste rock dump
WRTSF	Waste Rock and Tailing Storage Facility

WSA	*Water Sustainability Act*
WSQG	working sediment quality guidelines
WT	Water treatment
WTP	water treatment plant
WZ	West Zone

1. INTRODUCTION AND PROJECT OVERVIEW

1.1 Application Background

This document is the 4950 tpd Joint *M-243* / *PE-107835* Amendments Application (4950 tpd Joint Application) by Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies, to increase the Brucejack Mine average daily ore production rate from the currently authorized average 3800 tpd to 4950 tpd (1.387 Mtpa to 1.807 Mtpa).

Following Newcrest Mining Limited's (Newcrest's) acquisition of Pretium in Q1 2022, Brucejack Mine operations were reviewed to identify short and long-term opportunities to optimize the mine's operations and to increase its longevity and sustainability. The following objectives were identified from this review process:

1. Short-term objective: Increase the mine's ore production rate in the short-term based on minimal changes beyond the production rate. This includes no changes to the:

- Brucejack Mine Environmental Assessment (EA) Certificate M15-01 life-of-mine (LOM) ore limit of 18.5 Mt
- *Mines Act* (*MA*) Permit M-243 current Waste Rock and Tailings Storage Facility (WRTSF) waste rock deposition limit of 11.9 Mt; and

2. Long-term objective: Initiate work that will enable mine life extension in the longer term.

This 4950 tpd Joint Application is to request authorizations specific to the shorter-term objective identified above (bullet #1). As above, Pretium's overall approach to the 4950 tpd Joint Application is to minimize changes aside from increasing the ore production rate.

Separate from this application, Pretium is initiating work to address the longer-term objective of increasing mine life (bullet #2). This requires additional exploration to confirm more ore reserves, additional mine planning and design, and other mining and environmental related studies. This will be followed by additional applications to amend Brucejack Mine permits and other authorizations as appropriate.

1.2 Application Structure

The following outlines the application structure for the 4950 tpd Joint Application.

1. **Introduction and Project Overview** – This chapter introduces the 4950 tpd Joint Application, Pretium, and the Brucejack Mine, and presents an overview of proposed production rate increase related mine/operations changes.
2. **Baseline Information** – Chapter 2 provides high level descriptions of baseline environmental conditions; references baseline information presented in the 2014 Application for an Environmental Assessment Certificate / Environmental Impact Statement (EAC/EIS Application) (Pretium 2014) and 2015 Applications for *MA and Environmental Management Act (EMA)* Permits Application (*MA/EMA* Permits Application) (Pretium 2015); and references locations in the 4950 tpd Joint Application where currently available monitoring and other information (i.e. the pre-4950 'condition') are presented.

3. **Mine Plan** – Chapter 3 describes the 4950 tpd mine plan, including underground mine development; changes to underground and surface infrastructure including the mill and WRTSF; mine waste handling and deposition in the underground mine and the WRTSF; and underground mine and WRTSF geotechnical considerations.
4. **Reclamation and Closure Plan** – Chapter 4 summarizes the content of the Reclamation and Closure Plan, including updates specific to the proposed 4950 tpd production rate increase and to reflect minor changes since the 2020 Mine Plan and Reclamation Program update submission in July 2020 (2020 Update: Pretium, 2020b). The Reclamation and Closure Plan presented as a chapter in the 2020 Update has been revised to a stand-alone management plan that is appended to this application.
5. **Modelling, Mitigation and Discharges** – Chapter 5 summarizes results of groundwater, water balance, and water quality modeling that has been updated for the 4950 tpd Joint Application, and characterizes the modeled discharge concentrations. Modeling details are presented in modeling report appendices using the same approach as the 2020 Update (Pretium, 2020b).
6. **Environmental Assessment Predictions** – Chapter 6 provides an assessment of potential residual effects to aquatic life from predicted changes to water quantity or quality associated with increase to an average 4950 tpd production rate.
7. **Environmental Monitoring** – Chapter 7 describes existing monitoring plans, which are regularly updated. Results of monitoring programs, including changes to monitoring plans that were made each year, are reported in the Brucejack Mine Annual Report for *Mines Act* Permit M-243 and *Environmental Management Act* Permits PE-107835 and PA-107025 *(MA/EMA* Annual Report).
8. **Health and Safety** – Chapter 8 describes that existing Health and Safety related management plans and associated procedures will remain in effect with the proposed production rate increase; no changes are necessary specific to the change in production rate. This chapter also provides an overview of underground mine emergency preparedness.
9. **Management Plans** – This section describes proposed changes to management plans associated with increase to an average 4950 tpd ore production rate.

Refer to Appendix 1-2 for the final Joint Information Requirements Table (JIRT) which serves as the table of concordance and specifies where information requested during the JIRT review period can be located within the 4950 tpd Joint Application. The application is intended to provide the information requested in the final JIRT (Appendix 1-2) and the Application Instruction Document (Appendix 1-3).

1.3 Proponent Information

Newcrest Mining Limited is a publicly traded company, with common shares trading on Australian Securities Exchange (ASX), Toronto Stock Exchange (TSC) and the Papua New Guinea (PNG) Exchange Markets (PNGX). Newcrest's head office is located in Melbourne, Australia. Following its acquisition of Pretium Resources Inc. in Q1 2022, Newcrest established a regional office in Vancouver British Columbia (BC). Newcrest also has a northwest BC office and warehouse located in Smithers BC. Newcrest owns operating mines in Australia, Canada and Papua New Guinea. Newcrest's Canadian mines are the Red Chris Mine and Brucejack Mine, both of which are located in northwest BC.

Pretium Resources Inc. is a corporation existing under the *Business Corporations Act* (British Columbia) and the permittee for Brucejack Mine authorizations.

Newcrest's regional office address and contact information is as follows:

Newcrest operations
800-1066 Hastings Street West
Vancouver, BC, V6E 3X1
Phone: 604-558-1784
Toll Free: 1-877-558-1784
Website: www.newcrest.com

Communications regarding the proposed 4950 tpd Joint Application should be directed to:

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Smithers, BC V0J 2N5
Canada
Phone: 778-653-8049
Email: Sylvia.VanZalingen@newcrest.com.au

1.4 Project Overview

1.4.1 Project History

1.4.1.1 Exploration, Development and Ownership History

Exploration of the Brucejack Property and the surrounding region dates back to the 1880s, when placer gold was discovered in Sulphurets and Mitchell creeks. In 1935, prospectors Bruce and Jack Johnson discovered copper-molybdenum mineralization on the Sulphurets Property in the vicinity of a copper zone located approximately 6 km northwest of Brucejack Lake.

In 1960, Granduc Mines Limited (Granduc) and prospectors staked the main claim group covering the known copper and gold-silver occurrences, which collectively became known as the Sulphurets Property. The Sulphurets Property was a larger claim group that included what is now the Brucejack Property. Exploration was conducted by Granduc and Esso Minerals through 1984 evaluating high-

grade prospects including the West Zone (WZ). In 1985 Newhawk Gold Mines Ltd. entered into a 60:40 joint venture with Granduc to explore and develop the Sulphurets Property.

Between 1986 and 1991, Granduc (40%) and the Newcana (Newhawk Gold Mines Ltd. and Lacana Mining Corp., 60%) Joint Venture spent approximately $21 million developing the WZ and other smaller precious metal veins on what would later become the Brucejack Property. The historic WZ portal, which provided access for development of several km of underground workings during the late 1980's, dates from this time. The Sulphurets Project was also proposed and approved during this period under the Regional Mine Development Review Process in existence at that time. Waste rock and ore from the historic advanced exploration activity was subsequently deposited into Brucejack Lake in 1999 under direction of BC Ministry of Energy and Mines.

Between 1999 and 2001, Silver Standard Resources (now SSR Mining Inc.) acquired interest and control of the Brucejack Gold Mine Project, including 100% interest in the Brucejack Property. Silver Standard Resources began initial exploration work on the Brucejack area in 2006 and began a large diamond drilling campaign on the Brucejack Valley of the Kings (VOK) Zone in 2009.

Pretium acquired the Brucejack Gold Mine Project, along with other associated assets, pursuant to an acquisition agreement dated October 28, 2010.

In 2012, Pretium commenced an underground exploration program designed to access the VOK deposit, excavate a 10,000 t underground bulk sample and demonstrate continuity of the high-grade gold mineralization. In late December 2012, the widening of the historical WZ underground workings was completed and excavation commenced of the access ramp from the WZ workings to the VOK. The bulk sample was collected and processed to improve confidence in both the geological model and the ore grade estimate.

Following issuance of authorizations required for mine construction and operations during 2015, construction of the Brucejack Mine commenced in September 2015. Commercial production was declared on July 3, 2017. EA Certificate M15-01 authorizes production of up to 18.5 Mt of ore over the life-of-mine. *MA* Permit M-243 (Appendix 1-1) authorizes a mining rate of 1,387,000 t on a calendar year basis (average 3,800 tpd). *Environmental Management Act* Permits PE-107835 (Appendix 1-1) and PA-107025 regulate mine effluent and air discharges respectively.

Newcrest Mining Limited acquired Pretium and the Brucejack operation on March 9, 2022.

1.4.1.2 Previous Reports, Studies, and Design Information

Previous reports, studies, and designs relevant to the 4950 tpd Joint Application include:

1.4.1.2.1 Major Authorizations Applications / Submissions

- *Brucejack Gold Mine Project: Application for an Environmental Assessment Certificate/Environmental Impact Statement (Pretium, 2014);*
- *Applications for Mines Act and Environmental Management Act Permits (Pretium, 2015);*
- *3800 tpd Amendment Application for Permits M-243 and PE-107835 (Pretium, 2018b); and*
- *2020 Mine Plan and Reclamation Program Update (Pretium, 2020b).*

1.4.1.2.2 Key Supporting Technical Reports

- *Brucejack Gold Mine: Assessment of Long-Term Sludge Stability for In-lake and Underground Deposition (Lorax, 2016a);*
- *Characterization of Overburden at the Brucejack Mine Site (Lorax, 2016b);*
- *Characterization of Overburden at the Brucejack Mine Site - Memorandum (Lorax, 2016c);*
- *Brucejack Gold Mine: 2018 Water Quality Model Report in Support of Amendment Applications for Ore Production Increase to 3800 tpd (Lorax, 2018);*
- *Brucejack Gold Mine: 2020 Groundwater Model Review and Update (Lorax, 2020a);*
- *Brucejack Gold Mine: 2020 Water Quality Model Review and Update (Lorax, 2020b);*
- *Brucejack Gold Mine: 2020 Water Balance Model Review and Update (Lorax, 2020c); and*
- *Changes to Brucejack Mine Groundwater Quality Monitoring Program (Lorax, 2022).*

1.4.1.2.3 *MA/EMA* Annual Reports

- *2015 MA/EMA Annual Report (Pretium, 2016);*
- *2016 MA/EMA Annual Report (Pretium, 2017);*
- *2017 MA/EMA Annual Report (Pretium, 2018a);*
- *2018 MA/EMA Annual Report (Pretium, 2019);*
- *2019 MA/EMA Annual Report (Pretium, 2020a);*
- *2020 MA/EMA Annual Report (Pretium, 2021a); and*
- *2021 MA/EMA Annual Report (Pretium, 2022a).*

1.4.2 Location, Access and Land Use

The Brucejack Mine is a gold-silver underground mine located in northwest BC approximately 950 km northwest of Vancouver and 60 km north-northwest of Stewart (Figure 1.4-1). More specifically, the Brucejack Mine is located at 56.4637, 130.1857. Ground access to the mine is via the Brucejack Access Road (BJAR), an approximately 73 km all weather access road that extends west from km 215 of Highway 37 North, and that is authorized under Pretium's Special Use Permit (SUP) S25923. The BJAR provides year-round access to the mine and is primarily a gravel surface road except for a 12 km section that traverses the Knipple Glacier. Air access is via helicopter from Stewart or other local communities, or by charter fixed-wing aircraft to Pretium's Bowser Aerodrome located at km 50 of the BJAR.

The mine's mining, processing and other primary infrastructure (mine site) is located at the headwaters of Brucejack Creek at an elevation of approximately 1365 masl.

The Brucejack Mine, the BJAR and the Brucejack transmission line lie within the asserted traditional territory of the Tsetsaut Skii km Lax Ha, and portions lie within the Nass Area of the Nisga'a Nation as defined in the Nisga'a Final Agreement, and the asserted territory of the Tahltan Nation.

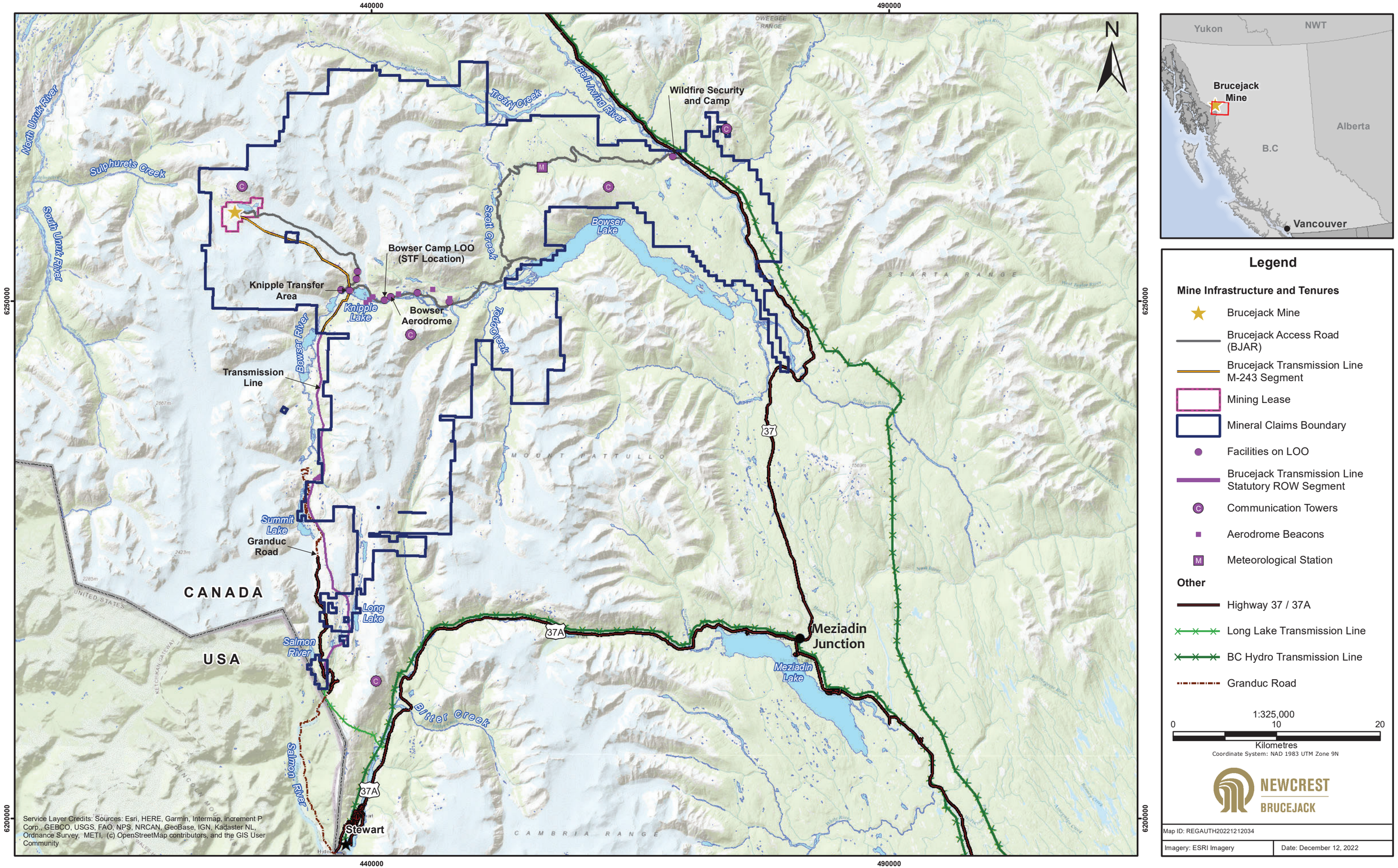


Figure 1.4-1. Brucejack Mine Regional Setting, Access and Tenures

The WRTSF has an area of approximately 81 ha; its original maximum depth was approximately 85 m. The WRTSF has a short ice-free season, generally occurring from July through October. The receiving environment for discharge from the WRTSF is Brucejack Creek, which flows into Sulphurets Creek, which is tributary to the North Unuk River (Figure 1.4-3). The receiving environment is non-fish-bearing from the WRTSF outlet to a fish barrier located more than 20 km downstream along Sulphurets Creek and several hundred metres upstream of its confluence with the North Unuk River (Figure 1.4-3).

Ice, rock and recently deglaciated areas dominate the surficial materials at the mine site and surrounding areas, with the mine site surface rock and areas north and south of it being gossanous (mineralized to surface) (Figure 1.4-4). Given this, the mine site is either non-vegetated or only sparsely vegetated and, with respect to land use at capability, serves as matrix habitat for wildlife moving through the area (i.e., habitat through which wildlife will move, but which does not provide life requisites). Extensive information on the baseline environmental / ecological conditions of the Brucejack Mine area can be found in the mine's 2014 application for an Environmental Assessment Certificate / Environmental Impact Statement (Pretium, 2014) and 2015 *MA/ EMA* Permits Application (Pretium, 2015).

Potential environmental effects associated with the Brucejack Mine identified through the 2014 pre-development and subsequent environmental assessments have and continue to be mitigated and managed through implementation of the mine's design and associated planned mitigation measures, and implementation of requirements under the various authorizations. The latter requirements include the mine's Environmental Management Plans, including 21 plans required under EAC #M15-01 Schedule B and additional plans required under other authorizations.

The Brucejack Mine primary infrastructure is located within four mining leases: 1038597 (53.6 ha), 1038598 (553.6 ha), 1038599 (35.7 ha), and 1038600 (107.2 ha), the outer extents of which are shown on Figure 1.4-1 and Figure 1.4-2.

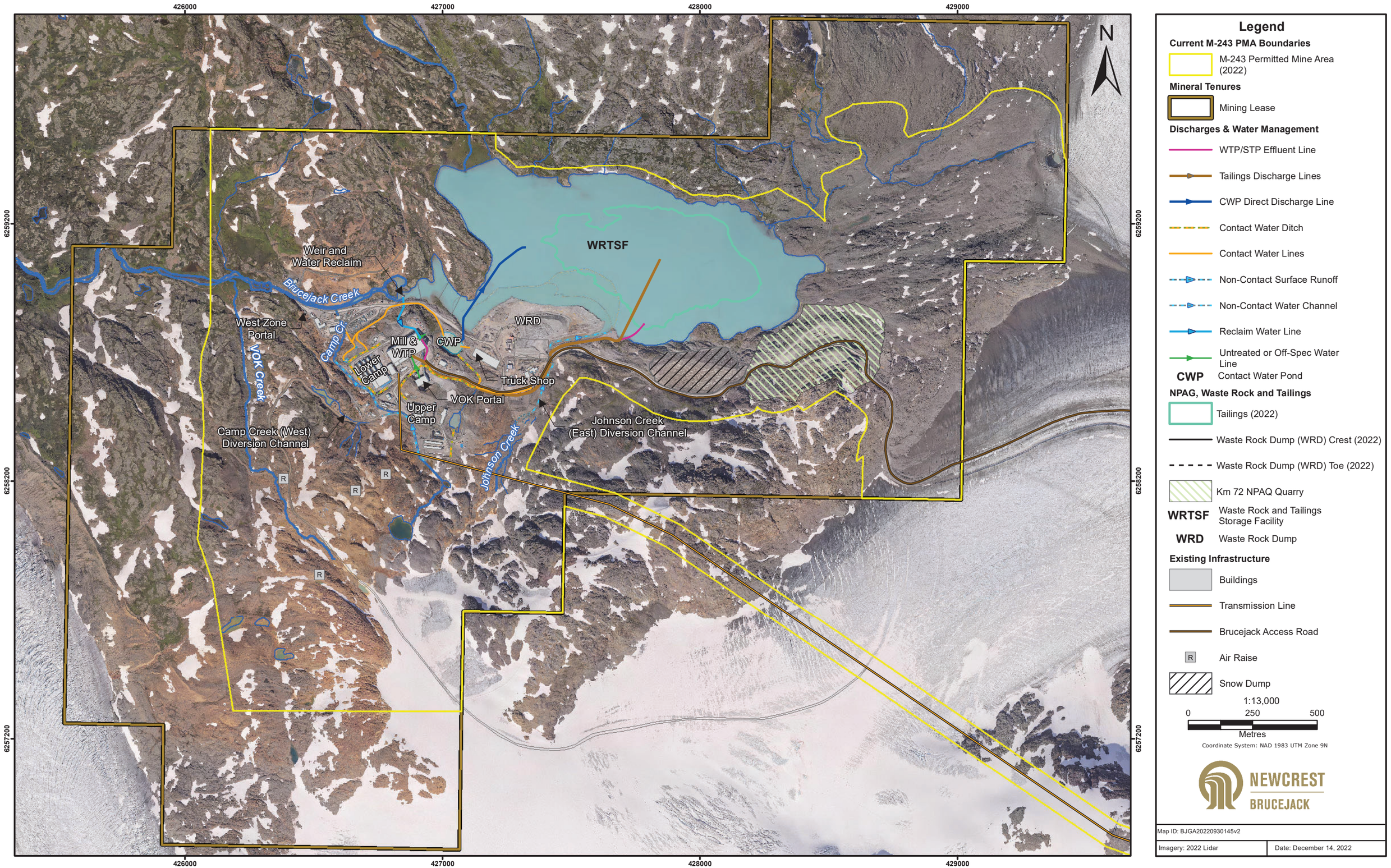


Figure 1.4-2. Brucejack Mine Surface Plan End of 2022 and M-243 Permitted Mine Area

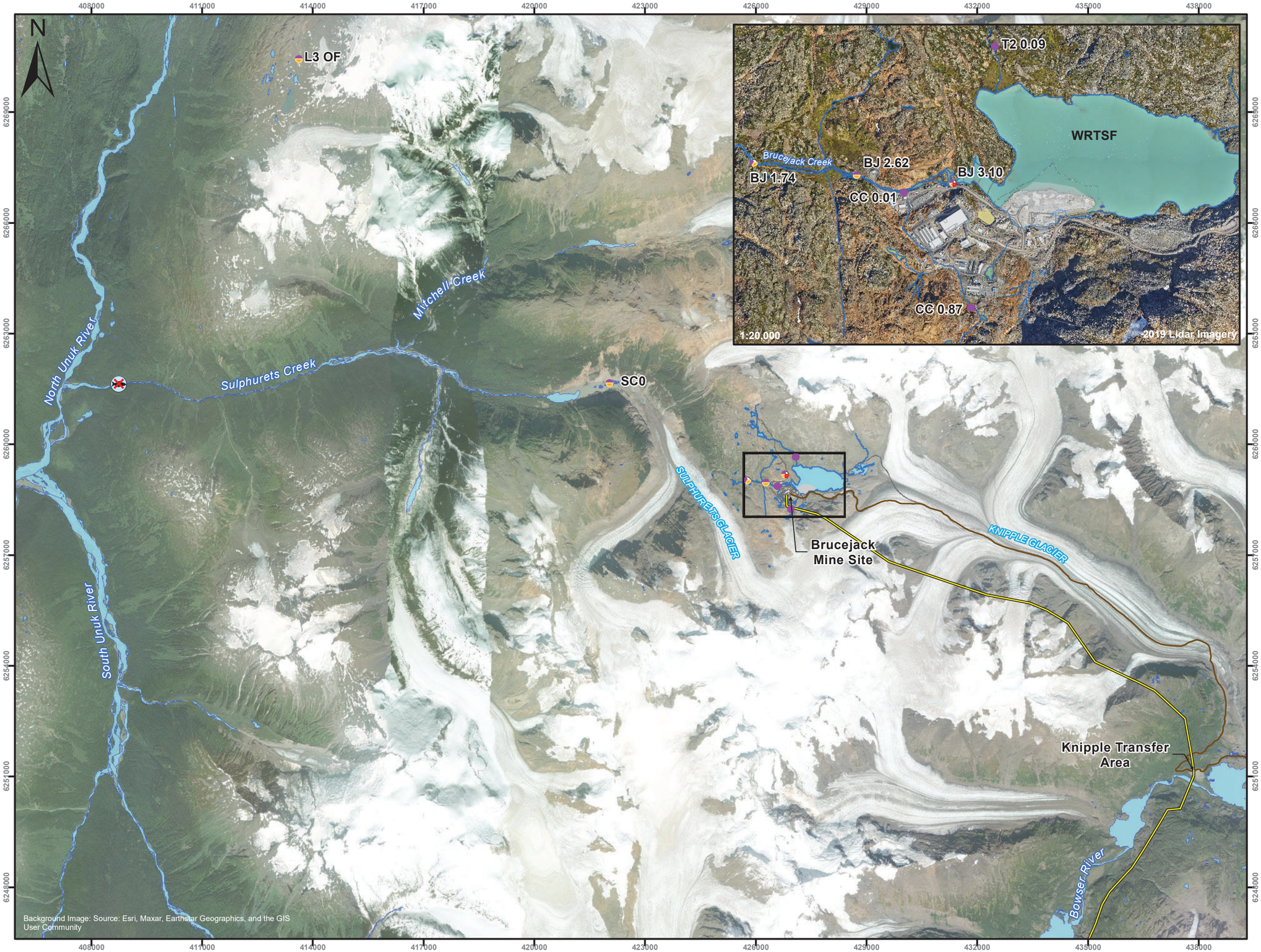


Figure 1.4-3 Brucejack Mine Water Monitoring Sites and Aquatic Receiving Environment

Figure 1.4-4. Mine Site Gossanous Terrain Setting as Viewed from Northwest to Southeast

1.4.3 Mine Components and Off-Site Infrastructure

1.4.3.1 Overview

Mine site facilities are an underground mine and related surface facilities, including:

- Underground mine with water management, electrical, and ventilation systems; underground crusher and conveyor connection to the mill; and mine openings, including two portals (WZ and VOK) and five raises (four currently developed);
- WZ pad with support infrastructure for the underground mine including a heavy duty shop, staging areas for waste rock, offices, covered storage, mine heater and associated propane storage and supply, fuel storage and dispensing, and diesel power station (DPS);
- Mill with ore processing equipment, a smelting furnace, a paste backfill plant, an assay laboratory, core processing facility, and a mine Water Treatment Plant (WTP);
- Camp including kitchen, recreation, laundry facilities, mine and mill dry facilities, medical clinic, administration/offices, potable water well and distribution system, potable water treatment plant, sewage treatment plant (STP), and solid waste management systems;

- WRTSF with a waste rock dump (WRD) for subaqueous waste rock deposition and into which tailings are also deposited (Figure 1.4-5);
- Surface water management system that includes a Contact Water Pond (CWP), a contact water collection and treatment system, mine dewatering facilities, and freshwater diversion channels;
- Various ancillary surface infrastructure, including waste handling facilities, including an incinerator, waste oil burners, and burn pits; mine and avalanche control explosives magazines; cement binder storage silo for pasting operations; warehouse, coverall storage and equipment laydown areas; surface heavy duty shop to service vehicles and mobile equipment; fire hall; communications systems; heli-pad; and mine site roads;
- Overburden stockpile; and
- Non-potentially acid generating (NPAG) rock quarry at BJAR km 72 (Figure 1.4-2).

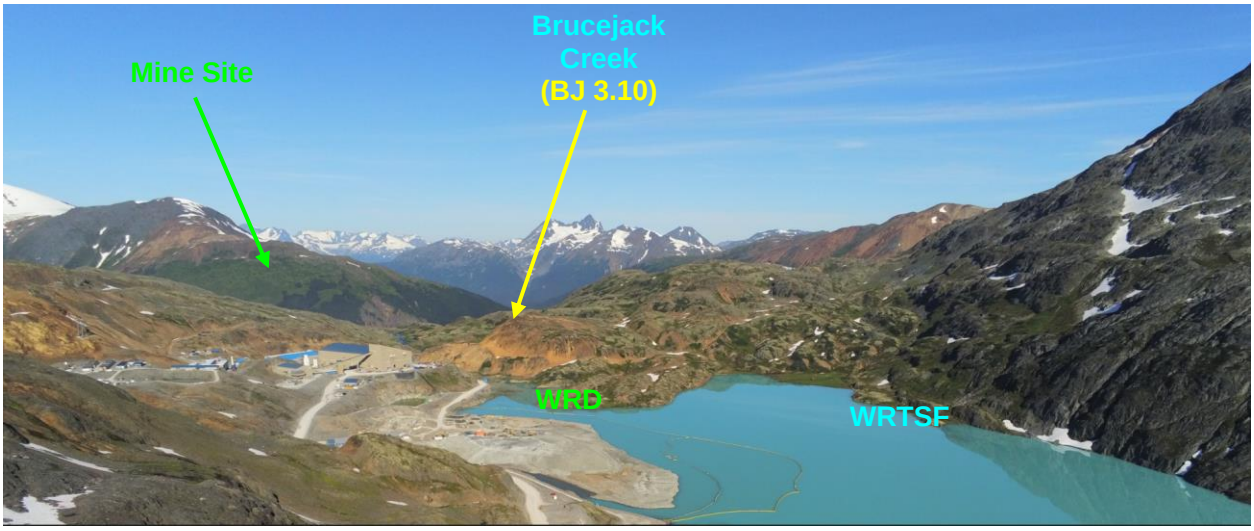


Figure 1.4-5. Brucejack Mine and WRTSF as seen from east side of WRTSF looking westward (August 2022).

The portion of the BJAR located within the mining leases is included in the M-243 Permitted Mine Area (PMA), as is the northernmost 19 km of the 56 km Brucejack transmission line. The Brucejack transmission line extends south from the mine to an intertie near the Long Lake Hydro facility and connects to the BC Hydro grid.

A new surface heavy duty shop is currently under construction and will replace the existing shop in 2023. A new warehouse is included within the new heavy shop that is currently under construction. Mine components and infrastructure, including these upgrades, are described in greater detail in Chapter 3.

1.4.3.2 Underground Mine

The underground mine has been designed to extract ore through a combination of transverse long hole open stoping (LHOS) and longitudinal LHOS. Paste backfill is integral to the mine plan to maximize both ore recovery and mining productivity. Modern trackless mobile equipment is used for most mining activities. No changes to mining methods or rock mechanics criteria are proposed for the proposed ore production rate increase from the currently authorized 3800 tpd to proposed 4950 tpd. An increased mining rate will be achieved through increased rates of drilling and development, supported by additional battery electric vehicles.

Major underground mine infrastructure includes the primary jaw crusher, conveyors, ventilation raises, fans, heating system, pumping stations, electrical substations, explosives magazines, paste fill booster pump station, refuges, underground batch plant, mine communications, and other ancillary installations.

1.4.3.3 Mill

The overall mill process, which includes crushing, grinding, gravity / flotation and tailings dewatering, will remain the same with the proposed production rate increase. To facilitate the production increase from 3800 tpd to 4950 tpd, the following upgrades to the mill are anticipated:

- Grinding circuit: increasing cyclone feed capacity and associated piping
- Gravity separation/concentration: upgrading gravity feed pump capacity, gravity screen, and an additional Knelson concentrator
- Floatation: pre-floatation trash screen installation, rougher concentrate to cleaner floatation bypass, and floatation circuit pump upgrades

These upgrades will be completed within the existing mill structure and do not require additional surface disturbance or facility construction.

1.4.3.4 Waste Rock and Tailings Storage Facility

Waste rock and tailings generated by the mine are either deposited in the WRTSF or backfilled in underground mined out stopes. These methods of mine waste placement will continue with the 4950 tpd mine plan, as described in Chapter 3.

The previously approved 3800 tpd mine plan (Pretium 2018b) allows for deposition of approximately 11.9 Mt of tailings and 7.8 Mt of waste rock within the WRTSF during the LOM. The 4,950 tpd mine plan does not increase the overall tailings and waste rock deposition to the WRTSF. Actual deposition tonnages into the WRTSF at the end of 2021 are recorded to be 3.56 Mt of tailings and 5.74 Mt of waste rock. From 2022 until the EOM, the 4,950 tpd mine plan has 7.8 Mt of tailings and 2.0 Mt of waste rock reporting to the WRTSF, for a total LOM tonnage of 11.3 Mt and 7.9 Mt, respectively.

Waste rock deposition will continue at the existing south WRD and (pending regulatory approval) potentially at an additional east waste rock dump (EWRD) described in the 2015 MA/EMA Permits Application that is required for existing operations. As described in Section 3.5.3, the additional WRD crest length and stockpiling capacity at the EWRD site will provide contingency management options.

The WRTSF (including WRD) is described in greater detail in Section 3.5.3 WRTSF geotechnical considerations for the increased production rate and operational controls needed to address geotechnical requirements are presented in the Waste Rock and Tailings Deposition Plan (Appendix 3-1).

1.4.3.5 Other Infrastructure and Components

Based on assessment of power consumption requirements for the proposed 4950 tpd ore production rate, an increase in power supplied by BC Hydro will be required (from current 20 MVA to 35.5 MVA. This increase in power does not require changes to the existing transmission line. Details on the transmission line can be found in Section 3.5.6 Brucejack Mine is in the process of electrifying part of its underground mine fleet.

The explosives consumption rate will increase as blasting activities increase for the first few years of operations with the 4950 tpd production rate increase, but then steadily decrease through operations as the rate of blasting and explosive quantities decrease. Section 3.5.1.4 summarizes types of explosives used and Section 3.5.7 describes the explosives magazines.

Risks associated with increasing the number of concentrate shipments (truck transportation) have been considered. Safety and environmental risks associated with concentrate transport along the BJAR are managed through the mine's Health and Safety, and Environmental Management systems, and will continue to be managed through these systems with a higher number of shipments. Relevant EMS component management plans include the Spill Response Plan, Traffic and Access Management Plan, Wildlife Management Plan and the Air Quality Management Plan. The current number of return trips by concentrate trucks from the mine to Port of Stewart varies based on weather and related road conditions and other factors, but averages 8 to 9 return trips per 24 h period (i.e., less than 1 truck per hour in either direction). Based on a proportional increase of 30% in the number of concentrate truck return trips, there would be an additional 2 to 3 return trips per day (i.e., average total of approximately 1 truck per hour in either direction). This is still an extremely low hourly traffic volume.

No changes specific to the proposed production rate increase are required for the BJAR or for Knipple or Wildfire camps and their associated infrastructure.

1.4.4 Mine Development and Operations

1.4.4.1 Mining

The updated mine plan presented in Chapter 3 has been adjusted to account for an increased ore production rate of 4950 tpd and for reconfiguration of mining within the West and VOK Zones. The mine envelope remains very similar to extents presented in the 3800 tpd Amendment Application for Permits M-243 and PE-107835 (Pretium 2018b) and in the 2020 Mine Plan and Reclamation Program Update (Pretium 2020b), with similar vertical and lateral extents.

The mining methods for the updated 4950 tpd mine plan remain the same as present – i.e., a combination of transverse LHOS and longitudinal LHOS. Overall mine waste handling methods also remain the same, with waste rock and tailings either placed in the underground mine as backfill or deposited/discharged within the WRTSF, dependent upon operational needs. Modern trackless mobile equipment will continue to be employed in the underground mine.

Mining production will remain focused on the VOK zone until 2025 when stoping in the higher silver, lower gold grade WZ is expected to begin. The proportion of material mined in the WZ compared to the VOK will then increase over the remainder of mine life.

VOK ramp development will advance continuously to the vertical extents of the mine. Levels will continue to be developed and stoping will continue, with all VOK and WZ reserves being mined over the LOM. Development of the WZ ramp is currently in progress to allow production from the lower WZ blocks by 2025.

Mining of the WZ deposit will begin in 2024/2025, with a gradual increase to full production from this area in 2027. Development (i.e., access to stopes) requirements will decrease significantly in the last 3 years of mine life. Installation of the last required ventilation raise is scheduled for 2025. Internal raises will be developed within the mine as determined by scheduling requirements.

WRD development, tailings deposition and km 72 NPAG quarry seasonal operations will continue during the 2027 to mine closure period. No additional surface infrastructure beyond the vent raise described above is planned for the period from 2027 to mine closure.

Because the ore production rate will be higher, the mine life will decrease. End of operations with the 4950 tpd mine plan will be 2029 rather than 2032.

Underground mine geotechnical considerations for the increased production rate are presented in Chapter 3. Ventilation requirements are also presented in Chapter 3.

1.4.4.2 Mill Process

The minor mill upgrades required for the proposed production rate increase are described in Section 1.4.3.3. These upgrades will be completed within the existing mill structure and will not require additional surface disturbance or facility construction.

1.4.4.3 Water Management and Quality

The Brucejack Mine water balance model has been updated for the proposed 4950 tpd production rate (refer to Appendix 5-2) and to reflect minor changes to mine site water management since 2020. The mine's groundwater model has also been updated (refer to Appendix 5-1).

Increased rates of waste rock and tailings deposition to the WRTSF and of backfilling underground, and changes to overall waste rock and tailings quantities, have the potential to affect water quality predictions. Water quality model updates, presented in Appendix 5-3, include the 4950 tpd waste rock and tailings deposition rates, the updated groundwater model and the water balance model results, and updated source terms. Additional information is presented in Chapter 5 Modelling, Mitigation, and Discharges.

1.4.4.4 Effluent and Air Discharges

The updated water quality modeling report (Appendix 5-3) presents updated predictions for effluent quality at the Brucejack Mine's WRTSF discharge location, monitoring site BJ 3.10, and further downstream at site BJ 2.62. These predictions and proposed mitigations are presented in Chapter 5. An aquatic effects assessment is presented in Chapter 6.

There are no changes to regulated air discharges related to the production increase and therefore no amendments of PA-107025 are required.

This information is presented in greater detail in Chapter 5 Modelling, Mitigation, and Discharges.

1.4.5 Mine Design and Assessment Team

Pretium / Newcrest personnel and consultants who provided technical input or other major contributions to this application are listed in Table 1.4-1 along with their primary roles and professional designations. Signed and sealed acknowledgements by the Qualified Professionals responsible for application technical chapters and information are provided in Chapter 10. Technical reports included as appendices to the 4950 tpd Joint Application are signed and sealed by Qualified Professionals, as appropriate, within those reports.

Table 1.4-1. 4950 tpd Joint Application Authors and Major Contributors

Personnel	Company	Title	Application Primary Role	Degree/ Professional Designation
Ben Wither	Pretium Resources Inc. (Pretium) / Newcrest Mining Limited	VP HSE and Permitting	Application senior review	B.Sc., M.B.A.
Sylvia Van Zalingen		Director, Permitting	Application management, senior review, preparation Reclamation and Closure Plan (Appendix 4-1) and chapter 4 excluding biophysical description and reclamation research sections, and preparation sections 7.1 , 7.2.1, 7.2.4, 7.3 and 7.4	M.S., P.Ag.
Brett DeHay-Turner		Senior Hydrogeochemist	Application coordination, compilation and review, management mine plan chapter and mine plan interface for water modeling reports, preparation sections 3.1, 3.2, 3.5, 7.2.5, and chapter 8	M.Sc.., P.Geo.
Greg Norton		VP Government Relations & Social Performance	Preparation section 1.6	M.Sc.
Sabrina Lakhani		Superintendent, Social Performance	Preparation section 1.6	BSc, MRespResDev
Nick Scarcelli -Casciola		Manager, Regional Mine Planning	Preparation sections 3.2.4, 3.3, 3.4, 3.5.1	P.Eng.
Scott Laliberte		Mill Operations Superintendent	Prepared section 3.5.2.5, 3.5.2.6 and 3.5.2.7	B.A.Sc.
Michael Yakimchuk		Mill Manager	Review sections 3.5.2 and 3.5.4	B.A.Sc., P.Eng.
Laura Fredrickson		Permitting Specialist	Compilation and support of sections 1.1, 1.2, 1.4, 1.5, 2.5, 2.7.1, 2.8, 2.9, 7.2.6, and chapter 9	B.A.Sc., E.I.T.
Xavier Pinto		Senior Hydrologist	Preparation sections 2.2 and 2.6.1 and review section 2.5	M.Sc., P.Geo.
Caitlin Scinocca		Intermediate Geotechnical Engineer	Prepared section 3.5.1.9	P.Eng.
Woo Shin		Senior Geotechnical Engineer	Review section 3.5.1.9, 4.6.4, 4.6.5, and Appendix 4-1 sections 12.4 and 12.5	Ph.D., P.Eng.
Dinesh Devathasan		Chief Mine Engineer	Review sections 3.5.1.5.1, 3.5.1.5.2, 3.5.5, and 3.5.7	P.Eng.
Alison Shaw	Lorax Environmental Services (Lorax)	Senior Geochemist	Senior technical review for geochemistry and water quality, contributed to sections 2.3, 2.4 and 7.2.5, preparation of Chapter 5, Water Quality Model (Appendix 5-3), and Table 1.4-4 (rows 2-5)	Ph.D., P.Geo.
Robert Goldblatt		Senior Biologist	Preparation of Chapter 6, contribute to preparation of Chapter 5, the Water Quality model report (Appendix 5-3) and Table 1.4-4 (rows 1 and 6-8), and reviewer of sections 2.7, 2.8, 2.9, 4.6.2 and Chapter 7.	B.Sc., RPBio
Colin Fraser		Senior Hydrologist	Preparation of Water Balance Model (Appendix 5-2)	M.Sc., P.Geo.
Joseph Xu		Senior Numerical Modeller	Preparation of Groundwater Model (Appendix 5-1) and Water Quality Model (Appendix 5-3)	Ph.D.
Jane May		Chemical Engineer	Preparation of Best Achievable Technology study (Appendix 5-4)	B.A.Sc., P.Eng.
Patrick Mueller		Environmental Chemist	Preparation of Water Quality Model (Appendix 5-3)	B.Sc., P.Chem.
Laura-Lee Findlater		Senior Hydrogeologist	Preparation of Groundwater Model (Appendix 5-1); contributed to sections 2.6.2, 2.7.2, 4.6.3, 7.2.2, Table 1.4-4 (rows 9-15), and Section 12.3 of Appendix 4-1.	B.Sc., P.Geo.
Justin Straker	Integral Ecology Group (IEG)	Soil Scientist, Forest Ecologist	Preparation Reclamation and Closure Plan (Appendix 4-1) reclamation research content	M.Sc., P.Ag.
Jeffrey Kwok	WSP Golder	Geotechnical Engineer, Mine Waste Canada	Review sections 3.2.3 and 3.5.3	P.Eng.
Krystle Batiuk	Environmental Resources Management (ERM)	Senior Consultant, Scientist	Review section 1.4.7 (except Table 1.4-4)	B.Sc., M.N.R.M., P.Biol.
Jackie Lerner		Principal Consultant	Preparation section 1.4.7 (except Table 1.4-4), 1.6	Ph.D., EP
Jessica Lowey		Senior Consultant, Terrestrial Biodiversity Lead	Preparation of section 4.2.1 (paragraphs 2 and 3) and Appendix 4-1 [prepared or approved soils and vegetation content in sections 2.2 (paragraphs 3 to 6) and 2.3 (paragraphs 2 and 4), and has prepared section 3.2 Climate Change Considerations)]	M.Sc., P.Ag.
Wade Brunham		Partner, Scientist	Preparation of section 4.2.1 (paragraphs 1 and 4) and Appendix 4-1 [prepared or approved wildlife content within sections 2.2 (paragraphs 3 to 6) and 2.3 (paragraphs 2 and 4)]	M.Sc., RPBio
Rhonda Netzel	Practical Engineering Ltd.	Electrical Engineer	Preparation section 3.5.7	B.Ap.Sc., P.Eng., PE

1.4.6 Spatial Data

1.4.6.1 Proposed Permitted Mine Area

No changes to the PMA are required to accommodate the 4950 tpd production rate increase. There will be no requested change to the approved mine site end land use of matrix habitat for wildlife.

1.4.6.2 Physical Disturbance Proposed Annually for 5 years

No changes to surface disturbance are required to accommodate the 4950 tpd production rate increase.

1.4.6.3 Reclamation Proposed Annually for 5 years

The design of the Brucejack mine site has focused on efficient and essential use of surface disturbances. This total surface disturbance area is small (terrestrial infrastructure area of 55 ha) (Appendix 4-1, Figure 8.1-1) and almost all is needed for operations. Because of this small, intensively used footprint, progressive reclamation has not been possible to date and there are no opportunities within the next 5 years beyond the small-scale areas being used to support reclamation research (see Appendix 4-1, Section 3.7) and small areas of disturbance from surface exploration. Reclamation activities for mine operations infrastructure areas will be completed during mine closure.

1.4.6.4 Proposed Life of Mine Disturbance and Reclamation Program

Refer to Appendix 4-1 for the updated Reclamation and Closure Plan. The reclamation liability costing has been updated and is being provided under separate cover to the Chief Permitting Officer as per Code Section 10.1.3(i).

1.4.6.5 Environmental Sampling Stations

No changes to environmental sampling stations are required to accommodate the 4950 tpd production rate increase. The locations of environmental sampling stations associated with PE-107835 and PA-107025 are described in the Aquatic Effects Monitoring Plan (AEMP) provided in Appendix 9-1-4 and in the Air Quality Management Plan provided in Appendix 9-1-2, respectively.

1.4.6.6 Site Infrastructure

Brucejack Mine site infrastructure is shown in Figure 1.4-2, and described in greater detail in Chapter 2 and 4.

1.4.7 Concordance with Environmental Assessment Conditions

EAC #M15-01 for the Brucejack Mine was issued under the BC Environmental Assessment Act (2002) on March 26, 2015. Many of the EAC #M15-01 Schedule B conditions (i.e., Conditions 1, 2, 3, 4, 7, 9, 10 and 14) pertained to management plans that were to be prepared and submitted to the EAO; this has already occurred. Consistent with previous applications and reviews, any required updates to these management plans will be completed after the review of the 4950 tpd Joint Application is complete to incorporate changes resulting from the review. Four other Schedule B conditions (i.e.,

Conditions 5, 6, 8, 13 and 15) pertain to the BJAR or other areas outside of the mining leases. Table 1.4-4 lists EAC #M15-01 Schedule B conditions that are relevant to the Joint Application.

Table 1.4-2. Concordance of EAC #M15-01 Conditions with 4950 tpd Joint Application Sections

Condition No.	Condition Description	Section in the Joint Application
11	The Holder must provide the results, analyses, and interpretation of test work conducted to demonstrate the effectiveness of all components of the construction and operations water treatment plants, to the satisfaction of EAO, MEM and MOE, prior to Construction related to the Mine Site.	Section 5.6.4.6. Influent and Effluent Water Quality
12	The Holder must complete the interpretation of groundwater conditions to increase confidence in the following predictions: • Groundwater inflow rates during operations; • Post-closure groundwater flow rate through the underground workings, and associated rate and area of contact-water discharge to surface water; and • The time required for the underground workings to flood during the closure period. The evaluation, at minimum, must include the following components: • Interpreted hydrogeological cross section along a flow path from the underground workings to the interpreted area(s) of groundwater discharge after closure; • Improvements to and/or sensitivity analysis of the groundwater-model calibration to the magnitude and direction of vertical and lateral hydraulic gradients, and the amplitude of transient response to seasonal recharge and underground dewatering; and • Associated sensitivity analysis with respect to predictions. The Holder must provide the evaluation, to the satisfaction of EAO, MEM and MOE, prior to Construction related to the Mine Site.	Section 5.3 Groundwater Model and Appendix 5-1 Groundwater Model Report

A comparison of the Certified Project Description with the 4950 tpd Joint Application project changes is provided below in Table 1.4-3. Table 1.4-4 summarizes permitting-level issues raised and commitments identified during Environmental Assessment Review. To develop Table 1.4-4, the permitting issues and comments that were identified during the original EA process (as identified in Table 10.1-5 of the 2015 Joint MA/EMA Application) were reviewed, and any items relating to the currently proposed Project changes were extracted and compiled in a new table. The section of the current Application where these issues are addressed for the proposed Project changes were then identified in the final column of the table.

Table 1.4-3. Comparison of Certified Project Description with 4950 tpd Joint Application Project Changes

Certified Project Description Section	Certified Project Description Detail	4950 tpd Joint Application Project Changes
1. Project Overview	The Brucejack Gold Mine Project (Project) uses underground mining methods to extract gold and silver ore from veins located in a mountainous area in northwestern British Columbia (BC). Ore is extracted using the long-hole open stoping (LHOS) and longitudinal LHOS methods with a combination of rock and paste backfill. The underground mining operation uses diesel- and electric-powered mobile equipment via a decline ramp system.	N/A – No new mining methods or equipment proposed.
	The Project will produce up to a maximum of 18.5 million tonnes (Mt) of ore at the Mine Site. The Project uses crushing, grinding, flotation, and gravity separation to produce gold and silver concentrate as well as semi-pure doré bars. The mine area includes camp accommodations, office facilities, a mill building, water and sewage treatment plants, a power station and ancillary infrastructure for the Project.	N/A – Life of mine ore extraction to remain within the 18.5 Mt maximum, no new milling processes proposed, and mill building to house the same project components.
	The Project stores waste rock and tailings in Brucejack Lake and uses a waste rock and tailings paste to backfill underground voids.	N/A – No new mine waste placement methods proposed.
	Project access is via the up to 76-kilometre (km) Brucejack Access Road that includes a glacier road.	N/A – The project access road remains the same.
	The Project houses construction workers at Wildfire Camp, located near the junction of Highway 37 and the Brucejack Access Road, and Bowser Camp, located at the Bowser Aerodrome, as well as at temporary camps at the mine site and at Stewart. Operation workers will be housed at the Mine Site, Bowser Camp, Wildfire Camp, and the Knipple Transfer Area; two explosives storage and staging areas west of Knipple Transfer Area and east of Bowser Aerodrome, respectively; remote avalanche control systems; and various communications tower sites and beacons for the aerodrome.	N/A – No new camps proposed.
	The Project includes the Bowser Aerodrome, an upgrade of the historic airstrip in the upper Bowser River Valley east of Knipple Lake. The Project includes the Brucejack Transmission Line a new, up to 60 km transmission line.	N/A – No changes to air transport or transmission line.
1.1 Location and Current Access	The Brucejack property is located at 56°28'20" N latitude by 130°11'31" W longitude, which is approximately 950 km northwest of Vancouver and 65 km north-northwest of Stewart. The Project is located within the Regional District of Kitimat-Stikine.	N/A – Location of the Project is static.
1.2 Project Components		
1.2.1 Bowser Aerodrome and Camp	Up to a 1600 metre runway with taxiway and apron. Portable air terminal building and generator. Approach and navigation lighting and flight control beacons. Septic field. One permanent and one temporary camp. Soil stockpile area. Meteorological station	N/A – No changes to aerodrome facility or camp.
1.2.2 Brucejack Access Road	Upgrades to the existing exploration access road to support Project construction and operations. Use of the existing Wildfire Camp, existing Wildfire Equipment Laydown area, and auxiliary laydown area for the purposes of accommodation and staging during life of mine. Remote avalanche control systems and meteorological station. Re-establishment and use of the existing road from Bowser Lake landing to the Brucejack Access Road. Realignment of the existing Lakeshore Drive to support Project construction and operations. Bulk emulsion staging areas with facilities for storage of explosives and the transfer and storage of bulk emulsion containers. **Use of and access to quarry materials in the Brucejack Access Road Disturbance Area.**	N/A – No changes required to the access road, camps, or laydown areas.
1.2.3 Brucejack Transmission Line	Up to 60-km-long transmission line, including a right-of-way up to 100 metres wide, from the mine site to the Bowser River Valley and then south-westerly to connect with the provincial grid at the Long Lake Hydro Project near Stewart, tap interconnection plus a substation and related facilities at the mine site. Temporary laydown staging area near Tide Lake and at Bowser Camp to support construction of the transmission line. Temporary camps for Construction with related water supply, sewage treatment, camp waste disposal facilities and construction waste disposal facilities at Bowser Aerodrome. Temporary camp for Construction in Stewart, BC located on private property with access to municipal water and sewer services, camp waste disposal facilities and construction waste disposal facilities.	N/A - Power consumption requirements for the 4950 tpd were assessed and an increased power supply from BC Hydro from 19.4 MW to 35 MW has been requested. This increase in power does not require changes to the existing transmission line.
1.2.4 Knipple Transfer Area	Laydown area for the transfer of materials and equipment between highway vehicles and specialized vehicles for transport over the Knipple Glacier. Step-down electrical power substation. Permanent camp for Knipple Transfer Area workers and road maintenance crews. Potable water supply. Septic field. Fuel storage facilities. Fuelling station.	N/A – No changes to Knipple Transfer Area.

Certified Project Description Section	Certified Project Description Detail	4950 tpd Joint Application Project Changes
	Lab for the assay of mineral samples, mill process samples and water samples. Ancillary buildings, including a maintenance and emergency vehicle building and cold storage building. Camp waste disposal facilities including incinerator. Construction waste disposal facilities. Soil stockpile area	
1.2.5 Mine Site	Underground mine using LHOS and longitudinal LHOS methods with a combination of rock and paste backfill. Underground mine ventilation. Mill building to house the ore processing and water treatment equipment and related facilities. Construction and operations camps, and related kitchen, recreation, administration, sewage treatment, and waste management facilities. Ancillary buildings, including carpenters' shop, maintenance shop, truck shop, and cold storage building. Incinerator. Explosives and detonator storage facilities. Pre-production ore storage and waste rock transfer area, where underground mining vehicles will deposit waste rock for transfer to surface vehicles for disposal in Brucejack Lake. Fuel storage facilities. Diesel power station. Concrete batch plant. Equipment laydown areas. Water management facilities, including mine dewatering facilities, freshwater diversion channels, contact water collection **ditches, process water pumping system** and contact water collection pond. Potable groundwater well and pipeline. Construction phase water treatment plant. Operations phase water treatment plant. Underwater waste rock and tailings disposal in Brucejack Lake. Turbidity curtains within and near the outlet of Brucejack Lake. Site roads to connect mine area facilities. Water supply pipeline to gravel borrow source. Helipad. Non-potentially acid generating (NPAG) rock quarry and sand/gravel borrow source to provide material for construction purposes. **Storage of Potentially Acid Generating (PAG) waste rock at surface for a duration and in a location within the Mine Site area as determined by the British Columbia Ministry of Energy and Mines.** **Snow Melter.**	N/A – No changes to this list of Mine Site facilities / components.
1.2.6 Communications Towers	Five radio and microwave communications towers.	N/A – No change to communications towers.
Figure 1-1	**Overview Map of Brucejack Gold Mine Project Figure 1-1 (27 June 2022)**	N/A – No change to figure required.
Figure 1-2**a**	**Brucejack CPD Figure 1-2a (27 June 2022)**	N/A– No change to figure required.
Figure 1-2b	**Brucejack CPD Figure 1-2b (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-2c	**Brucejack CPD Figure 1-2c (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-2d	**Brucejack CPD Figure 1-2d (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-2e	**Brucejack CPD Figure 1-2e (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-2f	**Brucejack CPD Figure 1-2f (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-2g	**Brucejack CPD Figure 1-2g (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-2h	**Brucejack CPD Figure 1-2h (27 June 2022)**	**N/A– No change to figure required.**
Figure 1-3	Brucejack Mine Site, Knipple Transfer Area, and Bowser Aerodrome, BJP-15-125, February 29, 2016.	N/A– No change to figure required.

Note: Plain text indicates language contained in the Certified Project Description attached as Schedule A to EAC #M15-01 in Amendment #2; bold text indicates revisions to the Certified Project Description subsequently ordered by the EAO in EAC Amendments #3 to 8.

Table 1.4-4. Summary of Permitting-level Issues Raised and Commitments Identified during Environmental Assessment Review and Related Sections of the 4950 tpd Joint Application

Organization, Comment Topic and Date	EA Review Comment Tracking ID#	Reviewer	Comment Summary	EA Review Response Provided	EA Review – Additional Comment	2015 Permitting Phase Response:	4950 tpd Joint Application Response:
Brucejack EAO Working Group Formal Review Comment Responses - October 31, 2014 and January 2015	49	Alaska Operations Unit, US EPA	Executive Summary, ES39. "In the Closure and Post-Closure Periods, total Se may occur at concentrations exceeding background conditions and guidelines in the quarry runoff." While there are no fish in the waters adjacent to the mine site, levels of selenium in ponded water have been known to be lethal to birds and wildlife so monitoring should include selenium and any necessary precautions taken if levels are high.	Selenium will be monitored as part of the Aquatic Effects Monitoring Program (AEMP) for the Project. Site-specific water quality models were developed to evaluate the potential effects of mining activities for the Project and included the conveyance of contact water associated with the quarry site to Brucejack Lake (Appendix 13C). No guideline exceedances for selenium were predicted to occur in Brucejack Lake for the expected case (base case) or any of the sensitivity analyses (Section 13.6.2, Appendix 13D) and thus potential effects to birds and wildlife due to selenium concentrations are not expected. However, water quality monitoring programs for the Project will be established as a requirement of the permits and licences under which the Project will operate (e.g., BC *Environmental Management Act* [EMA], MMER) to ensure regulatory compliance, monitor the effectiveness of mitigation measures, and to verify the predictions of the effects assessment. This will allow for adaptive management if effects on surface water quality and, by extension, birds and wildlife, are identified.	N/A	Selenium will be monitored as part of the Aquatic Effects Monitoring Plan (AEMP) for the Project presented in Appendix 6-I.	Selenium and other water quality parameters continue to be monitored according to requirements in PE-107835 and the AEMP. The AEMP is reviewed annually and updated if necessary. Results of aquatic effects monitoring are reported in the *MA/EMA* Annual Report for Mines Act Permit M-243, Effluent Permit 107835, and Air Permit 107025. Any updates to the AEMP are also reported in this *MA/EMA* annual report. Changes to the AEMP that are required due to the 4950 tpd mine plan will be noted in the *MA/EMA* annual report that follows the permit amendment date.
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	73	Andrew Rollo, Senior Environmental Geoscientist, MEM	1. The geological description provided in Section 5.4 and the mine development plans in Section 5.8 provide a reasonable basis for assessing whether samples included in the geochemical assessment adequately represent the mine development. If, during operations, the mine plan changes and additional resources are included in the mine development, further characterization work will be required. (Mines Act permit condition)	As noted, the comment will be addressed during the Mines Act permitting stage.	N/A	Comment noted. We anticipate that this will be a Mines Act permit condition if the mine plan changes.	Although the mine plan has changed, the geologic units to be excavated, exposed or disturbed have not changed. These geologic units have been well characterized through baseline studies and subsequent monitoring programs as per the ML/ARD Management Plan. Should new geologic units be encountered, characterization studies including static and kinetic tests will be initiated.
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation – December 2014 and January 2015	109	Andrew Rollo, Senior Environmental Geoscientist, MEM	35. MEM believes that the simplifying assumptions employed as part of the Brucejack water quality model are generally adequately reasonable and conservative. As part of the EA follow-up program to evaluate the performance of the water quality model, the assumptions incorporated into the Brucejack water quality model should also be re-evaluated and updated as more information becomes available through operational monitoring. (EA commitment and Mines Act permitting condition)	Comment noted. No response required.	N/A	Permit condition noted. No further response required. It is understood that the geochemical assessment and model predictions will need to be re-evaluated as more data becomes available.	The Brucejack Mine water quality model source terms underwent a comprehensive validation/calibration review and update as part of the 2020 Mine Plan and Reclamation Program Update (presented in Appendix 5.1.5 of the 2020 Update submission). The data sets used for source term derivation are reviewed on an annual basis and presented in the mine's Annual Reclamation Report. The source terms presented in the 4950 tpd Joint Application have been reviewed and updated using monitoring data sets and experimental data sets collected through to the end of 2021. The source terms, and the data used for their development, are described in detail in Section 3 of the water quality model report – Appendix 5-3 of the application.
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate - Pretivm Responses to Comments from the BC Ministry of	154	Andrew Rollo, Senior Environmental Geoscientist, MEM	N/A	N/A	20. MEM appreciates that a water quality model calibration run has been included in the updated version of the water quality model. It provides a level of confidence that the model is able to recreate historical conditions at the Brucejack site reasonably well. As part of the follow-up program to evaluate the performance of the	Permit condition noted. No further response required. It is understood that this will be a *Mines Act* permit condition.	The water quality model has been updated and reviewed several times since the EA application was submitted, with a major calibration/ validation effort having been carried out for the 2020 Mine Plan and Reclamation Program Update. The 4950 tpd application incorporates the results of updated operational monitoring data and experimental data acquired through to the end of 2021. Calibration of key source terms and a review of WTP treatment efficiencies based on operational data has been carried out

Organization, Comment Topic and Date	EA Review Comment Tracking ID#	Reviewer	Comment Summary	EA Review Response Provided	EA Review – Additional Comment	2015 Permitting Phase Response:	4950 tpd Joint Application Response:
Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015					water quality model, future versions of the water quality model should reassess calibration to ensure that the model continues to reproduce historic conditions reasonably well (*Mines Act* permit condition)		for this application, as presented in Appendix 5-2.
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate/Environmental Impact Statement (August 2014) - Pretivm Responses to Comments Received from the Ministries of Environment and Forest, Lands, and Natural Resource Operations, November 2014 and January 2015	8	BC Ministry of Environment, Kara Przeczek, EIA Biologist	**13.5.2.2 Metal Leachings/Acid Rock Drainage** 1) The plan is to maintain at least 1 m of water cover on tailings and PAG waste rock. How will this minimum water cover be maintained in the future? Has climate change been considered in long term projections? 2) Will the lime added to the paste backfill (which is the NAG tailings, correct?) also be sufficient to neutralize the acid generated by the waste rock used as fill in the underground? 3) What about displacement of water in Brucejack Lake as a result of disposal of waste rock and resulting effects on water level in the lake and flow in Brucejack Creek? 4) It is noted that dissolved arsenic may still occur at relatively high concentrations in the drainage water from the underground and that at closure, potential metal-leaching of arsenic will be actively mitigated by collecting seepage water from underground workings and directing it to the treatment plant for subsequent treatment and use/release with a reference to Chapter 5. However, in Section 5.15.1 it is noted that water treatment is not planned after operations although it will be used if necessary. Is the potential for ongoing water treatment incorporated into the closure costs and planning?	1) A concrete flow monitoring weir has been designed with an outlet level corresponding to 1364.5 masl, which is the average open water season lake level recorded the past two years. The final elevation of PAG waste rock will be a minimum of 1 m below this level. The weir will remain in place at closure to provide a long-terms Table outlet elevation. Climate change was considered in long term projections for the project; results are discussed in Section 7.2.3 Climate Change in Pretium Resources Inc., Brucejack Project Environmental Assessment - Water Management Plan dated June 6, 2014. (EA Application Appendix 5-C). 2) Paste backfill will consist of tailings and binding agents with a high neutralization potential, and the amount of paste backfill in the underground is significantly higher (by a factor of approximately 3) than the amount of waste rock. However, the question of whether the neutralization afforded by the paste backfill would be sufficient to neutralize the acid generated by waste rock has not been evaluated at this time. 3) Displacement of water in Brucejack Lake as a result of waste rock disposal was accounted for in the water balance model used to predict changes to flows in Brucejack Creek. This is noted in Section 5.7 and Figure 7-3 in Pretium Resources Inc., Brucejack Project Environmental Assessment - Water Management Plan dated June 6, 2014. (EA Appendix 5-C). 4) The potential for ongoing water treatment following closure was not incorporated into the closure costs and planning. It will be included in an updated closure cost estimate for the *Mines Act* and *Environmental Management Act* permit application.	1) Water lake level was not explicitly considered in the climate change assessment in Section 7.2.3 of the Water Management Plan, EA Appendix 5-c. Is the assumption that if precipitation increases outweigh increased evaporative losses by increased temperature and wind speed then water level in Brucejack Lake should not decrease?	Correct - that is the assumption.	The updated water balance model considering the increased production rate of 4950 tpd includes variable climate and climate change sensitivity model runs (Section 4.2.13 of Appendix 5-2) and the level of the WRTSF (formerly referred to as Brucejack Lake) is not predicted to decrease. Therefore, the minimum water cover will continue to be maintained.
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate/Environmental Impact Statement (August 2014) - Pretivm Responses to Comments Received from the Ministries of Environment and	16	BC Ministry of Environment, Kara Przeczek, EIA Biologist	**13.6.1.3 COPC screening - Table 2-2 from Appendix 13-C** In addition, do any parameters without an approved or working BC water quality or CCME guideline increase as a result of project activities? If so these should be considered to determine whether there is any potential concern associated with these parameters. A lack of a BC or CCME guideline does not necessarily mean that the parameter has no impacts. It could be that there is insufficient data to support a guideline. For example, we do not have a hardness guideline, but recent research has	As discussed Section 13.6 of the Application, the scope of the water quality effects assessment is restricted to include modelled water quality parameters with an approved BC water quality guideline for the protection of freshwater aquatic life and the following parameters with working BC water quality guidelines: cadmium, nickel, chromium and thallium. This approach was presented to the BC MOE in a memorandum outlining the proposed multi-step COPC screening process and residual effects assessment for the Project; comments were provided by the BC MOE on 9-May-2014 which were responded to. It is noted that the water quality model is currently being updated as per requests received by the Ministry of Energy and Mines;	Hardness was not modelled in the updated WQ model.	Calcium and magnesium were modelled in the updated water quality model. Base case model results for Ca and Mg correspond to a hardness range of 24-105 mg/L as $CaCO_3$ at BJ 2.62. Baseline hardness at BJ 2.62 ranged from 19-56 mg/L. Therefore, the Project is expected to produce a moderate increase to hardness in Brucejack Creek.	Calcium and magnesium were also included in the 4950 tpd model. Results are reported in the appendix to the Water Quality Model Report (Appendix A of Appendix 5.3). The hardness range for the 4950 tpd Base Case model during operations is 28-59 mg/L. The peak during closure is 156 mg/L. It is expected that mitigations developed in the Closure Underground Water Quality Adaptive Management Plan and which are not included in the 4950 tpd model will reduce the peak hardness during closure.

Organization, Comment Topic and Date	EA Review Comment Tracking ID#	Reviewer	Comment Summary	EA Review Response Provided	EA Review – Additional Comment	2015 Permitting Phase Response:	4950 tpd Joint Application Response:
Forest, Lands, and Natural Resource Operations, November 2014 and January 2015			indicated potential issues with increased hardness and there is work in progress to develop guidance for hardness in BC. I noted that Ca, Mg, K, and Na were all modelled (Table 2.2 in Appendix 13C), but they would have been excluded from COPC screening because they do not have guidelines (Figure 13. In the Chapter 13). Did any of these parameters without guidelines increase as a result of project activities?	update water quality predictions and COPC screening results will be provided under a separate cover.			
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate/Environmental Impact Statement (August 2014) - Pretivm Responses to Comments Received from the Ministries of Environment and Forest, Lands, and Natural Resource Operations, November 2014 and January 2015	22	BC Ministry of Environment, Kara Przeczek, EIA Biologist	**13.6.2.1 Brucejack Lake Outflow - Erosion and Sedimentation section** • 1) The use of flocculation agents is necessary to ensure tailings particles remain permanently on the bottom of Brucejack Lake. What flocculation agent is being proposed and has it been assessed for toxicity/impacts? • 2) TSS from waste rock deposition in the lake is expected to be mitigated by turbidity curtains and "other mitigation measures". What are these other measures? Make a reference to where they are discussed in the application. • 3) The conclusion is that water quality from BJ Lake will be suitable for year-round discharge and will not require treatment. This is based on a comparison to PCO and MMER discharge limits. Since the discharge is essentially 100% of the flows in BJ Creek this conclusion is really dependent on the results for the receiving environment site at BJ2.62.	1) The flocculation agent to be added to tailings has not yet been determined although Magnafloc 155, an anionic polymer, is being considered at this stage. The decision will be finalized and toxicity tests completed prior to the start of operations. 2) TSS from waste rock deposition in the lake will be mitigated by turbidity curtains. Other mitigation measures have been considered and may be identified for implementation in the near future as deposition plans are finalized. No other mitigation measures were described in the Application. 3) Yes, the conclusion that year-round discharge from the lake will not require treatment is dependent on predicted water quality at BJ 2.62. No treatment is planned. It is anticipated the discharge quality will not result in significant adverse environmental effects, will not exceed MMER requirements, and will be permitted by MOE under the BC *Environmental Management Act.*	1 & 2 will be considered in permitting	1) The flocculation agent to be added to tailings has not yet been determined. The decision will be finalized and toxicity tests completed prior to the start of operations. It is anticipated that identification of the flocculant to be used and results of toxicity tests will be required as a *Mines Act* permit condition. 2) Turbidity curtains are the primary TSS mitigation measure for Brucejack Lake discharge. If allowable TSS concentrations were exceeded, contingency measures would be undertaken, such as reducing the rate of waste rock deposition, as described in the Tailings and Waste Rock Management Plan (Appendix 6-O). In addition, Pretivm is undertaking field studies to refine the understanding of TSS migration within Brucejack Lake.	1) The flocculant being used for thickening of tailings is AN 910 VHM (manufactured by SNF Canada Ltd.). Section 12 of the Safety Data Sheet for AN 910 VHM reports results of toxicity testing on aquatic life. The tests found that AN 910 VHM did not cause acute toxicity to fish (Danio rerio) or invertebrates (Daphnia magna), and did not cause chronic toxicity to algae (Scenedesmus subspicatus), at the highest concentration tested (100 mg/L for all three tests). 2) The turbidity curtains in the WRTSF have effectively managed TSS in effluent. As well, results of TSS and turbidity monitoring of the WRTSF have been used to adaptively manage TSS at BJ 3.10 by depositing waste rock in the WRTSF in months with less potential for elevated TSS in surface water and stockpiling waste rock during months with higher potential for elevated TSS in surface water of the WRTSF.
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate/Environmental Impact Statement (August 2014) - Pretivm Responses to Comments Received from the Ministries of Environment and Forest, Lands, and Natural Resource Operations, November 2014 and January 2015	28	BC Ministry of Environment, Kara Przeczek, EIA Biologist	**13.7.2.1 Characterizing Residual Effects: Mine Site Area - Change in Water Quality in the Receiving Environment** • "Predicted arsenic exceedances during Construction and initial Operation are likely attributed to the subaqueous disposal of waste rock to Brucejack Lake and the subsequent soluble elemental loads from this activity. These source terms are scaled based particle size distribution results for the purpose of relating laboratory test-work to field conditions. The upper end-member (i.e., most conservative) result was used in this scaling process." What is meant by the highlighted sentence? Is this related to suspended sediment particle size? • The exceedences for arsenic are noted as being low magnitude during all phases, with the HQ ranging from 1.1 to 1.6. However, this is a maximum guideline and the	The particle size distribution (PSD) referred to is not related to suspended sediment particle size. Here, the PSD refers to that of blasted waste rock, derived from laboratory test work during the exploration phase. The waste rock PSD was used to identify the proportion of the waste rock that is expected to be reactive; i.e. used to derive an appropriate scaling factor for the corresponding geochemical source term in the model. The proportion less than 2 mm was used. This is equal to approximately 16.5% (in the highest of 3 PSDs available). So, 16.5% of the total waste rock volume was considered to be reactive. This is being revisited and will be refined in the application to be submitted in the near future for an effluent discharge permit. The water quality model is currently being updated as per requests received by the Ministry of Energy and Mines. The characterization of potential arsenic exceedances will be reviewed and clarified once results are available from the updated model. However, in the Application/EIS, the maximum value reported for predicted water quality parameters do not represent the highest average month predicted, but instead, is the maximum single value observed	1) This was changed according to the presentation on December 11th. Revisiting in permitting. 2) See comment on #23(3) regarding "maximum single monthly value". Appendix 13-E shows arsenic exceeding the guideline during both high and low flows during construction and operations. The Updated Effects Assessment predicts exceedances of arsenic WQG during both low and high flow periods during Operations and Post-Closure. See MOE comments on the Updated Effects Assessment Based on Revised Water Quality Predictions for Brucejack Lake and Brucejack	1) The approach to the waste rock source term derivation (and the use of waste rock PSD to inform source term loading assumptions) is revisited in the permit application. 2) An updated effects assessment is provided for total arsenic in the permit application	Source terms used in the 4950tpd water quality model have been updated as described in the Water Quality Model Report (Chapter 3 of Appendix 5-3). An updated effects assessment for arsenic and other parameters of concern is also included the Water Quality Model Report (Chapter 5 of Appendix 5.3).

Organization, Comment Topic and Date	EA Review Comment Tracking ID#	Reviewer	Comment Summary	EA Review Response Provided	EA Review – Additional Comment	2015 Permitting Phase Response:	4950 tpd Joint Application Response:
			predicted value is a monthly mean, even the maximum predicted is still just a monthly mean. Note that baseline 95th percentile does not exceed the guideline and the HQ for maximum predicted to 95th percentile baseline ranges from 1.1 to 1.8 and the HQ for mean predicted to mean baseline ranges from 2.2 to 2.7 during base case conditions. Thus the concentration of arsenic in Brucejack Creek is being increased from baseline conditions and is predicted to exceed the maximum water quality guideline regularly whereas under baseline conditions it is not exceeded even at the 95th percentile of background concentrations.	in that month, at any point during the specified Project Phase. As the only guideline available, the maximum BC water quality guideline for arsenic (0.005 mg/L) was applied in step 1 of the COPC screening process for both maximum and mean predicted concentrations; there is an error in the Appendix table, where the maximum arsenic guideline should be stated (0.005 mg/L) instead of a '-'. As discussed in a memorandum provided to BC MOE on 8-May-2014, if predicted concentrations did not exceed BG WQG, they were screened out in the COPC identification process as guidelines are determined by the BC MOE to be protective of freshwater aquatic life receptors; therefore, there is no potential for adverse effects to water quality. Further, mean arsenic values were not chronically identified as a COPC for the Project; HQ > 1.0 for mean arsenic concentrations are restricted to low flow periods in Operations (Section 13.6, Appendix 13-E).	Creek (December 19, 2014)		
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	28	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	The water balance model for the BJL-H1 catchment does not seem to include leakage to the underground workings. The leakage rate might be small but has it been concluded that leakage will be zero? The current groundwater model seems to indicate almost zero leakage but that seems to be a by-product of a slip-up with the boundary conditions near the outlet of Brucejack Lake. Groundwater levels were very responsive to underground dewatering, seems likely that leakage from Brucejack Lake to underground would be non-zero. Recommendation: please include this component in the water balance or justify why it would not be included.	Please refer to the technical memorandum Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 1 of 3 (FINAL) dated December 17, 2014.	A relatively small leakage rate from Brucejack Lake to the underground workings is accepted. Nevertheless, please include this component in the water balance so that it's clear that it's been considered. (EA Information Requirement) Please note that, contrary to the response, the "proportion that flows to the underground workings vs. the larger regional flow system" can definitely be determined. Agreed that the current estimate of lake leakage is an insignificant proportion of the average annual lake water balance. Many mines operate in proximity to lakes with no adverse impacts but occasionally leakage rates are considerably larger than anticipated, usually because of unanticipated geological structures. Please outline the monitoring program and associated data review that will be implemented to confirm our current understanding of expected leakage rates from the lake. (Permit Information Requirement)	Proposed groundwater monitoring locations and frequency for construction, operations, closure and post closure are outlined in the MA & EMA Permits Application Water Management Plan (Section 7.4). One of the objectives of the monitoring plan is to develop an understanding of the sources of groundwater inflow to the underground (and specifically the influence of Brucejack Lake and Creek flows on underground water management). Leakage from Brucejack Lake to the underground workings is included on Figure 8.3-3 in the Water Management Plan and the adaptive management approach to understanding leakage rates from Brucejack Lake and Brucejack Creek is outlined in Section 6.5 and Table 6.5-1.	Seepage losses from WRTSF to the underground mine are simulated by the 4950 tpd groundwater model and discussed in Section 5.3.3 of Appendix 5-1. On an average annual basis, this loss is <100 m3/d and remains a very small (<5%) component of the underground mine water balance. Monitoring wells located east of the West Zone continue to provide groundwater level data that serve to calibrate the groundwater model in this area.
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate - Pretivm Responses to Comments from the BC Ministry of	33	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	Wells MW-5A and 5B, and MW 12A seemed to respond more to dewatering than other wells that were closer to the workings. This phenomenon is often observed in fracture and fault-controlled bedrock groundwater systems. Please describe the drawdown response as a function of distance from the underground workings and discuss how this response informs the conceptual model. Please include a site plan that plots the	Please refer to the technical memorandum *Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 2 of 3 (FINAL)* dated December 19, 2014.	The pronounced heterogeneity of dewatering response suggests that **heterogeneity should be progressively incorporated into the model as the project proceeds.** Please continue to track and interpret the distance drawdown response as dewatering continues. (**Permit information**	Agreed: tracking and interpretation of the distance drawdown response will continue as dewatering continues. Additional detail on the adaptive management approach and its application to groundwater monitoring is provided in Section 6.5 and Section 7.4.2 of the Water	Continued monitoring of groundwater levels and underground dewatering rates since submission of the 2015 MA/EMA permit application has been used to inform the groundwater model, which underwent a major update in 2020. The 2020 groundwater model has been configured to simulated the 4950 tpd mine plan presented in this joint application (Appendix 5-1). The 2020 groundwater model introduced zonation in bedrock hydraulic conductivity values between lower lying areas and upland areas and simulated the Rainy and Brucejack

Organization, Comment Topic and Date	EA Review Comment Tracking ID#	Reviewer	Comment Summary	EA Review Response Provided	EA Review – Additional Comment	2015 Permitting Phase Response:	4950 tpd Joint Application Response:
Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015			drawdown response of each piezometer.		**Requirement and Permit Condition)** Please submit the monitoring plan for the time period between now and permitting. (**EA Information Requirement)**	Management Plan, Appendix 6-R to the Application.	faults as permeable features (Section 3.2.6 of App 5-1). Thus, heterogeneity has been incorporated into the groundwater model since the 2015 submissions on an as-needed basis to optimize the model calibration. In 2018, a series of monitoring well pairs were installed across the mine the site which has served to supplement the water level record from baseline monitoring wells (including BJ-GW11-5A/B and BJ-GW12-12A/B). The data from these new well pairs has been used to validate the 2020 model. Overall, the model reasonably simulates observed water levels and underground dewatering rates indicating that the 2020 model calibration, and thus heterogeneity, is appropriate for predictive simulations of 4950 tpd mine plan (see Section 4.3 of Appendix 5-1). The groundwater model is also well-positioned to inform future decisions regarding monitoring frequency and locations of new monitoring wells required by permit PE-107835.
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	61	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	The direction of groundwater flowpaths illustrated on the figures is not clear. Are all flowpaths from the workings or some flowpaths are from and some are toward?	Please refer to the technical memorandum Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 1 of 3 (FINAL) dated December 17, 2014.	The point is taken that the text describes the direction of groundwater flow described by the pathlines on Drawings 32A and 32B. For future pathline figures, please include arrows on the pathlines or a note on the figure. (Permit information requirement)	Refer to Drawing 22 from the Brucejack Project MA/EMA Permitting Phase - Numerical Hydrogeologic Model Update Report. Drawing Note 5 specifies the direction of pathlines for both forward and reverse particle tracking scenarios.	Appendix 5.1 presents findings of the 4950 tpd groundwater model. Backwards particle tracks are presented for end of mine flow solution in Figure 5-6, while forward particle tracks for the closure flow field are shown in Figure 6-2. Legends in the figures indicate the direction of the particle tracks.
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	22	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	Permit Condition: The groundwater model should be updated with any future dewatering effects to improve the understanding of dewatering effects.	Please refer to the technical memorandum Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 1 of 3 (FINAL) dated December 17, 2014.	N/A	Agreed. The groundwater model predictions will be reviewed against observed effects and revised as needed to support active mining and adaptive management initiatives for closure and post-closure. It is proposed that this review would, at a minimum, be completed to coincide with 5 year mine plan submissions under the Mines Act.	The groundwater model was substantially updated in 2020 in support of the 5 Year Mine Plan and Reclamation Program update. The model was recalibrated to underground dewatering data and groundwater level data collected up until the end of 2018. The 4950 tpd Joint Application groundwater model has been validated against additional underground dewatering and water level data collected between 2019 and 2021. Results of the model calibration and validation are presented in Section 4.3 of Appendix 5.1.
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	64	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	Permit Information Requirement: The closure and post-closure groundwater monitoring plans will understandably have some uncertainties at this stage of the project. However, additional specifics are nevertheless required: • objectives of the monitoring (e.g., will the monitoring be used to evaluate whether all groundwater flowpaths are toward the underground workings?), • approximate or minimum number of monitoring wells (for example, sampling of four monitoring wells would be inadequate), • approximate depths of monitoring well completions (for example, sampling only from wells that are completed to depths of say 50 ft would be inadequate), whether groundwater will be sampled at multiple	Please refer to the technical memorandum Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 1 of 3 (FINAL) dated December 17, 2014.	To be reviewed as part of the permit application process	Groundwater monitoring objectives, locations, rationale etc. are considered in the MA & EMA Permits Application Water Management Plan (Section 7.4). The general objectives of proposed monitoring wells are outlined specifically in Section 7.4.2, and Tables 7.4-2 through 7.4-5 of the Water Management Plan.	A groundwater monitoring program following the recommendations of the 2015 EA and Permitting review comments was incorporated in PE-107835 and has been implemented by the mine. The extents of the 4950 tpd mine plan are generally very similar to the 3800 tpd mine plan with exception to (i) deeper and broader extents of the VOK mining area, (ii) new exploration developments advanced south, west and north of the VOK, and (iii) a vent raise developed north of Brucejack Creek. The current monitoring network outlined in PE-107835 remains well positioned to monitor the influence of the mine on the groundwater system and no changes are proposed at this time. Continue implementation of daily monitoring underground dewatering rates and high resolution groundwater monitoring are recommended, per Section 8.2 of Appendix 5.1.

Organization, Comment Topic and Date	EA Review Comment Tracking ID#	Reviewer	Comment Summary	EA Review Response Provided	EA Review – Additional Comment	2015 Permitting Phase Response:	4950 tpd Joint Application Response:
			depths at each location (for example, sampling only from wells that are completed at a single depth would be inadequate), • the rationale for the chosen post-closure monitoring locations and depths. Also, a monitoring duration of three years postclosure does not seem credible considering that groundwater moves quite slowly. A longer monitoring period is required along with the rationale for the duration of monitoring. Finally, the groundwater monitoring costs (Table 30.11-1) are quite low and therefore do not seem to include new monitoring wells. Some provision should be made for installing new monitoring wells in case they are necessary.				
Proposed Brucejack Gold Mine Project Environmental Assessment Certificate - Pretivm Responses to Comments from the BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	66	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	Permit Information Requirement: Monitoring and inspection of sealed adit portals is not mentioned in Chapter 30 (Closure and Reclamation). Additional specifics will be required regarding the monitoring of adits and portals post-closure in Chapter 29 (Environmental and Monitoring Plans): • frequency and timing of checking for adit seepage, • criteria for determining whether the groundwater levels have reached maximum elevation, • analytical parameters of samples, whether or not flow will be monitored and by what method.	Please refer to the technical memorandum Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 1 of 3 (FINAL) dated December 17, 2014.	To be reviewed as part of the permit application process	Refer to response to IR #3165.	Monitoring of the post closure mine pool water quality and water levels is discussed in Section 12.3 of Appendix 4-1 of the Application. Seepage monitoring from portal plugs will be conducted in concert with geotechnical inspections ensuring that the plugs are operating as intended (Section 12.4 of Appendix 4-1).
BC Ministry of Energy and Mines on Hydrogeology, Geochemistry, and Reclamation - December 2014 and January 2015	67	Hugh McCreadie, Associate, Senior Hydrogeologist for MEM and MOE	Permit Information Requirement: Groundwater is a slow-moving pathway with potential for long-term, chronic impacts that become evident only years or decades after closure. Groundwater monitoring currently does not seem to be included in the post-closure monitoring program. Recommendation: include groundwater monitoring in the post-closure monitoring program.	Please refer to the technical memorandum Brucejack Project – Environmental Assessment Information Requests from MOE and MEM – Hydrogeology - Part 1 of 3 (FINAL) dated December 17, 2014.	To be reviewed as part of the permit application process	Groundwater monitoring in the closure and post closure periods is considered in Section 7.4.2 of the MA and EMA Permits Application Water Management Plan (WMP). Contingency for replacement of monitoring wells due to construction activities and installation of additional wells for operations/closure is considered in the WMP.	The frequency and duration of groundwater monitoring in the closure and post-closure periods is discussed in Section 4.6 of the main application document and Section 12.3 of Appendix 4.1. The discussion has included collection of monitoring data from wells proposed to be installed near closure (per PE-107835) and from the underground mine pool, per the Closure Underground Water Quality Adaptive Management Plan submitted in the 2020 5 Year Mine Plan and Reclamation Program Update.

1.5 Regulatory Framework

1.5.1 Current Authorizations

The Brucejack Mine received provincial EAC #M15-01 on March 26, 2015 and a federal *Canadian Environmental Assessment Act* (CEAA) 2012 Decision Statement on July 30, 2015. All the various provincial and federal authorizations required to construct, operate and decommission the mine were received in 2015. Surface construction activities began at the mine on September 5, 2015 and were completed mid-2017. Operations began in July 2017.

PA-107025 was issued on January 9, 2014, followed by *MA* Permit M-243 on July 22, 2015, and PE-107835 on August 31, 2015. In addition to the authorizations noted above, authorizations in place to enable the presence and operations of the mine and its supporting infrastructure include mining leases, water licenses and other *Water Sustainability Act* authorizations, *Land Act* tenures [Licenses of Occupation (LOO's) and a Statutory Right-of-Way (ROW)], a SUP for the portion of the mine's access road located outside of the mining leases, a cutting authorization, and many others.

Permits M-243, PE-107835 and PA-107025 have each been amended multiple times since their initial issuances. These amendments are summarized below in Table 1.5-1, Table 1.5-2 and Table 1.5-3.

Table 1.5-1. *Mines Act* Permit M-243 Amendment Summary

Amendment Date	Summary of Key Amendments
Issued August 26, 2015	Approving groundwater monitoring plan.
Issued September 9, 2015	Approving updated ML/ARD Management Plan.
Issued March 17, 2016	Approving temporary PAG waste rock stockpile and Non-PAG Quarry.
Issued August 4, 2016	Approving changes for disturbance area and construction Water Treatment Plant
Issued April 3, 2017	Approving PAG waste rock exposure extension, sludge deposition with tailings and Chromium Management Plan
Issued December 14, 2018	Approving Mine Plan and Reclamation Program for increased production rate and waste management
Issued December 18, 2020	Approving WZ Ramp, additional stope development, and underground exploration
Issued November 14, 2022	Approving PMA expansion for future access road realignment of the km 72 ramp
Issued August 1, 2023	Approving PMA expansion for km 72 NPAG quarry expansion

Table 1.5-2. Amendments to PE-107835 since issuance on August 31, 2015.

Amendment Date	Summary of Key Amendments
Issued February 4, 2016	Amended STP discharge rate and change of domestic wastewater treatment works (addition of temporary C25 treatment unit)
Issued July 12, 2016	Amended STP discharge rate, change of domestic wastewater treatment works (addition of second C75 treatment unit), revised CWP volume limits to reflect updated water balance, revised surface water quality monitoring requirements and non-compliance reporting schedules
Issued March 31, 2017	Amended surface water quality, WTP, and CWP monitoring requirements from updated water quality modelling and ecological effects assessment, authorization of subaqueous deposition of WTP sludge, references to updated ML/ARD Management Plan and Nitrogen Management Plan
Issued December 14, 2018	Amended thickened tailings slurry discharge rate to 3800 tpd, revised surface water quality discharge limits, groundwater monitoring requirements updated to include new monitoring well installations
Issued December 18, 2020	Amended STP discharge works to temporarily include third C75 treatment unit.
Issued June 16, 2022	Amended STP authorized works to permanently include third C75 unit and remove C25, administrative change of mine name from Brucejack Gold Mine to Brucejack Mine
Issued August 21, 2023	Amended groundwater monitoring requirements

Table 1.5-3. Amendments to PA-107025 since issuance on January 9, 2014.

Amendment Date	Summary of Key Amendments
Issued July 22, 2015	Amended authorized discharges to include fugitive dust, underground crusher ventilation raise, dust collection system, smelting furnace, assay lab exhaust, auxiliary fuel fired refuse incinerators, and miscellaneous sources
Issued July 12, 2016	Amended location of Brucejack Mine incinerator, number of burn pits, disposal of ash and residue from Brucejack and Knipple incinerators to authorize burial in soils and overburden at the Knipple Transfer Area, disposal of ash from open burning to authorize burial at sites adjacent to burn pits
Issued September 8, 2017	Amended to increase smelting furnace operating hours
Issued March 27, 2018	Amended location of Knipple Transfer Area burn pit
Issued July 8, 2021	Amended location of assay laboratory to the Brucejack Mine mill building and added assay lab discharges

1.5.2 Potential Amendments to Authorizations

The following describes potential or expected authorization amendment application requirements associated with the proposed increase to an average ore processing rate of 4950 tpd.

MA Permit M-243:

- Application to approve the updated Mine Plan and Reclamation Program.

- Increase the average annual ore production from 1,387,000 tpa to 1,806,750 tpa (Condition A.3.b).

Effluent Permit 107835:

- Based on water quality modeling results, increase discharge limits for arsenic and nitrate, and add discharge limits for dissolved copper and total selenium (Condition 1.1.1).

1.6 Indigenous Engagement

1.6.1 Background

The broader Brucejack Mine operations area, including the mine site with its primary mine infrastructure, lies within the traditional and ancestral lands of the Tsetsaut Skii km Lax Ha (Figure 1.6-1) and the Tahltan Nation (Figure 1.6-2), and within the Nass Area of the Nisga'a Nation as defined in the Nisga'a Final Agreement (Figure 1.6-3).

Background information on each of the affected Indigenous groups, including ethnography, language, land use setting and planning, governance, economy, and reserves, can be found in the 2014 EAC/EIS Application and the 2015 Brucejack Gold Mine Project Assessment Report (Assessment Report; EAO 2015) as indicated in Table 1.6-1,Table 1.6-2 and Table 1.6-3 below.

1.6.2 Asserted and Established Rights and Interests

1.6.2.1 Tsetsaut Skii km Lax Ha

The Brucejack Mine site and ancillary infrastructure, including the BJAR, are within the asserted traditional territory of the Tsetsaut Skii km Lax Ha.

Detailed information on Tsetsaut Skii km Lax Ha's current use of land and resources for traditional purposes, specific asserted Indigenous rights, potential effects of the Brucejack Mine on Indigenous rights and interests, as well as mitigation measures, can be found in the sections of the 2014 EAC/EIS Application and Assessment Report indicated in Table 1.6-1 below.

Table 1.6-1. References to Tsetsaut Skii km Lax Ha Information and Assessment of Impacts in the 2014 EAC/EIS Application and Assessment Report

2014 EAC/EIS Application	Assessment Report
Chapter 25 Assessment of Potential Effects to Current Use of Lands and Resources for Traditional Purposes Appendix 25-A Ethnographic Overview Report Appendix 25-B Tsetsaut/Skii km Lax Ha Nation Traditional Knowledge and Traditional Use Report Chapter 26 Assessment of Effects on Asserted or Established Aboriginal Rights and Interests	Section 23 Tsetsaut/Skii km Lax Ha

In summary, the Tsetsaut Skii km Lax Ha assert rights to hunt, fish, trap, and harvest berries and other food and medicinal plants throughout their traditional territory. Given mitigation measures, the residual effects of the Brucejack Mine were predicted to have an overall low level of impact on the Tsetsaut

Skii km Lax Ha's Indigenous rights and the mine was not expected to affect the ability of present and future generations to exercise their rights, or modify their customs and practices related to fishing (EAC Application Chapter 26, Section 26.7.1.4).

1.6.2.2 Tahltan Nation

The Brucejack Mine site is located outside of Tahltan Nation traditional territory. The easternmost portion of the BJAR is within Tahltan territory.

Detailed information on Tahltan Nation's current use of land and resources for traditional purposes, specific asserted Indigenous rights, potential effects of the Brucejack Mine on Indigenous rights and interests, as well as mitigation measures, can be found in the sections of the 2014 EAC/EIS Application and Assessment Report indicated in Table 1.6-2 below.

Table 1.6-2. References to Tahltan Nation Information and Assessment of Impacts in the 2014 EAC/EIS Application and Assessment Report

2014 EAC/EIS Application	Assessment Report
Chapter 25 Assessment of Potential Effects to Current Use of Lands and Resources for Traditional Purposes Appendix 25-A Ethnographic Overview Report Chapter 26 Assessment of Effects on Asserted or Established Aboriginal Rights and Interests	Section 22 Tahltan Nation

In summary, the Tahltan Nation assert rights to hunt, fish, trap, and harvest berries and other food and medicinal plants throughout their territory. Given mitigation measures to accommodate potential impacts, the overall effect on the Tahltan Nation's ability to exercise rights was expected to be low and was not expected to affect the ability of present and future generations to exercise their rights, or modify their customs and practices related to fishing, hunting, and gathering (EAC Application Chapter 26, Section 26.7.2.4).

1.6.2.3 Nisga'a Nation

The Nisga'a Final Agreement (NFA), a modern treaty and land claims agreement settled in 2000, gives the Nisga'a Nation a right to self-government and sets out in law specific treaty rights over lands and resources.

The Brucejack Mine site is located outside of areas and lands described in the NFA. However, the majority of the BJAR and Brucejack transmission line traverse an area of land defined in the NFA as the Nass Area, over which the Nisga'a hold treaty rights to harvest migratory birds, fish and aquatic plants.

Detailed information on Nisga'a Nation's current use of land and resources, treaty rights set out in the NFA, potential effects of the Brucejack Mine on treaty rights set out in the NFA, and mitigation measures can be found in the sections of the 2014 EAC/EIS Application and Assessment Report indicated in Table 1.6-3.

Table 1.6-3. References to Nisga'a Nation Information and Assessment of Impacts on Treaty Rights in the 2014 EAC/EIS Application and Assessment Report

2014 EAC/EIS Application	Assessment Report
Chapter 25 Assessment of Potential Effects to Current Use of Lands and Resources for Traditional Purposes Appendix 25-A Ethnographic Overview Report Chapter 27 Assessment of Nisga'a Nation Treaty Rights, Interests, and Information Requirements	Section 24 Introduction and Purpose Section 26 NFA 8(e) Environmental Effects Assessment Section 27 Nisga'a 8(f) Economic, Social and Cultural Well-Being Assessment

In addition to the 2014 EAC/EIS Application and Assessment Report, the BJAR Impact Assessment Report (ERM 2015b) assesses the potential effects of the BJAR on Nisga'a rights set out in the NFA. This report was prepared separately, in response to comments from the Nisga'a Nation, because the construction of the access road had been assessed in a screening-level environmental assessment and was not included in the scope of the 2014 EAC/EIS Application. Considering mitigation measures and the conditions to the EAC, the Brucejack Mine:

- was not reasonably expected to have adverse environmental effects on Nisga'a fishing rights or rights to harvest migratory birds (Chapter 10, section 8(e) of the NFA; see sections 26.9 and 26.12 of the Assessment Report); and
- was not reasonably expected to adversely affect the cultural well-being of the Nisga'a Nation (Chapter 10, section 8(f) of the NFA; see section 26.13 of the Assessment Report).

Potential Effects on Indigenous and Treaty Rights

As described in Section 25.4.3.1 of the EAC Application, the potential effects of the Brucejack Mine on Indigenous groups' current land and resource use included in the assessment were:

- Change in access or ability to access or use land and resource use areas;
- Change in quality of experience of the natural environment;
- Change in the abundance and distribution of resources; and
- Change to the quality of resources.

The proposed changes to the Brucejack Mine set out in this application—i.e., the increase to average daily ore production rate from the currently authorized average 3800 tpd to 4950 tpd—are not anticipated to further impact the Indigenous rights of the Tsetsaut Skii km Lax Ha or Tahltan Nation, or the treaty rights of the Nisga'a Nation set out in the NFA. The proposed increase in the ore production rate is not expected to change the anticipated effects of the Brucejack Mine on Indigenous peoples' rights to fish, hunt, trap or gather as assessed in the EAC Application, Assessment Report and the BJAR Impact Assessment Report for the following reasons:

- *Change in noise levels associated with the Brucejack Mine are expected to be negligible.*
- *No changes to visual quality are expected as a result of the increase in daily ore production and are therefore not anticipated to alter potential effects on Indigenous groups' quality of experience of the natural environment.*

- *The increase in daily ore production will not interact with wildlife or vegetation, and no effects on fish or fish habitat are expected – consequently, the proposed changes are not anticipated to alter the mine's potential effects on abundance and distribution of resources.*
- *The proposed changes are not anticipated to alter the mine's effects on the quality of resources, as no changes to effects on country foods are anticipated.*

Positive economic effects were identified in the Assessment Report associated with employment opportunities, but these were not characterized (the former *Environmental Assessment Act* did not require a consideration of positive effects). The proposed changes are likely to impact the Brucejack Mine's interaction with Indigenous groups' employment and economic opportunities given the anticipated shorter mine life (i.e., as a result of the ore production rate increase, the end of operations is anticipated in 2029 rather than 2032, and thus employment and economic benefits associated with it will end earlier than expected). However, with mitigation, there were no negative residual economic effects predicted at mine closure in the Assessment Report (see Section 18.6), and the proposed project changes are not anticipated to change this conclusion.

1.6.3 Engagement Efforts

Pretium's engagement approach involves actively exchanging information and listening to concerns and suggestions. Quarterly, Pretium meets with Nisga'a Lisims Government (NLG) Lands Department and Tahltan Central Government's (TCG) Lands Department to keep them informed of activities at the Brucejack Mine and activities that may require regulatory approvals or may have interest to the nation from an environmental or cultural impact perspective. These meetings create the opportunity to enhance the understanding of the project area's social, cultural, and environmental conditions and potentially adapt and improve the project.

The proposed production rate increase, and the present amendment application were discussed with the NLG during quarterly update meetings on June 30 and October 14, 2022, and February 13, 2023, and with the TCG on July 14, 2022. Pretium extended invitations to meet with the TCG in October 2022 but the parties were not able to meet due to mutual availability.

The project description for the 4950 tpd Joint Application and the draft JIRT was shared with the Tsetsaut Skii km Lax Ha, Nisga'a Lisims Government and Tahltan Central Government prior to submission to the Province to provide further details of Pretium's plan to submit a joint application to increase the Brucejack Mine ore production rate, and to seek early feedback on the planned application. As stated in the Project Description, feedback was being sought to help inform Pretium of any potential concerns with the planned application and support addressing these via pre-submission communications and/or through the application content. It was also intended to help advise Pretium of potential requirements, conditions, and options for the planned amendment applications.

Tsetsaut Skii km Lax Ha and Nisga'a Lisims Government did not provide comments on the project description or the JIRT. Tahltan Central Government provided comments on the JIRT and the Project Description via the EMLI MMO referral process for the JIRT. Pretium provided responses to the TCG comments via the JIRT Issues Tracking Table (ITT) and adjusted content of the 4950 tpd Joint Application as applicable.

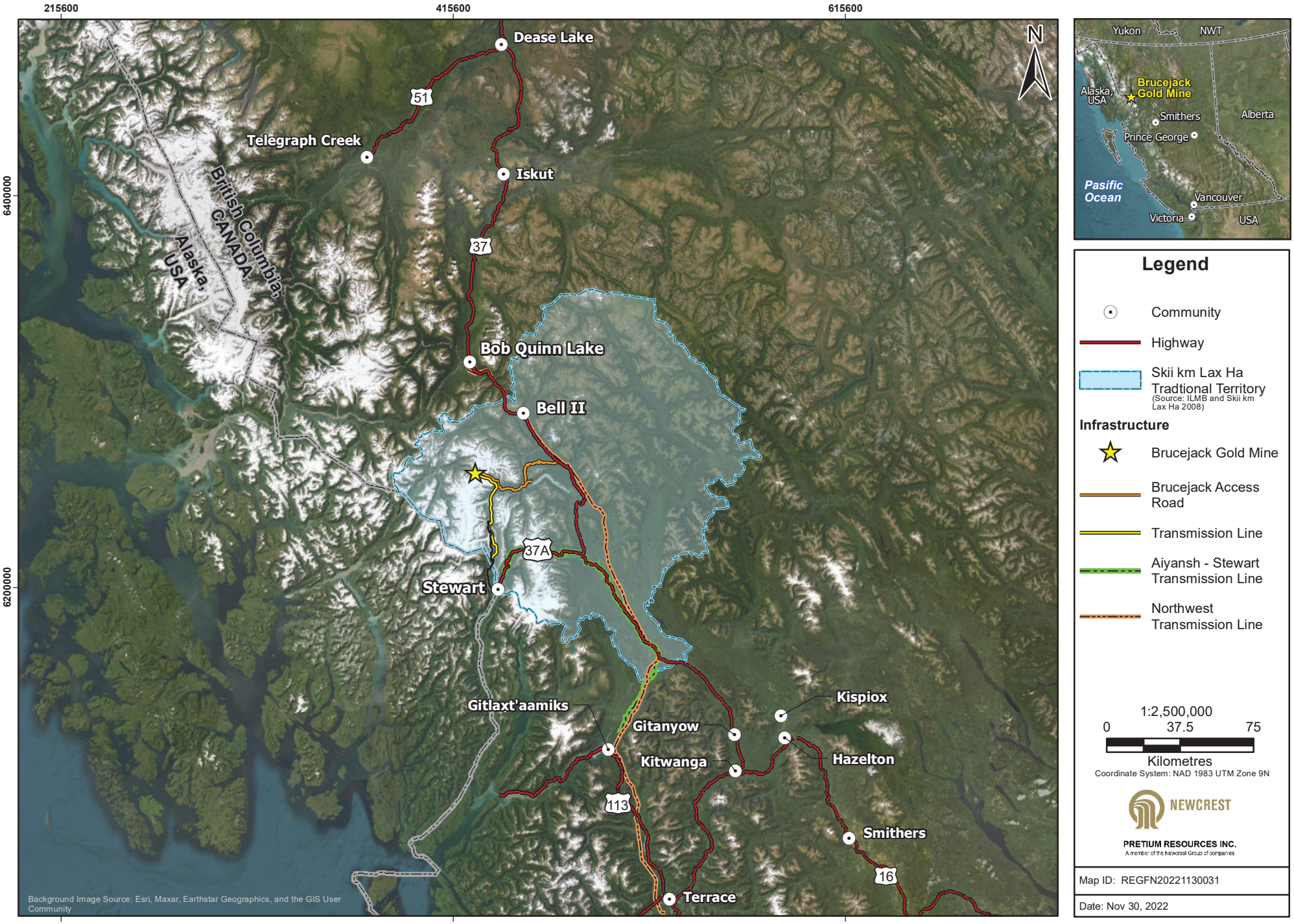


Figure 1.6-1 Asserted Traditional Territory of the Tsetsaut Skii km Lax Ha

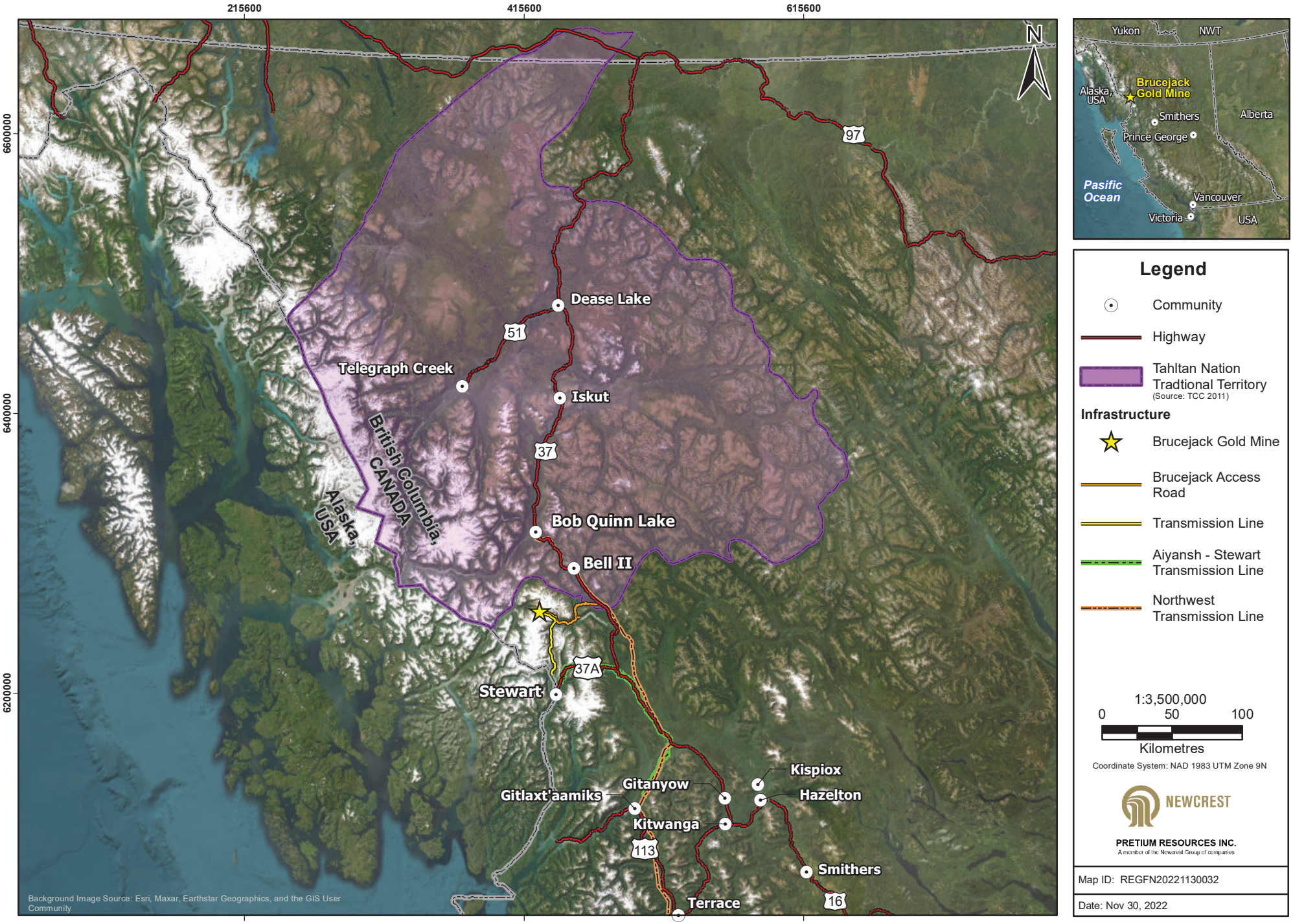


Figure 1.6-2 Tahltan Territory

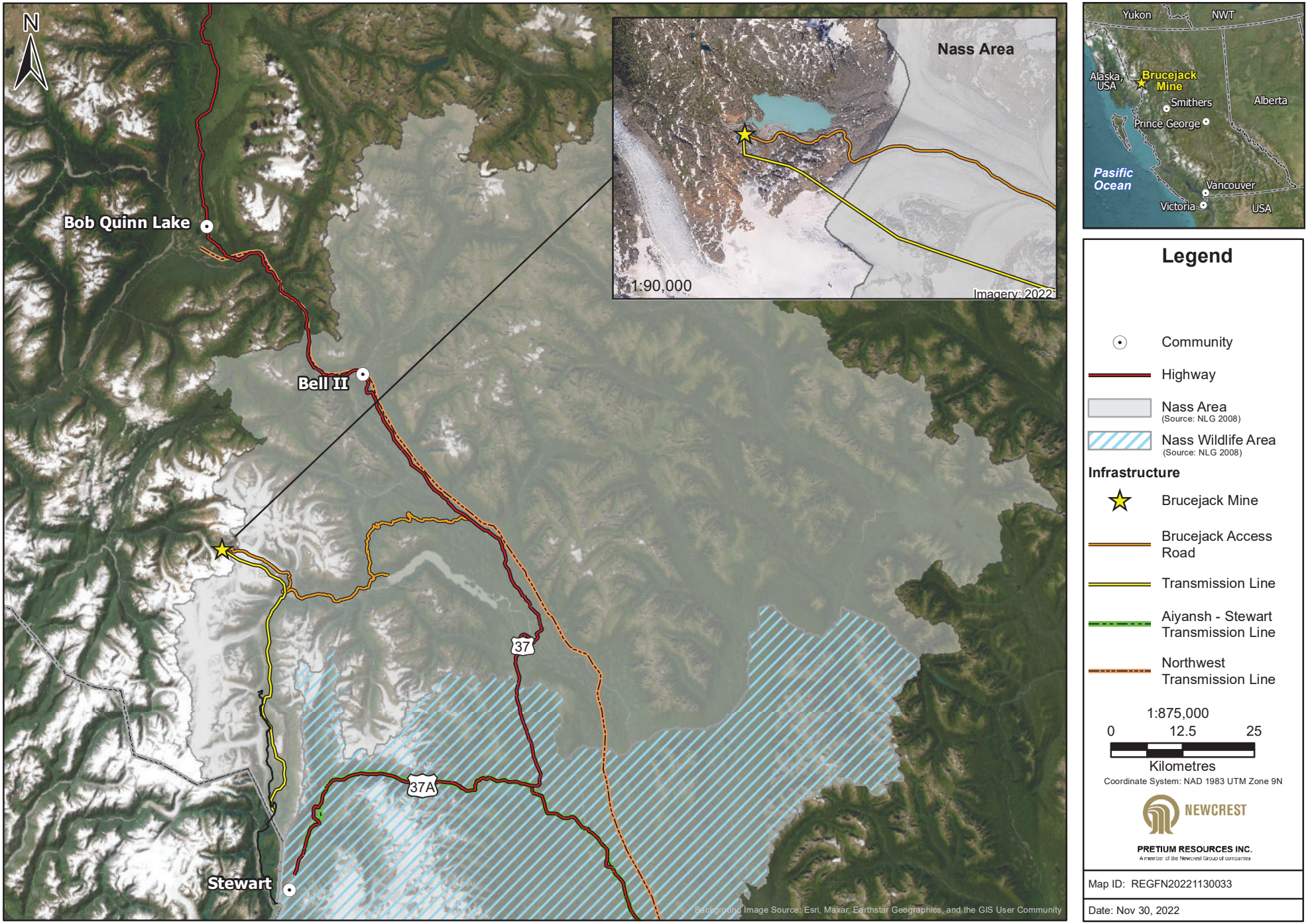


Figure 1.6-3 Nass Area of the Nisga'a Nation

2. BASELINE INFORMATION

2.1 Summary

Extensive environmental baseline information for the Brucejack Mine local and regional areas is provided in the 2014 EAC/EIS Application (Pretium 2014), the 2015 *MA/EMA* Permits Application (Pretium 2015), and the 2015 *MA/EMA* Annual Report (Pretium 2016). Baseline technical reports appended to the 2014 EAC/EIS Application include the:

- Brucejack Environmental Assessment: ML/ARD Baseline Report (BGC 2014a);
- Brucejack Gold Mine Project: Cumulative Surface Water Quality Baseline Report (ERM Rescan 2014b);
- Brucejack Project Environmental Assessment - Hydrogeology Baseline Report (BGC 2014b);
- Brucejack Gold Mine Project: 2012 Surface Water Hydrology Baseline Report (Rescan 2013a);
- Brucejack Project: 2012 Fish and Fish Habitat Baseline Report (Rescan 2013g);
- Brucejack Gold Mine Project: 2012 Wetland Baseline Report (Rescan 2013h);
- Brucejack Gold Mine Project: Wildlife Characterization Baseline Report (Rescan 2013b);
- Brucejack Gold Mine Project: Wildlife Habitat Suitability Report (Rescan 2013i);
- Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies (Rescan 2014);
- Brucejack Gold Mine Project: Cumulative Aquatic Resources Baseline Report (ERM Rescan 2014a);
- Brucejack Gold Mine Project: Non-traditional Land Use Baseline (Rescan 2013d);
- Brucejack Gold Mine Project: Ethnographic Overview Report (Rescan 2013c);
- Brucejack Gold Mine Project: Métis Interests Desktop Study (ERM Rescan 2014c);
- Brucejack Gold Mine Project: Tsetsaut/Skii km Lax Ha Nation Traditional Knowledge and Traditional Use Report (ERM Rescan 2014d);
- 2012 Archaeology Baseline Report (Rescan 2013e);
- 2013 Paleontology Baseline Report (ERM Rescan 2013);
- Brucejack Gold Mine Project: 2012 Air Quality Baseline Report (Rescan 2013j);
- Brucejack Gold Mine Project: 2012 Noise Baseline Report (Rescan 2013k);
- Brucejack Gold Mine Project: Socio-economic Baseline Report (Rescan 2013l);
- Brucejack Gold Mine Project: Country Foods Baseline Assessment (Rescan 2013m);
- Brucejack Gold Mine Project: 2012 Visual Quality Baseline Report (Rescan 2013n); and
- Brucejack Gold Mine Project: 2012 Meteorology Baseline Report (Rescan 2013f).

Baseline information presented in the above-referenced reports was collected before mine construction was initiated in late 2015. Additional monitoring information collected from 2015 onward is documented in the *MA/EMA* Annual Reports (Pretium 2016; 2017; 2018a; 2019; 2020a; 2021a; 2022a).

The following subsections provide overviews of baseline and environmental setting information, as well as a summary of data collected from the various monitoring programs through to the end of 2021, where relevant.

2.2 Meteorology and Climate

The following provides a summary of meteorological conditions for the period from late 2014 through 2021. Additional details of meteorological and climate information for the baseline period (i.e., prior to mine construction beginning in late 2015) and for the 2015 through 2021 period are provided as follows:

- Baseline meteorological and climate conditions: Appendix 7-A of the 2014 EAC/EIS Application (Pretium 2014).
- Pre-application baseline (September 2014 through July 2023) meteorological and climate conditions (Appendix 2-1 of this Application).
- 2015 through 2021 meteorological data and information: annual Meteorological Monitoring Reports that summarize calendar year monitoring data and current state of understanding with respect to meteorological conditions. These annual Meteorological Monitoring Reports are included as appendices within each MA/EMA Annual Report (Pretium 2016; 2017; 2018a; 2019; 2020a; 2021a; 2022a).
- Greenhouse Gas Emission Reports under B.C. Regulation 249/2015. Verification of the 2021 Emission Report by an independent, third party is provided in Appendix 2-2.
- Additional characterization of the pre- 4950 tpd Joint Application condition with respect to meteorological and climate conditions: Section 2.3 of the Water Balance Model report provided as Appendix 5-2 of this application.

Effects of climate change on temperature and precipitation are discussed in Section 2.3.6 of the Water Balance Model report provided in Appendix 5-2.

Site-specific meteorological monitoring by Pretium began in 2009 at the Brucejack Lake meteorological station, 2010 at the Scott Creek station, and 2011 at Wildfire Creek meteorological station (Table 2.2-1). To provide data at specific infrastructure sites (Bowser aerodrome and Scott Pass) and a more representative site at the mine site (VOK), the original three stations were decommissioned in August 2014 and their components moved to three new locations: VOK meteorological station, Bowser meteorological station, and Scott Pass meteorological station (Figure 2.2-1, Table 2.2-1).

Each meteorological monitoring station consists of a 10 m tower instrumented with research grade sensors sited according to guidelines by Environment and Climate Change Canada (ECCC) (EC 2004), and the BC Ministry of Environment and Climate Change Strategy (ENV; previously BC Ministry of Environment) (BC MOE 2016). Instrumentation is programmed to record air temperature,

relative humidity, average wind speed and gusts, solar radiation, net radiation, atmospheric pressure and total precipitation.

Climate data for the VOK for the period 2014-2021 are summarized in Figure 2.2-2. Air temperature data confirm December, January, and February as the coldest months on average, whereas July and August are the warmest months of the year. Air temperature data also indicate the transition from winter (sub-zero) to warmer (above-zero) temperatures typically occurs between April and May each year, triggering onset of freshet flow conditions owing to melt out of local snowpack.

Measured data for VOK indicate approximately 60% of the annual precipitation signature is realized as snowfall based on precipitation occurring primarily as snow between October and April, versus liquid precipitation (40%, rainfall) which occurs mainly between May and September each year. Local snow depth records show packs reach their maximum depth (2.5-4.2 m) by late winter (i.e., March, April or early May) (Figure 2.2-2, lower panel) and snowpacks ablate through May and June at the mine site following onset of warmer climatic conditions in the spring.

Table 2.2-1. Climate Station Locations and Operating Periods

Meteorological Station	Elevation (masl)		UTM Coordinates[1]		Operating Period	
		Status	Easting (m)	Northing (m)	Start	End
Brucejack Lake	1,360	Historical	425,729	6,259,022	Oct. 13, 2009	Aug. 30, 2014
Scott Creek	780	Historical	451,418	6,254,104	July 29, 2010	Aug. 27, 2014
Wildfire Creek	720	Historical	470,397	6,256,874	Aug. 13, 2011	Aug. 26, 2014
VOK	1,501	Current	426,301	6,258,276	Sept. 2, 2014	Active
Bowser	440	Current	443,003	6,250,540	Sept. 4, 2014	Active
Scott Pass	990	Current	456,394	6,262,968	Sept. 5, 2014	Active

1 Zone 9V, Datum NAD83

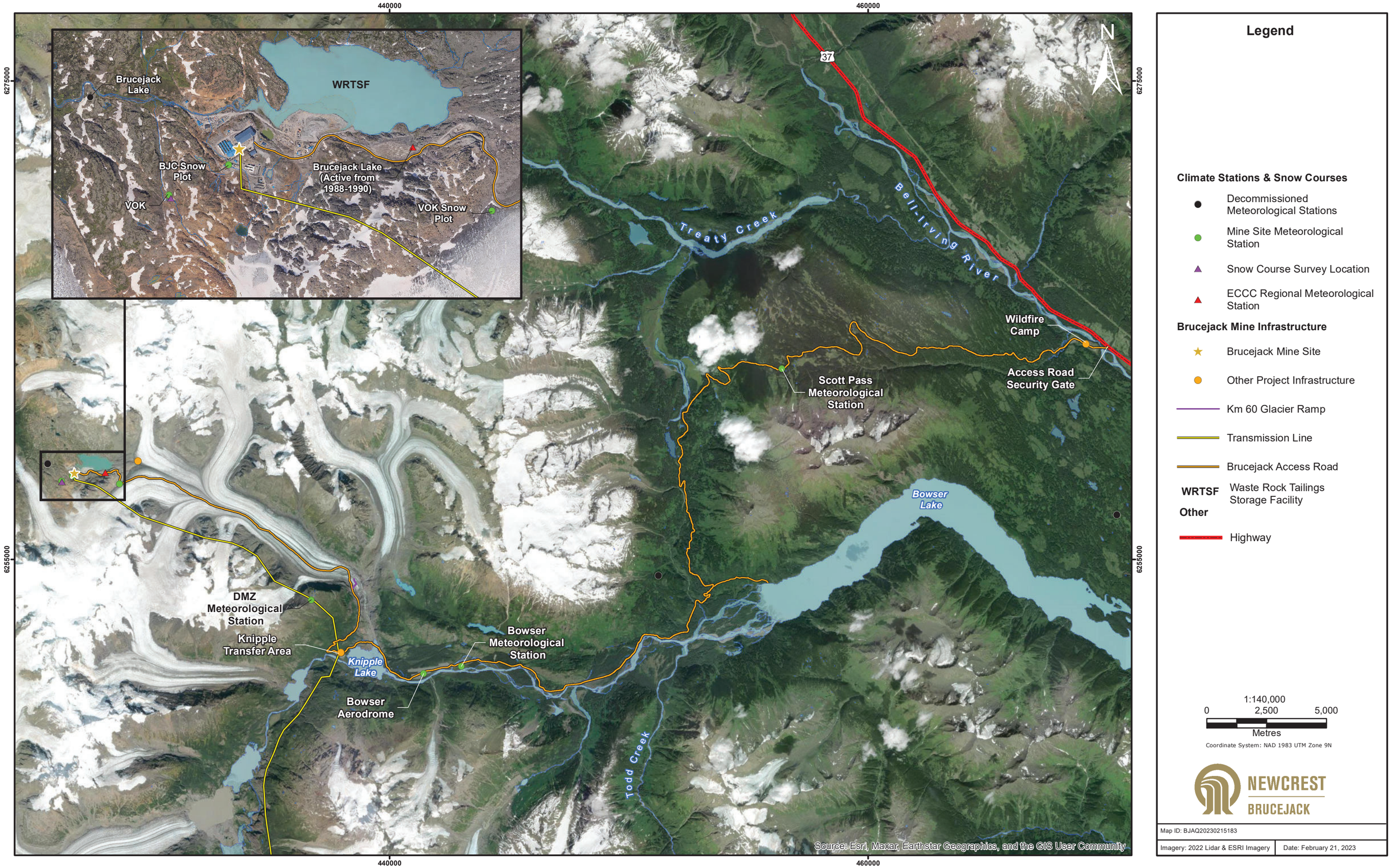


Figure 2.2-1. Schematic showing the Location of Brucejack Mine Climate Stations and Snow Courses

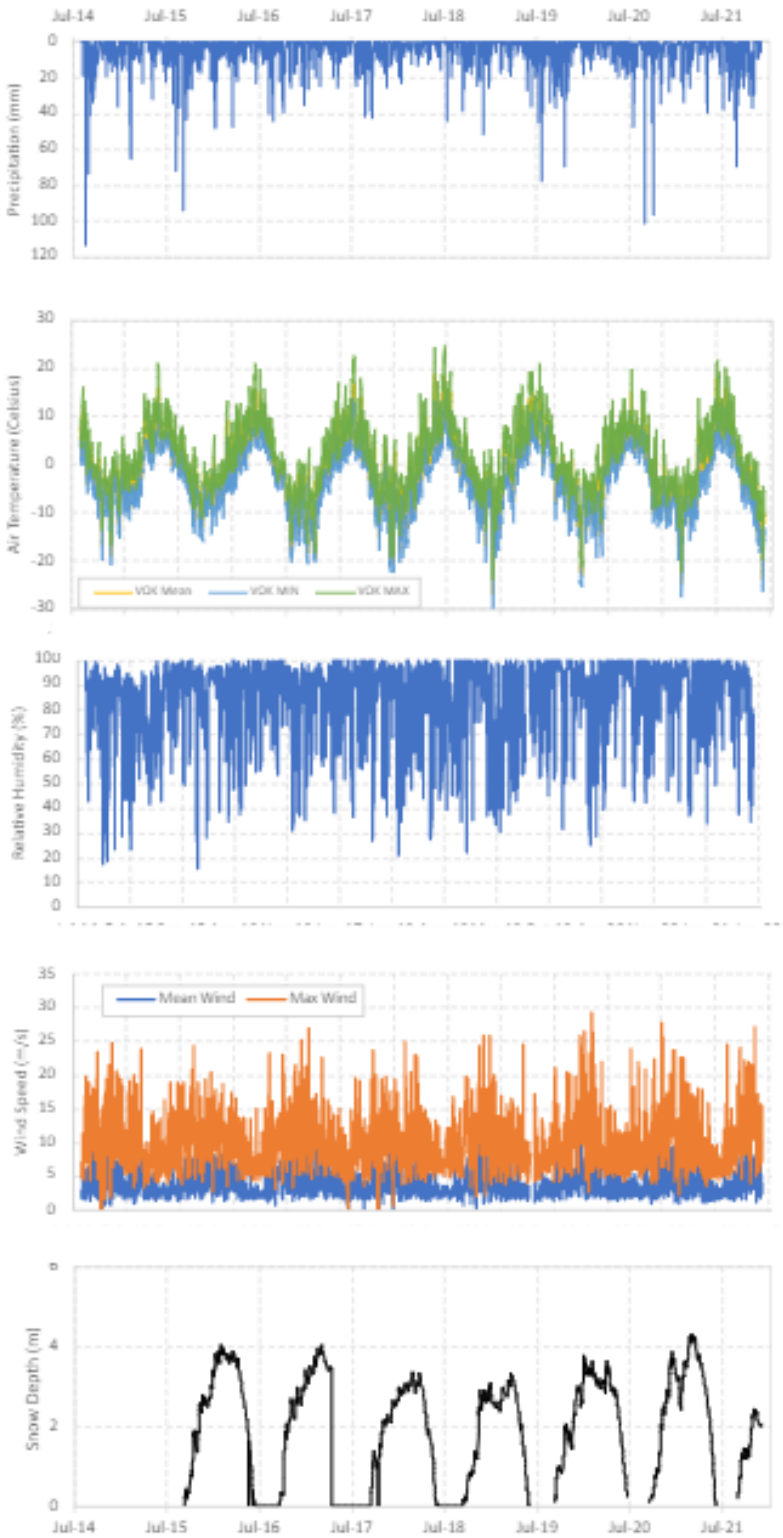


Figure 2.2-2. Time series plots for VOK climate station (2014 to 2021). Plots presented in the figure show patterns and trends in precipitation, air temperature, relative humidity, wind speed and snow depth.

2.3 Geology

The geology of the Brucejack Mine area has been presented previously in various reports including Appendix 5-B of the 2014 EAC/EIS Application (Pretium 2014), Section 2.2 of the 2015 *MA/EMA* Permits Application (Pretium 2015), and Section 1.3 of the Technical Report on the Brucejack Gold Mine (Tetra Tech 2020).

The Brucejack deposit is located on the western side of the Stikine Terrane in the Intermontane morphogeologic belt of the Canadian Cordillera and is currently defined as incorporating the VOK zone and West zone. The Brucejack deposit occurs in an exceptionally metals-rich tectonic assemblage hosted in volcanic island arc-related rocks in BC's Golden Triangle. The deposit is interpreted to be a deformed, porphyry-related transitional to intermediate sulphidation epithermal high-grade gold-silver deposit.

At the district level, the Brucejack deposit forms part of a well mineralized, north-south gossanous trend (the Sulphurets Mineral District) associated with a regional unconformity and proximal mineralized Early Jurassic porphyry intrusions on the eastern limb of the McTagg Anticlinorium. Rocks of the Sulphurets Mineral District record a long history of volcanism, telescoping magmatic-hydrothermal alteration, mineralization, and deformation.

The mine area is largely underlain by volcano-sedimentary rocks of the Lower Jurassic Hazelton Group. These rocks unconformably overlie volcanic arc sedimentary rocks of the Upper Triassic Stuhini Group. The main lithological units encountered within the mine area and which have been characterized through baseline studies, as well as subsequent monitoring programs, include the following:

- P1 [Office or Bridge]: Hornblende, feldspar phyric latite flows.
- P2: Megacrystic, plagioclase, potassium-feldspar, and hornblende phyric flow.
- V12 [Fragmental volcanics]: Hornblende and/or feldspar phyric latite to andesite fragmental volcanic rocks and subordinate flows with minor ash and lapilli tuff.
- S3-Poly [Polymictic conglomerate]: Heterolithic boulder to coarse cobble conglomerate with sandstone.
- Silicified Cap: Silicified rocks; typically, poorly sorted heterolithic conglomerate, lesser sandstone, and local mudstone; commonly includes rhyolite fragments.
- VSF [Volcanic Sedimentary Facies]: Volcanically derived siltstone and sandstone with minor arenite and pebble conglomerate.

If new lithological units are encountered as mine development proceeds, these units will be characterized, assessed, and managed following procedures outlined in the mine's ML/ARD Management Plan.

The surficial materials within the Brucejack area consist of a sparse veneer of well-graded glacial till overlying bedrock. Grain size varies from sand to gravel, with some silt and clay, and variable quantities of cobbles and boulders. The thickness of unconsolidated deposits varies at the site but is generally less than 5 m and commonly less than 1 m (BGC 2014a).

A geohazards map for the mine site is presented in in the Geohazards Management Plan (Appendix 9-2-3).

2.4 Geochemical Characterization and Source Terms

The geochemistry of rock that has been or will be disturbed, excavated, or exposed at the Brucejack Mine has been characterized through static and kinetic test programs as described in the ML/ARD Baseline Report (BGC 2014a), the 2020 ML/ARD Review and Update (Pretium 2020c), as well as in the *MA/EMA* Annual Reports (Pretium 2016, 2017, 2018a, 2019, 2020a, 2021a, 2022a). The characterization programs have also evaluated the water quality impacts of explosives used for blasting and cement products used in shotcrete and paste backfill. Static tests include acid base accounting (ABA) analyses to evaluate if material is PAG, elemental analyses to identify parameters that are elevated and of potential concern and shake flask extraction tests to provide an indication of soluble loads and drainage chemistry. Kinetic tests including field bins, humidity cells and saturated columns have been carried out to assess the long-term behaviour of materials under site-specific conditions.

Summaries of the baseline study results, and recent monitoring results related to geochemistry and mine impacted water are described below:

- Waste Rock: static and kinetic test results from six lithologic units (described in Section 2.3) indicate that rocks from all units are dominantly PAG (83%) with elevated concentrations of metals (e.g., silver, cadmium, zinc) and metalloids (arsenic, antimony) compared to continental crust. Many of the PAG samples contain significant amounts of carbonate minerals (mostly calcite) that will neutralize acidity generated and prolong the onset to acid generation (Pretium 2016). Confirmatory sampling results through to the end of 2021 remain consistent with the baseline assessment (Pretium 2022a).
- Ore, tailings, and paste backfill: The ore is characterized as PAG with elevated concentrations of silver, arsenic, cadmium, manganese, and selenium, compared to continental crust (BGC 2014a). Thickened tailings generated from the mill show the same metal enrichments, but samples are predominantly NPAG (Pretium 2018a, 2019). Paste samples are similar in composition to thickened tailings, but with a slightly higher median neutralization potential ratio (NPR). Confirmatory sampling results through to the end of 2021 remain consistent with the baseline assessment (Pretium 2022a).
- Quarry rock: The km 72 NPAG Quarry is comprised predominantly of volcanic (plagioclase-hornblende) porphyry, with lesser amounts of conglomerate, and has negligible sulfide mineralization. Characterization studies of the km 72 NPAG Quarry rock samples have confirmed that rock excavated from the km 72 NPAG Quarry is consistently NPAG, with low neutral metal leaching potential. Confirmatory sampling results through to the end of 2021 remain consistent with the baseline assessment (Pretium 2022a).
- Underground mine water: Underground mine water at the Brucejack Mine is dominantly comprised of groundwater with added geochemical loads from blasted rock, wall rock, waste rock backfill, and paste backfill. Despite the prevalence of PAG waste rock, the neutralization afforded by carbonate minerals is expected to buffer any acid generated from sulphide oxidation reactions for several decades or more (Pretium 2015). Confirmatory sampling results through to July 2022 suggest there are no sustained increases in dissolved metals associated

with the onset of ML/ARD as predicted by kinetic tests (e.g., cadmium, cobalt, copper, iron, zinc) since gold production commenced in June 2017 (Pretium 2022a).

- Water treatment plant effluent and associated treatment residues (i.e., sludge): The WTP effluent has consistently met design specifications. Sludge generated from the WTP is co-deposited with thickened tailings in the WRTSF. Static test results indicate that the sludge is NPAG with elevated concentrations (greater than 10x average continental crust concentrations) of several metals (e.g., silver, arsenic, cadmium, manganese, molybdenum, antimony, and selenium). The results show that the sludge is stable under a range of pH and redox conditions and low metal leaching rates are expected for the co-deposited tailings and sludge. Confirmatory sampling results through to the end of 2021 remain consistent with the baseline assessment (Pretium 2022a).
- Excavated surface rock exposures and runoff: Non-contact surface runoff from areas immediately surrounding the mine site are directed to the WRTSF via the East (Johnson Creek) Diversion Channel, and to Camp Creek via the West (Camp Creek) Diversion Channel. Camp Creek runoff is naturally acidic, with elevated metal concentrations (e.g., silver, cadmium, copper, and zinc). The water quality of Mine Site contact water is assessed based on drainage into the CWP and shake flask experiments carried out on all surface exposed rock units.
- Explosives-related residues: Explosives-related residues contain water soluble nitrogen compounds that can affect water quality in the receiving environment. Site monitoring data have been used to derive and refine water quality predictions with respect to these compounds (Lorax 2020b).

The results of the baseline characterization studies have informed the development of the mine's ML/ARD Management, Nitrogen Management, Chromium Management and Closure Underground Water Quality Adaptive Management plans which are designed to prevent or minimize potential geochemistry and chemistry related adverse environmental effects associated with development, operation, and closure/reclamation of the Brucejack Mine. The monitoring programs described in the plans are also used to verify and update source terms for the mine's water quality model. The source terms used to develop the water quality model for the 4950 tpd application are described in detail in the water quality model report (Appendix 5-3).

2.5 Topography and Surface Drainage Features

The Brucejack Mine site is located in a bedrock controlled, high elevation area (Figure 2.5-1) and is located above the tree line in the Coastal Mountain-heather Alpine (undifferentiated; CMAun) Biogeoclimatic Ecosystem Classification (BEC) zone. Pre-mine, and in remaining undisturbed or minimally disturbed areas, the bedrock surface was/is irregular with rounded surfaces broken by crevices and depressions where snow accumulates. There were localized areas with shallow, slightly weathered overburden and limited areas with developed soil cover. Bedrock and shallow overburden extended to the lake shoreline, with few level areas.

The Brucejack Mine site is situated within the Brucejack Creek watershed, which is a small headwater sub-basin within the Sulphurets Creek watershed (drainage area 299 km^2). Brucejack Creek drains into Sulphurets Creek before reaching the Unuk River (Figure 1.4-3), which flows southwest, eventually discharging to the Pacific Ocean northeast of Ketchikan, Alaska.

Most of what is now the mine site drained to Brucejack Lake (now the WRTSF, Figure 1.4-5), with some areas draining to Camp Creek or directly to Brucejack Creek (Figure 2.5-3 and Figure 2.5-4). Refer to Brucejack Gold Mine Project: 2012-2013 Terrestrial Ecosystem Baseline Studies for additional baseline information on topography and surface drainage features (Rescan 2014).

Operations drainage patterns differ from baseline, as described in Appendix 4-1 Section 3.3.1.1, where Figure 3.3-3 shows the operations contact water collection system. The Water Management Plan – OMS Manual describes operations surface water drainage patterns in greater detail (Pretium 2021a, Appendix 3-1-1-9). The WRTSF receives mine waste and treated effluents and is the headwaters to Brucejack Creek.

Additional inputs to Brucejack Creek downstream of the mine's final effluent discharge compliance point (BJ 3.10) within Pilsner Valley (upper elevation section of Brucejack Creek) include natural seasonally acidic tributaries traversing the gossan to the south and east (Camp Creek and VOK Creek) and a small, circum-neutral pH tributary (Unnamed Creek) draining to Brucejack Creek from the north. Camp Creek, VOK Creek and Unnamed Creek are seasonally dry.

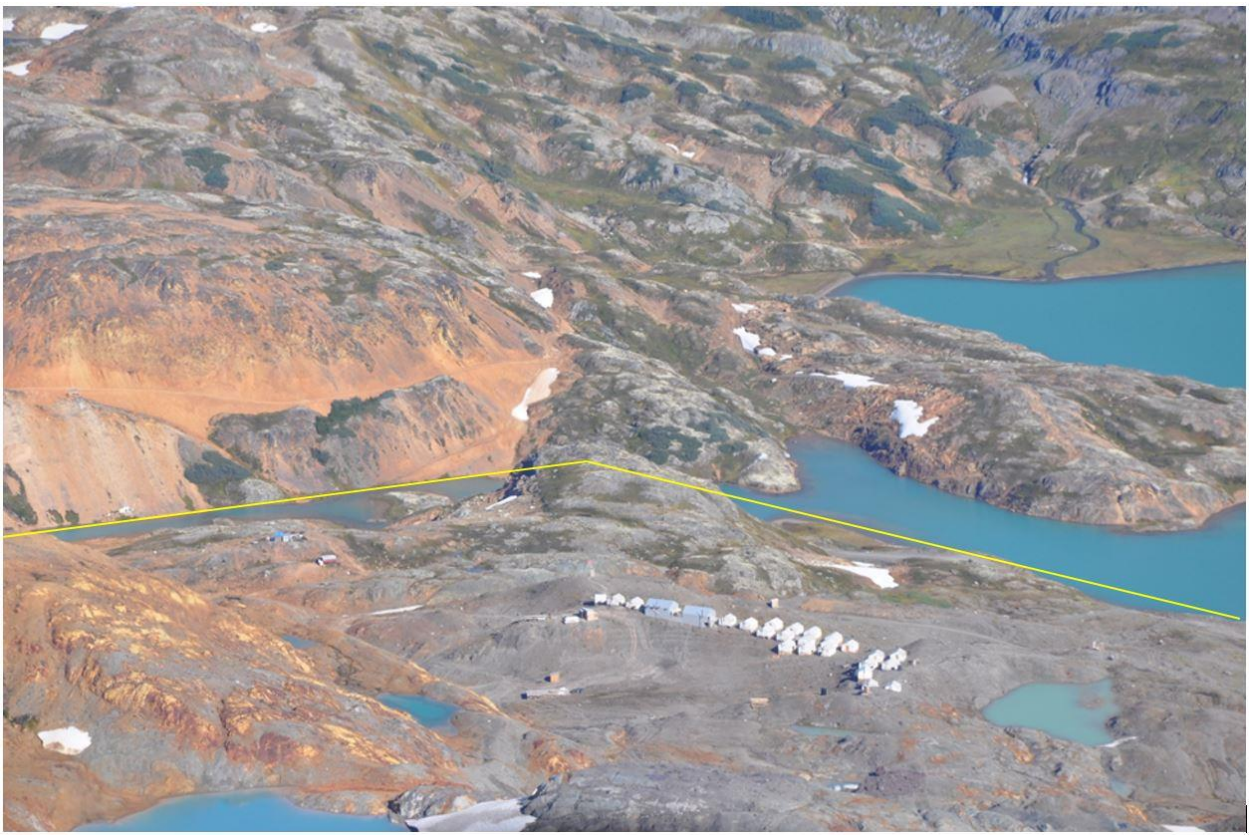


Figure 2.5-1. Mine Site 2008 During Exploration, Showing Bedrock Control.

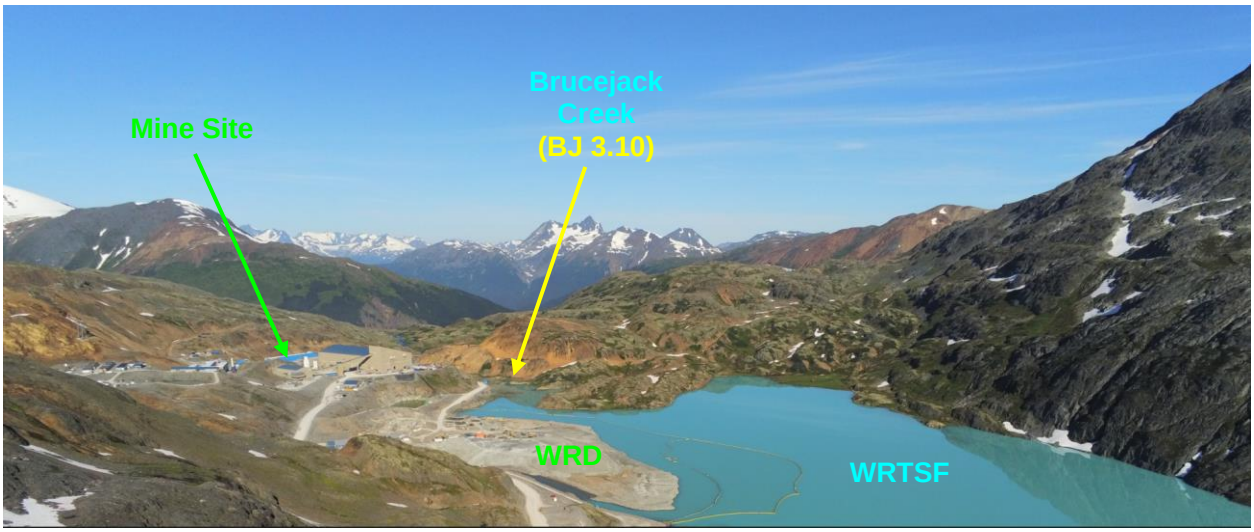


Figure 2.5-2. Brucejack Mine and WRTSF as seen from east side of WRTSF looking westward (August 2022).

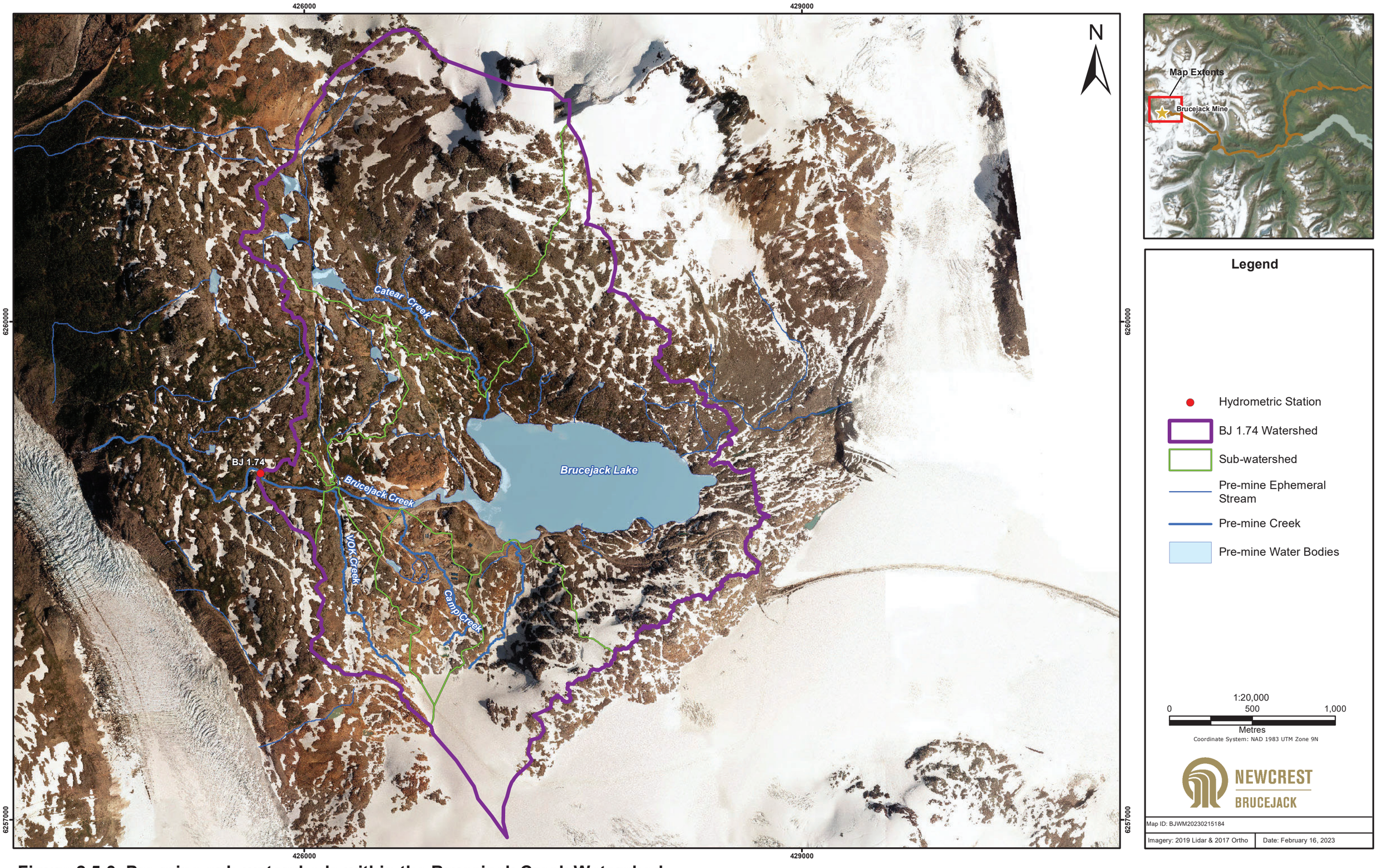


Figure 2.5-3. Pre-mine sub-watersheds within the Brucejack Creek Watershed

Figure 2.5-4: Pre-Mine Drainage Areas

2.6 Water Quantity

2.6.1 Surface Water Quantity

A summary of hydrological conditions for the period 2014 to 2021 is provided below. Additional details of hydrological information for the baseline period (i.e., prior to mine construction beginning in late 2015) and for the 2015 through 2021 period are provided as follows:

- Hydrometric monitoring network: described in the 2021 Hydrometric Monitoring Report included as Appendix 5.2-1 of the 2021 MA/EMA Annual Report (Pretium 2022a) and in Section 2.4 of the Water Balance Model report provided as Appendix 5-2 of this application.
- Baseline hydrological conditions: provided in Appendix 10-A of the 2014 EAC/EIS Application (Pretium 2014).
- 2015 through 2021 hydrometric data and information: provided in annual hydrometric monitoring reports that summarize calendar year monitoring data and current state of understanding with respect to streamflow conditions within the Brucejack Creek watershed. These annual hydrometric monitoring reports are included as appendices within each MA/EMA Annual Report (Pretium 2016; 2017; 2018a; 2019; 2020a; 2021a and 2022a).
- Additional characterization of the pre- 4950 tpd Joint Application condition with respect to hydrological conditions: Section 2.4 of the Water Balance Model report provided as Appendix 5-2.

The Brucejack Mine site lies within the Coast Mountains of northwestern British Columbia. The region is characterized by steep, rugged, high elevation topography with substantial glacier coverage receiving relatively high amounts of precipitation. The wet climate and physiography of the region result in dynamic watercourses with high annual runoff rates and high average stream flows, making water resource management an important component of mine operation and closure planning.

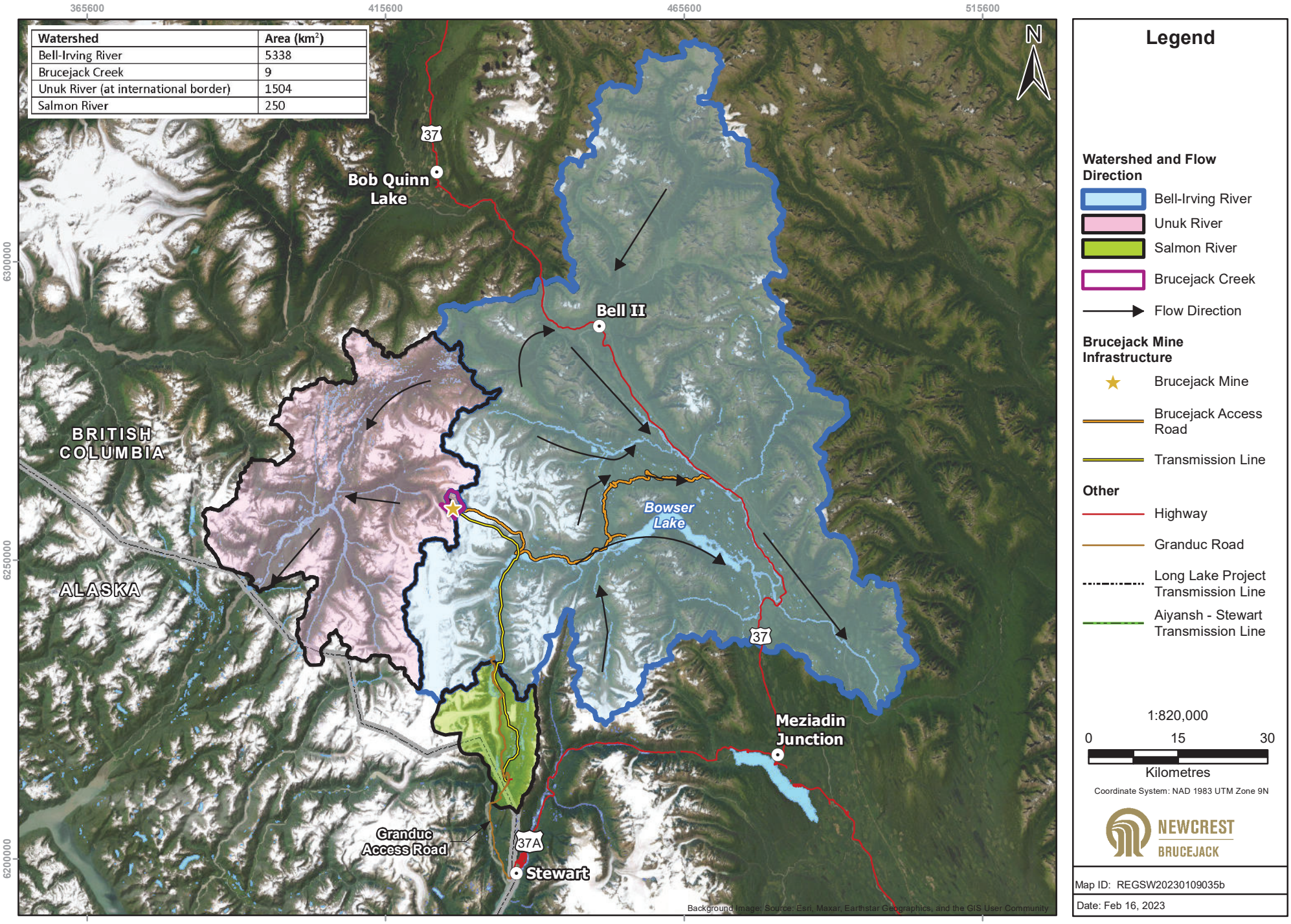
The Brucejack Creek catchment (drainage area 8.5 km^2 at water monitoring station BJ 1.74) is a small headwater sub-basin within the larger Sulphurets Creek watershed (drainage area 300 km^2 at the confluence with the Unuk River). The catchment is in a glaciated, alpine environment, with its uppermost portion flowing into the WRTSF (drainage area 6.7 km^2 at BJ 3.10). About 17 km downstream of Sulphurets Lake, Sulphurets Creek meets with the larger Unuk River which ultimately flows into the Pacific Ocean, northeast of Ketchikan, Alaska (Figure 2.6-1).

The Brucejack Mine hydrometric monitoring network includes four active hydrometric monitoring stations (Table 2.6-1, Figure 2.6-2 and Figure 2.6-3).

Table 2.6-1. Hydrometric Monitoring Network

Monitoring Station	Location	Easting a	Northing	Elevation (masl)	Drainage Area (km2)	Glacier Cover (km2 [%])	Period of Record	Monitoring Type
BJ 1.74	Brucejack Creek	425,739	6,259,085	1,349	8.5	0.82 [9.6]	2008 to present [b]	Continuous Stream Water Level
BJ WRTSF	Western shore of WRTSF near outflow	427,112	6,258,918	1,375	6.7	0.71 [11]	2013 to present	Continuous Lake Level
BJ 3.10	Brucejack Creek at WRTSF outflow	426,859	6,258,921	1,373			2018 to present	Continuous stream level and discharge [c]
SC-1	Sulphurets Creek downstream of the outlet of Sulphurets Lake	419,911	6,261,307	546	75.7	34.5 [46]	2016 to present	Continuous Stream Water Level

[a] UTM Zone 9U, NAD 83
[b] Originally BJL-H1, relocated to BJ 1.74 in 2014.
[c] Discharge measurements conducted on the channel downstream from the weir. No visible tributaries are located between the station and gauging section.



Watershed	Area (km^2)
Bell-Irving River	5338
Brucejack Creek	9
Unuk River (at international border)	1504
Salmon River	250

Figure 2.6-1. Regional Watershed Map

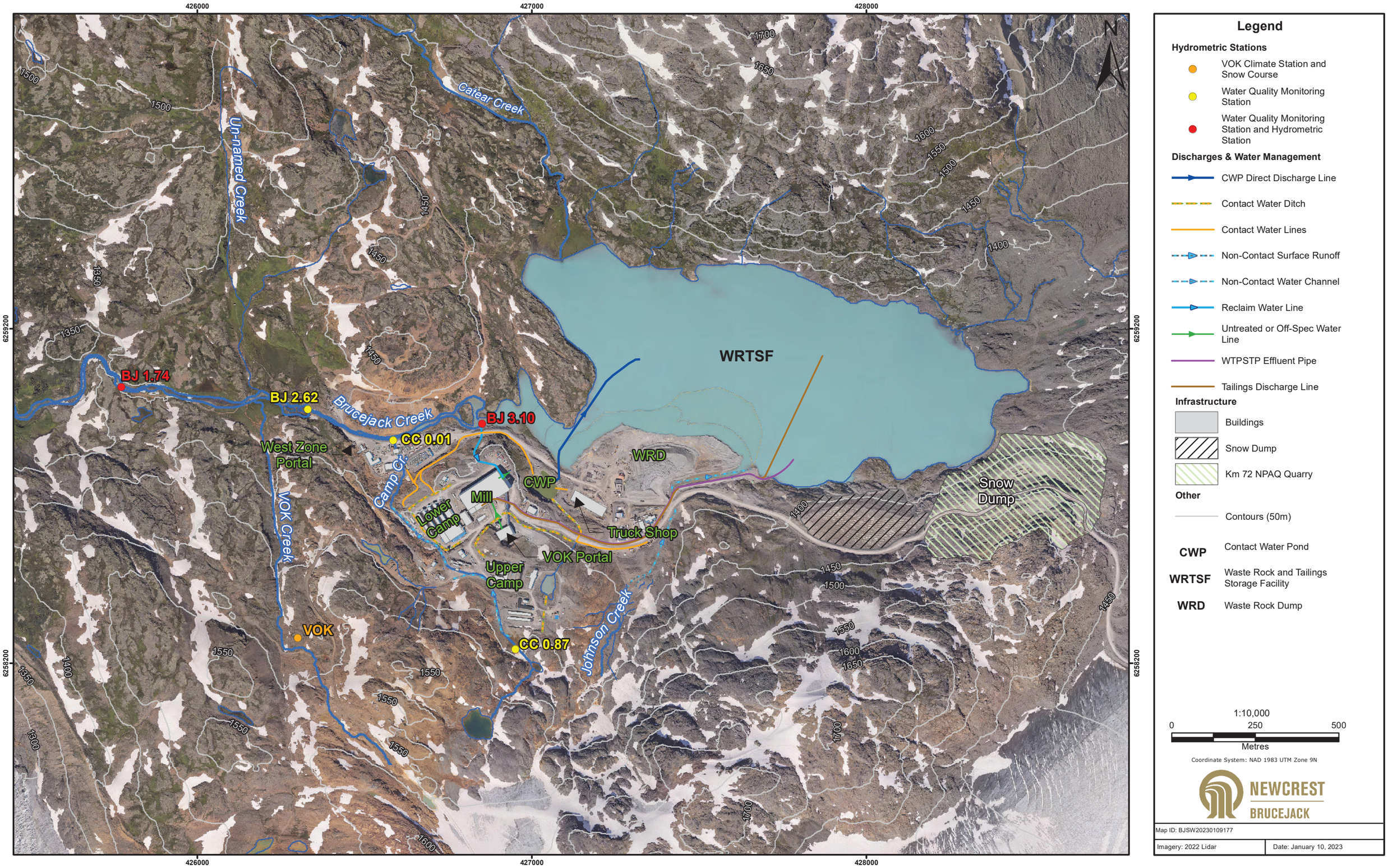


Figure 2.6-2. Hydrometric Stations at the Brucejack Mine

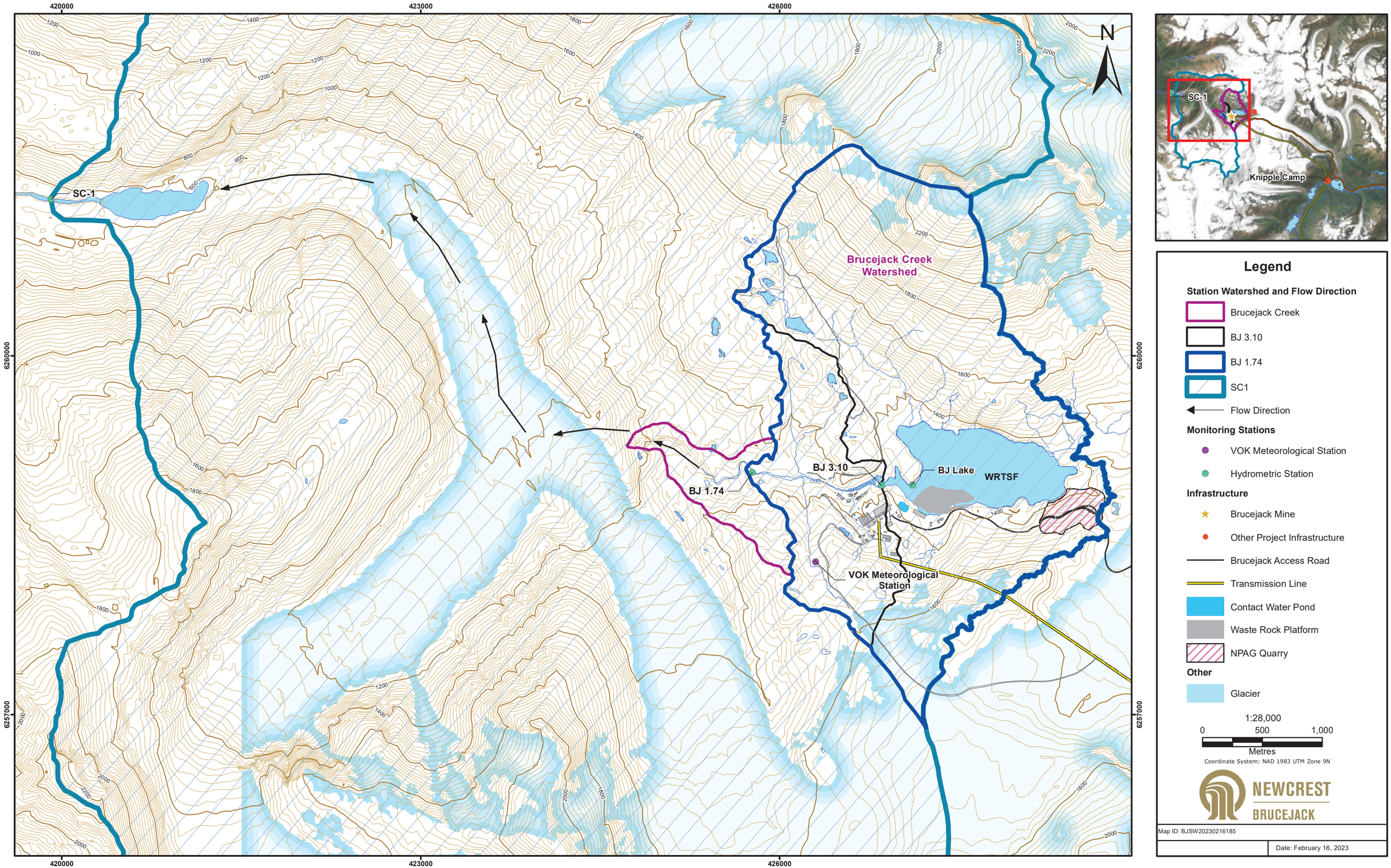


Figure 2.6-3. Brucejack Hydrometric Network

Snowmelt dominated streams, such as Brucejack Creek, tend to have relatively stable regimes especially in drainages where more than 5% of their areas are covered by glaciers, which act as runoff regulators of interannual variability (Eaton et al 2010). These runoff generating processes create the flow regime of Brucejack Creek, which is illustrated in the hydrograph provided in Figure 2.6-4. The low-flow period occurs through winter (December to March) when precipitation accumulates in the snowpack. High flows are associated with snowmelt following the onset of spring freshet in late-April to mid-May. Annual peak flows in Brucejack Creek occur in late-June. Flows ebb after this period until late-September to late-November when runoff is usually increased by sustained precipitation events.

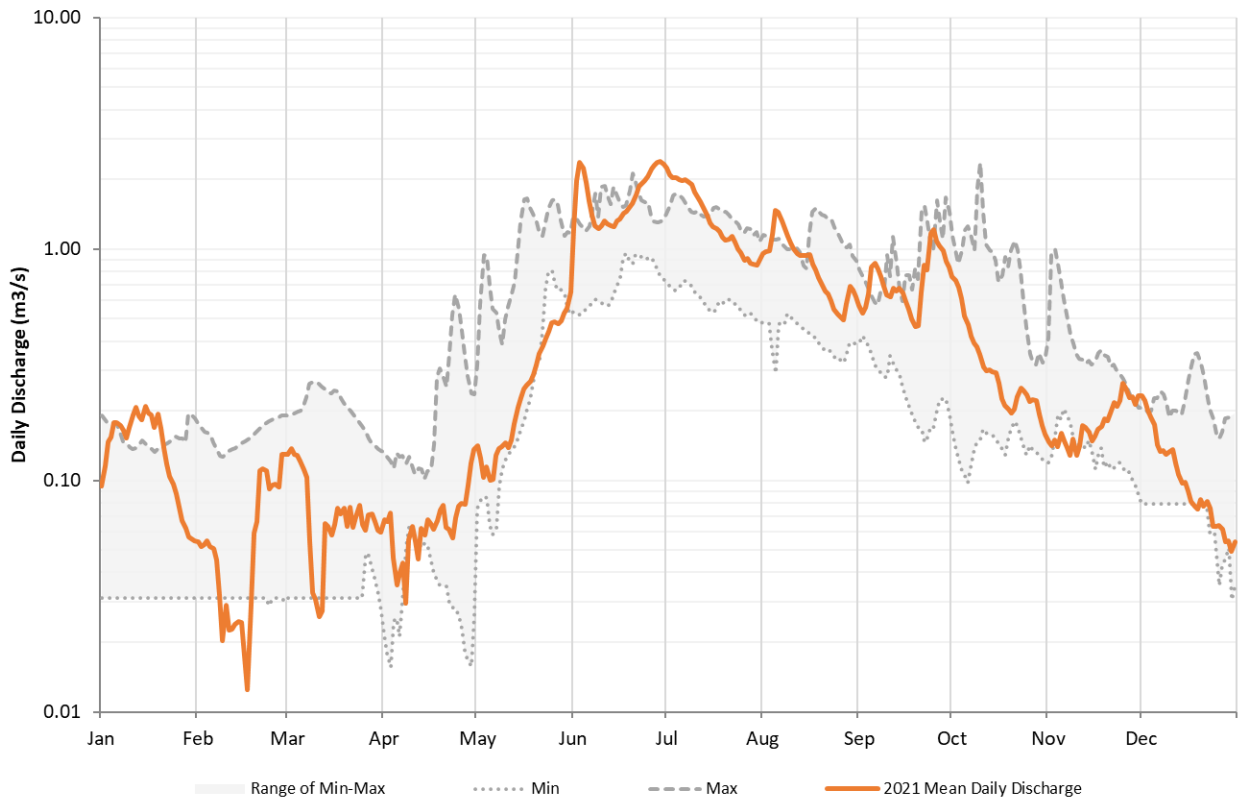


Figure 2.6-4. 2021 Annual Mean Daily Discharge at Station BJ 3.10 (percentiles calculated using data for period 2014-2020)

The flow regimes of BJ 1.74 and BJ 3.10 are highly similar where daily/monthly patterns of streamflow are strongly influenced by snow accumulation and snowmelt processes; roughly 85% of runoff on an annual basis is expected to report to receivers between May and the end of October. By comparison, discharges and runoff depths for other months of the year (*i.e.,* November through April) are much lower. Winter streamflow rates are well characterized within the Brucejack Creek watershed and typically range between 0.05-0.120 m^3/s at BJ 3.10 between December and April. The transition from annual low flow conditions coincides with warmer air temperatures in the spring and the melting of snowpack. Measured discharges through open-water (ice free) months typically range between 0.5-2.5 m^3/s (Figure 2.6-5 upper panel, at BJ 3.10).

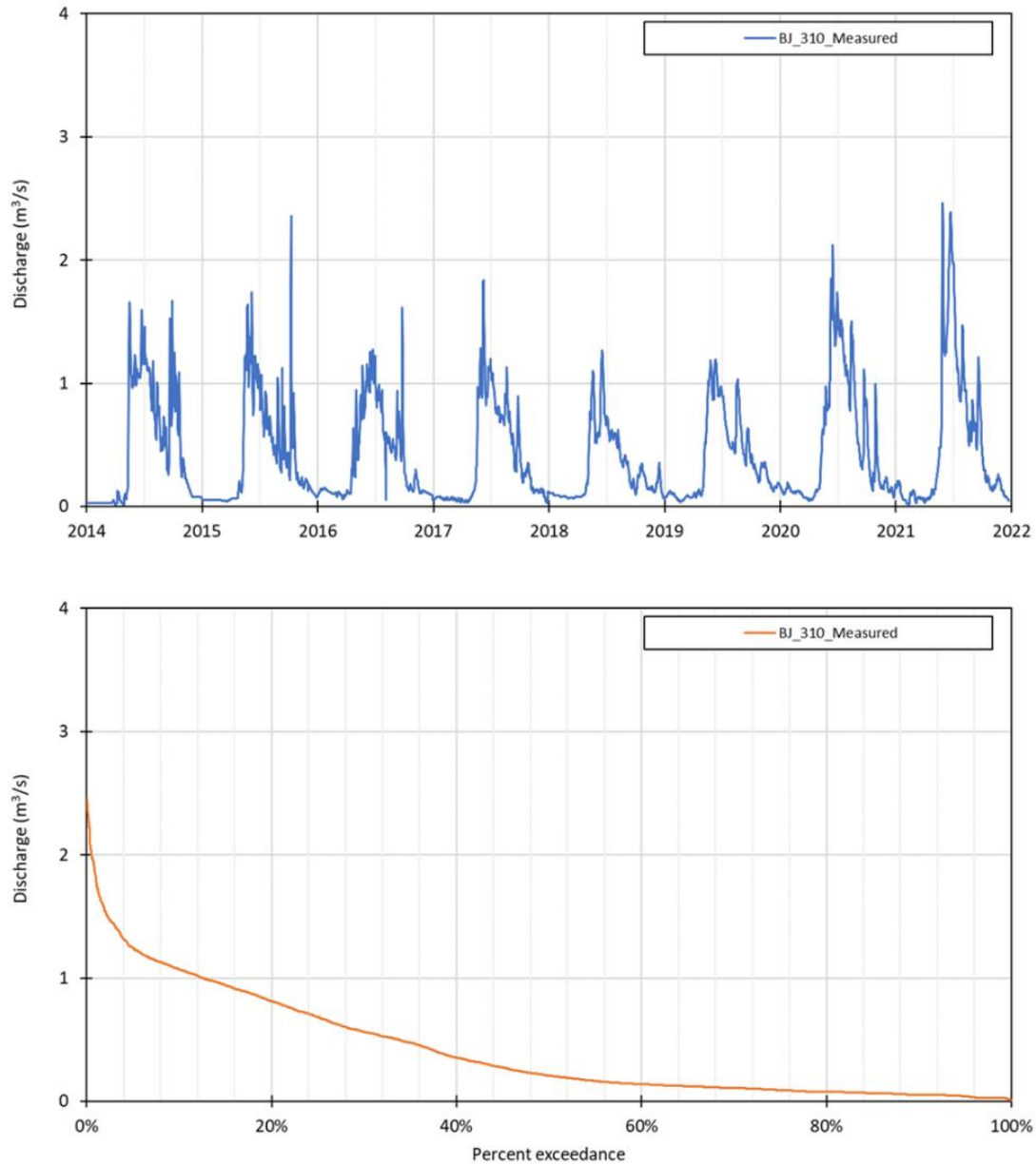


Figure 2.6-5. Streamflow measurements below the WRTSF outlet (BJ 3.10) for the period 2014-2021. Data for the station is presented in time series (upper panel) and flow duration curve format (lower panel).

2.6.2 Groundwater Quantity

The Brucejack Mine groundwater system has been characterized through several hydrogeological field investigations which have established a broad monitoring well network within and proximal to the mine. The current monitoring network is comprised of 31 monitoring wells as prescribed by Appendix B of Effluent Permit PE-107835 (BJ-GW18-22A was destroyed in 2022, and replacement is under review) (refer to Appendix 1-1 for Effluent Permit PE-107835). Appendix B of PE-107835 specifies monitoring locations, monitoring frequency and monitoring parameters for the groundwater monitoring

program. Four additional monitoring wells are monitored outside of permit requirements. Well locations, monitoring intervals and frequency are listed in Table 2.6-2. Currently monitored wells are shown in Figure 2.6-6.

Baseline groundwater quantity is summarized in Section 6 of the Brucejack Project Environmental Assessment Hydrogeology Baseline Report (Hydrogeology Baseline Report; BGC 2014b) which comprises Appendix 9-A of the 2014 EAC/EIS Application (Pretium 2014) and has been included as Appendix 2-3 to this Application. Data presented in the Hydrogeology Baseline Report (BGC 2014b) span 2010 through September 2013. Prior to mine dewatering, groundwater levels in the mine area were observed to follow topography, becoming deeper at higher elevations. Strong seasonal variations in groundwater levels were observed, particularly at higher elevations, indicating a snowmelt/precipitation-driven groundwater level hydrograph. Peak groundwater levels were observed in response to freshet and summer/fall storm events. Recharge beneath glaciers and in response to seasonal glacial melt was also identified as an unquantified contributor to groundwater recharge. Groundwater discharge zones are pervasive in the high-topography landscape, and include lakes, creeks, gullies, and seeps at breaks in slope.

Data collected since the beginning of mine construction in late 2015 have been summarized in Section 4 of stand-alone groundwater monitoring reports appended to and summarized within the *MA/EMA* Annual Reports. The 2021 annual groundwater monitoring report (Lorax, 2022b), which appears as Appendix 6.1-1 of Premium (2022a), has been included as Appendix 2-4 to this Application. Groundwater quantity is also summarized in the 4,950 tpd Groundwater Model Report (Appendix 5-1).

Recent (June 2021) groundwater levels are contoured in Figure 2.6-6. Continued dewatering of the VOK and WZ workings has created and sustained a marked cone of depression in the groundwater table in the footprint of the underground mine workings and farther afield. Water levels collected at wells near the VOK Zone suggest that drawdown at historic wells exceeds 100 m and that a groundwater divide exists between the VOK and WZ. The data recorded at higher elevation wells near the VOK indicates that seasonal water level fluctuations are on the order of tens of meters and hydraulic gradients at well pairs are moderately to strongly downward, reflecting depressurization of the groundwater system from depth. Groundwater flowpaths are towards the mine, with the exception of the area immediately downgradient of the CWP which is actively recharged by the pond. East of the WZ, water levels at selected well pairs are lower than the elevation of the WRTSF (1,364.5 masl) which suggests that the WRTSF is recharging groundwater at its outlet.

Groundwater inflows to the mine show significant seasonal variation with minimum flows in winter months ranging from 500 m^3/d to 750 m^3/d over the last several years of operations. Peak monthly flows during the open water season have ranged from 2,500 m^3/d to 3,000 m^3/d over the last two years, with peak daily flows on the order of 4,000 m^3/d on a couple of occasions during the 2021 freshet. Underground flows have remained within the WTP treatment capacity of 10,000 m^3/d and simulated monthly average flows show that underground flows are expected to remain below this threshold through operations. Treatment rates will be maximized at 10,000 m^3/d over a 15-month period at closure as described in the Closure Underground Water Quality Adaptive Management Plan (Appendix 9-2-2). This 15-month period includes seven months of mine flooding which will be accelerated using reclaim water from the WRTSF. The mine is predicted to flood to an equilibrium elevation of 1,404 masl on an average annual basis.

Table 2.6-2. Brucejack Mine Permit and Non-Permit Groundwater Monitoring Locations

Current PE-107835 Station Identifier[1]		Former PE-107835 Station Identifier[2]	Baseline Monitoring Location	Current Permit-Required Monitoring[3]		Install Date	Easting[4] (m)	Northing[4] (m)	Ground Surface Elevation[4] (m asl)	Top of Casing[4] (m asl)	Sand Pack Interval (m bgs)		Lithological Unit	Well Status
Project ID	EMS ID			GWL	GWQ						Top	Bottom		
BJ-GW11-1A	E303054	MW-BGC11-BJ-3A	Y	C	sQ	02-Oct-11	426,281	6,258,840	1,385.72	1,386.29	77.1	85.3	Office P1	
BJ-GW11-1B	E314692	MW-BGC11-BJ-3B	Y	C	sQ	02-Oct-11	426,280	6,258,841	1,385.72	1,386.39	31.3	38.7	Office P1	
MW-BGC11-BJ-2A	E303055	MW-BGC11-BJ-2A	Y	Decommissioned		03-Oct-11	426,885	6,258,812	1,423.17	1,423.42	64.9	80.3	P2	Decommissioned Jan-16
BJ-GW11-3A[5]	E303056	MW-BGC11-BJ-3A	Y	C	sQ	03-Oct-11	426,615	6,258,844	1,367.63	1,369.19	79.3	88.4	P2	
BJ-GW11-3B	E314693	MW-BGC11-BJ-3B	Y	C	sQ	04-Oct-11	426,615	6,258,844	1,367.53	1,369.76	4.5	9.1	P2	
MW-BGC11-BJ-4A	E303057	MW-BGC11-BJ-4A	Y	Decommissioned		04-Oct-11	427,031	6,258,750	1,390.46	1,390.86	18	31	VSF	Decommissioned Sep-15
MW-BGC12-BJ-4B	E303057	MW-BGC12-BJ-4B	Y	Decommissioned		20-Jun-12	427,031	6,258,752	1,390.43	1,391.00	91.6	98.1	VSF	Decommissioned Sep-15
BJ-GW11-5A	E303058	MW-BGC11-BJ-5A	Y	C	sQ	29-Sep-11	426,347	6,258,040	1,526.14	1,526.69	65.7	78	VSF	Dry as of 2019
BJ-GW11-5B	E314694	MW-BGC11-BJ-5B	Y	C	sQ	30-Sep-11	426,346	6,258,042	1,526.16	1,526.60	39.6	50.9	VSF	Dry as of 2017
BJ-GW12-8A[5]	E303059	MW-BGC12-BJ-8A	Y	C	sQ	18-Jun-12	426,106	6,258,818	1,403.38	1,403.63	86	95.1	Office P1	
BJ-GW12-8B[5]	E314695	MW-BGC12-BJ-8B	Y	C	sQ	19-Jun-12	426,106	6,258,819	1,403.30	1,403.54	44.3	51	Office P1	
BJ-GW12-9A	E303060	MW-BGC12-BJ-9A	Y	C	sQ	04-Aug-12	426,465	6,258,361	1,514.40	1,515.13	70.8	80	Office P1	Dry as of 2019
BJ-GW12-9B	E314696	MW-BGC12-BJ-9B	Y	C	sQ	01-Aug-12	426,461	6,258,362	1,514.56	1,515.23	38.4	47.4	Office P1	
MW-BGC12-BJ-10A	E303061	MW-BGC12-BJ-10A	Y	Decommissioned		22-Jun-12	426,989	6,258,341	1,445.59	1,445.97	51.6	60.1	VSF	Decommissioned Sep-15
MW-BGC12-BJ-10B	E303061	MW-BGC12-BJ-10B	Y	Decommissioned		22-Jun-12	426,989	6,258,341	1,445.64	1,446.36	35.6	41.4	VSF	Decommissioned Sep-15
BJ-GW12-11A	E303062	MW-BGC12-BJ-11A	Y	C	sQ	26-Jun-12	426,300	6,258,595	1,433.57	1,434.18	25.8	29.5	Office P1	
BJ-GW12-11B	E314697	MW-BGC12-BJ-11B	Y	C	sQ	28-Jun-12	426,299	6,258,595	1,432.96	1,433.57	48.2	53.8	Office P1	
BJ-GW12-12A	E303063	MW-BGC12-BJ-12A	Y	C	sQ	08-Aug-12	426,509	6,257,807	1,579.19	1,579.97	84.3	97	Bridge P1	Dry as of 2017
BJ-GW12-12B	E314698	MW-BGC12-BJ-12B	Y	C	sQ	10-Aug-12	426,505	6,257,807	1,579.16	1,579.94	45.2	53.1	Bridge P1	Dry as of 2015
BJ-GW14-13A	E303064	MW-BGC14-BJ-13A		C	NR	09-Sep-14	426,118	6,258,904	1,362.49	1,363.09	20.7	100.9	Office P1	
BJ-GW14-13B	E314699	MW-BGC14-BJ-13B		C	NR	13-Sep-14	426,118	6,258,904	1,362.76	1,363.61	21.2	75.4	Office P1	
BJ-GW14-14A	E303065	MW-BGC14-BJ-14A		C	sQ	11-Sep-14	426,096	6,258,924	1,352.09	1,352.95	14.9	34.9	Office P1	
BJ-GW14-14B	E314700	MW-BGC14-BJ-14B		C	sQ	23-Sep-14	426,099	6,258,925	1,351.99	1,352.91	0.5	4.6	Office P1	
BJ-GW18-17A	E303066	Location A		C	sQ	05-Jun-18	426,771	6,258,761	1,403.87	1,404.22	142.07	148.12	V12/V6b	
BJ-GW18-17B	E314701	Location A		C	sQ	08-Jun-18	426,772	6,258,760	1,403.99	1,404.25	72.1	75.76	Office P1	
BJ-GW18-18A	E303069	Location D		C	sQ	12-Jun-18	426,946	6,258,306	1,445.11	1,445.35	95.53	101.27	Office P1	
BJ-GW18-18B	E314702	Location D		C	sQ	09-Jun-18	426,947	6,258,306	1,445.11	1,445.33	61.54	65.57	Office P1	
BJ-GW18-19A	E303070	Location E		C	sQ	14-Jun-18	426,347	6,258,259	1,496.25	1,495.60	191.78	196.89	Office P1	
BJ-GW18-19B	E314703	Location E		C	sQ	17-Jun-18	426,346	6,258,259	1,495.94	1,495.45	154.92	159.54	Office P1	
BJ-GW18-20A	E303559	Location P4		C	B	17-Jun-18	426,147	6,258,341	1,493.59	1,494.02	159.92	167.53	Office P1	
BJ-GW18-20B	E314704	Location P4		C	B	20-Jun-18	426,148	6,258,342	1,493.60	1,494.07	113.27	118.45	Office P1	
BJ-GW18-21A[6]	E303071	Location F		C	B	24-Jun-18	426,661	6,257,806	1,550.33	1,551.01	193.49	204.83	S4-VSF	
BJ-GW18-21B[6]	E314705	Location F		C	B	29-Jun-18	426,660	6,257,807	1,550.34	1,551.03	152.05	159.45	S4-VSF	
BJ-GW18-22A	E303068	Location C		C	NR	01-Jul-18	426,575	6,258,498	1,444.64	1,444.73	369.58	379	S4-VSF	Destroyed Mar-22
BJ-GW18-22B	E314706	Location C		C	NR	06-Jul-18	426,576	6,258,499	1,444.64	1,444.91	82.99	87.82	S3-Poly	
BJ-GW18-23A	E314690	Location G		C	sQ	01-Jul-18	427,091	6,258,751	1,370.84	1,370.92	25.32	29.7	S4-VSF	
BJ-GW18-23B	E314691	Location G		C	sQ	02-Jul-18	427,091	6,258,752	1,370.81	1,370.94	7.61	11.3	S4-VSF	
BJ-GW11-6A*	n/a	n/a		C*	None	04-Oct-11	427,095	6,258,983	1,379.81	1,380.81	20.7	31.8	VSF	
BJ-GW12-6B*	n/a	n/a		C*	None	16-Jun-12	427,097	6,258,982	1,379.56	1,380.23	98.2	103.8	VSF	
BJ-GW16-5A*	n/a	n/a		C*	sQ*	11-Jul-16	427,011	6,258840	1,372.63	1,373.52	18.65	22.37	V12	
BJ-GW16-5B*	n/a	n/a		C*	sQ*	12-Jul-16	427,014	6,258,838	1,372.55	1,373.35	8.5	10.5	V12	

Notes:
n/a = not applicable, *station monitored outside of PE-107835 requirements
Per December 14, 2018 version of PE-107835
Per August 31, 2015 version of PE-107835
GWL = groundwater level, GWQ = groundwater quality, C = continuously recorded (logger); sQ = shifted quarter, B = biannual, NR = not required
Monitoring well ground surface coordinates and top of casing determined by RTK GPS, horizontal datum UTM Zone 9N NAD 83, Project vertical datum.
Top of casing elevations modified from original survey to accommodate Snap Sampler installation.
Top of casing elevation modified from original survey to add 0.6 m casing extension.

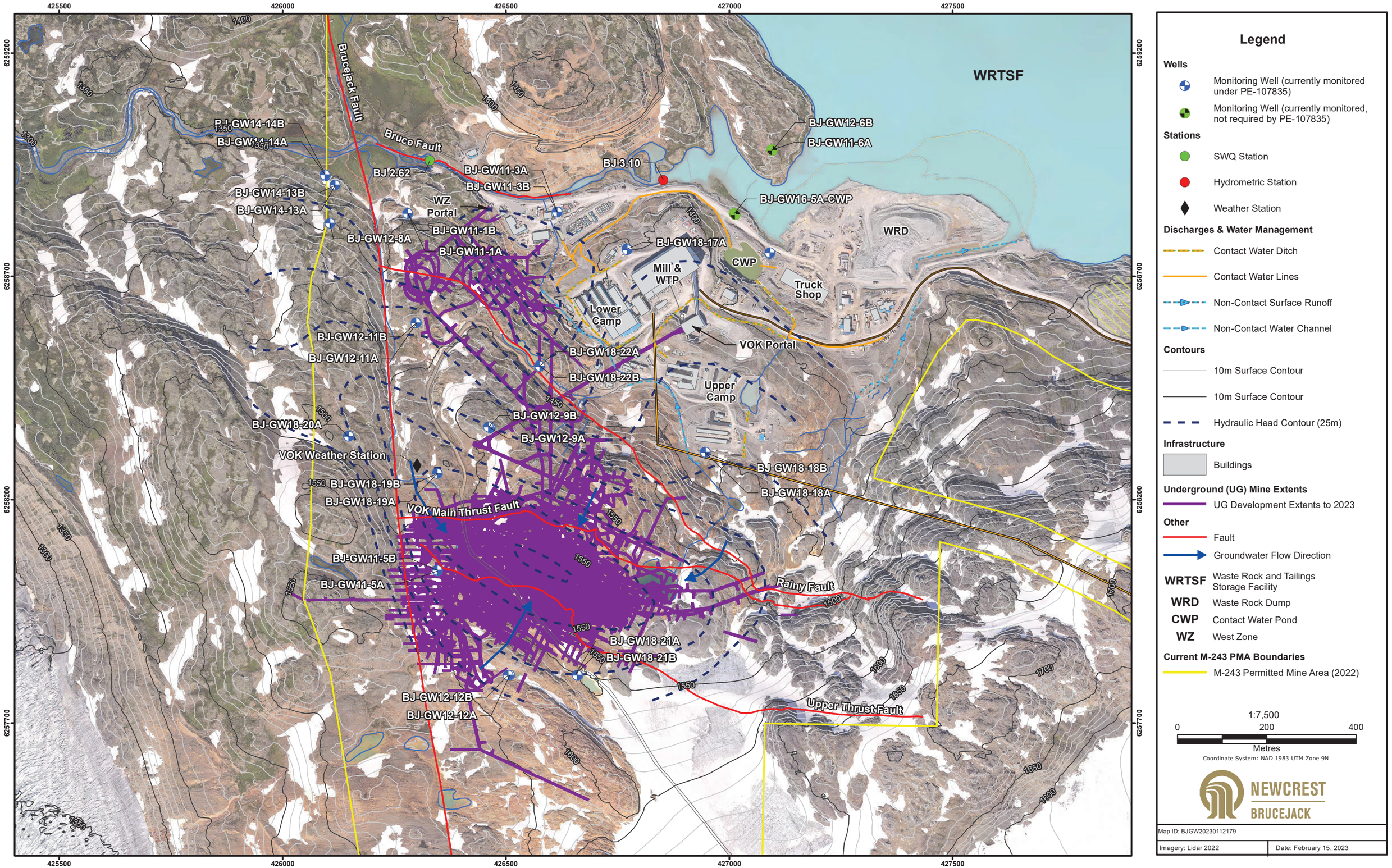


Figure 2.6-6. Groundwater Well Locations

2.7 Water Quality

2.7.1 Surface Water Quality

A summary of surface water quality for the period 2014 to 2021 is provided below. Additional details of surface water quality information for the baseline period (i.e., prior to mine construction beginning in late 2015) and for the 2015 through 2021 period are provided as follows:

- Baseline surface water quality: Appendix 13-A of the 2014 EAC/EIS Application (Pretium 2014).
- 2015 through 2021 surface water quality data and information: MA/EMA Annual Report (Pretium 2016; 2017; 2018a; 2019; 2020a; 2021a and 2022a).

The Brucejack Mine surface water quality monitoring program is designed to generate data that will allow for the evaluation of mine-related effects on the aquatic receiving environment. This monitoring program is described in greater detail in Section 7.2.4. A summary of the sampling stations is provided below and a map of these stations is provided as Figure 2.7-1 and Figure 2.7-2.

Brucejack Mine site water quality monitoring stations required under PE-107835 (Appendix 1-1) are as follows:

- BJ 3.10 [Environmental Management System (EMS) # E298312] is located at the WRTSF outlet (56.4696, 130.1878, Figure 2.7-3) and is the final (most downstream) mine effluent discharge location;
- CC 0.87 (EMS # E298331) is located in Camp Creek 0.87 km upstream of the confluence with Brucejack Creek (56.4636, 130.1852, Figure 2.7-4);
- CC 0.01 (EMS # E298334) is located at the mouth of Camp Creek (56.4686, 130.1914, Figure 2.7-5);
- Mine Water Influent at WTP (EMS # E303052) is located in the WTP prior to treatment;
- CWP Influent at WTP (EMS # E303053) is located in the WTP prior to treatment;
- WTP Effluent (EMS # E302957) is located in the WTP after treatment and prior to WRTSF discharge;
- Tailings Supernatant (EMS # E302910) is located after thickening prior to outfall;
- Treated Domestic Effluent (EMS # E302911) is located after treatment prior to outfall; and
- CWP Direct Discharge to WRTSF (EMS # E306114) is located in the CWP or direct discharge line.

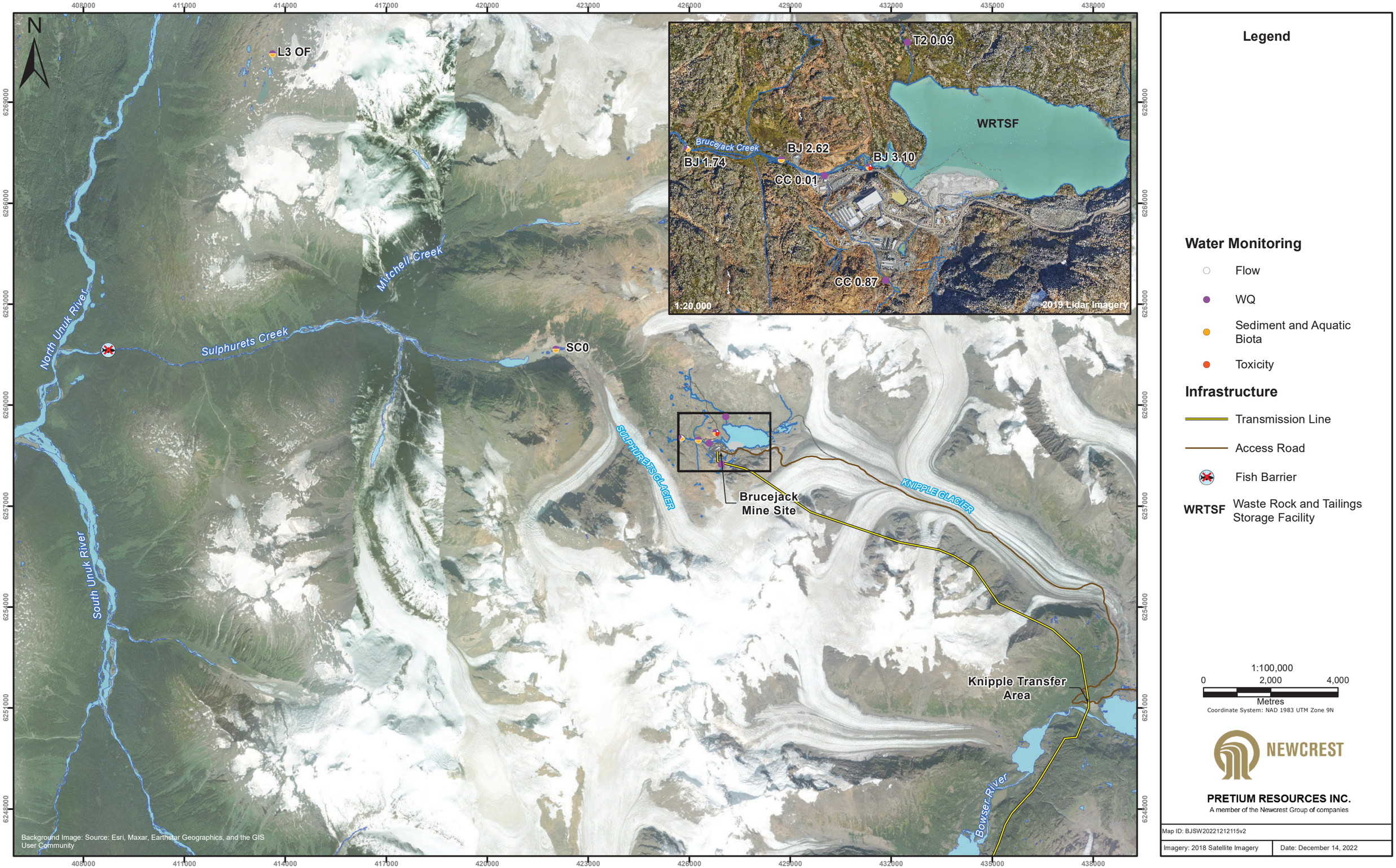


Figure 2.7-1. Brucejack Mine Water Monitoring Sites and Aquatic Receiving Environment

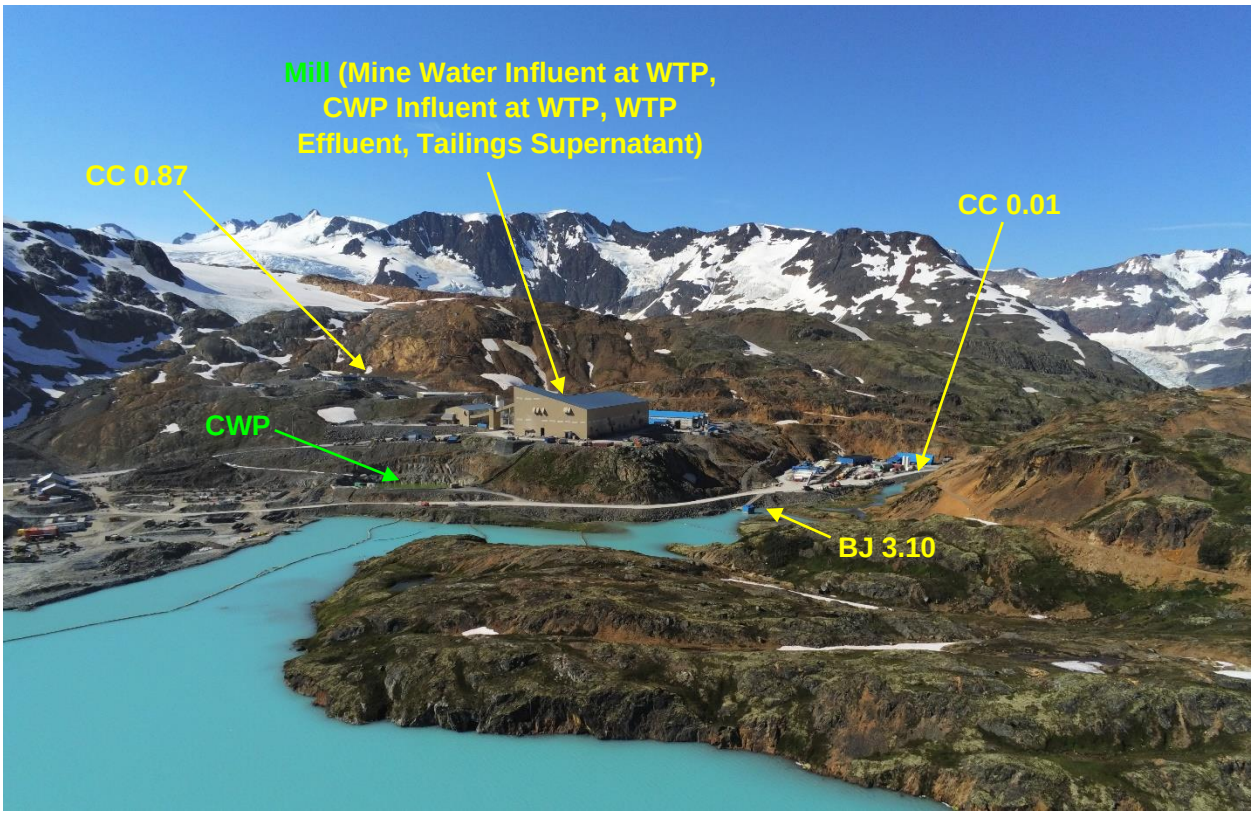


Figure 2.7-2. Mine site locations for surface water quality monitoring.

Figure 2.7-3. BJ 3.10 (Low Level Weir, WRTSF discharge) looking upstream (September 2022).

Figure 2.7-4. CC 0.87 looking upstream (August 2018).

Figure 2.7-5. CC 0.01 looking upstream at mouth of Camp Creek (August 2022).

Aquatic receiving environment monitoring stations and the reference monitoring site required under PE-107835 and the Aquatic Effects Monitoring Plan (Appendix 9-1-4X) are as follows (Figure 2.7-6 and Figure 2.7-7):

- *BJ 2.62 (EMS # E298332) is located in Brucejack Creek upstream of VOK Creek and downstream of Camp Creek (56.4697, 130.1978, Figure 2.7-8);*
- *BJ 1.74 (EMS # E298333) is located in Brucejack Creek downstream of VOK Creek (56.4699, 130.2048, Figure 2.7-9);*
- *SC0 (EMS # E303050) is located in Sulphurets Creek approximately 3 km downstream of the sub-glacial confluence of Brucejack Creek with Sulphurets Creek, and approximately 6.5 km downstream of the WRTSF (56.4929, 130.2662, Figure 2.7-10);*
- *L3 OF (EMS # E303051) is located at a reference creek approximately 20 km northwest of the mine site at the outflow of L3 Lake (56.5703, 130.2662, Figure 2.7-11);*
- *T2 0.09 (AEMP monitoring station only) is located in Catear Creek which is a northern tributary to the WRTSF (56.4742, 130.1833, Figure 2.7-12); and*
- *KG 0.4 (AEMP monitoring station only) is located in the creek flowing from Knipple Glacier, upstream of the bridge (BJAR) (56.4038, 129.9826, Figure 2.7-13).*

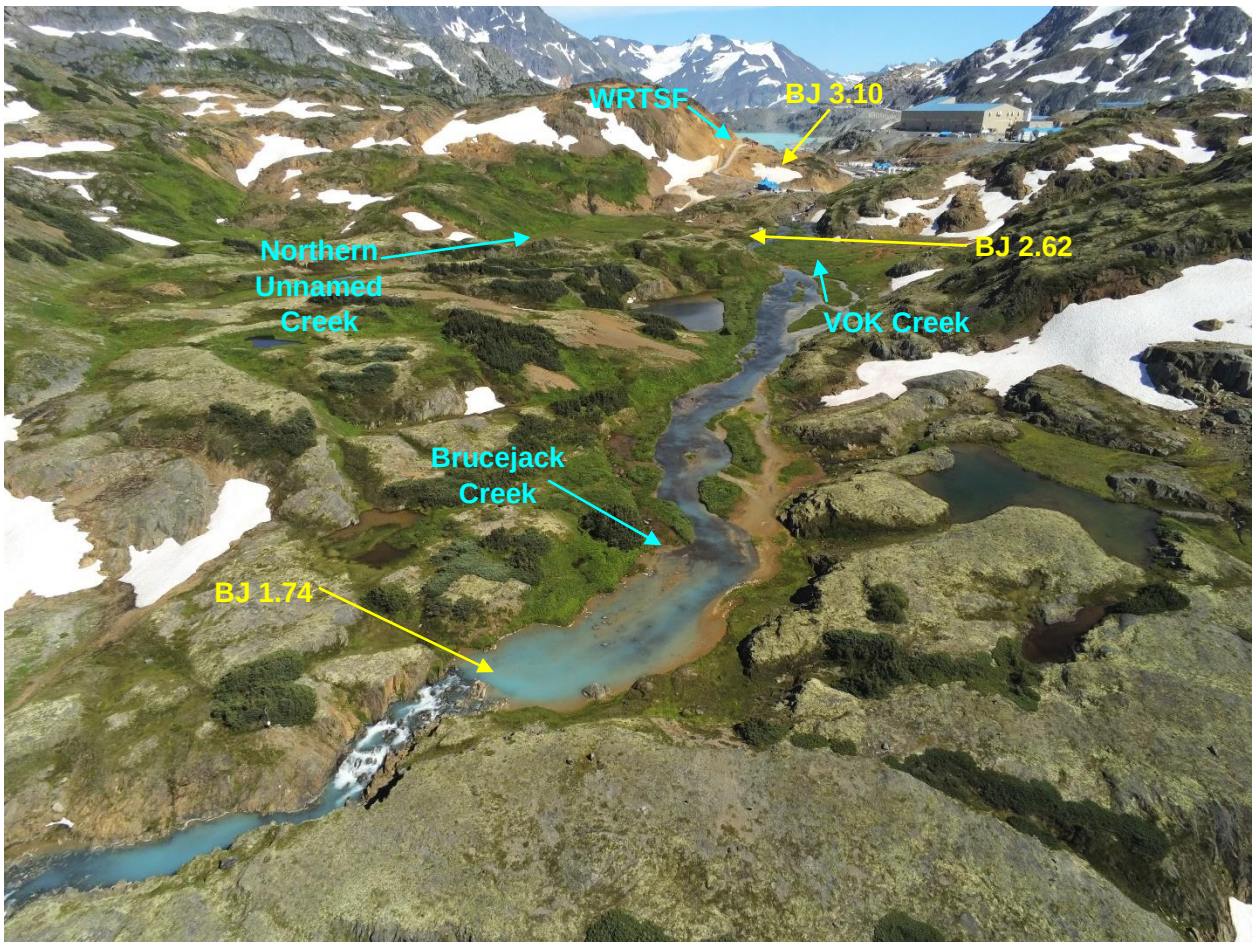


Figure 2.7-6. Aquatic receiving environment surface water quality monitoring locations (BJ 2.62 and BJ 1.74).

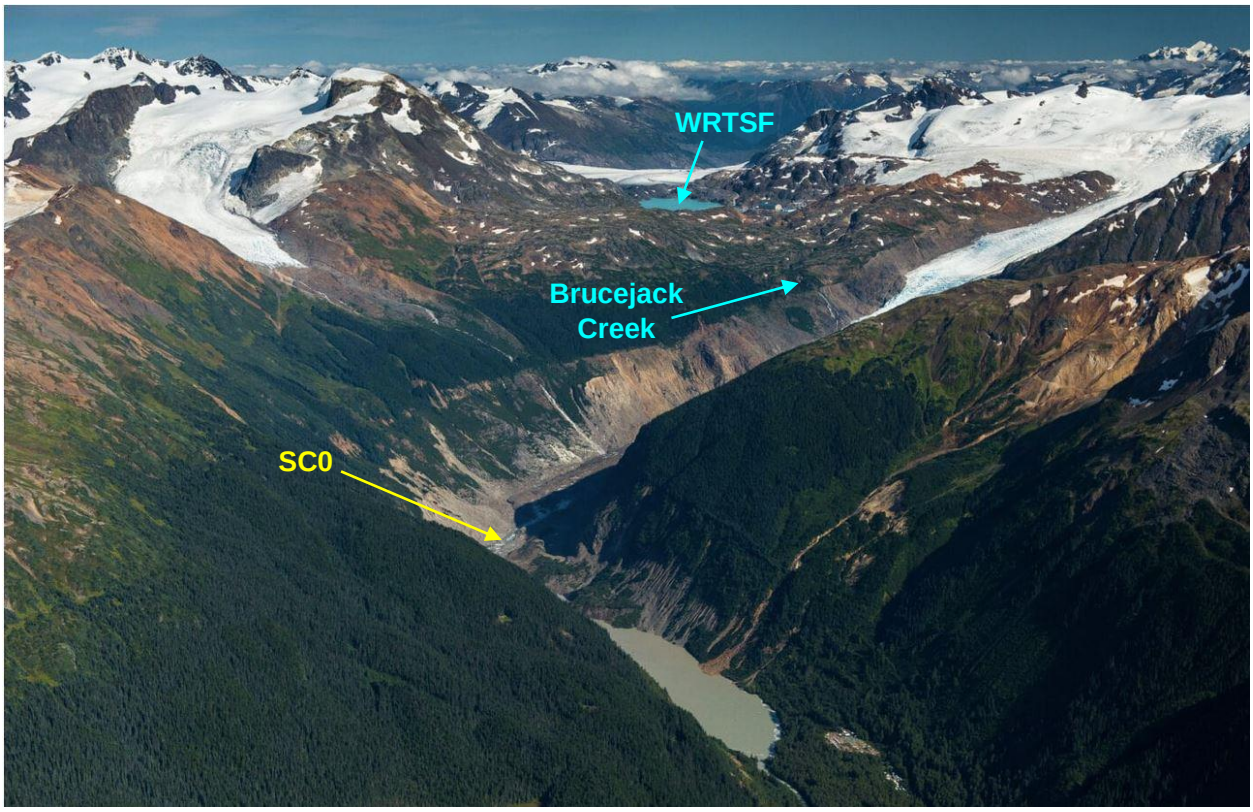


Figure 2.7-7. Aquatic receiving environment surface water quality monitoring locations (SC0).

Figure 2.7-8. BJ 2.62 looking upstream (October 2022).

Figure 2.7-9. BJ 1.74 looking upstream (October 2022).

Figure 2.7-10. SC0 looking upstream (June 2018).

Figure 2.7-11. L3 OF looking upstream (September 2022).

Figure 2.7-12. T2 0.09 looking downstream (September 2022).

Figure 2.7-13. KG 0.4 looking upstream (June 2022).

Surface water quality is monitored at the Brucejack Mine as required by Condition 4 and Appendix A of PE-107835 (Appendix 1-1), and in accordance with applicable Brucejack Mine management plans, including the Aquatic Effects Monitoring Plan (Appendix 9-1-4), ML/ARD Management Plan (Appendix 9-1-11), Chromium Management Plan (Appendix 9-2-1), and Nitrogen Management Plan (Appendix 9-2-6). Mine surface water quality monitoring is also a requirement of Condition D.4(d) of *Mines Act* Permit M-234 (Appendix 1-1).

BJ 3.10 is sampled weekly according to Condition 4 and Appendix A of PE-107835. Monitoring results are compared to discharge limits for BJ 3.10 specified in PE-107835 or BC Water Quality Guidelines (WQG) for the protection of freshwater aquatic life (FWAL) for parameters without discharge limits. Observed concentrations are evaluated using the trigger response plan presented in Section 5.9.

Monitoring of water quality in Brucejack Creek as presented in the *MA/EMA* Annual Reports has indicated mine related increases to concentrations of several parameters including hardness (Figure 2.7-14), nitrate (Figure 2.7-15), sulfate (Figure 2.7-16), antimony (Figure 2.7-17), and arsenic (Figure 2.7-18). BJ 3.10 water quality has been below current PE-107835 discharge limits during the 2015 through 2022 monitoring period except for short-duration TSS exceedances in October 2015 and in July 2022. The observed changes in water quality in Brucejack Creek are in line with the results of water quality modelling presented in the 3800 tpd Amendment Application for Permits M-243 and PE-107835 (Pretium 2022a). Refer to Section 5.5 and Appendix 5-3 for the updated water quality model that accounts for the increased ore production rate.

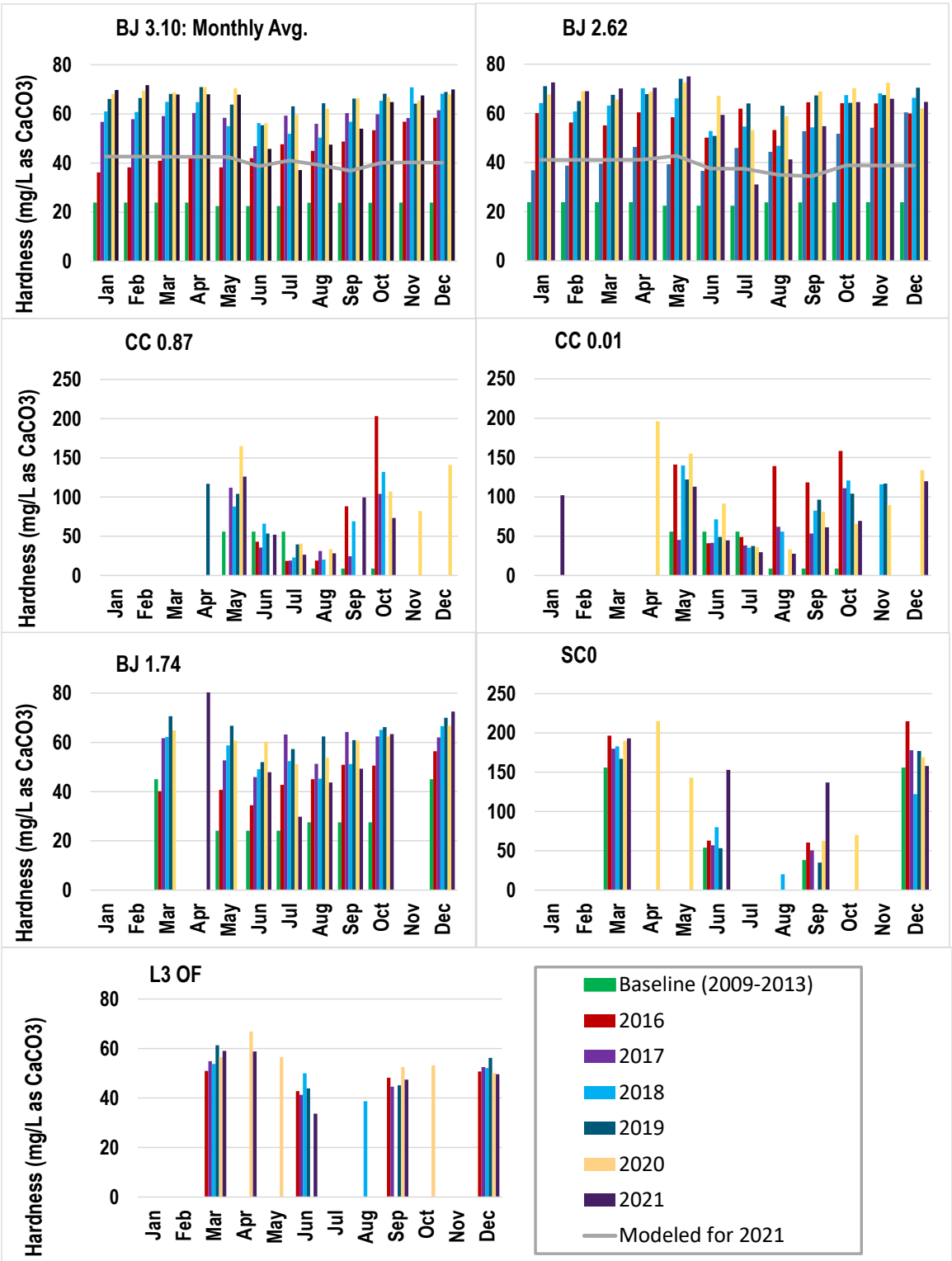


Figure 2.7-14. Total hardness measured in 2016-2021 compared to baseline.

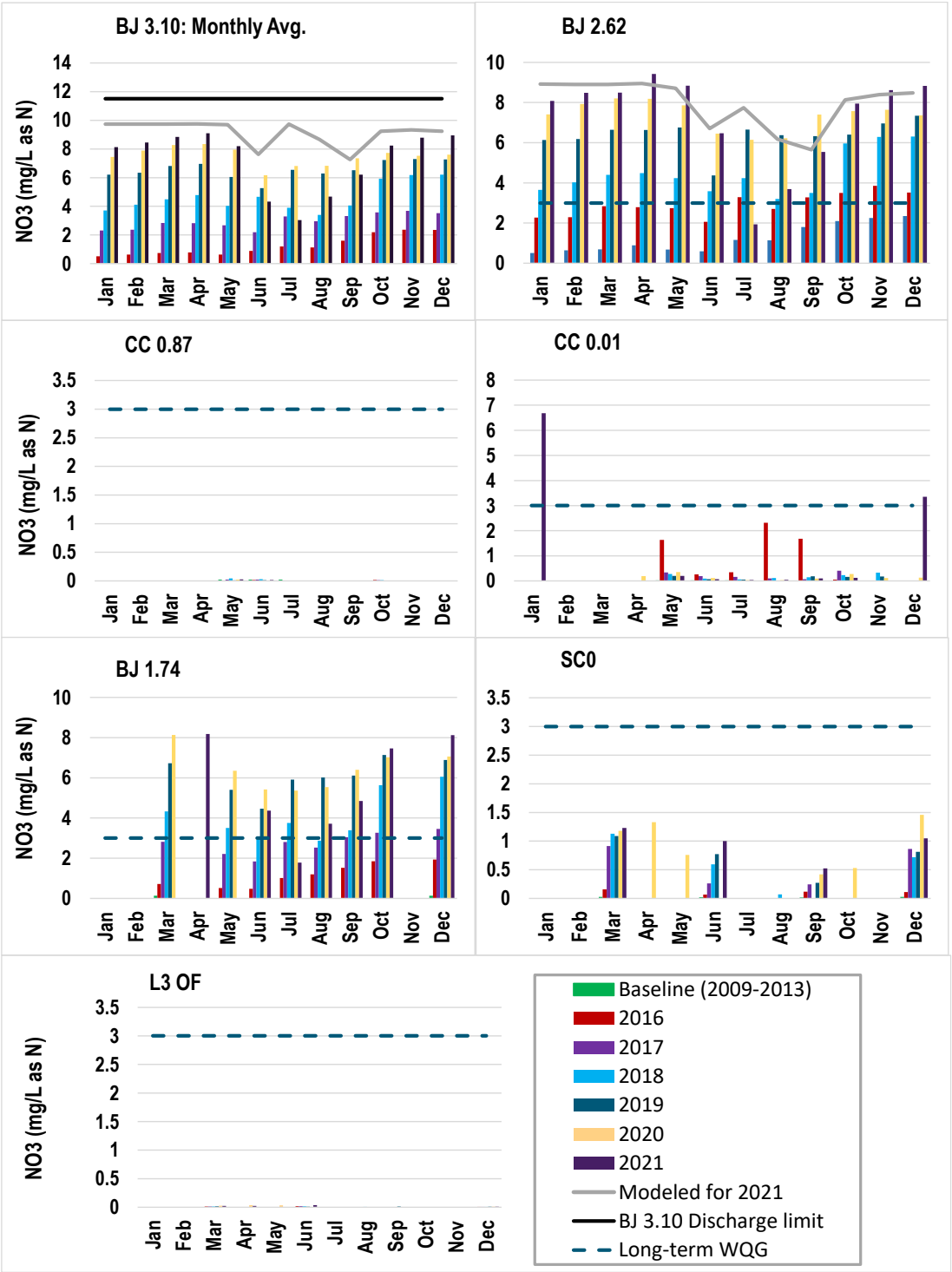


Figure 2.7-15. Nitrate (NO_3) measured in 2016-2021 compared to baseline.

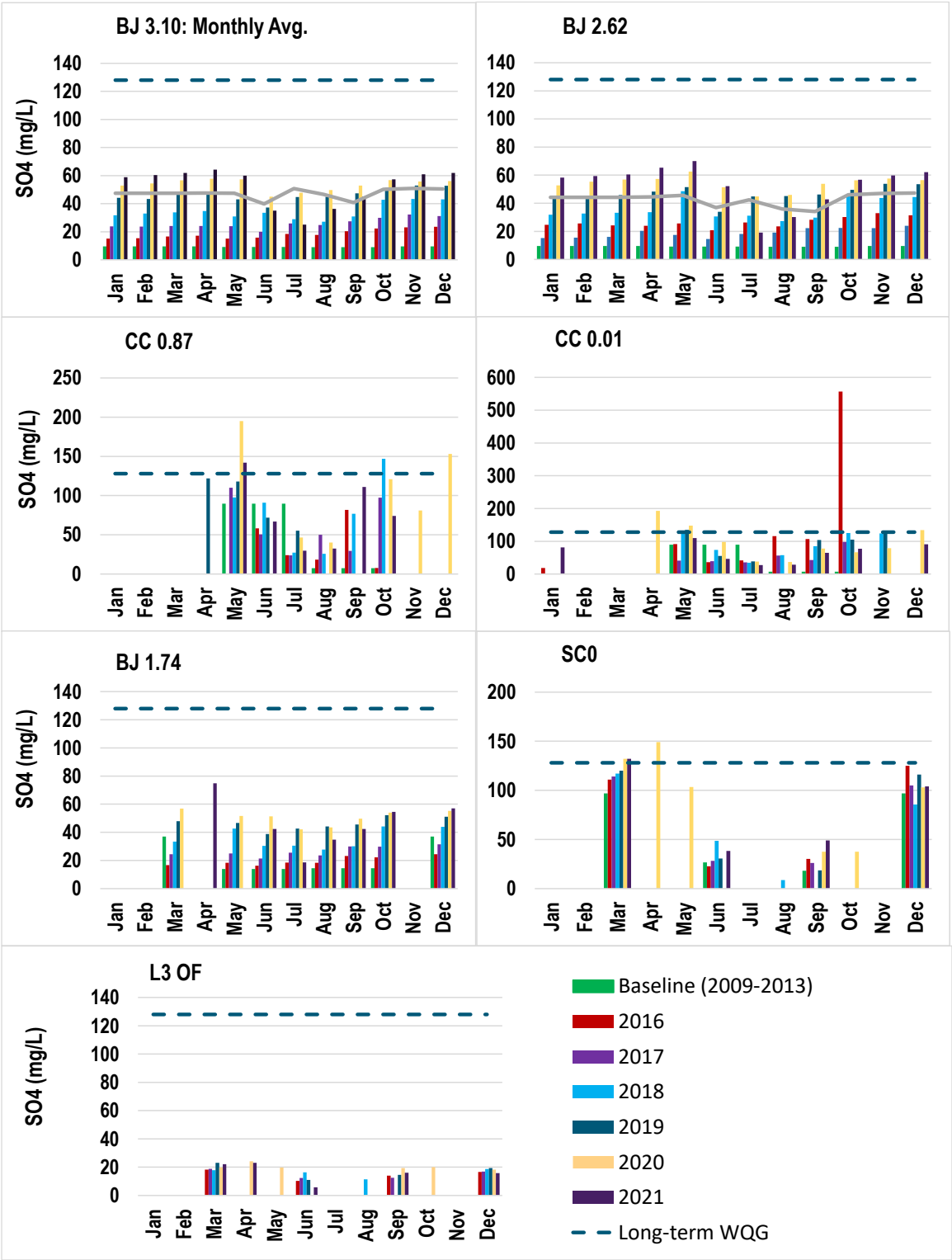


Figure 2.7-16. Sulfate (SO_4) measured in 2016-2021 compared to baseline.

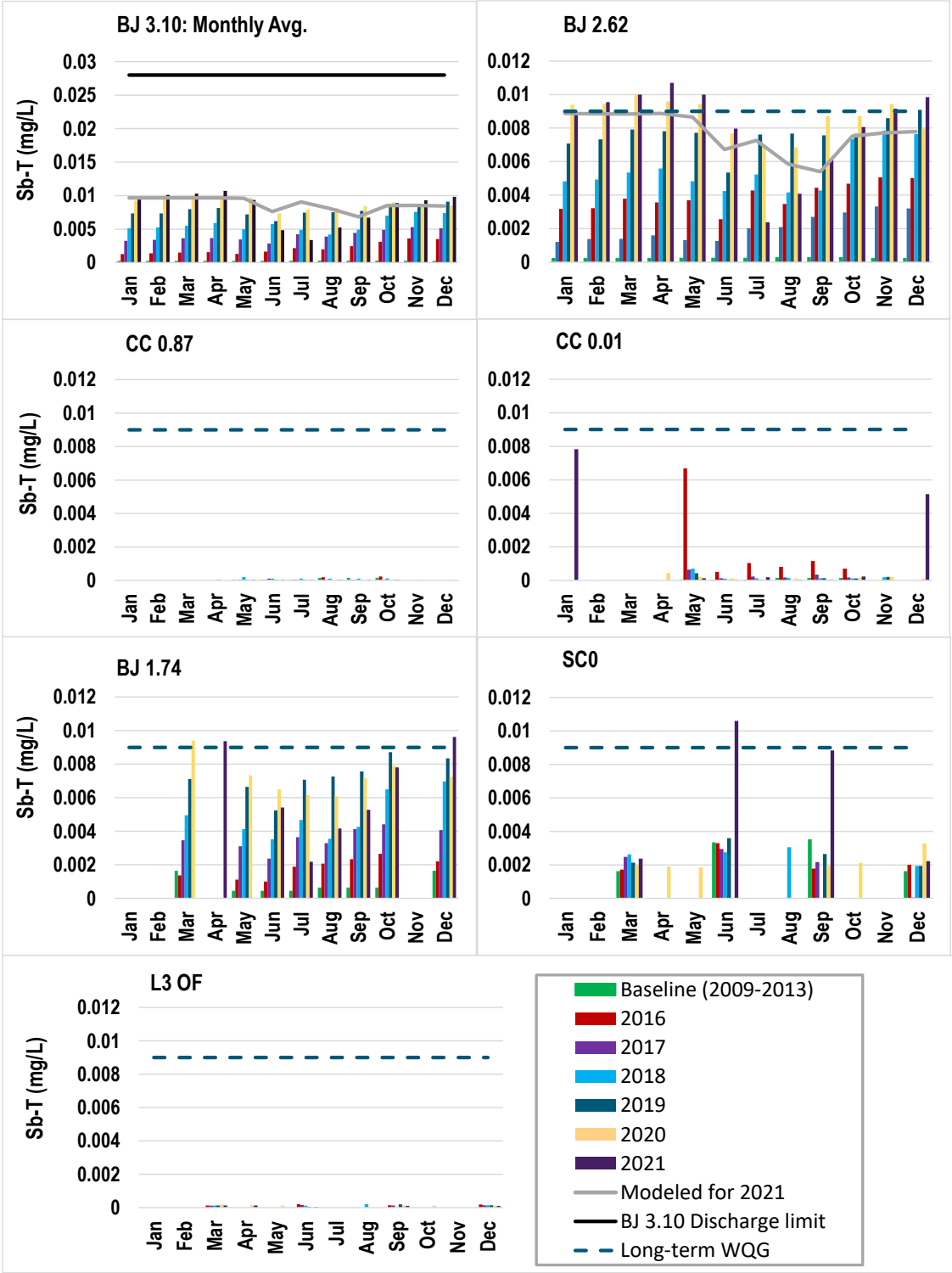


Figure 2.7-17. Total antimony (Sb-T) measured in 2016-2021 compared to baseline.

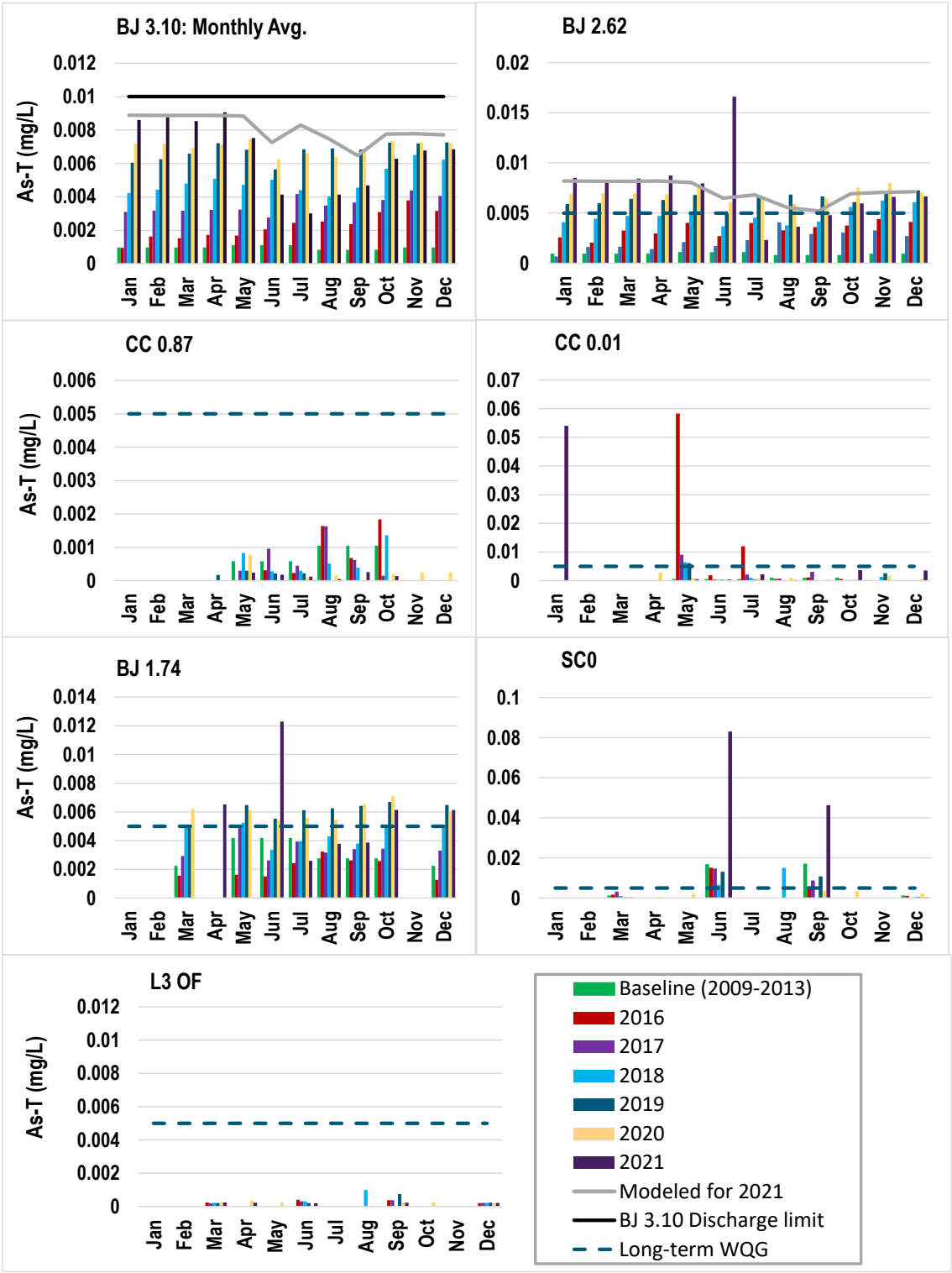


Figure 2.7-18. Total arsenic (As-T) measured in 2016-2021 compared to baseline.

2.7.1.1 Toxicity Testing

A summary of toxicity testing for the period 2014 to 2021 is provided below. Additional details of toxicity testing information for the baseline period (i.e., prior to mine construction beginning in late 2015) and for the 2015 through 2021 period are provided as follows:

- Baseline toxicity testing data: Appendix 14-A of the 2014 EAC/EIS Application (Pretium 2014).
- 2015 through 2021 toxicity testing data and information: *MA/EMA* Annual Report (Pretium 2016; 2017; 2018a; 2019; 2020a; 2021a and 2022a).
- Additional information on the toxicity testing monitoring program: Section 7.2.6.

Toxicity testing has and continues to be conducted as per PE-107835 and Metal and Diamond Mining Effluent Regulations (MDMER) requirements. PE-107835 currently requires that undiluted BJ 3.10 water not fail an acute lethality test using *Daphnia magna*, and not fail a growth inhibition test using a freshwater alga. PE-107835 also requires testing of survival and growth of the freshwater midge *Chironomus dilutus* in undiluted BJ 3.10 water, the results of which are interpreted in the annual reports but are not used for determining compliance with the permit. Toxicity testing of BJ 3.10 for PE-107385 is required quarterly. MDMER toxicity testing requirements have varied since Brucejack Mine became subject to MDMER on January 12, 2016. Currently, MDMER requires that undiluted BJ 3.10 be tested quarterly using the *Daphnia magna* acute lethality test, the rainbow trout acute lethality test, and the *Ceriodaphnia dubia* survival and reproduction test.

BJ 3.10 water has not failed any of the rainbow trout acute lethality tests conducted since testing for MDMER started in 2016. BJ 3.10 water has failed a Daphnia magna acute lethality test only once since testing began in 2015. During the construction phase, when toxicity testing was required monthly by PE-107835, a BJ 3.10 sample collected on December 20, 2015 failed the *D. magna* test. An investigation of cause was conducted but the investigation did not determine the cause. All subsequent *D. magna* tests have passed. BJ 3.10 water has passed all of the sublethal tests of growth using the freshwater alga *Pseudokirchneriella subcapitata* since testing of this species for PE-107835 began in 2016.

PE-107835 was amended in 2016 to remove the requirement for sublethal testing of BJ 3.10 water using *Ceriodaphnia dubia* and add the requirement to test BJ 3.10 water using the freshwater algal growth test. The algal growth test was added because arsenic had been identified as a parameter of potential concern, and algae are known to be sensitive to arsenic toxicity. The *C. dubia* test was removed because baseline testing, prior to the start of mine construction, found that BJ 3.10 water caused inhibition of reproduction in this species. Since *C. dubia* tests failed prior to mine construction, they could not be used to reliably indicate mine-related negative effects to water quality. While the requirement for *C. dubia* testing was removed from PE-107835, MDMER still required that *C. dubia* tests be conducted twice per year. Four of the six *C. dubia* tests conducted for MDMER between 2016 and 2018 had an inhibition of reproduction. In 2019, MDMER required the frequency of *C. dubia* testing to be changed to quarterly. There hasn't been an inhibition of *C. dubia* reproduction in any of the tests conducted after 2018. The cause of the change from BJ 3.10 water causing chronic toxicity to *C. dubia* during baseline and the early years of mine operation to not causing chronic toxicity after 2018 is uncertain but may be related to changes to BJ 3.10 water quality over time. For example, hardness of BJ 3.10 water increased in the first few years of operation (Figure 2.7-14) from well below the hardness recommended for culturing *C. dubia* (80-100 mg/L as $CaCO_3$; (Environment Canada 2007b)) to moderately below the recommended hardness.

Testing of survival and growth of the freshwater midge *Chironomus dilutus* in BJ 3.10 water began in February 2019 and is required quarterly. The purpose of the *Chironumus* tests are to identify long-term trends in toxicity. Statistical significance is determined relative to survival and growth in laboratory culture water. There was no statistically significant difference between survival in BJ 3.10 and laboratory water from in tests conducted from 2019 through 2021. Growth was statistically lower in BJ 3.10 water than in laboratory control water in February 2019 and in three of the four tests in 2021, while growth in other tests in 2019 and 2020 was not significantly different. While the more recent tests have had statistically significant differences, there has not been a noticeable long-term trend of increasing difference in biomass between individuals growing in laboratory control water and BJ 3.10 water (Pretium 2022a).

2.7.2 Groundwater Quality

Baseline groundwater quality is summarized in Section 7 of BGC (2014b) which comprised Appendix 9-A of the 2014 EAC/EIS Application (Pretium 2014) and is included as Appendix 2-3 to this Application. Groundwater samples are analyzed for physical parameters, anions and nutrients, and total and dissolved metals in accordance with PE-107835 requirements. Groundwater quality data presented in BGC (2014b) span 2011 through 2013. Data collected since the beginning of mine construction in late have been summarized in stand-alone groundwater monitoring reports appended to and summarized within the *MA/EMA* Annual Reports. Recent groundwater quality is summarized in Section 5 of the 2021 groundwater monitoring report (Appendix 2-4).

All Brucejack monitoring wells screen groundwater that is neutral to slightly alkaline (pH 7 to 8.5). Brucejack groundwater quality appears largely unimpacted by mining operations except for subtle shifts in major ion chemistry in wells dewatered by VOK development and isolated influences of surface infrastructure on shallower wells (such as seepage from the CWP). This is expected since groundwater flowpaths are largely towards the mine. There are limited instances where dissolved trace metals are measured above their background levels. Selected dissolved metals, such as arsenic appear to be naturally elevated in the groundwater system and are spatially variable across the site.

2.8 Sediment Quality

Baseline sediment quality are summarized in Section 14 of the 2014 EAC/EIS Application (Pretium 2014). Baseline sediment quality data span 2008 through 2013. Data collected in 2015 and 2016 are summarized in the 2015 and 2016 *MA/EMA* Annual Reports (Pretium 2016, 2017), and data collected each year starting in 2017 are summarized in stand-alone aquatics resources monitoring reports (ERM 2018a; 2018b; 2020; 2021; 2022) appended to and summarized within the *MA/EMA* Annual Reports (Pretium 2018a; 2019; 2020a; 2021a; 2022a).

PE-107835 requires sediment quality sampling annually at BJ 3.10 and BJ 2.62 during fall low flow conditions, and every three years at BJ 1.74, SC0, and L3 OF. Sediment samples are analyzed for particle size distribution, total organic carbon, pH, and metals in the <63 µm fraction.

Particle size distribution of sediment collected from Brucejack Creek sites varies from year to year and has not had a noticeable trend from baseline through 2021 (Figure 2.8-1). Particle size distribution at all sites was predominantly sand. Brucejack Creek sites had higher proportion of clay than SC0 in upper Sulphurets Creek or at reference site L3 OF. Particulate organic carbon content of sediment samples was low (<1%) at all sites and years sampled.

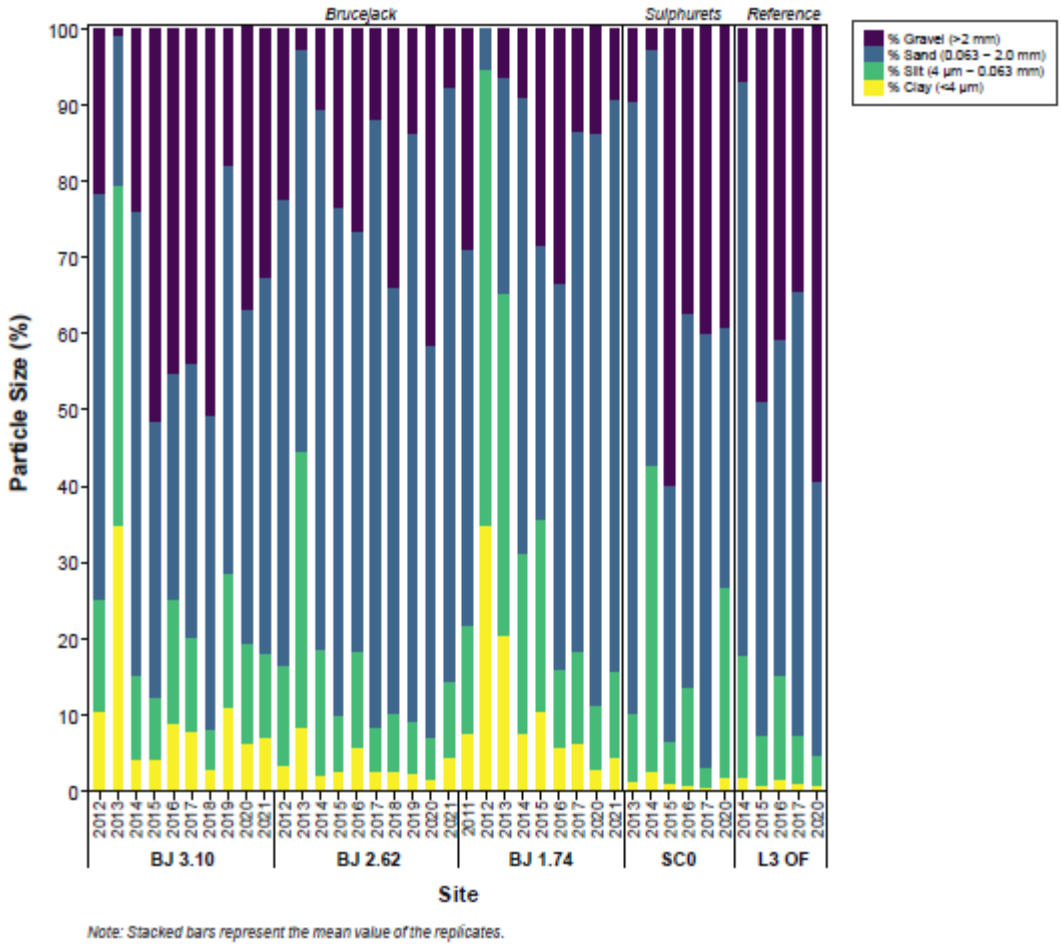


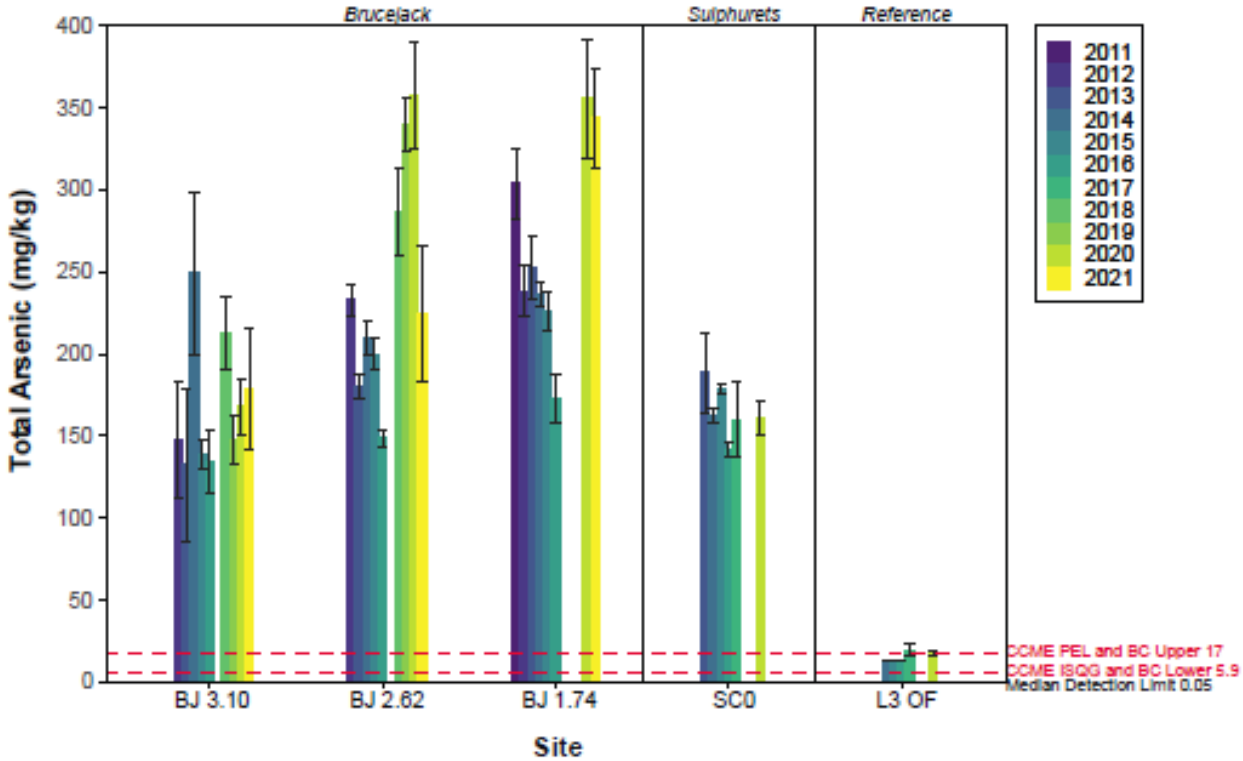
Figure 2.8-1. Sediment particle size distribution at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-1 of ERM (2022)).

British Columbia has working sediment quality guidelines (WSQGs) for several metals. These guidelines are defined as:

- Lower WSQG – a concentration that will protect aquatic life from adverse effects of toxic substance in most situations. Equal to the CCME interim sediment quality guideline for many metals.
- Upper WSQG – a concentration that if exceeded will likely cause severe effects to aquatic life. Equal to the CCME probable effects level for many metals.

Several metals have consistently had higher concentrations in sediment samples collected from lower Brucejack Creek (BJ 2.62 and BJ 1.74) than upper Brucejack Creek (BJ 3.10). BJ 2.62 is downstream of Camp Creek, and BJ 1.74 is downstream VOK Creek, both of which are seasonally acidic tributaries traversing the gossan to the south and east of Brucejack Creek, and do not receive mine contact water. The higher downstream concentrations of arsenic (Figure 2.8-2), cadmium (Figure 2.8-3), copper (Figure 2.8-4), lead (Figure 2.8-5), selenium (Figure 2.8-6), silver (Figure 2.8-7), and zinc (Figure 2.8-8) may reflect inputs from these seasonally acid streams. Mercury (Figure 2.8-9) is an

exception to the trend of increasing concentration with distance downstream in Brucejack Creek. Mercury concentrations at BJ 3.10 have consistently been greater than the Upper WSQG while concentrations at BJ 2.62 and BJ 1.74 have been between the lower and upper WSQGs. Mercury concentration at BJ 3.10 has not increased over time; therefore, it is unlikely that the higher concentrations measured at BJ 3.10 are related to mine inputs. Other metals have a similar pattern as mercury of being enriched in Brucejack Creek samples relative to the lower WSQG but not having a marked change in concentration after mine construction began in 2015 compared to baseline (Figure 2.8-2 through Figure 2.8-8).



Notes: Error bars represent the standard error of the mean.
Values below the detection limit were plotted as half the detection limit.
CCME sediment quality guideline: PEL = probable effect level; ISQG = interim sediment quality guideline.
Metals in 2017 were mistakenly analyzed on the <2 mm size fraction for BJ 3.10, BJ 2.62, and BJ 1.74. Results have been excluded from the graphs.

Figure 2.8-2. Arsenic concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-3 of ERM (2022)).

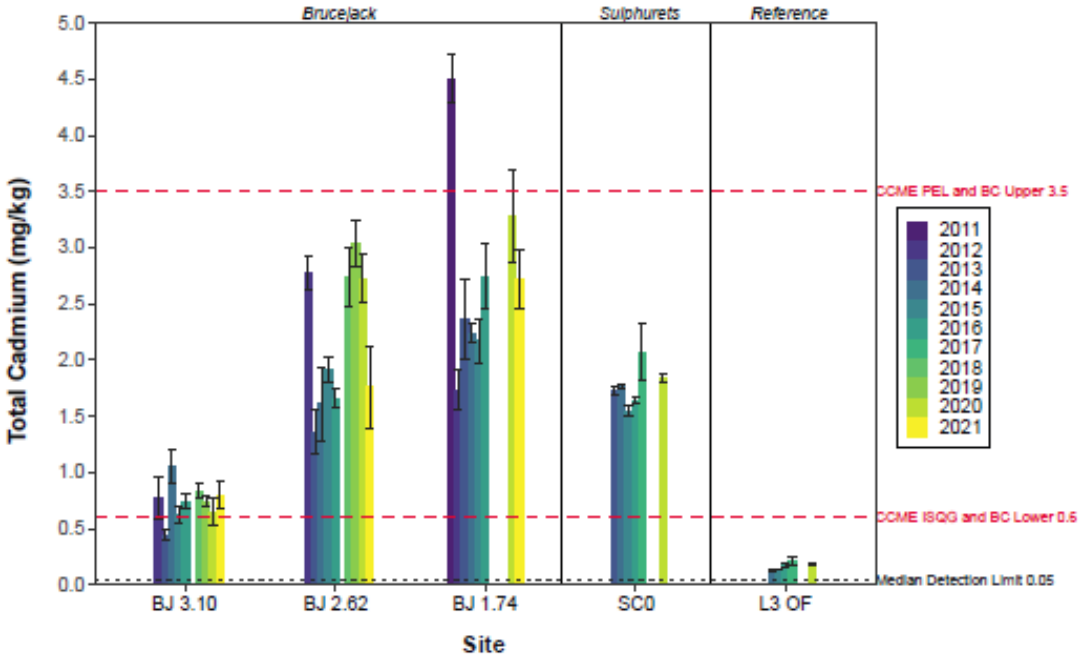


Figure 2.8-3. Cadmium concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-3 of ERM (2022)).

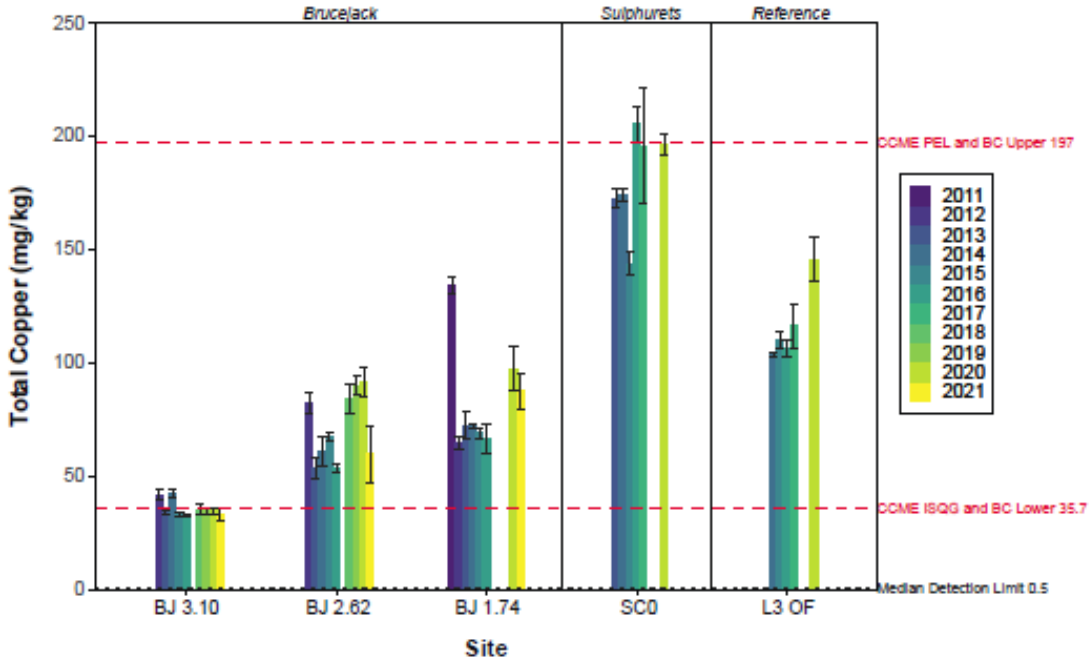


Figure 2.8-4. Copper concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-4 of ERM (2022)).

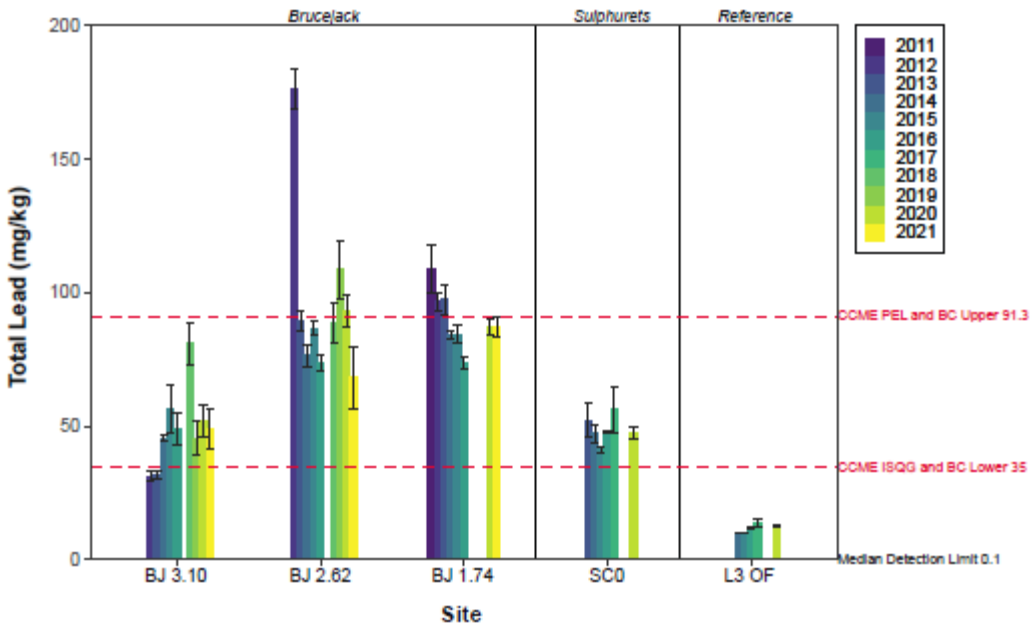


Figure 2.8-5. Lead concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-5 of ERM (2022)).

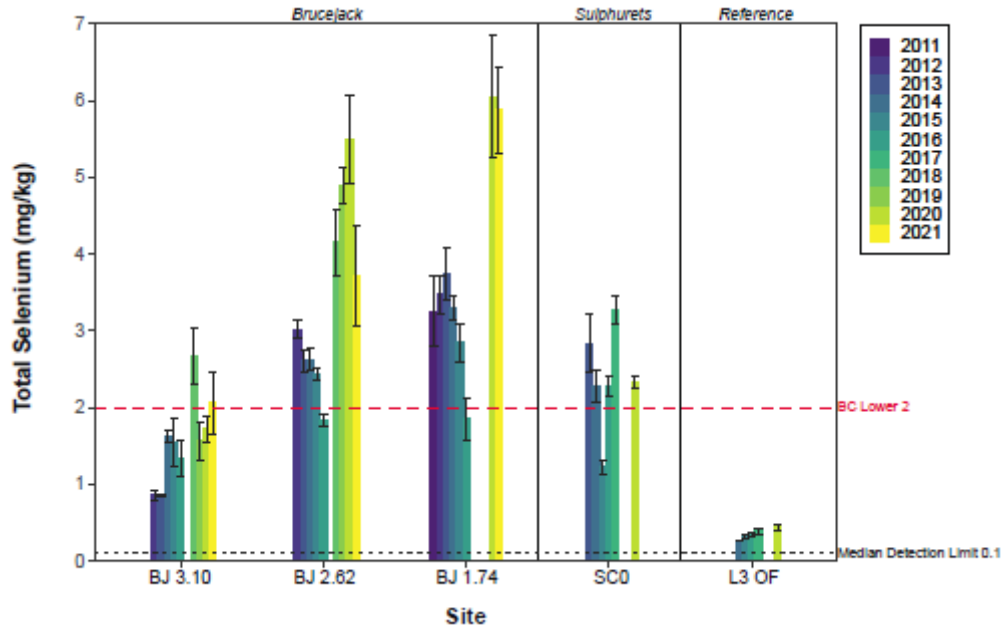


Figure 2.8-6. Selenim concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-7 of ERM (2022)).

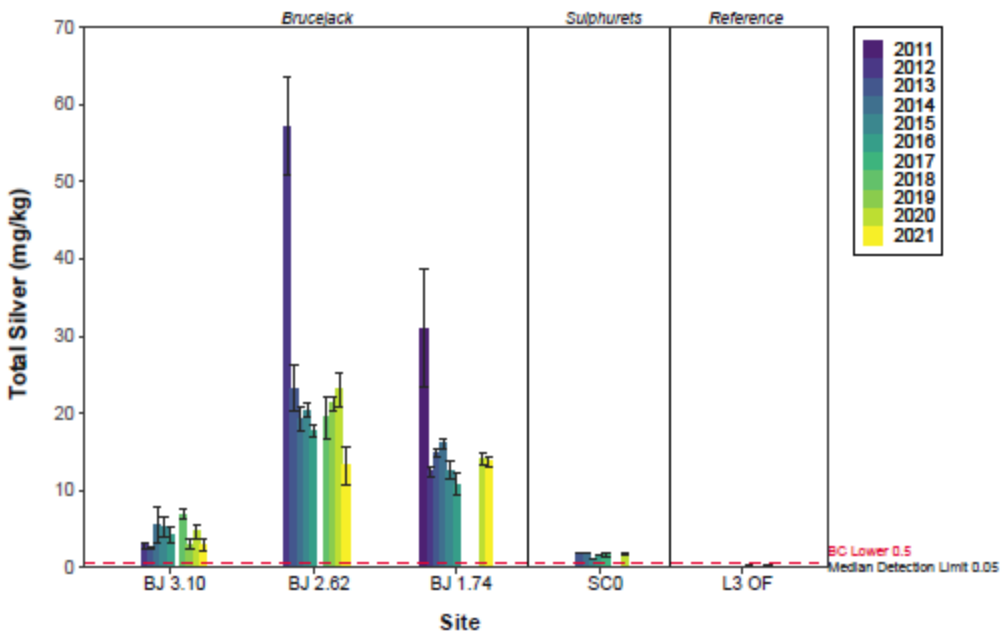


Figure 2.8-7. Silver concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-8 of ERM (2022)).

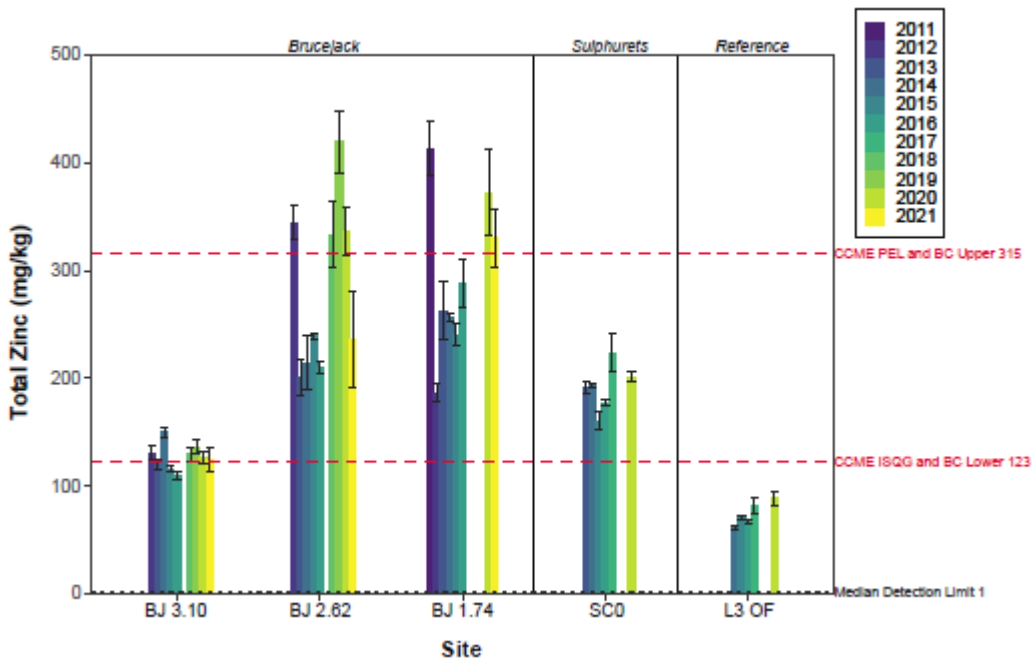


Figure 2.8-8. Zinc concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-8 of ERM (2022)).

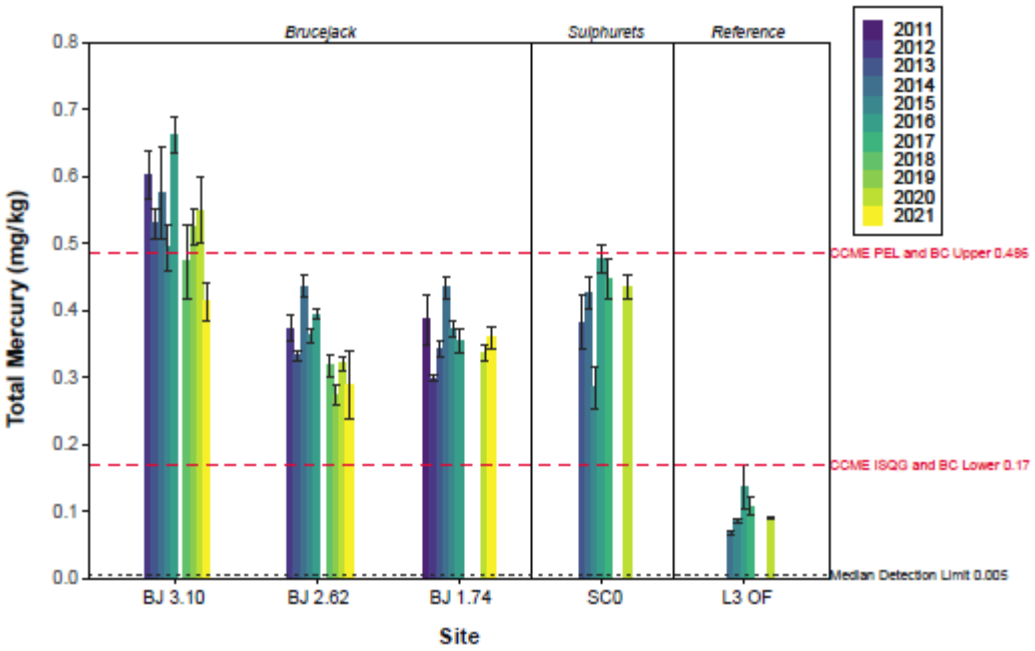


Figure 2.8-9. Mercury concentration in the <63 µm fraction of sediment samples collected at sites in Brucejack Creek, Sulphurets Creek, and reference site L3 OF since 2011 (Figure 5.2-6 of ERM (2022)).

2.9 Fisheries and Aquatic Resources

2.9.1 Periphyton and Benthic Invertebrate Community Measures

PE-107835 requires periphyton and benthic invertebrate monitoring annually at BJ 3.10, BJ 2.62 and BJ 1.74, and every three years at SC0 and L3 OF. Periphyton and benthic invertebrates are sampled in August annually, during low flow conditions. Periphyton biomass and taxonomy are measured as indicators of periphyton community characteristics at each station. Benthic invertebrates are sampled using a kick net following the Canadian Aquatic Biomonitoring Network (CABIN) protocol by CABIN-certified field personnel. Benthic invertebrate community characteristics are compared to reference station characteristics.

All periphyton biomass samples collected from Brucejack Creek during the 2015 through 2019 survey period were below the BC WQG of 10 µg/cm2 chlorophyll-a. There was high variability among replicates at each of the Brucejack Creek sites and high interannual variability. Brucejack Creek periphyton biomass and density increased moving downstream in 2021, with communities dominated by Cyanophyceae (blue-green algae), and Bacillariophyceae (diatoms). Both were dominant at BJ 2.62, with Bacillariophyceae largely represented by the genus *Achnanthidium* and Cyanophyceae by the genus *Calothrix*. At BJ 3.10, Cyanophyceae was represented by the genera *Pseudanabaena* and *Merismopedia*; and Chrysophyceae largely by the genus *Hydrurus*. Biomass and density in Brucejack Creek were generally elevated in 2021 compared to the historical range, in addition to increases in genus richness and diversity. Communities at BJ 3.10 have become increasingly diverse over the past two years after reaching low diversity in 2019. By contrast, richness and diversity have increased above the historical range over the past several years at BJ 2.62, largely attributable to more Cyanophyceae and Bacillariophyceae genera.

Benthic invertebrate community samples collected from Brucejack Creek during the 2015 through 2019 survey period exhibited large variability between stations and between years. There was also large year to year variability at reference site L3 OF. No relationship could be discerned between mine effects on water quality and benthic invertebrate communities over the five-year survey period. Benthic invertebrate abundance increased in Brucejack Creek moving downstream in 2021, dominated upstream by Diptera (true flies) and downstream by Plecoptera (stoneflies). Brucejack Creek in recent years has been dominated by Plecoptera, particularly the genus *Zapada* (family Nemouridae), representing a major shift in community composition. In 2021, however, upstream sites BJ 3.10 and BJ 2.62 returned to a historical composition with decreases in Plecoptera. Abundance was within the historical range at all sites. Family richness increased downstream and was within the historical range at upstream sites. Downstream at BJ1.74, richness was above the historical range yet had the lowest family diversity due to continuing dominance by Plecoptera (*Zapada*). Benthic invertebrate communities were compared to the Canadian Aquatic Biomonitoring Network (CABIN) BC central/north coast reference model. In 2021, benthic invertebrate communities at all three Brucejack Creek sites were classified as “Mildly Divergent” from the CABIN reference communities, having been classified as either “Mildly Divergent” or “Divergent” during baseline.

The interannual differences in periphyton biomass and community composition, and benthic invertebrate abundance and community composition over the monitoring period, which has included baseline, construction, and operation phases of the mine, appear unrelated to mining activities and can most likely be attributed to natural variability.

2.9.2 Fish and Fish Habitat

As described above in Section 2.5, the Brucejack Creek watershed is a small headwater sub-basin within the Sulphurets Creek watershed (drainage area 299 km^2). Brucejack Creek drains into Sulphurets Creek before reaching the Unuk River (Figure 1.4-3), which flows southwest, eventually discharging to the Pacific Ocean northeast of Ketchikan, Alaska.

Fish sampling programs in 2013 confirmed no fish presence in Brucejack Lake, Brucejack Creek, and Sulphurets Creek above a 200 m long cascade located approximately 1.3 km upstream of the Unuk River confluence (Rescan 2013g). Sampling was conducted immediately upstream of this barrier, in several large tributaries of Sulphurets Creek and in Brucejack Lake. Sampling effort above the cascade included 3,000 seconds of electrofishing sampling and 913 hours of minnow trapping. Therefore, the closest fish-bearing waters are more than 20 km downstream of the effluent discharge (refer to Figure 1.4-3).

Fisheries sampling conducted in 2013 (regional study area) included fish habitat surveys, and community surveys in streams (via electrofisher) and lakes (via minnow traps and gill nets). Biological characteristics of caught fish were recorded (i.e., species, weight, fecundity), and fish were sampled for genetics, tissue metals, and diet. Details of the fisheries program are available in the baseline report (Rescan 2013g).

The Unuk River within the region supports populations of Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*Oncorhynchus kisutch*), and Dolly Varden (*Salvelinus malma*), with historical data indicating the presence of Sockeye Salmon (*Oncorhynchus nerka*), Rainbow Trout (*Oncorhynchus mykiss*), Chum Salmon (*Oncorhynchus keta*), Pink Salmon (*Oncorhynchus gorbuscha*), and Cutthroat Trout (*Oncorhynchus clarkia*).

2.9.3 Tissue Residues

Fish tissues were collected in 2013 in the Unuk River downstream of the Sulphurets Creek confluence (Rescan 2013g). Unuk River Dolly Varden (eight samples) mean concentrations were 0.021 mg/kg wet weight for mercury, and 3.9 mg/kg dry weight for selenium. Coho Salmon (11 samples) mean concentrations were 0.020 mg/kg wet weight for mercury and 3.0 mg/kg dry weight for selenium. Baseline fish tissue concentrations were below the CCME tissue methylmercury guideline (0.033 mg/kg wet weight, assuming 100% of the total mercury in fish tissue was present as methylmercury) and the ENV selenium guideline for fish tissues (4 mg/kg dry weight).

3. MINE PLAN

3.1 Mine Plan Overview

As described in Chapter 1, Pretium Resources Inc., a member of the Newcrest Group of companies, is applying to increase the Brucejack Mine ore production rate authorized under *Mines Act* Permit M-243 from an annual average of 1.387 Mt to 1.807 Mt (equivalent to an increase from an average 3800 tpd to 4950 tpd). The 4950 tpd mine plan presented in this 4950 tpd Joint Application has been updated based on the mine plan presented in the 2019 National Instrument 43-101 Technical Report dated March 9th, 2020 (Tetra Tech 2020). The production rate increase from 3800 tpd to 4950 tpd would result in a shortened mine life from the 16 years spanning 2017 through 2032 presented in the 2020 mine plan, to 13 years spanning 2017 through 2029.

The Brucejack Mine produces gold and silver from the VOK and WZ deposits. The vertical and horizontal extents of the underground mine development for the 4950 tpd Joint Application mine plan remain similar to those presented in the 3800 tpd Amendment Application as per Permits M-243 and PE-107835 (Pretium 2018b) and the 2020 Mine Plan and Reclamation Program Update (Pretium 2020b). Mine plan changes in the 4950 tpd Joint Application compared to these previous submissions include updates to a subsection of the VOK called the North Block, and additional underground exploration development to the east, west and south.

Small portions of the updated exploration development extend beyond the current M-243 PMA boundary (Figure 3.2-1). In September 2022, Pretium submitted an M-243 permit amendment application to extend the mine's current PMA to the existing mining lease boundaries (M-243 Amendment #9). If approved, the exploration development currently outside of the PMA will be contained within it.

All waste rock at the mine is managed as PAG and is either deposited subaqueously at the mine's WRD within the WRTSF or backfilled in mined out areas of the underground mine below the predicted closure flooding elevation. Mine tailings are co-mingled with sludge from the mine's WTP and deposited subaqueously in the WRTSF. Total Life-of-Mine (LOM) waste rock deposition to the WRTSF remains within the 7.8 Mt currently authorized under M-243, and total tailings deposition to the WRTSF remains below the authorized 11.9 Mt. Total ore production does not exceed the 18.5 Mt authorized under EAC M#15-01.

The underground mine has been designed to extract ore through a combination of transverse long hole open stoping (LHOS) and longitudinal LHOS in a traditional primary/secondary sequence. Primary stopes are backfilled with cemented paste tailings and secondary stopes are backfilled with cemented paste tailings or waste rock. The mine utilizes a combination of conventional bulk sulphide flotation and gravity concentration to produce gold-silver floatation concentrate and doré from the on-site smelter. Both products are transported offsite for additional processing and refinement.

The increased mining rate from 3800 tpd to 4950 tpd will be sustained by expanding the battery electric vehicle (BEV) fleet and increased rates of drilling and development. No changes from the mining methods presented in the 2020 Mine Plan and Reclamation Program Update (Pretium 2020b) are required to achieve the production increase. Unrelated to the proposed production rate increase, Pretium is continuing to expand the Brucejack Mine battery electric vehicle fleet.

The following infrastructure upgrades and equipment changes have been identified to facilitate the production increase from 3800 tpd to 4950 tpd:

- Increasing the haul truck fleet size from eight to 11 (at minimum) 50 t BEVs and addition of an electric load-haul-dump (LHD) vehicle (Section 3.5.1.7);
- Additional Knelson concentrator within the mill, and upgrades to the gravity and floatation circuits (Sections 3.5.2.3.3 and 3.5.2.3.4);
- A fourth C75 domestic wastewater treatment unit (Section 3.5.4.6)
- Increasing the mine's power supply delivered by the existing 138 kV and 69 kV lines to 35 MVA, for which both lines are adequately rated (Section 3.5.7); and,
- Additional underground emulsion bay (Section 3.5.8.2).
- While no additional infrastructure is required to manage waste rock associated with a 4950 tpd production increase, Pretium is evaluating the development of a second waste rock dump (East WRD), temporary waste rock stockpile(s) (WP2) and supporting haul road east of the WRTSF. The potential upgrades to the existing waste rock management infrastructure are intended to improve the mine's waste rock management strategy, irrespective of the production rate increase. Therefore, the EWRD and WP2 stockpile(s) are contingency management options only. Should Pretium decide to advance development of this infrastructure, the required authorizations will to be pursued through separate authorization processes, outside of this amendment application.
- Similarly, a fifth vent raise (VR5) (Section 3.5.1.8) and four new tailings discharge lines to the WRTSF are being considered for installation between 2023 and 2026, regardless of production rate (Section 3.5.3.4 and Appendix 3-1). The new tailings lines are intended to replace existing and future tailings lines through LOM.

3.2 Existing Development

3.2.1 Mines Act Permit M-243 Authorized Infrastructure

Mines Act Permit M-243 authorizes infrastructure within Pretium's mining leases and the northernmost 19.5 km of the mine's 57 km-long high voltage transmission line connecting the mine to the BC Hydro grid near the Long Lake generating station (LNL) facility (Figure 3.2-1).

The following facilities are located within the mine site area as of January 2023 (Figure 3.2-1 and Figure 1.4-2):

- Four underground vent air raises.
- VOK and WZ underground mine portals.
- WZ pad, within which surface support infrastructure for the underground mine is located. This includes the old heavy shop, staging areas for waste rock, offices, covered storage, propane storage for mine air heater, and fuel storage and dispensing stations.
- Diesel power station (DPS) pad, including diesel generators and fuel storage serving as a back-up electrical generation facility.

- Mill building housing ore processing equipment, smelting furnace, WTP, paste backfill plant, assay laboratory, core processing area and related facilities.
- Lower and upper camps with kitchen, recreation, laundry, mine and mill dry facilities, medical clinic, fire hall, administration/offices, potable water well distribution and treatment system, STP, and solid waste management systems.
- Surface heavy duty shop to service surface vehicles and mobile equipment.
- Cement binder storage silo for pasting operations.
- Avalanche cap and powder magazines.
- Warehouse, coverall storage and equipment laydown areas.
- Heli-pad.
- Solid waste sorting and handling facilities, incinerator, waste oil burners, and burn pits.
- Contact and non-contact water management facilities, including mine dewatering, freshwater diversion channels, surface contact water collection system and a contact water storage pond (CWP).
- Overburden stockpile.
- The WRTSF containing five subaqueous tailings discharge pipelines, a treated WTP/STP effluent discharge pipeline, an emergency discharge pipeline from the CWP, and the WRD platform and associated temporary waste rock stockpile (WP1) that facilitates subaqueous waste rock deposition.
- A low-level weir (LLW) at the WRTSF outlet (site BJ 3.10) housing flow monitoring instrumentation and water reclaim equipment. The LLW facilitates continuous from the WRTSF to Brucejack Creek and houses a reclaim water pumping system that provides fresh water for to the mill.
- NPAG quarry (km 72 NPAG quarry) that provides NPAG material for surface and underground mine development and road maintenance.
- Site roads to connect mine area facilities, including the BJAR section between the km 72 NPAG quarry and the mine site.
- Communication, monitoring, and control systems, including wireless local area network receivers, underground fiber optic network, radio base stations, programmable logic controllers, and video cameras.

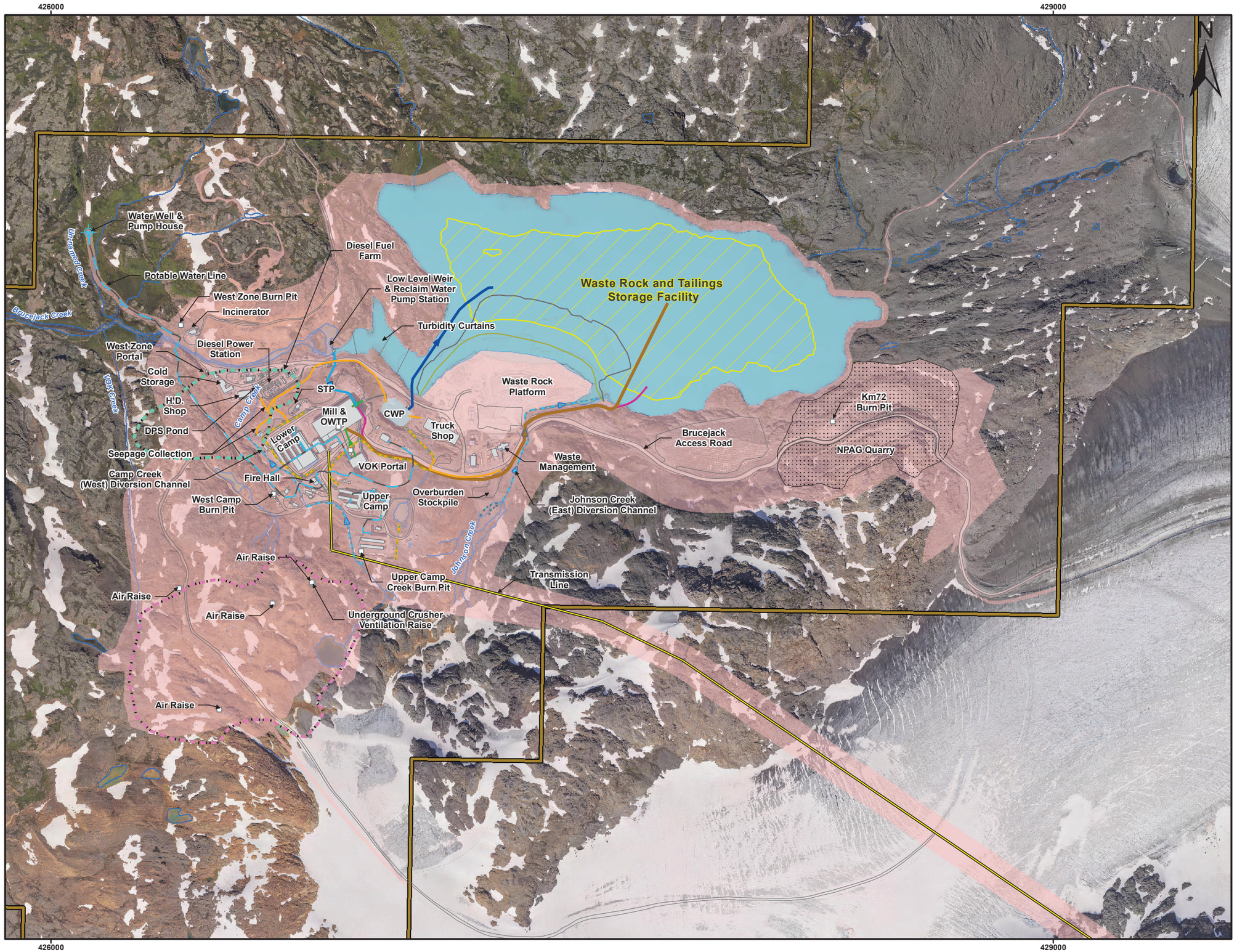
A new heavy-duty shop (truck shop) housing equipment and vehicle repair, washbays, and a warehouse will replace the existing shop and warehouse in 2023. Additional authorized surface infrastructure for which construction not yet initiated includes gravel borrow sources at the east end of the WRTSF, and future realignments of the upper BJAR ramp onto Knipple Glacier near BJAR km 72.

The M-243 approved surface disturbance area for the mine is 659.3 ha. This approved disturbance is categorized into disturbance types as per BC Ministry of Energy, Mines and Low Carbon Innovation (EMLI) guidance for reclamation reporting. The approved disturbance types include structures and their immediate surroundings: plant site (38 ha), roads (11 ha), lower and upper camps (5 ha), CWP

(0.7 ha), overburden stockpile (0.4 ha), seepage ponds (0.02 ha), transmission line (66 ha), historical exploration (66 ha), and WRTSF & NPAG quarry (90 ha) totaling 278 ha of actual disturbance.

3.2.2 Transmission Line

The Brucejack high voltage transmission line extends southeast from the mine site to a substation at Pretium's Knipple camp in the Bowser River Valley, and then south to a tap point on the 138 kV line between the Stewart substation (LNT) and LNL terminal generating station. Much of the 57 km transmission line is authorized under Statutory Right-of Way (ROW) #6408729. The boundary between the ROW and M-243 authorized portions of the transmission line is located approximately 5 km south of the Knipple transfer area at approximately km 37.1 of the transmission line. The transmission line segment authorized under ROW #6408729 is not described further in this amendment application.



Legend

Discharges & Water Management

- WTP/STP Effluent Line
- Tailings Discharge Lines
- CWP Direct Discharge Line
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Reclaim Water Line
- Untreated or Off-Spec Water Line
- Potable Water Well & Pump

NPAG, Waste Rock and Tailings

- Km 72 NPAQ Quarry
- Tailings Deposition (3800 tpd Ultimate)
- Waste Rock Dump Ultimate Toe (3800 tpd 3.81 M m³ Design)
- Waste Rock Dump Ultimate Crest (3800 tpd 3.81 M m³ Design)

Other

- Buildings
- Transmission Line
- Mining Leases

Underground Workings Surface Projection

- EOM VOK U/G Stopes Surface Projection (2020 Mine Plan)
- EOM WZ U/G Stopes Surface Projection (2020 Mine Plan)

- M-243 Permitted Area (Disturbed)
- Water

1:11,000

0 250 500

Metres

Coordinate System: NAD 1983 UTM Zone 9N

NEWCREST BRUCEJACK

Map ID: BJAUTH20230221187

Imagery: 2022 Lidar | Date: March 10, 2023

Figure 3.2-1 Mine Site General Arrangement and Detailed Infrastructure Plan - End of 2022

3.2.3 Waste Rock and Tailings Storage Facility

Brucejack Mine tailings and waste rock are subaqueously deposited into the WRTSF, and treated mine effluents (mine and wastewater from the WTP and STP respectively) are also discharged into this facility. Non-contact water runoff reports to the WRTSF from the facility perimeter and east non-contact water diversion channel (Johnson Creek). Contact water from the mine site is collected within the mine's contact water management system, and reports to the WTP before discharge. The WRTSF outlet, the LLW at BJ-3.10 (Section 3.5.4.5), allows for unobstructed outflow from the facility (no impoundment infrastructure), and serves as the mine's final effluent discharge point to Brucejack Creek.

Additional information, including descriptions of the site terrain, hydrogeological conditions, natural hazards, monitoring and emergency response are provided in the WRTSF – Operations, Maintenance and Surveillance (OMS) Manual (Appendix 9-1-17).

3.2.3.1 Tailings Storage

Brucejack Mine Tailings are classified as NPAG and are discharged to the WRTSF via pipelines for subaqueous storage. The discharge outfalls are located within 7.5 m off the tailings surface in accordance with PE-107835 Condition 1.3.2. Tailings Lines 1 and 2 are suspended in the WRTSF using an engineered cable system. Tailings Line 3 was installed in 2017 and Tailings Line 5 and 6 were both installed in 2021 and are anchored to the bottom of the WRTSF (Figure 3.2-1).

Prior to the commencement of tailings deposition in May 2017, the WRTSF had a maximum depth of approximately 85 m and a total volume of approximately 28.5 Mm^3. The 2018 3800 tpd Amendment Application for Permits M-243 and PE-107835 (Pretium 2018b) authorizes deposition of up to 11.9 Mt of tailings subaqueously in the WRTSF, with the remainder to be deposited as paste (consisting of thickened tailings and cement binder) backfill in the underground mine. The WRTSF storage capacity remains more than sufficient for placement of all tailings and waste rock requiring subaqueous deposition during the proposed 13-year mine life (Appendix 3-1).

The proposed 4950 tpd mine plan presented in this Joint Amendment Application allows for 11.3 Mt of tailings to be deposited into the WRTSF. Therefore, the proposed production increase to 4950 tpd does not result in an increase to the authorized total tailings deposition (11.9 Mt) to the WRTSF.

The 4950 tpd LOM tailings deposition plan is presented in Appendix 3-1. The mine's waste rock and tailings management operational procedures are described in the WRTSF – Operations, Maintenance and Surveillance (OMS) Manual (Appendix 9-1-17).

3.2.3.2 Waste Rock Storage

Most surface waste rock and all underground waste rock at the mine is managed as PAG, in accordance with M-243 Condition D.3. Waste rock is either deposited subaqueously within the WRTSF from the WRD or backfilled in the underground mine below the ultimate closure flooding elevation. The WRD and associated temporary waste rock stockpile (WP1) are located on the southern shore of the WRTSF near the outlet (Figure 3.2-1). Waste rock deposition into the WRTSF has been by remote operated dozer push since May 2021. Previous deposition methods included conventional dozer, telestacker and excavator bailing methods. These alternative deposition methods remain authorized and may be used again in future.

The 2018 3800 tpd Amendment Application for Permits M-243 and PE-107835 (Pretium 2018b) authorized subaqueous deposition of up to 7.8 Mt of surface and underground waste rock in the WRTSF, with the remainder to be backfilled in the underground mine. The 4950 tpd mine plan presented in this Joint Amendment Application allows for 6.4 Mt of underground waste rock to be deposited into the WRTSF. Therefore, total waste rock deposition to the WRTSF resulting from the proposed production increase is similar to the tonnage authorized in 2018.

The 4950 tpd LOM waste rock deposition plan is presented in Appendix 3-1-1, and incorporates the EWRD and associated WP2 stockpile(s) to demonstrate deposition with this contingency in place. Waste rock deposition at 4950 tpd without incorporating the EWRD is discussed in Section 3.5.3. The mine's operational procedures are described in the WRTSF – OMS Manual (Appendix 9-1-17). An updated geotechnical assessment that includes a summary of the subsurface conditions, design criteria, slope stability analyses, seismic hazard classification, and instrument monitoring recommendations for the WP1 temporary waste rock stockpile is provided in Appendix 3-2.

3.2.4 Underground Mine

Access and egress to the mine, including the transportation of waste rock out of the mine, is provided at the WZ portal and the VOK portal (Figure 3.2-1). A fleet of modern, diesel and battery powered, rubber-tired LHDs and trucks are used for ore and waste loading and transport from underground working areas through an internal ramp system that connects all levels to a centrally located crusher. Waste rock is primarily transferred from underground mine via the WZ portal and transported by haul truck to the WRD. Crushed ore is transferred from the underground mine to the mill concentrator/processing plant by conveyor via the VOK decline and VOK portal.

Permanent fans provide ventilation by forcing air down the declines, through the internal ramps, and exhausting to surface via four dedicated exhaust raises that connect the working levels to surface. The primary fans are located at each of the WZ and VOK portals. An electric mine air heating system is used, with a propane system available as a backup for supplemental heating.

Major underground infrastructure includes the primary jaw crusher, conveyors, ventilation raises, fans, heating system, pumping stations, electrical substations, explosives magazines, paste fill booster pump station, refuges, underground batch plant, mine communications, and other ancillary installations.

3.3 Life of Mine Plan

3.3.1 Mine Plan Summary

The 4950 tpd mine plan presented in this 4950 tpd Joint Application has a total LOM of 13 years spanning 2017 through 2029. Mining production is currently focused on the VOK zone (comprising the Main VOK, Fault Zone and North Block), with production also including the WZ beginning in 2025. The proportion of material mined in the WZ relative to the VOK will increase from 2025 over the remainder of mine life.

Initial development focus is on the VOK lower and middle blocks, with expansion into the Fault Zone area of the VOK. The Main VOK section is divided into four mining horizons separated by sill levels located at 960, 1080, 1200, and 1320 masl. Mining and development will progress over time, expanding out from the middle mining horizons.

The following development will occur in parallel with the VOK middle block development and mining:

- Advancement of the VOK decline to the 960 Level;
- Advancement of the VOK incline to the 1530 Level; and
- Development towards additional mining horizons such as the Fault Zone, North Block and WZ.

Development of the VOK ramp will advance continuously to the extents of the mine. Levels will continue to be developed and stoping will continue within the VOK and WZ deposits to a maximum of 18.5 Mt of total ore production (Table 3.3-1). Development of the WZ ramp is currently underway to allow production from the lower WZ blocks by 2025. Mining of the WZ deposit will begin in 2024/2025 but full production from this area does not begin until 2027. During this period of mine life, development requirements will decrease.

The 5th surface vent raise is planned to be completed by 2025. Internal raises will be developed within the mine as determined by scheduling requirements.

Figure 3.3-1 and Figure 3.3-2 are 3-dimensional views of the mine at EOM, showing mine development and the main stoping areas by year based on the 4950 tpd mine plan. Waste rock dump development, tailings deposition and km 72 NPAG quarry seasonal operations will continue until the mine closure period (2029-2031). No additional surface infrastructure related to the underground mine is planned for the period from 2025 to mine closure. Figure 3.3-3 shows the mine site area plan at EOM, with the horizontal extents of the mine.

As described in Section 3.1, the M-243 Amendment #9 application currently under review includes additional PMA that would address the boundaries authorization aspect of proposed exploration development in this amendment application that extends beyond the current PMA boundaries. Closure and reclamation planning is discussed in Chapter 4 and Appendix 4-1 of this 4950 tpd Joint Application.

Table 3.3-1. Projected Ore Schedule.

Year	Total Ore (kt)
2017	684
2018	952
2019	1,338
2020	1,252
2021	1,415
2022[1]	1,387
2023	1,418
2024	1,711
2025	1,807
2026	1,807
2027	1,807
2028	1,706
2029	1,213
Total	**18,498**

1. Planned ore schedule as per 4950 tpd mine plan starting in 2022.

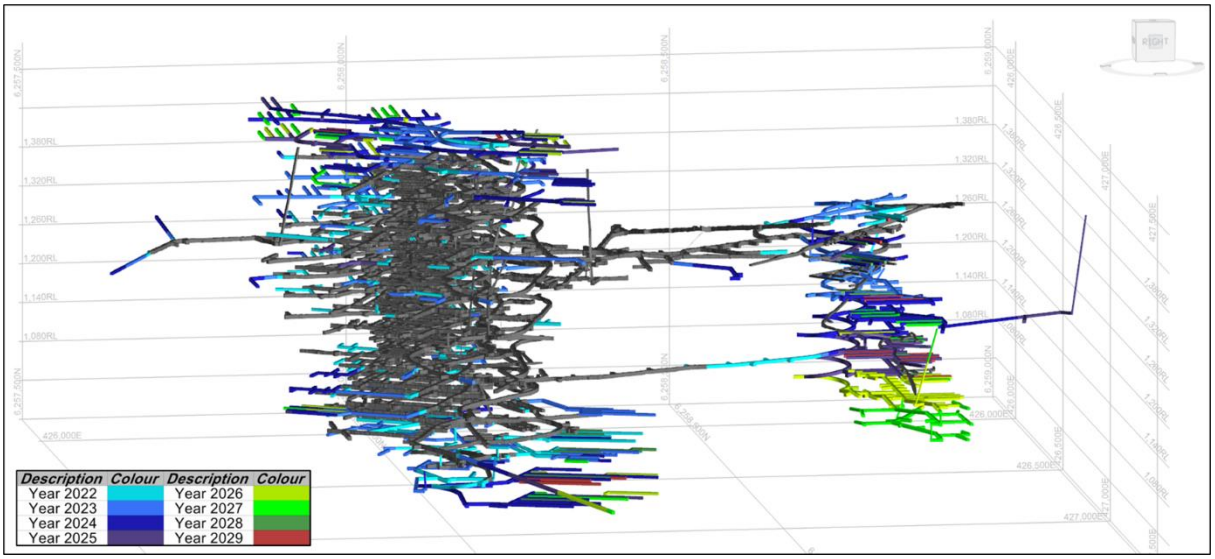


Figure 3.3-1. Life of Mine Development - Oblique View Facing West

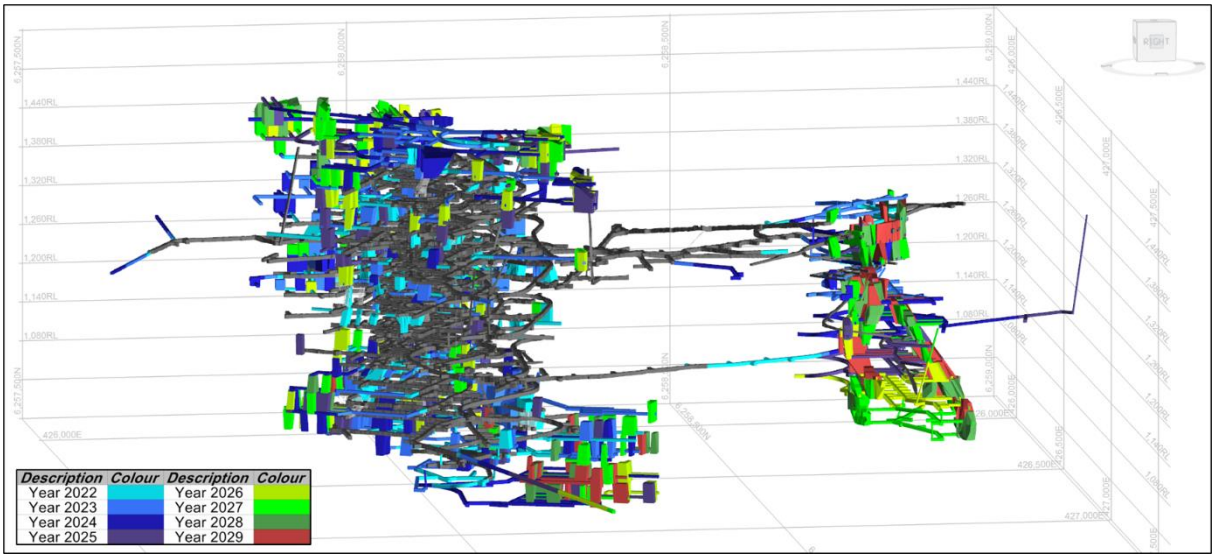


Figure 3.3-2.Life of Mine Stoping Area - Oblique View Facing West

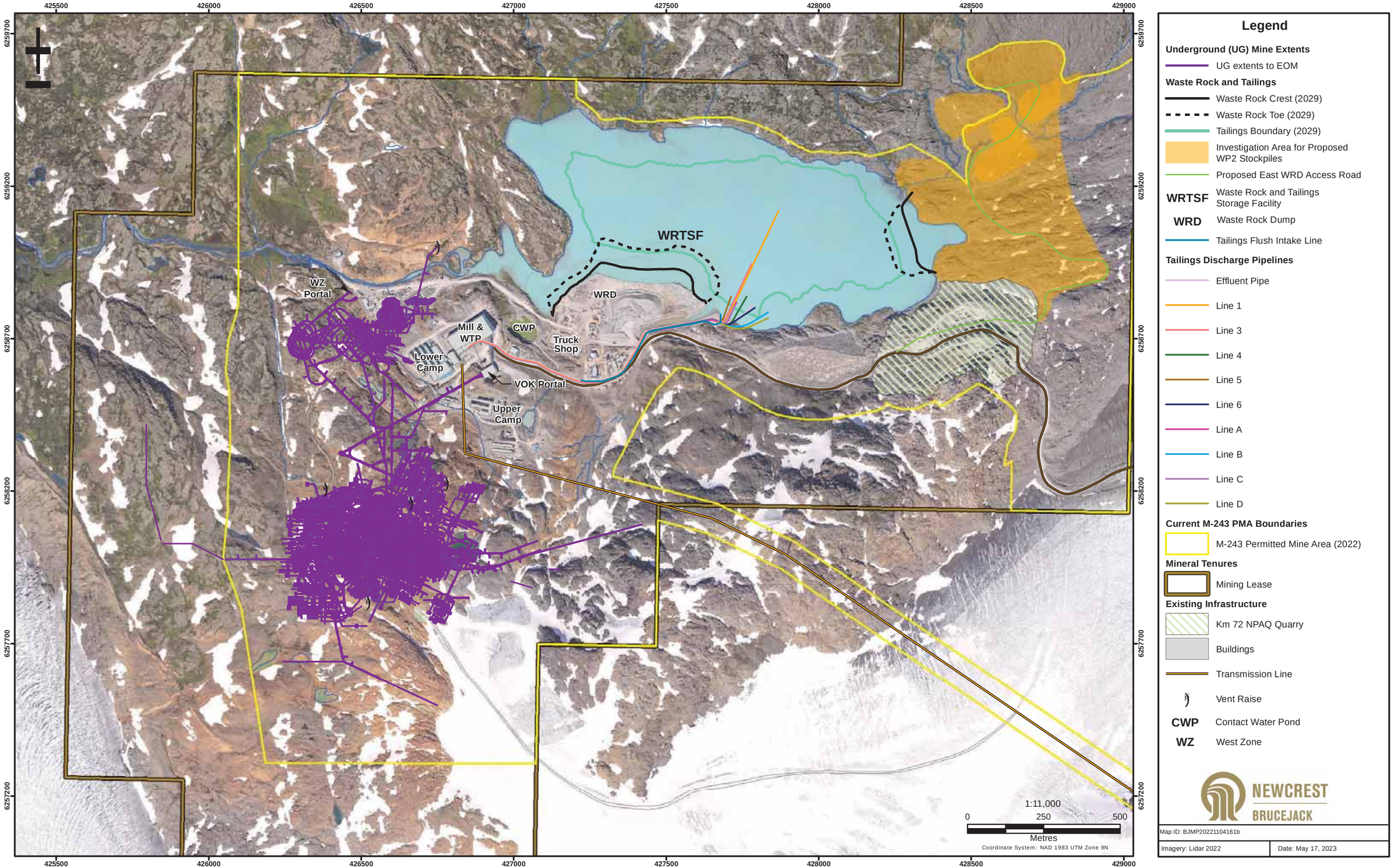


Figure 3.3-3. Mine Site Area Plan, End of Mine (EOM)

3.3.2 Mine Waste Materials

3.3.2.1 Mine Waste Rock Inventory

All underground waste rock is managed as PAG and either deposited subaqueously in the WRTSF or backfilled in the underground mine below the predicted flooding elevation. As backfill, waste rock is placed either as a bulk fill in remote stopes or placed with paste tailings in secondary stopes. The 4950 tpd mine plan is expected to produce approximately 8.0 Mt of underground and surface waste rock over the entire LOM (i.e., from start of construction in 2015 through EOM in 2029). Approximately 1.6 Mt of the total waste rock tonnes generated will be used as backfill. The total quantity of underground waste rock reporting to the WRTSF is similar to the total tonnage authorized in 2018.

Beginning in 2022, the percentage of waste rock used as underground mine backfill increases to approximately 40%, due to reductions in the total quantity of waste generated, as opposed to a higher percentage of waste rock fill stopes. The 1.6 Mt of waste rock fill over LOM accounts for approximately 13% of the total volumetric fill for the underground mine, with the remaining void volume filled with paste. Table 3.3-2 lists the annual waste rock inventory from 2015 to 2029 based on the 4950 tpd mine plan.

Table 3.3-2. Underground Waste Rock Inventory (2015-2029)

Year	Underground Total Waste Tonnes (kt)	Underground Waste Fill (kt)	Underground Waste to WRTSF (kt)
2015	98	-	98
2016	712	-	712
2017	484	-	484
2018	728	28	700
2019	788	22	766
2020	915	66	849
2021	894	102	792
2022[1]	809	231	578
2023	812	241	571
2024	803	173	630
2025	408	225	183
2026	253	220	33
2027	191	172	19
2028	62	59	3
2029	59	57	2
Total	**8,016**	**1,596**	**6,420**

1. Planned waste rock inventory as per 4950 tpd mine plan starting in 2022.

3.3.2.2 Tailings Inventory

Tailings generated during milling are either discharged subaqueously into the WRTSF or placed underground as cemented paste backfill. Table 3.3-3 presents the actual tailings deposition up to 2021, and the planned tailings deposition schedule starting in 2022. A total of 11.2 Mt of tailings reports to the WRTSF over LOM in this 4950 tpd mine plan. Tailings sent underground account for 87% of the total backfill volume required over LOM. The total quantity of tailings reporting to the WRTSF is similar to the total tonnage authorized in 2018.

Table 3.3-3. Tailings Inventory (2017-2029)

Year	Total Tailings (kt)	Tailings Underground (kt)	Tailings to WRTSF (kt)
2017	628	105	523
2018	1,006	411	595
2019	1,303	480	823
2020	1,307	474	833
2021	1,383	409	974
2022[1]	1,317	467	850
2023	1,346	521	826
2024	1,625	549	1,076
2025	1,715	571	1,144
2026	1,715	572	1,144
2027	1,715	592	1,123
2028	1,619	679	940
2029	1,152	760	391
Total	**17,832**	**6,590**	**11,242**

2. Planned tailings inventory as per 4950 tpd mine plan starting in 2022.

3.3.2.3 Underground Backfill Inventory

Table 3.3-4 tabulates the projected tonnages of waste to be generated from milled ore and development headings, and the destination of these materials over time. Over the total LOM, approximately 20% of waste tonnes and 37% of tailings generated from milled ore is placed back underground. The remaining balance is disposed of subaqueously in the WRTSF.

Table 3.3-4. LOM Backfill Inventory - Waste Rock and Tailings

Year	Total Tailings (kt)	Paste Fill Tonnes (kt)	Tailings to Surface (kt)	Underground Waste Tonnes (kt)	Underground Waste Fill Tonnes (kt)	Underground Waste to Surface (kt)
2015	-	-	-	98	-	98
2016	-	-	-	712	-	712
2017	628	105	523	484	-	484
2018	1,006	411	595	728	28	700
2019	1,303	480	823	788	22	766
2020	1,307	474	833	915	66	849
2021	1,383	409	974	894	102	792
2022[1]	1,317	467	850	809	231	578
2023	1,346	521	826	812	241	571
2024	1,625	549	1,076	803	173	630
2025	1,715	571	1,144	408	225	183
2026	1,715	572	1,144	253	220	33
2027	1,715	592	1,123	191	172	19
2028	1,619	679	940	62	59	3
2029	1,152	760	391	59	57	2
Total	**17,832**	**6,590**	**11,242**	**8,016**	**1,596**	**6,420**

3. Planned backfill inventory as per 4950 tpd mine plan starting in 2022.

3.4 Detailed Five Year Mine Plan

3.4.1 Introduction

The Brucejack Mine has two main zones of mining: the VOK and the West Zone. The VOK is further divided into three subzones: the Main VOK, the Fault Zone, and the VOK North Block. Levels within the Brucejack Mine are identified in meters above sea level (masl) according to mucking elevation. There are four main sill levels where stoping panels are initiated and stopes proceed vertically upward to the next sill level above. The sills are located at 960, 1080, 1200, and 1320 masl in the VOK zone, which is currently the primary source of ore until 2027 when stoping in the WZ increases.

3.4.2 2022

Most mining during 2022 was completed between the VOK 1050 and 1440 Levels, with minor production outside these levels. Mining occurred primarily in the Main VOK deposit with the Fault Zone as the secondary source. Initial development was completed for the VOK North Block to allow for additional drilling and exploration. The VOK ramp reached the 990 Level and initial level development was initiated. Development will continue within established levels to allow for future mining sequences.

The WZ decline continued to be developed with priority on establishing the development to access VR5. Development of internal raises for escapeways and ventilation began in the West Zone.

A 3-dimensional view of the underground mine at the end of 2022 is shown as Figure 3.4-1. The horizontal extent of the underground mine at end of 2022 is shown as Figure 3.3-2.

Construction of the new surface truck shop was initiated in 2022 (Figure 3.4-2). WRTSF tailings deposition and WRD operations continued along with seasonal operations at the km 72 NPAG quarry to source NPAG rock for underground and road surfacing and other operational purposes as needed.

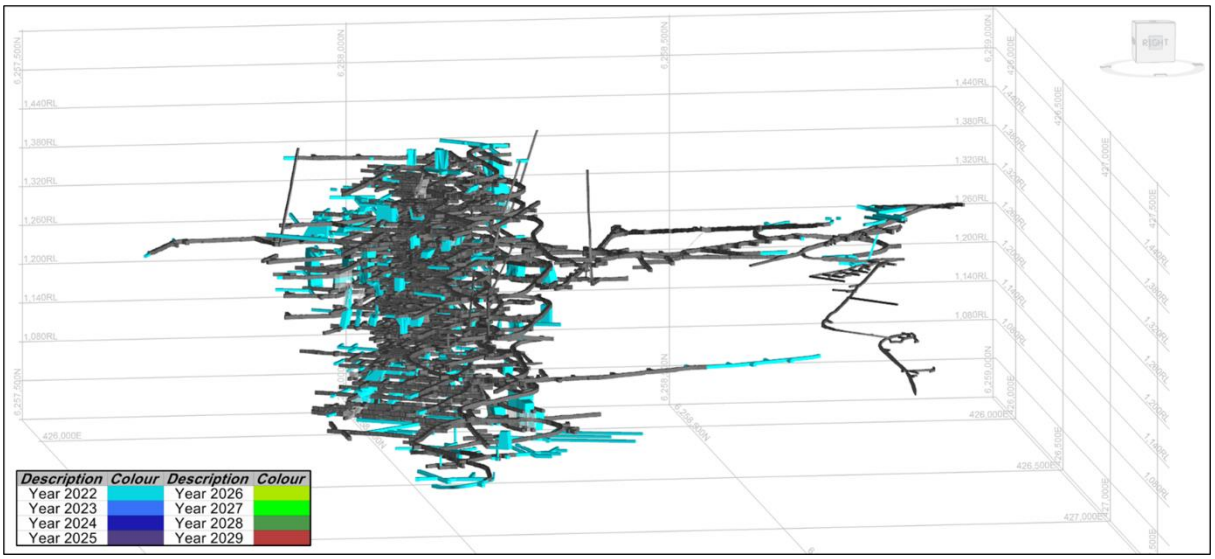


Figure 3.4-1. Three-dimensional Underground Mine View - End of 2022.

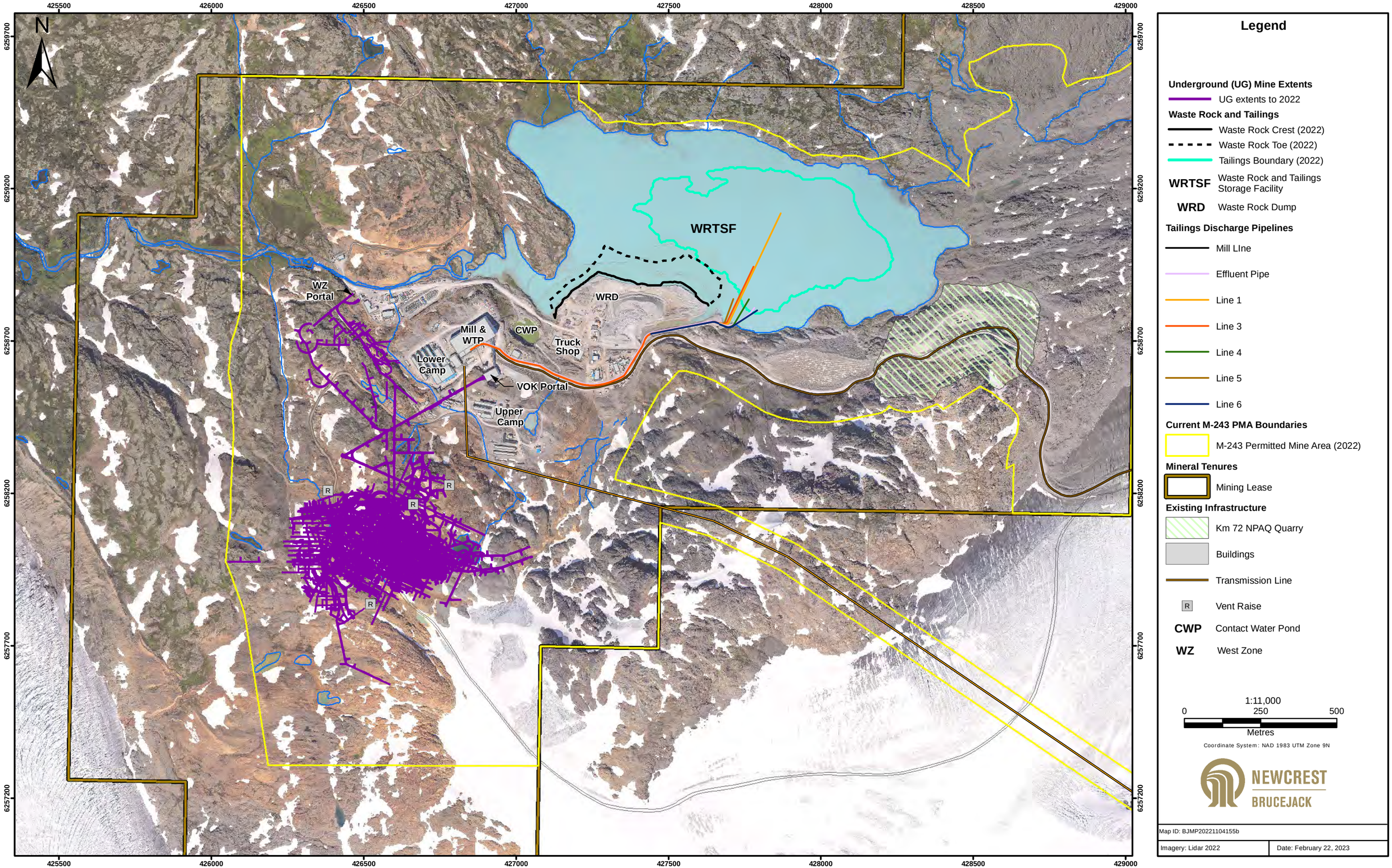


Figure 3.4-2. Mine Site Area Plan, End of 2022

3.4.3 2023

During 2023, mining focus will split relatively evenly between the Main VOK and the Fault Zone. Initial mining of the VOK North Block will begin but remain a minor contributor to the mill feed. The lower levels, 960-1050 masl, will begin to be mined at an increased rate.

In addition to development at the lower levels, level development will begin above the 1440 Level to target targeting upper VOK reserves. The WZ decline will continue to be developed with priority on establishing access to VR5. Internal raises for manways and ventilation will continue to be developed in the WZ. A 3-dimensional view of the underground mine at the end of 2023 is shown as Figure 3.4-3; the horizontal extent of the underground mine is shown on Figure 3.4-4.

Construction of the new truck shop will be completed in 2023 (Figure 3.4-4). Additional tailings management infrastructure to be installed in 2023 will include two new tailings discharge lines. Pending separate authorizations outside of this 4950 tpd amendment application, an access road will be constructed at the east end of the WRTSF to facilitate development of the EWRD and WP2 stockpiles, should Pretium determine to pursue development and authorization of this contingency infrastructure. WRTSF tailings deposition and WRD operations will continue as per the deposition plan (Appendix 3-1), along with seasonal operations of the km 72 NPAG quarry.

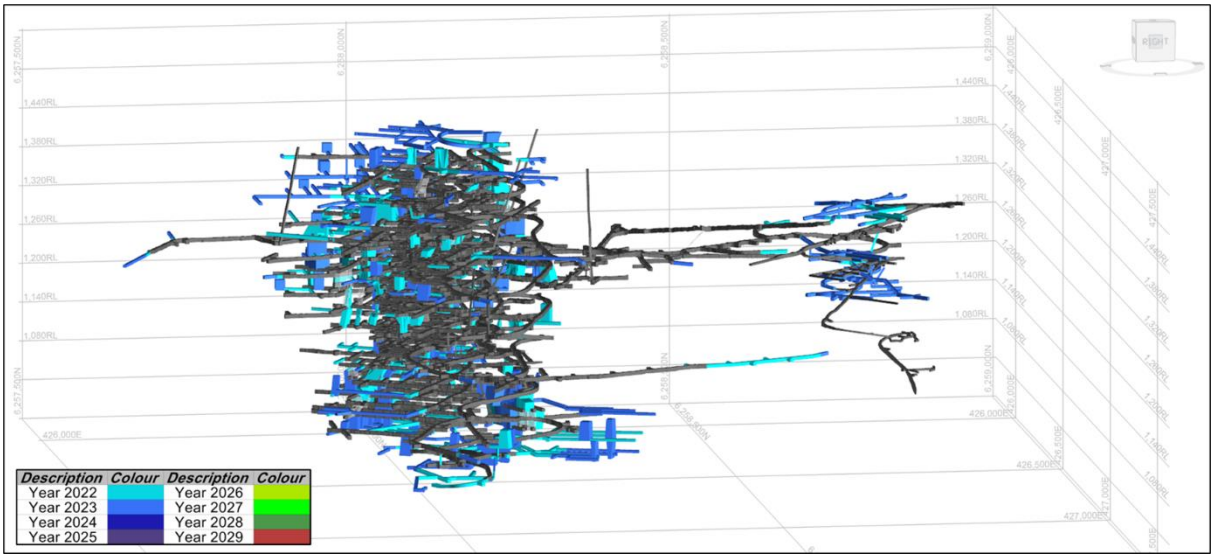


Figure 3.4-3. Three-Dimensional Underground Mine View - End of 2023.

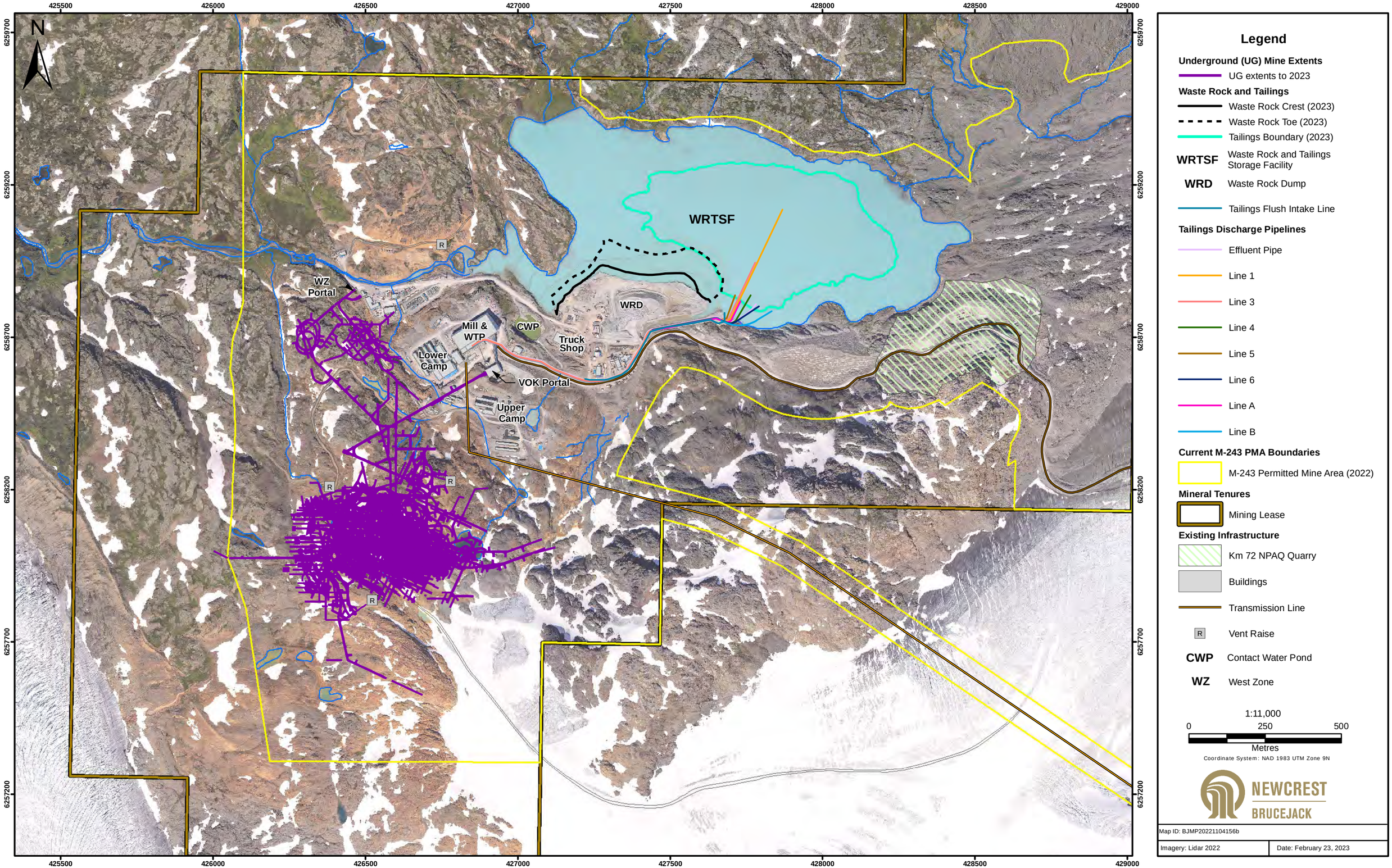


Figure 3.4-4. Mine Site Area Plan, End of 2023

3.4.4 2024

Production of the Main VOK is expected to be mostly complete between the 1200 and 1440 levels in 2024, with production primarily coming from the 990 to 1170 levels and levels above 1440. Mining will also continue in the Fault Zone. The VOK North Block will continue to be established and mined at a lower rate than the Main VOK and Fault Zone. Standalone West Zone stopes will begin to be mined ahead of VR5's completion. Ramp up to average 4950 tpd is expected to be achieved by the second quarter of 2024.

VOK ramp development will have been completed, with the primary focus for development shifted to the Fault Zone and VOK North Block portions of the VOK, and to the West Zone. The WZ development is expected to reach VR5 and preparation for the vertical development of this raise is planned to begin. A 3-dimensional view of the underground mine at the end of 2024 is shown as Figure 3.4-5. The horizontal extent of the underground mine at the end of 2024 is shown on Figure 3.4-6.

During 2024, construction of surface infrastructure commenced in 2023 will be completed (Figure 3.4-6). Tailings to the WRTSF and waste rock deposition at WP1 will continue. Pending separate authorization outside of this 4950 tpd amendment application, and if Pretium pursues development of contingency waste rock management infrastructure, the East WRD will be established using waste rock material temporarily stored in WP2, as per the waste rock and tailings deposition plan (Appendix 3-1). WRTSF tailings deposition and operations at both waste dump locations will continue, along with seasonal operations of the km 72 NPAG quarry.

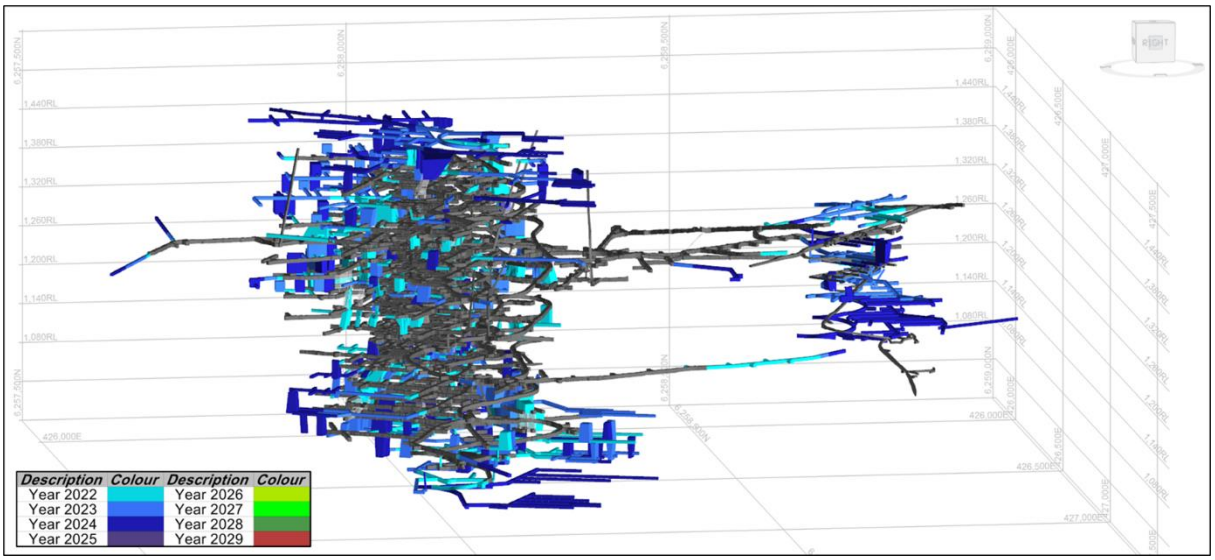


Figure 3.4-5. Three-Dimensional Underground Mine View - End of 2024.

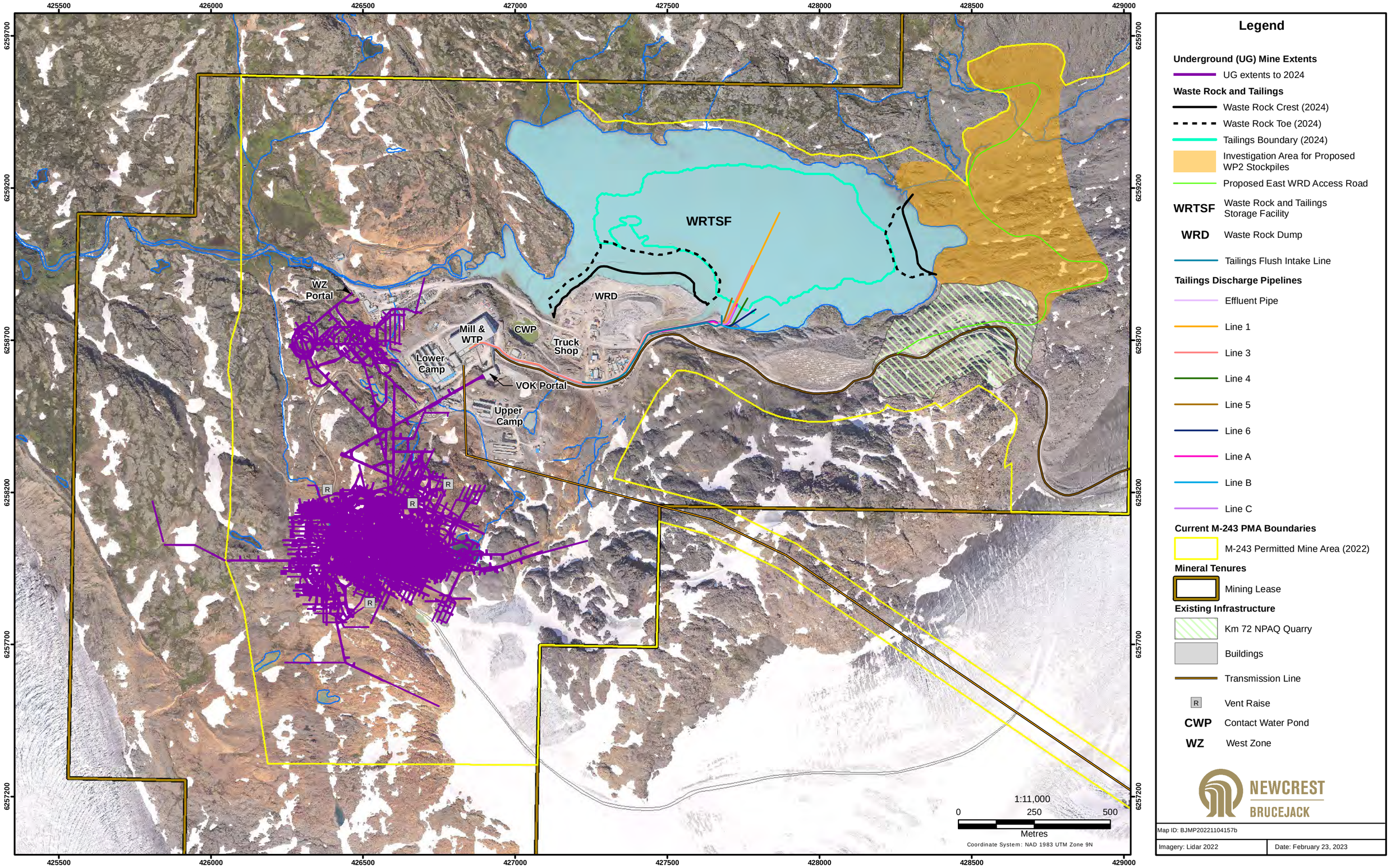


Figure 3.4-6. Mine Site Area Plan, End of 2024

3.4.5 2025

Primary stope production during 2025 is expected to be from the lower VOK levels and the Fault Zone with the VOK North Block continuing to provide secondary feed and level development. Completion of the return air raise of the WZ (VR5) is expected with further development of the WZ ramp and levels to set up for mining. Mining in the West Zone is still minor but most infrastructure is now established. A 3-dimensional view of the underground mine at the end of 2025 is shown as Figure 3.4-7; a horizontal view showing the maximum horizontal extents is shown on Figure 3.4-8.

WRTSF tailings deposition and WRD operations will continue, along with seasonal operations at the km 72 NPAG quarry. Contingent on Pretium's decision to pursue additional authorization for the EWRD and WP2 stockpiles, and as described in the waste rock and tailings deposition plan (Appendix 3-1), waste rock deposition from WP2 to the East WRD is scheduled for completion, with WP2 and the EWRD remaining available for contingency use.

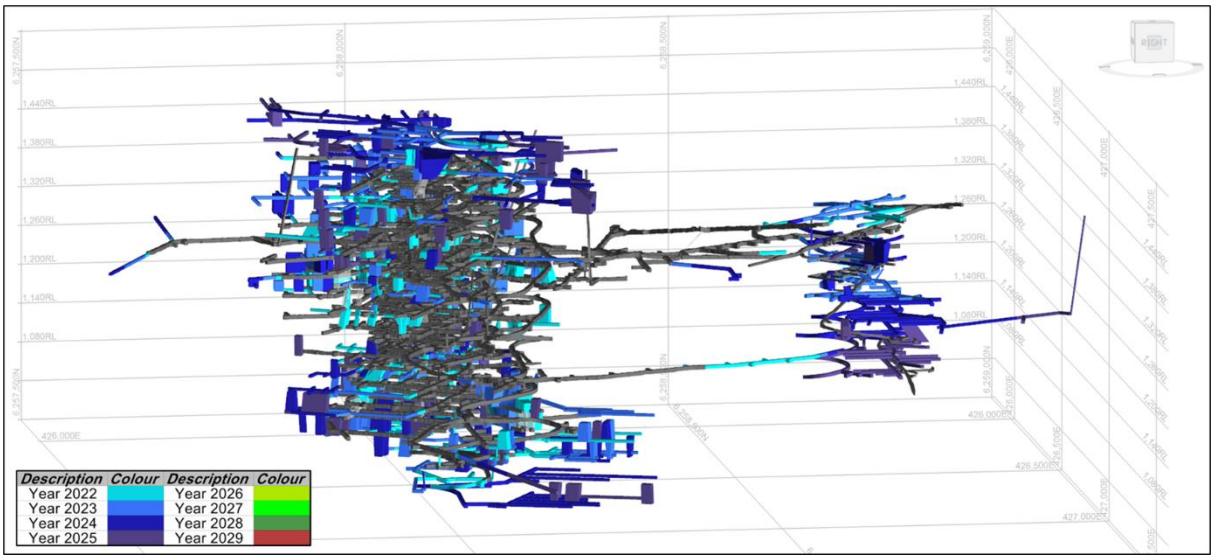


Figure 3.4-7. Three-Dimensional Underground Mine View - End of 2025.

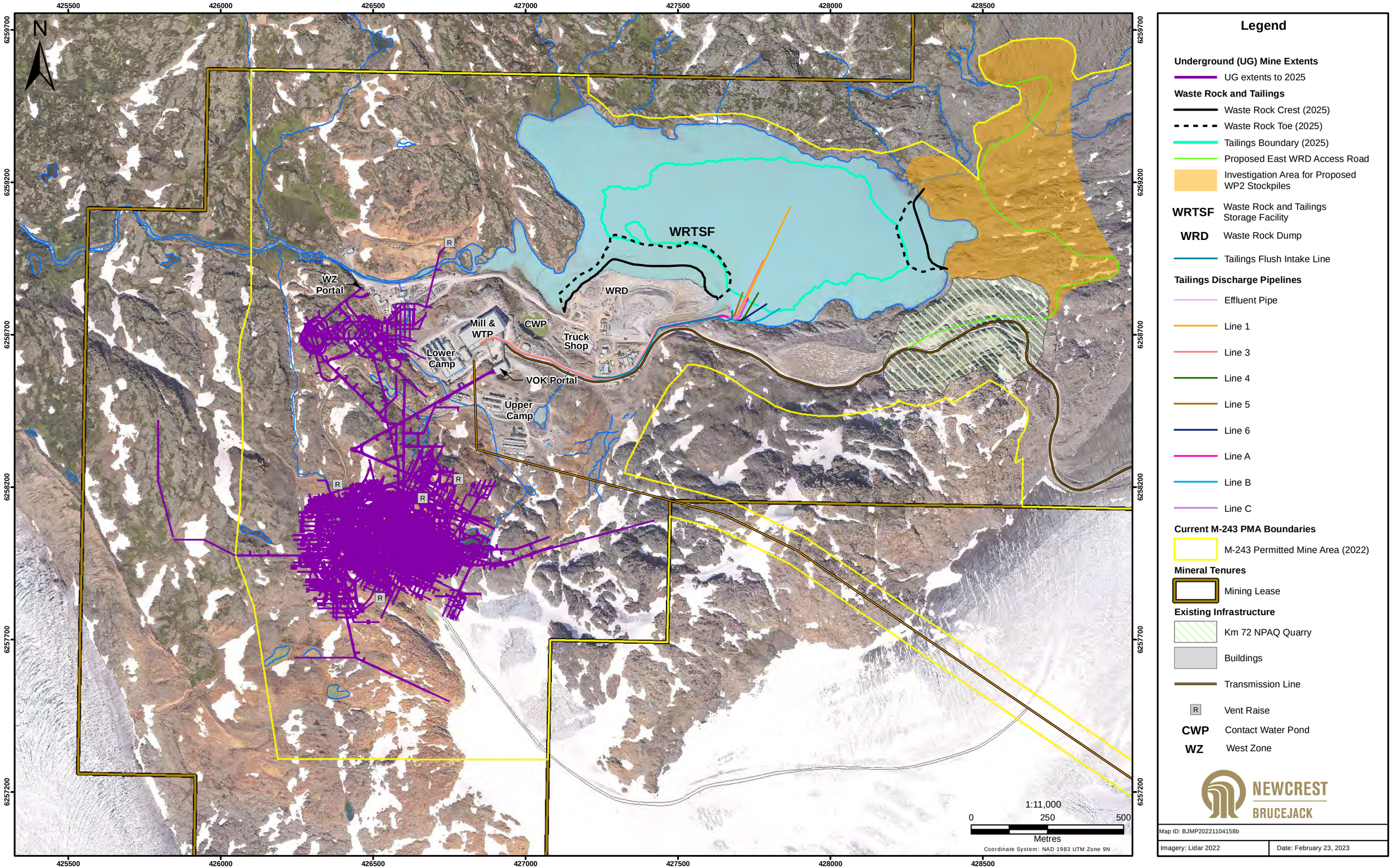


Figure 3.4-8. Mine Site Area Plan, End of 2025

3.4.6 2026

The production profile from 2025 will continue during 2026, with focus on the upper and lower VOK areas. The Main VOK and Fault Zone are evenly split in terms of production weight, with the VOK North Block providing minor supplement to the feed. The WZ will begin to ramp up production following the completion of VR5. The WZ development will be focused on establishing the lower mining horizons and WZ ramp development will reach the 1040 Level. The VOK North Block level development will be mostly complete by 2024, with future development focusing primarily on crosscut development.

WRTSF tailings deposition and WRD operations will continue, along with seasonal operations at the km 72 NPAG quarry.

A 3-dimensional view of the underground mine at the end of 2026 is shown as Figure 3.4-9; a horizontal view showing the maximum horizontal extent is shown on Figure 3.4-10.

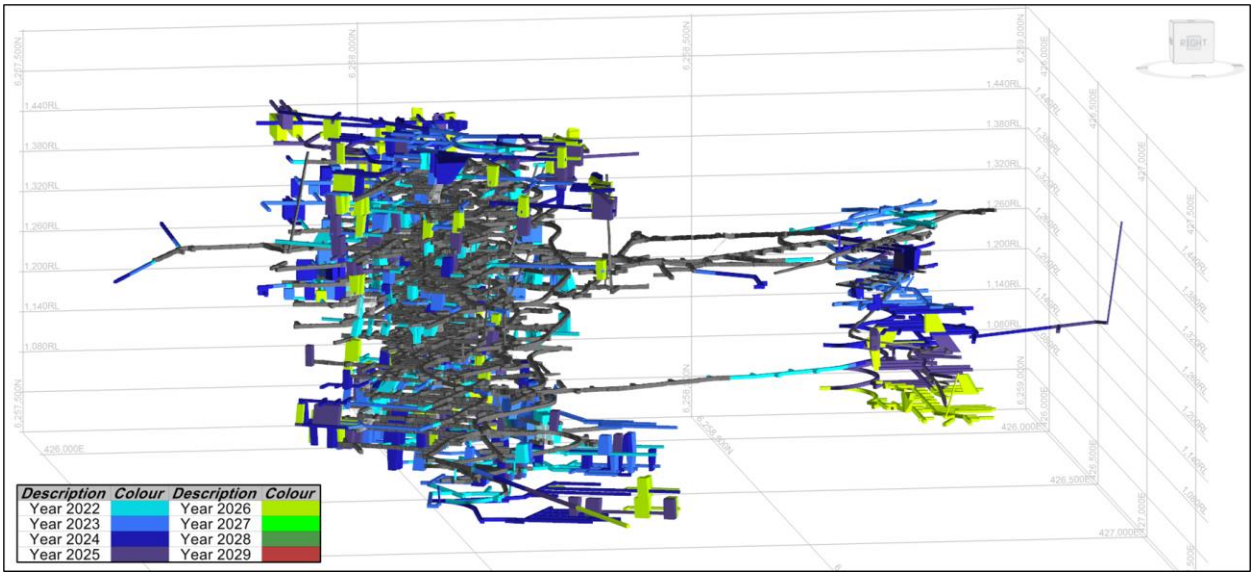


Figure 3.4-9. Three-dimensional Underground Mine View – End of 2026.

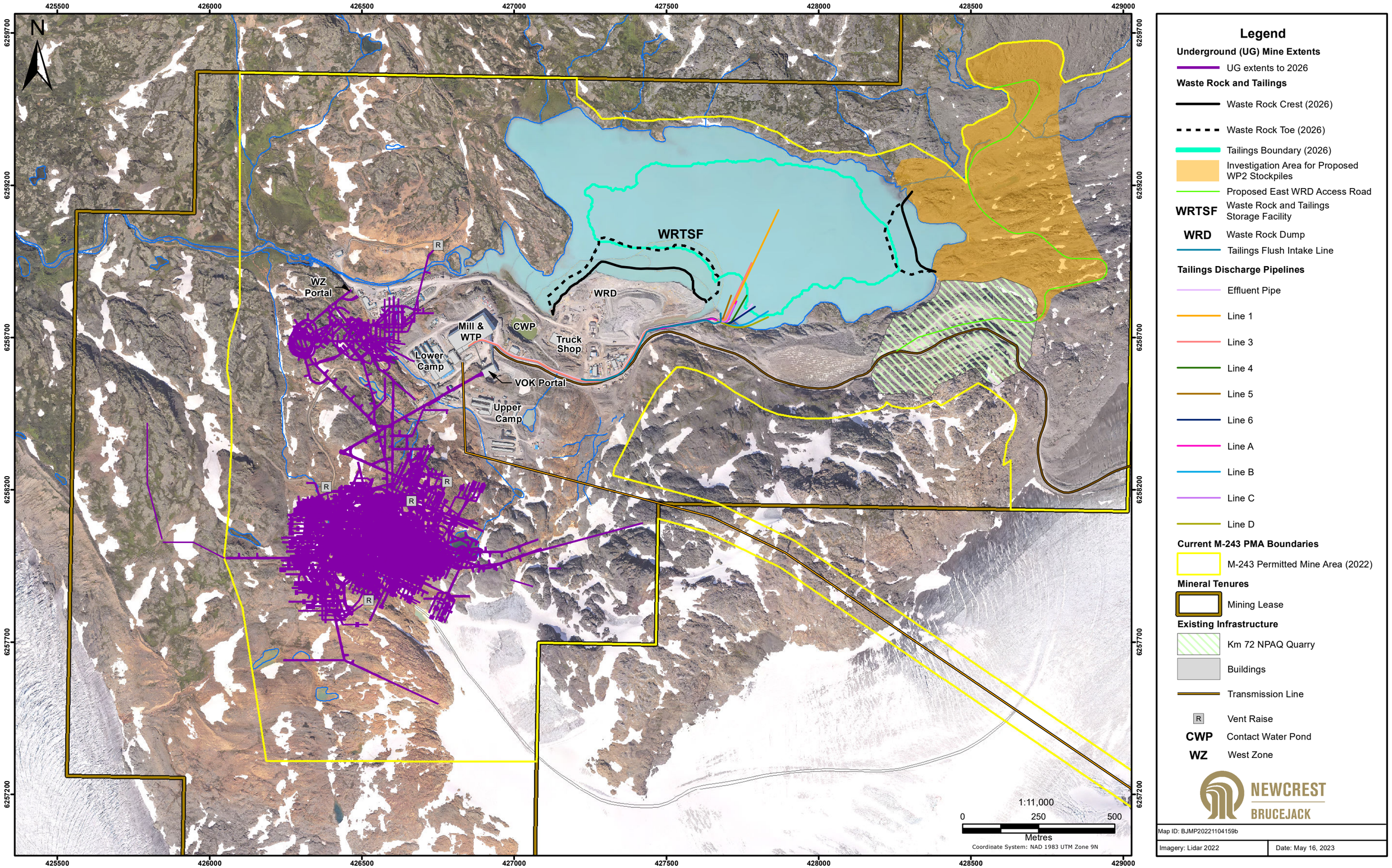


Figure 3.4-10. Mine Site Area Plan, End of 2026

3.4.7 2027

West Zone stoping will become a major contributor to the mine plan in 2027. The VOK North Block will also increase in proportion to compensate for the decrease in material being mined from the Main VOK. Development will be primarily focused in the WZ, with focus on crosscut development. A 3-dimensional view of the underground mine at the end of 2027 is shown as Figure 3.4-11; a horizontal view showing the maximum horizontal extent is shown on Figure 3.4-12.

WRTSF tailings deposition and WRD operations will continue, along with seasonal operations at the km 72 NPAG quarry.

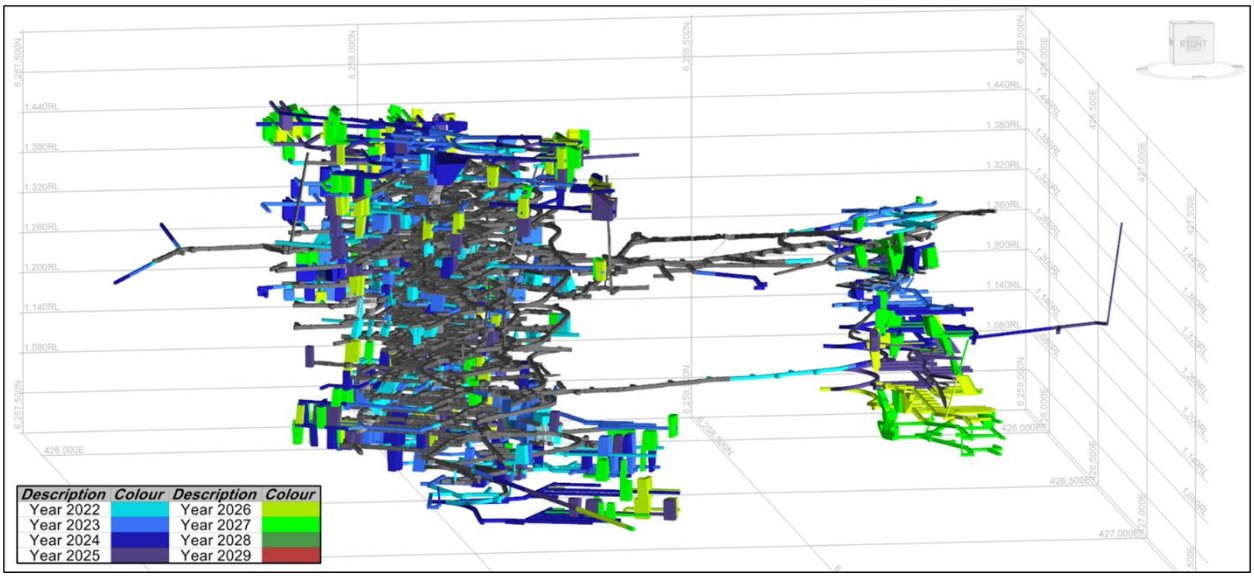


Figure 3.4-11. Three-dimensional Underground Mine View – End of 2027.

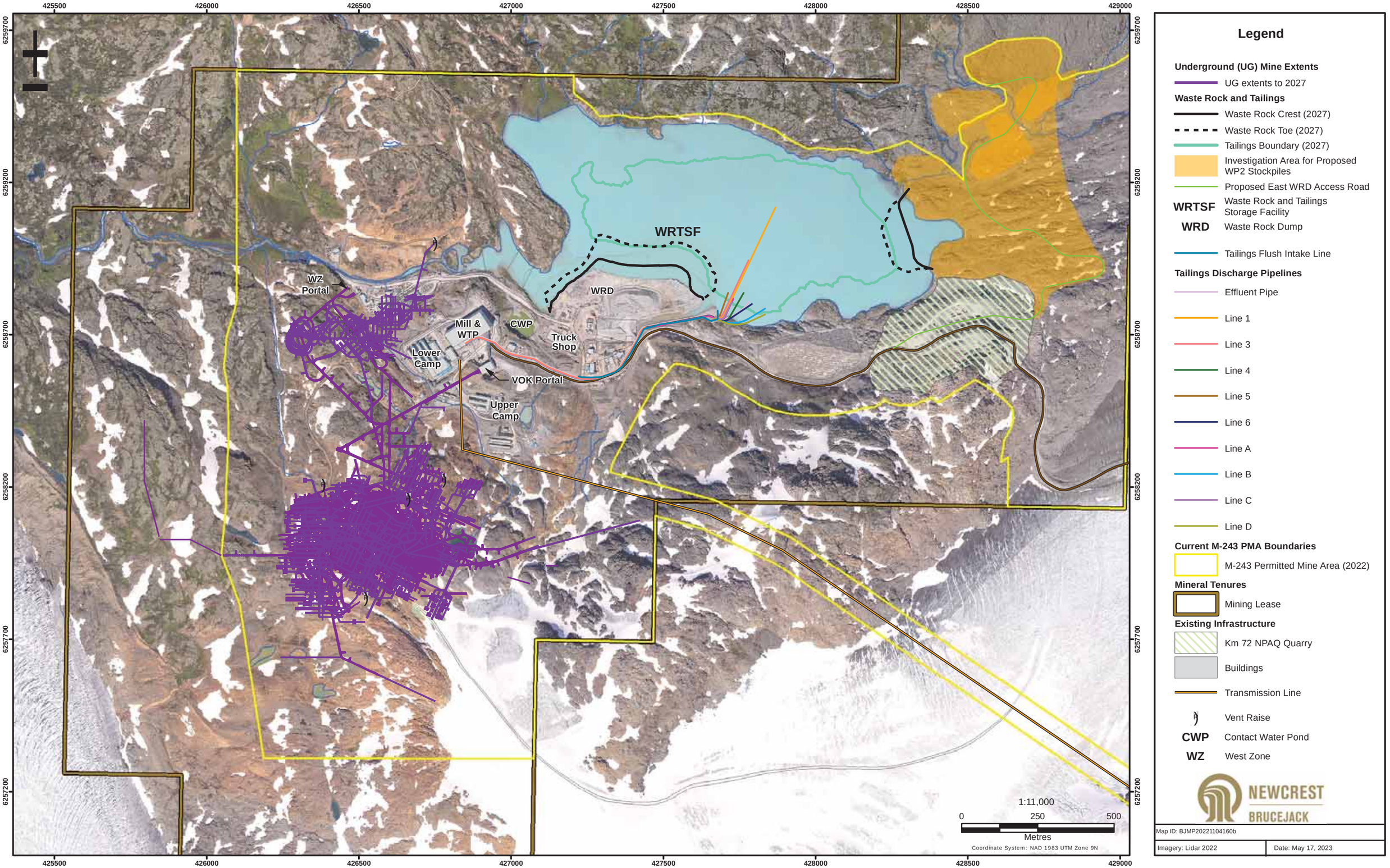


Figure 3.4-12. Mine Site Area Plan, End of 2027

3.5 Mine Facility Designs and Development

3.5.1 Underground Workings

3.5.1.1 Overview

The proposed mine plan is designed to extract average 4,950 tpd of ore through a combination of transverse LHOS and longitudinal LHOS mining methods. A fleet of diesel and electric LHDs and trucks is used for material loading and transport from the various underground working areas through an internal ramp system that connects all mine levels to the centrally located crusher.

Permanent fans provide ventilation by forcing air down the declines, through the internal ramps, eventually exhausting to surface via dedicated raises that connect the working levels to surface in each zone. The primary fans are located at each of the two surface portals. An electric mine air heating system is used, with a propane system available as a backup.

Major underground mine infrastructure includes the primary jaw crusher, conveyors, ventilation raises, fans, heating system, pumping stations, electrical substations, explosives magazines, paste fill booster pump station, refuges, mine communications and other ancillary installations.

No changes to the underground mining methods are required to facilitate the proposed production increase.

3.5.1.2 Mine Design

3.5.1.2.1 Access and Ramp Infrastructure

Two independent internal ramps and surface portals, one for the VOK zone and one for the WZ, connect all levels of the mine to surface. The VOK decline and surface portal is located proximal to the mill and contains the conveyor that transports ore from the crusher to the mill, in addition to providing access/egress for the underground mine. The WZ portal is the second access/egress for the mine and is used to access the mechanical shops for underground equipment and to haul waste rock to surface. Figure 3.5-1 illustrates the general ramp development arrangement.

For ease of entry and exit, ramps are designed with a 25 m turning radius and a 15% gradient, levelling out to a 0% gradient in proximity to a level access intersection. Passing bays are incorporated where required. Figure 3.5-2 shows the ramp system for both zones in perspective view.

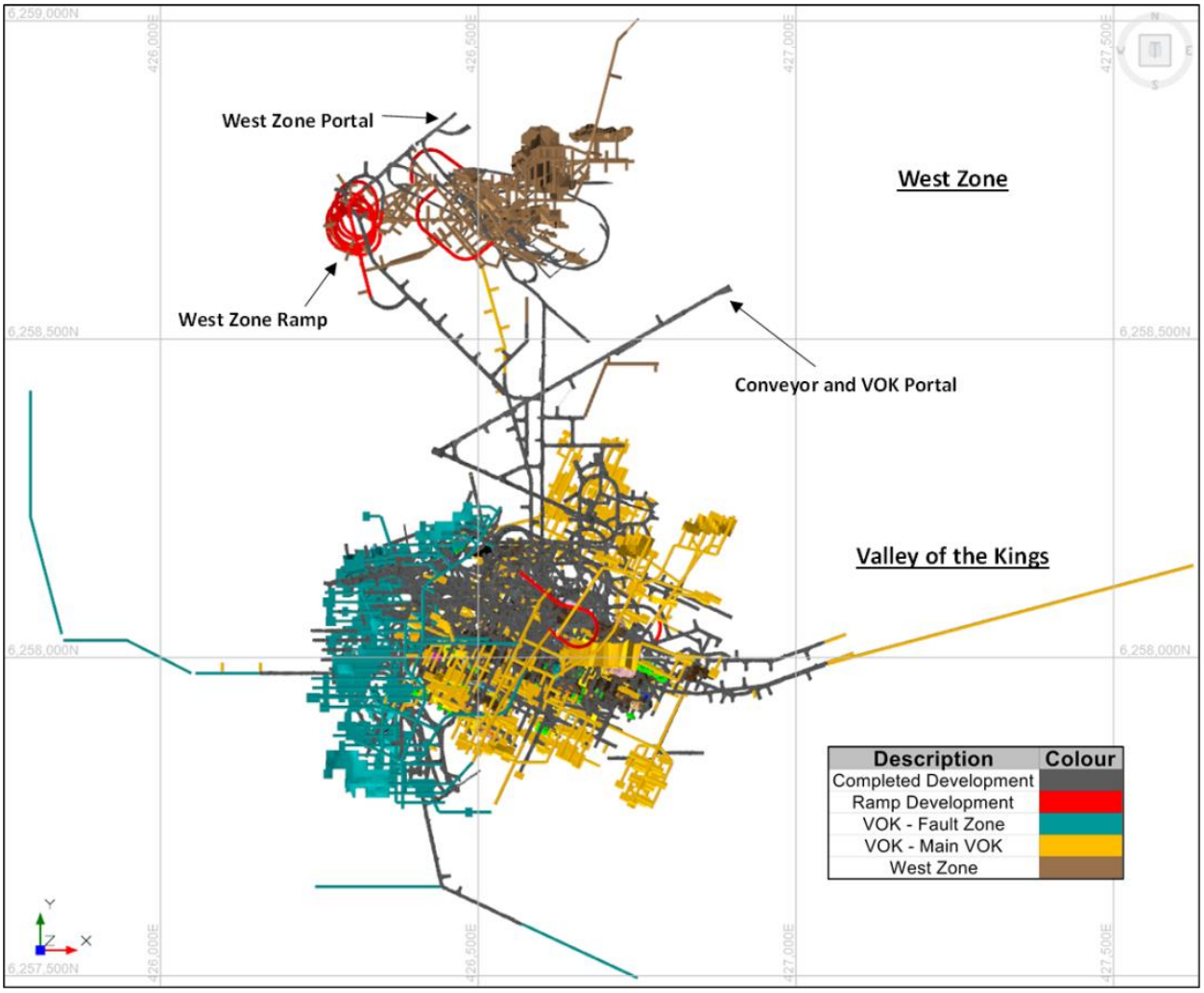


Figure 3.5-1. Underground Mine Access and Development Infrastructure.

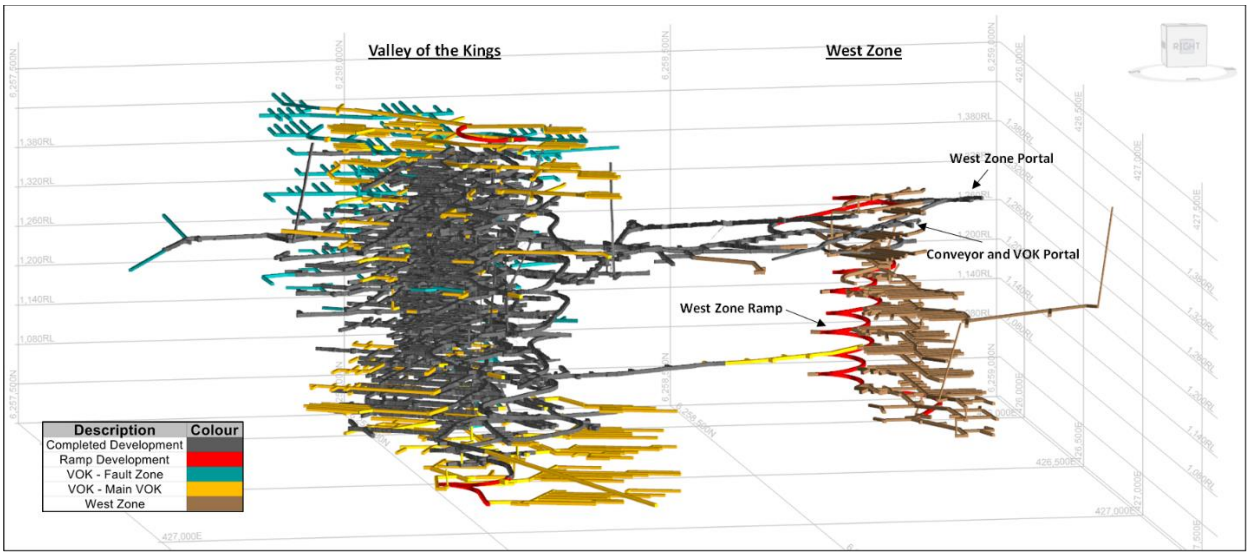


Figure 3.5-2. Brucejack Declines and Ramp System.

3.5.1.2.2 Level Development

Sublevels are accessed from the ramps at a 30 m vertical interval as defined by the planned stoping heights. Footwall and hanging wall drives are typically set back a minimum of 22.5 m from the ore contact, whereas ramp development is set back a minimum 50 m from the ore contact. This arrangement promotes long-term geotechnical stability and provides space for the placement of ancillary services between the ramp and level development. Sublevels have ventilation raises on the east and west sides of the level access points.

Level development follows the general strike of the various lenses, providing access to the mineralized zones in a manner that promotes stope mining. Generally, level development is in the hanging wall, with hanging wall drives typically including excavations for sumps, refuges, transformers, remuck bays, paste fill line, and raise accesses.

Stope access crosscuts are on 15 m spacings, with the exception of those levels where sill extraction or near-surface weathered ore is recovered in smaller stopes as determined by the geotechnical requirements. The design shows extraction of fault zone ore in stopes that are retreated perpendicular to the axis of the fault. Figure 3.5-3 illustrates the typical mining approach and level development requirements in the 4950 tpd mine plan.

Lateral development design considered equipment size, services, and required activity. The design parameters are summarized in Table 3.5-1. Figure 3.5-4 and Figure 3.5-5 illustrate standard designs for hanging wall drives and the main decline, respectively.

Table 3.5-1. Development Design Parameters.

Development Type	Parameter		
	Width(m)	Height/Length(m)	Maximum Gradient (%)
Remuck	5.5	5.5	2
Footwall Drives	5.5	5.5	15
Access Drive	5.5	5.5	2
Electric LHD Cut-out	5.5	5.5	2
Conveyor Decline	6.0	6.5	15
Main Access Decline	6.0	5.5	15
Infrastructure Drive	5.5	5.5	2
Drainage Cut-out	5.5	5.5	2
Waste Cross-cut	5.0	4.5	2
Refuge Bay Cut-out	5.5	5.5	2
Ore Cross-cut	5.0	4.5	2
Fresh Air Drive	5.5	5.0	2
Return Air Drive	5.5	5.0	2
Paste Fill Line Drive	5.5	5.0	2
Vertical			
Alimak Raise	3.0	3.0	-
Return Air Drive	3.0	3.0	-
Fresh Air Raise	3.0	3.0	-

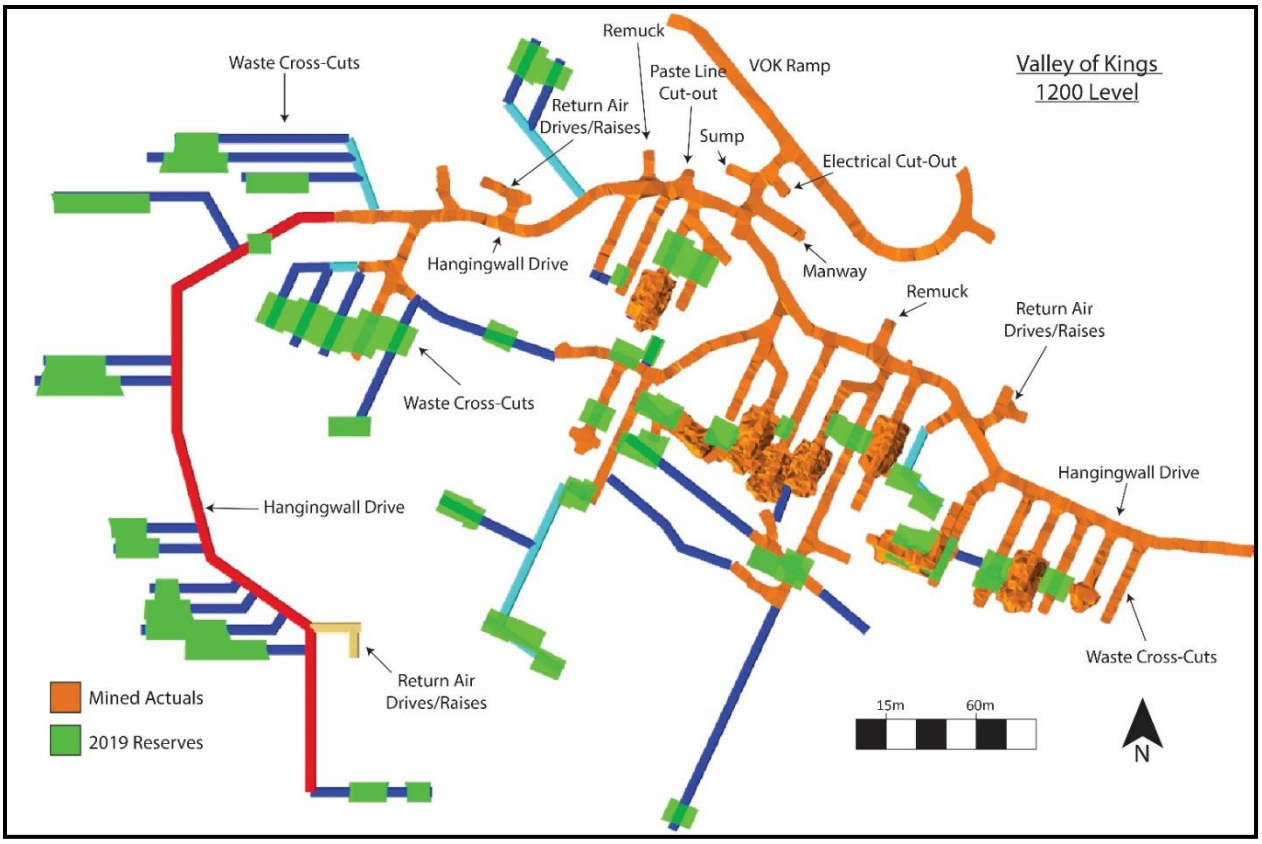


Figure 3.5-3. Typical Level Plan - 1200 Level in the VOK Zone.

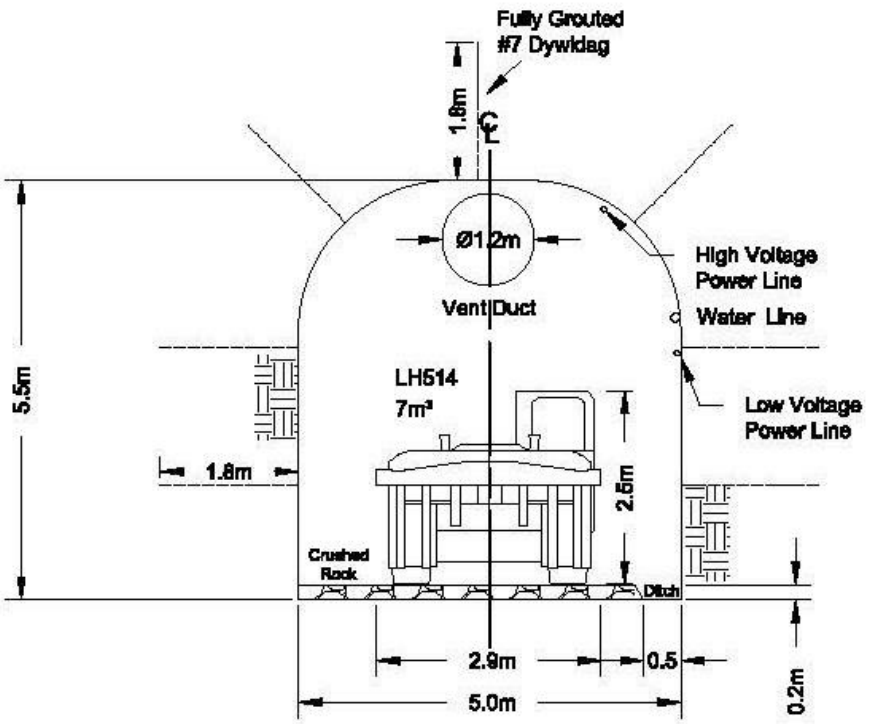


Figure 3.5-4. Standard Designs - Hanging Wall Drive.

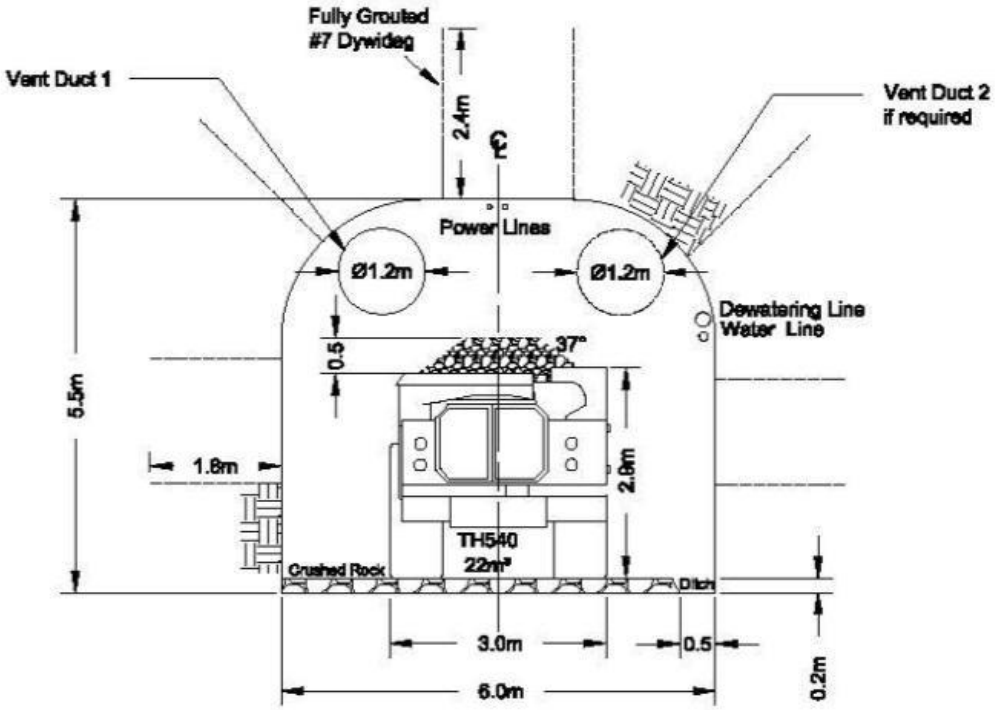


Figure 3.5-5. Standard Design - Main Decline.

3.5.1.2.3 Stope Design

The Brucejack Mine uses the Mineable Shape Optimizer (MSO) module from the Deswik mine planning software package to produce conceptual stope shapes. Table 3.5-2 summarizes the key design parameters used in the MSO. The conceptual stope shapes are refined as necessary to minimize planned dilution and to meet practical mining constraints. Individual areas meeting the cut-off grade are evaluated against access development costs to determine economic viability before including them in the mining plan.

For non-person entry excavations, such as long hole stopes, assessments of the stope dimensions presented in Table 3.5-3 are considered appropriate for the fair to good and poor to very poor rock mass classes (see Ground Control Management Plan, Appendix 9-2-4). Where stopes are planned within fault zones there is the potential for reduced stability and increased dilution. Further shortening of stope lengths is considered if adverse stope performance and dilution is unacceptable.

Table 3.5-2. Stope Design Parameters.

Parameter	Units	Valley of the Kings Zone			West Zone		
	Standard	Weathered[1]	Sill Pillar		Standard	Weathered[1]	Sill Pillar
NSR Cut-off	US$/t	185	185	185	180	180	180
Level Spacing	M	30	30	30	30	30	30
Stope Span	M	10	15	15	15	10	10
Minimum Mining Width	M	10	10	10	3	3	3
Minimum Waste Pillar Width	M	5	5	5	5	5	5
Minimum Footwall Dip	degrees	80	80	80	60	60	60
Minimum Hanging Wall Dip	degrees	80	80	80	60	60	60

Note: [1]Refers to stoping in weathered material immediately below the surface crown pillar. Weathered material extends 10 to 50 m below surface.

Table 3.5-3. Maximum Stope Dimensions by Rock Mass Condition.

Rock Mass Condition	Maximum Stope Dimensions (m)
Fair to Good (RMR76 > 40)	15 w x 30 h x 15 to 40 l
Poor to Very Poor (RMR76 < 40)	15 w x 30 h x 15 l

3.5.1.3 Mining Method and Sequence

3.5.1.3.1 Block Definition

The orebody is divided into six blocks defined by elevation and zone, that facilitate production from multiple working areas. Mining progresses upward from the lowest elevation in each block. The general levels are defined in the long-term mine plan, but selection has been redefined for operational considerations. The current block sill levels for the VOK zone are located at the 960 masl, 1080 masl, 1200 masl, and 1320 masl elevation levels.

3.5.1.3.2 Stope Cycle

The primary mining method is transverse LHOS and is based on a standard primary/secondary sequence. No permanent pillars are required, and maximum ore extraction is targeted. The secondary mining method is lateral LHOS and stopes are mined this way when they are narrower in width and continuous in the direction perpendicular to the standard crosscut development.

When the footwall drives are completed, a through ventilation circuit is established before mining begins between any two levels. Crosscuts are driven from the footwall drive, through the centre of the stope, to the far ore contact on the undercut and overcut levels. Crosscuts on both levels are supported by long support-system cables and split sets from the central access to pre-support the roof prior to full-width slashing of the entire stope footprint. The secondary stopes are not slashed to full width for ground control considerations.

Long holes are drilled with parallel holes, or in fan configurations, depending on whether the stope can be safely slashed across the entire mineralized width. Once the stope footprint is planned, a 762 mm pilot hole is drilled in the slot raise location. Production drilling follows in the raise and slot area, followed by the production rings, as drilling progresses towards the end of the stope.

The raise and slot are generally opened in five shots or less. Production blasting and mucking proceed cyclically until the stope is depleted and all ore has been mucked out. Long hole open stoping is a non-entry method, with remote mucking of blasted ore required once the draw point brow is open to the extent where the operator may be exposed to uncontrolled sloughing from the stope cavity. The empty stope is remotely surveyed with cavity monitoring equipment. A barricade is constructed in the draw point and the stope backfilled to just below the floor elevation of the top level. Crushed aggregate or run-of-mine (ROM) waste is spread over the fill surface to reduce backfill dilution and increase trafficability of mucking equipment for the next lift of the stope.

In sills and other areas where top access is not available, mining proceeds in a similar manner; however, raise development and production drilling is performed via drilling up holes from the bottom level. Figure 3.5-6 illustrates the typical LHOS design for these areas.

Longitudinal LHOS is also employed at the mine. In contrast to transverse LHOS, mining progresses along the strike of the orebody to a common access point. Where applicable, the overcut and undercut are slashed to the footwall and hanging wall contacts, although in numerous longitudinal stopes no overcut is required, and ore is extracted via upwards drilling. In all other respects, the stope cycle is similar to transverse LHOS.

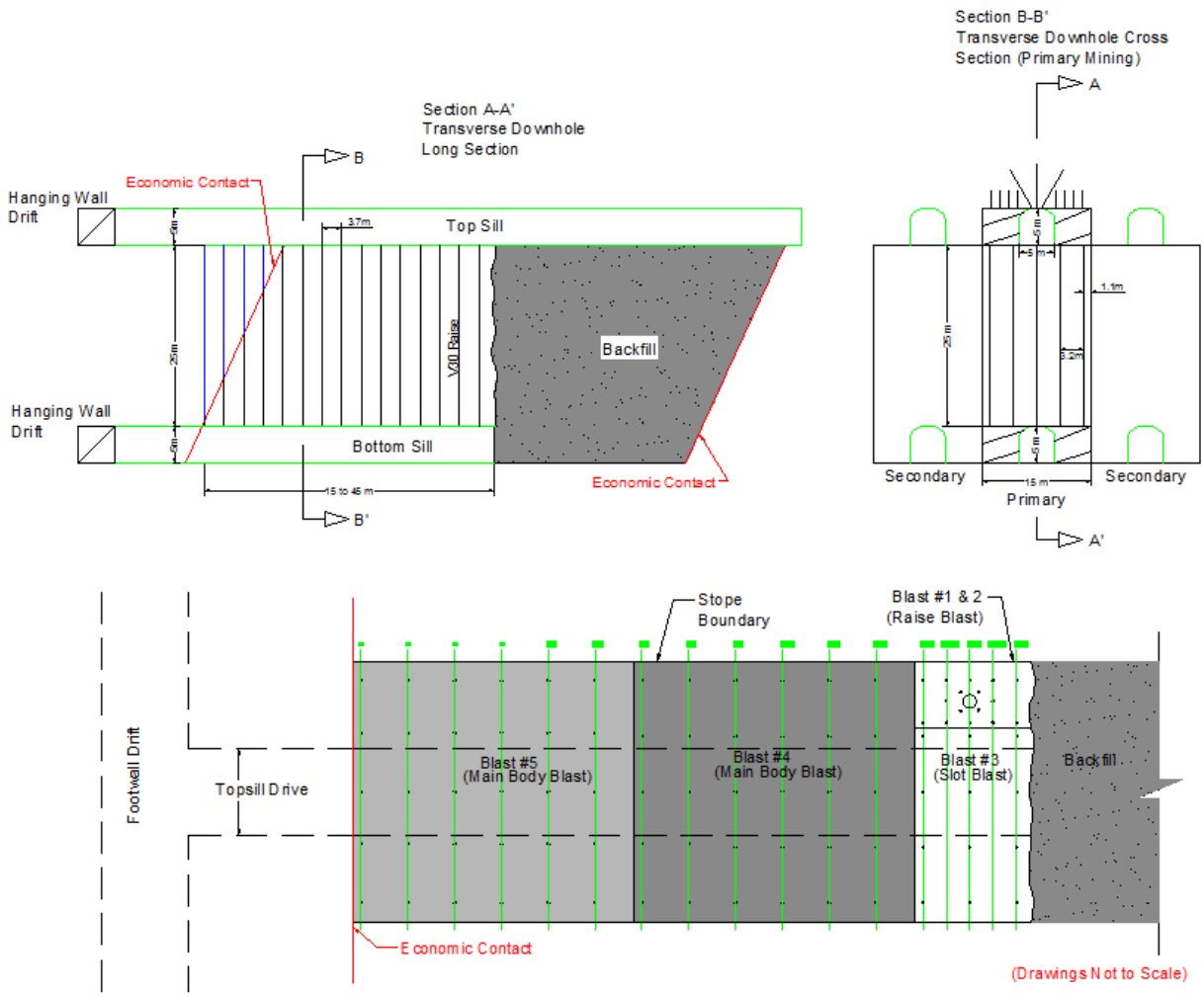


Figure 3.5-6. Typical LHOS Design.

3.5.1.3.3 Stope Sequence

The mining sequence in any area of a given block begins with extraction of the primary stopes on the first (lowest) level. Wherever feasible, the first primary stope is located near the middle of the lens to develop a pattern of stope extraction that moves outward to the extremities of the lens while progressing upward toward the top. This generally promotes a favorable redistribution of ground stress. When the adjacent primary stopes from the level above have been filled and cured, secondary stoping commences. Figure 3.5-7 illustrates typical sequencing for the more massive lenses at the mine.

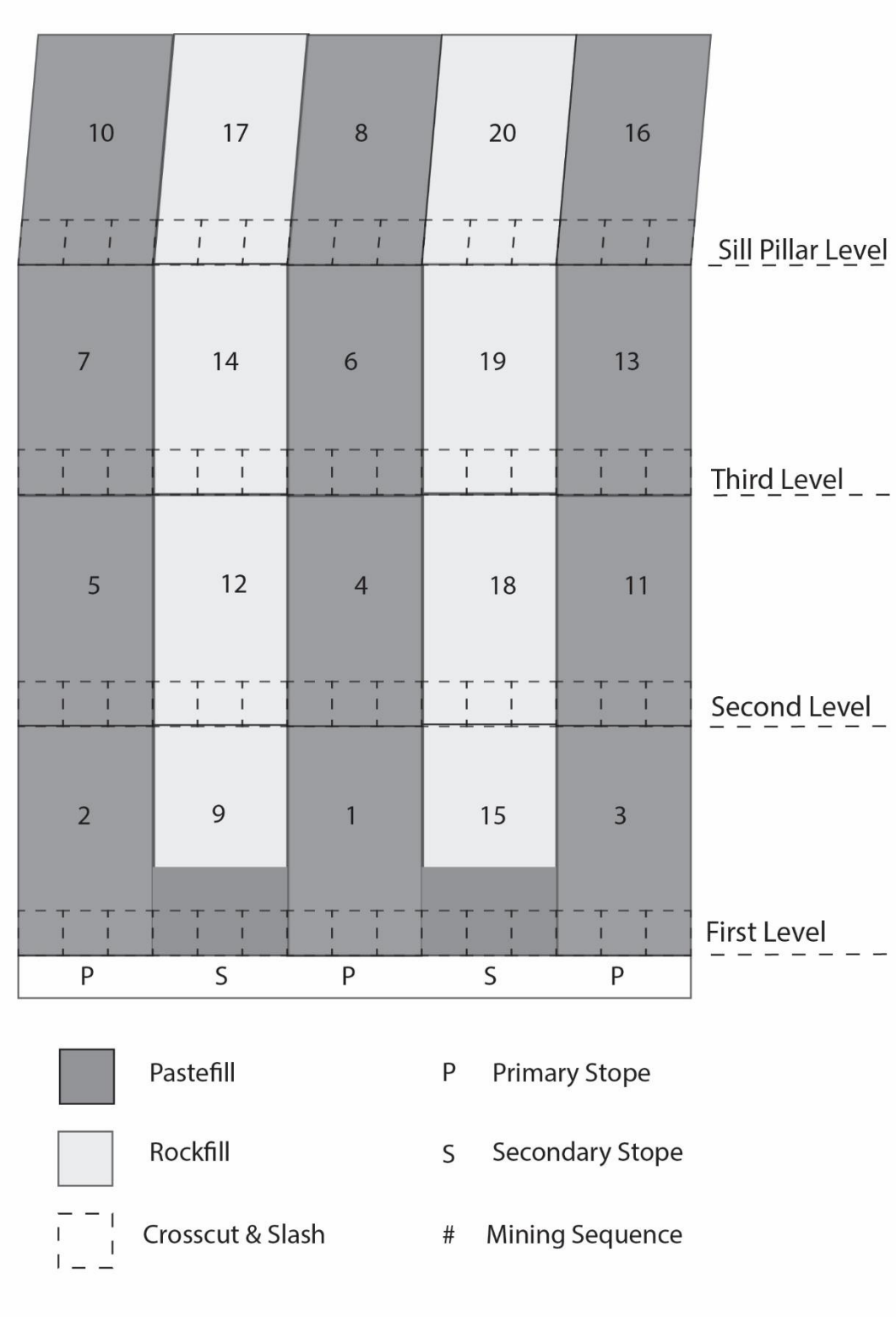


Figure 3.5-7. Example of Primary / Secondary LHOS at Brucejack Mine.

3.5.1.4 Blasting Products

Several blasting products are used in the mining process, including emulsion, cartridge explosives, primers and boosters, detonators, and detonating cord, as described in Table 3.5-4.

Table 3.5-4. Blasting Products Used at Brucejack Mine.

Blasting Product	Description	Use at Brucejack Mine
Emulsion	Water resistant and produces lower levels of ammonium nitrate in mine water. Emulsion has reliable and consistent performance and can be left for a significant period of time in blastholes before firing.	Bulk emulsion is the primary explosive product used for both lateral development and stoping at the mine.
Cartridge Explosives	Prepackaged explosives that have either emulsion or nitroglycerine-based explosives in a paper, cardboard, or plastic wrapper.	Used in lateral development or alimak raise rounds. Sometimes used for main blast holes in a development round and/or in combination with smaller diameter trim products for perimeter holes.
Primers and Boosters	Basic solid cartridge explosive products. Size of the booster varies depending on hole size and blast type.	Used in conjunction with detonators to initiate blasting agents such as emulsion.
Detonators	Basic electric and non-electric (nonel) detonation systems.	Electric detonators are typically only used to initiate a blast using a central blasting system, while nonel are used for most blasthole initiation at the mine.
Electronic Detonators	Programmable detonator delays that allow for increased blast size, precision, and promotes better fragmentation by reducing delay scatter.	Generally used for longhole stoping.
Detonating Cord	Consist of a continuous high explosive core bound by textile yarns and finished with plastic and wax as waterproofing.	Various grain strengths of detonating cord are used at the Brucejack Mine, primarily to tie nonel detonators to an initiating electric cap. Detonating cord may also be used as a trim product in perimeter holes of development rounds.
Stemming	Non-explosive crushed rock (10 to 19 mm).	Used at times to confine the explosive energy at the collar of stope blast down holes, thereby improving blasting efficiency.

3.5.1.5 Backfilling

The primary means of backfilling is paste fill generated from unclassified tailings mixed with adequate cementitious binder to meet the strength requirements of re-exposure. Regular strength paste fill is commonly required where there will be re-exposure of vertical stope walls.

Stopes that will not be re-exposed by adjacent mining are backfilled with unconsolidated waste rock and/or by paste fill with sufficient binder to remove any risk of future liquefaction (low-strength paste fill). High-strength paste fill is used in the lower portion of all primary and secondary stopes that are undercut by sill extraction from below.

Disused headings in mined-out areas below the post-closure flooding elevation are used for development waste rock disposal. The disposal of waste rock in underground stopes reduces the total void volume requiring paste backfill, and therefore reduces the quantities of tailings that are backfilled underground.

3.5.1.5.1 Backfill Management Plan

A Backfill Management Plan (Appendix 3-3) has been developed and implemented for the Brucejack Mine in accordance with M-243 Condition C.2(f). The plan addresses paste and waste rock fill practices, including:

- Backfill preparation, pour, and monitoring safe work procedures;
- Paste bulkhead design;
- Tight fill procedures;
- Paste mix designs for various types of spills;
- Paste emergency procedures;
- Line flushing procedures;
- Paste pipeline pressure monitoring procedures; and
- Paste quality control procedures.

Standard operating procedures regarding the mine's backfill practices are provided as appendices to the Backfill Management Plan.

The general paste distribution principals required for long hole open stoping are not expected to change with the proposed increase in ore production rate; however, Pretium expects that higher through-put from the paste plant will be required to ensure timely filling of stope voids. The Backfill Management Plan and current paste pump and reticulation network will be reviewed by a qualified third party and updated as required to facilitate the proposed production increase.

3.5.1.5.2 Paste Backfill Distribution

The paste fill distribution system transports paste from the surface plant to the underground stopes via pipeline. The mine currently operates the system at a nominal flow rate of 100 m^3/h. Typically, the paste is pumped in the range of 63% to 67% solids, with cement ratios between 4.3% and 11% depending on stope strength requirements.

A positive displacement pump in the surface paste fill plant provides paste to the lower zones of the VOK zone below the 1380 Level. The paste plant pump also feeds a booster pump located at the 1345 elevation near the VOK zone. This booster pumps paste to the upper VOK zone (1380 Level and above). The underground booster pump station houses the positive displacement pump, the pump hopper, a water tank with a high-pressure pump for pipeline flushing and pump hydraulic packs.

The schedule of the pipe varies with the pressure rating of the area. Victaulic couplings are used as the connection method.

Instrumentation for controlled operation includes 10 permanent pressure gauges, three permanent cameras, automated diversion valves at the sumps, and integrated process control with the paste fill plant.

3.5.1.6 Ore Handling

3.5.1.6.1 Mucking

Once blasted from either stope development headings or long hole blasts, ore is trammed by conventional diesel or battery powered LHD from the muck pile to a haul truck or a remuck bay. The remuck bays allow for surge and grade blending capability near the crusher. The LHDs used in stope mucking are equipped with remote control capabilities to remove open stope hazards to the operator. Development and production LHDs are in the 14 to 18 t (8 to 10 yard) class. Haul trucks transporting ore to the crusher ROM bin or remuck bays are either 30 t diesel or 50 t battery powered.

3.5.1.6.2 Truck Dump and Crusher

At the scalping grizzly, material smaller than 600 mm falls through to the ore bin and larger material is broken down by a hydraulic rock breaker stationed above the grizzly screen. Figure 3.5-8 shows a sectional projection through the coarse ore bin with the rock breaker and scalping grizzly. The rock breaker has the capability to be operated from a sound attenuated operator's compartment or remotely from the crusher operating room via video link.

The ore bin feeds material down through a hopper at the bottom of the bin to an apron feeder. The jaw crusher reduces the larger material to 100 to 120 mm size and drops the product down the fines chute to the crusher belt conveyor. Figure 3.5-9 shows an isometric view of the crusher feed and crusher.

The crusher conveyor transports ore from the crushing area to the intermediate conveyor. During ore transport on the conveyor, tramp iron is collected by magnet and deposited into a steel waste bin. The first main conveyor transports the ore up the VOK decline to the transfer station and to the second main conveyor. The second main conveyor exits the decline into the portal structure, where the ore is dropped onto the mill feed conveyor. From the portal structure, the ore is carried to the mill through an elevated, heated and enclosed gallery to the top of the mill fine ore surge bin.

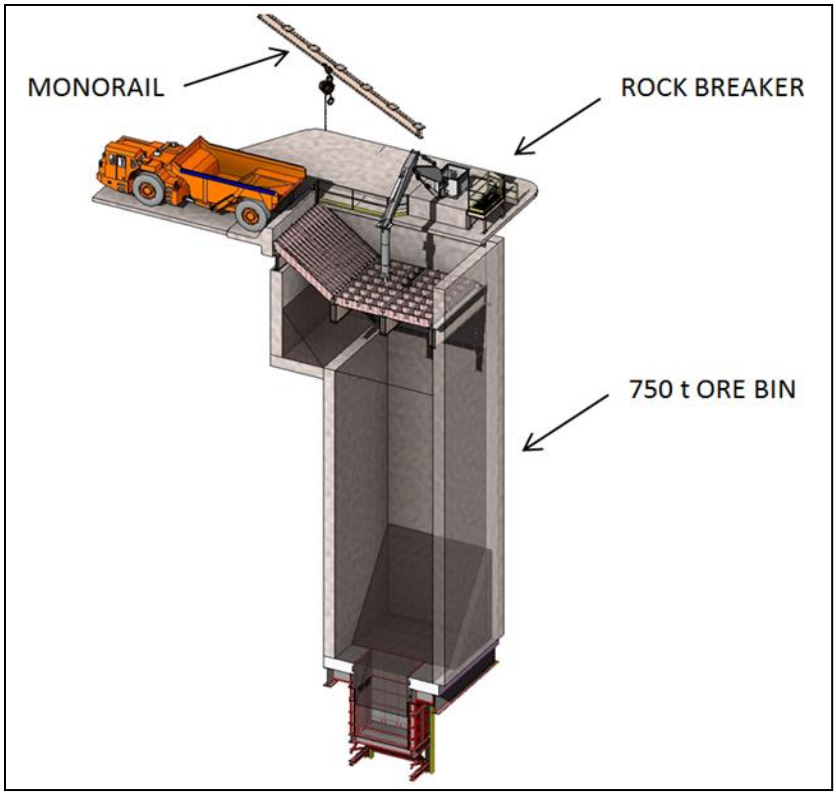


Figure 3.5-8. Truck Dump and Ore Bin Sectional Projection

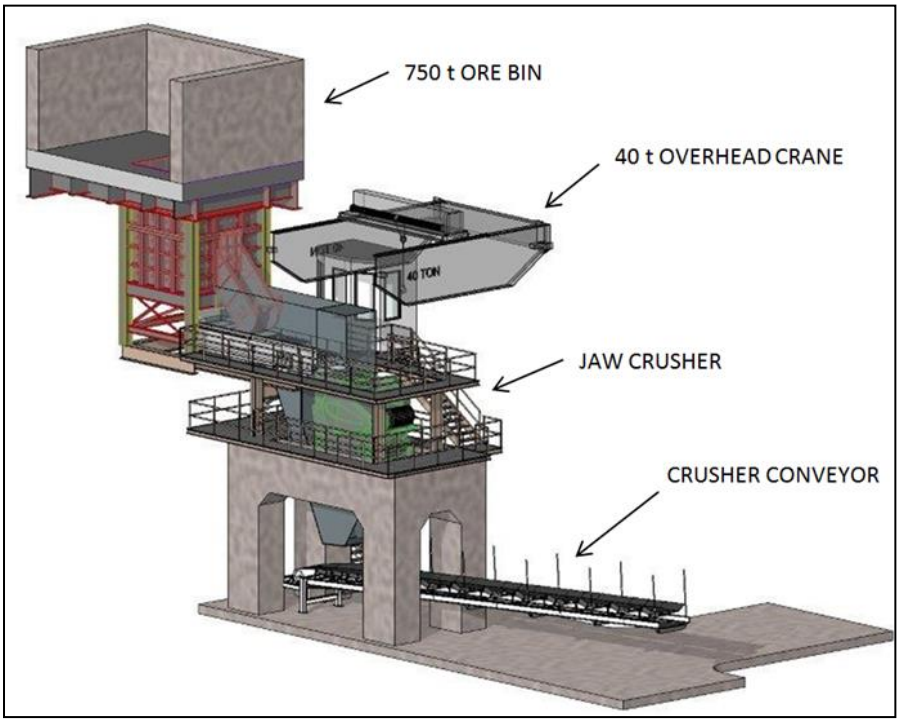


Figure 3.5-9. Crusher Feed and Crusher Isometric View.

3.5.1.7 Operations Mobile Equipment

Table 3.5-5 summarizes the quantity and types of mobile equipment currently in use in the Brucejack underground mine. The optimal fleet capacity for the increased throughput is currently under evaluation. Pretium anticipates upgrading the haul truck fleet size from eight to a minimum of 11 for the proposed production increase and will operate predominantly 50 t BEVs. An additional electric LHD is also anticipated for the proposed production increase to 4950 tpd. Pretium is planning for all new haul trucks to be battery electrics vehicles.

Table 3.5-5. Underground Mobile Equipment.

Equipment	Total[1]	Description
Two Boom, Electric / Hydraulic Jumbo	4	Used to drill lateral face rounds for both ore and waste headings. Electric/hydraulic bolters are used to install primary ground support in the ribs and back of development headings.
Single Boom Jumbo	1	
10 YD diesel powered LDH	1	Used to muck, tram, dump, and load both ore and waste into haul trucks.
8 YD diesel powered LHD	9	
3.5 YD diesel powered LHD	1	
30 tonne diesel powered haul truck	9	Used to transport both ore and waste. Planned to replace diesel powered equipment.
50 tonne battery electric truck	3	
Top Hammer Long Hole Drill	3	Production drilling is primarily completed with top hammer drills and ITH hammer drills. Some of the ITH drills can be fitted with V30 heads to drill the slot drop raises. The ITH drills are also used for level-to-level raises and utility holes.
ITH Long Hole Drill	2	
ITH Longhole Drill RC	5	
Explosives loader, diesel, emulsion (development face charger)	2	Load both development and production blast holes with emulsion and detonators. The loaders are equipped with appropriately constructed and separated compartments for carrying the emulsion, detonators, detonating cord, and boosters. The loaders are equipped with auto-retracting loading hoses.
Explosives loader, diesel, emulsion (production blasting)	1	
Shotcrete sprayer	1	Used to apply wet-type shotcrete on an as needed basis.
Transmixer	2	Equipped with a cement mixing drum transport shotcrete from the batch plant to the sprayer.
Emulsion Hauler and carriers	3	Used to transport bulk emulsion from surface to storage tanks in the underground magazines. The truck transports up to its 17,000 kg capacity of emulsion in custom ISO tanks to the underground storage tanks. The emulsion is pumped from the ISO tanks to the 21,000-L storage tanks. The carriers are used to transport emulsion from the emulsion storage to the development faces and stopes for loading.
Scissor Lift	6	Used to allow miners to work safely at height while installing utilities such as pipe and power cables. Scissor lifts are equipped with levelling jacks to provide a stable platform.
Personnel transport	48	Include diesel powered Kubota rough terrain vehicles, tractors equipped with additional seating, and dedicated crew carriers.
Misc. Support Utility and Telehandlers	16	Mechanics' lube trucks equipped with lubricant/fuel storage, and onboard air compressors for servicing equipment. A motor grader equipped with a low-profile cab and 12-foot long mold board is used to maintain underground roads.
Boom Truck	7	Flat deck trucks with onboard boom cranes are used to transport mining supplies from surface to underground storage/working areas. The boom trucks are equipped with outrigger jacks for stability.
Electric/hydraulic Maclean Bolter	6	Used to install cable bolts in the stope backs and in development intersections, as required. Bolters are used to drill the holes, then cables are installed manually, and grout is pumped into the hole containing the cable. Cable bolts are 6 to 12 m lengths.
Tamrock Bolter	1	

1. *Numbers in use as of 2022 to support 3800 tpd production rate. Additional BEV mobile equipment is expected to support the production increase.*

3.5.1.8 Ventilation

The ventilation system is designed to meet requirements in the Health, Safety and Reclamation Code for Mines in British Columbia (the Code) (EMLI 2022). The total ventilation requirements for mine operations are based on the airflow required for the diesel-powered mobile equipment fleet, underground fixed facilities and a leakage and balancing factor. The current total airflow requirement for the Brucejack Mine is as follows:

- Diesel equipment: 345 m^3/s
- Fixed facilities: 55 m^3/s
- Leakage and balancing (10%): 40 m^3/s
- Total – 440 m^3/s

All diesel-powered equipment operating underground is fitted with Canada Center for Mineral and Energy Technology certified engines or cleaner tier 4 engines. Additional air is supplied for fixed facilities and a leakage and balancing factor.

The ventilation design is based on a “push” configuration, with permanent surface fans and air heaters located at the WZ and VOK portals. These two intake airways provide sufficient ventilation capacity to support steady state mining operations. The VOK production ramp is connected to the intake ramps to deliver fresh air to the active production levels. An escape-way ladder system is installed in fresh air raises in parallel with the production ramp.

Fresh air travels from the production ramp, along the footwall drives and is exhausted to return air raises located at the extremities of the level. There are four exhaust raises to surface, with VR5 scheduled for development in 2025. Regulators are installed at the raise connections to distribute the required volume of air to the level. An appropriately designed auxiliary fan and duct system forces fresh air to development headings and active stope faces.

The underground fixed facilities have a dedicated return air raise to eliminate the introduction of dust and other unwanted contaminants into the production areas. The volume of air flowing through the crusher area is controlled with a combination of fans and regulators. Figure 3.5-10 shows an isometric view of the Brucejack ventilation system. Additional details regarding the mine’s ventilation systems are provided in the Production Ventilation Plan (Appendix 9-2-10).

The additional mobile equipment required to accommodate the proposed production rate increase are planned to be BEVs (Section 3.5.1.7). Therefore, no further changes beyond the installation of VR5 are required for the proposed 4950 tpd mine plan.

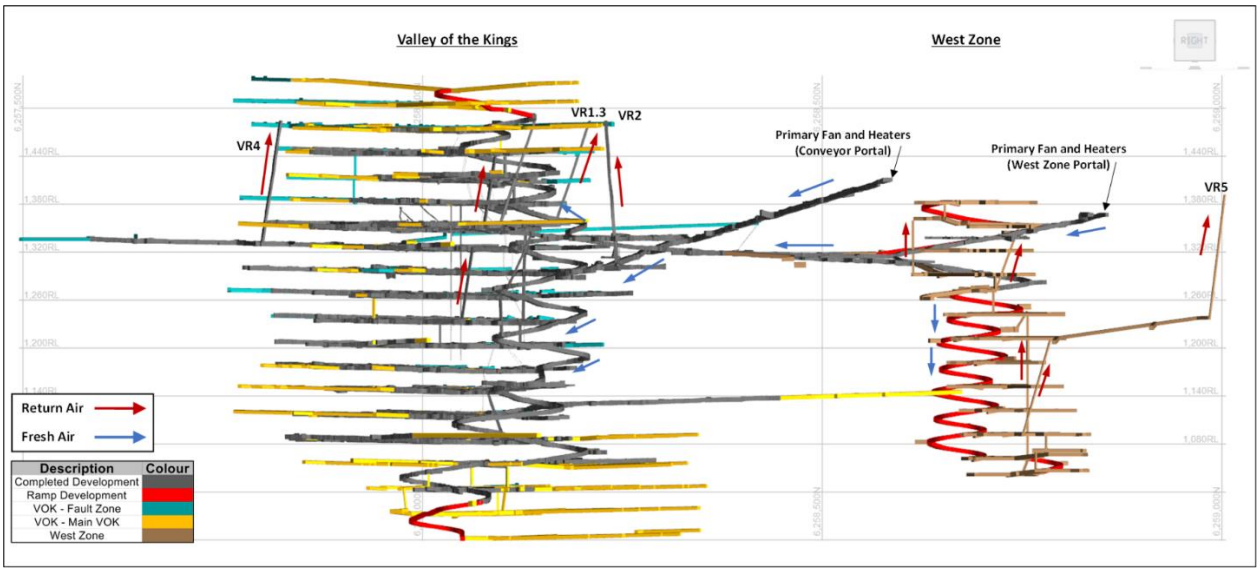


Figure 3.5-10. Brucejack Mine Underground Ventilation System – Looking West

3.5.1.8.1 Primary Fans

For operational flexibility over LOM, the primary fans include a variable frequency drive and adjustable pitch blades. The fans and motors can deliver the required duty to meet the demands of the production and development activities over the current LOM. Summary specifications of the primary fans are provided in Table 3.5-6.

Table 3.5-6. Primary Fans – Summary Specifications

Description	Specification
Fan Diameter	2.4 m
Type	Horizontal mount axial mine fan. Adjustable pitch blades.
Configuration	Two forcing fans, each connected with ducting to the WZ decline and conveyor decline (VOK portal)
Voltage	600V
Fan Motor	600 kW to 900 revolutions per minute, variable frequency drive capability

3.5.1.8.2 Mine Air Heating

The heating system is designed and installed as per the Code requirements (EMLI 2022). All intake air entering the mine is heated above the freezing point for the following reasons:

- to protect the health and safety of personnel working or travelling in intake airways;
- to prevent the freezing of service water and discharge lines;
- to ensure reliable operation of conveying and other mechanical equipment in the decline;
- to maintain ice-free and safely trafficable roadways;

- to prevent rock surface (or shotcrete lining) expansion/contraction damage from freezing and thawing of rock joints in the upper parts of the intake airways; and
- to prevent ice build-up in airways that would potentially lead to unsafe conditions.

Mine air heaters are positioned in front of permanent primary fans. Four MWs (two MWs per fan) of electrical heaters are installed as the primary heating method. Propane heating is installed to augment the electrical heating in extreme cold conditions.

3.5.1.8.3 Auxiliary Ventilation

All work areas, such as development headings and drawpoints not supplied with a direct flow of fresh air using auxiliary systems. The auxiliary systems consist of axial fans and flexible ducting. The fan power and duct size are specified to provide the required amount of air for each activity. Figure 3.5-11 shows a ventilation configuration for a typical production level with auxiliary fans ventilating active areas.

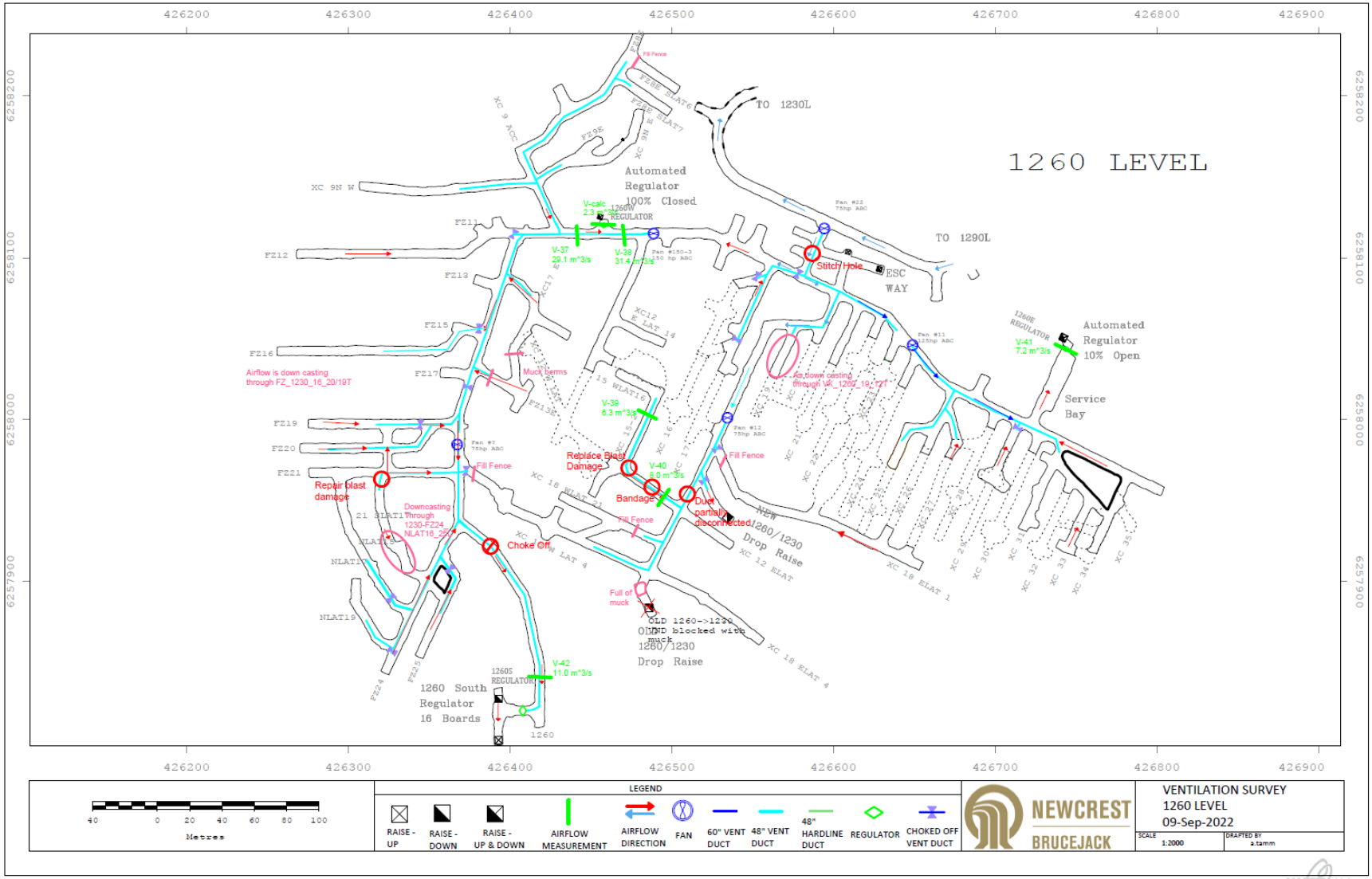


Figure 3.5-11. Ventilation Configuration for Typical Production Level.

3.5.1.9 Geotechnical Assessment and Ground Control

3.5.1.9.1 Geotechnical Design Basis

Initial site investigations and geotechnical assessments that continue to inform mine planning and design were completed by BGC Engineering Inc. and Pretium personnel. These initial assessments included:

- Geological and geotechnical drilling and logging;
- Borehole televiewer surveys;
- Rock core and discontinuity laboratory testing;
- Groundwater pressure monitoring;
- Rock mass and mechanics characterization;
- Structural geology interpretation;
- Geotechnical mapping; and
- Excavation and pillar stability analyses.

A comprehensive presentation of the assessment data is presented in BGC (2013) and summarized in the Ground Control Management Plan (GCMP) (Appendix 9-2-4). The geotechnical performance of excavations in the existing mine are reviewed regularly, with updates to the GCMP completed annually by Pretium. No changes to the geotechnical design basis are anticipated to accommodate the proposed production increase.

3.5.1.9.2 Ground Control Management Plan

The Brucejack GCMP is the authoritative record of data, information, and systems used to manage ground control at the mine. The key objectives of the plan are to reduce and / or mitigate the risks of uncontrolled ground failure and contribute to the development and maintenance of a safe and productive mining environment.

These objectives are achieved through:

- Clear definitions of ground control roles and responsibilities for key individuals;
- Ongoing assessment of the mine's geotechnical conditions, and evaluation of ground control risks;
- Design and implementation of ground control management systems;
- Development of standard operating procedures that address ground control issues;
- Communication of ground control matters and hazards within the workforce;
- Ground monitoring systems, and ground support testing;
- Internal and external auditing; and
- GCMP review, and scheduled updating.

The Brucejack GCMP is provided in Appendix 9-2-4. No changes to the Ground Control Management Plan are anticipated to accommodate the proposed production increase.

3.5.1.10 Subsidence Potential

A preliminary assessment of subsidence potential was completed by BGC Engineering Inc. (BGC 2013). Site-specific conditions and factors affecting the potential for subsidence indicate a very low probability that noticeable subsidence will occur. The two potential subsidence mechanisms identified at the Brucejack Mine are crown pillar failure and plug failure, both of which are mitigated by tight placement of cemented pastefill in the mined-out stopes and the installation of cable bolts in the upper stopes to reinforce the crown pillar. The preliminary assessment (BGC 2013) is appended to the Subsidence Monitoring and Management Plan prepared by SRK Consulting Inc. in 2020 as per MA-243 Condition D.13 (Appendix 9-2-8).

3.5.2 Processing Plant (Mill Building) and Associated Facilities

3.5.2.1 Overview

The process plant produces a gold and silver bearing flotation concentrate, and gold and silver doré from melting the gravity concentrate produced from the gravity concentration circuits. The final flotation concentrate is dewatered and removed offsite by ground transport. The gravity concentrate is smelted in the gold room on site to produce gold-silver doré. The process plant is designed to operate two 12-hour shifts per day, 365 days per year. The gold room is scheduled to be operated during day shifts only.

A portion of the flotation tailings is used to produce paste for backfilling excavated stopes in the underground mine, with the remaining balance deposited subaqueously in the WRTSF. Tailings are thickened prior to deposition in the WRTSF or use in paste backfilling, and the water from the tailings thickener overflow is recycled within the mill building as process make-up water. Treated water from the WTP is used for mill cooling, gland seal service, reagent preparation, and make-up water.

3.5.2.2 Process Flowsheet

The process flowsheet developed for the Brucejack mineralization is a combination of conventional bulk sulphide flotation and gravity concentration to recover gold and silver, and consists of the following:

- Primary crushing underground;
- Conveying system for crushed ore;
- A surge bin with a live capacity of 3,300 t on surface;
- Grinding and gravity concentration;
- Rougher/scavenger flotation;
- Cleaner/scavenger flotation;
- Gravity concentrate smelting to produce doré;
- Flotation concentrate dewatering, and load out; and
- Tailings thickener and disposal to the WRTSF or to the underground mine for paste backfilling.

A simplified flowsheet for the operation at 4950 tpd is shown in Figure 3.5-12.

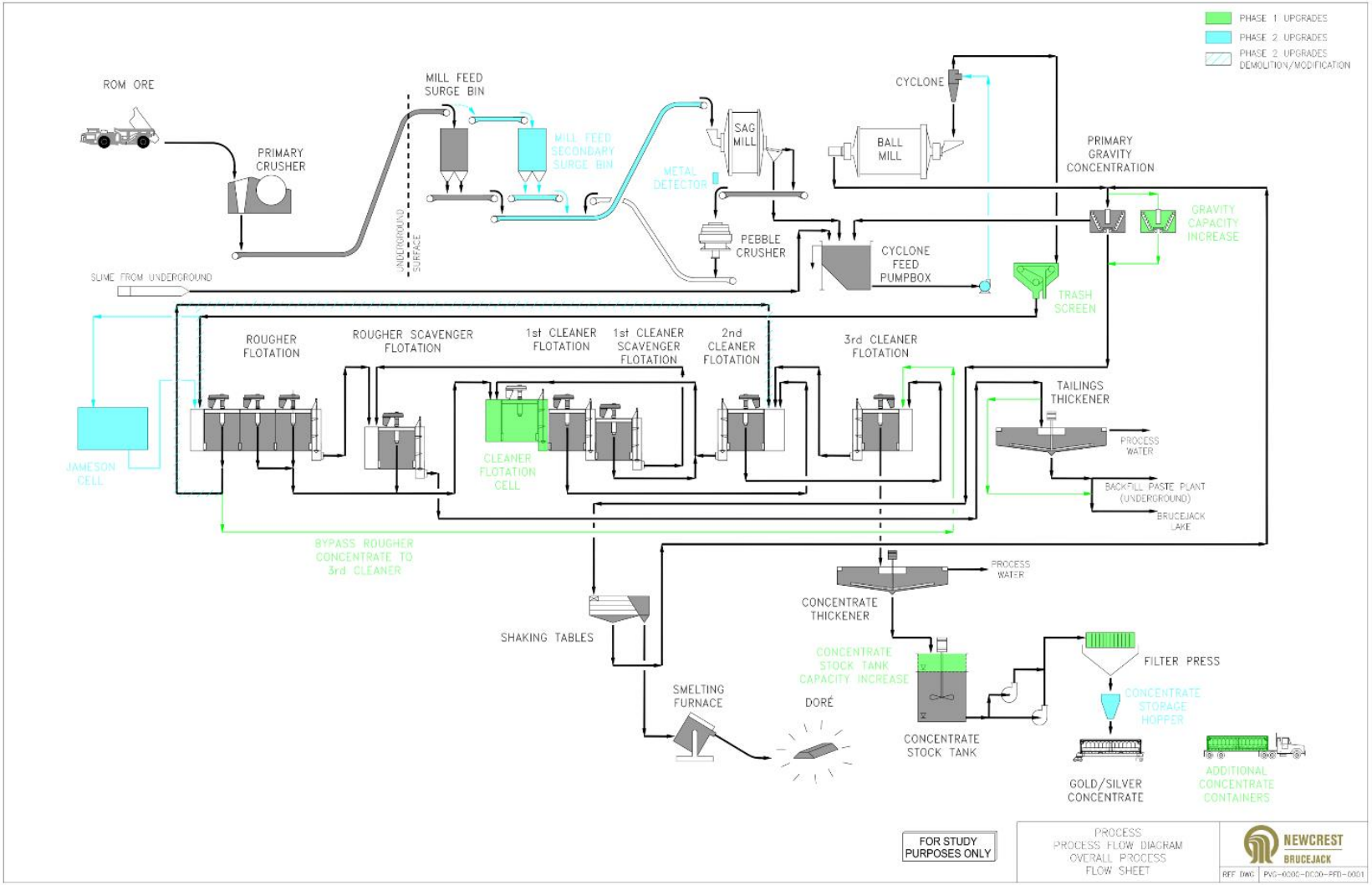


Figure 3.5-12. Simplified Process Flowsheet at 4950 tpd.

To facilitate the production increase from 3800 tpd to 4950 tpd, the following upgrades to the mill are anticipated:

- Grinding circuit: increasing cyclone feed capacity and associated piping; increasing belt conveyor capacity
- Gravity separation/concentration: upgrading gravity feed pump capacity, splitter box, , and an additional safety screen and Knelson concentrator
- Flotation: pre-flotation trash screen installation, rougher concentrate to cleaner flotation bypass, flotation circuit pump upgrades, and a new rougher cell
- Tailings circuit: thickener bypass to tailings disposal tank, and thickener underflow pump upgrade

These upgrades will be completed within the existing mill structure and will not require additional surface disturbance.

3.5.2.3 Process Plant Description

3.5.2.3.1 Primary Crusher (Underground)

The primary crushing facility is located underground. The major equipment and facilities for the underground primary crushing facility include a hydraulic rock breaker, a stationary grizzly, a jaw crusher (150 kW), an apron feeder, associated dump pocket and belt conveyor, belt scales, and a dust suppression system.

The particle size of the jaw crusher feed is typically less than 500 mm. The jaw crusher reduces the ROM material to 80% passing 100 to 120 mm. A rock breaker is installed to break any oversize rocks at the stationary grizzly prior to the jaw crusher.

The crushed product is transported by a conveyor system from the underground primary crushing facility to the semi-autogenous grinding (SAG) mill feed surge bin located on surface. The primary crushing and conveying facilities are equipped with dust suppression systems to control fugitive dust generated during crushing and conveyor loading. The crushing and conveying system are monitored by closed-circuit television and can be controlled from the process central control room located in the process plant.

3.5.2.3.2 Mill Feed Surge Bin

Crushed product from the underground primary crushing facility is conveyed to the transfer tower and then further transported to the SAG mill feed surge bin. The transfer tower, located within the portal building, receives crushed material from the underground primary crushing facility and transfers the ore onto the surge bin feed conveyor system.

Ore from the mill feed surge bin is reclaimed by two apron feeders onto the SAG mill feed conveyor. The stocking and material handling system for the crushed ore includes jaw crusher discharge belt conveyors, a transfer tower located in the portal building, a belt conveyor to feed the SAG mill feed surge bin, a mill feed surge bin, two apron feeders, and local dust collection systems. Each of the

crushed ore transfer points is equipped with a dust collection or suppression system to control fugitive dust that is generated while transporting the crushed material.

3.5.2.3.3 Primary Grinding, Classification, and Primary Gravity Concentration

A SAG mill/ball mill circuit is used for primary grinding. The circuit is equipped with two centrifugal gravity concentrators that recover gold/silver grains that are liberated or partially liberated from their host minerals. The grinding circuit consists of a SAG mill and a ball mill in a closed circuit with classifying hydrocyclones and a centrifugal gravity concentrator. Grinding is conducted as a wet process.

The grinding/gravity concentration circuit currently includes:

- One SAG mill driven by a variable frequency drive (VFD);
- One ball mill powered by a VFD;
- Two hydrocyclone feed slurry pumps;
- Six hydrocyclones;
- Two centrifugal gravity concentrators and ancillary screens;
- Pebble crusher, powered by a fixed drive;
- One particle size analyzer; and
- Five online samplers.

Crushed ore from the surge bin is reclaimed onto a set of belt conveyors that feeds ore to the SAG mill. The SAG mill is equipped with pebble ports to discharge oversize pebbles from the SAG mill, and the SAG mill discharge is screened by an external vibrating deck. Oversize material from the vibrating screen is transported by belt conveyors to a pebble crusher (or bypass) that discharges back onto the SAG mill feed belt, while undersize is discharged by gravity to the hydrocyclone feed pump box in the grinding circuit.

The ball mill operates in a closed circuit with hydrocyclones and two centrifugal gravity concentrators. The product from the ball mill is discharged into the gravity concentrator feed pump box. The entire ball mill discharge reports to the gravity concentration circuit. The stream is split in two and each stream feeds a safety screen with the undersize reporting to the centrifugal gravity concentrator. The gravity concentrator tailings reports to the hydrocyclone feed pump box, where it is pumped to the hydrocyclones. The gravity concentrator tailings are combined with the SAG mill vibrating screen undersize slurry. The blended slurry in the pump box is pumped to the hydrocyclones for classification. The hydrocyclone underflow returns by gravity to the ball mill. Steel balls are manually added into the mills on a batch basis as grinding media.

The gravity concentration process recovers gold particles from the ball mill discharge. Tailings from gravity concentration return to the hydrocyclone feed pump box for pumping. The gravity concentrate transfers by gravity to the gold room for further upgrading by tabling. Tailings from the tabling are further processed by a centrifugal concentrator in the gold room. The concentrate produced from the centrifugal concentrator is recycled back to the tabling circuit while the tailings transfer by gravity to the gravity concentrator feed pump box. The concentrate from the tabling circuit is further upgraded by smelting

using an electric induction furnace at site. The gravity concentration circuit has a security enclosure and CCTV cameras, and access is restricted to authorized personnel only.

Dilution water is added to the grinding circuit as required. A particle size analyzer monitors the particle size of the hydrocyclone overflow, in conjunction with an automatic sampling system and required instrumentation such as solid density, pressure, and flow rate meters.

To facilitate the increased production rate, a third centrifugal gravity concentrator and ancillary safety screen will be installed. Discharge from the ball mill be split between three stream feeds to the gravity concentration circuit.

3.5.2.3.4 Rougher and Scavenger Flotation

The pulp from the primary grinding circuit is subjected to conventional flotation to recover the free gold, silver, and their bearing minerals from the materials being processed. Flotation reagents are added to the flotation cells as defined through testing. The flotation reagents include potassium amyl xanthate as the collector and a proprietary frother blend. Concentrates produced from the rougher flotation circuit are pumped to the cleaner flotation circuit. The rougher flotation tailings are further processed by rougher scavenger flotation, along with the tailings from the cleaner scavenger flotation cells. The rougher scavenger concentrate is pumped with the rougher concentrate to the cleaner flotation circuit. Rougher and scavenger flotation is carried out at the natural pH level (without slurry pH adjustment). The rougher/scavenger flotation circuit consists of four 100 m^3 rougher flotation tank cells and two 100 m^3 scavenger flotation tank cells.

Tailings from the flotation circuit are transfered to the tailings thickener. Depending on the mining operation requirement, the thickener underflow is pumped to the paste backfill plant for excavated stope backfilling underground and/or to the WRTSF for subaqueous deposition. Automatic sampling systems collect samples required for process optimization and metallurgical accounting.

An additional rougher flotation cell will be added to accommodate the production increase.

3.5.2.3.5 Cleaner Flotation

The rougher and rougher scavenger flotation concentrates undergo three stages of cleaning by flotation to produce a final gold-silver bearing concentrate.

The major equipment in the cleaner flotation circuit includes:

- Four 15 m3 tank cells for the first cleaner flotation;
- Two 15 m3 tank cells for the first cleaner/scavenger flotation;
- Two 15 m3 tank cells running in parallel for the second cleaner flotation; and
- One 30 m3 tank cells for the third cleaner flotation.

The rougher and rougher scavenger concentrate is initially upgraded in the first cleaner tank cells. The resulting concentrate is pumped to the second cleaner circuit, while the tailings report to the cleaner scavenger flotation cells for further flotation. The cleaner scavenger flotation concentrate is recycled to the head of the first cleaner flotation cell bank together with the tailings from the second cleaner

flotation. The first cleaner scavenger flotation tailings are pumped to the rougher scavenger flotation feed box.

The concentrate from the second cleaner flotation stage is further upgraded by the third cleaner flotation, and the second cleaner tailings are pumped to the first cleaner flotation. The concentrate from the third cleaner flotation cells, which is the final concentrate, is pumped to the concentrate thickener. The third cleaner tailings are recycled back to the head of the second cleaner flotation circuit.

Reagents used in the primary bulk flotation circuits are added to first stage of cleaner flotation to float the target minerals. The cleaner flotation process is carried out at the natural slurry pH level.

3.5.2.3.6 Flotation Concentrate Handling

The concentrate from the third cleaner flotation is thickened, filtered, and loaded into bins prior to being transported to an off-site smelter(s). The concentrate handling facility has the following equipment:

- One high-rate thickener;
- Two peristaltic (hose) slurry pumps;
- One concentrate filter feed stock tank;
- One Larox pressure filter; and
- One bulk concentrate handling system.

The final flotation concentrate is pumped to the concentrate thickener. Flocculant is added to the thickener feed well to aid the settling process. The thickened concentrate is pumped to the concentrate stock tank. The concentrate stock tank is an agitated tank, which serves as the feed tank for the concentrate filter. A tower-type pressure filter is used for further concentrate dewatering. The filter press reduces the approximate moisture content of the thickener underflow to between 6 and 9%. The filter press solids are discharged through a surge bin and into a concentrate container. The concentrate containers are transported by ground to Stewart, BC for export.

The filtrate from the pressure filter is circulated back to the concentrate thickener feed as well as dilution water. The overflow from the concentrate thickener is pumped to the first rougher flotation cell.

3.5.2.3.7 Gravity Concentrate Upgrading and Smelting

The gravity concentrates produced from the primary grinding circuit are upgraded by conventional tabling followed by smelting to produce gold-silver doré.

Key equipment installed in the gold room includes:

- Two gravity concentration tables—one for the primary centrifugal gravity concentrate, and one for the secondary centrifugal gravity concentrate;
- Three concentrate storage bins;
- One secondary centrifugal gravity concentrator with concentration bowl;

- One table concentrate drying oven;
- Flux reagent storage;
- Flux mixer;
- Induction melting furnace;
- Off-gas and dust scrubbing system; and
- Ancillary equipment, including doré cleanup station.

The centrifugal gravity concentrate from the primary grinding circuit transfers by gravity to a holding bin. The holding bin collects gravity concentrate over a 24-hour period. After 24 hours, the stored concentrate is transferred by gravity to the primary shaking table. The concentrate from the table is dewatered, dried in a drying oven, weighed and stored in the vault prior to smelting. The tabling middling products are recycled back to their respective table feed stock bins. The table tailings are pumped to a secondary centrifugal gravity concentrator located in the gold room. The concentrate from the secondary centrifugal gravity concentrator reports to the secondary tabling storage bin. The secondary concentrator operates only while the shaking table is operating. The secondary storage bin is then transferred to the shaking table every three to five days. Tailings from the primary gravity concentrators is transferred by gravity to the hydrocyclone feed pump box. Tailings from the secondary gravity concentrator is transferred by gravity to the gravity concentrator feed pump box.

The dried tabling concentrate is mixed with flux, which consists of borax ($Na_2B_4O_2$), sodium nitrate ($NaNO_3$), silica sand (SiO_2), soda ash ($NaHCO_3$), and manganese dioxide (MnO_2). The concentrate and flux mixture is charged into an induction furnace and melted at approximately 1,300°C. The metal melt and slag is poured into bar molds in a cascade-casting arrangement. The doré bar is sampled while molten, cooled (with water), dried, cleaned (using hand power tools), weighed, stamped, and stored in the vault prior to being shipped to refiners.

The slag from the melting is crushed by a small jaw crusher and sampled. The remaining slag is stored at site for up to three months and transported off site to a precious metals recovery center.

A wet scrubbing system is used to ventilate and clean the off-gas generated during the flux mixing and melting operation. Sufficient ventilation is provided in the gold room to protect the operators. All clothes, gloves, and other safety equipment necessary for high-temperature protection is provided to the operators working in the secure area.

3.5.2.3.8 Flotation Tailings and Water Treatment Plant Sludge Management

The flotation tailings from the flotation circuit are dewatered using a high-compression-type thickener prior to being pumped either to the paste backfill plant for underground backfilling or to the WRTSF for subaqueous deposition. Sludge from the WTP is pumped to the tailings disposal stock tank where it is mixed with the thickened tailings prior to being pumped to the WRTSF for sub-aqueous deposition. Figure 3.5-13 shows the tailings and the sludge management flowsheet.

Flotation tailings from the flotation circuit are produced at a solids density of approximately 28% w/w. The flotation tailings are pumped to the tailings thickener feed well where an anionic flocculant is added to assist dewatering performance. Solid flocculant is prepared in a standard manner in a wetting and mixing system into a dilute solution prior to being dosed into the thickener feed well at a controlled rate. The thickening process currently dewaters the tailings to a solids density

at approximately 60 to 70% w/w. The overflow from the thickener is recycled to the mill process circuits as process water.

Depending on the backfill operating schedule, the thickened tailings are pumped either to the backfill plant to produce paste for underground mine backfilling or to the WRTSF for subaqueous deposition.

The intake water from the underground mine and the water from the CWP are pumped to the WTP. After treatment, the treated water is used as mill fresh water or discharged to the WRTSF. Approximately 65% of the process water used is recycled from the WTP. The WTP sludge is pumped to the tailings disposal surge tank, where it is mixed with thickened tailings prior to being pumped to the WRTSF for sub-aqueous disposal.

When the backfill plant is in operation, the tailings thickener underflow is pumped to a thickened tailings stock tank. The thickened tailings from the stock tank are blended with cement and water in a paste mixer to generate paste backfill. The paste is pumped to the excavated underground stopes for backfilling.

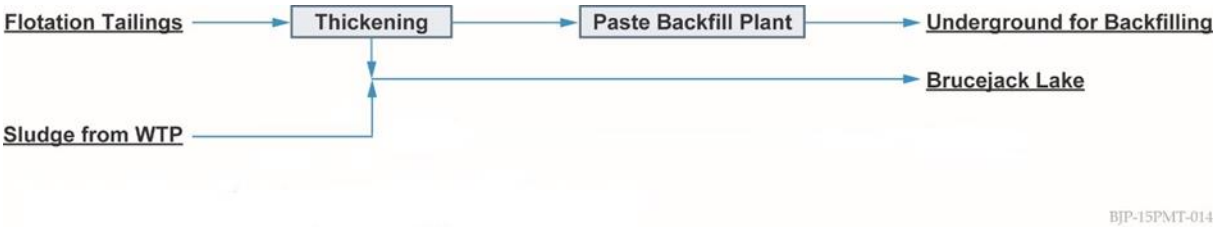


Figure 3.5-13. Flotation Tailings and Water Treatment Plant Sludge Management Flowsheet.

3.5.2.4 Tailings Disposal

The final tailings from the flotation circuit are thickened prior to being pumped either to the backfill plant for underground disposal or to the WRTSF for subaqueous deposition. The tailings handling equipment and facility components include a cone thickener with associated pumps, a mixing tank for tailings discharged to the WRTSF, a backfill plant to produce tailings paste for underground backfilling (including a tailings storage tank), and two paste slurry pumps and associated pipelines.

Control measures within the operation of the tailings system include on-line instrumentation coupled with technicians to oversee the operation and maintenance of the instrumentation and automation systems. Visual observation of operating conditions and manual checks to ensure instruments are functioning properly is closely aligned.

3.5.2.5 Assay and Metallurgical Laboratories

The assay laboratory, located within the mill building, is equipped with the necessary analytical instruments to provide all routine assays for the mine and process plant. The critical assay laboratory equipment and instruments include:

- Sample preparation equipment (e.g., jaw crushers, pulverizers, screens, splitters, weigh scales and drying ovens);
- Fire assay-related furnaces and devices;
- Wet chemistry lab for digestion of samples and rocks and associated equipment (e.g. hot plates, digestion blocks, fume hoods and balances;
- Analytical instruments (e.g., atomic absorption spectroscopy for Au and Ag, inductively coupled plasma OES for multi-element analysis and microbalances); and
- Two Leco sulphur and carbon analyzers.

The metallurgical laboratory monitors metallurgical performance, and its results are used to improve process flowsheet unit operations and efficiencies. The laboratory is equipped with a laboratory-sized rod mill, particle size analysis sieves, bench scale flotation cells, centrifugal gravity concentrators, filtering devices, sample splitting devices, balances, and pH meters.

3.5.2.6 Water Treatment Plant

The WTP is able to maintain effective treatment at influent flow rates between 1,400 m^3/d and 10,000 m^3/d. The nominal total suspended solids (TSS) concentration is 1,300 mg/L and the nominal treatment flow rate is 6,000 m^3/d. The WTP is designed to chemically precipitate targeted dissolved metals and remove influent TSS and the resultant chemical precipitates. A simplified WTP schematic is presented in Figure 3.5-14.

No significant changes to the water treatment plant design or process are required to facilitate the proposed production increase. A third disc filter may be installed to increase redundancy in the polishing filtration process. Additional details regarding water treatment are provided in Chapter 5, Section 5.6.1. A Best Achievable Technology report has been prepared and is provided in Appendix 5-4.

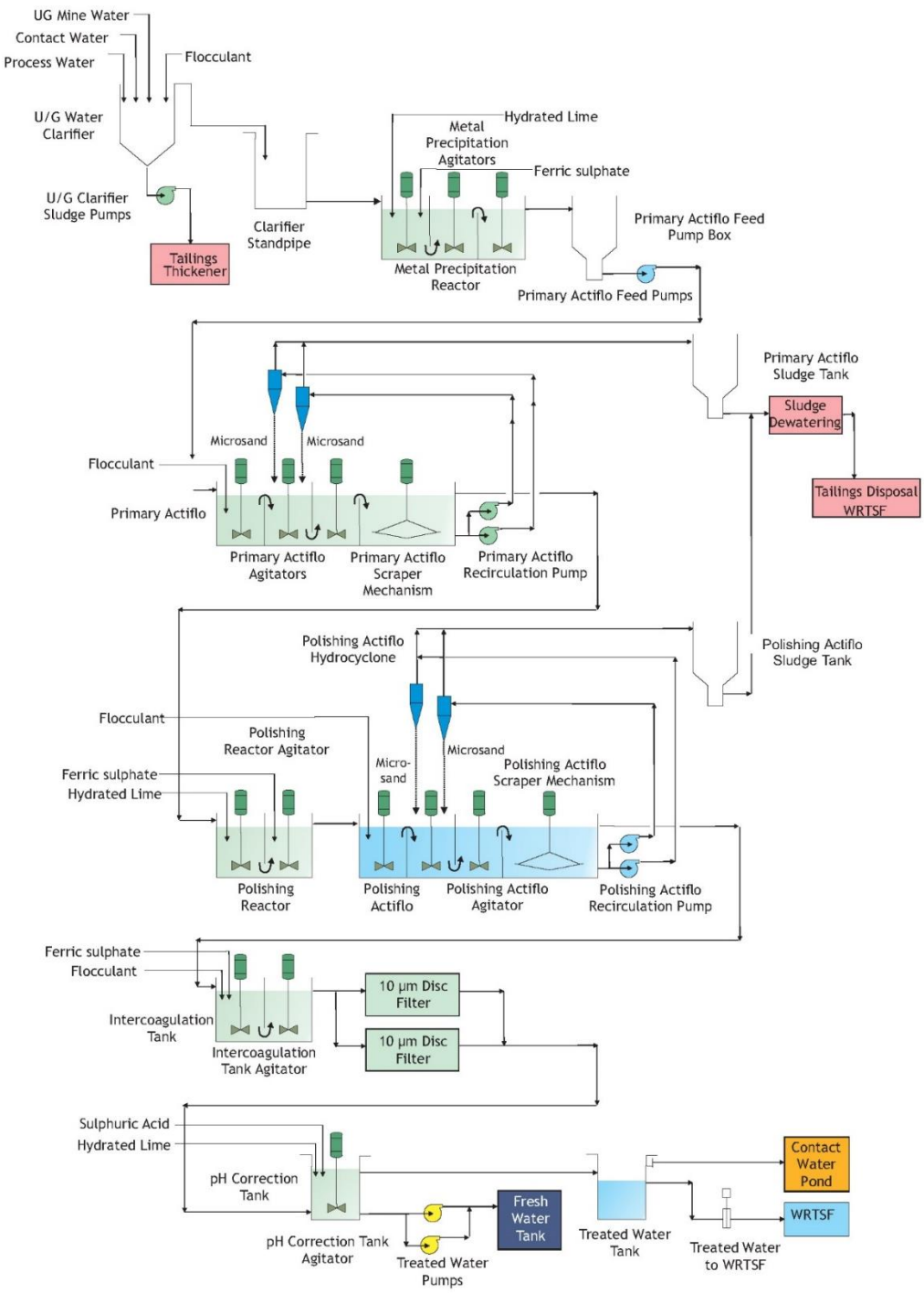


Figure 3.5-14. Simplified Water Treatment Plant Schematic.

3.5.2.6.1 Process Description

The WTP receives influent from the underground workings and the CWP via the 1350 Level mine sump pump and the CWP pumps, respectively. The mine sump pump includes four parallel pump trains consisting of two high pressure pumps in series operating on VFD, flowmeters, pressure, pH

and turbidity instrumentation. The CWP pumps include four submersible pumps with flowmeters on VFD, two 30 hp pumps, and two 75 hp pumps.

The WTP includes redundancy features and systems to maintain a robust process, including, but not limited to:

- Dual stage metal precipitation and Actiflo® units with downstream discfilter capacity. This full sequence of unit processes is not necessary to achieve water quality requirements during normal operations but adds additional water treatment capability in case one unit process is not operating optimally for mechanical, process or other reason.
- Two discfilters operated in parallel. A third discfilter is planned for future installation.
- Lab turbidity and pH meters are available to operators to verify the accuracy of automated instrumentation.
- Redundant duty/spare chemical dosing systems are installed in the WTP reagent area.
- The sulfuric acid dosing system is installed with duty/standby pumps.
- Duty/standby pumps are installed in all process applications to ensure continuous availability.

If for any reason the plant is unable to handle water requiring treatment, the influent is redirected to the CWP. Water already in the WTP is also directed to the CWP. CWP water levels are managed throughout the year to allow for storm surge or process upset containment.

3.5.2.6.1.1 Influent Water Clarifier

The influent water clarifier consists of a high rate settling clarifier with recirculation pumps. Influent water streams (underground water, CWP and process water) are introduced to the top of the clarifier, anionic flocculant is added and solid particles agglomerate and settle to the bottom of the clarifier. Underflow pumps withdraw the settled sludge, which either recirculates back to the top of clarifier to enhance thickening, or discharges to the tailings thickener in the mill.

The underground clarifier consists of a high rate settling clarifier; sludge recirculation /disposal pumps; and instrumentation, including overflow flowmeter, pH and turbidity probes.

3.5.2.6.1.2 Metal Precipitation

Combined influent water overflows the clarifier and enters the metal precipitation reactor. Ferric sulphate and hydrated lime are added to initiate coagulation and precipitation of heavy metals. Sludge removed from the downstream primary Actiflo® unit is recycled back to this reactor to assist with heavy metals precipitation and reduce chemical requirements. The pH of the metal reactor is maintained between 8.5 and 9.5 utilizing hydrated lime.

The metal precipitation reactor consists of a rectangular tank, high speed agitators, instrumentation including dual pH meters and discharge slurry pumps consisting of a pumpbox vessel and discharge pumps.

3.5.2.6.1.3 Primary Solids Removal (Primary Actiflo®)

Slurry from the metal precipitation reactor is pumped to the primary Actiflo® unit for removal of suspended solids. Functionally, Actiflo® is a sand-ballasted settling unit that employs a high-rate

coagulation/flocculation/sedimentation process. It utilizes microsand which provides a surface area that enhances flocculation and acts as a ballast or weight. Physically, Actflo® is a multi-chambered tank consisting of three agitated reaction chambers and a settling chamber.

Anionic flocculant is added to each of the first three agitated chambers. The coagulated solids combine with fine grained silica sand to form a high density, rapidly settling floc that separates in the final settling chamber equipped with lamella plate separators. Settled sand and sludge is removed from the bottom of the settling chamber, while solids free water overflows the settling chamber for further downstream processing. The sand and sludge mixture is pumped to a hydrocyclone, which separates the sand from the sludge. The sand returns to the agitated chambers of the Actiflo unit, while the sludge is transferred to a solid collection standpipe. The standpipe will allow some of the sludge to recirculate to the front of the WTP (metal precipitation reactor). The excess sludge reports to further dewatering and ultimately disposal with thickened tailings.

The primary Actiflo® unit includes one Actiflo® unit, high speed agitators, low speed scraper/rake system, sand recirculation pumps coupled with hydrocyclones and process instrumentation including turbidity and pH meters.

3.5.2.6.1.4 Polishing Solids Removal (Polishing Actiflo®)

Solids free water from the primary Actiflo® then flows into an agitated polishing reactor, where additional ferric sulphate and hydrated lime are added. The pH is maintained at approximately 7.5 to target different heavy metals that have lower solubilities at a circumneutral pH. Slurry from the polishing reactor is sent to the polishing Actiflo® unit for removal of suspended solids. The polishing Actiflo® behaves in an identical manner as the primary Actiflo®. Sludge from the polishing Actiflo® reports to sludge handling, while clarified overflow reports to polishing filtration.

The polishing reactor includes a tank, high speed agitators and process instrumentation including a pH meter.

3.5.2.6.1.5 Polishing Filtration

Polishing filtration removes fine suspended solids not previously captured by the Actiflo® units. Ten micron filters continuously remove residual solids from the water. The solids are discharged back to the front of the WTP and the filtered water continues downstream for final pH adjustment.

The discfilters are comprised of two 10 µm discfilters in parallel. Addition of a third 10 um discfilter is planned to provide added redundancy.

3.5.2.6.1.6 pH Adjustment

Treated water from polishing filtration, which has completed all solids and dissolved metals removal steps, is subjected to a final pH adjustment prior to controlled discharge. Sulphuric acid or hydrated lime is used to bring the pH of the water to a range between 6.5 to 8.5. Due to the operation of the polishing Actiflo® at a target pH of 7.5, very little pH adjustment is needed at the final stage.

The final pH correction tank includes a tank, high speed agitator and instrumentation including a pH sensor and a tank level indicator.

3.5.2.6.1.7 Treated Water Distribution

Treated water is monitored continuously for turbidity and pH levels, and sampled twice per month for metals and general parameters required by PE-107835, to ensure it meets the WTP discharge limits specified in PE-107835 Section 1.2. If the treated water meets the WTP discharge limits, it is allowed to discharge from the treated water tank to the WRTSF. If the treated water does not meet the discharge limits, discharge to the WRTSF is halted and the treated water tank discharges via controlled overflow to the CWP. A portion of the water discharged from the treated water tank is directed to the mill freshwater tank for use in the mill or underground mine. In all, the water distribution system includes four pumps in total.

The treated water tank includes a tank with process instrumentation that includes a turbidity and pH meter, and flow meters on each of the discharge pipes to the WRTSF and the CWP and an automated motorized valve for the discharge line leading to the WRTSF.

3.5.2.6.1.8 Sludge Handling

Metal precipitate sludges report to sludge handling where the fine precipitates are separated and recycled back to the metal precipitation reactor. Excess sludge not needed for the WTP process is sent for disposal with thickened tailings to the WRTSF in accordance with M-243 Condition D.3(c)(viii).

The sludge dewatering system includes the primary Actiflo® sludge tank, polishing Actiflo® sludge tank, and process instrumentation for each of the primary and polishing Actiflo® sludge tanks, including TSS analyzers and a flowmeter for the sludge wasting line.

3.5.2.6.1.9 Chemical Makeup and Dosing

The WTP includes reagent makeup and distribution systems for all chemicals required in the system. Hydrated lime slurry is prepared from bulk bags of hydrated lime. Ferric sulphate solution is prepared from bulk bags of ferric sulphate salt with a small quantity of sulfuric acid added to aid salt dissolution. Concentrated sulfuric acid is distributed directly from totes. The anionic polymeric flocculant solution is prepared from dry flocculant.

The reagent system includes:

- Lime preparation and dosing system including:
  - Dry lime hopper with screw feeder;
  - Lime mixing tank complete with agitator; and
  - Lime holding tank complete with agitator.
- Lime recirculation pumps and actuated proportional control valves for injection of lime into system.
- Ferric sulphate ($Fe_2(SO_4)_3$), preparation including:
  - Dry ferric sulphate hopper with screw feeder;
  - Mix tank with agitator;
  - Holding tank; and
  - Ferric sulphate dosing pumps;
- Sulphuric acid dosing system including;

  - Storage tote and transfer tote; and
  - Four electronic diaphragm dosing pumps;
- Anionic polymer preparation package including:
  - Polymer hopper with screw feeder and vacuum eductor;
  - Polymer mix tank with agitator; and
- Polymer holding tank;
- Six positive displacement dosing pumps.

3.5.2.6.1.10 Reagent Handling and Storage

Potassium amyl xanthate and frother is added to the flotation process slurry stream to modify the chemical and physical characteristics of mineral particle surfaces, and to enhance the floatability of the valuable mineral particles into the concentrate products. Flocculant is used as a settling aid for the flotation concentrate and tailings thickening. Anti-scalant is added as required to protect pipelines and process equipment. Liquid sodium hydroxide is used to prepare an alkaline solution for smelting furnace exhaust scrubbing.

Potassium amyl xanthate is shipped to the mine in solid form. The reagent is diluted to approximately 10% solution strength in a mixing tank and stored in a holding tank in the mill building. The solution is added to the various addition points by metering pumps. Freshwater is used to make up the required solution strength.

Frother is shipped to the plant as liquid in bulk intermodal containers. The reagent is stored in a holding tank in the mill building and pumped in undiluted form to the points of addition using metering pumps.

Solid flocculant is prepared in a wetting and mixing system to a diluted solution of less than 0.2% solution strength. The solution is stored in a holding tank in the mill building prior to being pumped by metering pumps to the thickener feed wells.

Anti-scalant chemicals are delivered in liquid form and added to the gravity concentrators and gland water system as required to minimize scale build-up in the water pipelines and process equipment. This reagent is added in undiluted form.

To ensure containment in the event of an accidental spill, each reagent preparation and storage facility is located within its own dedicated containment area in the mill building, designed to accommodate 110% of the content of the largest tank. The storage tanks are equipped with level indicators and instrumentation to prevent spills. Appropriate ventilation, fire and safety protection, and Safety Data Sheet stations are provided in these areas.

Each reagent line and addition point is labelled in accordance with Workplace Hazardous Materials Information Systems (WHMIS) standards. All operational personnel have WHMIS training, along with additional training for the safe handling and use of the reagents. Additional details regarding reagent handling and storage are found in the mine's Chemicals and Materials Storage and Handling Plan (Appendix 9-1-6).

3.5.3 Tailings Storage Facility and Associated Infrastructure

3.5.3.1 Facility Overview

Operation of the Brucejack Mine generates waste rock from mine development and tailings from ore processing. Waste rock is classified as PAG and is either directed to the WRTSF for subaqueous deposition or retained in underground mine secondary stopes as backfill. Thickened tailings are used to generate cemented paste backfill to fill/support voids in the underground workings and the remainder is deposited subaqueously to the WRTSF as tailings.

The maximum WRTSF water depth at the beginning of mine operations was approximately 85 m with an initial storage capacity of 28.5 Mm^3. The previously approved 3800 tpd mine plan (Pretium 2018b) allows for deposition of approximately 11.9 Mt of tailings and approximately 7.8 Mt of waste rock within the WRTSF during the LOM. The 4,950 tpd mine plan does not increase the overall tailings and similar waste rock deposition tonnages to the WRTSF. Actual deposition tonnages into the WRTSF at the end of 2021 are recorded to be 3.56 Mt of tailings and 5.74 Mt of waste rock. From 2022 until the EOM, the 4,950 tpd mine plan has 7.8 Mt of tailings and 2.0 Mt of waste reporting to the WRTSF, for a total LOM tonnage of 11.3 Mt and 7.9 Mt, respectively. The 19.2 Mt (or 12.2 Mm^3) combined total of waste rock and tailings planned for deposition in the WRTSF is less than the overall total storage available of 28.5 Mm^3.

All waste rock and tailings produced by the mine is contained within WRTSF without the need for any external containment structures. Within the footprint area of the WRTSF, lakebed sediments are dominated by sand, silt and clay particles and range in thickness between 5 m and 35 m, based on ground penetrating radar conducted in 2014. Geotechnical investigations conducted in 2022 generally confirmed the lakebed sediment thicknesses at the sample locations selected for cone penetration test-work. Tailings have a gradation where typically 80% of the particle sizes, by mass, are smaller than 162.4 µm. The milling strategy targets a maximum particle diameter of 0.3 mm.

Specific waste rock deposition procedures have been prepared to manage instability risks on the foundation of fine-grained sediments. These are discussed and documented in the Waste Rock and Tailings Storage Facility – OMS Manual (Appendix 9-1-17).

3.5.3.2 Waste Rock Deposition

Waste rock is transported from the underground mine to the WZ pad where it is transferred into surface haul trucks that deliver waste rock to the WRTSF. The waste rock is either temporarily stockpiled on the surface of the WRD (within the WP1 stockpile) or dumped 45 m from the crest, or at a safe setback distance designated by the Brucejack geotechnical site team, then pushed off the crest of the WRD by remote dozer.

The WRD is divided into nine zones, from Zone 1 (west side of WRTSF, adjacent to outlet) to Zone 9 with a design dump crest surface elevation of 1365 masl or approximately 0.5 m above the average water level in the WRTSF (Appendix 9-1-17). A temporary surface stockpile (WP1) is intended to be used for times when deposition into the WRTSF may not be possible, such as during periods of heavy ice cover in the WRTSF.

The waste rock deposition method has undergone several changes since the start of deposition in 2015. The current method used to deposit waste rock into the WRTSF is by remote operated dozer

push (as of May 2021 to date) which evolved from previous conventional dozer, telestacker and excavator bailing methods. The change to remote operated dozer was part of the response to the relatively lower deposition rates which could be achieved with the telestacker and excavator bailing methods. The previous waste rock deposition methods are still considered viable waste rock management options, and may be deployed as required, to maximize operational flexibility.

Waste rock deposition rates are determined primarily by the length of the active crest frontage. The design basis assumes daily deposition is approximately 7 m^3/d per meter of crest frontage. As described in Appendix 3-1-1, the design basis deposition rate conservatively accounts for equipment downtime. Assuming that waste rock deposition is suspended during winter months (December 15 to May 1), the average annual deposition rate is approximately 1,596 m^3/yr per m of crest frontage. This annual total (>1 Mt/yr at 2.06 t/m^3) exceeds the maximum waste rock to WRTSF tonnages (849 kt) presented in Table 3.3-2. Throughout the LOM, overall waste rock production will decrease, as will the required crest frontage to facilitate waste rock deposition. This principle would also apply with the EWRD should Pretium proceed with pursuing the contingency.

Pretium's geotechnical engineers prepare daily deposition plans that assign deposition activities in the WRD to the nine sequential zones. Deposition procedures are detailed in the WRTSF OMS Manual (Appendix 9-1-17). The primary considerations for waste rock deposition include the following:

- The deposition of waste rock leads to rapid undrained loading of the foundation sediments at the bottom of the WRTSF. Because characteristics of foundation sediment vary across the deposition area, the magnitude of settlement and preloading time are not consistent but require continuous monitoring and interpretation by the senior site geotechnical engineers with support from the WRTSF Engineer of Record as necessary.
- As deposition occurs, it is expected that minor surficial failures of the waste rock slope and outer foundation will occur. The deposition plan has been designed to allow for these to occur safely. The monitoring plan has been designed to monitor for the development of any larger failures that could affect the safety of those working on or around the WRTSF.
- Pretium's senior site geotechnical engineers oversee the preparation of the dump management plans to ensure appropriate foundation preloading times have elapsed, based on settlement rates and observational data before additional waste rock is deposited. Deposition planning is completed on a daily basis.
- Quantifiable performance objectives (QPOs) for settlement rates are followed to ensure stability of the WRD. QPOs and WRTSF deposition management practices are provided in detail in the WRTSF OMS Manual included in Appendix 9-1-17.

To facilitate depletion of WP1 and to control the rate of waste rock deposition due to pore pressure generation at the current WRD platform and mine operations, Pretium has adopted a GNSS (Global Navigation Satellite System that provides real time hourly settlement data. This eliminates downtime due to poor visibility and reliance on optical surveys. It also allows for identification of accelerated settlement much earlier and rapid response to mitigate overloading. This allows Pretium to adhere to the QPO for sustained periods of time and increase the crest line available for deposition with time. Additionally, Pretium commissioned a second remote dozer which provides redundancy and reduces delays associated with maintenance of the existing dozer.

As a contingency method for waste rock management, an additional waste rock dump site at the east end of the WRTSF (East WRD) is under evaluation. The East WRD would provide additional

deposition capacity via new deposition zones (increased crest frontage), thereby increasing the mine's flexibility to deposit waste rock into the WRTSF. The 4,950 tpd waste rock and tailings deposition plan (Appendix 3-1) takes this into consideration and incorporates the East WRD development. As the East WRD is intended improve the mine's waste rock deposition capabilities regardless of production rate, its authorization, if pursued by Pretium, would be sought via an M-243 amendment application separate from the 4950 tpd production uplift application.

3.5.3.3 Waste Rock Dump Management

Brucejack Mine operations personnel manage PAG waste rock exposure following M-243 Condition D.3(c)(iv) that requires that all PAG waste rock reporting to WRTSF be subaqueously deposited within two years of exposure, and Condition D.3(c)(v) that limits temporary waste rock storage on surface to two years.

The design basis for the active Brucejack Mine waste rock stockpile is the Updated Subaqueous Waste Rock Dump Design report (SRK 2018; Appendix 3-4) submitted to and approved by EMLI during the 2018 3800 tpd production increase application (Pretium 2018b). The approved design uses the observational method (Terzahghi and Peck 1967, Peck 1969), as the WRTSF is not a typical subaerial surface waste dump. The WRD design includes the temporary stockpile WP1, as it is located on and is integral to the WRD.

As the temporary surface waste rock stockpile WP1 has accumulated and grown over time, additional management considerations and design have been developed for continued safe operations of the WRD. A geotechnical assessment that includes a summary of the subsurface conditions, design criteria, slope stability analyses, seismic hazard classification, and instrument monitoring recommendations for WP1 is presented in Appendix 3-2.

Following the waste rock dump platform partial crest failure on 16 July 2022, a significant delay in depleting the temporary surface stockpile WP1 in 2022 occurred. This was taken into account and incorporated in the deposition plan for 4950 tpd as shown in Appendix 3-1. Further, the deposition plan in Appendix 3-1 incorporates a potential EWRD and additional WP2 stockpile(s) to demonstrate how this contingency infrastructure could be applied. The EWRD and WP2 stockpile(s) are not required to manage waste rock at the 4950 tpd production rate.

Temporarily stored PAG waste rock nearing the end of the allowable exposure period is managed through a combination of the following three methods:

- Sub-excavate PAG waste rock that is approaching an exposure time of two years, to a minimum depth of 1 m below water surface and replaced with NPAG waste rock.
- Sub-excavate PAG waste rock that is approaching an exposure time of two years, to a minimum depth of 1 m below water surface and replaced with PAG waste rock which has been immediately removed from mine development areas.
- Sub-excavate PAG waste rock that is approaching an exposure time of two years to a minimum depth of 1 m below water surface and retain a temporary pond in the excavated area.

Details of the waste rock dump management are provided in the WRTSF OMS manual Appendix 9-1-17.

3.5.3.4 Tailings Deposition

Tailings are produced during the process of milling the ore and are either placed back into the underground mine as a paste backfill, or deposited subaqueously in the WRTSF, dependent on operational needs. Tailings that report to WRTSF are conveyed through tailings pipelines that discharge subaqueously within 7.5 m of the WRTSF bottom in accordance with PE-107835 Section 1.3.

Deposition procedures are detailed in the Waste Rock and Tailings Storage Facility – OMS Manual (Appendix 9-1-17). The primary considerations for tailings deposition include the following:

- Sludge generated from the WTP is mixed in the tailings thickening tank with mine tailings and discharged to the WRTSF. WTP sludge is added to tailings in a mixing ratio that is less than 2% sludge by dry weight in accordance with PE-107835 Condition 1.4 and M-243 Condition D.3(c)(viii).
- The tailings conveyance system consists of two main heat-traced high-density polyethylene (HDPE) pipelines that enters a valve house structure where the slurry can either be distributed to the operational lines.
- The submerged elevations of the discharge pipes are adjusted or replaced as needed to maintain compliance with the 7.5 m distance above WRTSF bottom PE-107835 requirement.
- Digital bathymetric survey scans are completed annually to determine the elevation of the deposited tailings surface and depths of the pipeline outfalls. The beach slope varies at both the previous suspended cable supported pipelines and the perimeter discharge. The lakebed perimeter discharge pipeline beach slope varies from 10.5% to 3% and is effectively flat with distance.
- Ongoing monitoring of operations and TSS levels in the WRTSF during operation provides input for adjusting and optimizing the slurry densities throughout the LOM.
- It is anticipated that the subaqueous tailings deposition footprint will overlap with the subaqueous waste rock deposition footprint, resulting in waste rock being partially deposited onto a foundation of tailings beginning in 2022 on the easternmost side of the WRD.

Four additional tailings lines are planned for phased installation to replace the existing tailings pipelines as deposition progresses (Table 3.5-7; Appendix 3-1). The planned pipelines will be located according to the existing requirements in Section 1.3.2 of PE-107835.

Table 3.5-7. Planned Tailings Pipeline Discharge Locations and Recommended Installation Timing.

Tailings Line ID	Coordinates (Northing)	Coordinates (Easting)	Discharge Elevation (m)	Earliest Recommended Construction Year	Active Discharge Years
Line #5	427712.87	6258838.04	1318.21	Constructed	2022-2023
Line #6	427791.05	6258801.20	1322.26	Constructed	2022-2023
Line A	427730.45	6258818.47	1329.49	2023	2023-2025
Line B	427833.56	6258786.00	1334.95	2023	2025-2027
Line C	427723.47	6258807.98	1341.95	2024	2026-2029
Line D	427834.13	6258767.00	1345.60	2026	Standby

Emergency shut down procedures for the tailings discharge pipelines are provided in the Waste Rock and Tailings Storage Facility – OMS Manual (Appendix 9-1-17).

3.5.4 Water Management Structures

3.5.4.1 Overview

The mine's water management system consists of a network of diversion channels, collection ditches, weirs, sumps, and HDPE piping designed to divert non-contact water away from the mine site area and collect contact water for treatment and use in the mill process. Contact water in the CWP is pumped to the WTP, located in the mill building. The effluent from the WTP is either used as process water or discharged to the WRTSF.

Details of the mine's water management system and operations, including design drawings of the water collection systems, CWP, and LLW, are provided in Pretium's OMS Manual – Water Management Plan (Appendix 9-1-18). In accordance with *MA* Permit M-243 Condition C.4(e), the OMS Manual – Water Management Plan is reviewed annually at minimum. Updates to the manual are completed during the annual review, as required.

With the exception of the addition of a fourth Filterboxx C75 wastewater treatment unit (Section 3.5.4.6), no design or effluent monitoring changes to mine's water management systems are required to facilitate the proposed production increase.

3.5.4.2 Non-Contact Water Diversion Channels

Non-contact water from up-gradient of the mine site is intercepted by two diversion channels: Camp Creek (West) diversion and Johnson Creek (East) diversion. The Camp Creek diversion directs Camp Creek into Brucejack Creek. The Johnson Creek diversion drains the creek into the WRTSF.

3.5.4.3 Contact Water Management System

Contact water within the core infrastructure area of the mine site, where the main excavations of surface bedrock occurred during construction to create building pads, is directed to the CWP via weirs, ditches, sumps, and HDPE piping. A catchment area of approximately 15 ha currently reports to the CWP.

The CWP has been designed with sufficient storage capacity (approximately 50,000 m^3) to contain a 24-hour, 200-year return period rain-on-snow event (Q_{200}). Water within the CWP is pumped to the WTP at a maximum rate of 200 m^3/h, which is sufficient to prevent the pond from overtopping for the 200-year return period for rainfall events up to 10 days in duration. The CWP is managed such that sufficient storage is maintained for Q_{200}. An emergency spillway with an inlet at 1376.5 masl allows for controlled releases from the CWP to the WRTSF.

Influent from the CWP to the WTP is continuously monitored in-line at the mill for turbidity, pH, and flow rate, as per *EMA* Effluent Permit PE-107835. Water quality samples of the CWP influent are collected bi-weekly. In the event of a direct discharge event to the WRTSF, additional monitoring and water quality sampling is implemented, as described in Appendix A of PE-107835. Additional details on monitoring programs are provided in Chapter 7.

3.5.4.4 Underground Mine

Water pumped from the underground mine workings is directed to the WTP, where it is treated prior to use in the process plant or discharged to the WRTSF when there is an excess of process water available.

As per *EMA* Effluent Permit PE-107835, underground dewatering rates, including turbidity and pH, are monitored continuously as mine water influent at the WTP. Influent water quality samples are collected bi-weekly. Additional details on monitoring programs are provided in Chapter 7.

3.5.4.5 WRTSF Outlet Weir (LLW)

The LLW is located within Brucejack Creek at the outlet of the WRTSF. The facility houses effluent flow monitoring instrumentation and water reclaim equipment that supplies fresh water to the mill. The compound cross-section consists of a concrete, broad-crested structure with a low-level opening to pass average annual flows and an overflow crest to pass peak flows (up to Q_{200}). The LLW is enclosed in a concrete chamber founded on bedrock with a grating floor and heated superstructure above it. This configuration keeps the weir ice free during the winter period.

Conceptual drawings of the weir design are provided in Figure 3.5-15 and Figure 3.5-16. Water enters the upstream chamber through an underflow baffle, passes over the weir, and exits the downstream chamber through another underflow baffle. The reclaim water pumps are mounted on the floor above the upstream chamber. The water passes through a dividing wall into a secondary chamber through two openings, which are offset to either side of the pump intakes to minimize turbulence upstream of the weir. The weir and flow monitoring instrumentation are located in a secondary chamber.

Flow mixing is promoted by the inlet and outlet underflow baffles and by turbulence caused by water flowing over the weir crest. This design feature helps ensure that the effluent is well mixed prior to water quality sampling at the downstream end of the weir chamber. Automated instrumentation is in operation to continuously measure water level, which is converted to a flow rate using an equation for a rectangular broad-crested weir. Effluent discharge quality samples are collected weekly, and continuous flow monitoring is supplemented with quarterly manual flow measurements as per EMA Effluent Permit PE-107835. Additional details on monitoring programs are provided in Chapter 7.

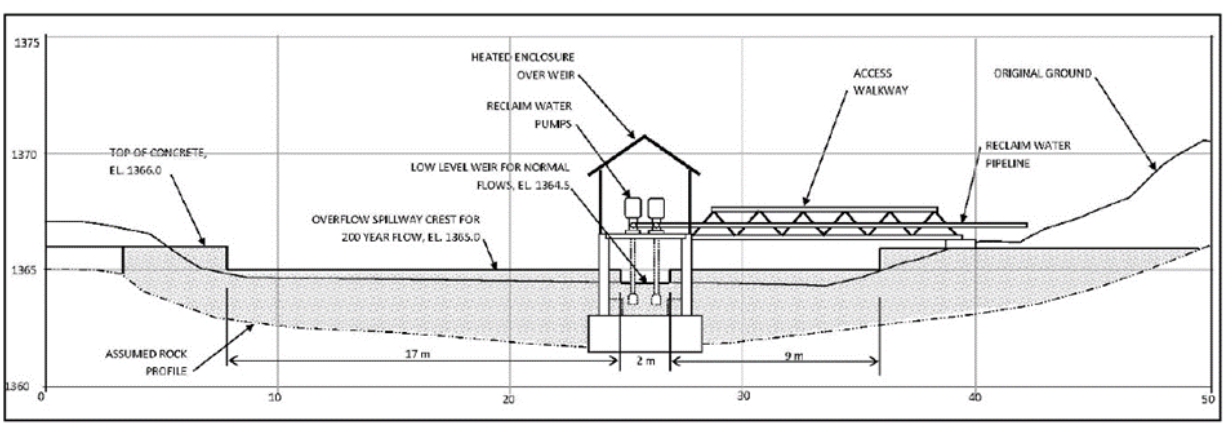


Figure 3.5-15*. Conceptual LLW facing upstream (looking east)*

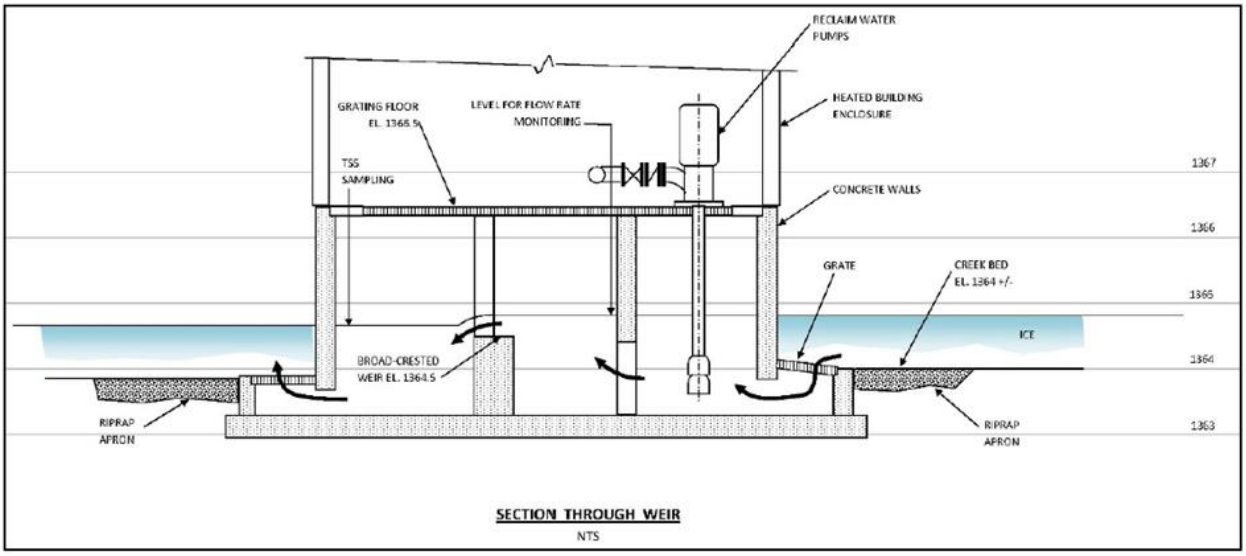


Figure 3.5-16*. Conceptual LLW cross section (looking north)*

3.5.4.6 Domestic Wastewater Treatment

Domestic wastewater at the mine site is treated using three Filterboxx C75 self-contained units with a total permitted effluent discharge rate of 175 m^3/day, 365 days/year (Condition 1.5.1 of PE-107835). Effluent from the STP is directed to the WTP discharge tank where the two effluents are combined and discharged through a single line to the WRTSF. Domestic wastewater sludge is dewatered to reduce the moisture content (minimum of 25% to 30% solid content, as per Condition 1.7.6 of *EMA* Air Permit PA-107025) and then discarded into the general waste stream or incinerated on site.

The addition of a fourth Filterboxx C75 unit is proposed as part of this production increase amendment. While there is capacity for an approximately 25% increase to the camp population within the existing permitting discharge limits, this amendment application is conservatively requesting the additional C75 unit to maintain redundancy of 1 full treatment unit in the event that capacity beyond 150 m^3/d treatment is utilized.

3.5.4.7 Freshwater Supply System

Water is supplied to a fresh/fire water storage tank in the mill from the LLW reclaim and WTP treated water. Aside from emergency and fire water, the freshwater from this tank is primarily used in the mill for slurry pump gland water, reagent and process water make-up, mine supply water, gravity concentrator fluidization water, and the gold room scrubber.

3.5.4.8 Potable Water Supply

Potable water is supplied from a groundwater well authorized under the BC *Water Sustainability Act* Conditional Water Licence #116102. Groundwater is pumped from the well to the potable water treatment plant where it undergoes filtration and disinfection prior to distribution. The potable water treatment and distribution system is authorized by a Permit to Operate issued under BC Northern Health.

3.5.5 Ore, Overburden, Soil and Construction Stockpiles

Approximately 30,000 m^3 of overburden is stockpiled at the mine site for reclamation purposes, in one stockpile. The overburden stockpile material is discussed further in Chapter 4. As there is no new surface construction/development for the proposed production rate increase, there will be no additional stockpiling or soil or construction materials.

3.5.6 Mine Access and Mine Haulage Roads

As per the mine's ML/ARD Management Plan (Appendix 9-1-11), only material classified as NPAG is excavated for use in road construction and/or road maintenance. Geohazard risks and mitigation measures related to access and haul roads within the mine site area are described in the mine's Geohazards Management Plan (Appendix 9-2-3) and Avalanche Safety Plan (Appendix 9-1-5).

If Pretium pursues authorization for the East WRD, a haul road will be required to transport waste rock to the WP2 stockpile(s) and dump site. As described in Section 3.1, the haul road design for East WRD and WP2 access road will be provided through a separate application for authorization.

No additional mine access or mine haulage roads are required to facilitate the production rate increase.

3.5.7 Power Supply and Distribution

3.5.7.1 Transmission Line

The Brucejack Mine's power is supplied by BC Hydro via a 138 kV transmission line (1L403) originating at LNT substation in Stewart and terminating at the independent power producer LNL station. The mine taps into 1L403 approximately 10 km from LNT and 1 km from LNL. The tap line runs approximately 1.5 km to the Brucejack terminal station (BJT). From the BJT, the 138 kV overhead line runs approximately 44 km to the Knipple substation where the voltage is stepped down to 69 kV. A 69 kV transmission line runs 13 km from the Knipple substation to the Brucejack substation. The northernmost 19.5 km of the transmission line, including the Knipple substation, is within the M-243 authorization area.

The 69 kV overhead line to the mine site terminates at a manual disconnect switch on the terminal gantry located outside of the mill pad at the 6020 tower. On the load side of the switches the 69 kV circuit transitions to single conductor insulated cables that are routed below-grade through a cable trench to the Brucejack substation located within the mill building.

The existing electricity supply agreement with BC Hydro for Brucejack demand is for 19.4 MW at 0.97pf (20 MVA). An application has been submitted to BC Hydro to increase the supply delivered through the 138 kV line to 35.5 MVA. The 138 kV line is adequately rated for an increase up to 35.5 MVA, and the 69 kV overhead line from the Knipple Substation to Brucejack mine is of sufficient capacity to increase to 35.5 MVA. Therefore, no changes or upgrades to the existing transmission line infrastructure are required for the proposed production rate increase.

3.5.7.2 Knipple Substation

The Knipple substation has two transformers rated 20/26.6 MVA that operate in an n+1 configuration allowing continued operation up to 26.6 MVA on one transformer. The Knipple substation is regularly operated on a single transformer in the winter for snow clearing.

For redundancy, installation of a third transformer installed in parallel at the Knipple substation is being evaluated, though not required. The existing transformers are adequate to accommodate the proposed production rate increase.

3.5.7.3 Brucejack Substation

The Brucejack substation is located inside the mill building and is comprised of two transformers rated 15/20/25 MVA, 69 kV-4.16 kV. The substation is a two-level design with a transformer vault on the ground floor and a switchgear room (69 kV and 4160 V) on the floor above to facilitate bottom entry equipment.

For redundancy, installation of a third transformer installed in parallel at the Brucejack substation is being evaluated, though not required. The existing transformers are adequate to accommodate the proposed production rate increase.

3.5.7.4 Backup Power Generation

The backup power system is comprised of 15 diesel reciprocating generators (four 0.5 MW, two 1.45 MW and nine 1.825 MW) connected to the 4160 V system at the DPS. In total, the back-up generators can produce approximately 21.3 MW of power when running at 100% load and running n+0. In a backup power scenario, the main power system is routed through the DPS electrical room to the central mill, portal building, and main camp electrical rooms, as well as the underground VOK substation.

No changes to the backup power system are anticipated to facilitate the proposed production rate increase.

3.5.7.5 Mine Site Surface Power Distribution

The 69 kV circuits feeds two circuit breakers which feed two parallel 69 kV to 4.16 kV transformers. The secondary of the transformers is connected via cable bus to the plant's main 4160 V switchgear which serves as the main switching point for the plant distribution system. Radial feeds from the 4160 V switch gear distribute power to the central mill, portal building, and main camp electrical rooms, as well as the DPS and underground VOK substations. The system is designed as secondary selective scheme with a tie-breaker such that the entire plant load can be carried by a single transformer in the event of failure or scheduled maintenance.

No changes to surface power distribution are anticipated to facilitate the proposed production rate increase.

3.5.7.5.1 Underground Electrical Demand and Distribution

3.5.7.5.1.1 Power Requirements

Ventilation, mining equipment, dewatering, paste backfill and underground crushing/conveying are the main consumers of power for the underground mine. The current peak underground load is approximately 8.0 MVA, and a typical mining level can have up to 1345 kVA of connected load. As development advances deeper into the mine, the dewatering power demand will increase due to a higher lifting head and increased inflows. A second underground paste backfill pump is under evaluation and may be added in 2023 depending on stope sequencing.

As described in Section 3.5.7.1, an application has been submitted to BC Hydro to increase the supply delivered through the 138 kV line to 35.5 MVA. Both the 138 kV and 69 kV transmission lines are adequately rated for 35 MW.

3.5.7.5.1.2 Underground Electrical Distribution

The underground mine distribution system is at 4160 V. Power is supplied by 4160 V circuits through the WZ portal, the VOK portal and a surface to underground borehole, to ensure the availability of an alternate and physically independent power source in cases of emergency. In the event of a loss of normal utility power to the Brucejack substation on the surface, the plant standby diesel power system can energize any underground 4160 V circuit to power critical loads (Section 3.5.7.4). The VOK underground substation has permanent distribution equipment at both 4160 V and 600 V to feed crushing, ore conveying, dust collection, paste backfill, and mine dewatering activities. Portable mining equipment in the form of mine load centers are located at each mining level and other key load locations. MLC ratings range from 500 kVA to 1500 kVA.

A transition to 13.8 kV was initiated as part of the 5-year plan in 2020. To that end, dual primary (5/15 kV) mining substations and 15 kV trunk cable have been installed and are energized temporarily at 5 kV. The cables run from the underground distribution center at the 1290 Level to the 1080 Level. As described in the 2020 Mine Plan Update (Pretium 2020b), all MLCs from the 1080 Level and below will be changed over to 13.8 kV primaries or replaced entirely. After the 15 kV system has been implemented, the upper areas of the mine (1140 Level and up) will remain powered by the 4160 V system.

No changes to underground electrical distribution are anticipated to facilitate the proposed production rate increase.

3.5.8 Explosives Storage Facilities

3.5.8.1 Surface Magazines

Explosives are stored on surface in two magazines located at km 73.3, approximately 20 m north of the road, with a combined total storage capacity of 5000 kg and up to 2000 detonators. The surface magazines supply explosives required for the mine's avalanche control program.

No additional surface magazines are required to facilitate the proposed production rate increase.

3.5.8.2 Underground Emulsion Storage

Bulk emulsion is stored in two underground storage tanks (21,000 L and 17,000 L) in two emulsion storage bays, each with roll-up fire door access (Figure 3.5-17). Bulk emulsion is delivered from the WZ to the underground storage bays via a custom-built underground emulsion hauler. Bulk emulsion is then transferred into the storage tanks with a pneumatic emulsion pump.

It is expected that a third underground emulsion bay will be required to facilitate the additional emulsion storage that is anticipate proposed production rate increase. The emulsion bay will be positioned to optimize distance and clearance based on the mine sequence, and the design will be consistent with the existing emulsion storage bays described in Figure 3.5-17.

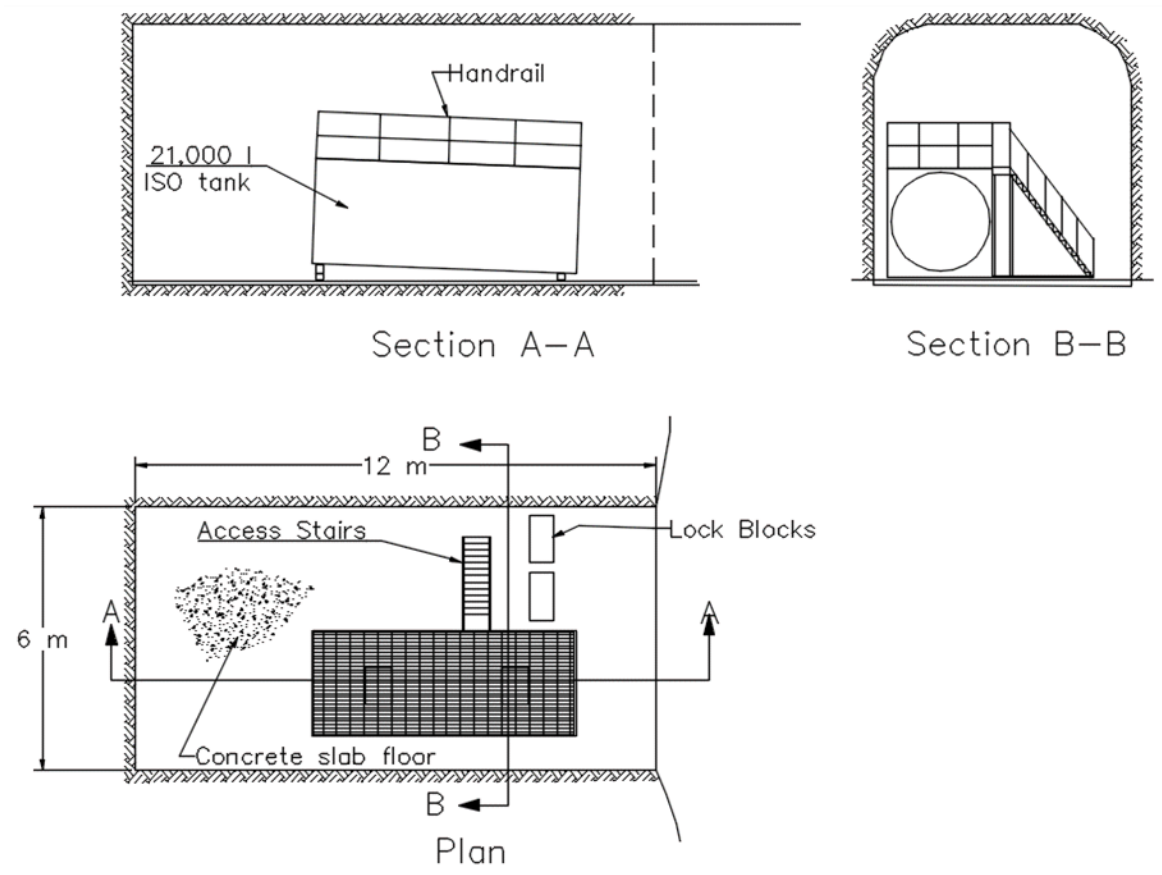


Figure 3.5-17*. Bulk Emulsion Storage - Plan and Sections.*

3.5.8.3 Underground Magazine

All other explosive products (excluding bulk emulsion and detonators) are stored on wooden shelving in an underground powder bay (Figure 3.5-18). A fourth bay is designated for the storage of detonators on wooden shelves.

No additional underground magazines are required to facilitate the production increase.

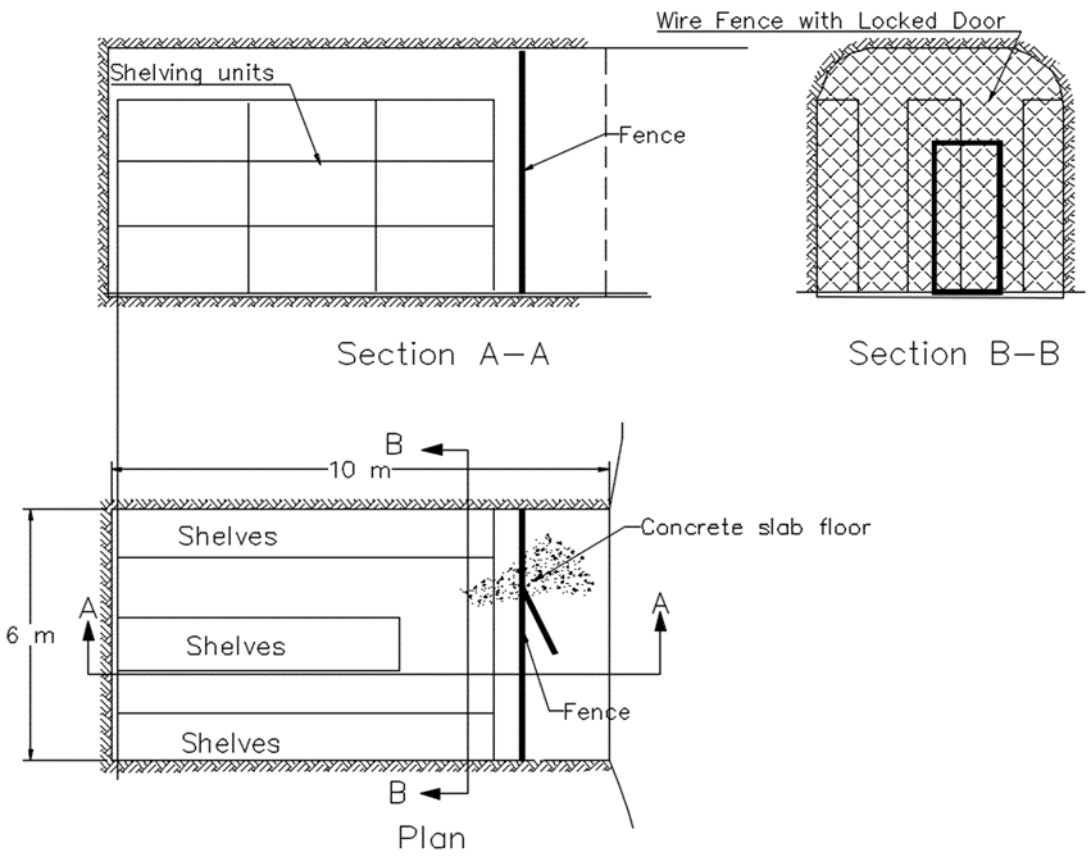


Figure 3.5-18*. Cap and Powder Storage - Plan and Section.*

3.5.9 Ancillary Facilities and Support Infrastructure

No additional changes to the mine's ancillary facilities and support infrastructure, beyond that which is described in the preceding sections, is anticipated to facilitate the proposed production rate increase.

4. RECLAMATION AND CLOSURE PLAN

4.1 Introduction

This chapter summarizes key content of the Brucejack Mine Reclamation and Closure Plan, provided as Appendix 4-1. The Reclamation and Closure Plan addresses mine infrastructure components and site disturbance authorized under M-243, including mine development within the PMA portion of the mining leases (Figure 1.4-4) and the portion of the mine's transmission line extending south from the mining leases to Pretium's Mineral Claim #1026976 (Figure 1.4-5). Permit M-243 authorizes the northernmost 19.5 km of the transmission line, whereas the 37.5 km segment located south of that is authorized under Statutory ROW #6408729 (Figure 1.4-1).

Based on the 4950 tpd mine plan (refer to Chapter 3), the remaining mine life is approximately 7 years, with operations ceasing at the end of 2029. This will be followed by a closure phase estimated at three years that includes two years of closure and reclamation within the M-243 area, and a third year of reclaiming off-site mine related infrastructure (i.e., the BJAR and adjacent infrastructure below Knipple Glacier and extending to the Highway 37 intersection, and the Statutory ROW authorized portion of the transmission line). A post-closure monitoring period of ten years is planned for the M-243 area following mine closure.

Brucejack Mine surface disturbance areas are limited in extent due primarily to it being an underground mine. The M-243 approved PMA is 659.3 ha (Figure 1.4-4 and Figure 1.4-5), with approximately 195 ha covering a 100 m corridor along the northernmost 19.5 km of the transmission line, and the remaining approximately 464 ha being located within the mining leases. Actual disturbance at end of 2022 was calculated at 278 ha (terrestrial disturbance area total for mine site 55 ha, buffer from historical exploration 66 ha, transmission line 66 ha, WRTSF and Waste Rock Platform 76 ha, and km 72 NPAG quarry 14 ha), however the historical exploration buffer areas are minimally disturbed and have been partially reclaimed. The terrestrial disturbance area total for the mine site primary infrastructure area is 55 ha (lower and upper camps 5 ha, plant site 38 ha, pond 0.02 ha, roads 11 ha, overburden stockpile 0.4 ha, CWP 0.7 ha), which includes mine site infrastructure and related disturbance areas. The transmission line calculated surface disturbance is primarily within the 6.7 km southernmost segment that is below the tree line. Most of the northernmost 12.8 km of the transmission line is comprised of clear spans over bedrock and ice; towers in this section are anchored in bedrock.

There is no new surface disturbance associated with the proposed production rate increase, and therefore the Reclamation and Closure Plan does not include changes specific to the 4950 tpd Joint Application with the exception of infrastructure timing shown on the reclamation progression figures (e.g. WRTSF related mine wastes extents and mine closure in 2029). The Reclamation and Closure Plan has however, been updated to reflect surface infrastructure changes since the 2020 update (Pretium, 2020b) and for planned or proposed changes that are required for the existing mine operation irrespective of increasing the production rate from the present average 3800 tpd.

Key content changes in the updated Reclamation and Closure Plan compared to the 2020 Update (Pretium, 2020b) are as follows:

- Updated areas of disturbance, including based on 2022 orthophotography. This includes all disturbance within the mining leases extents, including within the PMA (both mining and

surface exploration related) and surface exploration outside of the PMA but within the mining leases.

- Maps and figures updated to include camp infrastructure changes completed in 2021, new truck shop planned for completion in 2023, and updated PMA (Amendment #8, approved November 2022).
- Five Year Mine Reclamation Plan updated to reflect mine closure in 2029, and mine progression figures changed to reflect waste rock and tailings extents based on the 4950 tpd mine plan. Areas of disturbance within the WRTSF remain the same (no change to the PMA).
- Addition of a proposed east WRD in a location similar to that included as an option in the Tailings and Waste Rock Subaqueous Deposition Management Plan included as Appendix 6-O of the 2015 MA/EMA Permits Application (Pretium, 2015), along with preliminary information on three proposed associated temporary surface PAG rock stockpiles and access road connection through and from the km 72 NPAG Quarry area. This infrastructure is required for and proposed outside of the 4950 tpd Joint Application. Arrangements of this proposed infrastructure depicted in the Reclamation and Closure Plan are at a design concept level.
- Updated information on the reclamation research program in progress.
- Content provided in response to updated joint application information requirements (MEMPR & ENV 2019), including with respect to ecohydrological modeling for the mine site; landforms and drainage pre-mine, during operations, and post-mine; and temporary closure content.
- Changes to some aspects of closure approaches, including increased commitment to remove some types of waste materials (e.g. HDPE and PVC) and dispose of these off-site at licensed facilities.

4.2 End Land Use and Capability Objectives

End land use and capability objectives for Brucejack Mine components have been integrated with mine planning and design to promote successful reclamation and closure. The mine and its operations have been planned and designed to minimize the terrestrial development footprint and to prevent significant adverse effects on the downstream aquatic receiving environment, including both water quality and aquatic biota.

M-243 Condition E-3 requires Pretium to “reclaim the land with the intent of re-establishing average pre-mining capability to the following end land use objective: wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot on the mine site and high elevation sections of the transmission line, and moose and grizzly bear habitat at lower elevations of the transmission line. Achieving land capability objectives and habitat enhancement shall guide the reclamation program.” Part E of M-243 contains additional reclamation related requirements.

4.2.1 Mine Site

The Brucejack Mine site primary surface infrastructure area is located along the southwest shore of the WRTSF in an area dominated by gossanous (mineralized materials to surface) bedrock outcropping with some slightly weathered parent materials occurring as pockets with alpine vegetation (Figure 4.2-1). Matrix habitat at the mine site is a rocky area with limited vegetation cover that does

not provide life requisites for wildlife species (e.g., forage, cover, or other key habitat values), but which provides connectivity for animals to access adjacent habitat. It differs from a movement corridor in that it does not provide foraging value. As such, a central objective of reclamation planning for the mine site is to prevent the creation of obstructions or hazards to post-closure movement of wildlife.

Pre-mine, the Brucejack Mine site was characterized as dominantly exposed bedrock, with approximately 80% of the mine site described as non-vegetated or sparsely vegetated (Figure 4.2-2), and with limited extent and poor quality of soils (ERM Rescan 2014a). The mine site is located above the tree line in the CMAun BEC zone. This zone has the harshest climate of any biogeoclimatic zone in BC. Temperatures are low for most of the year, with much wind and snow. Temperatures remain low even during the growing season, which has an exceptionally short frost-free period. Mean annual temperatures range from 0°C to 4°C. Patches of snow, névé, and firn persist late into the year.

Figure 4.2-1. Brucejack Advanced Exploration 2013, Showing Mine Site Bedrock Outcrops and Pockets of Weathered Parent Materials.

Figure 4.2-2. Brucejack Mine Site 2012, Showing Bedrock Exposures and Limited Vegetation Extent.

Vegetation community development within the mine site and its vicinity was limited by the poor quality and limited availability of growth media, high snow pack, high winds and low temperatures.

Pre-mine habitat assessments of the mine site classified the habitat as matrix habitat for wildlife species resident in the general vicinity: hoary marmot, grizzly bear, and, to a more limited extent, mountain goat (ERM Rescan 2013i). Aerial and ground surveys in 2012 and 2022 found hoary marmot colonies northwest and west of the mine site, along and near Brucejack Creek. Beginning during Pretium's advanced exploration activities in 2011, grizzly and/or black bears have been occasionally observed passing through the area north of Brucejack Creek and the (now) WRTSF, or south and high above the mine site along the winter access that traverses the upper VOK area.

An additional consideration pertinent to end land use is that growth media (unconsolidated overburden and soils) at the mine site have naturally elevated metals concentrations, including arsenic, due to being located on gossanous material.

At closure, the mine site will be reclaimed to matrix habitat for mountain goat, grizzly bear and hoary marmot to facilitate movement by these target species and others, into better habitats. This will be achieved by reclamation measures that result in terrain that is free of mine related obstacles or hazards, thereby allowing free movement through the area by wildlife. The post-closure mine site will have low vegetation cover, consistent with its pre-mine condition and with surrounding areas, as most of the adjacent landscape is comprised of unvegetated bedrock exposures.

4.2.2 Transmission Line

Most of the M-243 portion of the transmission line route is located either above the tree line or in high subalpine areas. Transmission line construction was helicopter supported, with road-based support within the M-243 section limited to a few towers near the BJAR. Transmission line tower base sizes vary with the tower type, with most being approximately 3 m in diameter. Towers were sited on bedrock as much as possible (Figure 4.2-3). Due to all of these factors, surface disturbance and effects on vegetation as a result of the transmission line are relatively limited.

At closure, the transmission line will be reclaimed to wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot in the high elevation sections, and moose and grizzly bear habitat at lower elevations of the transmission line. Transmission line development has not altered terrain except to a very limited extent (approximately 200 m length) at Knipple transfer area.

Transmission line infrastructure will be removed during final reclamation. Removal of the towers, conductors and Knipple substation will remove whatever limited obstacles to wildlife movement are posed by the transmission line. Due to the lack of soil disturbance between tower sites in the southern vegetated portion of the M-243 transmission line extent, the limited extent of tower sites on materials other than bedrock, and because where present, disturbed soils around tower bases have already been seeded and additional reclamation will be conducted as feasible once towers are removed, the end land use objectives for the transmission line are expected to be achieved.

Figure 4.2-3. Transmission Tower on Bedrock in M-243 Vegetated Section (Photo August 2019).

4.3 Reclamation Approaches

4.3.1 Background

The Brucejack Mine site area has multiple unique or unusual characteristics that present substantial challenges for vegetation establishment and are not typical of mines in BC. These characteristics include the high elevation and harsh climatic conditions of the mine site area, the ubiquity of geochemically reactive gossanous materials throughout the mine site, and the pre-mine lack of soils and ecosystem development.

Because of these challenges, the general approach to reclamation planning for the mine has been to minimize surface disturbance through mine design and construction, and to then create post-mine topography and conditions that will achieve the matrix habitat end land use and support passive natural revegetation to the extent feasible. Key reclamation methods include recontouring to prevent barriers to movement of the target wildlife species and to create stable drainage features, and decompaction/scarification of potential growth media. Some limited additional measures are being investigated through the reclamation research program, discussed in Section 3.6 of Appendix 4-1.

Pre-development conditions and the approach to surficial materials use for reclamation within the Brucejack Mine site area and the M-243 portion of the transmission line are described in Appendix 4-1, Section 3. A key issue informing this approach is that overburden available as growth media within the mine site is predominantly PAG, with elevated element concentrations, particularly arsenic (Shaw and Simpson 2016) (Pretium 2020b, Appendix 3.3-1). This overburden is presently considered not suitable for use in reclamation and is instead recommended for handling in ways that will minimize potential for incremental acid rock drainage and metal leaching. It is not presently known if there are any areas within the mine site in which surficial materials may be amenable to active revegetation – this question is being investigated as part of reclamation research described in 2020 Mine Plan and Reclamation Program Update (Pretium 2020b) and initiated in 2021.

Until the reclamation research program is sufficiently advanced to resolve active revegetation areas and methodologies, the reclamation plan and associated reclamation liability costing assume that mine site disturbances will generally be recontoured, de-compacted as feasible, seeded with the Brucejack high elevation native species seed mix, and fertilized (i.e. to supplement passive natural revegetation).

4.3.2 Surficial Materials

Survey data indicate that soils and other surficial materials at the Brucejack Mine site are not suitable for use as reclamation growth media, and that overburden should not be spread as a reclamation cover but should be treated in a manner to minimize generation of acid rock drainage (Shaw and Simpson 2016). Although approximately 30,000 m^3 of this material was salvaged and stockpiled as required by EMLI, there is currently no plan to use these materials as reclamation covers pending results from ongoing reclamation research. Amendment of these materials, such as attempting to add neutralizing compounds, is not a feasible option. Vegetation cover pre-mine was limited and implementing measures such as enhancing soil size materials to promote plant growth is currently considered to pose a risk to local wildlife in that it may attract wildlife to consume vegetation with potential to contain elevated metals concentrations.

Shallow ripping will be conducted in areas of the mine site disturbance footprint as appropriate following decommissioning of structures to decompact surficial materials and facilitate any natural regeneration by native vegetation communities that may occur.

The northernmost 12.8 km of the Brucejack transmission line is comprised of clear spans over bedrock and ice dominated alpine terrain. Towers and lines were installed by helicopter. Towers are anchored in bedrock. Reclamation of this section of the transmission line at closure will entail removal of towers and conductor line.

The southern 6.7 km of the M-243 transmission line section was mostly forested pre-construction, however even here there are extensive areas of bedrock exposure or shallow growth media over bedrock, and most towers in this section are also anchored in bedrock. Trees were hand felled, and soils and surficial materials were not disturbed except at the tower sites due to tower construction using helicopter support. The small disturbed areas around tower sites with potential to support plant growth were seeded following transmission line construction. Following the removal of conductor and towers during mine closure, tower sites will be recontoured as feasible, including covering concrete foundations to the extent feasible. Any available growth media will be seeded with Pretium's elevation-specific native species seed mixture and fertilized to promote growth.

4.3.3 Landforms and Drainage

4.3.3.1 Pre-Mine Landforms and Drainage

The Brucejack Mine site is located in a bedrock controlled, high elevation area. Pre-mine, and in remaining undisturbed or minimally disturbed areas, the bedrock surface was/is irregular with rounded surfaces broken by crevices and depressions where snow accumulates. There were localized areas with shallow, slightly weathered overburden and limited areas with developed soil cover. Most of what is now the mine site drained to Brucejack Lake (now the WRTSF), with some areas draining to Camp Creek or directly to Brucejack Creek. Bedrock and shallow overburden extended to the lake shoreline, with few level areas.

4.3.3.2 Mine Operations Landforms, Water Management and Erosion Control

Mine construction required development of level pads (Figure 4.3-1**)** for surface infrastructure such as the mill and lower camp buildings. Parts of the pads were created by bedrock excavation; the remainder of the leveling was achieved by filling and compaction using excavated crushed rock sourced from the km 72 NPAG quarry. The pads are designed to be stable, and resulted in approximately 20 ha of level area being created on the site.

A contact water collection system was constructed to collect runoff from the mine site pads bedrock excavations as had been planned and permitted pre-mine because this bedrock is or is assumed PAG, and in accordance with the ML/ARD requirements of M-243 and the Brucejack ML/ARD Management Plan (Appendix 9-1-11).

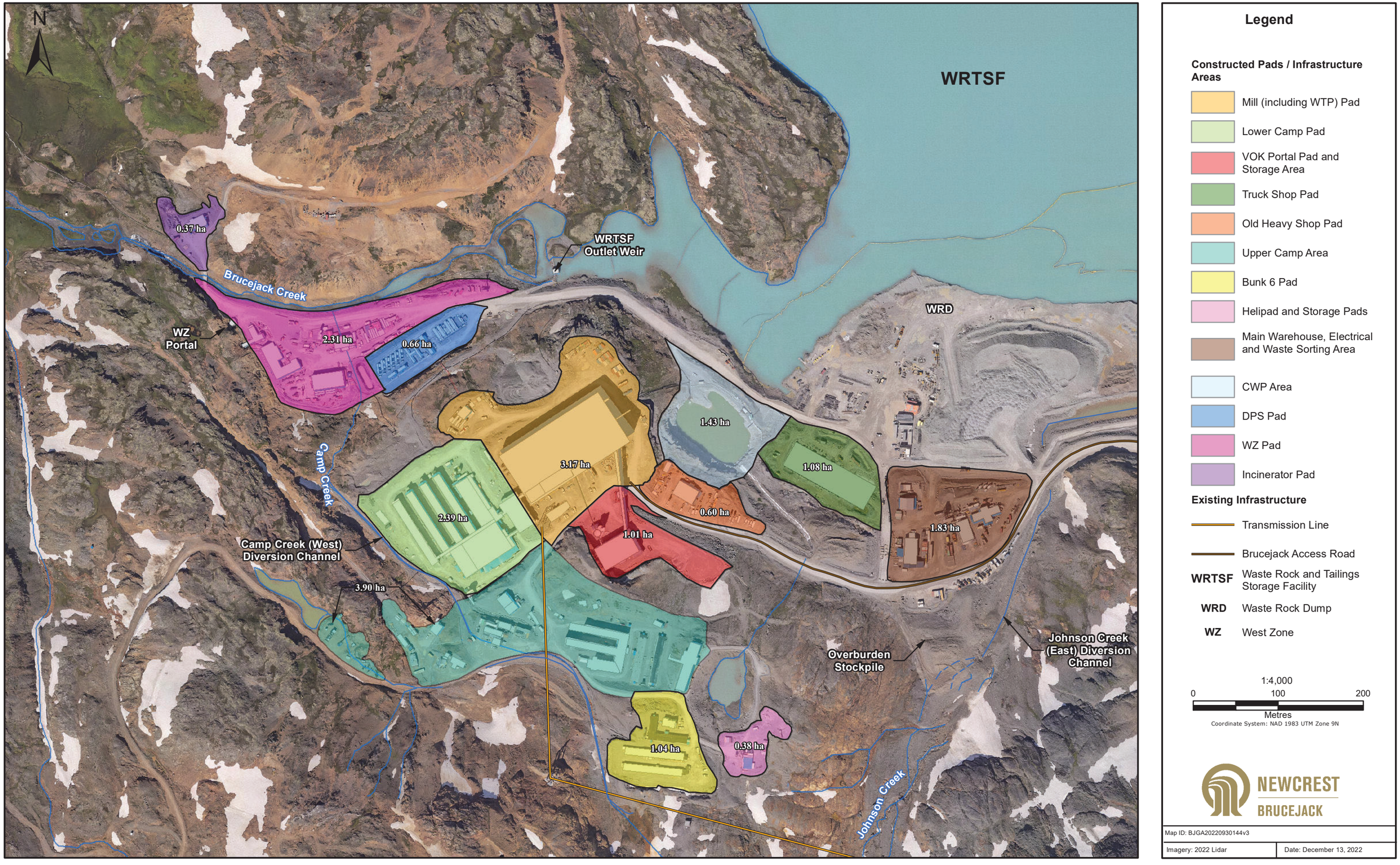


Figure 4.3-1. Constructed Pads and Infrastructure Areas

4.3.3.3 Post-Mine Landforms and Drainage

Following the removal of the active portions of the contact water collection system, the camp pad will drain passively to Camp Creek and the slopes below the mill, along with a portion of the mill pad, will drain to lower Camp Creek or to Brucejack Creek. The remainder of the mill pad and the areas passively draining to the CWP during operations will drain to the CWP and from there to the WRTSF. The CWP will remain in place, with the spillway remaining intact, and allowed to spill passively via the current emergency spillway, to the WRTSF. All areas east of the operations contact water collection system that drained passively to the WRTSF during operations will continue to do so post-closure. Post-closure, much of the mine site will continue to drain to the WRTSF, which will continue to passively collect and settle sediment. The West Zone Pad area will continue to drain to Brucejack Creek post-closure.

4.3.3.4 Transmission Line

Transmission line construction entailed very minimal surface disturbance and no significant effects on landforms. Removal of the transmission line infrastructure at closure (towers, conductor and Knipple substation) will result in the post- transmission line landforms being almost identical to the pre-mining landscape. There will be very minor and localized terrain changes compared to pre-development at some tower sites, but these are mainly limited to the vegetated southern portion of the line and are expected to become obscured by vegetation over time. The Knipple substation pad will be left level, in approximately the same topographical condition as existed prior to Pretium's use of this site.

4.4 Reclamation and Closure Prescriptions

4.4.1 Sequence and Schedule

Brucejack Mine closure activities are planned for implementation in a sequential manner such that infrastructure needed to the end of mine closure remains in place and all other reclamation activities occur in a logical progression. Key infrastructure to remain in place until confirmed to no longer be necessary are the WTP and infrastructure required to support it, including power supply, emergency generators, housing for WTP operators and support personnel and transportation infrastructure.

Final closure is expected to take approximately three years, including approximately two years of closure and reclamation activities within the M-243 disturbance area (primarily the mine site area), and an additional year of closing and reclaiming off-site ancillary infrastructure outside of the M-243 permitted area (Table 4.4-1). The latter includes the southern Statutory ROW portion of the transmission line and closing and reclaiming the BJAR and adjacent camps and infrastructure from km 59 to the intersection of the BJAR and Highway 37.

Reclamation activities within this period are planned and designed to provide for long term stable landforms and site conditions, and acceptable post-closure water quality in the Brucejack Creek aquatic receiving environment downstream of the mine. Underground mine reclamation, including removal of underground mobile equipment and completion of other pre-flooding preparatory measures, and flooding will begin immediately following closure (Table 4.4-2). Removal of surface equipment, buildings and infrastructure not required for water treatment and ongoing reclamation activities will occur during the first summer season of the closure phase. Surface reclamation will then be conducted as described below, including recontouring to prevent barriers or hazards to wildlife, establishment of stable post-closure surface drainage, and decompaction as appropriate.

Table 4.4-1. Brucejack Mine Reclamation and Closure Schedule

	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Mine Operations													
Closure Period		SITE RECLAMATION		OFF-SITE COMPLETION									
Post-Closure Period													

Table 4.4-2. Brucejack Mine Site Area Reclamation and Closure Schedule – Detail

	2030				2031				2032				2033				2034				2035				2036				2037				2038				2039				2040				2041			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
UG* Mine Reclamation																																																
UG Flooding & WT**																																																
Buildings & Equipment Removal																																																
Surface Reclamation																																																
Monitoring & Reporting																																																

**UG = underground mine*
**WT = water treatment

Mine flooding is estimated to be complete within seven months based on accelerated flooding accomplished by water withdrawal from the WRTSF; the withdrawal rate will be to the current licensed rate during the winter low flow period, and at accelerated rates during the freshet high flow period. Water treatment of the underground mine pool will continue throughout the active flooding period, predicted to be an additional eight months (total 15 months) [refer also to the Closure Underground Water Quality Adaptive Management Plan (Appendix 9-2-2)]. Watertight plugs will be installed in the WZ and VOK portals, and in the raise planned north of Brucejack Creek, during the first year of the closure phase to allow underground mine flooding to its ultimate flooding elevation. The mine equilibrium flooding elevation is predicted to be approximately 1404 masl (seasonal variation from 1394 to 1412 masl).

The WTP and related facilities will be removed when water treatment is no longer required. Mine openings to surface (portals and raises) will be sealed within the first two summer seasons of the closure phase, when access is no longer required. Remaining surface reclamation will be completed by the end of the second summer, along with removal of remaining surface infrastructure and equipment, including the transmission line. Monitoring and reporting will continue throughout the closure phase and for ten years following completion of site reclamation.

The Brucejack Mine site roads and the BJAR will be closed during the closure phase, therefore access for post-closure monitoring will be by helicopter. Post-closure monitoring will be carried out for site stability, surface and groundwater quality, aquatic resources, and reclamation success (including natural encroachment into facility areas by endemic vegetation). Geotechnical inspections will be conducted as required.

4.4.2 Mine Site Surface Reclamation

Mine reclamation at closure will begin with orderly and methodical removal of structures and equipment, except that required to support mine flooding and water treatment.

Most buildings and other infrastructure at the Brucejack Mine site are located on constructed pads (Table 4.4-3; Figure 4.3-1). The pads are stable, constructed with a combination of bedrock cuts (with excavated PAG surface material deposited into the WRTSF) and fill methods using NPAG quarried rock, or through placement of fill only. Off-pad facilities at the mine site include the upper camp area (including various offices and other, mostly modular, structures) CWP, site roads, contact water management infrastructure, overburden stockpile, WRTSF outlet weir, WRD, and the electrical services building and other structures located in the low lying area between the surface heavy shop and the Johnson Creek (East) diversion channel. Infrastructure within the upper camp area and warehouse and vicinity areas is mainly constructed on in-situ overburden, with several of these structures having been placed or constructed during advanced exploration or mine construction.

Table 4.4-3. Mine Site Constructed Pads and Infrastructure Areas.

Surface Infrastructure Pad	Area (ha)
Mill (including STPs) pad*	3.17
Lower camp pad*	2.39
VOK portal pad and storage *	1.01
Old heavy shop pad	0.60
Upper camp area (non-pad)	3.90
Upper camp bunk 6 pad*	1.04
Helipad and storage pads**	0.38
Main warehouse, electrical and waste sorting area	1.83
Diesel power station pad*	0.66
WZ portal pad**	2.31
Incinerator pad**	0.37
CWP	1.43
Truck shop pad	1.08
Total	**20.17**

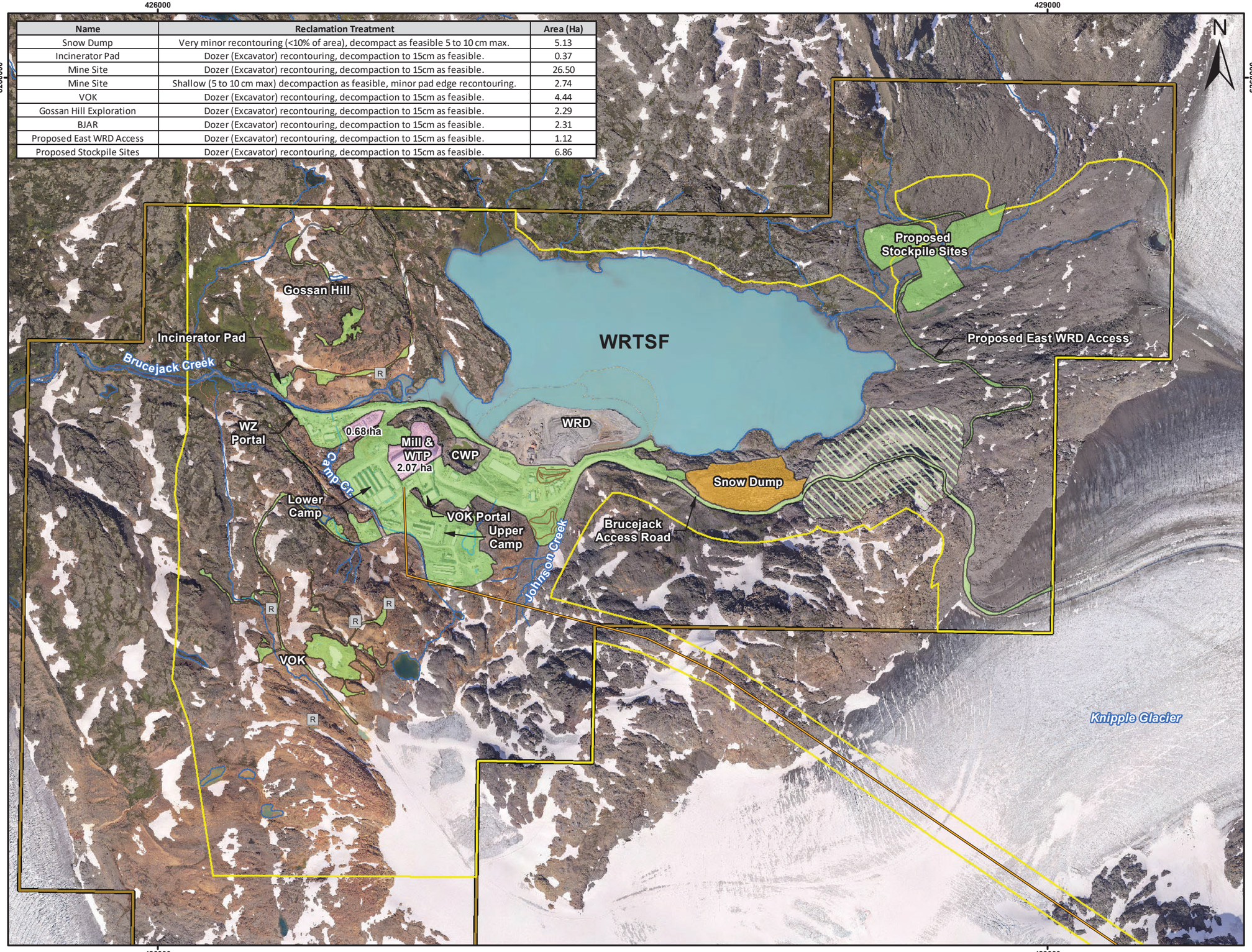
*Combination cut and fill
**Fill only

Facilities pads within the mine site will be left in place at mine closure following removal of structures and equipment, with some recontouring of NPAG rock fill materials to reduce any potential for slumping and erosion and to support achievement of the end land use objective. In preparation for final reclamation, the mine site road surfaces, NPAG crushed rock cover on the pads, and low gradient areas near the Johnson Creek Diversion will be shallow ripped to reduce surface compaction, minimize surface erosion, allow for downward water infiltration, and create the conditions for such passive natural revegetation as may occur. Concrete pads will be covered with overburden and/or crushed rock from adjacent portions of infrastructure pads as feasible, dependent on materials availability. Culverts will be removed from the roads and cross-drains and water bars will be established to create stable drainage. Figure 4.4-1 summarizes mine site area surface reclamation treatments at closure.

Recontouring and decompaction work during closure will be aimed primarily at preventing hazards or barriers to wildlife movement to achieve the end land use objective of wildlife matrix habitat (movement areas) particularly for mountain goat, grizzly bear, and hoary marmot (M-243, Condition E.3). These animals will be able to move across the mine site post-closure to access foraging areas or other habitat that provides life requisites. Reclamation work during closure will be secondarily aimed, to the extent feasible and suitable, at creating conditions for passive revegetation via propagules from local endemic vegetation species in adjacent areas. The Brucejack reclamation liability costing includes seeding much of the mine site using Pretium's high elevation native seed mixture, however a passive reclamation approach is preferred.

Contact water management infrastructure will remain in place until surface water collection and treatment is no longer required, at which time ditches not required for post-closure water management will be backfilled, pipeline and pumping infrastructure will be removed, and manholes will either be removed or rendered inactive. The seepage collection weirs below the lower camp pad will be breached or removed. The CWP, which is constructed in bedrock, will remain in place and be allowed to spill passively via its spillway. The non-contact diversion channels will remain in place.

Name	Reclamation Treatment	Area (Ha)
Snow Dump	Very minor recontouring (<10% of area), decompact as feasible 5 to 10 cm max.	5.13
Incinerator Pad	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	0.37
Mine Site	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	26.50
Mine Site	Shallow (5 to 10 cm max) decompaction as feasible, minor pad edge recontouring.	2.74
VOK	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	4.44
Gossan Hill Exploration	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	2.29
BJAR	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	2.31
Proposed East WRD Access	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	1.12
Proposed Stockpile Sites	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	6.86



Legend

Reclamation Treatments

- Dozer (Excavator) recontouring, decompaction to 15cm as feasible.
- Shallow (5 to 10 cm max) decompaction as feasible, minor pad edge recontouring.
- Very minor recontouring (<10% of area), decompact as feasible 5 to 10 cm max.

Existing Infrastructure

- Km 72 NPAQ Quarry
- Buildings
- Transmission Line
- Reclamation Stockpile
- R — Air Raise
- WRTSF — Waste Rock and Tailings Storage Facility
- CWP — Contact Water Pond
- WTP — Water Treatment Plant
- WZ — West Zone

Current M-243 PMA Boundaries

- M-243 Permitted Mine Area (2022)

Mineral Tenures

- Mining Lease

1:12,500

0 250 500

Metres

Coordinate System: NAD 1983 UTM Zone 9N

NEWCREST BRUCEJACK

Map ID: BJAUTH20220929140v3

Imagery: 2022 Lidar | Date: December 13, 2022

Figure 4.4-1. Mine Site Surface Reclamation Treatments

Waste rock dump development is planned such that most PAG rock will be placed subaqueously in the WRTSF during mine operations. At mine closure, remaining sections of exposed PAG rock on the dump pad will be placed subaqueously in a retreat manner, such that there are shallow ponded areas over much of the pad and exposed NPAG rock on surface near the shore of the WRTSF.

4.4.3 Underground Mine

At closure, all underground tanks and their contents will be removed and their contents shipped off site for re-use or shipment to licensed facilities. Hydrocarbons and hazardous materials from fixed equipment that is not being removed will also removed for off site shipment to licensed facilities. Fixed underground equipment suitable for re-use will be removed and transported off site. All mobile equipment and supplies will be removed from the underground mine and shipped off site for re-use or disposal as appropriate.

Most stopes will be backfilled with waste rock and paste tailings during operations. Flooding and water treatment during mine closure will occur as described in the Closure Underground Water Quality Adaptive Management Plan (Appendix 9-2-2). At closure, the underground mine workings will be flooded over a period of approximately seven months. Water treatment of the underground mine pool is planned to continue for an additional eight months, for a total treatment duration of 15 months.

Both portals and the raise planned north of Brucejack Creek will be sealed with watertight plugs to enable the mine to flood to the predicted elevations. The portals and all raises will be sealed when no longer required for access. Any seepage from the plugs will be allowed to drain to Brucejack Creek / WRTSF.

4.4.4 Transmission Line

The Brucejack transmission line will remain in operation until this power supply is no longer required at the mine site; this is expected to follow the scheduled 15 months of closure phase water treatment. When no longer required, the Brucejack transmission line towers and conductor will be removed using helicopter support as necessary. Substation equipment and components will be removed using ground access. Transmission line and substation components will be transported off site for recycling or disposal as appropriate.

Within the southernmost 6.7 km section of the M-243 portion transmission line that is below the tree line, there may be some disturbance of surficial materials in the areas around the tower bases during the dismantling of the towers. Tower sites will be recontoured and concrete bases covered as feasible, and any growth media will be seeded with either the high or low elevation seed mixture, as appropriate. Removal of transmission line structures over most of the M-243 transmission line section is not expected to result in significant ground disturbance nor effects on landforms, as these are anchored in rock. Post- transmission line and tower removal, all portions of the transmission line are expected to meet the wildlife matrix habitat end land use objective.

4.5 Five Year Mine Reclamation Plan

Design of the Brucejack mine site has focused on efficient and essential use of surface disturbances. Due to the small, intensively used operations footprint, revegetation has not been possible to date within the mine's primary infrastructure area and there are no foreseeable opportunities for progressive

reclamation in the next five years beyond the small areas being used to support reclamation research. Almost all reclamation within the PMA will be completed during mine closure.

Outside of the primary infrastructure area, progressive reclamation of areas disturbed through surface exploration will continue. The surface exploration disturbance is much less intensive than within the primary facilities area, and extents within the PMA are very small as most exploration proximal to the mine is conducted underground.

4.6 Post-Closure Monitoring and Maintenance

4.6.1 Overview

Monitoring is required under Section 10.7.21 of the Code to demonstrate that reclamation and environmental protection objectives including land use, productivity, water quality, and stability of structures are being achieved (EMLI 2022). Mine closure is estimated to be completed within three years, followed by post-closure monitoring over the following ten years. The results of the monitoring program are to be included in the Annual Reclamation Report (per Section 10.4.4 of the Code).

The following is a description of conceptual post-closure monitoring plans planned for the Brucejack Mine. The length of time required for monitoring may be extended if the early results of the program indicate further monitoring is required. All facilities will be dismantled and/or removed from site during closure with site drainage and landforms contoured to a final closed state. As such, regular maintenance is not anticipated. Maintenance needs will be identified on an as-needed basis based on the monitoring and inspection programs described below.

Monitoring programs will be designed to address evolving needs and are anticipated to decrease in scope through the closure and post-closure periods. During the closure period, monitoring programs will focus on monitoring and management of reclamation activities. During the post-closure period, monitoring programs will focus on demonstrating reclamation success. The general scope of monitoring programs will include:

- Surface water quality and quantity, sediments, and aquatic biological resources;
- Groundwater quality and levels, including water chemistry and level in the underground mine as feasible;
- Structural integrity of portals and raise watertight plugs;
- Geotechnical assessment of post-mine landform and watercourse stability, including for the surface above the underground mine (subsidence); and
- Assessments of reclamation program success in meeting the end land use objectives.

Additional details are provided in the subsections below.

4.6.2 Surface Water Quality and Quantity, Sediments, and Aquatic Biological Resources

Surface water quality and quantity, sediments and aquatic biological resources monitoring and sampling will continue to follow the requirements of PE-107835 through the closure period, with the exception of the reference site (L3) and effluent discharges as these cease (first tailings, then mine water and CWP influents and WTP effluent once water treatment has concluded, and finally treated

domestic wastewater once the site has been fully closed). Once there is no longer a presence at the Brucejack site, surface water quality and quantity (flow) monitoring will continue twice per year (spring/fall) and sediments and aquatic biological sampling will be conducted once per year (fall) until the end of the first ten years of the post-closure period.

4.6.3 Groundwater

Monitoring of select groundwater wells pertinent to closure and post-closure monitoring will continue quarterly through the active closure period. The program will be reviewed prior to the end of closure and adjusted as appropriate with ENV and EMLI approval. It is expected that groundwater monitoring of a reduced number of groundwater wells will continue twice per year for the first ten years of the post-closure period.

The underground mine water level will be monitored as feasible during the course of flooding, and post-closure via the groundwater well monitoring program.

Post-closure groundwater monitoring will comprise both water level and water quality monitoring. Selected monitoring wells and the mine pool itself will be targeted for water quality monitoring. Biannual groundwater and mine pool sampling events are recommended in early June and late September, bookending the open water season. Dedicated dataloggers deployed at groundwater monitoring installations and in the mine pool will be downloaded during sampling events to provide a continuous record of water level data. In the case of the mine pool, loggers will also record electrical conductivity.

4.6.4 Mine Openings

The structural integrity of the watertight plugs in the WZ and VOK portals and the raise north of Brucejack Creek will be checked prior to placement of exterior seals at the end of the closure period to ensure these are performing as required and designed. Repairs will be carried out if and as needed.

4.6.5 Geotechnical

Geotechnical monitoring, inspection and assessment of post-mine landforms will continue annually during closure and the first ten years of post-closure. Implementation of the Subsidence Monitoring and Management Plan (Appendix 9-2-8) will continue through closure, and with a modified program appropriate to post-closure, and as approved by MEMPR, implemented during the first ten years of post-closure. The CWP and its spillway, and post-mine watercourses (particularly the two diversion channels) will continue to be inspected annually for structural integrity and performance. Post-mine, pads, decommissioned roads (including drainage crossings), the km 72 NPAG quarry, the WRD pad, and other post-mine landscape features will be inspected for stability and performance. Repairs will be carried out if and as needed.

4.6.6 Reclamation Program

Monitoring and assessments of the reclamation program success in meeting the end land use objectives will be conducted annually during the first ten years of post-closure. This will include monitoring for erosion, particularly any determined to affect surface water quality downstream of the WRTSF discharge, and remediation as appropriate. The mine site area will be inspected to confirm that closure measures implemented to achieve the end land use objective of matrix habitat remain

intact, with remedial measures implemented as appropriate as necessary. Natural locally endemic vegetation species encroachment onto the mine site will be monitored and documented.

4.6.7 Post-Closure Personnel Requirements and Access

Since regular maintenance is not anticipated post-closure, limited personnel are required. During the first-year post-closure, there will be 2 full time environmental project management leads. For subsequent years, the environmental project management leads time allocation will be reduced to 25%. During the ten years post-closure, additional support will be received from consultants. The environmental project management leads will be based offsite and helicopter transportation will be used for post-closure site access.

Post-closure monitoring will require personnel and access to site twice per year for surface water quality monitoring, twice during first ten years for sediment and aquatics Monitoring, quarterly for groundwater monitoring, and annually for mine openings, geotechnical, and reclamation Monitoring.

4.7 Reclamation Cost Estimate

The Reclamation Cost Estimate has been updated to the Newcrest cost model and to reflect all relevant changes described above (e.g. infrastructure and disturbance area changes since 2020 and maximum liability in the next five years). It is being submitted to the Chief Permitting Officer under separate cover as per Code Section 10.1.3(i).

5. MODELLING, MITIGATION, AND DISCHARGES

5.1 Summary

The proposed increase to Brucejack Mine's ore production rate will result in increased rates of underground waste rock excavation, waste rock deposition, and tailings discharged to the WRTSF. The influence of these increased rates and the associated chemical loadings on water quality discharged from the WRTSF to Brucejack Creek have been evaluated.

The following sections and the associated appendices present updated groundwater model results, water balance model results, and water quality model predictions which incorporate changes associated with Pretium's application to increase the authorized average ore production rate. Parameters of potential concern (POPC) were identified from the water quality model predictions. While some POPCs are expected to be mitigated by natural processes that are not accounted for in the water quality model, others are predicted to exceed the mine's current discharge limits or go above a water quality guideline. For these parameters of concern (POCs), a best achievable technology (BAT) assessment was carried out to evaluate treatment options, associated costs, and feasibility of implementation. The results of this assessment are presented in Section 5.6, and in the associated appendix. Potential risk to aquatic life from the modelled POCs was assessed in the water quality model report (Appendix 5-3) and is summarized in Chapter 6.

Taking into consideration the results of the BAT assessment and the effects assessment, Pretium is proposing to amend effluent permit 107835 to increase current discharge limits for nitrate and total arsenic (T-As), and to request the addition of discharge limits for dissolved copper (D-Cu) and total selenium (T-Se). Section 5.7 presents the requested discharge limits and the rationale for these proposed amendments.

5.2 Conceptual Site Model

The conceptual models used for Brucejack Mine are described in the groundwater model report (Appendix 5-1 – Section 2.9), the water balance model report (Appendix 5-2 – Section 3.1) and the water quality model report (Appendix 5-3 – Section 2 and Section 5.2).

5.3 Groundwater Model

The Brucejack mine groundwater model was updated to identify how the proposed increased production rate and associated mine plan would impact the groundwater system during operations and at closure. The groundwater model results are presented in Appendix 5-1, entitled *Brucejack Mine: 4950 tpd Groundwater Model Report.*

As compared to prior models based on the 3800 tpd production rate, the updated 4590 tpd groundwater model predicts increased inflow rates over LOM, but less overall groundwater extraction. The increased flows to the underground mine will be managed effectively by the mine's current water collection and treatment system. Predicted changes in baseflow reporting to Brucejack Creek for the 4950 tpd production rate are similar to those predicted for the 3800 tpd production rate. Contact groundwater flows to Brucejack Creek at closure are predicted to be higher than those predicted for the 3800 tpd mine plan on account of the slightly deeper and broader mine development. Groundwater

modeling results predicted for the 4950 tpd production rate have been incorporated into the site wide water balance and water quality models.

5.4 Water Balance Model

An updated water balance model based on the proposed increased production rate and associated mine plan was developed. The results of this model are presented in Appendix 5-2, entitled *Brucejack Mine: 4950 tpd Water Balance Model Report.* The water balance model forms the basis for the updated water quality predictions.

The water balance report highlights anticipated changes to mine site and receiving stream flows based on the increased mining rate for a Base Case scenario, representing average climate conditions. The report also considers water balance model sensitivities related to tailings solids content, variable climate conditions and climate change.

5.5 Water Quality Model

The Brucejack Mine water quality model has been updated to account for the increased ore production rate and the associated mine plan. Revisions to the model include the incorporation of revised flows from the updated water balance model, changes to the mine waste schedules, and updates to geochemical source terms based on new data and trends observed in the monitoring data sets. Base Case and Upper Case water quality predictions are presented for two stations: BJ 3.10, the mine's regulated discharge point, located at the outlet to the WRTSF; and BJ 2.62, a downstream monitoring location in Brucejack Creek. The Base Case is considered to represent a conservative expected case; whereas the Upper Case incorporates the combined effects of upper case geochemical source terms for all mine-related inputs.

The water quality model report, entitled Brucejack Mine: 4950 tpd Water Quality Model Report, is presented in Appendix 5-3. Water quality model predictions and the associated effects assessment presented in the report form the basis for the mitigation options presented in Section 5.6 and the requested revisions to the WRTSF discharge concentration limits described in Section 5.7.

Summaries of the maximum Base Case predicted concentrations for BJ 3.10 and BJ 2.62 are presented in Table 5.5-1 and Table 5.5-2, respectively, as compared to BC FWAL guidelines, current PE-107835 effluent discharge limits and previous model results under a 3800 tpd scenario. Parameters of potential concern were identified as parameters having Base Case predictions within 80% of a water quality benchmark (discharge limit or BC FWAL guideline). These are ammonia, nitrite, nitrate, sulfate, total arsenic, dissolved aluminum, dissolved copper, and total selenium. Additional consideration of these POPCs determined that biochemical reactions of ammonia, and chemical reactions of D-Al, and that occur in the WRTSF and are not captured by the mass balance water quality model, will maintain these parameters below the ammonia discharge limit and the D-Al FWAL guidelines. As well, additional consideration of modelled sulfate determined that sulfate is expected to remain below the FWAL guideline throughout the life of mine. An effects assessment was conducted on the model results for the remaining five parameters (nitrite, nitrate, total arsenic, dissolved copper and total selenium). The water quality model report presents an effects assessment for these parameters, which is summarized in Chapter 6. The effects assessment concludes that there is low risk of adverse effects to aquatic life in Brucejack Creek from modelled concentrations of these POCs, except for Upper Case T-Se during closure phase which had a moderate risk rating.

Table 5.5-1. Maximum Concentrations from the BJ 3.10 Base Case Water Quality Model, for All Mine Phases, Compared to the Maximum from Previous Model Updates, BC Water Quality Guidelines, PE-107835 Effluent Discharge Limits, and POPC Benchmarks.

Parameter	Units	Maximum Modelled			POPC benchmark	BC FWAL Guidelines		Effluent Discharge Limit
		2023	2020	2018		Long-term	Short-term	
Ammonia	mg-N/L	**3.53**	3.20	2.8	3.2	NA	NA	4.0
Nitrite	mg-N/L	0.13	**0.23**	**0.2**	0.19	NA	NA	0.24
Nitrate	mg-N/L	**15.2**	9.9	8.7	9.2	NA	NA	11.5
Chloride	mg/L	8.2	6.6	1.4	120	150	600	NP
Fluoride	mg/L	0.29	0.18	0.14	0.66	NP	0.82	NP
Sulfate	mg/L	**114**	71	95	102	128	NP	NP
Aluminum-D	mg/L	**0.062**	**0.047**	0.039	0.040	0.050	0.10	NP
Antimony-T	mg/L	0.020	0.010	0.013	0.022	NA	NP	0.028
Arsenic-T	mg/L	**0.014**	**0.0093**	0.0070	0.008	NP	NA	0.01
Boron-T	mg/L	0.14	0.094	0.069	0.96	1.2	NP	NP
Barium-T	mg/L	0.048	0.061	0.072	0.80	1.0	NP	NP
Beryllium-T	mg/L	0.00003	0.00008	0.00007	0.00010	0.00013	NP	NP
Cadmium-D	mg/L	0.000012	0.000011	0.000012	0.000066	0.000083	0.000159	NP
Chromium-T	mg/L	0.00034	**0.00091**	**0.0013**	0.00080	0.0010	NP	NP
Cobalt-T	mg/L	0.00029	0.00048	0.00050	0.0032	0.0040	0.11	NP
Copper-D	mg/L	**0.00042**	**0.00078**	0.00028	0.00024	0.0003	0.0018	NP
Iron-D	mg/L	0.008	0.018	0.040	0.28	NP	0.35	NP
Iron-T	mg/L	0.040	0.18	0.19	1.36	NP	NA	1.7
Lead-T	mg/L	0.00030	0.00040	0.00050	0.00320	0.0039	0.0160	NP
Mercury-T	mg/L	0.000004	0.000006	0.000005	0.000016	0.000020	NP	NP
Manganese-T	mg/L	0.25	0.18	0.22	0.58	0.73	0.85	NP
Molybdenum-T	mg/L	0.016	0.009	0.009	6.08	7.6	46	NP
Nickel-T	mg/L	0.0005	0.0007	0.0009	0.0200	0.0250	NP	NP
Phosphorus-T	mg/L	0.012	0.012	0.027	NP	NP	NP	NP
Selenium-T	mg/L	**0.0021**	0.0012	0.0010	0.0016	0.0020	NP	NP
Silver-T	mg/L	0.00001	0.00002	0.00004	0.00037	NA	NA	0.00046
Thallium-T	mg/L	0.00009	0.00007	0.00010	0.00064	0.00080	NP	NP
Uranium-T	mg/L	0.0006	0.0004	0.0010	0.0068	0.0085	NP	NP
Zinc-T	mg/L	0.0021	0.0026	0.0029	0.0060	0.0075	0.033	NP

Notes: 2020 water quality model presented in the 2020 Update (Lorax 2020b)
2018 water quality model presented in the 3800 tpd Permit Amendment Application (Lorax 2018).
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
POPC benchmark is equal to 80% of a discharge limit or 80% of a BC FWAL for parameters without discharge limits.
Bold font indicates parameters and concentrations that are greater than their POPC benchmark.
Concentrations that are higher in the current model than in both previous models are underlined.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Table 5.5-2. Maximum Concentrations from the BJ 2.62 Base Case Water Quality Model, for All Mine Phases, Compared to the Maximum from Previous Model Updates, BC Water Quality Guidelines, PE-107835 Effluent Discharge Limits, and POPC Benchmarks.

Parameter	Units	Maximum Modelled			POPC benchmark	BC FWAL Guidelines		Effluent Discharge Limit
		2023	2020	2018		Long-term	Short-term	
Ammonia	mg-N/L	**3.21**	2.90	2.8	3.2	NA	NA	4.0
Nitrite	mg-N/L	**0.24**	**0.24**	**0.20**	0.19	NA	NA	0.24
Nitrate	mg-N/L	**13.8**	8.97	8.5	9.2	NA	NA	11.5
Chloride	mg/L	10.3	9.72	2.3	120	150	600	NP
Fluoride	mg/L	0.37	0.40	0.14	0.66	NP	0.82	NP
Sulfate	mg/L	**197**	**133**	94	102	128	NP	NP
Aluminum-D	mg/L	**0.057**	**0.044**	0.039	0.040	0.050	0.10	NP
Antimony-T	mg/L	0.018	0.011	0.014	0.022	NA	NP	0.028
Arsenic-T	mg/L	**0.013**	**0.011**	**0.013**	0.008	NP	NA	0.01
Boron-T	mg/L	0.18	0.15	0.074	0.96	1.2	NP	NP
Barium-T	mg/L	0.077	0.088	0.071	0.80	1.0	NP	NP
Beryllium-T	mg/L	0.00005	**0.00015**	**0.00012**	0.00010	0.00013	NP	NP
Cadmium-D	mg/L	0.000021	0.000022	0.000041	0.000066	0.000083	0.000159	NP
Chromium-T	mg/L	0.0005	**0.0009**	**0.0012**	0.00080	0.0010	NP	NP
Cobalt-T	mg/L	0.0021	**0.0041**	0.0008	0.0032	0.0040	0.11	NP
Copper-D	mg/L	**0.0017**	**0.0027**	**0.0007**	0.00024	0.0003	0.0018	NP
Iron-D	mg/L	0.013	0.022	**3.13**	0.28	NP	0.35	NP
Iron-T	mg/L	0.039	0.194	**3.34**	1.36	NP	NA	1.7
Lead-T	mg/L	0.0004	0.0006	0.0012	0.0032	0.0039	0.016	NP
Mercury-T	mg/L	0.000004	0.000006	0.000008	0.000016	0.000020	NP	NP
Manganese-T	mg/L	0.26	0.16	0.26	0.58	0.73	0.85	NP
Molybdenum-T	mg/L	0.014	0.013	0.009	6.08	7.6	46	NP
Nickel-T	mg/L	0.0005	0.0007	0.0009	0.0200	0.0250	NP	NP
Phosphorus-T	mg/L	0.012	0.012	0.026	NP	NP	NP	NP
Selenium-T	mg/L	**0.0037**	**0.0035**	0.0010	0.0016	0.0020	NP	NP
Silver-T	mg/L	0.00006	0.00007	0.00006	0.00037	NA	NA	0.00046
Thallium-T	mg/L	0.00012	0.00011	0.00010	0.00064	0.00080	NP	NP
Uranium-T	mg/L	0.0011	0.0019	0.0016	0.0068	0.0085	NP	NP
Zinc-T	mg/L	0.0038	0.0032	**0.0086**	0.0060	0.0075	0.033	NP

Notes: 2020 water quality model presented in the 2020 Update (Lorax 2020b)
2018 water quality model presented in the 3800 tpd Permit Amendment Application (Lorax 2018).
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
POPC benchmark is equal to 80% of a discharge limit or 80% of a BC FWAL for parameters without discharge limits.
Bold font indicates parameters and concentrations that are greater than their POPC benchmark.
Concentrations that are higher in the current model than in both previous models are underlined.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

5.6 Mitigation Methods

Source control is the primary method that is used to maintain acceptable effluent quality at the Brucejack Mine's regulated discharge locations (the outlet of the WRTSF (BJ 3.10) as well as WTP and CWP effluent). Source control procedures developed for the mine are outlined in various environmental management plans (i.e., ML/ARD Management Plan (Appendix 9-1-11), Nitrogen Management Plan (Appendix 9-2-6), Chromium Management Plan (Appendix 9-2-1), as well as the WRTSF and WMP OMS documents (Appendices 9-1-17 and 9-1-18, respectively)). These management plans include sampling recommendations, management triggers, and corrective actions that are designed to minimize potential adverse effects to water quality. Monitoring of the various sources of contaminant loadings to the WRTSF, and monitoring of WRTSF effluent at BJ 3.10, show that the source control measures implemented have been effective in maintaining acceptable discharge quality. It is anticipated that these measures will continue to be effective for a production rate of 4950 tpd.

The section below (Section 5.6.1) describes the mine's current water treatment plant and its ability to manage the predicted flows and influent water quality associated with the increased production rate. Certain POPCs will be mitigated through natural processes occurring in the WRTSF (e.g., precipitation reactions, adsorption reactions, biologically mediated nitrification) or through different water management strategies as outlined in the Closure Underground Water Quality Adaptive Management Plan (Appendix 9-2-2). However, four parameters are predicted to go above current discharge limits or BC FWAL guidelines. A BAT assessment was carried out to evaluate additional treatment options. The results of this study are summarized in Section 5.6.2.

5.6.1 The Brucejack Mine Water Treatment Plant

5.6.1.1 Description

The WTP, located in the mill building, receives and treats underground mine water from mine dewatering, CWP water, and recycled process water from the mill. The WTP is designed to chemically precipitate targeted dissolved metals and remove influent TSS and the resultant chemical precipitates at influent flow rates of 3,120 to 10,000 m^3/day. Key components of the WTP treatment process include a pre-treatment clarifier (for coarse TSS removal), primary metal precipitation stage (dissolved metal and TSS removal), secondary metal precipitation stage (for dissolved metal oxy-anion and TSS removal), final metal polishing by filtration (for small particulate TSS removal) and final pH adjustment. A simplified schematic of the WTP process is shown in Figure 5.6-1.

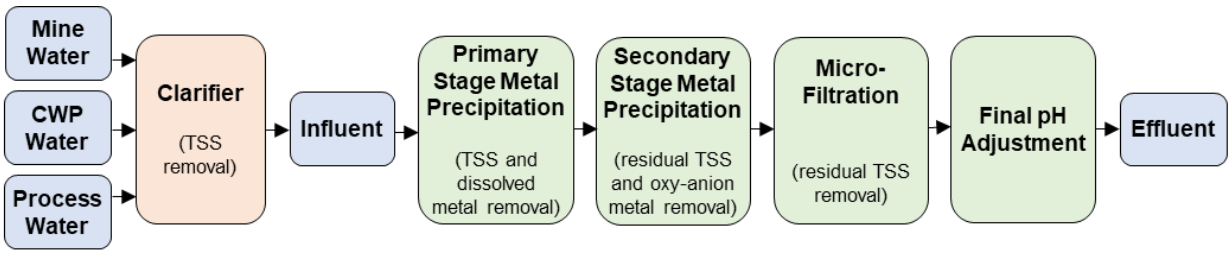


Figure 5.6-1. Schematic of the Brucejack Mine clarifier and WTP treatment process (green boxes represent the WTP components)

The WTP generates a solid waste product (sludge) that requires management and disposal. The mass of the sludge produced depends on the TSS content of the influent, the chemical composition of the influent, the flow rate and the nature of the solid particles. Sludge is currently deposited in the WRTSF at a sludge to tailings mixing ratio not exceeding 2% sludge (dry weight) in accordance with PE-107835 and permit M-243.

The current WTP began operating in mid-2017 and ferric sulfate has been successfully used for metal removal in both metal precipitation stages since that time. The combined influent water quality has been monitored in the clarifier overflow since May 2018. Influent concentrations of most dissolved parameters targeted by treatment are below WTP effluent limits (*i.e*., Ag, Cd, Co, Cu, Fe, Pb, Mn and Zn), or are effectively treated with ferric sulfate (*i.e*., Al, As); therefore, sodium sulfide treatment has not been activated. The sulfide circuit can be commissioned for use if needed to meet PE-107835 discharge requirements. The WTP will continue operating into the closure phase, until active water treatment is no longer required.

5.6.1.2 Changes to Influent and Effluent Quality

The concentration of parameters targeted for treatment are predicted to increase through operations (Appendix 5-3), as are the WTP influent flows (Appendix 5-1). The WTP flows are modelled to increase as the mine void expands, stabilizing in 2025 at approximately 7,500 m^3/day (median value). The daily influent flows are modelled to peak at levels above the WTP design flow (10,000 m^3/day) for a few days in June of each year (up to 12,566 m^3/day) (Appendix 5-3). However, it is assumed that influent flows will be managed to remain within the WTP design specifications through the implementation of various water management strategies, including reduction of WTP influent flows from the underground or the CWP, and temporary storage of water in these facilities (the CWP is drawn down each spring prior to freshet). Additional measures could include allowing the CWP to discharge to the WRTSF if the water quality meets CWP effluent limits, or reducing inflows of recycled mill process water to the WTP.

Modelled WTP effluent quality is based on predicted influent quality and treatment removal rates derived from operational or proxy data sets. Parameter specific treatment removal rates, expressed as % removal are applied to the following parameters: D-Al (90% removal), D-As (90% removal), D-Cd (25% removal), D-Cu (95% removal), D-Mo (25% removal), D-Pb (75% removal), D-P (75% removal), D-Sb (50% removal), D-Se (25% removal), D-U (50% removal), D-V (75% removal), and D-Zn (25% removal). The same treatment removal rates are applied for the Base Case and Upper Case scenarios and are generally set at, or below, the operational removal efficiencies (as described in Section 3.5.2 of Appendix 5-3).

Treatment removal rates are unchanged from the previous 3800 tpd model (Lorax 2020b), with the exception of D-Cu. The calculated removal efficiency for D-Cu (73%) is bounded by low Cu concentrations in the influent (i.e., the maximum observed influent D-Cu concentration from 2018-2022 is 0.0031 mg/L). Observations of Cu removal at the Britannia Mine treatment plant, using a precipitation process that is comparable to the one used at Brucejack Mine, indicate removal efficiencies of 99.9% for Cu (Madsen, 2007). Therefore, based on operational and proxy data, the removal efficiency for Cu is conservatively modelled at 95% in the 4950 tpd model.

The predicted WTP influent concentrations are generally below the WTP design basis (Table 5.6-1), with the exception of Upper Case D-Pb, D-P and D-Ag. As compared to the 2018 and 2020 3800 tpd

models, the predicted WTP influent and effluent water quality for the 4950 tpd water quality model are generally comparable (Table 5.6-2). However, the 4950 tpd model predicts fewer parameters (n=3) exceeding WTP effluent discharge limits, and of those predicted to exceed, the concentrations are lower than the 2020 3800 tpd model.

The model conservatively assumes the iron precipitation process will be used throughout operations and closure. The sulfide precipitation process can achieve lower treatment levels and higher removal efficiencies for Cd, Cu, Ag and Zn, and will be activated by Pretium as needed to meet WTP effluent limits.

Table 5.6-1. Maximum Concentrations Predicted by the 2023 (4950 tpd) Water Quality Model for WTP Influent (Operations and Closure) Compared to the WTP Design Basis Concentrations

Parameter	Units	WTP Design Basis [1]	Maximum Modelled – WTP Influent (2023 Model)	
			Base Case	Upper Case
T-Al	mg/L	47.4	0.18	2.2
D-Al	mg/L	28.6	0.18	2.1
T-As	mg/L	1.09	0.11	0.27
D-As	mg/L	0.39	0.11	0.27
T-Cd	mg/L	0.072	0.000061	0.015
D-Cd	mg/L	0.068	0.000061	0.015
T-Co	mg/L	0.090	0.012	0.054
D-Co	mg/L	0.061	0.012	0.054
T-Cu	mg/L	0.90	0.026	0.18
D-Cu	mg/L	0.75	0.026	0.18
T-Fe	mg/L	152.0	0.045	3.0
D-Fe	mg/L	64.7	0.039	3.0
T-Pb	mg/L	0.135	0.0021	0.017
D-Pb	mg/L	0.013	0.0020	**0.017**
T-Mn	mg/L	55.3	0.34	3.4
D-Mn	mg/L	52.7	0.34	3.4
T-P	mg/L	2.64	0.047	0.28
D-P	mg/L	0.14	0.039	**0.18**
T-Ag	mg/L	0.0097	0.00027	0.0012
D-Ag	mg/L	0.0003	0.00027	**0.0012**
T-Zn	mg/L	9.96	0.0071	0.70
D-Zn	mg/L	9.61	0.0070	0.70

Notes:
[1] Design basis concentrations reported in Table 7.1-41 of the 2015 MA/EMA Permits Application.
Modelled concentrations that are greater than the design basis are shown in **bold font and shaded grey**.

Table 5.6-2. Maximum Concentrations from the WTP Base Case Water Quality Model for Operations and Closure, Compared to the Maximum from Previous Model Updates and PE-107835 WTP Discharge Limits

Parameter	Units	Maximum Modelled –WTP Influent			Maximum Modelled –WTP Effluent			WTP Discharge Limit
		2023 model	2020 model	2018 model	2023 model	2020 model	2018 model	
Ammonia *	mg-N/L	27	17	38	27	17	38	-
Nitrite	mg-N/L	4.9	3.1	6.9	4.9	3.1	6.9	-
Nitrate *	mg-N/L	92	74	89	92	74	89	-
Chloride	mg/L	59	85	19	59	85	19	-
Fluoride	mg/L	1.7	2.6	2.3	1.7	2.6	2.3	-
Sulfate *	mg/L	832	751	1304	1032	751	1704	-
D-Al *	mg/L	0.18	0.23	0.19	0.018	0.023	0.19	-
T-Al	mg/L	0.18	0.24	0.25	0.018	0.024	0.25	0.30
T-Sb	mg/L	0.12	0.19	0.33	0.059	0.097	0.33	-
T-As *	mg/L	0.11	0.11	0.36	**0.011**	**0.011**	0.010	0.010
T-B	mg/L	1.2	1.5	1.5	1.2	1.5	1.5	-
T-Ba	mg/L	0.20	0.33	0.31	0.20	0.33	0.31	-
T-Be	mg/L	0.00025	0.00027	0.00012	0.00025	0.00027	0.00012	-
D-Cd	mg/L	0.000061	0.0011	0.00010	0.000046	0.00080	0.00010	-
T-Cd	mg/L	0.000061	0.0011	0.00010	0.000046	**0.00080**	0.00010	0.00025
T-Cr	mg/L	0.0022	0.0029	0.017	0.0022	0.0029	0.017	0.020
T-Co	mg/L	0.012	0.027	0.011	**0.012**	**0.027**	0.010	0.010
D-Cu *	mg/L	0.026	0.028	0.0012	0.0013	0.014	0.0012	-
T-Cu	mg/L	0.026	0.028	0.0012	0.0013	**0.014**	0.0012	0.010
D-Fe	mg/L	0.039	0.49	0.028	0.039	0.49	0.028	-
T-Fe	mg/L	0.045	0.49	0.054	0.045	0.49	0.054	1.0
T-Pb	mg/L	0.0021	0.0051	0.0089	0.00052	0.0013	0.0050	0.0050
T-Hg	mg/L	0.000012	0.000019	0.000011	0.000012	0.000019	0.000011	-
T-Mn	mg/L	0.34	0.37	1.7	0.34	0.37	1.7	22
T-Mo	mg/L	0.057	0.081	0.16	0.043	0.061	0.16	-
T-Ni	mg/L	0.0013	0.0038	0.0076	0.0013	0.0038	0.0076	-
T-P	mg/L	0.047	0.026	0.19	0.047	0.0065	0.19	-
T-Se *	mg/L	0.018	0.025	0.019	0.014	0.019	0.019	-
T-Ag	mg/L	0.00027	0.00040	0.00044	**0.00027**	**0.00040**	**0.00010**	0.00010
T-Tl	mg/L	0.00038	0.00033	0.0014	0.00038	0.00033	0.0014	-
T-U	mg/L	0.0069	0.015	0.028	0.0035	0.0075	0.028	-
T-Zn	mg/L	0.0071	0.054	0.017	0.0054	**0.040**	0.017	0.020

Notes:
2020 water quality model presented in the 2020 Update (Lorax 2020b).
2018 water quality model presented in the 3800 tpd Permit Amendment Application (Lorax 2018).
Concentrations that are higher in the current 2023 model as compared to previous 2020 model are underlined.
Effluent concentrations that exceed a WTP discharge limit are shown in **bold font and shaded grey**.
- = no limit specified in PE-107835.
* = parameter of potential concern at BJ 3.10.

5.6.2 Best Achievable Technology Assessment

A best achievable technology (BAT) assessment was conducted for water treatment at Brucejack Mine (Appendix 5-4). A BAT assessment is a site-specific evaluation of waste control technologies that have been proven in commercial application and whose risks are known, that accounts for site-specific operational, environmental, or geographic conditions and economic viability. Water quality modelling based on the mine plan for the proposed increased production rate predicts that concentrations of certain parameters will go above the current water quality discharge limits or BC FWAL guidelines at monitoring station BJ 3.10 during the operations phase. Therefore, the purpose of the BAT assessment is to evaluate options for water treatment at the outlet of the WRTSF to meet current discharge limits and applicable water quality guidelines at BJ 3.10 during the operations phase, under the proposed increased production rate scenario.

The WRTSF outlet is characterized by high volumes and relatively low concentrations, which poses a challenge for treatment. In general, it would be preferable to treat lower volumes of more concentrated sources upstream of the WRTSF outlet; however, the primary sources of POCs during operations at BJ 3.10 (i.e., NO_3, T-Se, D-Cu and T-As) are tailings and waste rock deposited in the WRTSF. Therefore, opportunities to treat the sources of POCs upstream of the WRTSF outlet are limited.

The BAT assessment has been conducted in accordance with the step-by-step process described in the ENV guidance document titled *Best Achievable Technology Assessment to Inform Waste Discharge Standards Handout*, published in October 2021. Treatment technologies for POCs were identified and evaluated for feasibility, reliability, control-effectiveness, and cost-effectiveness. The BAT assessment concluded that the low effluent limits for T-Se and D-Cu require the use of reverse osmosis (RO) technology, and RO is a robust treatment solution for NO_3 and T-As as well. Therefore, RO is considered best achievable technology to meet the current discharge criteria for all POCs during operations, based on the flows and water quality predicted for WRTSF discharge under the proposed increased production scenario. Based on treatment vendor engagement, the capital cost for a prefabricated RO-based system is expected to be approximately $73,000,000 CAD, assuming a design flow rate of 5,760 m^3/hr. The annual operating cost for the system is expected to be approximately $27,500,000 CAD per year.

While not addressed directly in the BAT assessment, it is preferable to limit the use of hazardous chemicals/reagents where possible. Health and safety considerations will be required in any subsequent feasibility assessment, including potential impacts to the mine's operational health and safety program, per the Health, Safety and Reclamation Code for Mines in British Columbia (EMLI, 2022). These considerations may include, but not be limited to:

- Chemical/reagent types and quantities required;
- Chemical/reagent transport and storage requirements for protection of human health and the environment;
- Risk management and mitigation measures associated with chemical/reagents, such as spill response, engineered and personal protective equipment, and dose delivery mechanisms; and
- Safe access to treatment facilities through operations and closure, given the geohazards and remote location of the Brucejack Mine site.

Based on the selected BAT (i.e., an RO-based system), treatment of the high flow rates expected at the WRTSF outlet would require an impractically large footprint and high energy demand. Further, the RO process generates a waste stream highly concentrated in contaminants (among other residuals, such as filter backwash), which will require management and additional treatment, resulting in additional operational complexity and cost. The estimated capital and operating costs of a WRTSF treatment system (with the capacity to treat approximately 50% of predicted peak flows) are approximately $73,000,000 CAD and $27,500,000 CAD/year, respectively. Therefore, treatment of the WRTSF is considered impractical and uneconomical. In lieu of treatment at the WRTSF outlet, new or increased BJ 3.10 discharge limits for POCs are proposed in the following section.

5.7 Proposed Effluent Permit 107835 Amendments

5.7.1 Introduction

Condition 1.1.1 of PE-107835, last amended June 16, 2022, specifies discharge limits applicable at the outlet to the WRTSF (station BJ 3.10) (Table 5.7-1). Because most of the flow in Brucejack Creek comes from the WRTSF, the discharge limits that Pretium has applied for are intended to be protective of aquatic life in Brucejack Creek without dilution. Discharge limits for T-Fe and T-Ag were applied for as part of the original application for *Mines Act* and *Environmental Management Act* permits (see Appendix 5.5-1 which is a copy of Appendix 7-Z of the 2015 MA/EMA application). The rationale for the T-Fe and T-Ag limits was that baseline monitoring showed that these parameters were occasionally naturally elevated in Brucejack Creek to concentrations greater than BC FWAL guidelines. The discharge limits for T-Fe and T-Ag in PE-107835 are the 95th percentiles of baseline monitoring results at BJ 2.62 from 2009 to 2013. Discharge limits for nitrate, nitrite, ammonia, T-Sb, and T-As were based on water quality model results and an effects assessment that concluded that the maximum modelled concentrations at BJ 3.10 have low risk of causing adverse effects to aquatic life in Brucejack Creek (Appendix 5.5-2 is PE-107835 Amendment Application #4 which includes the derivation of the nitrate and nitrite discharge limits; Appendix 5.5-3 is the Water Quality Model Report for the 3800 tpd Amendment Application which includes the derivation of the ammonia, T-Sb, and T-As discharge limits). The discharge limits for TSS and pH were not applied for by Pretium. Presumably these limits are standard conditions in mine effluent permits. The TSS limits are equal to limits specified by federal Metal and Diamond Mine Effluent Regulations.

Pretium is applying to increase the discharge limits for nitrate and arsenic, and to add new discharge limits for copper and selenium. The rationale for these amendments is described in the following sections and the application forms for these proposed amendments are provided in Appendix 5-6. Pretium is also applying to amend the Authorized Works in PE-107835 from three to four sewage treatment plant units to allow for redundancy, but no change to the permitted daily rate of discharge of treated STP effluent is being requested (Appendix 5.6).

Table 5.7-1. Current BJ 3.10 PE-107835 discharge limits and their associated derivation method, and application

Parameter	Maximum	Units	Derivation Method	Application
Total Suspended Solids	30 (maximum) 15 (monthly average)	mg-/L	Included in original permit issued in 2015	Pretium did not apply for TSS discharge limit
pH	6.5-8.5	pH	Included in original permit issued in 2015	Pretium did not apply for pH discharge limit
Nitrite	0.24	mg-N/L	Upper Case model	Effluent permit amendment #4 Nov 14, 2016
Nitrate	11.5	mg-N/L	Upper Case model	Effluent permit amendment #4 Nov 14, 2016
Ammonia	4.0	mg-N/L	Upper Case model	3800 tpd permit amendment March 2018
T-Sb	28	µg/L	Upper Case model	3800 tpd permit amendment March 2018
T-As	10	µg/L	Upper Case model	3800 tpd permit amendment March 2018
T-Fe	1.7	mg/L	Background concentration	2015 MA/EMA permits application
T-Ag	0.46	µg/L	Background concentration	2015 MA/EMA permits application

5.7.2 Proposed Amendment to Nitrate Discharge Limit

A change to Condition 1.1.1 of PE-107835 is being applied for to increase the maximum authorized nitrate concentration in discharge from the WRTSF from 11.5 mg-N/L to 20 mg-N/L (Table 5.7-2).

Table 5.7-2. Proposed Amendment: Condition 1.1.1 – Cumulative Compliance Requirements (Nitrate)

Parameter	Units	Current Maximum	Requested Amended Maximum
Nitrate	mg-N/L	11.5	20

Water quality model results for the 4950 tpd mine plan indicate that nitrate concentration at BJ 3.10 will exceed the current discharge limit of 11.5 mg-N/L. The Base Case model has monthly average nitrate predictions of up to 15 mg-N/L. The Upper Case model has monthly average nitrate predictions of up to 28 mg-N/L (Appendix 5.3). An ecological effects assessment concluded that 28 mg-N/L nitrate will have a low risk of causing adverse effects to aquatic life in Brucejack Creek. This conclusion was supported by site-specific toxicity testing using species representative of aquatic life in Brucejack Creek which found that the maximum modelled concentration was half of the lowest chronic endpoint (IC20 of 54.1 mg-N/L for *Ceriodaphnia dubia*). The effects assessment also concluded that risk of eutrophication from higher nitrate levels in Brucejack Creek is low because algal growth will continue to be limited by the low phosphorus levels in the stream. A discharge limit of 20 mg/L is being applied for, even though WRTSF nitrate levels have the potential to increase to 28 mg-N/L, because 20 mg-N/L will ensure that discharge from the WRTSF does not cause nitrate levels in upper Sulphurets Creek to increase above the long-term BC FWAL guideline of 3 mg-N/L, even during low flow months with minimal mixing of Brucejack Creek with Sulphurets Creek water.

5.7.3 Proposed Amendment to Arsenic Discharge Limit

A change to Condition 1.1.1 of PE-107835 is being applied for to increase the maximum authorized T-As concentration in discharge from the WRTSF from 10 µg/L to 26 µg/L (Table 5.7-3).

Table 5.7-3. Proposed Amendment: Condition 1.1.1 – Cumulative Compliance Requirements (Arsenic)

Parameter	Units	Current Maximum	Requested Amended Maximum
T-As	µg/L	10	26

Water quality model results for the 4950 tpd mine plan indicate that T-As concentration at BJ 3.10 will exceed the current discharge limit of 10 µg/L. The Base Case model has monthly average T-As predictions of up to 14 µg/L. The Upper Case model has monthly average T-As predictions of up to 26 µg/L (Appendix 5-3). An ecological effects assessment concluded that 26 µg/L T-As will have a low risk of causing adverse effects to aquatic life in Brucejack Creek. This conclusion was supported by site-specific toxicity testing of an algae species (*Pseudokirchneriella subcapitata*) that is known to be sensitive to chronic toxicity from arsenic and is representative of aquatic life present in Brucejack Creek. The proposed discharge limit is less than half the IC20 for growth (70 µg/L) from three *P. subcapitata* toxicity tests conducted using BJ 3.10 water. A discharge limit of 26 µg/L will not cause T-As levels in upper Sulphurets Creek to increase above the long-term BC FWAL guideline of 5 µg/L during low flow months. During high flow months, T-As concentration in upper Sulphurets Creek is naturally greater than the BC FWAL guideline due to the effects of glacial melt on water quality in upper Sulphurets Creek.

5.7.4 Proposed Amendment to Add a Copper Discharge Limit

A change to Condition 1.1.1 of PE-107835 is being applied for to add a maximum discharge limit of 0.9 µg/L dissolved copper in the discharge from the WRTSF (Table 5.7-4).

Table 5.7-4. Proposed Amendment: Condition 1.1.1 – Cumulative Compliance Requirements (Copper)

Parameter	Units	Current Maximum	Requested Amended Maximum
D-Cu	µg/L	There is currently no discharge limit for dissolved copper	0.9

Water quality model results for the 4950 tpd mine plan indicate that D-Cu concentrations at the WRTSF outlet during the operations phase will be higher than the typical long-term BC FWAL guideline of 0.3 µg/L (based on typical hardness, pH, and dissolved organic carbon at BJ 3.10). The Base Case model predicts D-Cu will increase to 0.42 µg/L at the end of operations (Appendix 5-3). The Upper-Case model results are up to 0.87 µg/L. An ecological effects assessment concluded that 0.9 µg/L D-Cu will have a low risk of causing adverse effects to aquatic life in Brucejack Creek. This conclusion was supported by site-specific toxicity testing. The proposed discharge limit is less than half the lowest IC20 (2.3 µg/L) from four toxicity tests conducted using BJ 3.10 water. The geographic extent of changes to D-Cu concentration from a discharge limit of 0.9 µg/L are considered localized to Brucejack

Creek, because D-Cu concentrations are typically greater than 0.9 µg/L at site SC0 in upper Sulphurets Creek (average of 4.2 µg/L from quarterly monitoring conducted from 2015 through 2021).

5.7.5 Proposed Amendment to Add a Selenium Discharge Limit

A change to Condition 1.1.1 of PE-107835 is being applied for to add a maximum discharge limit of 6.2 µg/L total selenium in the discharge from the WRTSF (Table 5.7-5).

Table 5.7-5. Proposed Amendment: Condition 1.1.1 – Cumulative Compliance Requirements (Selenium)

Parameter	Units	Current Maximum	Requested Amended Maximum
T-Se	µg/L	There is currently no discharge limit for total selenium	6.2

Water quality model results for the 4950 tpd mine plan indicate that T-Se concentrations at the WRTSF outlet during the operations phase will be higher than the BC FWAL guideline of 2 µg/L. The Base Case model predicts T-Se will increase to 2.1 µg/L towards the end of operations (Appendix 5-3). The Upper-Case model predictions are up to 6.2 µg/L. An ecological effects assessment concluded that 6.2 µg/L T-Se will have a low risk of causing adverse effects to aquatic life in Brucejack Creek. A discharge limit of 6.2 µg/L will not cause concentrations at SC0 to increase to greater than the BC FWAL guideline.

5.8 Initial Dilution Zone

The Brucejack Mine WRTSF is the headwater to Brucejack Creek (i.e., the receiving environment) and thus an initial dilution zone is not defined for WRTSF discharge. The current discharge limits and the proposed discharge limits were developed to be protective of aquatic life in Brucejack Creek without dilution (see Section 5.7.1).

5.9 Discharge Management

Discharge quality from the WRTSF is managed through source control and through treatment of contact water by the WTP and treatment of sewage by the STPs. Mine site water management has effectively maintained WRTSF effluent quality, measured at site BJ 3.10, below discharge limits in PE-107835 or below FWAL guidelines for parameters without discharge limits.

BJ 3.10 water quality is sampled weekly, in accordance with PE-107835. Results are typically received from the analytical laboratory (ALS Environmental) within 2 weeks of the sample date. Pretium staff review BJ 3.10 water quality results when received from the analytical laboratory and if any results are above discharge limits, notifications are provided in accordance with condition 5.3 of PE-107835. A result that is above a discharge limit is investigated to determine the probable cause, and to determine and implement remedial actions, if necessary, to prevent similar non-compliance in the future.

BJ 3.10 water quality results are evaluated by Pretium staff to identify POPCs, and to determine if additional measures are required to manage POPCs, using a trigger response plan (TRP) (Figure 5.9-1).

Step 1 of the TRP is to identify parameters that have concentrations greater than a trigger value. Trigger values at BJ 3.10 are set using criteria for defining POPCs (ENV, 2019). Trigger concentrations are equal to 80% of an applicable threshold, either the discharge limit in PE-107835 or

BC FWAL guidelines for parameters without discharge limits. Each weekly effluent sample is compared to trigger values based on discharge limits or short-term FWAL guidelines. Trigger values based on long-term FWAL guidelines are compared to the average concentration from the previous five weekly samples. If a BJ 3.10 result is less than a trigger value, routine monitoring is continued. If a result is greater than a trigger value, Step 2 is carried out.

Step 2 of the TRP is to assess whether a concentration is consistently greater than a trigger value. This is done by collecting a new BJ 3.10 sample as soon as possible and requesting rush analysis from the analytical laboratory. If a subsequent sample has already been collected, since BJ 3.10 is sampled weekly and ALS can take more than a week to issue reports, then ALS will be requested to rush the analyses of the most recent BJ 3.10 sample. If the follow-up sample concentration is below the trigger level, routine monitoring resumes. If the follow up sample is also greater than the trigger value, Step 3 is carried out.

Step 3 of the TRP involves examining recent BJ 3.10 monitoring results in comparison to historic levels and to expected concentrations based on the Brucejack water quality model. Also, recent concentrations and flows from the various sources to the WRTSF are assessed relative to the long-term monitoring datasets to identify if any sources have unusually high loadings to the WRTSF. If it is determined that the monitoring results are in line with expected water quality and are unlikely to increase to concentrations that are above a FWAL guideline or exceed a discharge limit, then routine monitoring is resumed. If the review of water quality trends at BJ 3.10 and of source loadings determines that a POPC concentration could increase to a value greater than a FWAL guideline or discharge limit, then Step 4 is carried out.

Step 4 of the TRP involves the design and implementation of actions to prevent concentrations reaching levels that are potentially harmful to the receiving environment. This will typically involve additional monitoring at BJ 3.10 and sources to the WRTSF to better understand the cause of the unanticipated water quality trend. If the monitoring results indicate that additional source control measures could reduce concentrations at BJ 3.10, they will be implemented if achievable. An effects assessment will be conducted to determine the risk to aquatic life in Brucejack Creek if concentrations increase to greater than the FWAL guideline or discharge limit. The results of the effects assessment will be used to determine whether management actions and/or regulatory tools will be needed. An example of a management action would be a process implemented to reduce loadings to the WRTSF or to reduce the concentration in the WRTSF discharge. An example of a regulatory tool is an application for a discharge limit that is greater than the FWAL guideline or existing discharge limit and is protective of aquatic life in Brucejack Creek.

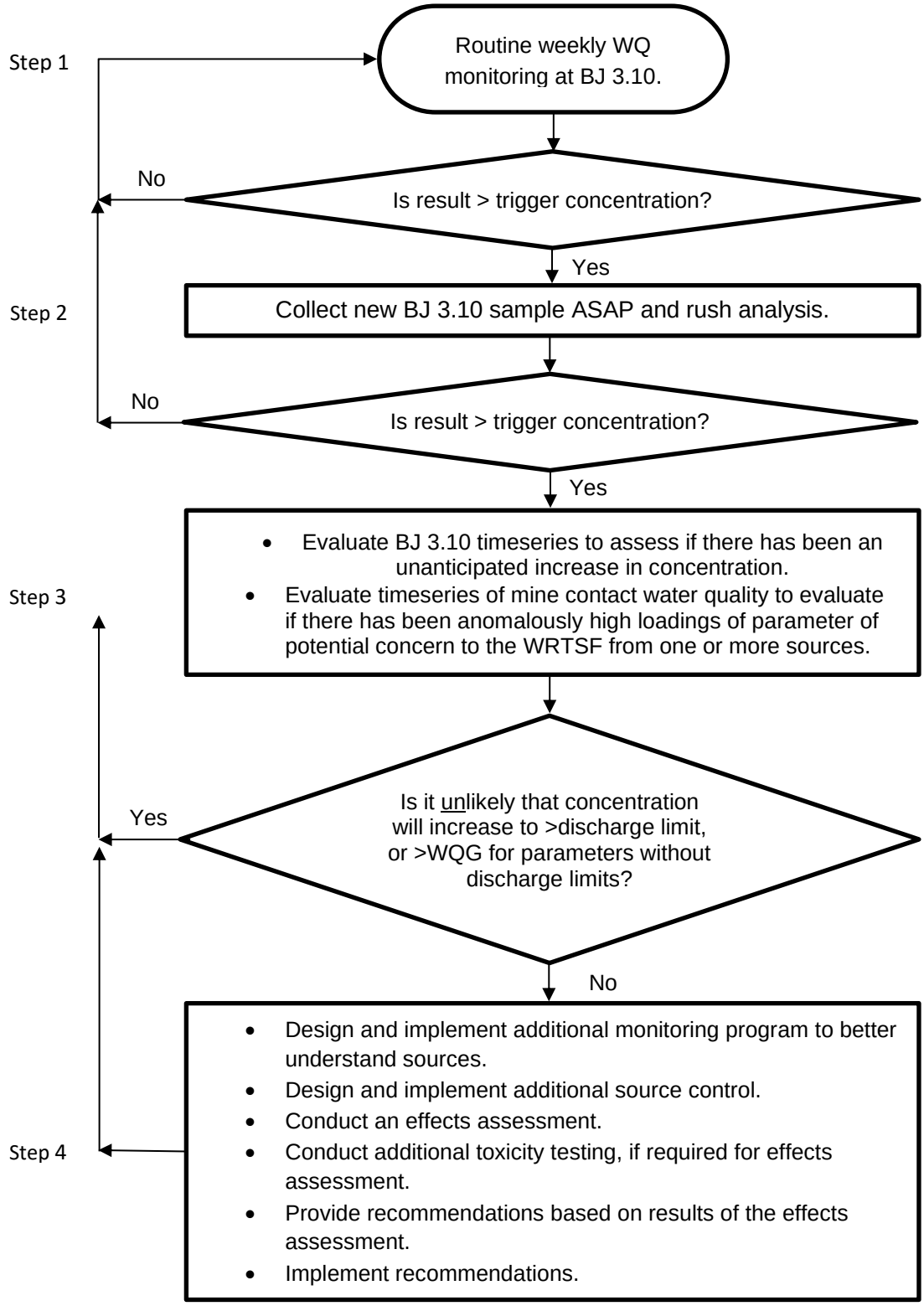


Figure 5.9-1. Trigger Response Plan flowchart for water quality at BJ 3.10

6. ENVIRONMENTAL ASSESSMENT PREDICTIONS

6.1 Introduction

The Brucejack Mine water quality model has been updated to account for the proposed increased ore production rate and the associated mine plan, as described in Section 5.3. Water quality was modelled at two sites in Brucejack Creek: site BJ 3.10, located at the outlet of the WRTSF, and at site BJ 2.62, located approximately 500 m downstream of BJ 3.10. BJ 2.62 represents the maximum modelled concentrations during closure and post-closure because all loadings from the flooded underground mine are modelled to flow to site BJ 2.62. The Base Case water quality model is considered an expected case; whereas the Upper Case incorporates the combined effects of upper-case geochemical source terms for all inputs and is considered a potential but unlikely scenario.

Water quality model results were screened to identify parameters of potential concern to aquatic life in the receiving environment. POPCs were identified as parameters that had a Base Case model result that was greater than 80% of a water quality benchmark (either a discharge limit or a BC FWAL guideline for parameters that do not have discharge limits) during any mine phase, as described in the BC Ministry of Environment and Climate Change Strategy's fact sheet on parameters of concern (ENV, 2019b). Concentrations that are below these benchmarks are considered protective of aquatic life in the receiving environment because discharge limits were developed to be protective of aquatic life without dilution in the receiving environment.

The screening of water quality model results identified eight POPCs: ammonia, nitrite, nitrate, sulfate, total arsenic, dissolved aluminum, dissolved copper, and total selenium. These POPCs were then evaluated to determine if there are reasons to exclude them from further assessment. Ammonia was excluded from further assessment because it was determined that denitrification in the WRTSF will convert ammonia to nitrate resulting in ammonia levels well below its discharge limit. Denitrification is a biochemical process that was not included in the mass balance water quality model. Dissolved aluminum was excluded from further assessment because it was determined that solubility constraints result in the precipitation of D-Al in the WRTSF, which reduces the concentration of D-Al at the WRTSF outlet to below its POPC benchmark. Sulfate was excluded from further assessment because the Base Case model results are less than the long-term BC FWAL guideline during all mine phases, when the sulfate guideline is calculated using the modelled hardness, instead of the baseline hardness of 28 mg/L used for calculating the POPC screening benchmark for sulfate.

A residual effects assessment was conducted on the remaining five parameters of concern (POCs). Details of water quality modelling and the effects assessment are presented in Appendix 5-3. Results of the residual effects assessment are summarized below.

6.2 Contaminant Transport

Contaminants transport from mine sources to aquatic life, terrestrial life, and to humans was considered as part of the residual effects assessment (Figure 6.2-1). Brucejack Creek is not used as a drinking water source for people working at the mine, and it is very unlikely that it will be used as a drinking water source in the future due to its remote location. Terrestrial wildlife have the opportunity to use Brucejack Creek as a source of drinking water from approximately July through October, when the stream is ice free. Observations of terrestrial wildlife during baseline studies (Rescan, 2013b;

Rescan, 2013i) and during mine construction and operation periods (incidental wildlife observations are recorded by mine staff and reported in Annual Reports for Permits M-243, PE-107835, and PA-107025) indicate that wildlife will infrequently use Brucejack Creek as a drinking water source: therefore, the effects assessment focused on aquatic life as the most likely receptor for potential adverse effects from changes to water quality. Brucejack Creek is non-fish-bearing and is not considered fish habitat because the closest fish-bearing waterbody is the mouth of Sulphurets Creek, more than 20 km downstream of Brucejack Creek. Therefore, the assessment endpoint of the effects assessment was the potential for modelled water quality in Brucejack Creek to cause toxicity to benthic invertebrates and periphyton inhabiting the stream. The potential for modelled nutrient concentrations (nitrogen and phosphorus) to cause eutrophication was also assessed. The potential for modelled selenium concentrations to cause adverse effects to waterbirds was also assessed.

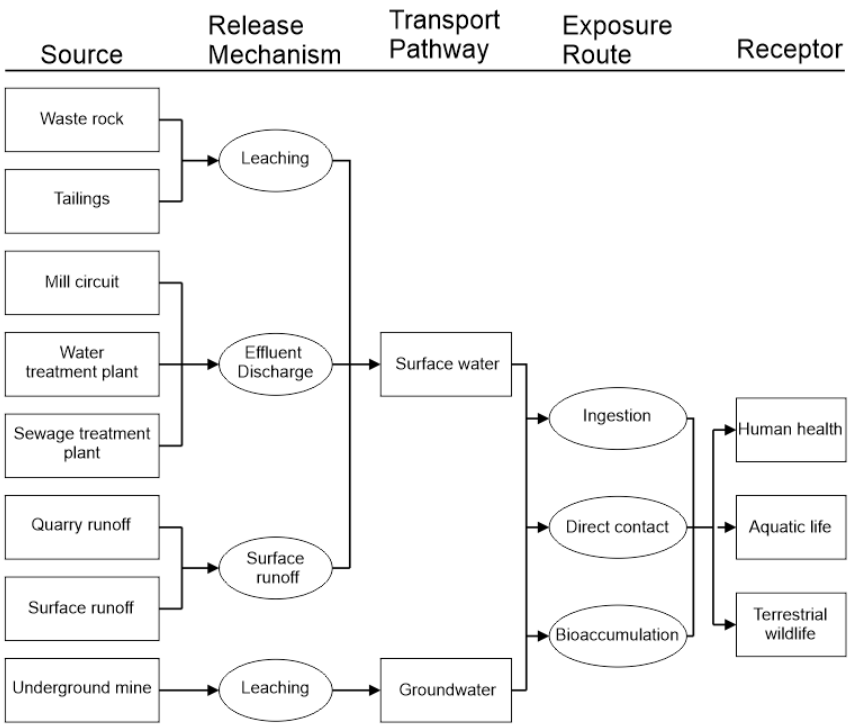


Figure 6.2-1. Conceptual site model of contaminant transport to receptors.

6.3 Effects Assessment Results

The residual effects assessment considered the ecological context of the receiving environment; the geographic extent over which the modelled concentrations of POCs could be above a water quality benchmark; the magnitude, duration, and frequency of model results that are above water quality benchmarks; the reversibility of changes to water quality after mine closure; and the resiliency of the aquatic community if changes to water quality caused adverse effects. These components of the effects assessment were used to derive a determination of risk to aquatic life from the modelled concentrations of POCs.

The risk to aquatic life from the maximum Base Case model result was determined to be low for all five POCs during all mine phases (Table 6.3-1). The risk to aquatic life from the maximum Upper

Case model result was determined to be low for all five POCs during all mine phases except for selenium during the closure phase which was rated as moderate (Table 6.3-1).

Table 6.3-1. Summary of Risk Ratings for Base Case and Upper Case Modelled Concentrations of Parameters of Concern.

	Base Case			Upper Case		
	Operations	Closure	Post-closure	Operations	Closure	Post-closure
Nitrate (eutrophication)	low	low	low	low	low	low
Nitrate (toxicity)	low	low	low	low	low	low
Nitrite	low	low	low	low	low	low
Total arsenic	low	low	low	low	low	low
Dissolved copper	low	low	low	low	low	low
Total selenium	low	low	low	low	moderate	low

Selenium was the only parameter with a risk rating that wasn't low, and only for the Upper-Case model during the closure phase. The Upper-Case model uses the upper case loadings of Se from all mine sources, and is considered unlikely to occur. Monitoring results from BJ 3.10 and BJ 2.62 support the conclusion that selenium concentrations in Brucejack Creek are best represented by the Base Case model and that the Upper-Case model is an overestimate of potential selenium levels (Figure 6.3-1). This indicates that Se concentrations in Brucejack Creek are likely to remain below, or slightly above, the BC FWAL guideline during operations. As well, water management strategies described in the Brucejack Closure Underground Water Quality Adaptive Management Plan (Appendix 9-2-2), which weren't modelled in the Base Case and Upper-Case water quality model scenarios, can be implemented to reduce Se concentrations during closure.

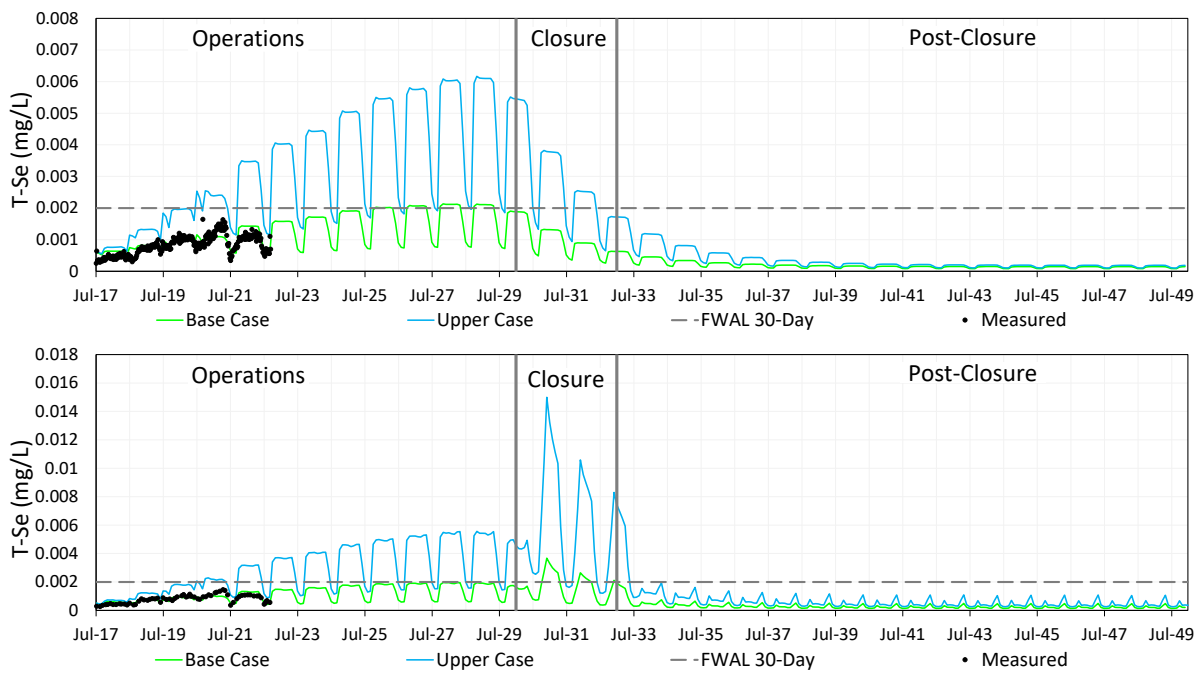


Figure 6.3-1. Modelled total selenium concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the BC FWAL guideline and to measured concentrations.

The selenium effects assessment (section 5.13 of Appendix 5.3) also shows that there are few receptors in the Brucejack Creek catchment that are potentially sensitive to elevated Se levels. It is generally thought that algae and invertebrates are tolerant of elevated Se concentrations, and the more important role of these organisms is the transfer of Se to egg-laying vertebrates (fish, amphibians, or waterbirds). Potential adverse effects to egg-laying vertebrates feeding on a high Se diet include reduced hatchability of eggs and defects in hatchlings. There are no fish or amphibians present in the Brucejack Creek catchment; therefore, potential receptors are the few waterbirds which have been observed around Brucejack Creek. Aquatic bird species that have been recorded that may feed on invertebrates in Brucejack Creek are a sandpiper species and semipalmated plover (ERM, 2022a included as Appendix F to Appendix 5-3, the water quality model report), which are not listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or the British Columbia Conservation Data Centre.

In summary, the maximum modelled concentrations of parameters of concern were evaluated to have low risk of causing adverse effects to aquatic life in Brucejack Creek, with the exception of Upper-Case modelled selenium concentrations during closure, which were evaluated to have a moderate risk of causing adverse effects to nesting birds that primarily feed on insects in Brucejack Creek, if any occur. It is likely that water can be managed during closure to reduce the peak concentrations that occur in the model when water from the flooded underground mine flows to Brucejack Creek.

Adverse effects to human health are not expected because Brucejack Creek water is not used as a drinking water source for humans. Brucejack Creek flows into Sulphurets Creek. There is a minimum mixing ratio of 6:1 (part Sulphurets Creek to Brucejack Creek) at upper Sulphurets Creek sites, and typically higher mixing ratios (ERM, 2017; included as Appendix B to the Appendix 5-3 (the water quality model report)). This level of mixing will produce concentrations in upper Sulphurets Creek at SC0 that are below BC drinking water guidelines, except for parameters that are naturally elevated at SC0 to concentrations that are above drinking water guidelines.

7. ENVIRONMENTAL MONITORING

7.1 Environmental Monitoring Program Design

Pretium implements an extensive environmental monitoring program at and in the vicinity of the Brucejack Mine site in accordance with the monitoring requirements of the mine's authorizations (e.g. EAC M15-01, CEAA 2012 Decision Statement, M-243, PE-107836, PA-107025, various *Water Sustainability Act* (*WSA*) and Northern Health authorizations) and component management plans of its EMS. The Brucejack Mine EMS includes 21 component management plans required under Schedule B of EAC #M15-01 and the 10 additional management plans required through other Provincial authorizations (mainly M-243, PE-107835 and PA-107025). These management plans are discussed in Chapter 9 and provided in Appendices 9-1 and 9-2. The proposed production rate increase is not expected to require changes to existing environmental monitoring programs.

Brucejack Mine effluent quality related monitoring programs have been designed and are implemented for all deposits and effluents to the WRTSF, as well as for the downstream aquatic receiving environment in accordance with the conditions of Permit M-243 and PE-107835 (Appendix 1-1). Key objectives of these effluent quality specific monitoring programs relate to the implementation and effectiveness of the mine's source control measures. Source control is the primary means by which acceptable effluent quality is maintained at the Brucejack Mine's regulated discharge locations [i.e. the outlet to the WRTSF (monitoring site BJ 3.10) and WTP and CWP effluent]. Source control measures include both mine infrastructure design (e.g. water management and water treatment infrastructure) and management procedures.

Specifically, the Brucejack Mine effluent quality environmental monitoring program is designed to:

- Verify that source control measures are being implemented as planned;
- Confirm the effectiveness of the source control measures, including that if monitoring of effluent management performance (e.g. effluent quality compared to PE-107835 effluent discharge limits) and/or receiving environment condition (results of aquatic effects monitoring in aquatic receiving environment) identifies measures are insufficiently effective, follow-up is initiated to address this;
- Specifically for ML/ARD, provide early warning of the potential onset of ML/ARD and the magnitude of any environmental effects, and verify source terms used in the water quality model, and associated water quality predictions;
- Provide monitoring data for inputs to the water quality model that is used to update predictions of BJ 3.10 discharge water quality (e.g. data for geochemical source terms, such as contact water from the underground mine which represents the cumulative geochemical load of wall rock, groundwater, paste backfill and rockfill in the underground mine workings as described in Appendix 5-3 Section 3.4.3) (refer to Section 5.5);
- Monitor flows and water quality at specified locations upstream, at and downstream of the regulated discharges (WTP and site BJ 3.10) to verify compliance with PE-107835; and
- Monitor sediments and aquatic biological indicators at and downstream of site BJ 3.10, and a reference site location to provide a basis for assessing potential aquatic biological effects of the mine's effluent discharge on the aquatic receiving environment.

Source control procedures developed for the Brucejack Mine are outlined in the following environmental management plans: ML/ARD Management Plan, Nitrogen Management Plan, Chromium Management Plan, WRTSF OMS Manual, and Water Management Plan OMS Manual). These plans, which are summarized in Chapter 9 and provided in Appendices 9-1 and 9-2, include sampling programs, management triggers, and corrective actions that are designed to minimize potential adverse effects to water quality.

As described in Section 5.6, monitoring of the various sources of contaminant loadings to the WRTSF, and monitoring of WRTSF effluent at BJ 3.10, shows that the source control measures implemented have been effective in maintaining acceptable discharge quality. It is anticipated that these measures will continue to be effective for a production rate of 4950 tpd.

7.2 Mine Site and Discharge Water Monitoring Program

7.2.1 Overview

The Brucejack Mine site water monitoring program, including the mine's regulated final effluent discharge point site BJ 3.10, is specified by M-243 and PE-107835 (Appendix 1-1) and associated management plans specific to the mine site. The associated management plans, including management plans to provide water quality management via mine waste management and other source control measures, are the ML/ARD Management Plan (Appendix 9-1-11), Nitrogen Management Plan (Appendix 9-2-6), Chromium Management Plan (Appendix 9-2-1), Water Management Plan – OMS Manual (Appendix 9-1-18) and Waste Rock and Tailings Storage Facility – OMS Manual (Appendix 9-1-17). These permits and management plans have established/confirmed monitoring site locations, sampling frequency, parameters for assessment, sampling and analytical laboratory methodologies, QA/QC programs, and reporting requirements. Monitoring programs are based on and conform to methods and requirements of the following relevant published ENV and EMLI guidance/requirements documents:

- Water and Air Baseline Monitoring Guidance Document
- British Columbia Field Sampling Manual
- Environmental Data Quality Assurance Regulation (EMA)
- British Columbia Environmental Laboratory Manual

7.2.2 Groundwater

The Brucejack Mine groundwater system has been characterized through several hydrogeological field investigations which have established a broad monitoring well network within and proximal to the mine. The current monitoring network is comprised of 31 monitoring wells as prescribed by Appendix B of Effluent Permit PE-107835 (Appendix 1-1) [BJ-GW18-22A was destroyed in 2022, and was replaced with a vibrating wire piezometer in 2023 (New Well @P2)]. Four additional monitoring wells are monitored outside of permit requirements. Permit-required monitoring well locations are shown in Figure 2.6-6 and monitoring intervals and frequency are listed in Table 7.2-1. Monitoring wells are situated broadly about the mine and located within the M-243 PMA boundary, with exception of one well pair. The groundwater monitoring network characterizes groundwater system response to mining of the VOK and West Zone and operation of the CWP and WRTSF. The one well pair located outside

of the M-243 PMA boundary, BJ-GW14-14A/B, was constructed during a 2014 potable water source investigation (BGC 2014c).

Hydraulic head and groundwater quality sampling are undertaken on a shifted quarter (sQ) or biannual basis, as specified by PE-107835. Shifted quarters are off-set from calendar quarters by one month. This offset allows for evaluation of groundwater quality that coincides with seasonal controls (*e.g.,* freshet, first snowfall). Continuous groundwater level data is collected using dataloggers programmed on a six-hour frequency. The data are compensated for barometric pressure changes and georeferenced to manual water level readings collected on a quarterly basis.

Samples are collected, preserved, stored, transported and tested in accordance with the requirements set forth in the British Columbia Environmental Laboratory Manual (Austin 2015) and the British Columbia Field Sampling Manual (Clark 2013). Groundwater quality samples are collected using low flow sampling methods whereby samples are collected when the well water level and field parameters (measured via flow-through cell and multi-parameter probe) stabilize while the well is purged. Monitoring wells are occasionally sampled with bailers when there is a limited water column, and the well is particularly slow to recharge. The site groundwater sampling protocol includes detailed SOPs for all low-flow sampling methods deployed at the mine and is included as an appendix to the annual groundwater monitoring report included with each *MA/EMA* Annual Report submission.

Groundwater quality QA/QC comprises collection and analysis of field blanks, equipment blanks, and field duplicates with each sampling campaign. Travel blanks are also analyzed. Groundwater samples are analyzed for physical parameters, anions and nutrients, and total and dissolved metals in accordance with permit requirements. The annual groundwater monitoring report includes a discussion of QA/QC results.

Inflows to the underground mine (and pumped to the water treatment plant) are also recorded daily per the Water Management Plan – OMS Manual (Appendix 9-1-18). Underground dewatering rates attributed to groundwater inflows are computed using the daily data record and are discussed in the annual groundwater monitoring report.

Table 7.2-1. Summary information PE-107385 groundwater monitoring sites

Monitoring Site Identifier (PE-107835 Dec. 14, 2018)		Current Permit-Required Monitoring[1]		Install Date	Easting[2] (m)	Northing[2] (m)	Elevation[2] (m)	Sand Pack Interval (m bgs)		Lithological Unit
Project ID	EMS ID	GWL	GWQ					Top	Bottom	
BJ-GW11-1A	E303054	C	sQ	Oct 02, 2011	426,281	6,258,840	1,385.72	77.1	85.3	Office P1
BJ-GW11-1B	E314692	C	sQ	Oct 02, 2011	426,280	6,258,841	1,385.72	31.3	38.7	Office P1
BJ-GW11-3A	E303056	C	sQ	Oct 03, 2011	426,615	6,258,844	1,367.63	79.3	88.4	P2
BJ-GW11-3B	E314693	C	sQ	Oct 04, 2011	426,615	6,258,844	1,367.53	4.5	9.1	P2
BJ-GW11-5A	E303058	C	sQ	Sep 29, 2011	426,347	6,258,040	1,526.14	65.7	78	VSF
BJ-GW11-5B	E314694	C	sQ	Sep 30, 2011	426,346	6,258,042	1,526.16	39.6	50.9	VSF
BJ-GW12-8A	E303059	C	sQ	Jun 18, 2012	426,106	6,258,818	1,403.38	86	95.1	Office P1
BJ-GW12-8B	E314695	C	sQ	Jun 19, 2012	426,106	6,258,819	1,403.30	44.3	51	Office P1
BJ-GW12-9A	E303060	C	sQ	Aug 04, 2012	426,465	6,258,361	1,514.40	70.8	80	Office P1
BJ-GW12-9B	E314696	C	sQ	Aug 01, 2012	426,461	6,258,362	1,514.56	38.4	47.4	Office P1
BJ-GW12-11A	E303062	C	sQ	Jun 26, 2012	426,300	6,258,595	1,433.57	25.8	29.5	Office P1
BJ-GW12-11B	E314697	C	sQ	Jun 28, 2012	426,299	6,258,595	1,432.96	48.2	53.8	Office P1
BJ-GW12-12A	E303063	C	sQ	Aug 08, 2012	426,509	6,257,807	1,579.19	84.3	97	Bridge P1
BJ-GW12-12B	E314698	C	sQ	Aug 10, 2012	426,505	6,257,807	1,579.16	45.2	53.1	Bridge P1
BJ-GW14-13A	E303064	C	NR	Sep 09, 2014	426,118	6,258,904	1,362.49	20.7	100.9	Office P1
BJ-GW14-13B	E314699	C	NR	Sep 13, 2014	426,118	6,258,904	1,362.76	21.2	75.4	Office P1
BJ-GW14-14A	E303065	C	sQ	Sep 11, 2014	426,096	6,258,924	1,351.10	14.9	34.9	Office P1
BJ-GW14-14B	E314700	C	sQ	Sep 23, 2014	426,095[3]	6,258,927[3]	1,355	0.5	4.6	Office P1
BJ-GW18-17A	E303066	C	sQ	Jun 05, 2018	426,771	6,258,761	1404.21	142.07	148.12	V12/V6b
BJ-GW18-17B	E314701	C	sQ	Jun 08, 2018	426,772	6,258,760	1404.24	72.1	75.76	Office P1
BJ-GW18-18A	E303069	C	sQ	Jun 12, 2018	426,946	6,258,306	1445.35	95.53	101.27	Office P1
BJ-GW18-18B	E314702	C	sQ	Jun 09, 2018	426,947	6,258,306	1445.32	61.54	65.57	Office P1
BJ-GW18-19A	E303070	C	sQ	Jun 14, 2018	426,347	6,258,259	1495.6	191.78	196.89	Office P1
BJ-GW18-19B	E314703	C	sQ	Jun 17, 2018	426,346	6,258,259	1495.45	154.92	159.54	Office P1
BJ-GW18-20A	E303559	C	B	Jun 17, 2018	426,147	6,258,341	1494.02	159.92	167.53	Office P1
BJ-GW18-20B	E314704	C	B	Jun 20, 2018	426,148	6,258,342	1494.07	113.27	118.45	Office P1
BJ-GW18-21A	E303071	C	B	Jun 24, 2018	426,661	6,257,806	1550.41	193.49	204.83	S4-VSF
BJ-GW18-21B	E314705	C	B	Jun 29, 2018	426,660	6,257,807	1550.43	152.05	159.45	S4-VSF
BJ-GW18-22A	E303068	C	NR	Jul 01, 2018	426,575	6,258,498	1444.73	369.58	379	S4-VSF
BJ-GW18-22B	E314706	C	NR	Jul 06, 2018	426,576	6,258,499	1444.91	82.99	87.82	S3-Poly
BJ-GW18-23A	E314690	C	sQ	Jul 01, 2018	427,091	6,258,751	1370.92	25.32	29.7	S4-VSF
BJ-GW18-23B	E314691	C	sQ	Jul 02, 2018	427,091	6,258,752	1370.94	7.61	11.3	S4-VSF

Notes:
1. GWL = groundwater level; GWQ = groundwater quality; C = continuously recorded (logger); sQ = shifted quarter, B = biannual, NR = not required
2. Monitoring well top of pipe coordinates determined by RTK GPS, horizontal datum UTM Zone 9N NAD 83, Project vertical datum.
3. Coordinates of BJ-GW14-14B are from a handheld GPS in UTM NAD 83 Zone 9N. Vertical datum is unknown.

7.2.3 Surface Water Quantity and Water Management Infrastructure

The Brucejack Mine hydrometric monitoring program is designed to collect and analyze hydrometric data required under the monitoring provisions of PE-107835 and the MDMER of the federal *Fisheries Act*. As described in Section 2.6.1 and Section 2.4 of Appendix 5-2, the active hydrometric monitoring program consists of three streamflow monitoring stations and a level monitoring station (Figures 2.6-2 and 2.6-3; Table 2.6-1): hydrometric gauges at water monitoring sites BJ 3.10 and BJ 1.74, located along Brucejack Creek; a hydrometric gauge at SC-1 located along Sulphurets Creek; and the BJ WRTSF level monitoring station. Record periods for the three hydrometric stations are as follows: BJ 1.74 (2008 – present), BJ 3.10 (2014 – present), and SC-1 (2016 – present). The BJ WRTSF monitoring site is located upstream of the final effluent discharge location, monitoring site BJ 3.10. Water monitoring site BJ 1.74 is located along Brucejack Creek 1.36 km downstream of site BJ 3.10. The most-downstream node considered in the site-wide WBM coincides with the location of the BJ 1.74 monitoring station. Water monitoring site SC-1 is also an aquatic receiver monitoring location, situated on Sulphurets Creek downstream of Sulphurets Lake (Brucejack Creek drains to Sulphurets Creek).

Hydrometric monitoring standards adopted by Pretium are based on standards published by ENV (2018), the United States Geological Survey (Turnipseed and Sauer 2010), and the International Organization for Standardization (ISO 2007). Standard discharge measurement techniques (ENV 2018) are employed at stations BJ 3.10, BJ 1.74, and SC-1 (*e.g.*, 20-panel waded measurements with a current meter) whereas methods used in the development of stage-discharge rating curves follow as close as possible guidelines by ENV (2018) and ISO (2010). A stage-discharge rating curve is an empirical relation used to calculate streamflow (discharge) from continuously recorded water level data.

Rating curves for Brucejack monitoring stations are constructed using the Rating Development Toolbox within Aquarius Time-Series (AQTS). In concept, discharges and water levels are manually measured over a range of flow conditions (*i.e.*, low to high) to generate the curve. Typically, a minimum of ten discharge measurements across a range of stage and streamflow conditions are recommended to develop a robust stage discharge relationship (ENV 2018), a threshold that is well exceeded for the Brucejack hydrometric stations. Rating curves for monitoring stations are updated annually as new data becomes available and/or stream channel conditions change.

Continuous flow monitoring instrumentation, specifically magnetic flow meters, is also installed in-pipe to measure flow rates for the mine water influent at the WTP, CWP influent at the WTP, and WTP effluent. Continuous flow monitoring (flow meter) and continuous density monitoring (nuclear density gauge) is also in place for the tailings discharge lines going to the WRTSF which is used to determine the continuous flow of tailings supernatant. Cumulative flow per day is monitored for treated domestic effluent. There has never been direct discharge from the CWP to the WRTSF, however instrumentation is in place to measure daily volume of any diverted mine water, direct discharge volume and staff gauge levels if direct discharge is necessary.

The Water Management Plan - OMS Manual (Appendix 9-1-18) prescribes operations and monitoring of primary mine site surface water management infrastructure through the operations and closure phases at Brucejack. This infrastructure includes:

- CWP and spillway;

- Contact water management system of ditches, sumps, pumps, weirs and pipelines;
- Non-contact diversion channels; and
- LLW and reclaim system at the outflow of Brucejack Lake.

Surveillance of the water management facilities is conducted to determine if the facilities are operating within expected parameters. Deviations from expected performance may require adjustments to operation, maintenance or design to facilitate ongoing safe and efficient operation of the facilities. Surveillance is undertaken by two primary methods – visual inspection and reading of instruments. Results of these qualitative and quantitative observations are compared to the expected performance of the facilities. If observations are within the expected range or performance, the results of the surveillance are simply recorded. If observations are outside the expected range, the results of the surveillance are recorded, and further evaluation is completed to determine if remedial action is necessary. If remedial action is needed it may range from a minor adjustment to operational procedures to initiation of emergency response, depending on the severity and nature of the deviation from expected performance.

Routine visual surveillance includes:

- Visual inspections of mill-associated water management structures, CWP (crest, cut slopes, and spillway), all pumping system and pipelines from CWP to WTP and the direct WRTSF discharge system conducted once per shift by Mill Operators;
    - Staff Environmental Scientists accompany these inspections at least twice annually;
- Visual inspections of non-contact water diversion channels and all aspects of the contact water management system upstream of the CWP conducted by Waste Management and De-Watering Coordinators once per shift during non-frozen conditions;
    - Environmental Scientists accompany these inspections at least twice annually;
- Visual inspections of CWP crest, cut slopes, and spillway conducted by Environmental Scientists pre- and post-freshet and pre-freeze in the fall;
- Visual inspections of CWP and LLW each time water quality samples are collected by Environmental Scientists; and
- Annual inspection of CWP, all contact water management infrastructure and non-contact water diversion channels conducted by CWP/Water Management Consultant (Technical Lead or Senior Engineer). This inspection is to address the requirement for M-243 Condition C4(e) for a Professional Engineer to perform an annual inspection of water management facilities on site including surface water ponds, ditches and diversion channels.

Additional monitoring of the CWP is required to check for any seepage that could warrant geotechnical assessment since the CWP was constructed without a liner, as it has been excavated entirely within bedrock. This includes:

- Quarterly monitoring of groundwater levels (including datalogger downloads of water level) and groundwater quality in BJ-GW16-5A/B, installed northwest of the CWP, and BJ-GW18-23A/B, installed northeast of the CWP, following the methodologies and parameters of the permitted (PE-107835 and M-243) groundwater monitoring network; and
- Recording water volumes in the CWP on at least a daily frequency.

7.2.4 Surface Water Quality

The Brucejack Mine surface water quality monitoring program is designed to generate data that enable determination of discharge quality compliance and evaluation of mine-related effects on the aquatic receiving environment. Surface water quality is monitored at the Brucejack Mine as required by Condition 4 and Appendix A of PE-107835 (Appendix 1-1), and in accordance with applicable Brucejack Mine management plans, including the Aquatic Effects Monitoring Plan (Appendix 9-1-4), ML/ARD Management Plan (Appendix 9-1-11), Chromium Management Plan (Appendix 9-2-1), and Nitrogen Management Plan (Appendix 9-2-6). Mine surface water quality monitoring is also a requirement of Condition D.4(d) of *Mines Act* Permit M-234.

Surface water quality is monitored at the mine site locations shown in Figure 7.2-1 upstream of and including the mine final discharge location site BJ 3.10, at the frequencies listed in Table 7.2-2. Locations include WTP influent and all effluent discharges to the WRTSF as described in Section 7.1. Samples are analyzed for general parameters, major ions and nutrients, total and dissolved metals, and total organic carbon (refer to Table 7.2-2 notes and footnotes for additional details).

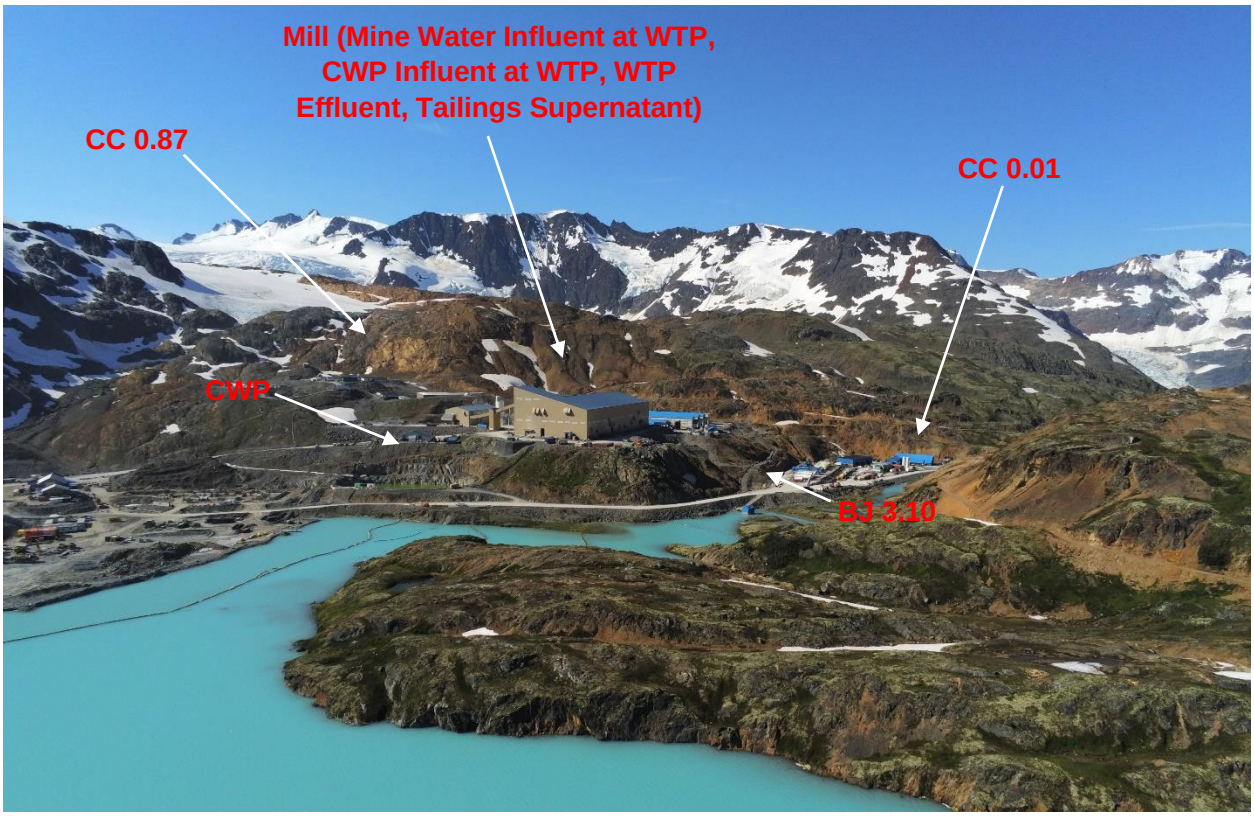


Figure 7.2-1. Mine site locations for surface water quality monitoring.

Table 7.2-2. Brucejack Mine Site and Discharge Water Monitoring Program

Station ID (EMS#) (lat., long.)	Description	Field Turbidity pH	Metals[1] & General[2]	Flow Rate / Staff Gauge	Toxicity
BJ 3.10 (E298312) (56.4696, 130.1878)	WRTSF outlet	-	Weekly	Continuous flow rate monitoring with manual checks quarterly	Quarterly
Mine Water Influent at WTP (E303052)	In plant prior to treatment	Continuous Monitoring	Two Times per Month	Continuous Monitoring	-
CWP Influent at WTP (E303053)	In plant prior to treatment	Continuous Monitoring	Two Times per Month (when discharging to the WTP)	Continuous Monitoring	-
WTP Effluent (E302957)	After treatment prior to WRTSF discharge	Continuous Monitoring	Two Times per Month	Continuous Monitoring	-
Tailings Supernatant (E302910)	After thickening prior to outfall	-	Monthly	Daily (cumulative flow per day)	-
Treated Domestic Effluent (E302911)	After treatment prior to outfall	-	Quarterly (BOD and TSS only)	Daily (cumulative flow per day)	-
CWP Direct Discharge to WRTSF (E306114)	In CWP or direct discharge line	Two Times per Day	Once for each direct discharge event	-Daily volume of any diverted mine water -Direct discharge volume and 2 times daily staff gauge levels -May through October (sQ 2&3) 2 times weekly staff gauge levels	-

[1] Metals refers to Low level ICP or equivalent analysis of Total and Dissolved Metals including Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Copper, Iron, lead, Lithium, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Tin, Uranium, Vanadium and Zinc, and Mercury analysis which are to be included at the WRTSF outlet (BJ 3.10), the WTP effluent, the tailings supernatant on a s Quarterly basis.

[2] General Parameters are defined as:

- Laboratory analysis: pH, Specific Conductivity, Hardness, Alkalinity, Sulphate, Chloride, Fluoride, Calcium, Magnesium, Sodium, Ammonia, Nitrate, Nitrite, Total & Ortho Phosphorous, Total Organic Carbon, Total Suspended & Total Dissolved Solids, and Turbidity;
- Field measurements: Turbidity, pH, Conductivity and Temperature;
- Dissolved Phosphorous and Dissolved Organic Carbon which are to be included as part of the General Parameters at Site BJ 3.10 at a frequency of 3x/ ice free period, and 1x mid-winter; and
- Total Extractable Hydrocarbon analysis which is to be included at the CWP prior to direct discharge to Brucejack Lake and prior to treatment at the WTP; at a frequency of once for each event that DPS pond effluent is pumped to the CWP.

Aquatic receiving environment surface water quality monitoring locations in Brucejack Creek are shown in Figure 7.2-2 and Figure 7.2-3 shows monitoring location in upper Sulphurets Creek. Monitoring frequencies are listed in Table 7.2-3. Aquatic receiving environment monitoring locations are BJ 2.62, BJ 1.74, and SC0; the reference monitoring location is site L3-OF. Samples are analyzed for general parameters, major ions and nutrients, total and dissolved metals, and total organic carbon (refer to Table 7.2-3 notes and footnotes for additional details).

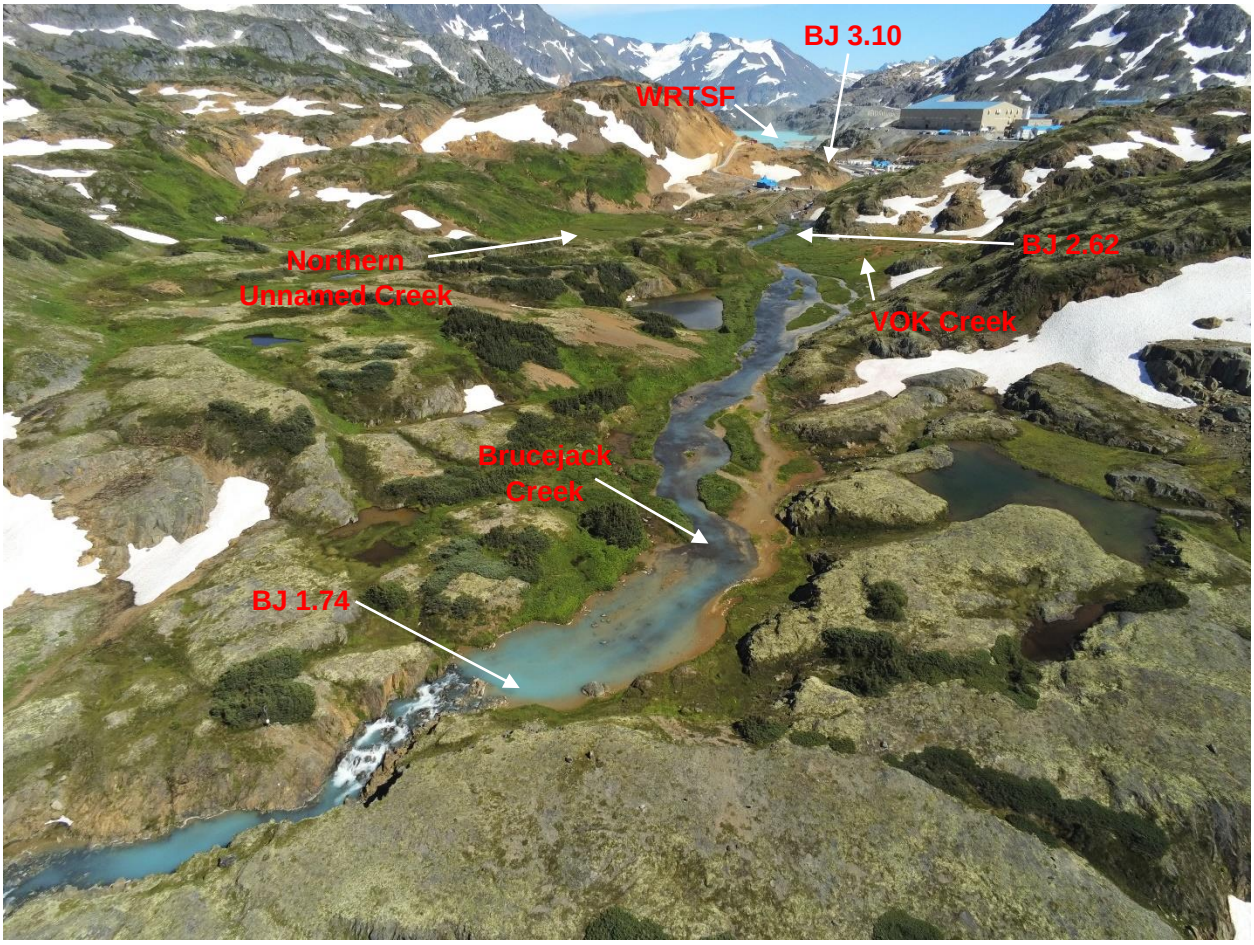


Figure 7.2-2. Aquatic receiving environment surface water quality monitoring locations (BJ 2.62 and BJ 1.74).

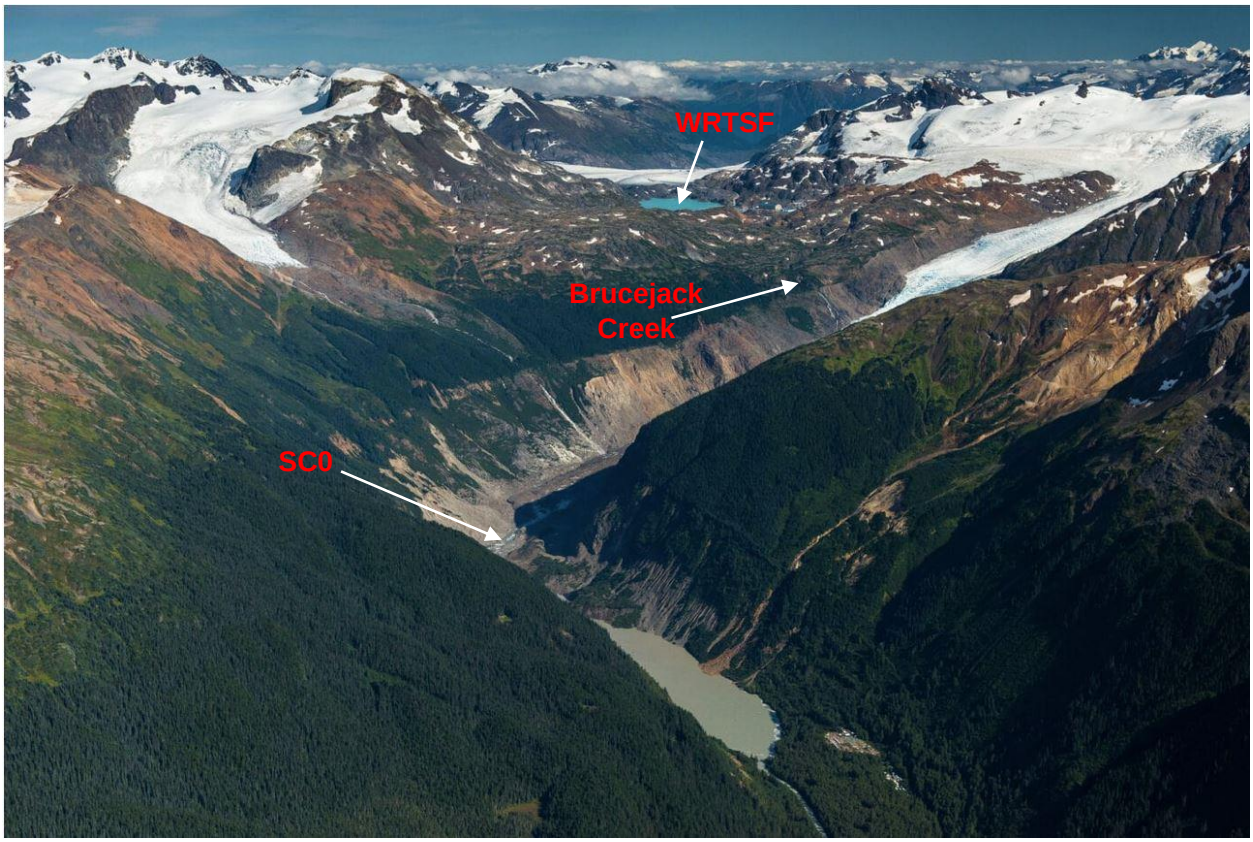


Figure 7.2-3. Aquatic receiving environment surface water quality monitoring locations (SC0).

Table 7.2-3. Brucejack Mine Surface Environmental Water Monitoring Program

Station ID (EMS#) (lat., long.)	Description	Metals[1] & General[2]	Flow Rate	5 in 30 days[3]
BJ 2.62 (E298332) (56.4697, 130.1978)	Brucejack Creek upstream of VOK Ck & downstream of Camp Creek	Monthly	-	-
BJ 1.74 (E298333) (56.4699, 130.2048)	Brucejack Creek downstream of VOK Creek	Monthly (May through October (sQ 2&3)) Quarterly (sQ 1&4)	Four times per summer (manually at low flow and no recent precipitation)	-
CC 0.87 (E298331) (56.4636, 130.1852)	Camp Creek 0.87 km upstream of confluence with Brucejack Creek	Monthly	-	-
CC 0.01 (E298334) (56.4686, 130.1914)	Mouth of Camp Creek	Monthly	-	-
SC0 (E303050) (56.4929, 130.2662)	Sulphurets Creek approximately 6.5 km downstream of the WRTSF	sQuarterly[4]	-	Once every 3 years
L3 OF (E303051) (56.5703, 130.2662)	Reference creek ~20 km north-west of mine site; outflow of L3 Lake	sQuarterly[4]	-	Once every 3 years

[1] Metals refers to Low level ICP or equivalent analysis of Total and Dissolved Metals including: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Copper, Iron, lead, Lithium, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Tin, Uranium, Vanadium and Zinc; and Mercury analysis which are to be included at Site BJ 2.62, SCO, BJ 1.74, on a sQuarterly basis. The mercury sampling frequency at Site L3 outflow must be during freshet and fall.

[2] General Parameters are defined as:

- Laboratory analysis: pH, Specific Conductivity, Hardness, Alkalinity, Sulphate, Chloride, Fluoride, Calcium, Magnesium, Sodium, Ammonia, Nitrate, Nitrite, Total & Ortho Phosphorous, Total Organic Carbon, Total Suspended & Total Dissolved Solids, and Turbidity;
- Field measurements: Turbidity, pH, Conductivity and Temperature; and
- Dissolved Phosphorous and Dissolved Organic Carbon which are to be included as part of the General Parameters at Site BJ 2.62 at a frequency of 3x/ ice free period, and 1x mid-winter.

[3] 5 in 30 days refers to 5 samples collected within 30 days, required at freshet and fall.

[4] sQuarterly refers to the following quarters: sQtr 1 (February, March, & April), sQtr 2 (May, June & July), sQtr 3 (August, September & October), and sQtr 4 (November, December & January).

WTP effluent quality is compared to discharge limits specified in PE-107835 and to long-term trends to ensure that treatment efficiency is maintained. BJ 3.10 monitoring results are compared to discharge limits specified in PE-107835 and to BC WQG for the protection of FWAL for parameters without discharge limits and reported according to Condition 5 of PE-107855.BJ 3.10 and BJ 2.62 monitoring results are evaluated in the *MA/EMA* Annual Reports in comparison to modelled water quality to determine if observed water quality is in-line with expected water quality. Where differences are observed, discussion of potential mine-related effects to surface water quality is presented. Monitoring of the various inputs to the WRTSF (Table 7.2-2) aid in the assessment of potential causes of differences between measures and modelled water quality, and in the development of remedial actions, if necessary. Monitoring results from reference station L3-OF and tributaries to Brucejack Creek, such as Camp Creek, aid in distinguishing changes to water quality in Brucejack Creek that are mine-related from natural changes.

7.2.5 Geochemical Source Terms and Solid Mine Wastes

The Brucejack Mine maintains a comprehensive monitoring program to verify geochemical source terms related to solid waste generated during mine production and development (Table 7.2-4). These source terms are incorporated into the mine's water quality model (Appendix 5-3) and are reviewed annually and updated as required. The geochemical and solid mine waste monitoring program includes:

- Material generated on surface within the mine site area, such as the NPAG quarry rock currently used for surface and underground construction material
- Lithology specific characterization of underground mine waste rock intended for deposition in the WRTSF or backfill within the mine, below the closure flooding elevation
- Characterization of thickened tailings and paste backfill cement, prior to deposition in the WRTSF or underground placement
- Water treatment plant sludge prior to co-mingled deposition with tailings into the WRTSF

Source terms are further developed from water quality samples associated with solid mine waste runoff and leachate, including:

- Mine site surface contact water reporting to the CWP and runoff from the NPAG quarry
- Leachate from saturated column, humidity cell, and field bin kinetic testwork for mine site surface (including the NPAG quarry) and underground waste rock
- Leachate from saturated column and humidity cell testwork for paste backfill and thickened tailings co-mingled with WTP sludge
- Thickened tailings supernatant and paste backfill bleed water
- Underground sumps reporting to the WTP and groundwater seeps reporting to the underground mine pool

Further description of the mine's geochemical source terms and solid mine waste monitoring programs are found in the ML/ARD Management Plan (Appendix 9-1-11), Chromium Management Plan (Appendix 9-2-1), and Nitrogen Management Plan (Appendix 9-2-6). Source term development is described in the Brucejack Mine: 4950 tpd Water Quality Model Report (Appendix 5-3).

Table 7.2-4. Brucejack Mine Geochemical and Solid Mine-waste Monitoring Program.

Station ID / Sample Type (EMS#	Description	Static Testwork[1] (Frequency)	Kinetic Testwork (Frequency)	Water Quality[2] (Frequency)	Flow Rate
MINE SITE					
NPAG Quarry (-)	Drill cuttings collected prior to blasting; quarry runoff water quality, and field bin water quality	ABA, Metals, SFE (per 10,000 m^3)	Field bin leachate (seasonal – summer)	Quarry runoff (bi-annual – spring and fall)	Manually collected at time of sampling
Surface Waste Rock (-)	Surface waste rock excavated during construction, prior to subaqueous deposition in the WRTSF and contact water diversions	ABA, Metals, SFE (per 10,000 m^3)	Saturated column leachate; Field bins (seasonal – summer)	Contact water (bi-annual – spring and fall)	Manually collected at time of sampling
PROCESS PLANT					
Thickened Tailings Slurry (E302910)	Thickened tailings prior to subaqueous deposition via pipeline to the WRTSF	ABA, Metals, SFE (Monthly)	Saturated column leachate (monthly); humidity cell leachate (Monthly)	Thickened tailings supernatant (Monthly)	Daily[3]
Water Treatment Plant Sludge (E302910)	WTP sludge prior to co-mingled subaqueous deposition with thickened tailings to the WRTSF	ABA, Metals (Quarterly); SE (Annually)	Saturated column leachate (Monthly)	-	Daily[3]
Paste Backfill (-)	Paste backfill prior to placement underground and, pate backfill bleed water following placement	ABA, Metals, SFE (Monthly)	Saturated column leachate (monthly), humidity cell leachate (Monthly)	Six chromium samples collected from 2 stopes (Annually)	-
Cement Binder (-)	Cement binder (Terraflow) prior to mixing with thickened tailings to form paste backfill	Chromium[5] (Monthly)	-	-	-
UNDERGROUND MINE					
Underground Waste Rock (-)	Lithology specific waste rock samples collected during mine development	ABA, Metals, SFE (per 25,000 m^3)	Wall washing (annual – water quality, surface oxidation products, and waste rock); saturated column leachate (monthly); humidity cell leachate (monthly); field bin leachate (seasonal – summer)	-	-
Underground Mine Water	Water reporting to underground sumps, or from mine seeps	-	-	Sumps and seeps (sQuarterly)	Manually collected at time of sampling (Seeps only)

1. ABA: acid-base accounting; Metals: solid phase elemental abundance by ICP-MS; SFE: shake flask extraction; SE: sequential extraction.
2. Water quality analysis suite includes general parameters, nutrients, total and dissolved metal (including mercury); dissolved organic carbon is analyzed in UG sumps.
3. Cumulative daily flow.
4. As per the ML/ARD Management Plan.
5. As per the Chromium Management Plan.

7.2.6 Toxicity Testing

Toxicity testing of effluent is conducted quarterly on water collected at BJ 3.10 following the procedures described in the British Columbia Field Sampling Manual Part E: Water and Wastewater Sampling (ENV 2013), as per Section 4.3 and 4.4 of the *EMA* permit (PE-107835) (Appendix 1-1). Testing is completed for a single concentration of 100% effluent, with effluent grab samples collected and processed without delay at an accredited facility. Test reports are included in Section 5.4 of the *MA/EMA* Annual Reports.

Quarterly toxicity tests required by Condition 4.3 of PE-107835 are:

- 48-hour acute lethality assay Daphnia magna (EPS 1/RM/14 2nd edition; EC 2000a); and
- 72-hour growth inhibition test using Pseudokirchneriella subcapitata (freshwater algae) (EPS 1/RM/25; EC 2007a).

Quarterly long-term trend toxicity testing required by Condition 4.4 of PE-107835 is:

- Survival and growth of the freshwater midge Chironomus dilutus (EPS 1/RM/32; EC 1997).

Results of the long-term toxicity testing are examined for trends in survival and growth, compared to previous tests, and placed into ecological context.

PE-108735 Condition 4.3 specifies that *Daphnia magna* tests must have a minimum survival of 50% in undiluted effluent, and that the algal growth inhibition test must have less than 25% growth inhibition in undiluted effluent compared to laboratory control water. Failure of either the *D. magna* survival or the algal growth test require an immediate non-compliance notification. PE-107835 Condition 4.4 specifies that, beginning in 2019, 100% effluent collected at BJ 3.10 be tested for survival and growth using larvae of freshwater midges (*Chironomus dilutus*) and trends in survival and growth be described in *MA/EMA* Annual Reports. The *Chironumus* tests are for examining long-term trends, and results are not used for compliance reporting.

QA/QC procedures for sample collection follow those outlined in the British Columbia Field Sampling Manual Part A: Quality Control and Quality Assurance (ENV 2013). Samples are collected by qualified personnel using suitable sampling equipment and are stored and transported using accepted procedures. Chain-of-Custody forms are used.

All laboratory processing and assays are conducted by accredited facilities.

Additional toxicity testing is required by MDMER. Section 2.7.1.1describes historical toxicity testing, while the information presented below describes present toxicity monitoring. Similar to the samples collected as required by PE-107835, the procedures described in the British Columbia Field Sampling Manual Part E: Water and Wastewater Sampling (ENV 2013) are followed and testing is completed for a single concentration of 100% effluent, with effluent grab samples collected and processed without delay at an accredited facility. All test reports are submitted on the Mine Effluent Reporting System (MERS) via the Single Window Information Manager (SWIM).

Quarterly toxicity testing required by MDMER includes:

- Single-concentration test to determine the mortality rate or Daphnia magna at 48 hours (Reference Method EPS 1/RM/14 2nd edition; EC 2000a); and
- Single-concentration test to determine the mortality rate of Rainbow trout at 96 hours (Report EPS 1/RM/13; EC 2000b).

Quarterly long-term trend toxicity testing required by PE-107835 includes:

- Test of reproduction and survival using the Cladoceran Ceriodaphnia dubia (Report EPS 1/RM/21; EC 2007b).

7.3 Aquatic Receiving Environment / Aquatic Effects Monitoring Program

The existing aquatic effects monitoring program, including monitoring of the aquatic receiving environment that receives Brucejack Mine effluent, is outlined in Effluent Permit 107835 and described in the AEMP (Appendix 9-1-4). The AEMP is designed to generate data needed to accomplish the following objectives:

1. <u>Determine the short- and long-term effects in the aquatic environment resulting from the mine:</u>

   Met by monitoring the aquatic receiving environment via AEMP and PE-107835 monitoring implementation in the short term (on an annual basis) and the long term (across all phases of mine life), augmented by more frequent effluent and receiving environment water quality monitoring. Physical, chemical, and biological characteristics of the aquatic environment are monitored to provide data needed to detect mine effects on the receiving environment.

2. <u>Evaluate the accuracy of mine effect predictions:</u>

   Evaluated based on the results of the monitoring plan addressed in Objective 1, and as part of the regular reporting process.

3. <u>Assess the effectiveness of existing mitigation and management measures:</u>

   The effectiveness of mitigation measures is determined by identifying changes in the receiving environment, which triggers assessment of the significance of such changes and – if significant – follow-up as appropriate (Objective 4). Results of AEMP monitoring and analyses are reported in the *MA/EMA* Annual Reports.

<u>Identify the need for additional mitigation measures to avert or reduce adverse environmental effects due to mine activities (adaptive management):</u>

The AEMP prescribes that if unanticipated effects or poor performance of existing measures are identified, additional mitigation and management measures will be developed. These additional proposed mitigation and management strategies are to be described in the *MA/EMA* Annual Reports.

4. <u>Comply with permit and other regulatory requirements:</u>

   Section 4.5 of PE-107835 requires that the AEMP and any proposed changes to it be approved by the director, and stipulates monitoring results submission requirements, including that these be prepared by a Qualified Professional. Environmental components specified in the AEMP are evaluated for effects by the methods outlined in the AEMP. These methods conform to ENV guidance documents (BC MOE 2016; EC 2012a; ENV 2013). Monitoring follows the

requirements specified in PE-107835 Section 4. PE107835 Section 5.5 requires that the AEMP annual report include results and interpretation of toxicity testing (acute and chronic), sediment and biological monitoring, key water quality trends, environmental effects, and an assessment of the protectiveness of the discharge limits. The MDMER study design and results are reported separately from the AEMP.

The AEMP study area comprises those aquatic receiving areas potentially influenced by Brucejack Mine activities (exposure), and areas beyond potential mine influences (reference). The primary mine-related activities that could affect the aquatic receiving environment, and that were therefore considered in the AEMP design, include:

- discharge of water from the WRTSF, which is the location of subaqueous deposition of waste rock and tailings and which receives treated effluent from the mine WTP and STP. The WRTSF outflow (monitoring site BJ 3.10) is the mine's discharge point into the Brucejack Creek aquatic receiving environment, and is the point of compliance for the EMA permit and MDMER;
- runoff from mine infrastructure, including pads, stockpiles, and roads. Most runoff from mine infrastructure is either contained within the contact water collection area and directed to water treatment, or drains passively to the WRTSF as per the OMS Manual - Water Management Plan (Appendix 9-1-18); and
- changes in streamflow related to mine water management and discharges.

AEMP monitoring sites are situated to monitor the aquatic receiving environment along the downstream gradient from the WRTSF to the inflow to Sulphurets Lake (Table 7.3-1 and Figure 7.3-1).

The monitoring components, with their respective sampling frequency and replication, are provided in Table 7.3-2. Section 6.3 of the AEMP (provided as Appendix 9-1-4) describes these monitoring components in greater detail.

Refer to the AEMP for additional details (Appendix 9-1-4).

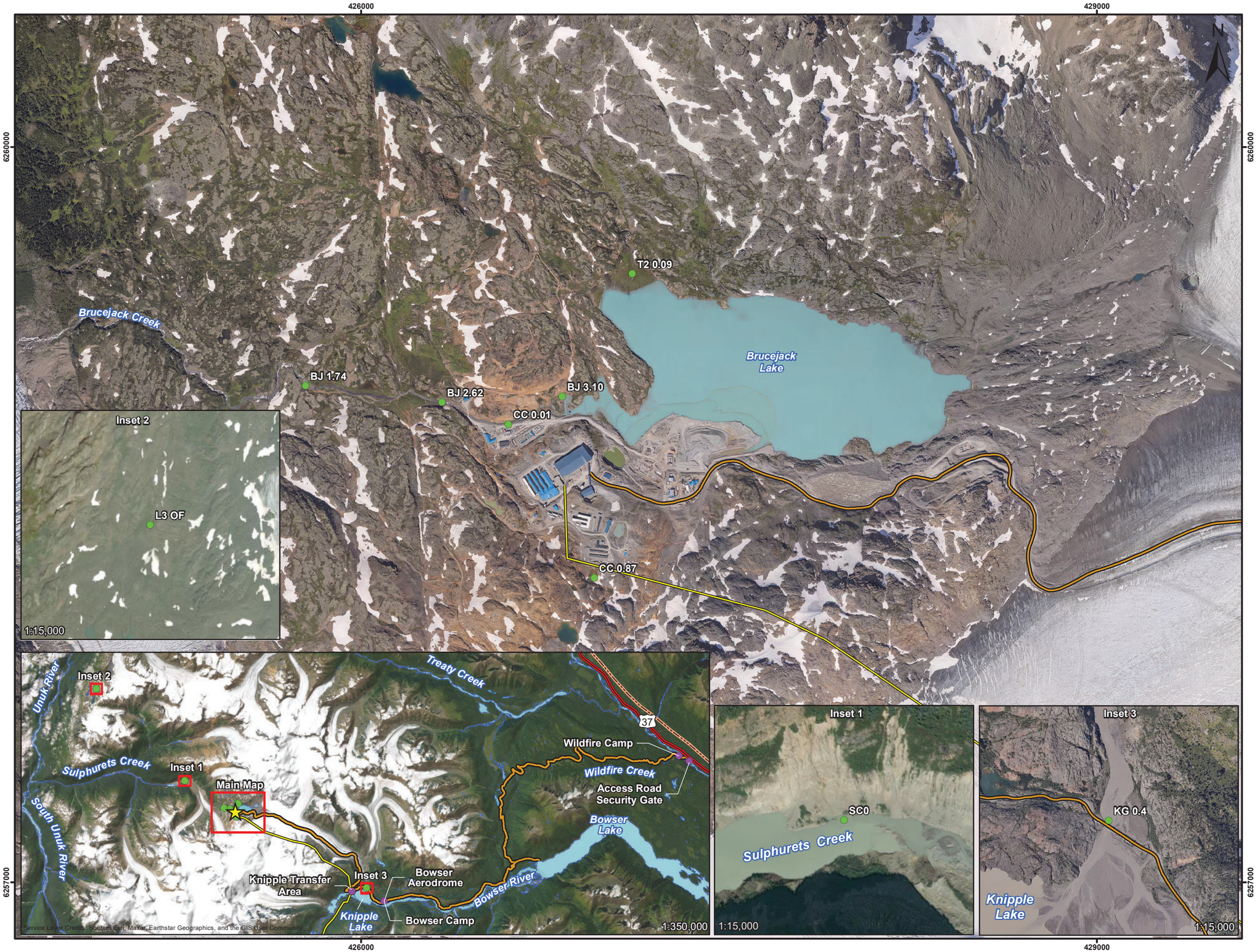
The sampling design for the AEMP is conceived to provide information for a statistical analysis incorporating a Before-After/Control-Impact (BACI) design on aquatic receiving environment indicators. Baseline information for the sampling locations (Table 7.3-1) is available from 1987 to 2014 (see Sections 13.3 and 14.3 in Chapters 13 and 14 of the Application for an Environmental Assessment Certificate /Environmental Impact Statement, ERM Rescan 2014a), and are the basis for the "Before" category in AEMP statistical analyses. Monitoring for the "After" category commenced in 2015, when the Construction Phase of the mine was initiated, with commercial production achieved on July 1, 2017.

Table 7.3-1. AEMP Monitoring Locations, Descriptions, and Purposes

Site	EMS ID	Location[a]		Description	Purpose
		Easting	Northing		
Mine Site Area					
BJ 3.10 (Weir)	E298312	426,820	6,258,983	WRTSF outflow	Mine discharge location; final discharge point for MDMER and effluent compliance conditions for PE-107835
CC 0.87[b]	E298331	426,951	6,258,242	Headwaters of Camp Creek	Upstream control site
CC 0.01[b]	E298334	426,601	6,258,868	Mouth of Camp Creek	Site to estimate non-contact water contributions from Camp Creek to Brucejack Creek.
BJ 2.62[b]	E298332	426,330	6,258,959	Brucejack Creek, immediately downstream of cascades	Monitor the receiving environment on Brucejack Creek approximately 0.5 km downstream of WRTSF outflow and downstream of Camp Creek.
BJ 1.74[b]	E298333	425,773	6,259,026	Brucejack Creek, downstream of VOK Creek confluence	Monitor the receiving environment on Brucejack Creek approximately 1.4 km downstream of WRTSF outflow
SC0[b]	E303050	422,038	6,261,659	Sulphurets Creek, downstream of Sulphurets Glacier, inflow to Sulphurets Lake	Far-field exposure site.
Access Road					
KG 0.4	-	439,360	6,251,460	Creek flowing from Knipple Glacier, upstream of bridge	Hydrocarbon monitoring location; not included in EMA permit
Reference Areas					
L3 Outflow[b]	E303051	413,622	6,270,435	Reference stream; lake-headed high alpine reference stream comparable to Brucejack Creek, located 17 km northwest of Brucejack Lake	Brucejack Creek reference stream site
T2 0.09	-	427,106	6,259,483	Catear Creek; northern tributary to Brucejack Lake	Applicable to MDMER sampling only. Upstream reference site for Brucejack Creek; downstream of historical Catear Mine site; Environment and Climate Change Canada recommended MDMER biological reference site

[a] UTM Zone 9, NAD83
[b] Sampling schedule may be adjusted during the winter months depending on conditions (i.e., flying, creek frozen to ground) and avalanche hazard.

The monitoring components, with their respective sampling frequency and replication are provided in Table 7.3-2. Section 6.3 of the AEMP (provided in Appendix 9-1-4) describe these monitoring components in greater detail.
Refer to the AEMP for additional details (Appendix 9-1-4).



Legend

- Sampling Location
- Highway
- Northwest Transmission Line

Infrastructure

- Brucejack Gold Mine
- Other Project Infrastructure
- Transmission Line
- Brucejack Access Road

1:15,000

0 250 500

Metres

Coordinate System: NAD 1983 UTM Zone 9N

NEWCREST BRUCEJACK

Map ID: BJSW20230110178

Main Map Imagery: 2022 Lidar | Date: January 10, 2023

Figure 7.3-1. AEMP Sampling Locations

Table 7.3-2. Physical, Chemical, and Biological Components in the AEMP Sampling Program

		Monitoring Location (EMS ID)							
Component	**Frequency**	**BJ 3.10 (E298312)**	**CC 0.87 (E298331)**	**CC 0.01 (E298334)**	**BJ 2.62 (E298332)**	**BJ 1.74 (E298333)**	**SC0 (E303050)**	**L3 OF (E303051)**	**KG 0.4 -**
Flow	Continuous + Manual Checks Quarterly	1	-	-	-	-	-	-	-
	Manually 4 x summer, with no recent precipitation	-	-	-	-	1	-	-	-
Water Quality	Weekly	1	-	-	-	-	-	-	-
	Monthly	-	1	1	1	-	-	-	-
	Monthly (May to October) / Quarterly (November to April)	-	-	-	-	1	-	-	-
	Quarterly[a]	-	-	-	-	-	1	1	1
	Freshet and Fall 5-in-30 once every 3 years	-	-	-	-	-	1	1	-
Toxicity [b]	Quarterly	1	-	-	-	-	-	-	-
Sediment [c]	Annually	5	-	-	5	-	-	-	5
	Once every 3 years	-	-		-	5	5	5	-
Periphyton Biomass (chl *a*)	Annually	6	-	-	6	6	-	-	-
	Once every 3 years	-	-	-	-	-	6	6	-
Periphyton Taxonomy	Annually	5	-	-	5	-	-	-	-
	Once every 3 years	-	-	-	-	-	-	5	-
Benthic Invertebrates (CABIN) [c]	Annually	1	-	-	1	1	-	-	-
	Once every 3 years	-	-	-	-	-	1	1	-

Note: *Values represent the number of replicate samples collected per site. Values do not include QA/QC.*
[a] *Shifted Quarterly: sQtr1 (February to April), sQtr2 (May to July), sQtr3 (August to October), and sQtr 4 (November to January).*
[b] *Toxicity: of 100% BJ 3.10 water (single concentration) for 48h Daphnia magna survival (EPS 1/RM/14), 72h freshwater algae growth (EPS 1/RM/25), and l survival and growth of Chironomus dilutus (EPS 1/RM/32, water only).*
[c] *Sampled during fall low flow*

7.4 Post-Closure Environmental Monitoring Program

Monitoring is required under Section 10.7.21 of the Code to demonstrate that reclamation and environmental protection objectives including land use, productivity, water quality, and stability of structures are being achieved. Mine closure is estimated to be completed within three years, followed by post-closure monitoring over the following ten years. The results of the monitoring program are to be included in the Annual Reclamation Report (per Section 10.4.4 of the Code).

The following summarizes conceptual post-closure monitoring planned for the Brucejack Mine. The length of time required for monitoring may be extended if the early results of the program indicate further monitoring is required. All facilities will be dismantled and/or removed from site during closure with site drainage and landforms contoured to a final closed state. As such, regular maintenance is not anticipated. Maintenance needs will be identified on an as-needed basis based on the monitoring and inspection programs described below.

Monitoring programs are anticipated to evolve and decrease in scope through the closure and post-closure periods. During the closure period, monitoring programs will focus on monitoring and management of reclamation activities, confirming of ongoing compliance with regulatory requirements, and including confirming effectiveness of water quality protection related closure activities relative to modelled predictions such that adaptive management will be triggered if/as appropriate (e.g. Closure Underground Water Quality Adaptive Management Plan, Appendix 9-2-2).

During the post-closure period, monitoring programs will focus on demonstrating reclamation success. The general scope of post-closure monitoring programs includes:

- Surface water quality, sediments, and aquatic biological resources;
- Groundwater quality and levels, including water chemistry and level in the underground mine as feasible;
- Structural integrity of portals and raise watertight plugs;
- Geotechnical assessment of post-mine landform and watercourse stability, including for the surface above the underground mine (subsidence); and
- Assessments of reclamation program success in meeting the end land use objectives.

Additional details are provided in section 12 of the Reclamation and Closure Plan (Appendix 4-1).

8. HEALTH AND SAFETY

Existing Brucejack Mine Health and Safety related management plans and associated procedures will remain in effect with the proposed production rate increase; no changes are necessary specific to the change in production rate. The Mine Emergency Response Plan is included as Appendix 9-1-12, and the Health Services Monitoring Program is Appendix 9-1-9. A summary of Brucejack Mine emergency preparedness is provided as follows.

Due to its remote location, the Brucejack Mine has a medical clinic staffed with a Registered Nurse (RN), Advanced Care Paramedic (ACP), or Primary Care Paramedic (PCP) combination to provide site healthcare, and with the ability to enable offsite medical transfer via land or air for any conditions requiring higher level of care.

The mine's emergency response procedures incorporate on-site mine rescue teams composed of an interdepartmental workforce trained in first aid, fire-fighting procedures, and other mine rescue operations. Emergency coordination occurs from the incident control room, where all information and communications can be monitored. A variety of incidents will initiate the emergency response plan and/or evacuation plan including fire, rock fall, injured personnel, or major ventilation equipment breakdown.

The underground mine ventilation system is designed to meet the Code requirements (EMLI 2022). The 'push' configuration of the mine ventilation system distributes fresh air to the mine via the WZ and VOK ramps. Both ramps serve as escapeways for most levels.

Ladderways are installed in each of the fresh air intake raises located adjacent to the main ramps and serve as the primary escape ways for the production stoping blocks. The fresh air intake raises are appropriately sized to afford easy passageway and are designed, installed, and maintained in compliance with Code sections 6.28.1 through 6.28.7 (EMLI 2022). The exhaust raises to surface are for ventilation only and do not provide secondary egress; therefore, the exhaust raises do not have ladderways.

A stench gas warning system is installed on the supply side of the WZ vehicle portal and VOK conveyor portal. When initiated, this system will release stench gas into the main fresh air system, allowing the gas to permeate rapidly throughout the mine workings. Once stench gas is released, underground mine personnel report immediately to the nearest mine refuge station or to surface, depending on proximity and safe access.

A permanent 40-person refuge station has been established and services both the WZ and VOK, and a permanent 60-person refuge station has been established and services the lower VOK. Additional portable refuge chambers are positioned within the most appropriate areas for ongoing mining activity. A summary of the refuge stations is provided in Table 8-1.

Fire doors are positioned in accordance with Code sections 6.32.1 and 6.32.2 (EMLI 2022) and are intended to isolate areas of high fire potential and prevent noxious gas distribution through the mine workings. The primary purposes of fire doors are to prevent noxious gases from reaching workers should they be trapped underground and to prevent fire from spreading as much as possible. Fire doors have also been installed to isolate the magazine and conveyor decline. The mine portal doors are designed to meet fire door criteria.

Table 8-1. Summary of Refuge Stations

Refuge #	Location	Capacity
1	1440 Escapeway	12
2	1020 Escapeway	16
3	1260-15	16
4	1110 East RM	16
5	1170 Escapeway	16
6	1335 Permanent	40
7	1080 Escapeway	16
8	1200-16 Permanent	60
9	WZ 1270 Ramp	6

9. MANAGEMENT PLANS

9.1 Environmental Management System

The Brucejack Mine EMS is comprised of 21 component management plans required under Schedule B of EAC #M15-01 and 10 additional management plans required through other BC provincial authorizations (mainly Permit M-243, PE-107835 and PA-107025). The 21 EAC component management plans are provided in Appendix 9-1, except for the Reclamation and Closure Plan which is provided in Appendix 4-1. The 10 additional management plans are provided in Appendix 9-2. A list of the management plans and their associated review and distribution histories is provided in Table 9.1-1. The Reclamation and Closure Plan has been updated to reflect mine site changes since the last major update in 2020.

It should be noted that there are several differences in management plan terminology between the requirements under EAC #M15-01 and the M-243 and other authorizations requiring plans:

- EAC #M15-01 refers to the entire compilation of required management plans as the 'Environmental Management Plan' (EMP) whereas Mines Act Permit M-243 uses the more typical terminology of an EMS with component EMPs.
- EAC #M15-01, Schedule B, Appendix A lists a 'Tailings and Subaqueous Waste Rock Deposition Management Plan'. This management plan has been expanded to an OMS Manual to meet EMLI requirements under M-243 Condition C.3(a)(i) for content that includes procedures, reporting and responsibility information. The title of this document as included in Appendix 9-1-17 is OMS Manual – Waste Rock and Tailings Storage Facility.
- EAC #M15-01, Schedule B, Appendix A lists a 'Water Management Plan'. This management plan has also been expanded to an OMS Manual to meet EMLI requirements under Permit M-243.

9.1.1 Environmental Policy Statement

Pretium adheres to the Newcrest Mining Ltd. Environmental Policy which states that Newcrest is committed to excellence in environmental performance to maintain and enhance our license to operate and commits to the following:

- Inform all employees, contractors and vendors about this Policy and make them aware of their environmental responsibilities;
- Throughout the life-cycle of our activities engage with stakeholders to identify and manage sustainable development risks and opportunities as part of our business planning and execution;
- Comply with applicable environmental laws, regulations and voluntary commitments to which the organisation subscribes, as a minimum;
- Ensure effective systems, practices and documented plans are in place to manage and mitigate environmental impacts and pollution from our activities by proactively managing risks;

- Establish and document processes to identify and manage risks and opportunities for the efficient use of energy and water, manage emissions linked with climate change and reduce waste generation that lessens the Company's environmental footprint;
- Ensure that integrated approaches to land use planning and environmental management are implemented in areas where we operate and/or manage that contribute to the conservation of biodiversity;
- Integrate mine closure and progressive rehabilitation into the life-cycle of our operations to minimise our environmental legacies;
- Continually strive to improve our environmental performance based on defined objectives and targets for monitoring, measuring and reporting performance; and
- Report openly, honestly and in a timely manner to stakeholders on the Company's environmental and sustainability performance.

9.1.2 Environmental Management Plans Content

Each of the management plans contains information as relevant on the following:

- Roles and responsibilities;
- Information on statutory requirements, including applicable local, provincial, or federal environmental standards and guidelines, permit requirements, regulations, and orders;
- Information on environmental standards and procedures, including all applicable sector-specific standards, guidelines, best management practices, and codes of practice;
- Organizational structure; and
- Training programs.

9.1.3 Training Program

In addition to the specified training within each of the EMPs, all site personnel complete an environmental site orientation prior to commencing work on site. The goal of the environmental site orientation is to educate and train all employees and contractors on the EMS and specifically on relevant EMPs.

Table 9.1-1. Summary of EAC Component Management Plans and Plans per Other Provincial Authorizations and Requirements

Brucejack Mine Management Plans	Relevant Regulatory Authority	Current Version Date (Revision Status)	Distribution Timing/Status	Reviews/Audits
BC EAC #M15-01 Component Management Plans (refer to Appendix 3-1-1 for plans)				
Aboriginal Consultation Plan (Appendix 9-1-1)	EAO	January 2022	September 2016 edition sent to EAO, Nisga'a Lisims Government and First Nations September 16, 2016; submitted to EAO on December 31, 2018 and with *MA & EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Version control table and cover page updated in 2018. No significant changes required based on 2019 review. In March 2021, the Plan was updated to reflect changes in contact info and reference made to Spill Response Plan. In January 2022, the Plan was updated to reflect changes to key contacts. No changes were made based on 2023 review.
Air Quality Management Plan (Appendix 9-1-2)	ENV	January 2022	Original May 2015 via *MA & EMA* Permits Application; submitted to EAO on December 31, 2018 and with *MA & EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Annual major plan audit via Annual Air Quality Report and related compliance assessment (Annual Status Form) submitted to ENV (and EMLI) as part of the Annual Report due by March 31st of the following year. The plan was sent out for review/consultation in 2019 with relevant Indigenous groups, and comments were received. The review process continued through 2020 and an updated version, reflecting comments via consultation, was prepared in January 2021. In January 2022, the Plan was updated to include references to compliance limits in 2021 air permit amendment. No changes were made based on 2023 review.
Ancillary Infrastructure Decommissioning and Reclamation Plan (Appendix 9-1-3)	LWRS/Forests/EMLI	December 2018	Original May 2015 via *MA & EMA* Permits Application; current edition submitted to EAO on December 31, 2018 and with *MA & EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder.	Content was updated based on the 2018 review to reflect constructed infrastructure rather than proposed, and to separate ancillary infrastructure from that within the M-243 permitted area. No changes required based on 2019 review. No changes based on 2020 review. No changes based on 2021 review. No changes based on 2022 review.
Aquatic Effects Monitoring Plan (Appendix 9-1-4)	ENV	February 2022	Original May 2015 via *MA & EMA* Permits Application; submitted to EAO on December 31, 2018 and with *MA & EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2019 Annual Report in March 2020; submitted with *MA & EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Plan is reviewed a minimum of annually, including via the Annual Aquatics Report and related compliance assessment (Annual Status Form) required by ENV as part of the MA/EMA Annual Report. Based on the 2018 review, the Plan was updated to align with the amended effluent permit (PE-107835) issued Dec. 14th, 2018, and with MDMER revised regulations. In 2019, comments were received by ENV in consultation with Nisga'a Lisims Government, which were reflected in the February 2020 update. In March 2021, the plan was again updated to add zinc triggers to the monitoring program. In February 2022, the plan was updated to reflect changes to cited references. No changes were made based on 2023 review.
Avalanche Safety Plan (EAC Preliminary Avalanche Hazard Management Plan for Mine Construction and Operations) (Appendix 9-1-5)	LWRS/Forests/EMLI	October 2023 (updated)	Original May 2015 via *MA & EMA* Permits Application; *MA & EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA & EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Avalanche Safety Plan produced in 2018 replaces the original Preliminary Avalanche Hazard Management Plan from 2015. The Avalanche Safety Plan is used operationally by Pretium's Mountain Safety avalanche technicians and is reviewed and updated frequently (generally annually). There are frequent inspections/audits under the plan by Pretium's full-time year-round Mountain Safety avalanche technicians. No significant changes required based on 2019 review. Plan was reviewed in 2020 and updated February 2021 to reflect changes in operational procedures. Plan was once again reviewed in 2021 and updated in February 2022 to reflect changes to operational procedures. No changes were made based on 2023 review. Appendix N was added in October 2023.
Chemicals and Materials Storage and Handling Plan (Appendix 9-1-6)	MEMLI/ENV	January 2023 (updated)	Original May 2015 via *MA & EMA* Permits Application; *MA & EMA* joint 2016 Annual Report submitted March 2017; *MA & EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA & EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Lessons learned from the execution of several mock spill chemical response drills at different times of the year (i.e., winter and summer) with different crews and locations, were incorporated into the Plan update in December 2018. The 2018 update also includes revisions for Operations chemicals and materials. No changes required based on 2019 review. A 2020 review resulted in updates to newly added (in 2020) reagents used in the milling process. In July 2021, the Plan was updated to reflect changes to the chemicals and materials used for mine operations and to the Mill Reagent Storage Plan. In November 2022 the Plan was updated to reflect changes to chemicals and materials used for mine operations and to the Mill Reagent Storage Plan. In January 2023 the Plan was updated to reflect changes to Table 6-1 (Chemicals and Materials for Mine Operation).

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Economic and Social Effects Mitigation Plan (Appendix 9-1-7)	EAO	March 2022	March 2017 edition sent to NLG, Tahltan Central Government (TCG), Tsetsaut/Skii km Lax Ha First Nation (TSKLH) and EAO March 30, 2017; current edition submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Based on the 2018 review the plan was updated to reflect activities completed to date. Annual report on implementation of the plan sent to NLG, TSKLH, TCG, EAO and local communities from Telegraph Creek to Smithers on January 31, 2019. No changes required based on 2019 review. No changes required based on 2020 or 2021 review. In March 2022, the Plan was updated and sent to NGL, TSKLH, TCG, EAO and local communities from Telegraph Creek to Smithers.
Heritage Management Plan (Appendix 9-1-8)	LWRS/Forests/EMLI	January 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; current edition submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Version control table and cover page updated in 2018. No changes required based on 2019 review. No changes required based on 2020 review. No changes based on 2021 review. Version control table and cover page updated January 2023.
Health Services Monitoring Plan (Appendix 9-1-9)	EAO	November 2023 (updated)	June 2016, distributed to Northern Health and Nisga'a Lisims Government and First Nations; current edition submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Plan was originally developed in consultation with Northern Health per EAC requirements. Northern Health conducts (minimum) annual physical inspections of the camp and related medical facilities, and there are monthly meetings between Pretium Health and Safety and Northern Health to review implementation. Version control table and cover page updated in 2018. No changes based on 2019 review. No changes based on 2020 review. No changes based on 2021 review. Version control table and cover page updated in January 2023. Significant updates to general infrastructure references and general updates throughout.
Invasive Plants Management Plan (Appendix 9-1-10)	LWRS/Forests/EMLI	January 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; current edition submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Annual inspections arranged through Northwest Invasive Plants Council (NWIPC) beginning in 2016, with control implemented beginning in 2017. Plan is evaluated through the course of the inspections and follow-up reporting. Version control table and cover page updated in 2018. No changes based on 2019 review. No changes required based on 2020 review. No changes based on 2021 review. Version control table and cover page updated in January 2023.
Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan (Appendix 9-1-11)	LWRS/Forests/EMLI	February 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; MEMPR and ENV March 6, 2017; *MA* & *EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA* & *EMA* joint 2019 Annual Report in March 2020; current version submitted with *MA* & *EMA* joint 2020 Annual Report in March 2021; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Plan is reviewed with every application to amend water quality discharge limits of PE-107835 and/or to amend geochemistry or mine plan related conditions of M-243 and amended based on outcomes from government reviews of those applications. The December 2018 update stemmed from the December 14, 2018 issuance of final authorizations for the 3800 tpd production increase. The March 2020 update included minor revisions to some sampling procedures. The Plan is also reviewed for *MA* & *EMA* joint Annual Report submissions, as there are extensive annual reporting requirements under it, and through the extensive monitoring under this plan. The 2020 review resulted in minor revisions to sampling procedures. No changes required based on 2021 review. Version control table and cover page updated in February 2023.
Mine Emergency Response Plan (Appendix 9-1-12)	MEMLI	February 2022	Original May 2015 via *MA* & *EMA* Permits Application; submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Plan reviewed annually. Plan was updated based on the 2018 review, including updates to align with 2017 MEMPR Guidance (v1.4). No changes required based on 2019 review. The 2020 annual review resulted in updates to align with current safety standards and practices. In February 2022, the Plan was updated to include the current risk matrix and an incident report template. No changes required based on 2023 review.
Reclamation and Closure Plan (Appendix 4-1)	MEMLI	March 2023 (updated)	May 2015 via *MA* & *EMA* Permits Application; submitted to EAO on December 31, 2018; current addition distributed via 2020 Mine Plan and Reclamation Program Update (as Chapter 3) submitted July 2020; internally via Management Plans folder.	Content was updated based on the 2018 review to reflect constructed infrastructure rather than proposed, and to separate infrastructure within the M-243 permitted area from ancillary infrastructure located outside of that area. In 2020, the plan was updated as Chapter 3 of the 2020 Mine Plan and Reclamation Program Update (Pretium 2020b), including to address content requirements of *Mines Act* Permit M-243 Condition E.14. No changes required based on 2021 review. In 2022, the plan was updated, including to reflect changes associated with increased ore production.
Soils Management Plan (Appendix 9-1-20)	LWRS/Forests/EMLI	July 2020	May 2015 via *MA* & *EMA* Permits Application; submitted to EAO on December 31, 2018. Currently the Soils Management Plan is addressed through the Reclamation and Closure Plan.	Plan was implemented during construction, which was mostly completed by end of summer 2017. Plan was reviewed in 2018 and extracted from Chapter 5 MA/EMA Permit Application document and presented as a stand-alone Plan. In 2020 onwards, updates to soil management, mainly with respect to reclamation research, are addressed in the Reclamation and Closure Plan.

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Spill Response Plan (Appendix 9-1-13)	EMLI/ENV	March 2022	Original May 2015 via *MA* & *EMA* Permits Application; *MA* & *EMA* joint 2016 Annual Report submitted March 2017; *MA* & *EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA* & *EMA* joint 2019 Annual Report in March 2020; current edition submitted with *MA* & *EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Formal spill response training exercises are conducted annually by third party consultant, Northwest Response Ltd. These sessions are delivered to personnel at all camps (i.e., Wildfire, Bowser, Knipple, and Brucejack), and target all rotations, including those on night shift. Mock hydrocarbon spill response drills are also carried out periodically. The site orientation, which all employees must attend, includes a spill response training component. Lessons learned from these activities were incorporated into the 2018 update. In February 2020, the Plan was updated to reflect changes in regulations, contact information and current practices at the mine site. In March 2021, relevant measures on newly added (in 2020) reagents were updated, as was mapping on charting potential spill flow along the road. In March 2022, the Plan was updated to incorporate changes from IAAC Information Request July 22, 2021 and reflect changes to contact information for IAAC and First Nations. No changes based on 2022 review.
Traffic and Access Management Plan (Appendix 9-1-14)	LWRS/Forests/EMLI	January 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; current edition submitted to EAO on December 31, 2018; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Augmented by the Standard Road Procedures document, most current issued version of which is December 2018. Reviews/evaluation ongoing through the road use. Updated based on 2018 review to reflect Operations phase use of the road. No changes required based on 2019 review. No changes required based on 2020 review. No changes required based on 2021 review. Version control table, cover page, and section 5.4 call out procedure updated in January 2023.
Vegetation Management Plan (Appendix 9-1-15)	LWRS/Forests/EMLI	February 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; current edition submitted to EAO on December 31, 2018; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Plan was implemented during construction, which was mostly completed by end of summer 2017. Version control table and cover page updated for 2018. Plan was reviewed in 2019 resulting in no changes. No changes required based on 2020 review. No significant construction planned moving forward that would entail additional vegetation management. No changes based on 2021 review. Version control table and cover page updates based on 2023 review.
Waste Management Plan (Appendix 9-1-16)	ENV	December 2021 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; January 2017 edition submitted to ENV January 2017; *MA* & *EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Designated waste management coordinators and staff work to achieve compliance with Pretium's updated Waste Management Plan; this includes routine internal environmental/waste management inspections at each camp. Training sessions/presentations are delivered regularly to site personnel on maintaining good waste management practices and minimizing wildlife attractants. Version control table and cover page updated in 2018. No changes required based on 2019 review. No changes required based on 2020 review. In December 2021, the Plan was updated to reflect current operations and maintenance procedures. No changes based on 2022 review.
Waste Rock and Tailings Storage Facility – OMS Manual (Appendix 9-1-17)	EMLI	June 2021	Original May 2015 via *MA* & *EMA* Permits Application; November 2017 to MEMPR; *MA* & *EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA & EMA* joint 2019 Annual Report submitted March 2020; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder.	Original Tailings and Waste Rock Subaqueous Deposition Management Plan replaced by Waste Rock and Tailings Storage Facility – OMS Manual. The OMS Manual reviewed annually and updated, as needed, to reflect changes as facility develops per requirements of M-243 Condition C.3(a)(i). WRTSF reviews also captured under M-243 requirements for an Annual Construction Report, and Code requirements for annual review by the EOR and an Independent Tailings Review Board. OMS Manual was updated by SRK Consulting in October 2018 to align with changes from the 3800 tpd production increase and related WRTSF design update. The OMS Manual was again updated in March 2020 to align with current surveys, regulations and changes to the company organizational chart. A review of the plan was again conducted in December 2020 and an updated version is anticipated to be completed in 2021. The OMS Manual was once again updated in June 2021 to align with current surveys, regulations and changes to the company organizational chart. A review of the plan was again conducted in 2022 and an updated version is anticipated to be completed in 2023.

Brucejack Mine Management Plans	Relevant Regulatory Authority	Current Version Date (Revision Status)	Distribution Timing/Status	Reviews/Audits
Water Management Plan – OMS Manual (Appendix 9-1-18)	LWRS/Forests/EMLI	February 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; updated OMS version via *MA* & *EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA* & *EMA* joint 2019 Annual Report submitted March 2020; submitted with *MA* & *EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA* & *EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Original Water Management Plan has been replaced by the 'Operation, Maintenance and Surveillance Manual (OMS Manual) – Water Management Plan', which incorporates details of Operations water management (contact and non-contact water). Inspections under the plan are completed by site personnel in accordance with the plan. This Plan was updated in 2018 to reflect current status, including drawing revisions/updates. The Plan was again updated in March 2020 to reflect change of EOR from BGC to SRK and to align with revised regulations and practices. In February 2021, the plan was updated to reflect changes to the company organizational chart, roles and responsibilities table and maps. In February 2023, the plan was updated to reflect changes to the company organizational chart, roles and responsibilities tables and maps.
Wildlife Management Plan (Appendix 9-1-19)	LWRS/Forests/EMLI	February 2023 (updated)	May 2015 via *MA* & *EMA* Permits Application; current version submitted to EAO on December 31, 2018 and with *MA* & *EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Plan is implemented on an ongoing basis, with much of the most important aspects on preventing adverse impacts accomplished through implementation of the closely related Waste, Refuse Incinerator, and Goat Management Plans (last stemming from the Wildlife Management Plan), plus plans related to spills and water quality. The plan is also one of the key plans/documents under review of the Wildlife Advisory Committee (WAC). The Plan was reviewed and updated in December 2018 in response to an EAO inspection report received October 2018. No changes required based on 2019 review. No changes required based on 2020 review. No changes required based on 2021 review. The plan was reviewed and updated in 2022 in response to comments received from MFLNRO during the 2022 Wildlife Advisory Committee (WAC), internal and ERM review. Version control and table updates based on January 2023 review.
Additional Management Plans Per Other Provincial Authorizations and Requirements (refer to Appendix 3-1-2 for plans)				
Chromium Management Plan (Appendix 9-2-1)	ENV	February 2023 (updated)	Original to MEMPR and ENV March 6, 2017; updated version via *MA* & *EMA* joint 2017 Annual Report submitted March 2018; current edition submitted via *MA* & *EMA* joint 2018 Annual Report submitted March 2019; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Concentrations of total, dissolved and dissolved hexavalent Cr are monitored monthly in mine influent. Overall, the monitoring data indicate the CMP has been effective for chromium source control. Based on the 2018 review, the CMP was updated to reflect operational monitoring data and to align with changes from the 3800 tpd production increase approved December 14, 2018. No changes required based on 2019 review. No changes required based on 2020 review. No changes required based on 2021 review. Version control and table updates based on February 2023 review.
Closure Underground Water Quality Adaptive Management Plan (Appendix 9-2-2)	ENV	July 2020	New plan. Distributed via 2020 Mine Plan and Reclamation Program Update submitted July 2020.	Prepared as required by PE-107835 Condition 3.3. No changes required based on 2020 review. No changes required based on 2021 review. No changes required based on 2022 review.
Geohazards Management Plan (Appendix 9-2-3)	EMLI	October 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; submitted via *MA* & *EMA* joint 2016 Annual Report submitted March 2017; current version submitted with *MA* & *EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	M-243 Condition C.9 requires annual review of geohazard management practices being implemented at the mine site by a Professional Engineer. No changes required based on 2019, 2020 or 2021 review. The plan was reviewed and updated by BGC in October 2023.
Ground Control Management Plan (Appendix 9-2-4)	EMLI	February 2023 (updated)	Original May 2015 via *MA* & *EMA* Permits Application; updated version via *MA* & *EMA* joint 2017 Annual Report submitted March 2018; submitted to EAO on December 31, 2018; *MA* & *EMA* joint 2018 Annual Report submitted March 2019; submitted with *MA* & *EMA* joint 2020 Annual Report in March 2021; current version submitted with *MA* & *EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Ground Control Management Plan is reviewed annually and updated as deemed necessary by a Professional Engineer, per requirements of M-243 Condition C.2(d). M-243 Condition C.2(m)(i) requires annual review of the underground workings by a Professional Engineer and C.2(m)(ii) requires a third-party audit of the Ground Control Management Plan by a Professional Engineer, beginning in 2018. The 2018 GCMP Audit was completed by BGC, and BGC also updated the GCMP during Q1 2019. The 2019 audit was completed by SRK, resulting in no required updates. The 2020 audit was completed by SRK and resulted in changes to operational procedures. The Ground Control Management plan was updated in January 2022 to reflect changes to current operational procedures. The Ground Control Management plan was updated in February 2023 to reflect changes to current operational procedures.

Brucejack Mine Management Plans	Relevant Regulatory Authority	Current Version Date (Revision Status)	Distribution Timing/Status	Reviews/Audits
Mountain Goat Management Plan (Appendix 9-2-5)	LWRS/Forests	January 2023 (updated)	Directly to FLNRORD and Wildlife Advisory Committee April 27, 2017; submitted via *MA & EMA* joint 2017 Annual Report submitted March 2018; current version submitted with *MA & EMA* joint 2020 Annual Report in March 2021; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Reviewed by FLNRORD and by Wildlife Advisory Committee (WAC). Plan is subject to ongoing review as deemed necessary by the WAC. The Plan was sent out for review to the WAC members in 2019 with comments received. The review process continued into 2020 and an updated version was finalized in June 2020. No changes required based on 2021 review. Version control table and cover page updates based on 2023 review.
Nitrogen Management Plan (Appendix 9-2-6)	ENV/EMLI	March 2023 (updated)	Original distributed as appendix of ML/ARD Mgmt Plan provided to ENV and MEMPR November 2016, as part of PE-107835 Amendment Application #4; *MA & EMA* joint 2017 Annual Report submitted March 2018; *MA & EMA* joint 2018 Annual Report submitted March 2019; 2020 Mine Plan and Reclamation Program Update submitted July 2020; current version submitted with *MA & EMA* joint 2021 Annual Report in March 2022; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Nitrogen audits under plan conducted minimum 6 times annually. Plan itself audited/reviewed each time water quality predictions and related nitrogen sources terms are to be updated. Based on the 2018 review, this plan was updated to reflect current operating conditions and changes associated with the 3800 tpd production increase approved December 14, 2018. Plan was reviewed and updated in 2020 to reflect current practices, including changes to production blasting methods. The Plan was again updated in 2021 to reflect current practices. Plan was reviewed and updated in 2023 to reflect current practices, including additional data from 2023 and changes in methodology utilized for calculating development powder factors and nitrogen loading to mine water.
Refuse Incinerator Management Plan (Appendix 9-2-7)	ENV	February 2023 (updated)	Original to ENV August 2016; updated version via *MA & EMA* joint 2017 Annual Report submitted March 2018; current edition submitted via *MA & EMA* joint 2019 Annual Report submitted March 2020; internally via Management Plans folder. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Formal operator training on both incinerators are conducted at site by the manufacturer (Eco Waste Solutions) to relevant personnel (e.g., Waste Management Coordinators and Operators). Incinerator logs and daily routine inspections are used to monitor compliance with all relevant Plans, including but not limited to, the Refuse Incinerator Management Plan, Waste Management Plan and Air Quality Monitoring Plan. Based on 2018 review of this plan, it was determined that no update was required. The Plan was updated March 2020 to align with current permits, regulations, and on-site logistics/practices. A review of the plan later in 2020 resulted in no required changes. No changes required based on 2021 review. Version control and cover page updates based on 2023 review.
Subsidence Monitoring and Management Plan (Appendix 9-2-8)	EMLI	February 2023 (updated)	New plan. Distributed via 2020 Mine Plan and Reclamation Program Update submitted July 2020. Current edition submitted via 2022 Annual Report; internally via Management Plans folder.	Prepared as required by M-243 Condition D.13. No changes required based on 2021 review. Plan was reviewed and updated in 2023 to include update on monitoring, mining zones, and monitoring methods including version control and cover page updates.
Surface Erosion Prevention and Sediment Control Plan (Appendix 9-2-9)	EMLI	March 2015	Original May 2015 via *MA & EMA* Permits Application, as an appendix of the Construction Environmental Management Plan (CEMP)	Plan reviewed at least annually, as per M-243 Condition D.7. No changes required based on 2021 review. No changes based on 2022 review.
Ventilation Plan (Appendix 9-2-10)	EMLI	February 2022	Original prepared February 2018; 2020 update distributed via 2020 Mine Plan and Reclamation Program Update submitted July 2020 (Pretium, 2020b). Current edition submitted via *MA & EMA* joint 2021 Annual Report submitted March 2022; internally via Management Plans folder.	Prepared as required by MEMLI Senior H&S Inspector and as per relevant sections of the Health, Safety and Reclamation Code for Mines in BC (e.g., sections 3.4, 3.5, 6.33, 6.34, 6.36 and 6.37). In 2020, the Plan was updated based on changes to the mine plan. In February 2022, the Plan was updated to reflect changes to current operations. No changes based on 2022 review.

9.1.4 Other Management Plans

9.1.4.1 Discharge Management Plan

As described in Section 5.9, discharge quality from the WRTSF is managed through source control, the water treatment plant, and the sewage treatment plant. Source control includes measures from mine design and management via implementation of various management plans, including the ML/ARD Management Plan (Appendix 9-1-11), the Nitrogen Management Plan (Appendix 9-2-6), the Chromium Management Plan (Appendix 9-2-1), the OMS Manual - Water Management Plan (Appendix 9-1-18), and the WRTSF OMS Manual (Appendix 9-1-17). Mine site water management has effectively maintained WRTSF effluent quality, measured at site BJ 3.10, below discharge limits in PE-10835 or below FWAL guidelines for parameters without discharge limits.

BJ 3.10 water quality is sampled weekly, in accordance with PE-107835. Results are typically received from the analytical laboratory (ALS Environmental) within 2 weeks of the sample date. Pretium staff review BJ 3.10 water quality results when received from the analytical laboratory and if any results are above discharge limits, notifications are provided in accordance with condition 5.3 of PE-107835. A result that is above a discharge limit is investigated to determine the probable cause, and to determine and implement remedial actions, if necessary, to prevent similar non-compliance in the future.

BJ 3.10 water quality results are evaluated by Pretium staff to identify POPCs, and to determine if additional measures are required to manage POPCs, using a TRP, which is described in Section 5.9 and shown in a flowchart in Figure 5.9-1.

9.1.4.2 Construction Environmental Management Plan

There is no new surface construction proposed for the 4950 tpd Joint Application, therefore the Construction Environmental Management Plan (CEMP) has not been included. The CEMP is included as Appendix 6-G of the 2015 *MA/EMA* Permits Application.

9.1.4.3 Fugitive Dust Management Plan

Fugitive dust management is part of the existing Brucejack Mine Air Quality Management Plan, therefore a separate Fugitive Dust Management Plan has not been included in this application. The Brucejack Mine site is snow-covered for most of the year and typically wet during much of the brief summer months. Being an underground mine, the extent of surface disturbance is small; the primary potential source of fugitive dust from surfaces is roads and facility pads. During the infrequent and usually short duration periods of dry conditions at the mine site, road and pads watering is implemented.

9.2 Management Plans Reviews and Distribution

Pretium conducts reviews (internal and external) of the EMS component management plans on an ongoing basis, and updates and distributes management plans and associated review results as required/appropriate. Plan implementation inspections/audits and reviews of the plans themselves are scheduled specific to each management plan, with consideration of risk, as well as type, frequency and extent of monitoring (e.g., weekly water quality monitoring at the discharge location which verifies the effectiveness of all management plans that influence Brucejack Mine effluent quality).

Management plan implementation inspections/audits may be as frequent as weekly or semi-monthly. There are annual inspection requirements (via permit) for several of the plans, which – in addition to compliance/conformance outcomes – determine need for further evaluation and potential management plan updates. Updated component management plans are included in the Annual Reports, which are submitted to EMLI, ENV, Tsetsaut Skii km La Ha, Nisga'a Lisims Government, and Tahltan Central Government.

9.3 Expected Management Plan Update Requirements

Consistent with previous applications and reviews, any required updates to management plans for the proposed production increase will be completed post-review to incorporate changes resulting from the review.

Pretium currently anticipates that the following management plans and OMS manuals may require revisions following the 4950 tpd Joint Application review process:

- Metal Leaching / Acid Rock Drainage (ML/ARD) Management Plan – to reflect operational procedures, updated water quality predictions and revised trigger threshold levels as appropriate; the Chromium Management Plan (an appendix to the ML/ARD Management Plan) will also be updated to reflect paste backfilling procedures developed and to report the results of kinetic test work required by the plan;
- Nitrogen Management Plan – to reflect the increased mine development and production schedules as well as the associated water quality predictions, effluent permit conditions, management triggers, and water quality mitigation options;
- Subaqueous Waste Rock and Tailings Deposition Management OMS Manual – to reflect the updated waste rock and tailings deposition plan. As described previously, the production increase is not anticipated to affect waste rock dump stability or monitoring aspects of this OMS manual;
- Closure Underground Water Quality Adaptive Management Plan – to incorporate revisions to the groundwater and water quality models based on the increased mine production, and to revise discharge limits and applicable BC FWAL guidelines;
- Backfill Management Plan – to reflect higher through-put from the paste plant to ensure timely filling of stope voids; and
- Ventilation Management Plan – to reflect the addition of VR5.

The Reclamation and Closure Plan has been updated and is provided in Appendix 4-1.

While this list only includes management plans that Pretium anticipates will require revisions, as mentioned above, Pretium conducts reviews of the EMS component management plans on an ongoing basis, and updates and distributes management plans and associated review results as required/appropriate. Any plans requiring revisions that have not been listed above, will be captured and identified during regular reviews.

10. AUTHORS AND QUALIFIED PROFESSIONALS

Pretium / Newcrest personnel and consultants who provided technical input or other major contributions to this application are listed in Table 1.4-1 along with their primary roles and professional designations. Signed and sealed acknowledgements by the Qualified Professionals responsible for application technical chapters and information are provided below (presented in alphabetical order by last name) and ENV Declaration Forms are provided in Appendix 10-1. Technical reports included as appendices to the 4950 tpd Joint Application are signed and sealed by Qualified Professionals, as appropriate, within those reports.

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Krystle Batiuk, B.Sc., M.N.R.M., P.Biol.:

- 1.4.7 Concordance with EAC (except Table 1.4-4)

Krystle Batiuk P.Biol., #1820, June 16, 2023

Krystle Batiuk, B.Sc., M.N.R.M., P.Biol.
Senior Consultant, Scientist
Environmental Resources Management (ERM)

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Wade Brunham, M.Sc., R.P.Bio.:

- Section 4.2.1 paragraphs 1 and 4

R.P.Bio., #3571, June 16, 2023

Wade Brunham, M.Sc., R.P.Bio.
Partner, Scientist
Environmental Resources Management (ERM)

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were authored by Brett Dehay-Turner, M.Sc., P.Geo.:

- 3.1 Mine Plan Overview
- 3.2 Existing Development
- 3.2.1 Surface Infrastructure and Layout
- 3.2.2 Mine Site Area

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2023-06-07

Brett Dehay-Turner, M.Sc., P.Geo.
Senior Hydrogeochemist
Newcrest operations

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Dinesh Devathasan, P.Eng.:

- 3.5.1.5.1 Backfill Management Plan
- 3.5.1.5.2 Paste Backfill Distribution
- 3.5.5 Mine Access and Mine Haulage Roads
- 3.5.~~7~~ 8 Explosives Storage Facilities

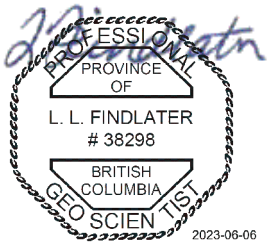
Oct 30th 2023

PROFESSIONAL PROVINCE OF D. DEVATHASAN # 18422 BRITISH COLUMBIA ENGINEER

Dinesh Devathasan, P.Eng.
Chief Mine Engineer
Pretium Resources Inc.
Brucejack Mine

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were authored by Laura-Lee Findlater, P.Geo.:

- Table 1.4-4 (rows 9-15)
- 2.6.2 Groundwater Quantity
- 2.7.2 Groundwater Quality
- 4.6.3 Groundwater
- 7.2.2 Groundwater
- Section 12.3 of Appendix 4-1: Groundwater



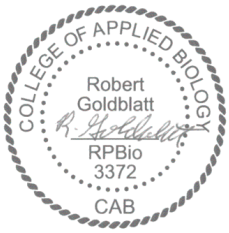
Laura-Lee Findlater, P.Geo.
Senior Hydrogeologist
Lorax Environmental Services Ltd.

Robert Goldblatt (B.Sc., RPBio) contributed to the 4950 tpd Joint MA/EMA Application for the Brucejack Mine as author of:

- Table 1.4-4 (rows 1 and 6-8)
- 5.7 Proposed Effluent Permit 107835 Amendments
- 5.8 Initial Dilution Zone
- 5.9 Discharge Management
- 6 Environmental Assessment Predictions

and reviewer of:

- 2.7.1 Surface Water Quality
- 2.8 Sediment Quality
- 2.9 Fisheries and Aquatic Resources
- 5.5 Water Quality Model
- 7.1 Environmental Monitoring Program Design
- 7.2.1 Mine Site and Discharge Water Monitoring Program Overview
- 7.2.3 Surface Water Quantity and Water Management
- 7.2.4 Surface Water Quality
- 7.2.6 Toxicity Testing
- 7.3 Aquatic Receiving Environment/Aquatic Effects Monitoring Program
- 7.4 Post-Closure Environmental Monitoring Program



Robert Goldblatt, B.Sc., RPBio.
Senior Biologist
Lorax Environmental Services Ltd.

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Jessica Lowey, M.Sc., P.Ag.:

- Section 4.2.1 paragraphs 2 and 3

P.Ag., #3292, June 16, 2023

Jessica Lowey, M.Sc., P.Ag.
Senior Consultant, Terrestrial Biodiversity Lead
Environmental Resources Management (ERM)

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were authored by Rhonda Netzel, P.Eng., PE:

- 3.5.6 Power Supply Distribution

Rhonda Netzel, P.Eng., PE
Electrical Engineer
Practical Engineering Ltd.

Permit to Practice #1000949

PROFESSIONAL
PROVINCE OF
R. L. NETZEL
19998
BRITISH COLUMBIA
ENGINEER
2023-06-07

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were authored by Xavier Pinto, M.Sc., P.Geo.:

- 2.2 Meteorology and Climate
- 2.5 Topography and Surface Drainage Features
- 2.6.1 Surface Water Quantity

Pretium Resources Inc. EGBC Permit to Practice No. 1003677

2023-06-07

Xavier Pinto, M.Sc., P.Geo.
Senior Hydrologist
Pretium Resources Inc.
Brucejack Mine

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were authored by Nick Scarcelli, P.Eng.:

- 3.2.4 Underground Mine
- 3.3 Life of Mine Plan
- 3.3.1 Mine Plan Summary
- 3.3.2 Mine Waste Materials
- 3.4 Detailed Five Year Mine Plan

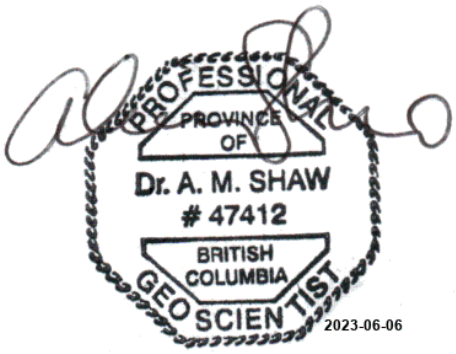
PROFESSIONAL
PROVINCE OF
N. D. SCARCELLI-CASCIOLA
48043
BRITISH COLUMBIA
ENGINEER

June 15th /2023

Nick Scarcelli, P.Eng.
Mine Engineering Manager
Pretium Resources Inc.
Brucejack Mine

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were authored by Alison Shaw, Ph.D., P.Geo.:

- Table 1.4-4 (rows 2-5)
- 2.3 Geology
- 2.4 Geochemical Characterization and Source Terms
- 7.2.5 Geochemical Source Terms and Solid Mine Wastes



Alison Shaw, Ph.D., P.Geo.
Senior Geochemist
Lorax Environmental Services Ltd.

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Woo Shin, Ph.D., P.Eng.:

- 3.5.1.9 Geotechnical Assessment and Ground Control

PROFESSIONAL
PROVINCE OF
Dr. S. W. SHIN
43539
BRITISH COLUMBIA
ENGINEER

Woo Shin, Ph.D., P.Eng.
Senior Geotechnical Engineer
Pretium Resources Inc.
Brucejack Mine

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Sylvia Van Zalingen, M.S., P.Ag.:

- Chapter 4 except 4.3.1 and 4.2.1 (paragraphs 1-4)

BRITISH COLUMBIA INSTITUTE OF AGROLOGISTS
827
Sylvia Van Zalingen
P.Ag.

Sylvia Van Zalingen
June 14, 2023

Sylvia Van Zalingen, M.S., P.Ag.
Director, Permitting
Pretium Resources Inc.
Brucejack Mine

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Michael Yakimchuk, B.A.Sc., P.Eng.:

- 3.5.2 Processing Plant (Mill Building) and Associated Facilities
- 3.5.4 Water Management Structures

Michael Yakimchuk

EGBC License #55100
Pretium Resources Inc: 1003677
15-June-2023

Michael Yakimchuk, B.A.Sc., P.Eng.
Mill Manager
Pretium Resources Inc.
Brucejack Mine

The following sections of the 4950 tpd Joint MA/EMA Permits Application for the Brucejack Mine were reviewed by Justin Straker, M.Sc., P.Ag.:

- 4.3.1 Background

June 14, 2023

Justin Straker, M.Sc., P.Ag. (#1420)
Soil Scientist, Forest Ecologist
Integral Ecology Group (IEG)

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Chapter 1 Appendices

Appendix 1-1: *Mines Act* Permit M-243 and Effluent Discharge Permit PE-107835

PROVINCE OF BRITISH COLUMBIA
MINISTRY OF ENERGY, MINES AND LOW CARBON INNOVATION

PERMIT

APPROVING MINE PLAN AND RECLAMATION PROGRAM

(Issued pursuant to section 10 of the *Mines Act* R.S.B.C. 1996, c. 293)

Permit: **M-243** Mine No: **0100270**

Issued to: **Pretium Resources Inc.**
Suite 2300, Four Bentall Centre
1055 Dunsmuir Street
PO Box 49334
Vancouver, BC
V7X 1L4

for work located at the:

Brucejack Mine

Issue Date	**Permit**
July 22, 2015	Approving Mine Plan and Reclamation Program

This permit supersedes and amends all previous versions of Permit M-243 issued pursuant to Part 10 of the Mines Act. All previously approved works systems are hereby transferred under this permit.

Amended at Victoria, British Columbia this 1st day of August in the year 2023.

J. Lowell Constable
Deputy Chief Permitting Officer
Major Mines Office

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PREAMBLE

The *Mines Act* Permit application, and applications for changes to approved works and conditions to Permit M-243, have been submitted to the Chief Permitting Officer, in accordance with Section 10(1) and/or 10(6) of the *Mines Act*, and Sections 10.1.2 and 10.1.18 of *the Health, Safety and Reclamation Code for Mines in British Columbia* (Code).

Where more than one version of information exists in the application, the most recent version must be considered the approved version unless otherwise stated or determined by the Chief Permitting Officer.

1. Approving Mine Plan and Reclamation Program (Issued July 22, 2015)

1.1 Application entitled, '*Brucejack Gold Mine: Application for Mines Act and Environmental Management Act Permits*', prepared by Pretium Resources Inc., dated May 2015.

1.2 Report entitled, '*Brucejack Gold Mine Project: Metal Leaching and Acid Rock Drainage Management Plan*', prepared by Pretium Resources Inc., dated June 30, 2015.

1.3 Memorandum entitled, '*Brucejack Project MA/EMA Permitting Phase – Responses to Information Requests from MEM & MOE – Groundwater Quality and Quantity Monitoring Plan*', prepared by BGC Engineering Inc., dated June 19, 2015.

1.4 Memorandum entitled, '*Brucejack Project MA/EMA Permitting Phase – Responses to Information Requests from MEM & MOE – Part 1 of 2*', prepared by BGC Engineering Inc., dated June 19, 2015.

1.5 Memorandum entitled, '*Brucejack Project MA/EMA Permitting Phase – Responses to Information Requests from MEM & MOE – Part 2 of 2*', prepared by BGC Engineering Inc., dated June 19, 2015.

1.6 Report entitled, '*Groundwater Monitoring and Sampling Protocol – Brucejack Mine; Revision 3*', prepared by Pretium Resources Inc., dated June 2015.

1.7 Letter entitled, '*Response to BC Ministry of Energy and Mines 'Information Requirements' and 'Clarifications' regarding underground geotechnical aspects of the Brucejack Project's Application for Mines Act and Environmental Management Act Permits*', prepared by BGC Engineering, dated June 18, 2015.

1.8 Report entitled, '*Brucejack Gold Mine Project - Invasive Plants Management Plan*', prepared by Pretium Resources Inc., dated July 2015.

1.9 Confidential Memorandum entitled, '*Brucejack Mine Project Mines Act Permit Application – Reclamation Cost Estimate*', prepared by ERM dated June 22, 2015.

1.10 Report entitled, '*Brucejack Gold Mine Project Wildlife Management Plan*', prepared by ERM dated July 2015.

2. Approving Groundwater Monitoring Plan (Issued August 26, 2015)

2.1 Report entitled, '*Brucejack Gold Mine Project – Location, purpose, timing and monitoring schedule for monitoring wells to be installed to augment the Water Management Plan per Mines Act Permit M-243 Section D Part 4(c) – REV 1*', prepared by Pretium Resources Inc., dated August 21, 2015.

3. Approving Updated Brucejack ML/ARD Management Plan (Issued September 9, 2015)

3.1 Report entitled, '*Brucejack Gold Mine Project – Metal Leaching and Acid Rock Drainage Management Plan*', prepared by Pretium Resources Inc., dated September 8, 2015.

4. Approving Temporary PAG Waste Rock Stockpile and Non-PAG Quarry (Issued March 17, 2016)

4.1 Application entitled, '*Request for Authorization of Temporary Surface PAG Waste Rock Stockpile, Mines Act Permit M-243, Brucejack Mine*', prepared by Pretium Resources Inc., dated October 18, 2015.

4.2 Application entitled, '*Application for Modification of Km 72 NPAG Quarry, Permit M-243, Brucejack Mine*', prepared by Pretium Resources Inc., dated November 3, 2015.

5. Approving Changes for Disturbance Area and Construction Water Treatment Plant (Issued August 4, 2016)

5.1 Application entitled, '*Proposed Changes to Approved Disturbance Area, Mines Act Permit M-243, Brucejack Gold Mine – Amendment Application #2*', prepared by Pretium Resources Inc., dated April 11, 2016.

5.2 Application entitled, '*Application for Approval of Mine Water Treatment Plant Process Change for Nitrite Treatment*', prepared by Pretium Resources Inc., dated April 25, 2016.

5.3 Report entitled, '*Brucejack Gold Mine 2016 Freshet Water Management Plan*', prepared by Pretium Resources Inc., dated March 2016.

6. Approving PAG Waste Rock Exposure Extension, Sludge Deposition with Tailings In Brucejack Lake and Chromium Management Plan (Issued April 3, 2017)

6.1 Report entitled, '*Brucejack Mine: Proposed Extension for Waste Rock Storage on Surface*', prepared by Pretium Resources Inc., dated November 10, 2016.

6.2 Report entitled, '*Brucejack Gold Mine: Assessment of Long-Term Sludge Stability for In-Lake and Underground Deposition*', prepared by Pretium Resources Inc., dated December 19, 2016.

6.3 Report entitled, '*Chromium Management Plan*', prepared by Pretium Resources Inc., dated February 23, 2017.

6.4 Report entitled, '*Metal Leaching and Acid Rock Drainage Management Plan*', prepared by Pretium Resources Inc., dated March 2017.

6.5 Report entitled, '*Operation, Maintenance and Surveillance Manual: Brucejack Gold Mine Subaqueous Waste Rock and Tailings Deposition; VERSION 04*', prepared by Pretium Resources Inc., dated March 2017.

7. Approving Mine Plan and Reclamation Program for Increased Production Rate and Waste Management (Issued December 14, 2018)

7.1 Application entitled, '*3800 tpd Amendment Application for Permits M-243 and PE-107835*', prepared by Pretium Resources Inc., dated December 2017.

7.2 Report entitled, '*Brucejack Gold Mine: Updated Subaqueous Waste Rock Dump Design*', prepared by SRK Consulting, dated October 2018.

7.3 Letter entitled, '*Brucejack Gold Mine, Mine No. 0100270 MA Permit M-243 Section D.1 (d)*', prepared by Pretium Resources Inc., dated March 8, 2018.

8. Approving West Zone Ramp, Additional Stope Development, and Underground Exploration (Issued December 18, 2020)

8.1 Application entitled, '*Mines Act Permit M-243 Amendment Application: Permit Boundary Amendment*', prepared by ERM Worldwide Group Ltd., dated August 2020.

8.2 Report entitled, '*OMS Manual - Water Management Plan*' prepared by SRK Consulting Inc., dated March 2020.

8.3 Report entitled, '*Brucejack Gold Mine: 2020 Groundwater Model Review and Update*', prepared by Lorax Environmental, dated July 20, 2020.

8.4 Report entitled, '*Brucejack Gold Mine Ground Control Management Plan – Version 7*', prepared by Pretium Resources Inc., dated October 2020.

8.5 Report entitled, '*Production Ventilation Plan Brucejack Gold Mine*', prepared by Pretium Resources Inc., dated July 10, 2020.

9. Approving Permitted Mine Area (PMA) Expansion for Future Access Road Realignment km 72 Ramp (Issued November 14, 2022)

9.1 Application entitled, '*Permit M-243 Brucejack Mine – Amendment Application to Increase Permitted Mine Area for Future Brucejack Access Road km 72 Ramp Realignments*', prepared by Pretium Resources Inc., dated December 2, 2021.

9.2 Document entitled, '*Geohazards Management Plan Revision 1*', prepared by Pretium Resources Inc., dated December 2016.

9.3 Report entitled, '*Brucejack Access Road 72 km Glacier Ramp Design Basis*', prepared by Onsite Engineering Ltd., dated August 19, 2022.

10. Approving Permitted Mine Area Change (Issued August 1, 2023)

10.1 Application entitled, '*M-243 PMA Expansion Application – Amendment Application #9 Area B'*, prepared by Pretium Resources Ltd., dated July 4, 2023.

This permit contains the requirements of the Ministry of Energy, Mines and Low Carbon Innovation (EMLI). It also is compatible, to the extent possible, with the requirements of other provincial ministries. However, nothing in this permit limits the authority of other provincial ministries to set other conditions, or to act independently, under their respective permits and legislation.

The mine is located within the consultative territory of Tsetsaut /Skii-km Lax Ha and portions of the mine permitted area are located in the Nass Area as defined in the Nisga'a Final Agreement. Tsetsaut/ Skii-km Lax Ha, Nisga'a Lisims Government and Tahltan Central Government have been consulted with respect to this permit and have expressed their interests regarding potential concerns to their asserted or established rights.

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CONDITIONS

The Chief Permitting Officer hereby approves the Mine Plan and Reclamation Program as submitted in the applications, subject to compliance with the following conditions:

A. General

1. Compliance with *Mines Act* and Code

The Permittee must ensure all work is in compliance with all sections and parts of the *Mines Act* and the Health, Safety and Reclamation Code for Mines in B.C. (Code), and the owner, agent or manager (Permittee) must obey all orders issued by the Chief Inspector or their delegate.

2. Departure from Approval

The Permittee must notify the Chief Inspector of Mines (Chief Inspector) in writing of any intention to depart from the approved Application(s) and this *Mines Act* permit (M-243) to any substantial degree, and must not proceed to implement the proposed changes without the written authorization of the Chief Inspector.

3. Permit Approval

(a) The Permittee is authorized under this permit (M-243) for the following activities:

(i) Development, including surface disturbance and works and management buffers associated with 19 km of the Transmission Line extending southward from the Mine Site, within the area encompassing approximately 702 Ha as outlined in Figure 1a and 1b (Permitted Mine Area), which includes management buffers around the approved disturbance; and

(ii) Ore production rate must not exceed an average annual 1,387,000 tonnes on a calendar year basis.

4. Permit

This Permit is not transferable or assignable.

5. Maintenance of Mine

The Permittee must maintain mine facilities and infrastructure in a manner to meet design objectives and environmental protection and reclamation requirements.

6. Reports to be signed by a Qualified Professional

Unless otherwise specified in permit conditions, all reports required to be submitted under this permit the Permittee must ensure are reviewed and signed by a Qualified Professional with applicable experience and registered in the province of British Columbia.

7. Responsibility to Reclaim

Any outstanding reclamation associated with Reclamation Permit MX-1-842 that exists within the permitted mine area for the Brucejack Gold Mine defined in Figure 1a and Figure 1b is the responsibility of the Permittee under the terms and conditions of this permit.

8. First Nations Reporting Requirements

Unless otherwise requested, the Permittee must provide to the Tsetsaut/Skii-km Lax Ha, Nisga'a Lisims Government and Tahltan Central Council Government all material reports and plans relevant to this permit, including annual monitoring reports and material changes to the approved Reclamation and Closure Plan.

9. Compliance Status Report

The Permittee must track compliance status of all permit conditions, inspection orders or advisories in a form acceptable to the Chief Inspector. The Permittee must maintain a tracking table on site, and ensure it is revised when compliance changes or as required by the Chief Inspector. The Permittee must ensure that the tracking table is available at the mine site at all times and to a Mines Inspector upon request. An annual Compliance Status report must be submitted to the Chief Inspector by March 31st and must include a summary of outstanding non-compliance issues and an action plan, to the satisfaction of the Chief Inspector, for meeting compliance.

B. Health and Safety

1. Mine Emergency Response Plan (MERP)

(a) The Permittee must update the Mine Emergency Response Plan (MERP) The Permittee must keep the MERP up to date and file updates with the Chief Inspector, and make the updated MERP available at the mine site at all times.

(b) The Permittee must ensure that mine site employees and contractors are knowledgeable and accountable for fulfilling the actions of the MERP.

C. Geotechnical

1. General

(a) The Permittee must ensure that all geotechnical/designs, specifications, work plans, monitoring requirements and reports required to be prepared under Section (C) are signed by a Professional Engineer and are submitted to the Chief Inspector.

(b) The Permittee must ensure that all geotechnical/designs, specifications, work plans, monitoring requirements and reports required to be prepared under section (C) are maintained on site and made available to any Inspector of Mines upon request.

(c) The Permittee must ensure all construction is completed under the supervision of a Professional Engineer and that sufficient field reviews have been conducted to ensure that all construction and facilities are built in conformance with the design, accepted engineering practices and the Code.

(d) The Permittee must ensure that recommendations by a Professional Engineer relating to health and safety, geotechnical stability or environmental protection are followed unless a suitable alternative course of action is approved in writing by a Professional Engineer.

(e) The Permittee must submit an Advice of Geotechnical Incident form to the Chief Inspector for any geotechnical incident that is classified as a dangerous occurrence or any other incident as described in the current EMLI Advice of Geotechnical Incident form.

2. Underground Mine

(a) The Permittee must maintain an up-to-date mine design that includes computer models, drawings, calculations, specifications, and written descriptions of:

(i) The geometry of all existing and proposed excavations,
(ii) The geologic, hydrogeologic and geotechnical conditions affecting the mine, and
(iii) Excavation design and ground support design that considers stress, structure and rockmass conditions.

(b) The mine design must be periodically, at a minimum of annually, updated to reflect site experience and the actual geological, hydrological and geotechnical conditions encountered.

(c) The Permittee must ensure the dimensions of all excavations and pillars are within nominal tolerances per the recommendation of a Professional Engineer.

(d) Ground Control Management Plan

The Permittee must implement the Ground Control Management Plan (GCMP). The GCMP must be reviewed annually by a Professional Engineer and updated as required. The Permittee must submit the updated GCMP to the Chief Inspector within 60 days of being issued, and it must include (but is not limited to) the following components:

(i) Ground control program roles, responsibilities, accountabilities, implementation, records and communications,
(ii) Design basis information and assumptions used to develop the mine design and the ground control program,
(iii) Geological model for the mine,
(iv) Hydrogeological model for the mine,
(v) Geotechnical (rock mechanics) model for the mine including stress, structure and rockmass,
(vi) Historical experience,
(vii) Mine design including mining methods, and excavation dimensions, pillar dimensions, stope sequencing, etc.; and criteria used in dimensioning of excavations and pillars,
(viii) Water control measures including specific precautions to be taken where bodies of water, water bearing structures, overburden, tailings etc., may inundate the mine workings,
(ix) Ground support systems and materials to be employed,
(x) Criteria used in selection, dimensioning, spacing and extent of ground support,
(xi) Standards and procedures to ensure worker safety including,
(xii) Minimum ground support standards to be employed at Mine,
(xiii) Blasting methods,
(xiv) Employee procedures and training,
(xv) Monitoring program to verify acceptable performance, detect early signs of instability, and confirm design basis information and assumptions,
(xvi) QA/QC program,
(xvii) Risk management, and
(xviii) Ground Control Management Plan reviews, audits, and scheduled update program.

(e) The Permittee must install ground support in new and rehabilitated excavations in accordance with the recommendations of a Professional Engineer.

(f) Mining-Backfill Standard Operating Procedure (SOP)

The Permittee must implement and maintain a Mining-Backfill Standard Operating Procedure (SOP). The Permittee must ensure the Mining Backfill SOP be reviewed annually by a Professional Engineer and updated as required. The Mining Backfill SOP must consider (but is not limited to) the following components:

(i) Barricade and berm design for anticipated loading conditions;
(ii) Procedures for determining suitable barricade location;
(iii) QA/QC procedures for constructed barricades;
(iv) Design rationale for minimum strength requirements for operating beside and underneath backfill at the design dimensions;
(v) Prescribed fill rates within stopes;
(vi) Paste line flushing procedures;
(vii) Procedures to ensure tight backfill has occurred,
(viii) Safe filling procedures that include safe worker setback distance from active paste pours, and
(ix) QA/QC backfill testing requirements.

(g) The Permittee must ensure that no placement of paste backfill into a mined void proceeds unless the fill retention barricades constructed for the placed paste backfill are inspected and approved by a Professional Engineer.

(h) Monitoring

(i) The Permittee must maintain a geotechnical model of the underground openings that record the stress conditions, structure and rock mass in all headings and stopes.

(ii) The Permittee must conduct performance testing on installed ground support to ensure performance is in accordance with design values. The Permittee must ensure quantifiable performance objectives provide triggers for when rehabilitation of ground support is required.

(i) The Permittee must maintain a Ground Control Log Book that must be available at any time at the mine site to any Mines Inspector and includes, but is not limited to, the following information:

(i) Records of damaged, loaded, or failed support;
(ii) Areas of ground support non-conformance to design;
(iii) Records of working ground such as cracks, noise, movement, or other signs of instability;
(iv) Records of uncontrolled falls of ground;

(v) Unusual or unexpected geological, hydrogeological and geotechnical conditions;

(vi) Identification of ground control concerns, coupled with a plan for mitigation/remediation and prioritization; and

(vii) A record of the implementation of the mitigation/remediation to address the concern in C.2(i)(vi).

(j) The Permittee must monitor the strength of the paste backfill through laboratory or in-situ testing methods and ensure that no mining occur in areas below or adjacent to where low strength fill is encountered.

(k) The Permittee must ensure that the Ground Control Log Book is read and signed each day by the shift boss and the Mine Manager, or a mine engineer designated by the Mine Manager.

(l) The Permittee must ensure that in the event of mining induced seismicity, all mining must immediately cease until an observation, management and surveillance plan specific to mining in a mining induced seismically active area is submitted to the Chief Inspector and approved. The plan must provide measures to monitor micro seismicity and mitigate rock burst potential.

(m) Reporting

(i) The Permittee must ensure an annual review of the underground workings is undertaken by a Professional Engineer, and observations and recommendations made during the review are summarized in a report and submitted to the Chief Inspector by March 31 of the year following the inspection.

(ii) Starting in 2018, and every four years thereafter, or at the discretion of the Chief Inspector, the Permittee must ensure third party audits of the Ground Control Management Plan be conducted by a Professional Engineer and that they include a review of the instrumentation/monitoring program, QA/QC testing, stress management and pillar performance, and performance of installed ground support.

(iii) Starting in 2021, and every four years thereafter, or at the discretion of the Chief Inspector, the Permittee must ensure third party audits of the paste backfill operations be conducted by a Professional Engineer and that they include plant operations, paste reticulation system and paste placement procedures.

3. Subaqueous Waste Rock and Tailings Storage Facility (WRTSF)

(a) Operations

(i) The Permittee must implement the Subaqueous Waste Rock and Tailings Storage Facility Operation, Maintenance, and Surveillance Manual (OMS Manual; Document 6.5). The Permittee must ensure the OMS manual is reviewed annually and updated, as needed, to reflect changes in status as the facility develops.

(ii) The Permittee must ensure all employees and contractors involved in the operation of the WRTSF are trained in the implementation of the OMS Manual and that records of the training be maintained on site.

(iii) The Permittee must ensure that all subaqueous placement of tailings is to be performed under the guidance of a Professional Engineer.

(iv) The Permittee must assign a qualified person to monitor dumping and to provide a daily work schedule that shows the locations and quantities of waste rock to dump. No dumping of material must occur unless approved by the qualified person.

(v) The Permittee must ensure that no weak, cohesive materials or snow be dumped within the ultimate design limits of the subaqueous waste rock dump area, with the exception that high fines (cohesive) materials may be placed under the direction of the qualified person in areas approved by the Engineer of Record. The Permittee must ensure the locations, total volume and percentage (with respect to total placed) material of the high fines content is documented and included in the semi-annual and annual reports.

(vi) The Permittee must ensure any weak, cohesive materials or snow that is dumped outside the ultimate design limits of the WRTSF, be documented (locations and quantities) and included in the applicable semi-annual and annual reports.

(vii) The Permittee may, following standard operating procedures set in the OMS manual, and as outlined in Document 7.2, use a conveyor, excavator, or remotely operated vehicle to place waste rock into the ponded portion of the WRTSF.

(viii) The Permittee must develop an operational setback and delineation of high risk zone, including the following:

(a) The operational setback distance at the crest is defined with a Factor of Safety FoS > 1.1 for short term analysis of deep seated failures and areas with less than a FoS of 1.1 are identifiable as a high-risk zone;
(b) The zone must be clearly marked at all times;
(c) No personnel must work alone within this zone at any time;
(d) A clear, unobstructed escape route for equipment working within this zone must be maintained;
(e) Personal protective equipment, rescue equipment, communication equipment must be present at the location of work for all personnel working within the zone;
(f) At minimum a 10m operational setback distance must be maintained; and
(g) Prior to work occurring within the high risk zone, the area must be inspected and deemed safe by a Qualified Professional following all recommendations of the Engineer of Record.

(ix) The Permittee must implement an earthquake monitoring system with an alarm to trigger evacuation of personnel from the dump in the event of an earthquake.

(b) Monitoring and Reporting

(i) The Permittee must monitor dump crest movement and implement a failure alert procedure on all active waste dumps and closed high consequence dumps.

(ii) The Permittee must install instrumentation to monitor the rate of settlement of the subaqueous waste rock dump. Reports of the settlement rates are to be made available to the Mine Inspector upon request.

(iii) The Permittee must install a water level gauge or other suitable pond level monitoring system to monitor Brucejack Lake water level.

(c) Annual Construction Progress Report

The Permittee must submit an annual construction progress report to the Chief Inspector by March 31 of that year, on the construction and monitoring of the WRTSF. The Permittee must ensure the report includes:

(i) A review of construction documentation,
(ii) Rock deposition advancement,
(iii) A discussion detailing any potential amendments to original design based on field observations,
(iv) Recommendations for the placement of material in all weather conditions, and
(v) Confirmation the report was reviewed by the Engineer of Record.

(d) Annual Review of WRTSF

(i) The Permittee must ensure that an annual review of the WRTSF is conducted by a Professional Engineer and a report submitted to the Chief Inspector until 2021.

(ii) Starting in 2022, and every five (5) years thereafter, the Permittee must ensure that a review of the WRTSF is conducted by a Professional Engineer and a report submitted to the Chief Inspector.

4. Surface Water Ponds, Ditches and Diversion

(a) The Permittee must not commence construction of surface water ponds and ditches that carry mine-influenced water or diversion channels until issued for construction (IFC) drawings, signed by a Professional Engineer, are submitted to the Chief Inspector. This condition does not apply to temporary diversion channels required to facilitate construction.

(b) The Permittee must ensure that water surface ponds, ditches and diversion channels are designed to convey the design flood without overtopping or side slope failure, and with adequate armour or lining to prevent significant erosion.

(c) Ponds must be designed with a minimum 0.5 m freeboard under the design flood. The design flood must be chosen with consideration of the consequence of failure, and duty life of the ponds, but must be no less than the 1:200 year peak flow event.

(d) The Permittee must submit an 'As-Built' report to the Chief Inspector for all surface water ponds, ditches and diversion channels. The Permittee must ensure that the report certifies that each facility has been constructed in accordance with the design and the applicable guidelines.

(e) The Permittee must implement the Operations Maintenance and Surveillance Manual for the Contact Water Pond. The Permittee must ensure the OMS manual is reviewed annually and updated, as needed, to reflect changes in status as the facility develops.

(f) The Permittee must include all surface water ponds, ditches and diversion channels in an annual inspection by a Professional Engineer of water management facilities on the mine site. The annual inspections must be documented and inspection reports must be maintained onsite and provided to any inspector upon request.

5. Temporary Soil, Overburden, Rock, and Organic Material Stockpiles

The Permittee must ensure that the temporary soil, overburden, rock, and organic materials stockpiles are designed by a Professional Engineer and builtin accordance with the designs.

6. Borrow and Quarry Excavations

The Permittee must ensure that borrow and quarry excavations are designed by a Professional Engineer and developed in accordance with the designs.

7. Mine Site Roads

(a) The Permittee must ensure that all new mine roads are constructed in accordance with the designs and recommendations prepared by a Qualified Professional.

(b) The Permittee must ensure that all new roads with cut or fill slopes exceeding 6 m in height or located on terrain that can be classified as moderate (or higher) likelihood of initiating a landslide are designed by a Professional Engineer.

(c) The Permittee must ensure that all roads are reviewed at least every five years by a Qualified Professional. The Permittee must document the review and any recommendations and maintain a copy on site and provide it to an Inspector of Mines upon request.

(d) The Permittee must ensure that all roads are operated, maintained, and inspected in accordance with acceptable industry standards and guidelines.

8. Mine Site, Plant, Shop, and Other Infrastructure Foundations

(a) The Permittee must ensure that all building foundation designs address bearing capacity, potential settlement, and any necessary foundation preparation or treatment.

(b) The Permittee must ensure an inspection of the prepared excavation prior to the placement of permanent foundations is completed.

9. Geohazards Assessment

(a) The Permittee must develop and implement a Geohazards Management Plan. The Permittee must ensure that the plan is developed by a Qualified Professional. The Permittee must manage the geohazards associated with surface works in accordance with the plan. The plan must include mapping, an assessment of potential geohazards, and identification of risks prior to construction of the associated surface works.

(b) The Permittee must ensure a Qualified Professional conducts an annual review of the geohazard management practices being implemented by mine personnel at the mine site. The Permittee must provide the results of this inspection in an annual report to the Chief Inspector by March 31 of the year following the inspection.

D. Protection of Land and Watercourses

1. Environmental Management System

(a) The Permittee must maintain and implement an Environmental Management System (EMS) consisting of Environmental Management Plans (EMPs) and Standard Operating Procedures (SOPs). The EMS must reference relevant policies and establish proactive procedures to provide direction for effective operational management and monitoring on-site.

(b) The Permittee must audit the EMS annually, revise it as soon and as often as required, and make it available to a Mines Inspector at the mine site at all times. The findings of the annual audit of the EMS must be reported in the Annual Reclamation Report.

(c) The Permittee must ensure that mine site employees and contractors are knowledgeable and accountable to act consistently with the requirements of the EMPs and SOPs that form the EMS.

2. Environmental Manager

(a) The Permittee must ensure that an Environmental Manager is assigned.

(b) The Environmental Manager must have the authority to implement remedial actions as may be necessary to ensure maintenance of environmental standards and permit requirements. If suspension of construction or operations occurs due to environmental concerns, the Permittee or Environmental Manager must immediately notify the Chief Inspector.

3. Metal Leaching (ML) and Acid Rock Drainage (ARD)

(a) General

(i) The Permittee must ensure all materials with the potential to generate ML/ARD are placed in a manner that minimizes the production and release of metals and contaminants to levels that assure protection of environmental quality.

(ii) Unless otherwise approved, The Permittee must ensure all plans for the prediction, and if necessary, the prevention, mitigation and management of metal leaching and acid rock drainage are prepared in accordance with the *Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia* (1998).

(iii) The Permittee must ensure no changes are made to the criteria for ML/ARD definition, waste handling procedures, mitigation strategies, or materials monitoring program without the approval of the Chief Inspector.

(b) Definition of Potentially ARD Generating (PAG) and Metal Leaching (ML) Materials

All waste rock, quarry rock, borrow materials and tailings must be considered PAG if NP/AP is < 2, where AP is calculated from total sulphur and NP is calculated from total carbon.

(c) Mine Materials Handling and ML/ARD Mitigation

(i) The Permittee must ensure only non-PAG materials are used for construction purposes.

(ii) Prior to their use, the Permittee must ensure representative samples of quarry and borrow materials used for construction are tested and characterized in accordance with the ML/ARD Management Plan for their potential to generate ML/ARD.

(iii) The Permittee must ensure all waste rock generated from surface or underground development is backfilled in the underground workings, below the ultimate flood limit of the workings, or deposited in Brucejack Lake.

(iv) The Permittee must ensure all PAG waste rock deposited in Brucejack Lake is covered with a minimum 1 m water cover.

(v) The Permittee must ensure waste rock stored temporarily on surface, within the mine contact water collection system, for no longer than 2 years. Permanent disposal of waste rock on surface is not permitted.

(vi) The Permittee must ensure all tailings are either backfilled underground or deposited in Brucejack Lake.

(vii) The Permittee must ensure sludge generated from the Operations Water Treatment Plant is comingled with tailings and deposited in Brucejack Lake at a mixing ratio not to exceed 2% sludge by dry weight.

(viii) Underground co-disposal of Operations Water Treatment Plant sludge with cemented paste tailings is not permitted until such time as the Permittee can demonstrate the long term stability of these materials and an updated ML/ARD Management Plan and Subaqueous Waste Rock and Tailings Deposition OMS Manual is provided to the Chief Inspector for review and approval.

(ix) The placement of sludge from the Operations Water Treatment Plant in the underground workings is prohibited until such time the Permittee can demonstrate the long-term geochemical stability is demonstrated and an updated ML/ARD Management Plan and Subaqueous Waste Rock and Tailings Deposition OMS are provided to the Chief Inspector for review and approval.

(d) ML/ARD Operational Monitoring

(i) The ML/ARD Management Plan is approved and must be implemented. The Permittee must ensure no changes are made to the plan without the approval of the Chief Inspector.

(ii) The Permittee must ensure all personnel involved in waste rock and tailings generation and handling are trained and kept up to date on the content and implementation requirements of the ML/ARD Management Plan and the Subaqueous Waste Rock and Tailings Deposition OMS.

(iii) The Permittee must maintain an inventory of waste rock, quarry rock, borrow materials, exposed rock units in the underground workings, tailings products and water treatment plant sludge generated, including (as appropriate) information on source, composition, quantity of material, disposal location, elevation (meters), depth of water cover, and date of placement. This inventory must be kept on site and be made available to any Mines Inspector upon request.

(iv) Concurrent with mine development and operations, the Permittee must characterize excavated materials produced and mine surfaces exposed, including waste rock, quarry rock, borrow materials, exposed rock units in the underground, tailings products and generated water treatment plant sludge to determine ML/ARD generating potential, validate pre-mining predictions, guide material management decisions, confirm effectiveness of waste handling procedures, and determine the need for mitigation and contingency measures that ensure environmental protection.

(v) The Permittee must maintain a record of waste rock placed within the platform and active face areas of the waste rock dump. The record must include information on the type, amount and exposure time (in months) of waste rock prior to submergence in Brucejack Lake. The record must be kept on site and be made available to any Mines Inspector upon request. The record must be reported in the Annual Reclamation Report.

(e) Analytical Requirements

(i) The Permittee must present analytical QA/QC results in the Annual Reclamation Report.

(f) ML/ARD Reporting

(i) The Permittee must report results of the ML/ARD analytical testwork (including raw data, sample descriptions, analytical QA/QC, and materials inventory) and underground geologic mapping in the Annual Reclamation Report. Any significant changes or trends must be discussed, and implications for materials handling must be identified.

4. Water Management and Monitoring

(a) Water Management

(i) The Permittee must obtain any necessary permits and licenses for water diversion and discharge.

(ii) The Permittee must ensure water from the underground workings is collected and directed to water treatment.

(iii) The Permittee must ensure that water from the Contact Water Pond is collected and either directed to water treatment or to Brucejack Lake through the direct discharge line, as per the Contact Water Pond OMS manual required as a condition of this permit.

(b) Groundwater

(i) The Permittee must ensure the Operation, Maintenance and Surveillance Manual: Mine Site Surface Water Management Facilities is kept up to date, reviewed annually, revised as soon and as often as required and is made available to an Inspector at the mine site at all times. Updated versions of the manual must be submitted to the Chief Inspector.

(ii) The Permittee must ensure updates to the post-closure groundwater elevation predictions be provided with each Five Year Mine Plan Update, commencing July 31, 2020. Any changes to predicted post-closure groundwater levels must be used to revise the ML/ARD Management Plan and the Water Management Plan, as required.

(c) Chromium Management Plan

(i) The Permittee must implement the Chromium Management Plan (Document 6.3).

(ii) The Permittee ensure the Chromium Management Plan is kept up to date, reviewed annually, revised as soon and as often as required and made available to an Inspector at the mine site at all times. The findings of any investigations undertaken and any significant changes to the plan must be reported in the Annual Reclamation Report.

(iii) The Permittee must ensure that mine site employees and contractors are knowledgeable and accountable to act consistently with the requirements of the Chromium Management Plan.

(d) Monitoring and Reporting

(i) The Permittee must monitor and track changes to mine site surface water and groundwater quality and quantity from the underground workings (including pumping rate of water into and out of the underground workings), groundwater monitoring wells, Contact Water Pond, and tailings supernatant. The Permittee must ensure the program is capable of providing early warning about the onset of ARD or an increase in contaminant loading and provide refined predictions regarding the post-closure groundwater elevation.

(ii) The Permittee must ensure detection limits are sufficient to compare to provincial water quality guidelines and permit requirements established by the British Columbia Ministry of Environment.

(iii) The Permittee must ensure an effective QA/QC program for mine site contact water is implemented.

(iv) The Permittee must ensure monitoring results of water quality and water quantity, including interpretation of the results, are kept up to date in a dedicated database available for review by a Mines Inspector and reported in the Annual Reclamation Report.

(v) The Permittee must ensure that the Annual Reclamation Report includes a table comparing relevant monitoring and testwork data to source term concentrations used in water quality predictions. The Permittee must ensure implications of the results for source term refinement, water quality mitigation and adaptive management is discussed in the report.

(e) Water Quality Predictions

During operations, the Permittee must track water quality and flow monitoring data to enable validation and refinement of water quality predictions based on site-specific monitoring information. The Permittee must ensure water quality model updates is provided in every 5 Year Mine Plan update thereafter, or more frequently as necessary to inform mine planning and mitigation design and engineering.

5. Closure Underground Water Quality Adaptive Management Plan

The Permittee must implement an appropriate monitoring program with water quality triggers and management actions that will be used to ensure the groundwater discharging from the underground workings during post-closure is protective of receiving environment water quality.

6. Water Treatment

(a) Operations

(i) The Permittee must ensure the Operations Water Treatment Plant Operations and Maintenance Manual (OWTP OMS) is kept up to date, reviewed annually, revised as soon and as often as required and be made available to an Inspector at the mine site at all times. The Permittee must submit updated versions of the OWTP OMS to the Chief Inspector.

(ii) The Permittee must ensure no substantive changes are made to the operations phase water treatment processes without the approval of the Chief Inspector.

(b) Monitoring and Reporting

(i) The Permittee must monitor, track and report in the Annual Reclamation Report on the performance of the Water Treatment Facility. The Permittee must report information on system performance, volume and quality of contact water influent and effluent of the water treatment system, volumes of reagents used, volumes and characteristics of waste generated, and information on any process changes.

(ii) The Permittee must ensure the Annual Reclamation Report includes a breakdown of all annual costs associated with operation of the Operations Water Treatment Facility, including labour, electricity, waste handling and storage and all delivered costs for diesel, reagents, etc.

7. Sediment and Erosion Control

(a) The Permittee must ensure that the Erosion and Sediment Control Management Plan is implemented. This plan must be reviewed at least annually and updated to reflect results of effectiveness monitoring and potential contingency requirements, changing site conditions, and site-specific freshet-related considerations. The Permittee must ensure substantive changes are provided to the Chief Inspector prior to implementation, and annual updates are reported in the Annual Reclamation Report.

(b) The Permittee must ensure that erosion and sediment control prescriptions, and associated effectiveness monitoring programs, are developed based on site-specific assessments of risk and consequence prior to construction of individual mine and water management components.

(c) The Permittee must ensure that unauthorized release of sediment-laden water released from the authorized water management system must be characterized and reported to the Chief Inspector, with recommendations for improvement to the water management system if required.

(d) The Permittee must initiate progressive reclamation where practicable to control erosion around the mine area.

8. Soil Salvage and Storage

(a) The Permittee must salvage and stockpile topsoil, overburden, and organic material to the greatest extent possible for use in reclamation.

(b) The Permittee must ensure a Qualified Professional monitor and direct sampling, soil salvage, stockpiling activities on-site.

(c) The Permittee must ensure an inventory of salvaged and stockpiled soil, including the locations, origins, and quantities of material, is documented and reported in the Annual Reclamation Report.

(d) The Permittee must protect stockpiles from erosion, degradation, and contamination using appropriate best management practices, and monitor them as appropriate to ensure effective controls are maintained. The Permittee must ensure stockpile protection activities and monitoring results are documented and reported in the Annual Reclamation Report.

(e) The Permittee must ensure soil stockpiles are located in areas that minimize handling requirements during site preparation and mine operations, provide adequate accessibility for reclamation activities, and optimize sediment control options.

(f) The Permittee must ensure soil stockpiles are clearly marked to ensure that they are protected during construction and mine operations.

(g) The Permittee must ensure stockpiled soil suitable for use in reclamation is not used as fill.

9. Vegetation Management

(a) The Permittee must ensure that the Vegetation Management Plan is implemented.

(b) The Permittee must limit disturbance to vegetation to those areas approved by this permit (Figure 1a and Figure 1b) and ensure that disturbance limits are clearly communicated and adhered to on-site. Where only minimal vegetation removal is proposed, the Permittee must ensure efforts are made to limit ground disturbance to minimize soil erosion and maximize the regeneration potential of the site.

(c) The Permittee must ensure that the Invasive Plants Management Plan, dated July 2015 is implemented.

(d) The Permittee must prevent the establishment of invasive plants on-site, manage and control weeds that do establish on the site, and take reasonable efforts to ensure that weeds do not move from the site to adjacent areas. The Permittee must ensure that seed used on-site is certified weed free and consider using non-toxic means for weed control.

(e) The Permittee must salvage and stockpile woody debris, including stumps, roots, limbs and rotting logs, that is generated during clearing and grubbing operations. The Permittee must keep an inventory of salvaged and stockpiled woody debris, including the locations, origins, and quantities of material, and report in the Annual Reclamation Report.

(f) The Permittee must avoid chipping or burning of woody debris suitable for use in reclamation.

10. Wildlife Protection

(a) The Permittee will implement the Wildlife Management Plan (REF 1.10), to prevent and mitigate impacts to wildlife, with the monitoring results provided in the Annual Reclamation Report.

(b) The Permittee must ensure that strategies, designed by a Qualified Professional with suitable experience, to prevent human-wildlife interactions are included in the Waste Management Plan and implemented.

(c) The Permittee must ensure that where exclusion fencing is installed that it is maintained in effective working order at all times that people are present on site.

(d) The Permittee must conduct monitoring and/or track incidental observations of bats in the underground throughout mine life. If bats are observed to be present the Permittee must:

(i) Develop, and submit to the Chief Inspector within 3 months of bat observations, an operational management plan to minimize risk to bats, particularly with respect to direct mortality and spread of white nose syndrome and

(ii) Conduct a bat survey and take all reasonable efforts to move bats out of the underground, prior to securing the underground openings.

(e) The Permittee must avoid wildlife sensitive periods and/or adhere to timing windows for construction activities. Where this is not practicable, the Permittee must adhere to mitigation measures outlined in the Wildlife Management Plan.

(f) Pursuant to Part 1.6.9 of the Code, the Mine Manager must incorporate in the mine safety program a no hunting and shooting policy, for the mine permit area (Figure 1a and Figure 1b).

(g) The Permittee must implement a policy of no fishing and hunting for all employees and contractors while on company business or while commuting to and from the mine on the Brucejack Access Road west of Highway 37.

11. Archaeological Resources

If archaeological materials or cultural features are encountered during construction or related activities, the Permittee must implement procedures as set out in the Heritage Management Plan.

12. Ongoing Reclamation Research

(a) The Permittee must by July 31, 2020, submit to the Chief Inspector a Reclamation Research Program that includes details for achieving the research requirements outlined in this permit with a schedule for implementation and description for how results will be utilized and reported.

(b) The Permittee must ensure a summary of all research being conducted under this section is provided in the Annual Reclamation Report and a detailed summary of results is provided in the Five Year Mine Plan and Reclamation Program updates.

(c) The Permittee must ensure research is conducted to explore opportunities for enhancement of both habitat and surface drainage control on the Mine Site, particularly with respect to design of the surface topography predicted to remain once infrastructure is decommissioned at closure. The scope of this research must include evaluation of options to optimize remaining concrete foundations.

(d) The Permittee must ensure research is conducted to evaluate opportunities for amending soil that is to be used for reclamation purposes to enhance the soil suitability, if necessary, based on soil analyses.

(e) The Permittee must ensure testwork is conducted to determine soil replacement depths and locations required to achieve the designed surface topography and end land use objectives.

(f) The Permittee must ensure research is conducted to determine the viability of revegetation with native plant species, including culturally important species.

(g) The Permittee must ensure research is conducted to assess decompaction methodologies to ensure that the severity of compaction that exists prior to commencing reclamation activities is effectively addressed in a manner intended to achieve end land use objectives and erosion control. The scope of this research must include mine access roads and mine site pads.

(h) The Permittee must develop a reclamation success monitoring program designed to evaluate the success of revegetation, landscape design, and erosion control that specifies sampling parameters and performance criteria.

(i) The Permittee must develop a monitoring program for evaluating metal uptake in exposed terrestrial and aquatic ecosystems, which specifies sampling requirements and performance criteria and targets areas where potential pathways for metal uptake via (e.g., dust, growth medium, or contact water). Where harmful levels are found, the Permittee must take any corrective action necessary to mitigate to ensure levels are safe for plant and animal life.

13. Subsidence Monitoring

The Permittee must develop a Subsidence Monitoring and Management Plan and submit it to the Chief Inspector as part of the 5 Year Mine Plan and Reclamation Program update. The plan must be designed to evaluate the effectiveness of subsidence controls, provide early warning of surface expression that may result in changes to terrestrial or aquatic values and include an adaptive management approach to ensure that appropriate mitigation and/or closure plans are developed as needed.

E. Reclamation and Closure Program

1. Reclamation Security

(a) The Permittee must maintain a total security for this permit of Thirty One Million Seven Hundred Thousand ($31,700,000.00) dollars. The security will be held by the Minister of Finance for the proper performance of the approved program and all the conditions of this permit in a manner satisfactory to the Chief Inspector.

(b) Notwithstanding the security posted as a condition of this Permit, the Permittee remains responsible for covering all closure and reclamation costs associated with reclamation and environmental protection.

2. Annual Reclamation Report

By March 31 of each year, starting in 2016, the Permittee must submit an Annual Reclamation Report in a form containing the information required by the Chief Inspector.

3. Land Use

The Permittee must reclaim the land with the intent of re-establishing average pre-mining capability to the following end land use objective: wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot on the mine site and high elevation sections of the Transmission Line, and moose and grizzly bear habitat at lower elevations of the Transmission Line. Achieving land capability objectives and habitat enhancement must guide the reclamation program.

4. Revegetation

(a) The Permittee must, where vegetation is a necessary component of fulfilling the approved end land use objective, ensure the land is revegetated to a self-sustaining state using appropriate and or native plant species including culturally important native species.

(b) The Permittee must ensure revegetation programs are designed to restore wildlife habitat where practicable.

(c) The Permittee must ensure revegetation practices are conducted to provide appropriate species and densities that are similar to naturally occurring ecosites at similar elevations, aspects, and climatic conditions.

(d) The Permittee must develop details of the proposed revegetation programs, including species and densities prescribed for specific areas, based on input from the reclamation research program required as a condition of this permit.

5. Growth Medium

(a) Where replacement of salvaged soil will occur, the Permittee must ensure surface preparation is done in a manner that controls erosion and achieves end land use objectives.

(b) The Permittee must monitor soil replacement to ensure the minimum depths are achieved and a confirmation sampling plan must be implemented to ensure quality of soil used for reclamation purposes will achieve end land use objectives. The Permittee must present the results in the Annual Reclamation Report.

(c) With the exception of areas where closure plans require compaction prior to placement of growth medium in order to reduce infiltration and contact water, the Permittee must ensure all areas are reclaimed and decompacted to the minimum depth required to adequately address the severity of compaction prior to placement of soil and or vegetation, in a manner intended to achieve end land use objectives and erosion control.

6. Contaminated Sites Assessment

The Permittee must develop and implement risk-based monitoring programs designed to ensure all potential sources of contamination have been addressed in order to satisfy reclamation success objectives and water quality requirements.

7. Erosion Control

The Permittee must ensure that long term erosion potential is minimized through landform configuration, appropriate surface preparation, development of maintenance-free vegetation covers, where applicable, and self-sustaining drainage control features and watercourses.

8. Surface Water Management Ponds and Channels

(a) The Permittee must ensure all surface water management ponds and water diversions are reclaimed to satisfy stability and erosion control requirements and the approved end land use once no longer required.

(b) At least 3 months prior to decommissioning water treatment facilities, the Permittee must develop and submit to the Chief Inspector for approval, a Closure Plan that addresses all non-contact and contact water management features that will no longer be required.

9. Transmission Line

At least 3 months prior to decommissioning the Transmission Line, the Permittee must develop and submit to the Chief Inspector for approval, a Reclamation and Closure Plan to satisfy the approved end land use objectives.

10. Borrows and Quarries

The Permittee must ensure borrow pits and quarries are reclaimed to satisfy stability and erosion control requirements and the approved end land use, once no longer required.

11. Mine Roads

(a) The Permittee must ensure all mine roads are reclaimed, in accordance with recommendations of a Qualified Professional, to satisfy the approved end land use objectives, including all reasonable effort to fully re-configure to conform to adjacent landscape where long-term stability is not compromised, unless permanent access is required.

(b) Individual mine roads may be exempted from the requirement for total reclamation pursuant to this permit if either:

(i) the Permittee can demonstrate that an agency of the Crown has explicitly accepted responsibility for the operation, maintenance and ultimate deactivation and abandonment of the road or

(ii) the Permittee can demonstrate that another private party has explicitly agreed to accept responsibility for the operation, maintenance and ultimate deactivation and abandonment of the road and has, in this regard, agreed to comply with all the terms and conditions, including bonding provisions, of this reclamation permit, and to comply with all other relevant provincial government (and federal government) regulatory requirements.

(c) The Permittee must ensure all access roads are effectively blocked to prevent inadvertent vehicular access to surface areas of the mine that may be dangerous.

12. Structures and Equipment

Prior to abandonment, the Permittee must, unless the Chief Inspector has made a ruling with respect to heritage project status or industrial use:

(a) Remove all machinery, equipment and building superstructures, unless the Permittee can demonstrate that another private party has explicitly agreed to accept responsibility for its operation and maintenance;

(b) Remove all synthetic sediment control structures, such as turbidity curtains, ditch liners, and soil covers not required after closure and where practical ,disposed of in the underground prior to flooding or buried in place where sufficient cover materials exist;

(c) Remove all concrete foundations, or covered with sufficient growth medium and re-vegetated, or otherwise reclaimed to fulfill approved end land use objectives based on input from the reclamation research program required as a condition of this permit; and

(d) Remove all scrap material and dispose of in an approved facility.

13. Temporary Shutdown

(a) If the mine ceases production, including for seasonal closure, within one month the Permittee must submit a Care and Maintenance Plan which describes, documents, and tracks key aspects of the ongoing mitigation, monitoring, and maintenance requirements for the care and maintenance of the site. The Permittee must ensure the manual documents the outstanding reclamation activities and closure requirements for the site, and develop a trigger action response plan that will be implemented to activate closure activities based on monitoring results and site conditions. This document must be a living document with updates submitted to the Chief Inspector whenever material changes occur.

14. Mine Plan and Reclamation Program Update

On or before July 31, 2020, and every 5 years thereafter, the Permittee must submit an updated Mine Plan and Reclamation Program, providing, but not limited to, the following:

(a) The current status of the mine plan and reclamation obligations;
(b) A compilation and interpretation of all monitoring including ML/ARD prediction, water quality and quantity, and post-closure groundwater elevation prediction updates;
(c) Closure and maintenance activities;
(d) Any changes to the reclamation program that affect long-term mitigation;

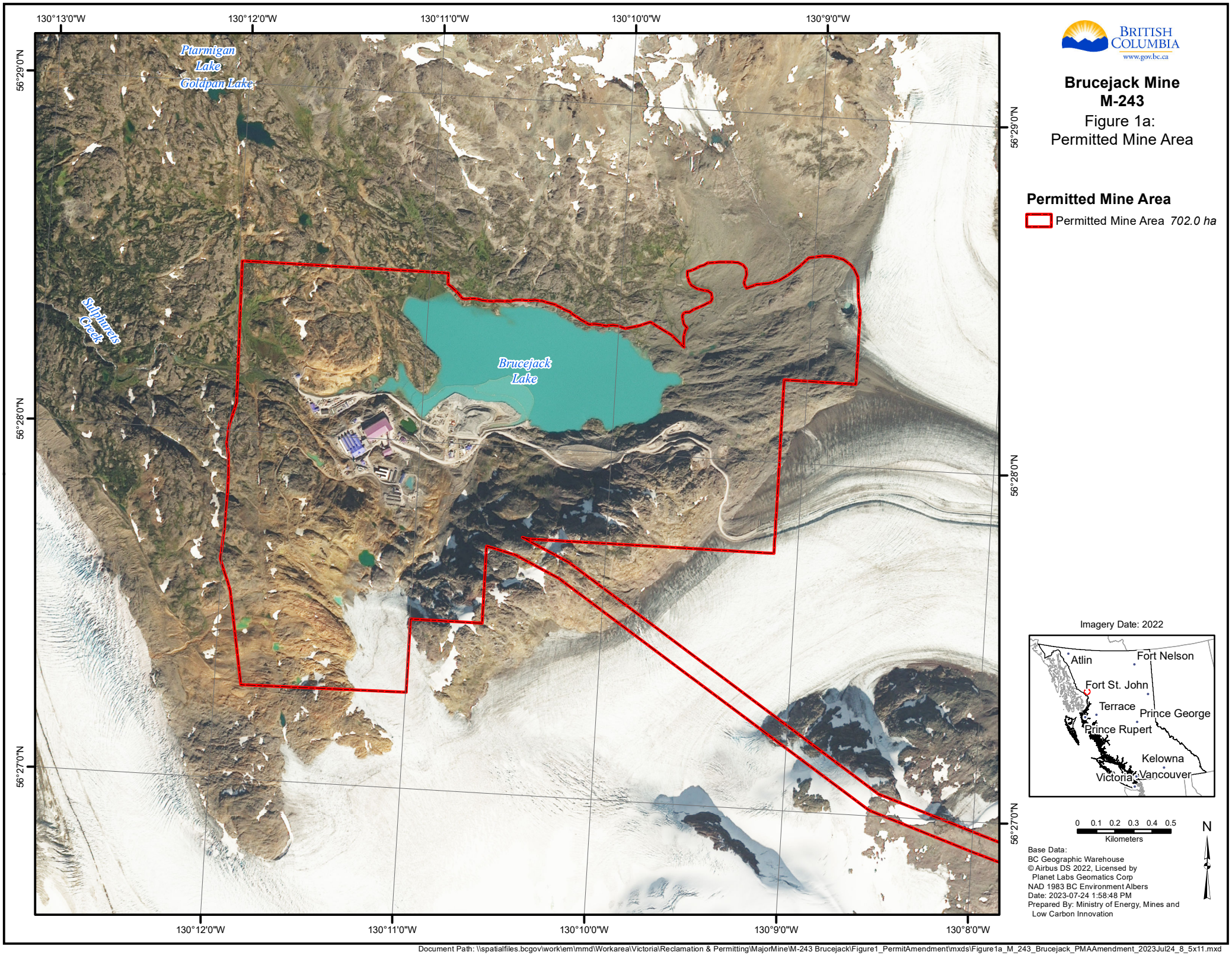
(e) Reclamation research program;
(f) Contingency plans;
(g) Schedule for completion of reclamation works and
(h) A breakdown of outstanding liabilities and associated costs.

15. Closure Plan

(a) Twelve months prior to final closure, the Permittee must submit a Closure Plan providing, but not limited to, the following:

(i) Closure objectives and criteria for each mine component;
(ii) Provide the current status of the mine plan and reclamation obligations;
(iii) A compilation and interpretation of all monitoring including ML/ARD prediction, water quality and quantity;
(iv) Closure and maintenance activities;
(v) Any changes to the reclamation program that affect long-term mitigation;
(vi) Reclamation research program;
(vii) Contingency plans;
(viii) Schedule for completion of reclamation works and
(ix) A breakdown of outstanding liabilities and associated costs.

(b) Concurrent with the final Closure Plan, the Permittee must submit a Closure Management Manual which describes and documents key aspects of the operational surveillance and monitoring requirements used to track important changes that could affect long-term mitigation performance, monitoring and maintenance requirements. This document must be a living document with updates submitted to the Chief Inspector, at least every five years while the permit remains active, and when material changes occur.



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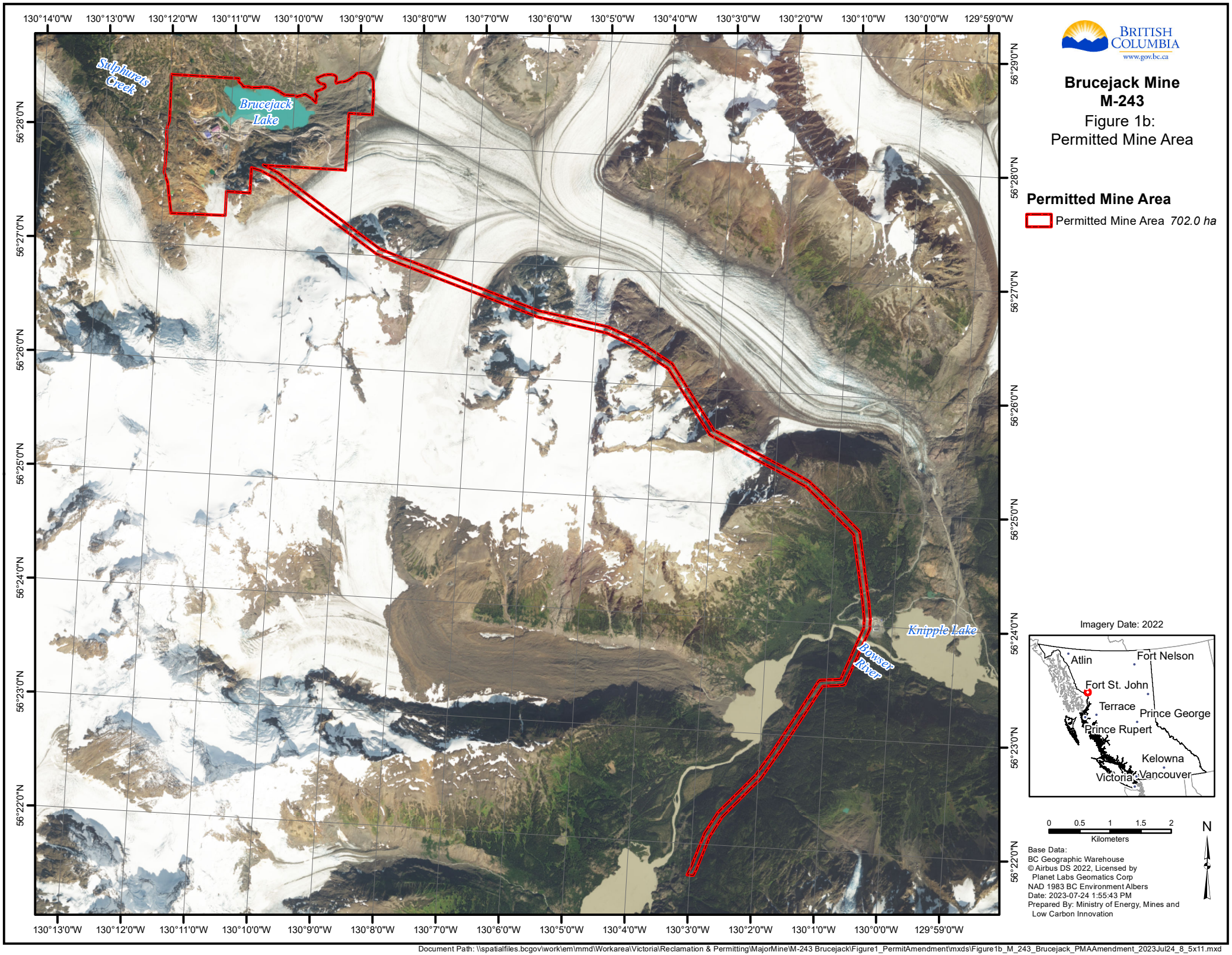

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August 21, 2023

Tracking Number: 415871
Authorization Number: 107835

REGISTERED MAIL

Pretium Resources Inc.
Suite 2300, Four Bentall Centre
PO BOX 49334 1055 Dunsmuir Street
Vancouver, BC V7X1L4

Dear Permittee:

Enclosed is Amended Permit 107835 issued under the provisions of the *Environmental Management Act*. Your attention is respectfully directed to the terms and conditions outlined in the permit. An annual fee will be determined according to the Permit Fees Regulation.

This permit does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority rests with the permittee. This permit is issued pursuant to the provisions of the *Environmental Management Act* to ensure compliance with Section 120(3) of that statute, which makes it an offence to discharge waste, from a prescribed industry or activity, without proper authorization. It is also the responsibility of the permittee to ensure that all activities conducted under this authorization are carried out with regard to the rights of third parties, and comply with other applicable legislation that may be in force.

When a spill or the risk of a spill occurs, the responsible person (spiller) must report it immediately by calling 1-800-663-3456 in accordance with the Spill Reporting Regulation. More information is available at:
https://www2.gov.bc.ca/gov/content?id=1EAB9109A9E9407EA646050A9D431C41

Pursuant to Section 16 of the *Environmental Management Act*, the director has amended authorization 107835.

This decision may be appealed to the Environmental Appeal Board in accordance with Part 8 of the *Environmental Management Act*. An appeal must be delivered within 30 days from the date that notice of this decision is given. For further information, please contact the Environmental Appeal Board at (250) 387-3464.

Administration of this permit will be carried out by staff from the Environmental Protection Division's Regional Operations Branch. Plans, data and reports pertinent to

the permit are to be submitted by email or electronic transfer to the Director, designated Officer, or as further instructed.

Please be reminded that the director may, for the protection of the environment in accordance with Section 16 of the *Environmental Management Act*, require the permittee to do one or more of the following at any time:

- repair, alter, remove, improve or add to existing works, or construct new works, and submit plans and specifications for works specified in this authorization.
- conduct monitoring, and may specify procedures for monitoring and analysis, and procedures or requirements respecting the handling, treatment, transportation, discharge or storage of waste.
- provide security in the amount and form, and subject to the conditions, specified by the director.
- conduct studies and report information in accordance with the specifications of the director.
- recycle certain wastes and recover certain reusable resources, including energy potential from wastes, in accordance with the specifications of the director.
- submit copies of reports and notifications to specified Indigenous Groups, within specified timelines, in accordance with the specifications of the director.

For more information about how the Ministry will assess compliance with your permit please refer to gov.bc.ca/environmentalcompliance.

For more information about how to make changes to your permit and to access waste discharge amendment forms and guidance, please refer to gov.bc.ca/wastedischarge-authorizations.

Yours truly,

Neil Bailey, P. Eng.
for Director, *Environmental Management Act*
Authorizations - North Region

MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE STRATEGY

PERMIT

107835

Under the Provisions of the Environmental Management Act

Pretium Resources Inc.

Suite 2300, Four Bentall Centre
PO BOX 49334 1055 Dunsmuir Street
Vancouver, BC V7X1L4

is authorized to discharge mine related contaminants and effluent to Brucejack Lake and Brucejack Creek, from the Brucejack Mine located approximately 60 km North of Stewart, British Columbia, subject to the requirements listed below.

Contravention of any of these requirements is a violation of the Environmental Management Act and may lead to prosecution.

This authorization supersedes and replaces all previous versions of Permit 107835 issued under Section 14 of the *Environmental Management Act*.

Where this authorization provides that the director may require an action to be carried out, the permittee must carry out the action in accordance with the requirements of the director.

1. AUTHORIZED DISCHARGES

1.1 Brucejack Lake Final Discharge Point

The permittee must manage the operations and authorized discharges in sections 1.2, 1.3, 1.4, and 1.5, such that water quality at the outlet of Brucejack Lake (monitoring site BJ 3.10) does not exceed the maximum concentrations specified in section 1.1.1. The site reference number and final point of compliance for this discharge is E298312.

Date issued: August 31, 2015
Date amended: August 21, 2023
(most recent)

Neil Bailey, P. Eng.
for Director, *Environmental Management Act*
Authorizations - North Region
Permit Number: 107835

1.1.1 The characteristics of the Brucejack Lake Outlet (BJ3.10) water quality must not exceed the following:

Parameter	Maximum (1)	Units
48 hr Daphnia magna single concentration toxicity test	50% Survival in 100% Concentration, Minimum (2)	Not applicable
Algal Growth Inhibition Test (EPS 1/RM/25)	Growth Inhibition must be less than 25% for 100% Lake Outlet Water (2)	Not applicable
Total Suspended Solids	30 (maximum) 15 (monthly average)	mg/L mg/L
pH	6.5- 8.5	
Nitrite	240	µg/L as N
Nitrate	11.5	mg/L as N
Ammonia	4.0	mg/L as N
Total Antimony	28	µg/L
Total Arsenic	10	µg/L
Total Iron	1.7	mg/L
Total Silver	0.46	µg/L

(1) Maximum allowable concentration in any grab sample.
(2) Refer to section 4.3.

1.1.2 The annual average authorized discharge rate from Brucejack Lake is 50,000 m^3/day. The average authorized discharge volume has been set to enable the calculation of discharge fees as required by the Permit and Approval Fees and Charges Regulation.

1.1.3 The discharge is authorized from Authorized Works, which are various discharge lines and outfalls from treatment works, collection works, ditches, oil/water separator, pipes, sumps, pumps, flow

monitoring and water sampling devices, a low-level weir, and Brucejack Lake.

1.1.4 The location of the facilities from which the discharge is authorized to originate and the point where the discharge is authorized to occur is Mining Lease 1038598. The Authorized Works and various points of discharge are as shown in attached Site Plan A.

1.2 Water Treatment Plant and Contact Water Pond Effluent

This section applies to the discharge of effluent from the Water Treatment Plant (WTP) and the Contact Water Pond (CWP) to Brucejack Lake and/or for use as process water within the mill building. The site reference number for the WTP discharge is E302957. The site reference number for the CWP direct discharge is E306114.

1.2.1 The maximum authorized rate of discharge from the WTP to Brucejack Lake is 10,000 m^3/day.

1.2.2 The maximum authorized rate of discharge from the CWP to Brucejack Lake is indeterminate.

1.2.3 Subject to subsection 1.2.4, the characteristics of the WTP and CWP discharge to Brucejack Lake must not exceed the following:

Parameter	CWP Maximum (1)	WTP Maximum (1)	Units
Total Suspended Solids (TSS)	25 (2) 150 NTU (3)	25	mg/L
pH	6.5 – 8.5	6.5 – 8.5	pH
Total Aluminum	0.3	0.3	mg/L
Total Arsenic	10	10	µg/L
Total Cadmium	0.25	0.25	µg/L
Total Cobalt	10	10	µg/L
Total Chromium (see section 3.4)	20	20	µg/L
Total Copper	10	10	µg/l
Total Iron	1.0	1.0	mg/L
Total Lead	5	5	µg/L
Total Manganese	22	22	mg/L
Total Silver	0.1	0.1	µg/L
Total Zinc	20	20	µg/L

(1) Concentration in any grab sample that triggers requirements in section 1.2.4
(2) When available CWP storage capacity is between 10,000 and 50,000 m^3
(3) When available CWP storage capacity is less than 10,000 m^3.

1.2.4 Should the concentrations in section 1.2.3 be exceeded for the WTP or CWP discharge to Brucejack Lake, the permittee must immediately upon receipt of analytical results recirculate effluent through the CWP and WTP until treated water quality does not exceed the discharge characteristics specified in section 1.2.3.

Date issued: August 31, 2015
Date amended: August 21, 2023
(most recent)

Neil Bailey, P. Eng.
for Director, *Environmental Management Act*
Authorizations - North Region
Permit Number: 107835

1.2.5 **Water Treatment Plant Authorized Works**

The discharge is authorized from Authorized Works, which are Brucejack Lake, and the WTP that utilizes pH adjustment for metals precipitation using hydrated lime and, if necessary, sodium sulphide; coagulation using ferric sulphate; and flocculation using anionic polymer and microsand for removal of TSS; clarification using lamella plates and disc filter; sludge dewatering using centrifuge and cationic polymer; and pH neutralization using sulfuric acid and calcium hydroxide.

1.2.6 **Contact Water Pond Authorized Works**

The discharge is authorized from Authorized Works, which are Brucejack Lake and a CWP with a minimum storage capacity of 50,000 m^3. Related appurtenances include a permanent emergency spillway for events exceeding the design capacity as well as a drawdown pump and pipeline system to a deep lake outfall.

1.2.7 The location of the WTP and the deep lake discharge line are as shown on Site Plan B. The sources of the WTP influent are mine water, process water and the CWP.

1.2.8 The location of the CWP and the direct discharge line are as shown on Site Plan B. The sources of the CWP influent are various surface water collection works surrounding the mine site, Diesel Power Station (DPS) pond effluent, WTP effluent, as well as emergency storage of untreated Mine Water.

1.3 **Thickened Tailings Slurry**

This section applies to the discharge of Thickened Tailings Slurry via the tailings discharge lines to Brucejack Lake. The site reference number for this discharge is E302910.

1.3.1 The annual average authorized rate of discharge is 3,800 tonnes per day.

1.3.2 The tailings outfall must never be positioned more than 7.5 m above the lake bottom (i.e., the top of the natural lake bottom or deposited tailings, whichever is higher) unless approved by the director.

1.3.3 The discharge is authorized from Authorized Works, which are Brucejack Lake, tailings discharge lines to Brucejack Lake, and thickening processes and related appurtenances approximately located as shown on Site Plan B.

1.4 Water Treatment Plant Sludge

This section applies to co-deposition of the WTP Sludge with tailings via the tailings discharge lines to Brucejack Lake. The site reference number for this discharge is E302910.

1.4.1 The maximum rate of sludge deposition is indeterminate.

1.4.2 The mixing ratio of WTP Sludge to tailings must not exceed 2% sludge by dry weight.

1.4.3 The discharge is authorized from Authorized Works, which are Brucejack Lake, tailings discharge lines to Brucejack Lake, tailings thickening processes and related appurtenances approximately located as shown on Site Plan B.

1.5 Treated Domestic Wastewater

This section applies to the discharge of Treated Domestic Wastewater from the mine operations and camp infrastructure to Brucejack Lake. The site reference number for this discharge is E302911.

1.5.1 The maximum authorized rate of discharge is 175 m^3/day, 365 days/year.

1.5.2 The characteristics of the treated effluent must not exceed:

(a) 45 mg/L for Total Suspended Solids, and

(b) 45 mg/L for 5-day Biological Oxygen Demand.

1.5.3 The discharge is authorized from Authorized Works, which are Brucejack Lake and three Filterboxx C75 treatment units, or an equivalent unit(s) approved by the director, and related appurtenances including a deep lake outfall.

1.5.4 The location of the Domestic Wastewater Treatment plant and the deep lake outfall discharge line are as shown on Site Plans A and B.

2. GENERAL CONDITIONS

2.1 Maintenance of Works and Emergency Procedures

2.1.1 The permittee must regularly inspect the Authorized Works and maintain them in good working order. If components of the Authorized Works have a manufacturer's recommended schedule, then those components must, at a minimum, be maintained in accordance with that schedule.

2.1.2 The permittee must maintain a record of inspections and maintenance of the Authorized Works and make the record available to an officer upon request.

2.1.3 In the event of an emergency or other condition which prevents normal operation of the Authorized Works or leads to an unauthorized discharge, the permittee must take remedial action immediately to restore the normal operation of the Authorized Works and to prevent any unauthorized discharges. The permittee must immediately report the emergency or other condition and the remedial action that has and will be taken to the EnvironmentalCompliance@gov.bc.ca email address or as otherwise instructed by the director.

2.1.4 The director may require the permittee to reduce or suspend operations until the Authorized Works have been restored, and/or corrective steps have been taken to prevent unauthorized discharges.

2.2 Construction of Water Management and pollution Control Works

2.2.1 The permittee must ensure the plans and specifications for the various phases of the WTP, the Domestic Wastewater Treatment Plant and other associated works authorized under sections 1.2, 1.3, 1.4, and 1.5 are certified by a Qualified Professional and retained on site for inspection prior to the commencing any of the discharges from either sources.

2.2.2 The permittee must cause the Qualified Professional to certify that the works have been constructed in accordance with such plans and specifications before discharge commences under this authorization, and a maximum of 45 days following completion of construction.

2.3 Controlled Bypasses

The permittee must not allow any discharge authorized by this authorization to bypass the Authorized Works, except with the prior written approval of the director.

2.4 Temporary Shutdown

In the event of a temporary shutdown in construction and mining activities at the site, the permittee must notify the director in writing and must ensure all permit conditions continue to be met.

2.5 Publication of Documents

The Ministry of Environment and Climate Change Strategy publishes Regulatory Documents on its website for the purpose of research, public education and to provide transparency in the administration of environmental laws. The permittee acknowledges that the Province may publish any Regulatory Documents submitted by the permittee, excluding information that would be exempted from disclosure if the document was disclosed pursuant to a request under section 5 of the Freedom of Information and Protection of Privacy Act, and the permittee consents to such publication by the Province.

3. OPERATIONAL REQUIREMENTS

3.1 Turbidity Curtains

The Waste Rock and Tailings disposal must not proceed unless a minimum of three turbidity curtains are in place across the lake outlet approximately as shown on Site Plan B.

3.2 Source Control of Nitrite and Nitrogen

3.2.1 The permittee must maintain an up-to-date version of the Nitrogen Management Plan (NMP) on site for inspection by Environmental Protection staff.

3.2.2 The permittee must implement the most current version of the NMP. The NMP describes source control measures, monitoring, auditing and reporting activities that are undertaken to ensure nitrogen sources are controlled and minimized, and that the discharge standards in section 1.1 are met.

3.2.3 The permittee must maintain records of the activities described in the NMP available for inspection at the request of Environmental Protection staff.

3.3 **Closure Underground Water Quality Adaptive Management Plan**

3.3.1 The permittee must develop a post closure management plan with the intent of limiting all impacts within Brucejack Creek to levels acceptable to the director.

3.3.2 The Plan must assess all available management options including but not limited to:

(a) directing mine pool water on closure to the CWP to allow for attenuation there,

(b) continuing to use the WTP and/or discharging the water where it would have minimal impact.

(c) In addition, the plan must include appropriate monitoring, water quality triggers, and management actions to maintain water quality throughout closure and post closure.

3.3.3 The Plan must include all available and updated hydrology, hydrogeology and geochemistry results and propose further work necessary to better define closure and post closure Water Quantity and Quality predictions.

3.3.4 An initial Plan submission is due by July 31, 2020. Subsequent updates with respect to ongoing findings and management options are required every five (5) years or as requested by the director. The final report must be submitted 2 years prior to closure for the approval of the director.

3.4 **Chromium Management Plan**

3.4.1 The permittee must maintain an up-to-date Chromium Management Plan (CMP) on site for inspection by Environmental Protection staff.

3.4.2 The permittee must implement the most current version of the CMP to manage, monitor and mitigate the release of hexavalent chromium from cement in the underground workings, and ensure that the BC Water Quality guidelines for Cr(III) and Cr(VI) are not exceeded at Brucejack Lake outlet (BJ 3.10).

3.4.3 The permittee shall implement the monitoring program and mitigations described in the most current version of the CMP if either of the following occurs:

(a) dissolved Chromium levels prior to treatment in the WTP exceed the trigger level of 10 µg/L,

(b) dissolved Chromium levels at BJ 3.10 exceed 1 µg/L.

3.5 Outfall Inspection

3.5.1 The permittee must cause the outfall(s) and discharge lines to be inspected once every year by a Qualified Professional or certified tradesperson to ensure they and all associated piping are in good working condition, there are no leaks, no major bends which would erode due to the flow of the tailings slurry, and the height of tailings discharge is in compliance with section 1.1.3 of this permit.

3.5.2 Inspections may include a combination of the following: bathymetric surveys, camera inspections, visual inspections, digital sonar surveys, etc.

3.5.3 The permittee must submit an inspection report as part of each annual report unless concerns are noted. In the latter instances, the permittee must submit an inspection report accompanied by a mitigation plan to the director with 45 days after the inspection date.

3.6 Water Treatment Plant Sludge

3.6.1 The permittee must implement the WTP sludge monitoring and management program outlined in the most current version of the Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan.

3.6.2 Co-subaqueous deposition of WTP Sludge in Brucejack Lake with tailings is permitted as described in section 1.4.

3.6.3 On-site sub-aerial storage of the WTP Sludge must not exceed twelve (12) months, unless approved by the director.

3.6.4 Disposal of the WTP Sludge does not require approval if it is disposed off- site at a licensed facility.

3.7 **Reagents**

3.7.1 The permittee must maintain records of reagent types, volumes and usage rates for various water treatment and ore concentration process.

3.7.2 When commissioning any specific process and or adding/changing reagent(s) the permittee must compile and submit documentation to the director 15 days prior to their usage.

3.8 **Diesel Power Station (DPS) Oil/Water Separator**

3.8.1 The permittee must develop and implement a preventative maintenance, monitoring, and inspection program for the DPS separator system and DPS pond by January 31, 2019.

3.8.2 The permittee must maintain records of inspections, cleanouts, accidental discharges, and a site plan, available for inspection at the request of Environmental Protection staff.

4. **MONITORING REQUIREMENTS**

Locations of all monitoring sites are depicted in Site Plans C and D. Appendices A and B specify the monitoring periods and frequencies, and monitoring parameters for the surface water and groundwater monitoring sites.

The groundwater monitoring frequencies will be as per Appendix B unless the permittee documents specific safety conditions present at a given well, or other condition such as lack of recovery, frozen or dry wells, that justify missing a specific sampling event. The director may approve revisions to the Groundwater Monitoring Program subject to the permittee submitting a review and recommendations by a Qualified Professional.

4.1 **Benthic Invertebrates**

4.1.1 The permittee must implement the benthic invertebrate program as specified in Appendix A using personnel or Qualified Professionals trained in the Environment Canada CABIN protocol.

4.1.2 The benthic invertebrate monitoring frequencies at BJ 2.62 and BJ 1.74 will be annually, as per Appendix A, for 3 years (i.e., 2019, 2020 and 2021) after which time the permittee may request a reduction of the monitoring frequency to once every 3 years.

4.2 **Sediment Sampling**

4.2.1 The permittee must implement the sediment program as specified in Appendix A using personnel or Qualified Professionals trained in the procedures.

4.2.2 The Program must analyze biologically relevant fine sediments less the 63 µm in size.

4.3 **Toxicity Sampling Requirements for the Outlet of Brucejack Lake (BJ 3.10)**

4.3.1 As per section 1.1, the discharge at the outlet of Brucejack Lake must not be acutely toxic to aquatic organisms or inhibit algal growth. The required test methods are:

(a) Acute/ Lethal Toxicity - 48 hr Daphnia magna single concentration toxicity test (EPS 1/RM/14 2nd edition, December 2000), and

(b) Growth Inhibition Test Using a Freshwater Alga (EPS 1/RM/25).

4.3.2 A lethal toxicity test failure is defined as undiluted effluent that results in >50% mortality of Daphnia magna in 48 hours.

4.3.3 A Growth Inhibition test failure is defined as whenever the growth inhibition in 100% lake outlet effluent is determined to be greater than 25%.

4.3.4 In the event of failures, the Ministry must be notified (as per section 5.3 "Non-compliance Notification) and the specific test must be immediately repeated.

4.3.5 For acute toxicity, the follow-up test must use multiple concentrations to determine the 48 hr LC50 for Daphnia magna.

4.3.6 Test results must be validated, and results must be reported as described in approved Environment Canada biological test methods as referred to above.

4.4 **Long Term Trend Analysis Toxicity Sampling**

4.4.1 A test for survival and growth using larvae of freshwater midges (Chironomus dilutus) (water only) (test method EPS1/RM/32) must

be conducted on 100% lake outlet effluent. Results must be included in the Annual Report.

4.4.2 Trends in survival and growth must be plotted, including all available data from previous tests.

4.4.3 The summary must include a description of the results in the context of ecological effects in the receiving environment.

4.5 Aquatic Effects Monitoring Program (AEMP)

4.5.1 The permittee must implement the most current version of the AEMP, approved by the director.

4.5.2 The permittee must submit results of the AEMP, prepared by a Qualified Professional, to the director by March 31st of the year after the studies are conducted in accordance with section 5.5. Based on the results of this monitoring program, the monitoring requirements may be extended or altered by the director.

4.5.3 Changes to the AEMP must be approved by the director in writing regardless of any language in the approved program indicating otherwise.

4.5.4 Recommendations for changes to the monitoring program must be prepared by a Qualified Professional and submitted to the director.

4.6 Sampling and Analytical Procedures

4.6.1 The permittee must carry out sampling in accordance with the procedures described in the "British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples, 2013 Edition" or most recent edition, or by alternative procedures as authorized by the director.

A copy of the above manual is available on the Ministry web page at https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual.

4.6.2 The permittee must carry out analyses in accordance with procedures described in the "British Columbia Environmental Laboratory Manual (2015 Permittee Edition)", or the most recent edition, or by alternative procedures as authorized by the director.

A copy of the above manual is available on the Ministry web page at: https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-environmental-laboratory-manual

4.7 Quality Assurance Quality Control (QA/QC)

4.7.1 The permittee must obtain from the analytical laboratory(ies) their precision, accuracy and blank data for each sample set submitted by the permittee and an evaluation of the data acceptability, based on criteria set by such laboratory.

4.7.2 The permittee must submit samples to analytical laboratory(ies) that meet the definition of a qualified laboratory under the Environmental Data Quality Assurance Regulation.

4.8 Exceedance of Guidelines at BJ 3.10

4.8.1 In the event that water quality parameters measured at BJ 3.10 exceed their respective "British Columbia Water Quality Guidelines" or discharge standards in section 1.1, the director may require the following:

(a) Additional sampling and monitoring;

(b) Risk assessment that incorporates the loadings and concentrations considering biological sensitivity of the area;

(c) Submission of an **Environmental Management Plan** in accordance with the following section for each parameter of concern; and

(d) Submission of any other information the director considers necessary to assess environmental impact or to protect the environment.

4.8.2 An **Environmental Management Plan** must be to the satisfaction of the director and include but not be limited to:

(a) Remedial and mitigation measures for the parameters(s) of concern;

(b) An attainment schedule, whereby the permittee must specify actions and interim targets with associated timelines for reducing the amount of contaminants discharged into the

environment, with the goal of attainment of water quality guidelines or other criteria as specified by the director;

(c) Revised modelling predictions for the parameter of concern based on monitoring data and refinements to source term information; and,

(d) Periodic review of the activities to date, and the implementation of future strategies as required by the director. The review will include but not be limited to performance and progress report on control and reduction programs and also provide an opportunity for adjustments to the monitoring program in light of new scientific knowledge and other related technical advances.

5. REPORTING REQUIREMENTS

5.1 Spill Reporting

The permittee must immediately report all spills to the environment (as defined in the Spill Reporting Regulation) in accordance with the Spill Reporting Regulation. Notification must be via the Provincial Emergency Program at 1-800-663-3456.

5.2 Reporting of Monitoring Results

The permittee must submit field and laboratory monitoring results, including a summary of non-compliances and corrective actions taken, by email to the Ministry at EnvAuthorizationsReporting@gov.bc.ca within 30 days of the end of the month in which the monitoring occurred. The permittee must submit such data and information in a form that is tabulated, graphically represented, and interpreted to the satisfaction of the director.

For guidelines on how to properly name the files and email subject lines or for more information visit the Ministry website:

https://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/comply#submitroutinereport

5.3 Non-Compliance Notification

5.3.1 The permittee must immediately notify the director or designate by email at EnvironmentalCompliance@gov.bc.ca, or as otherwise instructed by the director of any non-compliance with the

requirements of this authorization by the permittee and take remedial action to remedy any effects of such non- compliance.

5.3.2 The permittee must provide the director with written confirmation of all such non-compliance events, including available test results within 24 hours of the original notification unless otherwise instructed by the director.

5.3.3 Non-compliance notification must also be provided to the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

5.3.4 Exceedances of the WTP discharge characteristics specified in section 1.2.3 are not non-compliance events. A non-compliance event would be not complying with requirements in section 1.2.4, which are triggered in the event of discharge characteristics in section 1.2.3 being exceeded.

5.4 Non-Compliance Reporting

5.4.1 If the permittee fails to comply with any of the requirements of this authorization, the permittee must, within 30 days of such non-compliance, submit to the director a written report that is satisfactory to the director and includes, but is not necessarily limited to, the following:

(a) All relevant test results obtained by the permittee related to the non- compliance,

(b) An explanation of the most probable cause(s) of the non-compliance, and

(c) A description of remedial action planned and/or taken by the permittee to prevent similar non-compliance(s) in the future.

5.4.2 The permittee must submit all non-compliance reporting required to be submitted under this section by email to the Ministry's Compliance Reporting Submission Mailbox (CRSM) at EnvironmentalCompliance@gov.bc.ca or as otherwise instructed by the director. For guidelines on how to report a non- compliance or for more information visit the Ministry website:

https://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/comply#reportnoncompliance

5.4.3 Non-compliance follow up reports must also be provided to the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

5.5 Annual Reporting

5.5.1 The permittee must submit to the director a comprehensive Annual Report by March 31st of each year, in a report format that follows directions of the "Technical Guidance 4 – Annual Reporting under the Environmental Management Act (2016)", or the most recent edition.

5.5.2 The Annual Report must be submitted to the Ministry (see section 5.2). Copies of the annual report must also be made available to the Ministry of Energy, Mines, and Low Carbon Innovation.

5.5.3 The Annual Report must include but not be limited to:

(a) an evaluation of the impacts of the discharge on the receiving environment, adequacy of monitoring and recommendations;

(b) spills and other environmental incidents;

(c) a comparison of monitoring data, including acute and chronic toxicity results, with Permit standards, BC Water Quality guidelines, and water quality modelling predictions;

(d) results of long-term toxicity sampling including plots of all data, trends in survival and growth, and a description of the results in the context of ecological effects in the receiving environment;

(e) an interpretation (including graphs) of upward trending parameters monitored and/or predicted to potentially exceed BC Water Quality guidelines, or Permit standards;

(f) results of water treatment operation and removal efficiency for all contaminants of potential concern;

(g) a summary of all non-compliances submitted in an Annual Status Form, mitigation and continuous improvement efforts employed by the mine;

(h) a summary of all surface water and groundwater quality, and hydrometric and groundwater levels for the previous year, including tables and graphs where appropriate to indicate trends in key water quality parameters, and including an assessment of relevant quality assurance data;

(i) flow measurements and discharge rates data for all authorized discharges, estimates of the amount and type of chemical additions (flocculants and chemicals used in the WTP and mill for ore processing and tailings thickening process);

(j) results and interpretations of receiving environment aquatic effects program monitoring, including: results and interpretations of acute and chronic toxicity testing, sediment and biological monitoring; analyses of key water quality trends; environmental effects; and assessment of the protectiveness of the discharge limits;

(k) results of any additional hydrogeological investigation and assessment work and updates to the groundwater model for the site;

(l) results and analyses of ongoing review of the site water quality predictions and source terms, water balance and water management at the site; and

(m) results of ongoing ML/ARD chemistry studies.

5.5.4 The annual report must also be provided to the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

5.6 **Mine Data and Water Quality Modelling Review**

5.6.1 Every five years during the operating life of the mine, or as required by the director in the event of significant changes with respect to monitoring results, production rates and or other factors, the permittee must conduct a review of the environmental monitoring required under this permit and reassess the predictive modelling with respect to the environmental impacts.

5.6.2 The permittee must ensure that the review be conducted by independent, third-party Qualified Professionals.

5.6.3 The permittee must cause the Qualified Professional to consider all the available data and any other information available to the permittee or Ministry of Environment staff. Each review will recommend what actions or permit amendments, if any, are advisable to limit impacts from the current or future activities at the mine site on the receiving environment and to ensure compliance with permit requirements.

5.6.4 The director shall consider these recommendations and may make amendments to the permit and/or the environmental monitoring plan that the director considers necessary for the protection of the environment.

5.6.5 A report summarizing the results of a five-year review must be submitted to the director and the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), and the Nisga'a Nation, through Nisga'a Lisims Government by July 31st of the year in which the review is required. The first five-year review report is due on July 31, 2020.

5.7 Electronic Submission of Data into EMS

The permittee must cause a private laboratory or certified third party to electronically submit all the water quality data collected under this permit into the Environmental Management System (EMS) database on their behalf. For instructions on the electronic submission process or for more information visit the Ministry website:

https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/environmental-monitoring-system

6. GLOSSARY

Capitalized terms referred to in this authorization are defined in the attached Glossary. Other terms used in this authorization have the same meaning as those defined in the Environmental Management Act and applicable regulations.

6.1 "Authorized Works"

"Authorized Works" means Brucejack Lake, low level weir, contact water pond, emergency spillway, contact water pond direct discharge line and outfall, tailings discharge line and outfall, water treatment plant, domestic

wastewater treatment plant, water treatment plant and domestic wastewater treatment plant effluent discharge line and outfall, collection works, ditches, pipelines, sumps, pumps, flow monitoring, water sampling, and related appurtenances at stated in sections 1.1.3, 1.2.5, 1.2.6, 1.3.3, 1.4.3, and 1.5.3.

6.2 **"Province"**

"Province" means His Majesty the King in right of British Columbia.

6.3 **"Regulatory Document**

"Regulatory Document" means any document that the permittee is required to provide to the Director or the Province pursuant to:

(i) this Authorization;

(ii) any regulation made under the Environmental Management Act that regulates the facility described in this Authorization or the discharge of waste from that facility; or

(iii) any order issued under the Environmental Management Act directed against the permittee that is related to the facility described in this Authorization or the discharge of waste from that facility.

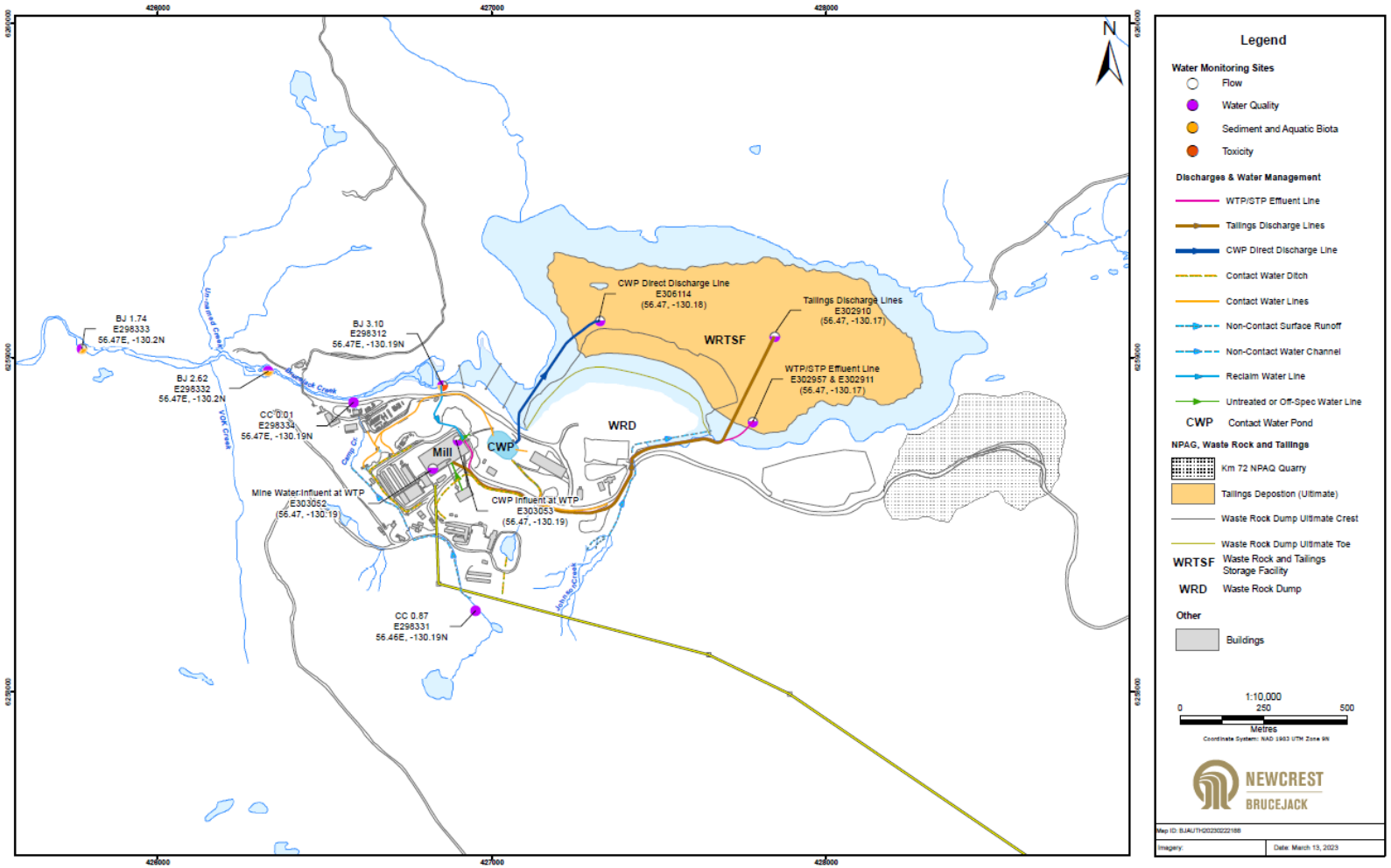
6.4 **"Qualified Professional**

"Qualified Professional" means an applied scientist or technologist specializing in an applied science or technology applicable to the duty or function, including, if applicable and without limiting this, agrology, biology, chemistry, engineering, geology or hydrogeology and who:

(i) is registered with the appropriate professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization, and

(ii) through suitable education, experience, accreditation and/or knowledge, may be reasonably relied on to provide advice within their area of expertise.

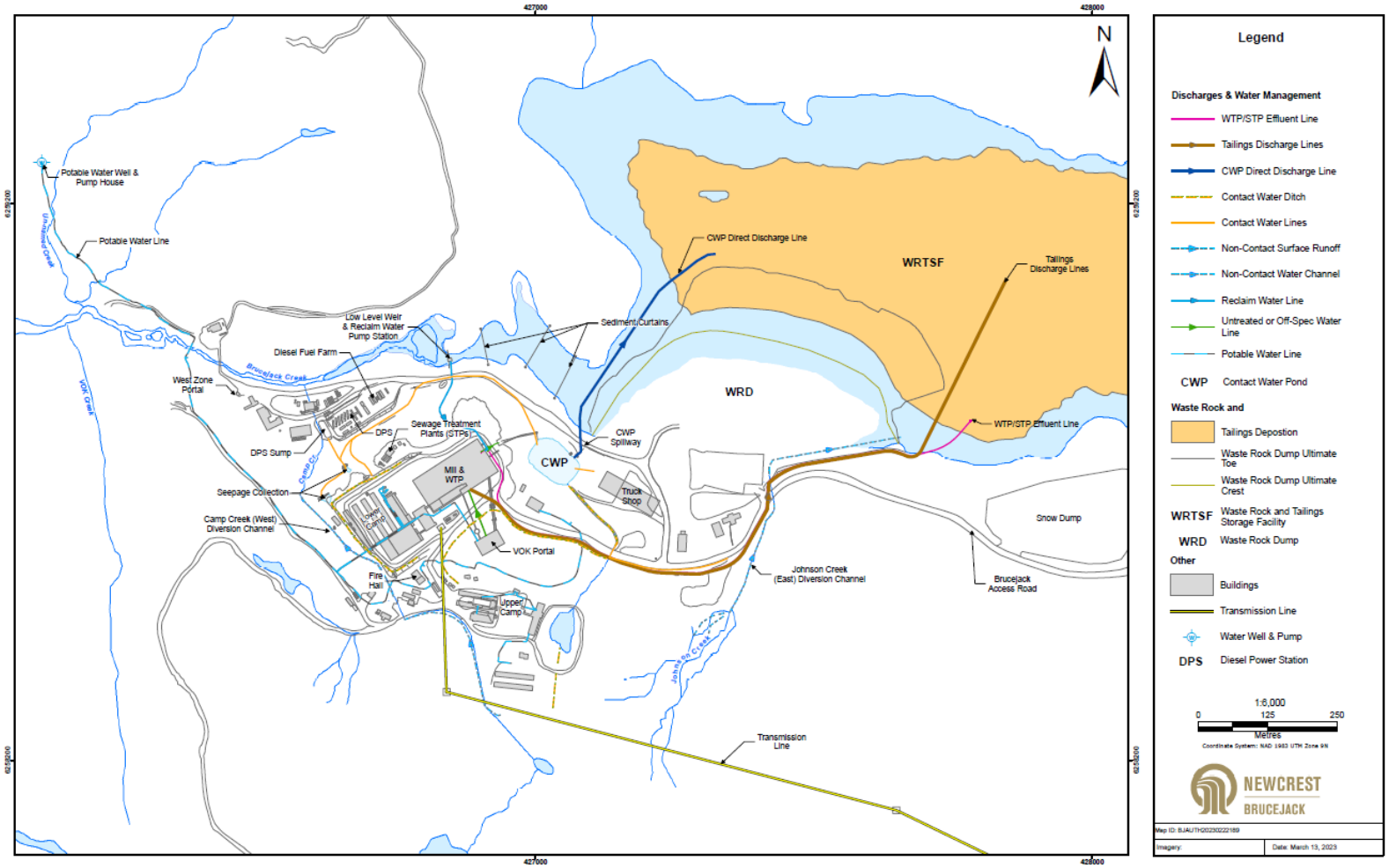
All documents submitted to the Director by a Qualified Professional must be signed by the author(s).



Site Plan A: Brucejack Mine Discharge and Monitoring Locations

Date issued: August 31, 2015
Date amended: August 21, 2023
(most recent)

Neil Bailey, P. Eng.
for Director, *Environmental Management Act*
Authorizations - North Region
Permit Number: 107835



Site Plan B: General Arrangement and Water Management Infrastructure

Date issued: August 31, 2015
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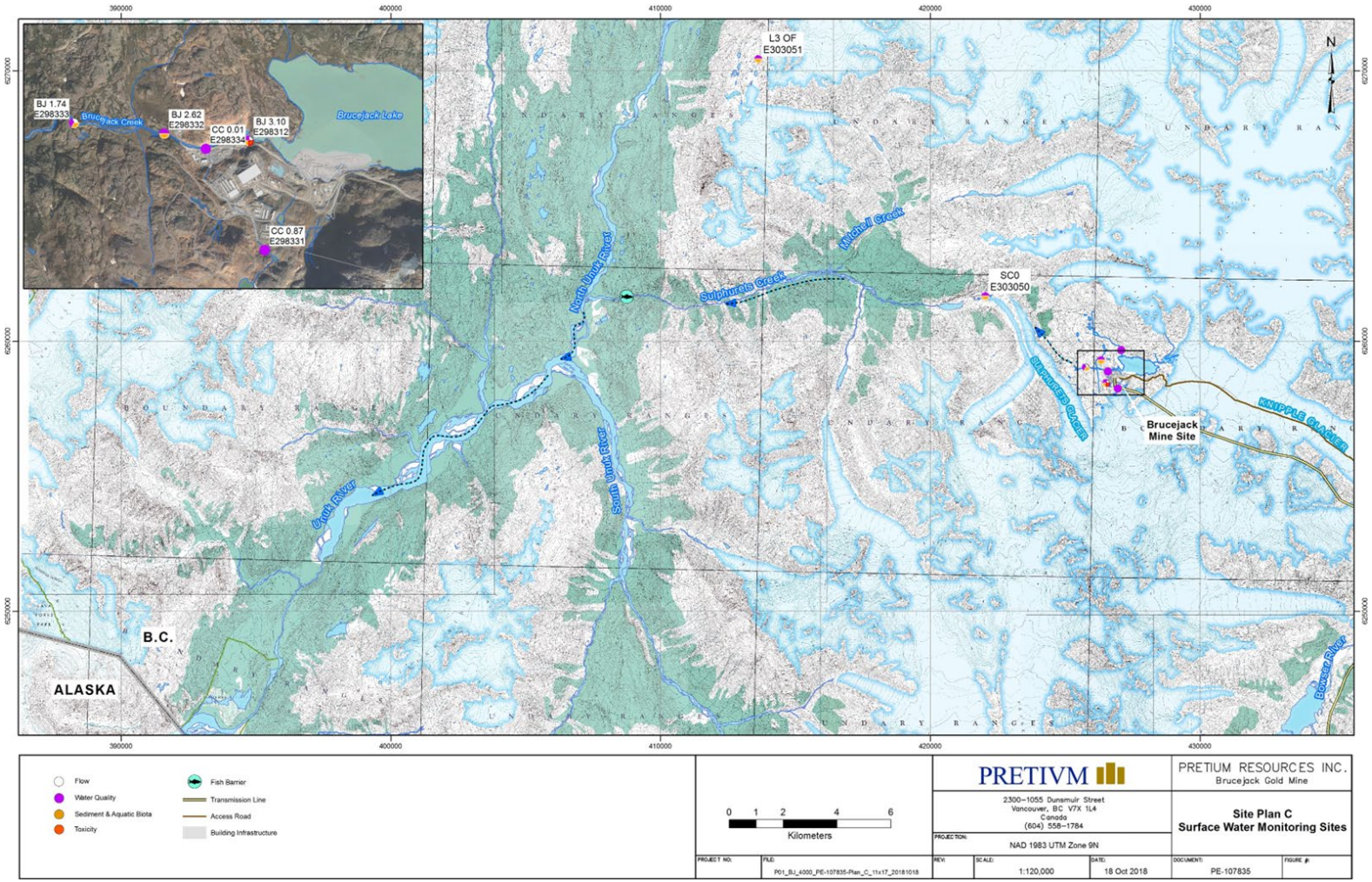

Date issued: August 31, 2015
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(most recent)

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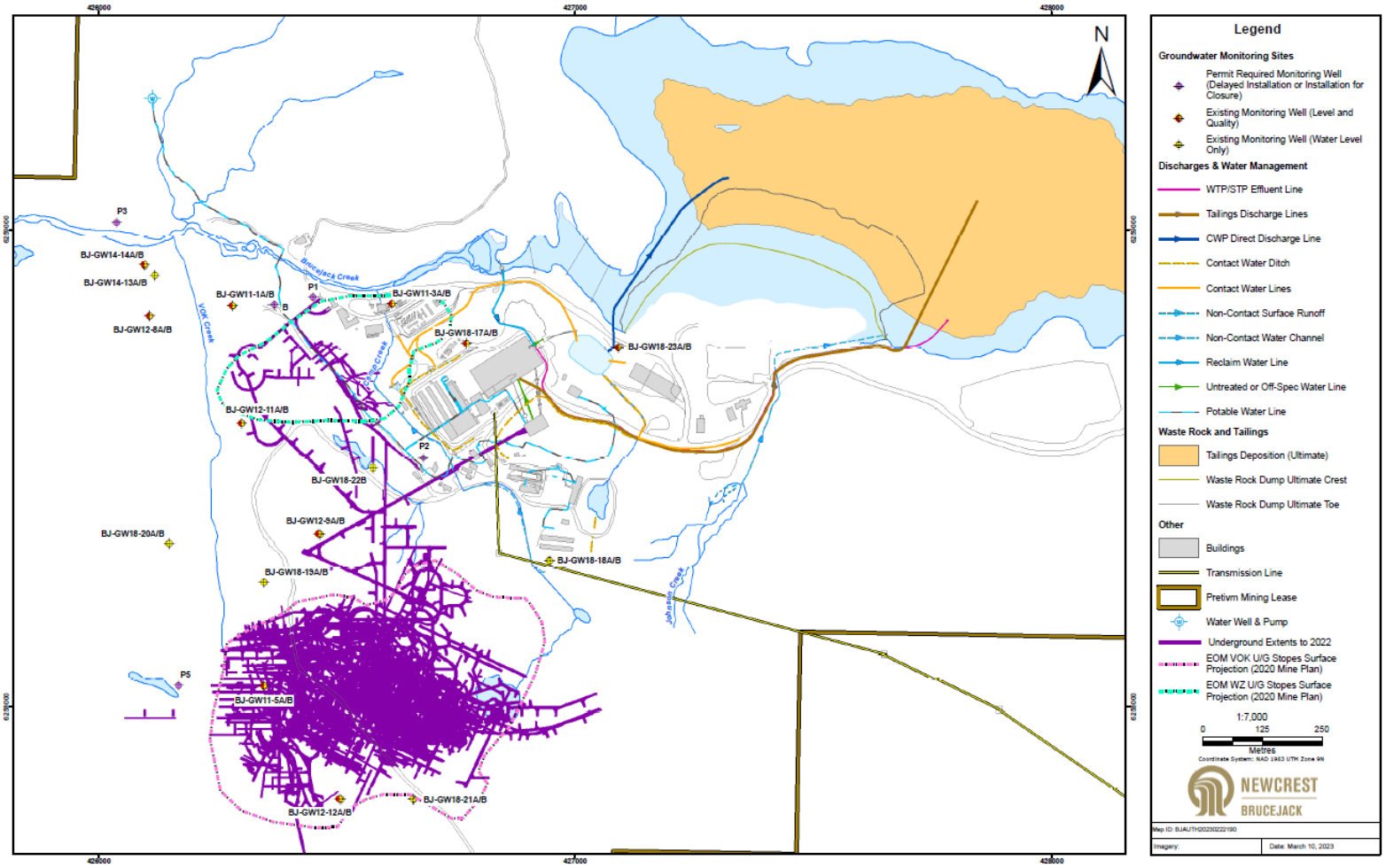

Site Plan D: Groundwater Monitoring Sites

Date issued: August 31, 2015
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(most recent)

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for Director, *Environmental Management Act*
Authorizations - North Region
Permit Number: 107835

Appendix A – Surface Water Quality Monitoring Requirements

Sample Site Name	Location	EMS ID	Field Turbidity[20] pH	Metals & General[1]	Flow Rate / Staff Gauge	5 in 30 days	Toxicity[21]	Sediment[15]	Periphyton[17]	Benthic Invertebrates[19]
BJ 3.10	Weir at Brucejack Lake Outlet	E298312	-	W[2]	C Q[8]	-	Q	A[16]	A[16]	A[16]
CC 0.87	Camp Crk US mine site	E298331	-	M	-	-	-	-	-	-
CC0.01	Camp Crk DS mine site at mouth	E298334	-	M	-	-	-	-	-	-
BJ 2.62	Brucejack Crk just US of VOK Crk	E298332	-	M[2]	-	-	-	A[16]	A[16]	A[16]
BJ 1.74	Brucejack Crk approx. 1.4km DS of lake outlet	E298333	-	M[3] Q	4/S[9]	-	-	3A[16]	A[16, 18]	A[16]
SC0	Sulphurets Crk approx. 8 km DS Mine Site, see Site Plan C	E303050	-	sQ	-	3A[14]	-	3A[16]	3A[16, 18]	3A[16]
L3 outflow	Reference Site approx. 20 Km to the NW, see Site Plan C	E303051	-	sQ	-	3A[14]	-	3A[16]	3A[16]	3A[16]
Mine water Influent at WTP	In plant prior to treatment	E303052	C	2/M	C	-	-	-	-	-
CWP influent at WTP	In plant prior to treatment	E303053	C	2/M[4]	C	-	-	-	-	-
WTP Effluent	After treatment prior to lake discharge	E302957	C	2/M	C	-	-	-	-	-
Tailings Supernatant	After thickening prior to outfall	E302910	-	M	D[10]	-	-	-	-	-

Date issued: August 31, 2015
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for Director, *Environmental Management Act*
Authorizations - North Region
Permit Number: 107835

Sample Site Name	Location	EMS ID	Field Turbidity[20] pH	Metals & General[1]	Flow Rate / Staff Gauge	5 in 30 days	Toxicity[21]	Sediment[15]	Periphyton[17]	Benthic Invertebrates[19]
Treated Domestic Effluent	After treatment prior to outfall	E302911	-	Q[5]	D[10]	-	-	-	-	-
CWP direct discharge to lake	In Contact Water Pond or direct discharge line	E306114	2/D[6]	E[7]	D[11] 2/D[12] 2/W[13]	-	-	-	-	-

Notes: 3A = Once every 3 years, A = Annually, Q = Quarterly, M = Monthly, 2/M = two times per month, W = Weekly, 2/W = two times per week, D = Daily, C = Continuous monitoring, 2/D = two times per day, E = once per event, 4/S = four times per summer, sQ = Quarterly refers to shifting the Quarterly monitoring as follows: sQtr 1- Feb, Mar, & April, sQtr 2 - May, June & July, sQtr 3 - Aug, Sept & Oct, sQtr 4 - Nov, Dec & Jan

1. See details on Metals & General parameters on page 23
2. See additions specified under General parameters
3. May through October (sQ 2 & 3)
4. When discharging to the WTP
5. BOD and TSS only
6. Field turbidity only
7. Once for each direct discharge event
8. Continuous flow with manual checks quarterly
9. Manually at low flow and no recent precipitation
10. Cumulative flow per day
11. Daily volume of any diverted mine water
12. Direct discharge volume and 2 times daily staff gauge levels
13. May through October (sQ 2&3) 2 times weekly staff gauge levels
14. Freshet and Fall
15. Total Metals[1] and Total Organic Carbon
16. Fall low flow
17. Chlorophyll-a, Abundance and Taxonomy
18. Chlorophyll-a only
19. Abundance and Taxonomy
20. Field turbidity as NTU or "as mg/L TSS"
21. Per section 4.3 and 4.4

Date issued: August 31, 2015
Date amended: August 21, 2023
(most recent)

Neil Bailey, P. Eng.
for Director, *Environmental Management Act*
Authorizations - North Region
Permit Number: 107835

Appendix B – Groundwater Monitoring Requirements

Well ID on Site Plan D	EMS ID	Easting (m)	Northing (m)	Depth (m)	Water Level	Metals & General*
BJ-GW11-1A	E303054	426281	6258840	103	C	sQ
BJ-GW11-1B	E314692	426280	6258841	39	C	sQ
BJ-GW11-3A	E303056	426615	6258844	94	C	sQ
BJ-GW11-3B	E314693	426615	6258844	9	C	sQ
BJ-GW11-5A	E303058	426347	6258040	103	C	sQ
BJ-GW11-5B	E314694	426346	6258042	51	C	sQ
BJ-GW12-8A	E303059	426106	6258819	92	C	sQ
BJ-GW12-8B	E314695	426106	6258819	51	C	sQ
BJ-GW12-9A	E303060	426465	6258361	80	C	sQ
BJ-GW12-9B	E314696	426461	6258362	50	C	sQ
BJ-GW12-11A	E303062	426300	6258595	30	C	sQ
BJ-GW12-11B	E314697	426299	6258595	54	C	sQ
BJ-GW12-12A	E303063	426509	6257807	100	C	sQ
BJ-GW12-12B	E314698	426505	6257807	53	C	sQ
BJ-GW14-13A	E303064	426118	6258904	101	C	-
BJ-GW14-13B	E314699	426118	6258904	75	C	-
BJ-GW14-14A	E303065	426096	6258924	35	C	sQ
BJ-GW14-14B	E314700	426095	6258927	5	C	sQ
BJ-GW18-17A	E303066	426771	6258761	148	C	sQ
BJ-GW18-17B	E314701	426772	6258760	75	C	sQ
BJ-GW18-18A	E303069	426946	6258306	101	C	-
BJ-GW18-18B	E314702	426947	6258306	65	C	-
BJ-GW18-19A	E303070	426347	6258259	197	C	-
BJ-GW18-19B	E314703	426346	6258259	159	C	-
BJ-GW18-20A	E303559	426147	6258341	167	C	-
BJ-GW18-20B	E314704	426148	6258342	118	C	-
BJ-GW18-21A	E303071	426661	6257806	205	C	-
BJ-GW18-21B	E314705	426660	6257807	159	C	-
BJ-GW18-22B	E314706	426576	6258499	87	C	-
BJ-GW18-23A	E314690	427091	6258751	29	C	sQ
BJ-GW18-23B	E314691	427091	6258752	11	C	sQ
New well @ P2 [1]	E303557	426681	6258521	400	C	-

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Well ID on Site Plan D	EMS ID	Easting (m)	Northing (m)	Depth (m)	Water Level	Metals & General*
New well @ P5 [1]	E303560	426168	6257920	400	C	-

Well ID on Site Plan D	EMS ID	Easting (m)	Northing (m)	Installation Requirements
New well @ B	E303067	426368	6258843	Closure
New well @ P1	E303556	426450	6258858	Closure
New well @ P3	E303558	426037	6259015	Closure

Notes:

1 New wells @ P2 and @ P5 will be vibrating wire piezometers (VWP)
C – Continuous
- Not Required
sQ - Quarterly refers to shifting the Quarterly monitoring as follows:
sQtr 1- Feb, Mar, & April;
sQtr 2 - May, June & July;
sQtr 3 - Aug, Sept & Oct;
sQtr 4 - Nov, Dec & Jan.
Closure - Submit installation plan 2 years prior to closure

Metals & General* - Appendices A & B

Metals refers to:

1. Low level ICP or equivalent analysis of Total and Dissolved Metals including: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Copper, Iron, lead, Lithium, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Tin, Uranium, Vanadium and Zinc; and
2. Mercury analysis which are to be included at the Brucejack Lake outlet (BJ 3.10), the WTP effluent, the tailings supernatant; Site BJ 2.62, SCO, BJ 1.74, on a sQuarterly basis. The mercury sampling frequency at Site L3 outflow must be during freshet and fall.

General Parameters are defined as:

1. Laboratory analysis: pH, Specific Conductivity, Hardness, Alkalinity, Sulphate, Chloride, Fluoride, Calcium, Magnesium, Sodium, Ammonia, Nitrate, Nitrite, Total & Ortho Phosphorous, Total Organic Carbon, Total Suspended & Total Dissolved Solids, and Turbidity;
2. Field measurements: Turbidity, pH, Conductivity and Temperature;
3. Dissolved Phosphorous and Dissolved Organic Carbon which are to be included as part of the General Parameters at Sites BJ 3.10 & BJ 2.62 at a frequency of 3x/ ice free period, and 1x mid-winter;

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4. General groundwater monitoring does not need to include Total and Dissolved Organic Carbon;
5. Total Extractable Hydrocarbon analysis which is to be included at the CWP prior to direct discharge to Brucejack Lake and prior to treatment at the WTP; at a frequency of once for each event that DPS pond effluent is pumped to the CWP.

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Appendix 1-2: Final Joint Information Requirements Table

Joint Information Requirements Table

for

Mines Act and *Environmental Management Act* Permits

Prepared by:

British Columbia Ministry of Energy, Mines and Petroleum Resources

&

British Columbia Ministry of Environment and Climate Change Strategy

September 2019

Introduction

The Information Requirements Table (IRT) serves as the single list of information requirements for a *Mines Act* (MA) permit application, issued by the Ministry of Energy, Mines and Petroleum Resources (EMPR), and an effluent discharge permit application under the *Environmental Management Act* (EMA), by the Ministry of Environment (ENV). The IRT is intended to:

- Be used in conjunction with the document entitled, "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits"[1] and is intended for use in the development of both new and/or permit amendment applications. The information contained within the IRT will be developed to meet the unique nature of each project.
- It is also to be used in conjunction with all other guidance provided by either ENV or EMPR[2].
- Inform clients of the detailed information required to support MA and EMA permit applications and ensure all the information necessary to support the MA and EMA applications is provided; and
- Aid ENV and EMPR technical staff during the screening phase.

Overview

The IRT is intended to aid proponents and reviewers through the coordinated authorizations review process: during the pre-application stage to determine the information requirements, prior to submitting an application, and in screening, to ensure the required information has been included in the application submission.

It is recommended that proponents carefully review the entire Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits and consider any possible information requirements that may apply to their project proposal. If a specific methodology from the Joint Application Information Requirements guidance document is being proposed, this should be identified in the IRT and initially be described at a high level by proponents during the pre-application stage. More detail or specific Information Requirements can be added by adding in new lines into the IRT in the appropriate section.

After proponents have created a first draft of the IRT, reviewers will carefully review the project

[1] https://www2.gov.bc.ca/gov/content/industry/mineral-exploration-mining/permitting This link does not lead directly to the referenced document: https://www2.gov.bc.ca/assets/gov/environment/waste-management/industrial-waste/industrial-waste/mining-smelt-energy/2019_09_24_joint_application_information_requirements.pdf

[2] https://www2.gov.bc.ca/gov/content/environment/waste-management/industrial-waste/mining-smelting This link does not lead directly to the referenced document : https://www2.gov.bc.ca/gov/content/environment/waste-management/industrial-waste/mining-smelting/guidance-documents

proposal and draft IRT prior to meeting with proponents to identify any missing information requirements or areas that require further discussion. The pre-application phase is most often an iterative set of discussions between the proponent and technical reviewers, regarding the information requirements and any specifics and/or methodologies that may be required in a joint MA/EMA permit application.

Once complete, the province will send the final IRT to proponents for their use in preparing their application. A copy of the IRT must accompany the application submission by proponents and must indicate the locations of each information requirement within the application (far right-hand column).

It is important to note that changes in a project proposal may occur during the pre-application, screening, and/or review phases of the process. These changes may require a reassessment of the information required for an application. Proponents and reviewers will work together to discuss these changes and identify any revisions or additional information requirements.

Abbreviations

CEMP	Construction Environmental Management Plan
CSM	Conceptual Site Model
EMA	*Environmental Management Act*
EMPR	Ministry of Energy, Mines and Petroleum Resources
ENV	Ministry of Environment and Climate Change Strategy
IFC	Issued for Construction
IRT	Information Requirements Table
MA	*Mines Act*
ML/ARD	Metal Leaching and Acid Rock Drainage
WHMIS	Workplace Hazardous Materials Information System

Application Sign-Off

Project: Brucejack Mine 4950 tpd Joint M-243/PE-107835 Amendments Application

Applicant Representative:

Name: Pretium Resources Inc., Sylvia Van Zalingen

Title: Director, Permitting

Applicant Signature to indicate Agreement with Requirements

_____ Date signed: _____

Ministry of Environment and Climate Change Strategy, Environmental Protection Division

Application (AMS Tracking #: 418137), Authorization #: PE-107835

Ministry Representative:

Name: Todd Adamsson

Title: Environmental Protection Officer

Ministry Representative Signature to indicate Agreement with Requirements

_____Date signed: _____

Ministry of Energy, Mines, and Petroleum Resources, Major Mines Office

Ministry Representative:

Name: _____

Title: _____

Ministry Representative Signature to indicate Agreement with Requirements

_____Date signed: _____

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	Requirements	Comments	Location in Final Application
1. INTRODUCTION AND PROJECT OVERVIEW			
1.1. Application Background	Required ☒ Methods ☐		Section 1.1
1.2. Proponent Information	Required ☒ Methods ☐		Section 1.3
1.3. Project Overview			
1.3.1. Project History	Required ☒ Methods ☐		Section 1.4.1
1.3.2. Overview of Products and Markets, and Projected Project Benefits	Required ☐ Methods ☐		N/A
1.3.3. Location, Access and Land Use	Required ☒ Methods ☐		Section 1.4.2
1.3.4. Mine Components and Off-Site Infrastructure	Required ☒ Methods ☐		Section 1.4.3
1.3.5. Mine Development and Operations	Required ☒ Methods ☒		Section 1.4.4
1.3.6. Mine Design and Assessment Team	Required ☒ Methods ☒		Section 1.4.5
1.3.7. Spatial Data	Required ☒ Methods ☐		Section 1.4.6
1.3.8. Concordance with Environmental Assessment Conditions	Required ☒ Methods ☐	Summary of concordance with EA Certificate M15-01 conditions.	Section 1.4.7
1.4. Regulatory Framework	Required ☒ Methods ☐	An outline of existing licences/permits/authorizations and which will be amended.	Section 1.5
1.5. Indigenous Engagement			
1.5.1. Background	Required ☒ Methods ☐		Section 1.6.1
1.5.2. Asserted and Established Rights and Interests	Required ☒ Methods ☐		Section 1.6.2
1.5.3. Engagement Efforts	Required ☒ Methods ☐		Section 1.6.3
2. BASELINE INFORMATION			
2.1. Summary	Required ☒ Methods ☒	1) Reference will be provided to previously submitted documents containing baseline information. 2) Will provide updated climate, water quantity and water quality characterizations based on monitoring data collected through 2021.	1) Section 2.1 and Chapter 2 subsections 2) Section 2.2 and Appendix 5-2 (Updated climate and water quantity characterizations), Appendix 5-3 (updated water quality characterization)
2.2. Meteorology and Climate	Required ☒ Methods ☒	1) Predicted effects of climate change on temperature and precipitation to 2100 will be included in the water balance model report. 2) Will provide the mine's tCO2 reported in 2021, including the 3rd party verification report for the 2021 reporting year.	1) Appendix 5-2 2) Appendix 2-1
2.3. Geology			
2.3.1. Regional Geology	Required ☒ Methods ☐		Section 2.3
2.3.2. Deposit (Ore) Geology	Required ☒ Methods ☐		Section 2.3
2.3.3. Surficial Geology, Terrain, and Geohazard Mapping	Required ☒ Methods ☐		Section 2.3
2.3.4. Natural and Seismic Hazards Assessments	Required ☐ Methods ☐		N/A
2.3.5. Soil Survey and Soil Characterization for Reclamation	Required ☐ Methods ☐		N/A
2.4. Geochemical Characterisation and Source Terms	Required ☒ Methods ☐		Section 2.4 and Appendix 5-3
2.4.1. Geochemical Characterization	Required ☒ Methods ☒	Summarized in Section 2.4 with reference to previously submitted documents. Additional characterization information will be provided in the source term section of the Water Quality Modeling Report.	Section 2.4 and Appendix 5-3 (Section 3)
2.4.2. Geochemical Source Terms	Required ☒ Methods ☒	Will provide this information in the Water Quality Modeling Report.	Section 3 of Appendix 5-3
2.5. Topography and Surface Drainage Features	Required ☒ Methods ☐		Section 2.5
2.6. Water Quantity			
2.6.1. Surface Water Quantity	Required ☒ Methods ☒	This information will be provided in the water balance modeling report that will be appended to the application and includes information	Section 2.6.1 and Appendix 5-2

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	Requirements	Comments	Location in Final Application
		regarding current surface water discharge volumes and a comparison to a potential increase in discharge volume resulting from the proposed production increase.	
2.6.2. Groundwater Quantity	Required ☒ Methods ☒	This information will be provided in the groundwater modeling report that will be appended to the application.	Section 2.6.2 and Appendix 5-1
2.7. Water Quality			
2.7.1. Surface Water Quality	Required ☒ Methods ☒	The Water Quality Modeling report will compare existing discharge concentrations to modeled concentrations, and to existing and proposed discharge limits for POPCs.	Section 2.7.1 and Appendix 5-3
2.7.2. Groundwater Quality	Required ☒ Methods ☒		Section 2.7.2 and Appendix 5-1
2.8. Sediment Quality	Required ☒ Methods ☐		Section 2.8
2.9. Fisheries and Aquatic Resources			
2.9.1. Periphyton and Benthic Invertebrate Community Measures	Required ☒ Methods ☐		Section 2.9.1
2.9.2. Fish and Fish Habitat	Required ☒ Methods ☐		Section 2.9.2
2.9.3. Tissue Residues	Required ☒ Methods ☐		Section 2.9.3
2.10. Ecosystems and Wildlife	Required ☐ Methods ☐		N/A
2.11. Land Status and Use	Required ☐ Methods ☐		N/A
2.12. Archaeology	Required ☐ Methods ☐		N/A
2.13. Cultural Use	Required ☐ Methods ☐		N/A
3. MINE PLAN			
3.1. Mine Plan Overview	Required ☒	1) Any changes to mining methods will be presented in the mine plan chapter. (No changes are proposed to mining methods.) 2) With respect to blasting agents, any changes will be incorporated into the nitrogen source terms described in the water quality model report. The specific locations where this information is provided will be identified in the Table of Concordance.	1) Sections 3.1 and 3.5 2) Section 3.8 of Appendix 5-3 (Nitrogen source terms)
3.2. Existing Development	Required ☒		Section 3.2
3.3. Life of Mine Plan	Required ☒		Section 3.3
3.4. Detailed Five Year Mine Plan	Required ☒	Mine plan vertical extents will be depicted in the mine plan chapter.	Section 3.4
3.5. Mine Facility Designs and Development	Required ☐		N/A
3.5.1. Open Pits	Required ☐		N/A
3.5.2. Underground Workings	Required ☒	1) The horizontal and vertical extents of the underground mine workings associated with the mine plan will be presented in the application. 2) A description will be provided of any changes in stope and/or drift sizing. (No changes are proposed.)	1) Section 3.3 and Section 3.4 2) Section 3.5 (no change)
3.5.3. Processing Plant (Mill) and Associated Facilities	Required ☒	Describe changes required for the proposed increased ore processing rate.	Section 3.1 (for summary of changes), Section 3.5
3.5.4. Tailings Storage Facility and Associated Infrastructure	Required ☒	1) Describe any changes to the WRTSF and associated infrastructure and operations with the 4950 tpd mine plan. This includes both the Waste Rock Dump (WRD) and tailings deposition within the WRTSF. [Note that the presented changes include subaqueous deposition of waste rock at the east end of the WRTSF (east WRD) and associated infrastructure (access and surface stockpile sites) that are proposed for existing operations and for which there will be applications for authorization outside of the 4950 tpd Joint Application process.	1) Sections 3.1, 3.4, and Section 3.5 2) Section 3.2 and Section 3.5 3) Sections 3.3 and 3.4 4) Appendix 3-2 and Appendix 9-1-17 5) Appendix 9-1-17 6) Appendix 9-1-17 7) Section 3.4 8) Appendix 3-1

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	**Requirements**	**Comments**	**Location in Final Application**
		2) The application will confirm that the capacity of current or updated mine waste storage facilities have the required capacities. 3) Mine progression figures included in the mine plan chapter will present the anticipated end of year footprints for waste rock dump and tailings within the WRTSF for 2022 through 2027, and the end of mine operations (2029). 4) Current methods used to manage and monitor pore water pressures based on dump performance and settlement in WRD during placement will be described, along with additional methods and instrumentation being considered to monitor pore water pressures. 5) The SOP for remote dozer placement of waste rock material is in the current OMS manual and details will be provided. 6) The Waste Rock and Tailings Storage Facility Operations, Maintenance and Surveillance (OMS) Manual will be provided, which includes a description of dump settlement monitoring. 7) The anticipated year by year increase in the tailings/WRD footprint will be provided via mine progression figures for end of 2022 through 2027, and the end of mine operations (2029). 8) Effects of increased processing rate on deposition of waste rock and tailings into the WRTSF will be described.	
3.5.5. Waste Rock Dumps	Required ☒	1) The information for both waste rock and tailings will be provided in a combined section as noted in the comments for section 3.5.4. 2) Preliminary design of the temporary waste stockpiles currently placed in the WRTSF will be described. The application will also describe other stockpile alternatives, such as a WRD and associated stockpiles proposed at the east end of the WRTSF that are needed for current mine operations and for which separate (from the 4950 tpd Joint Application) applications will be submitted. 3) Any aspects relevant to the production increase will be described. 4) Current waste rock management strategies will be described. 5) The application will also describe, to the extent that information is currently available, proposed waste rock management strategies that are aligned with the requirements set out in Permit condition D.3.(c).(v) and intended to fulfill requirements of open Order 185855-S1-O1. 6) The application will include life of mine extents of the waste rock and tailings based on the updated mine plan,	1) Section 3.5 2) Appendix 3-2 3) Section 3.5 and Appendix 3-1 4) Section 3.5, Appendix 3-1 and Appendix 9-1-17 5) Section 3.5 and Appendix 3-1 and Appendix 9-1-17 6) Section 3.4 7) Appendix 3-2 8) Section and Appendix 3-1

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	**Requirements**	**Comments**	**Location in Final Application**
		7) Stability analysis for the main waste rock dump and temporary surface stockpile, design assumptions and criteria based on current information available, and recommendations for additional geotechnical investigation, laboratory testing, instrumentation and liquefaction assessment. 8) The application will describe potential development of an additional subaqueous waste rock deposition site at the east end of the WRTSF (East WRD), proposed via separate authorization process because of its requirement for current operations, which is expected to address waste rock deposition requirements for operations at both the current and proposed production rates, and to address depletion of the current temporary waste stockpiles.	
3.5.6. Water Management Structures	Required ☒	1) Describe any changes to water management structures. 2) Information regarding increased rates of tailings and waste water discharges to Brucejack Lake will be provided in the Water Balance Model Report. 3) Any changes to water management structures due to the proposed production increase will be provided in the Water Management subsection of the Mine Plan chapter.	1) Section 3.1 (for summary of changes) and Section 3.5 2) Appendix 5-2 3) Section 3.1 (for summary of changes) and Section 3.5
3.5.7. Ore, Overburden, Soil and Construction Stockpiles	Required ☒		Section 3.2 and Section 3.5
3.5.8. Mine Access and Mine Haulage Roads	Required ☒	No mine access or haul road upgrades are required for the production rate increase. Proposed access to the (proposed) East WRD required for existing operations, and to be authorized via separate process, will be described.	Sections 3.1, 3.4, and 3.5
3.5.9. Power Supply and Distribution Infrastructure	Required ☒	Describe any changes to power supply requirements.	Sections 3.1 and 3.5
3.5.10. Explosives Storage Facilities	Required ☒	Describe any changes to explosives storage facilities.	Sections 3.1 and 3.5
3.5.11. Ancillary Facilities and Support Infrastructure	Required ☒	Describe any changes to ancillary facilities and support infrastructure.	Sections 3.1 and 3.5
4. RECLAMATION AND CLOSURE PLAN			
4.1. End Land Use and Capability Objectives	Required ☐	No change to existing.	Section 4.2 and Appendix 4-1 Section 2
4.2. Reclamation Approaches Required ☐ Comments Click here to enter text.			
4.2.1. Soil Resources	Required ☐	No change to existing reclamation approaches.	Section 4.3.2 and Appendix 4-1 Section 3.2
4.2.2. Landform Design and Erosion Control	Required ☐		Section 4.3.3 and Appendix 4-1 Section 3.3
4.2.3. Revegetation Strategy	Required ☐		Appendix 4-1 Section 3.4
4.2.4. Progressive Reclamation/Sequencing	Required ☐		Appendix 4-1 Section 3.5
4.2.5. Reclamation Research	Required ☐		Appendix 4-1 Section 3.6
4.2.6. Reclamation Monitoring	Required ☐		Appendix 4-1 Section 3.7
4.2.7. Habitat Compensation Works	Required ☐		N/A
4.3. Trace Element Uptake in Soils and Vegetation	Required ☐ Methods ☐		Appendix 4-1 Section 4
4.4. Contaminated Sites, Human Health and Ecological Risk Assessment	Required ☐ Methods ☐		Appendix 4-1 Section 5
4.5. Disposal of Chemicals, Reagents, Hazardous Materials and Contaminated Materials	Required ☐ Methods ☐		Appendix 4-1 Section 6
4.6. Groundwater Well Decommissioning	Required ☐ Methods ☐		Appendix 4-1 Section 7
4.7. Reclamation and Closure Prescriptions			

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	Requirements	Comments	Location in Final Application
4.7.1. Structures and Equipment	Required ☒	Existing reclamation and closure prescriptions will be updated as appropriate.	Section 4.4.2 and Appendix 4-1 Section 8.2
4.7.2. Waste Rock Dump Reclamation	Required ☒		Section 4.4.2 and Appendix 4-1 Section 8.3
4.7.3. Tailings Storage Facility Reclamation	Required ☒		Appendix 4-1 Section 8.3
4.7.4. Open Pit Reclamation Prescriptions	Required ☐		N/A
4.7.5. Watercourse Reclamation Prescriptions	Required ☒		Appendix 4-1 Section 8.4
4.7.6. Road Reclamation	Required ☒		Appendix 4-1 Section 8.8
4.7.7. Schedule	Required ☒		Section 4.4.1 and Appendix 4-1 Section 8.1.1
4.8. Detailed Five-Year Mine Reclamation Plan	Required ☒	Update as appropriate from 2020 Update based on 2029 end of operations.	Section 4.5 and Appendix 4-1 Section 10
4.9. Temporary Shutdown	Required ☐		Appendix 4-1 Section 11
4.10. Post-Closure Monitoring and Maintenance	Required ☒	Update as appropriate or state no change.	Section 4.6 and Appendix 4-1 Section 12
4.11. Reclamation Cost Estimate			
4.11.1. Conventional Reclamation and Closure	Required ☒		Section 4.7, submitted to the Chief Permitting Officer under separate cover as per Code Section 10.1.3(i).
4.11.2. Post-Closure Monitoring	Required ☒		Section 4.7, submitted to the Chief Permitting Officer under separate cover as per Code Section 10.1.3(i).
4.11.3. Post-Closure Maintenance (excluding Water Treatment)	Required ☒		Section 4.7, submitted to the Chief Permitting Officer under separate cover as per Code Section 10.1.3(i).
4.11.4. Life of Mine Water Treatment	Required ☒	The updated reclamation liability costing calculations to be submitted to BC EMLI will include updated costs for water treatment during mine closure while the underground mine floods, and for monitoring 5 years post closure.	Section 4.7, submitted to the Chief Permitting Officer under separate cover as per Code Section 10.1.3(i).
5. MODELLING, MITIGATION, AND DISCHARGES			
5.1. Summary	Required ☒		Section 5.1
5.2. Conceptual Site Model	Required ☒ Methods ☒	Pretium will provide documentation of the conceptual models and the new mine plan in sections within the respective stand-alone modeling reports (Water Balance, Groundwater and Water Quality).	Section 5.2 and appendices 5-1 (Groundwater Model Report), 5-2 (Water Balance Model Report), and 5-3 (Water Quality Model Report)
5.3. Site-Wide Water Balance Model	Required ☒ Methods ☒		Section 5.4 and Appendix 5-2
5.4. Surface Water Quality Model	Required ☒ Methods ☒	Existing model will be updated with updated water balance model, updated groundwater model, and updated source terms. A standalone surface water quality model report describing the modeling methods will be included as part of the application. The water quality model background source terms for the WRTSF include the historic input of Goldwedge to the WRTSF through Catear Creek, based on Brucejack Lake water quality data to 2013. This will be described in the Water Quality Model report.	Section 5.5 and Appendix 5-3
5.5. Groundwater Model			
5.5.1. Conceptual Hydrogeologic Model	Required ☒ Methods ☒	A standalone groundwater model report will be provided that includes documentation of field data that were used to support development of a conceptual groundwater model.	Appendix 5-1

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	Requirements	Comments	Location in Final Application
5.5.2. Numeric Hydrogeologic Model	Required ☒ Methods ☒	A full groundwater modeling report will be provided as an appendix of the Joint Application, with a summary provided in the main report chapter.	Section 5.3 and Appendix 5-1
5.6. Mitigation Methods	Required ☒		
5.6.1. Best Achievable Technology Evaluation	Required ☒ Methods ☒	A BAT study will be presented to evaluate treatment options at the outlet to the WRTSF for the POCs identified in Water Quality Model Report.	Section 5.6 and Appendix 5-4
5.6.2. Volume and Quantity Control Methods	Required ☐ Methods ☐		N/A
5.6.3. Geochemical Attenuation Processes	Required ☐ Methods ☐		N/A
5.6.4. Water Treatment			
5.6.4.1. Description	Required ☒	The current treatment plant and its ability to treat the anticipated water quality and water quantity predicted for the 4950 tpd production rate will be described.	Section 5.6 and Appendix 5 (Section 3.5)
5.6.4.2. Location	Required ☒		Sections 1.4 and 3.2
5.6.4.3. Detailed Design	Required ☒	Will be provided if changes are proposed.	N/A – No changes to existing water treatment are proposed
5.6.4.4. Treatment Effectiveness	Required ☒	If the production rate increase results in changes to influent quantity or quality the application will include an assessment of how those changes may affect treatment effectiveness.	Section 5.6.1
5.6.4.5. Performance Risks	Required ☒	This will be provided if changes are proposed.	N/A – No changes to existing water treatment are proposed
5.6.4.6. Influent and Effluent Water Quality	Required ☒	Any changes will be described.	Section 5.6 and Appendix 5-3
5.6.4.7. Waste and By-Products	Required ☒	This will be provided if changes are proposed.	N/A – No changes are proposed
5.6.4.8. Maintenance	Required ☒	This will be provided if changes are proposed.	N/A – No changes are proposed
5.6.4.9. Emergency Response Plans	Required ☒	This will be provided if changes are proposed.	N/A – No changes are proposed
5.6.4.10. Monitoring Plans	Required ☒	This will be provided if changes are proposed.	N/A – No changes are proposed
5.6.4.11. Schedule	Required ☒	This will be provided if changes are proposed.	N/A – No changes are proposed
5.6.4.12. Cost Estimate	Required ☒	This will be provided if changes are proposed.	N/A – No changes are proposed
5.7. Domestic Water/Sewage Treatment	Required ☒ Methods ☐	No changes to the existing STP are proposed. The application will conservatively include a request for a 4th sewage treatment unit to ensure continued full redundancy of one treatment unit in case discharge above 150 m3/d is required.	Clause change form – revised description of the treatment works. (No change is proposed to the current discharge rate of 175 m3/d.)
5.8. Effluent Discharge	Required ☒ Methods ☒	Characterization of effluent discharge water quantity and quality will be provided.	Effluent quantity – Section 5.4 and Appendix 5-2 Effluent quality – Section 5.5 and Appendix 5-3
5.9. Initial Dilution Zone	Required ☐ Methods ☐	An IDZ is not required if the discharge is not chronically toxic. QP documentation will be provided to support the current discharge limits and that the proposed discharge limits are not expected to cause the effluent to be chronically toxic.	N/A
6. ENVIRONMENTAL ASSESSMENT PREDICTIONS			
6.1. Aquatic Resources	Required ☒ Methods ☒	Nutrients will be included in the assessment provided.	Section 5 of Appendix 5-3
6.2. Terrestrial Resources	Required ☐ Methods ☐	No increase to surface disturbance expected with production increase.	N/A
7. ENVIRONMENTAL MONITORING			
7.1. Environmental Monitoring Program Design	Required ☒ Methods ☒	The production rate increase is not expected to require changes to existing environmental monitoring plans.	Section 7.1

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	Requirements	Comments	Location in Final Application
		The existing environmental monitoring program will be described.	
7.2. Mine Site Water Monitoring Program	Required ☒ Methods ☒		Section 7.2
7.3. Discharge Monitoring Program	Required ☒ Methods ☒	The existing discharge monitoring program is outlined in Effluent Permit 107835 and the Aquatic Effects Monitoring Plan (AEMP). Pretium will provide a summary of the program, with references to PE-107835 and the AEMP. Any proposed changes to the discharge monitoring program due to the proposed production increase will be described.	Section 7.3
7.4. Environment Monitoring Program	Required ☒ Methods ☒	The existing environmental monitoring program is outlined in Effluent Permit 107835, Air Permit 107025, Mines Act Permit M-243, in various other authorizations and in the Brucejack Mine EMS component management plans. Pretium will provide a summary of the program, with references to key authorizations and managements. In the case of groundwater, these include PE-107835 and the AEMP. Any proposed changes to the environmental monitoring program, including the groundwater monitoring program, due to the proposed production increase will be described.	Section 7.1
7.5. Cumulative Effects	Required ☐ Methods ☐	Pretium will meet with TCG to discuss cumulative effects. The water quality modeling includes cumulative historic effects of drainage from the Goldwedge site, as that is reflected in the baseline data.	N/A
7.6. Post-Closure Environmental Monitoring Program	Required ☒ Methods ☒	The proposed post-closure environmental monitoring program will be described in the updated Reclamation and Closure Plan that will be a stand-alone appendix of the application. Post-closure water quality predictions and related environmental effects assessments will be provided in the Water Quality Modeling Report.	Section 7.4 and Appendix 4-1
7.7. Aquatic Effect Monitoring Program	Required ☒ Methods ☒	The existing aquatic effects monitoring program is outlined in Effluent Permit 107835 and described in the Aquatic Effects Monitoring Plan (AEMP). Pretium will provide a summary of the program, with references to PE-107835 and the AEMP.	Section 7.5
8. HEALTH AND SAFETY			
8.1. Occupational Health and Safety Program			
8.1.1. Occupational Health Risk Assessment	Required ☐	The production rate increase does not require changes to existing occupational health and safety programs.	N/A
8.1.2. Ergonomics	Required ☐		N/A
8.1.3. Emergency Wash Facilities	Required ☐		N/A
8.1.4. Hazardous Dust	Required ☐		N/A
8.1.5. Lunchrooms, Mine Dry, and Sanitary Conveniences	Required ☐		N/A
8.2. Post-Permitting Requirements			
8.2.1. Issued for Construction Plans	Required ☐		N/A
8.2.2. Letters of Assurance	Required ☐		N/A
8.2.3. Occupational Health Programs	Required ☐		N/A
8.2.4. Workplace Hazardous Materials Information System (WHMIS)	Required ☐		N/A
8.2.5. Additional Information and Certifications	Required ☐		N/A
9. MANAGEMENT PLANS			
9.1. Environmental Management System	Required ☒	Any proposed changes to management plans will be described in the application. Consistent with previous applications and reviews, any required updates to management plans will be completed post-review to incorporate changes resulting from review.	Section 9.1

Information (refer to "Joint Application Information Requirements for *Mines Act* and *Environmental Management Act* Permits" for additional info on each section)	Requirements	Comments	Location in Final Application
		Pretium will describe the existing Environmental Management System, and any changes anticipated to be needed to existing component Management Plans due to the proposed production increase.	
9.2. Surface Erosion Prevention and Sediment Control Plan	Required ☒		Appendix 9-2
9.3. Soil Management Plan	Required ☒		Appendix 9-1
9.4. Construction Environmental Management Plan	Required ☒		N/A
9.5. ML/ARD Management Plan	Required ☒		Appendix 9-1
9.6. Mine Site Water Management Plan	Required ☒		Appendix 9-1
9.7. Discharge Management Plan	Required ☒	1) The BAT to be provided in accordance with comment ENV JIRT-6 for JIRT Section 5.6.4 will describe any recommended changes to water treatment and associated water management, however it is not currently anticipated that changes to either will be proposed. 2) The application will include a draft Trigger Response Plan that is based on monitoring at BJ 3.10, which is the outflow from the WRTSF and the headwaters of Brucejack Creek.	1) N/A No changes to water treatment are proposed 2) Section 5.9
9.8. Vegetation Management Plan	Required ☐		Appendix 9-1
9.9. Invasive Plant Management Plan	Required ☐		Appendix 9-1
9.10. Wildlife Management Plan	Required ☐		Appendix 9-1
9.11. Archaeological Management and Impact Mitigation Plan	Required ☐		Appendix 9-1
9.12. Mine Emergency Response Plan	Required ☐		Appendix 9-1
9.13. Mine Site Traffic Control Plan	Required ☐		Appendix 9-1
9.14. Fuel Management and Spill Control Plan	Required ☒	The proposed increase in production rate is not expected to require any changes to the Spill Response Plan, as spill response methodologies and other aspects of this plan are unlikely to require change. However, if changes to this or any other management plan are determined during the application review to be necessary, such changes will be made post-review.	Appendix 9-1
9.15. Combustible Dust Management Plan	Required ☐		N/A
9.16. Chemicals and Materials Storage, Transfer, and Handling Plan	Required ☒	The proposed increase in production rate is not expected to require any changes to the Chemicals and Materials Storage and Handling Plan, including because there are no plans to change reagents or other chemicals in relation to increasing the production rate. However, if changes to this or any other management plan are determined during the application review to be necessary, such changes will be made post-review.	Appendix 9-1
9.17. Waste (Refuse and Emissions) Management Plan	Required ☒	The relevant JIRT guidance document content requirements for a Waste (Refuse and Emissions) Management Plan are addressed through the Brucejack Mine's existing Air Quality Management Plan and Refuse Incinerator Management Plan. No changes to either management plan are expected to be needed in relation to the proposed 4950 tpd production increase. However, if changes to this or any other management plan are determined during the application review to be necessary, such changes will be made post-review.	Air Quality Management Plan - Appendix 9-1 Refuse Incinerator Management Plan - Appendix 9-2
9.18. Fugitive Dust Management Plan	Required ☒☐		N/A

Appendix 1-3: Application Instruction Document

January 16, 2023

Authorization Number: 107835
Tracking Number: 418137

VIA EMAIL: Sylvia Van Zalingen SVanZalingen@pretivm.com

Pretium Resources Inc.
2300 – 1055 Dunsmuir Street
Four Benthall Centre
PO Box 49334
Vancouver, BC
V7X 1L4

Dear Applicant:

Re: Confirmation of *Environmental Management Act* and *Mines Act* Authorizations Joint Amendment Application Information Requirements

This letter is to provide written confirmation of the application information that is required for your application to be considered complete and ready for consideration by the Mine Review Committee. This letter is your Application Instruction Document (AID) and details the information which must be included in your Final Application.

Technical Requirements

Attached you will find the final Information Requirements Table (IRT) which defines the technical aspects that should be included in your final application. A Technical Assessment Report which addresses all the information requirements in the IRT must be submitted with your Final Application. A copy of the final IRT must have the "Location in Final Application" column completed and be included with the final application. Guidance on how to prepare this report is available on the Ministry website[1].

To ensure professional accountability, the Ministry of Environment and Climate Change Strategy (ENV) requires that persons fulfilling legal requirements as qualified professionals (QPs) under ENV legislation must submit signed Declarations of Competency and signed Conflict of Interest Disclosure Statements. Completed declaration forms should be included in your final application. Each QP must provide declarations for the portion of the application for which they are responsible. Copies of the forms, and additional information, are available on the ENV website[2].

[1] Guidance Documents https://www2.gov.bc.ca/gov/content/environment/waste-management/industrial-waste/mining-smelting/guidance-documents.
[2] **QP forms and EPN Template** Apply for a waste discharge authorization - Province of British Columbia (gov.bc.ca)

Engagement Requirements

Indigenous Groups Consultation Requirements

The Project, as described in the Project Description dated July 22, 2022, is located within the traditional territory of the Tsetsaut Skii Km Lax Ha and Tahltan First Nations. It also has the potential to impact the Nass Wildlife Area of the Nisga'a Nation. Consultation with Indigenous groups is the responsibility of the Province of British Columbia and will be led by the Major Mines Office, Ministry of Energy, Mines and Low Carbon Innovation. It is recommended that Pretium Resources Inc. engage with the above identified First Nations throughout the authorization process.

Public Notification Requirements

The amendment application for the *Environmental Management Act* authorization is considered significant under the *Public Notification Regulation* (the Regulation)[3]. A completed Environmental Protection Notice[4] (EPN) must be submitted to ENV for review prior to posting or publication.

Notification must follow the procedures outlined in the Regulation, including:

- Posting notification as outlined in columns 4 and 5 of Schedule A;
- Posting on site;
- Notification of relevant municipalities (Terrace, Smithers and other towns that may experience an increase in air or road travel) and the Regional District of Kitimat-Stikine;
- Publication in the BC Gazette, Part I at the applicant's expense;
- Publication in local newspapers at the applicant's expense, including:
    - Smithers Interior News; and,
    - Terrace Standard;
- Publication of the application Technical Assessment Report in a format that is suitable for public access, such as a digital format available at a local public library or available online for download.

Notification and Engagement Report

Once notifications are complete and after the public comment period closes, a Notification and Engagement Report must be prepared for submission to ENV. The Notification and Engagement Report must be submitted during the application review phase. Guidance on the notification process is available on the ENV website[4].

Next Steps

Now that the Preliminary Application Phase is complete, it is up to you, the applicant, to prepare your final application for submission in accordance with the technical and engagement requirements identified in this AID.

[3] **Public Notification Regulation** https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/202_94
[4] **Guidance on Notifications for Authorizations**: https://www2.gov.bc.ca/assets/gov/environment/waste-management/waste-discharge-authorization/guides/forms/7063_env_regionalops_notification_guide_web.pdf

The applicant should submit all documents for the final application package, including the final application forms to PermitAdministration.VictoriaEPD@gov.bc.ca, or via mail/courier to the addresses on the final application form. Final application forms and guidance on the application process for waste discharge authorizations are available on the ENV website[1].

If you have any questions, please contact the undersigned or Todd Adamsson at Todd.Adamsson@gov.bc.ca or 250-739-8393 and include your tracking number.

Yours truly,

Neil Bailey, P.Eng
Section Head, Northern Mining Authorizations
for director, *Environment Management Act*

Enclosure: IRT Table

Chapter 2 Appendices

Appendix 2-1 Brucejack 4950 tpd Permit Application Screening, Climate Data Summary Report

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

Brucejack 4950 tpd Permit Application Screening, Climate Data Summary

Prepared for:

Pretium Resources Inc.
2300 – 1055 Dunsmuir Street
Vancouver, BC
V7X 1L4

Prepared by:

Lorax Environmental Services
2289 Burrard St.
Vancouver, B.C., V6J 3H9

Project No. A624-2

26 October 2023

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1. Introduction

Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies, is the permittee for the Brucejack Mine, an underground gold mine located approximately 60 km NNW of Stewart, B.C. Pretium has submitted a joint application to amend *Mines Act* Permit M-243 and Effluent Permit 107835 for changes that would authorize an increase in the average daily ore production rate from the currently authorized 3800 tpd to 4950 tpd (4950 tpd Joint Application).

This report has been prepared to address a comment received from BC Ministry of Environment and Climate Change Strategy (ENV) during screening of the 4950 tpd Joint Application (Comment ID 1 in the information tracking table) that baseline (*i.e.*, prior to the permit amendment application) normal and extreme ranges of the following climate parameters be provided, at both monthly and annual intervals, including descriptions of the techniques used to determine them:

- Air temperature;
- Precipitation;
- Snowpack;
- Evaporation;
- Solar Radiation; and
- Wind Speed and Direction.

The sections that follow provide: 1) an overview of the Brucejack Meteorological Monitoring Program (MMP) (Section 2); 2) a discussion of the relevant steps taken to compile and process site-specific climate data (Section 3); and 3) a summary of relevant meteorological data collected at the Valley of King (VOK) meteorological station (Section 4), a station situated nearest the mine operation, at elevation 1,501 m asl.

It is noted that content presented in Section 2 and Section 3 of this report is synthesized from Meteorology Monitoring Reports (MMR) that are prepared annually (*e.g.*, Pretium 2021, Pretium 2022a and Pretium 2023). The reader is directed to these MMRs, and reports that precede them, for further detail regarding the Brucejack MMP.

The primary authorizations for construction and operation of the Brucejack Mine were received in 2015, including the CEAA 2012 Decision Statement, EA Certificate M15-01, *Mines Act* Permit M-243, Effluent Permit 107835 and amended Air Permit 107025. Construction began in late 2015. Baseline data for the period prior to construction are

documented in the EAC/EIS application (Rescan, 2013) and MA/EMA Permits Application (Pretium, 2015).

2. Brucejack Meteorological Monitoring Program

2.1 Background

The MMP aims to characterize current climate conditions in the immediate vicinity of the Brucejack Mine and associated infrastructure. The MMP is a component of the Air Quality Management Plan (Pretium 2022b) and a requirement of *Environmental Management Act* Permit PA-107025 (Discharge to Air) Section 5.3.

Meteorological data are routinely used to support daily activities at the mine site, such as air discharge operations and monitoring, avalanche forecasting and control, planning of water management activities, road maintenance and airstrip operations. Site-specific meteorological data are also primary inputs to technical evaluations conducted by Newcrest and their technical consultants (*e.g.*, Brucejack groundwater model and the Brucejack site-wide water balance and water quality model).

2.2 Monitoring Network

The Brucejack MMP has been ongoing since 2009 to characterize on-site meteorological conditions. In 2009, focus was placed on initiating monitoring in the deposit area, near the former Brucejack Lake, with the installation of the Brucejack meteorological station. In 2010 and 2011 the MMP expanded with the installation of the Scott Creek and Wildfire meteorological stations in response to evolving infrastructure development plans.

In August and September 2014, the three historical climate stations were decommissioned, and stations were re-established at new locations (Table 2-1, Figure 2-1). The former Brucejack meteorological station was moved 1 km to the southeast within the Valley of Kings (VOK) and is referred to herein as the VOK meteorological station. Owing to the near proximity of this station to the mining operation, the climate tables and time series plots presented in Section 4 of this report are for VOK meteorological station.

The Scott Creek meteorological station was relocated to an area adjacent to the Brucejack Access Road (BJAR) at road Kilometer 49.5 and was renamed Bowser meteorological station. The Bowser station location is useful in providing weather conditions for the Bowser aerodrome. The Wildfire meteorological station equipment was moved to an area adjacent to the BJAR at road Kilometer 18 and renamed Scott Pass meteorological station. The Scott Pass location was chosen to provide weather information along the Access Road.

In May 2016, a new station consisting of a ceilometer and visibility sensor was installed in Bowser camp to measure cloud ceiling heights and visibility in support of aircraft traffic at

Bowser Aerodrome (Bowser Lake Air, Table 2-1). In December 2019, a new station (DMZ) measuring air temperature, barometric pressure, wind speed, snow depth, and precipitation was commissioned near kilometer 60 of the Brucejack Access Road to support avalanche forecasting and control operations.

Regarding local snow surveys, a ten-point snow course was established adjacent the VOK meteorological station in 2015 (Table 2-1,Figure 2-1). Snow course surveys are conducted here following guidelines by BC MOE (BC MOE 1981). On each survey, up to ten snow cores are taken along a 250 m long transect at intervals ranging between 18 and 44 m. The cores are then used to calculate the average snow densities and snow water equivalents (SWEs) for the sampling date.

Finally, VOK and BJC snow plots (Table 2-1) are used by the Brucejack Mountain Safety team to collect manual snow depth observations. Daily manual data from the snow plots are used to supplement data for the VOK meteorological station when the automated snow depth sensor at the climate tower malfunctions.

Table 2-1:
Meteorological Station Locations and Operating Periods

Meteorological Station	Elevation (masl)		UTM Coordinates[1]		Operating Period	
		Status	Easting (m)	Northing (m)	Start	End
Brucejack Lake	1,360	Historical	425,729	6,259,022	Oct. 13, 2009	Aug. 30, 2014
Scott Creek	780	Historical	451,418	6,254,104	July 29, 2010	Aug. 27, 2014
Wildfire Creek	720	Historical	470,397	6,256,874	Aug. 13, 2011	Aug. 26, 2014
VOK[2]	1,501	Current	426,301	6,258,276	Sept. 2, 2014	Active
Bowser	440	Current	443,003	6,250,540	Sept. 4, 2014	Active
Scott Pass	990	Current	456,394	6,262,968	Sept. 5, 2014	Active
Bowser Lake Air	450	Current	441,427	6,250,228	May 12, 2016	Active
DMZ	1,277	Current	436,731	6,253,311	Dec 9, 2020	Active
VOK Snow Plot	1,470	Current	428,710	6,258,156	Sept 21,2021	Active
BJC Snow Plot	1,420	Current	426,747	6,258,499	Oct 12, 2021	Active

[1] *Zone 9V, Datum NAD83*
[2] *Meteorological station and snow course.*

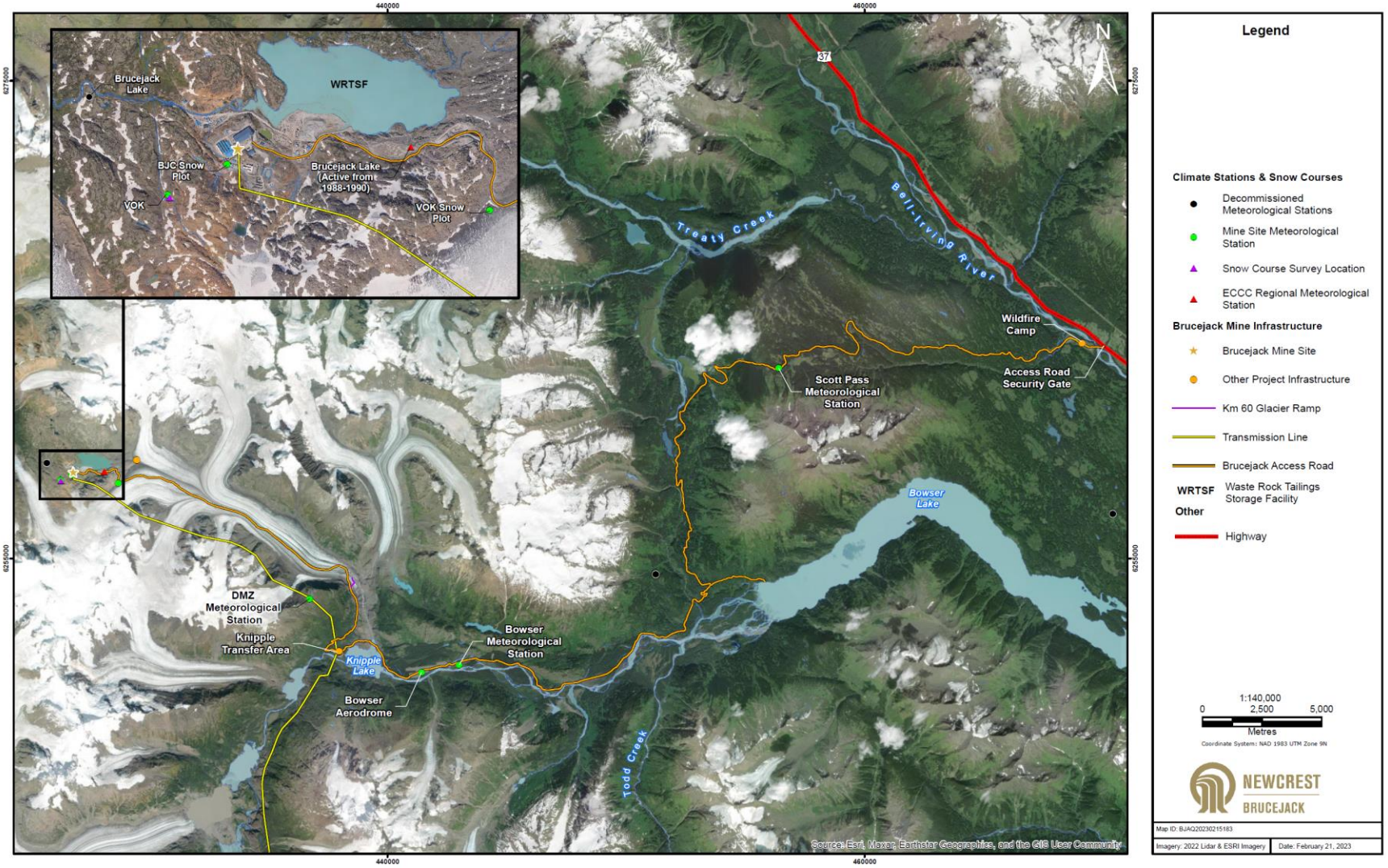


Figure 2-1: Locations of Meteorological Stations and Snow Course Surveys, Brucejack Mine

2.3 Station Instrumentation

Table 2-2 lists the climate parameters monitored at the continuously recording meteorological stations (*i.e.*, the VOK, Bowser and Scott Pass stations). Two-way satellite telemetry systems are installed on each station. These communication systems allow for automated remote downloading of data, faster identification of instrumentation issues, and more informed planning for field visits. Each satellite telemetry system includes a Moxa 5110 server and a Hughes 9502 terminal and antenna.

Combination temperature and relative humidity sensors (either Rotronic HC2-S3 or Vaisala HMP45C212) are mounted on each tower, approximately three to five meters above the ground (to prevent burial in the snowpack) and are protected from solar radiation by a multi-plate solar radiation shield (RM Young model 41003).

Geonor Model T-200B all-season precipitation gauges are used to measure liquid precipitation (*i.e.*, rainfall) and solid precipitation (i.e., snowfall; measured as SWE). The gauges are each mounted on 2.5 m high pedestals complete with a single Alter wind screen to help reduce wind-induced undercatch.

Local snow depths are monitored by Campbell Scientific model SR50A acoustic distance sensors mounted to each station tower at the Bowser and Scott Pass stations. At VOK meteorological station, the SR50A is mounted to a separate tower approximately 15 m away from the main tower.

Incoming solar radiation (direct and indirect short-wave radiation from the sky) is monitored using Kipp & Zonen SP Lite or SP Lite 2 pyranometers, whereas barometric pressure is monitored using RM Young models 61205V or 61302 barometric pressure sensors mounted inside respective datalogger enclosures.

Wind speed and direction are measured at the three continuously recording meteorological stations with RM Young Model 05305 wind sensors installed at the top of the steel towers - at a height of 10 m above the ground. This is the standard height for the collection of wind speed and wind direction data (EC 2012; WMO 2018; BC MOE 2016).

Climate sensors at each station are wired to Campbell Scientific dataloggers. A datalogger program scans each sensor at 5 second intervals and generates hourly and daily data tables along with instantaneous, average, maximum, minimum, total, and standard deviation values, depending on the meteorological variable. Data saved to the dataloggers are stored in internal memory as well to a compact flash card connected to each datalogger.

Pretium conducts periodic site visits to ensure ongoing and proper functioning of the meteorological stations. Maintenance and/or troubleshooting is conducted as needed with

summaries of site visit and sensor maintenance tasks reported in MMRs (*e.g.*, Pretium 2023).

Table 2-2:
Variables Monitored at Brucejack Meteorological Stations

Variable	Meteorological Station		
	VOK	**Bowser**	**Scott Pass**
Air Temperature	✓	✓	✓
Relative Humidity	✓	✓	✓
Precipitation (Rainfall + SWE[1])	✓	✓	✓
Wind Speed and Direction	✓	✓	✓
Incoming Solar and Net Radiation	✓	✓	✓
Barometric Pressure	✓	✓	✓
Snow Depth	✓	✓	✓

[1] – *Snow water equivalent (SWE)*

3. Data Processing and Method

3.1 Initial Screening

To prepare the climate data summary presented in Section 4, Lorax received copies of the daily- and hourly output files for the VOK meteorological station. These data spanned the period September 2, 2014, through October 19, 2023, and are managed by Newcrest using Aquarius Time Series™ software (v. 21.4., Aquatic Informatics Inc.). The Aquarius Time Series™ software platform is a centralized database specifically designed for the storage, management, and analysis of climatic and hydrologic data, and is widely used by water monitoring agencies such as the Water Survey of Canada (WSC) and ENV.

QA/QC algorithms are implemented in Aquarius, based on screening criteria by ECCC (EC 2004) and ERM (2018), to screen raw data that is offloaded from the Brucejack meteorological stations. Further, Lorax understands that data stored in Aquarius are reviewed periodically to ensure proper operation of the station sensors. Erroneous data are flagged and removed from the finalized reported dataset to the extent possible, with significant periods of flagged erroneous or missing data for the station discussed in annual MMRs.

3.2 Data Processing

Data received from Newcrest were further inspected upon receipt to identify erroneous or missing information. Next, pivot tables of the hourly climate records were computed to determine level of completeness. Computed completeness thresholds were very high for most parameters: *e.g.*, air temperature (99%); relative humidity (99%); solar radiation (100%); atmospheric pressure (97%); and wind speed and direction (99%).

Using hourly data as the input, pivot tables were then compiled at monthly/annual time steps to isolate averages and extremes (*i.e.*, maximum and minimum values) for key variables at the VOK meteorological station. Several time series plots were also prepared to demonstrate data completeness and any patterns/trends per climate variable for the 9+ years of record available for VOK meteorological station.

While daily/hourly data for October 2023 are shown in the time series plots presented in Section 4, monthly pivot table values for October 2023 are removed because data for this month are incomplete.

3.3 Precipitation

Lorax received infilled and adjusted precipitation data for VOK meteorological station current to August 16, 2023, to complete this technical report. Since precipitation data for August 2023 were only 52% complete, pivot tables presented in Section 4 for precipitation variables exclude reporting for this month.

3.3.1 Wind Induced Precipitation Undercatch Adjustment

Most precipitation gauges are affected by wind undercatch which is an underestimation attributable to wind turbulence around the gauge opening prevents precipitation particles from entering the gauge. Wind turbulence especially affects lighter solid precipitation particles (*i.e.*, snow). To account for precipitation underestimation caused by wind undercatch, the 2017 Meteorology Monitoring Report (ERM 2018) evaluated different undercatch equations and determined the equation developed by McDonald and Pomeroy (2007) was best suited for the snowfall characteristics of the BC coastal region.

This equation was used for daily precipitation adjustments in this report and is described below:

$$CE = 1.01 \times \exp(-0.09 \times U)$$

where CE is the catch efficiency of a single Alter wind screen Geonor precipitation gauge referenced to true snowfall, and U is the wind speed (m/s) at the Geonor orifice gauge height. The undercatch equation was not applied to rainfall as the catch efficiency is near 100% for all wind speeds (ERM 2018).

Because each catch efficiency equation requires wind speed at the precipitation gauge orifice, the logarithmic wind profile (assuming neutral vertical stability; refer to Stull 2016) was used to estimate precipitation gauge orifice height wind speeds. The following logarithmic wind profile equation is used at the Brucejack Mine:

$$U_2 = U_1 \times (\ln(z_2/z_0) / \ln(z_1/z_0)$$

Values for these coefficients were assumed as follows: z_0 as 0.017 m, z_1 as 10 m, U_1 as the daily mean wind speed (m/s) measured at 10 m above the ground, and z_2 is the height of the Geonor precipitation gauge orifice above the ground (3.3 m at VOK, and 3.6 m at Bowser and Scott Pass).

A detailed description of these undercatch coefficients is provided in the 2017 Meteorology Monitoring report (ERM 2018).

3.3.2 Estimating Missing Precipitation Data

The equations shown in Table 3-1 are reproduced from the 2021 MMR (see Pretium 2022a for more detail). When necessary, missing precipitation, temperature, and snow depth data are estimated using linear equations based on established relationships developed from data collected at the VOK, Bowser and Scott Pass meteorological stations.

The precipitation equations were derived using orthogonal correlation on concurrent historical monthly precipitation datasets (2014 to 2021) among all three stations. Orthogonal correlation was used to derive the resulting equations because the method yielded better R values than simple linear correlation. The precipitation equations were developed using total monthly precipitation datasets and were applied to the daily dataset by dividing the derived intercept values by the average number of days per month (30.5). When applying these equations, any resulting negative precipitation values were set to zero.

Table 3-1:
Example correlations to infill missing climate data, Brucejack Meteorological Monitoring Program

Dependent Variable	Independent Variable	Equation	Correlation Coefficient (R)	Dataset	No. of Pairs
Precipitation (mm)					
P_{Bowser}	$P_{ScottPass}$	$P_{Bowser} = 1.17 \times P_{ScottPasss} - (10/30.5)$	0.94	2014 - 2021	63
P_{VOK}	$P_{ScottPass}$	$P_{VOK} = 1.24 \times P_{ScottPasss} - (8.72/30.5)$	0.91		63
P_{VOK}	P_{Bowser}	$P_{VOK} = 1.10 \times P_{ScottPasss} - (16.68/30.5)$	0.86		64
Temperature (°C)					
$T_{ScottPass}$	T_{VOK}	$T_{ScottPass} = 1.144 \times T_{VOK} + 3.311$	0.98	2021	356
T_{Bowser}	T_{VOK}	$T_{Bowser} = 1.082 \times T_{VOK} + 5.044$	0.92	2021	356
T_{VOK}	T_{Bowser}	$T_{VOK} = 0.655 \times T_{Bowser} - 3.288$	0.91	2021	356
Snow Depth (m)					
SD_{VOK}	$SD_{SnowPlot}$	$SD_{VOK} = 0.7607 \times SD_{SnowPlot} + 0.1912$	0.98	2020-2021	164

Note: Any resulting negative precipitation estimates were set to zero.

3.4 Potential Evaporation

Potential evaporation estimates prior to May 30, 2023, were computed for the VOK meteorological station using measured climate data and the Ref-ET calculator - a compiled, stand-alone computer program that calculates reference evapotranspiration (ASCE, 2005). An hourly input file was prepared for Ref-ET based on measured data for the following parameters: air temperature, relative humidity, incoming solar radiation, atmospheric pressure, and wind speed.

From the assembled climate inputs, Ref-ET returns potential evaporation (PE) computations at daily time-step for an array of evaporation models. Outputs based on the ASCE Standardized Reference Evapotranspiration Equation are reported in Section 4 of the report. The VOK meteorological station was re-programmed on June 1, 2023, and now computes and compiles daily estimates of potential evaporation using the ASCE 2005 formulation.

4. Results

4.1 Air temperature

The following air temperature summaries are presented in this section of the report:

- Average air temperature measurements are presented for the VOK meteorological station at monthly and annual time step (Table 4-1).
    - On average, July and August are the warmest months at the mine site (7.8°C), whereas December (-8.3°C) and February (-8.4°C) are the coldest.
    - A mean annual temperature (MAT) estimate of -0.9°C was computed for VOK meteorological station based on the record period available (*i.e.*, September 2014 through September 2023).
- Table 4-2 summarizes the maximum hourly temperature readings recorded by month and year at VOK meteorological station for the record period.
- Table 4-3 summarizes the minimum hourly temperature readings recorded by month and year at VOK meteorological station for the record period.
- In Figure 4-1, maximum-, average- and minimum daily air temperature readings at VOK meteorological station (September 2014-October 2023) are plotted in time series format.
- Figure 4-2(upper panel) presents the daily averaged air temperature signature for VOK meteorological station (based on 9 years of data; 2014-2023) whereas Figure 4-2 (lower panel) presents the monthly average air temperature signature for VOK.

Table 4-1:
Average air temperature readings at VOK meteorological station (2014-2023).

	Average Air Temperature (°C)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	5.6	-0.6	-4.7	-5.7	---
2015	-5.5	-5.2	-4.4	-3.3	5.2	5.9	7.4	6.2	2.0	0.3	-5.0	-8.1	-0.3
2016	-5.4	-4.9	-3.2	-0.7	2.8	5.5	7.8	8.3	3.5	-1.6	-4.6	-10.8	-0.3
2017	-6.8	-10.1	-9.3	-1.7	1.9	3.3	4.3	8.5	5.0	-1.2	-7.7	-7.1	-1.7
2018	-7.3	-9.6	-6.6	-3.3	2.8	4.9	10.1	8.3	3.5	-0.1	-3.2	-7.5	-0.6
2019	-6.0	-11.7	-3.4	-2.7	4.6	5.6	7.3	7.9	4.6	-2.3	-3.8	-5.9	-0.6
2020	-11.5	-7.8	-7.2	-3.5	2.3	3.0	6.4	5.0	5.2	-2.9	-6.7	-5.6	-1.9
2021	-7.4	-11.2	-6.9	-2.2	0.5	6.5	8.1	6.5	2.6	-3.0	-5.4	-12.7	-2.0
2022	-8.1	-5.9	-5.0	-5.2	0.7	6.4	8.0	9.7	5.6	2.0	-7.6	-10.9	-0.8
2023	-4.7	-9.3	-7.8	-3.7	4.2	5.6	10.2	9.8	3.4	---	---	---	---
2014 to 2023	-7.0	-8.4	-6.0	-2.9	2.8	5.2	7.8	7.8	4.1	-1.0	-5.4	-8.3	-0.9

Table 4-2:
Maximum hourly air temperature readings at VOK meteorological station (2014-2023).

	Maximum Hourly Air Temperature (°C)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	15.8	6.3	3.0	-0.4	---
2015	1.8	4.5	1.2	2.5	12.9	13.2	20.4	13.0	8.8	6.9	2.7	-2.4	20.4
2016	-0.9	5.3	12.2	8.1	12.1	15.0	20.1	19.2	9.4	2.5	0.5	-3.0	20.1
2017	0.5	2.4	-0.9	4.8	12.7	16.3	16.1	22.0	17.4	8.3	-0.9	5.4	22.0
2018	4.5	-2.7	5.7	11.9	12.0	23.7	23.7	18.4	9.6	8.6	2.5	-1.3	23.7
2019	2.8	1.7	7.7	8.6	15.8	18.3	14.6	19.4	12.4	4.1	2.2	2.0	19.4
2020	-1.4	-2.3	2.6	9.1	12.2	13.0	19.4	11.2	14.4	9.8	6.5	4.7	19.4
2021	-1.2	-1.1	-0.7	12.7	10.3	21.4	19.8	19.4	13.9	2.8	2.0	-4.3	21.4
2022	2.4	0.0	2.4	5.0	11.3	15.8	18.4	19.3	14.4	13.9	3.4	2.8	19.3
2023	1.8	-1.7	5.3	8.3	18.2	16.4	20.7	19.3	13.6	---	---	---	---
2014 to 2023	4.5	5.3	12.2	12.7	18.2	23.7	23.7	22.0	17.4	13.9	6.5	5.4	23.7

Table 4-3:
Minimum hourly air temperature readings at VOK meteorological station (2014-2023).

	Minimum Hourly Air Temperature (°C)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	-2.2	-6.0	-19.0	-12.8	---
2015	-20.3	-14.9	-11.1	-8.4	-5.5	-1.1	2.0	-1.5	-2.6	-4.6	-14.1	-15.1	-20.3
2016	-10.7	-12.5	-9.9	-5.7	-4.7	-1.1	3.1	2.4	-2.0	-5.1	-10.8	-19.7	-19.7
2017	-16.3	-19.6	-20.1	-8.4	-5.3	-1.6	0.5	0.9	-0.9	-6.6	-17.4	-22.2	-22.2
2018	-22.0	-19.6	-16.3	-11.3	-3.5	-1.5	0.9	2.4	-1.5	-6.4	-8.8	-15.5	-22.0
2019	-19.8	-30.3	-14.3	-11.2	-3.8	-0.8	2.4	-2.0	-3.2	-10.6	-13.9	-12.9	-30.3
2020	-24.5	-15.5	-17.9	-18.1	-4.4	-1.9	2.6	0.3	-1.5	-11.5	-12.3	-12.5	-24.5
2021	-19.2	-26.0	-15.2	-11.1	-6.0	-0.9	2.6	-0.5	-2.4	-8.6	-12.2	-26.2	-26.2
2022	-26.0	-17.6	-11.9	-13.3	-5.4	-1.0	1.4	3.0	-0.7	-9.9	-20.9	-25.8	-26.0
2023	-12.7	-22.6	-18.4	-11.7	-3.6	-2.2	1.0	2.1	-1.7	---	---	---	---
2014 to 2023	-26.0	-30.3	-20.1	-18.1	-6.0	-2.2	0.5	-2.0	-3.2	-11.5	-20.9	-26.2	-30.3

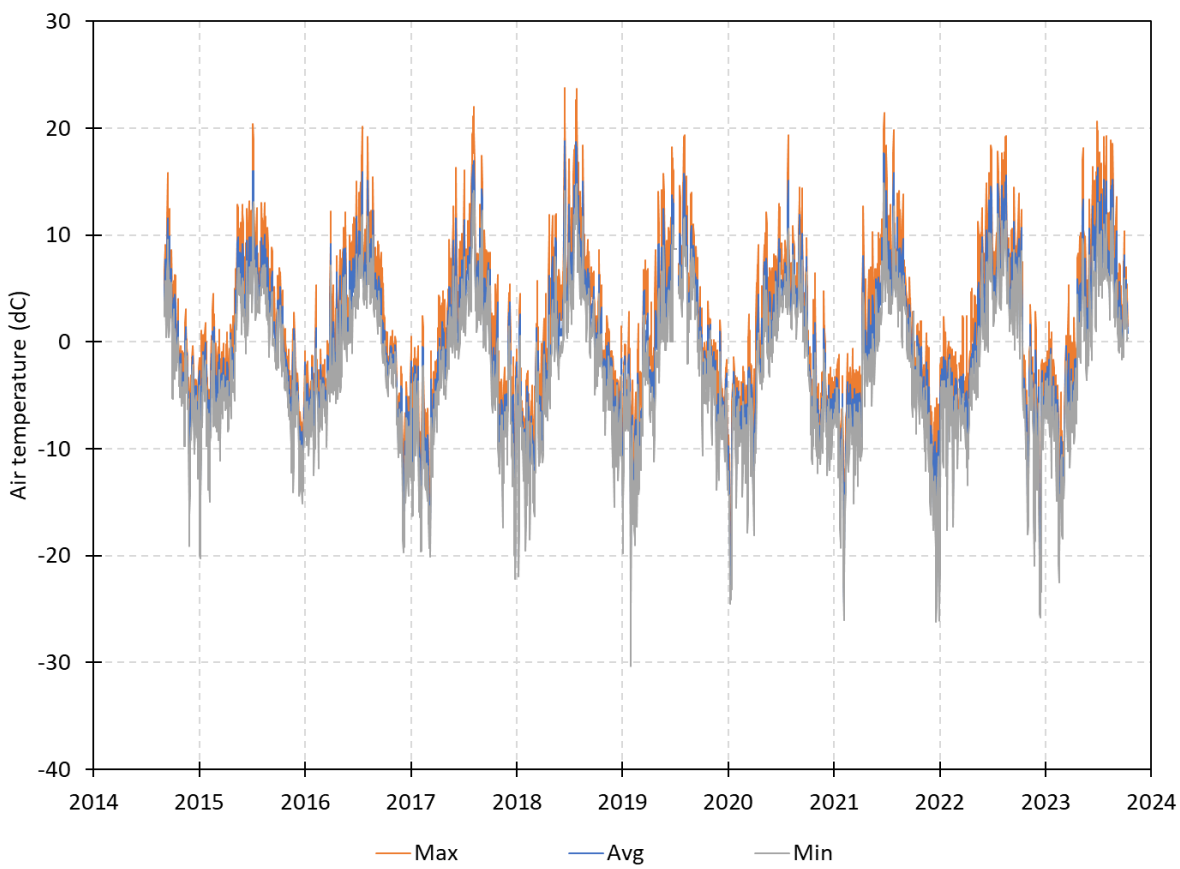


Figure 4-1: Maximum-, average- and minimum daily air temperature readings at VOK meteorological station (September 2014-October 2023).

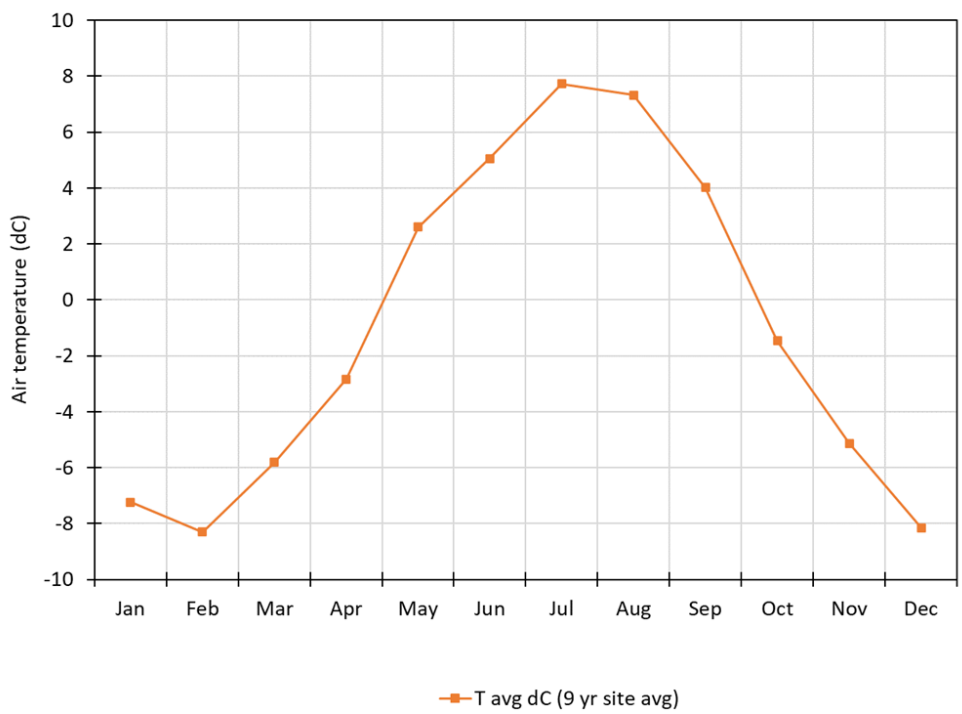


Figure 4-2: Daily- and monthly averaged air temperature signatures for VOK meteorological station (based on 9 years of data; 2014-2023).

4.2 Precipitation

The following precipitation summaries are presented in this section of the report:

- Monthly and annual precipitation depths recorded at VOK meteorological station are presented in Table 4-4.
  - On average, October (259 mm) and November (233 mm) are the wettest months at the mine site, whereas May (85 mm), June (93 mm) and July (95 mm) are the driest months.
  - A mean annual precipitation (MAP) estimate of 1,820 mm was computed for VOK meteorological station based on the record period available (*i.e.*, September 2014 through August 2023).
    - The least amount of precipitation was recorded in the 2018 calendar year (1,224 mm) versus the most precipitaiton which was recorded in the 2021 calendar year (2,143 mm).
- In Figure 4-3, daily precipitation readings are plotted for the VOK meteorological station between September 2014 and August 2023.
  - More than ten daily precipitation depths were in excess of 60 mm, four precipitation depths were in excess of 80 mm, and one precipitation depth was recorded in excess of 110 mm.
- Figure 4-4 (upper panel) presents the daily averaged precipitation signature for VOK meteorological station (based on 9 years of data; 2014-2023) whereas Figure 4-4 (lower panel) presents the monthly average precipitation signature for VOK.

Table 4-4:
Monthly- and annual precipitation depths at VOK meteorological station (2014-2023).

	Precipitation (mm)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	308	346	98	129	---
2015	241	96	177	152	19	105	143	213	201	392	190	139	2,069
2016	122	188	75	161	118	48	83	63	230	82	212	144	1,527
2017	161	97	143	44	107	117	64	176	180	231	108	130	1,556
2018	111	92	84	81	71	50	60	100	59	189	163	164	1,224
2019	182	33	76	119	29	81	187	356	152	260	294	121	1,890
2020	130	162	104	89	95	155	127	278	189	191	277	161	1,956
2021	214	169	204	99	95	86	53	156	378	296	308	86	2,143
2022	242	185	95	77	74	60	88	156	166	429	309	84	1,965
2023	186	246	62	221	159	131	47	---	---	---	---	---	---
2014 to 2023	177	141	113	116	85	93	95	187	194	259	233	129	1,820

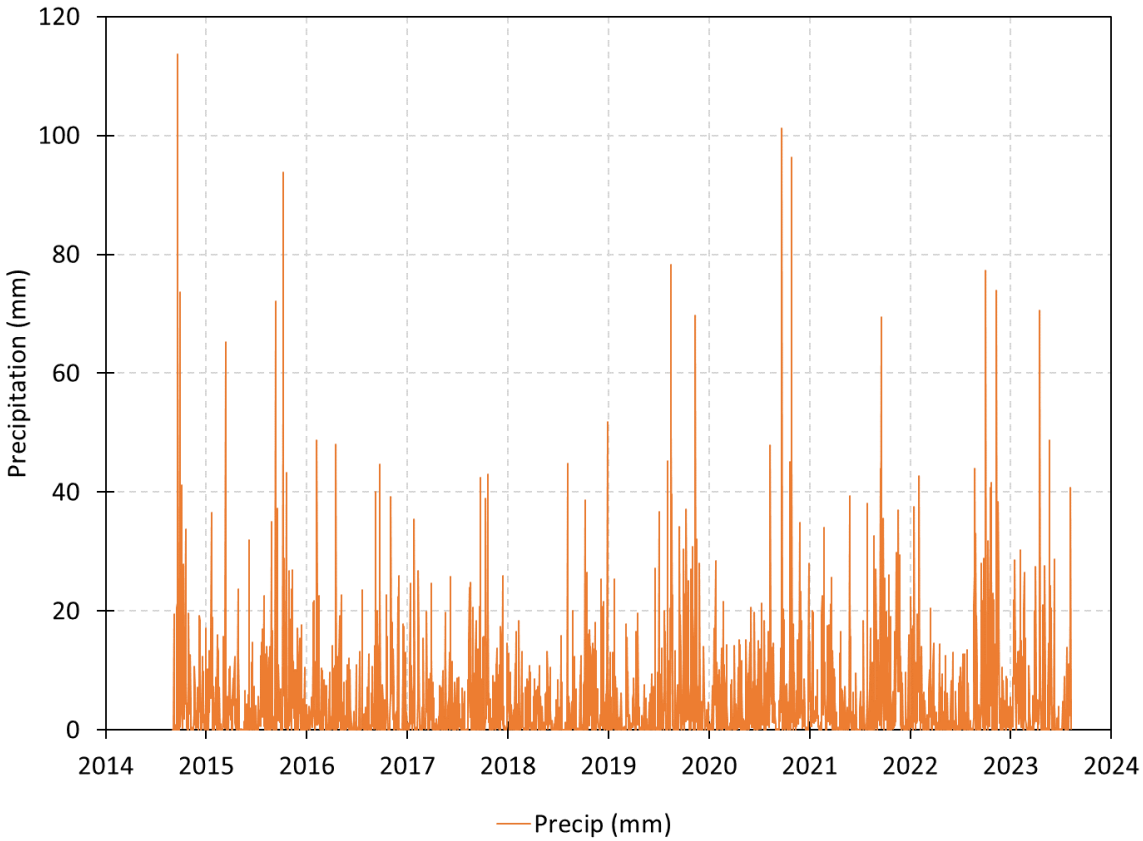
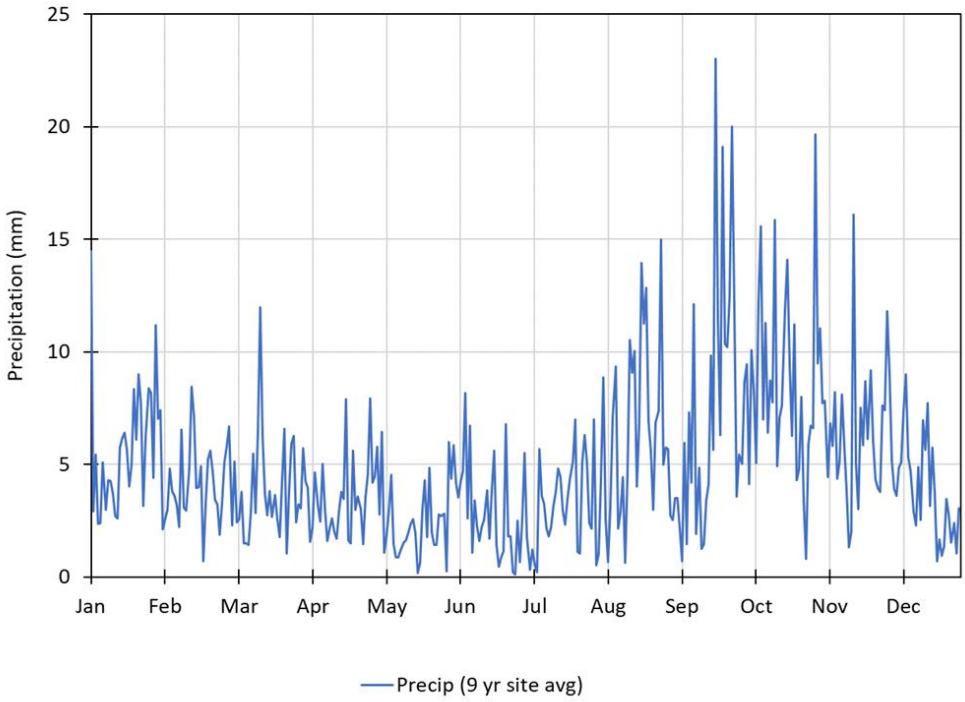


Figure 4-3: Record period total daily precipitation readings at VOK meteorological station (September 2014-August 2023).



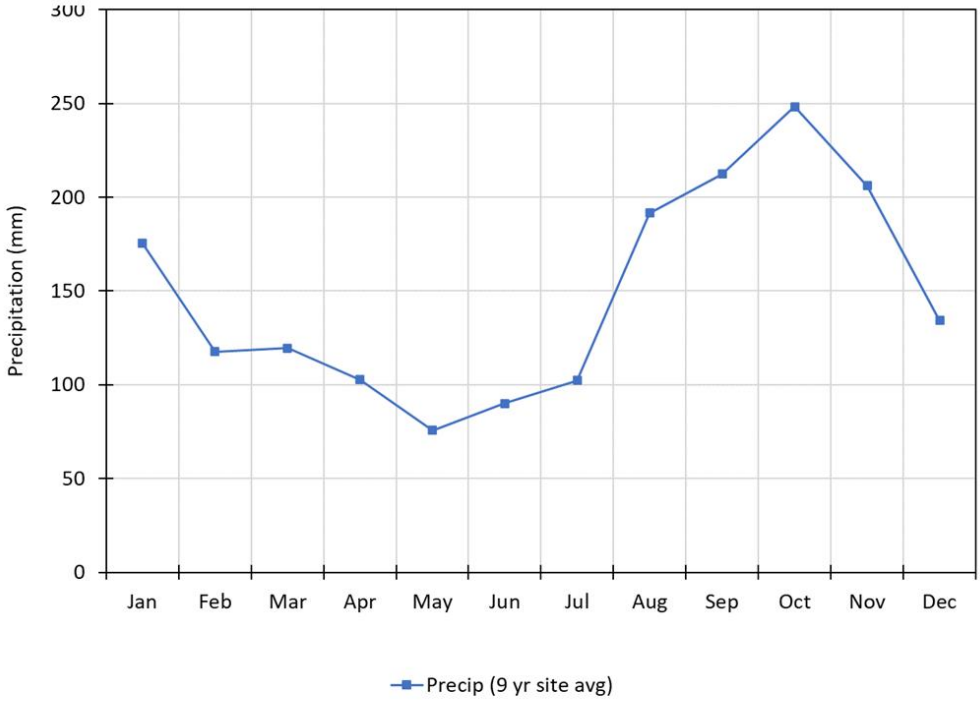


Figure 4-4: Daily- and monthly averaged precipitation signatures for VOK meteorological station (based on 9 years of data; 2014-2023).

4.3 Snow depth Readings and Snow Surveys

The following snow depth summaries are presented in this section of the report:

- Average snow depth readings are presented for the VOK meteorological station at monthly and annual time step (Table 4-5).
  - On average, snow depths reach their annual maxima in March (3.3 m) and April (3.4 m), with melt out of snow storage occurring typically by June or July.
  - A mean annual temperature (MAT) estimate of -0.9°C was computed for VOK meteorological station based on the record period available (*i.e.*, September 2014 through September 2023).
- Table 4-6 summarizes the maximum hourly snow depth readings recorded by month and year at VOK meteorological station for the record period.
- Table 4-7 summarizes the minimum hourly snow depth readings recorded by month and year at VOK meteorological station for the record period.
- Daily snow depth readings at VOK meteorological station (2015-2023) are presented in time series format in Figure 4-5.
- In Figure 4-6, median, 2nd percentile, 10th percentile, 90th percentile and 98th percentile snow depth summaries are plotted for the VOK meteorological station (based on 9 years of data; 2014-2023).
- A map demarcating the VOK snow course is presented in Figure 4-7. Snow course data (*i.e.*, snow depth, SWE and snow density) collected at the snow course since 2015 is presented in Table 4-8.

Table 4-5:
Average snow depth readings for VOK meteorological station (2015-2023).

	Average Snow Depth (m)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2015	---	---	---	---	---	---	---	---	---	0.3	1.3	2.4	1.5
2016	2.8	3.6	3.8	3.7	3.2	1.7	0.1	---	---	0.1	1.8	2.5	1.9
2017	2.9	3.3	3.8	3.7	1.4	---	---	---	---	0.5	1.4	2.1	1.6
2018	2.6	2.9	3.1	3.1	2.4	1.0	---	---	---	0.2	0.9	2.1	1.5
2019	2.8	2.6	2.7	3.1	2.5	0.9	---	---	---	0.7	1.5	2.0	2.1
2020	2.9	3.4	3.2	3.1	3.1	2.3	0.8	---	---	0.2	1.0	2.5	2.4
2021	3.5	3.0	3.8	4.0	3.2	1.6	0.1	---	---	---	---	---	3.1
2023	2.0	2.8	2.7	3.0	2.2	0.9	0.1	---	---	---	---	---	2.2
2015-2023	2.8	3.1	3.3	3.4	2.6	1.2	0.2	---	---	0.3	1.3	2.3	2.0

Table 4-6:
Maximum hourly snow depth readings at VOK meteorological station (2015-2023).

	Maximum Daily Snow Depth (m)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2015	---	---	---	---	---	---	---	---	---	0.7	1.9	2.8	2.8
2016	3.4	4.1	4.0	3.9	3.7	2.6	0.6	---	---	0.3	2.4	3.0	4.1
2017	3.4	3.5	4.0	4.1	3.5	---	---	---	---	1.4	2.2	2.3	4.1
2018	3.0	3.1	3.4	3.4	3.0	1.7	---	---	---	0.6	1.4	2.9	3.4
2019	3.1	2.8	3.0	3.3	3.0	1.8	---	---	---	1.0	2.1	2.8	3.3
2020	3.8	3.7	3.7	3.6	3.5	2.9	1.4	---	---	0.3	2.0	2.9	3.8
2021	3.8	3.5	4.3	4.3	3.8	2.6	0.2	---	---	---	---	---	4.3
2023	2.4	3.1	3.0	3.3	3.0	1.6	0.1	---	---	---	---	---	3.3
2015-2023	3.8	4.1	4.3	4.3	3.8	2.9	1.4	---	---	1.4	2.4	3.0	4.3

Table 4-7:
Minimum hourly snow depth readings at VOK meteorological station (2015-2023).

	Minimum Daily Snow Depth (m)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2015	---	---	---	---	---	---	---	---	---	0.0	0.7	1.7	0.0
2016	2.5	3.2	3.6	3.6	2.6	0.0	0.0	---	---	0.0	0.3	2.2	0.0
2017	2.5	3.1	3.4	3.4	---	---	---	---	---	0.0	0.0	2.0	0.0
2018	2.1	2.8	2.9	2.8	1.8	0.0	---	---	---	0.0	0.7	1.2	0.0
2019	2.6	2.4	2.4	2.7	1.8	0.0	---	---	---	0.1	0.8	1.4	0.0
2020	2.5	3.3	3.0	2.8	2.8	1.5	0.2	---	---	0.1	0.5	1.9	0.1
2021	2.9	2.4	3.5	3.7	2.7	0.3	0.0	---	---	---	---	---	0.0
2023	1.5	2.5	2.5	2.6	1.5	0.1	0.0	---	---	---	---	---	0.0
2015-2023	1.5	2.4	2.4	2.6	0.0	0.0	0.0	---	---	0.0	0.0	1.2	0.0

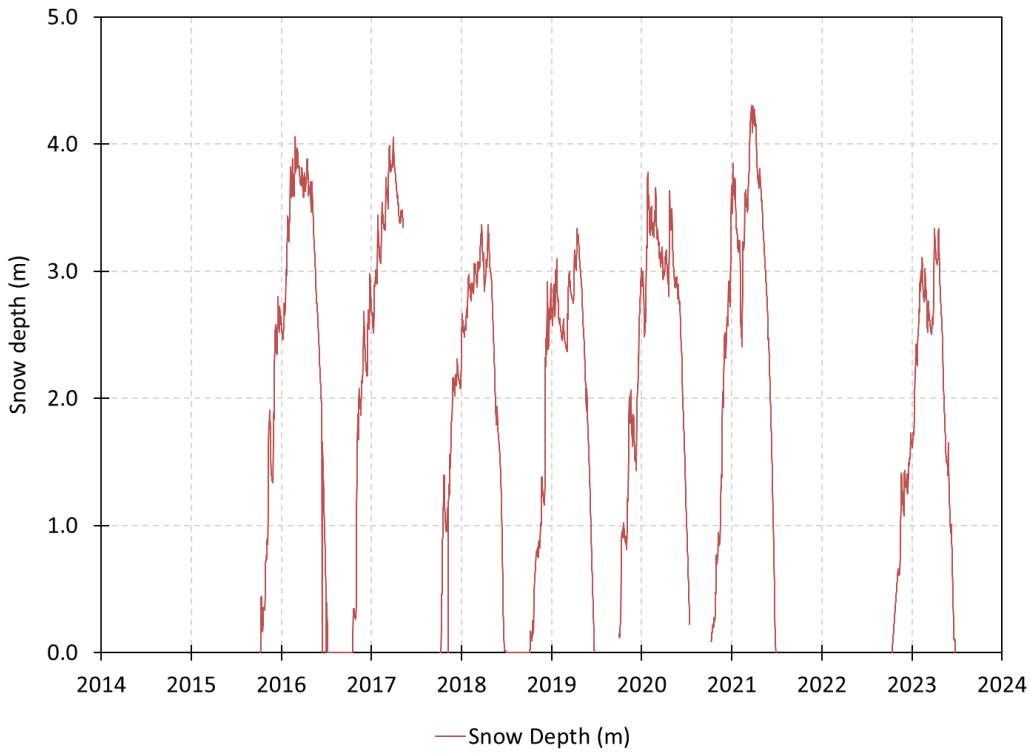


Figure 4-5: Daily snow depth readings at VOK meteorological station (2015-2023).

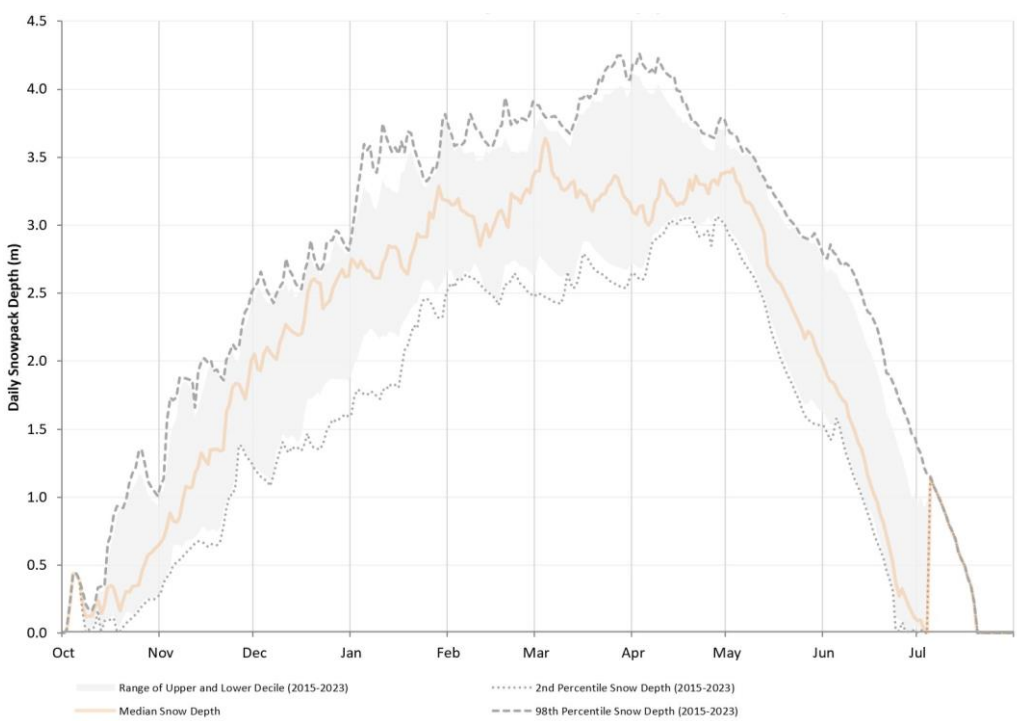
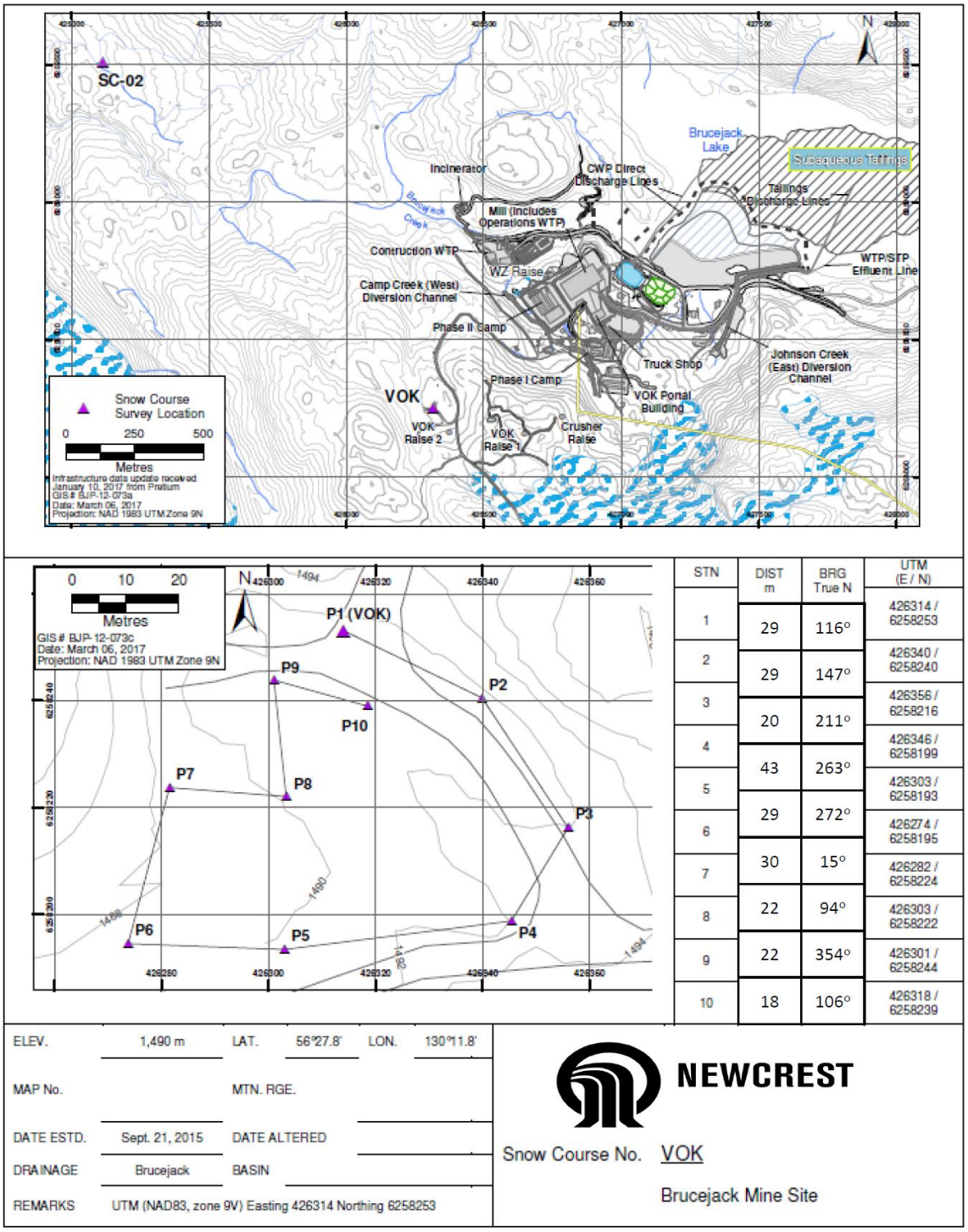


Figure 4-6: Summary of VOK meteorological station snow depth data (2015-2023). Median, 2nd percentile, 10th percentile, 90th percentile and 98th percentile data are shown in the plot.



STN	DIST m	BRG True N	UTM (E / N)
1	29	116°	426314 / 6258253
2	29	147°	426340 / 6258240
3	20	211°	426356 / 6258216
4	43	263°	426346 / 6258199
5	29	272°	426303 / 6258193
6	30	15°	426274 / 6258195
7	22	94°	426282 / 6258224
8	22	354°	426303 / 6258222
9	18	106°	426301 / 6258244
10			426318 / 6258239

Figure 4-7: VOK snow course location maps

Table 4-8:
VOK snow course data summary

Date	Samples per transect (n)	Snow Depth Range (cm)	Mean Snow Depth (cm)	SWE Range (cm)	Mean SWE (cm)	Snow Density Range (%)	Mean Snow Density (%)
23-Mar-15	5	109 - 269	225	32 - 117	91	29 - 44	39
17-Mar-16	10	233 - 361	276	88 - 146	104	34 - 42	38
20-May-16	10	170 - 272	213	91 - 137	118	49 - 63	56
28-Nov-16	10	86 - 178	118	22 - 58	36	24 - 36	30
2-Feb-17	10	156 - 269	211	47 - 108	73.9	30 - 40	35
26-Mar-17	6[1]	110 - 306	203.7	35 - 127	76	30 - 50	36
2-Feb-18	9	144 - 280	218	45 - 107	77	31 - 39	35
3-Mar-18	8	136 - 296	213	45 - 120	74	29 - 41	35
2-Apr-18	9	145 - 297	233	50 - 120	89	35 - 40	38
5-Feb-19	6	169 - 267	221	62 - 116	88	37 - 43	39
5-Mar-19	10	152 - 248	201	62 - 107	84	40 - 45	42
6-Apr-19	10	180 - 278	226	69 - 132	96	35 - 51	43
3-May-19	9	210 - 309	255	93 - 155	115	38 - 52	45
2-Jan-20	8	243 - 328	268	81 - 112	90	33 - 35	34
7-Feb-20	10	187 - 392	306	75 - 154	113	27 - 49	37
7-Mar-20	10	159 - 505	314	37 - 208	108	23 - 41	33
6-Apr-20	4	184 - 294	248	66 -119	101	36 - 43	45
15-Feb-21	9	179 - 311	255	72 - 133	105	37 - 43	41
4-Apr-21	8	219 - 434	363	68 - 163	132	31 - 38	36
4-May-21	10	173 - 322	278	77 - 162	128	42 - 51	46
13-Jan-22	9	180 - 289	234	66 - 100	82	33 - 37	35
6-Feb-22	10	289 - 386	331	102 - 142	118	33 - 38	36
23-Feb-22	10	293 - 430	365	102 - 170	134	34 - 40	37
31-Mar-22	9	302 - 402	365	108 - 155	143	36 - 41	39
2-May-22	10	192 - 419	293	75 - 192	125	39 - 46	42

[1]One of the six samples was a duplicate.

4.4 Relative Humidity

The following relative humidity summaries are presented in this section of the report:

- Average relative humidity estimates are presented for the VOK meteorological station at monthly and annual time step (Table 4-9).
- Table 4-10 summarizes the maximum hourly relative humidity readings recorded by month and year at VOK meteorological station for the record period.

- Table 4-11 summarizes the minimum hourly relative humidity readings recorded by month and year at VOK meteorological station for the record period.
- In Figure 4-8, maximum-, average- and minimum daily relative humidity readings at VOK meteorological station (September 2014-October 2023) are plotted in time series format.

Table 4-9:
Average relative humidity readings at VOK meteorological station (2014-2023).

	Average Relative Humidity (%)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	81	88	71	81	---
2015	83	72	75	79	67	81	84	86	90	86	79	85	81
2016	84	90	82	85	79	83	88	87	89	86	92	75	85
2017	80	70	88	79	81	87	88	78	84	85	86	76	82
2018	92	75	81	82	82	83	75	82	75	83	93	89	83
2019	91	65	66	80	74	85	94	83	82	90	92	90	83
2020	85	93	71	75	78	92	93	96	82	91	90	92	86
2021	91	87	93	75	85	80	83	81	94	84	89	73	85
2022	87	84	80	77	77	75	88	82	85	88	81	82	82
2023	93	90	80	88	78	81	78	80	93	---	---	---	---
2014 to 2023	87	81	79	80	78	83	86	84	86	87	86	83	83

Table 4-10:
Maximum hourly relative humidity readings at VOK meteorological station (2014-2023).

	Maximum Hourly Relative Humidity (%)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	100	100	98	97	---
2015	99	96	97	99	99	100	100	100	100	100	100	99	100
2016	99	100	99	100	100	100	100	100	100	100	100	99	100
2017	100	100	100	100	100	100	100	100	100	100	100	100	100
2018	100	100	100	100	100	100	100	100	100	100	100	100	100
2019	100	100	100	100	100	100	100	100	100	100	100	100	100
2020	100	100	100	100	100	100	100	100	100	100	100	100	100
2021	100	100	100	100	100	100	100	100	100	100	100	100	100
2022	100	100	100	100	100	100	100	100	100	100	100	100	100
2023	100	100	100	100	100	100	100	100	100	---	---	---	---
2014 to 2023	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 4-11:
Minimum hourly relative humidity readings at VOK meteorological station (2014-2023).

	Minimum Hourly Relative Humidity (%)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	28	45	11	10	---
2015	21	24	15	43	31	40	31	41	53	34	12	30	12
2016	24	29	26	30	26	31	40	34	42	41	60	23	23
2017	19	20	56	42	28	39	39	20	36	16	37	25	16
2018	63	13	27	30	31	13	25	25	30	29	13	20	13
2019	28	14	17	23	25	33	41	41	27	39	21	33	14
2020	29	57	14	17	28	41	41	66	31	34	33	37	14
2021	38	43	29	18	36	18	40	31	41	43	25	21	18
2022	25	19	14	30	30	25	32	25	21	35	14	24	14
2023	17	32	27	22	18	25	29	24	41	---	---	---	---
2014 to 2023	17	13	14	17	18	13	25	20	21	16	11	10	10

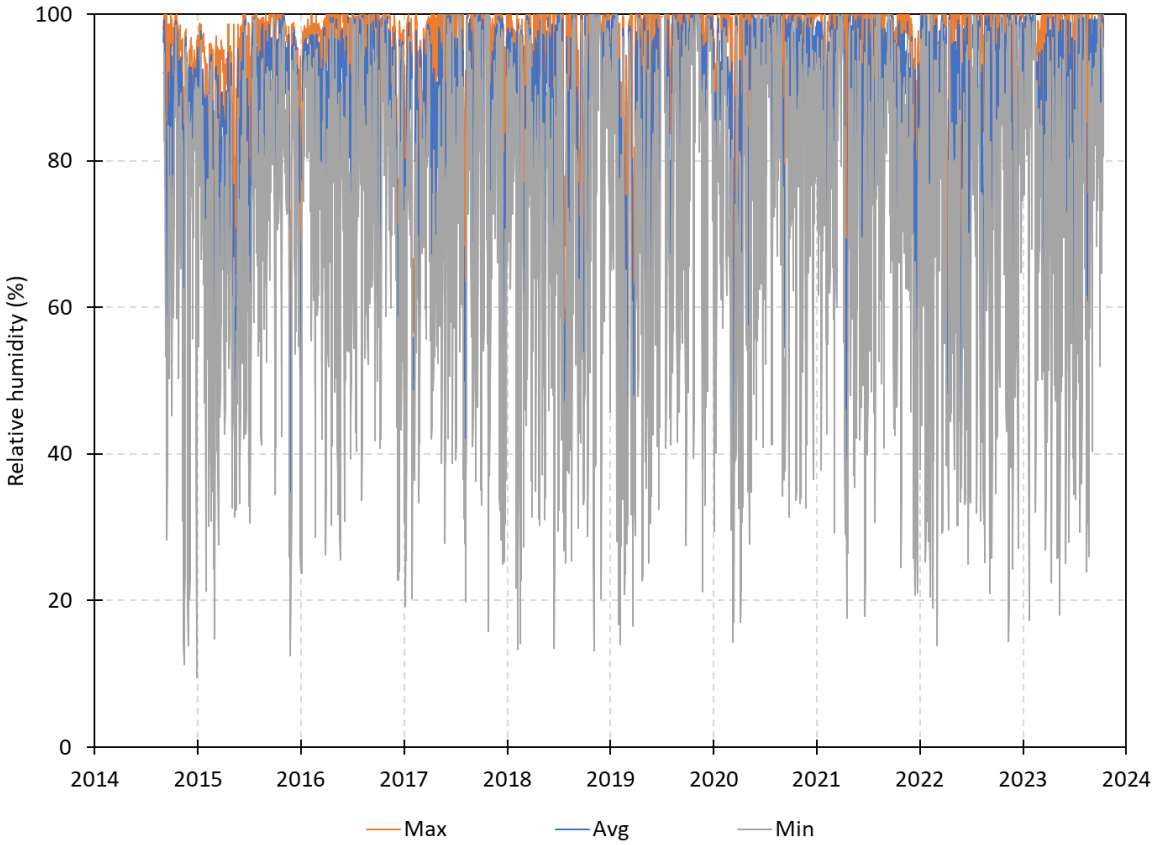


Figure 4-8: Maximum-, average- and minimum daily relative humidity readings at VOK meteorological station (September 2014-October 2023).

4.5 Solar Radiation

The following solar radiation summaries are presented in this section of the report:

- Average solar radiation estimates are presented for the VOK meteorological station at monthly and annual time step (Table 4-12).
- Table 4-13 summarizes the maximum hourly solar radiation readings recorded by month and year at VOK meteorological station for the record period.
- Table 4-14 summarizes the minimum hourly solar radiation readings recorded by month and year at VOK meteorological station for the record period.
- In Figure 4-9, maximum-, average- and minimum daily solar radiation readings at VOK meteorological station (September 2014-October 2023) are plotted in time series format.

Table 4-12:
Average solar radiation readings at VOK meteorological station (2014-2023).

	Average Solar Radiation (W/m^2)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	109	54	31	14	---
2015	21	63	124	197	288	239	181	141	96	57	25	14	121
2016	19	50	119	178	234	223	166	154	90	60	25	13	111
2017	20	60	107	202	227	209	203	169	107	60	30	12	117
2018	20	59	119	199	239	244	219	165	119	59	26	14	124
2019	21	67	133	199	250	226	105	158	102	55	20	14	113
2020	19	46	122	197	241	209	158	104	104	54	24	12	107
2021	20	50	98	204	234	244	199	140	75	81	24	12	116
2022	20	49	109	197	252	253	180	159	99	49	27	12	117
2023	19	48	114	175	242	246	218	170	92	---	---	---	---
2014 to 2023	20	55	116	194	245	233	183	151	99	59	26	13	116

Table 4-13: Maximum hourly solar radiation readings at VOK meteorological station (2014-2023).

	Maximum Hourly Solar Radiation (W/m^2)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	677	514	333	237	---
2015	289	483	737	923	1047	1041	916	806	622	485	291	196	1047
2016	209	393	642	866	926	980	824	752	636	476	323	264	980
2017	276	422	729	1023	960	972	878	872	779	499	291	167	1023
2018	214	401	838	911	914	962	852	871	705	485	339	197	962
2019	233	432	639	812	1058	926	802	749	659	521	207	158	1058
2020	189	419	625	923	942	920	846	793	641	477	267	167	942
2021	238	389	552	813	905	864	884	785	634	499	287	146	905
2022	214	384	597	922	883	914	804	714	623	445	285	170	922
2023	274	445	653	771	1016	1004	852	819	682	---	---	---	---
2014 to 2023	289	483	838	1023	1058	1041	916	872	779	521	339	264	1058

Table 4-14: Minimum hourly solar radiation readings at VOK meteorological station (2014-2023).

	Minimum Hourly Solar Radiation (W/m^2)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	0	0	0	0	---
2015	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0	0
2019	0	0	0	0	0	0	0	0	0	0	0	0	0
2020	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	0	0	0	0	0	0	0	0	0	0	0	0	0
2022	0	0	0	0	0	0	0	0	0	0	0	0	0
2023	0	0	0	0	0	0	0	0	0	---	---	---	---
2014 to 2023	0	0	0	0	0	0	0	0	0	0	0	0	0

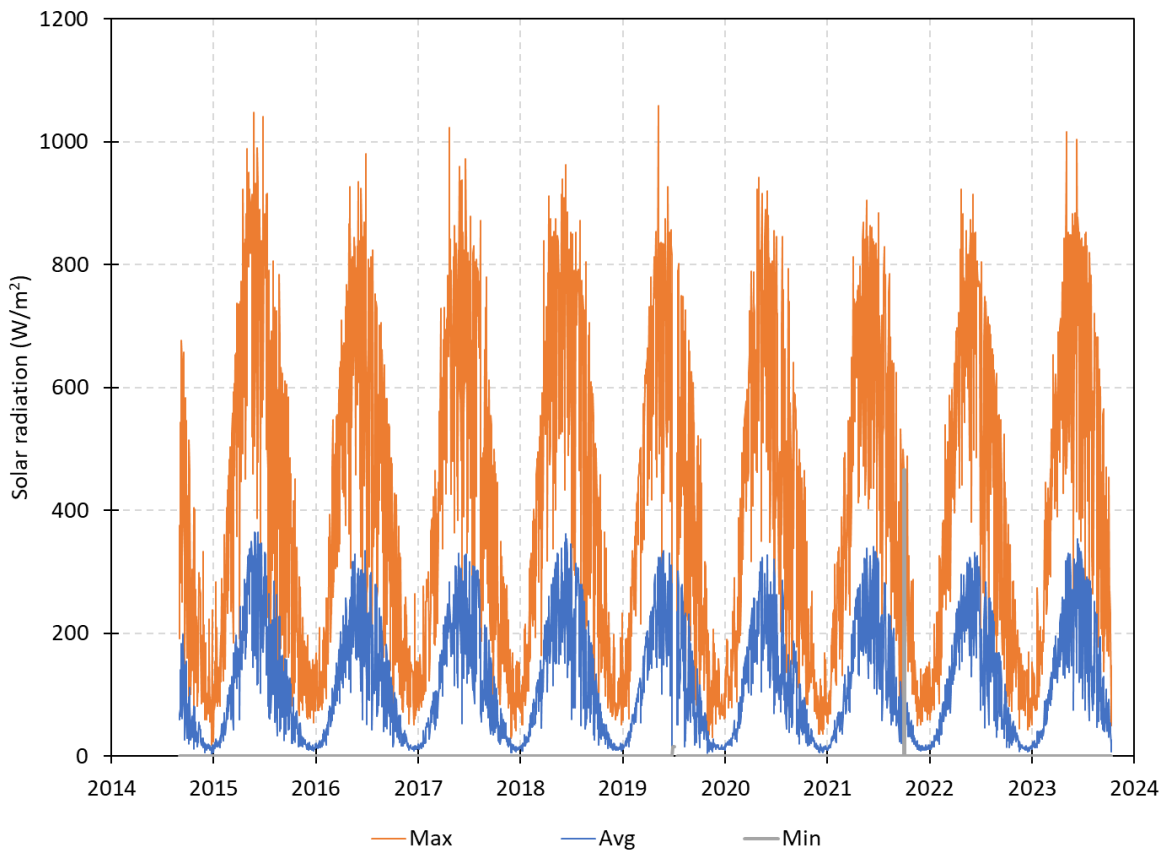


Figure 4-9: Maximum-, average- and minimum daily solar radiation readings at VOK meteorological station (September 2014-October 2023).

4.6 Atmospheric Pressure

The following atmospheric pressure summaries are presented in this section of the report:

- Average station pressure readings are presented for the VOK meteorological station at monthly and annual time step (Table 4-15).
- Table 4-16 summarizes the maximum hourly station pressure readings recorded by month and year at VOK meteorological station for the record period.
- Table 4-17summarizes the minimum hourly station pressure readings recorded by month and year at VOK meteorological station for the record period.
- In Figure 4-10, maximum-, average- and minimum daily station pressure readings at VOK meteorological station (September 2014-October 2023) are plotted in time series format.

Table 4-15: Average station pressure readings at VOK meteorological station (2014-2023).

	Average Station Pressure (kPa)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	84.4	83.2	83.5	83.1	---
2015	83.4	83.6	83.4	83.4	84.6	84.7	84.7	84.4	83.9	83.7	83.2	82.4	83.8
2016	82.9	83.1	83.1	83.8	84.3	84.5	84.7	84.9	84.3	83.4	82.8	82.8	83.7
2017	83.9	83.7	83.5	84.1	84.5	84.6	85.0	84.9	84.7	84.3	83.5	84.8	84.3
2018	83.7	84.2	84.1	84.2	84.8	84.7	85.4	85.0	84.8	84.5	84.1	83.7	84.4
2019	83.9	84.2	84.7	84.2	84.7	84.9	85.0	84.9	84.6	84.4	84.3	83.6	84.4
2020	83.2	84.1	84.1	84.5	84.7	84.6	84.8	84.6	84.8	84.6	83.5	83.8	84.3
2021	83.5	83.8	83.8	84.6	84.8	84.8	85.1	84.9	84.1	84.4	84.5	84.5	84.4
2022	---	---	83.9	84.1	84.3	84.8	85.0	85.0	84.8	84.4	84.4	83.9	---
2023	83.9	83.5	83.8	83.9	84.9	84.9	85.2	85.2	84.5	---	---	---	---
2014 to 2023	83.5	83.8	83.8	84.1	84.6	84.7	85.0	84.9	84.5	84.1	83.8	83.6	84.2

Table 4-16: Maximum hourly station pressure readings at VOK meteorological station (2014-2023).

	Maximum Hourly Station Pressure (kPa)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	85.4	84.5	85.2	85.3	---
2015	84.8	85.1	84.6	84.8	85.2	85.4	85.8	85.5	84.9	85.3	85.1	84.3	85.8
2016	84.1	84.4	85.3	84.8	85.3	85.7	85.7	86.3	85.5	84.5	84.0	84.1	86.3
2017	85.9	85.8	85.0	85.5	85.4	85.9	86.2	86.2	85.7	86.0	85.4	86.2	86.2
2018	85.4	85.6	85.2	85.6	85.8	85.6	86.0	86.1	85.8	85.8	85.8	85.3	86.1
2019	86.0	85.6	85.7	85.8	86.0	85.6	85.5	85.7	85.7	86.5	85.6	85.0	86.5
2020	84.3	85.5	85.7	86.0	86.1	85.5	85.7	85.4	86.6	86.0	85.3	85.0	86.6
2021	85.9	85.3	85.1	85.9	85.4	86.0	85.6	86.0	85.3	84.6	84.5	84.5	86.0
2022	---	---	85.7	85.3	85.9	85.9	85.7	85.6	86.0	86.1	86.7	86.1	---
2023	86.1	84.9	85.6	85.2	86.0	85.5	85.8	85.9	85.4	---	---	---	---
2014 to 2023	86.1	85.8	85.7	86.0	86.1	86.0	86.2	86.3	86.6	86.5	86.7	86.2	86.7

Table 4-17:
Minimum hourly station pressure readings at VOK meteorological station (2014-2023).

	Minimum Hourly Station Pressure (kPa)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	83.0	82.1	81.7	81.1	---
2015	82.1	79.9	81.8	81.9	83.1	83.8	83.7	82.1	82.9	81.9	80.8	81.0	79.9
2016	82.0	81.1	81.4	82.8	83.3	83.3	83.8	84.0	83.0	81.7	81.4	80.8	80.8
2017	81.1	81.7	82.0	82.5	83.4	83.2	84.4	83.6	83.2	81.3	81.5	83.0	81.1
2018	82.2	82.2	82.9	82.6	83.9	83.6	84.8	84.0	84.0	82.9	82.4	81.4	81.4
2019	81.9	82.4	82.8	82.5	83.5	83.9	83.2	83.4	83.5	81.9	82.6	82.1	81.9
2020	81.0	82.0	82.2	82.8	83.4	83.7	84.0	83.5	82.3	82.5	81.6	82.1	81.0
2021	81.0	81.9	82.5	82.7	83.7	83.5	84.6	83.6	82.3	82.9	84.5	84.5	81.0
2022	---	---	82.6	81.6	83.3	83.3	84.3	83.8	83.9	81.1	82.1	81.8	---
2023	82.0	81.9	81.3	81.8	83.8	83.9	84.5	84.2	83.0	---	---	---	---
2014 to 2023	81.0	79.9	81.3	81.6	83.1	83.2	83.2	82.1	82.3	81.1	80.8	80.8	79.9

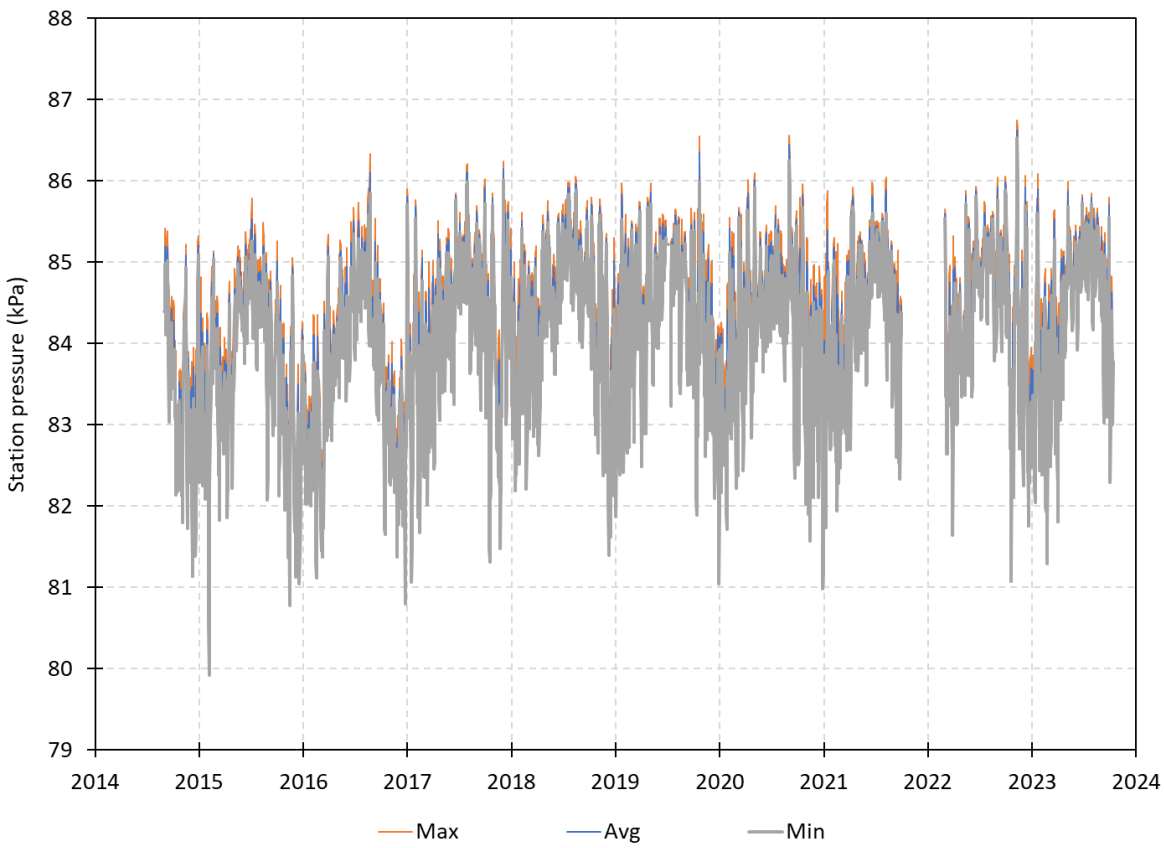


Figure 4-10: Maximum-, average- and minimum station pressure readings at VOK meteorological station (September 2014-October 2023).

4.7 Wind Speed and Direction

The following atmospheric pressure summaries are presented in this section of the report:

- Average wind speed readings are presented for the VOK meteorological station at monthly and annual time step (Table 4-18).
- Table 4-19 summarizes the maximum hourly wind speed readings recorded by month and year at VOK meteorological station for the record period.
- Table 4-20 summarizes the minimum hourly wind speed readings recorded by month and year at VOK meteorological station for the record period.
- In Figure 4-11, maximum-, average- and minimum daily wind speed readings at VOK meteorological station (September 2014-October 2023) are plotted in time series format.
- Annual wind rose and wind speed summaries (Figure 4-12) and an annual wind class frequency distribution (Figure 4-13) are presented for the VOK meteorological station based on the available record period.
- Monthly wind rose/wind speed summaries and monthly wind class frequency distributions (i.e., January through December) are also presented for the VOK meteorological station (see Figure 4-14 through Figure 4-37 inclusive).

Table 4-18:
Average wind speed readings at VOK meteorological station (2014-2023).

	Average Wind Speed (m/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	3.0	4.9	4.5	5.2	---
2015	5.4	4.4	4.1	4.3	2.6	2.7	2.7	2.8	3.2	4.2	3.9	4.6	3.7
2016	5.5	5.2	5.2	4.7	3.5	2.6	2.3	2.5	2.7	4.2	5.4	4.7	4.0
2017	5.0	4.9	5.5	4.4	3.4	3.5	2.7	3.3	2.9	3.4	4.9	4.4	4.0
2018	5.5	3.4	4.3	5.0	3.1	3.0	2.4	2.5	3.2	3.6	3.8	5.1	3.7
2019	4.7	4.8	4.2	3.9	3.0	2.5	2.6	2.8	2.9	3.5	3.9	4.0	3.6
2020	6.3	3.6	4.0	3.6	4.0	3.1	2.8	3.3	2.9	3.2	4.3	5.0	3.8
2021	5.3	5.0	3.9	3.8	2.8	2.7	2.4	2.7	3.7	4.9	5.5	3.7	3.9
2022	5.0	4.2	4.0	4.3	3.4	3.3	2.4	2.5	2.8	3.7	4.9	4.6	3.8
2023	5.0	4.4	5.0	4.6	2.9	2.7	2.4	2.4	3.6	---	---	---	---
2014 to 2023	5.3	4.4	4.5	4.3	3.2	2.9	2.5	2.7	3.1	4.0	4.6	4.6	3.8

Table 4-19:
Maximum hourly wind speed readings at VOK meteorological station (2014-2023).

	Maximum Hourly Wind Speed (m/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	8.7	12.4	17.3	15.0	---
2015	19.6	14.8	14.9	14.7	6.9	8.2	6.8	9.9	9.0	10.3	16.0	14.3	19.6
2016	13.4	14.2	14.2	10.8	9.8	9.7	8.0	8.2	9.8	9.5	14.6	11.7	14.6
2017	13.2	13.4	13.6	15.9	10.3	9.6	8.6	8.1	7.5	12.3	11.5	14.0	15.9
2018	13.5	13.3	15.2	16.9	9.1	7.7	6.9	6.4	8.9	11.9	10.2	18.2	18.2
2019	13.9	14.0	10.8	10.6	10.4	6.5	8.8	7.8	6.6	10.6	9.6	9.7	14.0
2020	16.9	10.4	15.2	11.1	11.4	10.7	11.1	7.6	8.6	9.4	11.3	13.3	16.9
2021	17.1	15.6	11.8	13.2	12.0	9.0	6.8	8.1	10.4	15.4	16.4	10.8	17.1
2022	14.1	10.7	10.5	13.6	11.0	8.8	7.3	6.0	8.5	9.1	12.2	12.5	14.1
2023	12.4	11.2	12.4	13.6	9.4	9.1	8.5	7.6	11.5	---	---	---	---
2014 to 2023	19.6	15.6	15.2	16.9	12.0	10.7	11.1	9.9	11.5	15.4	17.3	18.2	19.6

Table 4-20:
Minimum hourly wind speed readings at VOK meteorological station (2014-2023).

	Minimum Hourly Wind Speed (m/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	---	---	---	---	---	---	---	---	0.3	0.5	0.1	0.1	---
2015	0.2	0.1	0.4	0.1	0.5	0.3	0.5	0.2	0.0	0.4	0.2	0.3	0.0
2016	0.1	0.5	0.5	0.6	0.3	0.3	0.4	0.3	0.3	0.1	0.5	0.6	0.1
2017	0.6	0.7	0.6	0.1	0.4	0.3	0.2	0.5	0.2	0.2	0.5	0.3	0.1
2018	0.0	0.1	0.2	0.3	0.3	0.3	0.5	0.2	0.1	0.0	0.1	0.0	0.0
2019	0.0	0.4	0.6	0.4	0.1	0.3	0.3	0.0	0.3	0.3	0.3	0.0	0.0
2020	0.2	0.0	0.4	0.3	0.0	0.3	0.2	0.2	0.3	0.3	0.0	0.5	0.0
2021	0.4	0.1	0.1	0.0	0.1	0.3	0.2	0.3	0.0	0.0	0.5	0.3	0.0
2022	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.5	0.3	0.6	0.3	0.2
2023	0.5	0.0	0.3	0.3	0.2	0.2	0.3	0.1	0.4	---	---	---	---
2014 to 2023	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0

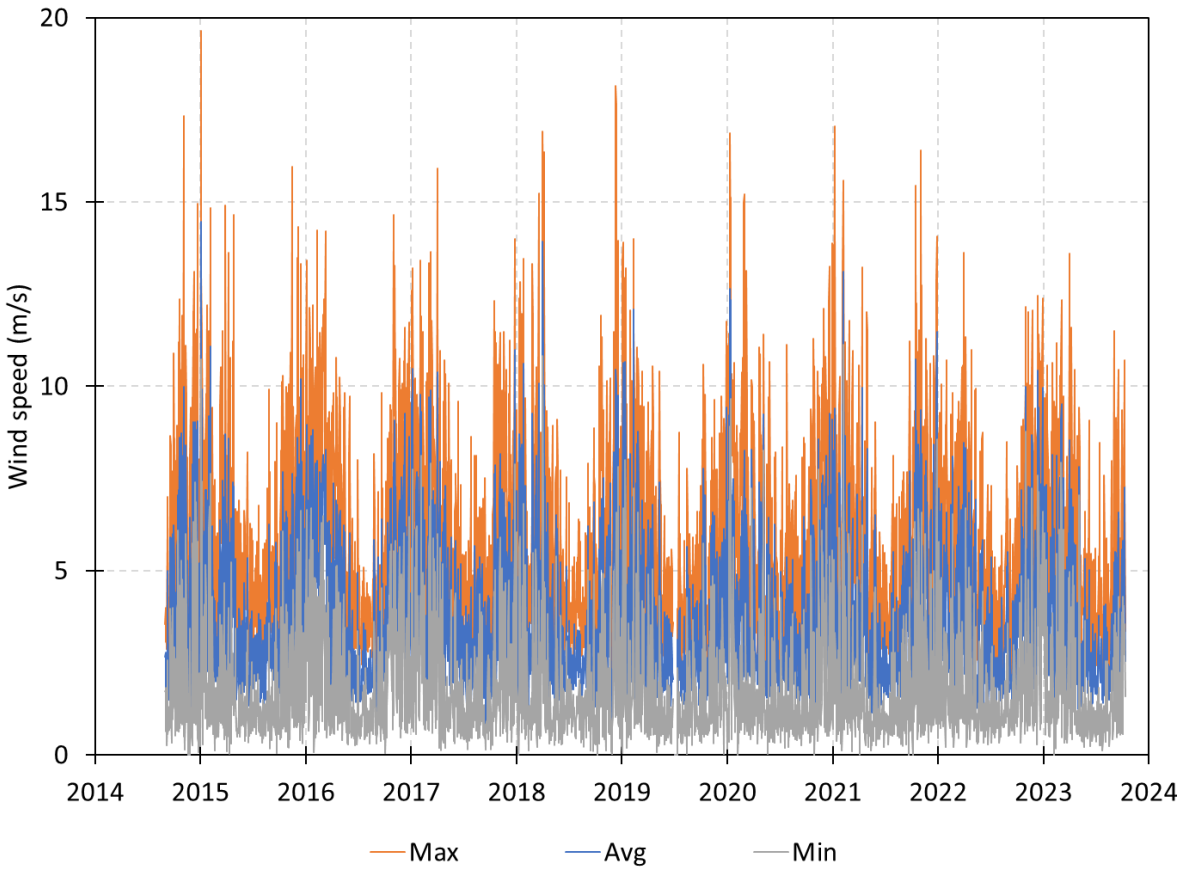


Figure 4-11: Maximum-, average- and minimum wind speed readings at VOK meteorological station (September 2014-October 2023).

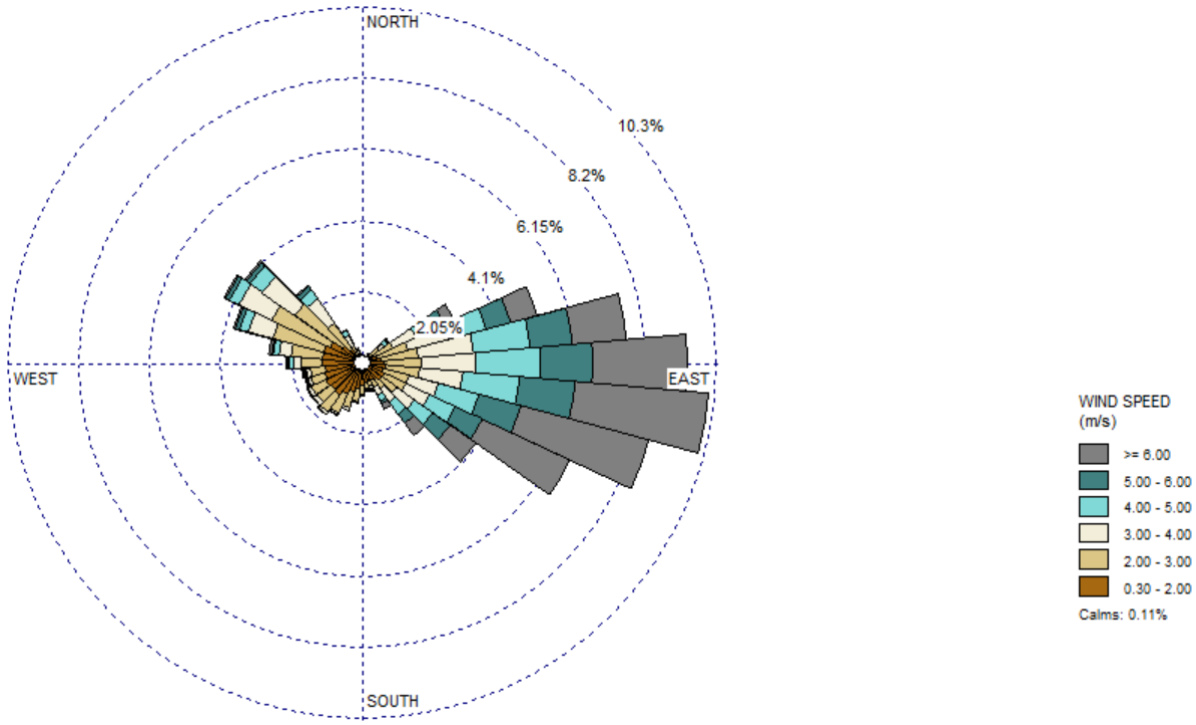


Figure 4-12: Annual wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

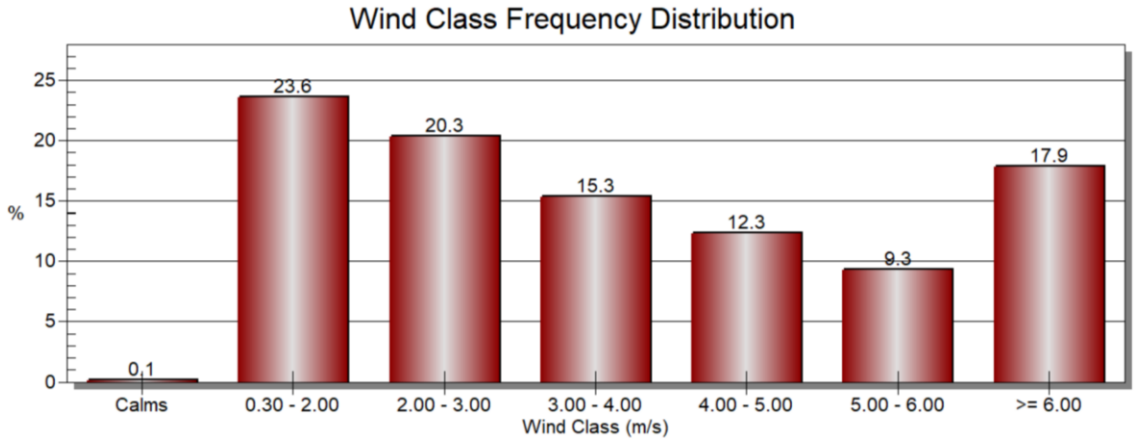


Figure 4-13: Annual wind class frequency distribution, VOK meteorological station (2014-2023).

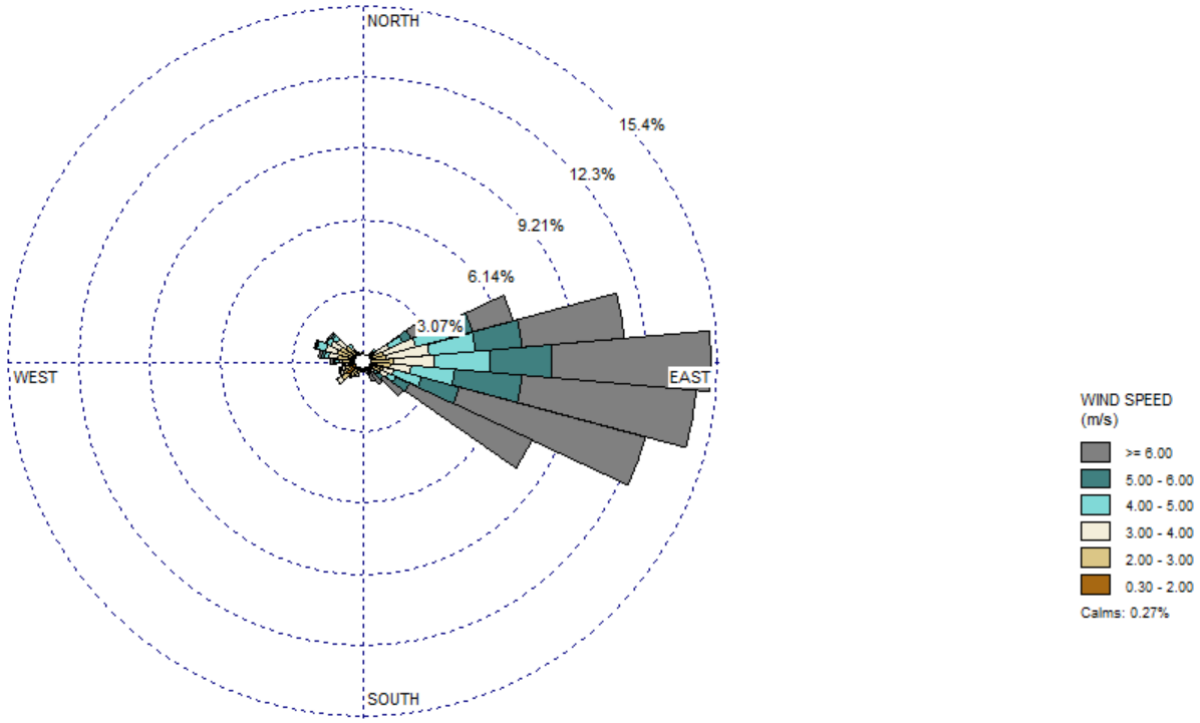


Figure 4-14: January wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

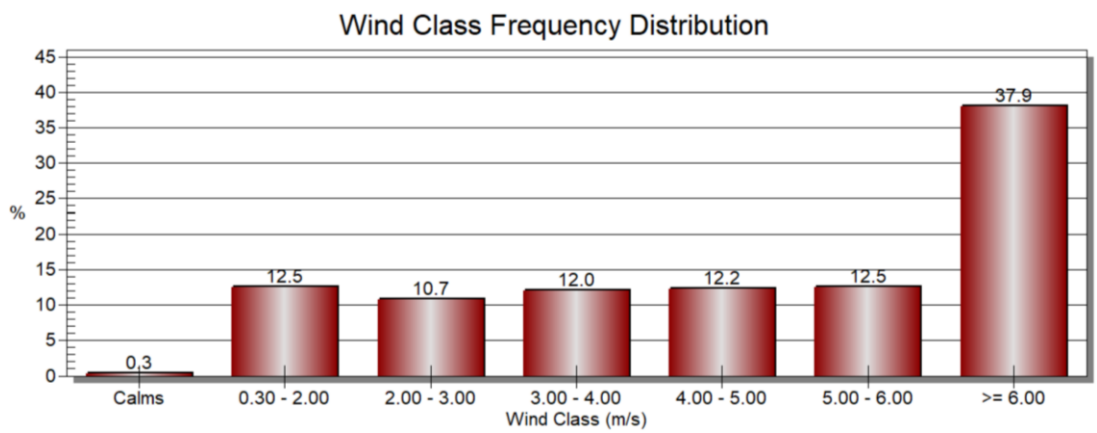


Figure 4-15: January wind class frequency distribution, VOK meteorological station (2014-2023).

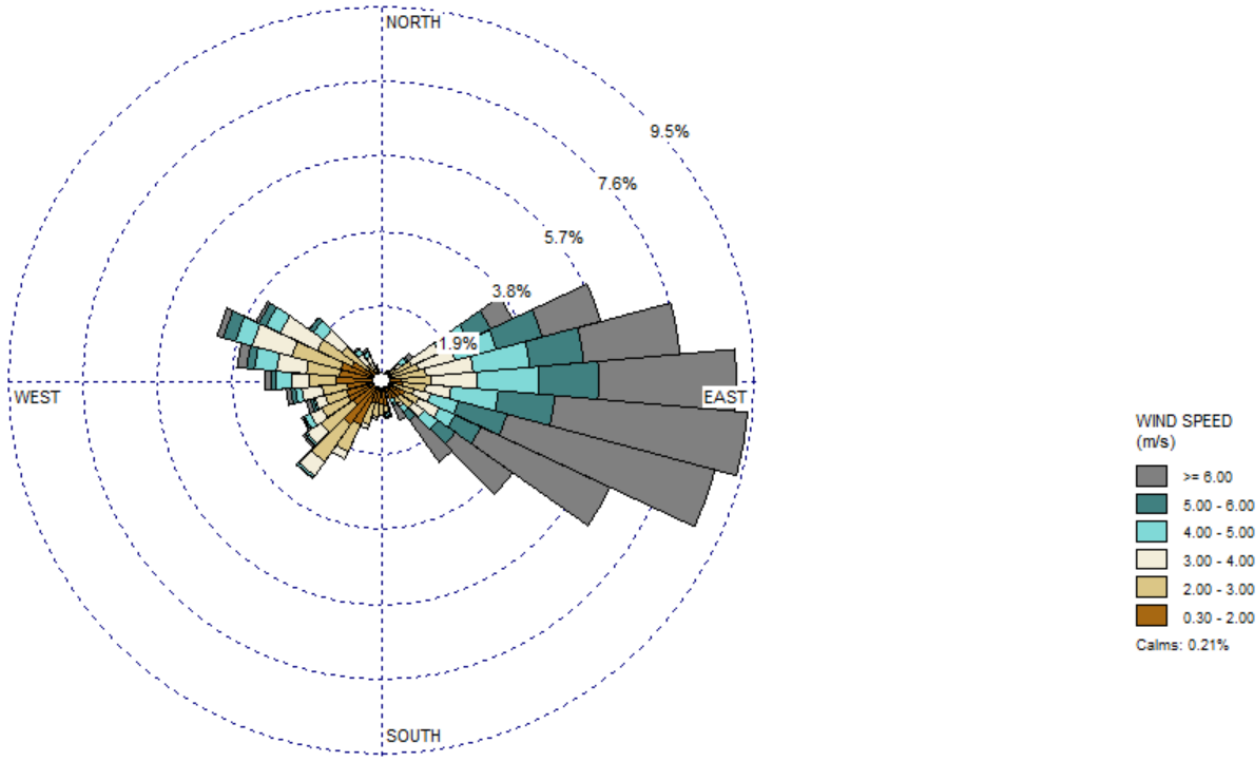


Figure 4-16: February wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

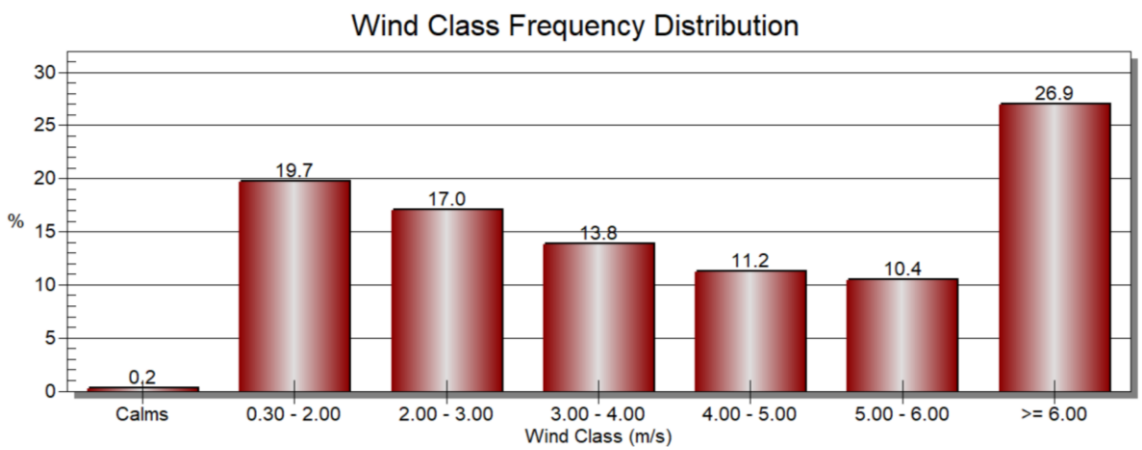


Figure 4-17: February wind class frequency distribution, VOK meteorological station (2014-2023).

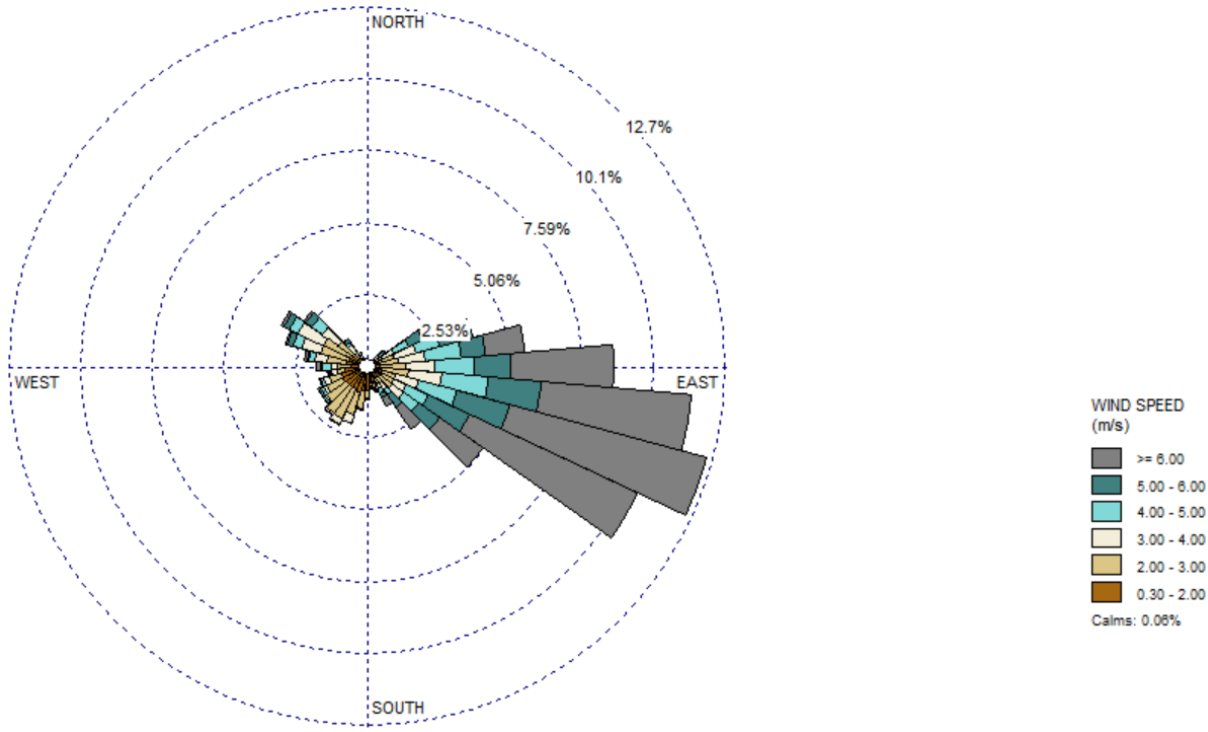


Figure 4-18: March wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

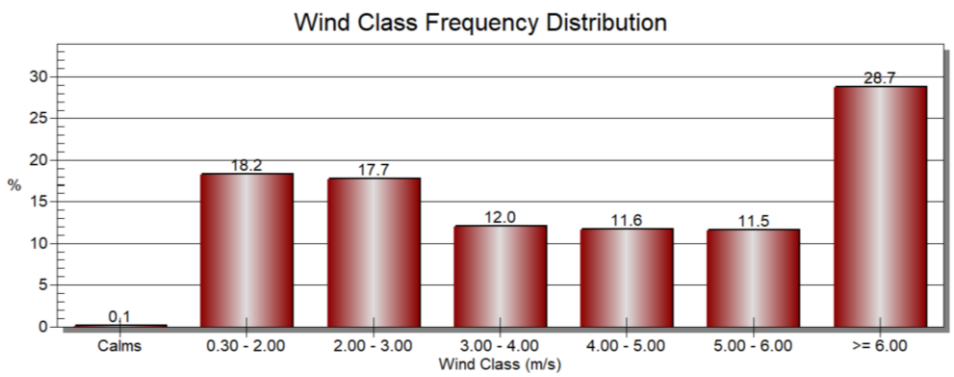


Figure 4-19: March wind class frequency distribution, VOK meteorological station (2014-2023).

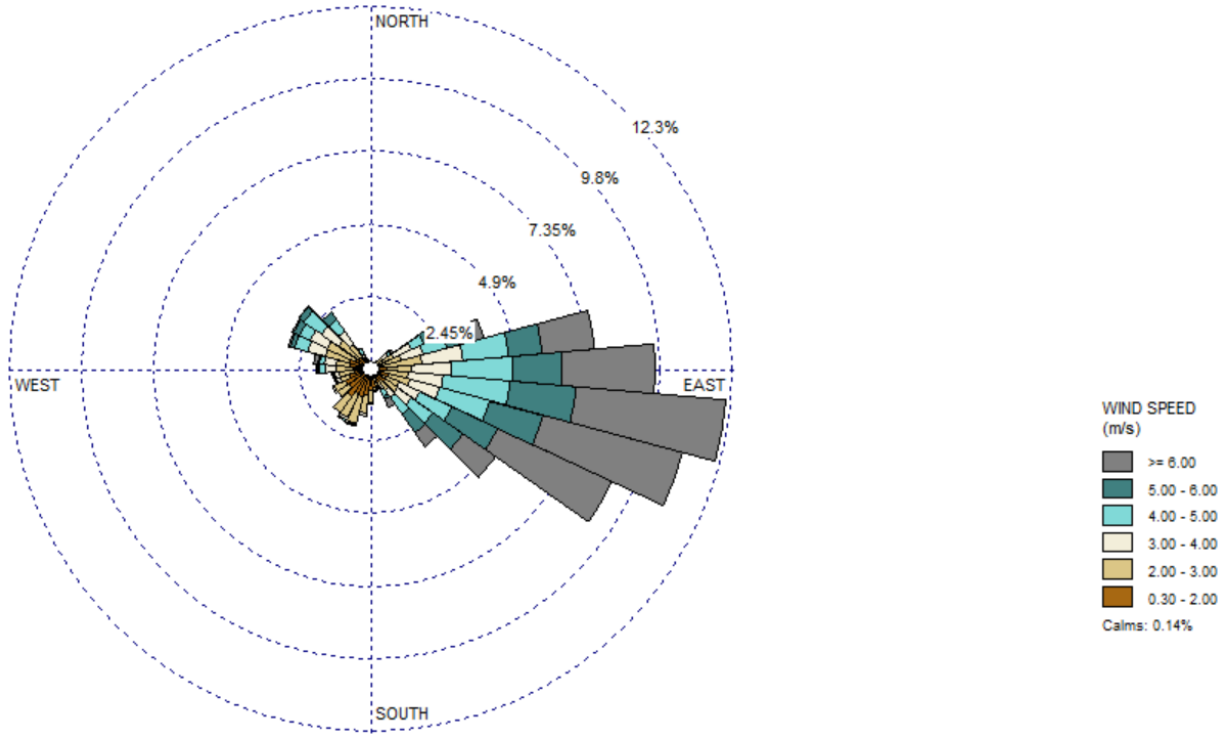


Figure 4-20: April wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

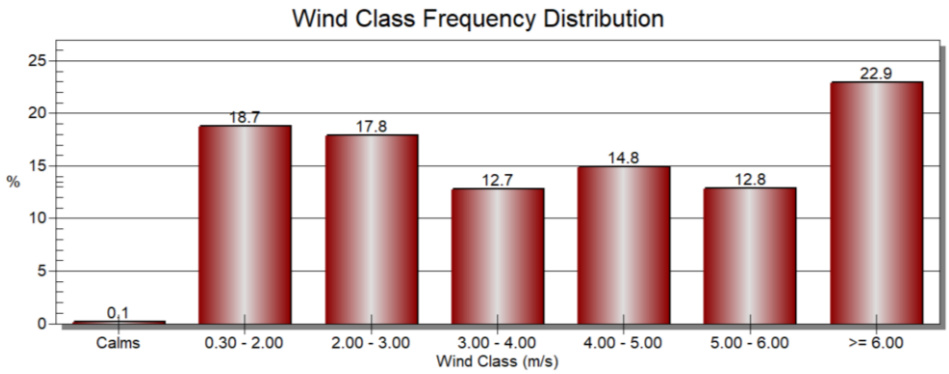


Figure 4-21: April wind class frequency distribution, VOK meteorological station (2014-2023).

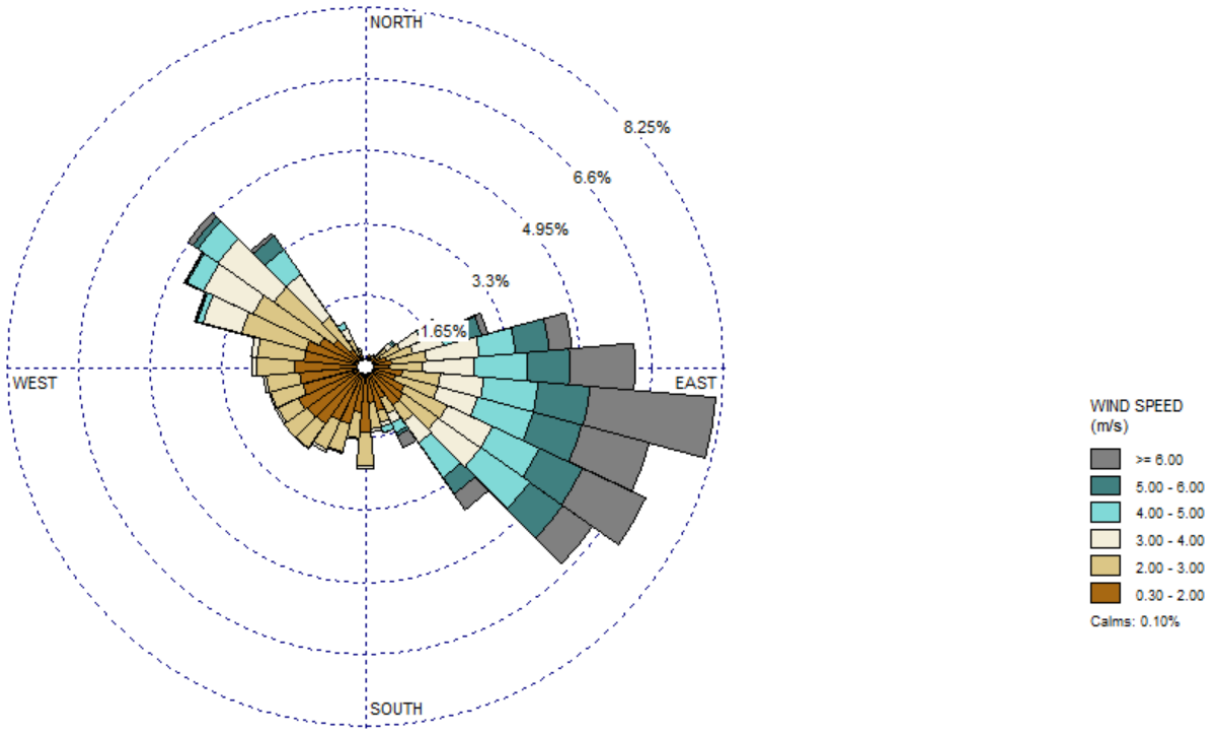


Figure 4-22: May wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

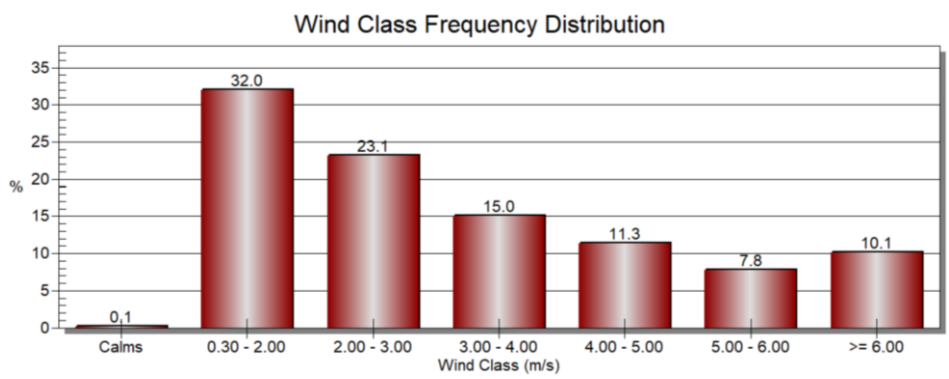


Figure 4-23: May wind class frequency distribution, VOK meteorological station (2014-2023).

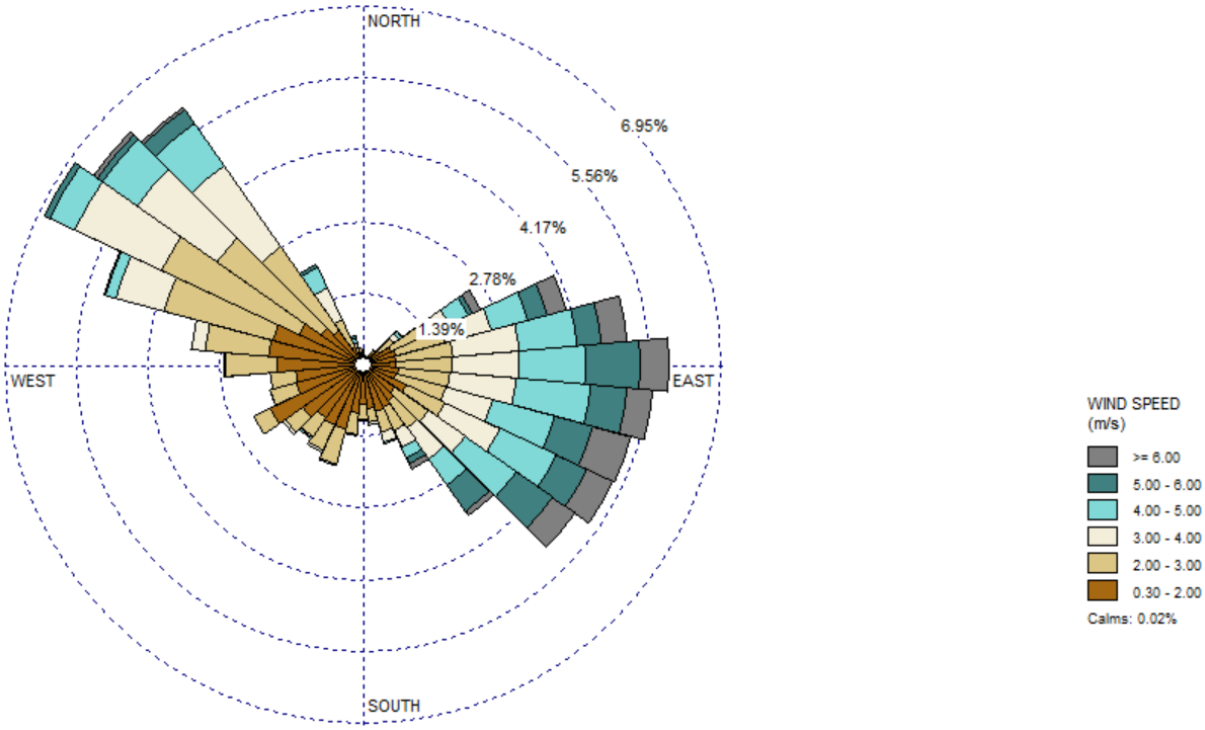


Figure 4-24: June wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

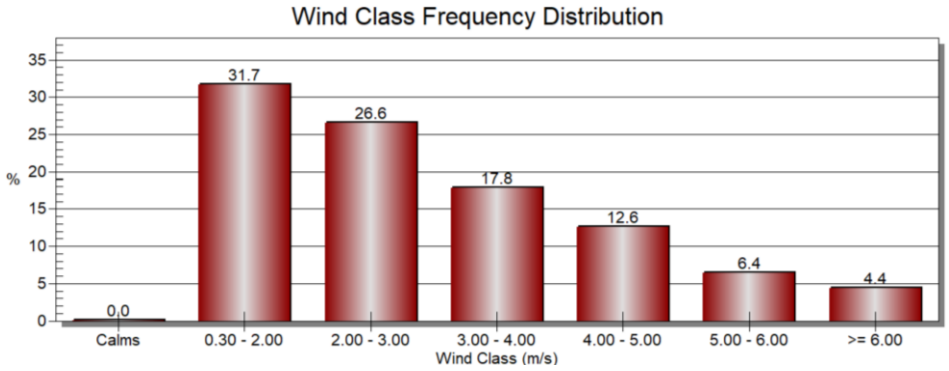


Figure 4-25: June wind class frequency distribution, VOK meteorological station (2014-2023).

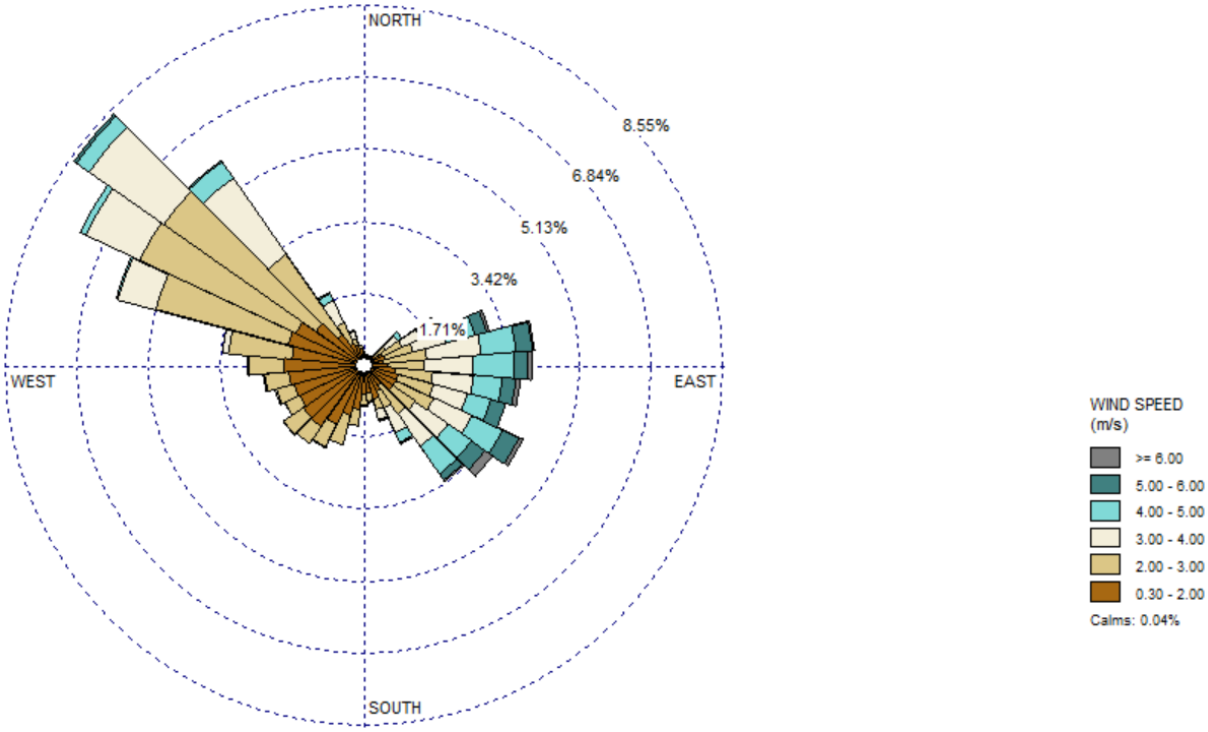


Figure 4-26: July wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

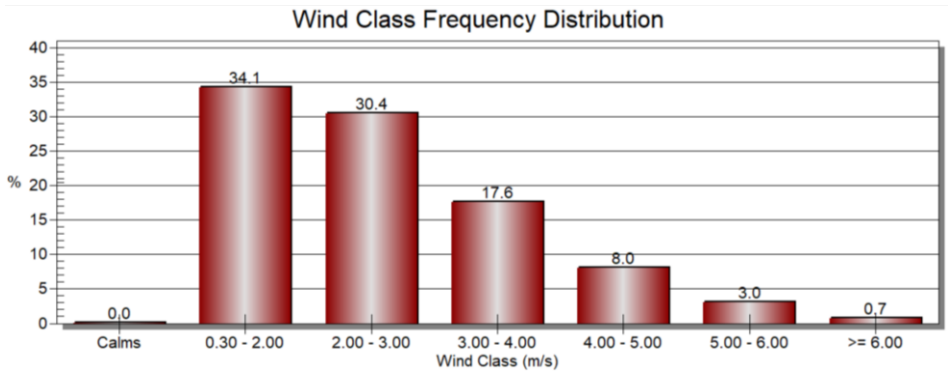


Figure 4-27: July wind class frequency distribution, VOK meteorological station (2014-2023).

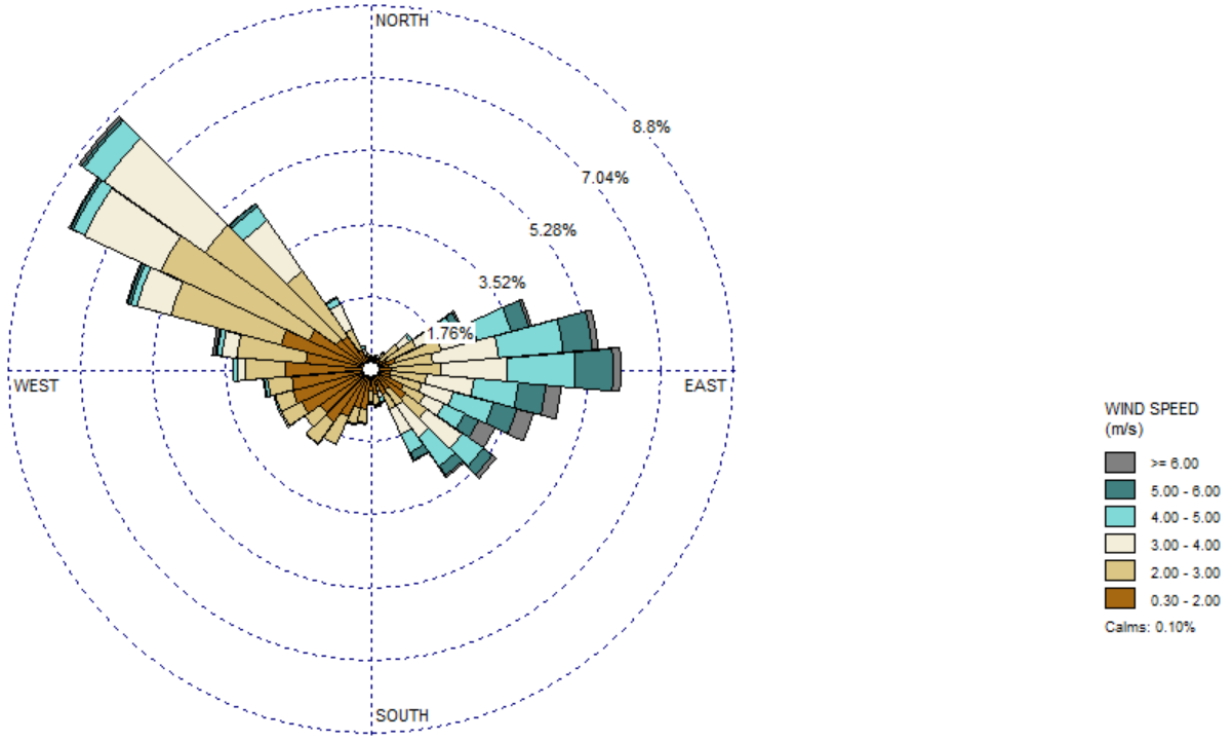


Figure 4-28: August wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

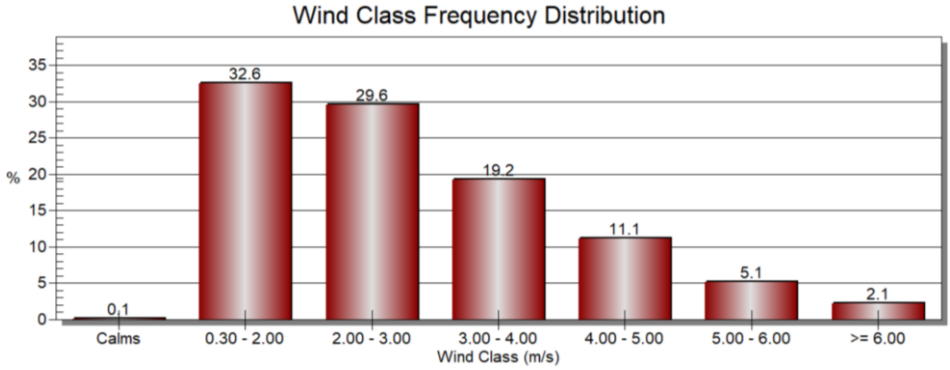


Figure 4-29: August wind class frequency distribution, VOK meteorological station (2014-2023).

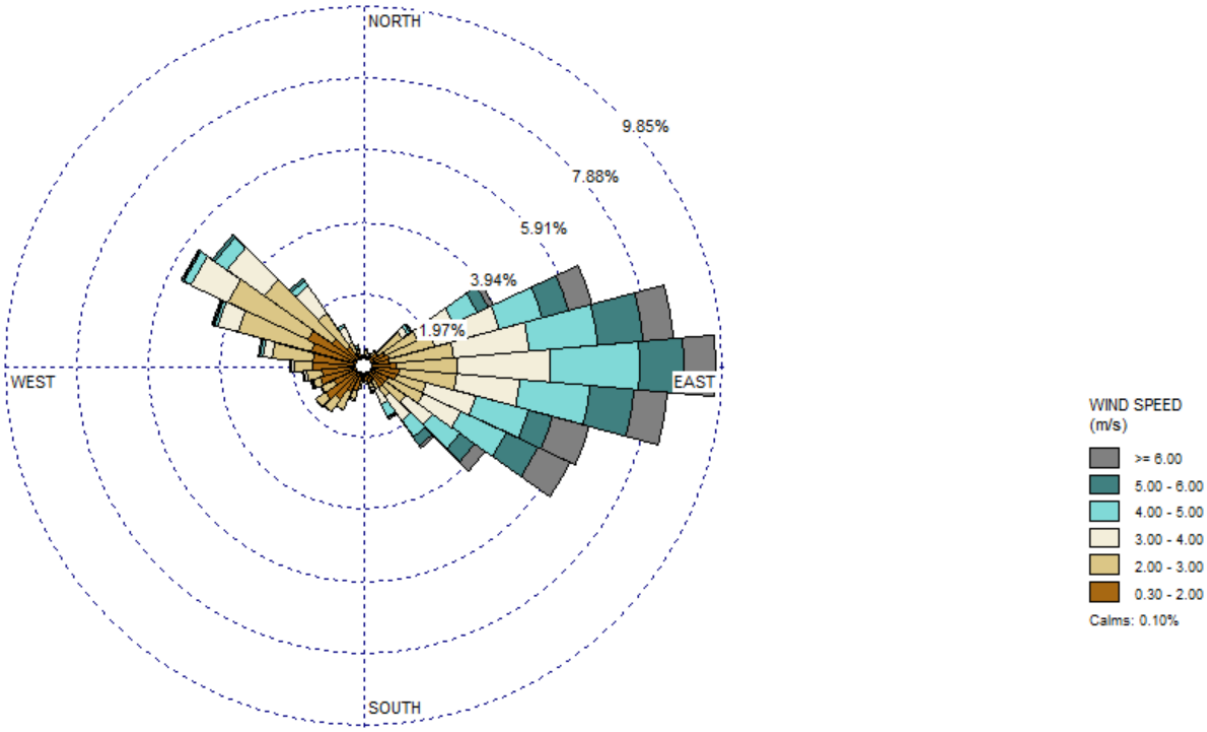


Figure 4-30: September wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

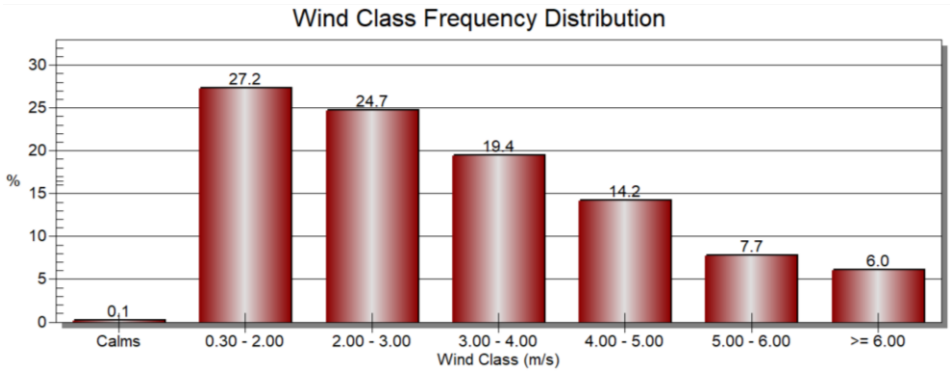


Figure 4-31: September wind class frequency distribution, VOK meteorological station (2014-2023).

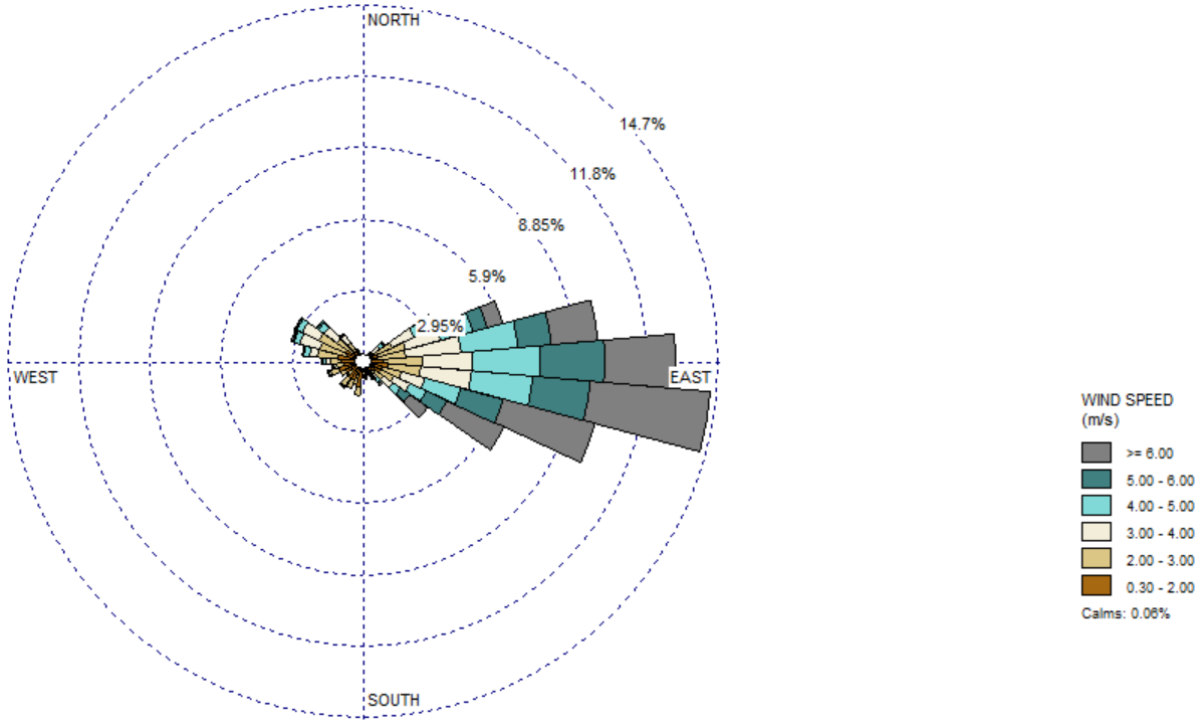


Figure 4-32: October wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

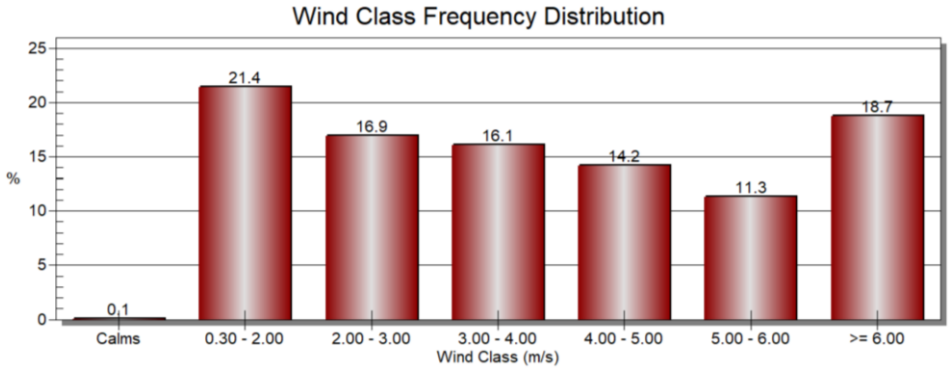


Figure 4-33: October wind class frequency distribution, VOK meteorological station (2014-2023).

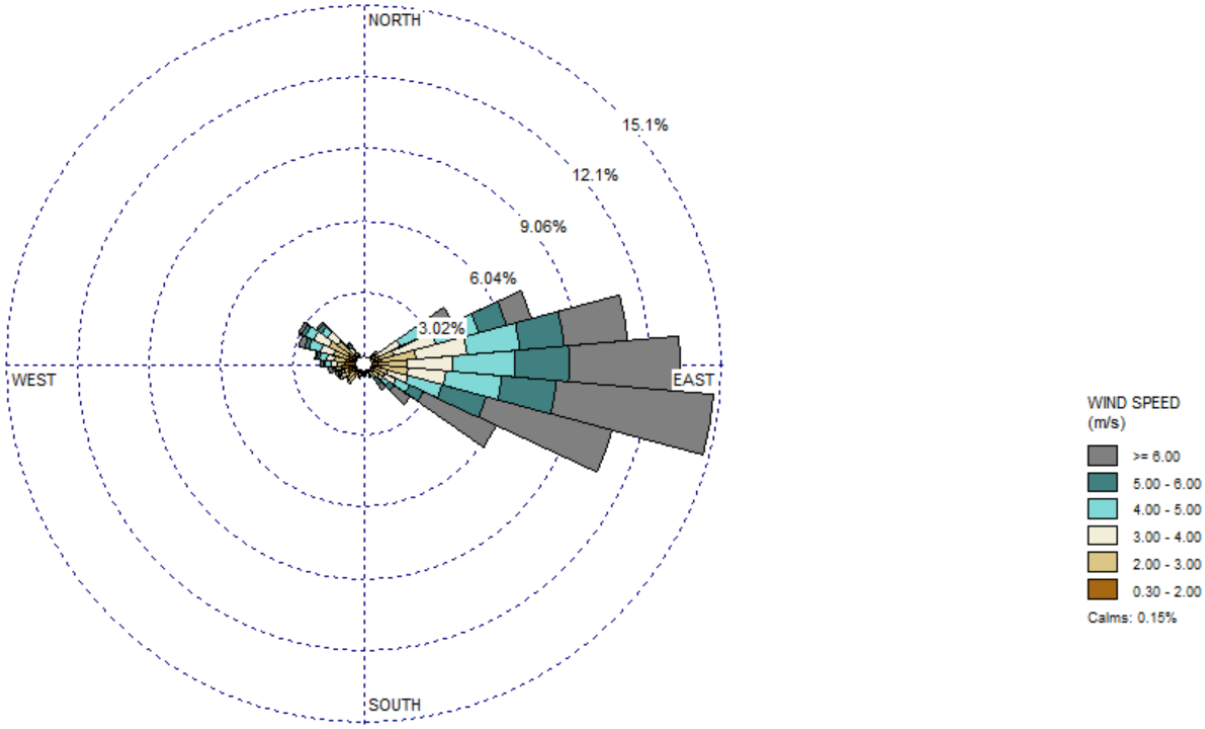


Figure 4-34: November wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

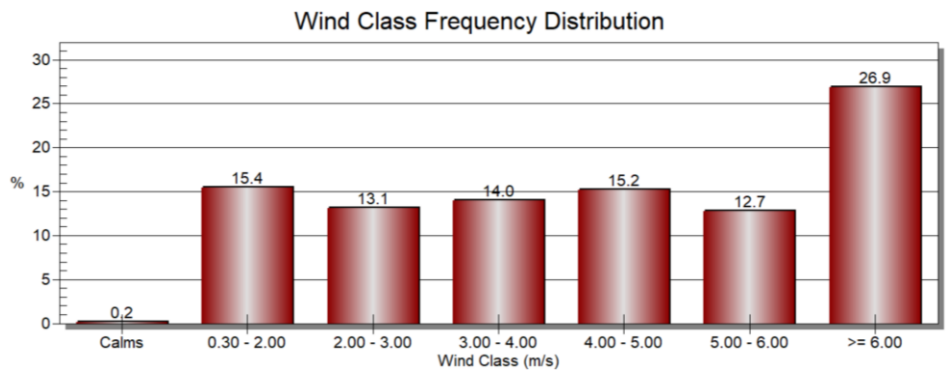


Figure 4-35: November wind class frequency distribution, VOK meteorological station (2014-2023).

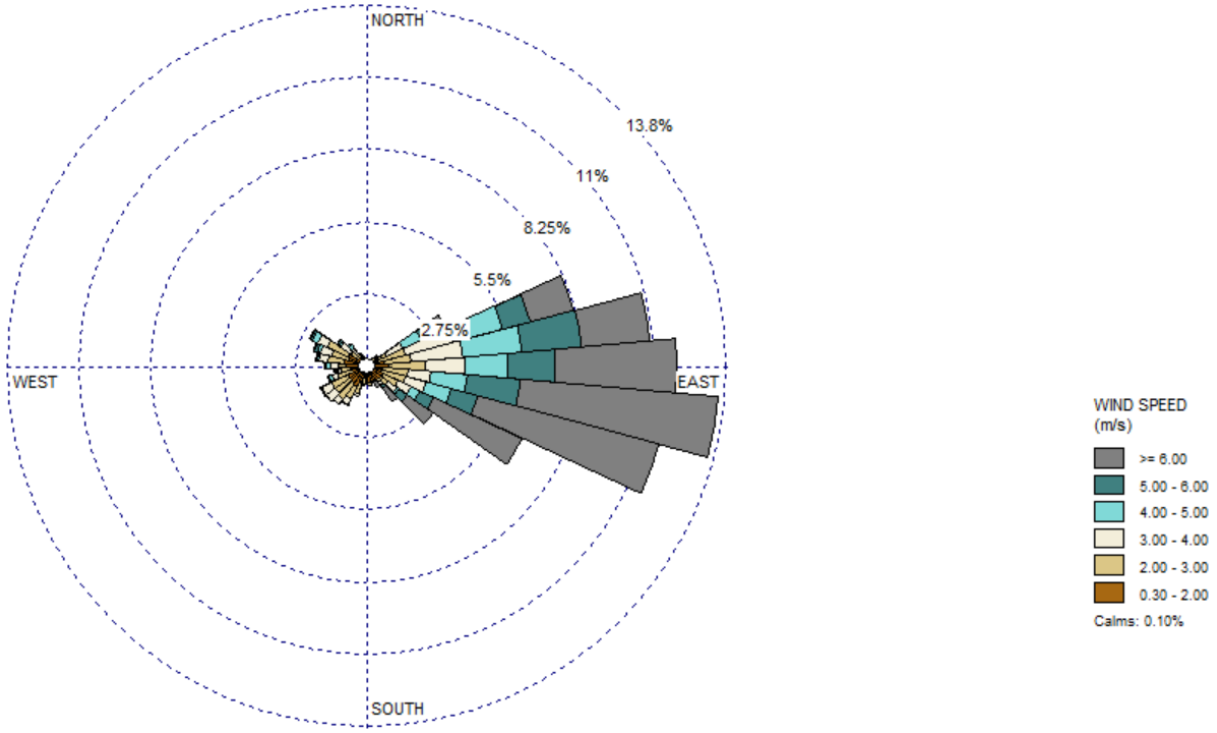


Figure 4-36: December wind rose and wind speed summary, VOK meteorological station (2014-2023). Note that data are summarized in 'blowing from' format.

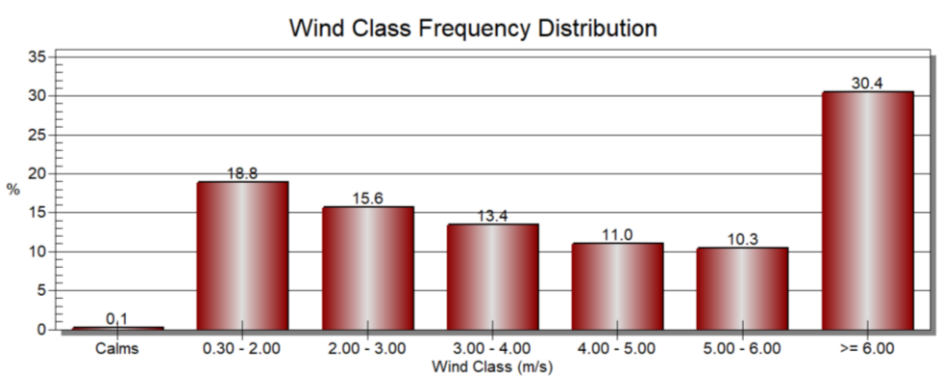


Figure 4-37: December wind class frequency distribution, VOK meteorological station (2014-2023).

4.8 Potential Evaporation

The following potential evaporation summaries are presented in this section of the report:

- Monthly and annual potential evaporation estimates are presented for VOK meteorological station for the available record period (Table 4-21).
  - Monthly potential evaporation depths are highest, on average, during months of May, June, July and August.
  - Long-term average rates of potential evaporation are estimated to be 296 mm (May-September) and approximately 400 mm annually.
- In Figure 4-38, daily potential estimates computed for VOK meteorological station (September 2014-October 2023) are plotted in time series format.

Table 4-21:
Monthly and annual potential evaporation estimates for VOK meteorological station (2014-2023).

	Potential Evaporation (mm)													
Period	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**May-Sep**	**Ann**
2014	---	---	---	---	---	---	---	---	34	15	15	9	---	---
2015	9	15	25	40	94	76	64	46	23	14	12	6	303	423
2016	9	9	26	39	69	69	60	54	24	12	3	4	277	379
2017	5	11	15	45	62	58	61	68	34	14	4	4	283	382
2018	1	8	22	39	68	73	91	60	37	15	5	2	330	422
2019	4	12	36	44	83	73	25	60	33	12	5	5	275	394
2020	5	7	25	43	70	57	55	32	36	11	7	5	249	352
2021	5	7	16	51	63	83	76	49	21	19	6	4	291	400
2022	5	9	20	39	69	89	67	62	32	16	9	4	320	422
2023	5	5	22	35	78	79	86	---	---	---	---	---	---	---
Average (2014-2023)	6	9	23	42	73	73	65	54	31	14	7	5	296[1]	401

[1]This potential evaporation estimate compares well to the 30-yr (1991-2020) May-September estimate of 279 mm returned by ClimateBC (https://climatebc.ca/) for a grid point and elevation corresponding to the VOK climate station.

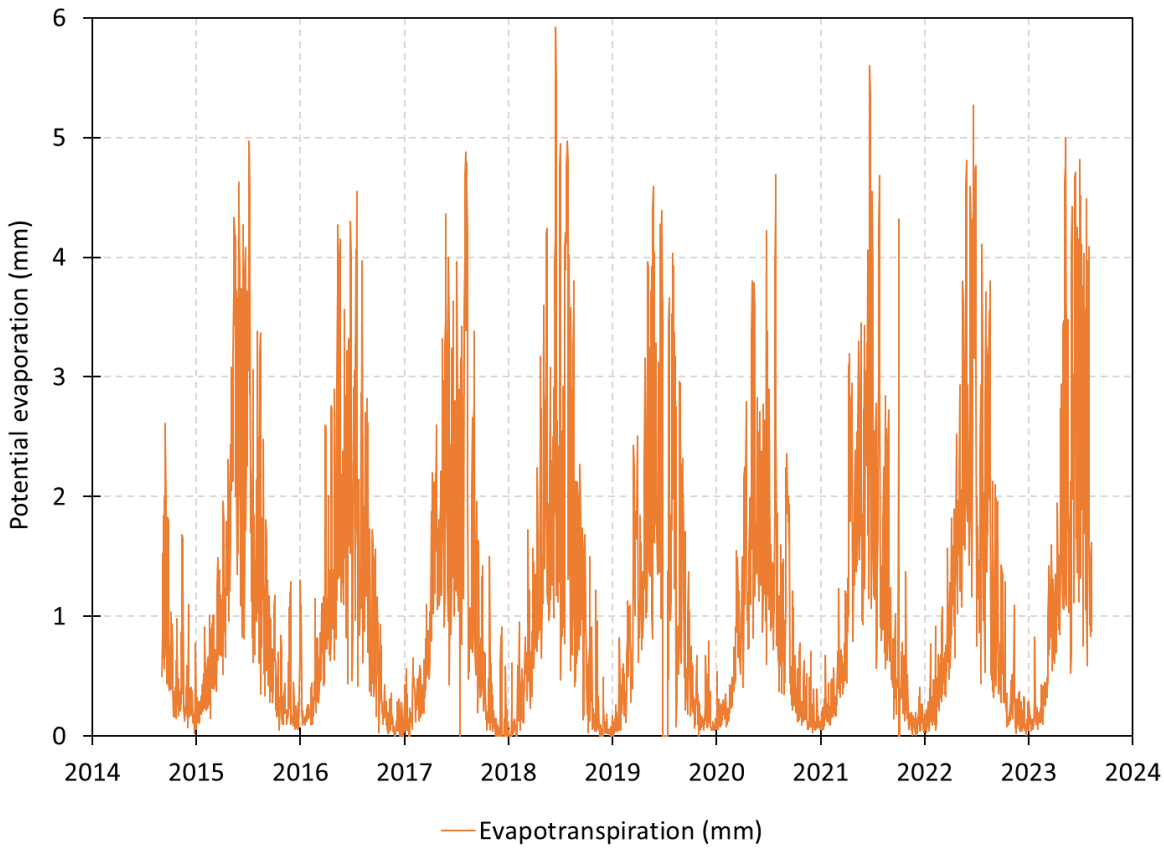


Figure 4-38: Daily potential evaporation estimates for VOK meteorological station (September 2014-August 2023).

5. Closure

We trust this report meets your requirements at this time. Please contact us should you have any questions or concerns or require additional information in support of this work.

Yours sincerely,

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Engineers and Geoscientists British Columbia Permit to Practice Number: 1001840.

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Appendix 2-2 Verification Report 2021 Greenhouse Gas Emissions

DILLON CONSULTING

NEWCREST MINING LIMITED

Verification Report

Brucejack Gold Mine Facility Submission under the BC Greenhouse Gas Emission Reporting Regulation, BC Regulation 249/2015

January 1, 2021 to December 31, 2021 Emission Report)

May 31, 2022

May 31, 2022

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Brittany Moore
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Vancouver, British Columbia
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Verification Report and Statement – Version 2.0
Greenhouse Gas Emission Reporting Regulation – B.C. Regulation 249/2015 – ANAB Accreditation under ISO 14065
2021 Emission Report for the Facility

Dear Ms. Moore:

Dillon Consulting Limited (Dillon) is pleased to present Newcrest Mining Limited (Newcrest) with this Verification Report under British Columbia Greenhouse Gas Emission Reporting Regulation (B.C. Reg. 249/2015 [the Regulation]) under the *Greenhouse Gas Industrial Reporting and Control Act* for the Brucejack Gold Mine Facility, located north of Stewart, British Columbia, Canada (Facility or Site). The Facility is registered with the BC Ministry of Environment (MOE) and Climate Change Strategy with BCGHG ID # 22122200002.

The Facility used quantification methodologies developed in consideration of British Columbia Greenhouse Gas Emission Reporting Regulation (Regulation), CleanBC Industrial Incentive Program Guideline and the Western Climate Initiative (WCI) *Final Essential Requirements of Mandatory Reporting: Amended for Canadian Harmonization* (2011).

Dillon has reviewed production numbers in support of the CleanBC Industrial Incentive Program (CIIP) application, however was unable to review the final CIIP report as it was not available for review before May 31, 2022. As a result, we have not provided a statement in regards to the CIIP production at this time. Dillon will provide an updated report once the CIIP application report has been provided.

Please contact Zachary Zehr at 226.752.9319 or zzehr@dillon.ca, should you have any questions.

Sincerely,

DILLON CONSULTING LIMITED

Zachary Zehr, P.Eng.
Lead Verifier

MHH:mjm
Our file: 22-3530

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A Verification and Sampling Plan
B Emission Report Verification Statement and Conflict of Interest Report

1.0 Verification Overview

1.1 Introduction

Dillon Consulting Limited (Dillon) presents Newcrest Mining Limited (Newcrest) (formerly Pretium Exploration Inc.) with this Verification Report for Greenhouse Gas (GHG) Inventory and CIIP Verification Services under British Columbia Greenhouse Gas Emission Reporting Regulation (B.C. Reg. 249/2015 [the Regulation]) under the *Greenhouse Gas Industrial Reporting and Control Act* for the Brucejack Gold Mine Facility, located north of Stewart, British Columbia, Canada (Facility or Site). In particular, the scope involves the verification of the Facility's 2021 Emission Report and CIIP Production.

1.2 Objectives

The objectives of this assignment are to provide Newcrest and BC MOE Climate Action Secretariat (CAS) (the Regulator) with a reasonable level of assurance, independent, third party verification, and opinion on whether the Facility's 2021 Emission Report and Production Data under the CleanBC Industrial Incentive Program (CIIP) is free of material misstatements, as well as that the information reported is accurate and consistent with the requirements of the Regulation.

1.3 Verification Scope

The following is a summary from the 2021 Emission Report scope for the Facility.

Time Period – January 1, 2021 through December 31, 2021.

Geographic and Organizational Boundaries: This scope includes the emissions generated and 2021 production at the Facility at the physical address as listed below. The emissions are related to specific GHG activities listed in the Regulation and emitted by the Facility. The Facility is located at the following address:

56°27'55.94"N, 130°11'10.06"W
Approximately 65 km north of Stewart
Regional District of Kitimat-Stikine, British Columbia

Activities and Processes: The Facility is an underground high-grade gold mine. The operations and camps are connected to the BC Hydro power grid with full diesel backup generation capacity. The Facility includes three (3) active camp sites, and one (1) closed camp site: Wildfire Camp, Knipple Camp, Brucejack Camp, and Bowser Camp (closed). Operations on-site include:

- WCI.280 – Mobile Equipment at Facilities:
  - Diesel in heavy equipment; and
  - Gasoline in off-road mobile equipment;
- WCI.020 – General Stationary Combustion:
  - Diesel in backup generators;

  - Propane in space heaters;
  - Waste materials in incinerator; and
  - Open burning of wood waste; and
- WCI.200 – Wastewater treatment on-site.

GHG Emission Sources, Categories, and GHG Types: The applicable Facility GHG activities are provided in **Table A** (attached).

Organizational-level Sector: 2 – Mining and mineral production.

1.4 Level of Assurance and Materiality

The verification was conducted to a reasonable level of assurance, per the requirements of the Regulation and CIIP.

The materiality threshold for the Facility was set at plus or minus 5% of the Emissions reported in 2021, consistent with Section 32 of the Regulation. The materiality threshold for the Facility under the CIIP was set at plus or minus 5% of the 2021 Production Data.

BC Regulation requires that net of all over or understatements cannot exceed the lesser of 1,000 tonnes of CO_2e or 1% of the total emissions. In addition, CIIP requires that all correctable errors be corrected and that the aggregate effects of error results in any inaccuracy be no greater than 0.1%.

Individual errors, omissions, misstatements, or the aggregation of discrete errors, omissions, or misstatements, were considered material. As further described in **Section 4.0** and **Section 5.0**, the Facility's 2021 Reported Emissions and Production Data did not exceed the materiality threshold.

1.5 Verification Criteria

Dillon conducted the verification in accordance with the requirements and criteria outlined in the Regulation, including the following:

- *ISO 14064-1:2018 – Part 1: Specification with guidance at the organization level for quantification and reporting of GHG emissions and removals,* ISO, December 2018;
- *ISO 14064-3:2006 – Part 3: Specification with guidance for the validation and verification of GHG assertions,* ISO, March 2006;
- SBC 2014, Chapter 29: *Greenhouse Gas Industrial Reporting and Control Act*, current to January 20, 2021;
- CleanBC Industrial Incentive Program (CIIP) Guidelines;
- BC Regulation 249/2015: *Greenhouse Gas Industrial Reporting Regulation: Greenhouse Gas Emission Reporting Regulation (Regulation),* as amended by BC Reg. 294/2020, December 21, 2020;
- B.C. Regulation 231/2019: *Greenhouse Gas Industrial Reporting and Control Act*;

- Western Climate Initiative (WCI) *Final Essential Requirements of Mandatory Reporting: Amended for Canadian Harmonization*, December 17, 2010;
- WCI *2011 Amendments for Harmonization of Reporting in Canadian Jurisdictions*, December 21, 2011; and
- WCI *Quantification Method 2013 Addendum to Canadian Harmonization version*, December 10, 2013.

2.0 Verification Body and Verification Team

Table 1 below provides an overview of the Verification Body (VB), Dillon Consulting Limited. **Table 2** below provides details regarding the Verification Team.

Table 1: Verification Body Overview

Name	Dillon Consulting Limited
Mailing and physical address	51 Breithaupt St, Kitchener, ON N2H 5G5
Contact information	Zachary Zehr zzehr@dillon.ca 519-571-9833
Accrediting agency	ANAB
Accreditation ID	8896

Table 2: Verification Team Overview

Verification Team	
Lead Verifier and Technical Expert	Zachary Zehr, P.Eng.
Contact Information	zzehr@dillon.ca , 519-571-9833
Additional Qualifications	Zach is a licensed professional engineer in Ontario, and has a Bachelor of Engineering in Environmental Engineering from the University of Guelph. Zach has more than eight years of experience working in a variety of air and noise compliance and GHG projects, including air compliance assessments, permitting, dispersion modelling, stack testing, odour abatement, and noise assessments, and validation and verification of GHG emissions reporting and offset projects. Zach has worked on numerous voluntary and regulated emission offsets and compliance projects in Canada, spanning the waste, manufacturing, institutional, oil and gas, power generation, cement manufacturing, and pulp and paper sectors. Zach has completed well over 100 verification assignments in the following programs: • Alberta (oil and gas extraction, and pulp and paper); • Ontario (institutional/general, manufacturing, power generation, mining and mineral production, chemical production, and oil and gas extraction); • VCS (wind power); • ARB Cap-and-Trade Program (livestock and ODS); • CSA Clean Projects Registry (power generation); and • Québec (fuel distribution).

Verification Team

Responsibilities	All verification activities including data reviews, recalculations, and verification report preparation.
Lead Verifier-in-Training	Martha Hamre, EIT
Contact Information	mhamre@dillon.ca
Additional Qualifications	Martha is an engineering intern with four (4) years of work experience specializing in both atmospheric, infrastructure, and mining related projects, and two years of verification experience. Martha has experience quantifying emissions from both stationary and mobile sources and has performed regulatory dispersion modelling assessments to assist clients across Ontario. Martha has conducted verifications under The Climate Registry, the Greenhouse Gas Protocol, Ontario Regulation 390/18, and the Output-Based Pricing System, for facilities across Canada and the United States.
Responsibilities	All verification activities including data reviews, recalculations, and verification report preparation, and site visit.
Verifier	Alyssa Hooge, B.Sc.
Contact Information	ahooge@dillon.ca
Additional Qualifications	Alyssa is an Environmental Technologist and has a Bachelor of Technology in Environmental Engineering. Alyssa has a broad range of experience in solid waste management and environmental compliance in Canada. She has experience in GHG reporting and verification projects with Dillon for a variety client sectors, including power generation, manufacturing, oil and gas, agriculture, and waste. Through this work, she is well-versed in a number of GHG programs and protocols in Canada and the United States. She has assisted in GHG verifications under the Output-Based Pricing System, the British Columbia GHG Emission Reporting, and other Regulations.
Responsibilities	All verification activities including data reviews, recalculations, and verification report preparation.
Peer Reviewer	Jack Wallace, P.Eng., M.A.Sc.
Contact Information	jwallace@dillon.ca
Additional Qualifications	Jack is an Associate with Dillon and a licensed professional engineer in Alberta and British Columbia, and has over nine years of experience working in a variety of solid waste management and GHG projects. Jack is located in Dillon's Calgary, Alberta office and holds a range of project experience including: evaluation and design of waste processing facilities, waste management system planning and financial analysis, wastewater characterization and treatment system design, validation and verification of GHG emissions reporting and offset projects, and modelling for waste and emissions studies.
Responsibilities	Independent Peer Review activities.

Independent Reviewer Statement

By signing this Verification Report, the Independent Reviewer has reviewed the qualifications of the Verification Team and confirms that the team meets the qualification requirements found in the Regulation.

3.0 Verification Methodology

A detailed review of the verification scope and criteria, Verification Team, project understanding, timeline, and verification methodology are provided below and further detailed in the Final Verification and Sampling Plan (VSP) in **Appendix A.** This includes a detailed Sampling Plan, which describes the nature, scale, and complexity of verification activities undertaken.

3.1 Procedures

3.1.1 Conflict of Interest

Dillon performed a self-evaluation conflict of interest (COI) check to determine the potential of an actual or perceived COI that Dillon may have with the Client. The risk-based evaluation required by the Verification Criteria resulted in a low risk for COI between Dillon and the Facility/Client. The Conflict of Interest Report is included as **Appendix B and C**.

3.1.2 Project Initiation

Dillon held a kick-off conference call on February 22, 2022 to discuss verification scope; sources, sinks, and reservoirs (SSRs); and verification timelines, and to provide the Client with an initial information request. Site visit scheduling and logistics were also discussed during this meeting.

3.1.3 Verification and Sampling Plan

Dillon developed a risk-based VSP that guided the verification process. Dillon notes that this document was dynamic and did change throughout the verification process. The following was contained within the VSP:

- The verification objective, scope, and program criteria;
- The level of assurance provided, the Client's GHG assertion, and the materiality threshold;
- A description of the verification procedures (nature, timing, and extent) applied to address risks identified at the assertion level in the Facility's report;
- A qualitative narrative of the Uncertainty Risk Assessment;
- Members and roles of the Verification Team including team experience and qualifications;
- The verification schedule; and
- A dynamic Sampling Plan.

Dillon submitted an initial VSP to Newcrest on February 25, 2022. The updated VSP (including revised Sampling Plan) that is representative of the audit works undertaken, is provided in **Appendix A.**

3.1.4 Site Visit

A site visit was conducted on March 30, 2022. The site visit was conducted by Martha Hamre and included interviews with Newcrest personnel, witness of site operations and SSRs, verification of

monitoring equipment and calibration records, and a review of data collection and management procedures. Newcrest personnel who attended the site visit included Brittany Moore – Environmental Engineer-in-Training; Robert Shea – Power Generation Technician; Terry McRobb – Maintenance Planner; Gordon Everitt – Lead Waste & Potable Water Operator; Eicenober Jimenez – Waste & Potable Water Operator; Ryland Glaim – Warehouse & Freight Logistics Coordinator; and Vaughan Blackman – Environmental Scientist.

3.1.5 Independent Peer Review

An independent peer review of the Verification Report findings was performed by Jack Wallace, the Independent Peer Reviewer for the verification, on **May 26, 2022** to identify any errors in planning, data sampling, findings, and conclusions of the Verification Team. The Independent Peer Reviewer was not involved in the verification process other than by providing the independent peer review.

Upon completion of the independent review, Dillon's Independent Peer Reviewer concurred with the verification findings presented by the Verification Team.

3.2 Schedule

The verification was conducted over the schedule presented in **Table 3** below.

Table 3: Verification Schedule

Task		Timeline
0	Project award and contract signing	February 2 - 11, 2022
1	Project kick-off call	February 22, 2022
2	Initial VSP preparation and submission to Newcrest	February 25, 2022
---	Newcrest review and approval of VSP	March 7 - 11, 2022
3	Data and information exchange	March 7 - 11, 2022
4	Site visit	March 30, 2022
5	Data checks and recalculation development	March 14 - April 1, 2022
6	First round issues log submission to Newcrest	April 6, 2022
---	Newcrest review and response to issues log	April 6 – April 29, 2022
7	Second round issues log submission to Newcrest	April 29, 2022
---	Newcrest review and response to issues log	April 29 – May 24, 2022
8	Draft Verification Report preparation	April 6 – May 25, 2022
9	Independent Review	May 26, 2022
10	Submittal of Draft Verification Report to Newcrest	May 27, 2022
---	Newcrest review and response to Draft Verification Report	Within two days
11	Submittal of Final Verification Report to Newcrest and BC CAS	May 31, 2022

3.3 Risk Assessment

Dillon developed a Risk Assessment for the following aspects with respect to the Regulation:

- Facility boundary;
- Data management including acquisition equipment, sampling and frequency, and processing and tracking;
- Consistency with previous reporting periods and applied benchmarks;
- Facility production; and
- Facility GHG emissions by source (i.e., stationary combustion, mobile combustion, etc.).

Each of the above categories were developed and assessed as low, medium, or high risk, as it related to the following risk categories:

- Inherent Risk;
- Control Risk; and
- Detection Risk.

The Risk Assessment related to the above was documented in a table format within the VSP, provided in **Appendix A**.

4.0 Verification Findings

Dillon performed data checks of all supporting information and data provided by the Facility. A complete list of the documents provided to Dillon during the verification is presented in **Table B**.

The issues log was developed to summarize the data checks completed by Dillon and present any material and immaterial discrepancies that Dillon identified during verification. Any issues identified were documented in the issues log. The Facility would have an opportunity to respond to the issues identified in the issues log through verbal communication or email correspondence. The final issues log detailing all issues and their resolutions is provided in **Table C**. There were no unresolved qualitative or quantitative findings associated with the data or data management systems.

4.1 Assessment of Data Management Systems and Controls

Newcrest made available to Dillon all documentation that supported a review of the Facility Emission Report. These records include meter and raw data, operational records and logs, data management systems, quality assurance and quality control (QA/QC) practices, quantification methodologies, and staff interviews. A complete list of the documents provided to Dillon during the verification is presented in **Table B**.

The site has physical and digital data collection, and data is retained indefinitely in Newcrest's digital data management system. Data collected in physical data collection forms are digitized and stored. The source of data is acceptable for use in the Emission Report.

Dillon assessed the information systems and controls for sources of potential errors, omissions, and misrepresentations, taking into consideration the following:

- Selection and management of the GHG data and information;
- Processes for collecting, processing, consolidating, and reporting GHG data information;
- Systems and processes that ensure the accuracy of the GHG data and information;
- Degree of automation;
- Use of database features;
- Length of operation;
- Linkage to other systems;
- Standardization within an organization;
- Transparency of calculations;
- Design and maintenance of the GHG information system;
- Systems and processes that support the GHG information system; and
- Results of previous assessment.

4.2 Assessment of GHG Sources and Calculation Methodologies

Table 4 below presents Dillon's assessment of emissions data for the 2021 Submission for each SSR included in the GHG boundary and for Production. A complete list of the documents provided to Dillon during the verification is presented in **Table B**.

Table 4: Assessment of Data Findings

SSR/ Production	Verification Findings
Consistency with Previous Years	Dillon reviewed the emissions reported in 2020 and 2021 and identified a 1.3% increase in overall attributable emissions
WCI.020 – General Stationary Combustion	General stationary combustion consists primarily of backup diesel generators and propane space heaters. Additionally, solid waste materials are incinerated at the Brucejack and Knipple camp sites. Several pits are used for open burning of clean wood waste (pallets, clearing debris), with volumes estimated by dimensions logged and a default void content and density applied. The fuels combusted include: • Propane; • Diesel; • Wood waste; and • Mixed solid waste. Newcrest applied default emission factors under Part 020 of the WCI guidelines, as listed in Table 20-1 though Table 20-7, and default material property values from IPCC (2006) Volume 5: Waste for the estimation of waste emissions from incineration. Default organic and fossil carbon content values are applied based on the type of material combusted. The material breakdown of each batch incineration batch is assessed visually and logged. The methodology for waste combustion was modified from 2020 to 2021 to follow Methodology 1 of WCI.23 rather than formulas from IPCC (2006) as previously referenced. The emission factor for N_2O was revised to reference WCI Table 20-7. Based on bulk diesel delivery to the site, diesel consumption is allocated to stationary equipment based on equipment run hours, power ratings from manufacturer specifications (generator cut sheets), and default load factors. Dillon completed a recalculation of stationary combustion emissions using raw data from invoices as well as observations on the engineering estimates from the site visit and default emission factors and carbon contents (waste). Minor discrepancies were identified due to the availability of generator cut sheet information which detail fuel loads, which are not material.
WCI.280 – Mobile Equipment at Facilities	All gasoline is used for mobile equipment. Based on bulk diesel delivery to the site, and diesel consumption allocated to stationary combustion, the remainder of the diesel delivered to site is allocated to mobile equipment use. Newcrest applied default emission factors under Part 020 of the WCI guidelines, as listed in Table 20-2. Part 280 of the WCI guidelines were followed for general procedures such as sampling frequency and data management.

SSR/ Production	Verification Findings
	Dillon completed a recalculation of mobile equipment emissions using raw data from invoices and default emission factors. Minor discrepancies were identified due to generator cut sheet information referenced for General Stationary Combustion calculations, which are not material.
WCI.200 – Wastewater Emissions	Newcrest reported N_2O emissions from the aerobic wastewater treatment systems, following methodologies under Part 200 of the WCI guidelines. Total nitrogen in effluent results based on the permitted composite sample are used. Dillon completed a recalculation of wastewater emissions using raw data from total nitrogen results and wastewater flow. Minor discrepancies were identified due to wastewater volumes which are not material.
Production	Gold and silver production is tracked through the weigh data of final product using calibrated weigh scales. Weigh scales are checked with a traceable test weight before and after every recorded production weigh-in. Product is weighed prior to loading on shipment vehicles. Electricity is purchased from the grid-supplied network and invoiced monthly. Dillon reviewed electricity invoices. Dillon did not identify any discrepancies in the production reported under CIIP.

The data provided was appropriately employed by Newcrest and is deemed acceptable for quantification of the 2021 Emission Report. In addition, the emissions and production quantification methodologies referenced in the 2021 Emission Report are the same as the ones used in the baseline emissions submission.

4.3 Summary of Recalculation

Dillon performed a complete recalculation of the GHG emissions reported and production in the Facility's 2021 Emission Report and CIIP. Dillon's recalculation of GHG emissions were completed in accordance with the Verification Criteria and applicable quantification methodologies. A detailed list of Dillon's findings is presented in the Issues Log in **Table C** following the report text. The verification findings present a summary of the independent quantifications from the document review and recalculation of the GHG emissions and production reported in the Facility Inventory.
Table 5 and **Table 6** summarizes the results of Dillon's recalculated GHG emissions and production against the Facility reported regulated GHG emissions for each SSR and reported production, as well as relevant findings.

Table 5: Regulated GHG Emissions Quantification

SSR/ Production	Facility Reported Emissions	Dillon Recalculated Emissions	Difference (tonnes CO_2e)	% Difference
WCI.020 – Stationary Fuel Combustion				
Diesel	4,086	4,153	-66.55	-1.6%
Propane	3,095	3,095	0.00	0%
Wood	247	247	0.00	0%
Incineration	123	123	0.00	0%
Subtotal	7,552	7,619	-66.55	-0.88%
WCI.280 – Mobile Equipment at Facilities				
Diesel	21,324	21,258	66.55	0.3%
Gasoline	863	863	0.00	0%
Subtotal	22,187	22,121	66.55	0.30%
WCI.200 – Wastewater Emissions				
Subtotal	3.24	3.23	0.01	0.4%
Total Emissions (tonnes)	**29,743**	**29,743**	**0.01**	**0.00004%**

Table 6: Facility CIIP Production Data

Name of CIIP Product	Facility Reported Production	Dillon Recalculated Production	Difference	Difference (%)
Facility Production				
Electricity Consumption (Purchased) (GWh)	145.16	145.16	0	0%
Heat Consumption	0	0	0	0%
Tonnes of Gold Equivalent	11.124	11.124	0	0%

The accumulated evidence supports the Facility's 2021 Emission Report and CIIP assertion in terms of the required reasonable level of assurance and plus or minus 5% materiality threshold for both production and emissions separately.

5.0 Verification Statement

5.1 Statement of Verification

The Facility reported **29,743 tonnes CO_2e** of regulated emissions for the 2021 year. Dillon conducted a verification of the Newcrest 2021 Emission Report GHG assertion prepared under B.C. Reg. 249/2015 per the Verification Criteria as follows:

- *ISO 14064-1:2018 – Part 1: Specification with guidance at the organization level for quantification and reporting of GHG emissions and removals,* ISO, December 2018;
- *ISO 14064-3:2006 – Part 3: Specification with guidance for the validation and verification of GHG assertions,* ISO, March 2006;
- SBC 2014, *Chapter 29: Greenhouse Gas Industrial Reporting and Control Act*, current to January 20, 2021;
- BC Regulation 249/2015: *Greenhouse Gas Industrial Reporting Regulation: Greenhouse Gas Emission Reporting Regulation (Regulation), as amended by BC Reg. 294/2020*, February 2021.
- B.C. Regulation 231/2019: *Greenhouse Gas Industrial Reporting and Control Act*;
- Western Climate Initiative (WCI) *Final Essential Requirements of Mandatory Reporting: Amended for Canadian Harmonization*, December 17, 2010;
- WCI *2011 Amendments for Harmonization of Reporting in Canadian Jurisdictions*, December 21, 2011;
- WCI *Quantification Method 2013 Addendum to Canadian Harmonization version*, December 10, 2013; and,
- CleanBC Industrial Incentive Program Guideline (CIIP)

Based on the procedures undertaken, it is our opinion that:

- The assertions in the Newcrest 2021 Emission Report prepared under the BC Greenhouse Gas Emission Reporting Regulation (BC Reg. 249/2015) are materially correct and are a fair and accurate representation of the Facility's total attributable emissions for the 2021 reporting period; and
- The Newcrest 2021 Emission Report was prepared and the emissions reported in it quantified in accordance with the Regulation.

A completed Emissions Report Verification Statement, as required by CAS and based on the template provided, is included as **Appendix B**.

5.2 Limitation of Liability

This report and statement was prepared exclusively for the purposes, project, and site locations outlined in the report and statement. The report is based on information provided to, or obtained by Dillon Consulting Limited ("Dillon") as indicated in the report, and applies solely to site conditions existing at the time of the site investigation(s). Although a reasonable level of assurance investigation was

conducted by Dillon, Dillon's investigation was by no means exhaustive. Rather, Dillon's report represents a reasonable review of available information within an agreed work scope, schedule, and budget. Further review and updating of the report may be required as conditions and the regulatory and planning frameworks, change over time.

This report was prepared by Dillon for the sole benefit of our Client. The material in it reflects Dillon's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The information and opinions rendered in this report are exclusively for use by Newcrest. Dillon will not distribute or publish this report without Newcrest's consent except as required by law or court order. The information and opinions expressed in this report are given in response to a limited assignment and should only be evaluated and implemented in connection with that assignment. Dillon accepts responsibility for the competent performance of its duties in executing the assignment and preparing this report in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages.

The work completed for this verification was completed as part of the legally enforceable contract for GHG assurance services. The associated reports and statements provided to Newcrest as part of the assurance services provided, are intended for the use of Newcrest and the BC Ministry of Environment Climate Action Secretariat as the regulator only. Should Newcrest wish to use Statements or Marks provided throughout this process, they must seek do so via written statement.

6.0 Conflict of Interest Report

The Conflict of Interest Report, as required by the Regulation, is included as **Appendix B**.

Tables

Table A
Newcrest Mining Limited - Brucejack Gold Mine Facility
Verification Report

Greenhouse Gas (GHG) Activities in Facility Boundary

Specified GHG Activity	GHG Source / Risk Factor	Applicable (Y/N)	Emissions (tonnes CO_2e) (2021)	Percent of Overall Emissions	Production (oz)	GHG Type						
						Carbon Dioxide (CO_2) from Biomass	Non-Biomass CO_2	Methane (CH_4)	Nitrous Oxide (N_2O)	Hydro-fluorocarbons (HFCs)	Per-fluorocarbons (PFCs)	Sulphur Hexafluoride (SF_6)
General												
---	Facility Boundary	Y	-	-	-	-	-	-	-	-	-	-
---	Data Management Systems	Y	-	-	-	-	-	-	-	-	-	-
---	Consistency with previous years	Y	-	-	-	-	-	-	-	-	-	-
---	Electricity Purchased (GWh)	Y	-	-	145	-	-	-	-	-	-	-
---	Heat Purchased	Y	-	-	-	-	-	-	-	-	-	-
---	Total Gold production (oz)	Y	-	-	351,194	-	-	-	-	-	-	-
---	Total Silver Production (oz)	Y	-	-	461,652	-	-	-	-	-	-	-
Emission Sources												
1	WCI.020 - General Stationary Combustion (Diesel)	Y	4,086	13.74%	-	n/a	Y	Y	Y	n/a	n/a	n/a
2	WCI.020 - General Stationary Combustion (Propane)	Y	3,095	10.41%	-	n/a	Y	Y	Y	n/a	n/a	n/a
3	WCI.020 - General Stationary Combustion (Mixed Waste)	Y	123	0.41%	-	Y	Y	Y	Y	n/a	n/a	n/a
4	WCI.020 - General Stationary Combustion (Wood Waste)	Y	247	0.83%	-	Y	n/a	Y	Y	n/a	n/a	n/a
5	WCI.280 - Mobile Equipment at Facilities (Diesel)	Y	21,324	71.70%	-	n/a	Y	Y	Y	n/a	n/a	n/a
6	WCI.280 - Mobile Equipment at Facilities (Gasoline)	Y	863	2.90%	-	n/a	Y	Y	Y	n/a	n/a	n/a
7	WCI.200 - Wastewater Emissions	Y	3.24	0.01%	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Legend:

Y	Included Parameter in Emission Source
N/A	Not applicable
NEG	Negligible Parameter in Emission Source

Table B
Newcrest Mining Limited - Brucejack Gold Mine Facility
Verification Report

Documents Listing

No.	File Name	Folder	File Type	Category	Date
Incineration					
1	01. January 2021 Incineration Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
2	02. February 2021 Incineration Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
3	03. March 2021 Incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
4	04. April 2021 Incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
5	05. May 2021 Incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
6	06. June 2021 Incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
7	07. July 2021 incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
8	08. August 2021 incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
9	09. September 2021 Incinerator Log Brucejack.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
10	10. october 20201 incinerator log bj.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
11	11. November 2021 Incinerator Log Brucejack	Incinerator Logs > Brucejack	PDF	Raw data	Apr-22
12	12. December 2021 Incinerator BJ log.pdf	Incinerator Logs > Brucejack	PDF	Raw data	Mar-22
13	1 - January burn log.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
14	10-oct.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
15	11-nov.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
16	12-dec.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
17	2- feb.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
18	3-march.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
19	4-april.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
20	5-may.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
21	6-june.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
22	7-july.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
23	8-aug.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
24	9-sep.xlsx	Incinerator Logs > Knipple	Excel	Raw data	Mar-22
Mobile Diesel and Gasoline					
25	3116506 - pretium volumes 2021 - winter	Mobile Diesel and Gas	Excel	Raw data	Mar-22
26	3134778 - pretium volumes 2021 -summer	Mobile Diesel and Gas	Excel	Raw data	Mar-22
27	-1_20210408 Pretivm B9378_0001.pdf	Mobile Diesel and Gas	PDF	Raw data	Apr-22
28	-1_20210106 Pretivm B9138_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
29	-1_20210106 Pretivm B9139_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
30	-1_20210108 Pretivm B9141_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
31	-1_20210111 Pretivm B9150_0002.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
32	-1_20210119 Pretivm B9169_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
33	-1_20210121 Pretivm B9171_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
34	-1_20210129 Pretivm B9194_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
35	-1_20210201 Pretivm B9200_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
36	-1_20210204 Pretivm B9211_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
37	-1_20210208 Pretivm B9222_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
38	-1_20210212 Pretivm B9235_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
39	-1_20210216Pretivm B9242_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
40	-1_20210222 Pretivm B9250_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
41	-1_20210301 Pretivm B9272_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
42	-1_20210303 Pretivm B9287_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
43	-1_20210310 Pretivm B9292_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
44	-1_20210310_ Pretivm B92970001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
45	-1_20210321 Pretivm B9342_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
46	-1_20210322 Pretivm B9335_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
47	-1_20210323 Pretivm B9321_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
48	-1_20210329 Pretivm B9354_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
49	-1_20210408 Pretivm B9378_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
50	-1_20210413 Pretivm B9395_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
51	-1_20210420 Pretivm B9413_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
52	-1_20210422 Pretivm B9419_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
53	-1_20210423 Pretivm B9427_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
54	-1_20210426 Pretivm B9436_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
55	-1_20210428 Pretivm B9440_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
56	-1_20210504 Pretivm B9461_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
57	-1_20210511 Pretivm B9476_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
58	-1_20210512 Pretivm B9480_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
59	-1_20210518 Pretivm B9497_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
60	-1_20210518 Pretivm B9501_0002.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
61	-1_20210520 Pretivm B9508_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
62	-1_20210525 Pretivm B9517_0002.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
63	-1_20210526 Pretivm B9521_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
64	-1_20210531 Pretivm B9529_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
65	-1_20210607 Pretivm B9557_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
66	-1_20210611 Pretivm B9570_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
67	-1_20210615 Pretivm B9582_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
68	-1_20210616_ Pretivm B98550002.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
69	-1_20210621 Pretivm B9600_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
70	-1_20210622 Pretivm B9608_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
71	-1_20210625 Pretivm B9615_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
72	-1_20210628 Pretivm B9620_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
73	-1_20210702 Pretivm B9634_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
74	-1_20210712 Pretivm B9645_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
75	-1_20210714 Pretivm B9658_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
76	-1_20210719 Pretivm B9672_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
77	-1_20210721 Pretivm B9688_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
78	-1_20210728 Pretivm B9696_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
79	-1_20210728 Pretivm B9699_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
80	-1_20210728 Pretivm B9704_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
81	-1_20210809 Pretivm B9740_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
82	-1_20210809 Pretivm B9740_0001_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
83	-1_20210813 Pretivm B9746_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
84	-1_20210813 Pretivm B9757_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
85	-1_20210816 Pretivm B9768_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
86	-1_20210818 Pretivm B9781_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
87	-1_20210826 Pretivm B_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
88	-1_20210827 Pretivm B9812_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
89	-1_20210830 Pretivm B9816_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
90	-1_20210831 Pretivm B9817_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
91	-1_20210917 Pretivm B9867_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22

No.	File Name	Folder	File Type	Category	Date
92	-1_20210920 Pretivm B9869_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
93	2021_11_03_PRETIVM_B9995.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
94	2021_11_18_PRETIVM_B10029.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
95	2021_11_18_PRETIVM_B10033.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
96	Northwest Fuels BACKUP Documents_20201230 Pretivm B9121_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
97	Northwest Fuels BACKUP Documents_20210104 Pretivm B9124_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
98	Northwest Fuels BACKUP Documents_20210113 Pretivm B9159_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
99	Northwest Fuels BACKUP Documents_20210115 Pretivm B9161_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
100	Northwest Fuels BACKUP Documents_20210121 Pretivm B9179_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
101	Northwest Fuels BACKUP Documents_20210122 Pretivm B9180_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
102	Northwest Fuels BACKUP Documents_20210126 Pretivm B9186_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
103	Northwest Fuels BACKUP Documents_20210201 Pretivm B9198_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
104	Northwest Fuels BACKUP Documents_20210208 Pretivm B9221_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
105	Northwest Fuels BACKUP Documents_20210210 Pretivm B9232_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
106	Northwest Fuels BACKUP Documents_20210223 Pretivm B9249_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
107	Northwest Fuels BACKUP Documents_20210301 Pretivm B9274_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
108	Northwest Fuels BACKUP Documents_20210310 Pretivm B9297_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
109	Northwest Fuels BACKUP Documents_20210316 Pretivm B9317_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
110	Northwest Fuels BACKUP Documents_20210325 Pretivm B9348_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
111	Northwest Fuels BACKUP Documents_20210331 Pretivm B9359_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
112	Northwest Fuels BACKUP Documents_20210401 Pretivm B9366_0002.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
113	Northwest Fuels BACKUP Documents_20210405 Pretivm B9368_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
114	Northwest Fuels BACKUP Documents_20210406 Pretivm B9372_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
115	Northwest Fuels BACKUP Documents_20210412 Pretivm B9391_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
116	Northwest Fuels BACKUP Documents_20210415 Pretivm B9405_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
117	Northwest Fuels BACKUP Documents_20210419 Pretivm B9409_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
118	Northwest Fuels BACKUP Documents_20210423 Ro Tinto B9427_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
119	Northwest Fuels BACKUP Documents_20210427 Pretivm B9437_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
120	Northwest Fuels BACKUP Documents_20210505 Pretivm B9465_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
121	Northwest Fuels BACKUP Documents_20210511 Pretivm B9468_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
122	Northwest Fuels BACKUP Documents_20210517 Pretivm B9495_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
123	Northwest Fuels BACKUP Documents_20210601 Pretivm B9535_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
124	Northwest Fuels BACKUP Documents_20210610 Pretivm B9565_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
125	Northwest Fuels BACKUP Documents_20210615 Pretivm B9579_0002.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
126	Northwest Fuels BACKUP Documents_20210629 Prewtivm B9624_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
127	Northwest Fuels BACKUP Documents_20210712 Pretivm B9649_0001.pdf	Northwest Fuel Receipts 2021	PDF	Raw data	Mar-22
128	NW65876CR	Northwest Fuel Receipts 2021	PDF	Raw data	Apr-22
129	32590859.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
130	32590860.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
131	32590861.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
132	32590862.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
133	32590863.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
134	32637486.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
135	32637487.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
136	32637488.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
137	32637489.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
138	32637490.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
139	32637491.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
140	33249994.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
141	33249995.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
142	33251091.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
143	33251092.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
144	33251093.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
145	33256949.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
146	33256951.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
147	33256953.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
148	33256955.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
149	33256957.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
150	33256959.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
151	33256960.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
152	33256962.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
153	33256964.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
154	33335280.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
155	33335281.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
156	33335282.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
157	33335283.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
158	33575156.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
159	33575157.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
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162	33575160.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
163	33575161.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
164	33575162.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
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168	34312177.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
169	34312178.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
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171	34312180.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
172	34312181.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
173	34312182.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
174	34733513.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
175	34733514.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
176	34978920.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
177	35198212.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
178	35198471.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
179	35244758.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
180	35293744.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
181	35736341.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
182	35736342.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
183	35736343.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
184	35736351.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
185	35736355.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
186	35736357.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
187	35736359.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
188	35736363.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
189	36033032.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
190	36033185.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
191	36033313.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
192	36480491.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22

No.	File Name	Folder	File Type	Category	Date
193	36516694.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
194	36518555.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
195	36519661.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
196	36520409.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
197	36615917.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
198	36615918.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
199	36615919.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
200	36615920.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
201	36615921.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
202	36615922.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
203	36865408.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
204	36934962.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
205	36983478.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
206	37055980.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
207	37055983.pdf	Response to Issues Log V2 > Missing Superior Propane Invoices	PDF	Raw data	May-22
Stationary Diesel					
208	2021 Hours and Kilometers	Stationary Diesel	Excel	Raw data	Mar-22
209	PVG_Stationary Diesel_2021	Stationary Diesel	Excel	Raw data	Mar-22
210	example of generator checks	Stationary Diesel	PDF	Raw data	Apr-22
211	Serial numbers of Generators at Brucejack	Stationary Diesel	Word	Raw data	Apr-22
212	GEN-001-004 - CAT C18 EP Genset -LC6 500kW DPS.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
213	GEN-005-6 - CAT 3516B Genset SR4B 1.5MW DPS.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
214	GEN-007-012 - CAT XQ2000.PNG	Stationary Diesel > Gen Cut sheets	.png	Raw data	Apr-22
215	GEN-013 - CAT D100-6 Genset - 4.4.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
216	GEN-015 - CAT D125-6.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
217	GEN-016 - CAT D125.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
218	GEN-020 - Terex-T270C-Cummins-Operator-Service-Parts-Manual.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
219	GEN-022 - CAT D60-4LC - C4.4.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
220	GEN-023 - Magnum Pro MMG75.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
221	GEN-027 - Cummins-C150D6D-data-sheet.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
222	GEN-028 - Whisperwatt - Stuart - DCA25USI4CAN_Data_Sheet.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
223	GEN-029-030 - Isuzu prime power WQ175-T3-Generator-Specs.pdf	Stationary Diesel > Gen Cut sheets	PDF	Raw data	Apr-22
224	GEN-007-012 - CAT XQ2000	Response to Issues Log V2	PDF	Raw data	May-22
225	GEN-031-CAT-XQ1250-Spec-Sheet	Response to Issues Log V2	PDF	Raw data	May-22
226	PVG_Stationary Diesel_2021_v2	Response to Issues Log V2	Excel	Raw data	May-22
Stationary Propane					
227	pret	Stationary Propane	Excel	Raw data	Mar-22
228	Propane Receipts 2021	Stationary Propane	PDF	Raw data	Apr-22
229	2021 propane deliveries pretium	Response to Issues Log V2	Excel	Raw data	May-22
230	Propane - Propane Receipt Review - Copy	Response to Issues Log V3	Excel	Raw data	May-22
Wastewater Treatment					
231	21.01.04_STP_VA21A0114_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
232	21.02.07_STP_VA21A2320_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
233	21.03.07_STP_VA21A4229_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
234	21.04.04_STP_VA21A6275_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
235	21.05.02_STP_VA21A8334_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
236	21.06.06_STP_VA21B1338_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
237	21.07.04_STP_VA21B3588_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
238	21.08.08_STP_VA21B6576_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
239	21.09.06_STP_VA21B9249_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
240	21.10.19_STP_VA21C3333_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
241	21.11.07_STP_VA21C5016_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
242	21.12.22_STP_VA21C8663_0_COA - Merged.pdf	STP > STP Composite Total Nitrogen Results	PDF	Raw data	Mar-22
243	April Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
244	August Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
245	December Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
246	February Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
247	January Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
248	July Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
249	June Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
250	March Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
251	May Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
252	November Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
253	October Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
254	September Brucejack C75WW-B 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
255	April Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
256	August Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
257	December Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
258	February Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
259	January Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
260	July Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
261	June Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
262	March Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
263	May Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
264	November Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
265	October Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
266	September Brucejack C75WW-C 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
267	April Brucjack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
268	August Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
269	December Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
270	February Brucjack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
271	January Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
272	July Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
273	June Brucjack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
274	March Brucjack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
275	May Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
276	November Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
277	October Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
278	September Brucejack C75WW-A 2021.xlsm	STP > STP Effluent Volumes	Excel	Raw data	Mar-22
Open Burning					
279	2021 Open Pit Burn log	n/a	Word	Raw data	Mar-22
280	2021_Burn Pit Log Sheet Bowser (WOOD)	n/a	Excel	Raw data	Mar-22
Purchased Electricity					
281	Scope 2 GHG from our electricity supply 2021 updated KU	Purchased Electricity	Excel	Electricity Summary	Apr-22
282	Vancouver - bills included in lease	Purchased Electricity > BC Hydro Receipts	Doc	Raw data	Apr-22
283	302924.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22
284	334574.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22
285	360833.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22
286	401750.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22
287	443894.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22
288	443897.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22

No.	File Name	Folder	File Type	Category	Date
289	492532.pdf	Purchased Electricity > 4th Ave Pole 1 Stewart	PDF	Raw data	Apr-22
290	302926.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
291	334576.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
292	360835.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
293	401753.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
294	443899.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
295	443901.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
296	492534.pdf	Purchased Electricity > 516 4th Ave Stewart	PDF	Raw data	Apr-22
297	302928.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
298	334578.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
299	360837.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
300	401756.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
301	443927.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
302	443929.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
303	492536.pdf	Purchased Electricity > 520 4th Ave Stewart	PDF	Raw data	Apr-22
304	280246.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
305	302930.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
306	334580.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
307	334582.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
308	360839.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
309	401759.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
310	401761.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
311	401763.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
312	443903.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
313	443905.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
314	467074.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
315	467076.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
316	492538.pdf	Purchased Electricity > 2965 Tatlow Rd Smithers	PDF	Raw data	Apr-22
317	April.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
318	August.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
319	December.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
320	February.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
321	January.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
322	July.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
323	June.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
324	March.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
325	May.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
326	November.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
327	October.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
328	September.pdf	Purchased Electricity > Brucejack	PDF	Raw data	Apr-22
Production					
329	Production Values	Production Values	png	Production	May-22
330	Chapter 2 Mining Program Annual Report	Production Values	Word	Production	May-22
331	RE_ Production Scales - Calibration	n/a	Email	Production	May-22
Other					
332	Issues Log V2	n/a	Excel	Issues log responses	Apr-22
333	Camp Populations for 2021	n/a	Excel	Raw data	Mar-22
334	GHG Worksheet_2021	n/a	Excel	GHG calculation workbook for 2021	Mar-22
335	GHG Worksheet_2021	n/a	Excel	Revised GHG calculation workbook for 2021	Apr-22
336	22.05.08_GHG Worksheet_2021	Response to Issues Log V2	Excel	Revised GHG calculation workbook for 2022	May-22
337	20220429 - Issues Log V2 - responses	Response to Issues Log V2	Excel	Issues log responses	May-22
338	22.05.18_GHG Worksheet_2021	n/a	Excel	Revised GHG calculation workbook for 2022	May-22
339	22.05.25_ GHG Worksheet_2021_updates highlighted	n/a	Excel	Revised GHG calculation workbook for 2022	May-22
340	2021 BCGHG Report Preview - DRAFT May 25,2022	n/a	Excel	SWIM report	May-22
341	Brucejack 2022_metal_ore_mining_calculator	n/a	Excel	CIIP calculation workbook	May-22
342	Submitted BC GHG Report 27_05_22	n/a	PDF	SWIM report	May-22

Legend:

Y	Included Parameter in Emission Source
N/A	Not applicable
NEG	Negligible Parameter in Emission Source

Table C
Newcrest Mining Limited - Brucejack Gold Mine Facility
Verification Report

Final Issues Log

Issue No.	Type	Date	Issue Detail	Client Response V1	Status	Client Response V2	Status
1	CL	17-Mar-22	File: 2021 Open Pit Burn log Please clarify for months with multiple burn dates, whether the provided volume burned corresponds to monthly total, or burn volume per event	Where multiple burns occurred during a month, volumes were added up to give a total volume for that month. KU 12/4	Closed		
2	DR	17-Mar-22	File: 11. Novmber 2021 Incinerator BJ log File appears to be a duplicate of the October 2021 data. Please provide November 2021 Incinerator BJ log	Please find November, now updated, in the sharefile. 14/3 KU	Closed		
3	CL	28-Mar-22	File: PVG_Stationary Diesel_2021 Bowser stationary diesel usage is calculated at 50% load instead of 75% of load. Please clarify reason for change from other camps.	The generator at Bowser is rarely used and when it is, it has far more power than required for the area it supplies. Hence the load on it is less than the standard 75%. Talked to Jarret and he explained over email too.	Discussed during site visit. Closed.		
4	CL	28-Mar-22	File: PVG_Stationary Diesel_2021 Location - Stuart appears to be excluded from totals. Please clarify reason for exclusion, or include.	Now included. KU 16/4	Closed		
5	OB	28-Mar-22	File: PVG_Stationary Diesel_2021 Dillon recalculated with a volume conversion factor of 3.78541 Litres per Gallon, which results in a non-material discrepancy	Acknowledged. We understand. We can improve for next year by following spec sheet consumption, which is preffered.	Closed		
6	DR	28-Mar-22	Please provide generator cut sheets to verify fuel consumption ratings	Have upoaded what we have. Acknowledge that is good to have for next year. We will upload more as they come.	Dillon identified that data in cut sheets does not align with information in the *2021 Hours and Kilometers* workbook. Significant difference in GEN-022 and GEN-007 through GEN-012 Please review and confirm data source for provided fuel consumption ratings.	Updated fuel consumption values in *PVG_Stationary Diesel_2021_v2* spreadsheet to match rates in cut sheets. Uploaded cut sheet for GEN-007 through GEN-012 (rates differ from Google search screenshot values). Also uploaded cut sheet for GEN-031. Updated total values in workbook *22.05.06_GHG Worksheet_2021* . (BM / 05-May-22)	Closed
7	DR	28-Mar-22	Please include production data, including purchased heat and electricity, in accordance with CIIP documentation: https://www2.gov.bc.ca/assets/gov/environment/climate-change/ind/cleanbc-program-for-industry/guidance/metal_ore_mining_sector_guidance.pdf	Uploaded 13/4 KU	Please provide production data and completed metal_ore_mining_calculator_2021.xlsx workbook from CleanBC Purchased electricity records provided, closed.	Final production values from Mine Site Controller provided. (KU-17-May-22)	Closed
8	DR	28-Mar-22	Please provide production weigh scale calibration records	Need to ask	Data pending	As per email *RE_Production Scales - Calibration* there are no calibration records for the dore weighing scale. A 20kg traceable test weight is used to check the scale reading before and after packing a dore shipment. (BM / 05-May-22)	Closed
9	OB	25-Mar-22	File: GHG Worksheet_2021 Minor discrepancies are noted in the total food and domestic waste incineration for Brucejack. Please review data provided and confirm sums of waste incinerated align with the Brucejack Incinerator Log data.	Discrepancies should be rectified now. KU 15/4	Closed		
10	OB	25-Mar-22	File: GHG Worksheet_2021 Include "Kitchen Grease/Oils" in Waste Incinerator summary for Brucejack	Included. All waste numbers should be up to date. 15/4 KU	Closed		
11	DR	25-Mar-22	Please provide reference data for 2021 Total Volume Effluent Processed, by month	If you look in the STP > STP effluent volumes > see the report C75. Volumes are recorded in those spreadsheets.	Closed		
12	CL	25-Mar-22	File: GHG Worksheet_2021; Mobile Gas tab Please confirm GWP referenced to calculated CO2e emission factor (2.379)	Resolved. Calculation has been adjusted.	Open: Please review conversion from kg to tonnes. In Totals tab, please complete mobile gasoline CO2e emissions in kg	Updated conversion factor to be tonnes = kg/1000. Added gasoline CO2e emissions in kg to Totals tab.(BM / 06-May-22)	Closed
13	DR	28-Mar-22	Please provide supporting invoices/records for propane deliveries	Additionals have been added to stationary propane folder.	Supporting invoices and records do not comprehensively support propane deliveries. Please review and adjust accordingly.	Previous missing invoices were downloaded from JD Edwards and uploaded to Dillon file share site. (BM / 06-May-2022)	Closed
14	CL	17-Mar-22	File: GHG Worksheet_2021 Please confirm data source for wood waste (open burn) emission factors	https://www2.gov.bc.ca/assets/gov/environment/climate-change/ind/quantification/wci-2012.pdf	Open: Please review CO2e emission factor applied (0.02)	Rather than applying a separate emission factor to calculate the quanitiy of CO2e, I summed the CO2, CH4 and N2O emissons. I applied this method to all emissions sources. (BM / 06-May-2022)	Closed
15	DR	28-Mar-22	File: GHG Worksheet_2021 Please include calculations and results for biogenic CO2 (see GHG Worksheet_2020.xlsx as example)	Resolved. Now included.	Open. Dillon identified that the totals tab does not differentiate non-biogenic and biogenic emissions. Please adjust accordingly.	Updated. (BM / 07-May-22)	Closed
16	CL	28-Mar-22	File: 3134778 - pretium volumes 2021 -summer Please confirm the inclusion of the October 6, 2021 transaction NW65876CR (-2,886.00), and provide invoice backup	Mobile diesel and Gas > Pretium volumes 2021 - summer . Line 244 has all deliveries. BOL has now been included also. See Northwest receipts	Closed		
17	OB	28-Mar-22	File: GHG Worksheet_2021 Wastewater nitrogen data references composite sample results. Dillon recalculated using highest effluent nitrogen value, which results in a non-material discrepancy	Discussed during site visit. We use composite effluent for permit. Resolved	Closed		

Issue No.	Type	Date	Issue Detail	Client Response V1	Status	Client Response V2	Status
18	OB	28-Mar-22	File: GHG Worksheet_2021 Please include wastewater and incineration activities in total site emissions calculation	Updated.	Open. In Totals tab: - Dillon identified that the Stationary incineration did not include CH4 and N2O. Please adjust accordingly. In Waste Incineration tab: - Please confirm data source for 60 g N2O/t MSW	Added CH4 and N2O emissions for stationary incineration.Updated all calculations to follow Methodology 1 of WCI.23 rather than formulas from 2006 IPCC Guidelines for National GHG Inventories. Updated emisison factor for N2O emissions from MSW obtained from WCI.23 Table 20-7. (BM / 07-May-22)	Closed
19	CL	13-Apr-22	Confirm if accelerants are used in the burn pit	No. A blow torch is used to start the burn.	Closed		
20	CL	14-Apr-22	What is the size of the burn pit	25' x 25'	Closed		
21	DR	14-Apr-22	Include serial numbers of the generators	They have been added to the PVG_Stationary_Diesel excel file	Closed		
22	DR	14-Apr-22	Include example of daily/weekly generator checks/inspections	Uploaded to stationary diesel folder 14/4 KU	Closed		

Notes:

DR Data request
CL Clarification request
OR Observations request
FAR Forward action request

Appendix A

Verification and Sampling Plan

May 31, 2022

3820 Cessna Drive
Suite 510
Richmond
British Columbia
Canada
V7B 0A2
Telephone
604.278.7847
Fax
604.278.7894

Newcrest Mining Limited
2300 – 1055 Dunsmuir Street
Vancouver, British Columbia
V7X 1L4

Attention: Brittany Moore, EIT, ATAg
Environmental Engineer-in-Training

Risk-Based Verification and Sampling Plan
Greenhouse Gas Emission Reporting Regulation – B.C. Regulation 249/2015 – ANAB Accreditation under ISO 14065
2021 Emission Report for the Newcrest Brucejack Gold Mine Facility

Introduction

Dillon Consulting Limited (Dillon) is pleased to present Newcrest Mining Limited (Newcrest; formerly Pretium Exploration Inc.) with this risk-based Verification and Sampling Plan under British Columbia Greenhouse Gas Emission Reporting Regulation (B.C. Reg. 249/2015 [the Regulation]) under the *Greenhouse Gas Industrial Reporting and Control Act* for the Newcrest Brucejack Gold Mine Facility, located north of Stewart, British Columbia, Canada (Facility or Site). The Facility is registered with the BC Ministry of Environment (MOE) and Climate Change Strategy with BCGHG ID # 22122200002.

The Facility is using quantification methodologies developed in consideration of British Columbia Greenhouse Gas Emission Reporting Regulation (Regulation), CleanBC Industrial Incentive Program (CIIP) and the Western Climate Initiative (WCI) *Final Essential Requirements of Mandatory Reporting: Amended for Canadian Harmonization* (2011).

Verification Objectives

The objectives of this assignment were to provide Newcrest and BC MOE Climate Action Secretariat (CAS) (the Regulator) with a reasonable level of assurance, independent, third party verification, and opinion on whether the Facility's 2021 Emission Report and Production under the CleanBC Industrial Incentive Program (CIIP) are free of material misstatements, as well as that the information reported is accurate and consistent with the requirements of the Regulation and CIIP.

Verification Scope

The following is a summary from the 2021 Project Report for the Project.

Time Period – January 1, 2021 through December 31, 2021

Geographic and Organizational Boundaries: This scope includes the production and emissions generated at the Facility at the physical address as listed below. The emissions are related to specific GHG activities listed in the Regulation and emitted by the Facility. The Facility is located at the following address:

Approximately 65 km north of Stewart
Regional District of Kitimat-Stikine, British Columbia
Coordinates: 56°27'55.94"N, 130°11'10.06"W

Activities and Processes: The Facility is an underground high-grade gold mine. The operations and camps are connected to the BC Hydro power grid with full diesel backup generation capacity. The Facility includes three active camp sites, and one closed camp site: Wildfire Camp, Knipple Camp, Brucejack Camp, and Bowser Camp (closed). Operations on-site include:

- WCI.280 – Mobile Equipment at Facilities:
  - Diesel in heavy equipment; and
  - Gasoline in off-road mobile equipment;
- WCI.020 – General Stationary Combustion:
  - Diesel in backup generators;
  - Propane in space heaters;
  - Waste materials in incinerator; and
  - Open burning of wood waste; and
- Wastewater treatment on-site.

GHG Emission Sources, Categories, and GHG Types: Based on Dillon's current understanding of Facility operations, the applicable Facility emission sources and gases are marked with a "Y" in the appended **Table A.** For completeness, the emission sources and gases that are not applicable to the Facility are marked with an "N/A", and sources and gases that are negligible are marked with an "NEG".

Verification Criteria

Dillon completed the verification based on and including the following criteria:

- *ISO 14064-1:2018 – Part 1: Specification with guidance at the organization level for quantification and reporting of GHG emissions and removals,* ISO, December 2018;
- *ISO 14064-3:2006 – Part 3: Specification with guidance for the validation and verification of GHG assertions*, ISO, March 2006;
- SBC 2014, Chapter 29: *Greenhouse Gas Industrial Reporting and Control Act*
- B.C. Regulation 231/2019: *Greenhouse Gas Industrial Reporting and Control Act*;

- BC Regulation 249/2015: *Greenhouse Gas Industrial Reporting Regulation: Greenhouse Gas Emission Reporting Regulation* (Regulation), as amended by BC Reg. 294/2020, February 2021;
- Western Climate Initiative (WCI) *Final Essential Requirements of Mandatory Reporting: Amended for Canadian Harmonization,* December 17, 2010;
- WCI *2011 Amendments for Harmonization of Reporting in Canadian Jurisdictions,* December 21, 2011;
- WCI *Quantification Method 2013 Addendum to Canadian Harmonization version,* December 10, 2013; and,
- CleanBC Industrial Incentive Program Guideline (CIIP)

Level of Assurance and Materiality

The verification was conducted to a reasonable level of assurance, per the requirements of the Regulation and CIIP.

The materiality threshold for the Facility was set at plus or minus 5% of the reported 2021 emissions. Dillon understands that the Facility also reported their production under the CleanBC Industrial Incentive Program (CIIP) and the materiality was set at 5% of the 2021 production.

BC Regulation requires that net of all over or understatements cannot exceed the lesser of 1,000 tonnes of CO_2e or 1% of the total emissions. In addition, CIIP requires that all correctable errors be corrected and that the aggregate effects of error results in any inaccuracy be no greater than 0.1%.

Verification Procedures

Dillon used a risk-based verification methodology consistent with the requirements of the Regulation and CIIP. The following subsections detail Dillon's verification procedures for the document and data reviews, and the contents of the Sampling Plan and Risk Assessment.

Kick-Off Meeting

The kick-off meeting was hosted via teleconference following the award of the work by Newcrest to Dillon and the finalization of the verification contract. The meeting covered the following key items:

- Review of roles and responsibilities;
- Review of schedule;
- Review of the audit process to be implemented by Dillon;
- Resolution of any questions; and
- Site Visit and Health and Safety Requirements.

Document and Data Reviews

Dillon completed the verification process using the following fundamental practices:

- Assessment of GHG information systems and controls;
- Assessment of GHG data and information; and
- Assessment against validation or verification criteria.

Upon acceptance of the Verification/Sampling Plan, Dillon submitted an initial information and data request. This request consisted of:

- The Facility's 2021 Emission Report;
- The Facility's CIIP Application;
- Inventory and stock records for production;
- Onsite and offsite delivery records;
- Purchase and delivery records for inputs;
- Previous quantification and verification reports (as applicable);
- Application or project report and any other submission documents;
- Process flow diagrams;
- Third party fuel consumption invoicing;
- Internal metering data;
- Calibration certificates and maintenance schedule for internal meters;
- Quantification details;
- Calculations/spreadsheets used to create the reports; and
- Other materials/sources that were used to support the 2021 Emission Report.

Assessment of Data Management Systems and Internal Controls

Dillon assessed the information systems and controls for sources of potential errors, omissions, and misrepresentations, taking into consideration the following:

- Selection and management of the GHG data and information;
- Processes for collecting, processing, consolidating, and reporting GHG data information;
- Systems and processes that ensure the accuracy of the GHG data and information;
- Degree of automation;
- Use of database features;
- Length of operation;
- Linkage to other systems;
- Standardization within an organization;
- Transparency of calculations;

- Design and maintenance of the GHG information system;
- Systems and processes that support the GHG information system; and
- Results of previous assessment, if available and appropriate.

Assessment of Data and Information Flow

In parallel to the assessment of data management systems and internal controls, Dillon also examined and assessed the data and information flows that formed the basis for Newcrest's GHG assertion with professional skepticism. This assessment was informed by the Verification/Sampling Plan, and like the Verification/Sampling Plan, the assessment of data and information flow was a dynamic and changing process. The Verification Team reviewed sufficient data and information sources to complete the verification in accordance with the Regulation. Accordingly, the Verification/Sampling Plan contains the following requirements, as applicable to the assignment:

- Where possible, review full data sets. When full data sets were not feasible, the Designated Signing Authority determined based on magnitude and accuracy, to what degree (or confidence interval) the data and information was reviewed;
- Review of collection frequency and retention period;
- Complete a rank-based Risk Assessment for each source including the risks related to data and information sources, along with items such as metering, third party data, and self-calculation;
- Focus on data and information sources that may result in a material misstatement; and
- Quality assurance and quality control of the data sets.

Where information or data was either not supplied by Newcrest or was determined to be insufficient, the Verification Team requested additional data and/or information.

Site Visit

Dillon visited the Facility on March 30, 2022 as agreed upon during the kick-off meeting (and subsequent communications) as required by B.C. Reg. 249/2015 subsection (2) (d) and the CIIP verification requirements. The purpose of the site visit was to interview Newcrest personnel, witness site operations, production parameters and GHG emissions sources, verify monitoring equipment and calibration records, as well as review data collection and management procedures.

Uncertainty and Risk Assessment

Dillon developed a Risk Assessment for the following aspects with respect to the Regulation:

- Facility boundary;
- Data management including acquisition equipment, sampling and frequency, and processing and tracking;

- Consistency with previous reporting periods and applied benchmarks;
- Facility production; and
- Facility GHG emissions by source (i.e., stationary combustion, mobile combustion, etc.).

Each of the above categories were developed and assessed as low, medium, or high risk, as it related to the following risk categories:

- Inherent Risk;
- Control Risk; and
- Detection Risk.

The Risk Assessment related to the above were documented in a table format within the Verification/Sampling Plan and Verification Report, respectively. The Risk Assessment is appended in **Table B**.

Working Papers

Throughout the verification process, the Verification Team developed a set of working papers that outline the information reviewed, re-calculation of data sets as applicable, and issues developed by Dillon and their subsequent resolution status. The working papers do not form part of the Final Verification Report, but the information contained within them contributed to the Verification Statement issued by Dillon.

Issues Log

Throughout the verification process, the Verification Team developed a list of verification findings in an issues log, representing clarifications and corrective actions for Newcrest to respond to. The issues logs were be based on the results of Dillon's independent recalculations of Newcrest's GHG assertion, as well our assessment of data management, controls, and data flow. Upon closure, the verification proceeded to the independent peer review and reporting stages.

Independent Review

As a final step of verification, Dillon conducted an independent review of the verification. The independent review included a review of the working papers developed by the Verification Team and the Draft/Final Verification Report and Statement prepared by the team. Dillon notes that the Final Verification Report and Statement were not finalized until approval was received from the Independent Reviewer.

Verification Report and Statement

At the conclusion of the verification process, Dillon prepared a Draft Verification Report that was be subject to internal peer review, as well as review by Newcrest. The Verification Report was be prepared utilizing the appropriate Verification

Statement and Conflict of Interest Report Form as detailed in the Regulation and was prepared by the Lead Verifier.

The Conflict of Interest Report, as set out in the Regulation, includes:

- An assessment of threats to independence;
- Strategies for mitigating threats to independence; and
- A report on the implementation of the strategies referred to above.

The Verification Report and Statement includes:

- Statement of Verification completed in accordance with the Regulation;
- Identification of the following:
  - Information in the emission report that was not reported or quantified in accordance with the Regulation but was corrected during the verification process;
  - Information in the emission report that was not reported or quantified in accordance with the Regulation and was not corrected during the verification process; and
  - The materiality of any errors, omissions, or misstatements in the emission report;
- The name and business address of the Verification Body;
- The name, business email address, and business telephone number of the Lead Verifier;
- The name, business email address, and business telephone number of the Verifiers who assisted the Lead Verifier in performing the verification;
- With respect to the reporting operation, the information referred to in Section 14 (2) of the Regulation;
- With respect to a linear facilities operation, identification of each individual Facility of the reporting operation that has attributable emissions in the reporting period that are:
  - Greater than or equal to 10,000 tonnes of carbon dioxide equivalent, not including carbon dioxide produced from biomass listed in Schedule C;
  - Greater than or equal to 1,000 tonnes and less than 10,000 tonnes of carbon dioxide equivalent, not including carbon dioxide produced from biomass listed in Schedule C; or
  - Less than 1,000 tonnes of carbon dioxide equivalent, not including carbon dioxide produced from biomass listed in Schedule C;
- The date the Verification Statement was completed;
- The scope of the Verification Statement, including whether it relates to all the matters required to be verified under Section 28 of the Regulation;

- The amount referred to in Section 14(3)(a) of the Regulation, with subtotals setting out the total amounts of:
  - Carbon dioxide from non-biomass;
  - Carbon dioxide from biomass listed in Schedule C of the Regulation; and
  - Carbon dioxide from biomass not listed in Section C;
- The name of the member of the International Accreditation Forum by which the verification body is accredited and any associated identification numbers, accompanied by the affirmation of the International Accreditation Forum that the accreditation status is in good standing;
- A summary of the work the verification body performed as part of the verification, including a description of:
  - The verification procedures used to test the data included in the emission report prepared by the reporting operation; and
  - Additional information, not included in the emission report, that was directly or indirectly relied on by the verification body in the course of conducting the verification;
- Identification of each site visit made in the verification and the date the site visit was conducted;
- Identification of (CIIP only):
  - Errors, omissions, and misstatements related to the reported product data that were corrected as part of the verification process
  - Errors, omissions, and misstatements related to the reported product data that were not corrected as part of the verification process, and;
  - The materiality of any errors, omissions, and misstatements related to the reported product data included in the CIIP application.
- A signed declaration by the Lead Verifier on behalf of the verification body that:
  - The Lead Verifier represents an accredited verification body;
  - The evidence obtained during the verification is sufficient and appropriate to support the verification opinion;
  - The Verification Statement is true, accurate and complete; and
  - The verification work documented in the statement was performed in accordance with the Regulation and CIIP;
- A signed declaration from an Independent Peer Reviewer that:
  - The Independent Peer Reviewer was not involved in the verification documented in the Verification Statement, other than by providing an independent peer review; and
  - The verification used to produce the Verification Statement was appropriate;
- A conflict of interest report; and
- Any other information required by the Regulation and CIIP.

Verification Team

For this assignment, Dillon assembled an experienced Verification Team consisting of the following individuals.

Lead Verifier and Technical Expert – Zachary Zehr, P.Eng.

Zach is a licensed professional engineer in Ontario, and has a Bachelor of Engineering in Environmental Engineering from the University of Guelph. Zach has more than eight (8) years of experience working in a variety of air and noise compliance and GHG projects, including air compliance assessments, permitting, dispersion modelling, stack testing, odour abatement, and noise assessments, and validation and verification of GHG emissions reporting and offset projects.

Zach has worked on numerous voluntary and regulated emission offsets and compliance projects in Canada, spanning the waste, manufacturing, institutional, oil and gas, power generation, cement manufacturing, and pulp and paper sectors. Zach has completed well over 100 verification assignments in the following programs:

- Alberta (oil and gas extraction, and pulp and paper);
- Ontario (institutional/general, manufacturing, power generation, mining and mineral production, chemical production, and oil and gas extraction);
- VCS (wind power);
- ARB Cap-and-Trade Program (livestock and ODS);
- CSA Clean Projects Registry (power generation); and
- Québec (fuel distribution).

Lead Verifier-in-Training – Martha Hamre, EIT

Martha is an engineering intern with four (4) years of work experience specializing in both atmospheric, infrastructure, and mining related projects, and two years of verification experience. Martha has experience quantifying emissions from both stationary and mobile sources and has performed regulatory dispersion modelling assessments to assist clients across Ontario. Martha has conducted verifications under The Climate Registry, the Greenhouse Gas Protocol, Ontario Regulation 390/18, and the Output-Based Pricing System, for facilities across Canada and the United States.

Verifier – Alyssa Hooge, B.Sc.

Alyssa is an Environmental Technologist and has a Bachelor of Technology in Environmental Engineering. Alyssa has a broad range of experience in solid waste management and environmental compliance in Canada. She has experience in GHG reporting and verification projects with Dillon for a variety client sectors, including power generation, manufacturing, oil and gas, agriculture, and waste. Through this work, she is well-versed in a number of GHG programs and protocols in Canada and

the United States. She has assisted in GHG verifications under the Output-Based Pricing System, the British Columbia GHG Emission Reporting, and other Regulations.

Peer Reviewer – Jack Wallace, P.Eng., M.A.Sc.

Jack is an Associate with Dillon and a licensed professional engineer in Alberta and British Columbia, and has over nine years of experience working in a variety of solid waste management and GHG projects. Jack is located in Dillon's Calgary, Alberta office and holds a range of project experience including: evaluation and design of waste processing facilities, waste management system planning and financial analysis, wastewater characterization and treatment system design, validation and verification of GHG emissions reporting and offset projects, and modelling for waste and emissions studies.

Jack has extensive experience in a wide range of GHG projects including sectoral scopes ranging from but not limited to: renewable power generation (wind, geothermal, and hydroelectric), oil and gas, agricultural, manufacturing, institutional, chemical plants, pulp and paper facilities, and landfill gas/biogas combustion plants. These projects have been conducted under numerous GHG programs including: California Air Resources Board (ARB) Cap-and-Trade Compliance Offset Program, Verified Carbon Standard (VCS), Canadian Standards Association (CSA) CleanProjects, The Climate Registry, Gold Standard, and the Alberta, British Columbia, and Ontario Reporting and Offset Programs.

Jack has completed well over 50 validation or verification assignments in the following programs:

- British Columbia (institutional/general, oil and gas extraction, pulp and paper, waste, landfill);
- Alberta (oil and gas extraction, composting, landfill, chemical, biogas plants, pulp and paper, food processing);
- Ontario (institutional/general, manufacturing, power generation, mining and mineral production, chemical production, waste);
- VCS (wind power and landfill/waste);
- ARB Cap-and-Trade Program (livestock and ozone depleting substances [ODS]);
- CSA Clean Projects Registry (composting, energy efficiency, electrification, fuel switching);
- United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) (landfill, wind power, hydroelectric, ODS, solar); and
- The Climate Registry (manufacturing, power generation, electric power transactions).

Uncertainty Risk Assessment and Sampling Plan

Based upon available information at the onset of the verification process, Dillon developed a Qualitative Narrative of the Uncertainty Risk Assessment, presented as **Table B** (attached).

In compliment to the Risk Assessment, Dillon developed a Sampling Plan as presented in **Table C** (attached).

Final versions of both **Table B** and **Table C** are provided with the final Verification Report.

Use of Statements and Marks

This Verification and Sampling Plan is part of the legally enforceable contract for GHG assurance services. This Verification and Sampling Plan, and associated reports and statements provided to Newcrest as part of the assurance services provided, are intended for the use of Newcrest and the BC CAS as the regulator only. Should Newcrest wish to use Statements or Marks provided throughout this process, they must seek to do so via a written statement.

Verification Schedule

Dillon provided assurance services consistent with the tasks and schedule presented in **Table 1** below. Dillon is aware of the BC CAS reporting deadline of May 31, 2022 for verified 2021 emissions.

Table 1: Scope of Work Tasks and Schedule

Task		Timeline
0	Project award and contract signing	February 2 - 11, 2022
1	Project kick-off call	February 22, 2022
2	Initial VSP preparation and submission to Newcrest	February 25, 2022
---	Newcrest review and approval of VSP	March 7 - 11, 2022
3	Data and information exchange	March 7 - 11, 2022
4	Site visit	March 30, 2022
5	Data checks and recalculation development	March 14 - April 1, 2022
6	First round issues log submission to Newcrest	April 6, 2022
---	Newcrest review and response to issues log	April 6 – April 29, 2022
7	Second round issues log submission to Newcrest	April 29, 2022
---	Newcrest review and response to issues log	April 29 – May 24, 2022
8	Draft Verification Report preparation	April 6 – May 25, 2022
9	Independent Review	May 26, 2022
10	Submittal of Draft Verification Report to Newcrest	May 27, 2022
---	Newcrest review and response to Draft Verification Report	Within two days
11	Submittal of Final Verification Report to Newcrest and BC CAS	May 31, 2022

Closure

Please do not hesitate to contact Zachary Zehr at 226-752-9319 or zzehr@dillon.ca should you have any questions.

Sincerely,

DILLON CONSULTING LIMITED

Zachary Zehr, P.Eng
Lead Verifier

MHH:mjm

Attachments: Table A: Greenhouse Gas Emission Sources and Sinks
Table B: Qualitative Narrative – Uncertainty Risk Assessment
Table C: Sampling Plan

CC: Kevin Udema, Environmental Scientist
Brucejack Operations

Our file: 22-3530

Version	Changes	Date
1.0	Initial version	February 25, 2022
2.0	Draft Verification Report	May 26, 2022
3.0	Draft Verification Report (Emissions Only)	May 27, 2022
4.0	Final Verification Report	May 31, 2022

Appendix A

Greenhouse Gas Emission Sources and Sinks

Table A
Newcrest Mining Limited - Brucejack Gold Mine Facility
Verification and Sampling Plan

Greenhouse Gas (GHG) Activities in Facility Boundary

Specified GHG Activity	GHG Source / Risk Factor	Applicable (Y/N)	Emissions (tonnes CO_2e) (2021)	Percent of Overall Emissions	Production	GHG Type						
						Carbon Dioxide (CO_2) from Biomass	Non-Biomass CO_2	Methane (CH_4)	Nitrous Oxide (N_2O)	Hydro-fluorocarbons (HFCs)	Per-fluorocarbons (PFCs)	Sulphur Hexafluoride (SF_6)
General												
---	Facility Boundary	Y	-	-	-	-	-	-	-	-	-	-
---	Data Management Systems	Y	-	-	-	-	-	-	-	-	-	-
---	Consistency with previous years	Y	-	-	-	-	-	-	-	-	-	-
---	Electricity Purchased (GWh)	Y	-	-	145	-	-	-	-	-	-	-
---	Heat Purchased	Y	-	-	-	-	-	-	-	-	-	-
---	Total Gold production (oz)	Y	-	-	351,194	-	-	-	-	-	-	-
---	Total Silver Production (oz)	Y	-	-	461,652	-	-	-	-	-	-	-
Emission Sources												
1	WCI.020 - General Stationary Combustion (Diesel)	Y	4,086	13.74%	-	n/a	Y	Y	Y	n/a	n/a	n/a
2	WCI.020 - General Stationary Combustion (Propane)	Y	3,095	10.41%	-	n/a	Y	Y	Y	n/a	n/a	n/a
3	WCI.020 - General Stationary Combustion (Mixed Waste)	Y	123	0.41%	-	Y	Y	Y	Y	n/a	n/a	n/a
4	WCI.020 - General Stationary Combustion (Wood Waste)	Y	247	0.83%	-	Y	n/a	Y	Y	n/a	n/a	n/a
5	WCI.280 - Mobile Equipment at Facilities (Diesel)	Y	21,324	71.70%	-	n/a	Y	Y	Y	n/a	n/a	n/a
6	WCI.280 - Mobile Equipment at Facilities (Gasoline)	Y	863	2.90%	-	n/a	Y	Y	Y	n/a	n/a	n/a
7	WCI.200 - Wastewater Emissions	Y	3.24	0.01%	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Legend:

Y	Included Parameter in Emission Source
N/A	Not applicable
NEG	Negligible Parameter in Emission Source

Appendix B

Qualitative Narrative – Uncertainty Risk Assessment

Table B
Newcrest Mining Limited - Brucejack Gold Mine Facility
Verification and Sampling Plan

Qualitative Narrative - Uncertainty Risk Assessment

SSR	GHG Source / Risk Factor	Percentage of Emissions	Risk Type	Risk Level	Risk Action
General					
---	Facility Boundary	N/A	Inherent	Low	Low risk action, facility boundaries are well defined and include operations that largely do not change year to year.
			Control	Low	
			Detection	Low	
---	Data Management Systems	N/A	Inherent	Low	The detection and control risks for data management systems can be classified as a medium risk, as there may be instances when transcription errors and double counting may occur. Instances where emissions calculations software is not updated or checked automatically may also exist. As a whole, the risk of errors with the data management system were medium to low.
			Control	Medium	
			Detection	Medium	
---	Consistency with Baseline	N/A	Inherent	Low	The detection risk for emissions changes and consistency with previous years can be classified as a medium risk, as there may be instances when transcription errors may occur. As a whole the risk of errors due to inconsistencies with previous years were low.
			Control	Low	
			Detection	Medium	
---	Production	N/A	Inherent	Medium	The inherent and control risk has been set to medium as the process of collecting data for these production sources can be complex and require multiple departments and sources. There is also a risk of allocation and omitting production data. Detection risk has been set to low as Dillon reviewed the data which was made available.
			Control	Medium	
			Detection	Low	
Emission Sources					
1	WCI.020 - General Stationary Combustion (Diesel)	13.74%	Inherent	Medium	Significant source for reporting with resulting high inherent risk. Third party invoices for fuel consumption may lead to accounting errors, and allocation across stationary vs. mobile sources may lead to reporting errors, both resulting in medium control risk. All invoices were reviewed and assessed with trending and equipment inventory to reduce inherent and control risks, resulting in a lower detection risk.
			Control	Medium	
			Detection	Low	
2	WCI.020 - General Stationary Combustion (Propane)	10.41%	Inherent	Low	Smaller scale source when compared with diesel, resulting in low inherent risk. Understood to make use of third party invoices, resulting in medium detection risk. Detection risk was set to medium given low inherent risk.
			Control	Medium	
			Detection	Medium	
3	WCI.020 - General Stationary Combustion (Mixed Waste)	0.41%	Inherent	Low	Minor source, resulting in low inherent risk. Understood to be estimated on-site based on mass quantities or loads, increasing control risk. Detection risk was set to medium given low inherent risk.
			Control	High	
			Detection	Medium	
4	WCI.020 - General Stationary Combustion (Wood Waste)	0.83%	Inherent	Low	Minor source, resulting in low inherent risk. Understood to be estimated on-site based on mass quantities or loads, increasing control risk. Detection risk was set to medium given low inherent risk.
			Control	High	
			Detection	Medium	
5	WCI.280 - Mobile Equipment at Facilities (Diesel)	71.70%	Inherent	Medium	Significant source for reporting with resulting higher inherent risk. Third party invoices for fuel consumption may lead to accounting errors, and allocation across stationary vs. mobile sources may lead to reporting errors, both resulting in medium control risk. All invoices were reviewed and assessed with trending and equipment inventory to reduce inherent and control risks, resulting in a lower detection risk.
			Control	Medium	
			Detection	Low	
6	WCI.280 - Mobile Equipment at Facilities (Gasoline)	2.90%	Inherent	Medium	Minor source for reporting with resulting medium inherent risk. Third party invoices for fuel consumption may lead to accounting errors, and allocation across stationary vs. mobile sources may lead to reporting errors, both resulting in medium control risk. All provided invoices were reviewed and assessed with trending and equipment inventory to reduce inherent and control risks, resulting in a lower detection risk.
			Control	Medium	
			Detection	Low	
7	WCI.200 - Wastewater Emissions	0.01%	Inherent	Low	Minor source, resulting in low inherant risk. Wastewater volumes measured and collected by Newcrest. Operations were observed to minimize risk detection and control risks.
			Control	Low	
			Detection	Low	

Appendix C

Sampling Plan

Table C
Newcrest Mining Limited - Brucejack Gold Mine Facility
Verification and Sampling Plan

Sampling Plan

SSR	GHG Source	Percentage of Emissions	Data Check and Document Review Methods	Data Sources / Parameters	Monitoring Schedule	Sampling Action
General						
---	Facility Boundary	N/A	• Reviewed historical reporting and Site Visit to assess boundary. • Interviewed key Facility and head office staff	• Process flow diagram(s) • Emissions report(s) • Site visit	Once at Start	• Reviewed the past emissions report for consistency with current year. • Interviewed Facility staff.
---	Data Management Systems	N/A	• Reviewed Data Management Systems and their interactions with staff and each other • Reviewed meter calibrations and tracking of work orders	• Data historian, management systems • Operational records, staff logs • Calibration and inspection records and reports • Quality Assurance/Quality Control (QA/QC) procedures • Staff interviews	As recorded or annualy	• Reviewed the Facility's data systems including frequency of data collection. • Interviewed Facility staff. • Reviewed calibration records and maintenance logs for meters and equipment.
---	Consistency with previous years	N/A	• Reviewed regulatory and Programme changes, updated guidelines and standards, and quantification methods • Reviewed quantification methodology applied	• Quantification methodology document (QMD) or similar • Regulation, Programme documents, standards, and guidelines	Once at Start	• Reviewed the past emissions report for consistency with current year.
---	Electricity purchased	N/A	• Reviewed regulatory and Programme changes, updated guidelines and standards • Reviewed Production requirements	• Data historian, management systems. • Operational records, staff logs. • Calibration and inspection records and reports. • Electricity meter data • Staff interviews.	As recorded or annually	• Reviewed the Facility's data systems including frequency of data collection. • Interviewed Facility staff. • Reviewed production data collection system
---	Heat Purchased	N/A	• Reviewed regulatory and Programme changes, updated guidelines and standards • Reviewed Production requirements	• Data historian, management systems. • Operational records, staff logs. • Calibration and inspection records and reports. • Steam and Heat Production • Staff interviews.	As recorded or annually	• Reviewed the Facility's data systems including frequency of data collection. • Interviewed Facility staff. • Reviewed calibration records and production data collection system
---	Total Gold production	N/A	• Reviewed regulatory and Programme changes, updated guidelines and standards, and quantification methods. • Reviewed quantification methodology applied. • Reviewed Production requirements	• Data historian, management systems. • Operational records, staff logs. • Calibration and inspection records and reports. • Weigh scales and production tracking system • Staff interviews.	As recorded or annually	• Reviewed production values and management of data • Review calibration records • Interviewed Facility staff
---	Total Silver Production	N/A	• Review regulatory and Programme changes, updated guidelines and standards, and quantification methods. • Review quantification methodology applied • Review Production requirements	• Data historian, management systems. • Operational records, staff logs. • Calibration and inspection records and reports. • Weigh scales and production tracking system • Staff interviews.	As recorded or annually	• Review past production reports and sale records. • Review production values and management of data • Review calibration records and maintenance logs for meters and equipment. • Review the Facility's data systems including frequency of data collection. • Interview Facility staff.
Emission Sources						
1	WCI.020 - General Stationary Combustion (Diesel)	13.74%	• Raw and metered data. • Full recalculation of emissions. • Reviewed data assumptions and methods. • Reviewed consistency to regulatory defaults, emission factors, and calculation methodologies. • Reviewed regulatory compliance. • Operational status of equipment.	• Calculation workbooks. • Invoiced data (third party invoices, heating values, carbon content). • Metered data (flow rates, steam generation). • Calibration records and operations logs. • Regulatory parameters. • Heating equipment inventory.	As recorded or monthly	• Invoiced quantities. • Engineering estimates and assumptions. • Default factors from regulatory documents. • Review methodology for stationary emissions estimations. • Review equipment list and operating data. • Review allocation methods for stationary vs. mobile equipment.
2	WCI.020 - General Stationary Combustion (Propane)	10.41%				
3	WCI.020 - General Stationary Combustion (Mixed Waste)	0.41%				
4	WCI.020 - General Stationary Combustion (Wood Waste)	0.83%				
5	WCI.280 - Mobile Equipment at Facilities (Diesel)	71.70%	• Full recalculation of emissions • Reviewed data assumptions and methods • Reviewed consistency to regulatory defaults, emission factors, and calculation methodologies • Reviewed regulatory compliance • Operational status of vehicle	• Calculation workbooks • Third party invoices • Regulatory parameters • On-site vehicle inventory	As recorded or monthly	• Engineering estimates and assumptions • Default factors from regulatory documents • Review methodology for on-site transportation emissions estimations. • Review vehicle list and operating data. • Review allocation methods for stationary vs. mobile equipment.
6	WCI.280 - Mobile Equipment at Facilities (Gasoline)	2.90%				
7	WCI.200- Wastewater Emissions	0.01%	• Full recalculation of emissions • Reviewed data assumptions and methods • Reviewed consistency to regulatory defaults, emission factors, and calculation methodologies • Reviewed regulatory compliance	• Calculation workbooks • Regulatory parameters	As recorded or annually	• Engineering estimates and assumptions • Default factors from regulatory documents • Review calibration records and maintenance logs for meters and equipment. • Review the Facility's data systems including frequency of data collection. • Interview Facility staff.

Appendix B

Emission Report Verification Statement and Conflict of Interest Report

DILLON CONSULTING

Ministry of Environment & Climate Change Strategy
Climate Action Secretariat

Emission Report Verification Statement and Conflict of Interest Report

Template Version 3 – February 2021

1 OVERVIEW

1.1 INTRODUCTION / VERIFICATION OBJECTIVE

The Verification Statement provides the opinion of a Verification Body as to whether a Reporting Operation's Emission Report is free of material errors, omissions or misstatements and conforms to the requirements of the *Greenhouse Gas Industrial Reporting and Control* Act (the Act), the Greenhouse Gas Emission Reporting Regulation (the Regulation), ISO 14064-3 and IAF MD4. The content of the Verification Statement is based on section 31 and 33 of the Greenhouse Gas Emission Reporting Regulation (the Regulation) and must identify information that was not reported or quantified in accordance with the Regulation and indicate whether or not that information was corrected through the verification process. The Verification Statement identifies the materiality of any errors, omissions or misstatements in the Emission Report. Additionally, the Verification Body must ensure the Verification Statement includes, in the form and manner specified by the Director, any additional information required to be included by the Director in accordance with section 31(1)(c) of the Regulation.

1.2 VERIFICATION BODY

General Information	
Verification Body *Regulation s.33(2)(a)*	Dillon Consulting Limited
Business Address *Regulation s.33(2)(a)*	Dillon Consulting Limited 51 Breithaupt Street Suite 200 Kitchener, Ontario, N2H 5G5
Accreditation *Regulation s.33(2)(h)*	ANSI National Accreditation Board (ANAB) #8896
Accreditation Status *Regulation s.33(2)(h)*	Accreditation is in good standing.
Verification Body Team	
Lead Verifier *Regulation s.33(2)(b)*	Zachary Zehr, P. Eng. zzehr@dillon.ca

	519-571-9833 x 3151
Verification Team Members *Regulation s.33(2)(c)*	Martha Hamre, EIT mhamre@dillon.ca 519-571-9833 x 3136 Alyssa Hooge ahooge@dillon.ca T - 604.278.7847 ext. 4234
Independent Peer Reviewer *Regulation s.33(2)(l)*	Jack Wallace, P. Eng. jwallace@dillon.ca 403-215-8880 x 4364

1.3 REPORTING OPERATION

General Information	
Reporting Operation *Regulation s.33(2)(d)*	Newcrest Mining Limited
BCGHG ID *Regulation s.33(2)(d)*	22122200002
Operator *Regulation s.33(2)(d)*	Newcrest Mining Limited Brucejack Mine, BC
Operation Representative *Regulation s.33(2)(d)*	Jason Gabora Environmental Coordinator T: +1 778 724 4186 x103 jgabora@pretivm.com
Person Primarily Responsible for Preparing and Submitting the Emission Report	Brittany Moore Environmental Engineer-in-Training

Regulation s.33(2)(d)	Brucejack Operations 2965 Tatlow Road Smithers, BC V0J 2N5 T: +1 778 724 4186 x139 bmoore@pretivm.com
Name of Facility *Regulation s.33(2)(d)*	Brucejack Gold Mine Facility
Facility type:	Single Facility Operation
Facility Address *Regulation s.33(2)(d)*	Brucejack Mine, BC 56°27'55.94"N, 130°11'10.06"W
Individual Facilities within an LFO *Regulation s. 33(2)(d.1), s.14(4)*	Not applicable.
National Pollutant Release Inventory Identification Number *Regulation s.33(2)(d)*	29072
Process flow diagram *Regulation s.33(2)(d), s.30(4)(c)*	Confirmed that a process flow diagram was submitted and that it is accurate and reliable for the purposes of the verification.

1.4 VERIFICATION SCOPE

Verification Scope	
Reporting Period: *Regulation s.33(2)(d)*	Janaury 1, 2021 to December 31, 2021
Scope of Verification Statement *Regulation s.33(2)(f)*	Please identify the circumstances that apply in relation to the Reporting Operation and the scope of the Verification Statement (check all that apply):

	The Emission Report to which this Verification Statement applies was prepared for a Reporting Operation for the purpose of submitting an application to the CleanBC Industrial Incentive Program.	☐
	The Reporting Operation had Attributable Emissions over 25,000 tonnes CO_2e, not including Reporting-Only Emissions, during the reporting period for which this verification statement applies.	☒
	The Reporting Operation had Attributable Emissions over 25,000 tonnes CO_2e, not including Reporting-Only Emissions, at least once in the previous three reporting periods (not including the reporting period to which this Verification Statement applies).	☒
	The Reporting Operation had Attributable Emissions less than 25,000 tonnes CO_2e, not including Reporting-Only Emissions, during the reporting period for which this verification statement applies.	☐
	A Supplementary Emission Report to which Section 29 (1) or (2) of the Regulation applies was required.	☐

1.5 REPORTING OPERATION EMISSIONS

Reporting Operation Emissions	
Total Emissions Attributable to the Reporting Operation during the Reporting Period.	29,743 tonnes CO_2e
Total Emissions *that are not* Reporting-Only Emissions Attributable to the Reporting Operation during the Reporting Period.	7,314 tonnes CO_2e
Total Reporting-Only Emissions Attributable to the Reporting Operation during the Reporting Period.	22,429 tonnes CO_2e

Total amount of carbon dioxide *from non-Biomass* that is Attributable to the Reporting Operation during the Reporting Period.	28,233 tonnes CO_2
Total amount of carbon dioxide *from Biomass not listed in Schedule C* of the Regulation that is Attributable to the Reporting Operation during the Reporting Period:	43 tonnes CO_2
Total amount of carbon dioxide *from Biomass listed in Schedule C* of the Regulation Attributable to the Reporting Operation during the Reporting Period:	242 tonnes CO_2

2 VERIFICATION PROCESS

2.1 SITE VISITS

Site Visits	
Fill out the following information for each site visited, including head office visits. Add additional lines for multiple facilities.	
Site Visited *Regulation s.33(2)(j) and s.30(3)*	Brucejack Gold Mine Facility
Type of Site Visit *Regulation s.30(3)(a)*	Conducted in-person
Date of Site Visit *Regulation s.33(2)(j) and s.30(3)*	March 30, 2022
Information and Communication Technology (ICT) used *IAF MD4: 2018* *Regulation s.33(2)*	Not applicable, as an in-person site visit was performed.

Risk identification and mitigation *IAF MD4: 2018* *Regulation s.33(2)*	Not applicable, as an in-person site visit was performed.
Requirements for virtual site visits *Regulation s. 30(4)*	Not applicable, as an in-person site visit was performed.

3 VERIFICATION FINDINGS

Dillon performed data checks of all supporting information and data provided by the Facility. A complete list of the documents provided to Dillon during the verification is presented in **Table B**.

The issues log was developed to summarize the data checks completed by Dillon and present any material and immaterial discrepancies that Dillon identified during verification. Any issues identified were documented in the issues log. The Facility would have an opportunity to respond to the issues identified in the issues log through verbal communication or email correspondence. The final issues log detailing all issues and their resolutions is provided in **Table C**. There were no unresolved qualitative or quantitative findings associated with the data or data management systems.

Assessment of Data Management Systems and Controls

Newcrest made available to Dillon all documentation that supported a review of the Facility Emission Report. These records include meter and raw data, operational records and logs, data management systems, quality assurance and quality control (QA/QC) practices, quantification methodologies, and staff interviews. A complete list of the documents provided to Dillon during the verification is presented in Table B.

The site has physical and digital data collection, and data is retained indefinitely in Newcrest's digital data management system. Data collected in physical data collection forms are digitized and stored. The source of data is acceptable for use in the Emission Report.

Dillon assessed the information systems and controls for sources of potential errors, omissions, and misrepresentations, taking into consideration the following:

- Selection and management of the GHG data and information;
- Processes for collecting, processing, consolidating, and reporting GHG data information;
- Systems and processes that ensure the accuracy of the GHG data and information;
- Degree of automation;
- Use of database features;
- Length of operation;
- Linkage to other systems;
- Standardization within an organization;
- Transparency of calculations;
- Design and maintenance of the GHG information system;
- Systems and processes that support the GHG information system; and
- Results of previous assessment.

Assessment of GHG Sources and Calculation Methodologies

Table 1 below presents Dillon's assessment of emissions data for the 2021 Submission for each SSR included in the GHG boundary and for Production. A complete list of the documents provided to Dillon during the verification is presented in **Table B**.

Table 1: Assessment of Data Findings

SSR/ Production	Verification Findings
Consistency with Previous Years	Dillon reviewed the emissions reported in 2020 and 2021 and identified a 1.3% increase in overall attributable emissions
WCI.020 – General Stationary Combustion	General stationary combustion consists primarily of backup diesel generators and propane space heaters. Additionally, solid waste materials are incinerated at the Brucejack and Knipple camp sites. Several pits are used for open burning of clean wood waste (pallets, clearing debris), with volumes estimated by dimensions logged and a default void content and density applied. The fuels combusted include: • Propane; • Diesel; • Wood waste; and • Mixed solid waste.

SSR/ Production	Verification Findings
	Newcrest applied default emission factors under Part 020 of the WCI guidelines, as listed in Table 20-1 though Table 20-7, and default material property values from IPCC (2006) Volume 5: Waste for the estimation of waste emissions from incineration. Default organic and fossil carbon content values are applied based on the type of material combusted. The material breakdown of each batch incineration batch is assessed visually and logged. The methodology for waste combustion was modified from 2020 to 2021 to follow Methodology 1 of WCI.23 rather than formulas from IPCC (2006) as previously referenced. The emission factor for N_2O was revised to reference WCI Table 20-7. Based on bulk diesel delivery to the site, diesel consumption is allocated to stationary equipment based on equipment run hours, power ratings from manufacturer specifications (generator cut sheets), and default load factors. Dillon completed a recalculation of stationary combustion emissions using raw data from invoices as well as observations on the engineering estimates from the site visit and default emission factors and carbon contents (waste). Minor discrepancies were identified due to the availability of generator cut sheet information which detail fuel loads, which are not material.

SSR/ Production	Verification Findings
WCI.280 – Mobile Equipment at Facilities	All gasoline is used for mobile equipment. Based on bulk diesel delivery to the site, and diesel consumption allocated to stationary combustion, the remainder of the diesel delivered to site is allocated to mobile equipment use. Newcrest applied default emission factors under Part 020 of the WCI guidelines, as listed in Table 20-2. Part 280 of the WCI guidelines were followed for general procedures such as sampling frequency and data management. Dillon completed a recalculation of mobile equipment emissions using raw data from invoices and default emission factors. Minor discrepancies were identified due to generator cut sheet information referenced for General Stationary Combustion calculations, which are not material.
WCI.200 – Wastewater Emissions	Newcrest reported N_2O emissions from the aerobic wastewater treatment systems, following methodologies under Part 200 of the WCI guidelines. Total nitrogen in effluent results based on the permitted composite sample are used. Dillon completed a recalculation of wastewater emissions using raw data from total nitrogen results and wastewater flow. Minor discrepancies were identified due to wastewater volumes which are not material.
Production	Gold and silver production is tracked through the weigh data of final product using calibrated weigh scales. Weigh scales are checked with a traceable test weight before and after every recorded production weigh-in. Product is weighed prior to loading on shipment vehicles. Electricity is purchased from the grid-supplied network and invoiced monthly. Dillon reviewed electricity invoices. Dillon did not identify any discrepancies in the production reported under CIIP.

3.1 ERRORS, OMISSIONS, MISSTATEMENTS AND OPPORTUNITIES FOR IMPROVEMENT

Identified Error, Omission or Misstatement	Material/Immaterial	Resolution
Stationary Fuel Combustion	Immaterial -66.65 tonnes of CO_2e	Not resolved

	-0.22% of total	
Mobile Equipment	Immaterial 66.65 tonnes of CO_2e 0.22% of total	Not resolved
Wastewater:	Immaterial 0.01 tonnes of CO_2e 0.00004% of total	Not resolved
Summary Misstatements		
Total Absolute Misstatement	0.01 tonnes of CO_2e 0.00004% of total reported emissions	
Opportunities for Improvement		
Opportunities for improvement	No Opportunities for Improvement were identified.	

4 DECLARATIONS

LEAD VERIFIER DECLARATION

In signing this declaration, I certify that:

- the Emission Report was prepared and the Emissions reported in it were quantified in accordance with the Regulation;
- the verification of the Emission Report was conducted in a manner consistent with ISO 14064-3 and IAF MD4 requirements, and in accordance with the Act and the Regulation;
- any information that is required but was not included in the Emission Report, any information that was not reported or quantified in accordance with the Regulation, and the materiality of any errors, omissions or misstatements, has been identified in the Verification Statement;
- any information required by the Director has been included in the Verification Statement; and
- a Conflict of Interest Report was completed prior to verifying the Emission Report, showing that the Verification Body is qualified under the Regulation to complete the verification.

The evidence obtained by the Verification Body during the verification is sufficient and appropriate to support the verification opinion. Based on the processes and procedures conducted and described in

this Verification Statement, the Verification Body is satisfied the Emission Report, including the total Attributable Emissions, for the Reporting Period is materially correct, and a fair and accurate representation of the Reporting Operation's total Attributable Emissions for the Reporting Period in accordance with the verification criteria, in all material respects, and are substantiated by sufficient and appropriate evidence.

The Verification Statement is true, accurate and complete.

Verification Body-Signatory Name and Title:	Zachary Zehr, P.Eng. Associate
Signature:	Signatory is authorized to represent the Verification Body.
Date:	2022/05/31

INDEPENDENT PEER REVIEWER DECLARATION

In signing this form, I certify that I was not involved in the verification documented in the Verification Statement, other than providing an independent peer review, and that the verification used to produce the Verification Statement was appropriate

Name and Title:	Jack Wallace, P.Eng. Associate
Signature:	
Date:	2022/05/31

5 APPENDIX A: CONFLICT OF INTEREST REPORT

1 ASSESSMENT AND PROCEDURES

1.1 ASSESSMENT OF THREATS TO INDEPENDENCE -SECTION 41 (3)

Prior to issuing a proposal to the client for GHG verification services, Dillon's verification team reviewed the assignment to determine if there are any threats that would impact impartiality. Regardless of who at Dillon received or solicited the opportunity, the opportunity was forwarded on to Dillon's Climate Change Partner. The Climate Change Partner reviewed the opportunity at the Policy, Organization level to determine if there are any threats to impartiality.

Upon approval, the Climate Change Partner worked with the applicable Program Manager and Staffing Coordinator to assign a competent Project Team. Once assigned, each Project Team Member was required to complete an internal Project Impartiality, Resources and Conflict (PIRC) Form for the assignment indicating that they do not have any perceived threats against COI or impartiality. Dillon completed this process for the verification of the Facility, and as a result of this process and the PIRC Form, did not identify any threats to independence or conflicts of interest requiring further mitigation.

In addition to the Climate Change Partner's involvement in screening opportunities, a Risk Screening Partner is engaged to review opportunities from a corporate risk and impartiality perspective. The Risk Screening Partner role spans all of Dillon's service sectors. The role of the Risk Screening Partner and their competencies are outlined within Dillon's Quality Management System. Specifically relating to GHG projects, the Risk Screening Partner will be responsible for the following:

- Review contracts relating to risks (financial, liability, etc.), and provide as necessary with the Dillon Business Administration Manual, approvals of contracts
- Overall Go/No-Go decisions, utilizing the Climate Change Partner as required, and
- Review corporate level COI considerations and provide approval for proceeding with projects

1.2 MITIGATION PROCEDURES -SECTION 41 (3)

Mitigation procedures were not required based on the assessment completed as described under Section 1.1 above.

1.3 IMPLEMENTATION OF PROCEDURES -SECTION 41 (3)

Not applicable.

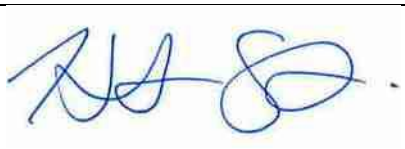
2 AFFIRMATION

In signing this document, I certify, on behalf of the Verification Body that:

I am an authorized officer of the Verification Body and have personally examined and am familiar with the information submitted in this Conflict of Interest Report.

Based upon reasonable investigation, including my inquiry of those individuals responsible for completing the assessment and implementing the procedures, I hereby warrant that the Verification Body avoided any actual or potential conflict of interest with the operator of the Reporting Operation or Regulated Operation.

I understand that any false statement made in the submitted information may be a violation of the Greenhouse Gas Emission Reporting Regulation, section 41.

Verification Body-Signatory Name and Title:	Heather Stuart Partner
Signature:	
Date:	2022/05/31

6 APPENDIX B: TEMPLATE MODIFICATION LOG

Modification to Emission Report Verification Statement Template	
Section/Subsection and page number	Rationale for Modification(s)/Addition(s)
n/a	

Appendix 2-3 2014 Baseline Hydrogeology Report

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PRETIUM RESOURCES INC.

BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT

HYDROGEOLOGY BASELINE REPORT

FINAL

PROJECT NO.:	1008-010	DISTRIBUTION:	
DATE:	June 13, 2014	PRETIUM:	2 copies
DOCUMENT NO.:	BJ-2014-15	BGC:	2 copies
		RESCAN:	1 copy

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
#800-1045 Howe Street
Vancouver, B.C.
Canada V6Z 2A9
Tel: 604.684.5900
Fax: 604.684.5909

June 13, 2014
Project No: 1008-010

Ian Chang, P.Eng. Vice President, Project Development
Pretium Resources Inc..
Suite 1600 – 570 Granville Street
Vancouver BC, V6C 3P1

Dear Mr. Chang,

Re: Brucejack Project Environmental Assessment – Hydrogeology Baseline Report

Please find attached a copy of the above-referenced final report, summarizing the baseline hydrogeology study completed in support of the Environmental Assessment (EA) for the Brucejack Project.

We appreciate the continued opportunity to take part in the development of the Brucejack Project; should you have any questions or comments, please do not hesitate to contact me.

Yours sincerely,

BGC ENGINEERING INC.
per:

ISSUED AS DIGITAL DOCUMENT.
SIGNED HARDCOPY ON FILE WITH
BGC ENGINEERING INC.

Trevor Crozier, M.Eng., P.Eng.
Senior Hydrogeological Engineer

EXECUTIVE SUMMARY

BGC Engineering Inc. (BGC) was retained by Pretium Resources Inc. (Pretium) to complete a baseline groundwater hydrology, or hydrogeology, study for the Brucejack Project located in northwestern British Columbia, Canada. The Brucejack Project (the Project) is a proposed gold-silver mine previously explored by Newhawk Gold Mines Ltd. during the 1980's and 1990's (Pretium, 2012).

The objective of this report is to define the current understanding of the baseline hydrogeologic conditions in the local study area for the Project. This report will support the Environmental Assessment (EA) Certificate application, to be submitted for the Brucejack Project during 2014.

SPATIAL AND TEMPORAL BOUNDARIES

The baseline hydrogeology assessment was completed for the local study area (LSA) within the Brucejack Creek watershed. The LSA is defined as "*the Project footprint (all physical structures and activities that comprise the Project) and surrounding area within which there is a reasonable potential for immediate effects on a specific intermediate component or receptor VC [valued component] due to an interaction with a Project component(s) or physical activity*" (Rescan, 2013a). For the purposes of a hydrogeologic assessment, such effects may include drawdown due to dewatering, alteration in the flow regime, changes to groundwater recharge and/or discharge, and changes to groundwater chemistry. It is anticipated that the effects on the groundwater system at the Brucejack Project site will be focused around the underground mine development, and that the LSA from a hydrogeologic perspective will extend over a radial distance of a few kilometres from the proposed mine.

Hydrogeological data specific to the Brucejack Project site have been collected since 2010 by BGC, through site investigations associated with a Preliminary Economic Assessment (PEA), a Feasibility Study (FS) and an Environmental Assessment (EA). The most recent data presented in this report are from September 2013.

APPROACH AND METHODOLOGY

This baseline hydrogeologic assessment for the LSA involved the compilation and review of available geological, geotechnical, hydrogeologic, and geochemical data obtained from investigations of the Brucejack site, comprising:

- The drilling and hydraulic response testing completed in boreholes at the site
- Installation and development of groundwater monitoring wells
- Water level monitoring and groundwater sampling conducted at the site in support of the baseline hydrogeologic assessment.

PHYSICAL HYDROGEOLOGIC RESULTS

Surface topography has a pronounced influence on the groundwater flow system at the site. Measured groundwater elevations suggest that the water table is a subdued replica of

topography, with depths to groundwater typically greater in the uplands relative to lowlands, and greater seasonal variation at higher elevations. It follows that, in general, groundwater flow at the site follows topography, with groundwater recharge occurring at higher elevations and groundwater discharge occuring in the vicinity of Brucejack Creek and Brucejack Lake. A component of groundwater flow also occurs westwards, towards the Sulphurets Glacier.

The hydrostratigraphy of the site is composed of a thin, discontinuous layer of glacial till or colluvium underlain by bedrock. Thicker overburden deposits are confined to local sections of the valley bottom and are not present in the vicinity of the proposed underground mine.

Bedrock of the Brucejack Project area can be broadly divided as follows:

- Triassic marine sedimentary and volcanic rocks of the Stuhini Group.
- Jurassic sediments and volcanics of the Hazelton Group.
- Early Jurassic dikes, sills, and plugs of diorite, monzonite, syenite, and granite, the most common of which are grouped as the “Sulphurets Intrusions”.

Site wide, a general trend of decreasing bedrock hydraulic conductivity with depth is observed, though hydraulic conductivity varies by 2 to 3 orders of magnitude at any given depth. Based on available data, there is no apparent relationship between hydraulic conductivity and the major structure in the immediate vicinity of the Brucejack Project, the Brucejack Fault.

Adit dewatering, which occurred from November 2011 to February 2012 and August 2012 onwards, created a pronounced decrease in groundwater elevation in nearby monitoring wells. Dewatering activities also changed hydraulic head gradients, leading to increasingly large gradients associated with downward groundwater flow in areas affected by dewatering.

GEOCHEMICAL RESULTS

For the purposes of this baseline hydrogeologic assessment, and consistent with the requirements of the Project Application Information Requirements (AIR), concentrations of physical parameters, total metals, and dissolved metals were compared to appropriate regulatory guidelines for the protection of freshwater aquatic life (Canadian Council of Ministers of the Environment Water Quality Guidelines; and British Columbia Ministry of Environment (BC MOE) Water Quality Guidelines) and for drinking water use (BC MOE Water Quality Guidelines). Guideline exceedance does not imply contaminated groundwater, but rather suggests that background concentrations are higher than typically found in groundwater at other natural sites in Canada due to mineralization in the area. Observed concentrations are considered to be reflective of the natural site conditions.

In general, all groundwaters sampled present moderate alkaline pH values (~ pH 8), low to below detection limit chloride and nutrient concentrations (e.g., ammonia, nitrate, nitrate) and temperatures of approximately 2°C, with minimal seasonal variation. The groundwater sampled from the monitoring wells were grouped based on the geological model unit surrounding the well screens, and pertain to four material types: Office P1, P2, VSF and Bridge P1. Piper diagrams show all groundwaters present similar major cation concentrations, however anion constituents appear to show material-specific trends. Office P1 is

representative of one end-member, with low sulphate and high alkalinity, and Bridge P1 is highlighted as the opposite end-member. An analysis of bulk chemistries from the four material types revealed several metals presented common exceedances to guideline values. Specifically, six metals are shown to be enriched in all groundwaters sampled at the Project site (i.e., Al, Ag, As, Cr, Cu, and Fe). In addition to these metals, several material-specific enrichments were noted; by geologic mdel unit type these are: P2 (F, total Hg and Zn), VSF (F, total Cd, Co, Pb, and Zn), and Bridge P1 (F, total Cd, Pb, and Zn). These results, coupled with general groundwater chemistries (observed from Piper diagram results), imply Bridge P1 and Office P1 likely represent baseline groundwater high and low end-members (respectively) present at the Project site.

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LIST OF ACRONYMS & ABBREVIATIONS

AET	actual evapotranspiration
AIR	Application Information Requirements
BC MOE	British Columbia Ministry of Environment
BCWRA	British Columbia Water Resources Atlas
CCME	Canadian Council of Ministers of the Environment
CCME FW	CCME Water Quality Guideline for the Protection of Freshwater Aquatic Life
COC	chain of custody
CSR	Contaminated Sites Regulation
CSR AW	Contaminated Sites Regulation Aquatic Life Standard
DOC	dissolved organic carbon (chemical parameter)
EA	Environmental Assessment
EC	electrical conductivity (chemical parameter)
EIS	Environmental Impact Statement
FS	Feasibility Study
GAL	Galena Zone
K	hydraulic conductivity
KCBL	Klohn Crippen Berger Ltd.
LSA	local study area
mah	metres along hole
m asl	metres above sea level
m bgs	metres below ground surface
m btoc	metres below top of casing
MDRU	Mineral Deposit Research Unit
ML/ARD	metal leaching / acid rock drainage
PEA	Preliminary Economic Assessment
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RISC	Resource Information Standards Committee
RPD	relative percent difference
RSA	regional study area
SI	site investigation
S_s	specific storage
S_y	specific yield
TDS	total dissolved solids (chemical parameter)

LIST OF ACRONYMS & ABBREVIATIONS CONT'D

TKN	total kjeldahl nitrogen (chemical parameter)
TOC	total organic carbon (chemical parameter)
TSS	total suspended solids (chemical parameter)
VC	valued component
VOK	Valley of Kings Zone
VWP	vibrating wire piezometer
WZ	West Zone

LIMITATIONS

BGC Engineering Inc. (BGC) prepared this document for the account of Pretium Resources Inc.. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending BGC's written approval. If this document is issued in an electronic format, an original paper copy is on file at BGC and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

1.0 INTRODUCTION

BGC Engineering Inc. (BGC) was retained by Pretium Resources Inc. (Pretium) to complete a baseline groundwater hydrology, or hydrogeology, study for the Brucejack Project located in northwestern British Columbia, Canada. The objective of this report is to define the baseline hydrogeologic conditions in the local study area for the proposed Brucejack minse site. This report will support the Environmental Assessment (EA) Certificate application, to be submitted for the Brucejack Project during 2014.

1.1. Project Background

The Brucejack Project is a proposed underground mine targeting a gold-silver deposit in the high alpine in the Sulphurets District of the Iskut River region of British Columbia. The project is located approximately 70 km north-northwest of Stewart and 30 km west of Bowser Lake, at latitude 56°28’20” N and longitude of 130°11’31” W (Drawing 01). Access to the site is via an all-season road that crosses the Knipple Glacier, or via helicopter from one of Bell II, Stewart, B.C., or Grand Duc via Hyder, Alaska.

The Brucejack Project proposes to open a mine in an area previously explored by Newhawk Gold Mines Ltd. during the 1980’s and 1990’s (Pretium, 2012). At the end of Newhawk’s tenure, the project site included camp facilities, shop facilities, a ventilation shaft, an adit, and approximately 5,300 m of exploratory underground development (McLeod, 1999). A major reclamation program was completed in 1999 and the property was placed on a schedule of care and maintenance (McLeod, 1999).

The Brucejack Project was acquired by Silver Standard Resources Inc. in 1999-2000, and subsequently by Pretium Resources Inc. following the discovery of the Valley of Kings Zone in 2009-2010 (Pretium, 2013). Active exploration has been ongoing at the site since that time, including a bulk sample excavation from the Valley of Kings in 2013. A *Feasibility Study and Technical Report* was completed for the project, and submitted in June 2013 (Tetra Tech, 2013).

The proposed underground operation is to be located to the southwest of Brucejack Lake (Drawing 02). The project will include development of a mill adjacent to Brucejack Lake for primary processing of the ore. Flotation tailings from this mill will be deposited in Brucejack Lake along with waste rock from the underground mine. Waste rock and paste thickened tailings will also be used to backfill portions of the underground mine. Concentrate produced at the mine site will be hauled off-site by truck along the 70 km long access road that connects to Highway 37.

2.0 SCOPE OF WORK

This report is based on a review of the results from geological, geotechnical and groundwater quality investigations conducted by BGC on behalf of Pretium, and presents the conceptual understanding of the pre-construction and pre-mining hydrogeologic setting of the Brucejack Project. Predicted effects of the project on groundwater hydrology during construction, operations and closure (decommissioning and reclamation) and post-closure are addressed under separate covers (BGC, 2013a; 2013b).

The assessment was completed in general accordance with the requirements of Section 5 of the *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (British Columbia Ministry of Environment [BC MOE], 2012), and is generally consistent with the document *Groundwater Mapping and Assessment in British Columbia* (Resource Information Standards Committee [RISC], 2013). This report has also considered information requirements outlined in Section 4.1 of the document *Framework for a Hydrogeologic Study in support of an application for an Environmental Assessment Certificate under the Environmental Assessment Act and Regulations* for groundwater extraction projects (BC MOE, 2013). Finally, the study meets requirements in *Brucejack Gold Mine Project: Application Information Requirements for Pretium Resources Inc.'s Application for an Environmental Assessment Certificate* (BC EAO, 2014), the 'AIR', and in *Environmental Impact Statement Guidelines for the Brucejack Gold Mine Project* (CEAA, 2013), the 'EIS'.

2.1. Temporal Boundaries

Hydrogeological data specific to the Brucejack Project site have been collected since 2010 by BGC, through site investigations associated with a Preliminary Economic Assessment (PEA), a Feasibility Study (FS) and an Environmental Assessment (EA). The most recent data presented in this report are from September 2013.

2.2. Spatial Boundaries

There are nine groundwater regions in British Columbia, classified in relation to physiography (Foweraker, 1994). The proposed mine site lies within the Coastal Mountains sub-region of the Insular and Coastal Mountains physiographic region. Parsons and Quinn (1994) provide a general overview of the groundwater occurrence, recharge and quality for the Insular and Coastal Mountains, which extend from the United States border to the Yukon. The extent of the Coastal Mountain sub-region and location of the project area are shown on Drawing 03.

2.2.1. Regional and Local Study Areas

The regional study area (RSA), defined as "*the spatial area within which direct and indirect effects are anticipated to occur*" (Rescan, 2013a), comprises the area selected for numerical hydrogeologic modeling, discussed in more detail in the report entitled *Brucejack Project Environmental Assessment – Numerical Hydrogeologic Model* (BGC, 2014a).

The baseline hydrogeology assessment was completed for the local study area (LSA) within the Brucejack Creek watershed. Catchment boundaries for the Brucejack Creek watershed are shown on Drawing 04.

The LSA is defined as "*the Project footprint (all physical structures and activities that comprise the Project) and surrounding area within which there is a reasonable potential for immediate effects on a specific intermediate component or receptor VC [valued component] due to an interaction with a Project component(s) or physical activity*" (Rescan, 2013a).

For the purposes of a hydrogeologic assessment, such effects may broadly include:

1. Drawdown of the water table or hydraulic heads due to mine dewatering;
2. Accompanying changes in groundwater recharge and/or discharge rates; and/or,
3. Changes to groundwater chemistry from geochemical reactions within the mine or waste materials, or within any zones that are dewatered.

It is anticipated that these stresses to the groundwater system at the Brucejack Project site will be focused around the underground mine development, and that the LSA from a hydrogeologic perspective will extend over an approximately radial distance of a few kilometers from the proposed mine.

3.0 SITE DESCRIPTION

3.1. Physiography

The Brucejack Project is located within the Boundary Range of the Coast Mountain Physiographic Belt along the western margin of the Intermontane Tectonic Belt. The region is characterized by steep mountains and extensive glaciation. Within the local project area, elevations vary from 1,300 to 2,000 m asl. Prominent depositional and erosional features that have resulted from glaciation include melt water channels on sloping surfaces, and small depressions frequently occupied by ponds and lakes. No permafrost conditions have been observed in the Project mine site area.

The tree line is at approximately 1,200 m elevation; therefore the mine site is sparsely vegetated. Sparse fir, spruce, and alder grow along the valley bottoms, and scrub alpine spruce, juniper, alpine grasses, moss, and heather cover the steep valley walls (Rescan, 2011a).

3.2. Climate & Meteorology

The climate at lower elevations in the regional study area is generally that of a temperate or northern coastal rainforest, with subarctic conditions at the high elevations where the Brucejack Project is located. An orographic influence of increased precipitation with increased elevation is often observed in mountainous terrain (Loukas & Quick, 1996). This same effect is expected within the study area, the result being highly variable precipitation and air temperature (Rescan, 2012). Though the Brucejack Project is located more than 200 km inland from the Pacific Ocean, lower mountains near the coast and a corridor created by Behm Canal, Burroughs Bay, and the Unuk River valley allow penetration of maritime air to the mine site area and subsequent abundant precipitation.

Meteorology baseline studies for the Brucejack Project were initiated in 2009, with the installation of an automated meteorological station near the site at an elevation of 1,360 m asl (Rescan, 2012). Precipitation and climate have also been monitored within the region at the Unuk River – Eskay Creek (#1078L3D) and Bob Quinn (#1200R0J) stations. Both stations are operated by Environment Canada from 1989 – present and 1977 – 1994, respectively.

The estimated mean annual adjusted precipitation at the Brucejack meteorological station is 1,589 mm based on data collected from January 2010 to December 2012 (Rescan, 2013b). This may under-predict precipitation, however, as the high wind speeds at the project site may result in under-catch. Average annual precipitation estimated by ClimateBC (Wang, 2012) for an elevation of 1,400 m asl exceeds 2,000 mm, as does annual average precipitation observed at lower-elevation Unuk River – Eskay Creek station. Average monthly precipitation data from the Brucejack Lake, Unuk River – Eskay Creek, and Bob Quinn meteorological stations, as well as estimates from the ClimateBC model, are presented Table 1. Data from all stations indicate that most of the precipitation occurs over the winter months, while the meteorological

station at Brucejack Lake indicates that the highest average monthly precipitation in the LSA occurs during September.

From October to May, most precipitation falls as snow. At higher elevations, snow accumulation can reach between 10 m and 15 m, while snow accumulation in low river valleys ranges from 2 m to 3 m (Rescan, 2011a). Strong winds in all seasons at high elevations in the project area lead to significant redistribution of snow (Rescan, 2012). The length of the snow-free season varies from about May through November at lower elevations and from July through September at higher elevations. Monthly mean air temperatures range from approximately -10°C in December and January to +10°C in July and August for this area (Rescan, 2011a). These temperatures are generally similar to regional climate normals for the Unuk River – Eskay Creek station.

3.3. Hydrology

The local study area contains glaciated areas, as well as several streams, wetlands and lakes, the largest of which is Brucejack Lake. Brucejack Lake is located in the immediate vicinity of the Brucejack Project within a relatively small sub-basin (10.1 km^2) of the Sulphurets Creek watershed (300 km^2). Sulphurets Creek is a tributary to the Unuk River (2,577 km^2) which flows southwest, draining into the Pacific Ocean to the northeast of Ketchikan, Alaska.

The hydrology of the project area is characteristic of a snowmelt dominated regime supplemented by glacier meltwaters in the late summer. Peak flows typically occur in mid-summer and low flow conditions occur during the winter months of January to March (Rescan, 2013a). The long period of snow and ice cover limit evaporation at the site. The local terrain at the Brucejack Project is steep, with elevations ranging from 1,300 to 2,000 m above sea level.

The Brucejack Lake catchment is approximately 41% glaciated (Rescan, 2013c), however, estimates of glacier contributions to streamflow are not yet available.

Data collection for a hydrology baseline study for the Brucejack Project commenced in 2010 (Rescan, 2011b). The baseline study includes data from automated hydrometric stations installed by Rescan during 2007 and 2008 to characterize the hydrology at a neighbouring property. The hydrometric stations relevant for the Brucejack Project are BJL-H1 (Drawing 04) and SL-H1 which collect continuous water level data downstream of Brucejack Lake and Sulphurets Lake, respectively.

Average monthly and annual streamflow, and runoff data for the area are presented in Table 1, along with the precipitation data. Streamflow data are from the hydrometric station BJL-H1 which is located at the discharge point of an approximately 11.7 km^2 catchment area containing the Brucejack Lake sub-basin and three intervening tributaries (Drawing 04). Runoff estimates, which are calculated from streamflow, are expected to represent all of the runoff from the upstream watershed, as baseflow bypassing the hydrometric station is not believed to be susbstantial (BGC, 2014b). The highest average monthly runoff occurs during the months of May through August, and is mostly related to snowmelt in late May and throughout the summer.

This meltwater also appears to act as a significant source for groundwater recharge (discussed further in Section 6.2).

Average annual runoff of 1,746 mm is reported, based on available monthly streamflow data over the period of 2007-2012 (Rescan, 2013d). This estimate exceeds the estimated annual precipitation of 1,589 mm. The discrepancy between annual precipitation and runoff could be related to any one or combination of the following justifications:

1. Prevalent orographic effect causing a difference in precipitation amounts at the two station locations;
2. Precipitation underestimates due to under-catch; or,
3. There is a significant contribution to runoff from glacial melt (BGC, 2014b).

3.4. Geology

The regional geology of the area has previously been described in detail by Grove (1971, 1986), Alldrick (1989), Britton and Alldrick (1988), Alldrick and Britton (1988), Roach and MacDonald (1992), McPherson et al., (1994) and Savell (2008). Regional geology is illustrated on Drawing 05, while site-specific geology is summarized briefly in Sections 3.4.1 though 3.4.4; for more detail on local geology, refer to the FS level rock mechanics assessment completed by BGC and provided under separate cover (BGC, 2013b).

Pretium's geological model units (shown on Drawing 06 and cross-sections 12 and 13) are discussed in Section 3.4.5, in relation to site-specific geology.

3.4.1. Overburden

The overburden in the LSA consists of a veneer of well-graded glacial till over bedrock. Grain size varies from sand to gravel, with some silt and clay, and variable quantities of cobbles and boulders. Clasts are subrounded to rounded, and color varies from orangey brown to grey. Overburden thickness varies but is generally less than 5 m, often less than 1 m, and occasionally absent. A thin (often less than 0.5 m, but occasionally up to 3.0 m) layer of sandy organics overlies the overburden.

3.4.2. Bedrock Geology

The Brucejack Property is underlain by Upper Triassic volcaniclastic and epiclastic sedimentary rocks of the Stuhini Group and Lower to Middle Jurassic volcanic, volcaniclastic, and sedimentary rocks of the Hazelton Group. An angular unconformity marks the contact between the sedimentary rocks of the Stuhini Group and medium- to coarse-grained sandstones of the Jack Formation which is the basal formation of the Hazelton Group and is dated at about 196 million years (Ma).

The sedimentary rocks belonging to the Jack Formation are overlain by a 10-50 m thick unit of mudstone/argillite and cherty argillite belonging to the Unuk River Member of the Betty Creek

Formation. This argillaceous unit is exposed along the southwest side of the West Zone deposit.

Overlying the argillite unit is a 500 m thick package of hornblende and plagioclase-phyric andesitic flows, flow breccias and intermediate tuffaceous rocks intercalated with volcaniclastic conglomerates, sandstones and siltstones. These rocks form the bulk of the Unuk River Member in the Brucejack Property and outcrop extensively within a northwest-trending belt that passes beneath Brucejack Lake. U-Pb geochronology and biochronology done by Mineral Deposit Research Unit (MDRU) geoscientists have determined the age of the Unuk River Member volcanics to be in the range of 196 to 194 Ma.

The rocks of the Unuk River Formation are overlain by a thick sequence of dacitic pyroclastic rocks (tuff-breccia, lapilli tuff, crystal-lithic tuffs, minor ash tuff) and flows with thin argillite interbeds belonging to the Brucejack Lake Member of the Betty Creek Formation. These are exposed on the mountainside north of Brucejack Lake.

The intrusive Unuk River Member andesites are the most important host rocks to the gold and silver bearing quartz veins discovered in the Brucejack Property (P&E Mining Consultants, 2009), and are the focus of the proposed development in the Valley of Kings (VOK) and West Zone (WZ).

3.4.3. Lithologies and Alterations

Multiple stages and zones of alteration have been noted in the project area. The rocks in the VOK and WZ are highly altered, and in many cases stratigraphic relationships must be used on top of lithologic descriptions. The main lithologies include:

- Volcanics: Felsic, intermediate, and mafic volcanics as well as mafic dykes
- Porphyries: Plagioclase-hornblende porphyritic rocks, potassium feldspar-hornblende-plagioclase porphyritic rocks, and plagioclase porphyritic rocks
- Intrusives: Felsic, intermediate, and mafic intrusives
- Sediments: Conglomerates, sandstone/arenite, mudstone/siltstone/pelites, carbonates, cherts/jasperites
- Hydrothermals: Quartz veins, quartz-carbonate veins, quartz-silicate veins, hydrothermal replacement, hydrothermal breccias, and intensely silicified breccia zones
- Metamorphics: Metamorphosed felsic igneous rock, and metamorphosed intermediate to mafic igneous rocks (these lithologies present only at the adjacent Snowfields property)
- Fault zones

Alteration assemblages vary with proximity to deformation events, but sericitic alteration is pervasive throughout the project area. Carbonate, chlorite, and silica alteration are also common.

As summarized by Greig (2012), mid-Cretaceous deformation, which represents the major phase of regional deformation, has deformed both the mineralized zones and the host stratigraphy and therefore post-dates the mineralization event. The regional event led to the development of the predominant WNW to ENE trending and very steeply dipping foliation best displayed in the altered rocks which are the immediate hosts to the mineralization. Late stage brittle faulting has locally disrupted some of the earlier tectonic fabrics. There is evidence for northerly, northwest, and northeast fault trends.

Two major phases of folding are present on the property. Although their origin is uncertain, they may have been developed during the mid-Cretaceous event. One fold axis generally trends northerly but with an arcuate shape, and the other is a tightly folded syncline plunging to the east-southeast with the above-mentioned dominant foliation primarily axially parallel to it. Both fold axes are steeply plunging.

3.4.4. Major Structures and Faulting

The major regional lineaments, as interpreted by ERSi (2010), around the Brucejack area are the Brucejack Fault lineament, the Upper Treaty Glacier lineament and the Treaty Creek lineament. The Bruce Fault, a west-trending fault occupying Brucejack Creek was also identified at earlier stages of exploration as a major feature at the site (McPherson et al., 1994).

The Brucejack Fault truncates several site-scale faults at the western extent of the Brucejack property, and thus has been interpreted as post-dating site-scale deformation events. Orientations parallel to the inferred Brucejack Fault lineament were commonly observed in downhole structural measurements across the property. All interpreted structural domains include sets oriented along the Brucejack Fault with dips ranging from 56˚ to vertical.

The Upper Treaty Glacier lineament is a prominent high angle topographic lineament north of the Brucejack property. Although not associated with a specific fault set, similarities in regional topography and drainages make it likely that parallel structures will be prevalent throughout the study area. The Upper Treaty Glacier appears in drill hole and underground mapping data in the northern regions of the property, and appears locally in the West Zone and VOK 1 domains as a moderately strong shear and joint set. It also aligns with the topographic lineament used to define the VOK 2 – VOK 3 structural domain boundary (BGC, 2013b).

The Treaty Creek lineament strikes east-southeast and extends north to the Iskut River Fault. The lineament marks the contact between the Hazelton Group and Bowser Lake Group rocks to the north of the property, and is a common orientation for valleys and drainages in the region. It is expected that lineament-parallel steep structures will be prevalent throughout the study area. The Treaty Creek lineament was observed in drill hole data as a joint and shear set throughout the property, and parallels the VOK 1 – VOK 2 domain boundary.

The Brucejack Fault lineament is currently the only known major structure that intersects the proposed mining footprint. It is a northerly striking anastomosing fault zone located along the western margin of the study area and extends north to the Iskut River Fault. In places the

lineament appears to be several sub-vertical to moderately (greater than 60°) dipping fault strands braided together. The zone has normal faulting with variable displacement estimated at 500 to 800 m (ERSi, 2010).

3.4.5. Geological Model Units

As discussed above, the Brucejack Property contains a wide range of rock types, with 24 unique rock lithologies identified by Pretivm geologists from drill core. Mapping within the Brucejack area shows many of these rock types are intensely altered and this, in addition to a diverse range of mineral assemblages, adds to the difficulty in relating logged drill core to stratigraphic sequences.

Pretivm developed a geological model to relate these logged lithologies to 7 model units that best categorize the rock composition:

- P2 Model Unit – characterized as megacrystic, plagioclase, K-feldspar and hornblende phyric flow. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.
- Fragmental Model Unit – characterized as Hornblende and/or feldspar phyric latite to andesite fragmental volcanic rocks and subordinate flows with minor ash and lapilli tuff. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.
- Conglomerate Model Unit – characterized as Heterolithic boulder to course cobble conglomerate with sandstone. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.
- Silicified Cap Model Unit – characterized as Silicified rocks; typically poorly sorted heterolithic conglomerate, lesser sandstone and local mudstone; commonly includes rhyolite fragments. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.
- Volcanic Sedimentary Facies (VSF) Model Unit – characterized as Volcanically derived siltstone and sandstone with minor arenite and pebble conglomerate. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.
- Office P1 Model Unit – characterized as Hornblende, feldspar phyric latite flows. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.
- Bridge P1 Model Unit – characterized as Hornblende, feldspar phyric latite flows. The Bridge P1 unit is the same general rock type as Office P1 but with a different age and geochemical signature. Sulphide content comprises pyrite with minor sphalerite and trace chalcopyrite.

For the geochemical characterization of the site, sample materials are classified as one of the seven geological model units based on geochemical assay results (i.e., Ti/V) and/or its proximity to intensely silicified rocks located within the central part of the deposit (BGC, 2014d).

4.0 GROUNDWATER RESOURCES

4.1. Regional Groundwater Resources

Regional groundwater resources were assessed by reviewing information available from the BC Ministry of Environment (MOE) Water Stewardship Division and other online resources.

Groundwater in the mountains generally occurs within voids and fractures in bedrock and can be irregularly distributed due to the variability of the fractures (Parsons and Quinn, 1994). Variations in permeability and topographic relief have a strong effect on the direction of groundwater flow, and mountain springs are common where lower permeability rock impedes the downward movement of groundwater.

Groundwater generally occurs in the intervening valley fill deposits between mountain ranges in granular deposits such as sand and gravel, however, low permeability deposits are often present and are not suitable as sources of groundwater supply. The Insular and Coastal Mountains include significant thicknesses (up to hundreds of metres) of unconsolidated material in the valleys which dissect the mountain ranges due to glacial processes during the Pleistocene ice age (Parsons and Quinn, 1994).

Parsons and Quinn (1994) indicate that groundwater quality is generally dependent on the mineral composition of rocks that the groundwater moves through. In areas with base metal mineralization, groundwater may have high concentrations of these metals and may not be suitable for drinking water. In crystalline bedrock of low solubility, the groundwater is typically good quality for drinking water and other uses. Mountainous terrain is considered especially vulnerable to contamination due to generally sparse soil cover and limited natural attenuation and retardation of flow in crystalline fractures.

4.2. Local Groundwater Resources

The BC MOE online British Columbia Water Resources Atlas (BCWRA) did not show any aquifers mapped in the vicinity of the proposed mine LSA. The nearest wells shown in the BCWRA are located approximately 40 km to the east, northeast and northwest of the project site. A map showing the locations of these wells in relation to the project site and Bowser Lake is included as Appendix A, along with associated well records.

There are a total of six wells within approximately 40 km of the Brucejack project site. One well is mapped to the east of the project site in the Wildfire camp area and is owned by Pretium Exploration. Two wells are mapped to the northeast of the project site and are owned by Vallard Construction and designated for commercial and industrial use. Three wells are mapped to the northwest of the project site and owned by Alta Gas. Of these wells, two are designated for commercial and industrial use and one is designated for “other” uses.

A groundwater supply well is proposed for the Brucejack Project site but this well had not been sited, drilled or tested at the time of report writing. Results from a desktop potable groundwater supply well assessment for Brucejack Mine Camp (BGC, 2014c) indicated that:

1. Selecting a successful location for potable groundwater supply wells for the Brucejack Camp will be difficult, and may not be able to supply the maximum demand (i.e., 500 person camp).
2. A bedrock well may only yield approximately an estimated 20 US gallons per minute. A field of three wells (two operating and one back-up well to be used during maintenance and redevelopment of the main production wells) may be sufficient to supply a 50 person camp.
3. Some treatment of the groundwater from the mineralized area may be required to meet drinking water quality standards.

Based on the absence of public-domain hydrogeologic information, the preliminary evaluation of groundwater resources within the local study area is based entirely on site investigations conducted by BGC. Available information on groundwater occurrence and quality and on aquifer formation parameters are discussed in the subsequent sections of this report.

5.0 APPROACH AND METHODS FOR ASSESSMENT

This baseline hydrogeologic assessment for the LSA involved the compilation and review of available geological, geotechnical, hydrogeologic, and geochemical data obtained from investigations of the Brucejack site. The subsequent sections discuss:

1. The installation and development of groundwater monitoring wells
2. The geotechnical drilling and hydraulic response testing completed in boreholes at the site
3. Water level monitoring and groundwater sampling conducted at the site in support of the baseline hydrogeologic assessment.

5.1. Groundwater Monitoring Wells

In the fall of 2011, nine groundwater monitoring wells were installed at six different locations in the vicinity of the existing underground workings and proposed new development areas (Drawing 06). The monitoring wells were completed as three sets of nested shallow and deep wells (MW-BGC11-BJ-1A/B, MW-BGC11-BJ-3A/B, and MW-BGC11-BJ-5A/B), and three individual wells (MW-BGC11-BJ-2A, MW-BGC11-BJ-4A, and MW-BGC11-BJ-6A).

Between June and August 2012, an additional twelve groundwater monitoring wells at two existing locations (MW-BGC12-BJ-4B, MW-BGC12-BJ-6B) and five new locations were installed at the Brucejack site (MW-BGC12-BJ-8A/B, MW-BGC12-BJ-9A/B, MW-BGC12-BJ-10A/B, MW-BGC12-BJ-11A/B, MW-BGC12-BJ-12A/B). The monitoring wells are identified with either the letters ‘A’ or ‘B’, to differentiate the deep (A) and shallow (B) well in each nest.

The locations for the installation of monitoring wells were selected based on the following considerations:

- Locations of the mineral deposits and surface water receptors (i.e., Brucejack Creek and Brucejack Lake);
- Good spatial distribution of groundwater elevation data;
- Locations of existing vibrating wire piezometer installations;
- Access to wells during the winter; and,
- Proximity to Brucejack Fault.

Originally, nested wells were planned for each site, however, the number of installations and depths were adjusted based on static water levels observed in the field and the presence or absence of water bearing fractures. For example, at MW-BGC11-2A it was determined that a shallow completion was not necessary because the static water level was deeper than 50 m. Installation depths varied from 8.8 to 103.3 m and well screen intervals were selected based on the intersection of water bearing fractures and on the depth to static water level.

Drilling of the PQ-sized holes for monitoring well installations was conducted by Radius Drilling Corporation and Matrix Diamond Drilling using heli-portable diamond drills. Drilling fluid consisted of freshwater obtained from Brucejack Lake, Brucejack Creek, or other nearby

surface bodies of water. No drilling additives or muds were used for the groundwater investigation drill holes, with the exception of MW-BGC12-BJ-12A which was drilled with grease to get past a significant discontinuity at an approximate depth of 50 m bgs. Where overburden thickness exceeded 0.3 m, a short length of surface casing was installed to facilitate drilling and monitoring well installation.

Monitoring wells were constructed using 2” solid pvc, and 0.20 slot PVC screens. Wells were completed with 10/20 silica sand packs placed around the screened intervals, and 3/8” coated bentonite pellet seals placed above the sand packs. The borehole annulus above the bentonite plug was filled with a cement-bentonite grout. The 2011 monitoring wells could not be grouted at the time of installation due to winter drilling conditions and available supplies on site, though the bentonite plugs above the sandpacks in the boreholes and at ground surface are considered sufficient to maintain the integrity of these monitoring wells. Completion of the 2011 wells is documented in the memo entitled *Brucejack Project – Preliminary Summary of October 2011 Groundwater Investigation* (BGC, 2012).

Following installation, BGC developed all monitoring wells by removing approximately 10 well volumes of water from the wells and monitoring the stability of field chemistry parameters, namely pH, electrical conductivity (EC), temperature, and total dissolved solids (TDS). Groundwater was removed from the wells using dedicated Waterra inertial pumps fitted with surge blocks, dedicated bailers, an air compressor, or by removing a length of PVC casing and allowing the well to flow naturally (for artesian wells MW-BGC11-BJ-3A and -3B). Well development was considered to be sufficient once the field parameters stabilized and there was no further visual improvement in water quality.

Following well development, pressure transducers (HOBO data loggers by Onset Corporation) were installed in all monitoring wells which collect continuous water level measurements at 6-hour time intervals.

Well logs and drill hole details for the Brucejack site groundwater monitoring wells are provided in Appendix B and summarized in Table 2. The locations of the monitoring wells are shown on Drawing 06.

5.2. Vibrating Wire Piezometers

Three geotechnical drill holes were completed by BGC at Brucejack in 2010 as part of a geotechnical site investigation that also included borehole televiewer surveys, packer testing and the installation of vibrating wire piezometers (VWPs). Nested shallow and deep VWPs were installed in two of the angled geotechnical drill holes (SU-82, SU-88), with a single VWP installed in the third (SU-77). Continuous single-channel data loggers set to record measurements of pressure and temperature at 6-hour intervals were attached to all VWP installations.

In the spring and fall of 2012, an additional 17 geotechnical drill holes were completed as part of FS-level underground and plant site investigations (Drawing 06). A total of 18 VWPs were

installed in 12 of the drill holes (Table 3) and attached to continuous single-channel data loggers recording at 6-hour intervals. Standpipe piezometers were installed in three of the shallow geotechnical holes (DH-BGC12-28, DH-BGC12-29, and DH-BGC12-30), with the same procedures and materials described above in Section 5.1.

Geotechnical drill hole logs are provided in Appendix C with borehole details summarized in Table 3. Details on the vibrating wire installations, including VWP tip coordinates and depths, are provided in Table 4.

5.3. Hydraulic Response Testing

5.3.1. Packer Tests

Packer testing is a method for obtaining hydraulic conductivity estimates in rock, and may be performed using a single or double packer set-up. There are three different types of packer tests that can be performed:

1. Constant head tests (i.e., constant pressure)
2. Falling head tests
3. Flow recession tests.

Of these, constant head packer tests are preferred, as information can be gained on both the permeability of the tested interval and the rock and fracture behaviour.

The general procedure for conducting a packer test involves isolation of a predetermined testing interval within a borehole by lowering packers down the hole inside drill rods and inflating them with nitrogen gas or water. After isolation, a constant pressure head is applied to the test interval and maintained using a pump located at the surface. For each test, three ascending and two descending pressure stages were applied. A flow totalizer was used to record the total volume of water that is pumped down the hole during each test over a given time (generally 5 to 10 minutes per stage). The bulk hydraulic conductivity across the test interval may then be estimated using a formula involving the applied pressure differential, the observed steady-state flow rate, and an empirical shape factor based on the geometry of the test interval.

A falling head test may be conducted if the hydraulic conductivity is found to be too low to perform a constant head test (i.e., hydraulic conductivity less than ~$1x10^{-8}$ m/s at which flows are generally too low for measurement using commercially available, non-specialized, flow metres). This type of test typically involves addition of water to a predetermined level within the drill rods and recording the rate at which the water level drops, and is very similar to the procedure described below in Section 5.3.2.

A flow recession test may be performed if the sealed packer interval is found to be flowing artesian. For this test, the artesian interval is sealed and the pressure buildup over time is recorded. After the pressure has stabilized, the interval is unsealed and the discharge rate monitored until pressure in the interval returns to pre-test conditions.

Hydraulic conductivity data from a total of 52 packer tests carried out in the bedrock at the Brucejack Site were available for analysis and review. Six packer test results were available from 2010 investigations at the site, with an additional 46 results obtained during the 2012 site investigations. Hydraulic conductivity values estimated from packer tests are summarized in Table 5.

5.3.2. Slug Tests

Rising and falling head tests were carried out by BGC in 2012 to obtain estimates of the hydraulic conductivity of the near-surface, fractured rock zone in which the monitoring wells are completed. Generally, the procedure for these tests involves bailing water from, or adding a displacement slug to, a monitoring well and measuring the resulting water level recovery with time. Test results were analyzed using the Hvorslev (1951) method to estimate the hydraulic conductivity of the formation around the test interval.

A total of 15 falling or rising head tests were conducted in monitoring wells at the Brucejack Site during the 2012 site investigations. Results of the rising and falling head slug test analyses are summarized in Table 6.

5.4. Water Level Monitoring

Hydraulic head data were collected by the network of data loggers attached to VWPs and pressure transducers deployed in groundwater monitoring wells (Sections 5.1 and 5.2). These data loggers were downloaded during each site visit, depending on accessibility and status of the water column (i.e., frozen or unfrozen). Hydraulic head data were corrected for barometric pressure and are plotted as groundwater hydrographs along with climate data in Appendix D.

Hydraulic head data from data loggers were supplemented by manual water level measurements in standpipe piezometers. Static groundwater levels and total well depth were measured from a notch cut at the top of the PVC pipe at each monitoring well using a water level tape, and well stick-up height was measured using a measuring tape. Given the topographic relief, the measurement accuracy of 0.01 m for groundwater levels is considered adequate for baseline characterization of the groundwater flow system in the Brucejack Project LSA. Water level measurements were not always possible during the winter months due to deep snow cover prohibiting access to the wells, or due to frozen water columns. Manual water level measurements from groundwater monitoring wells are presented along with installation and lithologic data in Table 2.

5.5. Groundwater Sampling

Groundwater samples have been collected from monitoring wells at the Brucejack site on a quarterly basis since installation, though weather and site access occasionally prevented a monitoring well from being sampled during a given sampling event, particularly during the winter. The general methodology for groundwater sampling is summarized below.

In general, at least three well volumes were purged from monitoring wells to remove stagnant water from the well and filter pack prior to collection of groundwater samples. For wells screened in low permeability formations, less than tree well volumes may have been purged prior to sampling due to slow well recovery. Purging was conducted using Waterra inertial pumps, dedicated polyethylene bailers, mini-monsoon pumps, or for later sampling events Grundfos Redi-Flo 2 pumps. All pumps were used with dedicated tubing for each monitoring well. Purge volumes were measured in 20 L pails, and discarded at ground surface away from the borehole annulus. For all purging methods an effort was made to minimize agitation of the water column, to reduce sediment suspension in sample water.

During purging, in-situ parameters (pH, temperature, and EC) were monitored until relatively constant readings were observed (i.e., constant temperature, 0.1 pH variation, 2-5% EC variation). It was assumed that water in the well was formation water representative of in-situ groundwater conditions when these parameters were determined to be stable.

Samples were collected from each well using dedicated Waterra tubing with inertial or mechanical pumps, or dedicated single-use polyethylene bailers and placed into the appropriate sterile sample containers provided by the laboratory. Samples were filtered and/or preserved as required and were stored in coolers with ice packs at approximately 4°C until they were transported under chain of custody to ALS Environmental Laboratories in Burnaby, BC for analysis.

The samples were submitted for analysis of physical parameters, anions, nutrients, cyanides, organic carbon, total metals, and dissolved metals. Quality assurance and quality control (QA/QC) samples including field blanks, travel blanks and field duplicates were submitted as required, and were tested for the same parameters as the groundwater samples. In general, one set of field blanks and one set of travel blanks were included with each sampling event, along with one set of duplicates, which equates approximately to a 1:10 ratio. Results of groundwater sampling are summarized in Appendix E and lab certificates are compiled in Appendix F.

6.0 PHYSICAL HYDROGEOLOGY RESULTS

Results of the physical hydrogeologic investigations based on the approach and methods for data collection described in Sections 5.1 to 5.4 are described in the subsections that follow. Specifically, this includes discussion of:

1. Hydraulic conductivities in the LSA;
2. Groundwater elevation data;
3. Groundwater flow directions;
4. Hydraulic gradients and groundwater recharge and discharge; and,
5. The occurrence of groundwater springs and seeps.

6.1. Hydraulic Conductivity

Hydraulic conductivity data from a total of 67 hydraulic tests (15 slug tests and 52 packer tests) carried out in bedrock at the Brucejack Site were available for analysis and review. Six packer tests results were available from 2010 investigations at the site, with an additional 46 results obtained during the 2012 site investigations. Slug tests completed in monitoring wells at the Brucejack project in 2012 provide another 15 estimates of hydraulic conductivity. Hydraulic conductivity data are presented in Tables 5 and 6.

Hydraulic conductivity data are illustrated schematically versus depth by test type (i.e., packer test or slug test) in Drawing 07, by lithology in Drawing 08, and by discontinuity class (i.e., 0-1 discontinuities, 2+ discontinuities, or fault zone) in Drawing 09. The general trend of decreasing hydraulic conductivity with depth (or with increasing confining stress) shown is commonly observed within bedrock, and is illustrated in Figure 6-1 from Rutqvist and Stephansson (2003).

Though a general trend of decreasing hydraulic conductivity with depth is observed in site data, hydraulic conductivity is observed to vary by two to three orders of magnitude at any given depth. The geometric mean of hydraulic conductivity estimates from slug tests (8.3×10^{-7} m/s) is higher than the geometric mean of estimates from packer tests (1.5×10^{-7} m/s). This is expected, as site monitoring wells have well screens within 100 m of ground surface, and were installed to target conductive zones in order to facilitate groundwater quality sampling for the purposes of the EA baseline monitoring program. Packer tests, while generally targeting conductive features as well, were completed over intervals at depths reaching up to 500 m below ground surface.

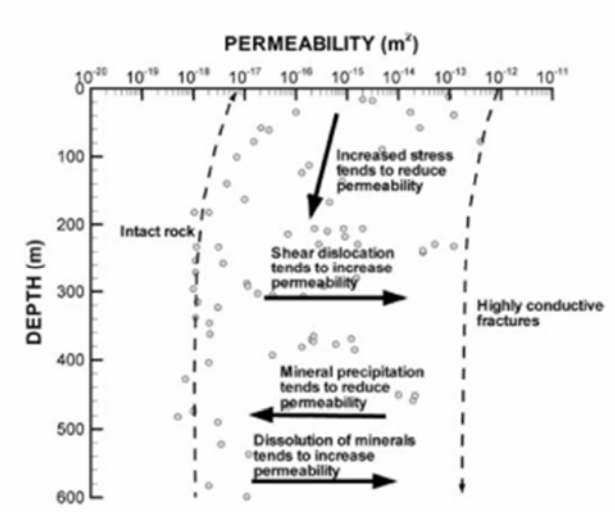

Figure 11. Permeability measured in short-interval well tests fractured crystalline rocks in Gidea, Sweden. Effects of shear dislocation and mineral precipitation/dissolution processes obscure the dependency of permeability on depth (stress). The permeability values on the left-hand side represent intact rock granite, whereas the permeability values on the right-hand side represent highly conductive fractures.

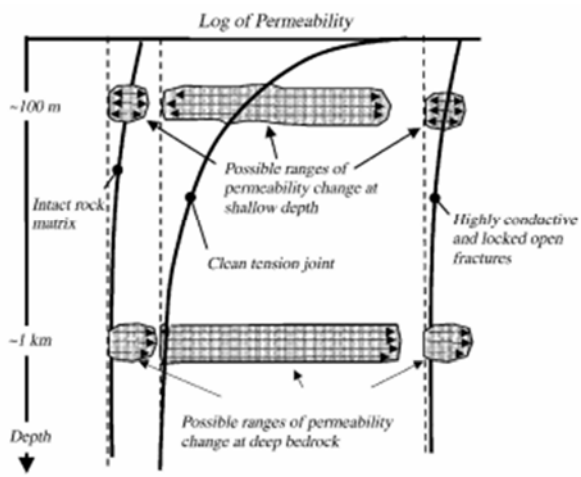

Figure 23. Schematic representation of possible permeability changes at shallow and deep locations in fractured bedrock. The solid lines represent the depth-(or stress-) permeability function for intact rock, clean tension joints and highly conductive and locked-open fractures.

Figure 6-1. Permeability vs. Depth - from Rutqvist and Stephansson, 2003.

Overburden permeability data are not available in the immediate vicinity of the Brucejack Project, though estimated hydraulic conductivity from falling head tests conducted within boreholes and in standpipe piezometers in the overburden during the 2008 and 2009 drilling programs by Rescan and KCBL at a neighbouring property ranged from $1x10^{-5}$ m/s to $3x10^{-9}$ m/s, with a geometric mean of $2x10^{-7}$ m/s (BGC, 2010b).

6.2. Groundwater Elevation

As described in Section 5.4, hydraulic head data are collected by the network of data loggers attached to VWPs and pressure transducers deployed in monitoring wells, and supplemented by manual water level measurements in standpipe piezometers. Plots of groundwater elevation through time for instruments installed at the Brucejack site are included in Appendix D.

The VWPs installed in 2010 have the longest continuous record of groundwater elevation at the site, with data extending back to September of 2010. These hydrographs show pronounced annual variation in groundwater elevation for a given location, with water levels slowly decreasing over the course of the winter season, and recovering rapidly with the recharge that occurs during snowmelt. In general, groundwater elevations are observed to mimic topography (i.e., higher groundwater elevations in instrumentation completed at higher elevations and vice versa), and show greater seasonal variation at higher elevations.

Groundwater levels in the monitoring wells varied over the monitoring period by over 30 m at higher elevations (MW-BGC11-BJ-5A/B) and less than 5 m at lower elevations (MW-BGC11/12-BJ-4A/B and MW-BGC11/12-BJ-6A/B). Observed hydraulic heads at the Brucejack Project site ranged from at or just above ground surface, typically at lower elevations (e.g., MW-BGC11-BJ-3A/B), to 60-80 m below ground surface (e.g., MW-BGC12-BJ-12A).

Interpretation of hydraulic head data at the Brucejack Project is complicated by dewatering and drilling activity at the site. Adit dewatering, which occurred from November 2011 to February 2012, created a very pronounced decrease in the water table in nearby wells, with some water levels dropping below the level of the pressure transducers (e.g., greater than 30 m decrease in groundwater elevation in MW-BGC11-BJ-1A, with water level dropping below the level of the data logger in December 2011). Dewatering recommenced in August 2012, and has been ongoing on a continuous basis, though at a variable pumping rate since that time, maintaining the groundwater elevation at approximately the 1300L in the WZ.

Drilling associated with mineral exploration and geotechnical investigations has also impacted groundwater levels within the LSA, as drilling involves the rapid, localized injection of water on a sporadic basis throughout the Brucejack Project area. This is reflected in the groundwater hydrographs as a spiky pattern of rapidly fluctuating water levels in some wells (e.g., MW-BGC11-BJ-5A/B).

6.3. Potentiometric Surface and Groundwater Flow Direction

Using groundwater elevations measured in the Brucejack Project area, BGC prepared interpreted equipotential contour maps for both summer (Drawing 10) and winter (Drawing 11) baseline conditions. The summer contour map was created using groundwater elevations measured in August 2012. Because winter groundwater elevations observed in 2012-2013 were impacted by dewatering activity at the site, a combination of groundwater elevations from 2011, 2012, and 2013 were used to create the interpreted winter groundwater elevation contour map. Data were selected based on the absence of a dewatering or drilling signal, from the months of March and April when the water table reached its lowest elevation in each well.

BGC also prepared two interpreted hydrogeologic cross sections for the project area showing summer groundwater elevations and hydraulic conductivity data in relation to Pretium's geologic block model. Cross section alignments are shown on Drawing 06 and the cross sections are included as Drawings 12 and 13 in this report.

Groundwater flow in the LSA generally occurs downward and northward from the Valley of Kings Zone under topographically driven gradients towards Brucejack Creek and Brucejack Lake. A component of flow appears to be directed westwards towards the Sulphurets Glacier. Pronounced seasonal variation is observed in the potentiometric surface, with lower groundwater elevations occurring in winter months, though no prominent changes to overall flow direction are observed.

There are three deep VWPs (DH-BGC12-19, SU-88D, and SU-77) at which pressures corresponding to low groundwater elevations are consistently observed; these suggest structural controls (e.g., faults or other discontinuities) or a deeper component of flow directed westwards towards the Sulphurets Glacier. These low groundwater elevations, in particular the observation at SU-77, distort the flow field for both summer and winter baseline conditions, though it is unclear whether the low pressure observation at this location represents a deep water table or rather is indicative of a strong gradient driving downward flow.

6.4. Vertical Gradients and Recharge/Discharge Zones

Vertical hydraulic gradients were calculated using groundwater elevation data from nested groundwater monitoring wells where simultaneous measurements were available. For nested wells, a higher groundwater elevation in the shallow well vs. the deeper well indicates a hydraulic gradient driving downward flow, whereas a higher groundwater elevation in the deeper well indicates an upward flow direction. Vertical hydraulic gradients calculated from manual water level measurements in March, August, and September 2012, as well as January, April, July, and September 2013 are summarized in Table 7. Vertical gradients based on data logger records are plotted over time on Drawings 14 and 15 for each well nest with available data.

The interpretation of gradients is complicated by ongoing dewatering and drilling activity at the Brucejack site, as discussed in Section 6.2 (Groundwater Elevation). Vertical gradients between March and August 2012 are considered to be the most representative of baseline groundwater conditions because they are not affected by dewatering of underground workings at the site, which occurred from November 2011 to February 2012 and from August 2012 onwards. However, exploration drilling, in addition to geotechnical and hydrogeologic drilling all occurred between March and August 2012, potentially disturbing hydraulic gradients.

Nested monitoring wells completed at lower elevations (e.g., MW-BGC11-BJ-1A/B, MW-BGC11-BJ-3A/B, and MW-BGC11/12-BJ-4A/B) have small vertical gradients (0.00 – 0.05) associated with upward groundwater flow under baseline conditions. Nested wells in the VOK Zone (e.g., MW-BGC11-BJ-5A/B and MW-BGC12-BJ-12A/B) appear to be in a groundwater recharge zone with vertical gradients associated with downward flow. Monitoring wells MW-BGC12-BJ-8A/B and MW-BGC12-BJ-10A/B had slight gradients driving upward groundwater flow in August 2012, and MW-BGC11/12-BJ-6A/B appear to have consistent, small gradients driving downward flow.

The timeseries plots of vertical hydraulic gradients (Drawings 14 and 15) show clear dewatering impacts within the LSA. For example, wells MW-BGC11-BJ-1A and -1B respond immediately to dewatering. During the first dewatering period at the site (Nov 2011 – Feb 2012), an abrupt reversal of hydraulic gradient was observed, causing the flow direction to quickly shift from upward to downward. During the second, and ongoing dewatering period, the hydraulic gradient associated with downward groundwater flow has become more pronounced as dewatering progresses.

Nearby well pairs MW-BGC11-BJ-3A/B and MW-BGC12-BJ-8A/B also appear to respond to dewatering, though to a lesser degree. Well pairs MW-BGC11-BJ-5A/B and MW-BGC12-BJ-11A/B, located in the VOK, do not show an immediate response to dewatering, though develop strong (>0.8) hydraulic gradients driving downward groundwater flow in the months following the August 2012 start of dewatering. This may be related to the VOK drift advanced for the bulk sample. Wells located farther from the adit and new VOK development (e.g., MW-BGC11-BJ-4A & MW-BGC12-BJ-4B, MW-BGC11-BJ-6A & MW-BGC12-BJ-6B) do not appear to be impacted by dewatering, and generally present small hydraulic gradients.

6.5. Springs and Seeps

Springs and seeps represent natural groundwater discharge, and can be used as an indicator of in-situ geochemistry. They are often found in topographic lows or where permeable rock units overlie rocks of much lower permeability (Figure 6-2). Seeps and springs can also occur where faults or fracture zones daylight in low permeability rock, where groundwater movement is principally through these fractures (Fetter, 2001).

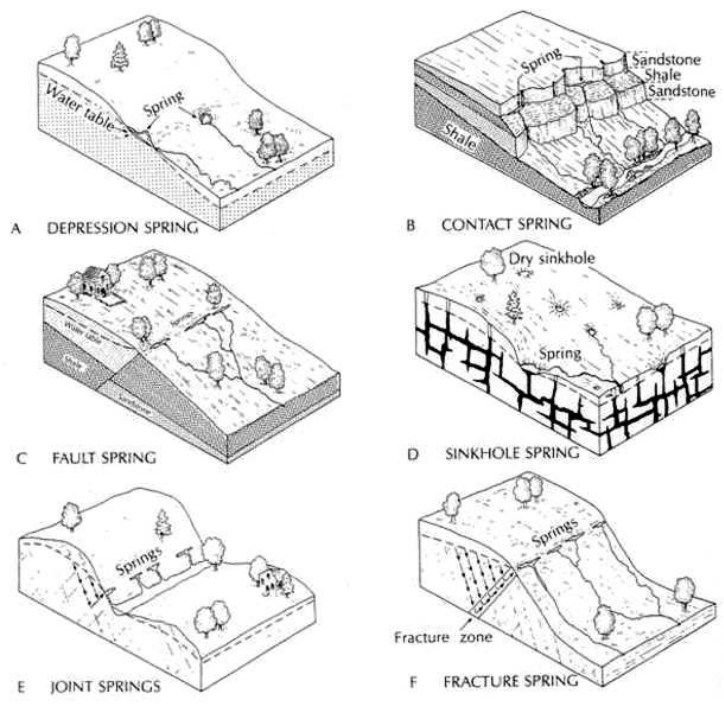

Figure 6-2. Types of springs - from Fetter, 2001.

To date, no seeps or springs have been observed above the ground surface at the Brucejack Project site. Seeps have been observed in the underground and these chemistries were used to estimate scaling factors for the derivation of underground water quality source terms. More details can be found in Lorax (2014).

7.0 GROUNDWATER QUALITY RESULTS

As noted previously, groundwater monitoring and sampling have been carried out at the Brucejack site since October 2011 on a quarterly basis, with the objective of determining baseline groundwater quality prior to mine development. All wells were sampled during these events, with the exception of those that were inaccessible due to depth of snow or potentially hazardous conditions.

On-site drilling operations, during these sampling periods, have the potential to impact water quality sampling. Therefore, the groundwater quality dataset is curated to remove those samples that are identified as 'influenced by drilling operations' and no longer represent baseline conditions. A discussion of the conditions to identify these samples is also included in the succeeding sections.

Groundwater samples were analyzed for physical parameters, major cations and anions, nutrients, cyanides, organic carbon, dissolved metals and total metals (Table 8). The analytical chemistry results for groundwater samples collected during each sampling event are summarized in Appendix E. All samples are compared to the regulatory framework outlined in the AIR and the EIS, as described in Section 7.1 below.

A geochemical assessment of the groundwater at Brucejack is detailed herein by way of review of major water quality indicators to improve the conceptual understanding of the LSA hydrogeology.

7.1. Regulatory Framework

In compliance with the EIS and AIR, the groundwater data collected as part of the baseline assessment is compared with British Columbia Ministry of the Environment (BC MOE) and Canadian Council of Ministers of the Environment (CCME) guidelines. Specifically, as outlined in Section 8.3.1 of the AIR, groundwater data are compared to:

- British Columbia Water Quality Guidelines for Protection of Freshwater Aquatic Life (BC MOE AW) and Drinking Water (BC MOE DW) (BC MOE 2010)
- Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME FW) (CCME 2012b).

Within the Environmental Management Act (BC MOE, 2011), the water quality guidelines provide numerical concentrations for the evaluation of groundwater quality. The groundwater standards are divided into different categories based on specified uses, such as aquatic life (AW), irrigation, livestock watering or drinking water (DW). The BC MOE AW and DW guidelines specify concentrations for total concentrations of heavy metals, metalloids, and inorganic ions as well as dissolved concentrations for aluminum and iron. Additionally, the guidelines are divided into 30 day average concentrations and maximum one-time concentration. For the purpose of this assessment, all results have been initially compared to the 30 day average concentrations and,in scenarios of 30-day threshold exceedance, the concentrations are subsequently compared to the maximum one-time concentration.

The Canadian Water Quality Guidelines set by the CCME for the protection of freshwater aquatic life (FW) include numerical concentrations to support and maintain the freshwater aquatic environment (CCME, 2012b). The CCME FW guideline values apply to the total element or substance in an unfiltered sample. Within the guidelines, there are thresholds for short-term and long-term concentrations. Results in this assessment are compared with the long-term concentration thresholds.

The full suite of guidelines used in this assessment is shown in Table 9, with additional detail on the calculation of CCME ammonia concentration guidelines provided in Table 10.

As indicated in Table 9, some BC MOE standards and CCME guidelines for metals and metalloids are dependent on hardness, temperature, and/or pH. The hardness-dependent standards and guidelines were calculated using the laboratory reported hardness (as $CaCO_3$) for each sample analyzed. The pH- and temperature-dependent standards and guidelines were compared to the range of pH and temperature measurements recorded in the field during sample collection. Where field pH measurements were not recorded, the analytical results were compared to laboratory reported pH.

Elevated concentrations above the BC MOE or CCME guidelines do not imply that the groundwater at the site is contaminated; rather they suggest that background concentrations of these parameters are higher than typically found in groundwater at other natural sites in Canada due to local mineralization. It should be noted that some areas of the site exist in a disturbed condition due to historical and current exploration activities, however, except where noted, observed concentrations are considered to be reflective of the natural site conditions.

7.2. Quality Assurance and Quality Control

7.2.1. General QA/QC procedures

To provide sampling data that are meaningful and reproducible, a Quality Assurance/Quality Control (QA/QC) program is incorporated into each sampling event. This program includes careful labeling of samples, identification of boreholes, and collection of trip blanks, field blanks and blind field duplicates.

QA/QC in the field is achieved by careful data collection and double-checking of names and labels. Prior to work, the identification of the monitoring well is confirmed on a map, by locating the relative position of other monitoring wells and by cross-checking the label on the well riser.The labels on the sample bottles are clearly filled out, while at the sample location and confirmed during sample collection. Proper preservation is added (where applicable) and samples are kept in coolers (with ice packs) to minimize changes to a sample's physic-chemical characteristics by warmer temperatures or exposure to sunlight.

Following collection, samples are promptly shipped to ALS Environmental Laboratories (ALS) along with chain of custody (COC) documentation. Upon receipt at ALS, the temperature of the samples is measured and recorded on the COC form. The COC form is part of the QA/QC

process as it links the samples at the time of shipment receipt to the source and records the movement of samples during handling, transportation and analysis.

Field Blanks and Trip Blanks

Field blanks consist of de-ionized water and are submitted in the same laboratory in the same sample bottles/jars as used for other samples. Field blanks provide information on contaminants encountered during the sampling procedure, other samples in the cooler at transport and during lab analysis. Field blanks were prepared during or immediately after sample collection. One field blank was submitted per sampling event.

Trip or travel blanks are prepared by the laboratory and consist of jars filled with de-ionized water. They are shipped along with the empty sample bottles to the field and are returned to the laboratory unopened. The purpose of the trip blank is to determine if sample bottle preparation, delivery, handling or storage have an impact on the integrity of the samples.

Duplicate Samples

Duplicate samples are collected at the same location and time as its replicate sample, using the same procedure. Duplicate samples are submitted as ‘blind’ samples and provide a QA/QC check on laboratory analytical methods and reproducibility. In theory, the duplicate sample should be similar to within 20% relative percent difference (RPD) of the original sample if at least one of the values is greater than 5 times the detection limit (BC Ministry of Water, Land and Air Protection, 2003). The groundwater baseline program designated one duplicate sample to be submitted during each sampling campaign.

7.2.2. Review of QA/QC Results

Results from the QA/QC monitoring program are provided in Appendix E along with full groundwater quality results, and are summarized below:

Field Blanks and Trip Blanks

Concentrations in the 8 field blanks were generally below the detection limit for all parameters. A single field blank (March 2012) exceeded the detection limits for total suspended solids (TSS), total kjeldahl nitrogen (TKN) and total nitrogen. The field blanks from September 2012 contained measureable total lithium, but were slightly above (i.e., 1.3 times) the detection limit value (i.e., 0.00005 mg/L).

Five trip blanks were analyzed as part of the Brucejack groundwater baseline. All trip blanks were below the detection limits except for a single sample (September 2012) with detectable total lithium at 1.2 times the detection limit.

Duplicate Samples

Charge balances were calculated for all duplicate samples using PHREEQC (v.3.0.6; Parkhurst and Appelo, 2013), considering dissolved concentrations select species and parameters (i.e., Ca, Mg, K, Na, SO_4, Cl, F, alkalinity, and pH) and ranged between -4.07% to

1.28%. Charge balances within ± 5% error suggest analytical results account for the major species in a sample's chemistry.

The majority of duplicate samples (i.e., 5 of 7) showed median RPD values less than 7%, for those concentrations with values greater than 5 times the minimum detection limit. The two duplicates with median RPD values greater than 20% were sampled September 2012 and April 7th from MW-BGC12-BJ-4B and MW-BGC11-BJ-2A (respectively). The latter sample showed significantly higher RPDs from total metals, relative to dissolved metals, whereas the former sample showed high RPDs for the majority of parameters analyzed. Specifically, TSS values differ by 6 times and 2 times between the replicate samples from these locations and is suggestive of particulate contamination during sampling.

General parameters and anions (i.e., pH, conductivity, TSS, TDS, turbidty, alkalinity, F, and sulphate) showed mean RPDs less than 20% for all duplicate samples tested. Nutrient concentrations (i.e., TKN, Total N, Total P) were less robust and had mean RPDs greater than 30%. Total metal concentrations were more susceptible to larger RPDs, relative to dissolved metals, which suggests particulate concentrations may govern these RPD exceedances. This observation is supported by the high median TSS (i.e., > 100 mg/L) concentrations from 10 (of 14 sampled) groundwater locations.

7.3. Laboratory Results

Groundwater quality results for all samples collected in groundwater monitoring wells on the Brucejack Project Site are presented in Appendix E, along with timeseries plots for selected parameters. The results are compared to the BC MOE AW and DW guidelines as well as CCME FW regulatory guidelines (Table 9). As described in Section 7.1, the results are compared with BC MOE 30 day average concentrations where these guidelines are available and the long-term maximum concentrations outlined in CCME. Where concentrations exceed these guidelines, the result is indicated by one of bolding, italics or underline dependent on the specific guideline exceeded.

The following sub-sections discuss the curation of the groundwater quality sample dataset, and groundwater chemistry results by geological model unit.

7.3.1. Dataset Curation

A total of 70 unique samples were taken from Brucejack monitoring wells between 2011 and 2013. Each well-specific dataset was curated to remove samples with a high likelihood of contamination from proximal drilling activities, surface water interaction, grout contamination, etc.. Specifically, these quality control measures include a temporal comparision between sampling and on-site actitivities (e.g., drilling and dewatering) and statistical analyses to identify outlier values.

Following this review, it was determined that 18 samples should be removed from the 70-sample dataset, from the following wells:

- MW-BGC11-BJ-03A (n = 1)
- MW-BGC11-BJ-03B (n = 1)
- MW-BGC11-BJ-04A (n = 1)
- MW-BGC12-BJ-04B (n = 4)
- MW-BGC11-BJ-05A (n = 2)
- MW-BGC11-BJ-05B (total concentrations only)
- MW-BGC11-BJ-06A (n = 2)
- MW-BGC12-BJ-06B (n = 3)
- MW-BGC12-BJ-08B (n = 3)
- MW-BGC12-BJ-12A (n = 1)

The reasoning and motivation for removing the above listed samples is discussed in the following sections.

7.3.1.1. MW-BGC11-BJ-3A/B

Two samples, collected from monitoring wells -03A (Sept. 25th, 2013) and -03B (Sept. 4th, 2012), were removed from the dataset due to high likelihood of contamination. Specifically, the chemistry of these samples was observed to be statistically uncharacteristic of their groundwater datasets and several parameters were identified as 'outlier' concentrations. Seventeen parameters from the MW-03A sample presented concentrations that were higher than the reasonable range displayed by this dataset (i.e., TSS; Total N; Total P; Total Al, Sb, As, Cd, Co, Cu, Fe, Pb, Mg, K, Ag, Tl, Zn; Dissolved Sb). A similar scenario was observed for the sample from MW-03B, as 19 parameters were higher than a reasonable range (i.e., TSS; Total Al, Cd, Cr, Co, Cu, Fe,Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Tl, and Zn; Dissolved Tl). The proximity of this nested monitoring well to the underground adit makes it susceptible to underground, as well as surface, drilling/exploration activities.

7.3.1.2. MW-BGC11/12-BJ-4A/B

The first sample from both the shallow (-04A; Oct. 10, 2011) and deep (-04B; Sept 3, 2012) monitoring well was removed from their respective datasets. In both scenarios, groundwater chemistries presented concentrations that were outside of a reasonable dataset range (i.e., TSS; turbidity; Total Sb, Cr, Cu, Ni ± As, Hg, K, Mo, and Zn; Dissolved Sb, K ± As, Co, Mo, Ni, Zn). Three additional samples were removed from the 4B dataset (i.e., April 8, 2013; July 11, 2013; Sept 25, 2013), due to significant increases to measured pHs by 2.0 – 2.5 pH units (i.e., pH 7.8 to pH 9.8 – 10.4) suggestive of grout contamination. As well, these three samples presented significant shifts to major cations concentrations, whereby Na values increased by one order of magnitude or greater and Ca, Mg and K concentrations decreased to extremely low, dilute values (i.e., Ca < 10 mg/L and Mg < 1 mg/L).

7.3.1.3. MW-BGC11-BJ-5A/B

These nested monitoring wells were installed in October 2011 and sampling was discontinued in the following summer (July, 2012) due to the well nest location in an area of significant drilling activity and potential for temporary contamination by drilling fluids. Total suspended solid (TSS) concentrations in these wells show extremely high TSS and turbidity values (4000 NTU). The first deep well (-05A) sample did not show evidence of contamination and will be used in the baseline review, whereas the subsequent two samples (March 28, 2012 and June 26, 2012; -05B) were removed. In regards to the shallow well (-05B), the presence of extremely high TSS values (i.e., > 3800 mg/L) from all three samples collected suggests total elemental concentrations should not be used in baseline water quality analyses. However, dissolved concentrations are comparable to those from 5A and are considered applicable to the baseline water quality discussion.

7.3.1.4. MW-BGC11/12-BJ-6A/B

Groundwater wells 6A and 6B are located on the north side of Brucejack Lake near its outflow to Brucejack Creek. The shallow well (-06A) was installed in October 2011, whereas the deeper well (-06B) was installed the following summer (June 2012). The installation of the deep well resulted in grout contamination of the fractured bedrock surrounding the well screen. As well, grout likely migrated towards the shallow (-06A) well and is assumed to be the source of significant increases to measured pH values (by 1 – 2 pH units). Therefore, two samples (June 26, 2012 and Sept 3, 2012) are removed from the -06A dataset and samples from -06B are not included in baseline groundwater quality analyses.

7.3.1.5. MW-BGC12-BJ-8B

Groundwater well -08B was installed on June 18, 2012, and samples taken 10 days later (June 28, 2012) and on September 5th 2012 show chemistries with significantly higher solute concentrations than the averaged dataset. Coupled with these high concentrations are significantly high TSS and turbidity values that suggest surrounding groundwater may have been temporarily contaminated with drilling waters/mud or require a longer period to be developed or flushed (i.e., TSS = 5340 and 984 mg/L; Turbidity = 6000 and 969 mg/L).

The third sample point from Well -08B (April 8, 2013) was removed due to its significantly high dissolved Al values, in lieu of basic pH (i.e., pH 8.23). These dissolved Al concentrations are not considered real and are likely attributed to possible colloidal material and/or insufficient filtration. In general, Al concentrations are controlled by secondary mineral precipitates (e.g., $Al(OH)_3$(am) or Gibbsite) at pH values greater than 4.0 and very low to negligible Al concentrations (i.e., parts per billion range) are typical of waters with pH values > 5.5.

7.3.1.6. MW-BGC12-BJ-12A

Samples taken on Sept 5th, 2012 from Well -12A (i.e., less than 1 month following its installation) were removed from the -12A dataset. Specifically, September 2012 water

chemistry shows high TSS and turbidity (842 mg/L and 272 mg/L), which is unlike the other 2 samples taken. It should be noted that -12A waters are significantly higher than Well -08A, -08B or tributary waters with respect to several metals.

The above samples are included in Appendix E, but have not been included in the remainder of the assessment. Laboratory reports are compiled in Appendix F, and all groundwater samples were analyzed for the parameter set listed in Table 8.

7.3.2. Groundwater Quality by Geological Model Unit

In this section, monitoring wells are grouped based on geological model units, namely Office P1, P2, Volcanic Sedimentary Facies (VSF) and Bridge P1 (Section 3.4.5). The monitoring wells are grouped in this manner to assist with the identification of trends or characteristic groundwater chemistries specific to one or more geological model units.

7.3.2.1. Office P1

Two sets of nested monitoring wells have well screens seated in Office P1 material; MW-BGC11-BJ-1A/B and MW-BGC12-BJ-8A/B. Both monitoring wells are located in the same area to the southwest of the exploration camp. The former is approximately 50 m to the east side of the Brucejack Fault, whereas the latter is approximately 50 m west of the same fault. This dataset consists of eleven samples, with the majority (i.e., n = 9) collected from -08A (n = 6) and -08B (n = 3). Only one sample was taken from MW-BGC11-BJ-01A and -01B, immediately following installation, due to suspected movement of the well screen and/or well stick-up during the winter period (e.g., frost heave).

The aqueous chemistry from this location is relatively consistent. Specifically, general parameters show pH values between pH 8.0 and pH 8.3 and modest TSS and turbidity concentrations (i.e., < 200 mg/L and < 100 NTU). In regards to anions and nutrients; total alkalinity values are typically 75 ± 10 mg/L, with below detection to low nutrients (e.g., ammonia, nitrate, nitrite and orthophosphate), and fluoride concentrations that are below CCME guidelines. Sulphate values do not show seasonal variation and are approximately 30 – 36 mg/L. Median values of each well are plotted on a Piper diagram (red symbols; Figure 7-1) and results generally suggest groundwater is reasonably similar between the four locations. The one exception is the single sample from MW-BGC-11-BJ-01B, which has 4 to 10 times greater Na concentration than the other samples in this dataset. All other concentrations from -01B are within the range demonstrated by this compiled dataset. Therefore, this sample may represent a groundwater end member of the possible chemistries from Office P1.

Table 11 presents the statistical parameters from each nested well and those values for the 'Office P1' dataset. The compiled Office P1 dataset shows median values exceed CCME and/or BC MOE aquatic life (30-day average) guidelines for total concentrations of Al, As, Cu, Cr and Fe. A few samples show CCME or BC MOE AW exceedances of total Cd (MW-08A), Pb (MW-01A), Hg (MW-08B) and Zn (MW-01A and -08A). Measured total Ag concentrations exceeds BC MOE 30-day average and maximum one-time values in most groundwater wells.

Although Office P1 compiled (median) total Ag values do not exceed these guidelines, the frequency of this observation suggests Ag enrichment is likely characteristic of this material-specific ground. Therefore, groundwater sampled from Office P1 fractured bedrock contains enrichments of total Al, Ag, As, Cr, Cu, and Fe concentration, relative to guideline values.

7.3.2.2. P2

A total of 21 samples were taken from three monitoring wells situated in P2 material (MW-BGC11-BJ-02A: n = 8; MW-BGC11-BJ-03A: n = 7; MW-BGC11-BJ-03B: n = 6). As noted in Section 7.3.1, one sample from the MW-BGC11-BJ-03B dataset was identified as 'likely contaminated' and removed from the baseline dataset. In general, groundwater samples taken from these wells show moderately alkaline pH values (i.e., pH 8.0) with little variation (i.e., ± 0.2 pH units). These waters are typically more turbid than groundwater wells from the Office P1 unit, with ranges between 1.97 to 777 NTU. Alkalinities and sulphate concentrations are also similar between these locations with average values between 75 – 95 mg $CaCO_3$/L and 48 – 101 mg/L (respectively). Piper plots of the dominant cation and anion constituents plot within the same region of the trilinear diagram (Figure 7-1). These results suggest waters from fractured P2 bedrock are comparable and spatially consistent.

Several parameter concentrations show values that are consistently higher than CCME and/or BC MOE aquatic life guidelines. Specificially, total Al, Ag, As, Cr, Cu, Fe, and Zn generally exceed CCME guidelines for most samples, whereas total Ag, Cu, and Zn also exceed BC MOE AW 30-day average values. Total Zn values from MW-03A also exceeds its BC MOE one-time maximum guideline for the majority of samples taken from this location. Fluoride and total Cd, Pb, Se and dissolved Al concentrations exceed CCME and/or BC MOE AW guidelines on a sporadic to frequent basis. Total Hg concentrations from MW-BGC11-BJ-02A and -03A samples show common exceedances to CCME, and were not identified in shallow well (MW-BGC11-BJ-03B) and suggest some spatial variability within the aquifer.

It should be noted that the nested wells MW-BGC11-BJ-03A/B are located close to the underground adit and, following dewatering and active exploration in 2012 through to 2013, several spikes are observed in the samples collected from this location. Given the shorter duration of this dataset, and the potential for influence by nearby exploration activities, these wells were not included in the evaluation for temporal trends.

Bulk groundwater chemistries from P2 material (Table 12) indicate baseline conditions present higher elemental concentrations of F and total Al, Ag, As, Cu, Cr, Fe, Hg, and Zn relative to CCME and/or BC MOE aquatic life guidelines. Note that F and total Hg were included in this dataset given frequency of exceedances in select wells, which may point towards some spatial variability in this material type.

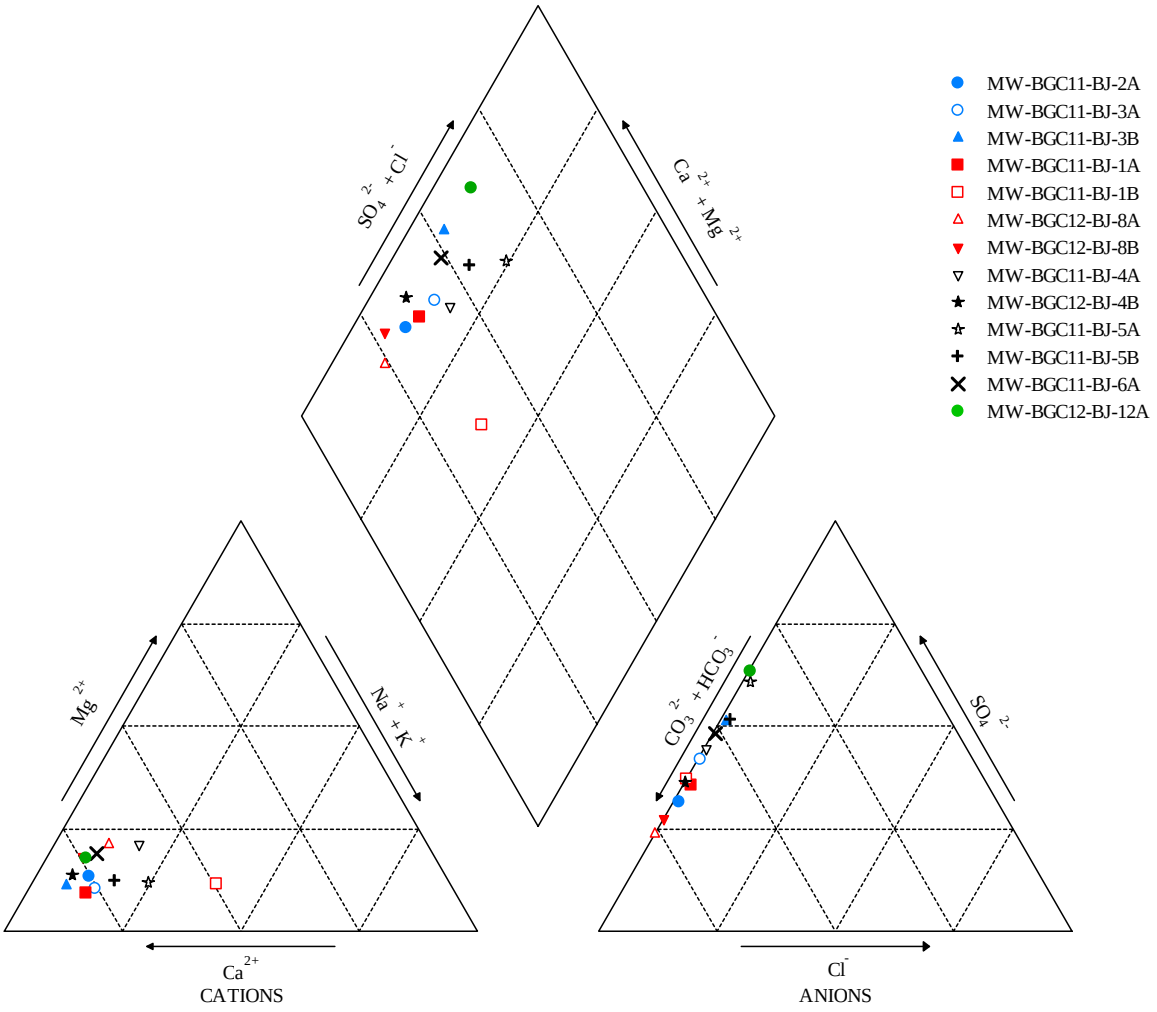

Figure 7-1. Piper diagram showing median groundwater concentrations measured from Brucejack monitoring wells.

7.3.2.3. Volcanic Sedimentary Facies (VSF)

Three nested monitoring well sets are installed in VSF material (i.e., MW-BGC11/12-BJ-04A/B, MW-BGC11-BJ-05A/B, and MW-BGC11/12-BJ-06A/B) for a total of 18 samples. Groundwater chemistries measured from VSF material typically show moderately alkaline pHs (i.e., pH ~ 8.0) and modest sulphate ranges (i.e., 69 – 140 mg/L) relative to those values observed from Office P1 and P2. Alkalinities from the VSF grouped dataset range between 40 – 126 mg $CaCO_3$/L.

The major anion and cation constituents of VSF groundwater chemistries are shown on the Piper diagram in Figure 7-1, relative to those chemistries from Office P1 and P2. These plots show anion concentrations (i.e., sulphate and alkalinity) exhibit the main differences between material-specific chemistries. Specifically, samples from fractured VSF material present higher median sulphate values and lower alkalinities, relative to Office P1 and P2, whereas most samples have similar alkali concentrations (i.e., Ca, Mg, Na, and K).

Compiled results for all monitoring wells in VSF material are shown in Table 13. Floride exceeds CCME guidelines (0.12 mg/L) in all samples with the exception of those from MW-BGC11-04A (Table 13). Dissolved Al shows some values greater than BC MOE aquatic life in a single monitoring well (i.e., MW -06A), and in most cases exceeds the one-time maximum value (i.e,. 0.2 mg/L).

Total Al and Fe concentrations surpass CCME values of 5 – 100 µg/L and 0.3 mg/L (respectively) in all collected samples. Total Cr and As concentrations from most samples exceed CCME and both, CCME and BC MOE aquatic life guideline values.

Measured total Ag, Cd, Co and Cu concentrations surpass CCME or BC MOE aquatic life values in select monitoring wells (i.e., -05A and -06A). Additionally, concentrations of total Pb, Hg, Se, Tl and Zn are highlighted as parameters of concern in MW-BGC11-BJ-06A only. In particular, total Pb values exceed CCME, BCMOE aquatic life 30-day average and one-time maximum, and BC MOE DW values.

A compilation of these results indicates bulk groundwaters from VSF material likely present enriched values of F and total Al, Ag, As, Cd, Co, Cr, Cu, Fe, Pb, and Zn. It should be mentioned, that although median Ag, Cd, Co, Cu and Pb concentrations for VSF groundwater (Table 13) are not above guidelines, they are included in the above list as these metals surpass guidelines values by 10 – 100 times and/or may show spatially signficant enrichments in this material type.

7.3.2.4. Bridge P1

One monitoring well (MW-BGC12-BJ-12A) was situated in Bridge P1 material. Two samples from this well are used in the baseline analysis and, due to the limited sample suite, these results should be considered preliminary. In general, these waters are characterized as very hard (> 181 mg/L), moderately alkaline (pH 7.8) with high sulphate (177 mg/L) concentrations

and moderate alkalinity (104 mg $CaCO_3$/L). Although samples from this location are limited, the average Bridge P1 values are likely identified as distinct from other units when plotted on trilinear diagrams (Figure 7-1). Similar to other observations, the anion constituents from this monitoring well differentiate these waters from those of Office P1, P2 and VSF units.

Concentrations are shown in Table 14 and, in regards to metal exceedances, F, total Al, Ag, Cd, Cr, Cu, Fe, Pb, and Zn concentrations are observed to surpass higher values from BC MOE aquatic life and/or CCME guidelines. Average total As values (0.14 mg/L) also exceed BC MOE drinking water standards by greater than 4 times (i.e., 0.03 mg/L). These 10 parameters (i.e., F and total Al, Ag, As, Cd, Cr, Cu, Fe, Pb and Zn) appear to be naturally elevated in baseline waters.

7.4. Groundwater Quality Summary

The average temperature of most samples was approximately 2°C and minimal seasonal variation was observed. Chloride and nutrient concentrations (i.e., ammonia, nitrate and nitrite) from all samples are observed to be below the lowest guideline value and therefore will not be discussed in this report. The groundwater quality timeseries plots (Appendix E) do not show any evident seasonal or temporal trends. Note that monitoring wells MW-BGC11-BJ-03A/B were not included in this discussion, as observed variations may be equally attributed to their proximity to the underground adit. Specifically, dewatering of the underground may have influenced measured chemistries and underground exploration activities were concentrated in 2013 summer months.

The dominant cation constituents of groundwaters sampled at Brucejack are observed to be comparable, but do resemble a continuum in regards to anion concentrations. Specifically, Office P1 likely represents one end-member with low sulphate and high alkalinity and Bridge P1 resembles the higher end-member with high sulphate and low alkalinity. In addition to major cation/anions, this review of the groundwater quality specific to four geological model units (i.e., Office P1, P2, VSF and Bridge P1) revealed several parameters consistently present high concentrations in all materials tested (Table 15).

Specifically, six metals are shown to be enriched in all groundwaters sampled over the three-year Brucejack sampling campaign (i.e., Al, Ag, As, Cr, Cu, and Fe). Office P1 presents the least amount of exceedances and, coupled with its low sulphate and high alkalinity (Figure 7-1), is likely representative of the least amount of metal enrichment for the Brucejack area. In addition to the six enriched metals listed above, groundwater sampled from VSF-specific monitoring wells is representative of groundwater with the highest amount of metal exceedances (i.e., F, total Cd, Co, Pb, and Zn). Although the dataset from Bridge P1 is limited, groundwater chemistries from this material also present several additional metal exceedances (i.e., F, total Cd, Pb and Zn). These observations, coupled with the lowest alkalinities and highest sulphate values observed from Bridge P1 groundwater samples, suggests this material may be reflective of the groundwater with the highest likelihood for metal enrichment.

8.0 CONCLUDING SUMMARY

The baseline hydrogeologic conditions at the Brucejack Project site are summarized in this report, which includes a detailed description of the site, groundwater resources, methods of hydrogeologic assessment, and physical and geochemical hydrogeologic results. Data in support of the hydrogeologic baseline assessment were obtained through site investigations between 2010 and 2013 that involved:

1. the installation of geotechnical borehole instrumentation and groundwater monitoring wells;
2. hydraulic response testing (packer tests, rising and falling head tests);
3. continuous monitoring of groundwater elevation; and,
4. routine groundwater sampling.

The LSA, located within the Brucejack Creek catchment area, is partially glaciated and is snow-covered from approximately October to June. Snowmelt, which generally occurs in May-June leads to recharge and the rapid recovery of groundwater levels, which decrease slowly over the course of the winter at the site. The LSA is sparsely vegetated, and ET is not considered to have a significant impact on the hydrogeologic system.

Within the fractured bedrock at the site, a general trend of decreasing hydraulic conductivity with depth is observed, although hydraulic conductivity is observed to vary by two to three orders of magnitude at any given depth. The geometric means of hydraulic conductivity estimates from slug tests and packer tests are 8.3×10^{-7} m/s and 1.5×10^{-7} m/s, respectively. Overburden permeability data are not available in the immediate vicinity of the Brucejack Project, though overburden cover is sparse and discontinuous, and not considered to be significant from a hydrogeologic perspective at the site.

In general, groundwater elevations are observed to mimic topography (i.e., higher groundwater elevations in instrumentation completed at higher elevations and vice versa), and show greater seasonal variation at higher elevations. It follows that, in general, groundwater flow at the site follows topography, with groundwater recharge occurring at higher elevations and groundwater discharge occuring in the vicinity of Brucejack Creek and Brucejack Lake. A component of groundwater flow also occurs westwards, towards the Brucejack Fault and Sulphurets Glacier.

Adit dewatering, which occurred from November 2011 to February 2012 and August 2012 onwards, created a very pronounced decrease in groundwater elevation in nearby wells. Dewatering activities impact hydraulic gradients, leading to increasingly strong gradients driving groundwater flow downward in areas affected by dewatering.

For the purposes of this baseline hydrogeologic assessment, concentrations of physical parameters, total metals, and dissolved metals are compared with BC MOE (aquatic life and drinking water) and CCME freshwater guidelines. Seventy unique samples were collected from 14 monitoring wells and, following curation of the dataset to exclude likely contaminated samples, a total of 52 samples were used in the baseline review. In general, the pH of the groundwater is moderately alkaline (~ pH 8) and groundwater temperatures are approximately

2°C, with minimal seasonal variation. All samples from the curated dataset showed chloride and nutrient concentrations (i.e., ammonia, nitrate and nitrite) to be below the lowest guideline values.

Monitoring wells were grouped based on the geological model unit surrounding the well screens. Specifically, groundwater samples pertain to four material types; Office P1, P2, VSF and Bridge P1. An analysis of bulk chemistries from each material revealed several metals presented common exceedances to guideline values. Specifically, six metals are shown to be enriched in all groundwaters sampled over the three-year Brucejack sampling campaign (i.e., Al, Ag, As, Cr, Cu, and Fe). Office P1 presents the least amount of exceedances, whereas groundwater sampled from VSF-specific monitoring wells is representative of the highest amount of metal exceedances (i.e., F, total Cd, Co, Pb, and Zn). Although the dataset from Bridge P1 is limited, groundwater chemistries from this material do present several metal exceedances (i.e., F, total Cd, Pb and Zn).

Piper diagrams show all groundwaters present similar major cation concentrations, however anion constituents appear to show material-specific trends. Office P1 is representative of one end member, with low sulphate and high alkalinity, and Bridge P1 is highlighted as the opposite end-member. These results, coupled with the previous discussion of metal exceedances, imply Bridge P1 and Office P1 likely represent baseline groundwater high and low end-members (respectively) present at the Project site.

9.0 CLOSURE

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

ISSUED AS DIGITAL DOCUMENT. SIGNED HARDCOPY ON FILE WITH BGC ENGINEERING INC.

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TABLES

Table 1. Mean Monthly Precipitation Data and BJL-H1 Observed Streamflow and Runoff

Month	Brucejack Lake (1,360 masl)[1]	Climate BC Model (1,400 masl)[2]	Unuk River Eskay Creek (887 masl)[3]	Bob Quinn AGS (610 masl)[4]	Average Runoff[5]	Average Flow[6]
	(mm)	(mm)	(mm)	(mm)	(mm)	(m^3/s)
January	137	239	249	60	18	0.078
February	99	165	214	41	14	0.066
March	114	113	181	27	19	0.084
April	106	100	97	25	32	0.143
May	90	80	88	29	299	1.308
June	84	105	67	34	378	1.707
July	88	121	83	57	346	1.512
August	128	160	139	51	245	1.069
September	367	242	207	86	194	0.874
October	180	377	247	102	114	0.500
November	124	235	215	62	54	0.245
December	72	228	247	69	33	0.146
Total	**1,589**	**2,165**	**2,034**	**643**	**1,746**	**7.732**
Monthly Average	**132**	**180**	**170**	**54**	**146**	**0.644**

Notes:
1. Data collected from the Brucejack meteorological station from 2010 to 2012 (Rescan, 2013a)
2. Climate normals (1981 to 2009) generated from the Climate BC climate model for latitude (56°28'20"), longitude (130°11'31"W), elevation (1,400 masl) (Wang, 2012)
3. Environment Canada Unuk River Eskay Creek climate station (1989 to 2010)
4. Environment Canada Bob Quinn AGS climate station (1977 to 1994)
5. Average runoff and flow are based on streamflow data from the Brucejack Lake hydrometric station (BJL-H1) for the years 2007-2012, reported in (Rescan, 2013d)
6. Streamflows are typically estimated for winter months due to ice and snow conditions hindering access to the site, methods of estimation are provided in ERM Rescan (2014)

Table 2. Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC11-BJ-1A	2-Oct-11	426280.6	6258840.0	1386.286	0.57	1385.716	0.57	10-Oct-11	9:10	21.598	1364.688	78.6	84.8	77.1	85.3	0.05	0.10	PHP	
							0.57	23-Mar-12	12:00	35.230	1351.056								
							0.57	14-Aug-12	13:30	25.890	1360.396								
							0.57	7-Sep-12	17:30	27.545	1358.741								
							0.57	9-Jul-13	14:55	56.341	1329.945								
							0.57	21-Sep-13	11:20	57.933	1328.353								
MW-BGC11-BJ-1B	2-Oct-11	426280.0	6258841.0	1386.393	0.67	1385.723	0.67	10-Oct-11	9:40	24.605	1361.788	35.3	38.4	31.3	38.7	0.05	0.10	PHP	
							0.67	23-Mar-12	12:00	35.300	1351.093								
								14-Aug-12	13:30	-									unable to locate due to snowpack
							0.67	7-Sep-12	17:35	23.286	1363.107								
							0.67	9-Jul-13	15:05	24.972	1361.421								
							0.67	21-Sep-13	11:10	23.345	1363.048								
MW-BGC11-BJ-2A	3-Oct-11	426885.3	6258811.7	1423.420	0.25	1423.170	0.25	9-Oct-11	9:58	51.052	1372.368	70.7	76.8	64.9	80.3	0.05	0.10	PHPP	
							0.25	19-Jan-12	12:00	58.150	1365.270								no stickup due to snowpack, use previous stickup to correct WL
							0.25	23-Mar-12	unk	58.350	1365.070								
							0.25	30-Mar-12	11:30	58.310	1365.110								
							0.25	25-Jun-12	14:10	50.290	1373.130								
							0.25	1-Jul-12	9:55	51.270	1372.150								
							0.25	3-Jul-12	10:55	51.420	1372.000								
							0.25	14-Aug-12	14:05	52.800	1370.620								
							0.25	25-Aug-12	16:35	54.150	1369.270								
							0.25	27-Aug-12	17:15	54.304	1369.116								
							0.25	1-Sep-12	15:45	53.695	1369.725								
							0.25	4-Sep-12	17:00	53.470	1369.950								
							0.25	3-Apr-13	15:50	59.578	1363.842								
							0.25	9-Jul-13	11:30	54.091	1369.329								
							0.25	21-Sep-13	9:35	53.271	1370.149								
MW-BGC11-BJ-3A	3-Oct-11	426615.4	6258843.9	1368.433	0.81	1367.627	0.2	8-Oct-11	10:51	flowing	>1367.7	83.0	88.3	79.3	88.4	0.05	0.10	PP	removed stickup extension - su approx 20 cm
							0.2	23-Jan-12	12:00	9.670	1358.157								removed stickup extension - su approx 20 cm
							2.0	23-Mar-12	unk	2.010	1367.617								
							2.0	28-Mar-12	unk	1.740	1367.887								

Table 2. cont'd Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC11-BJ-3A	3-Oct-11	426615.4	6258843.9	1368.433	0.81	1367.627	2.0	24-Jun-12	9:35	1.230	1368.397	83.0	88.3	79.3	88.4	0.05	0.10	PP	WL measured with stickup extension, removed for sampling
							2.0	3-Jul-12	9:35	0.833	1368.794								artesian pressure contained by stickup
							2.06	14-Aug-12	14:30	5.560	1364.127								
							2.11	28-Aug-12	14:50	2.097	1367.640								
							2.11	4-Sep-12	9:30	5.030	1364.707								
							2.11	3-Apr-13	14:15	19.040	1350.697								
							0.806	10-Jul-13	15:00	10.846	1357.587								New stickup, recorded water level adjusted to fit hydrograph
							0.806	21-Sep-13	9:10	4.845	1363.588								
MW-BGC11-BJ-3B	4-Oct-11	426615.1	6258844.2	1369.762	2.23	1367.532	0.2	8-Oct-11	10:51	flowing	>1367.8	5.8	8.8	4.5	9.1	0.05	0.10	PP	
							0.2	23-Jan-12	12:00	8.400	1359.332								removed stickup extension - su approx 20 cm
							0.2	23-Mar-12	unk	2.140	1365.592								
							0.2	28-Mar-12	11:00	1.450	1366.282								
							0.2	24-Jun-12	10:00	flowing	>1367.8								
							0.2	3-Jul-12	9:35	flowing	>1367.8								overflowing artesian - influenced by nearby drilling
							2.13	14-Aug-12	14:30	1.130	1368.532								
							2.13	28-Aug-12	16:15	2.182	1367.480								
							2.23	4-Sep-12	9:35	1.535	1368.227								
							2.23	3-Apr-13	14:20	10.290	1359.472								bailed until empty and failed to recover after 4 days.
							2.23	10-Jul-13	15:05	2.275	1367.487								
							2.23	21-Sep-13	9:15	10.646	1359.116								
MW-BGC11-BJ-4A	4-Oct-11	427030.7	6258749.8	1390.857	0.40	1390.457	0.49	8-Oct-11	11:20	27.870	1362.987	21.3	30.5	18.0	31.0	0.05	0.10	FV	
							0.49	18-Jan-12	14:00	13.720	1377.137								no stickup due to snowpack
							0.49	23-Mar-12	unk	14.620	1376.237								
							0.49	26-Jun-12	14:50	11.030	1379.827								
							0.49	30-Jun-12	11:10	12.000	1378.857								
							0.49	3-Jul-12	10:00	12.060	1378.797								
							0.40	14-Aug-12	14:20	13.010	1377.847								
							0.40	27-Aug-12	16:50	13.190	1377.667								
							0.40	29-Aug-12	11:30	15.850	1375.007								
							0.40	30-Aug-12	8:55	14.055	1376.802								
							0.40	31-Aug-12	9:00	14.729	1376.128								

Table 2. cont'd Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC11-BJ-4A	4-Oct-11	427030.7	6258749.8	1390.857	0.40	1390.457	0.40	31-Aug-12	16:15	14.145	1376.712	21.3	30.5	18.0	31.0	0.05	0.10	FV	
							0.40	1-Sep-12	8:00	13.561	1377.296								
							0.40	2-Sep-12	8:15	15.558	1375.299								
							0.40	3-Sep-12	14:30	14.058	1376.799								
							0.40	3-Apr-13	15:15	17.032	1373.825								
							0.40	9-Jul-13	11:00	13.042	1377.815								
							0.40	21-Sep-13	8:20	14.055	1376.802								
MW-BGC12-BJ-4B	20-Jun-12	427030.7	6258752.5	1391.100	0.67	1390.430	0.67	26-Jun-12	14:40	11.430	1379.670	94.9	97.9	91.6	98.1	0.05	0.12		slow response following development
							0.67	3-Jul-12	10:00	12.245	1378.855								
							0.67	11-Aug-12	14:00	12.840	1378.260								
							0.67	14-Aug-12	14:15	13.230	1377.870								
							0.67	27-Aug-12	16:55	13.312	1377.788								
							0.67	29-Aug-12	11:30	13.680	1377.420								
							0.67	30-Aug-12	8:50	14.105	1376.995								
							0.67	31-Aug-12	8:55	14.228	1376.872								
							0.67	1-Sep-12	7:55	14.252	1376.848								
							0.67	3-Sep-12	14:35	13.598	1377.502								
							0.67	7-Sep-12	9:35	13.350	1377.750								
							0.67	8-Sep-12	8:20	13.335	1377.765								recovered back to static post-development and testing
							0.67	3-Apr-13	15:20	17.921	1373.179								
							0.67	9-Jul-13	11:05	15.069	1376.031								
							0.67	21-Sep-13	8:30	15.304	1375.796								
MW-BGC11-BJ-5A	29-Sep-11	426346.6	6258040.4	1526.694	0.55	1526.144	0.6	10-Oct-11	13:18	17.662	1509.032	68.6	77.7	65.7	78.0	0.05	0.10	FV	
							0.6	23-Mar-12	12:00	42.130	1484.564								
							0.6	28-Mar-12	9:30	41.950	1484.744								
							0.6	24-Jun-12	9:45	4.300	1522.394								influenced by nearby drilling
							0.6	1-Jul-12	11:00	6.230	1520.464								
							0.6	3-Jul-12	11:40	2.675	1524.019								influenced by nearby drilling
							0.55	14-Aug-12	17:30	14.010	1512.684								possible mistake?
							0.55	25-Aug-12	14:22	10.690	1516.004								
							0.55	27-Aug-12	12:10	10.717	1515.977								
							0.55	10-Jul-13	9:25	15.045	1511.649								
							0.55	21-Sep-13	13:25	45.041	1481.653								

Table 2. cont'd Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC11-BJ-5B	30-Sep-11	426346.0	6258041.5	1526.595	0.44	1526.155	0.4	10-Oct-11	13:18	18.325	1508.270	41.0	50.2	39.6	50.9	0.05	0.10	FV	
							0.4	23-Mar-12	15:00	40.090	1486.505								
							0.4	28-Mar-12	10:10	40.110	1486.485								
							0.4	26-Jun-12	10:20	6.240	1520.355								influenced by nearby drilling
							0.4	1-Jul-12	14:00	7.620	1518.975								
							0.4	3-Jul-12	11:40	0.835	1525.760								influenced by nearby drilling
							0.44	14-Aug-12	17:30	11.030	1515.565								
							0.44	25-Aug-12	14:20	14.095	1512.500								
							0.44	27-Aug-12	12:00	14.109	1512.486								
							0.44	10-Jul-13	9:35	17.415	1509.180								
							0.44	21-Sep-13	13:30	40.832	1485.763								
MW-BGC11-BJ-6A	4-Oct-11	427094.8	6258983.4	1380.810	1.00	1379.810	*0.1*	8-Oct-11	14:49	8.235	1371.675	21.2	30.3	20.7	31.8	0.05	0.10	FV	
							0.1	23-Mar-12	15:00	13.700	1366.210								
							0.1	30-Mar-12	12:30	13.710	1366.200								
							0.1	26-Jun-12	11:45	7.350	1372.560								possible grout migration into well
							0.1	30-Jun-12	9:15	7.210	1372.700								
							0.1	3-Jul-12	8:50	8.140	1371.770								
							1.0	14-Aug-12	8:30	9.270	1371.540								
							1.0	31-Aug-12	10:55	10.468	1370.342								
							1.0	3-Sep-12	11:30	10.358	1370.452								
							1.0	5-Apr-13	8:45	15.976	1364.834								Stick up detached, must repair in summer
							1.0	9-Jul-13	10:30	10.890	1369.920								Stick up repaired
							1.0	21-Sep-13	15:15	11.693	1369.117								
MW-BGC12-BJ-6B	16-Jun-12	427097.3	6258982.5	1380.234	0.67	1379.564	0.77	23-Jun-12	10:50	11.330	1368.904	100.3	103.3	98.2	103.8	0.05	0.12	IV	prior to development
							0.77	3-Jul-12	8:55	11.730	1368.504								prior to development
							0.77	14-Aug-12	8:30	12.400	1367.834								
							0.67	28-Aug-12	12:10	12.995	1367.239								
							0.67	31-Aug-12	10:45	13.083	1367.151								
							0.67	1-Sep-12	10:00	13.086	1367.148								
							0.67	2-Sep-12	10:20	13.092	1367.142								
							0.67	3-Sep-12	11:35	13.063	1367.171								
							0.67	6-Sep-12	10:20	12.872	1367.362								
							0.67	5-Apr-13	8:30	16.274	1363.960								
							0.67	9-Jul-13	10:20	13.202	1367.032								

Table 2. cont'd Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC12-BJ-6B	16-Jun-12	427097.3	6258982.5	1380.234	0.67	1379.564	0.67	21-Sep-13	15:20	14.123	1366.111	100.3	103.3	98.2	103.8	0.05	0.12	IV	
MW-BGC12-BJ-8A	18-Jun-12	426105.9	6258818.5	1403.734	0.35	1403.384	0.38	22-Jun-12	9:10	12.570	1391.164	86.2	92.3	86.0	95.1	0.05	0.12	PHP	prior to development
							0.38	28-Jun-12	10:30	13.620	1390.114								
							0.38	1-Jul-12	15:00	13.430	1390.304								
							0.38	3-Jul-12	12:05	13.675	1390.059								
							0.35	12-Aug-12	16:00	14.390	1389.344								
							0.35	14-Aug-12	13:15	14.680	1389.054								
							0.35	29-Aug-12	14:50	15.338	1388.396								
							0.35	30-Aug-12	10:45	15.416	1388.318								
							0.35	4-Sep-12	14:20	15.277	1388.457								
							0.35	6-Apr-13	8:25	36.525	1367.209								
							0.35	9-Jul-13	14:10	15.119	1388.615								
							0.35	26-Sep-13	9:05	13.409	1390.325								
MW-BGC12-BJ-8B	19-Jun-12	426106.1	6258819.1	1403.630	0.33	1403.300	0.35	22-Jun-12	10:20	15.970	1387.660	44.8	50.9	44.3	51.0	0.05	0.12	PHP	prior to development
							0.35	27-Jun-12	15:20	18.630	1385.000								
							0.35	1-Jul-12	16:30	17.100	1386.530								
							0.35	3-Jul-12	12:05	17.416	1386.214								
							0.35	12-Aug-12	16:00	17.910	1385.720								
							0.35	14-Aug-12	13:15	18.040	1385.590								
							0.33	29-Aug-12	15:00	18.726	1384.904								
							0.33	30-Aug-12	11:20	18.812	1384.818								
							0.33	4-Sep-12	16:25	18.338	1385.292								
							0.33	6-Apr-13	8:15	37.228	1366.402								
							0.33	9-Jul-13	14:15	18.054	1385.576								
							0.33	21-Sep-13	9:00	17.104	1386.526								
MW-BGC12-BJ-9A	4-Aug-12	426464.5	6258360.6	1515.130	0.73	1514.400	0.77	14-Aug-12	18:00	58.960	1456.170	72.9	79.0	70.8	80.0	0.05	0.12		
							0.73	25-Aug-12	14:10	63.380	1451.750								
							0.73	6-Sep-12	14:20	62.920	1452.210								
							0.73	3-Apr-13	16:20	79.794	1435.336								
							0.73	10-Jul-13	10:00	79.811	1435.319								
							0.73	21-Sep-13	14:25	79.906	1435.224								
MW-BGC12-BJ-9B	1-Aug-12	426460.6	6258361.8	1515.228	0.67	1514.558	0.67	14-Aug-12	16:05	17.100	1498.128	40.6	46.7	38.4	47.4	0.05	0.12		difficult to locate water surface
							0.67	25-Aug-12	14:00	31.485	1483.743								
							0.67	6-Sep-12	14:50	30.008	1485.220								
							0.67	7-Sep-12	11:10	29.784	1485.444								

Table 2. cont'd Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC12-BJ-9B	1-Aug-12	426460.6	6258361.8	1515.228	0.67	1514.558	0.67	9-Sep-12	13:55	29.793	1485.435	40.6	46.7	38.4	47.4	0.05	0.12		
							0.67	3-Apr-13	16:15	46.232	1468.996								
							0.67	10-Jul-13	10:20	39.547	1475.681								
							0.67	21-Sep-13	3:36	43.402	1471.826								
MW-BGC12-BJ-10A	22-Jun-12	426989.1	6258340.8	1445.966	0.38	1445.586	0.44	3-Jul-12	11:21	6.664	1439.362	53.2	59.3	51.6	60.1	0.05	0.12	IV	prior to development
							0.38	11-Aug-12	8:30	7.840	1438.126								
							0.38	12-Aug-12	7:30	50.720	1395.246								still recovering from development
							0.38	14-Aug-12	8:30	10.840	1435.126								slow response following development, expect WL still recovering
							0.38	25-Aug-12	15:45	47.381	1398.585								
							0.38	8-Sep-12	10:50	45.480	1400.486								still recovering from well development
							0.38	21-Sep-13	10:40	32.122	1413.844								
MW-BGC12-BJ-10B	22-Jun-12	426989.1	6258341.2	1446.359	0.72	1445.639	0.72	3-Jul-12	11:24	13.089	1433.270	38.1	41.1	35.6	41.4	0.05	0.12	IV	
							0.72	11-Aug-12	8:15	13.255	1433.104								
							0.76	14-Aug-12	13:55	13.210	1433.149								
							0.76	9-Jul-13	11:55	13.572	1432.787								
							0.76	9-Jul-13	11:55	13.572	1432.787								
							0.76	21-Sep-13	10:51	14.996	1431.363								
MW-BGC12-BJ-11A	26-Jun-12	426300.3	6258594.9	1434.181	0.61	1433.571	0.61	3-Jul-12	12:15	5.975	1428.206	26.5	29.5	25.8	29.5	0.05	0.12	PHP	
							0.61	12-Aug-12	11:30	6.500	1427.681								prior to development
							0.61	14-Aug-12	13:00	6.920	1427.261								
							0.63	25-Aug-12	15:15	6.794	1427.387								
							0.61	27-Aug-12	14:15	6.820	1427.361								
							0.61	7-Sep-12	14:00	6.822	1427.359								
							0.61	9-Jul-13	13:45	14.362	1419.819								
							0.61	21-Sep-13	11:52	18.037	1416.144								
MW-BGC12-BJ-11B	28-Jun-12	426299.3	6258594.6	1433.589	0.63	1432.959	0.63	3-Jul-12	12:15	6.574	1427.015	50.7	53.8	48.2	53.8	0.05	0.10	PHP	
							0.63	12-Aug-12	11:30	7.500	1426.089								prior to development
							0.63	14-Aug-12	13:00	7.150	1426.439								
							0.63	25-Aug-12	15:10	7.506	1426.083								
							0.63	27-Aug-12	13:20	7.498	1426.091								
							0.63	9-Jul-13	13:50	21.936	1411.653								
							0.63	21-Sep-13	11:45	37.097	1396.492								
MW-BGC12-BJ-12A	8-Aug-12	426508.7	6257806.6	1579.965	0.78	1579.185	0.78	14-Aug-12	17:30	51.680	1528.285	87.8	93.9	84.3	97.0	0.05	0.12		difficult to locate water surface
							0.78	15-Aug-12	11:25	51.560	1528.405								

Table 2. cont'd Summary of Groundwater Monitoring Wells and Water Levels

Well ID	Installation Date	Easting (m)	Northing (m)	Top of PVC Elevation (m asl)	Surveyed Standpipe Stickup Height (m)	Ground Surface Elevation (m asl)	Measured Standpipe Stickup Height (m)	Manual Water Level Readings				Screen		Sand Pack		PVC Casing Diameter (m)	Drilled Diameter (m)	Screened Geologic Unit	Comments
								Date	Time	Water Level (m btoc)	Water Level (m asl)	From (m bgs)	To (m bgs)	From (m bgs)	To (m bgs)				
MW-BGC12-BJ-12A	8-Aug-12	426508.7	6257806.6	1579.965	0.78	1579.185	0.78	25-Aug-12	14:45	50.325	1529.640	87.8	93.9	84.3	97.0	0.05	0.12		
							0.78	2-Sep-12	16:00	52.202	1527.763								
							0.78	5-Sep-12	10:15	51.781	1528.184								
							0.78	9-Apr-13	9:30	74.435	1505.530								water too far from surface for compressor. Used bailers on wireline.
							0.78	10-Jul-13	8:40	68.010	1511.955								
							0.78	26-Sep-13	11:50	82.190	1497.775								
MW-BGC12-BJ-12B	10-Aug-12	426504.8	6257807.0	1579.938	0.78	1579.158	0.78	14-Aug-12	17:30	37.600	1542.338	46.7	52.8	45.2	53.1	0.05	0.12		difficult to locate water surface
							0.78	15-Aug-12	13:30	37.730	1542.208								
							0.78	25-Aug-12	14:40	42.442	1537.496								
							0.78	2-Sep-12	16:00	52.202	1527.736								
							0.78	4-Sep-12	10:20	46.786	1533.152								
							0.78	6-Sep-12	12:00	50.026	1529.912								still recovering from development
							0.78	7-Sep-12	12:00	51.785	1528.153								still recovering from development
							0.78	9-Sep-12	13:30	51.550	1528.388								still recovering from slug test
							0.78	9-Apr-13	9:35	52.486	1527.452								
							0.78	10-Jul-13	8:55	52.592	1527.346								
							0.78	26-Sep-13	11:40	52.529	1527.409								

Table 3. Summary of Geotechnical Drill Holes

BGC Hole ID	Pretium Hole ID	Drilling Contractor[1]	Investigation Objective[2]	Completion Date	Easting[3] (m)	Northing[3] (m)	Elevation[3] (m)	Total Hole Length (m)	Hole Plunge / Trend (°)	Depth to Rock (m)	Instrumentation Installed in Borehole[4]
-	SU-77	Radius	2010 Site Investigation	1-Aug-10	426,721	6,258,133	1507.2	550	66 / 180	0.0	VWP @ 268.2 m
-	SU-82	Radius	2010 Site Investigation	15-Aug-10	426,632	6,257,847	1541.6	518	59 / 247	0.0	2 VWP's @ 76.2 & 393.2 m
-	SU-88	Radius	2010 Site Investigation	21-Aug-10	426,694	6,258,727	1389.8	300	75 / 360	0.0	2 VWP's @ 75.0 & 215 m
DH-BGC12-19	SU-290	Radius	West Zone (UG Design)	17-Mar-12	426,563	6,258,822	1,375.0	425.3	75 / 131	15.1	VWP @ 214.3 m
DH-BGC12-20	SU-295	Radius	West Zone (UG Design)	26-Mar-12	426,552	6,258,607	1,419.0	420.3	76 / 222	0.0	none
DH-BGC12-21	SU-304	Radius	Valley of Kings (UG Design)	9-Apr-12	426,406	6,258,223	1,499.0	544.4	75 / 145	0.0	2 VWP's @ 251.8 & 513.9 m
DH-BGC12-22	SU-316	Radius	Valley of Kings (UG Design)	25-Apr-12	426,473	6,257,930	1,544.0	585.8	75 / 036	0.0	2 VWP's @ 95.7 & 447.9 m
DH-BGC12-23	SU-318	Radius	Valley of Kings (UG Design)	3-May-12	426,502	6,257,853	1,582.0	566.0	70 / 271	0.0	2 VWP's @ 501.1 & 564.6 m
DH-BGC12-24	SU-329	Radius	Valley of Kings (UG Design)	4-May-12	426,644	6,257,880	1,548.0	501.4	68 / 002	0.0	2 VWP's @ 98.5 & 499.9 m
DH-BGC12-25	SU-337	Radius	Valley of Kings (UG Design)	13-May-12	426,350	6,258,086	1,524.0	371.3	45 / 176	0.0	2 VWP's @ 30.6 & 369.8 m
DH-BGC12-26	SU-381	Radius	Mine Site (Foundations)	8-Jun-12	426,753	6,258,745	1,406.0	30.5	75 / 180	0.3	VWP @ 29.0 m
DH-BGC12-27	SU-383	Radius	Mine Site (Foundations)	8-Jun-12	426,843	6,258,669	1,409.0	30.2	75 / 315	0.0	VWP @ 29.3 m
DH-BGC12-28	SU-385	Radius	Mine Site (Foundations)	9-Jun-12	426,907	6,258,772	1,417.0	30.5	80 / 360	0.5	STP @ 26.2 to 30.5 m
DH-BGC12-29	SU-389	Radius	Mine Site (Foundations)	11-Jun-12	426,899	6,258,739	1,417.0	30.5	80 / 270	0.0	STP @ 28.1 to 30.5 m
DH-BGC12-30	SU-391	Radius	Mine Site (Foundations)	11-Jun-12	426,976	6,258,751	1,393.0	32.3	80 / 225	2.4	STP @ 27.4 to 30.5 m
DH-BGC12-31	SU-583	Radius	North Portal	29-Sep-12	426,960	6,258,615	1,410.3	50.0	75 / 256	4.3	2 VWP's @ 22.56 & 43.90 m
DH-BGC12-32	SU-586	Radius	South Portal	30-Sep-12	426,981	6,258,578	1,410.8	50.0	75 / 240	2.1	VWP @ 43.90 m
DH-BGC12-33	SU-587	Radius	Mine Site (Foundations)	1-Oct-12	427,073	6,258,623	1,392.7	29.3	75 / 095	7.2	VWP @ 23.18 m
DH-BGC12-34	SU-588	Radius	Mine Site (Foundations)	1-Oct-12	427,046	6,258,650	1,396.0	31.4	75 / 244	5.8	Thermistor
DH-BGC12-35	SU-589	Radius	Mine Site (Foundations)	2-Oct-12	427,021	6,258,692	1,389.4	32.9	75 / 154	1.7	VWP @ 23.77 m
						Total Meterage (17 holes)		3,762.0			

Notes:
1. Radius - Radius Drilling Corp., Prince George, BC; exploration drilling company.
2. UG Design objective refers to Underground Design.
3. Borehole coordinates and elevations from handheld GPS in NAD83 UTM Zone 9.
4. VWP = vibrating wire piezometer grouted in hole; depth corresponds to location of probe. SP = standpipe piezometer; 50.88 mm PVC or 2"" diameter PVC; depth range corresponds to measuring interval/sand pack. No instrumentation installed in hole DH-BGC12-20."

Table 4. Summary of Vibrating Wire Piezometer Completion Details

BGC Hole ID	Pretium Hole ID	Installation Date	Trend (°)	Plunge (°)	VWP Tip Easting [1] (m)	VWP Tip Northing [1] (m)	VWP Tip Elevation (m asl)	VWP Tip Depth (mah)
-	SU-77	1-Aug-10	66	180	426,596	6,258,207	1,267	268.2
-	SU-82	15-Aug-10	59	247	426,475	6,258,025	1,475	76.2
					426,328	6,257,961	1,202	393.2
-	SU-88	21-Aug-10	75	360	426,572	6,258,939	1,317	75.0
					426,574	6,258,971	1,181	215.0
DH-BGC12-19	SU-290	17-Mar-12	75	131	426,611	6,258,787	1,159	214.3
DH-BGC12-21	SU-304	9-Apr-12	75	145	426,440	6,258,176	1,293	251.8
					426,489	6,258,100	1,007	513.9
DH-BGC12-22	SU-316	25-Apr-12	75	036	426,492	6,257,958	1,447	95.7
					426,548	6,258,039	1,109	447.9
DH-BGC12-23	SU-318	3-May-12	70	271	426,330	6,257,863	1,114	501.1
					426,308	6,257,866	1,054	564.6
DH-BGC12-24	SU-329	4-May-12	68	002	426,644	6,257,913	1,456	98.5
					426,656	6,258,066	1,086	499.9
DH-BGC12-25	SU-337	13-May-12	45	176	426,352	6,258,065	1,506	30.6
					426,360	6,257,795	1,302	369.8
DH-BGC12-26	SU-381	8-Jun-12	75	180	426,757	6,258,741	1,378	29.0

Table 4. cont'd Summary of Vibrating Wire Piezometer Completion Details

BGC Hole ID	Pretium Hole ID	Installation Date	Trend (°)	Plunge (°)	VWP Tip Easting 1 (m)	VWP Tip Northing 1 (m)	VWP Tip Elevation (m asl)	VWP Tip Depth (mah)
DH-BGC12-27	SU-383	8-Jun-12	75	315	426,841	6,258,676	1,386	29.3
DH-BGC12-31	SU-583	29-Sep-12	75	256	426,954	6,258,613	1,388	22.6
					426,949	6,258,612	1,368	43.9
DH-BGC12-32	SU-586	30-Sep-12	75	240	426,971	6,258,572	1,368	43.9
DH-BGC12-33	SU-587	1-Oct-12	75	095	427,079	6,258,622	1,370	23.2
DH-BGC12-35	SU-589	2-Oct-12	75	154	427,024	6,258,686	1,366	23.8

Notes:
1. VWP tip coordinates calculated based on surface coordinates provided by Pretium from professional surveys in UTM NAD 83 Zone 9N.
2. "m asl" refers to metres above sea level; "mah" refers to metres along hole.

Table 5. Summary of Packer Test Results

Monitoring Well / Borehole ID	Easting[1] (m)	Northing (m)	Elevation (m asl)	Plunge / Trend (°)	Test No.	Test Interval					Depth to Midpt (m bgs)	Discons/ Faults[2]	Simplified Geology[3]	K Estimate (m/s)
						From (mah)	To (mah)	From (m bgs)	To (m bgs)	Interval (m)				
Constant Head Packer Tests														
SU-77	426,599	6,258,328	1,507.16	64	1	67.5	96.6	60.8	87.0	26.2	73.9	DIS 1	SEDIMENTARY	1.2E-07
				63	2	174.2	203.3	155.7	181.7	26.0	168.7	FAULT	SEDIMENTARY	4.7E-07
				63	3	308.3	337.4	274.1	300.0	25.9	287.1	STK	METAMORPHIC	1.5E-08
SU-82	426,510	6,258,042	1,541.57	59	1	97.2	127.1	83.7	109.4	25.7	96.6	FAULT	METAMORPHIC	7.8E-08
SU-88	426,572	6,258,921	1,389.77	76	1	55.3	84.4	53.8	82.0	28.3	67.9	STK	VOLCANIC	7.9E-08
DH-BGC12-19	426,567	6,258,826	1,365.04	-75 / 131	3	313.0	317.6	302.3	306.8	4.4	304.6	STK	IGNEOUS/INTRUSIVE	3.3E-07
					4	401.4	425.8	387.7	411.3	23.6	399.5	STK	SEDIMENTARY	3.9E-08
DH-BGC12-20	426,552	6,258,607	1,419.00	-76 / 222	1	33.2	50.0	32.2	48.5	16.3	40.4	FAULT	SEDIMENTARY/HYDROTHERMAL	3.9E-07
					3	240.5	264.9	233.4	257.0	23.7	245.2	STK	SEDIMENTARY	1.7E-07
DH-BGC12-21	426,406	6,258,223	1,499.00	-75 / 145	1	36.6	50.6	35.4	48.9	13.5	42.1	STK	IGNEOUS/INTRUSIVE	1.6E-07
					2	131.4	148.1	126.9	143.1	16.1	135.0	DIS 1	IGNEOUS/INTRUSIVE	3.5E-08
					3	228.9	248.6	221.1	240.1	19.0	230.6	STK	IGNEOUS/INTRUSIVE	(4)
					4	331.0	349.3	319.7	337.4	17.7	328.6	FAULT	SEDIMENTARY	3.8E-08
					5[5]	417.9	437.7	403.7	422.8	19.1	413.2	DIS 2	SEDIMENTARY	1.7E-06
DH-BGC12-22	426,481	6,257,936	1,539.76	-75 / 036	1	50.9	61.6	49.2	59.5	10.3	54.3	FAULT	SEDIMENTARY	1.9E-08
					2	258.2	271.9	249.4	262.6	13.2	256.0	STK	VOLCANIC	1.2E-07
					3	361.8	381.6	349.5	368.6	19.1	359.0	STK	SEDIMENTARY/HYDROTHERMAL	4.3E-08
DH-BGC12-23	426,503	6,257,856	1,583.69	-70 / 271	1	189.6	210.0	178.2	197.4	19.2	187.8	STK	SEDIMENTARY	3.8E-07
					2	308.5	331.3	289.9	311.3	21.5	300.6	STK	IGNEOUS/INTRUSIVE	8.6E-09
					4	531.0	550.3	498.9	517.2	18.2	508.0	FAULT	IGNEOUS/INTRUSIVE	2.0E-08
DH-BGC12-24	426,646	6,257,878	1,547.61	-68 / 002	1	292.6	306.3	271.3	284.0	12.7	277.7	STK	SEDIMENTARY	3.1E-08
					2	384.1	406.9	356.1	377.3	21.2	366.7	STK	SEDIMENTARY	2.7E-08
					3	432.8	458.7	401.3	425.3	24.0	413.3	STK	SEDIMENTARY	1.9E-08
					4	460.3	470.9	426.7	436.6	9.9	431.7	FAULT	SEDIMENTARY	6.7E-08

Table 5. cont'd Summary of Packer Test Results

Monitoring Well / Borehole ID	Easting[1)] (m)	Northing (m)	Elevation (m asl)	Plunge / Trend (°)	Test No.	Test Interval					Depth to Midpt (m bgs)	Discons/ Faults[2]	Simplified Geology[3]	K Estimate (m/s)
						From (mah)	To (mah)	From (m bgs)	To (m bgs)	Interval (m)				
Constant Head Packer Tests cont'd														
DH-BGC12-25	426,350	6,258,086	1,527.77	-45 / 176	1	198.7	212.5	140.5	150.2	9.7	145.4	DIS 2	SEDIMENTARY	3.3E-08
					2	238.7	255.4	168.8	180.6	11.9	174.7	DIS 2	SEDIMENTARY	3.9E-07
DH-BGC12-32	426,981	6,258,578	1,410.76	-75 / 240	1	30.2	50.0	29.2	48.3	19.1	38.7	STK	SEDIMENTARY	1.8E-07
DH-BGC12-33	427,073	6,258,623	1,392.65	-75 / 095	1	14.0	30.8	13.5	29.7	16.2	21.6	FAULT	VOLCANIC	1.4E-06
DH-BGC12-34	427,046	6,258,650	1,395.96	-75 / 244	1	14.6	31.4	14.1	30.3	16.2	22.2	STK	VOLCANIC	4.6E-07
DH-BGC12-35	427,021	6,258,692	1,389.40	-75 / 154	1	16.2	32.9	15.6	31.8	16.2	23.7	FAULT	SEDIMENTARY	1.5E-07
MW-BGC12-BJ-4B	427,031	6,258,752	1,390.43	-	1	93.6	98.1	93.2	97.8	4.6	95.5	FAULT	SEDIMENTARY	2.0E-07
					2	78.7	81.7	78.4	81.4	3.0	79.9	FAULT	SEDIMENTARY	(4)
MW-BGC12-BJ-6B	427,097	6,258,982	1,379.56	-	1	66.8	78.3	66.8	78.3	11.5	72.6	STK	VOLCANIC	2.6E-08
					2	48.7	51.8	48.7	51.8	3.1	50.2	STK	VOLCANIC	1.5E-07
MW-BGC12-BJ-8A	426,106	6,258,818	1,403.38	-	1	18.6	23.1	18.6	23.1	4.6	20.8	FAULT	IGNEOUS/INTRUSIVE	4.4E-06
					2	48.7	53.1	48.7	53.1	4.5	50.9	DIS 2	IGNEOUS/INTRUSIVE	8.1E-08
					3	63.7	68.1	63.7	68.1	4.5	65.9	FAULT	IGNEOUS/INTRUSIVE	2.6E-07
					4	87.6	92.1	87.6	92.1	4.6	89.8	FAULT	IGNEOUS/INTRUSIVE	4.6E-06
MW-BGC12-BJ-9A	426,465	6,258,361	1,514.40	-	1a[(7)]	25.1	29.7	25.1	29.7	4.6	27.4	STK	IGNEOUS/INTRUSIVE	3.7E-08
					1	36.5	41.0	36.5	41.0	4.5	38.8	STK	IGNEOUS/INTRUSIVE	9.8E-08
					2	75.5	80.0	75.5	80.0	4.5	77.8	STK	IGNEOUS/INTRUSIVE	2.8E-07
MW-BGC12-BJ-10A	426,989	6,258,341	1,445.59	-	1	15.7	20.3	15.7	20.3	4.6	18.0	STK	VOLCANIC	7.1E-08
					2	42.7	50.3	42.7	50.3	7.6	46.5	STK	VOLCANIC	1.4E-08
MW-BGC12-BJ-11B	426,299	6,258,595	1,432.96	-	1	12.7	17.4	12.7	17.4	4.7	15.0	STK	IGNEOUS/INTRUSIVE	(4)
					2	34.0	38.6	34.0	38.6	4.6	36.3	FAULT	IGNEOUS/INTRUSIVE	4.0E-07
					3	46.2	53.8	46.2	53.8	7.7	50.0	FAULT	IGNEOUS/INTRUSIVE	6.5E-07
MW-BGC12-BJ-12A	426,509	6,257,807	1,579.19	-	1	48.0	50.0	48.0	50.0	2.0	49.0	STK	IGNEOUS/INTRUSIVE	1.8E-06
					2	66.0	70.5	66.0	70.5	4.5	68.3	FAULT	IGNEOUS/INTRUSIVE	1.8E-06

Table 5. cont'd Summary of Packer Test Results

Monitoring Well / Borehole ID	Easting[1] (m)	Northing (m)	Elevation (m asl)	Plunge / Trend (°)	Test No.	Test Interval					Depth to Midpt (m bgs)	Discons/ Faults[2]	Simplified Geology[3]	K Estimate (m/s)
						From (mah)	To (mah)	From (m bgs)	To (m bgs)	Interval (m)				
Falling Head Packer Tests														
SU-82	426,510	6,258,042	1,541.57	59	2	219.9	249.0	189.4	214.5	25.1	202.0	STK	VOLCANIC	4.3E-06
DH-BGC12-19	426,567	6,258,826	1,365.04	-75 / 131	1	50.9	55.5	49.2	53.6	4.4	51.4	FAULT	SEDIMENTARY	1.6E-07
					2	215.5	220.1	208.2	212.6	4.4	210.4	FAULT	SEDIMENTARY	2.6E-07
DH-BGC12-20	426,552	6,258,607	1,419.00	-76 / 222	2	127.7	149.0	123.9	144.6	20.7	134.2	DIS 1	SEDIMENTARY	1.7E-08
					4	380.7	403.6	369.4	391.6	22.2	380.5	STK	SEDIMENTARY	6.4E-08
DH-BGC12-23	426,503	6,257,856	1,583.69	-70 / 271	3	491.3	513.0	461.7	482.0	20.3	471.9	FAULT	IGNEOUS/INTRUSIVE	9.4E-07
MW-BGC12-BJ-6B	427,097	6,258,982	1,379.56	-	3	12.7	15.8	12.7	15.8	3.1	14.2	STK	VOLCANIC	(4)
MW-BGC12-BJ-10A	426,989	6,258,341	1,445.59	-	3	54.7	62.3	54.7	62.3	7.6	58.5	FAULT	VOLCANIC	6.2E-07

Notes:
1. Drill hole coordinates and elevations for the DH and MW-series holes provided by Pretium from professional surveys in NAD83 UTM Zone 9N, with the exception of DH-BGC12-20 and -21 which are from a handheld GPS and are limited to the accuracy of that tool.
2. "Discons" refers to discontinuities observed during core logging; "STK" indicates stick rock, "DIS1" indicates observation of 1 discontinuity, "DIS2" indicates observation of 2 or more discontinuities, "FAULT" indicates observation of a fault zone.
3. Simplified geology represents the most prevalent geologic material encountered over the packer interval within a borehole, based on core logging completed by BGC and Pretium staff.
4. Incomplete packer test due to failure of packer to seat properly (MW-BGC12-BJ-4B, MW-BGC12-BJ-11B), or insufficient flow (DH-BGC12-21, MW-BGC12-BJ-6B).
5. Unable to achieve pressure required for a constant head test or falling head test. Estimated K represents minimum possible hydraulic conductivity for the interval, derived from estimates of flow at 0 psi.
6. First attempt at MW-BGC12-BJ-9A was drilled using an HQ3 drill head, and was abandoned prior to completion of the hole. Packer test 1a was completed prior to abandonment.

Table 6. Summary of Slug Test Data and Hydraulic Conductivity (K) Estimates

Monitoring Well / Borehole ID	Easting[1] (m)	Northing (m)	Elevation (m asl)	Sand Pack Interval			Depth to Midpt (m bgs)	Well Screen Interval			Discons/ Faults[2]	Simplified Geology[3]	K Estimate (m/s)
				From (m bgs)	To (m bgs)	Interval Length (m)		From (m bgs)	To (m bgs)	Interval Length (m)			
Rising and Falling Head Slug Tests													
MW-BGC11-BJ-2A	426,885	6,258,812	1,423.17	64.9	80.3	15.4	72.6	70.7	76.8	6.1	DIS 1	IGNEOUS/INTRUSIVE	1.1E-06
MW-BGC11-BJ-3A	426,615	6,258,844	1,367.63	79.3	88.4	9.1	83.9	83.0	88.3	5.3	STK	IGNEOUS/INTRUSIVE	2.4E-06
MW-BGC11-BJ-3B	426,615	6,258,844	1,367.53	4.5	9.1	4.6	6.8	5.8	8.8	3.0	FAULT	IGNEOUS/INTRUSIVE	6.2E-06
MW-BGC11-BJ-4A	427,031	6,258,750	1,390.46	18.0	31.0	13.0	24.5	21.3	30.5	9.2	FAULT	VOLCANIC	3.0E-09
MW-BGC12-BJ-4B	427,031	6,258,752	1,390.43	91.6	98.1	6.5	94.9	94.9	97.9	3.1	FAULT	SEDIMENTARY	1.2E-07
MW-BGC11-BJ-5A	426,347	6,258,040	1,526.14	65.7	78.0	12.3	71.9	68.6	77.7	9.1	STK	VOLCANIC	6.3E-07
MW-BGC11-BJ-5B	426,346	6,258,042	1,526.16	39.6	50.9	11.3	45.3	41.0	50.2	9.2	STK	VOLCANIC	1.3E-06
MW-BGC11-BJ-6A	427,095	6,258,983	1,379.81	20.7	31.8	11.1	26.3	21.2	30.3	9.1	STK	VOLCANIC	1.8E-07
MW-BGC12-BJ-6B	427,097	6,258,982	1,379.56	98.2	103.8	5.6	101.0	100.3	103.3	3.1	FAULT	VOLCANIC	2.4E-07
MW-BGC12-BJ-8A	426,106	6,258,818	1,403.38	86.0	95.1	9.1	90.6	86.2	92.3	6.1	FAULT	IGNEOUS/INTRUSIVE	3.0E-05
MW-BGC12-BJ-8B	426,106	6,258,819	1,403.30	44.3	51.0	6.7	47.6	44.8	50.9	6.1	FAULT	IGNEOUS/INTRUSIVE	2.8E-07
MW-BGC12-BJ-9A	426,465	6,258,361	1,514.40	70.8	80.0	9.2	75.4	72.9	79.0	6.1	STK	IGNEOUS/INTRUSIVE	(4)
MW-BGC12-BJ-9B	426,461	6,258,362	1,514.56	38.4	47.4	9.0	42.9	40.6	46.7	6.1	STK	IGNEOUS/INTRUSIVE	8.3E-07
MW-BGC12-BJ-10A	426,989	6,258,341	1,445.59	51.6	60.1	8.5	55.9	53.2	59.3	6.1	FAULT	VOLCANIC	(4)
MW-BGC12-BJ-10B	426,989	6,258,341	1,445.64	35.6	41.4	5.8	38.5	38.1	41.1	3.1	FAULT	VOLCANIC	7.9E-07
MW-BGC12-BJ-11A	426,300	6,258,595	1,433.57	25.8	29.5	3.7	27.7	26.5	29.5	3.1	FAULT	IGNEOUS/INTRUSIVE	(4)
MW-BGC12-BJ-11B	426,299	6,258,595	1,432.96	48.2	53.8	5.6	51.0	50.7	53.8	3.1	FAULT	IGNEOUS/INTRUSIVE	4.0E-06
MW-BGC12-BJ-12A	426,509	6,257,807	1,579.19	84.3	97.0	12.7	90.7	87.8	93.9	6.1	FAULT	IGNEOUS/INTRUSIVE	1.5E-05
MW-BGC12-BJ-12B	426,505	6,257,807	1,579.16	45.2	53.1	7.9	49.2	46.7	52.8	6.1	STK	IGNEOUS/INTRUSIVE	(4)

Notes:
1. Monitoring well coordinates provided by Pretium from professional surveys in UTM NAD 83 Zone 9N.
2. "Discons" refers to discontinuities observed during core logging; "STK" indicates stick rock, "DIS1" indicates observation of 1 discontinuity, "DIS2" indicates observation of 2 or more discontinuities, "FAULT" indicates observation of a fault zone.
3. Simplified geology represents the most prevalent geologic material encountered over the well completion interval, based on core logging completed by BGC and Pretium staff.
4. Wells not tested due to slow well response.

Table 7. Vertical Hydraulic Gradients in Monitoring Wells

Well ID	Midpoint of Screened Interval		Vertical Distance (m)	March 2012		August 2012		September 2012		January 2013		April 2013		July 2013		September 2013	
	From (m bgs)	To (m bgs)		Water Level (m asl)	Vertical Gradient [1]	Water Level (m asl)	Vertical Gradient	Water Level (m asl)	Vertical Gradient	Water Level (m asl)	Vertical Gradient	Water Level (m asl)	Vertical Gradient	Water Level (m asl)	Vertical Gradient	Water Level (m asl)	Vertical Gradient
MW-BGC11-BJ-1A	77.1	85.3	46.2	1351.1	0.00	1360.4	-0.11	1358.7	-0.09	-	-	-	-	1329.9	-0.68	1328.4	-0.75
MW-BGC11-BJ-1B	31.3	38.7		1351.1		1365.7		1363.1		-		-		1361.4		1363.0	
MW-BGC11-BJ-3A	79.3	88.4	77.1	1368.0	0.02	1364.2	-0.06	1364.7	-0.05	-	-	1350.7	-0.11	1357.6	-0.13	1363.6	-0.07
MW-BGC11-BJ-3B	4.5	9.1		1366.3		1368.6		1368.2		-		1359.5		1367.5		1368.6	
MW-BGC11-BJ-4A	18.0	31.0	70.4	1376.2	-	1377.8	0.00	1376.8	0.01	1375.5	0.00	1373.8	-0.01	1377.8	-0.03	1376.8	-0.01
MW-BGC12-BJ-4B	91.6	98.1		(3)		1377.9		1377.5		1375.3		1373.2		1376.0		1375.8	
MW-BGC11-BJ-5A	65.7	78.0	26.6	1484.7	-0.07	1512.7	-0.11	-	-	1502.7	0.07	-	-	1511.6	0.09	1481.7	-0.15
MW-BGC11-BJ-5B	39.6	50.9		1486.5		1515.6		-		1500.8		-		1509.2		1485.8	
MW-BGC11-BJ-6A	20.7	31.8	74.7	1366.2	-	1371.5	-0.05	1370.5	-0.04	1365.8	-0.01	1364.8	-0.01	1369.9	-0.04	1369.1	-0.04
MW-BGC12-BJ-6B	98.2	103.8		(3)		1367.8		1367.2		1364.7		1364.0		1367.0		1366.1	
MW-BGC12-BJ-8A	86.0	95.1	42.9	(3)	-	1389.1	0.08	1388.5	0.07	1372.4	0.04	1367.2	0.02	1388.6	0.07	1390.3	0.09
MW-BGC12-BJ-8B	44.3	51.0		(3)		1385.6		1385.3		1370.9		1366.4		1385.6		1386.5	
MW-BGC12-BJ-9A	70.8	80.0	32.5	(3)	-	1456.2	-1.29	1452.2	-1.02	-	-	(4)	-	(4)	-	(4)	-
MW-BGC12-BJ-9B	38.4	47.4		(3)		1498.1		1485.4		-		1469.0		1475.7		1471.8	
MW-BGC12-BJ-10A	51.6	60.1	17.4	(3)	-	1435.1	0.11	(5)	-	-	-	-	-	(5)	-	(5)	-
MW-BGC12-BJ-10B	35.6	41.4		(3)		1433.1		-		-		-		1432.8		1431.4	
MW-BGC12-BJ-11A	25.8	29.5	23.4	(3)	-	1427.3	-0.04	1427.4	-	-	-	-	-	1419.8	-0.35	1416.1	-0.84
MW-BGC12-BJ-11B	48.2	53.8		(3)		1426.4		-		-		-		1411.7		1396.5	
MW-BGC12-BJ-12A	84.3	97.0	41.5	(3)	-	1528.3	-0.34	1528.2	-	1513.7	-	1505.5	-	1512.0	-	1497.8	-
MW-BGC12-BJ-12B	45.2	53.1		(3)		1542.3		(4)		(4)		(4)		(4)		(4)	

Notes:
1. Vertical hydraulic gradients are calculated based on manual water level measurements taken during groundwater sampling events. A positive vertical gradient indicates upward flow, whereas a negative vertical gradient indicates downward flow.
2. Values in grey are considered uncertain; the ground surface was reconfigured at wells 3A/B between April to July 2013, and needs to be re-surveyed before groundwater level data can be accurately corrected to elevation.
3. Groundwater monitoring well not yet installed; no vertical hydraulic gradient calculated.
4. Water level below well screen; no vertical hydraulic gradient calculated.
5. Well slow to respond to development; groundwater elevation data not considered representative of in-situ conditions.

Table 8. Groundwater Quality Parameter Monitoring Set

Parameter Set	Comment
Field parameters	Temperature, pH, Electrical Conductivity (EC)
Laboratory physical parameters	Temperature, Conductivity, Turbidity, TDS, Total Suspended Solids (TSS), pH, Hardness, Colour
Cyanide	Total Cyanide and Weak Acid Dissociable (WAD) Cyanide
Anions	Cl, SO_4, NO_3, NO, Total Alkalinity
Nutrients	Total Kjeldahl Nitrogen (TKN), NH_3, Total Nitrogen, Ortho-PO_4,
Carbon	Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC)
Total Metals	Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, V, U, Zn
Dissolved Metals	Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, V, U, Zn

Table 9. Groundwater Quality Guidelines as Specified in the Brucejack Project AIR

Parameter	Unit	BC MOE[1]				CCME[2]
		Drinking Water		Aquatic Life		
		30 d Ave.	Max.	30 d Ave.	Max.	Long Term Max
Physical Tests						
Colour, True	CU	-	-	-	-	BD[3]
Conductivity	uS/cm	-	-	-	-	-
Hardness (as CaCO3)	mg/L	-	-	-	-	-
pH	pH	6.5 - 8.5		6.5 - 9.0		6.5 - 9.0
Total Suspended Solids	mg/L	-	-	BD		BD
Total Dissolved Solids	mg/L	-	-	-	-	-
Turbidity	NTU	BD		BD		BD
Anions and Nutrients						
Acidity (as CaCO3)	mg/L	-	-	-	-	-
Alkalinity, Bicarbonate (as CaCO3)	mg/L	-	-	-	-	-
Alkalinity, Carbonate (as CaCO3)	mg/L	-	-	-	-	-
Alkalinity, Hydroxide (as CaCO3)	mg/L	-	-	-	-	-
Alkalinity, Total (as CaCO3)	mg/L	-	-	-	-	-
Ammonia (as N)	mg/L	-	-	0.38 – 2.08[4]	1.99-23.2[4]	0.502 – 23.1[5]
Bromide (Br)	mg/L	-	-	-	-	-
Chloride (Cl)	mg/L	250		150	600	120
Fluoride (F)	mg/L	1	1.5	0.4[6]		0.12
Nitrate (as N)	mg/L	-	10	40	200	13
Nitrite (as N)	mg/L	-	1.0	0.02-0.20[7]	0.06	0.06
Total Kjeldahl Nitrogen	mg/L	-	-	-	-	-
Total Nitrogen	mg/L	-	-	-	-	-
Orthophosphate - Dissolved (as P)	mg/L	-	-	-	-	-
Phosphorus (P)-Total	mg/L	-	-	-	-	-
Sulfate (SO4)	mg/L	500	500	128-429[8]	-	-
Cyanides						
Cyanide, Weak Acid Diss	mg/L	-	-	<0.005	0.01	0.005 as free

[1] British Columbia Water Quality Guidelines for Protection of Freshwater Aquatic Life and Drinking Water (BC MOE), Accessed May, 2014

[2] Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life, Accessed May 2014

[3] Background dependent

[4] Ammonia concentration is pH and temperature dependent based on tabulations shown in BC MOE aquatic life guidelines. Assumes average temperature range of 0°C – 5°C and pH range of 7.0 – 8.5

[5] Ammonia concentration is pH and temperature dependent (see Table 10) based on average temperature range of 0°C – 5°C and pH range of 7.0 – 8.5

[6] Fluoride concentration - 0.4 as a maximum where the water hardness is 10 mg/L CaCO3 otherwise use the equation: *LC50 fluoride = -51.73 + 92.57 log10 (Hardness)* and multiply by 0.01

[7] Nitrite concentration – dependent on chloride concentration (0.06 mg/L as a maximum, 0.2 mg/L as a 30 d ave.)

[8] Sulfate concentration – dependent on water hardness: very soft (0-30 mg/L) – 128 mg/L SO4; soft to moderately soft (31-75 mg/L) – 218 mg/L SO4; moderately soft/hard to hard (76-180 mg/L) – 309 mg/L SO4; very hard (181-250 mg/L) – 419 mg/L SO4.

Parameter	Unit	BC MOE[1]				CCME[2]
		Drinking Water		Aquatic Life		
		30 d Ave.	Max.	30 d Ave.	Max.	Long Term Max
Cyanide, Total	mg/L	0.2	0.20	-	-	-
Organic/ Inorganic Carbon						
Dissolved Organic Carbon	mg/L	-	-	BD	BD	-
Total Organic Carbon	mg/L	4	4	BD	BD	-
Total Metals						
Aluminum (Al)	mg/L	-	-	-	-	0.005 - 0.1[9]
Antimony (Sb)	mg/L	-	-	-	-	-
Arsenic (As)	mg/L	0.025[10]		0.005		0.005
Barium (Ba)	mg/L	-	-	-	-	-
Beryllium (Be)	mg/L	-	-	-	-	-
Bismuth(Bi)	mg/L	-	-	-	-	-
Boron (B)	mg/L	5	5	1.2	1.2	1.5
Cadmium (Cd)	mg/L	-	-	-	-	0.00009[11]
Calcium (Ca)	mg/L	-	-	-	-	-
Chromium (Cr)	mg/L	-	-	-	-	0.001[12]
Cobalt (Co)	mg/L	-	-	0.004	0.110	-
Copper (Cu)	mg/L	-	0.5	0.00004-0.002[13]	0.002-0.026[13]	0.002-0.004[14]
Iron (Fe)	mg/L	-	-	1.0	1.0	0.3
Lead (Pb)	mg/L	None proposed	0.05	0.004-0.016[15]	0.003-0.33[15]	0.001-0.007[16]
Lithium (Li)	mg/L	-	-	-	-	-
Magnesium (Mg)	mg/L	-	-	-	-	-
Manganese (Mn)	mg/L	-	-	0.605-1.9[17]	0.54-3.8[17]	-
Mercury (Hg)	mg/L	-	0.001	0.00000125-0.0002	-	0.000026

[9] Aluminum concentration - 5 µg/L if pH < 6.5; 100 µg/L if pH ≥ 6.5

[10] Arsenic interim guideline

[11] Cadmium concentration - When the water hardness is > 0 to < 17 mg/L: 0.04 µg/L; At hardness ≥ 17 to ≤ 280 mg/L, calculated using this equation cadmium *(µg/L) = 10{0.83(log[hardness]) – 2.46 };* At hardness > 280 mg/L: 0.37 µg/L

[12] Chromium concentration is for Chromium hexavalent CrVI

[13] Copper concentration (BC MOE)– 30 d average: at hardness ≤ 50 mg/L then less than or equal to 2 µg/L, at hardness > 50 mg/L then less than or equal to *0.04 (mean hardness)* in µg/L; maximum concentration: concentration is *(0.094(hardness)+2)* in µg/L

[14] Copper concentration (CCME) -When the water hardness is 0 to < 82 mg/L, 2 µg/L; At hardness ≥82 to ≤180 mg/L, calculated using this equation: copper *(µg/L) = 0.2 * e{0.8545[ln(hardness)]-1.465};* At hardness >180 mg/L, 4 µg/L. If the hardness is unknown, 2 µg/L.

[15] Lead concentration (BC MOE) – 30 d average: at hardness greater than 8 mg/L, calculated using the equation *3.31 + e(1.273 ln (mean hardness) - 4.704)* in µg/L; maximum concentration: at hardness ≤ 8 mg/L then 3 µg/L total lead, at hardness > 8 mg/L calculated using *e(1.273 ln (hardness) -1.460)* in µg/L.

[16] Lead concentration (CCME) - When the hardness is 0 to ≤ 60 mg/L, maximum is 1 µg/L; at hardness >60 to ≤ 180 mg/L maximum is calculated using this equation concentration (µg/L) = *e{1.273[ln(hardness)]-4.705}*; at hardness >180 mg/L, the CWQG is 7 µg/L. If the hardness is unknown, the CWQG is 1 µg/L.

[17] Manganese concentration – 30 d average: calculated from *0.0044 hardness + 0.605;* maximum concentration: calculated from *0.01102 hardness + 0.54*

Parameter	Unit	BC MOE[1]				CCME[2]
		Drinking Water		Aquatic Life		
		30 d Ave.	Max.	30 d Ave.	Max.	Long Term Max
Molybdenum (Mo)	mg/L	-	0.25	1	2	0.073
Nickel (Ni)	mg/L	-	-	-	-	0.025-0.150[18]
Phosphorus (P)	mg/L	-	-	-	-	-
Potassium (K)	mg/L	-	-	-	-	-
Selenium (Se)	mg/L	-	0.010	0.002	-	0.001
Silicon (Si)	mg/L	-	-	-	-	-
Silver (Ag)	mg/L	-	-	0.00005-0.0015[19]	0.0001-0.003[19]	0.0001
Sodium (Na)	mg/L	-	-	-	-	-
Strontium (Sr)	mg/L	-	-	-	-	-
Thallium (Tl)	mg/L	-	-	0.0003[20]		0.0008
Tin (Sn)	mg/L	-	-	-	-	-
Titanium (Ti)	mg/L	-	-	-	-	-
Uranium (U)	mg/L	-	-	0.3[20]		0.015
Vanadium (V)	mg/L	-	-	-	-	-
Zinc (Zn)	mg/L	5	5	0.0075-0.240[21]	0.033-2.65[21]	0.03
Dissolved Metals						
Aluminum (Al)	mg/L	-	0.2	0.005-0.05[22]	0.02-0.1	-
Iron (Fe)	mg/L	-	-	-	0.35	-

[18] Nickel concentration - When the water hardness is 0 to ≤ 60 mg/L, 25 µg/L; at hardness > 60 to ≤ 180 mg/L, calculated using this equation CWQG *(µg/L) = e{0.76[ln(hardness)]+1.06}; a*t hardness >180 mg/L, the CWQG is 150 µg/L. If the hardness is unknown, the CWQG is 25 µg/L.

[19] Silver concentration – 30 d average: at hardness ≤ 100 mg/L concentration is 0.05 µg/L, at hardness > 100 mg/L concentration is 1.5 µg/L; maximum concentration: at hardness ≤ 100 mg/L concentration is 0.1 µg/L, at hardness > 100 mg/L concentration is 3.0 µg/L.

[20] Working guideline based on the water quality guidelines for Ontario.

[21] Zinc concentration – 30 d average: use the equation *7.5 + 0.75 x (hardness -90)*; maximum concentration: use the equation *33 + 0.75 x (hardness -90)*

[22] Aluminum (dissolved) concentration – 30 d average: at pH ≥ 6.5, 0.05 mg/L, at pH <6.5, calculated using $e(1.6 - 3.327\ (median\ pH) + 0.402\ K)$ where K = $(median\ pH)^2$; maximum concentration: : at pH ≥ 6.5, 0.1 mg/L , at pH <6.5, calculated using $e(1.209 - 2.426\ (pH) + 0.286\ K)$ where $K = (pH)^2$.

Table 10. Tabulation of CCME Maximum Long-Term Ammonia Concentration Guidelines

		pH							
		6.0	6.5	7.0	7.5	8.0	8.5	9.0	10.0
Temp (ºC)	0	231	73.0	23.1	7.32	2.33	0.749	0.25	0.042
	5	153	48.3	15.3	4.84	1.54	0.502	0.172	0.034
	10	102	32.4	10.3	3.26	1.04	0.343	0.121	0.029
	15	69.7	22.0	6.98	2.22	0.715	0.239	0.089	0.026
	20	48.0	15.2	4.82	1.54	0.499	0.171	0.067	0.024
	25	33.5	10.6	3.37	1.08	0.354	0.125	0.053	0.022
	30	23.7	7.50	2.39	0.767	0.256	0.094	0.043	0.021

Notes:

1. CCME long-term maximum guideline for ammonia concentration is pH and temperature dependent (see Table 9), and is calculated based on the matrix above.

Table 11. Statistical Summary of Water Quality Results from Monitoring Wells Completed in Office P1 Material.

		MW-BGC11-BJ-1A (n=1)	MW-BGC11-BJ-1B (n=1)	MW-BGC11-BJ-8A (n=6)				MW-BGC11-BJ-8B (n=3)			Office P1 All (n=11)			
		-	-	Min	Max	Med.	Ave.	Min	Max	Med.	Min	Max	Med.	Ave.
Field Parameters	**Unit**													
Temperature	°C	-	-	1.90	4.92	2.88	3.05	1.00	2.60	1.90	1.00	4.92	2.60	2.64
Physical Tests	**Unit**													
pH	pH	7.96	7.99	7.02	8.30	8.20	7.68	8.02	8.21	8.12	7.02	8.30	8.14	7.81
Total Suspended Solids	mg/L	31.6	86.2	7.10	212	18.7	63.1	17.2	193	182	7.10	212	31.6	80.8
Turbidity	NTU	34.1	99.7	3.29	118	9.51	31.4	53.1	266	174	3.29	266	43.6	74.1
Anions and Nutrients	**Unit**													
Alkalinity, Total (as CaCO3)	mg/L	29.2	86.1	72.5	76.0	74.2	74.5	68.2	73.2	69.9	29.2	86.1	73.9	70.3
Ammonia (as N)	mg/L	0.028	0.023	<0.0050	<0.0050	-	-	<0.0050	<0.0050	-	<0.0050	0.028	0.0025	0.0067
Chloride (Cl)	mg/L	0.66	<0.50	<0.50	<0.50	-	-	<0.50	<0.50	-	<0.50	0.66	0.25	0.29
Fluoride (F)	mg/L	0.039	*0.25*	0.027	0.031	0.030	0.029	0.021	0.023	0.023	0.021	*0.25*	0.029	0.048
Nitrate (as N)	mg/L	0.014	0.026	0.0065	0.027	0.014	0.015	0.015	0.022	0.020	0.0065	0.027	0.018	0.017
Nitrite (as N)	mg/L	*<0.0010*	0.0036	*<0.0010*	<0.0010	-	-	<0.0010	<0.0010	-	<0.0010	0.0036	-	-
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	-	-	<0.0010	<0.0010	-	<0.0010	<0.0010	-	-
Phosphorus (P)-Total	mg/L	0.032	0.072	0.0021	0.10	0.0058	0.024	0.0096	0.093	0.091	0.0021	0.10	0.022	0.040
Sulfate (SO4)	mg/L	19.1	60.0	30.1	36.6	33.0	33.3	32.0	35.7	35.1	19.1	60.0	33.9	34.7
Total Metals	**Unit**													
Aluminum (Al)-Total	mg/L	*0.80*	*2.43*	*0.30*	*5.14*	*0.89*	*1.99*	*2.83*	*12.2*	*7.02*	*0.30*	*12.2*	*2.43*	*3.38*
Antimony (Sb)-Total	mg/L	0.00086	0.0014	0.00074	0.0016	0.00085	0.00097	0.00097	0.0018	0.0018	0.00074	0.0018	0.00097	0.0011
Arsenic (As)-Total	mg/L	*0.0056*	*0.029*	*0.0074*	*0.032*	*0.0086*	*0.012*	*0.030*	*0.082*	*0.069*	*0.0056*	*0.082*	*0.0089*	*0.026*
Barium (Ba)-Total	mg/L	0.061	0.11	0.021	0.10	0.026	0.040	0.079	0.28	0.16	0.021	0.28	0.061	0.085
Beryllium (Be)-Total	mg/L	<0.0010	<0.0010	<0.00010	0.00073	0.000050	0.00023	<0.00010	0.00031	0.00017	<0.00010	0.00073	0.00017	0.00026
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	<0.00050	<0.20	-	-
Boron (B)-Total	mg/L	<0.10	<0.10	0.011	0.014	0.012	0.012	<0.010	0.012	0.0050	<0.010	0.014	0.012	0.018
Cadmium (Cd)-Total	mg/L	0.000061	0.000032	0.000012	*0.00024*	0.000017	5.5E-05	<0.000010	0.000040	0.000033	<0.000010	*0.00024*	0.000032	4.6E-05
Calcium (Ca)-Total	mg/L	16.8	29.5	26.3	41.4	30.5	31.6	30.3	39.0	32.3	16.8	41.4	30.3	30.7
Chromium (Cr)-Total	mg/L	*0.0013*	*0.0012*	0.00019	*0.0067*	0.00090	*0.0023*	0.00080	*0.016*	*0.0023*	0.00019	*0.016*	*0.0012*	*0.0032*
Cobalt (Co)-Total	mg/L	0.00049	0.0010	<0.00010	0.0016	0.00016	0.00042	0.00056	0.0033	0.0030	<0.00010	0.0033	0.00056	0.00099
Copper (Cu)-Total	mg/L	*0.012*	*0.0047*	<0.00050	*0.018*	0.0015	*0.0049*	0.0018	*0.0098*	*0.0077*	<0.00050	*0.018*	*0.0047*	*0.0059*
Iron (Fe)-Total	mg/L	*1.02*	*1.89*	0.092	*4.97*	*0.33*	*1.20*	*1.41*	*6.82*	*5.06*	0.092	*6.82*	*1.30*	*2.13*
Lead (Pb)-Total	mg/L	*0.0017*	0.0019	0.00013	0.0075	0.00055	0.0020	0.0010	0.0057	0.0042	0.00013	0.0075	0.0017	0.0024
Lithium (Li)-Total	mg/L	0.0073	0.082	0.0082	0.011	0.0097	0.0099	0.0066	0.0096	0.0096	0.0066	0.082	0.0096	0.016
Magnesium (Mg)-Total	mg/L	1.19	4.19	5.03	6.89	5.75	5.89	4.08	5.28	4.81	1.19	6.89	5.28	4.99
Manganese (Mn)-Total	mg/L	0.080	0.13	0.0049	0.28	0.021	0.063	0.061	0.33	0.29	0.0049	0.33	0.061	0.12
Mercury (Hg)-Total	mg/L	0.000011	<0.000010	<0.000010	<0.000010	-	-	<0.000010	*0.000056*	*0.000040*	<0.000010	*0.000056*	0.0000050	1.3E-05
Molybdenum (Mo)-Total	mg/L	<0.0010	0.0024	0.0013	0.0026	0.0016	0.0018	0.0016	0.0031	0.0019	0.0013	0.0031	0.0017	0.0018
Nickel (Ni)-Total	mg/L	0.0012	0.0010	<0.00050	0.0042	0.00051	0.0012	0.00051	0.0087	0.0025	<0.00050	0.0087	0.0010	0.0019
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	<0.30	-	-	<0.30	<0.30	-	<0.30	<0.30	-	-
Potassium (K)-Total	mg/L	<2.0	3.2	0.49	1.88	0.60	0.85	1.28	3.07	2.09	0.49	3.20	1.00	1.43
Selenium (Se)-Total	mg/L	<0.0010	<0.0010	0.00016	0.00023	0.00018	0.00018	0.00022	0.00028	0.00028	0.00016	<0.0010	0.00022	0.00026
Silicon (Si)- Total	mg/L	2.06	5.77	3.24	13.6	5.05	7.18	6.86	23.4	15.6	2.06	23.4	5.77	8.79
Silver (Ag)-Total	mg/L	*0.00011*	0.000073	<0.000010	*0.00022*	0.000049	0.000093	0.000036	*0.00077*	*0.00023*	<0.000010	*0.00077*	0.000075	*0.00016*
Sodium (Na)-Total	mg/L	2.6	25.3	4.2	7	5.6	5.6	2.5	2.8	2.6	2.5	25.3	4.2	6.29
Strontium (Sr)-Total	mg/L	0.21	0.90	0.63	0.76	0.73	0.71	0.43	0.49	0.46	0.21	0.90	0.63	0.61
Thallium (Tl)-Total	mg/L	<0.00020	<0.00020	<0.000010	0.00013	0.000014	3.8E-05	0.000045	0.00017	0.00012	<0.000010	0.00017	0.000059	6.9E-05
Tin (Sn)-Total	mg/L	0.0040	0.0017	<0.00010	0.00047	0.00021	0.00023	<0.00010	0.00065	0.00034	<0.00010	0.0040	0.00034	0.00074
Titanium (Ti)-Total	mg/L	<0.010	0.030	<0.010	0.051	0.021	0.026	0.047	0.19	0.12	<0.010	0.19	0.030	0.050
Uranium (U)-Total	mg/L	<0.00020	<0.00020	0.00020	0.0012	0.00036	0.00059	0.00018	0.00052	0.00023	<0.00020	0.0012	0.00032	0.00043
Vanadium (V)-Total	mg/L	0.0011	0.0020	<0.0010	0.0048	0.00050	0.0015	0.0033	0.011	0.0081	<0.0010	0.011	0.0020	0.0032
Zinc (Zn)-Total	mg/L	*0.039*	0.018	<0.0030	*0.034*	0.0041	0.0098	0.0082	*0.034*	*0.031*	<0.0030	*0.039*	0.014	0.017

Table 11 continued

		MW-BGC11-BJ-1A (n=1)	MW-BGC11-BJ-1B (n=1)	MW-BGC11-BJ-8A (n=6)				MW-BGC11-BJ-8B (n=3)			Office P1 All (n=11)			
		-	-	Min	Max	Med.	Ave.	Min	Max	Med.	Min	Max	Med.	Ave.
Dissolved Metals	**Unit**													
Aluminum (Al)-Dissolved	mg/L	0.034	0.015	0.012	0.020	0.014	0.015	0.017	0.035	0.031	0.012	0.035	0.016	0.020
Antimony (Sb)-Dissolved	mg/L	0.00080	0.00093	0.00081	0.0014	0.00086	0.00094	0.00067	0.00072	0.00067	0.00067	0.0014	0.00085	0.00086
Arsenic (As)-Dissolved	mg/L	0.0011	0.0080	0.0069	0.0083	0.0070	0.0073	0.016	0.017	0.017	0.0011	0.017	0.0078	0.0093
Barium (Ba)-Dissolved	mg/L	0.028	0.022	0.019	0.022	0.021	0.021	0.015	0.0171	0.016	0.015	0.028	0.020	0.020
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	<0.00010	<0.0010	-	-
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	<0.00050	<0.20	-	-
Boron (B)-Dissolved	mg/L	<0.10	<0.10	<0.010	0.013	0.012	0.011	<0.010	<0.010	-	<0.010	0.013	0.011	0.016
Cadmium (Cd)-Dissolved	mg/L	0.000027	<0.000017	<0.000010	0.000012	0.0000050	7.2E-06	<0.000010	<0.000010	-	<0.000010	0.000027	0.0000050	0.0000085
Calcium (Ca)-Dissolved	mg/L	16.4	29.7	26.3	31.1	27.8	28.5	30.4	33.2	32.2	16.4	33.2	29.7	28.4
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	0.00019	0.000050	0.000095	<0.00010	0.00013	0.000050	<0.00010	0.00019	0.000050	0.00016
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	<0.00010	<0.00030	-	-
Copper (Cu)-Dissolved	mg/L	0.0090	<0.0010	<0.00050	<0.00050	-	-	<0.00050	<0.00050	-	<0.00050	0.0090	0.00025	0.0011
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	0.045	0.015	0.020	<0.030	<0.030	-	<0.030	0.045	0.015	0.018
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.000050	<0.000050	-	-	<0.000050	<0.000050	-	<0.000050	<0.00050	-	-
Lithium (Li)-Dissolved	mg/L	0.0073	0.078	0.0083	0.011	0.0091	0.0092	0.0050	0.0055	0.0053	0.0050	0.078	0.0089	0.014
Magnesium (Mg)-Dissolved	mg/L	1.01	3.80	4.88	5.53	5.30	5.25	3.39	3.75	3.53	1.01	5.53	4.88	4.27
Manganese (Mn)-Dissolved	mg/L	0.033	0.031	0.0025	0.012	0.0042	0.0051	0.00051	0.0082	0.00066	0.00051	0.033	0.0043	0.0095
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	<0.000010	<0.000010	-	-
Molybdenum (Mo)-Dissolved	mg/L	<0.0010	0.0023	0.0014	0.0025	0.0016	0.0017	0.0016	0.0022	0.0017	0.0014	0.0025	0.0016	0.0017
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.0010	<0.00050	0.00084	0.00025	0.00040	<0.00050	0.0013	0.00025	<0.00050	0.0013	0.00025	0.00047
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	-	-	<0.30	<0.30	-	<0.30	<0.30	-	-
Potassium (K)-Dissolved	mg/L	<2.0	2.50	0.44	0.86	0.50	0.55	0.54	0.63	0.60	0.44	2.50	0.542	0.76
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	0.00017	0.00019	0.00018	0.00018	0.00021	0.00024	0.00023	0.00017	0.00024	0.00019	0.00019
Silicon (Si)-Dissolved	mg/L	0.98	2.77	1.90	2.06	2.01	2.00	1.92	2.04	1.97	0.98	2.77	1.99	1.97
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	<0.000010	<0.000020	-	-
Sodium (Na)-Dissolved	mg/L	2.9	25.8	3.9	6.9	5.6	5.4	2.3	2.4	2.3	2.3	25.8	4.0	6.19
Strontium (Sr)-Dissolved	mg/L	0.21	0.90	0.61	0.74	0.69	0.68	0.44	0.45	0.45	0.21	0.90	0.66	0.59
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	<0.000010	0.000011	0.0000050	0.0000060	<0.000010	<0.000010	-	<0.000010	0.000011	0.0000050	5.7E-06
Tin (Sn)-Dissolved	mg/L	0.0016	0.0012	<0.00010	<0.00010	-	-	<0.00010	<0.00010	-	<0.00010	0.0016	0.000050	0.00029
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	-	-	<0.010	<0.010	-	<0.010	<0.010	-	-
Uranium (U)-Dissolved	mg/L	<0.00020	<0.00020	0.00018	0.00030	0.00024	0.00024	0.00016	0.00016	0.00016	0.00016	0.00030	0.00019	0.00021
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	-	-	<0.0010	<0.0010	-	<0.0010	<0.0010	-	-
Zinc (Zn)-Dissolved	mg/L	0.017	<0.0050	<0.0030	0.0063	0.0015	0.0023	<0.0030	<0.0030	-	<0.0030	0.017	0.0015	0.0035

Table 12. Statistical Summary of Water Quality Results from Monitoring Wells Completed in P2 Material.

		MW-BGC11-BJ-2A (n=8)				MW-BGC11-BJ-3A (n=7)				MW-BGC11-BJ-3B (n=6)				P2 All (n=21)			
		Min	Max	Med.	Ave.	Min	Max	Med.	Ave.	Min	Max	Med.	Ave.	Min	Max	Med.	Ave.
Field Parameters	**Unit**																
Temperature	°C	0.81	4.50	2.35	2.22	1.80	3.50	2.70	2.68	0.60	3.30	1.90	1.90	0.60	4.50	2.35	2.30
Physical Tests	**Unit**																
pH	pH	7.13	8.14	8.04	7.73	7.97	8.22	8.12	8.11	7.86	8.22	8.07	8.02	7.13	8.22	8.07	7.91
Total Suspended Solids	mg/L	9.60	655	319	368	<3.0	520	54.9	160	1.50	675	301	327	<3.0	675	293	287
Turbidity	NTU	19.1	581	244	295	2.94	270	40.2	103	1.97	777	246	295	1.97	777	199	231
Anions and Nutrients	**Unit**																
Alkalinity, Total (as CaCO3)	mg/L	63.3	81.5	78.9	74.8	89.4	102	93.8	94.8	42.9	94.6	86.0	79.8	42.9	102	85.6	82.9
Ammonia (as N)	mg/L	<0.0050	0.041	0.0046	0.013	0.028	0.070	0.031	0.036	0.015	0.032	0.028	0.026	<0.0050	0.070	0.028	0.024
Chloride (Cl)	mg/L	0.67	3.73	1.22	1.71	<0.50	0.6	0.25	0.30	<0.50	2.36	0.25	0.76	<0.50	3.73	0.60	0.97
Fluoride (F)	mg/L	0.030	0.10	0.040	0.050	0.18	0.22	0.19	0.19	0.091	0.16	0.11	0.12	0.030	0.22	0.11	0.12
Nitrate (as N)	mg/L	<0.0050	0.093	0.018	0.029	<0.0050	0.0059	0.0025	0.0030	<0.0050	0.21	0.0039	0.040	<0.0050	0.21	0.0025	0.024
Nitrite (as N)	mg/L	<0.0010	<0.0010	-	-	<0.0010	0.0024	0.00050	0.0013	<0.0010	0.044	0.0015	0.0083	<0.0010	0.044	0.00050	0.0030
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	-	-	<0.0010	0.0030	0.00050	0.00094	<0.0010	0.0021	0.00085	0.0010	<0.0010	0.0030	0.00050	0.00080
Phosphorus (P)-Total	mg/L	0.010	0.54	0.29	0.29	<0.0020	0.29	0.059	0.091	<0.0020	0.51	0.20	0.21	<0.0020	0.54	0.23	0.20
Sulfate (SO4)	mg/L	34.7	63.3	47.8	48.2	80.9	89.8	89.1	87.4	82.5	125	98.8	101	34.7	125	84.0	76.3
Total Metals	**Unit**																
Aluminum (Al)-Total	mg/L	0.41	14.2	9.44	8.88	0.52	11.2	1.64	3.78	0.017	10.0	7.60	6.22	0.017	14.2	7.15	6.42
Antimony (Sb)-Total	mg/L	0.00099	0.0022	0.0013	0.0014	0.0020	0.021	0.0050	0.0084	0.0011	0.019	0.0054	0.0076	0.00099	0.021	0.0027	0.0055
Arsenic (As)-Total	mg/L	0.0016	0.047	0.015	0.020	0.013	0.087	0.024	0.035	0.016	0.11	0.047	0.054	0.0016	0.11	0.024	0.035
Barium (Ba)-Total	mg/L	0.065	0.42	0.25	0.26	0.040	0.44	0.064	0.14	0.044	0.41	0.27	0.26	0.040	0.44	0.20	0.22
Beryllium (Be)-Total	mg/L	0.00011	0.00095	0.0005	0.00051	<0.00010	0.00069	0.00014	0.00028	0.00023	0.00088	0.00050	0.00050	<0.00010	0.00095	0.00050	0.00043
Bismuth(Bi)- Total	mg/L	<0.00050	<0.20	-	-	<0.00050	<0.20	-	-	<0.00050	<0.2	-	-	<0.00050	<0.20	-	-
Boron (B)-Total	mg/L	0.013	<0.10	0.018	0.025	0.039	0.054	0.048	0.047	0.029	<0.10	0.040	0.040	0.013	0.054	0.040	0.036
Cadmium (Cd)-Total	mg/L	0.000021	0.0042	0.00014	0.00066	<0.000017	0.00055	0.000097	0.00016	<0.000017	0.00059	0.00031	0.00031	<0.000017	0.0042	0.00014	0.00039
Calcium (Ca)-Total	mg/L	31.1	60.2	40.3	43.9	31.8	65.4	53.1	52.3	58.4	75.9	68.9	67.87	31.1	75.9	55.9	53.6
Chromium (Cr)-Total	mg/L	0.0018	0.11	0.026	0.040	0.00046	0.019	0.0016	0.0049	<0.0010	0.0045	0.0025	0.0025	0.00046	0.11	0.0035	0.018
Cobalt (Co)-Total	mg/L	<0.00030	0.0076	0.0040	0.0039	<0.00030	0.0060	0.00071	0.0015	<0.00030	0.0052	0.0019	0.0022	<0.00030	0.0076	0.0021	0.0026
Copper (Cu)-Total	mg/L	0.0033	0.030	0.019	0.018	<0.0010	0.035	0.0029	0.0080	<0.0010	0.024	0.0099	0.012	<0.0010	0.035	0.012	0.013
Iron (Fe)-Total	mg/L	0.83	21.5	13.1	12.6	0.067	16.4	1.88	4.41	0.055	15.7	6.87	6.87	0.055	21.5	7.75	8.24
Lead (Pb)-Total	mg/L	0.00053	0.014	0.0071	0.0073	<0.00050	0.027	0.0052	0.0083	<0.00050	0.020	0.0061	0.0083	<0.00050	0.027	0.0061	0.0079
Lithium (Li)-Total	mg/L	0.0088	0.036	0.018	0.020	0.016	0.075	0.031	0.036	0.010	0.028	0.017	0.018	0.0088	0.075	0.021	0.025
Magnesium (Mg)-Total	mg/L	1.89	5.91	4.3	4.15	2.64	6.80	4.51	4.66	3.87	7.43	5.80	5.78	1.89	7.43	4.53	4.78
Manganese (Mn)-Total	mg/L	0.046	0.83	0.46	0.44	0.22	1.60	0.25	0.50	0.39	1.14	0.53	0.62	0.046	1.60	0.42	0.52
Mercury (Hg)-Total	mg/L	<0.000010	0.00017	0.000041	0.000058	<0.000010	0.000053	0.0000050	1.5E-05	<0.000010	0.000072	0.000026	0.000031	<0.000010	0.00017	0.000022	3.6E-05
Molybdenum (Mo)-Total	mg/L	0.0024	0.013	0.0037	0.0048	0.0013	0.0040	0.0024	0.0025	<0.0010	0.0022	0.00086	0.0011	<0.0010	0.013	0.0024	0.0030
Nickel (Ni)-Total	mg/L	<0.0010	0.049	0.013	0.016	<0.00050	0.011	0.0011	0.0026	<0.0010	0.0033	0.0019	0.0019	<0.00050	0.049	0.0020	0.0074
Phosphorus (P) - Total	mg/L	<0.30	0.49	0.23	0.26	<0.30	0.45	0.15	0.19	<0.30	0.54	0.15	0.24	<0.30	0.54	0.15	0.23
Potassium (K)-Total	mg/L	<2.0	4.15	2.27	2.32	1.78	5.96	2.10	2.79	<2.0	5.26	2.47	2.77	1.78	5.96	2.26	2.60
Selenium (Se)-Total	mg/L	0.00017	<0.0010	0.00028	0.00031	<0.00010	0.0014	0.00032	0.00041	0.00046	0.0021	0.00085	0.0011	<0.00010	0.0021	0.00046	0.00057
Silicon (Si)- Total	mg/L	2.77	33.1	19.8	19.8	4.27	25.9	7.36	9.63	3.57	30.3	19.0	17.64	2.77	33.1	13.8	15.79
Silver (Ag)-Total	mg/L	0.000064	0.0019	0.00097	0.0010	<0.000020	0.0052	0.00052	0.0012	<0.000020	0.0043	0.0013	0.0017	<0.000020	0.0052	0.00090	0.0013
Sodium (Na)-Total	mg/L	3.9	20.9	5.55	8.06	8.20	36.5	10.0	15.8	3.20	6.60	5.65	5.30	3.20	36.5	5.90	9.84
Strontium (Sr)-Total	mg/L	0.87	2.18	1.44	1.49	1.01	1.48	1.20	1.21	1.04	3.03	1.68	1.81	0.87	3.03	1.41	1.49
Thallium (Tl)-Total	mg/L	0.000042	0.00020	0.00010	0.00012	0.000025	0.00067	0.00017	0.00022	<0.00020	0.00042	0.00024	0.00025	0.000025	0.00067	0.00014	0.00019
Tin (Sn)-Total	mg/L	0.00018	0.0030	0.00070	0.00093	<0.00010	0.00031	0.00012	0.00015	0.00016	0.00032	0.00025	0.00025	<0.00010	0.0030	0.00025	0.00048
Titanium (Ti)-Total	mg/L	0.013	0.47	0.25	0.22	<0.010	0.26	0.052	0.074	<0.010	0.28	0.12	0.14	<0.010	0.47	0.10	0.15
Uranium (U)-Total	mg/L	0.00033	0.0018	0.00066	0.00089	<0.00020	0.00053	0.00023	0.00026	0.00025	0.00098	0.00079	0.00070	<0.00020	0.0018	0.00057	0.00063
Vanadium (V)-Total	mg/L	<0.0010	0.021	0.012	0.012	<0.0010	0.017	0.0033	0.0059	<0.0010	0.016	0.011	0.0095	<0.0010	0.021	0.011	0.0092
Zinc (Zn)-Total	mg/L	0.0070	0.17	0.057	0.069	<0.0050	0.068	0.013	0.025	<0.0050	0.055	0.031	0.030	<0.0050	0.17	0.035	0.043

Table 12. Continued

		MW-BGC11-BJ-2A (n=8)				MW-BGC11-BJ-3A (n=7)				MW-BGC11-BJ-3B (n=6)				P2 All (n=21)			
		Min	**Max**	**Med.**	**Ave.**	**Min**	**Max**	**Med.**	**Ave.**	**Min**	**Max**	**Med.**	**Ave.**	**Min**	**Max**	**Med.**	**Ave.**
Dissolved Metals	**Unit**																
Aluminum (Al)-Dissolved	mg/L	0.012	0.20	0.018	0.045	0.0065	0.024	0.016	0.016	0.0075	0.047	0.015	0.021	0.0065	0.20	0.016	0.028
Antimony (Sb)-Dissolved	mg/L	0.00020	0.0018	0.00042	0.00058	0.0013	0.012	0.0033	0.0048	0.0011	0.019	0.0026	0.0051	0.00020	0.019	0.0018	0.0033
Arsenic (As)-Dissolved	mg/L	0.00050	0.0022	0.00098	0.0011	0.0055	0.028	0.0076	0.012	0.0077	0.028	0.015	0.016	0.00050	0.028	0.0069	0.0090
Barium (Ba)-Dissolved	mg/L	0.027	0.069	0.040	0.041	0.022	0.031	0.029	0.027	0.034	0.053	0.043	0.044	0.022	0.069	0.037	0.037
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.0010	-	-	<0.00010	<0.0010	-	-	<0.00010	<0.0010	-	-	<0.00010	<0.0010	-	-
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.20	-	-	<0.00050	<0.20	-	-	<0.00050	<0.20	-	-	<0.00050	<0.20	-	-
Boron (B)-Dissolved	mg/L	<0.010	<0.10	0.014	0.021	0.037	<0.10	0.047	0.045	0.025	<0.10	0.034	0.037	<0.010	<0.10	0.037	0.034
Cadmium (Cd)-Dissolved	mg/L	<0.000010	0.0010	0.0000085	0.00013	0.0000050	0.000038	0.0000050	1.5E-05	<0.000017	0.000081	0.000052	4.7E-05	<0.000010	0.0010	0.000014	7.0E-05
Calcium (Ca)-Dissolved	mg/L	29.5	49.6	36.9	40.0	31.5	60.0	53.4	50.8	57.2	66.6	60.0	61.3	29.5	66.6	49.6	49.7
Chromium (Cr)-Dissolved	mg/L	<0.00010	0.0069	0.00031	0.0011	<0.00010	<0.0010	-	-	<0.00010	<0.0010	0.000075	0.00021	<0.00010	0.0069	0.00010	0.00054
Cobalt (Co)-Dissolved	mg/L	<0.00010	0.00041	0.00015	0.00019	<0.00010	0.00038	0.00015	0.00015	<0.00010	0.00050	0.00015	0.00018	<0.00010	0.00050	0.00015	0.00017
Copper (Cu)-Dissolved	mg/L	<0.00050	0.0020	0.00025	0.00053	<0.00050	<0.0010	0.00025	0.00032	<0.00050	0.00089	0.00038	0.00044	<0.00050	0.0020	0.00025	0.00044
Iron (Fe)-Dissolved	mg/L	<0.030	0.11	0.015	0.030	0.015	0.015	-	-	<0.030	0.076	0.015	0.029	<0.030	0.11	0.015	0.024
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.00050	0.000048	0.000094	<0.000050	<0.00050	0.000065	0.00011	<0.000050	<0.00050	-	-	<0.000050	<0.00050	0.000025	1.0E-04
Lithium (Li)-Dissolved	mg/L	0.0047	0.032	0.0073	0.011	0.016	0.074	0.022	0.033	<0.0050	0.015	0.010	0.0099	0.0047	0.074	0.012	0.018
Magnesium (Mg)-Dissolved	mg/L	1.50	2.38	1.8	1.92	2.45	4.34	3.93	3.85	2.78	5.32	3.80	3.86	1.50	5.32	3.46	3.12
Manganese (Mn)-Dissolved	mg/L	0.000431	0.13	0.051	0.053	0.13	0.22	0.19	0.18	0.041	0.40	0.19	0.20	0.00043	0.40	0.13	0.14
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-	<0.000010	<0.000010	-	-
Molybdenum (Mo)-Dissolved	mg/L	0.00086	0.0044	0.0017	0.0022	0.0011	0.0026	0.0015	0.0017	<0.0010	0.0012	0.00060	0.00071	0.00086	0.0044	0.0013	0.0016
Nickel (Ni)-Dissolved	mg/L	<0.00050	0.0063	0.00063	0.0018	<0.00050	0.0018	0.00050	0.00061	<0.00050	0.00083	0.00038	0.00043	<0.00050	0.0063	0.00050	0.0010
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	-	-	<0.30	<0.30	-	-	<0.30	<0.30	-	-	<0.30	<0.30	-	-
Potassium (K)-Dissolved	mg/L	0.24	<2.0	0.54	0.60	<2.0	1.55	1.47	1.34	0.98	1.76	1.04	1.16	0.24	1.76	1.00	1.01
Selenium (Se)-Dissolved	mg/L	<0.00010	<0.0010	0.00012	0.00019	<0.00010	<0.0010	0.000050	0.00020	0.00017	0.0012	0.00050	0.00054	<0.00010	0.0012	0.00017	0.00029
Silicon (Si)-Dissolved	mg/L	1.63	2.32	1.92	1.92	2.91	3.51	3.31	3.32	1.91	3.49	2.98	2.90	1.63	3.51	2.91	2.67
Silver (Ag)-Dissolved	mg/L	<0.000010	0.000011	0.0000050	0.0000070	<0.000010	<0.000020	-	-	<0.000010	<0.000020	-	-	<0.000010	0.000011	0.0000050	6.7E-06
Sodium (Na)-Dissolved	mg/L	2.50	20.0	4.60	6.94	7.90	36.7	9.90	15.5	3.10	6.40	5.10	4.98	2.50	36.7	5.60	9.23
Strontium (Sr)-Dissolved	mg/L	0.85	1.97	1.40	1.39	0.99	1.34	1.18	1.18	1.03	2.90	1.61	1.75	0.85	2.90	1.36	1.42
Thallium (Tl)-Dissolved	mg/L	<0.000010	<0.00020	0.0000080	0.000031	<0.000010	0.00015	0.000076	7.3E-05	0.000032	<0.00020	0.000050	6.2E-05	<0.000010	0.00015	0.000044	5.4E-05
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00050	0.000050	0.00012	<0.00010	<0.00050	-	-	<0.00010	<0.00050	-	-	<0.00010	<0.00050	0.000050	0.00011
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-	<0.010	<0.010	-	-
Uranium (U)-Dissolved	mg/L	0.00015	0.00043	0.00032	0.00029	<0.00020	0.00018	0.00014	0.00014	0.00024	0.00066	0.00053	0.00049	0.00015	0.00066	0.00029	0.00030
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	-	-	<0.0010	<0.0010	-	-	<0.0010	<0.0010	-	-	<0.0010	<0.0010	-	-
Zinc (Zn)-Dissolved	mg/L	<0.0030	0.019	0.0020	0.0058	<0.0030	0.031	0.0015	0.0059	<0.0030	0.0074	0.0015	0.0027	<0.0030	0.031	0.0015	0.0049

Table 13. Statistical Summary of Water Quality Results from Monitoring Wells Completed in Volcanic Sedimentary Facies (VSF) Material.

		MW-BGC11-BJ-4A (n=7)				MW-BGC12-BJ-4B (n=1)	MW-BGC11-BJ-5A (n=1)	MW-BGC11-BJ-5B (n=3)			MW-BGC11-BJ-6A (n=6)				VSF All (n=18)			
		Min	Max	Med.	Ave.	-	-	Min	Max	Med.	Min	Max	Med.	Ave.	Min	Max	Med.	Ave.
Field Parameters	**Unit**																	
Temperature	°C	1.6	4.3	2.3	2.4	1.4	0	-	-	-	2.0	4.1	2.3	2.8	1.4	4.3	2.3	2.5
Physical Tests	**Unit**																	
pH	pH	7.26	8.16	8.12	7.86	8.19	7.96	8.05	8.13	8.12	7.99	8.22	8.16	8.12	7.26	8.22	8.13	7.98
Total Suspended Solids	mg/L	14.2	51.7	19.5	25.5	<3.0	62.2	3830	34400	6220	717	3460	2055	2120	14.2	34400	389	3190
Turbidity	NTU	9.19	20.7	11.5	12.9	1.99	66.6	>4000	>4000	-	836	>4000	1755	2130	1.99	>4000	16.3	669
Anions and Nutrients	**Unit**																	
Alkalinity, Total (as CaCO3)	mg/L	106	126	115	114	121	39.5	70.8	89.3	75.6	58.7	97.9	68.5	76.2	39.5	126	97.0	91.8
Ammonia (as N)	mg/L	0.11	0.24	0.16	0.17	0.056	0.10	0.12	0.39	0.23	0.021	0.090	0.080	0.070	0.021	0.39	0.12	0.14
Chloride (Cl)	mg/L	<0.50	1.89	0.74	0.82	<0.50	1.47	0.76	4.31	2.97	<0.50	0.67	0.38	0.41	<0.50	4.31	0.61	1.00
Fluoride (F)	mg/L	0.075	0.086	0.078	0.079	0.11	*0.15*	*0.18*	*0.26*	*0.24*	*0.15*	*0.18*	*0.17*	*0.17*	0.075	*0.26*	*0.15*	*0.14*
Nitrate (as N)	mg/L	0.0072	0.19	0.12	0.12	<0.0050	0.0057	<0.0050	<0.0050	-	<0.0050	0.0074	0.0025	0.0033	<0.0050	0.19	0.0041	0.048
Nitrite (as N)	mg/L	0.0035	0.038	0.0058	0.012	0.0011	0.0011	<0.0010	0.0011	0.0005	<0.0010	0.0011	0.00050	0.00068	<0.0010	0.038	0.0011	0.0050
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	0.0032	0.0013	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0010	0.0043	0.0027	0.0024	<0.0010	0.0043	0.00075	0.0014
Phosphorus (P)-Total	mg/L	0.013	0.049	0.021	0.025	<0.0020	0.042	1.11	15.7	2.97	0.16	3.55	0.95	1.45	0.013	15.7	0.10	1.59
Sulfate (SO4)	mg/L	109	140	122	123	98.2	73.6	89.2	121	96.3	69.2	96.1	83.4	82.1	69.2	140	97.3	102
Total Metals	**Unit**																	
Aluminum (Al)-Total	mg/L	*0.24*	*0.79*	*0.42*	*0.47*	0.056	*1.04*	-	-	-	*4.90*	*44.8*	*26.3*	*26.4*	0.056	*44.8*	*0.792*	*10.8*
Antimony (Sb)-Total	mg/L	0.0017	0.0085	0.0035	0.0042	0.00061	0.0032	-	-	-	0.0075	0.021	0.012	0.013	0.00061	0.021	0.00474	0.0074
Arsenic (As)-Total	mg/L	*0.016*	*0.031*	*0.021*	*0.021*	0.0037	*0.013*	-	-	-	*0.047*	*0.64*	*0.19*	*0.27*	0.0037	*0.64*	*0.0225*	*0.12*
Barium (Ba)-Total	mg/L	0.047	0.098	0.055	0.060	0.022	0.072	-	-	-	0.33	33.1	13.6	14.9	0.022	33.1	0.072	6.00
Beryllium (Be)-Total	mg/L	<0.00010	<0.0010	-	-	<0.00010	<0.0010	-	-	-	<0.0010	<0.010	0.0025	0.0027	<0.00010	<0.0010	-	-
Bismuth(Bi)- Total	mg/L	<0.00050	<0.20	-	-	<0.00050	<0.20	-	-	-	<0.00050	<0.20	-	-	<0.00050	<0.20	-	-
Boron (B)-Total	mg/L	0.064	0.070	0.069	0.065	0.021	<0.10	-	-	-	<0.050	<0.10	0.035	0.037	0.021	0.070	0.05	0.050
Cadmium (Cd)-Total	mg/L	0.000015	0.000054	0.000026	3.2E-05	<0.000010	*0.00023*	-	-	-	*0.00055*	*0.0023*	*0.0012*	*0.0013*	<0.000010	*0.0023*	0.000054	*0.00057*
Calcium (Ca)-Total	mg/L	50.3	62.4	56.5	55.9	74.2	32.4	-	-	-	60.0	114	71.4	76.2	32.4	114	60.3	63.7
Chromium (Cr)-Total	mg/L	0.00070	*0.0032*	*0.0011*	*0.0013*	0.00073	*0.0020*	-	-	-	*0.0024*	*0.024*	*0.013*	*0.013*	*0.00070*	*0.024*	*0.002*	*0.0060*
Cobalt (Co)-Total	mg/L	0.00064	0.0012	0.00078	0.00083	0.00013	0.0044	-	-	-	0.0042	0.027	0.010	0.013	0.00013	0.027	0.00123	0.0059
Copper (Cu)-Total	mg/L	0.0010	0.0018	0.0015	0.0014	0.00075	*0.0091*	-	-	-	*0.052*	*0.17*	*0.074*	*0.099*	0.00075	*0.17*	0.00179	*0.041*
Iron (Fe)-Total	mg/L	*0.36*	*0.82*	*0.41*	*0.50*	<0.030	*1.50*	-	-	-	*6.90*	*95.3*	*35.1*	*44.3*	<0.030	*95.3*	*0.821*	*18.1*
Lead (Pb)-Total	mg/L	0.00051	0.0012	0.00072	0.00078	0.000085	0.0025	-	-	-	**0.067**	*0.28*	**0.13**	**0.15**	0.000085	*0.28*	0.00118	**0.062**
Lithium (Li)-Total	mg/L	0.028	0.034	0.030	0.030	0.020	0.023	-	-	-	0.0058	0.054	0.029	0.031	0.0058	0.054	0.0292	0.029
Magnesium (Mg)-Total	mg/L	11.4	14.1	11.8	12.21	7.77	3.60	-	-	-	4.90	22.0	11.5	12.3	3.60	22.0	11.6	11.4
Manganese (Mn)-Total	mg/L	0.099	0.17	0.11	0.13	0.060	0.65	-	-	-	0.73	3.49	1.12	1.72	0.060	3.49	0.171	0.79
Mercury (Hg)-Total	mg/L	<0.000010	0.000023	0.000005	9.7E-06	<0.000010	<0.000010	-	-	-	*0.00013*	*0.0011*	*0.00048*	*0.00055*	<0.000010	*0.0011*	0.000014	*0.00023*
Molybdenum (Mo)-Total	mg/L	0.00098	0.0021	0.0013	0.0014	0.00049	0.0063	-	-	-	<0.0010	0.0074	0.0039	0.0040	0.00049	0.0074	0.00206	0.0027
Nickel (Ni)-Total	mg/L	0.00057	0.0011	0.00074	0.00077	0.00080	0.0038	-	-	-	0.0048	0.027	0.012	0.014	0.00057	0.027	0.0011	0.0063
Phosphorus (P) - Total	mg/L	<0.30	<0.30	-	-	<0.30	<0.30	-	-	-	0.64	2.72	1.01	1.42	<0.30	2.72	0.15	0.66
Potassium (K)-Total	mg/L	1.62	2.20	1.70	1.80	0.97	3.3	-	-	-	4.8	11.9	9.36	8.80	0.97	11.9	2.2	4.64
Selenium (Se)-Total	mg/L	<0.00010	<0.0010	-	-	<0.00010	<0.0010	-	-	-	<0.0010	<0.010	*0.0014*	*0.0020*	<0.00010	<0.0010	-	-
Silicon (Si)- Total	mg/L	3.33	4.97	4.02	4.06	2.48	4.92	-	-	-	11.1	86.6	60.5	58.2	2.48	86.6	4.92	25.7
Silver (Ag)-Total	mg/L	<0.000020	0.000074	0.000019	2.9E-05	0.000074	*0.00052*	-	-	-	*0.0024*	*0.026*	*0.011*	*0.012*	0.000074	*0.026*	0.000074	*0.0050*
Sodium (Na)-Total	mg/L	17.9	27.6	18.4	20.4	7.9	12.4	-	-	-	2.3	6.9	6.2	5.32	2.30	27.6	12.4	13.0
Strontium (Sr)-Total	mg/L	2.58	3.05	2.84	2.80	1.05	0.84	-	-	-	1.01	3.34	2.59	2.47	0.84	3.34	2.65	2.42
Thallium (Tl)-Total	mg/L	0.000021	<0.00020	0.000027	3.6E-05	0.000013	<0.00020	-	-	-	<0.00020	<0.0020	0.00063	0.00061	0.000013	<0.0020	0.00010	0.00027
Tin (Sn)-Total	mg/L	0.00018	<0.00050	0.00025	0.00027	0.00020	0.0019	-	-	-	0.00056	<0.0050	0.00074	0.0011	0.00018	<0.0050	0.00036	0.00071
Titanium (Ti)-Total	mg/L	0.011	0.025	0.017	0.018	<0.010	0.020	-	-	-	0.12	0.87	0.60	0.59	<0.010	0.87	0.025	0.25
Uranium (U)-Total	mg/L	0.0021	0.0050	0.0028	0.0032	0.00080	0.00028	-	-	-	0.00055	0.0018	0.0011	0.0011	0.00028	0.0050	0.0018	0.0020
Vanadium (V)-Total	mg/L	<0.0010	0.0011	0.00050	0.00059	<0.0010	0.0015	-	-	-	0.0074	0.078	0.043	0.043	<0.0010	0.078	0.0011	0.018
Zinc (Zn)-Total	mg/L	0.0037	0.0084	0.0070	0.0066	0.026	*0.032*	-	-	-	*0.30*	*1.19*	*0.53*	*0.63*	0.0037	*1.19*	0.026	*0.26*

Table 13 Continued.

		MW-BGC11-BJ-4A (n=7)				MW-BGC12-BJ-4B (n=1)	MW-BGC11-BJ-5A (n=1)	MW-BGC11-BJ-5B (n=3)			MW-BGC11-BJ-6A (n=6)				VSF All (n=18)		
		Min	**Max**	**Med.**	**Ave.**	-	-	**Min**	**Max**	**Med.**	**Min**	**Max**	**Med.**	**Ave.**	**Min**	**Max**	**Med.**
Dissolved Metals	**Unit**																
Aluminum (Al)-Dissolved	mg/L	0.0036	0.019	0.0080	0.0093	0.0074	0.057	0.030	0.087	0.075	0.010	0.83	0.040	0.17	0.0036	0.83	0.020
Antimony (Sb)-Dissolved	mg/L	0.0016	0.0087	0.0035	0.0039	0.00052	0.0028	0.0046	0.011	0.0072	0.0018	0.0068	0.0035	0.0039	0.00052	0.011	0.0035
Arsenic (As)-Dissolved	mg/L	0.013	0.030	0.016	0.018	0.0030	0.0064	0.0053	0.012	0.010	0.0017	0.029	0.024	0.019	0.0017	0.030	0.015
Barium (Ba)-Dissolved	mg/L	0.033	0.044	0.034	0.037	0.020	0.027	0.024	0.049	0.042	0.035	0.14	0.049	0.059	0.020	0.14	0.037
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.0010	-	-	<0.00010	<0.0010	<0.00020	<0.0010	-	<0.00010	<0.0010	-	-	<0.00010	<0.0010	-
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.20	-	-	<0.00050	<0.20	<0.0010	<0.20	-	<0.00050	<0.20	-	-	<0.00050	<0.20	-
Boron (B)-Dissolved	mg/L	0.063	0.072	0.066	0.065	0.018	<0.10	0.039	<0.10	0.050	<0.020	<0.10	0.030	0.032	<0.020	0.072	0.050
Cadmium (Cd)-Dissolved	mg/L	<0.000017	0.000034	0.000012	1.9E-05	<0.000010	0.00011	<0.000017	0.00033	0.0000085	<0.000010	0.00036	0.000013	0.000072	<0.000010	0.00036	0.000012
Calcium (Ca)-Dissolved	mg/L	49.5	61.5	57.1	56.1	69.8	31.3	48.6	58.5	56.9	42.3	68.7	48.5	52.7	31.3	68.7	55.6
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.0010	0.00014	0.00015	<0.00010	<0.0010	<0.00020	<0.0010	-	<0.00010	<0.0010	-	-	<0.00010	<0.0010	0.00012
Cobalt (Co)-Dissolved	mg/L	0.00011	0.00065	0.00026	0.00029	<0.00010	0.0033	<0.00030	0.00037	0.00015	<0.00010	<0.00030	-	-	<0.00010	0.00065	0.00015
Copper (Cu)-Dissolved	mg/L	<0.00050	<0.0010	-	-	<0.00050	0.0024	<0.0010	<0.0010	-	<0.00050	0.0024	0.00038	0.00076	<0.00050	0.0024	0.00025
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	-	-	<0.030	0.072	<0.030	<0.030	-	<0.030	0.32	0.015	0.066	<0.030	0.32	0.015
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.00050	-	-	<0.000050	<0.00050	<0.00010	<0.00050	-	<0.00010	0.0010	0.00024	0.00032	<0.000050	0.0010	0.000096
Lithium (Li)-Dissolved	mg/L	0.027	0.035	0.031	0.030	0.016	0.021	0.0094	0.023	0.015	<0.0050	0.0066	0.0061	0.0051	<0.0050	0.035	0.019
Magnesium (Mg)-Dissolved	mg/L	11.3	14.1	12.0	12.2	7.33	3.22	5.74	6.38	5.91	3.45	4.45	3.77	3.89	3.22	14.1	6.15
Manganese (Mn)-Dissolved	mg/L	0.052	0.14	0.071	0.086	0.057	0.57	0.13	0.55	0.26	0.036	0.062	0.044	0.046	0.036	0.55	0.066
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	-	-	<0.000010	<0.000010	<0.000010	<0.00010	-	<0.000010	<0.000010	-	-	<0.000010	<0.00010	-
Molybdenum (Mo)-Dissolved	mg/L	0.00089	0.0020	0.0012	0.0013	0.00044	0.0058	0.0055	0.016	0.0075	<0.0010	0.0035	0.0023	0.0019	0.00044	0.016	0.0019
Nickel (Ni)-Dissolved	mg/L	<0.00050	0.00064	0.00052	0.00047	0.00061	0.0026	<0.0010	0.0017	0.00050	<0.00050	0.0031	0.00050	0.00085	<0.00050	0.0031	0.00050
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	-	-	<0.30	<0.30	<0.30	<0.30	-	<0.30	<0.30	-	-	<0.30	<0.30	-
Potassium (K)-Dissolved	mg/L	1.59	1.62	1.61	1.52	0.92	2.50	3.70	7.4	5.53	2.20	2.67	2.51	2.51	0.92	7.40	2.34
Selenium (Se)-Dissolved	mg/L	<0.00010	<0.0010	-	-	<0.00010	<0.0010	<0.00020	<0.0010	-	0.00023	0.00064	0.00041	0.00041	<0.00010	0.00064	0.00027
Silicon (Si)-Dissolved	mg/L	2.90	3.23	3.00	3.03	2.27	1.94	2.57	3.78	2.80	2.26	5.49	3.66	3.63	1.94	5.49	3.00
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000020	-	-	<0.000010	<0.000020	<0.000020	<0.000020	-	<0.000020	0.000048	0.000012	0.000019	<0.000010	0.000048	0.000010
Sodium (Na)-Dissolved	mg/L	17.3	27.7	17.9	20.3	6.60	12.3	9.80	14.5	12.7	2.50	5.10	4.05	3.9	2.50	27.7	12.5
Strontium (Sr)-Dissolved	mg/L	2.56	3.04	2.81	2.80	0.98	0.81	0.75	1.66	1.55	0.89	2.22	2.00	1.88	0.75	3.04	2.09
Thallium (Tl)-Dissolved	mg/L	0.000017	<0.00020	0.000018	3.0E-05	<0.000010	<0.00020	<0.00020	0.00013	0.00010	0.000053	<0.00020	0.000077	7.8E-05	<0.000010	0.00013	0.000064
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00050	-	-	<0.00010	0.00091	<0.00020	0.0012	0.00025	<0.00010	0.00052	0.00010	0.00018	<0.00010	0.0012	0.000075
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	-	-	<0.010	<0.010	<0.010	<0.010	-	<0.010	0.023	0.0050	0.0080	<0.010	0.023	0.0050
Uranium (U)-Dissolved	mg/L	0.0020	0.0049	0.0027	0.0031	0.00073	0.00022	0.00082	0.0015	0.0011	<0.00020	0.00069	0.00046	0.00044	<0.00020	0.0049	0.00095
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	-	-	<0.0010	<0.0010	<0.0010	<0.0020	-	<0.0010	<0.0020	-	-	<0.0010	<0.0020	-
Zinc (Zn)-Dissolved	mg/L	<0.0030	0.0037	0.0031	0.0027	0.017	0.010	<0.0050	<0.0060	-	<0.0030	0.055	0.0020	0.011	<0.0030	0.055	0.0028

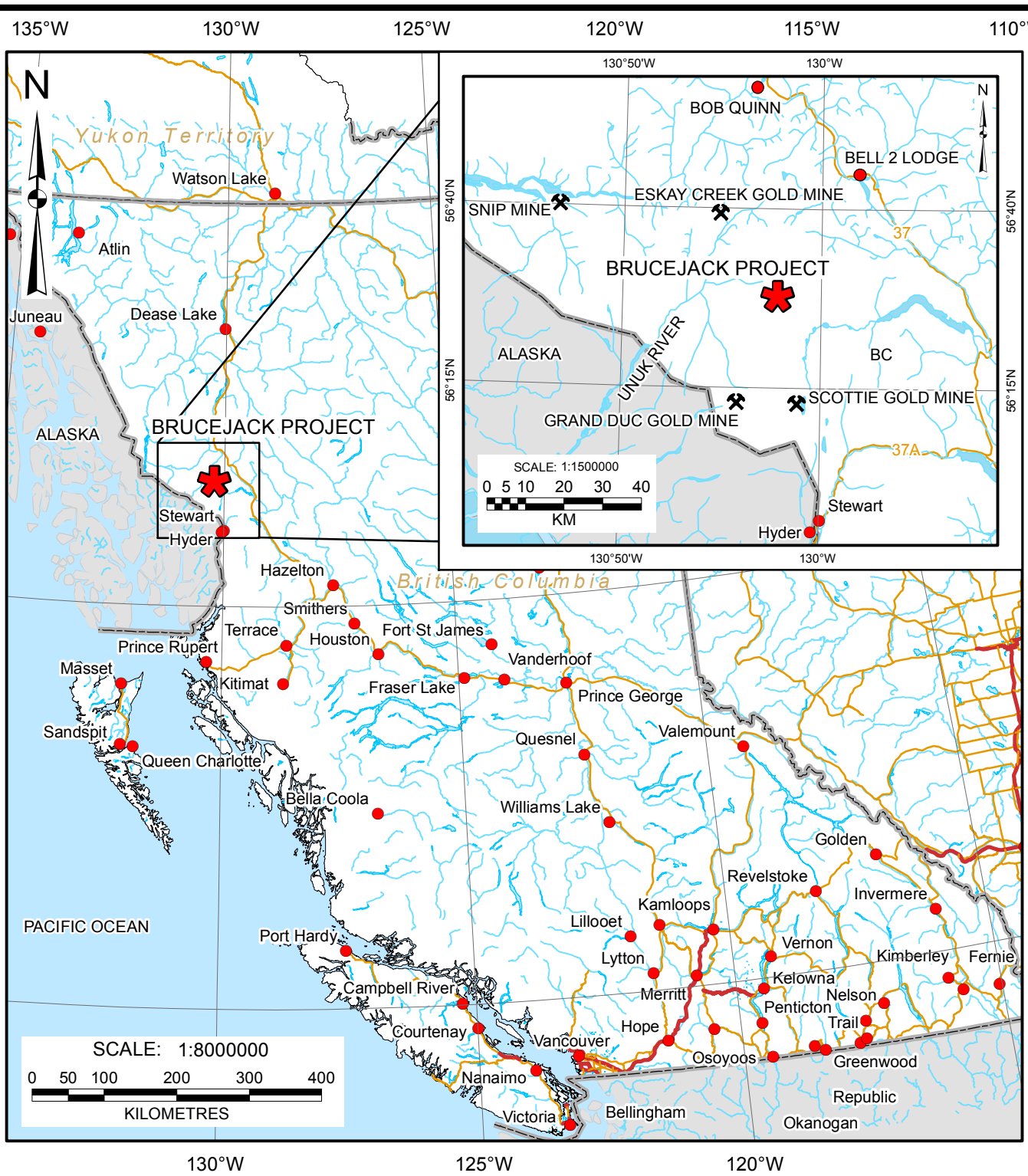
Table 14. Statistical Summary of Water Quality Results from Monitoring Wells Completed Bridge P1 Material.

		MW-BGC12-BJ-12A (n=2)	
		Min	**Max**
Field Parameters	**Unit**		
Temperature	°C	1.3	2.5
Physical Tests	**Unit**		
pH	pH	7.69	8.06
Total Suspended Solids	mg/L	183	488
Turbidity	NTU	2.40	164
Anions and Nutrients	**Unit**		
Alkalinity, Total (as CaCO3)	mg/L	98.8	109
Ammonia (as N)	mg/L	0.15	0.17
Chloride (Cl)	mg/L	0.71	1.05
Fluoride (F)	mg/L	*0.15*	*0.16*
Nitrate (as N)	mg/L	<0.0050	0.0088
Nitrite (as N)	mg/L	<0.0010	-
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	-
Phosphorus (P)-Total	mg/L	0.21	0.27
Sulfate (SO4)	mg/L	159	195
Total Metals	**Unit**		
Aluminum (Al)-Total	mg/L	*1.48*	*4.39*
Antimony (Sb)-Total	mg/L	0.0032	0.0050
Arsenic (As)-Total	mg/L	*0.083*	*0.19*
Barium (Ba)-Total	mg/L	0.23	0.30
Beryllium (Be)-Total	mg/L	<0.00010	0.0005
Bismuth(Bi)- Total	mg/L	<0.00050	-
Boron (B)-Total	mg/L	0.021	0.026
Cadmium (Cd)-Total	mg/L	0.00029	*0.00052*
Calcium (Ca)-Total	mg/L	74.5	95.3
Chromium (Cr)-Total	mg/L	*0.029*	*0.16*
Cobalt (Co)-Total	mg/L	0.0022	0.00255
Copper (Cu)-Total	mg/L	*0.014*	*0.016*
Iron (Fe)-Total	mg/L	*5.36*	*8.02*
Lead (Pb)-Total	mg/L	*0.021*	*0.047*
Lithium (Li)-Total	mg/L	0.011	0.016
Magnesium (Mg)-Total	mg/L	10.5	14
Manganese (Mn)-Total	mg/L	0.37	0.43
Mercury (Hg)-Total	mg/L	<0.000010	0.000012
Molybdenum (Mo)-Total	mg/L	0.0028	0.00524
Nickel (Ni)-Total	mg/L	0.013	0.059
Phosphorus (P) - Total	mg/L	<0.30	-
Potassium (K)-Total	mg/L	5.28	5.33
Selenium (Se)-Total	mg/L	0.00031	0.00070
Silicon (Si)- Total	mg/L	6.08	13.8
Silver (Ag)-Total	mg/L	*0.00087*	*0.0017*
Sodium (Na)-Total	mg/L	6.4	9.2
Strontium (Sr)-Total	mg/L	1.41	1.87
Thallium (Tl)-Total	mg/L	0.00015	0.00024
Tin (Sn)-Total	mg/L	0.0014	0.0028
Titanium (Ti)-Total	mg/L	0.041	0.054
Uranium (U)-Total	mg/L	0.00055	0.0016
Vanadium (V)-Total	mg/L	0.0024	0.0029
Zinc (Zn)-Total	mg/L	*0.047*	*0.061*
Dissolved Metals	**Unit**		
Aluminum (Al)-Dissolved	mg/L	0.0050	0.012
Antimony (Sb)-Dissolved	mg/L	0.00055	0.0013
Arsenic (As)-Dissolved	mg/L	0.0043	0.025
Barium (Ba)-Dissolved	mg/L	0.040	0.071
Beryllium (Be)-Dissolved	mg/L	<0.00010	-
Bismuth(Bi)- Dissolved	mg/L	<0.00050	-
Boron (B)-Dissolved	mg/L	0.02	0.022
Cadmium (Cd)-Dissolved	mg/L	<0.000010	0.000039
Calcium (Ca)-Dissolved	mg/L	73.1	85.4
Chromium (Cr)-Dissolved	mg/L	0.00012	0.0019
Cobalt (Co)-Dissolved	mg/L	0.00033	0.00072
Copper (Cu)-Dissolved	mg/L	<0.00050	-
Iron (Fe)-Dissolved	mg/L	<0.030	-
Lead (Pb)-Dissolved	mg/L	<0.000050	-
Lithium (Li)-Dissolved	mg/L	0.010	0.013
Magnesium (Mg)-Dissolved	mg/L	10.1	13
Manganese (Mn)-Dissolved	mg/L	0.31	0.34
Mercury (Hg)-Dissolved	mg/L	<0.000010	-
Molybdenum (Mo)-Dissolved	mg/L	0.0021	0.0030
Nickel (Ni)-Dissolved	mg/L	0.0021	0.0072
Phosphorus (P)-Dissolved	mg/L	<0.30	-
Potassium (K)-Dissolved	mg/L	4.47	4.53
Selenium (Se)-Dissolved	mg/L	<0.00010	0.00010
Silicon (Si)-Dissolved	mg/L	3.63	3.69
Silver (Ag)-Dissolved	mg/L	<0.000010	-
Sodium (Na)-Dissolved	mg/L	6.20	9.20
Strontium (Sr)-Dissolved	mg/L	1.37	1.78
Thallium (Tl)-Dissolved	mg/L	0.000018	0.000024
Tin (Sn)-Dissolved	mg/L	<0.00010	0.00018
Titanium (Ti)-Dissolved	mg/L	<0.010	0.010
Uranium (U)-Dissolved	mg/L	0.00026	0.00036
Vanadium (V)-Dissolved	mg/L	<0.0010	-
Zinc (Zn)-Dissolved	mg/L	0.0030	0.0057

Table 15. Metal Exceedances Common to Material-Specific Baseline Groundwater Chemistries

Parameter	Office P1	P2	VSF	Bridge P1
Total Al	X	X	X	X
Total Ag	X	X	X	X
Total As	X	X	X	X
Total Cr	X	X	X	X
Total Cu	X	X	X	X
Total Fe	X	X	X	X
Total Cd			X	X
Total Co			X	
Total Hg		X		
Total Pb			X	X
Total Zn		X	X	X
F		X	X	X

DRAWINGS



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BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE:
PROJECT LOCATION

CLIENT:
PRETIUM RESOURCES INC.

PROJECT No.:	DWG No.:	REV.:
1008010	01	

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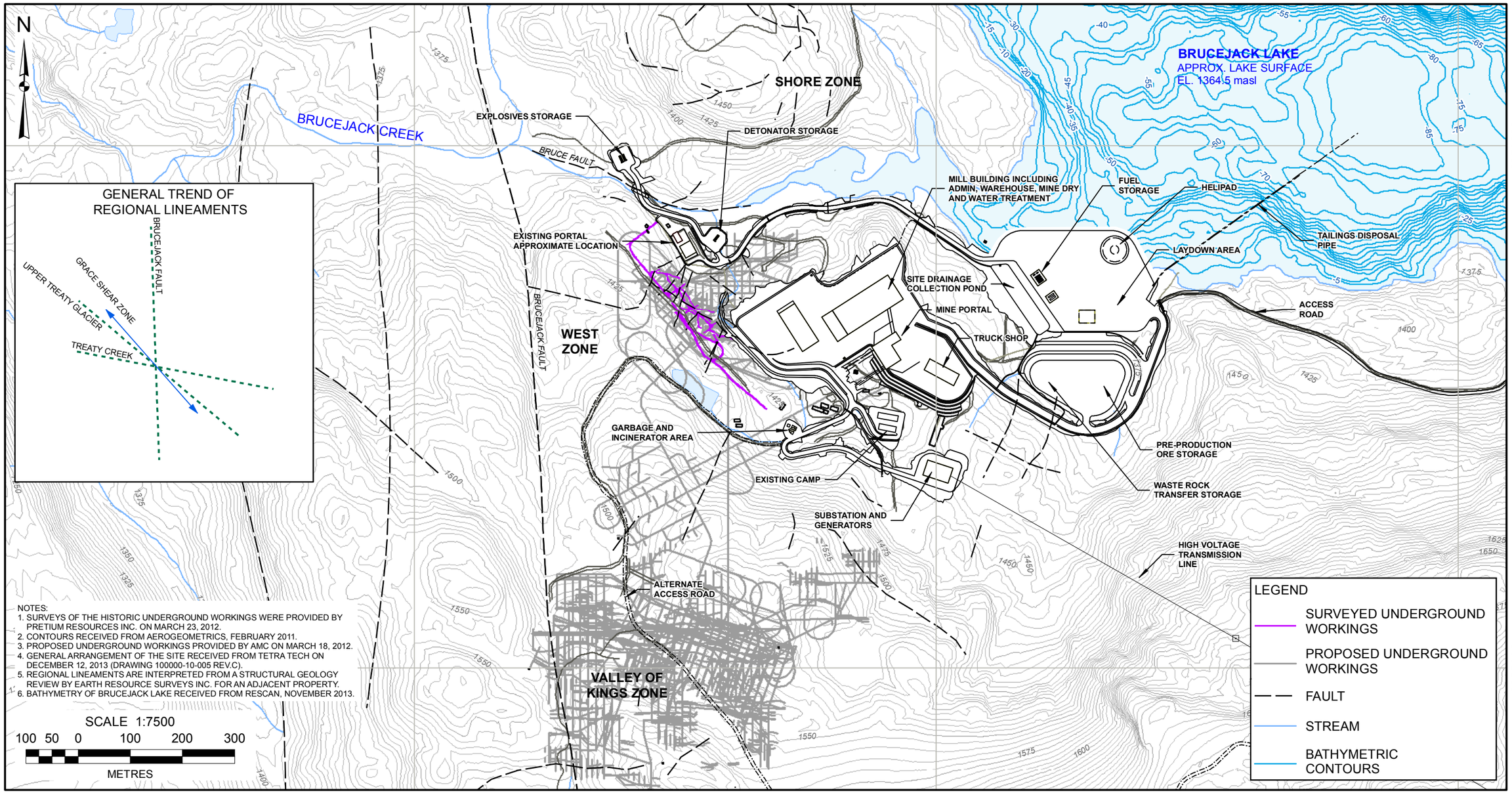

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TITLE: SITE PLAN BRUCEJACK PROJECT

PROJECT No.:	DWG No.:	REV.:
1008010	02	

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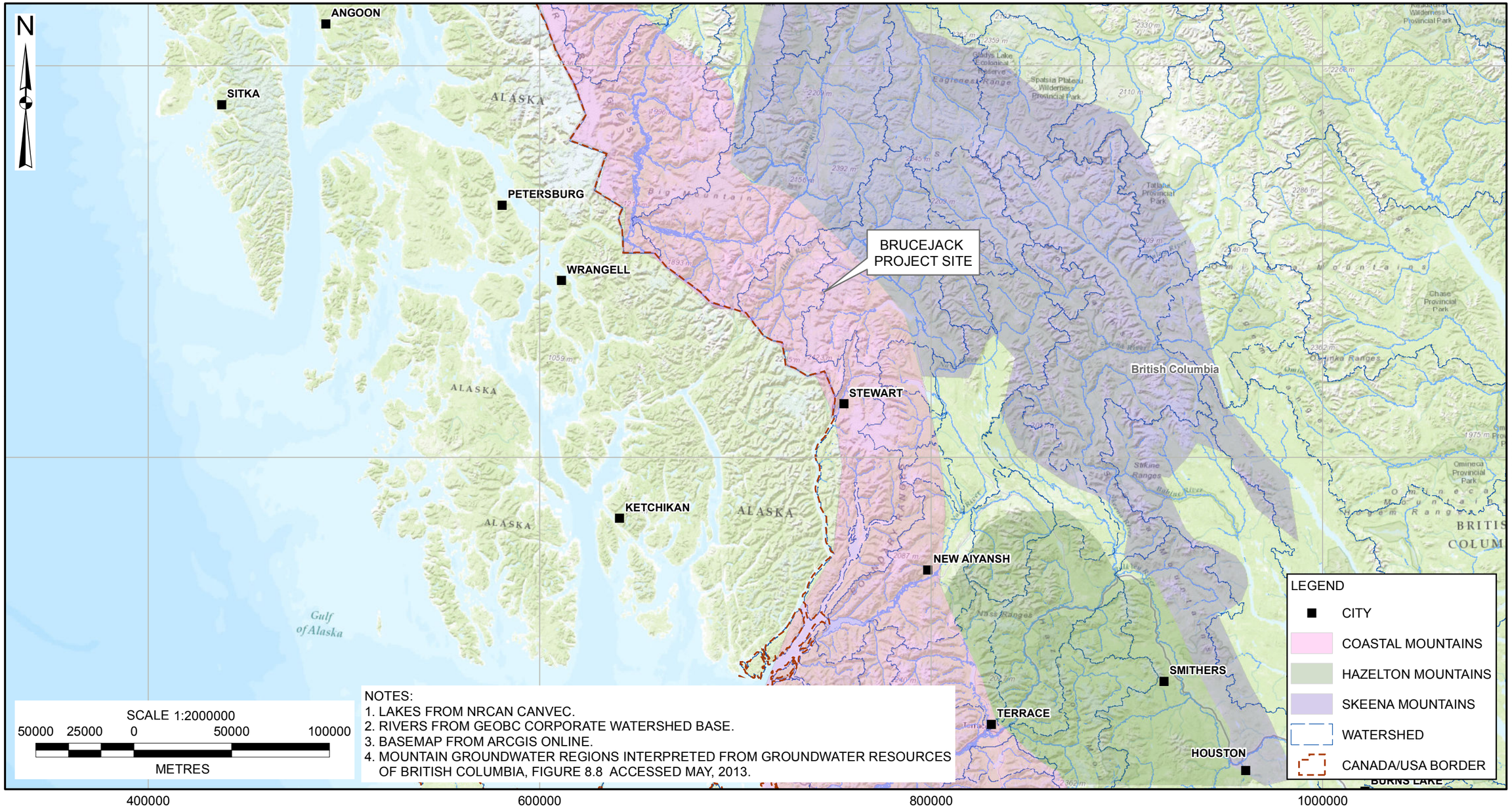

NOTES:
1. LAKES FROM NRCAN CANVEC.
2. RIVERS FROM GEOBC CORPORATE WATERSHED BASE.
3. BASEMAP FROM ARCGIS ONLINE.
4. MOUNTAIN GROUNDWATER REGIONS INTERPRETED FROM GROUNDWATER RESOURCES OF BRITISH COLUMBIA, FIGURE 8.8 ACCESSED MAY, 2013.

BC MOE ALBERS NAD83

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TITLE: COASTAL MOUNTAINS SUB-REGION

PROJECT No.:	DWG No.:	REV.:
1008010	03	

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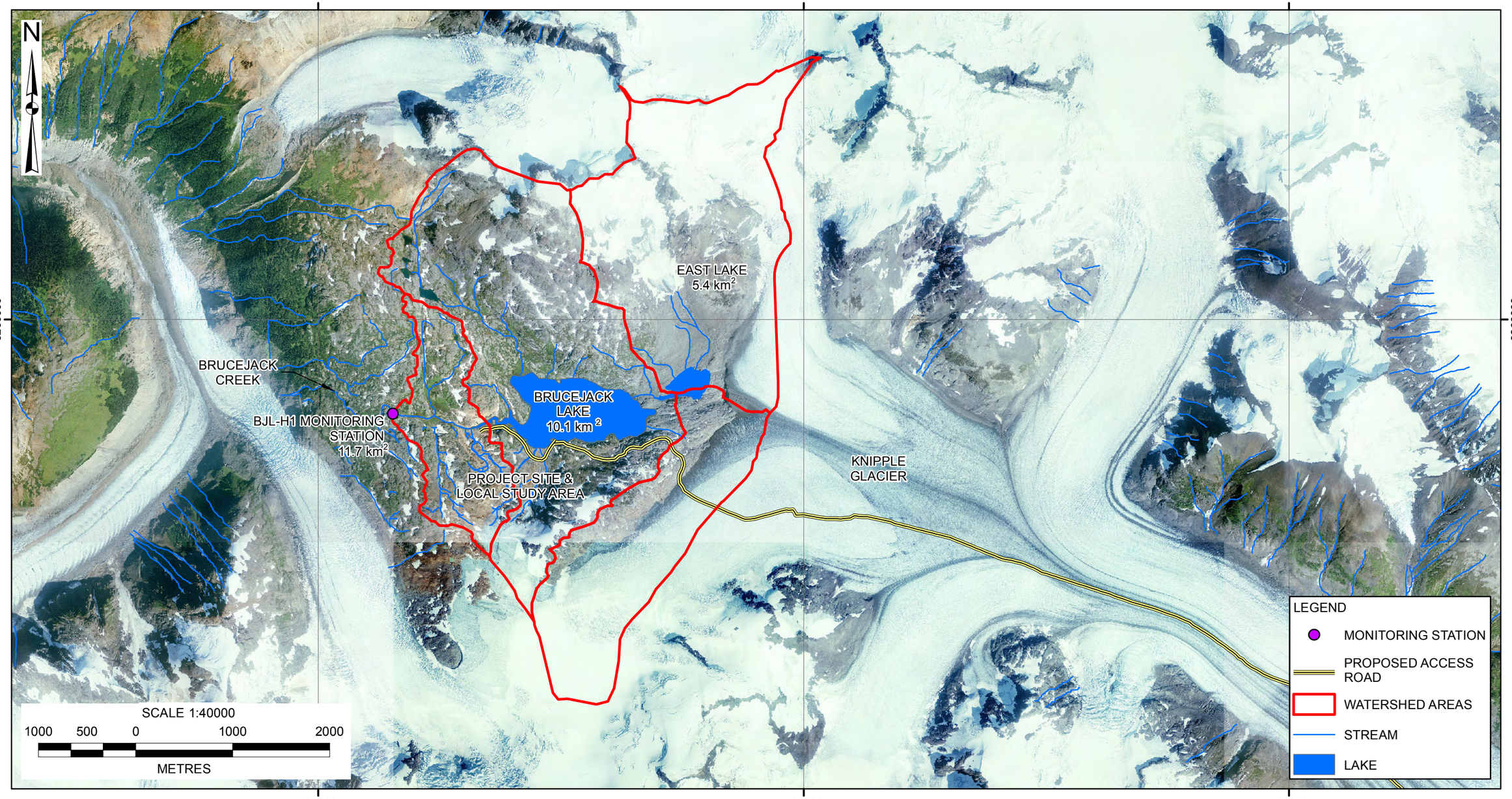

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HYDROGEOLOGY BASELINE REPORT

TITLE:
WATERSHED BOUNDARIES AND LOCAL STUDY AREA

PROJECT No.:	DWG No.:	REV.:
1008010	04	

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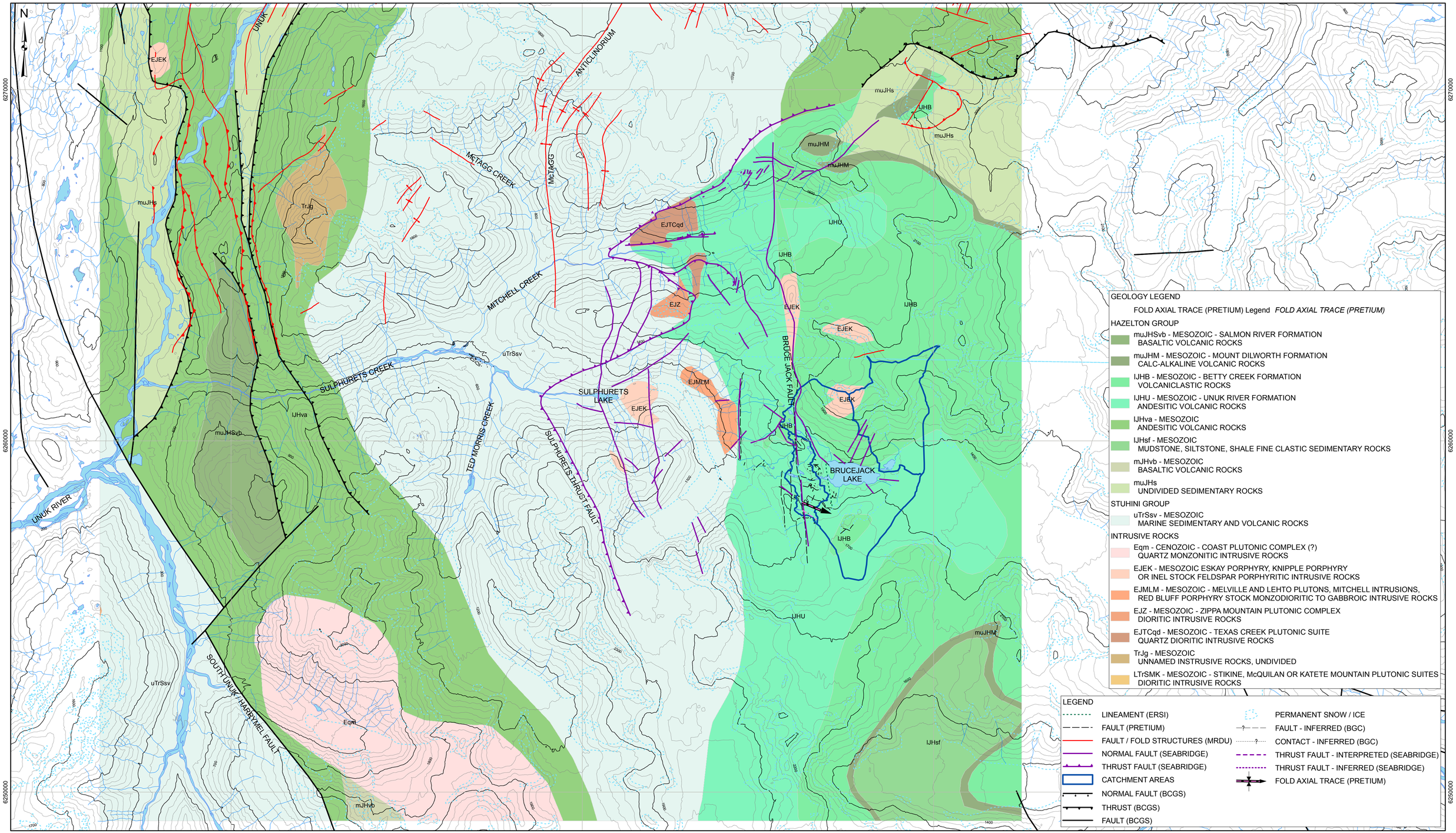

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2 1 0 2 4 6

KILOMETRES

NOTES:
1. GEOLOGICAL BOUNDARIES ACQUIRED FROM BRITISH COLUMBIA GEOLOGICAL SURVEY GEOFILE GF2005-9.
2. TOPOGRAPHIC INFORMATION OUTSIDE LIDAR BOUNDARIES BASED ON GEOBASE DATA, NATURAL RESOURCES CANADA.

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TITLE: BRUCEJACK PROJECT REGIONAL GEOLOGY

PROJECT No.:	DWG No.:	REV.:
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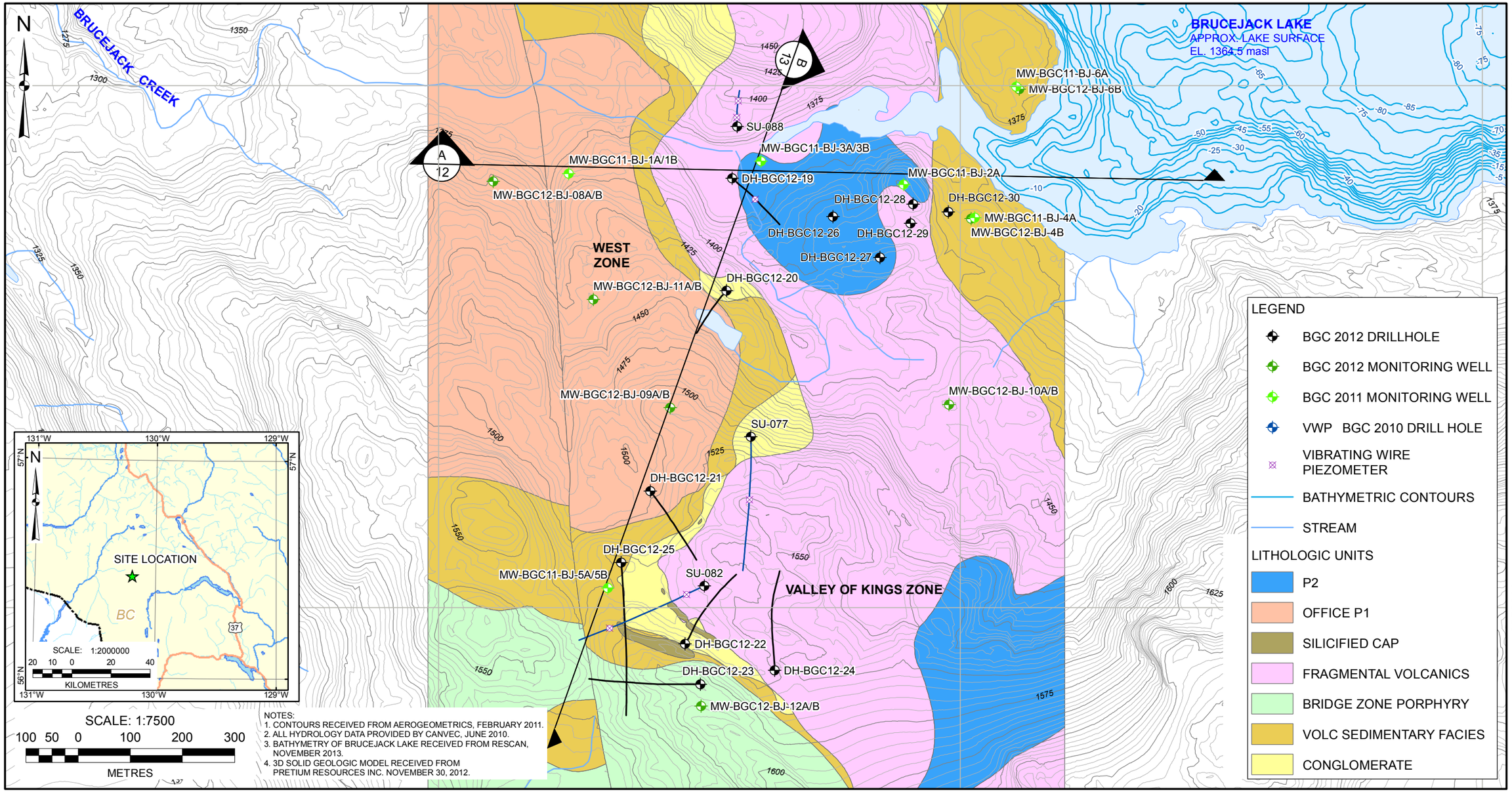

NOTES:
1. CONTOURS RECEIVED FROM AEROGEOMETRICS, FEBRUARY 2011.
2. ALL HYDROLOGY DATA PROVIDED BY CANVEC, JUNE 2010.
3. BATHYMETRY OF BRUCEJACK LAKE RECEIVED FROM RESCAN, NOVEMBER 2013.
4. 3D SOLID GEOLOGIC MODEL RECEIVED FROM PRETIUM RESOURCES INC. NOVEMBER 30, 2012.

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TITLE: MONITORING WELL AND DRILLHOLE LOCATIONS

PROJECT No.:	DWG No.:	REV.:
1008010	06	

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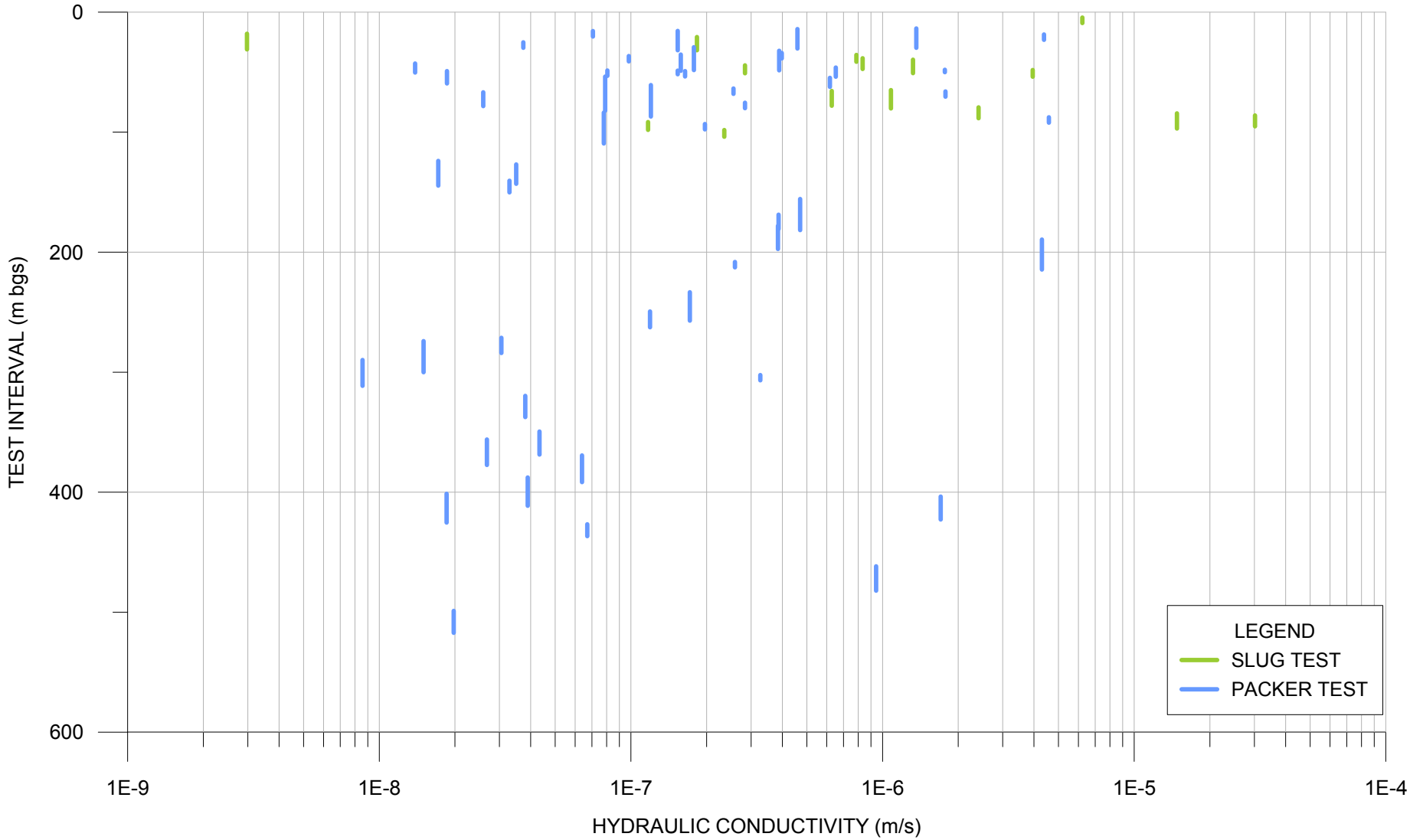
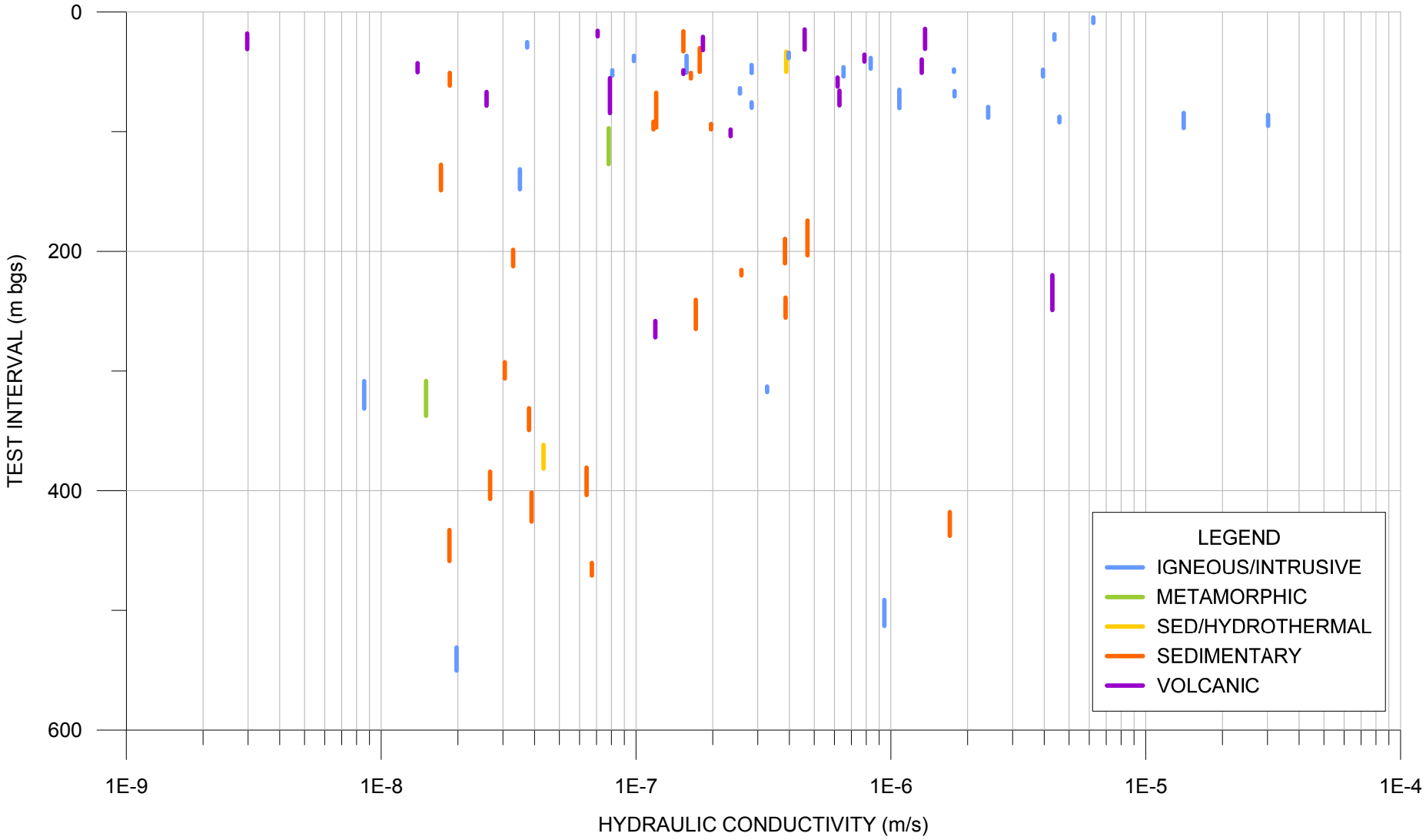


SCALE: N/A	DESIGNED: DP	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: JUN 2014	CHECKED: CM		TITLE: HYDRAULIC CONDUCTIVITY VS. DEPTH BY TEST TYPE
DRAWN: DP	APPROVED: TC		
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / FIG No. 07 / REV. 1

N:/Projects/1008 Pretium/010 EA 2013/002 Hydrogeology/09 Reporting/ 02 EA Modeling Report/02 Drawings

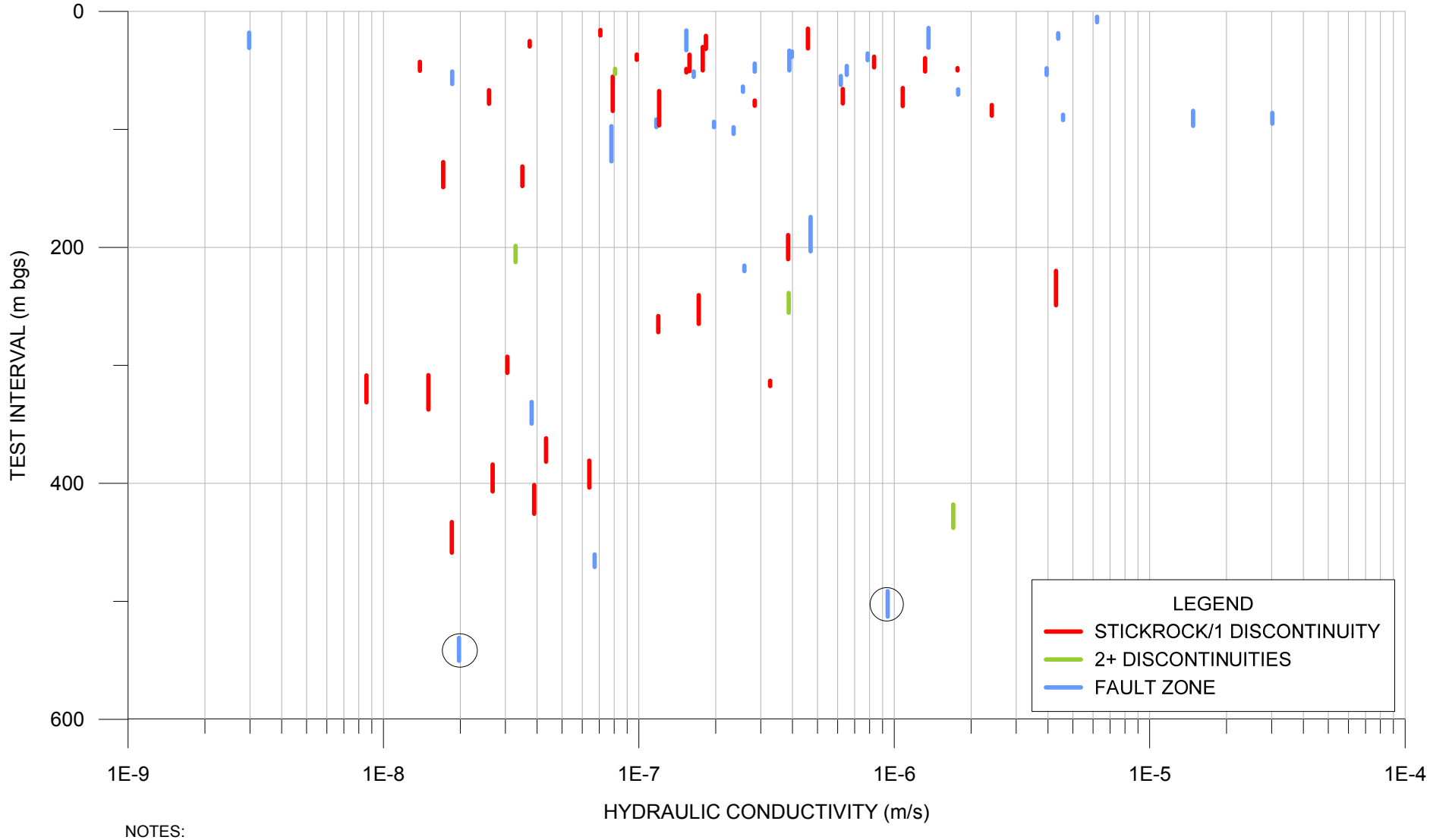
DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT DATED JUN 2014



SCALE: N/A	DESIGNED: DP	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: JUN 2014	CHECKED: CM		TITLE: HYDRAULIC CONDUCTIVITY VS. DEPTH BY LITHOLOGY
DRAWN: DP	APPROVED: TC		
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / FIG No. 08 / REV. 1

N:/Projects/1008 Pretium/010 EA 2013/002 Hydrogeology/09 Reporting/ 02 EA Modeling Report/02 Drawings

DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUN 2014

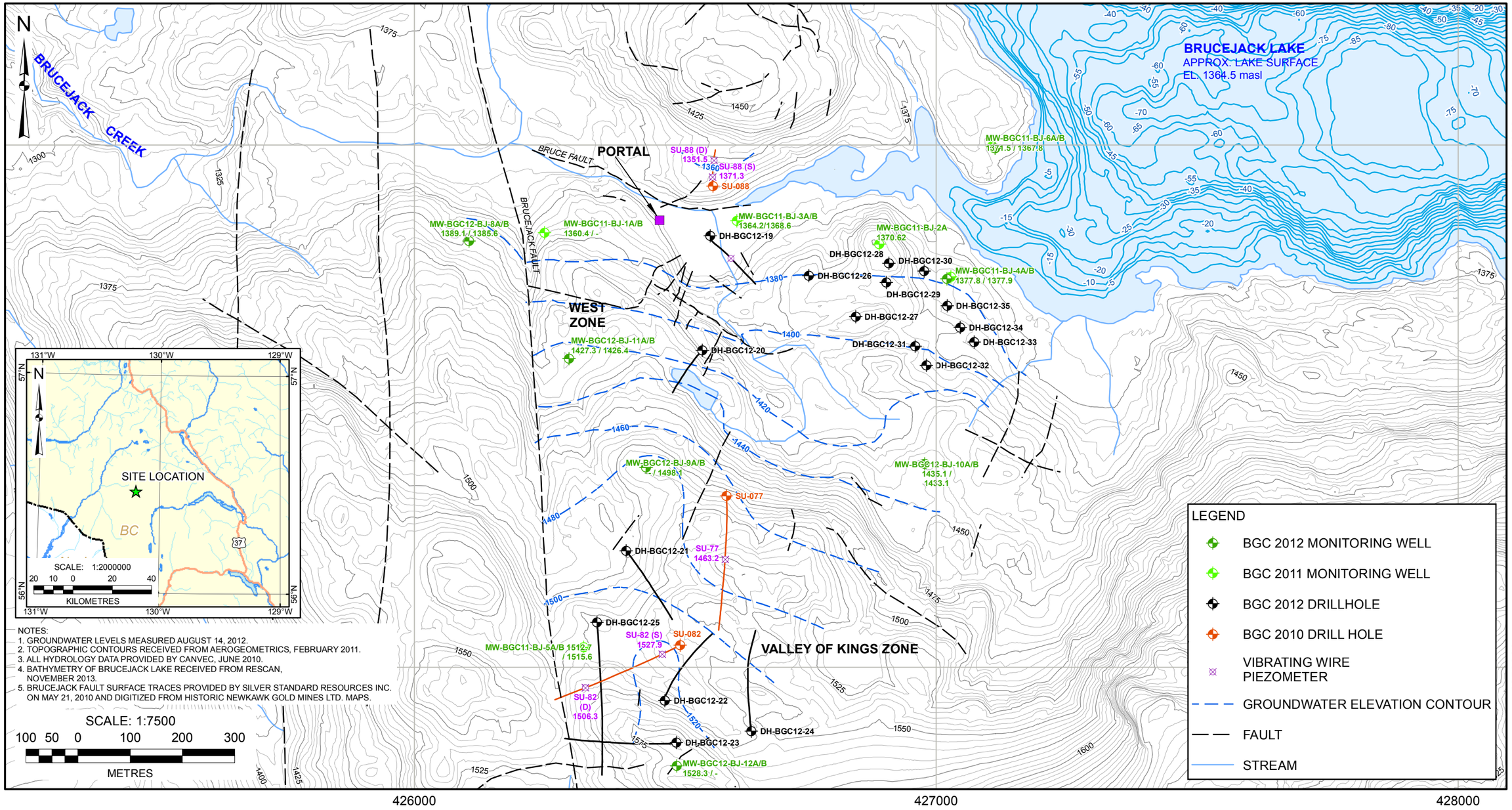


NOTES:
1) Circled results (2) are packer tests completed in the Brucejack Fault.

SCALE: N/A	DESIGNED: DP	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: JUN 2014	CHECKED: CM		TITLE: HYDRAULIC CONDUCTIVITY VS. DEPTH BY DISCONTINUITY CLASS
DRAWN: DP	APPROVED: TC		
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / FIG No. 09 / REV. 1

N:/Projects/1008 Pretium/010 EA 2013/002 Hydrogeology/09 Reporting/ 02 EA Modeling Report/02 Drawings

DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUN 2014



NOTES:
1. GROUNDWATER LEVELS MEASURED AUGUST 14, 2012.
2. TOPOGRAPHIC CONTOURS RECEIVED FROM AEROGEOMETRICS, FEBRUARY 2011.
3. ALL HYDROLOGY DATA PROVIDED BY CANVEC, JUNE 2010.
4. BATHYMETRY OF BRUCEJACK LAKE RECEIVED FROM RESCAN, NOVEMBER 2013.
5. BRUCEJACK FAULT SURFACE TRACES PROVIDED BY SILVER STANDARD RESOURCES INC. ON MAY 21, 2010 AND DIGITIZED FROM HISTORIC NEWKAWK GOLD MINES LTD. MAPS.

CONTOUR INTERVAL 5 m
NAD 1983 UTM Zone 9N

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REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:7500
DATE:	JUN 2014
DRAWN:	JCS, ST
DESIGNED:	DP
CHECKED:	CAM
APPROVED:	TC

PROFESSIONAL SEAL:

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT:
PRETIUM RESOURCES INC.

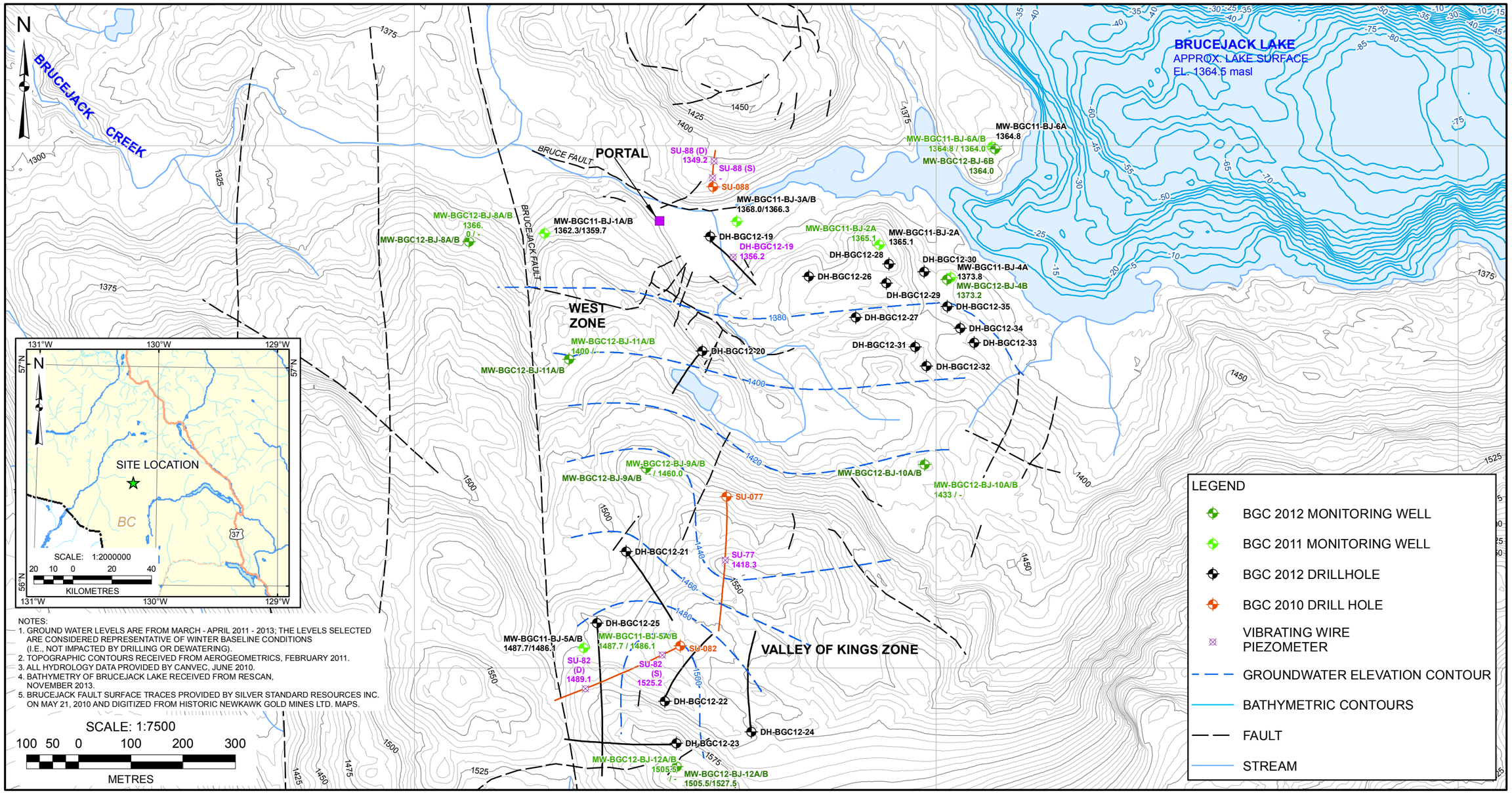
PROJECT:
BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE:
INTERPRETED GROUNDWATER ELEVATION CONTOUR MAP
SUMMER

PROJECT No.:	DWG No.:	REV.:
1008010	10	

X:\Projects\1008\010\Workspace\20132#_REPORT_BRUCEJACKPROJECT_ENVIRONMENTALASSESSMENT_HYDROGEOLOGY_BASELINE_REPORT\10_Interpreted_Groundwater_Elevation_Contour_Map_Summer.mxd

DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUNE 2014



NOTES:
1. GROUND WATER LEVELS ARE FROM MARCH - APRIL 2011 - 2013; THE LEVELS SELECTED ARE CONSIDERED REPRESENTATIVE OF WINTER BASELINE CONDITIONS (I.E., NOT IMPACTED BY DRILLING OR DEWATERING).
2. TOPOGRAPHIC CONTOURS RECEIVED FROM AEROGEOMETRICS, FEBRUARY 2011.
3. ALL HYDROLOGY DATA PROVIDED BY CANVEC, JUNE 2010.
4. BATHYMETRY OF BRUCEJACK LAKE RECEIVED FROM RESCAN, NOVEMBER 2013.
5. BRUCEJACK FAULT SURFACE TRACES PROVIDED BY SILVER STANDARD RESOURCES INC. ON MAY 21, 2010 AND DIGITIZED FROM HISTORIC NEWKAWK GOLD MINES LTD. MAPS.

CONTOUR INTERVAL 5 m
NAD 1983 UTM Zone 9N

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REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:7500
DATE:	JUN 2014
DRAWN:	MIB, ST
DESIGNED:	DP
CHECKED:	CAM
APPROVED:	TC

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: INTERPRETED GROUNDWATER ELEVATION CONTOUR MAP WINTER

PROJECT No.:	DWG No.:	REV.:
1008010	11	

DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUNE 2014

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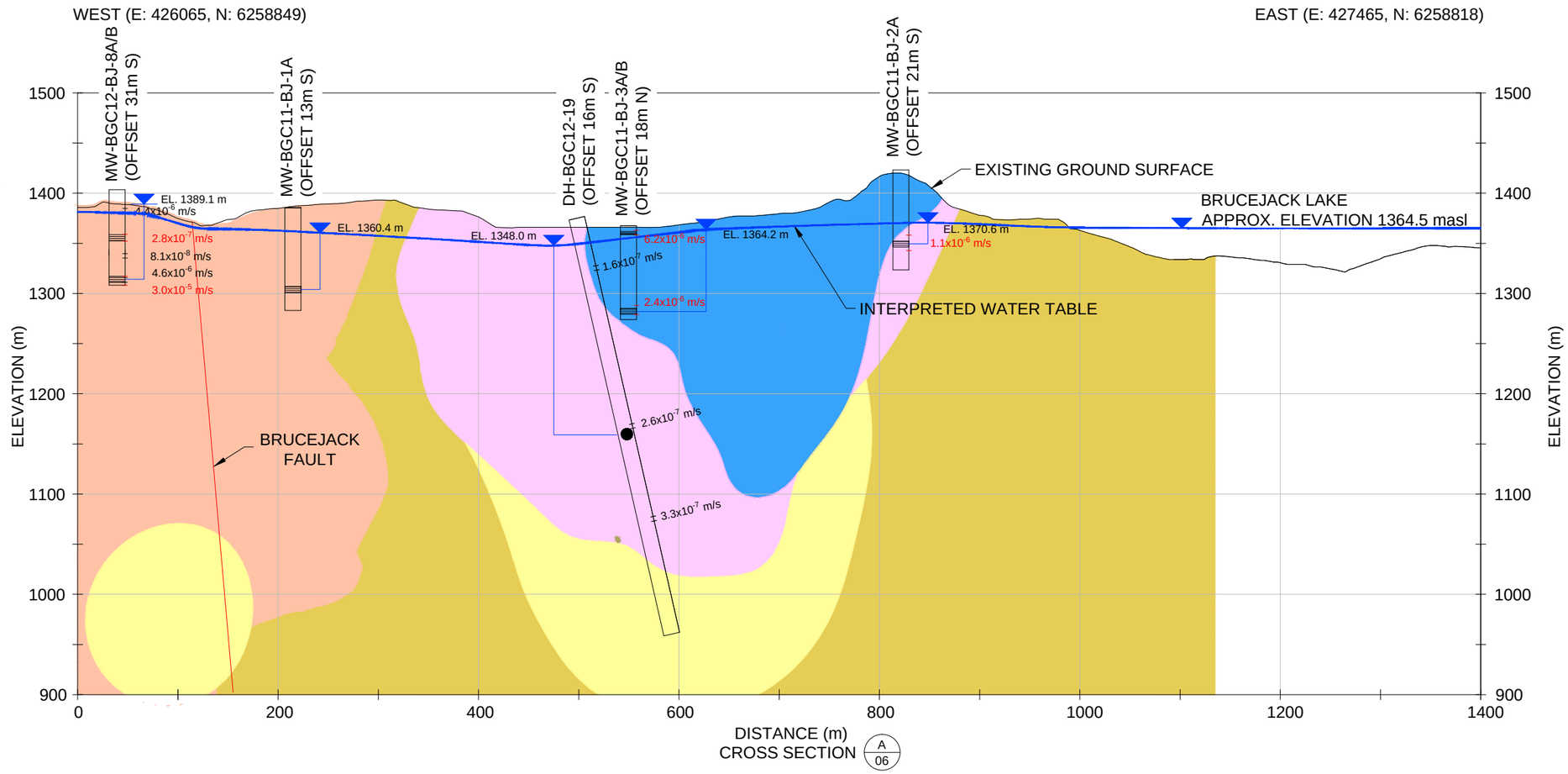

LEGEND		LITHOLOGY	
▼	GROUNDWATER ELEVATION		P2
●	VIBRATING WIRE PIEZOMETER		OFFICE P1
4.6x10-6 m/s	PACKER TEST		SILICIFIED CAP
1.1x10-6 m/s	SLUG TEST		FRAGMENTAL
	FAULT		VSF
	WELL SCREEN		CONGLOMERATE

SCALE 1:5000

100 0 100 200 300

METRES

NOTES:

1. WATER LEVELS MEASURED ON AUGUST 14, 2012.
2. DATA SETS RECEIVED FROM PRETIUM RESOURCES INC.: 3D SOLID GEOLOGIC MODEL NOVEMBER 30, 2012, UNDERGROUND DESIGN JULY 08, 2013, BULK SAMPLE AS BUILT - AUGUST 06 2013.
3. BASE TOPOGRAPHIC DATA BASED ON EAGLE MAPPING LIDAR PROVIDED BY PRETIUM RESOURCES INC, DATED OCTOBER 18, 2012.

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REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:5000
DATE:	JUN 2014
DRAWN:	SKS
DESIGNED:	DP
CHECKED:	CAM
APPROVED:	TC

PROFESSIONAL SEAL:

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: HYDROGEOLOGICAL CROSS-SECTION A

PROJECT No.:	DWG No:	REV.:
1008010	12	

DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUNE 2014

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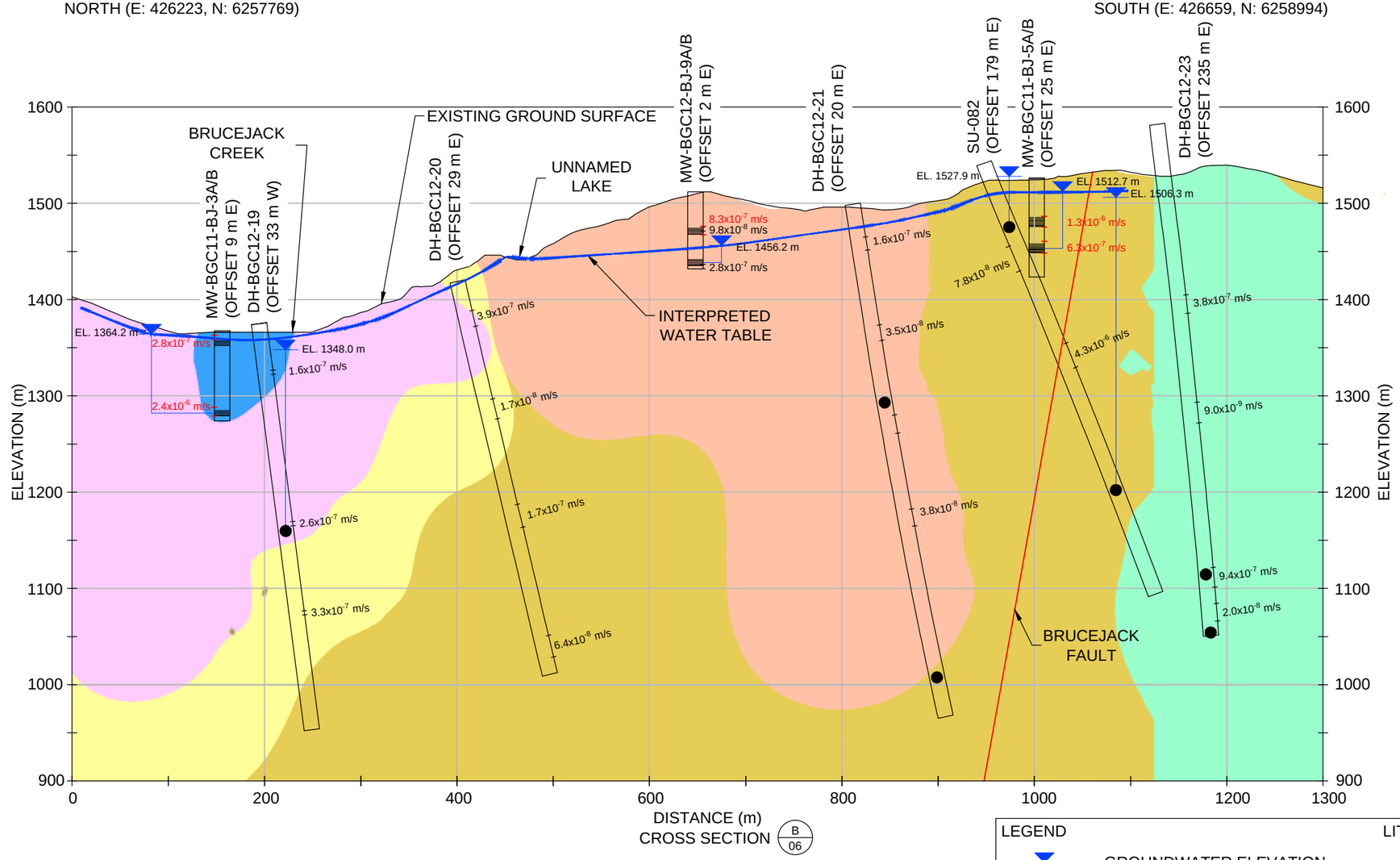

SCALE 1:5000

100 0 100 200 300

METRES

NOTES:

1. WATER LEVELS MEASURED ON AUGUST 14, 2012.
2. DATA SETS RECEIVED FROM PRETIUM RESOURCES INC.: 3D SOLID GEOLOGIC MODEL NOVEMBER 30, 2012, UNDERGROUND DESIGN JULY 08, 2013, BULK SAMPLE AS BUILT - AUGUST 06 2013.
3. BASE TOPOGRAPHIC DATA BASED ON EAGLE MAPPING LIDAR PROVIDED BY PRETIUM RESOURCES INC, DATED OCTOBER 18, 2012.

LEGEND		LITHOLOGY	
	GROUNDWATER ELEVATION		P2
	VIBRATING WIRE PIEZOMETER		OFFICE P1
$4.6x10^{-6}$ m/s	PACKER TEST		SILICIFIED CAP
$1.1x10^{-6}$ m/s	SLUG TEST		FRAGMENTAL
	FAULT		BRIDGE ZONE PORPHYRY
	WELL SCREEN		VSF
			CONGLOMERATE

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REV.	DATE	REVISION NOTES	DRAWN	CHECK	APPR.

SCALE:	1:5000
DATE:	JUN 2014
DRAWN:	SKS
DESIGNED:	DP
CHECKED:	CAM
APPROVED:	TC

PROFESSIONAL SEAL:

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: HYDROGEOLOGICAL CROSS-SECTION B

PROJECT No.:	DWG No:	REV.:
1008010	13	

DWG TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUNE 2014

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Notes:

1) Positive values for vertical hydraulic gradient indicate upward groundwater flow, while negative values indicate downward groundwater flow.
2) Dewatering of underground workings impacting groundwater elevations and gradients at the site occured from Nov 2011 to Feb 2012, and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: DP	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: JUN 2014	CHECKED: TCC		TITLE: VERTICAL HYDRAULIC GRADIENTS - WELLS 1A/B, 3A/B, 4A/B
DRAWN: DP	APPROVED: TC		
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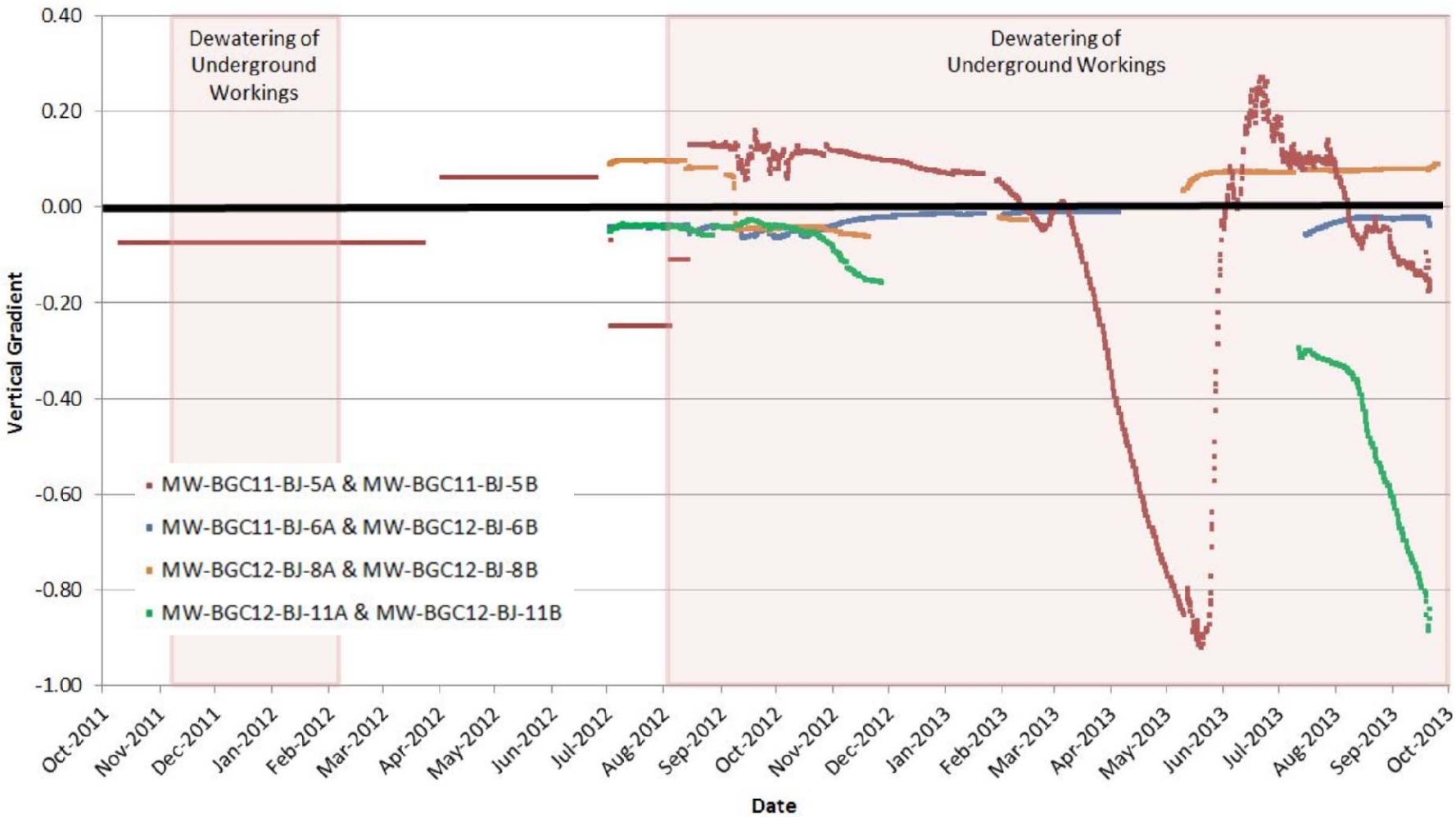
N:/BGC/Projects/0011/080 Fedorova Project/Water Management/contact water dam/Seepage Estimate/Memo/Figure 2_Run 1_0 Output.srf

DWG. TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUN 2014



Notes:

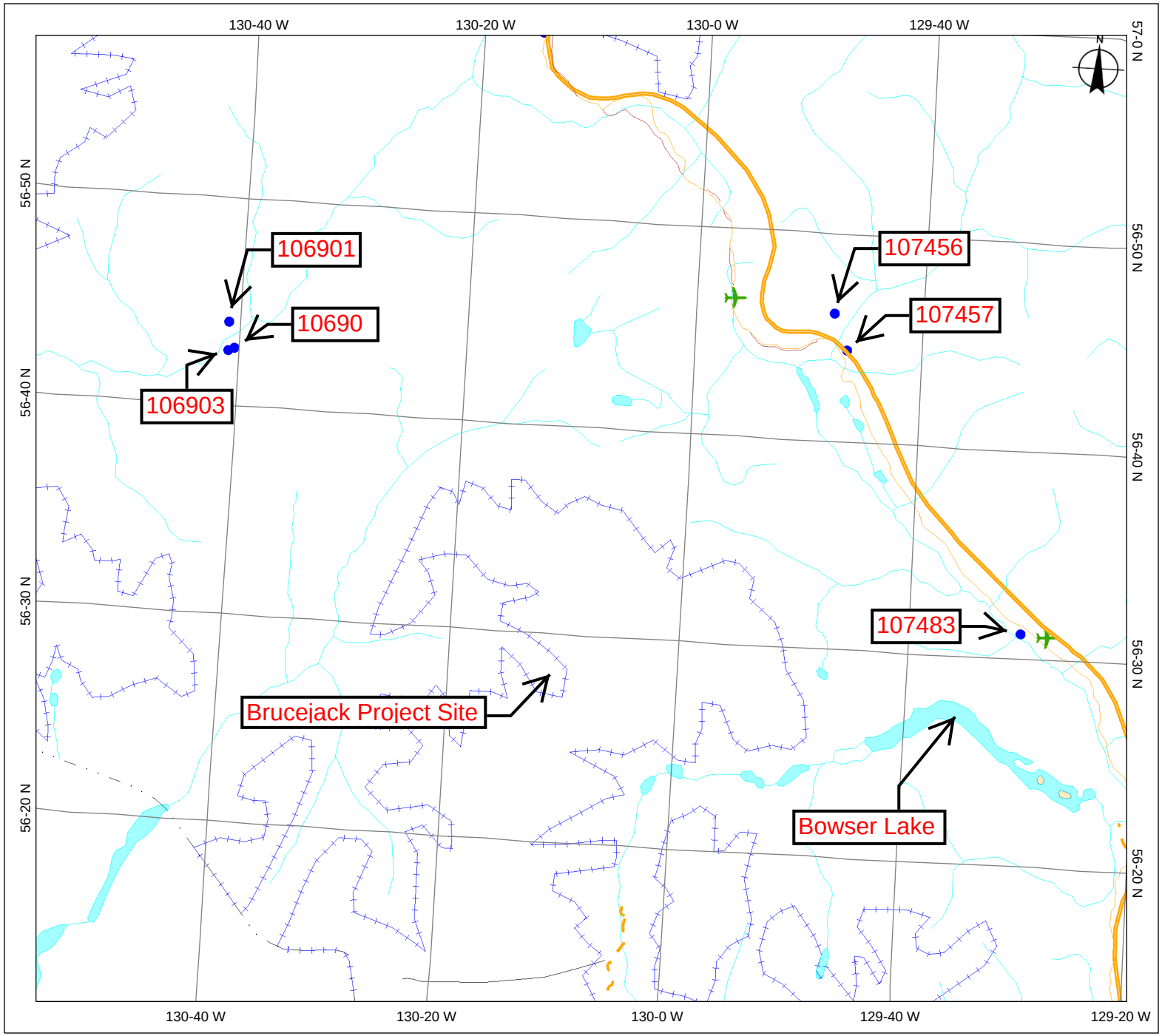
1) Positive values for vertical hydraulic gradient indicate upward groundwater flow, while negative values indicate downward groundwater flow.
2) Dewatering of underground workings impacting groundwater elevations and gradients at the site occured from Nov 2011 to Feb 2012, and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: DP	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: JUN 2014	CHECKED: TCC		TITLE: VERTICAL HYDRAULIC GRADIENTS - WELLS 5A/B, 6A/B, 8A/B, 11A/B
DRAWN: DP	APPROVED: TC		
AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT AND AUTHORIZATION FOR USE AND/OR PUBLICATION OF DATA, STATEMENTS CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS IS RESERVED PENDING OUR WRITTEN APPROVAL.		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / FIG No. 15 / REV. 0

N:/BGC/Projects/0011/080 Fedorova Project/Water Management/contact water dam/Seepage Estimate/Memo/Figure 2_Run 1_0 Output.srf

DWG. TO BE READ WITH BGC REPORT TITLED "BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT - HYDROGEOLOGY BASELINE REPORT" DATED JUN 2014

APPENDIX A
BC MOE DATABASE AQUIFER AND WELL SEARCH RESULTS



BRITISH COLUMBIA

BC Water Resources Atlas

Legend

Transportation - Roads, Railroads, etc. (1:250,000)

- Road - Paved lanes 2 or More Divided
- Ferry Route
- Aerial Cableway
- Road (Gravel Undivided) - 1 Lane
- Road (Gravel Undivided) - 3 Lanes
- Road (Paved Undivided) - Not Elevated - 1 Lane
- Road (Paved Undivided) - Not Elevated - 2 Lanes
- Road - Paved lanes 3 or More Undivided
- Road (Unimproved)
- Road - Loose access Dry Weather
- Road (Winter Road)
- Road - Paved lanes 2 Undivided
- Road - Paved lanes 2 Undivided U C
- Road - Paved Divided access Non Standard
- Track - Cart or Tractor
- Causeway (Railway)
- Cut (Roadway)
- Trail
- Tunnel
- Bridge
- Rail Line - Narrow Gauge - Single Track
- Rail Line (Multiple Track)
- Rail Line (Single Track)
- Rail Line - Abandoned Track
- Cable - Telephone
- Line (Transmission) - Electrical
- Line (Transmission) - Electrical - Primary

0 7 14 km.

Scale: 1:500,000

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Datum/Projection: NAD83, Albers Equal Area Conic

Key Map of British Columbia

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 106900

Owner: ALTA GAS LTD

Address: FORREST KERR CAMP

Area: BOB QUINN LAKE

WELL LOCATION:
Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): Well:

Class of Well: Water supply
Subclass of Well: Non-domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Commercial and Industrial
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: Y
Well Depth: 475 feet
Elevation: feet (ASL)
Final Casing Stick Up: 24 inches
Well Cap Type: 6" WTC
Bedrock Depth: 145 feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2011-12-01 00:00:00

Driller: Double D Drilling
Well Identification Plate Number: 33554
Plate Attached By: ROBERT STANVICK
Where Plate Attached: WELL HEAD

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 4 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 177.5 feet

WATER QUALITY:
Character:
Colour:
Odour: IRON
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material: Bentonite clay
Method: Poured
Depth (ft): 15 feet
Thickness (in): 2 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size

Casing from	to feet	Diameter	Material	Drive Shoe
0	360	6	Steel	Y

GENERAL REMARKS:
THIS WELL MAY BE PVC LINED FROM 340-475 FT. INSTALLED PVC LINER JAN 2012. 4 GPM AIRLIFT.

LITHOLOGY INFORMATION:
From 0 to 145 Ft. Medium VOLCANIC ROCK black
From 145 to 360 Ft. Soft POSSIBLE FRACTURES ENCOUNTERED: 145, 192, 207, 250, 330, 347 grey bedrock
From 360 to 475 Ft. MEDIUM SOFT GREY BLACK; OPEN HOLE 360-475'. POSSIBLE FRACTURE 423. vari-coloured bedrock
From 475 to 575 Ft. Soft grey bedrock

- Return to Main
- Return to Search Options
- Return to Search Criteria

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The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 106901

Owner: ALTA GAS

Address:

Area:

WELL LOCATION:
Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): Well:

Class of Well: Water supply
Subclass of Well: Non-domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Commercial and Industrial
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: Y
Well Depth: 175 feet
Elevation: feet (ASL)
Final Casing Stick Up: 18 inches
Well Cap Type: 6" WTC
Bedrock Depth: feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2011-11-12 00:00:00

Driller: Double D Drilling
Well Identification Plate Number: 33552
Plate Attached By: ROBERT STANVICK
Where Plate Attached: WELL HEAD

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 30 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 130 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material: Bentonite clay
Method: Poured
Depth (ft): 15 feet
Thickness (in): 2 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size
162	175		100

Casing from	to feet	Diameter	Material	Drive Shoe
0	162	6	Steel	Y

GENERAL REMARKS:
GROUND ELEVATION: 286 M. SURFACE SEAL: TYPE: 3/8 BENTONITE.

LITHOLOGY INFORMATION:
From 0 to 15 Ft. Medium WASTE ROCK & OR FILL brown
From 15 to 35 Ft. Medium BRKN ROCK, SAND, GRAVEL brown
From 35 to 48 Ft. Medium BRKN ROCK, SAND, GRAVEL brown
From 48 to 58 Ft. LAVA, RELATIVE HARDNESS: N/H black
From 58 to 85 Ft. Medium BRKN LAVA W/VOIDS black
From 85 to 128 Ft. Medium LAVA black
From 128 to 135 Ft. Medium BRKN LAVA OR FRACTURED ROCK W/B@ 130' black
From 135 to 162 Ft. Medium LAVA black
From 162 to 171 Ft. Medium MAJOR FAULT BRKN ROCK 30 Gallons per Minute (U.S./Imperial) AIR LIFT black
From 171 to 175 Ft. Medium VOLCANIC ROCK black

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 106903

Owner: ALTA GAS

Address:

Area:

WELL LOCATION:
Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): Well:

Class of Well: Water supply
Subclass of Well: Non-domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Other
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: Y
Well Depth: 375 feet
Elevation: feet (ASL)
Final Casing Stick Up: 20 inches
Well Cap Type: 6" WTC
Bedrock Depth: feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2011-11-15 00:00:00

Driller: Double D Drilling
Well Identification Plate Number: 33553
Plate Attached By: ROBERT STANVICK
Where Plate Attached: WELL HEAD

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 45 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 290 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material: Bentonite clay
Method: Poured
Depth (ft): 15 feet
Thickness (in): 2 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size
362	375		100

Casing from	to feet	Diameter	Material	Drive Shoe
0	368	6	Steel	Y

GENERAL REMARKS:
SUB-CLASS OF WELL: POSS. DOMESTIC BACK UP. SURFACE SEAL: TYPE: 3/8 BENTONITE.

LITHOLOGY INFORMATION:
From 0 to 4 Ft. Medium LAVA BRKN red
From 4 to 18 Ft. Hard SOLID ROCK black
From 18 to 35 Ft. Medium BRKN VOLCANIC black
From 35 to 255 Ft. VOLCANIC ROCK, RELATIVE HARDNESS: M/H VARIOUS VOIDS OR NO RETURNS DUE TO FORMATION black
From 255 to 295 Ft. Medium OXIDIZED VOLCANIC ROCK COLOUR: R/BLK vari-coloured
From 295 to 310 Ft. Very hard VOLCANIC black
From 310 to 332 Ft. Very hard VOLCANIC FRACTURE @ 324' black
From 332 to 348 Ft. Very hard VOLCANIC ROCK W/BRN TILE black
From 348 to 355 Ft. Medium FINE & MED SAND, ROCK & TRACE FINE GRAVEL COLOUR: MULTI vari-coloured
From 355 to 375 Ft. Medium MIXED SAND & MIXED GRAVEL 45 Gallons per Minute (U.S./Imperial) grey

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 107456

Owner: VALLARD CONSTRUCTION

Address: HIGHWAY 37

Area: BELL II

WELL LOCATION:
Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): Well:

Class of Well: Water supply
Subclass of Well: Non-domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Commercial and Industrial
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: Y
Well Depth: 225 feet
Elevation: 620 feet (ASL)
Final Casing Stick Up: 18 inches
Well Cap Type: 6" WTC
Bedrock Depth: feet
Lithology Info Flag:
File Info Flag:
Sieve Info Flag:
Screen Info Flag:

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2012-08-13 00:00:00

Driller: Double D Drilling
Well Identification Plate Number: 33574
Plate Attached By: ROBERT STANVICK
Where Plate Attached: WELL HEAD

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 4 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag:
Artesian Flow:
Artesian Pressure (ft):
Static Level: 174 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag:
Material: Bentonite clay
Method:
Depth (ft): 15 feet
Thickness (in): 4 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size
221	225		10

Casing from	to feet	Diameter	Material	Drive Shoe
0	220	6	Steel	Y

GENERAL REMARKS:
CLIENT DID NOT SUPPLY LEGAL DESCRIPTIONS

LITHOLOGY INFORMATION:

From	0 to	15 Ft.	Medium MED COARSE GRAVEL MIXED SANDS	brown
From	15 to	30 Ft.	Medium STICKY SAND & GRAVEL TRACE OF TILL	grey
From	30 to	170 Ft.	Hard grey till	
From	170 to	180 Ft.	FINE SAND & SILT MEDIUM HARD grey	
From	180 to	193 Ft.	Hard grey till	
From	193 to	225 Ft.	Medium FINE SAND TRACE SILT	black
From	225 to	235 Ft.	Medium FINE SAND TRACE SILT	grey
From	235 to	251 Ft.	Medium FINE SAND TRACE SILT	black
From	251 to	280 Ft.	Medium CLAY SILT	grey
From	280 to	295 Ft.	Medium FINE SAND TRACE OF SILT	grey

- Return to Main

- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 107457

Owner: VALLARD CONSTRUCTION

Address: HIGHWAY 37

Area: BELL II

WELL LOCATION:
Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): Well:

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Commercial and Industrial
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: Y
Well Depth: 45 feet
Elevation: 597 feet (ASL)
Final Casing Stick Up: 18 inches
Well Cap Type: 6" WTC
Bedrock Depth: 107 feet
Lithology Info Flag: Y
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: Y

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2012-08-11 00:00:00

Driller: Double D Drilling
Well Identification Plate Number: 33573
Plate Attached By: ROBERT STANVICK
Where Plate Attached: WELL HEAD

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 8 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Pumping
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 22 feet

WATER QUALITY:
Character:
Colour:
Odour: SLIGHT IRON
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: Y
Material: Bentonite clay
Method: Poured
Depth (ft): 15 feet
Thickness (in): 4 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size
41	45		50

Casing from	to feet	Diameter	Material	Drive Shoe
0	42	6	Steel	Y

GENERAL REMARKS:
CLIENT DID NOT PROVIDE LEGAL DESCRIPTIONS

LITHOLOGY INFORMATION:
From 0 to 8 Ft. Hard COARSE GRAVEL BOULDERS MIXED SAND TRACE TILL grey
From 8 to 35 Ft. Medium SOME COBBLES COARSE GRAVEL MIXED SANDS DAMP VERY STICKY; POSSIBLE WB @ 25' brown
From 35 to 47 Ft. Medium FINE-MED GRAVEL MIXED SAND 8 U.S. Gallons per Minute grey
From 47 to 90 Ft. Medium SILT CLAY grey
From 90 to 107 Ft. Hard grey till
From 107 to 135 Ft. Hard black bedrock

- Return to Main
- Return to Search Options
- Return to Search Criteria

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BRITISH COLUMBIA

Report 1 - Detailed Well Record

Well Tag Number: 107483

Owner: PRETIUM EXPLORATION

Address: KM215 HIGHWAY 37

Area: WILDFIRE CAMP

WELL LOCATION:
Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island:
BCGS Number (NAD 27): Well:

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Private Domestic
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: 6 inches
Casing drive shoe: Y
Well Depth: 95 feet
Elevation: feet (ASL)
Final Casing Stick Up: 18 inches
Well Cap Type: 6" WTC
Bedrock Depth: feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: Y

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2012-11-06 00:00:00

Driller: Double D Drilling
Well Identification Plate Number: 33581
Plate Attached By: ROBERT STANVICK
Where Plate Attached: WELL HEAD

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 50 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 63 feet

WATER QUALITY:
Character:
Colour: SLIGHT BR
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: Y
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name: WILDFIRE CAMP
Water Supply System Well Name: WILDFIRE CAMP

SURFACE SEAL:
Flag: Y
Material: Bentonite clay
Method: Poured
Depth (ft): 15 feet
Thickness (in): 4 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

Screen from	to feet	Type	Slot Size
91	95		50

Casing from	to feet	Diameter	Material	Drive Shoe
0	90	6	Steel	Y

GENERAL REMARKS:
WELL WILL CLEAN UP WITH PUMPING. CLIENT DID NOT SUPPLY LEGAL DESCRIPTION.

LITHOLOGY INFORMATION:
From 0 to 8 Ft. Hard COARSE GRAVEL COBBLES COARSE SAND brown
From 8 to 33 Ft. Hard grey till
From 33 to 95 Ft. Hard COARSE GRAVEL COARSE SAND 50 GPM AIRLIFT; TEMP = 2.2C black

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- Return to Search Options
- Return to Search Criteria

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APPENDIX B
MONITORING WELL LOGS

Project: Brucejack
Project No.: 1008-004

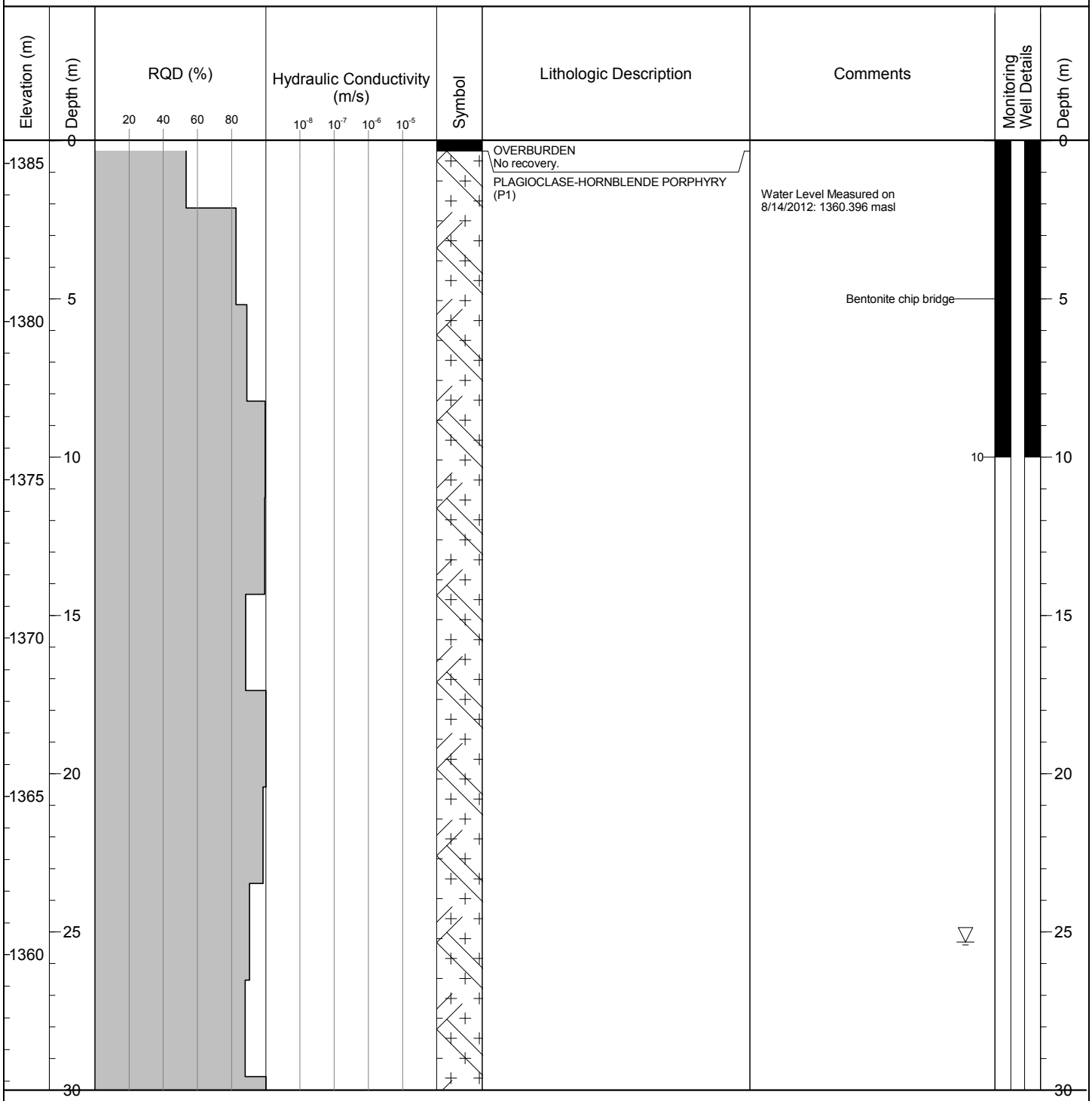
DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

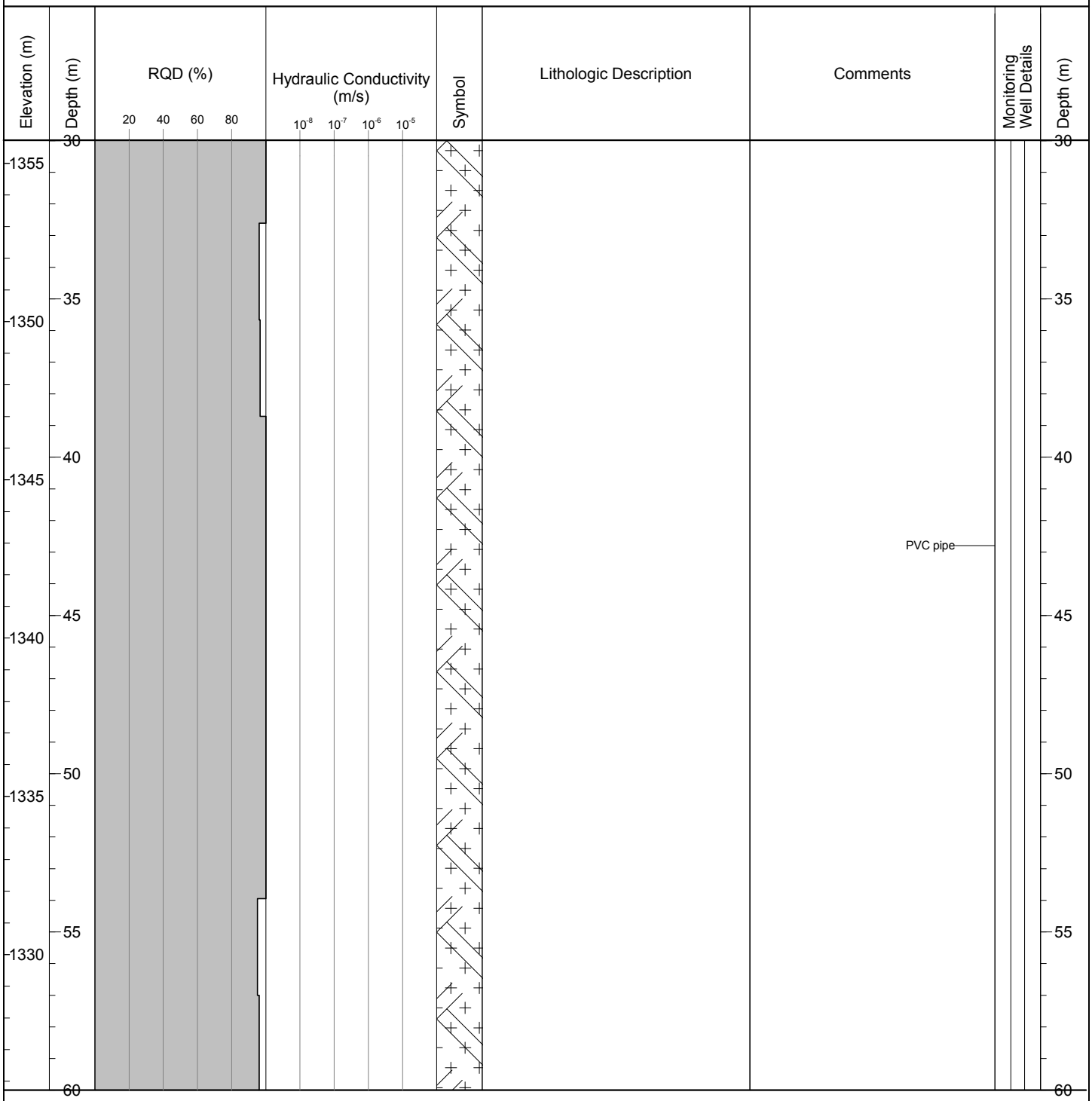
DRILL HOLE # MW-BGC11-BJ-1A

Project: Brucejack
Project No.: 1008-004
Location: West Zone

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

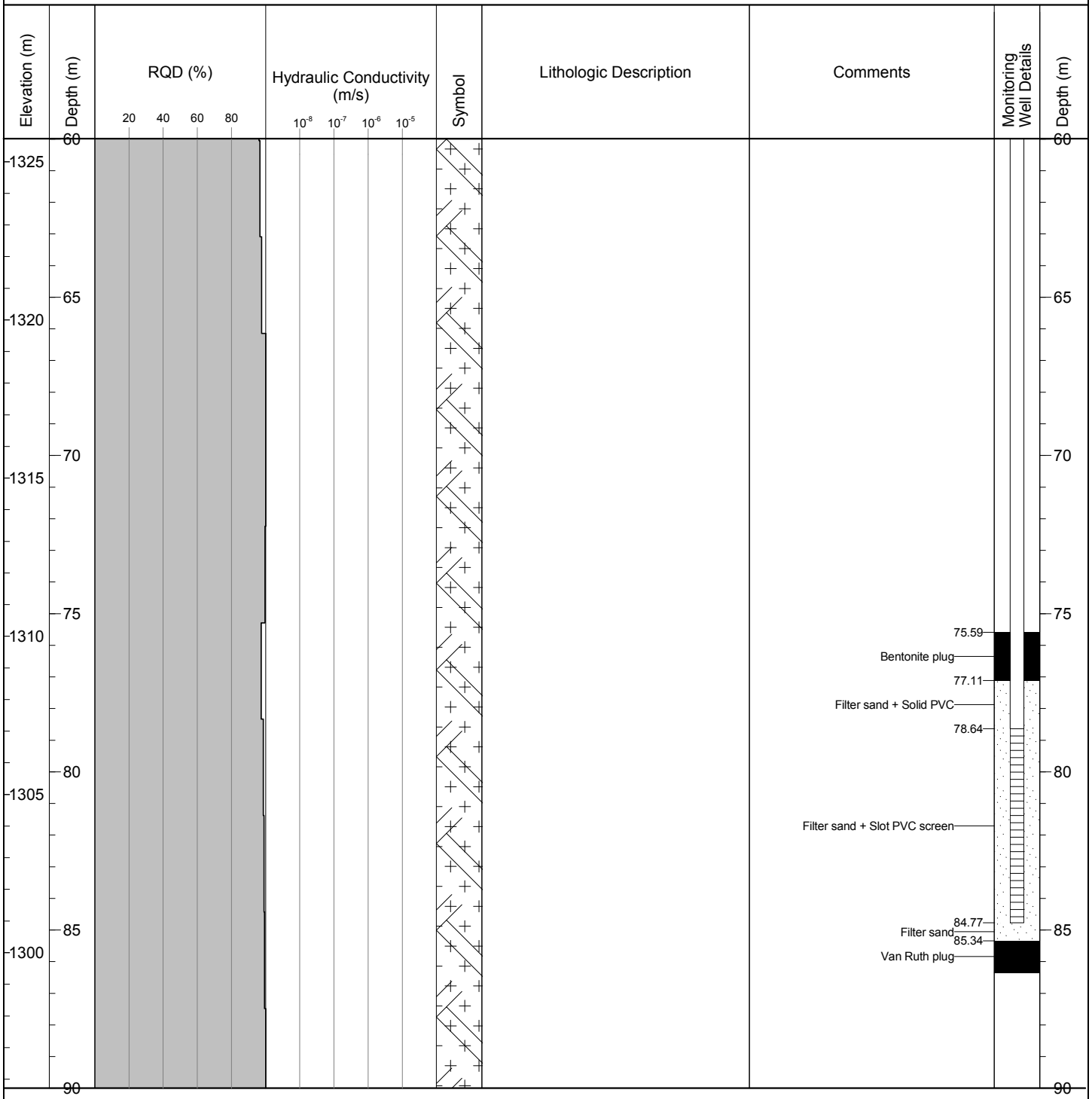
DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

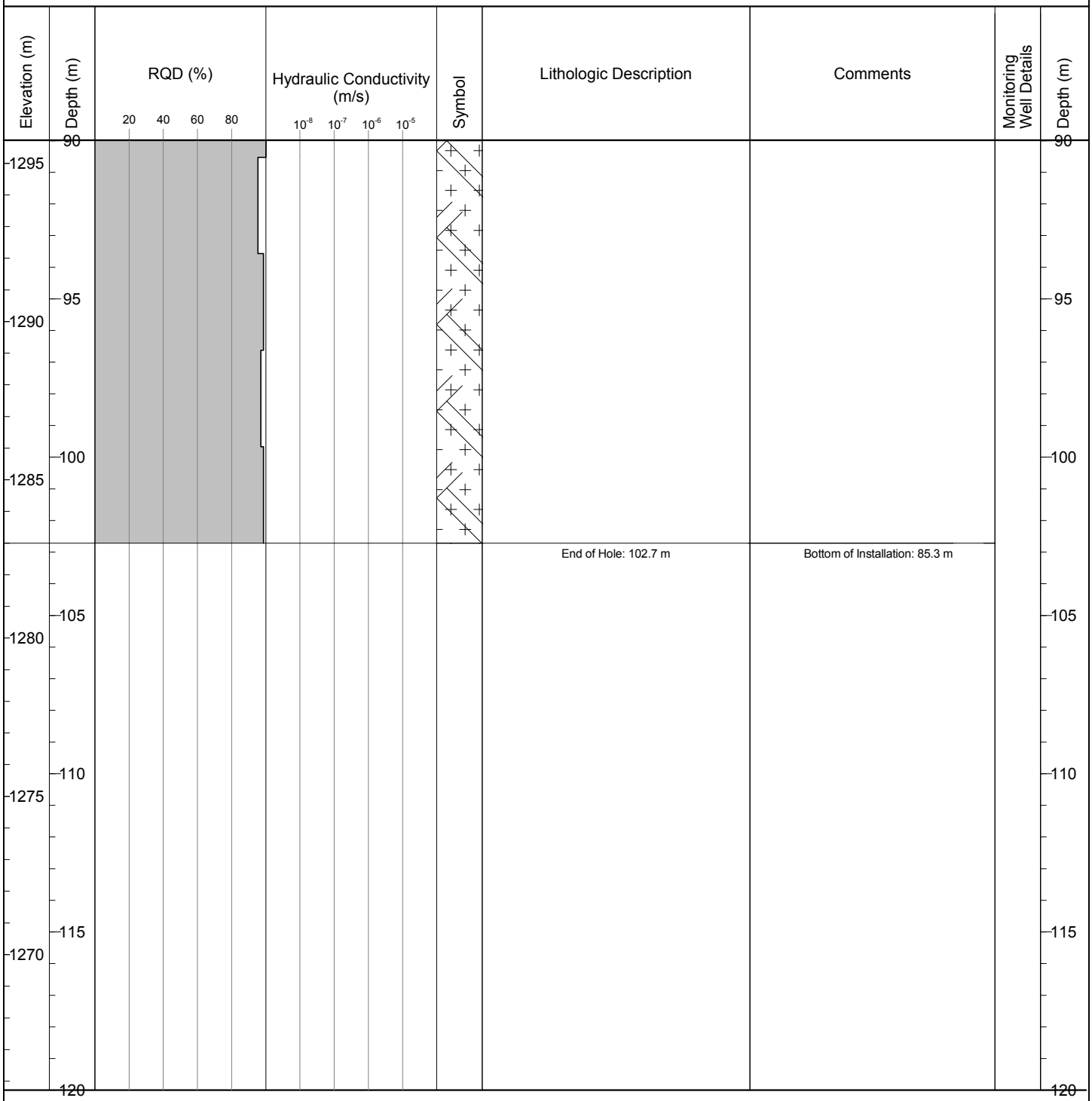
DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1B

Location: West Zone

Co-ordinates (m): 426,280E - 6,258,841N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.4
Cased To (m): NO CASING INSTALLED

Start date: 02 Oct 11
Finish Date: 02 Oct 11
Final Depth (m): 38.7
Depth To Top Of Rock (m): 0.4
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1385	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		OVERBURDEN No recovery. PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)			0
						Bentonite chip bridge		
	5							5
1380						6		
	10							10
1375								
	15							15
1370								
						PVC pipe		
	20							20
1365								
	25							25
1360								
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC11-BJ-1B

Project: Brucejack
Project No.: 1008-004
Location: West Zone

Co-ordinates (m): 426,280E - 6,258,841N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.4
Cased To (m): NO CASING INSTALLED

Start date: 02 Oct 11
Finish Date: 02 Oct 11
Final Depth (m): 38.7
Depth To Top Of Rock (m): 0.4
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1355	30					30.1 Bentonite plug; 31.3 Filter sand + Solid PVC		30
1350	35					35.3 Filter sand + Slot PVC screen; 38.4 Filter sand		35
1345	40				End of Hole: 38.7 m	Bottom of Installation: 38.7 m		40
1340	45							45
1335	50							50
1330	55							55
	60							60

BGC ENGINEERING INC.
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CLIENT: Pretium Resources Inc.

Project: Brucejack
Project No.: 1008-004

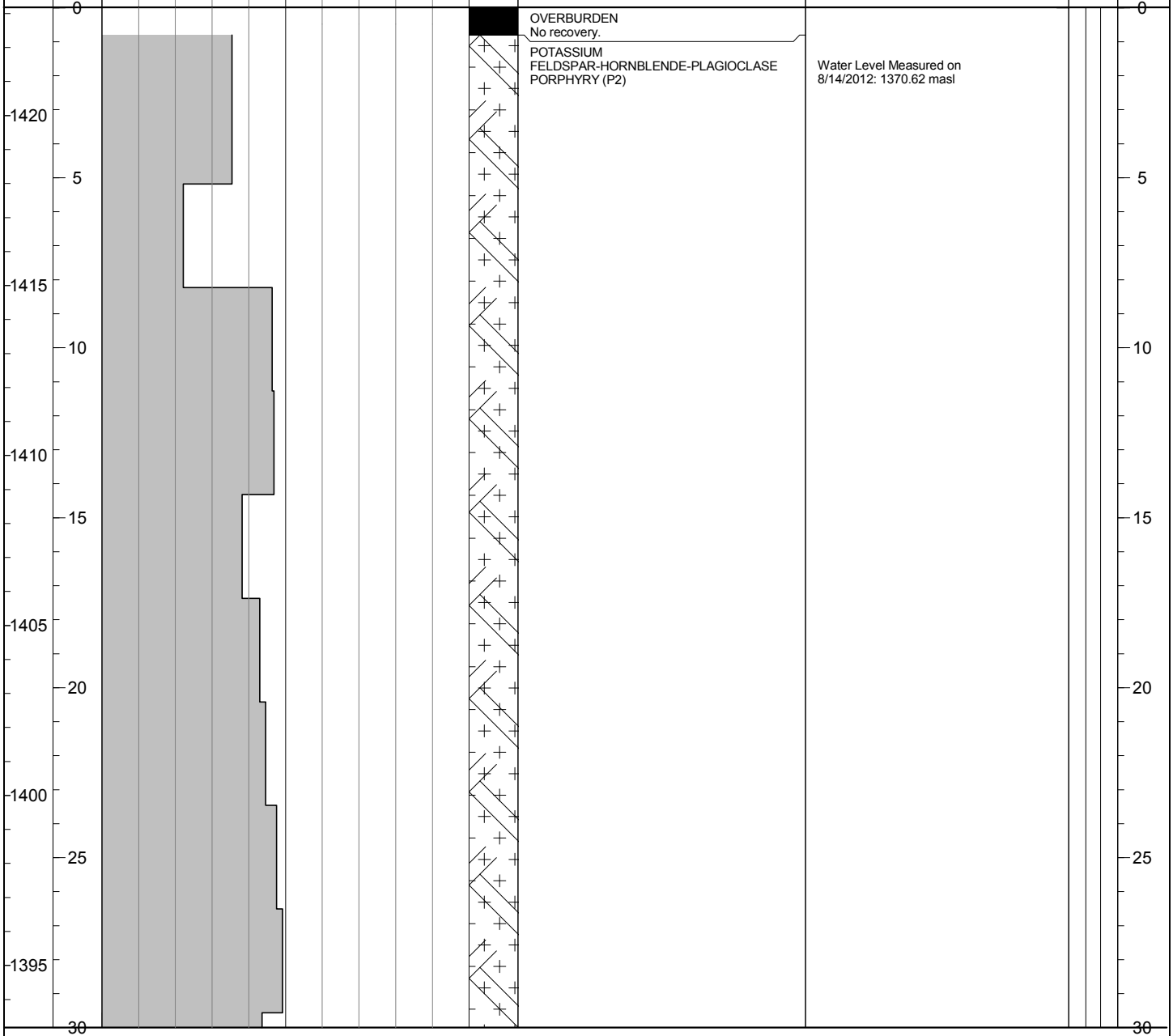
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

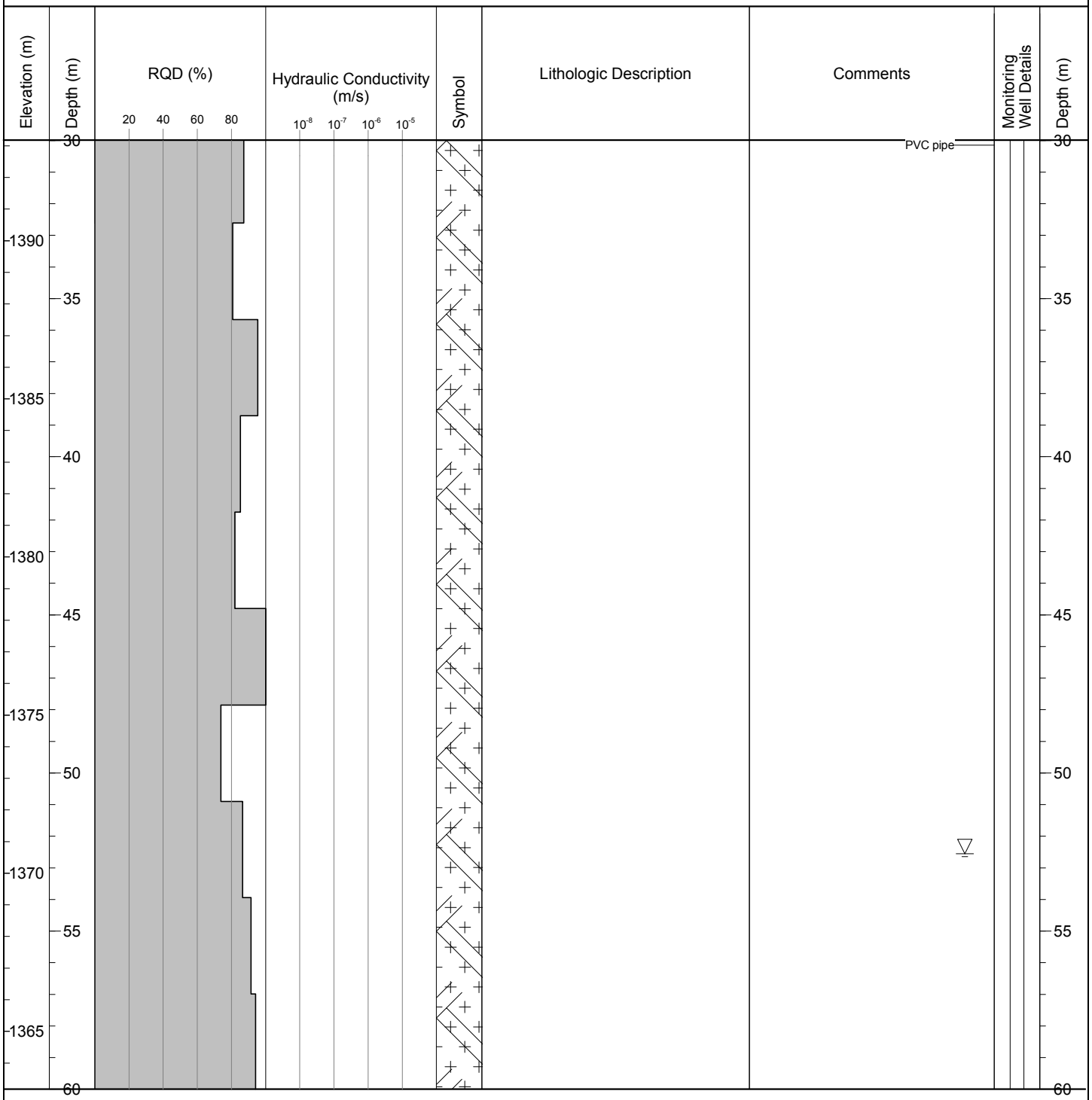
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

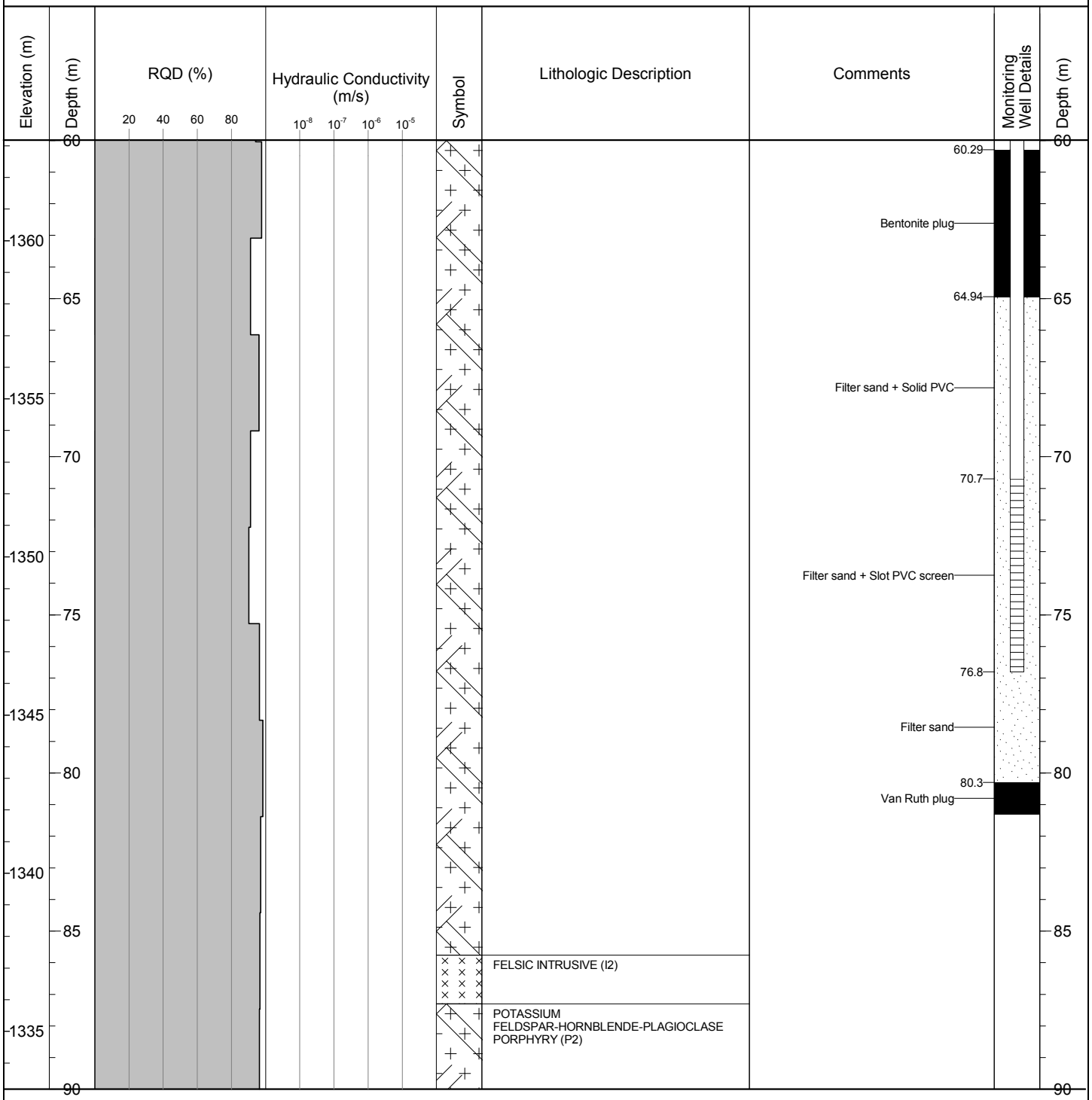
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90							90
1330					POLYLITHIC CONGLOMERATE (S3)			
	95							95
1325								
	100				FELSIC VOLCANICS (V11)	Bottom of Installation: 80.3 m		100
					End of Hole: 99.7 m			
1320								
	105							105
1315								
	110							110
1310								
	115							115
1305								
	120							120

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		OVERBURDEN No recovery.			0
1365					PLAGIOCLASE PORPHYRY (P3)	Water Level Measured on 8/14/2012: 1364.177 masl		
	5							5
1360								
	10							10
1355								
	15							15
1350								
	20							20
1345								
	25							25
1340								
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

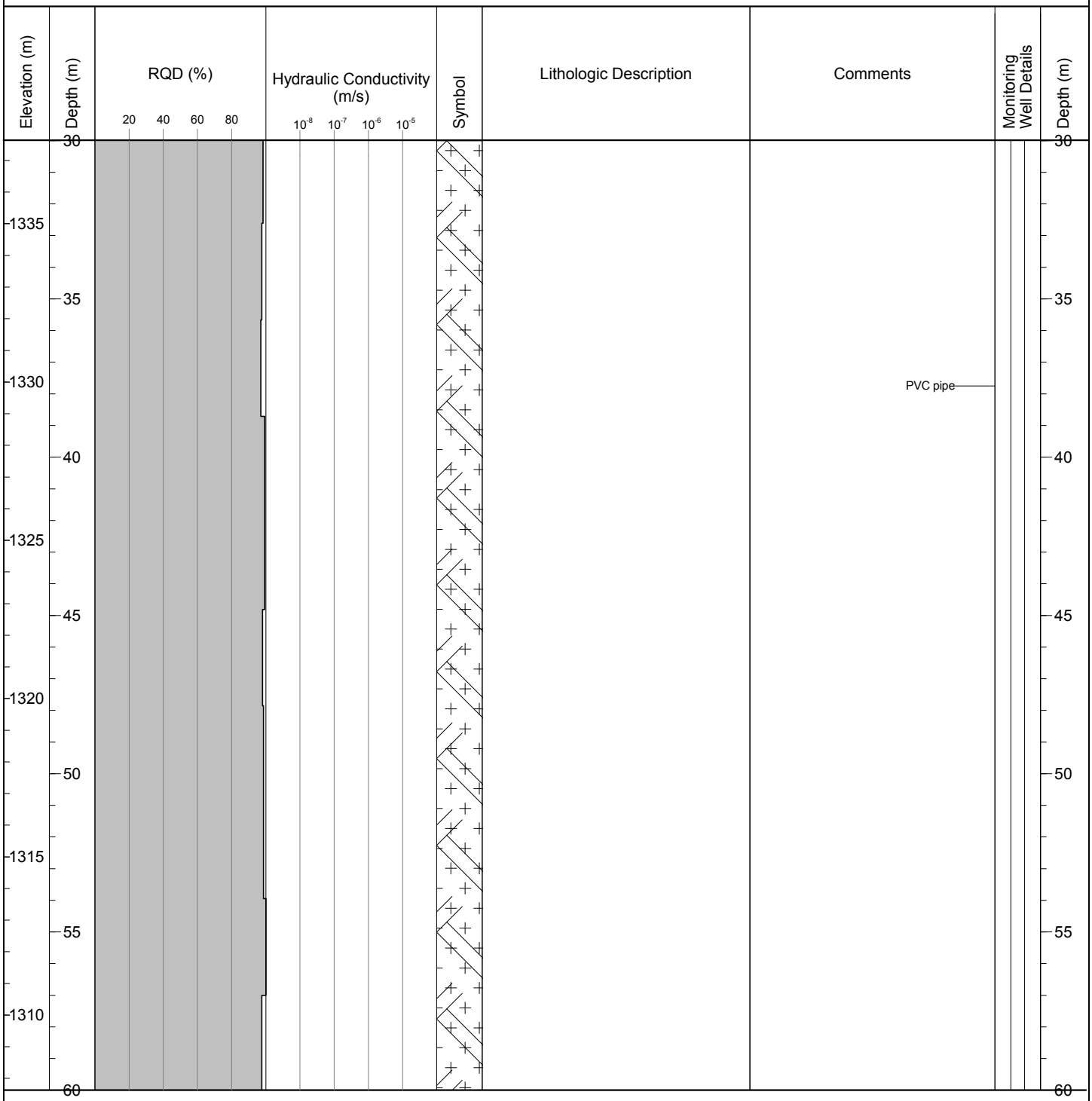
DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

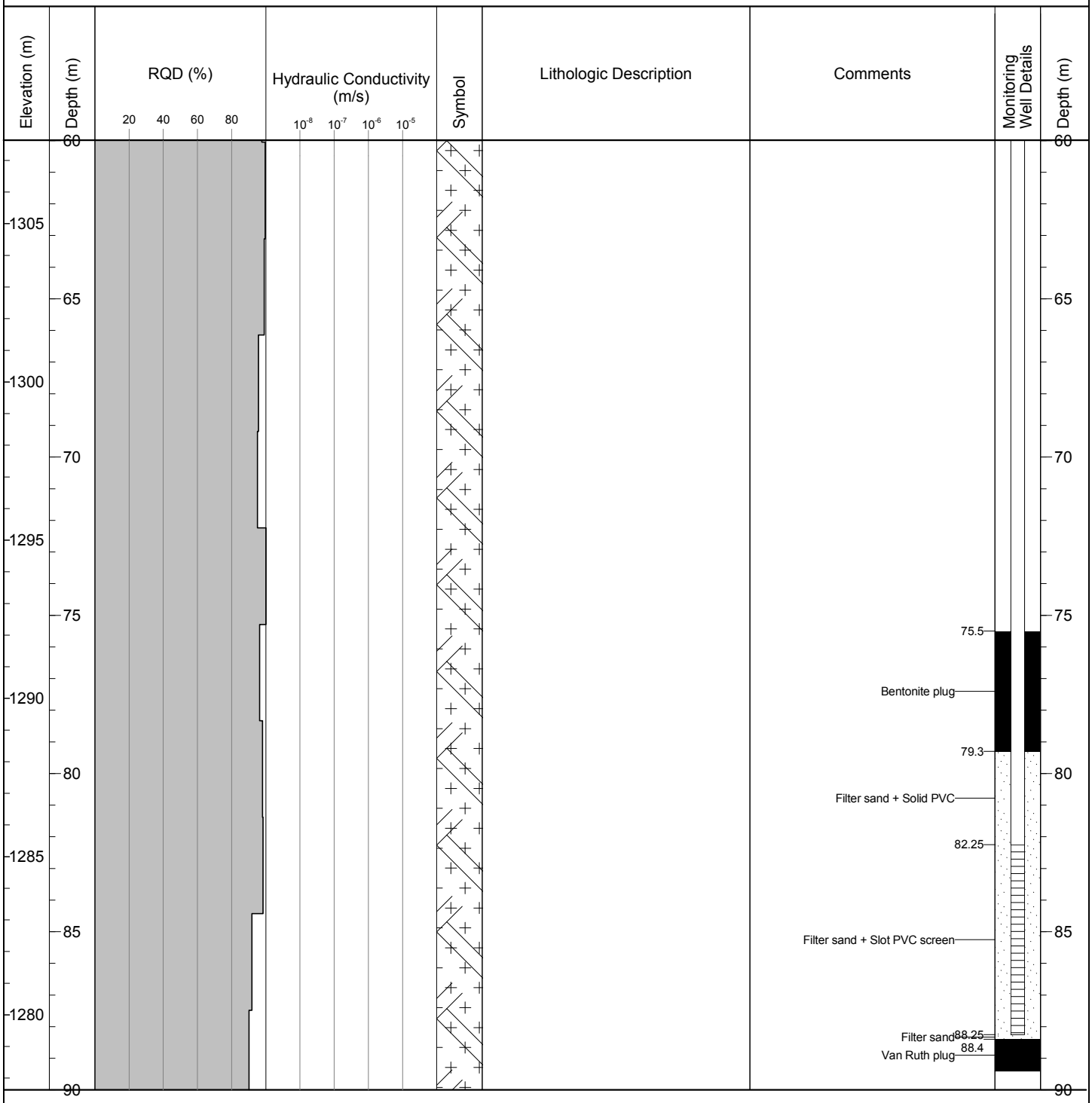
DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1275	90							90
					End of Hole: 93.6 m	Bottom of Installation: 88.4 m		
1270	95							95
1265	100							100
1260	105							105
1255	110							110
1250	115							115
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC11-BJ-3B

Project: Brucejack
Project No.: 1008-004
Location: West Zone

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.53
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.23
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 9.4
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		OVERBURDEN No recovery.			0
1365					PLAGIOCLASE PORPHYRY (P3)	Water Level Measured on 8/14/2012: 1368.632 m	Bentonite plug	
	5						4.5 Filter sand + Solid PVC 5.8	5
1360							Filter sand + Slot PVC screen Filter sand 8.8	
	10				End of Hole: 9.4 m	Bottom of Installation: 9.1 m		10
1355								
	15							15
1350								
	20							20
1345								
	25							25
1340								
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

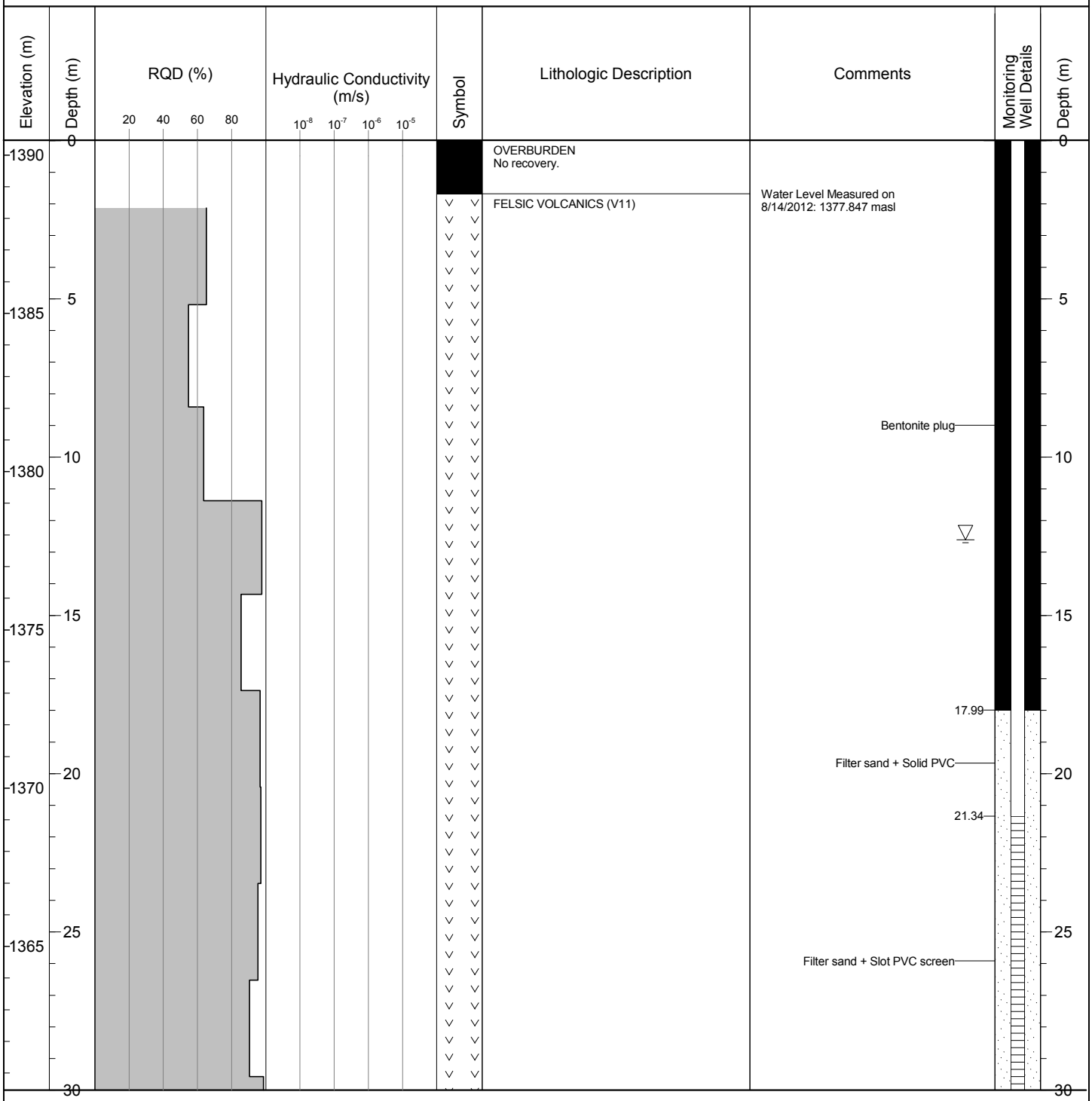
DRILL HOLE # MW-BGC11-BJ-4A

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,750N
Ground Elevation (m): 1,390.46
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.4
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1390.9
Cased To (m): 3

Start date: 04 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 32.6
Depth To Top Of Rock (m): 1.7
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-4A

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,750N
Ground Elevation (m): 1,390.46
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.4
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1390.9
Cased To (m): 3

Start date: 04 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 32.6
Depth To Top Of Rock (m): 1.7
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1360	30					Filter sand 30.49–31; Van Ruth plug		30
					End of Hole: 32.6 m	Bottom of Installation: 31.0 m		
1355	35							35
1350	40							40
1345	45							45
1340	50							50
1335	55							55
	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1390	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PELITE (S5) Interbedded with arenite (S4) with some clasts that are subangular and moderately sorted. No significant mineralization or veining (1-2%). Medium strong (R3-R3.5) from top of bedrock to 5.1 m below ground surface. Strong to very strong (R4-R4.5) below 5.1 m. Slight to moderate weathering (W2-W2.5) on major discontinuities from top of bedrock to 5.1 m below ground surface. Faint alteration (A1-A1.5) below 5.1 m.	Water Level Measured on 8/14/2012: 1377.87 masl		0
1385	5							5
1380	10							10
1375	15				ARENITE (S4) Grey-green, medium grained, interbedded with minor sections of finer grained sands and silts (S5). Quartz-calcite-pyrite concretions and chlorite stringers evident. Locally laminated at approximately 30 degrees TCA. Strong to very strong (R4-R4.5). Faint to no alteration (A1-A1.5).			15
1370	20							20
1365	25							25
	30							30

BGC ENGINEERING INC.
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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

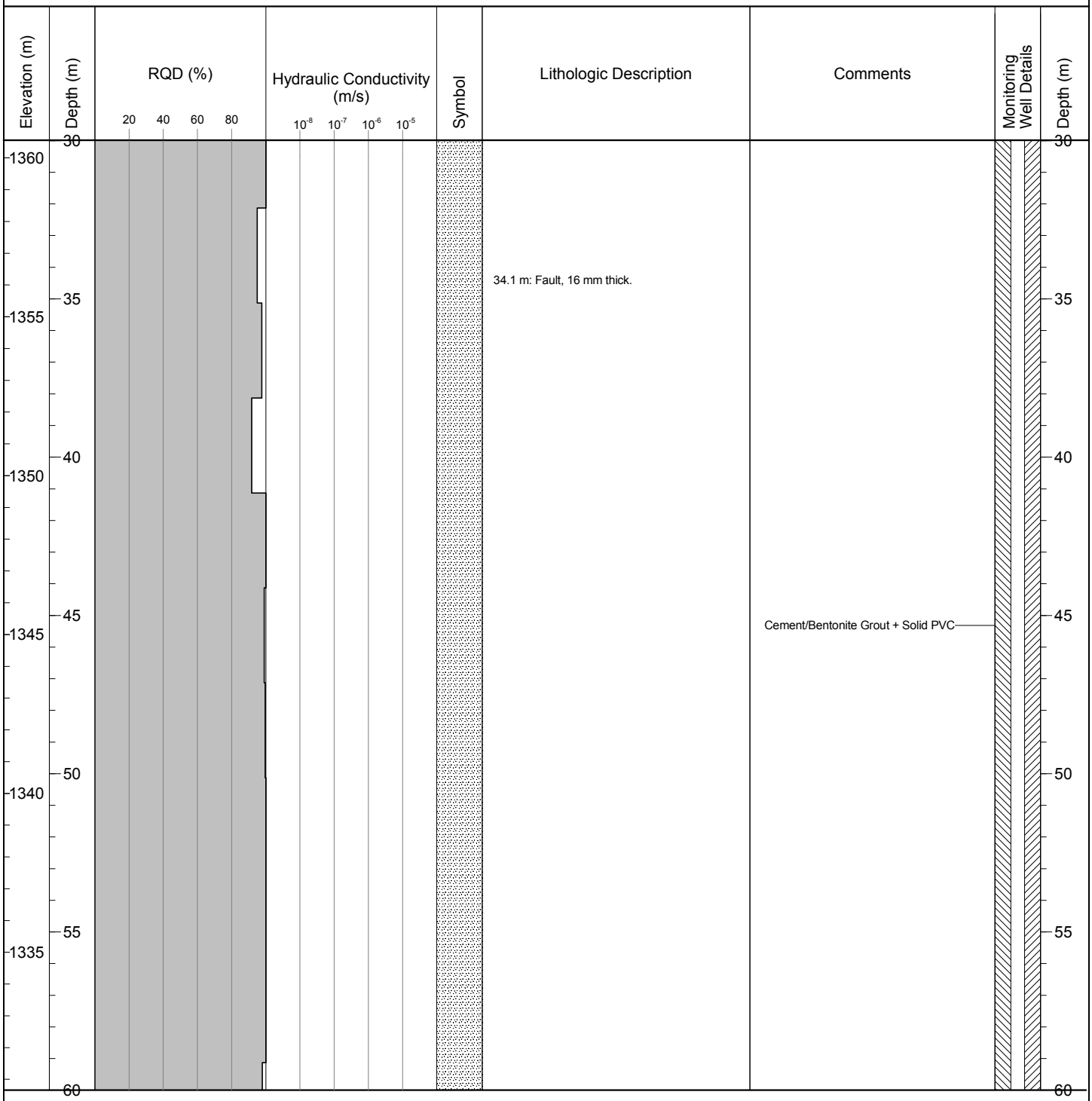
DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1330	60							60
1325	65				65.1 m: Shear, 1 mm thick. 66.5 - 98.13 m: Coarser grained sandstone. Minor sections of larger clasts (on pebble scale). Larger clasts more angular and poorly sorted. Pyrite replacement of clasts, and pyrite abundant in veinlets and blebs. Veining 1-5%.			65
1320	70				72.9 m: Fault, 80 mm thick, broken rock.			70
1315	75							75
1310	80							80
1305	85							85
	90							90

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1300	90					90.63 3/8" Coated Bentonite pellets + Solid PVC 91.63		90
1295	95				95.7 m: Fault, 100 mm thick, broken rock.	94.88 10/20 Filter sand + 0.020 Slot PVC screen 97.93		95
					End of Hole: 98.1 m	Bottom of Installation: 98.1 m		
1290	100							100
1285	105							105
1280	110							110
1275	115							115
	120							120

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

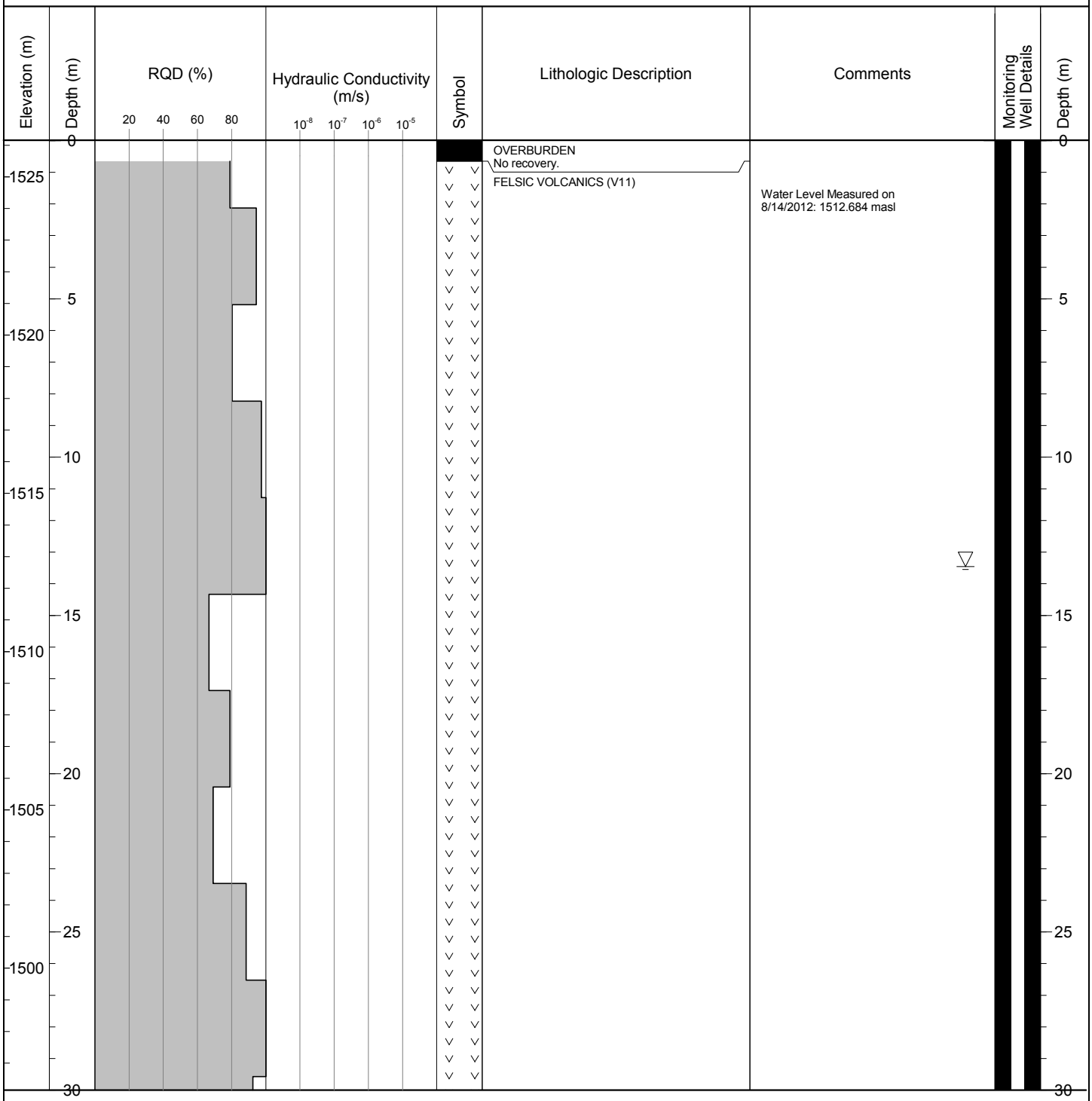
DRILL HOLE # MW-BGC11-BJ-5A

Location: Valley of Kings Zone

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

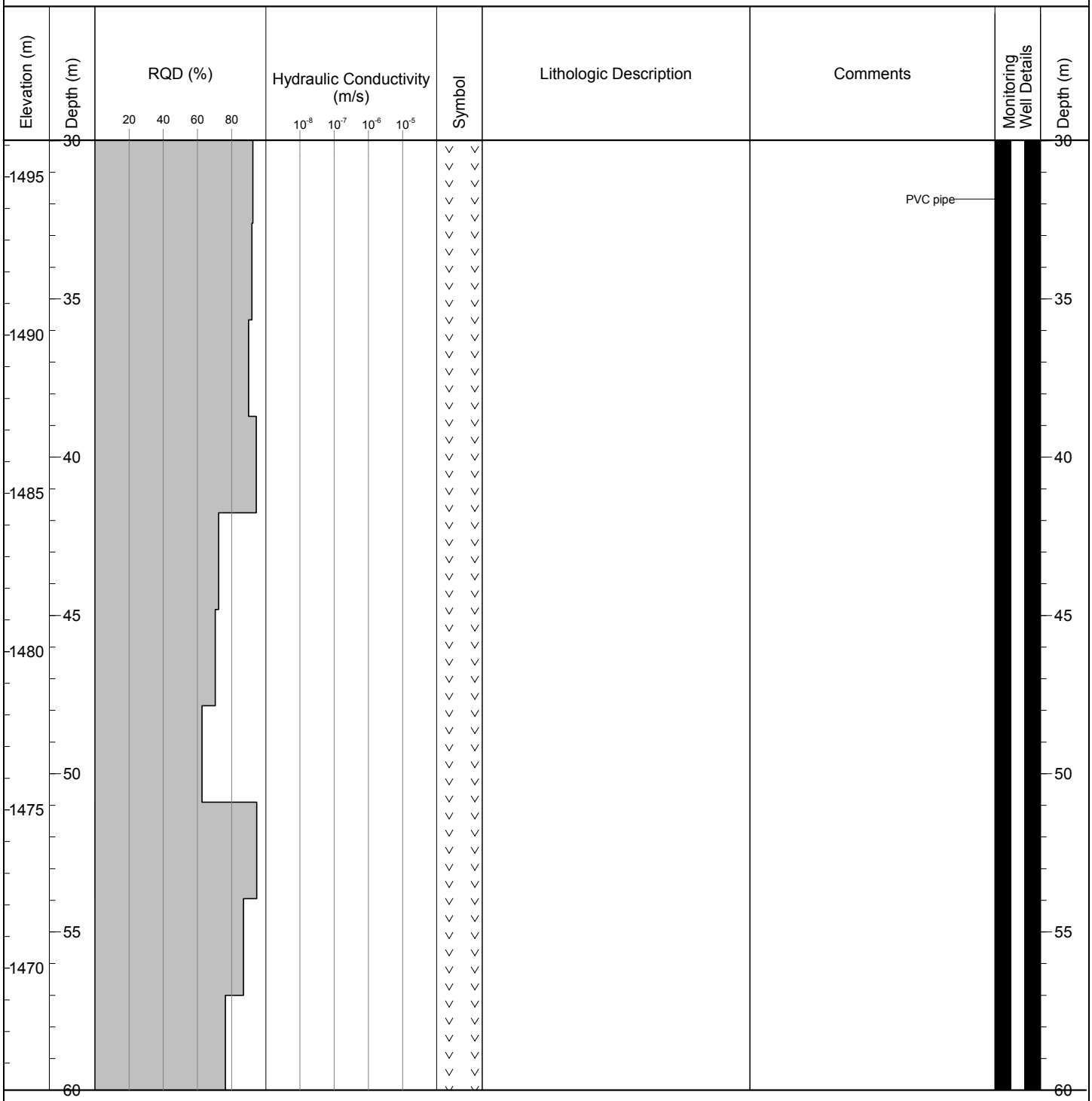
DRILL HOLE # MW-BGC11-BJ-5A

Location: Valley of Kings Zone

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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Project: Brucejack
Project No.: 1008-004

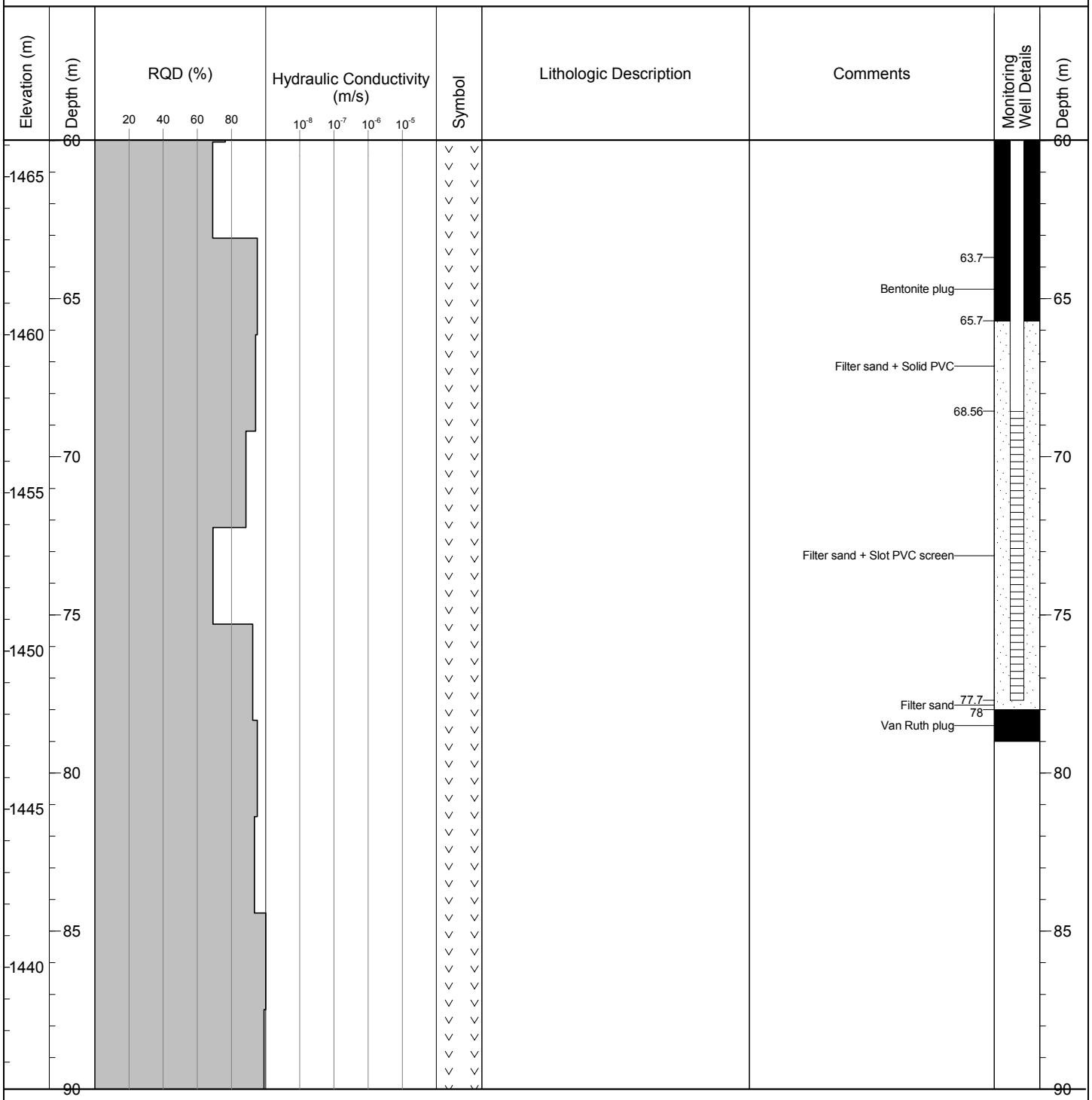
DRILL HOLE # MW-BGC11-BJ-5A

Location: Valley of Kings Zone

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

Location: Valley of Kings Zone

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1435	90							90
1430	95							95
1425	100							100
1420	105				End of Hole: 102.7 m	Bottom of Installation: 78.0 m		105
1415	110							110
1410	115							115
	120							120

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

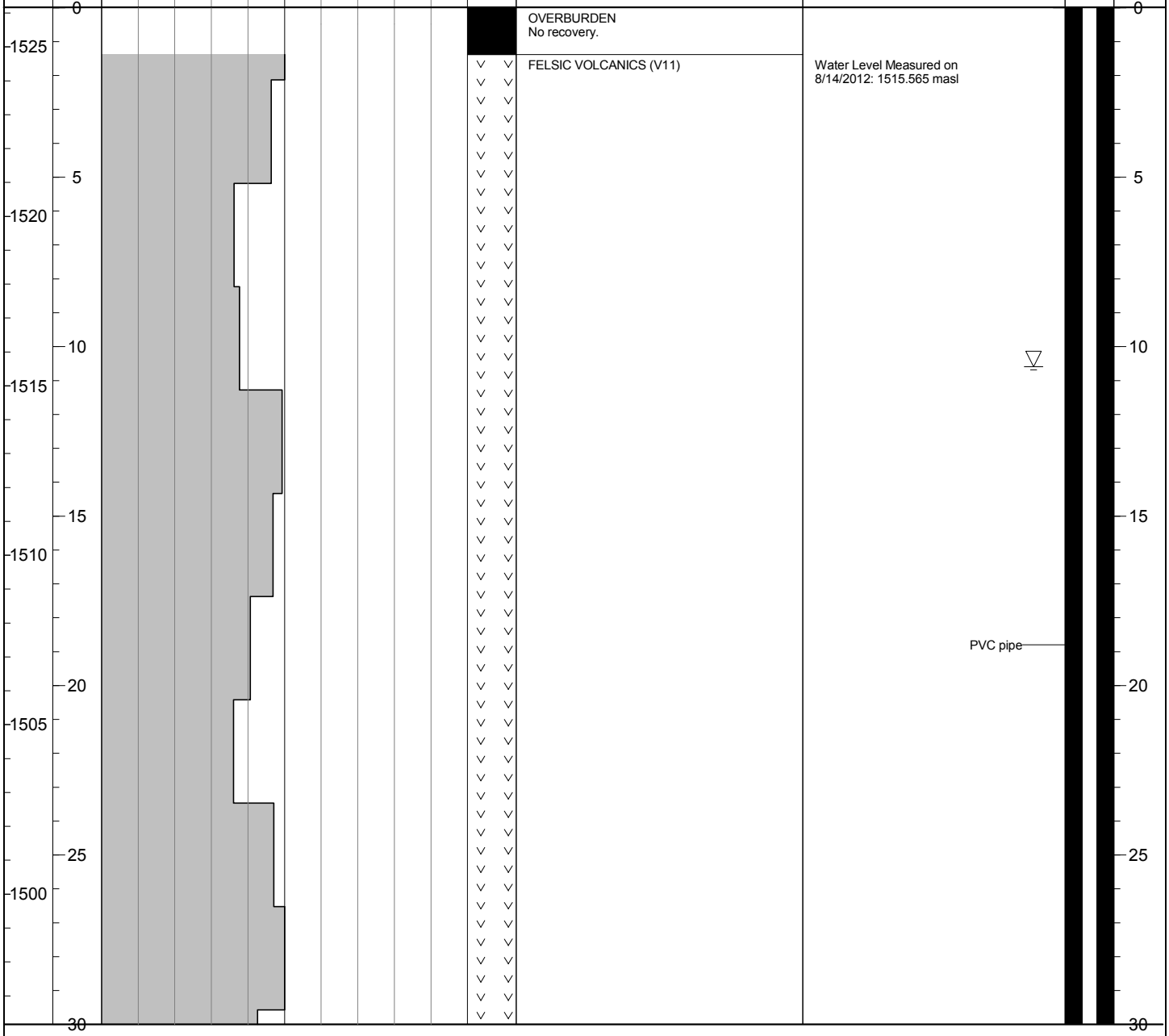
DRILL HOLE # MW-BGC11-BJ-5B

Location: Valley of Kings Zone

Co-ordinates (m): 426,346E - 6,258,042N
Ground Elevation (m): 1,526.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.44
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.6
Cased To (m): NO CASING INSTALLED

Start date: 29 Sep 11
Finish Date: 30 Sep 11
Final Depth (m): 50.9
Depth To Top Of Rock (m): 1.4
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

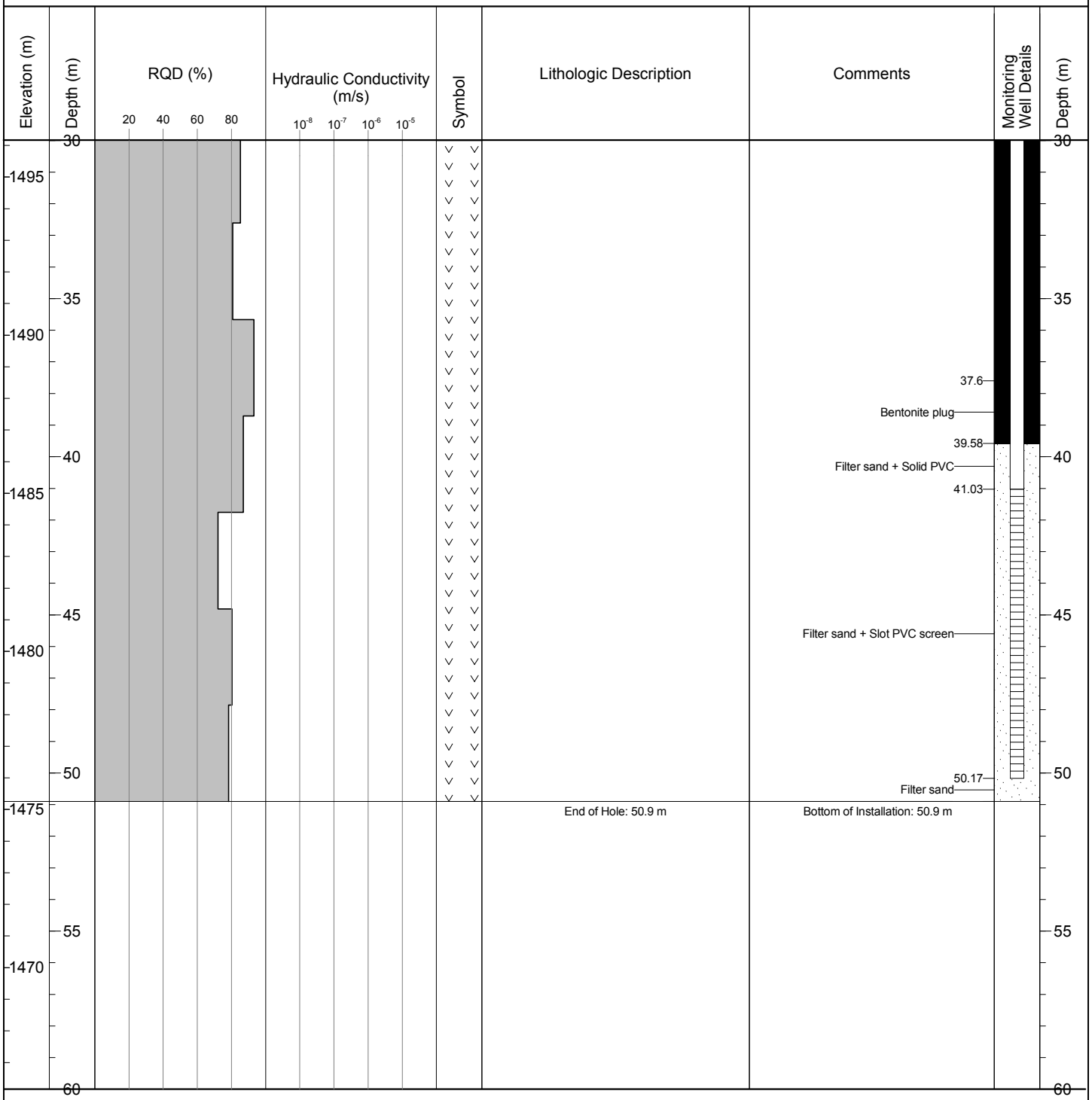
DRILL HOLE # MW-BGC11-BJ-5B

Project: Brucejack
Project No.: 1008-004
Location: Valley of Kings Zone

Co-ordinates (m): 426,346E - 6,258,042N
Ground Elevation (m): 1,526.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.44
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.6
Cased To (m): NO CASING INSTALLED

Start date: 29 Sep 11
Finish Date: 30 Sep 11
Final Depth (m): 50.9
Depth To Top Of Rock (m): 1.4
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-6A

Location: Shore Zone

Co-ordinates (m): 427,095E - 6,258,983N
Ground Elevation (m): 1,379.81
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 1
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1380.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 29.6
Depth To Top Of Rock (m): 2.0
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		OVERBURDEN No recovery.			0
					FELSIC VOLCANICS (V11)	Water Level Measured on 8/14/2012: 1371.54 masl		
1375	5							5
1370	10					Bentonite plug		10
1365	15							15
						Filter sand + Solid PVC 18.42–18.92		
1360	20							20
						Filter sand + Slot PVC screen		
1355	25							25
						28.07 Filter sand		
1350	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-6A

Location: Shore Zone

Co-ordinates (m): 427,095E - 6,258,983N
Ground Elevation (m): 1,379.81
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 1
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1380.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 29.6
Depth To Top Of Rock (m): 2.0
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) 20 40 60 80	Hydraulic Conductivity (m/s) 10^{-8} 10^{-7} 10^{-6} 10^{-5}	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30				End of Hole: 29.6 m	Bottom of Installation: 31.8 m		30
1345	35							35
1340	40							40
1335	45							45
1330	50							50
1325	55							55
1320	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				GRAVEL (GW) Coarse, sub-angular, green to brown, odourless, dry, weathered.	Water Level Measured on 8/14/2012: 1367.834 masl		0
1375	5				INTERMEDIATE VOLCANICS (V12) Tuff and crystal tuff with minor zones of brecciation. High degree of disseminated pyrite (up to ~15% in places). Increased base metal sulphides from 35.3 - 37.5 m. Sericite clast replacement with minor fuschite seen throughout unit. Medium strong (R3-R3.5) from top of bedrock to 11.3 m. Strong to very strong (R4-R4.5) below 11.3 m. Slight to moderate alteration (A2.5) on major discontinuities from top of bedrock to 8.3 m. Faint to no alteration (A1-A1.5) below 8.3 m. 3.0 m: Fault, 220 mm thick, weathered rock. 5.5 m: Fault, 130 mm thick. 6.5 m: Fault, 350 mm thick. 7.6 m: Fault, 250 mm thick. 8.1 m: Fault, 220 mm thick.			5
1370	10							10
1365	15							15
1360	20							20
1355	25							25
1350	30							30

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

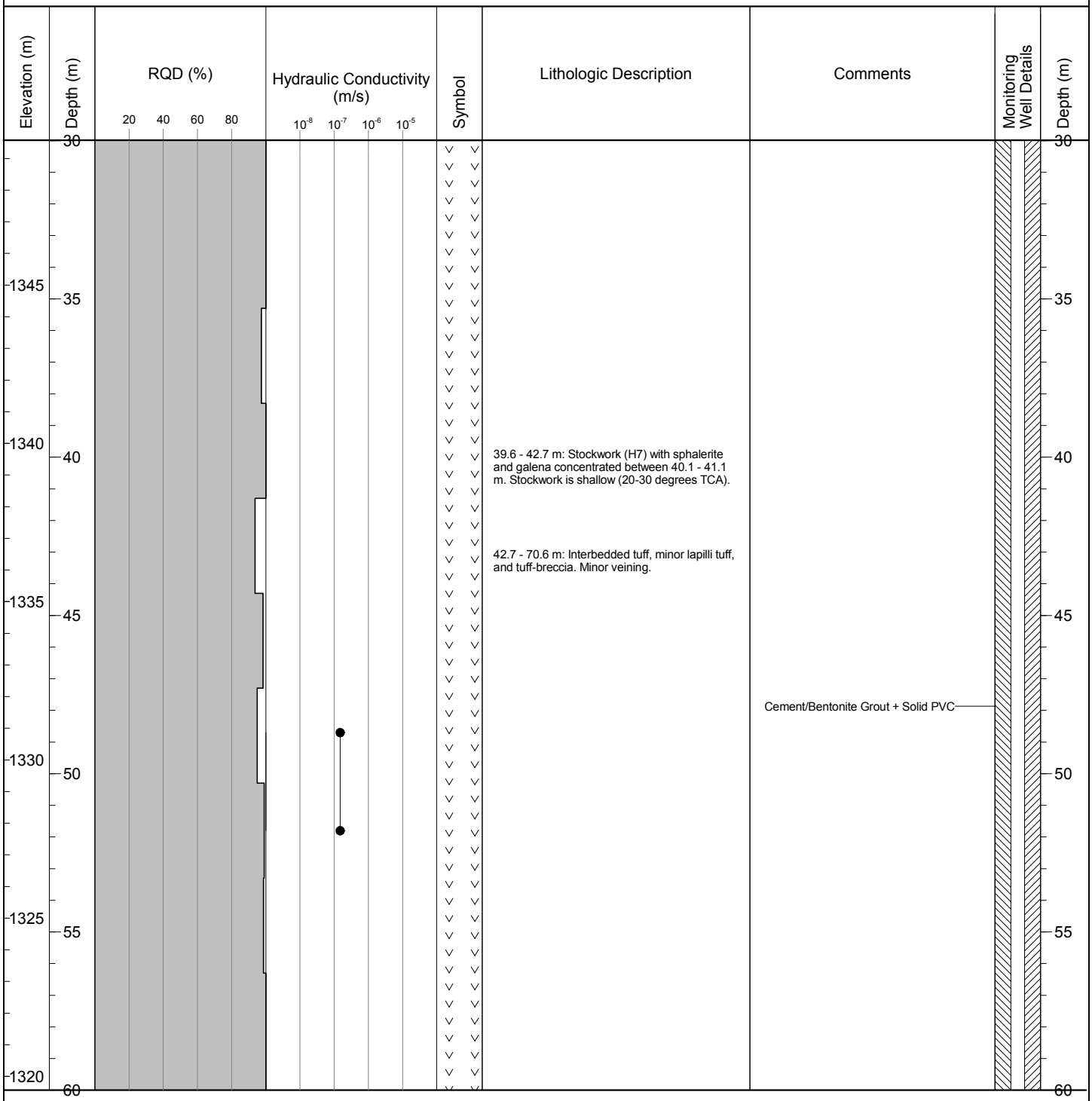
DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	60							60
1315	65							65
1310	70							70
1305	75							75
1300	80							80
1295	85							85
1290	90							90

STOCKWORK (H7)
Quartz-calcite-rhodochrosite with banded chlorite, abundant galena and sphalerite. Strong to very strong (R4-R4.5). Faint to no alteration (A1).
71.9 - 72.5 m: Brecciated section of stockwork.
72.5 - 74.0 m: Stockwork oriented at 10 degrees TCA.

75.4 - 80.0 m: Wall rock, broken rock, sphalerite, galena, pyrite.

87.9 - 90.2 m: Wall rock, broken rock, galena and sphalerite.

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC12-BJ-6B

Project: Brucejack
Project No.: 1008-007
Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		INTERMEDIATE VOLCANICS (V12) Tuff to crystal tuff with pyrite replacement clasts, significant veining and chlorite stringers. Strong to very strong (R4-R4.5). Faint to slight alteration (A1-A2).			90
1285	95					95.74		95
					96.7 m: Fault, 120 mm thick, crushed rock.	3/8" Coated Bentonite pellets + Solid PVC		
					97.6 m: Fault, 250 mm thick, gouge.	98.2		
1280	100				98.5 m: Fault, 50 mm thick, weathered & broken rock.	100.27		100
					101.4 m: Fault, 30 mm thick, weathered & broken rock.	10/20 Filter sand + 0.020 Slot PVC screen		
						103.32		
					End of Hole: 103.8 m	Bottom of Installation: 103.8 m		
1275	105							105
1270	110							110
1265	115							115
1260	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

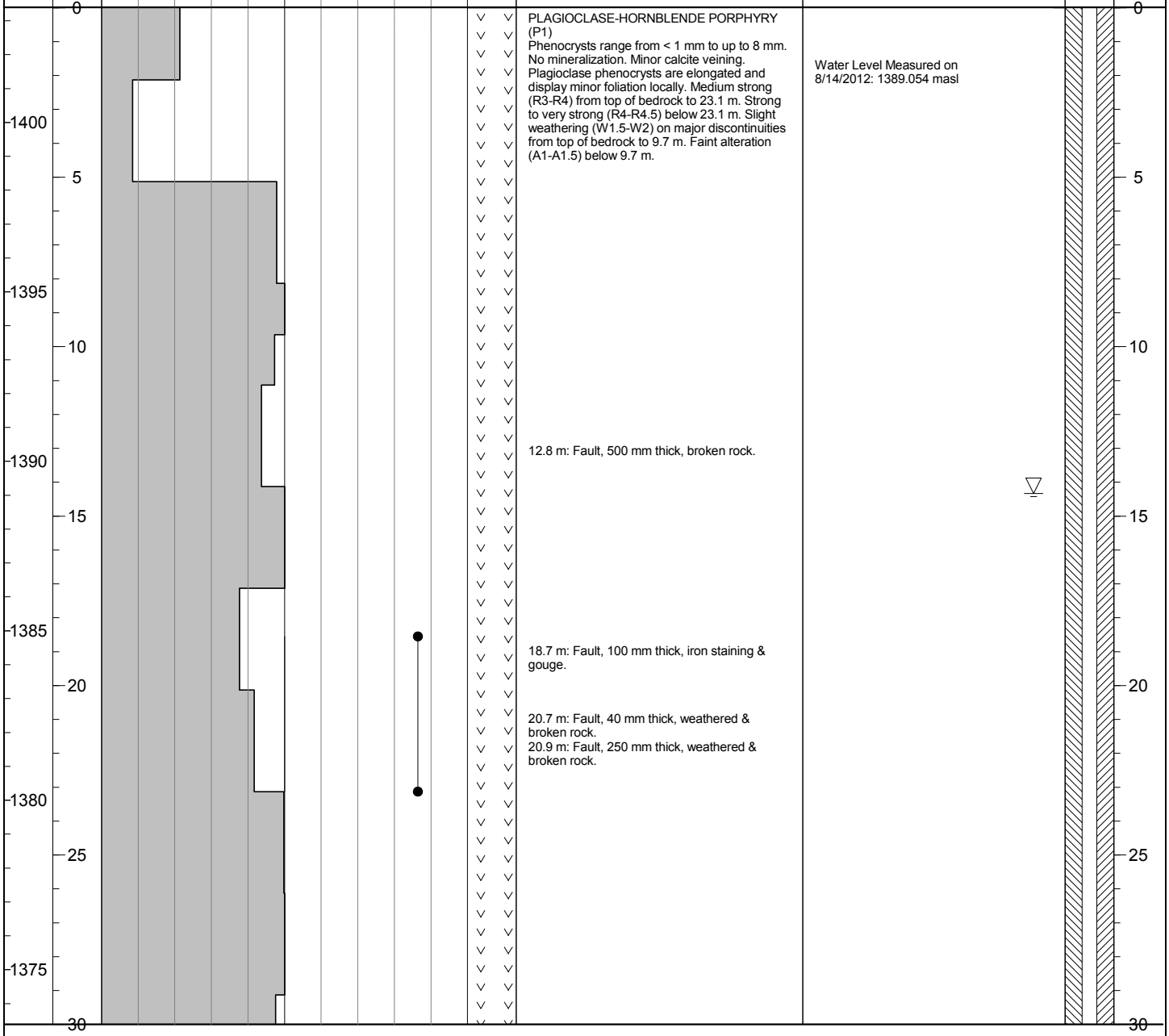
DRILL HOLE # MW-BGC12-BJ-8A

Location: Brucejack

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description	Comments
PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Phenocrysts range from < 1 mm to up to 8 mm. No mineralization. Minor calcite veining. Plagioclase phenocrysts are elongated and display minor foliation locally. Medium strong (R3-R4) from top of bedrock to 23.1 m. Strong to very strong (R4-R4.5) below 23.1 m. Slight weathering (W1.5-W2) on major discontinuities from top of bedrock to 9.7 m. Faint alteration (A1-A1.5) below 9.7 m.	Water Level Measured on 8/14/2012: 1389.054 masl
12.8 m: Fault, 500 mm thick, broken rock.	
18.7 m: Fault, 100 mm thick, iron staining & gouge.	
20.7 m: Fault, 40 mm thick, weathered & broken rock. 20.9 m: Fault, 250 mm thick, weathered & broken rock.	

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

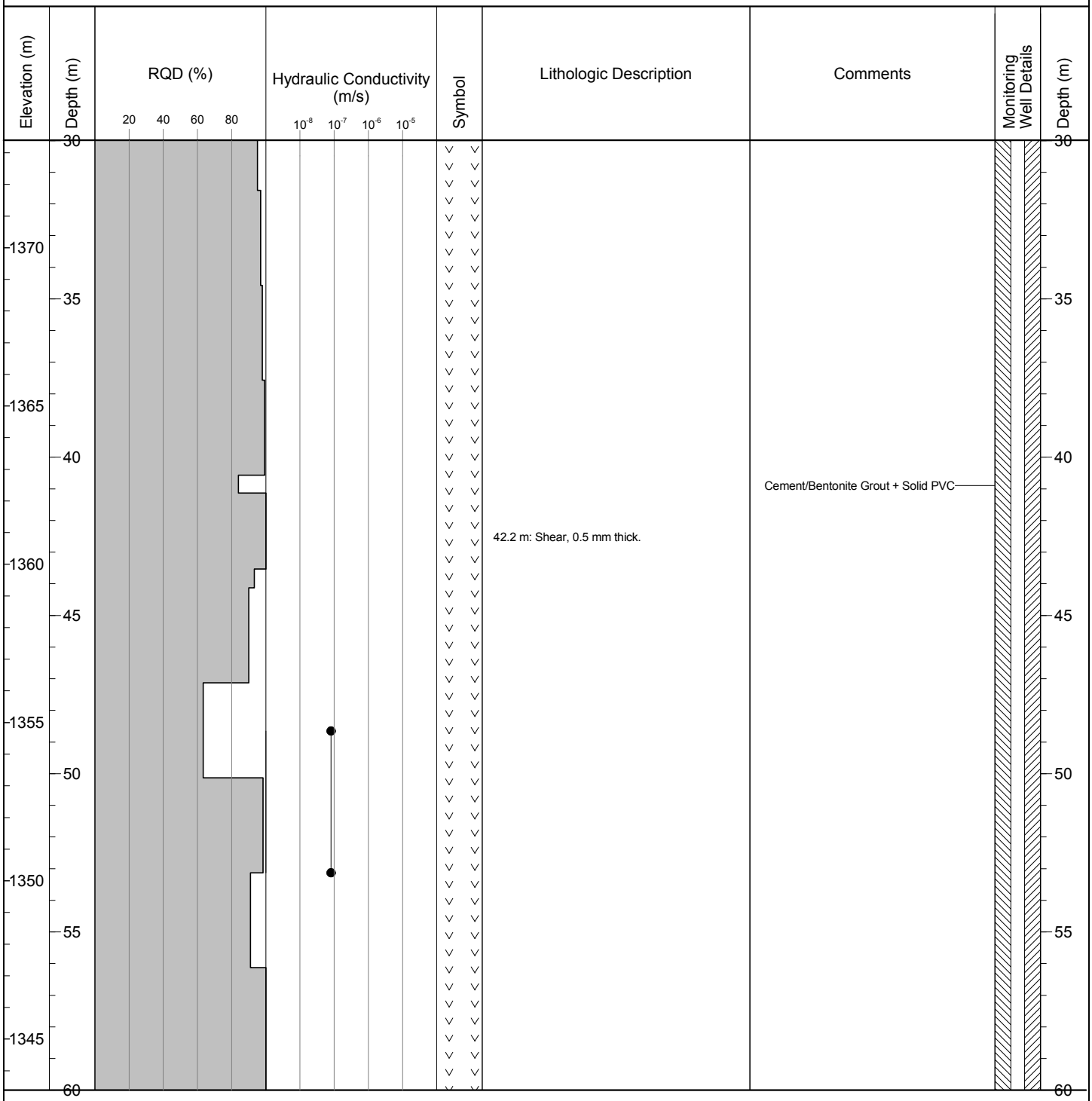
DRILL HOLE # MW-BGC12-BJ-8A

Location: Brucejack

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

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Datum: UTM NAD 83 Zone 9
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Surface Completion: PVC Stick-Up

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Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
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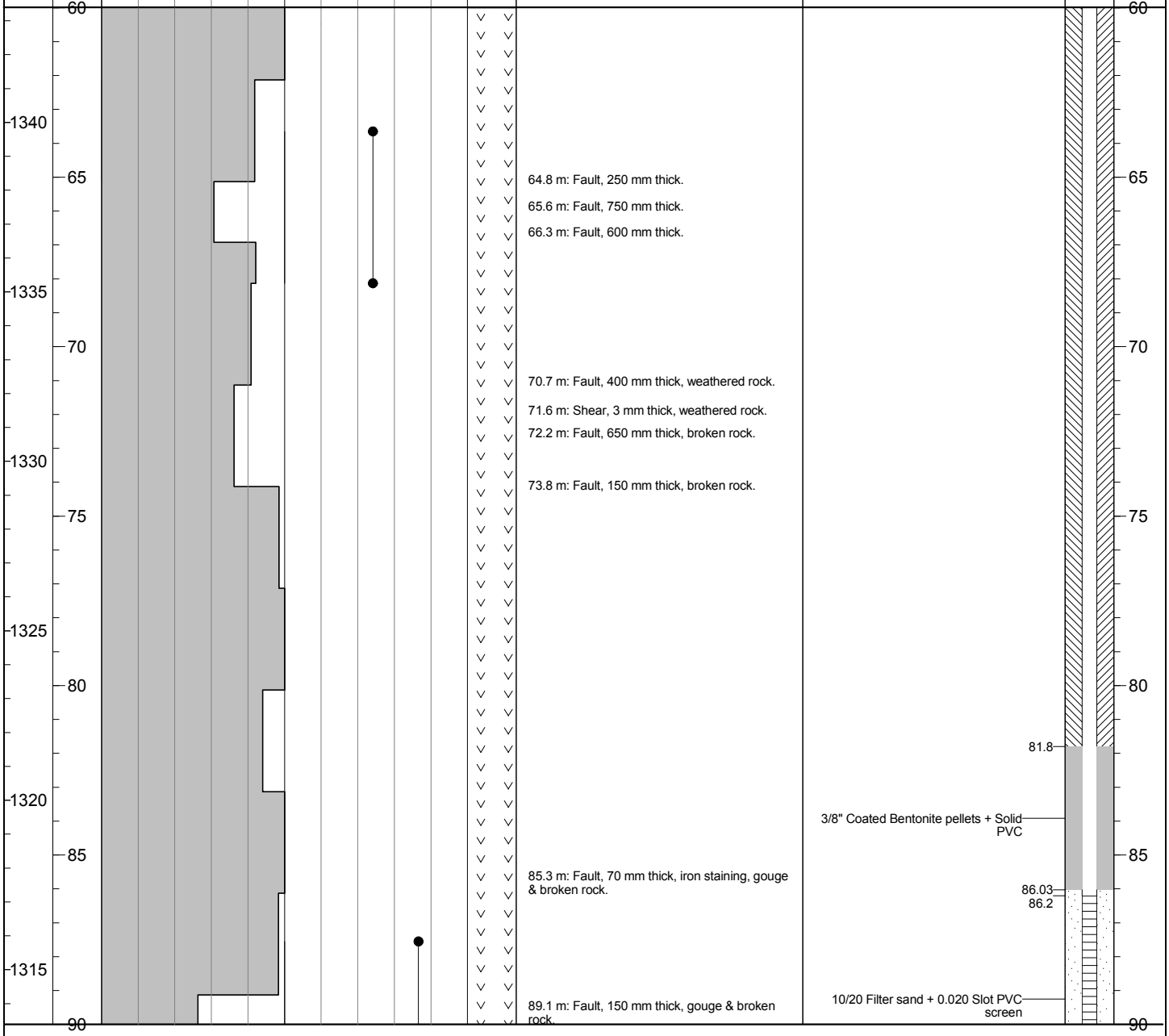

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Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90				90.1 m: Fault, 70 mm thick, broken rock.			90
1310					91.4 m: Fault, 300 mm thick, iron staining & gouge.	92.3		
	95				End of Hole: 95.1 m	Bottom of Installation: 95.1 m		95
1305								
	100							100
1300								
	105							105
1295								
	110							110
1290								
	115							115
1285								
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8B

Location: Brucejack

Co-ordinates (m): 426,106E - 6,258,819N
Ground Elevation (m): 1,403.30
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.33
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.6
Cased To (m): 1.12

Start date: 18 Jun 12
Finish Date: 19 Jun 12
Final Depth (m): 51.0
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1400, 1395, 1390, 1385, 1380, 1375	0, 5, 10, 15, 20, 25, 30	20, 40, 60, 80	10^{-8}, 10^{-7}, 10^{-6}, 10^{-5}		PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Phenocrysts range from < 1 mm to up to 8 mm. No mineralization. Minor calcite veining. Plagioclase phenocrysts are elongated and display minor foliation locally. Medium strong (R3-R4) from top of bedrock to 23.1 m. Strong to very strong (R4-R4.5) below 23.1 m. Slight weathering (W1.5-W2) on major discontinuities from top of bedrock to 9.7 m. Faint alteration (A1-A1.5) below 9.7 m.	Water Level Measured on 8/14/2012: 1385.59 masl Cement/Bentonite Grout + Solid PVC		0, 5, 10, 15, 20, 25, 30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

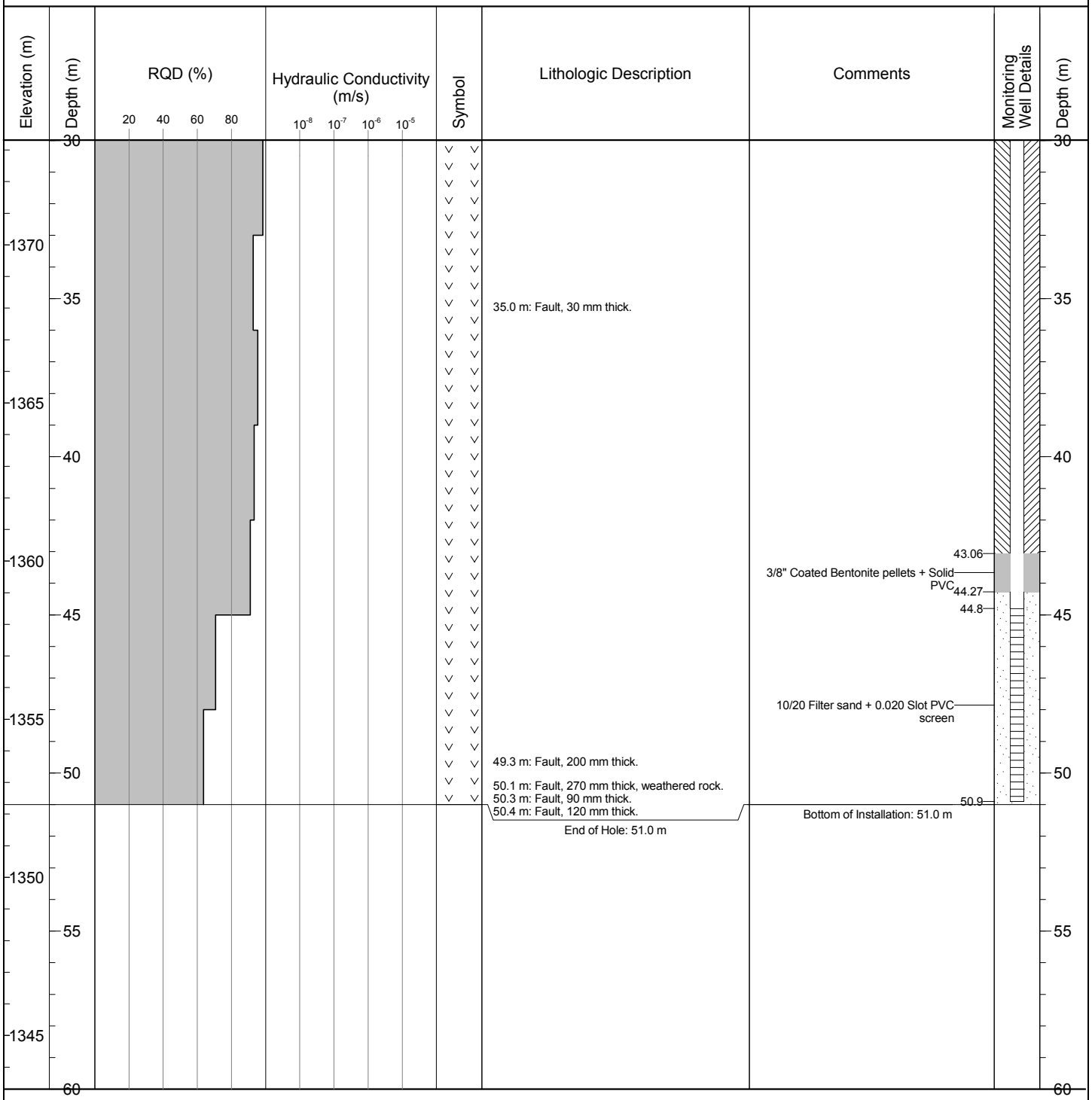
DRILL HOLE # MW-BGC12-BJ-8B

Location: Brucejack

Co-ordinates (m): 426,106E - 6,258,819N
Ground Elevation (m): 1,403.30
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.33
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.6
Cased To (m): 1.12

Start date: 18 Jun 12
Finish Date: 19 Jun 12
Final Depth (m): 51.0
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9A

Location: Brucejack

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Moderately homogeneous porphyry, <2% veining, sericite alteration of matrix and phenocrysts. Strong to very strong (R4-R5). Faint weathering (W1-W1.5)	Water Level Measured on 8/14/2012: 1456.17 masl		0
1510	5							5
					7.7 m: Shear, 5 mm thick.			
1505	10							10
1500	15							15
1495	20							20
1490	25							25
1485	30							30

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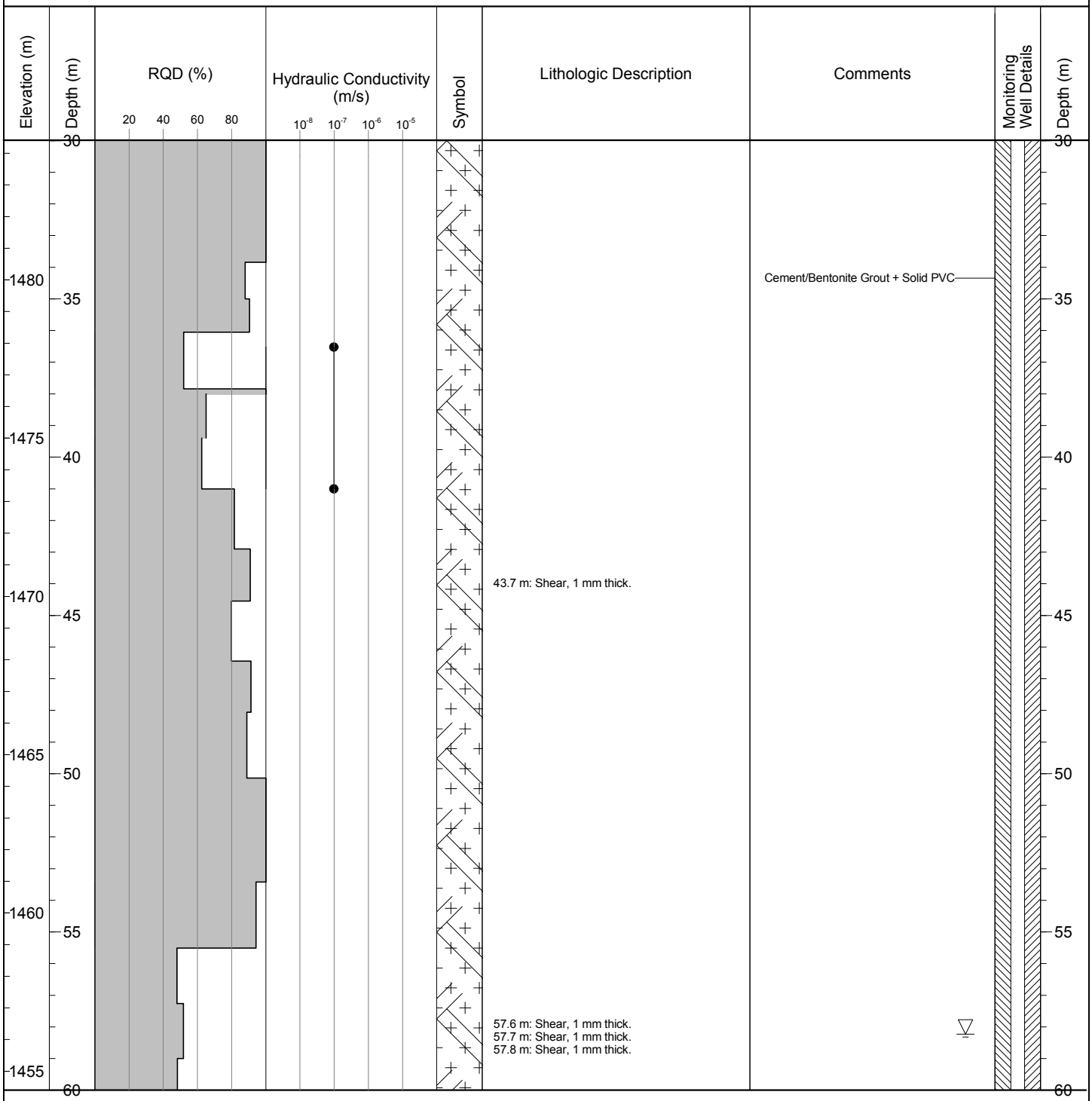
DRILL HOLE # MW-BGC12-BJ-9A

Project: Brucejack
Project No.: 1008-007
Location: Brucejack

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

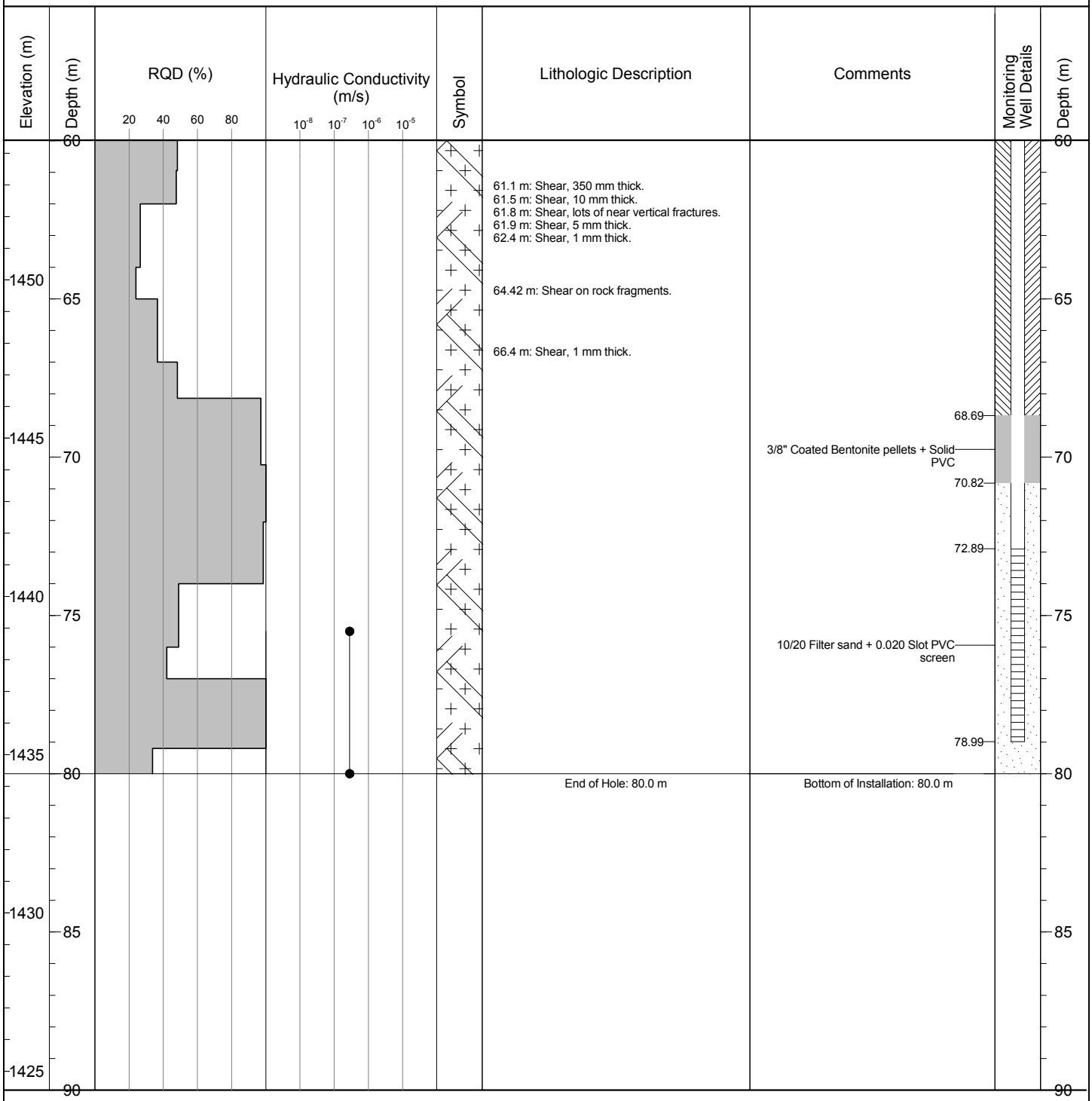
DRILL HOLE # MW-BGC12-BJ-9A

Location: Brucejack

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9B

Location: Brucejack

Co-ordinates (m): 426,461E - 6,258,362N
Ground Elevation (m): 1,514.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.2
Cased To (m): 1.09

Start date: 30 Jul 12
Finish Date: 01 Aug 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Moderately homogeneous porphyry, <2% veining, sericite alteration of matrix and phenocrysts. Strong to very strong (R4-R5). Faint alteration (A1.5)	Water Level Measured on 8/14/2012: 1498.128 masl		0
1510	5							5
1505	10							10
1500	15							15
						Cement/Bentonite Grout + Solid PVC		
1495	20				20.4 m: Shear, 1 mm thick.			20
1490	25							25
1485	30							30

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

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Core: PQ
Top of PVC Elevation (m): 1515.2
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Start date: 30 Jul 12
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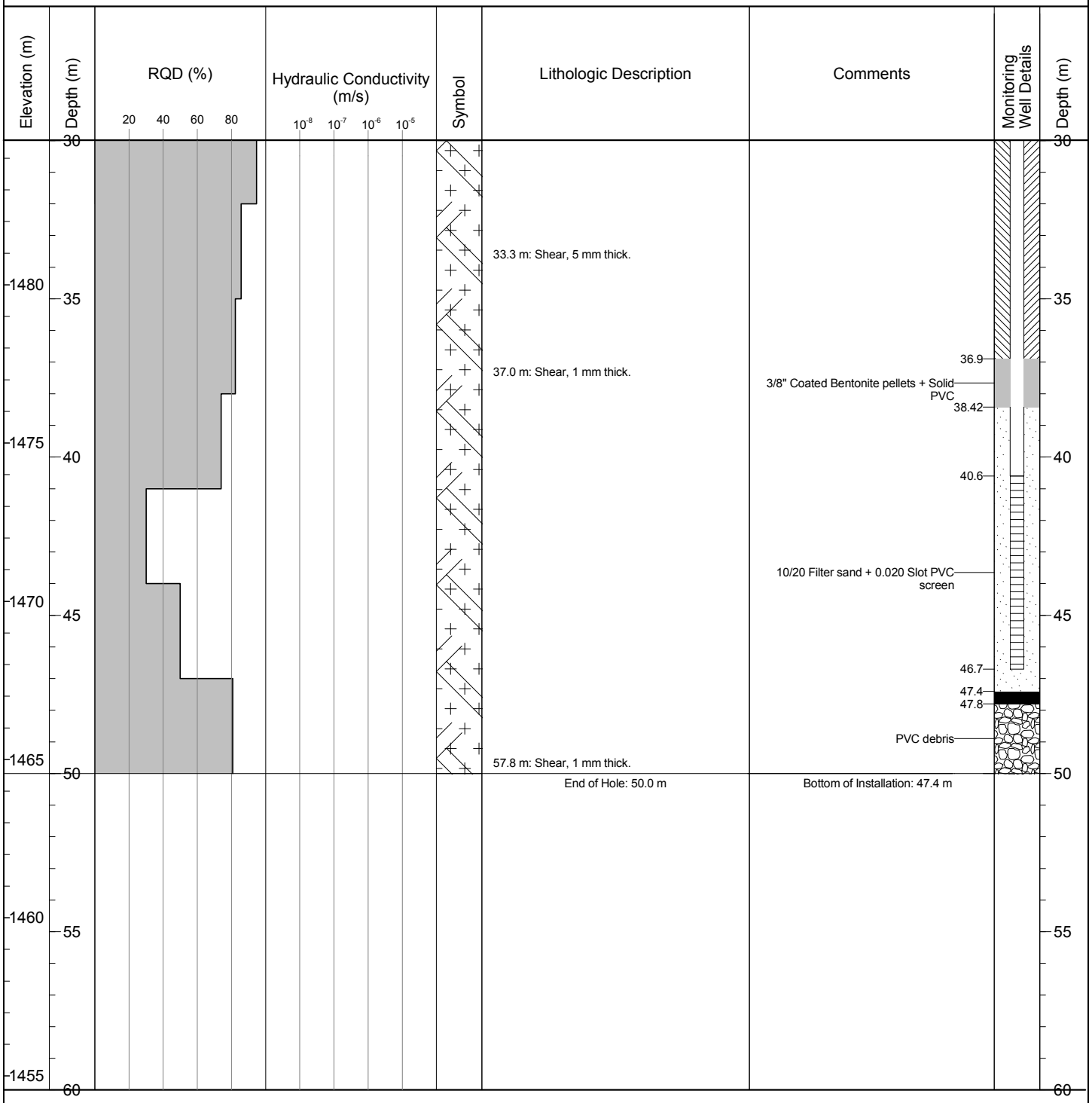
Final Depth (m): 50.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

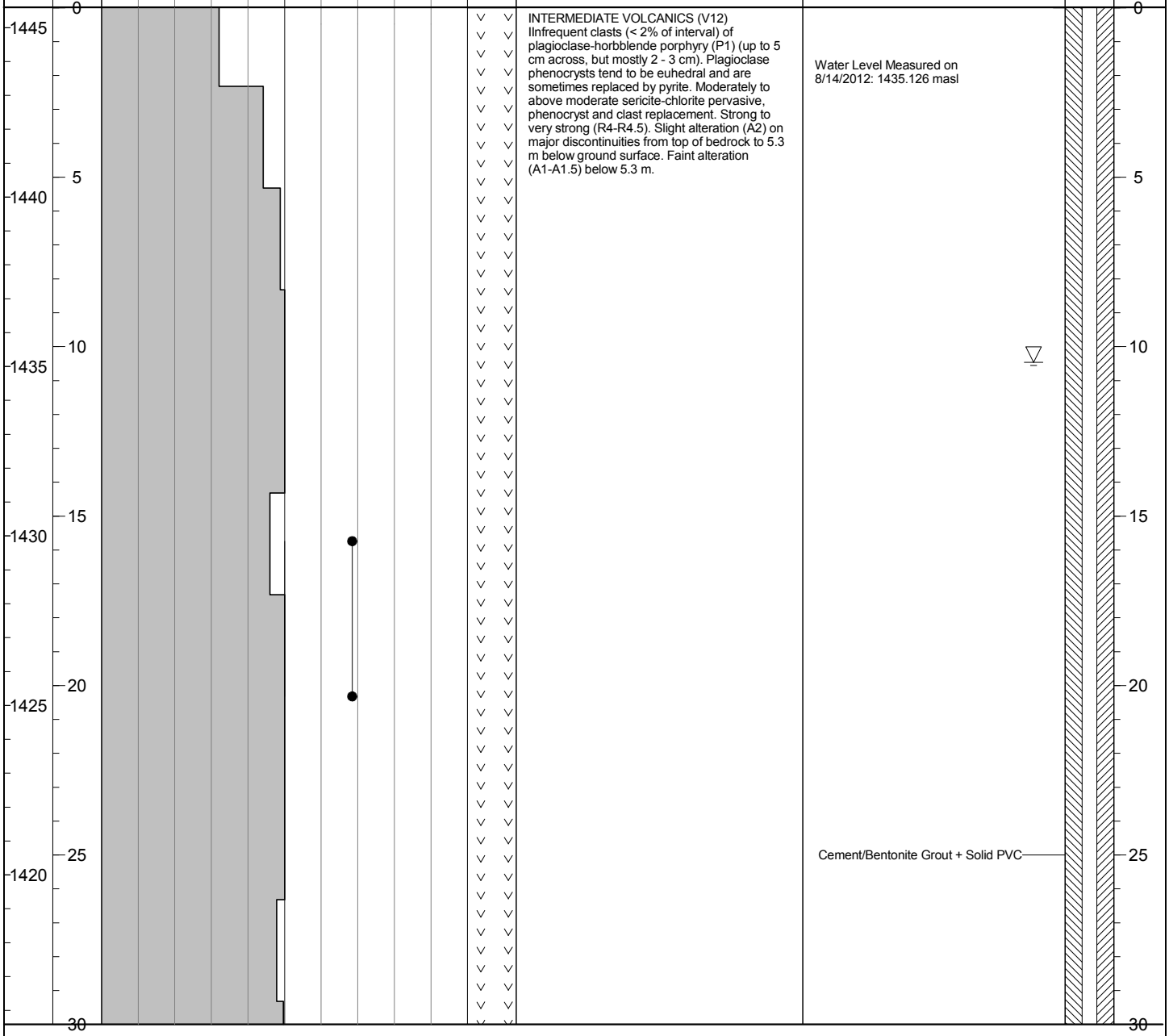
DRILL HOLE # MW-BGC12-BJ-10A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



INTERMEDIATE VOLCANICS (V12)
IInfrequent clasts (< 2% of interval) of plagioclase-horbblende porphyry (P1) (up to 5 cm across, but mostly 2 - 3 cm). Plagioclase phenocrysts tend to be euhedral and are sometimes replaced by pyrite. Moderately to above moderate sericite-chlorite pervasive, phenocryst and clast replacement. Strong to very strong (R4-R4.5). Slight alteration (A2) on major discontinuities from top of bedrock to 5.3 m below ground surface. Faint alteration (A1-A1.5) below 5.3 m.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10A

Location: Brucejack (Plant Site)

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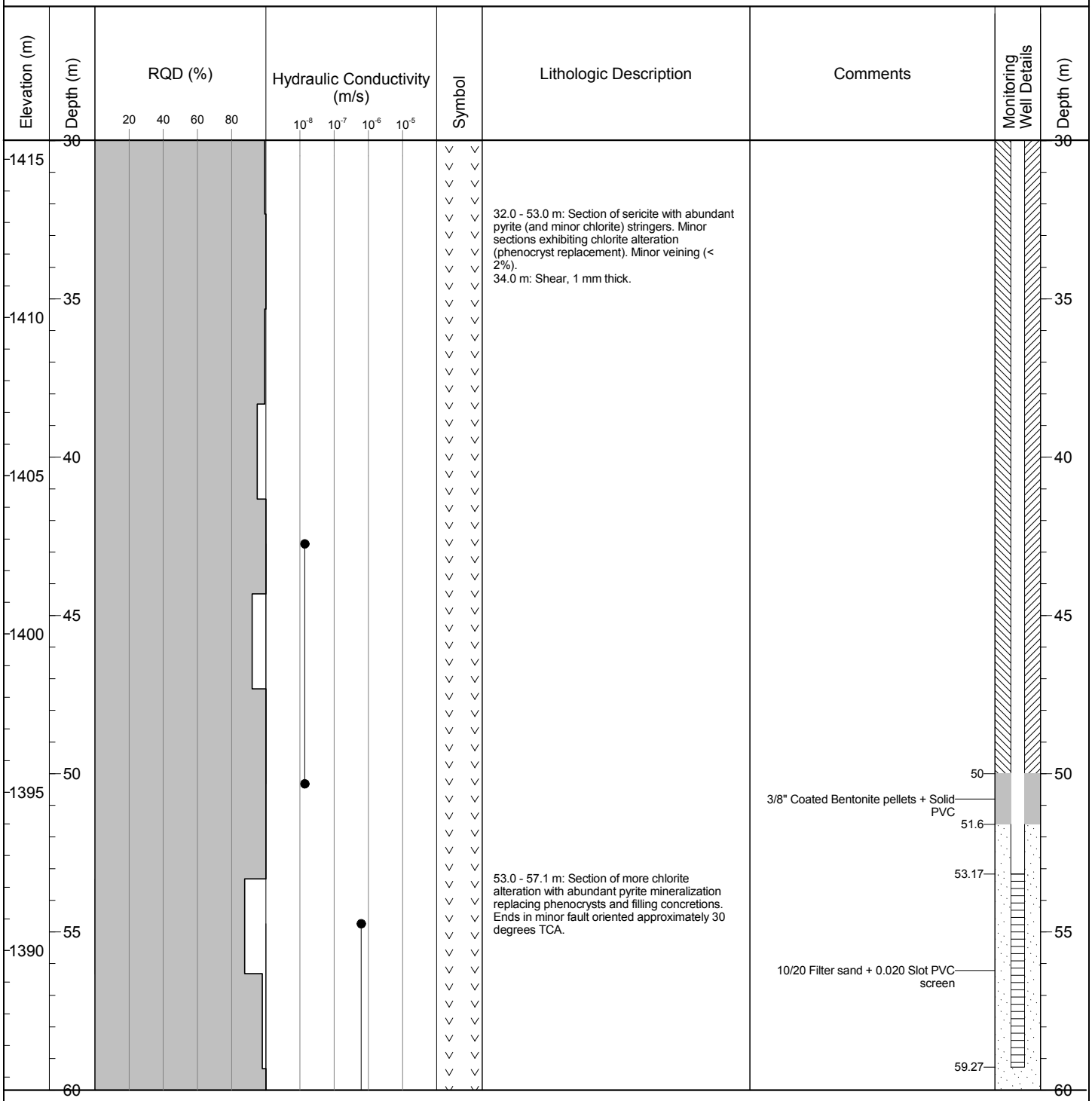
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10A

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Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1385	60					3/8" Coated Bentonite pellets 60.13–60.48		60
					End of Hole: 62.3 m	Bottom of Installation: 60.1 m		
1380	65							65
1375	70							70
1370	75							75
1365	80							80
1360	85							85
	90							90

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10B

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.64
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.72
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.4
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 41.4
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1445	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		INTERMEDIATE VOLCANICS (V12) Infrequent clasts (< 2% of interval) of plagioclase-horbblende porphyry (P1) (up to 5 cm across, but mostly 2 - 3 cm). Plagioclase phenocrysts tend to be euhedral and are sometimes replaced by pyrite. Moderately to above moderate sericite-chlorite pervasive, phenocryst and clast replacement. Strong to very strong (R4-R4.5). Slight alteration (A2) on major discontinuities from top of bedrock to 5.3 m below ground surface. Faint alteration (A1-A1.5) below 5.3 m.	Water Level Measured on 8/14/2012: 1433.149 masl		0
1440	5							5
1435	10							10
1430	15					Cement/Bentonite Grout + Solid PVC		15
1425	20							20
1420	25							25
	30							30

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10B

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.64
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.72
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.4
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 41.4
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1415	30							30
					32.0 - 41.4 m: Section of sericite with abundant pyrite (and minor chlorite) stringers. Minor sections exhibiting chlorite alteration (phenocryst replacement). Minor veining (< 2%).			
1410	35					34.5 3/8" Coated Bentonite pellets + Solid PVC 35.6		35
						38.05		
					39.0 m: Fault, 100 mm thick, fault on vein.	10/20 Filter sand + 0.020 Slot PVC screen		
1405	40					41.1		40
					End of Hole: 41.4 m	Bottom of Installation: 41.4 m		
1400	45							45
1395	50							50
1390	55							55
	60							60

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11A

Location: West Zone

Co-ordinates (m): 426,300E - 6,258,595N
Ground Elevation (m): 1,433.57
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1434.2
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 26 Jun 12
Final Depth (m): 29.5
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Contains pervasive sericite-chlorite alteration with phenocryst replacement. Multiple veinlets. Medium strong to strong (R3-R3.5). Faint to slight alteration (A1.5-A2). 1.5 m: Fault, 300 mm thick, weathered rock. 2.1 m: Fault, 400 mm thick. 2.5 m: Fault, 300 mm thick, weathered & broken rock.	Water Level Measured on 8/14/2012: 1427.261 masl		0
1430	5				4.9 m: Fault, 100 mm thick.			5
1425	10							10
						Cement/Bentonite Grout + Solid PVC		
1420					12.9 - 23.5 m: Stockwork (H7) with minimal mineralization. Steep wall rock veinlets (oriented 50-90 degrees TCA).			
	15				15.8 m: Fault, 110 mm thick, broken rock.			15
1415								
	20							20
1410					23.5 - 29.5 m: Some sections of conglomerated porphyry.			
	25					24.9 3/8" Coated Bentonite pellets + Solid PVC 25.8 26.45		25
1405					27.2 m: Fault, 350 mm thick, weathered & broken rock.	10/20 Filter sand + 0.020 Slot PVC screen		
	30				End of Hole: 29.5 m	Bottom of Installation: 29.5 m		30

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

Project: Brucejack
Project No.: 1008-007

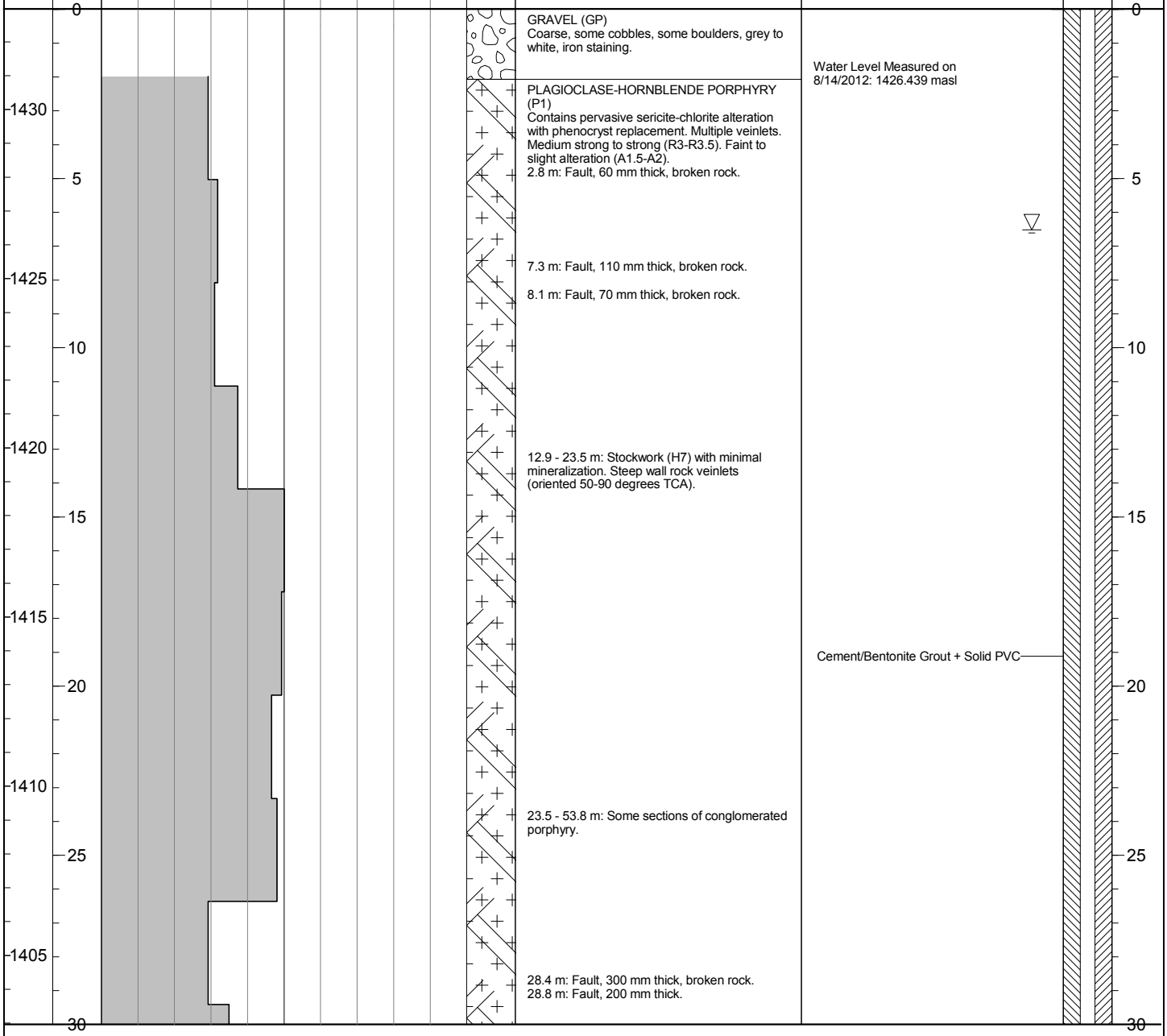
DRILL HOLE # MW-BGC12-BJ-11B

Location: West Zone

Co-ordinates (m): 426,299E - 6,258,595N
Ground Elevation (m): 1,432.96
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1433.6
Cased To (m): 1.06

Start date: 26 Jun 12
Finish Date: 28 Jun 12
Final Depth (m): 53.8
Depth To Top Of Rock (m): 2.1
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description

GRAVEL (GP)
Coarse, some cobbles, some boulders, grey to white, iron staining.

PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)
Contains pervasive sericite-chlorite alteration with phenocryst replacement. Multiple veinlets. Medium strong to strong (R3-R3.5). Faint to slight alteration (A1.5-A2).
2.8 m: Fault, 60 mm thick, broken rock.

7.3 m: Fault, 110 mm thick, broken rock.

8.1 m: Fault, 70 mm thick, broken rock.

12.9 - 23.5 m: Stockwork (H7) with minimal mineralization. Steep wall rock veinlets (oriented 50-90 degrees TCA).

23.5 - 53.8 m: Some sections of conglomerated porphyry.

28.4 m: Fault, 300 mm thick, broken rock.
28.8 m: Fault, 200 mm thick.

Comments

Water Level Measured on 8/14/2012: 1426.439 masl

Cement/Bentonite Grout + Solid PVC

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

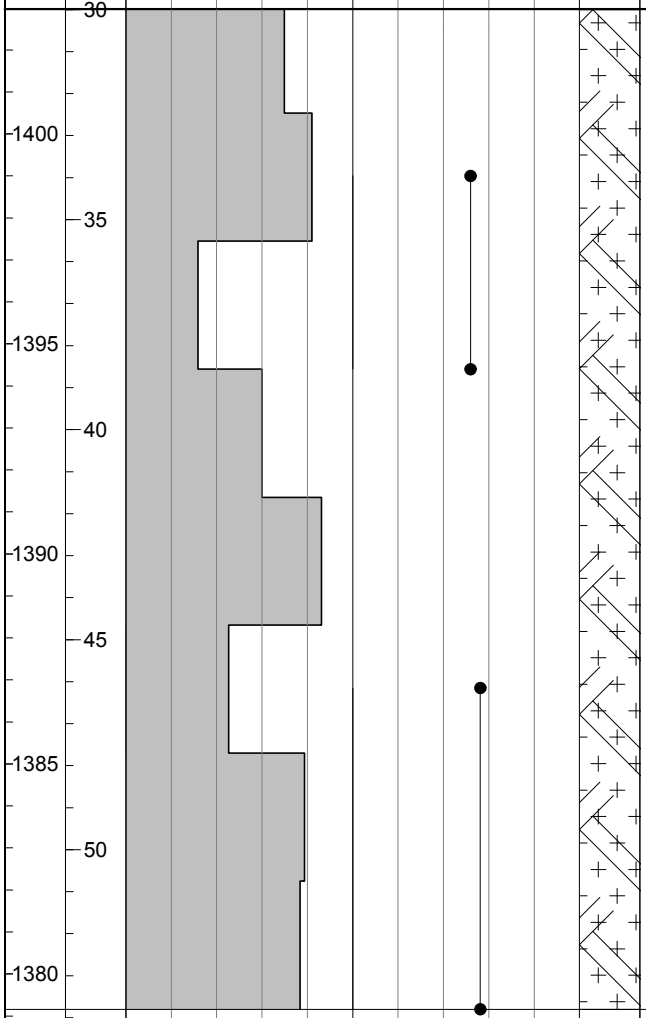
DRILL HOLE # MW-BGC12-BJ-11B

Project: Brucejack
Project No.: 1008-007
Location: West Zone

Co-ordinates (m): 426,299E - 6,258,595N
Ground Elevation (m): 1,432.96
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1433.6
Cased To (m): 1.06

Start date: 26 Jun 12
Finish Date: 28 Jun 12
Final Depth (m): 53.8
Depth To Top Of Rock (m): 2.1
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description

30.2 m: Fault, 50 mm thick.

32.0 m: Fault, 90 mm thick.
32.4 m: Fault, 120 mm thick.

35.3 m: Fault, 50 mm thick.
35.8 m: Fault, 100 mm thick, broken rock.
36.1 m: Fault, 120 mm thick, broken rock.
36.5 m: Fault, 400 mm thick, broken rock.

37.3 m: Fault, 80 mm thick, broken rock.
37.6 m: Fault, 70 mm thick, broken rock.
37.7 m: Fault, 160 mm thick, broken rock.
38.3 m: Fault, 90 mm thick, broken rock.

39.5 m: Fault, 950 mm thick, broken rock.

41.9 m: Fault, 160 mm thick, weathered & broken rock.

44.9 - 45.9 m: Fault zone, 4 faults 60-450 mm thick, iron staining & broken rock.

47.9 m: Fault, 150 mm thick.

48.5 m: Fault, 60 mm thick, fault on calcite vein.
49.0 m: Fault, 130 mm thick, broken rock.

52.4 m: Fault, 80 mm thick, fault on vein.
52.8 m: Fault, 140 mm thick, fault on vein.

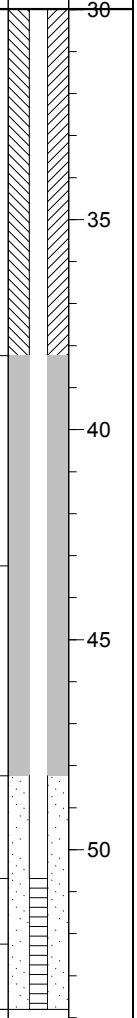
End of Hole: 53.8 m

Comments

3/8" Coated Bentonite pellets + Solid PVC

10/20 Filter sand + 0.020 Slot PVC screen

Bottom of Installation: 53.8 m



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

Location: Valley of Kings Zone

Co-ordinates (m): 426,509E - 6,257,807N
Ground Elevation (m): 1,579.19
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Heavily sericite altered. Mainly homogenous porphyry textures. Strong to very strong (R4-R5). 7.9 – 10.5 m: strength reduced to medium strong (R3). Slight alteration (A1.5) from top of bedrock to 2.0 m. Faint weathering (1-1.5) below 2.0 m	Water Level Measured on 8/14/2012: 1528.285 masl		0
1575	5							5
1570	10							10
1565	15							15
1560	20				19.8 m: Fault, 5 mm thick, gouge.			20
1555	25							25
1550	30							30

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Drill Method: Diamond
Core: PQ
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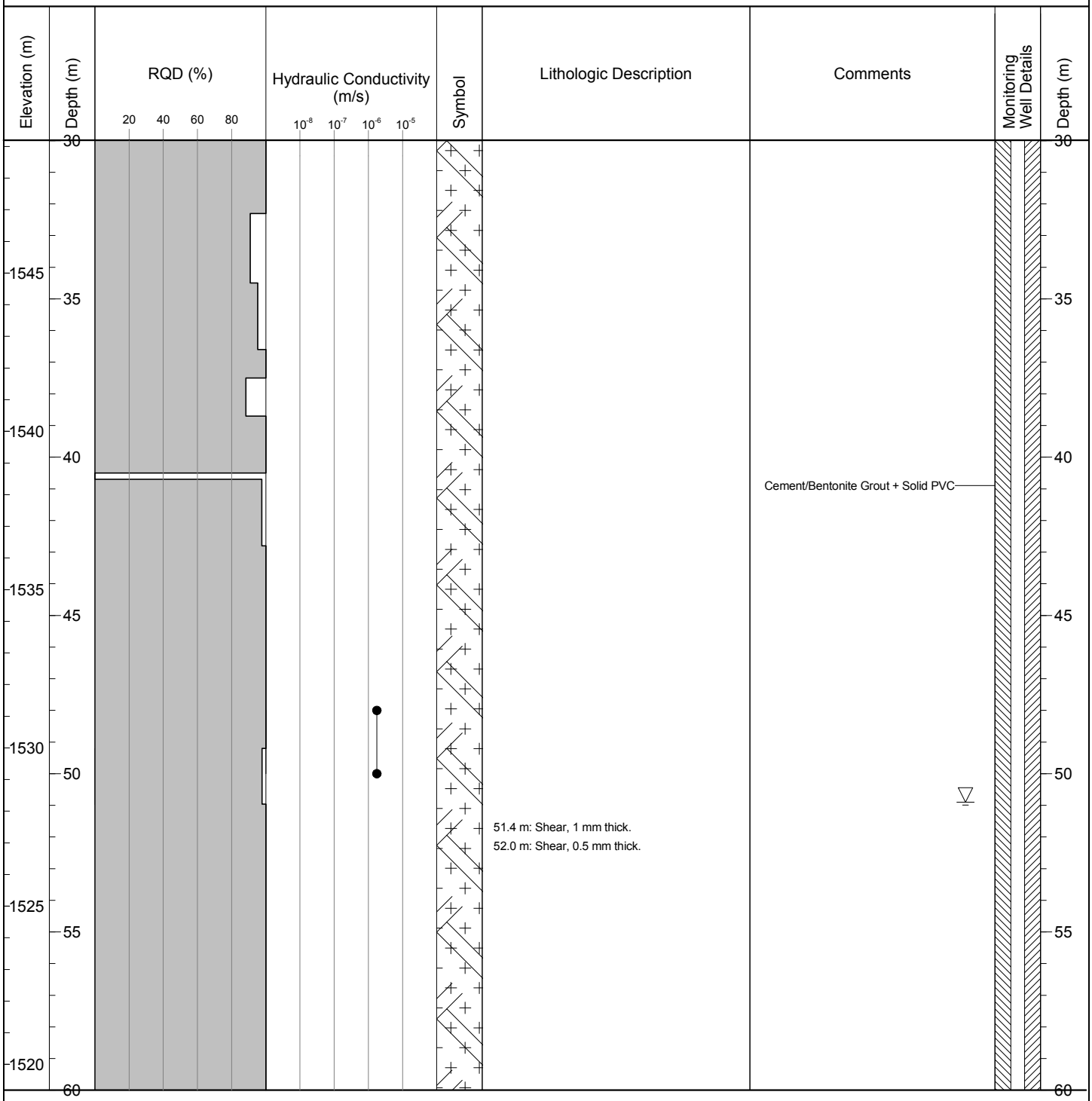
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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Core: PQ
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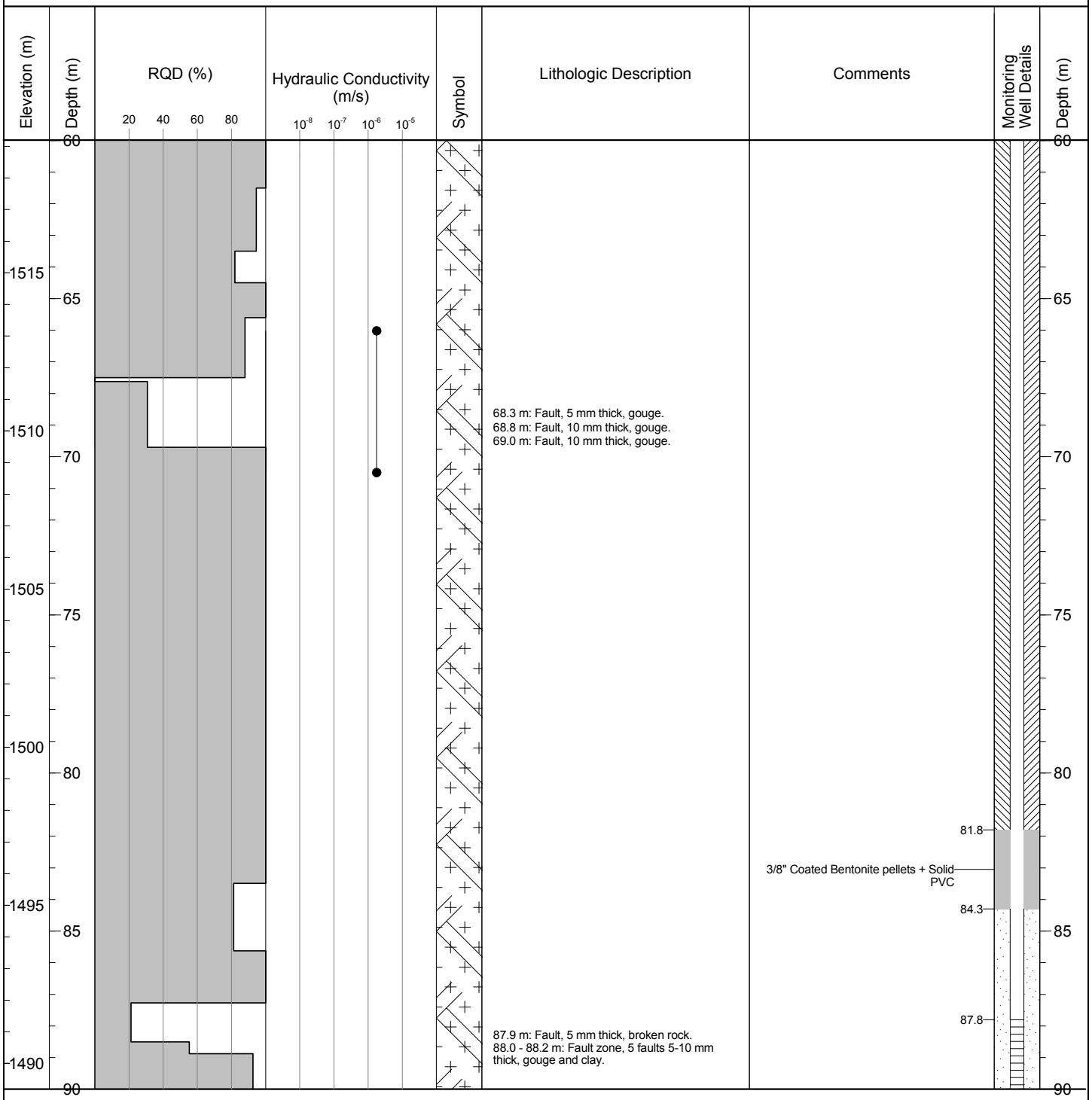
Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

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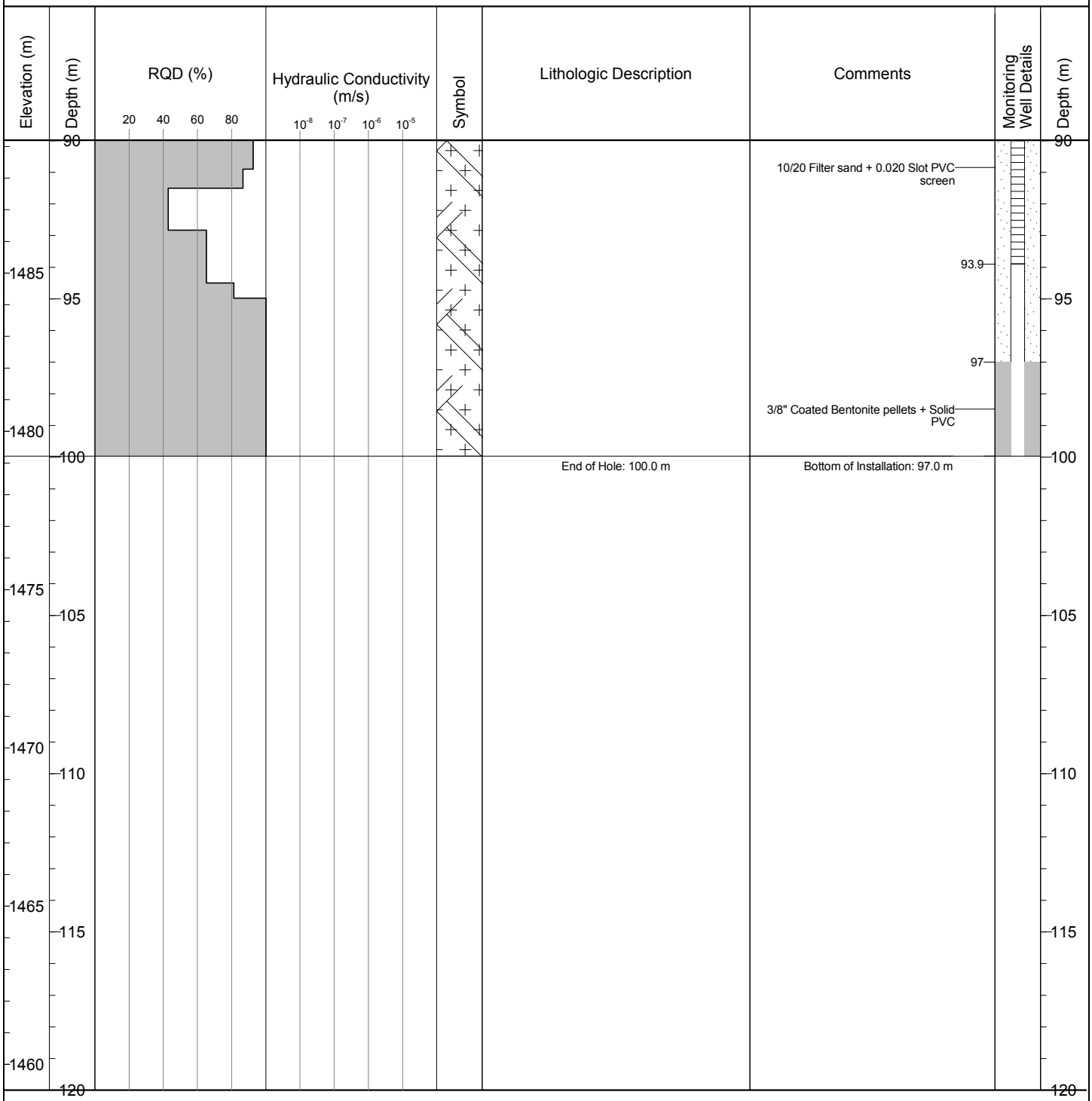
Logged by: DP/LL
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

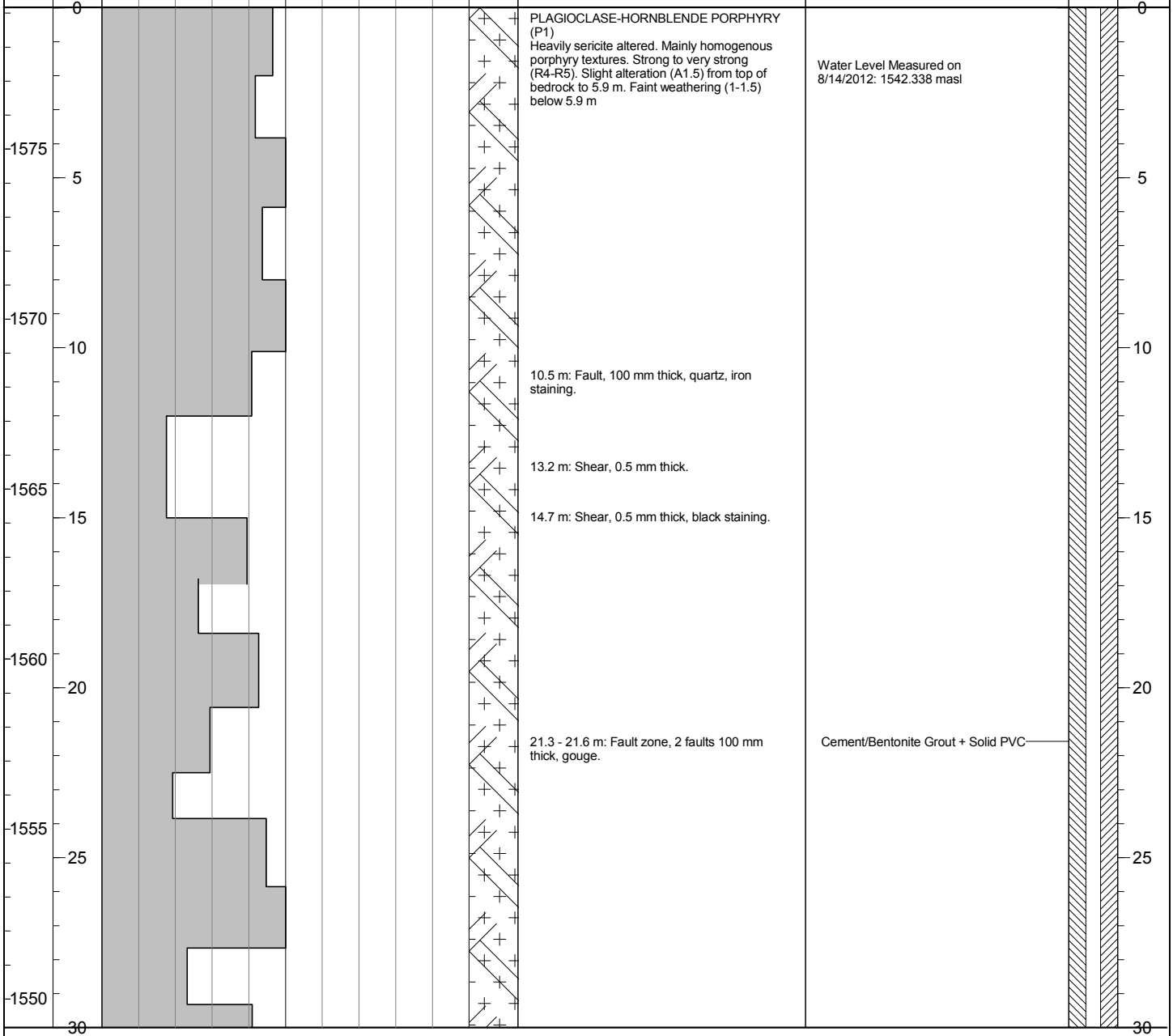
DRILL HOLE # MW-BGC12-BJ-12B

Location: Valley of Kings Zone

Co-ordinates (m): 426,505E - 6,257,807N
Ground Elevation (m): 1,579.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1579.9
Cased To (m): 1

Start date: 09 Aug 12
Finish Date: 10 Aug 12
Final Depth (m): 53.1
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



Lithologic Description	Comments
PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Heavily sericite altered. Mainly homogenous porphyry textures. Strong to very strong (R4-R5). Slight alteration (A1.5) from top of bedrock to 5.9 m. Faint weathering (1-1.5) below 5.9 m	Water Level Measured on 8/14/2012: 1542.338 masl
10.5 m: Fault, 100 mm thick, quartz, iron staining.	
13.2 m: Shear, 0.5 mm thick.	
14.7 m: Shear, 0.5 mm thick, black staining.	
21.3 - 21.6 m: Fault zone, 2 faults 100 mm thick, gouge.	Cement/Bentonite Grout + Solid PVC

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
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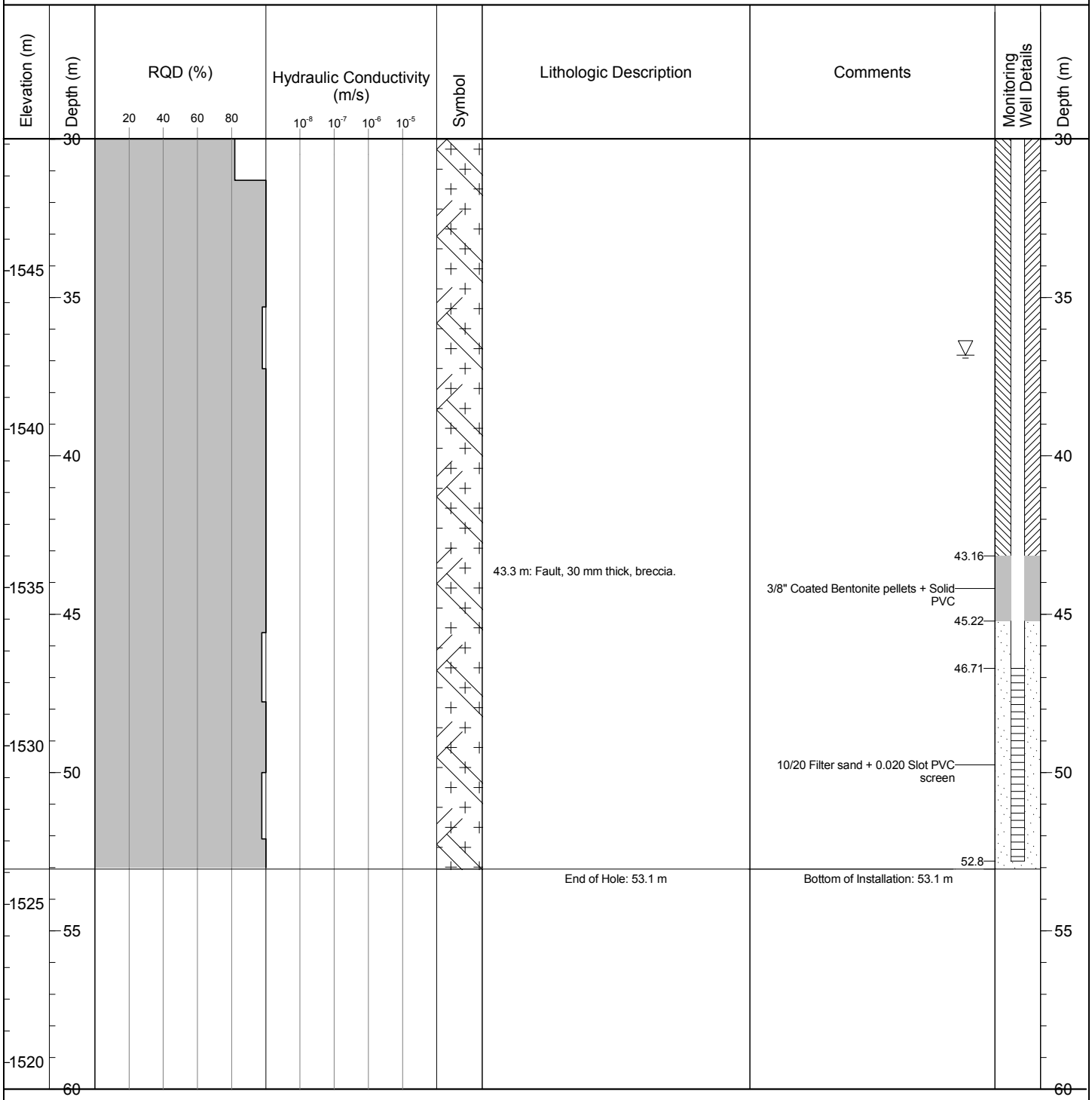
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1579.9
Cased To (m): 1

Start date: 09 Aug 12
Finish Date: 10 Aug 12
Final Depth (m): 53.1
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

APPENDIX C
GEOTECHNICAL DRILL HOLE LOGS

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description	Su - kPa (40, 80, 120, 160) / ★ % Fines / Core Recovery (20, 40, 60, 80)	▲ UC/2 / △ Pocket Pen /2 / ● SPT (blows/300mm) / Moisture Content & SPT N (W_p% W% W_L%) (20, 40, 60, 80)
0						OVERBURDEN No Recovery.		
1								
2								
3								
4								
5								
6								
7								
8								

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Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Project: Brucejack
Project No.: 1008-007
Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description	Su - kPa (40, 80, 120, 160) ★ % Fines ▲ UC/2 △ Pocket Pen /2 ● SPT (blows/300mm) Core Recovery (20, 40, 60, 80) Moisture Content & SPT N W_p% W% W_l% (20, 40, 60, 80)
8							
9							
10							
11							
12							
13							
14							
15							
						Rock encountered at 15.1 m depth. Refer to DH-BGC12-19 rock log.	
16							

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
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Drill Designation: Heliportable
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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
8			Refer to DH-BGC12-19 Overburden Log						
9									
10									
11									
12									
13									
14									
15									
16			ARENITE (S4) Dark grey, fine grained, massive sandstone, weakly altered, no bedding evident, weakly crackled with calcite veinlets, lower contact is not evident with broken core present; possibly faulted. Medium strong to strong (R3.5-R4). Faint weathering (W1.5) on major discontinuities.						

Weathering grade scale: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade scale: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD: 0, 25, 50, 75, 90, 100 %
Longest stick / fracture intercept: 0.001, 0.01, 0.3, 1, 3 m; V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76): 0, 6, 12, 20, 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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Start Date: 06 Mar 12
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Final Depth (m): 425.3
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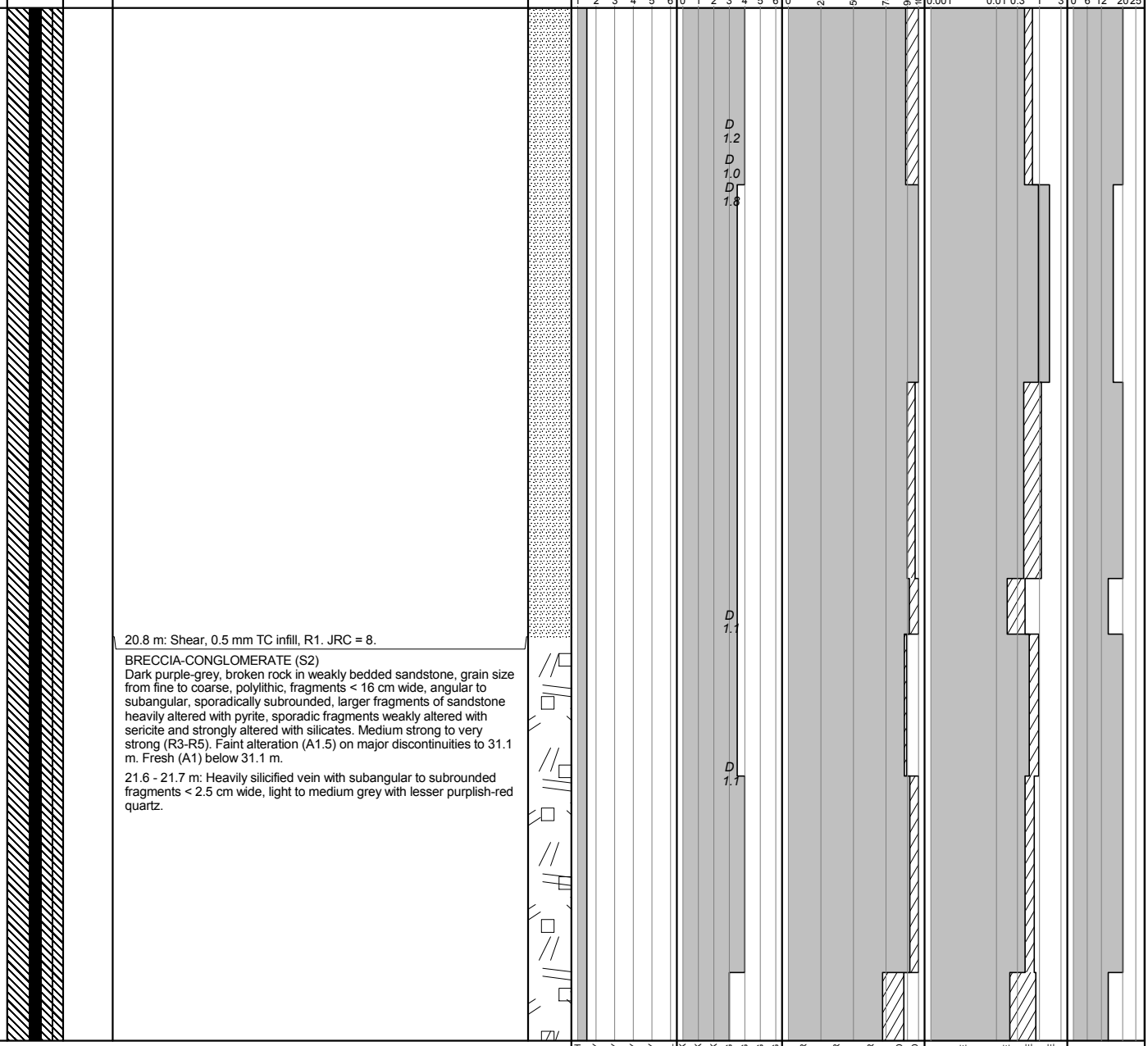
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — *TEST TYPE: DIAMETRAL (D); AXIAL (A)*
1.5— Is_{50} *(MPa)*

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
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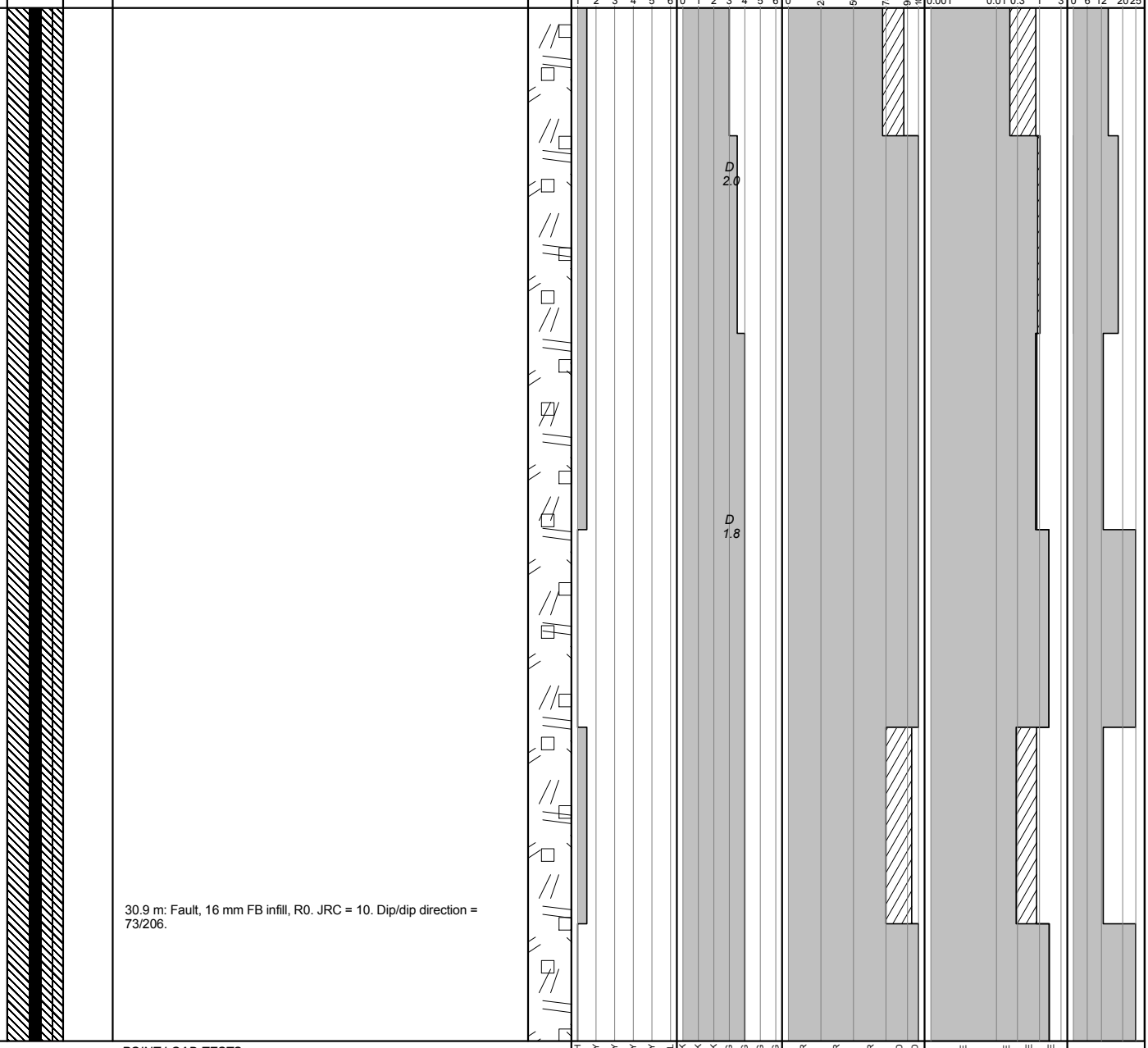
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24–32			30.9 m: Fault, 16 mm FB infill, R0. JRC = 10. Dip/dip direction = 73/206.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
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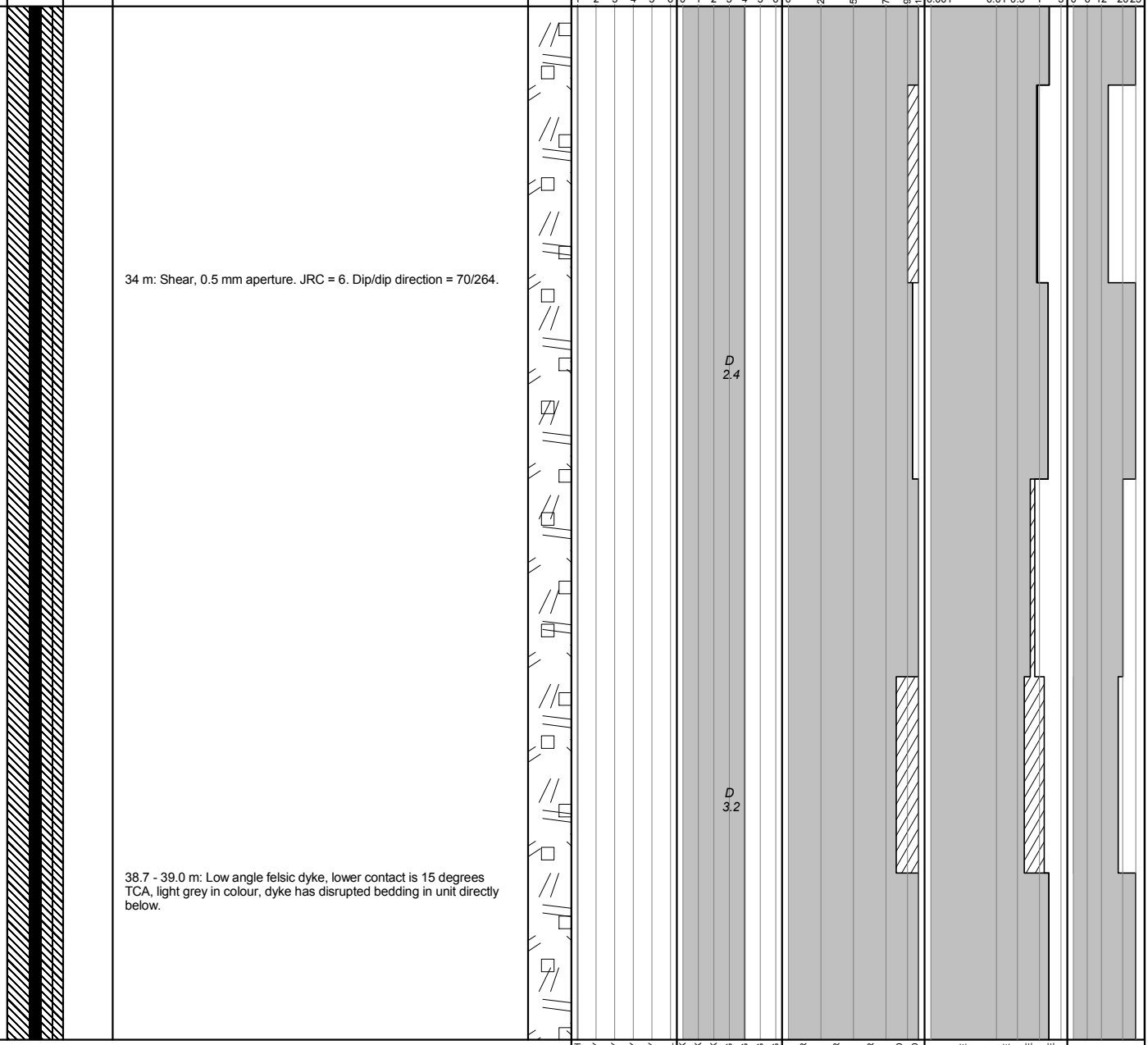
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
32									
33									
34			34 m: Shear, 0.5 mm aperture. JRC = 6. Dip/dip direction = 70/264.			D 2.4			
35									
36									
37									
38			38.7 - 39.0 m: Low angle felsic dyke, lower contact is 15 degrees TCA, light grey in colour, dyke has disrupted bedding in unit directly below.			D 3.2			
39									
40									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

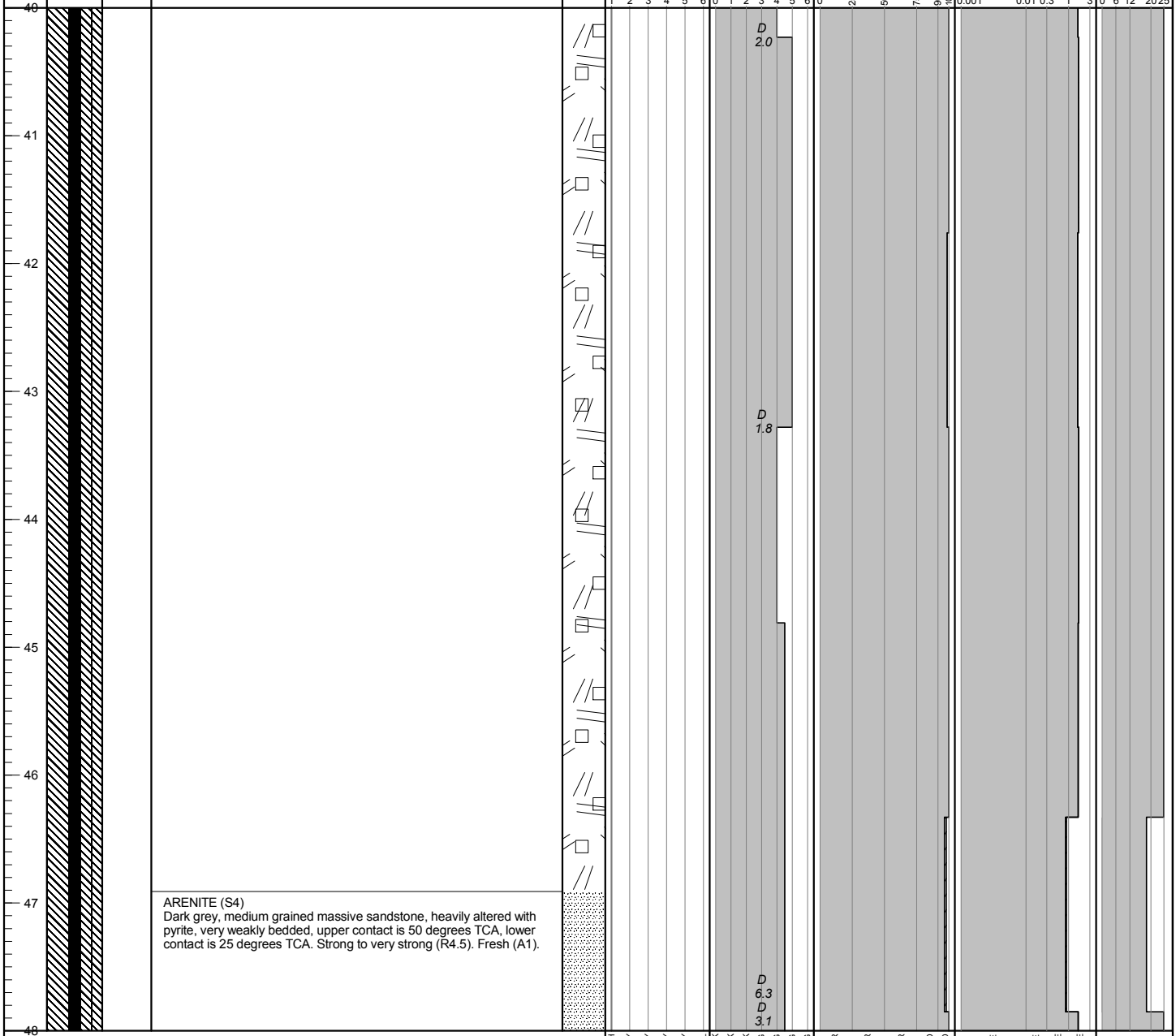
Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



ARENITE (S4)
Dark grey, medium grained massive sandstone, heavily altered with pyrite, very weakly bedded, upper contact is 50 degrees TCA, lower contact is 25 degrees TCA. Strong to very strong (R4.5). Fresh (A1).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
48			
49			BRECCIA-CONGLOMERATE (S2) Dark purpleish-grey, broken rock in weakly bedded sandstone, fine to medium grained, polylithic, smaller fragments < 4 cm, subangular with rare subround fragments, locally whitish-grey to light greyish-purple. Medium strong to strong (R3.5-R4). Fresh (A1).
50			50.4 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 61/240.
51			Falling head test from 50.9 - 55.5 m. Estimated hydraulic conductivity is 1.6E-07 m/s. 51.6 m: Shear, 0.1 mm aperture. JRC = 10. Dip/dip direction = 74/331.
52			52.5 m: Fault, 15 mm FB infill, R1. JRC = 13. Dip/dip direction = 69/014. 52.7 m: Fault, 8 mm FG infill, R0. JRC = 16. Dip/dip direction = 52/014.
53			53 m: Fault, 0.5 mm FG infill, R0. JRC = 8. Dip/dip direction = 73/357. 53.6 m: Fault, 11 mm FB infill, R2. JRC = 20. Dip/dip direction = 58/360. 53.6 m: Fault, 4 mm FB infill, R2. JRC = 20. Dip/dip direction = 47/247.
54			54.2 m: Fault, 13 mm FB infill, R0. JRC = 20. Dip/dip direction = 54/048. 54.3 m: Fault, 40 mm FB infill, R0. JRC = 8. Dip/dip direction = 47/036. 54.6 m: Shear, 0.5 mm aperture. JRC = 13. Dip/dip direction = 66/250.
55			54.9 m: Fault, 10 mm FB infill, R1. JRC = 6. 55.1 m: Shear, 0.5 mm aperture. JRC = 13. 55.4 m: Shear. JRC = 15. Dip/dip direction = 72/250.
56			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
56			56 m: Shear, 0.2 mm aperture. JRC = 13. Dip/dip direction = 39/241.						
57			57.1 m: Shear, 0.2 mm aperture. JRC = 10. Dip/dip direction = 60/233.			D 1.6			
58			58.3 m: Shear, 0.5 mm aperture. JRC = 6. Dip/dip direction = 53/303.						
59			59.1 m: Fault, 6 mm FG infill, R0. JRC = 8. Dip/dip direction = 73/252. 59.2 m: Fault, 5 mm FB infill, R0. JRC = 10.						
60			60.4 m: Fault, 7 mm FB infill, R0. JRC = 16. Dip/dip direction = 83/26.						
61			60.9 m: Fault, 3 mm FB infill, R0. JRC = 6. Dip/dip direction = 57/341. PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Dark grey, fine grained groundmass with medium grained tabular to subrounded feldspar crystals with selective crystals replaced by calcite, hornblende needles visible with majority replaced by sericite or chlorite, selective sections have sericite replaced feldspar crystals. Medium strong to strong (R3-R4). Fresh (A1).			D 4.0			
62									
63									
64									

Scales: WEATHERING GRADE (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL. STRENGTH GRADE (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG. TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD. LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE. AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

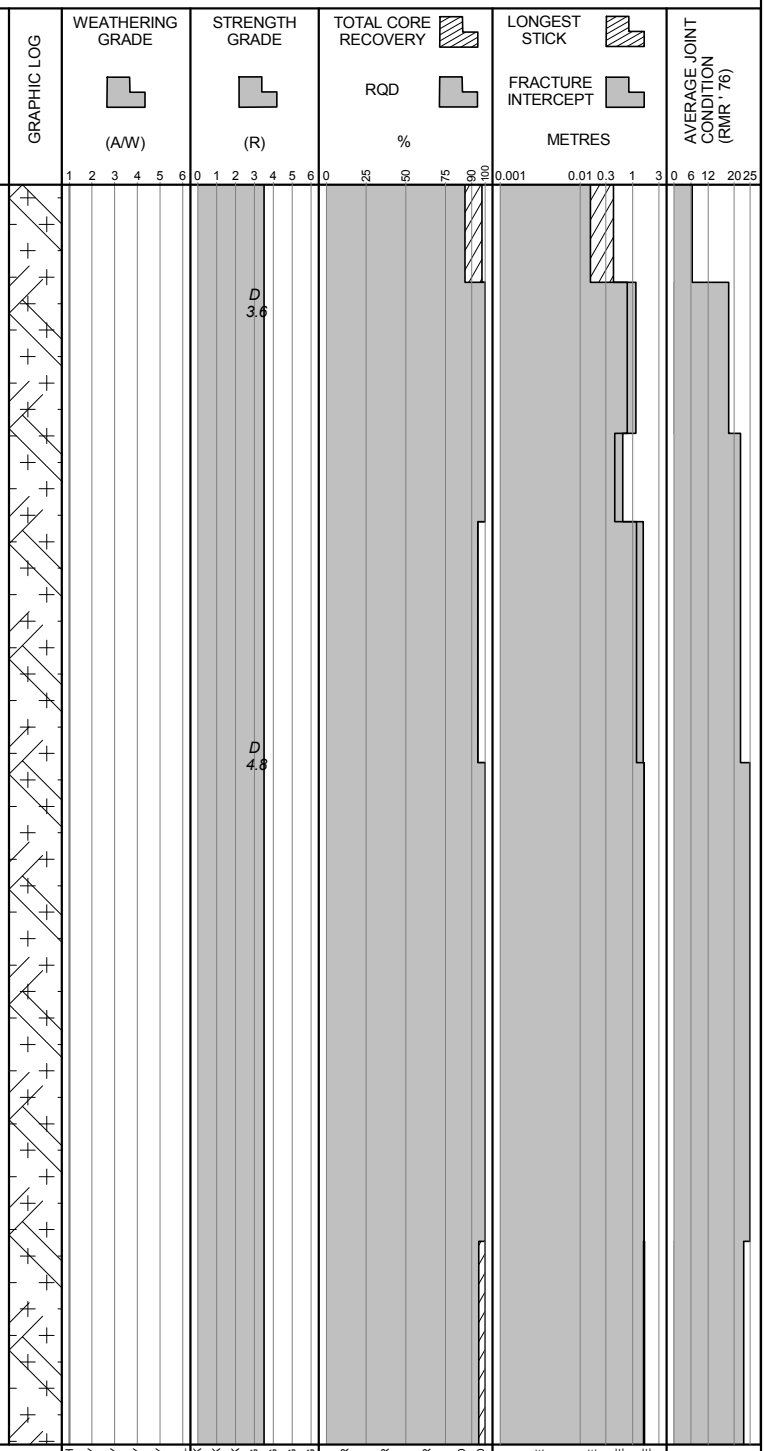
Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
64			64.1 m: Fault, 85 mm FB infill, R2. JRC = 15. Dip/dip direction = 56/299.
65			
66			
67			
68			
69			
70			
71			
72			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
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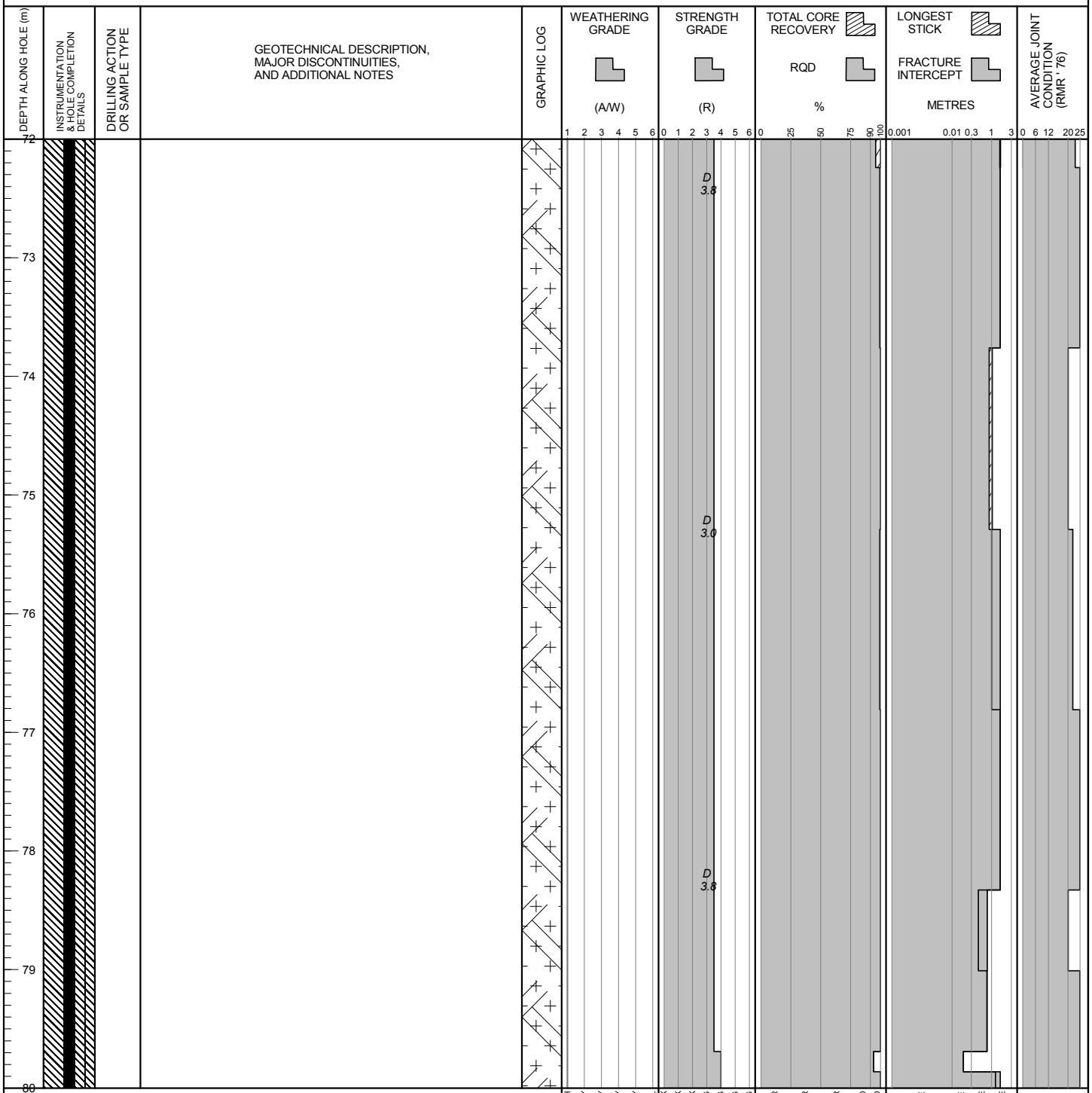
Logged By: AGC/JND/KM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

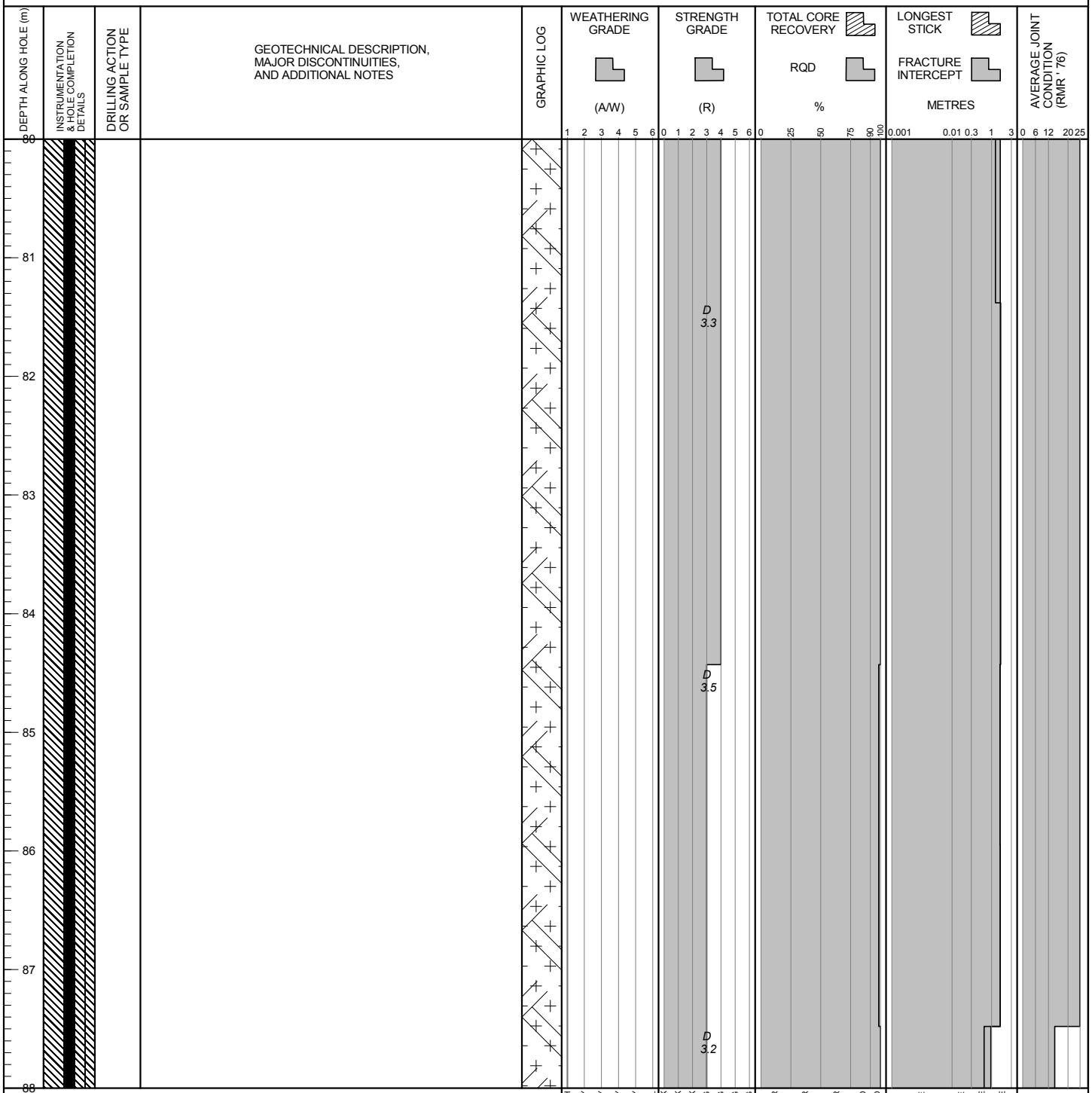
DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
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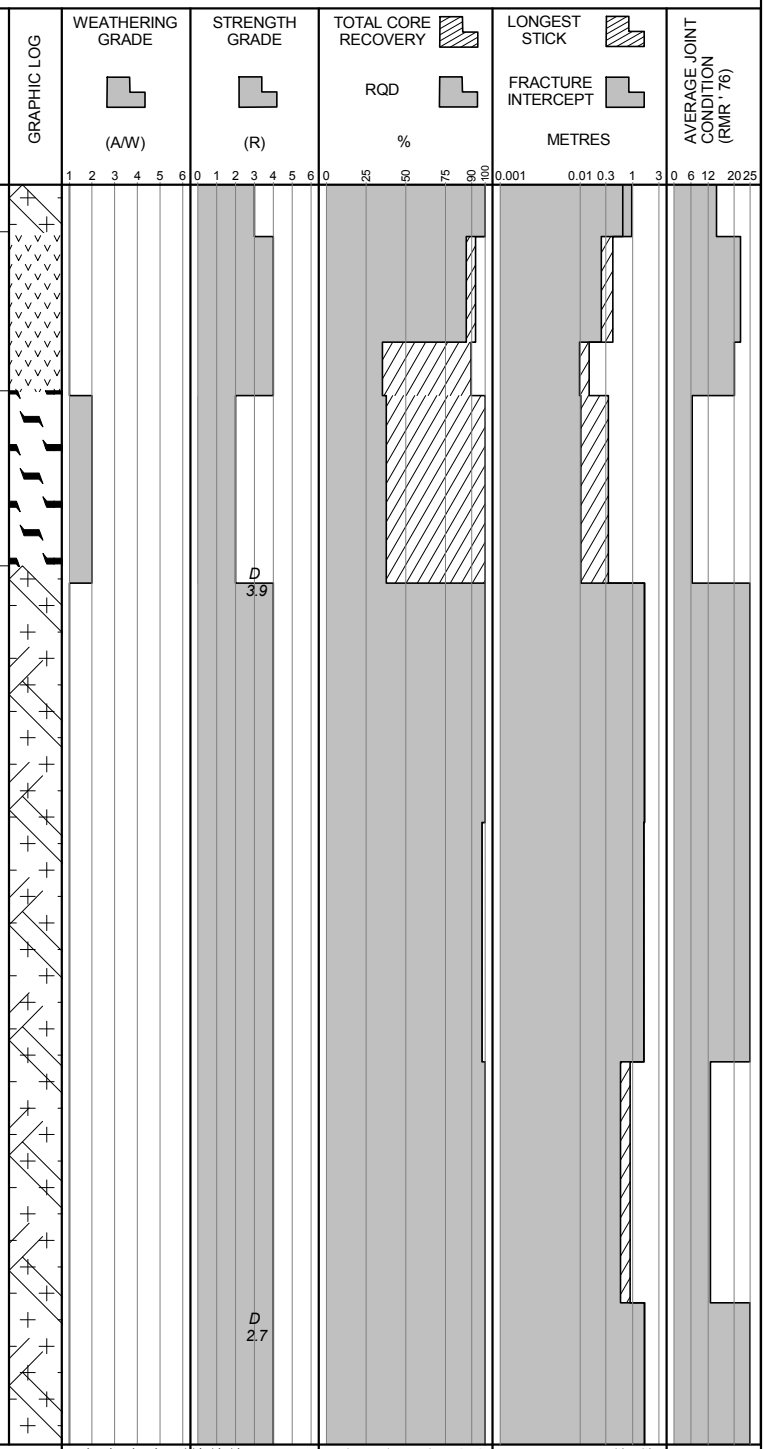
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
88			
			QUARTZ VEIN (H1) Whitish-pink, contains lesser calcite blebs, contains wall rock content with pyrite blebs, 20 degrees TCA. Strong (R4). Fresh (A1).
89			
			FAULT ZONE Contained within P1 unit, fault gouges in the unit trend approximately 20 degrees TCA. Weak (R2). Slightly altered (A2).
90			
			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Medium to dark grey, feldspar less visible than previous P1, select hornblende needles have been replaced by sericite, lower contact is faulted. Strong to very strong (R4-R5). Fresh (A1).
91			
92			
93			
94			
95			
96			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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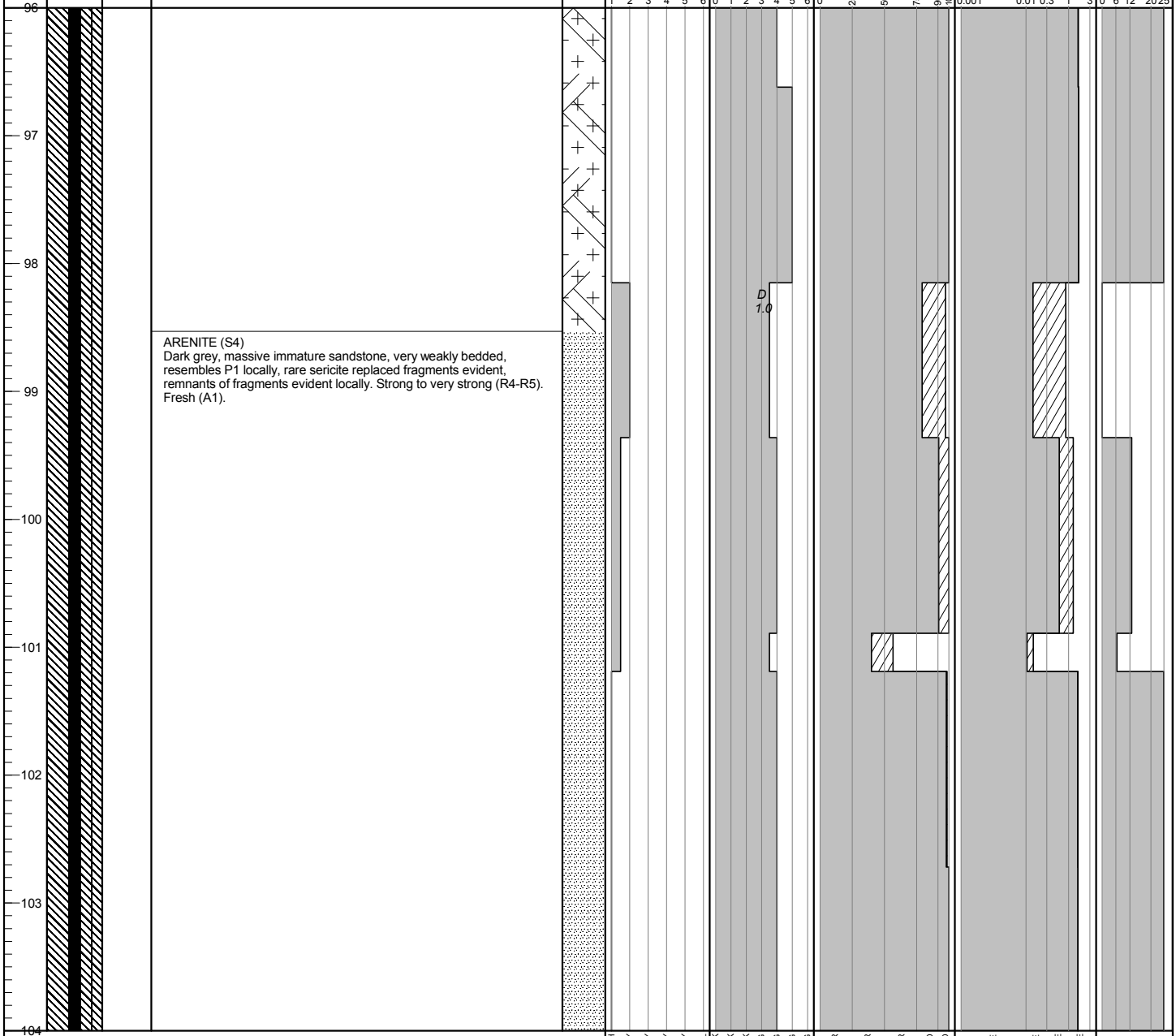
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



ARENITE (S4)
Dark grey, massive immature sandstone, very weakly bedded, resembles P1 locally, rare sericite replaced fragments evident, remnants of fragments evident locally. Strong to very strong (R4-R5). Fresh (A1).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
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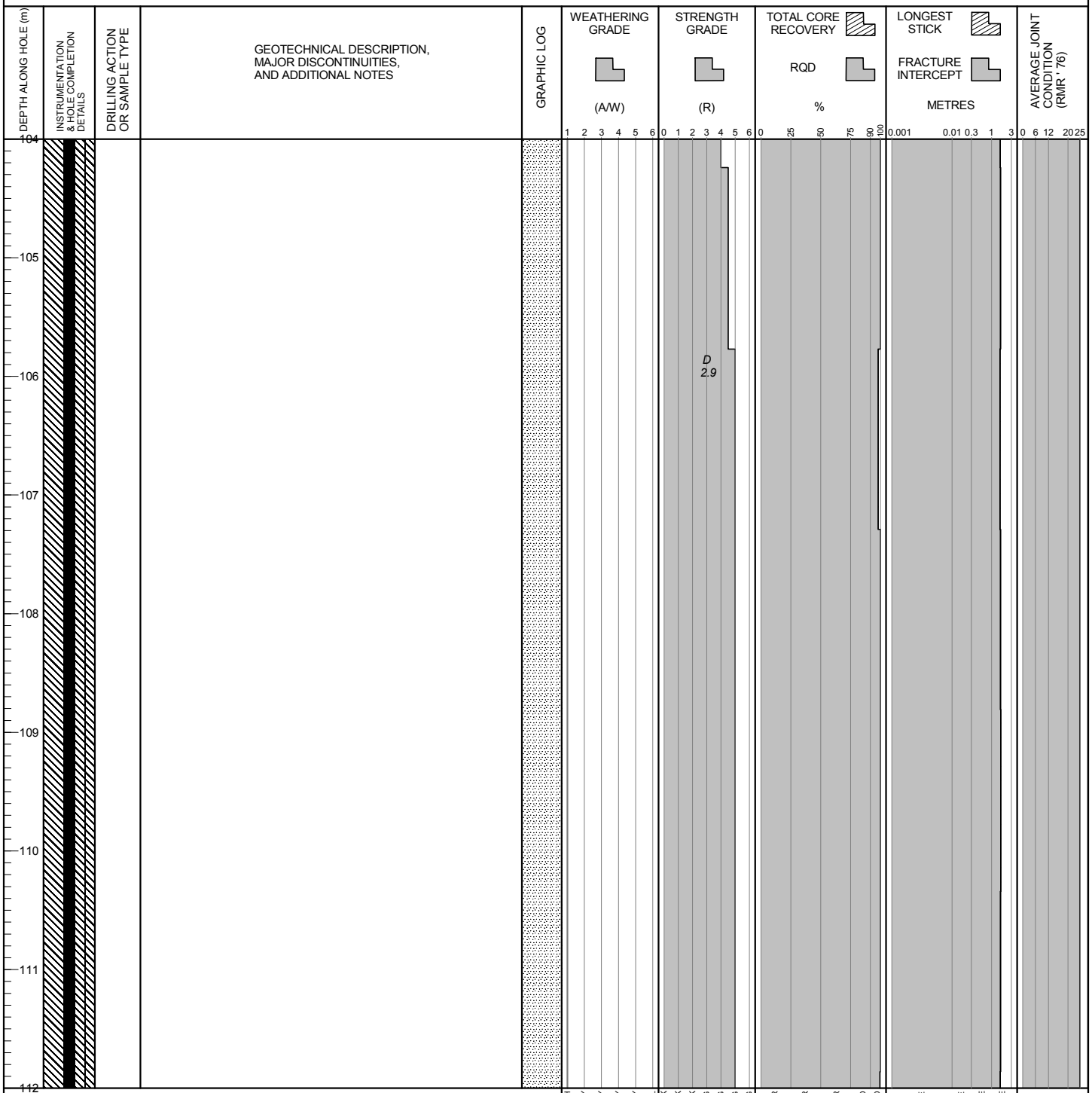
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

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Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
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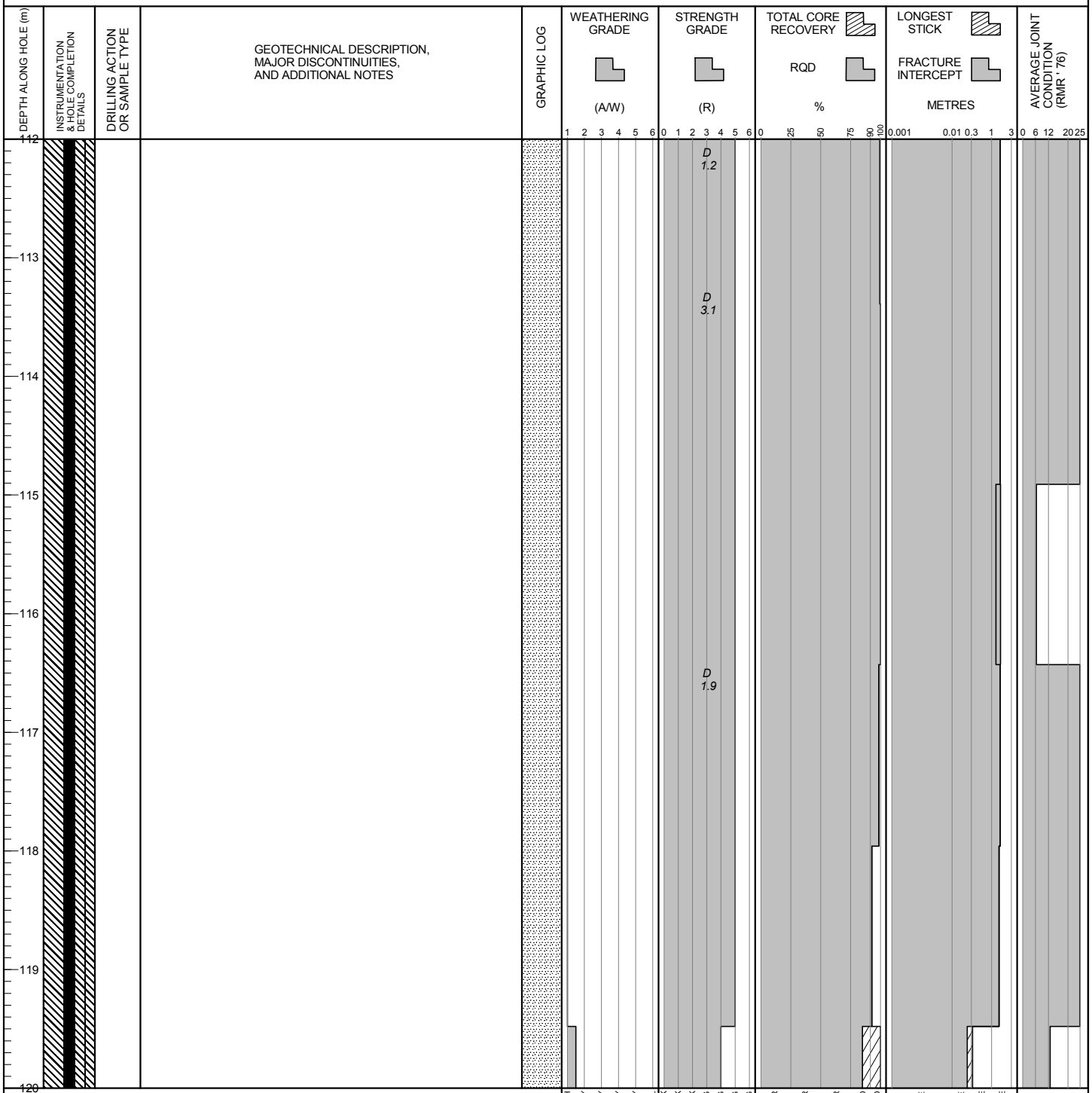

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
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Drill Designation: Heliportable
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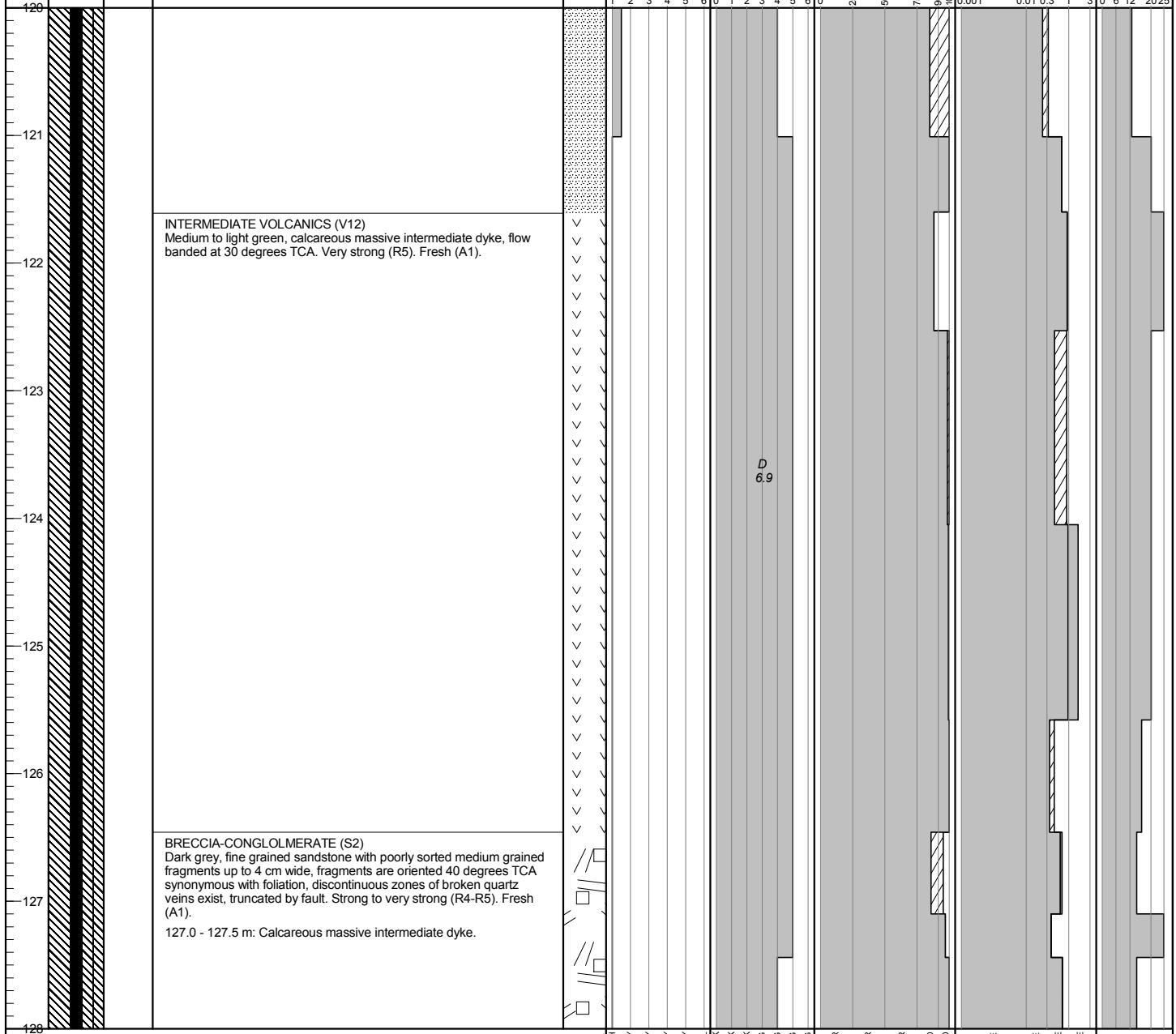
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



INTERMEDIATE VOLCANICS (V12)
Medium to light green, calcareous massive intermediate dyke, flow banded at 30 degrees TCA. Very strong (R5). Fresh (A1).

BRECCIA-CONGLOLMERATE (S2)
Dark grey, fine grained sandstone with poorly sorted medium grained fragments up to 4 cm wide, fragments are oriented 40 degrees TCA synonymous with foliation, discontinuous zones of broken quartz veins exist, truncated by fault. Strong to very strong (R4-R5). Fresh (A1).

127.0 - 127.5 m: Calcareous massive intermediate dyke.

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

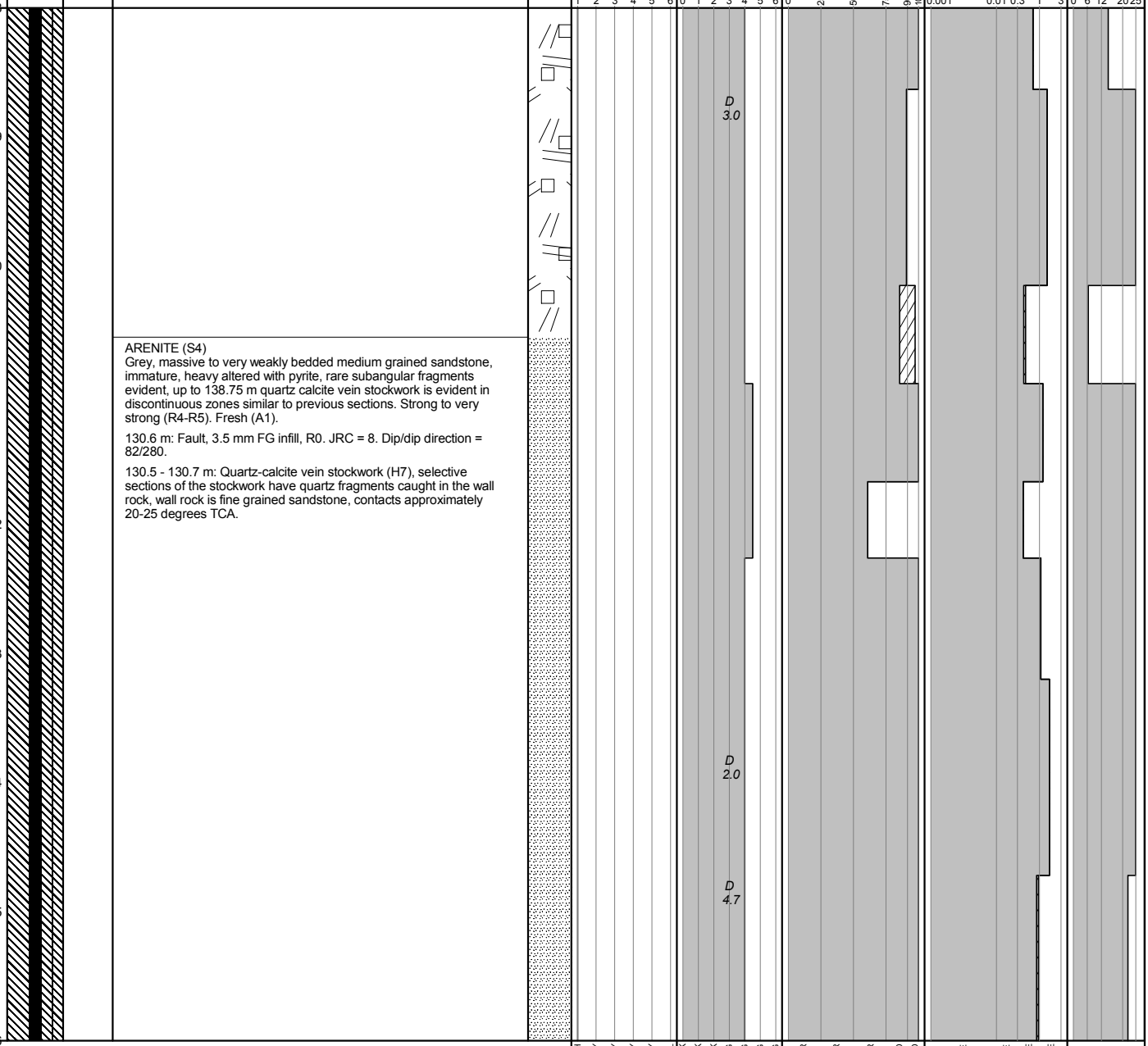
DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

128
129
130
131
132
133
134
135
136

ARENITE (S4)
Grey, massive to very weakly bedded medium grained sandstone, immature, heavy altered with pyrite, rare subangular fragments evident, up to 138.75 m quartz calcite vein stockwork is evident in discontinuous zones similar to previous sections. Strong to very strong (R4-R5). Fresh (A1).

130.6 m: Fault, 3.5 mm FG infill, R0. JRC = 8. Dip/dip direction = 82/280.

130.5 - 130.7 m: Quartz-calcite vein stockwork (H7), selective sections of the stockwork have quartz fragments caught in the wall rock, wall rock is fine grained sandstone, contacts approximately 20-25 degrees TCA.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
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POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

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Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY RQD %	LONGEST STICK FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
152					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
153									
154									
155									
156									
157						D 4.6			
158									
159			158.7 - 160.5 m: Quartz-calcite vein stockwork (H7) similar to previous zone, slightly more brecciated.						
160					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-19

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Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

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Depth To Top Of Rock (m): 15.1
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Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
160									
161									
162			162.3 m: Fault, 8 mm FB infill, R0. JRC = 10. Dip/dip direction = 77/273.			D 2.7			
163									
164									
165									
166			166.5 m: Fault, 3 mm FB infill, R0. JRC = 12. Dip/dip direction = 87/294.			D 2.1			
167			167 m: Fault, 2 mm FB infill, R0. JRC = 13. Dip/dip direction = 64/046. 167.2 m: Fault, 0.5 mm FG infill, R0. JRC = 8. Dip/dip direction = 49/227.						
168									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
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Reviewed By: JW

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
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Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
176					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
177						D 8.1			
178									
179									
180						D 2.5			
181									
182						D 4.9			
183									
184									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
184									
185			185.0 - 187.3 m: Stockwork (H7) in sandstone, locally brecciated, quartz veins are < 30 cm wide.			D 3.9			
186									
187									
			QUARTZ VEIN (H1) White to milky white, mineralized quartz calcite vein, massive, rare wall rock fragments present, locally vein has a greenish colouration due to sericite alteration, oriented roughly 25 degrees TCA, black specks are visible in vein. Strong to very strong (R4-R4.5). Fresh (A1).						
188									
189						D 5.7			
190									
191									
192									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY 0 25 50 75 90 100; LONGEST STICK 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
192						D 5.8			
			ARENITE (S4) Grey, medium grained sandstone brecciated by veining, similar to previous sandstone units. Strong to very strong (R4-R4.5). Fresh (A1). 192.5 - 199.2 m: Stockwork (H7) in sandstone, locally brecciated, quartz veins are < 30 cm wide.						
193									
194									
195									
						D 6.6			
196			196.1 m: Shear, 1 mm aperture. JRC = 12. Dip/dip direction = 81/298.						
197									
198						D 5.0			
199			199.2 m: Shear, 0.2 mm aperture. JRC = 8.						
200									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 100 EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

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Client: Pretium Resources Inc.

LOG SCALE: 1:50

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DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

QUARTZ VEIN (H1)
White to milky white, quartz-calcite vein with weakly altered wall rock fragments. Strong to very strong (R4-R4.5). Fresh (A1).

201.8 m: Fault, 2 mm FB infill, R1. JRC = 8. Dip/dip direction = 83/189.

ARENITE (S4)
Medium to dark grey, medium grained sandstone, weakly bedded and immature, discontinuous zones of brecciation evident (localized crackle breccia and vein brecciation present), locally vein "fragments" look to have been caught in the sandstone, rare subangular fragments present up to 4 cm wide. Strong to very strong (R4-R4.5). Fresh (A1).

203.1 m: Shear, 1 mm aperture. JRC = 13. Dip/dip direction = 80/347.

D 7.2
D 5.5
D 7.2
D 6.2
D 7.2

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

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Client: Pretium Resources Inc.

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BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

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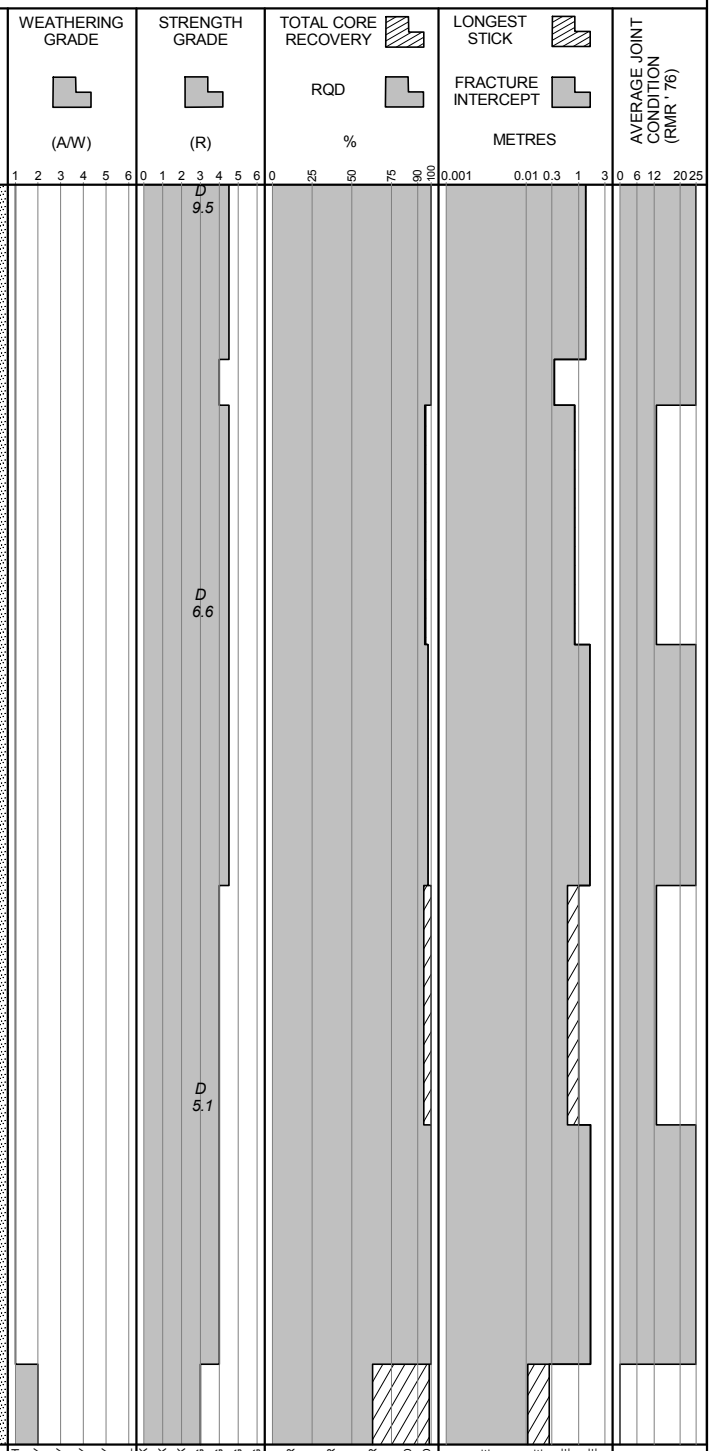
DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
208			
209			209.7 m: Fault, 2 mm FB infill, R0. JRC = 10. Dip/dip direction = 67/354.
210			
211			
212			
213			
214			213.9 m: Fault, 3 mm FB infill, R1. JRC = 12. Dip/dip direction = 62/358.
215			
216			Falling head test from 215.5 - 220.1 m. Estimated hydraulic conductivity is 2.6E-07 m/s. 215.6 m: Fault on vein, 2.5 mm FB infill, R0. JRC = 6. Dip/dip direction = 46/013.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Client: Pretium Resources Inc.

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216			215.8 m: Fault, 40 mm FG infill, R0. JRC = 8. Dip/dip direction = 55/348. 216.1 m: Fault, 4 mm FG infill, R0. JRC = 10. Dip/dip direction = 54/002. 216.1 m: Fault, 4 mm FB infill, R0. JRC = 13. 216.3 m: Fault, 8 mm FG infill, R0. JRC = 12. Dip/dip direction = 77/016.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
217									
218			218.4 m: Shear, 0.5 mm SE infill, R0. JRC = 8. Dip/dip direction = 60/359. 218.8 m: Fault, 2 mm FB infill, R1. JRC = 12. Dip/dip direction = 42/021.			D 7.0			
219									
220									
221			INTERMEDIATE VOLCANICS (V12) Green, massive intermediate dyke, approximately 10% calcite blebs, chlorite altered fractures, weakly calcareous. Strong to very strong (R4.5). Fresh (A1).			D 9.5			
222									
223			ARENITE (S4) Grey, fine to medium grained sanstone, very weakly bedded, contains sporadic subangular fragments up to 1 cm wide, up to 223.45 m unit is vein brecciated with quartz/calcite filling the spaces between fragments. Strong (R4). Fresh (A1). 223.5 m: Fault, 2 mm FB infill, R0. JRC = 8. Dip/dip direction = 42/332.			D 6.3			
224					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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LOG SCALE: 1:50

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Trend (°): 131

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Drilling Contractor: Radius
Drill Method: Diamond
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Fluid: Polymer
Cased To (m) : 16.3

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224			224.3 - 228.0 m: Mineralized quartz-calcite stockwork in sandstone, minor vein brecciation locally.
225			
226			
227			227.2 m: Drillhole intersected an old drillhole, water lost.
228			QUARTZ VEIN (H1) White to milky white, vuggy quartz-calcite vein, weakly mineralized, contains wall rock fragments, possibly sandstone. Strong (R4). Fresh (A1).
229			
230			
231			STOCKWORK (H7) Medium to light grey, vein brecciated stockwork, quartz-calcite veining, sporadic vugs evident < 2 cm wide. Strong (R4). Fresh (A1).
232			

POINT LOAD TESTS
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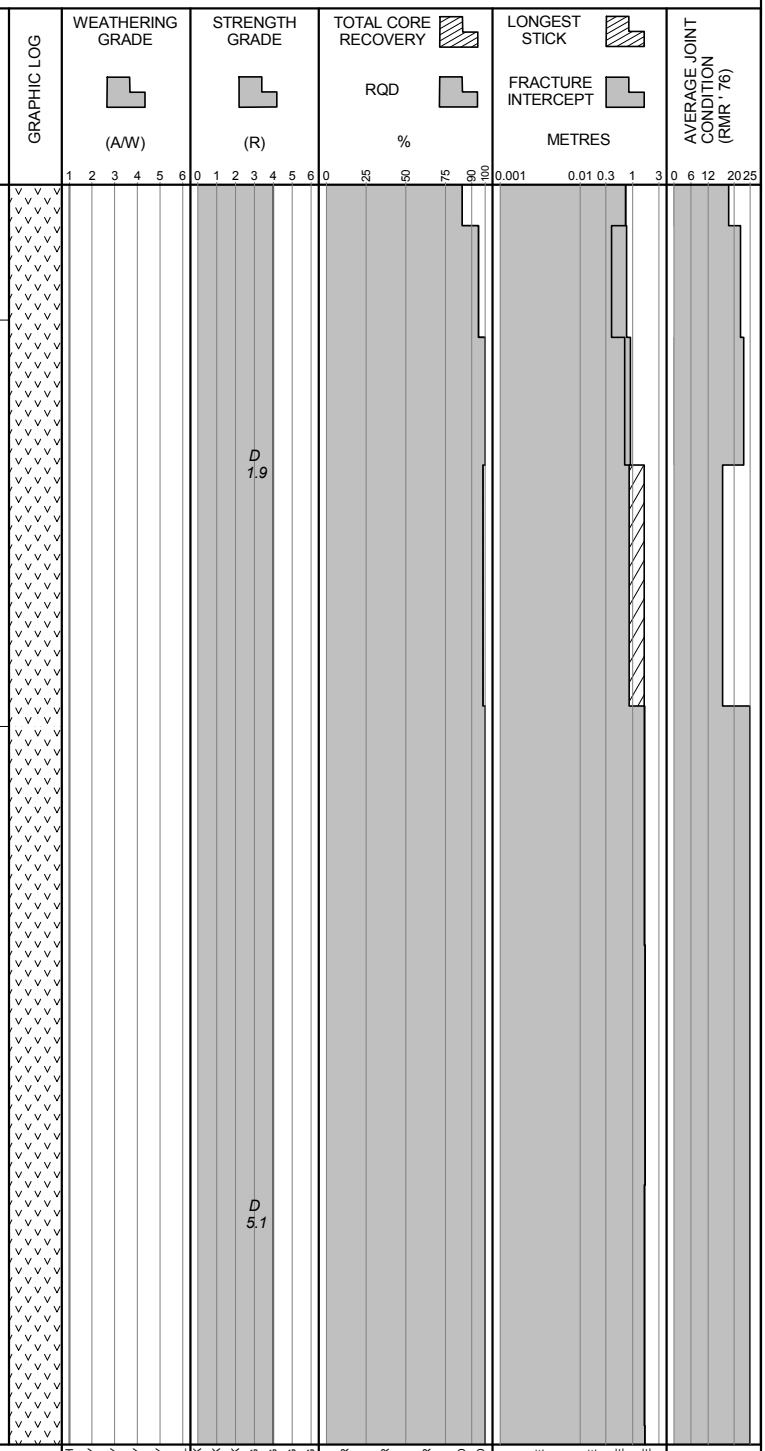
232			
233			QUARTZ VEIN (H1) White to milky white, vuggy quartz-calcite vein, weakly mineralized, contains wall rock fragments. Strong (R4). Fresh (A1).
234			
235			
236			STOCKWORK (H7) Medium to light grey, stockwork in massive sandstone or porphyry, multiple phases of veining overprinting itself in certain portions of the unit, veining looks to be offset by fracturing. Strong to very strong (R4-R5). Fresh (A1).
237			
238			
239			
240			



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Fluid: Polymer
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240									
241									
242									
243									
244			244 m: Fault, 1 mm FB infill, R0. JRC = 10. Dip/dip direction = 64/238.						
245									
246									
247						D 6.9 D 5.2			
248									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

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Drill Method: Diamond
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248						D 5.8 D 5.7			
249						D 8.6			
250									
251									
252									
253									
254						D 4.2			
255									
256									

Weathering grade scale: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade scale: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD %: 0, 25, 50, 75, 90, 100
Longest stick / fracture intercept metres: 0.001, 0.01, 0.3, 1, 3
Average joint condition (RMR '76): 0, 6, 12, 20, 25
Fracture intercept: V. CLOSE, CLOSE, MODERATE, WIDE
Graphic log: SOIL

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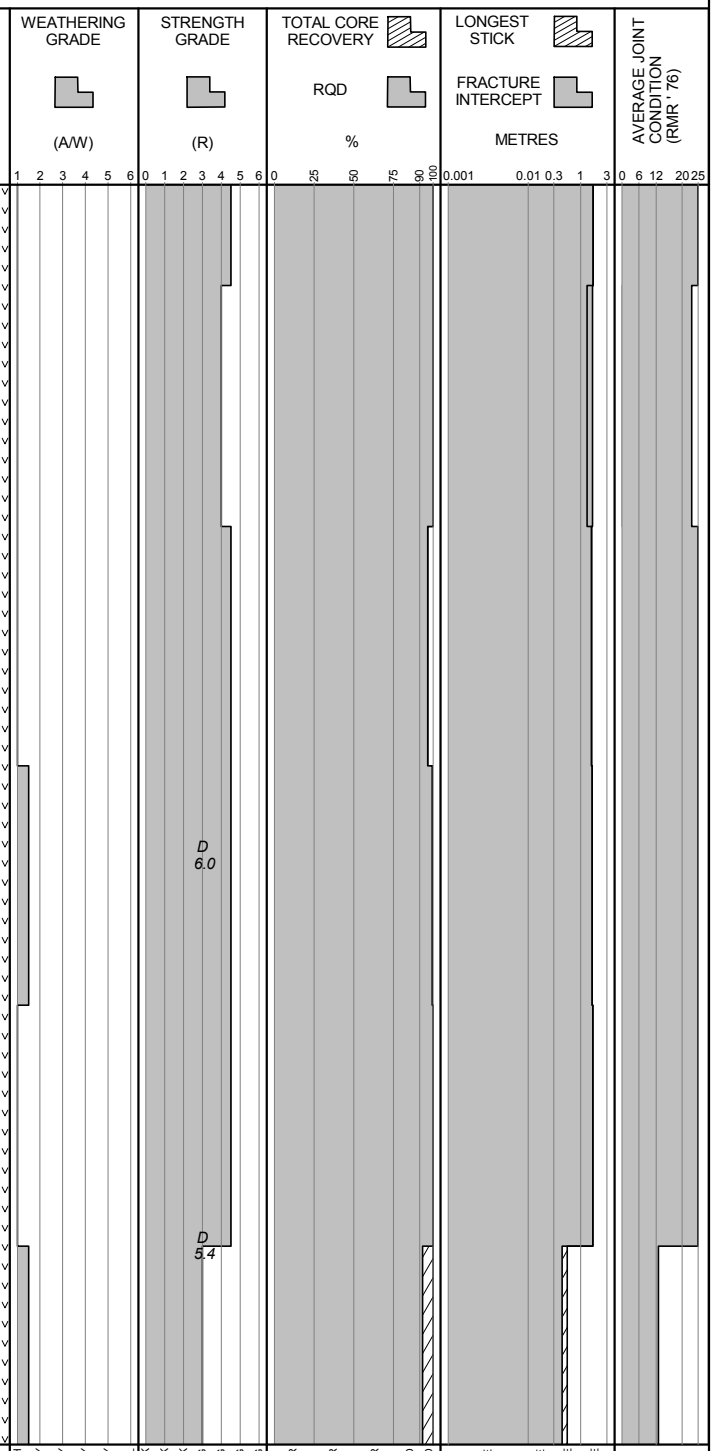
256			
257			
258			
259			
260			
261			
262			
263			263.8 m: Shear, 80 mm DX infill, R0. JRC = 10. Dip/dip direction = 36/220.
264			



POINT LOAD TESTS
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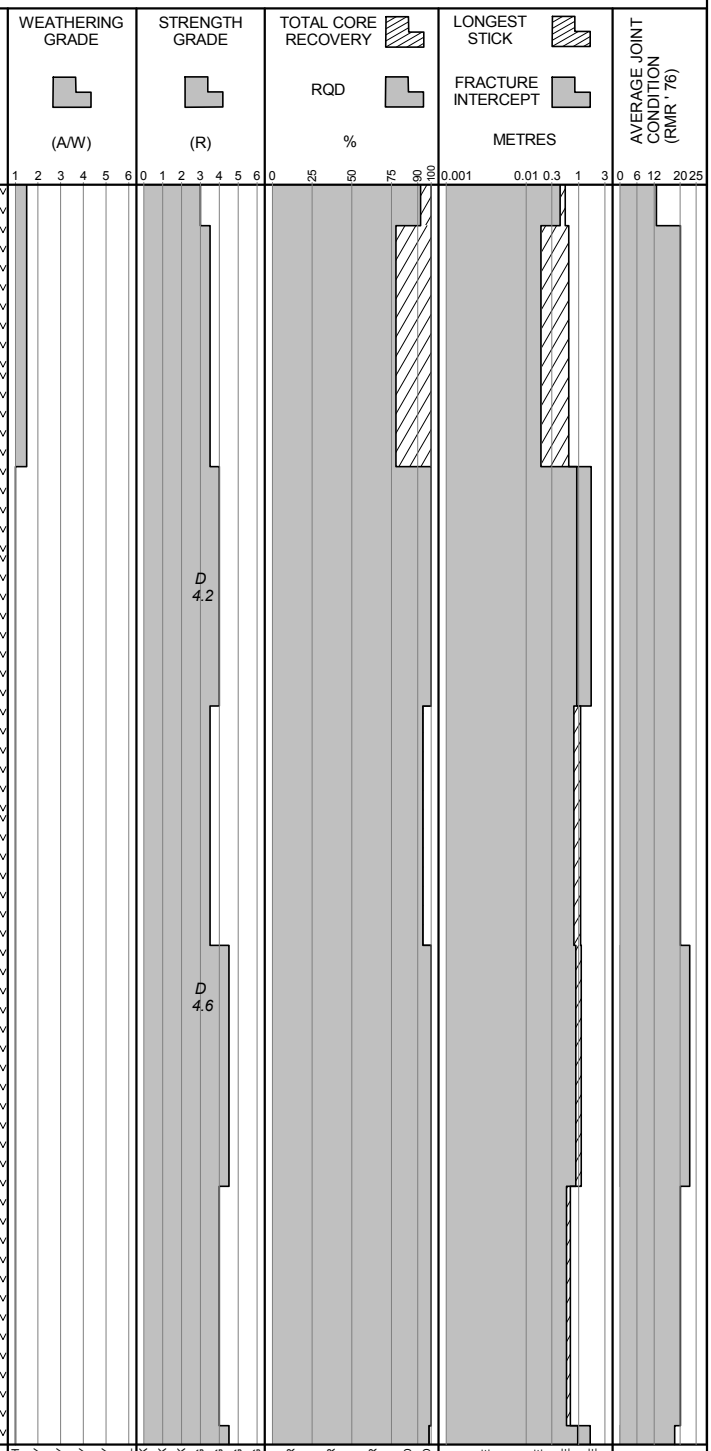
264			264.6 m: Shear, 0.5 mm aperture. JRC = 10. Dip/dip direction = 55/233.
265			265.1 m: Shear, 60 mm CX infill, R0. JRC = 20. Dip/dip direction = 17/202.
			VERY SILICEOUS ROCKS (H8) Medium to light purple-grey, heavily silicified rhyolite, upper contact is faulted with unknown orientation, brecciated and chaotic quartz veining present with few veins intact. Medium strong to strong (R3.5-R4). Fresh to faint alterations (A1-A1.5).
266			
			STOCKWORK (H7) Grey, stockwork in massive sandstone or porphyry, multiple phases of veining overprinting itself in certain portions of the unit, veining looks to be offset by fracturing, sporadic subangular fragments < 3 cm wide are replaced by sericite. Medium strong to strong (R3.5-R4). Fresh (A1).
267			
268			VERY SILICEOUS ROCKS (H8) Medium to light purplish-grey, heavily silicified rhyolite, similar to previous H8 unit, heavily vein brecciated, rare subangular fragments < 3 cm wide present, strong sphalerite mineralization. Strong to verry strong (R3.5-R5). Fresh (A1).
269			
270			
271			
272			



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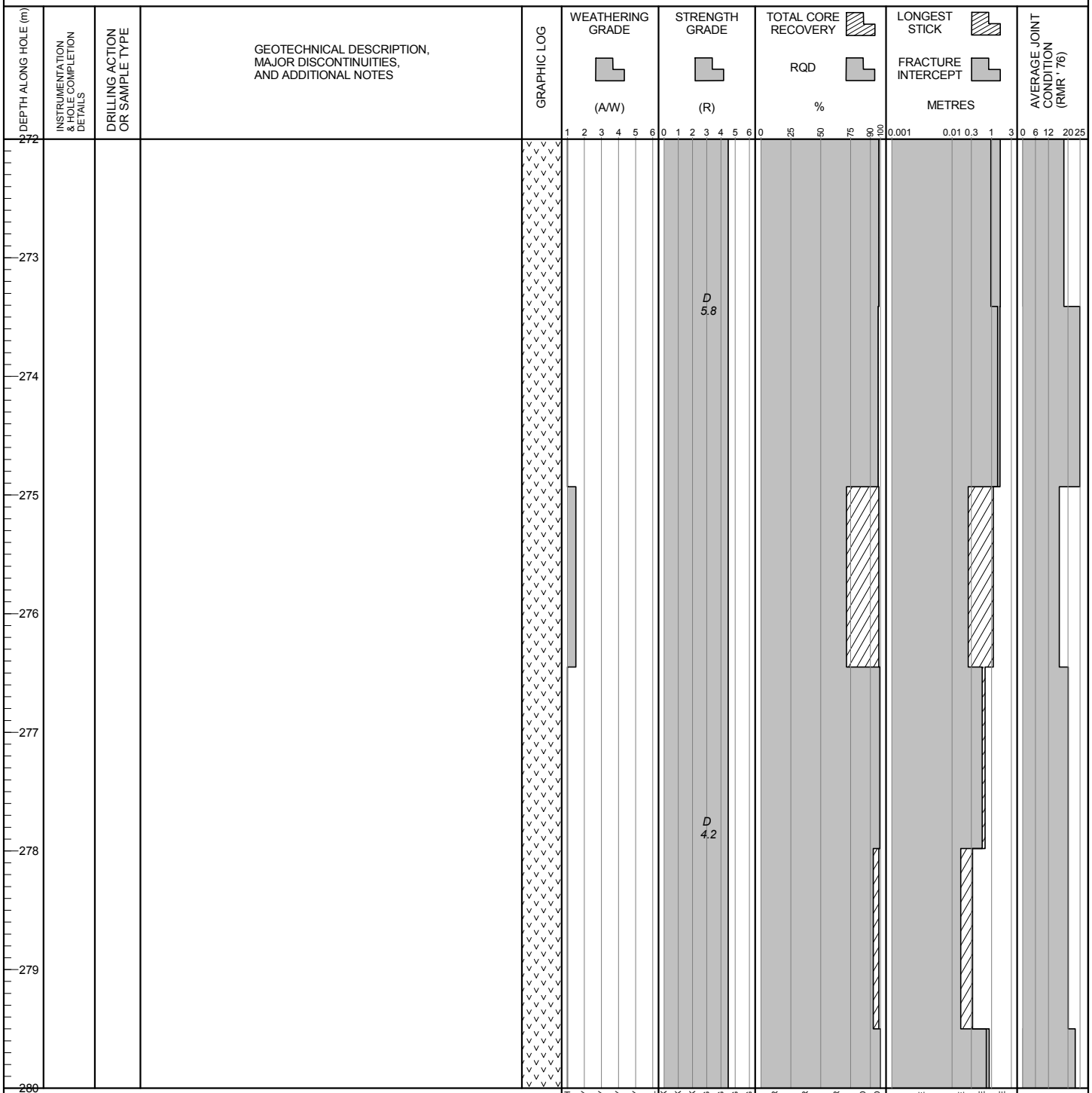

POINT LOAD TESTS
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280									
281									
282			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Medium to light greenish-grey, sericite replaced hornblende and feldspar, contains angular to subangular light grey aphanitic fragments as well as medium to dark grey porphyritic fragments up to 6 cm wide, suggesting a porphyritic flow breccia. Strong to very strong (R4-R5). Fresh (A1). 282.1 m: Fault on vein, 5 mm FG/CX infill. JRC = 16. Dip/dip direction = 25/210.						
283						D 4.7 D 6.8			
284						D 7.3 D 5.3			
285									
286									
287			287.3 m: Shear, 1 mm SE infill, R2. JRC = 4. Dip/dip direction = 50/286. 287.7 m: Shear, 1 mm SE infill, R2. JRC = 4. 287.7 m: Shear, 1 mm SE infill, R2. JRC = 4.						
288									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

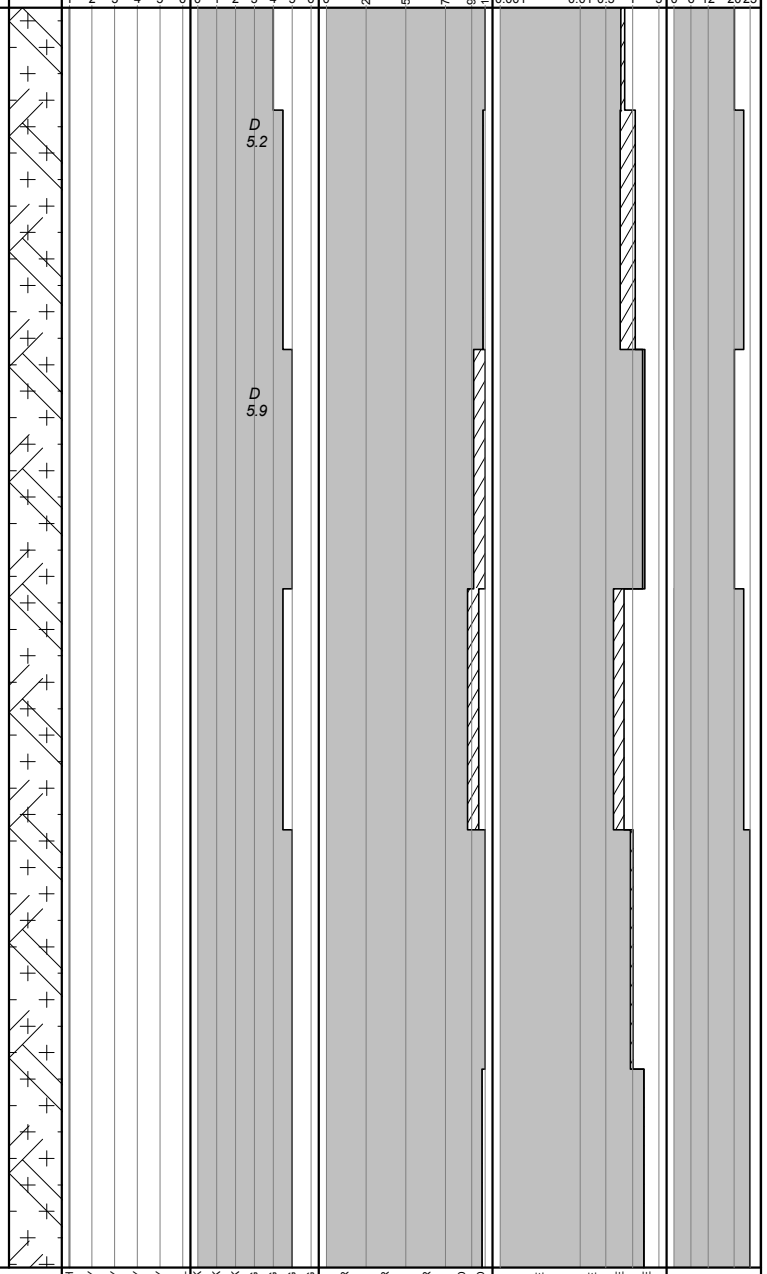
Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
288			288 m: Shear, 1 mm SE infill, R2. JRC = 8. Dip/dip direction = 78/305.
			288.8 m: Shear, 0.5 mm aperture. JRC = 4.
289			
290			
291			
			291.6 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 64/272.
292			291.9 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 40/242.
293			293.1 m: Shear, 1 mm CH infill, R2. JRC = 2. Dip/dip direction = 88/267.
294			
295			
296			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Project : Brucejack
Project No. 1008-007

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
296			
297			297.7 m: Shear, 0.5 mm CH infill, R1. JRC = 8. Dip/dip direction = 34/058. 297.8 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 82/129.
298			
299			
300			
301			
302			302.5 m: Shear, 2 mm QZ infill, R4. JRC = 12. Dip/dip direction = 72/266.
303			
304			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 7.1

D 3.8

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
304			
305			
306			
307			
308			HYDROTHERMAL BRECCIA (H15) Medium to light purplish-grey, vein brecciated, contains P1 fragments from the previous unit after 309.49 m, rhyolite fragments are also present. Very strong (R5). Fresh (A1).
309			
310			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Medium to light greenish-grey, sericite replaced hornblende and feldspar. Very strong (R5). Fresh (A1).
311			
312			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 6.5
D 5.5
D 6.1
D 8.7

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
312			
313			Constant head test from 313 - 317.6 m. Estimated hydraulic conductivity is 3.3E-07 m/s.
314			
315			
316			
317			
318			
319			
320			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 9.3
D 3.9
D 6.7
D 2.5

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

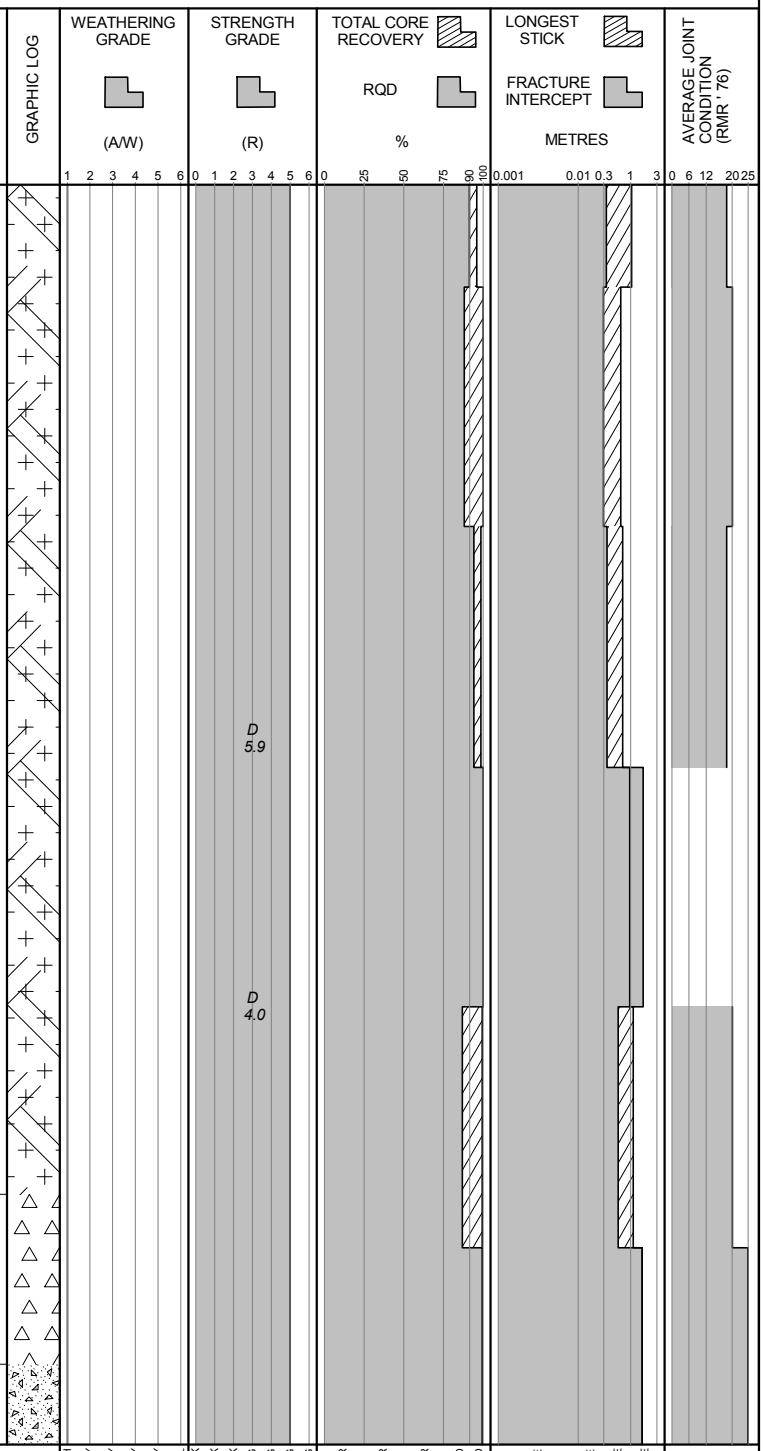
Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
320			320.1 m: Shear on vein, 35 mm BX/CX infill, R4. JRC = 4. Dip/dip direction = 60/271.
321			
322			
323			
			323.6 m: Shear, 2 mm aperture. JRC = 8.
324			
325			
326			
			HYDROTHERMAL BRECCIA (H15) Medium to light purplish-grey, vein brecciated, rhyolite fragments present. Very strong (R5). Fresh (A1).
327			
			CONGLOMERATE (S3) Medium to light purplish-grey, very altered subangular to subrounded clasts, sericite and silicate replaced. Large clasts or chunks of very siliceous rocks at 340 and 348.5 m. Very strong (R5). Fresh (A1).
328			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

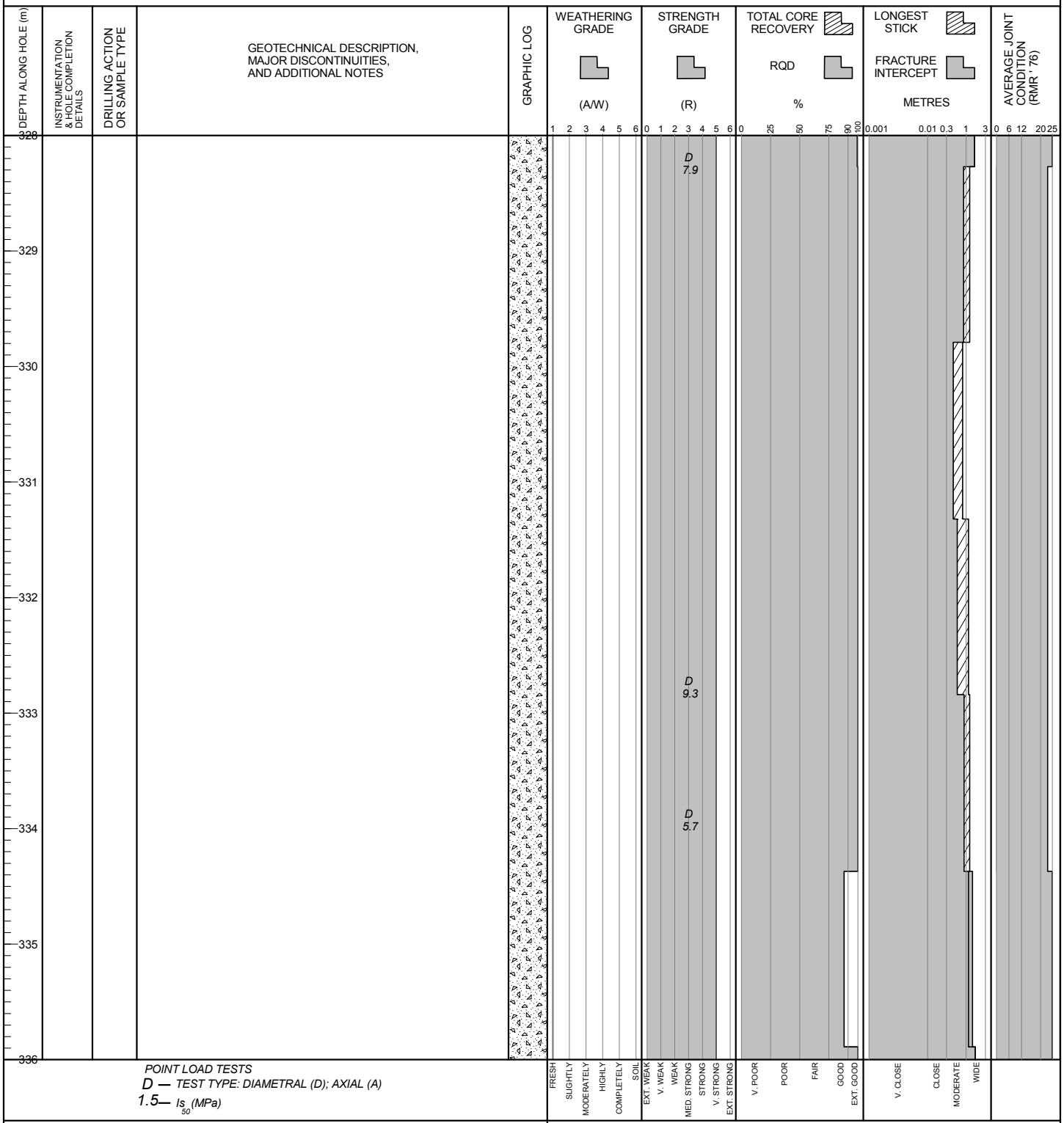
DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
336					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
337						D 5.6			
338									
339									
340									
341									
342						D 12.3			
343									
344						D 6.5			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
344									
345									
346						D 1.4			
347									
348			348.1 - 348.5 m: Small layer of rhyolite flow or exhalite; banding is truncated by unit above.						
349									
350									
351									
352									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

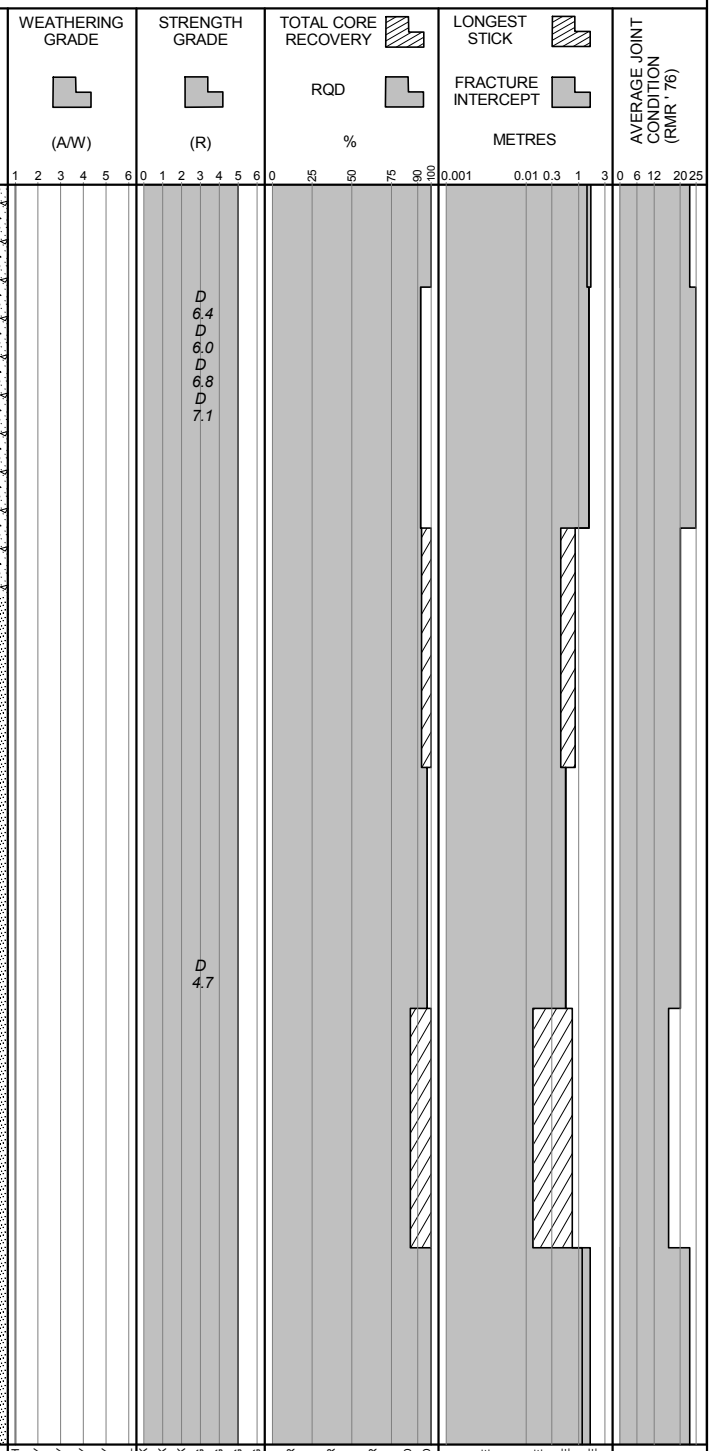
Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
352									
353						D 6.4 D 6.0 D 6.8 D 7.1			
354									
			ARENITE (S4) Grey, fine grained matrix with some medium grained matrix. Chlorite and pyrite replaced mm-sized fragments or clasts. Very strong (R4.5-R5). Fresh (A1).						
355									
356									
357						D 4.7			
358									
359									
360									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
360			
361			
362			
363			
364			
365			
366			
367			367.4 m: Shear, 3 mm FG infill, R0. JRC = 4. 367.4 m: Shear, 12 mm CX/BX infill. JRC = 4. Dip/dip direction = 18/149. 367.6 m: Shear, 10 mm CX/BX infill. JRC = 8. Dip/dip direction =
368			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
368			31/256.			D 6.1			
369									
370									
371									
372						D 6.2			
			QUARTZ CARBONATE VEIN (H2) Medium to light purple-grey, quartz-rhodocrosite vein running along axis, approximately 10 cm wide, S4/S3 host rock. Very strong (R5). Fresh (A1).						
373									
374			CONGLOMERATE (S3) Grey, sericite replaced matrix, some interbedded sandstone, all clasts are replaced and difficult to tell composition. Very strong to strong (R4-R5). Fresh (A1).						
375						D 11.7			
376									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

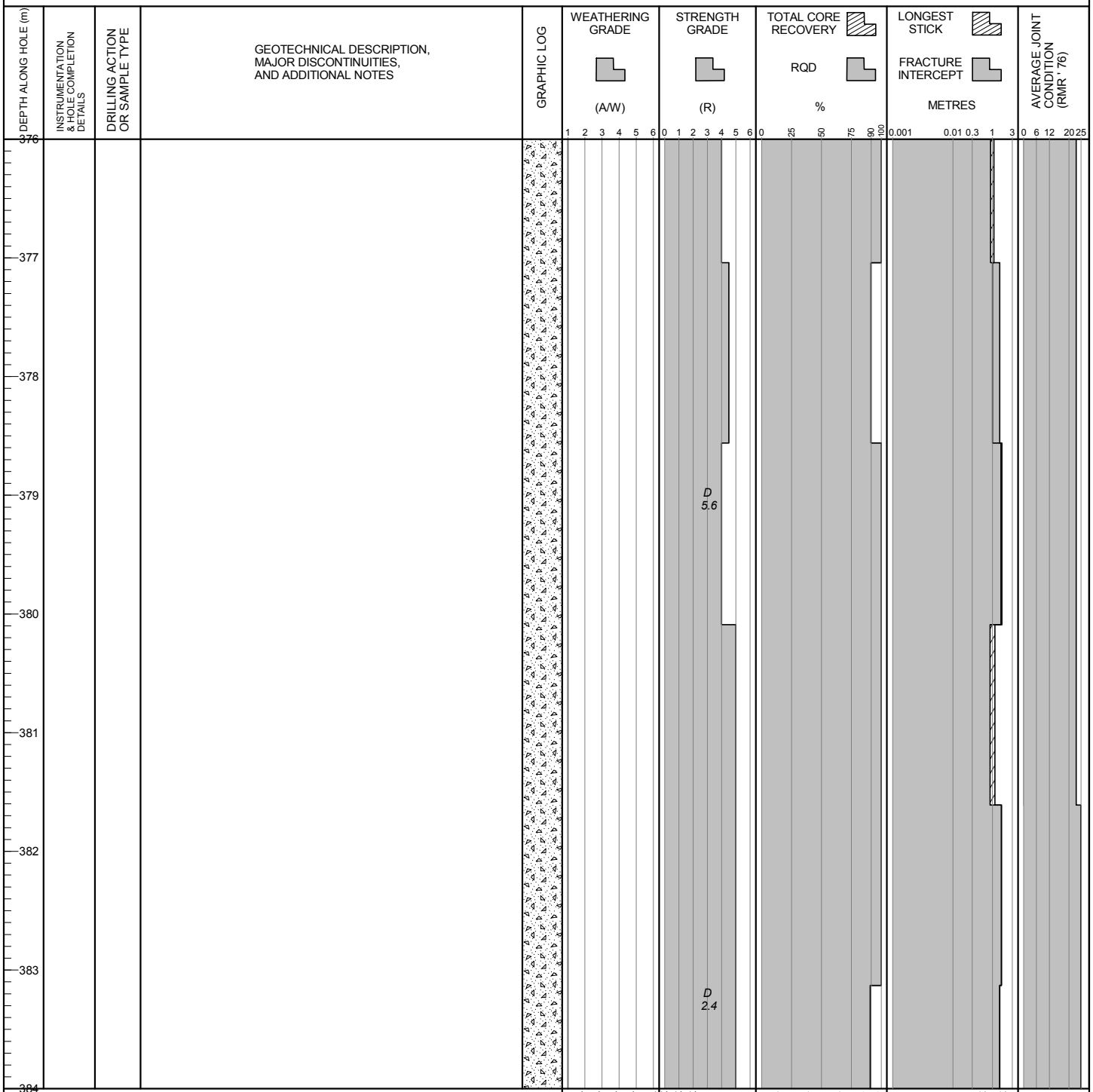
Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-19

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
384			
385			
386			
387			
388			
389			Darker coloured, pyrite replaced matrix below 389.6 m, fairly abundant rhyolite clasts, more clast supported.
390			
391			
392			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 5.2
D 5.8
D 8.0

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
392					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
393						D 2.9			
394									
395									
396						D 3.2			
397									
398									
399									
400					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
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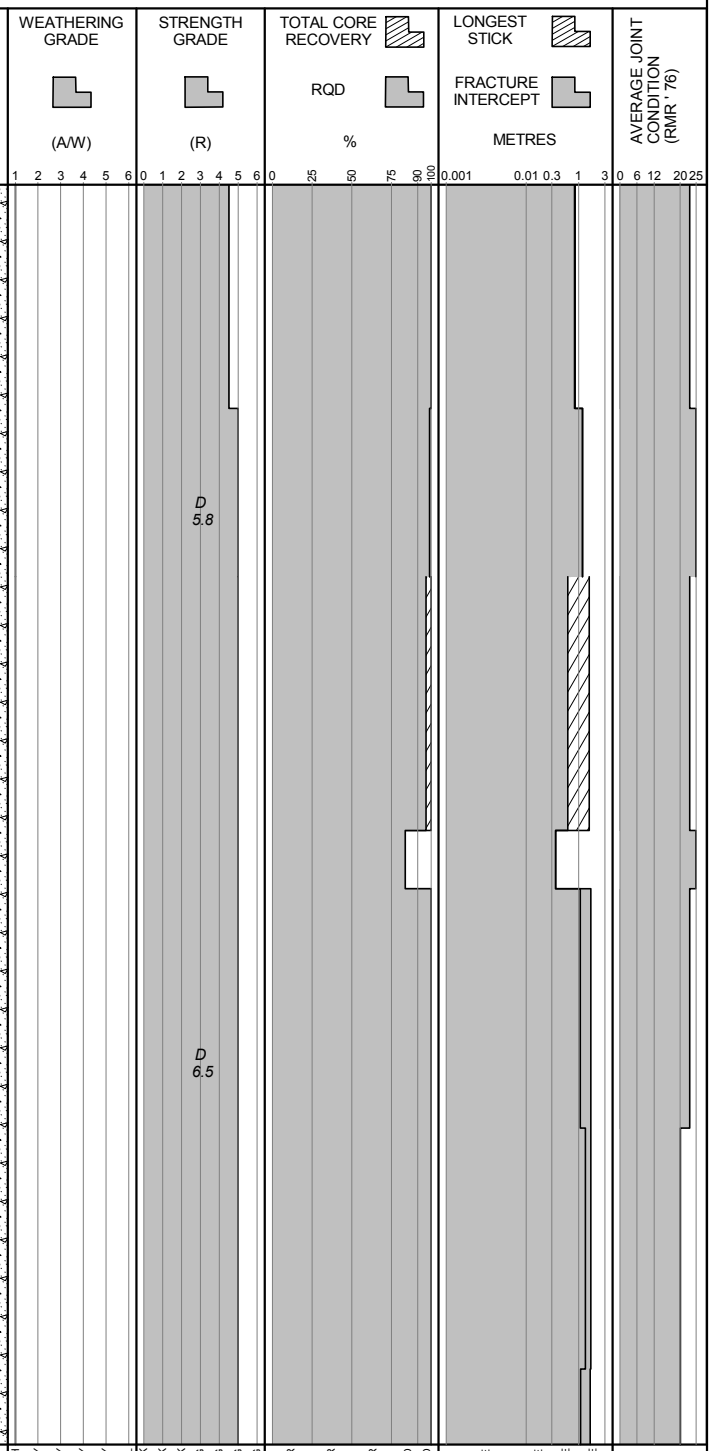
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
400				
401			Constant head test from 401.4 - 425.8 m. Estimated hydraulic conductivity is 3.9E-08 m/s.	
402			402.4 m: Small layer of rhyolite flow or exhalite; banding is trunctated by unit above.	
403				
404				
405				
406				
407				
408				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
408									
409						D 5.5			
410									
411			ARENITE (S4) Greenish-grey, interbedded coarse to fine grained sandstone, sericite replaced matrix, light green colour. Very strong (R5). Fresh (A1).						
412									
413						D 10.4			
414									
415									
416									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
Depth To Top Of Rock (m): 15.1
Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
416									
417									
418									
419			CONGLOMERATE (S3) Greenish-grey, sericite replaced matrix, light green, some interbedded coarse polymictic sandstone. Very strong (R5). Fresh (A1).						
420									
421						D 12.4 D 8.2 D 10.2			
422									
423									
424									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-19

Location: West Zone

Co-ordinates (m): 426,567E - 6,258,826N
Ground Elevation (m): 1,365.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 131

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 16.3

Start Date: 06 Mar 12
Finish Date: 17 Mar 12
Final Depth (m): 425.3
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Logged By: AGC/JND/KM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
424									
425						D 13.2			
			END OF DRILLHOLE AT 425.3 m Notes: 1. Vibrating wire piezometer installed at 214.3 m.						
426									
427									
428									
429									
430									
431									
432									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN AND WEATHERED ROCK Very poor recovery.
1						
2						
3						Rock encountered at 3.0 m depth. Refer to DH-BGC12-20 rock log.
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

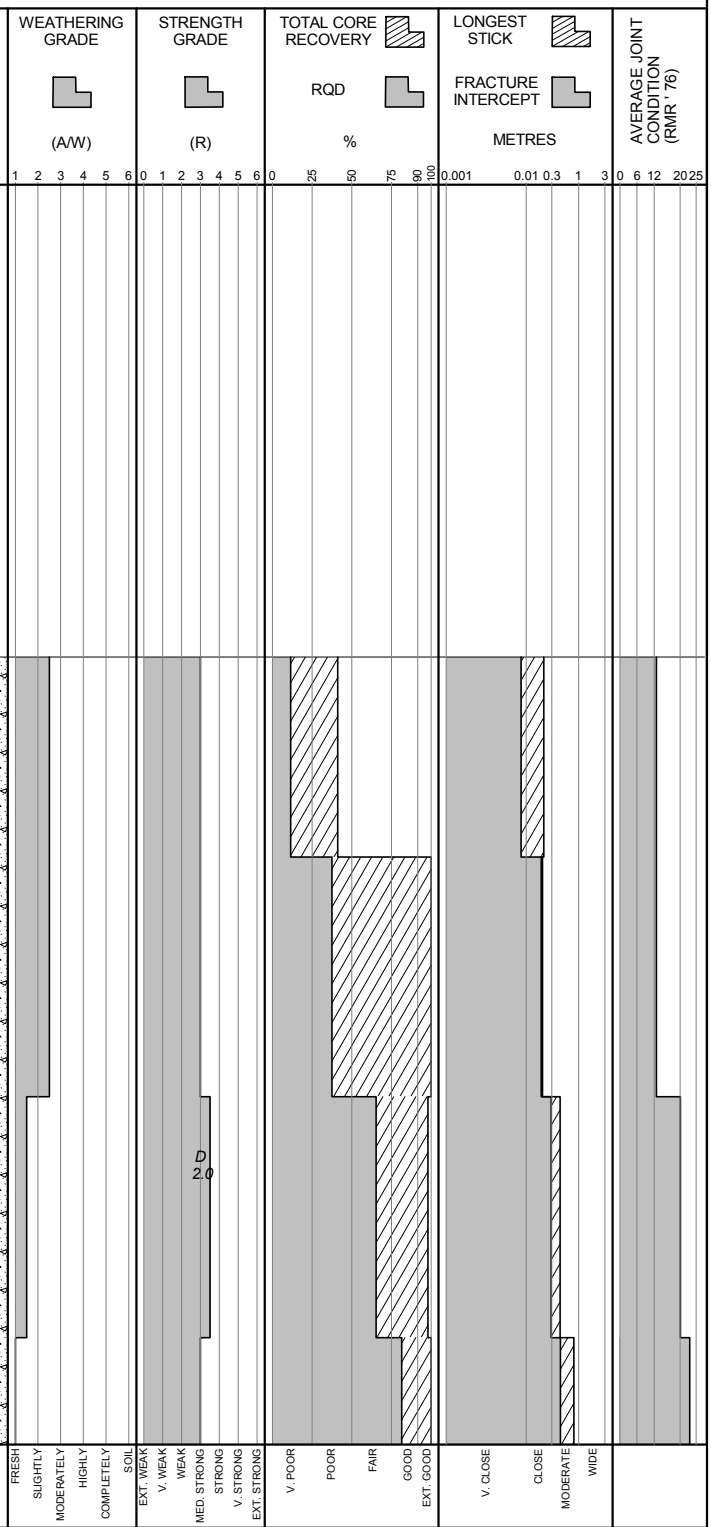
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	***Drill Designation:*** Heliportable	***Start Date:*** 17 Mar 12
Ground Elevation (m): 1,419.0	***Drilling Contractor:*** Radius	***Finish Date:*** 26 Mar 12
Survey Method: Hand Held GPS	***Drill Method:*** Diamond	***Final Depth (m):*** 420.3
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 3.0
Plunge (°): -76	***Fluid:*** Polymer	***Logged By:*** HKM/SW
Trend (°): 222	***Cased To (m) :***	***Reviewed By:*** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
0			Refer to DH-BGC12-20 Overburden Log	
3			CONGLOMERATE (S3) Light to bright green, polylithic conglomerate with variances in sericite alteration. Clasts vary in size from mm to cm. Very weak to moderately strong (R1-R3.5). Faint to moderate alteration (A1.5-A3.5) on major discontinuities from top of bedrock to 16.5 m. Fresh to faint alteration (A1-A1.5) below 16.5 m. Strength increases to medium strong to strong (R3-R4) from 19.5-33.3 m.	



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	***Drill Designation:*** Heliportable	***Start Date:*** 17 Mar 12
Ground Elevation (m): 1,419.0	***Drilling Contractor:*** Radius	***Finish Date:*** 26 Mar 12
Survey Method: Hand Held GPS	***Drill Method:*** Diamond	***Final Depth (m):*** 420.3
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 3.0
Plunge (°): -76	***Fluid:*** Polymer	***Logged By:*** HKM/SW
Trend (°): 222	***Cased To (m) :***	***Reviewed By:*** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
8				
9				
10				
11				
12				
13				
14			14.5 m: Fault, 60 mm DX/BX infill, R0. JRC = 4.	
15			14.9 m: Fault, 340 mm CX/BX infill, R1. JRC = 4. 15.3 m: Fault, 150 mm CX/BX infill, R1. JRC = 8.	
16				

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No. 1008-007

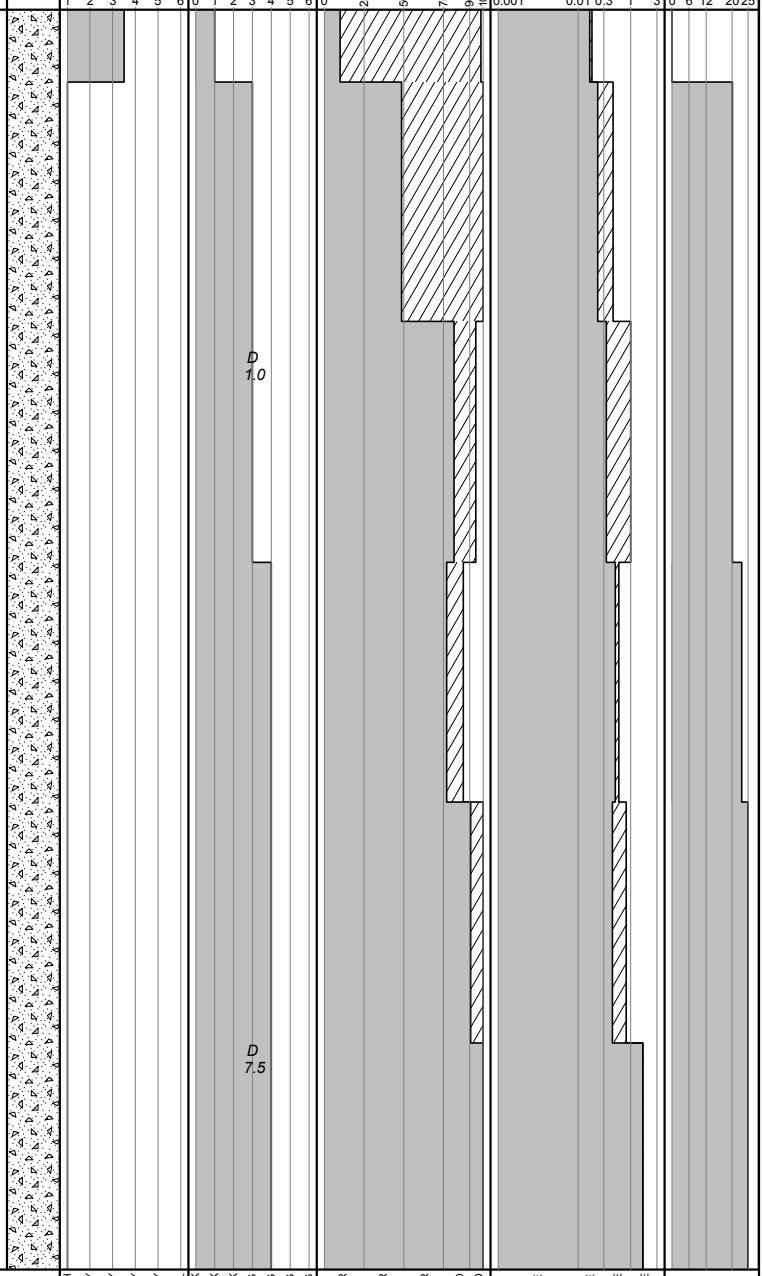
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			17.5 m: Shear, 0.5 mm aperture. JRC = 2. 17.7 m: Shear, 0.5 mm aperture. JRC = 2.
18			
19			
20			
21			
22			
23			
24			



POINT LOAD TESTS
D — *TEST TYPE: DIAMETRAL (D); AXIAL (A)*
1.5 — Is_{50} *(MPa)*

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

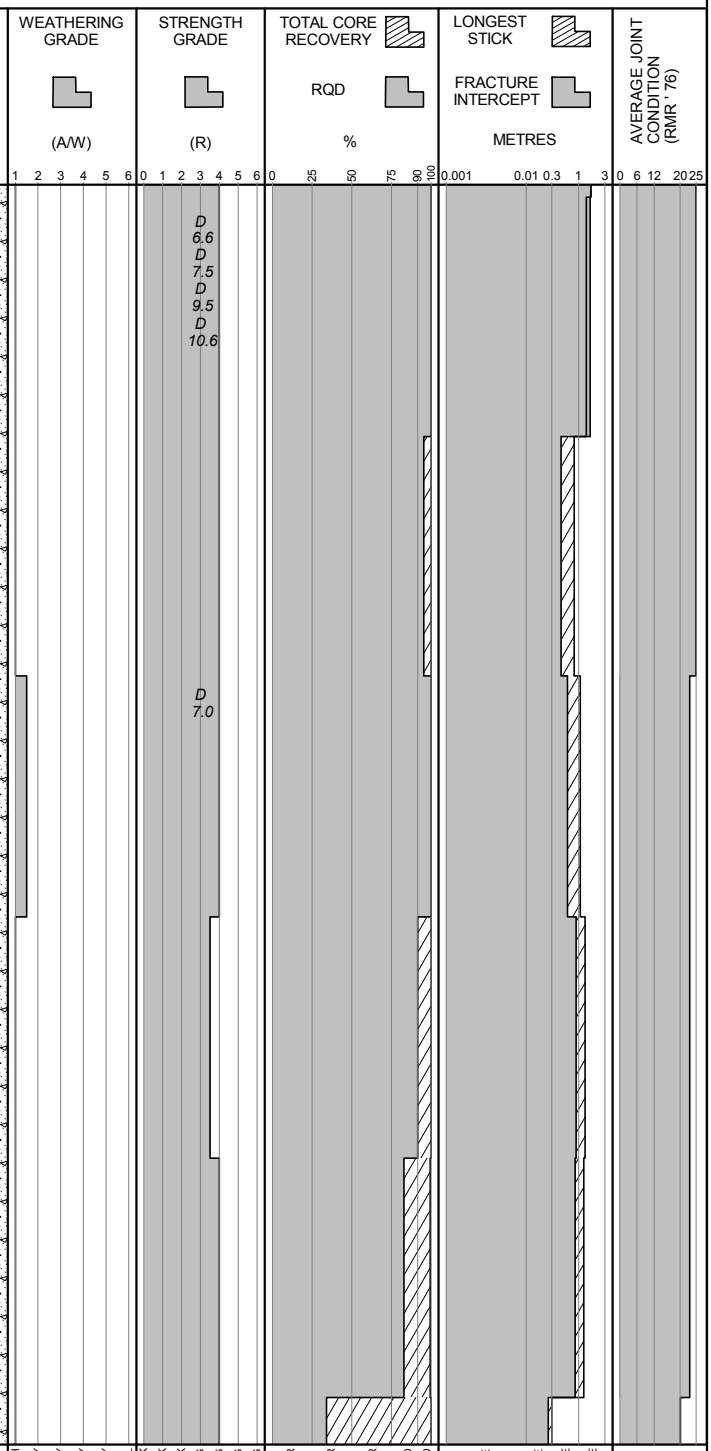
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
24				
25			25.4 m: Shear, 0.5 mm aperture. JRC = 8.	
26				
27				
28				
29				
30			30.0 - 39.3 m: Finer grained, between coarse sand and matrix supported conglomerate, clasts are much smaller than above.	
31			31.5 m: Shear, JRC = 2.	
32				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
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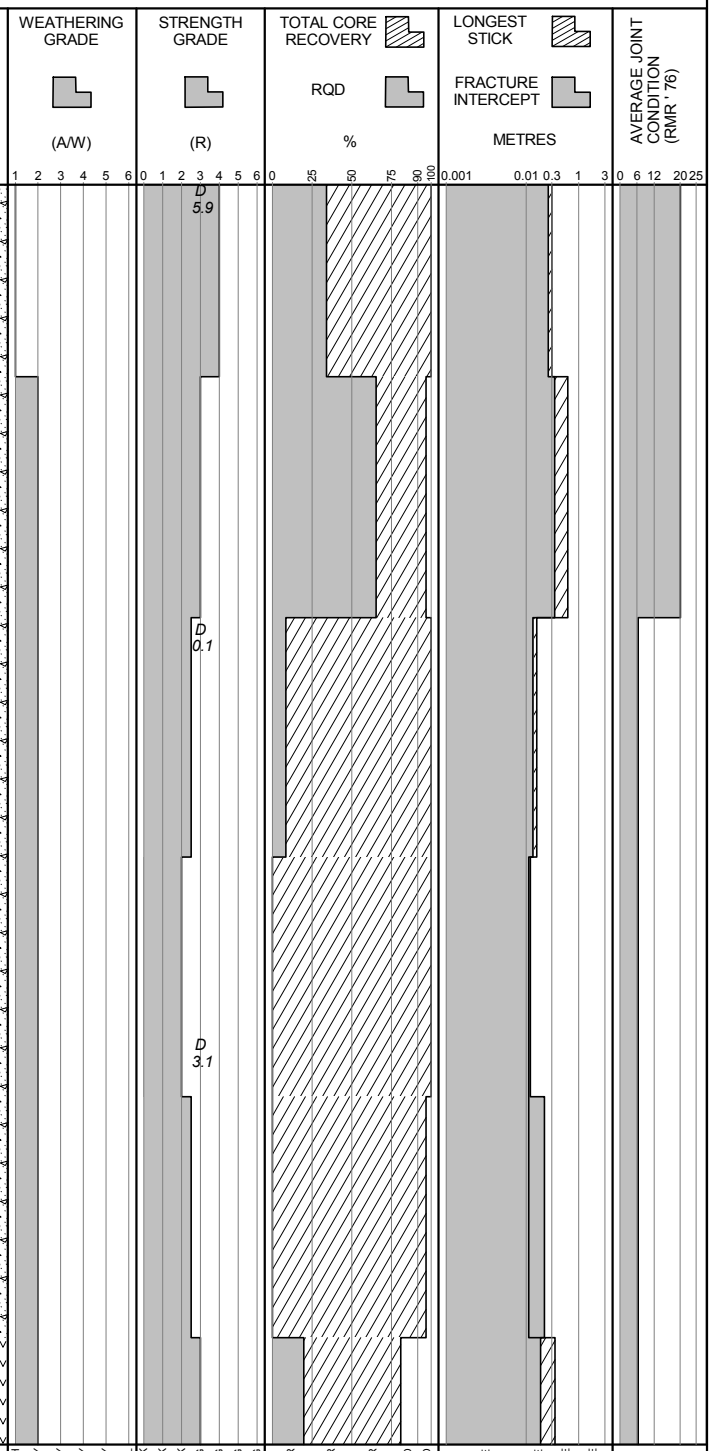
Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
32			
33			Constant head test from 33.2 - 50 m. Estimated hydraulic conductivity is 3.9E-07 m/s.
34			
35			
36			36.1 m: Shear, 20 mm CX infill, R1. JRC = 4.
			36.6 m: Shear, 1 mm CL infill, R0. JRC = 8.
			36.9 m: Fault, 60 mm CX/DX infill, R0. JRC = 4.
37			37 m: Fault, 30 mm CX/DX infill, R0. JRC = 8.
38			37.9 m: Fault, 25 mm FB infill, R0. JRC = 12.
39			38.9 m: Shear, 1 mm CX infill, R0. JRC = 12.
			39.2 m: Shear, 0.5 mm aperture. JRC = 12.
			VERY SILICEOUS ROCKS (H8) Purple to blue-grey pebbley rhyolite interbedded with heavily sericite altered rock. At 47 m, rock is pervasively siliceously altered. Medium strong to strong (R2.5-R4.5). Fresh (A1).
40			39.3 m: Shear, 15 mm CX infill, R0. JRC = 2.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

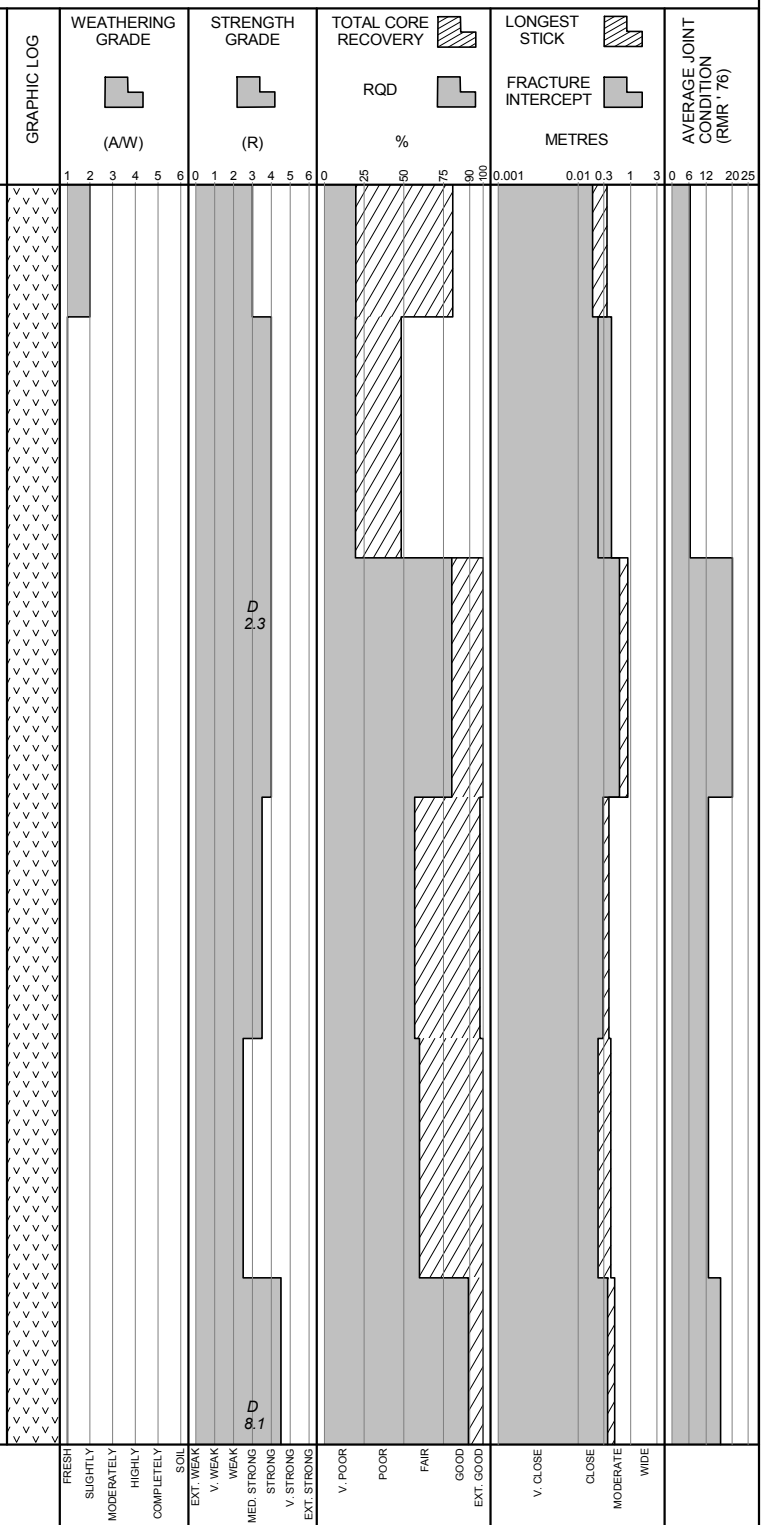
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
40			39.8 m: Shear, 40 mm CX infill, R0. JRC = 8.
41			
42			
43			
44			
45			44.8 m: Shear, 2 mm CX infill, R1. JRC = 2.
46			
47			46.8 m: Shear, 0.5 mm aperture. JRC = 1. 46.9 m: Shear, 0.5 mm aperture. JRC = 1.
48			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
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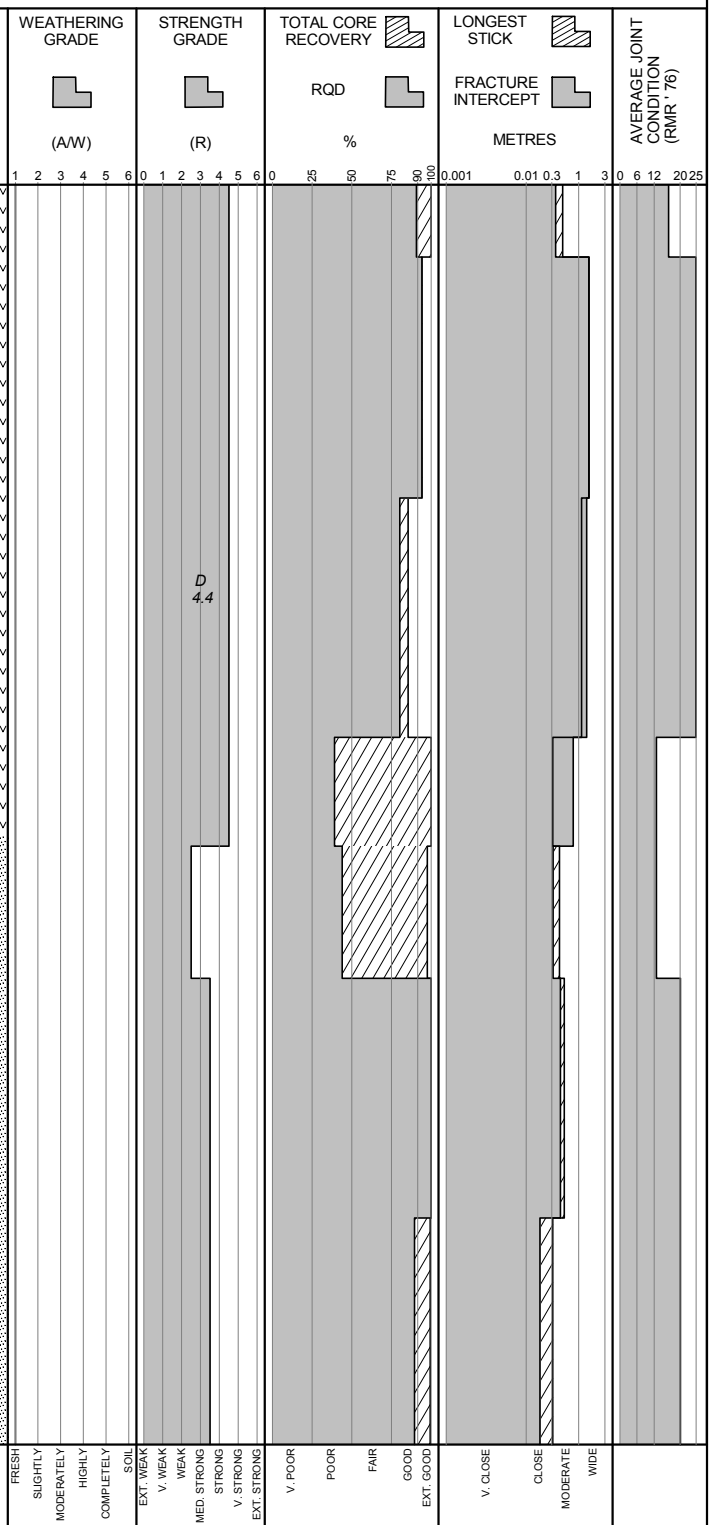
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
48			
49			
50			
51			
52			ARENITE (S4) Greenish-grey. Moderately strong to strong (R2.5-R4.5). Fresh (A1). 52.4 m: Shear, 0.5 mm aperture. JRC = 1. 52.7 m: Shear, 0.5 mm aperture. JRC = 4. 53 m: Shear, 0.5 mm aperture. JRC = 2.
53			
54			54 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 58/320. 54.3 m: Shear, 0.5 mm aperture. JRC = 8.
55			
56			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

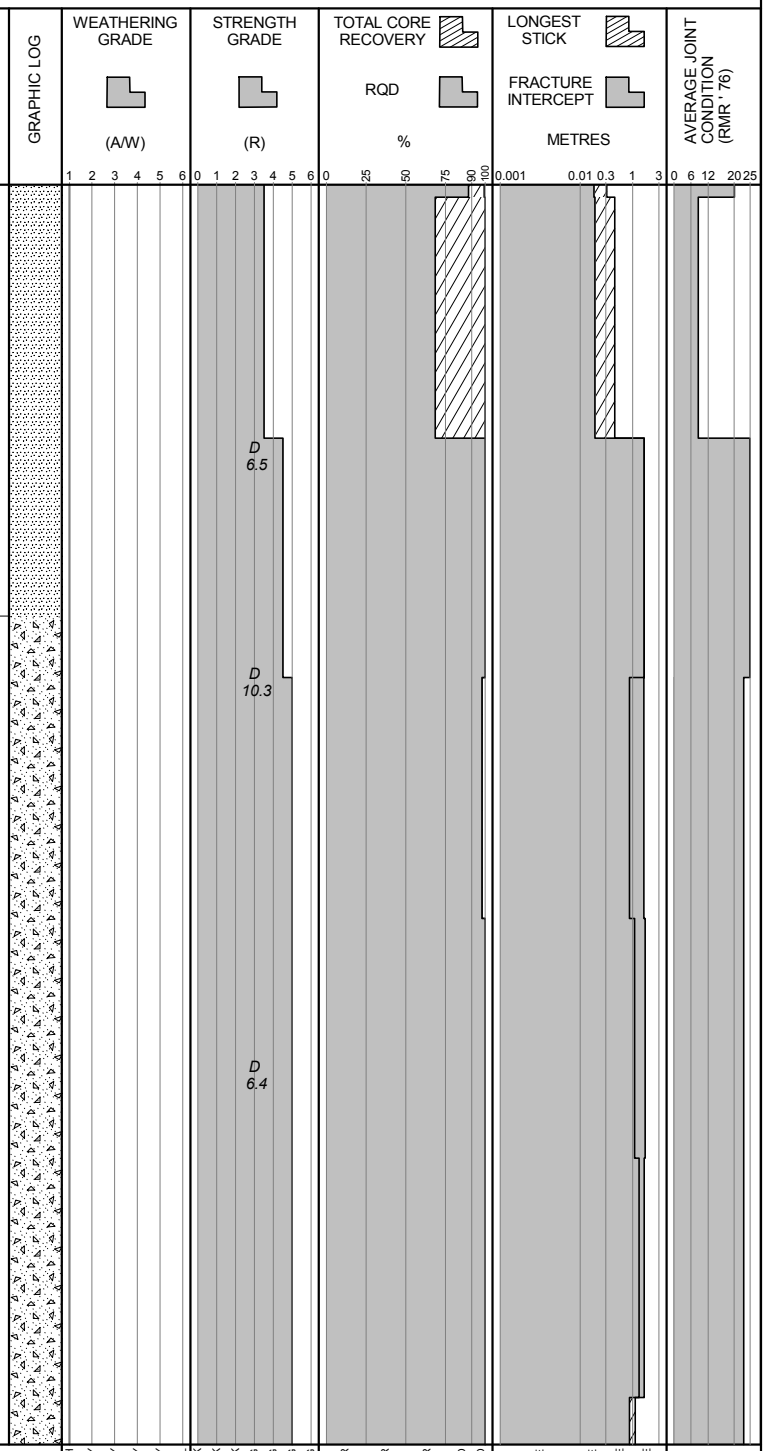
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
56			56.2 m: Shear on vein, 0.5 mm aperture. JRC = 8. Dip/dip direction = 60/164.
57			56.9 m: Shear, 0.5 mm aperture. JRC = 20. 57 m: Shear, 1.5 mm CX infill. JRC = 4. Dip/dip direction = 54/232. 57.2 m: Fault, 2 mm FG infill, R0. JRC = 8. Dip/dip direction = 50/243. 57.4 m: Shear, 0.5 mm aperture. JRC = 12.
58			
			CONGLOMERATE (S3) Greenish-grey, polylithic conglomerate; clasts are heavily chloritized. Strong to very strong (R4-R5). Fresh (A1).
59			
60			
61			
62			
63			
64			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
64									
65									
66						D 6.8 D 6.3 D 7.0			
67									
68									
69			68.8 m: Shear. JRC = 4. Dip/dip direction = 69/284.						
70						D 4.5			
71									
72									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

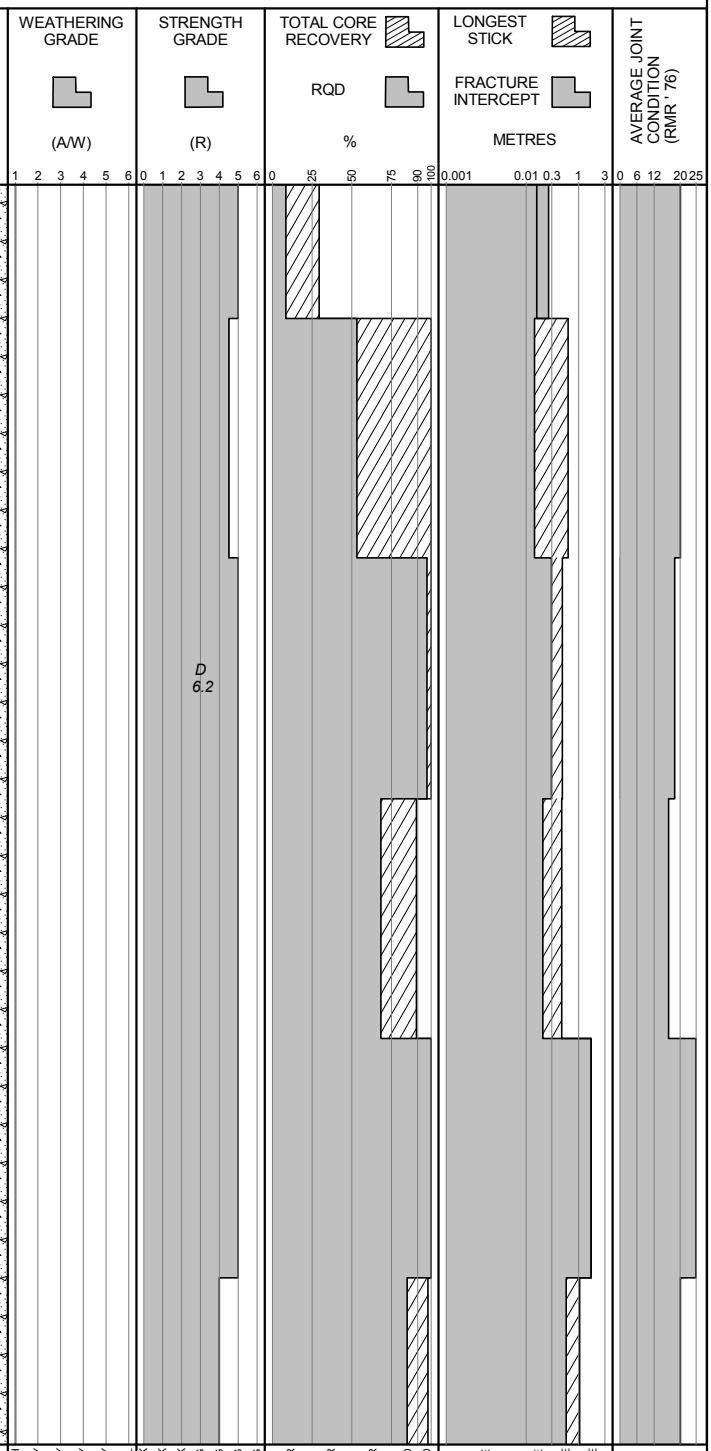
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	***Drill Designation:*** Heliportable	***Start Date:*** 17 Mar 12
Ground Elevation (m): 1,419.0	***Drilling Contractor:*** Radius	***Finish Date:*** 26 Mar 12
Survey Method: Hand Held GPS	***Drill Method:*** Diamond	***Final Depth (m):*** 420.3
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 3.0
Plunge (°): -76	***Fluid:*** Polymer	***Logged By:*** HKM/SW
Trend (°): 222	***Cased To (m) :***	***Reviewed By:*** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
72				
73				
74			74.2 m: Shear, 0.5 mm aperture. JRC = 2.	
75			75.4 m: Shear on vein, 0.5 mm QZ infill. JRC = 20. 75.7 m: Shear on vein, 0.5 mm QZ infill. JRC = 8.	
76				
77				
78				
79				
80				



POINT LOAD TESTS
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1.5— Is_{50} (MPa)

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AN APPLIED EARTH SCIENCES COMPANY

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Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

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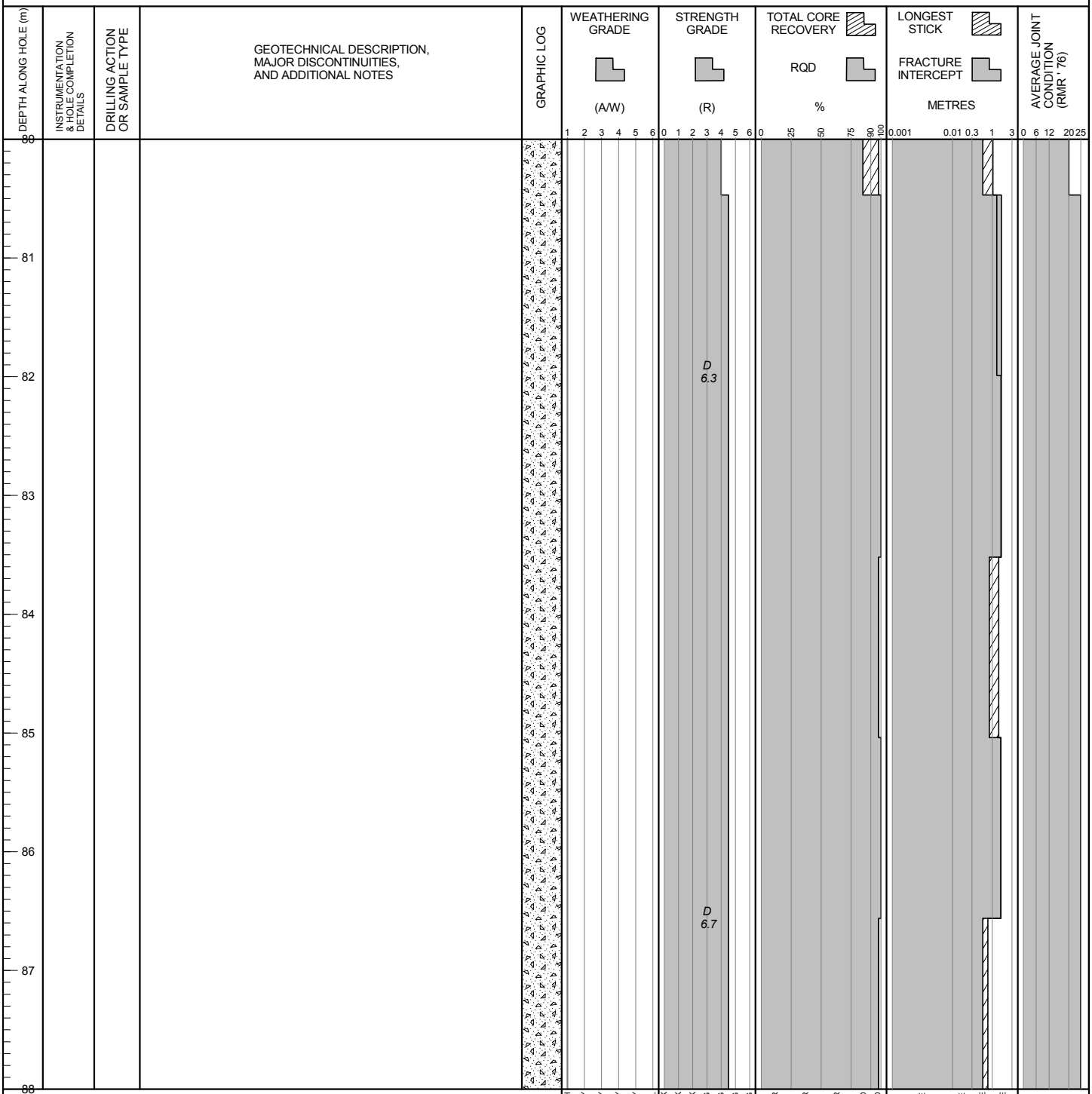
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
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Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

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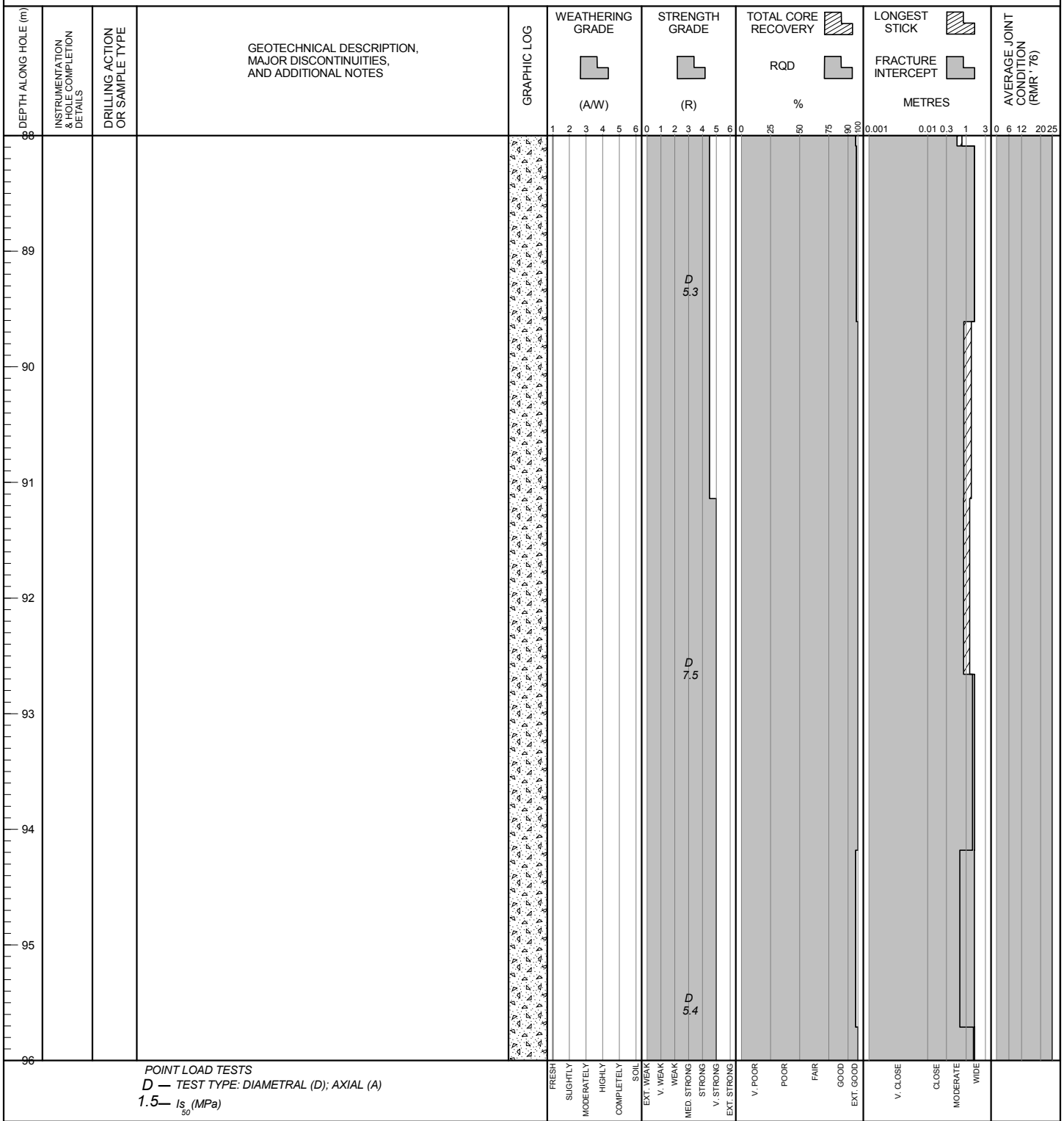

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
96			
97			97.1 m: Shear, 0.5 mm aperture. JRC = 4.
98			98.1 m: Shear, 0.5 mm aperture. JRC = 8.
99			
100			100.5 m: Shear, 0.5 mm aperture. JRC = 8.
101			
102			
103			
104			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 8.6
D 10.0
D 11.6

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
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Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

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Finish Date: 26 Mar 12
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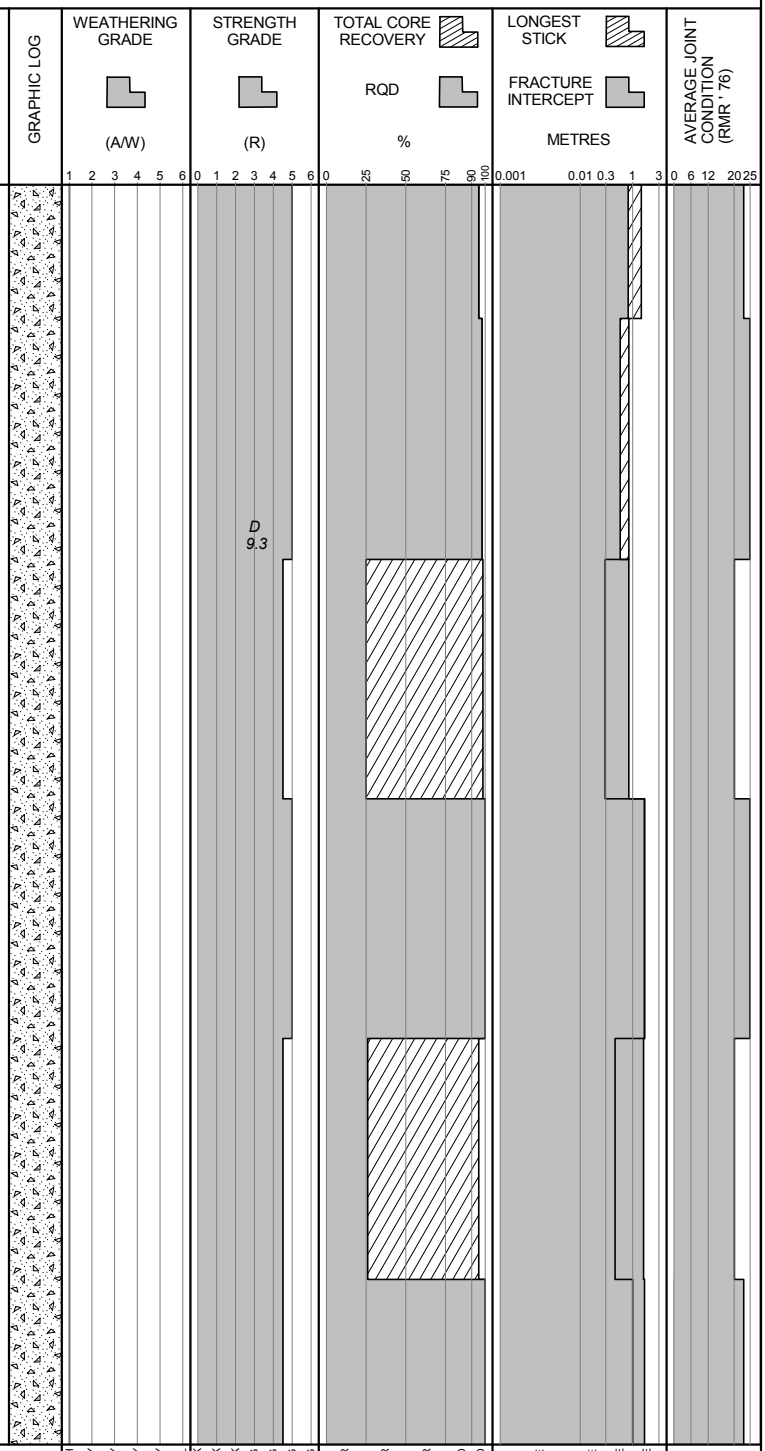
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
104			
			104.7 m: Shear, 0.5 mm aperture. JRC = 8.
			104.7 m: Shear, 0.5 mm aperture. JRC = 20. Dip/dip direction = 16/305.
105			
106			
107			107 m: Shear, 0.5 mm QZ infill, R5. JRC = 8. Dip/dip direction = 62/263.
			107.7 m: Shear, 0.5 mm QZ infill, R5. JRC = 4. Dip/dip direction = 72/254.
108			
109			
110			
111			
112			111.9 m: Shear, 1 mm QZ infill, R5. JRC = 12. Dip/dip direction =



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

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LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
112			79/289.						
113						D 8.5 D 10.6			
114						D 11.9			
115									
			115.5 - 123.4 m: Dense vein stockwork overprinting host rock. 115.6 m: Shear, 0.5 mm aperture. JRC = 16. Dip/dip direction = 71/111.						
116									
117									
118						D 5.6			
119									
120									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Project No.1008-007

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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
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Fluid: Polymer
Cased To (m) :

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
120									
121						D 8.3			
122									
123									
124									
125						D 7.9			
126									
127									
128			Falling head test from 127.7 - 149 m. Estimated hydraulic conductivity is 1.7E-08 m/s.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

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Drill Method: Diamond
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Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
128									
129									
130									
131						D 12.4			
			131.6 m: Fault on vein, 40 mm BX/CX infill, R3. JRC = 8. Dip/dip direction = 24/194.						
132									
133									
134									
135						D 7.1			
136									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

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136									
137									
138						D 7.2			
139									
140									
141						D 3.9			
142									
143									
144									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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LOG SCALE: 1:50

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144									
145									
146									
147									
148									
149						D 7.8			
150									
151									
152									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

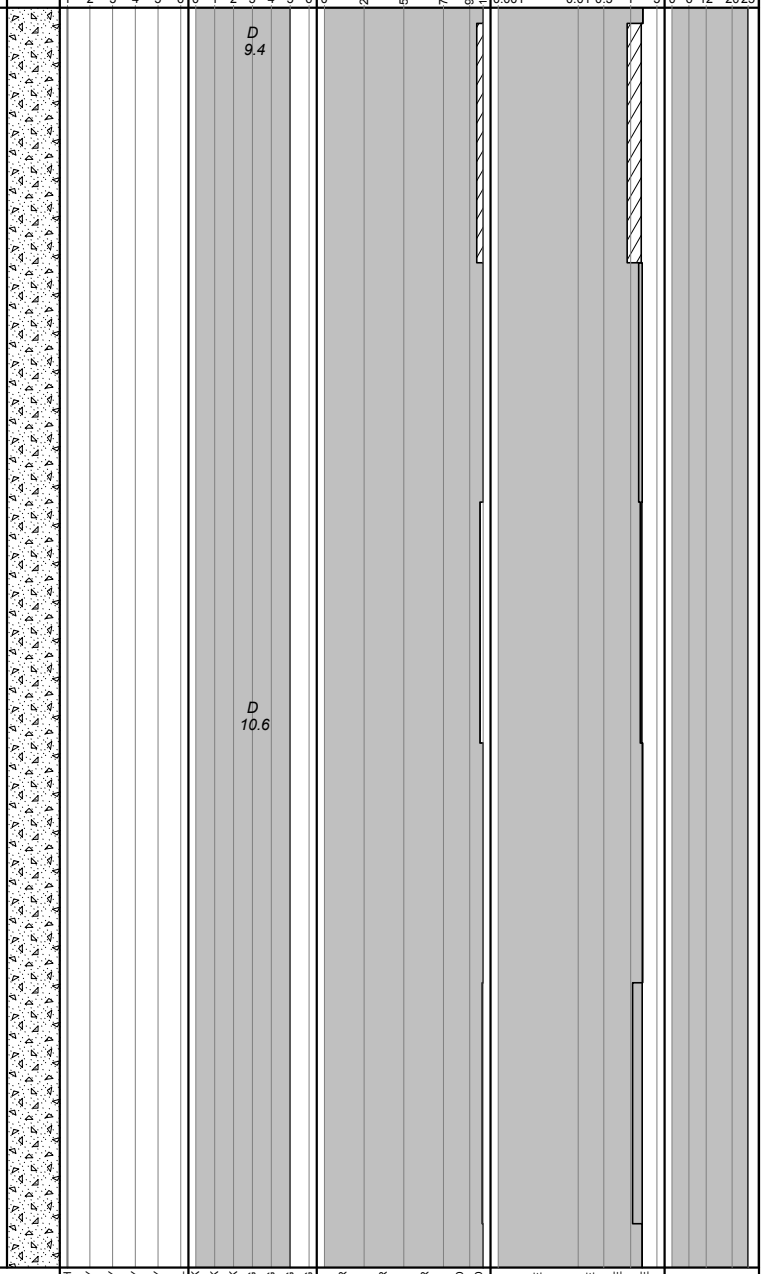
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
152			
153			
154			
155			155.2 m: Shear, 0.5 mm CA infill, R3. JRC = 1.
156			
157			
158			158.7 m: Shear, 0.5 mm aperture. JRC = 1.
159			
160			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
160									
						D 12.2			
161									
162									
163									
164									
165						D 8.0			
						D 9.5			
166									
167									
168									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

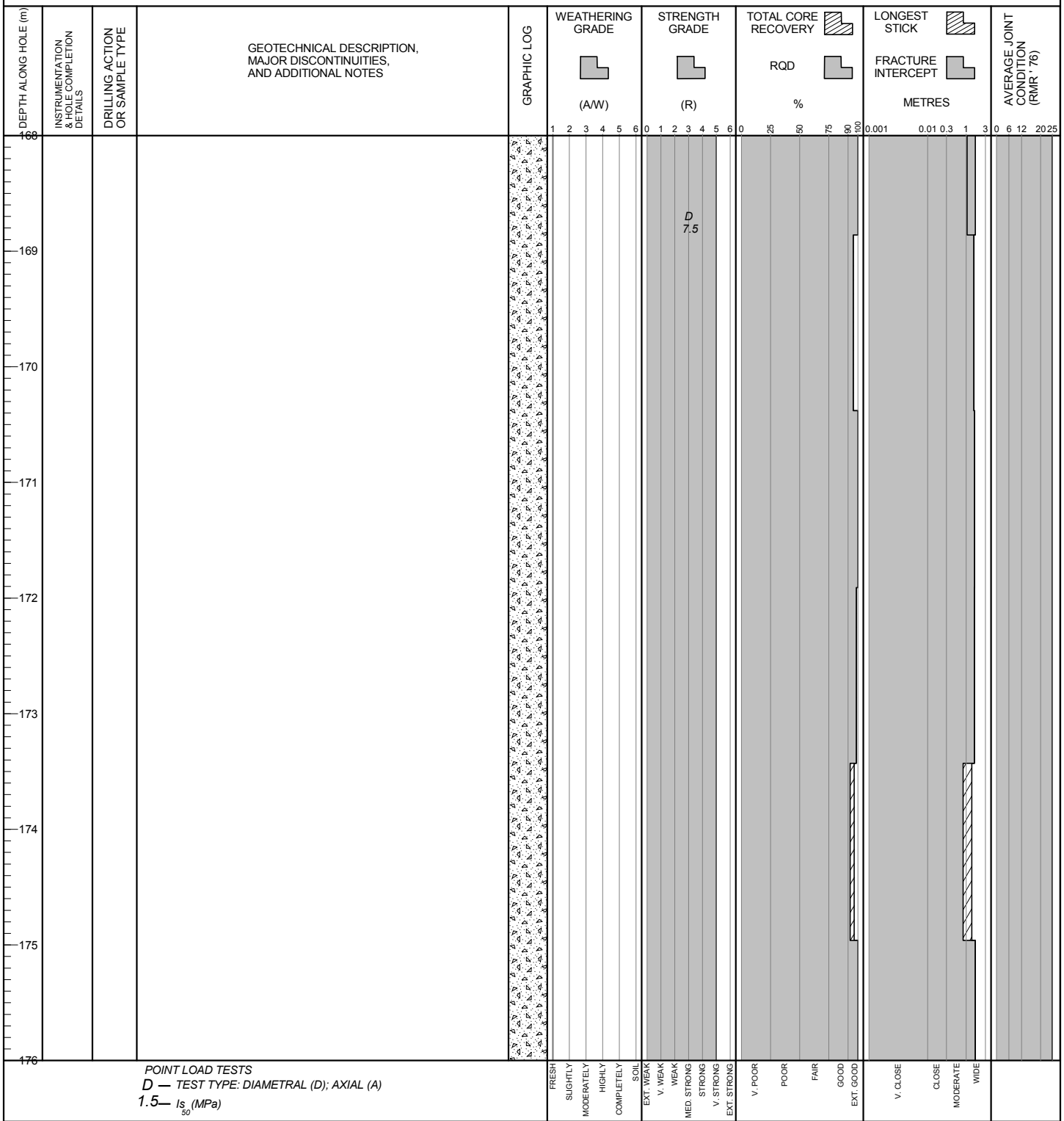
DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

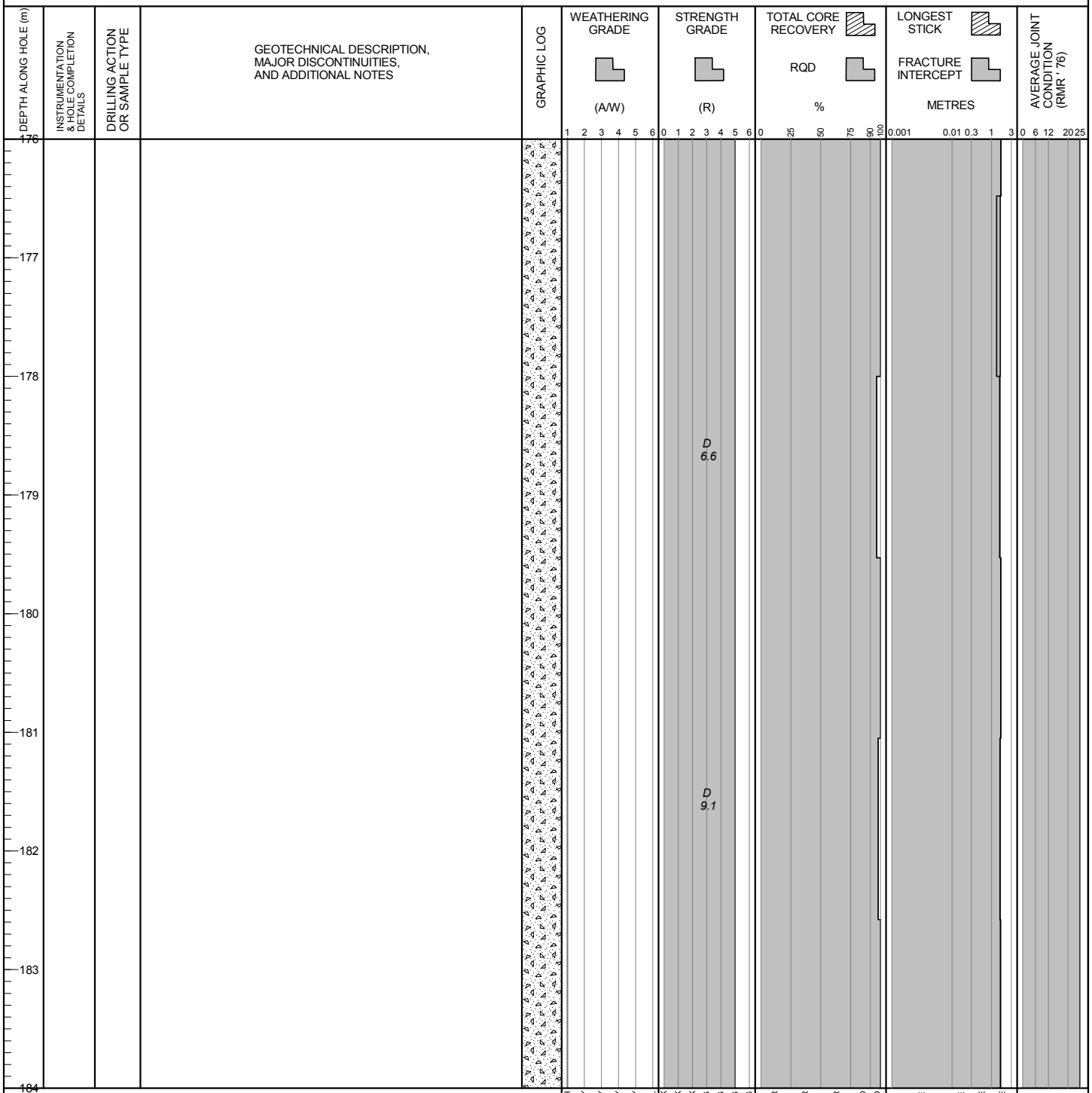
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	***Drill Designation:*** Heliportable	***Start Date:*** 17 Mar 12
Ground Elevation (m): 1,419.0	***Drilling Contractor:*** Radius	***Finish Date:*** 26 Mar 12
Survey Method: Hand Held GPS	***Drill Method:*** Diamond	***Final Depth (m):*** 420.3
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 3.0
Plunge (°): -76	***Fluid:*** Polymer	***Logged By:*** HKM/SW
Trend (°): 222	***Cased To (m) :***	***Reviewed By:*** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-20

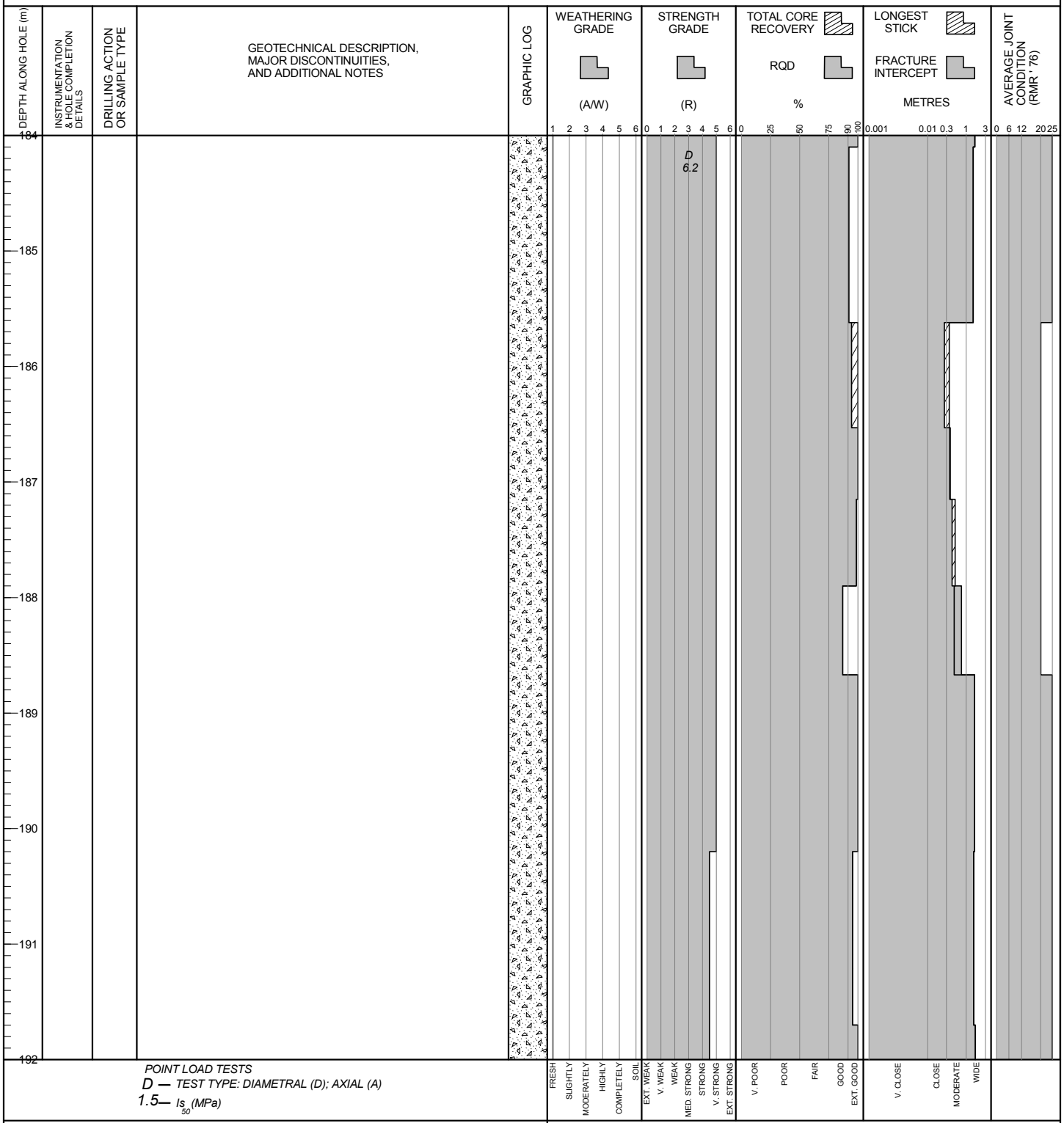
Project : Brucejack
Project No. 1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
192					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
193									
194						D 9.2			
195									
196									
197						D 13.9			
198									
199									
200						D 12.6			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

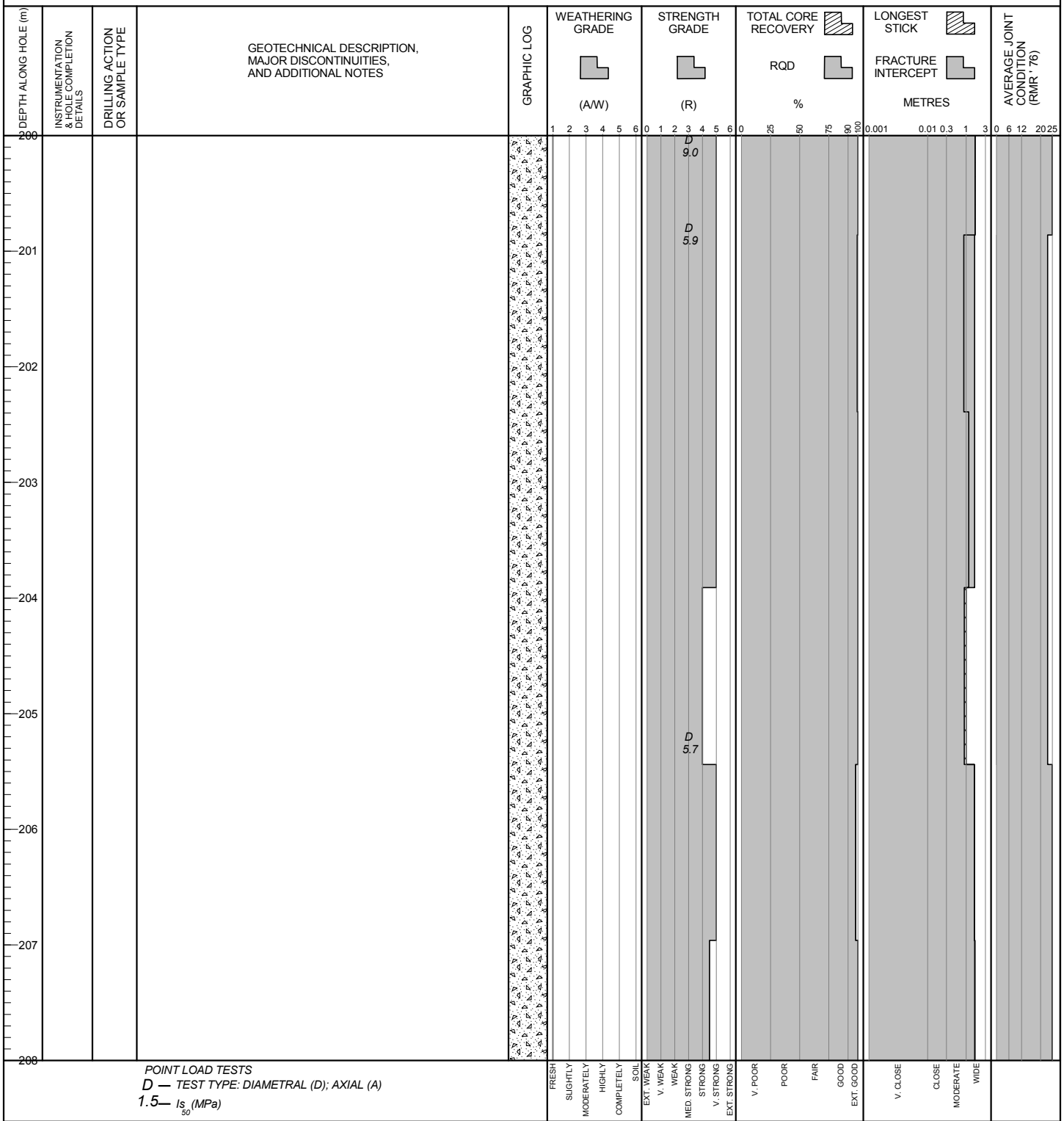
Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
208									
209			ARENITE (S4) Greenish-grey, homolithic volcanic sandstone, chlorite and sericite alteration. Interbedded with coarser grained conglomerate (S3). Strong to very strong (R4-R5). Fresh (A1).			D 13.2			
210									
211									
212									
213									
214									
215									
216									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
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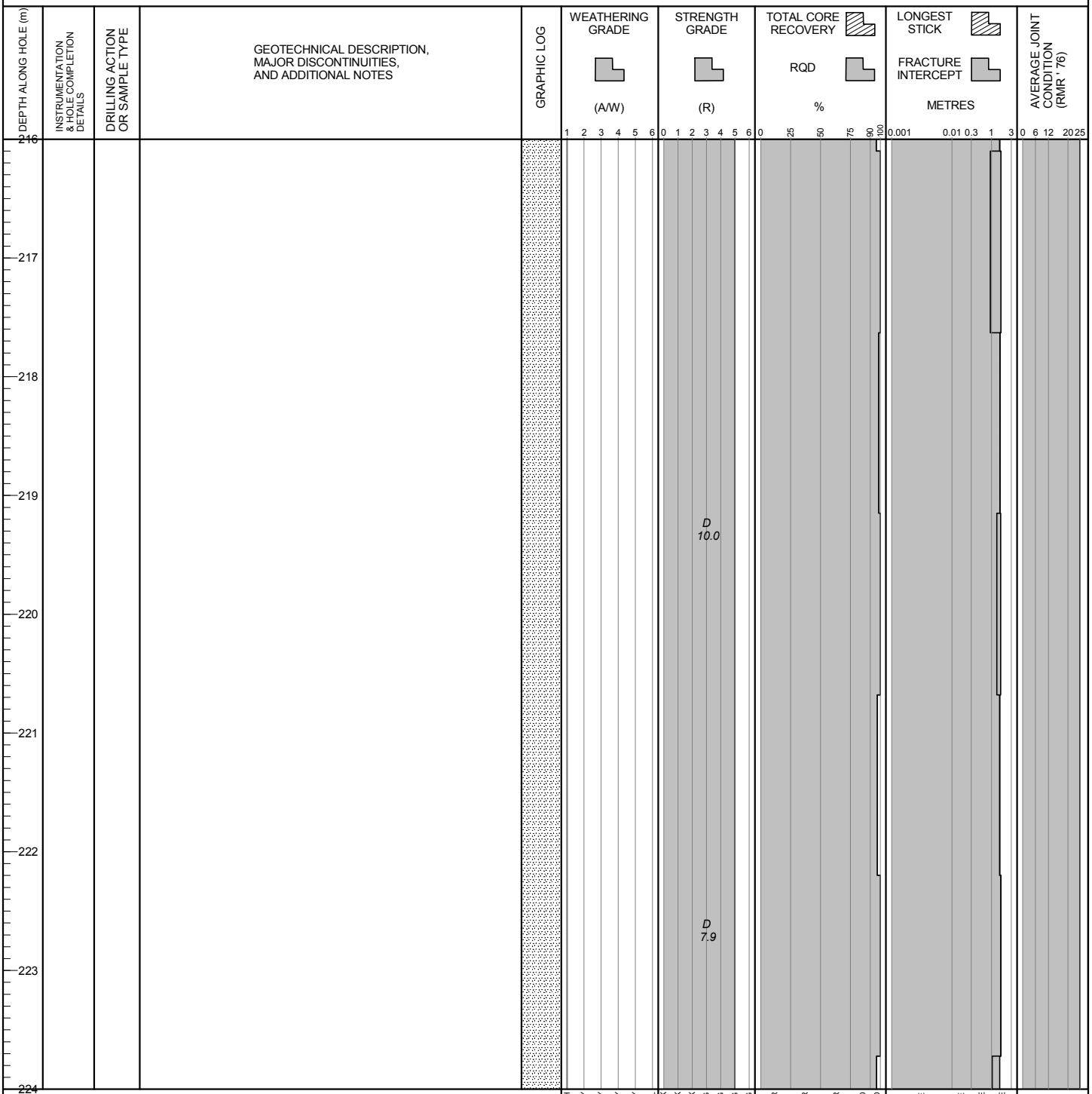
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

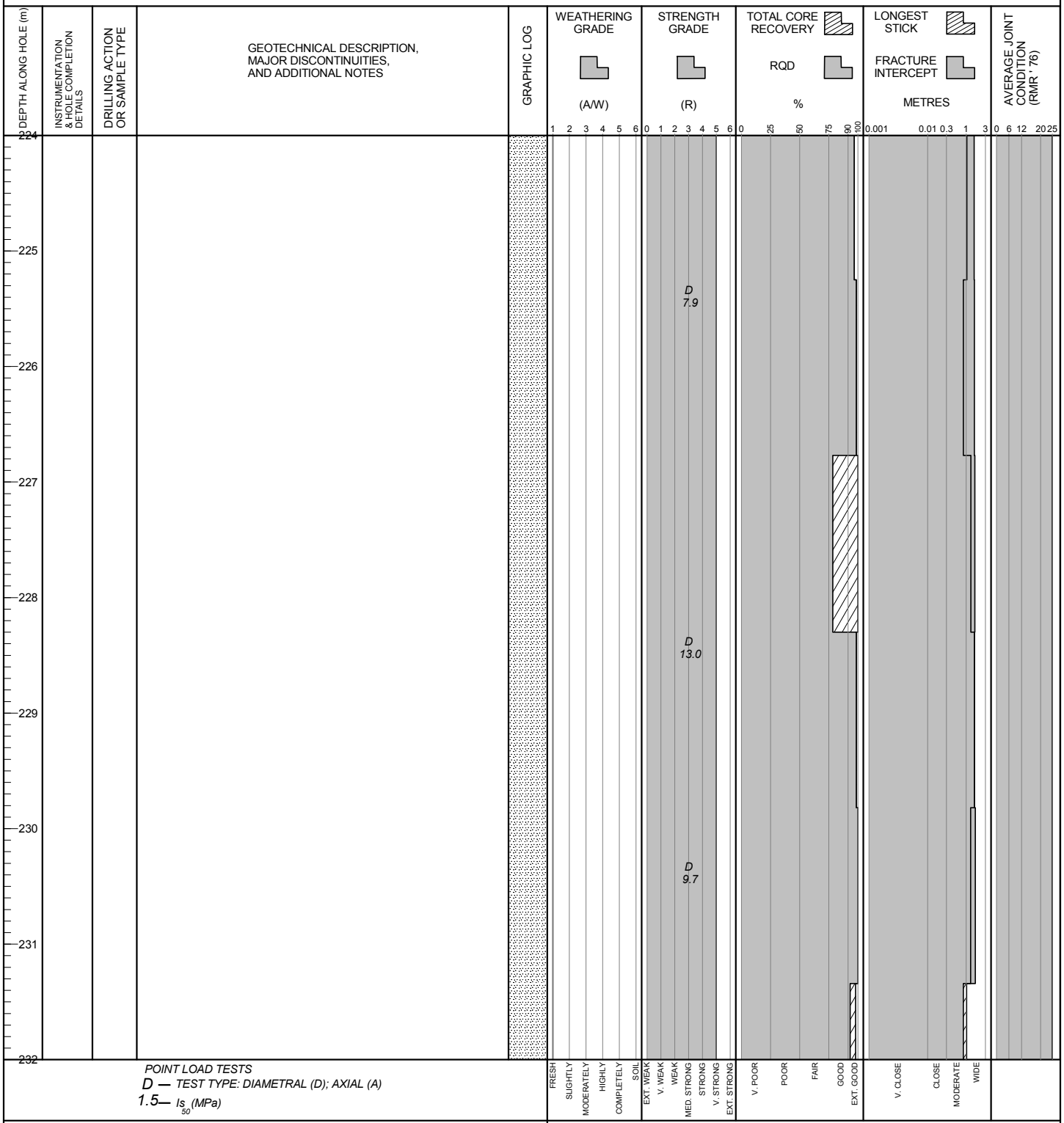
DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

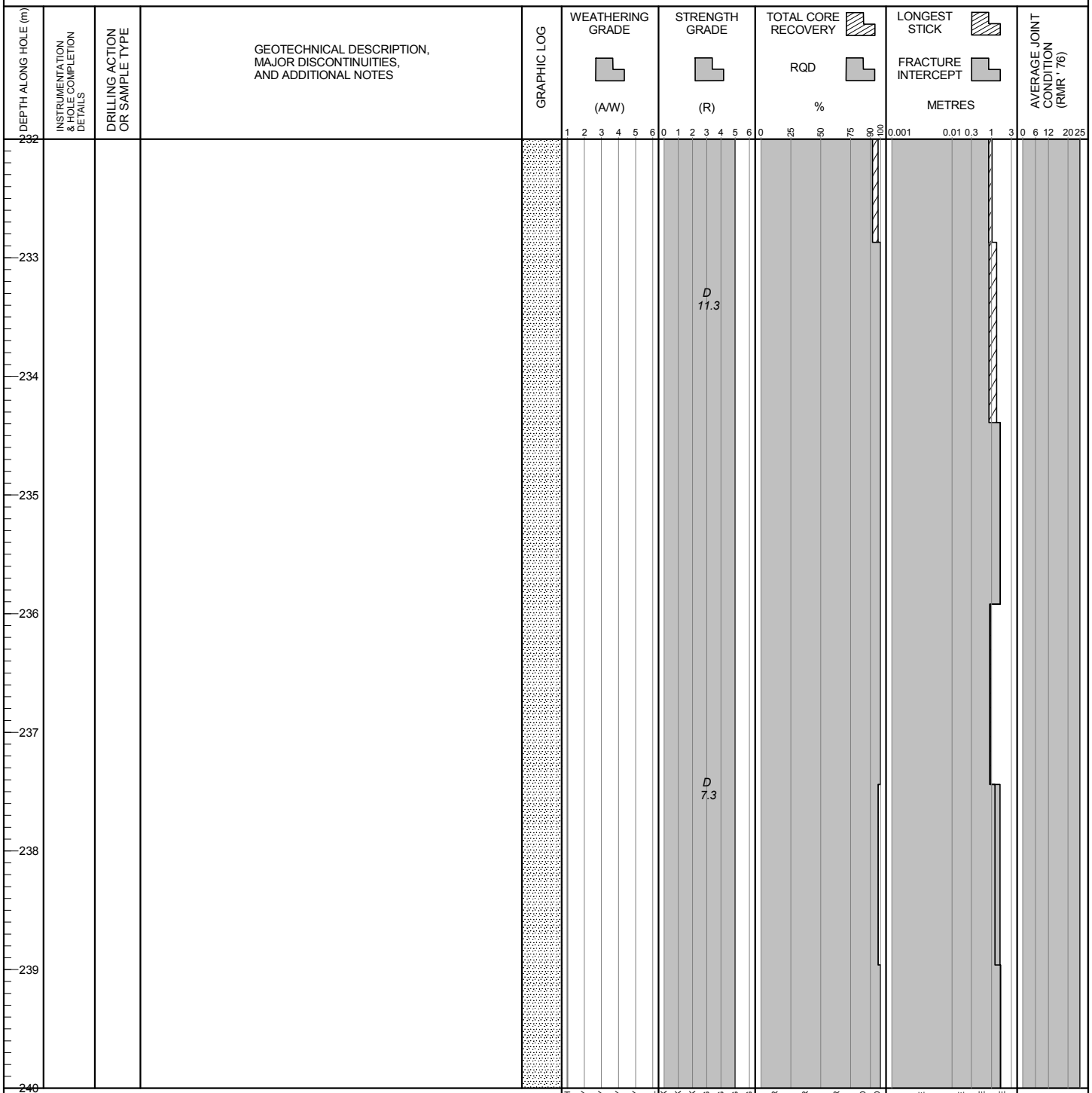
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-20

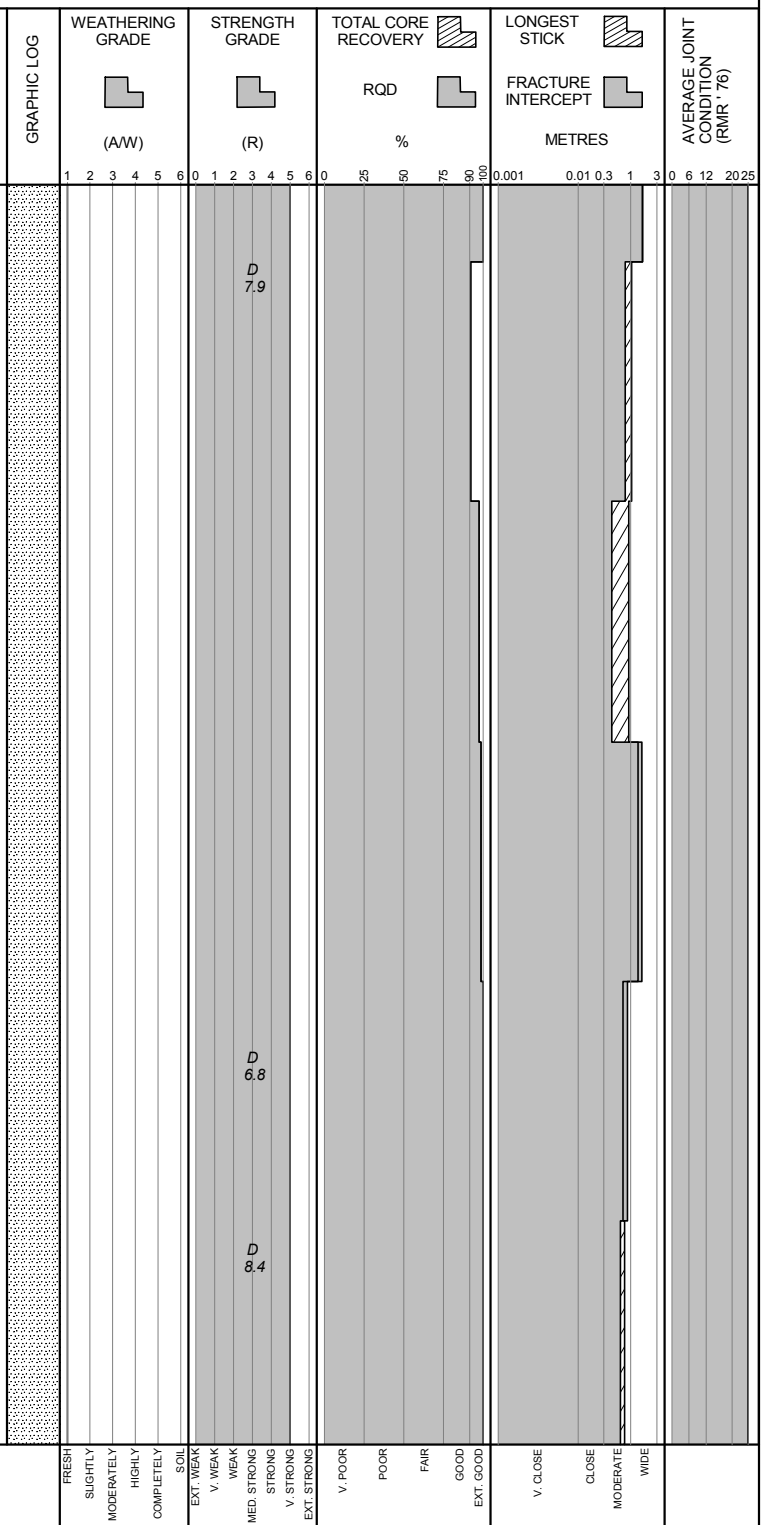
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
240			Constant head test from 240.5 - 264.9 m. Estimated hydraulic conductivity is 1.7E-07 m/s.
241			
242			
243			243.2 m: Shear, 1.5 mm CX infill, R1. JRC = 1. Dip/dip direction = 77/090. 243.3 m: Shear, 1 mm CA infill, R4. JRC = 1. 243.4 m: Shear, 1 mm aperture. JRC = 4.
244			
245			
246			
247			
248			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
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Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
248					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
249									
250									
251									
252									
253									
254									
255									
256					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
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Drill Designation: Heliportable
Drilling Contractor: Radius
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Core: HQ3
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Cased To (m) :

Start Date: 17 Mar 12
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Final Depth (m): 420.3
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
256					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
257									
258									
259									
260									
261									
262									
263						D 6.9			
264					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
264			
265			
266			266 m: Shear, 0.5 mm CA infill, R4. JRC = 12. Dip/dip direction = 82/090.
267			267.2 m: Shear, 1 mm CA infill, R4. JRC = 12. Dip/dip direction = 79/096. 267.4 m: Shear, 0.5 mm CA infill, R4. JRC = 2. Dip/dip direction = 81/028.
268			
269			
270			270.7 m: Shear, 0.5 mm aperture. JRC = 12.
271			
272			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 6.8

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

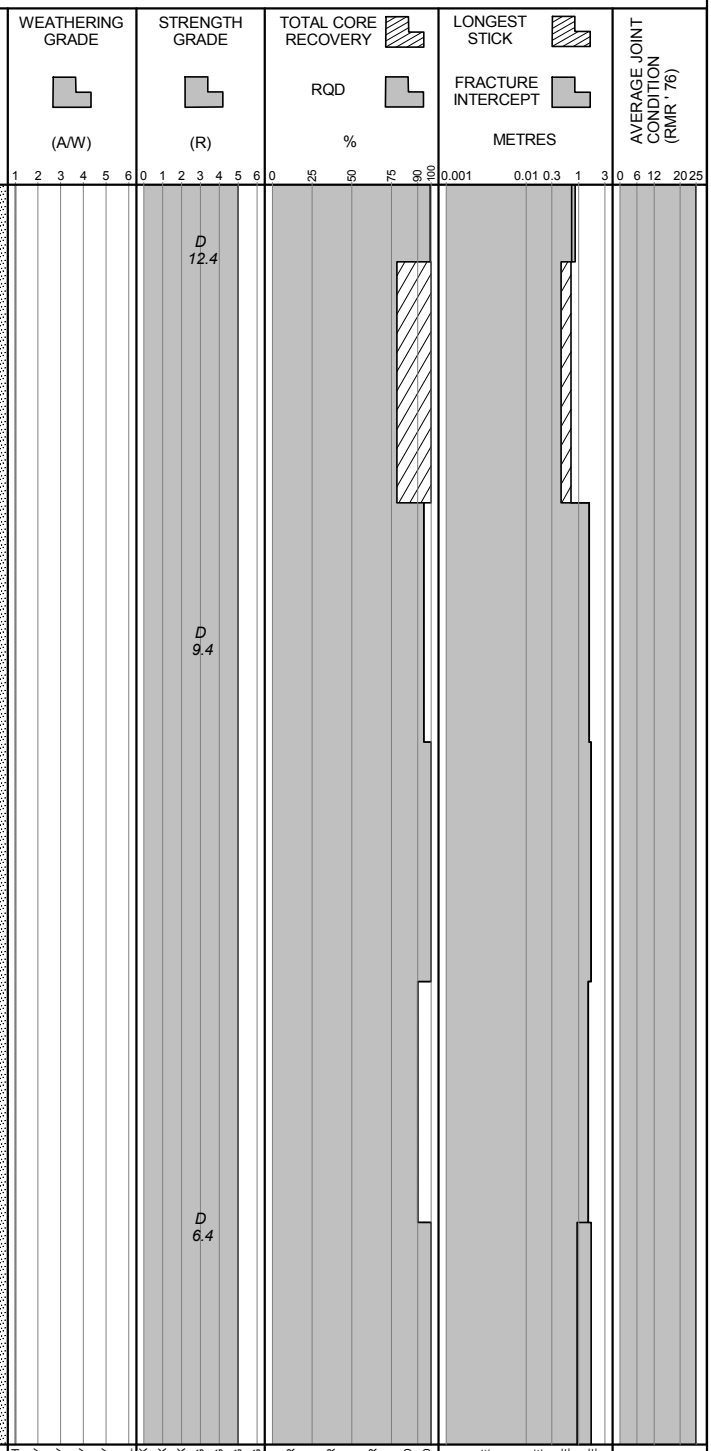
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
272			
273			
274			
275			
276			
277			
278			
279			279.4 m: Shear, 0.5 mm aperture. JRC = 1. Dip/dip direction = 83/052.
280			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

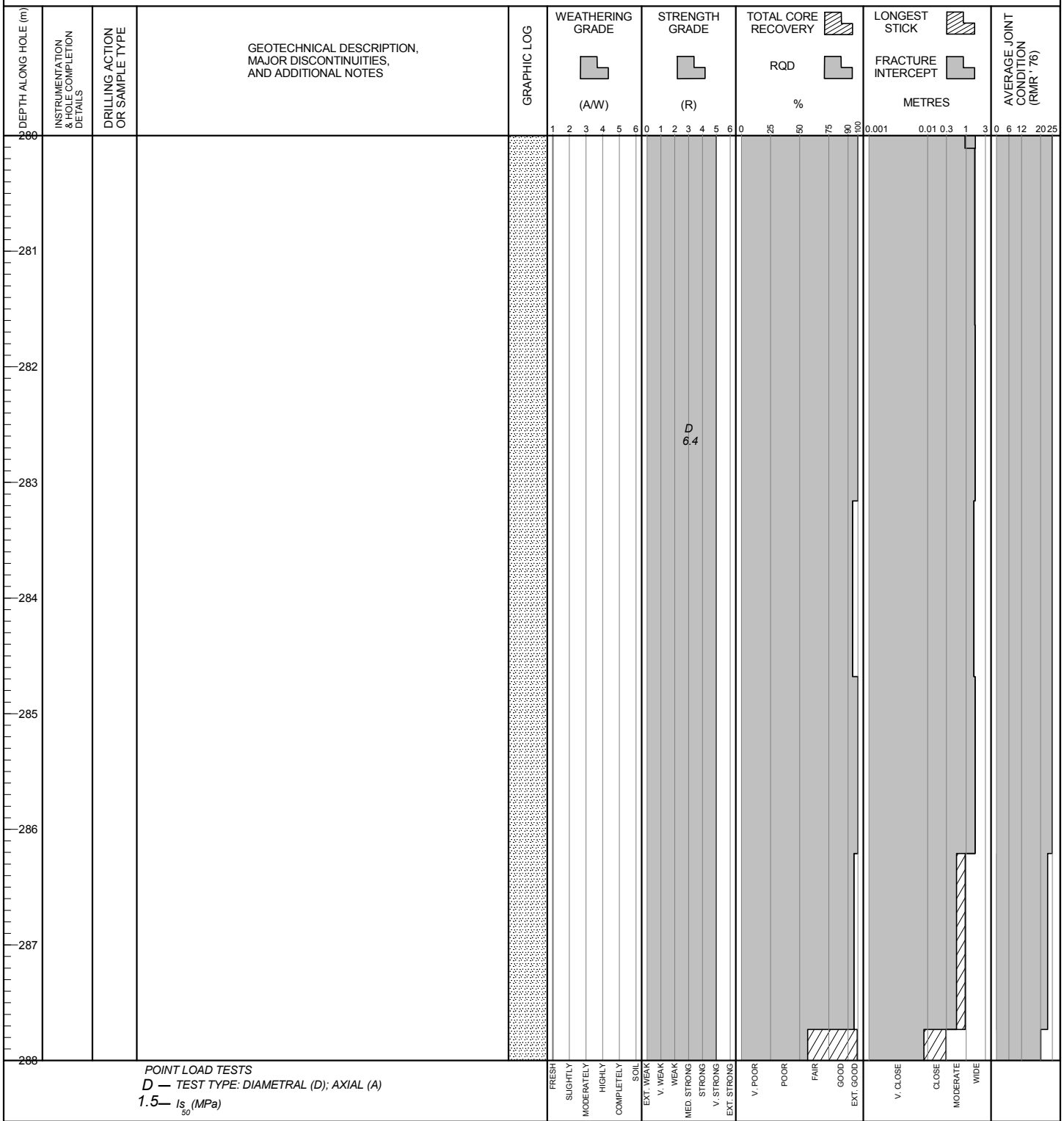
DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
288						D 9.7			
289									
290									
291						D 6.7			
292						D 8.7			
293									
294									
295			294.7 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 80/097. 295.2 m: Shear, 0.5 mm aperture. JRC = 2.						
296									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
296			
297			
298			298 m: Shear, 1 mm aperture. JRC = 12.
299			
300			300 m: Shear, 0.5 mm aperture. JRC = 1.
301			
302			302.4 m: Shear, 1 mm BX infill, R4. JRC = 12.
303			303.7 m: Shear, 1 mm BX infill, R4. JRC = 20.
304			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

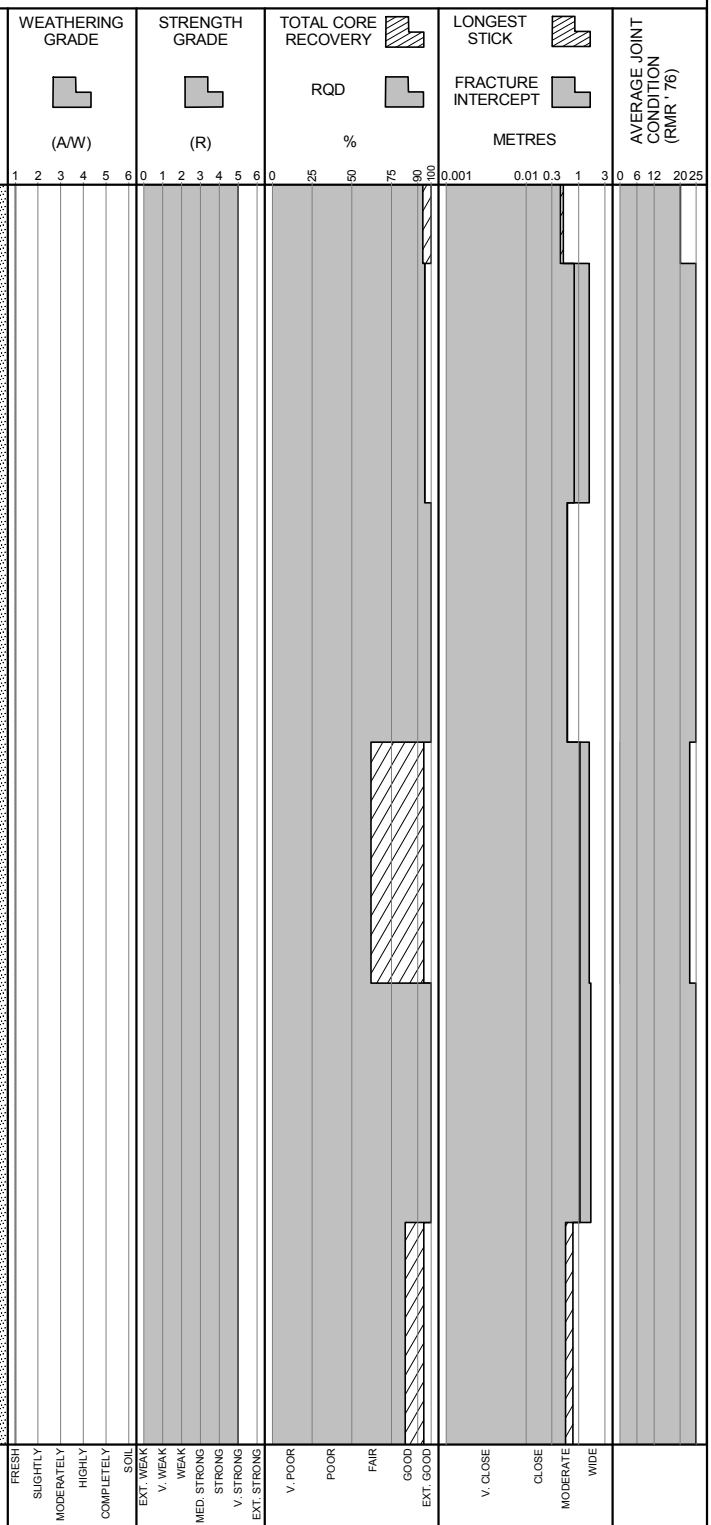
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
304			304.2 m: Shear, 0.5 mm aperture. JRC = 20.
305			
306			
307			307.1 m: Shear, 1 mm CA infill, R4. JRC = 4.
308			
309			308.8 m: Shear, 1 mm CA infill, R4. JRC = 8. Dip/dip direction = 73/249.
310			
311			311.2 m: Shear, 1 mm CA infill, R4. JRC = 2.
312			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

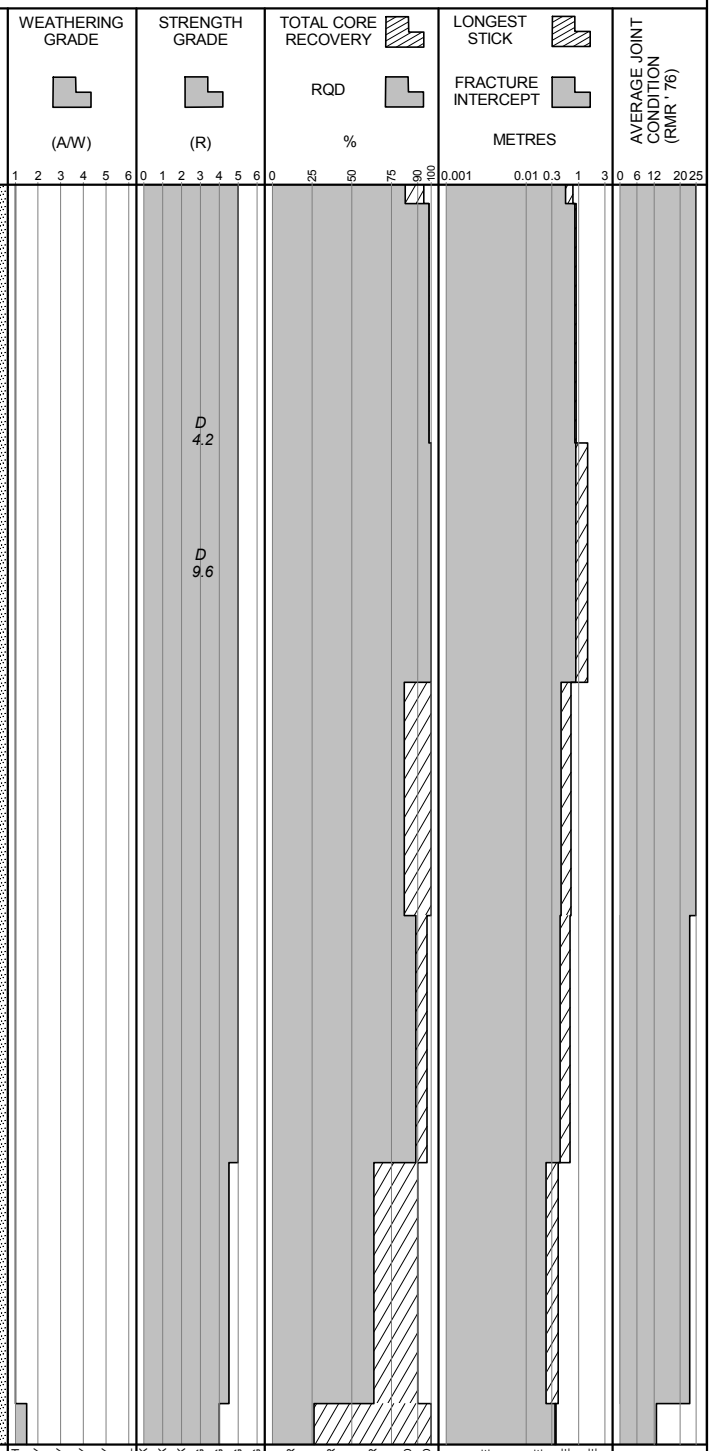
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
312			311.9 m: Shear, 2 mm CA infill, R4. JRC = 2. Dip/dip direction = 82/092.
313			
			313.7 m: Shear, 0.5 mm aperture. JRC = 2.
314			
315			
316			
317			
318			
319			319.3 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 84/027.
320			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

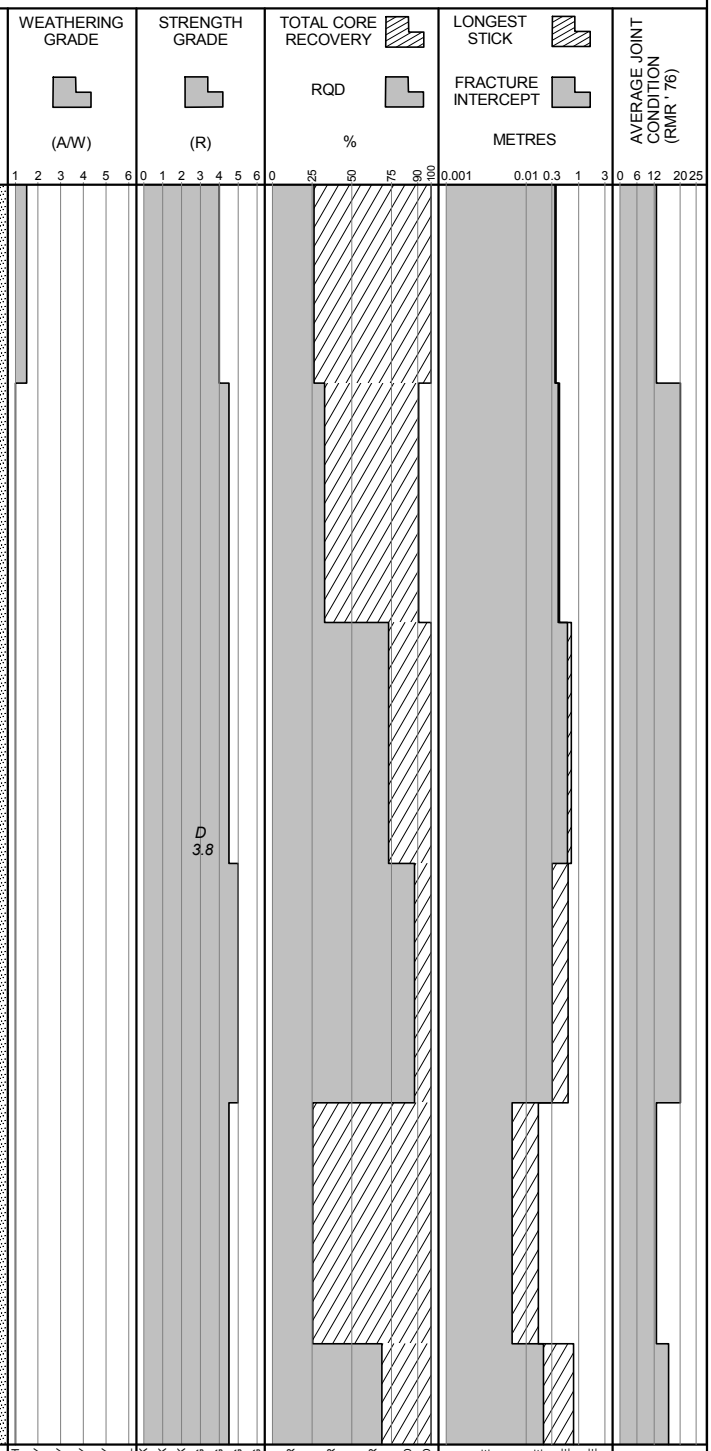
Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
321			321.1 m: Shear, 0.5 mm aperture. JRC = 1. Dip/dip direction = 68/317.
			321.2 m: Shear, 8 mm CX infill, R1. JRC = 4. Dip/dip direction = 73/309.
323			322.9 m: Shear, 2 mm CX infill, R2. JRC = 8. Dip/dip direction = 51/294.
324			D 3.8
			324.5 m: Shear, 2 mm CL infill, R1. JRC = 4. Dip/dip direction = 81/087.
326			326.2 m: Shear, 0.5 mm aperture. JRC = 2.
			326.2 m: Shear, 0.5 mm aperture. JRC = 16.
			326.8 m: Fault, 2 mm CX infill. JRC = 12.
327			326.8 m: Fault, 2 mm CX infill. JRC = 4. Dip/dip direction = 80/313.
			326.9 m: Fault, 1 mm CX infill. JRC = 12.
			327 m: Shear, 1 mm aperture. JRC = 8.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
328					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
329									
330						D 5.3			
331									
332									
333						D 7.1			
334									
335									
336					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
336					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
337									
338									
339									
340									
341									
342									
343									
344									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N	**Drill Designation:** Heliportable	**Start Date:** 17 Mar 12
Ground Elevation (m): 1,419.0	**Drilling Contractor:** Radius	**Finish Date:** 26 Mar 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 420.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 3.0
Plunge (°): -76	**Fluid:** Polymer	**Logged By:** HKM/SW
Trend (°): 222	**Cased To (m) :**	**Reviewed By:** JW

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
352					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
353						D 5.8			
354									
355									
356						D 11.9			
357						D 5.4			
358									
359									
360					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
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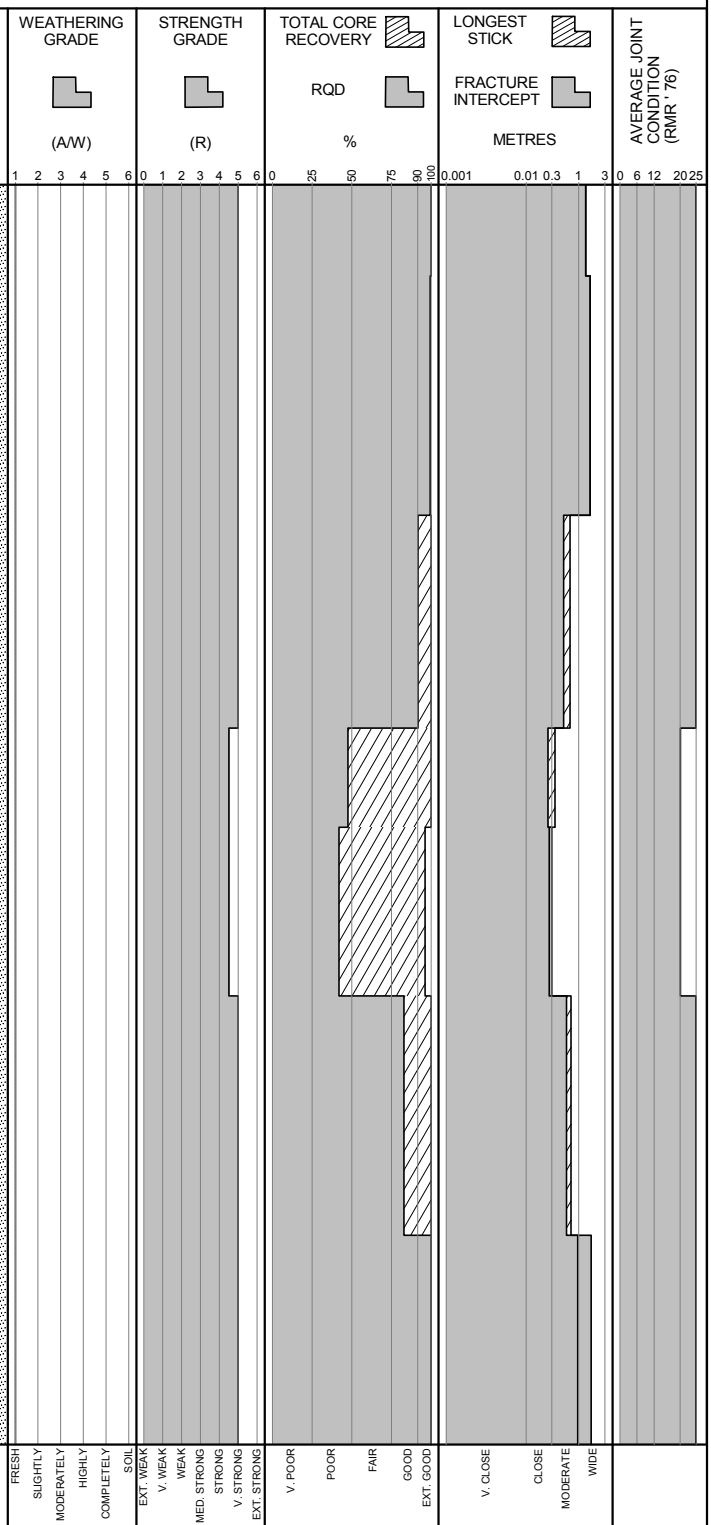
Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
360			
361			
362			
363			
364			364 m: Shear, 0.5 mm aperture. JRC = 8.
365			
366			366.3 m: Shear, 0.5 mm aperture. JRC = 1.
367			367.6 m: Shear, 0.5 mm aperture. JRC = 1.
368			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
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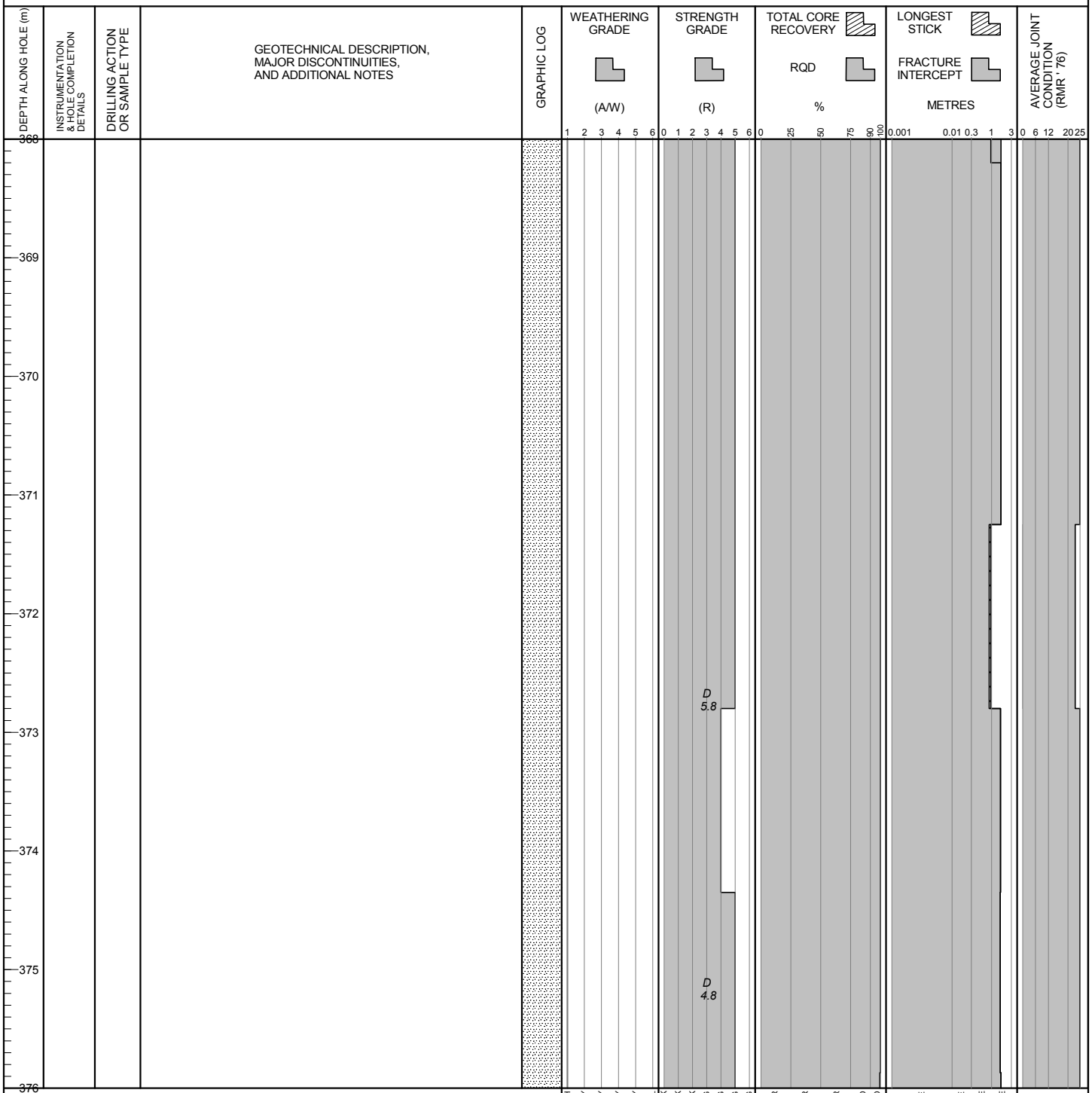

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
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Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
376									
377									
378									
379									
380						D 6.1			
381			Falling head test from 380.7 - 403.6 m. Estimated hydraulic conductivity is 6.4E-08 m/s.						
382						D 5.8			
383									
384									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
384					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
385									
386						D 7.8			
387									
388									
389									
390									
391									
392									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
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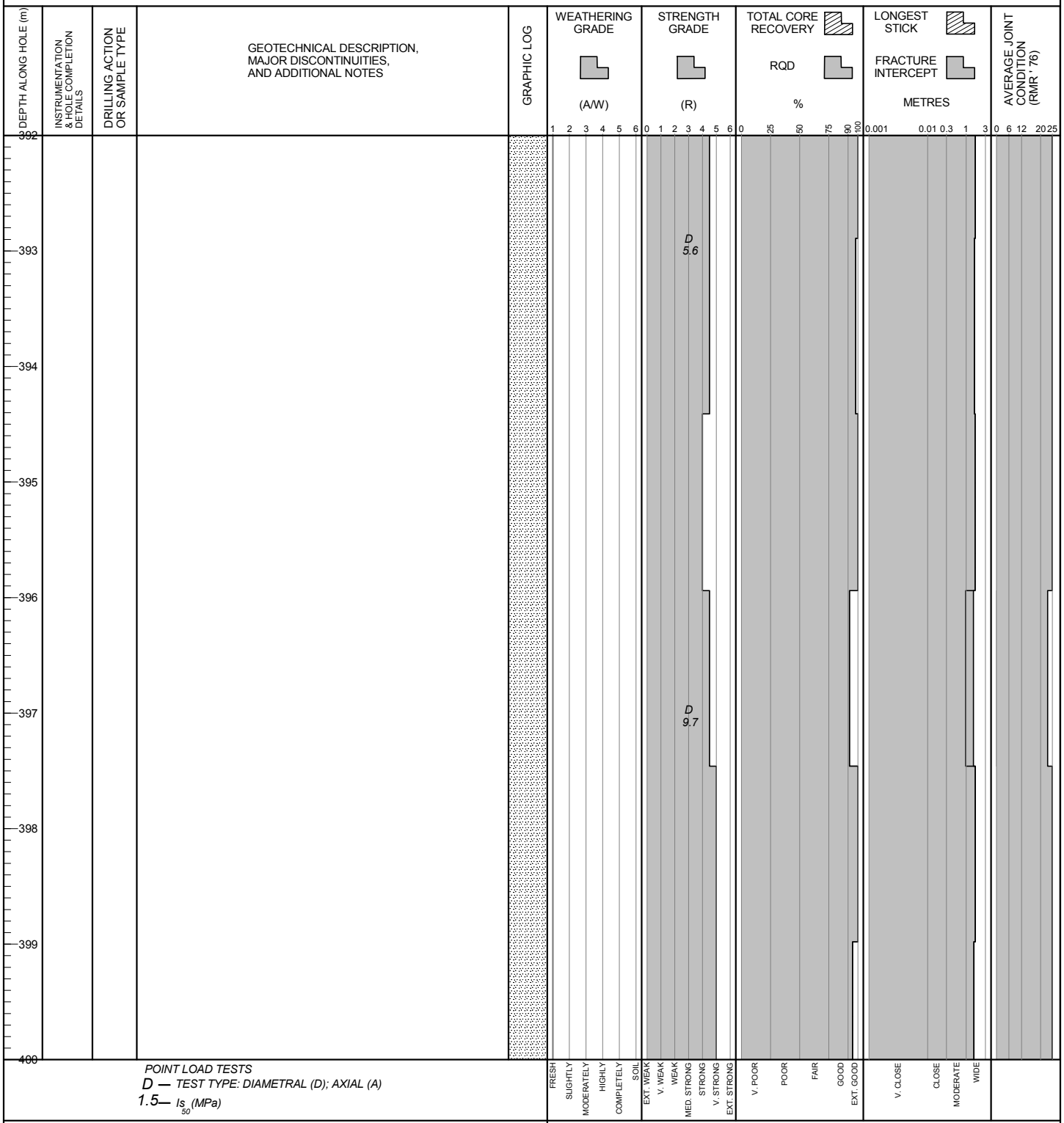
Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
400					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
401									
402									
403									
404									
405									
406						D 12.6			
407									
408									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-20

Project : Brucejack
Project No.1008-007

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
408			
409			
410			410.4 m: Shear, 0.5 mm aperture. JRC = 20.
411			
412			
413			
414			414.1 m: Shear, 0.5 mm aperture. JRC = 12. 414.2 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 78/071.
415			414.8 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 71/058. 415.3 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 82/067.
416			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-20

Location: West Zone

Co-ordinates (m): 426,552E - 6,258,607N
Ground Elevation (m): 1,419.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -76
Trend (°): 222

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) :

Start Date: 17 Mar 12
Finish Date: 26 Mar 12
Final Depth (m): 420.3
Depth To Top Of Rock (m): 3.0
Logged By: HKM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
416					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
417									
418									
419									
420									
421			END OF DRILLHOLE AT 420.3 m						
422									
423									
424									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN No Recovery.
1						
2						Rock encountered at 1.8 m depth. Refer to DH-BGC12-21 rock log.
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

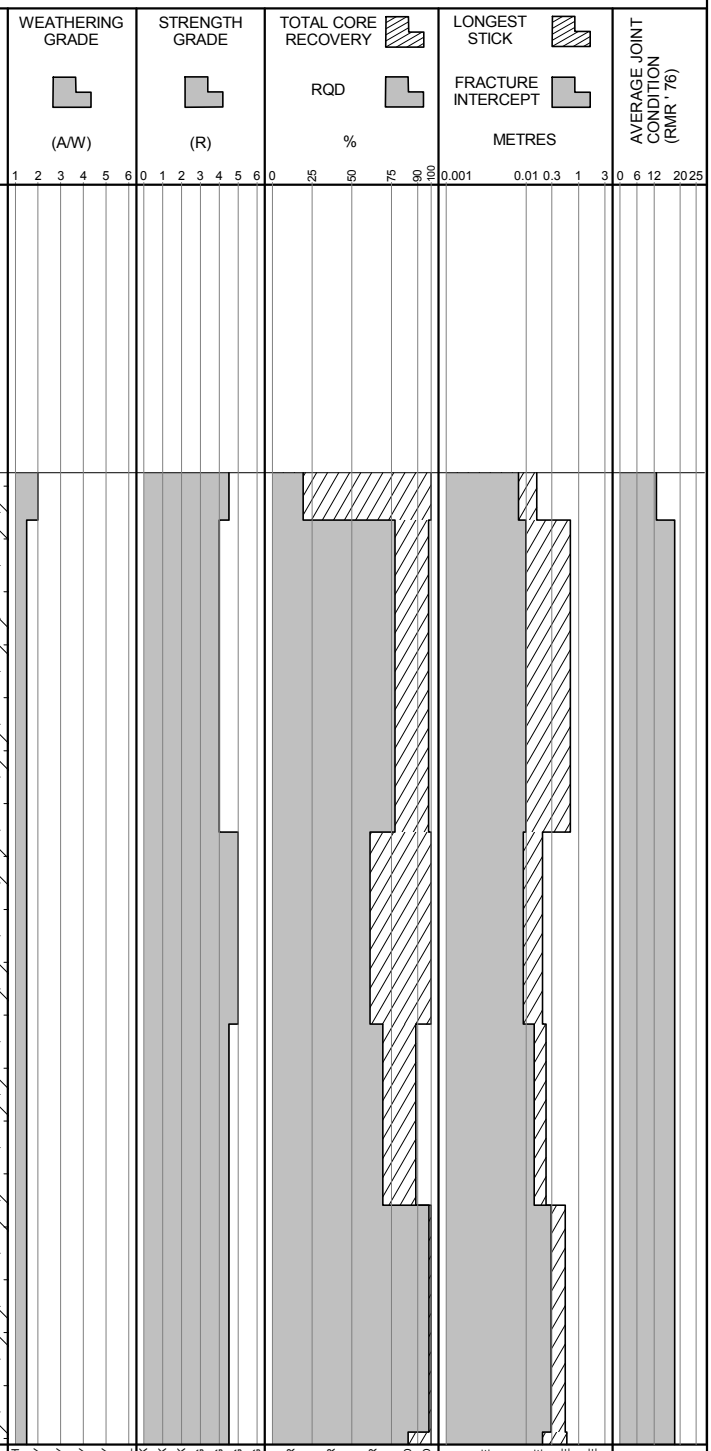
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-21 Overburden Log						
2			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Light greenish-grey, porphyry with mm-scale phenocrysts in a fine grained ground mass. Strong to very strong (R4-R5.5). Faint alteration (A1-A1.5) on major discontinuitues from top of bedrock to 26.2 m. Fresh (A1) below 26.2 m. Strength decreases to medium strong to strong (R3-R4) below 169.5 m.						
4			4 m: Shear, ST infill. JRC = 8.						
5			5 m: Shear, 0.5 mm ST infill. JRC = 8. 5.2 m: Shear, 0.5 mm ST infill. JRC = 12.						
7			7.8 m: Shear, 0.5 mm aperture. JRC = 12.						



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
8									
9									
10									
11			10.9 m: Shear, 0.5 mm CH infill, R2. JRC = 12. 11 m: Shear, 0.5 mm aperture. JRC = 8. 11.2 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 12. 11.4 m: Shear, 0.5 mm aperture. JRC = 8.						
12									
13			13.4 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 4.						
14									
15									
16									

Weathering grade: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
Longest stick / fracture intercept: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
Average joint condition (RMR '76): 0, 6, 12, 20, 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			15.9 m: Shear, 0.5 mm aperture. JRC = 8.
17			17.4 m: Shear, 0.5 mm FE infill, R4. JRC = 8.
18			17.9 m: Shear on vein, 0.5 mm QZ infill. JRC = 15. 18.1 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 8.
19			
20			
21			
22			
23			
24			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

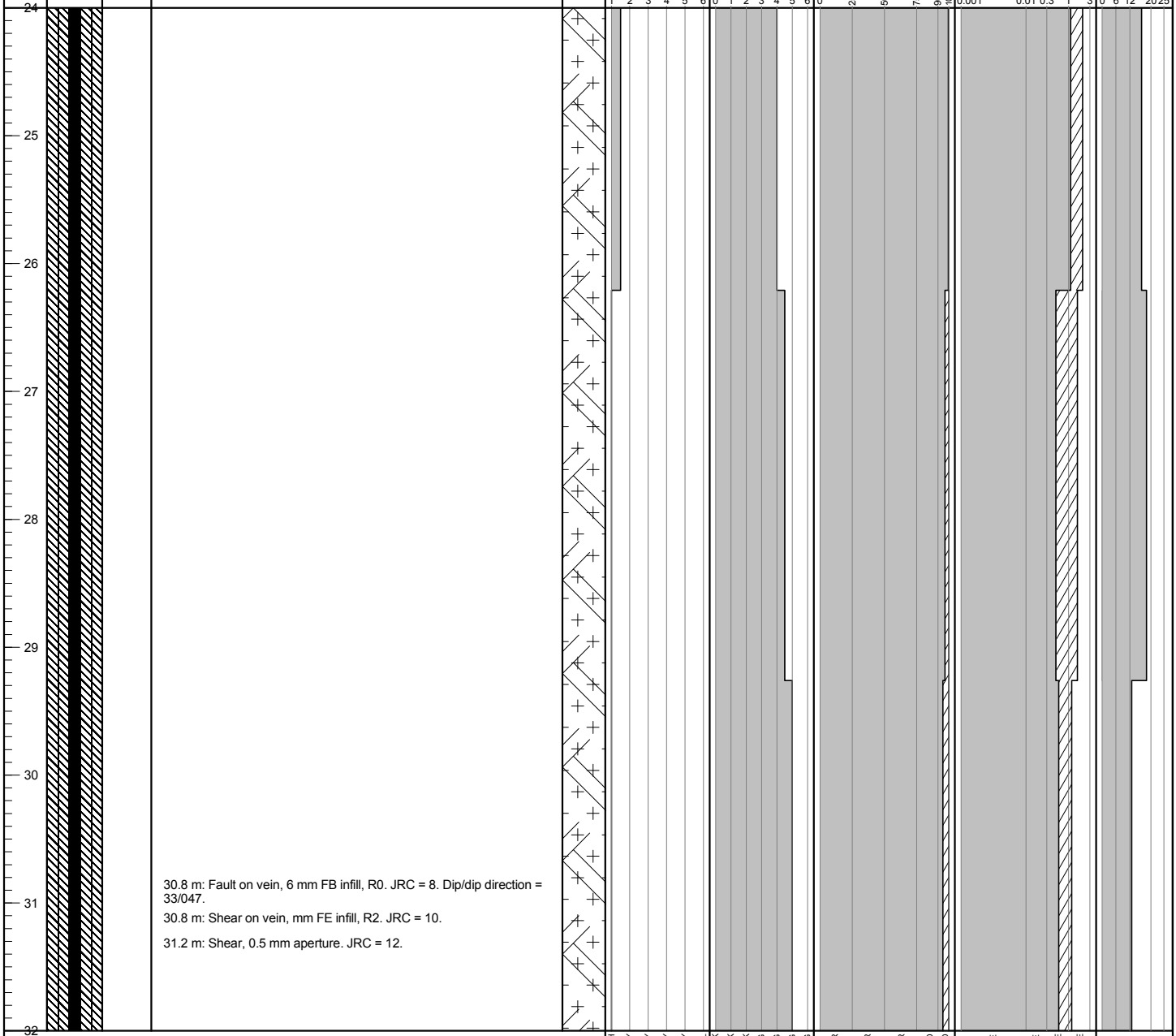
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



30.8 m: Fault on vein, 6 mm FB infill, R0. JRC = 8. Dip/dip direction = 33/047.

30.8 m: Shear on vein, mm FE infill, R2. JRC = 10.

31.2 m: Shear, 0.5 mm aperture. JRC = 12.

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

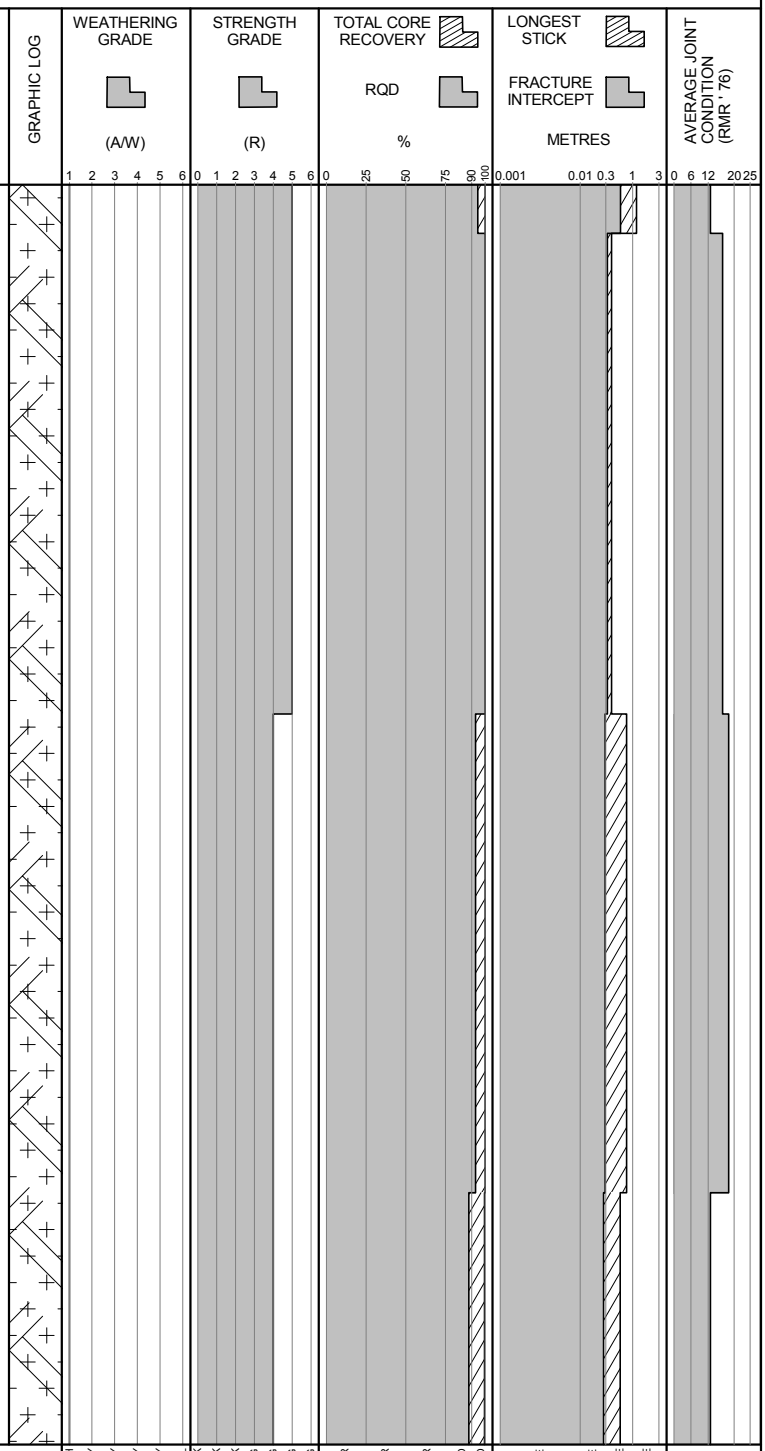
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
32			
33			33.3 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 8. Dip/dip direction = 53/108.
34			34.1 m: Shear, 0.5 mm aperture. JRC = 13. Dip/dip direction = 47/097.
35			
36			Constant head test from 36.6 - 50.6 m. Estimated hydraulic conductivity is 1.6E-07 m/s.
37			
38			38 m: Shear on vein, 1 mm QZ infill, R4. JRC = 10.
39			
40			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

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Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

40.4 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 8.

40.7 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 6. Dip/dip direction = 54/268.

42.6 m: Shear, 0.5 mm aperture. JRC = 13.

46.4 m: Shear on vein, 0.5 mm CH infill, R2. JRC = 13. Dip/dip direction = 75/256.

46.8 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 13. Dip/dip direction = 85/294.

47.8 m: Shear on vein, 1.5 mm BX infill, R3. JRC = 13. Dip/dip

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL | EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG | V. POOR, POOR, FAIR, GOOD, EXT. GOOD | V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
48			direction = 88/302.
			48.3 m: Shear on vein, 0.5 mm CH infill, R2. JRC = 15. Dip/dip direction = 86/303.
49			49.2 m: Fault, 2 mm FB infill, R1. JRC = 8. Dip/dip direction = 54/261.
50			
51			51.3 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 8.
			51.4 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 20.
52			
53			
54			
55			
56			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
56					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
57									
58									
59									
60									
61									
62									
63									
64									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

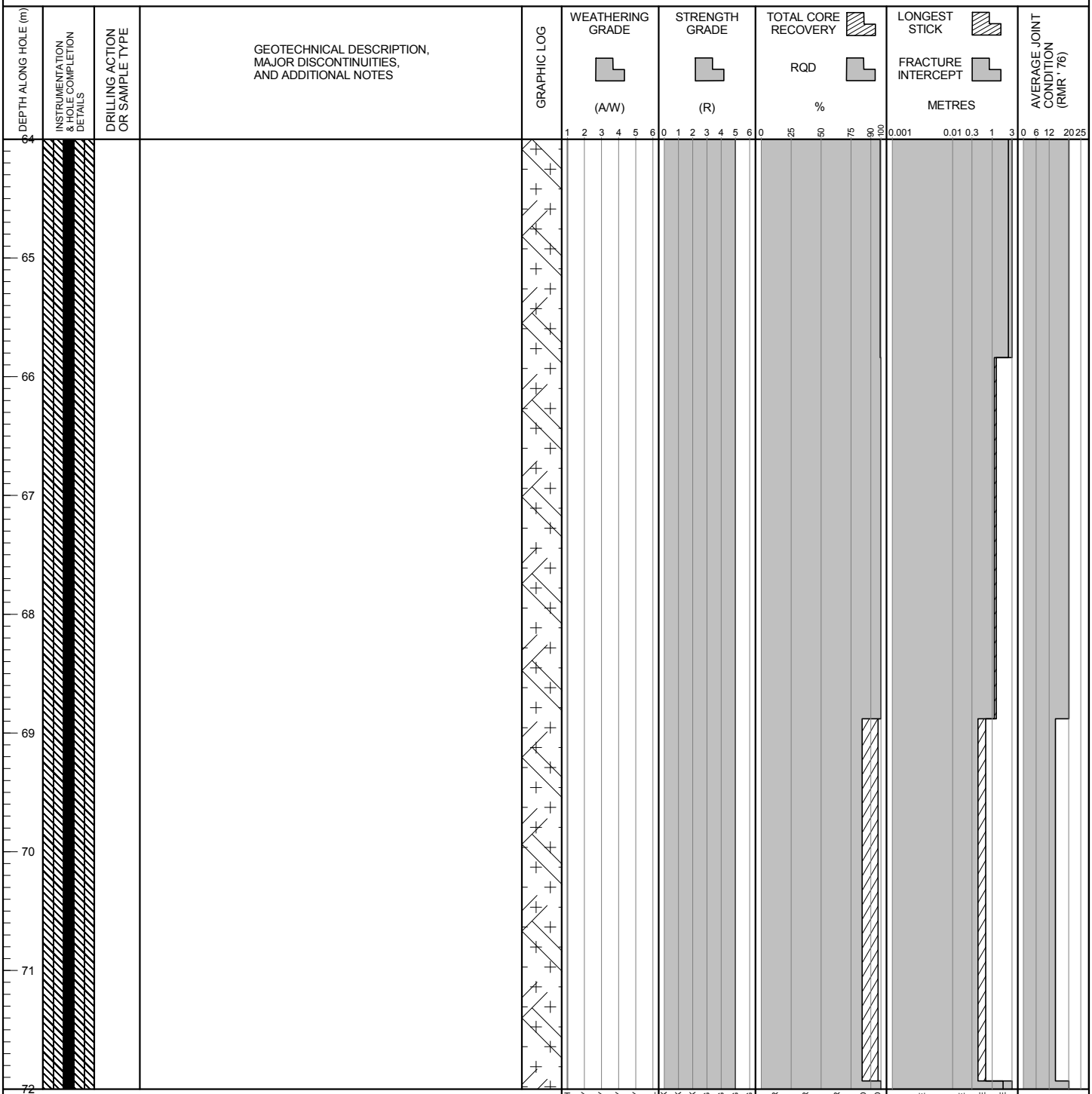
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
72			
73			
74			
75			
			75.6 m: Shear, 0.5 mm aperture. JRC = 4. Dip/dip direction = 80/228.
76			
77			
78			
			78.7 m: Shear on vein, QZ infill. JRC = 8. Dip/dip direction = 49/278.
79			
			79.5 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 85/288.
80			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
80					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
81									
82									
83			83.2 m: Shear, 0.5 mm CA infill. JRC = 4. 83.3 m: Shear, 0.5 mm CA infill. JRC = 4.						
84									
85									
86									
87			87.5 m: Shear, 0.5 mm aperture. JRC = 4.						
88									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

88
89
90
91
92
93
94
95
96

89.7 m: Shear, 0.5 mm CA infill. JRC = 4. Dip/dip direction = 47/217.

89.9 m: Shear, 1 mm aperture. JRC = 4.

90.4 m: Shear on vein, 0.5 mm CA infill. JRC = 8.

91.7 m: Shear on vein, 0.5 mm CA infill. JRC = 12. Dip/dip direction = 72/231.

94.3 m: Shear, 2 mm BX infill. JRC = 1. Dip/dip direction = 58/243.

94.9 m: Shear, 0.5 mm aperture. JRC = 12.

95.2 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 45/208.

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0, 25, 50, 75, 90, 100 %
LONGEST STICK / FRACTURE INTERCEPT: 0.001, 0.01, 0.3, 1, 3 METRES
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

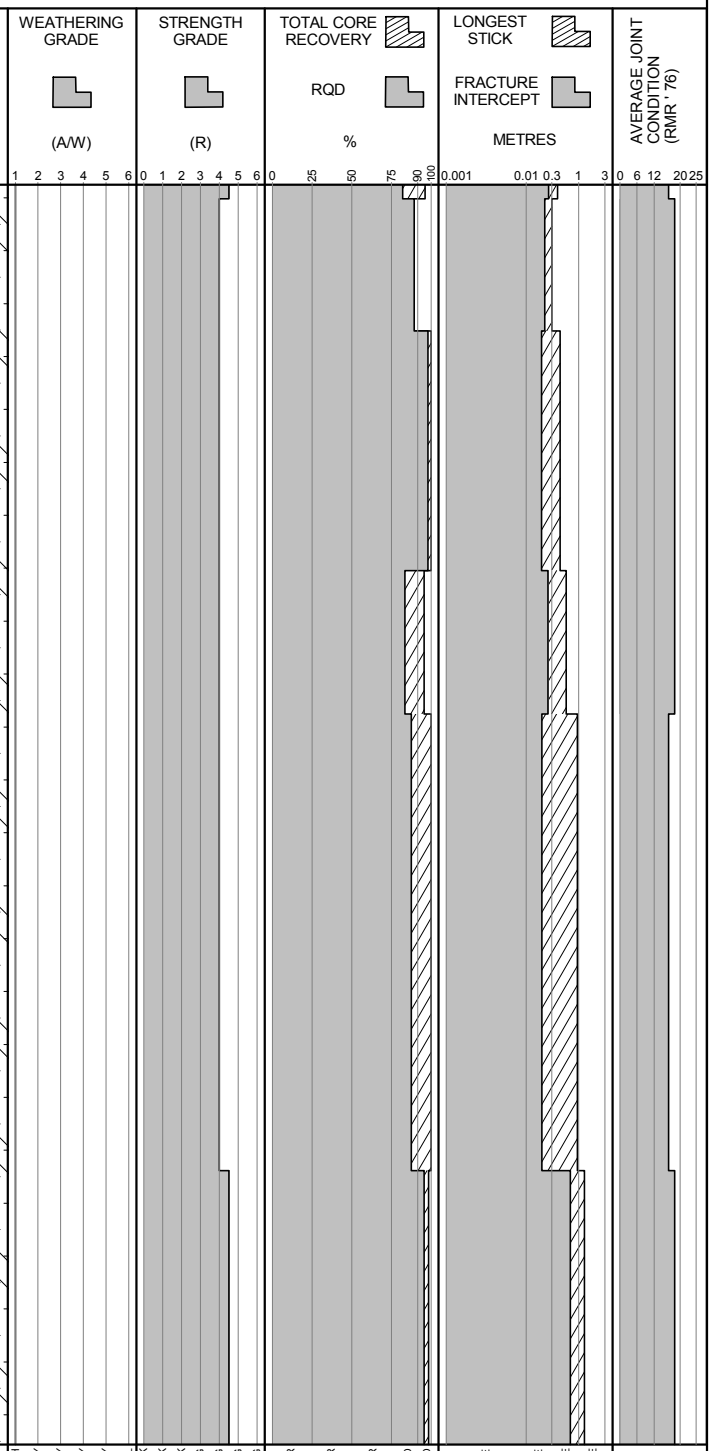
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
96			
97			97.7 m: Shear on vein, 0.5 mm CA infill. JRC = 15. Dip/dip direction = 85/273.
98			
99			
100			100.7 m: Shear, 2 mm aperture. JRC = 15.
101			101.4 m: Shear, 0.5 mm aperture. JRC = 12.
102			101.9 m: Shear, 0.5 mm CA infill. JRC = 13.
103			102.9 m: Shear on vein, 1 mm CA infill. JRC = 20.
104			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
104			
105			
106			
			106.7 m: Shear on vein, 0.5 mm CA infill. JRC = 13. Dip/dip direction = 52/095.
107			106.9 m: Shear on vein, 1 mm CA infill. JRC = 15.
108			
109			
			109.3 m: Shear on vein, 0.5 mm aperture. JRC = 8. Dip/dip direction = 44/201.
			109.7 m: Shear, 0.5 mm aperture. JRC = 12.
110			109.9 m: Shear on vein, 1 mm CA infill. JRC = 4.
			109.9 m: Shear, 0.5 mm aperture. JRC = 8.
			110.4 m: Shear, 0.5 mm aperture. JRC = 2.
111			110.8 m: Shear, 0.5 mm CH infill. JRC = 4. Dip/dip direction = 37/181.
112			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

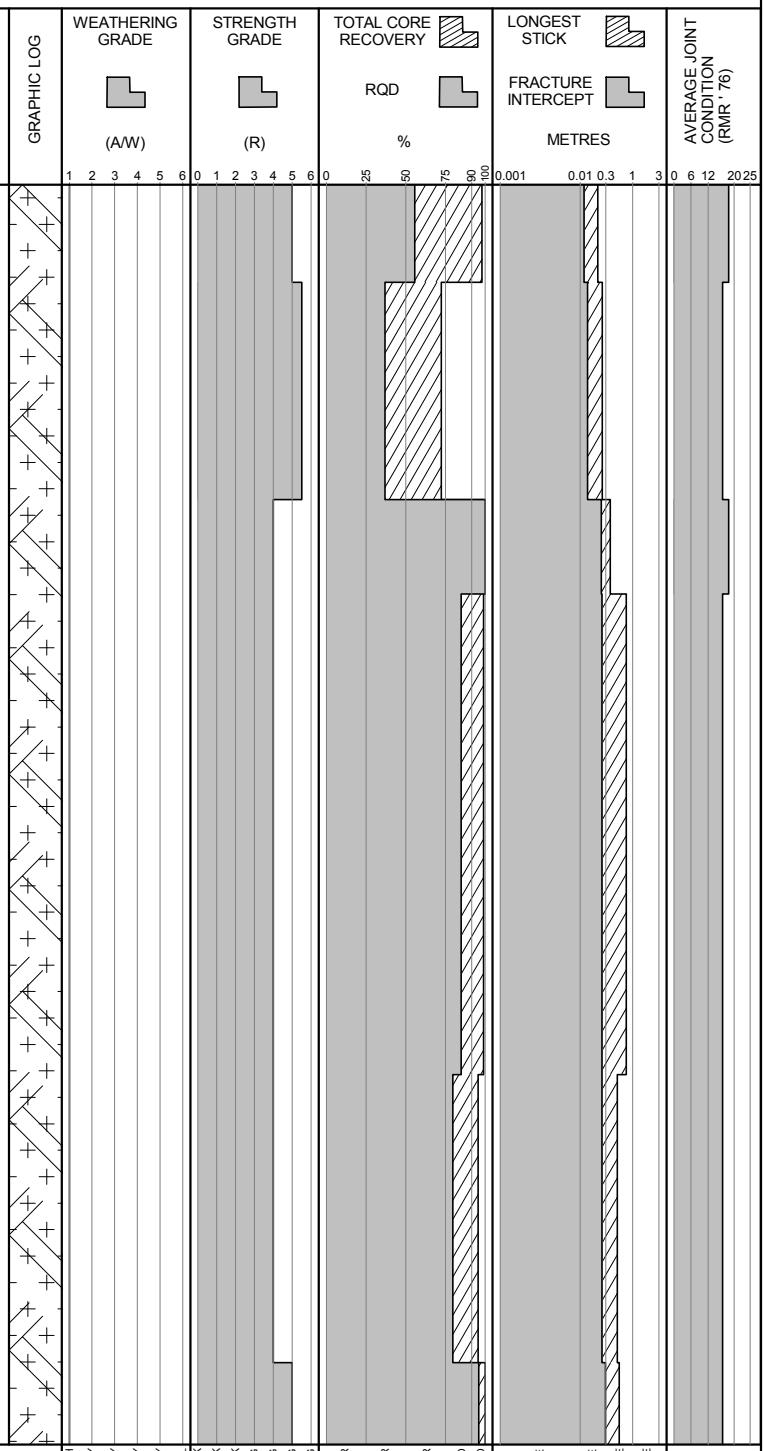
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
112			112.2 m: Shear on vein, 30 mm BX infill. JRC = 1. Dip/dip direction = 29/073.
113			113.5 m: Shear, 0.5 mm aperture. JRC = 4.
114			113.9 m: Shear on vein, mm CA infill. JRC = 8.
			114.3 m: Shear on vein, 1 mm aperture. JRC = 8.
115			
116			116.1 m: Shear, 0.5 mm aperture. JRC = 12.
117			116.9 m: Shear, 1 mm aperture. JRC = 15.
			117.1 m: Shear, 0.5 mm aperture. JRC = 4.
			117.3 m: Shear, 0.5 mm CA infill. JRC = 8.
			117.8 m: Shear, 2 mm aperture. JRC = 8.
118			
119			119 m: Shear, 0.5 mm aperture. JRC = 8.
120			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

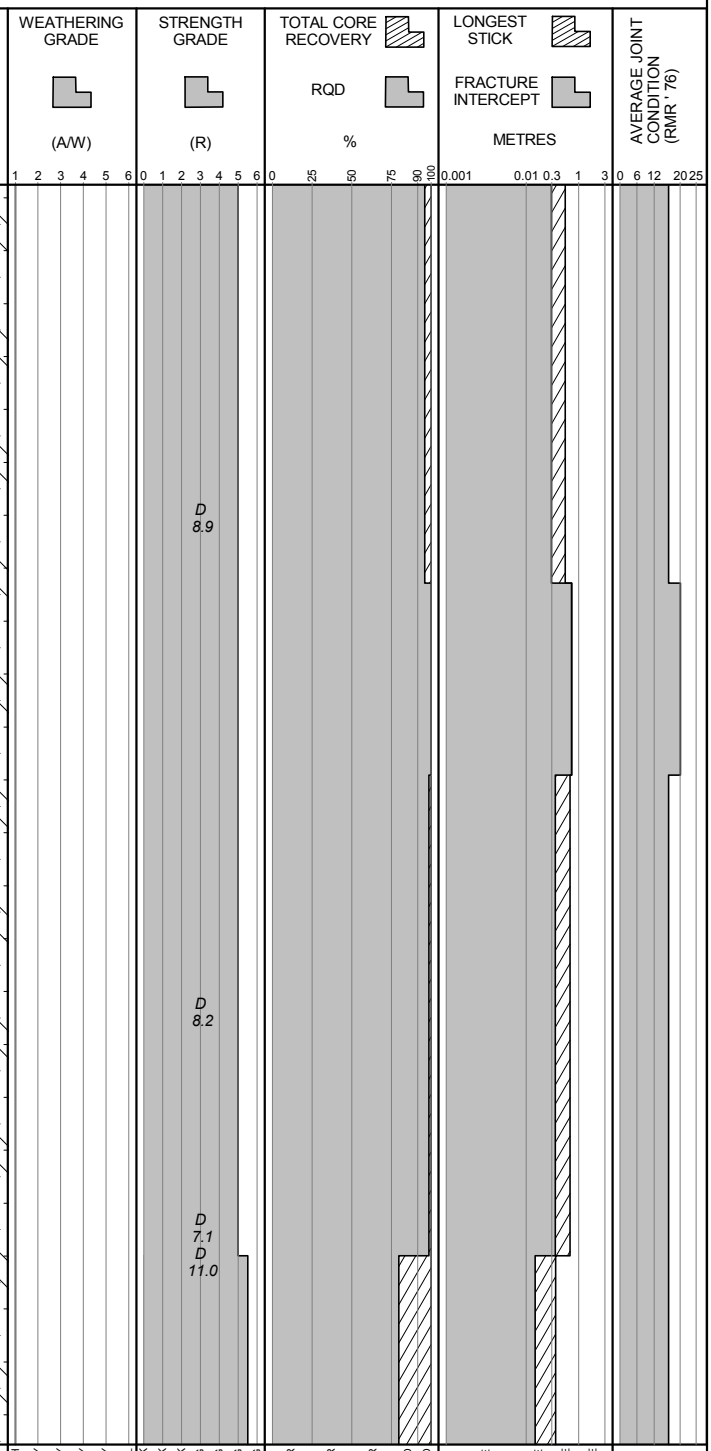
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
120			
			120.5 m: Shear on vein, 0.5 mm CA infill. JRC = 4.
121			
122			
123			123.1 m: Shear, 0.5 mm aperture. JRC = 12.
124			
			124.6 m: Shear, 0.5 mm CA infill. JRC = 8.
125			
126			
			126.5 m: Shear on vein, 1 mm CA infill. JRC = 4.
127			
			127.2 m: Shear on vein, 1 mm CH infill. JRC = 4.
			127.7 m: Shear, 0.5 mm CA infill. JRC = 15.
128			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
128			128.2 m: Shear on vein, 1 mm CA infill. JRC = 4. Dip/dip direction = 48/226.
			128.5 m: Shear on vein, 2 mm CA infill. JRC = 4. Dip/dip direction = 28/205.
			128.8 m: Shear on vein, 1 mm CA infill. JRC = 15. Dip/dip direction = 51/233.
129			
130			130.3 m: Shear on vein, 1 mm CA infill. JRC = 8.
			130.3 m: Shear, 0.5 mm CA infill. JRC = 4.
131			130.9 m: Shear on vein, 1 mm CA infill. JRC = 13.
			Constant head test from 131.4 - 148.1 m. Estimated hydraulic conductivity is 3.5E-08 m/s.
132			132.1 m: Shear on vein, 0.5 mm CA infill. JRC = 12.
133			
134			133.7 m: Shear on vein, 1 mm CA infill. JRC = 8. Dip/dip direction = 61/233.
			133.9 m: Shear, 1 mm CA infill. JRC = 4. Dip/dip direction = 61/282.
			134.1 m: Shear on vein, 1 mm CA infill. JRC = 13. Dip/dip direction = 43/250.
			134.7 m: Shear, 0.5 mm aperture. JRC = 12.
135			
			135.3 m: Shear, 0.5 mm CA infill, R4. JRC = 4. Dip/dip direction = 85/254.
			135.6 m: Shear, 0.5 mm CH infill, R3. JRC = 20.
			135.6 m: Shear, 0.5 mm CA infill, R4. JRC = 20.
136			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
136			135.7 m: Shear, 1 mm CA infill. JRC = 15. 135.8 m: Shear, 1 mm CA infill. JRC = 13. 136.4 m: Shear on vein, 0.5 mm aperture. JRC = 8. 136.4 m: Shear, 0.5 mm CA infill, R2. JRC = 8. Dip/dip direction = 62/308. 136.7 m: Shear on vein, 0.5 mm CA infill. JRC = 15.						
137									
138						D 6.1			
139						D 11.6			
			139.6 m: Shear, 0.5 mm CA infill. JRC = 12.						
140									
141			141 m: Shear, 0.5 mm CA infill. JRC = 8. 141.1 m: Shear, 0.5 mm CA infill. JRC = 8. 141.2 m: Shear, CH infill. JRC = 15. Dip/dip direction = 62/268.						
142			142.2 m: Shear, CH infill. JRC = 15. 142.3 m: Shear, 0.5 mm CA infill, R3. JRC = 2. 142.4 m: Shear, 0.5 mm CA infill. JRC = 4. 142.5 m: Shear, 0.5 mm aperture. JRC = 4. 142.8 m: Shear, 110 mm BX infill. JRC = 12.						
143			143.6 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 53/200.			D 3.8			
144									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

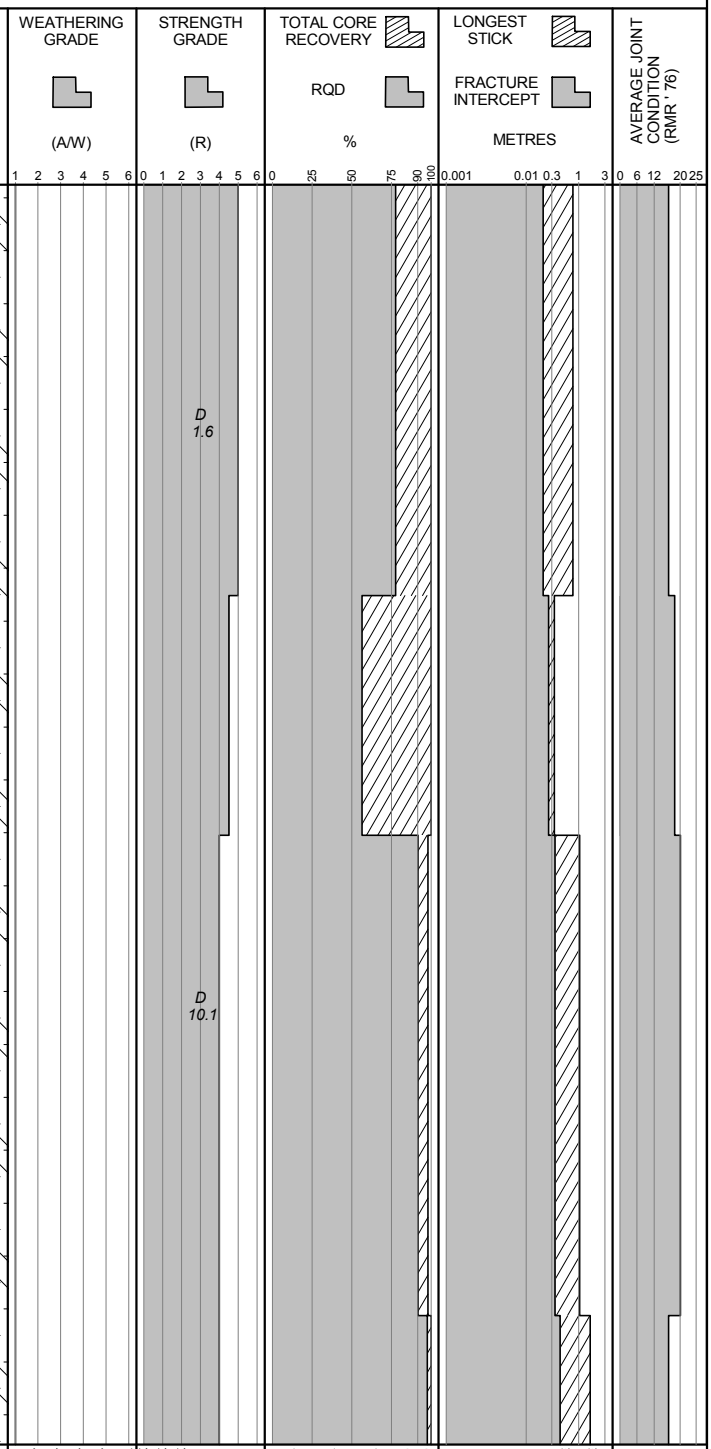
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
144			144.1 m: Shear on vein, 0.5 mm CA infill. JRC = 8. Dip/dip direction = 63/198.
			144.5 m: Shear on vein, 0 mm CA infill, R4. JRC = 13. Dip/dip direction = 65/202.
			144.7 m: Shear, 0.5 mm CH infill. JRC = 15.
145			145.1 m: Shear, 0.5 mm CA infill. JRC = 8.
			145.2 m: Shear, 0.5 mm CA infill. JRC = 4.
			145.6 m: Shear on vein, 0.5 mm CA infill. JRC = 8. Dip/dip direction = 27/219.
146			146.1 m: Shear on vein, 0.5 mm CA infill. JRC = 12.
147			147.2 m: Shear, 0.5 mm aperture. JRC = 1.
			147.2 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 48/209.
148			
149			149 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 8.
150			
151			
			151.4 m: Shear, 0.5 mm aperture. JRC = 10.
			151.5 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 47/042.
152			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
152									
153						D 5.9			
154			154.3 m: Shear, 0.5 mm aperture. JRC = 4.						
155						D 5.4			
156									
157			156.9 m: Shear, 0.5 mm aperture. JRC = 4.						
158						D 4.0			
159			158.3 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 8. Dip/dip direction = 89/095.						
160			159.6 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 10.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

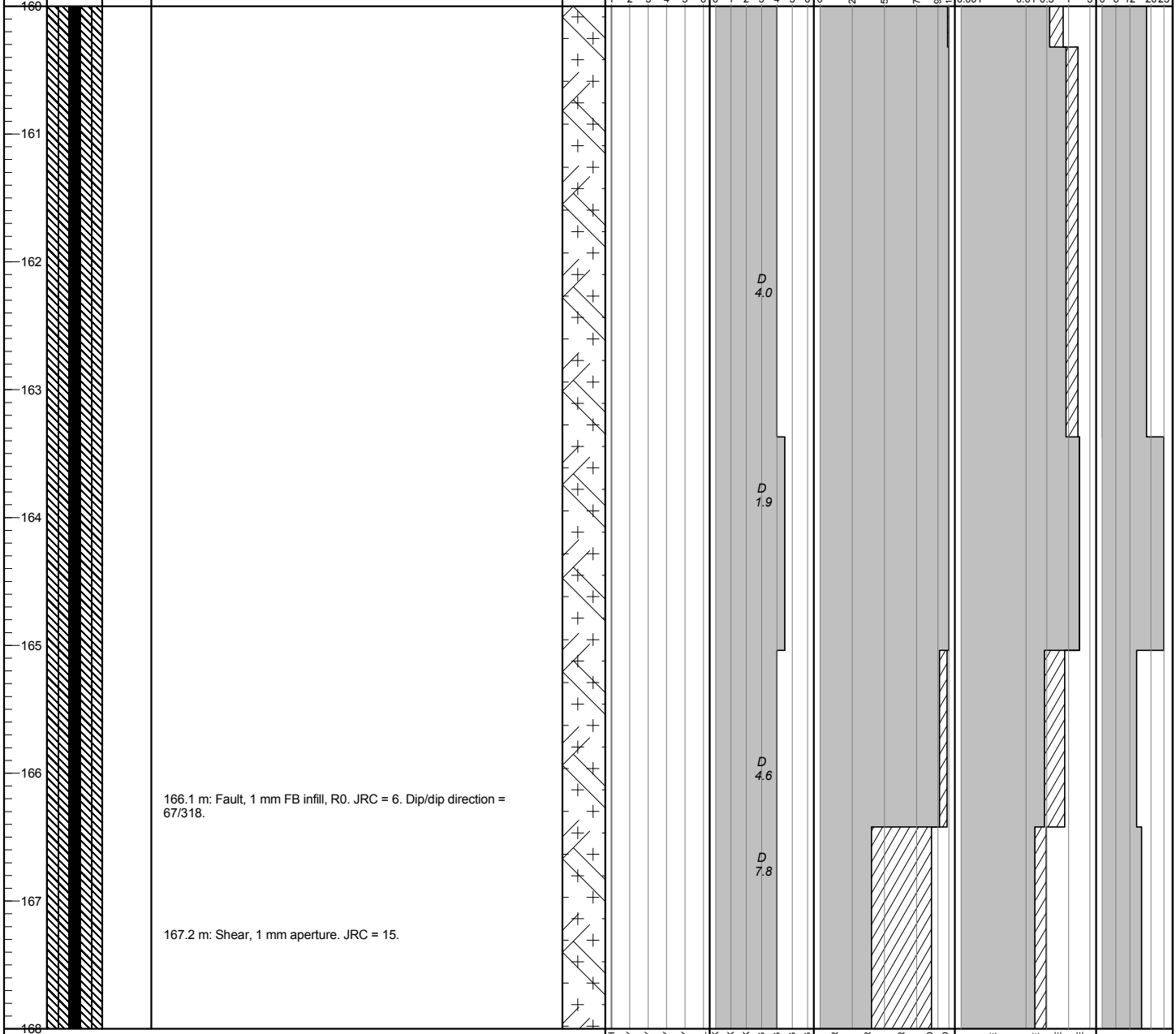
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

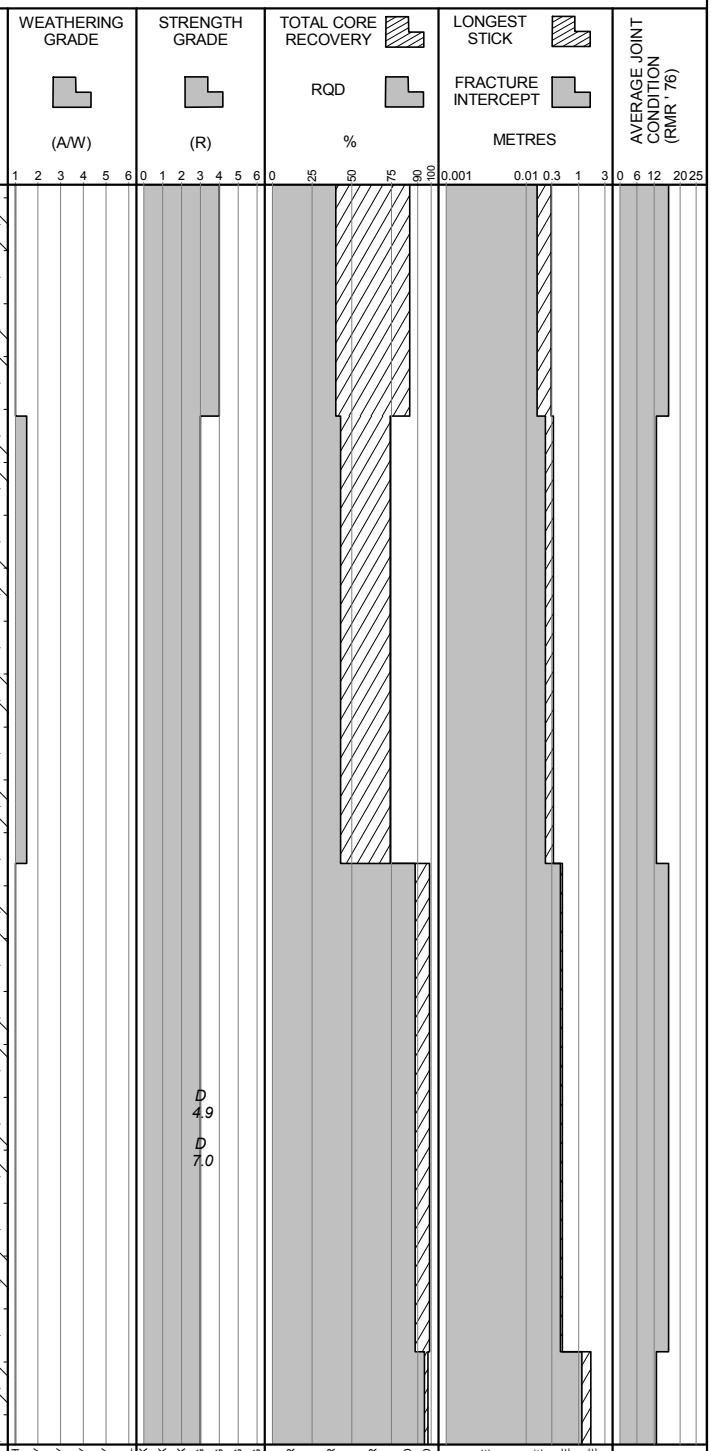
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
168									
169									
170									
171			171.2 m: Fault, 1.5 mm FB infill, R0. JRC = 20.						
172									
173			173.2 m: Shear, 1 mm CA infill, R2. JRC = 13.						
174						D 4.9 D 7.0			
175									
176									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

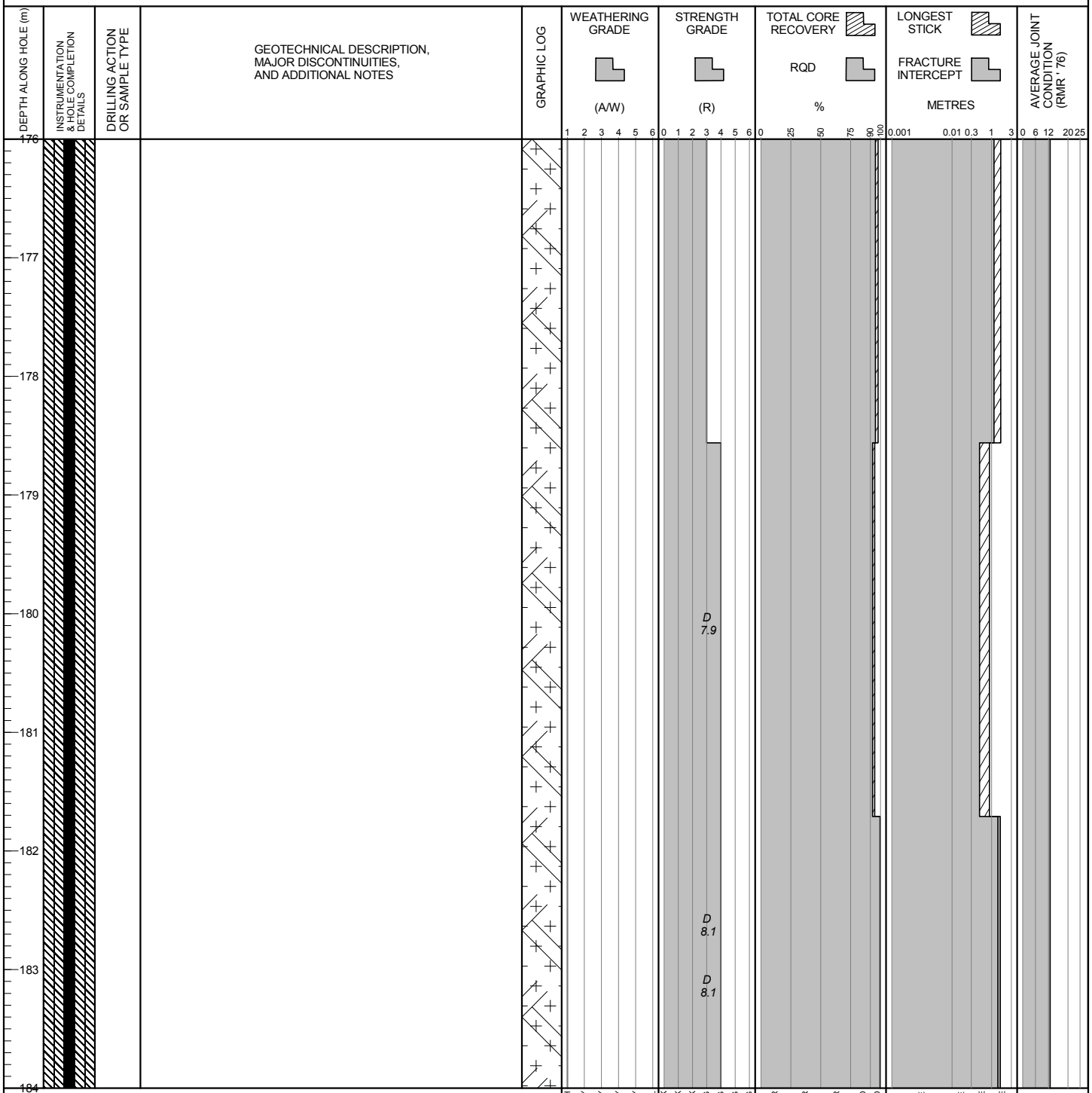
DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

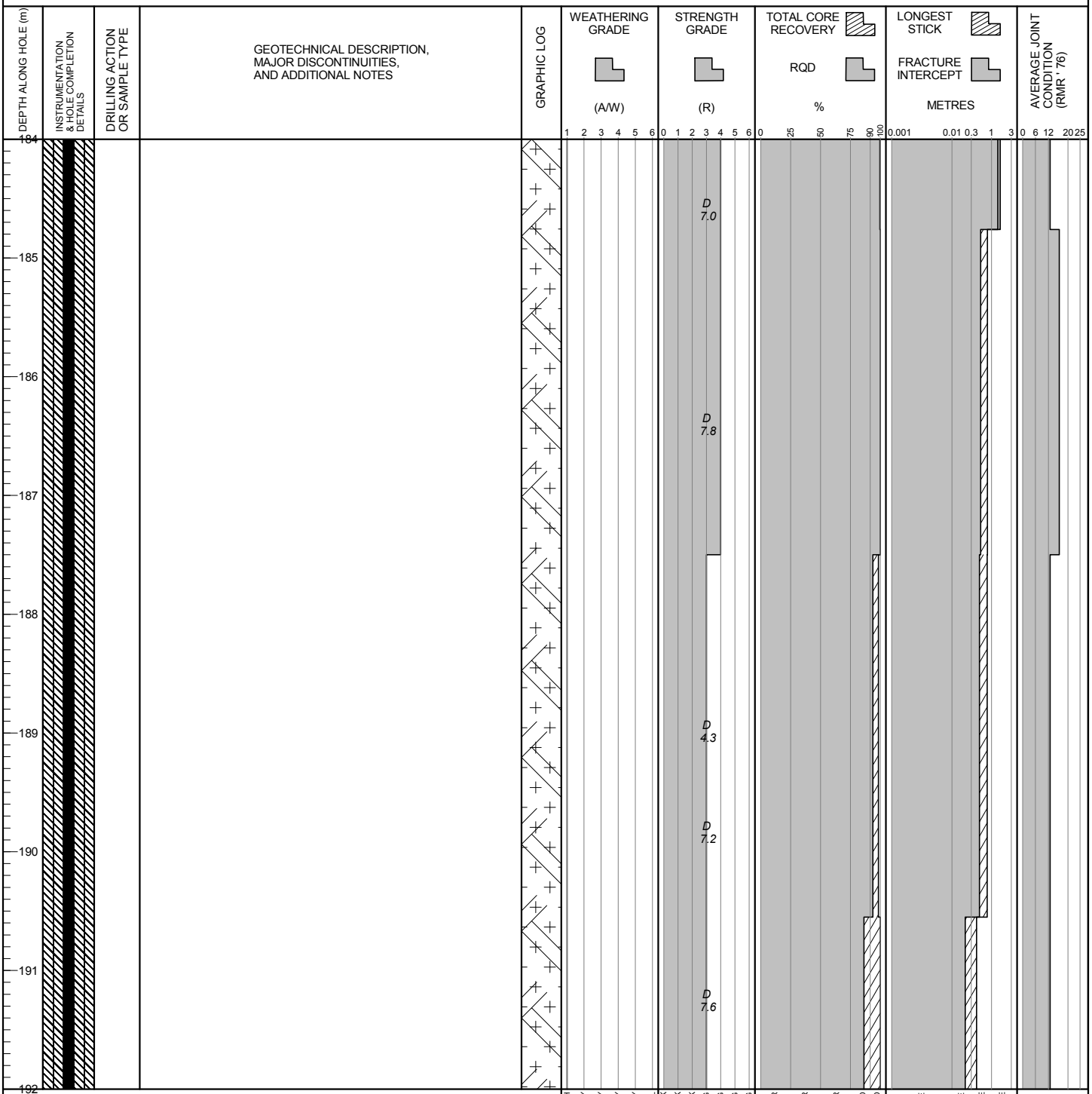
DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

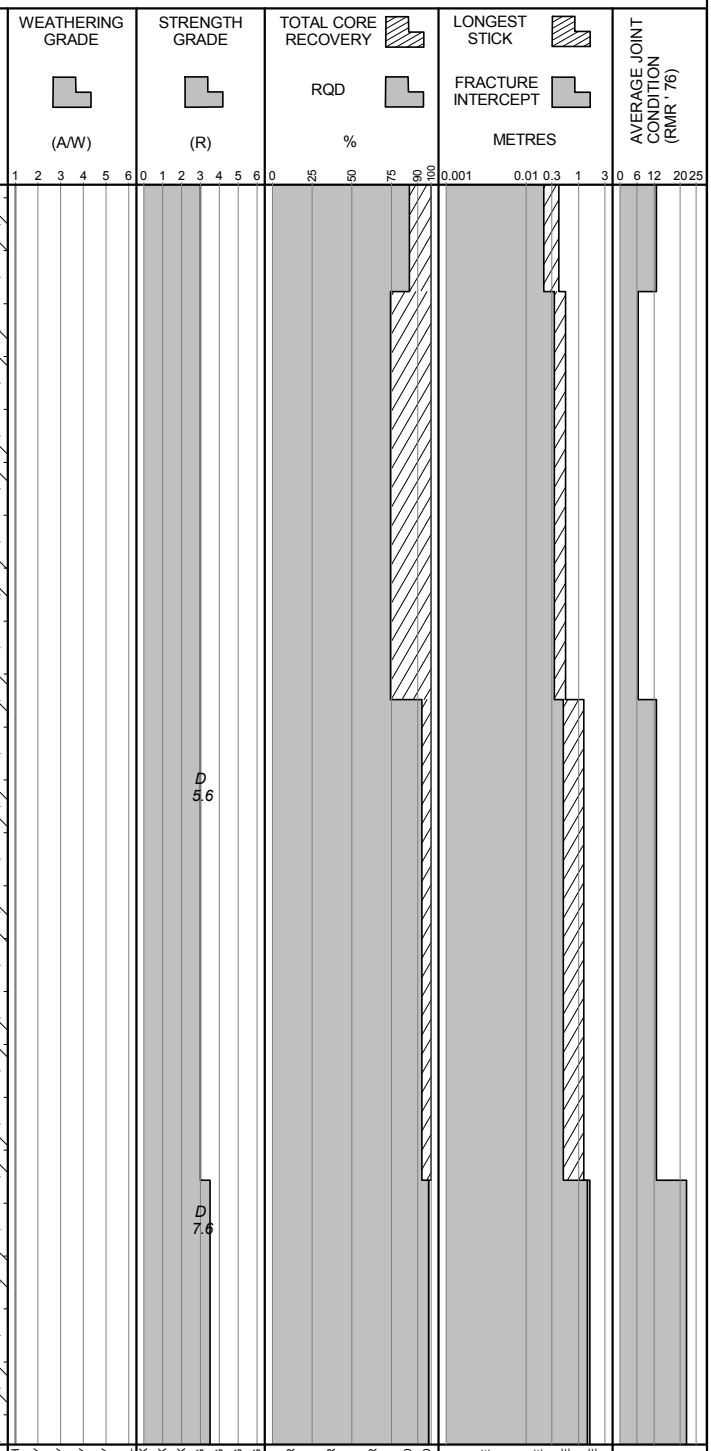
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
192			192.4 m: Shear, 0.5 mm aperture. JRC = 8.
			192.8 m: Shear, 0.5 mm aperture. JRC = 8.
193			193.1 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 58/205.
194			193.9 m: Shear, 0.5 mm aperture. JRC = 4. Dip/dip direction = 55/209.
			194.5 m: Shear, 10 mm aperture. JRC = 8.
195			
196			D 5.6
197			
			197.7 m: Shear, 1 mm aperture. JRC = 8.
198			198.1 m: Shear, 0.5 mm aperture. JRC = 8.
			D 7.6
199			
200			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

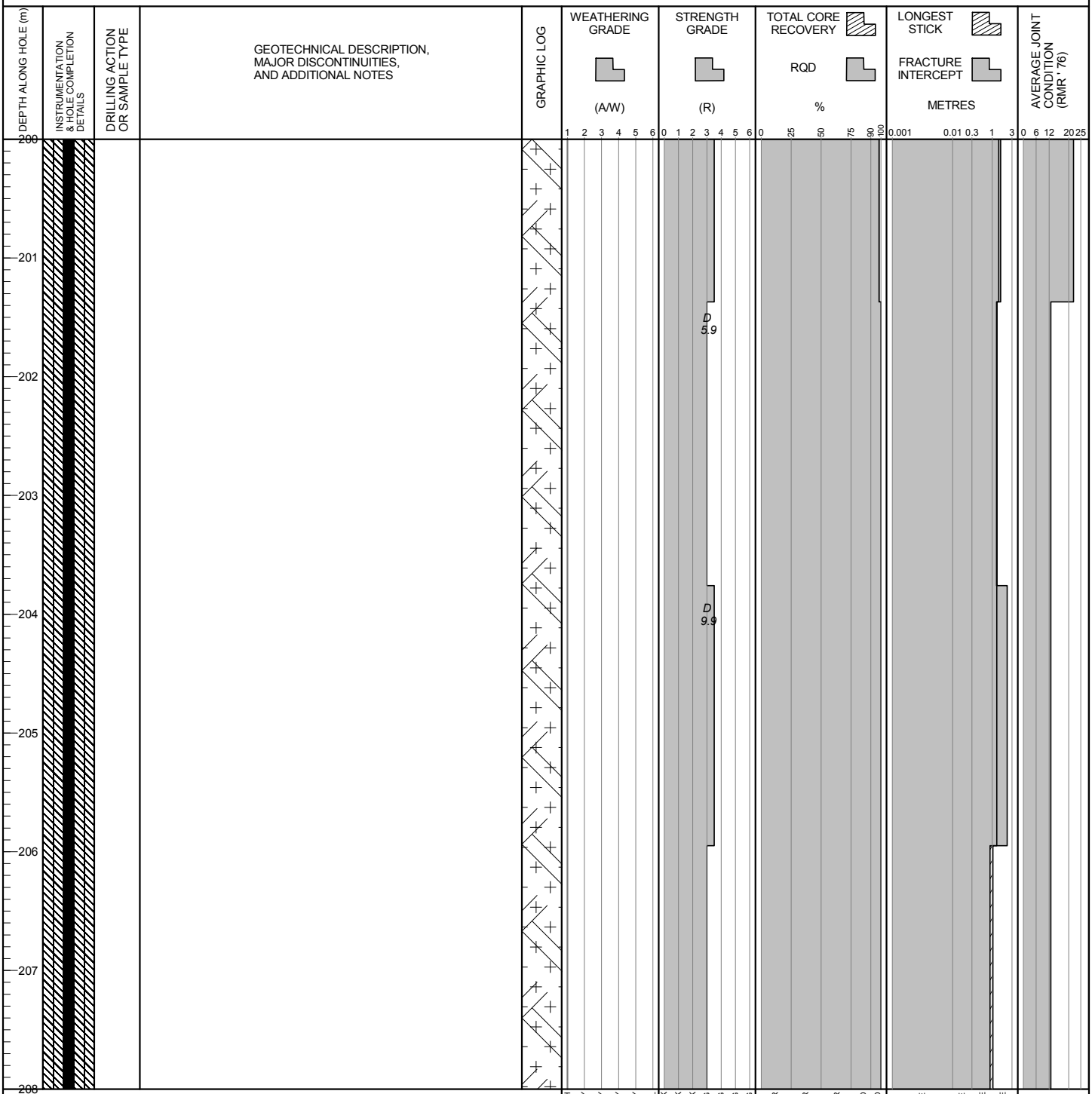
DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

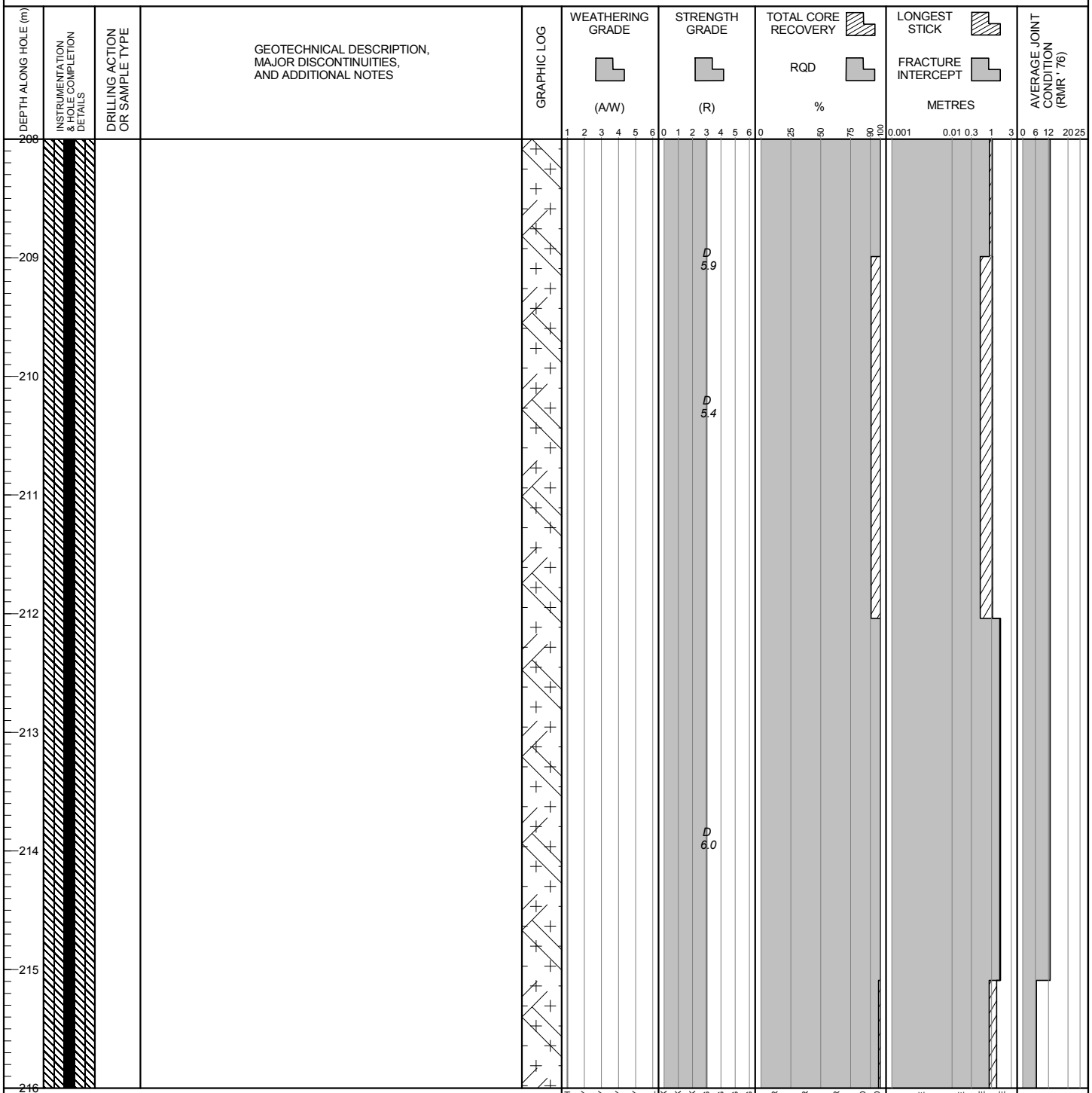
DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

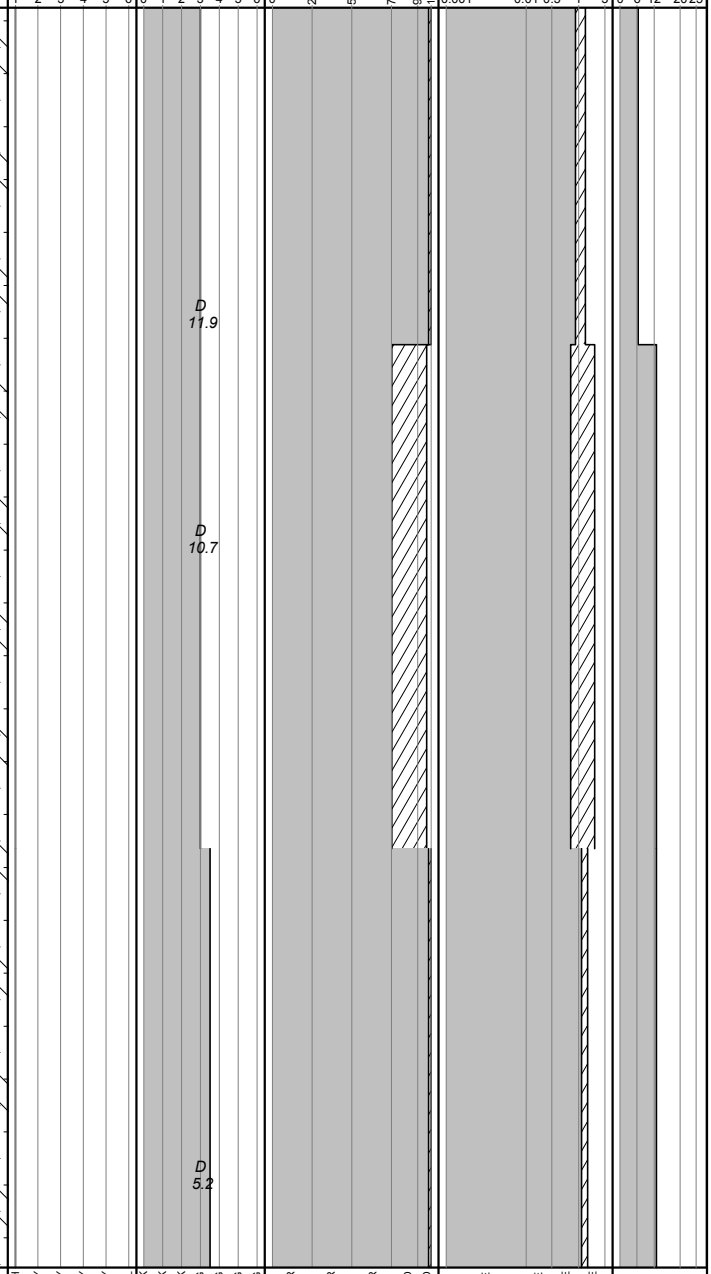
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
216									
217			217.2 m: Shear, 0.5 mm aperture. JRC = 4.						
218						D 11.9			
219						D 10.7			
220									
221									
222									
223						D 5.2			
224									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

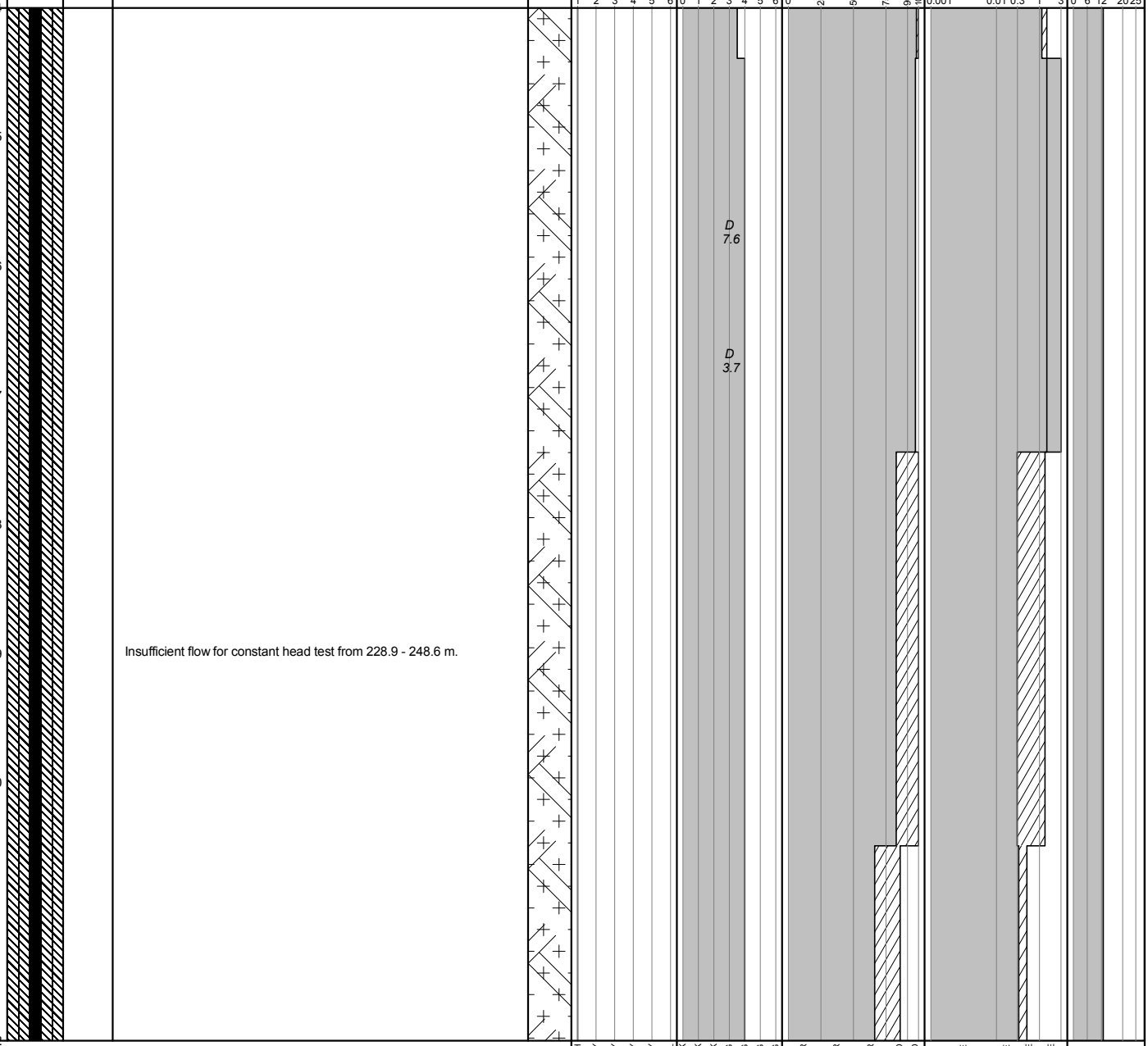
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
224									
225									
226						D 7.6			
227						D 3.7			
228									
229			Insufficient flow for constant head test from 228.9 - 248.6 m.						
230									
231									
232									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

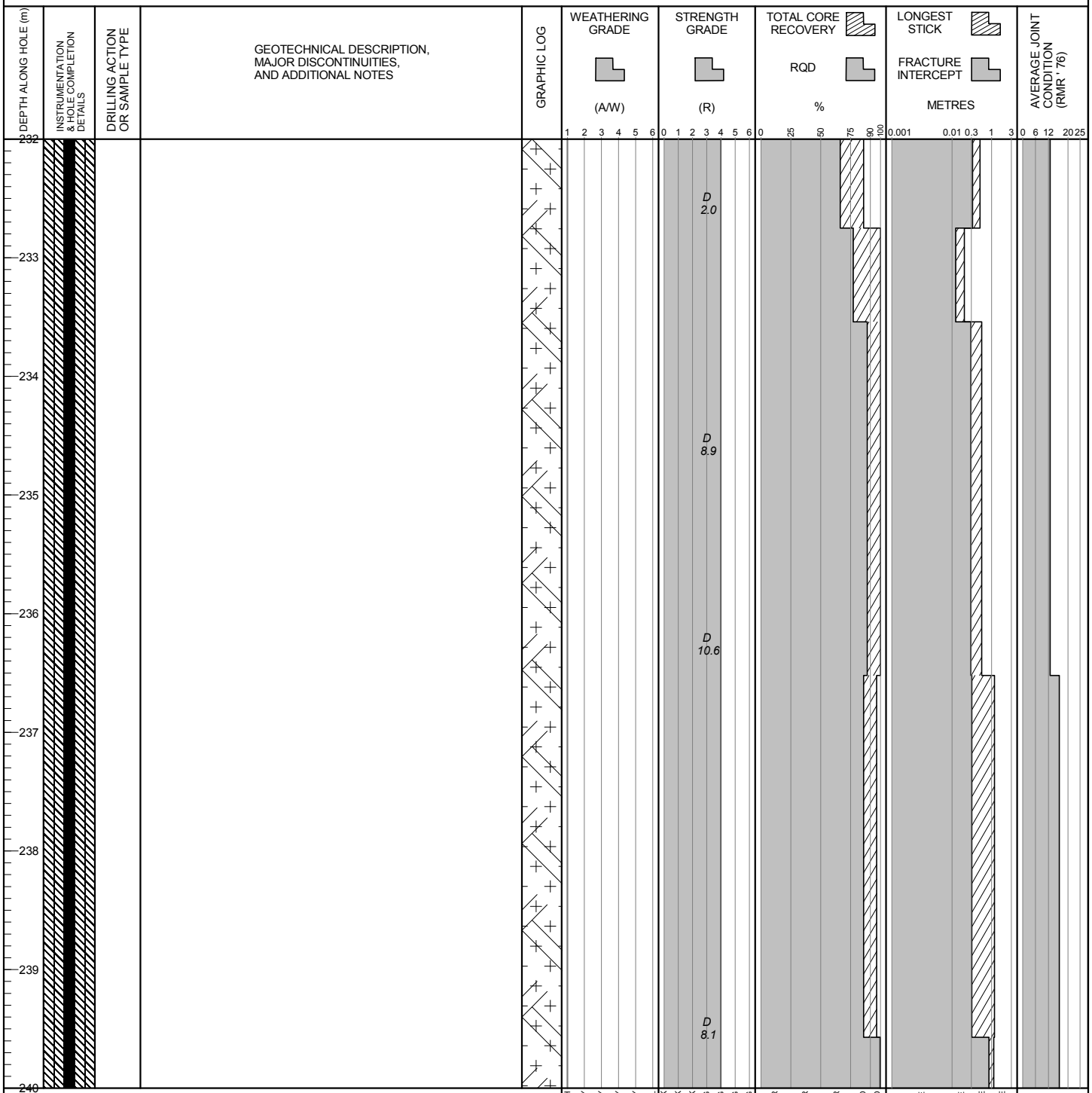
Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
240			240 m: Shear, 0.5 mm aperture. JRC = 12.						
241									
242									
243						D 10.2			
244						D 4.1			
						D 8.7			
245						D 9.9			
246									
247						D 5.3			
248									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

248
249
250
251
252
253
254
255
256

250.2 m: Fault, 1 mm FB infill. JRC = 13.

MAFIC DYKE (V6)
Dark green dyke. Stong (R4). Faint alteration (A1.5).

253.5 m: Fault, 0.5 mm FB infill. JRC = 13.

254 m: Fault, 1.5 mm FB infill. JRC = 13. Dip/dip direction = 69/327.

PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)
Light greenish-grey to grey. Strong (R4). Faint weathering (A1-A1.5).

255.5 m: Fault, 40 mm FG infill, R0.

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 5.5
D 7.5

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

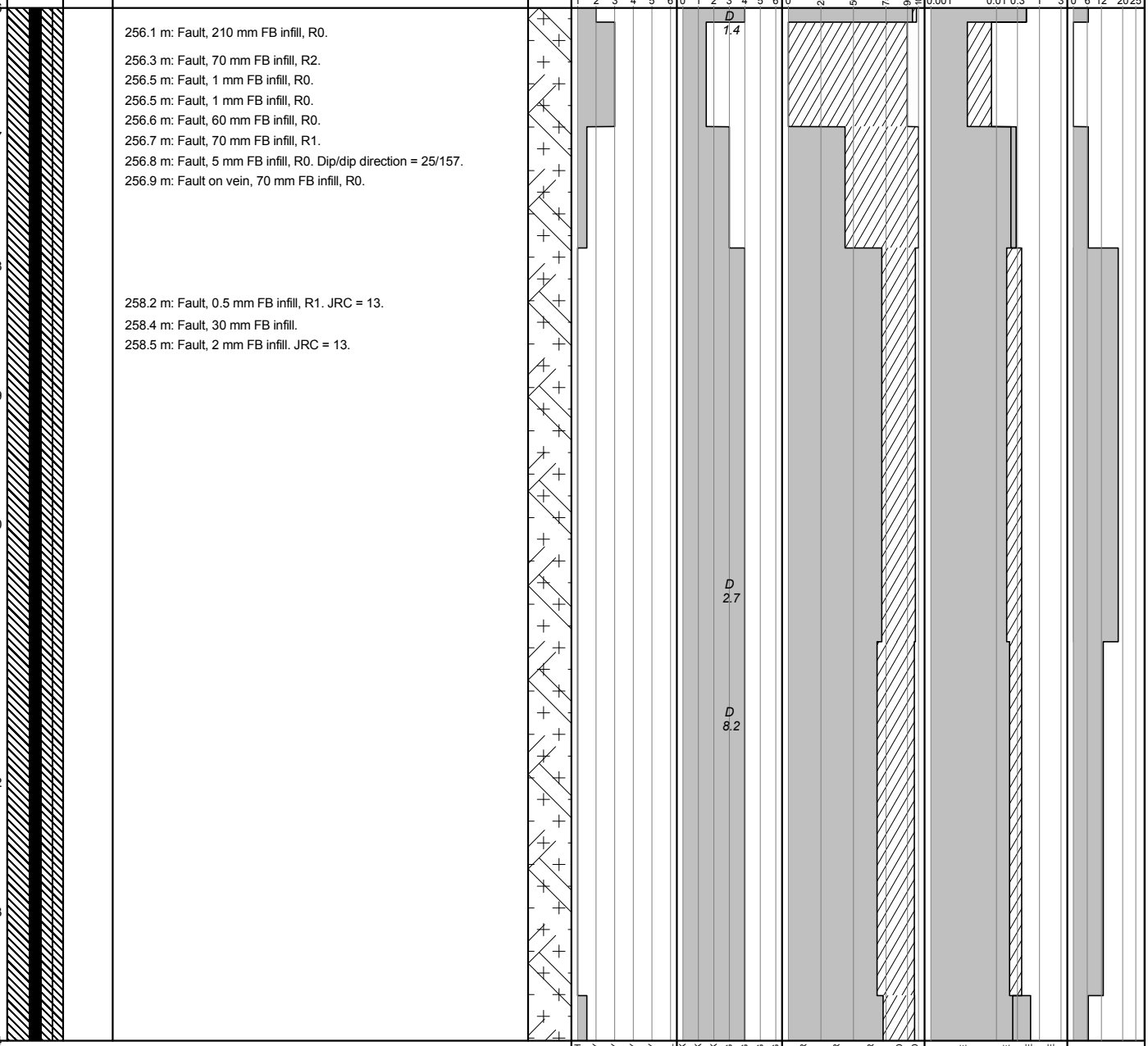
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
256			256.1 m: Fault, 210 mm FB infill, R0.
			256.3 m: Fault, 70 mm FB infill, R2.
			256.5 m: Fault, 1 mm FB infill, R0.
			256.5 m: Fault, 1 mm FB infill, R0.
			256.6 m: Fault, 60 mm FB infill, R0.
257			256.7 m: Fault, 70 mm FB infill, R1.
			256.8 m: Fault, 5 mm FB infill, R0. Dip/dip direction = 25/157.
			256.9 m: Fault on vein, 70 mm FB infill, R0.
258			258.2 m: Fault, 0.5 mm FB infill, R1. JRC = 13.
			258.4 m: Fault, 30 mm FB infill.
			258.5 m: Fault, 2 mm FB infill. JRC = 13.
259			
260			
261			
262			
263			
264			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

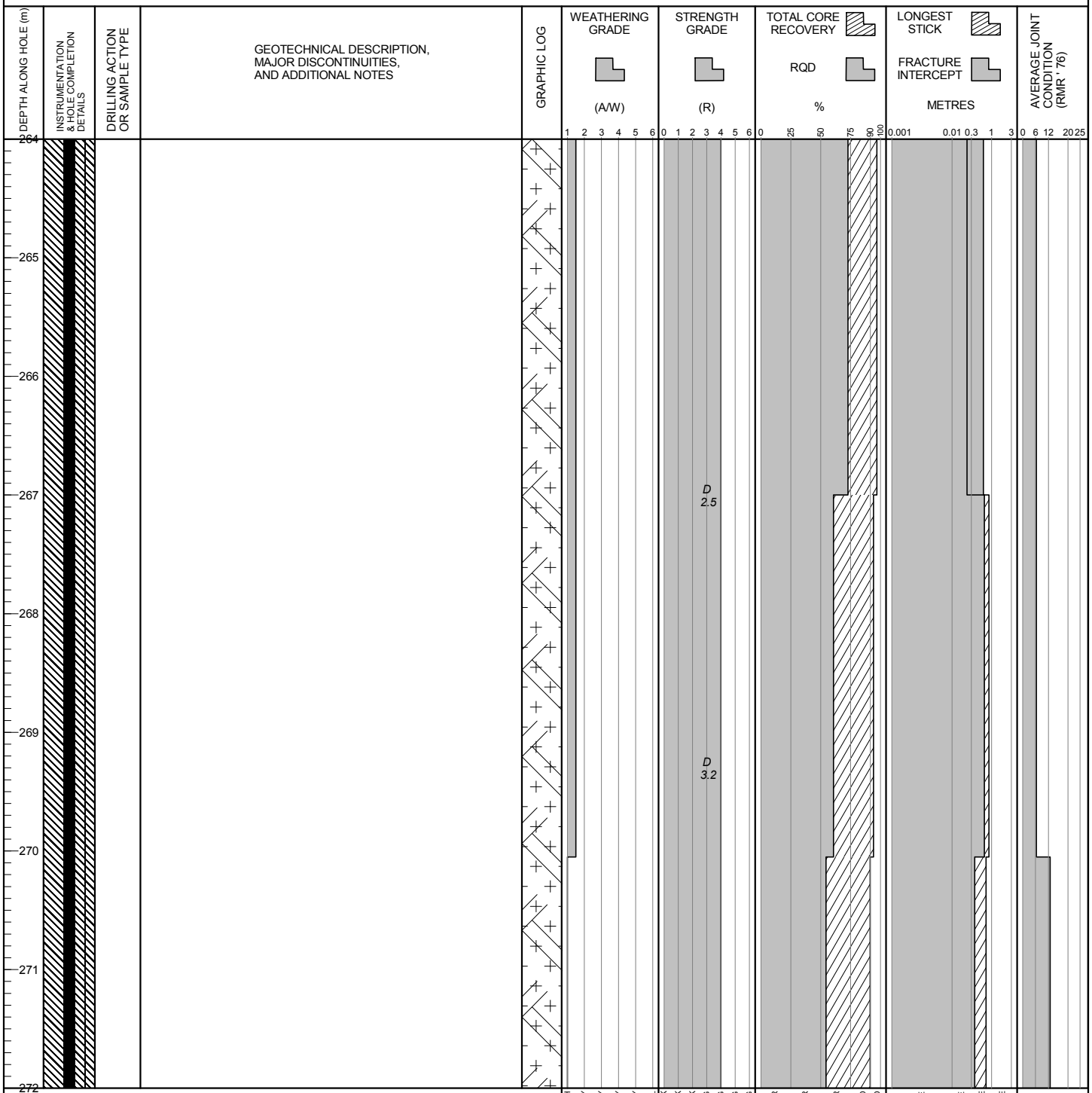
Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-21

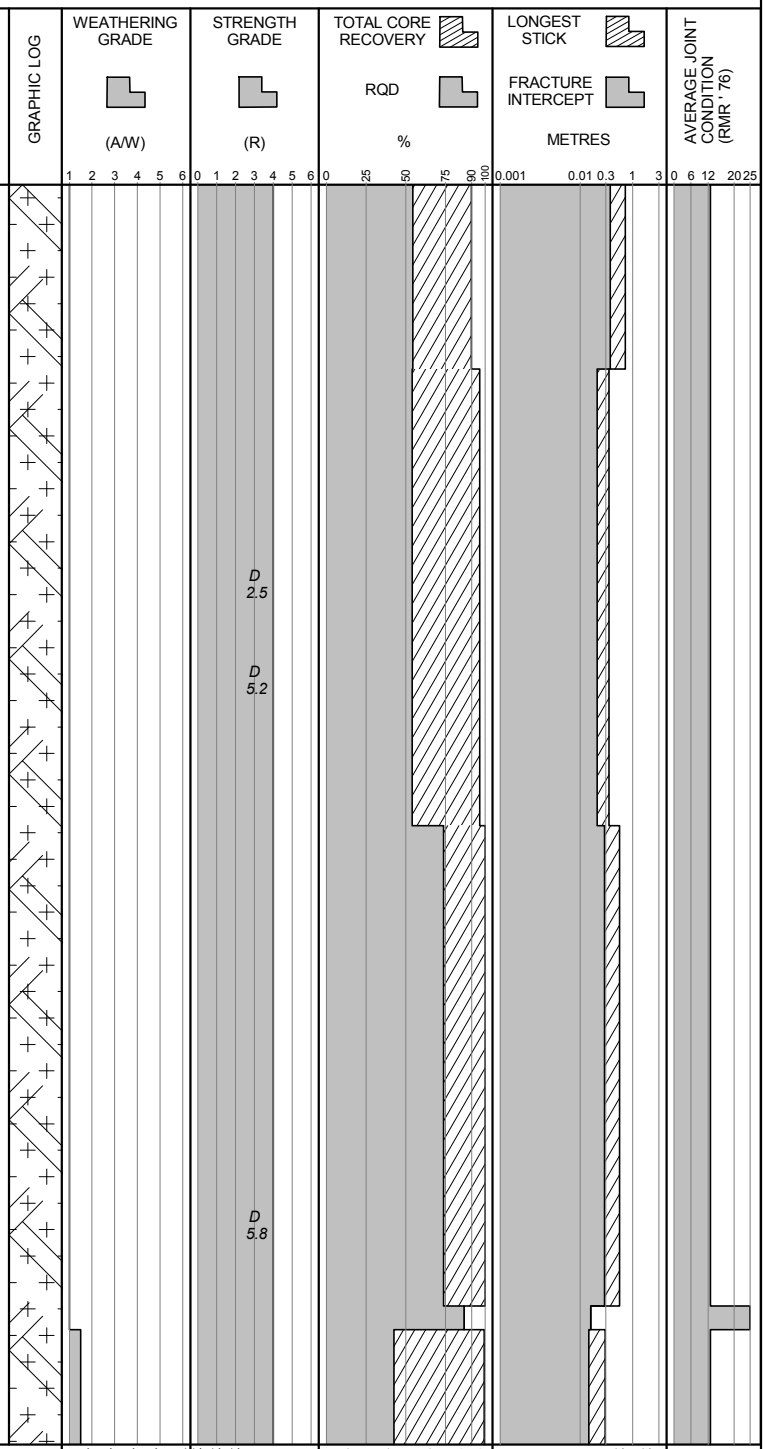
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
272			272.4 m: Fault, 500 mm FB infill, R3.
273			273.3 m: Fault, 1 mm FB infill, R3. JRC = 13.
			273.6 m: Fault, 10 mm FG infill, R2.
274			274.1 m: Fault, 11 mm FG infill, R2. JRC = 13.
275			
276			276.2 m: Fault, 10 mm FB infill. JRC = 13.
			276.4 m: Fault, 10 mm FB infill, R2. JRC = 13. Dip/dip direction = 50/040.
			276.6 m: Fault, 5 mm FB infill, R2. JRC = 13.
277			276.9 m: Fault, 50 mm FB infill, R2. JRC = 13. Dip/dip direction = 83/338.
278			
279			278.8 m: Fault, 10 mm FG infill, R2. JRC = 12. Dip/dip direction = 64/282.
280			



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D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

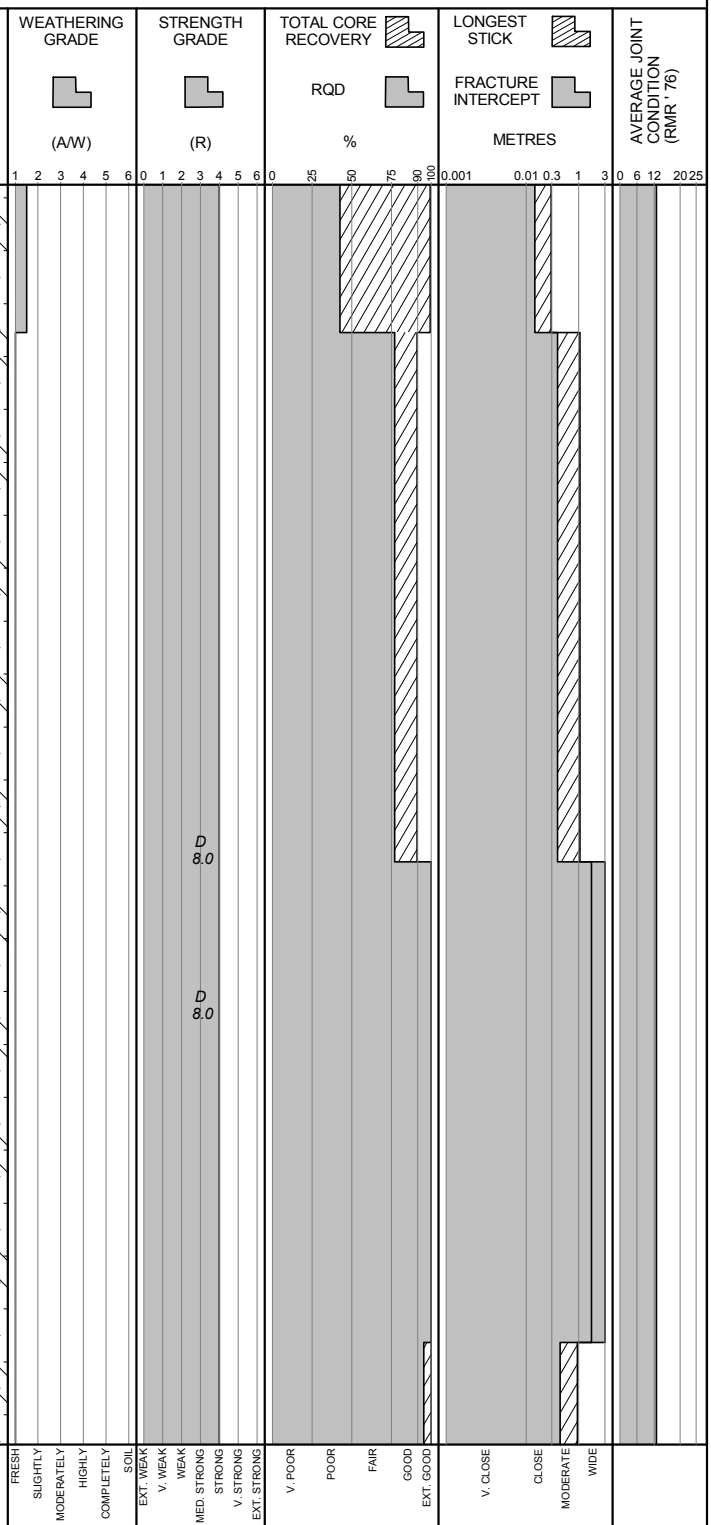
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
280			280.2 m: Fault, 60 mm FB infill, R3. JRC = 13. Dip/dip direction = 59/270.
281			
282			
283			
284			
285			
286			
287			
288			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

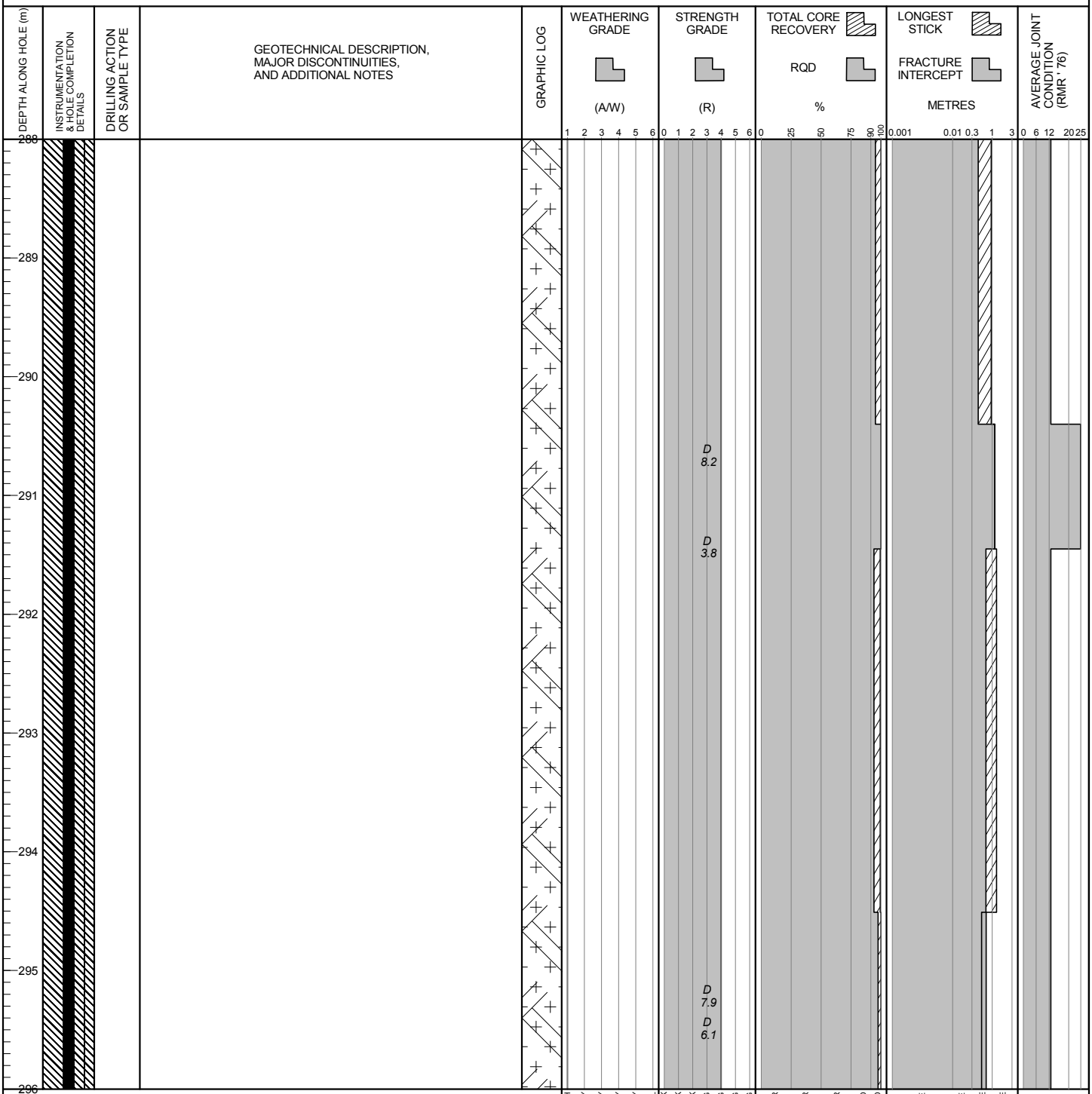
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

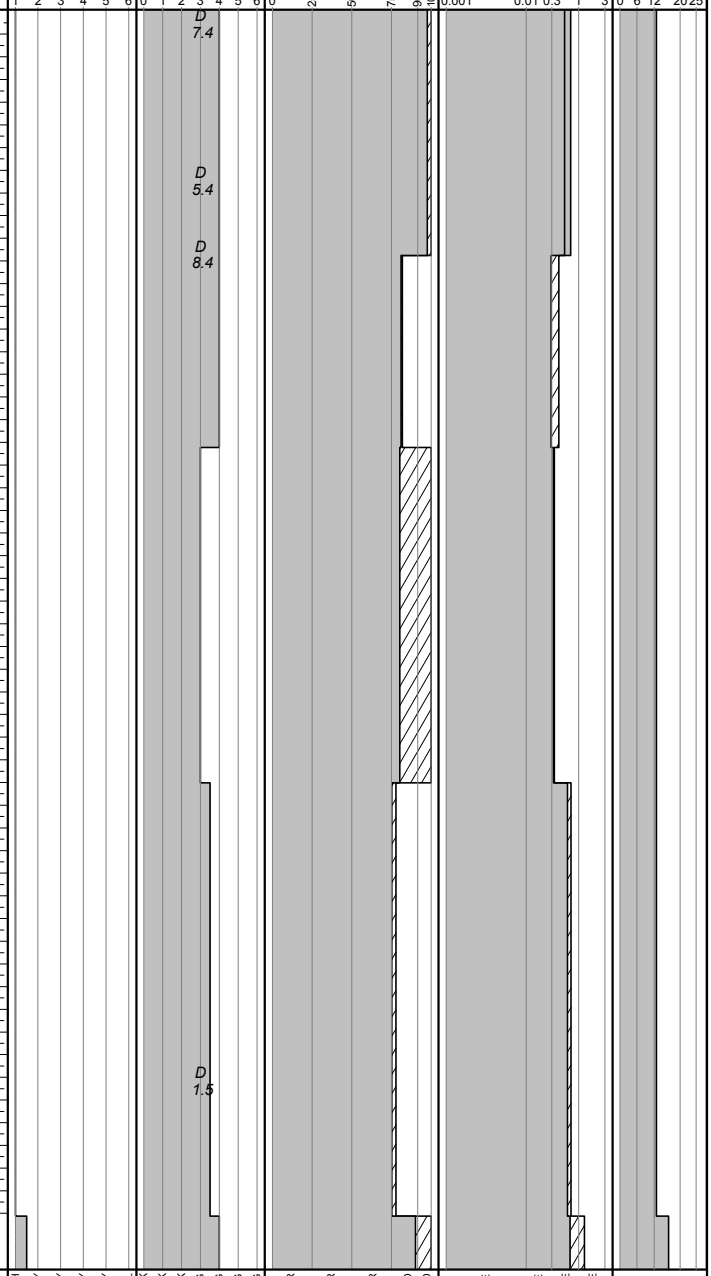
DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

296
297
298
299
300
301
302
303
304

PELITE (S5)
Light greenish-grey, silty to sandy concretion bearing sedimentary rock. Medium strong to strong (R3-R4). Fresh (A1).

302 m: Fault, 70 mm FB infill, R4. JRC = 13. Dip/dip direction = 81/316.

MAFIC DYKE (V6)
Green dyke with lower margin at 35 degrees TCA. Strong (R4). Faint alteration (A1.5).



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

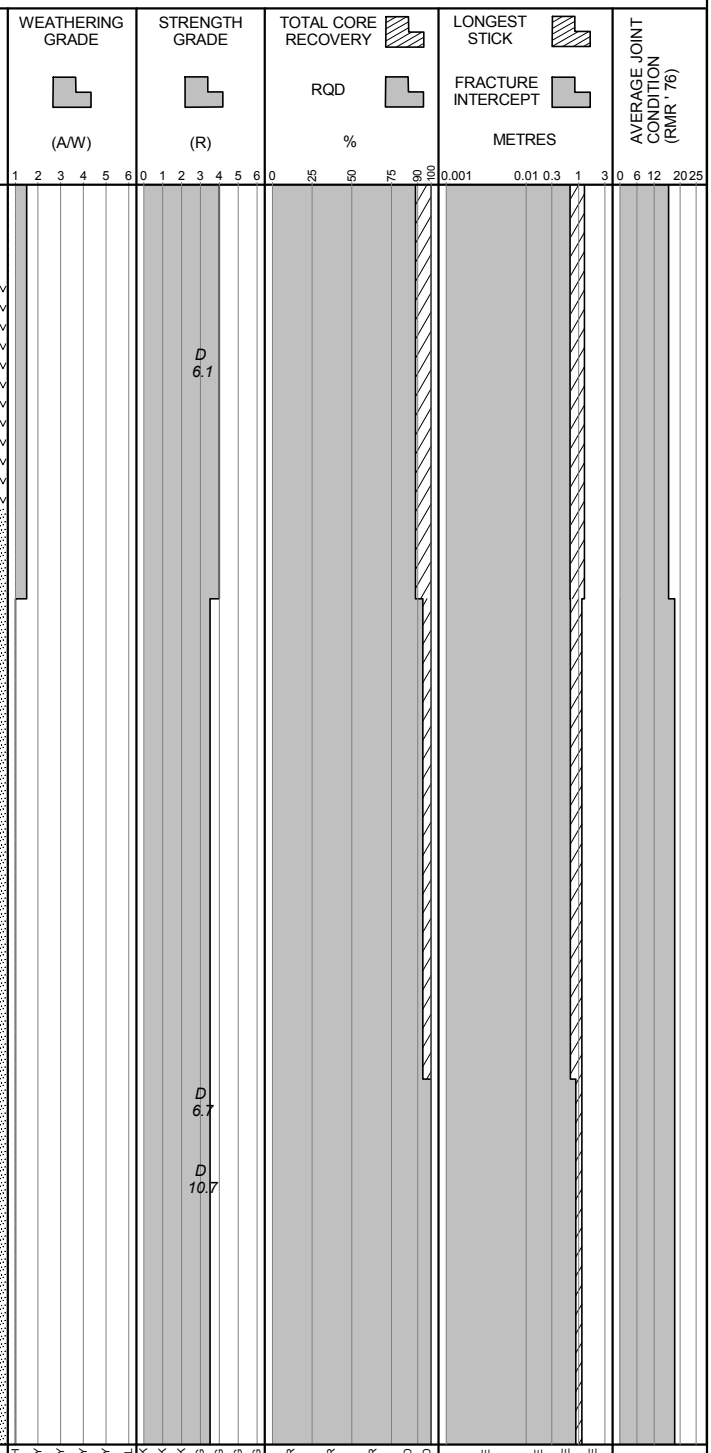
Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
304			
			STOCKWORK (H7) Greyish-white. Strong (R4). Faint alteration (A1.5).
305			
306			ARENITE (S4) Light greenish-grey, interbedded silts and fine sands, well sorted. Medium strong to very strong (R3-R4.5). Fresh (A1). 306.1 m: Shear, 0.5 mm CX infill. JRC = 13.
307			307.1 - 309.0 m: Stockwork veining.
308			308.6 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 13.
309			
310			
311			311.4 - 312.7 m: Stockwork quartz-carbonate veining.
312			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
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Logged By: HKM/JND/LL
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POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
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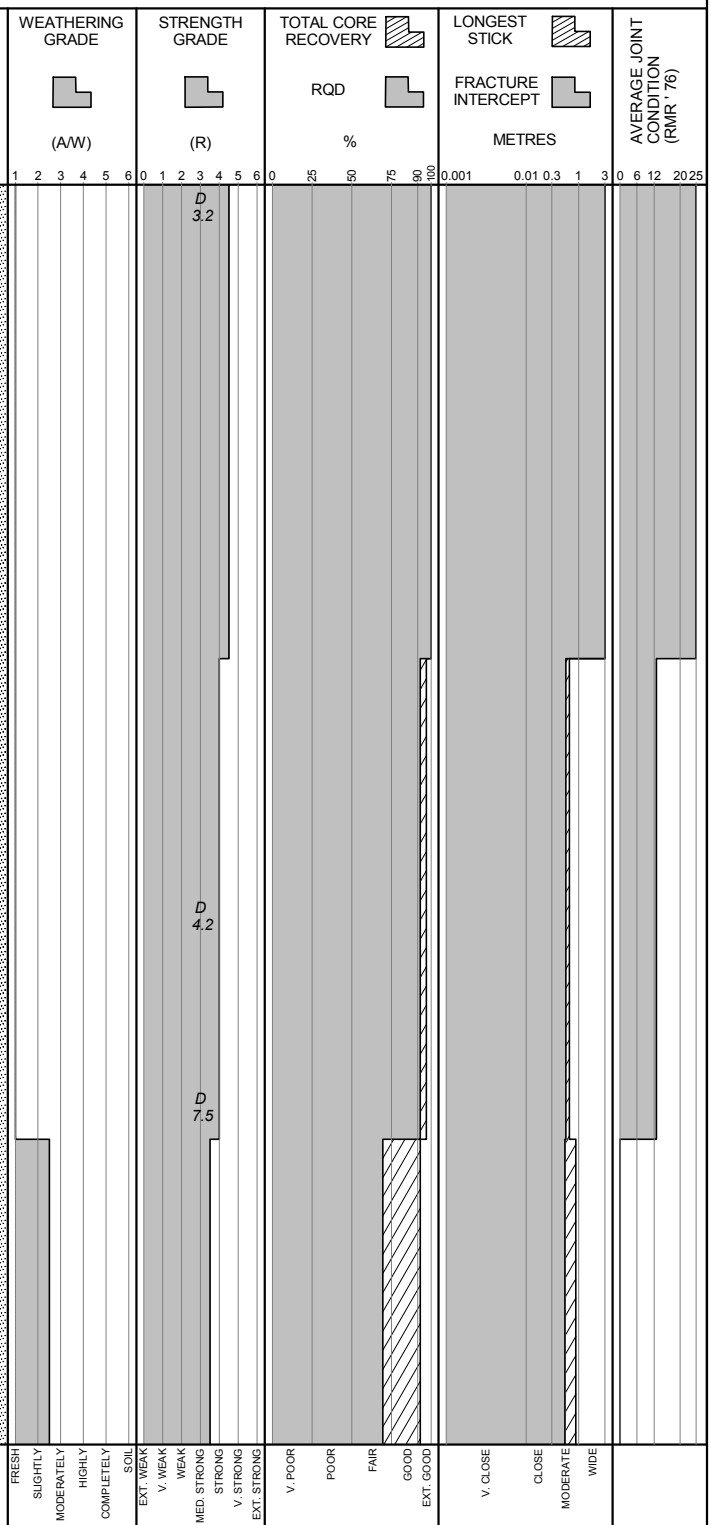
DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
328			
329			
330			330.0 - 333.49 m: Stockwork veining.
331			Constant head test from 331 - 349.3 m. Estimated hydraulic conductivity is 3.8E-08 m/s.
332			
333			
334			
335			335.2 m: Fault, 30 mm FB infill, R3. JRC = 13.
336			



POINT LOAD TESTS
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AN APPLIED EARTH SCIENCES COMPANY

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Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
336			336.1 m: Fault, 50 mm FB infill, R2. JRC = 20.			D 0.3			
337			336.9 m: Fault, 40 mm FG infill, R0. JRC = 20. Dip/dip direction = 80/293.						
338									
339									
340									
341						D 4.6			
342									
343									
344									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

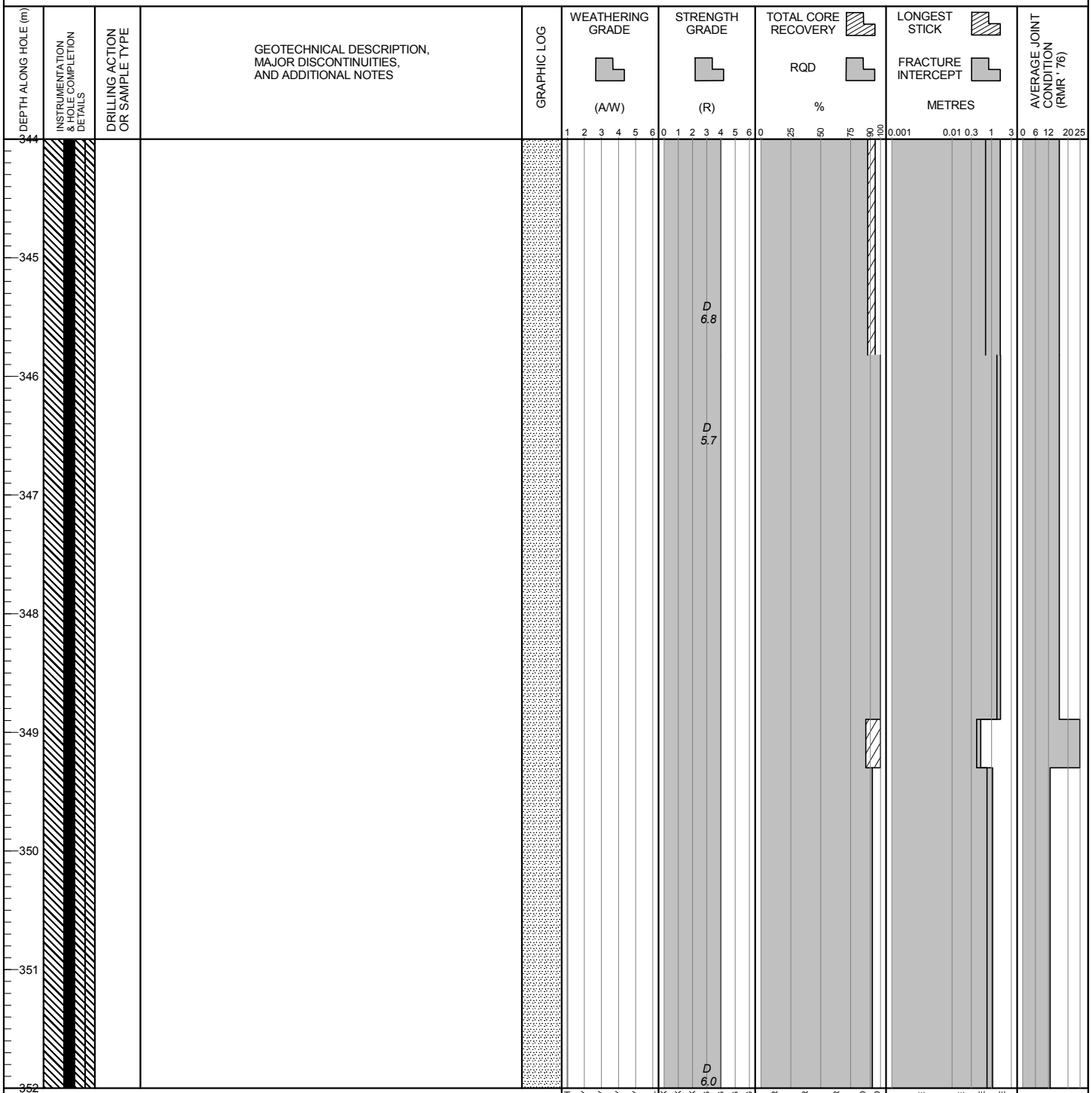
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

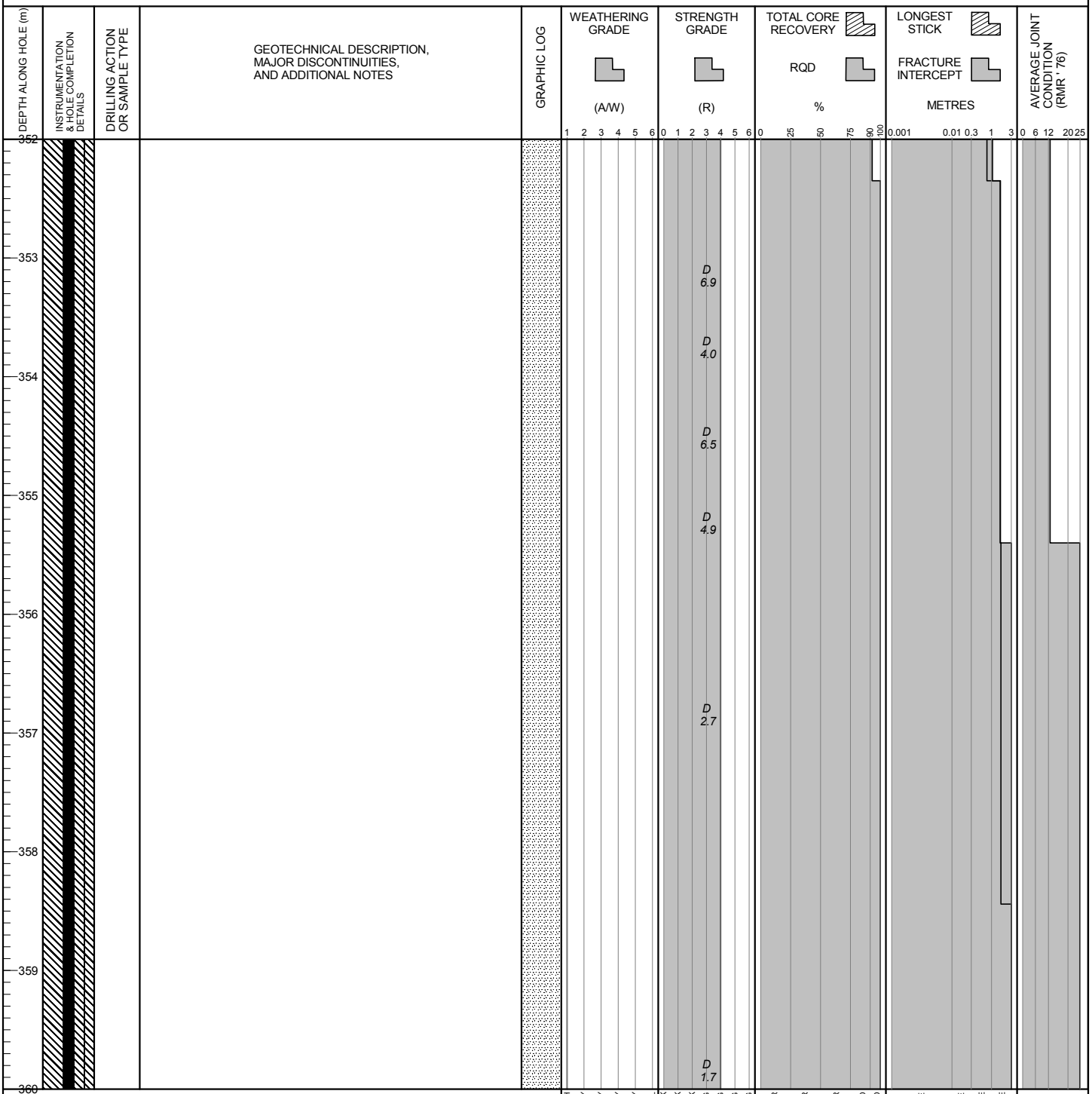
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
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BGC ENGINEERING INC.
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DRILL HOLE # DH-BGC12-21

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Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
360									
361									
362									
363						D 7.1			
364									
			364.5 - 378.7 m: Stockwork veining.						
365									
366									
367									
368									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

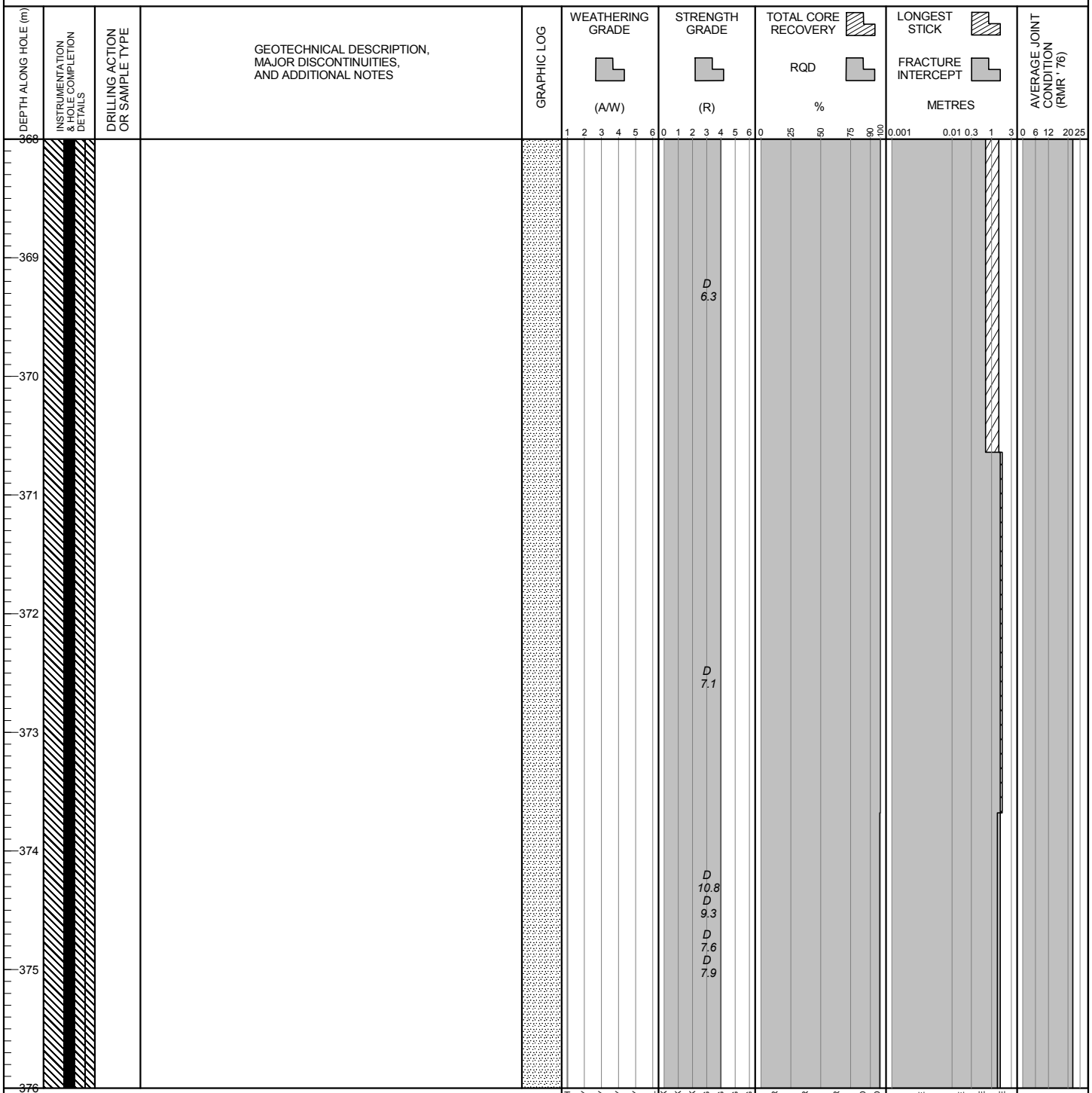
DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

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Project No.1008-007

DRILL HOLE # DH-BGC12-21

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Co-ordinates (m): 426,406E - 6,258,223N
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Datum: UTM NAD 83 Zone 9
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Drilling Contractor: Radius
Drill Method: Diamond
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Start Date: 28 Mar 12
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DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

376
377
378
379
380
381
382
383
384

PELITE (S5)
Light greenish-grey, interbedded fine sands and silts, sericite altered, concretions in silty sections. Strong (R4). Fresh (A1).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

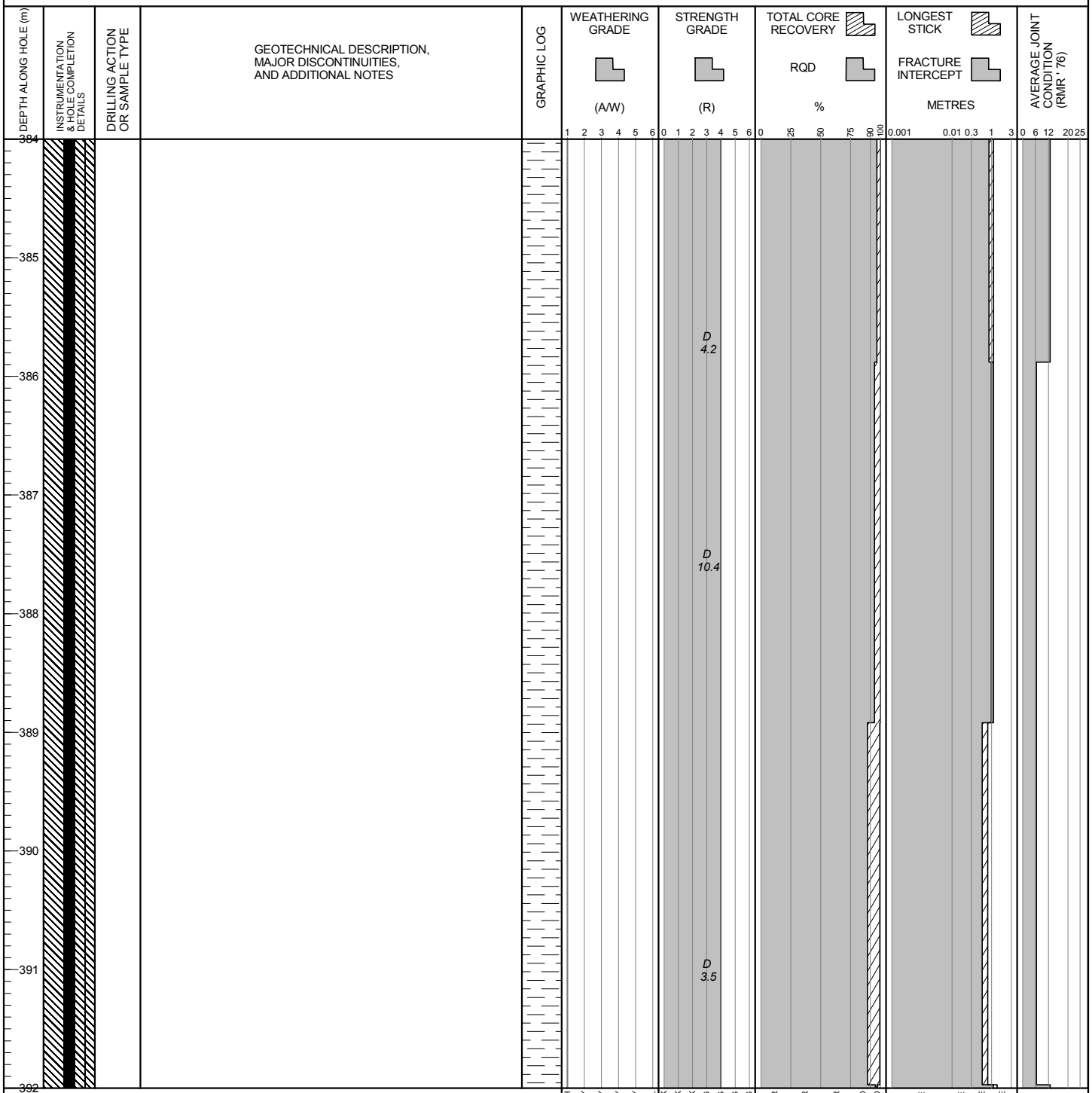
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
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Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
392					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
393									
394									
395						D 4.2			
396			396.3 - 403.2 m: Stockwork veining.						
397									
398						D 6.5			
399									
400									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
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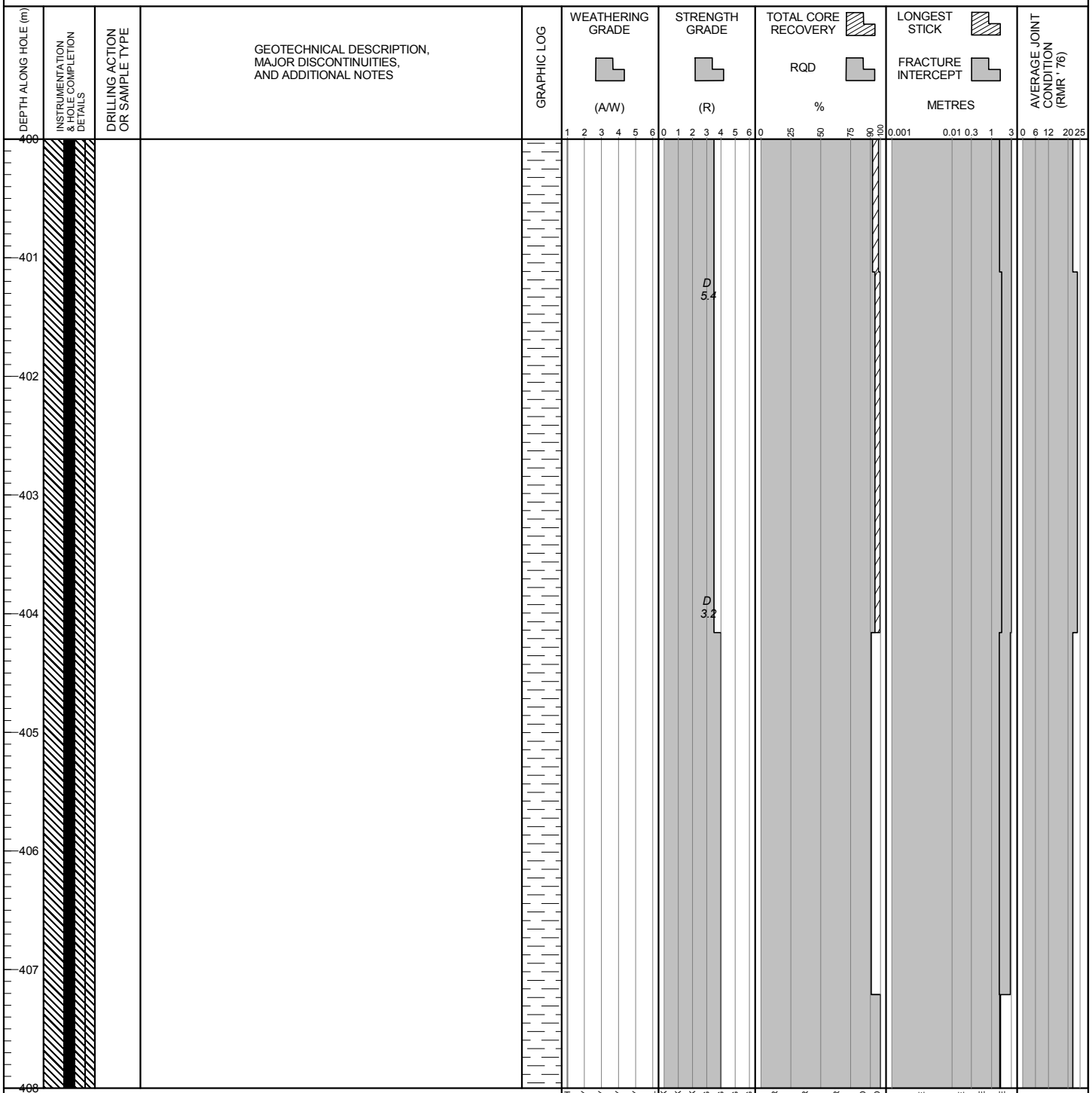
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
408						D 10.0			
409									
410			409.9 - 412.2 m: Stockwork veining.						
411						D 5.6			
412			412.2 m: Rock becomes very foliated with light green, fine grained and elongate dark grey fragments.						
413									
414									
415									
416									

Weathering grade scale: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade scale: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD: 0, 25, 50, 75, 90, 100 %
Longest stick / fracture intercept: 0.001, 0.01, 0.3, 1, 3 m
Average joint condition: 0, 6, 12, 20, 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
416						D 6.5			
417						D 10.7			
						D 4.8			
418									
419						D 5.4			
420									
421									
422									
423						D 1.6			
			Arenite (S4) Light greenish-grey, silty sand to fine grained sandstone. Strong (R3.5-R4.5). Fresh (A1).						
424									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

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DRILL HOLE # DH-BGC12-21

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Datum: UTM NAD 83 Zone 9
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Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
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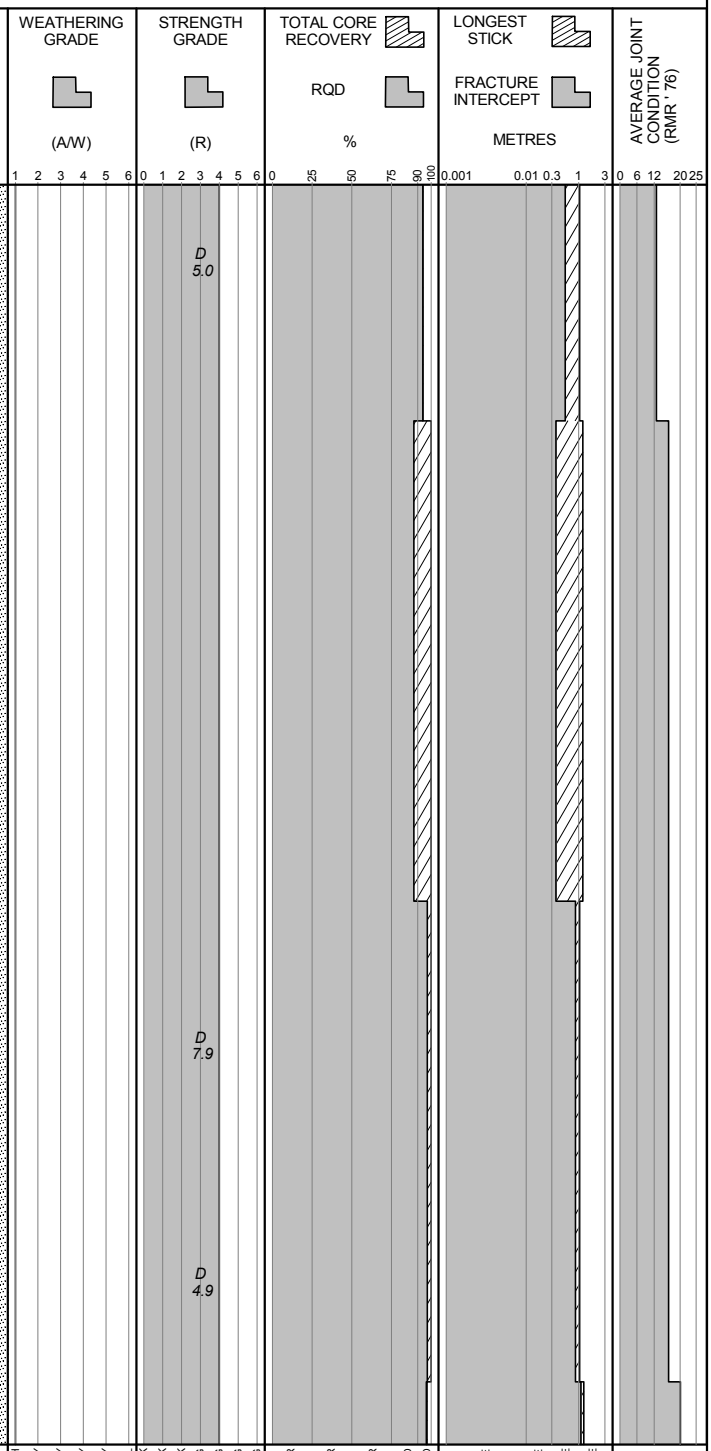
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
424			424.3 m: Fault, 20 mm FG infill, R2. JRC = 12. Dip/dip direction = 22/223.
425			
426			
427			427.5 m: Fault, 20 mm FB infill, R3. JRC = 12. Dip/dip direction = 28/211.
			427.8 m: Fault, 30 mm FB infill, R3. JRC = 12.
428			
429			429.7 - 433.1 m: Stockwork veining.
430			
431			
432			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

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432									
433			433.1 m: Sparse 0.5-2.5 cm clasts amongst finely lamininated sands.						
434						D 10.6			
435									
436									
437									
438						D 6.1			
						D 7.0			
439									
						D 8.2			
440									

Weathering grade scale: 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL)
Strength grade scale: 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG)
Total core recovery / RQD: 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD)
Longest stick / fracture intercept: 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE)
Average joint condition (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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AN APPLIED EARTH SCIENCES COMPANY

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DRILL HOLE # DH-BGC12-21

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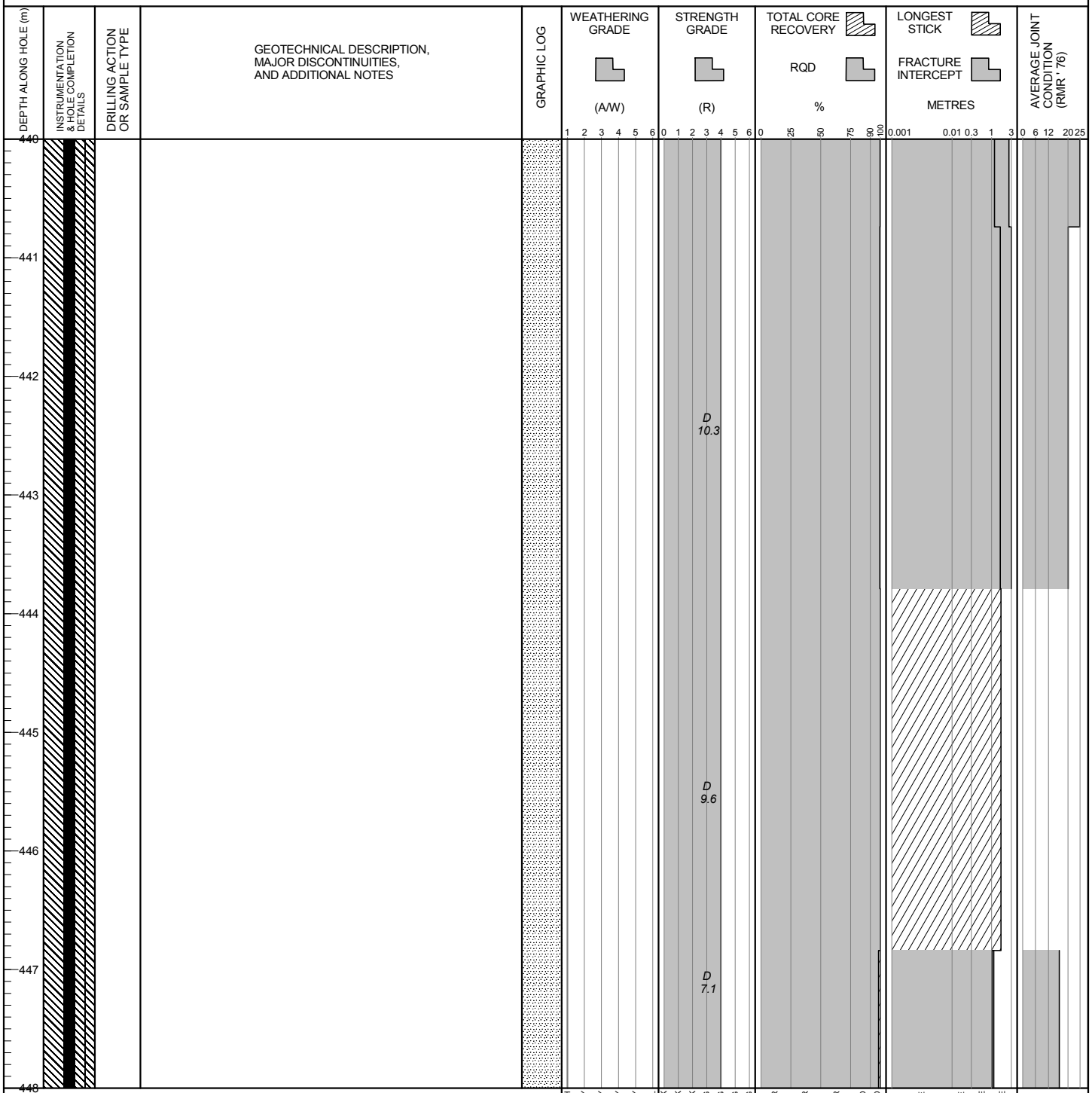

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

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DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
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Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

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Fluid: Polymer
Cased To (m) : 1.8

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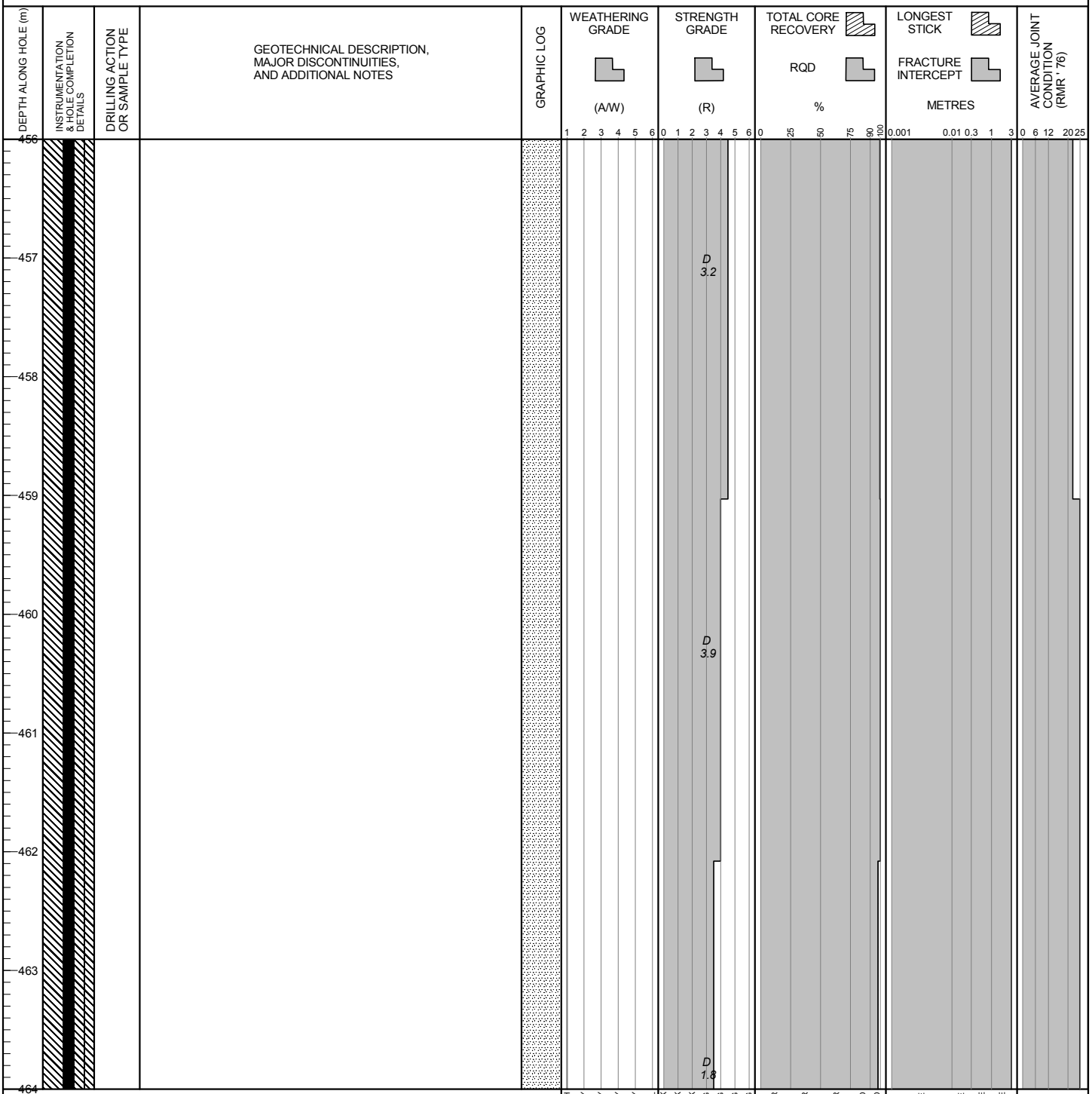

POINT LOAD TESTS
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464					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
465						D 6.6 D 5.1			
466						D 7.1 D 6.6			
467						D 6.7			
468									
469									
470						D 8.5			
471									
472									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

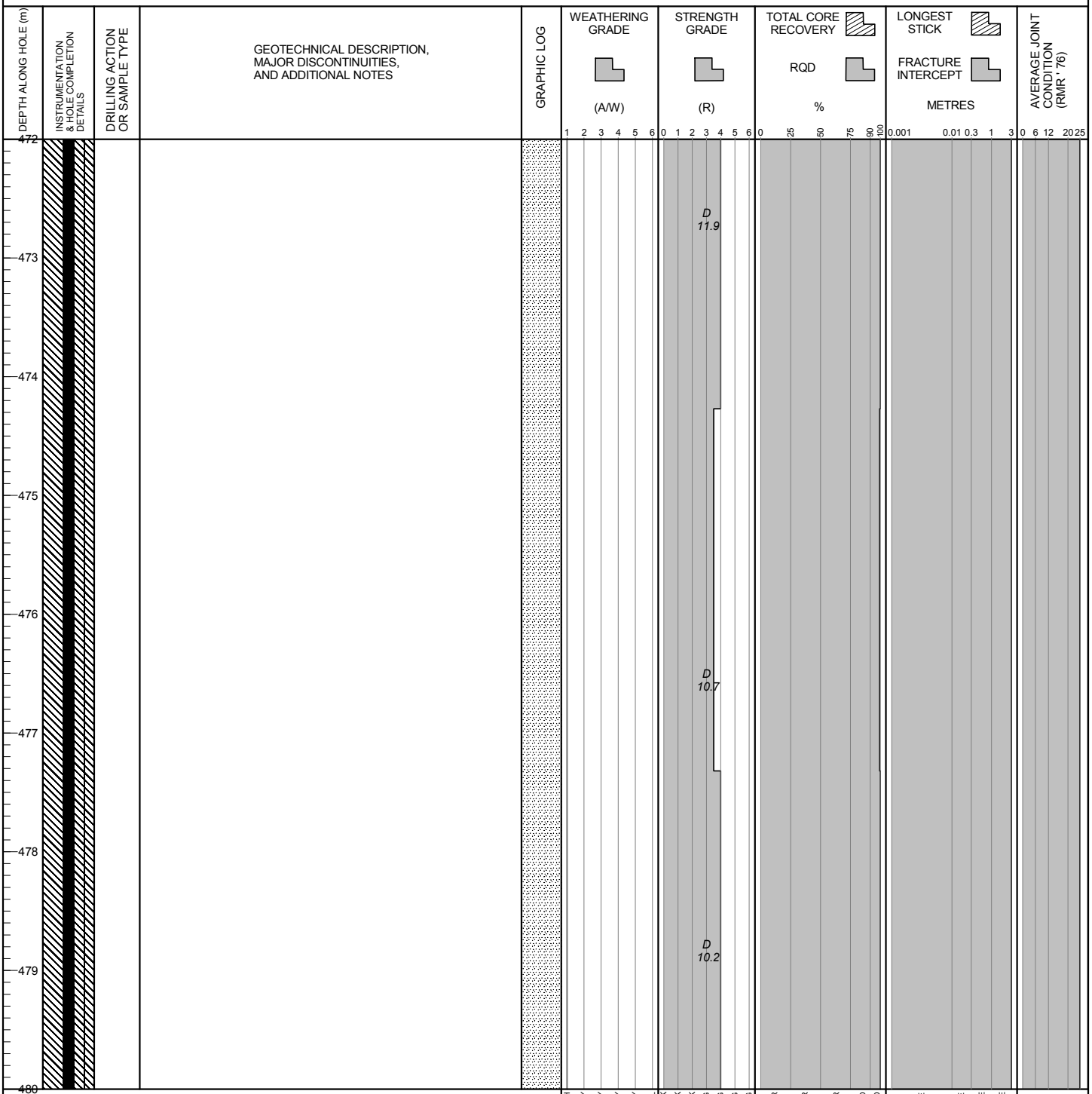
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

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Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
480									
481									
482			482.4 - 490.5 m: Multiphase veining with web-like mineralized veining.						
483									
484									
485						D 8.6			
486						D 3.8			
487									
488									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
488									
489									
490			490.5 m: Sandstone is fine to medium grained with no bedding or laminations.			D 10.3			
491									
492						D 5.5			
493									
494									
495									
496									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-21

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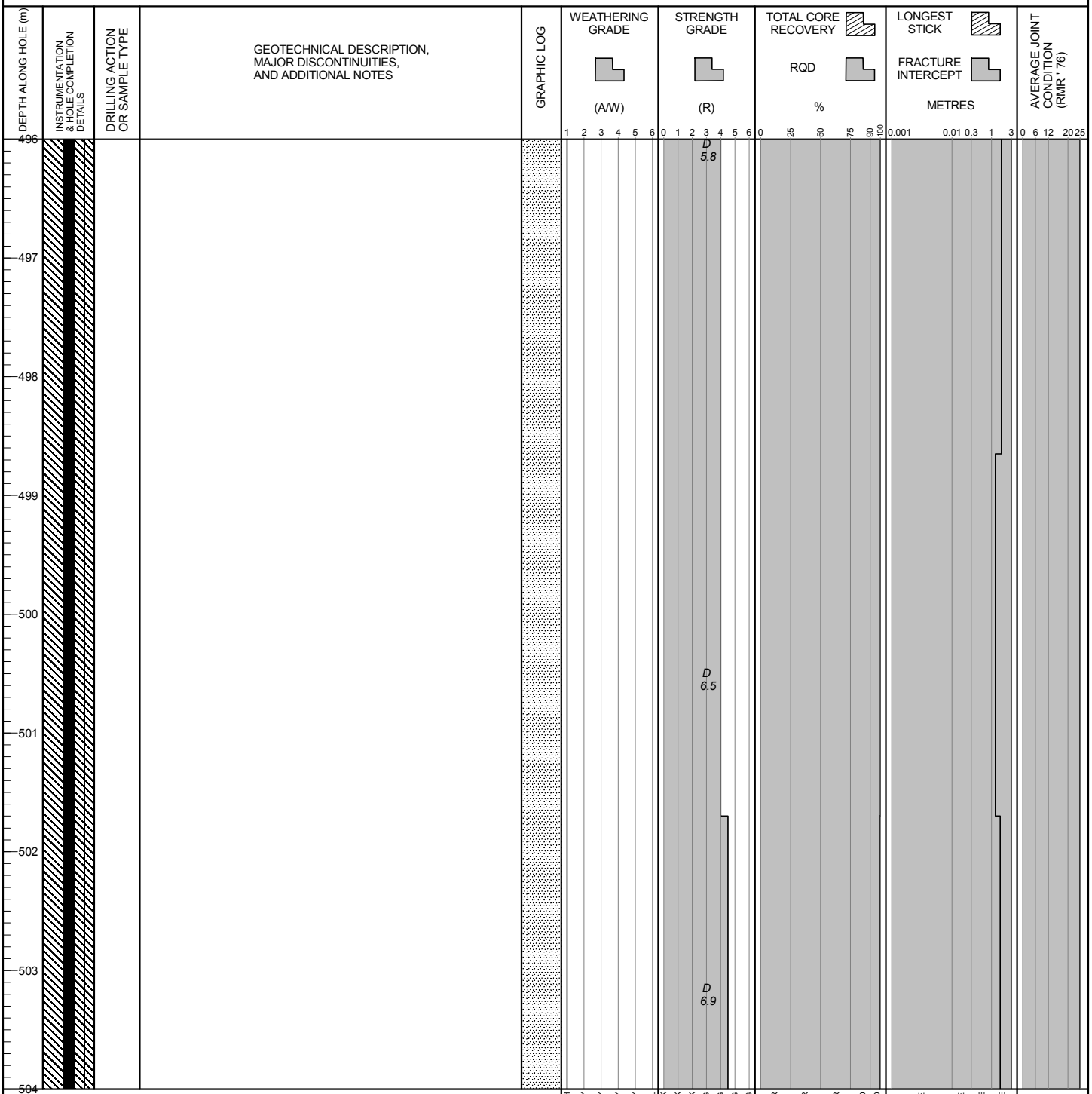


POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

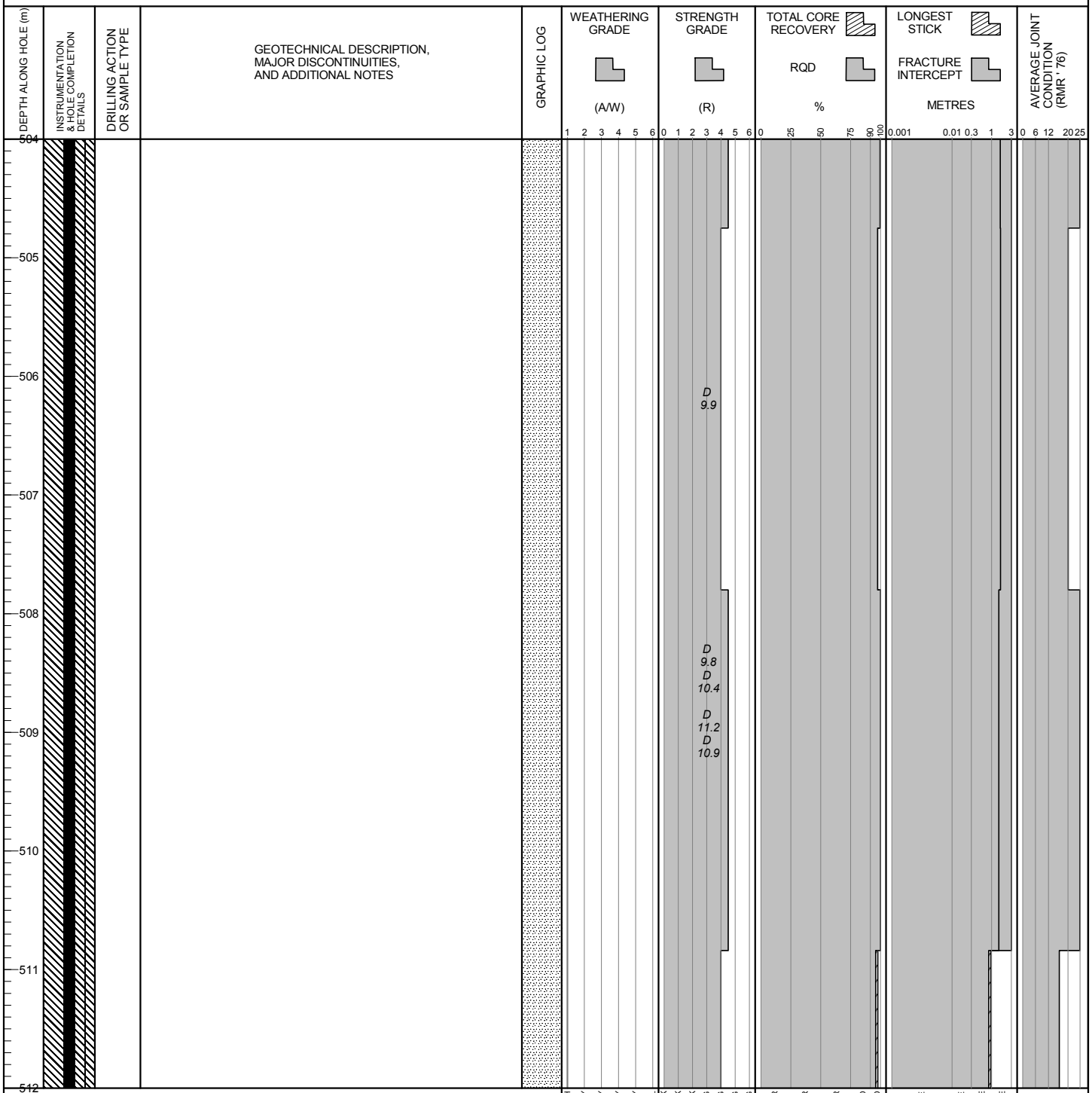
Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

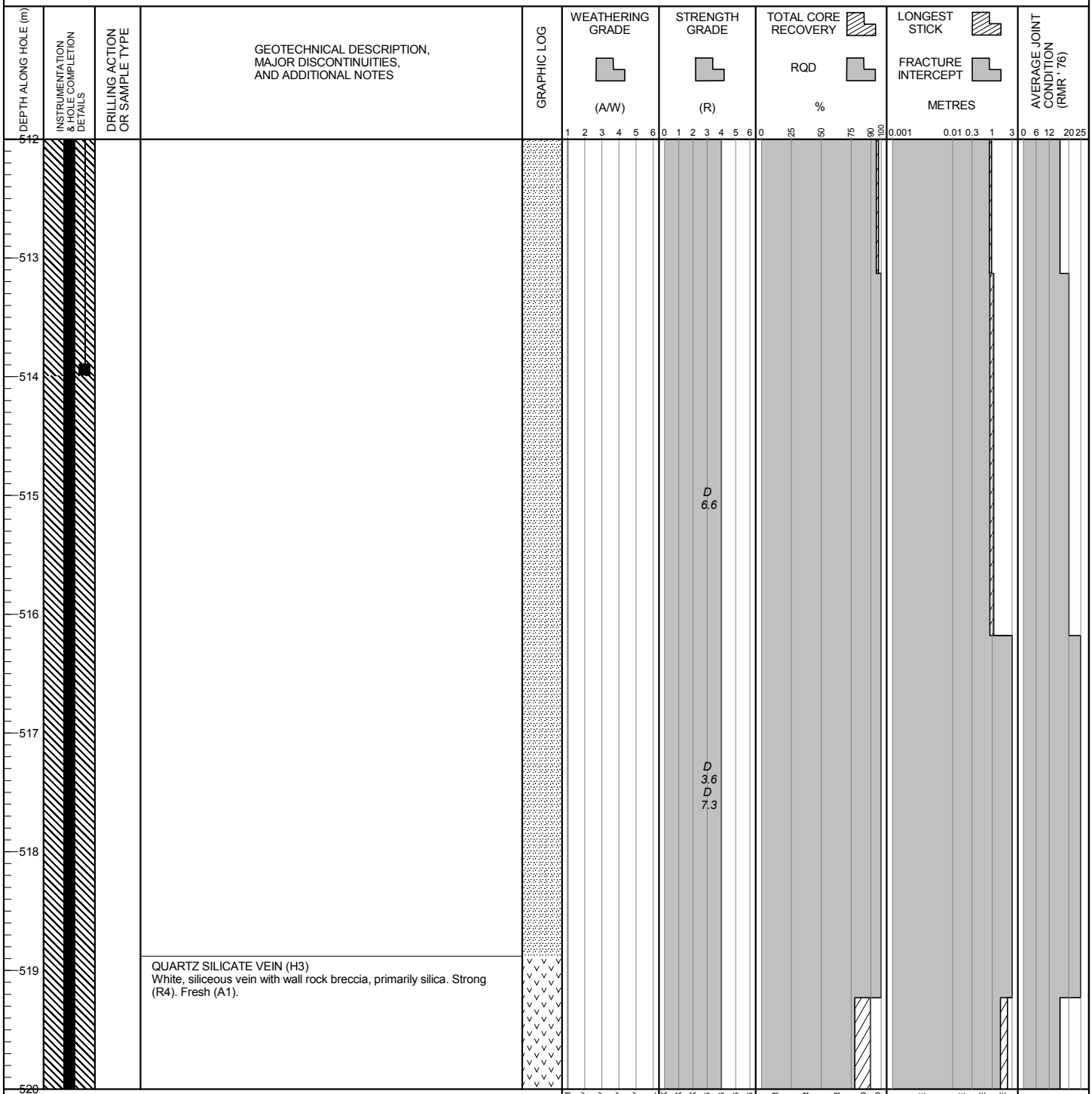
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N	**Drill Designation:** Heliportable	**Start Date:** 28 Mar 12
Ground Elevation (m): 1,499.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Apr 12
Survey Method: Hand Held GPS	**Drill Method:** Diamond	**Final Depth (m):** 556.6
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** HKM/JND/LL
Trend (°): 145	**Cased To (m) :** 1.8	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
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Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
520			ARENITE (S4) Light grey to light greenish-grey, fairly well sorted, fine to very fine grained sandstone. Strong (R4). Fresh (A1).			D 10.2			
521									
522									
523									
524						D 6.8			
525									
526						D 6.9			
527									
528									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
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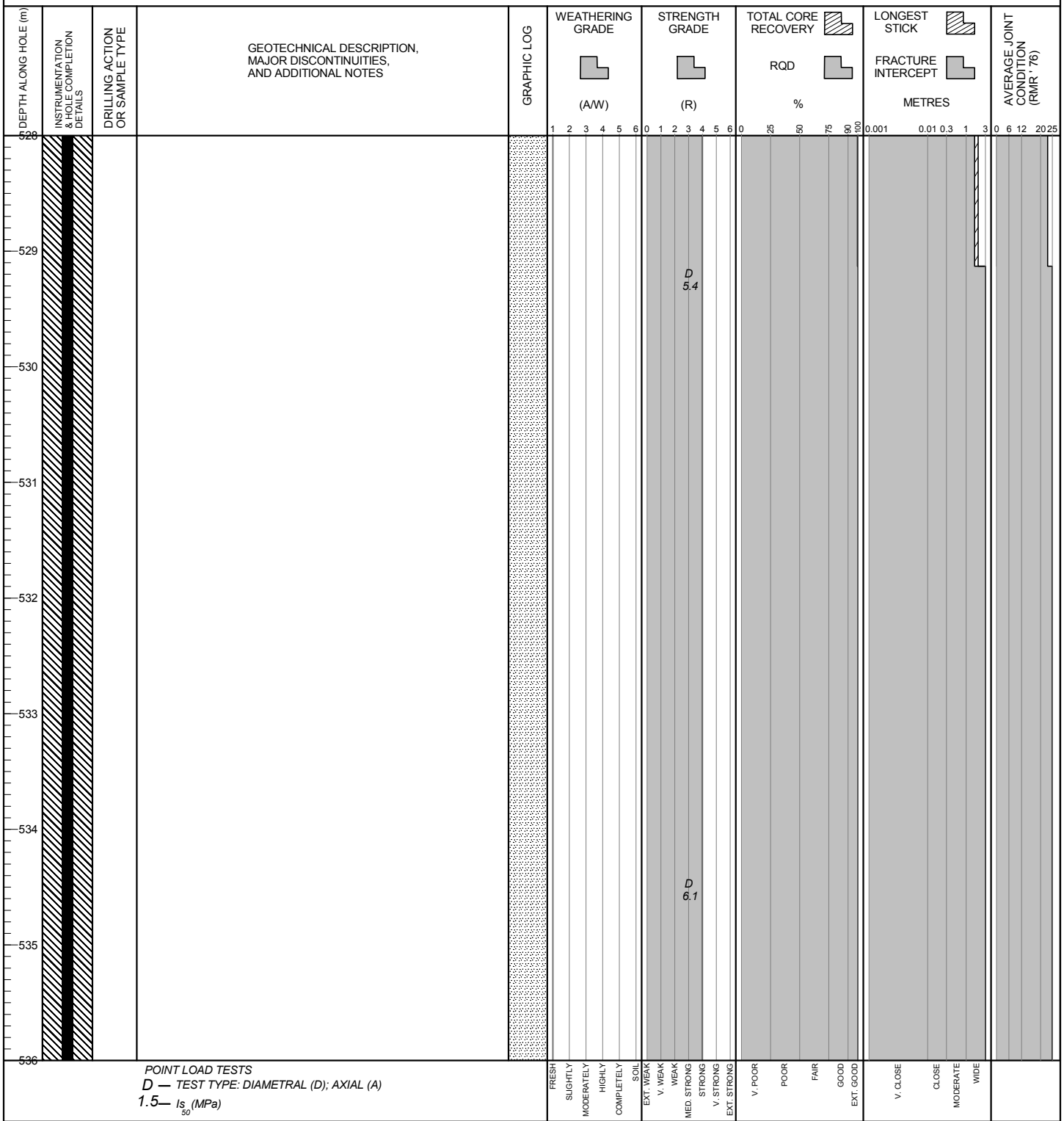

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
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Drill Designation: Heliportable
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
536									
537						D 4.1			
538									
539									
540									
541						D 8.0			
542									
543			543.1 - 547.7 m: Stockwork veining, lower portion contains silicate flooding around wall rock fragments.			D 4.9 D 5.3			
544									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-21

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
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Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
544					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
545						D 3.4 D 4.3			
546									
547						D 6.5			
548									
549									
550						D 4.7			
551									
552									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-21

Location: Valley of Kings Zone

Co-ordinates (m): 426,406E - 6,258,223N
Ground Elevation (m): 1,499.0
Survey Method: Hand Held GPS
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 145

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Mar 12
Finish Date: 09 Apr 12
Final Depth (m): 556.6
Depth To Top Of Rock (m): 1.8
Logged By: HKM/JND/LL
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
552					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
553						D 3.4			
554									
555						D 4.1			
556									
557			END OF DRILLHOLE AT 566.6 m Notes: 1. Two vibrating wire piezometers installed at 251.8 m and 513.9 m.						
558									
559									
560									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN AND WEATHERED ROCK Very poor recovery.
1						
2						
						Rock encountered at 2.3 m depth. Refer to DH-BGC12-22 rock log.
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

BRUCEJACK (SOIL) BRUCEJACK_SOIL.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
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Cased To (m) : 2.3

Start Date: 11 Apr 12
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Final Depth (m): 585.8
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Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-22 Overburden Log						
1									
2									
3			CONGLOMERATE (S3) Medium to light grey, subrounded clasts up to 5 cm in width, selective clasts look to be stretched and elongated. Medium strong to strong (R3-R4.5). Faint alteration (A1-A1.5) on major discontinuities.			D 4.0			
4									
5						D 3.7			
6									
7			7.2 m: Fault, 20 mm FB/FG infill, R2. JRC = 12.			D 4.2			
8									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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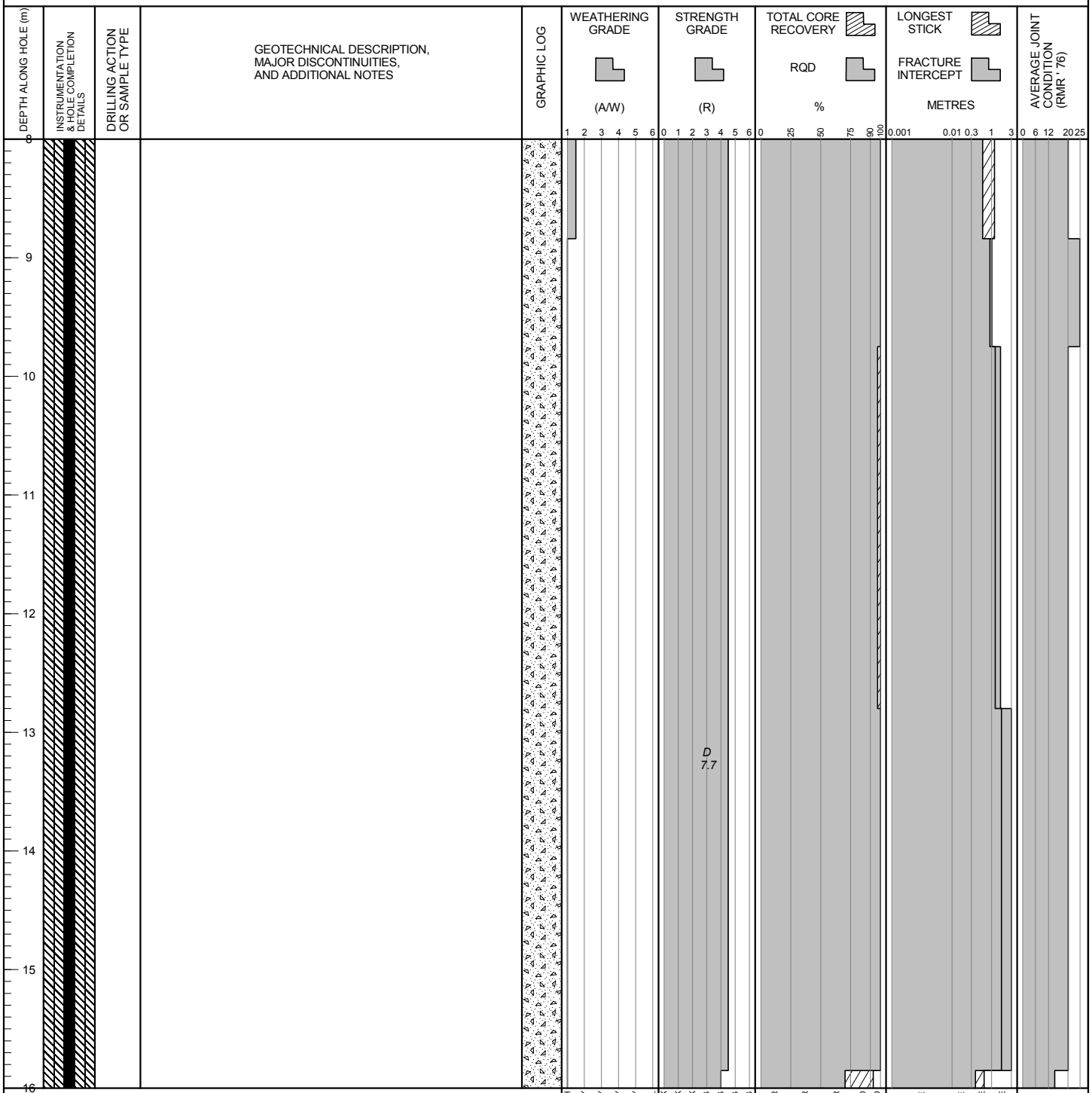


POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

16
17
18
19
20
21
22
23
24

FAULT ZONE
Contained within in the pebble conglomerate unit, orientation is variable from 40 to 70 degrees TCA based on gouge orientation. Medium strong to strong (R3-R4). Faint alteration (A1-A1.5) on major discontinuities.

17.4 m: Fault, 50 mm FB/FG infill, R2. JRC = 15.

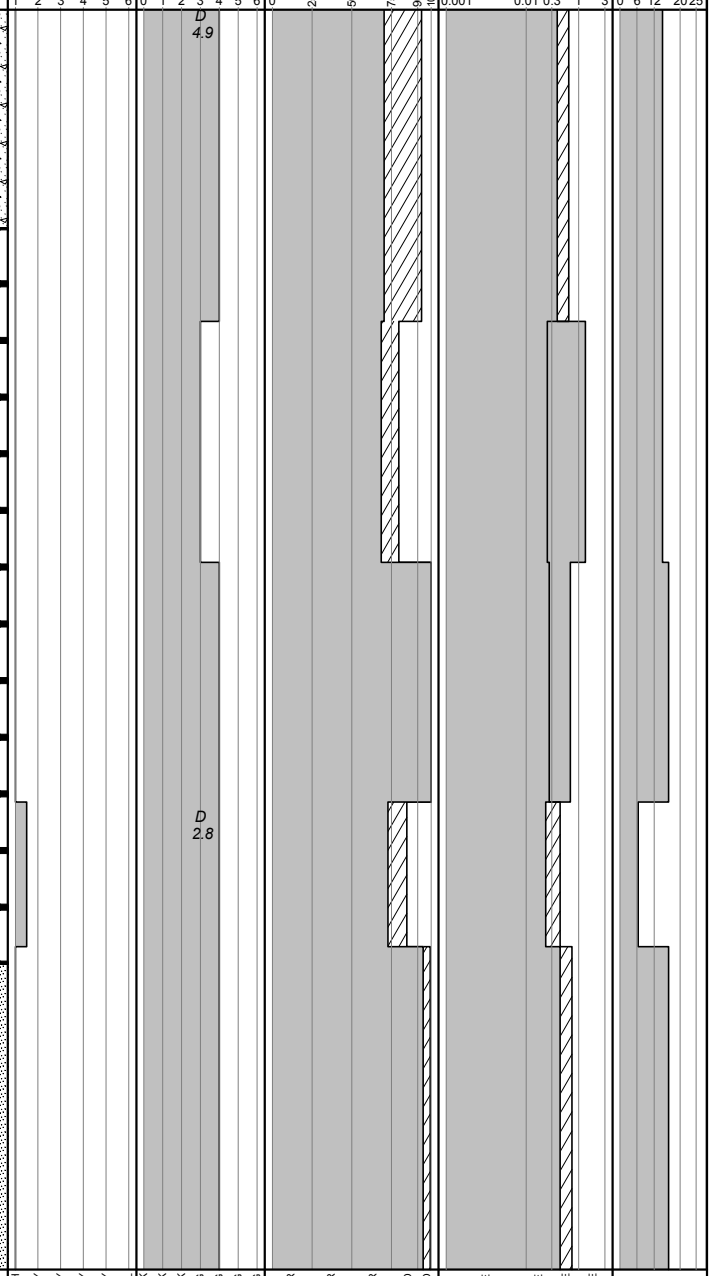
17.5 m: Fault, 20 mm FB/FG infill, R2. JRC = 15.

17.8 m: Fault, 600 mm FB/FG infill, R2. JRC = 8.

20.9 m: Fault, 130 mm FB/FG infill, R2. JRC = 13.

21.9 m: Fault, 50 mm FB infill, R2.

ARENITE (S4)
Medium to light grey, coarse grained sandstone with pebble sized clasts present, very weakly bedded, contains rare quartz fragments up to 5 cm. Medium strong to very strong (R3.5-R4.5). Faint alteration (A1-A1.5) to 61.6 m. Fresh (A1) below 61.6 m.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY RQD %	LONGEST STICK FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24						D 3.7			
25						D 8.0 D 2.7			
26						D 4.8			
27						D 4.3			
28									
29									
30			29.9 m: Fault, 3 mm FB infill, R2. JRC = 12. Dip/dip direction = 62/223.						
31			30.9 m: Fault, 5 mm FB infill, R2. JRC = 15. Dip/dip direction = 90/242. 31 m: Fault, 30 mm FB infill, R2.						
32									

WEATHERING GRADE: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
32			32.5 m: Fault, 160 mm BX infill, R2.						
33						D 6.4			
34									
35						D 3.1			
36									
37									
38									
39									
40						D 9.6 D 6.2			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
40					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
41									
42						D 2.9			
43									
44									
45									
46						D 7.0 D 5.8			
47						D 7.8			
48						D 3.3			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
48									
49									
50						D 7.5			
51			Constant head test from 50.9 - 61.6 m. Estimated hydraulic conductivity is 1.9E-08 m/s.						
52									
53						D 2.6			
54			53.9 m: Fault, 15 mm FB/FG infill, R2. 53.9 - 54.2 m: Fault containing chunks of a quartz-calcite vein up to 5 cm wide, oriented 70 degrees TCA. 54 m: Fault, 2 mm FB/FG infill, 2. JRC = 20. 54 m: Fault, 30 mm BX/FB infill, R3. 54.2 m: Fault, 20 mm FB/FG infill, R2. JRC = 13. Dip/dip direction = 45/191. 54.3 m: Fault, 50 mm FB/FG infill, R2.						
55									
56									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
56									
57									
58						D 3.8			
59									
60			60 m: Fault, 20 mm BX/FB infill, R2. JRC = 15. 60.2 m: Fault, 60 mm FB/FG infill, R0. JRC = 20. Dip/dip direction = 62/214.			D 5.2			
61									
62									
63									
64									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

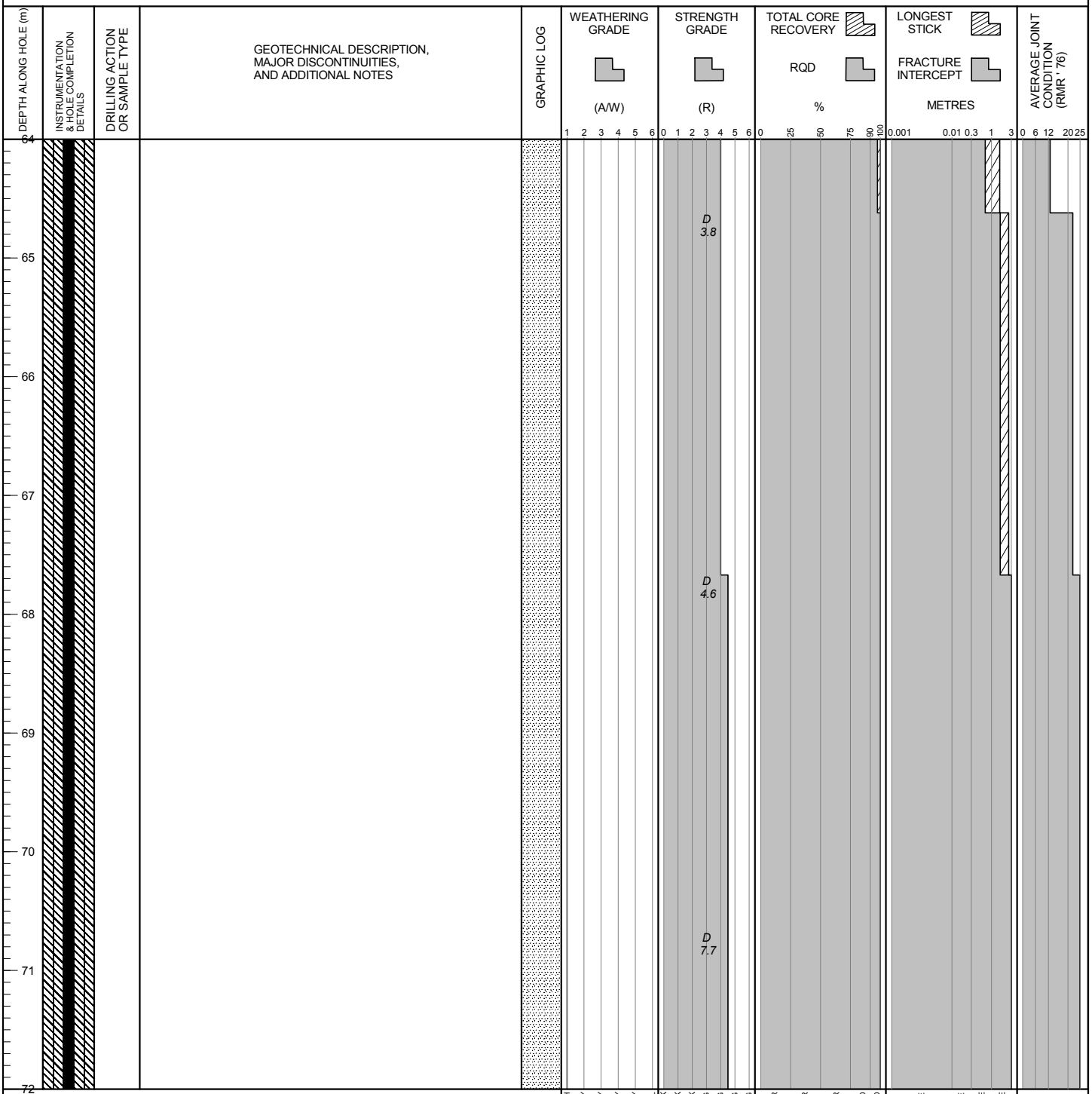
Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
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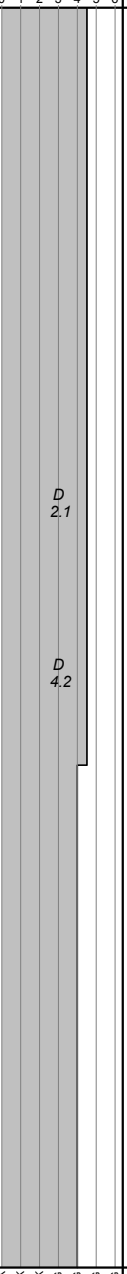
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
72			
73			
74			
75			
76			
77			QUARTZ SULPHIDE VEIN (H4) Medium to light purple-grey quartz vein with approximately 60% pyrite, quartz vein is occasionally obscured by pyrite, oriented 15 degrees TCA, conatins wall rock from previous sandstone unit. Strong (R4). Fresh (A1).
78			
79			
80			ARENITE (S4) Medium to light grey, coarse grained sandstone with pebble sized clasts present, very weakly bedded. Strong (R4). Fresh (A1).

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG



TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
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Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD (%) | LONGEST STICK / FRACTURE INTERCEPT (METRES) | AVERAGE JOINT CONDITION (RMR '76)

80 81 82 83 84 85 86 87 88

D 4.0
D 2.1
D 4.5
D 3.9
D 4.2
D 4.9
D 3.2

VERY SILICEOUS ROCKS (H8)
Medium to light purplish-grey, strongly silicified rhyolite, fairly uniform and moderately fractured, contains subangular rhyolite fragments up to 3 cm. Medium strong to strong (R3-R4). Fresh (A1).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
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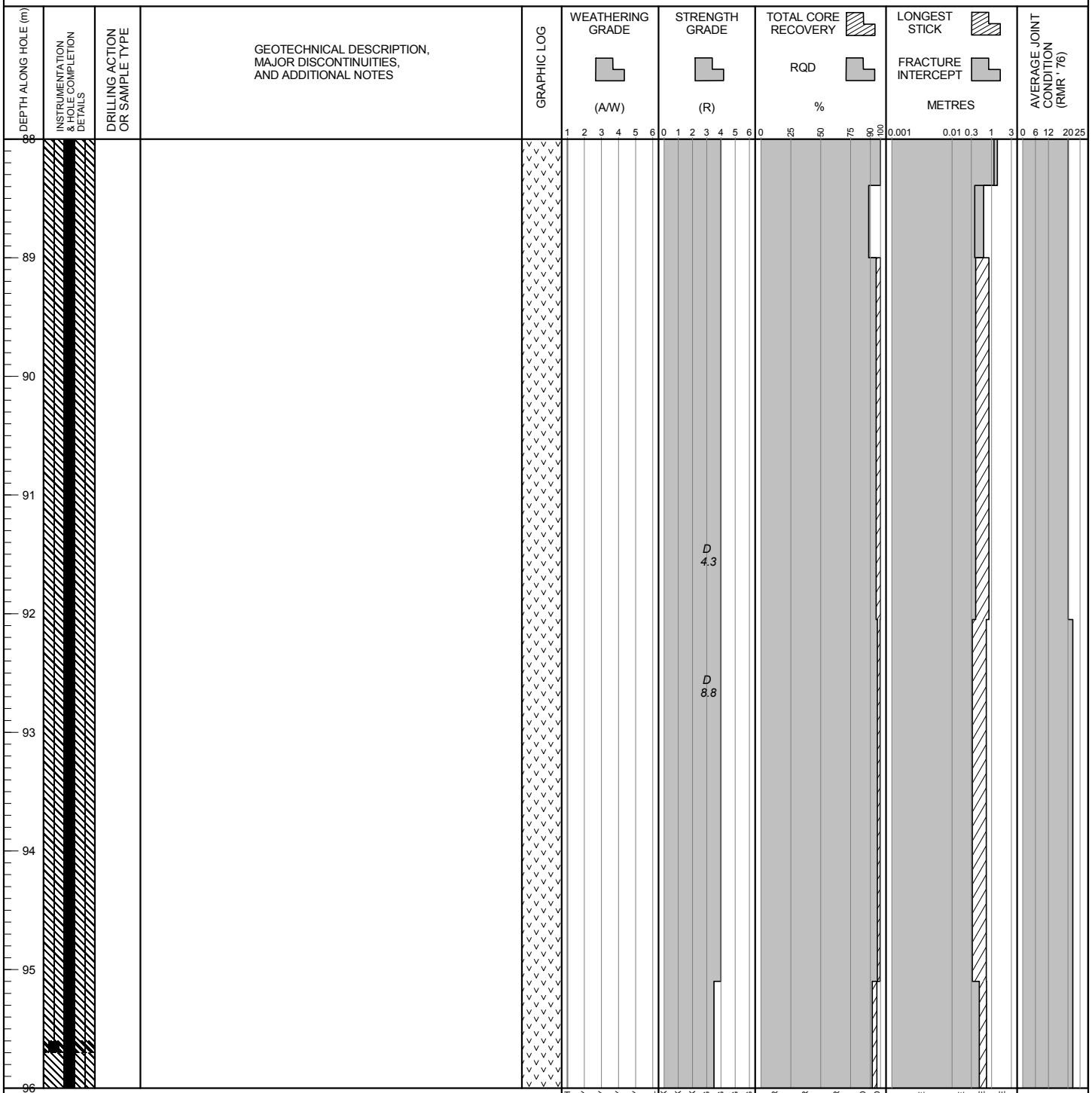
Logged By: LL/LH
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

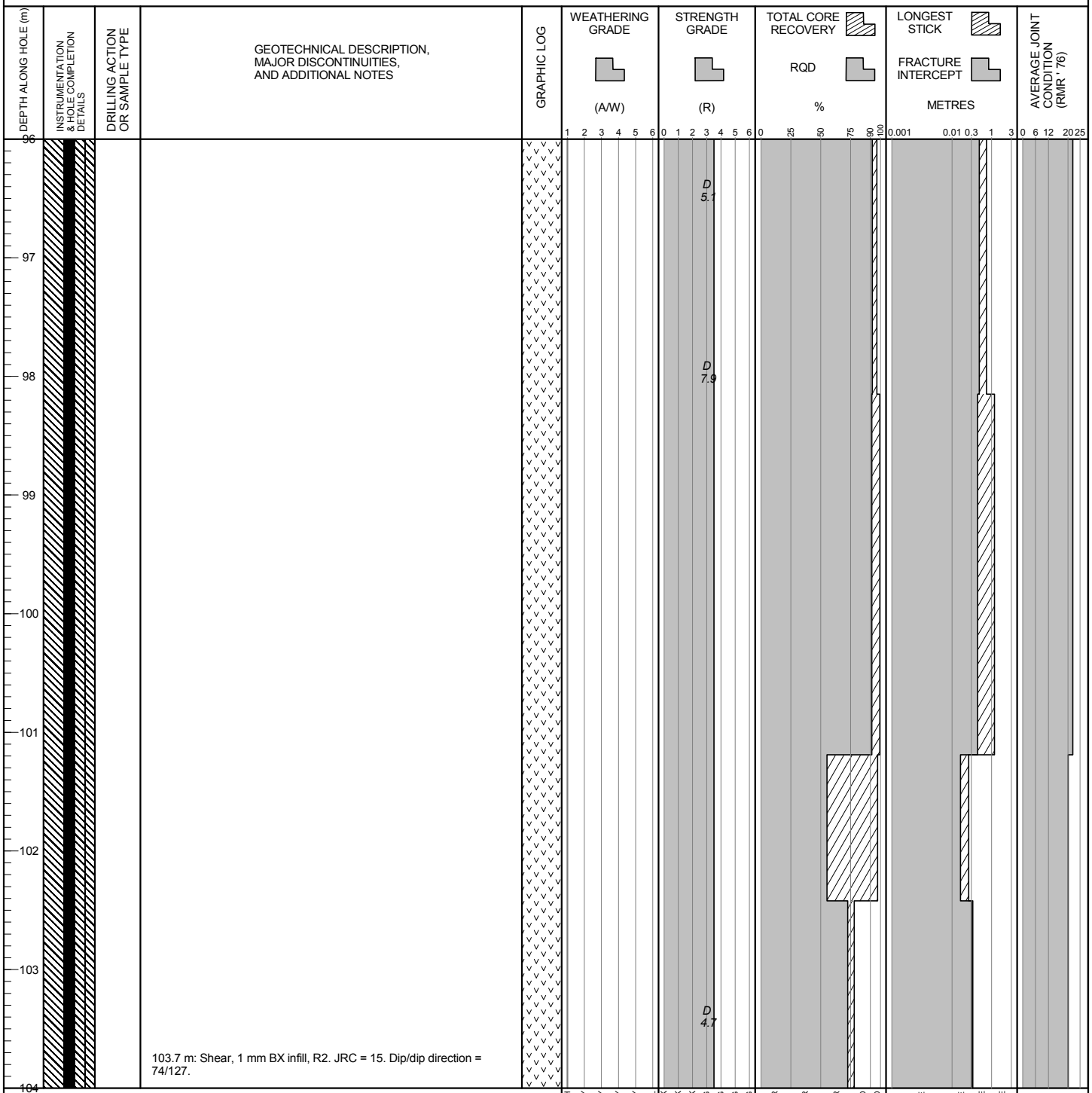
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

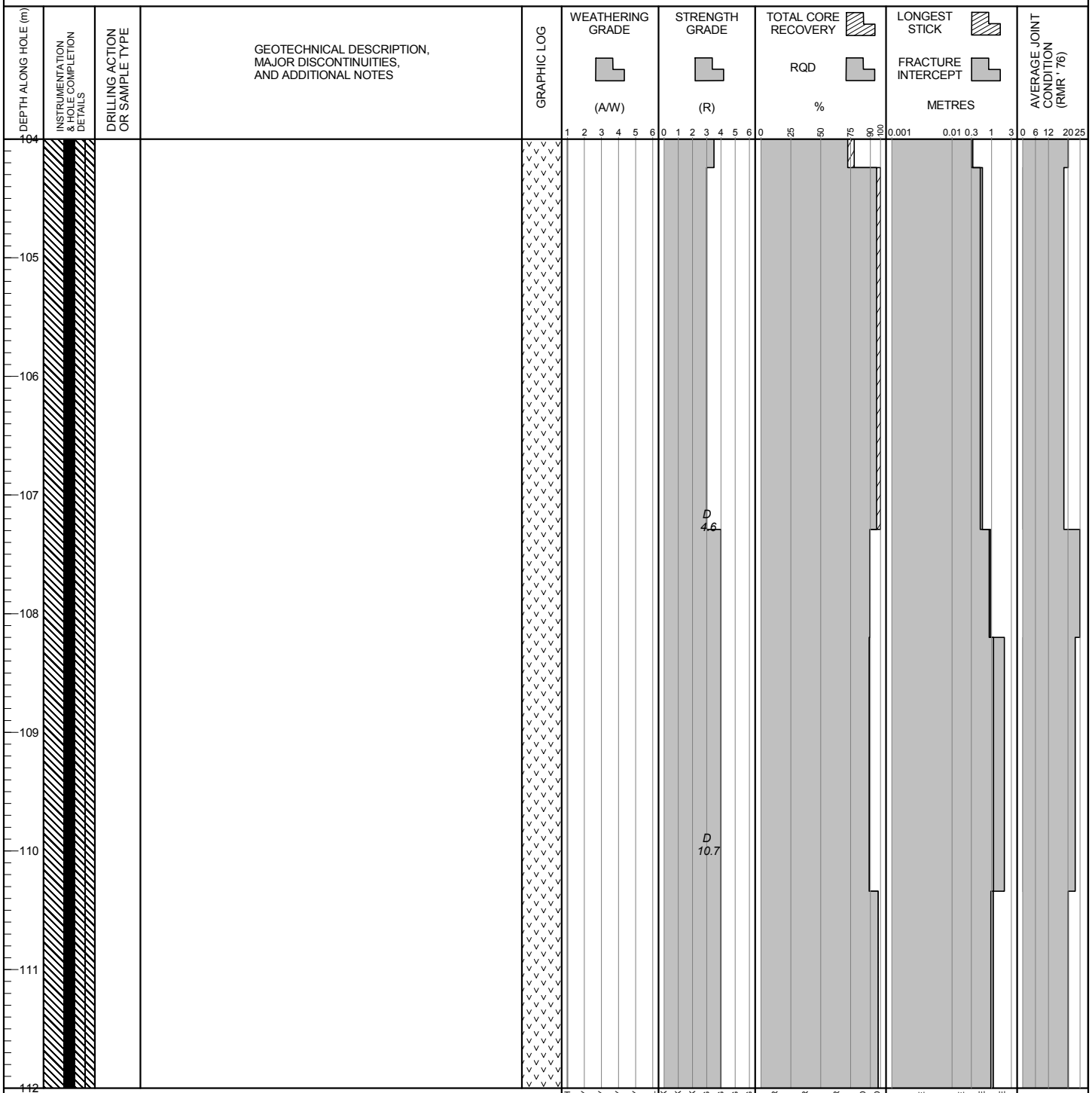
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

112
113
114
115
116
117
118
119
120

ARENITE (S4)
Medium to light grey, pebble rich sandstone, variably altered. Medium strong to strong (R3-R3.5). Fresh (A1).

115.2 - 115.4 m: Fault, moderately to strongly developed, oriented 85 degrees TCA.

115.6 m: Fault, 40 mm FB infill, R2. JRC = 13. Dip/dip direction = 63/198.

D 5.7
D 5.9
D 4.0
D 2.3
D 5.2

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
120					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
121									
122									
123			123.4 m: Fault, 1.5 mm SE/FB infill, R0. JRC = 12. Dip/dip direction = 72/234.						
124			123.9 m: Fault, 20 mm SE/FB infill, R0. JRC = 20. Dip/dip direction = 76/237.			D 5.5			
125									
126									
127									
128					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

128
129
130
131
132
133
134
135
136

VERY SILICEOUS ROCKS (H8)
Medium to light purplish-grey, strongly silicified rhyolite with m-scale sericitized interbeds, variably fractured but fairly uniform, sericitized sections are massive. Medium strong to strong (R3-R4). Fresh (A1).

D 1.3
D 7.0
D 8.7

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

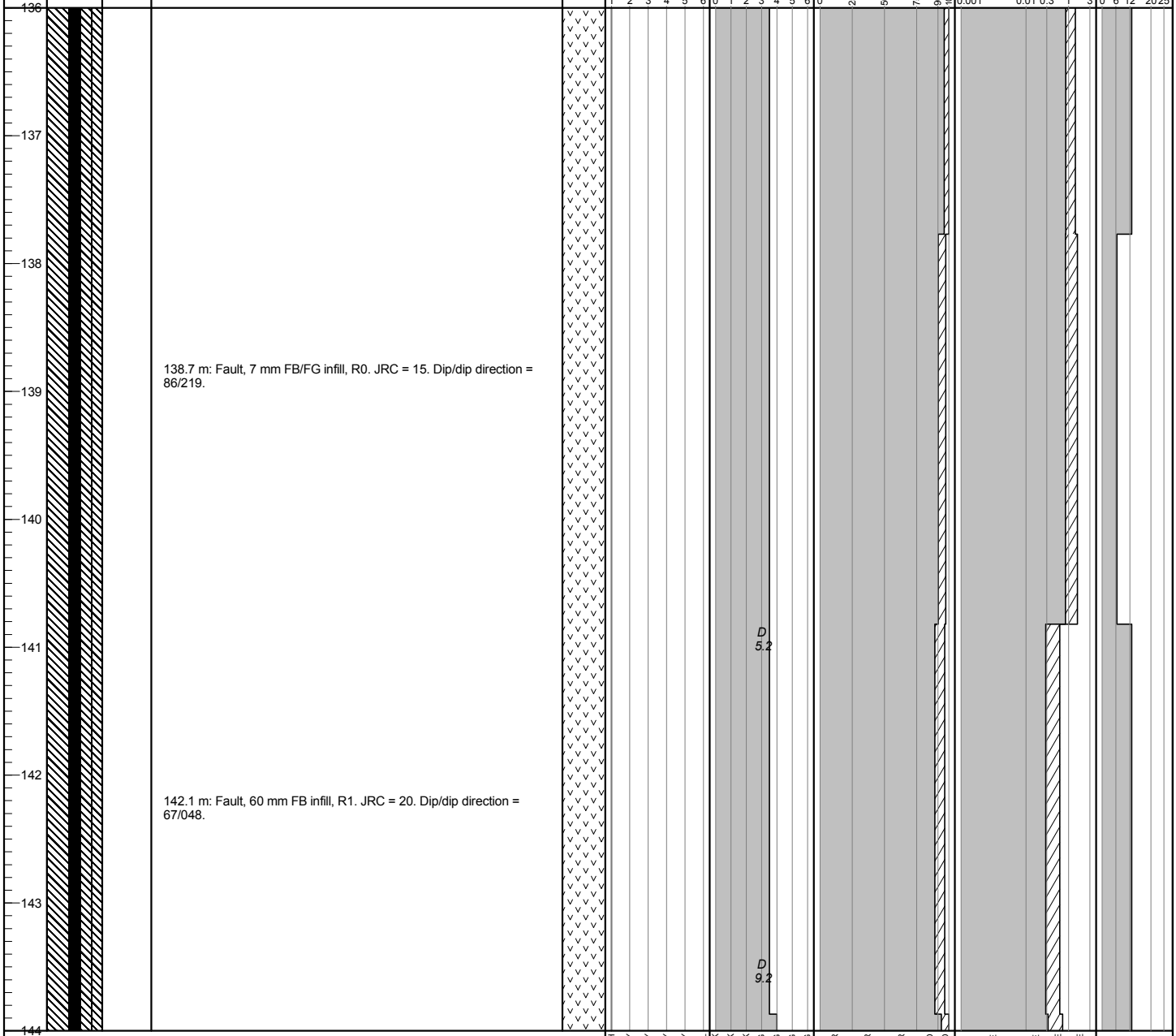
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

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DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
144			144.4 m: Sporadic green translucent very strong sericite mottles up to 1m, fragments generally remain very silicified, sporadically replaced by sericite.						
145									
146			145.9 m: Fault, 1 mm FB infill, R2. JRC = 20.						
147						D 3.8			
148									
149			148.9 m: Fault, 5 mm FB infill, R1. JRC = 15. Dip/dip direction = 56/030.						
150									
151						D 4.3			
152									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
152									
153									
154									
155						D 5.9			
156						D 4.1			
157									
158			158.6 m: Fault, 40 mm FG/FB infill, R3. JRC = 13. Dip/dip direction = 17/021.						
159						D 6.4			
160									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
160									
161						D 3.8			
162									
163			162.8 m: Fault, 100 mm FB infill, R2. JRC = 13. Dip/dip direction = 81/216.						
164			164.2 m: Fault, 20 mm FB infill, R2. JRC = 15. Dip/dip direction = 63/222.						
165									
166									
167						D 4.0			
168									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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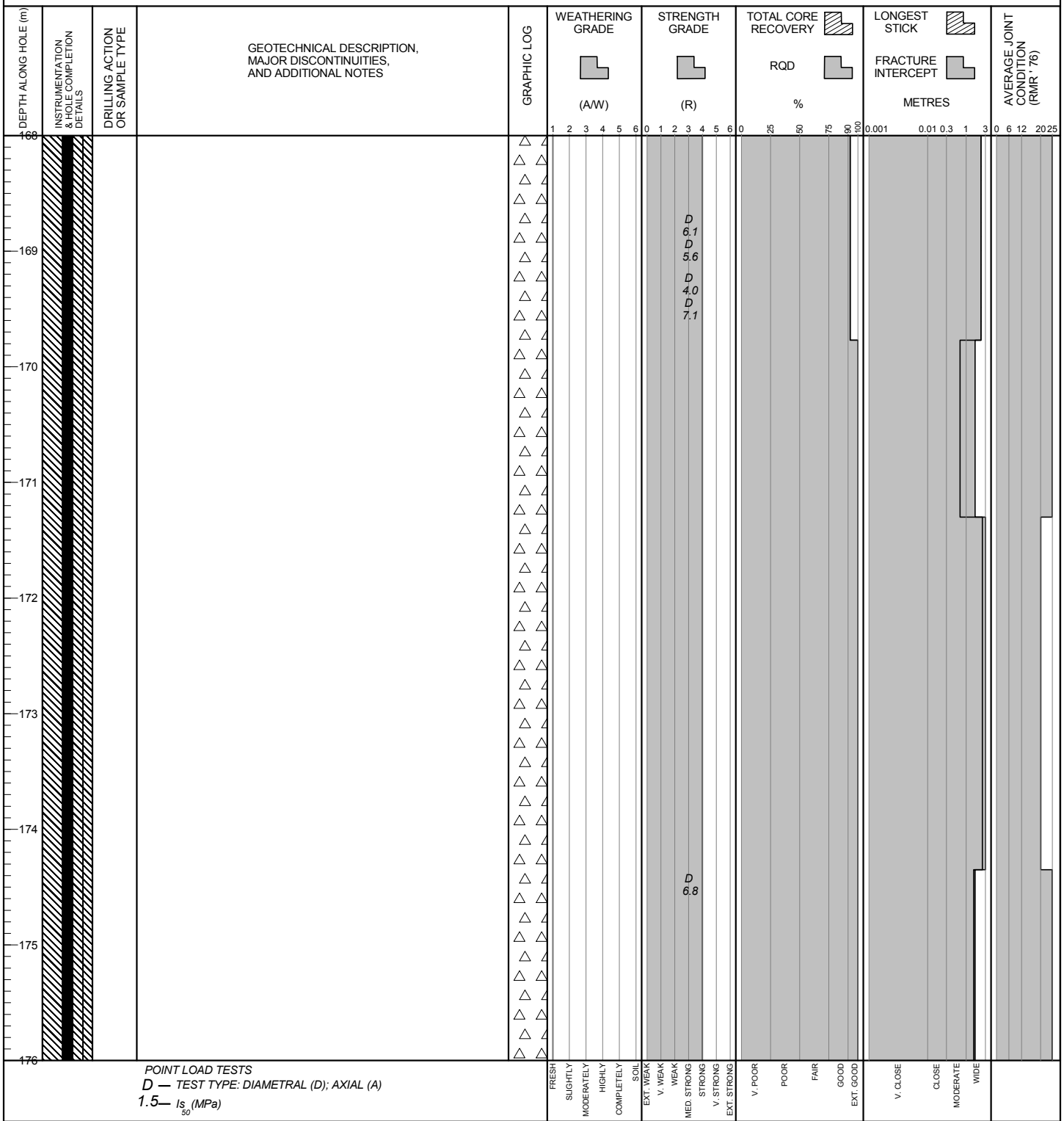

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

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Datum: UTM NAD 83 Zone 9
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Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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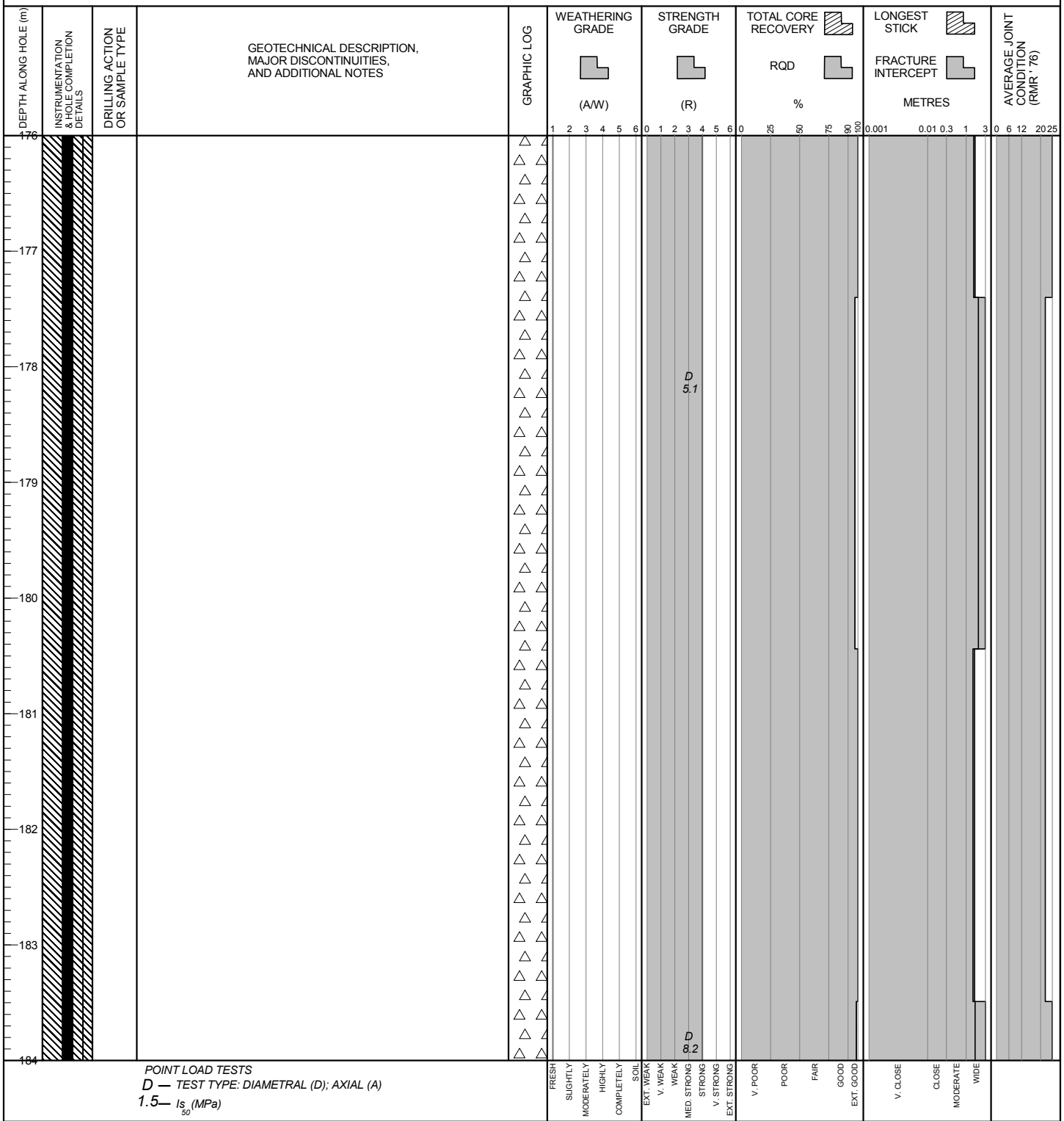

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

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Datum: UTM NAD 83 Zone 9
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Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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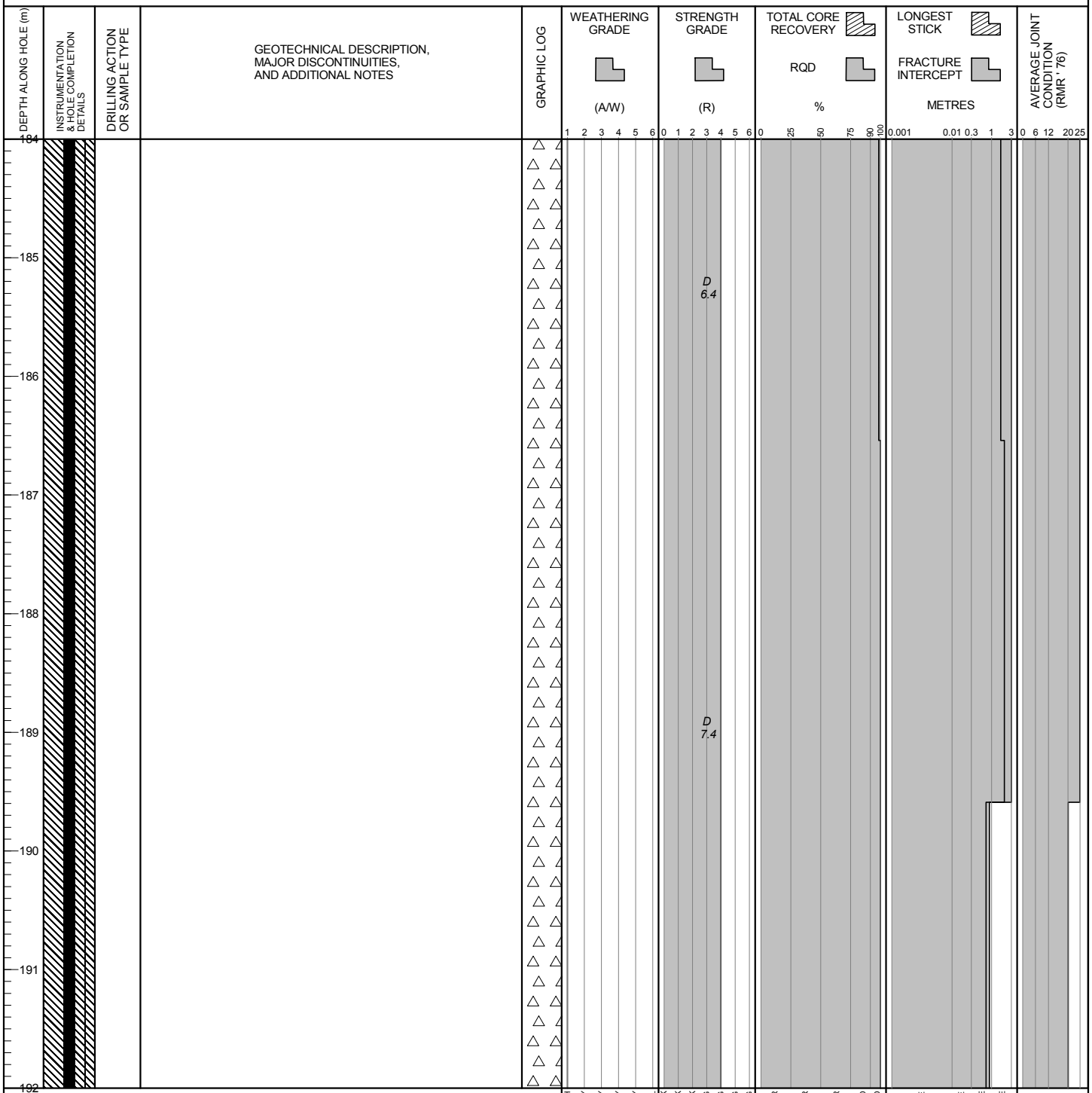

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
192									
193						D 9.5			
194									
195			INTERMEDIATE VOLCANICS (V12) Medium to light grey, cobble-sized matrix supported fragmental unit in a massive tuffaceous unit, weakly foliated locally, fragments are < 30 cm wide & cobble to pebble size. Medium strong to strong (R3.5-R4). Fresh (A1).						
196									
197						D 7.0			
198									
199									
200									

Scales: WEATHERING GRADE (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; STRENGTH GRADE (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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200					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
201									
202						D 5.3			
203									
204									
205						D 6.6			
206			206.3 m: Shear on vein, 0.5 mm aperture. JRC = 8.						
207									
208									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

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208					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
209									
210									
211						D 8.2			
212									
213									
214									
215									
216									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

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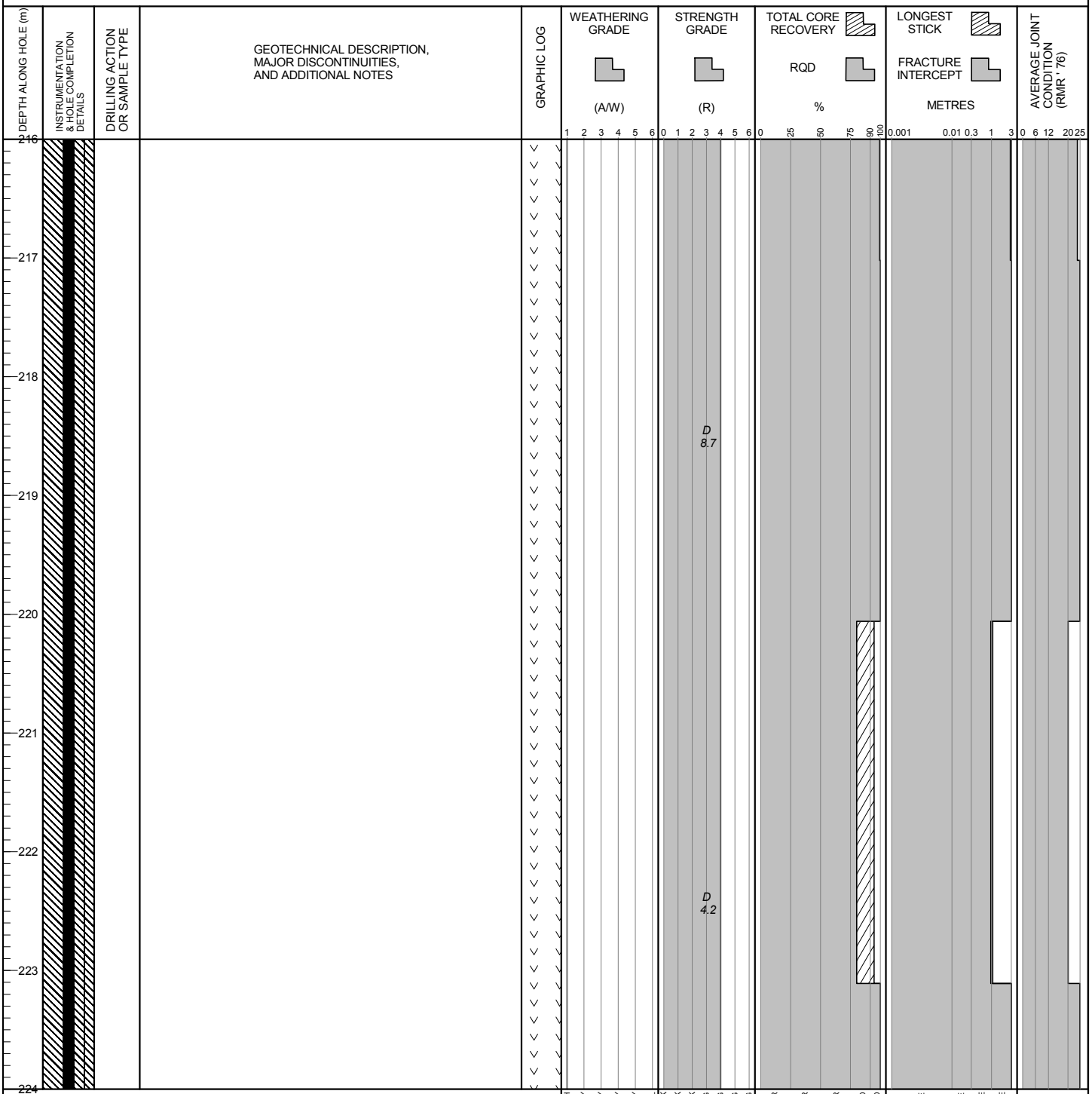

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
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Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
224					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
						D 9.0			
						D 10.0			
225									
						D 9.2			
226						D 6.1			
227									
228						D 7.0			
229									
230									
231									
232						D 7.0			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
232					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
233									
234									
235									
236									
237									
238									
239									
240									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
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Datum: UTM NAD 83 Zone 9
Plunge (°): -75
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
240					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
241						D 8.7			
242									
243									
244									
245									
246									
247						D 5.1			
248					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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Final Depth (m): 585.8
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Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
248–256					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
256									
257									
258			Constant head test from 258.2 - 271.9 m. Estimated hydraulic conductivity is 1.2E-07 m/s.						
259						D 3.9			
260									
261									
262									
263									
264									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

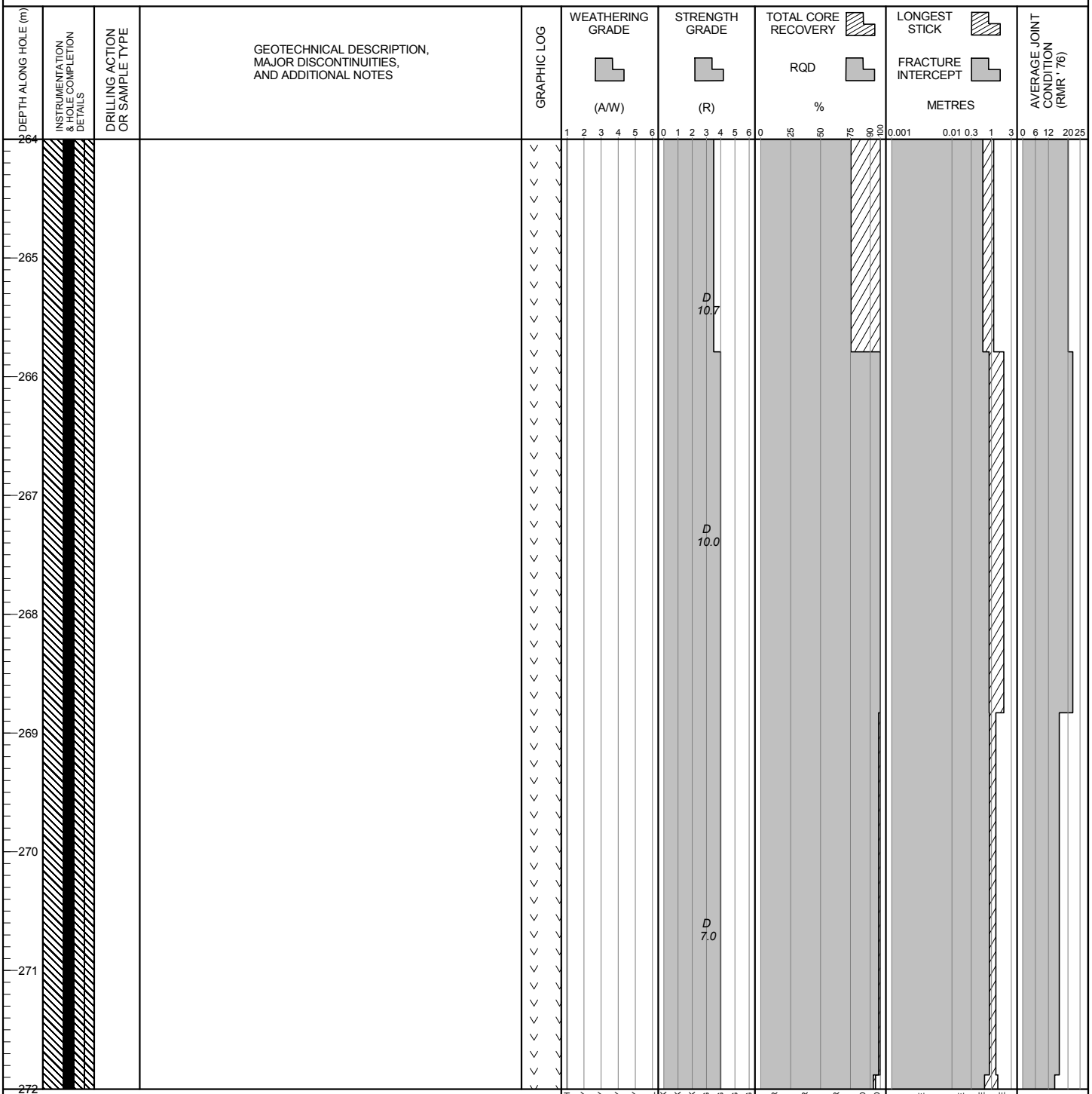
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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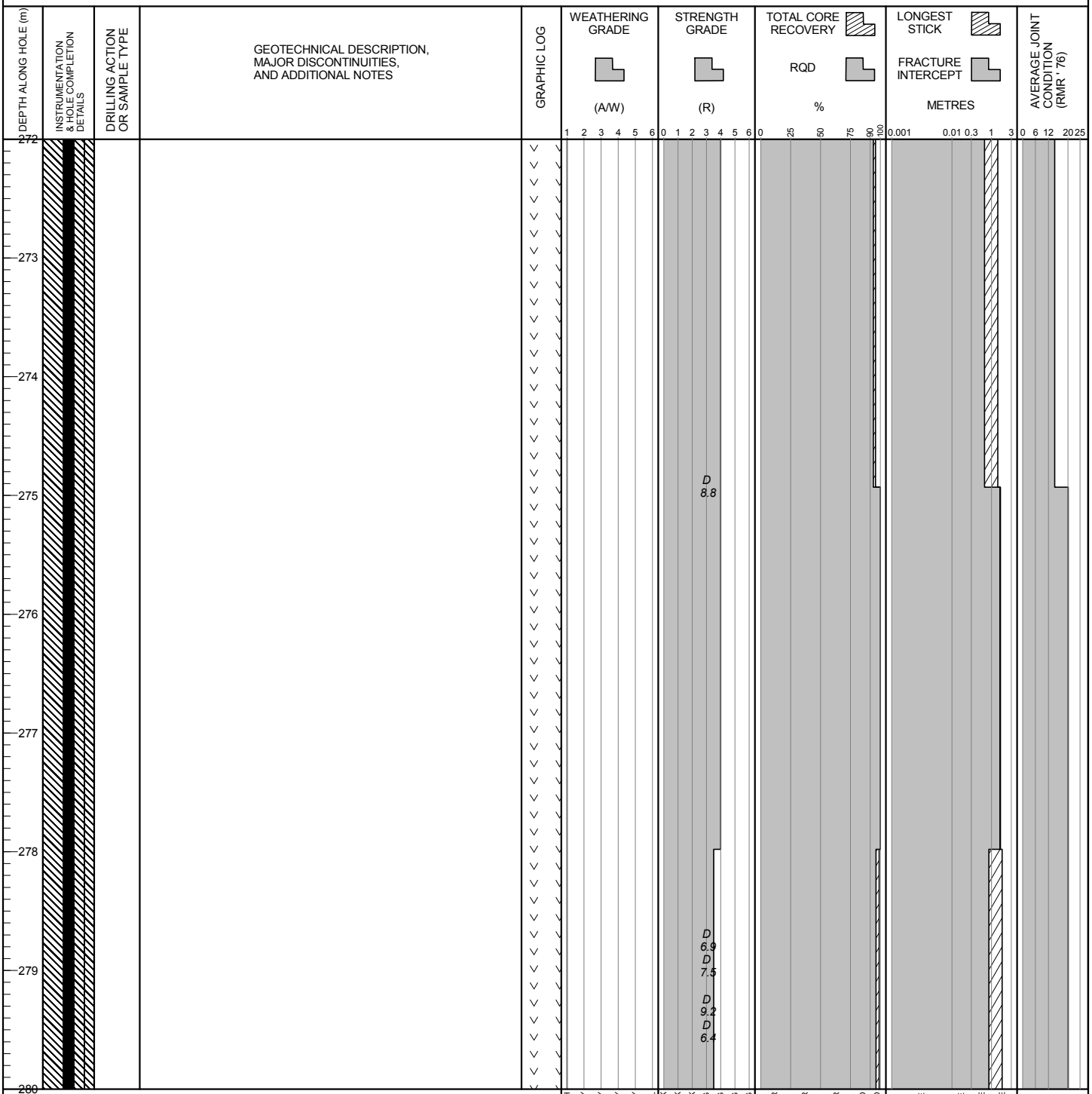
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
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Datum: UTM NAD 83 Zone 9
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Start Date: 11 Apr 12
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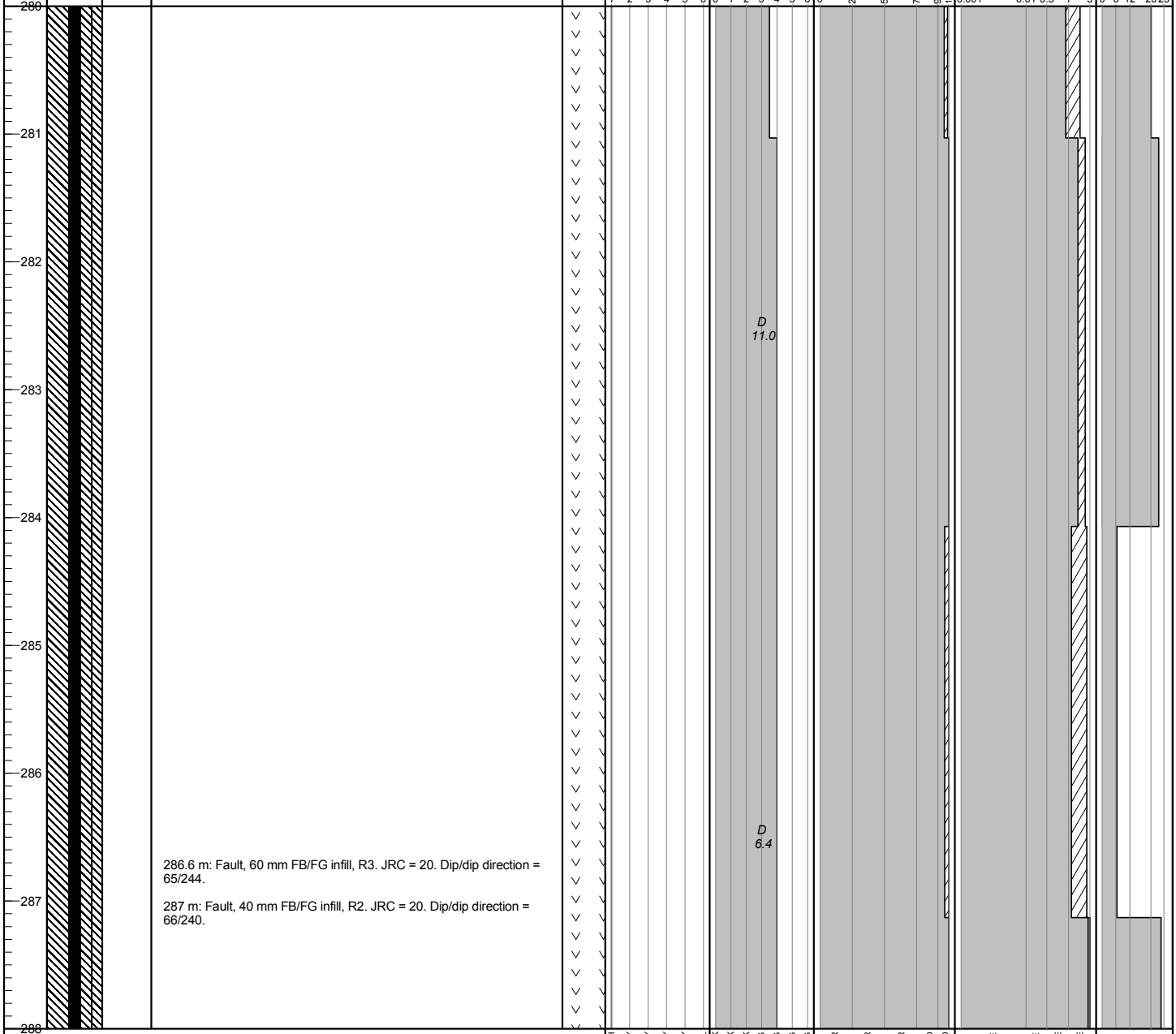
DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



286.6 m: Fault, 60 mm FB/FG infill, R3. JRC = 20. Dip/dip direction = 65/244.

287 m: Fault, 40 mm FB/FG infill, R2. JRC = 20. Dip/dip direction = 66/240.

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

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Drill Designation: Heliportable
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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

288
289
290
291
292
293
294
295
296

D
7.2

QUARTZ VEIN (H1)
White to milky-white quartz vein, contains some traces of base metal sulphides (sphalerite), oriented 35 degrees TCA. Strong (R4). Fresh (A1).

INTERMEDIATE VOLCANICS (V12)
Grey, cobble-sized matrix supported fragmental unit in a massive tuffaceous unit, weakly foliated locally, fragments are < 30 cm wide and cobble to pebble size. Sericite and chlorite altered fragments. Strong (R4). Fresh (A1).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
296					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
297						D 7.0			
298									
299						D 5.5			
300									
301									
302									
303									
304					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
304			304.2 m: Fault, 15 mm FB infill, R4. JRC = 13. Dip/dip direction = 73/217.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
305									
306									
307									
308									
309									
310									
311									
312					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

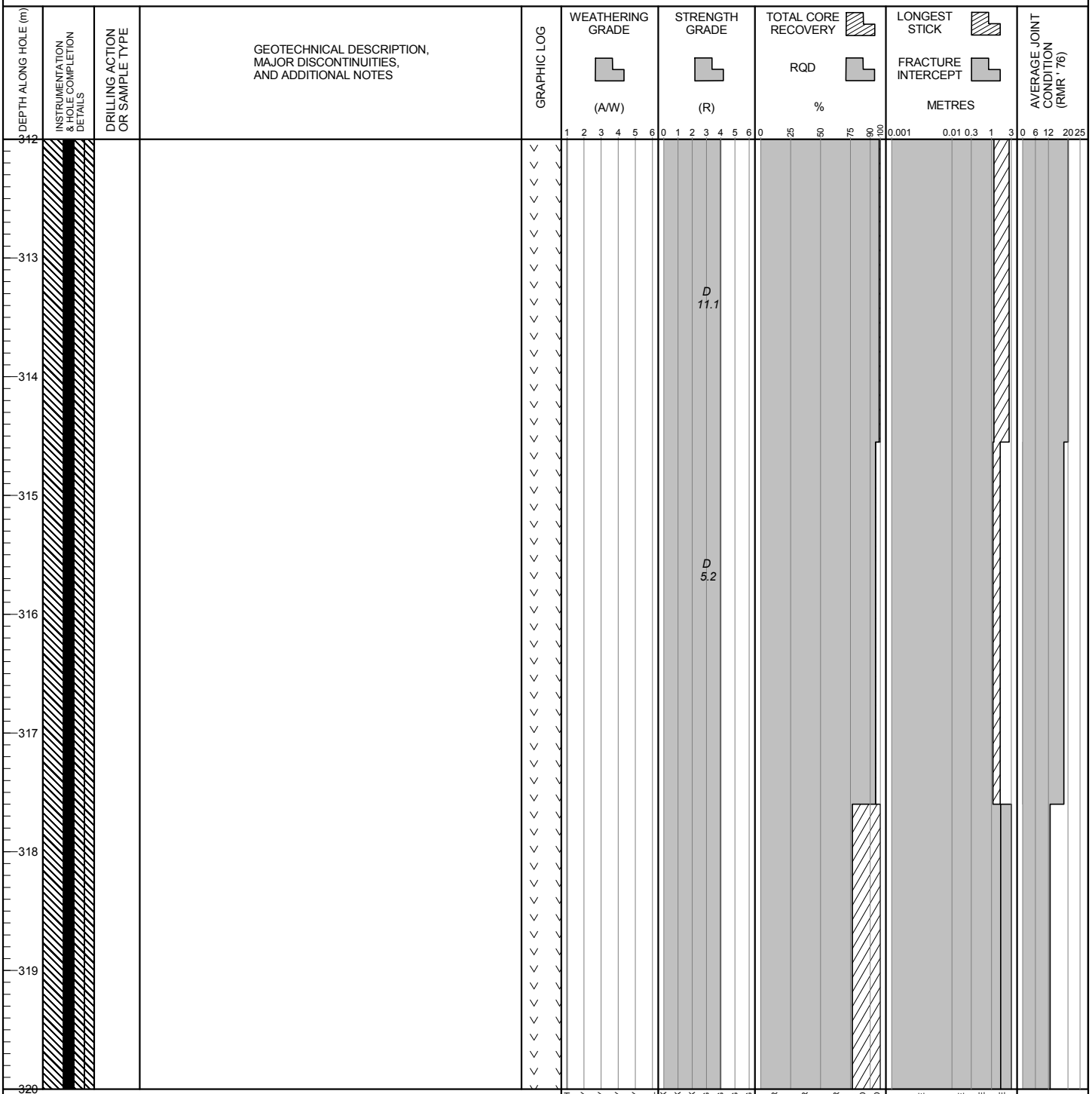
Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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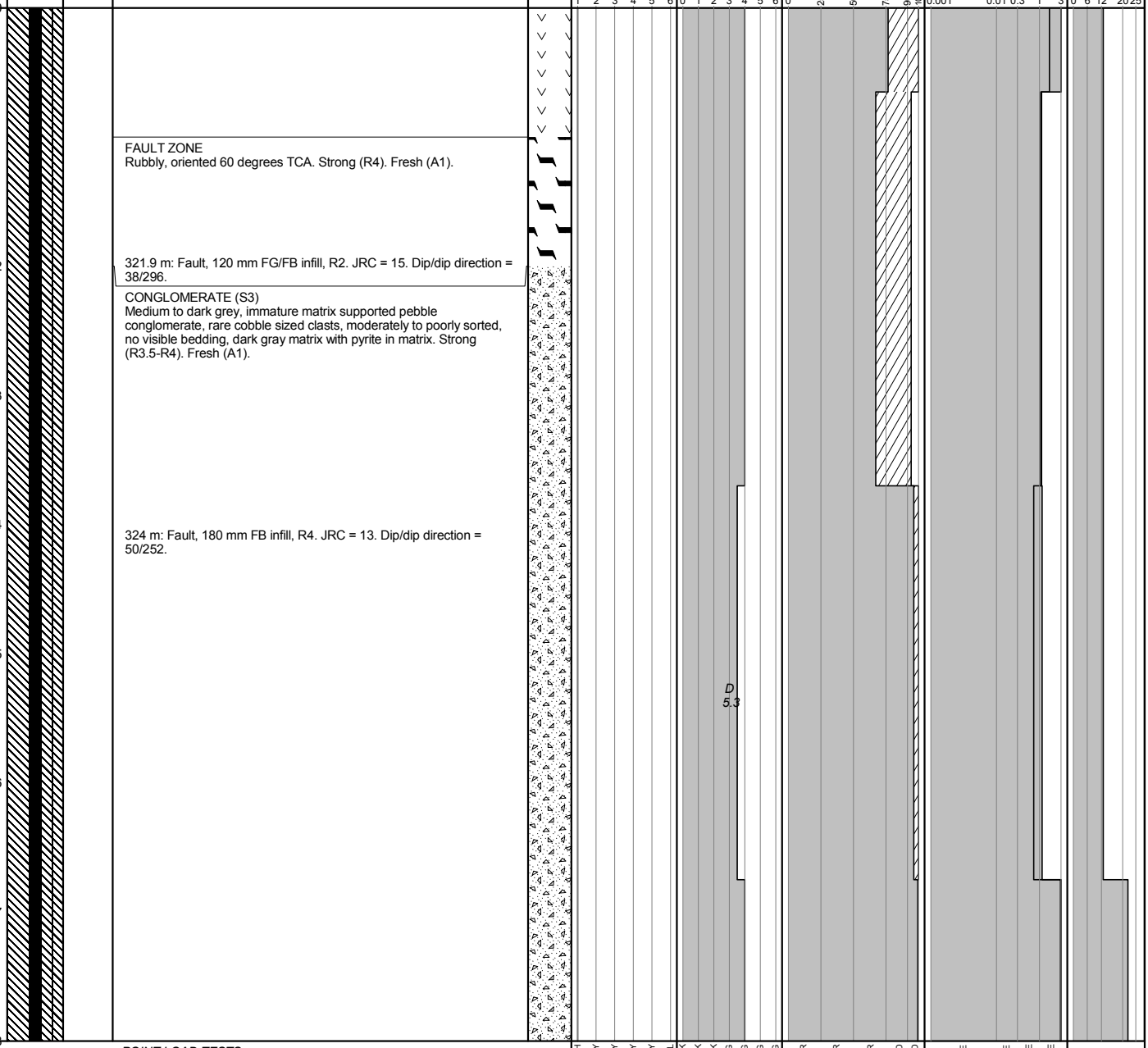
DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
320									
321			FAULT ZONE Rubbly, oriented 60 degrees TCA. Strong (R4). Fresh (A1).						
322			321.9 m: Fault, 120 mm FG/FB infill, R2. JRC = 15. Dip/dip direction = 38/296. CONGLOMERATE (S3) Medium to dark grey, immature matrix supported pebble conglomerate, rare cobble sized clasts, moderately to poorly sorted, no visible bedding, dark gray matrix with pyrite in matrix. Strong (R3.5-R4). Fresh (A1).						
323									
324			324 m: Fault, 180 mm FB infill, R4. JRC = 13. Dip/dip direction = 50/252.						
325						D 5.3			
326									
327									
328									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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LOG SCALE: 1:50

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Core: HQ3
Fluid: Polymer
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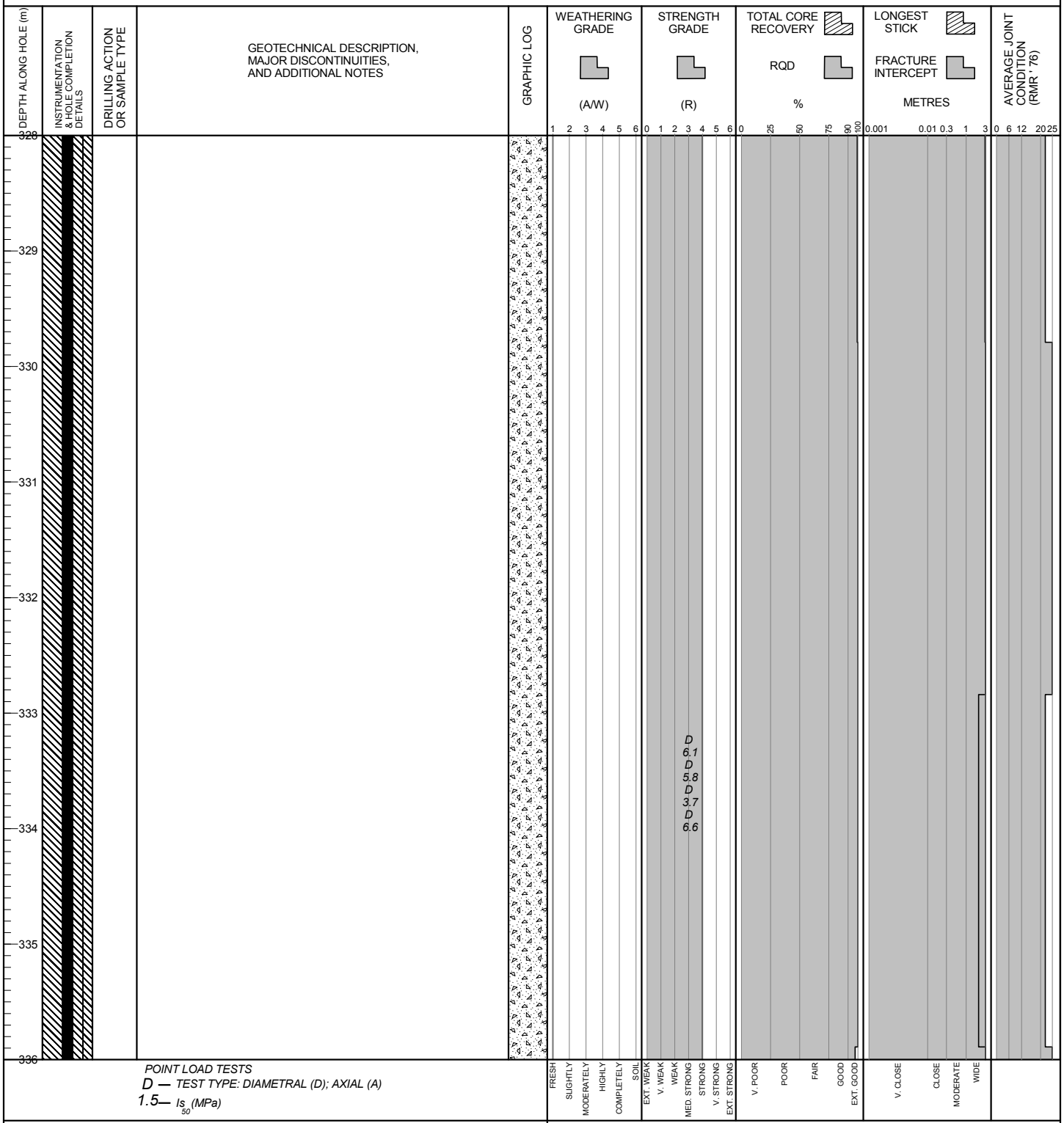


POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD (%)	LONGEST STICK / FRACTURE INTERCEPT (METRES)	AVERAGE JOINT CONDITION (RMR '76)
336					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
337									
338						D 8.8			
339									
340									
341									
342						D 8.3			
343									
344									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

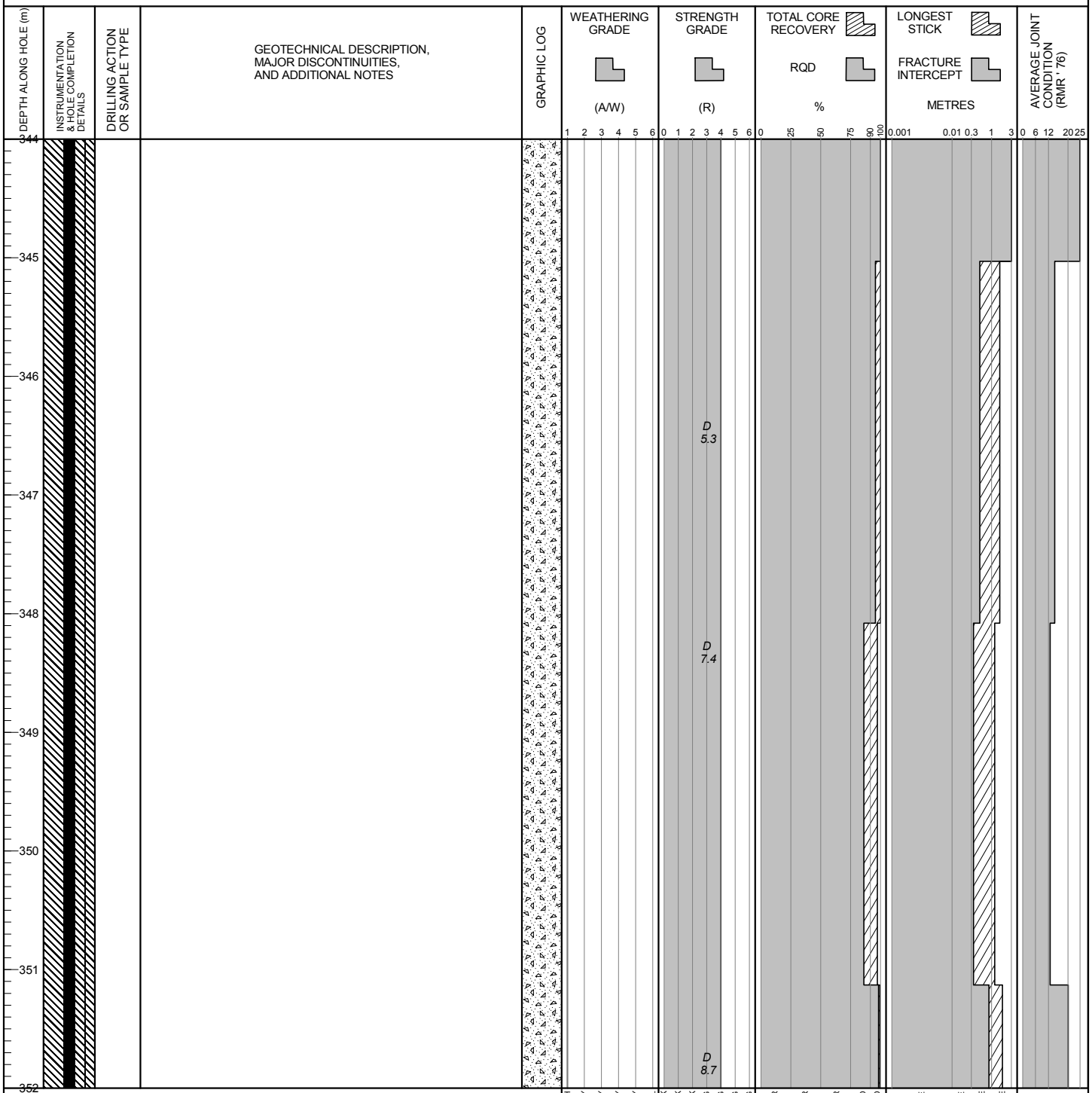
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
352					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
353									
354									
355									
356						D 8.4			
357									
358									
359			358.9 m: Fault, 1 mm FG infill, R0. JRC = 12. Dip/dip direction = 68/212.						
360									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

360

361

VERY SILICEOUS ROCKS (H8)
Medium to light purplish-grey, strongly silicified rhyolite, moderately fractured, pyrite is disseminated in fractures. Strong (R4). Fresh (A1).

Constant head test from 361.8 - 381.6 m. Estimated hydraulic conductivity is 4.3E-08 m/s.

D 4.5

362

363

D 4.1

364

CONGLOMERATE (S3)
Medium to light grey, matrix supported pebble conglomerate, immature with angular clasts, contains chunks of rhyolite, becomes moderately to strongly silicified after 370 m. Strong (R3.5-R4). Fresh (A1).

365

366

367

368

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
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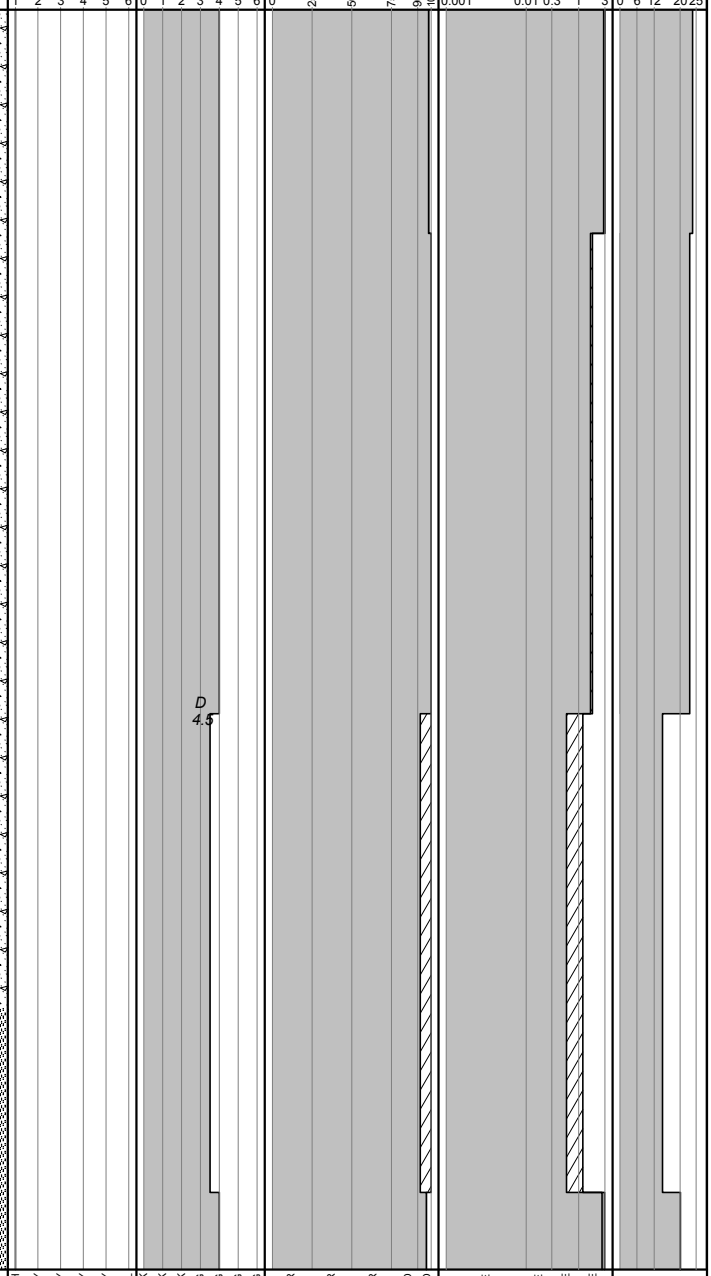
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

368 369 370 371 372 373 374 375 376

ARENITE (S4)
Grey-green, interbedded sandstone and conglomerate units on a m-scale, conglomerate is matrix supported with sericite replaced clasts, contains concretions in sandstone sections. Strong (R3.5-R4.5). Fresh (A1).

374.3 - 379.7 m: Stockwork within sandstone, consists of veinlets and veins with wall rock fragments within them.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

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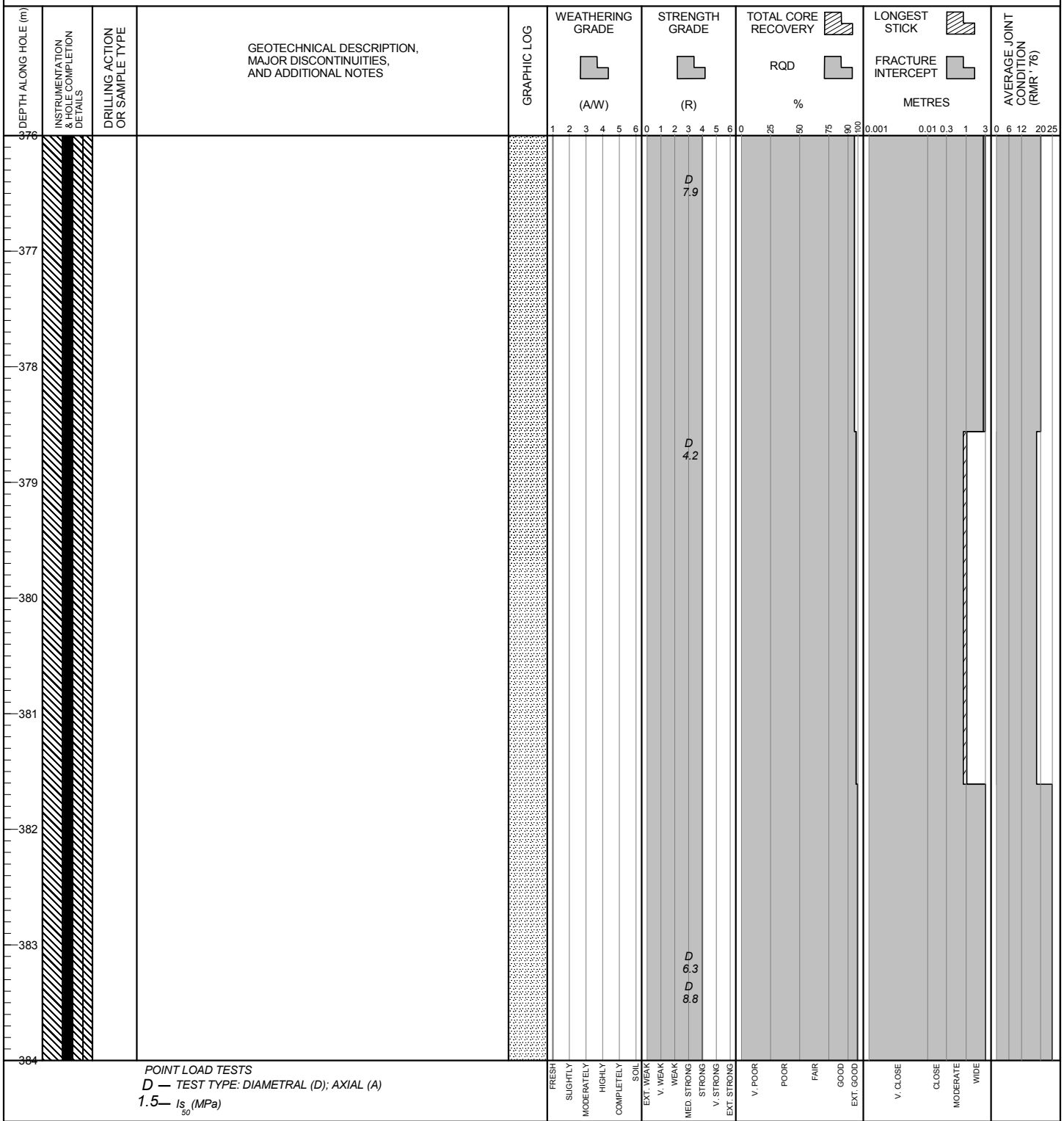

POINT LOAD TESTS
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1.5— Is_{50} (MPa)

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DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

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Ground Elevation (m): 1,539.8
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Datum: UTM NAD 83 Zone 9
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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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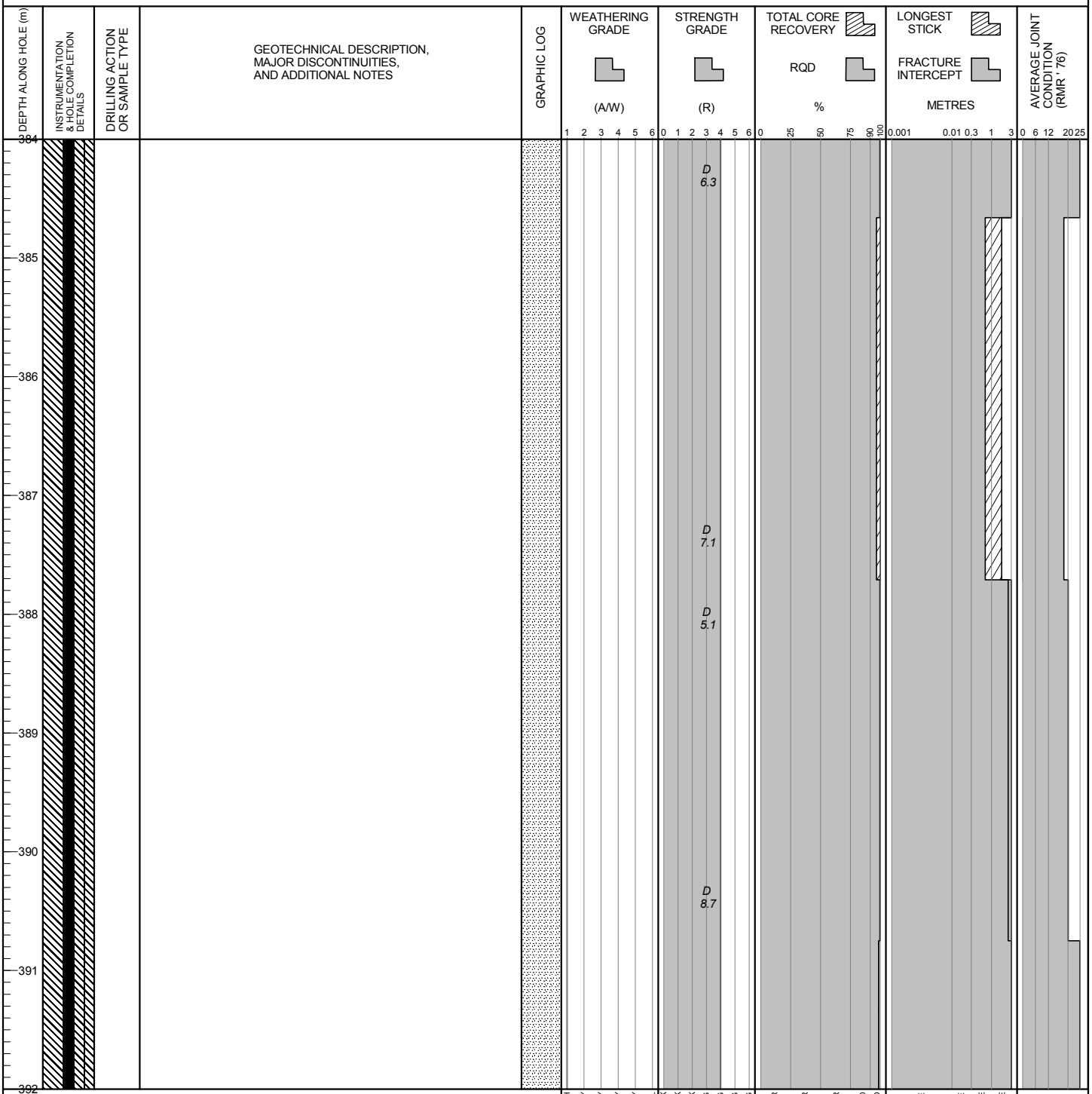

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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AN APPLIED EARTH SCIENCES COMPANY

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DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

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Fluid: Polymer
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392					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
393									
394									
395									
396									
397									
398									
399									
400									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

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DRILL HOLE # DH-BGC12-22

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400									
401						D 4.2			
402									
403									
404						D 3.2			
405									
406									
407						D 5.6			
408									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

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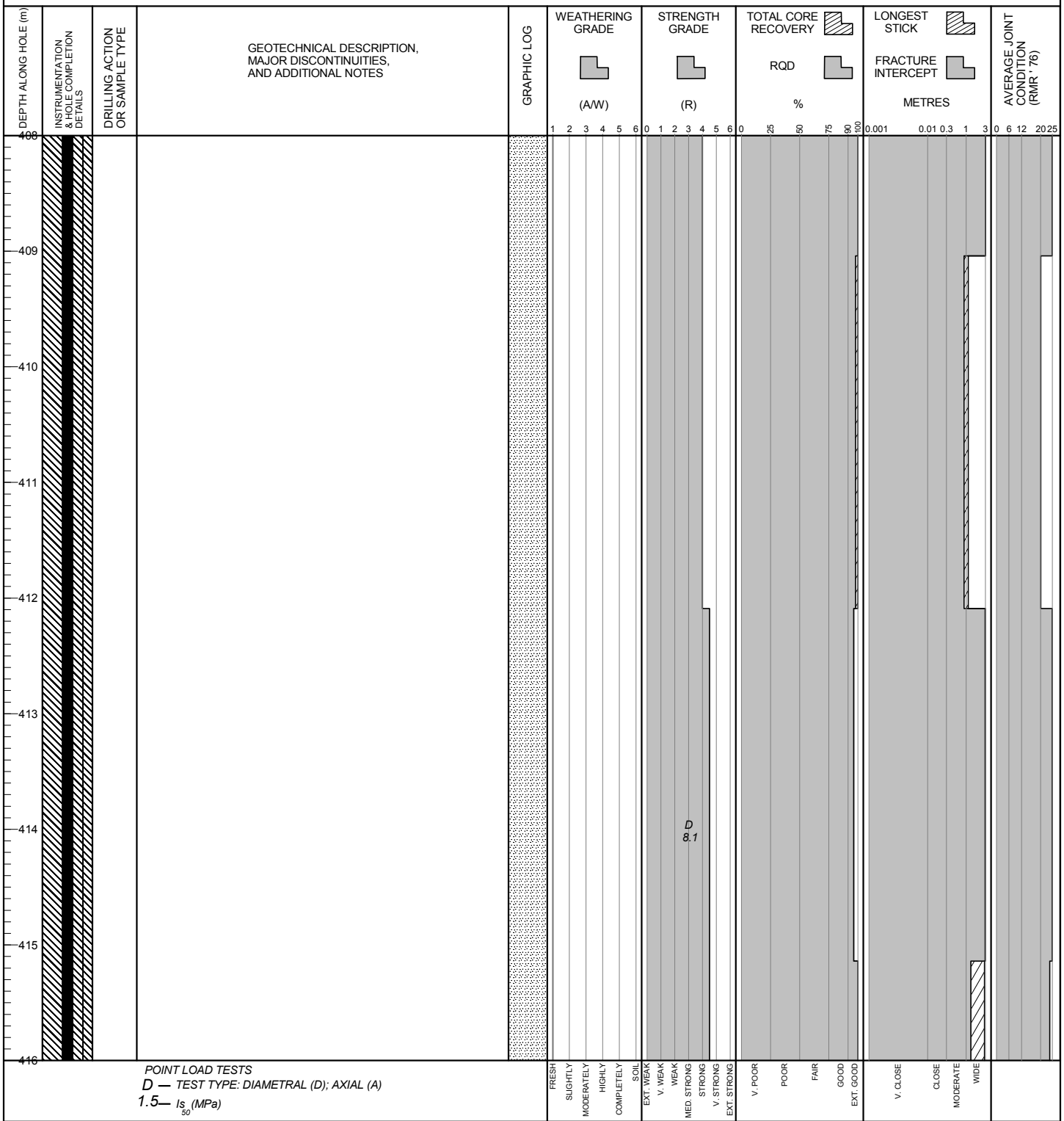

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
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416					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
417									
418									
419									
420									
421									
422									
423									
424									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
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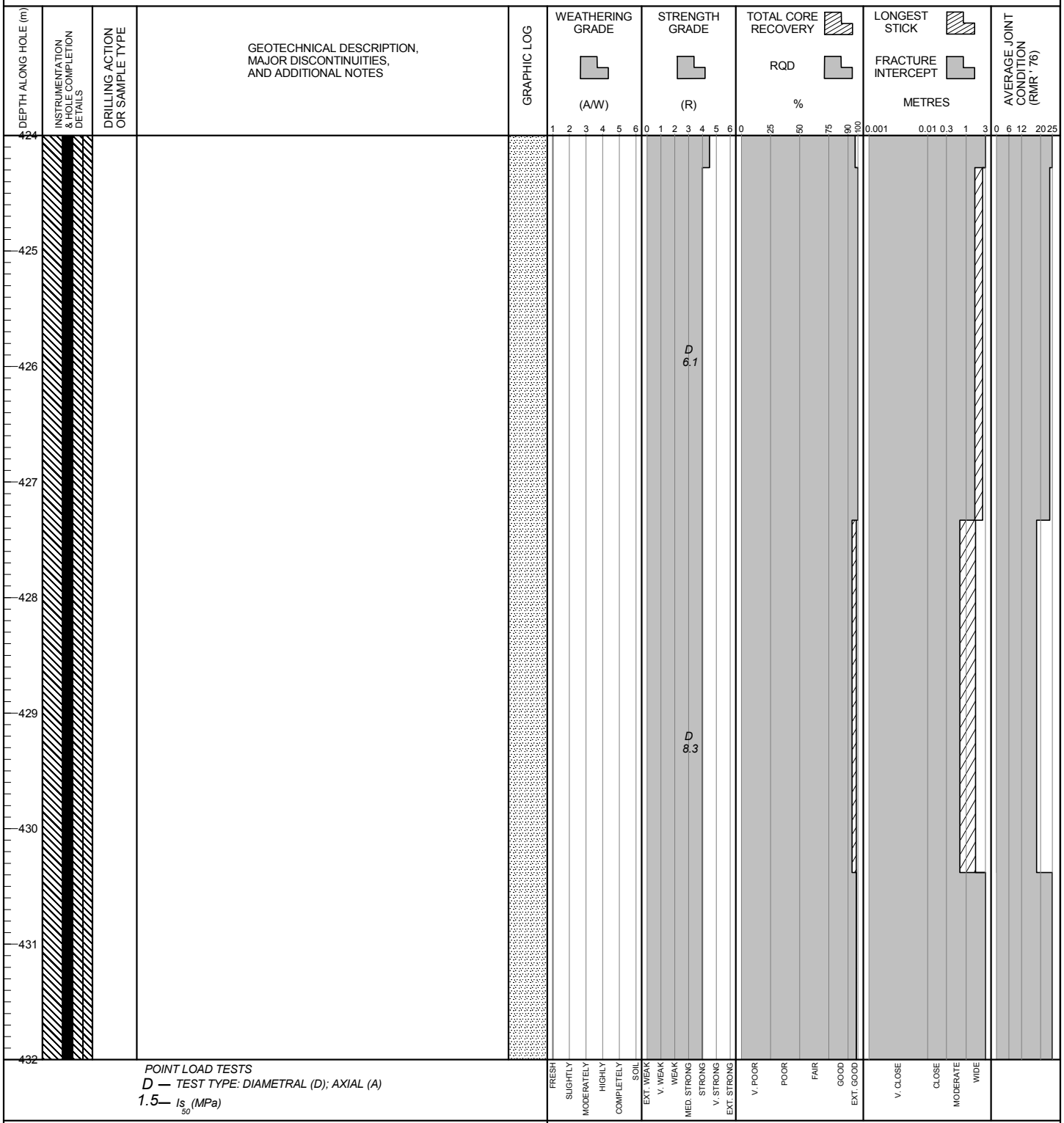

POINT LOAD TESTS
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432					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
433									
434									
435									
436									
437						D 8.1 D 8.3 D 7.9			
438									
439									
440									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
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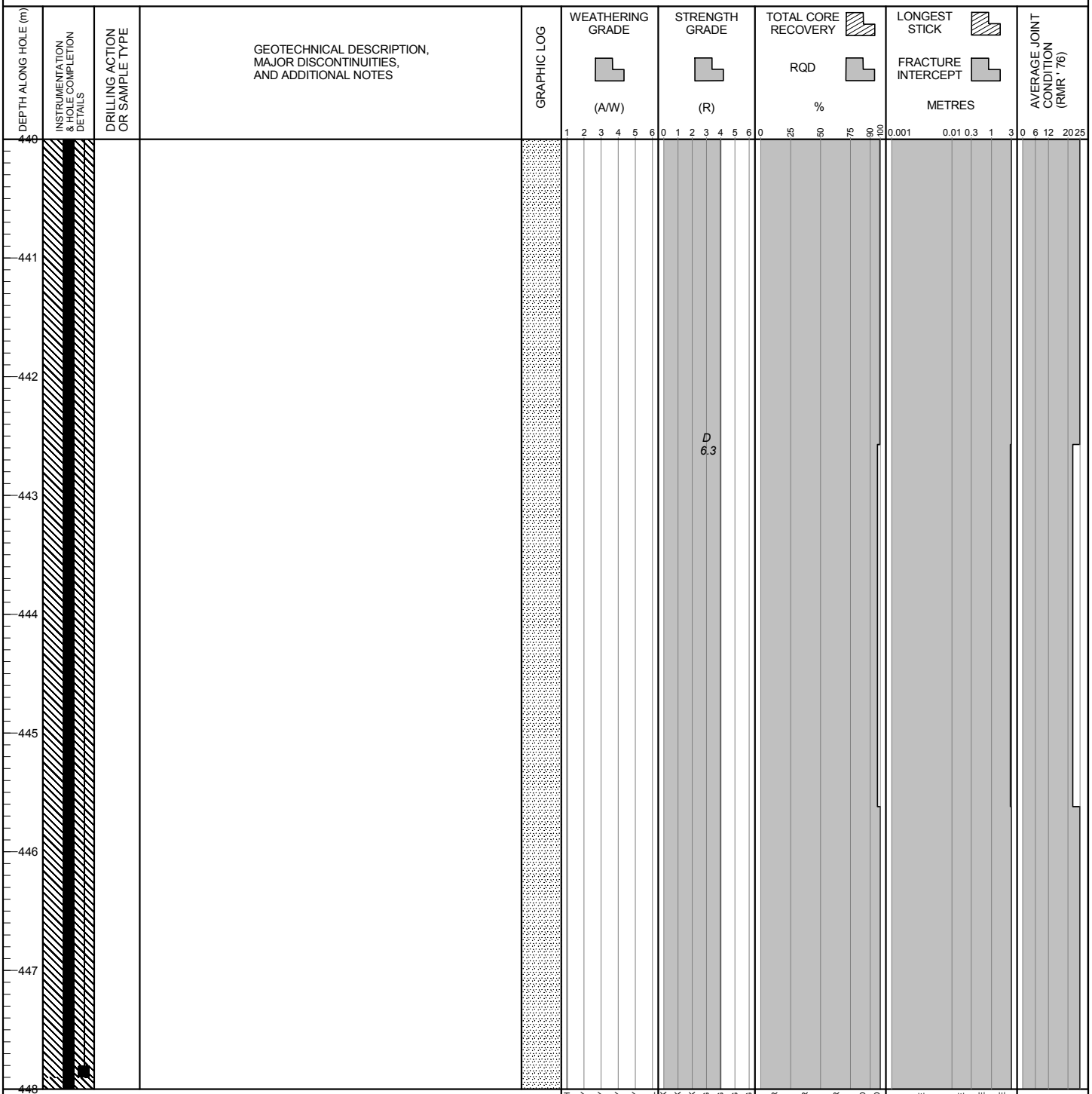

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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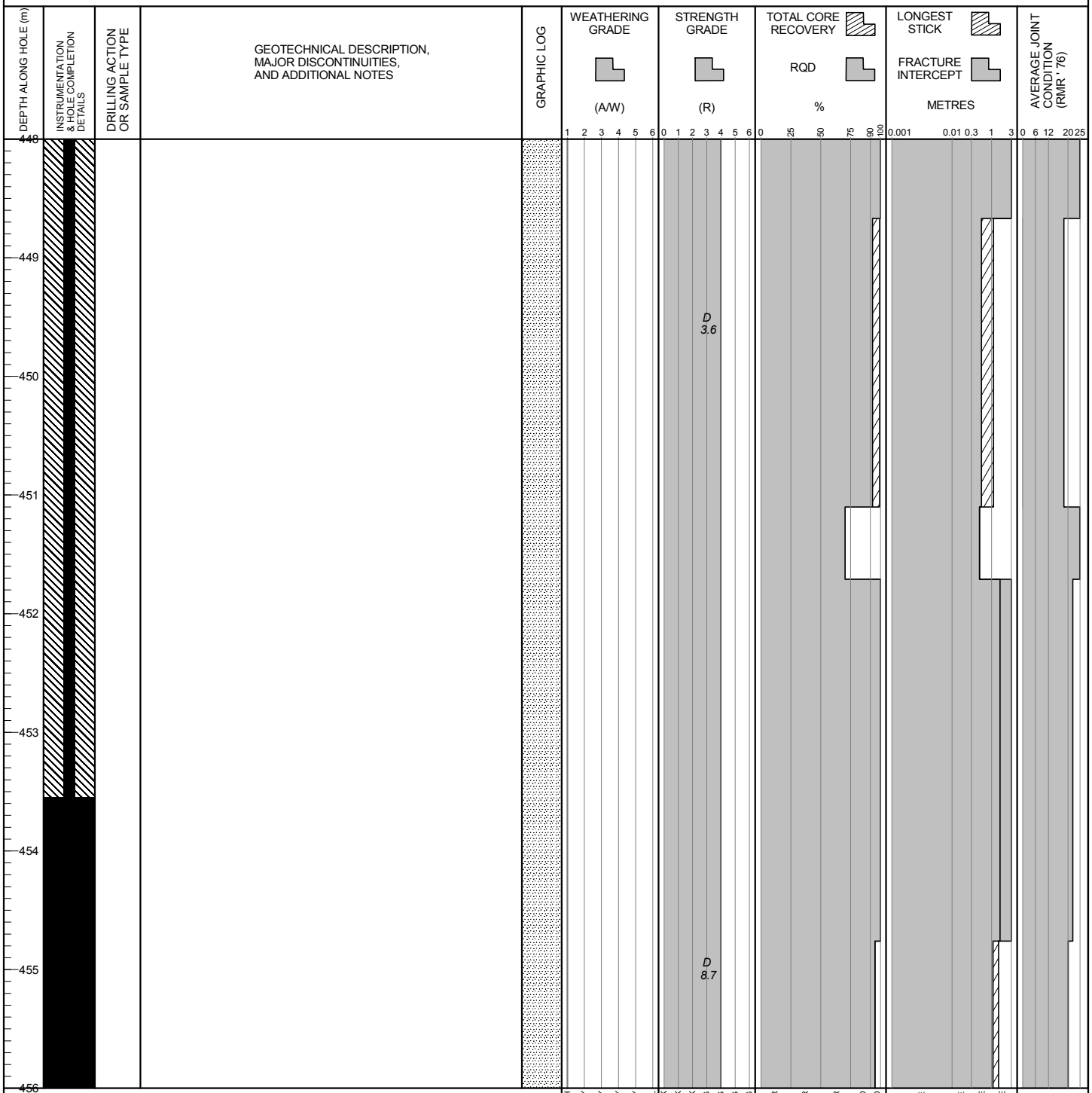
Logged By: LL/LH
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

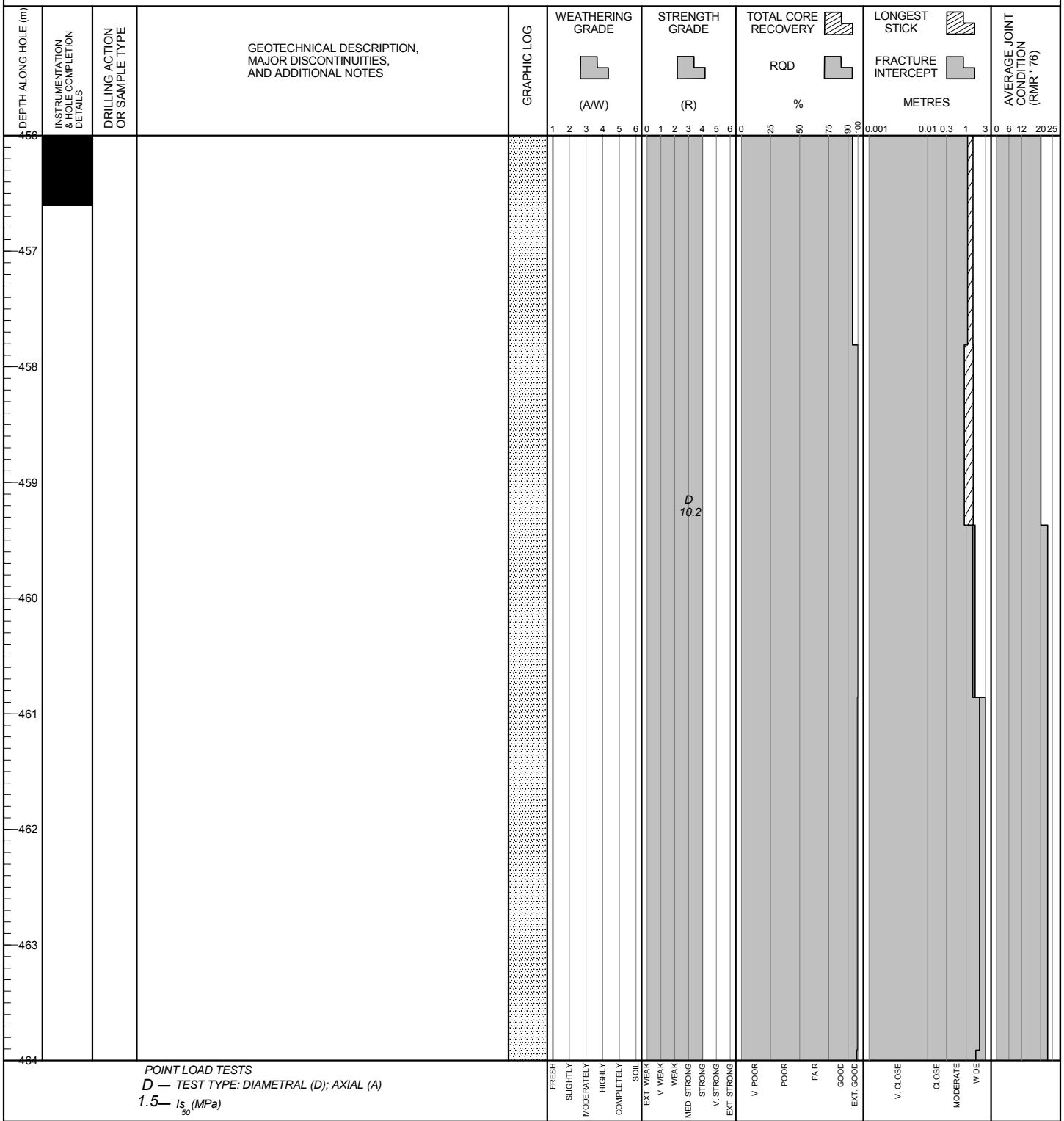
Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
464					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
465									
466									
467						D 8.6			
468						D 4.2			
469									
470						D 7.3			
471									
472									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

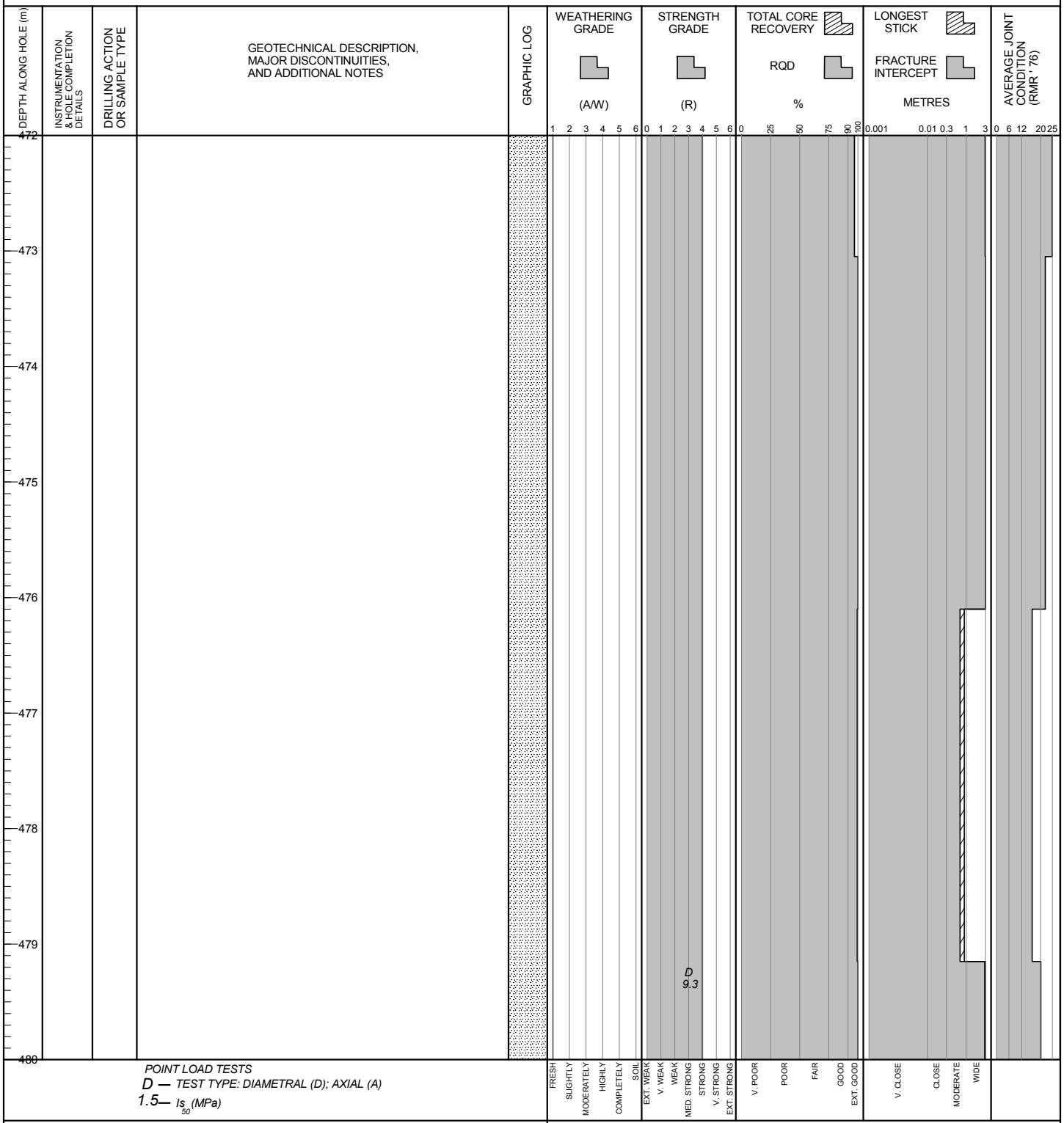
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	***Drill Designation:*** Heliportable	***Start Date:*** 11 Apr 12
Ground Elevation (m): 1,539.8	***Drilling Contractor:*** Radius	***Finish Date:*** 25 Apr 12
Survey Method: Surveyed	***Drill Method:*** Diamond	***Final Depth (m):*** 585.8
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 2.3
Plunge (°): -75	***Fluid:*** Polymer	***Logged By:*** LL/LH
Trend (°): 036	***Cased To (m) :*** 2.3	***Reviewed By:*** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

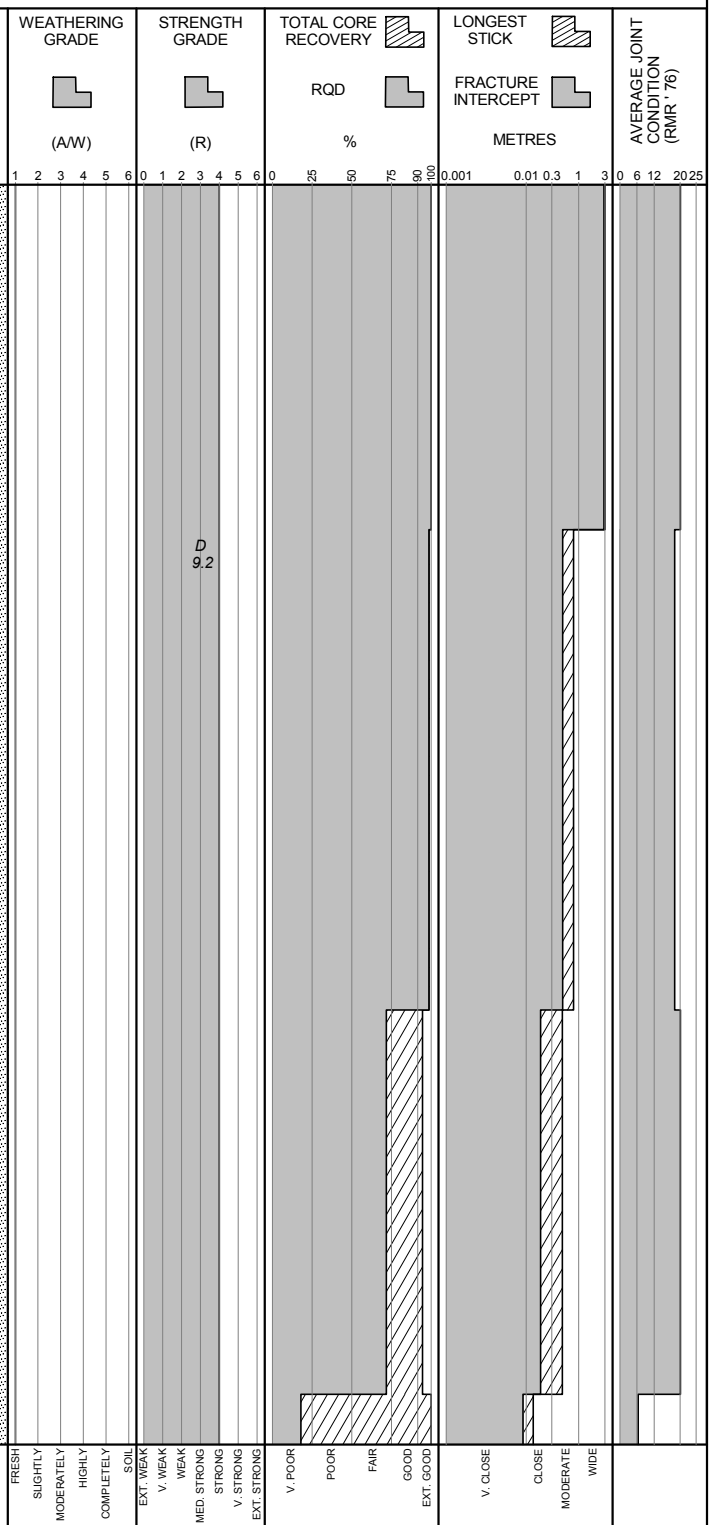
Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
480			
481			
482			
483			
484			
485			
486			
487			486.9 m: Fault, 20 mm FB infill, R4. JRC = 15. Dip/dip direction = 84/207. 487.2 m: Fault, 10 mm FB infill, R2. JRC = 13. Dip/dip direction = 9/055. 487.8 m: Fault.
488			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

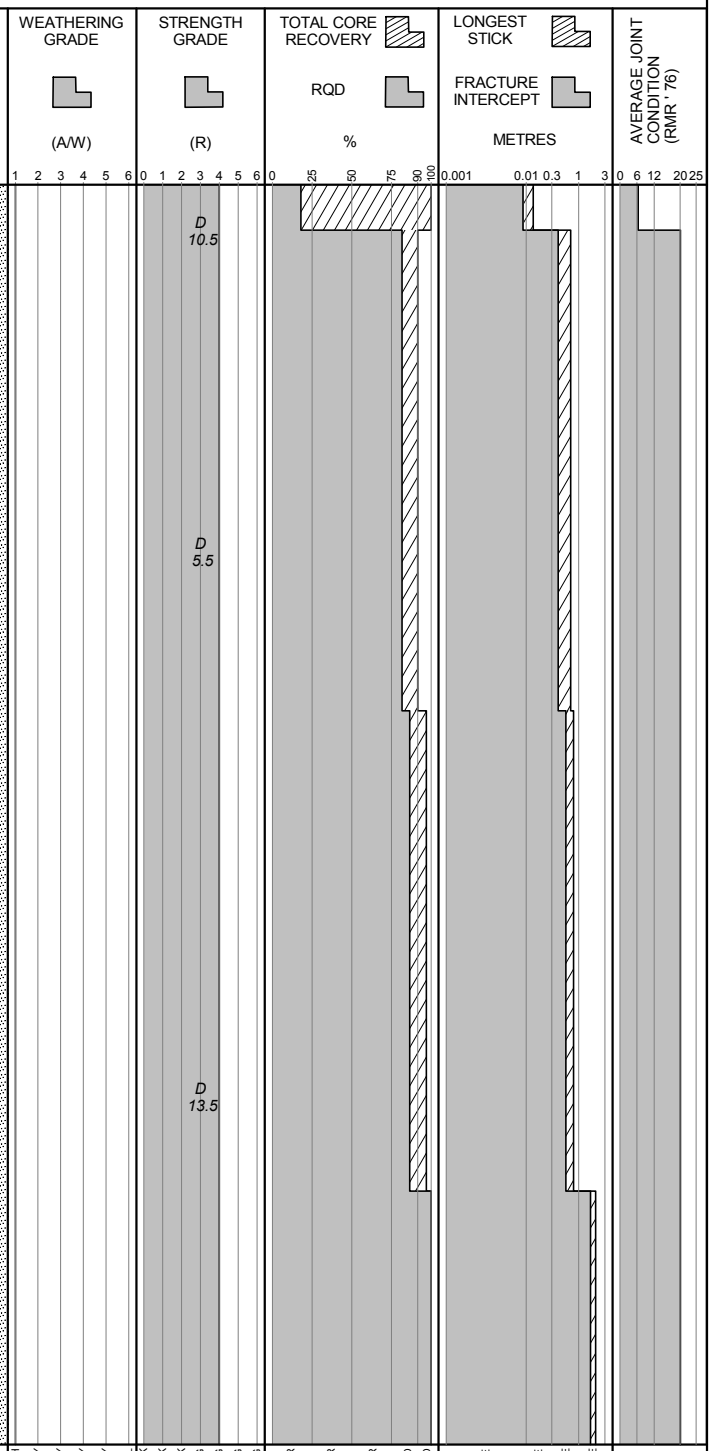
Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
488			487.9 m: Fault, 2 mm BX infill, R4. JRC = . Dip/dip direction = 47/210. 488.1 m: Fault, 20 mm BX/CX infill. JRC = 13. 488.2 m: Fault, 10 mm FG/FB infill, R0. JRC = . Dip/dip direction = 41/188.
489			
490			
491			
492			
493			492.8 m: Fault, 1.5 mm BX/FG infill. JRC = 12. Dip/dip direction = 81/059.
494			
495			
496			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
496					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
497									
498									
499									
500						D 12.3			
501									
502									
503									
504					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

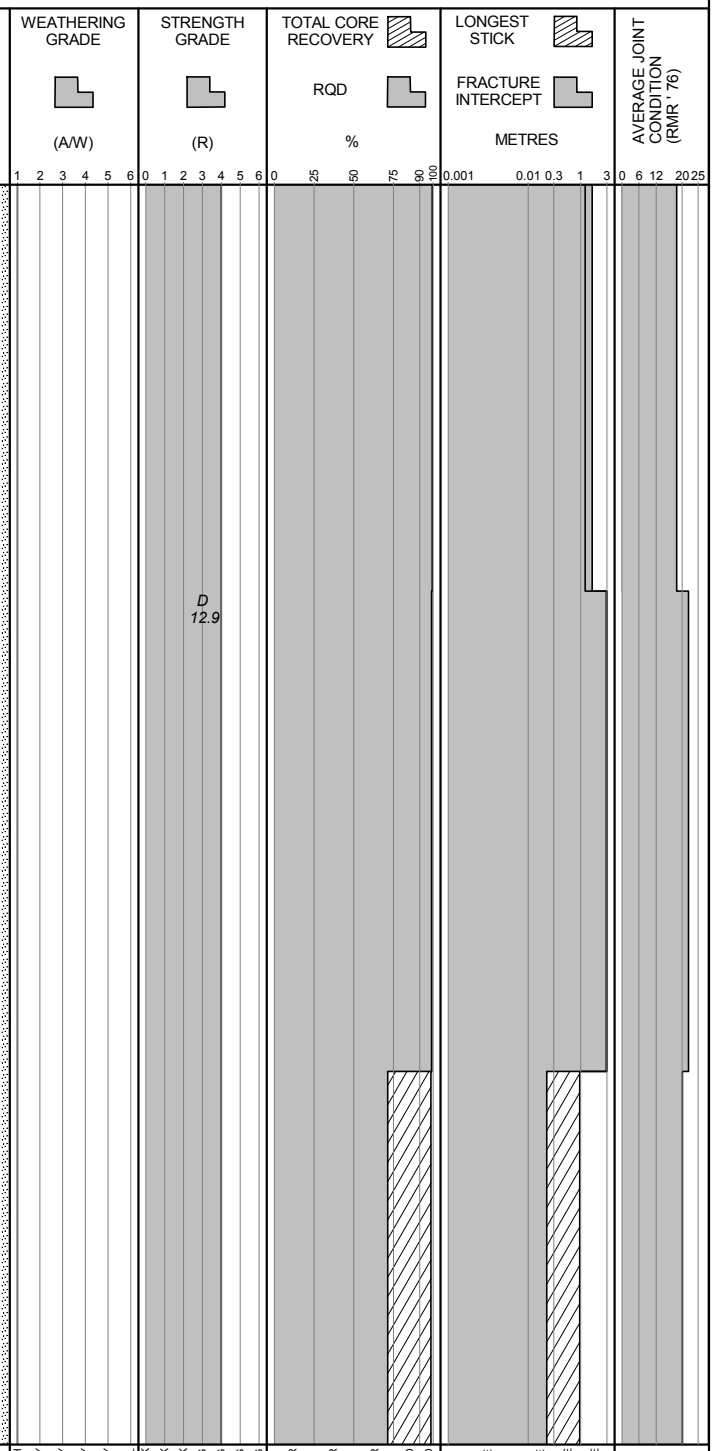
Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
504			
505			
506			
507			
508			
509			
510			
511			511.1 m: Fault, 40 mm FB infill, R2. 511.5 m: Fault, 50 mm FB infill, R2. 511.5 m: Fault, 80 mm FB infill, R4. JRC = 13. Dip/dip direction = 60/266.
512			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

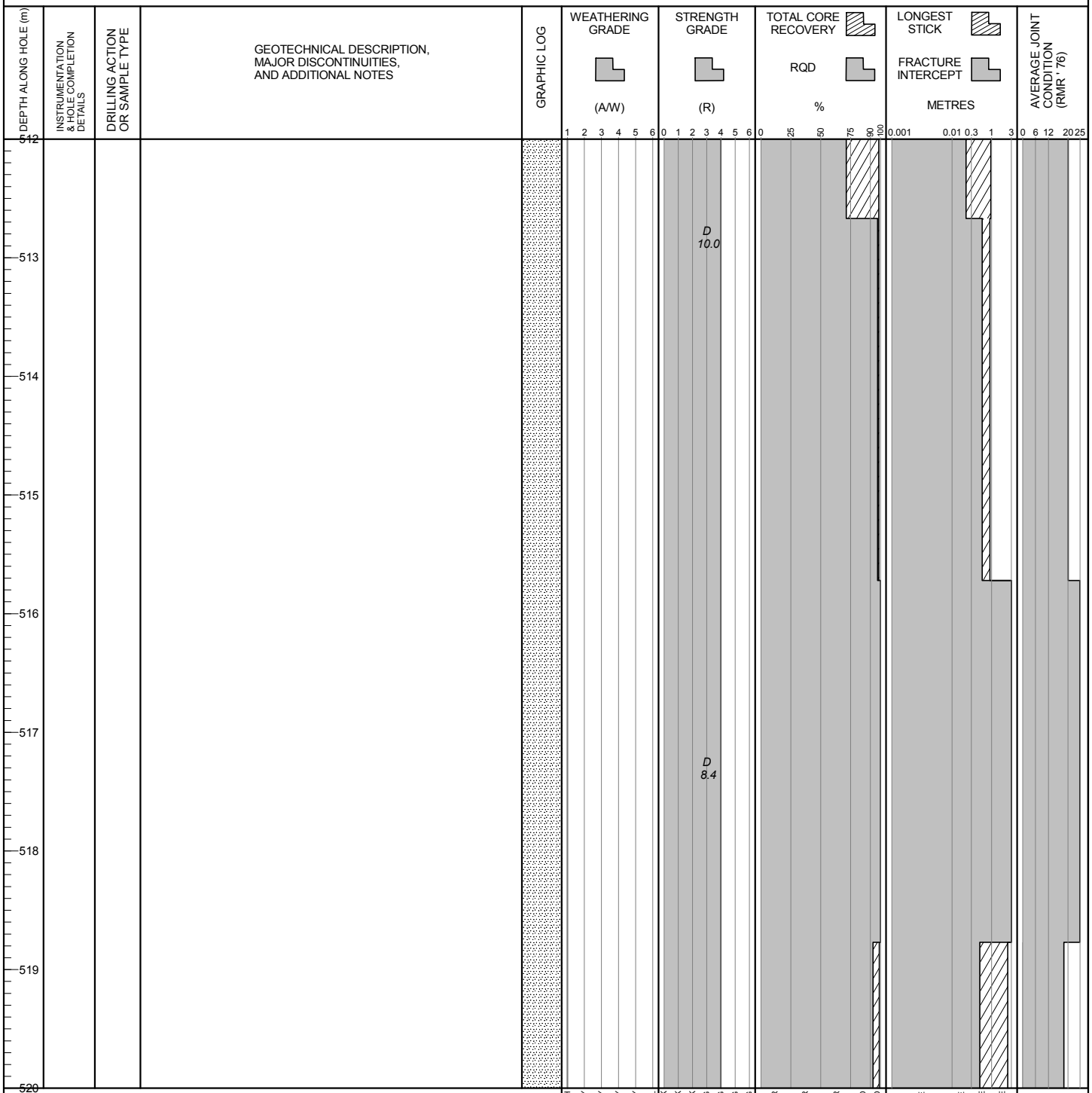
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N	**Drill Designation:** Heliportable	**Start Date:** 11 Apr 12
Ground Elevation (m): 1,539.8	**Drilling Contractor:** Radius	**Finish Date:** 25 Apr 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 585.8
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** LL/LH
Trend (°): 036	**Cased To (m) :** 2.3	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
520					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
521									
522									
523									
524			CONGLOMERATE (S3) Grey-green, pebble rich conglomerate with altered clasts, surficial weathering in the form of anchorite. Pyrite-calcite replaced concretions present. Strong (R4). Fresh (A1).			D 7.9			
525									
526									
527									
528						D 5.6			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
528									
529									
530			ARENITE (S4) Grey-green, interbedded sericite altered sandstone with coarse conglomerate. Strong (R4). Fresh (A1).			D 4.3			
531									
532			532.5 m: Shear on vein, 1.5 mm CX infill, R. JRC = 12.			D 9.9			
533			533.4 m: Shear, 0.5 mm aperture. JRC = 15.						
534									
535									
536									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
536									
537									
538									
539						D 3.7			
540			540.1 m: Shear on contact. JRC = 13.						
541									
542									
543						D 10.2			
544									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

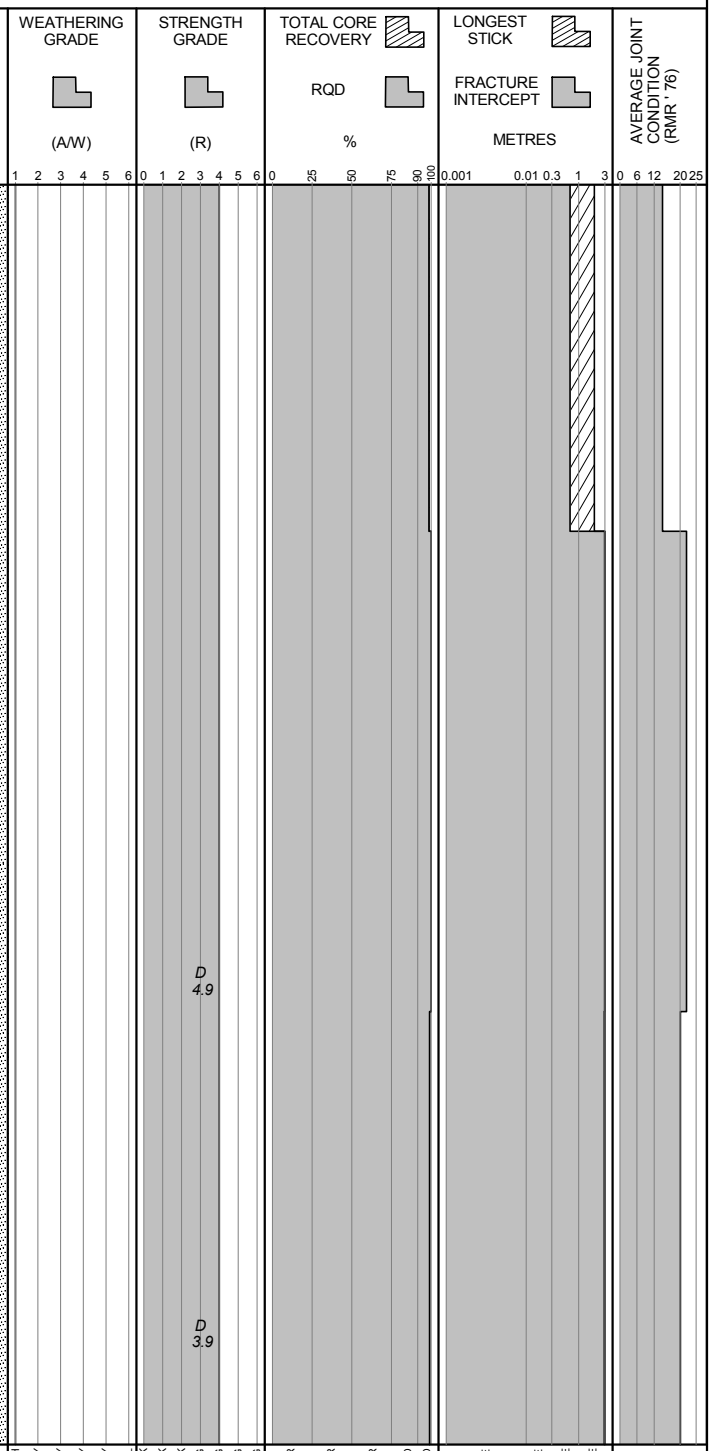
Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
544			
545			
546			
547			
548			548.3 - 553.8 m: Stockwork sections with vein breccia texture, mostly unmineralizled, but some pyrite.
549			
550			
551			
552			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
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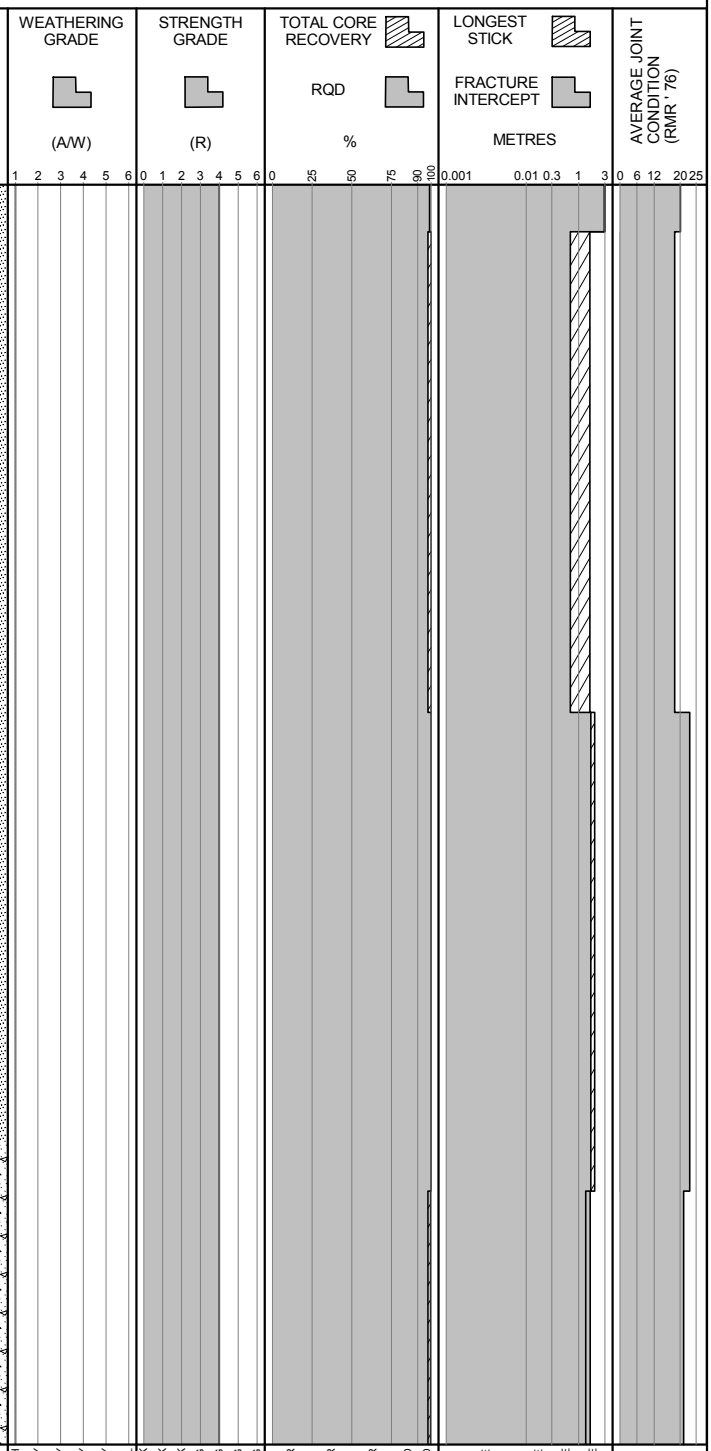
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
552									
553			553.8 m: Some calcite-pyrite concretions.						
554									
555									
556			556.6 m: Shear on vein, 1 mm CA infill, R3. JRC = 12.						
557									
558			CONGLOMERATE (S3) Grey-green, sericite-chlorite replacement clasts in matrix supported conglomerate. Strong (R4). Fresh (A1).						
559			558.9 m: Shear on vein, 1 mm BX infill, R4. JRC = 20. Dip/dip direction = 81/289.						
560									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
560			560.2 m: Shear on vein, 0.5 mm aperture. JRC = 8.
561			
562			ARENITE (S4) Grey-green, fine grained sericite altered sandstone, grades into a coarse grained conglomerate. Strong (R4). Fresh (A1). 562.2 m: Shear on vein, 1 mm aperture. JRC = 13. Dip/dip direction = 67/288. 562.3 m: Shear on vein, 1 mm aperture. JRC = 20. 562.4 m: Shear, 0.5 mm aperture. JRC = 8.
563			563.3 m: Shear on vein, 2 mm CA infill, R4. JRC = 20.
564			
565			CONGLOMERATE (S3) Grey-green, sericite altered conglomerate with sericite and chlorite replaced clasts, some clasts up to 2 cm diameter. Strong (R4). Fresh (A1).
566			
567			ARENITE (S4) Grey-green, sericite altered sandstone, very sparse veining, chalcopyrite in quartz vein, pyrite-calcite replacement concretions. Strong (R3.35-R4). Fresh (A1). 566.9 m: Shear, 0.5 mm aperture. JRC = 12. 567 m: Shear, 0.5 mm aperture. JRC = 8.
568			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

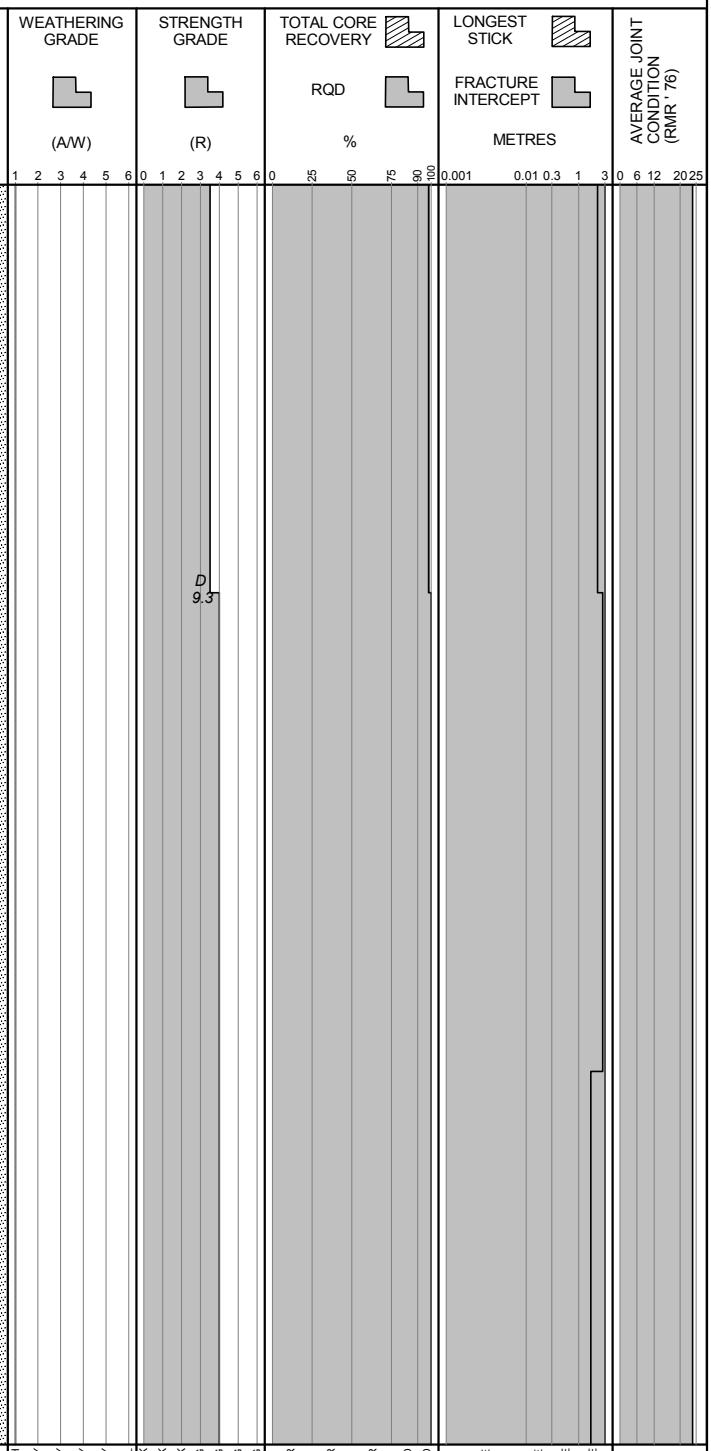
Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
568			568.4 m: Shear on vein, 0.5 mm QZ/CA infill, R4. JRC = 8.
569			
570			570.2 m: Shear on vein, 0.5 mm CA infill, R4. JRC = 8.
571			
572			
573			
574			
575			575.2 m: Shear on vein, 1 mm CA infill, R4.
576			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-22

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
576					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
577						D 3.6			
578									
579									
580									
581						D 9.0			
582									
583									
584					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-22

Location: Valley of Kings Zone

Co-ordinates (m): 426,481E - 6,257,936N
Ground Elevation (m): 1,539.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 036

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.3

Start Date: 11 Apr 12
Finish Date: 25 Apr 12
Final Depth (m): 585.8
Depth To Top Of Rock (m): 2.3
Logged By: LL/LH
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
584					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
585									
586			END OF DRILLHOLE AT 585.8 m Notes: 1. Two vibrating wire piezometers installed at 95.7 m and 447.9 m.						
587									
588									
589									
590									
591									
592									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN No Recovery.
1						
2						Rock encountered at 2.0 m depth. Refer to DH-BGC12-23 rock log.
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

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Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
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Final Depth (m): 566.0
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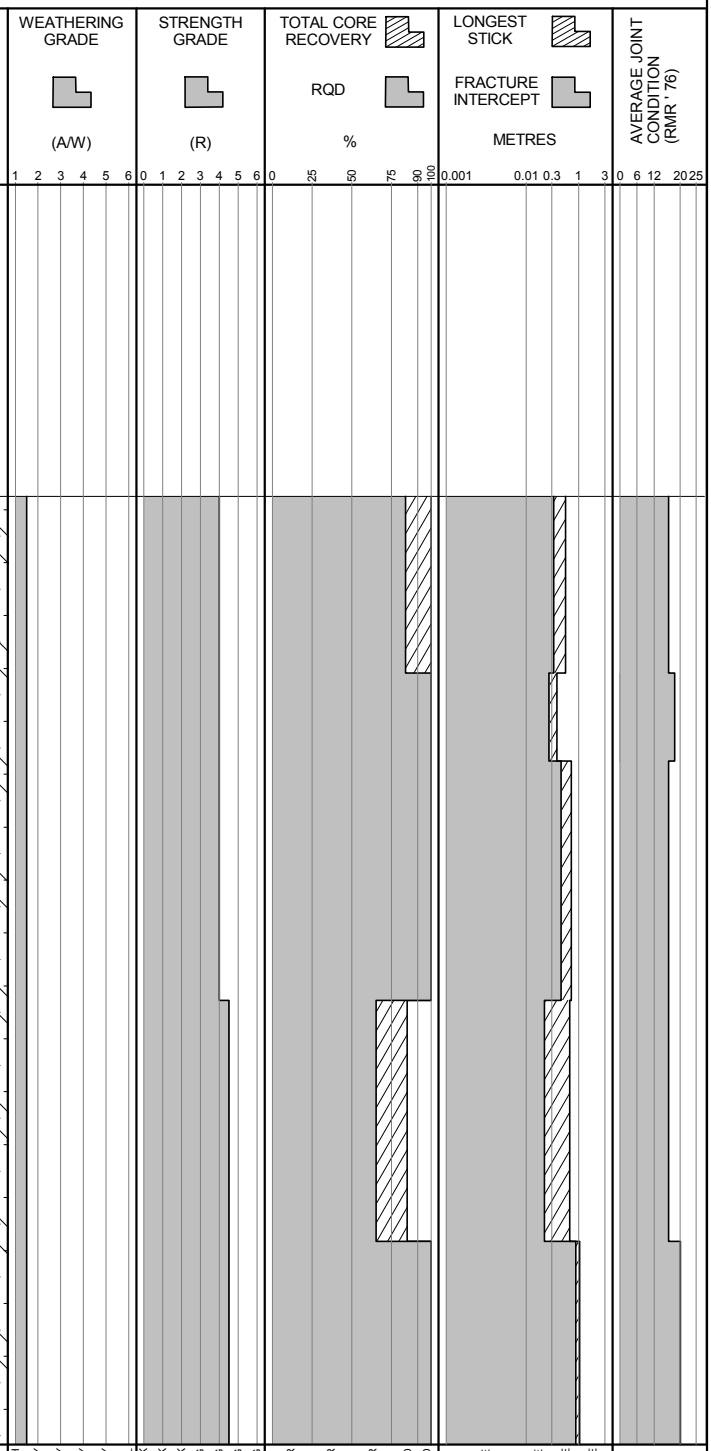
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0–1			Refer to DH-BGC12-23 Overburden Log						
2–8			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Grey, homogeneous, crystals often sericite or chlorite altered and often pyrite replaced. Strong to very strong (R4-R5). Slight to faint weathering (W1-W1.5) on major discontinuities. 4.7 m: Shear, 0.5 mm FE infill, R2. JRC = 12.						



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

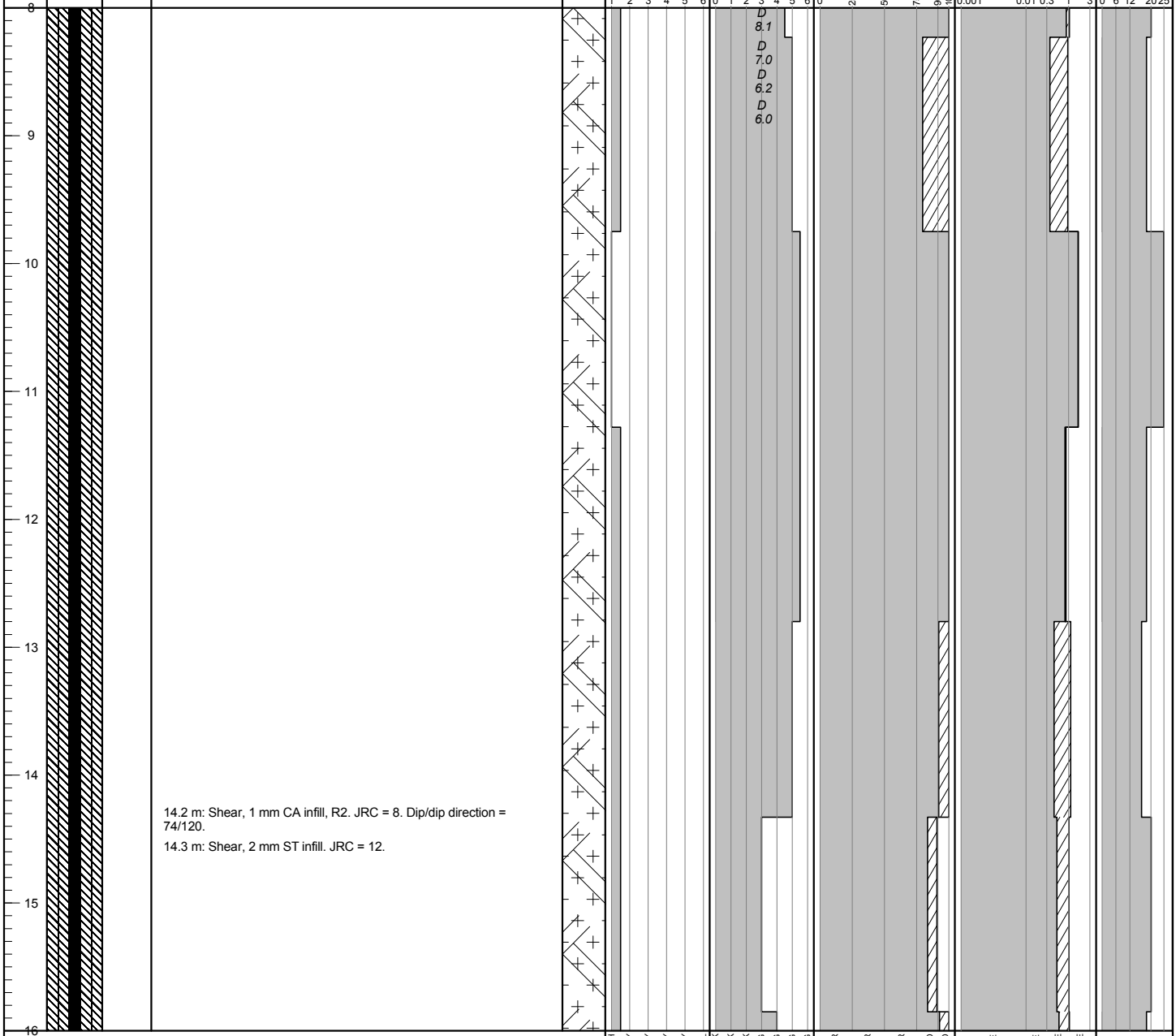
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
16						D 4.3			
17									
18									
19						D 5.7			
20			20 m: Fault, 0.5 mm aperture. JRC = 12.						
21									
22						D 5.8 D 7.0			
23						D 6.5 D 9.1			
24									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

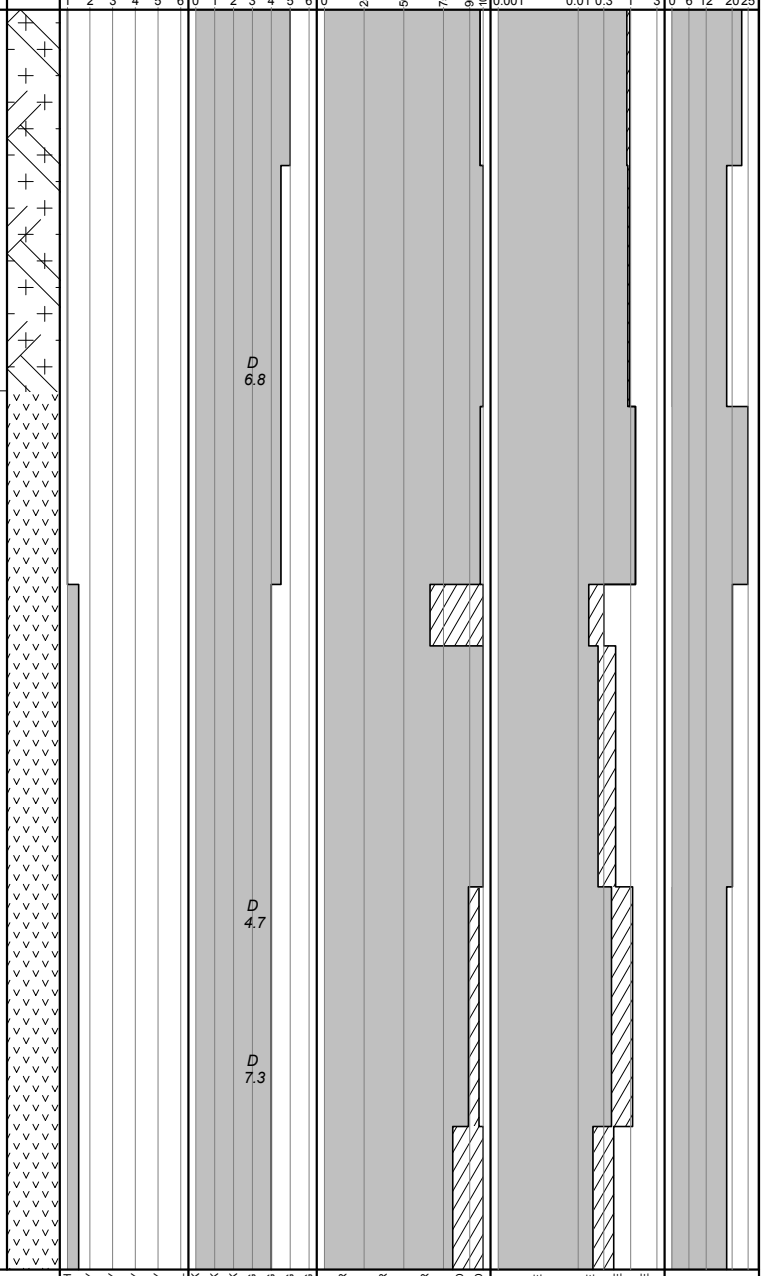
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
24			
25			
26			
			QUARTZ SULPHIDE VEIN (H4) White, contains abundant mm-scale fractures and vugs with abundant pyrite, sphalerite, galena, chalcopyrite and acanthite infill. Contains minor P1 wall rock fragments near contacts. Strong to very strong (R4-R4.5). Slight to faint weathering (W1-W1.5) on major discontinuities.
27			
28			
29			
30			
31			
32			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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DRILL HOLE # DH-BGC12-23

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Drill Designation: Heliportable
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
32				
33				
34			34.4 m: Fault, 1 mm FE infill, R4. JRC = 15. Dip/dip direction = 13/026.	
35				
36			36.6 m: Shear, 0.5 mm FE infill, R2. JRC = 13.	
37			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Grey-green, relatively homogenous volcanics with phenocrysts often sericite or chlorite altered and pyrite replacement. Base metal sulphides and silver veins <1m continue until 61.90m. Strong to very strong (R4-R5). Slight to faint weathering (W1-W1.5) on major discontinuities above 47.9 m. Fresh (A1) below 47.9 m.	
38				
39				
40				

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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DRILL HOLE # DH-BGC12-23

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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
40			40.4 m: Shear, 1 mm aperture. JRC = 20.						
41						D 1.2			
42									
43									
44									
45			45 m: Shear, 1 mm aperture. JRC = 12.						
46						D 4.8 D 6.2 D 5.0 D 5.7			
47									
48									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

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LOG SCALE: 1:50

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
48									
49			48.8 m: Shear on vein, 110 mm BX infill. JRC = 15.						
			49.6 m: Fault, 100 mm BX infill. JRC = 8. Dip/dip direction = 87/060.			D 7.1			
50									
51									
52									
53									
54									
55									
56									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

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Drill Method: Diamond
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Fluid: Polymer
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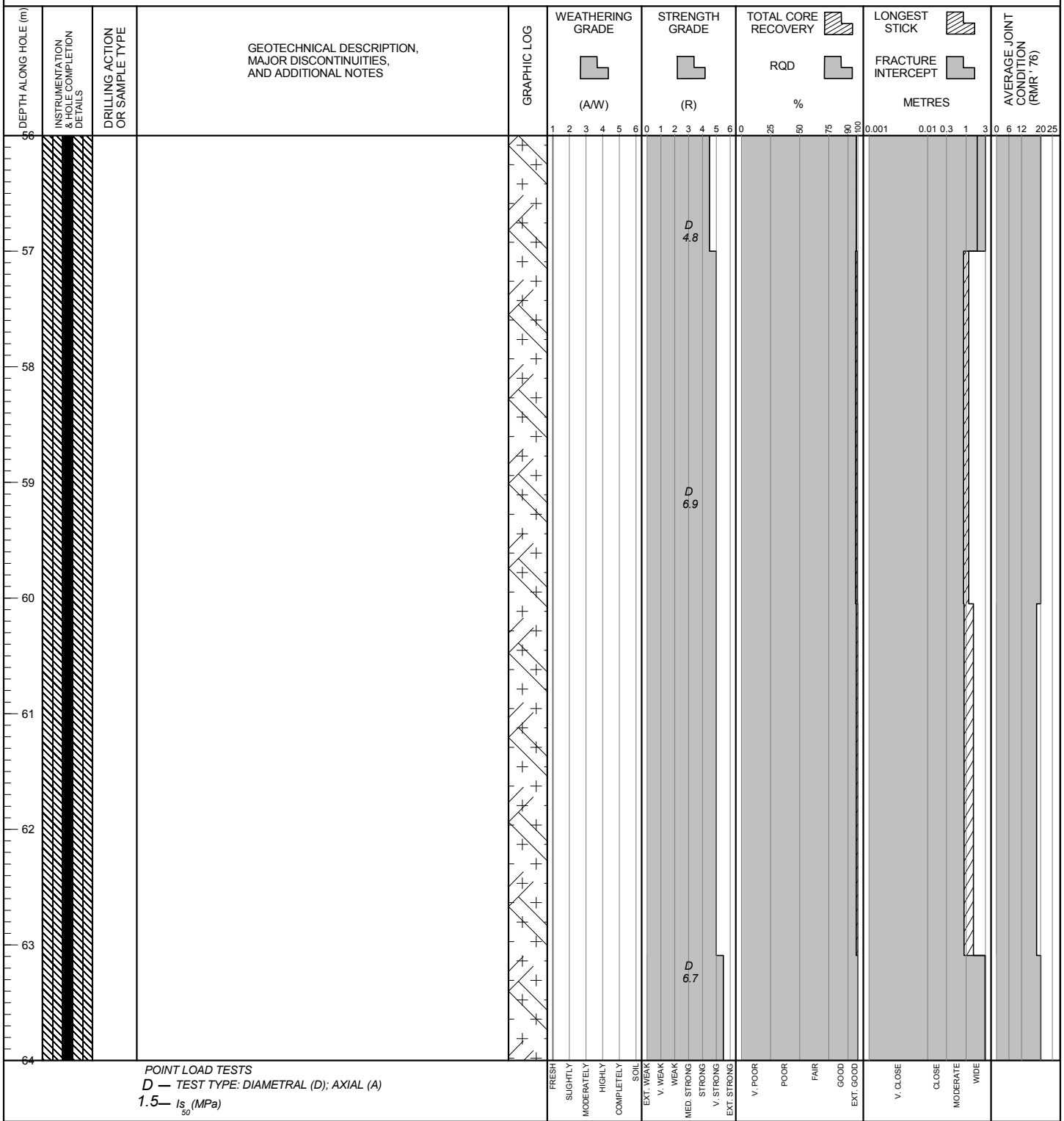

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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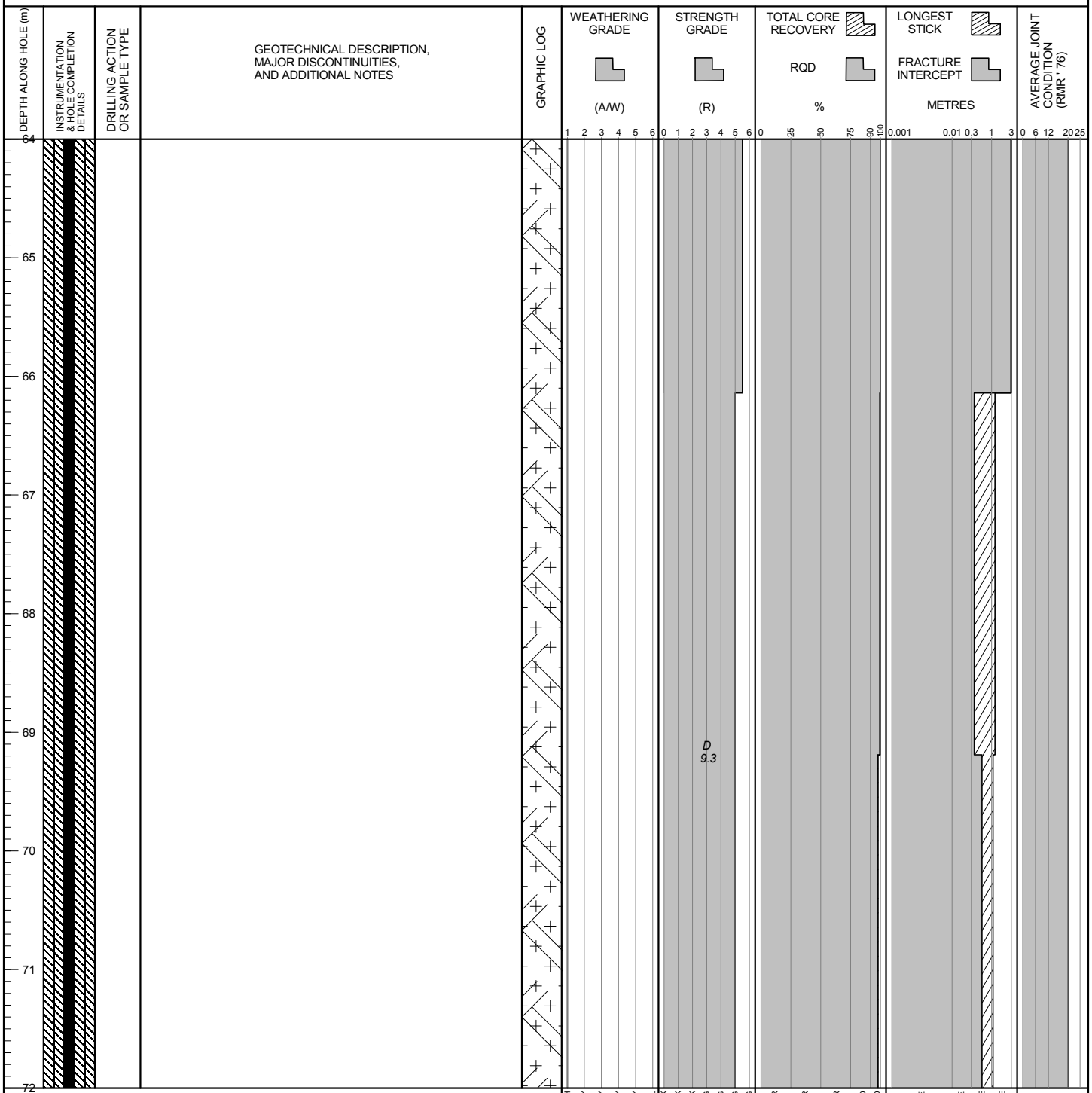
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
72									
73									
74									
75									
76			76.2 m: Shear on vein, 0.5 mm CA infill, R4. JRC = 4.			D 6.7			
77									
78						D 9.3			
79									
80									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

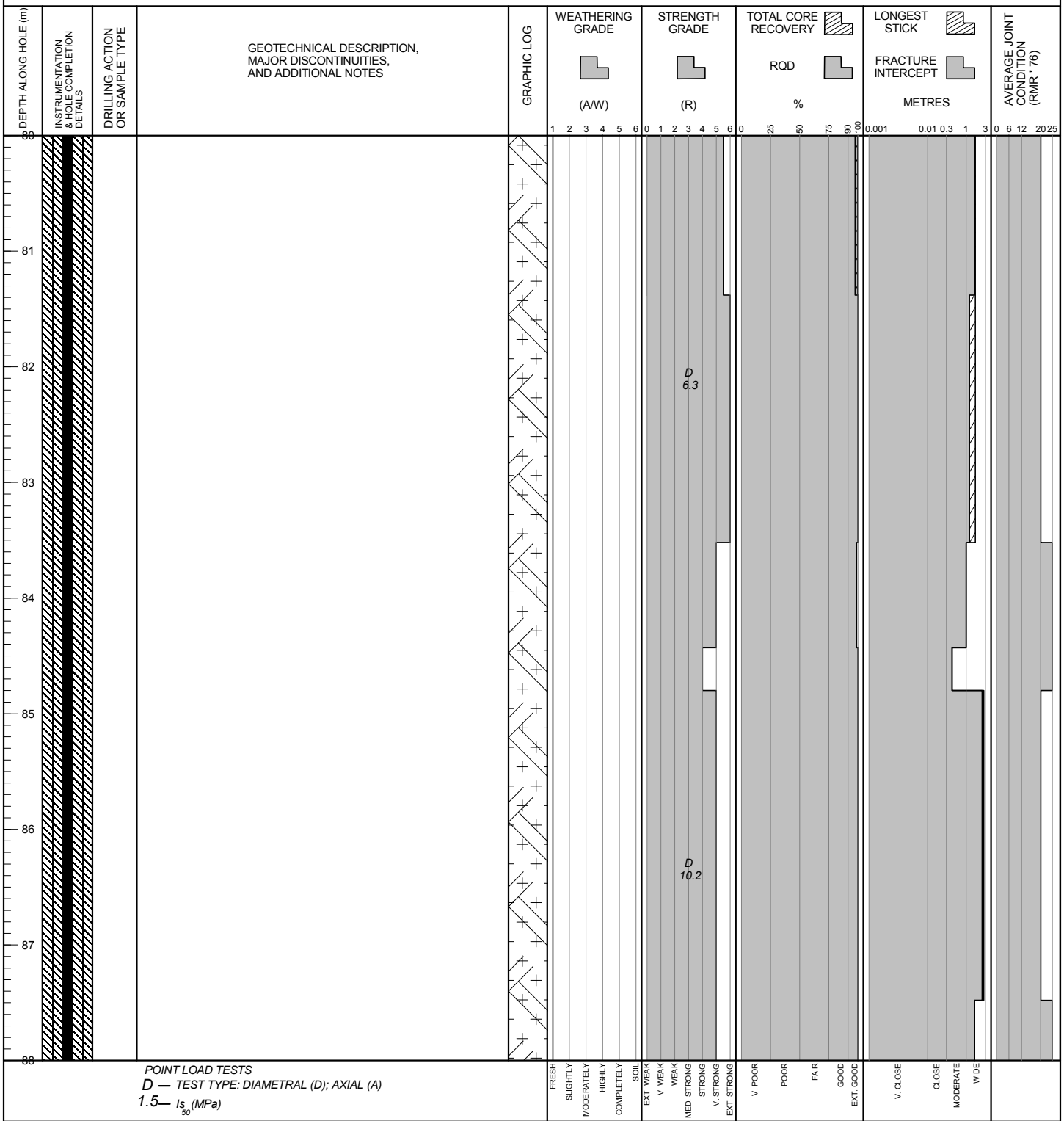
Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

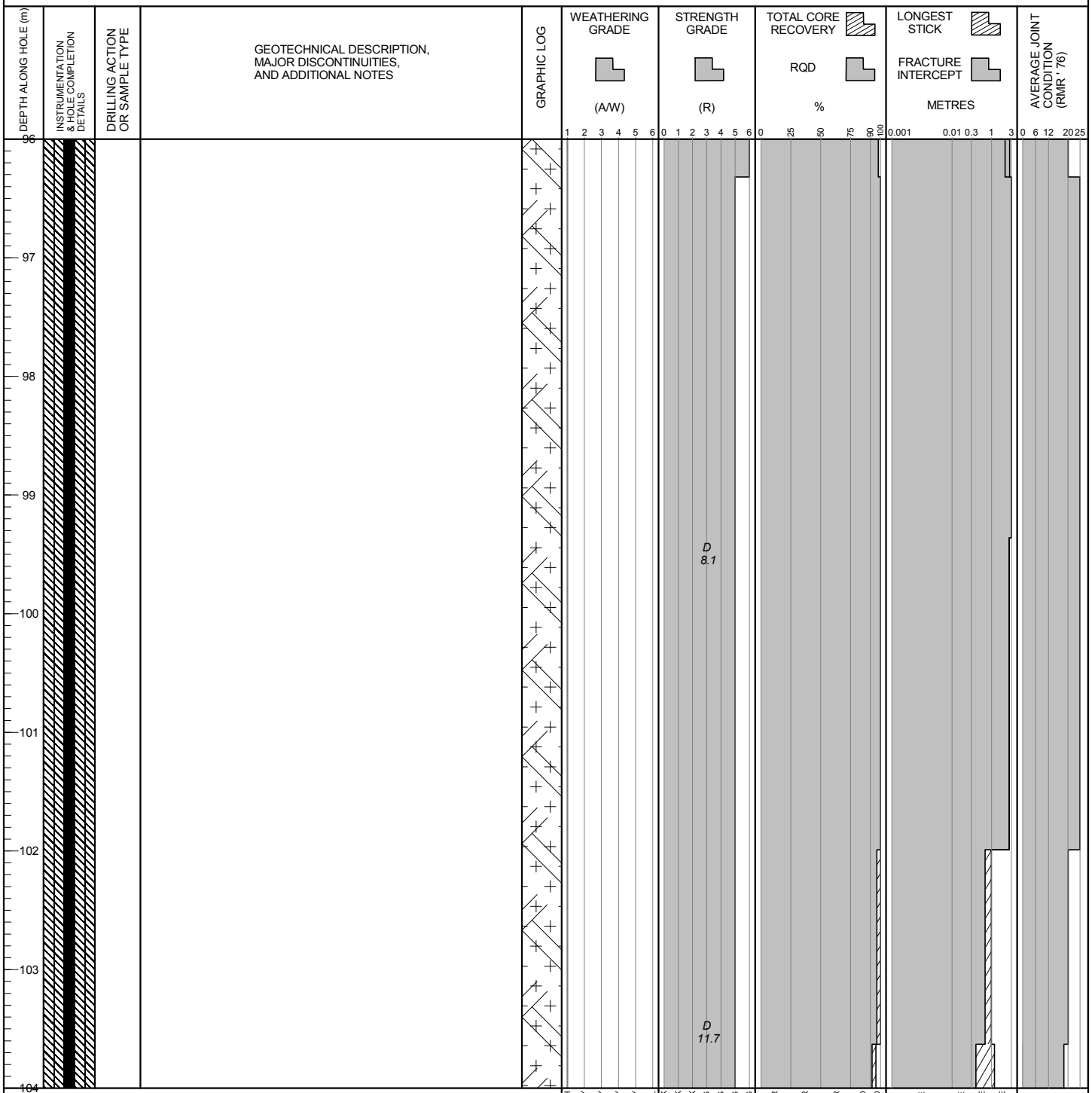
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

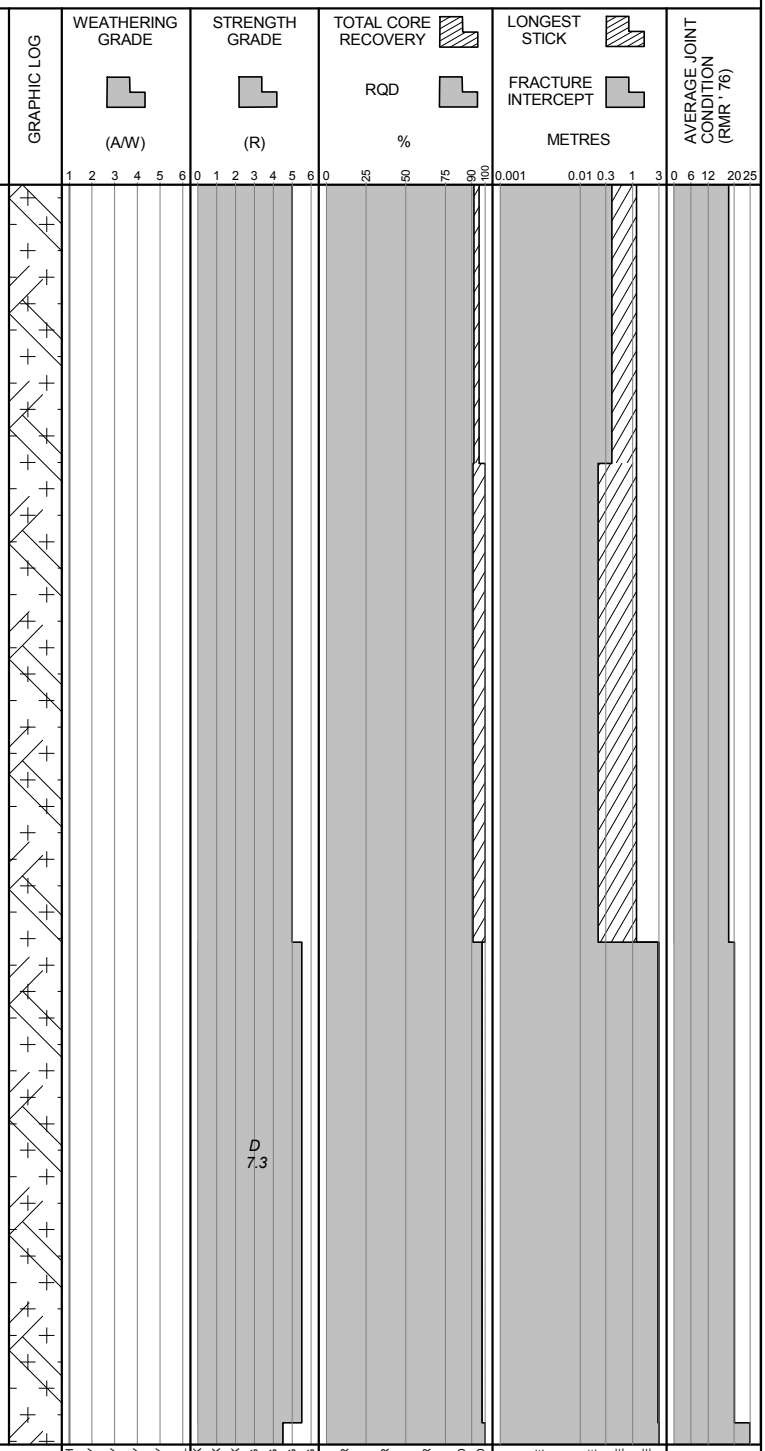
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
104			
			104.5 m: Shear, 1 mm aperture. JRC = 8.
105			
106			
107			
108			108 m: Shear, 1 mm SE infill, R2. JRC = 13.
109			
110			
111			
112			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

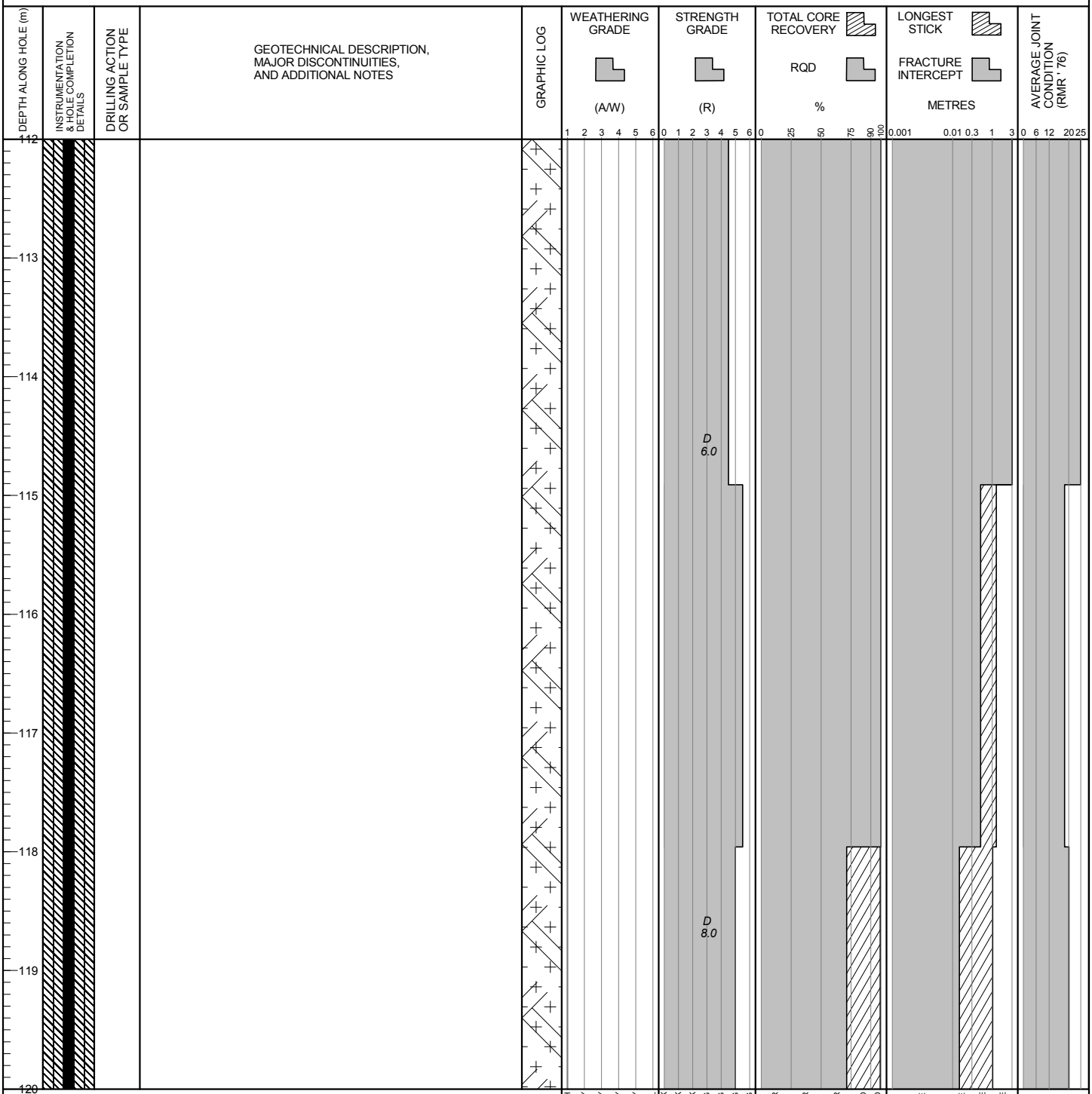
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

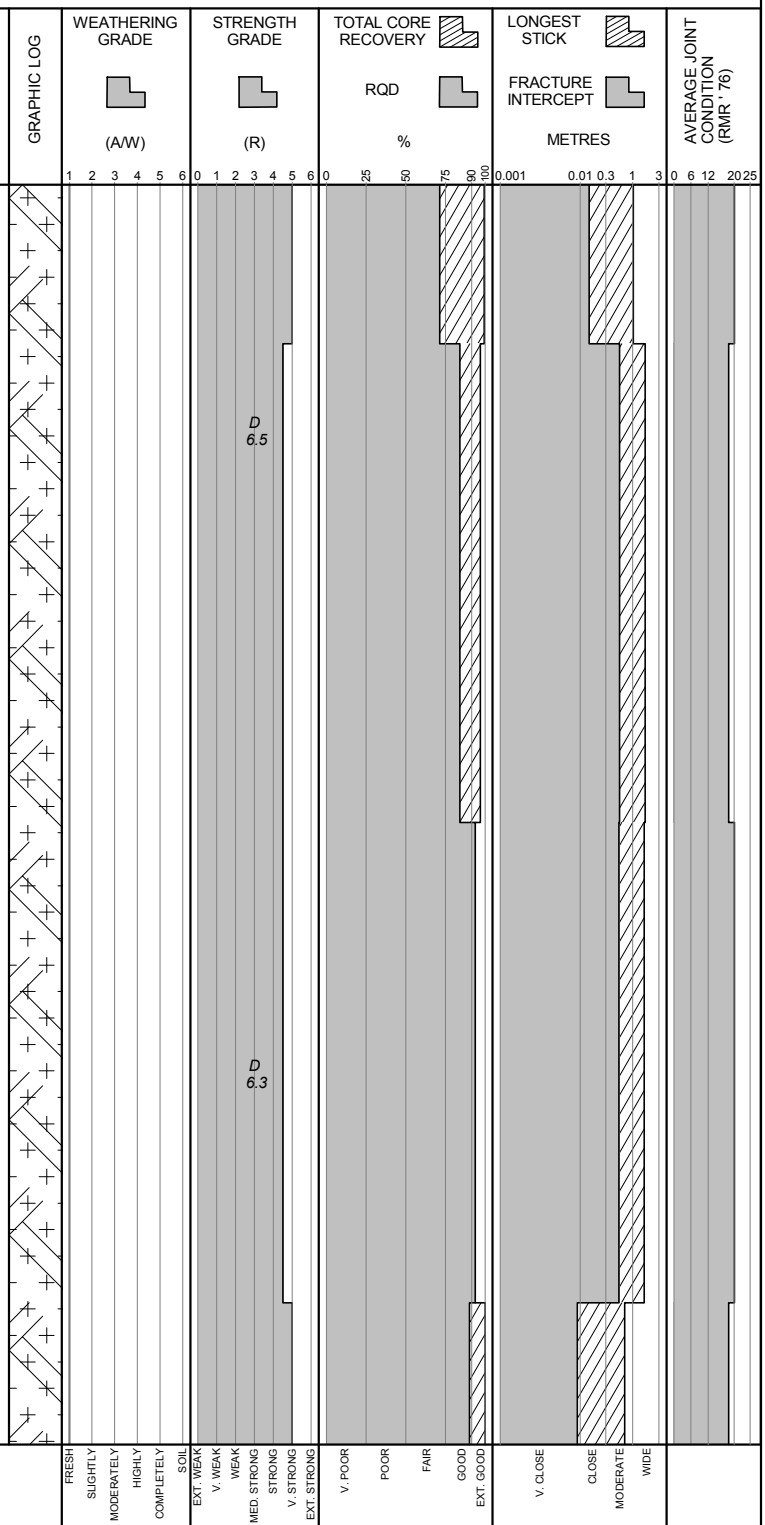
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
120			120 m: Shear on vein, 0.5 mm CA infill. JRC = 13.
121			
122			
123			
			123.7 m: Shear, 250 mm BX infill. JRC = 4. Dip/dip direction = 70/194.
124			
125			
126			
127			
			127.5 m: Shear, 60 mm BX infill. JRC = 12. Dip/dip direction = 79/193.
128			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

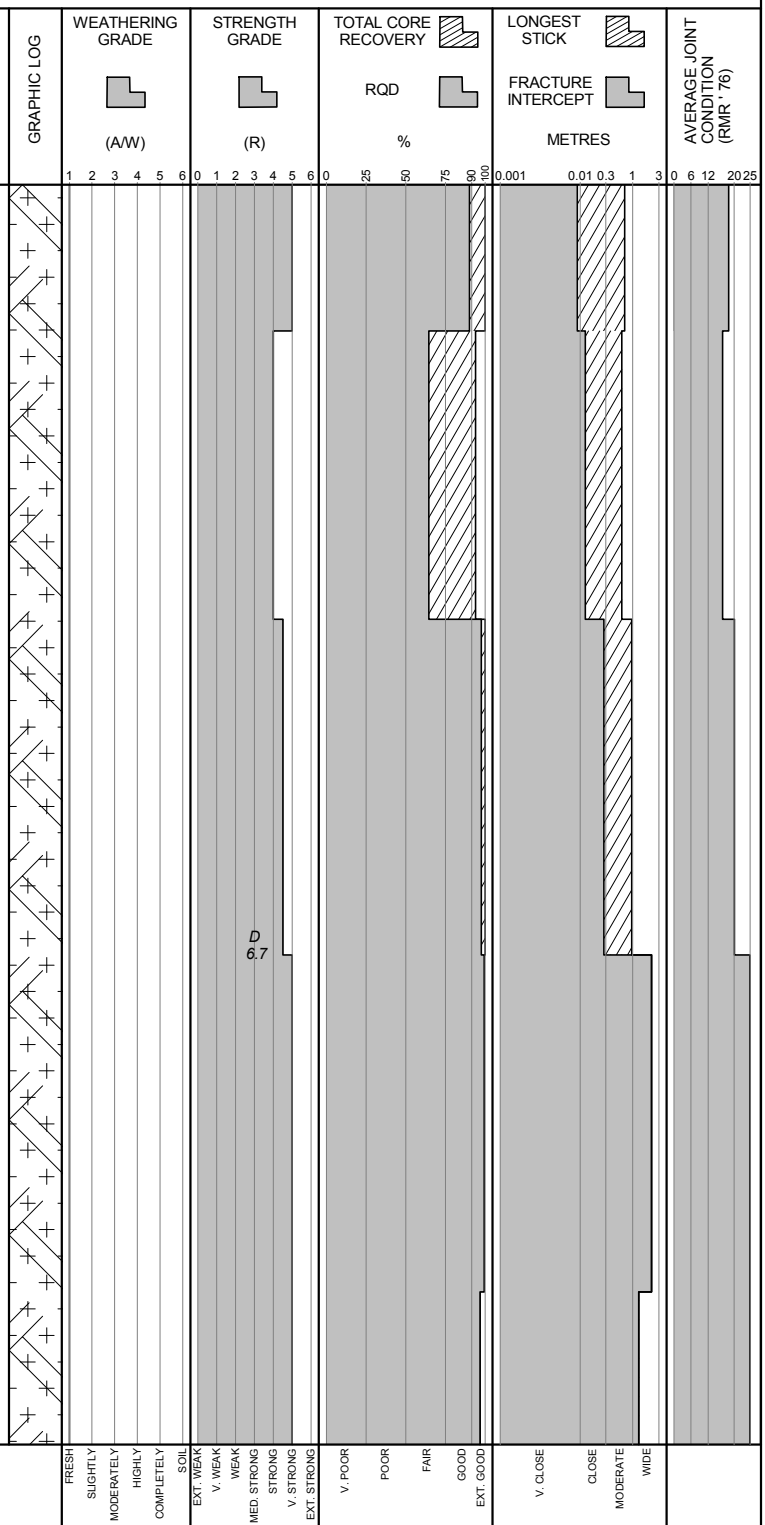
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
128			
129			128.9 m: Fault, 180 mm FG infill, S4. JRC = 12. Dip/dip direction = 55/212.
			129.4 m: Shear, 0.5 mm aperture. JRC = 13.
			129.7 m: Shear, 0.5 mm aperture. JRC = 8.
130			
131			130.9 - 133.6 m: Stockwork quartz-calcite veining runs sub-parallel TCA. Stockwork contains minor sphalerite, galena, chalcopyrite and silver sulphides.
132			
133			
134			
135			
136			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
136									
137			137.2 - 142.4 m: Stockwork veining, 30-40%. Runs sub-parallel TCA. Minor base metal sulphides throughout.			D 5.7			
138						D 12.0			
139									
140									
141									
142						D 10.0			
143									
144									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
144			144.4 m: Shear, 0.5 mm aperture. JRC = 8.			D 6.9			
145									
146			146.4 - 149.1 m: Stockwork veining, 25-30%. Mostly a single vein running along core axis.			D 8.7 D 8.6 D 8.9			
147									
148									
149						D 8.4			
150									
151			150.7 m: Shear, 0.5 mm aperture. JRC = 8.						
152			151.9 m: Shear, 4 mm BX infill. JRC = 4. Dip/dip direction = 75/081.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
152			152.4 - 156.6 m: Stockwork veining, 25-30%, generally sub-parallel TCA.						
153									
154									
155						D 8.7			
156									
157									
158									
159						D 10.1			
160									

WEATHERING GRADE: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
160			160.2 - 163.7 m: Stockwork veining, 25-30%, sub-parallel TCA.			D 10.7			
161									
162									
163									
164			CONGLOMERATE (S3) Grey-green conglomerate with 10-15% stockwork veining. Contact is gradational or lost in stockwork. Intermediate volcanics clasts are far more dominant than highly siliceous clasts. Clasts often pyrite replaced. Strong to very strong (R4.5-R5). Fresh (A1).						
165									
166						D 7.1			
167									
168									

Weathering grade scale: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade scale: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
Total core recovery / RQD: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
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Plunge (°): -70
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
168									
169			168.9 m: Shear, 0.5 mm aperture. JRC = 8.						
170									
171									
172									
173									
174						D 9.9			
175									
176									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
176									
177						D 3.6			
178									
179									
180						D 9.0			
181			180.9 m: Shear, 0.5 mm aperture. JRC = 20.						
182									
183									
184									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
184									
185									
186						D 7.6			
187									
188									
189			Constant head test from 189.6 - 210 m. Estimated hydraulic conductivity is 3.8E-07 m/s.						
190						D 10.6			
191									
192									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

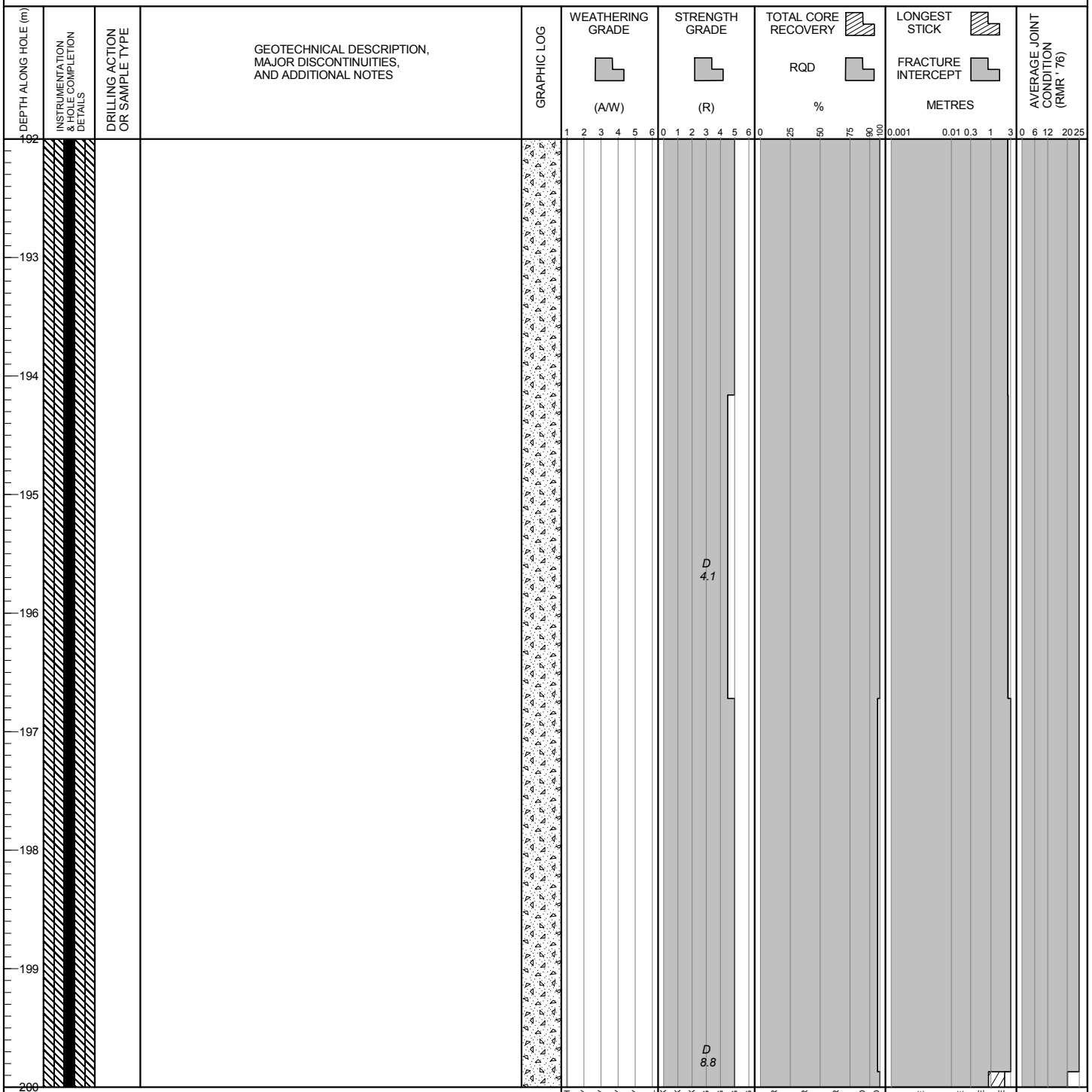
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
200									
201									
202						D 7.5 D 8.0 D 6.4			
203			202.7 m: Fault, 1 mm aperture. JRC = 12.						
204			ARENITE (S4) Green, locally bedded at 60 degrees TCA. Contains sporadic pebble sized clasts. Veining mostly sub parallel TCA. Very strong (R5). Fresh (A1).						
205									
206									
207									
208									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 % (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 METRES (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
208									
209						D 10.0			
210									
211			211.1 m: Shear, 0.5 mm aperture. JRC = 4. Dip/dip direction = 34/352. 211.1 m: Fault, 1 mm FG/CX infill, S4. JRC = 7. 211.1 m: Shear on vein, 1 mm BX infill. JRC = 4. PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Green, hornblende is chlorite altered, feldspar is sericite altered. Often pyrite replaced. Contains 10% quartz-calcite veining. Strong to extremely strong (R4-R6). Fresh (A1).			D 6.4			
212									
213			212.8 m: Shear on vein, 0.5 mm aperture. JRC = 8. 213 m: Fault on vein, 10 mm FG infill, S4. JRC = 8. Dip/dip direction = 31/215.						
214			214 m: Shear, 0.5 mm aperture. JRC = 8. 214.7 m: Fault, 8 mm FB infill, R0. JRC = 8.						
215			215.2 m: Water pumped down hole for 5-10 minutes to get tube to lock. High conductivity zone suspected.						
216									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
216			
217			217.1 m: Shear, 0.5 mm aperture. JRC = 6.
218			218.3 m: Shear, 0.5 mm CA infill, R2. JRC = 12.
			218.7 m: Shear, 0.5 mm CA infill, R2. JRC = 13.
219			219.1 m: Shear, 0.5 mm aperture. JRC = 4.
			219.6 m: Shear, 0.5 mm aperture. JRC = 13. Dip/dip direction = 70/194.
220			
			220.5 m: Shear, 0.5 mm aperture. JRC = 8.
			220.7 m: Fault, 19 mm FB infill, R0. JRC = 2.
221			
			221.2 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 70/057.
222			
223			222.9 m: Shear on vein, 0.5 mm aperture. JRC = 4. Dip/dip direction = 62/171.
224			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 7.4

D 9.2

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

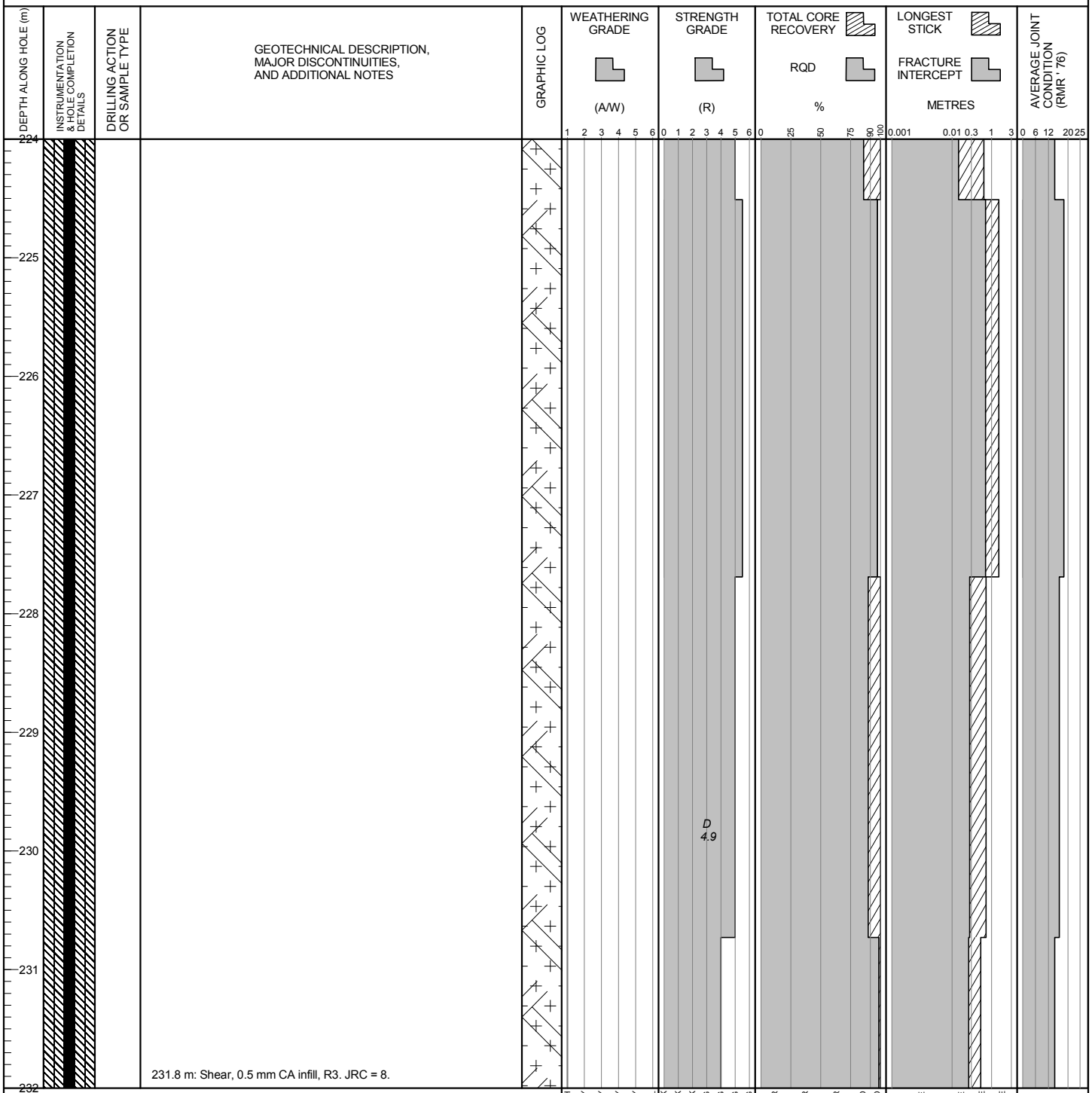
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

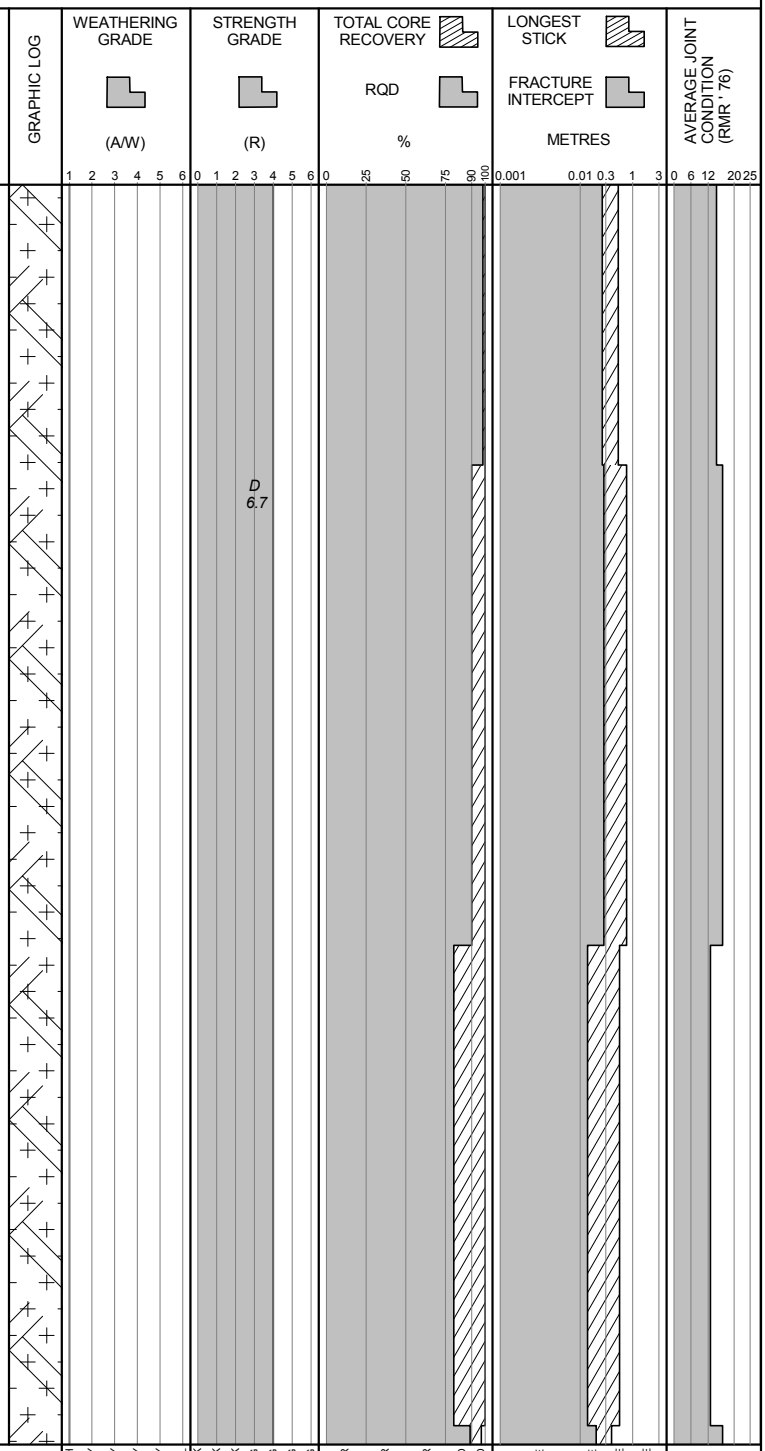
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
232			232.0 m: Shear on vein, 3 mm BX infill. JRC = 2.
			232.6 m: Shear on vein, 0.5 mm aperture. JRC = 8.
233			233.1 m: Shear, 0.5 mm aperture. JRC = 2.
			233.7 m: Shear, JRC = 1.
234			234.1 m: Shear, 0.5 mm aperture. JRC = 1.
			234.1 m: Shear on vein, 0.5 mm aperture. JRC = 3.
			234.2 m: Shear, 1 mm CA infill, R3. JRC = 20.
			234.4 m: Shear, 3 mm BX infill. JRC = 4.
			234.5 m: Shear, 1 mm aperture. JRC = 15.
235			
236			
237			
			237.6 m: Shear, 1 mm CA infill, R4. JRC = 8.
238			
			238.3 m: Shear, 0.5 mm aperture. JRC = 15.
			238.5 m: Shear, 0.5 mm CA infill, R4. JRC = 2.
239			
			239.2 m: Shear, JRC = 1.
240			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

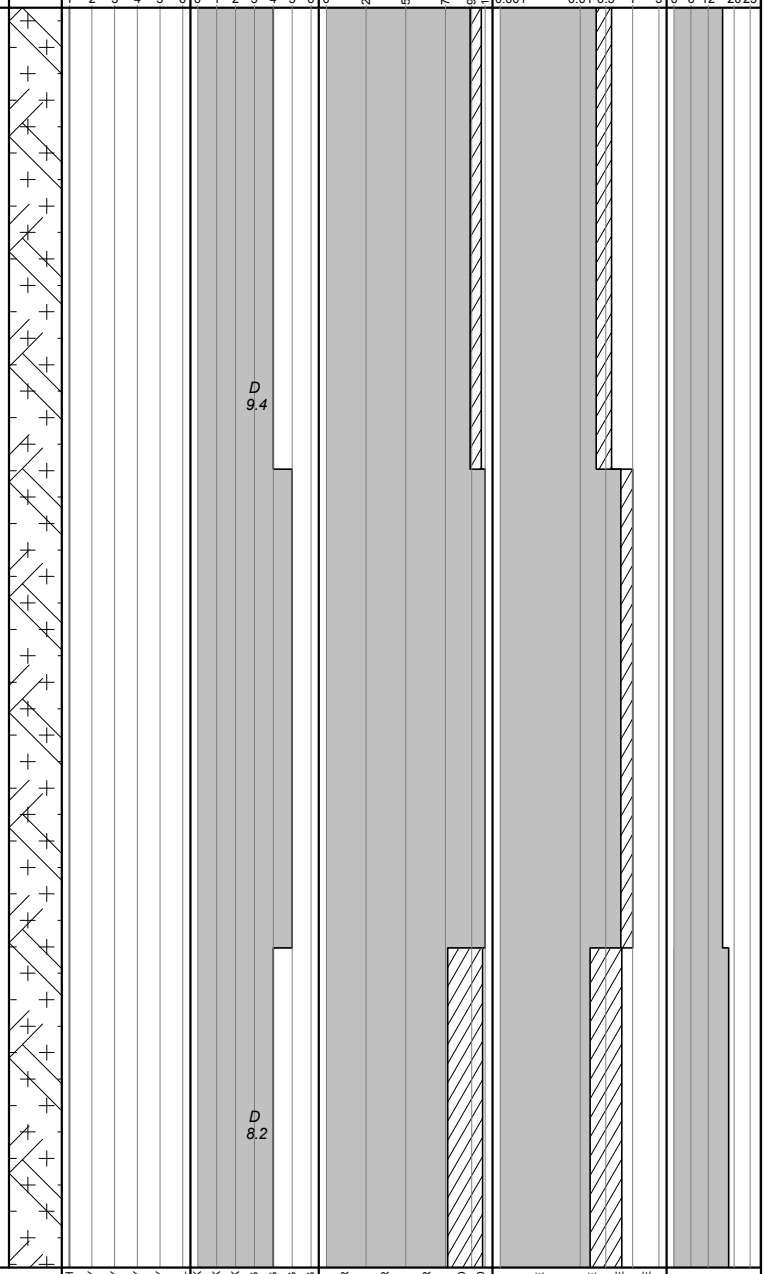
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
240			239.9 m: Shear, 0.5 mm aperture. JRC = 12.
241			241.1 m: Shear, 0.5 mm aperture. JRC = 12.
			241.4 m: Shear, 0.5 mm CA infill, R2. JRC = 2.
242			
243			243.7 m: Shear. JRC = 4.
244			
245			245 m: Shear on vein, 5 mm BX infill. JRC = 8. Dip/dip direction = 72/082.
246			
247			
248			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Project : Brucejack
Project No.1008-007

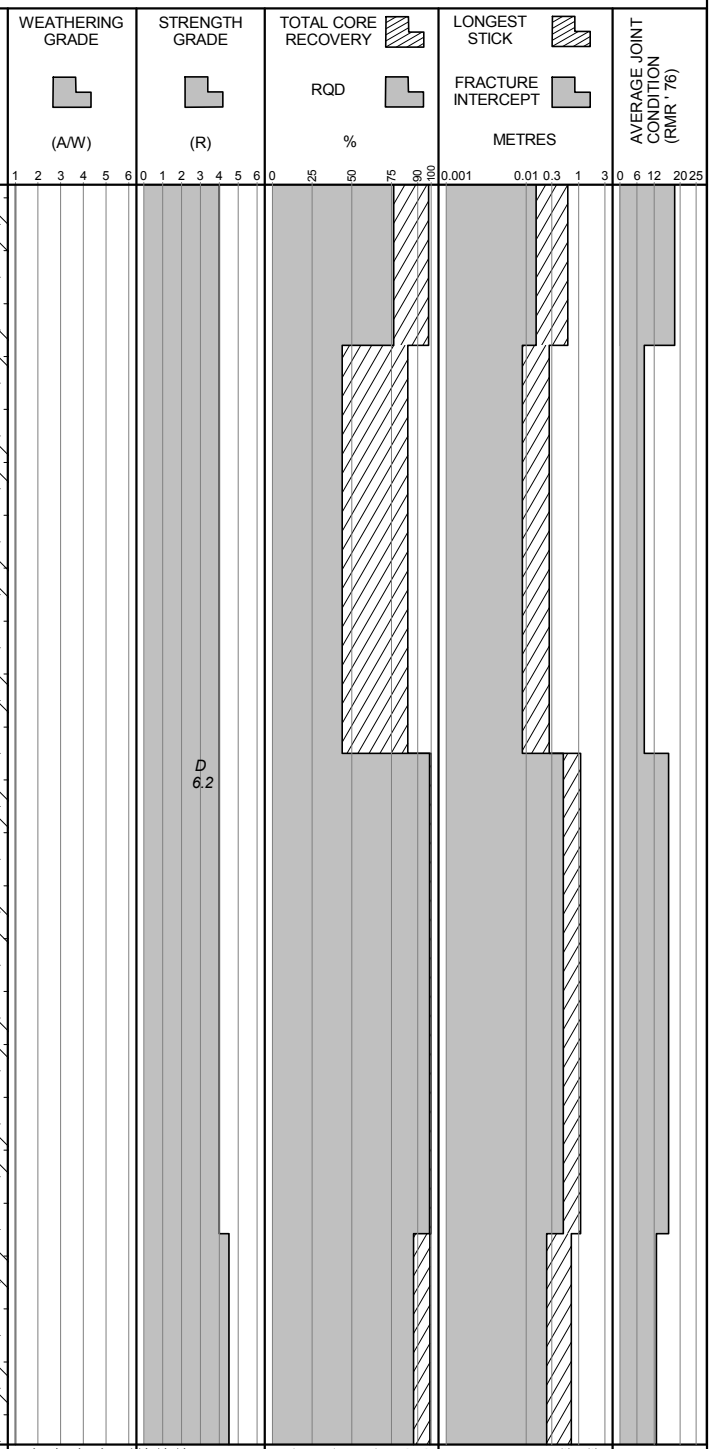
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
248			248 m: Shear, 0.5 mm CA infill, R3. JRC = 2.
			248.3 m: Shear, 0.5 mm CA infill, R4. JRC = 8. Dip/dip direction = 37/195.
			248.4 m: Shear, 0.5 mm CA infill, R3. JRC = 2. Dip/dip direction = 30/214.
249			
			249.7 m: Shear, 0.5 mm aperture. JRC = 1. Dip/dip direction = 26/199.
250			249.7 m: Shear, 0.5 mm CA infill, R3. JRC = 13.
			249.9 m: Shear, 0.5 mm aperture. JRC = 4.
			250.0 m: Shear, 0.5 mm CA infill. JRC = 8.
			250.8 m: Shear, 60 mm BX infill. JRC = 8.
251			250.8 m: Shear, 0.5 mm aperture. JRC = 13.
			250.8 m: Shear. JRC = 8.
			250.9 m: Shear, 100 mm BX infill. JRC = 8. Dip/dip direction = 37/227.
			251.1 m: Shear. JRC = 4.
			251.3 m: Fault, 5 mm FG infill, S5. JRC = 4.
			251.5 m: Shear, 14 mm BX infill. JRC = 8. Dip/dip direction = 48/194.
252			251.6 m: Shear. JRC = 12.
			251.8 m: Shear, 10 mm BX infill. JRC = 15.
			252.2 m: Shear, 1 mm CA infill, R3. JRC = 2.
			252.3 m: Shear, 1 mm CA infill, R3. JRC = 4.
253			
254			
			254.4 m: Shear on vein, 0.5 mm aperture. JRC = 12.
255			
			255.3 m: Shear, 0.5 mm aperture. JRC = 13.
			255.8 m: Shear on vein, 0.5 mm aperture. JRC = 14.
256			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
256			255.8 m: Shear, 0.5 mm aperture. JRC = 16. Dip/dip direction = 57/142. 256 m: Shear, 0.5 mm aperture. JRC = 12. 256.1 m: Shear, 0.5 mm aperture. JRC = 10.			D 4.0			
257									
258									
259									
260						D 7.3			
261						D 4.4 D 6.2 D 8.0			
262									
263									
264									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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Final Depth (m): 566.0
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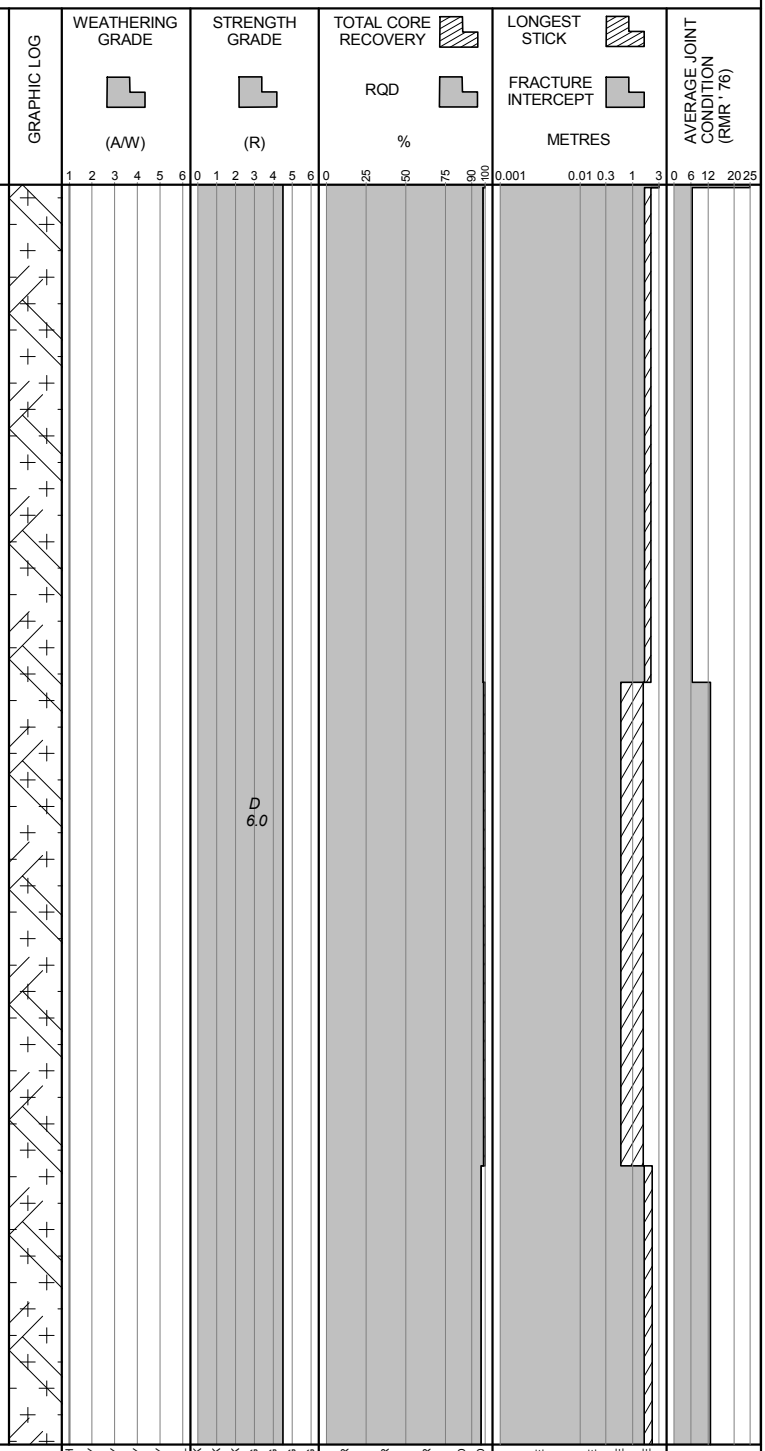
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
264			264.2 m: Shear on vein, 1 mm aperture. JRC = 13.
265			
266			266.3 m: Shear, 0.5 mm aperture. JRC = 12.
267			267.5 m: Shear, 0.5 mm aperture. JRC = 15.
268			267.9 m: Shear on vein, 0.5 mm aperture. JRC = 8. Dip/dip direction = 31/170.
			268.6 m: Shear, 0.5 mm aperture. JRC = 15.
269			
270			
271			270.8 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 78/167.
272			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

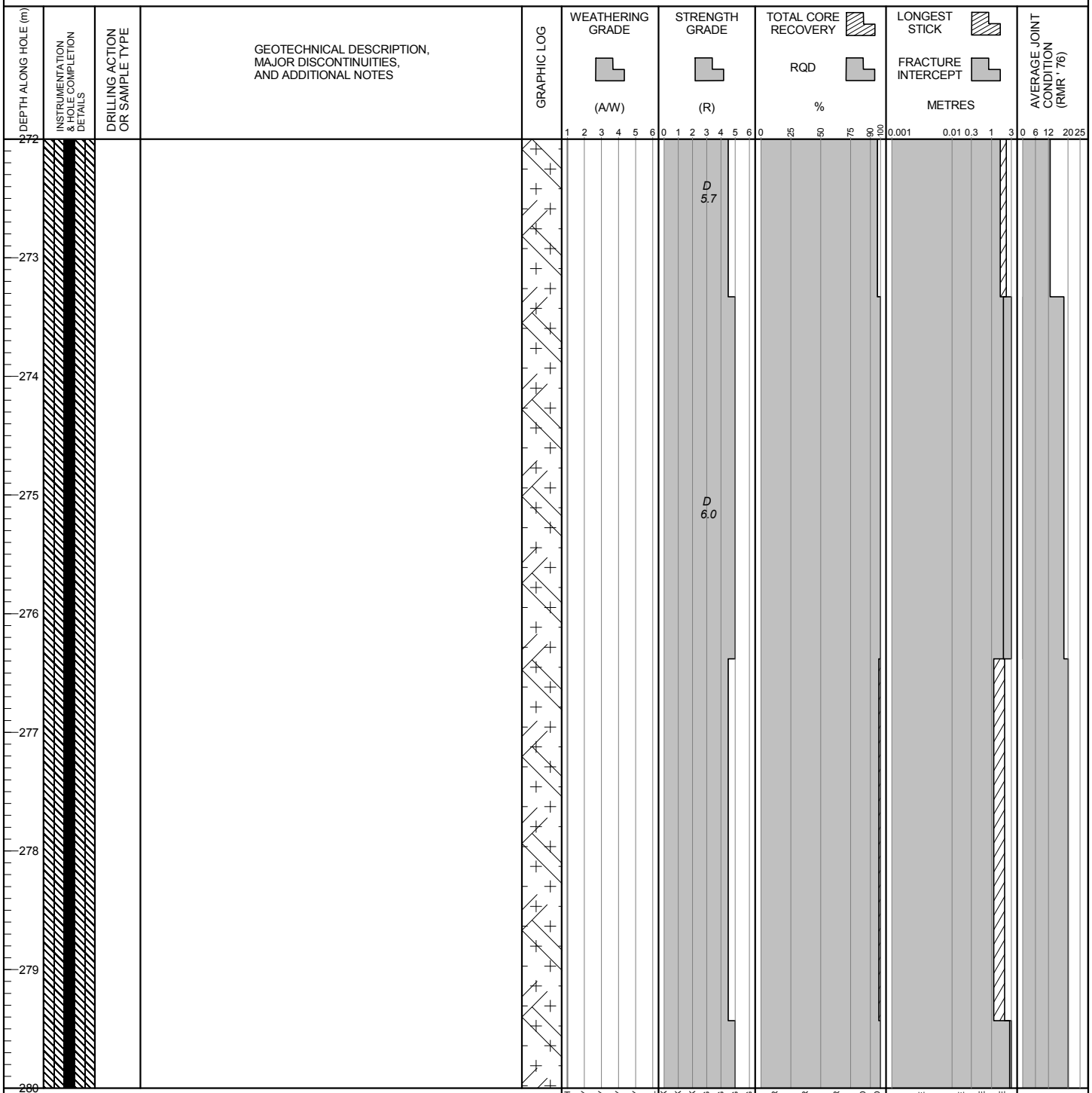
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

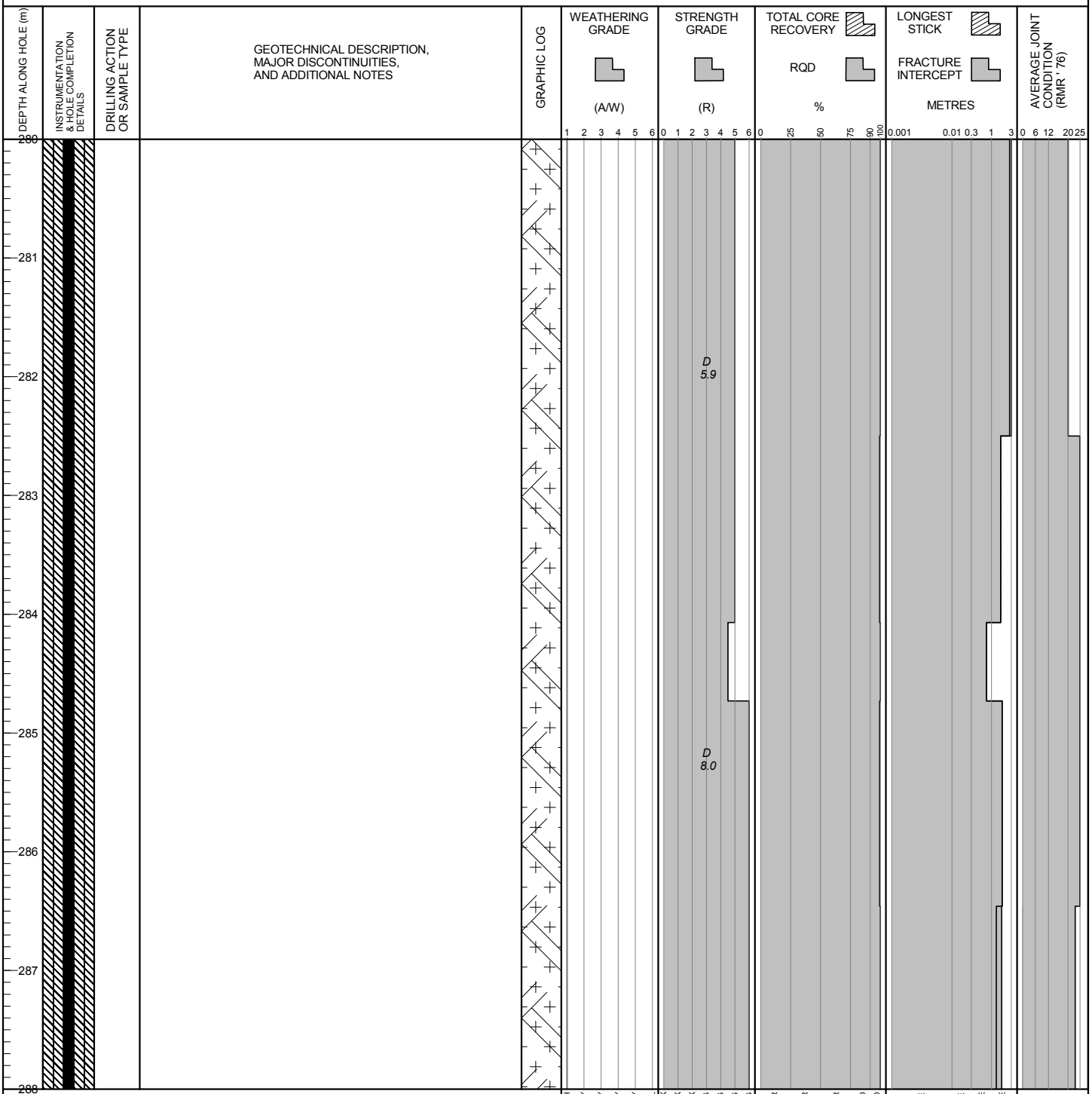
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
288			
289			289.3 m: Shear, 80 mm BX infill. JRC = 8. 289.6 m: Shear on vein. JRC = 12.
290			290.1 m: Shear on vein, 0.5 mm aperture. JRC = 8.
291			
292			
293			293.1 - 302.53 m: 60% quartz-calcite veining with minor pyrite.
294			
295			
296			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

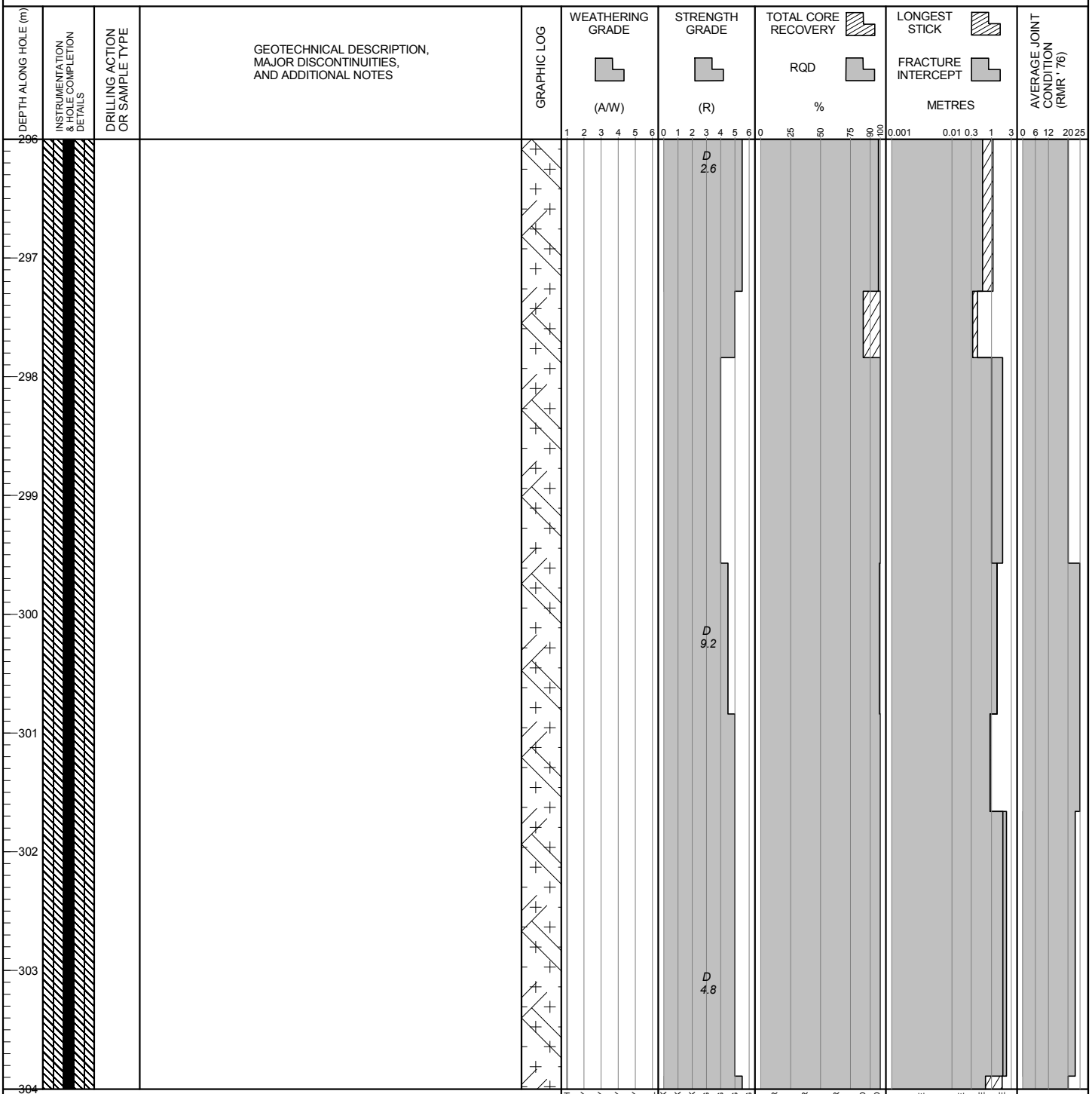
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
304					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
305									
306									
307									
			307.7 m: Shear, 0.5 mm aperture. JRC = 13.						
308									
			Constant head test from 308.5 - 331.3 m. Estimated hydraulic conductivity is 8.6E-09 m/s.						
309						D 5.5			
						D 5.9 D 7.9 D 6.1			
310									
311									
312									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
312					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
313			313.4 m: Shear, 0.5 mm SE infill, R2. JRC = 15.						
314									
315									
316						D 4.0			
317									
318									
319			318.8 m: Shear on vein, 0.5 mm CA infill, R2. JRC = 8. Dip/dip direction = 90/083. 319.1 m: Shear on vein, 0.5 mm CA infill, R2. JRC = 4.						
320					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

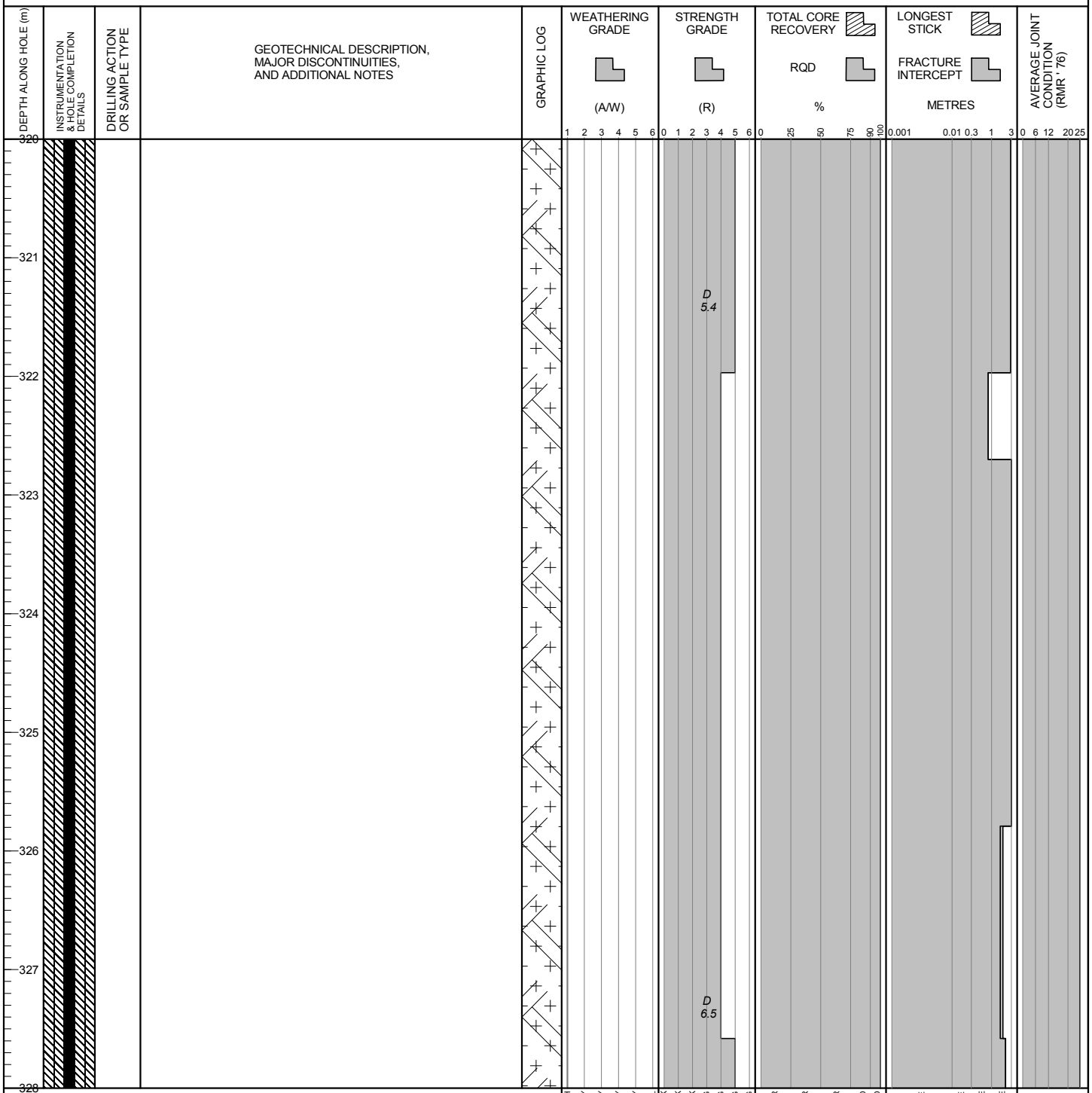
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

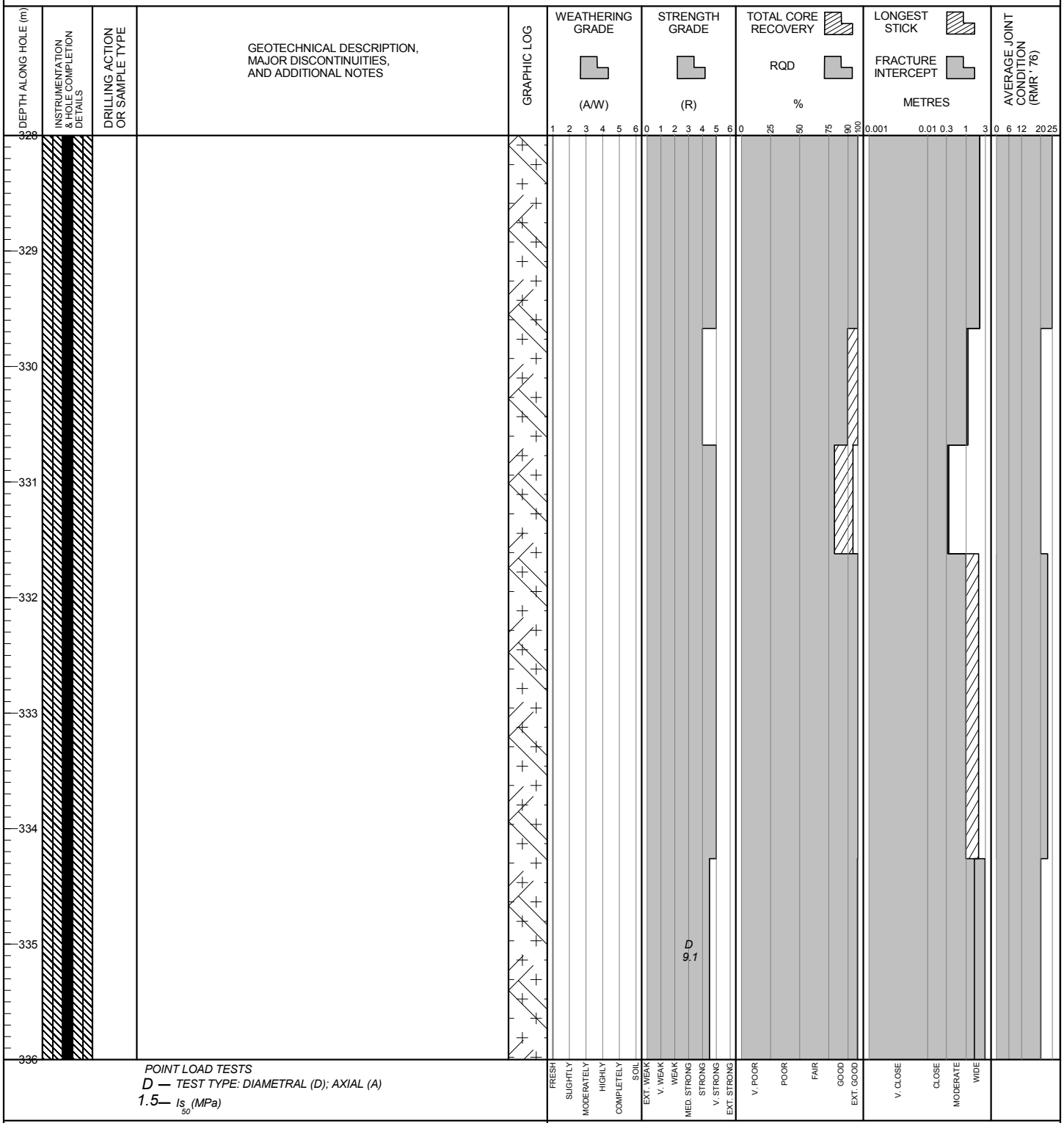
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
336									
						D 7.3			
						D 7.2			
337						D 8.9			
338									
339									
340						D 6.3			
341			340.9 m: Shear, 1 mm aperture. JRC = 12. Dip/dip direction = 35/166.						
342									
343									
344									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

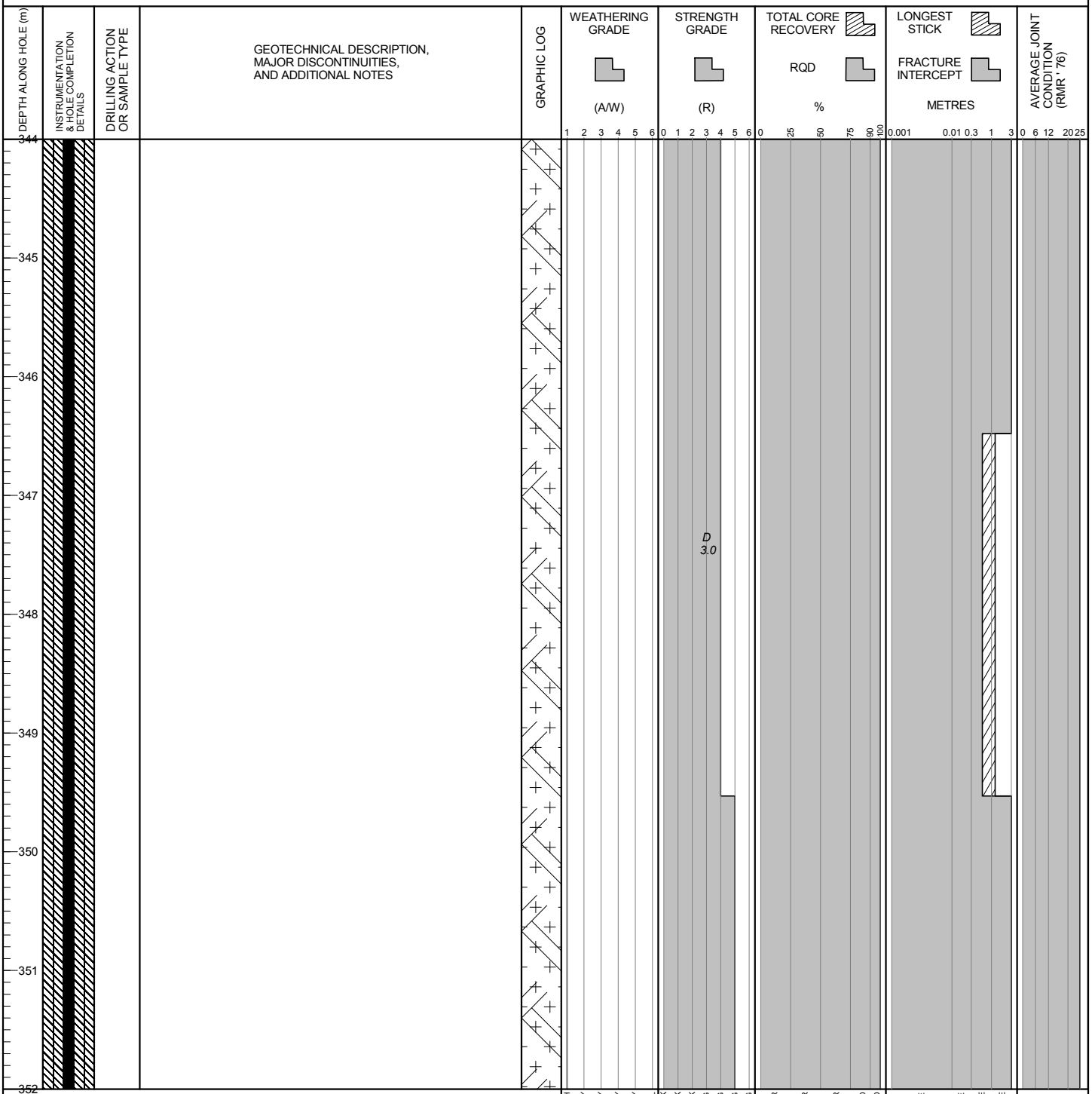
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

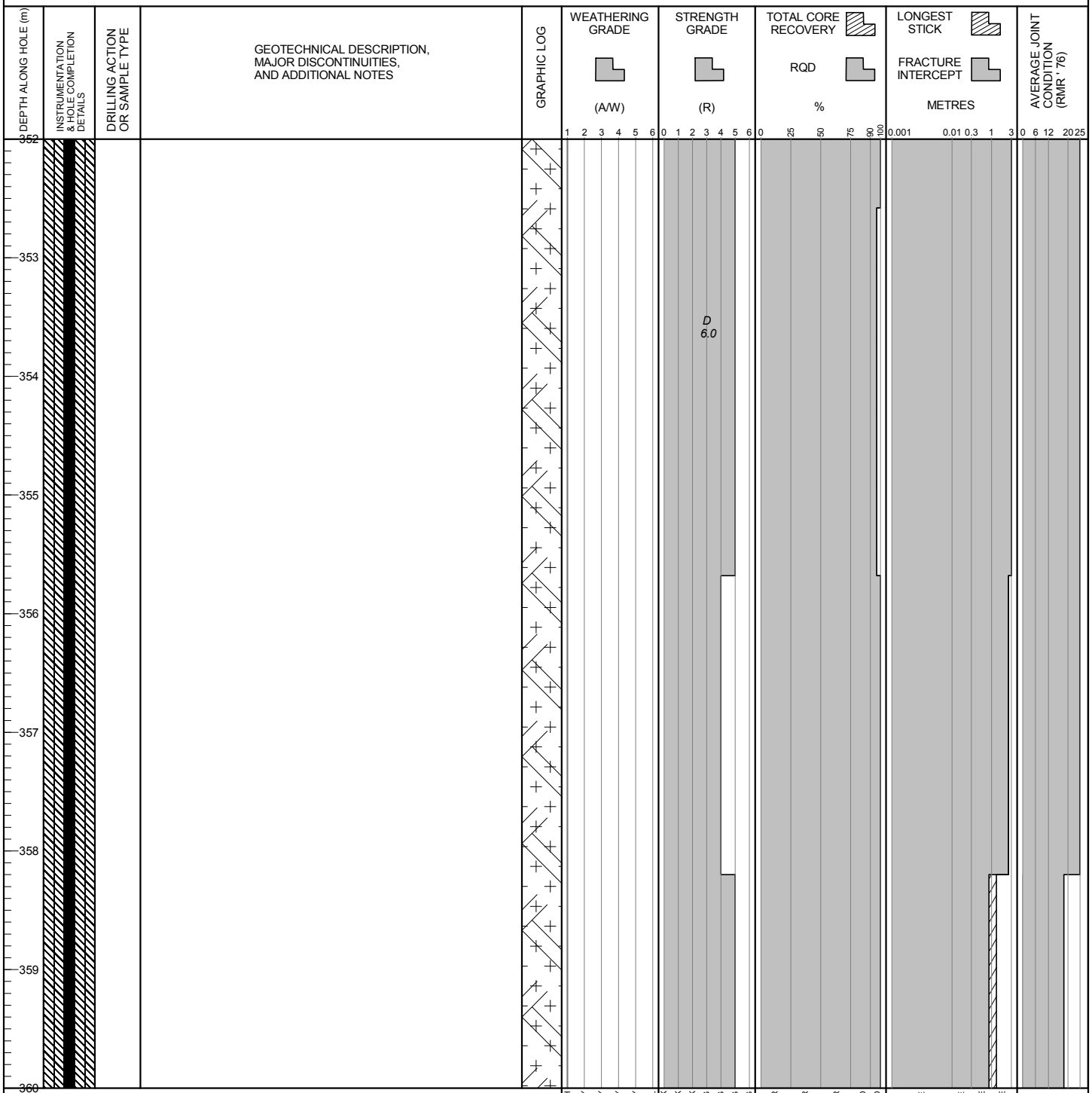
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

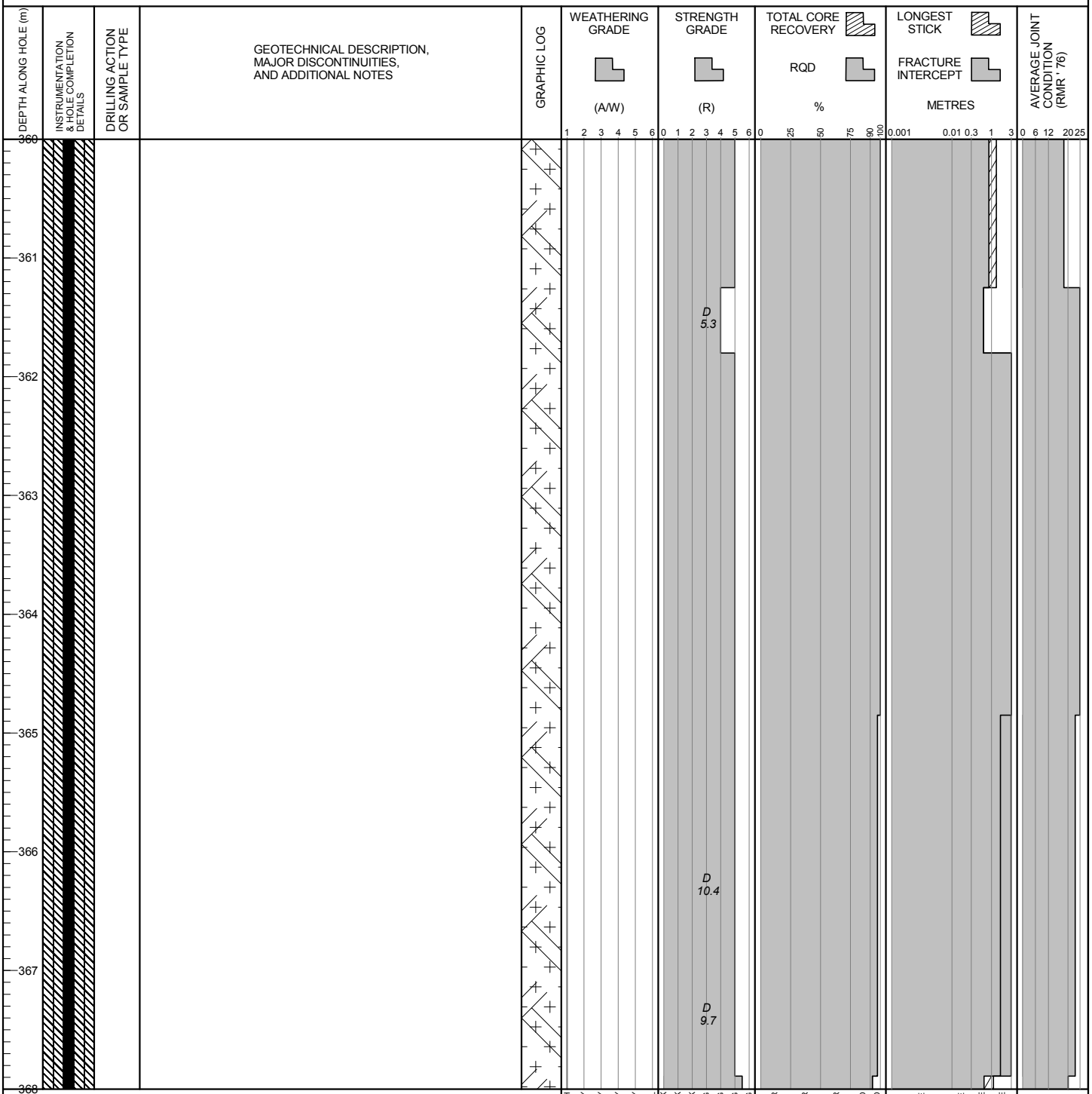
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

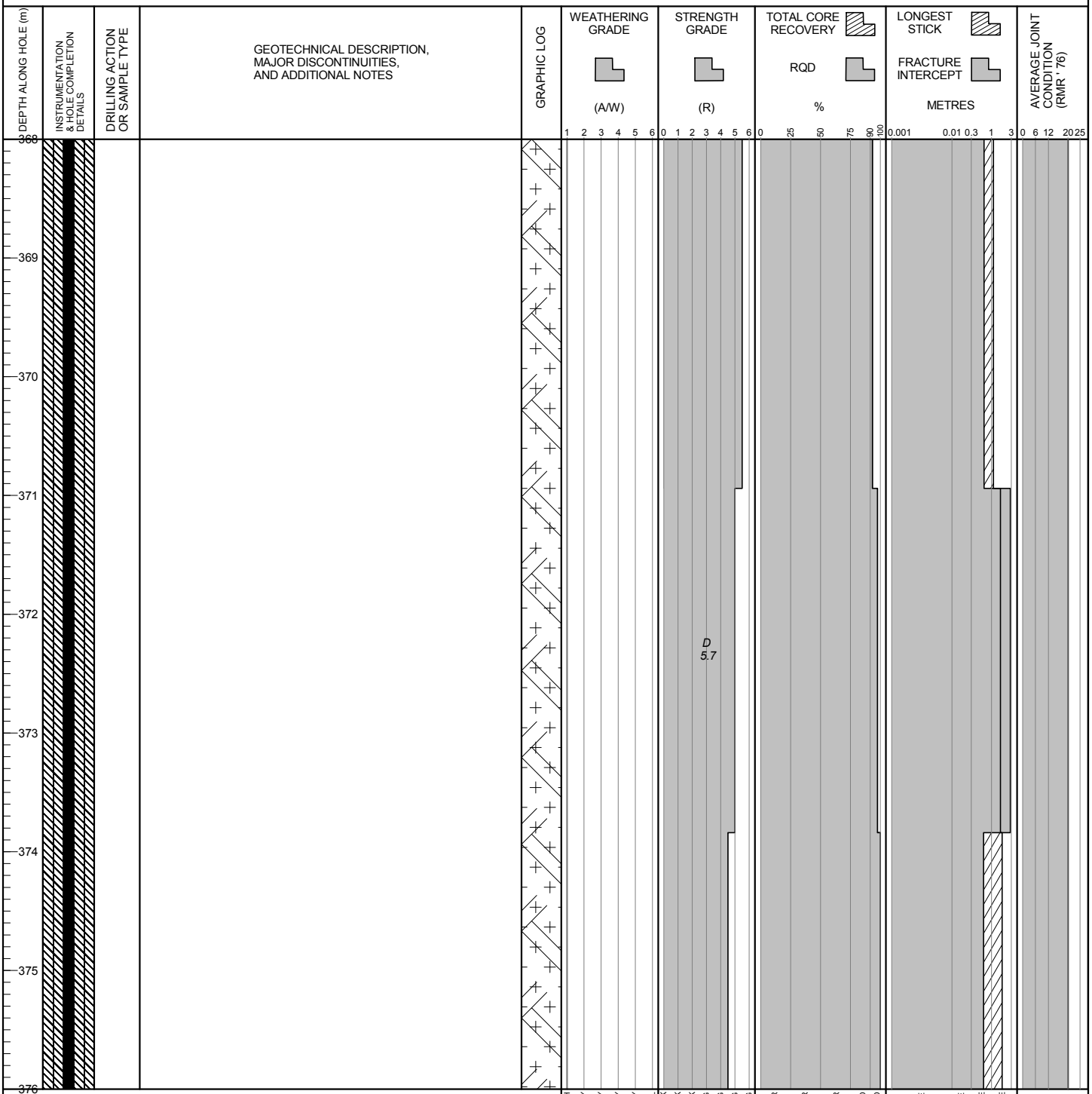
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

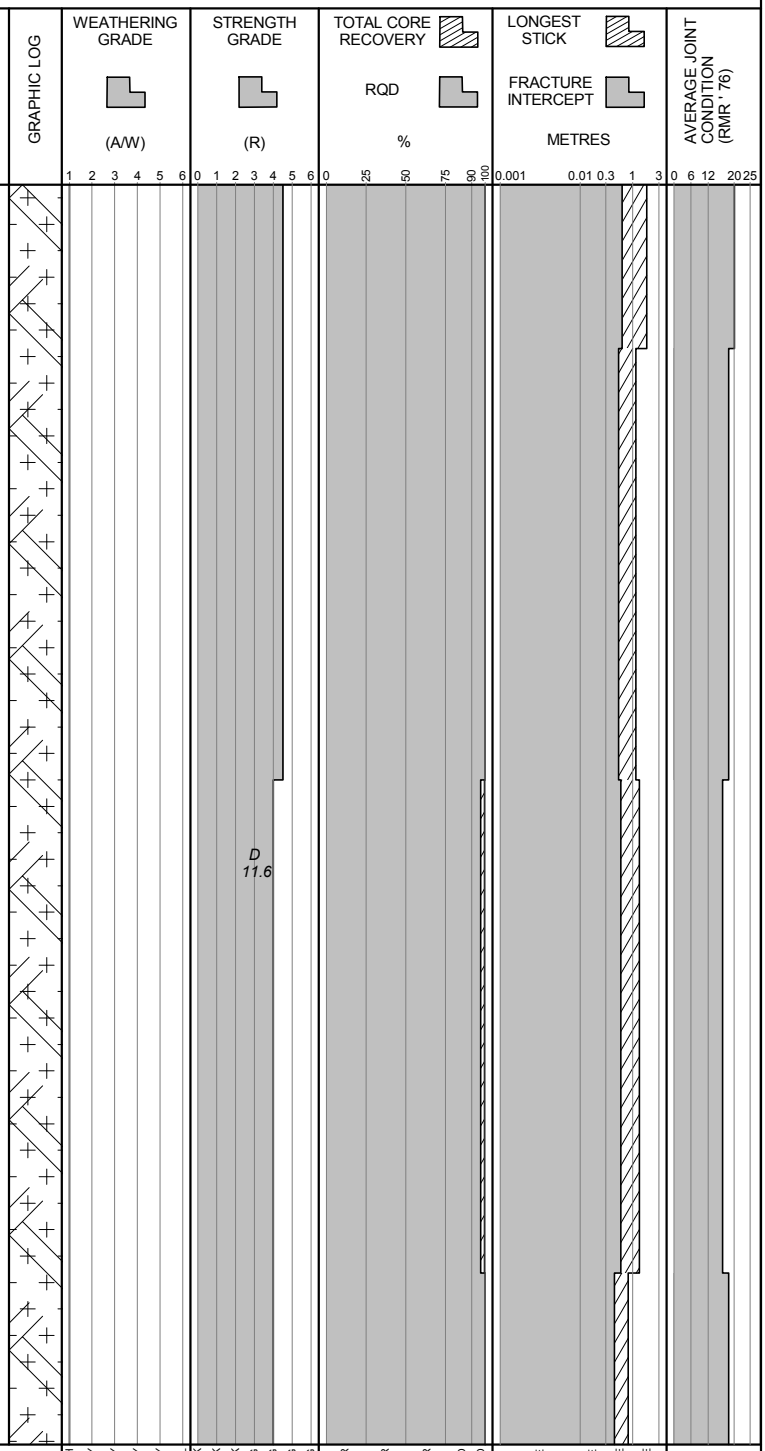
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
376			
			376.7 m: Shear, 0.5 mm CA infill, R2. JRC = 2.
377			
378			378.1 m: Shear, 0.5 mm CA infill, R2. JRC = 15. Dip/dip direction = 64/228.
379			379 m: Shear, 1.5 mm aperture. JRC = 4.
380			
381			381.3 m: Shear, 0.5 mm CA infill, R4. JRC = 4. Dip/dip direction = 58/267.
382			381.8 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 62/328.
			382.6 m: Shear, 0.5 mm CA infill, R2. JRC = 2.
383			
384			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD (%)	LONGEST STICK / FRACTURE INTERCEPT (METRES)	AVERAGE JOINT CONDITION (RMR '76)
384					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
			384.5 m: Shear, 0.5 mm aperture. JRC = 2.						
385						D 10.9			
			385.4 m: Shear, 0.5 mm aperture. JRC = 8.						
			385.6 m: Shear on vein, 0.5 mm aperture. JRC = 16.						
386									
387									
			387.6 m: Shear, 0.5 mm CA infill, R3. JRC = 12.						
388									
389						D 11.5			
390									
			390.5 m: Shear, 0.5 mm CA infill, R3. JRC = 4.						
391			390.9 m: Shear, mm CA infill, R2. JRC = 1. Dip/dip direction = 59/304.						
			391.3 m: Shear, mm CA infill, R2. JRC = 8.						
392									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

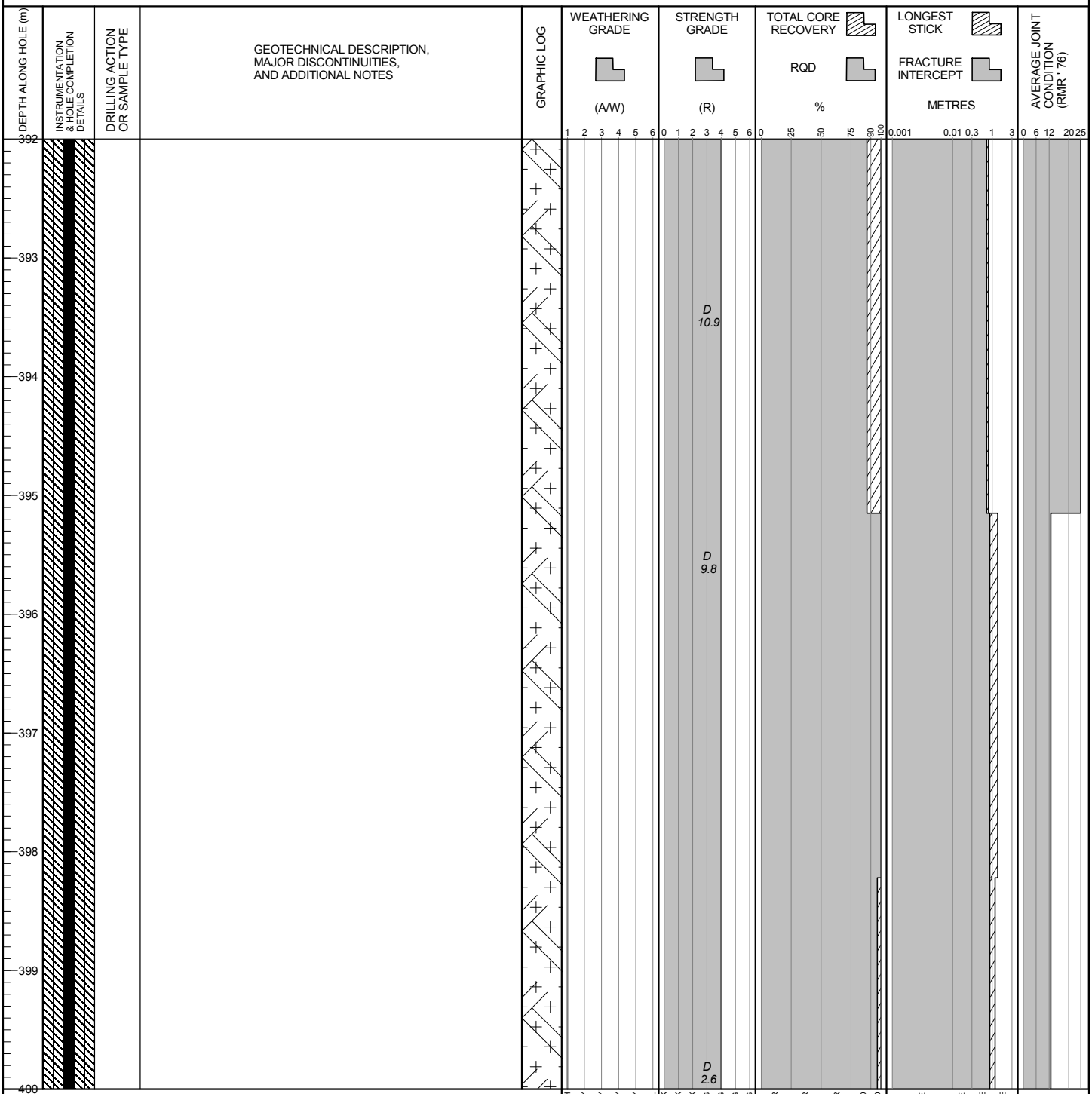
Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

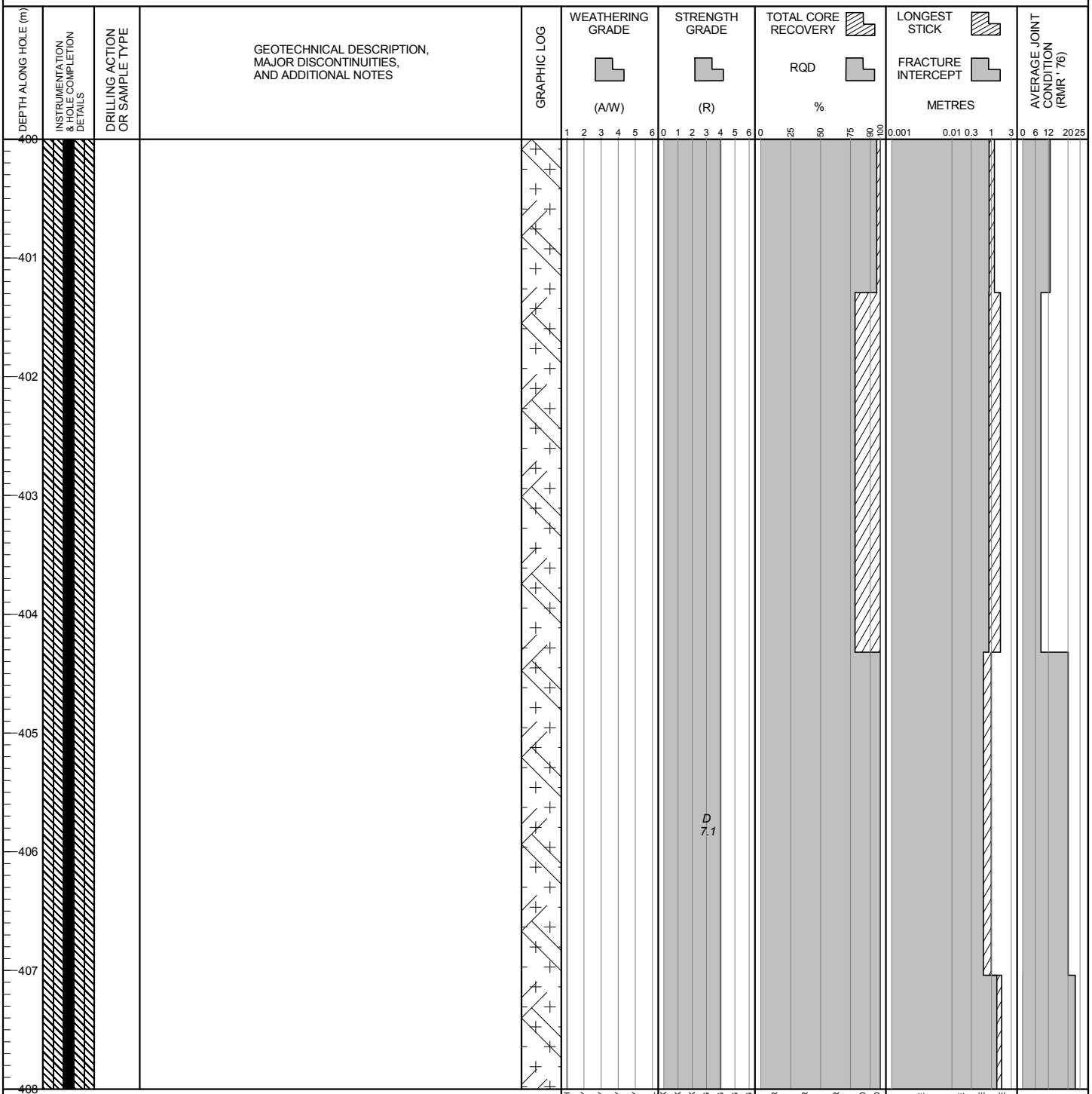
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

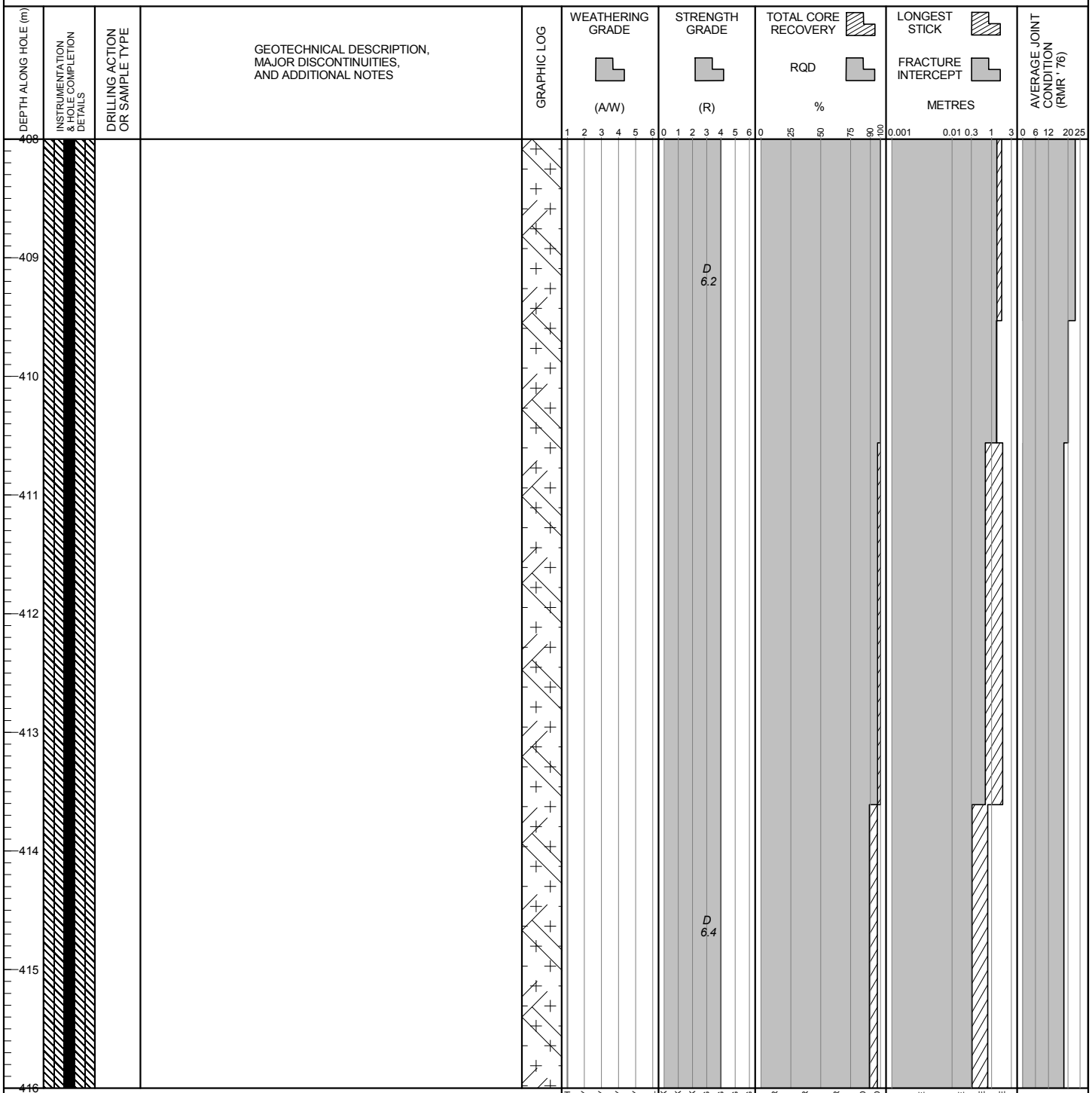
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

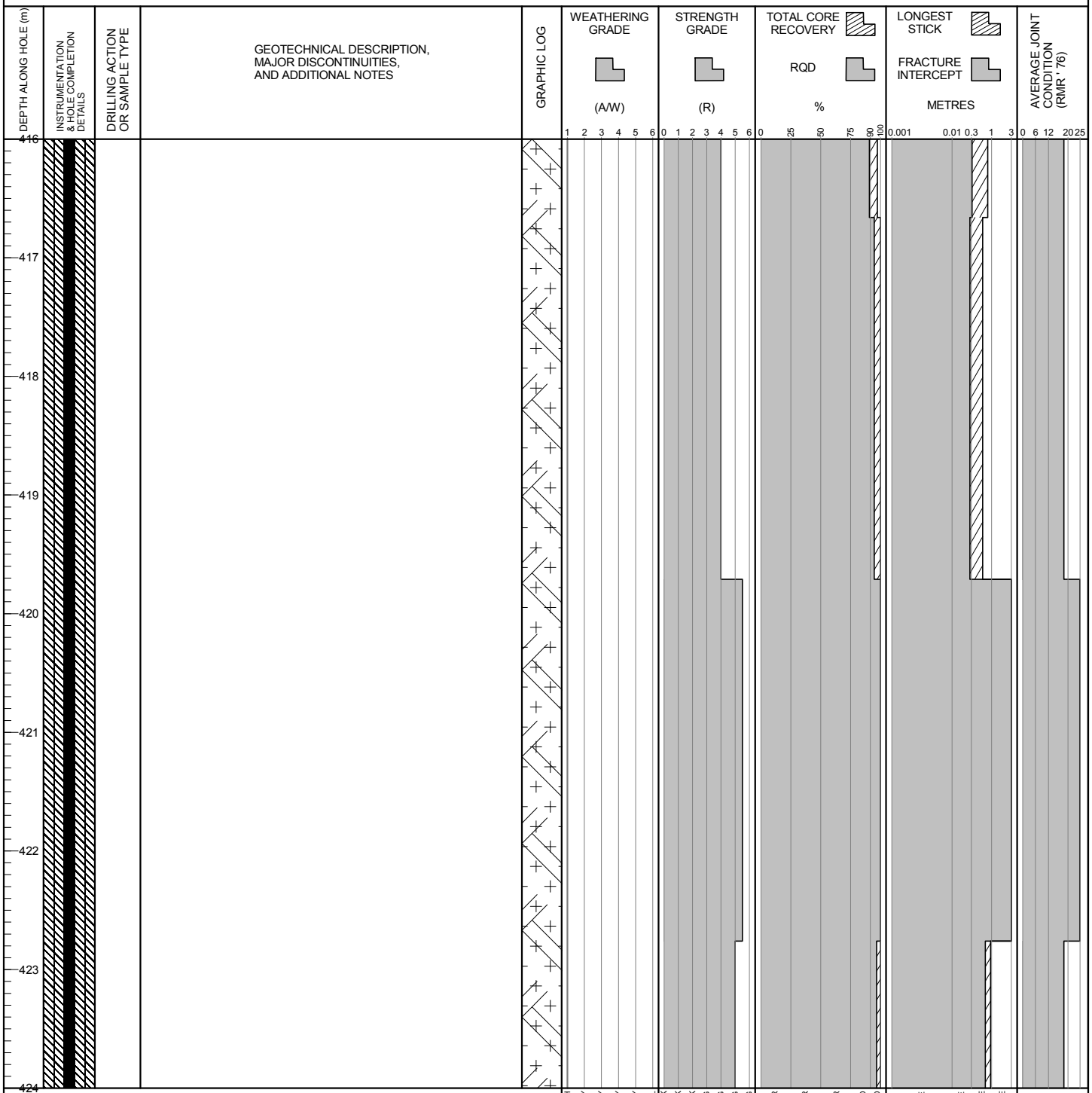
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
424			424.1 m: Shear, 0.5 mm aperture. JRC = 4.
425			
426			425.9 m: Shear, 1 mm CA infill, R3. JRC = 15. Dip/dip direction = 56/232.
427			
428			
429			428.9 m: Fault, 3 mm FG infill, S3. JRC = 8. Dip/dip direction = 31/218.
430			
431			
432			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
432									
433			ARENITE (S4) Light green, mm-scale laminations at 40 degrees TCA. Contact with P1 is 35 degrees TCA. cm-scale concretions throughout. Pyrite, calcite and chlorite replaced. Extremely strong (R6). Fresh (A1).						
434									
435						D 9.6			
436									
437									
438									
439						D 9.1			
440									

Weathering grade scale: 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL)
Strength grade scale: 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG)
TCR/RQD scale: 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD)
Longest stick / fracture intercept scale: 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE)
Average joint condition (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

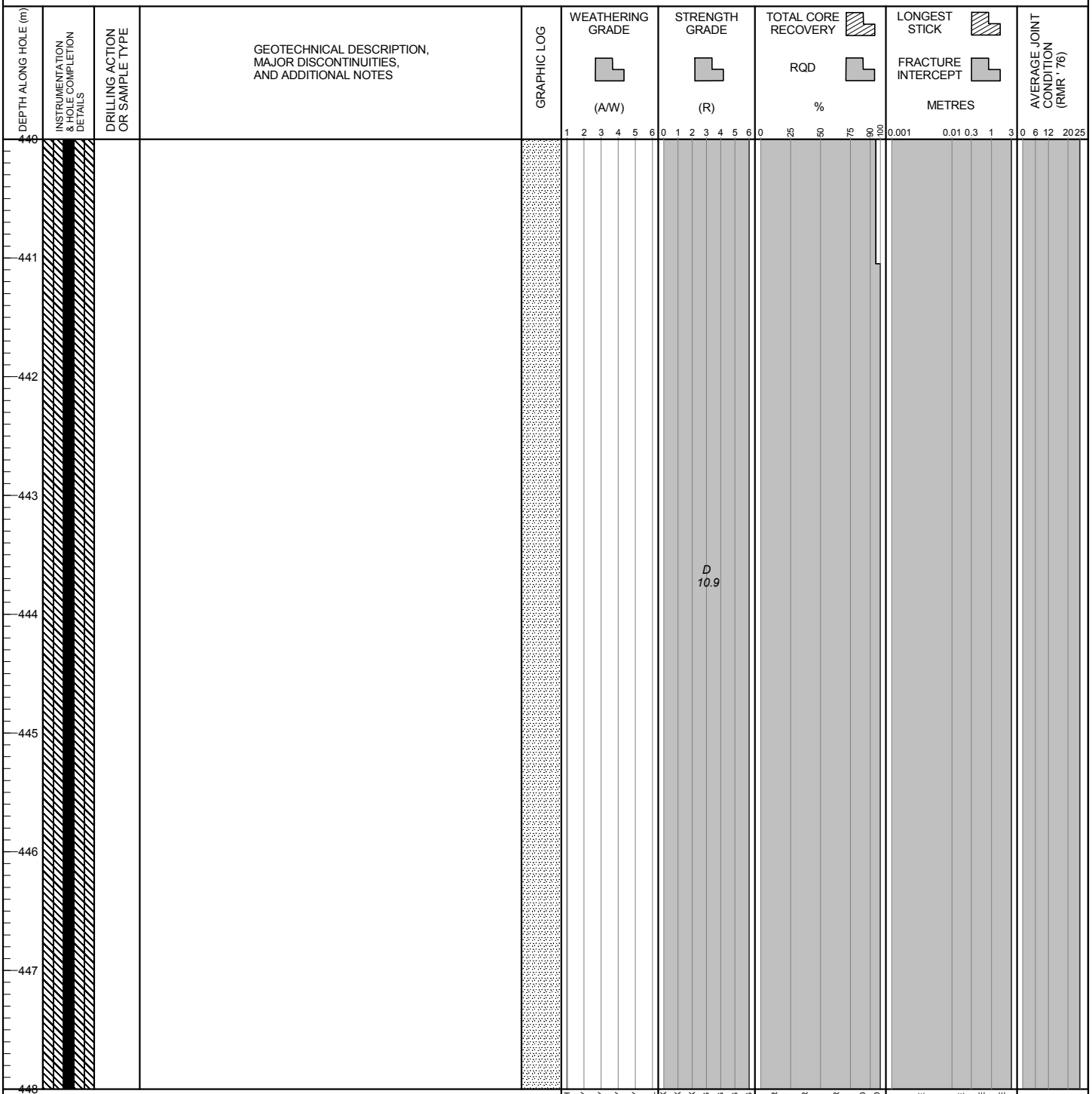
DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
448									
449						D 6.2			
450									
451									
452									
453						D 8.0			
454			PELITE (S5) Light green, mudstone. Upper contact grades from poly-pebble conglomerate. Contains sandstone layers sub-parallel TCA. Abundant concretions near end of interval. Very strong to extermely strong (R5-R6). Fresh (A1).						
455									
456									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

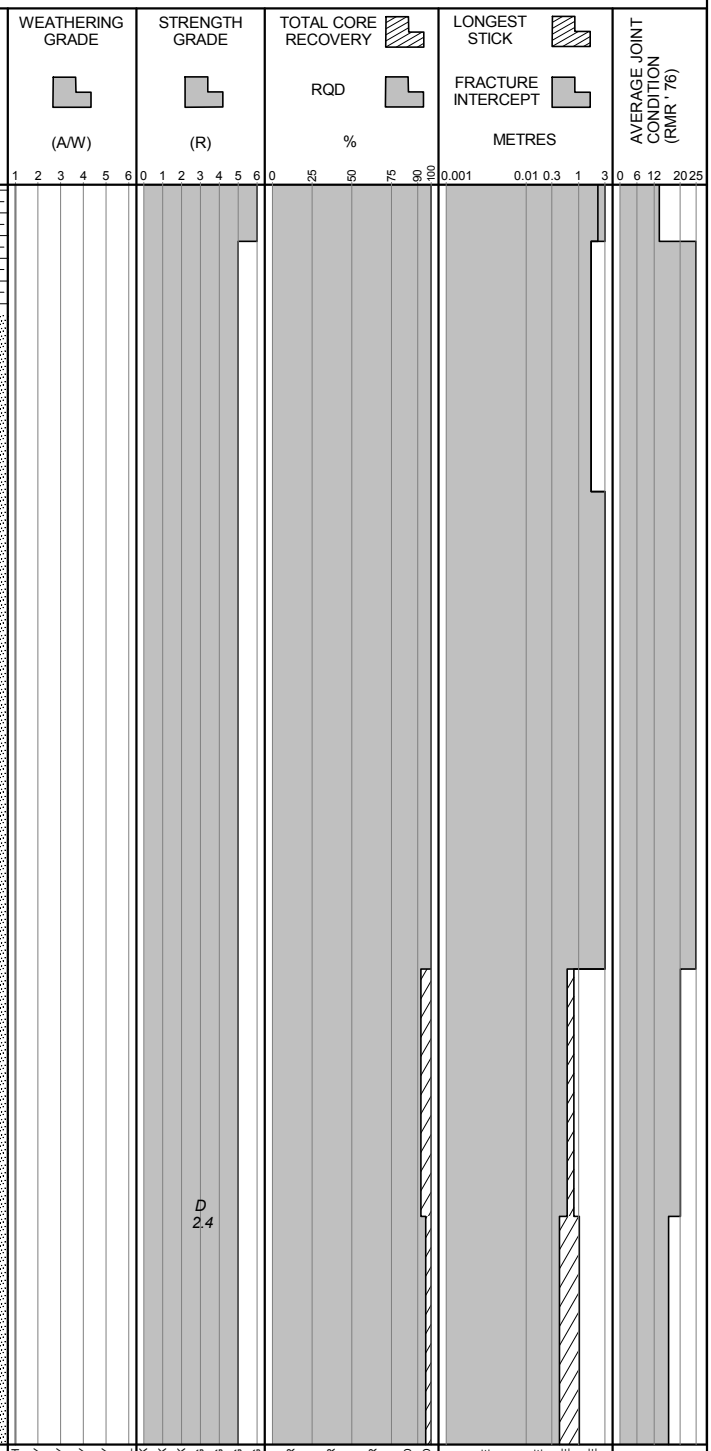
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
456									
457			ARENITE (S4) Light green, contains abundant mudstone interbeds often sub-parallel TCA. Clear bottom contact with P1 at 25-30 degrees TCA. Very strong to extermely strong (R5-R6). Fresh (A1).						
458									
459									
460									
461									
462						D 2.4			
463									
464									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
464									
465			465.1 m: Fault, 5 mm CA/BX infill. JRC = 16. Dip/dip direction = 86/069.			D 5.8			
466									
467									
468						D 8.0			
469									
470									
471									
472						D 5.7			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
472			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Green, relatively massive with 1-6 mm hornblende/feldspar phenocrysts. Veining increases significantly at 502.4 m. Last 7 m of interval blocky and becomes increasingly gougy near end of interval. Strong to very strong (R4-R5.5). Fresh (A1). 472.5 m: Fault, 5 mm CA/BX infill. JRC = 8. Dip/dip direction = 74/164.						
473									
474									
475									
476									
477									
478						D 6.4			
479									
480			479.8 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 38/184.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
480			479.8 m: Shear, 0.5 mm CA infill, R2. JRC = 8. Dip/dip direction = 29/182.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
481						D 9.5			
482									
483									
484									
485									
486			486.4 m: Shear, 400 mm BX infill. JRC = 12.						
487						D 8.1			
488									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
488					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
489									
490									
491			Falling head test from 491.3 - 513 m. Estimated hydraulic conductivity is 9.4E-07 m/s.						
492			492.4 m: Shear, 0.5 mm CA infill, R3. JRC = 4.						
493						D 9.1			
494			494.6 m: Fault, 500 mm BX infill. JRC = 4.						
495									
496									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

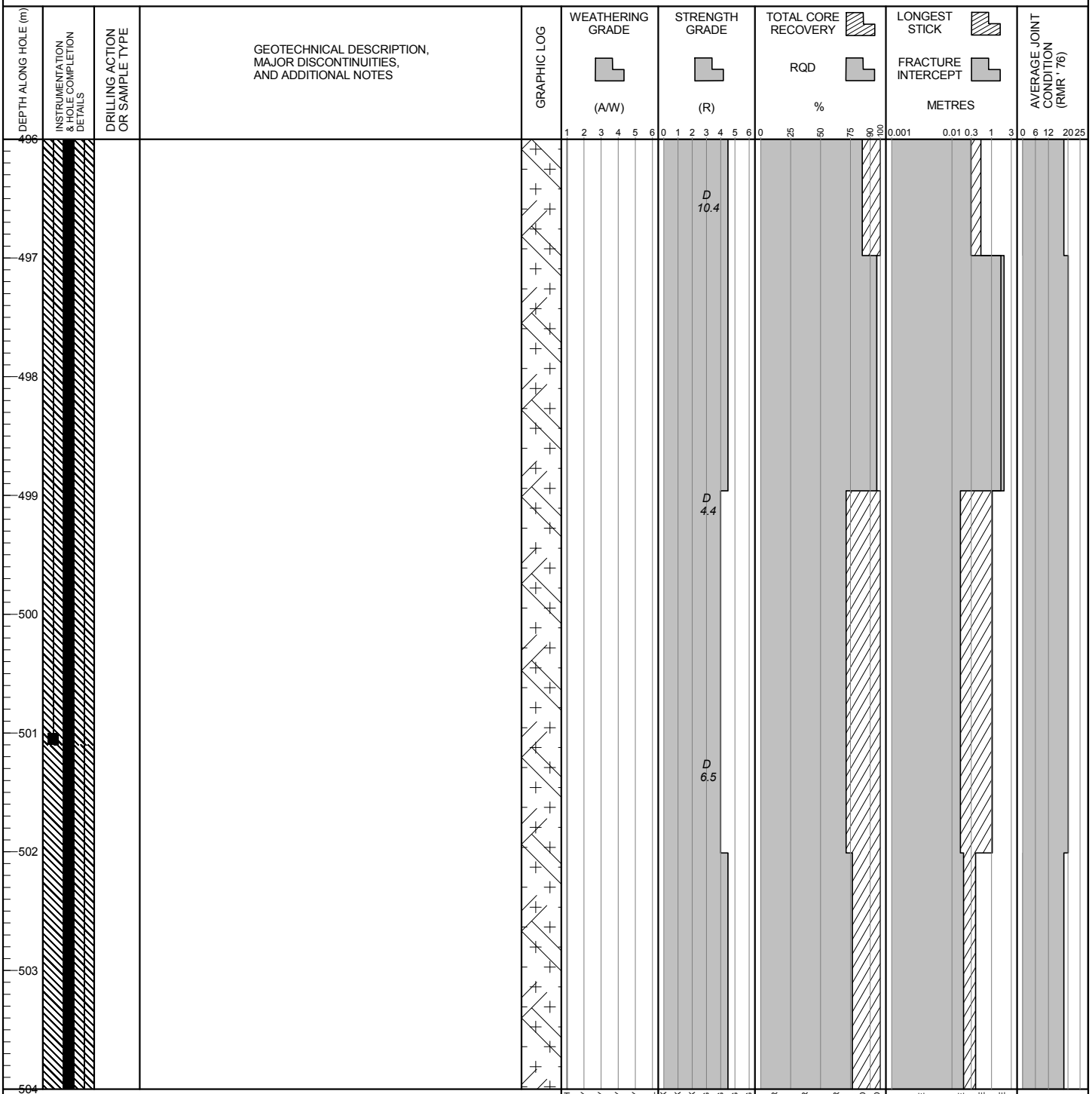
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N	**Drill Designation:** Heliportable	**Start Date:** 14 Apr 12
Ground Elevation (m): 1,583.7	**Drilling Contractor:** Radius	**Finish Date:** 03 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 566.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.0
Plunge (°): -70	**Fluid:** Polymer	**Logged By:** HKM/JND
Trend (°): 271	**Cased To (m) :** 2.0	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
504			
505			
506			
507			506.8 m: Last 7 m of the unit are blocky with increasing gouge to the end of the unit.
508			
509			
510			510 m: Fault, FG infill.
511			
512			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 9.2

D 4.4

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

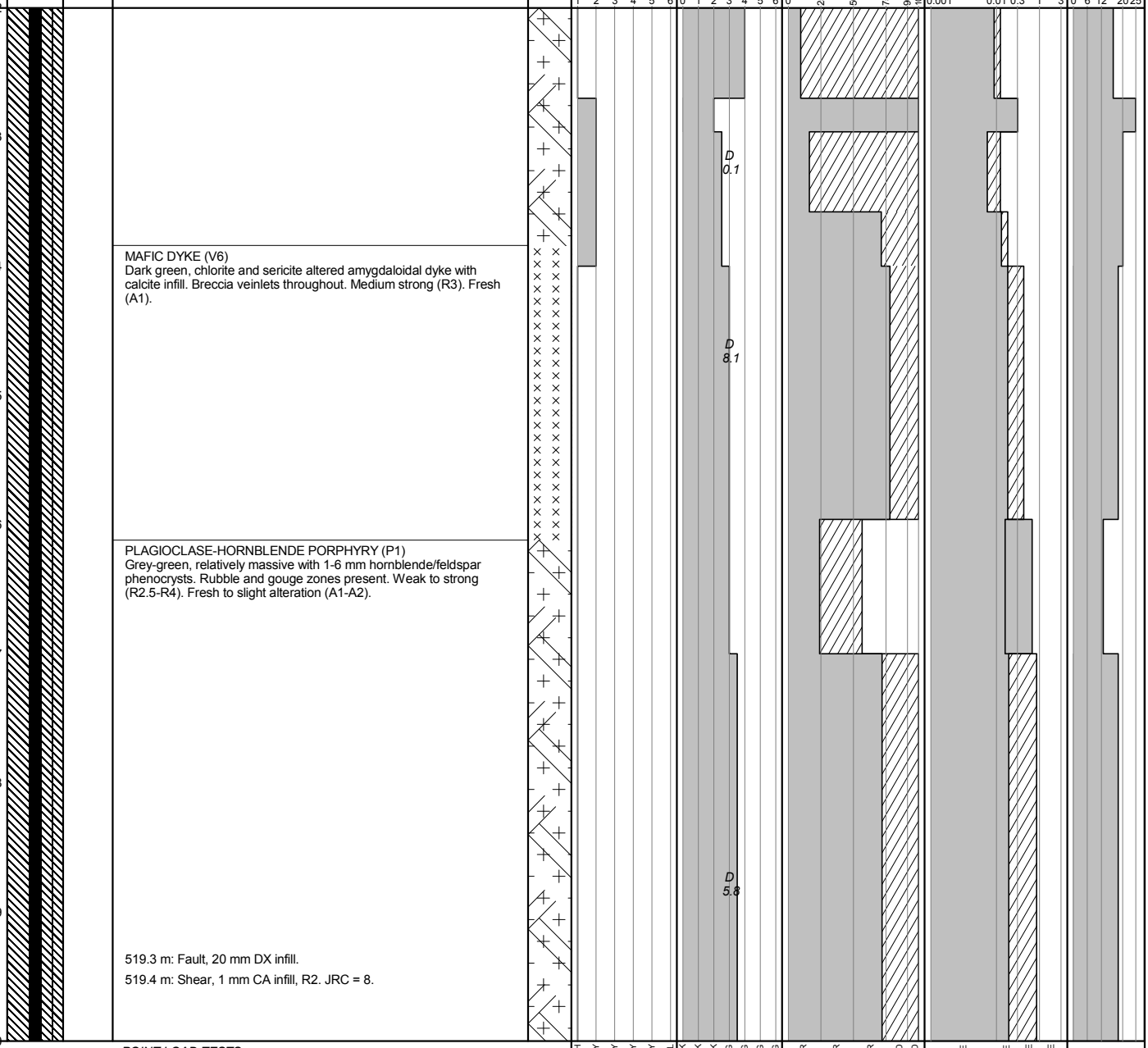
DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

512 513 514 515 516 517 518 519 520

MAFIC DYKE (V6)
Dark green, chlorite and sericite altered amygdaloidal dyke with calcite infill. Breccia veinlets throughout. Medium strong (R3). Fresh (A1).

PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)
Grey-green, relatively massive with 1-6 mm hornblende/feldspar phenocrysts. Rubble and gouge zones present. Weak to strong (R2.5-R4). Fresh to slight alteration (A1-A2).

519.3 m: Fault, 20 mm DX infill.
519.4 m: Shear, 1 mm CA infill, R2. JRC = 8.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
520									
521						D 6.5			
						D 7.5			
522			522 m: Fault on vein, 5 mm CA infill, R2.			D 9.2			
523									
524									
			524.7 m: Fault, 150 mm DX infill.						
525						D 0.4			
526						D 0.1			
527									
			527.7 m: Fault, 10 mm DX infill.						
528									

Weathering grade scale: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade scale: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD: 0, 25, 50, 75, 90, 100 %
Longest stick / fracture intercept: 0.001, 0.01, 0.3, 1, 3 m
Average joint condition: 0, 6, 12, 20, 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

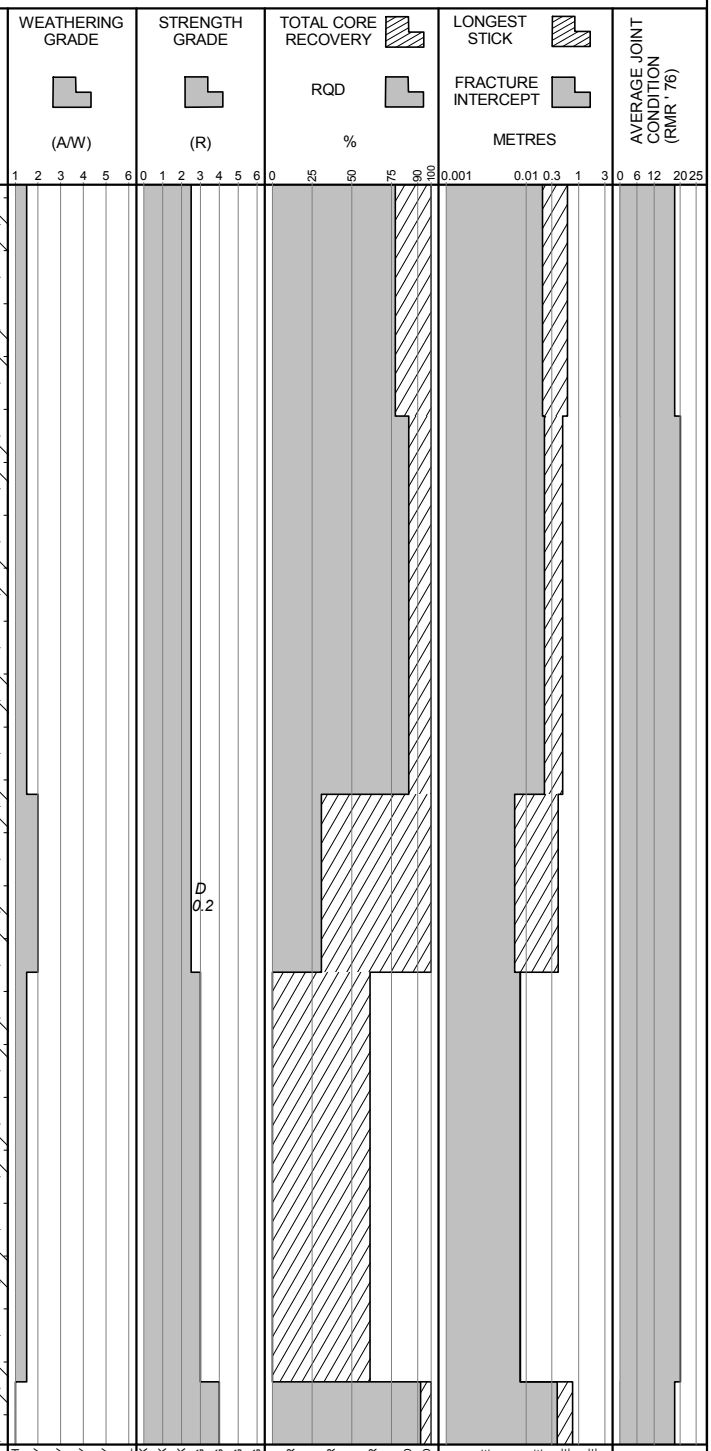
Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
528			
			528.7 m: Fault, 7.5 mm DX infill.
529			
530			
531			Constant head test from 531 - 550.3 m. Estimated hydraulic conductivity is 2.0E-08 m/s.
532			
533			533.3 m: Fault, 3 mm DX infill. JRC = 22.
534			534.2 m: Fault, 5 mm DX infill. JRC = 20.
535			
536			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
536									
537						D 0.9			
538			538.3 m: Fault, 10 mm DX infill.						
539									
540			539.7 m: Fault on vein, 2 mm CL infill, S3. JRC = 8.						
541									
542						D 0.2 D 0.3 D 0.1			
543			MAFIC DYKE (V6) Dark green, chlorite and sericite altered mafic dyke. Rounded 1-3 mm calcite infilled vesicles. Medium strong to very strong (R3-R5). Fresh to faint alteration (A1-A1.5).						
544									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

544
545
546
547
548
549
550
551
552

PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)
Grey-green, relatively massive with 1-6 mm hornblende/feldspar phenocrysts. Rubble and gouge zones present. Weak to medium strong (R2-R3.5). Slight to faint alteration (A1-A2.5).

548.6 m: Fault. JRC = 13. Dip/dip direction = 14/282.

549.3 m: Shear, 0.5 mm aperture. JRC = 20.

550.1 m: Shear, 0.5 mm aperture. JRC = 4.

551.7 m: Fault, 10 mm FG infill. JRC = 20. Dip/dip direction = 90/091.

D
0.0

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1, 3 WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
552			552.2 m: Fault, 10 mm FG infill. JRC = 20. Dip/dip direction = 44/015.						
553									
554			554.5 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 55/017.						
555						D 5.9			
556						D 3.5			
557						D 2.7			
558			MAFIC DYKE (V6) Dark green, chlorite and sericite altered mafic dyke. Rounded 1-3 mm calcite infilled vesicles. Medium strong (R3). Fresh (A1).						
559									
560			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Grey-green, relatively massive with 1-6 mm hornblende/feldspar phenocrysts. Medium strong to strong (R3-R3.5). Fresh (A1).						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-23

Location: Valley of Kings Zone

Co-ordinates (m): 426,503E - 6,257,856N
Ground Elevation (m): 1,583.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -70
Trend (°): 271

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 14 Apr 12
Finish Date: 03 May 12
Final Depth (m): 566.0
Depth To Top Of Rock (m): 2.0
Logged By: HKM/JND
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
560					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
561									
562									
563									
564									
565									
566			END OF DRILLHOLE AT 566.0 m Notes: 1. Two vibrating wire piezometers installed at 501.1 m and 564.6 m.						
567									
568									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN AND WEATHERED ROCK Very poor recovery.
1						
2						
3						Rock encountered at 2.7 m depth. Refer to DH-BGC12-24 rock log.
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

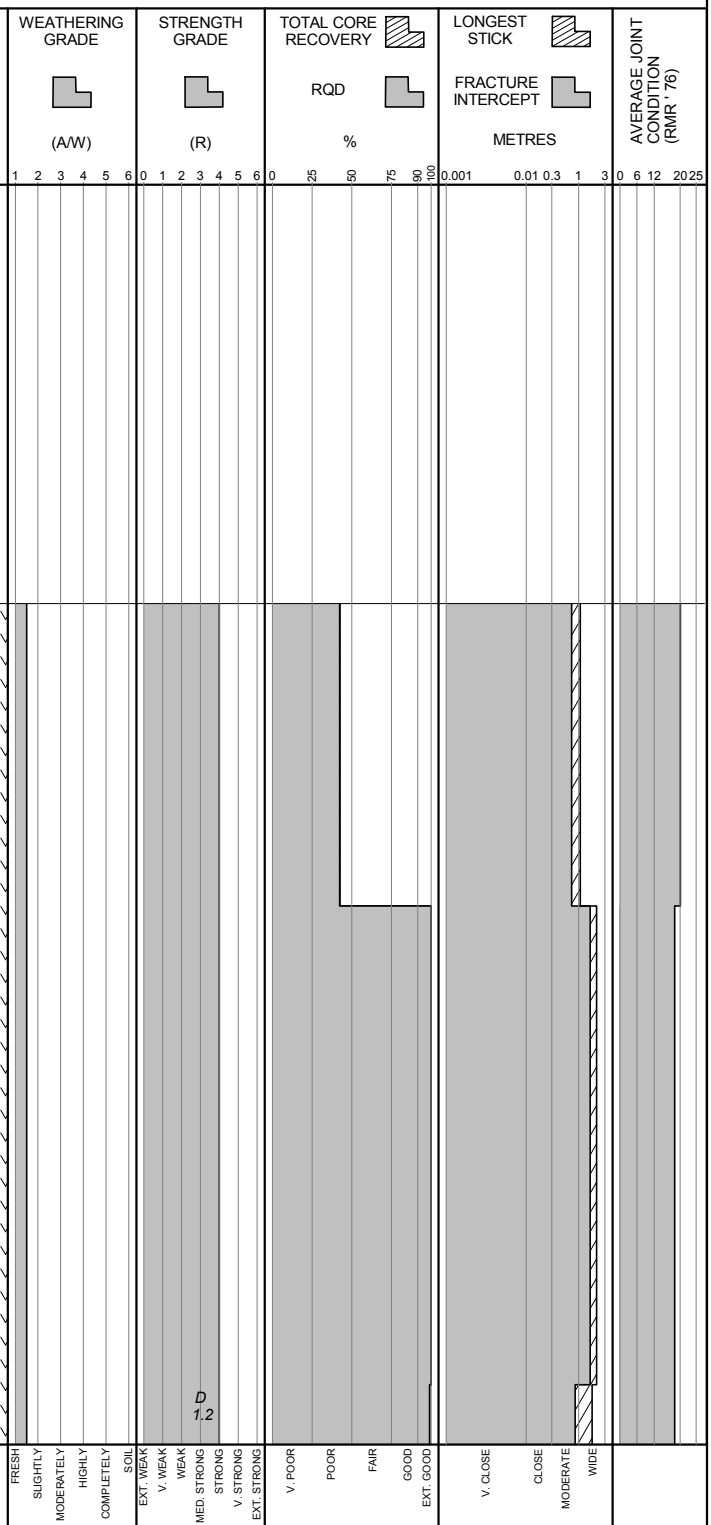
Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-24 Overburden Log						
3			INTERMEDIATE VOLCANICS (V12) Grey-green, mostly medium to coarse lapilli tuff with sericite altered fragments, matrix supported with sporadic areas fragment supported. Strong to very strong (R4-R5). Slight to faint weathering and alteration (W1.5-A1.5) from top of bedrock to 16.8 m. Fresh (A1) below 16.8 m.			D 1.2			

POINT LOAD TESTS
D — *TEST TYPE: DIAMETRAL (D); AXIAL (A)*
1.5— Is_{50} *(MPa)*



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
8					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
9									
10									
11									
12									
13									
14						D 4.2			
15									
16									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
16					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
17									
18									
19									
20						D 2.7			
21									
22									
23									
24									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

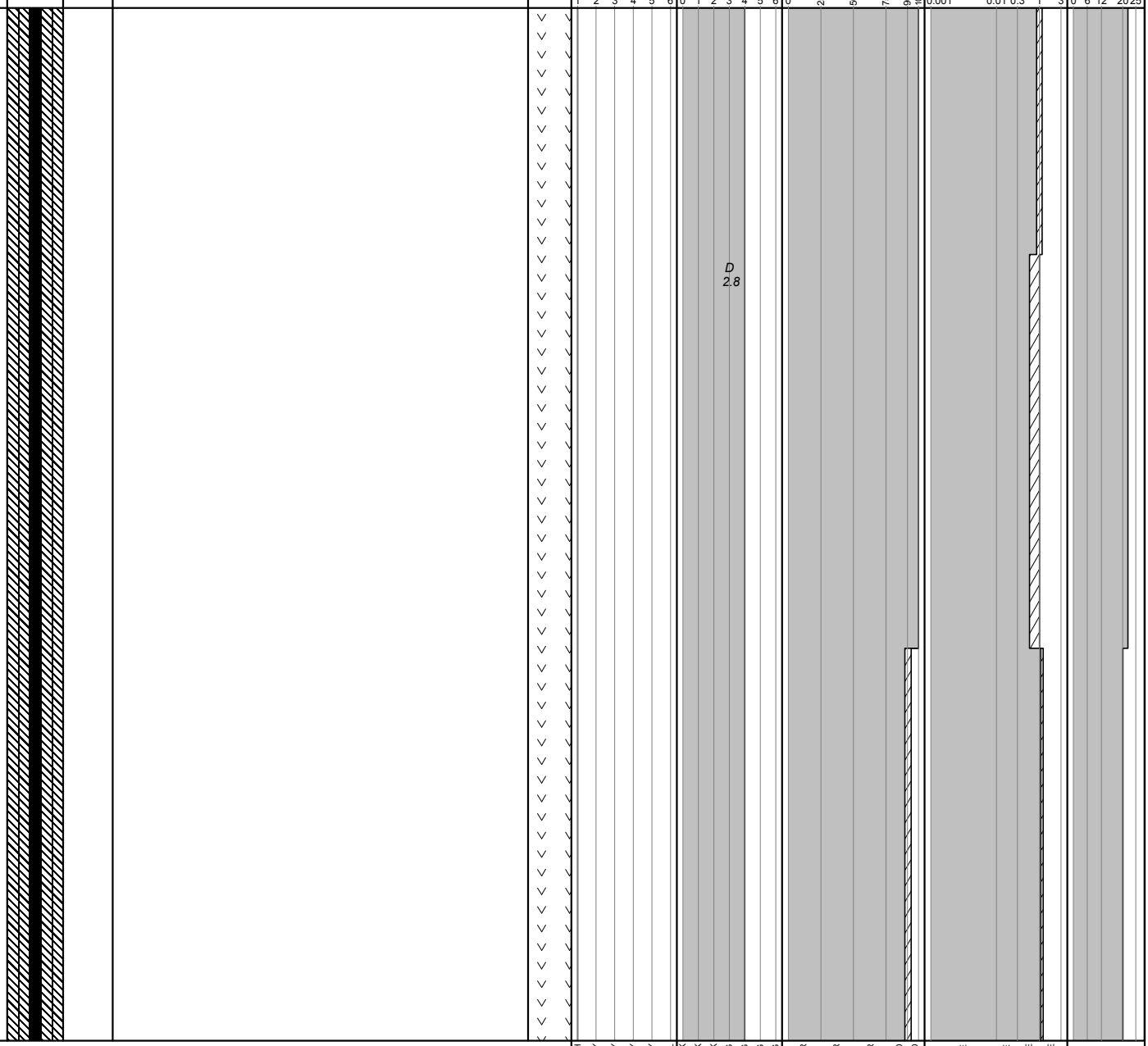
Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24–32					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
32					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
33						D 2.1			
34									
35									
36									
37									
38						D 3.0			
39									
40									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

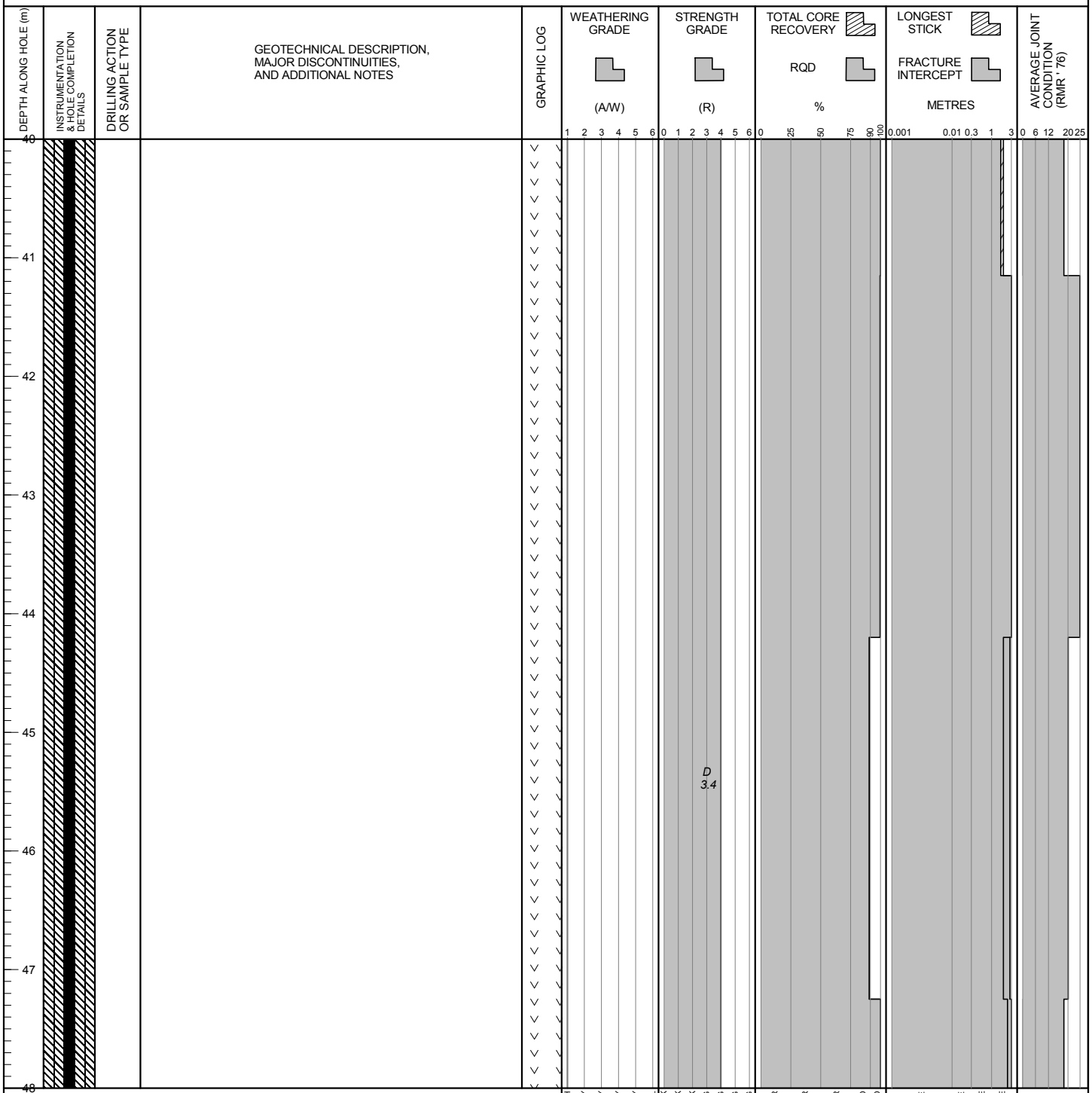
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-24

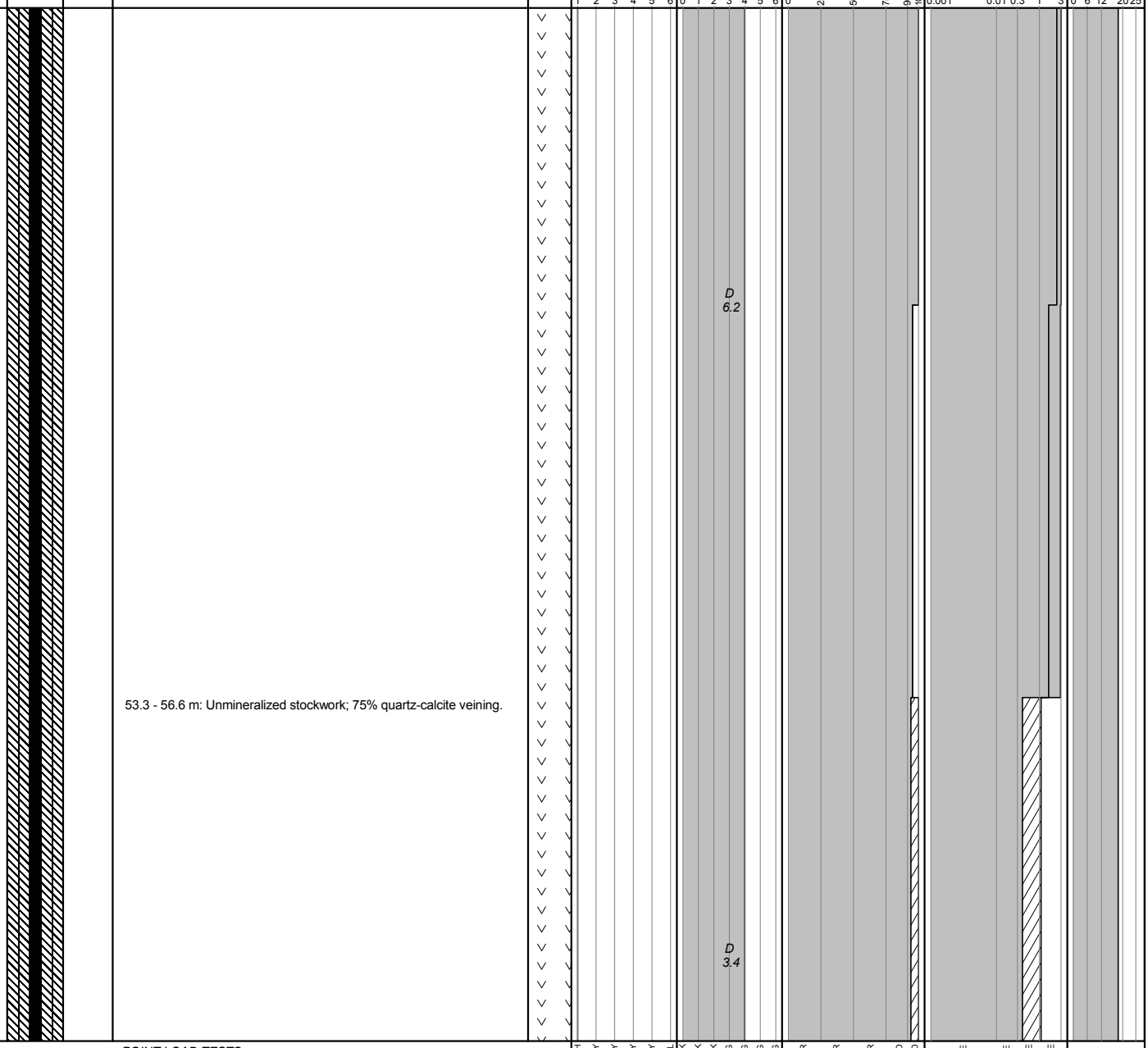
Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
48–56			53.3 - 56.6 m: Unmineralized stockwork; 75% quartz-calcite veining.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
56					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
57									
58									
59									
60						D 3.1			
61									
62									
63									
64									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

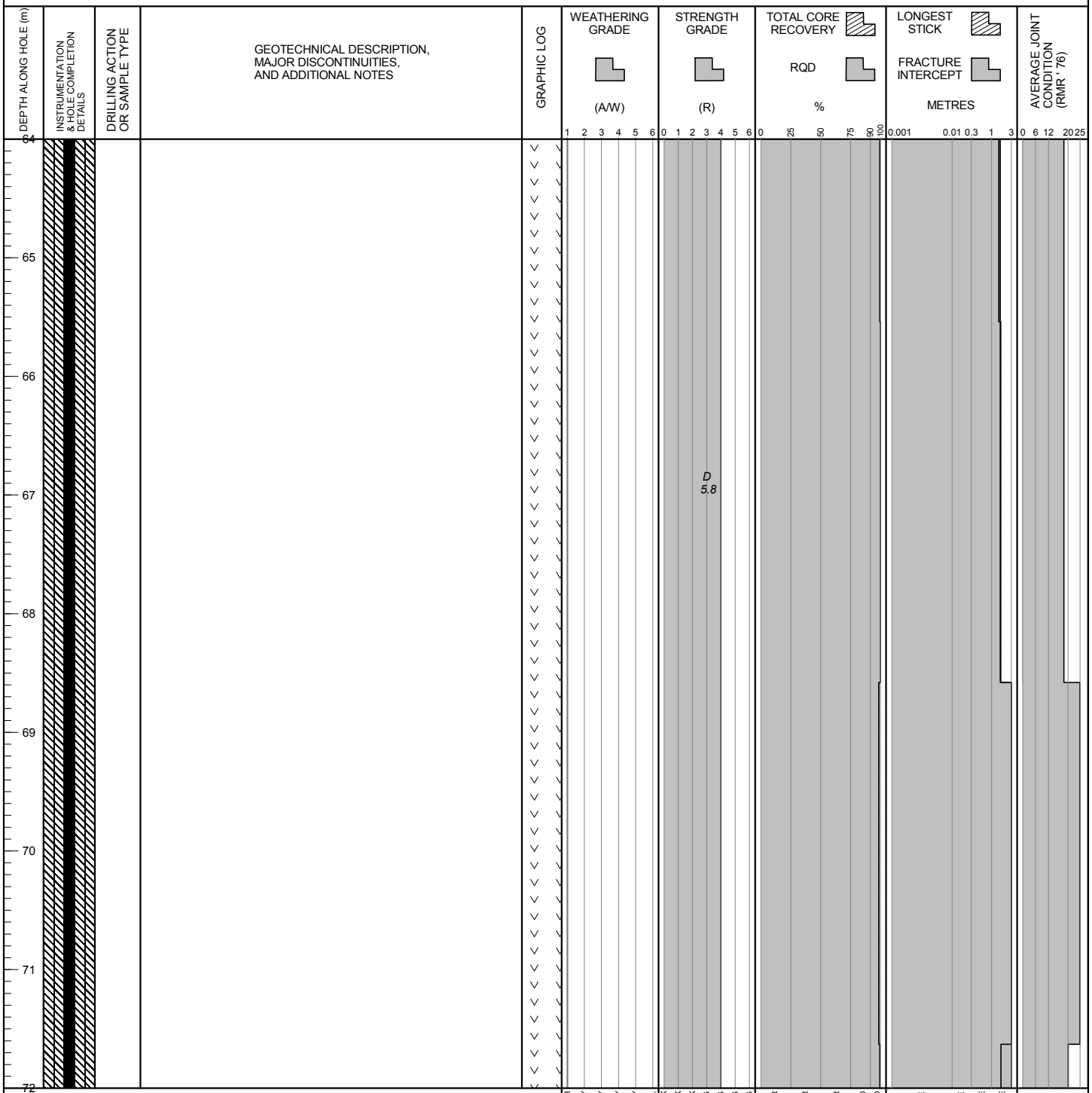
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
72					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
73						D 6.1; D 5.5; D 5.3			
74									
75									
76									
77						D 4.9			
78									
79									
80									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
80			
81			
82			
83			
84			83.7 m: Fault, 30 mm FB infill, R3. Dip/dip direction = 65/200.
85			84.7 m: Fault, 20 mm FB infill, R4. Dip/dip direction = 73/211.
86			
87			
88			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 5.7

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

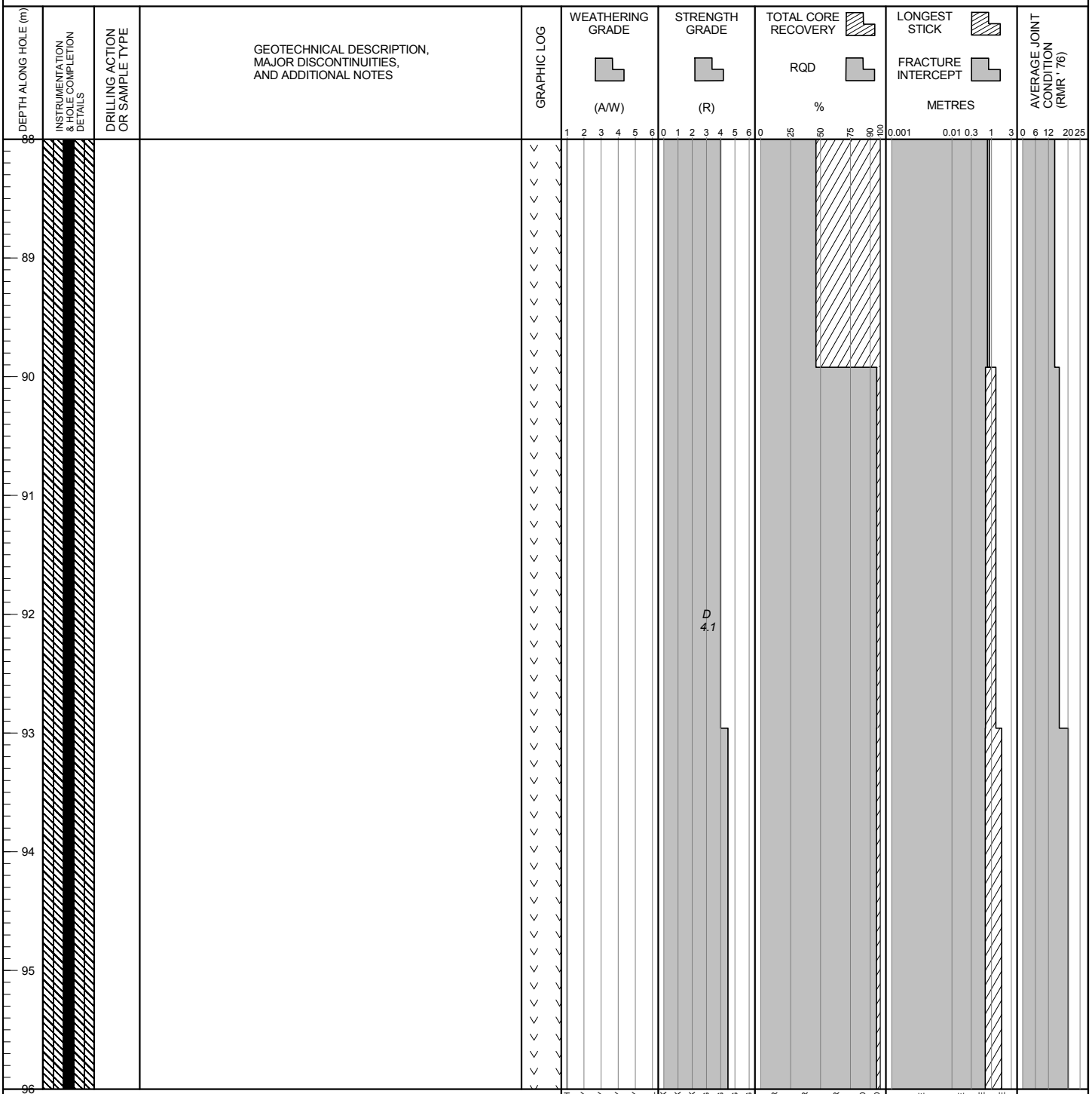
Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
96					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
97									
98						D 6.8			
99									
100									
101									
102									
103			102.8 m: Fault, 90 mm FB/FG infill, R2. Dip/dip direction = 73/226.			D 6.9			
104									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

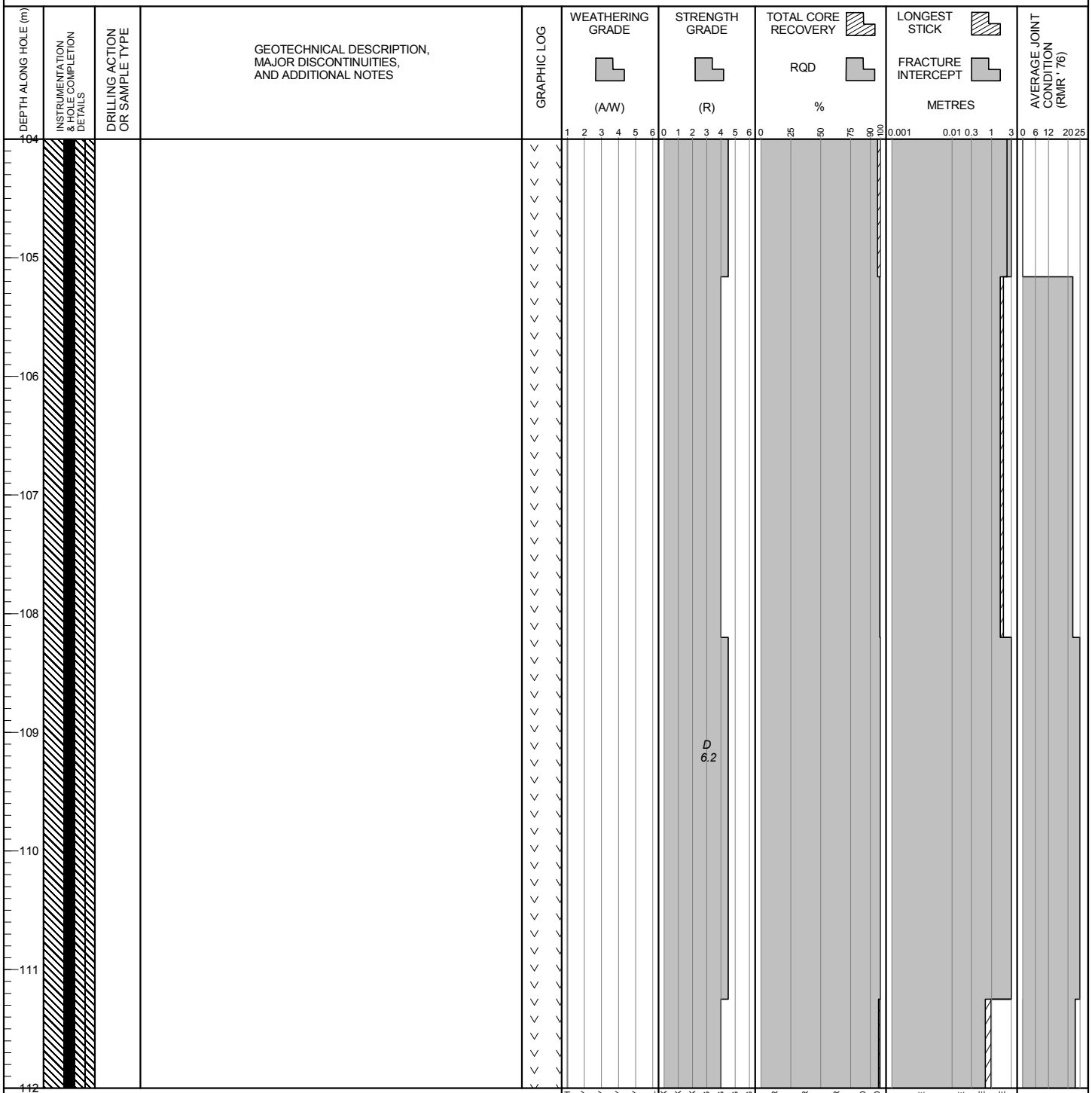
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

119.8 m: Fault, 50 mm BX/FB infill, R3. JRC = 12. Dip/dip direction =

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
120			64/190.						
121						D 6.8			
122									
123									
124									
125			124.8 m: Fault, 30 mm FB/FG infill, R0. JRC = 12. Dip/dip direction = 14/175. 124.8 m: Fault, 5 mm FB/FG infill, R0. JRC = 12. Dip/dip direction = 37/172. 124.9 m: Fault, 3 mm FB/FG infill, R0. JRC = 12. 125.1 m: Fault, 1 mm FG infill, R0. JRC = 13. Dip/dip direction = 81/209.						
126			126.2 m: Fault, 5 mm FG/FB infill, R1. JRC = 12. Dip/dip direction = 86/225.						
127									
128						D 4.3			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
128					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
129									
130			130.6 m: Shear, 0.5 mm aperture. JRC = 8.						
131									
132						D 6.3 D 6.1			
133						D 5.0			
134									
135									
136									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

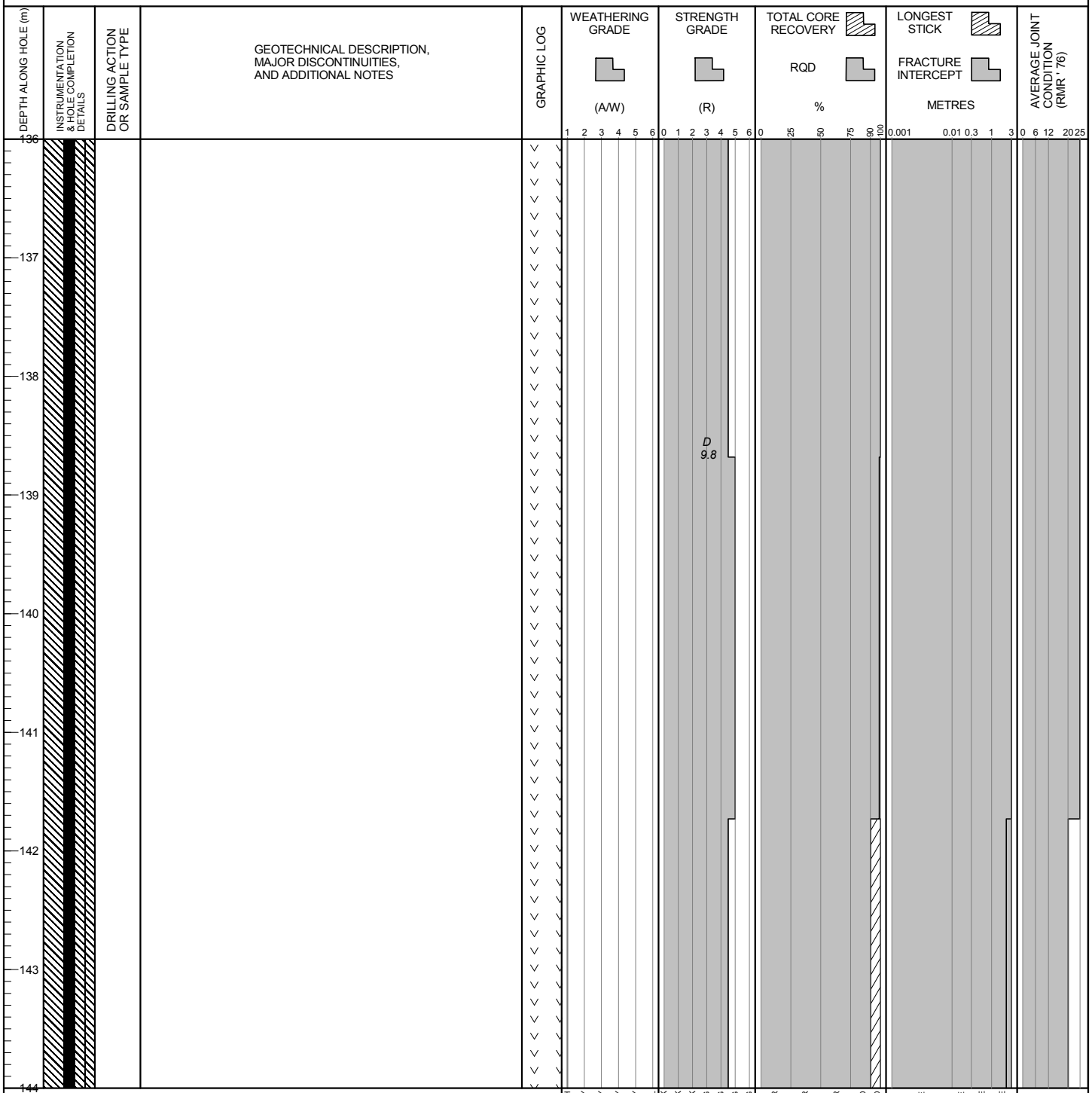
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
144			144.2 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 48/034.
145			145 m: Fault, 30 mm FG infill, R0. JRC = 2. Dip/dip direction = 60/205. 145.1 m: Shear, 0.5 mm aperture. JRC = 4.
146			145.7 m: Shear, 1 mm QZ infill, R5. JRC = 4. Dip/dip direction = 50/205. 146 m: Shear, 0.5 mm aperture. JRC = 1.
147			
148			
149			
150			
151			
152			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 3.2

D 5.7

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
152					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
153									
154									
155						D 8.5			
156									
157									
158									
159									
160									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

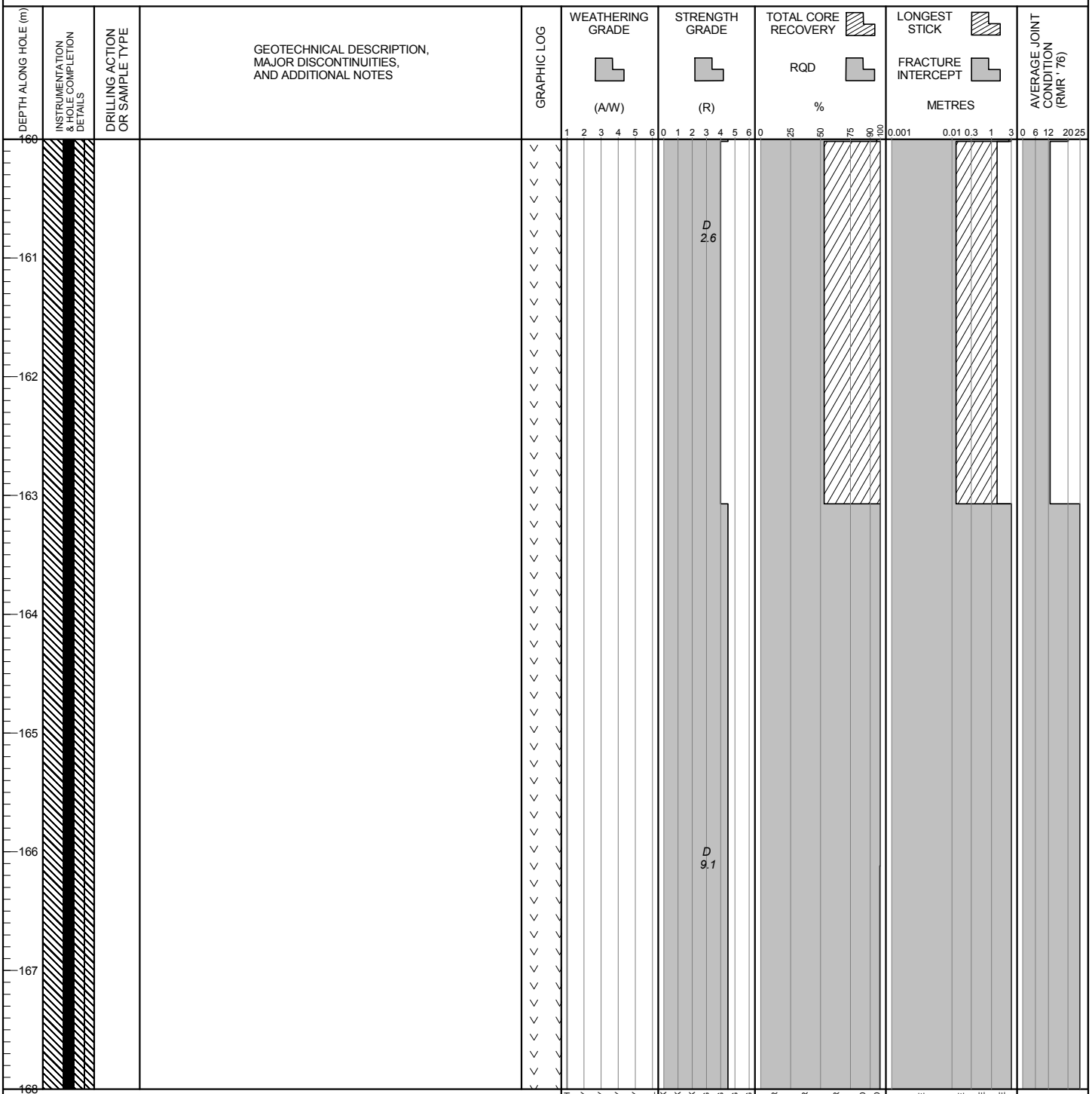
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

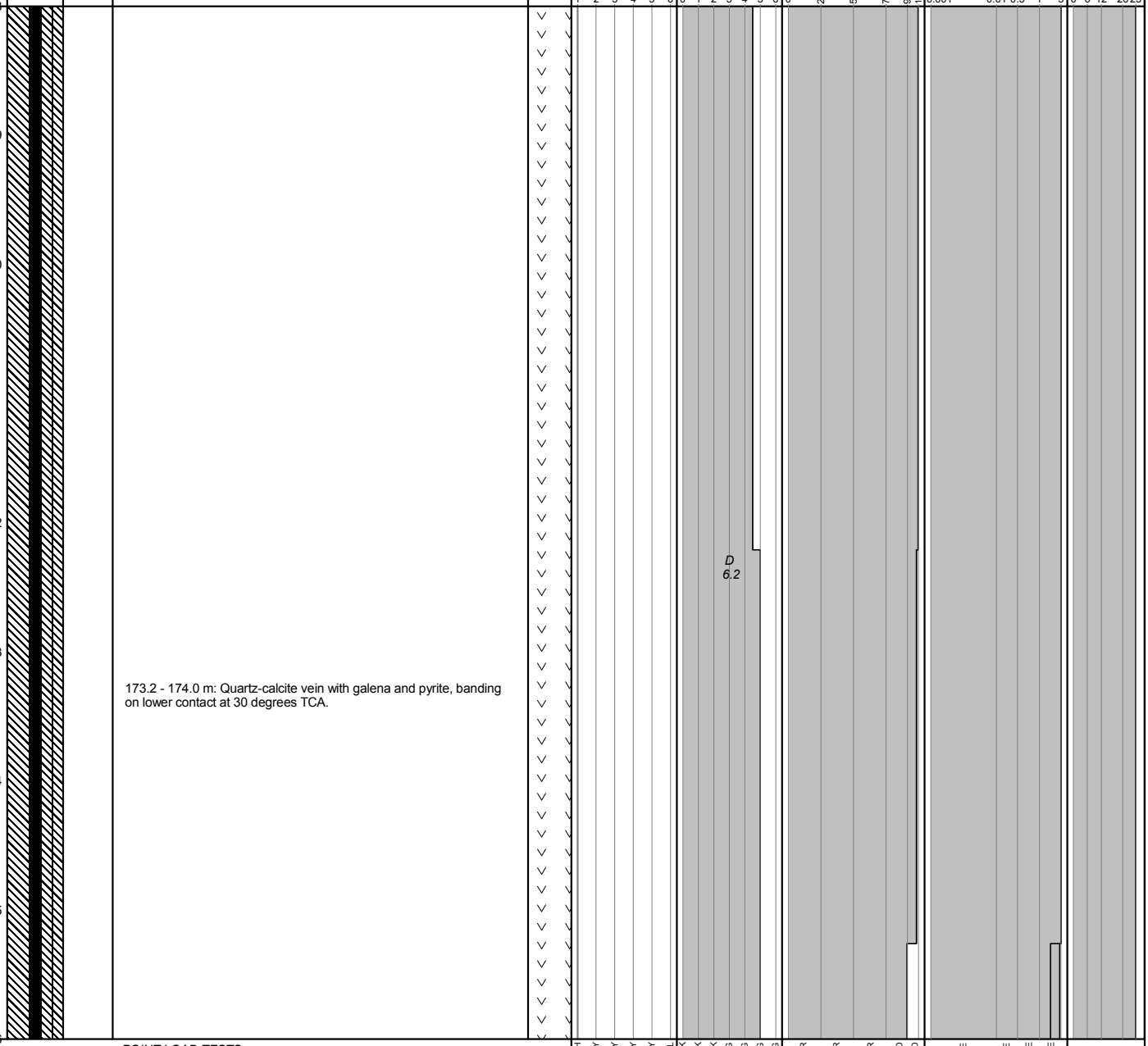
Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
168–176			173.2 - 174.0 m: Quartz-calcite vein with galena and pyrite, banding on lower contact at 30 degrees TCA.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
176									
177			176.9 m: Shear, 0.5 mm aperture. JRC = 12.						
178						D 6.7			
179									
180									
181									
182									
183			183.5 m: Shear, 0.5 mm aperture. JRC = 4.						
184									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No. 1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
184					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
185						D 11.6			
186									
187									
188									
189									
190						D 8.1			
191									
192									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
192					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
193									
194									
195									
196						D 7.2 D 6.3			
197						D 7.4			
198									
199									
200									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
200					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
201									
202									
203						D 6.8			
204									
205									
206									
207									
208									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

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Start Date: 25 Apr 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
208					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
209						D 5.1			
210									
211									
212									
213									
214									
215						D 7.6			
216									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

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Ground Elevation (m): 1,547.6
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Drill Designation: Heliportable
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Core: HQ3
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Cased To (m) : 3.7

Start Date: 25 Apr 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
216					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
217									
218									
219									
220									
221									
222						D 5.2			
223									
224									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
224			224.2 - 225.8 m: Mafic dyke with chilled margins.						
225			225.2 m: Shear, 0.5 mm SE infill, R3. JRC = 12.						
			225.6 m: Shear on vein, 10 mm SE/QZ infill, R4. JRC = 20. Dip/dip direction = 42/267.						
226			225.7 m: Shear on vein, 40 mm SE/QZ infill, R4. JRC = 20. Dip/dip direction = 38/307.						
227									
228						D 6.8			
229									
230									
231									
232									

Weathering grade scale: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade scale: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept metres: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76): 0, 6, 12, 20, 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

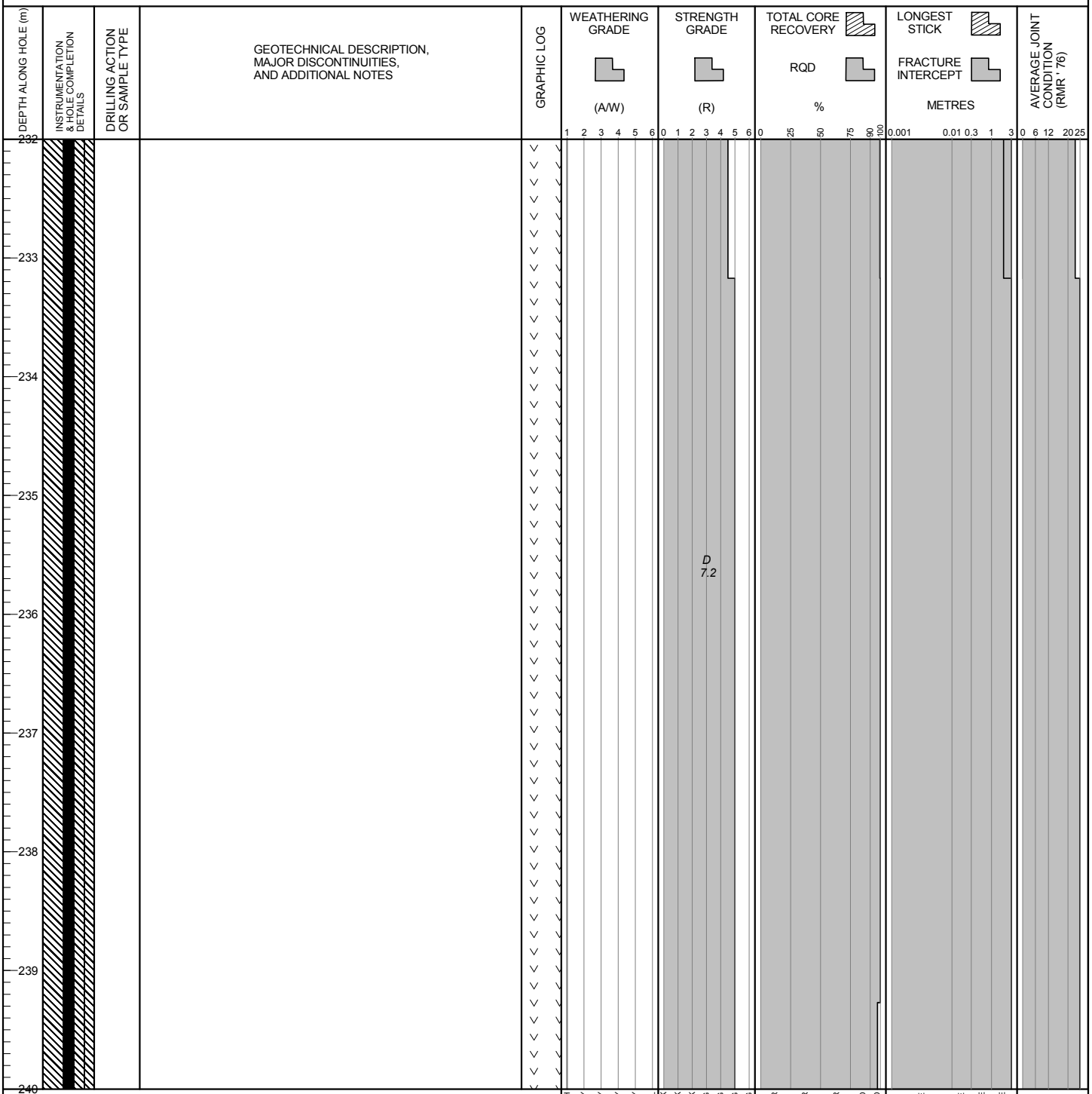
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

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Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
240					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
241									
242									
243						D 6.6			
244									
245									
246									
247									
248									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

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Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
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Final Depth (m): 501.4
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Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
248					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
249						D 7.4			
250									
251									
252									
253									
254									
255						D 7.6			
256									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-24

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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
256					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
257			257.6 - 258.4 m: Mafic dyke with chilled margins.						
258									
259									
260									
261									
262									
263									
264									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

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DRILL HOLE # DH-BGC12-24

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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
264									
						D 9.6			
						D 7.3			
265						D 7.9			
266									
267									
268			268 m: Shear, 0.5 mm CL infill, R2. JRC = 4. Dip/dip direction = 78/269.						
269									
270			270.1 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 75/245.			D 7.4			
271			271.5 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 74/247.						
272									

Weathering grade: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD: 0, 25, 50, 75, 90, 100 %
Longest stick / fracture intercept: 0.001, 0.01, 0.3, 1, 3 metres
Average joint condition (RMR '76): 0, 6, 12, 20, 25
Fracture intercept: V. CLOSE, CLOSE, MODERATE, WIDE

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
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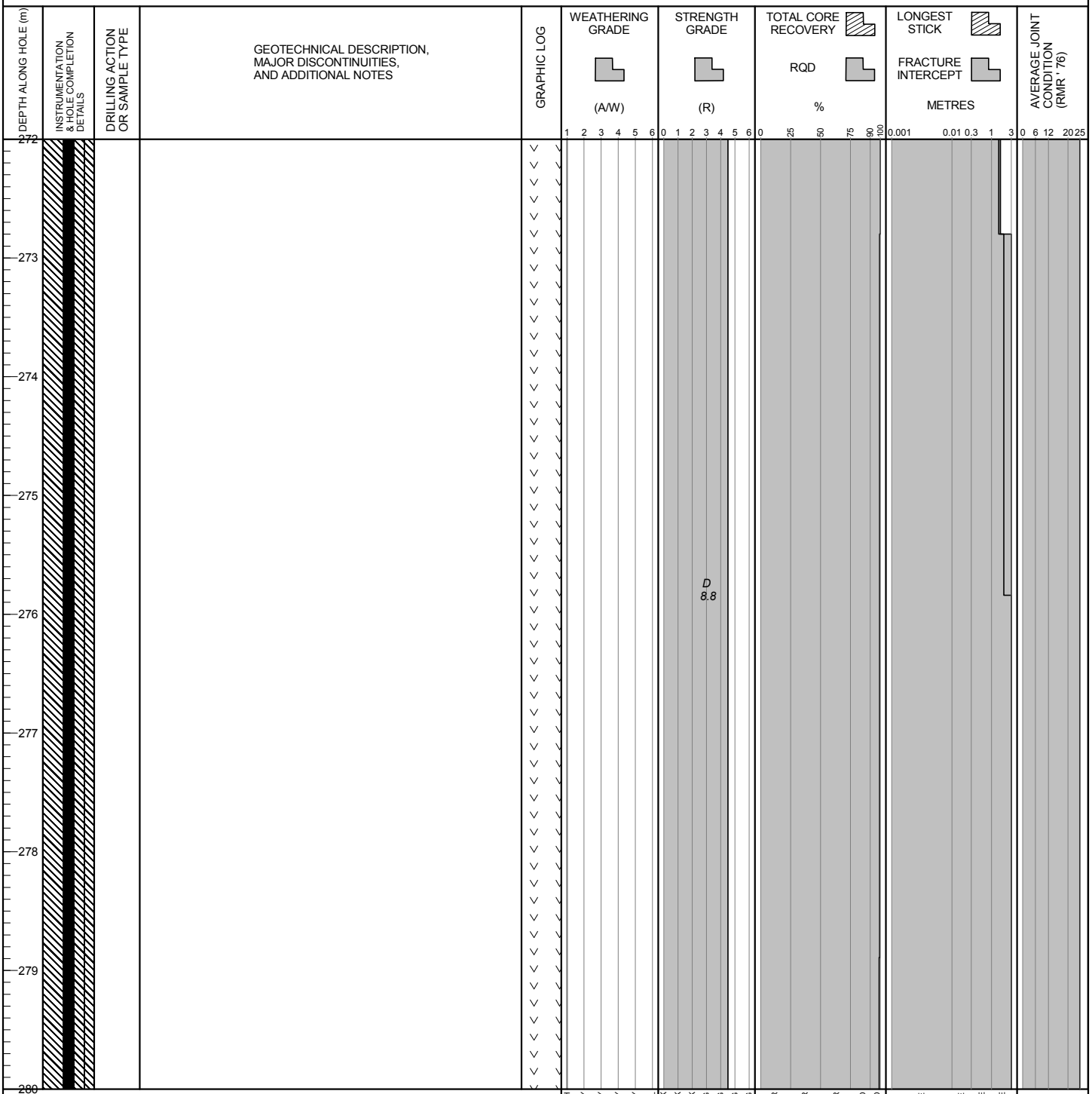

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Drill Method: Diamond
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Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD (%)	LONGEST STICK / FRACTURE INTERCEPT (METRES)	AVERAGE JOINT CONDITION (RMR '76)
280					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
281						D 7.4			
282									
283									
284									
285						D 3.8			
286			286.5 m: Shear, 0.5 mm aperture. JRC = 4. 286.5 m: Shear, 1 mm CX infill, R2. JRC = 4. Dip/dip direction = 72/257.						
287			287.5 m: Shear, 3 mm CX infill, R1. JRC = 8. Dip/dip direction = 82/333.						
288					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

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DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

288
289
290
291
292
293
294
295
296

Constant head test from 292.6 - 306.3 m. Estimated hydraulic conductivity is 3.1E-08 m/s.

293.6 m: Shear, 0.5 mm aperture. JRC = 2.

CONGLOMERATE (S3)
Grey-green, multi-cm clasts supported in a 0.5-1 cm sized matrix, polylithic. Strong foliation at 40 degrees TCA. Strong to very strong (R4-R4.5). Fresh (A1).

295 m: Shear, 1 mm CX infill, R2. JRC = 4.

295.4 m: Shear, 0.5 mm aperture. JRC = 8.

D 7.5

D 2.7

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL

STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

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Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
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296			296.5 m: Shear, 1 mm CX infill, R2. JRC = 2. Dip/dip direction = 38/231.						
297									
298									
299									
300						D 6.5			
301									
302						D 8.8 D 6.7 D 5.7			
303						D 7.4			
304									

Weathering grade scale: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade scale: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TCR/RQD scale: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept scale: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
304			304 m: Shear on vein, 3 mm QZ infill, R4. JRC = 20.						
305									
306						D 7.0			
307									
308									
309									
310									
311						D 4.7			
312									

POINT LOAD TESTS
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1.5— Is_{50} (MPa)

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AN APPLIED EARTH SCIENCES COMPANY

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Drill Method: Diamond
Core: HQ3
Fluid: Polymer
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Start Date: 25 Apr 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
312									
			QUARTZ SULPHIDE VEIN (H4) Solid white quartz vein with galena and sphalerite at 30 degrees TCA. Large 30 cm clast of rhyolite within the vein. Strong (R4). Fresh (A1).						
313									
			ARENITE (S4) Green, fine to coarse grained sandstone with some silt-sized beds, bedding fine upwards. Bedding is at 40 degrees TCA. Top of interval has intense seracite alteration and fragments of rhyolite. Strong to very strong (R4-R5). Medium strong rock (R3.5) from 355.0-358.2 m. Fresh (A1)						
314									
315									
316			316.4 m: Shear, 2 mm QZ infill, R4. JRC = 4. Dip/dip direction = 58/347.			D 5.8			
317									
318									
319									
320									

Scales: WEATHERING GRADE (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL. STRENGTH GRADE (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG. TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD. LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE. AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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320					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
321			321.7 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 47/064.			D 4.5 D 4.1			
322									
323									
324									
325									
326									
327									
328					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25
328									
329									
330						D 8.6			
331									
332									
333									
334									
335									
336									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
336					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
337						D 9.2			
338									
339									
340									
341						D 8.4			
342									
343									
344									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
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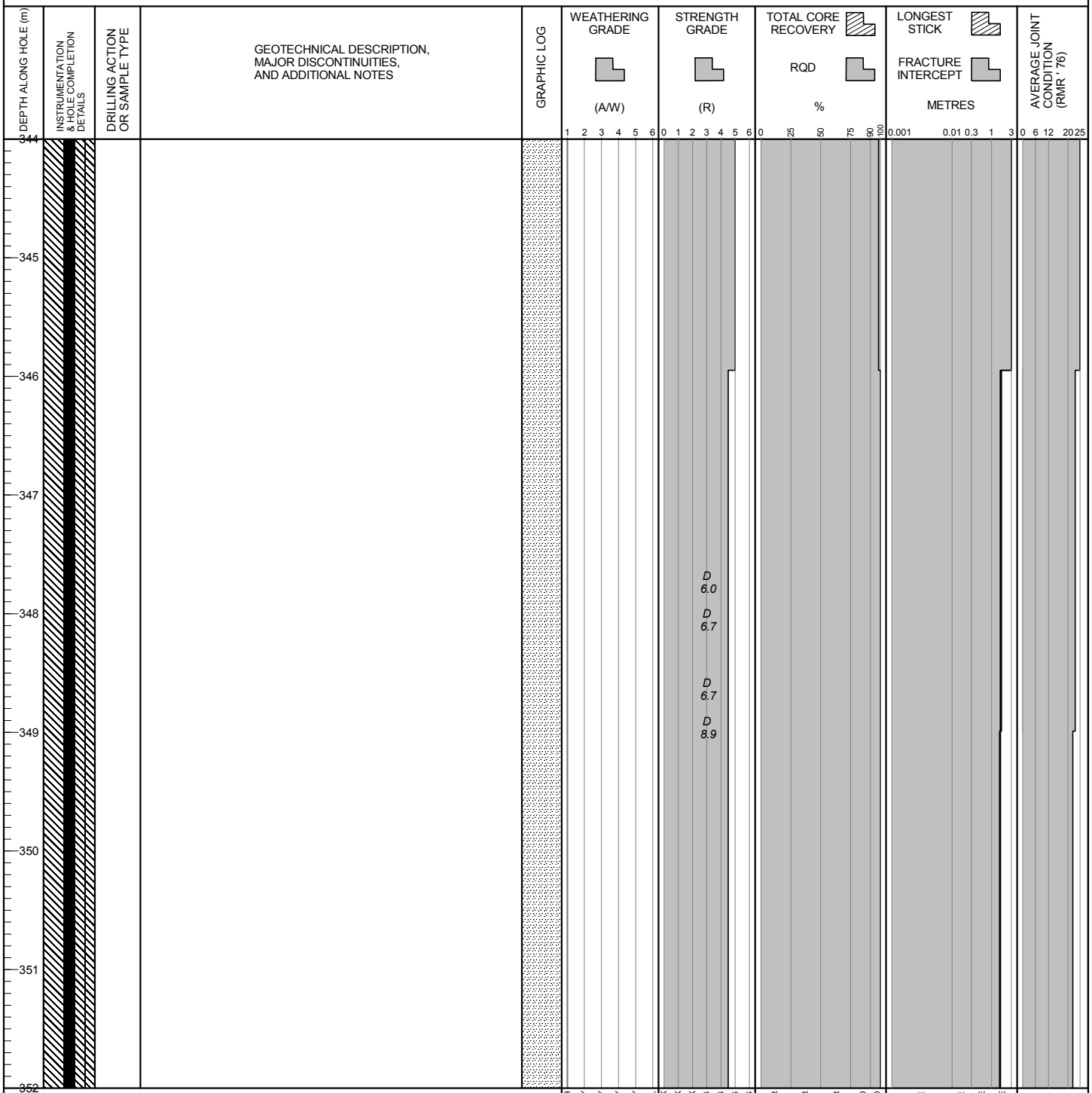
Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
352					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
353									
354									
355						D 10.8			
356									
357									
358									
359									
360					FRESH SLIGHTLY MODERATELY HIGHLY COMPLETELY SOIL	EXT. WEAK V. WEAK MED. STRONG STRONG V. STRONG EXT. STRONG	V. POOR POOR FAIR GOOD EXT. GOOD	V. CLOSE CLOSE MODERATE WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

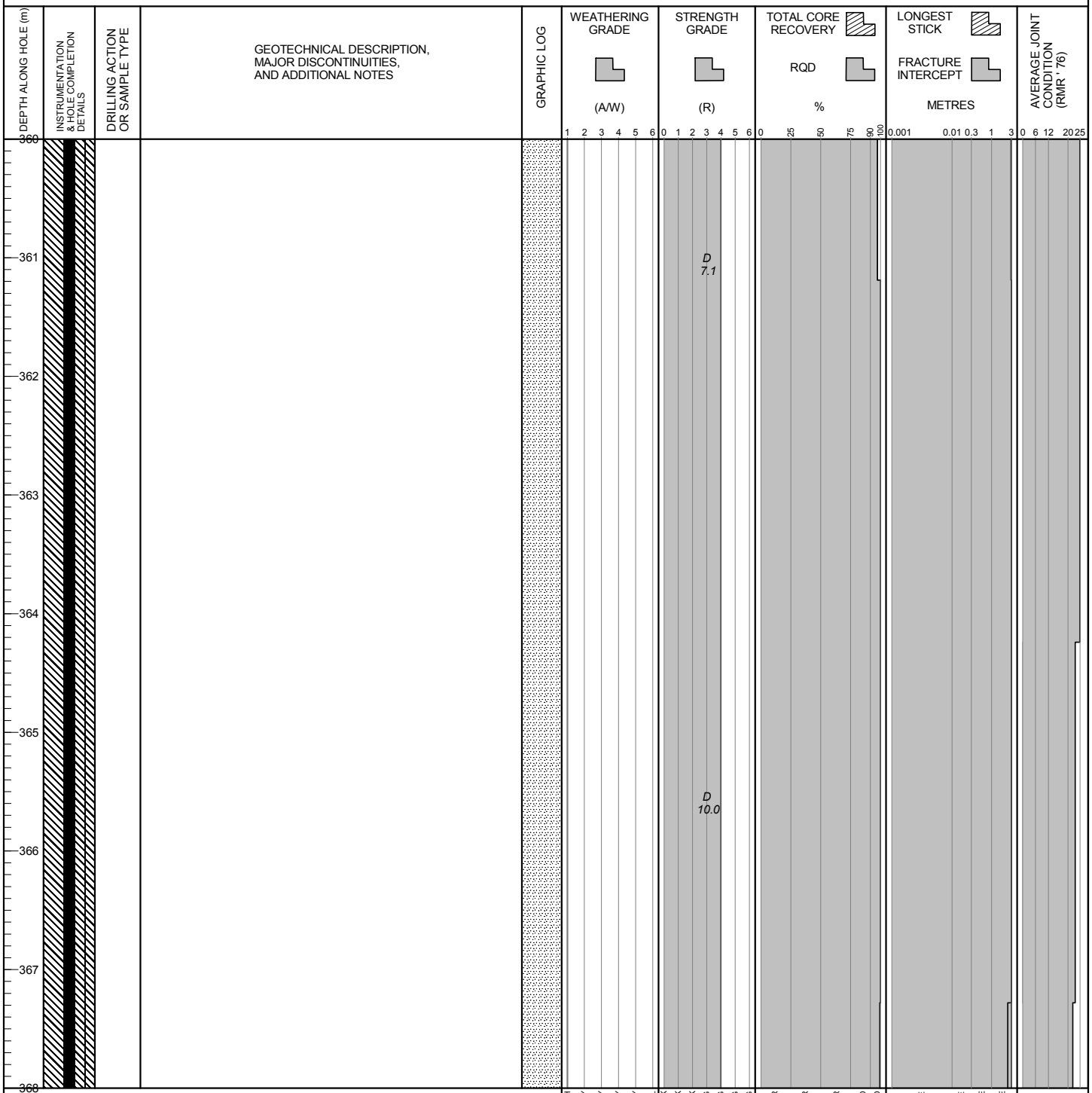
DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
368					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
369			369.7 m: Fault, 1.5 mm SE/BX infill, R3. JRC = 12. Dip/dip direction = 72/235.			D 7.3			
370									
371									
372									
373									
374									
375									
376									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
376									
377									
378						D 8.2			
379									
380									
381									
382			381.9 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 61/234.						
383									
384									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
384			Constant head test from 384.1 - 406.9 m. Estimated hydraulic conductivity is 2.7E-08 m/s.			D 9.4			
385									
386									
387									
388			388.1 m: Shear, 1 mm QZ infill. JRC = 8. Dip/dip direction = 75/226.						
389									
390						D 8.0			
391									
392									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25
392									
393									
394									
395									
396									
397									
398						D 8.8			
399									
400									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
400					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
401									
402						D 8.9			
						D 10.8			
403						D 10.2			
404									
405						D 7.8			
406									
407									
408									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
408					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
409									
410									
411									
412						D 7.0			
			412.6 m: Shear, 1 mm aperture. JRC = 12. Dip/dip direction = 65/229.						
413									
			413.7 m: Shear on vein, 2.5 mm QZ infill, R4. JRC = 16. Dip/dip direction = 73/278.						
414									
			414.8 m: Fault, 1.5 mm FB/FG infill, R0. JRC = 12. Dip/dip direction = 59/224.						
415			414.9 m: Shear, 0.5 mm aperture. JRC = 12. Dip/dip direction = 73/253.						
			414.9 m: Shear, 1 mm aperture. JRC = 12.						
416									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
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Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
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Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
416									
417									
418						D 10.9			
			418.5 m: Shear, 1 mm CX infill, R4. JRC = 2. Dip/dip direction = 67/230.						
419									
420									
421									
422									
423									
424						D 8.6			

Scales: WEATHERING GRADE (A/W) 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE (R) 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
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Final Depth (m): 501.4
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
424					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
425									
426									
427									
428									
429									
430						D 8.2			
431									
432									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
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DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
432			Constant head test from 432.8 - 458.7 m. Estimated hydraulic conductivity is 1.9E-08 m/s.						
433									
434									
435									
436									
437						D 4.5			
438									
439									
440									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; RQD 0 25 50 75 90 100; LONGEST STICK 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
440					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
441									
442									
443						D 7.2			
444									
445									
446									
447									
448									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
448						D 8.9			
449						D 10.0 D 7.8			
450									
451									
452									
453			453.2 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 16. Dip/dip direction = 34/013.						
454			453.8 m: Shear on vein, 0.5 mm QZ infill, R4. JRC = 12.						
455									
456									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

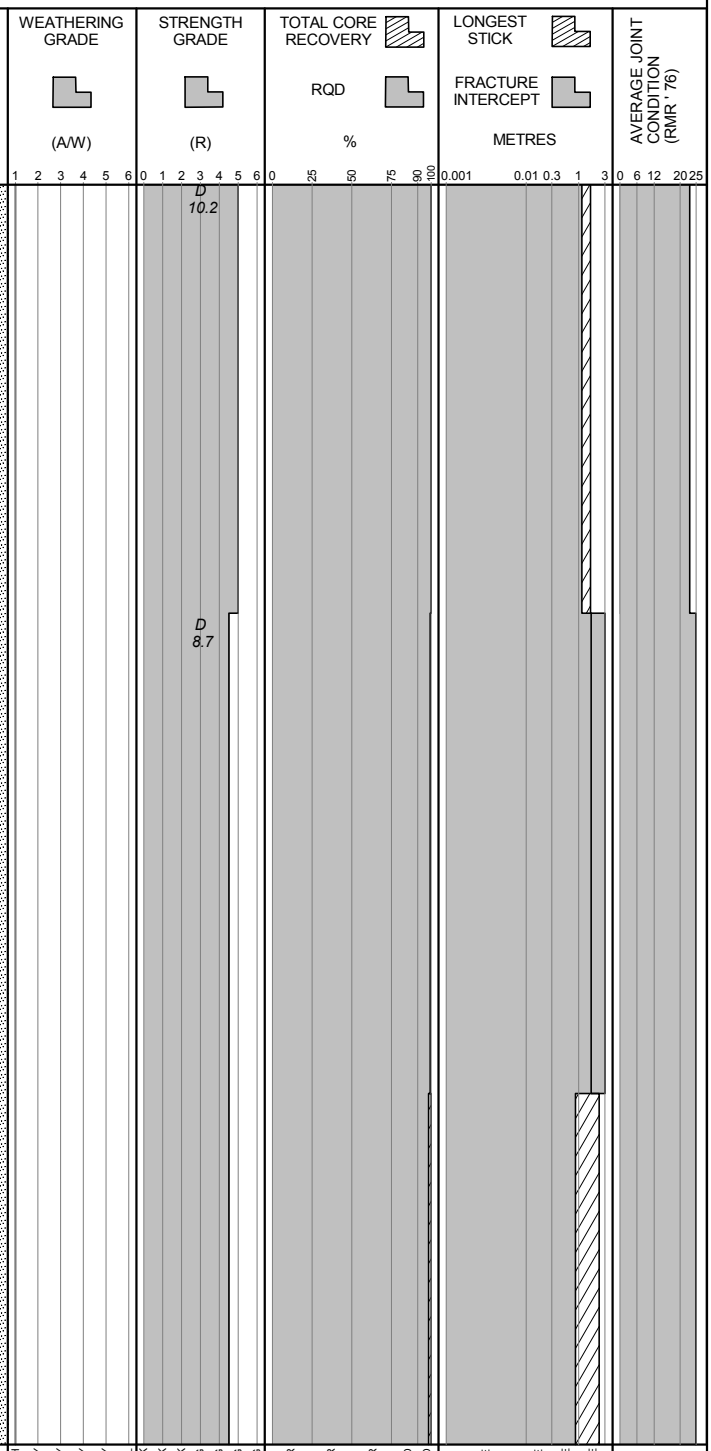
Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
456			456.3 m: Shear, 0.5 mm aperture. JRC = 8. Dip/dip direction = 41/258.
457			457 m: Shear, 0.5 mm aperture. JRC = 4. Dip/dip direction = 19/248.
458			
459			
460			460.2 m: Shear, 0.5 mm aperture. JRC = 16. Constant head test from 460.3 - 470.9 m. Estimated hydraulic conductivity is 6.7E-08 m/s.
461			
462			461.8 - 467.0 m: Small section of coarse sands, potentially polymictic with alteration. Contains cm-scale subrounded to rounded clasts, increasing downhole.
463			
464			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

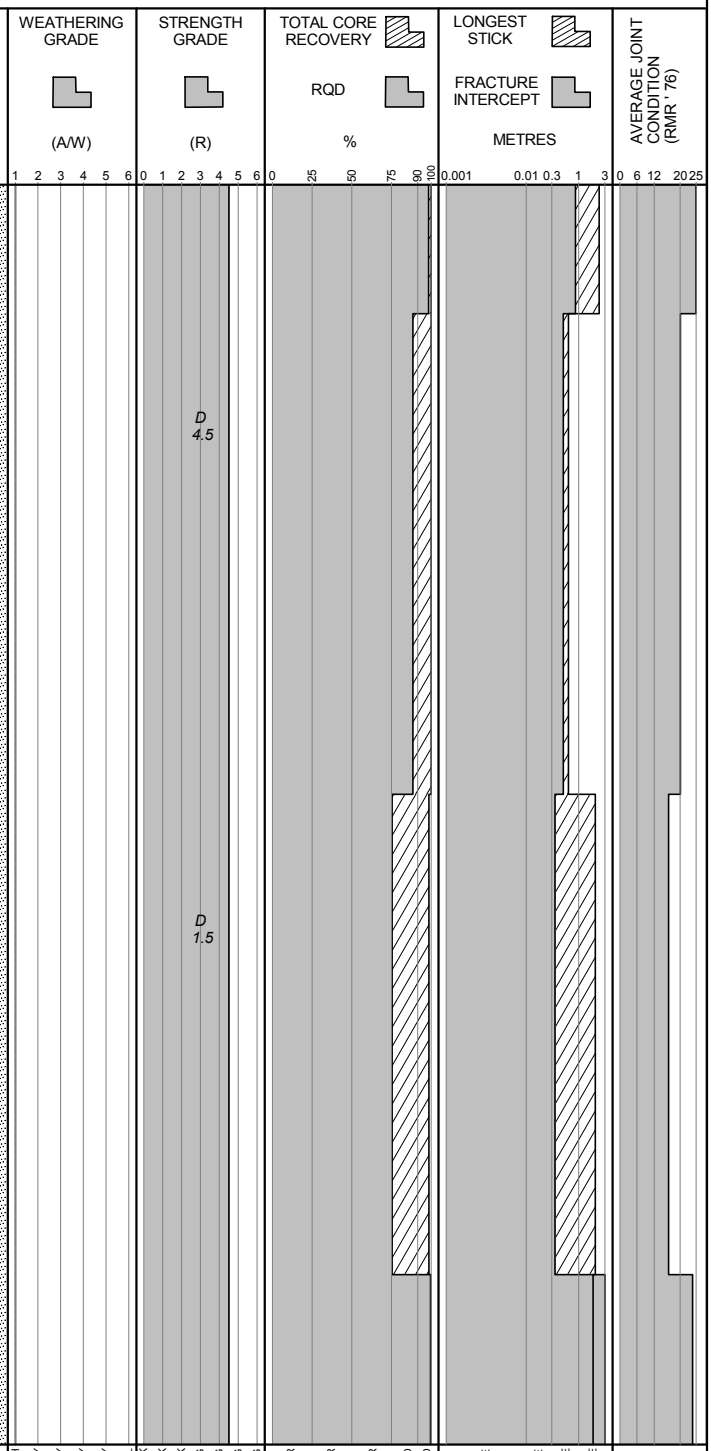
Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
464			464.1 m: Shear, 0.5 mm aperture. JRC = 4.
			464.5 m: Fault, 50 mm CX infill, R3. JRC = 4. Dip/dip direction = 49/273.
			464.6 m: Shear, 0.5 mm aperture. JRC = 8.
465			464.7 m: Shear, 0.5 mm aperture. JRC = 4. Dip/dip direction = 24/264.
			465.3 m: Shear, 0.5 mm aperture. JRC = 2. Dip/dip direction = 53/095.
466			466 m: Shear, 0.5 mm aperture. JRC = 20.
467			467.0 - 480.0 m: Massive sandy section with fault zone, no clasts, but concretions of pyrite, chlorite and calcite.
			467.1 m: Shear, 0.5 mm aperture. JRC = 8.
			467.5 m: Fault, 190 mm FB infill, R3. JRC = 20. Dip/dip direction = 56/237.
468			468.3 m: Fault, 30 mm CX infill, R3. JRC = 16. Dip/dip direction = 55/289.
469			468.8 m: Fault, 90 mm FB infill, R3. JRC = 16. Dip/dip direction = 45/249.
470			
471			
472			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
472			
473			
474			474.6 m: Fault on vein, 1 mm QZ infill, R4. JRC = 12.
475			475.4 m: Fault on vein, 1 mm QZ/FG infill, R4. JRC = 12. Dip/dip direction = 28/310.
476			
477			
478			478.7 m: Fault, 50 mm BX infill, R3. JRC = 20. 478.8 m: Fault, 40 mm BX infill, R3. JRC = 20. 478.9 m: Fault on vein, 0.5 mm aperture. JRC = 20. 479.1 m: Fault on vein, 0.5 mm aperture. JRC = 20. Dip/dip direction = 52/239. 479.4 m: Fault on vein, 20 mm CX infill, R3. JRC = 20. Dip/dip direction = 46/154. 479.6 m: Fault on vein, 80 mm CX infill, R3. JRC = 16.
479			
480			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 8.4

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
480			QUARTZ CARBONATE VEIN (H2) White, quartz-calcite-iron carbonate vein with wall rock clasts, no mineralization. Strong (R4). Fresh (A1). 480.6 m: Fault on vein, 5 mm CX infill, R3. JRC = 16. 480.8 m: Fault on vein, 2 mm CX infill, R3. JRC = 16. Dip/dip direction = 47/250.		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
481			ARENITE (S4) Green, sandstone with some cm-sized clasts. Strong to very strong (R4-R4.5). Fresh (A1). 482.9 m: Shear, 0.5 mm aperture. JRC = 20. Dip/dip direction = 72/243.			D 4.4 D 2.1			
482									
483									
484									
485									
486									
487									
488									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-24

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
488					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
489									
490									
491									
492									
493									
494						D 8.3 D 6.4 D 8.6 D 5.6			
495									
496									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-24

Location: Valley of Kings Zone

Co-ordinates (m): 426,646E - 6,257,878N
Ground Elevation (m): 1,547.6
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -68
Trend (°): 002

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 3.7

Start Date: 25 Apr 12
Finish Date: 04 May 12
Final Depth (m): 501.4
Depth To Top Of Rock (m): 2.7
Logged By: LH/SW/LM
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
496									
497			497.0 - 497.5 m: Dyke with contacts at 30 degrees TCA.						
498									
499			499.0 m: Shear, 0.5 mm aperture. JRC = 8.						
500						D 6.4			
501									
			END OF DRILLHOLE AT 501.4 m Notes: 1. Two vibrating wire piezometers installed at 98.5 m and 499.9 m.						
502									
503									
504									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

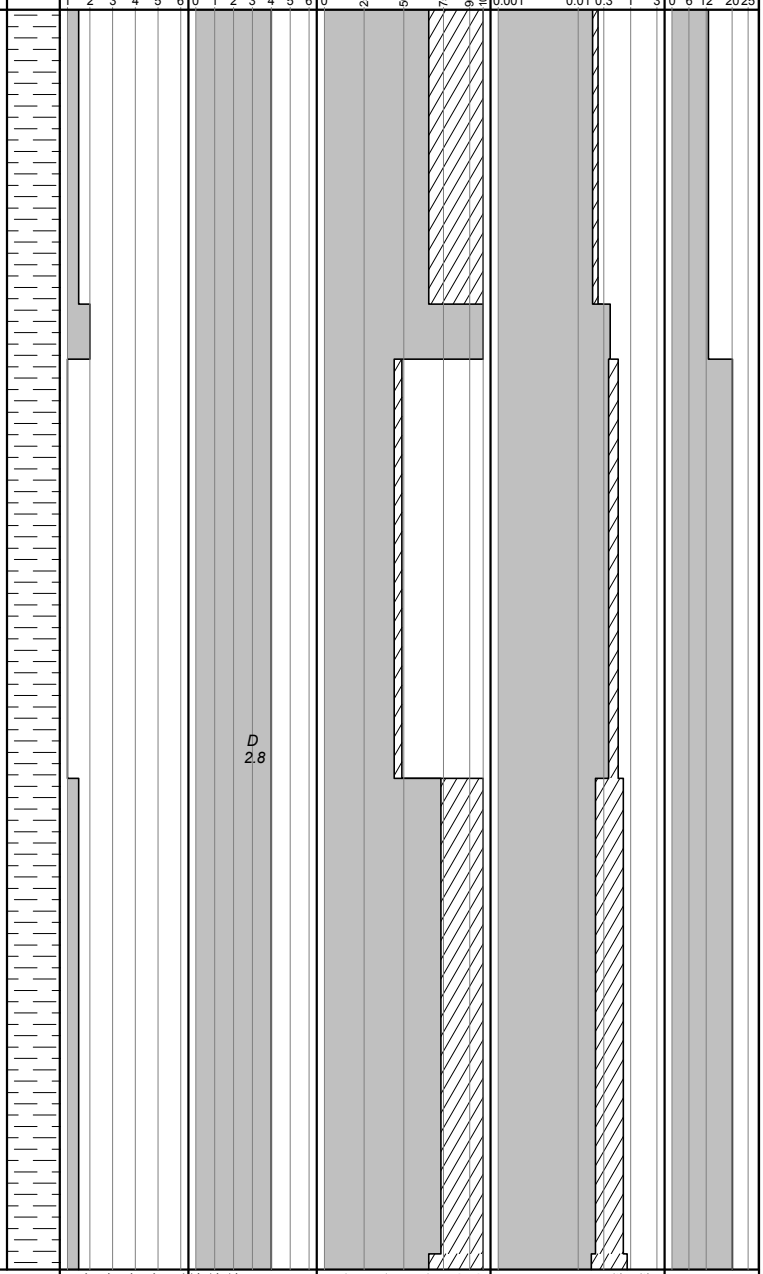
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N	**Drill Designation:** Heliportable	**Start Date:** 03 May 12
Ground Elevation (m): 1,527.8	**Drilling Contractor:** Radius	**Finish Date:** 13 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 371.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -45	**Fluid:** Polymer	**Logged By:** LM/SW
Trend (°): 176	**Cased To (m) :** 1.5	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			PELITE (S5) Grey, interbedded sedimentary unit, slightly faulted. Bedding visible in some areas, but layers are convoluted and sub-parallel to core axis. Strong (R4). Slight weathering from top of bedrock to 2.2 m. Faint to no alteration (A1-A1.5) below 2.2 m.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

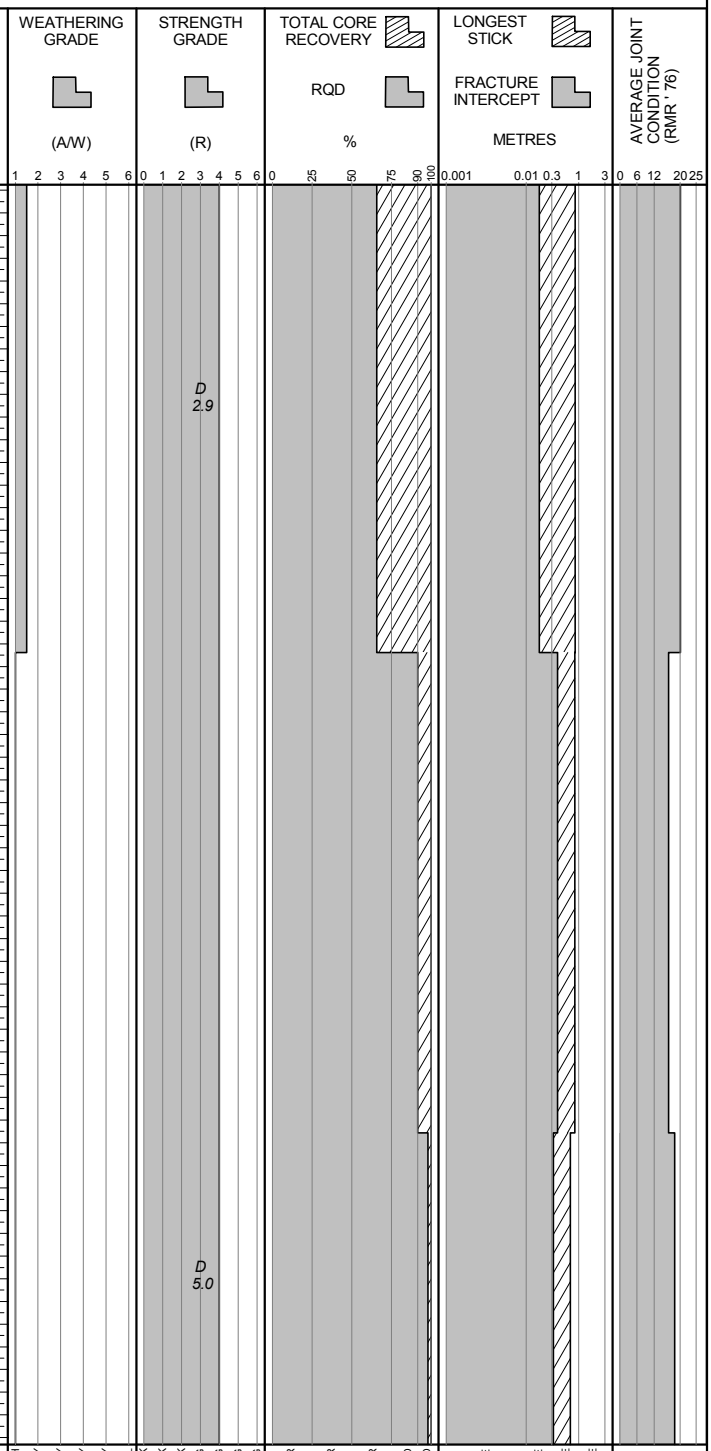
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N	**Drill Designation:** Heliportable	**Start Date:** 03 May 12
Ground Elevation (m): 1,527.8	**Drilling Contractor:** Radius	**Finish Date:** 13 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 371.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -45	**Fluid:** Polymer	**Logged By:** LM/SW
Trend (°): 176	**Cased To (m) :** 1.5	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			9.8 m: Fault, 20 mm FG infill.
11			
12			12.2 m: Shear, 0.5 mm aperture. JRC = 16.
13			
14			
15			15.4 m: Shear on vein, 0.5 mm aperture. JRC = 8.
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD (%)	LONGEST STICK / FRACTURE INTERCEPT (METRES)	AVERAGE JOINT CONDITION (RMR '76)
16									
17									
18									
19									
			19.6 m: Fault, 3 mm FG infill. JRC = 8.			D 2.1			
20									
21			21.1 m: Fault, 5 mm FG infill.						
22									
23									
24									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Project : Brucejack
Project No. 1008-007

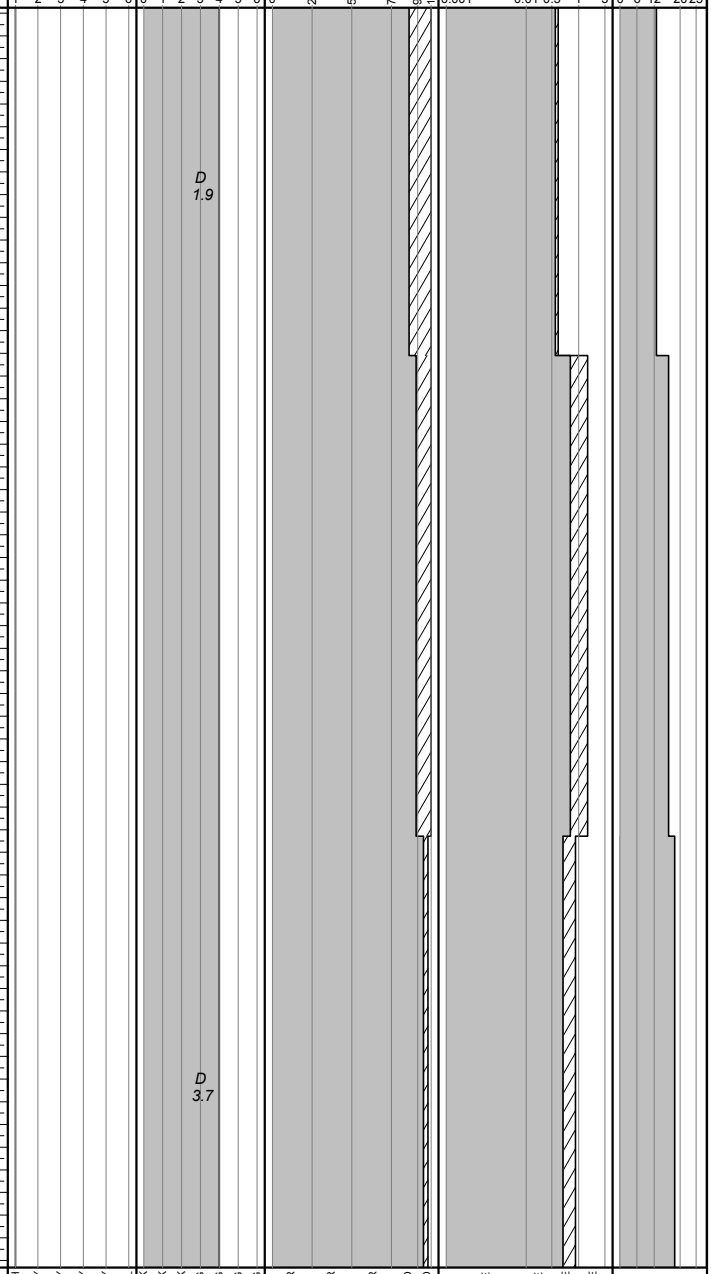
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24			24.3 m: Fault, 5 mm FG infill.						
25						D 1.9			
26									
27									
28									
29									
30									
31						D 3.7			
32									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

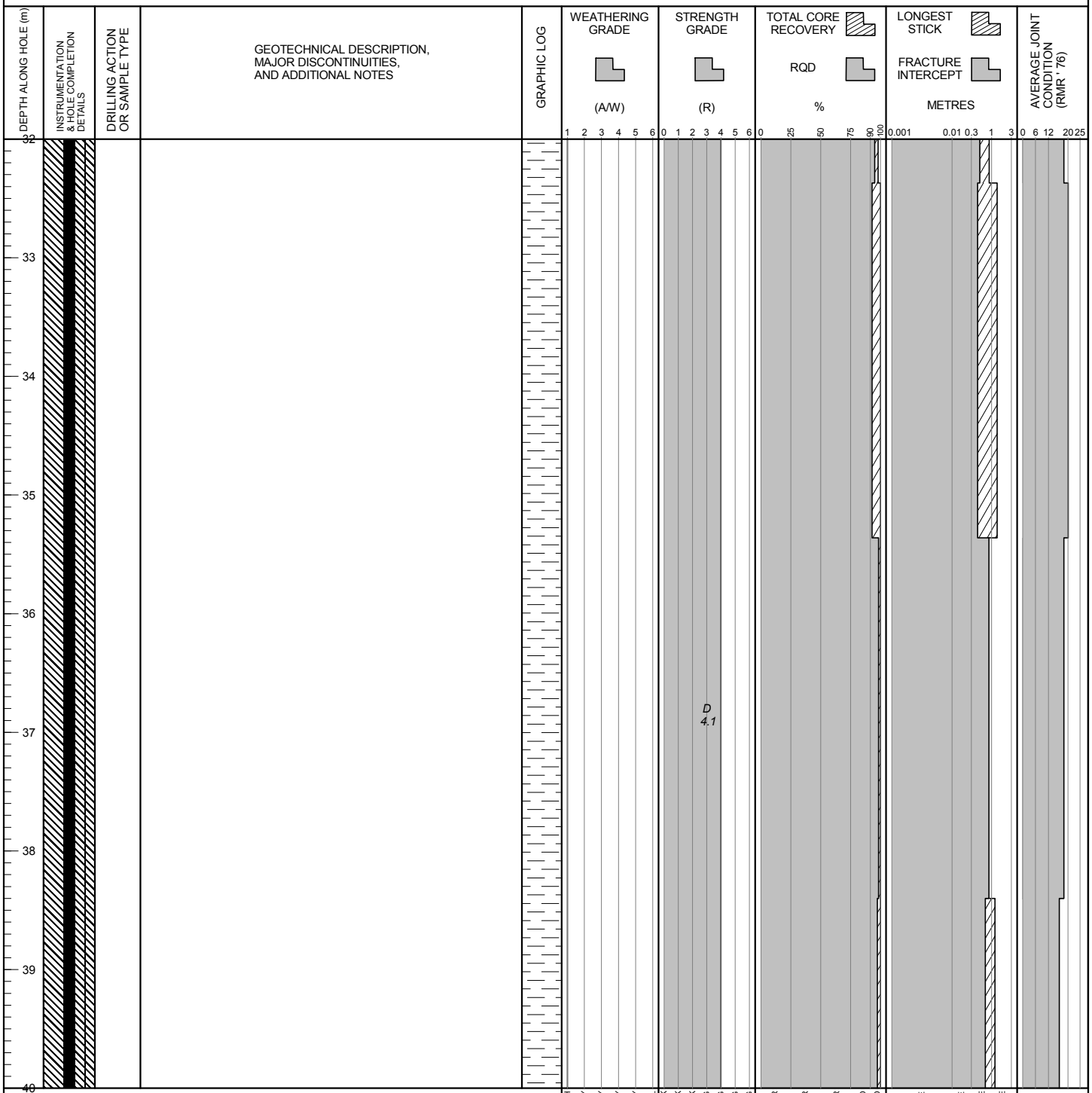
BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N	**Drill Designation:** Heliportable	**Start Date:** 03 May 12
Ground Elevation (m): 1,527.8	**Drilling Contractor:** Radius	**Finish Date:** 13 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 371.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -45	**Fluid:** Polymer	**Logged By:** LM/SW
Trend (°): 176	**Cased To (m) :** 1.5	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

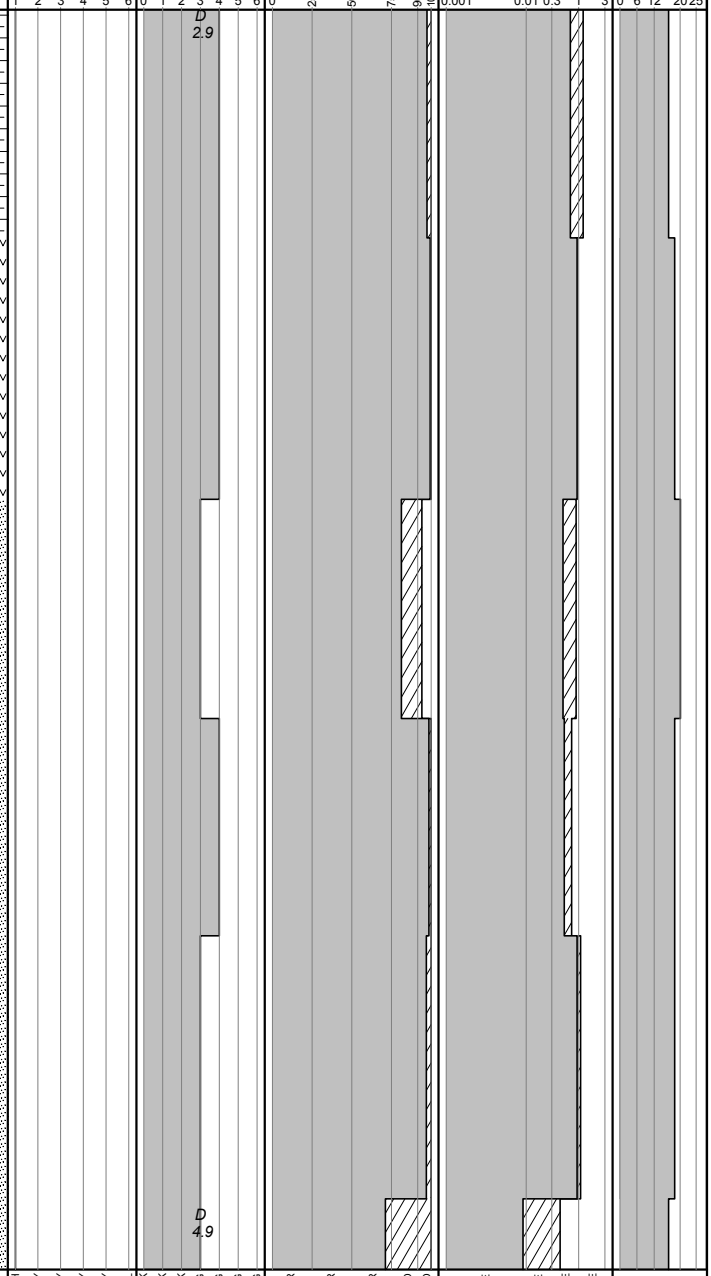
Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

40 41 42 43 44 45 46 47 48

STOCKWORK (H7)
White and grey, varies from coarse sandstone to mudstone. Strong (R4). Fresh (A1).

ARENITE (S4)
Grey, original composition and texture are difficult to discern due to sericite alteration. Massive pyrite increases as replacement clast pyrite decreases. Medium strong to strong (R3-R4). Fresh (A1). Weaker rock (R2.5-R3) from 160.5-180.5 m.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

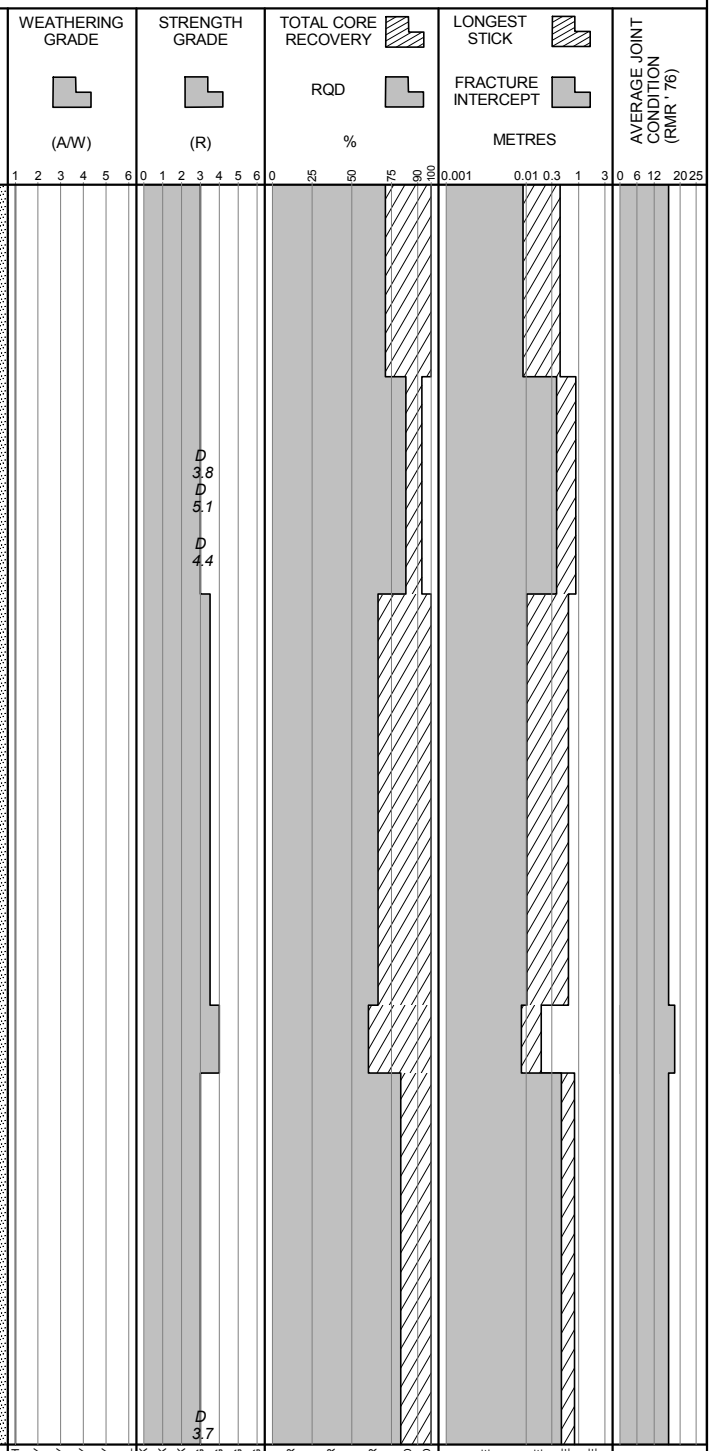
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
48			48.2 m: Shear, 0.5 mm aperture. JRC = 20.
			48.4 m: Shear, 0.5 mm CX infill. JRC = 8.
			48.4 m: Shear, 50 mm BX infill. JRC = 8.
			48.5 m: Shear, 0.5 mm aperture. JRC = 13.
49			48.9 m: Fault, 0.5 mm aperture. JRC = 8.
50			50.2 m: Shear, 51 mm BX infill. JRC = 20.
			50.2 m: Shear. JRC = 12.
51			
52			52.1 m: Fault, CX infill, R2. JRC = 8.
53			
54			
55			54.9 m: Fault, 80 mm CX infill, R2. JRC = 16.
			55.6 m: Fault, 110 mm BX infill, R2. JRC = 20.
56			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

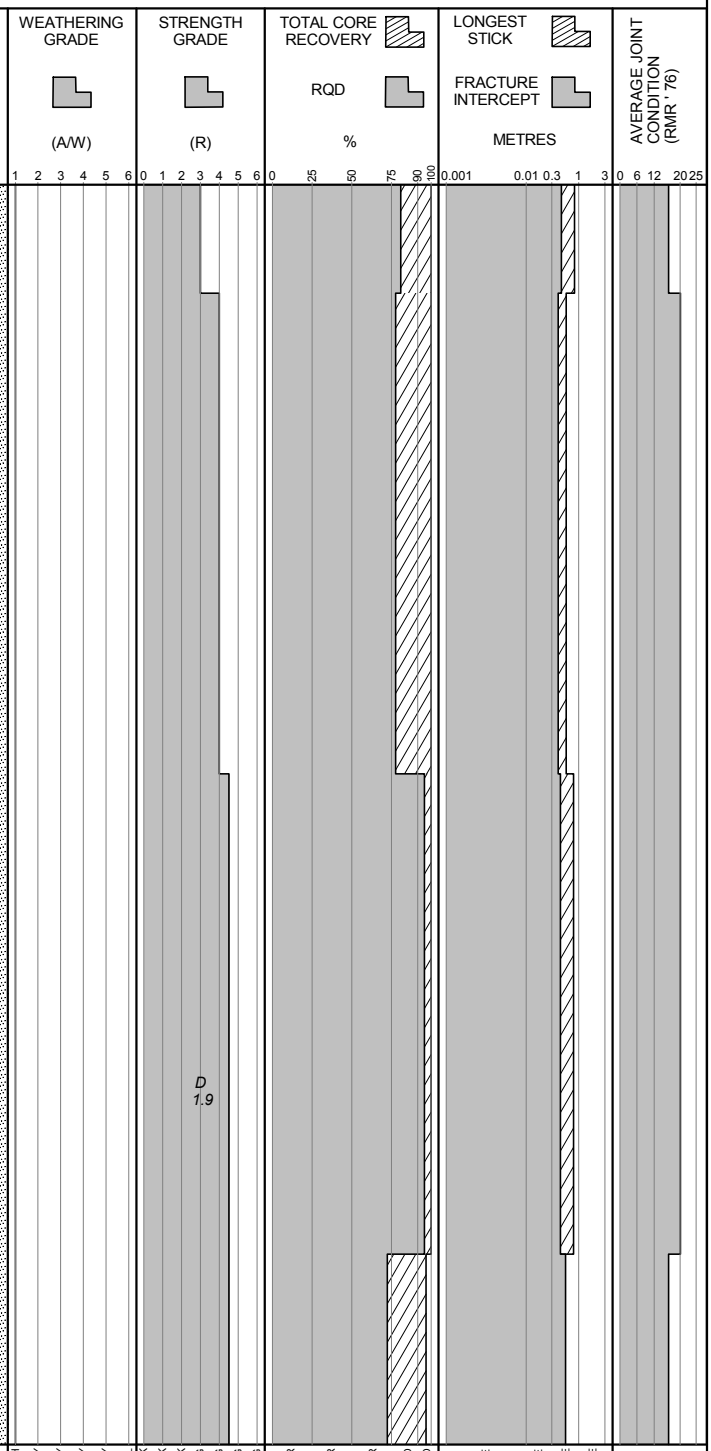
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
56			56.1 m: Fault, 150 mm BX infill, R2. JRC = 16.
57			
58			58 m: Fault on vein, 280 mm QZ/BX infill, R2. JRC = 12.
			58.5 m: Fault, 130 mm BX/QZ infill, R2. JRC = 13.
59			59 m: Fault, 2 mm FG infill, R0. JRC = 8.
			59.7 m: Fault, 35 mm BX infill, R2. JRC = 12.
60			
61			
			61.4 m: Fault, 1 mm FG infill, R2. JRC = 12.
			61.5 m: Shear, 0.5 mm aperture. JRC = 12.
			61.6 m: Fault, 2 mm FG infill, R2. JRC = 20.
62			61.8 m: Fault, 2 mm FG infill, R2. JRC = 16.
63			
64			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
64			64.3 m: Fault, 3 mm FG infill, R2. JRC = 16. 64.4 m: Fault, 40 mm BX infill, R2. JRC = 20.
65			65.1 m: Fault, 270 mm FG/BX infill, R2. JRC = 20.
			65.6 m: Fault, 30 mm FG/BX infill, R2. JRC = 16.
66			66.2 m: Fault, 600 mm FG/BX infill, R2. JRC = 20.
67			
68			
69			
70			70 m: Fault, 25 mm FG/BX infill, R2. JRC = 12.
			70.7 m: Fault, 2 mm FG infill, R2. JRC = 16.
71			70.9 m: Fault, 2 mm FG infill, R2. JRC = 20.
72			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 2.7

D 3.6

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

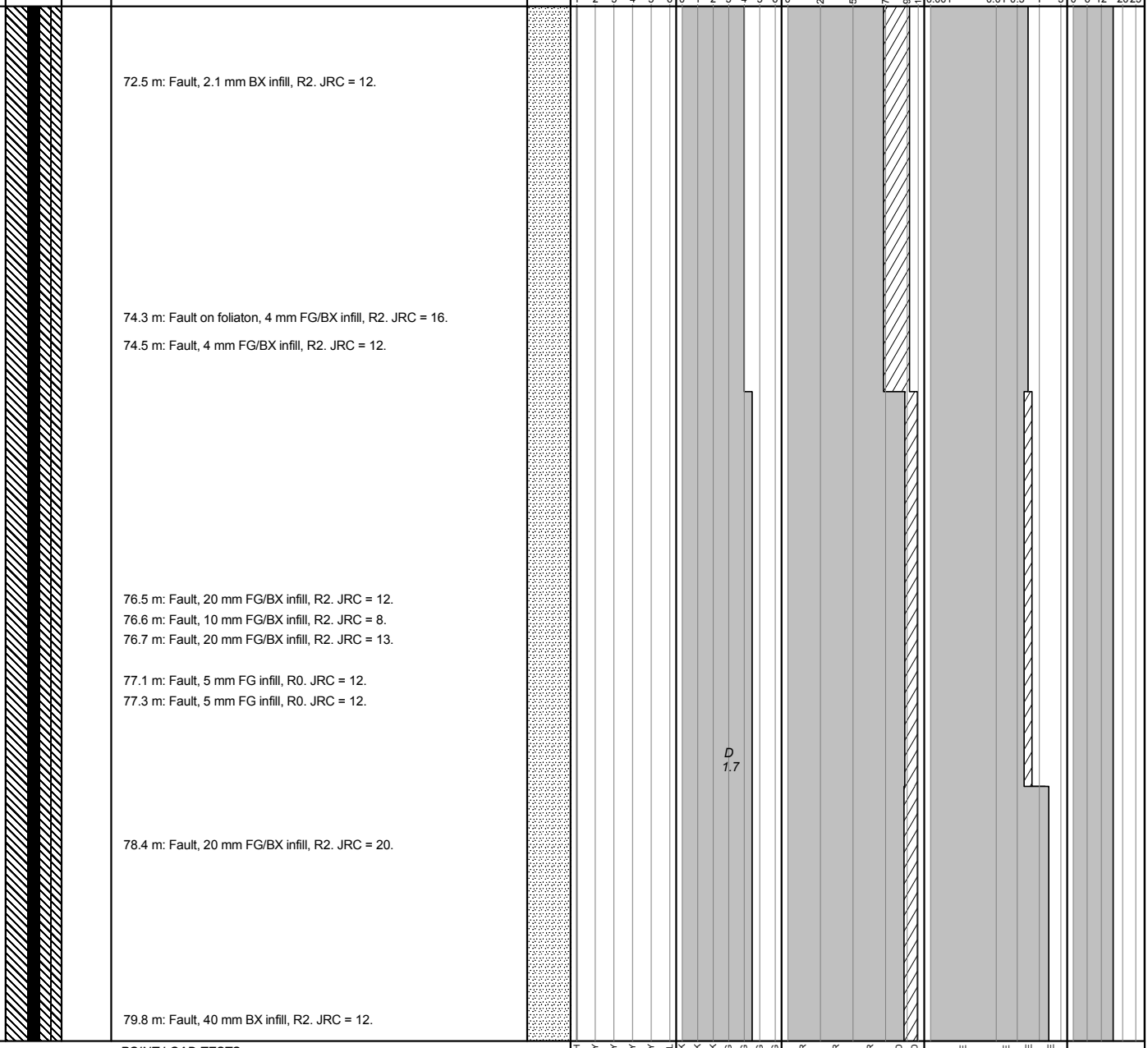
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
72									
			72.5 m: Fault, 2.1 mm BX infill, R2. JRC = 12.						
73									
74									
			74.3 m: Fault on foliaton, 4 mm FG/BX infill, R2. JRC = 16.						
			74.5 m: Fault, 4 mm FG/BX infill, R2. JRC = 12.						
75									
76									
			76.5 m: Fault, 20 mm FG/BX infill, R2. JRC = 12.						
			76.6 m: Fault, 10 mm FG/BX infill, R2. JRC = 8.						
			76.7 m: Fault, 20 mm FG/BX infill, R2. JRC = 13.						
77									
			77.1 m: Fault, 5 mm FG infill, R0. JRC = 12.						
			77.3 m: Fault, 5 mm FG infill, R0. JRC = 12.						
78						D 1.7			
			78.4 m: Fault, 20 mm FG/BX infill, R2. JRC = 20.						
79									
			79.8 m: Fault, 40 mm BX infill, R2. JRC = 12.						
80									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
80									
81			81.3 m: Fault, 20 mm CX/FG infill, R0. JRC = 20.			D 3.9			
82									
83			83.2 m: Fault, 1 mm FG infill, R0. JRC = 12.						
			83.8 m: Fault, 1 mm FG infill, R0. JRC = 20.						
84									
85						D 6.7 D 6.3			
86						D 5.3 D 3.8			
87									
88									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
88			88.4 m: Fault on vein, 20 mm BX/QZ infill, R2. JRC = 20.						
89									
90									
91			90.9 m: Fault, 13 mm BX infill, R2. JRC = 16.						
			91.5 m: Fault on vein, 10 mm QZ infill, R3. JRC = 16.			D 2.3			
92			92.1 m: Fault, 70 mm BX infill, R2. JRC = 20.						
93									
94									
95									
96									

Weathering grade scale: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade scale: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
Total core recovery / RQD scale: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept scale: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76) scale: 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

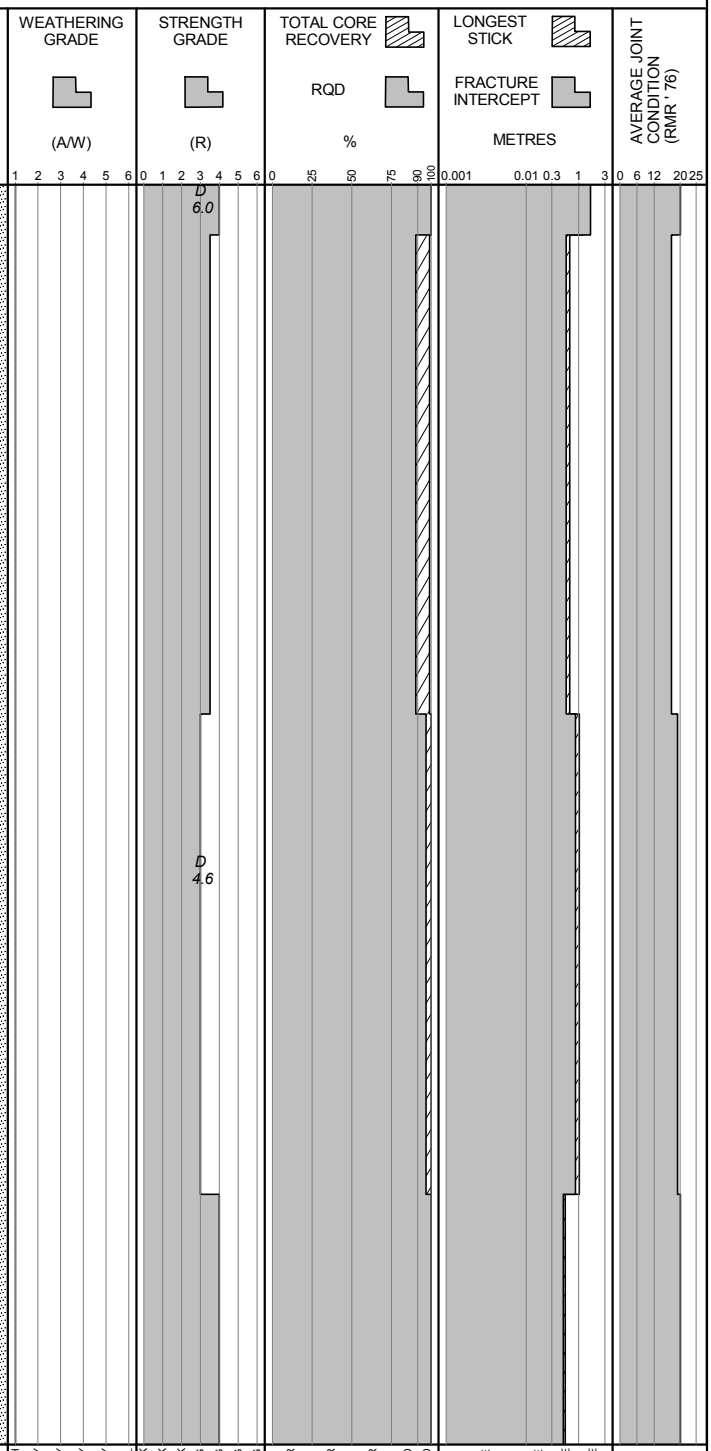
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
96			
97			
98			98 m: Fault, 1 mm BX infill, R2. JRC = 20. 98.3 m: Fault, 80 mm BX infill, R2. JRC = 20.
99			
100			
101			101.2 m: Shear, 0.5 mm aperture. JRC = 4.
102			102.3 m: Fault, 2 mm FG infill, R1. JRC = 12. 102.7 m: Shear, 0.5 mm aperture. JRC = 8.
103			103.2 m: Shear, 0.5 mm aperture. JRC = 4.
104			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
104									
105						D 5.0			
106									
107									
108									
109									
110			110.2 m: Shear, 0.5 mm QZ infill, R4. JRC = 4. 110.5 m: Shear, 0.5 mm aperture. JRC = 2.						
111						D 5.3			
112									

Scales: WEATHERING GRADE 1 2 3 4 5 6; STRENGTH GRADE 0 1 2 3 4 5 6; TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100; LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3; AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
112									
113			113 m: Shear, 0.5 mm aperture. JRC = 4.						
114			114.5 m: Shear, 0.5 mm aperture. JRC = 1.			D 7.1 D 7.9			
115						D 6.2			
116									
117									
118			117.8 m: Shear, 0.5 mm aperture. JRC = 2.						
119						D 5.5			
120									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
120									
			120.6 m: Shear, 0.5 mm aperture. JRC = 8.						
121									
122			122.1 m: Shear, 1 mm CX infill, R2. JRC = 8.						
			122.8 m: Shear, 0.5 mm aperture. JRC = 4.						
123			123.1 m: Shear, 0.5 mm aperture. JRC = 8.						
124									
125						D 5.0			
126									
			126.6 m: Shear, 0.5 mm aperture. JRC = 20.						
127									
128									

Scales: WEATHERING GRADE (A/W) 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE (R) 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Project : Brucejack
Project No.1008-007

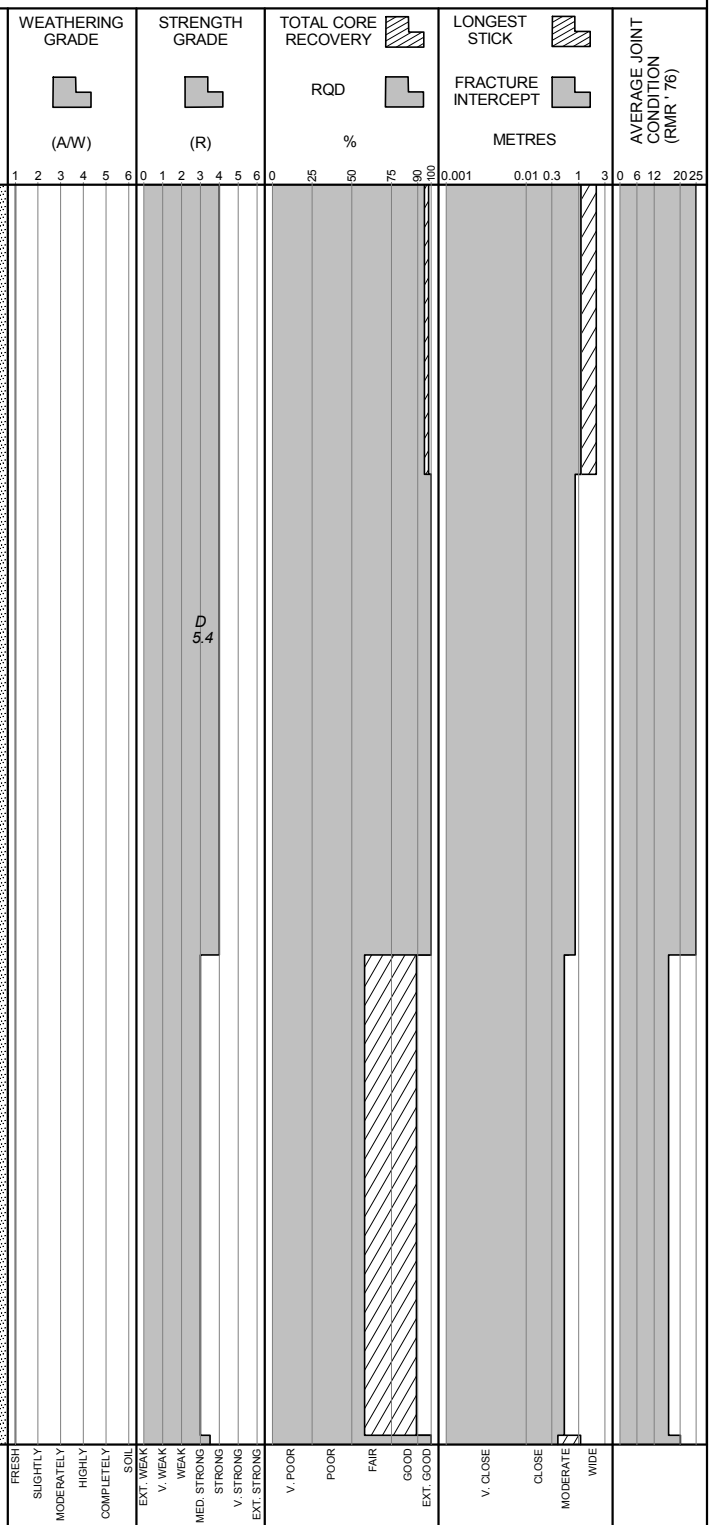
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
128			
129			
			129.7 m: Shear, 1 mm QZ infill, R4. JRC = 2.
130			
131			131 m: Shear, 0.5 mm aperture. JRC = 2.
			131.8 m: Shear, 0.5 mm aperture. JRC = 4.
132			
			132.4 m: Shear, 0.5 mm aperture. JRC = 12.
133			
134			
135			
			135.2 m: Fault, 20 mm FG infill, R1. JRC = 20.
			135.4 m: Fault, 30 mm FG infill, R0. JRC = 20.
			135.6 m: Fault, 60 mm FG infill, R0. JRC = 20.
136			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY RQD %	LONGEST STICK FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
136									
			136.7 m: Shear on vein, 0.5 mm aperture. JRC = 12.			D 4.4			
137									
138			138.5 m: Fault on foliaton, 2 mm FG/SE infill, R0. JRC = 16.						
139									
140									
141			141.2 m: Fault on vein, 3 mm QZ infill, R3. JRC = 20.						
			141.7 m: Shear on foliation, 0.5 mm aperture. JRC = 4.						
142			141.9 m: Fault, 1 mm FG/CL infill, R0. JRC = 8.						
			142.1 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			142.5 m: Fault, 15 mm FG/CX infill, R1. JRC = 20.						
			142.5 m: Fault, 15 mm FG/CX infill, R1. JRC = 20.			D 6.9			
			142.7 m: Fault, 30 mm FG/CX infill, R1. JRC = 20.						
143									
			143.5 m: Shear on foliation, 0.5 mm aperture. JRC = 8.						
			143.7 m: Shear on foliation, 0.5 mm aperture. JRC = 12.						
144									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION: 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
144			143.9 m: Fault, 50 mm BX infill, R3. JRC = 12.						
			144.1 m: Fault, 4 mm BX infill, R3. JRC = 12.						
			144.7 m: Fault, 1 mm FG/BX infill. JRC = 16.						
145			145.0 m: Fault, 5 mm FG/QZ infill, R2. JRC = 12.						
			145.7 m: Fault, 20 mm BX infill, R3. JRC = 20.						
146			145.9 m: Fault, 1 mm FG/BX infill, R2. JRC = 16.						
			146.0 m: Fault, 1 mm FG infill, R1. JRC = 20.						
			146.4 m: Fault, 2 mm FG infill, R1. JRC = 16.			D 4.8			
147			147.1 m: Fault, 50 mm BX infill. JRC = 20.						
			147.7 m: Fault, 10 mm FG/BX infill. JRC = 20.						
148			148.4 m: Fault, 2 mm FG infill. JRC = 20.						
			148.5 m: Fault, 1 mm FG infill. JRC = 20.						
149			148.9 m: Shear, 0.5 mm aperture. JRC = 4.						
			149.7 m: Fault, 50 mm BX infill, R2. JRC = 20.						
150									
151									
152						D 6.4			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1, 3 WIDE
AVERAGE JOINT CONDITION: 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
152			
153			
154			
155			
156			
157			157 m: Fault, 1 mm FG infill, R0. JRC = 12. 157.1 m: Fault, 15 mm FG/BX infill, R1. JRC = 20. 157.1 m: Fault, 1 mm FG infill, R0. JRC = 20. 157.2 m: Fault, 35 mm BX/FG infill, R1. JRC = 20. 157.4 m: Fault, 1 mm FG infill, R0. JRC = 12. 157.6 m: Fault, 0.5 mm aperture. JRC = 16.
158			157.8 m: Fault, 0.5 mm aperture. JRC = 16. 158.1 m: Fault, 2 mm QZ infill, R3. JRC = 12. 158.6 m: Fault, 1 mm FG infill, R0. JRC = 20. 158.7 m: Fault, 1 mm FG infill, R0. JRC = 16.
159			158.7 m: Shear, 0.5 mm aperture. JRC = 12. 159.3 m: Fault, 26 mm BX/FG infill, R2. JRC = 20.
160			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 1.9

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

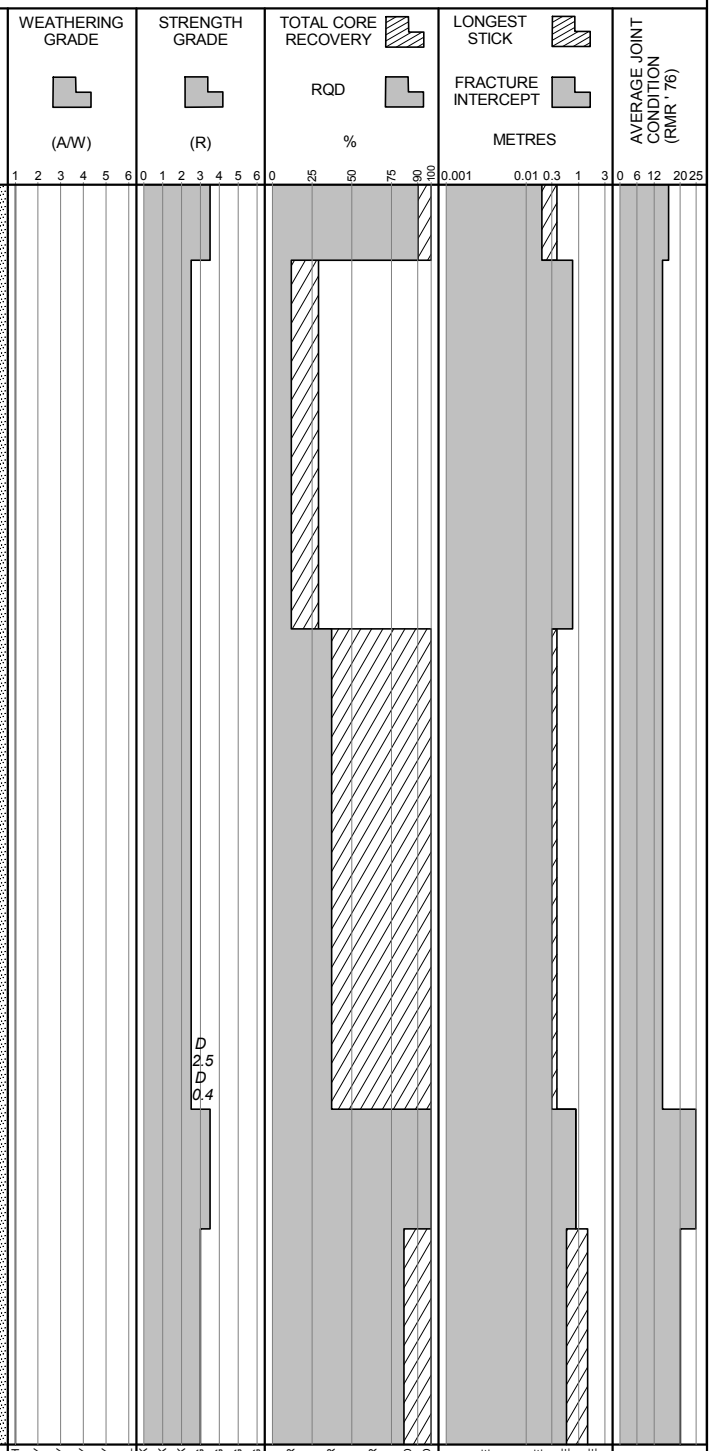
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
160			160.3 m: Fault, 44 mm BX/FG infill, R2. JRC = 12.
			160.4 m: Fault, 2 mm FG infill, R0. JRC = 12.
			160.8 m: Fault, 17 mm FG infill, R2. JRC = 20.
161			
162			
163			163 m: Shear, 0.5 mm aperture. JRC = 2.
164			164.1 m: Shear, 1 mm CX infill, R2. JRC = 12.
			164.8 m: Shear, 2 mm CX infill, R2. JRC = 12.
165			165.1 m: Shear, 0.5 mm aperture. JRC = 4.
166			
167			
168			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

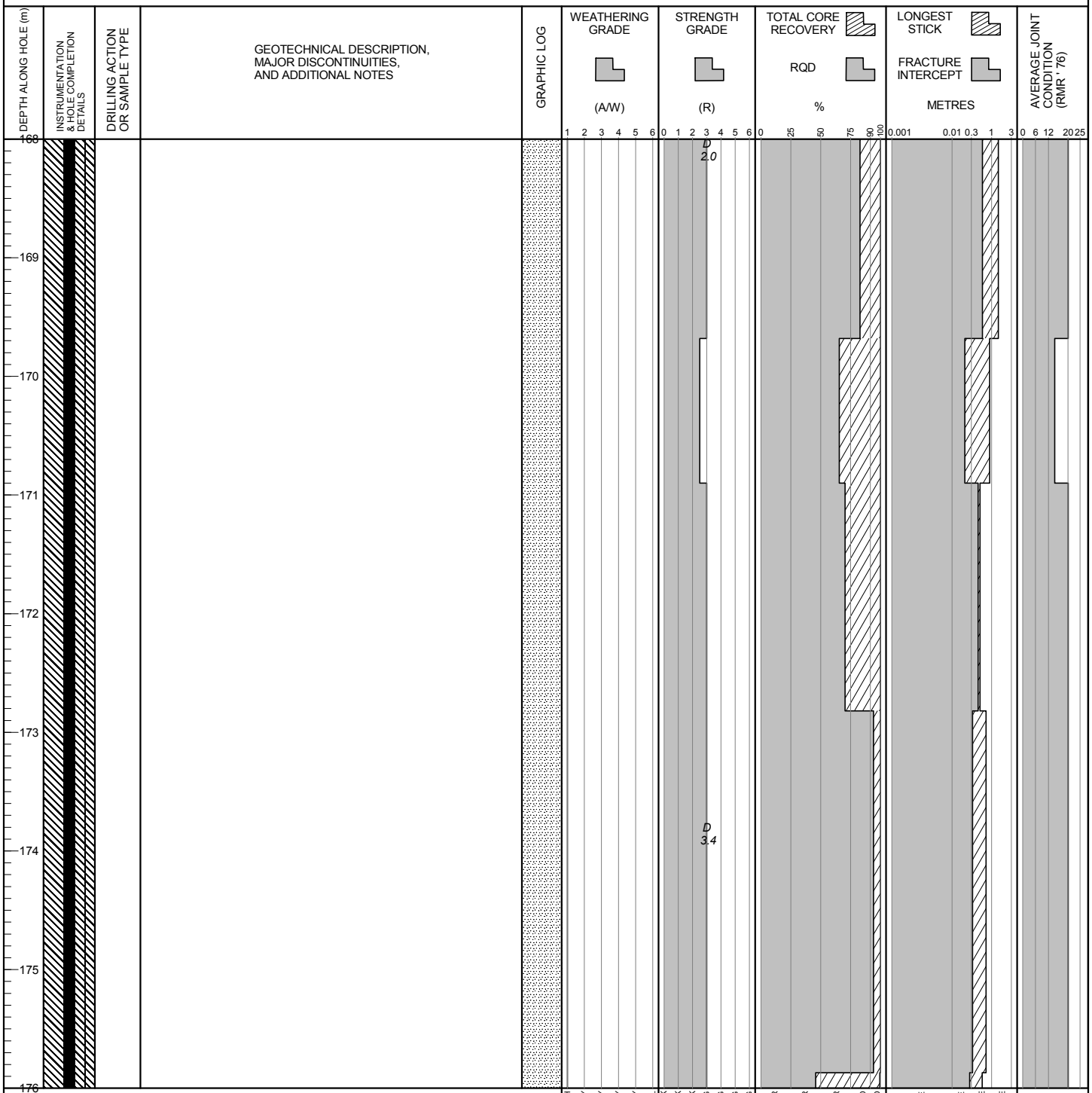
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N	**Drill Designation:** Heliportable	**Start Date:** 03 May 12
Ground Elevation (m): 1,527.8	**Drilling Contractor:** Radius	**Finish Date:** 13 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 371.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -45	**Fluid:** Polymer	**Logged By:** LM/SW
Trend (°): 176	**Cased To (m) :** 1.5	**Reviewed By:** JW



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
176									
177						D 3.5			
178									
179			179.1 m: Shear, 0.5 mm aperture. JRC = 4.						
180									
181			180.8 m: Shear, 0.5 mm aperture. JRC = 4. 181 m: Shear, 0.5 mm aperture. JRC = 4.						
182			181.8 m: Shear, 0.5 mm aperture. JRC = 4.						
183						D 4.6			
184									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1, 3 WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
184									
185			185.1 m: Shear, 0.5 mm aperture. JRC = 12. 185.6 m: Shear, 0.5 mm aperture. JRC = 8. 185.7 m: Shear, 0.5 mm aperture. JRC = 12.						
186									
187			187.5 m: Shear, 0.5 mm aperture. JRC = 4.						
188									
189			CONGLOMERATE (S3) Green-grey, most of the larger clasts, up to 5cm long, are completely replaced with sericite. Pervasive alteration decreases with a constant level of pyrite. Strong (R4). Fresh (A1).			D 6.2			
190									
191									
192									

Weathering grade scale: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade scale: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
Total core recovery / RQD scale: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept scale: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
192					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
193									
194						D 7.0			
			194.8 m: Shear, 0.5 mm aperture. JRC = 8.						
195									
196									
197									
			197.6 m: Fault, 3 mm FG/BX infill, R2. JRC = 12.						
198									
			198.2 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			198.4 m: Fault, 1 mm FG infill, R0. JRC = 12.						
199									
			199.3 m: Fault, 1 mm FG infill, R0. JRC = 4.						
			199.6 m: Fault, 10 mm BX infill, R2. JRC = 20.						
200									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

200

201 m: Fault, 1 mm FG infill, R0. JRC = 12.

201.3 m: Fault, 1 mm FG infill, R0. JRC = 16.

201.4 m: Fault, 1 mm FG infill, R0. JRC = 12.

ARENITE (S4)
Green-grey, sub-m scale interbedded sediments of mudstone to conglomerate with sericite alteration. Medium strong to strong (R3-R4). Fresh (A1)

201.6 m: Shear, 0.5 mm aperture. JRC = 8.

201.7 m: Shear, 0.5 mm aperture. JRC = 8.

201.8 m: Fault on vein, 1.5 mm FG/QZ infill, R0. JRC = 4.

202.3 m: Fault on vein, 1 mm FG infill, R0. JRC = 8.

202.4 m: Shear, 0.5 mm aperture. JRC = 4.

203.2 m: Fault on vein, 1 mm FG infill. JRC = 20.

203.9 m: Fault on vein, 1 mm FG infill. JRC = 4.

205.3 m: Fault, 1 mm FG infill, R0. JRC = 12.

205.4 m: Fault, 1 mm FG infill, R0. JRC = 12.

205.7 m: Fault, 16 mm FG/QZ infill, R2. JRC = 16.

206.5 m: Fault, 16 mm FG/QZ infill, R2. JRC = 16.

207 m: Fault, 3 mm DX infill, R2. JRC = 12.

208

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

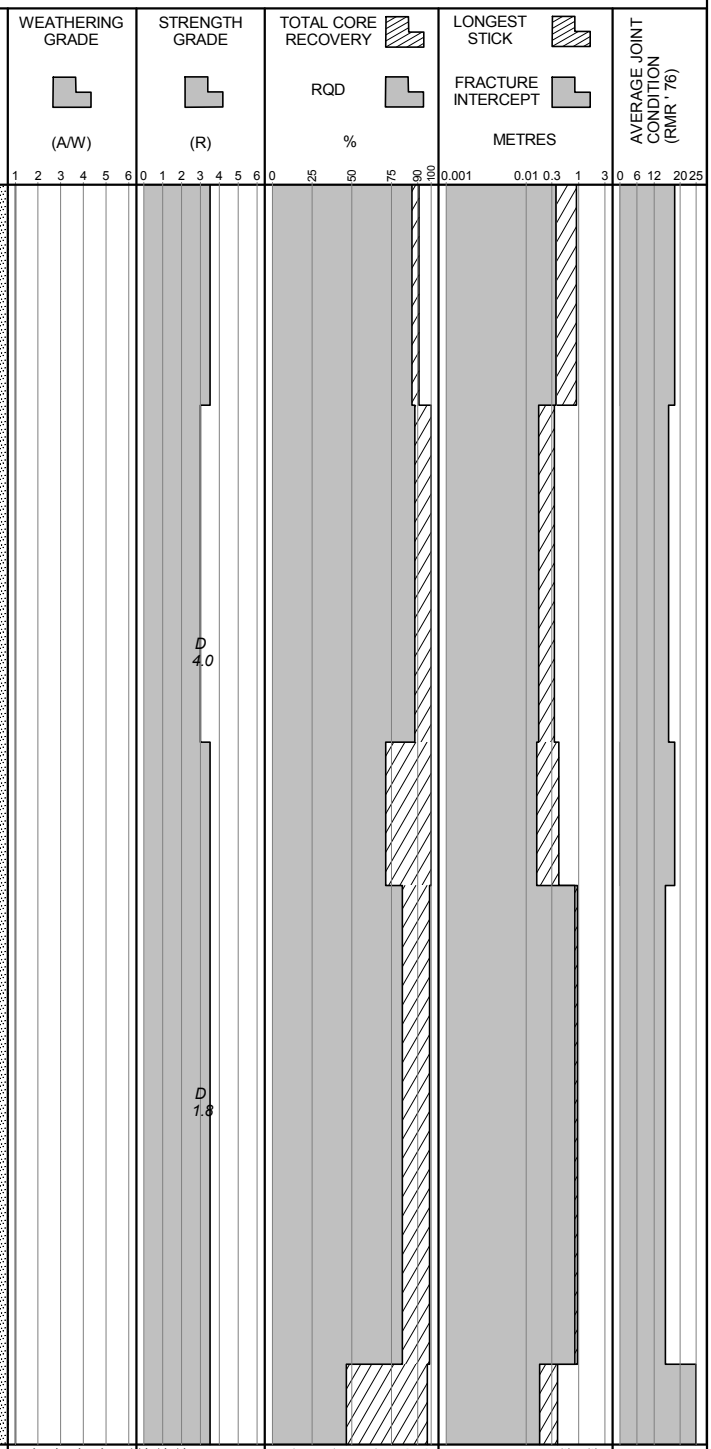
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
208			208.1 m: Fault, 2 mm FG/BX infill, R0. JRC = 20.
			208.2 m: Fault, 3 mm FG/DX infill, R2. JRC = 20.
			208.6 m: Fault, 40 mm CX/FG infill, R2. JRC = 20.
			208.8 m: Fault, 1 mm FG infill, R0. JRC = 20.
209			208.9 m: Fault, 1 mm FG infill, R0. JRC = 16.
			209.7 m: Shear, 0.5 mm aperture. JRC = 8.
210			
			210.8 m: Fault on vein, 90 mm FG, QZ, BX infill, R2. JRC = 12.
211			210.8 m: Fault, 3 mm FG infill, R0. JRC = 20.
			211.0 m: Fault, 1 mm FG infill. JRC = 12.
			211.3 m: Fault, 10 mm FG infill, R1. JRC = 20.
			211.5 m: Fault, 0.5 mm FG infill, R0. JRC = 12.
212			
213			213.2 m: Shear, 0.5 mm aperture. JRC = 4.
214			214.1 m: Fault, 12 mm FB infill, R2. JRC = 20.
215			
216			215.8 m: Shear, 0.5 mm aperture. JRC = 2.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

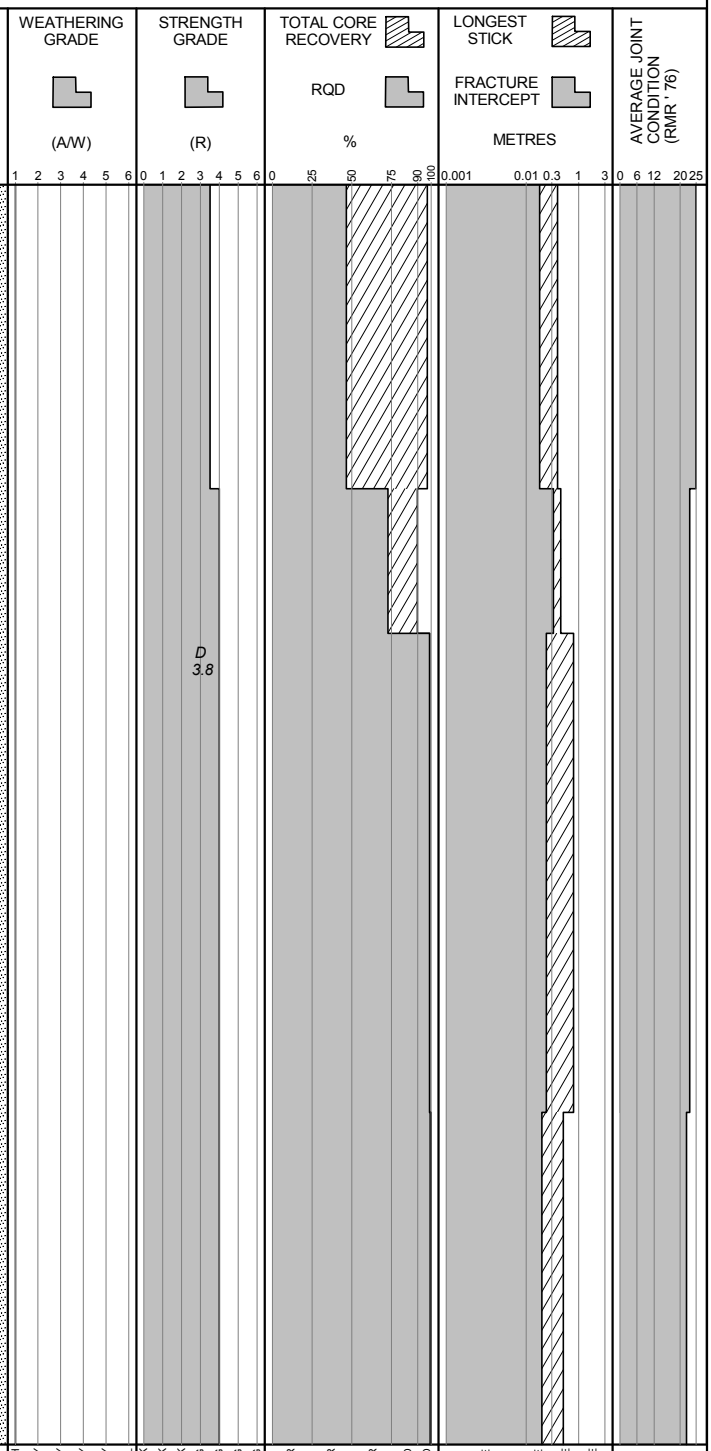
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
216			215.9 m: Shear, 0.5 mm aperture. JRC = 2.
			216.6 m: Shear, 0.5 mm aperture. JRC = 8.
			216.7 m: Shear, 0.5 mm aperture. JRC = 8.
217			216.8 m: Shear, 0.5 mm aperture. JRC = 4.
			216.9 m: Shear, 0.5 mm aperture. JRC = 2.
			217.0 m: Shear, 0.5 mm aperture. JRC = 8.
			217.2 m: Shear, 0.5 mm aperture. JRC = 4.
			217.5 m: Shear, 0.5 mm aperture. JRC = 2.
			217.7 m: Shear, 0.5 mm aperture. JRC = 8.
218			
219			
220			219.9 m: Fault, 1 mm FG infill, R0. JRC = 8.
			220.3 m: Fault, 1 mm FG infill, R0. JRC = 20.
221			
			221.1 m: Fault, 3 mm FG/CX infill, R1. JRC = 16.
			221.2 m: Fault, 1 mm FG infill, R0. JRC = 12.
222			
223			222.9 m: Shear, 0.5 mm aperture. JRC = 8.
224			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
224			224.6 m: Fault, 1 mm FG infill, R0. JRC = 12.
			224.8 m: Fault, 80 mm FG/BX infill, R1. JRC = 16.
225			225.1 m: Fault, 1 mm FG infill, R0. JRC = 8.
			225.4 m: Fault, 1 mm FG infill, R0. JRC = 12.
226			226.0 m: Fault on vein, 2 mm FG/BX infill, R1. JRC = 8.
			226.2 m: Fault, 10 mm BX infill, R2. JRC = 8.
227			
228			228.2 m: Fault, 70 mm BX infill, R2. JRC = 16.
			228.5 m: Fault, 20 mm CX/FG infill, R1. JRC = 16.
229			
			229.7 m: Fault, 12 mm FG/BX infill, R2. JRC = 12.
230			
			230.8 m: Fault, 1 mm FG infill, R0. JRC = 12.
231			230.9 m: Fault, 1.5 mm FG infill, R0. JRC = 12.
232			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
232									
233			233.0 m: Fault, 1.5 mm FG/CX infill, R1. JRC = 16.						
			233.7 m: Fault, 1 mm FG infill, R0. JRC = 8.						
234			233.9 m: Fault, 12 mm FG/BX infill, R1. JRC = 12.						
			234.0 m: Fault, 4 mm FG infill, R0. JRC = 20.						
235									
236			236.1 m: Fault, 1.5 mm FG infill, R0. JRC = 8.						
237						D 3.5			
			237.7 m: Fault, 1 mm FG infill, R0. JRC = 8.						
238			238.3 m: Fault, 1.5 mm FG infill, R0. JRC = 12.						
			238.6 m: Fault on vein, 1 mm FG/QZ infill, R2. JRC = 8.						
			238.8 m: Fault, 90 mm BX infill, R3. JRC = 12.						
239			239.0 m: Fault on vein, 1.5 mm QZ/FG infill, R2. JRC = 12.						
			239.4 m: Fault, 1 mm FG infill, R0. JRC = 8.						
240			239.9 m: Fault, 1 mm FG infill, R0. JRC = 16.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
240			239.9 m: Fault, 1 mm FG infill, R0. JRC = 12.						
			239.9 m: Fault, 1 mm FG infill, R0. JRC = 12.						
			240.0 m: Fault, 1 mm FG infill, R0. JRC = 12.						
			240.0 m: Fault, 2 mm FG/CX infill, R1. JRC = 16.						
			240.0 m: Fault, 2 mm FG/CX infill, R1. JRC = 12.						
			240.4 m: Fault, 2 mm FG/BX infill, R1. JRC = 8.						
241			240.7 m: Fault, 20 mm FG/CX infill, R1. JRC = 16.						
			241.1 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			241.2 m: Fault, 1 mm FG infill, R0. JRC = 16.						
242						D 4.3			
243									
244									
245						D 3.3			
246									
247			MAFIC DYKE (V6) Green with small calcite amygdules. Medium strong to strong (R3.5). Fresh (A1).						
248									

Scales: WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY RQD %	LONGEST STICK FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
248			ARENITE (S4) Green-grey, sub-m scale interbedded sediments of mudstone to conglomerate with sericite alteration. Follows VSF pattern. Medium strong to strong (R3.5-R4). Fresh (A1).			D 2.2 D 4.9			
249			249.4 m: Fault, 60 mm BX infill, R2. JRC = 20.						
250			250.4 m: Fault, 1 mm FG infill, R0. JRC = 16.						
251			250.8 m: Fault, 2 mm FG/CX infill, R1. JRC = 12. 250.9 m: Shear, 0.5 mm aperture. JRC = 8. 251.1 m: Fault, 1 mm FG infill, R0. JRC = 12. 251.2 m: Fault, 2 mm FG infill, R0. JRC = 12.						
252			252.2 m: Fault, 1 mm FG infill, R0. JRC = 12. 252.2 m: Fault, 1 mm FG infill, R0. JRC = 12. 252.2 m: Fault, 2 mm FG/CX infill, R1. JRC = 12.						
253			253.4 m: Fault, 1 mm FG infill, R0. JRC = 12. 253.5 m: Fault, 1 mm FG/CX infill, R0. JRC = 12. 253.5 m: Fault, 1.1 mm FG infill, R0. JRC = 12.			D 2.5			
254			253.9 m: Fault, 1 mm FG infill, R0. JRC = 8. 254.1 m: Fault, 4 mm FG/BX infill, R1. JRC = 12.						
255			255 m: Fault on vein, 50 mm QZ infill, R3. JRC = 20. 255.1 m: Fault, 120 mm FG/CX infill, R1. JRC = 20. 255.2 m: Fault, 1.5 mm FG infill, R0. JRC = 8. 255.3 m: Fault, 1 mm aperture, R1 infill. JRC = 8. 255.4 m: Fault, 3 mm FG infill, R0. JRC = 12. 255.8 m: Fault, mm FG/CX infill, R1. JRC = 12.						
256									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION: 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
256			256 m: Fault, 5 mm FG/CX infill, R1. JRC = 12.						
257									
258						D 2.5			
259									
260									
261			261.2 m: Fault, 1 mm aperture. JRC = 8.						
262									
263			262.8 m: Fault, 1 mm FG infill, R0. JRC = 12. 263.2 m: Fault, 20 mm FG/BX infill, R1. JRC = 16.			D 4.4 D 3.7			
264									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
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Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
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Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
264						D 2.8			
			264.7 m: Shear, 0.5 mm aperture. JRC = 4.						
265			264.9 m: Shear, 0.5 mm aperture. JRC = 4.						
266			266.2 m: Shear, 0.5 mm aperture. JRC = 4.						
267									
268			268 m: Shear, 0.5 mm aperture. JRC = 1.						
269			268.9 m: Shear, 0.5 mm aperture. JRC = 1.			D 3.2			
270									
271			270.7 - 275.6 m: Two multiphase stockwork zones; very little mineralization; clear boundaries at 50-55 degrees TCA.						
272									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
272			
			272.7 m: Fault, 3 mm FG infill, R0. JRC = 12.
273			
			273.3 m: Fault on vein, 2 mm FG infill, R0. JRC = 4.
274			
275			
			275.64 - 302.1 m: Laminations present locally at 25 degrees TCA.
276			
277			
			277.4 m: Fault, 30 mm FG/BX infill, R1. JRC = 12.
278			
279			279 m: Fault, 2 mm FG infill, R0. JRC = 8. 279 m: Fault, 2 mm FG infill, R0. JRC = 12. 279.3 m: Fault, 1 mm FG infill, R0. JRC = 12. 279.4 m: Fault, 1 mm FG infill, R0. JRC = 16. 279.4 m: Fault, 1 mm FG infill, R0. JRC = 12. 279.5 m: Fault, 1 mm FG infill, R0. JRC = 12.
280			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
280			279.5 m: Fault, 1 mm FG infill, R0. JRC = 12.
			279.5 m: Fault, 1 mm FG infill, R0. JRC = 16.
			279.7 m: Fault, 1 mm FG infill, R0. JRC = 8.
			279.8 m: Fault, 50 mm FG/BX infill, R1. JRC = 16.
281			280.9 m: Shear, 0.5 mm aperture. JRC = 8.
			281 m: Shear, 0.5 mm aperture. JRC = 2.
282			282.1 m: Shear, 0.5 mm aperture. JRC = 8.
			282.3 m: Shear, 0.5 mm aperture. JRC = 16.
283			
284			
285			
286			
287			
288			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 3.7

D 3.9

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
288					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
			288.8 m: Shear, 0.5 mm aperture. JRC = 1.						
289									
290									
			290.6 m: Shear, 0.5 mm aperture. JRC = 4.						
291						D 8.4			
292									
293									
294									
295									
296									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
296									
297			297.2 m: Fault, 1 mm FG infill, R0. JRC = 8.			D 0.2			
298			297.9 m: Fault, 2 mm FG infill, R0. JRC = 12.						
			298.5 m: Fault, 2 mm FG infill, R0. JRC = 12.						
299			298.9 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			299.2 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			299.6 m: Fault, 1 mm FG infill, R0. JRC = 8.						
300			299.9 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			300.2 m: Fault, 1 mm FG/BX infill, R1. JRC = 16.						
			300.3 m: Fault on vein, 3 mm FG/BX infill, R2. JRC = 16.			D 3.7			
			300.7 m: Fault, 1 mm FG infill, R0. JRC = 8.						
			300.7 m: Fault, 1 mm FG infill, R0. JRC = 16.						
301			301.1 m: Fault, 5 mm FG/CX infill, R1. JRC = 16.						
302			PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Green, medium grained crystals, sericite replaced, areas of hydrothermal brecciation, some chlorite alteration and an increase in cubic pyrite crystals within rock matrix, some cases of mineralization. Strong to medium strong (R3.5-R4). Fresh (A1).						
303						D 3.5			
304									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
304			304.1 m: Fault, 1 mm FG infill, R0. JRC = 8.
305			
			305.8 m: Shear, 0.5 mm aperture. JRC = 8.
306			306 m: Fault on vein, 1 mm FG infill, R0. JRC = 12.
			306.2 m: Fault, 1 mm FG infill, R0. JRC = 12.
307			
308			307.9 m: Shear on vein, 0.5 mm aperture. JRC = 8.
309			
			309.2 m: Shear on vein, 0.5 mm aperture. JRC = 8.
310			
311			310.9 m: Fault, 2 mm FG infill, R0. JRC = 12.
			310.9 m: Fault, 1 mm FG infill, R0. JRC = 8.
			311.5 m: Fault on vein, 4 mm FG/BX infill, R1. JRC = 12.
312			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

D 7.0

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD (%)	LONGEST STICK / FRACTURE INTERCEPT (METRES)	AVERAGE JOINT CONDITION (RMR '76)
312					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
313			313.9 m: Fault, 1 mm FG infill, R0. JRC = 8.			D 6.3			
314			314.2 m: Fault, 1 mm FG infill, R0. JRC = 8.						
315									
316									
317									
318						D 6.0			
319									
320									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Project : Brucejack
Project No.1008-007

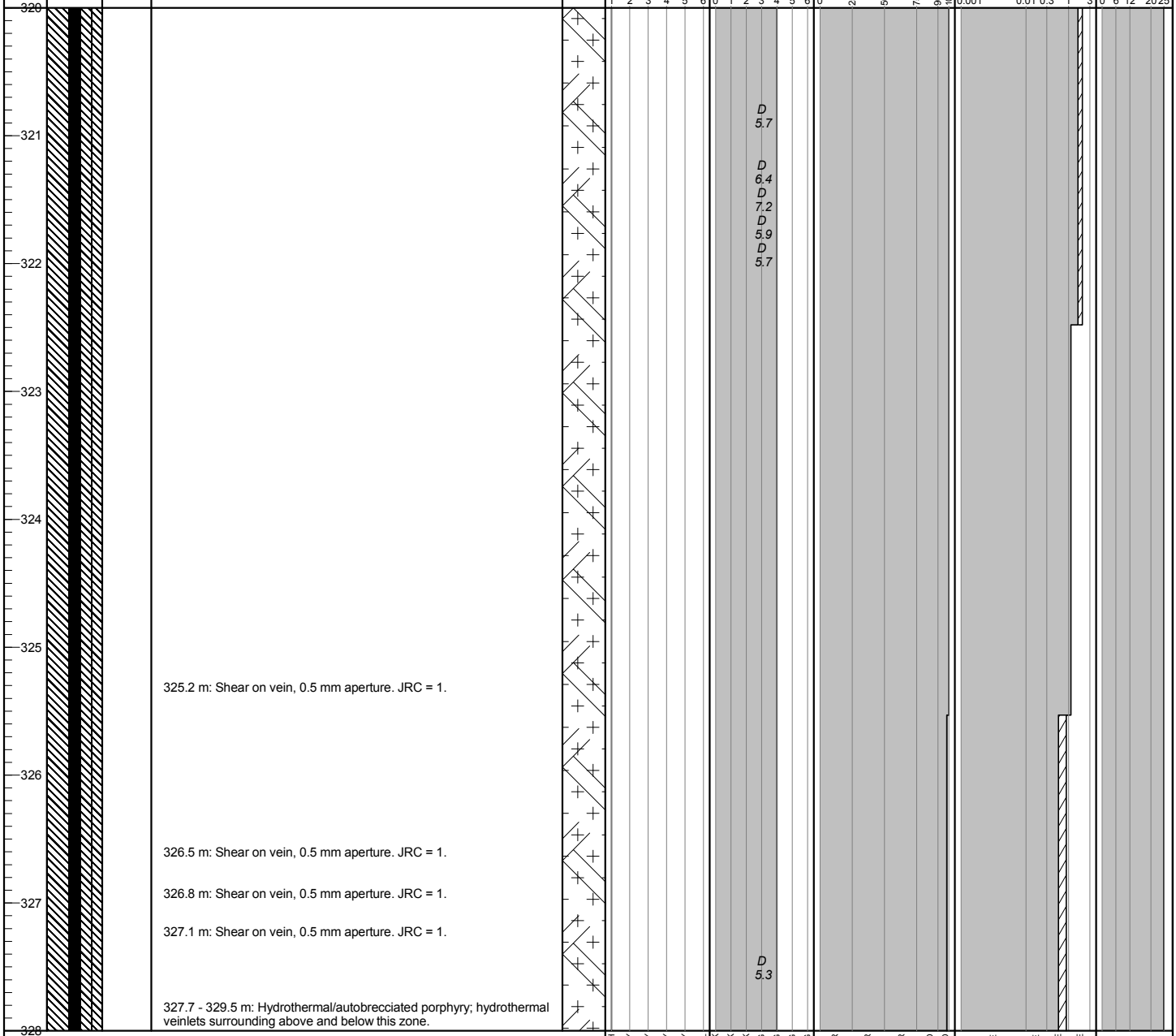
Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-25

Project : Brucejack
Project No.1008-007

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
328			327.8 m: Shear on vein, 0.5 mm aperture. JRC = 4.						
329			328.8 m: Shear on vein, 0.5 mm aperture. JRC = 4.						
330									
331									
332			332.5 - 333.4 m: Stockwork zone (brief) following autobrecciated porphyry; no significant base metal mineralization.			D 7.2			
333									
334									
335									
336									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
336						D 4.7			
337									
338			337.9 m: Shear on vein, 0.5 mm aperture. JRC = 1.						
339									
340									
341									
342						D 5.4			
343									
344									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

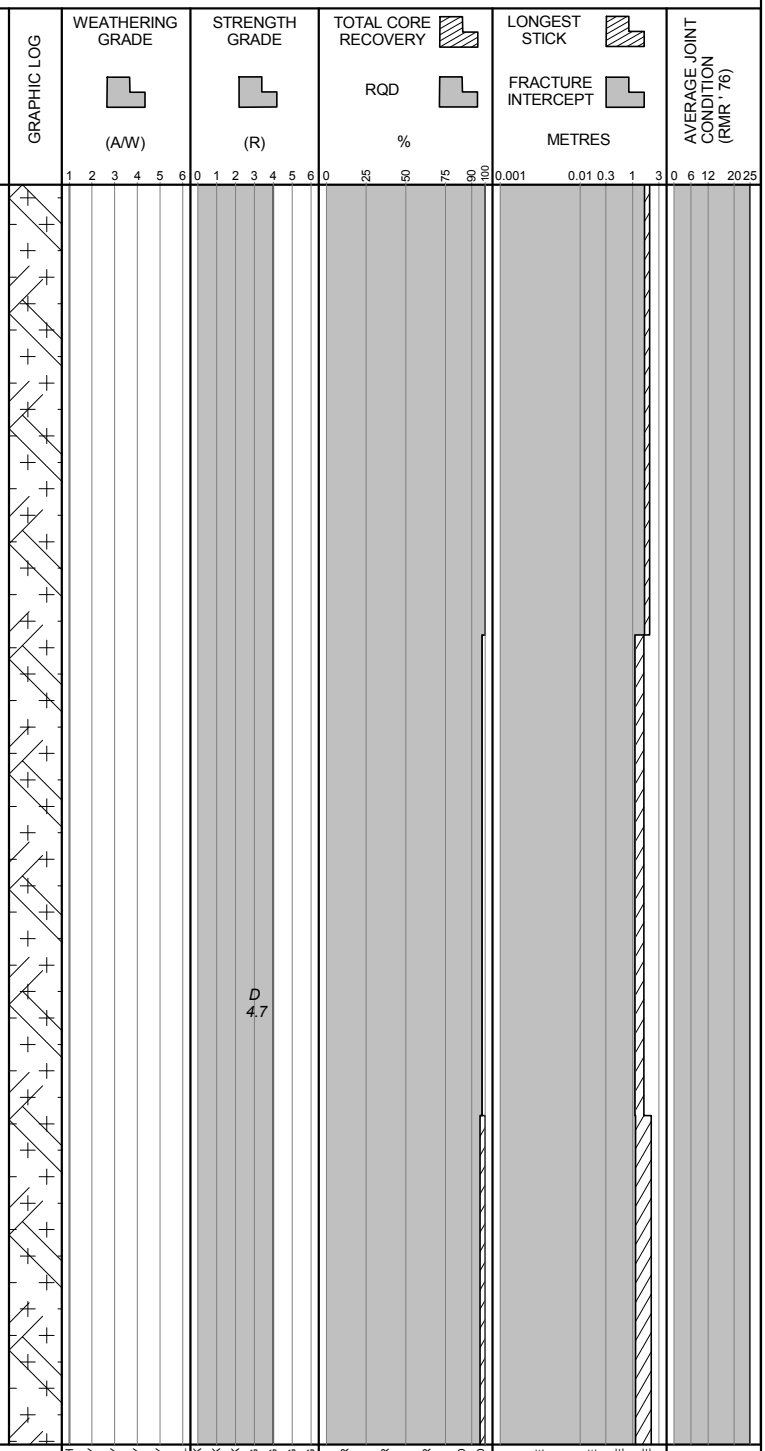
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N	**Drill Designation:** Heliportable	**Start Date:** 03 May 12
Ground Elevation (m): 1,527.8	**Drilling Contractor:** Radius	**Finish Date:** 13 May 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 371.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -45	**Fluid:** Polymer	**Logged By:** LM/SW
Trend (°): 176	**Cased To (m) :** 1.5	**Reviewed By:** JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
344			
345			345 m: Shear on vein, 0.5 mm aperture. JRC = 1.
346			
347			
348			348.3 m: Shear on vein, 0.5 mm aperture. JRC = 1.
349			349.6 m: Shear on vein, 0.5 mm aperture. JRC = 1. 349.7 m: Shear on vein, 0.5 mm aperture. JRC = 1.
350			
351			
352			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
352			352.1 m: Shear on vein, 0.5 mm aperture. JRC = 4. 352.2 m: Shear on vein, 0.5 mm aperture. JRC = 2.						
353									
354									
355						D 5.7			
356			356.2 m: Shear on vein, 0.5 mm aperture. JRC = 4.						
357									
358									
359									
360									

Weathering grade scale: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade scale: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
Total core recovery / RQD scale: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept scale: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR '76) scale: 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
360									
361			360.9 m: Fault on vein, 1 mm FG infill, R0. JRC = 4.			D 7.7			
362									
363									
364									
365									
366									
367									
368									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-25

Location: Valley of Kings Zone

Co-ordinates (m): 426,350E - 6,258,086N
Ground Elevation (m): 1,527.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -45
Trend (°): 176

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 03 May 12
Finish Date: 13 May 12
Final Depth (m): 371.3
Depth To Top Of Rock (m): 0.0
Logged By: LM/SW
Reviewed By: JW

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
368									
369			369 m: Shear on vein, 0.5 mm aperture. JRC = 8.			D 4.3			
370			370.6 m: Fault, 1 mm FG infill, R0. JRC = 8.						
371			END OF DRILLHOLE AT 371.3 m Notes: 1. Two vibrating wire piezometers installed at 30.6 m and 369.8 m.						
372									
373									
374									
375									
376									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-26

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,756E - 6,258,749N
Ground Elevation (m): 1,406.1
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 180

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 1.0

Start Date: 07 Jun 12
Finish Date: 08 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.3
Logged By: RH/LM
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN No Recovery.
						Rock encountered at 0.3 m depth. Refer to DH-BGC12-26 rock log.
1						
2						
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_p% W% W_L% 20, 40, 60, 80

BRUCEJACK (SOIL) BRUCEJACK_SOIL.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-26

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,756E - 6,258,749N	***Drill Designation:*** Heliportable	***Start Date:*** 07 Jun 12
Ground Elevation (m): 1,406.1	***Drilling Contractor:*** Radius	***Finish Date:*** 08 Jun 12
Survey Method: Surveyed	***Drill Method:*** Diamond	***Final Depth (m):*** 30.5
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 0.3
Plunge (°): -75	***Fluid:*** Water	***Logged By:*** RH/LM
Trend (°): 180	***Cased To (m) :*** 1.0	***Reviewed By:*** BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

Refer to DH-BGC12-26 Overburden Log

POTASSIUM FELDSPAR-HORNBLENDE-PLAGIOCLASE PORPHYRY (P2)
Green, medium grained, massive groundmass consisting of fragmented blocks with potassium feldspar phenocrysts 2 to 5 mm and sporadic megacrysts 6 to 10 mm. Medium strong (R3-R3.5), faintly to slightly weathered (W1.5-W2), discontinuity surfaces are typically rough with separations <1 mm (JRC = 16 to 23).

0 - 3.05 m: Drilled with a starting barrel resulting in poor recovery.

5.07 m: Fault, 90 mm FB infill, R3.5, JRC = 8.

D 2.2
D 3.5
D 1.8
D 1.9

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH | SLIGHTLY | MODERATELY | HIGHLY | COMPLETELY | SOIL
EXT. WEAK | V. WEAK | WEAK | MED. STRONG | STRONG | V. STRONG | EXT. STRONG
V. POOR | POOR | FAIR | GOOD | EXT. GOOD
V. CLOSE | CLOSE | MODERATE | WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

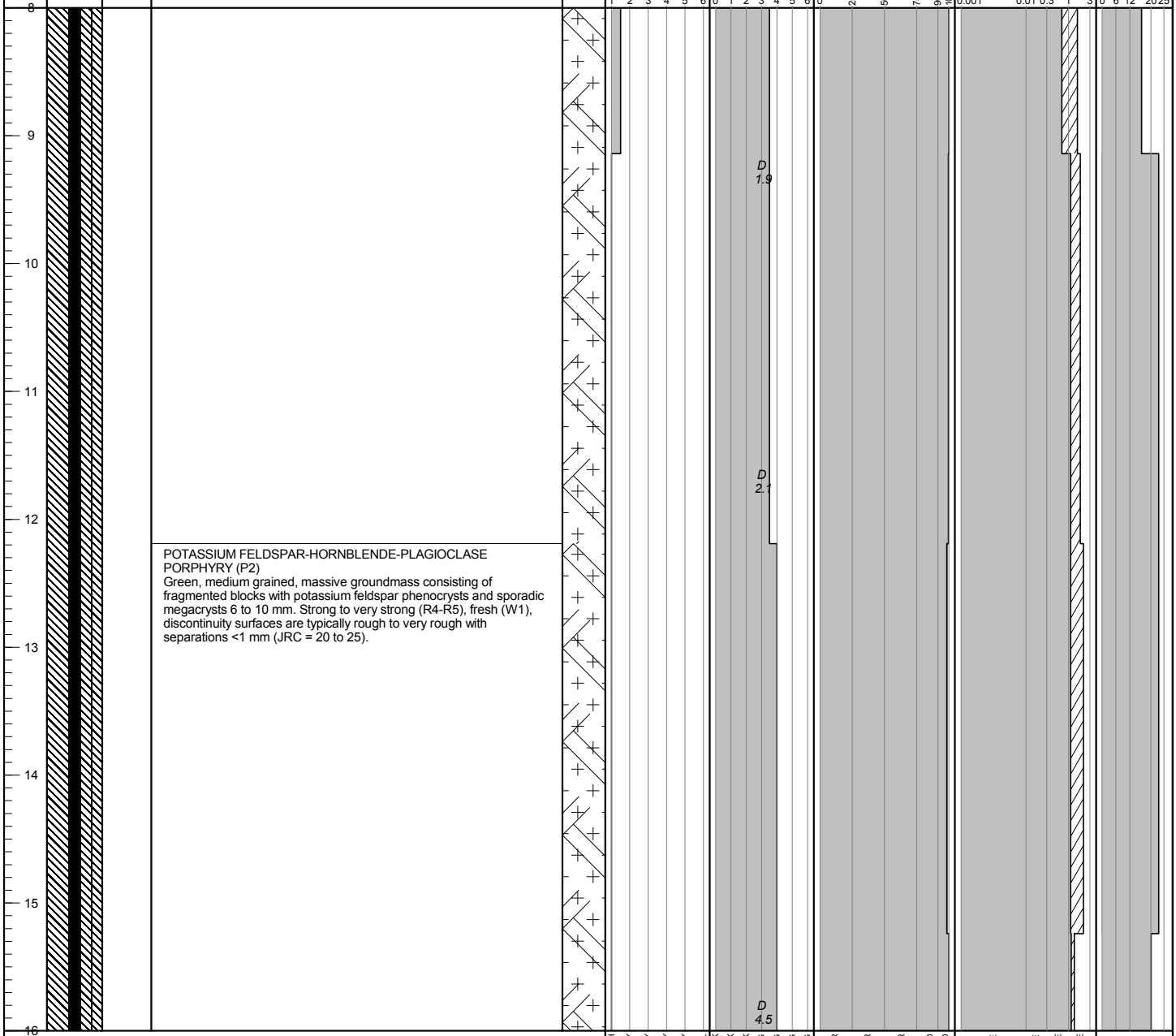
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-26

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,756E - 6,258,749N	**Drill Designation:** Heliportable	**Start Date:** 07 Jun 12
Ground Elevation (m): 1,406.1	**Drilling Contractor:** Radius	**Finish Date:** 08 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.5
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.3
Plunge (°): -75	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 180	**Cased To (m) :** 1.0	**Reviewed By:** BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

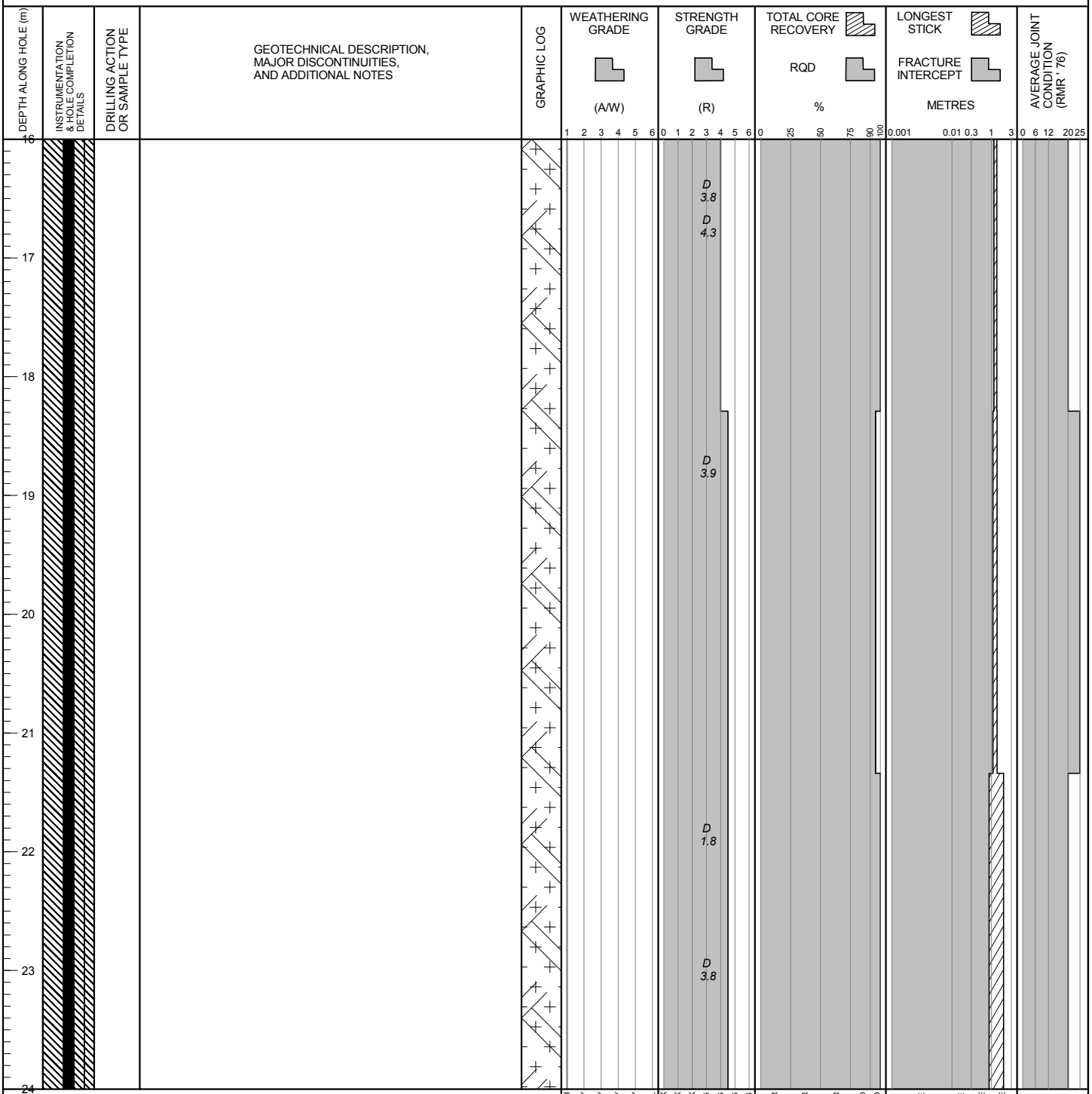
LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-26

Project : Brucejack
Project No.1008-007

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,756E - 6,258,749N	**Drill Designation:** Heliportable	**Start Date:** 07 Jun 12
Ground Elevation (m): 1,406.1	**Drilling Contractor:** Radius	**Finish Date:** 08 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.5
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.3
Plunge (°): -75	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 180	**Cased To (m) :** 1.0	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

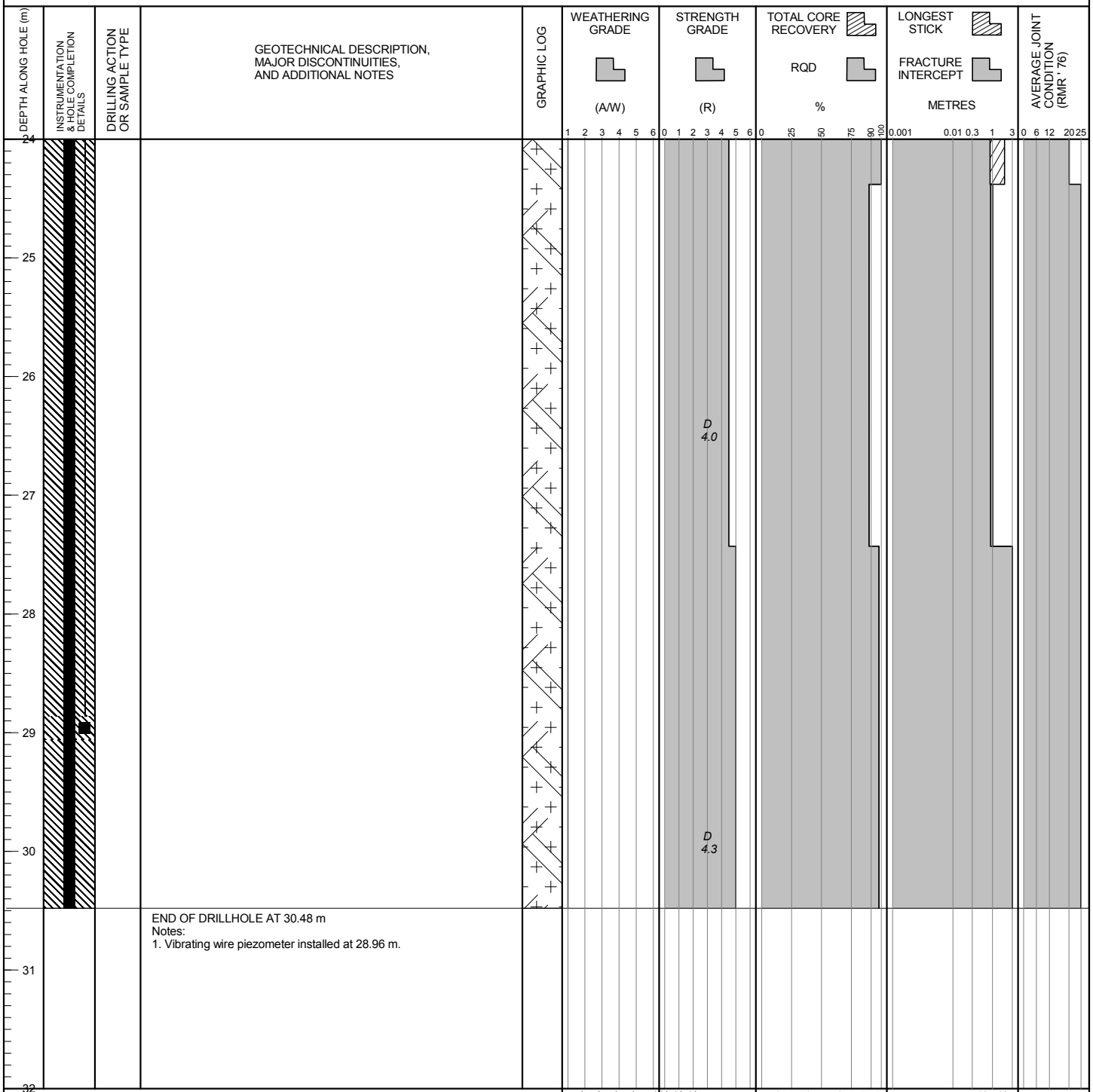
DRILL HOLE # DH-BGC12-26

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,756E - 6,258,749N
Ground Elevation (m): 1,406.1
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 180

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 1.0

Start Date: 07 Jun 12
Finish Date: 08 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.3
Logged By: RH/LM
Reviewed By: BMM



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-27

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,846E - 6,258,671N	**Drill Designation:** Heliportable	**Start Date:** 08 Jun 12
Ground Elevation (m): 1,414.1	**Drilling Contractor:** Radius	**Finish Date:** 08 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.2
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -75	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 315	**Cased To (m) :** 1.2	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			POTASSIUM FELDSPAR-HORNBLENDE-PLAGIOCLASE PORPHYRY (P2) Green, medium grained, massive groundmass with potassium feldspar phenocrysts 2 to 5 mm. Phenocrysts are sericite replaced and groundmass is sericite-chlorite replaced. Medium to very strong (R3.5-R5), slightly weathered (W1-W2), discontinuity surfaces are typically rough to very rough with separations <1 mm (JRC = 12 to 23).						
1									
2									
3			Below 2.74 m: Strength grade increases from R3.5 to R4-R5.			D 7.1			
4						D 6.2			
5						D 8.2 D 7.4			
6									
7			7.59 m: Fault, 1.5 mm FG infill, R0, JRC = 8.						
8			7.80 m: Fault, 2 mm FG infill, R0, JRC = 12.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

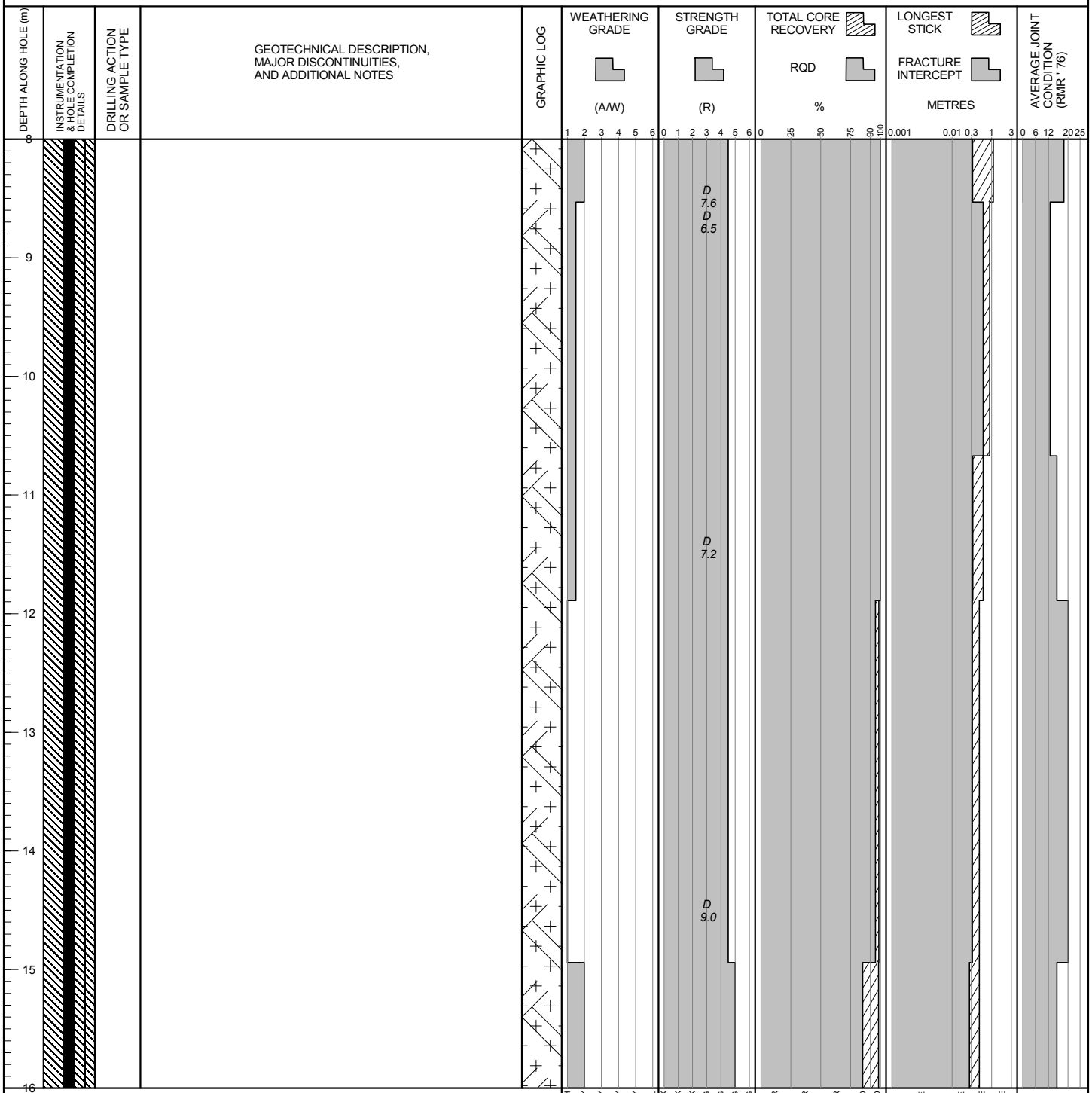
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-27

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,846E - 6,258,671N	**Drill Designation:** Heliportable	**Start Date:** 08 Jun 12
Ground Elevation (m): 1,414.1	**Drilling Contractor:** Radius	**Finish Date:** 08 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.2
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -75	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 315	**Cased To (m) :** 1.2	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

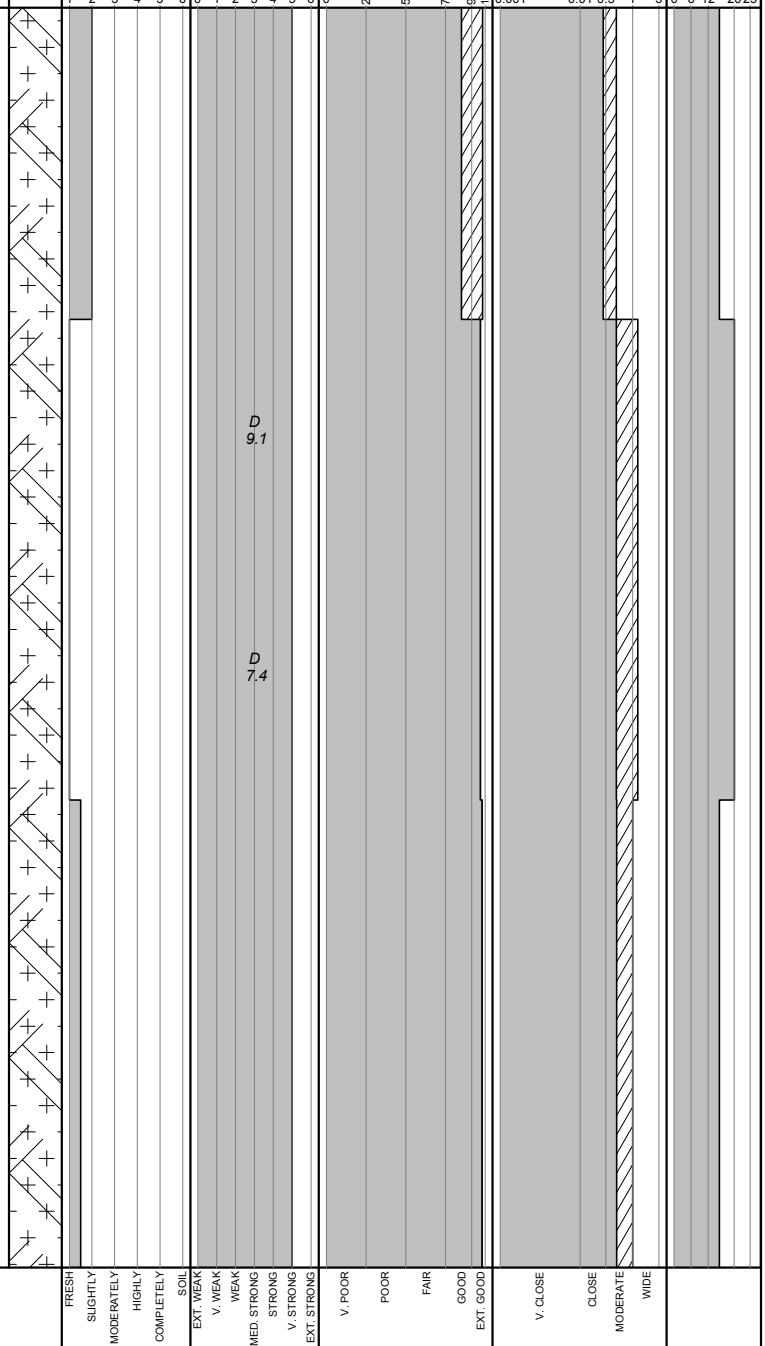
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-27

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,846E - 6,258,671N	**Drill Designation:** Heliportable	**Start Date:** 08 Jun 12
Ground Elevation (m): 1,414.1	**Drilling Contractor:** Radius	**Finish Date:** 08 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.2
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -75	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 315	**Cased To (m) :** 1.2	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			17.11 m: Broken rock, 90 mm BX and CX, R2.5.
18			
19			
20			
21			
22			
23			
24			23.83 m: Fault, 3 mm FG and CA infill, S1, JRC = 8.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-27

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,846E - 6,258,671N	***Drill Designation:*** Heliportable	***Start Date:*** 08 Jun 12
Ground Elevation (m): 1,414.1	***Drilling Contractor:*** Radius	***Finish Date:*** 08 Jun 12
Survey Method: Surveyed	***Drill Method:*** Diamond	***Final Depth (m):*** 30.2
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 0.0
Plunge (°): -75	***Fluid:*** Water	***Logged By:*** RH/LM
Trend (°): 315	***Cased To (m) :*** 1.2	***Reviewed By:*** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24			24.30 m: Fault, 5 mm CX infill, R2.5, JRC = 8.			D 0.6			
25									
26									
27						D 5.3 D 8.0			
28									
29									
30									
			END OF DRILLHOLE AT 30.18 m Notes: 1. Vibrating wire piezometer installed at 29.27 m.						
31									
32									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-28

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,910E - 6,258,774N
Ground Elevation (m): 1,421.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 360

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 1.4

Start Date: 09 Jun 12
Finish Date: 09 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.5
Logged By: RH/LM
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						OVERBURDEN No Recovery.
						Rock encountered at 0.5 m depth. Refer to DH-BGC12-28 rock log.
1						
2						
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-28

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,910E - 6,258,774N	**Drill Designation:** Heliportable	**Start Date:** 09 Jun 12
Ground Elevation (m): 1,421.0	**Drilling Contractor:** Radius	**Finish Date:** 09 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.5
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.5
Plunge (°): -80	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 360	**Cased To (m) :** 1.4	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-28 Overburden Log						
1			POTASSIUM FELDSPAR-HORNBLENDE-PLAGIOCLASE PORPHYRY (P2) Green, medium grained, massive groundmass with potassium feldspar phenocrysts 2 to 5 mm and locally present megacrysts up to 10 mm. Groundmass is sericite replaced. Strong (R4-R4.5), faintly weathered (W1-W1.5), discontinuity surfaces are typically rough to very rough with separations <1 mm (JRC = 18 to 23). 0 - 4.87 m: Drilled with a starting barrel resulting in poor recovery.			D 6.4 D 8.5			
2									
3									
4									
5									
6									
7									
8									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

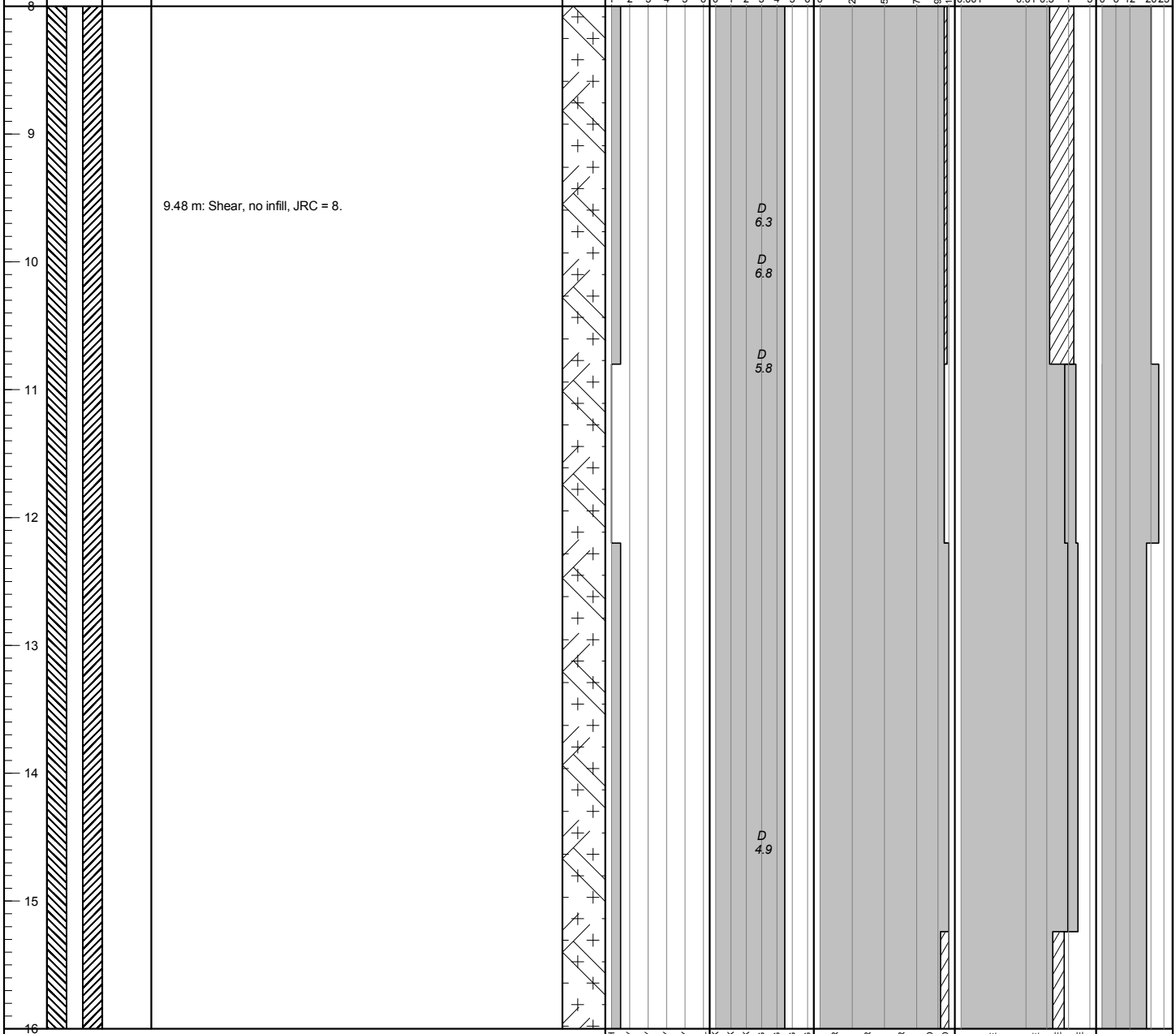
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-28

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,910E - 6,258,774N	***Drill Designation:*** Heliportable	***Start Date:*** 09 Jun 12
Ground Elevation (m): 1,421.0	***Drilling Contractor:*** Radius	***Finish Date:*** 09 Jun 12
Survey Method: Surveyed	***Drill Method:*** Diamond	***Final Depth (m):*** 30.5
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 0.5
Plunge (°): -80	***Fluid:*** Water	***Logged By:*** RH/LM
Trend (°): 360	***Cased To (m) :*** 1.4	***Reviewed By:*** BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

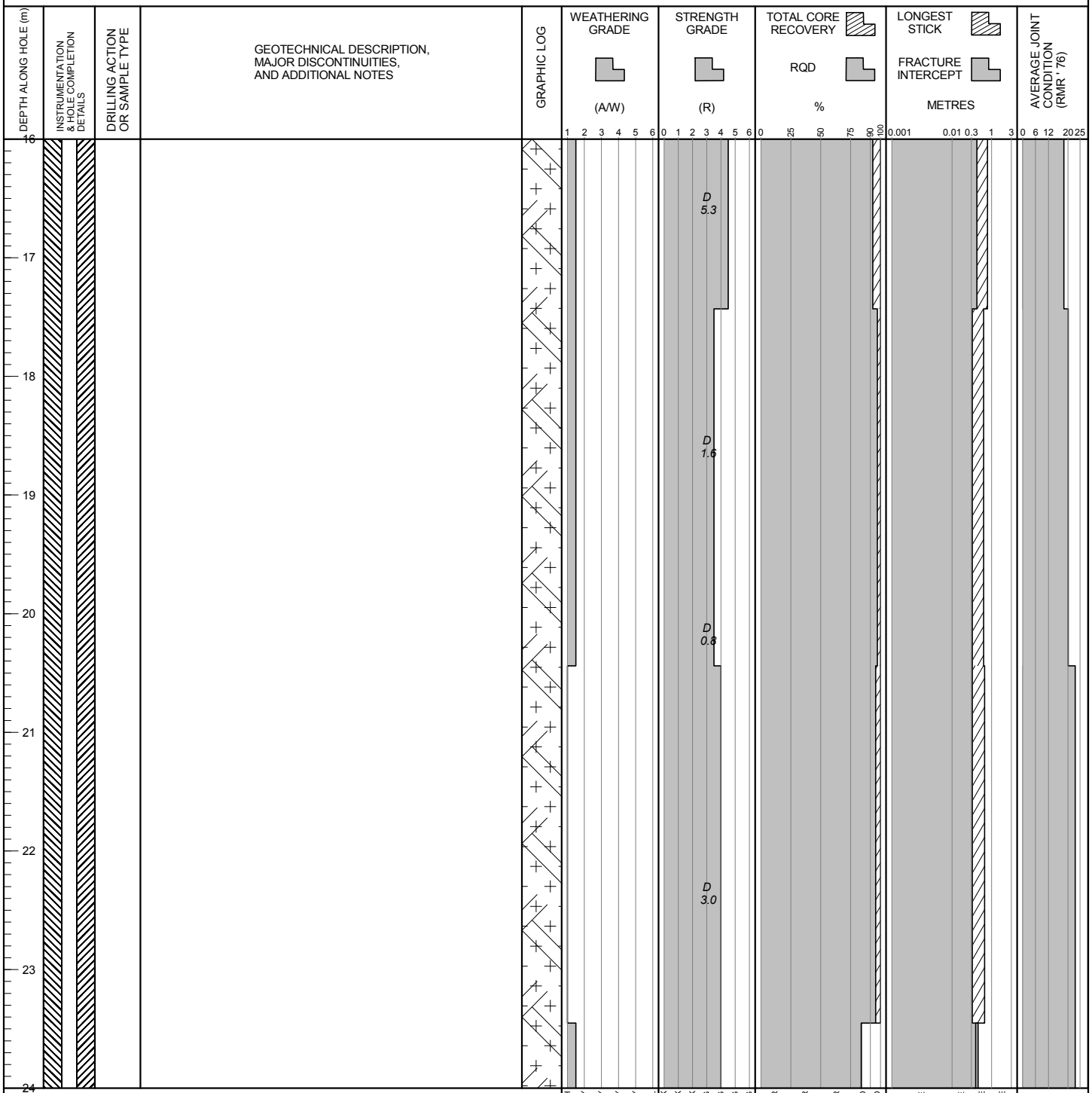
BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

DRILL HOLE # DH-BGC12-28

Project : Brucejack
Project No.1008-007

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,910E - 6,258,774N	***Drill Designation:*** Heliportable	***Start Date:*** 09 Jun 12
Ground Elevation (m): 1,421.0	***Drilling Contractor:*** Radius	***Finish Date:*** 09 Jun 12
Survey Method: Surveyed	***Drill Method:*** Diamond	***Final Depth (m):*** 30.5
Datum: UTM NAD 83 Zone 9	***Core:*** HQ3	***Depth To Top Of Rock (m):*** 0.5
Plunge (°): -80	***Fluid:*** Water	***Logged By:*** RH/LM
Trend (°): 360	***Cased To (m) :*** 1.4	***Reviewed By:*** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-28

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,910E - 6,258,774N
Ground Elevation (m): 1,421.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 360

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 1.4

Start Date: 09 Jun 12
Finish Date: 09 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.5
Logged By: RH/LM
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24									
25						D 2.7			
26									
27									
28			28.21 m: Fault, 30 mm FB and CX infill, R3, JRC = 8.			D 8.4			
29			29.56 m: Fault, 10 mm FG infill, S1.						
30						D 4.2			
31			END OF DRILLHOLE AT 30.48 m Notes: 1. Standpipe piezometer installed with completion zone from 26.20 m to 30.48 m. 2. The standpipe piezometer was installed in a inclined drillhole so there is some uncertainty in the quality of the bentonite seal and sand pack.						
32									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-29

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,904E - 6,258,737N	**Drill Designation:** Heliportable	**Start Date:** 10 Jun 12
Ground Elevation (m): 1,415.2	**Drilling Contractor:** Radius	**Finish Date:** 11 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 30.5
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 0.0
Plunge (°): -80	**Fluid:** Water	**Logged By:** RH/LM
Trend (°): 270	**Cased To (m) :** 2.8	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			POTASSIUM FELDSPAR-HORNBLENDE-PLAGIOCLASE PORPHYRY (P2) Green, medium grained, massive groundmass with potassium feldspar phenocrysts 2 to 6 mm and locally present megacrysts greater than 10 mm. Strong to very strong (R4-R5), faintly weathered (W1-W1.5), discontinuity surfaces are typically rough to very rough with separations <1 mm (JRC = 16 to 25).		1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
1									
2									
3						D 9.2			
4									
5						D 7.7 D 8.5			
6						D 8.7			
7						D 9.0			
8						D 8.5			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

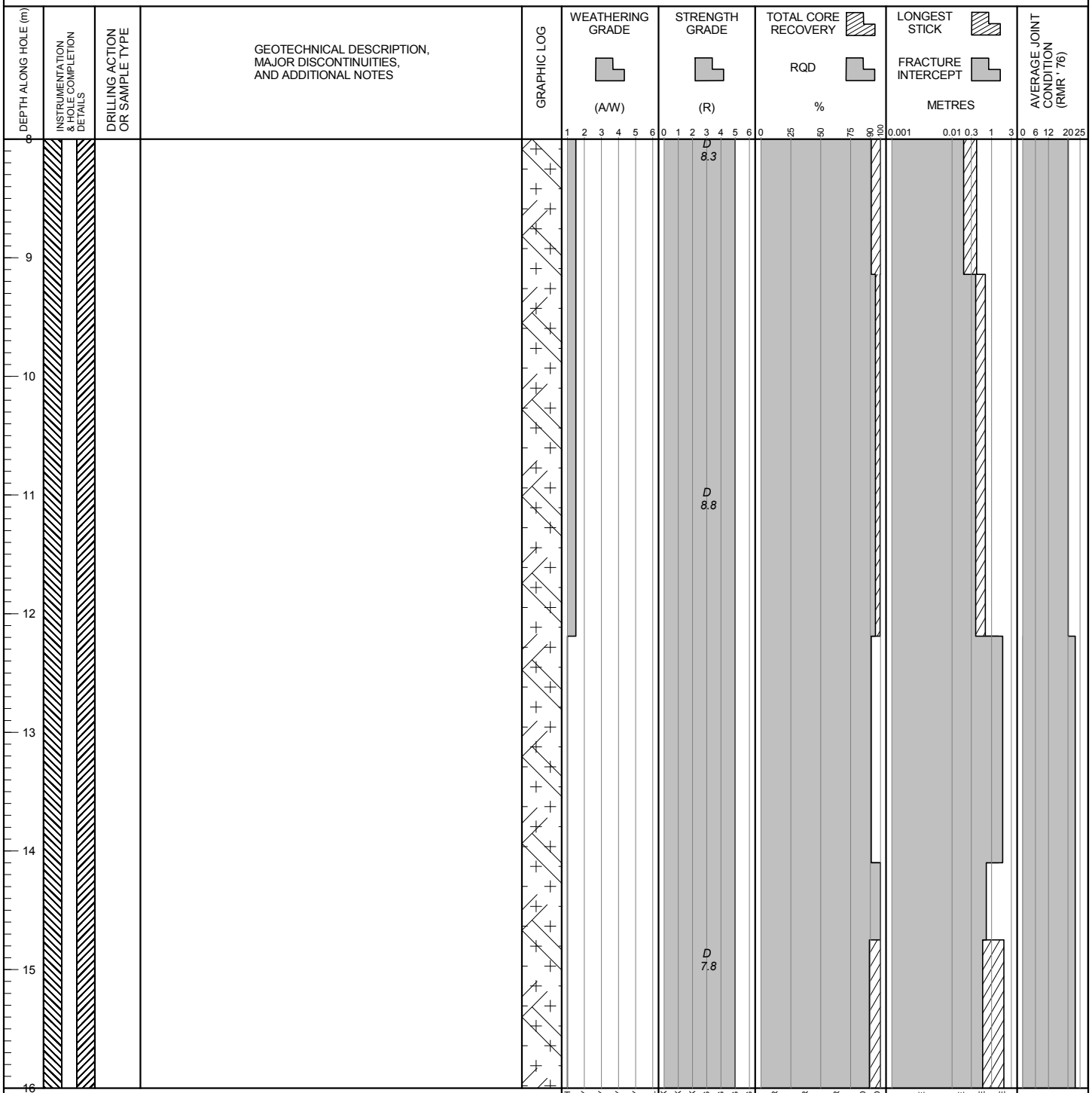
DRILL HOLE # DH-BGC12-29

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,904E - 6,258,737N
Ground Elevation (m): 1,415.2
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 270

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.8

Start Date: 10 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.0
Logged By: RH/LM
Reviewed By: BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

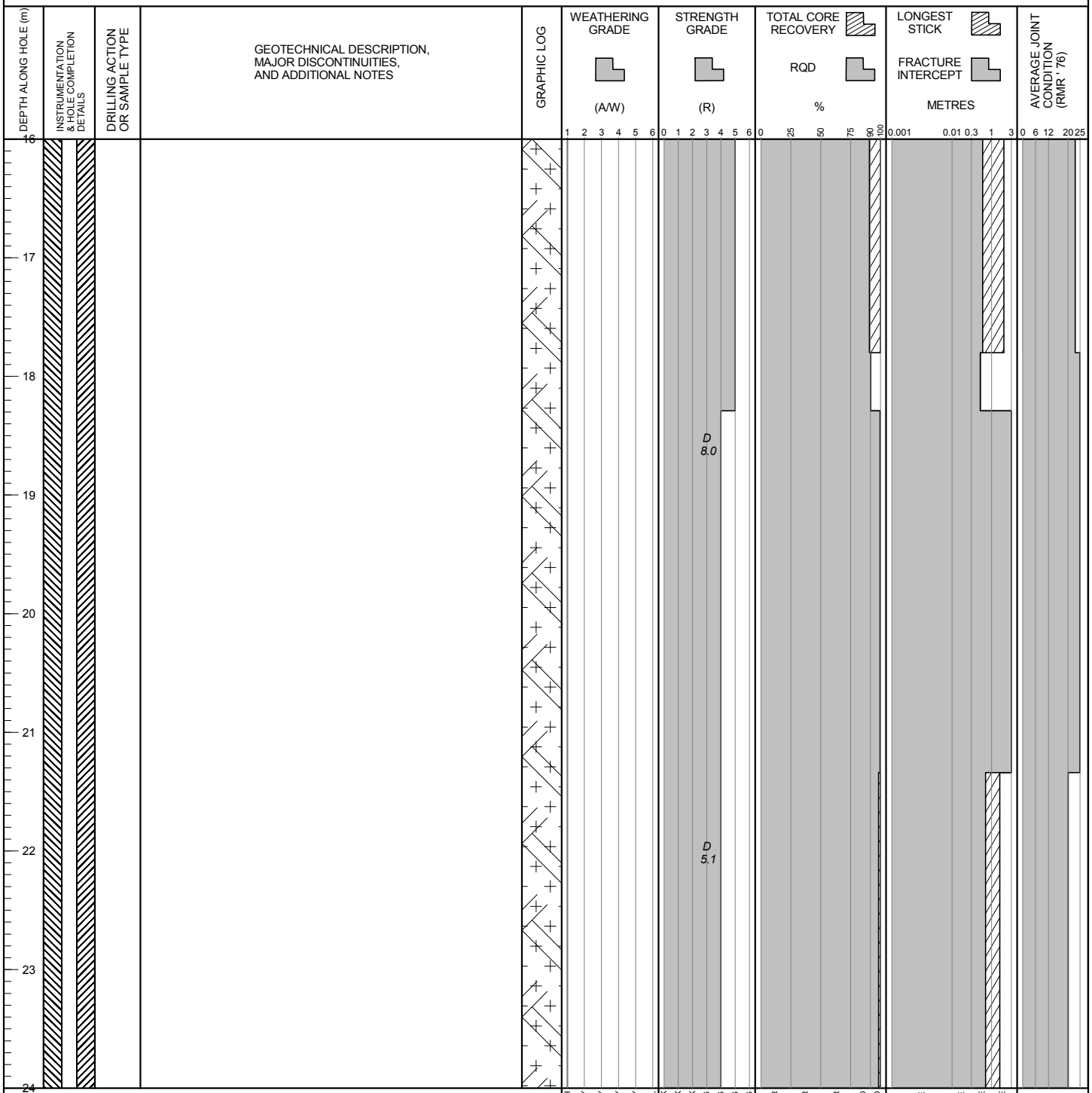
DRILL HOLE # DH-BGC12-29

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,904E - 6,258,737N
Ground Elevation (m): 1,415.2
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 270

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.8

Start Date: 10 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.0
Logged By: RH/LM
Reviewed By: BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-29

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,904E - 6,258,737N
Ground Elevation (m): 1,415.2
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 270

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.8

Start Date: 10 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 30.5
Depth To Top Of Rock (m): 0.0
Logged By: RH/LM
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24									
25						D 5.6			
26									
27									
28						D 7.7			
29									
30									
31			END OF DRILLHOLE AT 30.48 m Notes: 1. Standpipe piezometer installed with completion zone from 28.10 m to 30.48 m. 2. The standpipe piezometer was installed in a inclined drillhole so there is some uncertainty in the quality of the bentonite seal and sand pack.						
32									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-30

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,977E - 6,258,758N
Ground Elevation (m): 1,388.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 225

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.7

Start Date: 11 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 32.3
Depth To Top Of Rock (m): 2.4
Logged By: LM
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						GRAVEL (GP) Medium to coarse, some cobbles, poorly graded, maximum particle size > 50 mm, subrounded to angular, greyish brown with iron staining, odourless.
1						
2						
						Rock encountered at 2.4 m depth. Refer to DH-BGC12-30 rock log.
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_p% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

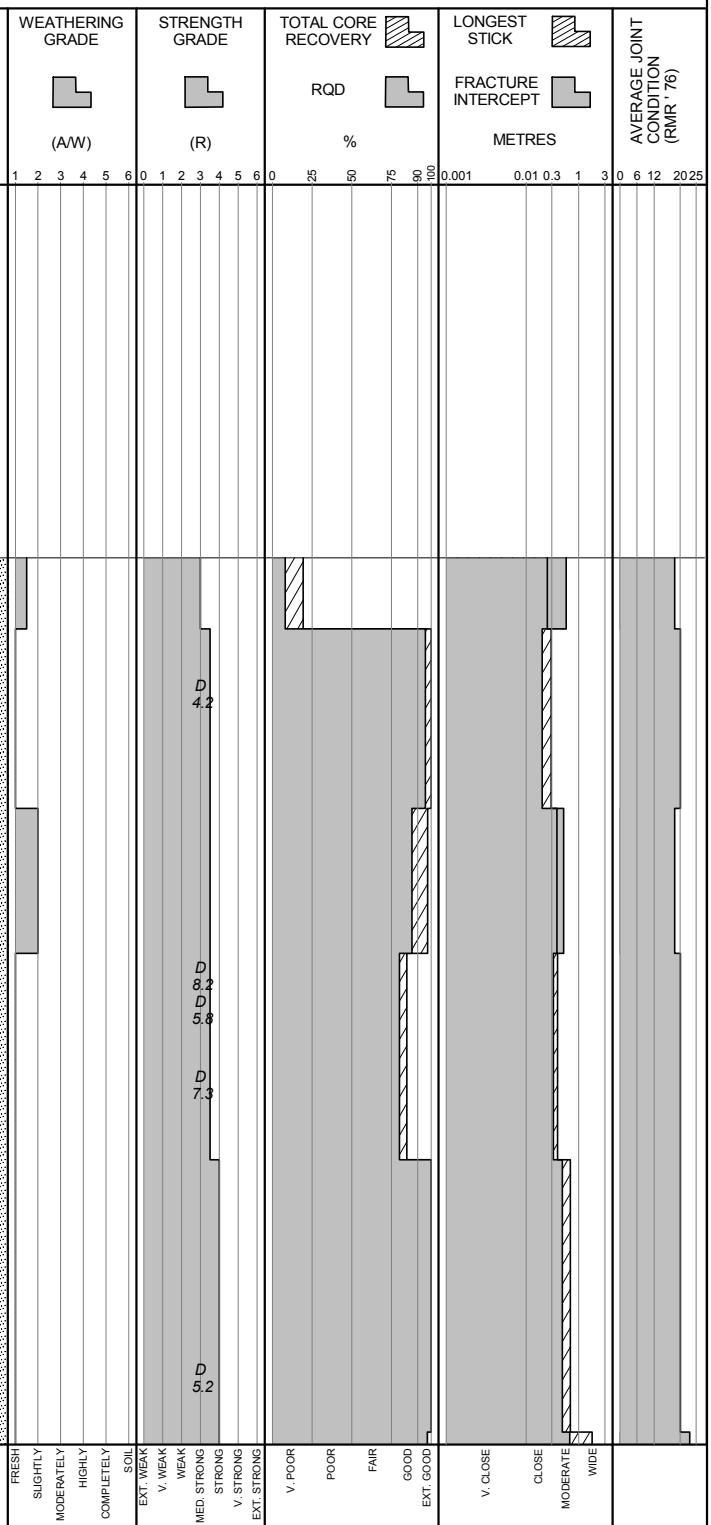
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-30

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,977E - 6,258,758N	**Drill Designation:** Heliportable	**Start Date:** 11 Jun 12
Ground Elevation (m): 1,388.3	**Drilling Contractor:** Radius	**Finish Date:** 11 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 32.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.4
Plunge (°): -80	**Fluid:** Water	**Logged By:** LM
Trend (°): 225	**Cased To (m) :** 2.7	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
0			Refer to DH-BGC12-30 Overburden Log	
2.4			ARENITE (S4) Grey, medium to coarse grained, massive sandstone. Medium strong (R3-R3.5), slightly weathered (W1.5-W2), discontinuity surfaces are typically rough to very rough with separations <1 mm (JRC = 16 to 20).	
5.0			ARENITE (S4) Grey, medium to coarse grained, massive sandstone. Strong (R4), fresh (A1), discontinuity surfaces are typically rough to very rough with separations <1 mm (JRC = 20 to 23).	
8				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-30

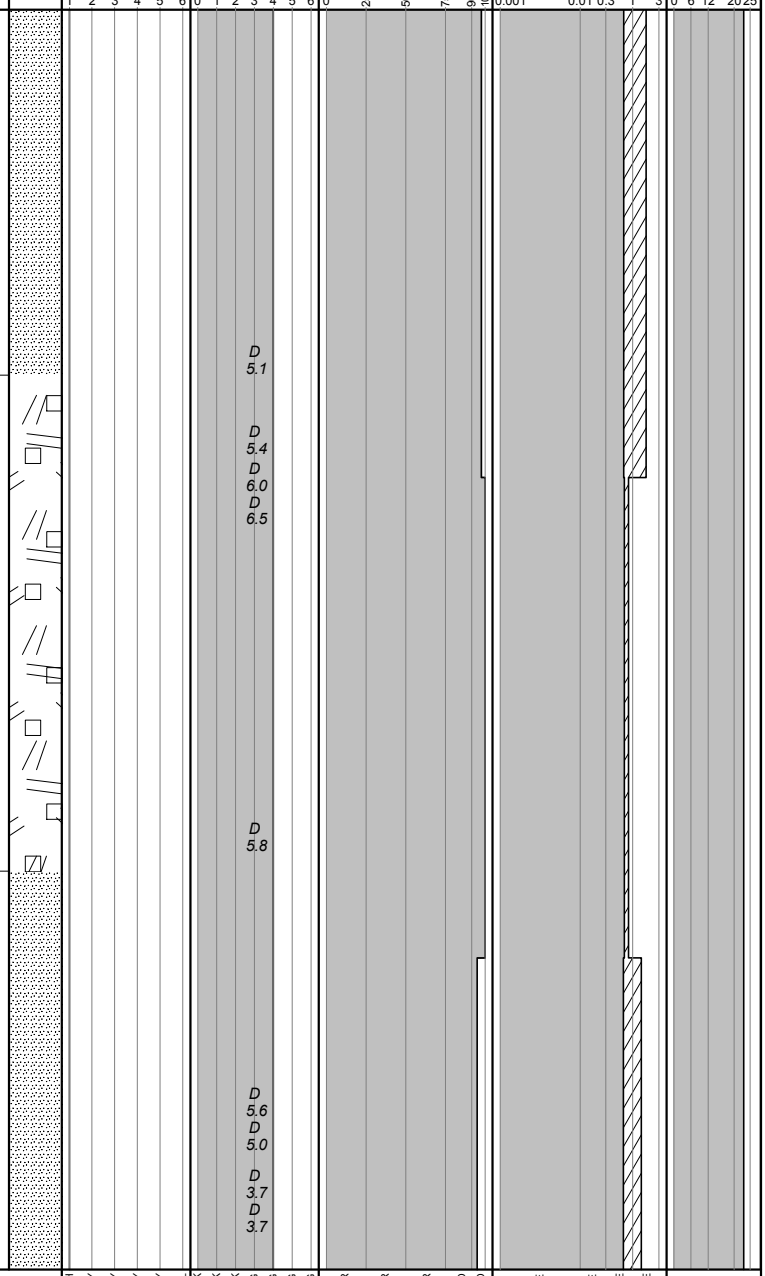
Location: Brucejack (Plant Site)

Co-ordinates (m): 426,977E - 6,258,758N	**Drill Designation:** Heliportable	**Start Date:** 11 Jun 12
Ground Elevation (m): 1,388.3	**Drilling Contractor:** Radius	**Finish Date:** 11 Jun 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 32.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.4
Plunge (°): -80	**Fluid:** Water	**Logged By:** LM
Trend (°): 225	**Cased To (m) :** 2.7	**Reviewed By:** BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

POLYLITHIC CONGLOMERATE (S3)
Grey, poorly sorted, 3 to 30 mm clasts, medium to coarse sandy matrix, moderate pyrite replacement in the matrix. Strong (R4), fresh (A1), discontinuity surfaces are typically very rough with separations <1 mm (JRC = 23).

ARENITE (S4)
Grey, medium to coarse grained, massive sandstone interbedded with mudstones. Sandier intervals contain pebble sized mudstone clasts. Local concretions are present in the finer grained sediments. Medium strong to strong (R3 to R4), fresh (A1), discontinuity surfaces are typically rough to very rough with separations <1 mm (JRC = 18 to 23).



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

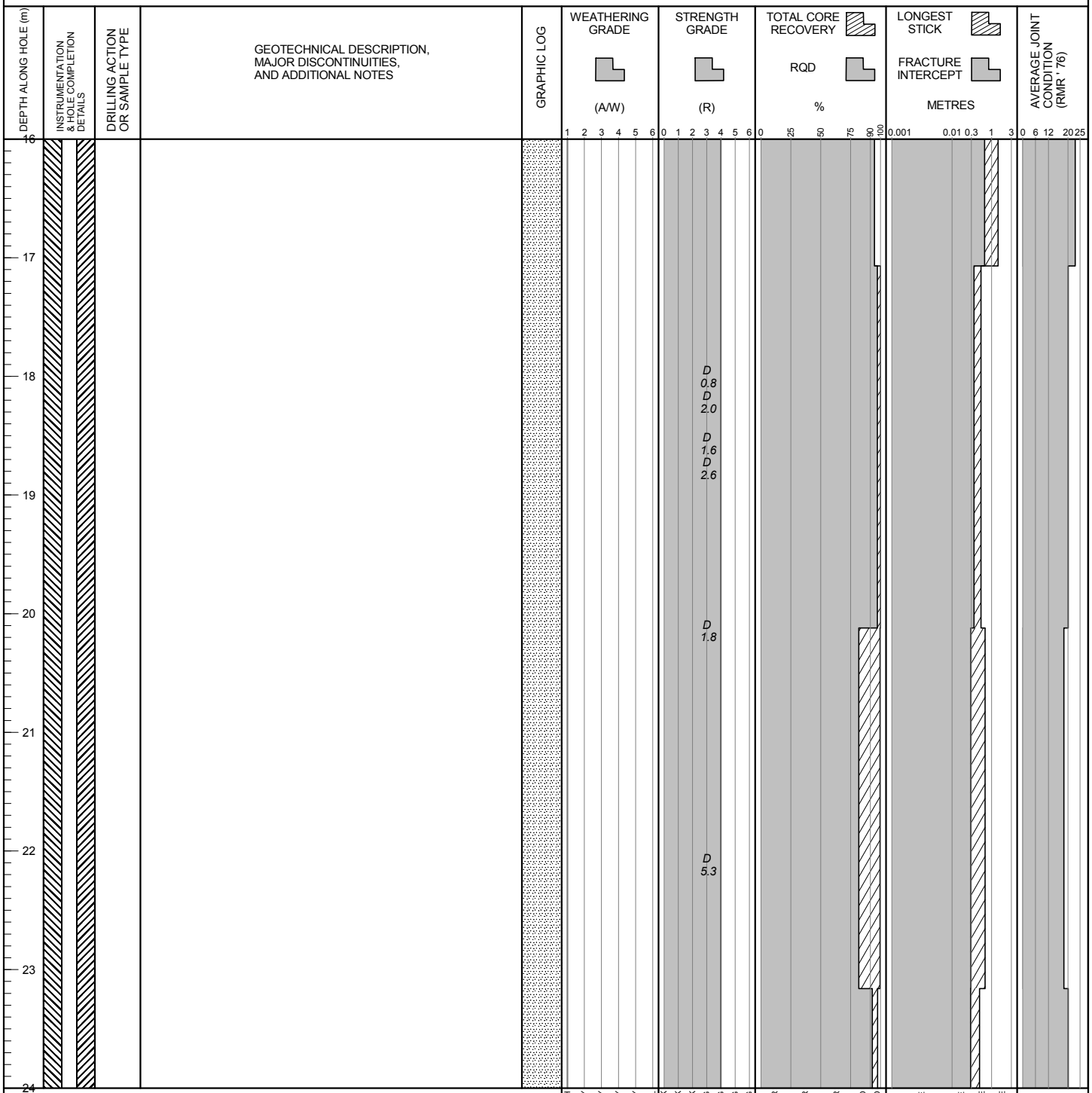
DRILL HOLE # DH-BGC12-30

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,977E - 6,258,758N
Ground Elevation (m): 1,388.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 225

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.7

Start Date: 11 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 32.3
Depth To Top Of Rock (m): 2.4
Logged By: LM
Reviewed By: BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

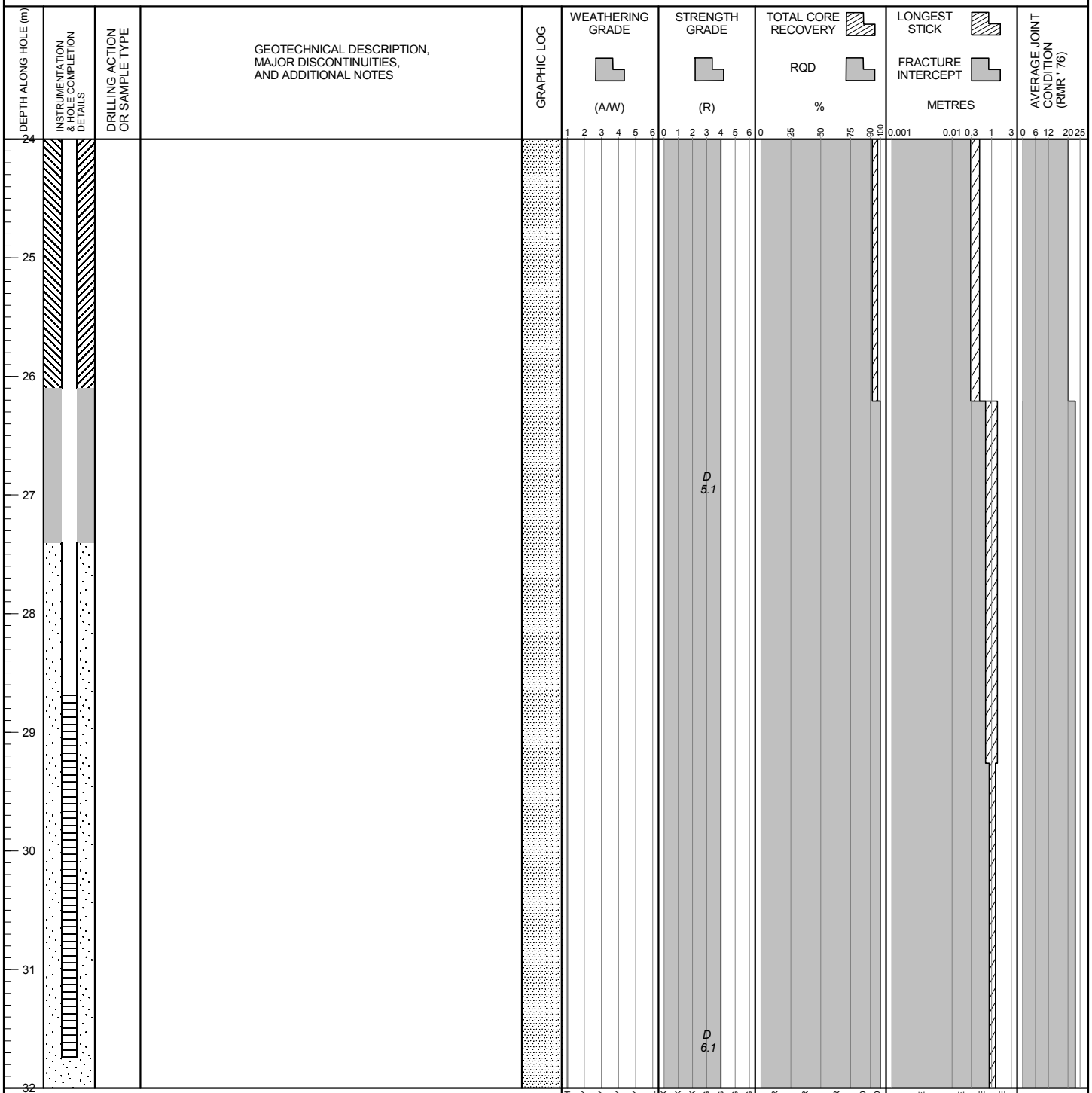
DRILL HOLE # DH-BGC12-30

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,977E - 6,258,758N
Ground Elevation (m): 1,388.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 225

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.7

Start Date: 11 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 32.3
Depth To Top Of Rock (m): 2.4
Logged By: LM
Reviewed By: BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-30

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,977E - 6,258,758N
Ground Elevation (m): 1,388.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -80
Trend (°): 225

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Water
Cased To (m) : 2.7

Start Date: 11 Jun 12
Finish Date: 11 Jun 12
Final Depth (m): 32.3
Depth To Top Of Rock (m): 2.4
Logged By: LM
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25
32									
33			END OF DRILLHOLE AT 32.31 m Notes: 1. Standpipe piezometer installed with completion zone from 27.40 m to 32.31 m. 2. The standpipe piezometer was installed in a inclined drillhole so there is some uncertainty in the quality of the bentonite seal and sand pack.						
34									
35									
36									
37									
38									
39									
40									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N
Ground Elevation (m): 1,410.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 256

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Sep 12
Finish Date: 29 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 4.3
Logged By: JW/SLP
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description	Su - kPa (40, 80, 120, 160) ★ % Fines ▲ UC/2 △ Pocket Pen /2 ● SPT (blows/300mm) Core Recovery (20, 40, 60, 80) Moisture Content & SPT N W_p% W% W_l% (20, 40, 60, 80)
0						SAND (SC) Medium to coarse, gravelly, some clay, some boulders, trace cobbles, well graded, compact, maximum particle size = 340 mm, subrounded, brown, no odour, moist, homogeneous, no cementation. Some recovery during drilling. [Glacial Till]	
1							
2							
3							
4							
						Rock encountered at 4.3 m depth. Refer to DH-BGC12-31 rock log.	
5							
6							
7							
8							

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N	**Drill Designation:** Heliportable	**Start Date:** 28 Sep 12
Ground Elevation (m): 1,410.3	**Drilling Contractor:** Radius	**Finish Date:** 29 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 4.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 256	**Cased To (m) :** 1.8	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-31 Overburden Log						
5			INTERMEDIATE VOLCANICS (V12) Dark grey tuff breccia. Medium-grained tuff and some pebble-sized porphyry fragments in a dark matrix with fine grained pyrite. Medium strong to strong (R3.5-R4), faintly to slightly weathered (W1.5-W2), discontinuity surfaces are slightly rough to slickensided with separations < 5 mm (JRC = 6 to 16).			D 2.3			
7			7.19 m: Fault, 50 mm FG/SM infill, S5, JRC = 8.			D 4.8			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N
Ground Elevation (m): 1,410.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 256

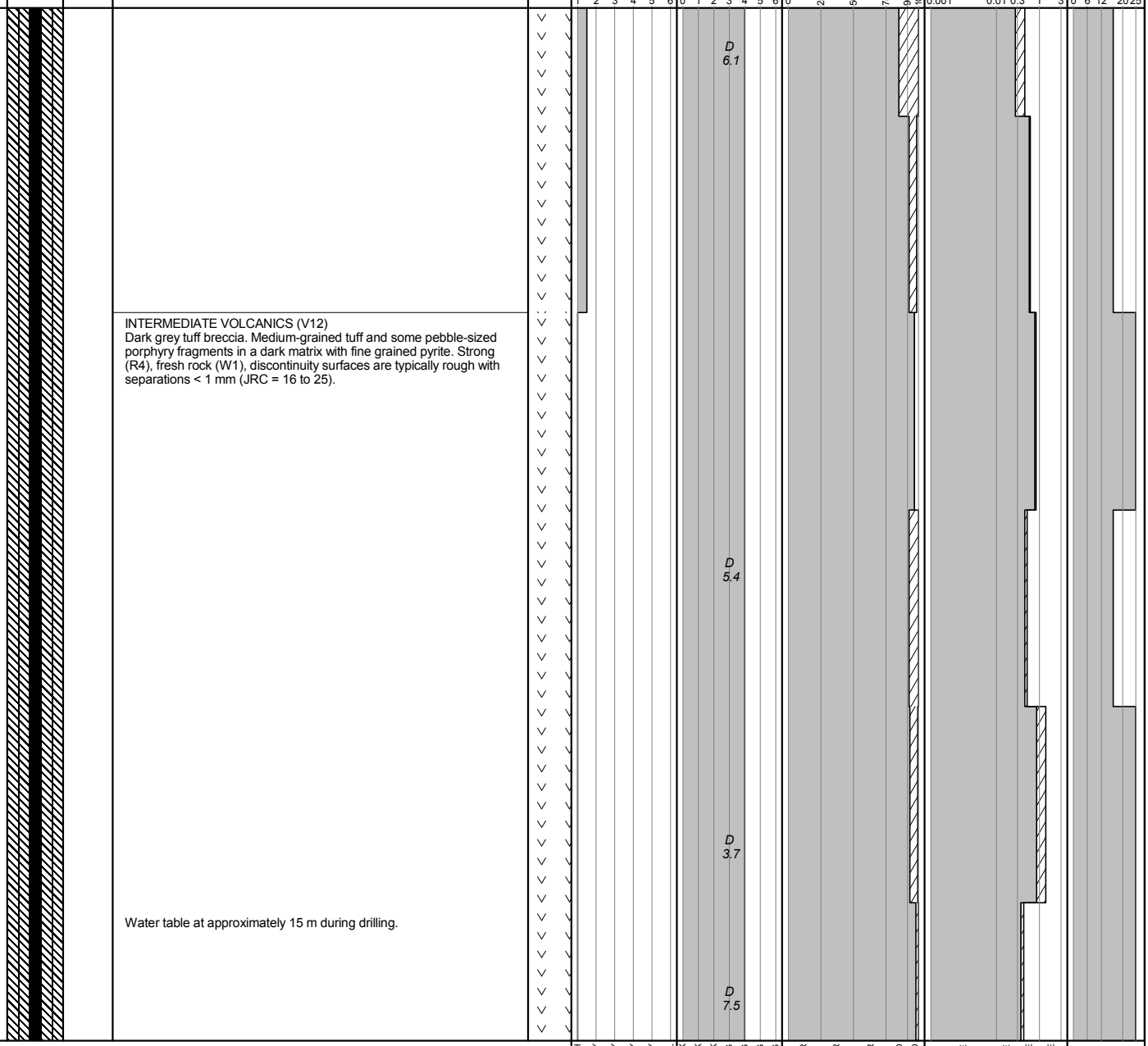
Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Sep 12
Finish Date: 29 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 4.3
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)

INTERMEDIATE VOLCANICS (V12)
Dark grey tuff breccia. Medium-grained tuff and some pebble-sized porphyry fragments in a dark matrix with fine grained pyrite. Strong (R4), fresh rock (W1), discontinuity surfaces are typically rough with separations < 1 mm (JRC = 16 to 25).

Water table at approximately 15 m during drilling.



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

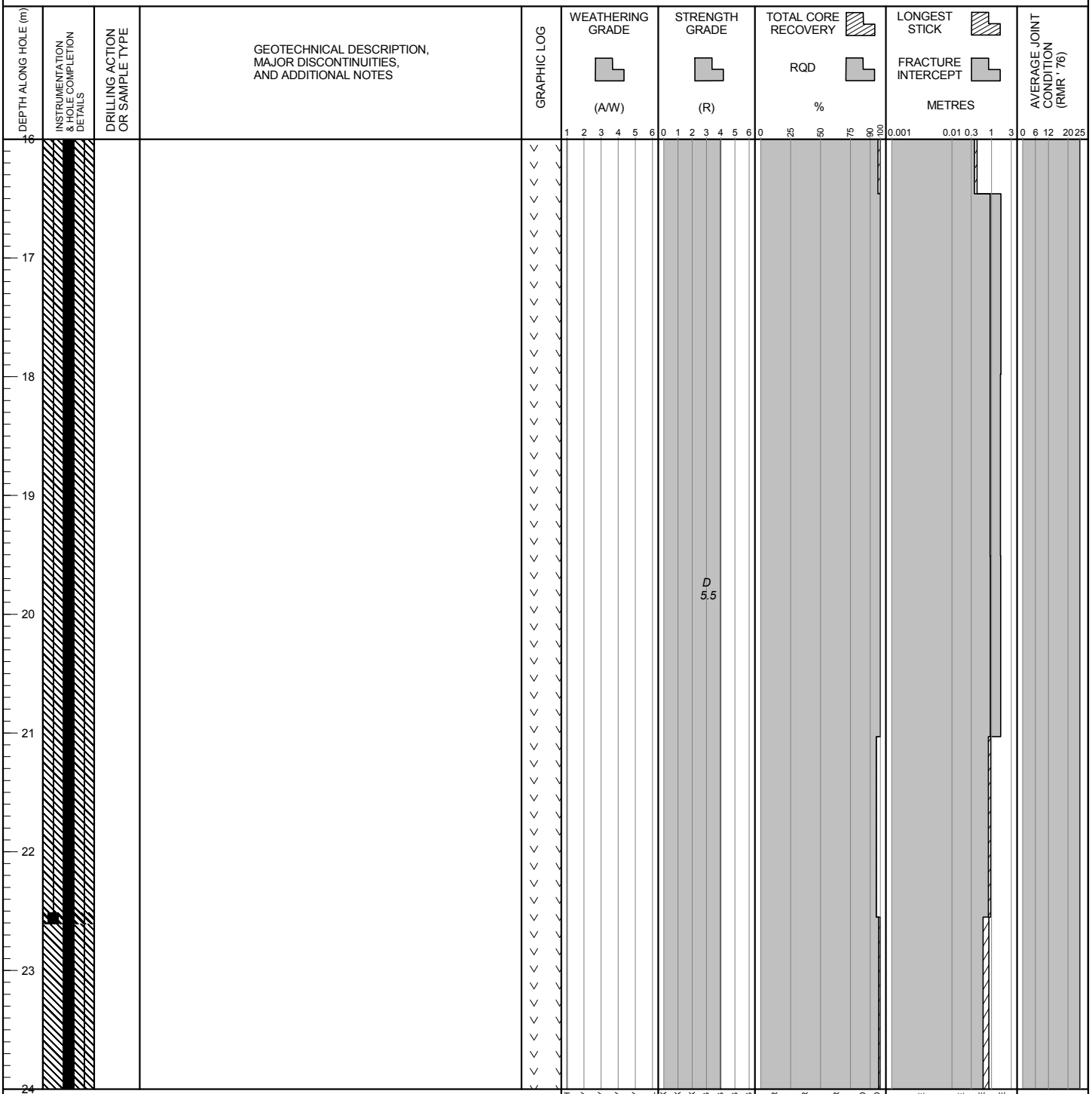
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N	**Drill Designation:** Heliportable	**Start Date:** 28 Sep 12
Ground Elevation (m): 1,410.3	**Drilling Contractor:** Radius	**Finish Date:** 29 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 4.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 256	**Cased To (m) :** 1.8	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

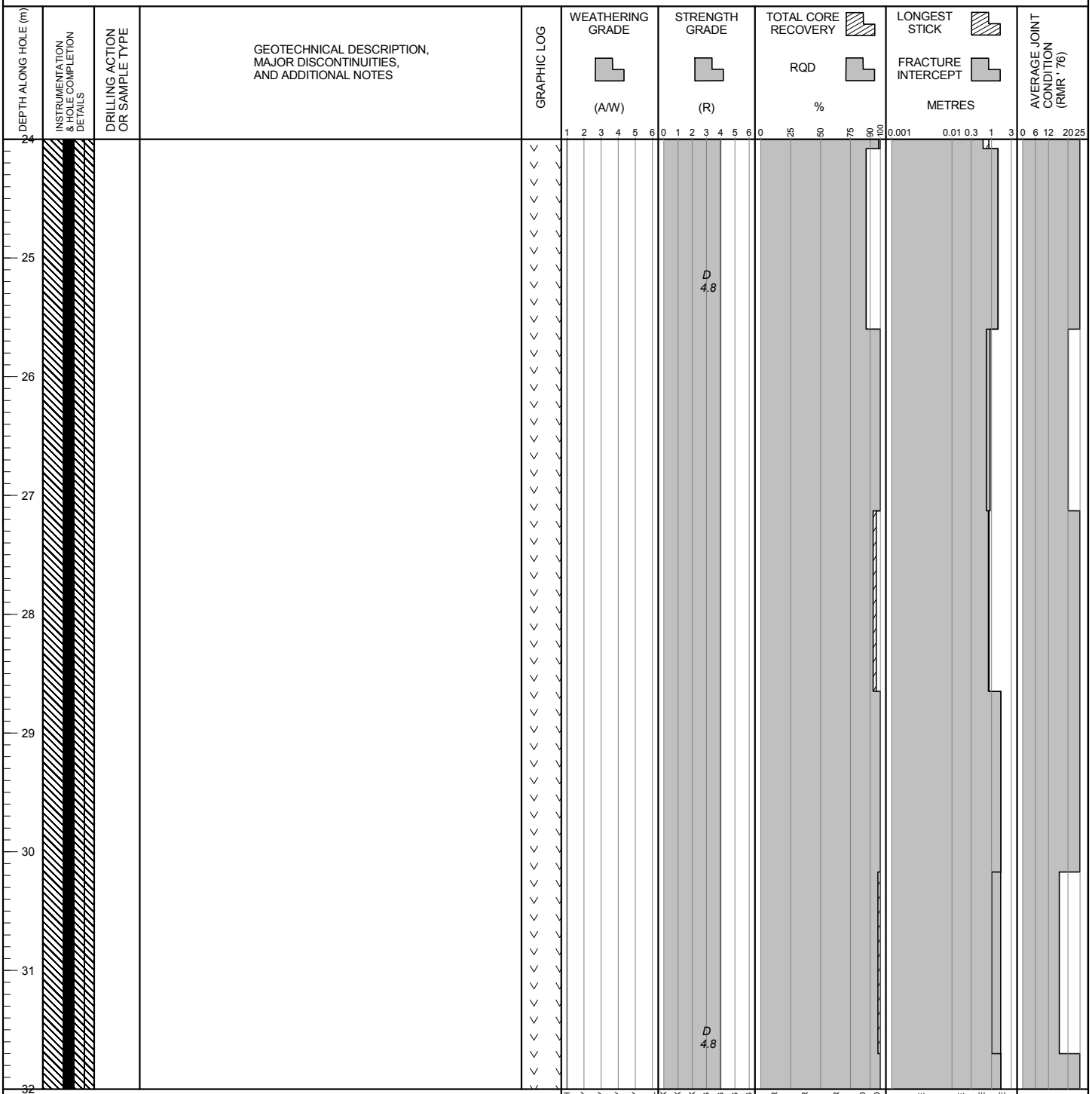
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N	**Drill Designation:** Heliportable	**Start Date:** 28 Sep 12
Ground Elevation (m): 1,410.3	**Drilling Contractor:** Radius	**Finish Date:** 29 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 4.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 256	**Cased To (m) :** 1.8	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

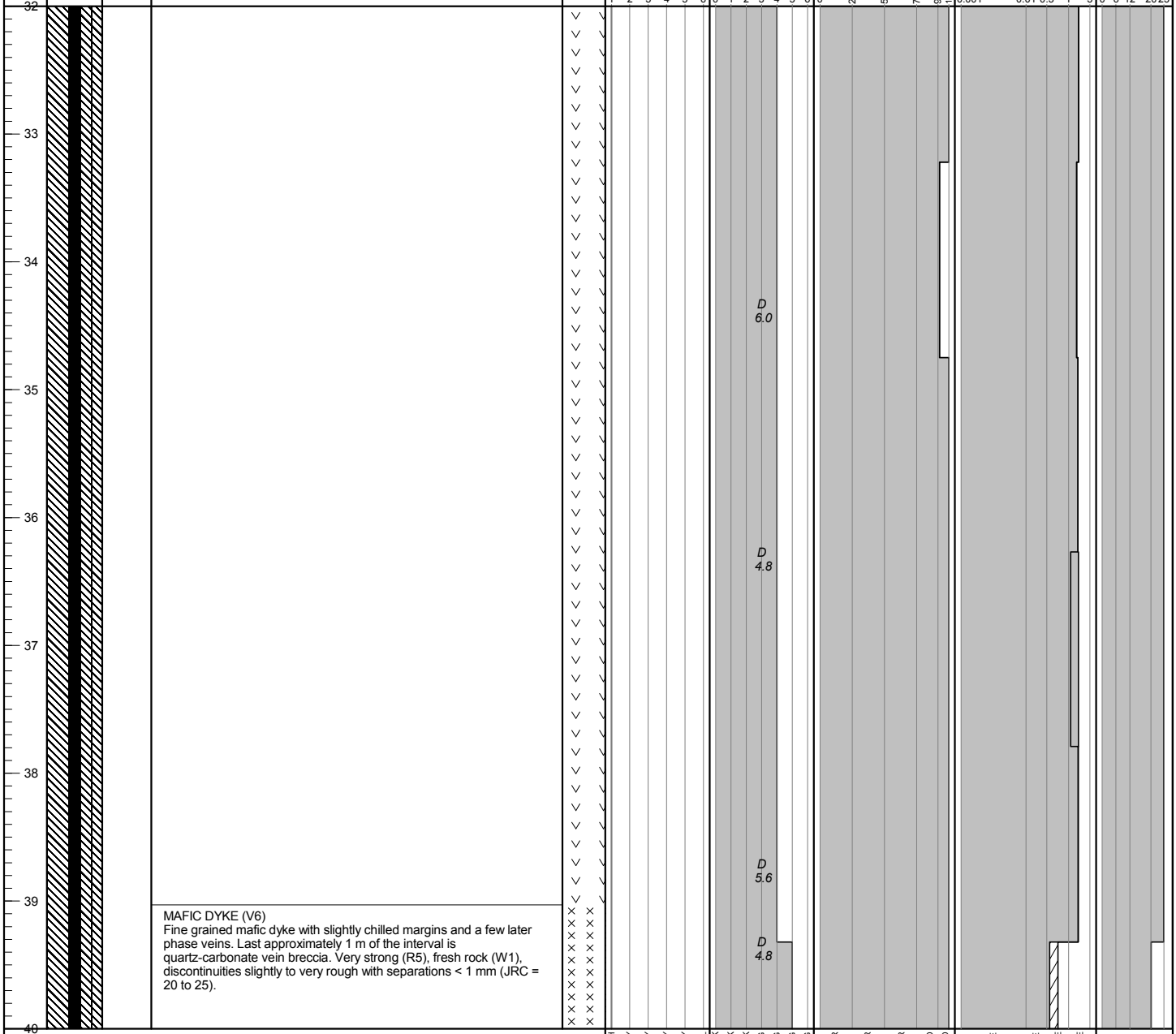
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N	**Drill Designation:** Heliportable	**Start Date:** 28 Sep 12
Ground Elevation (m): 1,410.3	**Drilling Contractor:** Radius	**Finish Date:** 29 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 4.3
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 256	**Cased To (m) :** 1.8	**Reviewed By:** BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



MAFIC DYKE (V6)
Fine grained mafic dyke with slightly chilled margins and a few later phase veins. Last approximately 1 m of the interval is quartz-carbonate vein breccia. Very strong (R5), fresh rock (W1), discontinuities slightly to very rough with separations < 1 mm (JRC = 20 to 25).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # DH-BGC12-31

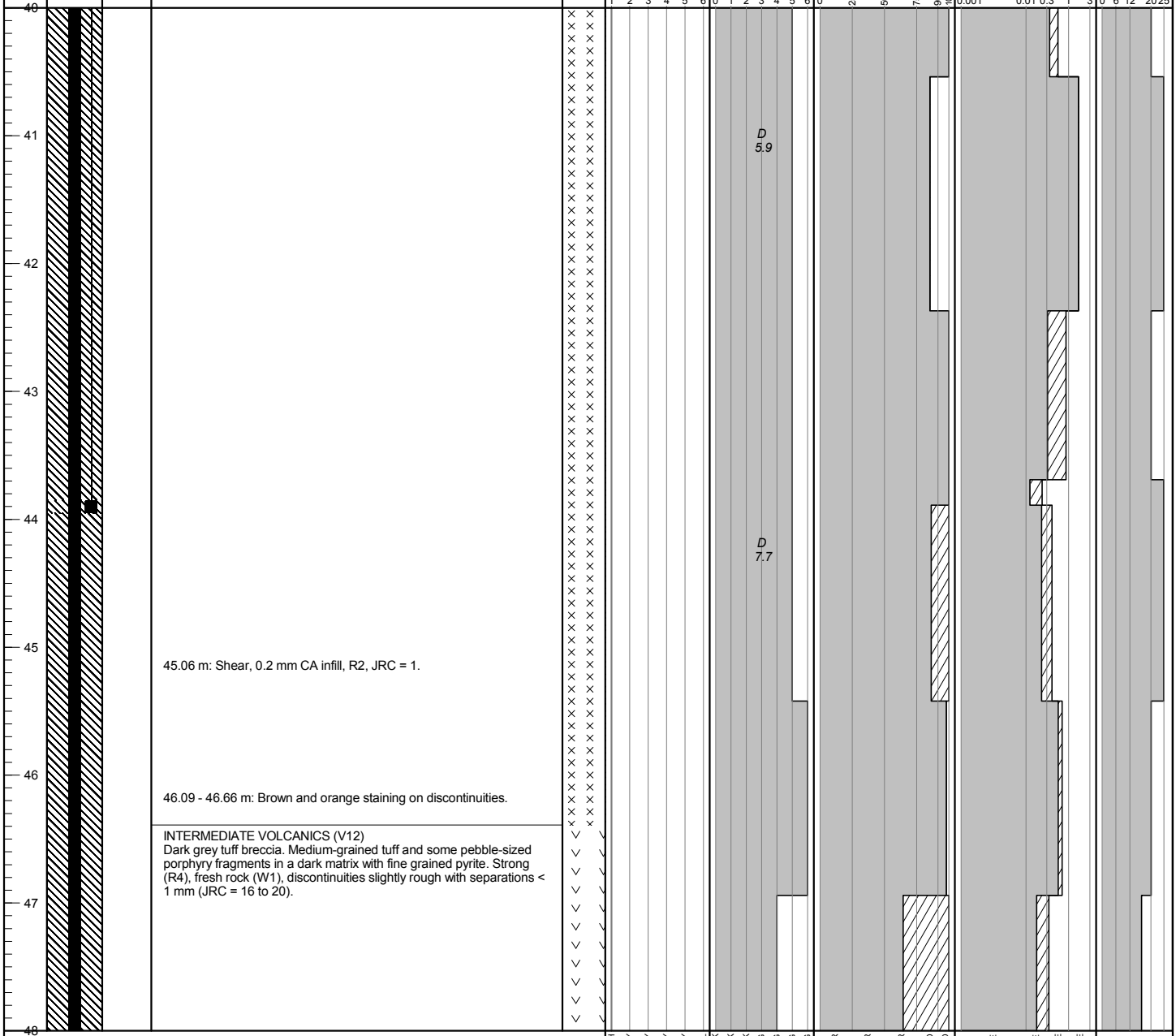
Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N
Ground Elevation (m): 1,410.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 256

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Sep 12
Finish Date: 29 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 4.3
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR '76)



45.06 m: Shear, 0.2 mm CA infill, R2, JRC = 1.

46.09 - 46.66 m: Brown and orange staining on discontinuities.

INTERMEDIATE VOLCANICS (V12)
Dark grey tuff breccia. Medium-grained tuff and some pebble-sized porphyry fragments in a dark matrix with fine grained pyrite. Strong (R4), fresh rock (W1), discontinuities slightly rough with separations < 1 mm (JRC = 16 to 20).

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-31

Location: Brucejack (North Portal)

Co-ordinates (m): 426,960E - 6,258,615N
Ground Elevation (m): 1,410.3
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 256

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.8

Start Date: 28 Sep 12
Finish Date: 29 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 4.3
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
48									
49						D 4.0			
50			END OF DRILLHOLE AT 50.00 m Notes: 1. Vibrating wire piezometers installed at 22.56 m and 43.90 m.						
51									
52									
53									
54									
55									
56									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N
Ground Elevation (m): 1,410.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 240

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 29 Sep 12
Finish Date: 30 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 2.1
Logged By: JW/SLP
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						SAND (SC) Coarse grained, clayey, some gravel, trace cobbles, gap graded, compact, maximum particle size = 280 mm, subangular, brown, no odour, moist, homogeneous, no cementation. Some washed gravel recovered during drilling. [Glacial Till]
1						
2						
						Rock encountered at 2.1 m depth. Refer to DH-BGC12-32 rock log.
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20 40 60 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N
Ground Elevation (m): 1,410.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 240

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 29 Sep 12
Finish Date: 30 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 2.1
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-32 Overburden Log						
1									
2									
3			CONGLOMERATE (S3) Dark with interbedded mudstone/siltstone. Clasts are dominantly subangular to subrounded, with some more angular. Some segments appear brecciated. Slightly weathered (W1.5-W2), medium strong to strong (R3.5-R4), discontinuities slightly rough with soft walls and separation < 1 mm (JRC = 12). Water table at approximately 3 m during drilling			D 4.5			
4									
5									
6			CONGLOMERATE (S3) Dark with interbedded mudstone/siltstone. Clasts are dominantly subangular to subrounded, with some more angular. Some segments appear brecciated. Strong to very strong (R4-R5), fresh rock (W1), discontinuities typically slightly rough with separation < 1 mm (JRC = 16 to 25).			D 4.3			
7									
8									

POINT LOAD TESTS
D — *TEST TYPE: DIAMETRAL (D); AXIAL (A)*
1.5— Is_{50} *(MPa)*

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

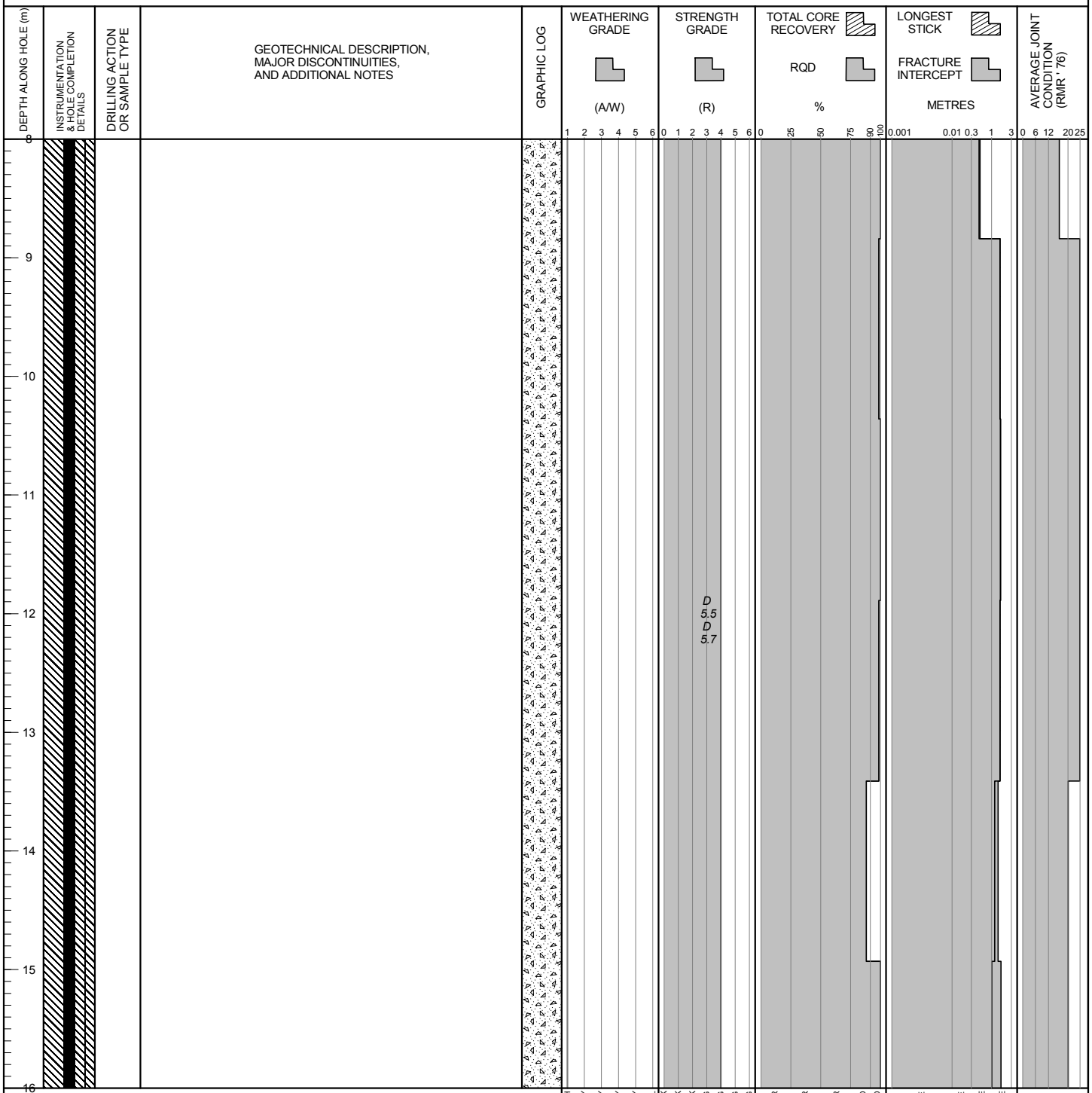
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N	**Drill Designation:** Heliportable	**Start Date:** 29 Sep 12
Ground Elevation (m): 1,410.8	**Drilling Contractor:** Radius	**Finish Date:** 30 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.1
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 240	**Cased To (m) :** 1.5	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N	**Drill Designation:** Heliportable	**Start Date:** 29 Sep 12
Ground Elevation (m): 1,410.8	**Drilling Contractor:** Radius	**Finish Date:** 30 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.1
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 240	**Cased To (m) :** 1.5	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
16									
17									
18						D 3.3			
19									
20			20.3 m: Joint with trace white clay infill, JRC = 6, 38 degrees TCA, JWCS = R4, Infill = R1.						
21			20.3 m: Joint with 1 mm white clay infill, JRC = 6, 30 degrees TCA, JWCS = R4, Infill = R1.						
22									
23									
24									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

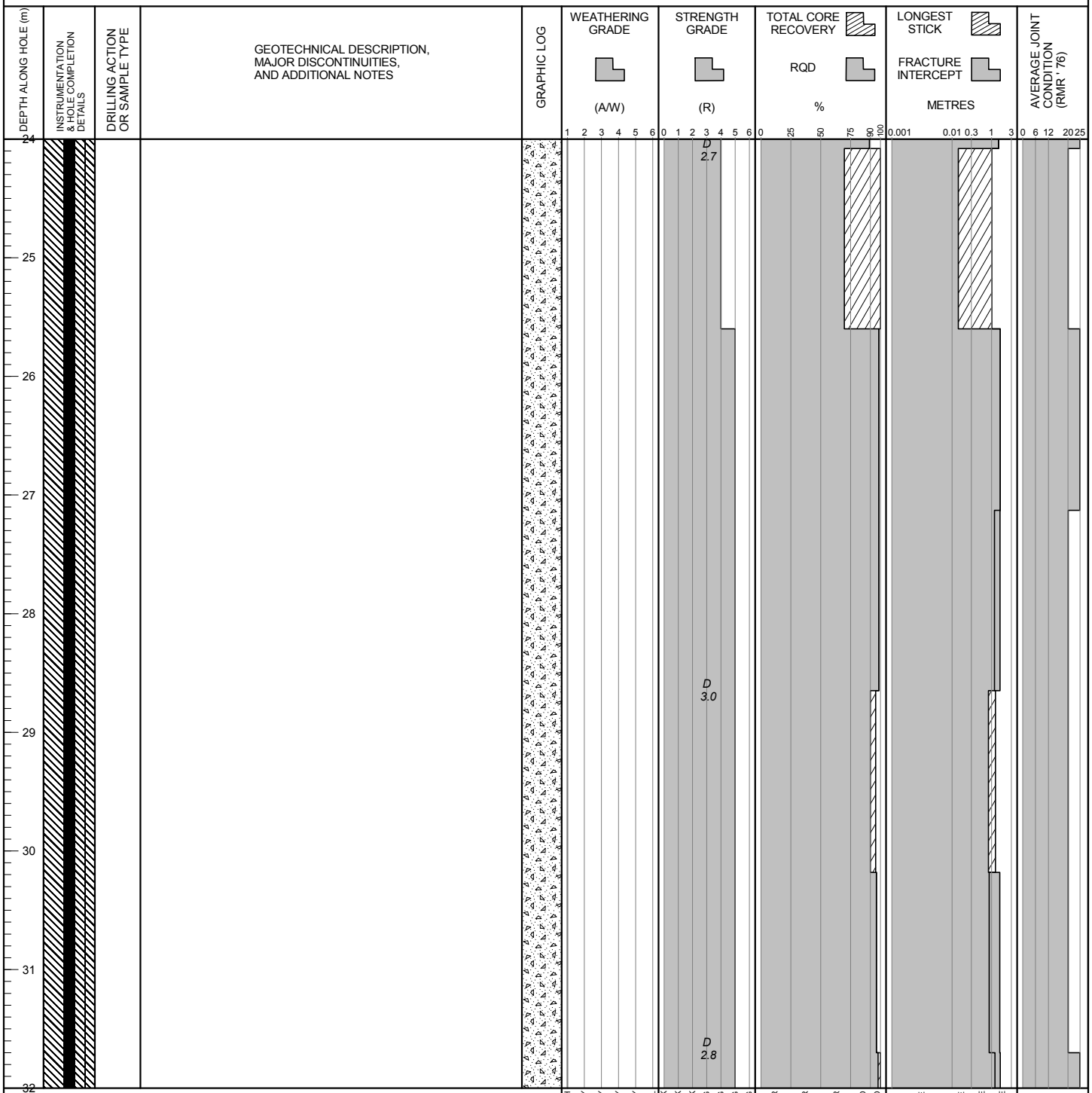
LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N	**Drill Designation:** Heliportable	**Start Date:** 29 Sep 12
Ground Elevation (m): 1,410.8	**Drilling Contractor:** Radius	**Finish Date:** 30 Sep 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.1
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 240	**Cased To (m) :** 1.5	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N	**Drill Designation:** Heliportable	**Start Date:** 29 Sep 12
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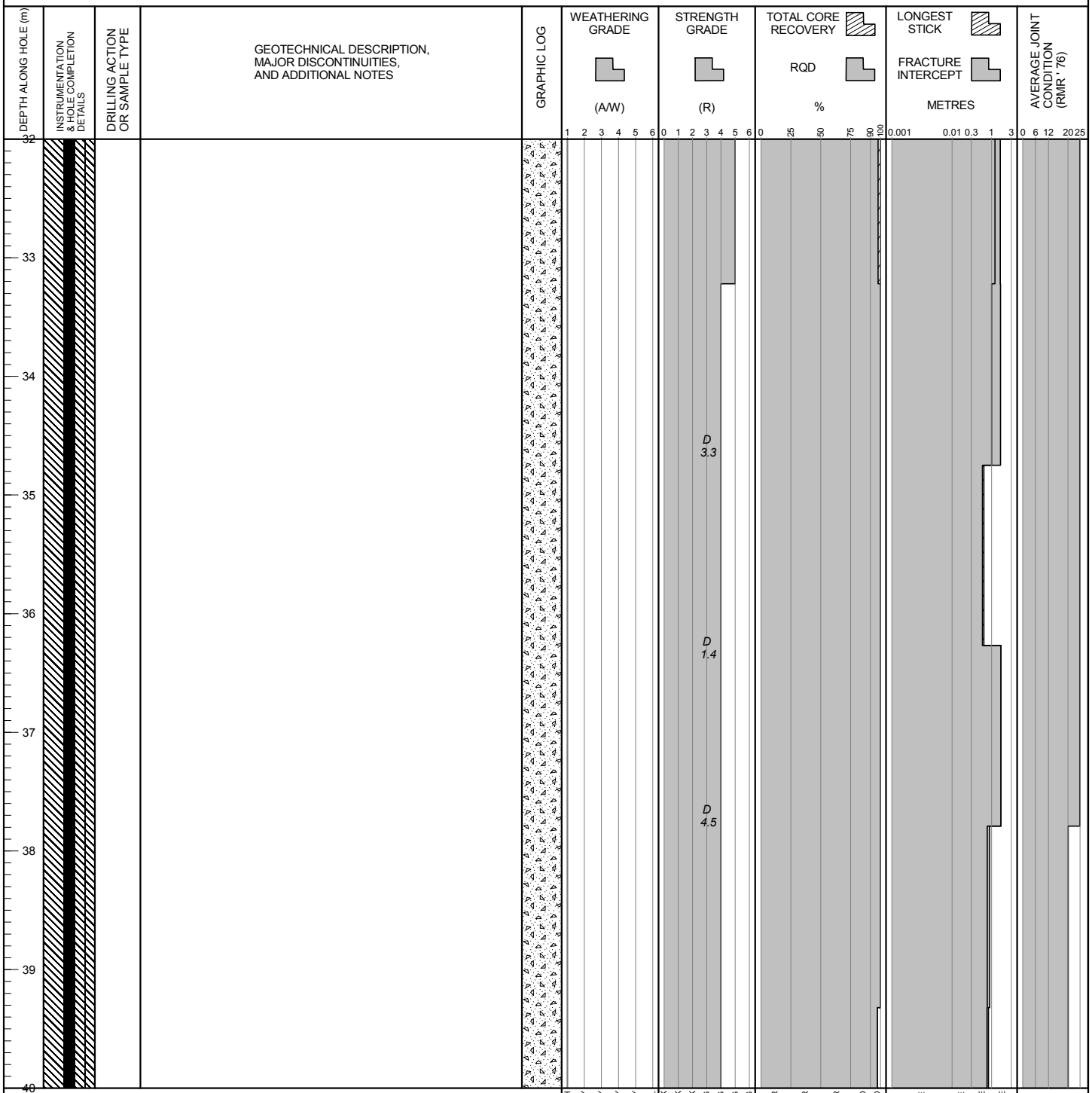
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 50.0
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 2.1
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 240	**Cased To (m) :** 1.5	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N
Ground Elevation (m): 1,410.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 240

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 29 Sep 12
Finish Date: 30 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 2.1
Logged By: JW/SLP
Reviewed By: BMM

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-32

Location: Brucejack (South Portal)

Co-ordinates (m): 426,981E - 6,258,578N
Ground Elevation (m): 1,410.8
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 240

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 1.5

Start Date: 29 Sep 12
Finish Date: 30 Sep 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 2.1
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
48					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
49									
50			END OF DRILLHOLE AT 49.99 m Notes: 1. Vibrating wire piezometer installed at 43.90 m.						
51									
52									
53									
54									
55									
56					FRESH / SLIGHTLY / MODERATELY / HIGHLY / COMPLETELY / SOIL	EXT. WEAK / V. WEAK / WEAK / MED. STRONG / STRONG / V. STRONG / EXT. STRONG	V. POOR / POOR / FAIR / GOOD / EXT. GOOD	V. CLOSE / CLOSE / MODERATE / WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-33

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,073E - 6,258,623N
Ground Elevation (m): 1,392.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 095

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.7

Start Date: 30 Sep 12
Finish Date: 01 Oct 12
Final Depth (m): 29.3
Depth To Top Of Rock (m): 7.2
Logged By: SLP
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						SAND (SC) Medium, clayey, gravelly, some cobbles, well-graded, compact, maximum particle size = 390 mm, subrounded, brown, no odour, moist, no cementation, trace organics/rootlets, clay is low plasticity. Some washed well graded gravel recovered during drilling. [Fill]
1						
2						
3						
4						
5						
6						
7						
						Rock encountered at 7.2 m depth. Refer to DH-BGC12-33 rock log.
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_p% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (SOIL) BRUCEJACK_SOIL.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-33

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,073E - 6,258,623N
Ground Elevation (m): 1,392.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 095

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.7

Start Date: 30 Sep 12
Finish Date: 01 Oct 12
Final Depth (m): 29.3
Depth To Top Of Rock (m): 7.2
Logged By: SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-33 Overburden Log						
1									
2									
3									
4									
5									
6									
7									
8			INTERMEDIATE VOLCANICS (V12) Well sorted crystal tuff (or sandstone) with sporadic cm-sized sericite altered clasts. Disseminated pyrite throughout. Medium strong (R3), faintly to moderately weathered (W1-W2.5), discontinuities typically slightly rough with separations < 1 mm (JRC = 12 to 20). 7.57 m: Shear, 1 mm ST infill, JRC = 2.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

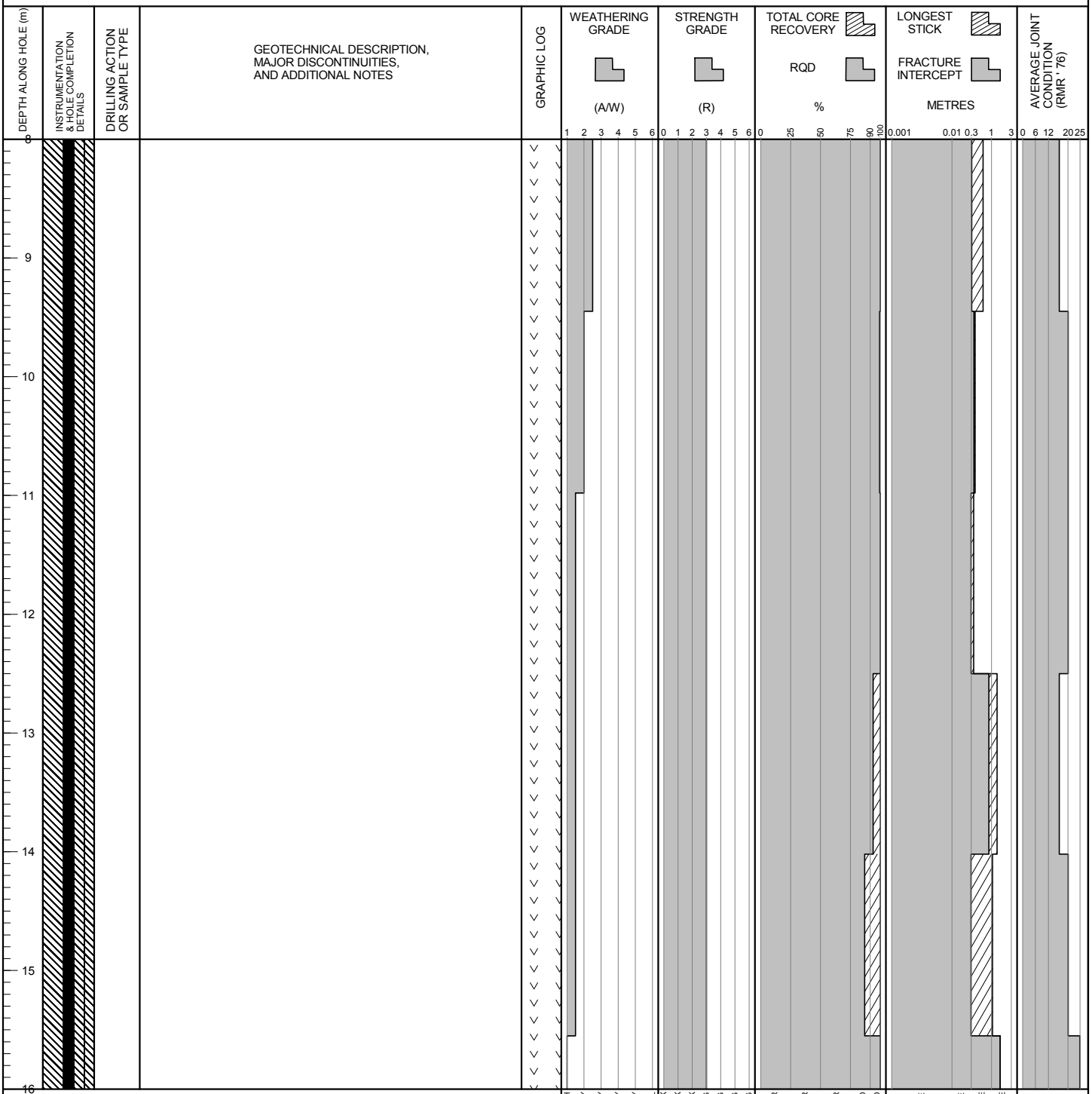
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-33

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,073E - 6,258,623N	**Drill Designation:** Heliportable	**Start Date:** 30 Sep 12
Ground Elevation (m): 1,392.7	**Drilling Contractor:** Radius	**Finish Date:** 01 Oct 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 29.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 7.2
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** SLP
Trend (°): 095	**Cased To (m) :** 6.7	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

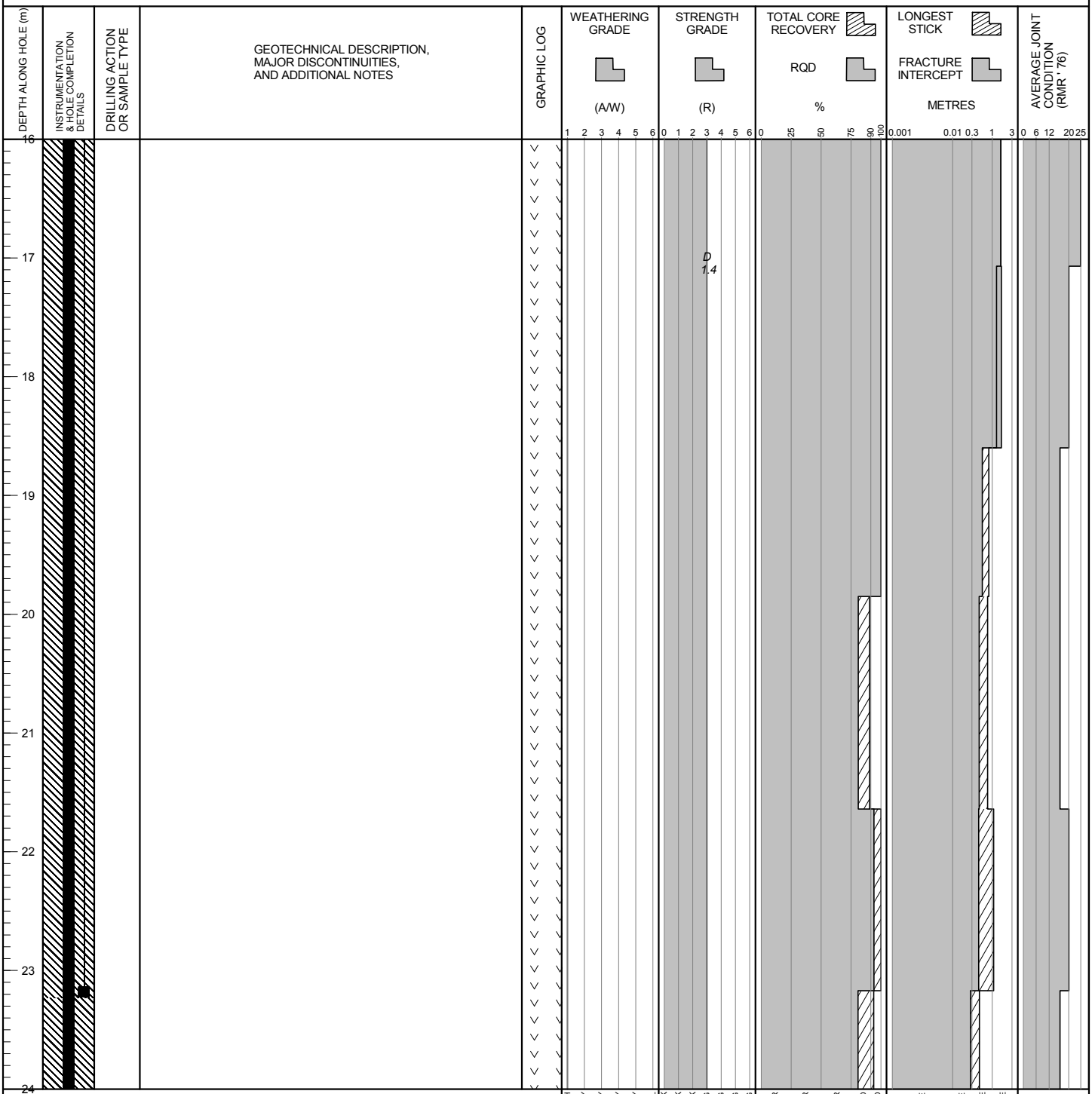
LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-33

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,073E - 6,258,623N	**Drill Designation:** Heliportable	**Start Date:** 30 Sep 12
Ground Elevation (m): 1,392.7	**Drilling Contractor:** Radius	**Finish Date:** 01 Oct 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 29.3
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 7.2
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** SLP
Trend (°): 095	**Cased To (m) :** 6.7	**Reviewed By:** BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-33

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,073E - 6,258,623N
Ground Elevation (m): 1,392.7
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 095

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.7

Start Date: 30 Sep 12
Finish Date: 01 Oct 12
Final Depth (m): 29.3
Depth To Top Of Rock (m): 7.2
Logged By: SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
25			25.58 m: Fault, 140 mm FB infill, R2, JRC = 10. 25.72 m: 1 mm CL infill, R1, JRC = 2.						
26			26.41 m: Fault, 10 mm CL infill, R1, JRC = 4.						
27									
28						D 2.1			
29						D 3.5			
			END OF DRILLHOLE AT 29.26 m Notes: 1. Vibrating wire piezometer installed at 23.18 m.						
30									
31									
32					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-34

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,046E - 6,258,650N
Ground Elevation (m): 1,396.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 244

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.1

Start Date: 01 Oct 12
Finish Date: 01 Oct 12
Final Depth (m): 31.4
Depth To Top Of Rock (m): 5.8
Logged By: JW/SLP
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						SAND (SC) Medium, clayey, gravelly,some cobbles, well-graded, compact, maximum particle size = 390 mm, subrounded, brown, no odour, moist, no cementation, trace organics/rootlets, clay is low plasticity. [Fill]
1						
2						
3						
4						
5						
6						Rock encountered at 5.8 m depth. Refer to DH-BGC12-34 rock log.
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20, 40, 60, 80

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-34

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,046E - 6,258,650N	**Drill Designation:** Heliportable	**Start Date:** 01 Oct 12
Ground Elevation (m): 1,396.0	**Drilling Contractor:** Radius	**Finish Date:** 01 Oct 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 31.4
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 5.8
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 244	**Cased To (m) :** 6.1	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
0			Refer to DH-BGC12-34 Overburden Log						
1									
2									
3									
4									
5									
6			INTERMEDIATE VOLCANICS (V12) Sericite-altered and minor chlorite-altered tuff with occasional brecciation/clasts. Very uniform. Strong (R4), faintly to slightly weathered (W1.5-W2), discontunities typically slightly rough with separation < 1 mm (JRC = 12 to 25).						
7									
8									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

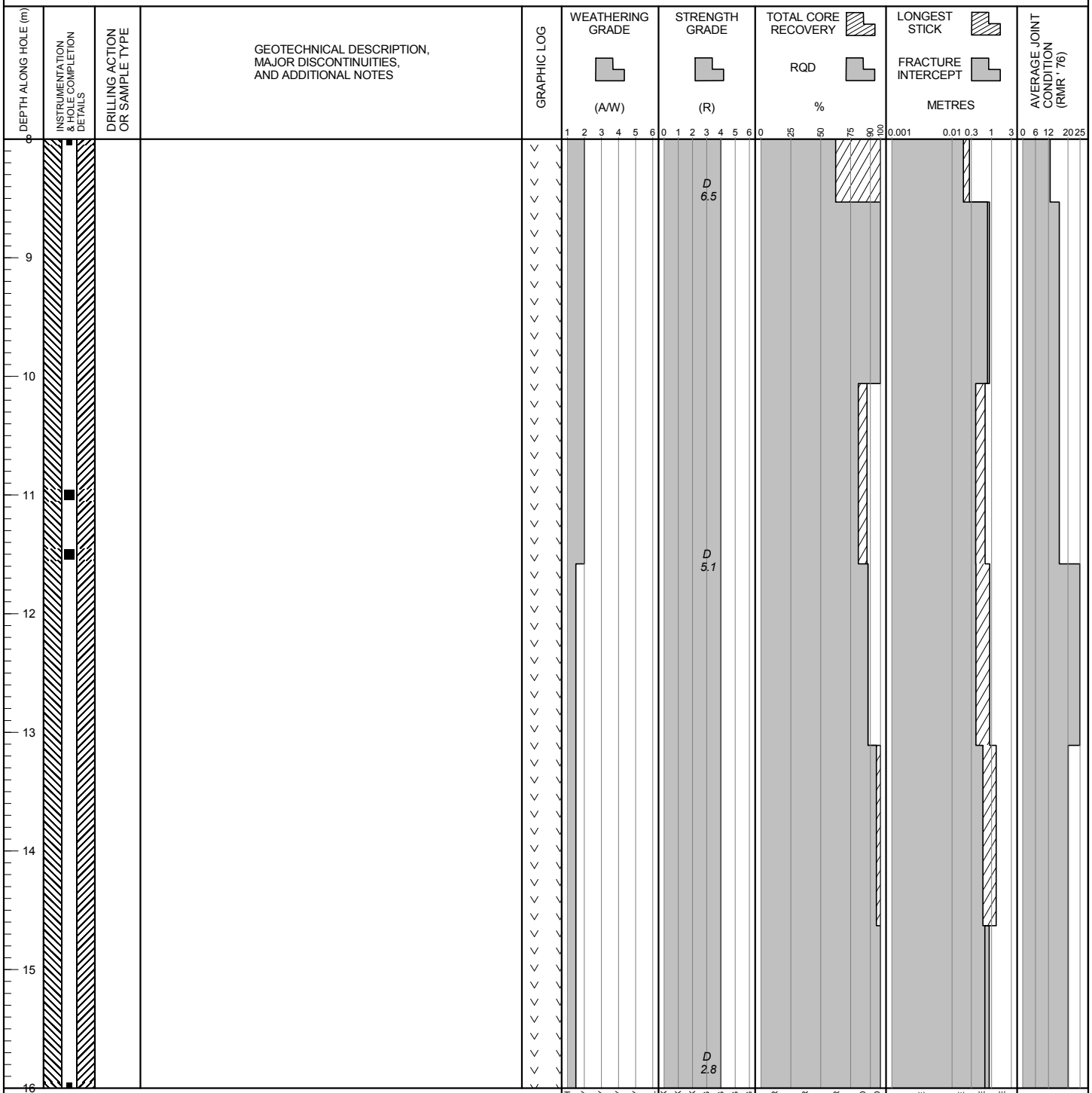
DRILL HOLE # DH-BGC12-34

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,046E - 6,258,650N
Ground Elevation (m): 1,396.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 244

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.1

Start Date: 01 Oct 12
Finish Date: 01 Oct 12
Final Depth (m): 31.4
Depth To Top Of Rock (m): 5.8
Logged By: JW/SLP
Reviewed By: BMM



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-34

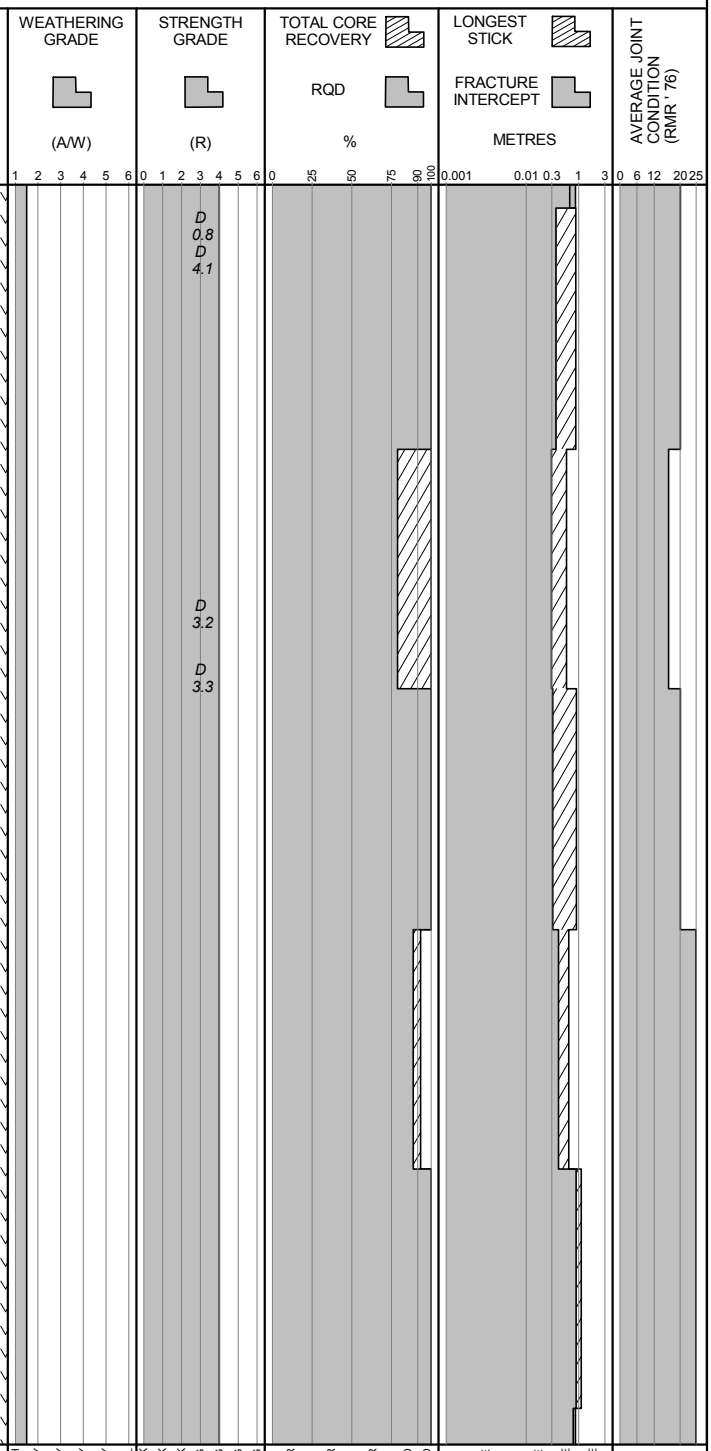
Location: Brucejack (Plant Site)

Co-ordinates (m): 427,046E - 6,258,650N
Ground Elevation (m): 1,396.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 244

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.1

Start Date: 01 Oct 12
Finish Date: 01 Oct 12
Final Depth (m): 31.4
Depth To Top Of Rock (m): 5.8
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			19.43 m: Shear, 1 mm CA infill, R2, JRC = 6.
20			
21			
22			
23			
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-34

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,046E - 6,258,650N
Ground Elevation (m): 1,396.0
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 244

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 6.1

Start Date: 01 Oct 12
Finish Date: 01 Oct 12
Final Depth (m): 31.4
Depth To Top Of Rock (m): 5.8
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
25									
26									
27						D 2.4 D 5.6			
28						D 5.0			
29									
30									
31						D 2.8			
32			END OF DRILLHOLE AT 31.39 m Notes: 1. Thermistor installed with 16 nodes at depths 1.0 m, 1.5 m, 2.0 m, 2.5 m, 3.0 m, 4.0 m, 6.0 m, 8.0 m, 11.0 m, 11.5 m, 16.0 m, 20.0 m, 21.0 m, 26.0 m, 30.0 m, and 30.5 m.						

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # DH-BGC12-35

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,021E - 6,258,692N
Ground Elevation (m): 1,389.4
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 154

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 4.6

Start Date: 02 Oct 12
Finish Date: 02 Oct 12
Final Depth (m): 32.9
Depth To Top Of Rock (m): 1.7
Logged By: JW/SLP
Reviewed By: BMM

Depth (m)	Sample Type	Sample No.	Symbol	Instrument Details	SPT Blows Per 150mm	Lithologic Description
0						SAND (SC) Medium, clayey, gravelly, some cobbles, well-graded, compact, maximum particle size = 390 mm, subrounded, brown, no odour, moist, no cementation, trace organics/rootlets, clay is low plasticity. [Fill]
1						
2						Rock encountered at 1.7 m depth. Refer to DH-BGC12-35 rock log.
3						
4						
5						
6						
7						
8						

Su - kPa: 40, 80, 120, 160
★ % Fines
▲ UC/2
△ Pocket Pen /2
● SPT (blows/300mm)
Core Recovery: 20, 40, 60, 80
Moisture Content & SPT N: W_P% W% W_L% 20 40 60 80

BRUCEJACK (SOIL) BRUCEJACK_SOIL.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

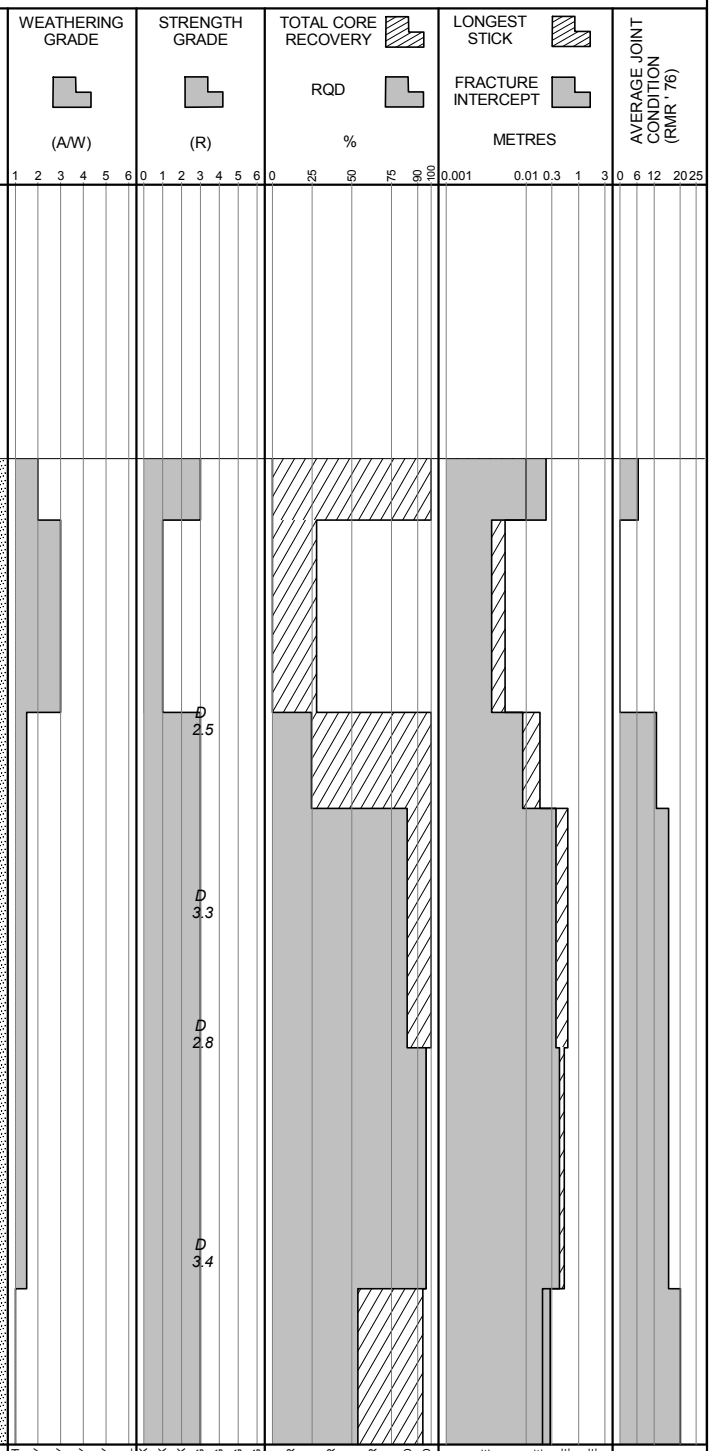
Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-35

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,021E - 6,258,692N	**Drill Designation:** Heliportable	**Start Date:** 02 Oct 12
Ground Elevation (m): 1,389.4	**Drilling Contractor:** Radius	**Finish Date:** 02 Oct 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 32.9
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.7
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 154	**Cased To (m) :** 4.6	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
0			Refer to DH-BGC12-35 Overburden Log	
1				
2			ARENITE (S4) Highly altered/disrupted interbedded sedimentary units. Mostly fine grained sand, with some coarser sand. Medium strong to strong (R3-R4), faintly weathered to 7.01 m and fresh rock below 7.01 m, discontinuities typically sligtly rough to very rough with separation < 1 mm (JRC = 16 to 25).	
3			3.35 m: Poor rock quality due to drilling process.	
4				
5				
6				
7				
8				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-35

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,021E - 6,258,692N
Ground Elevation (m): 1,389.4
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 154

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 4.6

Start Date: 02 Oct 12
Finish Date: 02 Oct 12
Final Depth (m): 32.9
Depth To Top Of Rock (m): 1.7
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
8									
9									
10									
11									
12									
13									
14									
15			14.89 m: Shear, 0.5 mm CA infill, R2, JRC = 2.			D 1.4			
16									

WEATHERING GRADE (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL

STRENGTH GRADE (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1, 3 WIDE

AVERAGE JOINT CONDITION (RMR '76): 0, 6, 12, 20, 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

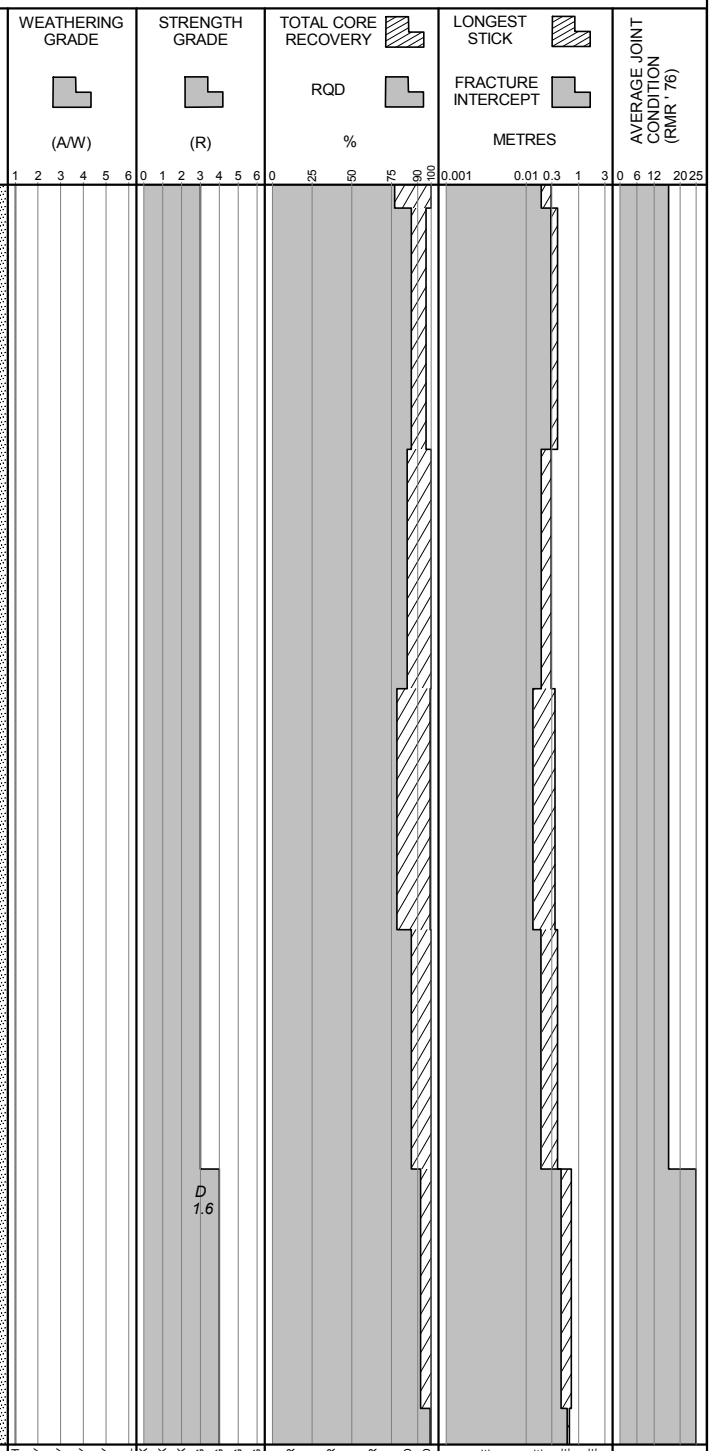
Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-35

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,021E - 6,258,692N	**Drill Designation:** Heliportable	**Start Date:** 02 Oct 12
Ground Elevation (m): 1,389.4	**Drilling Contractor:** Radius	**Finish Date:** 02 Oct 12
Survey Method: Surveyed	**Drill Method:** Diamond	**Final Depth (m):** 32.9
Datum: UTM NAD 83 Zone 9	**Core:** HQ3	**Depth To Top Of Rock (m):** 1.7
Plunge (°): -75	**Fluid:** Polymer	**Logged By:** JW/SLP
Trend (°): 154	**Cased To (m) :** 4.6	**Reviewed By:** BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
16			15.89 m: Shear, 1 mm CA infill, R2, JRC = 2.	
17				
18				
19				
20			20.23 m: Fault, 90 mm FB infill, R1, JRC = 6.	
21				
22				
23				
24				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project : Brucejack
Project No.1008-007

DRILL HOLE # DH-BGC12-35

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,021E - 6,258,692N
Ground Elevation (m): 1,389.4
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 154

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 4.6

Start Date: 02 Oct 12
Finish Date: 02 Oct 12
Final Depth (m): 32.9
Depth To Top Of Rock (m): 1.7
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
24									
25						D 5.2			
26									
27									
28									
29									
30			30.27 m: Fault, 10 mm CL infill, R1, JRC = 6.						
31						D 0.7			
32						D 2.2			

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR '76): 0 6 12 20 25

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AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCK) BRUCEJACK_ROCK.GDL BGC.GDT 6/4/13

Project : Brucejack
Project No. 1008-007

DRILL HOLE # DH-BGC12-35

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,021E - 6,258,692N
Ground Elevation (m): 1,389.4
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Plunge (°): -75
Trend (°): 154

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ3
Fluid: Polymer
Cased To (m) : 4.6

Start Date: 02 Oct 12
Finish Date: 02 Oct 12
Final Depth (m): 32.9
Depth To Top Of Rock (m): 1.7
Logged By: JW/SLP
Reviewed By: BMM

DEPTH ALONG HOLE (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR '76) 0 6 12 20 25
32									
33			END OF DRILLHOLE AT 32.91 m Notes: 1. Vibrating wire piezometer installed at 23.77 m.						
34									
35									
36									
37									
38									
39									
40									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

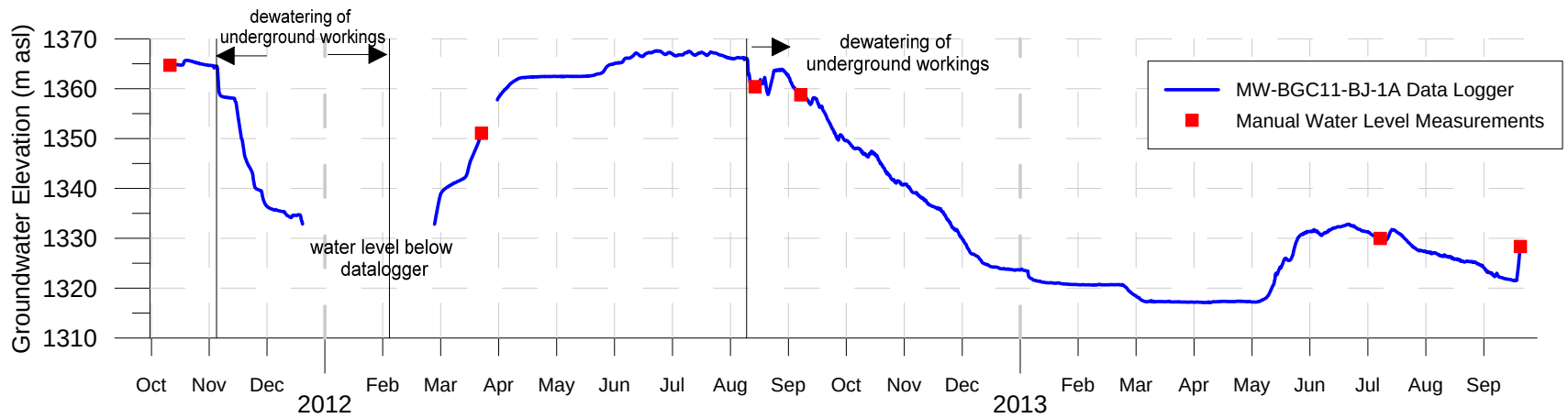
FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

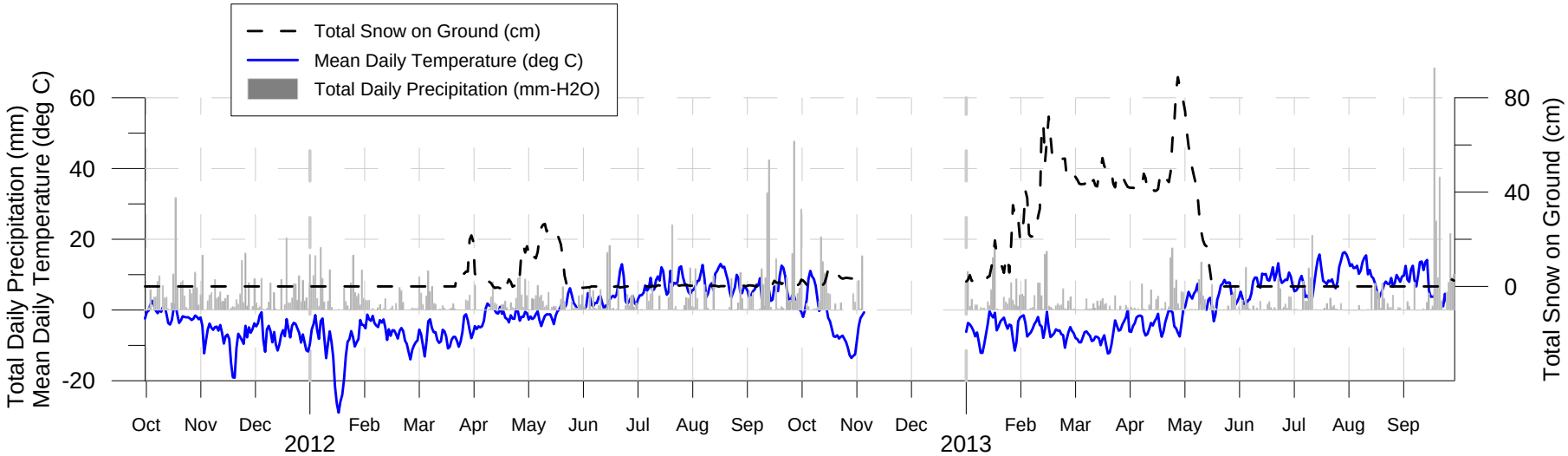
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

APPENDIX D
GROUNDWATER HYDROGRAPHS





Notes:
1) Well screened from 1300.92 to 1307.12 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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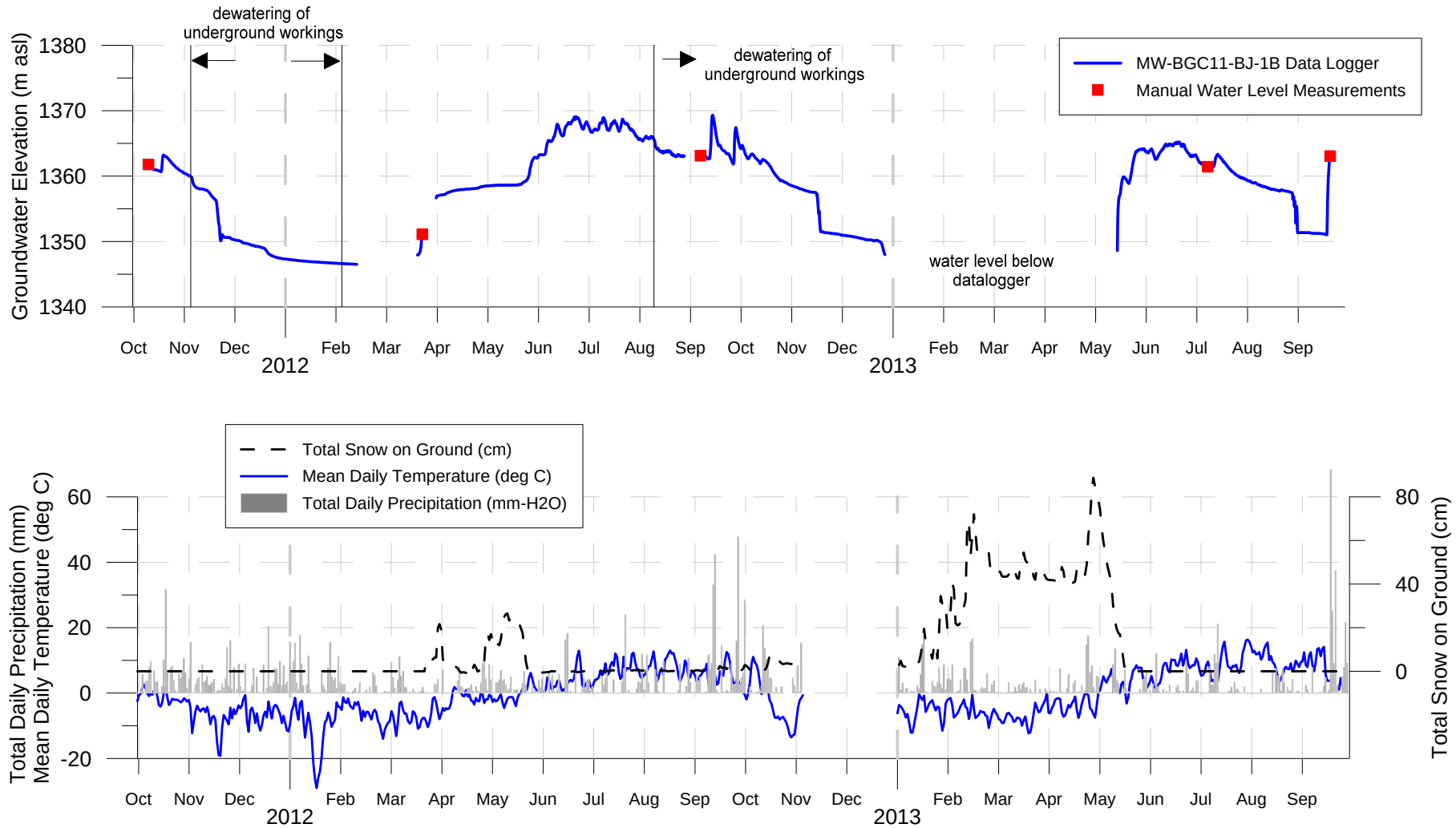
CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC11-BJ-1A GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D01	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-1A\Hydrograph_MW-BGC12-BJ-1A.grf



Notes:
1) Well screened from 1347.32 to 1350.42 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC11-BJ-1B GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D02	1

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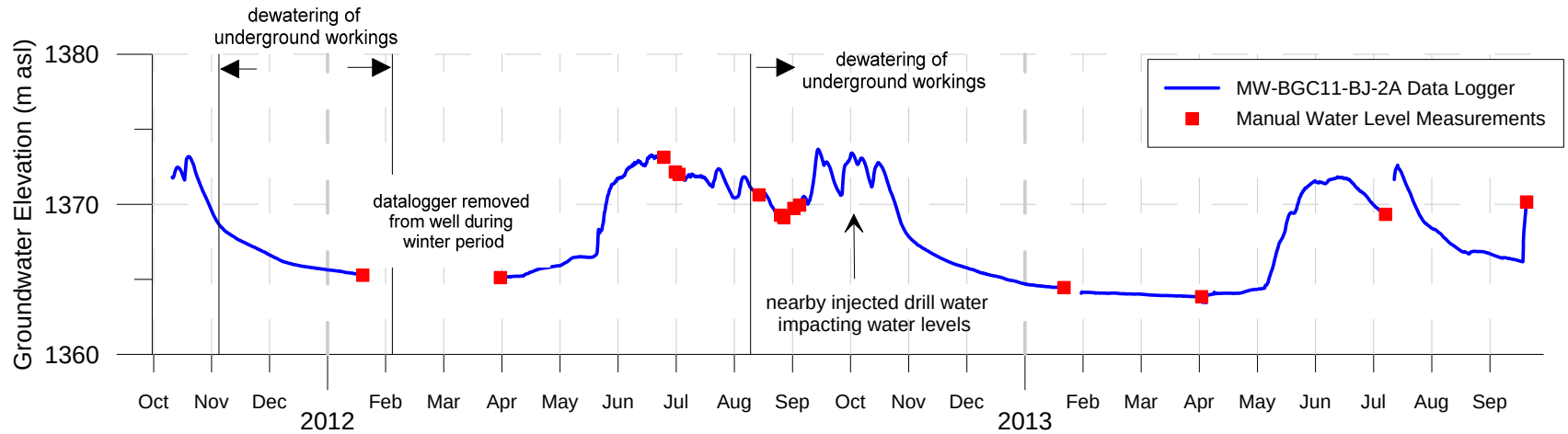

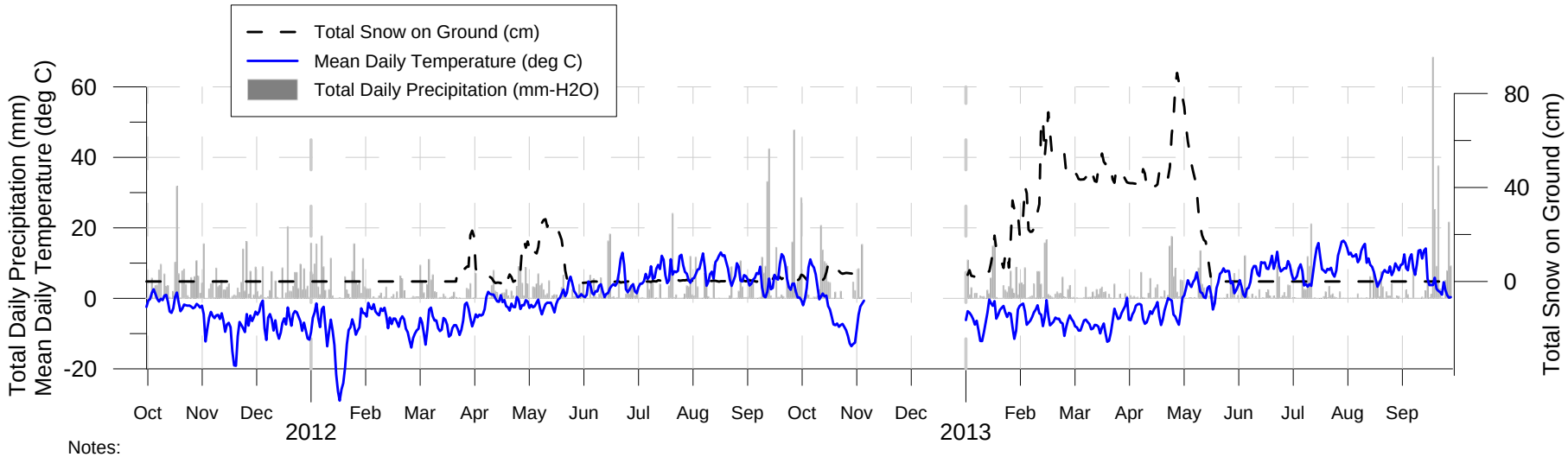

Notes:
1) Well screened from 1346.37 to 1352.47 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC11-BJ-2A GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D03	1

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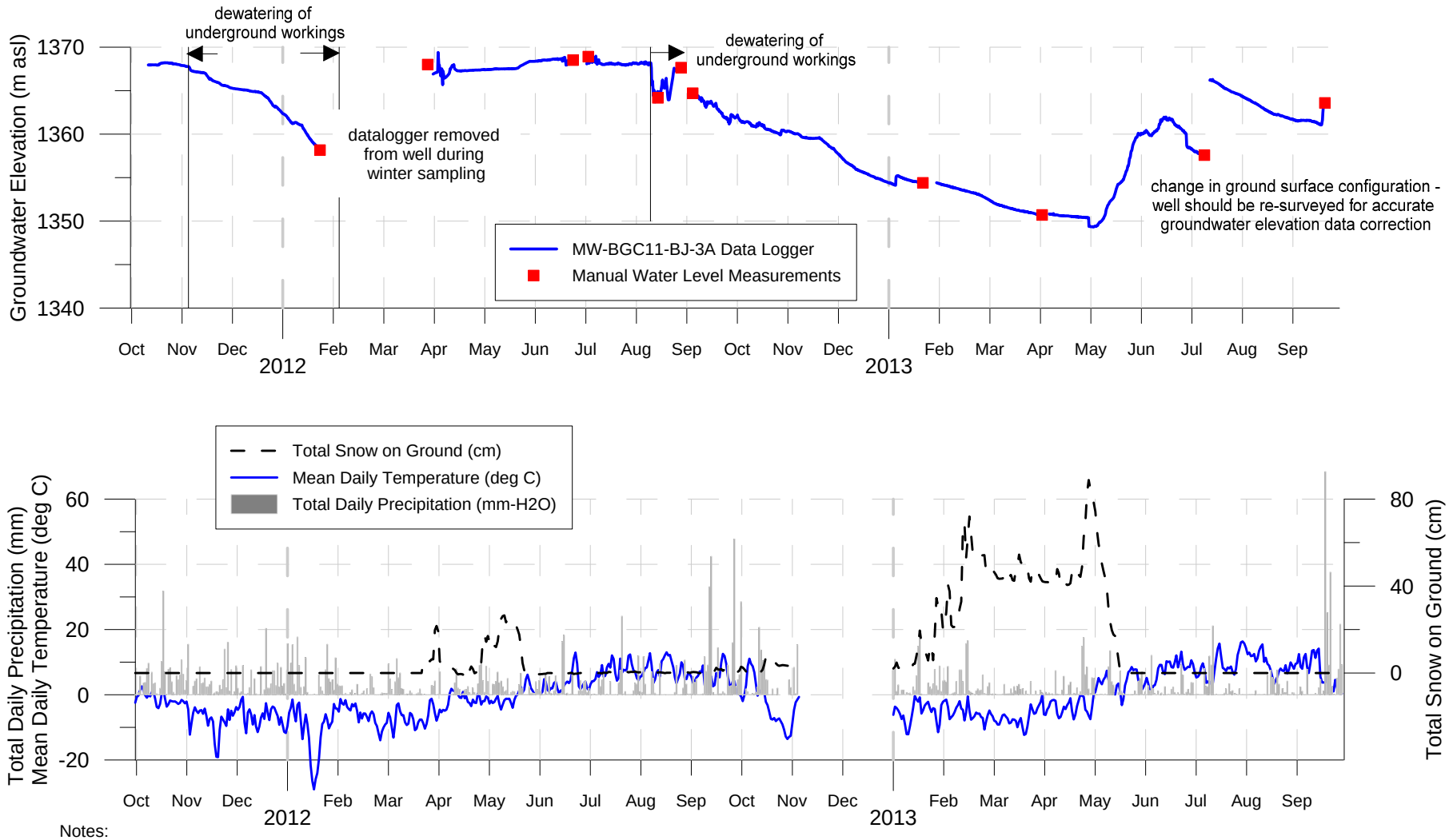

Notes:
1) Well screened from 1279.33 to 1284.63 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: MW-BGC11-BJ-3A GROUNDWATER HYDROGRAPH
DRAWN: LH, RET, BS	APPROVED: VC		
		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D04 / REV. 1

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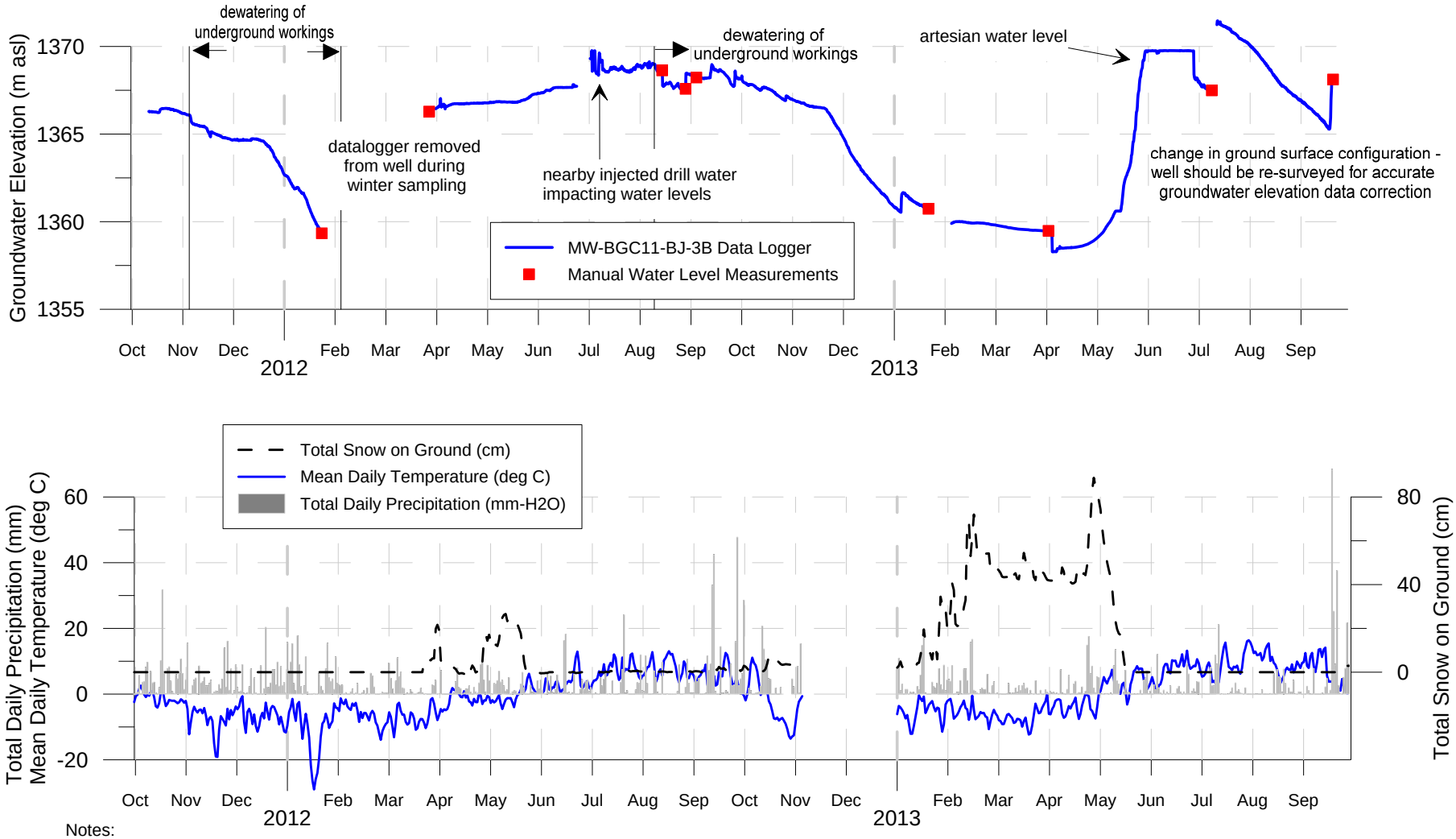

Notes:
1) Well screened from 1358.73 to 1361.73 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: MW-BGC11-BJ-3B GROUNDWATER HYDROGRAPH
DRAWN: LH, RET, BS	APPROVED: VC		
		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D05 / REV. 1

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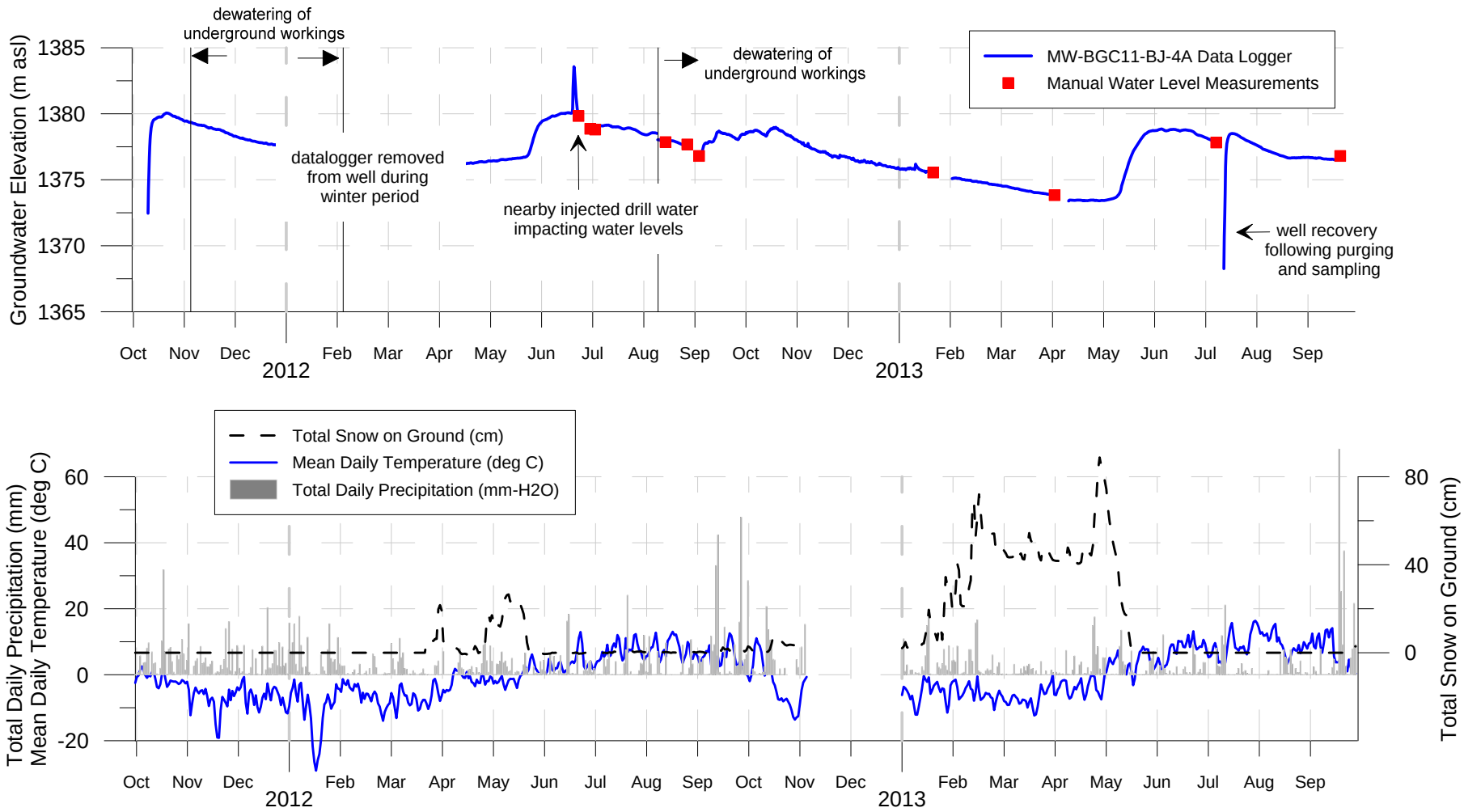

Notes:
1) Well screened from 1359.96 to 1369.16 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC11-BJ-4A GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D06	1

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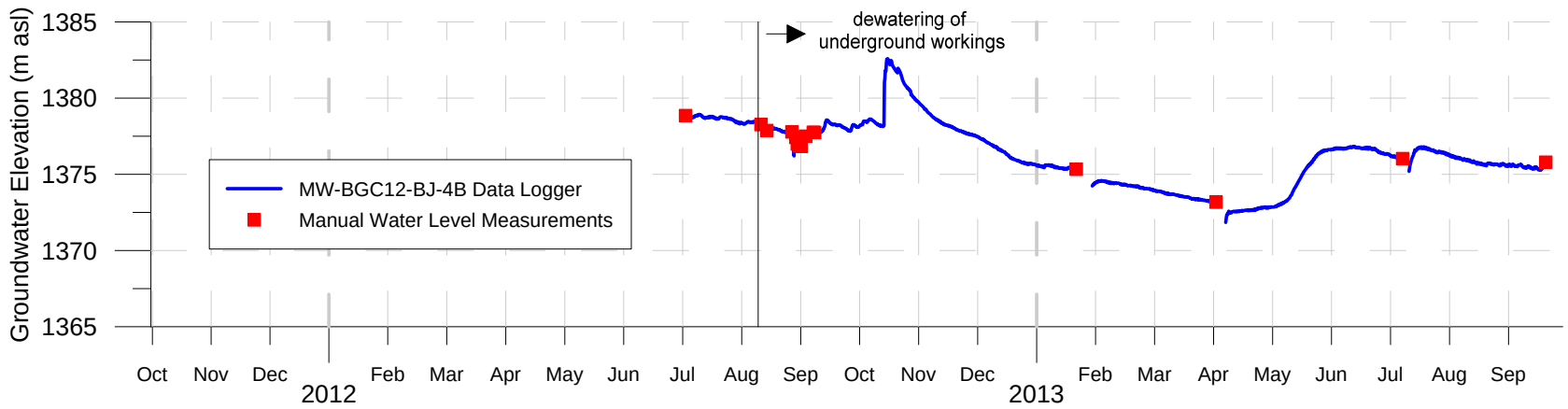

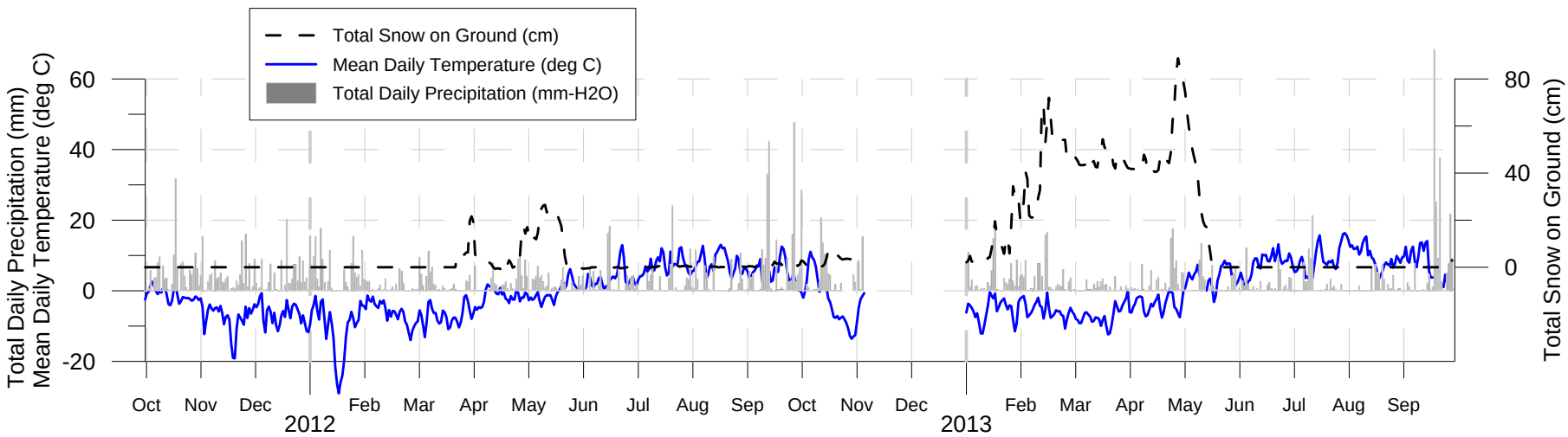

Notes:
1) Well screened from 1292.53 to 1295.53 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: MW-BGC12-BJ-4B GROUNDWATER HYDROGRAPH
DRAWN: LH, RET, BS	APPROVED: VC		
		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D07 / REV. 1

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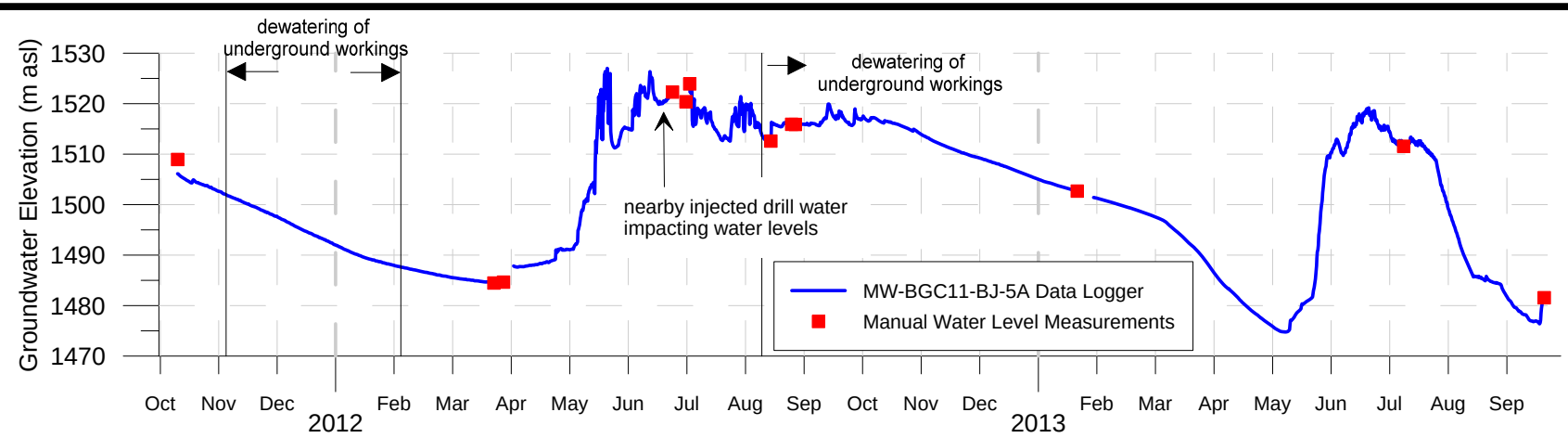
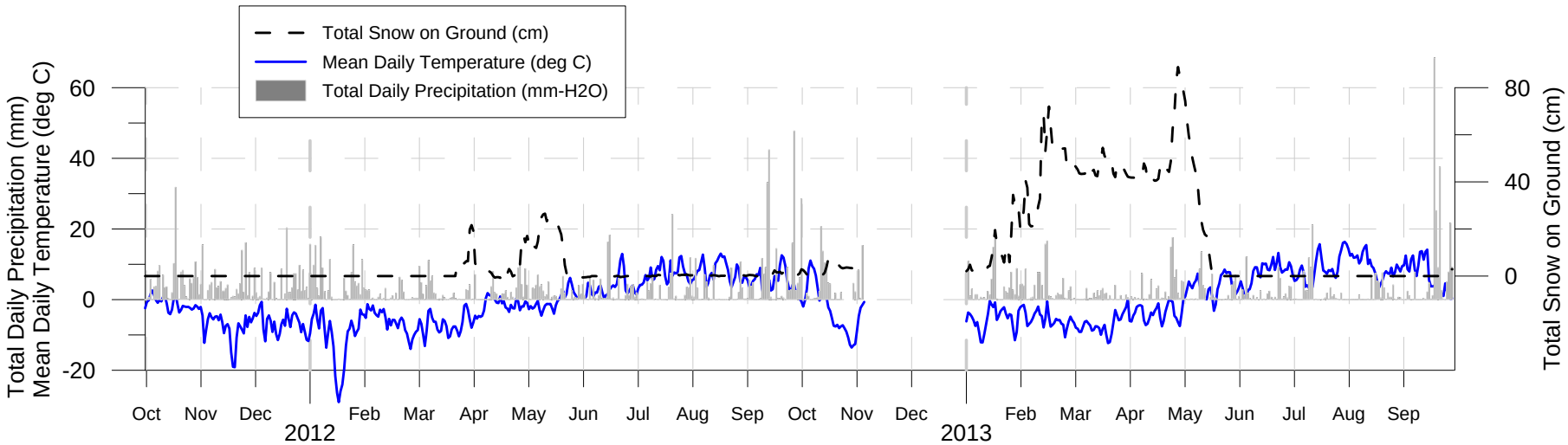
N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-4B\Hydrograph_MW-BGC12-BJ-4B.grf





Notes:
1) Well screened from 1448.44 to 1457.54 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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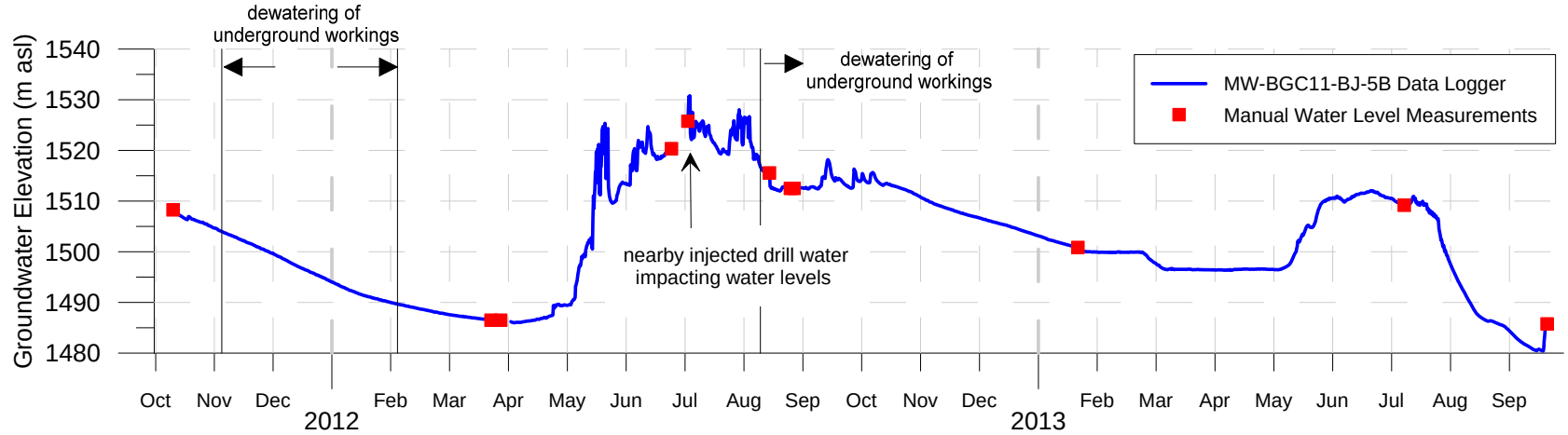
CLIENT: PRETIUM RESOURCES INC.

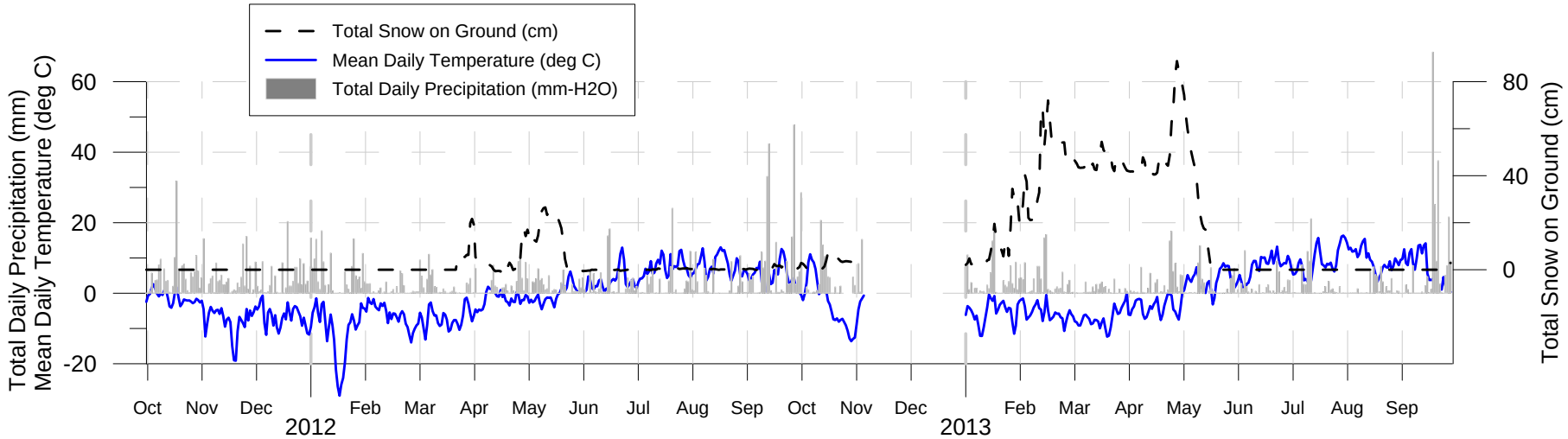
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC11-BJ-5A GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D08	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-5A\Hydrograph_MW-BGC12-BJ-5A.grf





Notes:
1) Well screened from 1475.96 to 1485.16 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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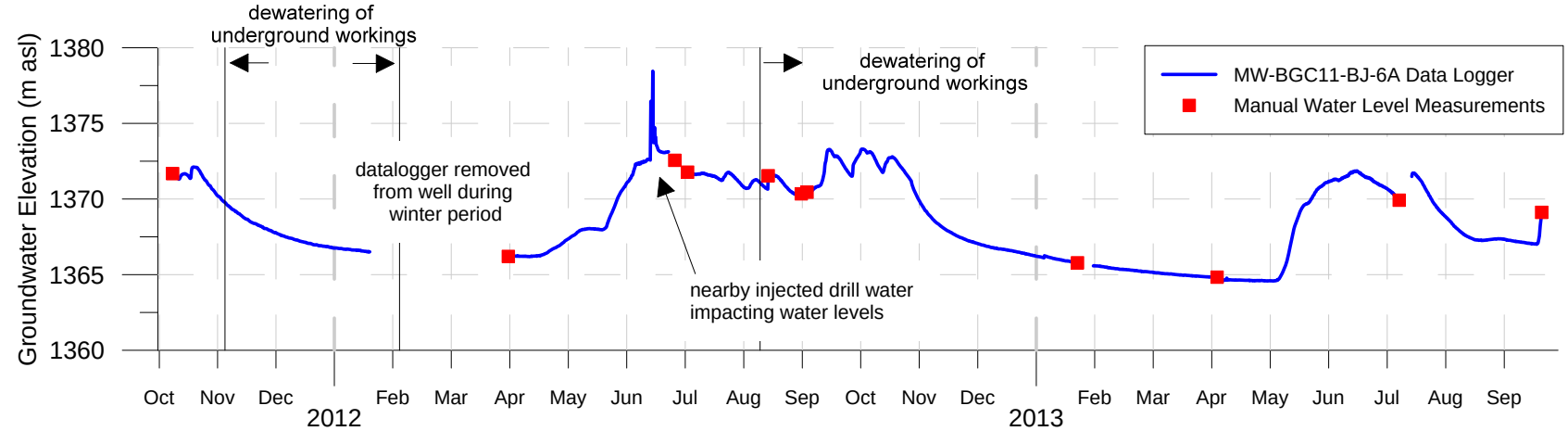
CLIENT: PRETIUM RESOURCES INC.

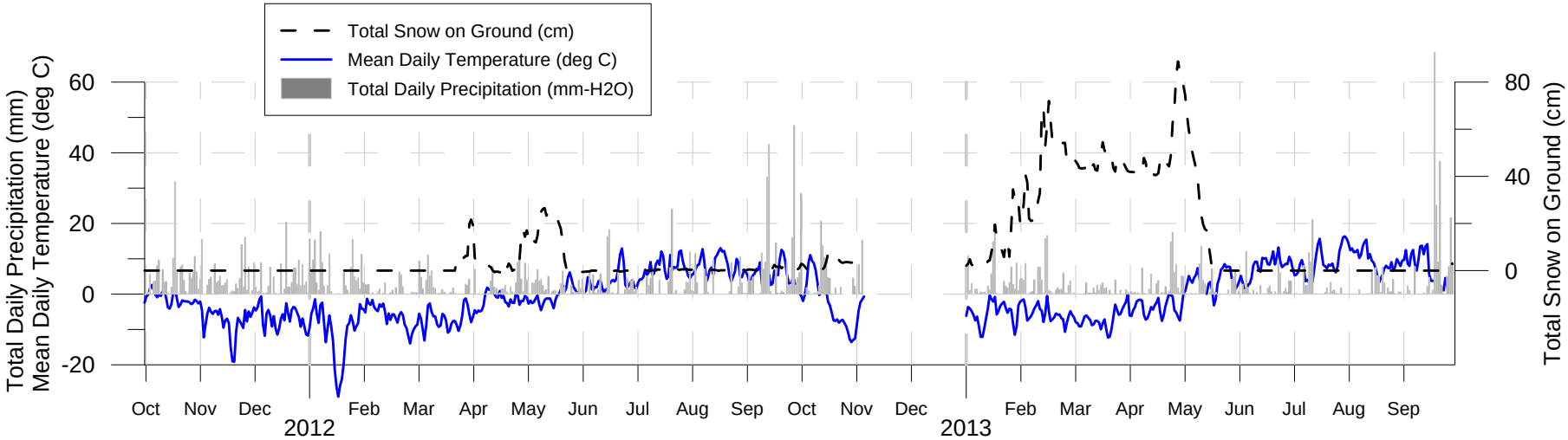
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC11-BJ-5B GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D09	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-5B\Hydrograph_MW-BGC12-BJ-5B.grf





Notes:
1) Well screened from 1349.51 to 1358.61 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: MW-BGC11-BJ-6A GROUNDWATER HYDROGRAPH
DRAWN: LH, RET, BS	APPROVED: VC		
		CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D10 / REV. 1

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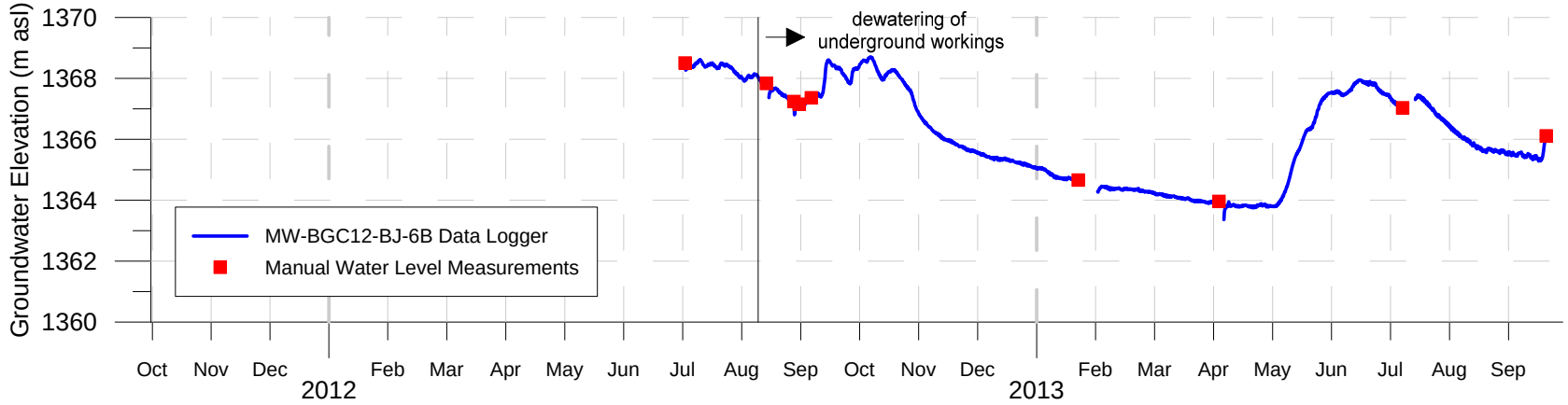
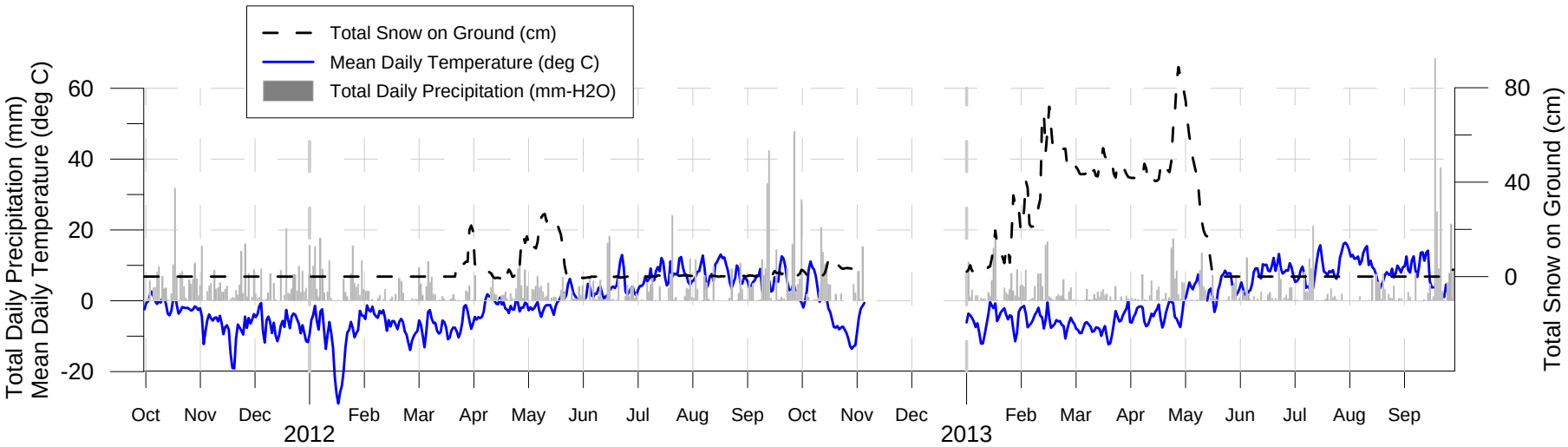
N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-6A\Hydrograph_MW-BGC12-BJ-6A.grf





Notes:
1) Well screened from 1276.26 to 1279.26 m asl, see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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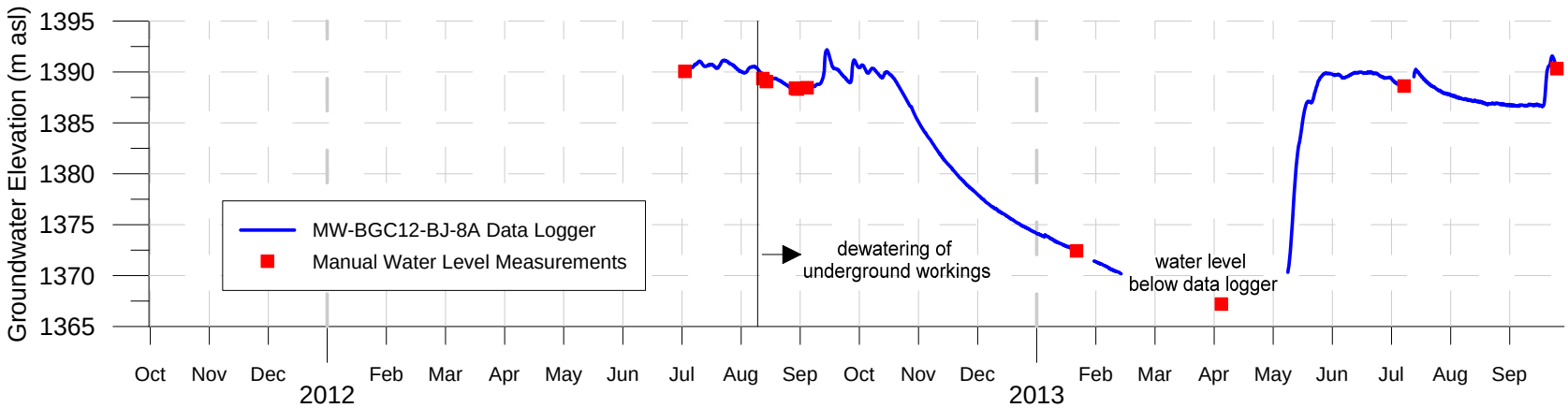
CLIENT: PRETIUM RESOURCES INC.

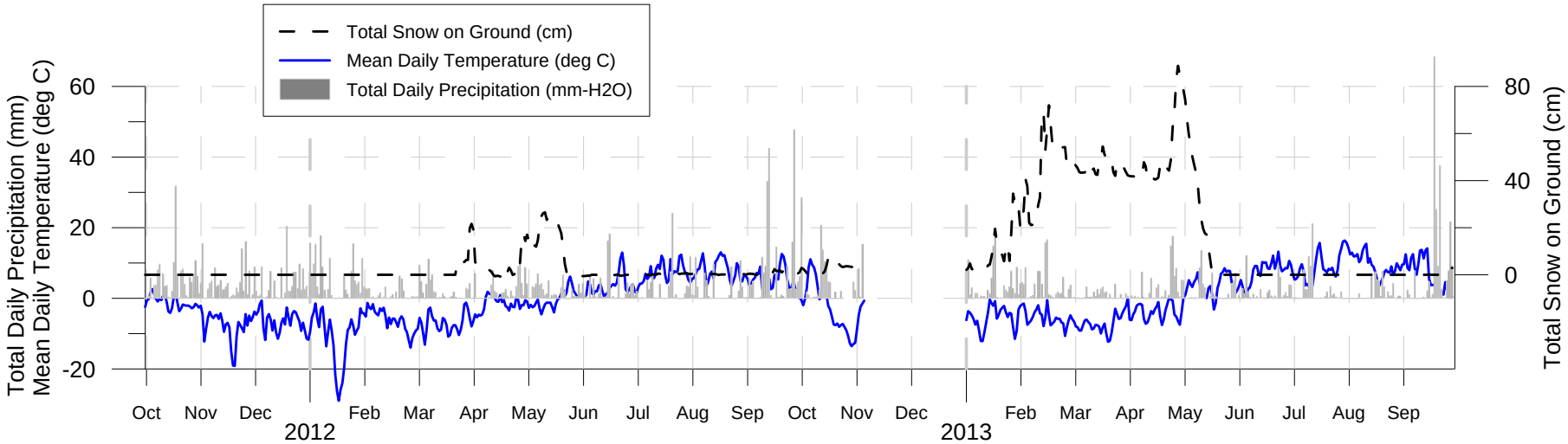
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-6B
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D11	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-6B\Hydrograph_MW-BGC12-BJ-6B.grf





Notes:
1) Well screened from 1311.08 to 1317.18 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-8A GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D12	1

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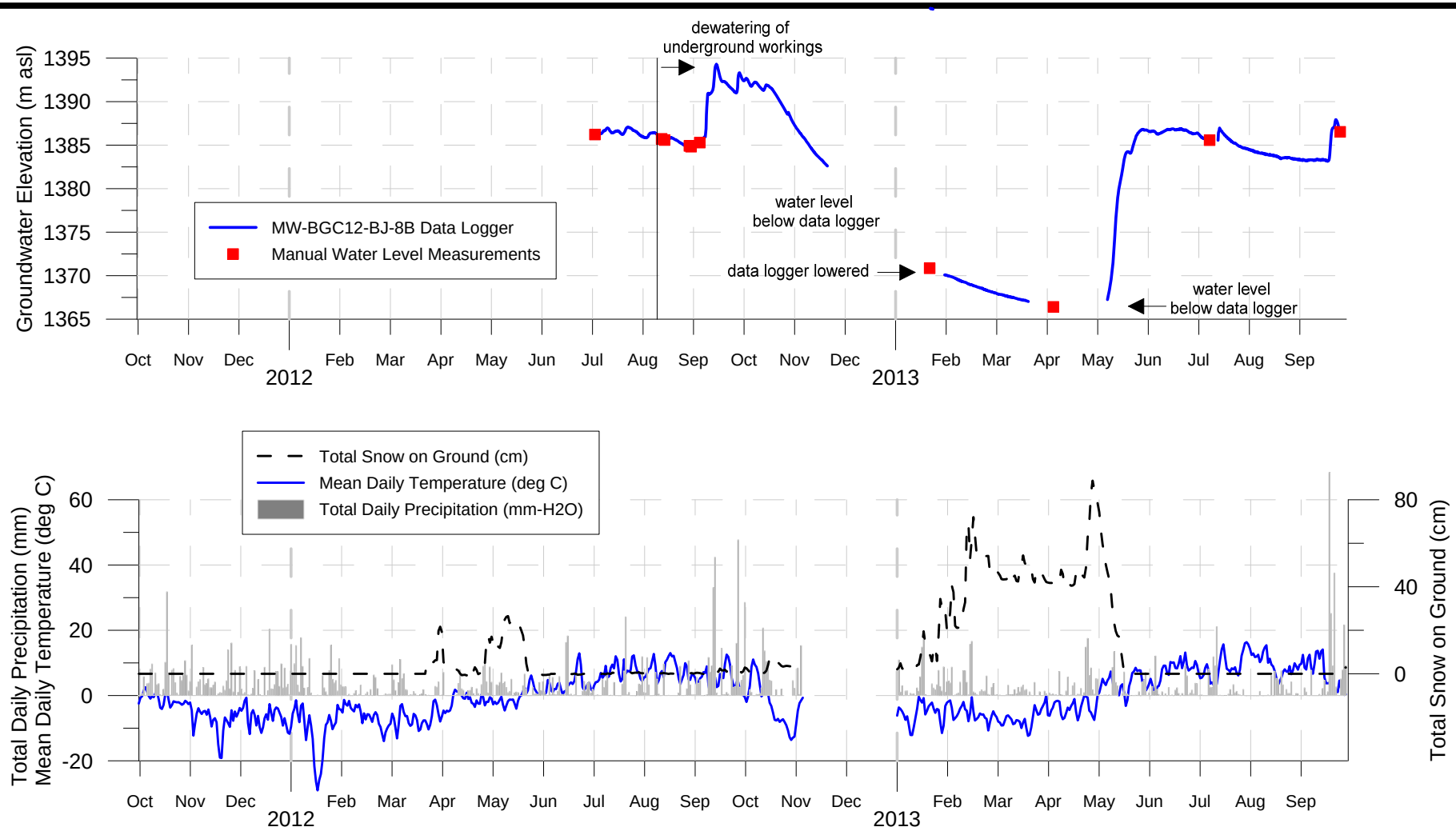

Notes:
1) Well screened from 1352.4 to 1358.5 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-8B GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D13	1

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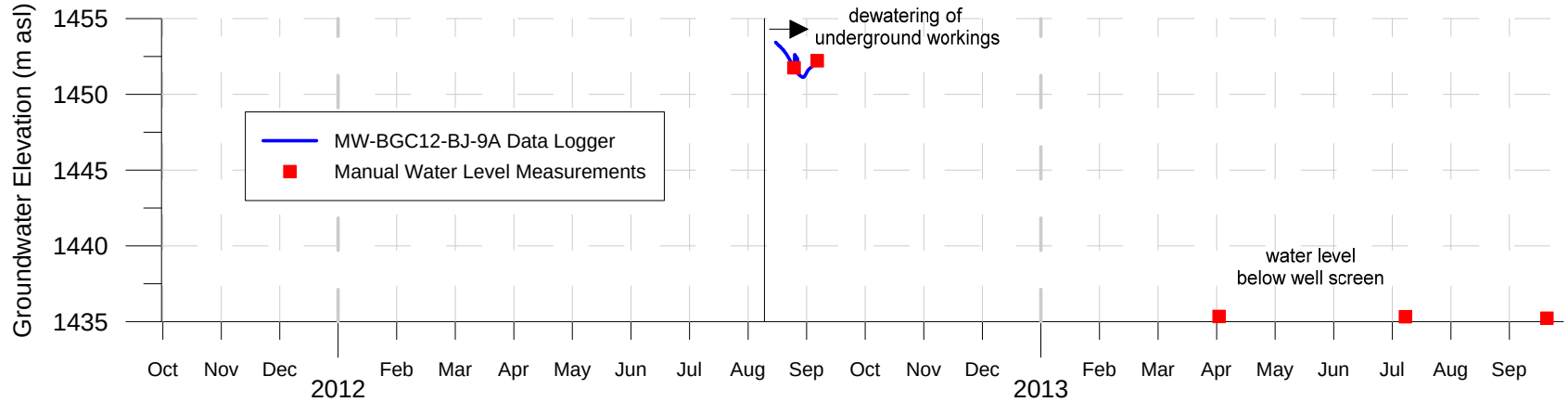

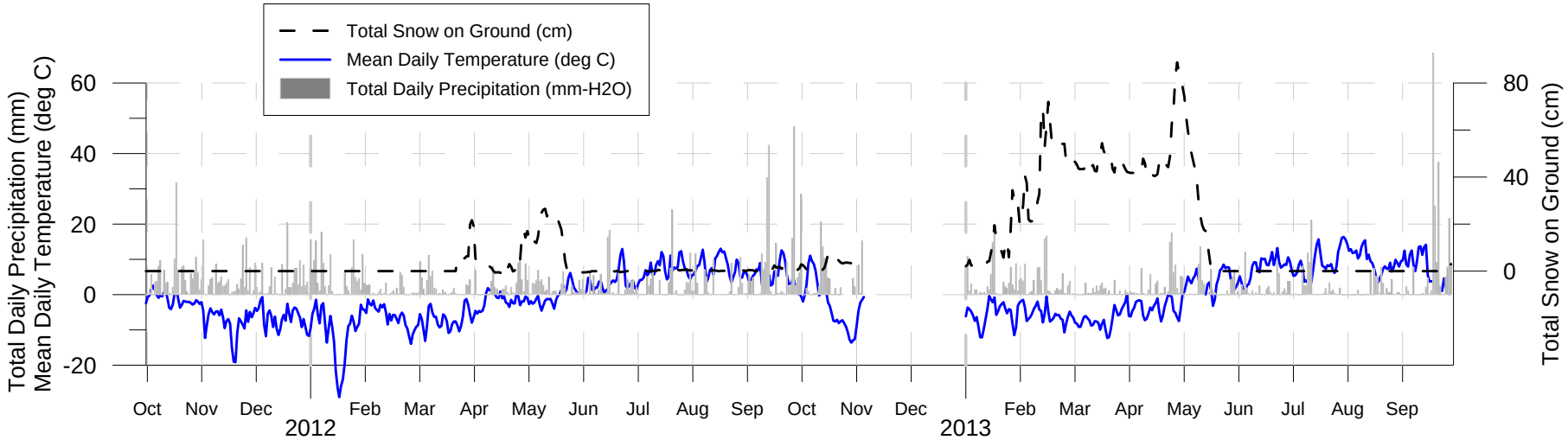

Notes:
1) Well screened from 1435.4 to 1441.5 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A		DESIGNED: KSJ	
DATE: APR 2014		CHECKED: DP	
DRAWN: LH, RET, BS		APPROVED: VC	

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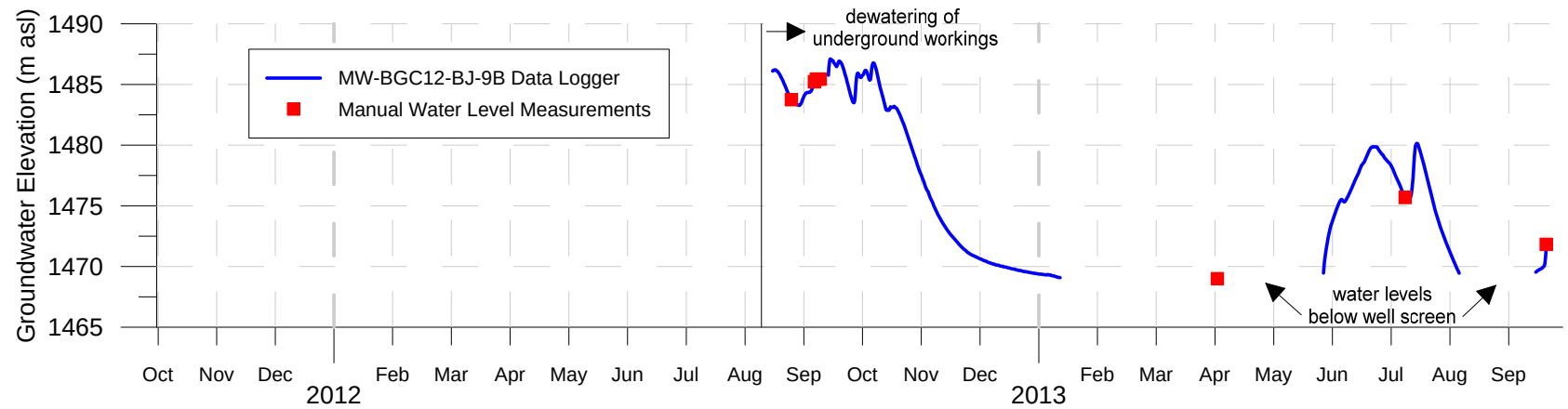
CLIENT: PRETIUM RESOURCES INC.

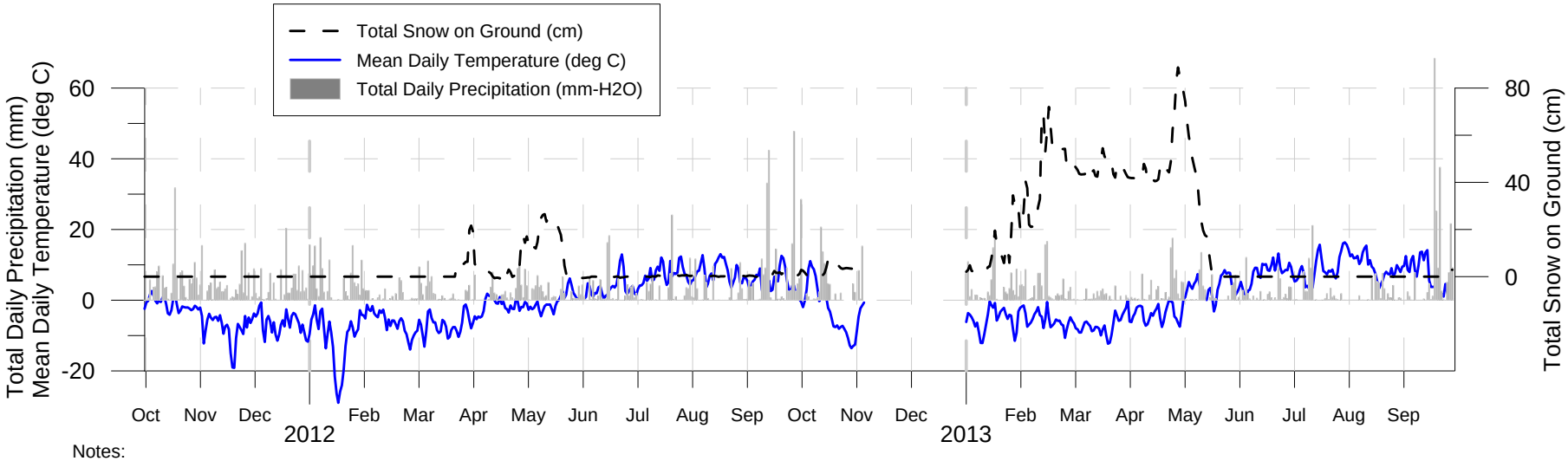
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-9A
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D14	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-9A\Hydrograph_MW-BGC12-BJ-9A.grf





Notes:
1) Well screened from 1467.86 to 1473.96 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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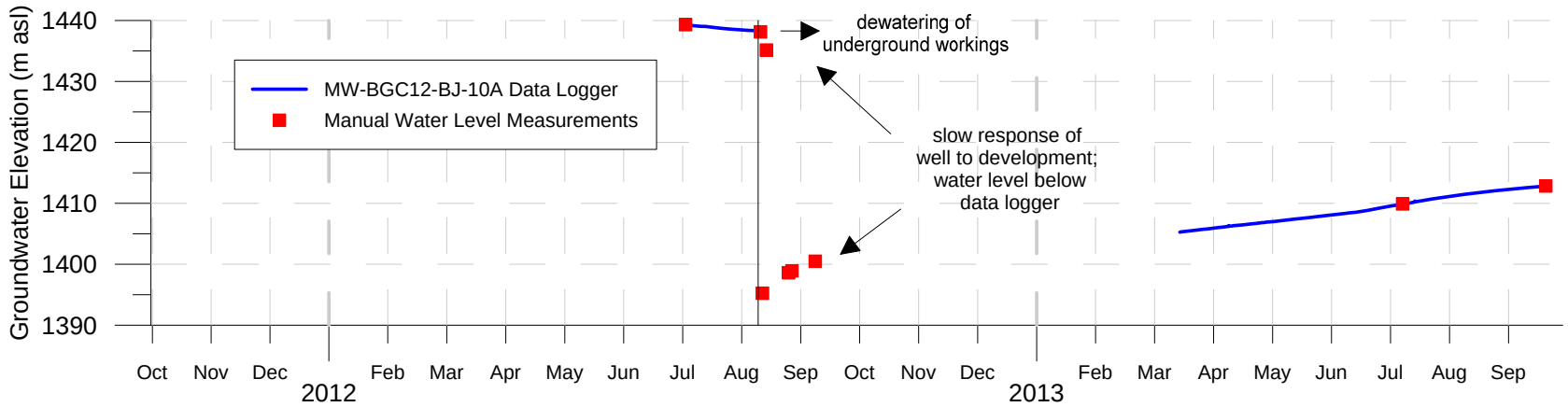
CLIENT: PRETIUM RESOURCES INC.

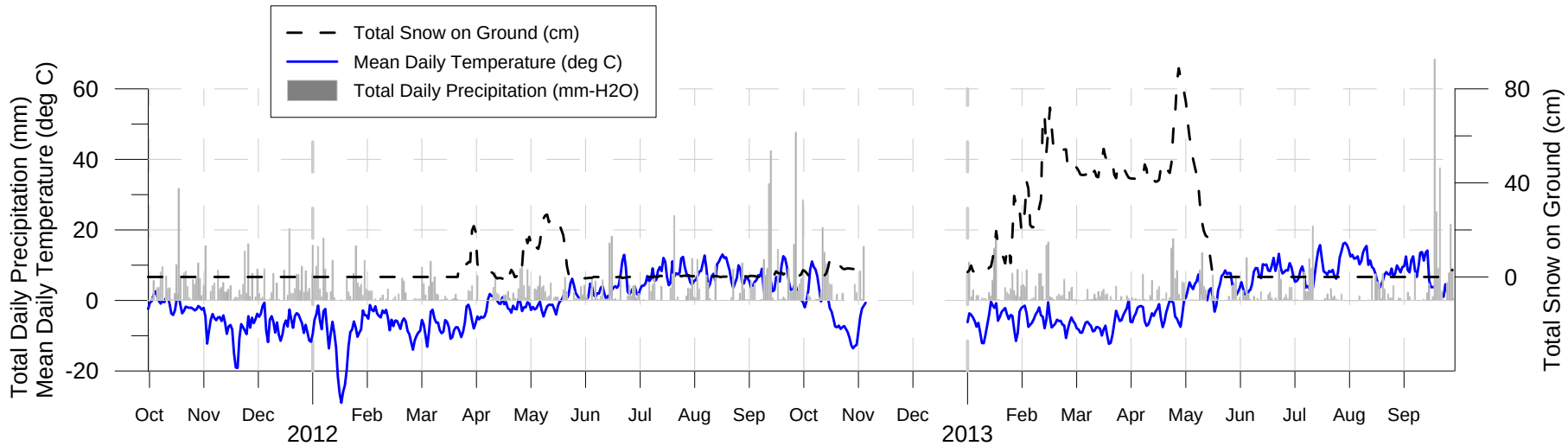
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-9B
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D15	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-9B\Hydrograph_MW-BGC12-BJ-9B.grf





Notes:
1) Well screened from 1386.29 to 1392.39 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: MW-BGC12-BJ-10A GROUNDWATER HYDROGRAPH
DRAWN: LH, RET, BS	APPROVED: VC	CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D16 / REV. 1

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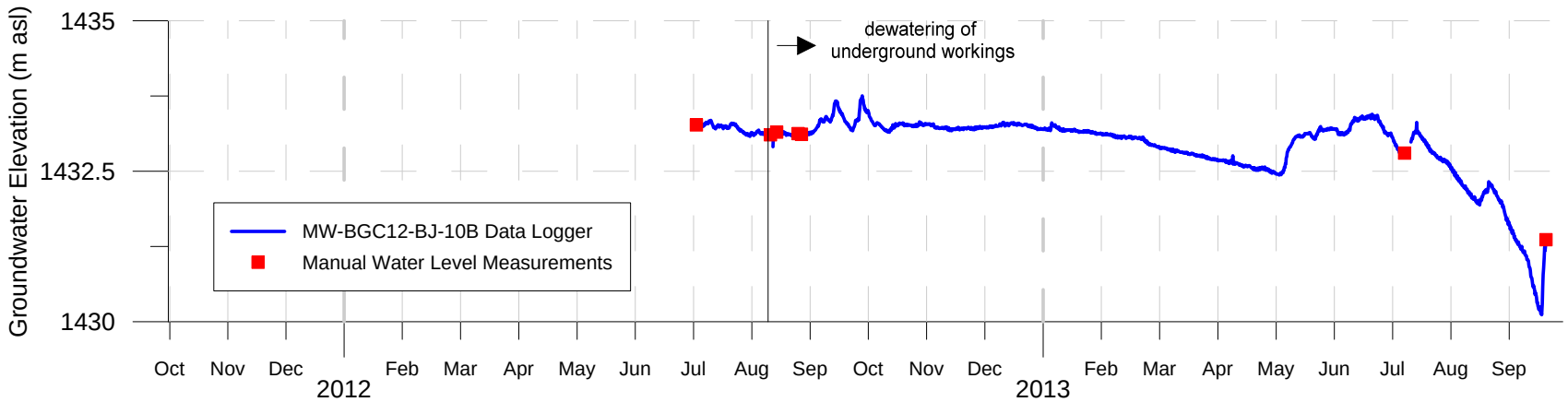
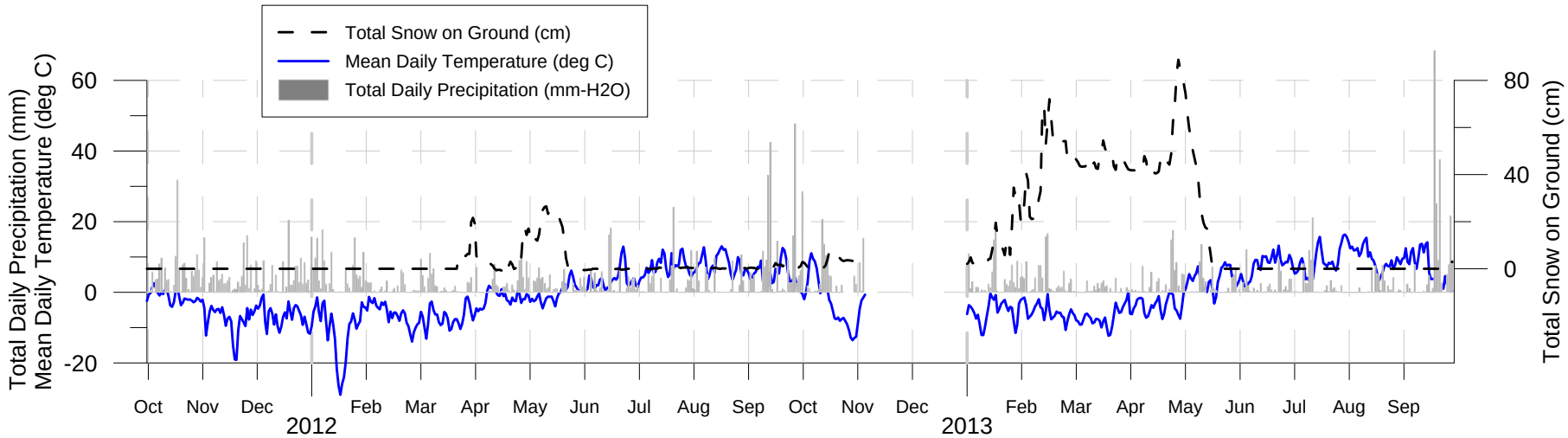
N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-10A\Hydrograph_MW-BGC12-BJ-10A.grf





Notes:
1) Well screened from 1404.54 to 1407.54 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A		DESIGNED: KSJ	
DATE: APR 2014		CHECKED: DP	
DRAWN: LH, RET, BS		APPROVED: VC	

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

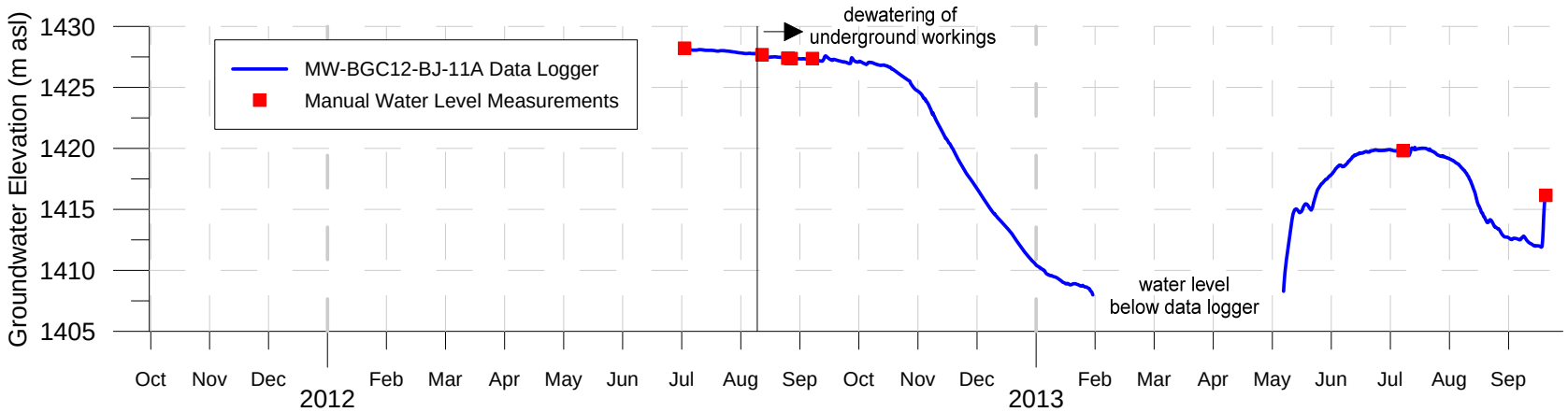
CLIENT: PRETIUM RESOURCES INC.

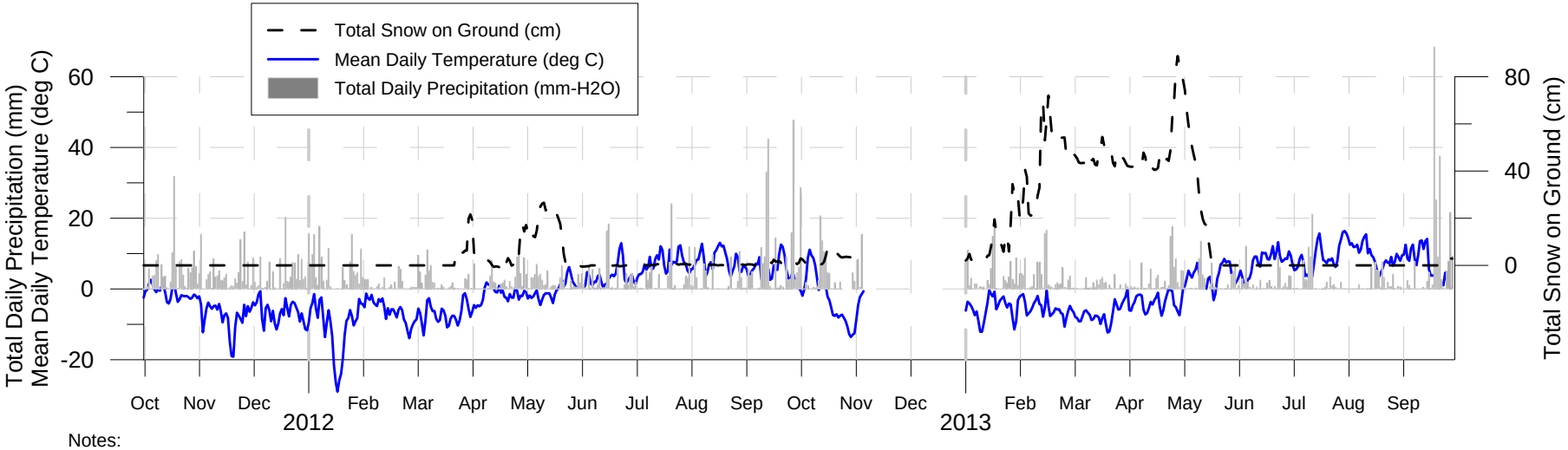
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-10B
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D17	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-10B\Hydrograph_MW-BGC12-BJ-10B.grf





Notes:
1) Well screened from 1404.07 to 1407.07 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-11A
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D18	1

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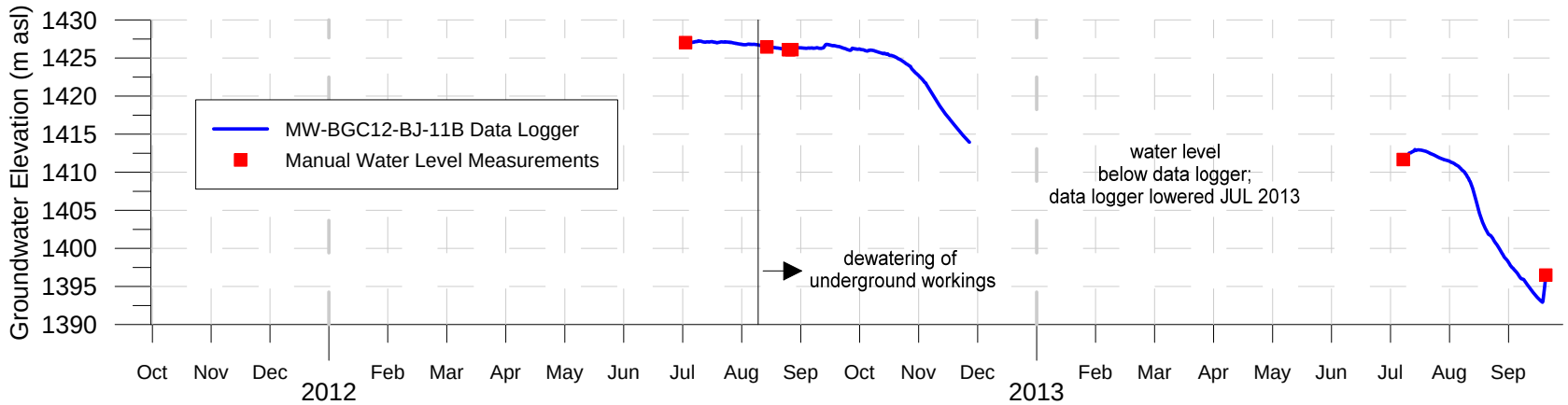

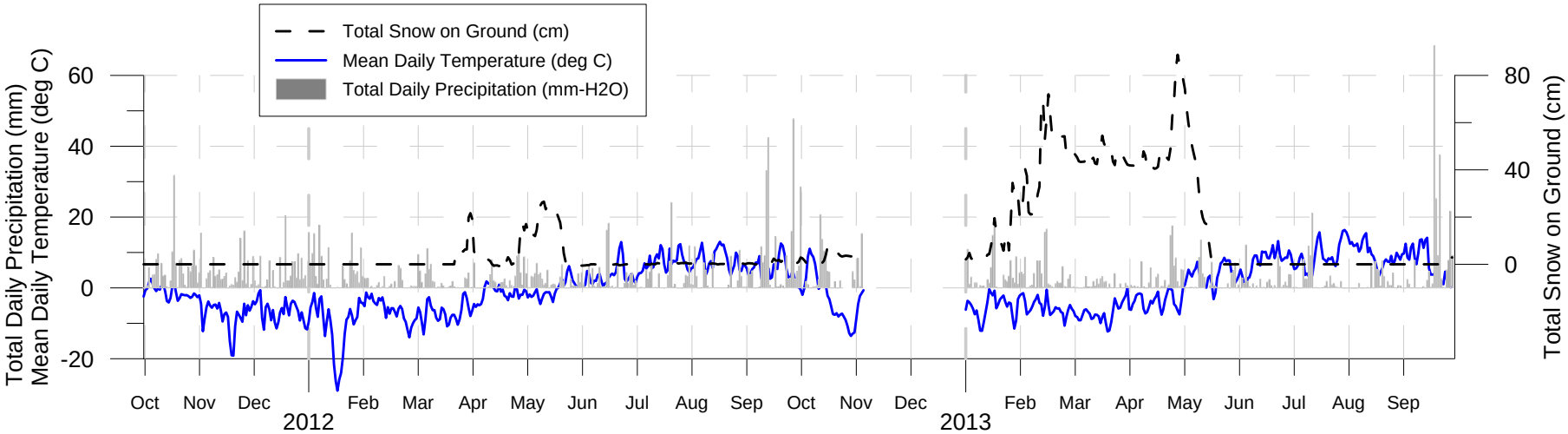

Notes:
1) Well screened from 1379.16 to 1382.26 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-11B
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D19	1

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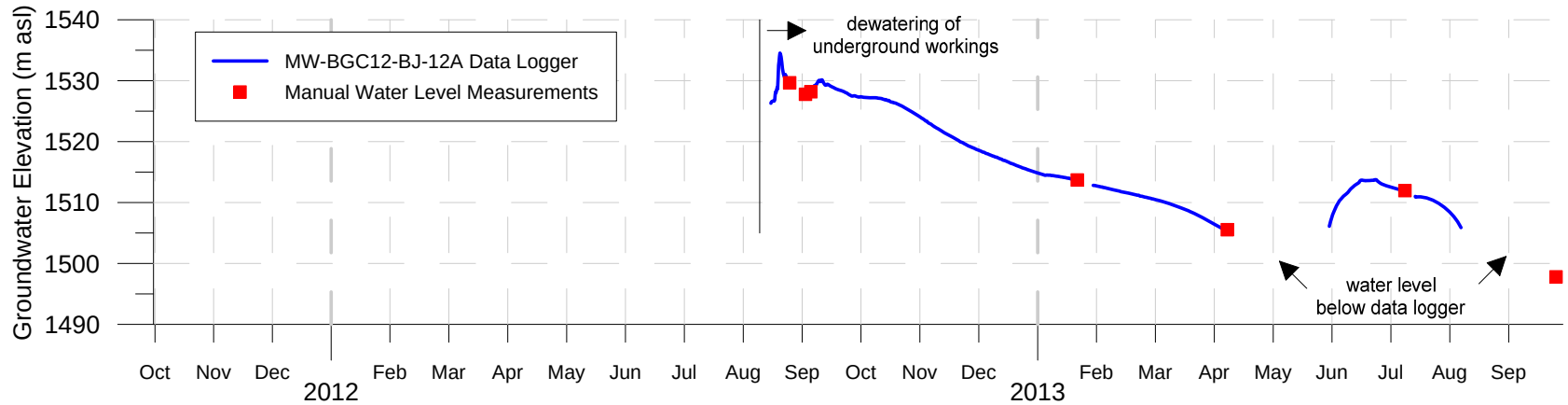

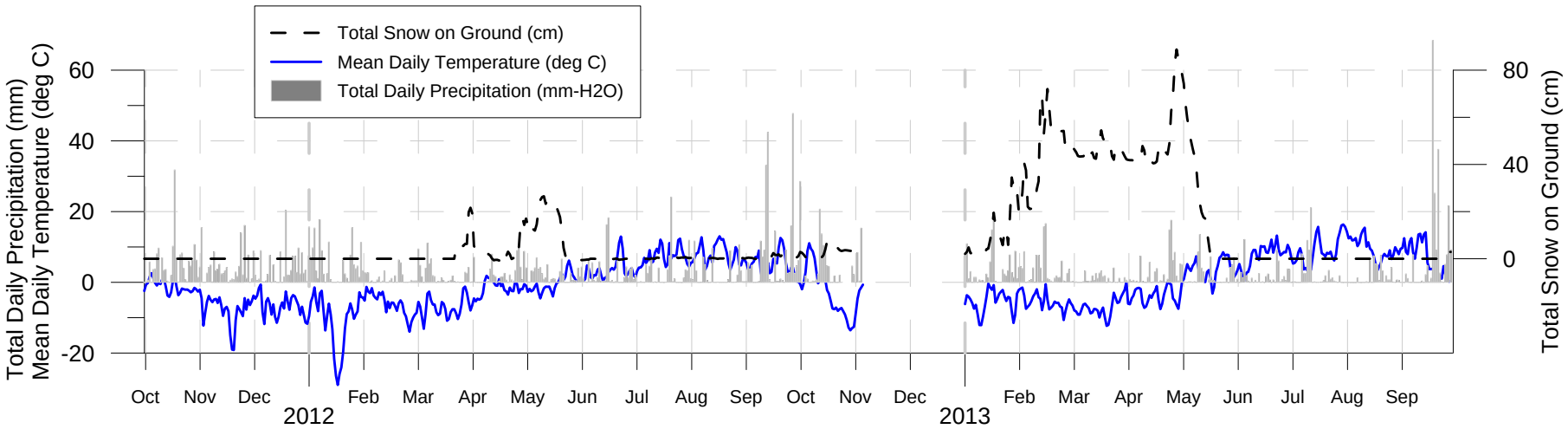

Notes:
1) Well screened from 1485.29 to 1491.39 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A		DESIGNED: KSJ	
DATE: APR 2014		CHECKED: DP	
DRAWN: LH, RET, BS		APPROVED: VC	

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AN APPLIED EARTH SCIENCES COMPANY

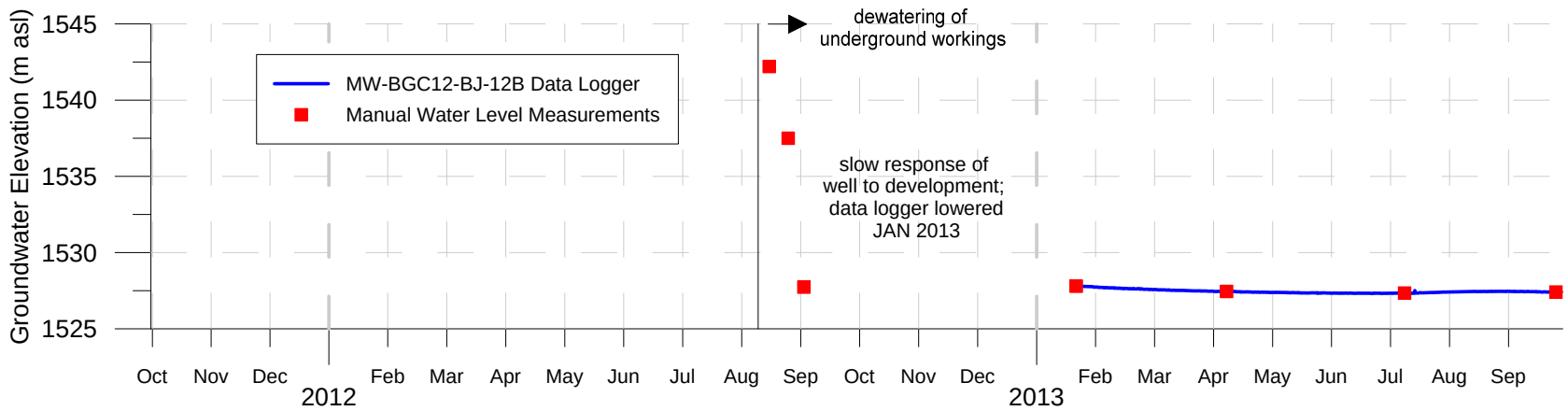
CLIENT: PRETIUM RESOURCES INC.

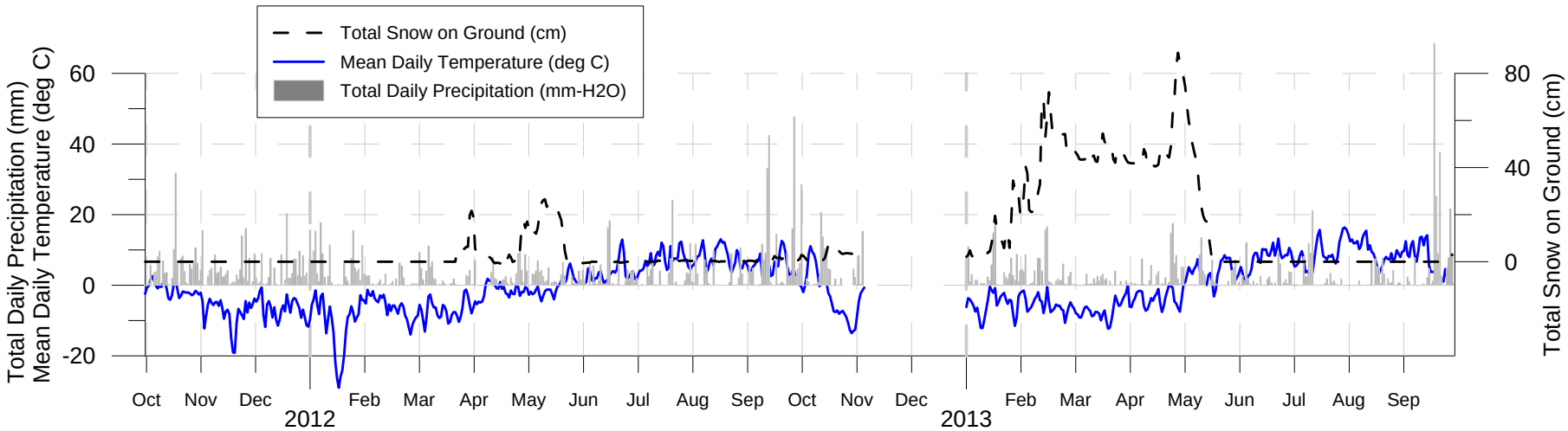
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-12A
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D20	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\MW-BGC12-BJ-12A\Hydrograph_MW-BGC12-BJ-12A.grf





Notes:
1) Well screened from 1526.36 to 1532.46 m asl; see Appendix B for well log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET, BS	APPROVED: VC		

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT

TITLE: MW-BGC12-BJ-12B GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D21	1

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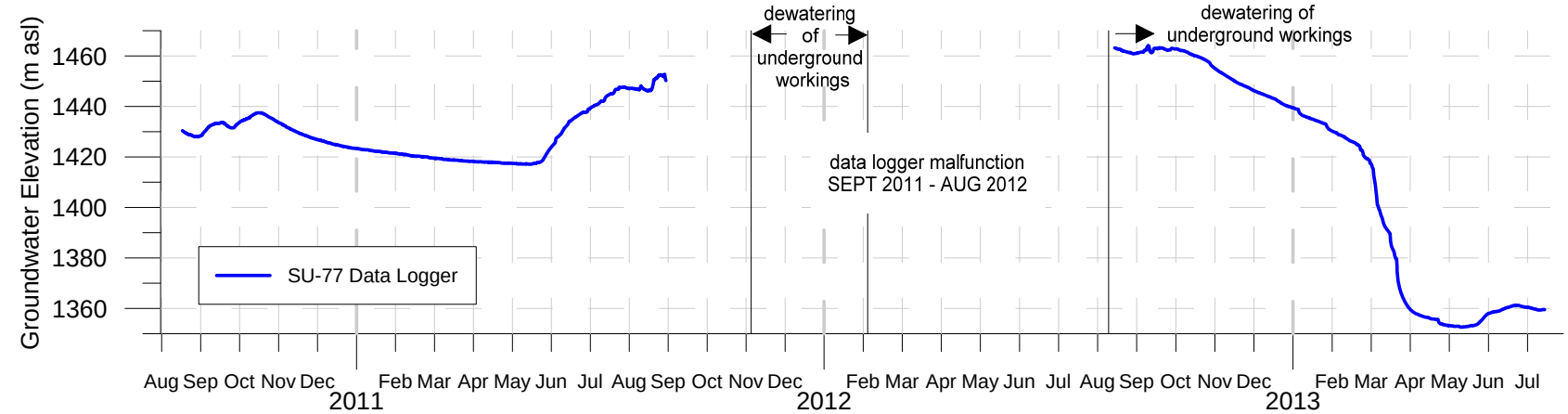

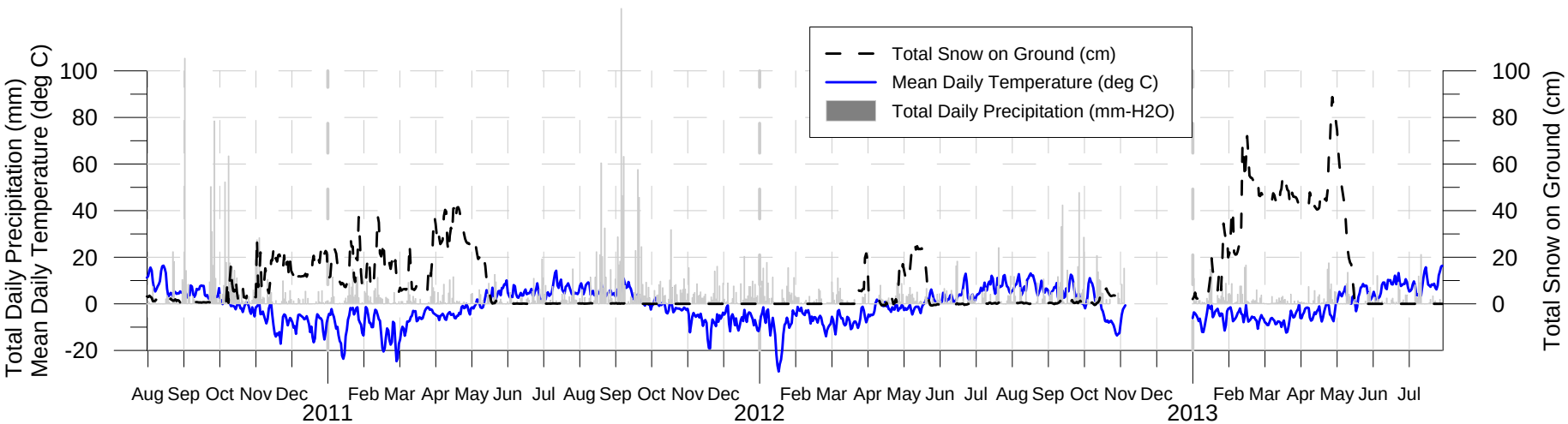

Notes:
1) VWP tip elevation at 1267.5 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A		DESIGNED: KSJ	
DATE: APR 2014		CHECKED: DP	
DRAWN: LH, RET		APPROVED: VC	

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CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: SU-77
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D22	1

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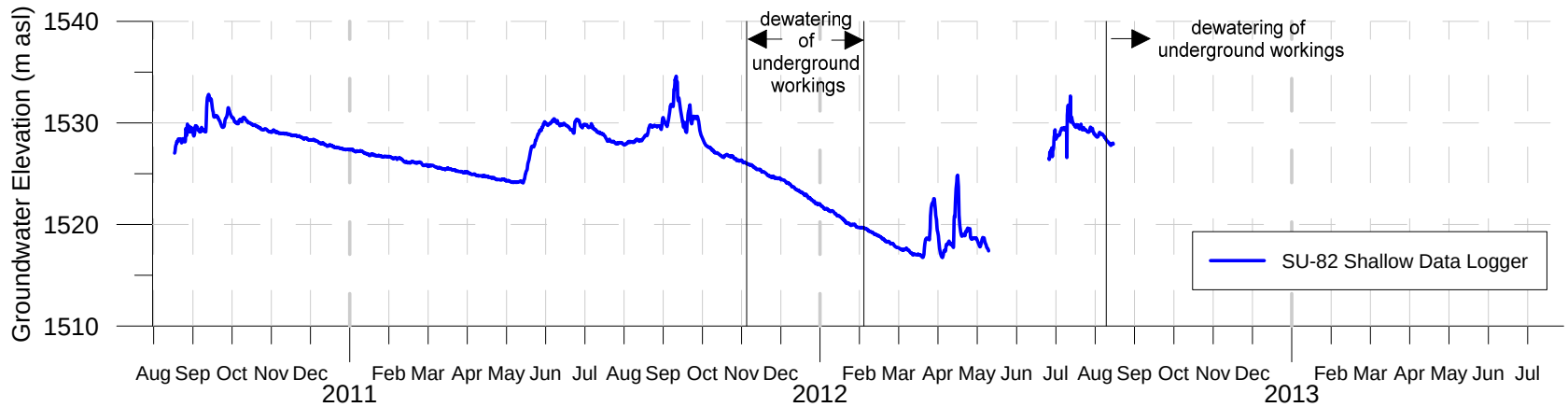

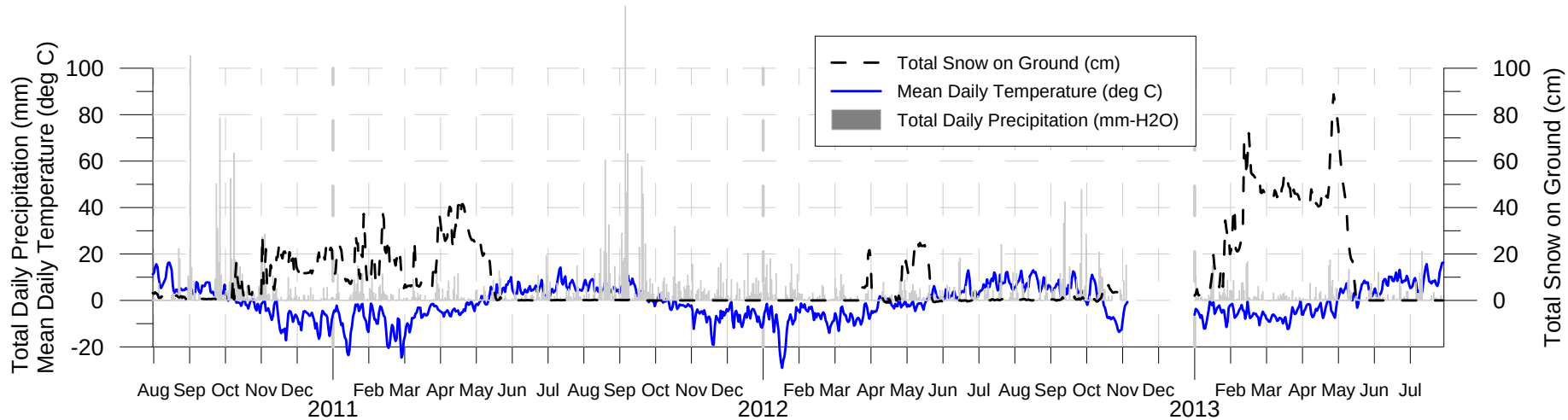

Notes:
1) VWP tip elevation at 1475.5 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: SU-82 SHALLOW GROUNDWATER HYDROGRAPH
DRAWN: LH, RET	APPROVED: VC	CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D23 / REV. 1

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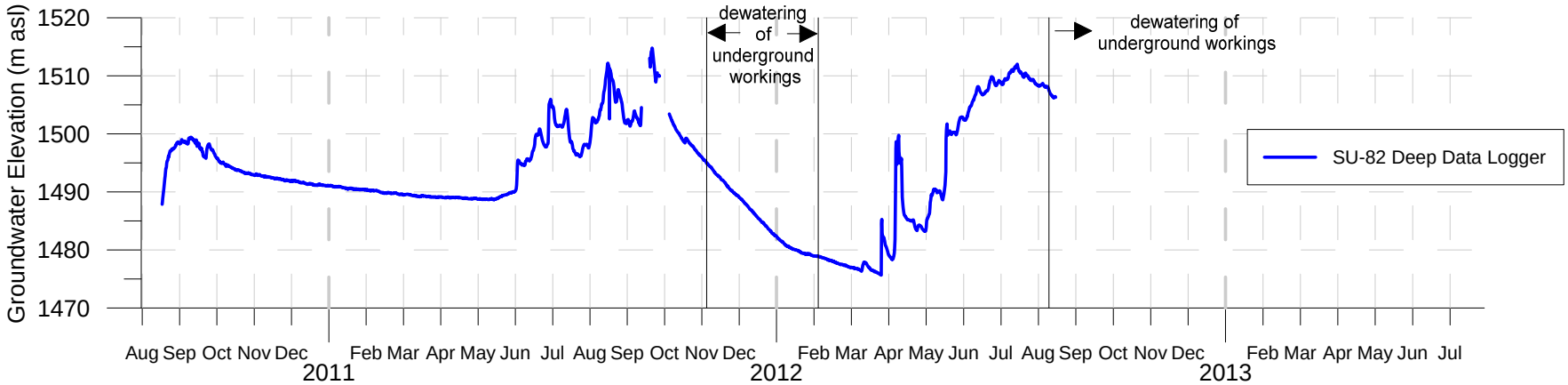
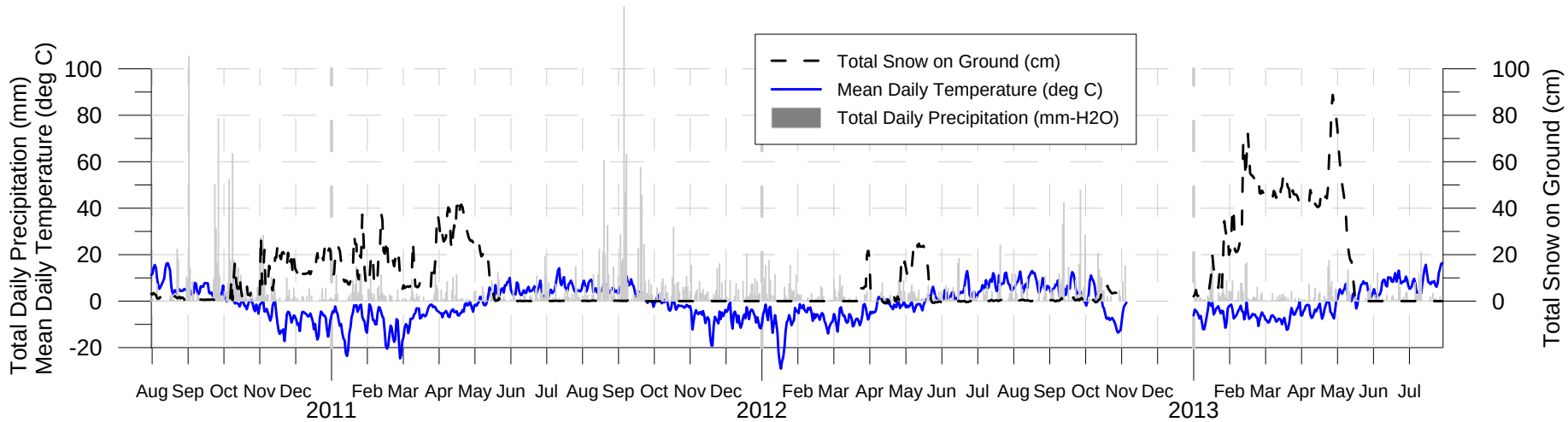
N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\SU82-Shallow\Hydrograph_SU82_Shallow.grf





Notes:
1) VWP tip elevation at 1202.4 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: SU-82 DEEP GROUNDWATER HYDROGRAPH
DRAWN: LH, RET	APPROVED: VC	CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D24 / REV. 1

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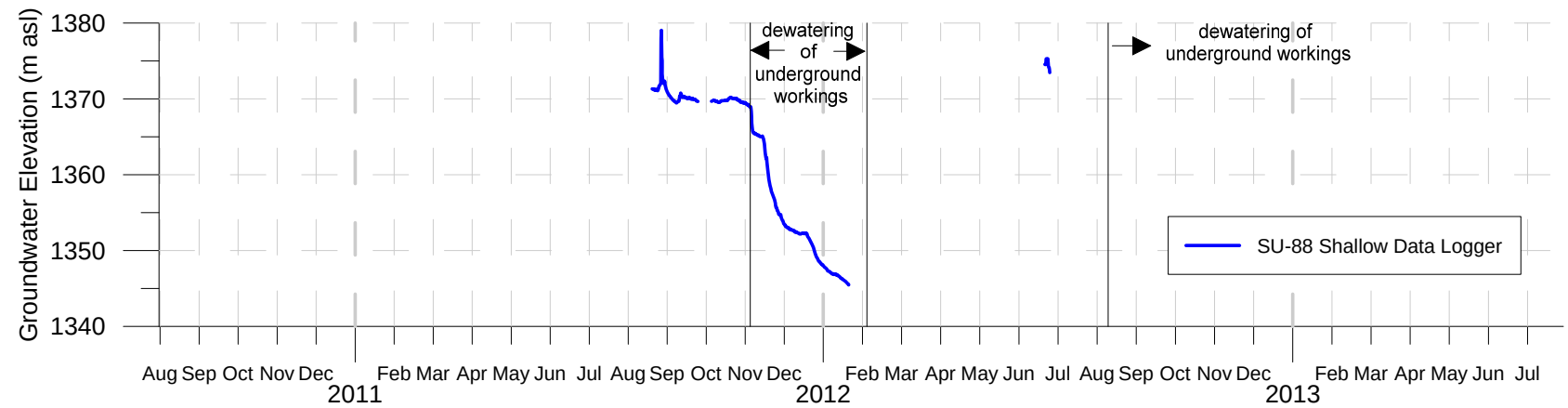

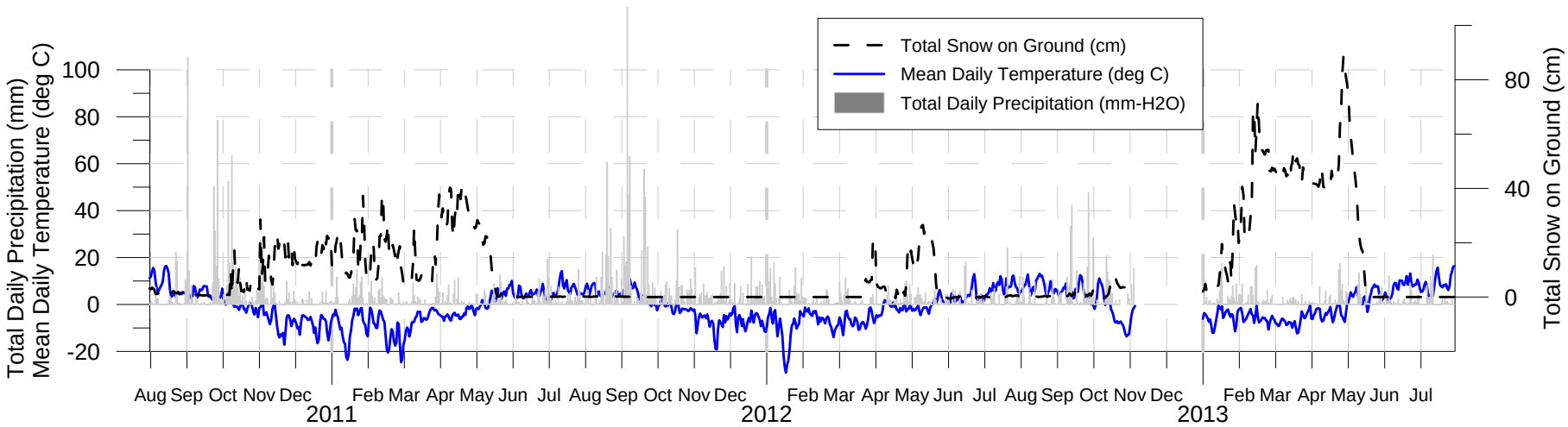

Notes:
1) VWP tip elevation at 1316.9 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
DRAWN: LH, RET	APPROVED: VC		

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AN APPLIED EARTH SCIENCES COMPANY

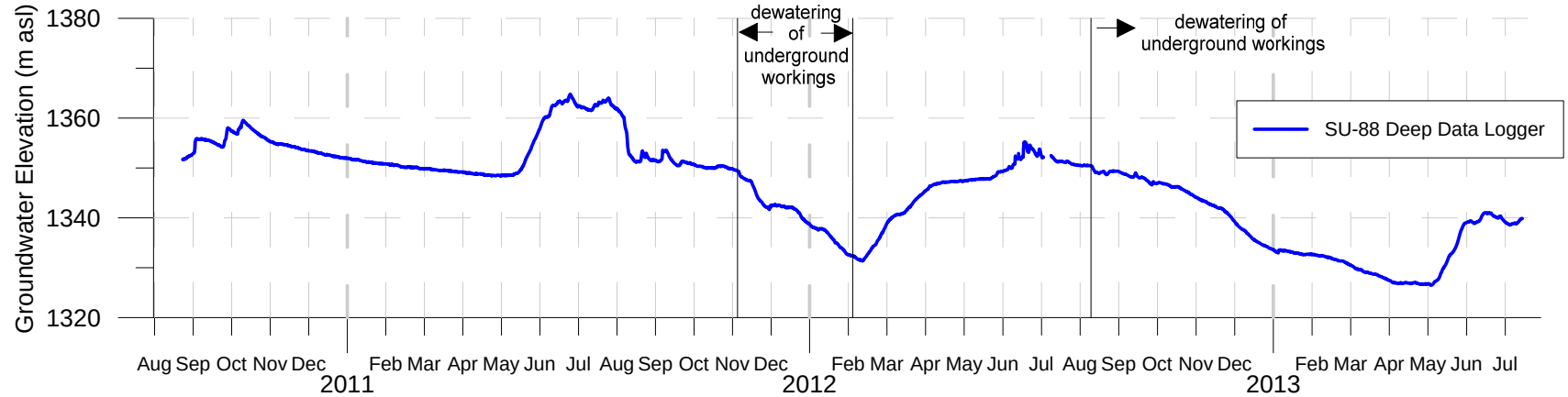
CLIENT: PRETIUM RESOURCES INC.

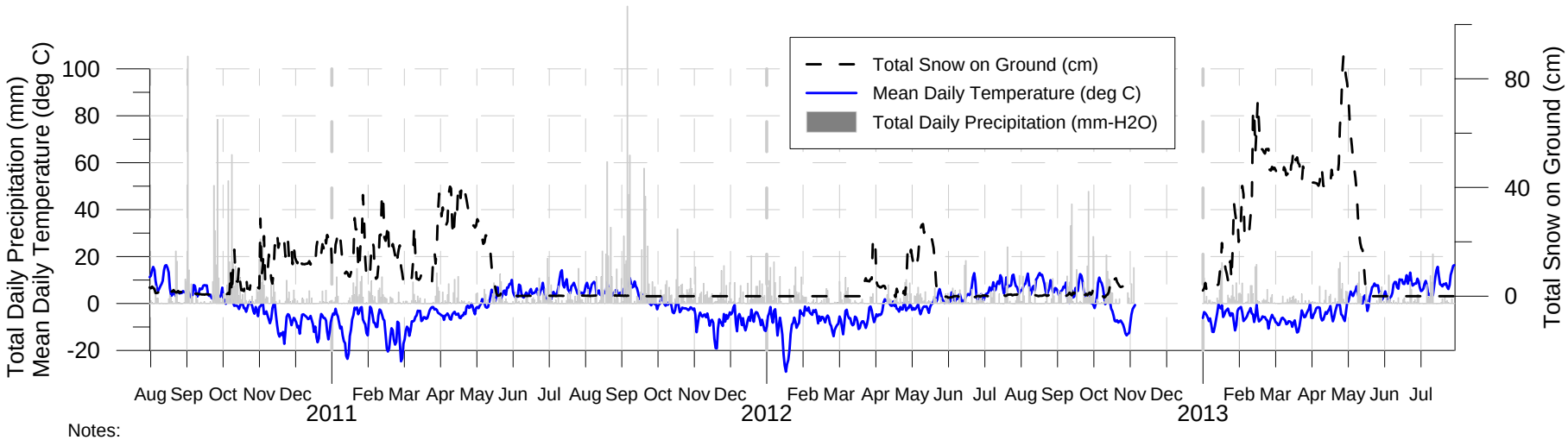
PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: SU-88 SHALLOW
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D25	1

N:\BGC\Projects\1008 Pretium\007 Feasibility\004 Hydrogeo - Office\01 Brucejack\02 Water Levels & Hydrographs\Dataloggers and Hydrographs\SU88-Shallow\Hydrograph_SU88_Shallow.grf





Notes:
1) VWP tip elevation at 1180.7 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Nov 2011 to Feb 2012 and from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT
DATE: APR 2014	CHECKED: DP		TITLE: SU-88 DEEP GROUNDWATER HYDROGRAPH
DRAWN: LH, RET	APPROVED: VC	CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D26 / REV. 1

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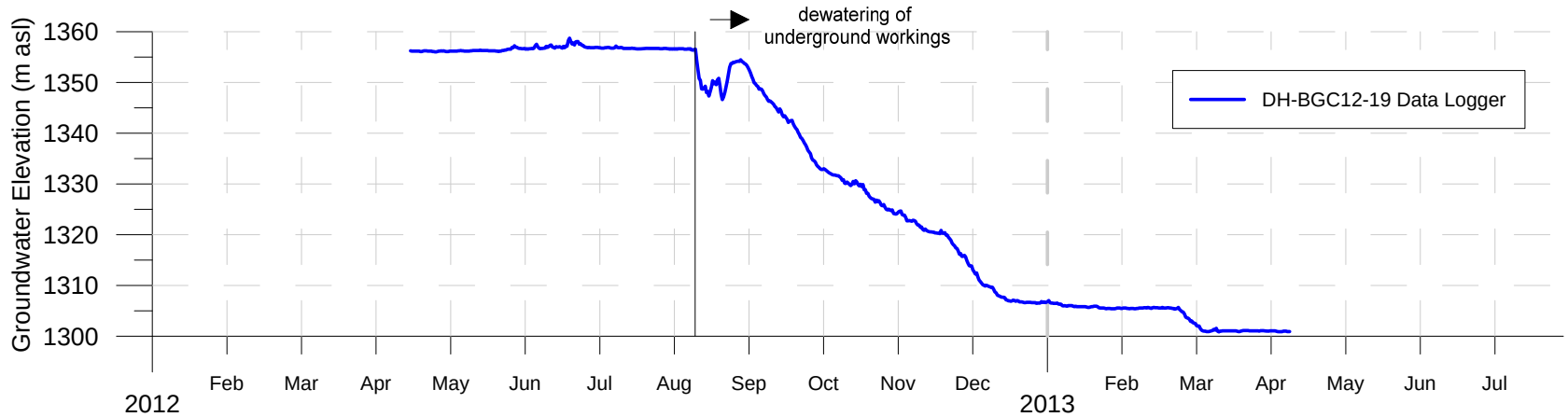

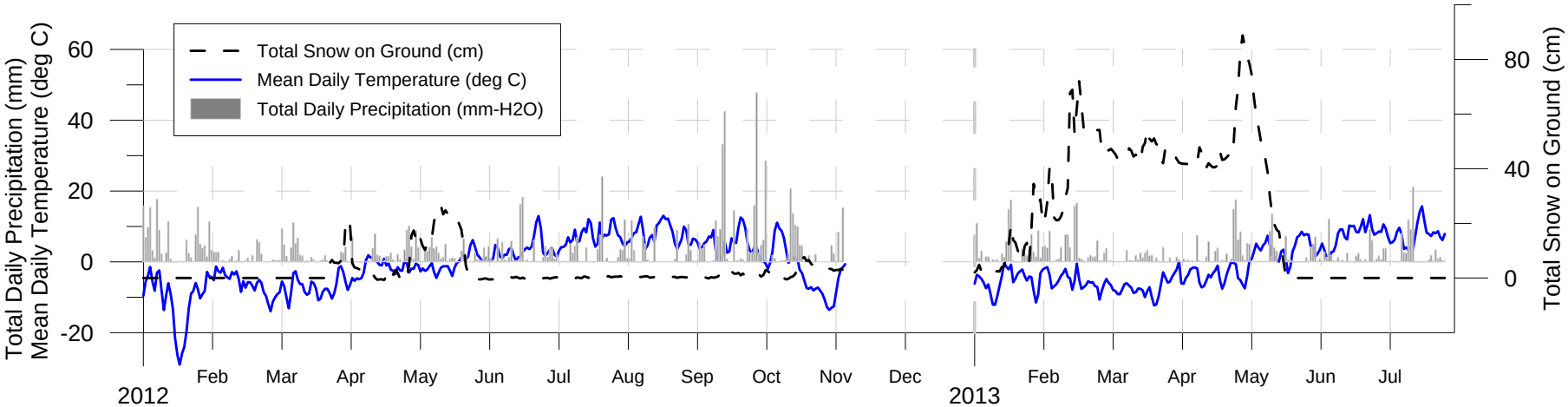

Notes:
1) VWP tip elevation at 1158.9 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

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DRAWN: LH, RET	APPROVED: VC		

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PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: DH-BGC12-19
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D27	1

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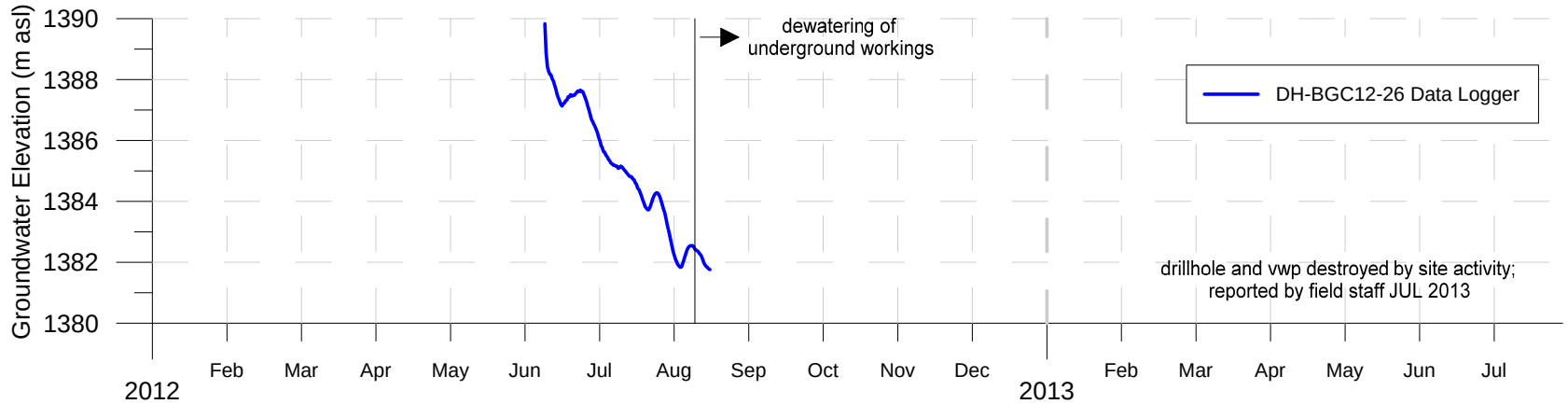

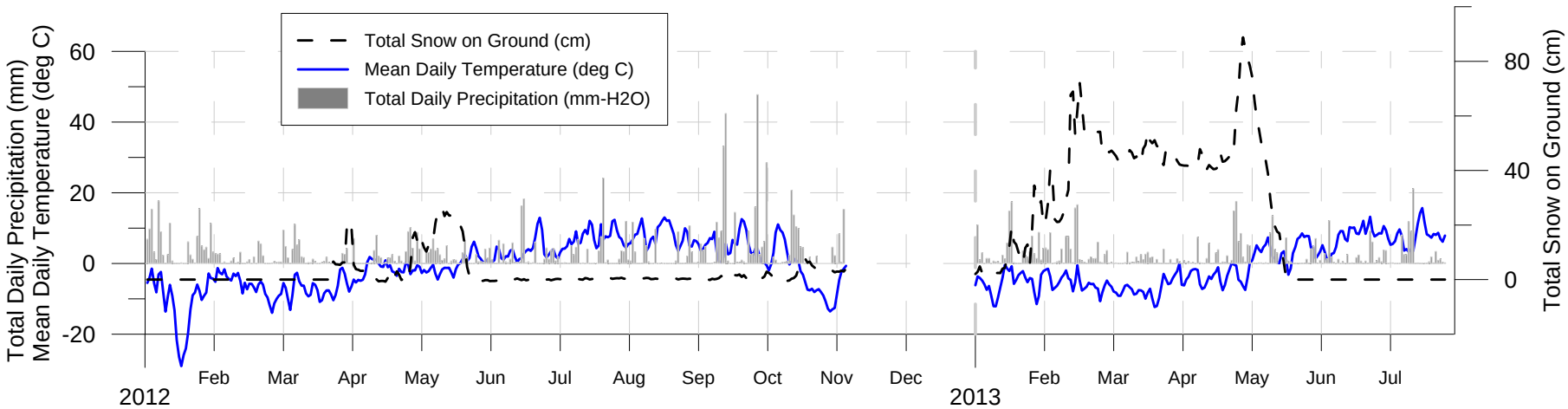

Notes:
1) VWP tip elevation at 1378.2 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ	PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT HYDROGEOLOGY BASELINE REPORT	
DATE: APR 2014	CHECKED: DP	TITLE: DH-BGC12-26 GROUNDWATER HYDROGRAPH	
DRAWN: LH, RET	APPROVED: VC		
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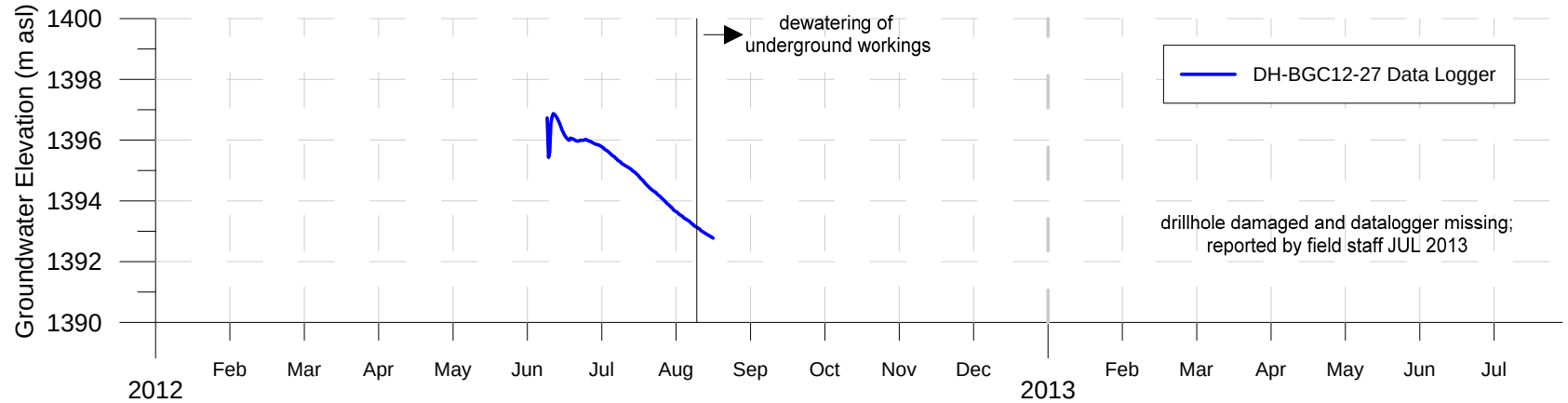

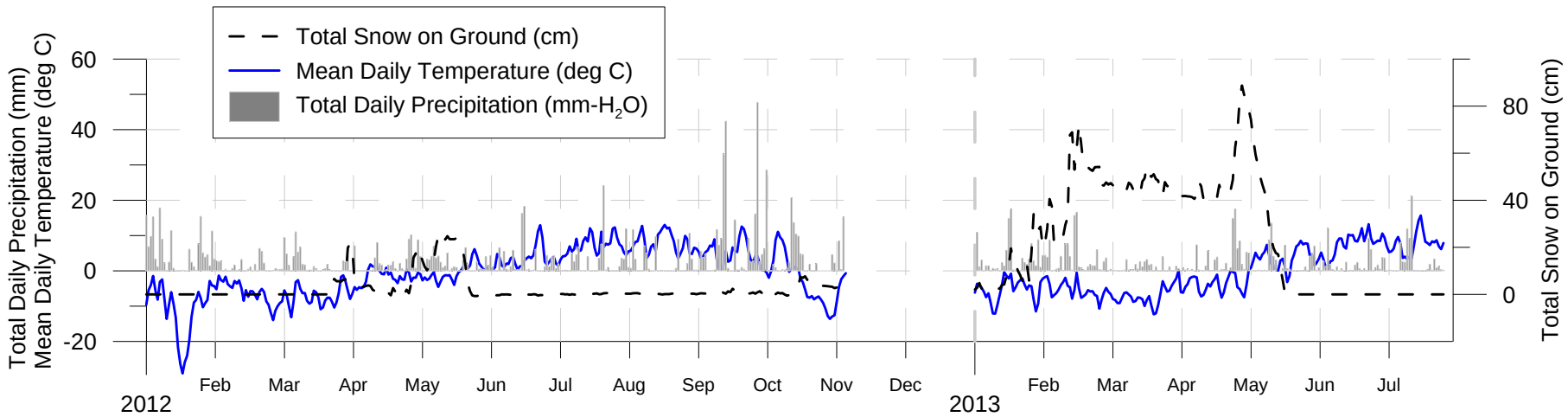

Notes:
1) VWP tip elevation at 1385.7 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

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TITLE: DH-BGC12-27
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D29	1

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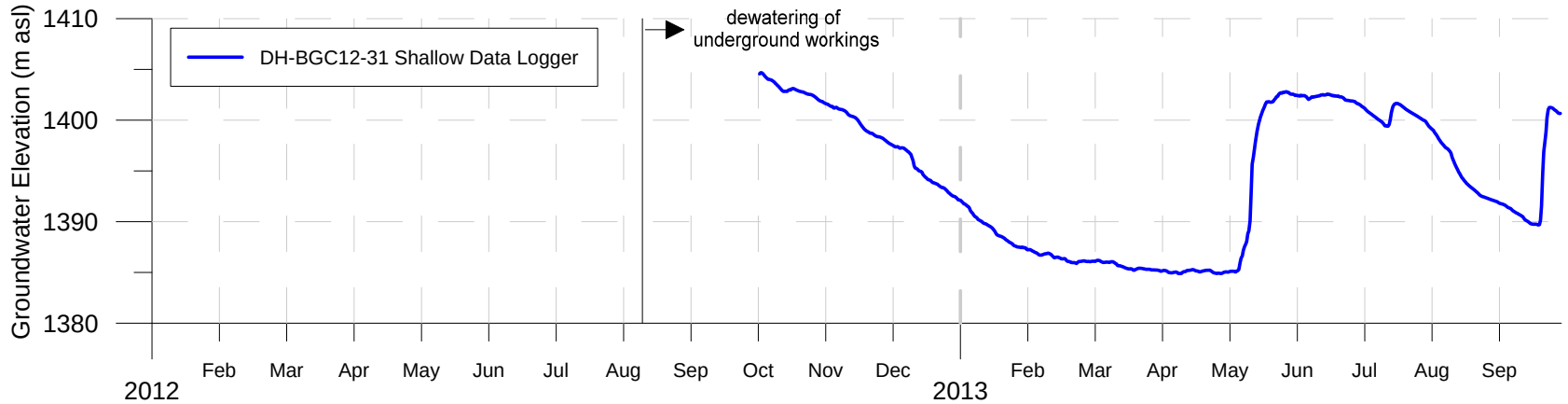

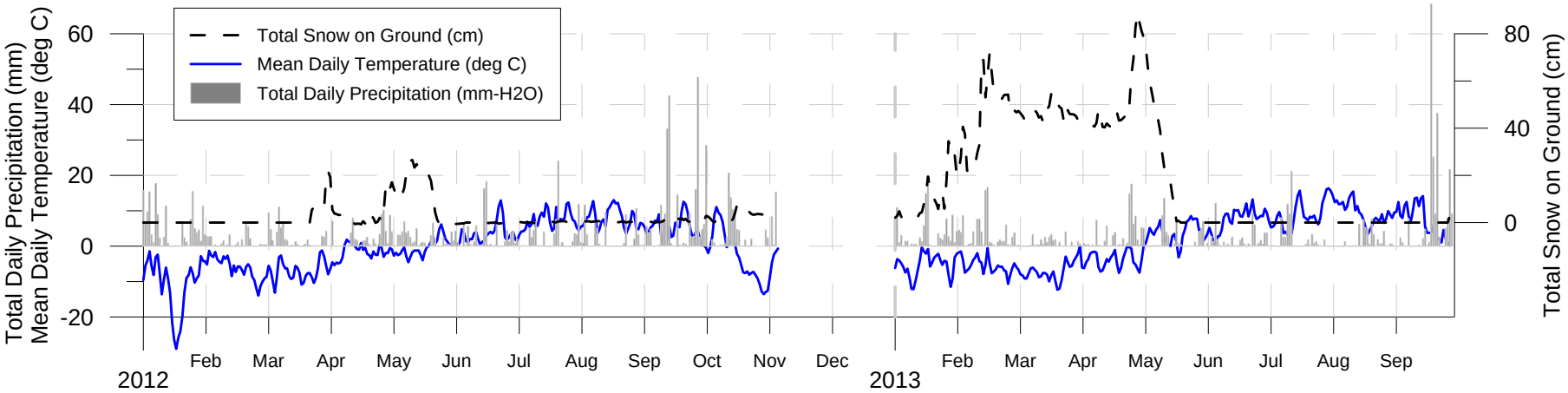

Notes:
1) VWP tip elevation at 1388.4 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

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PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: DH-BGC12-31 SHALLOW
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D30	1

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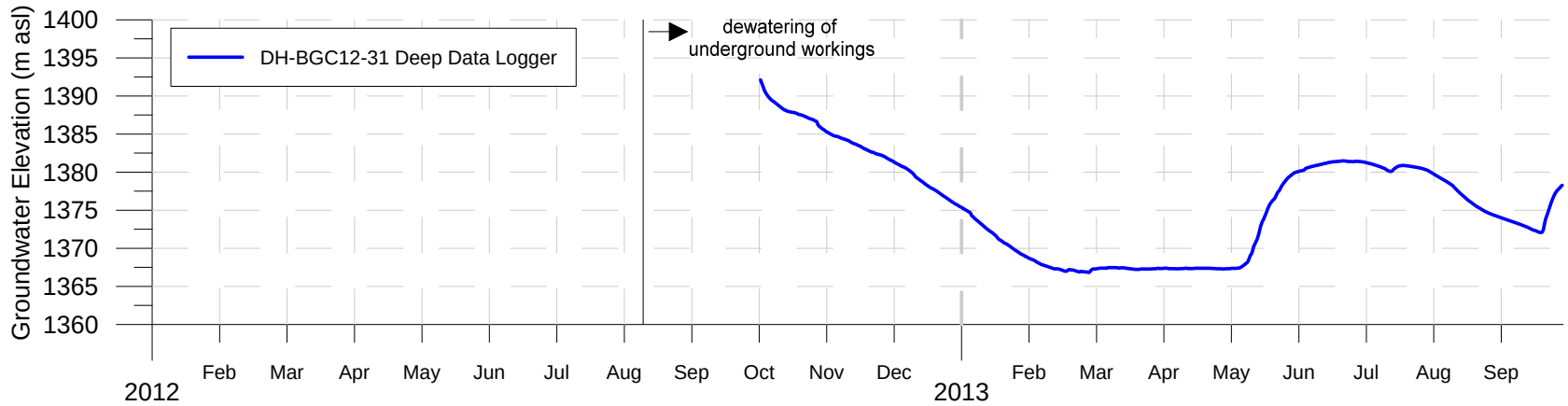

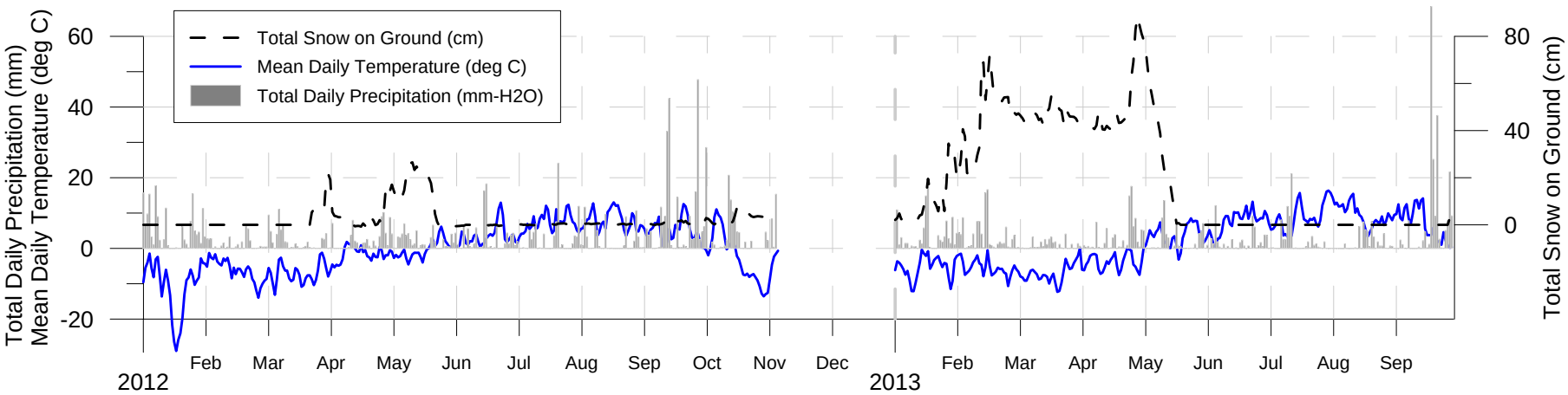

Notes:
1) VWP tip elevation at 1368 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
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PROJECT: BRUCEJACK PROJECT ENVIRONMENTAL ASSESSMENT
HYDROGEOLOGY BASELINE REPORT

TITLE: DH-BGC12-31 DEEP
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D31	1

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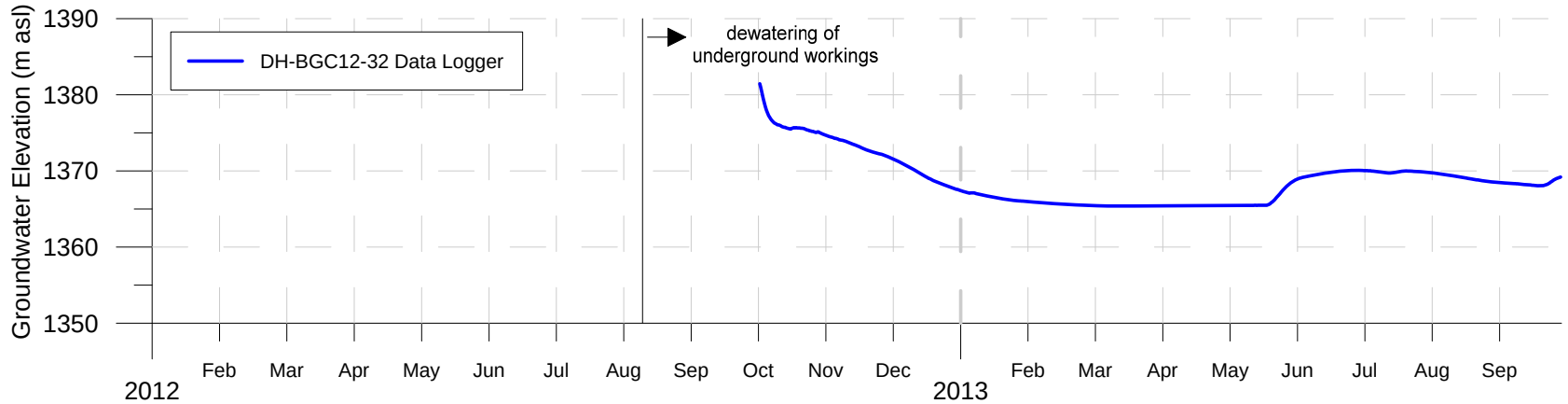

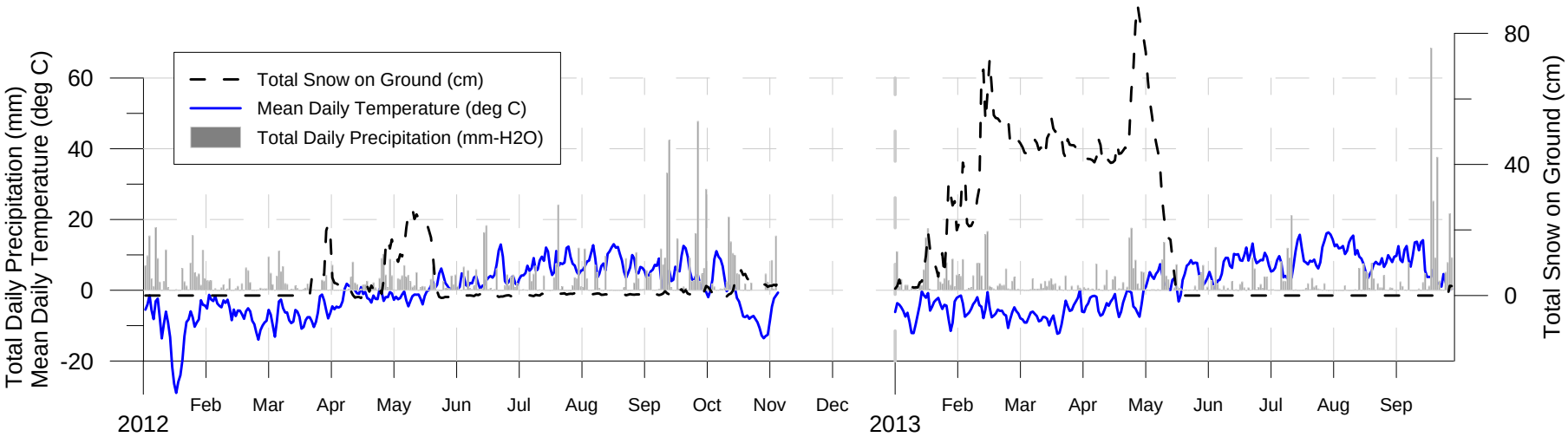

Notes:
1) VWP tip elevation at 1368.3 m asl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occurred from Aug 2012 onwards.

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DATE: APR 2014	CHECKED: DP		TITLE: DH-BGC12-32 GROUNDWATER HYDROGRAPH
DRAWN: LH, RET, BS	APPROVED: VC	CLIENT: PRETIUM RESOURCES INC.	PROJECT No. 1008-010 / DWG No. D32 / REV. 1

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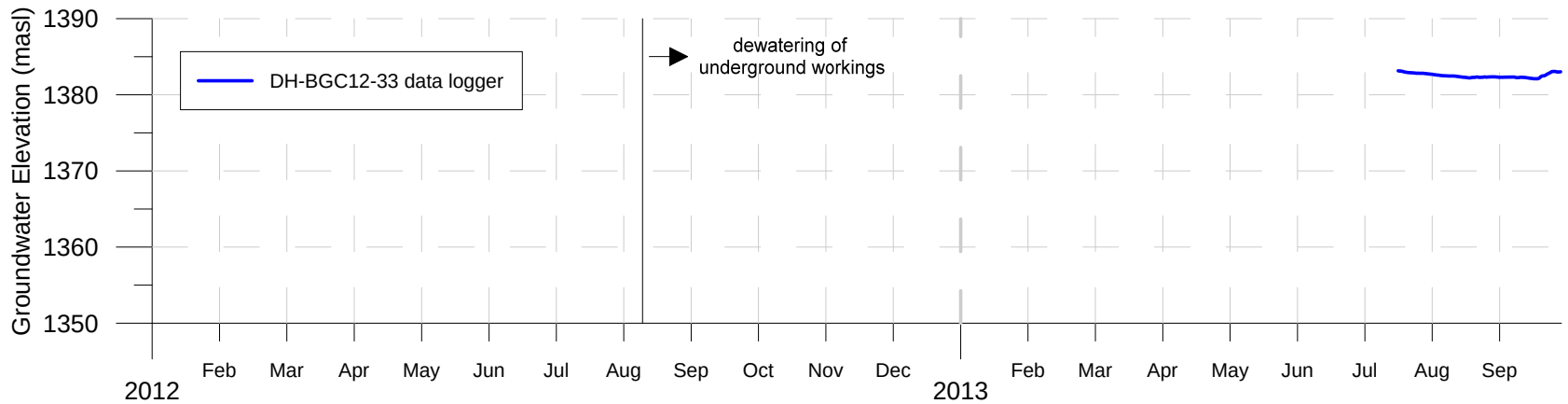

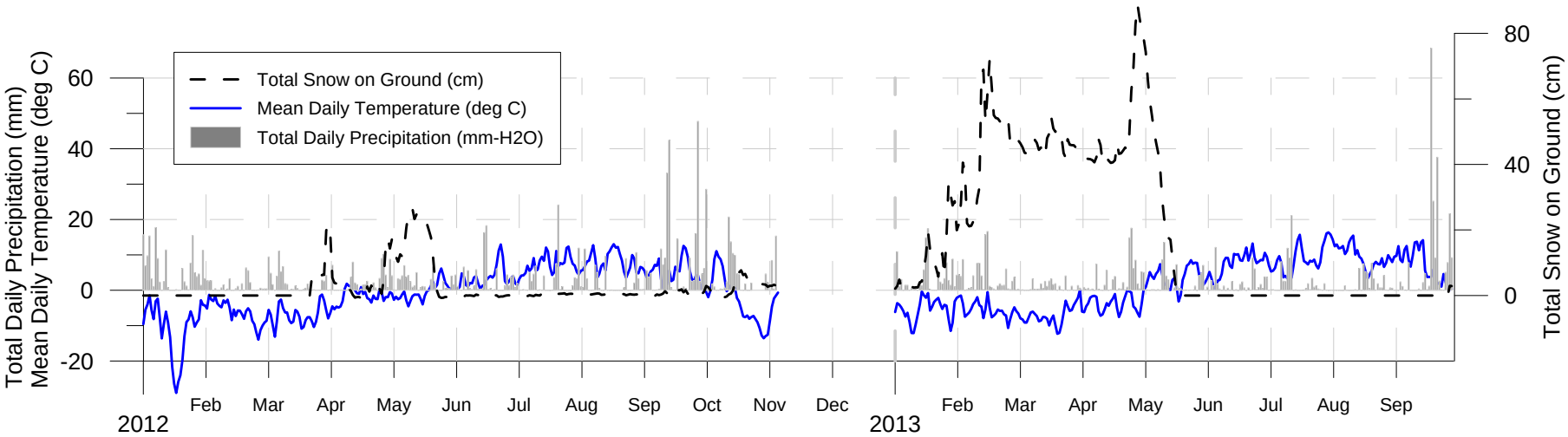

Notes:
1) VWP tip elevation at 1370 masl; see Appendix C for VWP summary log.
2) Meteorological data from the Brucejack meteorological station (Rescan, 2011-2013). No meteorological data available from Nov 2012 to Jan 2013.
3) Dewatering of underground workings impacting groundwater elevations at the site occured from Aug 2012 onwards.

SCALE: N/A	DESIGNED: KSJ		
DATE: APR 2014	CHECKED: DP		
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HYDROGEOLOGY BASELINE REPORT

TITLE: DH-BGC12-33
GROUNDWATER HYDROGRAPH

PROJECT No.	DWG No.	REV.
1008-010	D33	1

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APPENDIX E
SUMMARY OF WATER QUALITY RESULTS

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-1A	MW-BGC11-BJ-1B	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A
	BGC Sample ID	BJ-1a	BJ-1B	BJ-2A	BJ-2A	BJ-2A	BJ-2A	BJ-2A	02A	02A_DUP 1
	Date Sampled	10-Oct-11	10-Oct-11	11-Oct-11	30-Mar-12	26-Jun-12	4-Sep-12	27-Jan-13	7-Apr-13	7-Apr-13
	Time Sampled	9:10	9:40	9:00	11:30	14:10	00:00	00:00	00:00	00:00
	ALS Sample ID	L1071509-9	L1071509-10	L1071509-7	L1130044-3	L1171422-1	L1207447-5	L1263921-1	L1287525-1	L1287525-5
Field Parameters	**Unit**									
Temperature	°c			1.1	0.81	2.35	4.5	0.9	2.4	
Temperature (data logger)	°C	-0.5	-0.5	2.9	2.62	2.62	2.62	2.51	2.51	
Data logger reading date		10/10/2011	10/10/2011	10/11/2011	3/31/2012	6/25/2012	9/1/2012	1/21/2013	4/6/2013	
pH	pH			8.54	8.09	8	8.28	7.7	7.45	
Electrical conductivity (EC)	uS/cm			186	280		324	333	326	
Physical Tests	**Unit**									
Temperature	°c	9	9	9	0.1	12	7.9	-	10	10
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	110	289	217	262	255	243	256	274	271
Hardness (as CaCO3)	mg/L	45.2	89.8	96.8	133	80	99.7	132	133	130
pH	pH	7.96	7.99	8.14	8.04	7.84	8.09	8.04	8.13	8.12
Total Suspended Solids	mg/L	31.6	86.2	9.6	293	298	557	655	341	167
Total Dissolved Solids	mg/L	59	187	132	173	166	158	166	176	185
Turbidity	NTU	34.1	99.7	19.1	260	144	438	581	228	138
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	1.8	2.4	1.6	1.8	1.9	2	3.3	1.9	1.6
Alkalinity, Bicarbonate (as CaCO3)	mg/L	29.2	86.1	71	79.8	-	78.3	79.4	80.5	79.1
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	-	<1.0	<2.0	<2.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	-	<1.0	<2.0	<2.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	29.2	86.1	71	79.8	81.5	78.3	79.4	80.5	79.1
Ammonia (as N)	mg/L	0.0282	0.0229	0.0152	0.0067	0.0271	<0.0050	0.041	<0.0050	<0.0050
Bromide (Br)	mg/L	0.07	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.66	<0.50	0.94	0.67	3.73	3.32	1.44	1.29	1.2
Fluoride (F)	mg/L	0.039	*0.251*	0.081	0.045	0.097	0.055	0.041	0.037	0.036
Nitrate (as N)	mg/L	0.0137	0.0258	0.0259	0.0077	<0.0050	<0.0050	0.0142	0.0216	0.022
Nitrite (as N)	mg/L	*<0.0010*	0.0036	*<0.0010*	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.178	0.106	0.062	0.174	2.54	0.705	0.212	0.089	0.084
Total Nitrogen	mg/L	0.192	0.135	0.0876	0.182	2.54	0.705	-	-	-
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	0.0316	0.0721	0.0127	0.281	0.238	0.33	0.352	0.272	0.167
Sulfate (SO4)	mg/L	19.1	60	37.3	58.5	49.5	46.1	54.6	63.3	63.5
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	1.41	1.06	1.17	<0.50	-	0.81	0.53	<0.50	<0.50
Total Organic Carbon	mg/L	3.6	0.52	0.96	2.01	46.4	5	2.6	1.02	0.78

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A
	BGC Sample ID	BJ-2A	BJ-2A	BJ-3A	BJ-3A	BJ-3A	BJ-3A	Duplicate	BJ-3A	03A
	Date Sampled	13-Jul-13	26-Sep-13	8-Oct-11	28-Mar-12	27-Jun-12	4-Sep-12	27-Jun-12	28-Jan-13	7-Apr-13
	Time Sampled	00:00	16:00	16:30	13:15	09:35	00:00	09:45	00:00	00:00
	ALS Sample ID	L1333226-1	L1370207-1	L1071509-6	L1129695-1	L1171422-2	L1207447-1	L1171422-8	L1263921-2	L1287525-2
Field Parameters	**Unit**									
Temperature	°c	3.45		2.2	1.8	2.7	2.83		2.5	3.2
Temperature (data logger)	°C	2.62	0.217	2.2	1.88	2.2	2.3		2.41	2.62
Data logger reading date		7/9/2013	9/26/2013	10/11/2011	4/1/2012	6/27/2012	8/28/2012		1/21/2013	4/4/2013
pH	pH	7.8		7.03	7.87	7.95	8.27		7.95	7.98
Electrical conductivity (EC)	uS/cm	255	242	355	358	210	186		405	408
Physical Tests	**Unit**									
Temperature	°c	16	8.8	9	2	12	7.9	12	-	10
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	189	209	358	355	343	351	338	349	348
Hardness (as CaCO3)	mg/L	88.3	98.9	135	167	88.7	137	88.1	167	156
pH	pH	7.13	7.73	8.22	8.05	8.18	8.17	8.2	8.12	8.11
Total Suspended Solids	mg/L	280	507	<3.0	328	54.9	155	48.9	520	10.5
Total Dissolved Solids	mg/L	124	144	212	247	230	240	222	238	230
Turbidity	NTU	160	527	2.94	270	40.2	138	41.1	199	30.5
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	6.2	1.5	1.1	2.2	<1.0	1.9	<1.0	2.9	1.8
Alkalinity, Bicarbonate (as CaCO3)	mg/L	63.3	64.5	93.1	93.8	-	95.1	-	102	96.5
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	-	<2.0	-	<2.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	-	<2.0	-	<2.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	63.3	64.5	93.1	93.8	89.4	95.1	85.8	102	96.5
Ammonia (as N)	mg/L	<0.0050	<0.0050	0.0278	0.0289	0.0702	0.0341	0.055	0.0312	0.0325
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	1.15	1.1	<0.50	<0.50	0.6	<0.50	0.59	<0.50	<0.50
Fluoride (F)	mg/L	0.03	0.031	*0.208*	*0.186*	*0.215*	*0.176*	*0.214*	*0.188*	*0.197*
Nitrate (as N)	mg/L	0.068	0.0927	<0.0050	0.0059	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	0.0024	0.0023	0.0021	0.0032	*<0.0010*	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.162	0.273	0.064	0.119	0.133	0.092	0.144	0.169	0.057
Total Nitrogen	mg/L	-	0.366	0.0645	0.127	0.136	0.094	0.148	-	-
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.003	<0.0010	0.0028	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	0.307	0.544	<0.0020	0.113	0.0283	0.117	0.0351	0.293	0.0273
Sulfate (SO4)	mg/L	34.7	41.6	84	89.4	89.7	88.9	89.7	89.1	89.8
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0010	<0.0010	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	<0.50	0.63	1.16	<0.50	-	<0.50	-	0.53	<0.50
Total Organic Carbon	mg/L	1.06	1.19	<0.50	1	<0.50	<0.50	<0.50	0.77	<0.50

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B
	BGC Sample ID	BJ-3A	BJ-03A	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B
	Date Sampled	13-Jul-13	25-Sep-13	8-Oct-11	28-Mar-12	27-Jun-12	4-Sep-12	28-Jan-13	11-Jul-13	25-Sep-13
	Time Sampled	00:00	17:00	15:45	11:00	10:00	00:00	00:00	00:00	13:30
	ALS Sample ID	L1333226-2	L1370058-1	L1071509-5	L1129695-2	L1171422-3	L1207447-2	L1263921-3	L1331947-3	L1370058-2
Field Parameters	**Unit**									
Temperature	°c	3.5	4.3	2	0.6	1.72	2.42		1.9	3.3
Temperature (data logger)	°C	2.41	4.6	1.98	1.44	1.44	1.65	2.09	1.55	1.87
Data logger reading date		7/10/2013	9/25/02013	10/11/2011	3/31/2012	6/24/2012	9/4/2012	1/21/2013	7/10/2013	9/21/2013
pH	pH	7.96	8.16	7.03	7.84	7.58	8.24		7.84	7.84
Electrical conductivity (EC)	uS/cm	223	424	380	367	193	176		249	482
Physical Tests	**Unit**									
Temperature	°c	16	12.6	9	2	12	7.9	-	13	12.6
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	329	345	339	312	331	340	382	352	386
Hardness (as CaCO3)	mg/L	150	155	167	156	157	156	188	164	182
pH	pH	7.97	8.06	8.14	7.89	8.07	8.1	7.86	8.22	8.07
Total Suspended Solids	mg/L	48.5	1550	<3.0	275	326	1930	675	493	189
Total Dissolved Solids	mg/L	220	235	212	215	229	236	267	223	276
Turbidity	NTU	39.6	2130	1.97	204	288	2540	777	346	156
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	4	1.5	1.7	2.7	1.5	2.3	5	<1.0	1.4
Alkalinity, Bicarbonate (as CaCO3)	mg/L	93.7	99.5	86.4	42.9	-	87.9	76.2	94.6	92.9
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	93.7	99.5	86.4	42.9	85.6	87.9	76.2	94.6	92.9
Ammonia (as N)	mg/L	0.0291	0.0344	0.0318	0.0145	0.0295	0.0327	0.0316	0.0271	0.0239
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	1.19	<0.50	2.36
Fluoride (F)	mg/L	*0.188*	*0.196*	*0.132*	0.091	0.112	*0.135*	0.109	*0.163*	0.113
Nitrate (as N)	mg/L	<0.0050	0.0068	<0.0050	0.02	<0.0050	<0.0050	<0.0050	0.0052	0.205
Nitrite (as N)	mg/L	<0.0010	0.0019	*<0.0010*	0.0018	0.0016	*<0.0010*	0.0013	*<0.0010*	0.0438
Total Kjeldahl Nitrogen	mg/L	0.073	0.668	0.085	0.114	0.138	0.27	0.231	0.67	0.259
Total Nitrogen	mg/L	-	0.676	0.0854	0.136	0.139	0.27	-	-	0.508
Orthophosphate - Dissolved (as P)	mg/L	0.0011	0.0017	<0.0010	0.0021	0.0012	<0.0010	<0.0010	<0.0010	0.0013
Phosphorus (P)-Total	mg/L	0.0587	1.64	<0.0020	0.0453	0.288	1.24	0.506	0.225	0.179
Sulfate (SO4)	mg/L	80.9	89.3	82.5	108	89.6	91.6	125	87.2	112
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0010	<0.0010	0.0088	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	<0.50	0.55	0.74	<0.50	-	<0.50	2.05	<0.50	0.74
Total Organic Carbon	mg/L	0.69	4.6	<0.50	0.77	<0.50	1.23	3.12	0.53	1.01

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC12-BJ-4B
	BGC Sample ID	BJ-4A	BJ-4A	BJ-4A	BJ-4A	BJ-4A	04A	BJ-4A	BJ-4A	BJ-4B
	Date Sampled	10-Oct-11	30-Mar-12	26-Jun-12	3-Sep-12	28-Jan-13	8-Apr-13	13-Jul-13	25-Sep-13	3-Sep-12
	Time Sampled	11:10	14:05	14:45	00:00	00:00	00:00	00:00	10:20	00:00
	ALS Sample ID	L1071509-1	L1130044-4	L1171422-4	L1205274-1	L1263921-4	L1288325-3	L1333226-3	L1370058-3	L1205274-2
Field Parameters	**Unit**									
Temperature	°c	2.9	1.7	2.7	4.3	1.6	1.72	2.3	2.58	4.1
Temperature (data logger)	°C	2.09	2.09	2.09	2.09	2.09	2.09	2.09	4.6	2.09
Data logger reading date		10/10/2011	3/31/2012	6/23/2012	8/30/2012	1/21/2013	4/4/2013	7/9/2013	9/25/2013	8/29/2012
pH	pH	8.01	7.73	7.8	8.09	8.01	7.96	7.96		10.01
Electrical conductivity (EC)	uS/cm	681	480	245	476	465	560	950	340	511
Physical Tests	**Unit**									
Temperature	°c	4	0.1	12	6.5	-	3.8	16	12.6	6.5
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	453	454	402	425	423	430	490	452	389
Hardness (as CaCO3)	mg/L	203	212	170	177	203	190	195	185	67.2
pH	pH	8.08	8.14	8.11	7.26	8.16	8.15	7.94	8.12	**8.57**
Total Suspended Solids	mg/L	6.2	51.7	14.2	18.8	25.3	18.6	30.1	19.5	66.8
Total Dissolved Solids	mg/L	299	312	283	292	282	285	335	311	253
Turbidity	NTU	5.98	20.7	9.19	9.6	11.5	11.2	16.3	11.8	73.9
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	3.1	1.6	1.4	9	2.5	1.4	5.1	1.3	<1.0
Alkalinity, Bicarbonate (as CaCO3)	mg/L	120	126	-	106	115	115	117	112	93.4
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	2.3
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<1.0
Alkalinity, Total (as CaCO3)	mg/L	120	126	108	106	115	115	117	112	95.6
Ammonia (as N)	mg/L	0.269	0.239	0.182	0.163	0.197	0.131	0.114	0.144	0.0869
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	1.16	0.74	0.55	1.89	0.91	<0.50
Fluoride (F)	mg/L	0.083	0.079	0.077	0.086	0.078	0.081	0.078	0.075	*0.126*
Nitrate (as N)	mg/L	<0.0050	0.0072	0.116	0.114	0.0747	0.191	0.178	0.142	<0.0050
Nitrite (as N)	mg/L	*<0.0010*	0.0035	0.0118	0.0037	0.0045	0.0058	0.0135	0.0379	0.0017
Total Kjeldahl Nitrogen	mg/L	0.294	0.346	0.283	0.237	0.233	0.155	0.238	0.225	0.179
Total Nitrogen	mg/L	0.294	0.357	0.41	0.355	-	0.352	-	0.405	0.181
Orthophosphate - Dissolved (as P)	mg/L	0.0039	0.0032	0.0013	0.0014	<0.0010	<0.0010	<0.0010	0.0014	0.0013
Phosphorus (P)-Total	mg/L	0.0101	0.0304	0.0214	0.0214	0.0183	0.0128	0.0488	0.0194	0.0196
Sulfate (SO4)	mg/L	118	122	109	123	116	120	140	131	104
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	1.35	<0.50	-	2.22	1.02	<0.50	1.87	1.21	0.56
Total Organic Carbon	mg/L	1.2	1.27	1.15	2.35	1.36	1.15	2.33	1.83	1.18

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC11-BJ-4B	MW-BGC11-BJ-5A	MW-BGC11-BJ-5A	MW-BGC11-BJ-5A
	BGC Sample ID	Duplicate	BJ-4B	04B	BJ-4B	DUP1	BJ-4B	Bj-5A	BJ-5A	BJ-5A
	Date Sampled	3-Sep-12	28-Jan-13	8-Apr-13	11-Jul-13	11-Jul-13	25-Sep-13	10-Oct-11	28-Mar-12	26-Jun-12
	Time Sampled	00:00	00:00	00:00	00:00	00:00	9:50	14:12	09:30	09:45
	ALS Sample ID	L1205274-5	L1263921-5	L1288325-4	L1331947-1	L1331947-4	L1370058-4	L1071509-3	L1129695-3	L1171422-5
Field Parameters	**Unit**									
Temperature	°c		1.4	2.32	4.1		3.6			
Temperature (data logger)	°C		1.98	2.09	1.98		4.6	-0.5	-1.23	1.72
Data logger reading date			1/21/2013	4/4/2013	7/9/2013		9/25/2013	10/10/2011	3/28/2012	6/26/2013
pH	pH		7.76	9.84	10.11		10.37			
Electrical conductivity (EC)	uS/cm		520	595	666		238			
Physical Tests	**Unit**									
Temperature	°c	6.5	-	3.8	13	13	12.6	4	2	12
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	560	397	489	529	526	511	249	484	460
Hardness (as CaCO3)	mg/L	8.76	204	13.7	8.1	7.71	7.15	91.5	100	198
pH	pH	*9.87*	8.19	*9.37*	*9.46*	*9.43*	*9.71*	7.96	8.2	8.1
Total Suspended Solids	mg/L	10.8	<3.0	3.2	6.9	7.6	4.7	62.2	5380	4980
Total Dissolved Solids	mg/L	359	264	308	337	329	336	149	323	328
Turbidity	NTU	35.2	1.99	6.87	19.7	21.2	13.1	66.6	>4000	>4000
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	<1.0	2.2	<1.0	<1.0	<1.0	<1.0	2.9	1.1	1.5
Alkalinity, Bicarbonate (as CaCO3)	mg/L	74.5	121	96.7	89.8	97	106	39.5	83.1	-
Alkalinity, Carbonate (as CaCO3)	mg/L	97.5	<2.0	35.5	43.5	46.4	47.4	<2.0	<2.0	-
Alkalinity, Hydroxide (as CaCO3)	mg/L	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	-
Alkalinity, Total (as CaCO3)	mg/L	172	121	132	133	143	154	39.5	83.1	98.8
Ammonia (as N)	mg/L	0.162	0.0558	0.152	0.169	0.174	0.162	0.102	0.283	0.371
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	1.48	1.31	<0.50	1.47	1.47	3.27
Fluoride (F)	mg/L	*0.153*	0.114	*0.14*	*0.137*	*0.133*	*0.13*	*0.152*	*0.221*	*0.194*
Nitrate (as N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0107	0.0057	<0.0050	<0.0050
Nitrite (as N)	mg/L	*<0.0010*	0.0011	0.0034	*<0.0010*	<0.0010	0.0064	0.0011	*<0.0010*	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.202	0.093	0.181	0.192	0.25	0.225	0.294	0.46	0.685
Total Nitrogen	mg/L	0.202	-	0.184	-	-	0.242	0.301	0.46	0.685
Orthophosphate - Dissolved (as P)	mg/L	0.0025	<0.0010	<0.0010	0.0038	0.0035	0.0048	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	0.0078	<0.0020	0.0022	0.0061	0.0068	0.0099	0.0417	0.336	3.59
Sulfate (SO4)	mg/L	109	98.2	114	111	111	113	73.6	155	130
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0050	<0.0010
Cyanide, Total	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0050	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	<0.50	0.6	<0.50	0.71	0.66	0.93	3.13	3.02	-
Total Organic Carbon	mg/L	<0.50	0.55	0.53	0.6	1.16	1.28	3.17	6.13	4.61

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-5B	MW-BGC11-BJ-5B	MW-BGC11-BJ-5B	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A
	BGC Sample ID	BJ-5B	BJ-5B	BJ-5B	BJ-6A	BJ-6A	Duplicate	BJ-6A	BJ-6A	BJ-6A
	Date Sampled	10-Oct-11	28-Mar-12	26-Jun-12	8-Oct-11	30-Mar-12	30-Mar-12	26-Jun-12	3-Sep-12	27-Jan-13
	Time Sampled	13:30	10:10	10:20	14:50	13:25	13:40	11:45	00:00	00:00
	ALS Sample ID	L1071509-2	L1129695-4	L1171422-6	L1071509-4	L1130044-5	L1130044-1	L1171422-7	L1205274-3	L1263921-6
Field Parameters	**Unit**									
Temperature	°c				2	2.17		2.6	3.4	-
Temperature (data logger)	°C	-0.5	-1.23	1.72	2.41	2.41		2.41	2.41	2.41
Data logger reading date		10/10/2011	3/28/2012	6/26/2012	10/8/2011	4/1/2012		6/23/2012	8/31/2012	1/22/2013
pH	pH				7.72	7.96		10.9	10.2	7.96
Electrical conductivity (EC)	uS/cm				403	340		192	360	327
Physical Tests	**Unit**									
Temperature	°c	4	2	12	9	0.1	0.1	12	6.5	-
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	335	338	427	389	347	346	230	212	280
Hardness (as CaCO3)	mg/L	171	145	168	186	178	180	85.3	93.1	138
pH	pH	8.12	8.13	8.05	7.99	8.03	8.05	*9.63*	**8.71**	8.2
Total Suspended Solids	mg/L	34400	6220	3830	717	3460	3990	2580	3050	3410
Total Dissolved Solids	mg/L	255	237	290	255	248	243	171	172	196
Turbidity	NTU	>4000	>4000	>4000	836	>4000	>4000	>4000	>4000	>4000
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	2.4	1.5	1.7	2.8	2.2	1.9	<1.0	<1.0	1.8
Alkalinity, Bicarbonate (as CaCO3)	mg/L	70.8	75.6	-	97.9	96.1	95.3	-	22.7	58.7
Alkalinity, Carbonate (as CaCO3)	mg/L	<1.0	<2.0	-	<2.0	<2.0	<2.0	-	<1.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<1.0	<2.0	-	<2.0	<2.0	<2.0	-	<1.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	70.8	75.6	89.3	97.9	96.1	95.3	27.8	22.7	58.7
Ammonia (as N)	mg/L	0.393	0.121	0.225	0.0208	0.0636	0.0479	0.18	0.156	0.0902
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.76	2.97	4.31	0.67	<0.50	<0.50	0.58	<0.50	<0.50
Fluoride (F)	mg/L	*0.239*	*0.184*	*0.256*	*0.173*	*0.152*	*0.16*	*0.438*	*0.319*	*0.169*
Nitrate (as N)	mg/L	<0.0050	<0.0050	<0.0050	0.0074	<0.0050	<0.0050	<0.0050	0.0071	<0.0050
Nitrite (as N)	mg/L	0.0011	*<0.0010*	<0.0010	0.0011	*<0.0010*	<0.0010	0.0015	0.0014	*<0.0010*
Total Kjeldahl Nitrogen	mg/L	4.4	0.276	1.54	<0.050	1.2	0.254	0.29	1.27	1.26
Total Nitrogen	mg/L	4.4	0.276	1.54	0.0084	1.2	0.254	0.291	1.28	-
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.001	<0.0010	0.0042	0.0061	0.0043
Phosphorus (P)-Total	mg/L	15.7	1.11	2.97	0.492	3.55	3.22	1.8	1.7	0.161
Sulfate (SO4)	mg/L	96.3	89.2	121	96.1	86	84.7	73.8	75.6	81.7
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0050	<0.0050	<0.0010	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0050	<0.0050	<0.0010	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	3.68	0.6	-	3.63	<0.50	<0.50	-	0.82	0.52
Total Organic Carbon	mg/L	38.6	2.21	2.96	4.18	1.14	1.42	0.76	0.94	2.94

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC12-BJ-6B	MW-BGC12-BJ-6B	MW-BGC12-BJ-6B	MW-BGC11-BJ-8A	MW-BGC12-BJ-8A	MW-BGC11-BJ-8A
	BGC Sample ID	06A	BJ-6A	BJ-6A	BJ-6B	BJ-6B	06B	BJ-8A	BJ-8A	BJ-8A
	Date Sampled	7-Apr-13	11-Jul-13	25-Sep-13	3-Sep-12	27-Jan-13	7-Apr-13	28-Jun-12	4-Sep-12	28-Jan-13
	Time Sampled	00:00	00:00	14:00	00:00	00:00	00:00	14:30	00:00	00:00
	ALS Sample ID	L1287525-3	L1331947-2	L1370058-6	L1205274-4	L1263921-7	L1287525-4	L1174115-1	L1207447-3	L1263921-8
Field Parameters	**Unit**									
Temperature	°c	2.3	4.1	3.3	3.5		3.32	3.46	4.92	1.9
Temperature (data logger)	°C	2.41	2.41	4.6	2.52	2.52	2.52	2.19	1.66	1.55
Data logger reading date		4/5/2013	7/9/2013	9/25/2013	8/31/2012	1/22/2013	4/5/2013	7/2/2012	9/5/2012	1/21/2013
pH	pH	8.57	8.83	8.6	10.52	9.24	9.93	8.14	7.26	8.12
Electrical conductivity (EC)	uS/cm	302	453	351	386	523	373	130	246	333
Physical Tests	**Unit**									
Temperature	°c	10	13	12.6	6.5	-	10	-	7.9	-
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	258	284	293	331	333	309	203	200	209
Hardness (as CaCO3)	mg/L	120	126	137	9.83	7.7	9.01	90	85.8	98.2
pH	pH	8.18	8.22	8.14	*9.92*	*9.63*	*9.53*	8.22	8.3	8.24
Total Suspended Solids	mg/L	1340	1010	2770	886	1780	805	212	7.1	114
Total Dissolved Solids	mg/L	184	198	221	426	276	342	145	123	131
Turbidity	NTU	2160	1350	4190	1900	3940	2380	118	4.41	43.6
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.4
Alkalinity, Bicarbonate (as CaCO3)	mg/L	68.6	68.3	67.8	36.2	42.7	57.5	75.9	73.9	74.3
Alkalinity, Carbonate (as CaCO3)	mg/L	<1.0	<2.0	<2.0	56.1	42.8	29.4	<2.0	<1.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<1.0	<2.0	<2.0	<1.0	<1.0	<1.0	<2.0	<1.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	68.6	68.3	67.8	92.3	85.5	86.9	75.9	73.9	74.3
Ammonia (as N)	mg/L	0.084	0.0793	0.0806	0.192	0.156	0.135	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.51	0.5	<0.50	1.27	1.37	1.3	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	*0.184*	*0.169*	*0.149*	*0.243*	*0.252*	*0.233*	0.03	0.031	0.029
Nitrate (as N)	mg/L	<0.0050	<0.0050	<0.0050	0.0101	<0.0050	<0.0050	0.0268	0.0065	0.0072
Nitrite (as N)	mg/L	<0.0010	0.001	*<0.0010*	0.0034	*<0.0010*	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.66	0.838	1.5	0.86	0.219	0.82	<0.050	<0.050	<0.050
Total Nitrogen	mg/L	-	-	1.5	0.88	-	-	0.0268	<0.050	-
Orthophosphate - Dissolved (as P)	mg/L	0.0028	0.0026	0.003	0.0018	<0.0010	0.0017	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	1.33	0.573	2.58	0.264	0.382	0.327	0.104	0.0034	0.0222
Sulfate (SO4)	mg/L	69.2	74.4	85	68.4	72.9	67.9	33.9	31.4	36
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0029	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	<0.50	<0.50	0.8	1.04	1.72	1.02	-	<0.50	<0.50
Total Organic Carbon	mg/L	0.86	1.11	2.34	1.62	3.22	1.71	0.58	0.51	0.72

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC12-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8B	MW-BGC12-BJ-8B	MW-BGC11-BJ-8B	MW-BGC11-BJ-8B
	BGC Sample ID	BJ-DUP1	08A	BJ-8A	BJ-3A	BJ-DUP1	BJ-8B	BJ-8B	BJ-8B	08B
	Date Sampled	28-Jan-13	8-Apr-13	14-Jul-13	26-Sep-13	26-SEP-13	28-Jun-12	4-Sep-12	28-Jan-13	8-Apr-13
	Time Sampled	00:00	00:00	00:00	11:30	00:00	15:30	00:00	00:00	00:00
	ALS Sample ID	L1263921-10	L1288325-1	L1333226-4	L1370207-2	L1370207-4	L1174115-2	L1207447-4	L1263921-9	L1288325-2
Field Parameters	**Unit**									
Temperature	°c		2.23	3.1	2.66		4.9	3.56	1	1.4
Temperature (data logger)	°C		1.55	1.55	2.26		1.76	1.55	1.44	1.55
Data logger reading date			4/6/2013	7/9/2013	9/26/2013		7/2/2012	8/29/2012	1/21/2013	4/6/2013
pH	pH		8.01	8.68	6.67		8.33	8.49	7.74	8.22
Electrical conductivity (EC)	uS/cm		253	341	222		131	242	211	240
Physical Tests	**Unit**									
Temperature	°c	-	3.8	16	8.8	8.8	-	7.9	-	3.8
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	209	213	200	196	196	187	197	200	201
Hardness (as CaCO3)	mg/L	96.1	99.9	91.1	90.8	91.5	64.1	90.8	97.5	99.6
pH	pH	8.22	8.18	8.14	7.02	8.09	8.26	8.25	8.21	8.23
Total Suspended Solids	mg/L	118	15.7	21.7	7.9	8.4	5340	984	193	281
Total Dissolved Solids	mg/L	132	130	127	117	117	142	147	128	133
Turbidity	NTU	43.3	10.8	8.22	3.29	3.11	>4000	969	174	281
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	1.5	1.2	1.8	11	<1.0	<1.0	1	1.6	<1.0
Alkalinity, Bicarbonate (as CaCO3)	mg/L	79.7	76	72.5	74.1	74.8	55.2	72.9	73.2	67.6
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<1.0	<1.0	<2.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<1.0	<1.0	<2.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	79.7	76	72.5	74.1	74.8	55.2	72.9	73.2	67.6
Ammonia (as N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	0.0061	0.008	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.03	0.03	0.027	0.027	0.028	0.061	0.027	0.023	0.03
Nitrate (as N)	mg/L	0.0084	0.0092	0.0191	0.0182	0.018	<0.0050	<0.0050	0.0151	0.0176
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	0.57	0.32	0.082	0.068
Total Nitrogen	mg/L	-	<0.050	-	<0.050	<0.050	0.57	0.32	-	0.086
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0082	0.0012	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	0.0189	0.0058	0.0058	0.0021	<0.0020	1.26	0.33	0.091	0.152
Sulfate (SO4)	mg/L	36	36.6	32	30.1	30.2	40.3	33.3	35.7	37.1
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	<0.50	<0.50
Total Organic Carbon	mg/L	0.56	<0.50	<0.50	<0.50	0.56	8.07	2.5	0.71	0.54

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	MW-BGC12-BJ-8B	MW-BGC11-BJ-8B	MW-BGC12-BJ-12A	MW-BGC12-BJ-12A	MW-BGC11-BJ-12A	Drill Water	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)
	BGC Sample ID	BJ-8B	BJ-8B	BJ-12A	BJ-12A	BJ-12A	DRW	FB	FB	FB
	Date Sampled	14-Jul-13	26-Sep-13	5-Sep-12	15-Jul-13	30-Sep-13	27-Jun-12	30-Mar-12	11-Oct-11	27-Jun-12
	Time Sampled	00:00	8:10	12:40	00:00	16:15	11:00	14:30	9:00	11:40
	ALS Sample ID	L1333226-5	L1370207-3	L1206550-1	L1335562-1	L1372080-1	L1171422-10	L1130044-2	L1071509-8	L1171422-9
Field Parameters	**Unit**									
Temperature	°c	2.6	1.9	3	2.5	1.3				
Temperature (data logger)	°C	1.55	1.76	1.87	1.55	1.55				
Data logger reading date		7/9/2013	9/26/2013	9/1/2012	7/10/2013	9/26/2013				
pH	pH	8.67	7.67	8.17	8.41	8.5				
Electrical conductivity (EC)	uS/cm	188	213	252	540	555				
Physical Tests	**Unit**									
Temperature	°c	16	8.8	-	21	4.9	12	0.1	9	12
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Conductivity	uS/cm	200	194	455	485	557	321	<2.0	<2.0	<2.0
Hardness (as CaCO3)	mg/L	94.3	91.4	220	224	267	97.7	<0.50	<0.50	<0.50
pH	pH	8.12	8.02	8.14	8.06	7.69	7.76	*5.55*	*5.72*	*5.73*
Total Suspended Solids	mg/L	182	17.2	842	183	488	18000	6.4	<3.0	<3.0
Total Dissolved Solids	mg/L	131	121	330	338	400	227	<10	<10	<10
Turbidity	NTU	266	53.1	272	2.4	164	>4000	<0.10	<0.10	<0.10
Anions and Nutrients										
Acidity (as CaCO3)	mg/L	2.4	<1.0	2.3	3.1	8	2.6	1.7	1.3	1.7
Alkalinity, Bicarbonate (as CaCO3)	mg/L	68.2	69.9	81.8	98.8	109	-	<2.0	<2.0	-
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	-
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	-
Alkalinity, Total (as CaCO3)	mg/L	68.2	69.9	81.8	98.8	109	45.3	<2.0	<2.0	<2.0
Ammonia (as N)	mg/L	<0.0050	<0.0050	0.125	0.169	0.152	*0.504*	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	1.07	1.05	0.71	0.85	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.021	0.023	*0.204*	*0.16*	*0.149*	*0.278*	<0.020	<0.020	<0.020
Nitrate (as N)	mg/L	0.0215	0.0196	<0.0050	<0.0050	0.0088	0.0144	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	0.143	<0.050	0.18	0.671	0.592	10.8	0.143	<0.050	<0.050
Total Nitrogen	mg/L	-	<0.050	0.18	0.671	0.601	10.8	0.143	<0.0025	<0.0025
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020
Phosphorus (P)-Total	mg/L	0.093	0.0096	0.465	0.265	0.212	14.4	<0.0020	<0.50	<0.50
Sulfate (SO4)	mg/L	35.1	32	153	159	195	104	<0.50	0	0
Cyanides										
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	-	<0.0010
Cyanide, Total	mg/L	0.0018	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	0	0
Organic/ Inorganic Carbon										
Dissolved Organic Carbon	mg/L	<0.50	<0.50	0.57	1.05	0.63	-	<0.50	<0.50	<0.50
Total Organic Carbon	mg/L	0.66	0.54	4.5	12.3	8.3	7.45	<0.50	0	0

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	BJ-FB	Travel Blank	Travel Blank	Travel Blank
	BGC Sample ID	FB	BJ-FB	FB	BJ-FB	BJ-FB	TRAVEL BLANK	TB	TRAVEL BLANK
	Date Sampled	5-Sep-12	30-Jan-13	8-Apr-13	11-Jul-13	26-SEP-13	27-Jun-12	5-Sep-12	30-Jan-13
	Time Sampled	16:00	00:00	0:00	00:00	00:00	0:00	00:00	00:00
	ALS Sample ID	L1206550-2	L1264492-1	L1288325-5	L1331947-5	L1370207-5	L1171422-11	L1206550-3	L1264492-2
Field Parameters	**Unit**								
Temperature	°c								
Temperature (data logger)	°C								
Data logger reading date									
pH	pH								
Electrical conductivity (EC)	uS/cm								
Physical Tests	**Unit**								
Temperature	°c	-	1.8	3.8	13	8.8	12	-	1.8
Colour, True	CU	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	-	<5.0
Conductivity	uS/cm	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	<2.0
Hardness (as CaCO3)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	<0.50
pH	pH	*5.81*	*5.73*	*5.74*	*5.69*	*6.14*	*6.2*	-	*5.77*
Total Suspended Solids	mg/L	<3.0	<3.0	<3.0	<3.0	<3.0	<3.0	-	<3.0
Total Dissolved Solids	mg/L	<10	<10	<10	<10	<10	<10	-	<10
Turbidity	NTU	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10
Anions and Nutrients									
Acidity (as CaCO3)	mg/L	2.4	2.7	1.1	<1.0	<1.0	3	-	2
Alkalinity, Bicarbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	0	-	<2.0
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	0	-	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	0	-	<2.0
Alkalinity, Total (as CaCO3)	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	-	<2.0
Ammonia (as N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	-	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50
Fluoride (F)	mg/L	<0.020	<1.0	<0.020	<0.020	<0.020	<0.020	-	<0.020
Nitrate (as N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	-	<0.0050
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	-	<0.0010
Total Kjeldahl Nitrogen	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Nitrogen	mg/L	<0.050	-	<0.050	-	<0.050	<0.0025	-	-
Orthophosphate - Dissolved (as P)	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0010	<0.0010	-	<0.0010
Phosphorus (P)-Total	mg/L	<0.50	<0.50	<0.50	<0.50	<0.0020	<0.0020	-	<0.0020
Sulfate (SO4)	mg/L	0	0	0	0	<0.50	<0.50	-	<0.50
Cyanides									
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Total	mg/L	0	0	0	0	<0.0010	<0.0010	<0.0010	<0.0010
Organic/ Inorganic Carbon									
Dissolved Organic Carbon	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	-	<0.50	<0.50
Total Organic Carbon	mg/L	0	0	0	0	<0.50	<0.50	<0.50	<0.50

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-1: Groundwater Analytical Chemistry Results
(Physical Tests, Anions, Nutrients and Cyanide)

	Sample Location	Travel Blank	TRAVEL BLANK
	BGC Sample ID	TRAVEL BLANK	TRAVEL BLANK
	Date Sampled	7-Apr-13	25-SEP-13
	Time Sampled	00:00	00:00
	ALS Sample ID	L1287525-6	L1370058-5
Field Parameters	**Unit**		
Temperature	°c		
Temperature (data logger)	°C		
Data logger reading date			
pH	pH		
Electrical conductivity (EC)	uS/cm		
Physical Tests	**Unit**		
Temperature	°c	10	12.6
Colour, True	CU	<5.0	<5.0
Conductivity	uS/cm	<2.0	<2.0
Hardness (as CaCO3)	mg/L	-	-
pH	pH	*5.59*	*6.17*
Total Suspended Solids	mg/L	<3.0	<3.0
Total Dissolved Solids	mg/L	<10	<10
Turbidity	NTU	<0.10	<0.10
Anions and Nutrients			
Acidity (as CaCO3)	mg/L	1.7	<1.0
Alkalinity, Bicarbonate (as CaCO3)	mg/L	<2.0	<2.0
Alkalinity, Carbonate (as CaCO3)	mg/L	<2.0	<2.0
Alkalinity, Hydroxide (as CaCO3)	mg/L	<2.0	<2.0
Alkalinity, Total (as CaCO3)	mg/L	<2.0	<2.0
Ammonia (as N)	mg/L	<0.0050	<0.0050
Bromide (Br)	mg/L	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50
Fluoride (F)	mg/L	<0.020	<0.020
Nitrate (as N)	mg/L	<0.0050	<0.0050
Nitrite (as N)	mg/L	<0.0010	<0.0010
Total Kjeldahl Nitrogen	mg/L	<0.050	<0.050
Total Nitrogen	mg/L	-	<0.050
Orthophosphate - Dissolved (as P)	mg/L	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	<0.0020	<0.0020
Sulfate (SO4)	mg/L	<0.50	<0.50
Cyanides			
Cyanide, Weak Acid Diss	mg/L	<0.0010	<0.0010
Cyanide, Total	mg/L	<0.0010	<0.0010
Organic/ Inorganic Carbon			
Dissolved Organic Carbon	mg/L	-	-
Total Organic Carbon	mg/L	<0.50	<0.50

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-1A	MW-BGC11-BJ-1B	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A
	BGC Sample ID	BJ-1a	BJ-1B	BJ-2A	BJ-2A	BJ-2A	BJ-2A	BJ-2A
	Date Sampled	10/10/2011	10/10/2011	10/11/2011	3/30/2012	6/26/2012	9/4/2012	1/27/2013
	Time Sampled	9:10	9:40	9:00	11:30	14:10	00:00	00:00
	ALS Sample ID	L1071509-9	L1071509-10	L1071509-7	L1130044-3	L1171422-1	L1207447-5	L1263921-1
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*0.801*	*2.43*	*0.414*	*7.59*	*2.93*	*10.1*	*14.2*
Antimony (Sb)-Total	mg/L	0.00086	0.00136	0.00188	0.00116	0.00218	0.00105	0.00134
Arsenic (As)-Total	mg/L	*0.00559*	*0.0292*	0.00159	*0.0148*	*0.0119*	*0.0161*	*0.0237*
Barium (Ba)-Total	mg/L	0.061	0.114	0.065	0.273	0.153	0.213	0.356
Beryllium (Be)-Total	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.00011	0.00069	0.00095
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	<0.20	<0.20	<0.00050	<0.00050	<0.00050
Boron (B)-Total	mg/L	<0.10	<0.10	<0.10	<0.10	0.023	0.02	0.016
Cadmium (Cd)-Total	mg/L	0.000061	0.000032	0.000021	0.000138	*0.00424*	*0.000359*	*0.000258*
Calcium (Ca)-Total	mg/L	16.8	29.5	34.5	56.1	31.1	42.4	60.2
Chromium (Cr)-Total	mg/L	*0.0013*	*0.0012*	*0.0018*	*0.0153*	*0.105*	*0.0406*	*0.0968*
Cobalt (Co)-Total	mg/L	0.00049	0.00103	<0.00030	0.00366	0.00199	0.0046	0.00759
Copper (Cu)-Total	mg/L	*0.0119*	*0.0047*	*0.0033*	*0.0158*	*0.0232*	*0.0207*	*0.0301*
Iron (Fe)-Total	mg/L	*1.02*	*1.89*	*0.825*	*14.9*	*6*	*16.3*	*21.5*
Lead (Pb)-Total	mg/L	*0.00165*	0.00186	0.00053	0.00467	0.0144	0.00876	0.0115
Lithium (Li)-Total	mg/L	0.0073	0.0817	0.0088	0.0146	0.0357	0.0333	0.0207
Magnesium (Mg)-Total	mg/L	1.19	4.19	1.89	4.81	2.46	4.29	5.91
Manganese (Mn)-Total	mg/L	0.0797	0.129	0.0462	0.429	0.232	0.482	0.647
Mercury (Hg)-Total	mg/L	0.000011	<0.000010	<0.000010	*0.000038*	*0.000048*	*0.000043*	*0.000035*
Molybdenum (Mo)-Total	mg/L	<0.0010	0.0024	0.0047	0.004	0.00333	0.00283	0.0125
Nickel (Ni)-Total	mg/L	0.0012	0.001	<0.0010	0.0031	0.0256	0.0171	0.0493
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	0.31	<0.30	0.32	0.39
Potassium (K)-Total	mg/L	<2.0	3.2	<2.0	2.6	1.15	2.26	3
Selenium (Se)-Total	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.00031	0.00029	0.00026
Silicon (Si)- Total	mg/L	2.06	5.77	2.77	15.2	6.03	17.4	31
Silver (Ag)-Total	mg/L	*0.000105*	0.000073	0.000064	*0.000829*	*0.000569*	*0.0009*	*0.00185*
Sodium (Na)-Total	mg/L	2.6	25.3	5.9	5.7	20.9	13.5	5.4
Strontium (Sr)-Total	mg/L	0.205	0.896	1.33	1.6	1.47	2.04	2.18
Thallium (Tl)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	0.000042	0.0001	0.000204
Tin (Sn)-Total	mg/L	0.00401	0.00169	0.00104	<0.00050	0.00303	0.00132	0.00089
Titanium (Ti)-Total	mg/L	<0.010	0.03	0.013	0.274	0.072	0.09	0.27
Uranium (U)-Total	mg/L	<0.00020	<0.00020	0.00033	0.00058	0.000697	0.00134	0.00178
Vanadium (V)-Total	mg/L	0.0011	0.002	<0.0010	0.0116	0.0049	0.0109	0.0181
Zinc (Zn)-Total	mg/L	*0.0392*	0.0181	0.007	*0.0702*	*0.113*	*0.0592*	*0.174*

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A
	BGC Sample ID	02A	02A_DUP 1	BJ-2A	BJ-2A	BJ-3A	BJ-3A	BJ-3A
	Date Sampled	4/7/2013	4/7/2013	7/13/2013	9/26/2013	10/8/2011	3/28/2012	6/27/2012
	Time Sampled	00:00	00:00	00:00	16:00	16:30	13:15	09:35
	ALS Sample ID	L1287525-1	L1287525-5	L1333226-1	L1370207-1	L1071509-6	L1129695-1	L1171422-2
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*8.77*	*6.91*	*12.8*	*14.2*	*0.523*	*7.15*	*0.977*
Antimony (Sb)-Total	mg/L	0.00099	0.0009	0.00123	0.00127	0.00497	0.00446	0.00201
Arsenic (As)-Total	mg/L	*0.0116*	*0.00956*	*0.0294*	*0.0474*	*0.0242*	*0.0534*	*0.0301*
Barium (Ba)-Total	mg/L	0.219	0.247	0.358	0.417	0.04	0.18	0.0426
Beryllium (Be)-Total	mg/L	0.00051	0.00031	0.00035	0.00046	<0.0010	<0.0010	<0.00010
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.20	<0.20	<0.00050
Boron (B)-Total	mg/L	0.013	0.014	0.014	0.013	<0.10	<0.10	0.039
Cadmium (Cd)-Total	mg/L	0.000138	0.000097	0.000066	0.000089	<0.000017	*0.000257*	0.000024
Calcium (Ca)-Total	mg/L	54.2	51.2	34.9	38.1	51	59.4	31.8
Chromium (Cr)-Total	mg/L	*0.0334*	*0.0236*	*0.0177*	*0.00803*	<0.0010	*0.0033*	0.00046
Cobalt (Co)-Total	mg/L	0.00432	0.00299	0.00334	0.00543	<0.00030	0.00226	0.00022
Copper (Cu)-Total	mg/L	*0.0181*	*0.0116*	*0.0121*	*0.0204*	<0.0010	*0.0091*	0.00105
Iron (Fe)-Total	mg/L	*10.9*	*7.89*	*11.2*	*19.4*	0.067	*7.75*	*0.616*
Lead (Pb)-Total	mg/L	0.00621	0.00373	0.00477	0.00792	<0.00050	0.00931	0.00129
Lithium (Li)-Total	mg/L	0.012	0.0114	0.0147	0.0207	0.045	0.0249	0.0751
Magnesium (Mg)-Total	mg/L	4.38	3.42	3.9	5.54	4.18	5.77	2.64
Manganese (Mn)-Total	mg/L	0.363	0.267	0.533	0.826	0.224	0.64	0.246
Mercury (Hg)-Total	mg/L	<0.000010	0.000025	*0.00012*	*0.000172*	<0.000010	0.000022	<0.000010
Molybdenum (Mo)-Total	mg/L	0.00509	0.004	0.00329	0.00238	0.003	0.0019	0.00244
Nickel (Ni)-Total	mg/L	0.0176	0.0123	0.00896	0.00351	<0.0010	0.002	<0.00050
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	0.49	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	2.28	2.33	4.15	2.11	2.1	3.1	1.78
Selenium (Se)-Total	mg/L	0.00019	0.00016	0.00017	0.00026	<0.0010	<0.0010	<0.00010
Silicon (Si)- Total	mg/L	22.2	20	30.7	33.1	4.27	10.6	4.69
Silver (Ag)-Total	mg/L	*0.00104*	*0.000855*	*0.0011*	*0.00162*	<0.000020	*0.00108*	0.000092
Sodium (Na)-Total	mg/L	5.2	5.3	4	3.9	21	9.6	36.5
Strontium (Sr)-Total	mg/L	1.41	1.14	0.982	0.872	1.48	1.2	1.01
Thallium (Tl)-Total	mg/L	0.000136	0.000112	0.000169	0.000103	<0.00020	0.00023	0.000025
Tin (Sn)-Total	mg/L	0.0005	0.00039	0.00023	0.00018	<0.00050	<0.00050	<0.00010
Titanium (Ti)-Total	mg/L	0.237	0.27	0.369	0.471	<0.010	0.105	0.014
Uranium (U)-Total	mg/L	0.00118	0.000681	0.000627	0.000566	<0.00020	0.00033	0.000242
Vanadium (V)-Total	mg/L	0.012	0.011	0.0207	0.0162	<0.0010	0.0113	0.0013
Zinc (Zn)-Total	mg/L	*0.0401*	0.0291	*0.0354*	*0.055*	<0.0050	0.0291	0.0051

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3B
	BGC Sample ID	BJ-3A	Duplicate	BJ-3A	03A	BJ-3A	BJ-03A	BJ-3B
	Date Sampled	9/4/2012	6/27/2012	1/28/2013	4/7/2013	7/13/2013	9/25/2013	10/8/2011
	Time Sampled	00:00	09:45	00:00	00:00	00:00	17:00	15:45
	ALS Sample ID	L1207447-1	L1171422-8	L1263921-2	L1287525-2	L1333226-2	L1370058-1	L1071509-5
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*3.63*	*3.23*	*11.2*	*1.36*	*1.64*	*22.4*	0.0168
Antimony (Sb)-Total	mg/L	0.0027	0.00234	0.0211	0.0059	0.018	0.0467	0.00114
Arsenic (As)-Total	mg/L	*0.0234*	*0.0325*	*0.0873*	*0.0131*	*0.0156*	*0.128*	*0.0159*
Barium (Ba)-Total	mg/L	0.132	0.0897	0.44	0.0571	0.0643	0.795	0.044
Beryllium (Be)-Total	mg/L	0.00014	0.0001	0.00069	<0.00010	<0.00010	0.00117	<0.0010
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00053	<0.20
Boron (B)-Total	mg/L	0.048	0.038	0.054	0.047	0.039	0.055	<0.10
Cadmium (Cd)-Total	mg/L	0.000133	0.000041	*0.00055*	0.000037	0.000097	*0.00195*	<0.000017
Calcium (Ca)-Total	mg/L	49.4	34.7	65.4	55.9	53.1	67.7	61.5
Chromium (Cr)-Total	mg/L	*0.00163*	0.00054	*0.0185*	*0.00156*	*0.00859*	*0.0199*	<0.0010
Cobalt (Co)-Total	mg/L	0.00104	0.00031	0.00603	0.00043	0.00071	0.0149	<0.00030
Copper (Cu)-Total	mg/L	*0.00505*	0.00133	*0.0349*	0.00267	0.00288	*0.0625*	<0.0010
Iron (Fe)-Total	mg/L	*3.18*	*1.04*	*16.4*	*0.979*	*1.88*	*43.1*	0.055
Lead (Pb)-Total	mg/L	0.00524	0.00149	0.0272	0.00373	0.011	**0.12**	<0.00050
Lithium (Li)-Total	mg/L	0.0384	0.0861	0.0313	0.0195	0.0158	0.0466	0.0128
Magnesium (Mg)-Total	mg/L	4.6	2.92	6.8	4.51	4.13	11.2	3.87
Manganese (Mn)-Total	mg/L	0.367	0.269	1.6	0.215	0.216	1.29	0.419
Mercury (Hg)-Total	mg/L	0.000013	<0.000010	*0.000053*	<0.000010	<0.000010	*0.000119*	<0.000010
Molybdenum (Mo)-Total	mg/L	0.00158	0.00282	0.00395	0.00132	0.0031	0.00499	<0.0010
Nickel (Ni)-Total	mg/L	0.00095	0.00085	0.0114	0.00109	0.00176	0.0118	<0.0010
Phosphorus (P) - Total	mg/L	<0.30	<0.30	0.45	<0.30	<0.30	1.25	<0.30
Potassium (K)-Total	mg/L	2.72	2.28	5.96	1.99	1.86	8.49	<2.0
Selenium (Se)-Total	mg/L	0.00032	<0.00010	*0.00141*	<0.00010	<0.00010	*0.00391*	<0.0010
Silicon (Si)- Total	mg/L	8.17	9.36	25.9	6.39	7.36	65.3	3.57
Silver (Ag)-Total	mg/L	*0.00115*	*0.000154*	*0.00524*	*0.000337*	*0.000523*	*0.0149*	<0.000020
Sodium (Na)-Total	mg/L	15.6	39	10	9.4	8.2	10.4	5.6
Strontium (Sr)-Total	mg/L	1.2	1.09	1.3	1.14	1.12	1.22	1.71
Thallium (Tl)-Total	mg/L	0.000169	0.000054	0.000666	0.000089	0.000249	*0.00196*	<0.00020
Tin (Sn)-Total	mg/L	0.00012	<0.00010	0.00031	<0.00010	<0.00010	0.00044	<0.00050
Titanium (Ti)-Total	mg/L	0.056	0.058	0.256	0.033	0.052	0.566	<0.010
Uranium (U)-Total	mg/L	0.000232	0.000293	0.000532	0.000186	0.000203	0.00086	0.00025
Vanadium (V)-Total	mg/L	0.0053	0.003	0.0173	0.0021	0.0033	0.0341	<0.0010
Zinc (Zn)-Total	mg/L	0.0129	0.0058	*0.0683*	0.0115	*0.0443*	*0.319*	<0.0050

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-4A
	BGC Sample ID	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-4A
	Date Sampled	3/28/2012	6/27/2012	9/4/2012	1/28/2013	7/11/2013	9/25/2013	10/10/2011
	Time Sampled	11:00	10:00	00:00	00:00	00:00	13:30	11:10
	ALS Sample ID	L1129695-2	L1171422-3	L1207447-2	L1263921-3	L1331947-3	L1370058-2	L1071509-1
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*6.72*	*8.47*	*28.3*	*10*	*9.32*	*2.79*	*0.286*
Antimony (Sb)-Total	mg/L	0.00596	0.00388	0.0061	0.0186	0.0114	0.00478	0.0566
Arsenic (As)-Total	mg/L	*0.0568*	*0.0379*	*0.164*	*0.0637*	*0.113*	*0.0338*	*0.0627*
Barium (Ba)-Total	mg/L	0.168	0.339	1.26	0.397	0.408	0.197	0.083
Beryllium (Be)-Total	mg/L	<0.0010	0.00033	0.00171	0.00056	0.00088	0.00023	<0.0010
Bismuth(Bi)- Total	mg/L	<0.20	<0.00050	0.00101	<0.00050	<0.00050	<0.00050	<0.20
Boron (B)-Total	mg/L	<0.10	0.031	0.047	0.04	0.04	0.029	<0.10
Cadmium (Cd)-Total	mg/L	0.000185	*0.000432*	*0.00273*	*0.00049*	*0.000588*	0.000164	0.000033
Calcium (Ca)-Total	mg/L	58.4	68.1	84.1	73.7	75.9	69.6	61
Chromium (Cr)-Total	mg/L	*0.0023*	*0.00266*	*0.0176*	*0.00354*	*0.0045*	*0.0013*	*0.0024*
Cobalt (Co)-Total	mg/L	0.00172	0.00212	0.0127	0.00304	0.00518	0.0012	0.00137
Copper (Cu)-Total	mg/L	*0.0073*	*0.0125*	*0.0825*	*0.0236*	*0.0214*	*0.00523*	0.0027
Iron (Fe)-Total	mg/L	*5.95*	*7.79*	*43*	*7.96*	*15.7*	*3.74*	*0.338*
Lead (Pb)-Total	mg/L	0.00606	0.00614	**0.0888**	*0.0123*	0.0198	0.00518	0.00079
Lithium (Li)-Total	mg/L	0.0104	0.0243	0.0465	0.0199	0.0281	0.0132	0.0383
Magnesium (Mg)-Total	mg/L	4.53	6.69	12	7.43	7.25	4.9	13.2
Manganese (Mn)-Total	mg/L	0.385	0.737	2.26	0.646	1.14	0.422	0.135
Mercury (Hg)-Total	mg/L	0.000012	*0.000031*	*0.000224*	*0.000046*	*0.000072*	0.00002	*0.000543*
Molybdenum (Mo)-Total	mg/L	<0.0010	0.000973	0.00764	0.00218	0.00187	0.000749	0.0033
Nickel (Ni)-Total	mg/L	0.0019	0.00196	0.00973	0.00262	0.00333	0.00109	0.0061
Phosphorus (P) - Total	mg/L	<0.30	0.3	1.56	<0.30	0.54	<0.30	<0.30
Potassium (K)-Total	mg/L	2.1	2.84	9.63	5.26	3.6	1.82	2.6
Selenium (Se)-Total	mg/L	<0.0010	*0.0012*	*0.00546*	*0.00209*	*0.0019*	0.00046	<0.0010
Silicon (Si)- Total	mg/L	8.57	30.3	63.3	25.4	24.2	13.8	3.72
Silver (Ag)-Total	mg/L	*0.000387*	*0.00286*	*0.0281*	*0.00426*	*0.00225*	*0.000405*	0.000047
Sodium (Na)-Total	mg/L	3.2	5.7	7	5	6.6	5.7	18.2
Strontium (Sr)-Total	mg/L	1.04	1.65	1.78	3.03	1.59	1.84	2.74
Thallium (Tl)-Total	mg/L	0.00023	0.000244	*0.00125*	0.000418	0.000383	0.000126	<0.00020
Tin (Sn)-Total	mg/L	<0.00050	0.00016	0.00018	0.00032	0.00032	0.00018	0.00065
Titanium (Ti)-Total	mg/L	0.066	0.28	0.448	0.239	0.145	0.1	0.012
Uranium (U)-Total	mg/L	0.00046	0.000851	0.0021	0.000953	0.000975	0.000724	0.00186
Vanadium (V)-Total	mg/L	0.0105	0.011	0.0393	0.0147	0.0157	0.0048	<0.0010
Zinc (Zn)-Total	mg/L	0.0292	*0.0336*	*0.202*	*0.0407*	*0.0545*	0.0167	0.0131

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A
	BGC Sample ID	BJ-4A	BJ-4A	BJ-4A	BJ-4A	04A	BJ-4A	BJ-4A
	Date Sampled	3/30/2012	6/26/2012	9/3/2012	1/28/2013	4/8/2013	7/13/2013	9/25/2013
	Time Sampled	14:05	14:45	00:00	00:00	00:00	00:00	10:20
	ALS Sample ID	L1130044-4	L1171422-4	L1205274-1	L1263921-4	L1288325-3	L1333226-3	L1370058-3
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*0.792*	*0.62*	*0.243*	*0.592*	*0.419*	*0.332*	*0.297*
Antimony (Sb)-Total	mg/L	0.00853	0.00474	0.00354	0.0017	0.00332	0.00411	0.00314
Arsenic (As)-Total	mg/L	*0.0312*	*0.0214*	*0.0225*	*0.0209*	*0.0164*	*0.0189*	*0.0155*
Barium (Ba)-Total	mg/L	0.066	0.0487	0.0574	0.0473	0.0978	0.0547	0.0467
Beryllium (Be)-Total	mg/L	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Total	mg/L	<0.20	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Total	mg/L	<0.10	0.069	0.07	0.069	0.064	0.07	0.066
Cadmium (Cd)-Total	mg/L	0.000026	0.000015	0.00004	0.000025	0.000043	0.000054	0.000019
Calcium (Ca)-Total	mg/L	60.3	52.2	51.5	62.4	58.1	56.5	50.3
Chromium (Cr)-Total	mg/L	*0.0032*	*0.00113*	0.00075	0.0007	*0.00113*	*0.00118*	0.001
Cobalt (Co)-Total	mg/L	0.00069	0.00064	0.0007	0.00096	0.00082	0.00123	0.00078
Copper (Cu)-Total	mg/L	0.0011	0.00101	0.0017	0.001	0.00166	0.00179	0.00149
Iron (Fe)-Total	mg/L	*0.821*	*0.407*	*0.386*	*0.363*	*0.383*	*0.63*	*0.486*
Lead (Pb)-Total	mg/L	0.00105	0.000506	0.000528	0.000716	0.000753	0.00118	0.00071
Lithium (Li)-Total	mg/L	0.0312	0.0343	0.0298	0.028	0.0281	0.0292	0.0325
Magnesium (Mg)-Total	mg/L	14.1	11.8	11.6	13.3	11.5	11.8	11.4
Manganese (Mn)-Total	mg/L	0.147	0.106	0.114	0.171	0.102	0.141	0.099
Mercury (Hg)-Total	mg/L	0.000023	0.000011	<0.000010	<0.000010	<0.000010	0.000014	<0.000010
Molybdenum (Mo)-Total	mg/L	0.0021	0.00132	0.00135	0.00102	0.000983	0.00206	0.00104
Nickel (Ni)-Total	mg/L	0.0011	0.00067	0.00084	0.00063	0.00074	0.00085	0.00057
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	2.2	1.84	1.62	1.94	1.7	1.66	1.62
Selenium (Se)-Total	mg/L	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silicon (Si)- Total	mg/L	4.97	4.65	3.33	4.42	4.02	3.59	3.45
Silver (Ag)-Total	mg/L	<0.000020	0.000017	0.000031	0.000018	0.000019	0.000074	0.000032
Sodium (Na)-Total	mg/L	18	18.1	21	18.4	17.9	27.6	21.8
Strontium (Sr)-Total	mg/L	3.03	2.65	2.59	3.05	2.87	2.84	2.58
Thallium (Tl)-Total	mg/L	<0.00020	0.00003	0.000021	0.000028	0.000027	0.000027	0.000021
Tin (Sn)-Total	mg/L	<0.00050	0.00023	0.00033	0.00018	0.00023	0.00033	0.00036
Titanium (Ti)-Total	mg/L	0.025	0.025	0.014	0.021	0.017	0.016	0.011
Uranium (U)-Total	mg/L	0.00495	0.00277	0.00292	0.00235	0.00209	0.00485	0.00217
Vanadium (V)-Total	mg/L	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Total	mg/L	0.0067	0.0037	0.0071	0.0058	0.0072	0.0084	0.007

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC11-BJ-4B
	BGC Sample ID	BJ-4B	Duplicate	BJ-4B	04B	BJ-4B	DUP1	BJ-4B
	Date Sampled	9/3/2012	9/3/2012	1/28/2013	4/8/2013	7/11/2013	7/11/2013	9/25/2013
	Time Sampled	00:00	00:00	00:00	00:00	00:00	00:00	9:50
	ALS Sample ID	L1205274-2	L1205274-5	L1263921-5	L1288325-4	L1331947-1	L1331947-4	L1370058-4
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*1.12*	*0.802*	0.0555	*0.571*	*1.49*	*1.25*	*0.578*
Antimony (Sb)-Total	mg/L	0.00374	0.00396	0.00061	0.00115	0.0007	0.00066	0.00059
Arsenic (As)-Total	mg/L	*0.0143*	*0.0134*	0.00372	*0.0169*	*0.0129*	*0.0127*	*0.0115*
Barium (Ba)-Total	mg/L	0.0623	0.0578	0.0221	0.0222	0.0423	0.0369	0.0289
Beryllium (Be)-Total	mg/L	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Total	mg/L	0.054	0.046	0.021	0.057	0.069	0.062	0.065
Cadmium (Cd)-Total	mg/L	0.000011	0.000012	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Calcium (Ca)-Total	mg/L	22.8	29.5	74.2	7.06	2.94	2.74	2.58
Chromium (Cr)-Total	mg/L	*0.0122*	*0.011*	0.00073	*0.00179*	*0.00216*	*0.00189*	*0.00218*
Cobalt (Co)-Total	mg/L	0.00022	0.00026	0.00013	<0.00010	<0.00010	<0.00010	0.00016
Copper (Cu)-Total	mg/L	*0.00489*	*0.00666*	0.00075	0.00081	0.0009	<0.00050	0.00054
Iron (Fe)-Total	mg/L	*0.57*	*0.517*	<0.030	0.073	0.15	0.146	0.124
Lead (Pb)-Total	mg/L	0.00117	*0.00155*	0.000085	0.000164	0.000279	0.000232	0.000188
Lithium (Li)-Total	mg/L	0.176	0.156	0.0198	0.221	0.23	0.227	0.219
Magnesium (Mg)-Total	mg/L	2.21	2.9	7.77	0.932	0.511	0.466	0.342
Manganese (Mn)-Total	mg/L	0.0467	0.0591	0.0599	0.00665	0.012	0.0112	0.0109
Mercury (Hg)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Total	mg/L	0.00155	0.0017	0.00049	0.000956	0.00102	0.000946	0.000993
Nickel (Ni)-Total	mg/L	0.00592	0.00567	0.0008	0.00086	0.00079	0.00065	0.00096
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	1.71	1.62	0.967	0.969	1.35	1.21	0.934
Selenium (Se)-Total	mg/L	<0.00010	0.0001	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silicon (Si)- Total	mg/L	6.15	5.06	2.48	4.41	6.13	6.29	5.66
Silver (Ag)-Total	mg/L	0.000073	0.000095	0.000074	*0.000188*	0.000037	0.000031	0.000092
Sodium (Na)-Total	mg/L	86.2	72	7.9	111	116	115	113
Strontium (Sr)-Total	mg/L	0.437	0.491	1.05	0.146	0.112	0.0971	0.103
Thallium (Tl)-Total	mg/L	0.000044	0.00004	0.000013	0.00002	0.000042	0.000036	0.000019
Tin (Sn)-Total	mg/L	0.00035	0.00043	0.0002	0.00024	0.00014	<0.00010	0.00011
Titanium (Ti)-Total	mg/L	0.014	<0.010	<0.010	<0.010	0.011	0.01	<0.010
Uranium (U)-Total	mg/L	0.00121	0.00156	0.0008	0.000152	0.00014	0.000128	0.000128
Vanadium (V)-Total	mg/L	0.0019	0.0014	<0.0010	0.0011	0.0024	0.0022	0.001
Zinc (Zn)-Total	mg/L	0.0077	0.0098	0.0264	<0.0030	0.0041	0.0032	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-5A	MW-BGC11-BJ-5A	MW-BGC11-BJ-5A	MW-BGC11-BJ-5B	MW-BGC11-BJ-5B	MW-BGC11-BJ-5B	MW-BGC11-BJ-6A
	BGC Sample ID	Bj-5A	BJ-5A	BJ-5A	BJ-5B	BJ-5B	BJ-5B	BJ-6A
	Date Sampled	10/10/2011	3/28/2012	6/26/2012	10/10/2011	3/28/2012	6/26/2012	10/8/2011
	Time Sampled	14:12	09:30	09:45	13:30	10:10	10:20	14:50
	ALS Sample ID	L1071509-3	L1129695-3	L1171422-5	L1071509-2	L1129695-4	L1171422-6	L1071509-4
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*1.04*	*52.5*	*32.1*	*240*	*158*	*38.3*	*4.9*
Antimony (Sb)-Total	mg/L	0.00319	0.0029	0.0122	<0.010	0.013	0.0128	0.0075
Arsenic (As)-Total	mg/L	*0.0126*	*0.311*	*0.798*	*5.04*	*3.52*	*0.937*	*0.0465*
Barium (Ba)-Total	mg/L	0.072	0.76	1.37	6.33	3.44	2.08	0.331
Beryllium (Be)-Total	mg/L	<0.0010	0.0091	0.00345	<0.020	<0.020	0.00253	<0.0010
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	0.0024	<0.20	<0.20	0.0016	<0.20
Boron (B)-Total	mg/L	<0.10	0.11	0.065	0.25	0.15	0.059	<0.10
Cadmium (Cd)-Total	mg/L	*0.00023*	*0.0021*	*0.00809*	*0.0109*	*0.00641*	*0.0113*	*0.00229*
Calcium (Ca)-Total	mg/L	32.4	164	162	620	460	171	75.7
Chromium (Cr)-Total	mg/L	*0.002*	*0.0264*	*0.0481*	*0.241*	*0.146*	*0.0673*	*0.0024*
Cobalt (Co)-Total	mg/L	0.00435	0.0239	0.0337	0.202	0.152	0.038	0.00423
Copper (Cu)-Total	mg/L	*0.0091*	*0.12*	*0.198*	**1.52**	**1.04**	*0.294*	*0.0658*
Iron (Fe)-Total	mg/L	*1.5*	*54.8*	*82.3*	*460*	*344*	*92.6*	*6.9*
Lead (Pb)-Total	mg/L	0.00245	**0.121**	*0.139*	**0.518**	**0.267**	**0.127**	*0.13*
Lithium (Li)-Total	mg/L	0.0229	0.111	0.1	0.3	0.22	0.0794	0.0058
Magnesium (Mg)-Total	mg/L	3.6	24.5	21.8	118	94.3	21.9	4.9
Manganese (Mn)-Total	mg/L	0.654	1.94	3.8	24.4	17.9	5.06	1.15
Mercury (Hg)-Total	mg/L	<0.000010	*0.000124*	<0.00010	*0.0015*	*0.000351*	<0.00010	*0.00062*
Molybdenum (Mo)-Total	mg/L	0.0063	0.0058	0.0172	0.03	<0.020	0.0254	<0.0010
Nickel (Ni)-Total	mg/L	0.0038	0.0422	0.0749	*0.357*	*0.251*	0.0755	0.0048
Phosphorus (P) - Total	mg/L	<0.30	1.51	2.22	12.5	9.74	2.51	0.64
Potassium (K)-Total	mg/L	3.3	13.8	15.8	74.8	48.1	16.3	4.8
Selenium (Se)-Total	mg/L	<0.0010	<0.0050	*0.00594*	<0.020	<0.020	*0.00759*	<0.0010
Silicon (Si)- Total	mg/L	4.92	84.5	57.8	228	134	60.4	11.1
Silver (Ag)-Total	mg/L	*0.000524*	*0.0189*	*0.0412*	*0.244*	*0.136*	*0.0567*	*0.00238*
Sodium (Na)-Total	mg/L	12.4	62.5	29.9	14.3	11.1	15	2.3
Strontium (Sr)-Total	mg/L	0.842	4.65	3.47	3.83	4.33	2.35	1.01
Thallium (Tl)-Total	mg/L	<0.00020	*0.0018*	*0.00407*	*0.0105*	*0.0091*	*0.00329*	<0.00020
Tin (Sn)-Total	mg/L	0.00193	<0.0025	0.00066	<0.010	<0.010	0.00043	0.0006
Titanium (Ti)-Total	mg/L	0.02	0.075	0.143	0.335	0.228	0.188	0.106
Uranium (U)-Total	mg/L	0.00028	*0.0175*	0.00561	*0.0526*	0.0132	0.00393	0.00055
Vanadium (V)-Total	mg/L	0.0015	0.039	0.0478	0.341	0.221	0.0598	0.0074
Zinc (Zn)-Total	mg/L	*0.0317*	*0.321*	*0.461*	*1.63*	*1.27*	*0.5*	*0.55*

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A
	BGC Sample ID	BJ-6A	Duplicate	BJ-6A	BJ-6A	BJ-6A	06A	BJ-6A
	Date Sampled	3/30/2012	3/30/2012	6/26/2012	9/3/2012	1/27/2013	4/7/2013	7/11/2013
	Time Sampled	13:25	13:40	11:45	00:00	00:00	00:00	00:00
	ALS Sample ID	L1130044-5	L1130044-1	L1171422-7	L1205274-3	L1263921-6	L1287525-3	L1331947-2
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*44.8*	*44.7*	*28.1*	*29.6*	*40.2*	*24.3*	*15.8*
Antimony (Sb)-Total	mg/L	0.0207	0.0243	0.0131	0.0137	0.0166	0.0122	0.0087
Arsenic (As)-Total	mg/L	*0.643*	*0.72*	*0.331*	*0.36*	*0.437*	*0.173*	*0.12*
Barium (Ba)-Total	mg/L	33.1	34.3	18.8	20.9	24.8	13.3	4.1
Beryllium (Be)-Total	mg/L	<0.010	<0.010	0.00254	0.00359	0.00462	0.00188	0.00136
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	<0.0010	<0.0010	<0.0025	<0.0010	<0.00050
Boron (B)-Total	mg/L	<0.10	<0.10	0.03	0.034	<0.050	0.039	0.028
Cadmium (Cd)-Total	mg/L	*0.00145*	*0.00232*	*0.00194*	*0.0014*	*0.00216*	*0.000874*	*0.000702*
Calcium (Ca)-Total	mg/L	77	80.6	98.2	86.4	114	63.4	60
Chromium (Cr)-Total	mg/L	*0.019*	*0.018*	*0.0157*	*0.0184*	*0.0235*	*0.0106*	*0.00831*
Cobalt (Co)-Total	mg/L	0.0269	0.0337	0.0141	0.0154	0.0211	0.00865	0.00602
Copper (Cu)-Total	mg/L	*0.165*	*0.185*	*0.105*	*0.113*	*0.166*	*0.0646*	*0.0523*
Iron (Fe)-Total	mg/L	*95.3*	*110*	*46.3*	*55.6*	*74.7*	*30.1*	*18.9*
Lead (Pb)-Total	mg/L	**0.283**	**0.351**	**0.165**	**0.188**	**0.224**	**0.0896**	**0.0672**
Lithium (Li)-Total	mg/L	0.054	<0.050	0.0251	0.038	0.0483	0.0236	0.0178
Magnesium (Mg)-Total	mg/L	22	20	8.03	12.6	16.8	9	7.35
Manganese (Mn)-Total	mg/L	3.49	4.51	2.23	2.1	2.78	1.07	0.731
Mercury (Hg)-Total	mg/L	*0.0011*	*0.00111*	*0.00057*	*0.00046*	*0.00087*	*0.00024*	*0.00013*
Molybdenum (Mo)-Total	mg/L	<0.010	<0.010	0.0193	0.0108	0.00741	0.00407	0.00316
Nickel (Ni)-Total	mg/L	0.027	0.029	0.0141	0.0176	0.0222	0.009	0.00702
Phosphorus (P) - Total	mg/L	2.72	3.21	1.74	1.81	2.42	0.96	0.74
Potassium (K)-Total	mg/L	11.6	10.8	11.9	8.96	11.9	9.8	5.8
Selenium (Se)-Total	mg/L	<0.010	<0.010	*0.0025*	*0.00248*	*0.00314*	*0.00116*	0.00087
Silicon (Si)- Total	mg/L	53.9	51.3	49.7	63	61.2	76.8	59.8
Silver (Ag)-Total	mg/L	*0.0189*	*0.0245*	*0.0242*	*0.0211*	*0.0256*	*0.0117*	*0.00574*
Sodium (Na)-Total	mg/L	3.6	3.2	6.3	6.7	6.4	6.9	6.7
Strontium (Sr)-Total	mg/L	3.01	2.86	2.18	2.62	3.34	2.42	2.28
Thallium (Tl)-Total	mg/L	<0.0020	<0.0020	*0.000829*	0.000697	*0.000936*	0.000573	0.000377
Tin (Sn)-Total	mg/L	<0.0050	<0.0050	0.0006	0.00072	0.00142	0.00075	0.00072
Titanium (Ti)-Total	mg/L	0.539	0.545	0.441	0.515	0.522	0.841	0.66
Uranium (U)-Total	mg/L	<0.0020	<0.0020	0.000839	0.0011	0.0018	0.00105	0.00118
Vanadium (V)-Total	mg/L	0.078	0.078	0.049	0.0496	0.0656	0.0384	0.0211
Zinc (Zn)-Total	mg/L	*1.19*	*1.26*	*0.539*	*0.651*	*0.905*	*0.354*	*0.302*

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-6A	MW-BGC12-BJ-6B	MW-BGC12-BJ-6B	MW-BGC12-BJ-6B	MW-BGC11-BJ-8A	MW-BGC12-BJ-8A	MW-BGC11-BJ-8A
	BGC Sample ID	BJ-6A	BJ-6B	BJ-6B	06B	BJ-8A	BJ-8A	BJ-8A
	Date Sampled	9/25/2013	9/3/2012	1/27/2013	4/7/2013	6/28/2012	9/4/2012	1/28/2013
	Time Sampled	14:00	00:00	00:00	00:00	14:30	00:00	00:00
	ALS Sample ID	L1370058-6	L1205274-4	L1263921-7	L1287525-4	L1174115-1	L1207447-3	L1263921-8
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*28.2*	*16.7*	*23.9*	*22.9*	*5.14*	*0.785*	*3.91*
Antimony (Sb)-Total	mg/L	0.0119	0.00706	0.00628	0.00559	0.00156	0.00098	0.00074
Arsenic (As)-Total	mg/L	*0.21*	*0.0457*	*0.0592*	*0.042*	*0.0315*	*0.00761*	*0.00843*
Barium (Ba)-Total	mg/L	13.8	0.557	0.809	0.707	0.101	0.022	0.042
Beryllium (Be)-Total	mg/L	0.00307	0.00227	0.00295	0.00197	0.00044	<0.00010	0.00073
Bismuth(Bi)- Total	mg/L	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Total	mg/L	0.031	0.155	0.162	0.152	0.014	0.011	0.014
Cadmium (Cd)-Total	mg/L	*0.000546*	*0.00023*	*0.000335*	*0.000215*	*0.000235*	0.000014	0.000037
Calcium (Ca)-Total	mg/L	67	6.66	8.93	6.77	41.4	27	34.1
Chromium (Cr)-Total	mg/L	*0.0144*	*0.00826*	*0.0143*	*0.0094*	*0.00459*	0.00027	*0.00672*
Cobalt (Co)-Total	mg/L	0.0117	0.00841	0.0122	0.00835	0.00155	<0.00010	0.00057
Copper (Cu)-Total	mg/L	*0.0828*	*0.0662*	*0.101*	*0.0592*	*0.00741*	<0.00050	*0.0183*
Iron (Fe)-Total	mg/L	*40.1*	*25.1*	*36.4*	*24.6*	*4.97*	0.183	*1.3*
Lead (Pb)-Total	mg/L	**0.132**	*0.179*	*0.228*	*0.147*	0.00752	0.000447	0.00299
Lithium (Li)-Total	mg/L	0.0348	0.175	0.188	0.159	0.0114	0.00821	0.0103
Magnesium (Mg)-Total	mg/L	14	7.93	10.2	7.17	6.89	5.03	6.42
Manganese (Mn)-Total	mg/L	1.08	0.84	1.24	0.822	0.282	0.01	0.0421
Mercury (Hg)-Total	mg/L	*0.000338*	*0.000099*	*0.00025*	*0.000123*	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Total	mg/L	0.00366	0.00508	0.0045	0.0038	0.00261	0.00159	0.00197
Nickel (Ni)-Total	mg/L	0.014	0.00924	0.0143	0.00953	0.00116	<0.00050	0.00423
Phosphorus (P) - Total	mg/L	1.05	<0.30	0.48	0.32	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	8.92	6.74	8.43	8.98	1.88	0.606	0.99
Selenium (Se)-Total	mg/L	*0.00162*	*0.00143*	*0.00171*	0.00081	0.00023	0.00018	0.00019
Silicon (Si)- Total	mg/L	86.6	43	40.6	77.8	13.6	3.31	12.8
Silver (Ag)-Total	mg/L	*0.00935*	*0.00764*	*0.0107*	*0.00677*	*0.000223*	0.000021	*0.000209*
Sodium (Na)-Total	mg/L	6	67.8	67.6	67.7	6	7	6.8
Strontium (Sr)-Total	mg/L	2.76	0.348	0.394	0.315	0.762	0.627	0.724
Thallium (Tl)-Total	mg/L	0.000683	0.00035	0.00048	0.00052	0.000132	<0.000010	0.000059
Tin (Sn)-Total	mg/L	0.00056	0.00015	0.00062	0.00039	0.00047	0.00029	0.00039
Titanium (Ti)-Total	mg/L	0.871	0.223	0.198	0.689	0.051	<0.010	0.049
Uranium (U)-Total	mg/L	0.00108	0.000504	0.00067	0.000532	0.00119	0.000367	0.00111
Vanadium (V)-Total	mg/L	0.047	0.0304	0.0429	0.0406	0.0048	<0.0010	0.0023
Zinc (Zn)-Total	mg/L	*0.502*	*0.384*	*0.549*	*0.349*	*0.0337*	<0.0030	0.014

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC12-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8B	MW-BGC12-BJ-8B
	BGC Sample ID	BJ-DUP1	08A	BJ-8A	BJ-3A	BJ-DUP1	BJ-8B	BJ-8B
	Date Sampled	1/28/2013	4/8/2013	7/14/2013	9/26/2013	26-SEP-13	6/28/2012	9/4/2012
	Time Sampled	00:00	00:00	00:00	11:30	00:00	15:30	00:00
	ALS Sample ID	L1263921-10	L1288325-1	L1333226-4	L1370207-2	L1370207-4	L1174115-2	L1207447-4
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*3.51*	*0.868*	*0.91*	*0.298*	*0.369*	*50.4*	*17.1*
Antimony (Sb)-Total	mg/L	0.0007	0.00081	0.00088	0.00082	0.00088	0.00251	0.00271
Arsenic (As)-Total	mg/L	*0.00823*	*0.00736*	*0.00868*	*0.00887*	*0.00873*	*0.525*	*0.344*
Barium (Ba)-Total	mg/L	0.0411	0.0264	0.0265	0.0212	0.0223	0.91	0.494
Beryllium (Be)-Total	mg/L	0.00059	<0.00010	<0.00010	<0.00010	<0.00010	0.00732	0.00156
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.0016	<0.00050
Boron (B)-Total	mg/L	0.014	0.012	0.011	0.011	0.011	0.044	0.019
Cadmium (Cd)-Total	mg/L	0.000035	0.000015	0.000018	0.000012	0.000012	*0.000601*	*0.000177*
Calcium (Ca)-Total	mg/L	34.8	32	28.9	26.3	27.8	118	50.1
Chromium (Cr)-Total	mg/L	*0.00664*	*0.00112*	0.00068	0.00019	0.00024	*0.0281*	*0.0068*
Cobalt (Co)-Total	mg/L	0.00054	0.00016	0.00016	<0.00010	<0.00010	0.0334	0.0178
Copper (Cu)-Total	mg/L	*0.0131*	*0.0025*	0.00053	<0.00050	<0.00050	*0.104*	*0.0362*
Iron (Fe)-Total	mg/L	*1.12*	*0.33*	*0.339*	0.092	0.153	*52.2*	*25.3*
Lead (Pb)-Total	mg/L	0.00248	0.000485	0.000614	0.000127	0.000263	**0.0699**	0.0204
Lithium (Li)-Total	mg/L	0.0104	0.0114	0.00901	0.00903	0.00937	0.0531	0.0232
Magnesium (Mg)-Total	mg/L	6.25	5.63	5.51	5.86	5.74	19.4	10.2
Manganese (Mn)-Total	mg/L	0.0394	0.0246	0.0171	0.0049	0.00746	3.22	2.04
Mercury (Hg)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	*0.00048*	*0.000136*
Molybdenum (Mo)-Total	mg/L	0.00203	0.00169	0.00143	0.00131	0.00143	0.0015	0.00165
Nickel (Ni)-Total	mg/L	0.00418	0.00077	<0.00050	<0.00050	<0.00050	0.0212	0.00698
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	0.88	0.36
Potassium (K)-Total	mg/L	0.946	0.586	0.558	0.494	0.493	7.9	4.05
Selenium (Se)-Total	mg/L	0.0002	0.00017	0.00016	0.00017	0.00015	0.00061	0.00039
Silicon (Si)- Total	mg/L	11.3	4.88	5.22	3.24	3.67	84.7	40.5
Silver (Ag)-Total	mg/L	*0.000296*	0.000075	0.000022	<0.000010	<0.000010	*0.00161*	*0.000455*
Sodium (Na)-Total	mg/L	6.6	5.2	4.2	4.2	4	13.2	3.3
Strontium (Sr)-Total	mg/L	0.715	0.747	0.745	0.632	0.695	0.96	0.585
Thallium (Tl)-Total	mg/L	0.000048	0.000014	0.000014	<0.000010	<0.000010	*0.000912*	0.000404
Tin (Sn)-Total	mg/L	0.00034	0.00012	<0.00010	<0.00010	<0.00010	0.00134	0.00029
Titanium (Ti)-Total	mg/L	0.043	0.018	0.023	0.01	0.012	0.093	0.201
Uranium (U)-Total	mg/L	0.000972	0.00036	0.000323	0.000202	0.00024	0.0116	0.00207
Vanadium (V)-Total	mg/L	0.0021	<0.0010	<0.0010	<0.0010	<0.0010	0.049	0.0241
Zinc (Zn)-Total	mg/L	0.0195	0.0041	0.0041	<0.0030	0.0033	*0.358*	*0.0876*

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	MW-BGC11-BJ-8B	MW-BGC11-BJ-8B	MW-BGC12-BJ-8B	MW-BGC11-BJ-8B	MW-BGC12-BJ-12A	MW-BGC12-BJ-12A	MW-BGC11-BJ-12A
	BGC Sample ID	BJ-8B	08B	41469	41543	41157	41470	41547
	Date Sampled	1/28/2013	4/8/2013	00:00	1/0/1900	12:40	00:00	1/0/1900
	Time Sampled	00:00	00:00	L1333226-5	L1370207-3	L1206550-1	L1335562-1	L1372080-1
	ALS Sample ID	L1263921-9	L1288325-2	0	Water	Water	0	Water
Total Metals	**Unit**							
Aluminum (Al)-Total	mg/L	*7.02*	*12.7*	*12.2*	*2.83*	*5.93*	*1.48*	*4.39*
Antimony (Sb)-Total	mg/L	0.00176	0.0017	0.00181	0.00097	0.00716	0.00501	0.00318
Arsenic (As)-Total	mg/L	*0.0692*	*0.0671*	*0.0818*	*0.0301*	*0.326*	*0.192*	*0.0825*
Barium (Ba)-Total	mg/L	0.16	0.186	0.282	0.0789	0.641	0.3	0.234
Beryllium (Be)-Total	mg/L	0.00031	0.00028	0.00017	<0.00010	0.00057	<0.00010	0.0005
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	0.00056	<0.00050	<0.00050
Boron (B)-Total	mg/L	0.012	0.014	<0.010	<0.010	0.02	0.021	0.026
Cadmium (Cd)-Total	mg/L	0.00004	0.000042	0.000033	<0.000010	*0.00108*	0.00029	*0.000521*
Calcium (Ca)-Total	mg/L	39	33.6	32.3	30.3	87.7	74.5	95.3
Chromium (Cr)-Total	mg/L	*0.0156*	*0.0138*	*0.0023*	0.0008	*0.00853*	*0.158*	*0.0285*
Cobalt (Co)-Total	mg/L	0.00328	0.00333	0.00298	0.00056	0.00662	0.0022	0.00255
Copper (Cu)-Total	mg/L	*0.00979*	*0.00909*	*0.00771*	0.00179	*0.0246*	*0.0139*	*0.0155*
Iron (Fe)-Total	mg/L	*5.06*	*5.32*	*6.82*	*1.41*	*23.7*	*8.02*	*5.36*
Lead (Pb)-Total	mg/L	0.00419	0.00389	0.00573	0.00104	*0.0458*	*0.047*	*0.0213*
Lithium (Li)-Total	mg/L	0.00959	0.00846	0.00958	0.00663	0.00837	0.0107	0.0156
Magnesium (Mg)-Total	mg/L	5.28	5.69	4.81	4.08	11.5	10.5	14
Manganese (Mn)-Total	mg/L	0.29	0.29	0.334	0.0608	0.554	0.366	0.434
Mercury (Hg)-Total	mg/L	*0.00004*	<0.000010	*0.000056*	<0.000010	0.000011	<0.000010	0.000012
Molybdenum (Mo)-Total	mg/L	0.00306	0.00311	0.00185	0.00161	0.00385	0.00524	0.00279
Nickel (Ni)-Total	mg/L	0.00866	0.00888	0.00246	0.00051	0.00419	0.0592	0.013
Phosphorus (P) - Total	mg/L	<0.30	<0.30	<0.30	<0.30	0.46	<0.30	<0.30
Potassium (K)-Total	mg/L	3.07	3.14	2.09	1.28	7.68	5.33	5.28
Selenium (Se)-Total	mg/L	0.00028	0.00027	0.00028	0.00022	*0.00241*	0.0007	0.00031
Silicon (Si)- Total	mg/L	15.6	22.1	23.4	6.86	15.2	6.08	13.8
Silver (Ag)-Total	mg/L	*0.000772*	*0.00089*	*0.000231*	0.000036	*0.00464*	*0.00165*	*0.000871*
Sodium (Na)-Total	mg/L	2.6	2.7	2.8	2.5	5.7	6.4	9.2
Strontium (Sr)-Total	mg/L	0.492	0.564	0.462	0.432	1.24	1.41	1.87
Thallium (Tl)-Total	mg/L	0.00017	0.000158	0.00012	0.000045	0.000782	0.000146	0.000236
Tin (Sn)-Total	mg/L	0.00065	0.00029	0.00034	<0.00010	0.00046	0.00283	0.0014
Titanium (Ti)-Total	mg/L	0.121	0.175	0.189	0.047	0.041	0.041	0.054
Uranium (U)-Total	mg/L	0.000516	0.000399	0.000234	0.00018	0.00449	0.000545	0.00164
Vanadium (V)-Total	mg/L	0.0112	0.0117	0.0081	0.0033	0.0042	0.0024	0.0029
Zinc (Zn)-Total	mg/L	*0.0311*	0.0267	*0.0339*	0.0082	*0.171*	*0.0474*	*0.0608*

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	Drill Water	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)
	BGC Sample ID	41087	40998	FB	FB	FB	BJ-FB
	Date Sampled	11:00	14:30	10/11/2011	6/27/2012	9/5/2012	1/30/2013
	Time Sampled	L1171422-10	L1130044-2	9:00	11:40	16:00	00:00
	ALS Sample ID	Water	Water	L1071509-8	L1171422-9	L1206550-2	L1264492-1
Total Metals	**Unit**						
Aluminum (Al)-Total	mg/L	*338*	<0.0050	<0.00050	<0.00010	<0.00010	<0.00010
Antimony (Sb)-Total	mg/L	0.0119	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010
Arsenic (As)-Total	mg/L	*17.1*	<0.00050	<0.020	<0.000050	<0.000050	<0.000050
Barium (Ba)-Total	mg/L	2.91	<0.020	<0.0010	<0.00010	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	0.033	<0.0010	<0.20	<0.00050	<0.00050	<0.00050
Bismuth(Bi)- Total	mg/L	0.015	<0.20	<0.10	<0.010	<0.010	<0.010
Boron (B)-Total	mg/L	<0.20	<0.10	<0.000017	<0.000010	<0.000010	<0.000010
Cadmium (Cd)-Total	mg/L	*0.0688*	<0.000017	<0.10	<0.020	<0.020	<0.020
Calcium (Ca)-Total	mg/L	1960	<0.10	<0.0010	<0.00010	<0.00010	<0.00010
Chromium (Cr)-Total	mg/L	*0.671*	<0.0010	<0.00030	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	0.714	<0.00030	<0.0010	<0.00050	<0.00050	<0.00050
Copper (Cu)-Total	mg/L	**3.2**	<0.0010	<0.030	<0.030	<0.030	<0.030
Iron (Fe)-Total	mg/L	*1320*	<0.030	<0.00050	<0.000050	<0.000050	<0.000050
Lead (Pb)-Total	mg/L	**0.679**	<0.00050	<0.0050	<0.00050	0.00065	<0.00050
Lithium (Li)-Total	mg/L	0.682	<0.0050	<0.10	<0.0050	<0.0050	<0.0050
Magnesium (Mg)-Total	mg/L	228	<0.10	<0.00030	<0.000050	<0.000050	<0.000050
Manganese (Mn)-Total	mg/L	68.4	<0.00030	<0.000010	<0.000010	<0.000010	<0.000010
Mercury (Hg)-Total	mg/L	<0.00050	<0.000010	<0.0010	<0.000050	<0.000050	<0.000050
Molybdenum (Mo)-Total	mg/L	*0.0752*	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050
Nickel (Ni)-Total	mg/L	*1.83*	<0.0010	<0.30	<0.30	<0.30	<0.30
Phosphorus (P) - Total	mg/L	44.4	<0.30	<2.0	<0.050	<0.050	<0.050
Potassium (K)-Total	mg/L	107	<2.0	<0.0010	<0.00010	<0.00010	<0.00010
Selenium (Se)-Total	mg/L	*0.0292*	<0.0010	<0.050	<0.050	<0.050	<0.050
Silicon (Si)- Total	mg/L	339	<0.050	<0.000020	<0.000010	<0.000010	<0.000010
Silver (Ag)-Total	mg/L	*0.262*	<0.000020	<2.0	<2.0	<2.0	<2.0
Sodium (Na)-Total	mg/L	<4.0	<2.0	<0.0050	<0.00020	<0.00020	<0.00020
Strontium (Sr)-Total	mg/L	6.74	<0.0050	<0.00020	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	*0.0157*	<0.00020	<0.00050	<0.00010	<0.00010	<0.00010
Tin (Sn)-Total	mg/L	<0.0020	<0.00050	<0.010	<0.010	<0.010	<0.010
Titanium (Ti)-Total	mg/L	0.391	<0.010	<0.00020	<0.000010	<0.000010	<0.000010
Uranium (U)-Total	mg/L	*0.0156*	<0.00020	<0.0010	<0.0010	<0.0010	<0.0010
Vanadium (V)-Total	mg/L	0.55	<0.0010	<0.0050	<0.0030	<0.0030	<0.0030
Zinc (Zn)-Total	mg/L	*4.6*	<0.0050	0	0	0	0

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results
(Total Metals)

	Sample Location	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	BJ-FB	Travel Blank	Travel Blank	Travel Blank
	BGC Sample ID	FB	BJ-FB	BJ-FB	TRAVEL BLANK	TB	TRAVEL BLANK
	Date Sampled	4/8/2013	7/11/2013	26-SEP-13	6/27/2012	9/5/2012	1/30/2013
	Time Sampled	0:00	00:00	00:00	0:00	00:00	00:00
	ALS Sample ID	L1288325-5	L1331947-5	L1370207-5	L1171422-11	L1206550-3	L1264492-2
Total Metals	**Unit**						
Aluminum (Al)-Total	mg/L	<0.00010	<0.00010	<0.0030	<0.0030	<0.0030	<0.0030
Antimony (Sb)-Total	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Total	mg/L	<0.000050	<0.000050	<0.00010	<0.00010	<0.00010	<0.00010
Barium (Ba)-Total	mg/L	<0.00010	<0.00010	<0.000050	<0.000050	<0.000050	<0.000050
Beryllium (Be)-Total	mg/L	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Total	mg/L	<0.010	<0.010	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Total	mg/L	<0.000010	<0.000010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	<0.020	<0.020	<0.000010	<0.000010	<0.000010	<0.000010
Calcium (Ca)-Total	mg/L	<0.00010	<0.00010	<0.020	<0.020	<0.020	<0.020
Chromium (Cr)-Total	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	mg/L	<0.030	<0.030	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Total	mg/L	<0.000050	<0.000050	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Total	mg/L	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L	<0.0050	<0.0050	<0.00050	<0.00050	0.0006	<0.00050
Magnesium (Mg)-Total	mg/L	<0.000050	<0.000050	<0.0050	<0.0050	<0.0050	<0.0050
Manganese (Mn)-Total	mg/L	<0.000010	<0.000010	<0.000050	<0.000050	<0.000050	<0.000050
Mercury (Hg)-Total	mg/L	<0.000050	<0.000050	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Total	mg/L	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050
Nickel (Ni)-Total	mg/L	<0.30	<0.30	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P) - Total	mg/L	<0.050	<0.050	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	<0.00010	<0.00010	<0.050	<0.050	<0.050	<0.050
Selenium (Se)-Total	mg/L	<0.050	<0.050	<0.00010	<0.00010	<0.00010	<0.00010
Silicon (Si)- Total	mg/L	<0.000010	<0.000010	<0.050	<0.050	<0.050	<0.050
Silver (Ag)-Total	mg/L	<2.0	<2.0	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	mg/L	<0.00020	<0.00020	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)-Total	mg/L	<0.000010	<0.000010	<0.00020	<0.00020	<0.00020	<0.00020
Thallium (Tl)-Total	mg/L	<0.00010	<0.00010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	<0.010	<0.010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	<0.000010	<0.000010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Total	mg/L	<0.0010	<0.0010	<0.000010	<0.000010	<0.000010	<0.000010
Vanadium (V)-Total	mg/L	<0.0030	<0.0030	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Total	mg/L	0	0	<0.0030	<0.0030	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-2: Groundwater Analytical Chemistry Results (Total Metals)

	Sample Location	Travel Blank	TRAVEL BLANK
	BGC Sample ID	TRAVEL BLANK	TRAVEL BLANK
	Date Sampled	4/7/2013	25-SEP-13
	Time Sampled	00:00	00:00
	ALS Sample ID	L1287525-6	L1370058-5
Total Metals	**Unit**		
Aluminum (Al)-Total	mg/L	<0.0030	<0.0030
Antimony (Sb)-Total	mg/L	<0.00010	<0.00010
Arsenic (As)-Total	mg/L	<0.00010	<0.00010
Barium (Ba)-Total	mg/L	<0.000050	<0.000050
Beryllium (Be)-Total	mg/L	<0.00010	<0.00010
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050
Boron (B)-Total	mg/L	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	<0.000010	<0.000010
Calcium (Ca)-Total	mg/L	<0.020	<0.020
Chromium (Cr)-Total	mg/L	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L	<0.00010	<0.00010
Copper (Cu)-Total	mg/L	<0.00050	<0.00050
Iron (Fe)-Total	mg/L	<0.030	<0.030
Lead (Pb)-Total	mg/L	<0.000050	<0.000050
Lithium (Li)-Total	mg/L	<0.00050	<0.00050
Magnesium (Mg)-Total	mg/L	<0.0050	<0.0050
Manganese (Mn)-Total	mg/L	<0.000050	<0.000050
Mercury (Hg)-Total	mg/L	<0.000010	<0.000010
Molybdenum (Mo)-Total	mg/L	<0.000050	<0.000050
Nickel (Ni)-Total	mg/L	<0.00050	<0.00050
Phosphorus (P) - Total	mg/L	<0.30	<0.30
Potassium (K)-Total	mg/L	<0.050	<0.050
Selenium (Se)-Total	mg/L	<0.00010	<0.00010
Silicon (Si)- Total	mg/L	<0.050	<0.050
Silver (Ag)-Total	mg/L	<0.000010	<0.000010
Sodium (Na)-Total	mg/L	<2.0	<2.0
Strontium (Sr)-Total	mg/L	<0.00020	<0.00020
Thallium (Tl)-Total	mg/L	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	<0.010	<0.010
Uranium (U)-Total	mg/L	<0.000010	<0.000010
Vanadium (V)-Total	mg/L	<0.0010	<0.0010
Zinc (Zn)-Total	mg/L	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-1A	MW-BGC11-BJ-1B	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A
	BGC Sample ID	BJ-1a	BJ-1B	BJ-2A	BJ-2A	BJ-2A	BJ-2A
	Date Sampled	10/10/2011	10/10/2011	10/11/2011	3/30/2012	6/26/2012	9/4/2012
	Time Sampled	9:10	9:40	9:00	11:30	14:10	00:00
	ALS Sample ID	L1071509-9	L1071509-10	L1071509-7	L1130044-3	L1171422-1	L1207447-5
Dissolved Metals	**Unit**						
Aluminum (Al)-Dissolved	mg/L	0.0339	0.0145	0.0256	0.0188	0.0122	0.0598
Antimony (Sb)-Dissolved	mg/L	0.0008	0.00093	0.00181	<0.00050	0.00082	0.0005
Arsenic (As)-Dissolved	mg/L	0.00111	0.00797	0.00087	0.00091	0.00218	0.00105
Barium (Ba)-Dissolved	mg/L	0.028	0.022	0.041	0.044	0.0688	0.0394
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.20	<0.20	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	<0.10	<0.10	<0.10	<0.10	0.021	0.016
Cadmium (Cd)-Dissolved	mg/L	0.000027	<0.000017	<0.000017	<0.000017	0.00101	0.000014
Calcium (Ca)-Dissolved	mg/L	16.4	29.7	35.7	49.5	29.5	36.9
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.00694	0.00014
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	<0.00030	<0.00030	0.00041	<0.00010
Copper (Cu)-Dissolved	mg/L	0.009	<0.0010	<0.0010	<0.0010	0.002	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.030	0.039	<0.030
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	0.00008	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0073	0.0781	0.0084	0.007	0.0323	0.0205
Magnesium (Mg)-Dissolved	mg/L	1.01	3.8	1.86	2.38	1.53	1.81
Manganese (Mn)-Dissolved	mg/L	0.0331	0.0306	0.0353	0.0775	0.129	0.0181
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	<0.0010	0.0023	0.0044	0.0018	0.00252	0.00121
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.00632	0.00054
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	<2.0	2.5	<2.0	<2.0	0.81	0.669
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.00010	<0.00010
Silicon (Si)-Dissolved	mg/L	0.977	2.77	1.98	2.03	2.11	1.85
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	2.9	25.8	5.6	4.8	20	11.3
Strontium (Sr)-Dissolved	mg/L	0.208	0.897	1.36	1.52	1.39	1.74
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	0.00161	0.00118	<0.00050	<0.00050	0.00021	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	<0.00020	<0.00020	0.00031	0.00032	0.000323	0.000289
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	0.0167	<0.0050	0.0067	<0.0050	0.0188	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-2A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A
	BGC Sample ID	BJ-2A	02A	02A_DUP 1	BJ-2A	BJ-2A	BJ-3A	BJ-3A
	Date Sampled	1/27/2013	4/7/2013	4/7/2013	7/13/2013	9/26/2013	10/8/2011	3/28/2012
	Time Sampled	00:00	00:00	00:00	00:00	16:00	16:30	13:15
	ALS Sample ID	L1263921-1	L1287525-1	L1287525-5	L1333226-1	L1370207-1	L1071509-6	L1129695-1
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.201	0.0143	0.0121	0.0166	0.0124	0.0235	0.0142
Antimony (Sb)-Dissolved	mg/L	0.00048	0.00036	0.00033	0.00023	0.0002	0.00468	0.0013
Arsenic (As)-Dissolved	mg/L	0.00058	0.0005	0.00052	0.00107	0.00136	0.0226	0.00758
Barium (Ba)-Dissolved	mg/L	0.043	0.037	0.0376	0.0271	0.0291	0.029	0.031
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.0010	<0.0010
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.20	<0.20
Boron (B)-Dissolved	mg/L	0.01	0.012	0.012	<0.010	<0.010	<0.10	<0.10
Cadmium (Cd)-Dissolved	mg/L	0.000021	<0.000010	<0.000010	<0.000010	<0.000010	0.000029	0.000038
Calcium (Ca)-Dissolved	mg/L	49.2	49.6	48.2	32.9	36.8	47.4	60
Chromium (Cr)-Dissolved	mg/L	0.00047	<0.00010	<0.00010	0.0001	<0.00010	<0.0010	<0.0010
Cobalt (Co)-Dissolved	mg/L	0.00041	0.00022	0.00022	<0.00010	<0.00010	<0.00030	<0.00030
Copper (Cu)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0010	<0.0010
Iron (Fe)-Dissolved	mg/L	0.108	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	0.000071	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050
Lithium (Li)-Dissolved	mg/L	0.00751	0.00601	0.00541	0.00479	0.0047	0.0445	0.02
Magnesium (Mg)-Dissolved	mg/L	2.26	2.28	2.26	1.5	1.72	3.93	4.12
Manganese (Mn)-Dissolved	mg/L	0.0952	0.0657	0.0513	0.00124	0.000431	0.198	0.139
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.00376	0.00155	0.00126	0.0013	0.000855	0.0026	0.0015
Nickel (Ni)-Dissolved	mg/L	0.00434	0.00137	0.00128	0.00071	<0.00050	<0.0010	<0.0010
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	0.419	0.343	0.32	0.318	0.239	<2.0	<2.0
Selenium (Se)-Dissolved	mg/L	0.00012	0.00012	0.00012	<0.00010	0.00016	<0.0010	<0.0010
Silicon (Si)-Dissolved	mg/L	2.32	1.81	1.82	1.66	1.63	3.31	3.3
Silver (Ag)-Dissolved	mg/L	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	<0.000020	<0.000020
Sodium (Na)-Dissolved	mg/L	4.3	4.4	4.5	2.6	2.5	19.3	9.4
Strontium (Sr)-Dissolved	mg/L	1.97	1.41	1.08	0.912	0.852	1.34	1.18
Thallium (Tl)-Dissolved	mg/L	0.000016	0.000011	0.00001	<0.000010	<0.000010	<0.00020	<0.00020
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050	<0.00050
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.000427	0.000348	0.000309	0.000153	0.000178	<0.00020	<0.00020
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	0.0122	<0.0030	<0.0030	<0.0030	<0.0030	0.031	<0.0050

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A	MW-BGC11-BJ-3A
	BGC Sample ID	BJ-3A	BJ-3A	Duplicate	BJ-3A	03A	BJ-3A	BJ-03A
	Date Sampled	6/27/2012	9/4/2012	6/27/2012	1/28/2013	4/7/2013	7/13/2013	9/25/2013
	Time Sampled	09:35	00:00	09:45	00:00	00:00	00:00	17:00
	ALS Sample ID	L1171422-2	L1207447-1	L1171422-8	L1263921-2	L1287525-2	L1333226-2	L1370058-1
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.0159	0.0204	0.0168	0.021	0.0065	0.0088	0.0154
Antimony (Sb)-Dissolved	mg/L	0.00179	0.00133	0.00183	0.0118	0.00334	0.0094	0.0319
Arsenic (As)-Dissolved	mg/L	0.0279	0.00871	0.0276	0.00599	0.00691	0.00552	0.00404
Barium (Ba)-Dissolved	mg/L	0.0235	0.0294	0.0234	0.03	0.0252	0.0223	0.032
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	0.037	0.046	0.037	0.049	0.047	0.037	0.048
Cadmium (Cd)-Dissolved	mg/L	<0.000010	0.00002	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Calcium (Ca)-Dissolved	mg/L	31.5	48.3	31.3	59.9	55.4	53.4	54.8
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Dissolved	mg/L	<0.00010	0.00011	<0.00010	0.00038	<0.00010	0.00015	0.00059
Copper (Cu)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.000050	<0.000050	0.000065	<0.000050	0.000107	0.000108
Lithium (Li)-Dissolved	mg/L	0.074	0.0357	0.0737	0.0224	0.019	0.0156	0.0203
Magnesium (Mg)-Dissolved	mg/L	2.45	3.9	2.38	4.34	4.25	3.93	4.41
Manganese (Mn)-Dissolved	mg/L	0.192	0.193	0.192	0.22	0.176	0.132	0.149
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.00247	0.0014	0.00251	0.0018	0.00123	0.00114	0.00117
Nickel (Ni)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	0.00177	<0.00050	0.00072	0.00096
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	1.55	1.5	1.53	1.51	1.47	1.35	1.46
Selenium (Se)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	0.00018	<0.00010	<0.00010	0.00028
Silicon (Si)-Dissolved	mg/L	2.91	3.22	2.8	3.51	3.48	3.5	3.47
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	36.7	15.9	36.8	9.9	9.3	7.9	9.1
Strontium (Sr)-Dissolved	mg/L	0.991	1.23	0.994	1.26	1.15	1.1	1.12
Thallium (Tl)-Dissolved	mg/L	<0.000010	0.000055	0.00001	0.000147	0.000027	0.000076	0.000254
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.000181	0.00015	0.000193	0.000168	0.000136	0.000142	0.000179
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0032

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B	MW-BGC11-BJ-3B
	BGC Sample ID	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B	BJ-3B
	Date Sampled	10/8/2011	3/28/2012	6/27/2012	9/4/2012	1/28/2013	7/11/2013	9/25/2013
	Time Sampled	15:45	11:00	10:00	00:00	00:00	00:00	13:30
	ALS Sample ID	L1071509-5	L1129695-2	L1171422-3	L1207447-2	L1263921-3	L1331947-3	L1370058-2
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.0075	0.0158	0.0246	0.0489	0.0146	0.0474	0.0134
Antimony (Sb)-Dissolved	mg/L	0.00114	0.00245	0.00331	0.00508	0.019	0.00284	0.0019
Arsenic (As)-Dissolved	mg/L	0.0165	0.0202	0.00768	0.00542	0.0281	0.0128	0.00963
Barium (Ba)-Dissolved	mg/L	0.042	0.034	0.0384	0.0512	0.0521	0.0525	0.0431
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	<0.10	<0.10	0.025	0.034	0.032	0.036	0.028
Cadmium (Cd)-Dissolved	mg/L	<0.000017	0.00006	0.000081	0.000075	0.000057	0.00003	0.000046
Calcium (Ca)-Dissolved	mg/L	60.5	57.8	57.2	56.8	66.6	59.5	66.4
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	0.0001	<0.00010
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	0.00018	0.00027	0.0005	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.0010	<0.0010	<0.00050	<0.00050	0.00089	<0.00050	<0.00050
Iron (Fe)-Dissolved	mg/L	0.036	<0.030	<0.030	<0.030	<0.030	<0.030	0.076
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.000050	0.00009	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0115	<0.0050	0.0094	0.0132	0.0113	0.0152	0.00946
Magnesium (Mg)-Dissolved	mg/L	3.78	2.78	3.46	3.36	5.32	3.82	4.01
Manganese (Mn)-Dissolved	mg/L	0.397	0.0825	0.25	0.491	0.317	0.0412	0.133
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	<0.0010	<0.0010	0.000584	0.0018	0.00118	0.000882	0.000607
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.0010	<0.00050	0.00078	0.00083	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	<2.0	<2.0	0.976	1.49	1.76	1.15	1.08
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	0.00059	0.00104	0.00118	0.00029	0.00017
Silicon (Si)-Dissolved	mg/L	3.49	1.91	2.84	3.18	3.05	3.19	2.91
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000010	0.000011	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	5.5	3.1	5	6.3	4.7	6.4	5.2
Strontium (Sr)-Dissolved	mg/L	1.64	1.03	1.58	1.48	2.9	1.48	1.84
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	0.000044	0.000086	0.000055	0.00004	0.000032
Tin (Sn)-Dissolved	mg/L	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.00024	0.00032	0.000663	0.000661	0.000634	0.000425	0.000637
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	0.0074	<0.0050	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A	MW-BGC11-BJ-4A
	BGC Sample ID	BJ-4A	BJ-4A	BJ-4A	BJ-4A	BJ-4A	04A	BJ-4A
	Date Sampled	10/10/2011	3/30/2012	6/26/2012	9/3/2012	1/28/2013	4/8/2013	7/13/2013
	Time Sampled	11:10	14:05	14:45	00:00	00:00	00:00	00:00
	ALS Sample ID	L1071509-1	L1130044-4	L1171422-4	L1205274-1	L1263921-4	L1288325-3	L1333226-3
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	<0.0050	0.0055	0.0187	0.008	0.0036	0.0075	0.0089
Antimony (Sb)-Dissolved	mg/L	0.0546	0.00868	0.00463	0.00349	0.00155	0.00293	0.00354
Arsenic (As)-Dissolved	mg/L	0.0613	0.0295	0.019	0.0192	0.0159	0.014	0.015
Barium (Ba)-Dissolved	mg/L	0.069	0.039	0.0384	0.0338	0.0339	0.0338	0.0444
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	<0.10	<0.10	0.066	0.072	0.063	0.064	0.07
Cadmium (Cd)-Dissolved	mg/L	0.000019	<0.000017	0.000012	0.000024	0.000011	0.000033	0.000034
Calcium (Ca)-Dissolved	mg/L	59.8	61.5	49.5	51.5	60.7	57.1	58.2
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	0.00014	0.00015	<0.00010	<0.00010	0.00014
Cobalt (Co)-Dissolved	mg/L	0.00115	0.00037	0.00027	0.00026	0.00065	0.00012	0.00023
Copper (Cu)-Dissolved	mg/L	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0345	0.0314	0.0296	0.0306	0.0267	0.0274	0.0305
Magnesium (Mg)-Dissolved	mg/L	12.9	14.1	11.3	11.6	12.5	11.5	12.1
Manganese (Mn)-Dissolved	mg/L	0.116	0.126	0.0695	0.086	0.143	0.0521	0.0709
Mercury (Hg)-Dissolved	mg/L	0.000619	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.0028	0.0018	0.0012	0.00134	0.000939	0.000893	0.00203
Nickel (Ni)-Dissolved	mg/L	0.0054	<0.0010	0.00052	<0.00050	<0.00050	0.00058	0.00053
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	2.4	<2.0	1.62	1.59	1.59	1.61	1.61
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silicon (Si)-Dissolved	mg/L	2.89	3.23	3.07	2.9	3	3	3.04
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	17.5	17.9	17.9	21	17.3	17.7	27.7
Strontium (Sr)-Dissolved	mg/L	2.71	3.04	2.56	2.63	2.93	2.81	2.88
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	0.00002	0.000018	0.000017	0.000017	0.000018
Tin (Sn)-Dissolved	mg/L	<0.00050	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.00166	0.00487	0.00269	0.00307	0.00224	0.00201	0.00471
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	0.0091	<0.0050	<0.0030	0.0031	<0.0030	0.0036	0.0033

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-4A	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B	MW-BGC12-BJ-4B
	BGC Sample ID	BJ-4A	BJ-4B	Duplicate	BJ-4B	04B	BJ-4B	DUP1
	Date Sampled	9/25/2013	9/3/2012	9/3/2012	1/28/2013	4/8/2013	7/11/2013	7/11/2013
	Time Sampled	10:20	00:00	00:00	00:00	00:00	00:00	00:00
	ALS Sample ID	L1370058-3	L1205274-2	L1205274-5	L1263921-5	L1288325-4	L1331947-1	L1331947-4
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.0126	0.0587	0.327	0.0074	0.387	0.12	0.174
Antimony (Sb)-Dissolved	mg/L	0.0027	0.00316	0.00381	0.00052	0.00109	0.00068	0.00065
Arsenic (As)-Dissolved	mg/L	0.0132	0.00985	0.0186	0.003	0.0161	0.0129	0.0128
Barium (Ba)-Dissolved	mg/L	0.033	0.0353	0.0386	0.0195	0.016	0.0204	0.022
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	0.07	0.035	0.069	0.018	0.055	0.06	0.058
Cadmium (Cd)-Dissolved	mg/L	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Calcium (Ca)-Dissolved	mg/L	54.3	21.3	3.16	69.8	4.13	2.68	2.56
Chromium (Cr)-Dissolved	mg/L	<0.00010	0.00047	0.00043	<0.00010	0.00073	0.00039	0.00046
Cobalt (Co)-Dissolved	mg/L	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.00050	0.00086	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.030	0.039	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.000050	0.000087	<0.000050	0.000065	<0.000050	0.000051
Lithium (Li)-Dissolved	mg/L	0.0346	0.109	0.284	0.0158	0.21	0.226	0.227
Magnesium (Mg)-Dissolved	mg/L	12	3.38	0.212	7.33	0.832	0.341	0.319
Manganese (Mn)-Dissolved	mg/L	0.0534	0.00456	0.0029	0.0565	0.00159	0.00602	0.0061
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.000996	0.00149	0.000843	0.000441	0.000855	0.000877	0.000882
Nickel (Ni)-Dissolved	mg/L	0.00064	<0.00050	<0.00050	0.00061	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	1.62	1.42	1.58	0.915	0.794	0.822	0.808
Selenium (Se)-Dissolved	mg/L	<0.00010	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Silicon (Si)-Dissolved	mg/L	2.94	3.59	4.16	2.27	3.9	3.58	3.71
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	0.00006	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	22.6	57.6	120	6.6	107	113	113
Strontium (Sr)-Dissolved	mg/L	2.73	0.474	0.234	0.98	0.127	0.0953	0.0913
Thallium (Tl)-Dissolved	mg/L	0.000017	0.000015	0.000029	<0.000010	0.000013	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	0.00013	<0.00010	0.00019	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.0022	0.00213	0.000173	0.000728	0.000138	0.000099	0.000098
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	0.0037	<0.0030	<0.0030	0.0173	<0.0030	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-4B	MW-BGC11-BJ-5A	MW-BGC11-BJ-5A	MW-BGC11-BJ-5A	MW-BGC11-BJ-5B	MW-BGC11-BJ-5B	MW-BGC11-BJ-5B
	BGC Sample ID	BJ-4B	Bj-5A	BJ-5A	BJ-5A	BJ-5B	BJ-5B	BJ-5B
	Date Sampled	9/25/2013	10/10/2011	3/28/2012	6/26/2012	10/10/2011	3/28/2012	6/26/2012
	Time Sampled	9:50	14:12	09:30	09:45	13:30	10:10	10:20
	ALS Sample ID	L1370058-4	L1071509-3	L1129695-3	L1171422-5	L1071509-2	L1129695-4	L1171422-6
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.0637	0.0566	0.148	5.8	0.0868	0.0297	0.0747
Antimony (Sb)-Dissolved	mg/L	0.00054	0.00277	0.00501	0.01	0.0113	0.00722	0.00457
Arsenic (As)-Dissolved	mg/L	0.0117	0.00641	0.0144	0.0958	0.0102	0.012	0.00533
Barium (Ba)-Dissolved	mg/L	0.0211	0.027	0.021	0.285	0.042	0.024	0.0492
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.0010	<0.0010	0.00047	<0.0010	<0.0010	<0.00020
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.20	<0.20	<0.0010	<0.20	<0.20	<0.0010
Boron (B)-Dissolved	mg/L	0.062	<0.10	<0.10	0.047	<0.10	<0.10	0.039
Cadmium (Cd)-Dissolved	mg/L	<0.000010	0.000112	<0.000017	0.0012	<0.000017	<0.000017	0.00033
Calcium (Ca)-Dissolved	mg/L	2.44	31.3	30.1	63.9	58.5	48.6	56.9
Chromium (Cr)-Dissolved	mg/L	0.00065	<0.0010	<0.0010	0.00811	<0.0010	<0.0010	<0.00020
Cobalt (Co)-Dissolved	mg/L	<0.00010	0.00331	<0.00030	0.00437	<0.00030	<0.00030	0.00037
Copper (Cu)-Dissolved	mg/L	<0.00050	0.0024	<0.0010	0.0165	<0.0010	<0.0010	<0.0010
Iron (Fe)-Dissolved	mg/L	<0.030	0.072	0.038	9.15	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.00050	<0.00050	0.0186	<0.00050	<0.00050	<0.00010
Lithium (Li)-Dissolved	mg/L	0.219	0.0214	0.0865	0.0655	0.0094	0.0151	0.0232
Magnesium (Mg)-Dissolved	mg/L	0.256	3.22	6.1	9.37	5.91	5.74	6.38
Manganese (Mn)-Dissolved	mg/L	0.00676	0.569	0.0576	0.831	0.134	0.262	0.554
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.00010	<0.000010	<0.000010	<0.00010
Molybdenum (Mo)-Dissolved	mg/L	0.000902	0.0058	0.0054	0.0141	0.0075	0.0055	0.0158
Nickel (Ni)-Dissolved	mg/L	<0.00050	0.0026	<0.0010	0.0119	<0.0010	<0.0010	0.0017
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	0.35	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	0.795	2.5	5	8.49	7.4	3.7	5.53
Selenium (Se)-Dissolved	mg/L	<0.00010	<0.0010	<0.0010	0.00072	<0.0010	<0.0010	<0.00020
Silicon (Si)-Dissolved	mg/L	3.5	1.94	3.42	19.2	3.78	2.8	2.57
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000020	<0.000020	0.00503	<0.000020	<0.000020	<0.000020
Sodium (Na)-Dissolved	mg/L	107	12.3	65.2	29.2	12.7	9.8	14.5
Strontium (Sr)-Dissolved	mg/L	0.0958	0.811	2.16	2.54	0.747	1.55	1.66
Thallium (Tl)-Dissolved	mg/L	<0.000010	<0.00020	<0.00020	0.000746	<0.00020	<0.00020	0.000129
Tin (Sn)-Dissolved	mg/L	<0.00010	0.00091	<0.00050	<0.00020	0.00116	<0.00050	<0.00020
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	0.102	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.000099	0.00022	0.00167	0.00156	0.00146	0.00082	0.00107
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	0.0094	<0.0010	<0.0010	<0.0020
Zinc (Zn)-Dissolved	mg/L	<0.0030	0.0102	<0.0050	0.0425	<0.0050	<0.0050	<0.0060

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A
	BGC Sample ID	BJ-6A	BJ-6A	Duplicate	BJ-6A	BJ-6A	BJ-6A	06A
	Date Sampled	10/8/2011	3/30/2012	3/30/2012	6/26/2012	9/3/2012	1/27/2013	4/7/2013
	Time Sampled	14:50	13:25	13:40	11:45	00:00	00:00	00:00
	ALS Sample ID	L1071509-4	L1130044-5	L1130044-1	L1171422-7	L1205274-3	L1263921-6	L1287525-3
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.021	0.0102	0.0145	0.353	0.0967	0.0538	0.0252
Antimony (Sb)-Dissolved	mg/L	0.00178	0.00275	0.00306	0.0112	0.00975	0.00677	0.00339
Arsenic (As)-Dissolved	mg/L	0.00172	0.00375	0.00354	0.0795	0.0844	0.0293	0.0281
Barium (Ba)-Dissolved	mg/L	0.036	0.035	0.037	0.0446	0.0427	0.0499	0.0501
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.00020	<0.00020	<0.00010	<0.00020
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.20	<0.0010	<0.0010	<0.00050	<0.0010
Boron (B)-Dissolved	mg/L	<0.10	<0.10	<0.10	<0.020	0.021	0.027	0.032
Cadmium (Cd)-Dissolved	mg/L	0.000359	0.000029	0.000028	<0.000020	<0.000020	<0.000010	<0.000020
Calcium (Ca)-Dissolved	mg/L	68.7	64.1	64.7	33.6	34.5	49.2	42.3
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	0.00081	<0.00020	<0.00010	<0.00020
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	<0.00030	<0.00020	<0.00020	<0.00010	<0.00020
Copper (Cu)-Dissolved	mg/L	0.0024	<0.0010	<0.0010	0.0013	<0.0010	<0.00050	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00010	0.00024	0.000222	<0.00010
Lithium (Li)-Dissolved	mg/L	<0.0050	<0.0050	<0.0050	0.0021	0.0038	0.00664	0.0066
Magnesium (Mg)-Dissolved	mg/L	3.45	4.34	4.33	0.34	1.71	3.8	3.57
Manganese (Mn)-Dissolved	mg/L	0.0422	0.0617	0.0617	<0.00010	0.00236	0.0423	0.0465
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.00010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	0.0176	0.0094	0.0035	0.00232
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	0.0031
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	2.5	2.2	2.2	3.79	2.79	2.66	2.52
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	0.00169	0.00106	0.00064	0.00023
Silicon (Si)-Dissolved	mg/L	2.26	2.93	2.93	4.36	3.51	3.65	3.66
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000020	0.000049	0.000021	0.000019	<0.000020
Sodium (Na)-Dissolved	mg/L	2.5	2.9	2.8	5.3	5	4.5	4.8
Strontium (Sr)-Dissolved	mg/L	0.894	1.99	1.96	1.23	1.7	2.22	2
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	<0.00020	0.000051	0.000056	0.000068	0.000053
Tin (Sn)-Dissolved	mg/L	0.00052	<0.00050	<0.00050	<0.00020	<0.00020	<0.00010	<0.00020
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	<0.00020	0.00032	0.0003	<0.000020	0.000231	0.000617	0.000531
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	0.0051	0.002	<0.0010	<0.0020
Zinc (Zn)-Dissolved	mg/L	0.0548	<0.0050	<0.0050	<0.0060	<0.0060	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-6A	MW-BGC11-BJ-6A	MW-BGC12-BJ-6B	MW-BGC12-BJ-6B	MW-BGC12-BJ-6B	MW-BGC11-BJ-8A	MW-BGC12-BJ-8A
	BGC Sample ID	BJ-6A	BJ-6A	BJ-6B	BJ-6B	06B	BJ-8A	BJ-8A
	Date Sampled	7/11/2013	9/25/2013	9/3/2012	1/27/2013	4/7/2013	6/28/2012	9/4/2012
	Time Sampled	00:00	14:00	00:00	00:00	00:00	14:30	00:00
	ALS Sample ID	L1331947-2	L1370058-6	L1205274-4	L1263921-7	L1287525-4	L1174115-1	L1207447-3
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.0898	0.827	0.504	0.534	0.15	0.02	0.0123
Antimony (Sb)-Dissolved	mg/L	0.0037	0.00483	0.0108	0.00518	0.00261	0.00137	0.0009
Arsenic (As)-Dissolved	mg/L	0.026	0.0222	0.0294	0.0263	0.0192	0.00691	0.00703
Barium (Ba)-Dissolved	mg/L	0.0471	0.136	0.039	0.0391	0.0334	0.0223	0.0192
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	0.024	<0.020	0.145	0.149	0.14	0.013	0.013
Cadmium (Cd)-Dissolved	mg/L	0.000016	<0.000020	<0.000010	0.000066	<0.000010	0.000012	<0.000010
Calcium (Ca)-Dissolved	mg/L	44.4	47.7	3.68	2.86	3.36	27.7	26.3
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.00020	0.00019	0.00016	0.00011	0.00019	0.00018
Cobalt (Co)-Dissolved	mg/L	<0.00010	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.00050	0.00089	0.00092	0.00117	<0.00050	<0.00050	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	0.32	0.135	0.145	0.044	<0.030	0.045
Lead (Pb)-Dissolved	mg/L	0.000142	0.00103	0.00144	0.0016	0.000607	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.00655	0.0056	0.141	0.144	0.128	0.00913	0.00831
Magnesium (Mg)-Dissolved	mg/L	3.74	4.45	0.153	0.137	0.147	5.06	4.88
Manganese (Mn)-Dissolved	mg/L	0.0482	0.0364	0.00664	0.00805	0.00801	0.0118	0.00468
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.00246	0.00234	0.00644	0.00539	0.00371	0.00246	0.00159
Nickel (Ni)-Dissolved	mg/L	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	2.48	2.67	2.67	2.42	2.19	0.858	0.54
Selenium (Se)-Dissolved	mg/L	0.0003	0.00031	0.00075	0.00051	0.00021	0.00019	0.00017
Silicon (Si)-Dissolved	mg/L	3.81	5.49	5.49	4.83	3.91	2.03	1.9
Silver (Ag)-Dissolved	mg/L	0.000014	0.000048	0.000089	0.000112	0.000028	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	5.1	3.6	67.9	66.3	66.6	5.9	6.9
Strontium (Sr)-Dissolved	mg/L	1.98	2.18	0.214	0.182	0.19	0.655	0.608
Thallium (Tl)-Dissolved	mg/L	0.00006	0.000085	0.000037	0.000035	0.000023	0.000011	<0.000010
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	0.023	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.000689	0.00039	0.000135	0.000127	0.000073	0.000249	0.000289
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0020	0.0023	0.0021	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	<0.0030	0.0051	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC12-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8A	MW-BGC11-BJ-8B
	BGC Sample ID	BJ-8A	BJ-DUP1	08A	BJ-8A	BJ-3A	BJ-DUP1	BJ-8B
	Date Sampled	1/28/2013	1/28/2013	4/8/2013	7/14/2013	9/26/2013	26-SEP-13	6/28/2012
	Time Sampled	00:00	00:00	00:00	00:00	11:30	00:00	15:30
	ALS Sample ID	L1263921-8	L1263921-10	L1288325-1	L1333226-4	L1370207-2	L1370207-4	L1174115-2
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.016	0.0098	0.0142	0.0138	0.013	0.0153	2.12
Antimony (Sb)-Dissolved	mg/L	0.00081	0.00084	0.00085	0.00086	0.00086	0.00084	0.00148
Arsenic (As)-Dissolved	mg/L	0.00689	0.00701	0.00705	0.00775	0.00825	0.00804	0.0492
Barium (Ba)-Dissolved	mg/L	0.0213	0.0208	0.0218	0.0203	0.0191	0.0191	0.0575
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	0.011	0.011	0.012	<0.010	0.011	<0.010	0.017
Cadmium (Cd)-Dissolved	mg/L	<0.000010	<0.000010	0.000011	<0.000010	<0.000010	0.000013	<0.000010
Calcium (Ca)-Dissolved	mg/L	30.6	29.6	31.1	27.8	27.2	27.5	21.5
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00152
Cobalt (Co)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00029
Copper (Cu)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00108
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	0.768
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000639
Lithium (Li)-Dissolved	mg/L	0.00949	0.0094	0.0106	0.00901	0.00892	0.00903	0.00739
Magnesium (Mg)-Dissolved	mg/L	5.32	5.41	5.4	5.28	5.53	5.55	2.52
Manganese (Mn)-Dissolved	mg/L	0.00341	0.0033	0.00417	0.00432	0.00251	0.00239	0.0242
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.00173	0.00164	0.00163	0.00142	0.00139	0.00141	0.00301
Nickel (Ni)-Dissolved	mg/L	0.00084	0.00063	0.00055	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	0.519	0.52	0.484	0.454	0.441	0.442	1.86
Selenium (Se)-Dissolved	mg/L	0.00019	0.00019	0.00018	0.00017	0.00017	0.00015	0.00039
Silicon (Si)-Dissolved	mg/L	1.99	1.95	2.06	2.04	1.99	2.04	10.8
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000015
Sodium (Na)-Dissolved	mg/L	6.5	6.1	5.2	4	3.9	4	12.4
Strontium (Sr)-Dissolved	mg/L	0.696	0.706	0.737	0.701	0.679	0.685	0.328
Thallium (Tl)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.00005
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00016
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.04
Uranium (U)-Dissolved	mg/L	0.000298	0.000284	0.000231	0.000189	0.000181	0.000186	0.00111
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0045
Zinc (Zn)-Dissolved	mg/L	0.0063	0.0044	<0.0030	<0.0030	<0.0030	<0.0030	0.0044

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC12-BJ-8B	MW-BGC11-BJ-8B	MW-BGC11-BJ-8B	MW-BGC12-BJ-8B	MW-BGC11-BJ-8B	MW-BGC12-BJ-12A	MW-BGC12-BJ-12A
	BGC Sample ID	BJ-8B	BJ-8B	08B	BJ-8B	BJ-8B	BJ-12A	BJ-12A
	Date Sampled	9/4/2012	1/28/2013	4/8/2013	7/14/2013	9/26/2013	9/5/2012	7/15/2013
	Time Sampled	00:00	00:00	00:00	00:00	8:10	12:40	00:00
	ALS Sample ID	L1207447-4	L1263921-9	L1288325-2	L1333226-5	L1370207-3	L1206550-1	L1335562-1
Dissolved Metals	**Unit**							
Aluminum (Al)-Dissolved	mg/L	0.0497	0.0173	3.59	0.0352	0.0312	0.0281	0.0119
Antimony (Sb)-Dissolved	mg/L	0.00074	0.00072	0.00092	0.00067	0.00067	0.00289	0.00055
Arsenic (As)-Dissolved	mg/L	0.0199	0.0159	0.0235	0.0167	0.0166	0.0609	0.00433
Barium (Ba)-Dissolved	mg/L	0.0214	0.0171	0.0785	0.0156	0.0152	0.0412	0.0706
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)-Dissolved	mg/L	0.01	<0.010	0.012	<0.010	<0.010	0.015	0.02
Cadmium (Cd)-Dissolved	mg/L	<0.000010	<0.000010	0.000012	<0.000010	<0.000010	0.000156	0.000039
Calcium (Ca)-Dissolved	mg/L	30.8	33.2	32.5	32.2	30.4	72.1	73.1
Chromium (Cr)-Dissolved	mg/L	0.00016	<0.00010	0.00287	0.00013	<0.00010	<0.00010	0.00186
Cobalt (Co)-Dissolved	mg/L	<0.00010	<0.00010	0.00069	<0.00010	<0.00010	0.00067	0.00072
Copper (Cu)-Dissolved	mg/L	<0.00050	<0.00050	0.00164	<0.00050	<0.00050	0.00097	<0.00050
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	1.06	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.000050	0.000739	<0.000050	<0.000050	0.000053	<0.000050
Lithium (Li)-Dissolved	mg/L	0.00485	0.00545	0.00557	0.00501	0.00525	0.00638	0.01
Magnesium (Mg)-Dissolved	mg/L	3.37	3.53	4.45	3.39	3.75	9.83	10.1
Manganese (Mn)-Dissolved	mg/L	0.000784	0.00822	0.0929	0.000513	0.00066	0.361	0.314
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)-Dissolved	mg/L	0.00171	0.00224	0.00218	0.00166	0.00161	0.0023	0.00297
Nickel (Ni)-Dissolved	mg/L	<0.00050	0.00132	0.00226	<0.00050	<0.00050	0.00091	0.00716
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	mg/L	0.592	0.631	1.59	0.598	0.544	4.88	4.53
Selenium (Se)-Dissolved	mg/L	0.00033	0.00024	0.00026	0.00023	0.00021	<0.00010	0.0001
Silicon (Si)-Dissolved	mg/L	2.22	1.97	7.96	2.04	1.92	3.36	3.63
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	0.000085	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	2.7	2.3	2.4	2.3	2.4	5.5	6.2
Strontium (Sr)-Dissolved	mg/L	0.465	0.451	0.541	0.44	0.446	1.08	1.37
Thallium (Tl)-Dissolved	mg/L	<0.000010	<0.000010	0.00006	<0.000010	<0.000010	0.000075	0.000024
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00018
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	0.056	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.000322	0.000156	0.00027	0.00016	0.000156	0.00245	0.000257
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	0.004	<0.0010	<0.0010	<0.0010	<0.0010
Zinc (Zn)-Dissolved	mg/L	<0.0030	<0.0030	0.0063	<0.0030	<0.0030	0.0059	0.0057

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	MW-BGC11-BJ-12A	Drill Water	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)
	BGC Sample ID	BJ-12A	DRW	FB	FB	FB	FB
	Date Sampled	9/30/2013	6/27/2012	3/30/2012	10/11/2011	6/27/2012	9/5/2012
	Time Sampled	16:15	11:00	14:30	9:00	11:40	16:00
	ALS Sample ID	L1372080-1	L1171422-10	L1130044-2	L1071509-8	L1171422-9	L1206550-2
Dissolved Metals	**Unit**						
Aluminum (Al)-Dissolved	mg/L	0.005	0.25	<0.0050	<0.00050	<0.00010	<0.00010
Antimony (Sb)-Dissolved	mg/L	0.0013	0.0556	<0.00050	<0.00050	<0.00010	<0.00010
Arsenic (As)-Dissolved	mg/L	0.0252	0.0258	<0.00050	<0.020	<0.000050	<0.000050
Barium (Ba)-Dissolved	mg/L	0.0398	0.0181	<0.020	<0.0010	<0.00010	<0.00010
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.0020	<0.0010	<0.20	<0.00050	<0.00050
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.010	<0.20	<0.10	<0.010	<0.010
Boron (B)-Dissolved	mg/L	0.022	<0.20	<0.10	<0.000017	<0.000010	<0.000010
Cadmium (Cd)-Dissolved	mg/L	<0.000010	<0.00020	<0.000017	<0.10	<0.020	<0.020
Calcium (Ca)-Dissolved	mg/L	85.4	31.1	<0.10	<0.0010	<0.00010	<0.00010
Chromium (Cr)-Dissolved	mg/L	0.00012	<0.0020	<0.0010	<0.00030	<0.00010	<0.00010
Cobalt (Co)-Dissolved	mg/L	0.00033	<0.0020	<0.00030	<0.0010	<0.00050	<0.00050
Copper (Cu)-Dissolved	mg/L	<0.00050	<0.010	<0.0010	<0.030	<0.030	<0.030
Iron (Fe)-Dissolved	mg/L	<0.030	<0.060	<0.030	<0.00050	<0.000050	<0.000050
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.0010	<0.00050	<0.0050	<0.00050	<0.00050
Lithium (Li)-Dissolved	mg/L	0.0131	0.017	<0.0050	<0.10	<0.0050	<0.0050
Magnesium (Mg)-Dissolved	mg/L	13	4.88	<0.10	<0.00030	<0.000050	<0.000050
Manganese (Mn)-Dissolved	mg/L	0.344	0.0382	<0.00030	<0.000010	<0.000010	<0.000010
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.00050	<0.000010	<0.0010	<0.000050	<0.000050
Molybdenum (Mo)-Dissolved	mg/L	0.00212	0.0317	<0.0010	<0.0010	<0.00050	<0.00050
Nickel (Ni)-Dissolved	mg/L	0.00213	<0.010	<0.0010	<0.30	<0.30	<0.30
Phosphorus (P)-Dissolved	mg/L	<0.30	<0.60	<0.30	<2.0	<0.050	<0.050
Potassium (K)-Dissolved	mg/L	4.47	41.1	<2.0	<0.0010	<0.00010	<0.00010
Selenium (Se)-Dissolved	mg/L	<0.00010	<0.0020	<0.0010	<0.050	<0.050	<0.050
Silicon (Si)-Dissolved	mg/L	3.69	2.3	<0.050	<0.000020	<0.000010	<0.000010
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.00020	<0.000020	<2.0	<2.0	<2.0
Sodium (Na)-Dissolved	mg/L	9.2	<4.0	<2.0	<0.0050	<0.00020	<0.00020
Strontium (Sr)-Dissolved	mg/L	1.78	0.212	<0.0050	<0.00020	<0.000010	<0.000010
Thallium (Tl)-Dissolved	mg/L	0.000018	<0.00020	<0.00020	<0.00050	<0.00010	<0.00010
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.0020	<0.00050	<0.010	<0.010	<0.010
Titanium (Ti)-Dissolved	mg/L	0.01	<0.020	<0.010	<0.00020	<0.000010	<0.000010
Uranium (U)-Dissolved	mg/L	0.000364	<0.00020	<0.00020	<0.0010	<0.0010	<0.0010
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.020	<0.0010	<0.0050	<0.0030	<0.0030
Zinc (Zn)-Dissolved	mg/L	0.003	<0.060	<0.0050	<0.0050	<0.0030	<0.0030

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	Field Blank (De-Ionized water)	BJ-FB	Travel Blank	Travel Blank
	BGC Sample ID	BJ-FB	FB	BJ-FB	BJ-FB	TRAVEL BLANK	TB
	Date Sampled	1/30/2013	4/8/2013	7/11/2013	26-SEP-13	6/27/2012	9/5/2012
	Time Sampled	00:00	0:00	00:00	00:00	0:00	00:00
	ALS Sample ID	L1264492-1	L1288325-5	L1331947-5	L1370207-5	L1171422-11	L1206550-3
Dissolved Metals	**Unit**						
Aluminum (Al)-Dissolved	mg/L	<0.00010	<0.00010	<0.0030	<0.0030	-	-
Antimony (Sb)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	-	-
Arsenic (As)-Dissolved	mg/L	<0.000050	<0.000050	<0.00010	<0.00010	-	-
Barium (Ba)-Dissolved	mg/L	<0.00010	<0.00010	<0.000050	<0.000050	-	-
Beryllium (Be)-Dissolved	mg/L	<0.00050	<0.00050	<0.00010	<0.00010	-	-
Bismuth(Bi)- Dissolved	mg/L	<0.010	<0.010	<0.00050	<0.00050	-	-
Boron (B)-Dissolved	mg/L	<0.000010	<0.000010	<0.010	<0.010	-	-
Cadmium (Cd)-Dissolved	mg/L	<0.020	<0.020	<0.000010	<0.000010	-	-
Calcium (Ca)-Dissolved	mg/L	<0.00010	<0.00010	<0.020	<0.020	-	-
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	-	-
Cobalt (Co)-Dissolved	mg/L	<0.00050	<0.00050	<0.00010	<0.00010	-	-
Copper (Cu)-Dissolved	mg/L	<0.030	<0.030	<0.00050	<0.00050	-	-
Iron (Fe)-Dissolved	mg/L	<0.000050	<0.000050	<0.030	<0.030	-	-
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.000050	<0.000050	-	-
Lithium (Li)-Dissolved	mg/L	<0.0050	<0.0050	<0.00050	<0.00050	-	-
Magnesium (Mg)-Dissolved	mg/L	<0.000050	<0.000050	<0.0050	<0.0050	-	-
Manganese (Mn)-Dissolved	mg/L	<0.000010	<0.000010	<0.000050	<0.000050	-	-
Mercury (Hg)-Dissolved	mg/L	<0.000050	<0.000050	<0.000010	<0.000010	-	-
Molybdenum (Mo)-Dissolved	mg/L	<0.00050	<0.00050	<0.000050	<0.000050	-	-
Nickel (Ni)-Dissolved	mg/L	<0.30	<0.30	<0.00050	<0.00050	-	-
Phosphorus (P)-Dissolved	mg/L	<0.050	<0.050	<0.30	<0.30	-	-
Potassium (K)-Dissolved	mg/L	<0.00010	<0.00010	<0.050	<0.050	-	-
Selenium (Se)-Dissolved	mg/L	<0.050	<0.050	<0.00010	<0.00010	-	-
Silicon (Si)-Dissolved	mg/L	<0.000010	<0.000010	<0.050	<0.050	-	-
Silver (Ag)-Dissolved	mg/L	<2.0	<2.0	<0.000010	<0.000010	-	-
Sodium (Na)-Dissolved	mg/L	<0.00020	<0.00020	<2.0	<2.0	-	-
Strontium (Sr)-Dissolved	mg/L	<0.000010	<0.000010	<0.00020	<0.00020	-	-
Thallium (Tl)-Dissolved	mg/L	<0.00010	<0.00010	<0.000010	<0.000010	-	-
Tin (Sn)-Dissolved	mg/L	<0.010	<0.010	<0.00010	<0.00010	-	-
Titanium (Ti)-Dissolved	mg/L	<0.000010	<0.000010	<0.010	<0.010	-	-
Uranium (U)-Dissolved	mg/L	<0.0010	<0.0010	<0.000010	<0.000010	-	-
Vanadium (V)-Dissolved	mg/L	<0.0030	<0.0030	<0.0010	<0.0010	-	-
Zinc (Zn)-Dissolved	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	-	-

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations

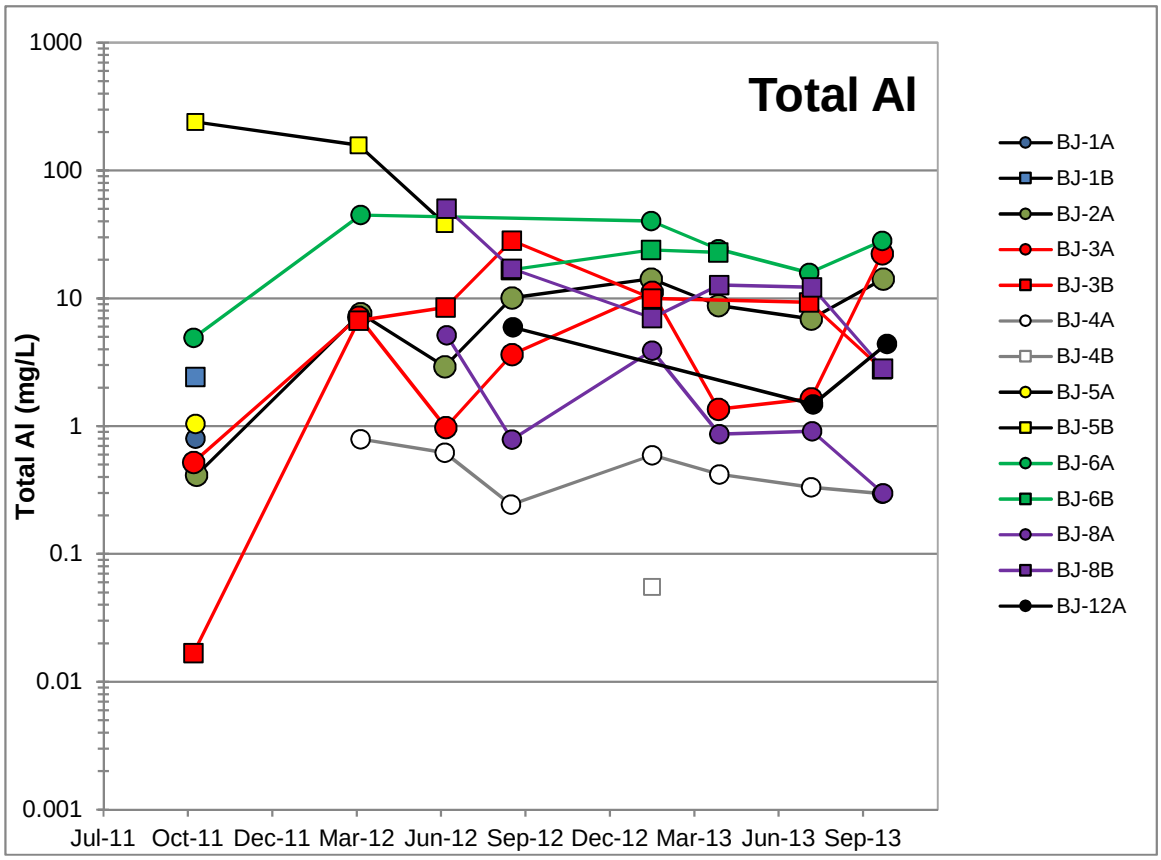
Table E-3: Groundwater Analytical Chemistry Results (Dissolved Metals)

	Sample Location	Travel Blank	Travel Blank	TRAVEL BLANK
	BGC Sample ID	TRAVEL BLANK	TRAVEL BLANK	TRAVEL BLANK
	Date Sampled	1/30/2013	4/7/2013	25-SEP-13
	Time Sampled	00:00	00:00	00:00
	ALS Sample ID	L1264492-2	L1287525-6	L1370058-5
Dissolved Metals	**Unit**			
Aluminum (Al)-Dissolved	mg/L	-	-	-
Antimony (Sb)-Dissolved	mg/L	-	-	-
Arsenic (As)-Dissolved	mg/L	-	-	-
Barium (Ba)-Dissolved	mg/L	-	-	-
Beryllium (Be)-Dissolved	mg/L	-	-	-
Bismuth(Bi)- Dissolved	mg/L	-	-	-
Boron (B)-Dissolved	mg/L	-	-	-
Cadmium (Cd)-Dissolved	mg/L	-	-	-
Calcium (Ca)-Dissolved	mg/L	-	-	-
Chromium (Cr)-Dissolved	mg/L	-	-	-
Cobalt (Co)-Dissolved	mg/L	-	-	-
Copper (Cu)-Dissolved	mg/L	-	-	-
Iron (Fe)-Dissolved	mg/L	-	-	-
Lead (Pb)-Dissolved	mg/L	-	-	-
Lithium (Li)-Dissolved	mg/L	-	-	-
Magnesium (Mg)-Dissolved	mg/L	-	-	-
Manganese (Mn)-Dissolved	mg/L	-	-	-
Mercury (Hg)-Dissolved	mg/L	-	-	-
Molybdenum (Mo)-Dissolved	mg/L	-	-	-
Nickel (Ni)-Dissolved	mg/L	-	-	-
Phosphorus (P)-Dissolved	mg/L	-	-	-
Potassium (K)-Dissolved	mg/L	-	-	-
Selenium (Se)-Dissolved	mg/L	-	-	-
Silicon (Si)-Dissolved	mg/L	-	-	-
Silver (Ag)-Dissolved	mg/L	-	-	-
Sodium (Na)-Dissolved	mg/L	-	-	-
Strontium (Sr)-Dissolved	mg/L	-	-	-
Thallium (Tl)-Dissolved	mg/L	-	-	-
Tin (Sn)-Dissolved	mg/L	-	-	-
Titanium (Ti)-Dissolved	mg/L	-	-	-
Uranium (U)-Dissolved	mg/L	-	-	-
Vanadium (V)-Dissolved	mg/L	-	-	-
Zinc (Zn)-Dissolved	mg/L	-	-	-

LEGEND
Concentration exceeds CCME Guideline
Concentration exceeds BC MOE AW 30-d avg. Standard
Concentration exceeds BC MOE AW Max. Standard
Concentration exceeds BC MOE DW Standard

Note: The British Columbia drinking water (BC MOE DW) and protection of aquatic life (BC MOE AW) standards as well as the Canadian Council of Ministers of the Environment (CCME) are shown in Table 10.

For CCME the results are compared to the long term max. concentrations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Total Al (mg/L)
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100
10
1
0.1
0.01
0.001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
BJ-4A
BJ-4B
BJ-5A
BJ-5B
BJ-6A
BJ-6B
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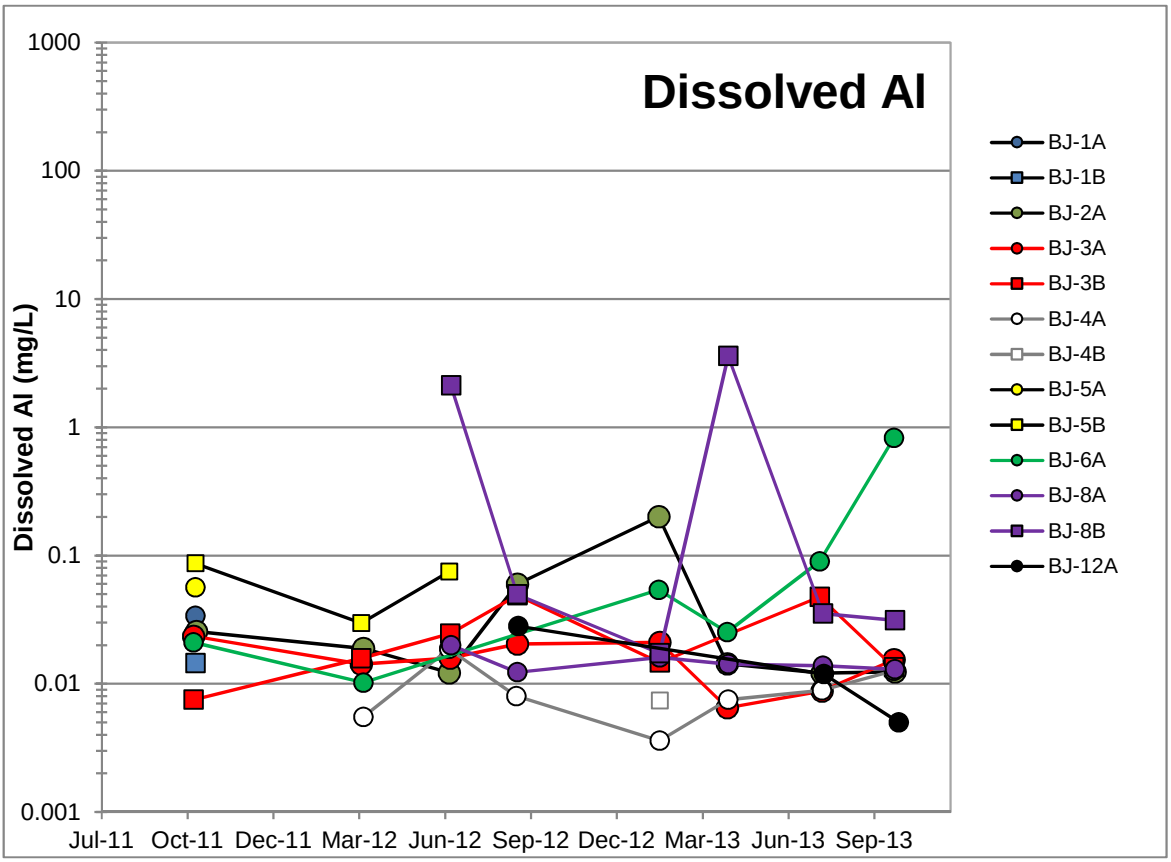
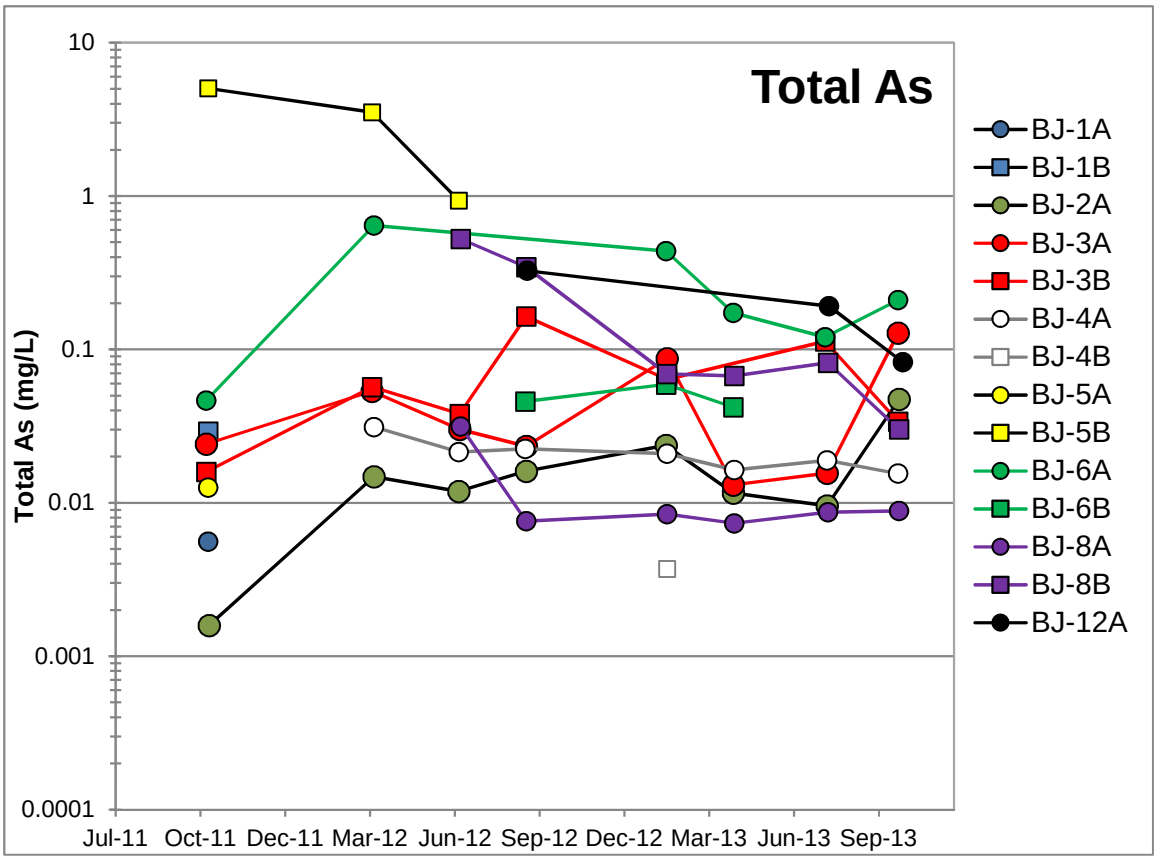
BJ-8B
BJ-12A


Dissolved Al
Dissolved Al (mg/L)
1000
100
10
1
0.1
0.01
0.001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
BJ-4A
BJ-4B
BJ-5A
BJ-5B
BJ-6A
BJ-8A
BJ-8B
BJ-12A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Total As (mg/L)
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1
0.1
0.01
0.001
0.0001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
BJ-4A
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BJ-5A
BJ-5B
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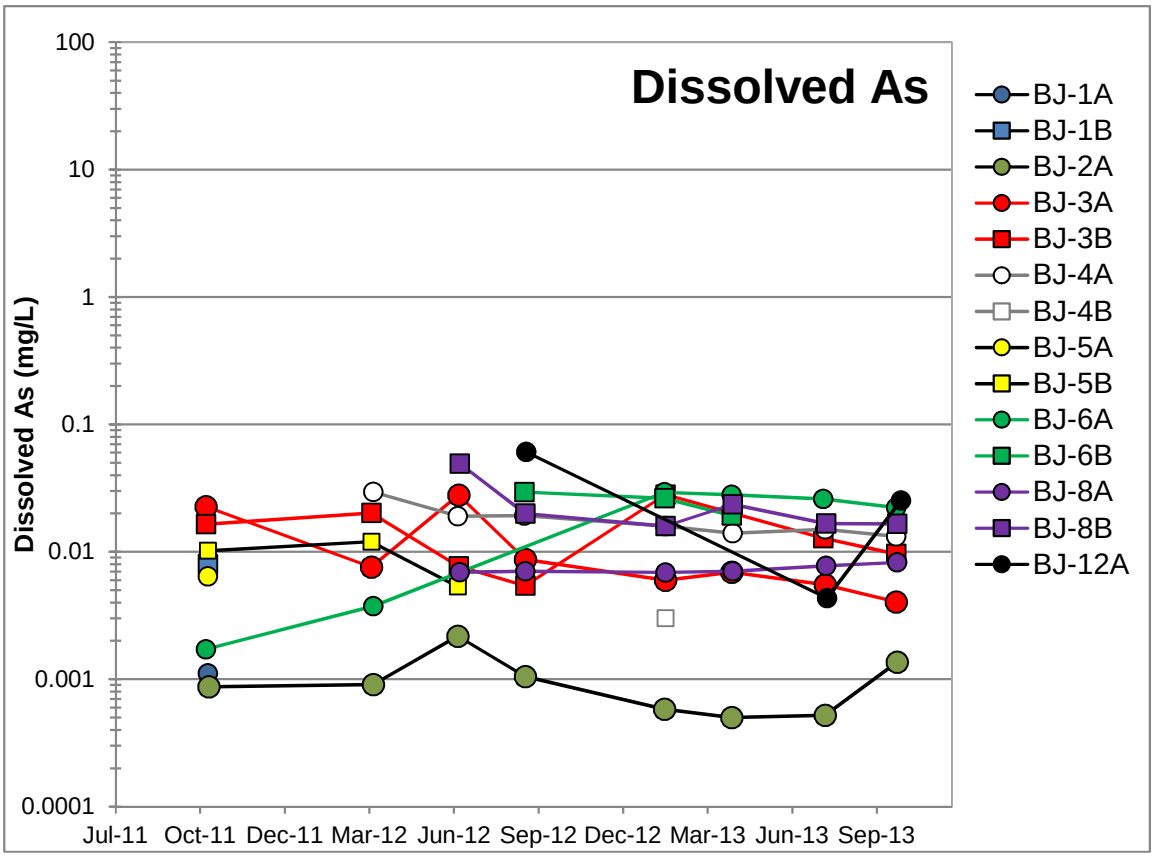
BJ-6B
BJ-8A
BJ-8B
BJ-12A


Dissolved As
Dissolved As (mg/L)
100
10
1
0.1
0.01
0.001
0.0001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
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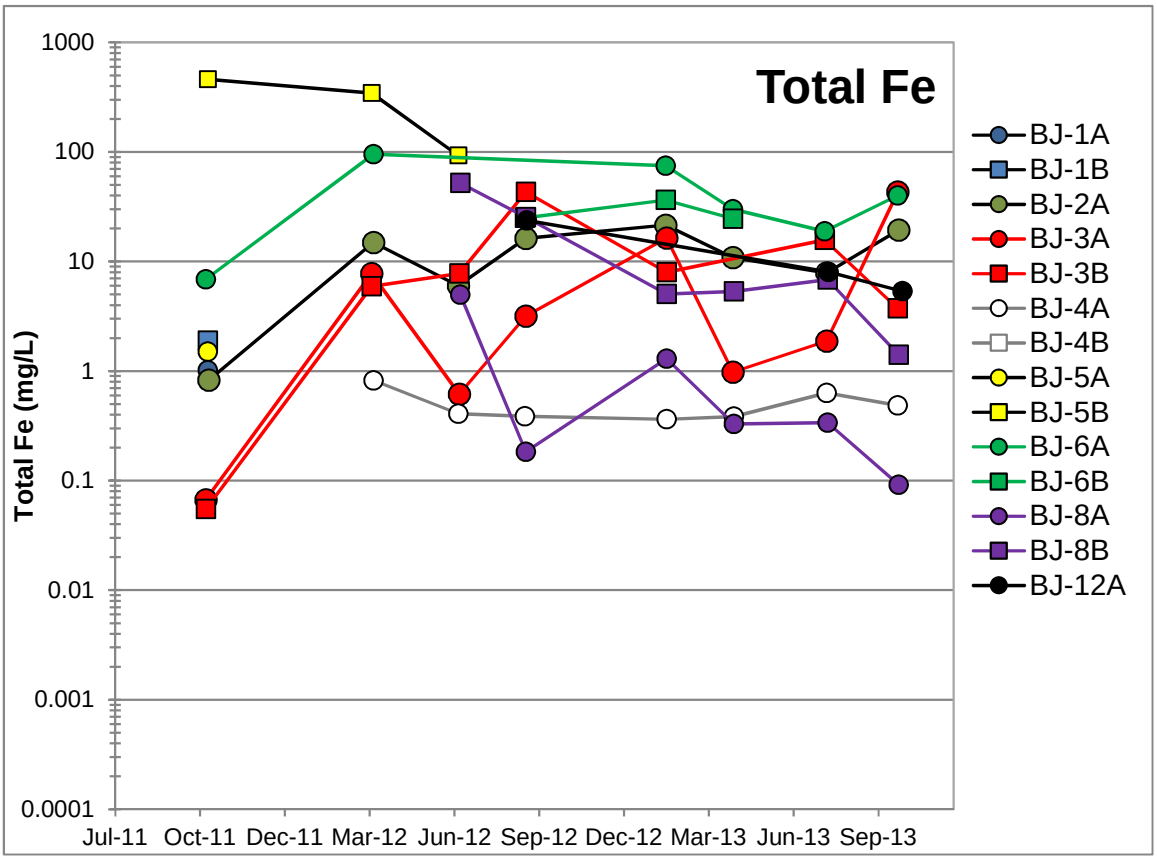
BJ-8B
BJ-12A


Total Fe
Total Fe (mg/L)
1000
100
10
1
0.1
0.01
0.001
0.0001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
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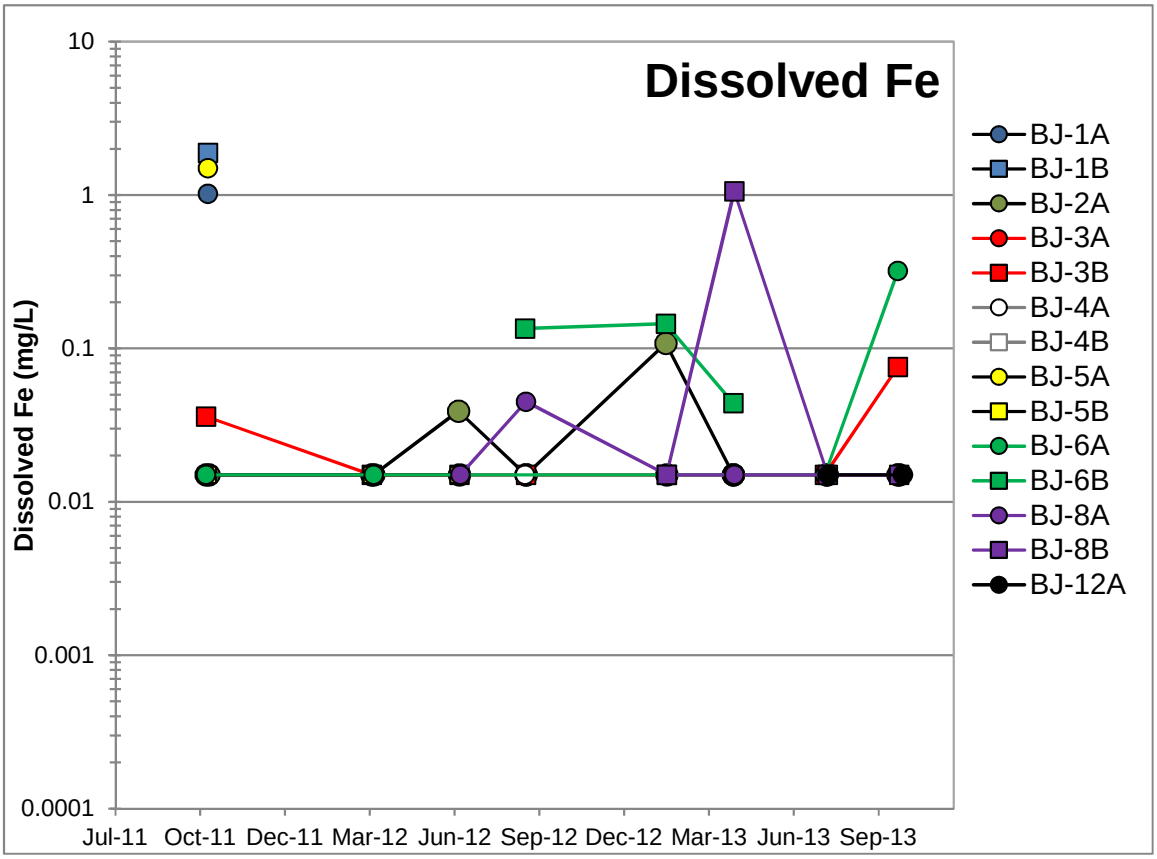
BJ-8B
BJ-12A


Dissolved Fe
Dissolved Fe (mg/L)
10
1
0.1
0.01
0.001
0.0001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
BJ-4A
BJ-4B
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BJ-5B
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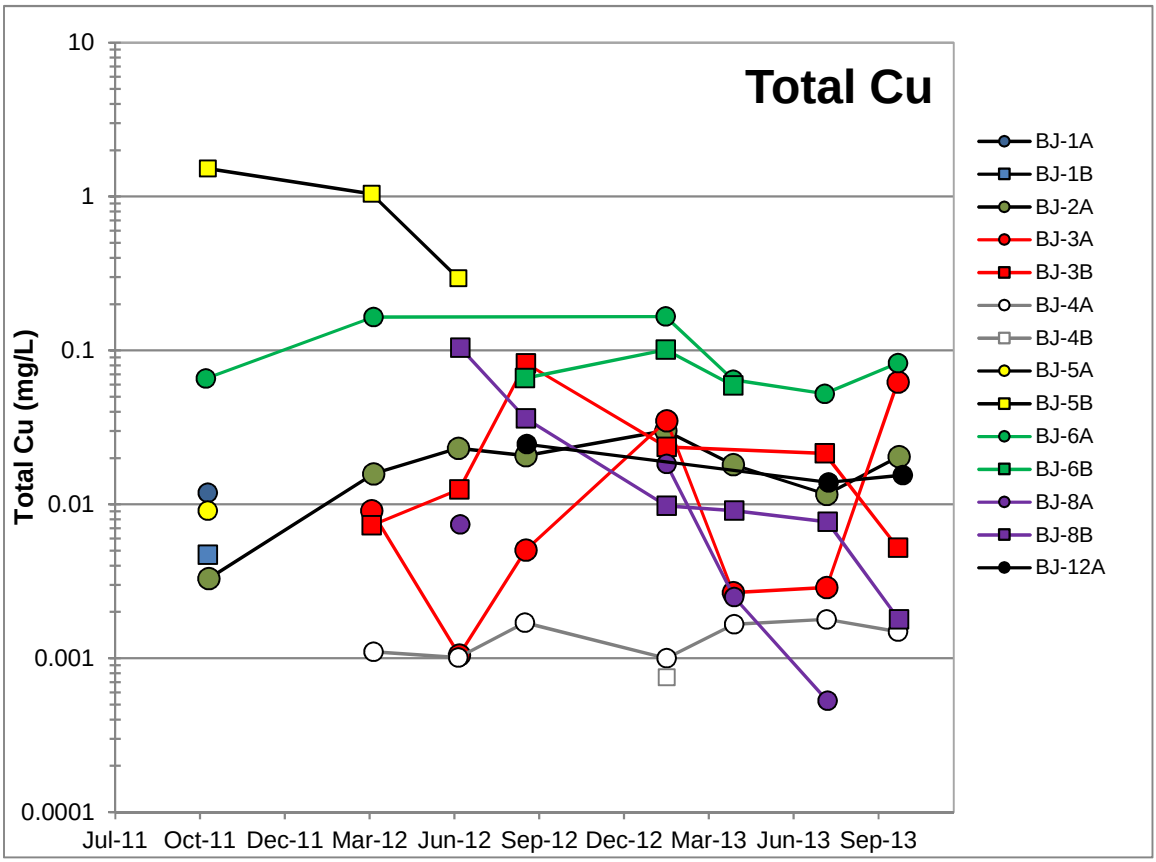
BJ-8B
BJ-12A


Total Cu
Total Cu (mg/L)
10
1
0.1
0.01
0.001
0.0001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
BJ-4A
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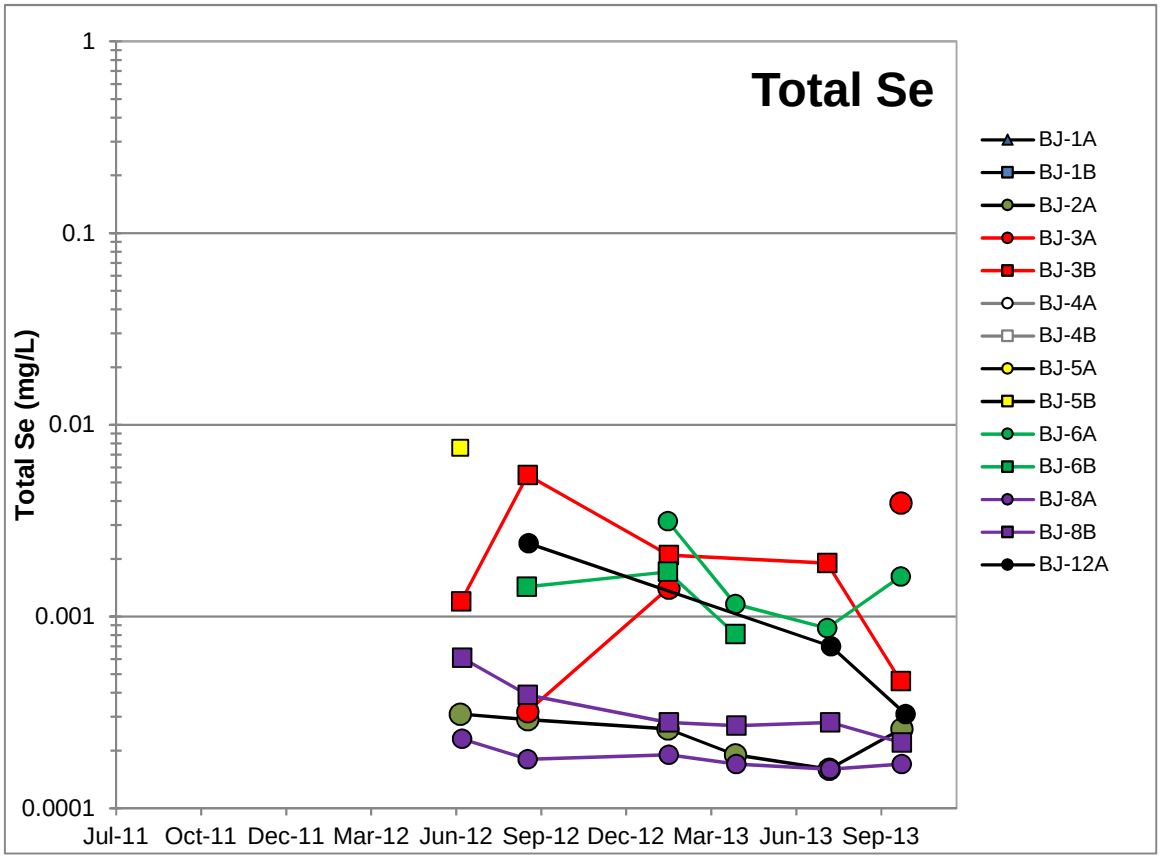
BJ-8B
BJ-12A


Total Se
Total Se (mg/L)
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0.1
0.01
0.001
0.0001
Jul-11
Oct-11
Dec-11
Mar-12
Jun-12
Sep-12
Dec-12
Mar-13
Jun-13
Sep-13
BJ-1A
BJ-1B
BJ-2A
BJ-3A
BJ-3B
BJ-4A
BJ-4B
BJ-5A
BJ-5B
BJ-6A
BJ-6B
BJ-8A
BJ-8B
BJ-12A

APPENDIX F
LABORATORY REPORTS AND CERTIFICATES

BGC ENGINEERING INC.
ATTN: Katherine Johnston
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 13-OCT-11
Report Date: 27-OCT-11 15:46 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1071509

Project P.O. #: BRUCE JACK
Job Reference: 1008-004-30
C of C Numbers: 4, 10-170928, 10-170929, 10-170930
Legal Site Desc:

Comments: Cyanide analysis was not performed for L1071509-8 as no appropriate sample with correct preservation was submitted.

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1071509-1	L1071509-2	L1071509-3	L1071509-4	L1071509-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	10-OCT-11	10-OCT-11	10-OCT-11	08-OCT-11	08-OCT-11
	Sampled Time	11:10	13:30	14:12	14:50	15:45
	Client ID	4A	5B	5A	6A	3B
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	453	335	249	389	339
	Hardness (as CaCO3) (mg/L)	203	171	91.5	186	167
	pH (pH)	8.08	8.12	7.96	7.99	8.14
	Total Suspended Solids (mg/L)	6.2	34400	62.2	717	<3.0
	Total Dissolved Solids (mg/L)	299	255	149	255	212
	Turbidity (NTU)	5.98	>4000	66.6	836	1.97
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	3.1	2.4	2.9	2.8	1.7
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	120	70.8	39.5	97.9	86.4
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<1.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<1.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	120	70.8	39.5	97.9	86.4
	Ammonia (as N) (mg/L)	0.269	0.393	0.102	0.0208	0.0318
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	0.76	1.47	0.67	<0.50
	Fluoride (F) (mg/L)	0.083	0.239	0.152	0.173	0.132
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0057	0.0074	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	0.0011	0.0011	0.0011	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.294	4.4	0.294	<0.050	0.085
	Total Nitrogen (mg/L)	0.294	4.4	0.301	0.0084	0.0854
	Orthophosphate-Dissolved (as P) (mg/L)	0.0039	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.0101	15.7	0.0417	0.492	<0.0020
	Sulfate (SO4) (mg/L)	118	96.3	73.6	96.1	82.5
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Cyanide, Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0088
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.35	3.68	3.13	3.63	0.74 RRV
	Total Organic Carbon (mg/L)	1.20	38.6	3.17	4.18	<0.50
Total Metals	Aluminum (Al)-Total (mg/L)	0.286	240	1.04	4.90	0.0168
	Antimony (Sb)-Total (mg/L)	0.0566	<0.010 DLA	0.00319	0.00750	0.00114
	Arsenic (As)-Total (mg/L)	0.0627	5.04	0.0126	0.0465	0.0159
	Barium (Ba)-Total (mg/L)	0.083	6.33	0.072	0.331	0.044
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.020 DLA	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Total (mg/L)	<0.10	0.25	<0.10	<0.10	<0.10
	Cadmium (Cd)-Total (mg/L)	0.000033	0.0109	0.000230	0.00229	<0.000017
	Calcium (Ca)-Total (mg/L)	61.0	620	32.4	75.7	61.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1071509-6	L1071509-7	L1071509-8	L1071509-9	L1071509-10
	Description	H2O	GW	GW	WATER	WATER
	Sampled Date	08-OCT-11	08-OCT-11	08-OCT-11		
	Sampled Time	16:30	09:00	10:00		
	Client ID	3A	2	7	1A	1B
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	358	217	<2.0	110	289
	Hardness (as CaCO3) (mg/L)	135	96.8	<0.50	45.2	89.8
	pH (pH)	8.22	8.14	5.72	7.96	7.99
	Total Suspended Solids (mg/L)	<3.0	9.6	<3.0	31.6	86.2
	Total Dissolved Solids (mg/L)	212	132	<10	59	187
	Turbidity (NTU)	2.94	19.1	<0.10	34.1	99.7
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.1	1.6	1.3	1.8	2.4
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	93.1	71.0	<2.0	29.2	86.1
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	93.1	71.0	<2.0	29.2	86.1
	Ammonia (as N) (mg/L)	0.0278	0.0152	<0.0050	0.0282	0.0229
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	0.070	<0.050
	Chloride (Cl) (mg/L)	<0.50	0.94	<0.50	0.66	<0.50
	Fluoride (F) (mg/L)	0.208	0.081	<0.020	0.039	0.251
	Nitrate (as N) (mg/L)	<0.0050	0.0259	<0.0050	0.0137	0.0258
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0036
	Total Kjeldahl Nitrogen (mg/L)	0.064	0.062	<0.050	0.178	0.106
	Total Nitrogen (mg/L)	0.0645	0.0876	<0.0025	0.192	0.135
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	<0.0020	0.0127	<0.0020	0.0316	0.0721
	Sulfate (SO4) (mg/L)	84.0	37.3	<0.50	19.1	60.0
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050		<0.0050	<0.0050
	Cyanide, Total (mg/L)	<0.0050	<0.0050		<0.0050	<0.0050
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.16 RRV	1.17	<0.50	1.41	1.06 RRV
	Total Organic Carbon (mg/L)	<0.50	0.96	<0.50	3.60	0.52
Total Metals	Aluminum (Al)-Total (mg/L)	0.523	0.414	<0.0050	0.801	2.43
	Antimony (Sb)-Total (mg/L)	0.00497	0.00188	<0.00050	0.00086	0.00136
	Arsenic (As)-Total (mg/L)	0.0242	0.00159	<0.00050	0.00559	0.0292
	Barium (Ba)-Total (mg/L)	0.040	0.065	<0.020	0.061	0.114
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Total (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Total (mg/L)	<0.000017	0.000021	<0.000017	0.000061	0.000032
	Calcium (Ca)-Total (mg/L)	51.0	34.5	<0.10	16.8	29.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1071509-1	L1071509-2	L1071509-3	L1071509-4	L1071509-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	10-OCT-11	10-OCT-11	10-OCT-11	08-OCT-11	08-OCT-11
	Sampled Time	11:10	13:30	14:12	14:50	15:45
	Client ID	4A	5B	5A	6A	3B
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.0024	0.241	0.0020	0.0024	<0.0010
	Cobalt (Co)-Total (mg/L)	0.00137	0.202	0.00435	0.00423	<0.00030
	Copper (Cu)-Total (mg/L)	0.0027	1.52	0.0091	0.0658	<0.0010
	Iron (Fe)-Total (mg/L)	0.338	460	1.50	6.90	0.055
	Lead (Pb)-Total (mg/L)	0.00079	0.518	0.00245	0.130	<0.00050
	Lithium (Li)-Total (mg/L)	0.0383	0.30	0.0229	0.0058	0.0128
	Magnesium (Mg)-Total (mg/L)	13.2	118	3.60	4.90	3.87
	Manganese (Mn)-Total (mg/L)	0.135	24.4	0.654	1.15	0.419
	Mercury (Hg)-Total (mg/L)	0.000543	0.0015	<0.000010	0.00062	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.0033	0.030	0.0063	<0.0010	<0.0010
	Nickel (Ni)-Total (mg/L)	0.0061	0.357	0.0038	0.0048	<0.0010
	Phosphorus (P)-Total (mg/L)	<0.30	12.5	<0.30	0.64	<0.30
	Potassium (K)-Total (mg/L)	2.6	74.8	3.3	4.8	<2.0
	Selenium (Se)-Total (mg/L)	<0.0010	<0.020 DLA	<0.0010	<0.0010	<0.0010
	Silicon (Si)-Total (mg/L)	3.72	228	4.92	11.1	3.57
	Silver (Ag)-Total (mg/L)	0.000047	0.244	0.000524	0.00238	<0.000020
	Sodium (Na)-Total (mg/L)	18.2	14.3	12.4	2.3	5.6
	Strontium (Sr)-Total (mg/L)	2.74	3.83	0.842	1.01	1.71
	Thallium (Tl)-Total (mg/L)	<0.00020	0.0105	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Total (mg/L)	0.00065	<0.010 DLA	0.00193	0.00060	<0.00050
	Titanium (Ti)-Total (mg/L)	0.012	0.335	0.020	0.106	<0.010
	Uranium (U)-Total (mg/L)	0.00186	0.0526	0.00028	0.00055	0.00025
	Vanadium (V)-Total (mg/L)	<0.0010	0.341	0.0015	0.0074	<0.0010
	Zinc (Zn)-Total (mg/L)	0.0131	1.63	0.0317	0.550	<0.0050
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	<0.0050	0.0868	0.0566	0.0210	0.0075
	Antimony (Sb)-Dissolved (mg/L)	0.0546	0.0113	0.00277	0.00178	0.00114
	Arsenic (As)-Dissolved (mg/L)	0.0613	0.0102	0.00641	0.00172	0.0165
	Barium (Ba)-Dissolved (mg/L)	0.069	0.042	0.027	0.036	0.042
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Dissolved (mg/L)	0.000019	<0.000017	0.000112	0.000359	<0.000017
	Calcium (Ca)-Dissolved (mg/L)	59.8	58.5	31.3	68.7	60.5
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cobalt (Co)-Dissolved (mg/L)	0.00115	<0.00030	0.00331	<0.00030	<0.00030
	Copper (Cu)-Dissolved (mg/L)	<0.0010	<0.0010	0.0024	0.0024	<0.0010
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	0.072	<0.030	0.036

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1071509-6	L1071509-7	L1071509-8	L1071509-9	L1071509-10
	Description	H2O	GW	GW	WATER	WATER
	Sampled Date	08-OCT-11	08-OCT-11	08-OCT-11		
	Sampled Time	16:30	09:00	10:00		
	Client ID	3A	2	7	1A	1B
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	<0.0010	0.0018	<0.0010	0.0013	0.0012
	Cobalt (Co)-Total (mg/L)	<0.00030	<0.00030	<0.00030	0.00049	0.00103
	Copper (Cu)-Total (mg/L)	<0.0010	0.0033	<0.0010	0.0119	0.0047
	Iron (Fe)-Total (mg/L)	0.067	0.825	<0.030	1.02	1.89
	Lead (Pb)-Total (mg/L)	<0.00050	0.00053	<0.00050	0.00165	0.00186
	Lithium (Li)-Total (mg/L)	0.0450	0.0088	<0.0050	0.0073	0.0817
	Magnesium (Mg)-Total (mg/L)	4.18	1.89	<0.10	1.19	4.19
	Manganese (Mn)-Total (mg/L)	0.224	0.0462	<0.00030	0.0797	0.129
	Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	<0.000010	0.000011	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.0030	0.0047	<0.0010	<0.0010	0.0024
	Nickel (Ni)-Total (mg/L)	<0.0010	<0.0010	<0.0010	0.0012	0.0010
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	2.1	<2.0	<2.0	<2.0	3.2
	Selenium (Se)-Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Silicon (Si)-Total (mg/L)	4.27	2.77	<0.050	2.06	5.77
	Silver (Ag)-Total (mg/L)	<0.000020	0.000064	<0.000020	0.000105	0.000073
	Sodium (Na)-Total (mg/L)	21.0	5.9	<2.0	2.6	25.3
	Strontium (Sr)-Total (mg/L)	1.48	1.33	<0.0050	0.205	0.896
	Thallium (Tl)-Total (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Total (mg/L)	<0.00050	0.00104	<0.00050	0.00401	0.00169
	Titanium (Ti)-Total (mg/L)	<0.010	0.013	<0.010	<0.010	0.030
	Uranium (U)-Total (mg/L)	<0.00020	0.00033	<0.00020	<0.00020	<0.00020
	Vanadium (V)-Total (mg/L)	<0.0010	<0.0010	<0.0010	0.0011	0.0020
	Zinc (Zn)-Total (mg/L)	<0.0050	0.0070	<0.0050	0.0392	0.0181
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	0.0235	0.0256	<0.0050	0.0339	0.0145
	Antimony (Sb)-Dissolved (mg/L)	0.00468	0.00181	<0.00050	0.00080	0.00093
	Arsenic (As)-Dissolved (mg/L)	0.0226	0.00087	<0.00050	0.00111	0.00797
	Barium (Ba)-Dissolved (mg/L)	0.029	0.041	<0.020	0.028	0.022
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Dissolved (mg/L)	0.000029	<0.000017	<0.000017	0.000027	<0.000017
	Calcium (Ca)-Dissolved (mg/L)	47.4	35.7	<0.10	16.4	29.7
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cobalt (Co)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
	Copper (Cu)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	0.0090	<0.0010
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1071509-1	L1071509-2	L1071509-3	L1071509-4	L1071509-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	10-OCT-11	10-OCT-11	10-OCT-11	08-OCT-11	08-OCT-11
	Sampled Time	11:10	13:30	14:12	14:50	15:45
	Client ID	4A	5B	5A	6A	3B
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Lithium (Li)-Dissolved (mg/L)	0.0345	0.0094	0.0214	<0.0050	0.0115
	Magnesium (Mg)-Dissolved (mg/L)	12.9	5.91	3.22	3.45	3.78
	Manganese (Mn)-Dissolved (mg/L)	0.116	0.134	0.569	0.0422	0.397
	Mercury (Hg)-Dissolved (mg/L)	0.000619	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.0028	0.0075	0.0058	<0.0010	<0.0010
	Nickel (Ni)-Dissolved (mg/L)	0.0054	<0.0010	0.0026	<0.0010	<0.0010
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	2.4	7.4	2.5	2.5	<2.0
	Selenium (Se)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Silicon (Si)-Dissolved (mg/L)	2.89	3.78	1.94	2.26	3.49
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Sodium (Na)-Dissolved (mg/L)	17.5	12.7	12.3	2.5	5.5
	Strontium (Sr)-Dissolved (mg/L)	2.71	0.747	0.811	0.894	1.64
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Dissolved (mg/L)	<0.00050	0.00116	0.00091	0.00052	<0.00050
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00166	0.00146	0.00022	<0.00020	0.00024
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	0.0091	<0.0050	0.0102	0.0548	0.0074

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1071509-6	L1071509-7	L1071509-8	L1071509-9	L1071509-10
	Description	H2O	GW	GW	WATER	WATER
	Sampled Date	08-OCT-11	08-OCT-11	08-OCT-11		
	Sampled Time	16:30	09:00	10:00		
	Client ID	3A	2	7	1A	1B
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Lithium (Li)-Dissolved (mg/L)	0.0445	0.0084	<0.0050	0.0073	0.0781
	Magnesium (Mg)-Dissolved (mg/L)	3.93	1.86	<0.10	1.01	3.80
	Manganese (Mn)-Dissolved (mg/L)	0.198	0.0353	<0.00030	0.0331	0.0306
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.0026	0.0044	<0.0010	<0.0010	0.0023
	Nickel (Ni)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	2.5
	Selenium (Se)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Silicon (Si)-Dissolved (mg/L)	3.31	1.98	<0.050	0.977	2.77
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Sodium (Na)-Dissolved (mg/L)	19.3	5.6	<2.0	2.9	25.8
	Strontium (Sr)-Dissolved (mg/L)	1.34	1.36	<0.0050	0.208	0.897
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	0.00161	0.00118
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	<0.00020	0.00031	<0.00020	<0.00020	<0.00020
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	0.0310	0.0067	<0.0050	0.0167	<0.0050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Qualifiers for Sample Submission Listed:

Qualifier	Description
SPL	Sample was Preserved at the laboratory - samples # 1-3 - Total Metals

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Sulfate (SO4)	MS-B	L1071509-1, -2, -3, -4, -5, -6, -7, -8

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RRV	Reported Result Verified By Repeat Analysis

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

Reference Information

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Dissociable Cyanide by Dist.	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-DIS-CCME-MS-VA	Water	Diss. Metals in Water by ICPMS (CCME)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-TOT-CCME-MS-VA	Water	Total Metals in Water by ICPMS (CCME)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

Reference Information

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-COL-VA	Water	TKN in Water by Colour	APHA 4500-NORG (TKN)

This analysis is carried out using procedures adapted from APHA Method 4500-Norg "Nitrogen (Organic)". Total Kjeldahl Nitrogen is determined using automated colourimetry.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

10-170928	10-170929	10-170930	4

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-170928

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of ____

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
Company:	BGC ENGINEERING	Standard: X	Other (specify):	X Regular (Standard Turnaround Times - Business Days)
Contact:	CATHERINE JOHNSTON	Select: PDF X	Excel Digital Fax	Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	500-1045 HOWE ST VANCOUVER BC	Email 1:	kjohnston@bgcengineering.ca	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	vcullen@bgcengineering.ca	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909			**Analysis Request**
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	**Client / Project Information**		(Indicate Filtered or Preserved, F/P)
	Copy of Invoice with Report? (circle) (Yes) or No	Job #:	1008-004-30	
Company:	PRETIUM RESOURCES	PO / AFE:	BRULEJACK.	
Contact:	KEN McNAUGHTON	LSD:		
Address:	570 GRANVILLE ST VANCOUVER			
Phone:	604 558 1784 Fax: 604 558 4784	Quote #:		
Lab Work Order # (lab use only)	L1071509	**ALS Contact:** D. Watt.	**Sampler:** K. JOHNSTON	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	4A	10-Oct-11	11:10	H_2O	
	~~1B~~ 5B	"	13:30	"	
	~~1A~~ 5A	"	14:12	"	

EMAILED INSTRUCTIONS TO DEAN / WATT

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
			BP	Oct. 13	9:14	4 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY GENF 18.01 Front

10-170929

L1071509-COFC

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of ____

Report To	Report Format / Distribution	Service Request:(Rush subject to availability - Contact ALS to confirm TAT)
Company: BGC Engineering	Standard: X Other (specify):	X Regular (Standard Turnaround Times - Business Days)
Contact: Katherine Johnston	Select: PDF X Excel Digital Fax	Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address: 500-1045 Howe St	Email 1: kjohnston@bgcengineering.ca	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Vancouver, BC V6Z 2A9	Email 2: vcullen@bgcengineering.ca	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone: (604) 684 5900 Fax: 604 684 5909		**Analysis Request**
Invoice To Same as Report ? (circle) Yes or (No) (if No, provide details)	**Client / Project Information**	(Indicate Filtered or Preserved, F/P)
Copy of Invoice with Report? (circle) (Yes) or No	Job #: 1008-004-30 BRUCEJACK	
Company: Premium Resources Inc	PO / AFE:	
Contact: Ken McNaughton	LSD:	
Address: 1600-570 Granville St Vancouver BC V6C 3P1		
Phone: 604 558 1784 Fax: 604	Quote #:	
Lab Work Order # (lab use only) L1071509	**ALS Contact:**	**Sampler:**

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	6A	08-Oct-11	14:50	H_2O	7
	3B	"	15:45	H_2O	7
	3A	"	16:30	H_2O	7

Sample Instructions emailed to D. Watt

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
			BP	Oct. 13	9:31	9 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY GENF 18.01 Front

10-170930

L1071509-COFC

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ___ of ___

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company: BGC ENGINEERING		Standard: X Other (specify):		X	Regular (Standard Turnaround Times - Business Days)
Contact: KATHERINE JOHNSTON		Select: PDF X Excel Digital Fax			Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address: 500-1045 HOWE ST		Email 1: kjohnston@bgcengineering.ca			Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
VANCOUVER, BC V6Z 2A9		Email 2: vcullen@bgcengineering.ca			Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone: 604 684 5900	Fax: 604 684 5909			Analysis Request	
Invoice To Same as Report ? (circle) Yes or (No) (if No, provide details)		Client / Project Information		(Indicate Filtered or Preserved, F/P)	
Copy of Invoice with Report? (circle) (Yes) or No		Job #: 1008-004-30			
Company: PRETIUM RESOURCES		PO / AFE: BRUCEJACK.			
Contact: KEN MCNAUGHTON		LSD:			
Address: 1600-570 GRANVILLE ST. VAN. BC					
Phone: 604 558 1784	Fax: 604 558 4784	Quote #:			
Lab Work Order # (lab use only)	L1071509	ALS Contact:	Sampler:		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	2	11-Oct-11	09:00	GW	
	7	"	10:00	GW	

HOLD FOR EMAIL INSTRUCTIONS

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
			BP	Oct.13	9:31	9°C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

GENF 18.01 Front

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

: Form

COC # NOTRECD

Page ____ of ____

L1071509-COFC

Report to:

Company: BGC Environmental

Contact:

Address:

Phone: Fax:

Standard: Other:

Select: PDF ____ Excel ____ Digital ____

Email 1:

Email 2:

Service Requested: (rush - subject to availability)

- Regular (Default)
- Priority (2-3 Business Days) - 50% Surcharge
- Emergency (1 Business Day) - 100% Surcharge
- For Emergency < 1 Day, ASAP or Weekend - Contact ALS

Invoice To: Same as Report ? Yes / No ?

Company:

Contact:

Address:

Phone: Fax:

Client / Project Information:

Job #:

PO / AFE:

Legal Site Description:

Quote #:

Lab Work Order # (lab use only): L1071509

ALS Contact:

Sampler:

Analysis Request

(Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date	Time	Sample Type	Number of Containers
	1A				
	1B				

Special Instructions / Regulations / Hazardous Details

SAMPLES RECEIVED WITHOUT COC

SHIPMENT RELEASE (client use)		SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)		
Released by:	Date & Time:	Received by: JH	Date: 13/OCT/11	Time: 18:00pm	Temperature: 9 °C	Verified by:	Date & Time:	Observations: Yes / No ? If Yes attach SIF

GENF 18.00 Front

BGC ENGINEERING INC.
ATTN: Katherine Johnston
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 30-MAR-12
Report Date: 12-APR-12 13:05 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1129695

Project P.O. #: BRUCEJACK
Job Reference: 1008-006-50
C of C Numbers: 10-196181
Legal Site Desc:

Dean Watt
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1129695-1	L1129695-2	L1129695-3	L1129695-4	
	Description	H2O	H2O	H2O	H2O	
	Sampled Date	28-MAR-12	28-MAR-12	28-MAR-12	28-MAR-12	
	Sampled Time	13:15	11:00	09:30	10:10	
	Client ID	BJ-3A	BJ-3B	BJ-5A	BJ-5B	
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	
	Conductivity (uS/cm)	355	312	484	338	
	Hardness (as CaCO3) (mg/L)	167	156	100	145	
	pH (pH)	8.05	7.89	8.20	8.13	
	Total Suspended Solids (mg/L)	328	275	5380	6220	
	Total Dissolved Solids (mg/L)	247	215	323	237	
	Turbidity (NTU)	270	204	>4000	>4000	
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	2.2	2.7	1.1	1.5	
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	93.8	42.9	83.1	75.6	
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	
	Alkalinity, Total (as CaCO3) (mg/L)	93.8	42.9	83.1	75.6	
	Ammonia, Total (as N) (mg/L)	0.0289	0.0145	0.283	0.121	
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	
	Chloride (Cl) (mg/L)	<0.50	<0.50	1.47	2.97	
	Fluoride (F) (mg/L)	0.186	0.091	0.221	0.184	
	Nitrate (as N) (mg/L)	0.0059	0.0200	<0.0050	<0.0050	
	Nitrite (as N) (mg/L)	0.0024	0.0018	<0.0010	<0.0010	
	Total Kjeldahl Nitrogen (mg/L)	0.119	0.114	0.460	0.276	
	Total Nitrogen (mg/L)	0.127	0.136	0.460	0.276	
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.0021	<0.0010	<0.0010	
	Phosphorus (P)-Total (mg/L)	0.113	0.0453	0.336	1.11	
	Sulfate (SO4) (mg/L)	89.4	108	155	89.2	
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
	Cyanide, Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	3.02	0.60	
	Total Organic Carbon (mg/L)	1.00	0.77	6.13	2.21	
Total Metals	Aluminum (Al)-Total (mg/L)	7.15	6.72	52.5	158	
	Antimony (Sb)-Total (mg/L)	0.00446	0.00596	0.0029	0.013	
	Arsenic (As)-Total (mg/L)	0.0534	0.0568	0.311	3.52	
	Barium (Ba)-Total (mg/L)	0.180	0.168	0.760	3.44	
	Beryllium (Be)-Total (mg/L)	<0.0010	<0.0010	0.0091	<0.020 DLA	
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	
	Boron (B)-Total (mg/L)	<0.10	<0.10	0.11	0.15	
	Cadmium (Cd)-Total (mg/L)	0.000257	0.000185	0.00210	0.00641	
	Calcium (Ca)-Total (mg/L)	59.4	58.4	164	460	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1129695-1	L1129695-2	L1129695-3	L1129695-4	
	Description	H2O	H2O	H2O	H2O	
	Sampled Date	28-MAR-12	28-MAR-12	28-MAR-12	28-MAR-12	
	Sampled Time	13:15	11:00	09:30	10:10	
	Client ID	BJ-3A	BJ-3B	BJ-5A	BJ-5B	
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.0033	0.0023	0.0264	0.146	
	Cobalt (Co)-Total (mg/L)	0.00226	0.00172	0.0239	0.152	
	Copper (Cu)-Total (mg/L)	0.0091	0.0073	0.120	1.04	
	Iron (Fe)-Total (mg/L)	7.75	5.95	54.8	344	
	Lead (Pb)-Total (mg/L)	0.00931	0.00606	0.121	0.267	
	Lithium (Li)-Total (mg/L)	0.0249	0.0104	0.111	0.22	
	Magnesium (Mg)-Total (mg/L)	5.77	4.53	24.5	94.3	
	Manganese (Mn)-Total (mg/L)	0.640	0.385	1.94	17.9	
	Mercury (Hg)-Total (mg/L)	0.000022	0.000012	0.000124	0.000351	
	Molybdenum (Mo)-Total (mg/L)	0.0019	<0.0010	0.0058	<0.020 DLA	
	Nickel (Ni)-Total (mg/L)	0.0020	0.0019	0.0422	0.251	
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	1.51	9.74	
	Potassium (K)-Total (mg/L)	3.1	2.1	13.8	48.1	
	Selenium (Se)-Total (mg/L)	<0.0010	<0.0010	<0.0050 DLA	<0.020 DLA	
	Silicon (Si)-Total (mg/L)	10.6	8.57	84.5	134	
	Silver (Ag)-Total (mg/L)	0.00108	0.000387	0.0189	0.136	
	Sodium (Na)-Total (mg/L)	9.6	3.2	62.5	11.1	
	Strontium (Sr)-Total (mg/L)	1.20	1.04	4.65	4.33	
	Thallium (Tl)-Total (mg/L)	0.00023	0.00023	0.0018	0.0091	
	Tin (Sn)-Total (mg/L)	<0.00050	<0.00050	<0.0025 DLA	<0.010 DLA	
	Titanium (Ti)-Total (mg/L)	0.105	0.066	0.075	0.228	
	Uranium (U)-Total (mg/L)	0.00033	0.00046	0.0175	0.0132	
	Vanadium (V)-Total (mg/L)	0.0113	0.0105	0.0390	0.221	
	Zinc (Zn)-Total (mg/L)	0.0291	0.0292	0.321	1.27	
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	
	Aluminum (Al)-Dissolved (mg/L)	0.0142	0.0158	0.148	0.0297	
	Antimony (Sb)-Dissolved (mg/L)	0.00130	0.00245	0.00501	0.00722	
	Arsenic (As)-Dissolved (mg/L)	0.00758	0.0202	0.0144	0.0120	
	Barium (Ba)-Dissolved (mg/L)	0.031	0.034	0.021	0.024	
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	
	Cadmium (Cd)-Dissolved (mg/L)	0.000038	0.000060	<0.000017	<0.000017	
	Calcium (Ca)-Dissolved (mg/L)	60.0	57.8	30.1	48.6	
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Cobalt (Co)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	<0.00030	
	Copper (Cu)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1129695-1	L1129695-2	L1129695-3	L1129695-4	
	Description	H2O	H2O	H2O	H2O	
	Sampled Date	28-MAR-12	28-MAR-12	28-MAR-12	28-MAR-12	
	Sampled Time	13:15	11:00	09:30	10:10	
	Client ID	BJ-3A	BJ-3B	BJ-5A	BJ-5B	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	0.038	<0.030	
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Lithium (Li)-Dissolved (mg/L)	0.0200	<0.0050	0.0865	0.0151	
	Magnesium (Mg)-Dissolved (mg/L)	4.12	2.78	6.10	5.74	
	Manganese (Mn)-Dissolved (mg/L)	0.139	0.0825	0.0576	0.262	
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Molybdenum (Mo)-Dissolved (mg/L)	0.0015	<0.0010	0.0054	0.0055	
	Nickel (Ni)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	5.0	3.7	
	Selenium (Se)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Silicon (Si)-Dissolved (mg/L)	3.30	1.91	3.42	2.80	
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Sodium (Na)-Dissolved (mg/L)	9.4	3.1	65.2	9.8	
	Strontium (Sr)-Dissolved (mg/L)	1.18	1.03	2.16	1.55	
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Uranium (U)-Dissolved (mg/L)	<0.00020	0.00032	0.00167	0.00082	
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Antimony (Sb)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Beryllium (Be)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Cadmium (Cd)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Copper (Cu)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Lead (Pb)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Lithium (Li)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Molybdenum (Mo)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Selenium (Se)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Silver (Ag)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Thallium (Tl)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Tin (Sn)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Uranium (U)-Total	DLA	L1129695-1, -2, -3, -4
Duplicate	Bromide (Br)	DLM	L1129695-1, -2, -3, -4
Duplicate	Nitrite (as N)	DLM	L1129695-1, -2, -3, -4
Matrix Spike	Chloride (Cl)	MS-B	L1129695-1, -2, -3, -4
Matrix Spike	Fluoride (F)	MS-B	L1129695-1, -2, -3, -4
Matrix Spike	Sulfate (SO4)	MS-B	L1129695-1, -2, -3, -4
Matrix Spike	Sulfate (SO4)	MS-B	L1129695-1, -2, -3, -4
Matrix Spike	Nitrate (as N)	MS-B	L1129695-1, -2, -3, -4
Matrix Spike	Sulfate (SO4)	MS-B	L1129695-1, -2, -3, -4
Matrix Spike	Ammonia, Total (as N)	MS-B	L1129695-1, -2, -3

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

Reference Information

ANIONS-NO3-IC-VA Water Nitrate in Water by Ion Chromatography EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA Water Sulfate by Ion Chromatography APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA Water Dissolved organic carbon by combustion APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA Water Total organic carbon by combustion APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-MID-HH-COL-VA Water Total Cyanide by HH Distillation APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA Water Weak Acid Dissociable Cyanide by Dist. APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

COLOUR-TRUE-VA Water Colour (True) by Spectrometer BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA Water Conductivity (Automated) APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA Water Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA Water Dissolved Mercury in Water by CVAFS(Low) EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA Water Total Mercury in Water by CVAFS(Low) EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-DIS-CCME-MS-VA Water Diss. Metals in Water by ICPMS (CCME) EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-TOT-CCME-MS-VA Water Total Metals in Water by ICPMS (CCME) EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or

Reference Information

microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

10-196181

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-196181

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1-800-668-9878

www.alsglobal.com

Report To

Company: BGC Engineering Inc
Contact: Katherine Johnston
Address: 500 - 1045 Howe Street
Vancouver BC V6Z 2A9
Phone: 604 684 5900 Fax: 604 684 5909

Report Format / Distribution

Standard: X Other (specify):
Select: PDF X Excel Digital Fax
Email 1: kjohnston@bgcengineering.ca
Email 2: vcullen@bgcengineering.ca

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- Y Regular (Standard Turnaround Times - Business Days)
- Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Invoice To Same as Report ? (circle) Yes or (No) (if No, provide details)

Copy of Invoice with Report? (circle) Yes or No

Company: Pretium Resources
Contact: Ken McNaughton
Address: 570 Granville St Vancover
Phone: 604 558 1784 Fax: 604 558 4784

Client / Project Information

Job #: 1008-006-50
PO / AFE: Brucejack
LSD:
Quote #:

Lab Work Order # (lab use only): L1129695

ALS Contact: D Watt.

Sampler: B Smith

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	BJ-3A	28-03-12	13:15	H_2O	
	BJ-3B	"	11:00	"	
	BJ-5A	"	09:30	"	
	BJ-5B	"	10:10	"	

AS for AS ID L1071509 - Ask D WATT

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by: Tristan	Date: Mar30	Time: 12:35	Temperature: 2 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

BGC ENGINEERING INC.
ATTN: Katherine Johnston
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 02-APR-12
Report Date: 12-APR-12 17:25 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1130044

Project P.O. #: BRUCEJACK
Job Reference: 1008-006-50
C of C Numbers: 10-174709
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1130044-1	L1130044-2	L1130044-3	L1130044-4	L1130044-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	30-MAR-12	30-MAR-12	30-MAR-12	30-MAR-12	30-MAR-12
	Sampled Time	13:40	14:30	11:30	14:05	13:25
	Client ID	BJ-DUP1	BJ-0A	BJ-2A	BJ-4A	BJ-6A
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	346	<2.0	262	454	347
	Hardness (as CaCO3) (mg/L)	180	<0.50	133	212	178
	pH (pH)	8.05	5.55	8.04	8.14	8.03
	Total Suspended Solids (mg/L)	3990	6.4	293	51.7	3460
	Total Dissolved Solids (mg/L)	243	<10	173	312	248
	Turbidity (NTU)	>4000	<0.10	260	20.7	>4000
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.9	1.7	1.8	1.6	2.2
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	95.3	<2.0	79.8	126	96.1
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	95.3	<2.0	79.8	126	96.1
	Ammonia, Total (as N) (mg/L)	0.0479	<0.0050	0.0067	0.239	0.0636
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	<0.50	0.67	<0.50	<0.50
	Fluoride (F) (mg/L)	0.160	<0.020	0.045	0.079	0.152
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0077	0.0072	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	0.0035	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.254	0.143	0.174	0.346	1.20
	Total Nitrogen (mg/L)	0.254	0.143	0.182	0.357	1.20
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	0.0032	0.0010
	Phosphorus (P)-Total (mg/L)	3.22	<0.0020	0.281	0.0304	3.55
	Sulfate (SO4) (mg/L)	84.7	<0.50	58.5	122	86.0
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Cyanide, Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Total Organic Carbon (mg/L)	1.42	<0.50	2.01	1.27	1.14
Total Metals	Aluminum (Al)-Total (mg/L)	44.7	<0.0050	7.59	0.792	44.8
	Antimony (Sb)-Total (mg/L)	0.0243	<0.00050	0.00116	0.00853	0.0207
	Arsenic (As)-Total (mg/L)	0.720	<0.00050	0.0148	0.0312	0.643
	Barium (Ba)-Total (mg/L)	34.3	<0.020	0.273	0.066	33.1
	Beryllium (Be)-Total (mg/L)	<0.010 DLA	<0.0010	<0.0010	<0.0010	<0.010 DLA
	Bismuth (Bi)-Total (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Total (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Total (mg/L)	0.00232	<0.000017	0.000138	0.000026	0.00145
	Calcium (Ca)-Total (mg/L)	80.6	<0.10	56.1	60.3	77.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1130044-1	L1130044-2	L1130044-3	L1130044-4	L1130044-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	30-MAR-12	30-MAR-12	30-MAR-12	30-MAR-12	30-MAR-12
	Sampled Time	13:40	14:30	11:30	14:05	13:25
	Client ID	BJ-DUP1	BJ-0A	BJ-2A	BJ-4A	BJ-6A
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.018	<0.0010	0.0153	0.0032	0.019
	Cobalt (Co)-Total (mg/L)	0.0337	<0.00030	0.00366	0.00069	0.0269
	Copper (Cu)-Total (mg/L)	0.185	<0.0010	0.0158	0.0011	0.165
	Iron (Fe)-Total (mg/L)	110	<0.030	14.9	0.821	95.3
	Lead (Pb)-Total (mg/L)	0.351	<0.00050	0.00467	0.00105	0.283
	Lithium (Li)-Total (mg/L)	<0.050 DLA	<0.0050	0.0146	0.0312	0.054
	Magnesium (Mg)-Total (mg/L)	20.0	<0.10	4.81	14.1	22.0
	Manganese (Mn)-Total (mg/L)	4.51	<0.00030	0.429	0.147	3.49
	Mercury (Hg)-Total (mg/L)	0.00111	<0.000010	0.000038	0.000023	0.00110
	Molybdenum (Mo)-Total (mg/L)	<0.010 DLA	<0.0010	0.0040	0.0021	<0.010 DLA
	Nickel (Ni)-Total (mg/L)	0.029	<0.0010	0.0031	0.0011	0.027
	Phosphorus (P)-Total (mg/L)	3.21	<0.30	0.31	<0.30	2.72
	Potassium (K)-Total (mg/L)	10.8	<2.0	2.6	2.2	11.6
	Selenium (Se)-Total (mg/L)	<0.010 DLA	<0.0010	<0.0010	<0.0010	<0.010 DLA
	Silicon (Si)-Total (mg/L)	51.3	<0.050	15.2	4.97	53.9
	Silver (Ag)-Total (mg/L)	0.0245	<0.000020	0.000829	<0.000020	0.0189
	Sodium (Na)-Total (mg/L)	3.2	<2.0	5.7	18.0	3.6
	Strontium (Sr)-Total (mg/L)	2.86	<0.0050	1.60	3.03	3.01
	Thallium (Tl)-Total (mg/L)	<0.0020 DLA	<0.00020	<0.00020	<0.00020	<0.0020 DLA
	Tin (Sn)-Total (mg/L)	<0.0050 DLA	<0.00050	<0.00050	<0.00050	<0.0050 DLA
	Titanium (Ti)-Total (mg/L)	0.545	<0.010	0.274	0.025	0.539
	Uranium (U)-Total (mg/L)	<0.0020 DLA	<0.00020	0.00058	0.00495	<0.0020 DLA
	Vanadium (V)-Total (mg/L)	0.078	<0.0010	0.0116	0.0011	0.078
	Zinc (Zn)-Total (mg/L)	1.26	<0.0050	0.0702	0.0067	1.19
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0145	<0.0050	0.0188	0.0055	0.0102
	Antimony (Sb)-Dissolved (mg/L)	0.00306	<0.00050	<0.00050	0.00868	0.00275
	Arsenic (As)-Dissolved (mg/L)	0.00354	<0.00050	0.00091	0.0295	0.00375
	Barium (Ba)-Dissolved (mg/L)	0.037	<0.020	0.044	0.039	0.035
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Dissolved (mg/L)	0.000028	<0.000017	<0.000017	<0.000017	0.000029
	Calcium (Ca)-Dissolved (mg/L)	64.7	<0.10	49.5	61.5	64.1
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cobalt (Co)-Dissolved (mg/L)	<0.00030	<0.00030	<0.00030	0.00037	<0.00030
	Copper (Cu)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1130044-1	L1130044-2	L1130044-3	L1130044-4	L1130044-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	30-MAR-12	30-MAR-12	30-MAR-12	30-MAR-12	30-MAR-12
	Sampled Time	13:40	14:30	11:30	14:05	13:25
	Client ID	BJ-DUP1	BJ-0A	BJ-2A	BJ-4A	BJ-6A
Grouping	**Analyte**					
WATER						
Dissolved Metals	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Lithium (Li)-Dissolved (mg/L)	<0.0050	<0.0050	0.0070	0.0314	<0.0050
	Magnesium (Mg)-Dissolved (mg/L)	4.33	<0.10	2.38	14.1	4.34
	Manganese (Mn)-Dissolved (mg/L)	0.0617	<0.00030	0.0775	0.126	0.0617
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	<0.0010	<0.0010	0.0018	0.0018	<0.0010
	Nickel (Ni)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	2.2	<2.0	<2.0	<2.0	2.2
	Selenium (Se)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Silicon (Si)-Dissolved (mg/L)	2.93	<0.050	2.03	3.23	2.93
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Sodium (Na)-Dissolved (mg/L)	2.8	<2.0	4.8	17.9	2.9
	Strontium (Sr)-Dissolved (mg/L)	1.96	<0.0050	1.52	3.04	1.99
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00030	<0.00020	0.00032	0.00487	0.00032
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrate (as N)	DLM	L1130044-1, -2, -3, -4, -5
Matrix Spike	Sulfate (SO4)	MS-B	L1130044-1, -2, -3, -4, -5
Matrix Spike	Total Organic Carbon	MS-B	L1130044-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Dissociable Cyanide by Dist.	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

Reference Information

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-DIS-CCME-MS-VA	Water	Diss. Metals in Water by ICPMS (CCME)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-TOT-CCME-MS-VA	Water	Total Metals in Water by ICPMS (CCME)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

10-174709

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-174709

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1-800-668-9878

www.alsglobal.com

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering	Standard: X	Other (specify):	X	Regular (Standard Turnaround Times - Business Days)
Contact:	Katherine Johnston	Select: PDF X	Excel X Digital Fax		Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	500 - 1045 Howe Street	Email 1:	Kjohnston@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancouver BC V6Z 2A9	Email 2:	VCullen@BGCengineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909			Analysis Request	
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information		(Indicate Filtered or Preserved, F/P)	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008-006-50		
Company:	Pretivm Resources	PO / AFE:	Brucejack		
Contact:	Ken Mc Naughton	LSD:			
Address:	570 Granville Street, Vancouver, BC				
Phone:	604 558 1784 Fax: 604 558 4784	Quote #:			
Lab Work Order # (lab use only)	L1130044	ALS Contact: D Watt	Sampler: B Smith		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Number of Containers
	BJ-Dupl	30-03-12	13:40	H_2O	7
	BJ-0A	"	14:30	"	7
	BJ-2A	"	11:30	"	7
	BJ-4A	"	14:05	"	7
	BJ-6A	"	13:25	"	7

AS FOR ALS ID: L1071509 - ASK D WATT

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Dissolved metals + DOC Not filtered or Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
BH	30/03/12		RWeeks	April 1, 12	10:35	0.1 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 03-JUL-12
Report Date: 13-JUL-12 12:48 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1171422

Project P.O. #: 1008-007 BRUCEJACK
Job Reference: 1008-007
C of C Numbers: 10-252137
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-1	L1171422-2	L1171422-3	L1171422-4	L1171422-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	26-JUN-12	27-JUN-12	27-JUN-12	26-JUN-12	26-JUN-12
	Sampled Time	14:10	09:35	10:00	14:45	09:45
	Client ID	MW 2A	MW 3A	MW 3B	MW 4A	MW 5A
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	255	343	331	402	460
	Hardness (as CaCO3) (mg/L)	80.0	88.7	157	170	198
	pH (pH)	7.84	8.18	8.07	8.11	8.10
	Total Suspended Solids (mg/L)	298	54.9	326	14.2	4980
	Total Dissolved Solids (mg/L)	166	230	229	283	328
	Turbidity (NTU)	144	40.2	288	9.19	>4000
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.9	<1.0	1.5	1.4	1.5
	Alkalinity, Total (as CaCO3) (mg/L)	81.5	89.4	85.6	108	98.8
	Ammonia, Total (as N) (mg/L)	0.0271	0.0702	0.0295	0.182	0.371
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	3.73	0.60	<0.50	<0.50	3.27
	Fluoride (F) (mg/L)	0.097	0.215	0.112	0.077	0.194
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	<0.0050	0.116	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	0.0023	0.0016	0.0118	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	2.54	0.133	0.138	0.283	0.685
	Total Nitrogen (mg/L)	2.54	0.136	0.139	0.410	0.685
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.0030	0.0012	0.0013	<0.0010
	Phosphorus (P)-Total (mg/L)	0.238	0.0283	0.288	0.0214	3.59
	Sulfate (SO4) (mg/L)	49.5	89.7	89.6	109	130
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	46.4	<0.50	<0.50	1.15	4.61
Total Metals	Aluminum (Al)-Total (mg/L)	2.93	0.977	8.47	0.620	32.1
	Antimony (Sb)-Total (mg/L)	0.00218	0.00201	0.00388	0.00474	0.0122
	Arsenic (As)-Total (mg/L)	0.0119	0.0301	0.0379	0.0214	0.798
	Barium (Ba)-Total (mg/L)	0.153	0.0426	0.339	0.0487	1.37
	Beryllium (Be)-Total (mg/L)	0.00011	<0.00010	0.00033	<0.00010	0.00345
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	0.0024
	Boron (B)-Total (mg/L)	0.023	0.039	0.031	0.069	0.065
	Cadmium (Cd)-Total (mg/L)	0.00424	0.000024	0.000432	0.000015	0.00809
	Calcium (Ca)-Total (mg/L)	31.1	31.8	68.1	52.2	162
	Chromium (Cr)-Total (mg/L)	0.105	0.00046	0.00266	0.00113	0.0481
	Cobalt (Co)-Total (mg/L)	0.00199	0.00022	0.00212	0.00064	0.0337
	Copper (Cu)-Total (mg/L)	0.0232	0.00105	0.0125	0.00101	0.198
	Iron (Fe)-Total (mg/L)	6.00	0.616	7.79	0.407	82.3

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-6	L1171422-7	L1171422-8	L1171422-9	L1171422-10
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	26-JUN-12	26-JUN-12	27-JUN-12	27-JUN-12	27-JUN-12
	Sampled Time	10:20	11:45	09:45	11:40	11:00
	Client ID	MW 5B	MW 6A	DUP1	FB	DRW
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	427	230	338	<2.0	321
	Hardness (as CaCO3) (mg/L)	168	85.3	88.1	<0.50	97.7
	pH (pH)	8.05	9.63	8.20	5.73	7.76
	Total Suspended Solids (mg/L)	3830	2580	48.9	<3.0	18000
	Total Dissolved Solids (mg/L)	290	171	222	<10	227
	Turbidity (NTU)	>4000	>4000	41.1	<0.10	>4000
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.7	<1.0	<1.0	1.7	2.6
	Alkalinity, Total (as CaCO3) (mg/L)	89.3	27.8	85.8	<2.0	45.3
	Ammonia, Total (as N) (mg/L)	0.225	0.180	0.0550	<0.0050	0.504
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	4.31	0.58	0.59	<0.50	0.85
	Fluoride (F) (mg/L)	0.256	0.438	0.214	<0.020	0.278
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0144
	Nitrite (as N) (mg/L)	<0.0010	0.0015	0.0032	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	1.54	0.290	0.144	<0.050	10.8
	Total Nitrogen (mg/L)	1.54	0.291	0.148	<0.0025	10.8
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.0042	0.0028	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	2.97	1.80	0.0351	<0.0020	14.4
	Sulfate (SO4) (mg/L)	121	73.8	89.7	<0.50	104
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	2.96	0.76	<0.50	<0.50	7.45
Total Metals	Aluminum (Al)-Total (mg/L)	38.3	28.1	3.23	<0.0030	338
	Antimony (Sb)-Total (mg/L)	0.0128	0.0131	0.00234	<0.00010	0.0119
	Arsenic (As)-Total (mg/L)	0.937	0.331	0.0325	<0.00010	17.1
	Barium (Ba)-Total (mg/L)	2.08	18.8	0.0897	<0.000050	2.91
	Beryllium (Be)-Total (mg/L)	0.00253	0.00254	0.00010	<0.00010	0.0330
	Bismuth (Bi)-Total (mg/L)	0.0016	<0.0010 DLA	<0.00050	<0.00050	0.015
	Boron (B)-Total (mg/L)	0.059	0.030	0.038	<0.010	<0.20 DLA
	Cadmium (Cd)-Total (mg/L)	0.0113	0.00194	0.000041	<0.000010	0.0688
	Calcium (Ca)-Total (mg/L)	171	98.2	34.7	<0.020	1960
	Chromium (Cr)-Total (mg/L)	0.0673	0.0157	0.00054	<0.00010	0.671
	Cobalt (Co)-Total (mg/L)	0.0380	0.0141	0.00031	<0.00010	0.714
	Copper (Cu)-Total (mg/L)	0.294	0.105	0.00133	<0.00050	3.20
	Iron (Fe)-Total (mg/L)	92.6	46.3	1.04	<0.030	1320

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-11				
	Description	WATER				
	Sampled Date					
	Sampled Time					
	Client ID	TRAVEL BLANK				
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0				
	Conductivity (uS/cm)	<2.0				
	Hardness (as CaCO3) (mg/L)					
	pH (pH)	6.20				
	Total Suspended Solids (mg/L)	<3.0				
	Total Dissolved Solids (mg/L)	<10				
	Turbidity (NTU)	<0.10				
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	3.0				
	Alkalinity, Total (as CaCO3) (mg/L)	<2.0				
	Ammonia, Total (as N) (mg/L)	<0.0050				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	<0.50				
	Fluoride (F) (mg/L)	<0.020				
	Nitrate (as N) (mg/L)	<0.0050				
	Nitrite (as N) (mg/L)	<0.0010				
	Total Kjeldahl Nitrogen (mg/L)	<0.050				
	Total Nitrogen (mg/L)	<0.0025				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	<0.0020				
	Sulfate (SO4) (mg/L)	<0.50				
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010				
	Cyanide, Total (mg/L)	<0.0010				
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	<0.50				
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030				
	Antimony (Sb)-Total (mg/L)	<0.00010				
	Arsenic (As)-Total (mg/L)	<0.00010				
	Barium (Ba)-Total (mg/L)	<0.000050				
	Beryllium (Be)-Total (mg/L)	<0.00010				
	Bismuth (Bi)-Total (mg/L)	<0.00050				
	Boron (B)-Total (mg/L)	<0.010				
	Cadmium (Cd)-Total (mg/L)	<0.000010				
	Calcium (Ca)-Total (mg/L)	<0.020				
	Chromium (Cr)-Total (mg/L)	<0.00010				
	Cobalt (Co)-Total (mg/L)	<0.00010				
	Copper (Cu)-Total (mg/L)	<0.00050				
	Iron (Fe)-Total (mg/L)	<0.030				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-1	L1171422-2	L1171422-3	L1171422-4	L1171422-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	26-JUN-12	27-JUN-12	27-JUN-12	26-JUN-12	26-JUN-12
	Sampled Time	14:10	09:35	10:00	14:45	09:45
	Client ID	MW 2A	MW 3A	MW 3B	MW 4A	MW 5A
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	0.0144	0.00129	0.00614	0.000506	0.139
	Lithium (Li)-Total (mg/L)	0.0357	0.0751	0.0243	0.0343	0.100
	Magnesium (Mg)-Total (mg/L)	2.46	2.64	6.69	11.8	21.8
	Manganese (Mn)-Total (mg/L)	0.232	0.246	0.737	0.106	3.80
	Mercury (Hg)-Total (mg/L)	0.000048	<0.000010	0.000031	0.000011	<0.00010 DLM
	Molybdenum (Mo)-Total (mg/L)	0.00333	0.00244	0.000973	0.00132	0.0172
	Nickel (Ni)-Total (mg/L)	0.0256	<0.00050	0.00196	0.00067	0.0749
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	0.30	<0.30	2.22
	Potassium (K)-Total (mg/L)	1.15	1.78	2.84	1.84	15.8
	Selenium (Se)-Total (mg/L)	0.00031	<0.00010	0.00120	<0.00010	0.00594
	Silicon (Si)-Total (mg/L)	6.03	4.69	30.3	4.65	57.8
	Silver (Ag)-Total (mg/L)	0.000569	0.000092	0.00286	0.000017	0.0412
	Sodium (Na)-Total (mg/L)	20.9	36.5	5.7	18.1	29.9
	Strontium (Sr)-Total (mg/L)	1.47	1.01	1.65	2.65	3.47
	Thallium (Tl)-Total (mg/L)	0.000042	0.000025	0.000244	0.000030	0.00407
	Tin (Sn)-Total (mg/L)	0.00303	<0.00010	0.00016	0.00023	0.00066
	Titanium (Ti)-Total (mg/L)	0.072	0.014	0.280	0.025	0.143
	Uranium (U)-Total (mg/L)	0.000697	0.000242	0.000851	0.00277	0.00561
	Vanadium (V)-Total (mg/L)	0.0049	0.0013	0.0110	<0.0010	0.0478
	Zinc (Zn)-Total (mg/L)	0.113	0.0051	0.0336	0.0037	0.461
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0122	0.0159	0.0246	0.0187	5.80
	Antimony (Sb)-Dissolved (mg/L)	0.00082	0.00179	0.00331	0.00463	0.0100
	Arsenic (As)-Dissolved (mg/L)	0.00218	0.0279	0.00768	0.0190	0.0958
	Barium (Ba)-Dissolved (mg/L)	0.0688	0.0235	0.0384	0.0384	0.285
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	0.00047
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.0010 DLA
	Boron (B)-Dissolved (mg/L)	0.021	0.037	0.025	0.066	0.047
	Cadmium (Cd)-Dissolved (mg/L)	0.00101	<0.000010	0.000081	0.000012	0.00120
	Calcium (Ca)-Dissolved (mg/L)	29.5	31.5	57.2	49.5	63.9
	Chromium (Cr)-Dissolved (mg/L)	0.00694	<0.00010	<0.00010	0.00014	0.00811
	Cobalt (Co)-Dissolved (mg/L)	0.00041	<0.00010	0.00018	0.00027	0.00437
	Copper (Cu)-Dissolved (mg/L)	0.00200	<0.00050	<0.00050	<0.00050	0.0165
	Iron (Fe)-Dissolved (mg/L)	0.039	<0.030	<0.030	<0.030	9.15
	Lead (Pb)-Dissolved (mg/L)	0.000080	<0.000050	<0.000050	<0.000050	0.0186
	Lithium (Li)-Dissolved (mg/L)	0.0323	0.0740	0.00940	0.0296	0.0655
	Magnesium (Mg)-Dissolved (mg/L)	1.53	2.45	3.46	11.3	9.37

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-6	L1171422-7	L1171422-8	L1171422-9	L1171422-10
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	26-JUN-12	26-JUN-12	27-JUN-12	27-JUN-12	27-JUN-12
	Sampled Time	10:20	11:45	09:45	11:40	11:00
	Client ID	MW 5B	MW 6A	DUP1	FB	DRW
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	0.127	0.165	0.00149	<0.000050	0.679
	Lithium (Li)-Total (mg/L)	0.0794	0.0251	0.0861	<0.00050	0.682
	Magnesium (Mg)-Total (mg/L)	21.9	8.03	2.92	<0.0050	228
	Manganese (Mn)-Total (mg/L)	5.06	2.23	0.269	<0.000050	68.4
	Mercury (Hg)-Total (mg/L)	<0.00010 DLM	0.00057 DLM	<0.000010	<0.000010	<0.00050 DLM
	Molybdenum (Mo)-Total (mg/L)	0.0254	0.0193	0.00282	<0.000050	0.0752
	Nickel (Ni)-Total (mg/L)	0.0755	0.0141	0.00085	<0.00050	1.83
	Phosphorus (P)-Total (mg/L)	2.51	1.74	<0.30	<0.30	44.4
	Potassium (K)-Total (mg/L)	16.3	11.9	2.28	<0.050	107
	Selenium (Se)-Total (mg/L)	0.00759	0.00250	<0.00010	<0.00010	0.0292
	Silicon (Si)-Total (mg/L)	60.4	49.7	9.36	<0.050	339
	Silver (Ag)-Total (mg/L)	0.0567	0.0242	0.000154	<0.000010	0.262
	Sodium (Na)-Total (mg/L)	15.0	6.3	39.0	<2.0	<4.0 DLA
	Strontium (Sr)-Total (mg/L)	2.35	2.18	1.09	<0.00020	6.74
	Thallium (Tl)-Total (mg/L)	0.00329	0.000829	0.000054	<0.000010	0.0157
	Tin (Sn)-Total (mg/L)	0.00043	0.00060	<0.00010	<0.00010	<0.0020 DLA
	Titanium (Ti)-Total (mg/L)	0.188	0.441	0.058	<0.010	0.391
	Uranium (U)-Total (mg/L)	0.00393	0.000839	0.000293	<0.000010	0.0156
	Vanadium (V)-Total (mg/L)	0.0598	0.0490	0.0030	<0.0010	0.550
	Zinc (Zn)-Total (mg/L)	0.500	0.539	0.0058	<0.0030	4.60
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0747	0.353	0.0168	<0.0030	0.250
	Antimony (Sb)-Dissolved (mg/L)	0.00457	0.0112	0.00183	<0.00010	0.0556 DTC
	Arsenic (As)-Dissolved (mg/L)	0.00533	0.0795	0.0276	<0.00010	0.0258
	Barium (Ba)-Dissolved (mg/L)	0.0492	0.0446	0.0234	<0.000050	0.0181
	Beryllium (Be)-Dissolved (mg/L)	<0.00020 DLA	<0.00020 DLA	<0.00010	<0.00010	<0.0020 DLA
	Bismuth (Bi)-Dissolved (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.00050	<0.00050	<0.010 DLA
	Boron (B)-Dissolved (mg/L)	0.039	<0.020 DLA	0.037	<0.010	<0.20 DLA
	Cadmium (Cd)-Dissolved (mg/L)	0.000330	<0.000020 DLA	<0.000010	<0.000010	<0.00020 DLA
	Calcium (Ca)-Dissolved (mg/L)	56.9	33.6	31.3	<0.020	31.1
	Chromium (Cr)-Dissolved (mg/L)	<0.00020 DLA	0.00081	<0.00010	<0.00010	<0.0020 DLA
	Cobalt (Co)-Dissolved (mg/L)	0.00037	<0.00020 DLA	<0.00010	<0.00010	<0.0020 DLA
	Copper (Cu)-Dissolved (mg/L)	<0.0010 DLA	0.0013	<0.00050	<0.00050	<0.010 DLA
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.060 DLM
	Lead (Pb)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.000050	<0.000050	<0.0010 DLA
	Lithium (Li)-Dissolved (mg/L)	0.0232	0.0021	0.0737	<0.00050	0.017
	Magnesium (Mg)-Dissolved (mg/L)	6.38	0.340	2.38	<0.0050	4.88

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-11				
	Description	WATER				
	Sampled Date					
	Sampled Time					
	Client ID	TRAVEL BLANK				
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	<0.000050				
	Lithium (Li)-Total (mg/L)	<0.00050				
	Magnesium (Mg)-Total (mg/L)	<0.0050				
	Manganese (Mn)-Total (mg/L)	<0.000050				
	Mercury (Hg)-Total (mg/L)	<0.000010				
	Molybdenum (Mo)-Total (mg/L)	<0.000050				
	Nickel (Ni)-Total (mg/L)	<0.00050				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	<0.050				
	Selenium (Se)-Total (mg/L)	<0.00010				
	Silicon (Si)-Total (mg/L)	<0.050				
	Silver (Ag)-Total (mg/L)	<0.000010				
	Sodium (Na)-Total (mg/L)	<2.0				
	Strontium (Sr)-Total (mg/L)	<0.00020				
	Thallium (Tl)-Total (mg/L)	<0.000010				
	Tin (Sn)-Total (mg/L)	<0.00010				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	<0.000010				
	Vanadium (V)-Total (mg/L)	<0.0010				
	Zinc (Zn)-Total (mg/L)	<0.0030				
Dissolved Metals	Dissolved Metals Filtration Location					
	Aluminum (Al)-Dissolved (mg/L)					
	Antimony (Sb)-Dissolved (mg/L)					
	Arsenic (As)-Dissolved (mg/L)					
	Barium (Ba)-Dissolved (mg/L)					
	Beryllium (Be)-Dissolved (mg/L)					
	Bismuth (Bi)-Dissolved (mg/L)					
	Boron (B)-Dissolved (mg/L)					
	Cadmium (Cd)-Dissolved (mg/L)					
	Calcium (Ca)-Dissolved (mg/L)					
	Chromium (Cr)-Dissolved (mg/L)					
	Cobalt (Co)-Dissolved (mg/L)					
	Copper (Cu)-Dissolved (mg/L)					
	Iron (Fe)-Dissolved (mg/L)					
	Lead (Pb)-Dissolved (mg/L)					
	Lithium (Li)-Dissolved (mg/L)					
	Magnesium (Mg)-Dissolved (mg/L)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-1	L1171422-2	L1171422-3	L1171422-4	L1171422-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	26-JUN-12	27-JUN-12	27-JUN-12	26-JUN-12	26-JUN-12
	Sampled Time	14:10	09:35	10:00	14:45	09:45
	Client ID	MW 2A	MW 3A	MW 3B	MW 4A	MW 5A
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	0.129	0.192	0.250	0.0695	0.831
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.00010 DLM
	Molybdenum (Mo)-Dissolved (mg/L)	0.00252	0.00247	0.000584	0.00120	0.0141
	Nickel (Ni)-Dissolved (mg/L)	0.00632	<0.00050	<0.00050	0.00052	0.0119
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	0.35
	Potassium (K)-Dissolved (mg/L)	0.810	1.55	0.976	1.62	8.49
	Selenium (Se)-Dissolved (mg/L)	<0.00010	<0.00010	0.00059	<0.00010	0.00072
	Silicon (Si)-Dissolved (mg/L)	2.11	2.91	2.84	3.07	19.2
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.00503
	Sodium (Na)-Dissolved (mg/L)	20.0	36.7	5.0	17.9	29.2
	Strontium (Sr)-Dissolved (mg/L)	1.39	0.991	1.58	2.56	2.54
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	0.000044	0.000020	0.000746
	Tin (Sn)-Dissolved (mg/L)	0.00021	<0.00010	<0.00010	<0.00010	<0.00020 DLA
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	0.102
	Uranium (U)-Dissolved (mg/L)	0.000323	0.000181	0.000663	0.00269	0.00156
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0094
	Zinc (Zn)-Dissolved (mg/L)	0.0188	<0.0030	<0.0030	<0.0030	0.0425
Aggregate Organics	COD (mg/L)	192	<20	26	<20	204

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-6	L1171422-7	L1171422-8	L1171422-9	L1171422-10
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	26-JUN-12	26-JUN-12	27-JUN-12	27-JUN-12	27-JUN-12
	Sampled Time	10:20	11:45	09:45	11:40	11:00
	Client ID	MW 5B	MW 6A	DUP1	FB	DRW
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	0.554	<0.00010 DLA	0.192	<0.000050	0.0382
	Mercury (Hg)-Dissolved (mg/L)	<0.00010 DLM	<0.00010 DLM	<0.000010	<0.000010	<0.00050 DLM
	Molybdenum (Mo)-Dissolved (mg/L)	0.0158	0.0176	0.00251	<0.000050	0.0317
	Nickel (Ni)-Dissolved (mg/L)	0.0017	<0.0010 DLA	<0.00050	<0.00050	<0.010 DLA
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.60 DLM
	Potassium (K)-Dissolved (mg/L)	5.53	3.79	1.53	<0.050	41.1
	Selenium (Se)-Dissolved (mg/L)	<0.00020 DLA	0.00169	<0.00010	<0.00010	<0.0020 DLA
	Silicon (Si)-Dissolved (mg/L)	2.57	4.36	2.80	<0.050	2.30
	Silver (Ag)-Dissolved (mg/L)	<0.000020 DLA	0.000049	<0.000010	<0.000010	<0.00020 DLA
	Sodium (Na)-Dissolved (mg/L)	14.5	5.3	36.8	<2.0	<4.0 DLM
	Strontium (Sr)-Dissolved (mg/L)	1.66	1.23	0.994	<0.00020	0.212
	Thallium (Tl)-Dissolved (mg/L)	0.000129	0.000051	0.000010	<0.000010	<0.00020 DLA
	Tin (Sn)-Dissolved (mg/L)	<0.00020 DLA	<0.00020 DLA	<0.00010	<0.00010	<0.0020 DLA
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.020 DLM
	Uranium (U)-Dissolved (mg/L)	0.00107	<0.000020 DLA	0.000193	<0.000010	<0.00020 DLA
	Vanadium (V)-Dissolved (mg/L)	<0.0020 DLA	0.0051	<0.0010	<0.0010	<0.020 DLA
	Zinc (Zn)-Dissolved (mg/L)	<0.0060 DLA	<0.0060 DLA	<0.0030	<0.0030	<0.060 DLA
Aggregate Organics	COD (mg/L)	171	64	<20	<20	81

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1171422-11				
	Description	WATER				
	Sampled Date					
	Sampled Time					
	Client ID	TRAVEL BLANK				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)					
	Mercury (Hg)-Dissolved (mg/L)					
	Molybdenum (Mo)-Dissolved (mg/L)					
	Nickel (Ni)-Dissolved (mg/L)					
	Phosphorus (P)-Dissolved (mg/L)					
	Potassium (K)-Dissolved (mg/L)					
	Selenium (Se)-Dissolved (mg/L)					
	Silicon (Si)-Dissolved (mg/L)					
	Silver (Ag)-Dissolved (mg/L)					
	Sodium (Na)-Dissolved (mg/L)					
	Strontium (Sr)-Dissolved (mg/L)					
	Thallium (Tl)-Dissolved (mg/L)					
	Tin (Sn)-Dissolved (mg/L)					
	Titanium (Ti)-Dissolved (mg/L)					
	Uranium (U)-Dissolved (mg/L)					
	Vanadium (V)-Dissolved (mg/L)					
	Zinc (Zn)-Dissolved (mg/L)					
Aggregate Organics	COD (mg/L)	<20				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Barium (Ba)-Dissolved	MB-LOR	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Method Blank	Barium (Ba)-Dissolved	MB-LOR	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sulfate (SO4)	MS-B	L1171422-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Phosphorus (P)-Total	MS-B	L1171422-2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Phosphorus (P)-Total	MS-B	L1171422-1
Matrix Spike	Phosphorus (P)-Total	MS-B	L1171422-1
Matrix Spike	Arsenic (As)-Total	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Calcium (Ca)-Total	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Manganese (Mn)-Total	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Strontium (Sr)-Total	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Zinc (Zn)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Molybdenum (Mo)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1171422-1, -10, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects
DTC	Dissolved concentration exceeds total. Results were confirmed by re-analysis.
MB-LOR	Method Blank exceeds ALS DQO. LORs adjusted for samples with positive hits below 5 times blank level. Please contact ALS if re-analysis is required.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	EPA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent

Reference Information

Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the

Reference Information

American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

10-252137

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Short Holding Time

ALS Environm

Rush Processing

Chain of Cu
Canad

L1171422-COFC

10-252137

Page 1 of 1

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering	Standard:	Y Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V. Cullen	Select: PDF	X Excel X Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	500 - 1045 Howe Street	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancouver, BC V6Z 2A9	Email 2:	KJohnston@BGCengineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909				

Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)	Client / Project Information	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008-007
Company:	Pretium Resources	PO / AFE:	~~1007-008~~ 1008 007 Bruejack
Contact:	Ken Mc Naughton	LSD:	
Address:	570 Granville St. Vancouver		
Phone:	604 558 1784 Fax: 604 558 4784	Quote #:	

Lab Work Order # (lab use only) L1171422 | **ALS Contact:** D. Watt | **Sampler:** BSmith / A Maxlow J McFum.

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals (P)	Diss. Metals (P)	Cyanides (P)	TOC (P)	COD / NH3 / TKN (P)							Number of Containers
	MW 2A	26-06-12	14:10	H_2O	✓	✓	✓	✓	✓	✓							
	MW 3A	27-06-12	9:35	"	✓	✓	✓	✓	✓	✓							
	MW 3B	27-06-12	10:00	"	✓	✓	✓	✓	✓	✓							
	MW 4A	26-06-12	14:45	"	✓	✓	✓	✓	✓	✓							
	MW 5A	26-06-12	9:45	"	✓	✓	✓	✓	✓	✓							
	MW 5B	26-06-12	10:20	"	✓	✓	✓	✓	✓	✓							
	MW 6A	26-06-12	11:45	"	✓	✓	✓	✓	✓	✓							
	Dupl	27-06-12	9:45.	"	✓	✓	✓	✓	✓	✓							
	FB	27-06-12	11:40	"	✓	✓	✓	✓	✓	✓							
	DRW	27-06-12	11:00	"	✓	✓	✓	✓	✓	✓							
	Travel Blank			"	✓	✓	✓	✓	✓	✓							

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Hold Samples MW 5A, MW 5B and MW 6A until instructed to process. Diss Metals Not Filtered or Preserved

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
	27 June 12		HD	JUN 3/12	10:38	12 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY — GENF 18.01 Front

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 06-JUL-12
Report Date: 18-JUL-12 18:14 (MT)
Version: FINAL REV. 2

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1174115

Project P.O. #: BRUCEJACK
Job Reference: 1008.007
C of C Numbers: 10-252136
Legal Site Desc:

Comments: ADDITIONAL 18-JUL-12 13:05

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1174115-1	L1174115-2			
	Description	WATER	WATER			
	Sampled Date	28-JUN-12	28-JUN-12			
	Sampled Time	14:30	15:30			
	Client ID	MW-8A	MW-8B			
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0			
	Conductivity (uS/cm)	203	187			
	Hardness (as CaCO3) (mg/L)	90.0	64.1			
	pH (pH)	8.22	8.26			
	Total Suspended Solids (mg/L)	212	5340			
	Total Dissolved Solids (mg/L)	145	142			
	Turbidity (NTU)	118	>4000			
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	75.9	55.2			
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<1.0			
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<1.0			
	Alkalinity, Total (as CaCO3) (mg/L)	75.9	55.2			
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0080			
	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	<0.50	<0.50			
	Fluoride (F) (mg/L)	0.030	0.061			
	Nitrate (as N) (mg/L)	0.0268	<0.0050			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Total Kjeldahl Nitrogen (mg/L)	<0.050	0.570			
	Total Nitrogen (mg/L)	0.0268	0.570			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.0082			
	Phosphorus (P)-Total (mg/L)	0.104	1.26			
	Sulfate (SO4) (mg/L)	33.9	40.3			
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010			
	Cyanide, Total (mg/L)	<0.0010	<0.0010			
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	0.58	8.07			
Total Metals	Aluminum (Al)-Total (mg/L)	5.14	50.4			
	Antimony (Sb)-Total (mg/L)	0.00156	0.00251			
	Arsenic (As)-Total (mg/L)	0.0315	0.525			
	Barium (Ba)-Total (mg/L)	0.101	0.910			
	Beryllium (Be)-Total (mg/L)	0.00044	0.00732			
	Bismuth (Bi)-Total (mg/L)	<0.00050	0.0016			
	Boron (B)-Total (mg/L)	0.014	0.044			
	Cadmium (Cd)-Total (mg/L)	0.000235	0.000601			
	Calcium (Ca)-Total (mg/L)	41.4	118			
	Chromium (Cr)-Total (mg/L)	0.00459	0.0281			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1174115-1	L1174115-2			
	Description	WATER	WATER			
	Sampled Date	28-JUN-12	28-JUN-12			
	Sampled Time	14:30	15:30			
	Client ID	MW-8A	MW-8B			
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	0.00155	0.0334			
	Copper (Cu)-Total (mg/L)	0.00741	0.104			
	Iron (Fe)-Total (mg/L)	4.97	52.2			
	Lead (Pb)-Total (mg/L)	0.00752	0.0699			
	Lithium (Li)-Total (mg/L)	0.0114	0.0531			
	Magnesium (Mg)-Total (mg/L)	6.89	19.4			
	Manganese (Mn)-Total (mg/L)	0.282	3.22			
	Mercury (Hg)-Total (mg/L)	<0.000010	0.000480 DLM			
	Molybdenum (Mo)-Total (mg/L)	0.00261	0.00150			
	Nickel (Ni)-Total (mg/L)	0.00116	0.0212			
	Phosphorus (P)-Total (mg/L)	<0.30	0.88			
	Potassium (K)-Total (mg/L)	1.88	7.90			
	Selenium (Se)-Total (mg/L)	0.00023	0.00061			
	Silicon (Si)-Total (mg/L)	13.6	84.7			
	Silver (Ag)-Total (mg/L)	0.000223	0.00161			
	Sodium (Na)-Total (mg/L)	6.0	13.2			
	Strontium (Sr)-Total (mg/L)	0.762	0.960			
	Thallium (Tl)-Total (mg/L)	0.000132	0.000912			
	Tin (Sn)-Total (mg/L)	0.00047	0.00134			
	Titanium (Ti)-Total (mg/L)	0.051	0.093			
	Uranium (U)-Total (mg/L)	0.00119	0.0116			
	Vanadium (V)-Total (mg/L)	0.0048	0.0490			
	Zinc (Zn)-Total (mg/L)	0.0337	0.358			
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB			
	Aluminum (Al)-Dissolved (mg/L)	0.0200	2.12			
	Antimony (Sb)-Dissolved (mg/L)	0.00137	0.00148			
	Arsenic (As)-Dissolved (mg/L)	0.00691	0.0492			
	Barium (Ba)-Dissolved (mg/L)	0.0223	0.0575			
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050			
	Boron (B)-Dissolved (mg/L)	0.013	0.017			
	Cadmium (Cd)-Dissolved (mg/L)	0.000012	<0.000010			
	Calcium (Ca)-Dissolved (mg/L)	27.7	21.5			
	Chromium (Cr)-Dissolved (mg/L)	0.00019	0.00152			
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00029			
	Copper (Cu)-Dissolved (mg/L)	<0.00050	0.00108			
	Iron (Fe)-Dissolved (mg/L)	<0.030	0.768			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1174115-1	L1174115-2			
	Description	WATER	WATER			
	Sampled Date	28-JUN-12	28-JUN-12			
	Sampled Time	14:30	15:30			
	Client ID	MW-8A	MW-8B			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000639			
	Lithium (Li)-Dissolved (mg/L)	0.00913	0.00739			
	Magnesium (Mg)-Dissolved (mg/L)	5.06	2.52			
	Manganese (Mn)-Dissolved (mg/L)	0.0118	0.0242			
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010			
	Molybdenum (Mo)-Dissolved (mg/L)	0.00246	0.00301 DTC			
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30			
	Potassium (K)-Dissolved (mg/L)	0.858	1.86			
	Selenium (Se)-Dissolved (mg/L)	0.00019	0.00039			
	Silicon (Si)-Dissolved (mg/L)	2.03	10.8			
	Silver (Ag)-Dissolved (mg/L)	<0.000010	0.000015			
	Sodium (Na)-Dissolved (mg/L)	5.9	12.4			
	Strontium (Sr)-Dissolved (mg/L)	0.655	0.328			
	Thallium (Tl)-Dissolved (mg/L)	0.000011	0.000050			
	Tin (Sn)-Dissolved (mg/L)	<0.00010	0.00016			
	Titanium (Ti)-Dissolved (mg/L)	<0.010	0.040			
	Uranium (U)-Dissolved (mg/L)	0.000249	0.00111			
	Vanadium (V)-Dissolved (mg/L)	<0.0010	0.0045			
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	0.0044			
Aggregate Organics	COD (mg/L)	<20	38			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1174115-1, -2
Duplicate	Chloride (Cl)	DLM	L1174115-1, -2
Duplicate	Fluoride (F)	DLM	L1174115-1, -2
Duplicate	Nitrite (as N)	DLM	L1174115-1, -2
Matrix Spike	Nitrate (as N)	MS-B	L1174115-1, -2
Matrix Spike	Phosphorus (P)-Total	MS-B	L1174115-1, -2
Matrix Spike	Aluminum (Al)-Total	MS-B	L1174115-1
Matrix Spike	Arsenic (As)-Total	MS-B	L1174115-1
Matrix Spike	Barium (Ba)-Total	MS-B	L1174115-1
Matrix Spike	Calcium (Ca)-Total	MS-B	L1174115-1
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1174115-1
Matrix Spike	Manganese (Mn)-Total	MS-B	L1174115-1
Matrix Spike	Strontium (Sr)-Total	MS-B	L1174115-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
DTC	Dissolved concentration exceeds total. Results were confirmed by re-analysis.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

Reference Information

ANIONS-SO4-IC-VA Water Sulfate by Ion Chromatography APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-TOC-VA Water Total organic carbon by combustion APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA Water Low Level Total Cyanide in water by CFA ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA Water Low level WAD Cyanide in water by CFA APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA Water Chemical Oxygen Demand by Colorimetric APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA Water Colour (True) by Spectrometer BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA Water Conductivity (Automated) APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA Water Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA Water Dissolved Mercury in Water by CVAFS(Low) EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA Water Total Mercury in Water by CVAFS(Low) EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or

Reference Information

microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

Reference Information

10-252136

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-252136

ALS Environmental

L1174115-COFC Form

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering Inc.	Standard: X	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V. Cullen	Select: PDF X	Excel X Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	500 - 1045 Howe St.	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancouver, BC V6Z 2A9	Email 2:	KJohnston@BGCengineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 4909				

Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008 007
Company:	Pretium Resources	PO / AFE:	Brucejack
Contact:	Ken Mc Naughton	LSD:	
Address:	570 Granville St. Vancover		
Phone:	604 558 1784 Fax: 604 558 4784	Quote #:	

Lab Work Order # (lab use only)	L1174115	ALS Contact:	D Watt	Sampler:	BSmith / T Beebe.

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals (P)	Diss Metals	Cyanides (P)	DOC (P)	COD/TKN/NH3 (P)							Number of Containers
	MW-8A	28-06-12	14:30	H_2O	✓	✓	✓	✓	✓	✓							6
	MW-8B	28-06-12	15:30	"	✓	✓	✓	✓	✓	✓							6

Short Holding Time

Rush Processing

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Diss Metals not filtered or Preserved

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Brett Smith	28/06/12		Brittany	July 6	10:20	17.7 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 06-SEP-12
Report Date: 17-SEP-12 17:20 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1205274

Project P.O. #: 1008007
Job Reference: BRUCEJACK
C of C Numbers: 10-239827
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1205274-1	L1205274-2	L1205274-3	L1205274-4	L1205274-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	03-SEP-12	03-SEP-12	03-SEP-12	03-SEP-12	03-SEP-12
	Sampled Time					
	Client ID	BJ-4A	BJ-4B	BJ-6A	BJ-6B	BJ-DUP1
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	425	389	212	331	560
	Hardness (as CaCO3) (mg/L)	177	67.2	93.1	9.83	8.76
	pH (pH)	7.26	8.57	8.71	9.92	9.87
	Total Suspended Solids (mg/L)	18.8	66.8	3050	886	10.8
	Total Dissolved Solids (mg/L)	292	253	172	426	359
	Turbidity (NTU)	9.60	73.9	>4000 TMV	1900	35.2
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	9.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	106	93.4	22.7	36.2	74.5
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	2.3	<1.0	56.1	97.5
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	106	95.6	22.7	92.3	172
	Ammonia, Total (as N) (mg/L)	0.163	0.0869	0.156	0.192	0.162
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.16	<0.50	<0.50	1.27	<0.50
	Fluoride (F) (mg/L)	0.086	0.126	0.319	0.243	0.153
	Nitrate (as N) (mg/L)	0.114	<0.0050	0.0071	0.0101	<0.0050
	Nitrite (as N) (mg/L)	0.0037	0.0017	0.0014	0.0034	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.237	0.179	1.27	0.86	0.202
	Total Nitrogen (mg/L)	0.355	0.181	1.28	0.88	0.202
	Orthophosphate-Dissolved (as P) (mg/L)	0.0014	0.0013	0.0061	0.0018	0.0025
	Phosphorus (P)-Total (mg/L)	0.0214	0.0196	1.70	0.264	0.0078
	Sulfate (SO4) (mg/L)	123	104	75.6	68.4	109
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	2.22	0.56	0.82	1.04	<0.50
	Total Organic Carbon (mg/L)	2.35	1.18	0.94	1.62	<0.50
Total Metals	Aluminum (Al)-Total (mg/L)	0.243	1.12	29.6	16.7	0.802
	Antimony (Sb)-Total (mg/L)	0.00354	0.00374	0.0137	0.00706	0.00396
	Arsenic (As)-Total (mg/L)	0.0225	0.0143	0.360	0.0457	0.0134
	Barium (Ba)-Total (mg/L)	0.0574	0.0623	20.9	0.557	0.0578
	Beryllium (Be)-Total (mg/L)	<0.00010	0.00011	0.00359	0.00227	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.0010 DLA	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.070	0.054	0.034	0.155	0.046
	Cadmium (Cd)-Total (mg/L)	0.000040	0.000011	0.00140	0.000230	0.000012
	Calcium (Ca)-Total (mg/L)	51.5	22.8	86.4	6.66	29.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1205274-1	L1205274-2	L1205274-3	L1205274-4	L1205274-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	03-SEP-12	03-SEP-12	03-SEP-12	03-SEP-12	03-SEP-12
	Sampled Time					
	Client ID	BJ-4A	BJ-4B	BJ-6A	BJ-6B	BJ-DUP1
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.00075	0.0122	0.0184	0.00826	0.0110
	Cobalt (Co)-Total (mg/L)	0.00070	0.00022	0.0154	0.00841	0.00026
	Copper (Cu)-Total (mg/L)	0.00170	0.00489	0.113	0.0662	0.00666
	Iron (Fe)-Total (mg/L)	0.386	0.570	55.6	25.1	0.517
	Lead (Pb)-Total (mg/L)	0.000528	0.00117	0.188	0.179	0.00155
	Lithium (Li)-Total (mg/L)	0.0298	0.176	0.0380	0.175	0.156
	Magnesium (Mg)-Total (mg/L)	11.6	2.21	12.6	7.93	2.90
	Manganese (Mn)-Total (mg/L)	0.114	0.0467	2.10	0.840	0.0591
	Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	0.00046	0.000099	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.00135	0.00155	0.0108	0.00508	0.00170
	Nickel (Ni)-Total (mg/L)	0.00084	0.00592	0.0176	0.00924	0.00567
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	1.81	<0.30	<0.30
	Potassium (K)-Total (mg/L)	1.62	1.71	8.96	6.74	1.62
	Selenium (Se)-Total (mg/L)	<0.00010	<0.00010	0.00248	0.00143	0.00010
	Silicon (Si)-Total (mg/L)	3.33	6.15	63.0	43.0	5.06
	Silver (Ag)-Total (mg/L)	0.000031	0.000073	0.0211	0.00764	0.000095
	Sodium (Na)-Total (mg/L)	21.0	86.2	6.7	67.8	72.0 DTC
	Strontium (Sr)-Total (mg/L)	2.59	0.437	2.62	0.348	0.491
	Thallium (Tl)-Total (mg/L)	0.000021	0.000044	0.000697	0.000350	0.000040
	Tin (Sn)-Total (mg/L)	0.00033	0.00035	0.00072	0.00015	0.00043
	Titanium (Ti)-Total (mg/L)	0.014	0.014	0.515	0.223	<0.010
	Uranium (U)-Total (mg/L)	0.00292	0.00121	0.00110	0.000504	0.00156
	Vanadium (V)-Total (mg/L)	<0.0010	0.0019	0.0496	0.0304	0.0014
	Zinc (Zn)-Total (mg/L)	0.0071	0.0077	0.651	0.384	0.0098
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0080	0.0587	0.0967	0.504	0.327
	Antimony (Sb)-Dissolved (mg/L)	0.00349	0.00316	0.00975	0.0108 DTC	0.00381
	Arsenic (As)-Dissolved (mg/L)	0.0192	0.00985	0.0844	0.0294	0.0186 DTC
	Barium (Ba)-Dissolved (mg/L)	0.0338	0.0353	0.0427	0.0390	0.0386
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00020 DLA	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.0010 DLA	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	0.072	0.035	0.021	0.145	0.069 DTC
	Cadmium (Cd)-Dissolved (mg/L)	0.000024	<0.000010	<0.000020 DLA	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	51.5	21.3	34.5	3.68	3.16
	Chromium (Cr)-Dissolved (mg/L)	0.00015	0.00047	<0.00020 DLA	0.00019	0.00043
	Cobalt (Co)-Dissolved (mg/L)	0.00026	<0.00010	<0.00020 DLA	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00050	0.00086	<0.0010 DLA	0.00092	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1205274-1	L1205274-2	L1205274-3	L1205274-4	L1205274-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	03-SEP-12	03-SEP-12	03-SEP-12	03-SEP-12	03-SEP-12
	Sampled Time					
	Client ID	BJ-4A	BJ-4B	BJ-6A	BJ-6B	BJ-DUP1
Grouping	**Analyte**					
WATER						
Dissolved Metals	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	0.135	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	0.00024	0.00144	0.000087
	Lithium (Li)-Dissolved (mg/L)	0.0306	0.109	0.0038	0.141	0.284 DTC
	Magnesium (Mg)-Dissolved (mg/L)	11.6	3.38 DTC	1.71	0.153	0.212
	Manganese (Mn)-Dissolved (mg/L)	0.0860	0.00456	0.00236	0.00664	0.00290
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.00134	0.00149	0.00940	0.00644 DTC	0.000843
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.0010 DLA	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	1.59	1.42	2.79	2.67	1.58
	Selenium (Se)-Dissolved (mg/L)	<0.00010	0.00011	0.00106	0.00075	<0.00010
	Silicon (Si)-Dissolved (mg/L)	2.90	3.59	3.51	5.49	4.16
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	0.000021	0.000089	<0.000010
	Sodium (Na)-Dissolved (mg/L)	21.0	57.6	5.0	67.9	120 DTC
	Strontium (Sr)-Dissolved (mg/L)	2.63	0.474	1.70	0.214	0.234
	Thallium (Tl)-Dissolved (mg/L)	0.000018	0.000015	0.000056	0.000037	0.000029
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00020 DLA	<0.00010	0.00013
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00307	0.00213 DTC	0.000231	0.000135	0.000173
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	0.0020	0.0023	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	0.0031	<0.0030	<0.0060 DLA	<0.0030	<0.0030
Aggregate Organics	COD (mg/L)	<20	<20	45	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Arsenic (As)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Duplicate	Beryllium (Be)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Duplicate	Lead (Pb)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Duplicate	Silver (Ag)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Duplicate	Tin (Sn)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Duplicate	Vanadium (V)-Dissolved	DLA	L1205274-1, -2, -3, -4, -5
Matrix Spike	Phosphorus (P)-Total	MS-B	L1205274-2, -3, -4, -5
Matrix Spike	Phosphorus (P)-Total	MS-B	L1205274-2, -3, -4, -5
Matrix Spike	Total Organic Carbon	MS-B	L1205274-1, -2, -3, -4, -5
Matrix Spike	Phosphorus (P)-Total	MS-B	L1205274-1
Matrix Spike	Sulfate (SO4)	MS-B	L1205274-1, -2, -3, -4, -5
Matrix Spike	Mercury (Hg)-Total	MS-B	L1205274-4
Matrix Spike	Mercury (Hg)-Total	MS-B	L1205274-4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DTC	Dissolved concentration exceeds total. Results were confirmed by re-analysis.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
TMV	Turbidity exceeded upper limit of the nephelometric method. Minimum value reported.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

Reference Information

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or

Reference Information

filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA Water TKN in Water by Fluorescence APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA Water Total Nitrogen (Calculation) BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-239827

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-239827

ALS E

L1205274-COFC

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering.	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	Virginia Cullen	Select: PDF ✓	Excel ✓ Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	508 - 1045 Howe Street.	Email 1:	V Cullen@BGCEngineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancouver, BC V6Z 2A9	Email 2:	K Johnston@BGCEngineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909			Analysis Request	
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information		(Indicate Filtered or Preserved, F/P)	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	Bruejack		
Company:	Pretium Resources.	PO / AFE:	1008 007		
Contact:	K. McNaughton.	LSD:			
Address:	1600-570 Granville Street, Vancouver, V6C3P1				
Phone:	Fax:	Quote #:			
Lab Work Order # (lab use only)	L1205274	ALS Contact:	D Watt.	Sampler:	B Smith A Marden.

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Cyanides	Total metals	Diss. Metals	DOC	TOC	NH_3/TKN/COD						Number of Containers
						F	P			P	P						
	BJ-4A	03-09-12		H_2O	✓	✓	✓	✓	✓	✓	✓						
	BJ-4B	03-09-12		"	✓	✓	✓	✓	✓	✓	✓						
	BJ-6A	03-09-12		"	✓	✓	✓	✓	✓	✓	✓						
	BJ-6B	03-09-12		"	✓	✓	✓	✓	✓	✓	✓						
	BJ-Dupl	03-09-12		"	✓	✓	✓	✓	✓	✓	✓						

Short Holding Time

Rush Processing

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Diss Metals + DOC Not Filtered or Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B Smith	09/09/12	10:00.	Brittany	Sept. 6	10:10	6.5 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

WHITE PAPER CO. 604-951-3900

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 10-SEP-12
Report Date: 19-SEP-12 15:38 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1206550

Project P.O. #: BRUCEJACK
Job Reference: 1008007
C of C Numbers: 10-239823
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1206550-1	L1206550-2	L1206550-3		
	Description	WATER	WATER	WATER		
	Sampled Date	05-SEP-12	05-SEP-12	05-SEP-12		
	Sampled Time	12:40	16:00			
	Client ID	BJ-12A	BJ-FB	TRAVEL BLANK		
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0			
	Conductivity (uS/cm)	455	<2.0			
	Hardness (as CaCO3) (mg/L)	220	<0.50	<0.50		
	pH (pH)	8.14	5.81			
	Total Suspended Solids (mg/L)	842	<3.0			
	Total Dissolved Solids (mg/L)	330	<10			
	Turbidity (NTU)	272	<0.10			
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	2.3	2.4			
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	81.8	<2.0			
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0			
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0			
	Alkalinity, Total (as CaCO3) (mg/L)	81.8	<2.0			
	Ammonia, Total (as N) (mg/L)	0.125	<0.0050	<0.0050		
	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	1.07	<0.50			
	Fluoride (F) (mg/L)	0.204	<0.020			
	Nitrate (as N) (mg/L)	<0.0050	<0.0050			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Total Kjeldahl Nitrogen (mg/L)	0.180	<0.050	<0.050		
	Total Nitrogen (mg/L)	0.180	<0.050			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	0.465	<0.0020			
	Sulfate (SO4) (mg/L)	153	<0.50			
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010		
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010		
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.57	<0.50	<0.50		
	Total Organic Carbon (mg/L)	4.50	<0.50	<0.50		
Total Metals	Aluminum (Al)-Total (mg/L)	5.93	<0.0030	<0.0030		
	Antimony (Sb)-Total (mg/L)	0.00716	<0.00010	<0.00010		
	Arsenic (As)-Total (mg/L)	0.326	<0.00010	<0.00010		
	Barium (Ba)-Total (mg/L)	0.641	<0.000050	<0.000050		
	Beryllium (Be)-Total (mg/L)	0.00057	<0.00010	<0.00010		
	Bismuth (Bi)-Total (mg/L)	0.00056	<0.00050	<0.00050		
	Boron (B)-Total (mg/L)	0.020	<0.010	<0.010		
	Cadmium (Cd)-Total (mg/L)	0.00108	<0.000010	<0.000010		
	Calcium (Ca)-Total (mg/L)	87.7	<0.020	<0.020		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1206550-1	L1206550-2	L1206550-3		
	Description	WATER	WATER	WATER		
	Sampled Date	05-SEP-12	05-SEP-12	05-SEP-12		
	Sampled Time	12:40	16:00			
	Client ID	BJ-12A	BJ-FB	TRAVEL BLANK		
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.00853	<0.00010	<0.00010		
	Cobalt (Co)-Total (mg/L)	0.00662	<0.00010	<0.00010		
	Copper (Cu)-Total (mg/L)	0.0246	<0.00050	<0.00050		
	Iron (Fe)-Total (mg/L)	23.7	<0.030	<0.030		
	Lead (Pb)-Total (mg/L)	0.0458	<0.000050	<0.000050		
	Lithium (Li)-Total (mg/L)	0.00837	0.00065	0.00060		
	Magnesium (Mg)-Total (mg/L)	11.5	<0.0050	<0.0050		
	Manganese (Mn)-Total (mg/L)	0.554	<0.000050	<0.000050		
	Mercury (Hg)-Total (mg/L)	0.000011	<0.000010	<0.000010		
	Molybdenum (Mo)-Total (mg/L)	0.00385	<0.000050	<0.000050		
	Nickel (Ni)-Total (mg/L)	0.00419	<0.00050	<0.00050		
	Phosphorus (P)-Total (mg/L)	0.46	<0.30	<0.30		
	Potassium (K)-Total (mg/L)	7.68	<0.050	<0.050		
	Selenium (Se)-Total (mg/L)	0.00241	<0.00010	<0.00010		
	Silicon (Si)-Total (mg/L)	15.2	<0.050	<0.050		
	Silver (Ag)-Total (mg/L)	0.00464	<0.000010	<0.000010		
	Sodium (Na)-Total (mg/L)	5.7	<2.0	<2.0		
	Strontium (Sr)-Total (mg/L)	1.24	<0.00020	<0.00020		
	Thallium (Tl)-Total (mg/L)	0.000782	<0.000010	<0.000010		
	Tin (Sn)-Total (mg/L)	0.00046	<0.00010	<0.00010		
	Titanium (Ti)-Total (mg/L)	0.041	<0.010	<0.010		
	Uranium (U)-Total (mg/L)	0.00449	<0.000010	<0.000010		
	Vanadium (V)-Total (mg/L)	0.0042	<0.0010	<0.0010		
	Zinc (Zn)-Total (mg/L)	0.171	<0.0030	<0.0030		
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB			
	Aluminum (Al)-Dissolved (mg/L)	0.0281	<0.0030			
	Antimony (Sb)-Dissolved (mg/L)	0.00289	<0.00010			
	Arsenic (As)-Dissolved (mg/L)	0.0609	<0.00010			
	Barium (Ba)-Dissolved (mg/L)	0.0412	<0.000050			
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050			
	Boron (B)-Dissolved (mg/L)	0.015	<0.010			
	Cadmium (Cd)-Dissolved (mg/L)	0.000156	<0.000010			
	Calcium (Ca)-Dissolved (mg/L)	72.1	<0.020			
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010			
	Cobalt (Co)-Dissolved (mg/L)	0.00067	<0.00010			
	Copper (Cu)-Dissolved (mg/L)	0.00097	<0.00050			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1206550-1	L1206550-2	L1206550-3		
	Description	WATER	WATER	WATER		
	Sampled Date	05-SEP-12	05-SEP-12	05-SEP-12		
	Sampled Time	12:40	16:00			
	Client ID	BJ-12A	BJ-FB	TRAVEL BLANK		
Grouping	**Analyte**					
WATER						
Dissolved Metals	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030			
	Lead (Pb)-Dissolved (mg/L)	0.000053	<0.000050			
	Lithium (Li)-Dissolved (mg/L)	0.00638	<0.00050			
	Magnesium (Mg)-Dissolved (mg/L)	9.83	<0.0050			
	Manganese (Mn)-Dissolved (mg/L)	0.361	<0.000050			
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010			
	Molybdenum (Mo)-Dissolved (mg/L)	0.00230	<0.000050			
	Nickel (Ni)-Dissolved (mg/L)	0.00091	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30			
	Potassium (K)-Dissolved (mg/L)	4.88	<0.050			
	Selenium (Se)-Dissolved (mg/L)	<0.00010	<0.00010			
	Silicon (Si)-Dissolved (mg/L)	3.36	<0.050			
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Dissolved (mg/L)	5.5	<2.0			
	Strontium (Sr)-Dissolved (mg/L)	1.08	<0.00020			
	Thallium (Tl)-Dissolved (mg/L)	0.000075	<0.000010			
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010			
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010			
	Uranium (U)-Dissolved (mg/L)	0.00245	<0.000010			
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010			
	Zinc (Zn)-Dissolved (mg/L)	0.0059	<0.0030			
Aggregate Organics	COD (mg/L)	49	<20	<20		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1206550-1, -2
Duplicate	Fluoride (F)	DLM	L1206550-1, -2
Duplicate	Nitrite (as N)	DLM	L1206550-1, -2
Duplicate	Nitrate (as N)	DLM	L1206550-1, -2
Duplicate	Bromide (Br)	DLM	L1206550-1, -2
Duplicate	Bromide (Br)	DLM	L1206550-1, -2
Duplicate	Fluoride (F)	DLM	L1206550-1, -2
Matrix Spike	Phosphorus (P)-Total	MS-B	L1206550-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there

Reference Information

could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-TOT-COMBUST-VA	Water	Total Nitrogen in Water by Combustion	BC: TN by Combustion/Chemiluminescence

This analysis is carried out, on hydrochloric acid preserved samples, following Method BC MOE "Total and Dissolved Nitrogen (TN) by Combustion with Chemiluminescence Detection". Total Nitrogen is determined directly by pyrolysis with chemiluminescence detection using automated instrumentation.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et

Reference Information

al.

P-T-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA Water pH by Manual Meter APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA Water pH by Manual Meter APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA Water TKN in Water by Fluorescence APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA Water Total Nitrogen (Calculation) BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-239823

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 31-JAN-13
Report Date: 12-FEB-13 13:36 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1263921

Project P.O. #: NOT SUBMITTED
Job Reference: 1008 007
C of C Numbers: 10-296455
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1263921-1	L1263921-2	L1263921-3	L1263921-4	L1263921-5
	Description	water	water	water	water	water
	Sampled Date	27-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13
	Sampled Time					
	Client ID	BJ-2A	BJ-3A	BJ-3B	BJ-4A	BJ-4B
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	256	349	382	423	397
	Hardness (as CaCO3) (mg/L)	132	167	188	203	204
	pH (pH)	8.04	8.12	7.86	8.16	8.19
	Total Suspended Solids (mg/L)	655	520	675	25.3	<3.0
	Total Dissolved Solids (mg/L)	166	238	267	282	264
	Turbidity (NTU)	581	199	777	11.5	1.99
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	3.3	2.9	5.0	2.5	2.2
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	79.4	102	76.2	115	121
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	79.4	102	76.2	115	121
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0312	0.0316	0.197	0.0558
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.44	<0.50	1.19	0.74	<0.50
	Fluoride (F) (mg/L)	0.041	0.188	0.109	0.078	0.114
	Nitrate (as N) (mg/L)	0.0142	<0.0050	<0.0050	0.0747	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	0.0013	0.0045	0.0011
	Total Kjeldahl Nitrogen (mg/L)	0.212	0.169	0.231	0.233	0.093
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.352	0.293	0.506	0.0183	<0.0020
	Sulfate (SO4) (mg/L)	54.6	89.1	125	116	98.2
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.53	0.53	2.05	1.02	0.60
	Total Organic Carbon (mg/L)	2.60	0.77	3.12	1.36	0.55
Total Metals	Aluminum (Al)-Total (mg/L)	14.2	11.2	10.0	0.592	0.0555
	Antimony (Sb)-Total (mg/L)	0.00134	0.0211	0.0186	0.00170	0.00061
	Arsenic (As)-Total (mg/L)	0.0237	0.0873	0.0637	0.0209	0.00372
	Barium (Ba)-Total (mg/L)	0.356	0.440	0.397	0.0473	0.0221
	Beryllium (Be)-Total (mg/L)	0.00095	0.00069	0.00056	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.016	0.054	0.040	0.069	0.021
	Cadmium (Cd)-Total (mg/L)	0.000258	0.000550	0.000490	0.000025	<0.000010
	Calcium (Ca)-Total (mg/L)	60.2	65.4	73.7	62.4	74.2
	Chromium (Cr)-Total (mg/L)	0.0968	0.0185	0.00354	0.00070	0.00073

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1263921-6	L1263921-7	L1263921-8	L1263921-9	L1263921-10
	Description	water	water	water	water	water
	Sampled Date	27-JAN-13	27-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13
	Sampled Time					
	Client ID	BJ-6A	BJ-6B	BJ-8A	BJ-8B	BJ-DUP1
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	280	333	209	200	209
	Hardness (as CaCO3) (mg/L)	138	7.70	98.2	97.5	96.1
	pH (pH)	8.20	9.63	8.24	8.21	8.22
	Total Suspended Solids (mg/L)	3410	1780	114	193	118
	Total Dissolved Solids (mg/L)	196	276	131	128	132
	Turbidity (NTU)	>4000 TMV	3940	43.6	174	43.3
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.8	<1.0	1.4	1.6	1.5
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	58.7	42.7	74.3	73.2	79.7
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	42.8	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<1.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	58.7	85.5	74.3	73.2	79.7
	Ammonia, Total (as N) (mg/L)	0.0902	0.156	<0.0050	<0.0050	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	1.37	<0.50	<0.50	<0.50
	Fluoride (F) (mg/L)	0.169	0.252	0.029	0.023	0.030
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0072	0.0151	0.0084
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	1.26	0.219	<0.050	0.082	<0.050
	Orthophosphate-Dissolved (as P) (mg/L)	0.0043	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.161	0.382	0.0222	0.091	0.0189
	Sulfate (SO4) (mg/L)	81.7	72.9	36.0	35.7	36.0
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.52	1.72	<0.50	<0.50	<0.50
	Total Organic Carbon (mg/L)	2.94	3.22	0.72	0.71	0.56
Total Metals	Aluminum (Al)-Total (mg/L)	40.2	23.9	3.91	7.02	3.51
	Antimony (Sb)-Total (mg/L)	0.0166	0.00628	0.00074	0.00176	0.00070
	Arsenic (As)-Total (mg/L)	0.437	0.0592	0.00843	0.0692	0.00823
	Barium (Ba)-Total (mg/L)	24.8	0.809	0.0420	0.160	0.0411
	Beryllium (Be)-Total (mg/L)	0.00462	0.00295	0.00073	0.00031	0.00059
	Bismuth (Bi)-Total (mg/L)	<0.0025 DLA	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	<0.050 DLA	0.162	0.014	0.012	0.014
	Cadmium (Cd)-Total (mg/L)	0.00216	0.000335	0.000037	0.000040	0.000035
	Calcium (Ca)-Total (mg/L)	114	8.93	34.1	39.0	34.8
	Chromium (Cr)-Total (mg/L)	0.0235	0.0143	0.00672	0.0156	0.00664

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1263921-1	L1263921-2	L1263921-3	L1263921-4	L1263921-5
	Description	water	water	water	water	water
	Sampled Date	27-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13
	Sampled Time					
	Client ID	BJ-2A	BJ-3A	BJ-3B	BJ-4A	BJ-4B
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	0.00759	0.00603	0.00304	0.00096	0.00013
	Copper (Cu)-Total (mg/L)	0.0301	0.0349	0.0236	0.00100	0.00075
	Iron (Fe)-Total (mg/L)	21.5	16.4	7.96	0.363	<0.030
	Lead (Pb)-Total (mg/L)	0.0115	0.0272	0.0123	0.000716	0.000085
	Lithium (Li)-Total (mg/L)	0.0207	0.0313	0.0199	0.0280	0.0198
	Magnesium (Mg)-Total (mg/L)	5.91	6.80	7.43	13.3	7.77
	Manganese (Mn)-Total (mg/L)	0.647	1.60	0.646	0.171	0.0599
	Mercury (Hg)-Total (mg/L)	0.000035	0.000053	0.000046	<0.000010	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.0125	0.00395	0.00218	0.00102	0.000490
	Nickel (Ni)-Total (mg/L)	0.0493	0.0114	0.00262	0.00063	0.00080
	Phosphorus (P)-Total (mg/L)	0.39	0.45	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	3.00	5.96	5.26	1.94	0.967
	Selenium (Se)-Total (mg/L)	0.00026	0.00141	0.00209	<0.00010	<0.00010
	Silicon (Si)-Total (mg/L)	31.0	25.9	25.4	4.42	2.48
	Silver (Ag)-Total (mg/L)	0.00185	0.00524	0.00426	0.000018	0.000074
	Sodium (Na)-Total (mg/L)	5.4	10.0	5.0	18.4	7.9
	Strontium (Sr)-Total (mg/L)	2.18	1.30	3.03	3.05	1.05
	Thallium (Tl)-Total (mg/L)	0.000204	0.000666	0.000418	0.000028	0.000013
	Tin (Sn)-Total (mg/L)	0.00089	0.00031	0.00032	0.00018	0.00020
	Titanium (Ti)-Total (mg/L)	0.270	0.256	0.239	0.021	<0.010
	Uranium (U)-Total (mg/L)	0.00178	0.000532	0.000953	0.00235	0.000800
	Vanadium (V)-Total (mg/L)	0.0181	0.0173	0.0147	<0.0010	<0.0010
	Zinc (Zn)-Total (mg/L)	0.174	0.0683	0.0407	0.0058	0.0264
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.201	0.0210	0.0146	0.0036	0.0074
	Antimony (Sb)-Dissolved (mg/L)	0.00048	0.0118	0.0190	0.00155	0.00052
	Arsenic (As)-Dissolved (mg/L)	0.00058	0.00599	0.0281	0.0159	0.00300
	Barium (Ba)-Dissolved (mg/L)	0.0430	0.0300	0.0521	0.0339	0.0195
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	0.010	0.049	0.032	0.063	0.018
	Cadmium (Cd)-Dissolved (mg/L)	0.000021	<0.000010	0.000057	0.000011	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	49.2	59.9	66.6	60.7	69.8
	Chromium (Cr)-Dissolved (mg/L)	0.00047	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00041	0.00038	0.00050	0.00065	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	0.00089	<0.00050	<0.00050
	Iron (Fe)-Dissolved (mg/L)	0.108	<0.030	<0.030	<0.030	<0.030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1263921-6	L1263921-7	L1263921-8	L1263921-9	L1263921-10
	Description	water	water	water	water	water
	Sampled Date	27-JAN-13	27-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13
	Sampled Time					
	Client ID	BJ-6A	BJ-6B	BJ-8A	BJ-8B	BJ-DUP1
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	0.0211	0.0122	0.00057	0.00328	0.00054
	Copper (Cu)-Total (mg/L)	0.166	0.101	0.0183	0.00979	0.0131
	Iron (Fe)-Total (mg/L)	74.7	36.4	1.30	5.06	1.12
	Lead (Pb)-Total (mg/L)	0.224	0.228	0.00299	0.00419	0.00248
	Lithium (Li)-Total (mg/L)	0.0483	0.188	0.0103	0.00959	0.0104
	Magnesium (Mg)-Total (mg/L)	16.8	10.2	6.42	5.28	6.25
	Manganese (Mn)-Total (mg/L)	2.78	1.24	0.0421	0.290	0.0394
	Mercury (Hg)-Total (mg/L)	0.00087	0.00025	<0.000010	0.000040	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.00741	0.00450	0.00197	0.00306	0.00203
	Nickel (Ni)-Total (mg/L)	0.0222	0.0143	0.00423	0.00866	0.00418
	Phosphorus (P)-Total (mg/L)	2.42	0.48	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	11.9	8.43	0.990	3.07	0.946
	Selenium (Se)-Total (mg/L)	0.00314	0.00171	0.00019	0.00028	0.00020
	Silicon (Si)-Total (mg/L)	61.2	40.6	12.8	15.6	11.3
	Silver (Ag)-Total (mg/L)	0.0256	0.0107	0.000209	0.000772	0.000296
	Sodium (Na)-Total (mg/L)	6.4	67.6	6.8	2.6	6.6
	Strontium (Sr)-Total (mg/L)	3.34	0.394	0.724	0.492	0.715
	Thallium (Tl)-Total (mg/L)	0.000936	0.000480	0.000059	0.000170	0.000048
	Tin (Sn)-Total (mg/L)	0.00142	0.00062	0.00039	0.00065	0.00034
	Titanium (Ti)-Total (mg/L)	0.522	0.198	0.049	0.121	0.043
	Uranium (U)-Total (mg/L)	0.00180	0.000670	0.00111	0.000516	0.000972
	Vanadium (V)-Total (mg/L)	0.0656	0.0429	0.0023	0.0112	0.0021
	Zinc (Zn)-Total (mg/L)	0.905	0.549	0.0140	0.0311	0.0195
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0538	0.534	0.0160	0.0173	0.0098
	Antimony (Sb)-Dissolved (mg/L)	0.00677	0.00518	0.00081	0.00072	0.00084
	Arsenic (As)-Dissolved (mg/L)	0.0293	0.0263	0.00689	0.0159	0.00701
	Barium (Ba)-Dissolved (mg/L)	0.0499	0.0391	0.0213	0.0171	0.0208
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	0.027	0.149	0.011	<0.010	0.011
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	0.000066	<0.000010	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	49.2	2.86	30.6	33.2	29.6
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	0.00016	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00050	0.00117	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Dissolved (mg/L)	<0.030	0.145	<0.030	<0.030	<0.030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1263921-1	L1263921-2	L1263921-3	L1263921-4	L1263921-5
	Description	water	water	water	water	water
	Sampled Date	27-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13
	Sampled Time					
	Client ID	BJ-2A	BJ-3A	BJ-3B	BJ-4A	BJ-4B
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	0.000071	0.000065	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.00751	0.0224	0.0113	0.0267	0.0158
	Magnesium (Mg)-Dissolved (mg/L)	2.26	4.34	5.32	12.5	7.33
	Manganese (Mn)-Dissolved (mg/L)	0.0952	0.220	0.317	0.143	0.0565
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.00376	0.00180	0.00118	0.000939	0.000441
	Nickel (Ni)-Dissolved (mg/L)	0.00434	0.00177	0.00083	<0.00050	0.00061
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.419	1.51	1.76	1.59	0.915
	Selenium (Se)-Dissolved (mg/L)	0.00012	0.00018	0.00118	<0.00010	<0.00010
	Silicon (Si)-Dissolved (mg/L)	2.32	3.51	3.05	3.00	2.27
	Silver (Ag)-Dissolved (mg/L)	0.000011	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	4.3	9.9	4.7	17.3	6.6
	Strontium (Sr)-Dissolved (mg/L)	1.97	1.26	2.90	2.93	0.980
	Thallium (Tl)-Dissolved (mg/L)	0.000016	0.000147	0.000055	0.000017	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000427	0.000168	0.000634	0.00224	0.000728
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	0.0122	<0.0030	<0.0030	<0.0030	0.0173
Aggregate Organics	COD (mg/L)	24	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1263921-6	L1263921-7	L1263921-8	L1263921-9	L1263921-10
	Description	water	water	water	water	water
	Sampled Date	27-JAN-13	27-JAN-13	28-JAN-13	28-JAN-13	28-JAN-13
	Sampled Time					
	Client ID	BJ-6A	BJ-6B	BJ-8A	BJ-8B	BJ-DUP1
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	0.000222	0.00160	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.00664	0.144	0.00949	0.00545	0.00940
	Magnesium (Mg)-Dissolved (mg/L)	3.80	0.137	5.32	3.53	5.41
	Manganese (Mn)-Dissolved (mg/L)	0.0423	0.00805	0.00341	0.00822	0.00330
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.00350	0.00539	0.00173	0.00224	0.00164
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	0.00084	0.00132	0.00063
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	2.66	2.42	0.519	0.631	0.520
	Selenium (Se)-Dissolved (mg/L)	0.00064	0.00051	0.00019	0.00024	0.00019
	Silicon (Si)-Dissolved (mg/L)	3.65	4.83	1.99	1.97	1.95
	Silver (Ag)-Dissolved (mg/L)	0.000019	0.000112	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	4.5	66.3	6.5	2.3	6.1
	Strontium (Sr)-Dissolved (mg/L)	2.22	0.182	0.696	0.451	0.706
	Thallium (Tl)-Dissolved (mg/L)	0.000068	0.000035	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000617	0.000127	0.000298	0.000156	0.000284
	Vanadium (V)-Dissolved (mg/L)	<0.0010	0.0021	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	<0.0030	0.0063	<0.0030	0.0044
Aggregate Organics	COD (mg/L)	29	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Beryllium (Be)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Bismuth (Bi)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Cadmium (Cd)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Chromium (Cr)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Cobalt (Co)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Lead (Pb)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Silver (Ag)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Tin (Sn)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Vanadium (V)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Zinc (Zn)-Dissolved	DLA	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Bromide (Br)	DLM	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Duplicate	Nitrite (as N)	DLM	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Total	MS-B	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1263921-1, -10, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
TMV	Turbidity exceeded upper limit of the nephelometric method. Minimum value reported.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

Reference Information

ANIONS-NO2-IC-VA Water Nitrite in Water by Ion Chromatography EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA Water Nitrate in Water by Ion Chromatography EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA Water Sulfate by Ion Chromatography APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA Water Dissolved organic carbon by combustion APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA Water Total organic carbon by combustion APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA Water Low Level Total Cyanide in water by CFA ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA Water Low level WAD Cyanide in water by CFA APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA Water Chemical Oxygen Demand by Colorimetric APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA Water Colour (True) by Spectrometer BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA Water Conductivity (Automated) APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA Water Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA Water Dissolved Mercury in Water by CVAFS(Low) EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA Water Total Mercury in Water by CVAFS(Low) EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Reference Information

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-296455

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 296455

Short Holding Time

Rush Processing

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering Inc.	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V Cullen.	Select: PDF ✓	Excel ✓ Digital ✓ Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	800-1045 Howe Street, Vancouver, BC V6Z 2A9.	Email 1:	VCullen@BGCEngineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	KJohnston@BGCEngineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684-5900 Fax:				

Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008 007
Company:	Pretium Resources.	PO / AFE:	
Contact:	K. Mc Naughton	LSD:	
Address:	1600-570 Granville St, Vancouver V6C 3P1		
Phone:	604 558 1784 Fax: 604 558 4784	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: D. Watt.	Sampler: B Smith, T Beebe.

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals	Diss. Metals	DOC	TOC	COD/TKN/NH3	Cyanides.						Number of Containers
						F			F	F	F						
	BJ-2A	27-01-13		H_2O	✓	✓	✓	✓	✓	✓	✓						7
	BJ-3A	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-3B	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-4A	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-4B	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-6A	27-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-6B	27-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-8A	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-8B	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7
	BJ-Dupl.	28-01-13		"	✓	✓	✓	✓	✓	✓	✓						7

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB

Diss Metals and DOC not filtered or preserved.

L1263921-COFC

Failure to complete all portions of this form may delay analysis. Please fill in this fo

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B. Smith	28/01/13	19:00.		Jan 31	12:20	#1: 6.0°C #2: 3.3				

WHITE PAPER CO. 604 951-3900

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 02-FEB-13
Report Date: 14-FEB-13 14:27 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1264492

Project P.O. #:	NOT SUBMITTED
Job Reference:	1008 007
C of C Numbers:	10-296699
Legal Site Desc:	

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1264492-1	L1264492-2			
	Description	water	water			
	Sampled Date	30-JAN-13	30-JAN-13			
	Sampled Time					
	Client ID	BJ-FB	TRAVEL BLANK			
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0			
	Conductivity (uS/cm)	<2.0	<2.0			
	Hardness (as CaCO3) (mg/L)	<0.50	<0.50			
	pH (pH)	5.73	5.77			
	Total Suspended Solids (mg/L)	<3.0	<3.0			
	Total Dissolved Solids (mg/L)	<10	<10			
	Turbidity (NTU)	<0.10	<0.10			
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	2.7	2.0			
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	<2.0	<2.0			
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0			
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0			
	Alkalinity, Total (as CaCO3) (mg/L)	<2.0	<2.0			
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050			
	Bromide (Br) (mg/L)	<0.050	<0.050			
	Chloride (Cl) (mg/L)	<0.50	<0.50			
	Fluoride (F) (mg/L)	<1.0 DLM	<0.020			
	Nitrate (as N) (mg/L)	<0.0050	<0.0050			
	Nitrite (as N) (mg/L)	<0.0010	<0.0010			
	Total Kjeldahl Nitrogen (mg/L)	<0.050	<0.050			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	<0.0020	<0.0020			
	Sulfate (SO4) (mg/L)	<0.50	<0.50			
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010			
	Cyanide, Total (mg/L)	<0.0010	<0.0010			
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50			
	Total Organic Carbon (mg/L)	<0.50	<0.50			
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030	<0.0030			
	Antimony (Sb)-Total (mg/L)	<0.00010	<0.00010			
	Arsenic (As)-Total (mg/L)	<0.00010	<0.00010			
	Barium (Ba)-Total (mg/L)	<0.000050	<0.000050			
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050			
	Boron (B)-Total (mg/L)	<0.010	<0.010			
	Cadmium (Cd)-Total (mg/L)	<0.000010	<0.000010			
	Calcium (Ca)-Total (mg/L)	<0.020	<0.020			
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1264492-1	L1264492-2			
	Description	water	water			
	Sampled Date	30-JAN-13	30-JAN-13			
	Sampled Time					
	Client ID	BJ-FB	TRAVEL BLANK			
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	<0.00010	<0.00010			
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050			
	Lithium (Li)-Total (mg/L)	<0.00050	<0.00050			
	Magnesium (Mg)-Total (mg/L)	<0.0050	<0.0050			
	Manganese (Mn)-Total (mg/L)	<0.000050	<0.000050			
	Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010			
	Molybdenum (Mo)-Total (mg/L)	<0.000050	<0.000050			
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30			
	Potassium (K)-Total (mg/L)	<0.050	<0.050			
	Selenium (Se)-Total (mg/L)	<0.00010	<0.00010			
	Silicon (Si)-Total (mg/L)	<0.050	<0.050			
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Total (mg/L)	<2.0	<2.0			
	Strontium (Sr)-Total (mg/L)	<0.00020	<0.00020			
	Thallium (Tl)-Total (mg/L)	<0.000010	<0.000010			
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010			
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010			
	Uranium (U)-Total (mg/L)	<0.000010	<0.000010			
	Vanadium (V)-Total (mg/L)	<0.0010	<0.0010			
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030			
Dissolved Metals	Dissolved Metals Filtration Location	LAB				
	Aluminum (Al)-Dissolved (mg/L)	<0.0030				
	Antimony (Sb)-Dissolved (mg/L)	<0.00010				
	Arsenic (As)-Dissolved (mg/L)	<0.00010				
	Barium (Ba)-Dissolved (mg/L)	<0.000050				
	Beryllium (Be)-Dissolved (mg/L)	<0.00010				
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050				
	Boron (B)-Dissolved (mg/L)	<0.010				
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010				
	Calcium (Ca)-Dissolved (mg/L)	<0.020				
	Chromium (Cr)-Dissolved (mg/L)	<0.00010				
	Cobalt (Co)-Dissolved (mg/L)	<0.00010				
	Copper (Cu)-Dissolved (mg/L)	<0.00050				
	Iron (Fe)-Dissolved (mg/L)	<0.030				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1264492-1	L1264492-2			
	Description	water	water			
	Sampled Date	30-JAN-13	30-JAN-13			
	Sampled Time					
	Client ID	BJ-FB	TRAVEL BLANK			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	<0.00050				
	Magnesium (Mg)-Dissolved (mg/L)	<0.0050				
	Manganese (Mn)-Dissolved (mg/L)	<0.000050				
	Mercury (Hg)-Dissolved (mg/L)	<0.000010				
	Molybdenum (Mo)-Dissolved (mg/L)	<0.000050				
	Nickel (Ni)-Dissolved (mg/L)	<0.00050				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	<0.050				
	Selenium (Se)-Dissolved (mg/L)	<0.00010				
	Silicon (Si)-Dissolved (mg/L)	<0.050				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	<2.0				
	Strontium (Sr)-Dissolved (mg/L)	<0.00020				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	<0.000010				
	Vanadium (V)-Dissolved (mg/L)	<0.0010				
	Zinc (Zn)-Dissolved (mg/L)	<0.0030				
Aggregate Organics	COD (mg/L)	<20	<20			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1264492-1, -2
Duplicate	Fluoride (F)	DLM	L1264492-1
Matrix Spike	Phosphorus (P)-Total	MS-B	L1264492-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

Reference Information

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-296699

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-296699

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering Inc.	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V Cullen	Select: PDF ✓	Excel ✓ Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	800 - 1045 Howe Street, Vancouver BC V6Z 2A9	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	KJohnston@BGCengineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909				
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	**Client / Project Information**		**Analysis Request**	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008 007	(Indicate Filtered or Preserved, F/P)	
Company:	Pretium Resources Ltd.	PO / AFE:			
Contact:	K. McNaughton	LSD:			
Address:	1600 - 570 Granville St, Vancouver, BC V6C 3P1				
Phone:	604 558 1984 Fax: 604 558 4784	Quote #:			
Lab Work Order # (lab use only)		**ALS Contact:** D. Watt	**Sampler:** B Smith T Boebo		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals (P)	Dissolved Metals	Cyanides (P)	TOC	DOC (P)	COD/TKN/NH3 (P)						Number of Containers
	BJ - FB	30-01-13		H_2O	✓	✓	✓	✓	✓	✓	✓						
	Travel Blank	30-01-13		H_2O	✓	✓	✓	✓	✓	✓	✓						

Short Holding Time

Rush Processing

L1264492-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B Smith	30/01/13	09:30		Feb02	11:30	1.8 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 09-APR-13
Report Date: 18-APR-13 13:49 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1287525

Project P.O. #: NOT SUBMITTED
Job Reference: 1008-007
C of C Numbers: 10-293380
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1287525-1	L1287525-2	L1287525-3	L1287525-4	L1287525-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	07-APR-13	07-APR-13	07-APR-13	07-APR-13	07-APR-13
	Sampled Time					
	Client ID	02A	03A	06A	06B	DUP 1
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	274	348	258	309	271
	Hardness (as CaCO3) (mg/L)	133	156	120	9.01	130
	pH (pH)	8.13	8.11	8.18	9.53	8.12
	Total Suspended Solids (mg/L)	341	10.5	1340	805	167
	Total Dissolved Solids (mg/L)	176	230	184	342	185
	Turbidity (NTU)	228	30.5	2160	2380	138
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.9	1.8	1.1	<1.0	1.6
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	80.5	96.5	68.6	57.5	79.1
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<1.0	29.4	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<1.0	<1.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	80.5	96.5	68.6	86.9	79.1
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0325	0.084	0.135	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.29	<0.50	0.51	1.30	1.20
	Fluoride (F) (mg/L)	0.037	0.197	0.184	0.233	0.036
	Nitrate (as N) (mg/L)	0.0216	<0.0050	<0.0050	<0.0050	0.0220
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.089	0.057	0.66	0.82	0.084
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	0.0028	0.0017	<0.0010
	Phosphorus (P)-Total (mg/L)	0.272	0.0273	1.33	0.327	0.167
	Sulfate (SO4) (mg/L)	63.3	89.8	69.2	67.9	63.5
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	0.0013	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	0.0029	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	<0.50	1.02	<0.50
	Total Organic Carbon (mg/L)	1.02	<0.50	0.86	1.71	0.78
Total Metals	Aluminum (Al)-Total (mg/L)	8.77	1.36	24.3	22.9	6.91
	Antimony (Sb)-Total (mg/L)	0.00099	0.00590	0.0122	0.00559	0.00090
	Arsenic (As)-Total (mg/L)	0.0116	0.0131	0.173	0.0420	0.00956
	Barium (Ba)-Total (mg/L)	0.219	0.0571	13.3	0.707	0.247
	Beryllium (Be)-Total (mg/L)	0.00051	<0.00010	0.00188	0.00197	0.00031
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.0010 DLA	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.013	0.047	0.039	0.152	0.014
	Cadmium (Cd)-Total (mg/L)	0.000138	0.000037	0.000874	0.000215	0.000097
	Calcium (Ca)-Total (mg/L)	54.2	55.9	63.4	6.77	51.2
	Chromium (Cr)-Total (mg/L)	0.0334	0.00156	0.0106	0.00940	0.0236

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1287525-6				
	Description	WATER				
	Sampled Date	07-APR-13				
	Sampled Time					
	Client ID	TRAVEL BLANK				
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0				
	Conductivity (uS/cm)	<2.0				
	Hardness (as CaCO3) (mg/L)					
	pH (pH)	5.59				
	Total Suspended Solids (mg/L)	<3.0				
	Total Dissolved Solids (mg/L)	<10				
	Turbidity (NTU)	<0.10				
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.7				
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Total (as CaCO3) (mg/L)	<2.0				
	Ammonia, Total (as N) (mg/L)	<0.0050				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	<0.50				
	Fluoride (F) (mg/L)	<0.020				
	Nitrate (as N) (mg/L)	<0.0050				
	Nitrite (as N) (mg/L)	<0.0010				
	Total Kjeldahl Nitrogen (mg/L)	<0.050				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	<0.0020				
	Sulfate (SO4) (mg/L)	<0.50				
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010				
	Cyanide, Total (mg/L)	<0.0010				
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)					
	Total Organic Carbon (mg/L)	<0.50				
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030				
	Antimony (Sb)-Total (mg/L)	<0.00010				
	Arsenic (As)-Total (mg/L)	<0.00010				
	Barium (Ba)-Total (mg/L)	<0.000050				
	Beryllium (Be)-Total (mg/L)	<0.00010				
	Bismuth (Bi)-Total (mg/L)	<0.00050				
	Boron (B)-Total (mg/L)	<0.010				
	Cadmium (Cd)-Total (mg/L)	<0.000010				
	Calcium (Ca)-Total (mg/L)	<0.020				
	Chromium (Cr)-Total (mg/L)	<0.00010				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1287525-1	L1287525-2	L1287525-3	L1287525-4	L1287525-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	07-APR-13	07-APR-13	07-APR-13	07-APR-13	07-APR-13
	Sampled Time					
	Client ID	02A	03A	06A	06B	DUP 1
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	0.00432	0.00043	0.00865	0.00835	0.00299
	Copper (Cu)-Total (mg/L)	0.0181	0.00267	0.0646	0.0592	0.0116
	Iron (Fe)-Total (mg/L)	10.9	0.979	30.1	24.6	7.89
	Lead (Pb)-Total (mg/L)	0.00621	0.00373	0.0896	0.147	0.00373
	Lithium (Li)-Total (mg/L)	0.0120	0.0195	0.0236	0.159	0.0114
	Magnesium (Mg)-Total (mg/L)	4.38	4.51	9.00	7.17	3.42
	Manganese (Mn)-Total (mg/L)	0.363	0.215	1.07	0.822	0.267
	Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	0.000240	0.000123	0.000025
	Molybdenum (Mo)-Total (mg/L)	0.00509	0.00132	0.00407	0.00380	0.00400
	Nickel (Ni)-Total (mg/L)	0.0176	0.00109	0.0090	0.00953	0.0123
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	0.96	0.32	<0.30
	Potassium (K)-Total (mg/L)	2.28	1.99	9.80	8.98	2.33
	Selenium (Se)-Total (mg/L)	0.00019	<0.00010	0.00116	0.00081	0.00016
	Silicon (Si)-Total (mg/L)	22.2	6.39	76.8	77.8	20.0
	Silver (Ag)-Total (mg/L)	0.00104	0.000337	0.0117	0.00677	0.000855
	Sodium (Na)-Total (mg/L)	5.2	9.4	6.9	67.7	5.3
	Strontium (Sr)-Total (mg/L)	1.41	1.14	2.42	0.315	1.14
	Thallium (Tl)-Total (mg/L)	0.000136	0.000089	0.000573	0.000520	0.000112
	Tin (Sn)-Total (mg/L)	0.00050	<0.00010	0.00075	0.00039	0.00039
	Titanium (Ti)-Total (mg/L)	0.237	0.033	0.841	0.689	0.270
	Uranium (U)-Total (mg/L)	0.00118	0.000186	0.00105	0.000532	0.000681
	Vanadium (V)-Total (mg/L)	0.0120	0.0021	0.0384	0.0406	0.0110
	Zinc (Zn)-Total (mg/L)	0.0401	0.0115	0.354	0.349	0.0291
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0143	0.0065	0.0252	0.150	0.0121
	Antimony (Sb)-Dissolved (mg/L)	0.00036	0.00334	0.00339	0.00261	0.00033
	Arsenic (As)-Dissolved (mg/L)	0.00050	0.00691	0.0281	0.0192	0.00052
	Barium (Ba)-Dissolved (mg/L)	0.0370	0.0252	0.0501	0.0334	0.0376
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00020 DLA	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.0010 DLA	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	0.012	0.047	0.032	0.140	0.012
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000020 DLA	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	49.6	55.4	42.3	3.36	48.2
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00020 DLA	0.00011	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00022	<0.00010	<0.00020 DLA	<0.00010	0.00022
	Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050 DLA	<0.00050	<0.00050
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	0.044	<0.030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1287525-6				
	Description	WATER				
	Sampled Date	07-APR-13				
	Sampled Time					
	Client ID	TRAVEL BLANK				
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	<0.00010				
	Copper (Cu)-Total (mg/L)	<0.00050				
	Iron (Fe)-Total (mg/L)	<0.030				
	Lead (Pb)-Total (mg/L)	<0.000050				
	Lithium (Li)-Total (mg/L)	<0.00050				
	Magnesium (Mg)-Total (mg/L)	<0.0050				
	Manganese (Mn)-Total (mg/L)	<0.000050				
	Mercury (Hg)-Total (mg/L)	<0.000010				
	Molybdenum (Mo)-Total (mg/L)	<0.000050				
	Nickel (Ni)-Total (mg/L)	<0.00050				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	<0.050				
	Selenium (Se)-Total (mg/L)	<0.00010				
	Silicon (Si)-Total (mg/L)	<0.050				
	Silver (Ag)-Total (mg/L)	<0.000010				
	Sodium (Na)-Total (mg/L)	<2.0				
	Strontium (Sr)-Total (mg/L)	<0.00020				
	Thallium (Tl)-Total (mg/L)	<0.000010				
	Tin (Sn)-Total (mg/L)	<0.00010				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	<0.000010				
	Vanadium (V)-Total (mg/L)	<0.0010				
	Zinc (Zn)-Total (mg/L)	<0.0030				
Dissolved Metals	Dissolved Metals Filtration Location					
	Aluminum (Al)-Dissolved (mg/L)					
	Antimony (Sb)-Dissolved (mg/L)					
	Arsenic (As)-Dissolved (mg/L)					
	Barium (Ba)-Dissolved (mg/L)					
	Beryllium (Be)-Dissolved (mg/L)					
	Bismuth (Bi)-Dissolved (mg/L)					
	Boron (B)-Dissolved (mg/L)					
	Cadmium (Cd)-Dissolved (mg/L)					
	Calcium (Ca)-Dissolved (mg/L)					
	Chromium (Cr)-Dissolved (mg/L)					
	Cobalt (Co)-Dissolved (mg/L)					
	Copper (Cu)-Dissolved (mg/L)					
	Iron (Fe)-Dissolved (mg/L)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1287525-1	L1287525-2	L1287525-3	L1287525-4	L1287525-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	07-APR-13	07-APR-13	07-APR-13	07-APR-13	07-APR-13
	Sampled Time					
	Client ID	02A	03A	06A	06B	DUP 1
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.00010 DLA	0.000607	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.00601	0.0190	0.0066	0.128	0.00541
	Magnesium (Mg)-Dissolved (mg/L)	2.28	4.25	3.57	0.147	2.26
	Manganese (Mn)-Dissolved (mg/L)	0.0657	0.176	0.0465	0.00801	0.0513
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.00155	0.00123	0.00232	0.00371	0.00126
	Nickel (Ni)-Dissolved (mg/L)	0.00137	<0.00050	0.0031	<0.00050	0.00128
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.343	1.47	2.52	2.19	0.320
	Selenium (Se)-Dissolved (mg/L)	0.00012	<0.00010	0.00023	0.00021	0.00012
	Silicon (Si)-Dissolved (mg/L)	1.81	3.48	3.66	3.91	1.82
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000020 DLA	0.000028	<0.000010
	Sodium (Na)-Dissolved (mg/L)	4.4	9.3	4.8	66.6	4.5
	Strontium (Sr)-Dissolved (mg/L)	1.41	1.15	2.00	0.190	1.08
	Thallium (Tl)-Dissolved (mg/L)	0.000011	0.000027	0.000053	0.000023	0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00020 DLA	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000348	0.000136	0.000531	0.000073	0.000309
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0020 DLA	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	<0.0030	<0.0030 DLA	<0.0030	<0.0030
Aggregate Organics	COD (mg/L)	<20	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1287525-6				
	Description	WATER				
	Sampled Date	07-APR-13				
	Sampled Time					
	Client ID	TRAVEL BLANK				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)					
	Lithium (Li)-Dissolved (mg/L)					
	Magnesium (Mg)-Dissolved (mg/L)					
	Manganese (Mn)-Dissolved (mg/L)					
	Mercury (Hg)-Dissolved (mg/L)					
	Molybdenum (Mo)-Dissolved (mg/L)					
	Nickel (Ni)-Dissolved (mg/L)					
	Phosphorus (P)-Dissolved (mg/L)					
	Potassium (K)-Dissolved (mg/L)					
	Selenium (Se)-Dissolved (mg/L)					
	Silicon (Si)-Dissolved (mg/L)					
	Silver (Ag)-Dissolved (mg/L)					
	Sodium (Na)-Dissolved (mg/L)					
	Strontium (Sr)-Dissolved (mg/L)					
	Thallium (Tl)-Dissolved (mg/L)					
	Tin (Sn)-Dissolved (mg/L)					
	Titanium (Ti)-Dissolved (mg/L)					
	Uranium (U)-Dissolved (mg/L)					
	Vanadium (V)-Dissolved (mg/L)					
	Zinc (Zn)-Dissolved (mg/L)					
Aggregate Organics	COD (mg/L)	<20				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Bicarbonate (as CaCO3)	B	L1287525-3, -4
Method Blank	Alkalinity, Total (as CaCO3)	B	L1287525-3, -4
Method Blank	Alkalinity, Bicarbonate (as CaCO3)	B	L1287525-3, -4
Method Blank	Alkalinity, Total (as CaCO3)	B	L1287525-3, -4
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Ammonia, Total (as N)	MS-B	L1287525-3, -4, -6
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Selenium (Se)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1287525-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit Adjusted For required dilution
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

Reference Information

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or

Reference Information

filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA Water pH by Manual Meter APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA Water pH by Manual Meter APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA Water TKN in Water by Fluorescence APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TSS-VA Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Reference Information

Chain of Custody Numbers:

10-293380

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-293880

ALS Environmental

L1287525-COFC

Report To	
Company:	BGC Engineering Inc.
Contact:	V. Cullen
Address:	800-1045 Howe Street Vancouver BC.
Phone:	604 684 5900 Fax: 604 684 5909.
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)
	Copy of Invoice with Report? (circle) Yes or No
Company:	Pretium Resources.
Contact:	K Mc Naughton
Address:	1600-570 Granville Street, Vancouver, BC
Phone:	604 558 1784 Fax: 604 558 4784
Lab Work Order # (lab use only)	L1287825

Standard: ✓	Other (specify):
Select: PDF ✓	Excel ✓ Digital ✓ Fax
Email 1:	VCullen@BGCEngineering.ca
Email 2:	KJohnston@BGCEngineering.ca.
Client / Project Information	
Job #:	1008 007
PO / AFE:	
LSD:	
Quote #:	
ALS Contact:	D. Watt.
Sampler:	B Smith T Beebe

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)

- ✓ Regular (Standard Turnaround Times - Business Days)
- Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals (P)	Dissolved Metals	DOC	TOC (P)	TKN/NH3/COD (P)	Cyanides (P)						Number of Containers
	02A	7-04-13		H_2O	✓	✓	✓	✓	✓	✓	✓						6
	03A	"		"	✓	✓	✓	✓	✓	✓	✓						6
	06A	"		"	✓	✓	✓	✓	✓	✓	✓						6
	06B	"		"	✓	✓	✓	✓	✓	✓	✓						6
	Dupl	"		"	✓	✓	✓	✓	✓	✓	✓						6
	Travel Blank	"		"	✓	✓			✓	✓	✓						4.

Short Holding Time

Rush Processing

Special Instructions / Regulation with water or land use (CCME-Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

DOC and Dissolved Metals Not Filtered and not Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B Smith	07/04/13	17:00	TV	Apr 9	11:55	10 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 10-APR-13
Report Date: 18-APR-13 16:56 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1288325

Project P.O. #: NOT SUBMITTED
Job Reference: 1008007
C of C Numbers: 10-293879
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1288325-1	L1288325-2	L1288325-3	L1288325-4	L1288325-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	08-APR-13	08-APR-13	08-APR-13	08-APR-13	08-APR-13
	Sampled Time					
	Client ID	08A	08B	04A	04B	FB
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	213	201	430	489	<2.0
	Hardness (as CaCO3) (mg/L)	99.9	99.6	190	13.7	<0.50
	pH (pH)	8.18	8.23	8.15	9.37	5.74
	Total Suspended Solids (mg/L)	15.7	281	18.6	3.2	<3.0
	Total Dissolved Solids (mg/L)	130	133	285	308	<10
	Turbidity (NTU)	10.8	281	11.2	6.87	<0.10
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.2	<1.0	1.4	<1.0	1.1
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	76.0	67.6	115	96.7	<2.0
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	35.5	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<1.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	76.0	67.6	115	132	<2.0
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	0.131	0.152	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	<0.50	0.55	<0.50	<0.50
	Fluoride (F) (mg/L)	0.030	0.030	0.081	0.140	<0.020
	Nitrate (as N) (mg/L)	0.0092	0.0176	0.191	<0.0050	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	0.0058	0.0034	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	<0.050	0.068	0.155	0.181	<0.050
	Total Nitrogen (mg/L)	<0.050	0.086	0.352	0.184	<0.050
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.0058	0.152	0.0128	0.0022	<0.0020
	Sulfate (SO4) (mg/L)	36.6	37.1	120	114	<0.50
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	<0.50	<0.50	<0.50
	Total Organic Carbon (mg/L)	<0.50	0.54	1.15	0.53	<0.50
Total Metals	Aluminum (Al)-Total (mg/L)	0.868	12.7	0.419	0.571	<0.0030
	Antimony (Sb)-Total (mg/L)	0.00081	0.00170	0.00332	0.00115	<0.00010
	Arsenic (As)-Total (mg/L)	0.00736	0.0671	0.0164	0.0169	<0.00010
	Barium (Ba)-Total (mg/L)	0.0264	0.186	0.0978	0.0222	<0.000050
	Beryllium (Be)-Total (mg/L)	<0.00010	0.00028	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.012	0.014	0.064	0.057	<0.010
	Cadmium (Cd)-Total (mg/L)	0.000015	0.000042	0.000043	<0.000010	<0.000010
	Calcium (Ca)-Total (mg/L)	32.0	33.6	58.1	7.06	<0.020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1288325-1	L1288325-2	L1288325-3	L1288325-4	L1288325-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	08-APR-13	08-APR-13	08-APR-13	08-APR-13	08-APR-13
	Sampled Time					
	Client ID	08A	08B	04A	04B	FB
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.00112	0.0138	0.00113	0.00179	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00016	0.00333	0.00082	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	0.00250	0.00909	0.00166	0.00081	<0.00050
	Iron (Fe)-Total (mg/L)	0.330	5.32	0.383	0.073	<0.030
	Lead (Pb)-Total (mg/L)	0.000485	0.00389	0.000753	0.000164	<0.000050
	Lithium (Li)-Total (mg/L)	0.0114	0.00846	0.0281	0.221	<0.00050
	Magnesium (Mg)-Total (mg/L)	5.63	5.69	11.5	0.932	<0.0050
	Manganese (Mn)-Total (mg/L)	0.0246	0.290	0.102	0.00665	<0.000050
	Mercury (Hg)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.00169	0.00311	0.000983	0.000956	<0.000050
	Nickel (Ni)-Total (mg/L)	0.00077	0.00888	0.00074	0.00086	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	0.586	3.14	1.70	0.969	<0.050
	Selenium (Se)-Total (mg/L)	0.00017	0.00027	<0.00010	<0.00010	<0.00010
	Silicon (Si)-Total (mg/L)	4.88	22.1	4.02	4.41	<0.050
	Silver (Ag)-Total (mg/L)	0.000075	0.000890	0.000019	0.000188	<0.000010
	Sodium (Na)-Total (mg/L)	5.2	2.7	17.9	111	<2.0
	Strontium (Sr)-Total (mg/L)	0.747	0.564	2.87	0.146	<0.00020
	Thallium (Tl)-Total (mg/L)	0.000014	0.000158	0.000027	0.000020	<0.000010
	Tin (Sn)-Total (mg/L)	0.00012	0.00029	0.00023	0.00024	<0.00010
	Titanium (Ti)-Total (mg/L)	0.018	0.175	0.017	<0.010	<0.010
	Uranium (U)-Total (mg/L)	0.000360	0.000399	0.00209	0.000152	<0.000010
	Vanadium (V)-Total (mg/L)	<0.0010	0.0117	<0.0010	0.0011	<0.0010
	Zinc (Zn)-Total (mg/L)	0.0041	0.0267	0.0072	<0.0030	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0142	3.59	0.0075	0.387	<0.0030
	Antimony (Sb)-Dissolved (mg/L)	0.00085	0.00092	0.00293	0.00109	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00705	0.0235	0.0140	0.0161	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0218	0.0785	0.0338	0.0160	<0.000050
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	0.012	0.012	0.064	0.055	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	0.000011	0.000012	0.000033	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	31.1	32.5	57.1	4.13	<0.020
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	0.00287	<0.00010	0.00073	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00069	0.00012	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00050	0.00164	<0.00050	<0.00050	<0.00050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1288325-1	L1288325-2	L1288325-3	L1288325-4	L1288325-5
	Description	WATER	WATER	WATER	WATER	WATER
	Sampled Date	08-APR-13	08-APR-13	08-APR-13	08-APR-13	08-APR-13
	Sampled Time					
	Client ID	08A	08B	04A	04B	FB
Grouping	**Analyte**					
WATER						
Dissolved Metals	Iron (Fe)-Dissolved (mg/L)	<0.030	1.06	<0.030	0.039	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000739	<0.000050	0.000065	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0106	0.00557	0.0274	0.210	<0.00050
	Magnesium (Mg)-Dissolved (mg/L)	5.40	4.45	11.5	0.832	<0.0050
	Manganese (Mn)-Dissolved (mg/L)	0.00417	0.0929	0.0521	0.00159	<0.000050
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.00163	0.00218	0.000893	0.000855	<0.000050
	Nickel (Ni)-Dissolved (mg/L)	0.00055	0.00226	0.00058	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.484	1.59	1.61	0.794	<0.050
	Selenium (Se)-Dissolved (mg/L)	0.00018	0.00026	<0.00010	<0.00010	<0.00010
	Silicon (Si)-Dissolved (mg/L)	2.06	7.96	3.00	3.90	<0.050
	Silver (Ag)-Dissolved (mg/L)	<0.000010	0.000085	<0.000010	0.000060	<0.000010
	Sodium (Na)-Dissolved (mg/L)	5.2	2.4	17.7	107	<2.0
	Strontium (Sr)-Dissolved (mg/L)	0.737	0.541	2.81	0.127	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	0.000060	0.000017	0.000013	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00019	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	0.056	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000231	0.000270	0.00201	0.000138	<0.000010
	Vanadium (V)-Dissolved (mg/L)	<0.0010	0.0040	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	0.0063	0.0036	<0.0030	<0.0030
Aggregate Organics	COD (mg/L)	<20	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Calcium (Ca)-Total	MB-LOR	L1288325-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Potassium (K)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Uranium (U)-Dissolved	MS-B	L1288325-1, -2, -3, -4, -5
Matrix Spike	Ammonia, Total (as N)	MS-B	L1288325-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MB-LOR	Method Blank exceeds ALS DQO. LORs adjusted for samples with positive hits below 5 times blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are

Reference Information

determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method

Reference Information

6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

Reference Information

10-293879

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-293879

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To
Company: BGC Engineering Inc.
Contact: V. Cullen
Address: 800 - 1045 Howe street, Vancouver, V6Z 2A9
Phone: 604 684 5900 Fax: 604 684 5909

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF ✓ Excel ✓ Digital ✓ Fax
Email 1: VCullen@BGCEngineering.ca
Email 2: KJohnston@BGCengineering.ca

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
✓ Regular (Standard Turnaround Times - Business Days)
Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
Same Day or Weekend Emergency - Contact ALS to confirm TAT

Invoice To Same as Report ? (circle) Yes or (No) (if No, provide details)
Copy of Invoice with Report? (circle) Yes or No
Company: Pretium Resources
Contact: K. McNaughton
Address: 1600 - 570 Granville st. Vancouver, V6C 3P1
Phone: 604 558 1784 Fax: 604 558 4786

Client / Project Information
Job #: 1008007
PO / AFE:
LSD:
Quote #:

Lab Work Order # (lab use only) L1288325
ALS Contact: D. Watt
Sampler: B Smith / T Beebe

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals (F)	Dissolved Metals	DOC (F)	TOC	COD/TKN/NH3 (F)	Cyanides (F)						Number of Containers
	08A	08-04-13		H_2O	✓	✓	✓	✓	✓	✓	✓						6
	08B	"		"	✓	✓	✓	✓	✓	✓	✓						6
	04A	"		"	✓	✓	✓	✓	✓	✓	✓						6
	04B	"		"	✓	✓	✓	✓	✓	✓	✓						6
	FB	"		"	✓	✓	✓	✓	✓	✓	✓						6

Short Holding Time
Rush Processing

L1288325-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquati... Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Dissolved Metals and DOC not filtered or preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B. Smith	08/04/13	17:00	[illegible]	Apr 10	12:36	3.8 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 13-JUL-13
Report Date: 01-AUG-13 16:36 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1331947

Project P.O. #: NOT SUBMITTED
Job Reference: 1008007
C of C Numbers: 10-268554
Legal Site Desc:

Comments: ADDITIONAL 30-JUL-13 16:09

Dean Watt
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1331947-1	L1331947-2	L1331947-3	L1331947-4	L1331947-5
	Description	water	water	water	water	water
	Sampled Date	11-JUL-13	11-JUL-13	11-JUL-13	11-JUL-13	11-JUL-13
	Sampled Time					
	Client ID	BJ-4B	BJ-6A	BJ-3B	DUP1	BJ-FB
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	529	284	352	526	<2.0
	Hardness (as CaCO3) (mg/L)	8.10	126	164	7.71	<0.50
	pH (pH)	9.46	8.22	8.22	9.43	5.69
	Total Suspended Solids (mg/L)	6.9	1010	493	7.6	<3.0
	Total Dissolved Solids (mg/L)	337	198	223	329	<10
	Turbidity (NTU)	19.7	1350	346	21.2	<0.10
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	89.8	68.3	94.6	97.0	<2.0
	Alkalinity, Carbonate (as CaCO3) (mg/L)	43.5	<2.0	<2.0	46.4	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<2.0	<2.0	<1.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	133	68.3	94.6	143	<2.0
	Ammonia, Total (as N) (mg/L)	0.169	0.0793	0.0271	0.174	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.48	0.50	<0.50	1.31	<0.50
	Fluoride (F) (mg/L)	0.137	0.169	0.163	0.133	<0.020
	Nitrate (as N) (mg/L)	<0.0050	<0.0050	0.0052	<0.0050	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	0.0010	<0.0010	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.192	0.838	0.670	0.250	<0.050
	Orthophosphate-Dissolved (as P) (mg/L)	0.0038	0.0026	<0.0010	0.0035	<0.0010
	Phosphorus (P)-Total (mg/L)	0.0061	0.573	0.225	0.0068	<0.0020
	Sulfate (SO4) (mg/L)	111	74.4	87.2	111	<0.50
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.71	<0.50	<0.50	0.66	<0.50
	Total Organic Carbon (mg/L)	0.60	1.11	0.53	1.16	<0.50
Total Metals	Aluminum (Al)-Total (mg/L)	1.49	15.8	9.32	1.25	<0.0030
	Antimony (Sb)-Total (mg/L)	0.00070	0.00870	0.0114	0.00066	<0.00010
	Arsenic (As)-Total (mg/L)	0.0129	0.120	0.113	0.0127	<0.00010
	Barium (Ba)-Total (mg/L)	0.0423	4.10	0.408	0.0369	<0.000050
	Beryllium (Be)-Total (mg/L)	<0.00010	0.00136	0.00088	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.069	0.028	0.040	0.062	<0.010
	Cadmium (Cd)-Total (mg/L)	<0.000010	0.000702	0.000588	<0.000010	<0.000010
	Calcium (Ca)-Total (mg/L)	2.94	60.0	75.9	2.74	<0.020
	Chromium (Cr)-Total (mg/L)	0.00216	0.00831	0.00450	0.00189	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1331947-1	L1331947-2	L1331947-3	L1331947-4	L1331947-5
	Description	water	water	water	water	water
	Sampled Date	11-JUL-13	11-JUL-13	11-JUL-13	11-JUL-13	11-JUL-13
	Sampled Time					
	Client ID	BJ-4B	BJ-6A	BJ-3B	DUP1	BJ-FB
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	<0.00010	0.00602	0.00518	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	0.00090	0.0523	0.0214	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	0.150	18.9	15.7	0.146	<0.030
	Lead (Pb)-Total (mg/L)	0.000279	0.0672	0.0198	0.000232	<0.000050
	Lithium (Li)-Total (mg/L)	0.230	0.0178	0.0281	0.227	<0.00050
	Magnesium (Mg)-Total (mg/L)	0.511	7.35	7.25	0.466	<0.0050
	Manganese (Mn)-Total (mg/L)	0.0120	0.731	1.14	0.0112	<0.000050
	Mercury (Hg)-Total (mg/L)	<0.000010	0.000130	0.000072	<0.000010	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.00102	0.00316	0.00187	0.000946	<0.000050
	Nickel (Ni)-Total (mg/L)	0.00079	0.00702	0.00333	0.00065	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	0.74	0.54	<0.30	<0.30
	Potassium (K)-Total (mg/L)	1.35	5.80	3.60	1.21	<0.050
	Selenium (Se)-Total (mg/L)	<0.00010	0.00087	0.00190	<0.00010	<0.00010
	Silicon (Si)-Total (mg/L)	6.13	59.8	24.2	6.29	<0.050
	Silver (Ag)-Total (mg/L)	0.000037	0.00574	0.00225	0.000031	<0.000010
	Sodium (Na)-Total (mg/L)	116	6.7	6.6	115	<2.0
	Strontium (Sr)-Total (mg/L)	0.112	2.28	1.59	0.0971	<0.00020
	Thallium (Tl)-Total (mg/L)	0.000042	0.000377	0.000383	0.000036	<0.000010
	Tin (Sn)-Total (mg/L)	0.00014	0.00072	0.00032	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.011	0.660	0.145	0.010	<0.010
	Uranium (U)-Total (mg/L)	0.000140	0.00118	0.000975	0.000128	<0.000010
	Vanadium (V)-Total (mg/L)	0.0024	0.0211	0.0157	0.0022	<0.0010
	Zinc (Zn)-Total (mg/L)	0.0041	0.302	0.0545	0.0032	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.120	0.0898	0.0474	0.174	<0.0030
	Antimony (Sb)-Dissolved (mg/L)	0.00068	0.00370	0.00284	0.00065	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.0129	0.0260	0.0128	0.0128	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0204	0.0471	0.0525	0.0220	<0.000050
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	0.060	0.024	0.036	0.058	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	0.000016	0.000030	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	2.68	44.4	59.5	2.56	<0.020
	Chromium (Cr)-Dissolved (mg/L)	0.00039	<0.00010	0.00010	0.00046	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1331947-1	L1331947-2	L1331947-3	L1331947-4	L1331947-5
	Description	water	water	water	water	water
	Sampled Date	11-JUL-13	11-JUL-13	11-JUL-13	11-JUL-13	11-JUL-13
	Sampled Time					
	Client ID	BJ-4B	BJ-6A	BJ-3B	DUP1	BJ-FB
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000142	<0.000050	0.000051	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.226	0.00655	0.0152	0.227	<0.00050
	Magnesium (Mg)-Dissolved (mg/L)	0.341	3.74	3.82	0.319	<0.0050
	Manganese (Mn)-Dissolved (mg/L)	0.00602	0.0482	0.0412	0.00610	<0.000050
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.000877	0.00246	0.000882	0.000882	<0.000050
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.822	2.48	1.15	0.808	<0.050
	Selenium (Se)-Dissolved (mg/L)	<0.00010	0.00030	0.00029	<0.00010	<0.00010
	Silicon (Si)-Dissolved (mg/L)	3.58	3.81	3.19	3.71	<0.050
	Silver (Ag)-Dissolved (mg/L)	<0.000010	0.000014	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	113	5.1	6.4	113	<2.0
	Strontium (Sr)-Dissolved (mg/L)	0.0953	1.98	1.48	0.0913	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	0.000060	0.000040	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000099	0.000689	0.000425	0.000098	<0.000010
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Aggregate Organics	COD (mg/L)	<20	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1331947-1, -2, -3, -4, -5
Duplicate	Nitrite (as N)	DLM	L1331947-1, -2, -3, -4, -5
Duplicate	Bromide (Br)	DLM	L1331947-1, -2, -3, -4, -5
Duplicate	Fluoride (F)	DLM	L1331947-1, -2, -3, -4, -5
Duplicate	Nitrite (as N)	DLM	L1331947-1, -2, -3, -4, -5
Duplicate	Nitrite (as N)	DLM	L1331947-1, -2, -3, -4, -5
Matrix Spike	Phosphorus (P)-Total	MS-B	L1331947-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L1331947-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1331947-1, -2, -3, -4, -5
Matrix Spike	Lithium (Li)-Dissolved	MS-B	L1331947-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1331947-1, -2, -3, -4, -5
Matrix Spike	Barium (Ba)-Total	MS-B	L1331947-1, -2, -3, -4
Matrix Spike	Calcium (Ca)-Total	MS-B	L1331947-1, -2, -3, -4
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1331947-1, -2, -3, -4
Matrix Spike	Strontium (Sr)-Total	MS-B	L1331947-1, -2, -3, -4

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

Reference Information

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United

Reference Information

States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Reference Information

VA ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-268554

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-268554

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V. Cullen.	Select: PDF ✓	Excel ✓ Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	800 - 1045 Howe Street.	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancouver, V6Z 2A9	Email 2:	KJohnston@BGCengineering.ca.		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909			Analysis Request	
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information		(Indicate Filtered or Preserved, F/P)	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008 007		
Company:	Pretium Resources	PO / AFE:			
Contact:	K Mc Naughton	LSD:			
Address:	1600 - 570 Granville Street Vancouver V6C 3P1				
Phone:	604 558 1784 Fax: 604 558 4786	Quote #:			
Lab Work Order # (lab use only)		ALS Contact:	D Watt.	Sampler:	BSmith S Blackmore.

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total metals (P)	Dissolved Metals	Cyanides (P)	DOC	TOC/COD/TKN/NH3 (P)						Number of Containers
	BJ-4B	11-07-13		H_2O	✓	✓	✓	✓	✓	✓						6
	BJ-6A	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-3B	"		"	✓	✓	✓	✓	✓	✓						6
	Dupl.	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-FB	"		"	✓	✓	✓	✓	✓	✓						6

Short Holding Time

Rush Processing

L1331947-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

DOC and Dissolved metals not filtered or Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
[signature]	11/07/13	19:00	TN	July 13	14:00	13 °C				

WHITE PAPER CO. 604 951-3900

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 16-JUL-13
Report Date: 30-JUL-13 18:04 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1333226

Project P.O. #:	NOT SUBMITTED
Job Reference:	1008 007
C of C Numbers:	10-268555
Legal Site Desc:	

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1333226-1	L1333226-2	L1333226-3	L1333226-4	L1333226-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	13-JUL-13	13-JUL-13	13-JUL-13	14-JUL-13	14-JUL-13
	Sampled Time					
	Client ID	BJ-2A	BJ-3A	BJ-4A	BJ-8A	BJ-8B
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	189	329	490	200	200
	Hardness (as CaCO3) (mg/L)	88.3	150	195	91.1	94.3
	pH (pH)	7.13	7.97	7.94	8.14	8.12
	Total Suspended Solids (mg/L)	280	48.5	30.1	21.7	182
	Total Dissolved Solids (mg/L)	124	220	335	127	131
	Turbidity (NTU)	160	39.6	16.3	8.22	266
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	6.2	4.0	5.1	1.8	2.4
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	63.3	93.7	117	72.5	68.2
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	63.3	93.7	117	72.5	68.2
	Ammonia, Total (as N) (mg/L)	<0.0050	0.0291	0.114	<0.0050	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.15	<0.50	1.89	<0.50	<0.50
	Fluoride (F) (mg/L)	0.030	0.188	0.078	0.027	0.021
	Nitrate (as N) (mg/L)	0.0680	<0.0050	0.178	0.0191	0.0215
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	0.0135	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.162	0.073	0.238	<0.050	0.143
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	0.0011	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.307	0.0587	0.0488	0.0058	0.093
	Sulfate (SO4) (mg/L)	34.7	80.9	140	32.0	35.1
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0018
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	<0.50	<0.50	1.87	<0.50	<0.50
	Total Organic Carbon (mg/L)	1.06	0.69	2.33	<0.50	0.66
Total Metals	Aluminum (Al)-Total (mg/L)	12.8	1.64	0.332	0.910	12.2
	Antimony (Sb)-Total (mg/L)	0.00123	0.0180	0.00411	0.00088	0.00181
	Arsenic (As)-Total (mg/L)	0.0294	0.0156	0.0189	0.00868	0.0818
	Barium (Ba)-Total (mg/L)	0.358	0.0643	0.0547	0.0265	0.282
	Beryllium (Be)-Total (mg/L)	0.00035	<0.00010	<0.00010	<0.00010	0.00017
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.014	0.039	0.070	0.011	<0.010
	Cadmium (Cd)-Total (mg/L)	0.000066	0.000097	0.000054	0.000018	0.000033
	Calcium (Ca)-Total (mg/L)	34.9	53.1	56.5	28.9	32.3
	Chromium (Cr)-Total (mg/L)	0.0177	0.00859	0.00118	0.00068	0.00230

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1333226-1	L1333226-2	L1333226-3	L1333226-4	L1333226-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	13-JUL-13	13-JUL-13	13-JUL-13	14-JUL-13	14-JUL-13
	Sampled Time					
	Client ID	BJ-2A	BJ-3A	BJ-4A	BJ-8A	BJ-8B
Grouping	**Analyte**					
WATER						
Total Metals	Cobalt (Co)-Total (mg/L)	0.00334	0.00071	0.00123	0.00016	0.00298
	Copper (Cu)-Total (mg/L)	0.0121	0.00288	0.00179	0.00053	0.00771
	Iron (Fe)-Total (mg/L)	11.2	1.88	0.630	0.339	6.82
	Lead (Pb)-Total (mg/L)	0.00477	0.0110	0.00118	0.000614	0.00573
	Lithium (Li)-Total (mg/L)	0.0147	0.0158	0.0292	0.00901	0.00958
	Magnesium (Mg)-Total (mg/L)	3.90	4.13	11.8	5.51	4.81
	Manganese (Mn)-Total (mg/L)	0.533	0.216	0.141	0.0171	0.334
	Mercury (Hg)-Total (mg/L)	0.000120	<0.000010	0.000014	<0.000010	0.000056
	Molybdenum (Mo)-Total (mg/L)	0.00329	0.00310	0.00206	0.00143	0.00185
	Nickel (Ni)-Total (mg/L)	0.00896	0.00176	0.00085	<0.00050	0.00246
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	4.15	1.86	1.66	0.558	2.09
	Selenium (Se)-Total (mg/L)	0.00017	<0.00010	<0.00010	0.00016	0.00028
	Silicon (Si)-Total (mg/L)	30.7	7.36	3.59	5.22	23.4
	Silver (Ag)-Total (mg/L)	0.00110	0.000523	0.000074	0.000022	0.000231
	Sodium (Na)-Total (mg/L)	4.0	8.2	27.6	4.2	2.8
	Strontium (Sr)-Total (mg/L)	0.982	1.12	2.84	0.745	0.462
	Thallium (Tl)-Total (mg/L)	0.000169	0.000249	0.000027	0.000014	0.000120
	Tin (Sn)-Total (mg/L)	0.00023	<0.00010	0.00033	<0.00010	0.00034
	Titanium (Ti)-Total (mg/L)	0.369	0.052	0.016	0.023	0.189
	Uranium (U)-Total (mg/L)	0.000627	0.000203	0.00485	0.000323	0.000234
	Vanadium (V)-Total (mg/L)	0.0207	0.0033	<0.0010	<0.0010	0.0081
	Zinc (Zn)-Total (mg/L)	0.0354	0.0443	0.0084	0.0041	0.0339
Dissolved Metals	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0166	0.0088	0.0089	0.0138	0.0352
	Antimony (Sb)-Dissolved (mg/L)	0.00023	0.00940	0.00354	0.00086	0.00067
	Arsenic (As)-Dissolved (mg/L)	0.00107	0.00552	0.0150	0.00775	0.0167
	Barium (Ba)-Dissolved (mg/L)	0.0271	0.0223	0.0444	0.0203	0.0156
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	<0.010	0.037	0.070	<0.010	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	<0.000010	0.000034	<0.000010	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	32.9	53.4	58.2	27.8	32.2
	Chromium (Cr)-Dissolved (mg/L)	0.00010	<0.00010	0.00014	<0.00010	0.00013
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	0.00015	0.00023	<0.00010	<0.00010
	Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1333226-1	L1333226-2	L1333226-3	L1333226-4	L1333226-5
	Description	H2O	H2O	H2O	H2O	H2O
	Sampled Date	13-JUL-13	13-JUL-13	13-JUL-13	14-JUL-13	14-JUL-13
	Sampled Time					
	Client ID	BJ-2A	BJ-3A	BJ-4A	BJ-8A	BJ-8B
Grouping	**Analyte**					
WATER						
Dissolved Metals	Lead (Pb)-Dissolved (mg/L)	<0.000050	0.000107	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.00479	0.0156	0.0305	0.00901	0.00501
	Magnesium (Mg)-Dissolved (mg/L)	1.50	3.93	12.1	5.28	3.39
	Manganese (Mn)-Dissolved (mg/L)	0.00124	0.132	0.0709	0.00432	0.000513
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.00130	0.00114	0.00203	0.00142	0.00166
	Nickel (Ni)-Dissolved (mg/L)	0.00071	0.00072	0.00053	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.318	1.35	1.61	0.454	0.598
	Selenium (Se)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00017	0.00023
	Silicon (Si)-Dissolved (mg/L)	1.66	3.50	3.04	2.04	2.04
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	2.6	7.9	27.7	4.0	2.3
	Strontium (Sr)-Dissolved (mg/L)	0.912	1.10	2.88	0.701	0.440
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	0.000076	0.000018	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000153	0.000142	0.00471	0.000189	0.000160
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	<0.0030	0.0033	<0.0030	<0.0030
Aggregate Organics	COD (mg/L)	<20	<20	<20	<20	92

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1333226-1, -2, -3, -4, -5
Duplicate	Chloride (Cl)	DLM	L1333226-1, -2, -3, -4, -5
Duplicate	Nitrite (as N)	DLM	L1333226-1, -2, -3, -4, -5
Matrix Spike	Phosphorus (P)-Total	MS-B	L1333226-1, -2, -4, -5
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1333226-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1333226-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1333226-1, -2, -3, -4, -5
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L1333226-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1333226-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by

Reference Information

colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-268555

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-268555

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To		Report Format / Distribution		Service Request: (Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering.	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V. Cullen	Select: PDF ✓	Excel ✓ Digital ✓ Fax		Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	800 - 1045 Howe Street	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancouver V6Z 2A9	Email 2:	KJohnston@BGCengineering.ca.		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909				
Invoice To	Same as Report ? (circle) Yes or (No) (if No, provide details)	Client / Project Information		Analysis Request	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008 007	(Indicate Filtered or Preserved, F/P)	
Company:	Pretium Resources.	PO / AFE:			
Contact:	K Mc Naughton	LSD:			
Address:	1600 - 570 Granville Street, Vancouver, V6C 3P1				
Phone:	604 558 1784 Fax: 604 558 4786.	Quote #:			
Lab Work Order # (lab use only)	L1333226.	ALS Contact:	D. Watt.	Sampler:	BSmith BTait

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals	Diss Metals	DOC	TOC/COD/TKN/NH3	Cyanides						Number of Containers
						P			P	P						
	BJ - 2A	13-07-13		H_2O	✓	✓	✓	✓	✓	✓						6
	BJ - 3A	13-07-13		"	✓	✓	✓	✓	✓	✓						6
	BJ - 4A	13-07-13		"	✓	✓	✓	✓	✓	✓						6.
	BJ - 8A	14-07-13		"	✓	✓	✓	✓	✓	✓						6
	BJ - 8B	14-07-13		"	✓	✓	✓	✓	✓	✓						6

Short Holding Time

Rush Processing

L1333226-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

DOC and Dissolved Metals Not filtered / Not Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B. Smith	14/07/13	17:00.	IN	July/16	6:10	16 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 20-JUL-13
Report Date: 31-JUL-13 18:02 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1335562

Project P.O. #: NOT SUBMITTED
Job Reference: R008007
C of C Numbers: 10-297711
Legal Site Desc:

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1335562-1				
	Description	water				
	Sampled Date	15-JUL-13				
	Sampled Time					
	Client ID	BJ-12A				
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0				
	Conductivity (uS/cm)	485				
	Hardness (as CaCO3) (mg/L)	224				
	pH (pH)	8.06				
	Total Suspended Solids (mg/L)	183				
	Total Dissolved Solids (mg/L)	338				
	Turbidity (NTU)	2.40				
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	3.1				
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	98.8				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Total (as CaCO3) (mg/L)	98.8				
	Ammonia, Total (as N) (mg/L)	0.169				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	1.05				
	Fluoride (F) (mg/L)	0.160				
	Nitrate (as N) (mg/L)	<0.0050				
	Nitrite (as N) (mg/L)	<0.0010				
	Total Kjeldahl Nitrogen (mg/L)	0.671				
	Total Nitrogen (mg/L)	0.671				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	0.265				
	Sulfate (SO4) (mg/L)	159				
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010				
	Cyanide, Total (mg/L)	<0.0010				
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	1.05				
	Total Organic Carbon (mg/L)	12.3				
Total Metals	Aluminum (Al)-Total (mg/L)	1.48				
	Antimony (Sb)-Total (mg/L)	0.00501				
	Arsenic (As)-Total (mg/L)	0.192				
	Barium (Ba)-Total (mg/L)	0.300				
	Beryllium (Be)-Total (mg/L)	<0.00010				
	Bismuth (Bi)-Total (mg/L)	<0.00050				
	Boron (B)-Total (mg/L)	0.021				
	Cadmium (Cd)-Total (mg/L)	0.000290				
	Calcium (Ca)-Total (mg/L)	74.5				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1335562-1				
	Description	water				
	Sampled Date	15-JUL-13				
	Sampled Time					
	Client ID	BJ-12A				
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.158				
	Cobalt (Co)-Total (mg/L)	0.00220				
	Copper (Cu)-Total (mg/L)	0.0139				
	Iron (Fe)-Total (mg/L)	8.02				
	Lead (Pb)-Total (mg/L)	0.0470				
	Lithium (Li)-Total (mg/L)	0.0107				
	Magnesium (Mg)-Total (mg/L)	10.5				
	Manganese (Mn)-Total (mg/L)	0.366				
	Mercury (Hg)-Total (mg/L)	<0.000010				
	Molybdenum (Mo)-Total (mg/L)	0.00524				
	Nickel (Ni)-Total (mg/L)	0.0592				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	5.33				
	Selenium (Se)-Total (mg/L)	0.00070				
	Silicon (Si)-Total (mg/L)	6.08				
	Silver (Ag)-Total (mg/L)	0.00165				
	Sodium (Na)-Total (mg/L)	6.4				
	Strontium (Sr)-Total (mg/L)	1.41				
	Thallium (Tl)-Total (mg/L)	0.000146				
	Tin (Sn)-Total (mg/L)	0.00283				
	Titanium (Ti)-Total (mg/L)	0.041				
	Uranium (U)-Total (mg/L)	0.000545				
	Vanadium (V)-Total (mg/L)	0.0024				
	Zinc (Zn)-Total (mg/L)	0.0474				
Dissolved Metals	Dissolved Metals Filtration Location	LAB				
	Aluminum (Al)-Dissolved (mg/L)	0.0119				
	Antimony (Sb)-Dissolved (mg/L)	0.00055				
	Arsenic (As)-Dissolved (mg/L)	0.00433				
	Barium (Ba)-Dissolved (mg/L)	0.0706				
	Beryllium (Be)-Dissolved (mg/L)	<0.00010				
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050				
	Boron (B)-Dissolved (mg/L)	0.020				
	Cadmium (Cd)-Dissolved (mg/L)	0.000039				
	Calcium (Ca)-Dissolved (mg/L)	73.1				
	Chromium (Cr)-Dissolved (mg/L)	0.00186				
	Cobalt (Co)-Dissolved (mg/L)	0.00072				
	Copper (Cu)-Dissolved (mg/L)	<0.00050				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1335562-1				
	Description	water				
	Sampled Date	15-JUL-13				
	Sampled Time					
	Client ID	BJ-12A				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Iron (Fe)-Dissolved (mg/L)	<0.030				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0100				
	Magnesium (Mg)-Dissolved (mg/L)	10.1				
	Manganese (Mn)-Dissolved (mg/L)	0.314				
	Mercury (Hg)-Dissolved (mg/L)	<0.000010				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00297				
	Nickel (Ni)-Dissolved (mg/L)	0.00716				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	4.53				
	Selenium (Se)-Dissolved (mg/L)	0.00010				
	Silicon (Si)-Dissolved (mg/L)	3.63				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	6.2				
	Strontium (Sr)-Dissolved (mg/L)	1.37				
	Thallium (Tl)-Dissolved (mg/L)	0.000024				
	Tin (Sn)-Dissolved (mg/L)	0.00018				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	0.000257				
	Vanadium (V)-Dissolved (mg/L)	<0.0010				
	Zinc (Zn)-Dissolved (mg/L)	0.0057				
Aggregate Organics	COD (mg/L)	45				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1335562-1
Duplicate	Chloride (Cl)	DLM	L1335562-1
Duplicate	Nitrite (as N)	DLM	L1335562-1
Duplicate	Bromide (Br)	DLM	L1335562-1
Duplicate	Chloride (Cl)	DLM	L1335562-1
Duplicate	Nitrite (as N)	DLM	L1335562-1
Duplicate	Bromide (Br)	DLM	L1335562-1
Duplicate	Chloride (Cl)	DLM	L1335562-1
Duplicate	Nitrite (as N)	DLM	L1335562-1
Method Blank	Barium (Ba)-Dissolved	MB-LOR	L1335562-1
Method Blank	Copper (Cu)-Dissolved	MB-LOR	L1335562-1
Matrix Spike	Total Organic Carbon	MS-B	L1335562-1
Matrix Spike	Total Organic Carbon	MS-B	L1335562-1
Matrix Spike	Barium (Ba)-Dissolved	MS-B	L1335562-1
Matrix Spike	Boron (B)-Dissolved	MS-B	L1335562-1
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1335562-1
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1335562-1
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1335562-1
Matrix Spike	Aluminum (Al)-Total	MS-B	L1335562-1
Matrix Spike	Arsenic (As)-Total	MS-B	L1335562-1
Matrix Spike	Barium (Ba)-Total	MS-B	L1335562-1
Matrix Spike	Calcium (Ca)-Total	MS-B	L1335562-1
Matrix Spike	Chromium (Cr)-Total	MS-B	L1335562-1
Matrix Spike	Lead (Pb)-Total	MS-B	L1335562-1
Matrix Spike	Magnesium (Mg)-Total	MS-B	L1335562-1
Matrix Spike	Manganese (Mn)-Total	MS-B	L1335562-1
Matrix Spike	Nickel (Ni)-Total	MS-B	L1335562-1
Matrix Spike	Potassium (K)-Total	MS-B	L1335562-1
Matrix Spike	Strontium (Sr)-Total	MS-B	L1335562-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or

Reference Information

filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

Reference Information

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-297711

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 297711

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page 1 of 1

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering.	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	V Cullen.	Select: PDF ✓	Excel ✓ Digital ✓ Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	800- 1045 Howe Street	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
	Vancover, BC V6Z 2A9	Email 2:	KJohnston@BGCengineering.ca.		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909.				

Invoice To	Same as Report ? (circle) Yes or (No) (If No, provide details)	Client / Project Information	
	Copy of Invoice with Report?. (circle) Yes or No	Job #:	1008007
Company:	Pretium Resources.	PO / AFE:	
Contact:	K Mc Naughton.	LSD:	
Address:	1600 - 570 Granville Street, Vancover V6C 3P1		
Phone:	604 558 1784 Fax: 604 558 4786.	Quote #:	

Lab Work Order # (lab use only): L1335562-COFC

ALS Contact: D Watt. Sampler: BSmith BTait

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	(TI	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total metals (P)	Diss Metals	DOC.	Cyanides. (P)	TOC/COD/TKN/NH3 (P)						Number of Containers
	BJ-12A	15-07-13		H_2O	✓	✓	✓	✓	✓	✓						6

Short Holding Time
Rush Processing

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Diss metals and DOC Not Filtered Not Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
BSmith	15/07/13	17h00	TW	July 20/13	3:10	21°C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY GENF 18.01 Front

WHITE PAPER CO. 604 951-3900

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 27-SEP-13
Report Date: 03-OCT-13 13:48 (MT)
Version: FINAL REV. 2

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1370058

Project P.O. #:	NOT SUBMITTED
Job Reference:	1008010
C of C Numbers:	10-334654
Legal Site Desc:	

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370058-1	L1370058-2	L1370058-3	L1370058-4	L1370058-5
	Description	water	water	water	water	water
	Sampled Date	25-SEP-13	25-SEP-13	25-SEP-13	25-SEP-13	25-SEP-13
	Sampled Time					
	Client ID	BJ-3A	BJ-3B	BJ-4A	BJ-4B	TRAVEL BLANK
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	345	386	452	511	<2.0
	Hardness (as CaCO3) (mg/L)	155	182	185	7.15	
	pH (pH)	8.06	8.07	8.12	9.71	6.17
	Total Suspended Solids (mg/L)	1550	189	19.5	4.7	<3.0
	Total Dissolved Solids (mg/L)	235	276	311	336	<10
	Turbidity (NTU)	2130	156	11.8	13.1	<0.10
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.5	1.4	1.3	<1.0	<1.0
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	99.5	92.9	112	106	<2.0
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	47.4	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<1.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	99.5	92.9	112	154	<2.0
	Ammonia, Total (as N) (mg/L)	0.0344	0.0239	0.144	0.162	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	<0.50	2.36	0.91	<0.50	<0.50
	Fluoride (F) (mg/L)	0.196	0.113	0.075	0.130	<0.020
	Nitrate (as N) (mg/L)	0.0068	0.205	0.142	0.0107	<0.0050
	Nitrite (as N) (mg/L)	0.0019	0.0438	0.0379	0.0064	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.668	0.259	0.225	0.225	<0.050
	Total Nitrogen (mg/L)	0.676	0.508	0.405	0.242	<0.050
	Orthophosphate-Dissolved (as P) (mg/L)	0.0017	0.0013	0.0014	0.0048	<0.0010
	Phosphorus (P)-Total (mg/L)	1.64	0.179	0.0194	0.0099	<0.0020
	Sulfate (SO4) (mg/L)	89.3	112	131	113	<0.50
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.55	0.74	1.21	0.93	
	Total Organic Carbon (mg/L)	4.60	1.01	1.83	1.28	<0.50
Total Metals	Aluminum (Al)-Total (mg/L)	22.4	2.79	0.297	0.578	<0.0030
	Antimony (Sb)-Total (mg/L)	0.0467	0.00478	0.00314	0.00059	<0.00010
	Arsenic (As)-Total (mg/L)	0.128	0.0338	0.0155	0.0115	<0.00010
	Barium (Ba)-Total (mg/L)	0.795	0.197	0.0467	0.0289	<0.000050
	Beryllium (Be)-Total (mg/L)	0.00117	0.00023	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	0.00053	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.055	0.029	0.066	0.065	<0.010
	Cadmium (Cd)-Total (mg/L)	0.00195	0.000164	0.000019	<0.000010	<0.000010
	Calcium (Ca)-Total (mg/L)	67.7	69.6	50.3	2.58	<0.020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370058-6				
	Description	water				
	Sampled Date	25-SEP-13				
	Sampled Time					
	Client ID	BJ-6A				
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0				
	Conductivity (uS/cm)	293				
	Hardness (as CaCO3) (mg/L)	137				
	pH (pH)	8.14				
	Total Suspended Solids (mg/L)	2770				
	Total Dissolved Solids (mg/L)	221				
	Turbidity (NTU)	4190				
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	67.8				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Total (as CaCO3) (mg/L)	67.8				
	Ammonia, Total (as N) (mg/L)	0.0806				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	<0.50				
	Fluoride (F) (mg/L)	0.149				
	Nitrate (as N) (mg/L)	<0.0050				
	Nitrite (as N) (mg/L)	<0.0010				
	Total Kjeldahl Nitrogen (mg/L)	1.50				
	Total Nitrogen (mg/L)	1.50				
	Orthophosphate-Dissolved (as P) (mg/L)	0.0030				
	Phosphorus (P)-Total (mg/L)	2.58				
	Sulfate (SO4) (mg/L)	85.0				
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010				
	Cyanide, Total (mg/L)	<0.0010				
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.80				
	Total Organic Carbon (mg/L)	2.34				
Total Metals	Aluminum (Al)-Total (mg/L)	28.2				
	Antimony (Sb)-Total (mg/L)	0.0119				
	Arsenic (As)-Total (mg/L)	0.210				
	Barium (Ba)-Total (mg/L)	13.8				
	Beryllium (Be)-Total (mg/L)	0.00307				
	Bismuth (Bi)-Total (mg/L)	<0.0010 DLA				
	Boron (B)-Total (mg/L)	0.031				
	Cadmium (Cd)-Total (mg/L)	0.000546				
	Calcium (Ca)-Total (mg/L)	67.0				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370058-1	L1370058-2	L1370058-3	L1370058-4	L1370058-5
	Description	water	water	water	water	water
	Sampled Date	25-SEP-13	25-SEP-13	25-SEP-13	25-SEP-13	25-SEP-13
	Sampled Time					
	Client ID	BJ-3A	BJ-3B	BJ-4A	BJ-4B	TRAVEL BLANK
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.0199	0.00130	0.00100	0.00218	<0.00010
	Cobalt (Co)-Total (mg/L)	0.0149	0.00120	0.00078	0.00016	<0.00010
	Copper (Cu)-Total (mg/L)	0.0625	0.00523	0.00149	0.00054	<0.00050
	Iron (Fe)-Total (mg/L)	43.1	3.74	0.486	0.124	<0.030
	Lead (Pb)-Total (mg/L)	0.120	0.00518	0.000710	0.000188	<0.000050
	Lithium (Li)-Total (mg/L)	0.0466	0.0132	0.0325	0.219	<0.00050
	Magnesium (Mg)-Total (mg/L)	11.2	4.90	11.4	0.342	<0.0050
	Manganese (Mn)-Total (mg/L)	1.29	0.422	0.0990	0.0109	<0.000050
	Mercury (Hg)-Total (mg/L)	0.000119	0.000020	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.00499	0.000749	0.00104	0.000993	<0.000050
	Nickel (Ni)-Total (mg/L)	0.0118	0.00109	0.00057	0.00096	<0.00050
	Phosphorus (P)-Total (mg/L)	1.25	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	8.49	1.82	1.62	0.934	<0.050
	Selenium (Se)-Total (mg/L)	0.00391	0.00046	<0.00010	<0.00010	<0.00010
	Silicon (Si)-Total (mg/L)	65.3	13.8	3.45	5.66	<0.050
	Silver (Ag)-Total (mg/L)	0.0149	0.000405	0.000032	0.000092	<0.000010
	Sodium (Na)-Total (mg/L)	10.4	5.7	21.8	113	<2.0
	Strontium (Sr)-Total (mg/L)	1.22	1.84	2.58	0.103	<0.00020
	Thallium (Tl)-Total (mg/L)	0.00196	0.000126	0.000021	0.000019	<0.000010
	Tin (Sn)-Total (mg/L)	0.00044	0.00018	0.00036	0.00011	<0.00010
	Titanium (Ti)-Total (mg/L)	0.566	0.100	0.011	<0.010	<0.010
	Uranium (U)-Total (mg/L)	0.000860	0.000724	0.00217	0.000128	<0.000010
	Vanadium (V)-Total (mg/L)	0.0341	0.0048	<0.0010	0.0010	<0.0010
	Zinc (Zn)-Total (mg/L)	0.319	0.0167	0.0070	<0.0030	<0.0030
Dissolved Metals	Dissolved Mercury Filtration Location	LAB	LAB	LAB	LAB	
	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	
	Aluminum (Al)-Dissolved (mg/L)	0.0154	0.0134	0.0126	0.0637	
	Antimony (Sb)-Dissolved (mg/L)	0.0319	0.00190	0.00270	0.00054	
	Arsenic (As)-Dissolved (mg/L)	0.00404	0.00963	0.0132	0.0117	
	Barium (Ba)-Dissolved (mg/L)	0.0320	0.0431	0.0330	0.0211	
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Boron (B)-Dissolved (mg/L)	0.048	0.028	0.070	0.062	
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	0.000046	0.000011	<0.000010	
	Calcium (Ca)-Dissolved (mg/L)	54.8	66.4	54.3	2.44	
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	0.00065	
	Cobalt (Co)-Dissolved (mg/L)	0.00059	<0.00010	0.00011	<0.00010	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370058-6				
	Description	water				
	Sampled Date	25-SEP-13				
	Sampled Time					
	Client ID	BJ-6A				
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.0144				
	Cobalt (Co)-Total (mg/L)	0.0117				
	Copper (Cu)-Total (mg/L)	0.0828				
	Iron (Fe)-Total (mg/L)	40.1				
	Lead (Pb)-Total (mg/L)	0.132				
	Lithium (Li)-Total (mg/L)	0.0348				
	Magnesium (Mg)-Total (mg/L)	14.0				
	Manganese (Mn)-Total (mg/L)	1.08				
	Mercury (Hg)-Total (mg/L)	0.000338				
	Molybdenum (Mo)-Total (mg/L)	0.00366				
	Nickel (Ni)-Total (mg/L)	0.0140				
	Phosphorus (P)-Total (mg/L)	1.05				
	Potassium (K)-Total (mg/L)	8.92				
	Selenium (Se)-Total (mg/L)	0.00162				
	Silicon (Si)-Total (mg/L)	86.6				
	Silver (Ag)-Total (mg/L)	0.00935				
	Sodium (Na)-Total (mg/L)	6.0				
	Strontium (Sr)-Total (mg/L)	2.76				
	Thallium (Tl)-Total (mg/L)	0.000683				
	Tin (Sn)-Total (mg/L)	0.00056				
	Titanium (Ti)-Total (mg/L)	0.871				
	Uranium (U)-Total (mg/L)	0.00108				
	Vanadium (V)-Total (mg/L)	0.0470				
	Zinc (Zn)-Total (mg/L)	0.502				
Dissolved Metals	Dissolved Mercury Filtration Location	LAB				
	Dissolved Metals Filtration Location	LAB				
	Aluminum (Al)-Dissolved (mg/L)	0.827				
	Antimony (Sb)-Dissolved (mg/L)	0.00483				
	Arsenic (As)-Dissolved (mg/L)	0.0222				
	Barium (Ba)-Dissolved (mg/L)	0.136				
	Beryllium (Be)-Dissolved (mg/L)	<0.00020 DLA				
	Bismuth (Bi)-Dissolved (mg/L)	<0.0010 DLA				
	Boron (B)-Dissolved (mg/L)	<0.020 DLA				
	Cadmium (Cd)-Dissolved (mg/L)	<0.000020 DLA				
	Calcium (Ca)-Dissolved (mg/L)	47.7				
	Chromium (Cr)-Dissolved (mg/L)	<0.00020 DLA				
	Cobalt (Co)-Dissolved (mg/L)	<0.00020 DLA				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370058-1	L1370058-2	L1370058-3	L1370058-4	L1370058-5
	Description	water	water	water	water	water
	Sampled Date	25-SEP-13	25-SEP-13	25-SEP-13	25-SEP-13	25-SEP-13
	Sampled Time					
	Client ID	BJ-3A	BJ-3B	BJ-4A	BJ-4B	TRAVEL BLANK
Grouping	**Analyte**					
WATER						
Dissolved Metals	Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	
	Iron (Fe)-Dissolved (mg/L)	<0.030	0.076	<0.030	<0.030	
	Lead (Pb)-Dissolved (mg/L)	0.000108	<0.000050	<0.000050	<0.000050	
	Lithium (Li)-Dissolved (mg/L)	0.0203	0.00946	0.0346	0.219	
	Magnesium (Mg)-Dissolved (mg/L)	4.41	4.01	12.0	0.256	
	Manganese (Mn)-Dissolved (mg/L)	0.149	0.133	0.0534	0.00676	
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Molybdenum (Mo)-Dissolved (mg/L)	0.00117	0.000607	0.000996	0.000902	
	Nickel (Ni)-Dissolved (mg/L)	0.00096	<0.00050	0.00064	<0.00050	
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	
	Potassium (K)-Dissolved (mg/L)	1.46	1.08	1.62	0.795	
	Selenium (Se)-Dissolved (mg/L)	0.00028	0.00017	<0.00010	<0.00010	
	Silicon (Si)-Dissolved (mg/L)	3.47	2.91	2.94	3.50	
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	
	Sodium (Na)-Dissolved (mg/L)	9.1	5.2	22.6	107	
	Strontium (Sr)-Dissolved (mg/L)	1.12	1.84	2.73	0.0958	
	Thallium (Tl)-Dissolved (mg/L)	0.000254	0.000032	0.000017	<0.000010	
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	
	Uranium (U)-Dissolved (mg/L)	0.000179	0.000637	0.00220	0.000099	
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	
	Zinc (Zn)-Dissolved (mg/L)	0.0032	<0.0030	0.0037	<0.0030	
Aggregate Organics	COD (mg/L)	84	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370058-6				
	Description	water				
	Sampled Date	25-SEP-13				
	Sampled Time					
	Client ID	BJ-6A				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Copper (Cu)-Dissolved (mg/L)	0.00089				
	Iron (Fe)-Dissolved (mg/L)	0.320				
	Lead (Pb)-Dissolved (mg/L)	0.00103				
	Lithium (Li)-Dissolved (mg/L)	0.0056				
	Magnesium (Mg)-Dissolved (mg/L)	4.45				
	Manganese (Mn)-Dissolved (mg/L)	0.0364				
	Mercury (Hg)-Dissolved (mg/L)	<0.000010				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00234				
	Nickel (Ni)-Dissolved (mg/L)	<0.0010 DLA				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	2.67				
	Selenium (Se)-Dissolved (mg/L)	0.00031				
	Silicon (Si)-Dissolved (mg/L)	5.49				
	Silver (Ag)-Dissolved (mg/L)	0.000048				
	Sodium (Na)-Dissolved (mg/L)	3.6				
	Strontium (Sr)-Dissolved (mg/L)	2.18				
	Thallium (Tl)-Dissolved (mg/L)	0.000085				
	Tin (Sn)-Dissolved (mg/L)	<0.00020 DLA				
	Titanium (Ti)-Dissolved (mg/L)	0.023				
	Uranium (U)-Dissolved (mg/L)	0.000390				
	Vanadium (V)-Dissolved (mg/L)	<0.0020 DLA				
	Zinc (Zn)-Dissolved (mg/L)	0.0051				
Aggregate Organics	COD (mg/L)	27				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Nitrite (as N)	DLM	L1370058-1, -2, -3, -4, -5, -6
Duplicate	Nitrate (as N)	DLM	L1370058-1, -2, -3, -4, -5, -6
Method Blank	Chromium (Cr)-Total	MB-LOR	L1370058-1, -2, -3, -4, -6
Matrix Spike	Total Organic Carbon	MS-B	L1370058-1, -2, -3, -4, -5, -6
Matrix Spike	Phosphorus (P)-Total	MS-B	L1370058-1, -2, -3, -4, -5, -6
Matrix Spike	Total Kjeldahl Nitrogen	MSTN	L1370058-1, -2, -3, -4, -5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit Adjusted For required dilution
DLM	Detection Limit Adjusted For Sample Matrix Effects
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
MSTN	TKN Matrix Spike recovery was low due to interference from high nitrate, which causes negative bias on TKN.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are

Reference Information

determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA Water Total organic carbon by combustion APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA Water Low Level Total Cyanide in water by CFA ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA Water Low level WAD Cyanide in water by CFA APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA Water Chemical Oxygen Demand by Colorimetric APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA Water Colour (True) by Spectrometer BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA Water Conductivity (Automated) APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA Water Hardness APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA Water Dissolved Mercury in Water by CVAFS(Low) EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA Water Total Mercury in Water by CVAFS(Low) EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA Water Dissolved Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA Water Total Metals in Water by CRC ICPMS APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or

Reference Information

microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-334654

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 334654

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)	
Company:	BGC Engineering Inc.	Standard: ✓	Other (specify):		Regular (Standard Turnaround Times - Business Days)
Contact:	V. Cullen	Select: PDF ✓	Excel ✓ Digital ✓ Fax	✓	Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	Suite 800 - 1045 Howe Street. Vancouver, V6Z 2A9	Email 1:	VCullen@BGCengineering.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	KJones@BGCengineering.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 684 5900 Fax: 604 684 5909.			**Analysis Request**	
Invoice To	Same as Report ? (circle) Yes or No (if No, provide details)	**Client / Project Information**		(Indicate Filtered or Preserved, F/P)	
	Copy of Invoice with Report? (circle) Yes or No	Job #:	1008 010		
Company:	Petrum Resources Ltd.	PO / AFE:			
Contact:	K. Mc Naughton.	LSD:			
Address:	1600 - 570 Granville Street, Vancouver, V6C 3P1				
Phone:	604 558 1784 Fax: 604 558 4786.	Quote #:			
Lab Work Order # (lab use only)		**ALS Contact:**	D Watt.	**Sampler:**	BSmith / SBlackmo.

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals	Diss Metals	TOC / Nutrients	DOC	Cyanides						Number of Containers
	BJ-3A	25-09-13		H_2O	✓	✓	✓	✓	✓	✓						6
	BJ-3B	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-4A	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-4B	"		"	✓	✓	✓	✓	✓	✓						6
	Travel Blank.	"		"	✓	✓	✓	✓		✓						5
	BJ-6A	"		"	✓	✓	✓	✓	✓	✓						6.

RUSH

Priority processing

L1370058-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Diss Metals and DOC Not filtered or preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
B Watt.	25/09/13	19:45	TINA	27 SEPT	13:25	12.6°C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 28-SEP-13
Report Date: 03-OCT-13 17:57 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1370207

Project P.O. #:	NOT SUBMITTED
Job Reference:	1008010
C of C Numbers:	10-334653
Legal Site Desc:	

Dean Watt
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370207-1	L1370207-2	L1370207-3	L1370207-4	L1370207-5
	Description	water	water	water	water	water
	Sampled Date	26-SEP-13	26-SEP-13	26-SEP-13	26-SEP-13	26-SEP-13
	Sampled Time					
	Client ID	BJ-2A	BJ-8A	BJ-8B	BJ-DUP1	BJ-FB
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0	<5.0	<5.0	<5.0	<5.0
	Conductivity (uS/cm)	209	196	194	196	<2.0
	Hardness (as CaCO3) (mg/L)	98.9	90.8	91.4	91.5	<0.50
	pH (pH)	7.73	7.02	8.02	8.09	6.14
	Total Suspended Solids (mg/L)	507	7.9	17.2	8.4	<3.0
	Total Dissolved Solids (mg/L)	144	117	121	117	<10
	Turbidity (NTU)	527	3.29	53.1	3.11	<0.10
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	1.5	11.0	<1.0	<1.0	<1.0
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	64.5	74.1	69.9	74.8	<2.0
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Alkalinity, Total (as CaCO3) (mg/L)	64.5	74.1	69.9	74.8	<2.0
	Ammonia, Total (as N) (mg/L)	<0.0050	<0.0050	<0.0050	0.0061	<0.0050
	Bromide (Br) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050
	Chloride (Cl) (mg/L)	1.10	<0.50	<0.50	<0.50	<0.50
	Fluoride (F) (mg/L)	0.031	0.027	0.023	0.028	<0.020
	Nitrate (as N) (mg/L)	0.0927	0.0182	0.0196	0.0180	<0.0050
	Nitrite (as N) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Total Kjeldahl Nitrogen (mg/L)	0.273	<0.050	<0.050	<0.050	<0.050
	Total Nitrogen (mg/L)	0.366	<0.050	<0.050	<0.050	<0.050
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	0.544	0.0021	0.0096	<0.0020	<0.0020
	Sulfate (SO4) (mg/L)	41.6	30.1	32.0	30.2	<0.50
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Cyanide, Total (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.63	<0.50	<0.50	<0.50	<0.50
	Total Organic Carbon (mg/L)	1.19	<0.50	0.54	0.56	<0.50
Total Metals	Aluminum (Al)-Total (mg/L)	14.2	0.298	2.83	0.369	<0.0030
	Antimony (Sb)-Total (mg/L)	0.00127	0.00082	0.00097	0.00088	<0.00010
	Arsenic (As)-Total (mg/L)	0.0474	0.00887	0.0301	0.00873	<0.00010
	Barium (Ba)-Total (mg/L)	0.417	0.0212	0.0789	0.0223	<0.000050
	Beryllium (Be)-Total (mg/L)	0.00046	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Total (mg/L)	0.013	0.011	<0.010	0.011	<0.010
	Cadmium (Cd)-Total (mg/L)	0.000089	0.000012	<0.000010	0.000012	<0.000010
	Calcium (Ca)-Total (mg/L)	38.1	26.3	30.3	27.8	<0.020

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370207-1	L1370207-2	L1370207-3	L1370207-4	L1370207-5
	Description	water	water	water	water	water
	Sampled Date	26-SEP-13	26-SEP-13	26-SEP-13	26-SEP-13	26-SEP-13
	Sampled Time					
	Client ID	BJ-2A	BJ-8A	BJ-8B	BJ-DUP1	BJ-FB
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.00803	0.00019	0.00080	0.00024	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00543	<0.00010	0.00056	<0.00010	<0.00010
	Copper (Cu)-Total (mg/L)	0.0204	<0.00050	0.00179	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	19.4	0.092	1.41	0.153	<0.030
	Lead (Pb)-Total (mg/L)	0.00792	0.000127	0.00104	0.000263	<0.000050
	Lithium (Li)-Total (mg/L)	0.0207	0.00903	0.00663	0.00937	<0.00050
	Magnesium (Mg)-Total (mg/L)	5.54	5.86	4.08	5.74	<0.0050
	Manganese (Mn)-Total (mg/L)	0.826	0.00490	0.0608	0.00746	<0.000050
	Mercury (Hg)-Total (mg/L)	0.000172	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Total (mg/L)	0.00238	0.00131	0.00161	0.00143	<0.000050
	Nickel (Ni)-Total (mg/L)	0.00351	<0.00050	0.00051	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	0.49	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	2.11	0.494	1.28	0.493	<0.050
	Selenium (Se)-Total (mg/L)	0.00026	0.00017	0.00022	0.00015	<0.00010
	Silicon (Si)-Total (mg/L)	33.1	3.24	6.86	3.67	<0.050
	Silver (Ag)-Total (mg/L)	0.00162	<0.000010	0.000036	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	3.9	4.2	2.5	4.0	<2.0
	Strontium (Sr)-Total (mg/L)	0.872	0.632	0.432	0.695	<0.00020
	Thallium (Tl)-Total (mg/L)	0.000103	<0.000010	0.000045	<0.000010	<0.000010
	Tin (Sn)-Total (mg/L)	0.00018	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Total (mg/L)	0.471	0.010	0.047	0.012	<0.010
	Uranium (U)-Total (mg/L)	0.000566	0.000202	0.000180	0.000240	<0.000010
	Vanadium (V)-Total (mg/L)	0.0162	<0.0010	0.0033	<0.0010	<0.0010
	Zinc (Zn)-Total (mg/L)	0.0550	<0.0030	0.0082	0.0033	<0.0030
Dissolved Metals	Dissolved Mercury Filtration Location	LAB	LAB	LAB	LAB	LAB
	Dissolved Metals Filtration Location	LAB	LAB	LAB	LAB	LAB
	Aluminum (Al)-Dissolved (mg/L)	0.0124	0.0130	0.0312	0.0153	<0.0030
	Antimony (Sb)-Dissolved (mg/L)	0.00020	0.00086	0.00067	0.00084	<0.00010
	Arsenic (As)-Dissolved (mg/L)	0.00136	0.00825	0.0166	0.00804	<0.00010
	Barium (Ba)-Dissolved (mg/L)	0.0291	0.0191	0.0152	0.0191	<0.000050
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Boron (B)-Dissolved (mg/L)	<0.010	0.011	<0.010	<0.010	<0.010
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	0.000013	<0.000010
	Calcium (Ca)-Dissolved (mg/L)	36.8	27.2	30.4	27.5	<0.020
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1370207-1	L1370207-2	L1370207-3	L1370207-4	L1370207-5
	Description	water	water	water	water	water
	Sampled Date	26-SEP-13	26-SEP-13	26-SEP-13	26-SEP-13	26-SEP-13
	Sampled Time					
	Client ID	BJ-2A	BJ-8A	BJ-8B	BJ-DUP1	BJ-FB
Grouping	**Analyte**					
WATER						
Dissolved Metals	Copper (Cu)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.00470	0.00892	0.00525	0.00903	<0.00050
	Magnesium (Mg)-Dissolved (mg/L)	1.72	5.53	3.75	5.55	<0.0050
	Manganese (Mn)-Dissolved (mg/L)	0.000431	0.00251	0.000660	0.00239	<0.000050
	Mercury (Hg)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Dissolved (mg/L)	0.000855	0.00139	0.00161	0.00141	<0.000050
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	0.239	0.441	0.544	0.442	<0.050
	Selenium (Se)-Dissolved (mg/L)	0.00016	0.00017	0.00021	0.00015	<0.00010
	Silicon (Si)-Dissolved (mg/L)	1.63	1.99	1.92	2.04	<0.050
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	2.5	3.9	2.4	4.0	<2.0
	Strontium (Sr)-Dissolved (mg/L)	0.852	0.679	0.446	0.685	<0.00020
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000178	0.000181	0.000156	0.000186	<0.000010
	Vanadium (V)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Dissolved (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Aggregate Organics	COD (mg/L)	27	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Total Organic Carbon	MS-B	L1370207-1, -2, -3, -4, -5
Matrix Spike	Dissolved Organic Carbon	MS-B	L1370207-3, -4, -5
Matrix Spike	Phosphorus (P)-Total	MS-B	L1370207-1, -2, -3, -4, -5
Matrix Spike	Calcium (Ca)-Dissolved	MS-B	L1370207-1, -2, -3, -4, -5
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L1370207-1, -2, -3, -4, -5
Matrix Spike	Strontium (Sr)-Dissolved	MS-B	L1370207-1, -2, -3, -4, -5
Matrix Spike	Sodium (Na)-Total	MS-B	L1370207-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA	Water	TKN in Water by Fluorescence	APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA	Water	Total Nitrogen (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-334653

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10-334653

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To
Company: BGC Engineering Inc.
Contact: V. Cullen.
Address: 800 - 1045 Howe Street, Vancouver BC. V6Z 2A9.
Phone: 604 684 5900 Fax: 604 684 5909.

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF ✓ Excel ✓ Digital ✓ Fax
Email 1: VCullen@BGCengineering.ca
Email 2: KJones@BGCengineering.ca.

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
- [ ] Regular (Standard Turnaround Times - Business Days)
- [x] Priority (2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- [ ] Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- [ ] Same Day or Weekend Emergency - Contact ALS to confirm TAT

Invoice To Same as Report ? (circle) Yes or (No) (if No, provide details)
Copy of Invoice with Report? (circle) Yes or No
Company: Pretium Resources Ltd.
Contact: K Mc Naughton
Address: 1600 - 570 Granville Street Vancouver V6C 3P1
Phone: 604 558 9784 Fax: 604 558 4786.

Client / Project Information
Job #: 1008010.
PO / AFE:
LSD:
Quote #:

Lab Work Order # (lab use only)

ALS Contact: D. Wall. Sampler: B Smith / S Blackmore.

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Cyanides	Total Metals	Diss Metals	TOC/Nutrients	DOC						Number of Containers
						F	F		F							
	BJ-2A	26/09/13		H_2O	✓	✓	✓	✓	✓	✓						6
	BJ-8A	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-8B	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-Dupl	"		"	✓	✓	✓	✓	✓	✓						6
	BJ-FB	"		"	✓	✓	✓	✓	✓	✓						6

RUSH
Priority processing

L1370207-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Diss Metals and DOC NOT Filtered or Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
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[signature]	26/09/13	19:15.	TINA	26 Sept	14:30	8.8 °C				

BGC ENGINEERING INC.
ATTN: Virginia Cullen
500 - 1045 Howe Street
Vancouver BC V6Z 2A9

Date Received: 02-OCT-13
Report Date: 07-OCT-13 15:57 (MT)
Version: FINAL

Client Phone: 604-684-5900

Certificate of Analysis

Lab Work Order #: L1372080

Project P.O. #: NOT SUBMITTED
Job Reference: 1008010
C of C Numbers: 10-334376
Legal Site Desc:

Dean Watt
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1372080-1				
	Description	water				
	Sampled Date	30-SEP-13				
	Sampled Time					
	Client ID	BJ-12A				
Grouping	**Analyte**					
WATER						
Physical Tests	Colour, True (CU)	<5.0				
	Conductivity (uS/cm)	557				
	Hardness (as CaCO3) (mg/L)	267				
	pH (pH)	7.69				
	Total Suspended Solids (mg/L)	488				
	Total Dissolved Solids (mg/L)	400				
	Turbidity (NTU)	164				
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	8.0				
	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	109				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<2.0				
	Alkalinity, Total (as CaCO3) (mg/L)	109				
	Ammonia, Total (as N) (mg/L)	0.152				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	0.71				
	Fluoride (F) (mg/L)	0.149				
	Nitrate (as N) (mg/L)	0.0088				
	Nitrite (as N) (mg/L)	<0.0010				
	Total Kjeldahl Nitrogen (mg/L)	0.592				
	Total Nitrogen (mg/L)	0.601				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	0.212				
	Sulfate (SO4) (mg/L)	195				
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0010				
	Cyanide, Total (mg/L)	<0.0010				
Organic / Inorganic Carbon	Dissolved Organic Carbon (mg/L)	0.63				
	Total Organic Carbon (mg/L)	8.30				
Total Metals	Aluminum (Al)-Total (mg/L)	4.39				
	Antimony (Sb)-Total (mg/L)	0.00318				
	Arsenic (As)-Total (mg/L)	0.0825				
	Barium (Ba)-Total (mg/L)	0.234				
	Beryllium (Be)-Total (mg/L)	0.00050				
	Bismuth (Bi)-Total (mg/L)	<0.00050				
	Boron (B)-Total (mg/L)	0.026				
	Cadmium (Cd)-Total (mg/L)	0.000521				
	Calcium (Ca)-Total (mg/L)	95.3				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1372080-1				
	Description	water				
	Sampled Date	30-SEP-13				
	Sampled Time					
	Client ID	BJ-12A				
Grouping	**Analyte**					
WATER						
Total Metals	Chromium (Cr)-Total (mg/L)	0.0285				
	Cobalt (Co)-Total (mg/L)	0.00255				
	Copper (Cu)-Total (mg/L)	0.0155				
	Iron (Fe)-Total (mg/L)	5.36				
	Lead (Pb)-Total (mg/L)	0.0213				
	Lithium (Li)-Total (mg/L)	0.0156				
	Magnesium (Mg)-Total (mg/L)	14.0				
	Manganese (Mn)-Total (mg/L)	0.434				
	Mercury (Hg)-Total (mg/L)	0.000012				
	Molybdenum (Mo)-Total (mg/L)	0.00279				
	Nickel (Ni)-Total (mg/L)	0.0130				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	5.28				
	Selenium (Se)-Total (mg/L)	0.00031				
	Silicon (Si)-Total (mg/L)	13.8				
	Silver (Ag)-Total (mg/L)	0.000871				
	Sodium (Na)-Total (mg/L)	9.2				
	Strontium (Sr)-Total (mg/L)	1.87				
	Thallium (Tl)-Total (mg/L)	0.000236				
	Tin (Sn)-Total (mg/L)	0.00140				
	Titanium (Ti)-Total (mg/L)	0.054				
	Uranium (U)-Total (mg/L)	0.00164				
	Vanadium (V)-Total (mg/L)	0.0029				
	Zinc (Zn)-Total (mg/L)	0.0608				
Dissolved Metals	Dissolved Mercury Filtration Location	LAB				
	Dissolved Metals Filtration Location	LAB				
	Aluminum (Al)-Dissolved (mg/L)	0.0050				
	Antimony (Sb)-Dissolved (mg/L)	0.00130				
	Arsenic (As)-Dissolved (mg/L)	0.0252				
	Barium (Ba)-Dissolved (mg/L)	0.0398				
	Beryllium (Be)-Dissolved (mg/L)	<0.00010				
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050				
	Boron (B)-Dissolved (mg/L)	0.022				
	Cadmium (Cd)-Dissolved (mg/L)	<0.000010				
	Calcium (Ca)-Dissolved (mg/L)	85.4				
	Chromium (Cr)-Dissolved (mg/L)	0.00012				
	Cobalt (Co)-Dissolved (mg/L)	0.00033				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1372080-1				
	Description	water				
	Sampled Date	30-SEP-13				
	Sampled Time					
	Client ID	BJ-12A				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Copper (Cu)-Dissolved (mg/L)	<0.00050				
	Iron (Fe)-Dissolved (mg/L)	<0.030				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	0.0131				
	Magnesium (Mg)-Dissolved (mg/L)	13.0				
	Manganese (Mn)-Dissolved (mg/L)	0.344				
	Mercury (Hg)-Dissolved (mg/L)	<0.000010				
	Molybdenum (Mo)-Dissolved (mg/L)	0.00212				
	Nickel (Ni)-Dissolved (mg/L)	0.00213				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	4.47				
	Selenium (Se)-Dissolved (mg/L)	<0.00010				
	Silicon (Si)-Dissolved (mg/L)	3.69				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	9.2				
	Strontium (Sr)-Dissolved (mg/L)	1.78				
	Thallium (Tl)-Dissolved (mg/L)	0.000018				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	0.010				
	Uranium (U)-Dissolved (mg/L)	0.000364				
	Vanadium (V)-Dissolved (mg/L)	<0.0010				
	Zinc (Zn)-Dissolved (mg/L)	0.0030				
Aggregate Organics	COD (mg/L)	60				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Bromide (Br)	DLM	L1372080-1
Duplicate	Fluoride (F)	DLM	L1372080-1
Duplicate	Nitrite (as N)	DLM	L1372080-1
Matrix Spike	Phosphorus (P)-Total	MS-B	L1372080-1
Matrix Spike	Phosphorus (P)-Total	MS-B	L1372080-1
Matrix Spike	Phosphorus (P)-Total	MS-B	L1372080-1
Matrix Spike	Dissolved Organic Carbon	MS-B	L1372080-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjusted For Sample Matrix Effects
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-SCR-VA	Water	Alkalinity by colour or titration	EPA 310.2 OR APHA 2320

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.
OR
This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrite is detected by UV absorbance.

ANIONS-NO3-IC-VA	Water	Nitrate in Water by Ion Chromatography	EPA 300.0

This analysis is carried out using procedures adapted from EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Nitrate is detected by UV absorbance.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-DOC-VA	Water	Dissolved organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)". Dissolved carbon (DOC) fractions are determined by filtering the sample through a 0.45 micron membrane filter prior to analysis.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-T-L-CFA-VA	Water	Low Level Total Cyanide in water by CFA	ISO 14403:2002

This analysis is carried out using procedures adapted from ISO Method 14403:2002 "Determination of Total Cyanide using Flow Analysis (FIA and CFA)". Total or strong acid dissociable (SAD) cyanide is determined by in-line UV digestion along with sample distillation and final determination by colourimetric analysis. Method Limitation: This method is susceptible to interference from thiocyanate (SCN). If SCN is present in the sample, there could be a positive interference with this method, but it would be less than 1% and could be as low as zero.

Reference Information

CN-WAD-L-CFA-VA	Water	Low level WAD Cyanide in water by CFA	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN I. "Weak Acid Dissociable Cyanide". Weak Acid Dissociable (WAD) cyanide is determined by in-line sample distillation with final determination by colourimetric analysis.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

COLOUR-TRUE-VA	Water	Colour (True) by Spectrometer	BCMOE Colour Single Wavelength

This analysis is carried out using procedures adapted from British Columbia Environmental Manual "Colour- Single Wavelength." Colour (True Colour) is determined by filtering a sample through a 0.45 micron membrane filter followed by analysis of the filtrate using the platinum-cobalt colourimetric method. Aparent Colour is determined without prior sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within +/- 1 pH unit.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

HG-DIS-LOW-CVAFS-VA	Water	Dissolved Mercury in Water by CVAFS(Low)	EPA SW-846 3005A & EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-TOT-LOW-CVAFS-VA	Water	Total Mercury in Water by CVAFS(Low)	EPA 245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	APHA 3030 B&E / EPA SW-846 6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modified from EPA Method 6020A).

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

P-T-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorous is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorous

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-F-VA Water TKN in Water by Fluorescence APHA 4500-NORG D.

This analysis is carried out using procedures adapted from APHA Method 4500-Norg D. "Block Digestion and Flow Injection Analysis". Total Kjeldahl Nitrogen is determined using block digestion followed by Flow-injection analysis with fluorescence detection.

TN-CALC-VA Water Total Nitrogen (Calculation) BC MOE LABORATORY MANUAL (2005)

Total Nitrogen is a calculated parameter. Total Nitrogen = Total Kjeldahl Nitrogen + [Nitrate and Nitrite (as N)]

TSS-VA Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

10-334376

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

10- 334376

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Report To
Company: BGC Engineering Inc.
Contact: V Cullen
Address: 800 - 1045 Howe Street.
Vancouver, BC V6Z 2A9
Phone: 604 684 5900 Fax: 604 684 5909

Report Format / Distribution
Standard: ✓ Other (specify):
Select: PDF ✓ Excel ✓ Digital ✓ Fax
Email 1: VCullen@BGCengineering.ca
Email 2: KJones@BGCengineering.ca.

Service Request: (Rush subject to availability - Contact ALS to confirm TAT)
- Regular (Standard Turnaround Times - Business Days)
- ✓ Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
- Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
- Same Day or Weekend Emergency - Contact ALS to confirm TAT

Invoice To Same as Report ? (circle) Yes or (No) (if No, provide details)
Copy of Invoice with Report? (circle) Yes or No
Company: Pretium Resources.
Contact: K McNaughton.
Address: 1600-570 Granville Street, Vancouver, V6C 3P1
Phone: 604 558 7784 Fax: 604 558 4786.

Client / Project Information
Job #: 1008010.
PO / AFE:
LSD:
Quote #:

Lab Work Order # (lab use only)

ALS Contact: D Watt. **Sampler:** BSmith SBlackmore.

Analysis Request (Indicate Filtered or Preserved, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Total Metals (F)	Diss Metals (F)	Cyanides (F)	TOC/Nutrients (F)	DOC						Number of Containers
	BJ-12A	30-09-13		H_2O	✓	✓	✓	✓	✓	✓						6

Priority processing

RUSH

L1372080-COFC

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

Diss Metals + DOC Not filtered, Not Preserved.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
[illegible]	30Sept 13	20:00	Joyce	Oct 2	13:15	4.9 °C				

WHITE PAPER CO. 604 951-3900

Appendix 2-4 2021 Groundwater Monitoring Report

2021 Groundwater Monitoring Report

Project No. A406-8
6 April 2022

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

LORAX ENVIRONMENTAL

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NEWCREST

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Glossary and Abbreviations

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Glossary and Abbreviations

Terminology in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

As	arsenic
BC	British Columbia
BC MECCS	BC Ministry of Environment and Climate Change Strategy (2017 onward)
Ca	calcium
Cr	chromium
Cu	copper
CWP	Contact Water Pond
DQO	data quality objective
HCO_3	bicarbonate
K	potassium
km	kilometre
L/min	litres per minute
m	metre
m asl	metres above sea level
m bgs	metres below ground surface
m/s	metres per second, unit of hydraulic conductivity
M-243	Mine's Act Permit 243
m^3/d	cubic metres per day
MDL	method detection limit
Mg	magnesium
Mg	magnesium
mg/L	milligram per litre, unit of concentration
mm	millimetre
mm/yr	millimetres per year
Mn	manganese
Mo	molybdenum
MOE	BC Ministry of Environment (prior to 2017)
Na	sodium
NH_3	ammonia
Ni	nickel
NO_2	nitrite
NO_3	nitrate
NTU	Nephelometric Turbidity Unit
ORP	oxidation-reduction potential
P1	Brucejack geologic unit; hornblende, feldspar phyric latite flows
P2	Brucejack geologic unit; megacrystic, plagioclase, potassium-feldspar, and hornblende phyric flow
PCIC	Pacific Climate Impacts Consortium

PE-107835	Mine Effluent Permit 107835 assigned under the Environmental Management Act
Pretium	Pretium Resources Inc.
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RPD	relative percent difference
RTK	real time kinematic
S3-Poly	Brucejack geologic unit; polymictic conglomerate
S4	Brucejack geologic unit; volcanic derived sandstone/arenite
Se	selenium
Sn	tin
SO_4	sulphate
sQ	shifted quarter
t/d	tonnes per day
TDS	total dissolved solids
TSS	total suspended solids
UTM NAD83	Universal Transverse Mercator projection, North American Datum 1983
V12	Brucejack geologic unit; fragmental volcanics
VOK	Valley of the Kings
VSF	Brucejack geologic unit; volcanic sedimentary facies
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant

1. Introduction

1. Introduction

1.1 Mine Description and Background

The Brucejack Mine (the mine), located in northwest British Columbia (BC), is a high-grade underground gold and silver mine operated by Pretium Resources Inc. (Pretium), a member of the Newcrest Mining Ltd. (Newcrest) group of companies. The mine is centered approximately at 56°28′20″N Latitude by 130°11′31″W Longitude, a position approximately 950 kilometers (km) northwest of Vancouver, 65 km north-northwest of Stewart, and 21 km south-southeast of the Eskay Creek Mine in BC (Figure 1-1 inset). The mine is accessed via a 73 km access road linking the Brucejack Camp to Highway 37 at km 215.

The underground development is located southwest of the waste rock and tailings storage facility (WRTSF), and the mill, used for primary processing of the ore, is located adjacent to the WRTSF (Figure 1-1). Thickened tailings from the mill are deposited into the WRTSF together with a component of waste rock from the underground mine. Waste rock and paste-thickened tailings are used to backfill portions of the underground mine.

The mine received its Environmental Certificate (#M15-01) in March 2015 and received a Mines Act Permit (M-243) and Effluent Permit (PE-107835) in July and August of 2015, respectively. Construction-related activity ramped up in September 2015 and the mine achieved commercial production in July 2017.

Mines Act Permit M-243 has been amended several times to accommodate mine plan changes, most recently in December 2021 to update the project boundaries and authorize the use of remote equipment. The Environmental Management Act discharge permits for waste discharges to water and air have been amended four times. The December 2018 amendment to PE-107835 included revision of the groundwater monitoring program to include monitoring wells installed in 2018 with selected wells sampled under reduced frequency. In December 2020, Pretium provided an update on timing of a future groundwater monitoring installation which was subsequently added to the PE-107835 file (Lorax 2020c).

1.2 Scope of Work

Pretium retained Lorax Environmental Services Ltd. (Lorax) in June 2019 to provide hydrogeological consulting services for the mine. All site groundwater monitoring activities are undertaken by Brucejack Environmental Department staff. Lorax provides in-office support to site staff, offering feedback on sampling methodology and well

development activities. Lorax and Brucejack Environmental Department staff have prepared this 2021 Annual Groundwater Monitoring Report.

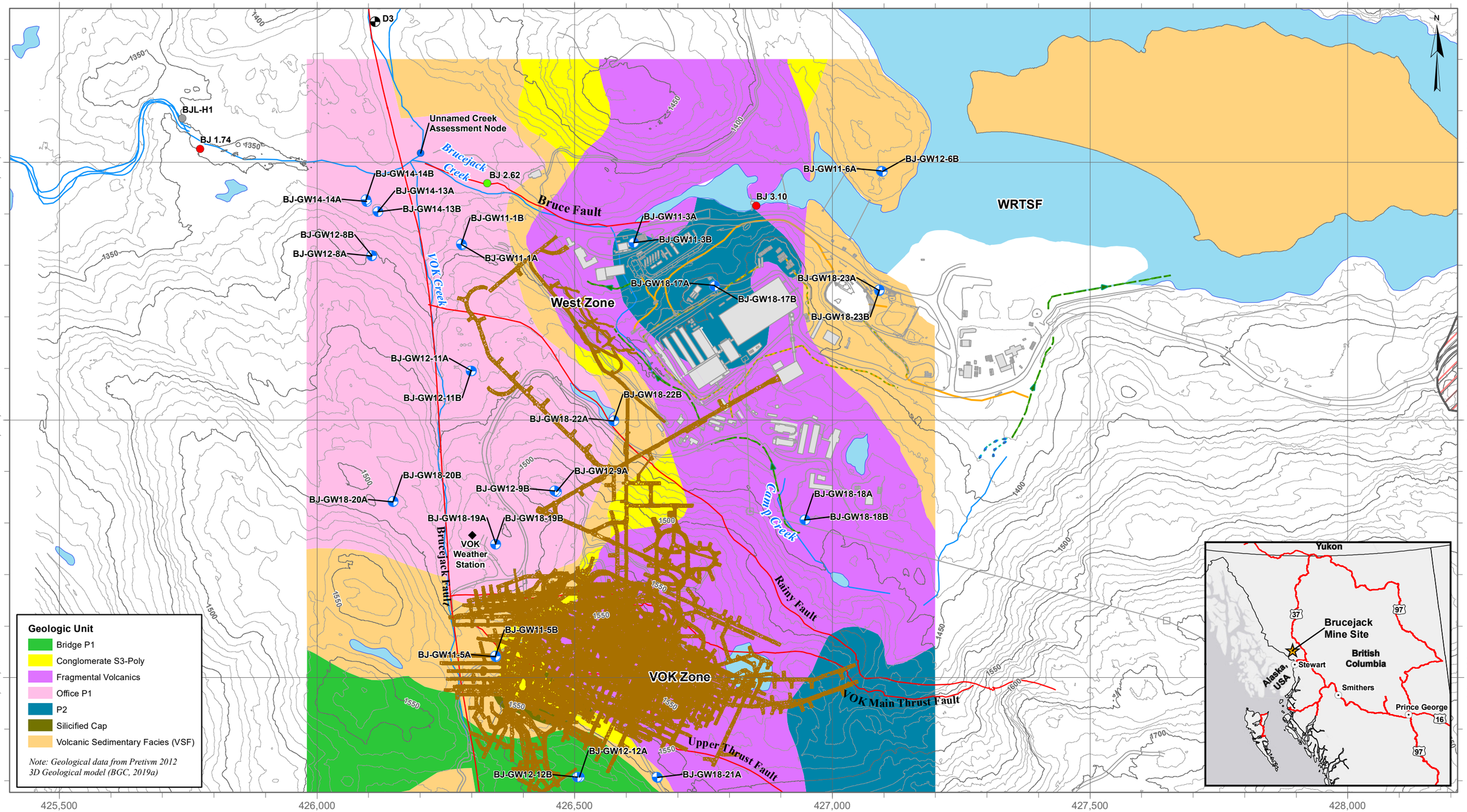
1.3 Objectives

The purpose of this 2021 Annual Groundwater Monitoring Report is to summarize the most recent groundwater monitoring data to allow for interpretation of mining impacts on the groundwater system.

This report fulfils both general annual reporting guidance provided in BC MOE (2016a) and specific reporting requirements given in M-243 and PE-107835 which include:

- A description of groundwater monitoring stations, methods and monitoring frequency demonstrating that the groundwater monitoring program fulfils the requirements of permits M-243 and PE-107835.
- An assessment of the groundwater quality control/quality assurance (QA/QC) program demonstrating that groundwater quality data are representative.
- An assessment of the temporal, seasonal and/or operational groundwater quantity (water levels and dewatering rates) and groundwater quality trends using tabular and graphical formats.
- A discussion of impacts to baseline water quality that may suggest the onset of Metal Leaching and/or Acid Rock Drainage.
- Inclusion of results from any additional hydrogeological investigation and assessment work and updates to the groundwater model for the site.

The data presented in this report is used to validate the recently updated site-wide groundwater model presented in 2020 Mine Plan and Reclamation Update (Pretium 2020c). The most recent comparison of simulated and observed groundwater data has been presented in Lorax (2022).



LEGEND

- Monitoring Well (not monitored)
- Monitoring Well (currently monitored)
- Production Well
- Model SW Assessment Node
- Hydrometric Station
- Hydrometric Station (Decommissioned)
- SWQ Station
- Weather Station
- 2021 Underground Workings (As-built)
- Fault
- Tailings Deposition
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Building Infrastructure
- Surface Contour (50m)
- Surface Contour (10m)

DATE SAVED:	Apr 16, 2022
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:7,000

0 100 200 Meters

CLIENT: NEWCREST

LORAX ENVIRONMENTAL

PROJECT: **2021 Groundwater Monitoring Report**

TITLE: Brucejack Mine General Arrangement

PROJECT #: A642-2

FIGURE: 1-1

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2. Mine Setting

2. Mine Setting

2.1 Physiography

The Brucejack Property is located in the Boundary Range of the Coast Mountain Physiographic Belt. Mine infrastructure is located at 1,360 to 1,415 metres above sea level (m asl) along Brucejack Creek (Figure 1-1). The mine site is devoid of trees with only sparse mosses along drainage pathways. The mine site lies in a transition zone between the very wet coastal and drier interior regions of BC. This part of northwestern BC is dominated by weather systems generated from the Pacific Ocean but is also strongly influenced by orographic effects caused by the local mountain topography that produces high spatial variability in snowfall, precipitation, temperatures and snowmelt. In addition, the extensive glacial areas around the mine site can impact snowmelt rates and produce high runoff volumes during the summer months. The humid climate and physical characteristics of the region result in dynamic streams and rivers with high annual runoff rates and high average stream flows.

2.2 Climate and Meteorology

Annual precipitation in the region ranges from approximately 1,500 to >2,200 mm, with approximately 70% of annual precipitation typically falling between October-April as snow. The months of October through to January typically have the highest monthly precipitation amounts, while late spring or early summer months see comparatively lower precipitation. Snowpack typically ranges from 1 to 2 m deep, but high winds can create snowdrifts up to 15 m deep. Mountainous terrain and permanent icefields are present in the upper reaches of the Brucejack Creek watershed. Precipitation in such terrain is spatially variable and subject to change with elevation owing to orographic cooling.

Site-specific weather data have been collected at a number of locations near the property since October 2009 which include measurement of the following climate information: wind speed and direction, air temperature and pressure, rainfall, snowfall, relative humidity, solar radiation, net radiation, and snow depth. With respect to collection of climate data near the mine, a key weather station was relocated from the WRTSF to its current position in the Valley of the Kings (VOK) valley (elevation 1,500 m asl) in September 2014 (Figure 1-1).

The reader is referred to the 2021 Annual Meteorological Monitoring Report (Pretium 2022a) for an in-depth analysis of current climate data. A brief analysis of recent site precipitation data is provided in this report for context when viewing water level hydrographs and underground dewatering data. Monthly precipitation from the VOK

weather station, corrected for gauge undercatch, is provided in Table 2-1 for the 2015 to 2021 time period. 2021 was on average 10% wetter than 2020, with wetter conditions being more prevalent during the winter, spring, and fall months. Between May and September, 2021 experienced slightly less rainfall than 2020. Compared to the 2015-2020 average VOK record, September and March 2021 precipitation were more than double, or nearly double, the average (Table 2-1).

Table 2-1:
Precipitation (mm) measured at VOK climate station.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2015	241	96	177	152	19	105	143	213	201	392	190	139	2,069
2016	122	188	75	161	118	48	83	63	230	82	212	144	1,527
2017	161	97	143	44	107	117	64	176	180	231	108	130	1,556
2018	111	92	84	81	71	50	60	100	59	189	163	164	1,224
2019	182	33	76	119	29	81	187	356	152	260	294	121	1,890
2020	130	162	104	89	95	155	127	278	189	190	277	161	1,955
2021	214	169	204	99	95	86	53	156	378	296	308	86	2,143
2015-2020 Avg.	158	111	110	108	73	93	111	198	169	224	207	143	1,704

2.3 Hydrology

The Brucejack Creek catchment (drainage area 6.5 km^2 at station BJ-3.10) is a small headwater sub-basin within the larger Sulphurets Creek watershed (drainage area 300 km^2 at the confluence with the Unuk River). It is located in a glaciated, alpine environment, with the uppermost part of the catchment flowing into the WRTSF (drainage area 6.7 km^2). About 17 km downstream of Sulphurets Lake, Sulphurets Creek forms a confluence with the larger Unuk River which ultimately flows into the Pacific Ocean, northeast of Ketchikan, Alaska.

In accordance with PE-107835, flow rates are measured at Station BJ-3.10 (approximately 250 m downstream of the WRTSF outlet, shown in Figure 1-1) and Station BJ-1.74 (1.74 km upstream of the Sulphurets Glacier). The hydrological regime of the mine area is snowmelt-dominated and supplemented by glacier meltwaters in the late summer. Peak flow conditions typically occur in mid-summer and low flow conditions occur during the winter months of January through March (Rescan 2013). The reader is referred to the 2021 Annual Hydrometric Monitoring Report (Pretium 2022b) for a discussion of hydrometric data collected in 2021.

2.4 Geology

The geology of the Brucejack Project area is described in detail in Shaw *et al.* (2020). The Brucejack Project area is largely underlain by volcano-sedimentary rocks of the Lower Jurassic Hazelton Group. These rocks unconformably overlie volcanic arc sedimentary rocks of the Upper Triassic Stuhini Group along the western-most part of the Brucejack Project area. The rocks are variably altered and deformed, with zones of intense quartz-sericite-pyrite (phyllic) alteration. The main lithologies encountered in boreholes advanced for groundwater monitoring well installations (Appendix A) include the following:

- P1 [Office]: Hornblende, feldspar phyric latite flows.
- P1 [Bridge]: As per Office P1 but with a different age and geochemical signature.
- P2: Megacrystic, plagioclase, potassium-feldspar, and hornblende phyric flow.
- V12 [Fragmental volcanics]: Hornblende and/or feldspar phyric latite to andesite fragmental volcanic rocks and subordinate flows with minor ash and lapilli tuff.
    - V6B: Mafic dykes
- S3-Poly [Polymictic conglomerate]: Heterolithic boulder to coarse cobble conglomerate with sandstone.
- Silicified Cap: Silicified rocks; typically, poorly sorted heterolithic conglomerate, lesser sandstone, and local mudstone; commonly includes rhyolite fragments.
- VSF [Volcanic Sedimentary Facies]: Volcanically derived siltstone and sandstone with minor arenite and pebble conglomerate.
    - S4-VSF: Sandstone/arenite.

These units may contain sulphide present as pyrite with trace to minor sphalerite and chalcopyrite. In the time since many of the hydrogeological holes have been advanced, Pretium geologists have amalgamated the P1 unit and no longer differentiate between Office and Bridge sub-units.

The surficial materials within the Brucejack Project area consist of a sparse veneer of well-graded glacial till overlying bedrock. Grain size varies from sand to gravel, with some silt and clay, and variable quantities of cobbles and boulders. The thickness of unconsolidated deposits varies at the site but is generally less than 5 m and commonly less than 1 m (BGC 2014).

The fault model developed by Pretium indicates four large (*i.e.,* mine-scale) fault zones intersecting the Brucejack Project area: the Brucejack Fault Zone, the Rainy Fault, the Valley of the Kings Main Thrust Fault, and the Upper Thrust Fault (Figure 1-1).

The Brucejack Fault Zone is a long lived northerly striking anastomosing vertical fault zone with predominantly left lateral strike slip movement showing a net displacement varying between 500 and 800 m (ERSi 2010). It is comprised of a core of highly fractured rock with a zone of less fractured, fault-disturbed rock mass on either side. The width of the fault zone varies with depth and along strike from approximately 5 to 40 m. It is considered to be continuous along strike.

The Rainy Fault, Valley of the Kings Main Thrust Fault and Upper Thrust Fault are three gently dipping south-southwest striking faults. The Rainy Fault has an average thickness of 2 m, with the thickness appearing to increase with depth. Often the Rainy Fault zone is comprised of multiple gouge zones separated by more competent zones of very blocky rock mass. Seepage conditions within the zone vary significantly, from dry to dripping.

Pretium staff indicate that the Rainy Fault is the most encountered fault within the mine workings and is typically shotcreted when encountered in the mine workings for geotechnical purposes. The Rainy Fault intersects a significant amount of mine workings between the 1200 m elevation to the 1350 m elevation, while the VOK Main Thrust intersects workings only on the 1440 m elevation and the 1470 m elevation. The Upper Thrust lies above the current mine workings, does not intersect any workings and is only identified through diamond drill core. Most current diamond drillholes are grouted upon completion except for select locations to facilitate controlled dewatering of areas of the Brucejack Fault in advance of mine workings development. Once completed, these remaining holes will also be grouted (Travis Murphy P.Geo, Chief Mine Geologist, pers. Communication). The Brucejack Fault and Rainy Fault are inferred to influence the hydrogeological conditions based on observations during mining, well yields near these features and contoured groundwater levels (Section 4.3).

2.5 Hydraulic Conductivity

The site hydraulic conductivity database has been updated to include results from the 2018 monitoring well installation program (BGC 2019a). Figure 2-1 plots hydraulic conductivity versus depth with starred symbols indicating tests where faults and/or fracture zones were identified in the core. Overall, the data suggest bedrock hydraulic conductivity decreases with depth but at any given depth, the hydraulic conductivity is highly variable. For example, between 0 m and 100 m depth, hydraulic conductivity ranges from 3E-09 m/s to 1.5E-05 m/s; between 400 m and 500 m, the hydraulic conductivity ranges from 2E-08 m/s to 1E-06 m/s. The data do not indicate a strong correlation between hydraulic conductivity and lithology and faulted rock intervals are not universally highly conductive.

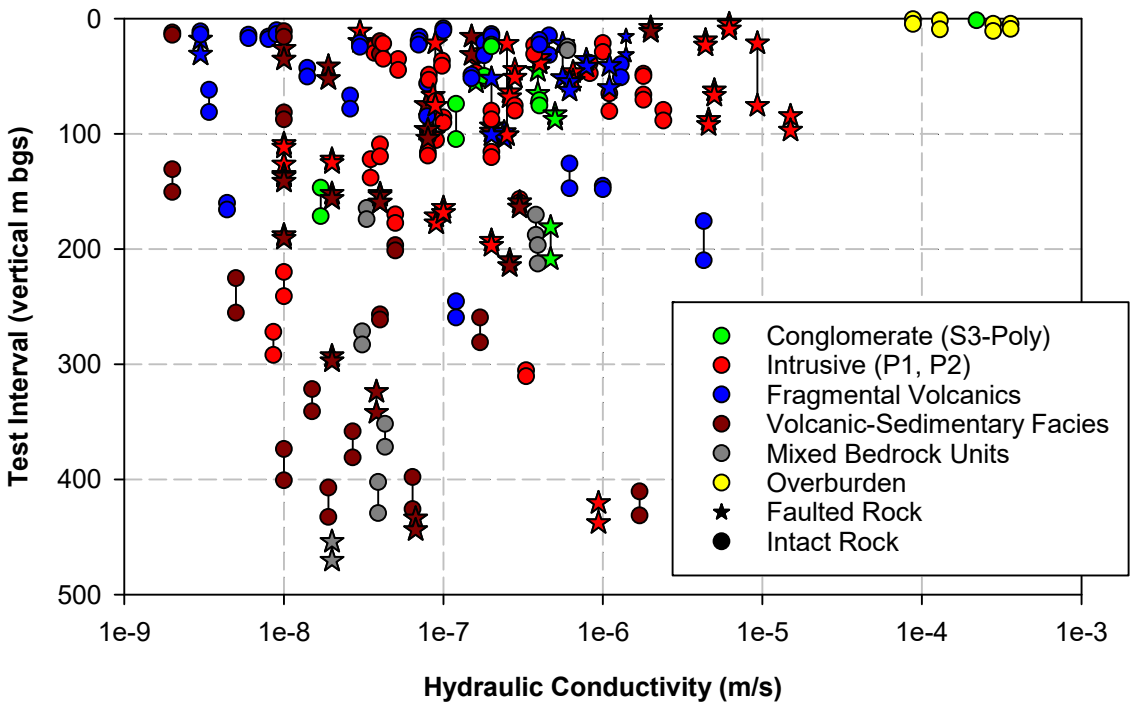

Figure 2-1: Hydraulic conductivity versus depth at Brucejack Mine from packer and slug tests.

3. Methodology

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3. Methodology

3.1 Monitoring Well Installations

Brucejack monitoring wells currently monitored under PE-107835 are listed in Table 3-1 and shown in Figure 1-1. Groundwater quality sampling on a quarterly or biannual basis is prescribed at 28 monitoring wells along with continuous water level monitoring. Four additional locations are prescribed for continuous water level monitoring only. The mine collects continuous groundwater levels from four monitoring wells outside of PE-107835; two of these wells are also sampled on a quarterly basis (Table 3-2). Locations formerly monitored under PE-107835 and since decommissioned are listed in Table 3-3.

Borehole logs for monitoring wells listed in Table 3-1 through Table 3-3 are provided in Appendix A. All monitoring wells are conventional monitoring wells consisting of a polyvinyl chloride (PVC) standpipe with slotted screen interval, backfilled with filter sand across the screened interval, sealed with bentonite above the filter pack, and then backfilled to surface with grout, bentonite, and/or sand. Construction details for 2011, 2014, 2016, and 2018 era monitoring wells are provided in BGC (2014, 2015b, 2017, 2019a).

3.2 Monitoring Procedures

Hydraulic head and groundwater quality sampling are undertaken on a shifted quarter (sQ) or biannual basis, as specified by PE-107835. The shifted quarters are defined as follows:

- sQ1: February 1st to April 30th
- sQ2: May 1st to July 31st
- sQ3: August 1st to October 31st
- sQ4: November 1st to January 31st

Shifted quarters are off-set from calendar quarters by one month. This offset allows for evaluation of groundwater quality that coincides with seasonal controls (*e.g.,* freshet, first snowfall). Table 3-4 provides a record of groundwater sample collection at all groundwater monitoring wells installed at the site.

Table 3-1:
Monitoring wells currently monitored under PE-107835

Monitoring Site Identifier (PE-107835 Dec. 14, 2018)		Current Permit-Required Monitoring[1]		Install Date	Easting[2] (m)	Northing[2] (m)	Ground Surface Elevation[2] (m)	Top of Casing (m)	Sand Pack Interval (m bgs)		Lithological Unit
Project ID	EMS ID	Water Levels	Water Quality						Top	Bottom	
BJ-GW11-1A	E303054	C	sQ	Oct 02, 2011	426,281	6,258,840	1,385.72	1,386.29	77.10	85.30	Office P1
BJ-GW11-1B	E314692	C	sQ	Oct 02, 2011	426,280	6,258,841	1,385.72	1,386.39	31.30	38.70	Office P1
BJ-GW11-3A	E303056	C	sQ	Oct 03, 2011	426,615	6,258,844	1,367.63	1,369.19[3]	79.30	88.40	P2
BJ-GW11-3B	E314693	C	sQ	Oct 04, 2011	426,615	6,258,844	1,367.53	1,369.76	4.50	9.10	P2
BJ-GW11-5A	E303058	C	sQ	Sep 29, 2011	426,347	6,258,040	1,526.14	1,526.69	65.70	78.00	VSF
BJ-GW11-5B	E314694	C	sQ	Sep 30, 2011	426,346	6,258,042	1,526.16	1,526.60	39.60	50.90	VSF
BJ-GW12-8A	E303059	C	sQ	Jun 18, 2012	426,106	6,258,818	1,403.38	1,403.63[3]	86.00	95.10	Office P1
BJ-GW12-8B	E314695	C	sQ	Jun 19, 2012	426,106	6,258,819	1,403.30	1,403.54[3]	44.30	51.00	Office P1
BJ-GW12-9A	E303060	C	sQ	Aug 04, 2012	426,465	6,258,361	1,514.40	1,515.13	70.80	80.00	Office P1
BJ-GW12-9B	E314696	C	sQ	Aug 01, 2012	426,461	6,258,362	1,514.56	1,515.23	38.40	47.40	Office P1
BJ-GW12-11A	E303062	C	sQ	Jun 26, 2012	426,300	6,258,595	1,433.57	1,434.18	25.80	29.50	Office P1
BJ-GW12-11B	E314697	C	sQ	Jun 28, 2012	426,299	6,258,595	1,432.96	1,433.57	48.20	53.80	Office P1
BJ-GW12-12A	E303063	C	sQ	Aug 08, 2012	426,509	6,257,807	1,579.19	1,579.97	84.30	97.00	Bridge P1
BJ-GW12-12B	E314698	C	sQ	Aug 10, 2012	426,505	6,257,807	1,579.16	1,579.94	45.20	53.10	Bridge P1
BJ-GW14-13A	E303064	C	NR	Sep 09, 2014	426,118	6,258,904	1,362.49	1363.09	20.70	100.90	Office P1
BJ-GW14-13B	E314699	C	NR	Sep 13, 2014	426,118	6,258,904	1,362.76	1363.61	21.20	75.40	Office P1
BJ-GW14-14A	E303065	C	sQ	Sep 11, 2014	426,096	6,258,924	1,352.09	1352.95	14.90	34.90	Office P1
BJ-GW14-14B	E314700	C	sQ	Sep 23, 2014	426,099	6,258,925	1,351.99	1352.91	0.50	4.60	Office P1
BJ-GW18-17A	E303066	C	sQ	Jun 05, 2018	426,771	6,258,761	1,403.87	1,404.22	142.07	148.12	V12/V6b
BJ-GW18-17B	E314701	C	sQ	Jun 08, 2018	426,772	6,258,760	1,403.99	1,404.25	72.10	75.76	Office P1
BJ-GW18-18A	E303069	C	sQ	Jun 12, 2018	426,946	6,258,306	1,445.11	1,445.35	95.53	101.27	Office P1
BJ-GW18-18B	E314702	C	sQ	Jun 09, 2018	426,947	6,258,306	1,445.11	1,445.33	61.54	65.57	Office P1
BJ-GW18-19A	E303070	C	sQ	Jun 14, 2018	426,347	6,258,259	1,496.25	1,495.60	191.78	196.89	Office P1
BJ-GW18-19B	E314703	C	sQ	Jun 17, 2018	426,346	6,258,259	1,495.94	1,495.45	154.92	159.54	Office P1
BJ-GW18-20A	E303559	C	B	Jun 17, 2018	426,147	6,258,341	1,493.59	1,494.02	159.92	167.53	Office P1
BJ-GW18-20B	E314704	C	B	Jun 20, 2018	426,148	6,258,342	1,493.60	1,494.07	113.27	118.45	Office P1
BJ-GW18-21A	E303071	C	B	Jun 24, 2018	426,661	6,257,806	1,550.33	1,551.01[4]	193.49	204.83	S4-VSF
BJ-GW18-21B	E314705	C	B	Jun 29, 2018	426,660	6,257,807	1,550.34	1,551.03[4]	152.05	159.45	S4-VSF
BJ-GW18-22A	E303068	C	NR	Jul 01, 2018	426,575	6,258,498	1,444.64	1,444.73	369.58	379.00	S4-VSF
BJ-GW18-22B	E314706	C	NR	Jul 06, 2018	426,576	6,258,499	1,444.64	1,444.91	82.99	87.82	S3-Poly
BJ-GW18-23A	E314690	C	sQ	Jul 01, 2018	427,091	6,258,751	1,370.84	1,370.92	25.32	29.70	S4-VSF
BJ-GW18-23B	E314691	C	sQ	Jul 02, 2018	427,091	6,258,752	1,370.81	1,370.94	7.61	11.30	S4-VSF

Notes:
1. C = continuously recorded (logger); sQ = shifted quarter, B = biannual, NR = not required
2. Monitoring well ground surface coordinates and top of casing determined by RTK GPS, horizontal datum UTM Zone 9N NAD 83, Project vertical datum.
3. Elevations modified from original survey to accommodate Snap Sampler installation.
4. An additional 0.6 m of PVC pipe added to previous RTK GPS survey.

Table 3-2:
Additional monitoring wells currently monitored outside of PE-107835

Monitoring Site Identifier		Current Monitoring[1]		Install Date	Easting[2] (m)	Northing[2] (m)	Ground Surface Elevation[2] (m)	Sand Pack Interval (m bgs)		Lithological Unit
Project ID	EMS ID	Water Levels	Water Quality					Top	Bottom	
BJ-GW11-6A	-	C	NR	Oct 04, 2011	427,095	6,258,983	1,379.81	20.7	31.8	VSF
BJ-GW12-6B	-	C	NR	Jun 16, 2012	427,097	6,258,982	1,379.56	98.2	103.8	VSF
BJ-GW16-5A	-	C	sQ	July 11, 2016	427011	6258840	1,372.63	18.65	22.37	V12
BJ-GW16-5B	-	C	sQ	July 12, 2016	427014	6258838	1,372.55	8.50	10.50	V12

Notes:
1. C = continuously recorded (logger); sQ = shifted quarter.
2. Well coordinates and ground elevations surveyed by Allnorth; coordinates are UTM NAD 83 Zone 9.

Table 3-3:
Monitoring wells formerly monitored under PE-107835 (2015-2017)

Monitoring Site Identifier		Install Date	Easting (m)	Northing (m)	Ground Surface Elevation (m)	Sand Pack Interval (m bgs)		Lithological Unit	Decommission Date
Project ID	EMS ID					Top	Bottom		
MW-BGC11-BJ-2A	E303055	Oct 03, 2011	426,885	6,258,812	1,423.17	64.90	80.30	P2	Jan 21, 2016
MW-BGC11-BJ-4A	E303057	Oct 04, 2011	427,031	6,258,750	1,390.46	18.00	31.00	VSF	Sep 14, 2015
MW-BGC12-BJ-4B	E303057	Jun 20, 2012	427,031	6,258,752	1,390.43	91.60	98.10	VSF	Sep 14, 2015
MW-BGC12-BJ-10A	E303061	Jun 22, 2012	426,989	6,258,341	1,445.59	51.60	60.10	VSF	Sep 14, 2015
MW-BGC12-BJ-10B	E303061	Jun 22, 2012	426,989	6,258,341	1,445.64	35.60	41.40	VSF	Sep 14, 2015

3.2.2 Hydraulic Head Measurements

Groundwater levels are manually measured at all wells on a quarterly basis using Heron Instruments Dipper-T2 water level meters. Starting in sQ3 a trial of the Solinst Sonic Water Level Meter was commenced to determine the viability of switching quarterly water level measurements from a manual water level meter to a sonic water level meter. The benefits of the Solinst Sonic Water Level meter are that it increases efficiency, reduces bias between different samplers that exists with the Dipper-T2 meters and reduces disruption to the logger cable. Thus far the Sonic Water Level Meter shows excellent correlation to the manual Dipper-T2 water level measurements (Figure 3-1).

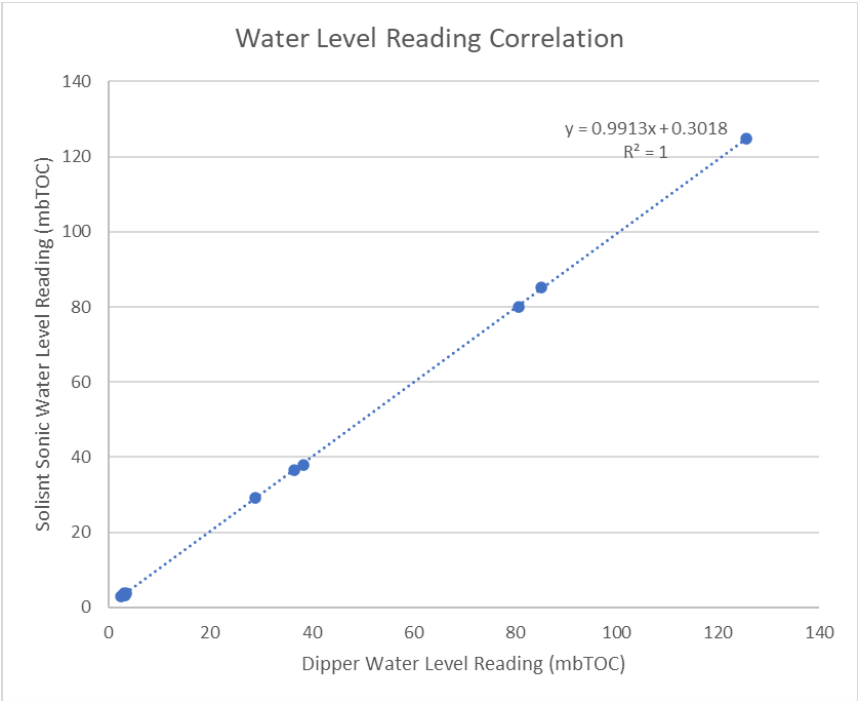


Figure 3-1: Correlation between manual water level and sonic water level readings.

Continuous groundwater level data are also measured at six-hour intervals (12AM, 6AM, 12PM and 6PM) by pressure transducers. Two brands of pressure transducers have been utilized at Brucejack, namely Onset HOBO dataloggers and Van Essen Instruments TD-Diver dataloggers. Additional HOBO and TD-Diver dataloggers record the atmospheric pressure at the same time intervals as the pressure transducers installed in the monitoring wells. As of sQ3 2020, all wells were transitioned to TD-Diver dataloggers to improve measurement consistency. Water level pressures recorded by the well transducers are corrected for barometric pressure and converted into water level elevations (m asl) using the manual groundwater level measurements. Van Essen Instruments direct read cables are in the process of being installed at 17 wells on site as a trial. These direct read cables allow data logger downloads from surface and reduce the need to raise and lower

data loggers for data downloads. By negating the need to remove the data logger from the well for data downloads, the potential for error in redeployment is eliminated, allowing an accurate understanding of the data logger depth so that manual groundwater level measurements can be used as a check instead of as a calibration point.

Quarterly manual groundwater level measurements and datalogger downloads were completed on all wells except for BJ-GW11-1A/B (sQ1), BJ-GW11-3B (sQ4), BJ-GW11-6A/B (sQ4), BJ-GW14-13A/B (sQ1 and sQ4) and BJ-GW14-14A/B (sQ1, sQ2 and sQ4) due to faulty equipment, frozen wells, or inaccessibility during the winter months.

3.2.3 Groundwater Quality

3.2.3.1 Monitoring Well Sampling

Groundwater sample collection at the mine transitioned from sampling methods that utilized inertial pumping (high purge) to low-flow sampling methods in mid-2019. Prior to mid-2019, groundwater sampling followed a traditional multiple volume purge method utilizing Waterra tubing and weighted polyethylene bailers, combined with field parameter stabilization. These sampling methods often resulted in the collection of groundwater samples containing elevated turbidity (>50 NTU). The low-flow sampling protocol continues to be implemented to minimize the turbidity and sediment load and to collect samples that better represent formation water.

The low-flow sampling protocol is implemented as follows:

- A Geotech Geopump peristaltic pump is used for wells less than 11 m in depth, namely BJ-GW11-3B, BJ-GW14-14B, BJ-GW16-5B and BJ-GW18-23B.
- A Grundfos Redi-flo 2 submersible pump is used for wells with depths ranging from 11 m to 91 m (most pre-2018 groundwater wells along with BJ-GW18-18B and BJ-GW18-23A).
- A Bennett Sample pump is used for wells with depths exceeding 91 m depth, namely BJ-GW18-17A and BJ-GW18-19B.

Table 3-5 provides details regarding the sampling method and equipment employed during each quarterly sampling event. The site groundwater sampling protocol (Appendix B) includes detailed SOPs for all low-flow sampling methods deployed at the mine. The low-flow sampling protocol has not been adopted at well BJ-GW12-11A where samples are collected with a bailer due to slow groundwater recharge rates. Bailers are occasionally deployed at wells with seasonally low water levels and slow recharge, or if there are functional difficulties with sampling equipment (BJ-GW11-1B (sQ3), BJ-GW12-9B (sQ2), BJ-GW18-17A (sQ4) and BJ-GW18-17B (sQ1, sQ4)).

Table 3-4:
Groundwater samples collected at Brucejack monitoring wells

Well ID	Total Number of Samples Collected															Sample Record Total
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021 sQ1	2021 sQ2	2021 sQ3	2021 sQ4	2021 Total	
BJ-GW11-1A	1	-	-	-	-	3	4	4	4	3	CNL	17 Jul VA21B4774-002	31 Oct VA21C4383-001	26 Jan VA22A1683-002	3	22
BJ-GW11-1B	1	-	-	-	-	2	3	2	1	1	CNL	17 Jul VA21B4774-003	IV	DRY	1	11
BJ-GW11-2A	1	4	3	2	4	DC	-	-	-	-	DC	DC	DC	DC	-	14
BJ-GW11-3A	1	4	3	2	4	4	4	4	4	3	26 Mar VA21A5837-001	20 Jun VA21B2508-002	23 Sep VA21C1212-001	4 Dec VA21C7213-001	4	37
BJ-GW11-3B	1	4	2	2	2	2	3	3	3	3	IV	20 Jun VA21B2508-003	23 Sep VA21C1212-002	FRZN	2	27
BJ-GW11-4A	1	4	3	2	2	DC	-	-	-	-	DC	DC	DC	DC	-	12
BJ-GW11-4B	-	2	3	2	2	DC	-	-	-	-	DC	DC	DC	DC	-	9
BJ-GW11-5A	1	2	-	-	-	2	2	-	-	0	DRY	DRY	DRY	DRY	0	7
BJ-GW11-5B	1	2	-	-	-	2	-	-	-	0	DRY	DRY	DRY	DRY	0	5
BJ-GW11-6A	1	4	3	2	4	1	-	-	-	-	NR	NR	NR	NR	-	15
BJ-GW11-6B	-	2	1	-	-	-	-	-	-	-	NR	NR	NR	NR	-	3
BJ-GW12-8A	-	3	3	2	4	4	4	4	4	3	23 Apr VA21A7804-002	21 Jun VA21B2626-002	17 Oct VA21C3094-002	27 Jan VA22A1795-001	4	35
BJ-GW12-8B	-	3	3	2	3	4	4	4	4	3	22 Apr VA21A7683-003	27 May VA21B0558-002	17 Oct VA21C3094-004	27 Jan VA22A1795-002	4	34
BJ-GW12-9A	-	-	-	-	-	-	1	-	-	0	DRY	DRY	IV	DRY	0	1
BJ-GW12-9B	-	-	-	-	-	2	1	1	2	2	IV	DRY	17 Sep VA21C0574-001	DRY	1	9
BJ-GW12-11A	-	-	-	-	-	3	3	3	4	3	24 Apr VA21A7804-003	29 May VA21B0672-001	16 Oct VA21C3093-001	IV	3	19
BJ-GW12-11B	-	-	-	-	-	2	2	3	3	2	DRY	IV	DRY	DRY	0	12
BJ-GW12-12A	-	1	2	2	1	2	-	-	-	0	DRY	DRY	DRY	FRZN	0	8
BJ-GW12-12B	-	-	-	-	1	-	-	-	-	0	DRY	DRY	DRY	DRY	0	1
BJ-GW14-13A	-	-	-	1	-	-	-	-	-	0	NR	NR	NR	NR	0	1
BJ-GW14-14A	-	-	-	-	-	2	1	2	1	1	FRZN	FRZN	14 Sep VA21C0110-003	FRZN	1	8
BJ-GW14-14B	-	-	-	-	-	3	2	3	1	2	FRZN	FRZN	14 Sep VA21C0110-001	FRZN	1	12
BJ-GW16-1B	-	-	-	-	-	1	-	-	-	0	DC	DC	DC	DC	0	1
BJ-GW16-2A	-	-	-	-	-	1	DC	-	-	0	DC	DC	DC	DC	0	1
BJ-GW16-2B	-	-	-	-	-	1	DC	-	-	0	DC	DC	DC	DC	0	1
BJ-GW16-3A	-	-	-	-	-	1	DC	-	-	0	DC	DC	DC	DC	0	1
BJ-GW16-4A	-	-	-	-	-	1	DC	-	-	0	DC	DC	DC	DC	0	1
BJ-GW16-5A	-	-	-	-	-	1	2	4	4	3	25 Apr VA21A7804-008	26 Jun VA21B3123-002	10 Oct VA21C2526-006	14 Nov VA21C5536-002	4	18
BJ-GW16-5B	-	-	-	-	-	1	2	4	4	3	25 Apr VA21A7804-009	23 Jun VA21B2897-002	10 Oct VA21C2526-005	15 Nov VA21C5605-002	4	18
BJ-GW18-17A	-	-	-	-	-	-	-	-	4	4	27 Apr VA21A8275-002	26 May VA21B0395-002	8 Oct VA21C2526-002	29 Jan VA22A1890-001	4	12
BJ-GW18-17B	-	-	-	-	-	-	-	3	4	4	5 Apr VA21A6365-001	31 Jul VA21B5926-001	15 Sep VA21C0275-001	29 Jan VA22A1890-002	4 (5)	15 (16)
BJ-GW18-18A	-	-	-	-	-	-	-	-	0(1)	0	NS	NS	NS	NS	0	0(1)
BJ-GW18-18B	-	-	-	-	-	-	-	3	4	3	DRY	23 May VA21B0116-002	11 Sep VA21B9857-002	7 Nov VA21C5014-001	3	13
BJ-GW18-19A	-	-	-	-	-	-	-	-	0	0	NS	NS	NS	NS	0	0
BJ-GW18-19B	-	-	-	-	-	-	-	1	3	2	DRY	18 Jul VA21B4774-005	18 Aug VA21B7639-001	DRY	2	8
BJ-GW18-20A	-	-	-	-	-	-	-	-	0	0	NS	NS	NS	NS	0	0
BJ-GW18-20B	-	-	-	-	-	-	-	-	0	0	NS	NS	NS	NS	0	0
BJ-GW18-21A	-	-	-	-	-	-	-	-	0	0	NS	NS	IV/NS	IV/NS	0	0
BJ-GW18-21B	-	-	-	-	-	-	-	-	0	0	IV/NS	IV/NS	IV/NS	IV/NS	0	0
BJ-GW18-23A	-	-	-	-	-	-	-	3	4	4	24 Apr VA21A7804-004	25 Jun VA21B3123-001	11 Oct VA21C2526-007	14 Nov VA21C5536-001	4	15
BJ-GW18-23B	-	-	-	-	-	-	-	3	4	4	24 Apr VA21A7804-006	23 Jun VA21B2897-001	7 Oct VA21C2526-003	15 Nov VA21C5605-001	4	15

Notes:
DC = decommissioned, NR = not required, CNL= could not locate (buried in deep snow), IV = insufficient volume and/or lack of recovery, FRZN = well frozen, DRY = well dry, NS = not sampled, no technical merit (see Section 3.2.3.3)
2 (3) = # of representative samples collected (total # samples collected)

Table 3-5: 2021 groundwater sampling summary

Sample Quarter			sQ1					sQ2					sQ3					sQ4				
Well ID	Top of Screen (m bgs)	Bottom of Screen (m bgs)	Sampling Method[1]	Sampling Equipment[2]	SWL (m bTOC)[3]	Well Vol (L)[4]	Purged Vol (L)	Sampling Method[1]	Sampling Equipment[2]	SWL (m bTOC)[3]	Well Vol (L)[4]	Purged Vol (L)	Sampling Method[1]	Sampling Equipment[2]	SWL (m bTOC)[3]	Well Vol (L)[4]	Purged Vol (L)	Sampling Method[1]	Sampling Equipment[2]	SWL (m bTOC)[3]	Well Vol (L)[4]	Purged Vol (L)
BJ-GW11-1A	78.6	84.8	NS	-	CNL	-	-	LF	Sub	26.08	122.5	40	HP	B	68.18	44.5	35	LF	Sub	74.16	33.4	60
BJ-GW11-1B	35.3	38.4	NS	-	CNL	-	-	LF	Sub	26.12	37.4	27.65	NS	-	IV	-	-	NS	-	DRY	-	-
BJ-GW11-3A	82.3	88.3	LF	Sub	17.95	149	13.13	LF	Sub	8.47	166.6	20.25	LF	Sub	3.51	175.8	30	LF	Sub	11.2	161.5	25.5
BJ-GW11-3B	5.8	8.8	NS	-	IV	-	-	LF	PP	ART	28.5	8.25	LF	PP	ART	28.5	10	NS	-	FRZN	-	-
BJ-GW12-8A	86.2	92.3	LF	Sub	35.27	133.3	52	LF	Sub	13.13	174.3	27.5	LF	Sub	18.6	164.2	37.5	LF	Sub	34.49	134.9	18.75
BJ-GW12-8B	44.8	50.9	LF	Sub	38.90	41.5	35	LF	Sub	23.79	69.5	42.5	LF	Sub	27.82	62	24	LF	Sub	38.24	42.9	27.5
BJ-GW12-9B	40.6	46.7	NS	-	IV	-	-	NS	-	DRY	-	-	HP	B	36.61	46.5	61	NS	-	DRY	-	-
BJ-GW12-11A	26.5	29.5	HP	B	21.16	27.1	40	HP	B	13.69	40.9	65	HP	B	17.56	33.8	58	NS	-	IV	-	-
BJ-GW12-11B	50.7	53.8	NS	-	DRY	-	-	NS	-	IV	-		NS	-	IV	-	-	NS	-	DRY	-	-
BJ-GW14-14A	18.2	30.7	NS	-	FRZN	-	-	NS	-	FRZN	-	-	LF	PP	ART	178.5	6	NS	-	FRZN	-	-
BJ-GW14-14B	1.5	4.4	NS	-	FRZN	-	-	NS	-	FRZN	-	-	LF	PP	2.21	26.3	15	NS	-	FRZN	-	-
BJ-GW16-5A	19.3	22.37	LF	Sub	6.42	41.8	68	LF	Sub	6.41	41.8	115	LF	Sub	5.94	42.7	40	LF	Sub	7	40.7	32.5
BJ-GW16-5B	9.0	10.5	LF	PP	2.13	22.8	15	LF	PP	2.78	21.6	11.75	LF	PP	2.43	22.2	11	LF	PP	4.54	18.3	12.4
BJ-GW18-17A	144.7	147.7	LF	Ben	113.99	81.9	150	LF	Ben	80.02	144.9	145	LF	Ben	85.18	135.3	210	HP	B	116.8	76.7	200
BJ-GW18-17B	72.2	75.3	HP	B	65.72	28.4	63	LF	Sub	45.11	66.6	228	LF	Sub	42.82	70.9	250	HP	B	69	22.3	48.5
BJ-GW18-18B	61.9	65.0	NS	-	DRY	-	-	LF	Sub	54.52	31.3	100	LF	Sub	28.91	78.8	55	LF	Sub	38.42	61.2	35
BJ-GW18-19B	155.5	158.5	NS	-	DRY	-	-	LF	Ben	148.30	32.6	120	LF	Ben	147.74	33.6	150	NS	-	DRY	-	-
BJ-GW18-23A	25.9	29.0	LF	Sub	3.63	59.9	20	LF	Sub	3.36	60.4	180	LF	Sub	3.16	60.8	57	LF	Sub	2.83	61.4	40
BJ-GW18-23B	7.8	10.8	LF	PP	3.47	24.3	7.5	LF	Sub	3.37	24.5	17	LF	PP	3.20	24.8	11.3	LF	PP	2.88	25.4	15

Notes
1. NS = not sampled, LF = low flow, HP = high purge
2. Sub = Redi Flo2 submersible pump, Ben = Bennett Pump (piston flow), PP = peristaltic pump, B = Bailer
3. SWL = static water level prior to sampling
4. Well volume = volume of water column occupying PVC and screened interval (assume 30% filter pack porosity)
5. IV = insufficient volume and/or lack of recovery, ART = artesian. FRZN = frozen

The discharge line from the pump is coupled to a flow-through cell allowing field parameters to be measured using a YSI Pro-DSS meter. A sample is collected once field parameters and water levels stabilize. If the well cannot be pumped continuously, or if a bailer is used, the sample is collected after field parameters stabilize and three well volumes have been extracted. If a bailer is used, a portion of the bailer volume is decanted into the YSI housing where field parameters are measured. Records of field data are compiled in Appendix C. The YSI Pro-DSS is calibrated within 24 hours of use, and can measure temperature, pH, specific conductivity, oxidation reduction potential (ORP), dissolved oxygen (DO) and turbidity Probe calibration data are reported in Appendix D.

3.2.3.2 Sampling Equipment Trial (Snap Sampler)

Historically, groundwater monitoring wells at the mine have elevated turbidity and TSS results, likely resulting from sampling with inertial pumps and/or bailers. While transitioning to low-flow techniques (peristaltic and submersible pumps) has reduced the observed turbidity and TSS results, mobilizing the necessary equipment to each well remains a challenge. Additionally, some deep and low-yield wells at the mine require prohibitively slow sampling rates (<0.1 L/min) and have significant annual water level fluctuations that complicate design for conventional dedicated systems such as bladder pumps. To help manage these constraints, a sampling trial using HydraSleeves, a no-purge sampling technique, was undertaken in 2019. Following a review of the HydraSleeve results, the trial was expanded to include Snap Samplers, a more robust no-purge sampling system, in sQ4 2020. Details of the HydraSleeve trial were presented in the 2019 Annual Monitoring Report (Lorax 2020a). The sQ4 2020 Snap Sampler trial results were presented the 2020 Annual Monitoring Report (Lorax 2021).

Snap Samplers provide a no-purge/passive groundwater sampling technique that allows for rapid sample collection with minimal equipment. These methods are particularly useful at remote field sites where logistical issues, adverse/unpredictable weather, difficult access, and low-yield wells make groundwater sampling challenging (ASTM 2014).

Both low-flow sampling and no-purge/passive methods are predicated on ambient flow from the formation through the well screen, a condition that is present in most properly constructed and developed wells (ASTM 2018). Under these conditions, water within the well screen is considered to be in equilibrium with the surrounding formation (Robin and Gillham 1987). These conditions may not be present in wells that recharge very slowly, with potential data quality issues arising from aeration, dewatering, and/or turbidity, regardless of the sampling method. In these instances, no-purge/passive sampling techniques, such as the Snap Sampler, may be the preferred sampling method provided there is sufficient equilibration time within the screen (ITRC 2007). As with other no-purge/passive techniques, the Snap Sampler is deployed within the well screen for a pre-determined period (at least two weeks at Brucejack Mine) prior to sample collection, allowing for equilibration with formation water following deployment.

A single Snap Sampler apparatus includes six replaceable 125 mL sample bottles aligned vertically in the well screen, for a total sample volume of 0.75 litres (Figure 3-2). The bottles are held open at both ends by a spring-loaded trigger mechanism operated by a pneumatic plunger at the top of the bottle array. A single HDPE tube is connected to the plunger, allowing for pressurization from surface, as well as deployment and withdrawal of the Snap Sampler. When the plunger is triggered, the recoiling springs seal the bottles, thereby capturing an in-situ, undisturbed sample from within the well screen. New bottles are installed following sample collection. Technical guidance and descriptive documents for the Snap Sampler are provided in Appendix E.

A total of seven Snap Samplers were deployed and eighteen samples collected from sQ1-sQ3 2021 on top of the six samples collected in sQ4 2020 (Table 3-6). Candidate wells were selected for a range of depths, yields, recharge, access and availability of historical data sets. After a minimum two-week equilibration period, the Snap Sampler was withdrawn from the well and sampled immediately prior to collecting the routine low-flow sample.

Figure 3-2: Snap Sampler assembled at surface.

Table 3-6:
Snap Sampler Trial Samples

Well ID	Date Sampled	Snap Sampler Sample ID *(Lab ID)*	Sample Time	Comparison Sample ID[1] *(Lab ID)*	Comparison Sample Method[1]	Comparison Sample Time[2]
BJ-GW11-3A	3-Jan-21	BJ-GW11-3A-snap *(VA21A0051-005)*	11:50	BJ-GW11-3A-E303056 *(VA21A0051-004)*	Sub	12:55
BJ-GW11-3A	26-Mar-21	Snap failed[3]	-	BJ-GW11-3A-E303056 *(VA21A5837-001)*	Sub	15:30
BJ-GW11-3A	20-Jun-21	BJ-GW11-3A-snap *(VA21B2508-001)*	14:00	BJ-GW11-3A-E303056 *(VA21B2508-002)*	Sub	15:50
BJ-GW11-3A	22-Sep-21	BJ-GW12-3A-snap *(VA21C0998-001)*	9:55	BJ-GW11-3A-E303056 *(VA21C1212-001)*	Sub	10:35
BJ-GW12-8A	27-Jan-21	BJ-GW12-8A-snap *(VA21A1647-001)*	10:22	BJ-GW12-8A-E303059 *(VA21A1647-002)*	Sub	12:45
BJ-GW12-8A	23-Apr-21	BJ-GW12-8A-snap *(VA21A7804-001)*	9:20	BJ-GW12-8A-E303059 *(VA21A7804-002)*	Sub	11:30
BJ-GW12-8A	21-Jun-21	BJ-GW12-8A-snap *(VA21B2626-001)*	9:35	BJ-GW12-8A-E303059 *(VA21B2626-002)*	Sub	10:30
BJ-GW12-8A	17-Oct-21	BJ-GW12-8A-snap *(VA21C3094-001)*	10:40	BJ-GW12-8A-E303059 *(VA21C3094-002)*	Sub	13:30
BJ-GW12-8B	28-Jan-21	BJ-GW12-8B-snap *(VA21A1808-001)*	10:50	BJ-GW12-8B-E314695 *(VA21A1808-002)*	Sub	12:40
BJ-GW12-8B	22-Apr-21	BJ-GW12-8B-snap *(VA21A7683-004)*	13:50	BJ-GW12-8B-E314695 *(VA21A7683-003)*	Sub	15:40
BJ-GW12-8B	27-May-21	BJ-GW12-8B-snap *VA21B0558-001)*	9:50	BJ-GW12-8B-E314695 *(VA21B0558-002)*	Sub	11:45
BJ-GW12-8B	17-Oct-21	BJ-GW12-8B-snap *(VA21C3094-001)*	11:20	BJ-GW12-8B-E314695 *(VA21C3094-004)*	Sub	15:35
BJ-GW18-17A	24-Jan-21	BJ-GW18-17A-snap *(VA21A1383-002)*	12:00	BJ-GW18-17A-E303066 *(VA21A1383-002)*	Ben	16:00
BJ-GW18-17A	27-Apr-21	BJ-GW18-17A-snap *(VA21A6199-002)*	8:55	BJ-GW18-17A-E303066 *(VA21A8275-002)*	Ben	13:05
BJ-GW18-17A	26-May-21	BJ-GW18-17A-snap *(VA21B0395-001)*	13:40	BJ-GW18-17A-E303066 *(VA21B0395-002)*	Ben	12:45
BJ-GW18-17A	8-Oct-21	Snap failed[3]	14:30	BJ-GW18-17A-E303066 *(VA21C2526-002)*	Ben	15:35
BJ-GW18-17B	30-Dec-20	BJ-GW18-17B-snap *(VA21A0005-001)*	13:30	BJ-GW18-17B-E314701 *(VA21A0475-001)*	B	09:55
BJ-GW18-17B	31-Mar-21	BJ-GW18-17B-snap *(VA21A6199-002)*	11:05	BJ-GW18-17B-E314701 *(VA21A6365-001)*	B	9:40
BJ-GW18-17B	26-Jul-21	BJ-GW18-17B-snap *(VA21B5469-001)*	10:00	BJ-GW18-17B-E314701 *(VA21B5926-001)*	Sub	14:00
BJ-GW18-17B	14-Sep-21	BJ-GW18-17B-snap *(VA21C0111-001)*	14:30	BJ-GW18-17B-E314701 *(VA21C0275-001)*	Sub	16:25
BJ-GW18-18B	9-Jan-21	BJ-GW18-18B-snap *(VA21A0475-002)*	11:25	BJ-GW18-18B-E314702 *(VA21A0475-003)*	Sub	12:30
BJ-GW18-18B	30-Mar-21	Well Dry	-	BJ-GW18-18B-E314702	Well Dry	-
BJ-GW18-18B	23-May-21	BJ-GW18-18B-snap *(VA21B0116-001)*	9:35	BJ-GW18-18B-E314702 *(VA21B9857-002)*	Sub	13:00
BJ-GW18-18B	11-Sep-21	BJ-GW18-18B-snap *(VA21B9857-001)*	14:20	BJ-GW18-18B-E314702 *(VA21C5014-001)*	Sub	16:15
BJ-GW18-19B	31-Jan-21	Well Dry	-	Well Dry	Sub	-
BJ-GW18-19B	3-Apr-21	Well Dry	-	Well Dry	-	-
BJ-GW18-19B	18-Jul-21	Snap failed[4]	-	BJ-GW18-19B-E314703 *(VA21B4774-005)*	Ben	15:45
BJ-GW18-19B	18-Aug-21	Snap failed[4]	-	BJ-GW18-19B-E314703 *(VA21B7639-001)*	Ben	13:35

Notes:
1. Sub = Redi Flo2 submersible pump, Ben = Bennett Pump (piston flow), B = Bailer
2. Low-flow comparison samples were collected immediately after the Snap Sampler, except for: BJ-GW18-17A (sQ1), where the comparison sample was collected on April 27, 2021; BJ-GW18-17B (sQ1), where comparison sample was collected April 5, 2021; BJ-GW18-17B (sQ2), where comparison sample was collected on July 29, 2021; BJ-GW12-3A (sQ3) where comparison sample was collected on September 23, 2021; BJ-GW18-17B where comparison sample was collected on September 15, 2021
3. Snap failure related to freezing of line/pressurization failure.
4. Snap failure related to hole in line or failure of seal.

3.2.3.3 Monitoring Well Development and Monitoring Network Evaluation

In 2021, Lorax advised Pretium staff to suspend development and prioritize water level monitoring at seven of the 2018 series monitoring wells due to persistent elevated pH, likely resulting from water contact with cement grout (Pohlmann and Alduino, 1992). Table 3-7 summarizes purge volumes and pH measurements current to the end of sQ3 2019 and additional discussion is provided in the 2020 Groundwater Monitoring Report (Lorax, 2021).

Subsequently, Lorax developed an updated numerical groundwater model in support of the 2020 Mine Plan and Reclamation Program Update (Lorax 2020b in Pretium 2020c). The updated model featured higher resolution discretization of the model domain and benefitted from a longer calibration period which included groundwater level and mine dewatering data collected until the end of 2018. With an improved conceptualization of mine developments at closure, the 2020 groundwater model predicts a narrower trajectory of contact water flowpaths from the flooded mine towards Brucejack Creek. The broader trajectory of contact water flowpaths west of the Brucejack Fault simulated by the 2015 groundwater model (BGC, 2015a), and the basis for the water quality monitoring requirements in many of the 2018-series wells, is not supported by the 2020 model. Eight of the groundwater wells installed in 2018 are not correctly located to intercept mine contact water at closure, the purpose for which they were installed.

In light of the model findings, Pretium has applied for an amendment to PE-107835 to revise the scope of groundwater quality monitoring at the 2018-series monitoring wells. This amendment was submitted to BC MECCS on February 10th, 2022, and includes a technical report outlining rationale for a streamlined groundwater quality monitoring scope (Lorax 2022).

3.3 Well Decommissioning and Maintenance

No groundwater wells were decommissioned or repaired in 2021.

Table 3-7: Well development status

Well ID	GWQ Monitoring[1]	Development Status	Well Depth (m bgs)	Filter Pack (m bgs)		GWL[2] (m bgs)		Bore Volume[2,3] (L)		Volume Purged to Date (L)	Bore Volumes[3] Purged (L)		pH
				Top	Bottom	Min	Max	Min	Max		Min	Max	
BJ-GW18-17A	Q	✓	147.7	142.1	148.1	*113.6*	*76.7*	*80*	*150*	1300	*9*	*16*	8.5-9
BJ-GW18-17B	Q	✓	75.3	72.1	75.8	72.9	41.1	12	73	281	4	24	8.7
BJ-GW18-18A	Q	Incomplete	101.0	95.5	101.3	*98.6*	*37.8*	*12*	*133*	405	*3*	*35*	>12
BJ-GW18-18B	Q	✓	65.0	61.5	65.6	51.5	7.5	35	117	2500	21	71	8.4
BJ-GW18-19A	Q	Incomplete	196.6	191.8	196.9	*171.2*	*157.4*	*61*	*87*	1350	*16*	*22*	12
BJ-GW18-19B	Q	✓	158.5	154.9	159.5	*155.8*	*126.6*	*13*	*70*	1220	*18*	*93*	<9 (8.1)
BJ-GW18-20A	B	Incomplete	167.1	159.9	167.5	*93.6*	*51.9*	*157*	*235*	2899	*12*	*18*	10
BJ-GW18-20B	B	Incomplete	117.7	113.3	118.5	*89.4*	*49.5*	*66*	*139*	1490	*11*	*23*	12
BJ-GW18-21A	B	Incomplete	204.5	193.5	204.8	*190.3*	*98.3*	*59*	*229*	265	*1.2*	*4.5*	3 to 7
BJ-GW18-21B	B	Incomplete	159.2	152.1	159.5	*150.8*	*126.9*	*37*	*81*	141	*1.7*	*3.8*	12
BJ-GW18-22A	NR	Incomplete	378.7	369.6	379.0	*136.7*	*117.0*	*475*	*511*	313	*0.6*	*0.7*	12.2
BJ-GW18-22B	NR	✓	87.5	83.0	87.8	*86.3*	*76.7*	*6*	*33*	186	*6*	*32*	8.1
BJ-GW18-23A	Q	✓	29.0	25.3	29.7	4.3	2.6	57	60	1055	18	19	7.8
BJ-GW18-23B	Q	✓	10.8	7.6	11.3	4.2	3.1	22	24	160	7	7	8

Notes:
Red text indicates well is not suitable for groundwater quality monitoring.
1. PE-107835 groundwater quality monitoring requirement; Q = quarterly; B = biannual; NR = not required (water level monitoring only).
2. *Italicised* numbers indicate full seasonal range in water levels not yet captured, seasonal range in borehole volumes (and range in purged volumes) may be larger. Volumes computed based on water levels collected until the end of December 2020.
3. Includes volume of water column inside casing and sand pack porosity.

4. Groundwater Quantity

4. Groundwater Quantity

4.1 Mining Operations and Water Management

A total of 1,415 kt of ore was produced at the Brucejack Mine during 2021. The base of the VOK zone workings was extended from 1038 m asl to 1015.5 m asl over the course of the year, with a maximum depth of 528.5 m bgs (Table 4-1). In the West Zone, approximately 150 m was mined at the 1320 ramp, while approximately 50 m was mined at the 1350 ramp in 2021. The 2021 West Zone development extends to 1278 m asl (150 m bgs); historical workings remain deeper than new developments (Table 4-1). Recently mined areas in the West Zone lie above the water level maintained in the workings (1,185 m asl) and are unlikely to have created water.

Mine dewatering is conducted to allow excavation of new workings, with water directed to the water treatment plant (WTP). The water level in the previously developed West Zone workings was maintained between 1,275 and 1,290 m asl in 2021. In the VOK, water is pumped from a series of sumps above and below the VOK 1300 m sump from where it is directed to the WTP.

Table 4-1:
Extent of Brucejack mine underground workings.

Mine Area	End of 2020	End of 2021	Projected End of Mine
VOK			
Max Elevation (m asl)	1,480	1,480	1,535
Min Elevation (m asl)	1,038	1,015.5	990
Max Depth (m bgs)	506	528.5	550
West Zone			
Max Elevation (m asl)	1,369	1,369	1,385
Min Elevation (m asl)	1,154	1,154	1,040
Max Depth (m bgs)	263	263	355

4.2 Underground Mine Dewatering

Underground dewatering rates attributed solely to groundwater are derived from daily measurements of underground influent to the WTP. These values are adjusted to account for water recirculated to the underground for drilling, dust suppression and washing. The recirculated water is reported as flow to the underground waterbox and is also recorded daily. For reporting purposes, it is assumed that all flow to the underground waterbox eventually reports back to the WTP, however Pretium staff indicate some of this water is lost to the mill (with ore) or to the WRTSF (with waste rock). Accordingly, calculated dewatering rates attributed solely to groundwater may be slightly underestimated.

Daily underground dewatering rates for 2021 are presented in conjunction with precipitation data in Figure 4-1. Annually, underground flow rates are higher during the open water season when precipitation reports as rainfall. Underground low flows fluctuated around 500 m^3/d in April 2021 with a few days reporting net negative flows (*i.e.*, more water sent underground for drilling than pumped back to surface). Underground dewatering rates remained low through May and rose sharply in response to a large (72 mm) rainfall event that occurred May 31st through June 2nd. Underground dewatering rates peaked on June 2nd at 4,200 m^3/d. A second peak of similar magnitude was experienced on June 29th following several days of warm weather (daily average temperature exceeding 10ºC) which melted the remaining snowpack. Dewatering rates stabilized around 2,500 m^3/d in August and September and declined through the fourth quarter to sub 1,000 m^3/d in December 2021.

The daily underground dewatering record indicates flashiness that is partly attributed to precipitation and is inferred to also be influenced by mining rate, mining elevation, ground conditions and/or other operational artefacts. Similar rapid upticks in dewatering rates in response to heavy rainfall events have been noted previously (Lorax 2020a, 2021), suggesting a component of fracture driven flow to the underground.

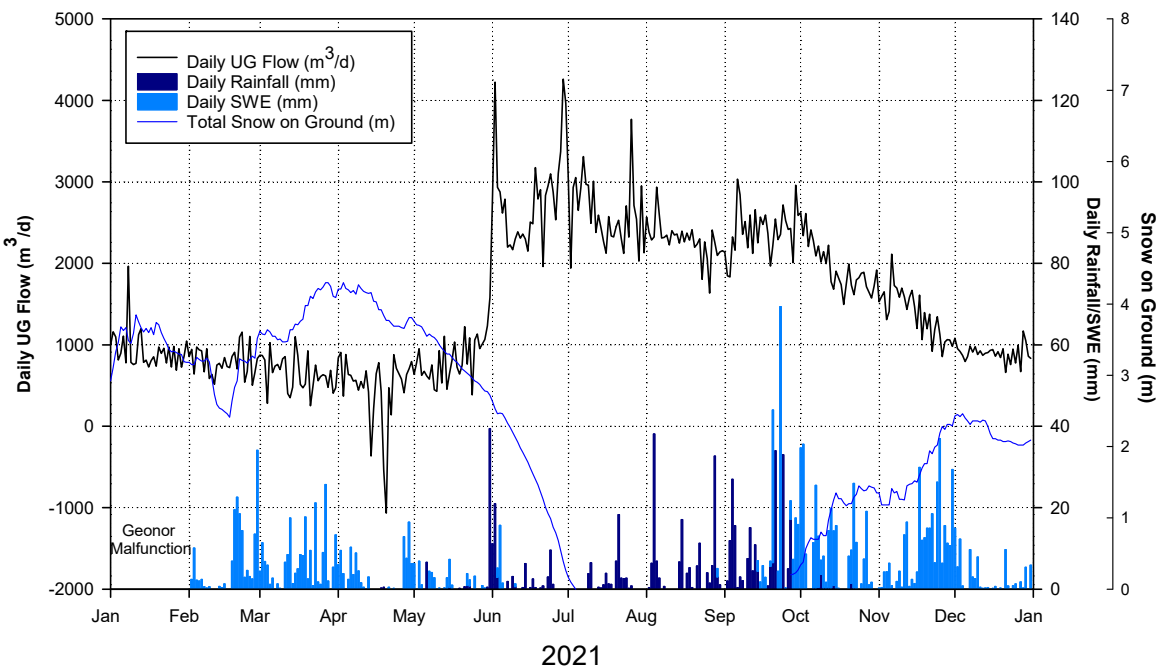


Figure 4-1: 2021 daily underground dewatering rates and daily rainfall and snow water equivalent.

Figure 4-2 shows monthly underground dewatering rates since 2013. A repeating series of monthly average underground dewatering over the 2013 to 2020 period is shown for

reference. Monthly average low flow dewatering rates measured in April 2021 (446 m^3/d) were slightly below low flow rates from prior years which ranged from 550 to 750 m^3/d. Peak monthly dewatering rates in June 2021 reached an all-time high of 2,800 m^3/d. Despite the large rainfall event which caused the June 2nd dewatering peak (Figure 4-1), total precipitation in June 2021 was slightly below average (Table 2-1). Further, May to September 2021 rainfall was about 10% less than the equivalent period in 2020. This supports the assertion that increased open water season dewatering rates are being influenced by the expanding mine development as much, if not more, than by climate.

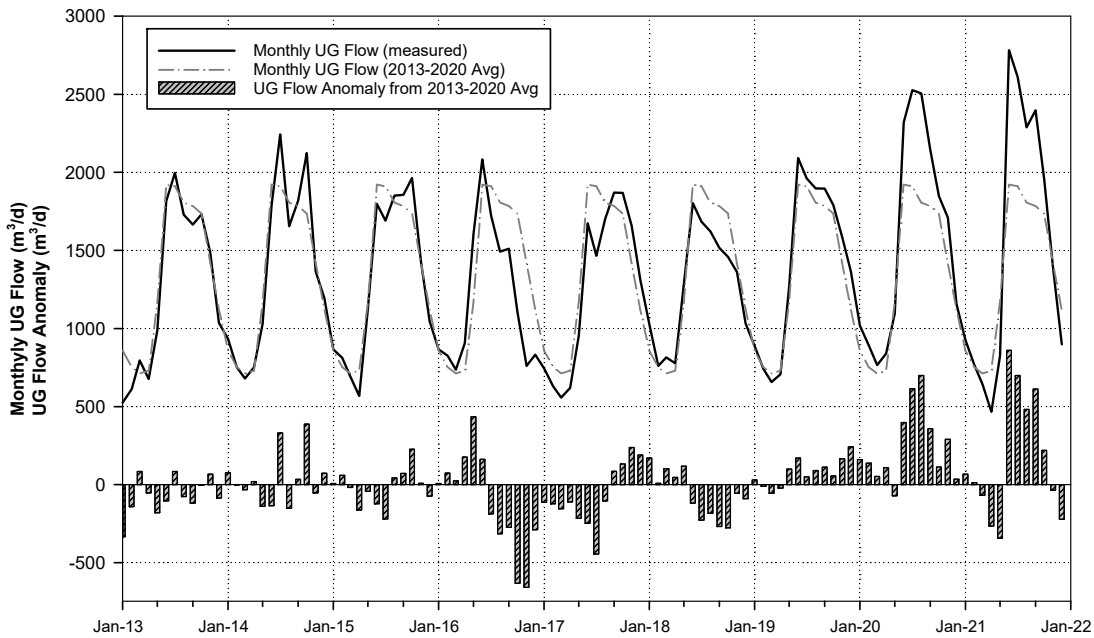
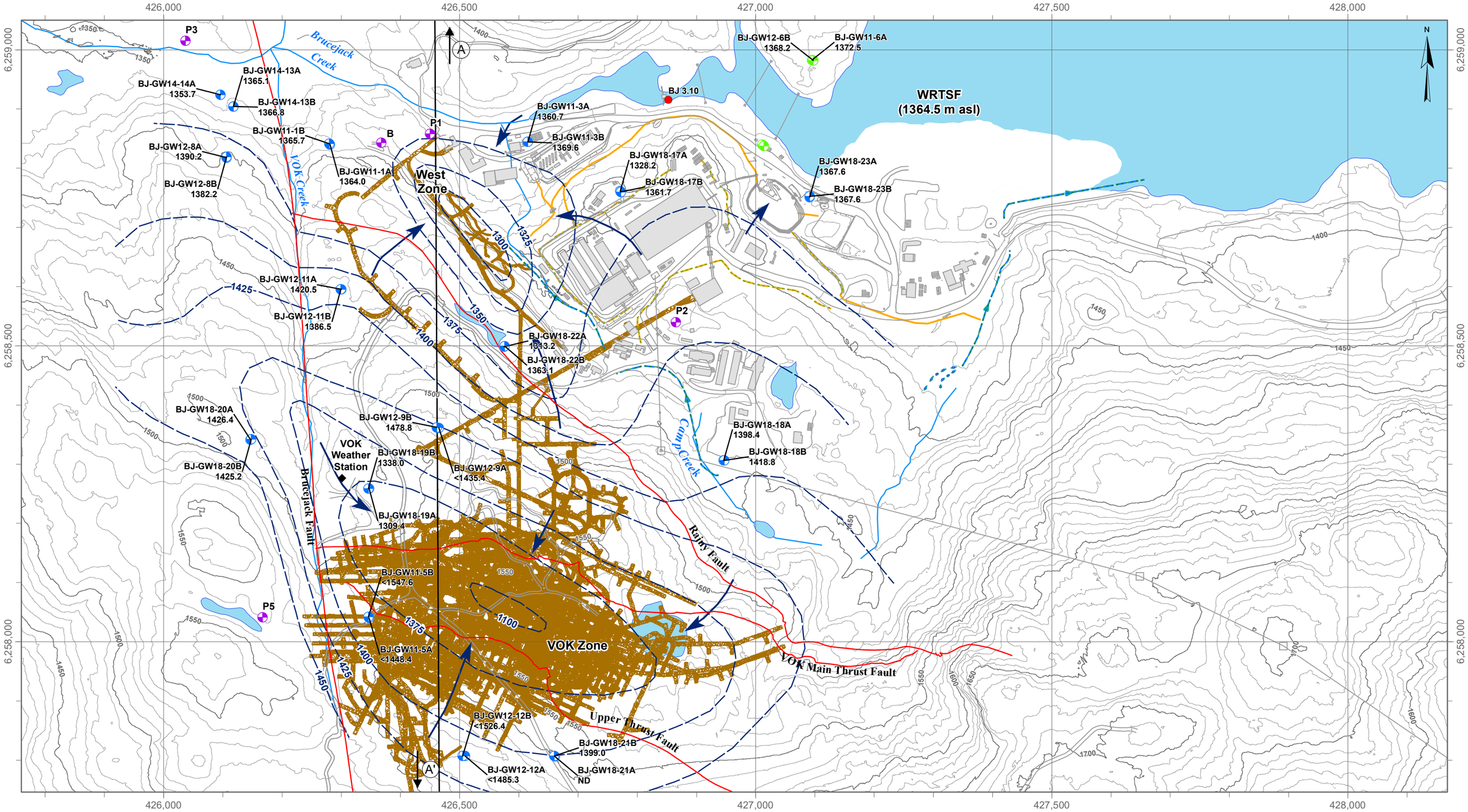


Figure 4-2: Monthly underground dewatering rates between 2013 and 2021.

4.3 Groundwater Elevations

4.3.1 Overview

Groundwater level data have been collected at the mine on a nearly continuous basis since the end of 2012. Water level hydrographs for all current groundwater monitoring wells are provided in Appendix F. Contoured water level data from high flow (June 15th, 2021) and low flow (April 15th, 2021) periods are presented in Figure 4-3 and Figure 4-4, respectively. The groundwater level contours were constructed with emphasis given to water levels measured at the shallow well of the nested pair, noting that all Brucejack wells are completed in bedrock (Table 3-1, Appendix A). A cross-section along A-A', populated with June 2021 water levels, is provided in Figure 4-5. The discussion below provides a brief overview of baseline conditions, an interpretation of the 2021 groundwater head distribution followed by an analysis of trends by mine area.



LEGEND

- Monitoring Well (currently monitored under PE-107835)
- Monitoring Well (currently monitored, not required by PE-107835)
- GW Monitoring Installation (Proposed)
- Hydrometric Station
- Weather Station
- Fault
- Hydraulic Head Contour (25m)
- Groundwater Flow Direction
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Building Infrastructure
- 2021 Underground Workings (As-Built)
- Surface Contour (50m)
- Surface Contour (10m)

<###: Dry Well
ND: No Data
(?): Suspect Data

DATE SAVED:	Apr 16, 2022
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:6,000

0 100 200 Meters

CLIENT: NEWCREST

LORAX ENVIRONMENTAL

TITLE:

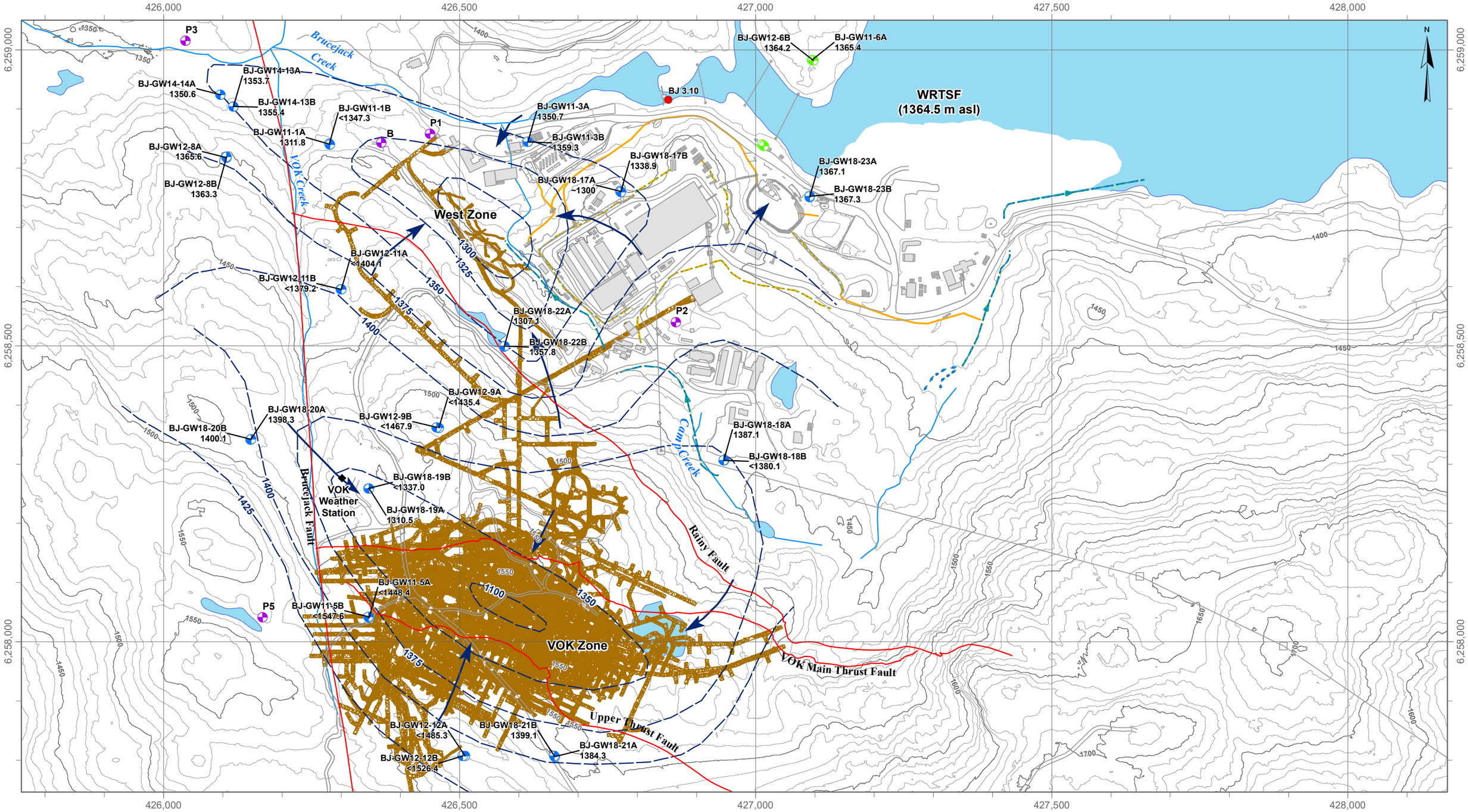
June 2021 Hydraulic Head Contours

PROJECT: 2021 Groundwater Monitoring Report

PROJECT #: A624-2

FIGURE: 4-3

P:\@Drafting\Brucejack\Drafting Figures\MXD\2021 Groundwater Report\Fig 4-3_Interpreted Hydraulic Head Contour Map_June2021_20220317.mxd



LEGEND

- Monitoring Well (currently monitored under PE-107835)
- Monitoring Well (currently monitored, not required by PE-107835)
- GW Monitoring Installation (Proposed)
- Hydrometric Station
- Weather Station
- Fault
- Hydraulic Head Contour (25m)
- Groundwater Flow Direction
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Building Infrastructure
- 2021 Underground Workings (As-Built)
- Surface Contour (50m)
- Surface Contour (10m)

<###: Dry Well
ND: No Data
(?): Suspect Data

DATE SAVED:	Apr 16, 2022
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:6,000

0 100 200 Meters

CLIENT: NEWCREST

LORAX ENVIRONMENTAL

TITLE:

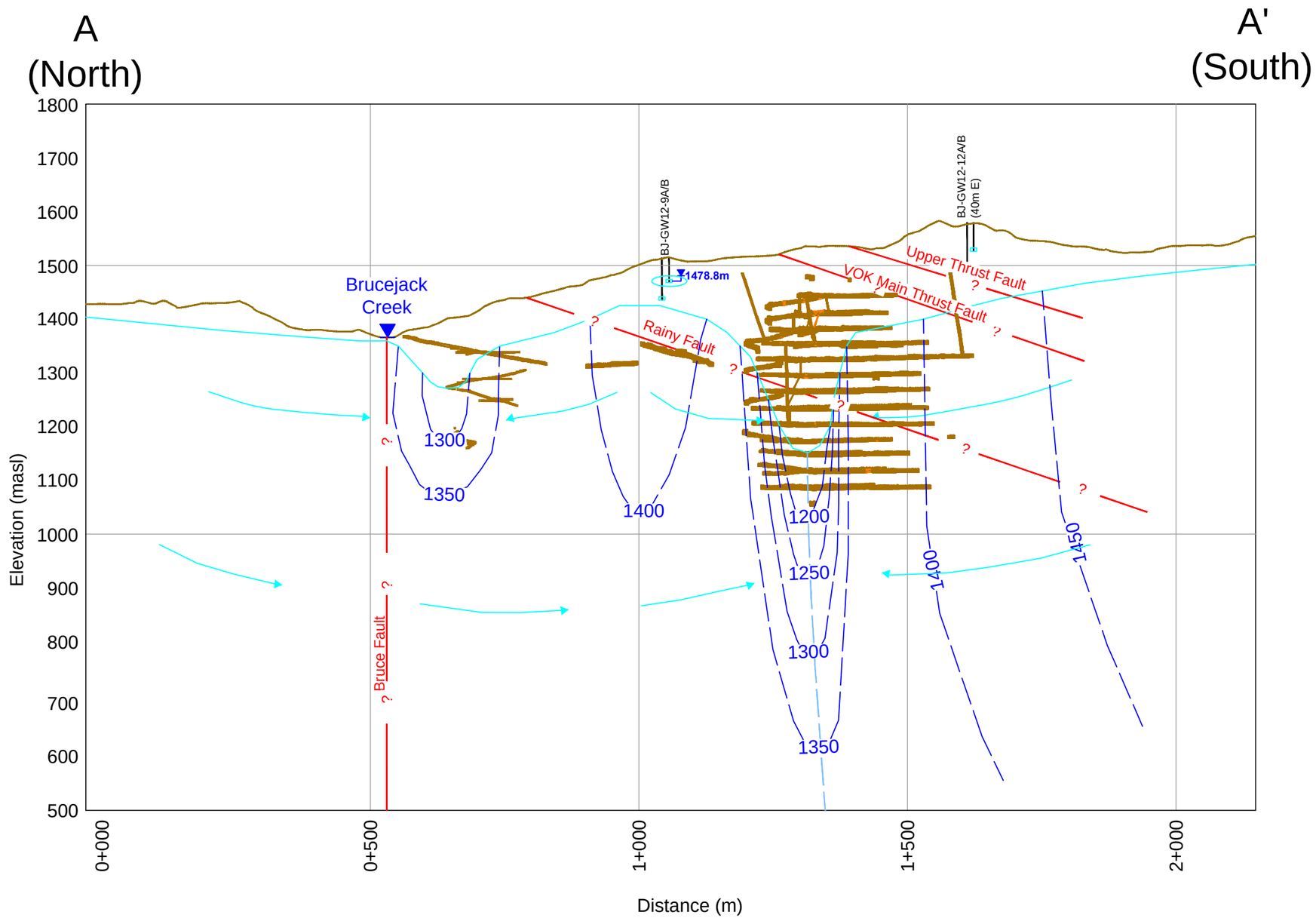
April 2021 Hydraulic Head Contours

PROJECT: 2021 Groundwater Monitoring Report

PROJECT #: A624-2

FIGURE: 4-4

P:\@Drafting\Brucejack\Drafting Figures\MXD\2021 Groundwater Report\Fig 4-4_Interpreted Hydraulic Head Contour Map_Apr2021_20220317.mxd



LEGEND

- Pre-mining Topography
- Hydraulic Head Contour
- Water Table (2021)
- Water Table (Baseline)
- Groundwater Flow Path
- GW Divide
- Workings (2021)
- Fault (Inferred)
- Borehole
- Screen
- Water Level (June 2021)

Note: Only workings within 100m of the cross section are shown.

DATE SAVED:	Mar 30, 2022
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

CLIENT: NEWCREST

LORAX ENVIRONMENTAL

PROJECT: **2021 Groundwater Monitoring Report**

TITLE: Section A-A' with June 2021 Water Levels

PROJECT #: A624-2

FIGURE: 4-5

P:\@Drafting\Brucejack\Drafting Figures\Autocad Figures\Cross Sections\2019 Groundwater Report\CS_A-A_20220317.dwg

4.3.2 Baseline

A description of the baseline groundwater system is provided in BGC (2014). Prior to mine dewatering, groundwater levels in the mine area were observed to follow topography, becoming deeper at higher elevations. Strong seasonal variations in groundwater levels were observed, particularly at higher elevations, indicating a snowmelt/precipitation-driven groundwater level hydrograph. Peak groundwater levels were observed in response to freshet and summer/fall storm events. Recharge beneath glaciers and in response to seasonal glacial melt was also identified as an unquantified contributor to groundwater recharge. Groundwater discharge zones are pervasive in the high-topography landscape, and include lakes, creeks, gullies, seeps, and breaks in slope.

4.3.3 Operations

4.3.3.1 Groundwater Level Surface

Continuous dewatering of the historical and current underground mine has occurred since August 2012. This has resulted in a depression of the water table in West Zone and VOK footprint areas and farther afield. The June and April 2021 water level contour plots reveal a similar groundwater level configuration, with June 2021 water levels 25 m to 50 m higher than April 2021 (Figure 4-3, Figure 4-4).

For wells where 2012 baseline data exist, annual drawdown based on June water levels has been computed (Table 4-2). Wells completed adjacent to the VOK (BJ-GW11-5A/B, BJ-GW12-12A) have experienced the most drawdown, with screens becoming desaturated during or before 2018. Water level data collected at nearby 2018-series monitoring wells (BJ-GW18-19A/B, BJ-GW18-21A/B) suggest that drawdown in the area of BJ-GW11-5A/B and BJ-GW12-12A exceeds 100 m; this is also supported by results from the 2020 model update (Lorax, 2020b).

A steep drawdown curve is expected within the footprint of the VOK workings itself, as the groundwater level is likely approaching the maximum depth of the workings (1,015.5 m asl). Slightly north of the VOK, shallow well BJ-GW12-9B (46 m deep) appears to screen a perched water table (*ca.* 1480 m asl) with the corresponding deeper well BJ-GW12-9A (76 m deep) essentially dry for the last several years (Figure 4-3, Appendix F).

Table 4-2:
Drawdown in selected monitoring wells since 2012.

Well ID	Ground Surface	Screen Top	Screen Bottom	Jun-12 (Baseline WLE)	Drawdown[2,3] (m)								
	(m asl)	(m asl)	(m bgs)	(m asl)	Jun-13	Jun-14	Jun-15	Jun-16	Jun-17	Jun-18	Jun-19	Jun-20	Jun-21[3]
BJ-GW11-1A	1385.7	78.6	84.8	1365.1	33.8	25.4	34.5	39.6	1.8	ND	1.8	1.7	1.4
BJ-GW11-1B	1385.7	35.3	38.4	1363.3	0.4	-0.2	-0.8	0.2	-0.3	4.6	0.0	2.5	-2.2
BJ-GW11-3A	1367.6	82.3	88.3	1368.4	8.4	8.7	11.1	15.3	13.1	12.3	8.9	7.4	7.7
BJ-GW11-3B	1367.5	5.8	8.8	1367.3	-2.4	-1.6	-1.6	-0.9	-0.7	-0.8	-2.0	-2.5	-2.3
BJ-GW11-5A	1526.1	68.6	77.7	1514.9	5.4	55.5	29.8	32.5	45.3	59.1*	>65.2*	ND	>65.2
BJ-GW11-5B	1526.2	41	50.2	1513.3	2.7	36.2	28.3	30.3	>35.3	>35.3	>35.3	ND	>35.3
BJ-GW11-6A	1379.8	18.9	28.1	1371.2	0.1	-1.3	-1.3	-1.2	-0.5	-0.2	-1.4	-1.4	-1.3
BJ-GW12-6B	1379.6	100.3	103.3	1368.5*	0.9	0.4	-0.2	0.5	0.4	1.4	0.7	0.3	0.3
BJ-GW12-8A	1403.4	86.2	92.3	1390.1*	0.3	-0.4	1.9	1.6	0.8	1.6	2.1	0.0	0.0
BJ-GW12-8B	1403.3	44.8	50.9	1386.3*	-0.4	-0.7	3.4	4.2	4.0	5.0	4.5	8.4	4.1
BJ-GW12-9B	1514.6	40.6	46.7	1486.2**	13.2	14.6	9.5	7.0	15.4	11.9	5.5	8.0***	7.6
BJ-GW12-11A	1433.6	26.5	29.5	1428.3*	10.6	9.1	7.5	7.5	8.2	8.5	9.4	8.0	7.7
BJ-GW12-11B	1433.0	50.7	53.8	1427.0*	14.1*	20.3	18.0	19.0	31.4	30.0	28.3	29.7	40.6
BJ-GW12-12A	1579.2	87.8	93.9	1528.3**	22.2	42.8	ND	36.1	>43	42.3	>43	ND	>43

Notes:
*Water level from July, ** Water level from August
***Water level from May
1. WLE = water level elevation, ND = no data
2. Positive values indicate drawdown, water levels preceded by ">" indicate well is dry. Negative values indicate water levels are above baseline levels.
3. Drawdown computed from water levels recorded on June 1 for years 2013 to 2020 (except where noted) and from June 15 for 2021.

The 2021 water level data indicate that groundwater is flowing towards the VOK from all directions. Both April and June water level contour interpretations depict a shallower groundwater divide between the West Zone and VOK (Figure 4-3 to Figure 4-5). At significant depth (*ca*. 500 m bgs), it is inferred that the strong depression in water levels at the VOK is causing groundwater flowpaths originating north of Brucejack Creek to bypass Brucejack Creek and deflect towards the VOK (Figure 4-5). This is supported by the findings of the groundwater model (Lorax 2020b).

Groundwater levels west of Brucejack Fault at BJ-GW18-20A/B are significantly higher than at BJ-GW18-19A/B, a well pair immediately northwest of the VOK and east of the Brucejack Fault. Water level differences between the deep (A) wells are on the order of 87 to 120 m in April and June, respectively (Figure 4-3, Figure 4-4). Water level differences between the shallow (B) wells is on the order of 87 m in June (Figure 4-3). The Brucejack Fault is inferred to be a permeable feature which is limiting the extent of drawdown west of the fault. The assumption of high permeability of the Brucejack Fault is supported by high airlift yield observed in the mine's water supply well (D3, Figure 1-1) and is supported by model findings (Lorax 2020b). The Brucejack Fault zone was intersected by mine workings in 2020 and 2021. The timing of the fault crossings and influence on mine water is currently being assessed by Pretium Environmental staff.

Water levels in the West Zone have been maintained between 1275 m asl and 1290 m asl for the last several years. Groundwater levels have declined on the order of 40 m at BJ-GW12-11B, about 170 m southwest of the West Zone, although this more likely due to the advancement of a development from the VOK towards the West Zone in 2021 (Figure 4-3). Water levels west of the West Zone at BJ-GW11-1A markedly declined by tens of meters through 2016 but have more recently recovered to baseline levels (Table 4-2). A similar trend is observed at BJ-GW11-3A, however, water levels are still depressed by several meters compared to baseline (Table 4-2,Figure 4-9). The deflection of water level contours towards BJ-GW18-17A/B suggests that this area may have an enhanced hydraulic connection to the West Zone (Figure 4-3, Figure 4-4). Water levels at BJ-GW18-17A/B are lower than the elevation of the WRTSF (1364.5 m) which suggests that the WRTSF is recharging the groundwater system. This is consistent with findings from the 2015 and 2020 groundwater models which predicted a small contribution of WRTSF water reporting to the underground workings during operations (BGC 2015a, Lorax 2020b).

4.3.3.2 Groundwater level time trends

Water level hydrographs for all monitoring wells are provided in Appendix F with selected hydrographs presented in the following sections. Underground dewatering rates and precipitation data are plotted for reference. Many hydrographs display seasonal peaks

consistent with freshet and summer precipitation events with annual minima experienced in April/May.

VOK Zone

Table 4-3 summarizes the water level and vertical gradient ranges measured at Brucejack monitoring wells in 2021. Historic monitoring wells located adjacent to the VOK (GW11-5A/B, BJ-GW12-12A/B, BJ-GW12-9A) have been essentially dry over the last two years or longer (Table 4-2). More consistent water level data from deeper monitoring wells established in 2018 are now available.

Similar to observations from historic wells, seasonal water level fluctuations at 2018-series wells completed near the VOK are on the order of tens to over 40 metres (BJ-GW18-20A,21A) (Table 4-3). On account of depressurization of the underground, a strong downward hydraulic gradient approaching unity is observed at BJ-GW18-21A/B and BJ-GW18-19A/B. Strong downward gradients were also observed in 2011-2012 era monitoring wells prior to the wells going dry (Lorax 2021, 2020a).

Water level hydrographs for selected shallow wells south (BJ-GW18-21B) and west (BJ-GW18-19B, BJ-GW18-20A) of the VOK are shown in Figure 4-6. The water level at BJ-GW18-21B is punctuated by a sharp spike near the beginning of June 2021 which coincides with a period of flooding at the wellhead, similar to that experienced in June 2020. This spike is also present in the deep well (Appendix F). Casing stickups at BJ-GW18-21A/B were extended in 2020 to prevent future ingress of surface water runoff. The stickup at BJ-GW18-21A/B will be inspected and further modified in 2022 to reduce the likelihood of future flooding events. Otherwise, the water level record at BJ-GW11-21B seems to indicate a declining trend which would be attributed to continued development of the VOK.

BJ-GW18-19B is northwest of the workings and shows water levels that were trending towards a maximum in August 2021, however, the water level did not recover after sampling in August so the full maximum may not have been captured. The incomplete record appears to suggest that water levels are declining. The seasonal minimum was not captured with the logger dry between December 2020 and June 2021 (Figure 4-6). For the period of overlap for the shallow and deep well logger data (Appendix F), a downward gradient approaching 100% is present (Table 4-3).

Nearby, the water level trend at BJ-GW12-9B shows some recovery of the shallower water table over the last three years (Figure 4-7) which is likely a result of higher precipitation from 2019-2021 compared to below average precipitation in 2016 to 2018 (Table 2-1).

Table 4-3: 2021 water level and vertical hydraulic gradient ranges in Brucejack monitoring wells

Well ID	Ground Surface (m asl)	Water Level Range (m bgs)		Water Level Range (m asl)		Range in Water Levels (m)	Range in Vertical Hydraulic Gradient[1,2] (%)		
		Min	Max	Min	Max				
BJ-GW11-1A	1,385.7	73.9	9.8	1,311.8	1,375.9	64.2	-86%	to	26%
BJ-GW11-1B	1,385.7	38.4	16.8	<1,347.3	1,368.9	21.6			
BJ-GW11-3A	1,367.6	16.9	-1.3	1,350.7	1,368.9	18.2	-12%	to	-2%
BJ-GW11-3B	1,367.5	8.2	-4.2	1,359.3	1,371.7	12.3			
BJ-GW11-5A	1,526.1	<1,448.4	<1,448.4	<1,448.4	<1,448.4	n/a	n/a		
BJ-GW11-5B	1,526.2	<1,476.0	<1,476.0	<1476.0	<1476.0	n/a			
BJ-GW11-6A	1,379.8	14.4	5.9	1,365.4	1,373.9	8.5	-7%	to	-1%
BJ-GW12-6B	1,379.6	15.4	9.1	1,364.2	1,370.5	6.3			
BJ-GW12-8A	1,403.4	37.9	11.2	1,365.5	1,392.2	26.7	5%	to	26%
BJ-GW12-8B	1,403.3	40.0	20.0	1,363.3	1,383.3	20.0			
BJ-GW12-9A	1,514.4	79.1	78.9	1,435.3	1,435.5	0.3	n/a		
BJ-GW12-9B	1,514.6	46.7	32.7	<1,467.9	1,481.9	14.0			
BJ-GW12-11A	1,433.6	29.5	12.1	<1,404.1	1,421.5	17.4	-172%	to	-114%
BJ-GW12-11B	1,433.0	53.8	46.5	<1,379.2	1,386.5	7.4			
BJ-GW12-12A	1,579.2	dry	dry	dry	dry	n/a	n/a		
BJ-GW12-12B	1,579.2	dry	dry	dry	dry	n/a			
BJ-GW14-13A[3]	1,362.5	8.8	-3.1	1,353.7	1,365.6	11.9	-38%	to	-29%
BJ-GW14-13B[3]	1,362.8	7.4	-4.5	1,355.4	1,367.3	11.9			
BJ-GW14-14A	1,352.1	1.5	-2.2	1,350.6	1,354.3	3.7	-1%	to	8%
BJ-GW14-14B	1,352.0	1.3	-0.8	1,350.7	1,352.8	2.1			
BJ-GW18-17A	1,403.9	118.1	71.6	1,285.8	1,332.3	46.5	-73%	to	-40%
BJ-GW18-17B	1,404.0	72.0	39.3	1,332.0	1,364.7	32.7			
BJ-GW18-18A	1,445.1	60.3	37.7	1,384.8	1,407.4	22.7	-63%	to	27%
BJ-GW18-18B	1,445.1	65.0	19.3	<1,380.1	1,425.8	45.7			
BJ-GW18-19A	1,495.7	186.4	181.5	1,309.3	1,314.2	4.9	-97%	to	-76%
BJ-GW18-19B	1,495.5	157.2	147.7	<1,338.3	*1,3478**	9.6*			
BJ-GW18-20A	1,493.6	97.7	48.9	1,395.9	1,444.7**	48.8**	-6%	to	8%
BJ-GW18-20B	1,493.6	95.7	44.1	1,397.9	1,449.5	51.6			
BJ-GW18-21A	1,550.3	193.2	90.7	1,357.1	1,459.6***	102.5***	-93%	to	133%
BJ-GW18-21B	1,550.3	159.2	141.9	<1,391.1	1,408.4	17.3			
BJ-GW18-22A	1,444.6	139.0	118.3	1,305.6	1,326.3	20.7	-18%	to	-12%
BJ-GW18-22B	1,444.6	87.4	76.0	<1,357.2	1,368.6	11.4			
BJ-GW18-23A	1,370.8	3.8	2.5	1,367.0	1,368.3	1.3	-2%	to	2%
BJ-GW18-23B	1,370.8	3.7	2.6	1,367.1	1,368.2	1.1			

Notes:
n/a – not applicable. Well dry for entire year.
* Maximum derived from a manual reading rather than a continuous WL record.
**Logger became over pressurized during period of seasonal maximum.
***Water level artificially increased due to ponding and ingress of meltwater at well head.
1. Hydraulic vertical gradient ranges are provided where a nearly complete WL record is available.
2. Upward gradients are positive.
3. Wells are artesian and pressurized prior to WL measurement; WL elevations and gradient may be inaccurate.

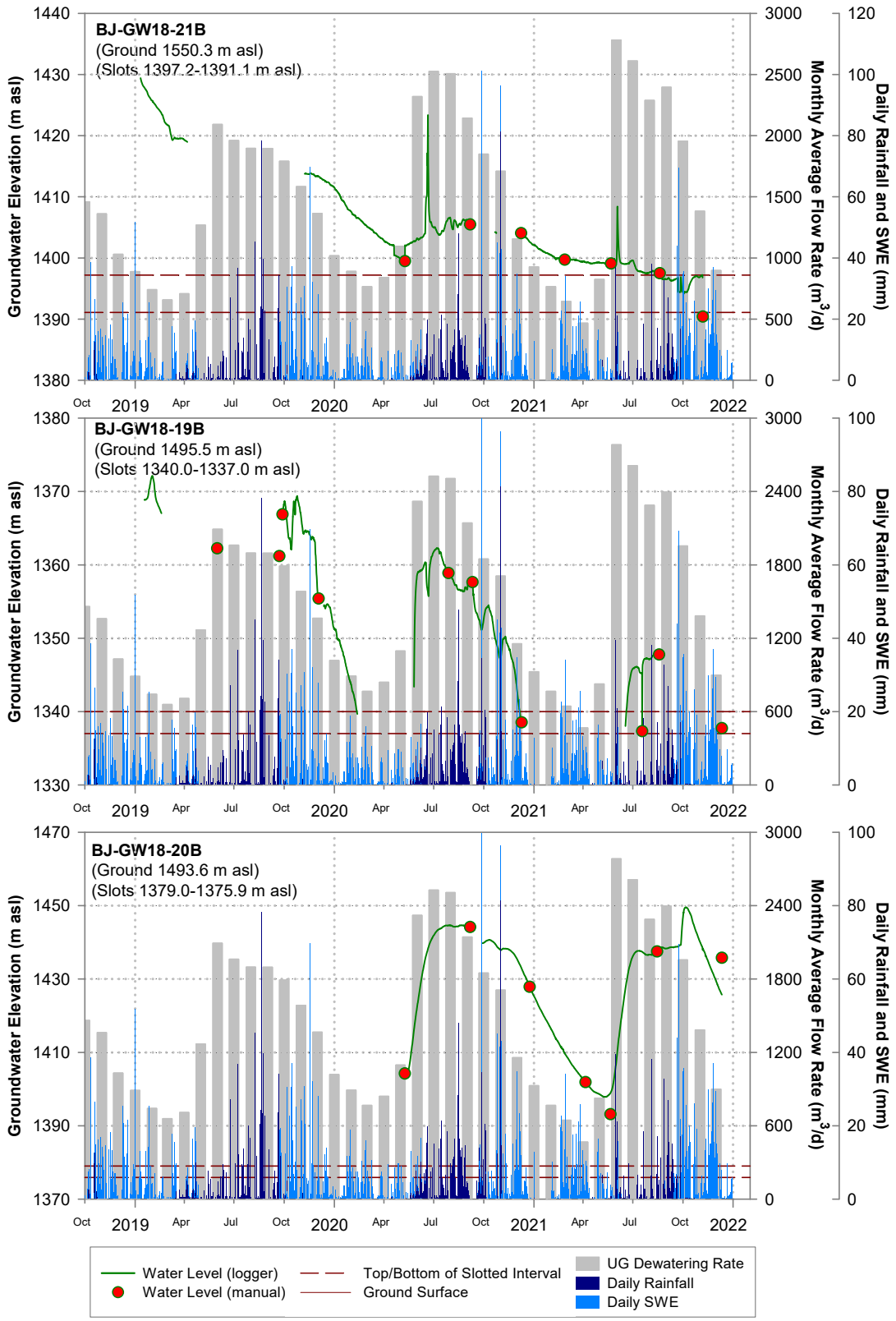


Figure 4-6: Water level hydrographs at BJ-GW18-21B, BJ-GW18-19B and BJ-GW18-20B.

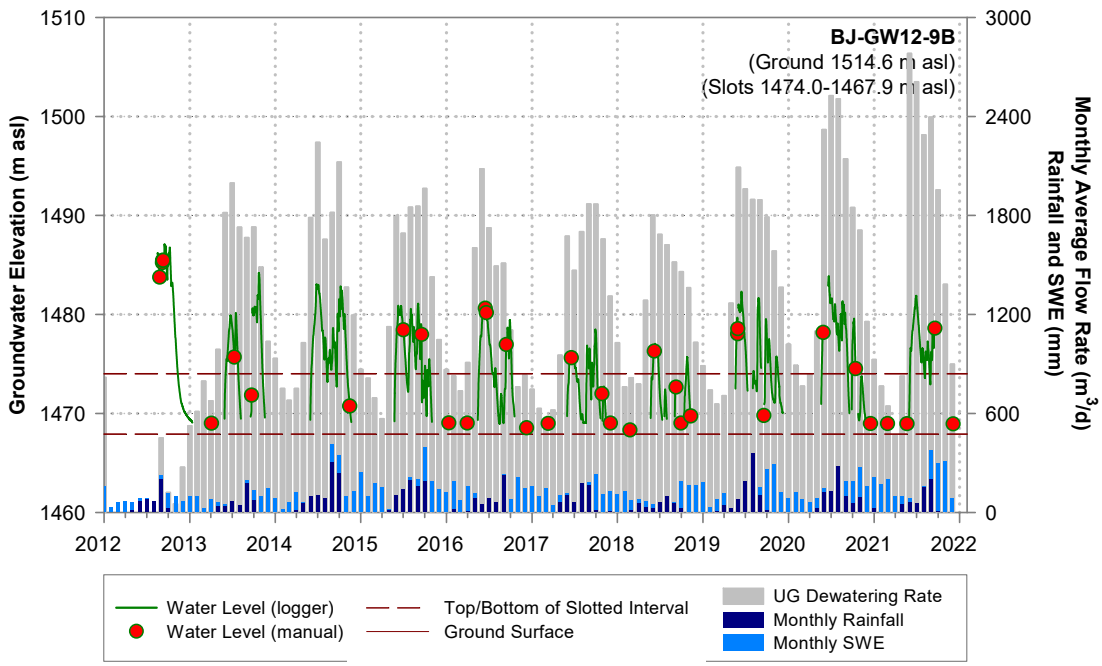


Figure 4-7: Water level hydrograph at BJ-GW12-9B.

The water level data record at BJ-GW18-20B demonstrates a minimum water level at the beginning of May and peak water levels in September/October 2021. The data record for the deeper well is of similar shape (Appendix F). Vertical hydraulic gradients at this well pair range from slightly downward (6%) to moderately upward (8%). This well pair has not shown an obvious water level response to crossing of the Brucejack fault by underground workings in 2020 and 2021. The relatively modest vertical gradients at this well pair suggest that the Brucejack fault is limiting the extent of groundwater depressurization west of the fault.

East of the VOK, well pair BJ-GW18-18A/B report upward gradients (26%) during the winter low flow period, which then switches to a downward gradient, starting in May, and persists through September (Table 4-3, Appendix F).

West Zone

The West Zone workings have been dewatered to an elevation ranging between 1,275 and 1,290 m asl for several years. Prior to 2019, monitoring of the West Zone was accomplished through several historic monitoring well pairs with maximum well depths of up to 80 m. New monitoring wells BJ-GW18-17A/B and BJ-GW18-22A/B provide water level information up to 370 m depth (Table 3-1). BJ-GW18-22A/B lies south of the West Zone along the decline to the VOK. The water level data indicate a modest downward hydraulic gradient (12-18%) and seasonal fluctuations on the order of 10 m to 20 m in the deep and shallow wells, respectively (Table 4-3).

2021 water levels measured at BJ-GW12-11A, west of the West Zone, are consistent with previous years' data. Water levels in the deeper well, BJ-GW12-11B, dropped significantly in 2021 after three years of reasonably consistent values with the water level maximum over 15 m lower than previous years (Figure 4-8). Downward vertical gradients have increased as a result and exceed 140%. Note that at this location, the "B" well is the deeper well. At this time, the downward trend in BJ-GW12-11B is thought to arise from a new development advanced from the VOK southwards towards the West Zone (Figure 4-3).

Water levels in nearby monitoring wells BJ-GW11-1A/B and BJ-GW11-3A/B started to diverge from 2018-2020 measurements, with some influence from annual precipitation trends. Water levels from BJ-GW11-1A/B, west of the West Zone portal, remain generally consistent from previous years, though peak water levels in BJ-GW11-1A were over 10 m higher than previous years on account of heavy precipitation in September/October (Appendix F, Table 2-1). A similar increase (6 m) was experienced east of the West Zone portal at BJ-GW11-3A (Figure 4-9). Water levels in the shallow well (BJ-GW11-3B) were above ground surface more consistently in 2021 than in 2019 and 2020, with the well maintaining artesian conditions late into the fall and freezing solid to the top of casing at the onset of winter. Downward hydraulic gradients at BJ-GW11-3A/B peaked in 2016 at 20% and are now in the range of 2% to 12% (Figure 4-9, Table 4-3).

Water level data from BJ-GW18-17A/B are shown in Figure 4-10. Both shallow and deep water levels are responsive to freshet and summer/fall rainfall, with similar trends to 2019 and 2020 observed. The well pair demonstrated a downward hydraulic gradient in the range of 40% to 73% over 2021 (Table 4-3).

BJ-GW12-8A/B, located west of the Brucejack Fault, responded to mine dewatering with peak water levels at the shallower well (BJ-GW11-8B) declining by ~10 m between 2013 and 2017 (Appendix F). Since then, water levels in the shallow well have remained reasonably consistent. Water levels at the deeper well (BJ-GW11-8A) have remained consistent since inception. Upward vertical gradients have generally increased since 2013, reaching a maximum of 25% in 2021 (Table 4-3).

Contact Water Pond

Nearly three years of water level data have been collected at BJ-GW18-23A/B, located directly downgradient of the Contact Water Pond (CWP). As expected, water levels at this well are strongly influenced by the controlled water level in the CWP and thus vary on the order of one meter throughout the year (Figure 4-11). Vertical gradients at this well pair are subtle and were more frequently downward (<2%) in 2021.

Background

Hydrographs from background monitoring wells BJ-GW11-6A/12-6B, BJ-GW14-13A/B and BJ-GW14-14A/B are provided in Appendix F. Continuous data from BJ-GW11-6A/12-6B indicate water levels are commensurate with previous years' data with exception to the deep well (BJ-GW11-6B) reaching a water level maximum two metres higher than previous years. Data from BJ-GW14-13A/B and BJ-GW14-14A/B are also commensurate with previous years' data. Vertical gradients and BJ-GW14-14A/B are modestly upward (<10%) for most of the year. The vertical gradient at BJ-GW14-13A/B is difficult to interpret since both wells are artesian when the loggers are downloaded and register pressures higher than the top of casing prior to the j-plug being removed. The gradient appears to be relatively constant and downward throughout the year, but the magnitude is not completely certain (Table 4-3, Appendix F).

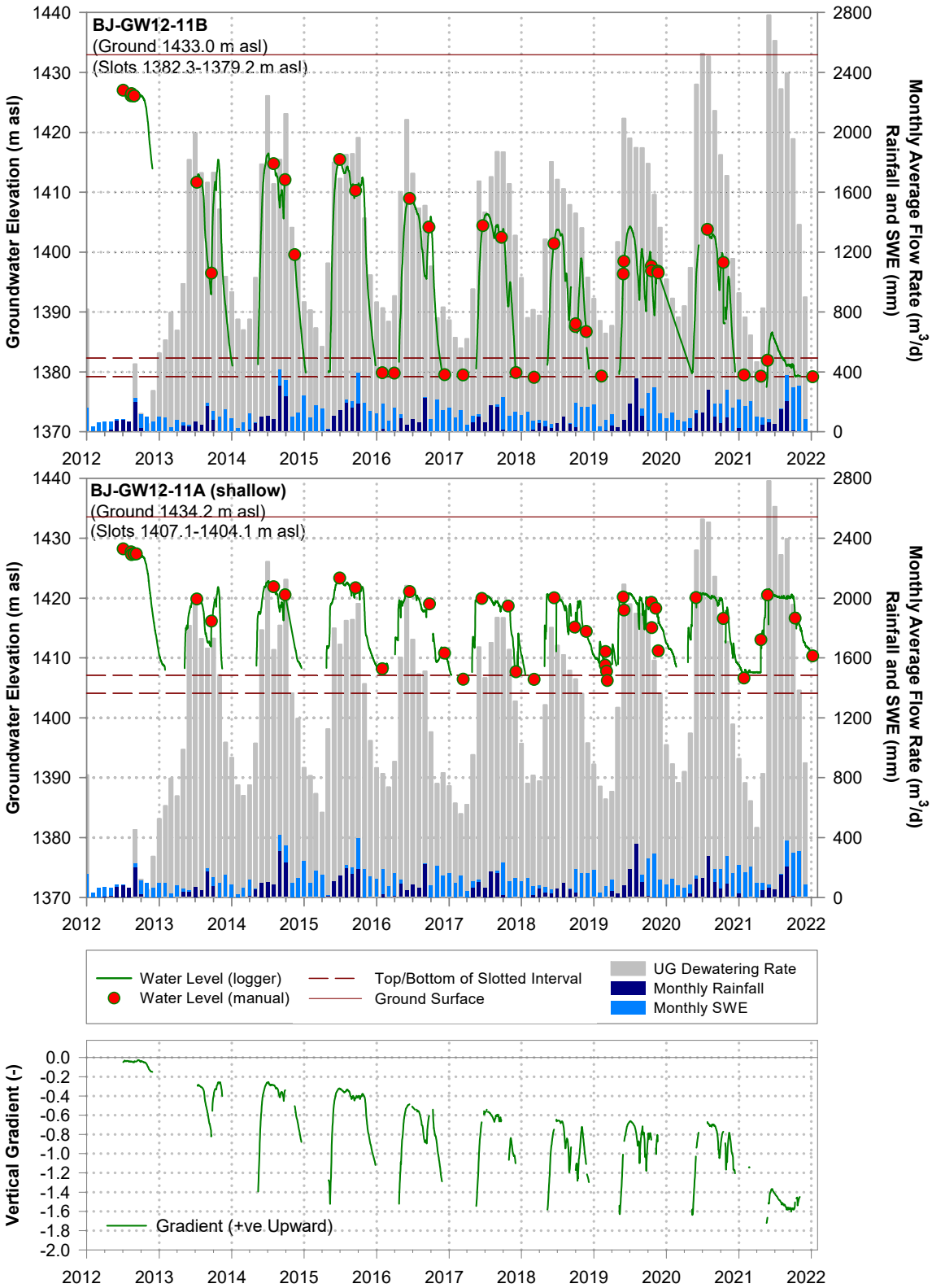


Figure 4-8: Groundwater levels and vertical gradient at BJ-GW12-11A/B.

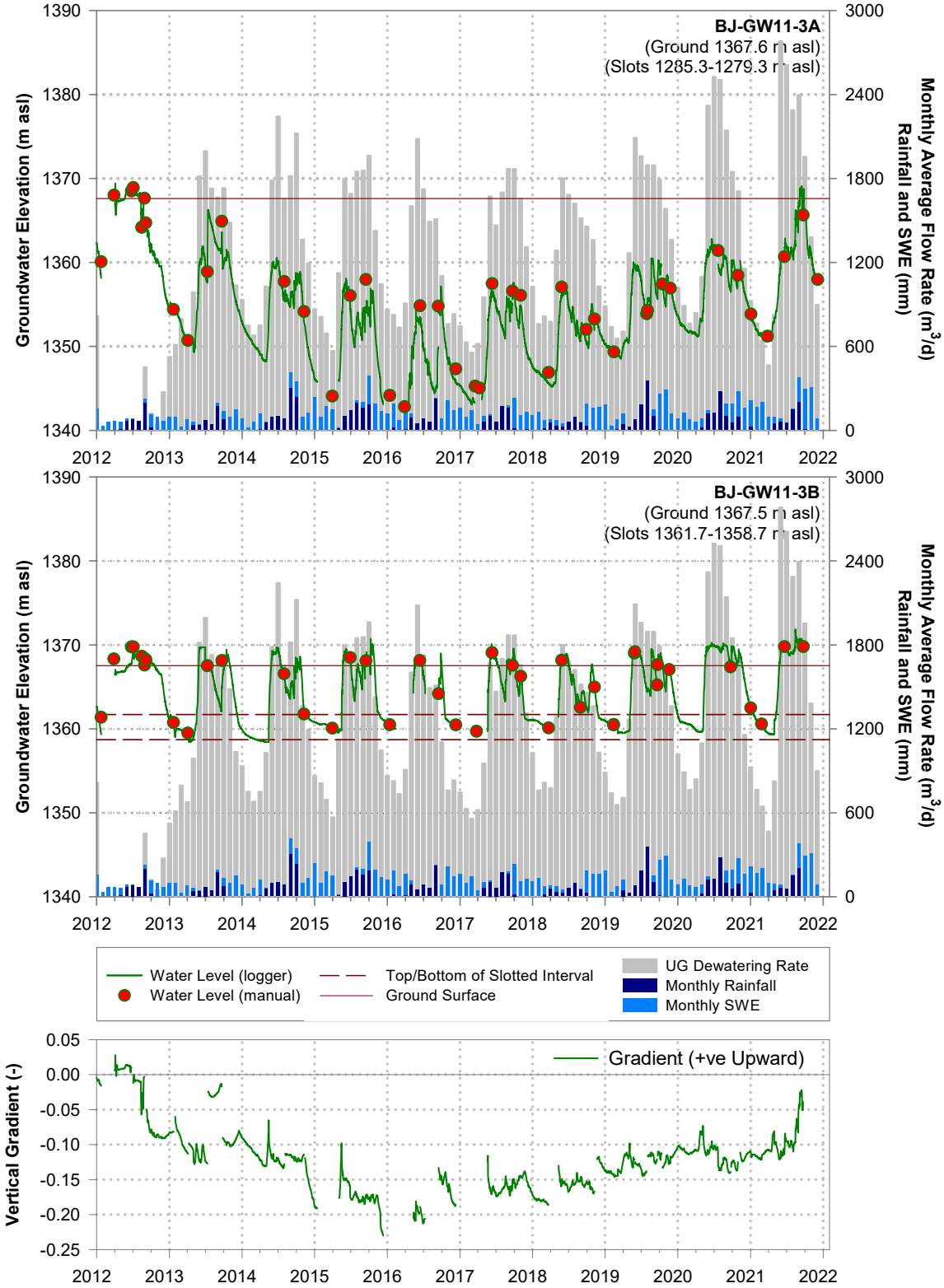


Figure 4-9: Groundwater levels and vertical hydraulic gradient at BJ-GW11-3A/B.

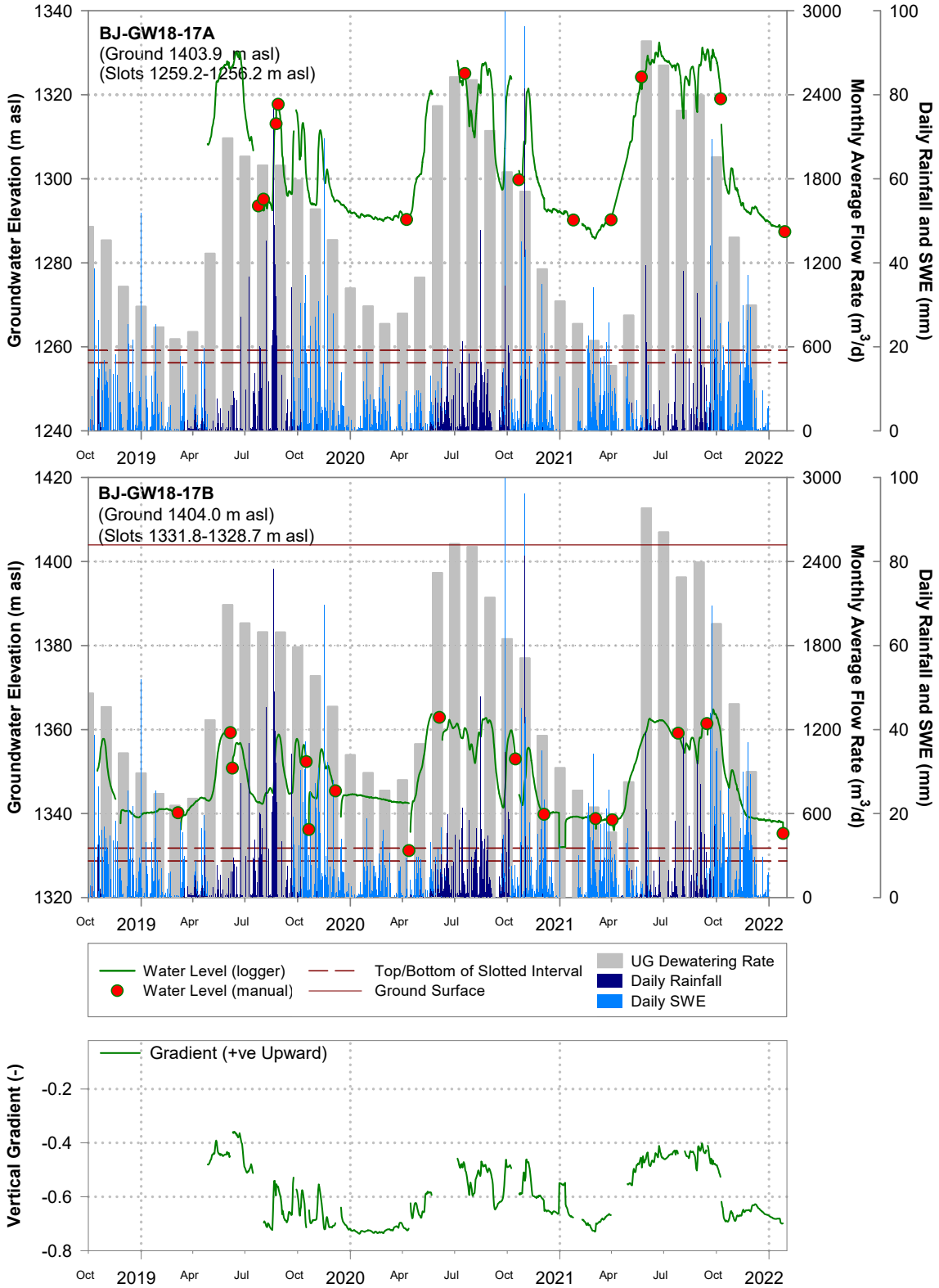


Figure 4-10: Groundwater levels and vertical hydraulic gradient at BJ-GW18-17A/B.

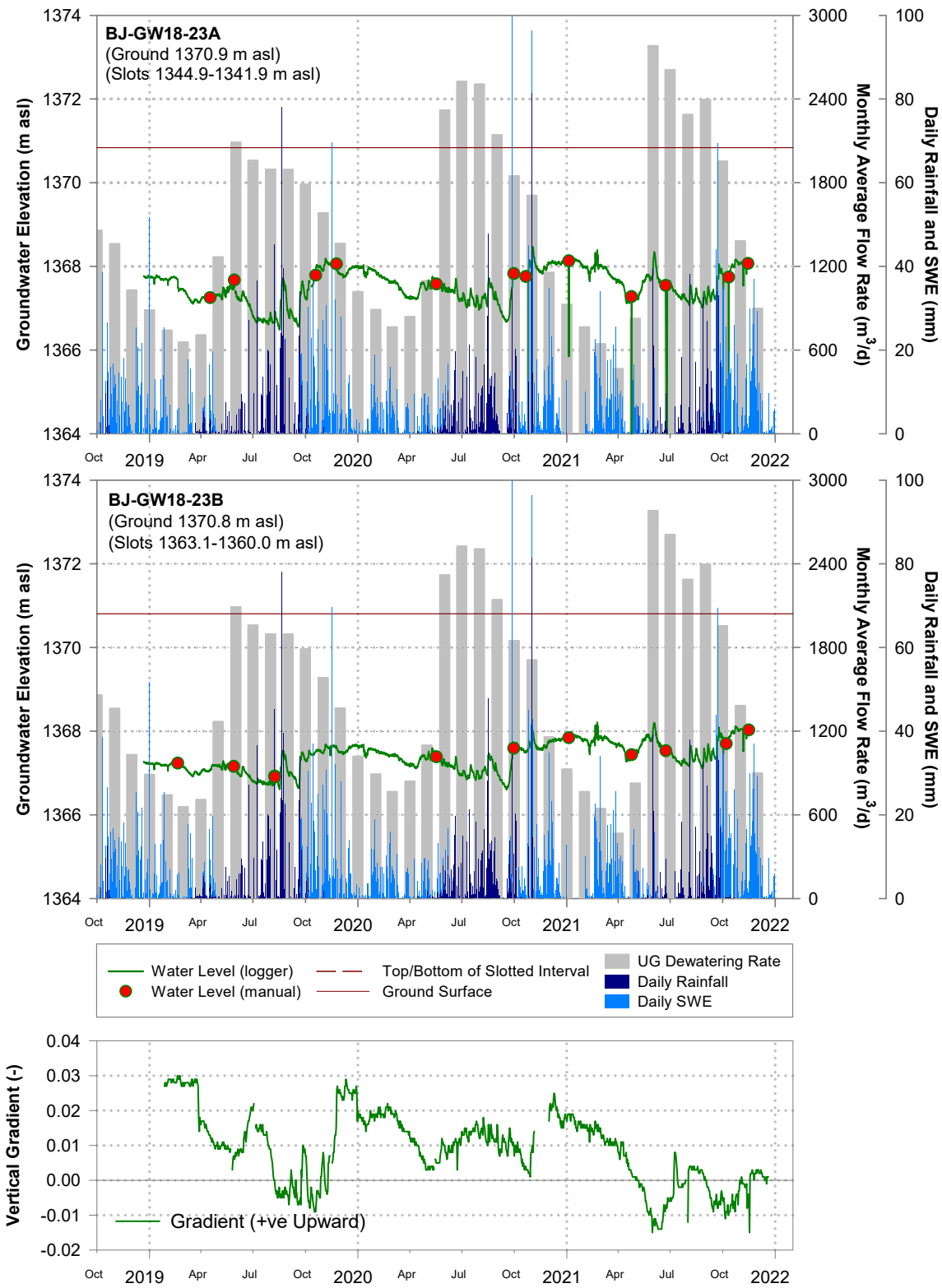


Figure 4-11: Groundwater levels and vertical hydraulic gradient at BJ-GW18-23A/B.

5. Groundwater Quality

5. Groundwater Quality

5.1 Quality Assurance and Quality Control

An extensive quality assurance/quality control (QA/QC) program was implemented for the groundwater quality monitoring program. Samples were collected, preserved, stored, transported and tested in accordance with the requirements set forth in the British Columbia Environmental Laboratory Manual (Austin, 2015) and the British Columbia Field Sampling Manual (Clark 2013). All groundwater quality samples were analysed by ALS Environmental (ALS) in Burnaby, BC. The 2021 QA/QC data is tabulated in Appendix D.

5.1.1 Field Blanks

Field blanks are used to detect potential contamination resulting from the sample collection method, handling, filtration, preservation, and exposure to the environment. Blank samples were collected by pouring de-ionized (DI) water into clean sample bottles at a well site and then processing the blank at the laboratory in the same manner as other samples.

One field blank was collected in sQ1 and sQ4 of 2021, with two field blanks collected in sQ3 of 2021. Field blanks were analyzed for general parameters, anions, nutrients, total and dissolved metals. Overall, most analytes in field blank samples reported below method detection limit (MDL) with the exception of parameters listed in Table 5-1. The field blank sample from sQ1, sQ3 and sQ4 had four, three and one detection(s) above the MDL, respectively, with four being less than double the lowest detection limit. All dissolved metals detected were notably lower than the co-located samples collected and as such, do not represent concerns for sample contamination.

Table 5-1:
Analyte detections in 2021 field blank samples

Sampling Period	Parameter	Unit	MDL (mg/L)	Result
sQ1	Hardness (as CaCO3), dissolved	mg/L	0.50	1.6
	Aluminum, dissolved	mg/L	0.0010	0.0011
	Calcium, dissolved	mg/L	0.050	0.641
	Strontium, dissolved	mg/L	0.00020	0.00036
sQ3 (1)	Acidity (as CaCO3)	mg/L	2.0	2.1
	Barium, dissolved	mg/L	0.00010	0.001
	Copper, dissolved	mg/L	0.00020	0.00063
sQ4	Acidity (as CaCO3)	mg/L	2.0	2.3

5.1.2 Travel Blanks

Travel blanks are used to assess the likelihood of sample contamination occurring during handling of the samples, or from the sample containers. Three travel blank samples were submitted in 2021; one each in sQ1, sQ2 and sQ4, respectively. Analyte detections are noted in Table 5-2, with none representing concerns to sample integrity.

Table 5-2:
Analyte detections in 2021 travel blank samples

Sampling Period	Parameter	Unit	MDL (mg/L)	Result
sQ1	Acidity (as CaCO3)	mg/L	2.0	2.3
sQ4	Acidity (as CaCO3)	mg/L	2.0	2.7
	Alkalinity, total (as CaCO3)	mg/L	1.0	1.1

5.1.3 Equipment Blanks

An equipment blank was collected from the Bennett sample pump in sQ1 immediately prior to collecting a sample from BJ-GW18-17A. Approximately 40 litres of dilute Alconox solution was pumped through the tubing, followed by 60 litres of Brucejack potable tap water and 40 litres (the approximate total volume of the tubing length) of DI water. The equipment blank sample was collected after approximately 20 litres of DI water discharge, when the water appeared clear. Several analytes were measured above MDL in the equipment blank and these detects are compared to the lowest concentrations measured in a groundwater sample collected with the Bennett pump since 2018 in Table 5-3.

A total of 16 samples have been collected with the Bennett sample pump between BJ-GW18-17A (10) and BJ-GW18-19B (6) since 2018. The lowest measured concentrations in the 16 samples are typically one to two orders of magnitude greater than those measured in the equipment blank. Some parameters measured above detection in the equipment blank have been reported below detection limit in groundwater samples collected with the Bennett pump (Table 5-3). The data suggest that potential cross-contamination from the Bennett sample pump has minimal, if any, impact on the interpretation of groundwater quality samples collected with the Bennett pump.

Additionally, equipment blanks were collected from the Grundfos Redi-Flo2 submersible pump in sQ1 and sQ2. After the pump was cleaned, approximately 10 litres of dilute Alconox solution was pumped through the pump, followed by approximately 12 litres of DI water, at which point a sample was collected. In sQ1, an intermediate sample was collected after the pump was cleaned and before flushing with Alconox and DI water. Several analytes were measured above MDL in the equipment blank and these detects are compared against the corresponding groundwater sample collected at the well in Table 5-4.

For the sQ1 sample, the intermediate sample yielded higher parameter concentrations than the primary equipment blank (Table 5-5). This suggests that continued flushing of the pumping (either with DI water when collecting an equipment blank, or with well water when collecting a groundwater sample) results in more representative samples. While the data indicate that there is the potential for cross-contamination from the submersible pump, the purging process reduces the impact of this effect and should not significantly impact the interpretation of groundwater samples collected with the submersible pump.

Table 5-3:
Analyte detections in the 2021 Bennett pump equipment blank sample

Parameter	MDL (mg/L)	Equipment Blank Result (mg/L)	Lowest Concentration Measured in Well Sampled with Bennett Pump		
			Result (mg/L)	Well	Sample Date
Hardness (as CaCO3), dissolved	0.50	0.7	11.9	BJ-GW18-17A	8-Apr-20
Hardness (as CaCO3), from total Ca/Mg	0.50	0.64	12.8	BJ-GW18-17A	8-Apr-20
Phosphorus, total	0.0010	0.002	<0.050	BJ-GW18-17A	24-Jan-21
Arsenic-T	0.00010	0.00068	0.0266	BJ-GW18-19B	22-Sep-19
Arsenic-D	0.00010	0.00066	0.0267	BJ-GW18-19B	22-Sep-19
Barium-T	0.00010	0.00049	0.0253	BJ-GW18-17A	8-Apr-20
Barium-D	0.00010	0.00053	<0.00010	BJ-GW18-19B	22-Sep-19
Calcium-T	0.050	0.256	4.67	BJ-GW18-17A	8-Apr-20
Calcium-D	0.050	0.280	4.33	BJ-GW18-17A	8-Apr-20
Copper-T	0.00050	0.00497	<0.00050	BJ-GW18-17A	27-Apr-21
Copper-D	0.00020	0.00518	<0.00020	BJ-GW18-17A	8-Oct-20
Manganese-T	0.00010	0.00127	0.00679	BJ-GW18-17A	8-Apr-20
Manganese-D	0.00010	0.00132	0.00595	BJ-GW18-17A	8-Apr-20
Silver-T	0.000010	0.000014	<0.000010	BJ-GW18-17A	27-Apr-21
Strontium-T	0.00020	0.00498	0.378	BJ-GW18-17A	25-Jul-19
Strontium-D	0.00020	0.00498	0.335	BJ-GW18-17A	25-Jun-19
Zinc-T	0.0030	0.0046	<0.0030	BJ-GW18-17A	8-Oct-20
Zinc-D	0.0010	0.0043	<0.0010	BJ-GW18-17A	9-Dec-19

Notes:
MDL = method detection limit

Table 5-4:
Analyte detections in the 2021 submersible pump equipment blank samples

Parameter	MDL (mg/L)	Equipment Blank Result (mg/L)	Concentration Measured in Well Sampled		
			Result (mg/L)	Well	Sample Date
Hardness (as CaCO3), from total Ca/Mg	0.50	0.61	103	BJ-GW12-8B	sQ1: 22-Apr-2021
Phosphorus-T	0.0020	0.0028	0.0115		
Aluminum-T	0.0030	0.0068	0.473		
Barium-T	0.00010	0.00077	0.0320		
Calcium-T	0.050	0.243	33.6		
Chromium-T	0.00050	0.00148	0.00717		
Copper-T	0.00050	0.00208	0.00178		
Iron-T	0.010	0.013	0.339		
Lead-T	0.000050	0.000051	0.000332		
Manganese-T	0.00010	0.00107	0.0400		
Molybdenum-T	0.000050	0.000133	0.00215		
Nickel-T	0.00050	0.00084	0.00488		
Barium-D	0.00010	0.00030	0.0220		
Calcium-D	0.050	0.151	33.3		
Copper-D	0.00020	0.00059	0.00063		
Manganese-D	0.00010	0.00049	0.00586		
Molybdenum-D	0.000050	0.000084	0.00190		
Strontium-D	0.00020	0.00229	0.582		
Zinc-D	0.0010	0.0015	0.0022		
Conductivity	2.0	2.1	144	BJ-GW11-1A	sQ2: 17-Jul-2021
Turbidity	0.10	0.44	8.86		
Phosphorus-T	0.0020	0.0085	0.0057		
Aluminum-T	0.0030	0.0172	0.124		
Barium-T	0.00010	0.00147	0.0260		
Calcium-T	0.050	0.171	25.1		
Chromium-T	0.00050	0.00062	0.00382		
Copper-T	0.00050	0.00292	0.00117		
Lead-T	0.000050	0.000060	0.000718		
Manganese-T	0.00010	0.00138	0.0786		
Molybdenum-T	0.000050	0.000073	0.000855		
Sodium-T	0.050	0.120	0.333		
Strontium-T	0.00020	0.00313	0.143		
Aluminum-D	0.0010	0.0024	<0.0010		
Barium-D	0.00010	0.00330	0.0116		
Calcium-D	0.050	0.132	24.4		
Copper-D	0.00020	0.00315	0.00022		
Manganese-D	0.00010	0.00068	0.00061		

Table 5-5:
Analyte detections between intermediate and primary equipment blank samples from the submersible pump in sQ1

Parameter	MDL (mg/L)	Post-Cleaning Result (Intermediate Equipment Blank) (mg/L)	Equipment Blank Result (Primary Equipment Blank) (mg/L)
conductivity	2.0	2.1	<2.0
hardness (as CaCO3), dissolved	0.50	1.28	<0.50
hardness (as CaCO3), from total Ca/Mg	0.50	0.89	0.61
turbidity	0.10	0.44	<0.10
phosphate, ortho-, dissolved (as P)	0.0010	0.0012	<0.0010
aluminum, total	0.0030	0.0132	0.0068
barium, total	0.00010	0.00111	0.00077
calcium, total	0.050	0.358	0.243
chromium, total	0.00050	0.00292	0.00148
copper, total	0.00050	<0.00050	0.00208
cobalt, total	0.00010	0.00017	<0.00010
iron, total	0.010	0.024	0.013
lead, total	0.000050	0.000290	0.000051
manganese, total	0.00010	0.00228	0.00107
molybdenum, total	0.000050	0.000583	0.000133
nickel, total	0.00050	0.00286	0.00084
silicon, total	0.10	0.11	<0.10
strontium, total	0.00020	0.00482	0.00360
barium, dissolved	0.00010	0.00051	0.00030
calcium, dissolved	0.050	0.512	0.151
copper, dissolved	0.00020	0.00037	0.00059
lead, dissolved	0.000050	0.000128	<0.000050
manganese, dissolved	0.00010	0.00202	0.00049
molybdenum, dissolved	0.000050	0.000316	0.000084
strontium, dissolved	0.00020	0.00744	0.00229
zinc, dissolved	0.0010	0.0015	0.0015

5.1.4 Field Duplicate Samples

Field duplicates are independent samples collected as close as possible from the same location and at the same time as the primary sample to characterize environmental variability and the precision of the entire sampling and analytical process (Clark 2013).

For analytes measured above five times the detection limit (5xMDL), a relative percent difference (RPD) exceeding 20% between primary and duplicate sample results could indicate potential integrity issues, while an RPD exceeding 50% suggests a definite integrity issue such as contamination or lack of sample representativeness (Clark 2013). For analytes measured at lower concentrations (*i.e.,* within 5xMDL), a generally accepted guidance is that the difference between primary and duplicate results be within twice the detection limit (2xMDL).

One field duplicate was collected per shifted quarter in 2021. The analytes from sample/duplicate pairs exceeding data quality objectives (DQOs) of 20% or >2xMDL are listed in Table 5-6. Duplicates taken in sQ1 (BJ-GW18-23A), sQ2 (BJ-GW12-8B), sQ3 (BJ-GW14-14A) and sQ4 (BJ-GW11-3A) had 1, 3, 0 and 3 exceedances of DQOs, respectively, largely related to the total metals suite and differences in TSS/Turbidity. Overall, the field duplicate analysis indicates adequate sampling precision in 2021, with large improvements over 2020 which saw 30 DQO exceedances, compared to 7 in 2021.

Table 5-6:
Differences between primary and field duplicate samples (sQ1 to sQ4)

Sampling Period and Well ID	Analyte	MDL (mg/L)	Sample (mg/L)	Duplicate (mg/L)	RPD
sQ1: BJ-GW18-23B	Zinc-D	0.0010	0.0065	0.0025	>2MDL
sQ2: BJ-GW12-8B	Phosphorus-T	0.0020	0.0079	0.0168	>2MDL
sQ2: BJ-GW12-8B	Chromium-T	0.00050	0.00913	0.0124	30%
sQ2: BJ-GW12-8B	Nickel-T	0.00050	0.00496	0.007	34%
sQ4: BJ-GW11-3A	TSS	3.0	20.9	<3	>2MDL
sQ4: BJ-GW11-3A	Turbidity	0.10	5.8	3.96	38%
sQ4: BJ-GW11-3A	Aluminum-T	0.0030	0.0279	0.0176	45%

Notes:
MDL = method detection limit, RPD = relative percent difference

5.1.5 Transport Temperature

Coolers containing groundwater samples were packed with icepacks and dispatched from site typically within one day of sample collection. Cooler temperature was measured at the laboratory upon receipt. Clark (2013) recommends that water samples are maintained

below 10ºC during transit. All but nine out of 38 cooler submissions arrived at ALS with an internal temperature below 10ºC. Of these nine coolers, four had temperatures between 10ºC and 12.5ºC and five had temperatures between 15ºC and 18ºC. These temperature exceedances are generally associated with long transport times between the mine site and ALS in Burnaby and are typically outside the control of site field personnel. The analytical results for the samples contained within these coolers were consistent with historical analytical results at the respective monitoring well locations. Hence, the warmer transport temperatures do not appear to have impacted analytical results for the affected samples.

5.1.6 Hold Times

Groundwater samples collected at Brucejack groundwater wells were received/analysed within recommended hold times for all tested parameters, except for the samples listed in Table 5-7, which exceeded some or all of the laboratory hold times for turbidity, nitrite, nitrate, orthophosphate-D, total sulfides, TDS and TSS. The hold time exceedance for these samples were due to delays with the cargo carrier or having to hold samples over the weekend before shipment.

The analytical results from these samples were consistent with historical nitrite, nitrate, turbidity, orthophosphate-D, total sulfides, TDS and TSS concentrations; hence these results are considered to be representative of the groundwater quality from these monitoring wells.

Table 5-7:
Hold Time Exceedances for 2021 (sQ1 to sQ4)

Sampling Period and Well ID	Orthophosphate-D	Nitrate	Nitrite	Turbidity	Total Sulfides	TDS	TSS
Hold Time	**3 days**	**3 days**	**3 days**	**3 days**	**7 days**	**7 days**	**7 days**
sQ1: BJ-GW18-17B	X	X	X	X			
sQ1: BJ-GW18-17B SNAP	X	X	X	X			
sQ1: BJ-GW11-3A	X	X	X				
sQ1: Travel Blank	X	X	X				
sQ1: BJ-GW18-17A SNAP		X	X				
sQ1: BJ-GW12-8A	X	X	X	X			
sQ1: BJ-GW12-8A SNAP	X	X	X	X			
sQ1: BJ-GW18-17A	X	X	X	X			
sQ1: Equipment Bank	X	X	X	X			
sQ2: BJ-GW18-17A	X	X	X	X			
sQ2:BJ-GW18-17A SNAP	X	X	X	X			
sQ2: BJ-GW18-18B	X	X	X				
sQ2: BJ-GW18-18B SNAP	X	X	X				
sQ2: BJ-GW12-8B	X	X	X	X			
sQ2: BJ-GW12-8B - 98	X	X	X	X			
sQ2: BJ-GW12-8B SNAP	X	X	X	X			
sQ2: BJ-GW12-11A	X	X	X				
sQ2: BJ-GW12-8A					X		
sQ2: BJ-GW12-8A SNAP					X		
sQ2: BJ-GW18-23B					X		
sQ2: BJ-GW16-5B					X		
sQ2: BJ-GW18-23A	X	X	X	X			
sQ2: Equipment Blank	X	X	X	X			
sQ2: BJ-GW18-17B	X	X	X	X			
sQ3: BJ-GW18-18B	X	X	X				
sQ3: BJ-GW18-18B SNAP	X	X	X				
sQ3: BJ-GW18-17B						X	X
sQ3: BJ-GW12-9B	X	X	X	X			
sQ3: BJ-GW16-5A	X						
sQ3: BJ-GW16-5B	X						
sQ3: BJ-GW-18-17A	X	X	X	X			
sQ3: Equipment Blank	X	X	X	X			
sQ3: BJ-GW18-23A				X			
sQ3: BJ-GW18-23B	X	X	X	X			
sQ3: BJ-GW18-23B - 99	X	X	X	X			
sQ3: BJ-GW12-11A	X	X	X	X			
sQ4: BJ-GW18-17A	X						
sQ4: BJ-GW18-17B	X						

5.1.7 Charge-Balance Error

The accuracy of groundwater quality analytical results was assessed by calculating the charge-balance error (CBE) according to the following formula:

$$\text{CBE} = \frac{\sum cations - |\sum anions|}{\sum cations + |\sum anions|} \; x \; 100\%$$

where cations include Na^+, K^+, Ca^{2+}, Mg^{2+} and Fe^{2+}, and anions include HCO_3^-, SO_4^{2-}, Cl^- and NO_3^-. Cation and anion concentrations in the CBE equation are expressed in milliequivalents per litre (meq/L). Seven of the 53 groundwater samples had a CBE greater than or equal to ± 5% as presented in Table 5-8. It should be noted that the non-permit wells BJ-GW16-5A/B were included within this section as they accounted for a significant number of the charge-balance errors.

Table 5-8:
Summary of Results for CBE (All Quarters)

Groundwater Well	sQ1 CBE (%)	sQ2 CBE (%)	sQ3 CBE (%)	sQ4 CBE (%)
BJ-GW11-1A	-	-1%	-2%	-3%
BJ-GW11-1B	-	1%	-	-
BJ-GW11-3A	-3%	-4%	-4%	-2%
BJ-GW11-3B	-	-3%	-4%	-
BJ-GW12-8A	-3%	-1%	1%	4%
BJ-GW12-8B	-3%	0%	0%	-1%
BJ-GW12-9B	-	-	2%	-
BJ-GW12-11A	-3%	0%	1%	-
BJ-GW12-11B	-	-	-	-
BJ-GW14-14A	-	-	-2%	-
BJ-GW14-14B	-	-	-4%	-
BJ-GW16-5A	-3%	**-5%**	-1%	**-5%**
BJ-GW16-5B	**16%**	-3%	0%	4%
BJ-GW18-17A	-1%	1%	4%	-4%
BJ-GW18-17B	**-7%**	**-7%**	**-5%**	**-7%**
BJ-GW18-18B	-	0%	1%	-4%
BJ-GW18-19B	-	-1%	-2%	-
BJ-GW18-23A	-2%	2%	3%	-2%
BJ-GW18-23B	0%	2%	3%	-1%

5.1.8 Total versus Dissolved Metals

In samples where both dissolved and total fractions of analytes are measured above 5xMDL, the dissolved metal concentration is flagged as a potential QA/QC issue if the ratio of dissolved to total concentration exceeds 120%. Parameters exceeding the DQO are listed in Table 5-9. Most exceedances are associated with selenium. ALS has indicated that results for dissolved selenium can be biased high on account of volatile organic selenium interfering with the ICP-MS. Digestion of the total metals sample prior to analysis allows the volatile selenium to off-gas and prevents this type of interference. Since selenium has not been identified as a parameter of concern for the Brucejack Mine, Pretium has not sought alternative sampling/analytical methodologies for dissolved selenium. Rather, dissolved versus total exceedances are flagged in summary tables (Appendix G).

Table 5-9:
Parameters where dissolved fraction exceeds total fraction (sQ1-sQ4)

Groundwater Well	Sampling Period	Parameter	Ratio of Dissolved/Total Metals (%)
BJ-GW18-17B SNAP	sQ1	Selenium-D	1971%
BJ-GW18-17A SNAP	sQ2	Potassium-D	130%
BJ-GW18-23A	sQ4	Selenium-D	201%
BJ-GW16-5A		Molybdenum-D	123%
BJ-GW16-5B		Zinc-D	129%
BJ-GW12-8B		Copper-D	124%
BJ-GW18-17A		Selenium-D	630%

5.1.9 Turbidity

The Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators (BC MOE 2016b) (the Guidance) highlights concerns regarding high turbidity values measured in groundwater quality datasets. These concerns are related to the representativeness of dissolved metal concentrations as bioavailable metal concentrations. The Guidance recommends that low flow sampling techniques should be employed if sample turbidity exceeds 50 NTU. Where turbidity is naturally elevated, the Guidance indicates that sample turbidity of up to 200 NTU may be acceptable.

Table 5-10 provides a breakdown of wells sampled in 2021 that had turbidity results greater than 50 NTU and 200 NTU, with samples >50 NTU including samples >200 NTU. Table 5-11 provides a comparison of pre-2021 and 2021 turbidity values at all the wells, with samples >50 NTU including samples >200 NTU. Upon implementation of the low-flow protocol in mid-2019 (Section 3.2.3.1), the number of locations with turbidity in

excess of 50 NTU and 200 NTU declined. One location, BJ-GW18-17B, presented more persistent turbidity issues in 2021.

BJ-GW18-17B was sampled via submersible pump in sQ2 and sQ3 and via bailer in sQ1 and sQ4. The high turbidity values reported at this well are largely attributed to a fine suspended sediment load in the well purge water. With well recharge rates extremely low, multiple bore volumes need to be purged in order to achieve parameter stabilization. In addition, the well screens anoxic groundwater that may be prone to oxidation in the unpreserved anions/physical parameters bottle, leading to formation of suspended hydroxides. This may also contribute to the high turbidity reported for this well. Similarly, wells BJ-GW11-1A and BJ-GW18-17A were sampled with a bailer in sQ3 and sQ4, respectively, which likely played a role in their elevated turbidity readings. Overall, the transition to low-flow sampling methodologies continues to improve in turbidity levels in groundwater samples in 2021.

Table 5-10:
Summary of high turbidity occurrence in Brucejack groundwater samples by date

Well ID	Total Sample Count	Samples >50 NTU	Samples >200 NTU
2021 sQ1	10	1 (BJ-GW18-17B)	1 (BJ-GW18-17B
2021 sQ2	15	2 (BJ-GW18-17B, BJ-GW18-18B)	1 (BJ-GW18-17B)
2021 sQ3	17	3 (BJ-GW11-1A, BJ-GW18-17B, BJ-GW18-23A)	0
2021 sQ4	11	3 (BJ-GW11-1A, BJ-GW18-17A, BJ-GW18-17B)	0
Total 2021	53	9	2
Total 2020	53	10	3
Total 2019	63	11	2
Total 2018	39	12	16

Table 5-11:
Summary of high turbidity occurrence in Brucejack groundwater samples by well

Well ID	Total Sample Record	Data Record (2011 - 2020)				2021				Screened Lithology
		Sample Count	Sample Count (Turbidity Reported)	Samples >50 NTU	Samples >200 NTU	Sample Count	Sample Count (Turbidity Reported)	Samples >50 NTU	Samples >200 NTU	
BJ-GW11-1A	22	19	19	8	5	3	3	2	0	Office P1
BJ-GW11-1B	11	10	10	8	5	1	1	0	0	Office P1
BJ-GW11-3A	37	33	33	21	13	4	4	0	0	P2
BJ-GW11-3B	27	25	25	11	6	2	2	0	0	P2
BJ-GW12-8A	35	31	31	13	7	4	4	0	0	Office P1
BJ-GW12-8B	34	30	30	21	16	4	4	0	0	Office P1
BJ-GW12-9B	9	8	8	5	0	1	1	0	0	Office P1
BJ-GW12-11A	19	16	16	9	3	3	3	0	0	Office P1
BJ-GW12-11B	12	12	12	7	4	0	0	0	0	Office P1
BJ-GW14-14A	8	7	7	5	5	1	1	0	0	Office P1
BJ-GW14-14B	13	11	11	6	3	1	1	0	0	Office P1
BJ-GW16-5A	18	14	14	2	0	4	4	0	0	V12
BJ-GW16-5B	18	14	14	7	4	4	4	0	0	V12
BJ-GW18-17A	12	8	8	0	0	4	4	1	0	V12/V6b
BJ-GW18-17B	15	11	11	10	5	4	4	4	2	Office P1
BJ-GW18-18B	13	10	10	3	3	3	3	1	0	Office P1
BJ-GW18-19B	8	6	6	3	1	2	2	0	0	Office P1
BJ-GW18-23A	15	11	11	3	0	4	4	1	0	S4-VSF
BJ-GW18-23B	15	11	11	3	3	4	4	0	0	S4-VSF

5.2 Groundwater Quality Interpretation

5.2.1 Overview

Complete groundwater quality data for all wells currently sampled under PE-107835 is tabulated in Appendix G. Appendix H tabulates groundwater quality statistics for each monitoring well (minimum, maximum, median, mean) for the baseline period (2011-2014) and annually from 2015-2021. Bar graphs of baseline and annual mean groundwater quality are presented in Appendix I, along with piper plots and times series graphs of selected parameters. Appendix J contains laboratory reports of analysis. Selected data from these appendices are presented below.

As identified in the groundwater level discussion (Section 4.3), groundwater flow patterns at site are dominated by the drawdown created from dewatering of the West Zone and VOK Zone. Declining water levels in wells may introduce more oxygenated water at depth or draw water in from areas different from baseline. Monitoring wells at lower elevations are more prone to impacts from surface activities such as construction and operation of surface infrastructure, such as the CWP. The mine undertook a hydrogeological study of the CWP in 2016 (BGC 2017) and it was determined that seepage losses to groundwater CWP would occur when the elevation of the pond was above 1369.2 m asl.

Table 5-12 summarizes average 2021 concentrations measured in Brucejack monitoring wells for selected parameters. Parameters excluded from this table were infrequently to rarely measured above baseline concentrations. Formatting in Table 5-12 indicates where 2021 average concentrations are higher than the baseline period (2011-2014). More notable trends are highlighted in the discussion below.

5.2.2 Major Ion Chemistry

As indicated in Table 5-12, several wells indicate elevated major ions (Ca-D, Mg-D, SO_4) compared to baseline. Both temporal and spatial trends in major ion chemistry are explored through piper plots and time series presented in this section and in Appendix I. Table 5-13 summarizes groundwater quality types across the Brucejack site and associated trends. Several historic wells (BJ-GW11-5A/B, BJGW12-12A) demonstrate trends in major ion chemistry arising from mine dewatering. Wells downgradient of the CWP (BJ-GW18-23A/B) and other site infrastructure (BJ-GW11-3B) show influence from mining activities manifested as elevated sulphate and chloride. All Brucejack monitoring wells screen groundwater that is neutral to slightly alkaline (pH 7 to 8.5).

Table 5-12:
Average 2021 concentrations of selected parameters in Brucejack groundwater

Well ID	Baseline Count	2021 Count	NO_3-N	NO_2-N	SO_4	Ca-D	Mg-D	Al-D	As-D	Cr-D	Cu-D	Se-D
			0.0050	*0.0010*	*0.30*	*0.050*	*0.10*	*0.0010*	*0.00010*	*0.00010*	*0.0002*	*0.000050*
Periphery of VOK Zone												
BJ-GW12-12A[1]	5	-	**0.18**	**0.005**	310	140	19	0.0017	0.016	0.0001	**0.0021**	0.00011
BJ-GW11-5A[1]	3	-	**0.043**	0.0017	187	76	**14**	0.0042	0.0091	0.0001	0.00056	0.000052
BJ-GW11-5B[1]	3	-	**0.42**	**0.046**	**247**	**116**	**15**	0.0065	0.018	0.0001	0.0002	0.00011
BJ-GW12-9B	-	1	0.0153	0.0001	40.4	44.3	1.1	0.0071	0.00069	0.00052	0.0006	0.000562
BJ-GW18-18B	-	3	0.00577	0.0011	175	56.6	9.9	0.0022	0.00106	0.00052	0.00025	0.000053
BJ-GW18-19B	-	2	0.0066	0.0038	130	37	6.3	0.0084	0.015	0.0005	0.0015	0.00007
West of the West Zone												
BJ-GW12-11A	-	3	0.105	0.001	48.8	23.7	3.4	0.017	0.00746	0.00057	0.000667	0.000362
BJ-GW12-11B[1]	-	-	0.0061	0.001	67	45	6.3	0.0065	0.0016	0.00022	0.00037	0.00092
BJ-GW11-1A	1	3	**0.464**	0.001	34.2	25.97	**2.1**	0.02	**0.00331**	0.001	0.00118	0.000233
BJ-GW11-1B	1	1	0.0268	0.0039	34.3	29.1	2.05	0.007	0.00342	0.00118	0.00102	0.000331
East of the West Zone												
BJ-GW11-3A	10	4	**0.016**	0.0016	92	58	4.3	0.0028	0.012	0.00037	0.00047	0.000079
BJ-GW11-3B	9	2	0.005	0.001	79	55	3.5	0.0015	0.0036	0.0005	0.00047	0.00005
BJ-GW18-17A	-	4	*0.0835*	*0.025*	199	45.33	1.5	0.016	0.0418	0.00044	0.000268	0.000369*
BJ-GW18-17B	-	4	0.047	0.008	270	82	3.7	0.26	0.03	0.0011	0.00029	0.00037
West of the Brucejack Fault												
BJ-GW12-8A	8	4	0.018	0.001	34	30	6	0.0044	0.0085	**0.00066**	0.00058	0.0002
BJ-GW12-8B	8	4	0.019	0.001	37	33	4.6	0.0031	0.013	0.0011	0.00095	0.0003
BJ-GW14-14A	-	1	0.005	0.001	45	25	4.7	0.0025	0.004	0.0005	0.0002	0.00005
BJ-GW14-14B	-	1	0.005	0.001	53.1	34	2.2	0.0027	0.0027	0.0005	0.00077*	0.00005
Downgradient of the CWP												
BJ-GW18-23A	-	4	8.59	0.1	452	107.5	15	0.0032	0.0349	*0.00074*	*0.000613*	0.000732*
BJ-GW18-23B	-	4	17.6	0.037	311	123.2	8.9	0.0014	0.000378	*0.00053*	0.000415	0.000724*

Notes:
1. Not sampled in 2021. Reported concentrations presented for 2016 (-12A/B, -5B), 2017 (-5A) and 2020 (-11B) (most recent samples)

Concentration exceeding mean 2011-2014 concentration by 20% is shaded, *e.g.* 5.4 mg/L. Concentration exceeding mean 2011-2014 concentration by 100% is shaded and bold, *e.g.* **5.4** mg/L
Underlined values are the highest average concentrations measured across the mine site in 2021
Italicized values include some data in 2021 with sample dilution due to high dissolved solid/electrical conductivity
* values indicate some data in 2021 may not be representative due to elevated dissolved/total metals ratios

Table 5-13:
Summary of Brucejack groundwater quality types

Well ID	Current Water Type	Trend (Mine Influence)
Periphery of VOK		
BJ-GW12-12A[1]	Ca-SO_4	increasing SO_4 influence (dewatering)
BJ-GW11-5A[1]	Ca-HCO_3,SO_4	increasing Ca influence (dewatering)
BJ-GW11-5B[1]	Ca-HCO_3,SO_4	increasing Ca, SO_4 influence (dewatering)
BJ-GW12-9B	Ca-HCO_3,SO_4	none
BJ-GW18-18B	Ca,Na-HCO_3,SO_4	none
BJ-GW18-19B	Ca,Na-HCO_3,SO_4	none
West of West Zone		
BJ-GW12-11A	Ca,Mg-HCO_3,SO_4	none
BJ-GW12-11B	Ca,Mg-HCO_3,SO_4	none
BJ-GW11-1A	Ca,Na-HCO_3	none but variable
BJ-GW11-1B	Ca-HCO_3	none
East of West Zone		
BJ-GW11-3A	Ca-HCO_3,SO_4	variable chloride (wash bay)
BJ-GW11-3B	Ca-HCO_3,SO_4	variable chloride (wash bay)
BJ-GW18-17A	(Ca),Na,-HCO_3,SO_4	potential seasonal trend to more Ca influence
BJ-GW18-17B	Ca,Na-HCO_3,SO_4	none
West of Brucejack Fault		
BJ-GW12-8A	Ca,Mg-HCO_3	none
BJ-GW12-8B	Ca,Mg-HCO_3	none
BJ-GW14-14A	Ca,Na-HCO_3,	none
BJ-GW14-14B	Ca,Mg-HCO_3,SO_4	none
Downgradient of CWP		
BJ-GW18-23A	Ca,Na-SO_4	None (CWP influence)
BJ-GW18-23B	Ca,Na-SO_4	None (CWP influence)

Historic wells upgradient of the VOK zone experienced increasing proportions of dissolved calcium (Ca-D) (BJ-GW11-5A/B) and sulfate (SO_4) (BJ-GW11-5A/B, BJ-GW12-12A) prior to going dry (Figure 5-1**,** Table 5-13). The water quality types at these wells prior to going dry was predominantly Ca-SO_4 with varying influence of HCO_3. The trends suggest that mine dewatering did influence surrounding chemistry, either by creating more oxic conditions (hence higher SO_4) or drawing in a younger (less sodic) water type. BJ-GW18-18B and BJ-GW18-19B continue to yield Ca,Na-HCO_3,SO_4 type water, which is not unlike baseline water quality at BJ-GW11-5A.

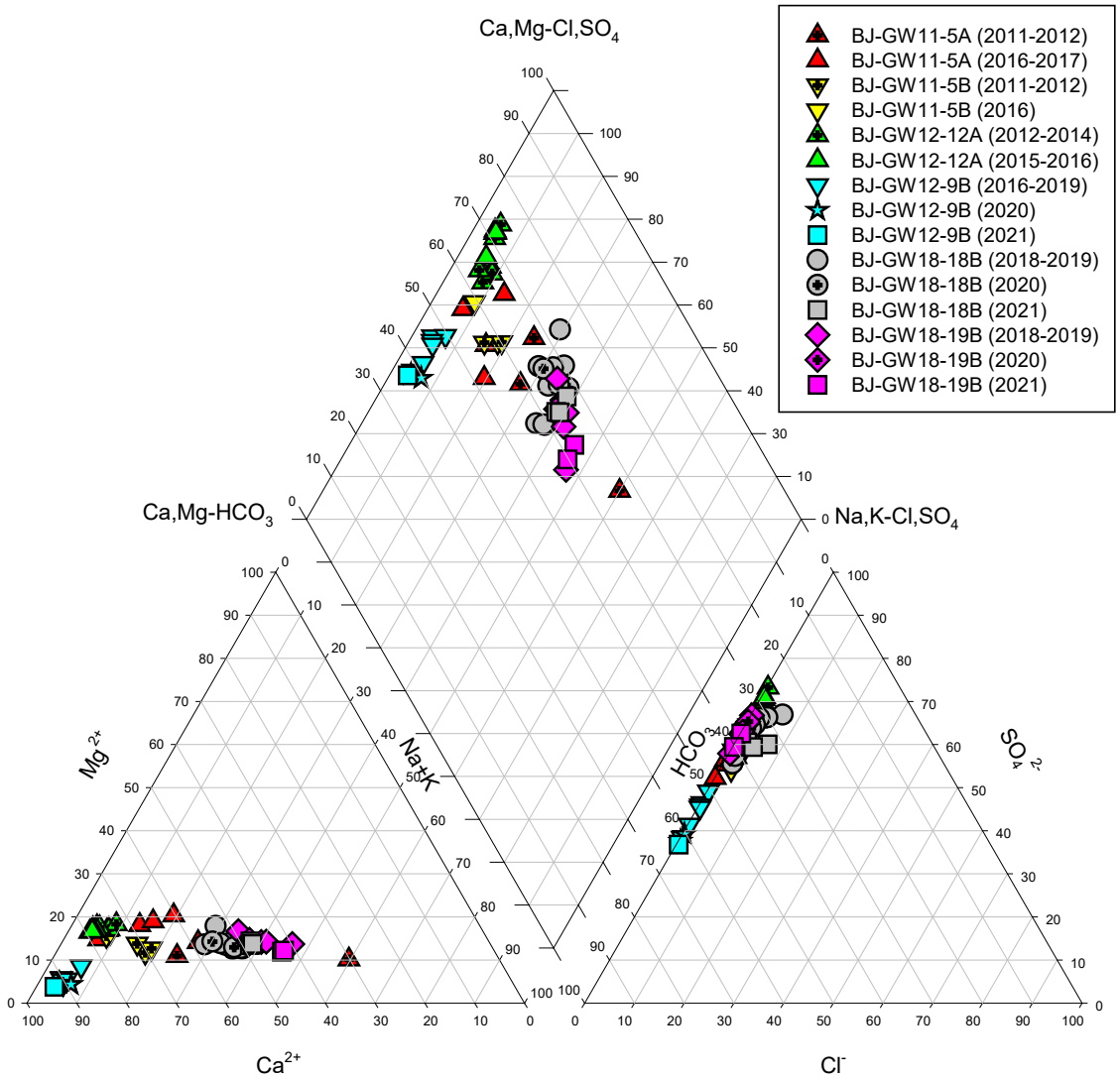


Figure 5-1: Trilinear plot of major ion chemistry in wells surrounding the VOK zone.

Major ion chemistry at BJ-GW11-3A, near the West Zone portal, originally had higher sodium content during the baseline period, however since 2015, the sodium content has remained low (<10 mg/L), rendering a Ca-HCO_3,SO_4 water type (Figure 5-2, Figure 5-3, Table 5-13). The shallow well BJ-GW11-3B shows water chemistry that is variable Ca-HCO_3,SO_4 type with elevated chloride through to 2020, though chloride levels in 2021 returned to low levels similar to baseline (Figure 5-2). Chloride in BJ-GW11-3B is believed to originate from salt application on pathways leading towards the nearby wash bay, which could have been diluted by precipitation that was higher in 2021 than recent years, leading to extended periods of artesian flow within the well. Ca-D and Mg-D are observed to follow similar trends as chloride with Na-D to a lesser extent (noting log scale for Na-D on Figure 5-2).

Wells BJ-GW18-17A/B are located near BJ-GW11-3A/B and show distinctly different water types (Figure 5-3). BJ-GW18-17B is installed at a similar depth to BJ-GW11-3A (Table 3-1), but shows a stronger influence of sodium (Na,Ca-HCO_3,SO_4). BJ-GW18-17A is screened 50 m to 75 m deeper than both wells. BJ-GW18-17A data from 2018/2019 (all events), and sQ1 and sQ4 of 2020 and 2021 are Na-HCO_3,SO_4 type (Figure 5-3). Samples collected in sQ2 and sQ3 of 2020 and 2021 reported a slight shift towards a more intermediate Na,Ca-HCO_3,SO_4 type water. All pH values for BJ-GW18-17A in 2021 were between 8.2 and 8.4.

The strong sodium signature at the BJ-GW18-17A/B well pair, in conjunction with strongly reducing conditions (evidenced by presence of sulphide), suggests that these wells screen older groundwater. Sulfate concentrations measured at BJ-GW18-17A/B ranged from 169 to 395 mg/L in 2021 and are some of the highest concentrations measured in groundwater outside of the CWP area (Table 5-12). Future sampling efforts at this well will focus on resolving seasonal differences in water quality and/or identifying potential artefacts of well installation.

BJ-GW18-23A/B, a shallow nest installation located adjacent to the CWP, continues to have the highest SO_4 concentrations on site ranging from 181 to 465 mg/L. Both wells have similar Na-D concentrations to BJ-GW18-17A/B, while BJ-GW18-23B shows variably increasing Cl (Figure 5-2). BJ-GW18-23A/B are generally Ca,Na-SO_4 type, though BJ-GW18-23B demonstrates intermittent mixing with increasing HCO_3 (Figure 5-3). The major ion chemistry of this well pair closely resembles that of the CWP (Figure 5-3).

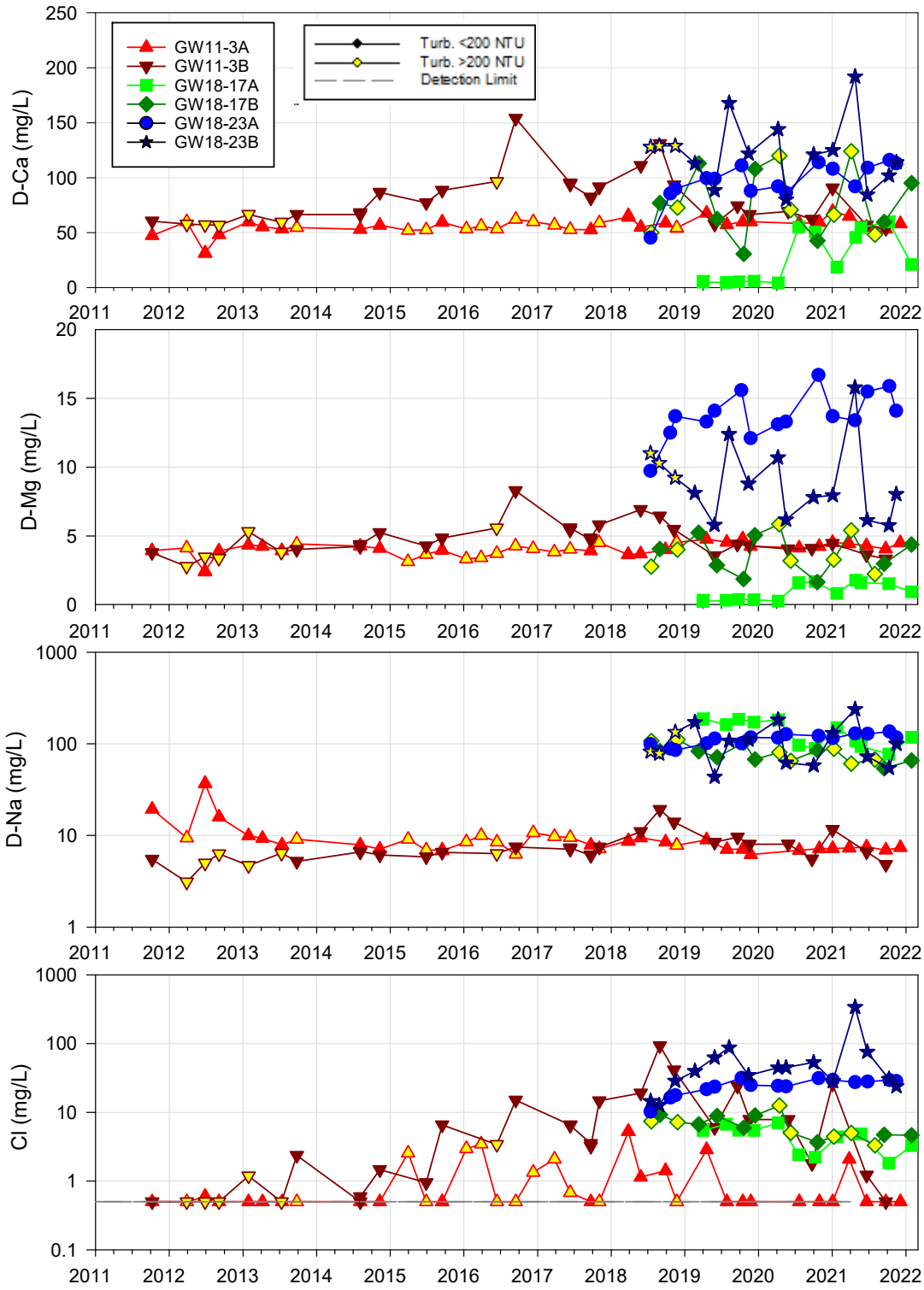


Figure 5-2: Time trends in Ca-D, Mg-D, Na-D and Cl at monitoring wells completed east of the West Zone portal. Note log axis for D-Na, D-Cl.

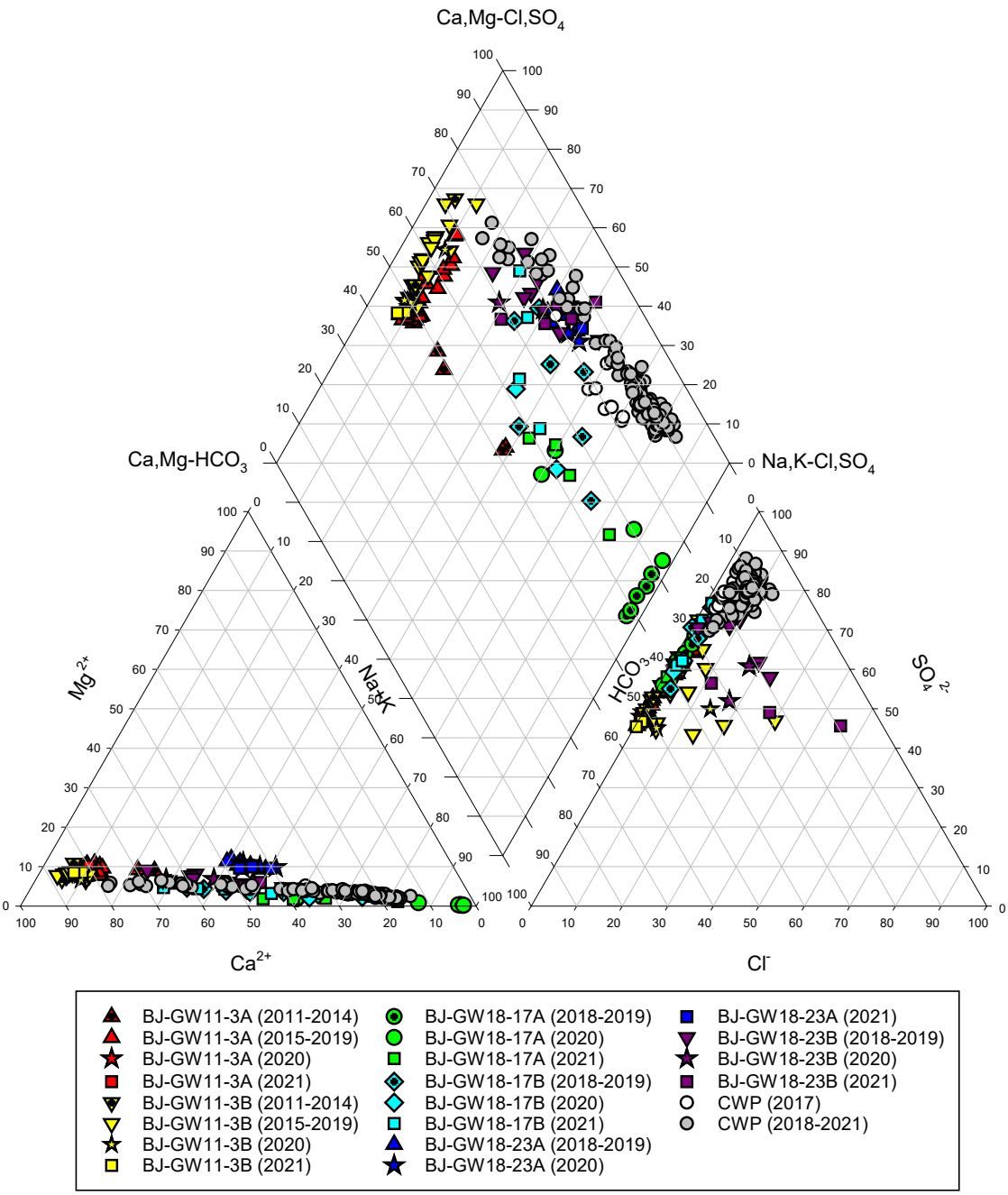


Figure 5-3: Trilinear plot of major ion chemistry in wells east of the West Zone

Major ion chemistry is largely stable in wells located between the West Zone portal and the Brucejack fault with samples from different years showing significant overlap in piper diagrams (Appendix I). Most samples are Ca,Mg-SO_4 type with varying influence of HCO_3. BJ-GW11-1A demonstrates seasonal peaks in D-Na that coincides with January/ February samples, shifting the water type to Ca,Na-HCO_3. Piper plots of groundwater quality west of the Brucejack Fault (BJ-GW12-8A/B and BJ-GW14-14A/B) do not indicate any trends in major ion composition (Appendix I).

5.2.3 Nitrate/Nitrite

Nitrogen species can occur naturally in groundwater through atmospheric deposition, nitrogen rich minerals, and through plant and microbial activities (Madison and Brunett 1985). In mining environments, blasting residues are responsible for elevated concentrations of nitrogen species in the receiving environment. Nitrite (NO_2) is less stable than nitrate (NO_3) and is accordingly found at much lower concentrations. In 2021, NO_3 was measured above detection limit (0.005 mg/L) in one or more sampling events at most Brucejack monitoring wells except BJ-GW11-3B and BJ-GW14-14A/B (Table 5-12).

As expected, the highest NO_3 and NO_2 concentrations measured in 2021 were encountered downgradient of the CWP at BJ-GW18-23A/B (Figure 5-4, Table 5-12). NO_3 and NO_2 concentrations are typically one to two orders of magnitude higher at BJ-GW18-23A/B relative to the other well sites. Nitrate is reasonably stable throughout the year at BJ-GW18-23A (Figure 5-6) with average 2021 concentrations about 30% higher than the previous two years (Figure 5-4). Nitrate concentrations at BJ-GW18-23B show strong seasonality, with maximum concentrations *ca.* 40 mg/L experienced in the winter (sQ1/sQ4) (Figure 5-6). The maxima coincide with concentration maxima observed in the CWP, which climb through winter. The high winter NO_3 concentrations are presumably due to lack of dilution by runoff to the CWP. Average NO_3 concentrations in BJ-GW18-23B declined slightly in 2021. Nitrite concentrations in BJ-GW18-23A/B are also the highest on site but declined in 2021 (Table 5-12, Figure 5-5).

East of the West Zone portal, average NO_3 concentrations at BJ-GW18-17A/B were similar in 2021 compared to 2020, and NO_2 concentrations at BJ-GW18-17A/B were lower in 2021 compared to 2020. Average NO_3 and NO_2 concentrations at BJ-GW18-17A/B remain higher relative to nearby well BJ-GW11-3A/B (Figure 5-4, Figure 5-5).

West of the West Zone portal, average NO_3 and NO_2 concentrations remained stable at BJ-GW12-11A in 2021 (Figure 5-4, Figure 5-5). Both NO_3 and NO_2 rose in BJ-GW11-1A in 2021 while equivalent parameter concentrations in BJ-GW11-1B remained stable.

West of the Brucejack Fault at BJ-GW12-8A/B, average NO_3 concentrations had been increasing since 2011 while remaining low (<0.035 mg/L) but have since shown a decreasing trend from 2019-2021 (Figure 5-4). Average NO_2 remained below detection limit (<0.001 mg/L) at BJ-GW12-8A/B and BJ-GW14-14A/B (Figure 5-5).

Within the VOK, average NO_3 are measured near or at detection limit at BJ-GW18-18B and BJ-GW18-19B in 2021 (Figure 5-4). Average 2021 NO_2 concentrations at these two wells are also low, near detection At BJ-GW18-18B and within 5xMDL at BJ-GW18-19B (Figure 5-5).

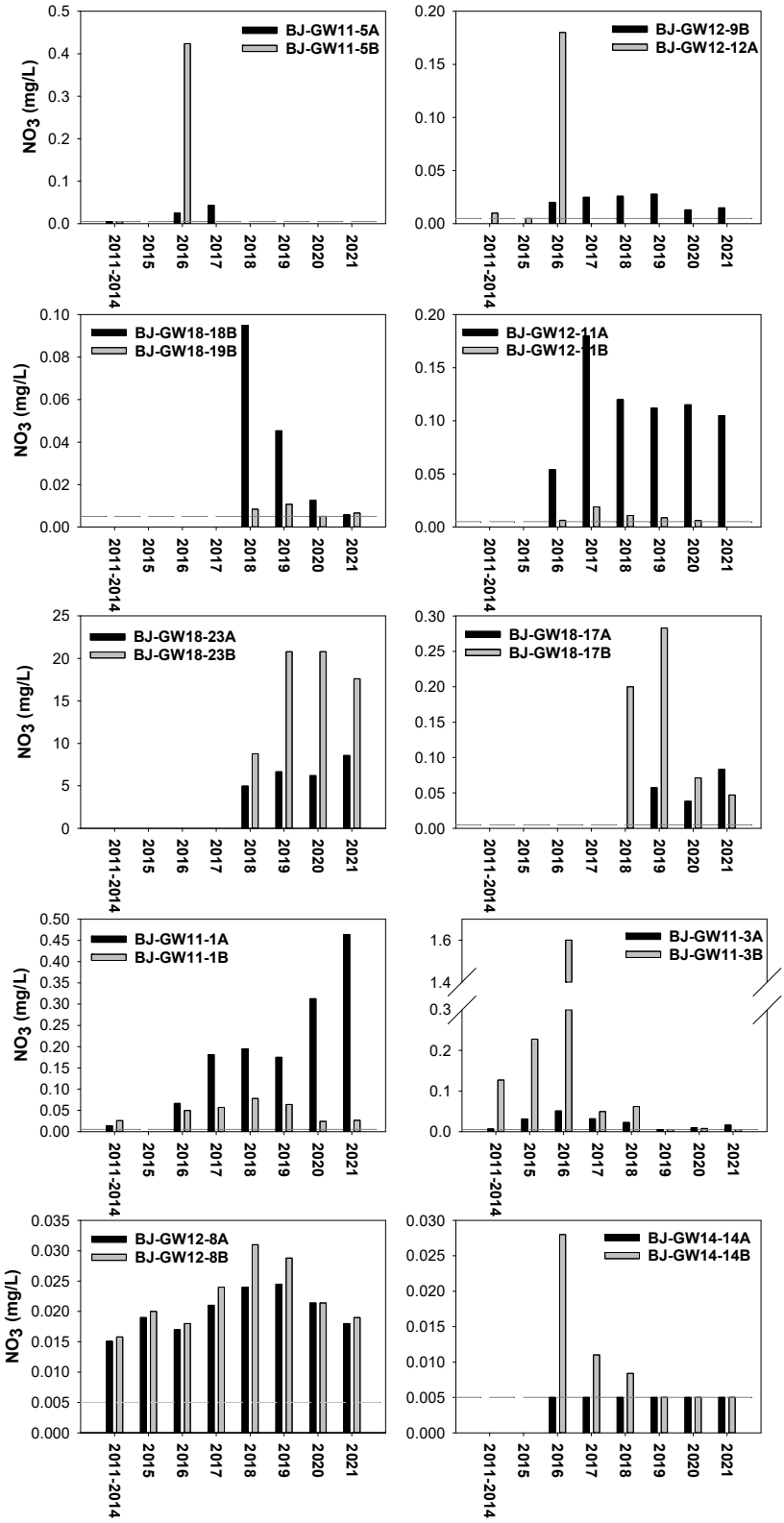


Figure 5-4: Annual average NO_3 in Brucejack monitoring wells. 2021 detection limit for NO_3 is 0.005 mg/L.

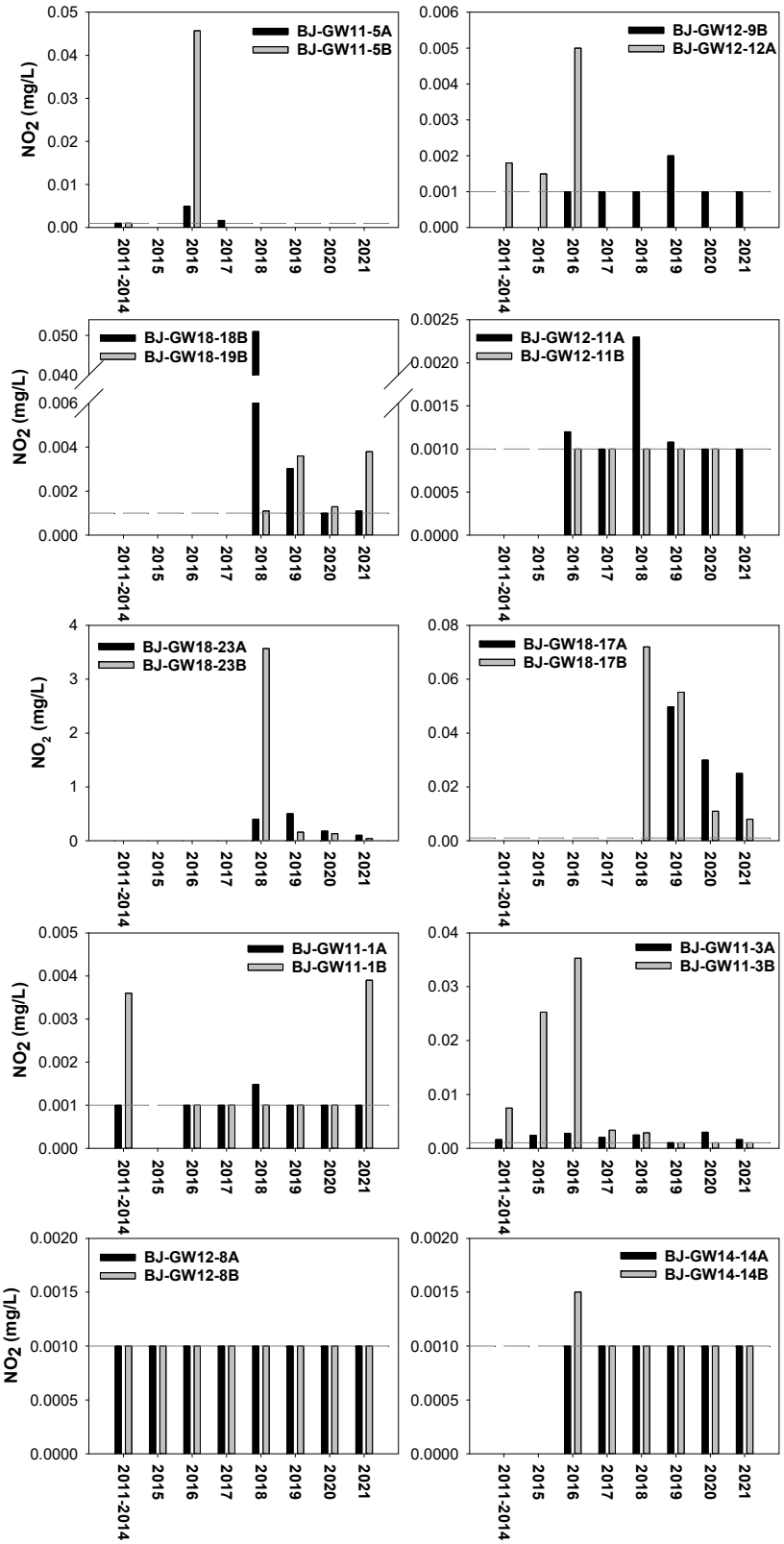


Figure 5-5: Annual average NO_2 in Brucejack monitoring wells. 2021 detection limit for NO_2 is 0.001 mg/L.

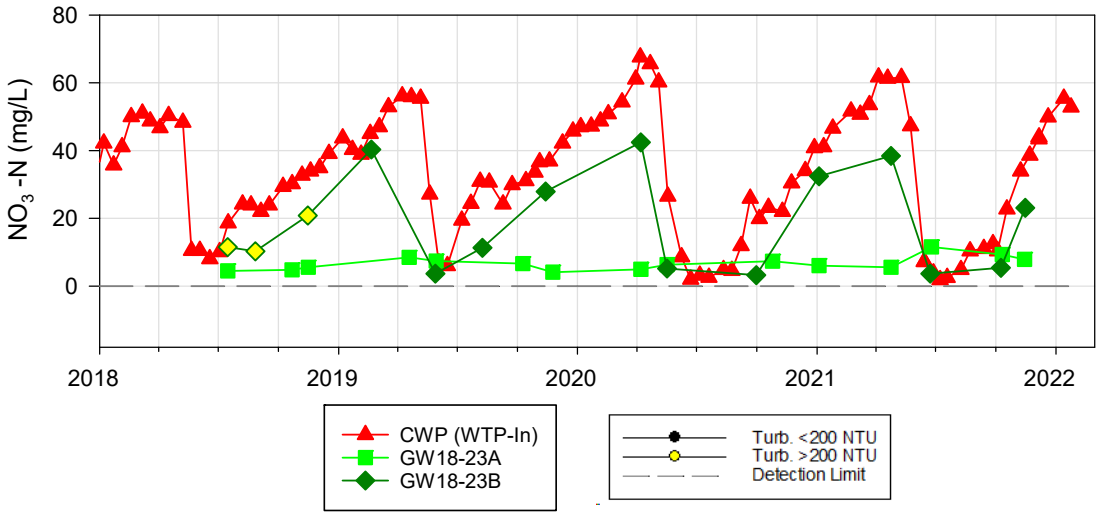


Figure 5-6: Nitrate time trends in CWP water (as influent to the WTP) and groundwater stations downgradient of the CWP (BJ-GW18-23A/B).

5.2.4 Trace Metals

Average annual concentrations of As-D at Brucejack wells are provided in Figure 5-7. Dissolved arsenic is mobile in reducing, circum-neutral environments as it tends to sorb to iron oxy-hydroxides in lower pH and more oxygenated waters. BJ-GW18-17A reported the highest annual average As-D concentration across the site in 2021 (0.0418 mg/L) (Table 5-12) however average concentrations have shown a sharp decline since 2019 (Figure 5-7). Dissolved arsenic concentrations are lower in sQ2 and sQ3 at this well, possibly reflecting increased sorption as pH decreases slightly (Appendix G). Elevated average arsenic concentrations are also measured at BJ-GW11-3A (0.012 mg/L), BJ-GW12-8B (0.013 mg/L), BJ-GW18-17B (0.03 mg/L), BJ-GW18-23A (0.0349 mg/L) and BJ-GW18-19B (0.015 mg/L) (Table 5-12). These arsenic concentrations are typically one to two orders of magnitude higher than groundwater screened at other locations. Prior to going dry, wells upgradient of the VOK zone also displayed elevated As-D in the range of 0.02 mg/L. High concentrations of As-D at BJ-GW12-12A measured during the baseline period (Figure 5-7) suggest that elevated As-D is naturally occurring in the groundwater environment.

Average Cu-D trends are shown for selected wells in Figure 5-8. The highest average concentration of Cu-D observed in 2021 is measured at BJ-GW11-1A (0.00118 mg/L) and has been gradually increasing since 2017. Increasing Cu-D trends have been observed at BJ-GW12-8B since 2017 but are barely exceeding 5xMDL.

Dissolved chromium (Cr-D) is generally measured at low concentrations in Brucejack groundwater but has been consistently increasing in several wells, namely BJ-GW18-23B,

BJ-GW11-1A/B, BJ-GW11-3B and BJ-GW12-8B (Figure 5-9). Other wells experienced increases in average Cr-D concentrations between 2020 and 2021. The highest concentrations of Cr-D in 2021 were in wells BJ-GW11-1A, BJ-GW11-1B, BJ-GW12-8B and BJ-GW18-17B, all being between 0.0010 mg/L and 0.0012 mg/L. It is uncertain if the high Cr-D results in conventional samples are representative or are an artefact of sampling with the submersible pump, with equipment blank samples collected in 2021 both having hits of Cr-D above the MDL. Cr-D is not considered a parameter of concern in groundwater at this time but is actively being investigated.

Dissolved selenium (Se-D) has been measured at several locations above 5xMDL (0.000050 mg/L) (Table 5-12). The QA/QC analysis on dissolved versus total metals (Section 5.1.8, Table 5-9) revealed that dissolved selenium can be biased high in the dissolved metals analysis due to the presence of volatile organic selenium species. With suspect wells removed, the highest average concentration in 2021 were reported at BJ-GW18-23B (0.00037 mg/L), with three other wells showing concentrations greater than 5xMDL. Most remaining wells continued to report low 2021 average concentrations (*i.e.*, below or near 5xMDL).

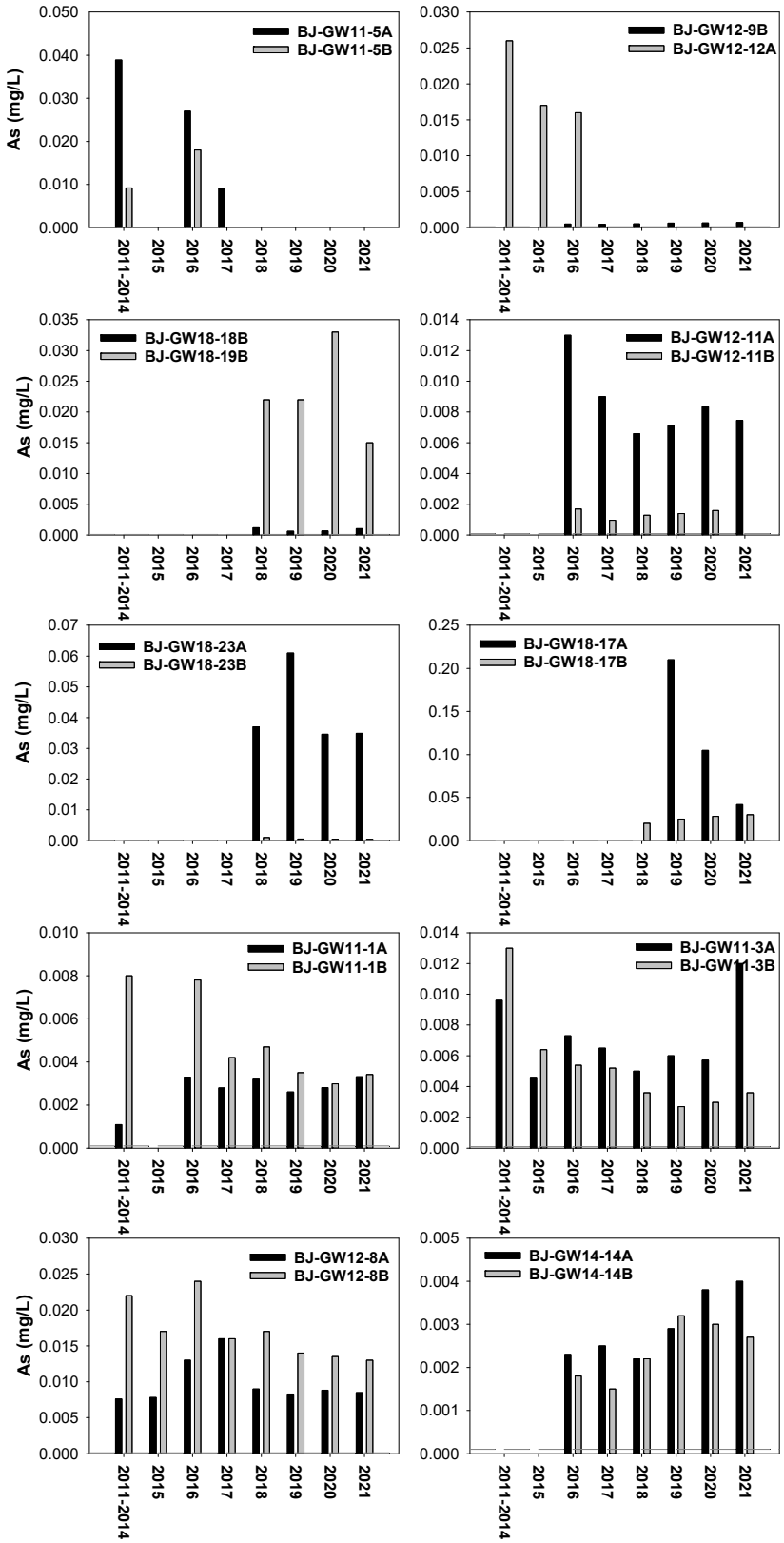


Figure 5-7: Average annual As-D in Brucejack monitoring wells. 2021 detection limit for As is 0.0001 mg/L.

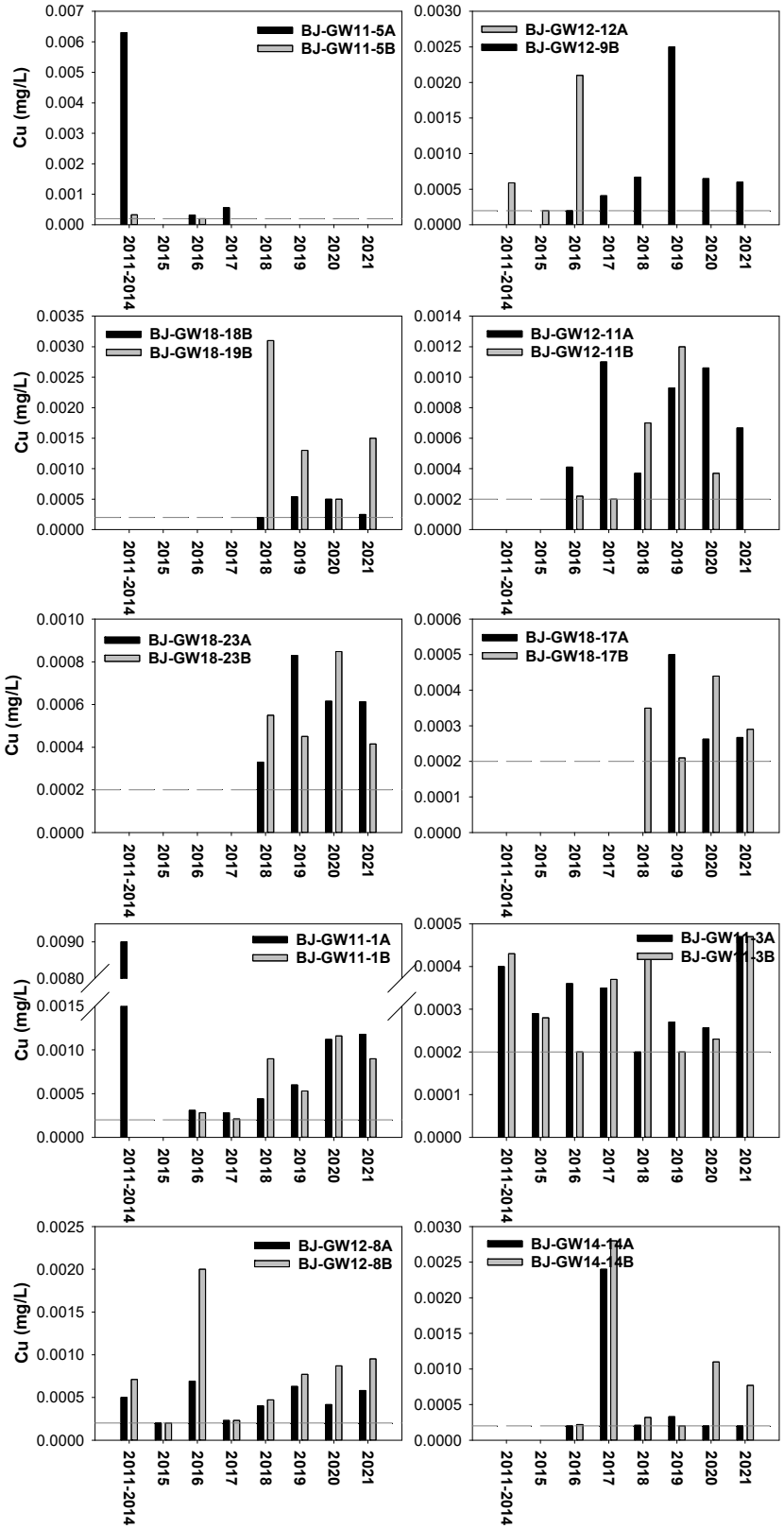


Figure 5-8: Annual average Cu-D in Brucejack monitoring wells. 2021 detection limit (0.0002 mg/L) shown as dashed line.

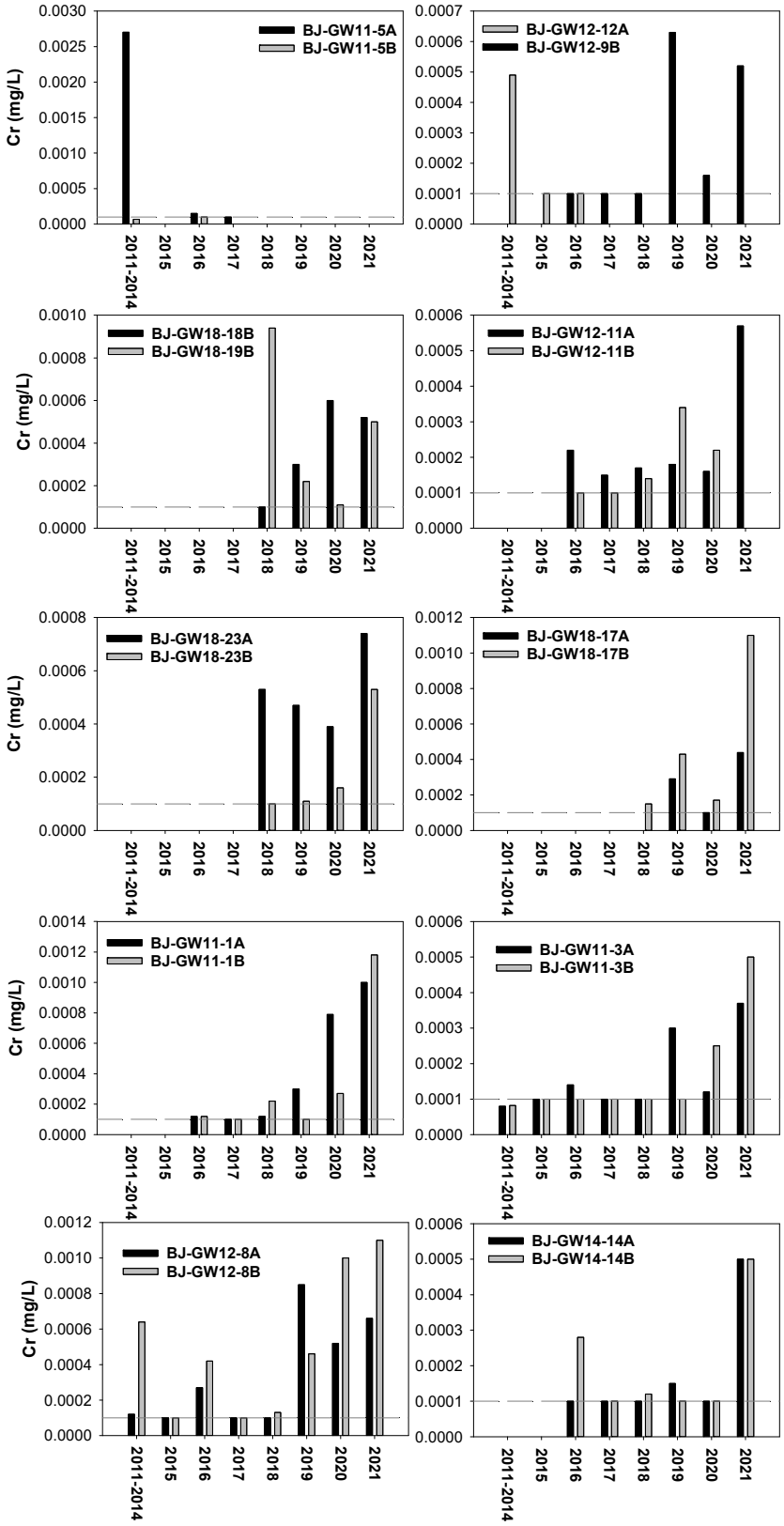


Figure 5-9: Annual average Cr-D in Brucejack monitoring wells. 2021 detection limit (0.0001 mg/L) shown as dashed line.

5.3 Snap-Sampler Trial

Snap samples (Snap) were compared to primary samples collected with traditional methods, immediately after the Snap, or in some cases, as close as possible to the Snap collection date. The preliminary analysis below reports the RPD's between parameters, with DQO's of >20% RPD where both samples are greater than x5MDL, as per the BC Field Sampling Manual QA/QC objectives for field duplicate samples (Clark 2013). Given that field duplicates are defined as samples collected by the same method, the DQO's selected for this preliminary analysis serve as guidelines only. When comparing sampling methods, observed differences between comparison samples may reflect the nature of the sample method, not necessarily the water quality (ITRC 2007).

In most wells, Snap samples compare well with primary samples for physical parameters, anions, nutrients and dissolved metals (Table 5-14, Table 5-15, Table 5-16, Table 5-17). Detailed RPD results are presented in Appendix K. Charge balance errors in excess of 5% were present in one sample throughout the trial period (BJ-GW18-18B-SNAP at -15% in sQ4 2020). This sample had notably higher alkalinity and TSS when compared to the corresponding primary low-flow sample (Table 5-14), suggesting suspended hydroxides may have contributed to the charge balance error. The Snap samples generally have elevated TSS and turbidity when compared to wells with lower TSS and turbidity from low-flow sampling methodologies (BJ-GW11-3A, BJ-GW12-8A/B) and lower TSS and turbidity when compared to wells with historically higher TSS and Turbidity from low-flow and high-flow sampling methodologies (BJ-GW18-17A/B).

Data quality objectives were most frequently exceeded in the total metals suite (Table 5-14, Table 5-15, Table 5-16, Table 5-17, Appendix K), where elevated turbidity and TSS are the likely cause. Where DQOs were exceeded with respect to dissolved metals, concentrations were consistently lower in Snap samples, with some exceptions mainly associated with BJ-GW18-17A/B (Table 5-18). Parameters exceeding DQOs in the anions/nutrients and dissolved metals suites occur most frequently in BJ-GW18-17A/B (Table 5-18).

The Snap Sampler trial was completed in sQ3 2021, and data processing and analysis are ongoing to assess reproducibility between traditional sampling methods, the influence of seasonal variation on water quality (*i.e.*, increased water level) and the effect of increased sampling proficiency with the Snap Samplers. No transition to no-purge/passive sampling will occur at the Brucejack Mine without regulator review and approval.

Table 5-14:
DQO exceedances between Snap Sampler and low-flow sample methodologies sQ4 2020

Sample ID[1]	BJ-GW11-3A-E303056	BJ-GW11-3A-snap	BJ-GW12-8A-E303059	BJ-GW12-8A-snap	BJ-GW12-8B-E314695	BJ-GW12-8B-snap
Date	03-Jan-21	03-Jan-21	27-Jan-21	27-Jan-21	28-Jan-21	28-Jan-21
Sample Method	Submersible	Snap	Submersible	Snap	Submersible	Snap
TSS	5.5	24.9	<3.0	30.4	7.4	5.4
TDS	242	251	131	137	122	126
Turbidity	4.45	18.1	1.28	6.23	7	0.81
Alkalinity	98.9	98.5	68.6	73.6	69	68.7
# Exceeding DQO – Anions/Nutrients	0		0		0	
# Exceeding DQO – Total Metals	10		11		6	
# Exceeding DQO – Dissolved Metals	3		0		1	
Sample ID	**BJ-GW18-17A-E303066**	**BJ-GW18-17A-snap**	**BJ-GW18-17B-E314701**	**BJ-GW18-17B-snap**	**BJ-GW18-18B-E314702**	**BJ-GW18-18B-snap**
Date	24-Jan-21	24-Jan-21	09-Jan-21	30-Dec-20	09-Jan-21	09-Jan-21
Sample Method	Bennett	Snap	Bailer	Snap	Submersible	Snap
TSS	9.6	68.2	473	44.2	5.3	193
TDS	482	491	532	500	356	424
Turbidity	4.6	37.9	540	59	4	-
Alkalinity	108	97.2	150	208	111	148
# Exceeding DQO – Anions/Nutrients	7		11		0	
# Exceeding DQO – Total Metals	8		20		11	
# Exceeding DQO – Dissolved Metals	10		11		6	

Notes:
1. DQO (data quality objective) is an RPD exceeding 20% in analytes greater than 5xMDL.

Table 5-15:
DQO exceedances between Snap Sampler and low-flow sample methodologies sQ1 2021

Sample ID[1]	BJ-GW11-3A-E303056	BJ-GW11-3A-snap	BJ-GW12-8A-E303059	BJ-GW12-8A-snap	BJ-GW12-8B-E314695	BJ-GW12-8B-snap
Date	Snap Fault	Snap Fault	23-Apr-21	23-Apr-21	22-Apr-21	22-Apr-21
Sample Method	Submersible	Snap	Submersible	Snap	Submersible	Snap
TSS	-	-	28.9	89.2	13.2	6.7
TDS	-	-	132	118	136	147
Turbidity	-	-	14.2	16.8	7.14	1.12
Alkalinity	-	-	72.3	72.4	72.9	73.4
# Exceeding DQO – Anions/Nutrients	-		8		1	
# Exceeding DQO – Total Metals	-		8		8	
# Exceeding DQO – Dissolved Metals	-		1		1	
Sample ID	**BJ-GW18-17A-E303066**	**BJ-GW18-17A-snap**	**BJ-GW18-17B-E314701**	**BJ-GW18-17B-snap**	**BJ-GW18-18B-E314702**	**BJ-GW18-18B-snap**
Date	27-Apr-21	31-Mar-21	5-Apr-21	3-Mar-21	Well Dry	Well Dry
Sample Method	Bennett	Snap	Bailer	Snap	Submersible	Snap
TSS	10.7	116	263	49.6	-	-
TDS	436	567	652	701	-	-
Turbidity	3.95	57.7	293	143	-	-
Alkalinity	135	102	117	306	-	-
# Exceeding DQO – Anions/Nutrients	3		10		-	
# Exceeding DQO – Total Metals	11		21		-	
# Exceeding DQO – Dissolved Metals	10		12		-	

Notes:
1. DQO (data quality objective) is an RPD exceeding 20% in analytes greater than 5xMDL.

Table 5-16:
DQO exceedances between Snap Sampler and low-flow sample methodologies sQ2 2021

Sample ID[1]	BJ-GW11-3A-E303056	BJ-GW11-3A-snap	BJ-GW12-8A-E303059	BJ-GW12-8A-snap	BJ-GW12-8B-E314695	BJ-GW12-8B-snap
Date	20-Jun-21	20-Jun-21	21-Jun-21	21-Jun-21	27-May-21	27-May-21
Sample Method	Submersible	Snap	Submersible	Snap	Submersible	Snap
TSS	9.4	3.1	16.8	104	9.6	26.2
TDS	234	204	123	130	121	143
Turbidity	3.47	2.33	12.4	22.1	3.74	1.56
Alkalinity	97.6	95.9	73	76.2	69.6	70.9
# Exceeding DQO – Anions/Nutrients	0		0		0	
# Exceeding DQO – Total Metals	8		15		14	
# Exceeding DQO – Dissolved Metals	1		1		2	
Sample ID	**BJ-GW18-17A-E303066**	**BJ-GW18-17A-snap**	**BJ-GW18-17B-E314701**	**BJ-GW18-17B-snap**	**BJ-GW18-18B-E314702**	**BJ-GW18-18B-snap**
Date	23-May-21	23-May-21	31-Jul-21	26-Jul-21	23-May-21	23-May-21
Sample Method	Bennett	Snap	Submersible	Snap	Submersible	Snap
TSS	3.9	52.1	468	92.2	27	31.6
TDS	426	506	493	548	438	430
Turbidity	2.74	31.8	613	116	54.4	25.8
Alkalinity	124	153	121	137	118	114
# Exceeding DQO – Anions/Nutrients	4		9		1	
# Exceeding DQO – Total Metals	11		21		8	
# Exceeding DQO – Dissolved Metals	10		10		1	

Notes:
2. DQO (data quality objective) is an RPD exceeding 20% in analytes greater than 5xMDL.

Table 5-17:
DQO exceedances between Snap Sampler and low-flow sample methodologies sQ3 2021

Sample ID[1]	BJ-GW11-3A-E303056	BJ-GW11-3A-snap	BJ-GW12-8A-E303059	BJ-GW12-8A-snap	BJ-GW12-8B-E314695	BJ-GW12-8B-snap
Date	23-Sep-21	22-Sep-21	17-Oct-21	17-Oct-21	17-Oct-21	17-Oct-21
Sample Method	Submersible	Snap	Submersible	Snap	Submersible	Snap
TSS	3	24.8	5.2	220	3.4	32.8
TDS	238	235	106	120	120	106
Turbidity	3.13	14.2	1.76	64.6	1.96	4.25
Alkalinity	95.6	102	72.4	73.6	71.1	72.4
# Exceeding DQO – Anions/Nutrients	0		1		0	
# Exceeding DQO – Total Metals	5		10		6	
# Exceeding DQO – Dissolved Metals	1		0		0	
Sample ID	**BJ-GW18-17A-E303066**	**BJ-GW18-17A-snap**	**BJ-GW18-17B-E314701**	**BJ-GW18-17B-snap**	**BJ-GW18-18B-E314702**	**BJ-GW18-18B-snap**
Date	Snap Fault	Snap Fault	15-Sep-21	14-Sep-21	11-Sep-21	11-Sep-21
Sample Method	Bennett	Snap	Submersible	Snap	Submersible	Snap
TSS	-	-	104	22.2	43.1	19.1
TDS	-	-	397	414	387	246
Turbidity	-	-	166	21.7	26.2	26.1
Alkalinity	-	-	112	112	96.6	69.7
# Exceeding DQO – Anions/Nutrients	-		6		3	
# Exceeding DQO – Total Metals	-		18		12	
# Exceeding DQO – Dissolved Metals	-		11		5	

Notes:
3. DQO (data quality objective) is an RPD exceeding 20% in analytes greater than 5xMDL.

Table 5-18:
Instances where Snap Sampler dissolved metals concentrations exceeded low-flow dissolved metals concentrations.

Well ID	sQ4 2020	sQ1 2021	sQ2 2021	sQ3 2021
BJ-GW11-3A-snap	Sb	-	-	Fe
BJ-GW12-8A-snap	-	-	-	-
BJ-GW12-8B-snap	-	-	-	-
BJ-GW18-17A-snap	Sb, As, Li, Mo	Sb, As, B, Li, Mo, Na	As, B, Li, Mo, Na	-
BJ-GW18-17B-snap	Na, Se, K	As, Li, Mn, K, Se, Si, Na, U	Ba, Ca, Mg, K, Sr, U	Sb, Ca, K, Sr
BJ-GW18-18B-snap	Ba, K	-	-	-

6. Conclusions

6. Conclusions

6.1 Groundwater Quantity

Monthly underground dewatering rates during the open water season were appreciably higher in 2021 than previous years, reaching an all-time high of 2,800 m^3/d in June. Previous monthly averages peaked at 2,500 m^3/d in 2020. Low flow dewatering rates in 2021, however, were similar if not lower than previous years' averages. Overall, 2021 had ~10% more precipitation that 2021, however, over the May to September period, rainfall was actually 10% lower than 2021. This supports the assertion that increased open water season dewatering rates are being influence by the expanding mine development as much, if not more, than by climate.

Continued dewatering of the VOK and West Zone workings has sustained a substantial cone of depression in the groundwater table in the footprint of the workings and farther afield. Water levels collected at wells near the VOK suggest that drawdown at historic wells exceeds 100 m and that a groundwater divide exists between the VOK and West Zone. East of the West Zone, water levels at BJ-GW11-3A and BJ-GW18-17A/B are lower than the elevation of the WRTSF (1364.5 m) which suggests that the WRTSF is recharging groundwater at its outlet. The low water level at BJ-GW18-17A/B appears to suggest an enhanced connection to the West Zone.

The data record at 2018 series wells indicates that seasonal water level fluctuations are on the order of tens of meters and hydraulic gradients at well pairs are moderately to strongly downward. This is consistent with observations at older monitoring wells. Several well pairs do experience upward hydraulic gradients for at least part of the year: BJ-GW18-20A/B, BJ-GW18-18B, BJ-GW18-23A/B, BJ-GW11-1A/B, BJ-GW14-14A/B and BJ-GW12-8A/B.

Notable water level time trends include increasing water levels trends at several wells (BJ-GW12-9B, BJ-GW11-1A, BJ-GW11-3A/B and BJ-GW11-6B) on account of higher precipitation in 2021 than in previous years. A few wells experienced notable drops in peak water levels including BJ-GW12-11B, BJ-GW18-19B and BJ-GW18-21B, presumably due to expansion and deepening of the VOK. Water levels at BJ-GW18-20A/B do not appear to be responding to mining. This supports the conceptualization of the Brucejack Fault as a highly permeable feature that is limiting the extent of groundwater system depressurization west of the fault.

6.2 Groundwater Quality

Groundwater sampling at the Brucejack Mine has been conducted in accordance with procedures outlined in the BC Groundwater Field Sampling Manual (Clark 2013). Groundwater sampling methods transitioned towards low-flow methodologies in 2019, resulting in fewer occurrences of high turbidity samples (>200 NTU) in 2021. The mine is currently experimenting with the Snap Sampler passive sampling system to determine if this sampling method is viable for select wells.

Overall, the quality assurance program indicates good contamination control, precision and sample homogeneity in field sampling. Samples are routinely transported to the laboratory at recommended temperatures and within recommended holding times. As in 2020, dissolved selenium may be biased high in select samples on account of volatile organic selenium complexes interfering with laboratory equipment. Since selenium has not been identified as a parameter of concern for the Brucejack Mine, Pretium has not sought alternative sampling/analytical methodologies. The 2021 monitoring results are considered to be representative of groundwater water quality at the time of sampling.

In 2021, NO_3 was measured above detection limit (0.005 mg/L) in one or more sampling events at most Brucejack monitoring wells except BJ-GW11-3B and BJ-GW14-14A/B. The highest average concentrations of NO_3 and NO_2 are measured downgradient of the CWP at BJ-GW18-23A/B (17.6 mg/L NO_3 at BJ-GW18-23B and 0.1 mg/L NO_2 at BJ-GW18-23A). Average NO_3 concentrations remain stable while average NO_2 continue to decline at the well pair. Average NO_3 and NO_2 are typically one to two orders of magnitude higher at BJ-GW18-23A/B than other wells across the mine. Sulphate is also highest in well nests downgradient of the CWP, with averages ranging from 181 mg/L to 465 mg/L at BJ-GW18-23A/B in 2021.

Dewatering of the underground caused slight shifts in major ion chemistry at historic wells prior to the wells going dry (BJ-GW11-5A/B and BJ-GW12-12A). This manifested as higher proportions of sulphate and/or calcium at these wells. BJ-GW11-3A/B show seasonally variable chloride which has been attributed to winter salt application near the wash bay. The only other wells showing clear influence of the mine in major ion chemistry are BJ-GW18-23A/B which intercept groundwater flowpaths from the CWP. All Brucejack monitoring wells screen groundwater that is neutral to slightly alkaline (pH 7 to 8.5).

Average concentrations of some dissolved trace metals (Al, As, Cu, Cr, Se) measure above detection in most wells, however in many cases concentrations of dissolved metals remain within 5xMDL. BJ-GW18-17A reported the highest annual average As-D concentration across the site in 2021 (0.0418 mg/L) and has dropped from 2020 average (0.11 mg/L).

Annual average concentrations of As-D at BJ-GW11-3A (0.012 mg/L), BJ-GW12-8B (0.013 mg/L), BJ-GW18-17B (0.03 mg/L), BJ-GW18-23A (0.0349 mg/L) and BJ-GW18-19B (0.0315 mg/L) are approximately one to two orders of magnitude greater than the mine's other monitoring wells. Cr-D is generally measured at low concentrations in Brucejack groundwater but has been consistently increasing in several wells, namely BJ-GW18-23B, BJ-GW11-1A/B, BJ-GW11-3B and BJ-GW12-8B (Figure 5 10). Other wells experienced increases in average Cr-D concentrations between 2020 and 2021. The mine is investigating whether this trend can be attributed to the sampling methodology.

Impacts from mining on Brucejack groundwater are limited to subtle shifts in major ion chemistry in wells dewatered by VOK development and isolated influences of surface features (CWP seepage, wash bay salting) on shallower wells. Groundwater at the Brucejack mine site is not displaying a signature that could be attributed to mine-induced ARD. This is not surprising given that the mine is currently acting as a groundwater sink.

7. Closure

7. Closure

The Brucejack Project 2021 Annual Groundwater Monitoring Report is a collaboration of Lorax and Pretium authors. This report has been prepared in fulfilment of annual reporting requirements for the Brucejack Mine. The material in it reflects the professional judgment of Lorax in light of the information available to Lorax at the time of document preparation. Reliance upon this document by third parties outside of its intended use is at the responsibility of the third party.

Yours sincerely,

LORAX ENVIRONMENTAL SERVICES LTD.

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Lorax Engineers and Geoscientists British Columbia Permit to Practice Number: 1001840

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NEWCREST

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Appendices

NEWCREST

Appendix A
Monitoring Well Logs

NEWCREST

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

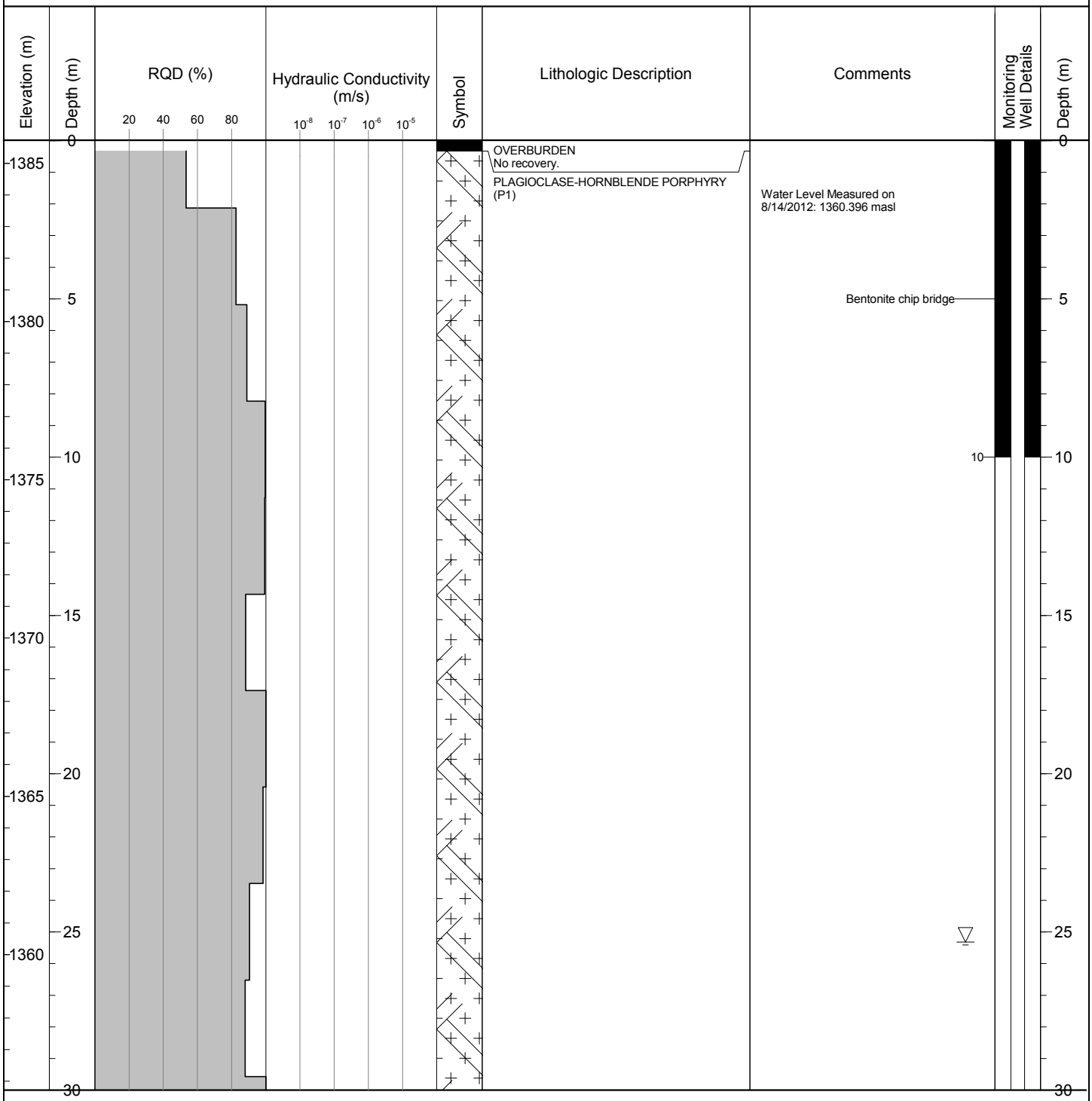
Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
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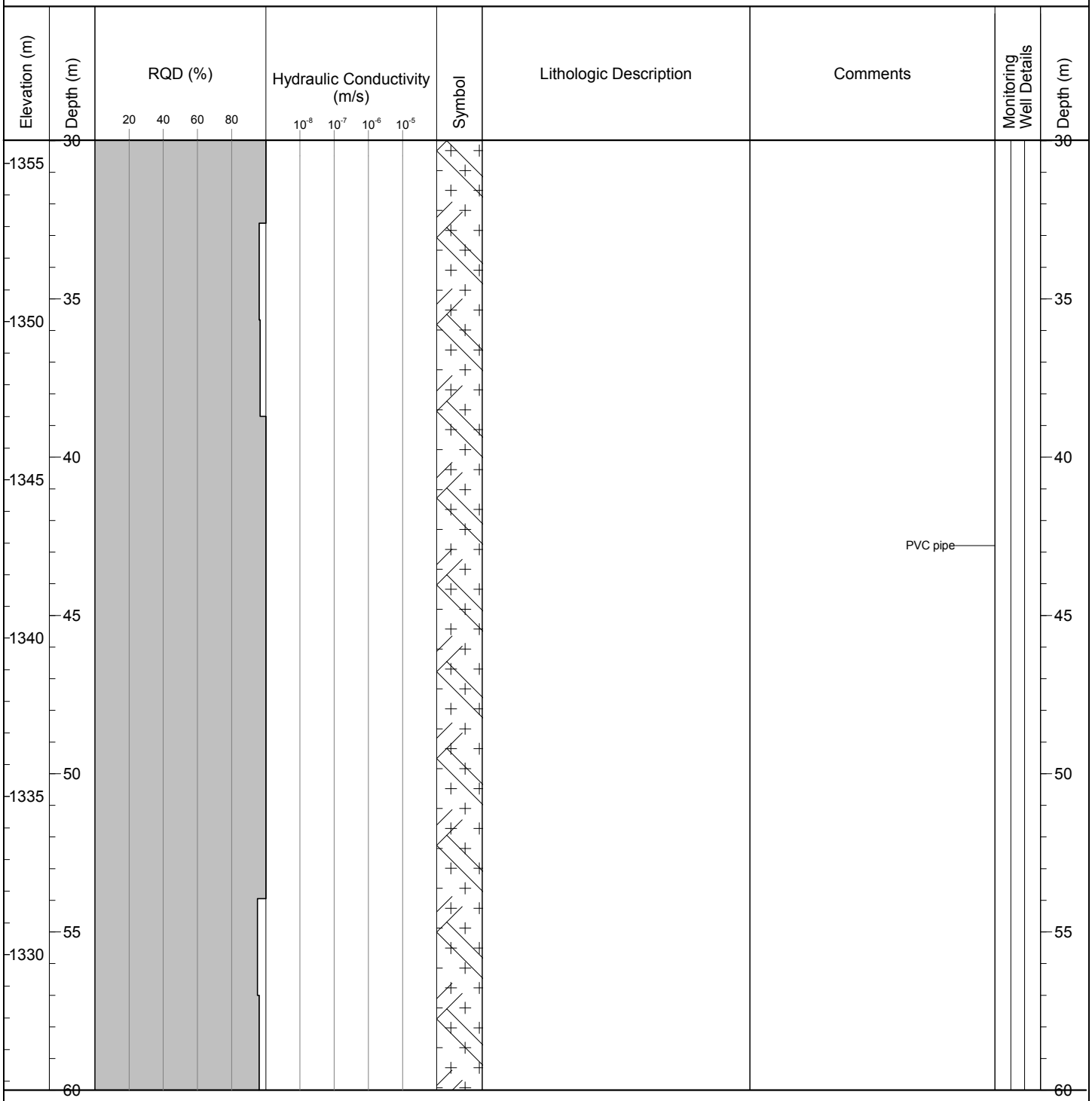
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
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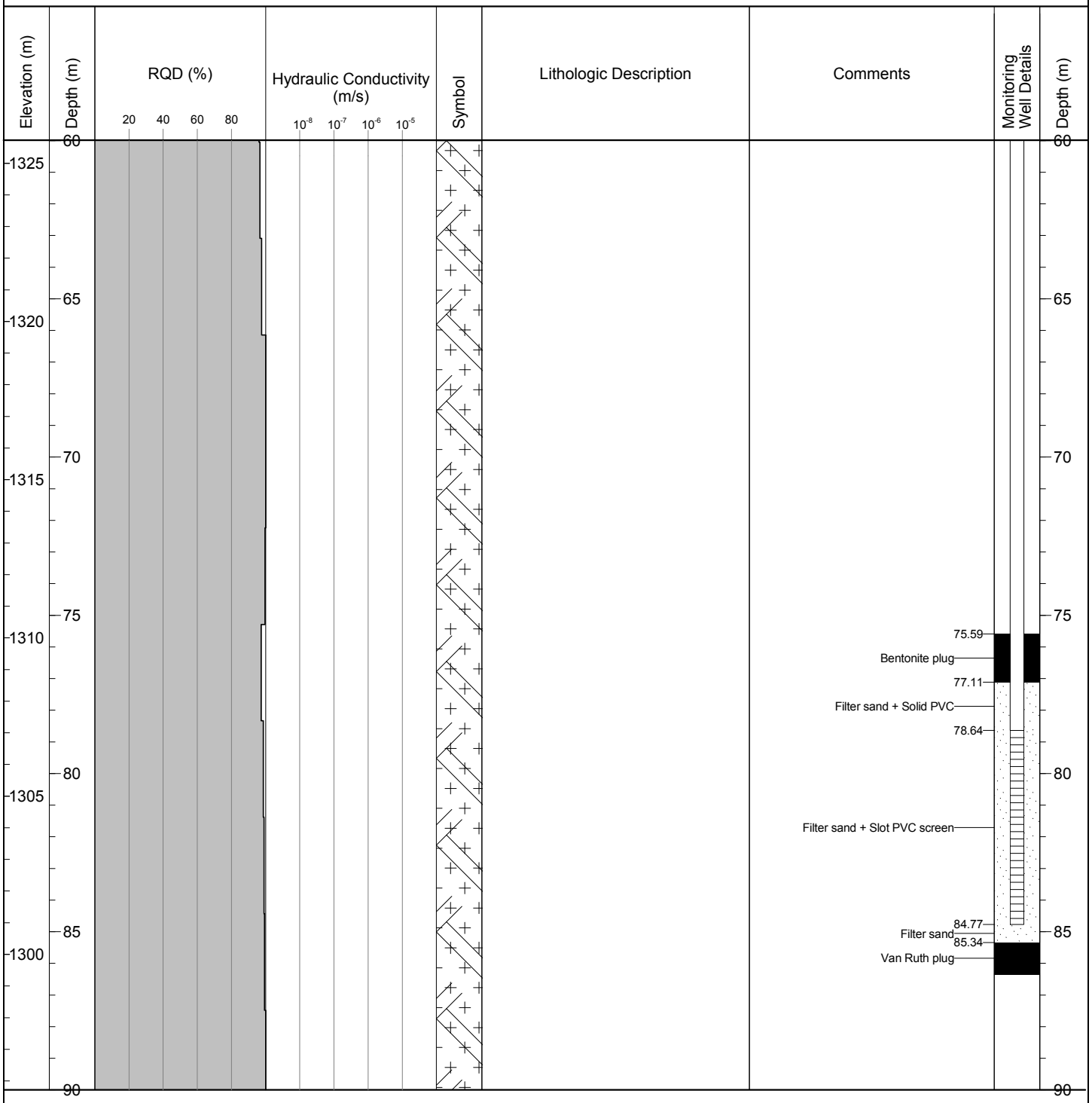
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

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Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1295	90							90
1290	95							95
1285	100							100
1280	105				End of Hole: 102.7 m	Bottom of Installation: 85.3 m		105
1275	110							110
1270	115							115
	120							120

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Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1B

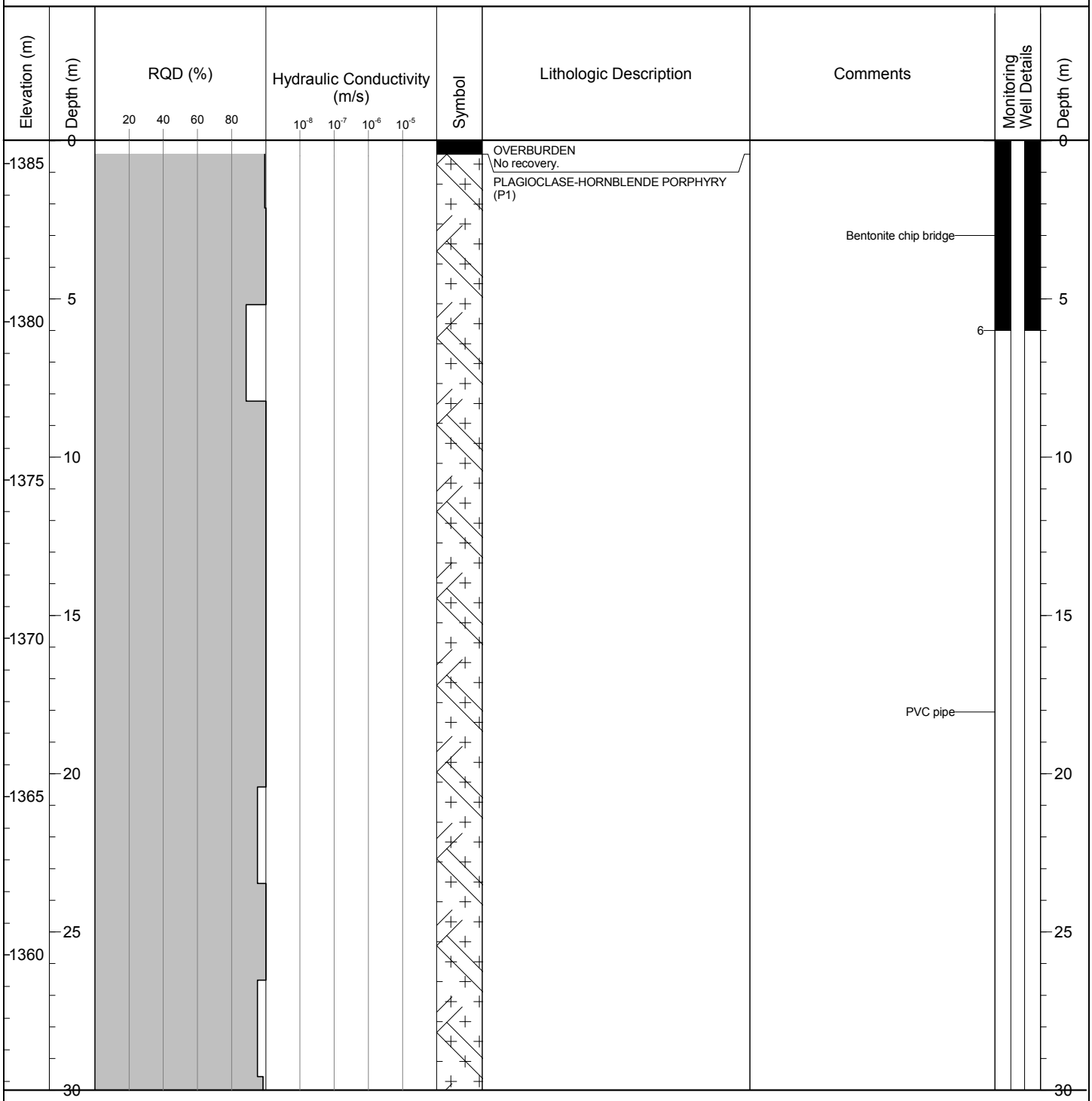
Location: West Zone

NEW ID: BJ-GW11-1B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,841N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.4
Cased To (m): NO CASING INSTALLED

Start date: 02 Oct 11
Finish Date: 02 Oct 11
Final Depth (m): 38.7
Depth To Top Of Rock (m): 0.4
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

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Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1B

Location: West Zone

NEW ID: BJ-GW11-1B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,841N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.4
Cased To (m): NO CASING INSTALLED

Start date: 02 Oct 11
Finish Date: 02 Oct 11
Final Depth (m): 38.7
Depth To Top Of Rock (m): 0.4
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1355	30							30
						30.1 Bentonite plug		
						31.3		
						Filter sand + Solid PVC		
	35							35
1350						35.3		
						Filter sand + Slot PVC screen		
						Filter sand 38.4		
					End of Hole: 38.7 m	Bottom of Installation: 38.7 m		
1345	40							40
1340	45							45
1335	50							50
1330	55							55
	60							60

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Project: Brucejack
Project No.: 1008-004

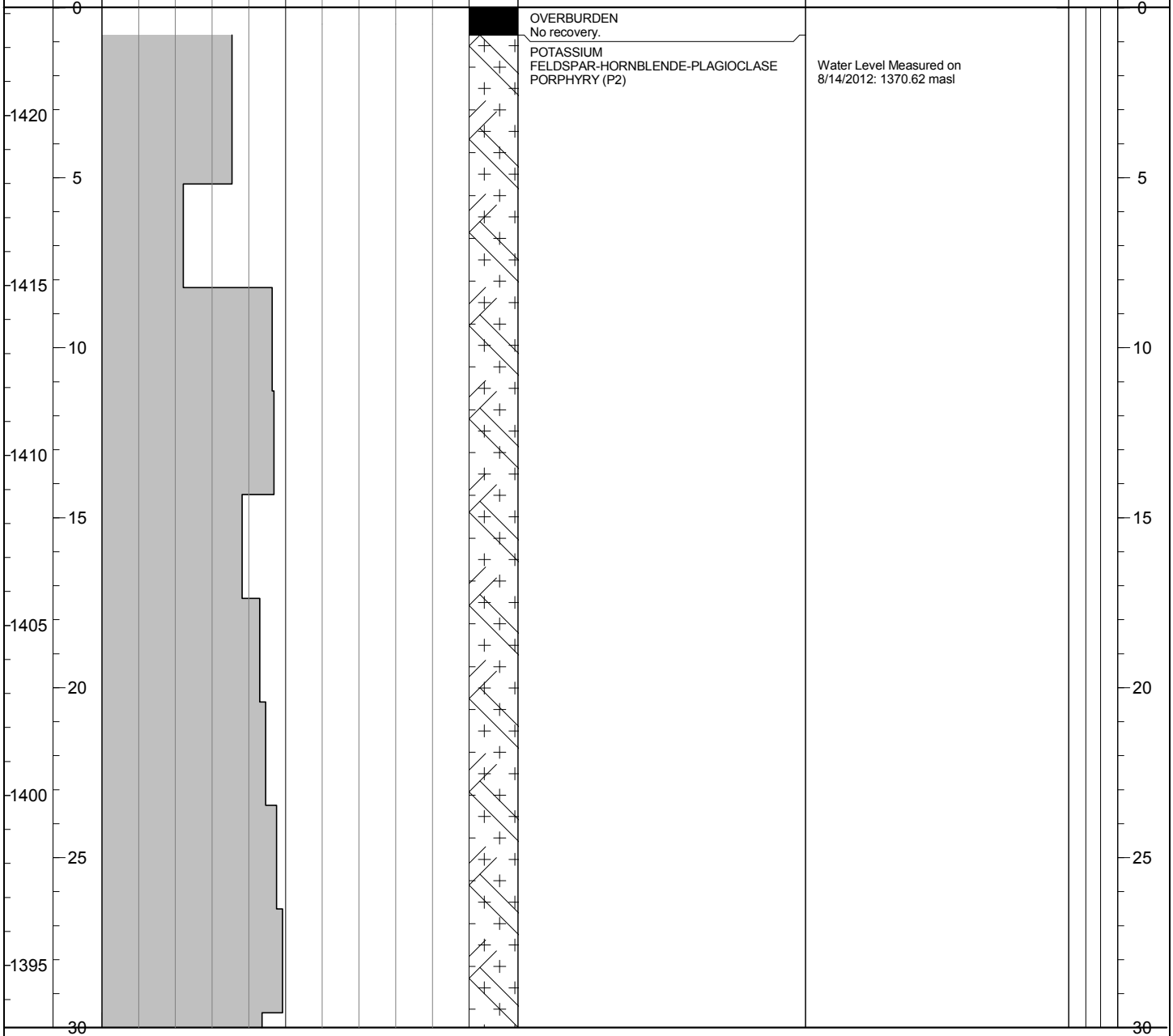
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

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Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
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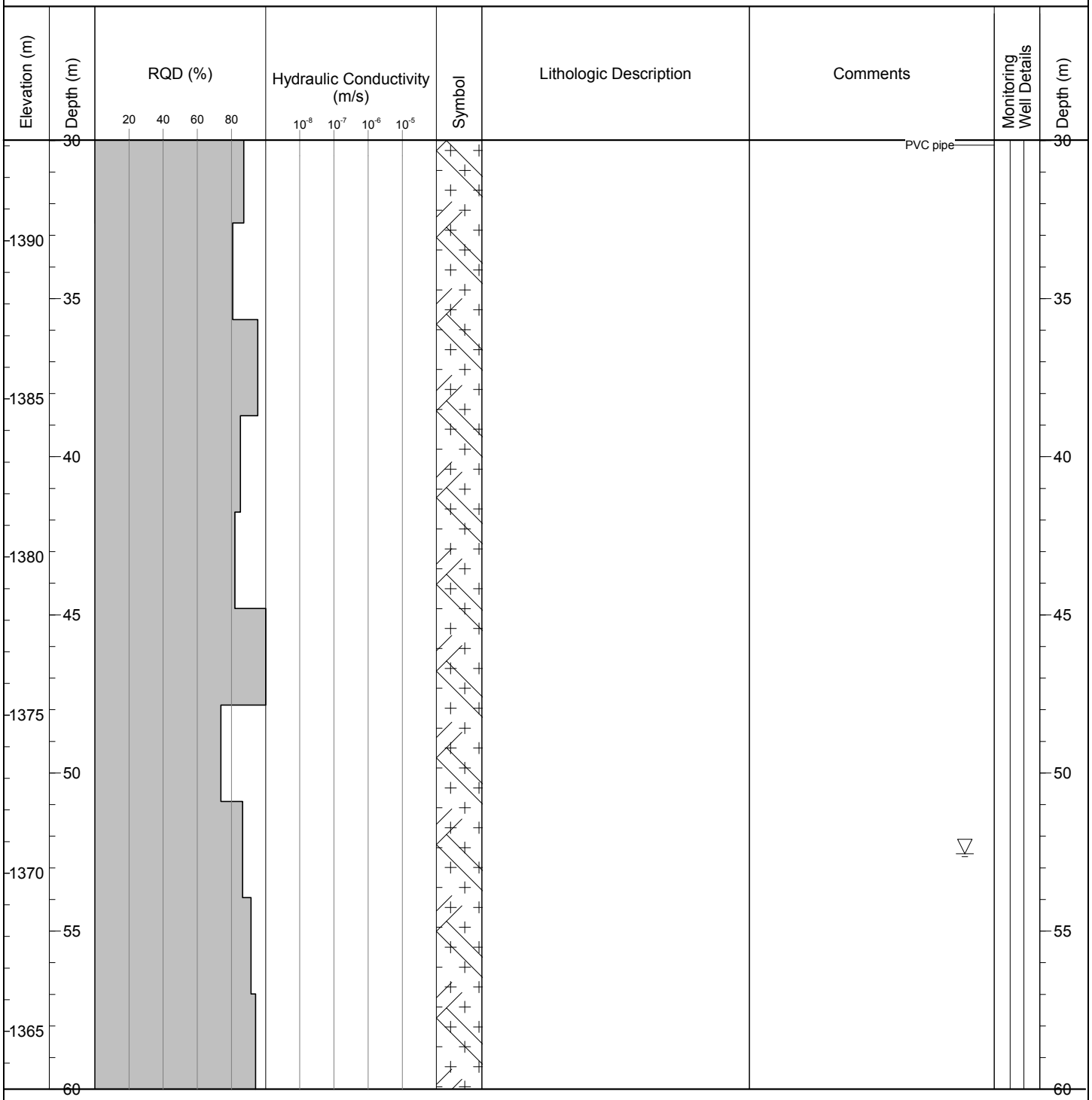
Reviewed by: BGC



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Project: Brucejack
Project No.: 1008-004

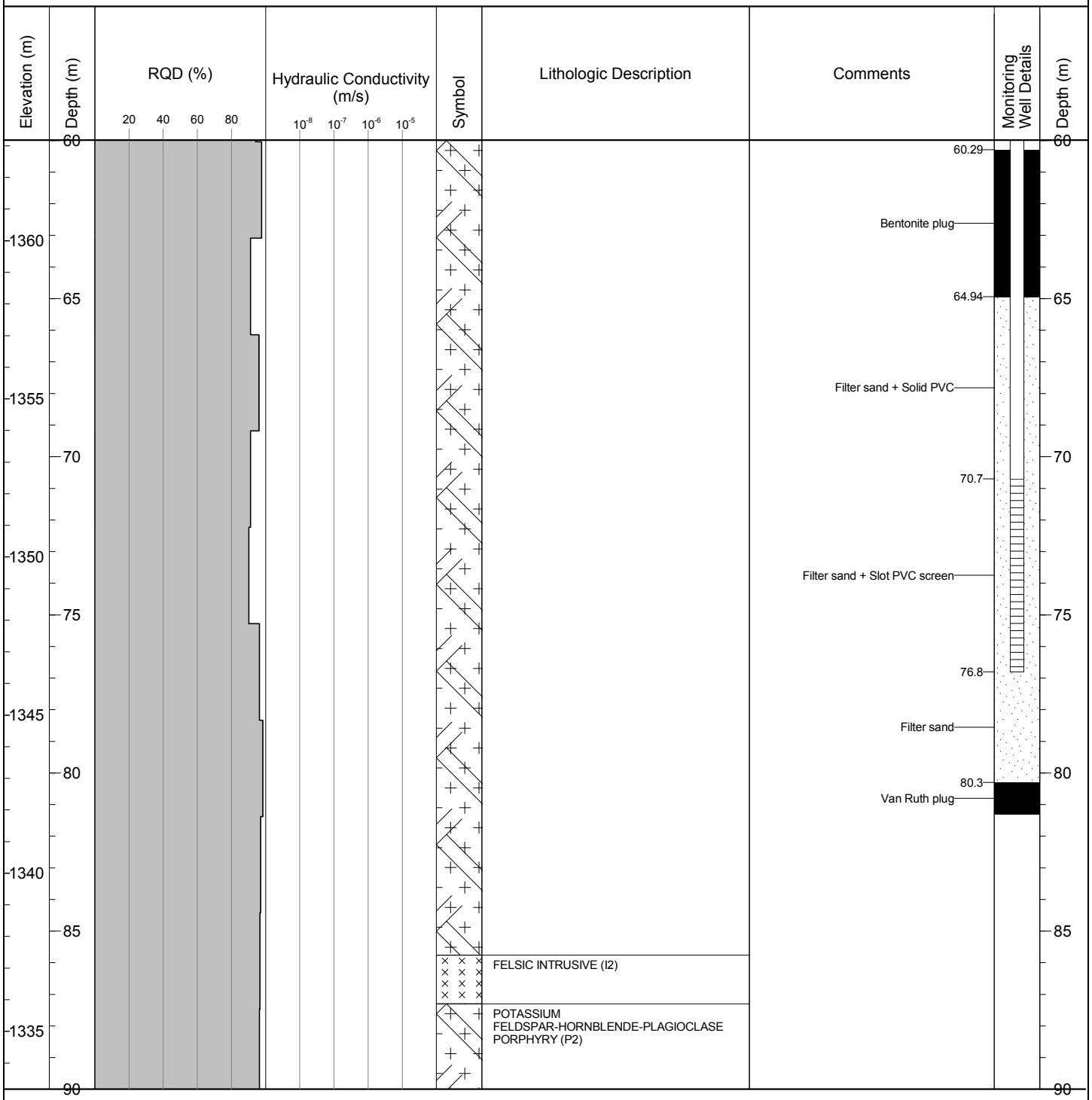
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

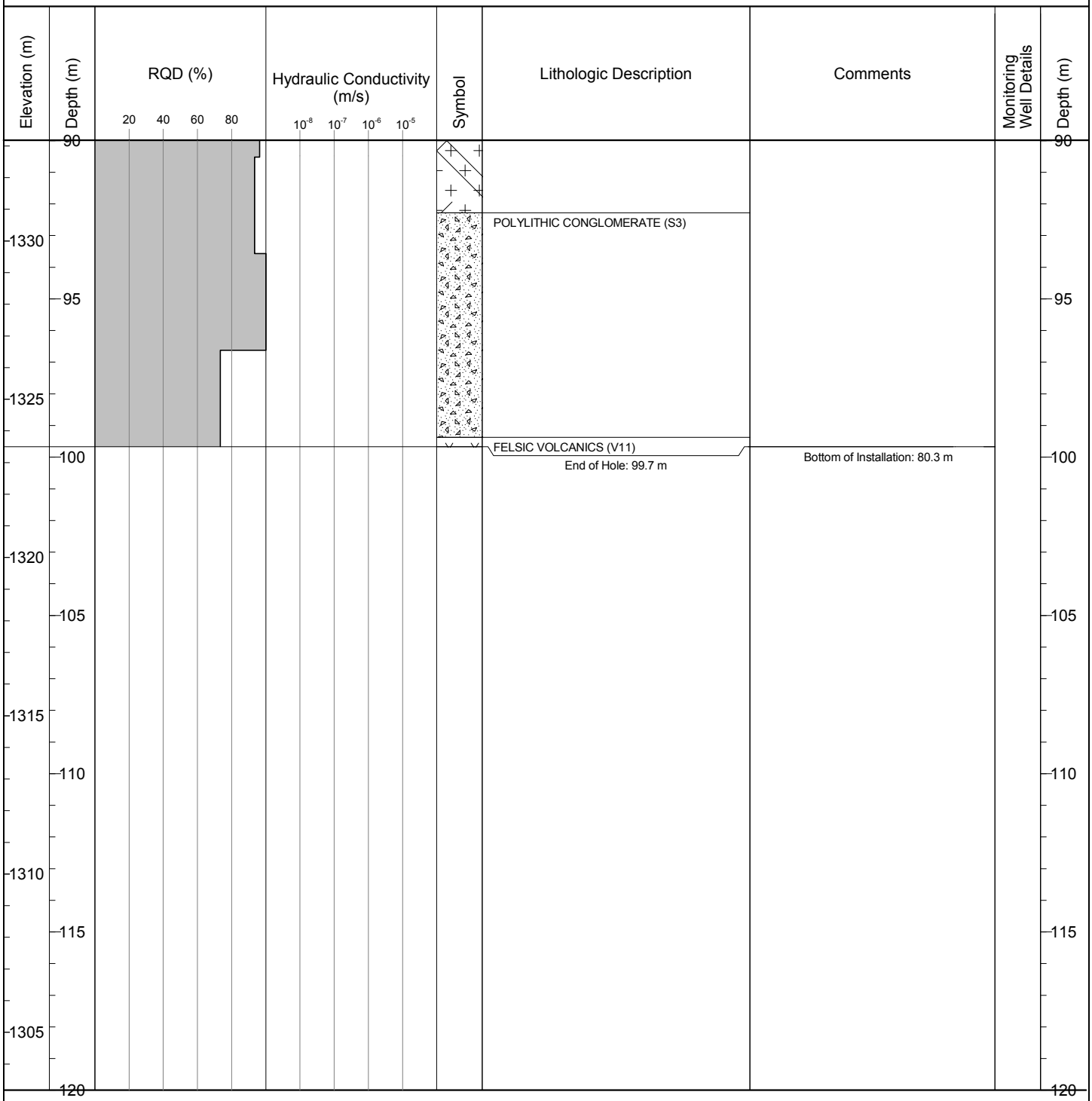
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		OVERBURDEN No recovery.			0
1365					PLAGIOCLASE PORPHYRY (P3)	Water Level Measured on 8/14/2012: 1364.177 masl		
	5							5
1360								
	10							10
1355								
	15							15
1350								
	20							20
1345								
	25							25
1340								
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30							30
1335								
	35							35
1330						PVC pipe		
	40							40
1325								
	45							45
1320								
	50							50
1315								
	55							55
1310								
	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

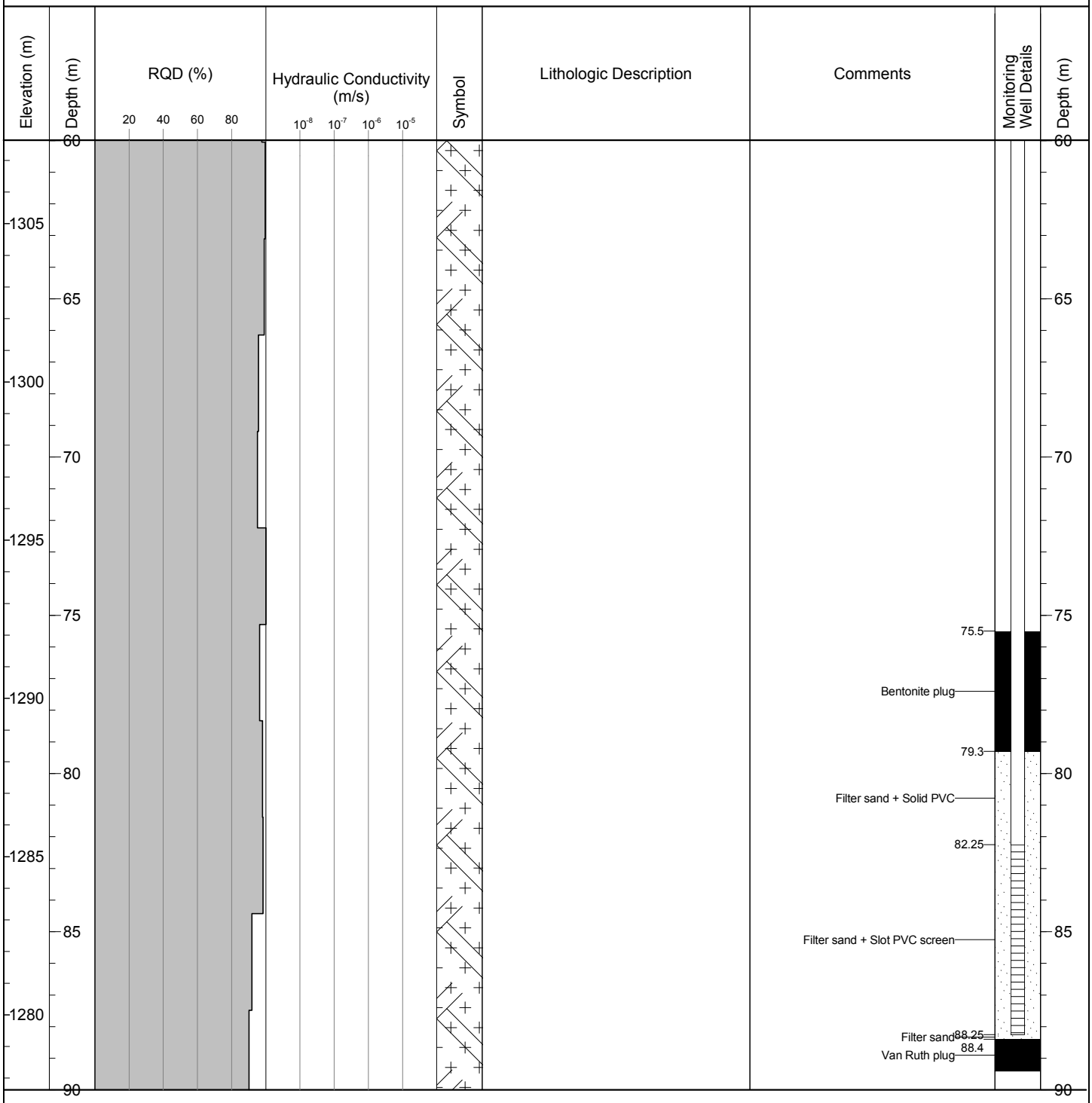
Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1275	90							90
					End of Hole: 93.6 m	Bottom of Installation: 88.4 m		
1270	95							95
1265	100							100
1260	105							105
1255	110							110
1250	115							115
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3B

Location: West Zone

NEW ID: BJ-GW11-3B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.53
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.23
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 9.4
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				OVERBURDEN No recovery.			0
1365					PLAGIOCLASE PORPHYRY (P3)	Water Level Measured on 8/14/2012: 1368.632 m	Bentonite plug	
	5						4.5 Filter sand + Solid PVC 5.8	5
1360							Filter sand + Slot PVC screen Filter sand 8.8	
					End of Hole: 9.4 m	Bottom of Installation: 9.1 m		
	10							10
1355								
	15							15
1350								
	20							20
1345								
	25							25
1340								
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

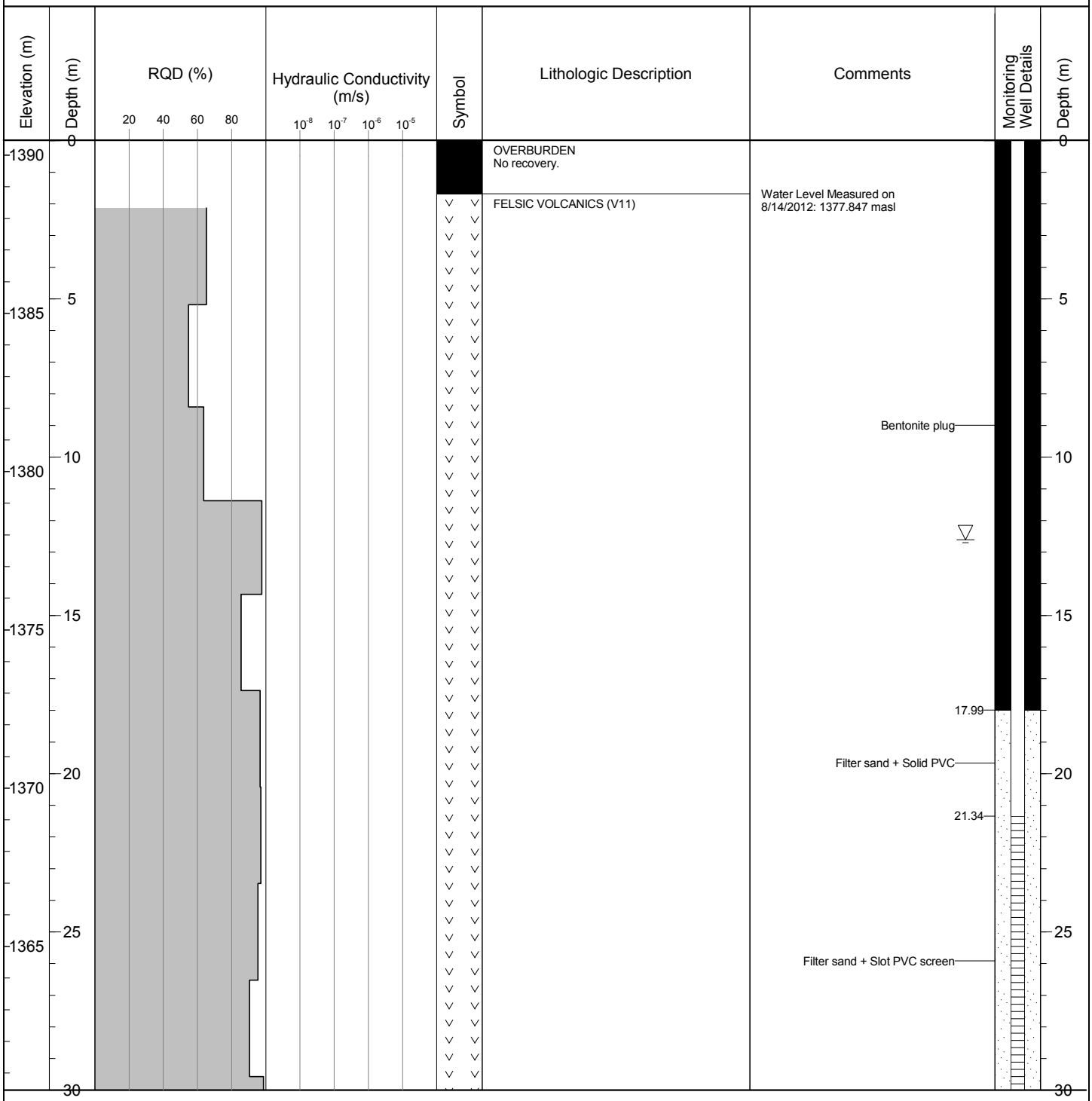
DRILL HOLE # MW-BGC11-BJ-4A

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,750N
Ground Elevation (m): 1,390.46
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.4
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1390.9
Cased To (m): 3

Start date: 04 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 32.6
Depth To Top Of Rock (m): 1.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-4A

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,750N
Ground Elevation (m): 1,390.46
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.4
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1390.9
Cased To (m): 3

Start date: 04 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 32.6
Depth To Top Of Rock (m): 1.7
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1360	30					Filter sand 30.49–31; Van Ruth plug		30
					End of Hole: 32.6 m	Bottom of Installation: 31.0 m		
1355	35							35
1350	40							40
1345	45							45
1340	50							50
1335	55							55
	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details
1390	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PELITE (S5) Interbedded with arenite (S4) with some clasts that are subangular and moderately sorted. No significant mineralization or veining (1-2%). Medium strong (R3-R3.5) from top of bedrock to 5.1 m below ground surface. Strong to very strong (R4-R4.5) below 5.1 m. Slight to moderate weathering (W2-W2.5) on major discontinuities from top of bedrock to 5.1 m below ground surface. Faint alteration (A1-A1.5) below 5.1 m.	Water Level Measured on 8/14/2012: 1377.87 masl	
1385	5						
1380	10						
1375	15				ARENITE (S4) Grey-green, medium grained, interbedded with minor sections of finer grained sands and silts (S5). Quartz-calcite-pyrite concretions and chlorite stringers evident. Locally laminated at approximately 30 degrees TCA. Strong to very strong (R4-R4.5). Faint to no alteration (A1-A1.5).		
1370	20						
1365	25						
	30						

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

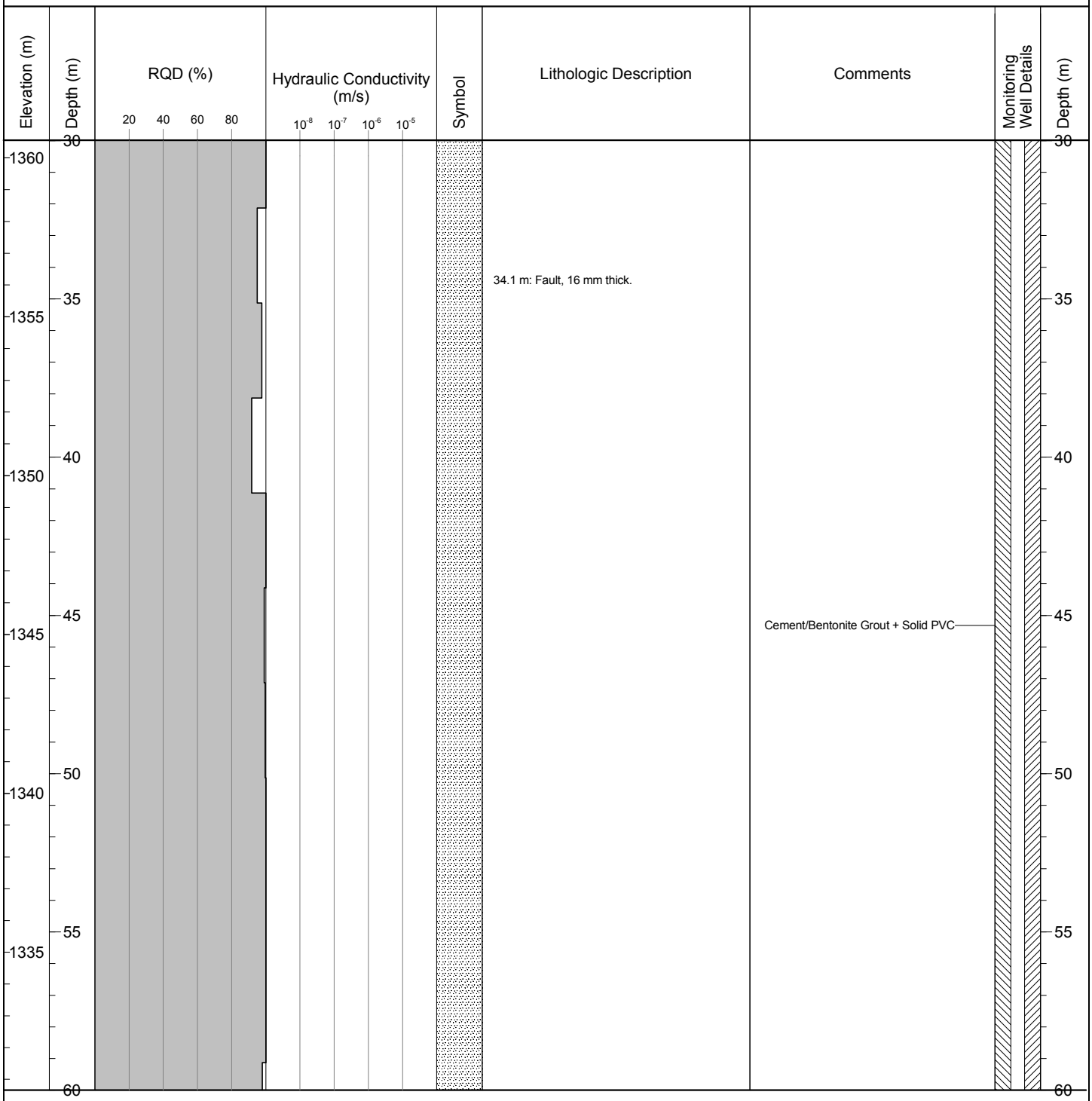
DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1330	60							60
1325	65				65.1 m: Shear, 1 mm thick. 66.5 - 98.13 m: Coarser grained sandstone. Minor sections of larger clasts (on pebble scale). Larger clasts more angular and poorly sorted. Pyrite replacement of clasts, and pyrite abundant in veinlets and blebs. Veining 1-5%.			65
1320	70				72.9 m: Fault, 80 mm thick, broken rock.			70
1315	75							75
1310	80							80
1305	85							85
	90							90

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CLIENT: Pretium Resources Inc.

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1300	90					90.63 3/8" Coated Bentonite pellets + Solid PVC 91.63		90
1295	95				95.7 m: Fault, 100 mm thick, broken rock.	94.88 10/20 Filter sand + 0.020 Slot PVC screen 97.93		95
					End of Hole: 98.1 m	Bottom of Installation: 98.1 m		
1290	100							100
1285	105							105
1280	110							110
1275	115							115
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

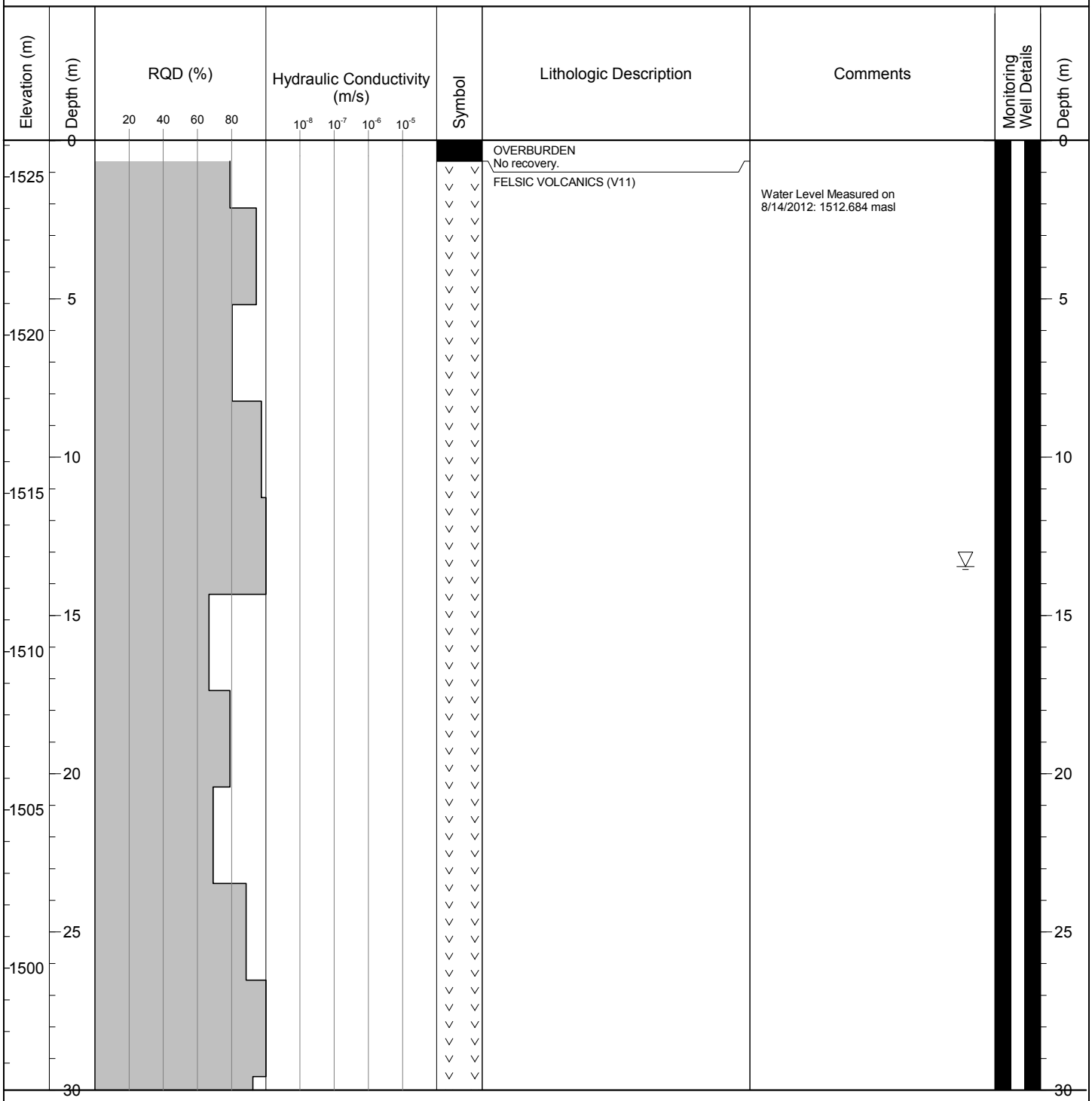
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

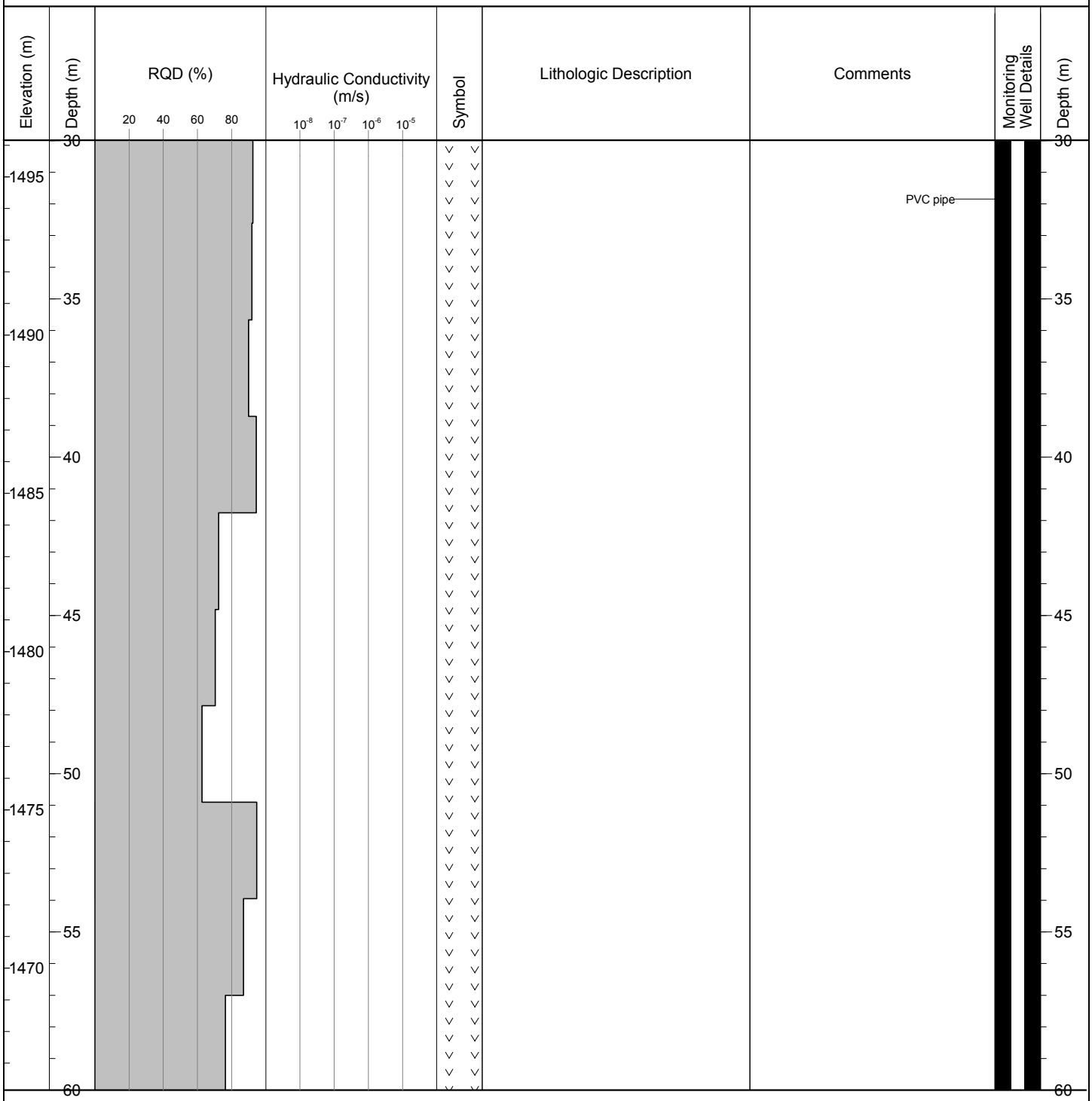
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

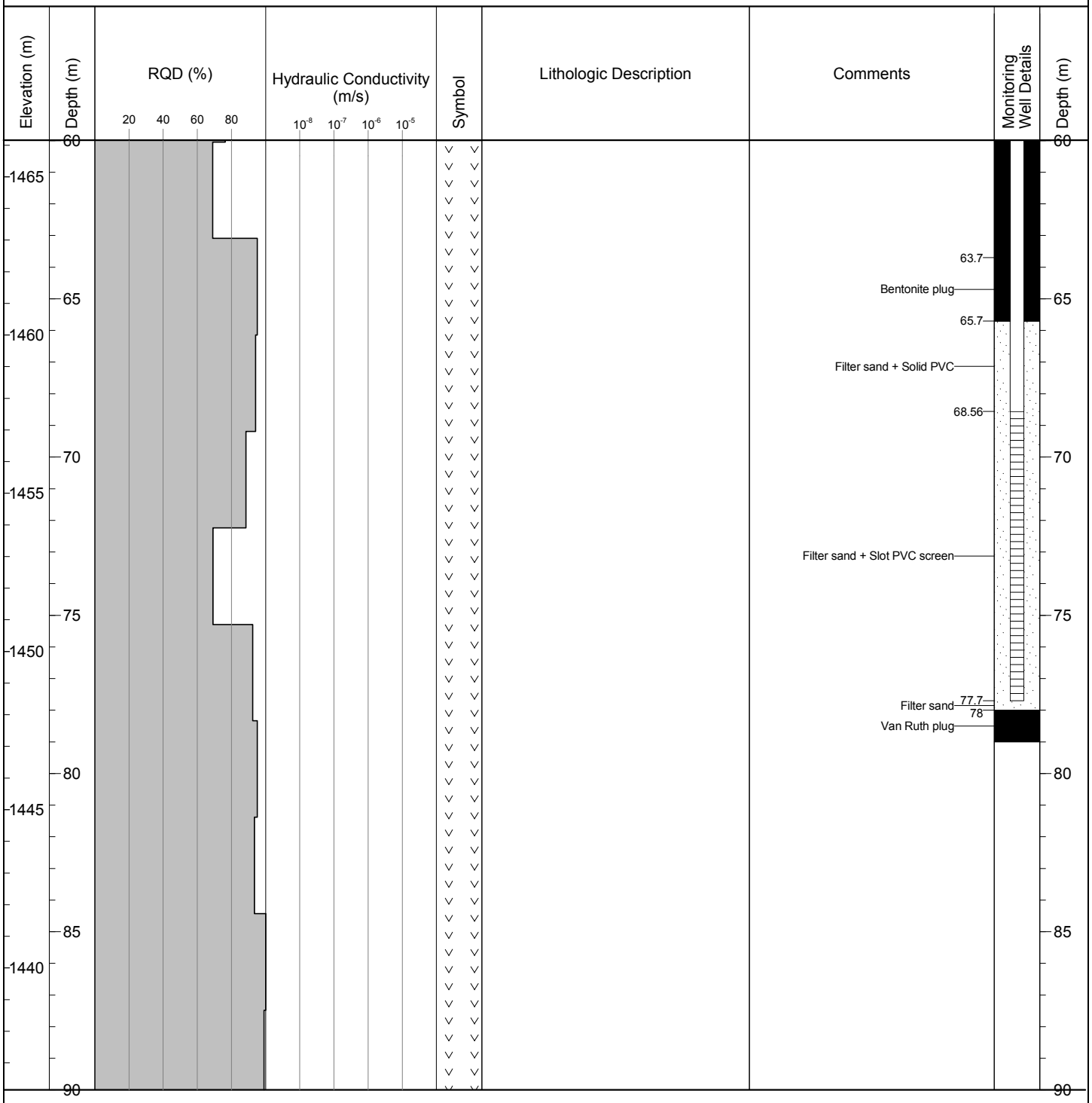
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1435	90							90
1430	95							95
1425	100							100
1420	105				End of Hole: 102.7 m	Bottom of Installation: 78.0 m		105
1415	110							110
1410	115							115
	120							120

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5B

Location: Valley of Kings Zone

NEW ID: BJ-GW11-5B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,346E - 6,258,042N
Ground Elevation (m): 1,526.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.44
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.6
Cased To (m): NO CASING INSTALLED

Start date: 29 Sep 11
Finish Date: 30 Sep 11
Final Depth (m): 50.9
Depth To Top Of Rock (m): 1.4
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				OVERBURDEN No recovery.			0
1525					FELSIC VOLCANICS (V11)	Water Level Measured on 8/14/2012: 1515.565 masl		
	5							5
1520								
	10							10
1515								
	15							15
1510								
						PVC pipe		
	20							20
1505								
	25							25
1500								
	30							30

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5B

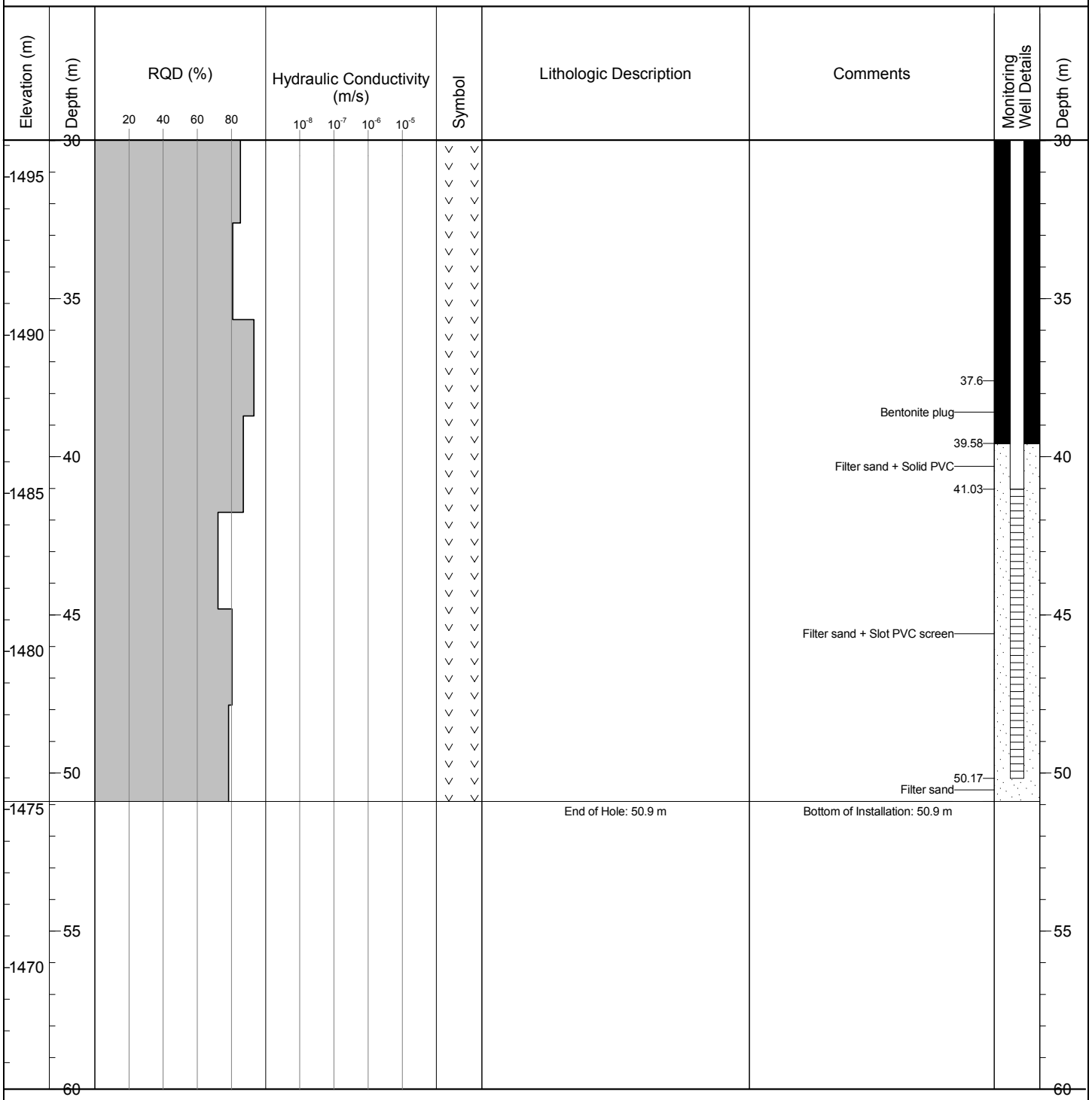
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,346E - 6,258,042N
Ground Elevation (m): 1,526.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.44
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.6
Cased To (m): NO CASING INSTALLED

Start date: 29 Sep 11
Finish Date: 30 Sep 11
Final Depth (m): 50.9
Depth To Top Of Rock (m): 1.4
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

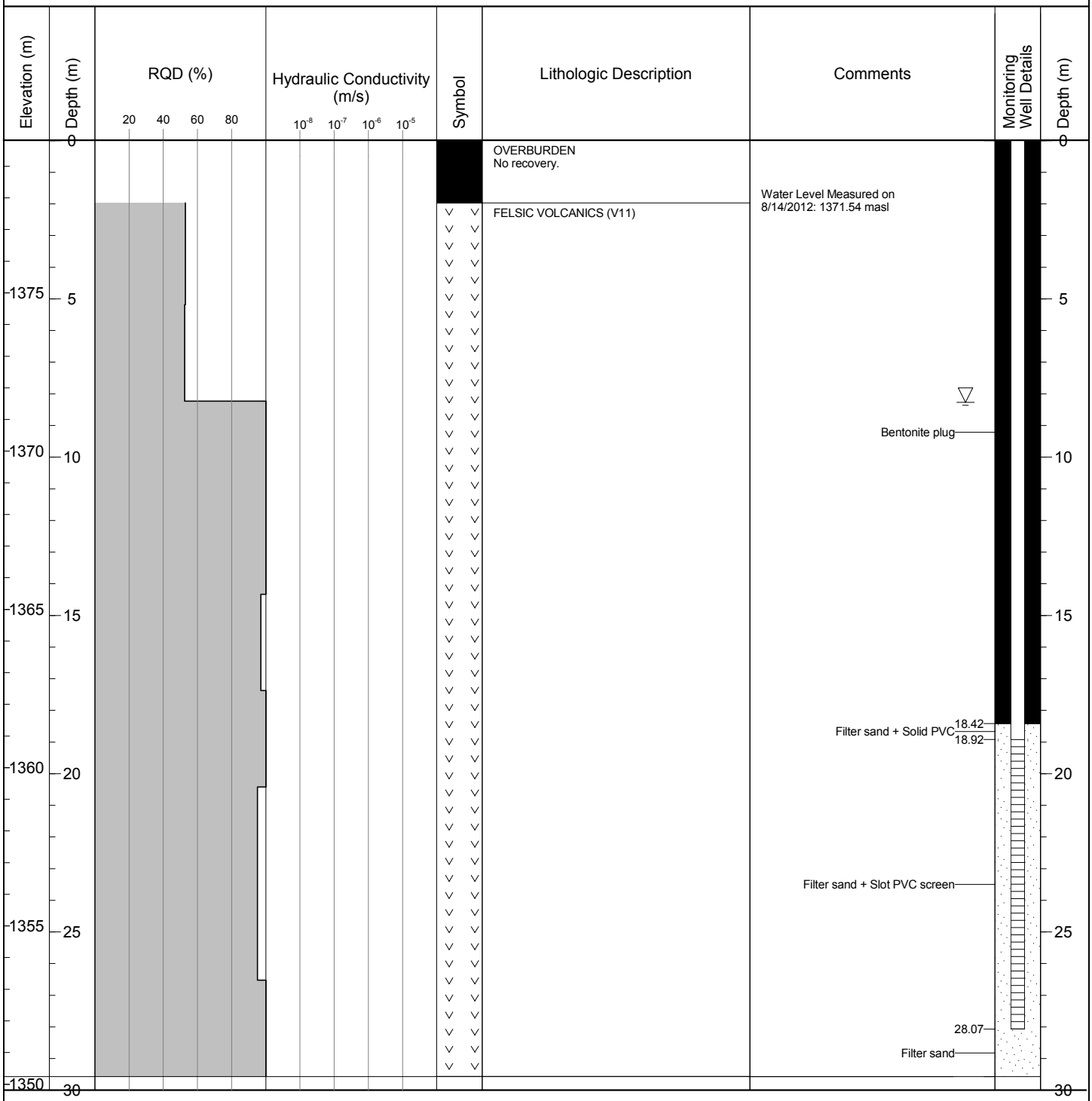
DRILL HOLE # MW-BGC11-BJ-6A

Location: Shore Zone

Co-ordinates (m): 427,095E - 6,258,983N
Ground Elevation (m): 1,379.81
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 1
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1380.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 29.6
Depth To Top Of Rock (m): 2.0
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-6A

Location: Shore Zone

Co-ordinates (m): 427,095E - 6,258,983N
Ground Elevation (m): 1,379.81
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 1
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1380.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 29.6
Depth To Top Of Rock (m): 2.0
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) 20 40 60 80	Hydraulic Conductivity (m/s) 10^{-8} 10^{-7} 10^{-6} 10^{-5}	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30				End of Hole: 29.6 m	Bottom of Installation: 31.8 m		30
1345	35							35
1340	40							40
1335	45							45
1330	50							50
1325	55							55
1320	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				GRAVEL (GW) Coarse, sub-angular, green to brown, odourless, dry, weathered.	Water Level Measured on 8/14/2012: 1367.834 masl		0
1375	5				INTERMEDIATE VOLCANICS (V12) Tuff and crystal tuff with minor zones of brecciation. High degree of disseminated pyrite (up to ~15% in places). Increased base metal sulphides from 35.3 - 37.5 m. Sericite clast replacement with minor fuschite seen throughout unit. Medium strong (R3-R3.5) from top of bedrock to 11.3 m. Strong to very strong (R4-R4.5) below 11.3 m. Slight to moderate alteration (A2.5) on major discontinuities from top of bedrock to 8.3 m. Faint to no alteration (A1-A1.5) below 8.3 m. 3.0 m: Fault, 220 mm thick, weathered rock. 5.5 m: Fault, 130 mm thick. 6.5 m: Fault, 350 mm thick. 7.6 m: Fault, 250 mm thick. 8.1 m: Fault, 220 mm thick.			5
1370	10							10
1365	15							15
1360	20							20
1355	25							25
1350	30							30

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

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Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
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Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
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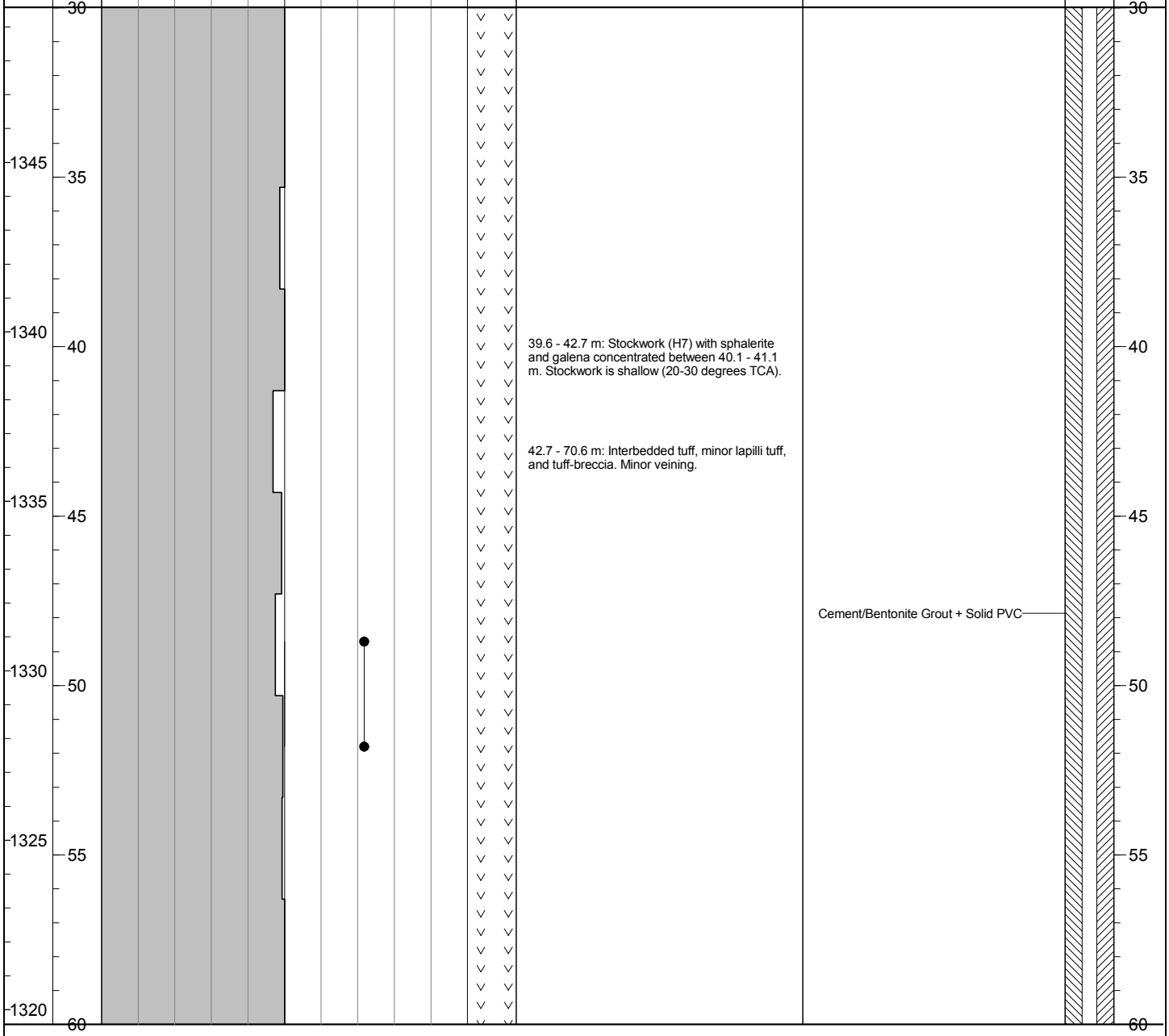
Logged by: LM/RH
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

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Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	60							60
1315	65							65
1310	70							70
1305	75							75
1300	80							80
1295	85							85
1290	90							90

STOCKWORK (H7)
Quartz-calcite-rhodochrosite with banded chlorite, abundant galena and sphalerite. Strong to very strong (R4-R4.5). Faint to no alteration (A1).
71.9 - 72.5 m: Brecciated section of stockwork.
72.5 - 74.0 m: Stockwork oriented at 10 degrees TCA.

75.4 - 80.0 m: Wall rock, broken rock, sphalerite, galena, pyrite.

87.9 - 90.2 m: Wall rock, broken rock, galena and sphalerite.

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Project: Brucejack
Project No.: 1008-007

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Logged by: LM/RH
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Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90				INTERMEDIATE VOLCANICS (V12) Tuff to crystal tuff with pyrite replacement clasts, significant veining and chlorite stringers. Strong to very strong (R4-R4.5). Faint to slight alteration (A1-A2).			90
1285	95					95.74		95
					96.7 m: Fault, 120 mm thick, crushed rock.	3/8" Coated Bentonite pellets + Solid PVC		
					97.6 m: Fault, 250 mm thick, gouge.	98.2		
1280	100				98.5 m: Fault, 50 mm thick, weathered & broken rock.	100.27		100
					101.4 m: Fault, 30 mm thick, weathered & broken rock.	10/20 Filter sand + 0.020 Slot PVC screen		
						103.32		
					End of Hole: 103.8 m	Bottom of Installation: 103.8 m		
1275	105							105
1270	110							110
1265	115							115
1260	120							120

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

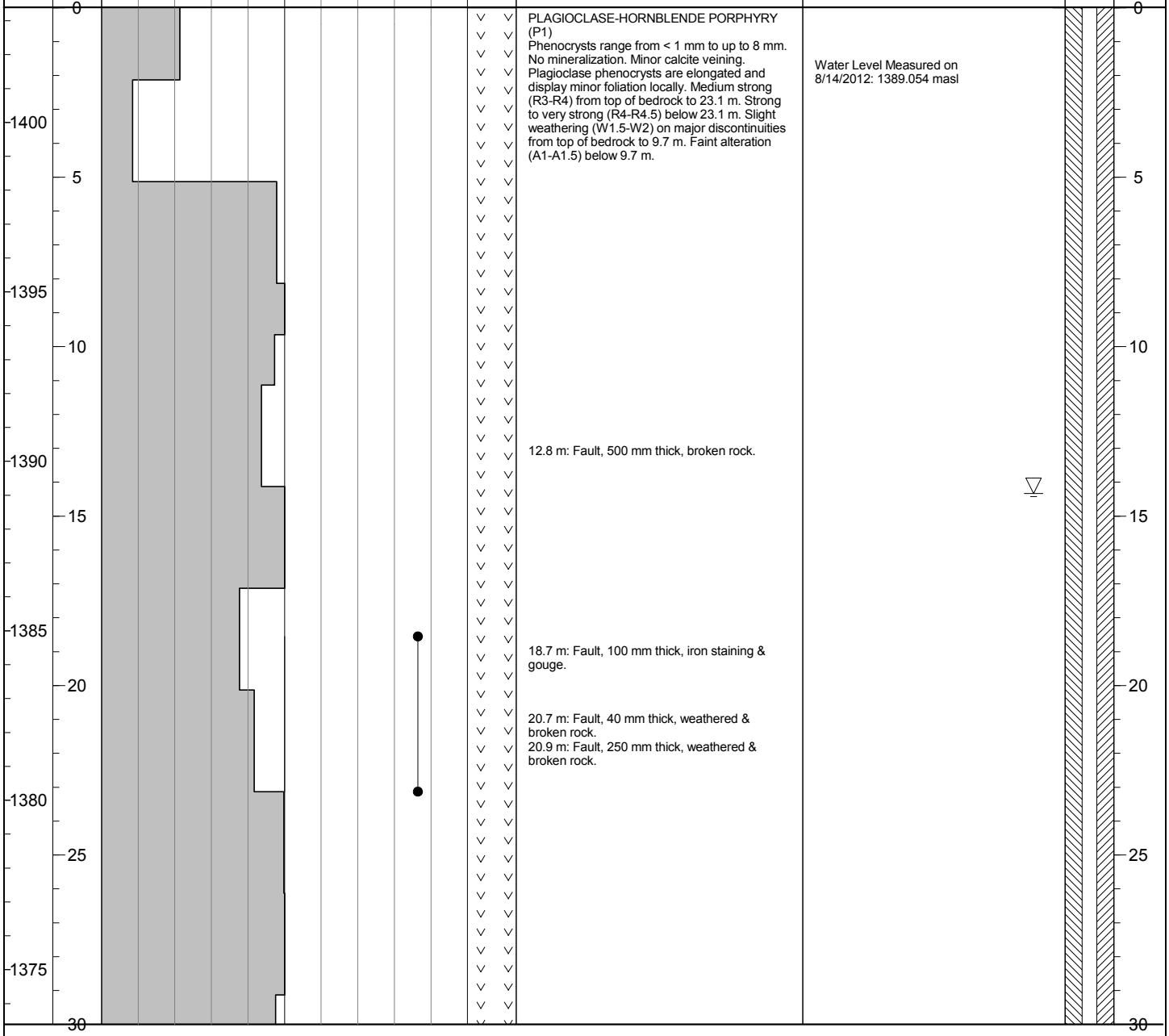
Location: Brucejack

NEW ID: BJ-GW12-8A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description	Comments
PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Phenocrysts range from < 1 mm to up to 8 mm. No mineralization. Minor calcite veining. Plagioclase phenocrysts are elongated and display minor foliation locally. Medium strong (R3-R4) from top of bedrock to 23.1 m. Strong to very strong (R4-R4.5) below 23.1 m. Slight weathering (W1.5-W2) on major discontinuities from top of bedrock to 9.7 m. Faint alteration (A1-A1.5) below 9.7 m.	Water Level Measured on 8/14/2012: 1389.054 masl
12.8 m: Fault, 500 mm thick, broken rock.	
18.7 m: Fault, 100 mm thick, iron staining & gouge.	
20.7 m: Fault, 40 mm thick, weathered & broken rock. 20.9 m: Fault, 250 mm thick, weathered & broken rock.	

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

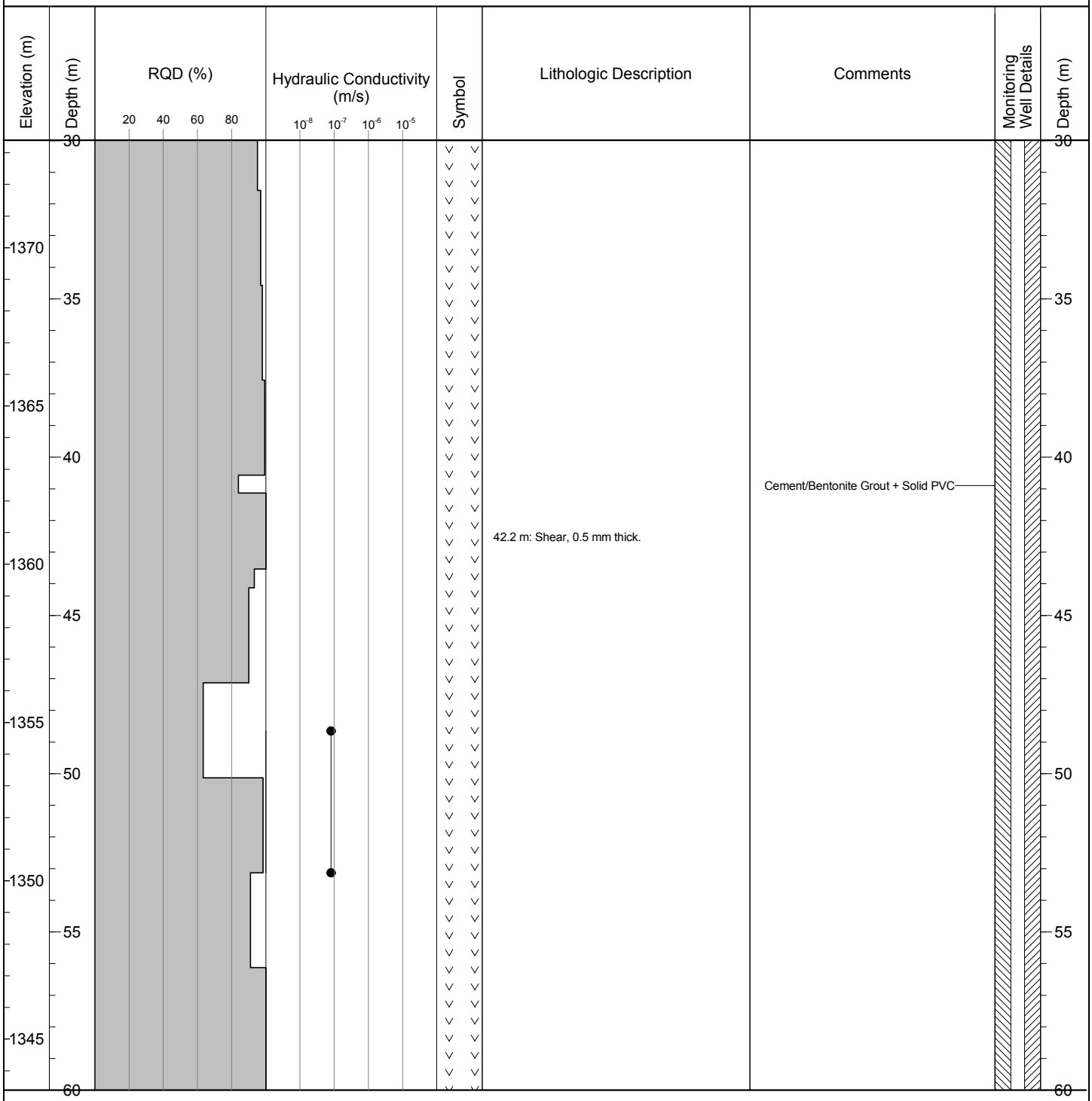
Location: Brucejack

NEW ID: BJ-GW12-8A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

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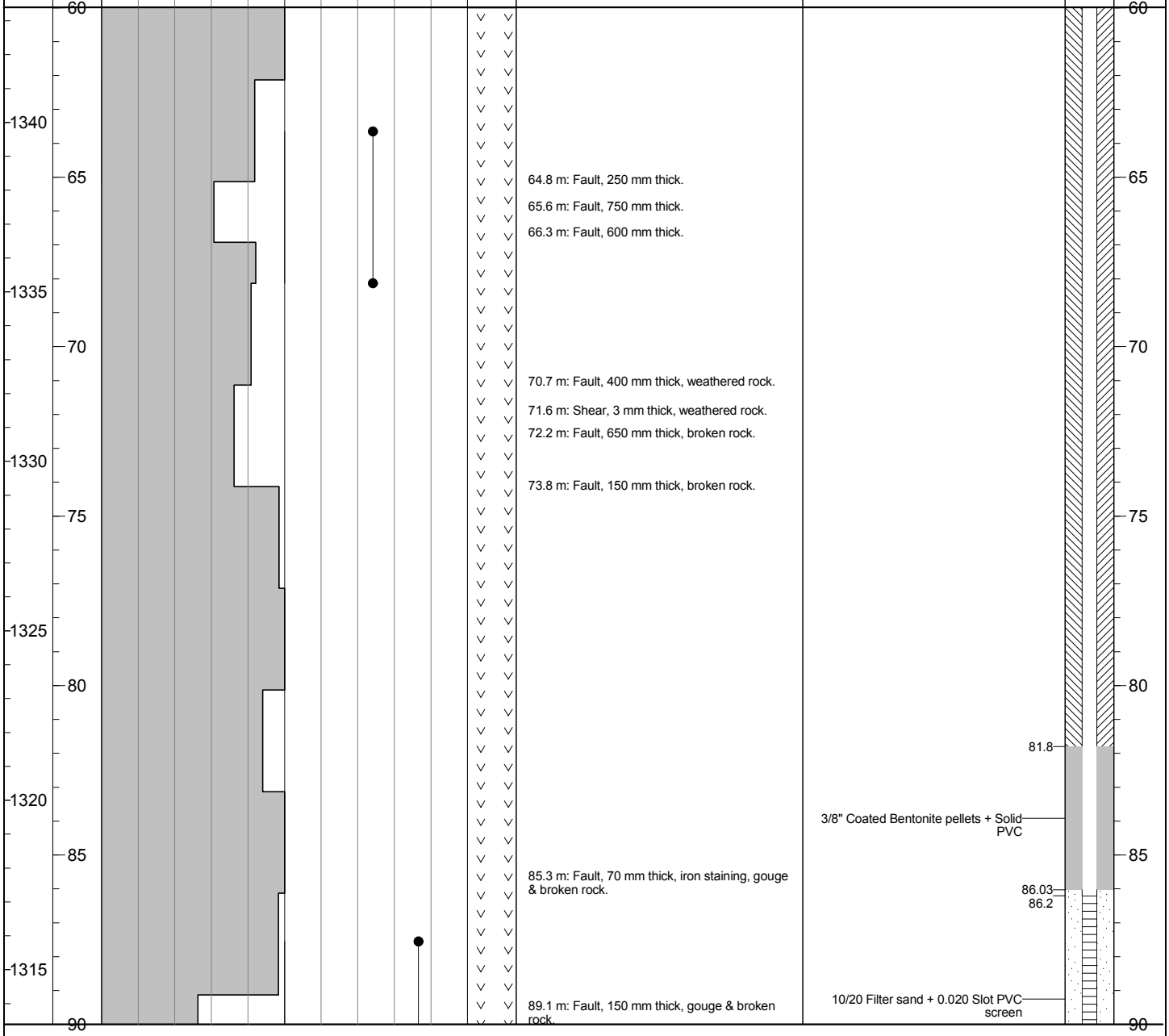

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Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90				90.1 m: Fault, 70 mm thick, broken rock.			90
1310					91.4 m: Fault, 300 mm thick, iron staining & gouge.	92.3		
	95				End of Hole: 95.1 m	Bottom of Installation: 95.1 m		95
1305								
	100							100
1300								
	105							105
1295								
	110							110
1290								
	115							115
1285								
	120							120

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8B

Location: Brucejack

NEW ID: BJ-GW12-8B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,819N
Ground Elevation (m): 1,403.30
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.33
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.6
Cased To (m): 1.12

Start date: 18 Jun 12
Finish Date: 19 Jun 12
Final Depth (m): 51.0
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1400, 1395, 1390, 1385, 1380, 1375	0, 5, 10, 15, 20, 25, 30				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Phenocrysts range from < 1 mm to up to 8 mm. No mineralization. Minor calcite veining. Plagioclase phenocrysts are elongated and display minor foliation locally. Medium strong (R3-R4) from top of bedrock to 23.1 m. Strong to very strong (R4-R4.5) below 23.1 m. Slight weathering (W1.5-W2) on major discontinuities from top of bedrock to 9.7 m. Faint alteration (A1-A1.5) below 9.7 m.	Water Level Measured on 8/14/2012: 1385.59 masl Cement/Bentonite Grout + Solid PVC		

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8B

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Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.6
Cased To (m): 1.12

Start date: 18 Jun 12
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Depth To Top Of Rock (m): 0.0
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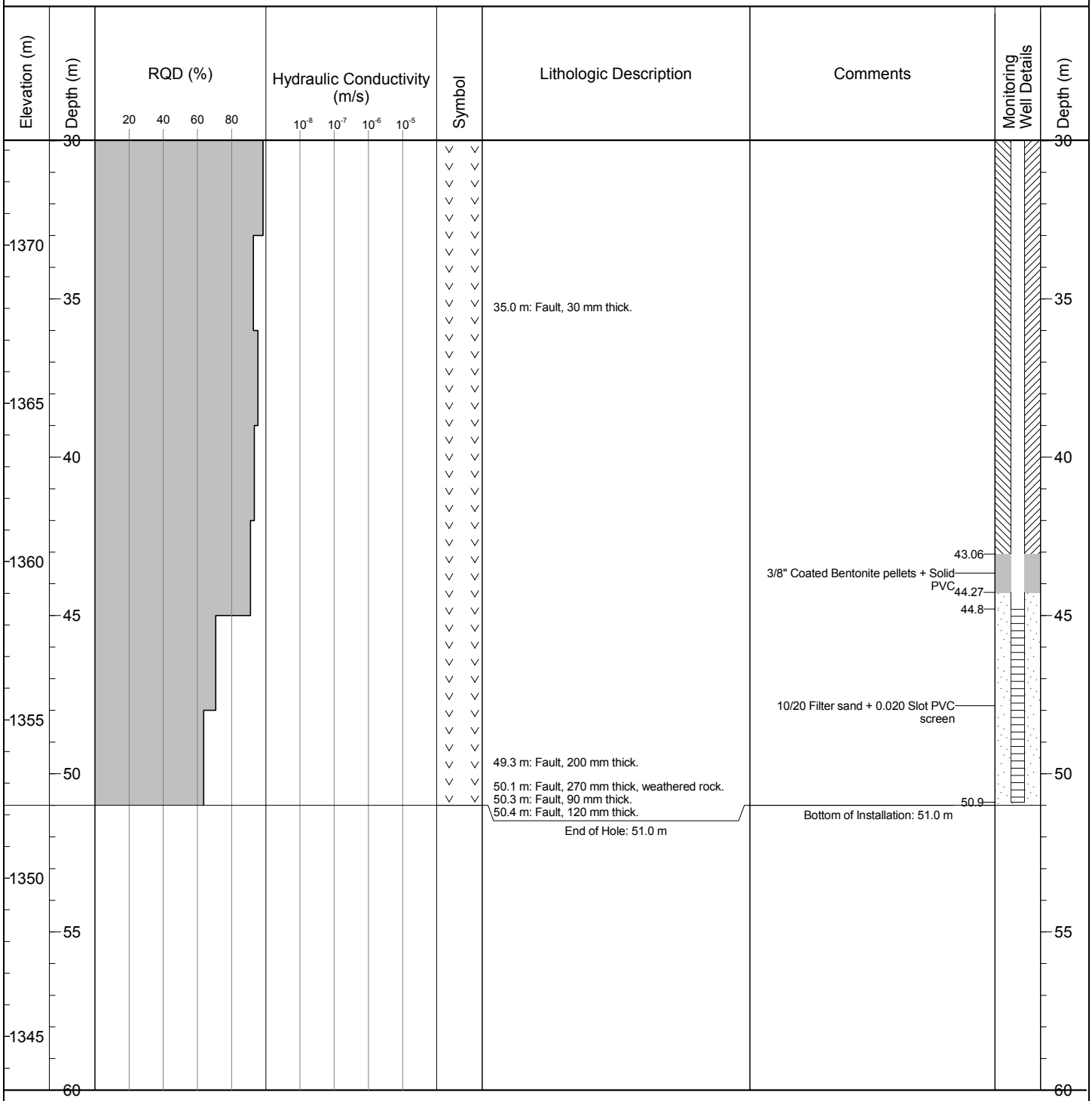

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9A

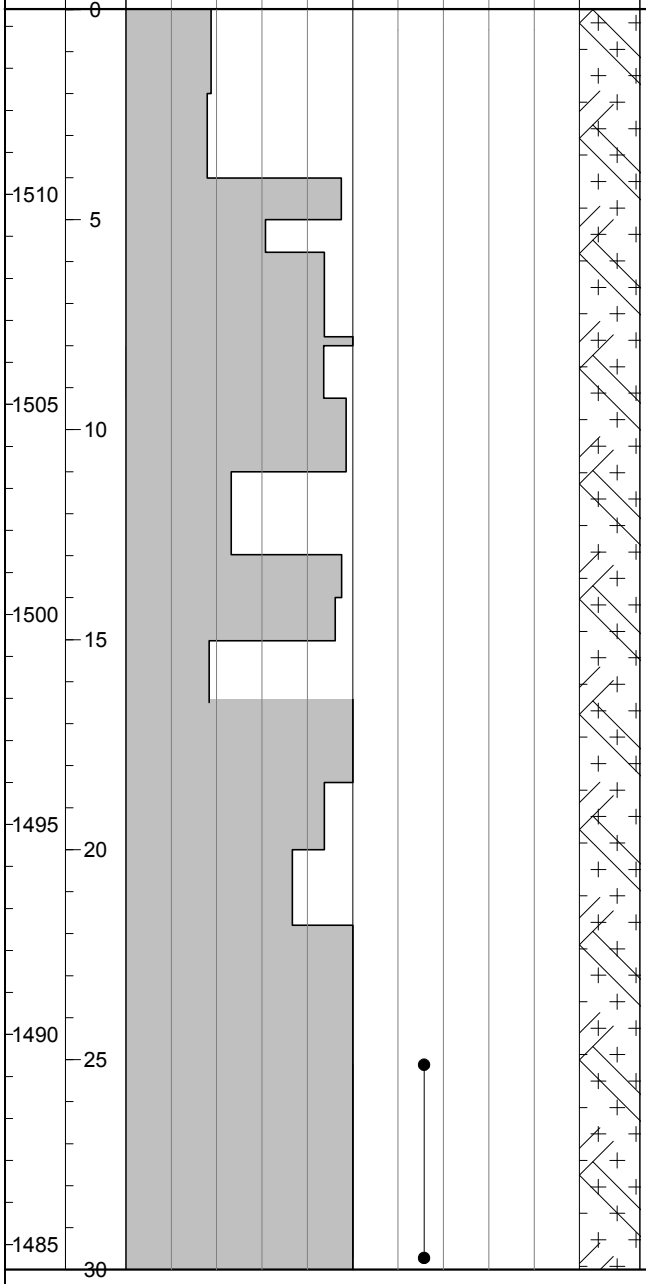
Location: Brucejack

NEW ID: BJ-GW12-9A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



Lithologic Description	Comments
PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Moderately homogeneous porphyry, <2% veining, sericite alteration of matrix and phenocrysts. Strong to very strong (R4-R5). Faint weathering (W1-W1.5)	Water Level Measured on 8/14/2012: 1456.17 masl
7.7 m: Shear, 5 mm thick.	

Monitoring Well Details

Depth (m)

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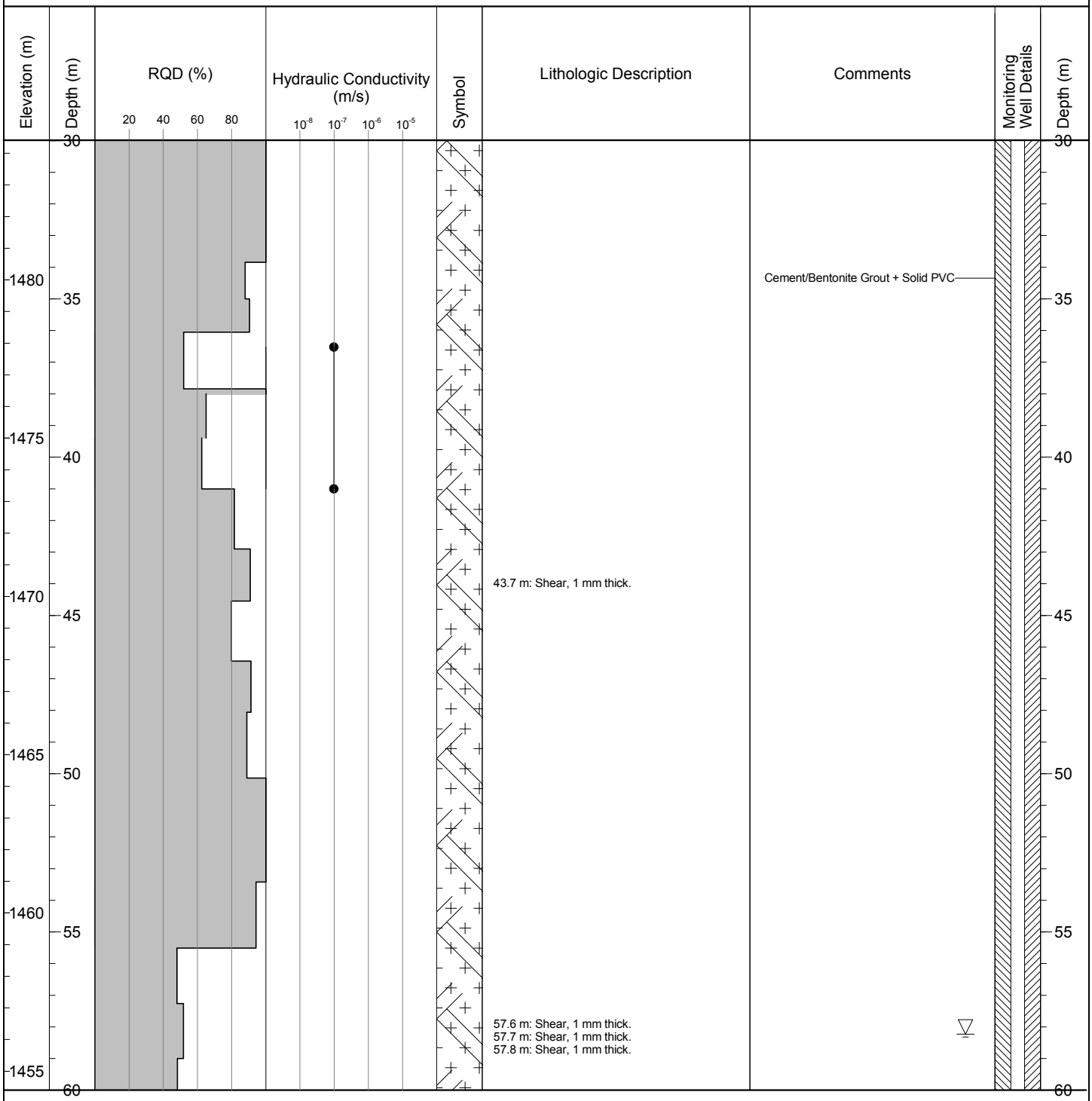

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CLIENT: Pretium Resources Inc.

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9A

Location: Brucejack

NEW ID: BJ-GW12-9A
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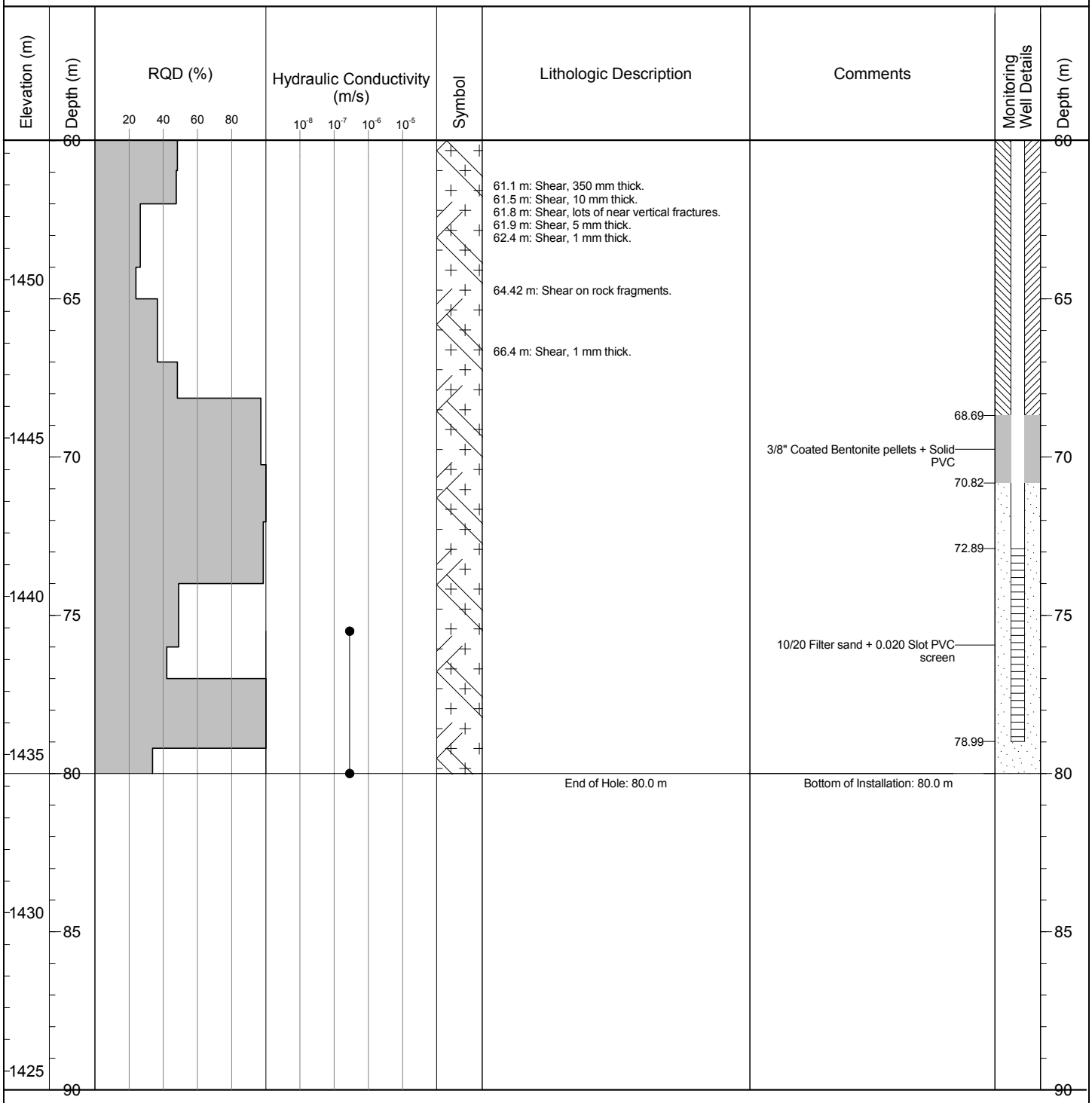

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9B

Location: Brucejack

NEW ID: BJ-GW12-9B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,461E - 6,258,362N
Ground Elevation (m): 1,514.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.2
Cased To (m): 1.09

Start date: 30 Jul 12
Finish Date: 01 Aug 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Moderately homogeneous porphyry, <2% veining, sericite alteration of matrix and phenocrysts. Strong to very strong (R4-R5). Faint alteration (A1.5)	Water Level Measured on 8/14/2012: 1498.128 masl		0
1510	5							5
1505	10							10
1500	15							15
						Cement/Bentonite Grout + Solid PVC		
1495	20				20.4 m: Shear, 1 mm thick.			20
1490	25							25
1485	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9B

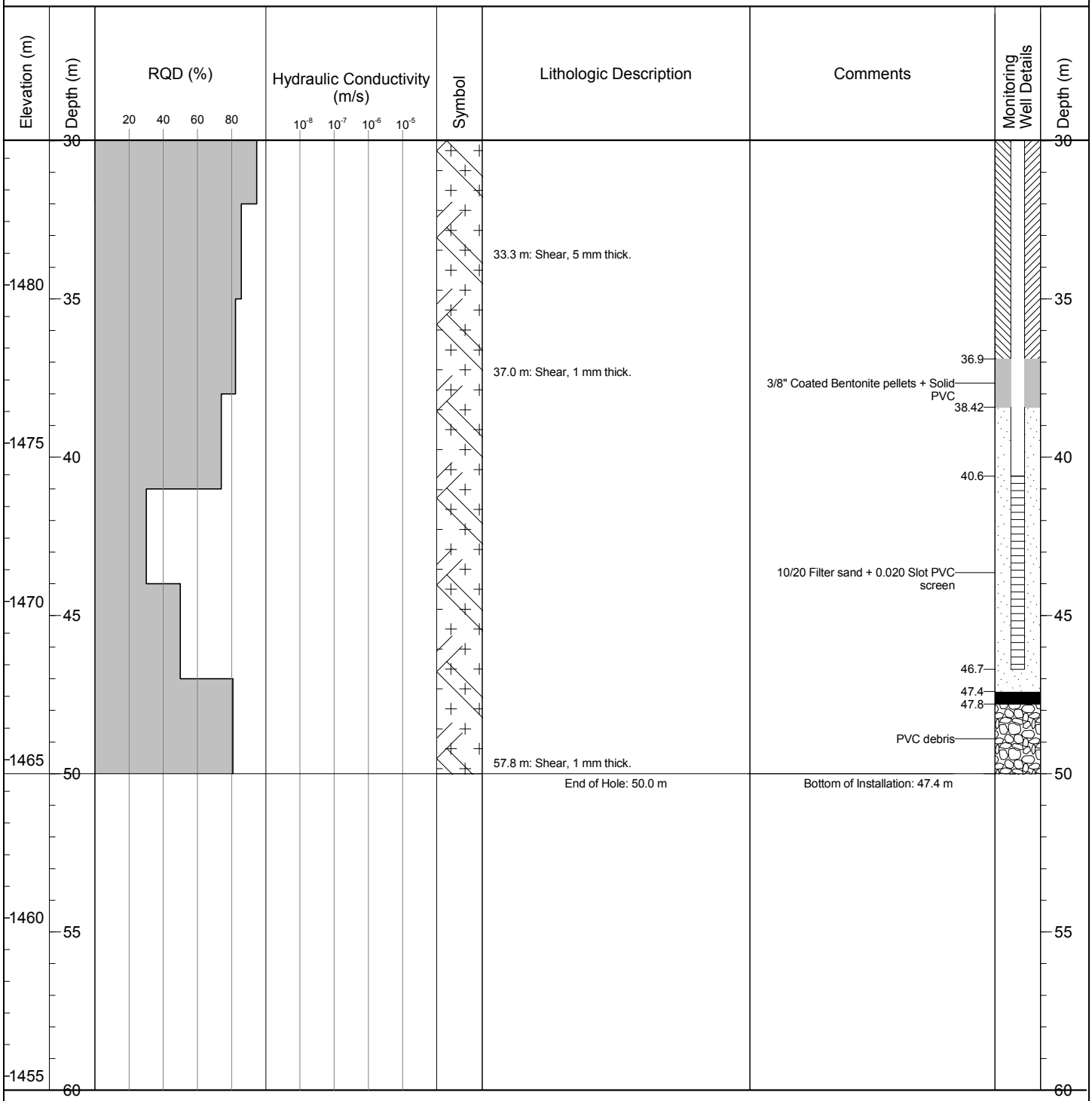
Location: Brucejack

NEW ID: BJ-GW12-9B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,461E - 6,258,362N
Ground Elevation (m): 1,514.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.2
Cased To (m): 1.09

Start date: 30 Jul 12
Finish Date: 01 Aug 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1445	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		INTERMEDIATE VOLCANICS (V12) IInfrequent clasts (< 2% of interval) of plagioclase-horbblende porphyry (P1) (up to 5 cm across, but mostly 2 - 3 cm). Plagioclase phenocrysts tend to be euhedral and are sometimes replaced by pyrite. Moderately to above moderate sericite-chlorite pervasive, phenocryst and clast replacement. Strong to very strong (R4-R4.5). Slight alteration (A2) on major discontinuities from top of bedrock to 5.3 m below ground surface. Faint alteration (A1-A1.5) below 5.3 m.	Water Level Measured on 8/14/2012: 1435.126 masl		0
1440	5							5
1435	10							10
1430	15							15
1425	20							20
1420	25					Cement/Bentonite Grout + Solid PVC		25
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

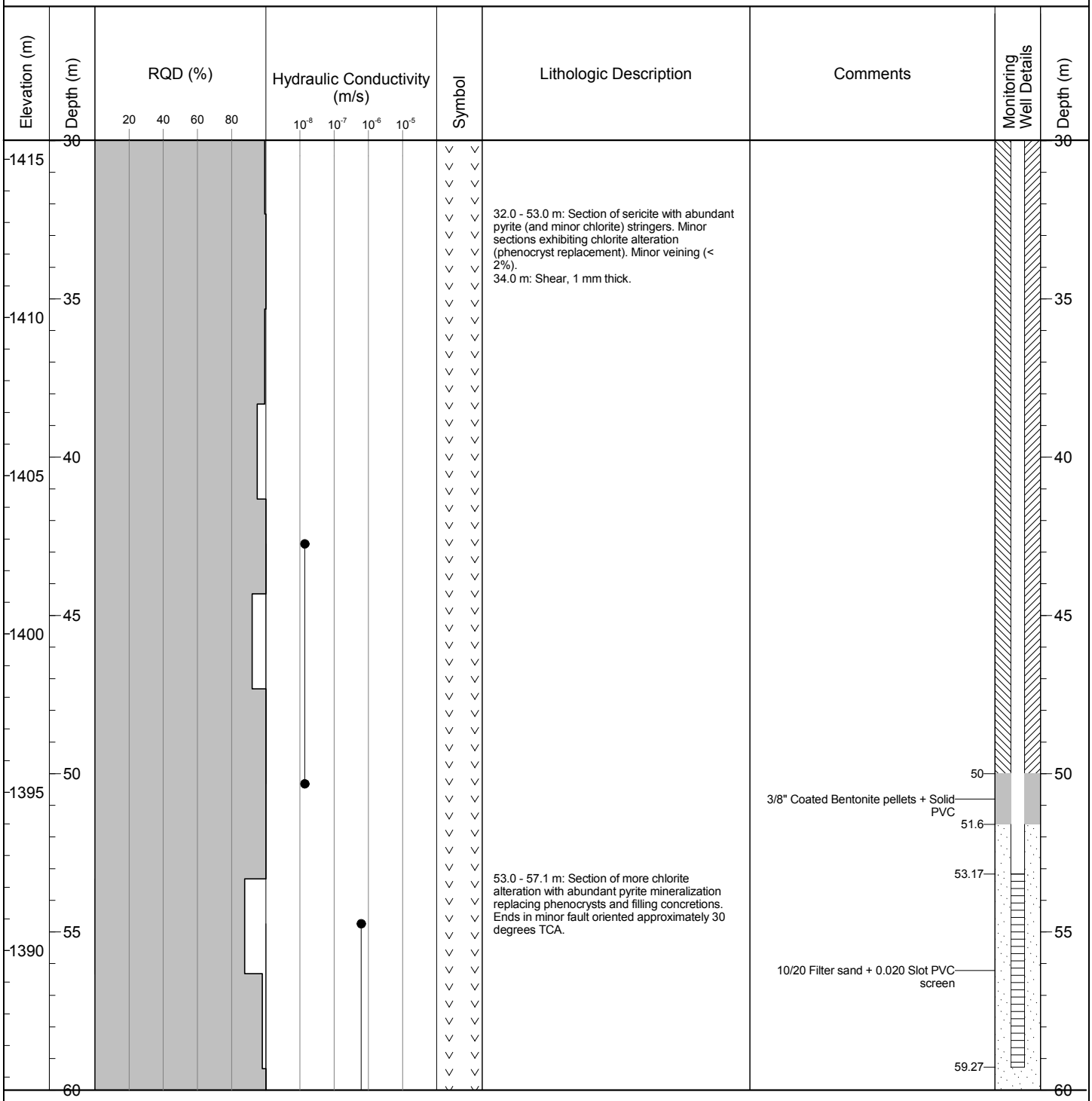
DRILL HOLE # MW-BGC12-BJ-10A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC12-BJ-10A

Project: Brucejack
Project No.: 1008-007
Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1385	60					3/8" Coated Bentonite pellets 60.13–60.48		60
					End of Hole: 62.3 m	Bottom of Installation: 60.1 m		
1380	65							65
1375	70							70
1370	75							75
1365	80							80
1360	85							85
	90							90

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10B

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.64
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.72
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.4
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 41.4
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1445	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		INTERMEDIATE VOLCANICS (V12) Infrequent clasts (< 2% of interval) of plagioclase-horbblende porphyry (P1) (up to 5 cm across, but mostly 2 - 3 cm). Plagioclase phenocrysts tend to be euhedral and are sometimes replaced by pyrite. Moderately to above moderate sericite-chlorite pervasive, phenocryst and clast replacement. Strong to very strong (R4-R4.5). Slight alteration (A2) on major discontinuities from top of bedrock to 5.3 m below ground surface. Faint alteration (A1-A1.5) below 5.3 m.	Water Level Measured on 8/14/2012: 1433.149 masl		0
1440	5							5
1435	10							10
1430	15					Cement/Bentonite Grout + Solid PVC		15
1425	20							20
1420	25							25
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC12-BJ-10B

Project: Brucejack
Project No.: 1008-007
Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.64
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.72
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.4
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 41.4
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1415	30							30
					32.0 - 41.4 m: Section of sericite with abundant pyrite (and minor chlorite) stringers. Minor sections exhibiting chlorite alteration (phenocryst replacement). Minor veining (< 2%).			
1410	35					34.5 3/8" Coated Bentonite pellets + Solid PVC 35.6		35
						38.05		
					39.0 m: Fault, 100 mm thick, fault on vein.	10/20 Filter sand + 0.020 Slot PVC screen		
1405	40					41.1		40
					End of Hole: 41.4 m	Bottom of Installation: 41.4 m		
1400	45							45
1395	50							50
1390	55							55
	60							60

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11A

Location: West Zone

NEW ID: BJ-GW12-11A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,300E - 6,258,595N
Ground Elevation (m): 1,433.57
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1434.2
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 26 Jun 12
Final Depth (m): 29.5
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Contains pervasive sericite-chlorite alteration with phenocryst replacement. Multiple veinlets. Medium strong to strong (R3-R3.5). Faint to slight alteration (A1.5-A2). 1.5 m: Fault, 300 mm thick, weathered rock. 2.1 m: Fault, 400 mm thick. 2.5 m: Fault, 300 mm thick, weathered & broken rock.	Water Level Measured on 8/14/2012: 1427.261 masl		0
1430	5				4.9 m: Fault, 100 mm thick.			5
1425	10					Cement/Bentonite Grout + Solid PVC		10
1420	15				12.9 - 23.5 m: Stockwork (H7) with minimal mineralization. Steep wall rock veinlets (oriented 50-90 degrees TCA). 15.8 m: Fault, 110 mm thick, broken rock.			15
1415	20							20
1410	25				23.5 - 29.5 m: Some sections of conglomerated porphyry. 27.2 m: Fault, 350 mm thick, weathered & broken rock.	24.9 3/8" Coated Bentonite pellets + Solid PVC 25.8 26.45 10/20 Filter sand + 0.020 Slot PVC screen		25
1405	30				End of Hole: 29.5 m	Bottom of Installation: 29.5 m		30

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11B

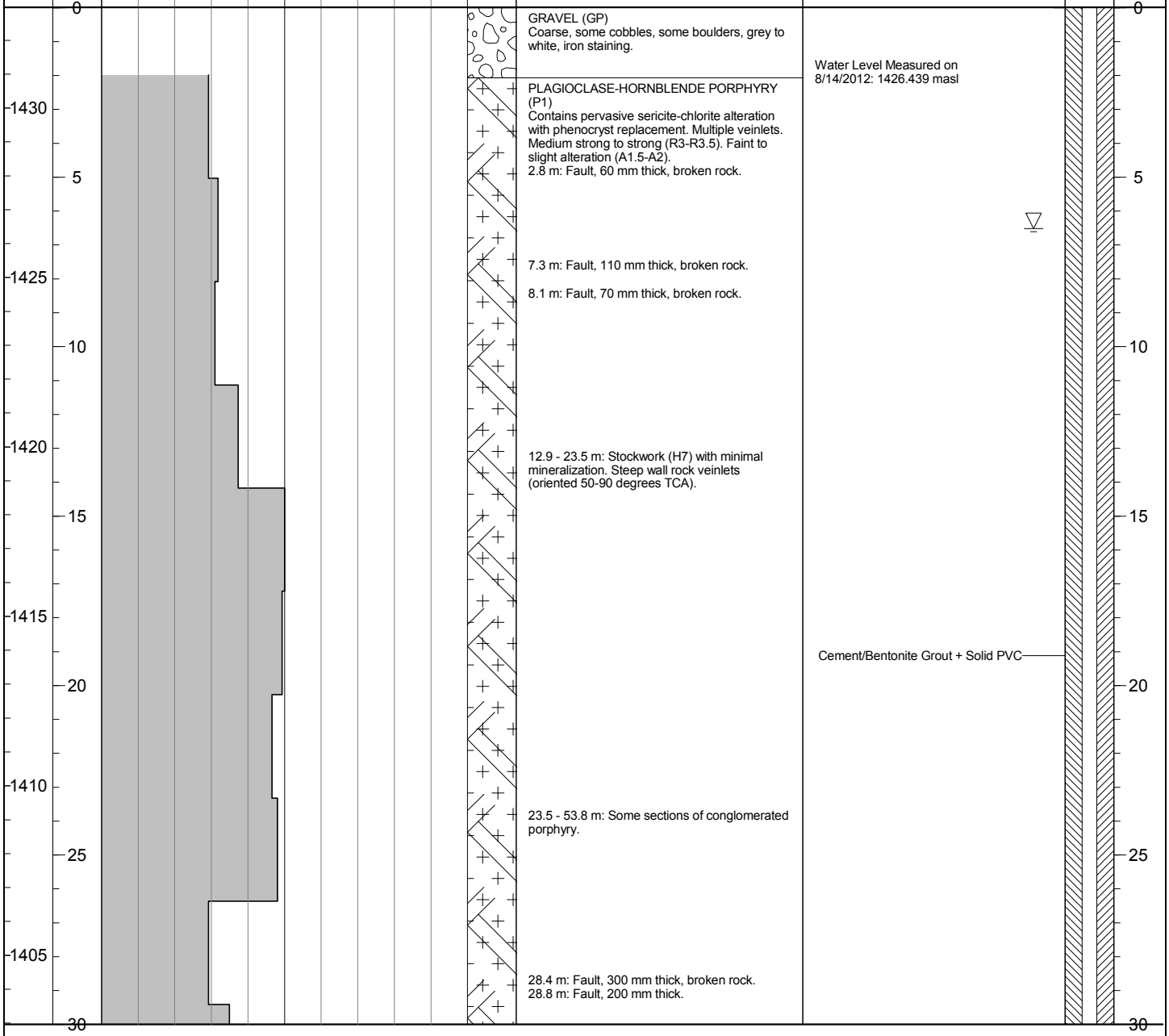
Location: West Zone

NEW ID: BJ-GW12-11B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,299E - 6,258,595N
Ground Elevation (m): 1,432.96
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1433.6
Cased To (m): 1.06

Start date: 26 Jun 12
Finish Date: 28 Jun 12
Final Depth (m): 53.8
Depth To Top Of Rock (m): 2.1
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description

GRAVEL (GP)
Coarse, some cobbles, some boulders, grey to white, iron staining.

PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)
Contains pervasive sericite-chlorite alteration with phenocryst replacement. Multiple veinlets. Medium strong to strong (R3-R3.5). Faint to slight alteration (A1.5-A2).
2.8 m: Fault, 60 mm thick, broken rock.

7.3 m: Fault, 110 mm thick, broken rock.

8.1 m: Fault, 70 mm thick, broken rock.

12.9 - 23.5 m: Stockwork (H7) with minimal mineralization. Steep wall rock veinlets (oriented 50-90 degrees TCA).

23.5 - 53.8 m: Some sections of conglomerated porphyry.

28.4 m: Fault, 300 mm thick, broken rock.
28.8 m: Fault, 200 mm thick.

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11B

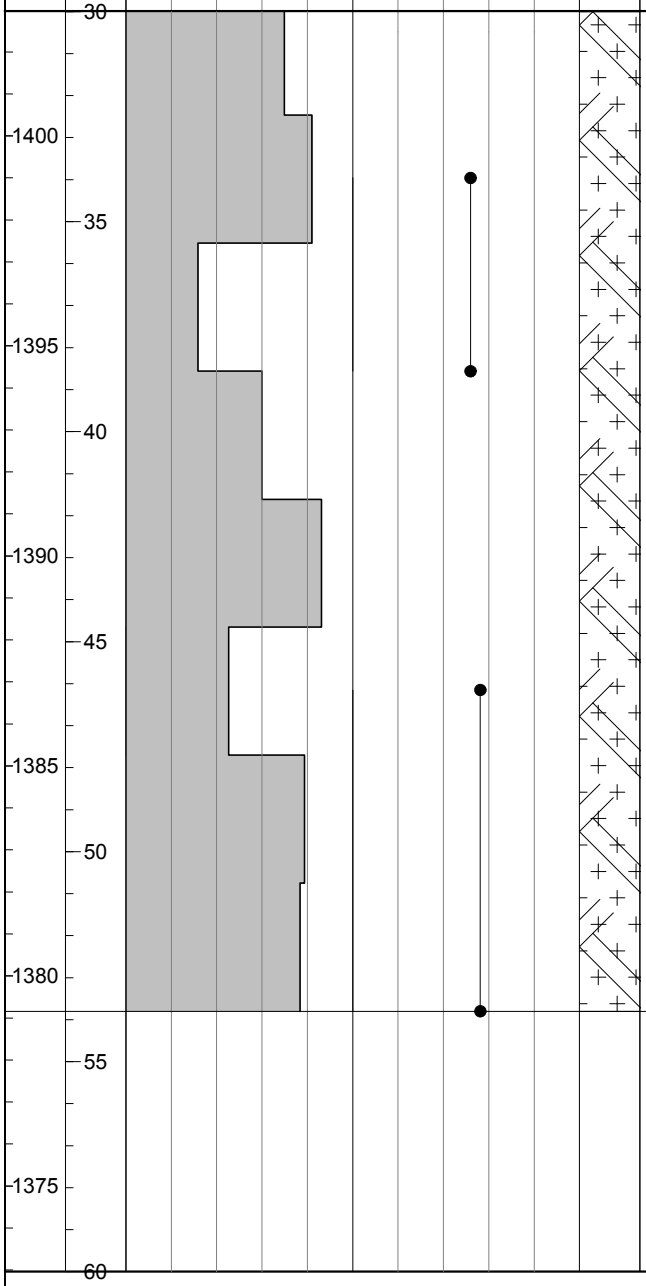
Location: West Zone

NEW ID: BJ-GW12-11B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,299E - 6,258,595N
Ground Elevation (m): 1,432.96
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1433.6
Cased To (m): 1.06

Start date: 26 Jun 12
Finish Date: 28 Jun 12
Final Depth (m): 53.8
Depth To Top Of Rock (m): 2.1
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description

30.2 m: Fault, 50 mm thick.

32.0 m: Fault, 90 mm thick.
32.4 m: Fault, 120 mm thick.

35.3 m: Fault, 50 mm thick.
35.8 m: Fault, 100 mm thick, broken rock.
36.1 m: Fault, 120 mm thick, broken rock.
36.5 m: Fault, 400 mm thick, broken rock.

37.3 m: Fault, 80 mm thick, broken rock.
37.6 m: Fault, 70 mm thick, broken rock.
37.7 m: Fault, 160 mm thick, broken rock.
38.3 m: Fault, 90 mm thick, broken rock.

39.5 m: Fault, 950 mm thick, broken rock.

41.9 m: Fault, 160 mm thick, weathered & broken rock.

44.9 - 45.9 m: Fault zone, 4 faults 60-450 mm thick, iron staining & broken rock.

47.9 m: Fault, 150 mm thick.

48.5 m: Fault, 60 mm thick, fault on calcite vein.
49.0 m: Fault, 130 mm thick, broken rock.

52.4 m: Fault, 80 mm thick, fault on vein.
52.8 m: Fault, 140 mm thick, fault on vein.

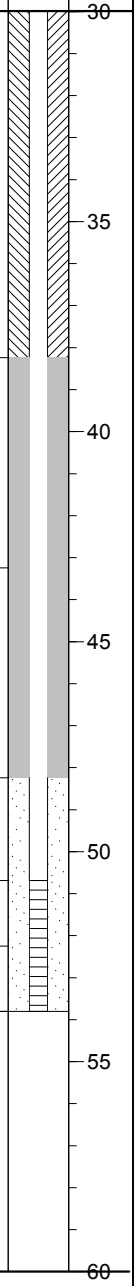
End of Hole: 53.8 m

Comments

3/8" Coated Bentonite pellets + Solid PVC

10/20 Filter sand + 0.020 Slot PVC screen

Bottom of Installation: 53.8 m



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,509E - 6,257,807N
Ground Elevation (m): 1,579.19
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Heavily sericite altered. Mainly homogenous porphyry textures. Strong to very strong (R4-R5). 7.9 – 10.5 m: strength reduced to medium strong (R3). Slight alteration (A1.5) from top of bedrock to 2.0 m. Faint weathering (1-1.5) below 2.0 m	Water Level Measured on 8/14/2012: 1528.285 masl		0
1575	5							5
1570	10							10
1565	15							15
1560	20				19.8 m: Fault, 5 mm thick, gouge.			20
1555	25							25
1550	30							30

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

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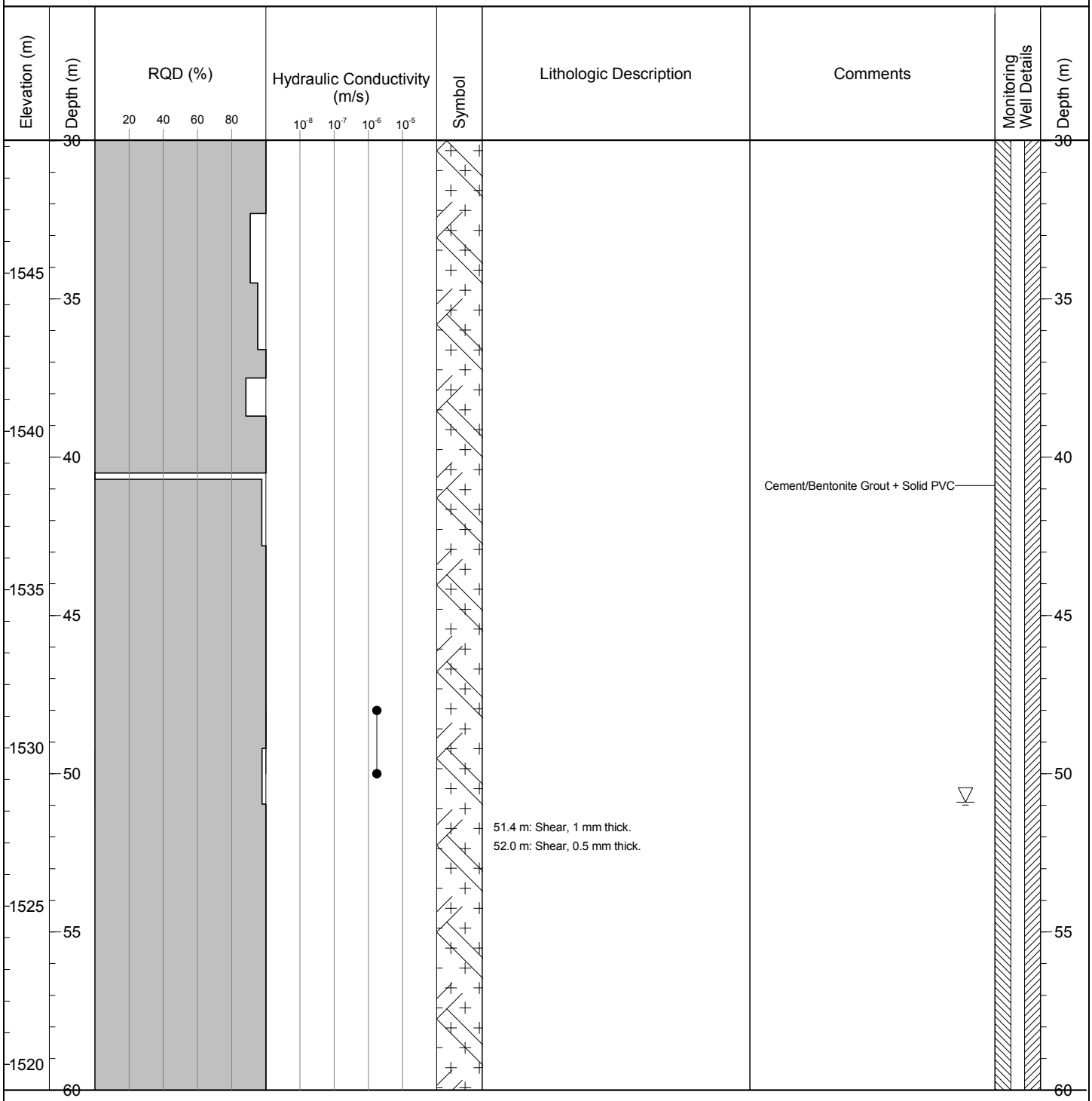
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
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Co-ordinates (m): 426,509E - 6,257,807N
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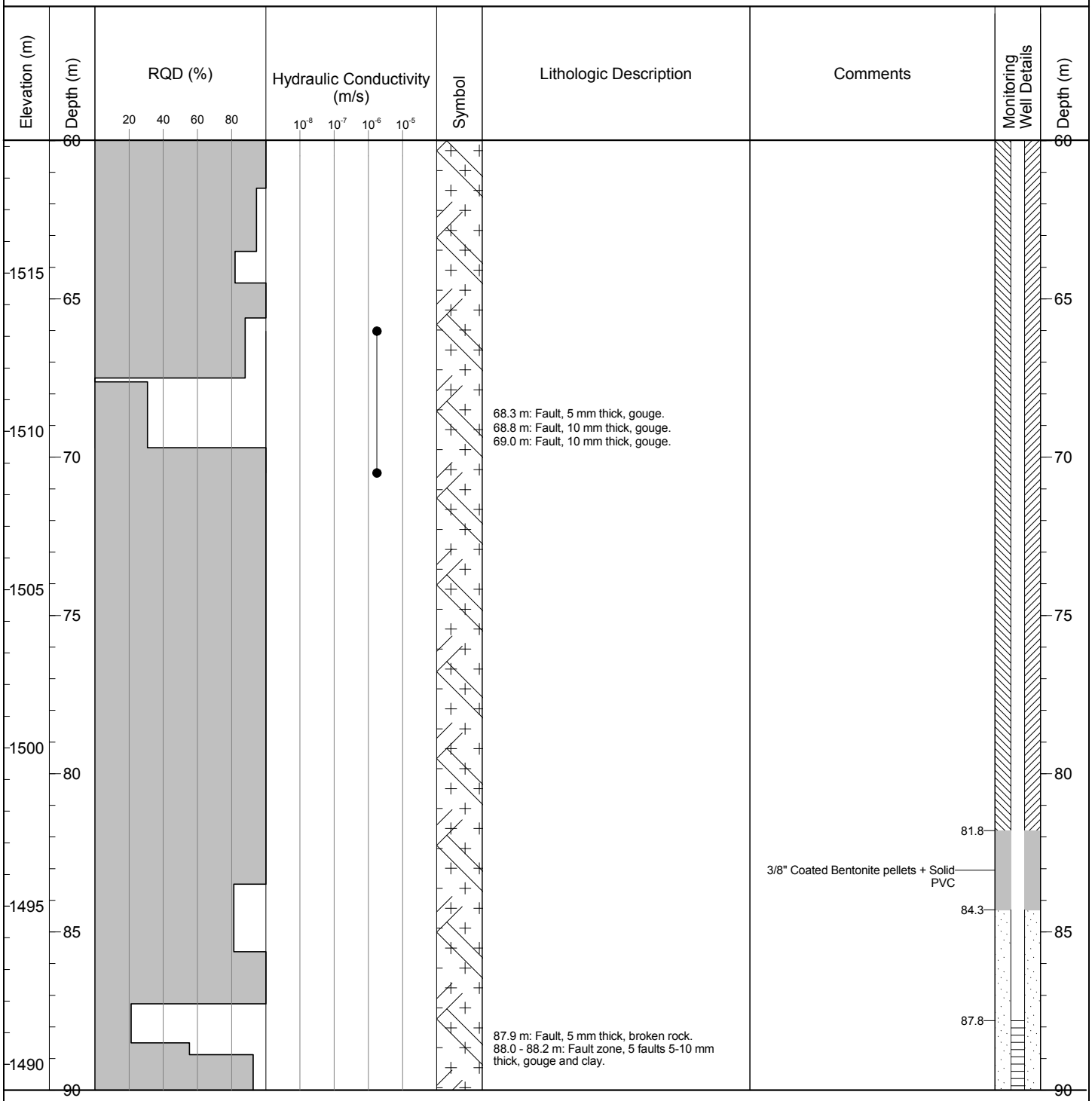
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
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Co-ordinates (m): 426,509E - 6,257,807N
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Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90					10/20 Filter sand + 0.020 Slot PVC screen		90
1485						93.9		
	95							95
						97		
1480						3/8" Coated Bentonite pellets + Solid PVC		
	100				End of Hole: 100.0 m	Bottom of Installation: 97.0 m		100
1475								
	105							105
1470								
	110							110
1465								
	115							115
1460								
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12B

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,505E - 6,257,807N
Ground Elevation (m): 1,579.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1579.9
Cased To (m): 1

Start date: 09 Aug 12
Finish Date: 10 Aug 12
Final Depth (m): 53.1
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Heavily sericite altered. Mainly homogenous porphyry textures. Strong to very strong (R4-R5). Slight alteration (A1.5) from top of bedrock to 5.9 m. Faint weathering (1-1.5) below 5.9 m	Water Level Measured on 8/14/2012: 1542.338 masl		0
1575	5							5
1570	10				10.5 m: Fault, 100 mm thick, quartz, iron staining.			10
1565					13.2 m: Shear, 0.5 mm thick.			
	15				14.7 m: Shear, 0.5 mm thick, black staining.			15
1560	20				21.3 - 21.6 m: Fault zone, 2 faults 100 mm thick, gouge.	Cement/Bentonite Grout + Solid PVC		20
1555	25							25
1550	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12B

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,505E - 6,257,807N
Ground Elevation (m): 1,579.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1579.9
Cased To (m): 1

Start date: 09 Aug 12
Finish Date: 10 Aug 12
Final Depth (m): 53.1
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}					30
1545	35							35
1540	40							40
1535	45				43.3 m: Fault, 30 mm thick, breccia.	43.16 3/8" Coated Bentonite pellets + Solid PVC 45.22 46.71		45
1530	50					10/20 Filter sand + 0.020 Slot PVC screen 52.8		50
					End of Hole: 53.1 m	Bottom of Installation: 53.1 m		
1525	55							55
1520	60							60

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

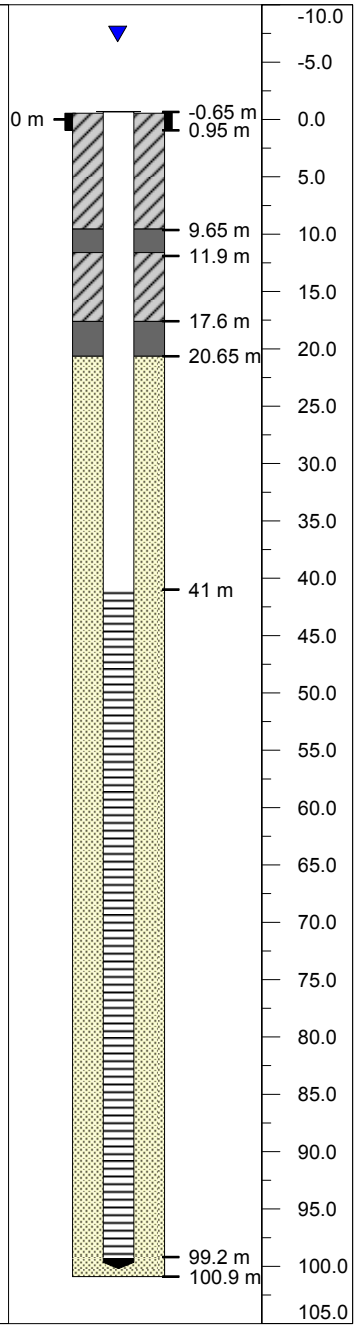
BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

NEW ID: BJ-GW14-13A
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-13A

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 4-8, 2014
				INSTALL DATE:	Sep 9, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Professional Survey	FINAL HOLE DEPTH (m):	100.9
COORDINATES:	426118 E, 6258904 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1362.49				
DATUM:	NAD 83 UTM ZONE 9N	DRILL METHOD:	Diamond-Triple Tube	REVIEWED BY:	DP/TC

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface				
5.0		VOLCANIC ROCK ; fine to medium grained porphyry latite flow with hornblende phenocrysts, sub-mm sericite carbonate replaced plagioclase feldspar and hornblende phenocrysts throughout, generally 5-12 % composition, volcanic flows are weakly phyllic altered, local intensities of altered phenocrysts do occur, commonly distal from weak-moderate phyllic alteration, phenocrysts follow preferential foliation (45 depth to core axis), which also could be a feature of flow characteristic.		Hole initially drilled to HQ diameter, then reamed to PQ diameter.		
10.0			Packer Test 1 9.4 - 13.9 m Invalid Test	At 11.8 m: Fault; infilled with fault gouge, grey, soft, complete loss of drilling fluid circulation. No drill fluid circulation between 11.8 m and 100.9 m (EOH).		
15.0				At 17.6 m: Fault; oxidation staining, many quartz and calcite intrusions.		
20.0			Packer Test 2 21.2 - 28.9 m K=1.0x10-6 m/s	Between 19.6 - 35 m: Highly fractured zone, oxidation staining, surfaces are red-brown.		
25.0						
30.0						
35.0						
40.0						
45.0				Between 48 - 49 m: Fault zone; heavily broken, some sand, average particle size 30 to 50 mm, some fault gouge, annealed fault.		
50.0						
55.0				Between 72 - 75 m: Highly fractured zone; most joints occur parallel to intrusions, 0.5 to 2 mm apperture At 96 m: Fault; clay infilling, grey, wet, soft.		
60.0			Packer Test 4 19.9 - 100.9 m K= 1.8 x 10-7 m/s			
65.0				NOTES: 1) Water was used as drilling fluid. 2) Drilling fluid circulation was lost between 12 m bgs and the EOH (101 m). 3) Water level at the end of drilling (before grouting in well completion) was 4.1 m bgs 4) The stickup for the PVC was measured at 0.6 m after the installation. 5) Flowing artesian conditions (approximately 1 gallon/min) were encountered after completion of the well installation. 6) Well installation completed using 3" (77 mm) dia. schedule 40 PVC; 020 slot schedule 40 PVC well screens. Enviroplug 1/4" pellets were used for the bentonite seal along with cement-bentonite grout. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter. 7) Geological descriptions provided by Pretivm geologists.		
70.0						
75.0						
80.0			Packer Test 3 66.6 - 100.9 m K=8.6x10-8 m/s			
85.0						
90.0						
95.0						
100.0		End of Hole at 100.9 m				
105.0						



LITHOLOGY

- Volcanic Rock
- Static Water Level

WELL CONSTRUCTION MATERIALS

- Well Cap
- Casing
- Solid PVC
- Screened PVC
- End Cap
- Bentonite Seal
- Grout
- Silica Sand

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NEW ID: BJ-GW14-13B
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-13B

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 11-12, 2014
				INSTALL DATE:	Sep 13, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Professional Survey	FINAL HOLE DEPTH (m):	75.4
COORDINATES:	426118 E, 6258904 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1362.76				
DATUM:	NAD 83 UTM ZONE 9N	DRILL METHOD:	Diamond-Triple Tube	REVIEWED BY:	DP/TC

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface OVERBURDEN		Between 0.9 - 6.3 m: Moderately fractured rock with surface staining.	0 m; -1.28 m; 2.2 m	0.0
5.0		VOLCANIC ROCK; Plagioclase-hornblende fine to medium grained porphyritic latite flows with sericite-chlorite pervasive alteration with chlorite preferentially replacing phenocrysts and to a lesser degree groundmass. Pyrite disseminated (~2%) and Rx (2%). Sub-mm ser-chl-carb replaced plagioclase feldspar and hornblende phenocrysts occur throughout, and are generally 4-8% composition. Phenocrysts follow preferential foliation (45dtca), which also could be a feature of flow characteristic(?). Trace joint oxidization runs to 39.5 m.				5.0
10.0				At 13.0 m : Complete loss of circulation, pressure drop while drilling. Between 13.8 - 14.4 m: Quartz vein stockwork, no fractures.		10.0
15.0						15.0
20.0				Between 19.8 - 24.30 m: Moderately fractured; poor circulation, joints include oxidation stains.	21.2 m	20.0
25.0			Packer Test 1 16.95 - 30.3 m Packer Test 2 18.45 - 33.3 m	At 23.1 m: Fault with 60 mm of fault gouge.		25.0
30.0				Between 28.8 - 34.4 m: Fractured rock, oxidation staining on joint surfaces.		30.0
35.0			Packer Test 3 27.45 - 39.3 m			35.0
40.0				Between 39.9 - 43.80 m: Quartz vein stockwork. At 47.39: Fault; 100 mm thick with fault gouge. At 50.66 Fault; 500 mm thick.		40.0
45.0				Between 54.3 - 55.4 m: Foliated rock. Between 57.15 - 57.25 m: Fault At 56.6: Fault with 80 mm of fault gouge At 59.7 m: Moderately fractured massive rock.		45.0
50.0				NOTES: 1) Packer tests terminated due to observation of returns at surface and through adjacent MW-BGC14-13A. 2) The water level was 4.1 m bgs prior to well installation on September 12, 2014. Artesian pressures were recorded as shut-in pressures following well completion on October 8, 2014. The PVC stick-up is 0.8 m at installation. 3) Well installation completed using 2" (52 mm) dia. schedule 40 PVC; 020 slot schedule 40 PVC well screens. Enviroplug 1/4" pellets were used for the bentonite seal. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter. 5) Geological descriptions provided by Pretivm geologists.		50.0
55.0						55.0
60.0					58.2 m	60.0
65.0			Packer Test 4 52.95 - 75.3 m			65.0
70.0						70.0
75.0		End of Hole at 75.4 m			73.6 m; 75.4 m	75.0

LITHOLOGY

- Overburden
- Volcanic Rock
- Static Water Level

WELL CONSTRUCTION MATERIALS

- Well Cap
- Casing
- Solid PVC
- Screened PVC
- End Cap
- Bentonite Seal
- Grout
- Silica Sand

BGC ENGINEERING INC.
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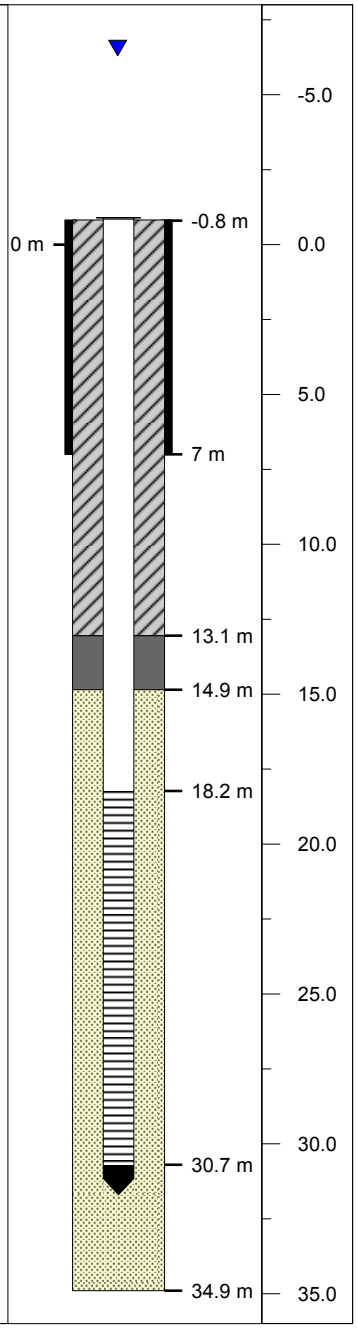
NEW ID: BJ-GW14-14A
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-14A

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 9-10, 2014
				INSTALL DATE:	Sep 11, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Professional Survey	FINAL HOLE DEPTH (m):	34.9
COORDINATES:	426096 E, 6258924 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1351.1				
DATUM:	NAD 83 UTM ZONE 9N	DRILL METHOD:	Diamond-Triple Tube	REVIEWED BY:	DP/TC

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface OVERBURDEN; sand, gravel and boulders, inferred based on drillers observations, no sample recovery				
5.0		VOLCANIC ROCK; Plagioclase hornblende fine to medium grained porphyritic latite flow with sericite-chlorite pervasive alteration with chlorite preferentially replacing phenocrysts and to a lesser degree groundmass. Sericite bleached zone from 16.5-20.2m. Local crack and fill chlorite open space crystalization. Pyrite disseminated (~2%) and Rx (2%). Sub-mm sericite-chlorite-carbonate replaced plagioclase feldspar and hornblende phenocrysts occur throughout, and are generally 5-10% composition. Phenocrysts follow preferential foliation (45dtca), which also could be a feature of flow characteristic(?).				
10.0						
15.0			Packer Test 1 10.9 - 19.9 m K= $3x10^{-8}$ m/s	Between 15.5 - 19.5 m: Iron staining on joints, some blocked runs.		
20.0			Packer Test 3 9.55 - 34.9 m K= $4.7x10^{-8}$ m/s	Between 19 - 21.9 m: Fault zone; includes fault gouge infilling, broken rock fragments, sand and gravel, iron staining.		
25.0			Packer Test 2 21.55 - 34.9 m K = 4.2x10-8 m/s	NOTES: 1) Drilling circulation was consistent for the duration of drilling the monitoring well. 2) The water level was 2.37 m bgs prior to well installation on September 10, 2014. Artesian pressures were recorded as shut-in pressures on October 8, 2014. The PVC stickup was 0.8 m at installation. 3) Well installation completed using 2" (52 mm) dia. schedule 40 PVC; 020 slot schedule 40 PVC well screen. Enviroplug 1/4" pellets were used for the bentonite seal along with cement-bentonite grout. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter. 4) Geological descriptions provided by Pretivm geologists.		
30.0						
35.0		End of Hole at 34.9 m				



LITHOLOGY

Overburden
Volcanic Rock
Static Water Level

WELL CONSTRUCTION MATERIALS

Well Cap
Screened PVC
Grout
Casing
End Cap
Silica Sand
Solid PVC
Bentonite Seal

BGC ENGINEERING INC.
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NEW ID: BJ-GW14-14B
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-14B

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 23, 2014
				INSTALL DATE:	Sep 23, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Hand Held GPS	FINAL HOLE DEPTH (m):	4.9
COORDINATES:	426095 E, 6258927 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1355	DRILL METHOD:	Rotary HW Casing Advancer with Tricone	REVIEWED BY:	DP/TC
DATUM:	NAD 83 UTM ZONE 9N				

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface			-0.9 m	
		OVERBURDEN; sand and gravel, boulders inferred based on drilling observations, drilling return fluid ranged from muddy brown to black in colour. No recovery from overburden deposits.			0 m	0.0
					0.45 m	
1.0					1 m	1.0
				At 1.5 m: Drill circulation return water was black with a slight hydrocarbon odour.	1.5 m	
2.0						2.0
			No Packer Tests in Overburden			
3.0						3.0
				NOTES: 1) The water level was 0.07 m below ground surface upon completion of the well installation on September 23, 2014. The PVC stickup was 0.9 m at installation. 2) PW casing was reamed over the HW casing. PW casing is permanently installed. 3) Well installation completed using 3" (77 mm) schedule 40 PVC; 020 slot schedule 40 PVC well screen. Enviroplug 1/4" pellets were used for the bentonite seal. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter.		
4.0					4.42 m	4.0
		End of Hole at 4.9 m			4.9 m	
5.0						5.0

LITHOLOGY

- Overburden
- Static Water Level

WELL CONSTRUCTION MATERIALS

- Well Cap
- Casing
- Solid PVC
- Screened PVC
- End Cap
- Bentonite Seal
- Grout
- Slough
- Silica Sand

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SYMBOLS AND TERMS

FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation

Project Number: 1008029

SOIL/ROCK SYMBOLS		
Overburden	Fill	Till
Fragmental volcanics [V12]	Porphyry [P1]	Conglomerate [S3-Poly]
Silicified con-glomerate [H8]	Sandstone/ arenite [S4-Vsf]	Mafic dyke [V6]

INSTRUMENT DETAILS SYMBOLS		
Grout	Cuttings / slough	Bentonite chips
Bentonite pellets	Sand	Standpipe screen in sand
Standpipe in bentonite	Standpipe in grout	

NOTES

1. Depths are along hole and relative to ground surface.

LIST OF ACRONYMS	
A	Alteration
K	Hydraulic conductivity
R	Strength grade
W	Weathering
RMR	Rock mass rating
RQD	Rock quality designation

SYMBOLS AND TERMS

FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation Project Number: 1008029

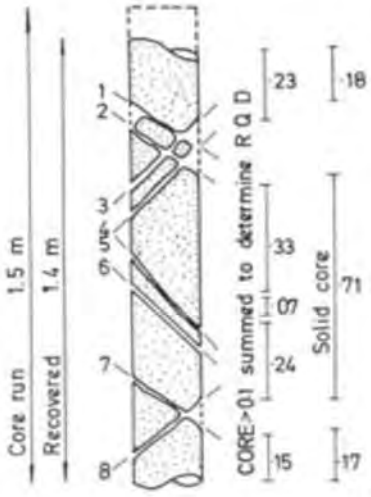
WEATHERING/ALTERATION [1]		
GRADE	**Description**	**Field Identification**
A/W 1	Fresh and Unweathered	No visible sign of rock material weathering
A/W 1.5	Faintly Weathered	Discolouration on major discontinuity surfaces
A/W 2	Slightly Weathered or Altered	Discolouration indicated weathering of rock material and discontinuity surfaces. All rock material may be discoloured by weathering and may be weaker than in its fresh condition.
A/W 3	Moderately Weathered or Altered	Less than 50% of rock material decomposed and/or disintegrated to soil. Fresh/ discoloured rock present as a continuous framework or corestones.
A/W 4	Highly Weathered or Altered	More than 50% rock material is decomposed or disintegrated to soil. Fresh/Discoloured rock present as discontinuous framework or corestones.
A/W 5	Completely Weathered or Altered	All rock material decomposed and/or disintegrated to soil. Original mass structure still largely intact
A/W 6	Residual Soil	All rock material converted to soil; mass structure and material fabric destroyed.

Note: Weathering/alteration half grades can be assigned to indicate a transition zone.

STRENGTH/HARDNESS CLASSIFICATION FOR ROCK [1]		
GRADE	**Description**	**Field Identification**
R6	Extremely Strong	Specimen can only be chipped with flat end of geological hammer
R5	Very Strong	Specimen requires many blows of flat end of geological hammer to fracture
R4	Strong	Specimen requires more than one blow of flat end of geological hammer to fracture
R3	Medium Strong	Cannot be scraped or peeled with pocket knife; can be fractured with single firm blow of flat end of the geologic hammer
R2	Weak	Can be peeled with pocket knife with difficulty; shallow indentation made by firm blow with point of geological hammer
R1	Very Weak	Crumbles under firm blow with point of geological hammer; can be peeled by a pocket knife
R0	Extremely Weak	Indented by thumbnail

Note: Strength/hardness half grades can be assigned to indicate a transition zone.

JOINT CONDITION [2]	
Condition of Joints	**Rating**
Very rough surfaces. Not continuous. No separation. Hard joint wall rock.	25
Slightly rough surfaces. Separation <1mm. Hard joint wall rock.	20
Slightly rough surfaces. Separation <1mm. Soft joint wall rock.	12
Slickensided surfaces or gouge <5mm thick or joints open 1-5mm. Continuous joints.	6
Soft gouge >5mm thick or joints open >5mm. Continuous joints.	0



Core recovery $= \frac{1.40}{1.50} = 93\%$

Solid core recovery $= \frac{1.06}{1.50} = 71\%$

R Q D $= \frac{0.95}{1.50} = 63\%$

Fracture index $= \frac{8}{1.50} = 5.3$ /m run

If strength grade ≤ R1, do not include in RQD.

SYMBOLS AND TERMS

FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation Project Number: 1008029

Texture [3]		
Term	**Particle Size**	**Examples**
Very Coarse	> 60 mm	Porphyritic
Coarse	2 - 60 mm	Breccia, Gneiss (measurable grains)
Medium	0.06 - 2 mm	Sandstone, Gabbro, Granite, Schist (visible grains)
Fine	0.002 - 0.06 mm	Tuff, Siltstone, Claystone, Mudstone, Basalt
Very Fine	< 0.002 mm	

Fabric	
Term	**Description**
Homogeneous/ Uniform	Equigranular or homogeneous grains
Bedded	Deposited in layers, can be sedimentary or volcaniclastic rocks
Foliated	Minerals are aligned due to shearing or metamorphism
Gneissic	Alternating layers of different colour or texture with mineral alignment and typically parts along layers
Porphyritic	Crystalline texture with bimodal grain size distribution, fine to medium grained groundmass with coarse to very coarse phenocrysts
Stockwork	Veins (typically quartz, calcite, or gypsum/anhydrite) make up greater than 10% of the rock mass, they may be aligned with foliation or irregularly oriented
Microfractured	Hairline fractures are the primary fabric of the rock, typically oriented in all directions and intersecting one another
Brecciated	Healed or welded angular clasts with matrix, may be matrix – or clast-supported

SYMBOLS AND TERMS
FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation Project Number: 1008029

REFERENCES

1) International Society of Rock Mechanics (ISRM). (1977). Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses. *International Journal of Rock Mechanics, Mineral Science, and Geomechanics Abstracts, 15,* 319-368.

2) Bieniawski, Z. T. (1976). Rock mass classifications in rock engineering. In Z. T. Bieniawski (Ed.), *Exploration for Rock Engineering (pp. 97-106). Cape Town, South Africa: Balkema.*

3) International Society for Rock Mechanics (ISRM). (1981). Basic Geotechnical Description of Rock Masses. *International Journal of Rock Mechanics, Mineral Science, and Geomechanics Abstracts, 18,* 85 -110.

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

Project No.: 1008-029

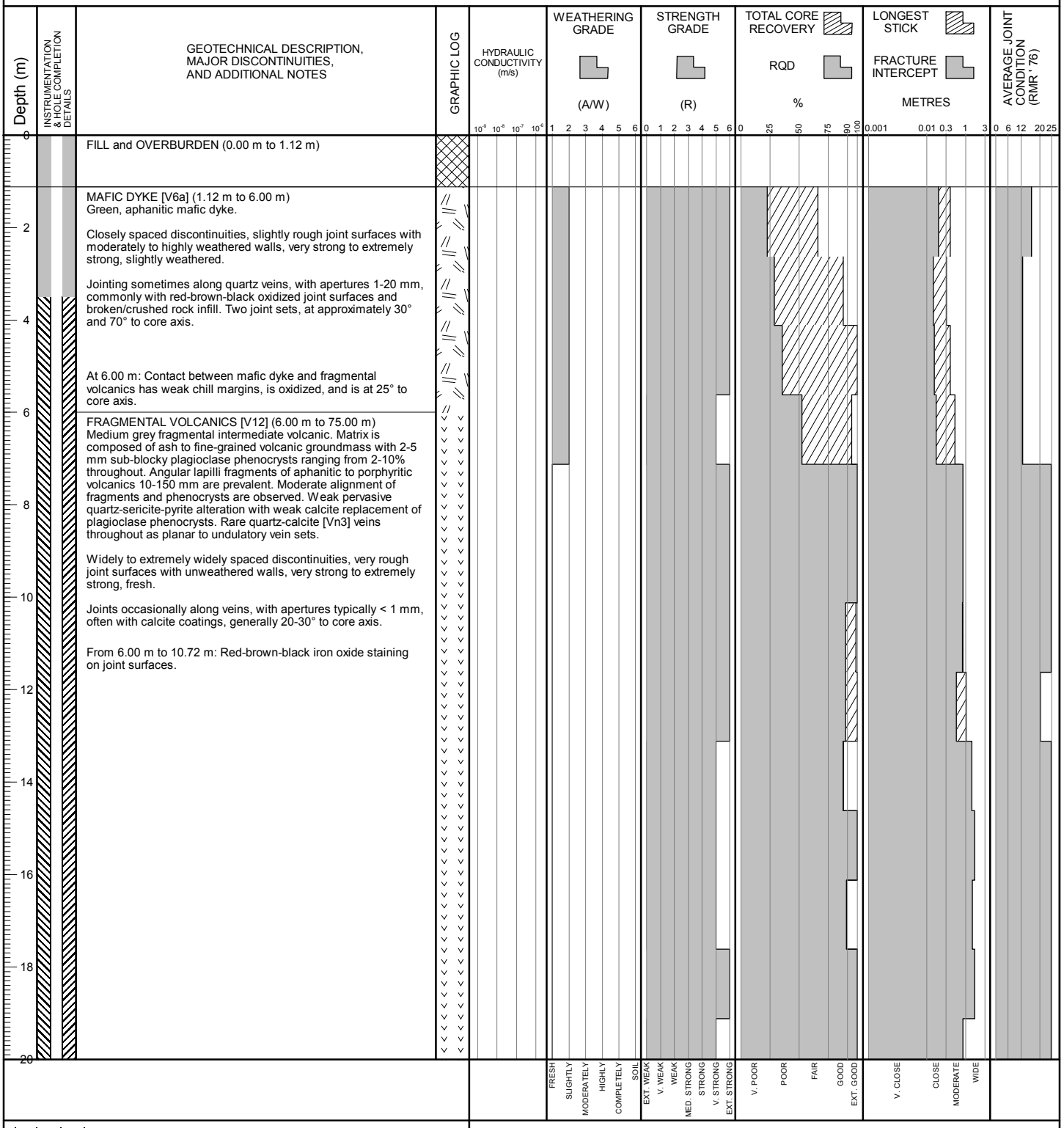
Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0	FILL and OVERBURDEN (0.00 m to 1.12 m)
1.12	MAFIC DYKE [V6a] (1.12 m to 6.00 m) Green, aphanitic mafic dyke. Closely spaced discontinuities, slightly rough joint surfaces with moderately to highly weathered walls, very strong to extremely strong, slightly weathered. Jointing sometimes along quartz veins, with apertures 1-20 mm, commonly with red-brown-black oxidized joint surfaces and broken/crushed rock infill. Two joint sets, at approximately 30° and 70° to core axis. At 6.00 m: Contact between mafic dyke and fragmental volcanics has weak chill margins, is oxidized, and is at 25° to core axis.
6.00	FRAGMENTAL VOLCANICS [V12] (6.00 m to 75.00 m) Medium grey fragmental intermediate volcanic. Matrix is composed of ash to fine-grained volcanic groundmass with 2-5 mm sub-blocky plagioclase phenocrysts ranging from 2-10% throughout. Angular lapilli fragments of aphanitic to porphyritic volcanics 10-150 mm are prevalent. Moderate alignment of fragments and phenocrysts are observed. Weak pervasive quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Rare quartz-calcite [Vn3] veins throughout as planar to undulatory vein sets. Widely to extremely widely spaced discontinuities, very rough joint surfaces with unweathered walls, very strong to extremely strong, fresh. Joints occasionally along veins, with apertures typically < 1 mm, often with calcite coatings, generally 20-30° to core axis. From 6.00 m to 10.72 m: Red-brown-black iron oxide staining on joint surfaces.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

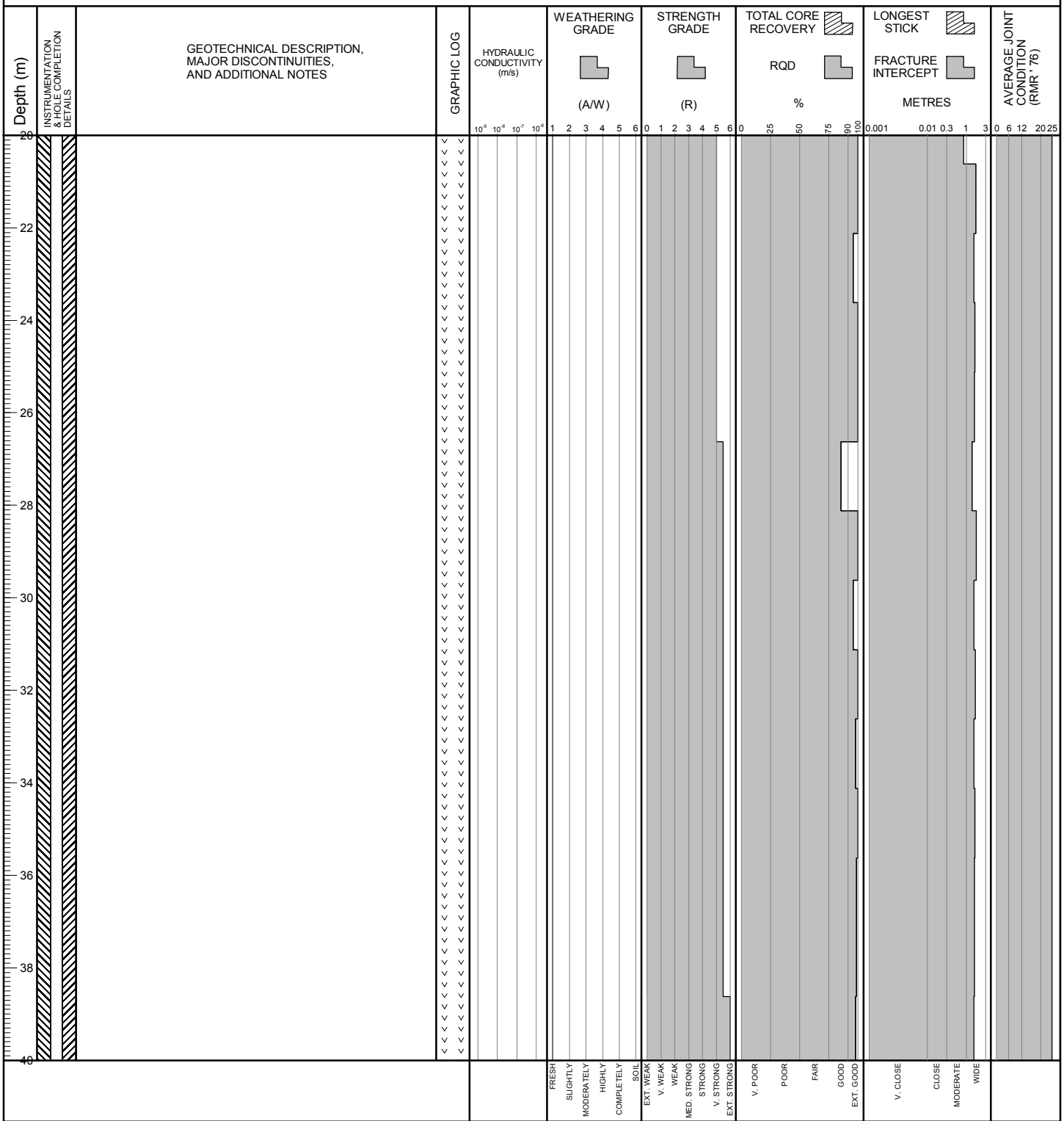
Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP



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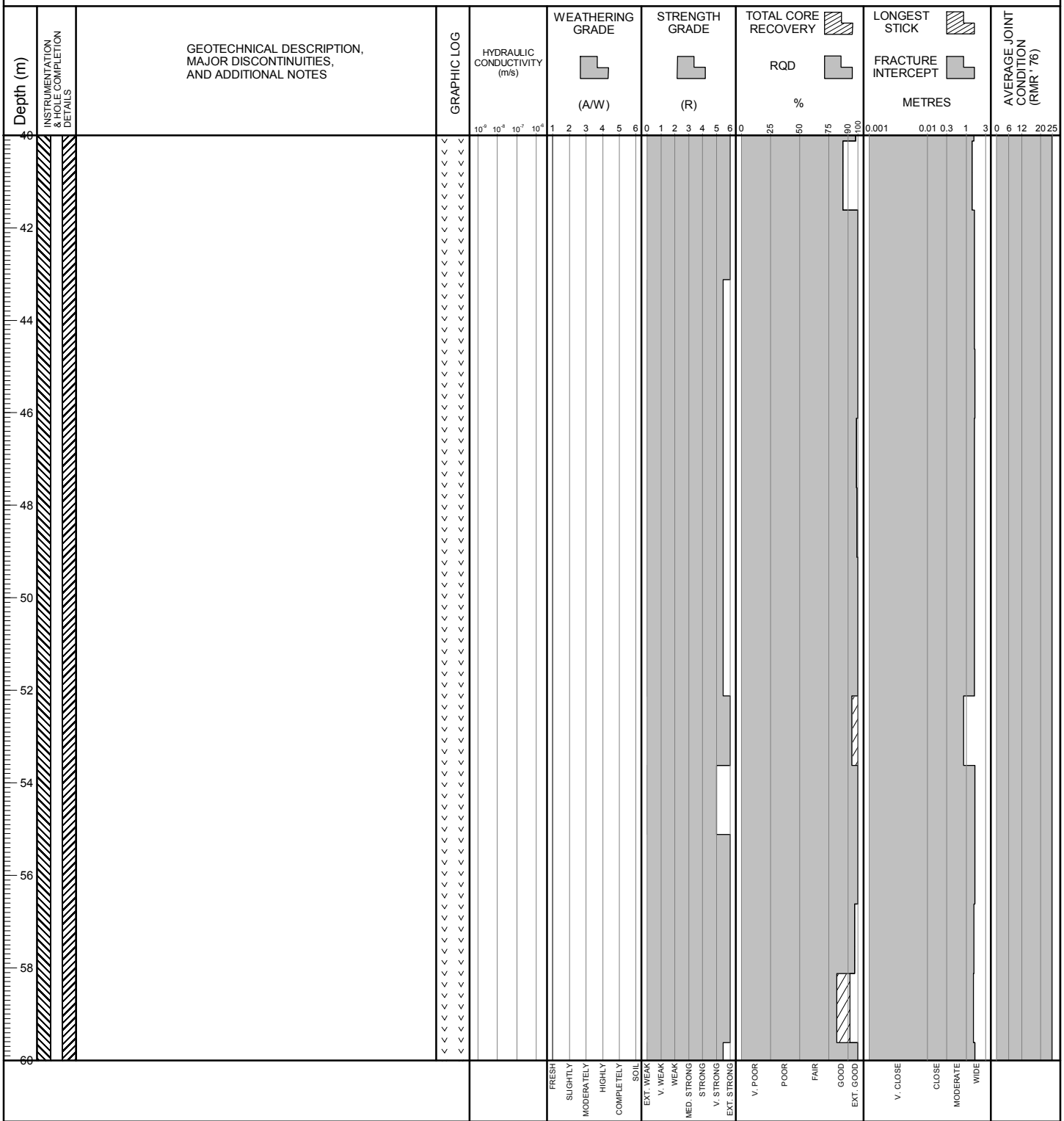

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 65.00 m to 76.76 m: Joint apertures 1-5 mm and infilled with silt and/or clay.

At 75.00 m: Contact between fragmental volcanics and porphyry is ambiguous.

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (75.00 m to 142.68 m)
Medium grey porphyritic volcanics/intrusives. Predominantly composed of euhedral, clay-altered mafic (hornblende?) phenocrysts and subhedral, calcite-altered plagioclase phenocrysts ranging from 5-25% throughout a grey, fine-grained matrix. Weak alignment of phenocrysts. Occasional intermediate fragments. Weak, pervasive, quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Rare quartz-calcite [Vn3] veins throughout as planar to undulatory vein sets.

Widely to extremely widely spaced discontinuities, slightly rough to very rough joint surfaces with unweathered walls, very strong to extremely strong, fresh.

Joints with apertures typically < 1 mm, sometimes with calcite or chlorite coatings.

Weathering grade: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Fracture intercept: V. CLOSE, CLOSE, MODERATE, WIDE

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

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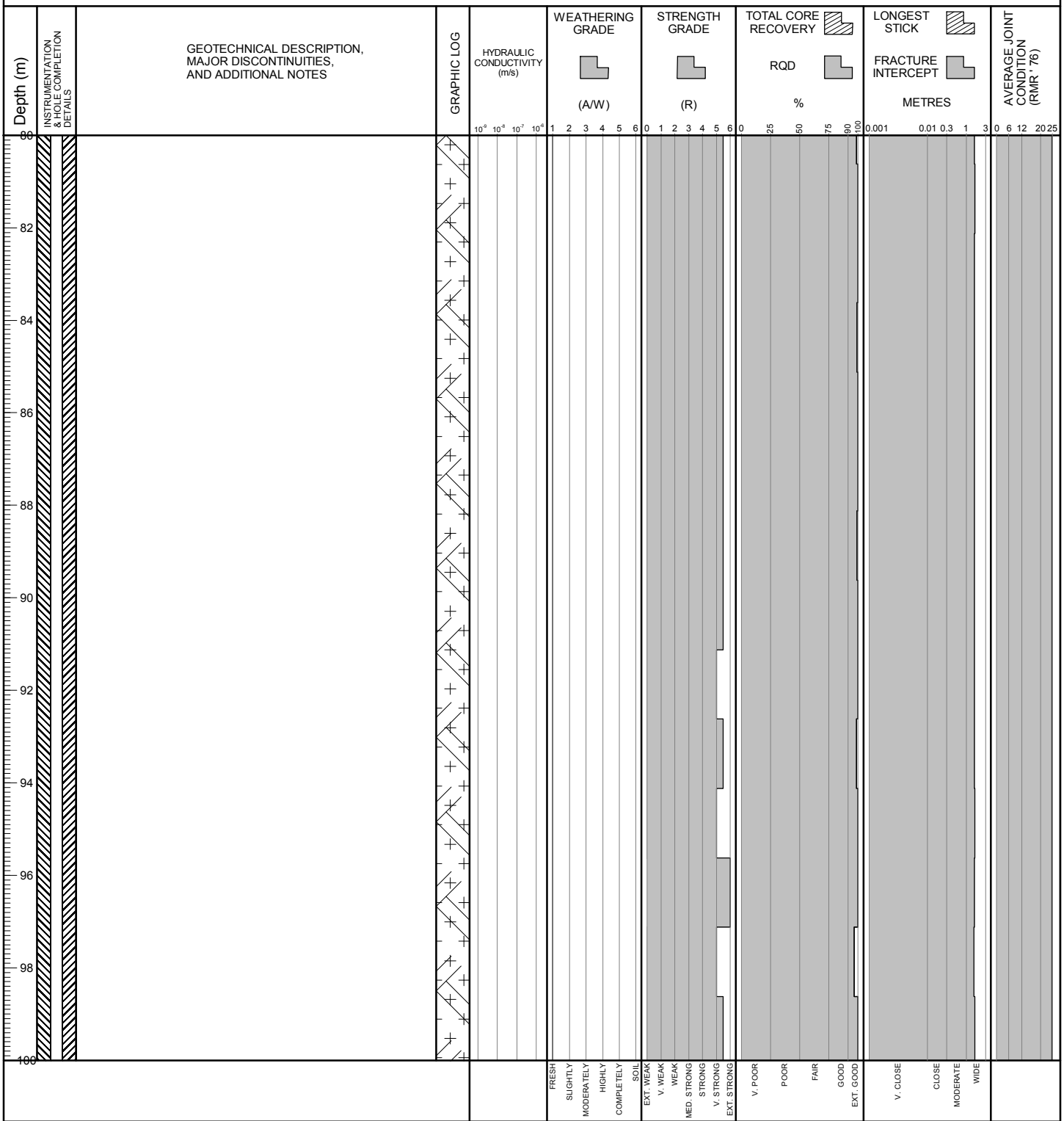

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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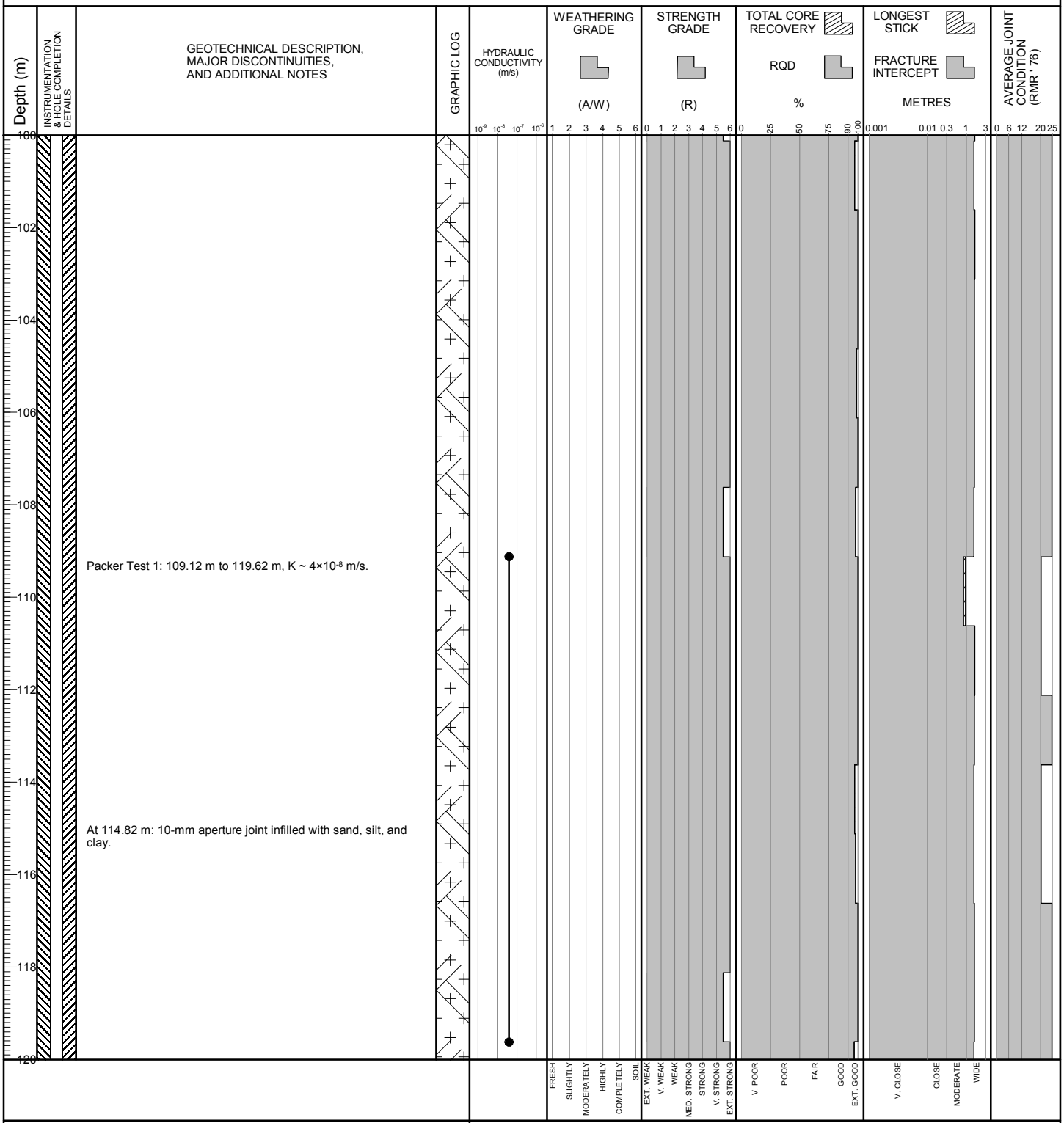

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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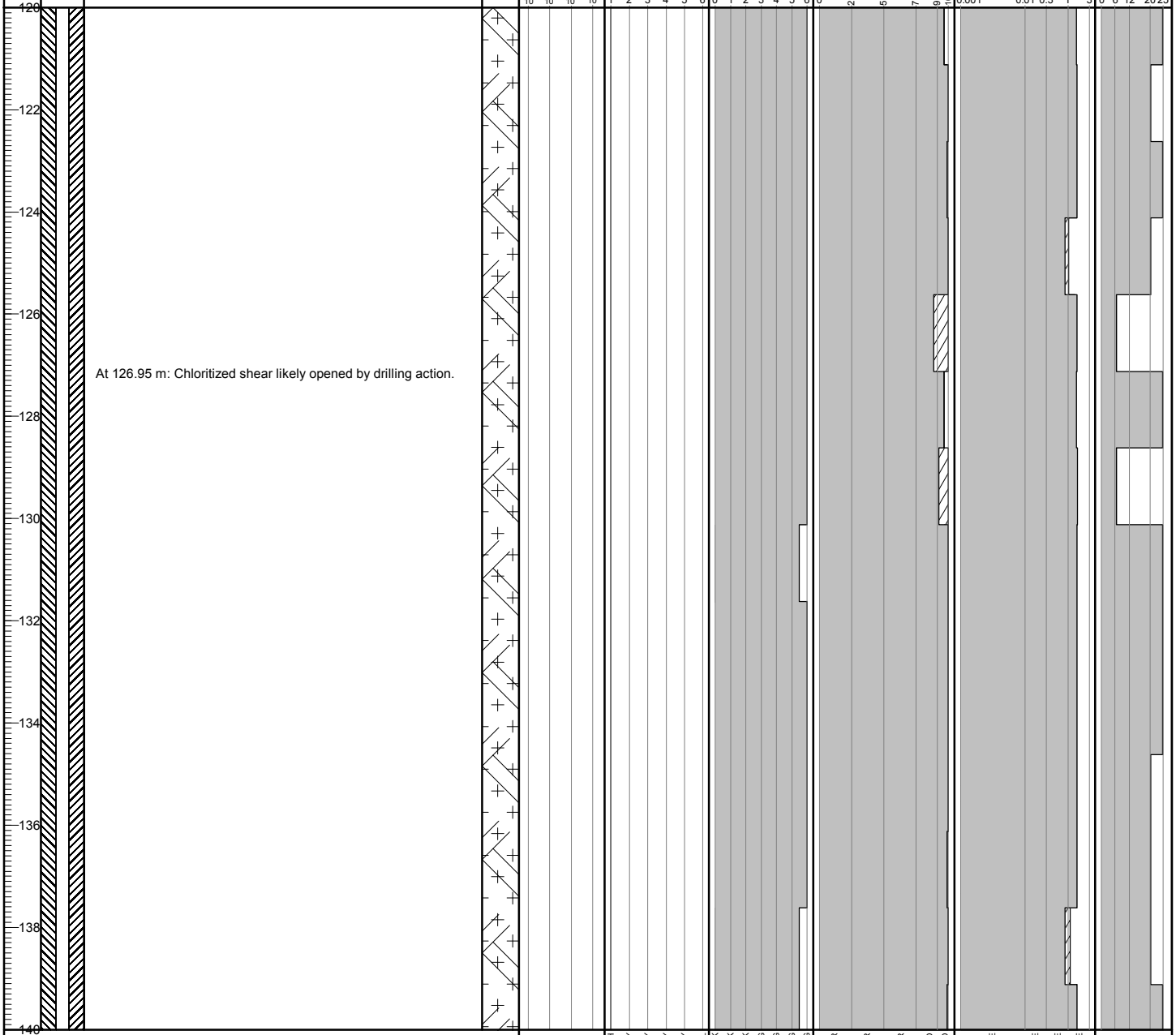
Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
120–140		At 126.95 m: Chloritized shear likely opened by drilling action.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
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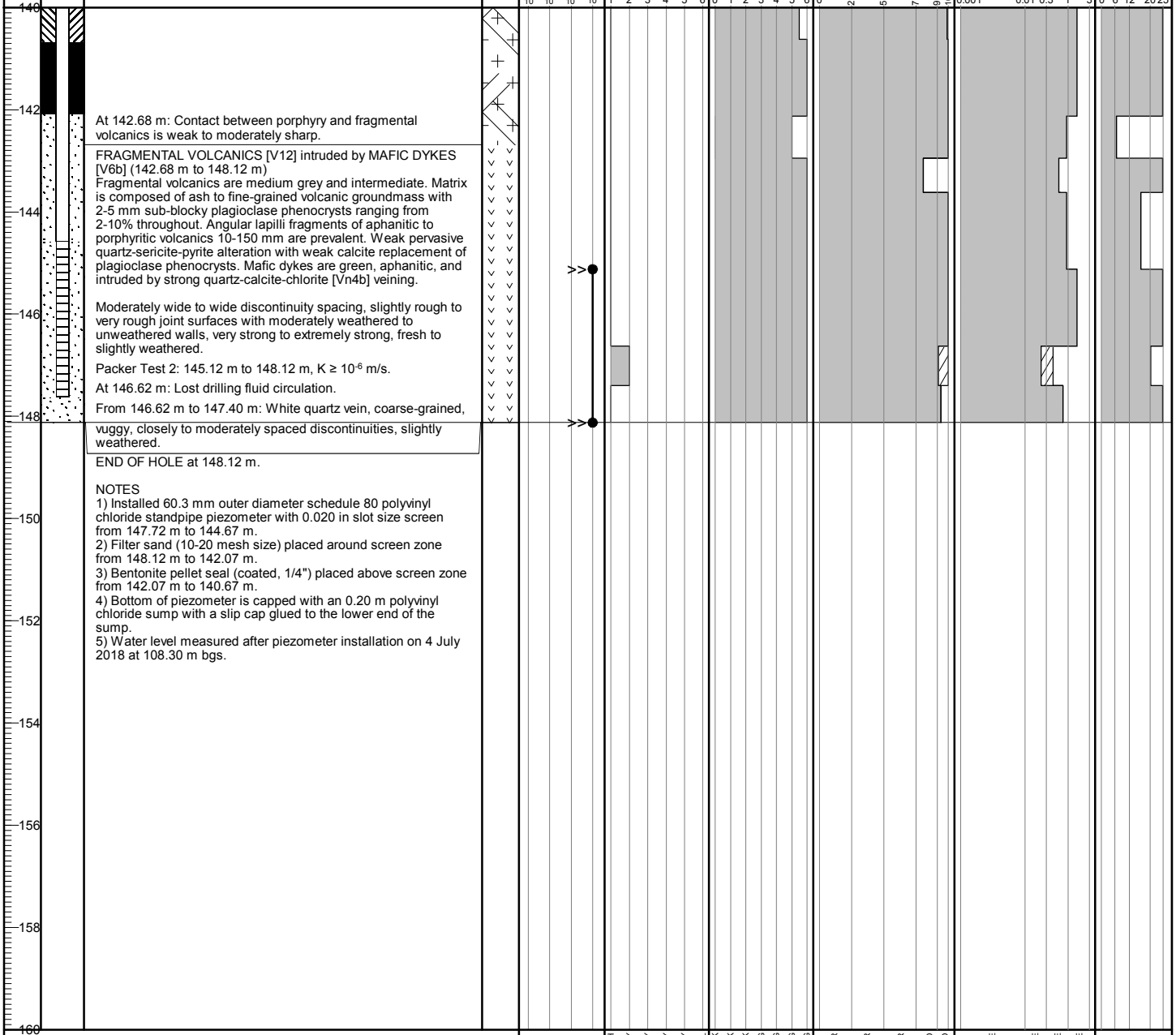
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)



At 142.68 m: Contact between porphyry and fragmental volcanics is weak to moderately sharp.

FRAGMENTAL VOLCANICS [V12] intruded by MAFIC DYKES [V6b] (142.68 m to 148.12 m)
Fragmental volcanics are medium grey and intermediate. Matrix is composed of ash to fine-grained volcanic groundmass with 2-5 mm sub-blocky plagioclase phenocrysts ranging from 2-10% throughout. Angular lapilli fragments of aphanitic to porphyritic volcanics 10-150 mm are prevalent. Weak pervasive quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Mafic dykes are green, aphanitic, and intruded by strong quartz-calcite-chlorite [Vn4b] veining.

Moderately wide to wide discontinuity spacing, slightly rough to very rough joint surfaces with moderately weathered to unweathered walls, very strong to extremely strong, fresh to slightly weathered.

Packer Test 2: 145.12 m to 148.12 m, K ≥ 10^{-6} m/s.

At 146.62 m: Lost drilling fluid circulation.

From 146.62 m to 147.40 m: White quartz vein, coarse-grained, vuggy, closely to moderately spaced discontinuities, slightly weathered.

END OF HOLE at 148.12 m.

NOTES
1) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 147.72 m to 144.67 m.
2) Filter sand (10-20 mesh size) placed around screen zone from 148.12 m to 142.07 m.
3) Bentonite pellet seal (coated, 1/4") placed above screen zone from 142.07 m to 140.67 m.
4) Bottom of piezometer is capped with an 0.20 m polyvinyl chloride sump with a slip cap glued to the lower end of the sump.
5) Water level measured after piezometer installation on 4 July 2018 at 108.30 m bgs.

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
Ground Elevation (m): 1,403.99
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
Depth To Top Of Rock (m): 1.19
Logged By: BDT/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

FILL and OVERBURDEN (0.00 m to 1.19 m)

FRAGMENTAL VOLCANICS [V12] (1.19 m to 69.28 m)
Medium grey fragmental intermediate volcanic. Matrix is comprised of ash to fine-grained volcanic groundmass with 2-5 mm sub-blocky plagioclase phenocrysts ranging from 2-10% throughout. Angular lapilli fragments of aphanitic to porphyritic volcanics 10-150 mm are prevalent. Weak pervasive quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Veining is negligible <1% throughout. Rare quartz-calcite [Vn3] generations are observed throughout as planar to undulatory vein sets.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with slightly weathered to unweathered walls, very strong to extremely strong, fresh.

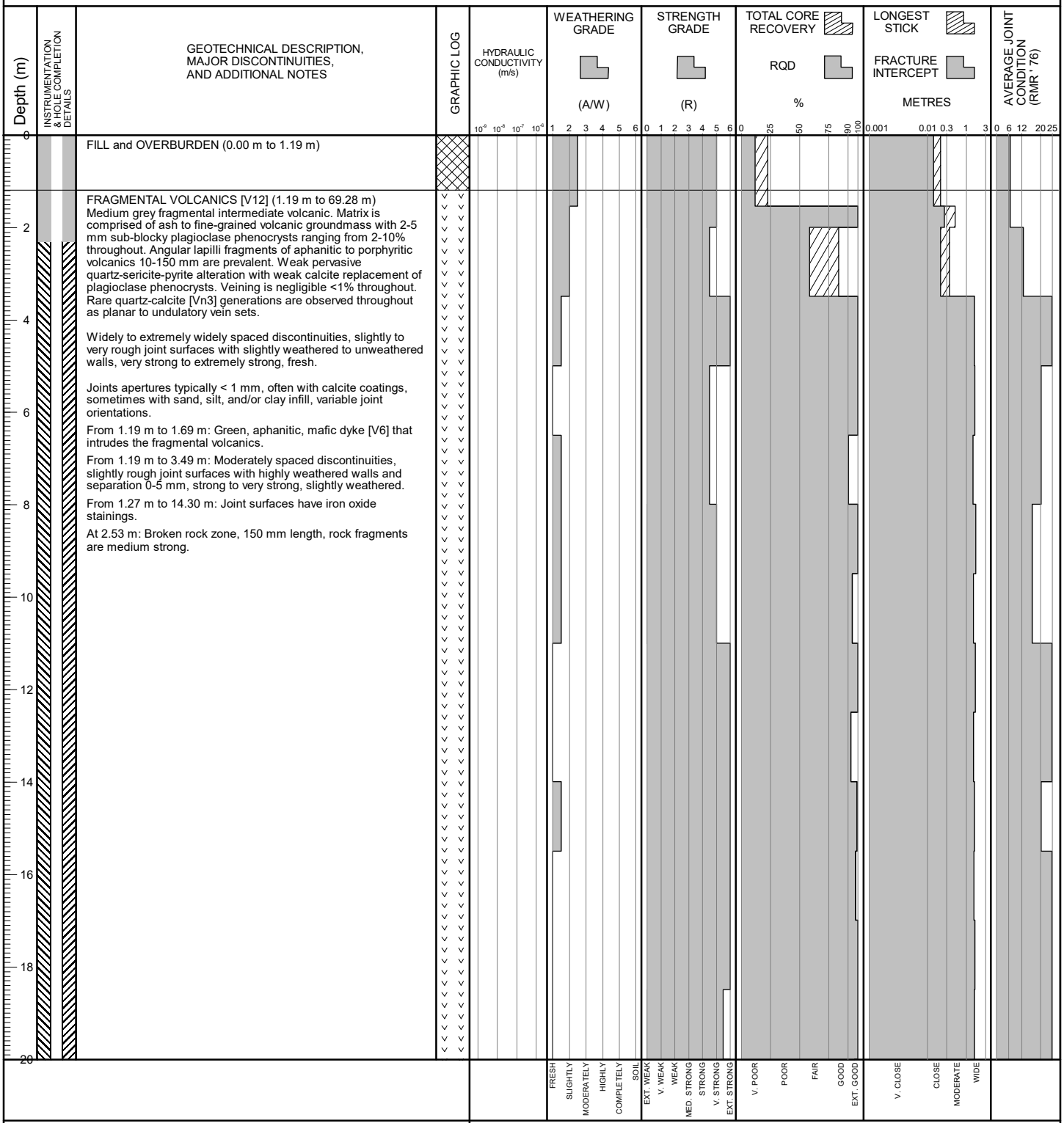
Joints apertures typically < 1 mm, often with calcite coatings, sometimes with sand, silt, and/or clay infill, variable joint orientations.

From 1.19 m to 1.69 m: Green, aphanitic, mafic dyke [V6] that intrudes the fragmental volcanics.

From 1.19 m to 3.49 m: Moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation 0-5 mm, strong to very strong, slightly weathered.

From 1.27 m to 14.30 m: Joint surfaces have iron oxide stainings.

At 2.53 m: Broken rock zone, 150 mm length, rock fragments are medium strong.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

Project No.: 1008-029

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Survey Method: Mine Survey
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Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
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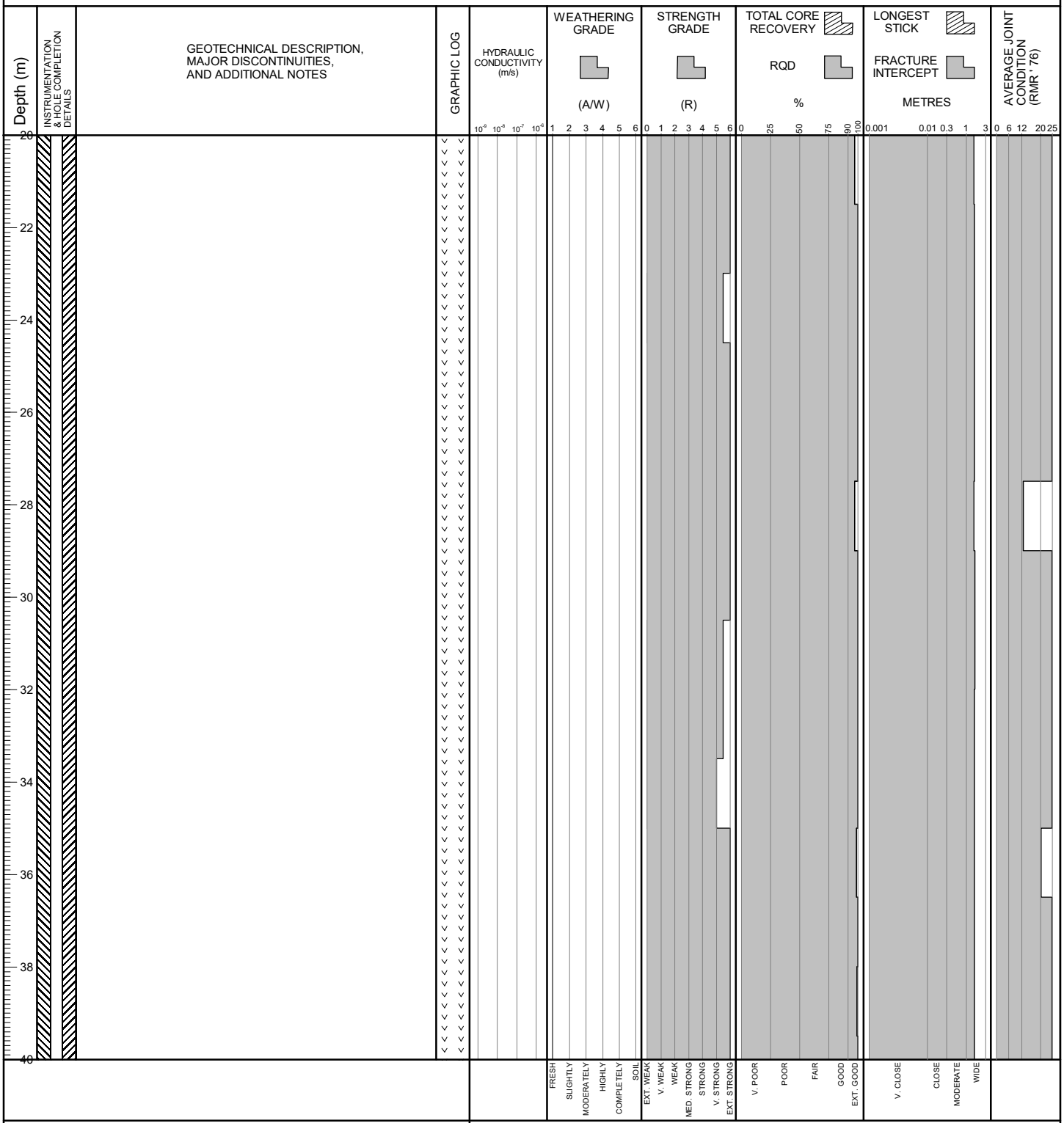

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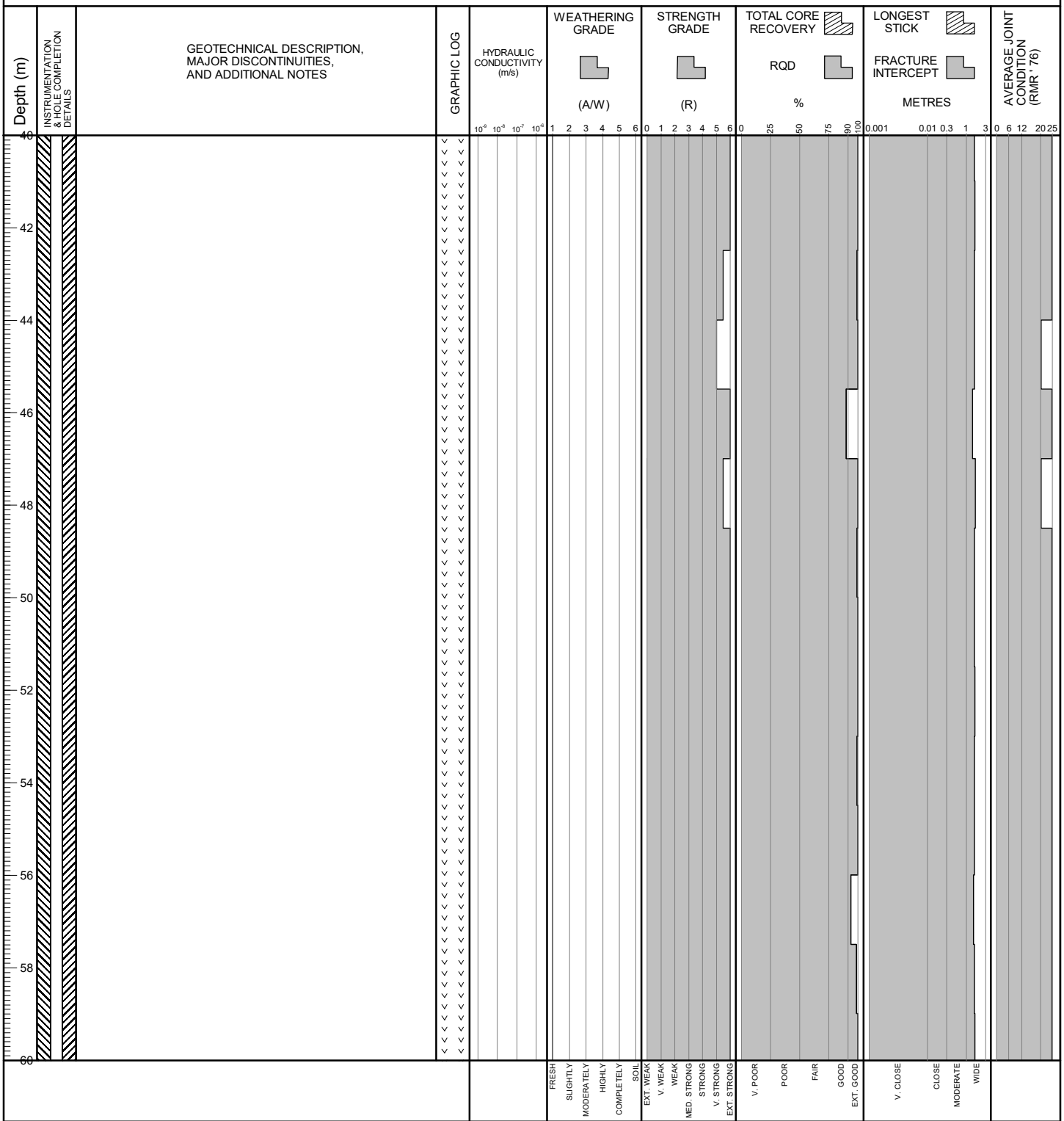

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At 69.28 m: Contact between [V12] and [P1] is weakly developed.

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (69.28 m to 105.49 m)
Medium grey porphyritic volcanic/intrusives. Predominantly comprised of euhedral, clay-altered mafic (hornblende?) phenocrysts and subhedral, calcite-altered plagioclase phenocrysts ranging from 5-25% throughout a grey, fine-grained matrix. Weak alignment of phenocrysts. Occasional intermediate fragments. Weak, pervasive, quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Veining is negligible <1% throughout. Rare quartz-calcite [Vn3] generations are observed throughout as planar to undulatory vein sets.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with slightly weathered to unweathered walls, very strong to extremely strong, fresh.

Joints apertures typically < 1 mm, often with calcite coatings, sometimes with sand, silt, and/or clay infill, generally 20-30° to core axis.

Packer Test 2: 71.49 m to 105.49 m, K ~ 9×10^{-8} m/s.

Packer Test 3: 74.49 m to 105.49 m, K ≤ 10^{-8} m/s.

WEATHERING GRADE (A/W): FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

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DRILL HOLE # BJ-GW18-17B

Project No.: 1008-029

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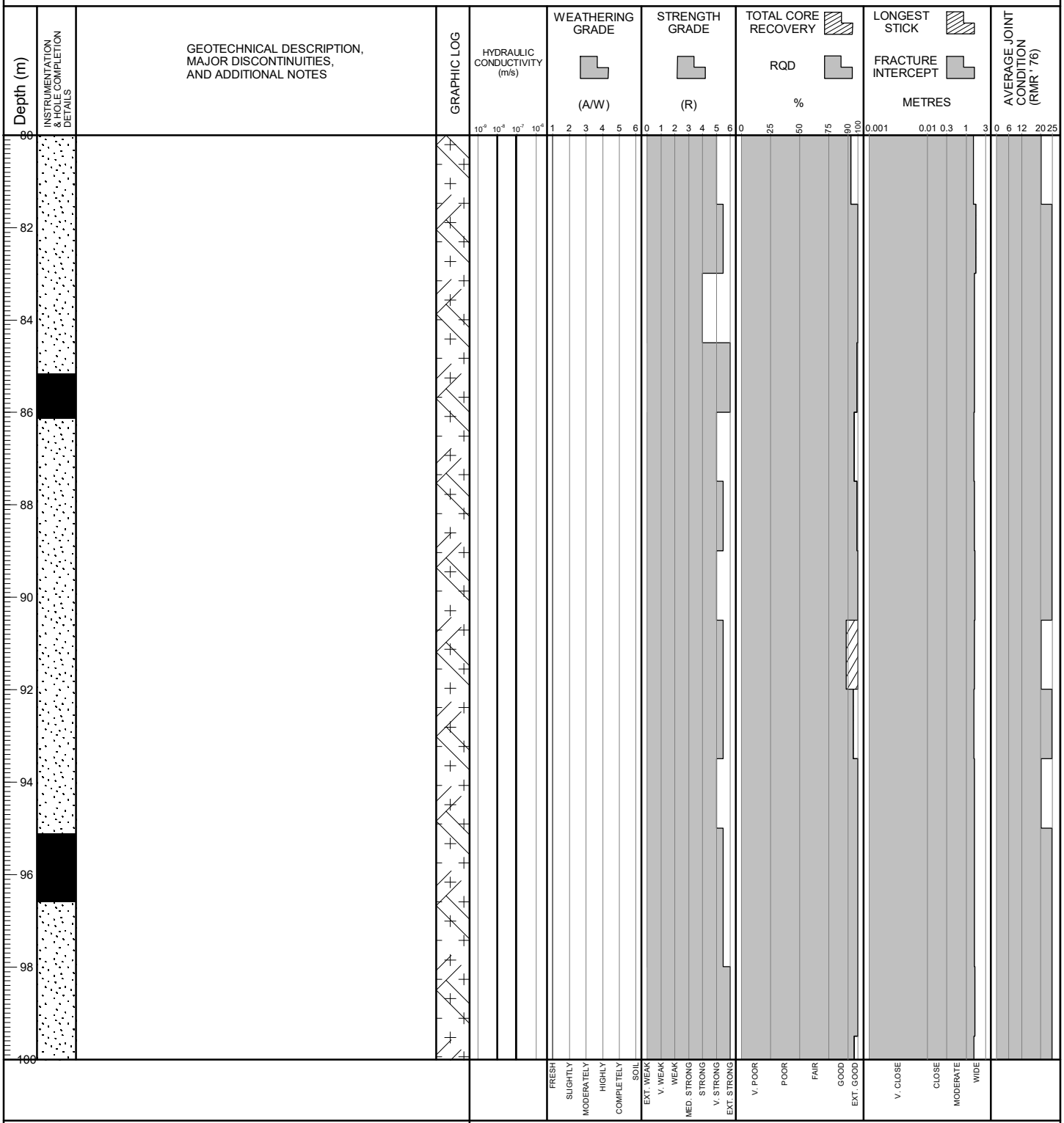

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Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes	Graphic Log	Hydraulic Conductivity (m/s)	Weathering Grade (A/W)	Strength Grade (R)	Total Core Recovery / RQD (%)	Longest Stick / Fracture Intercept (Metres)	Average Joint Condition (RMR' 76)
100		Packer Test 1: 100.99 m to 105.49 m, K ≤ 10^{-8} m/s.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
102									
104									
106		END OF HOLE at 105.49 m.							
108		NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 75.27 m to 72.22 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 75.76 m to 72.10 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 72.10 m to 69.68 m. 5) Water level measured after piezometer installation on 4 July 2018 at 60.22 m bgs.							
110									
112									
114									
116									
118									
120									

Weathering Grade: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

Strength Grade: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD

Fracture Intercept: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

FILL (0.00 m to 1.12 m)

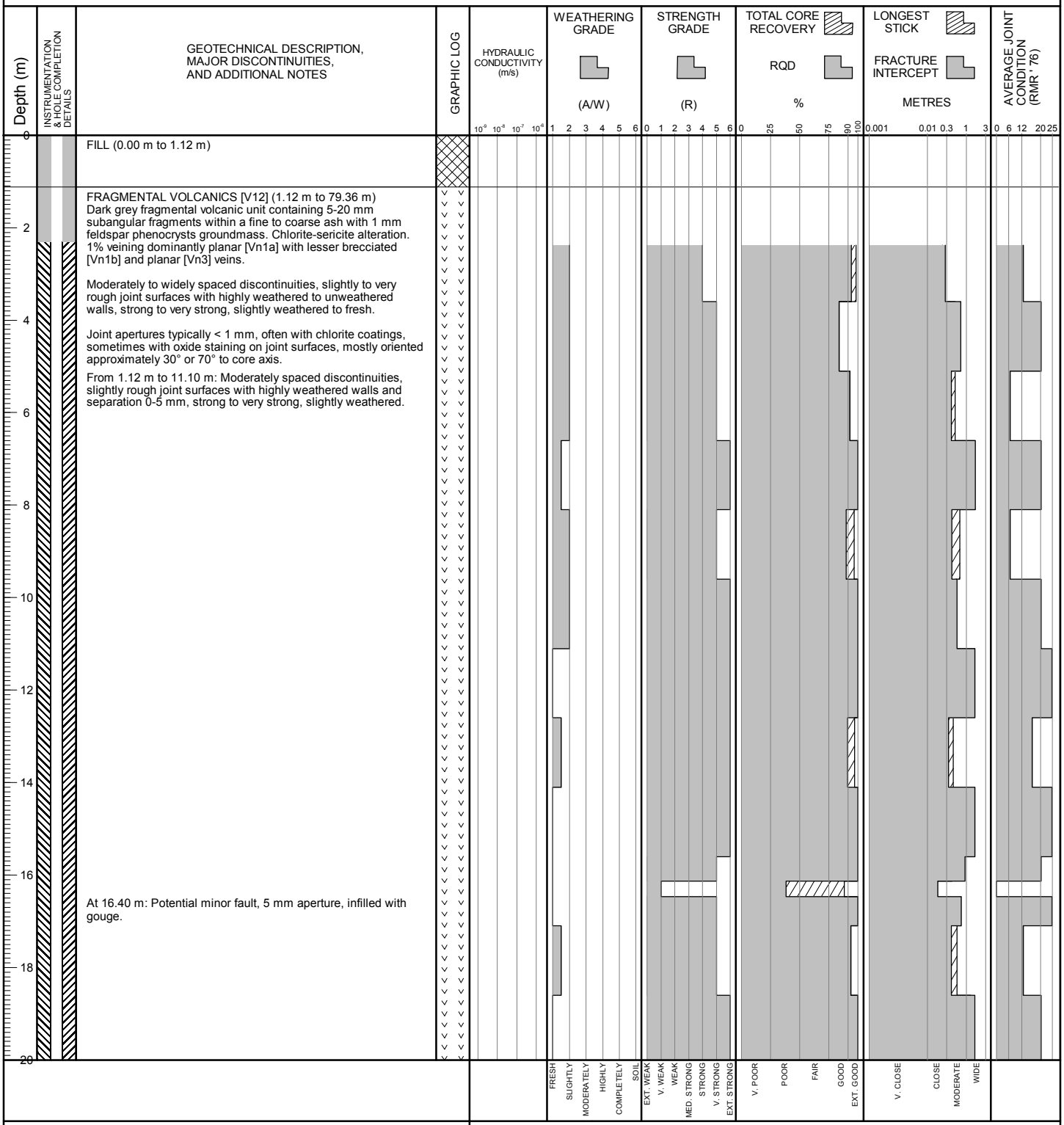
FRAGMENTAL VOLCANICS [V12] (1.12 m to 79.36 m)
Dark grey fragmental volcanic unit containing 5-20 mm subangular fragments within a fine to coarse ash with 1 mm feldspar phenocrysts groundmass. Chlorite-sericite alteration. 1% veining dominantly planar [Vn1a] with lesser brecciated [Vn1b] and planar [Vn3] veins.

Moderately to widely spaced discontinuities, slightly to very rough joint surfaces with highly weathered to unweathered walls, strong to very strong, slightly weathered to fresh.

Joint apertures typically < 1 mm, often with chlorite coatings, sometimes with oxide staining on joint surfaces, mostly oriented approximately 30° or 70° to core axis.

From 1.12 m to 11.10 m: Moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation 0-5 mm, strong to very strong, slightly weathered.

At 16.40 m: Potential minor fault, 5 mm aperture, infilled with gouge.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

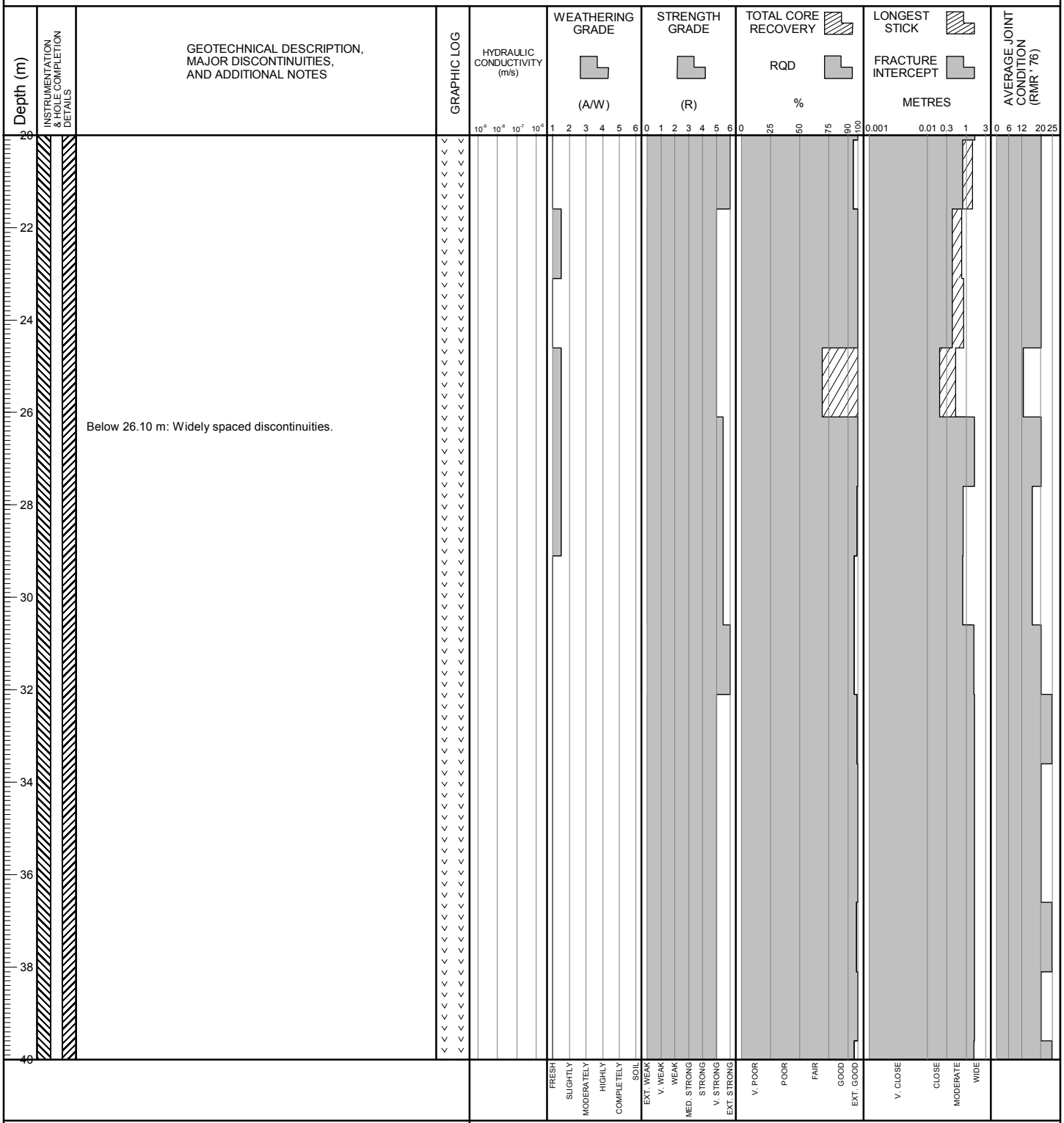
Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

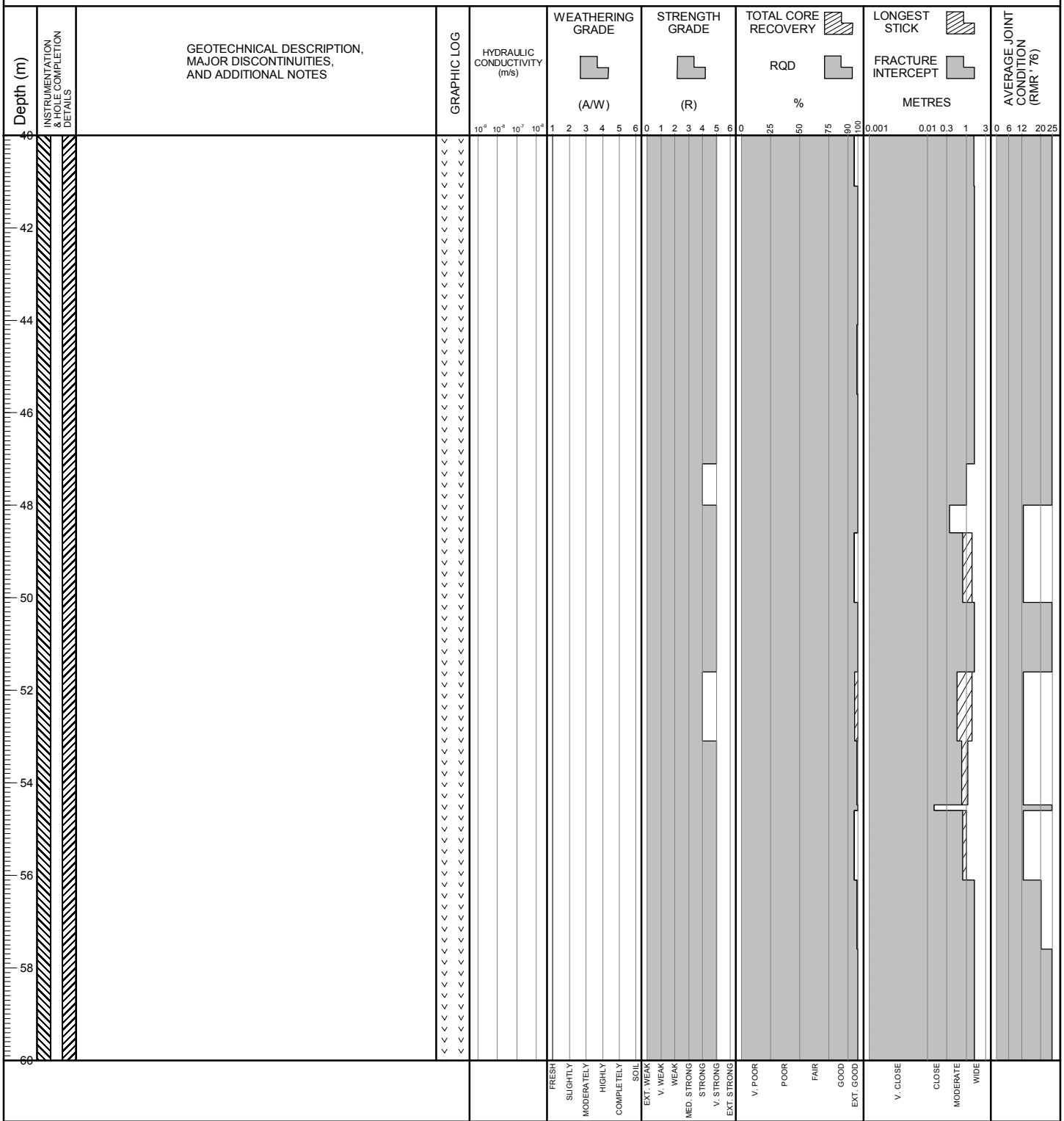
Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
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Final Depth (m): 110.10
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Logged By: DZ/DS
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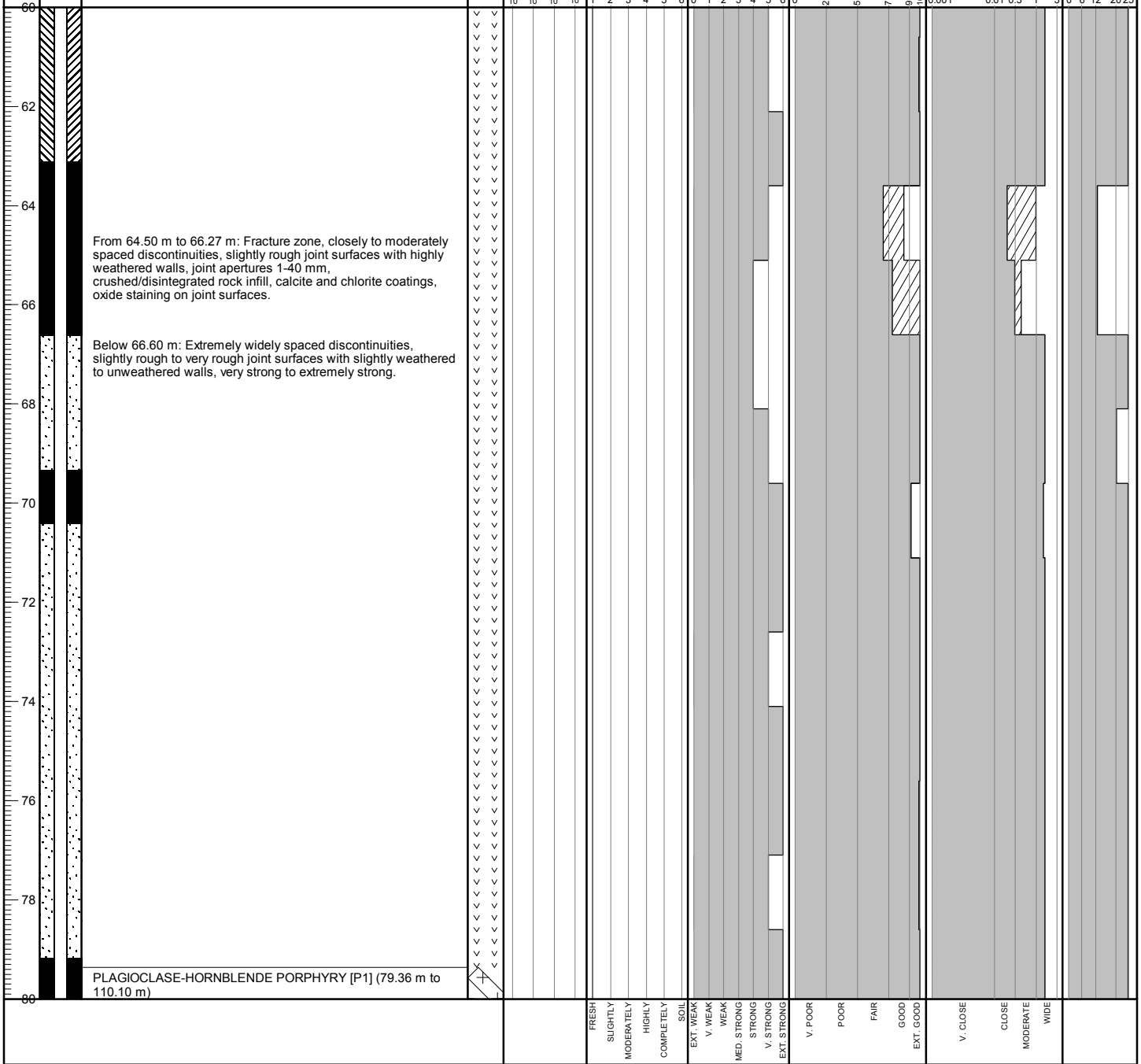
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP

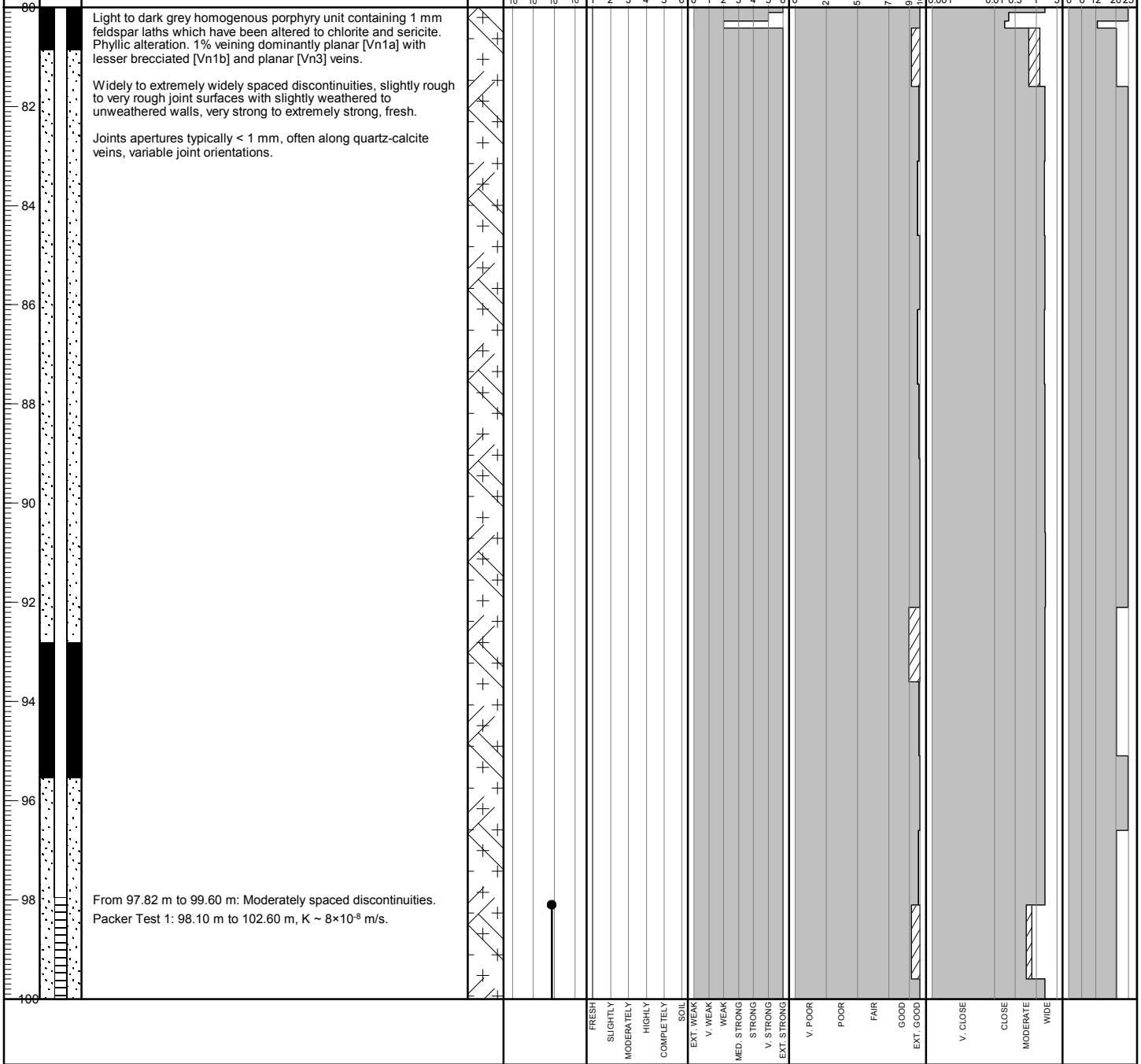
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Light to dark grey homogenous porphyry unit containing 1 mm feldspar laths which have been altered to chlorite and sericite. Phyllic alteration. 1% veining dominantly planar [Vn1a] with lesser brecciated [Vn1b] and planar [Vn3] veins.

Widely to extremely widely spaced discontinuities, slightly rough to very rough joint surfaces with slightly weathered to unweathered walls, very strong to extremely strong, fresh.

Joints apertures typically < 1 mm, often along quartz-calcite veins, variable joint orientations.

From 97.82 m to 99.60 m: Moderately spaced discontinuities.
Packer Test 1: 98.10 m to 102.60 m, K ~ 8×10^{-8} m/s.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

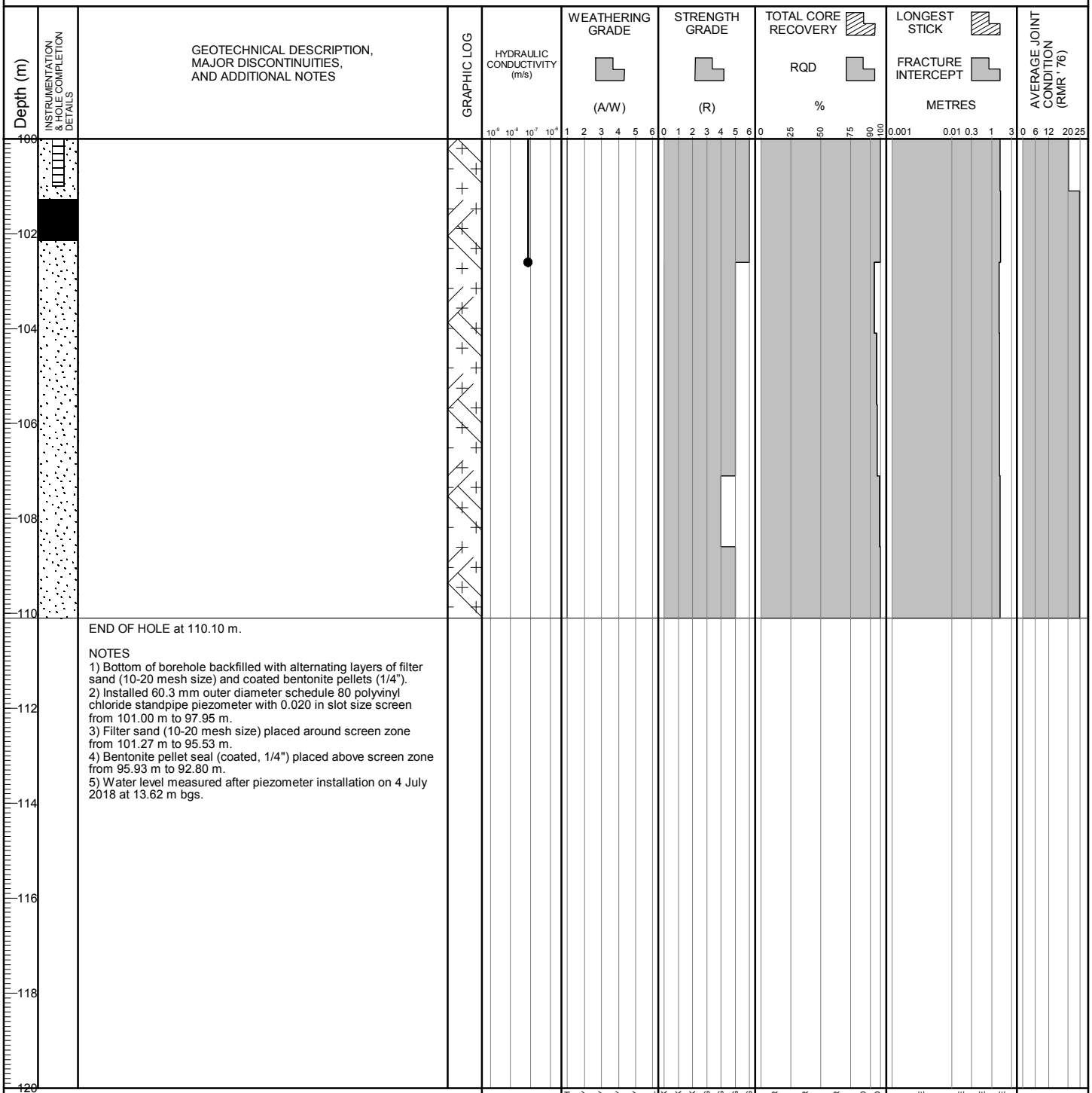
Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP



END OF HOLE at 110.10 m.

NOTES
1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4").
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 101.00 m to 97.95 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 101.27 m to 95.53 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 95.93 m to 92.80 m.
5) Water level measured after piezometer installation on 4 July 2018 at 13.62 m bgs.

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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

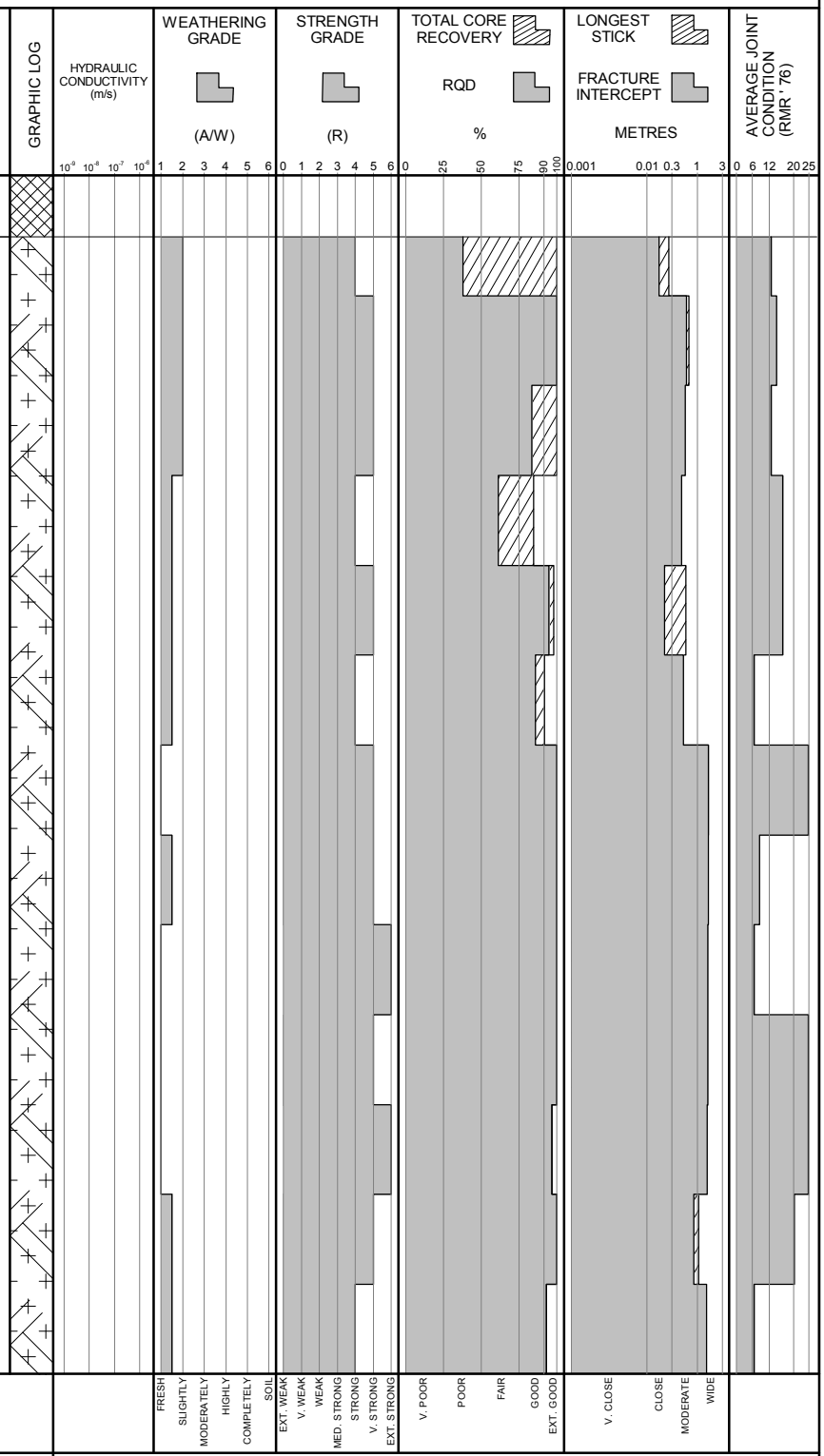
Location: Bunkhouse 6

Co-ordinates (m): 426,947E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.27

Start Date: 06 JUN 18
Finish Date: 09 JUN 18
Final Depth (m): 66.51
Depth To Top Of Rock (m): 1.03
Logged By: DZ/DS
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
0		FILL (0.00 m to 1.03 m)
1.03		PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (1.03 m to 66.51 m) Green porphyritic volcanic/intrusive. Predominantly comprised of subhedral, calcite-altered plagioclase phenocrysts ranging from 5-25%, with minor specks of dark mafic phenocrysts throughout a green, fine-grained matrix. Occasional mafic fragments. Weak to strong pervasive quartz-sericite-pyrite alteration with moderate pervasive chlorite replacement. Interval of minor 2% quartz-calcite veining. Dominantly comprised of cuspate-lobate [Vn1a] and planar to brecciate grey-pink calcite [Vn3] veins. Lesser crosscutting [Vn4b] tension gash style veins and pyrite-rich [Vn0] veins. Moderately to widely spaced discontinuities, variably slightly to very rough joint surfaces with highly weathered to unweathered walls, strong to very strong, slightly weathered to fresh. Joint apertures typically < 1 mm, often with oxide staining on joint surfaces, sometimes with calcite or chlorite coatings, mostly oriented approximately 30° or 70° to core axis. From 1.03 m to 8.22 m: Slightly weathered, moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation 0-5 mm.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

Location: Bunkhouse 6

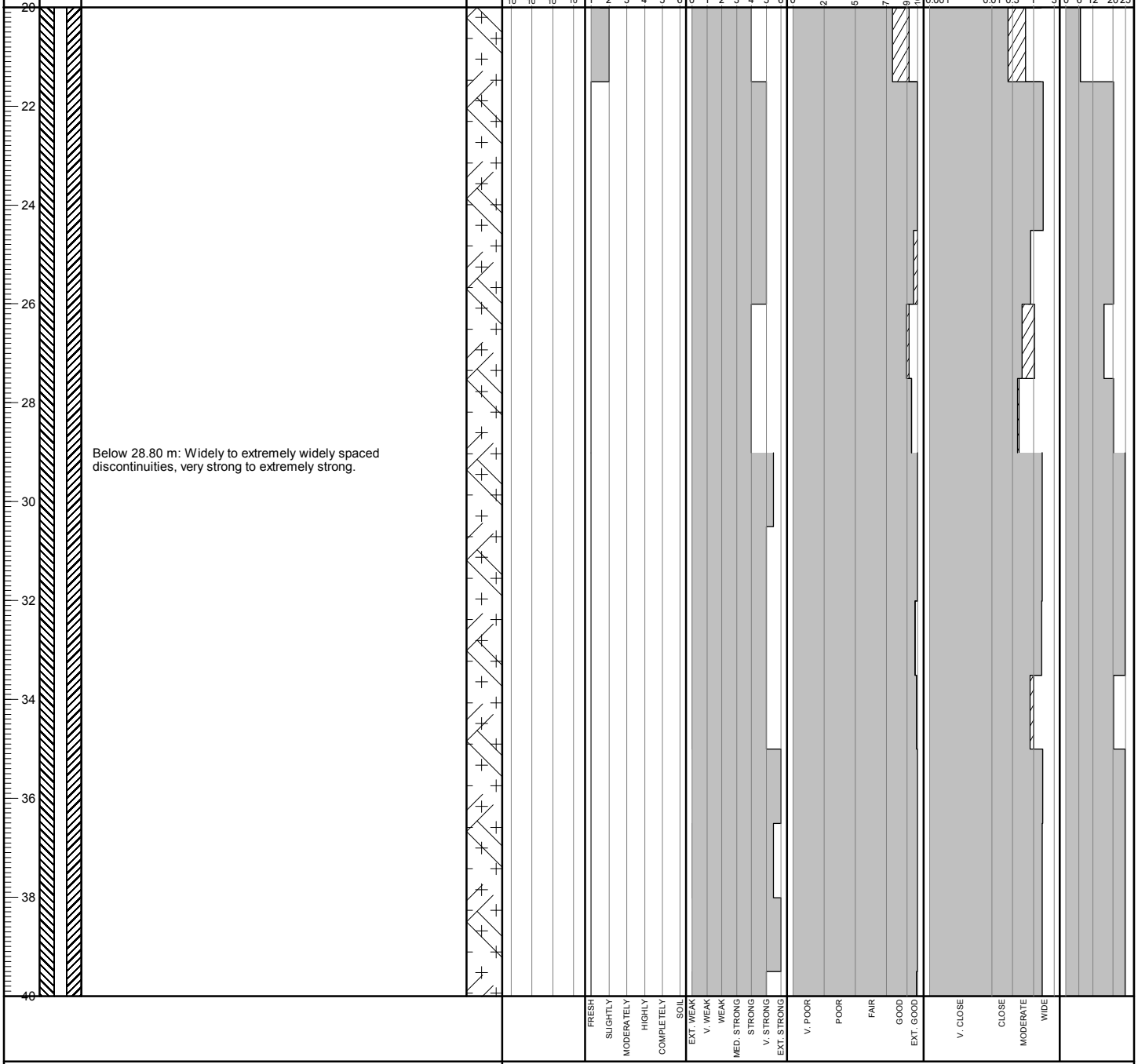
Co-ordinates (m): 426,947E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.27

Start Date: 06 JUN 18
Finish Date: 09 JUN 18
Final Depth (m): 66.51
Depth To Top Of Rock (m): 1.03
Logged By: DZ/DS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

Below 28.80 m: Widely to extremely widely spaced discontinuities, very strong to extremely strong.



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DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

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Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
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Final Depth (m): 66.51
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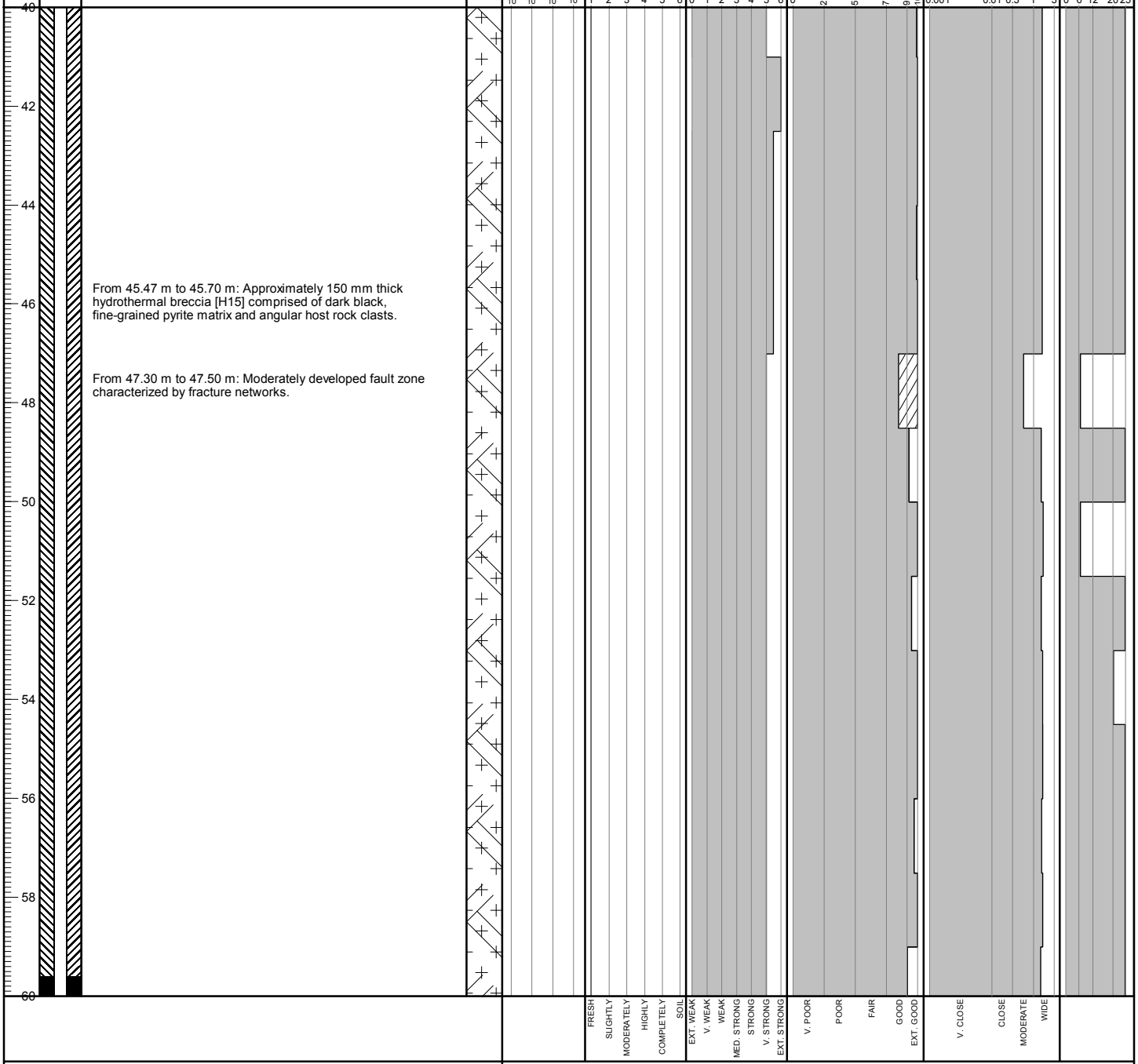
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 45.47 m to 45.70 m: Approximately 150 mm thick hydrothermal breccia [H15] comprised of dark black, fine-grained pyrite matrix and angular host rock clasts.

From 47.30 m to 47.50 m: Moderately developed fault zone characterized by fracture networks.



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Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

Location: Bunkhouse 6

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Datum: UTM NAD 83 Zone 9
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Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
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Finish Date: 09 JUN 18
Final Depth (m): 66.51
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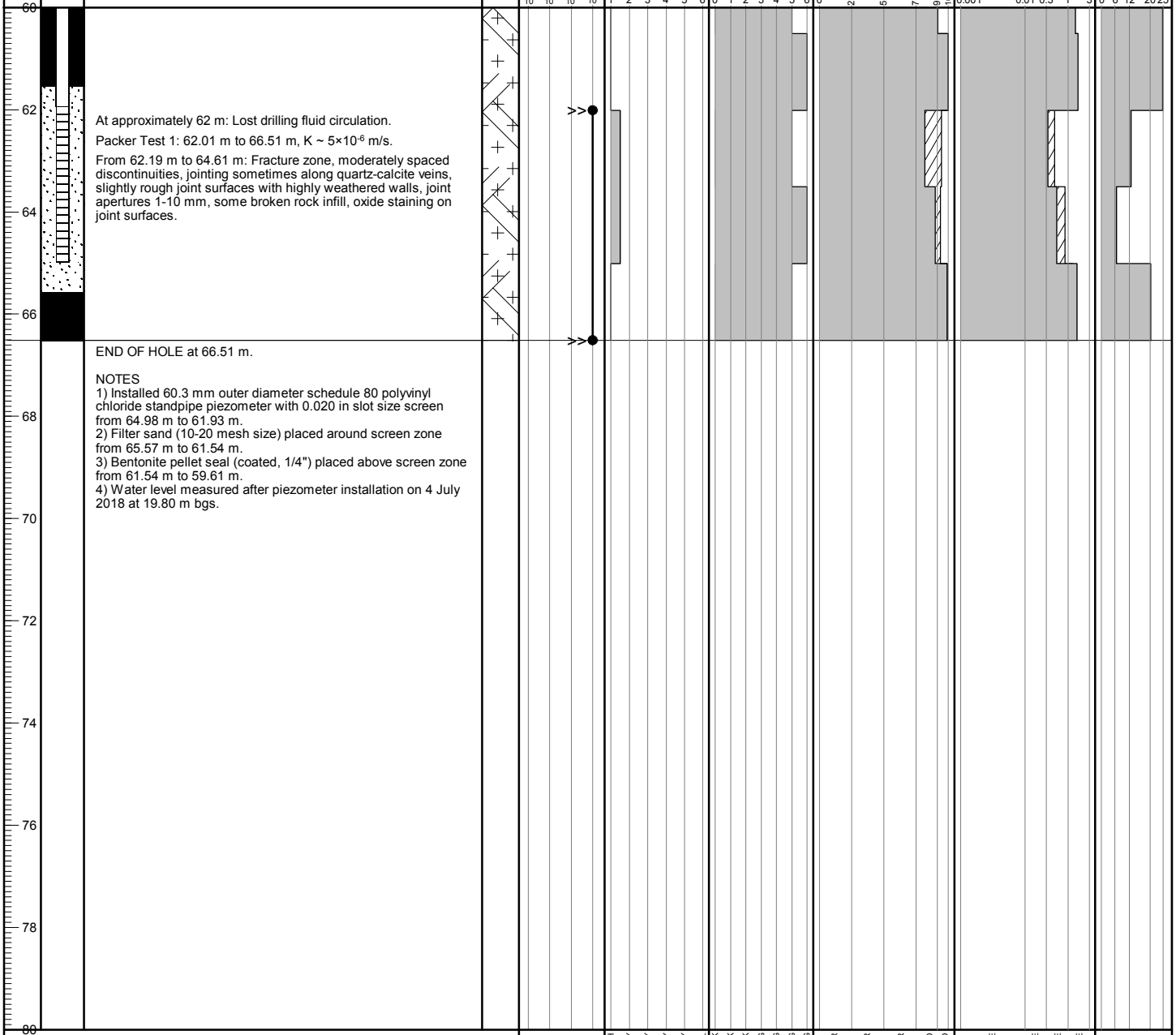
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19A

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (0.00 m to 196.89 m)
Light to dark green porphyritic volcanic/intrusive. Predominantly comprised of subhedral, sericite-altered plagioclase phenocrysts ranging from 5-25%, with minor specks of dark mafic phenocrysts throughout a green, fine-grained matrix. Weak alignment of phenocrysts. Rare mafic fragments. Moderate pervasive chlorite replacement with isolated intervals of strong pervasive quartz-sericite-pyrite alteration. Variable veining structures.

Variable rock mass and discontinuity properties detailed in specific intervals.

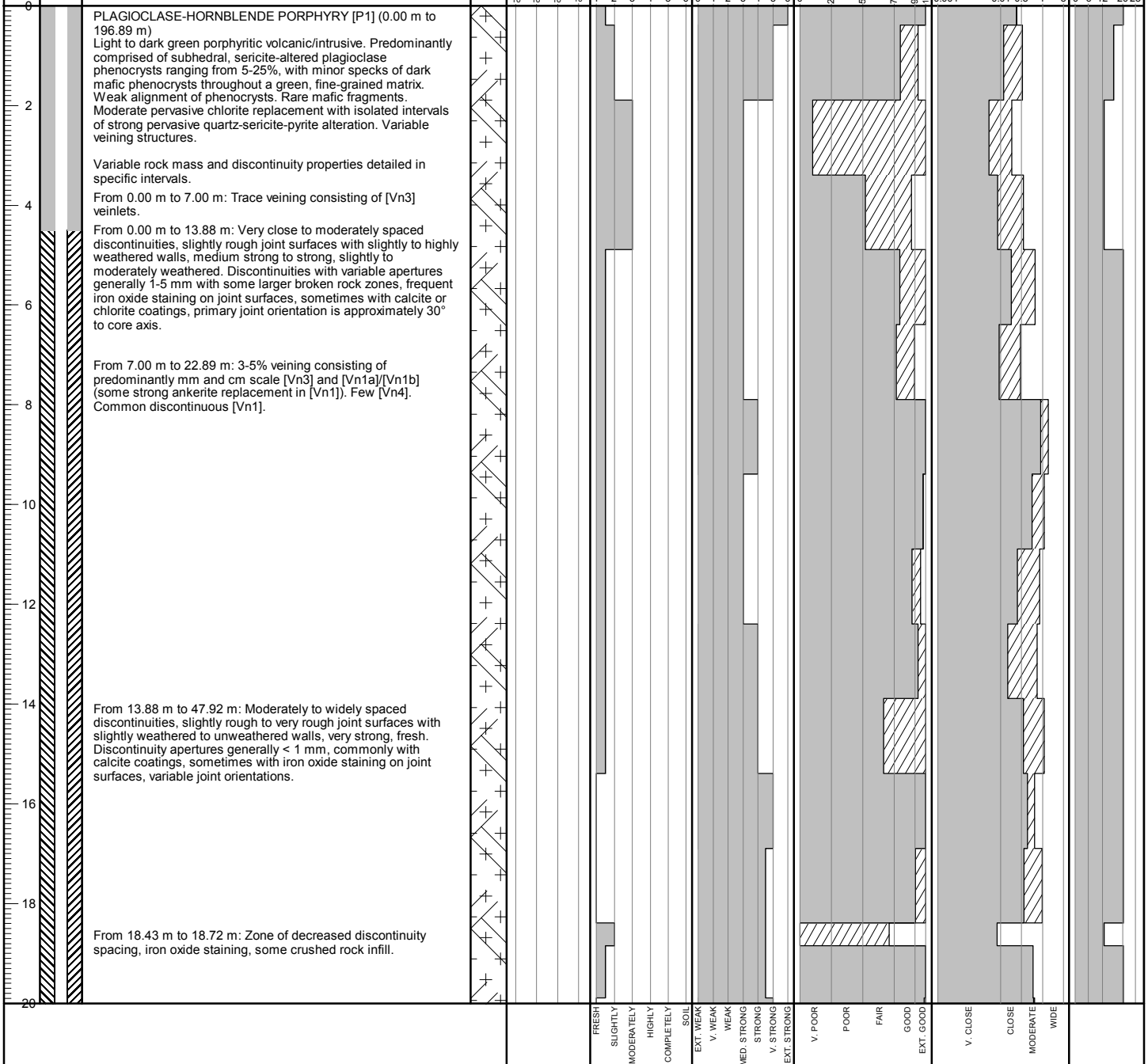
From 0.00 m to 7.00 m: Trace veining consisting of [Vn3] veinlets.

From 0.00 m to 13.88 m: Very close to moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, medium strong to strong, slightly to moderately weathered. Discontinuities with variable apertures generally 1-5 mm with some larger broken rock zones, frequent iron oxide staining on joint surfaces, sometimes with calcite or chlorite coatings, primary joint orientation is approximately 30° to core axis.

From 7.00 m to 22.89 m: 3-5% veining consisting of predominantly mm and cm scale [Vn3] and [Vn1a]/[Vn1b] (some strong ankerite replacement in [Vn1]). Few [Vn4]. Common discontinuous [Vn1].

From 13.88 m to 47.92 m: Moderately to widely spaced discontinuities, slightly rough to very rough joint surfaces with slightly weathered to unweathered walls, very strong, fresh. Discontinuity apertures generally < 1 mm, commonly with calcite coatings, sometimes with iron oxide staining on joint surfaces, variable joint orientations.

From 18.43 m to 18.72 m: Zone of decreased discontinuity spacing, iron oxide staining, some crushed rock infill.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

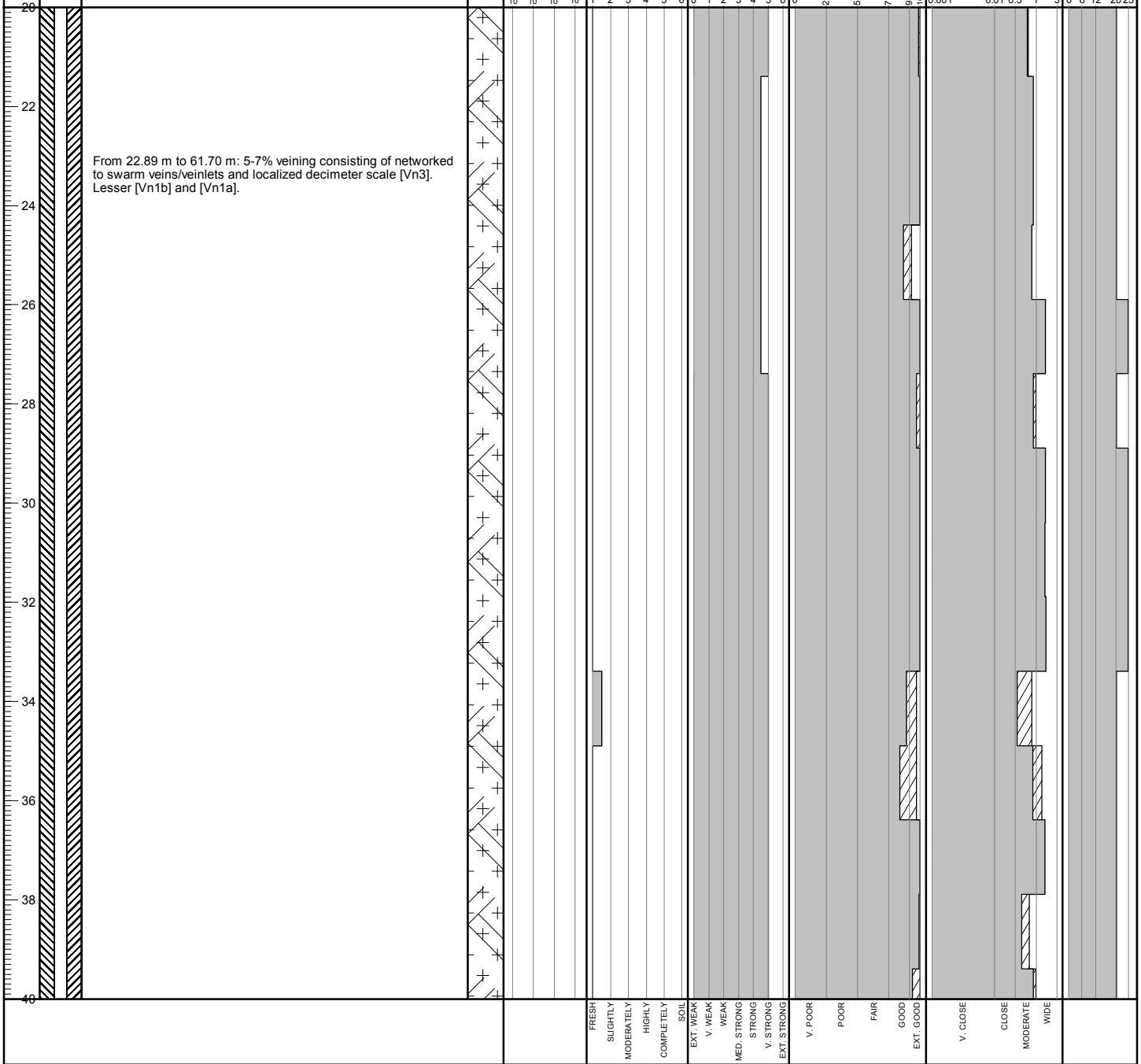
Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
20–40		From 22.89 m to 61.70 m: 5-7% veining consisting of networked to swarm veins/veinlets and localized decimeter scale [Vn3]. Lesser [Vn1b] and [Vn1a].



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

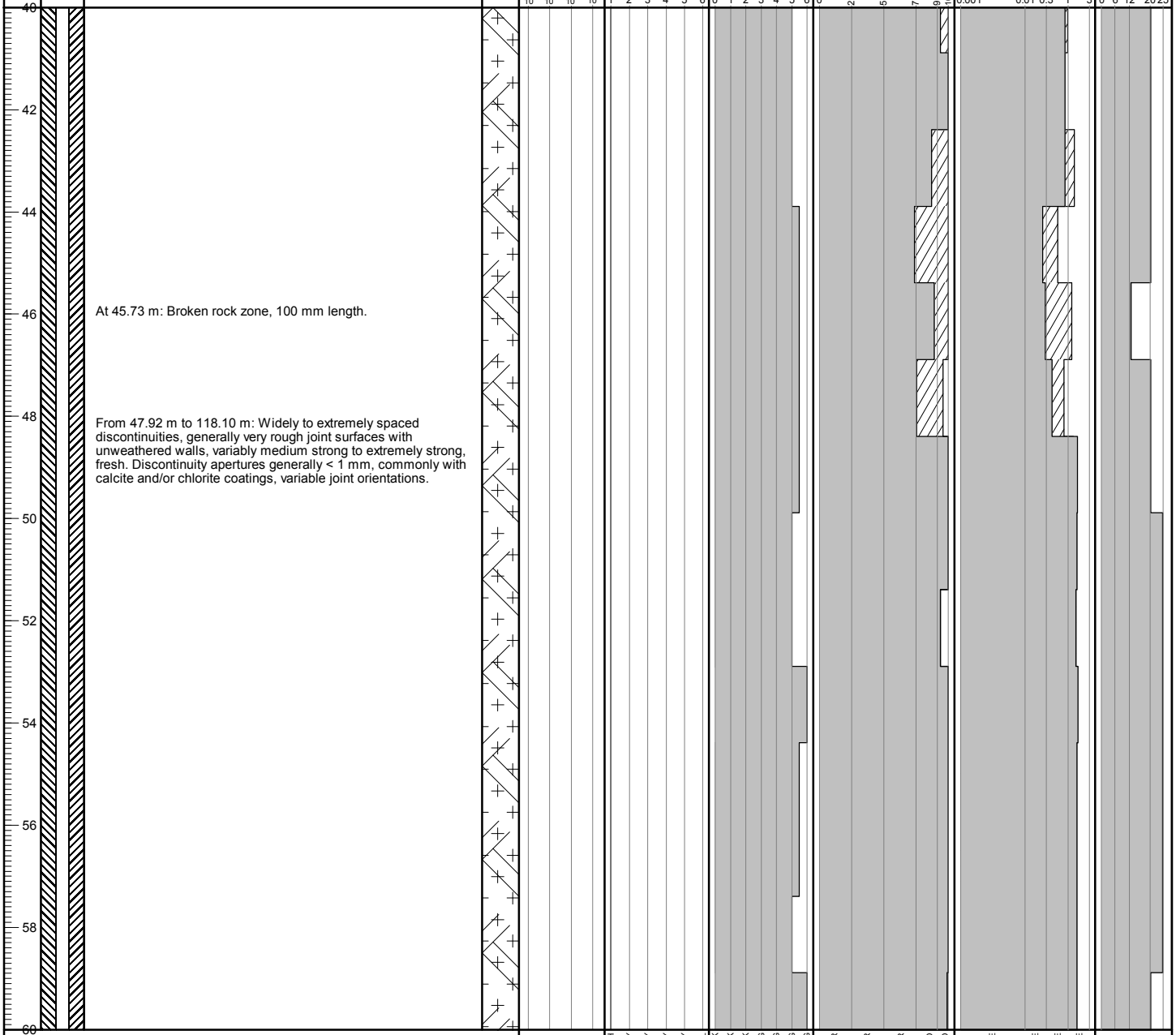
Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

At 45.73 m: Broken rock zone, 100 mm length.

From 47.92 m to 118.10 m: Widely to extremely spaced discontinuities, generally very rough joint surfaces with unweathered walls, variably medium strong to extremely strong, fresh. Discontinuity apertures generally < 1 mm, commonly with calcite and/or chlorite coatings, variable joint orientations.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
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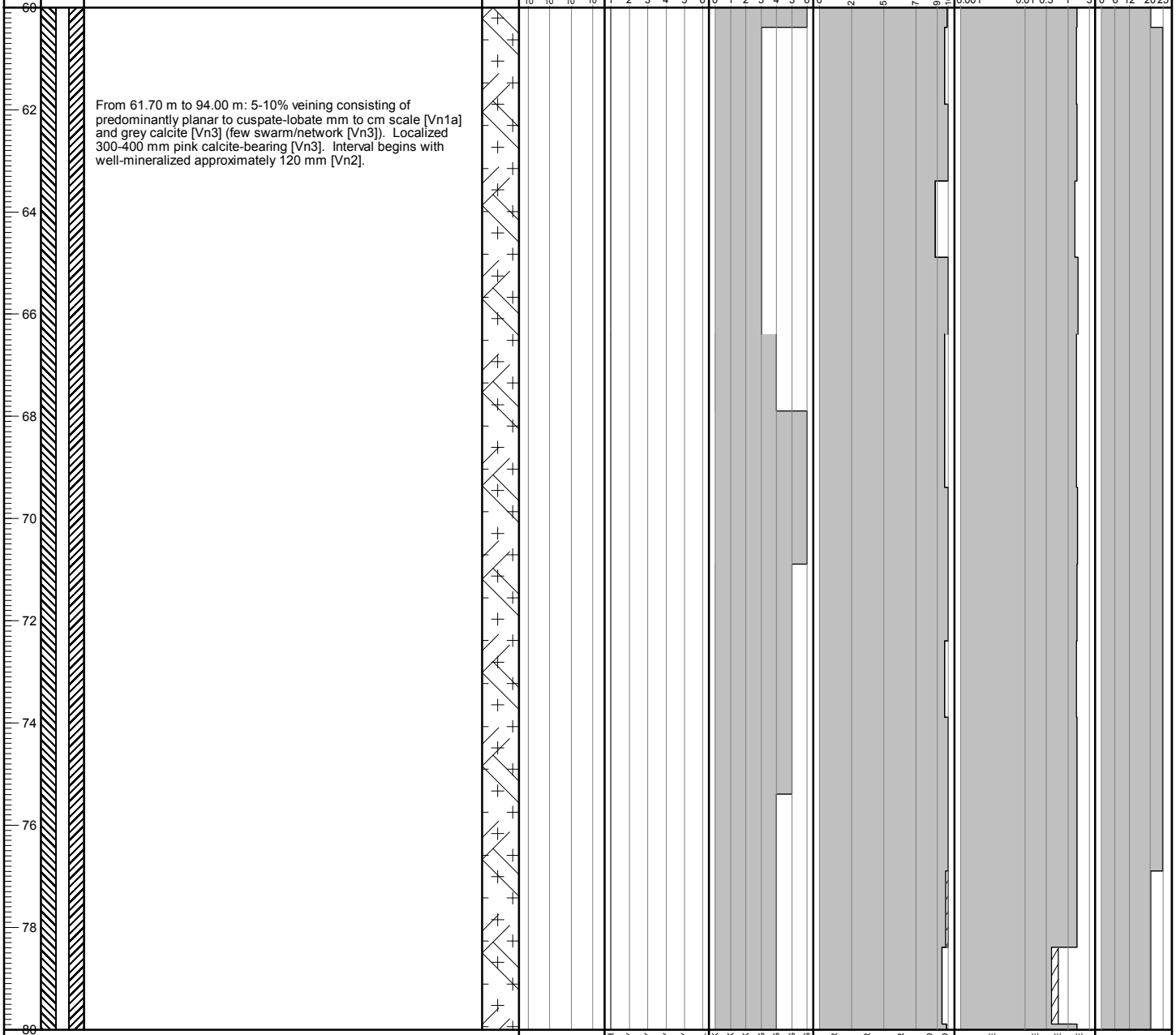
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

From 61.70 m to 94.00 m: 5-10% veining consisting of predominantly planar to cuspate-lobate mm to cm scale [Vn1a] and grey calcite [Vn3] (few swarm/network [Vn3]). Localized 300-400 mm pink calcite-bearing [Vn3]. Interval begins with well-mineralized approximately 120 mm [Vn2].



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
80–100		From 94.00 m to 104.52 m: 7-10% veining consisting of predominantly swarm/networked cm and mm scale [Vn3] (veins and veinlets). Few sheeted, brecciated, and boudinaged [Vn1a]/[Vn1b].		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25

Depth scale: 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD

FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
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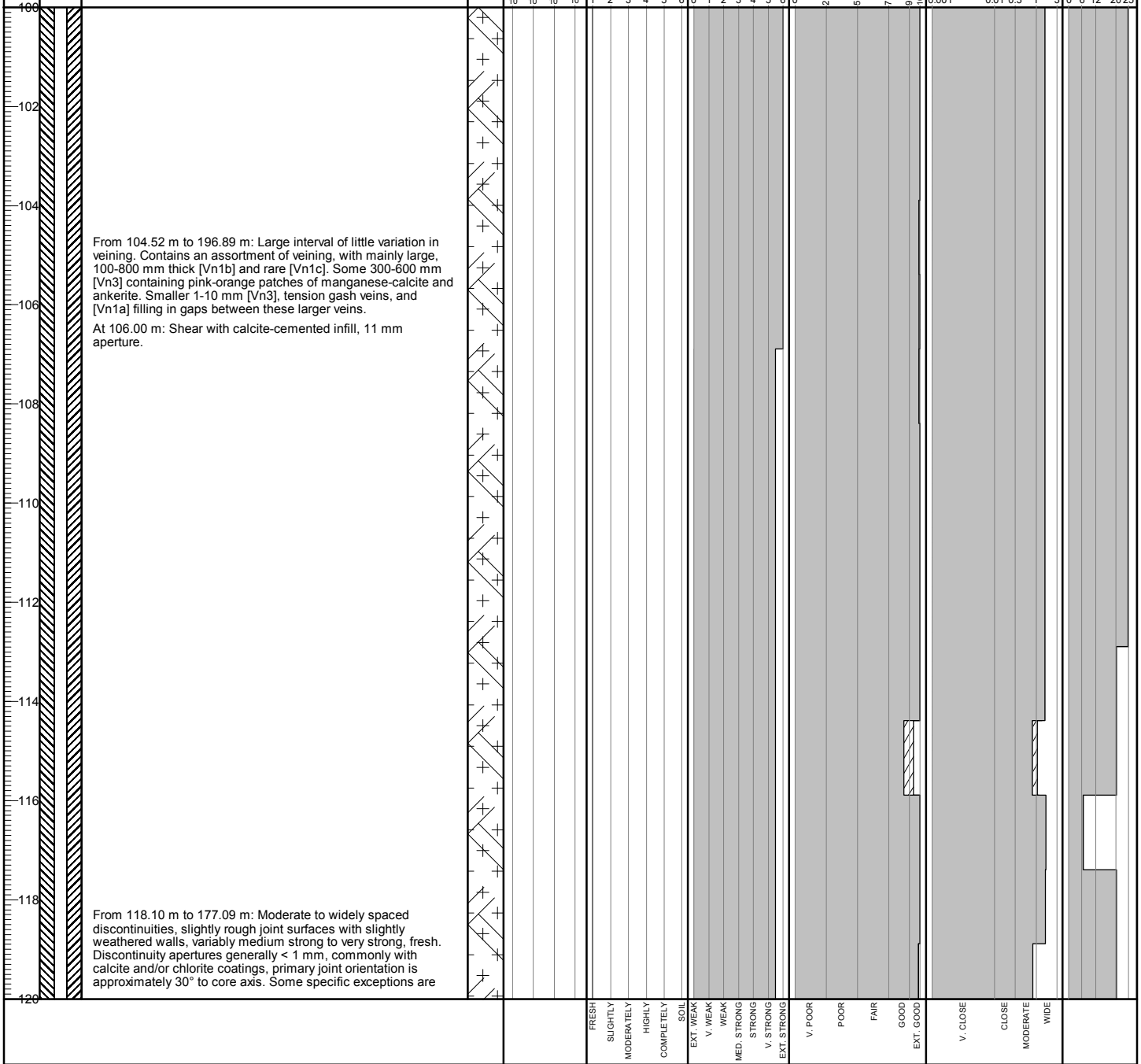
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
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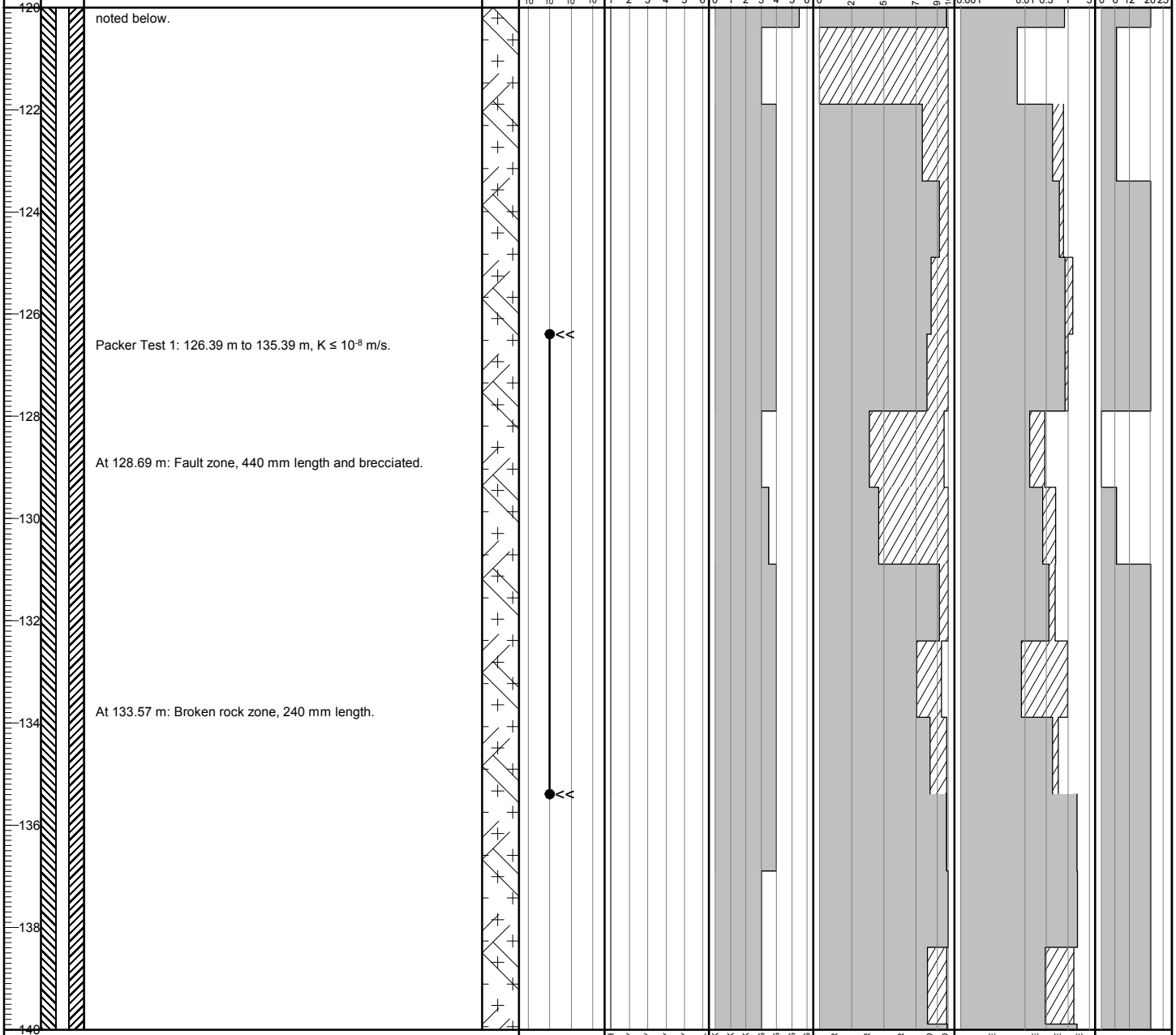
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

noted below.

Packer Test 1: 126.39 m to 135.39 m, K ≤ 10^{-8} m/s.

At 128.69 m: Fault zone, 440 mm length and brecciated.

At 133.57 m: Broken rock zone, 240 mm length.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

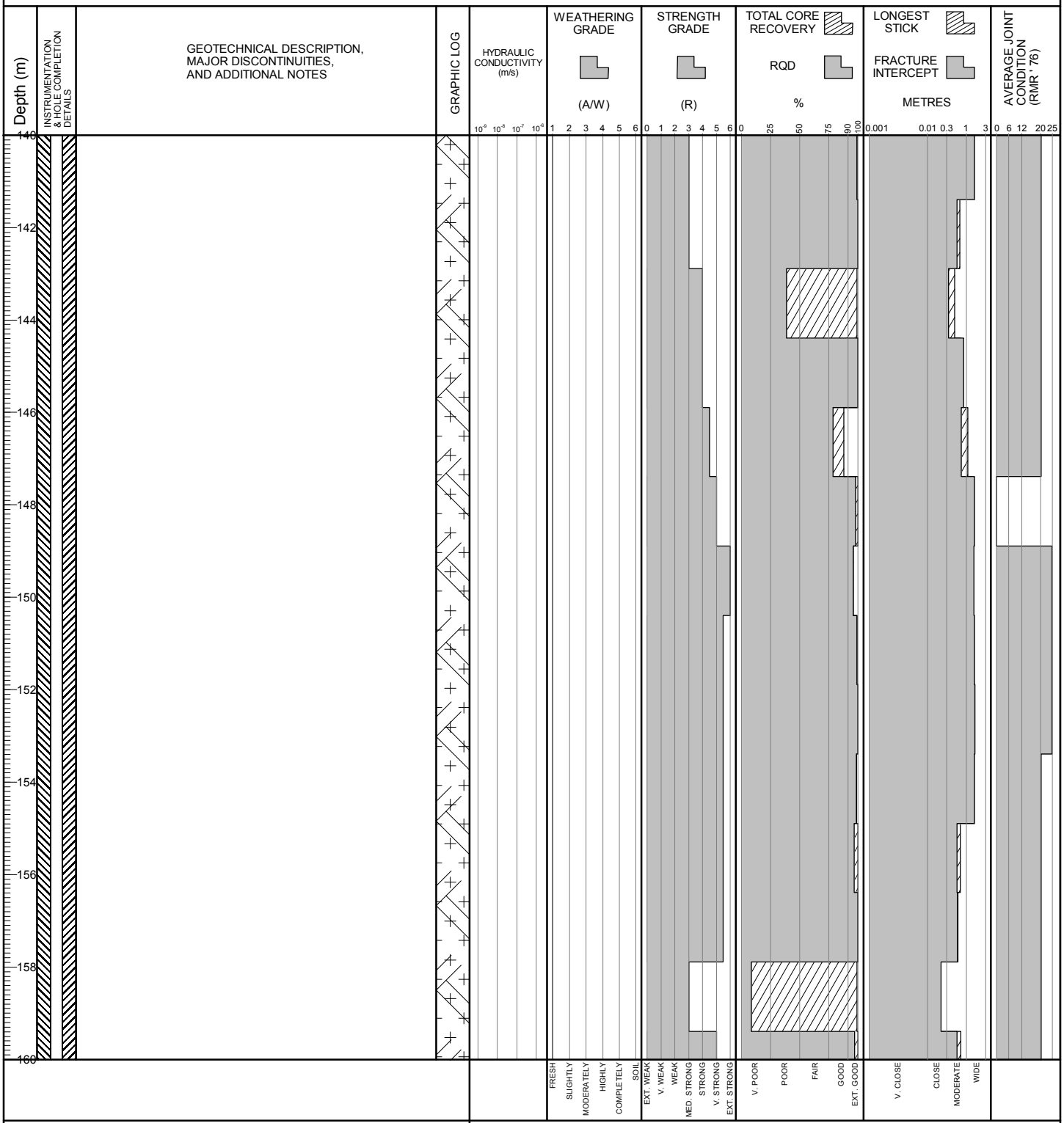
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
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Final Depth (m): 196.89
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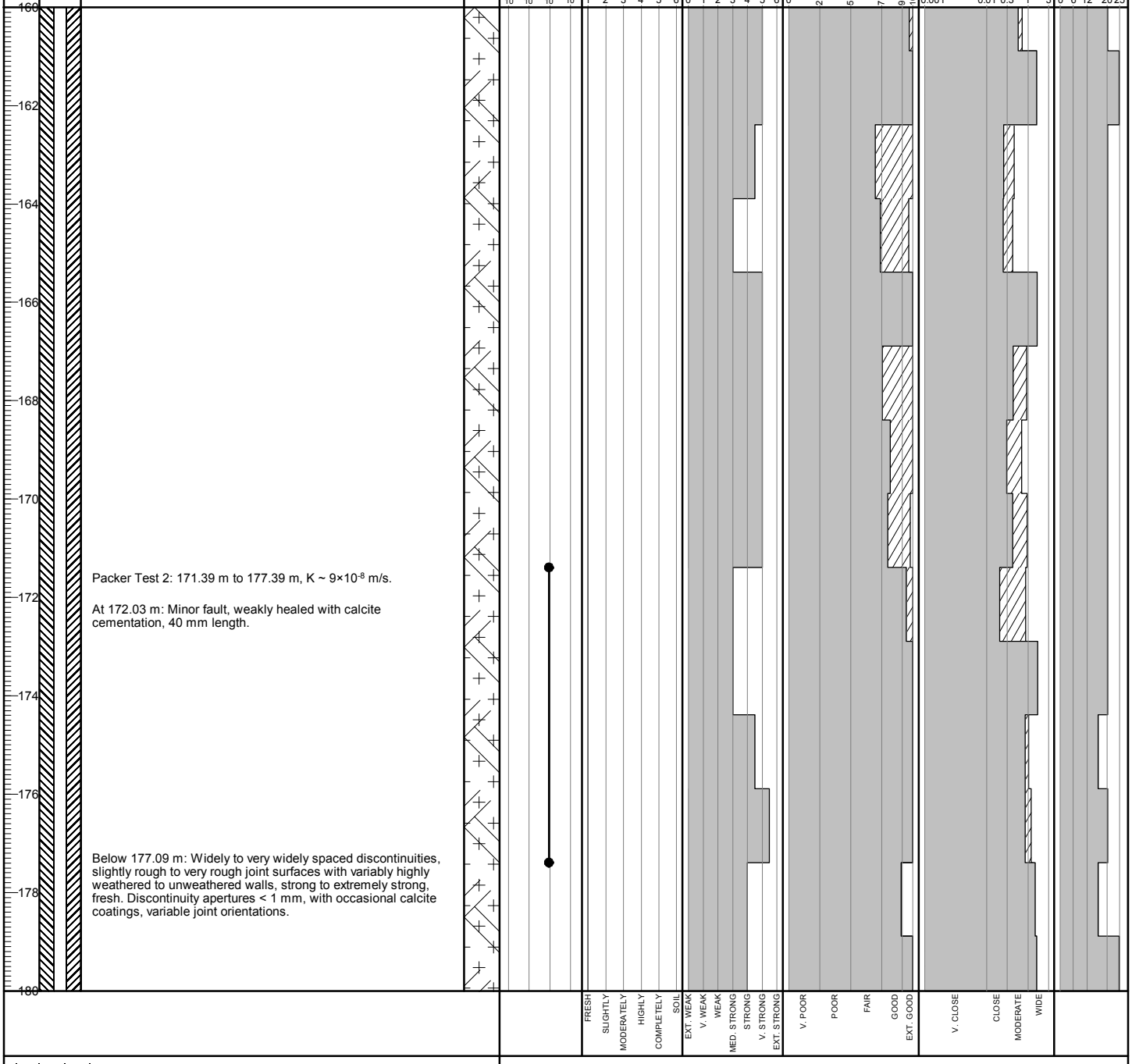
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 2: 171.39 m to 177.39 m, K ~ 9×10^{-8} m/s.

At 172.03 m: Minor fault, weakly healed with calcite cementation, 40 mm length.

Below 177.09 m: Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with variably highly weathered to unweathered walls, strong to extremely strong, fresh. Discontinuity apertures < 1 mm, with occasional calcite coatings, variable joint orientations.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-19A

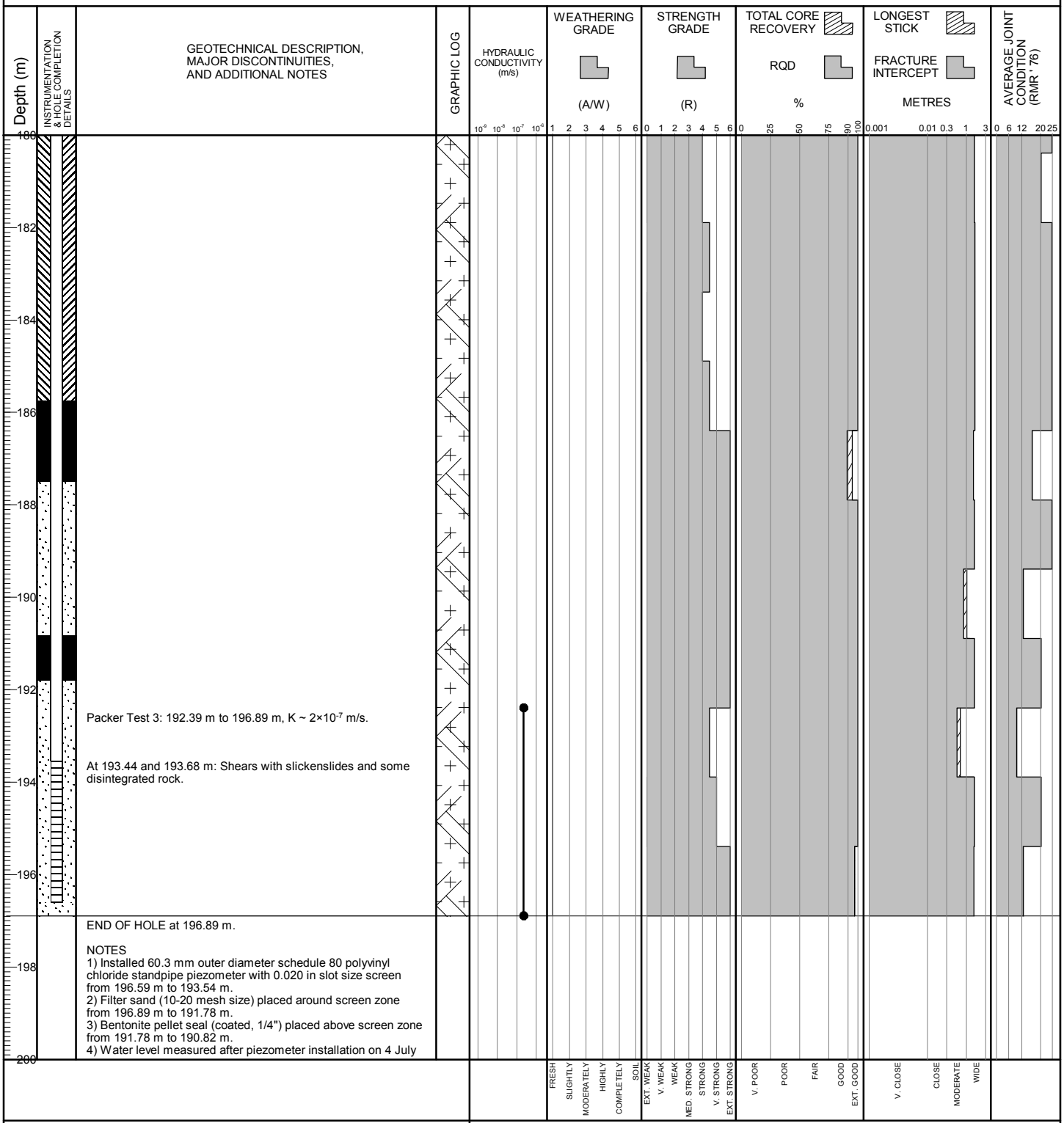
Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19A

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
200		2018 at 124.46 m bgs.							
202									
204									
206									
208									
210									
212									
214									
216									
218									
220									

Scales: HYDRAULIC CONDUCTIVITY 10^{-9} 10^{-8} 10^{-7} 10^{-6}; WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19B

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (0.00 m to 159.54 m)
Grey-green porphyritic unit with 2 mm feldspar laths. Both phenocrysts and groundmass have been altered to sericite. Chlorite and sericite alteration. Variable veining structures.

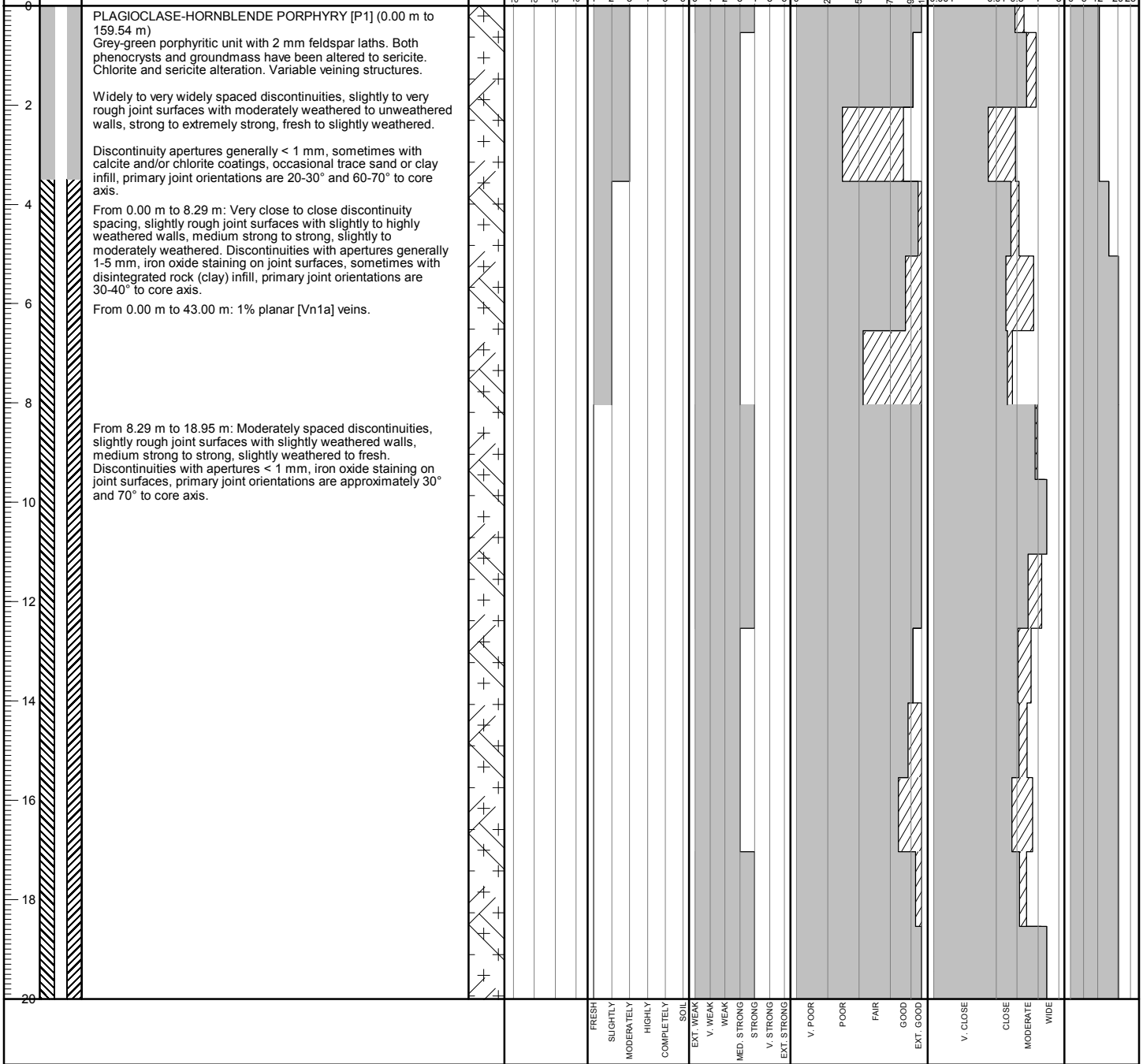
Widely to very widely spaced discontinuities, slightly to very rough joint surfaces with moderately weathered to unweathered walls, strong to extremely strong, fresh to slightly weathered.

Discontinuity apertures generally < 1 mm, sometimes with calcite and/or chlorite coatings, occasional trace sand or clay infill, primary joint orientations are 20-30° and 60-70° to core axis.

From 0.00 m to 8.29 m: Very close to close discontinuity spacing, slightly rough joint surfaces with slightly to highly weathered walls, medium strong to strong, slightly to moderately weathered. Discontinuities with apertures generally 1-5 mm, iron oxide staining on joint surfaces, sometimes with disintegrated rock (clay) infill, primary joint orientations are 30-40° to core axis.

From 0.00 m to 43.00 m: 1% planar [Vn1a] veins.

From 8.29 m to 18.95 m: Moderately spaced discontinuities, slightly rough joint surfaces with slightly weathered walls, medium strong to strong, slightly weathered to fresh. Discontinuities with apertures < 1 mm, iron oxide staining on joint surfaces, primary joint orientations are approximately 30° and 70° to core axis.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19B

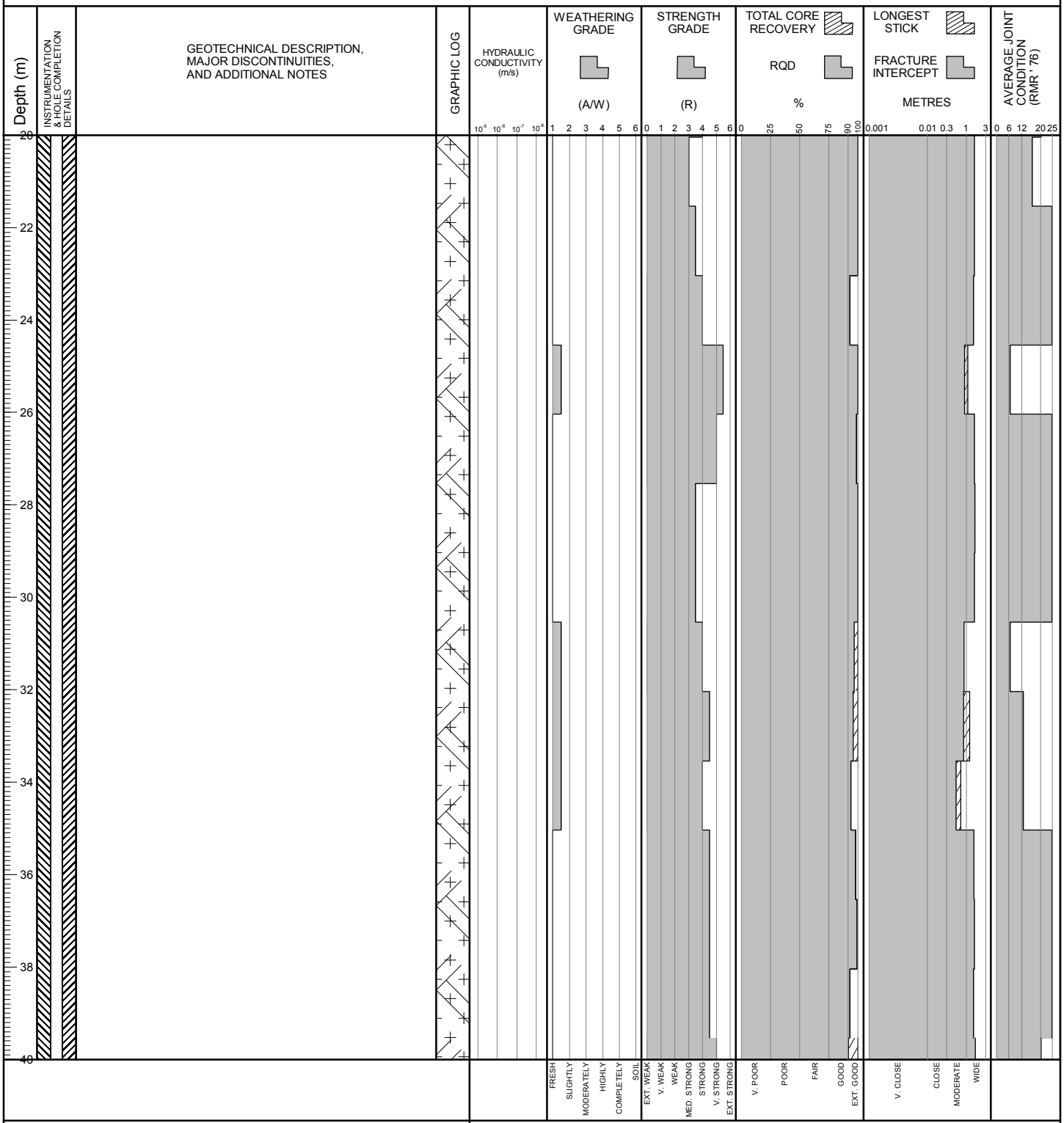
Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-19B

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
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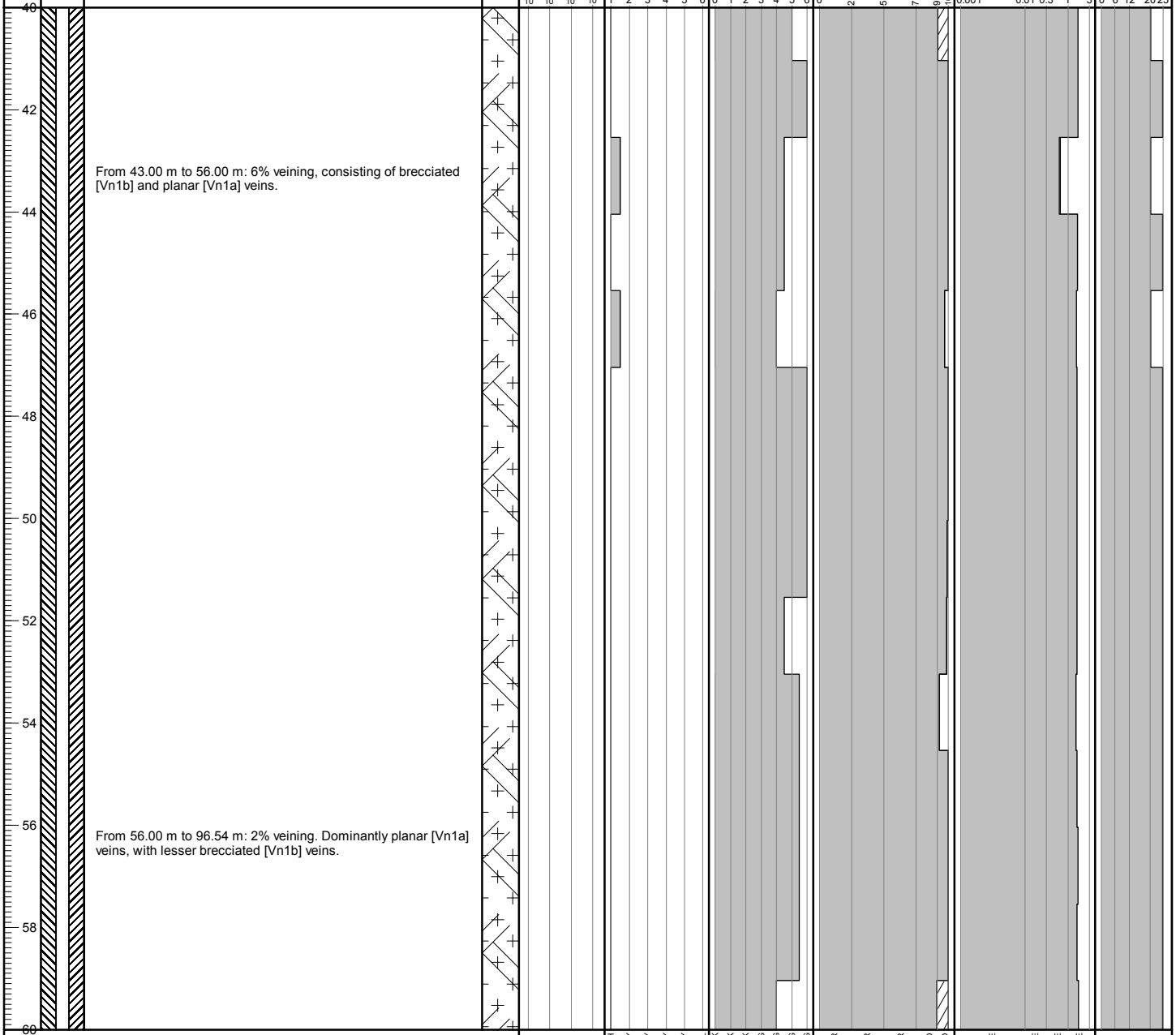
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 43.00 m to 56.00 m: 6% veining, consisting of brecciated [Vn1b] and planar [Vn1a] veins.

From 56.00 m to 96.54 m: 2% veining. Dominantly planar [Vn1a] veins, with lesser brecciated [Vn1b] veins.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
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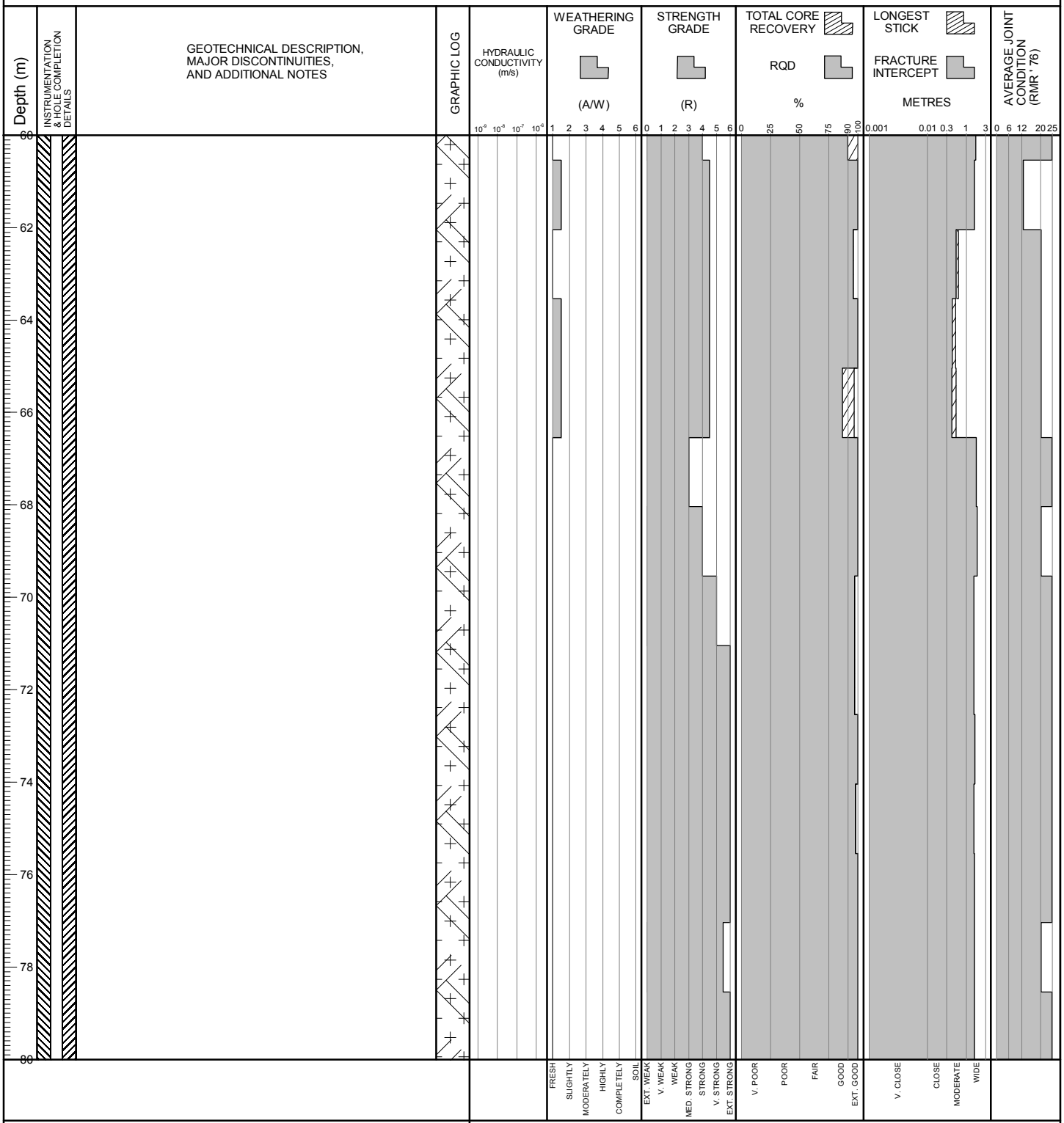
Logged By: HM/LS
Reviewed By: HP



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

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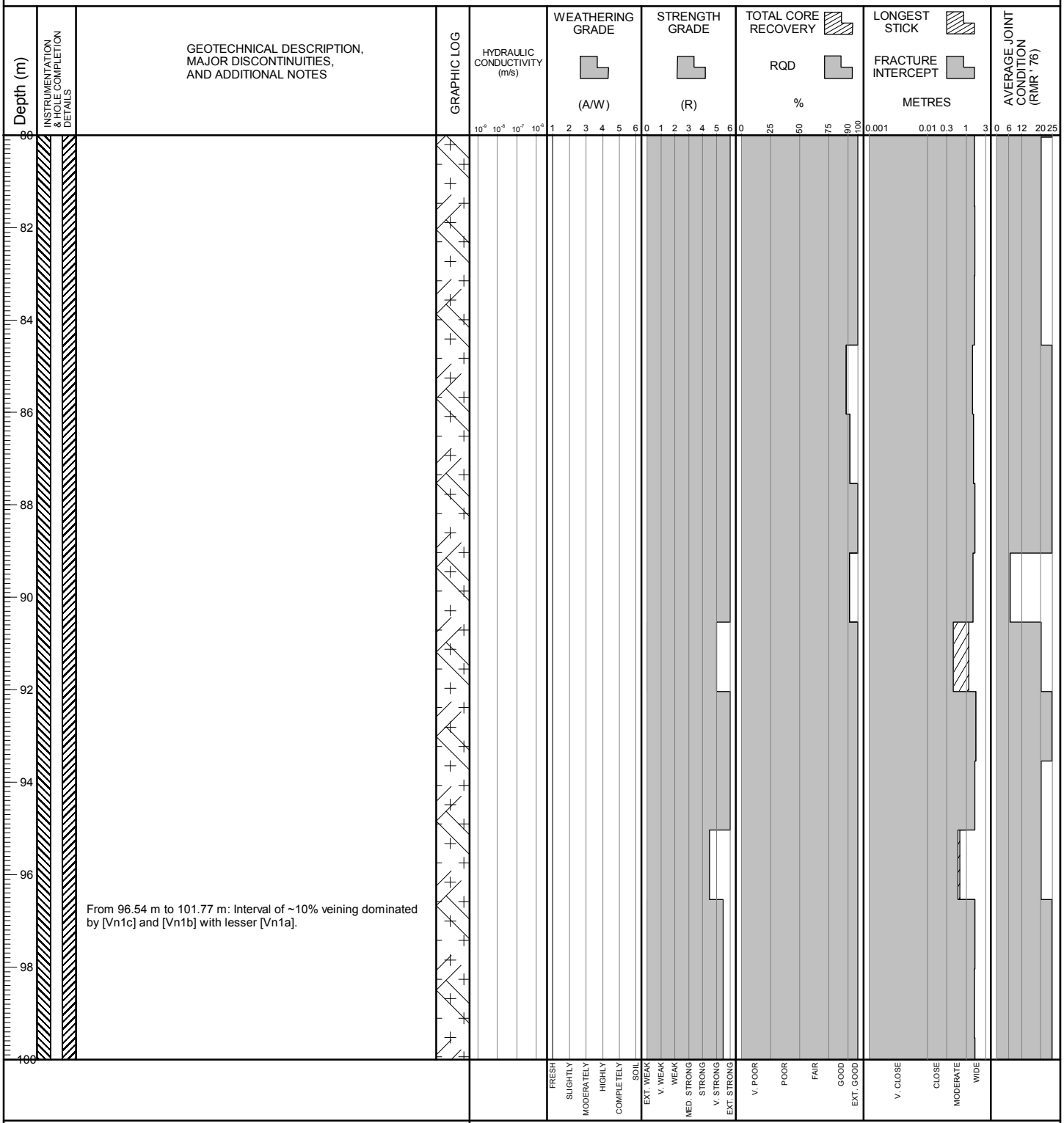
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

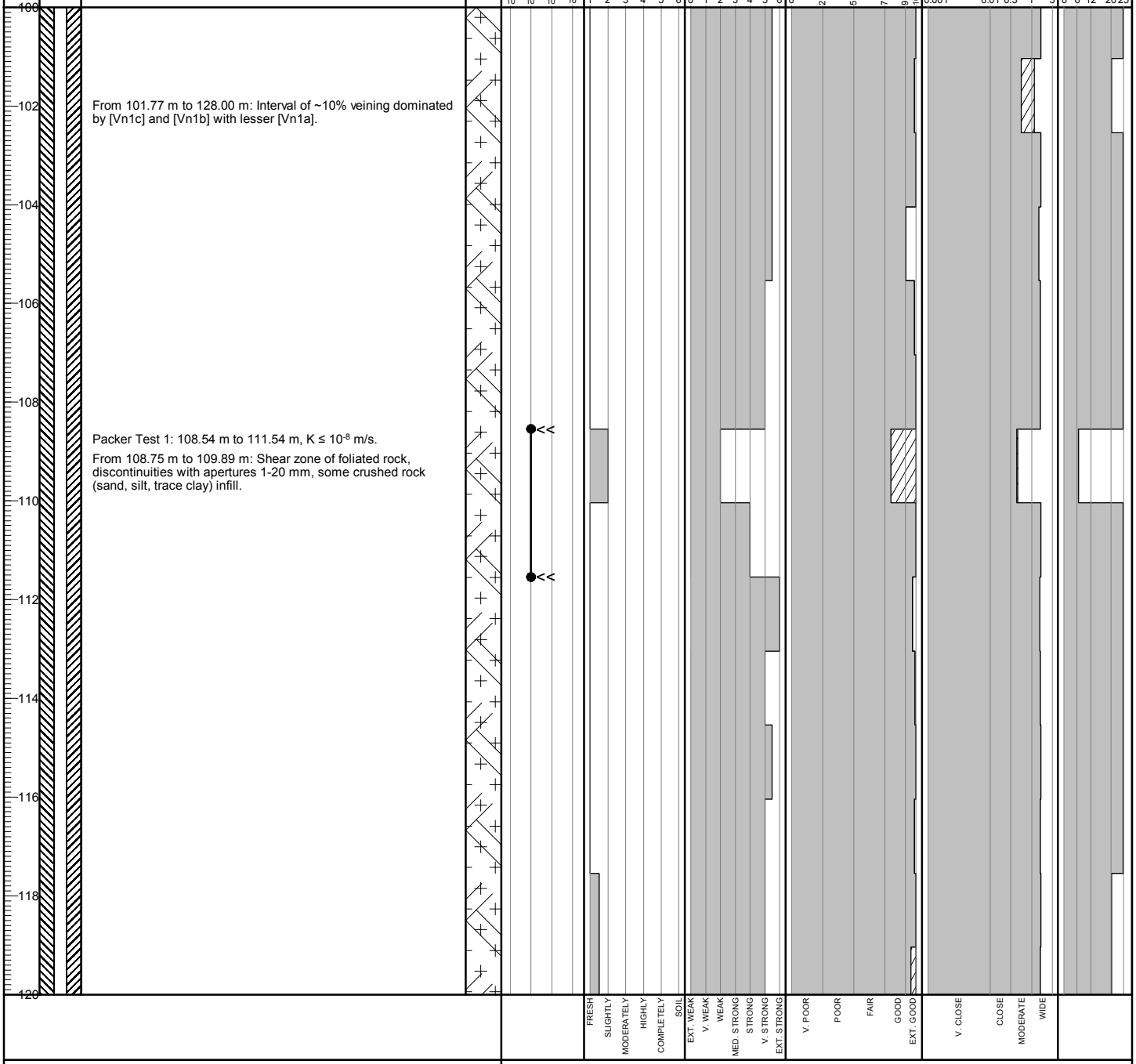
Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

From 101.77 m to 128.00 m: Interval of ~10% veining dominated by [Vn1c] and [Vn1b] with lesser [Vn1a].

Packer Test 1: 108.54 m to 111.54 m, K ≤ 10^{-8} m/s.

From 108.75 m to 109.89 m: Shear zone of foliated rock, discontinuities with apertures 1-20 mm, some crushed rock (sand, silt, trace clay) infill.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

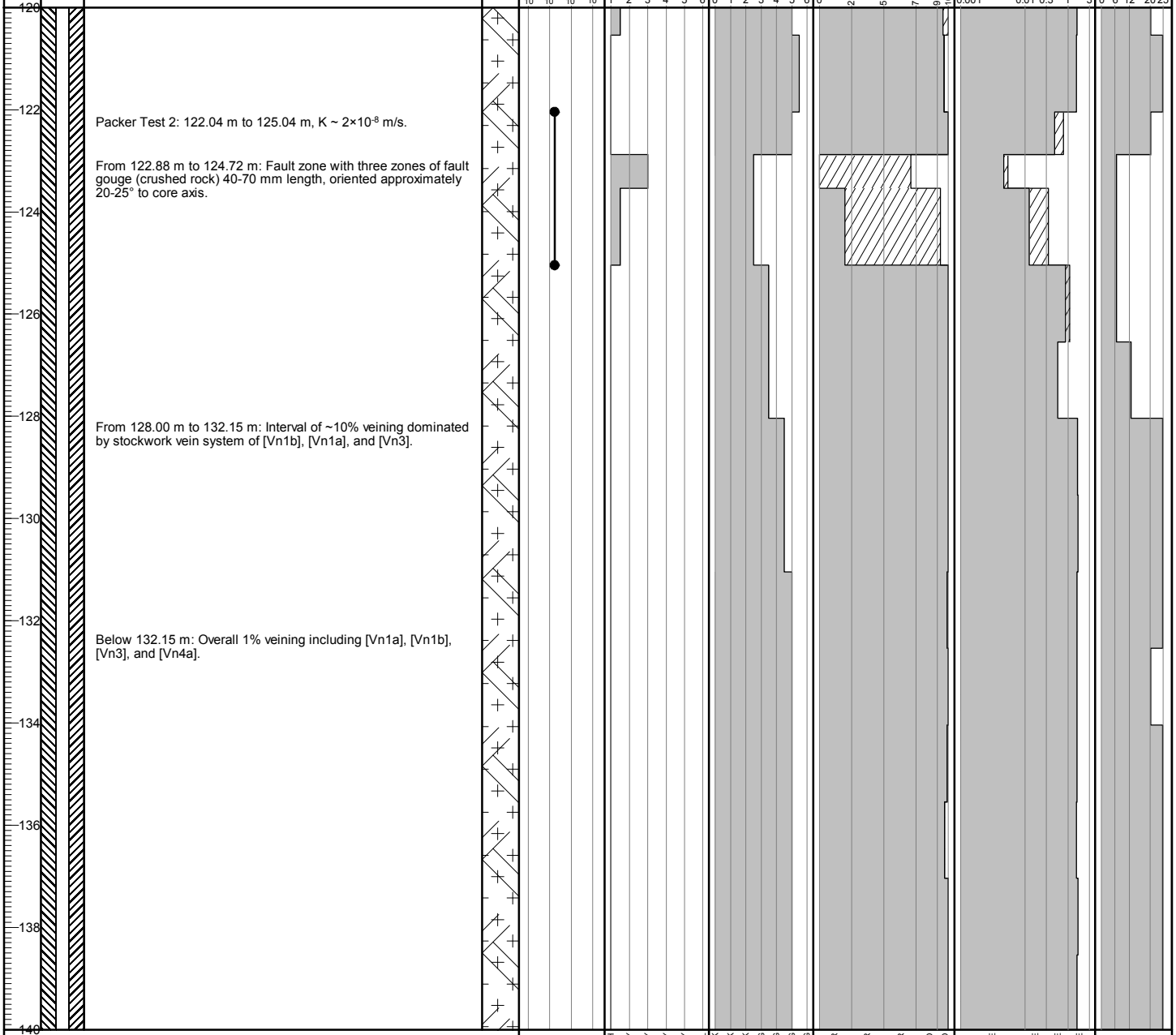
Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
122	Packer Test 2: 122.04 m to 125.04 m, K ~ 2×10^{-8} m/s.
124	From 122.88 m to 124.72 m: Fault zone with three zones of fault gouge (crushed rock) 40-70 mm length, oriented approximately 20-25° to core axis.
128	From 128.00 m to 132.15 m: Interval of ~10% veining dominated by stockwork vein system of [Vn1b], [Vn1a], and [Vn3].
132	Below 132.15 m: Overall 1% veining including [Vn1a], [Vn1b], [Vn3], and [Vn4a].



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19B

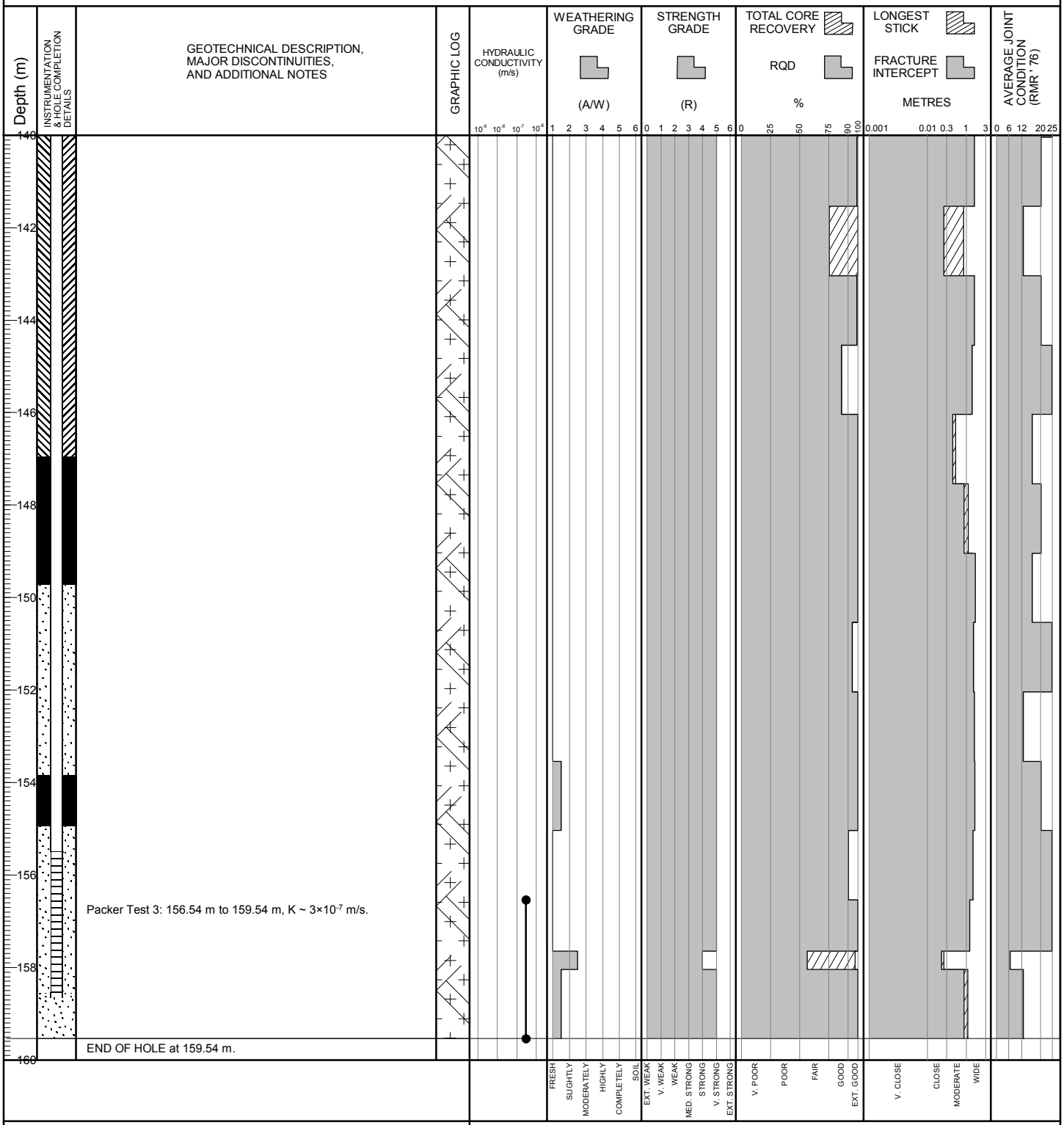
Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
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Final Depth (m): 159.54
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Logged By: HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
160		NOTES 1) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 158.54 m to 155.49 m. 2) Filter sand (10-20 mesh size) placed around screen zone from 159.54 m to 154.92 m. 3) Bentonite pellet seal (coated, 1/4") placed above screen zone from 154.92 m to 153.84 m. 4) Water level measured after piezometer installation on 4 July 2018 at 105.10 m bgs.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
162									
164									
166									
168									
170									
172									
174									
176									
178									
180					FRESH SLIGHTLY MODERATELY HIGHLY COMPLETELY SOIL	EXT. WEAK V. WEAK WEAK MED. STRONG STRONG V. STRONG EXT. STRONG	V. POOR POOR FAIR GOOD EXT. GOOD	V. CLOSE CLOSE MODERATE WIDE	

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

OVERBURDEN (0.00 m to 1.16 m)

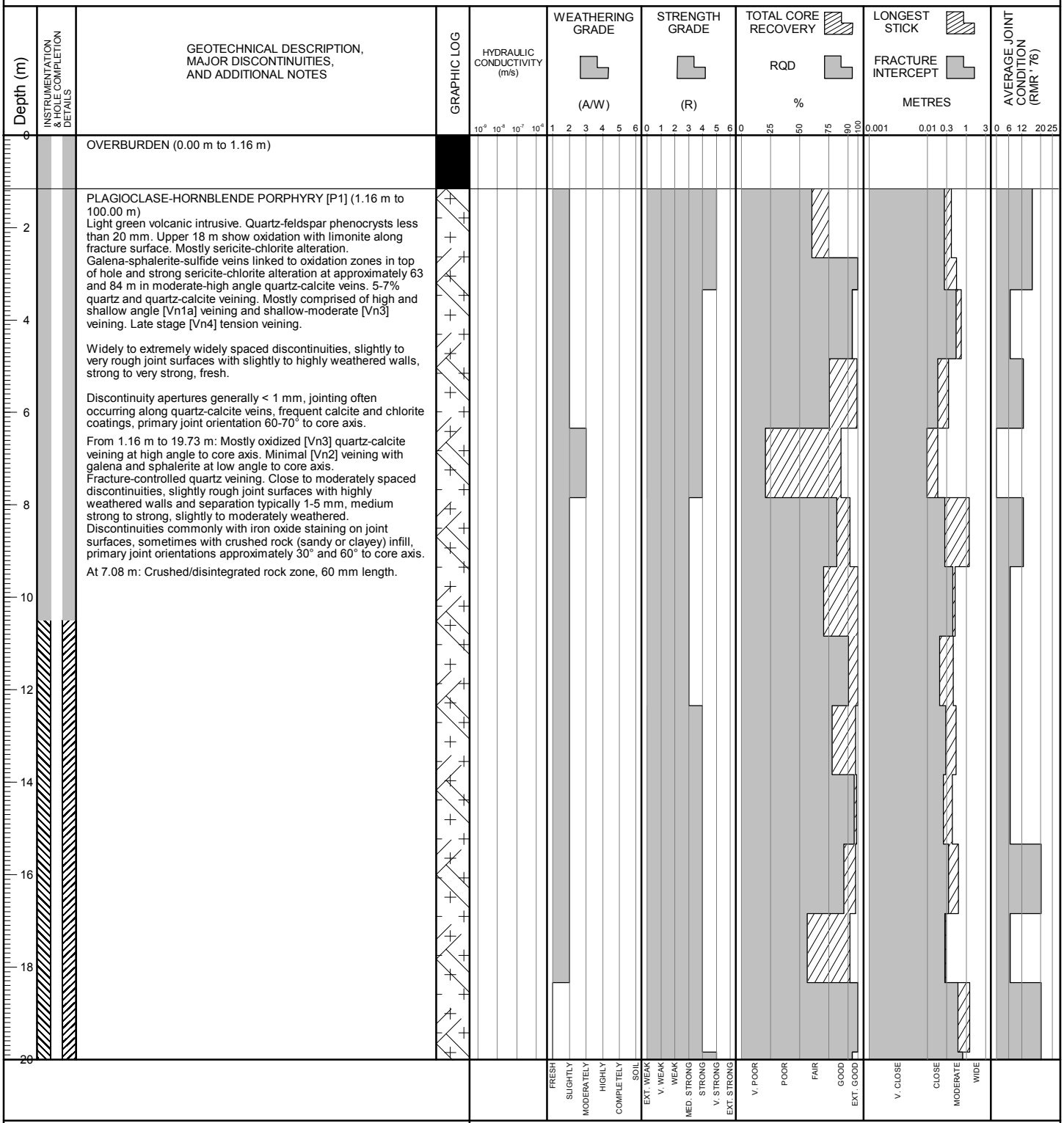
PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (1.16 m to 100.00 m)
Light green volcanic intrusive. Quartz-feldspar phenocrysts less than 20 mm. Upper 18 m show oxidation with limonite along fracture surface. Mostly sericite-chlorite alteration. Galena-sphalerite-sulfide veins linked to oxidation zones in top of hole and strong sericite-chlorite alteration at approximately 63 and 84 m in moderate-high angle quartz-calcite veins. 5-7% quartz and quartz-calcite veining. Mostly comprised of high and shallow angle [Vn1a] veining and shallow-moderate [Vn3] veining. Late stage [Vn4] tension veining.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with slightly to highly weathered walls, strong to very strong, fresh.

Discontinuity apertures generally < 1 mm, jointing often occurring along quartz-calcite veins, frequent calcite and chlorite coatings, primary joint orientation 60-70° to core axis.

From 1.16 m to 19.73 m: Mostly oxidized [Vn3] quartz-calcite veining at high angle to core axis. Minimal [Vn2] veining with galena and sphalerite at low angle to core axis.
Fracture-controlled quartz veining. Close to moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation typically 1-5 mm, medium strong to strong, slightly to moderately weathered. Discontinuities commonly with iron oxide staining on joint surfaces, sometimes with crushed rock (sandy or clayey) infill, primary joint orientations approximately 30° and 60° to core axis.

At 7.08 m: Crushed/disintegrated rock zone, 60 mm length.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
20	From 19.73 m to 42.46 m: Moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, strong, fresh. Discontinuity apertures generally < 2 mm, with calcite coatings, occasional iron oxide staining on joint surfaces, variable joint orientations.
22	
24	At 24.49 m: 100 mm shear zone.
26	
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32	
34	
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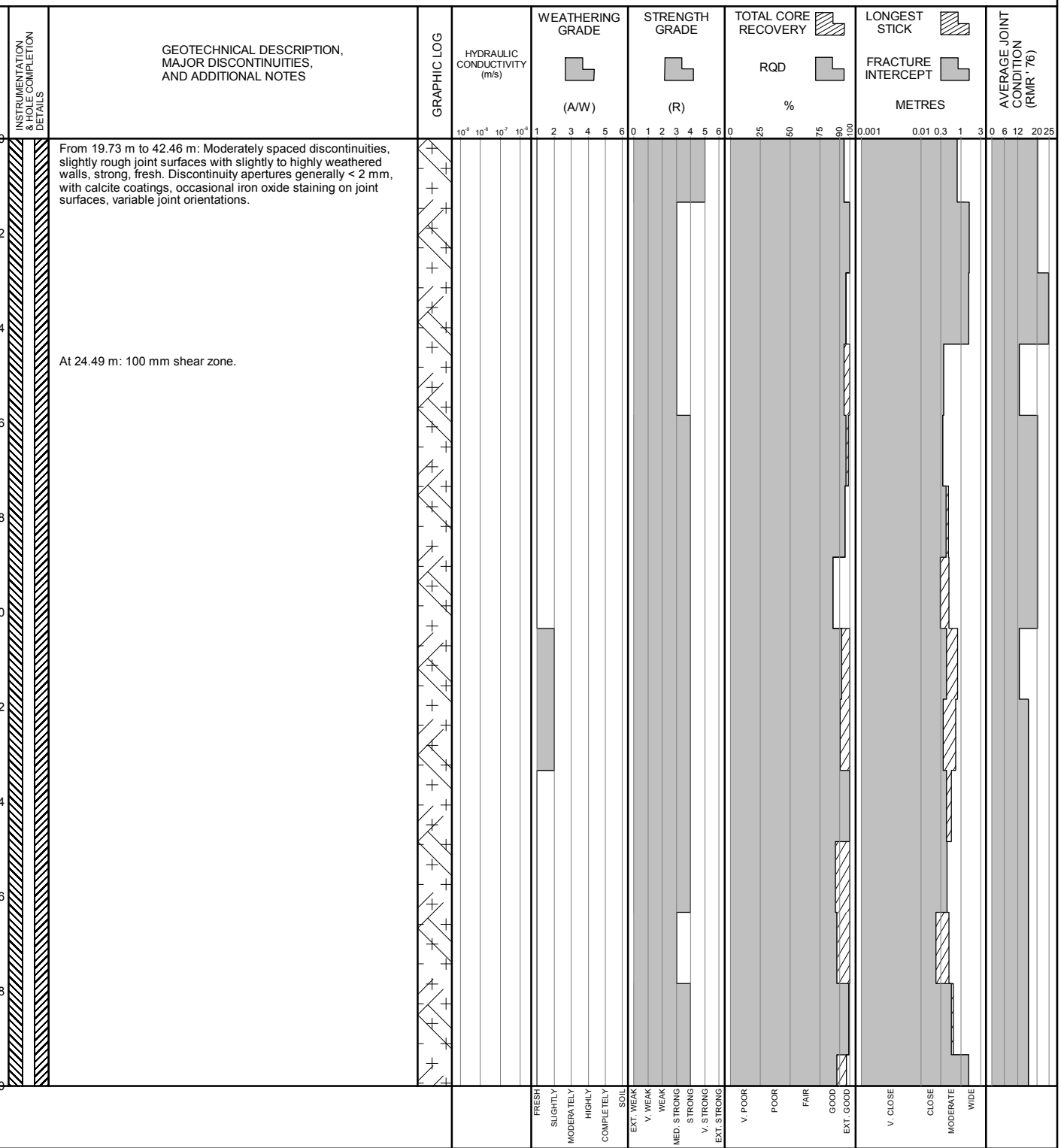
38	
40	



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
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BGC ENGINEERING INC.
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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

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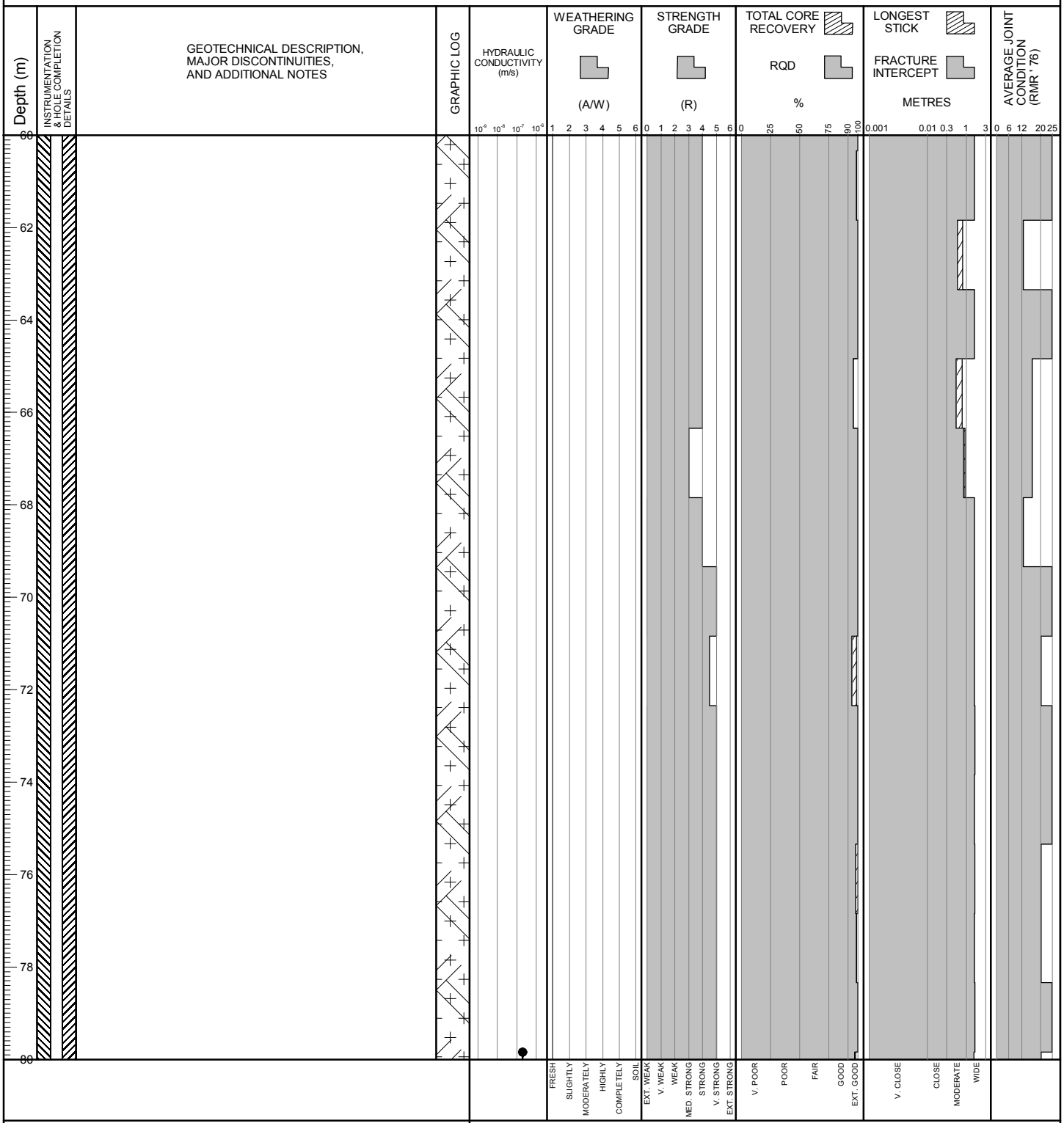

BGC ENGINEERING INC.
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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

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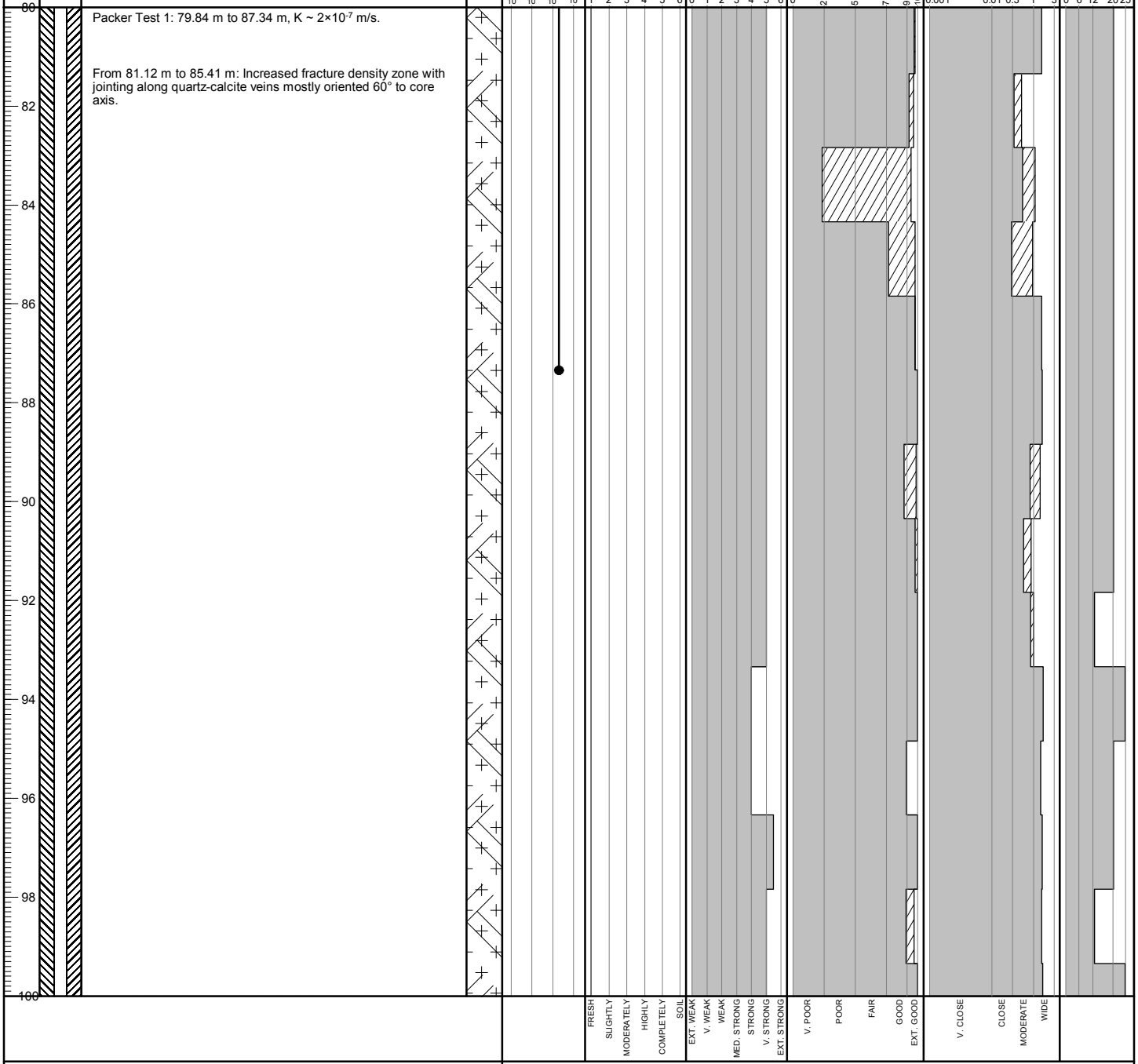
Packer Test 1: 79.84 m to 87.34 m, K ~ 2×10^{-7} m/s.

From 81.12 m to 85.41 m: Increased fracture density zone with jointing along quartz-calcite veins mostly oriented 60° to core axis.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

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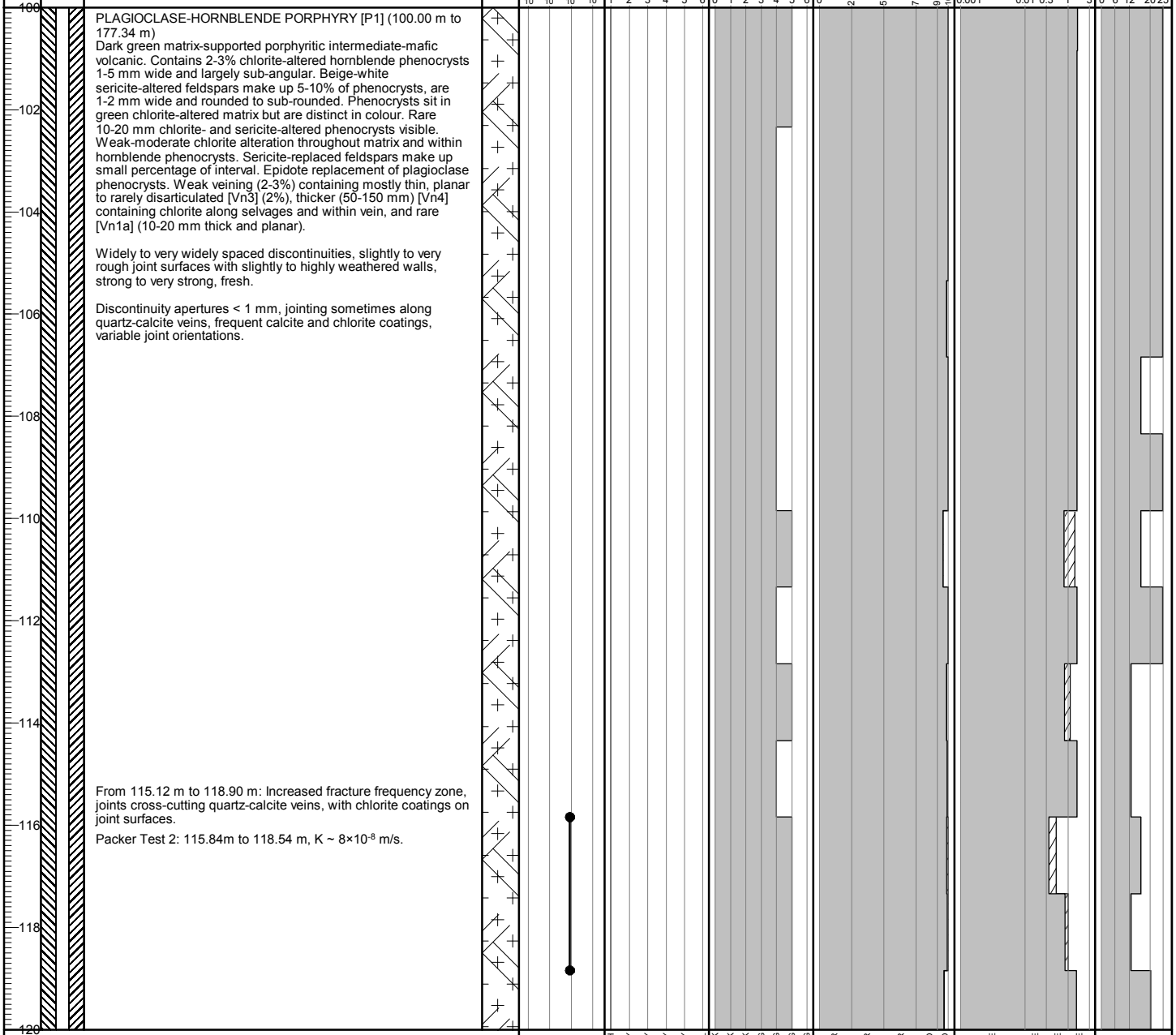
PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (100.00 m to 177.34 m)
Dark green matrix-supported porphyritic intermediate-mafic volcanic. Contains 2-3% chlorite-altered hornblende phenocrysts 1-5 mm wide and largely sub-angular. Beige-white sericite-altered feldspars make up 5-10% of phenocrysts, are 1-2 mm wide and rounded to sub-rounded. Phenocrysts sit in green chlorite-altered matrix but are distinct in colour. Rare 10-20 mm chlorite- and sericite-altered phenocrysts visible. Weak-moderate chlorite alteration throughout matrix and within hornblende phenocrysts. Sericite-replaced feldspars make up small percentage of interval. Epidote replacement of plagioclase phenocrysts. Weak veining (2-3%) containing mostly thin, planar to rarely disarticulated [Vn3] (2%), thicker (50-150 mm) [Vn4] containing chlorite along selvages and within vein, and rare [Vn1a] (10-20 mm thick and planar).

Widely to very widely spaced discontinuities, slightly to very rough joint surfaces with slightly to highly weathered walls, strong to very strong, fresh.

Discontinuity apertures < 1 mm, jointing sometimes along quartz-calcite veins, frequent calcite and chlorite coatings, variable joint orientations.

From 115.12 m to 118.90 m: Increased fracture frequency zone, joints cross-cutting quartz-calcite veins, with chlorite coatings on joint surfaces.

Packer Test 2: 115.84m to 118.54 m, K ~ 8×10^{-8} m/s.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
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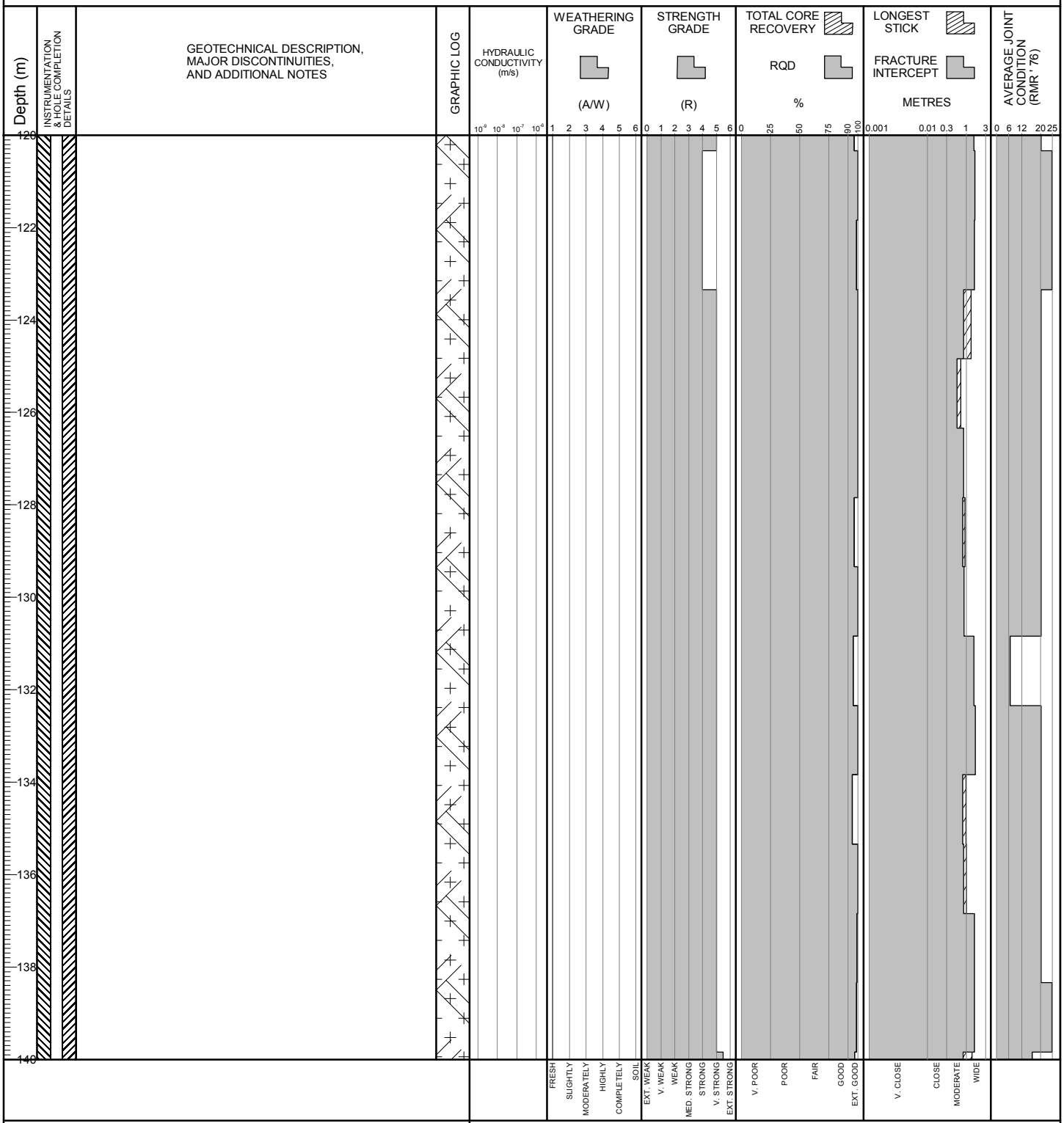

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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

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Datum: UTM NAD 83 Zone 9
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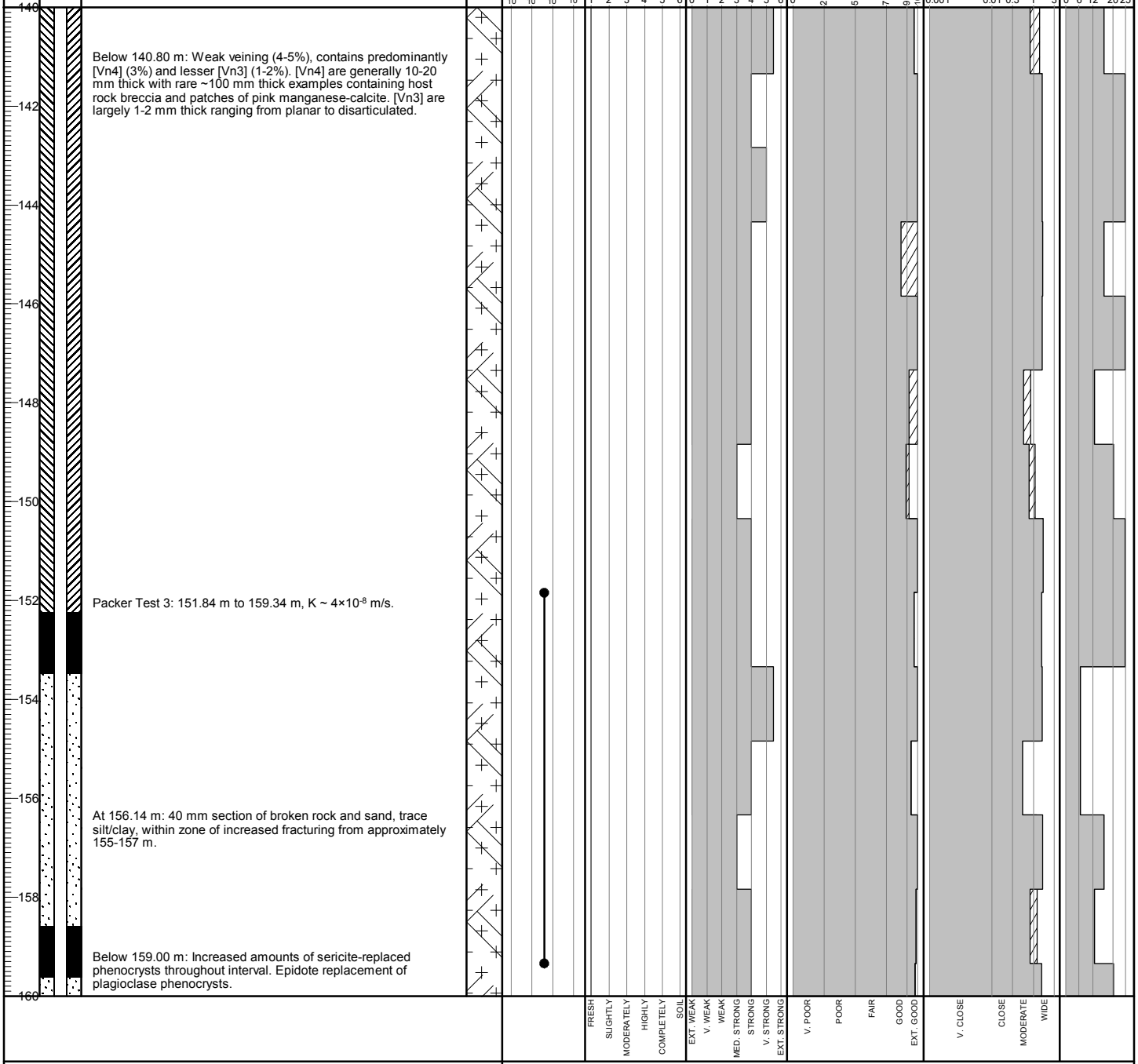
140
142
144
146
148
150
152
154
156
158
160

Below 140.80 m: Weak veining (4-5%), contains predominantly [Vn4] (3%) and lesser [Vn3] (1-2%). [Vn4] are generally 10-20 mm thick with rare ~100 mm thick examples containing host rock breccia and patches of pink manganese-calcite. [Vn3] are largely 1-2 mm thick ranging from planar to disarticulated.

Packer Test 3: 151.84 m to 159.34 m, K ~ 4×10^{-8} m/s.

At 156.14 m: 40 mm section of broken rock and sand, trace silt/clay, within zone of increased fracturing from approximately 155-157 m.

Below 159.00 m: Increased amounts of sericite-replaced phenocrysts throughout interval. Epidote replacement of plagioclase phenocrysts.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

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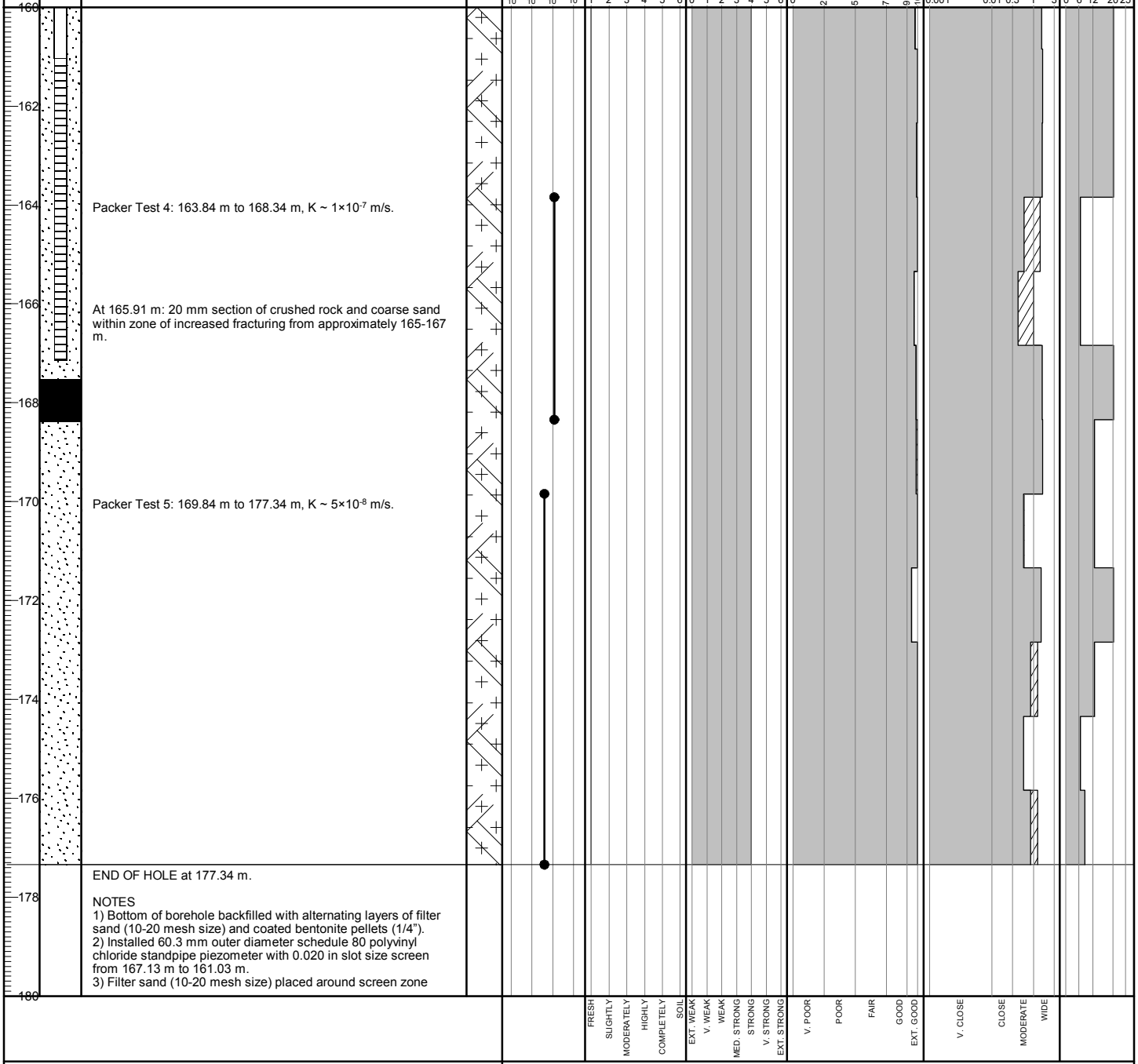
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD %	LONGEST STICK METRES / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
180		from 167.53 m to 159.62 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 159.62 m to 158.59 m. 5) Water level measured after piezometer installation on 4 July 2018 at 57.85 m bgs.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
182									
184									
186									
188									
190									
192									
194									
196									
198									
200					FRESH SLIGHTLY MODERATELY HIGHLY COMPLETELY SOIL	EXT. WEAK V. WEAK WEAK MED. STRONG STRONG V. STRONG EXT. STRONG	V. POOR POOR FAIR GOOD EXT. GOOD	V. CLOSE CLOSE MODERATE WIDE	

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
0		OVERBURDEN (0.00 m to 0.61 m)
0.61 – 20		PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (0.61 m to 120.34 m) Green porphyritic volcanic/intrusive. Predominantly comprised of subhedral, sericite-altered plagioclase phenocrysts ranging from 5-25%, with minor specks of dark mafic phenocrysts throughout a green, fine-grained matrix. Weak alignment of phenocrysts. Rare mafic fragments. Moderate pervasive chlorite replacement with isolated intervals of strong pervasive quartz-sericite-pyrite alteration. Moderate pervasive chlorite alteration throughout with strong sericite replacement of phenocrysts. Interval of moderate 4-5% quartz-calcite veining. Dominantly comprised of planar to undulatory [Vn1a] and grey-calcite [Vn3] veins typically oriented at a shallow angle to the core axis. Moderate [Vn4] tension gash style veins crosscut these veins and are oriented at a high angle to the core axis. Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with variably highly weathered to unweathered walls, generally strong to very strong, fresh. Discontinuity apertures typically < 1 mm, frequently with calcite and/or chlorite coatings, primary joint orientation approximately 40° to core axis. From 0.61 m to 17.25 m: Strong fracture-controlled orange oxidation and earthy orange goethite/limonite replacement in veins. Strong pervasive quartz-sericite-pyrite alteration. Interval of strong 10% quartz-base metal sulfide veining in highly fractured and oxidized zone. Dominantly comprised of strongly mineralized and sheeted [Vn2] base metal sulfide veins that are marginal to faults. [Vn1a] and overprinting [Vn3] grey-calcite networks/stockworks that are often fracture controlled. Veins often display vuggy textures that are replaced by orange earthy iron oxides (goethite/limonite). Lesser [Vn4] veins. Close to moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered wall rock, strong, slightly weathered. Discontinuity apertures typically 1-10 mm, common iron oxide staining on joint surfaces, some broken and crushed rock infill in larger aperture discontinuities, some chlorite coatings, variable joint orientations. From 5.09 m to 6.22 m: Strongly developed fault zone characterized by strongly oxidized surfaces, iron oxide replacement and quartz-base metal sulfide veining. Subsidiary fracture networks are common. Sections 10-60 mm length of fault gouge (broken/crushed rock, clayey), oriented approximately 30° to core axis. From 17.25 m to 40.51 m: Moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, strong, fresh. Discontinuity apertures approximately < 2 mm, frequent calcite and occasional chlorite coatings, occasional iron oxide staining on joint surfaces, variable joint orientations.

Graphic log

Hydraulic conductivity (m/s): 10^{-9} 10^{-8} 10^{-7} 10^{-6}

Weathering grade (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL

Strength grade (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG

Total core recovery / RQD (%): 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

Longest stick / Fracture intercept (metres): 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE

Average joint condition (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

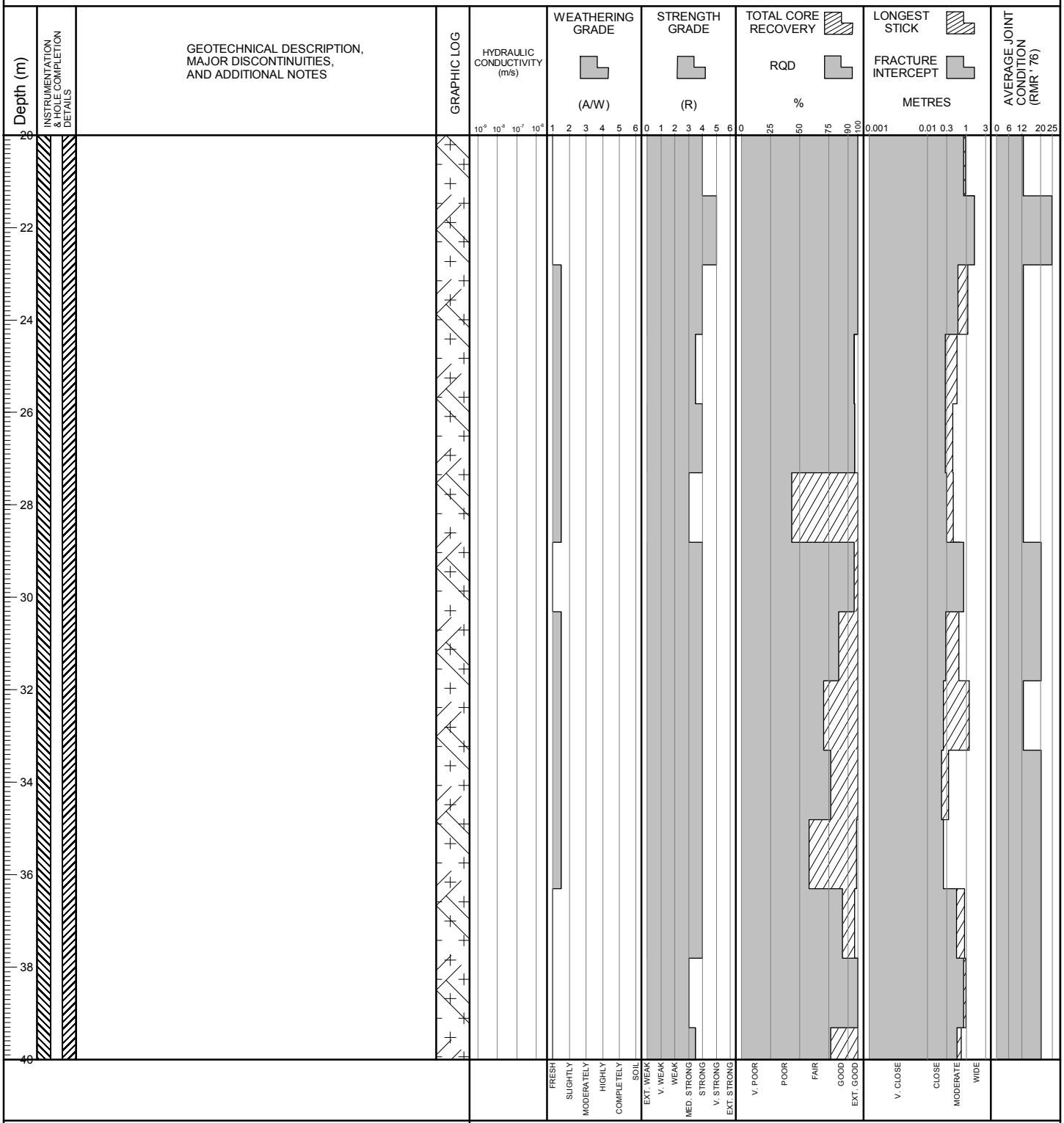
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

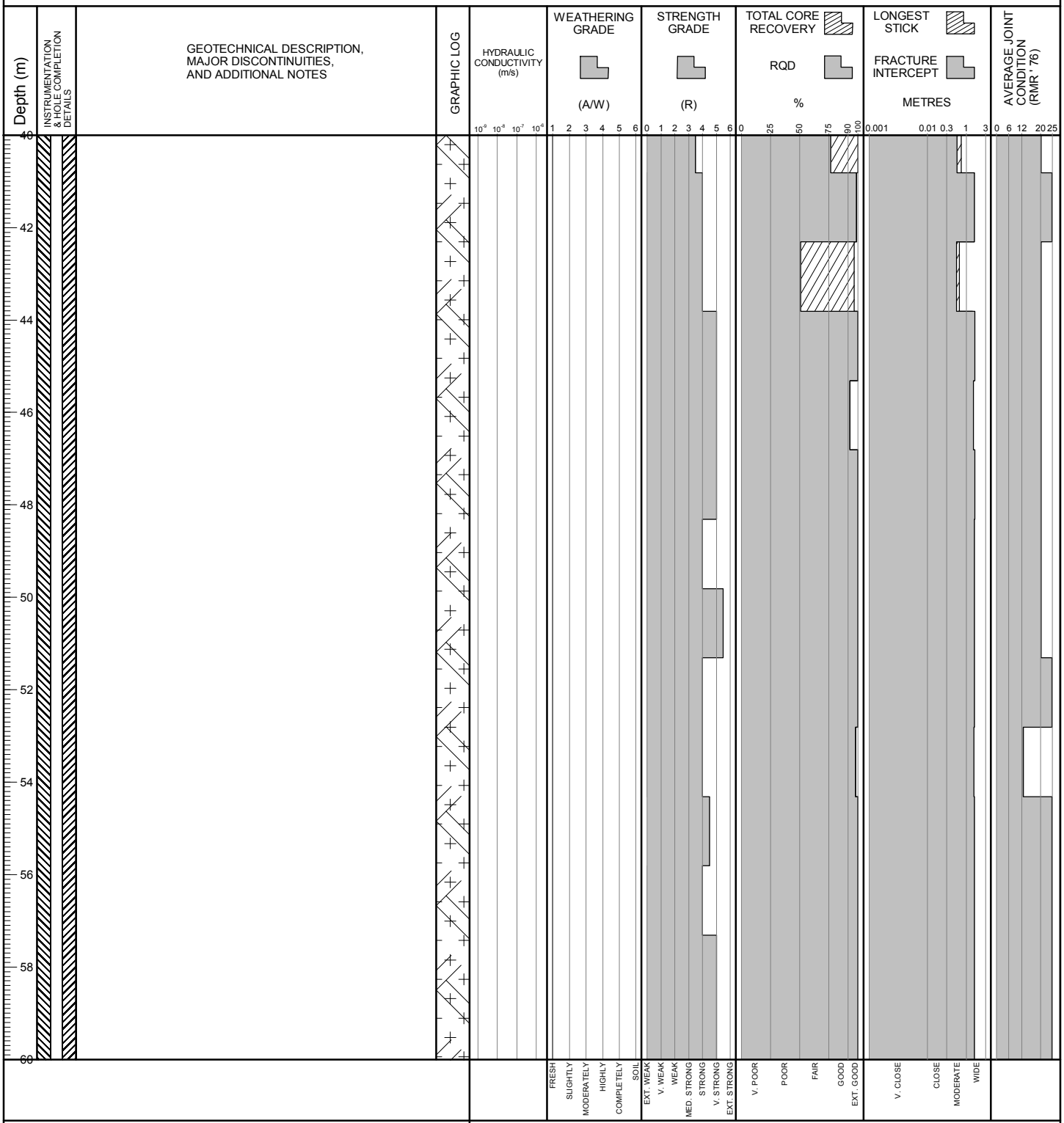
Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



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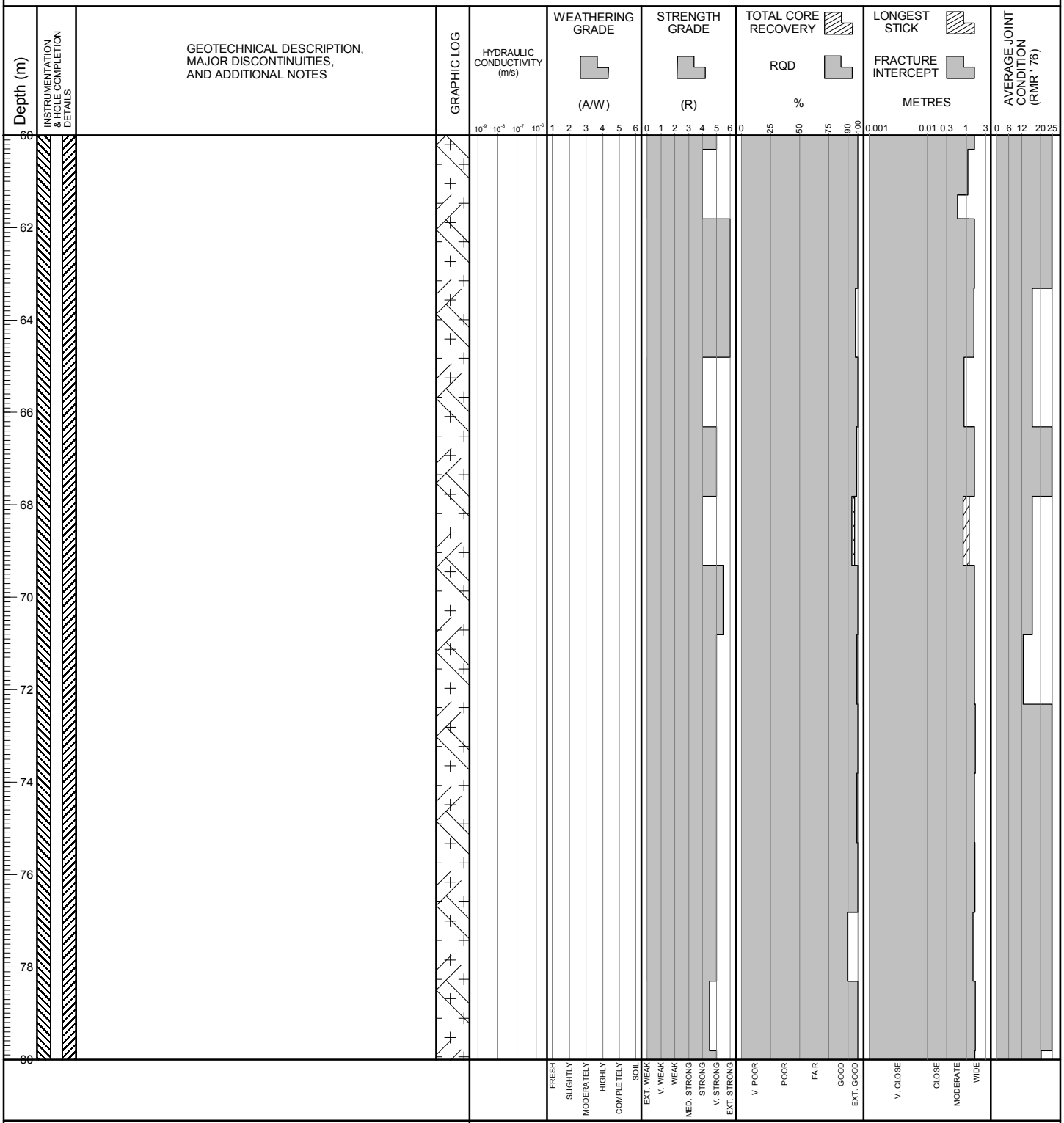
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

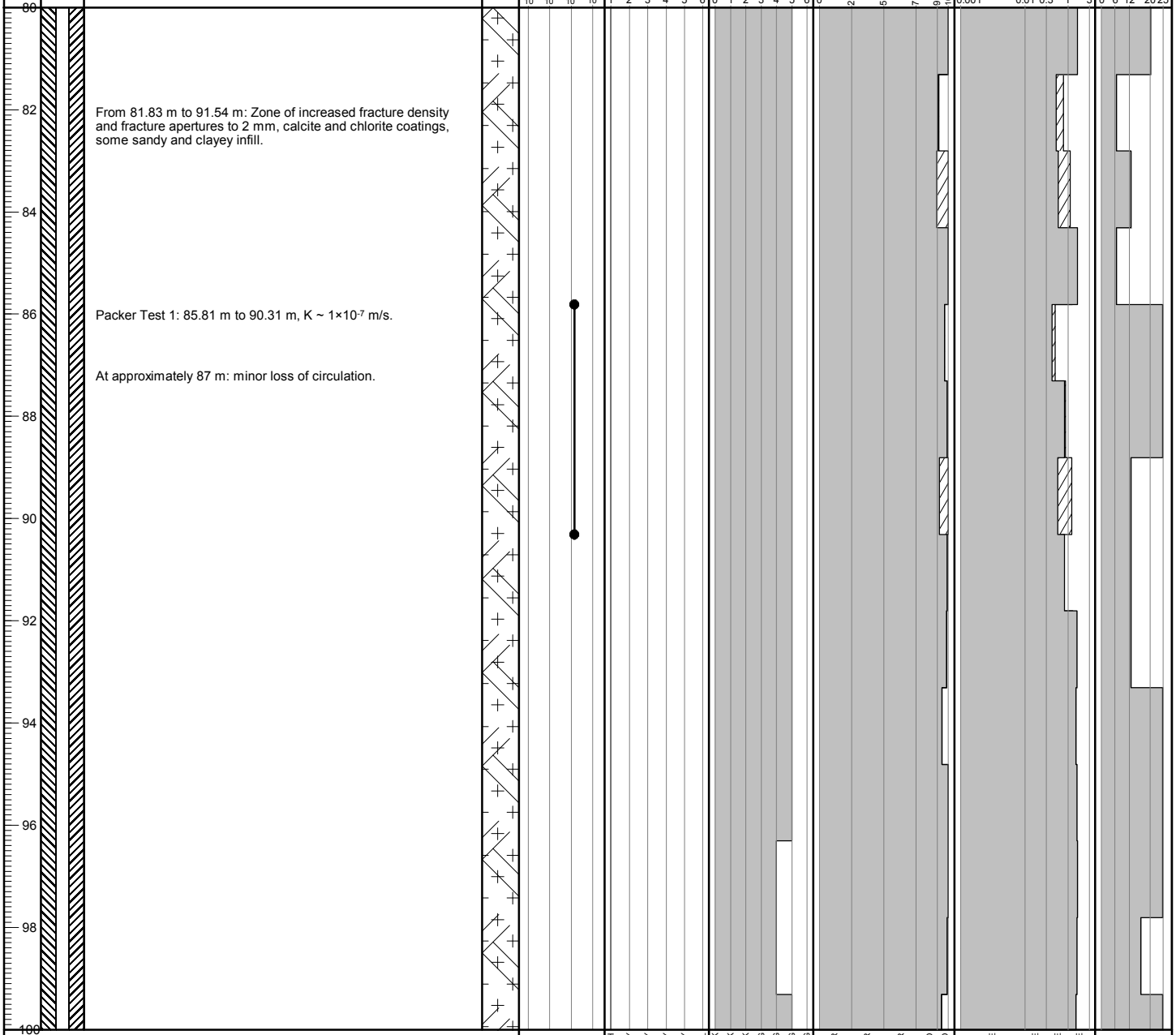
Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 81.83 m to 91.54 m: Zone of increased fracture density and fracture apertures to 2 mm, calcite and chlorite coatings, some sandy and clayey infill.

Packer Test 1: 85.81 m to 90.31 m, K ~ 1×10^{-7} m/s.

At approximately 87 m: minor loss of circulation.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

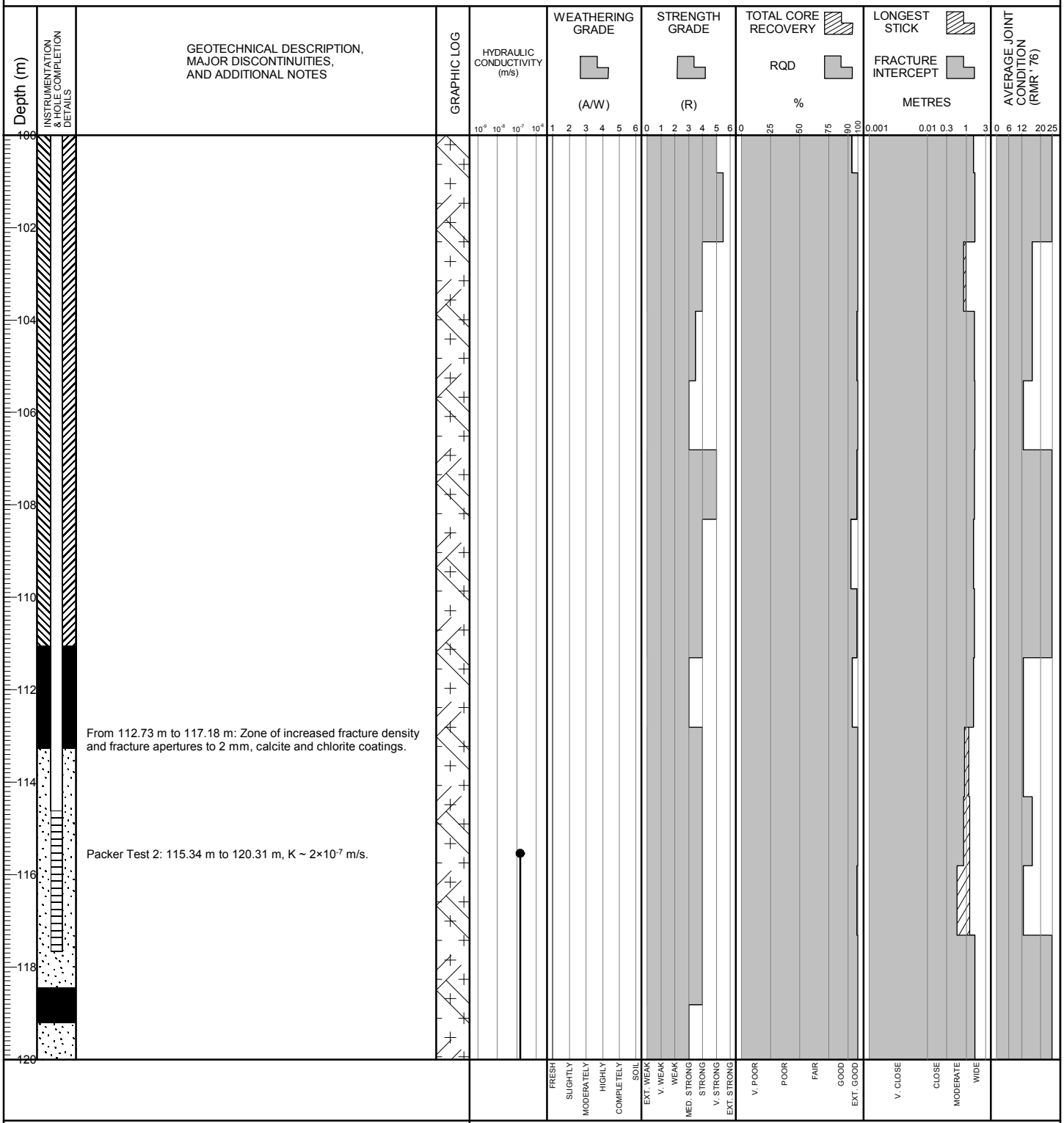
Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

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Project No.: 1008-029

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Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
120		END OF HOLE at 120.34 m.							
122		NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 117.67 m to 114.62 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 118.45 m to 113.27 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 113.27 m to 111.05 m. 5) Water level measured after piezometer installation on 4 July 2018 at 17.70 m bgs.							
124									
126									
128									
130									
132									
134									
136									
138									
140									

Scales: HYDRAULIC CONDUCTIVITY 10^{-9} 10^{-8} 10^{-7} 10^{-6}; WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21A

Project No.: 1008-029

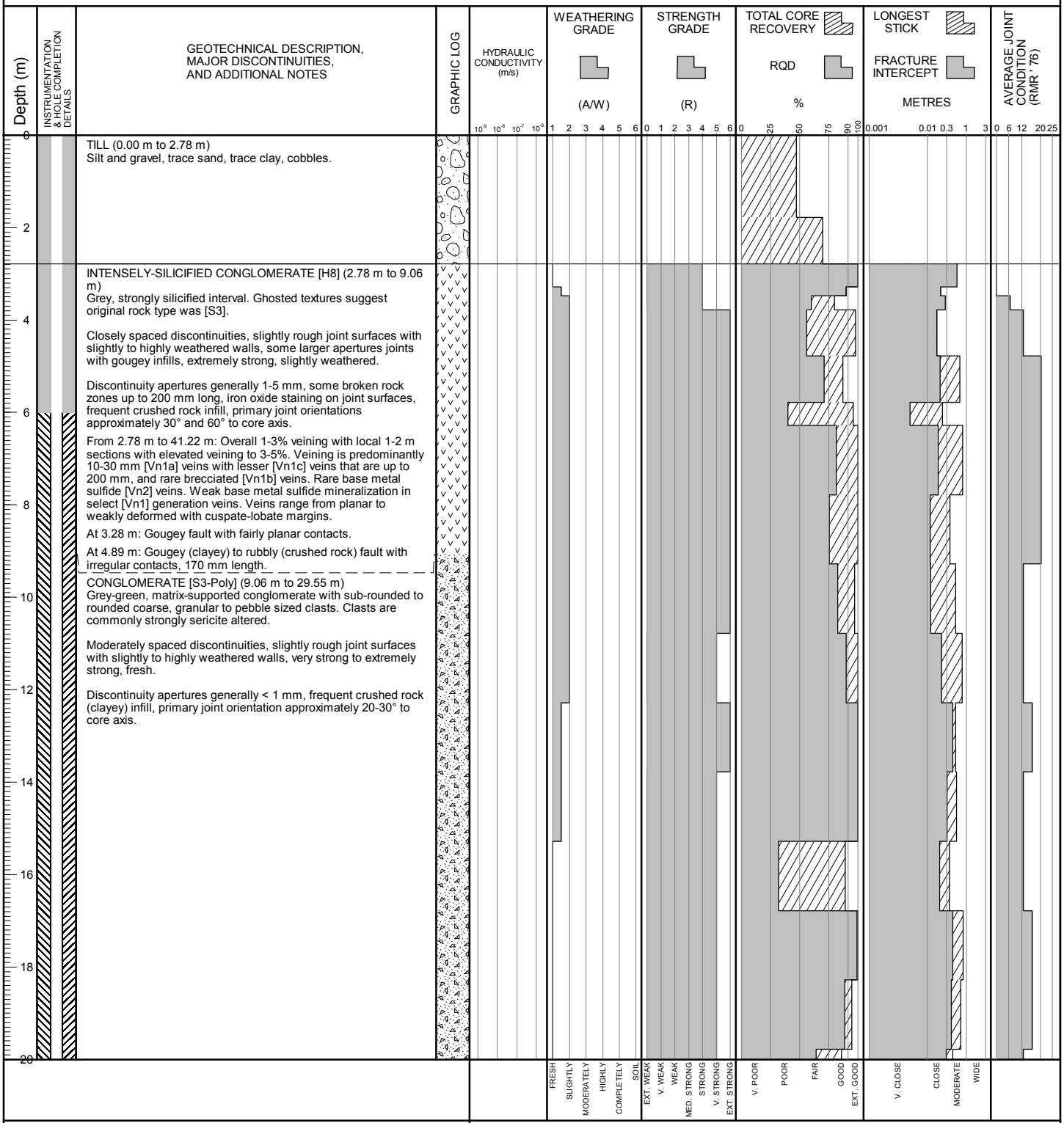
Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0	TILL (0.00 m to 2.78 m) Silt and gravel, trace sand, trace clay, cobbles.
3	INTENSELY-SILICIFIED CONGLOMERATE [H8] (2.78 m to 9.06 m) Grey, strongly silicified interval. Ghosted textures suggest original rock type was [S3]. Closely spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, some larger apertures joints with gougey infills, extremely strong, slightly weathered. Discontinuity apertures generally 1-5 mm, some broken rock zones up to 200 mm long, iron oxide staining on joint surfaces, frequent crushed rock infill, primary joint orientations approximately 30° and 60° to core axis. From 2.78 m to 41.22 m: Overall 1-3% veining with local 1-2 m sections with elevated veining to 3-5%. Veining is predominantly 10-30 mm [Vn1a] veins with lesser [Vn1c] veins that are up to 200 mm, and rare brecciated [Vn1b] veins. Rare base metal sulfide [Vn2] veins. Weak base metal sulfide mineralization in select [Vn1] generation veins. Veins range from planar to weakly deformed with cuspate-lobate margins. At 3.28 m: Gougey fault with fairly planar contacts. At 4.89 m: Gougey (clayey) to rubbly (crushed rock) fault with irregular contacts, 170 mm length.
9.06	CONGLOMERATE [S3-Poly] (9.06 m to 29.55 m) Grey-green, matrix-supported conglomerate with sub-rounded to rounded coarse, granular to pebble sized clasts. Clasts are commonly strongly sericite altered. Moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, very strong to extremely strong, fresh. Discontinuity apertures generally < 1 mm, frequent crushed rock (clayey) infill, primary joint orientation approximately 20-30° to core axis.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

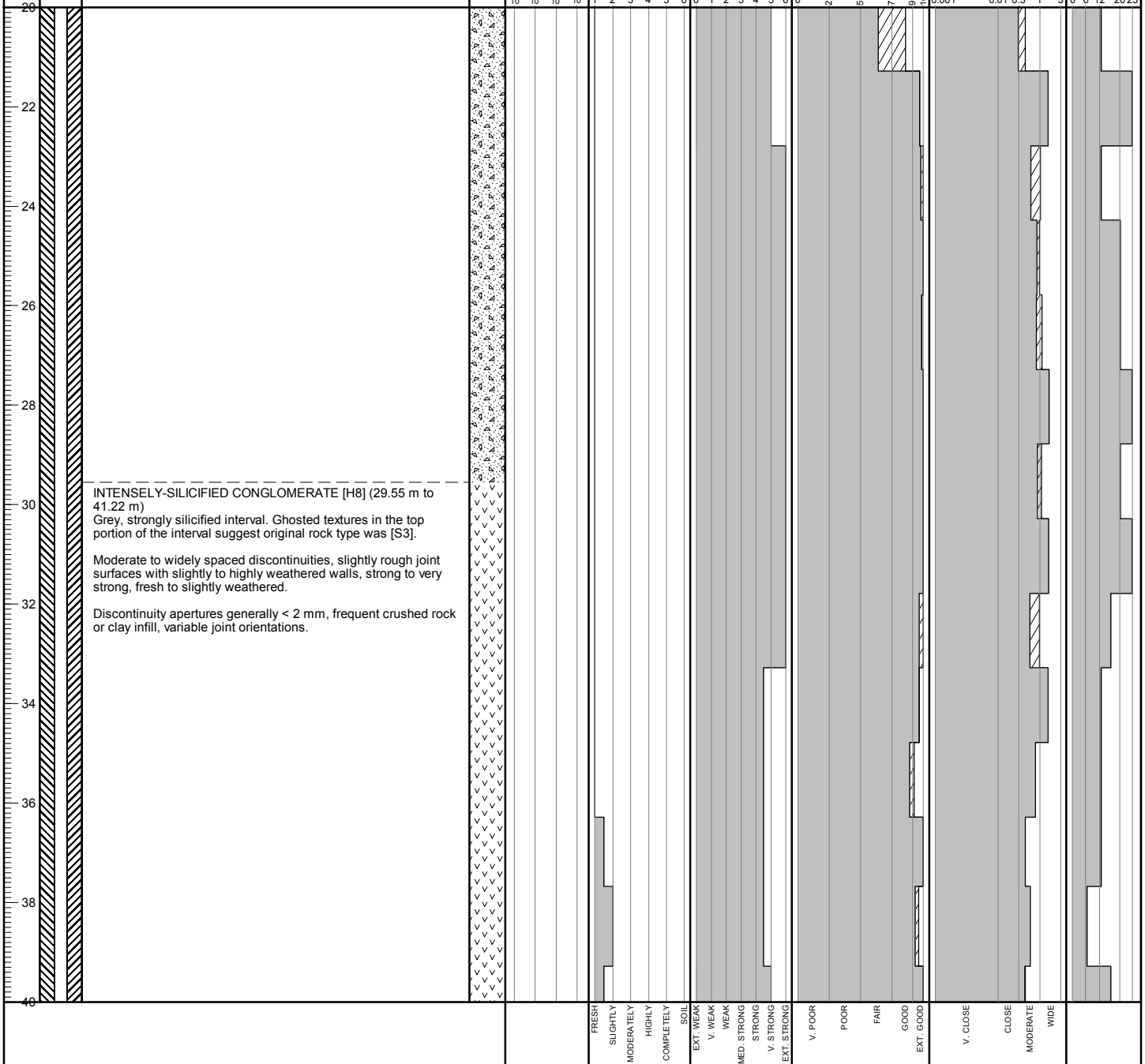
Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

INTENSELY-SILICIFIED CONGLOMERATE [H8] (29.55 m to 41.22 m)
Grey, strongly silicified interval. Ghosted textures in the top portion of the interval suggest original rock type was [S3].

Moderate to widely spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, strong to very strong, fresh to slightly weathered.

Discontinuity apertures generally < 2 mm, frequent crushed rock or clay infill, variable joint orientations.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

SANDSTONE/ARENITE [S4-Vsf] (41.22 m to 255.28 m)
Medium greenish-grey, massive, silty to coarse sand [S4-Vsf]. Rare < 1 m interbeds of [S3] as observed above. Occasional calcite-pyrite concretions. Some patches of high-temperature sericite alteration. Overall 1-3% veining with local 1-2 m sections with elevated veining to 3-5%. Veining is predominantly 10-30 mm [Vn1a] veins with lesser [Vn1c] veins that are up to 200 mm, and rare brecciated [Vn1b] veins. Occasional 20-50 mm grey, calcite-rich [Vn3] veins. Rare base metal sulfide [Vn2] veins. Weak base metal sulfide mineralization in select [Vn1] generation veins. Veins range from planar to weakly deformed with cuspate-lobate margins.

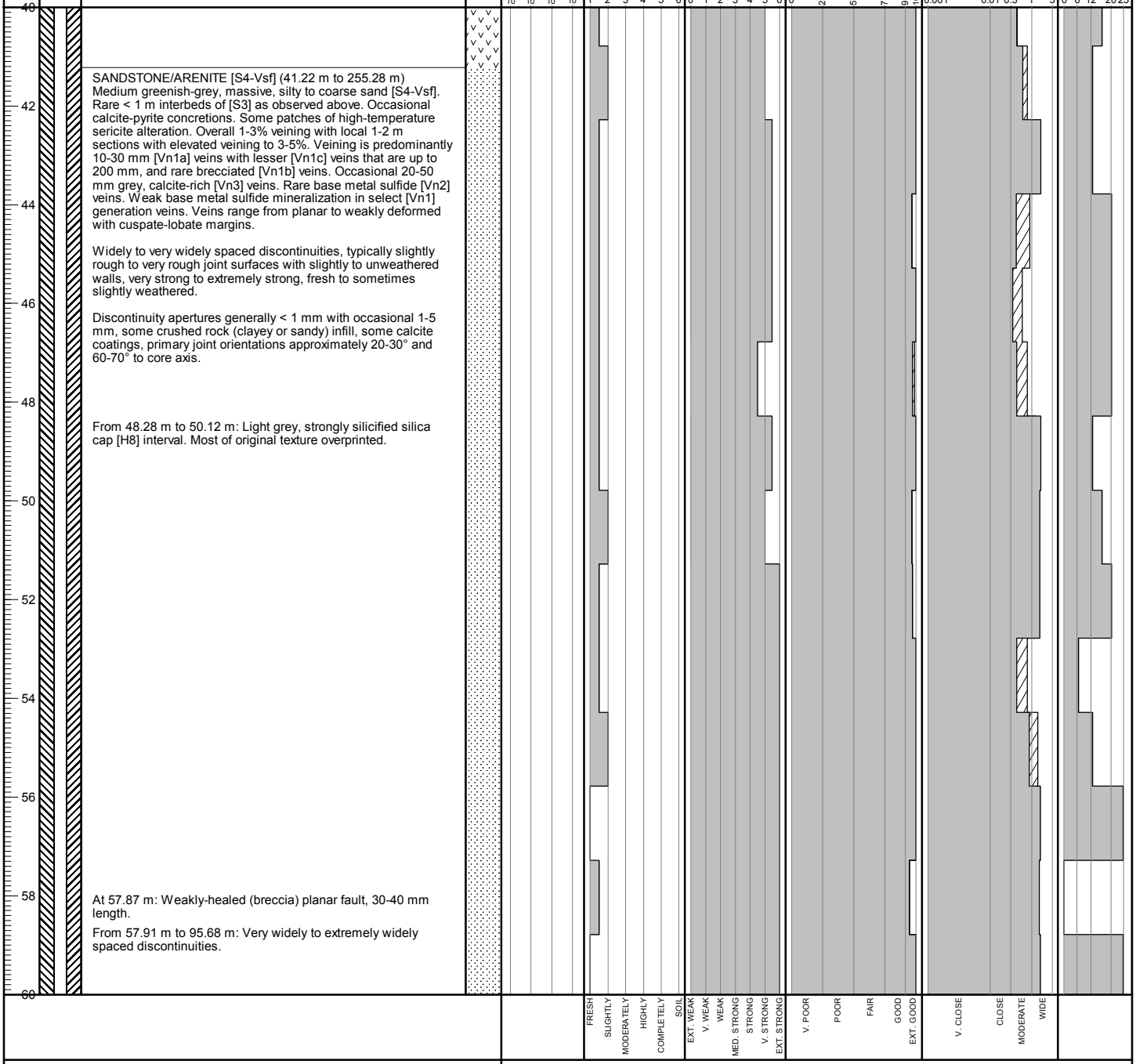
Widely to very widely spaced discontinuities, typically slightly rough to very rough joint surfaces with slightly to unweathered walls, very strong to extremely strong, fresh to sometimes slightly weathered.

Discontinuity apertures generally < 1 mm with occasional 1-5 mm, some crushed rock (clayey or sandy) infill, some calcite coatings, primary joint orientations approximately 20-30° and 60-70° to core axis.

From 48.28 m to 50.12 m: Light grey, strongly silicified silica cap [H8] interval. Most of original texture overprinted.

At 57.87 m: Weakly-healed (breccia) planar fault, 30-40 mm length.

From 57.91 m to 95.68 m: Very widely to extremely widely spaced discontinuities.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
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Logged By: HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY RQD %	LONGEST STICK FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
60–80		From 65.05 m to 84.53 m: Zone of strong veining with 5-8% overall but locally stronger due to larger [Vn1c] veins. Veining consists of a network of [Vn1] generations and common strongly mineralized base metal sulfide [Vn2] veins. Veins are moderately deformed and commonly have cuspate-lobate margins.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL)	0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG)	0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD)	0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE)	0 6 12 20 25

Project No.: 1008-029 **Location:** South Valley of Kings

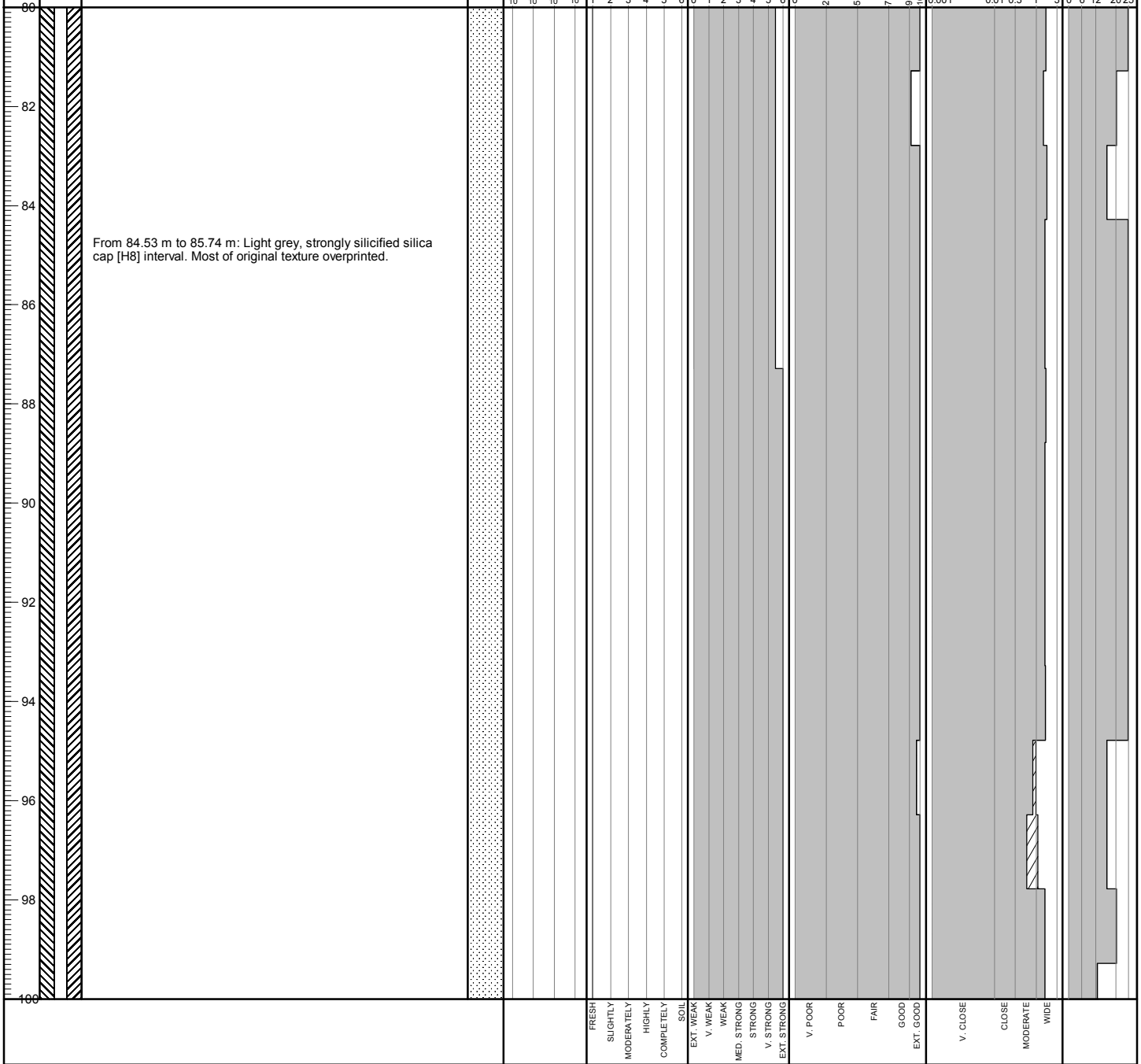
Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 84.53 m to 85.74 m: Light grey, strongly silicified silica cap [H8] interval. Most of original texture overprinted.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	***Drill Designation:*** Tech 5000	***Start Date:*** 18 JUN 18
Ground Elevation (m): 1,550.33	***Drilling Contractor:*** Hy-Tech Drilling Ltd.	***Finish Date:*** 24 JUN 18
Survey Method: Mine Survey	***Drill Method:*** Diamond Coring	***Final Depth (m):*** 255.28
Datum: UTM NAD 83 Zone 9	***Core:*** PQ3	***Depth To Top Of Rock (m):*** 2.78
Plunge (°): -90	***Fluid:*** Water	***Logged By:*** HM/LS
Trend (°): 000	***Cased To (m) :*** 3.00	***Reviewed By:*** HP

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-21A

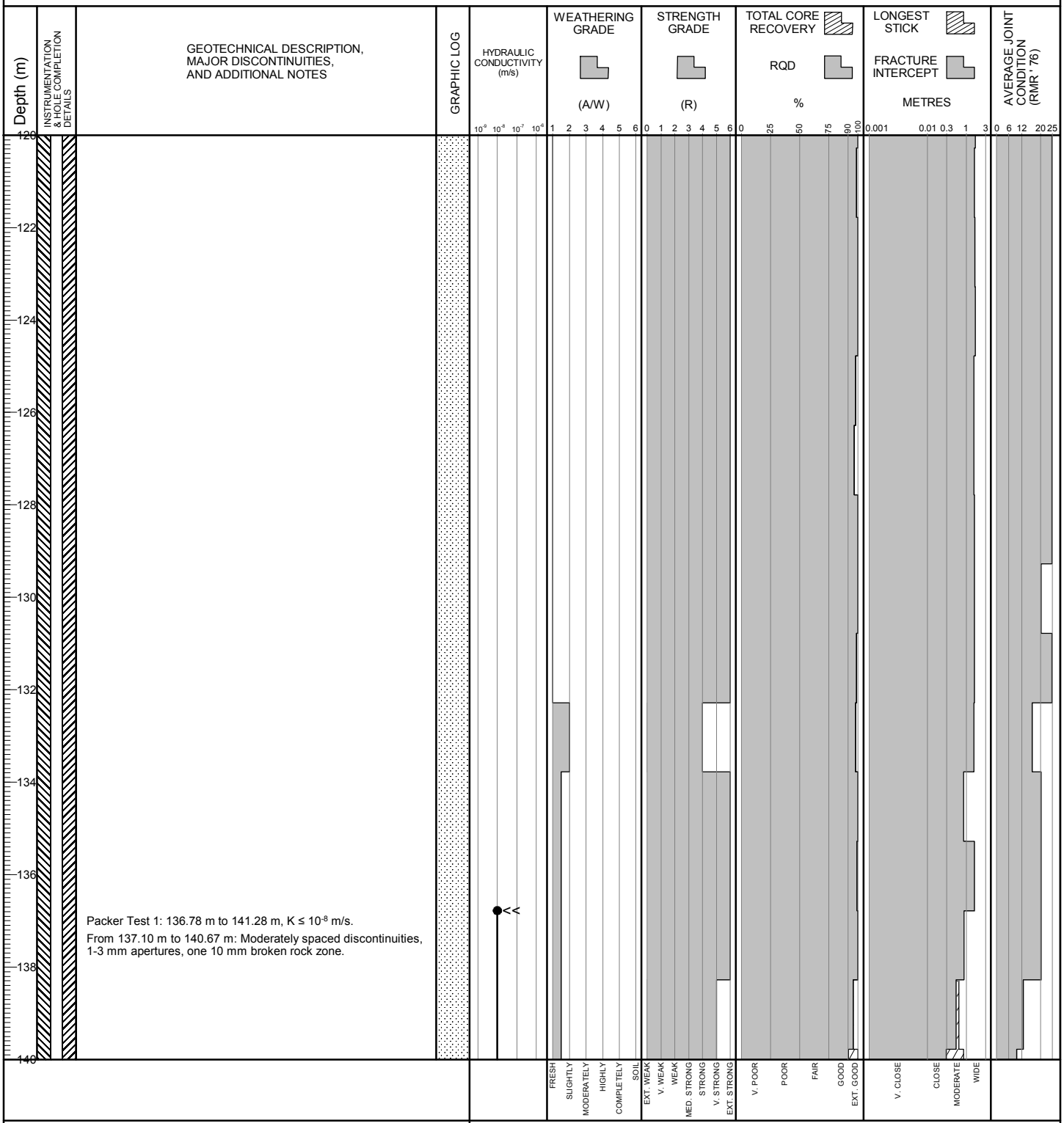
Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	***Drill Designation:*** Tech 5000	***Start Date:*** 18 JUN 18
Ground Elevation (m): 1,550.33	***Drilling Contractor:*** Hy-Tech Drilling Ltd.	***Finish Date:*** 24 JUN 18
Survey Method: Mine Survey	***Drill Method:*** Diamond Coring	***Final Depth (m):*** 255.28
Datum: UTM NAD 83 Zone 9	***Core:*** PQ3	***Depth To Top Of Rock (m):*** 2.78
Plunge (°): -90	***Fluid:*** Water	***Logged By:*** HM/LS
Trend (°): 000	***Cased To (m) :*** 3.00	***Reviewed By:*** HP

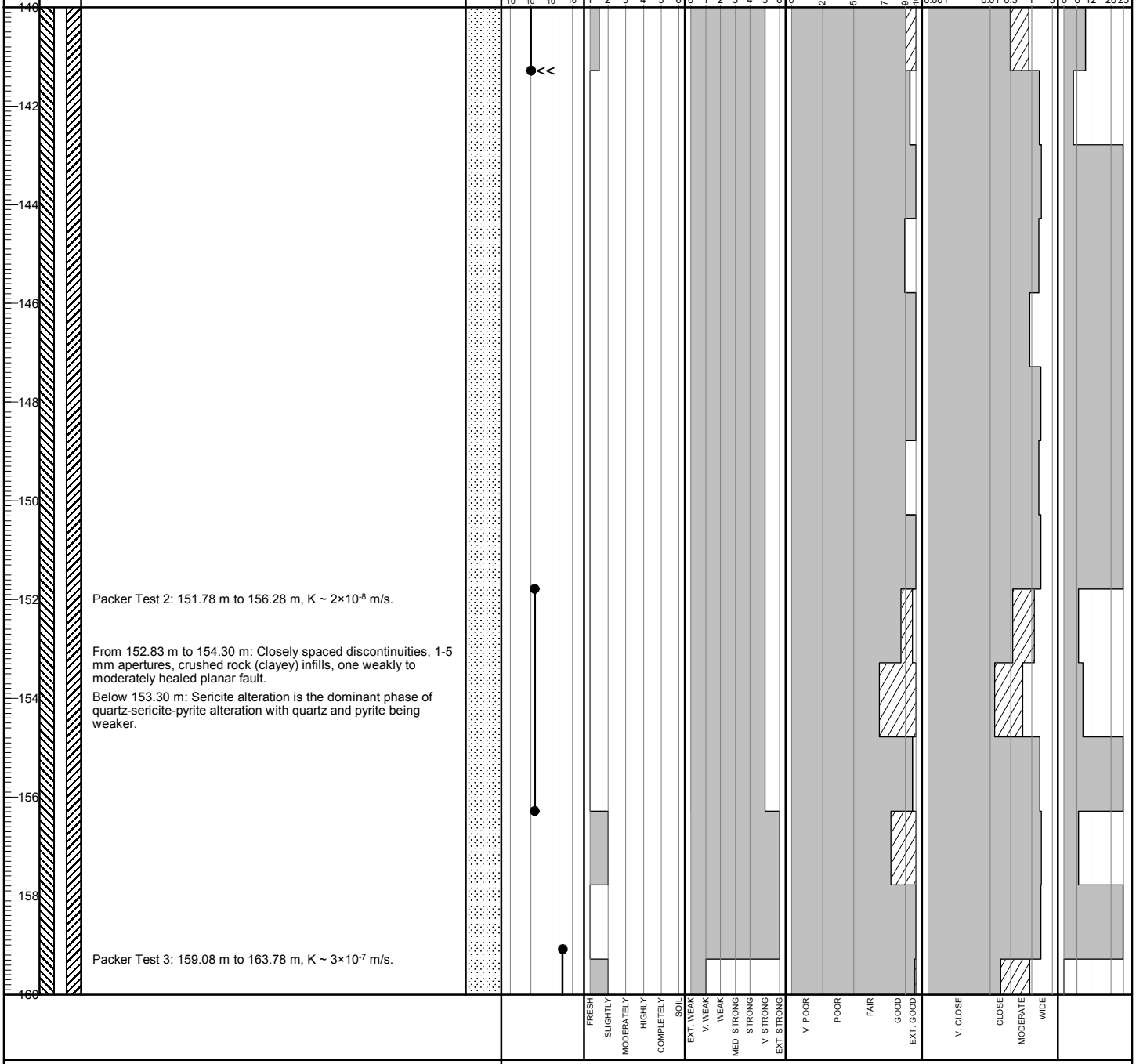
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 2: 151.78 m to 156.28 m, K ~ 2×10^{-8} m/s.

From 152.83 m to 154.30 m: Closely spaced discontinuities, 1-5 mm apertures, crushed rock (clayey) infills, one weakly to moderately healed planar fault.

Below 153.30 m: Sericite alteration is the dominant phase of quartz-sericite-pyrite alteration with quartz and pyrite being weaker.

Packer Test 3: 159.08 m to 163.78 m, K ~ 3×10^{-7} m/s.



BGC ENGINEERING INC.
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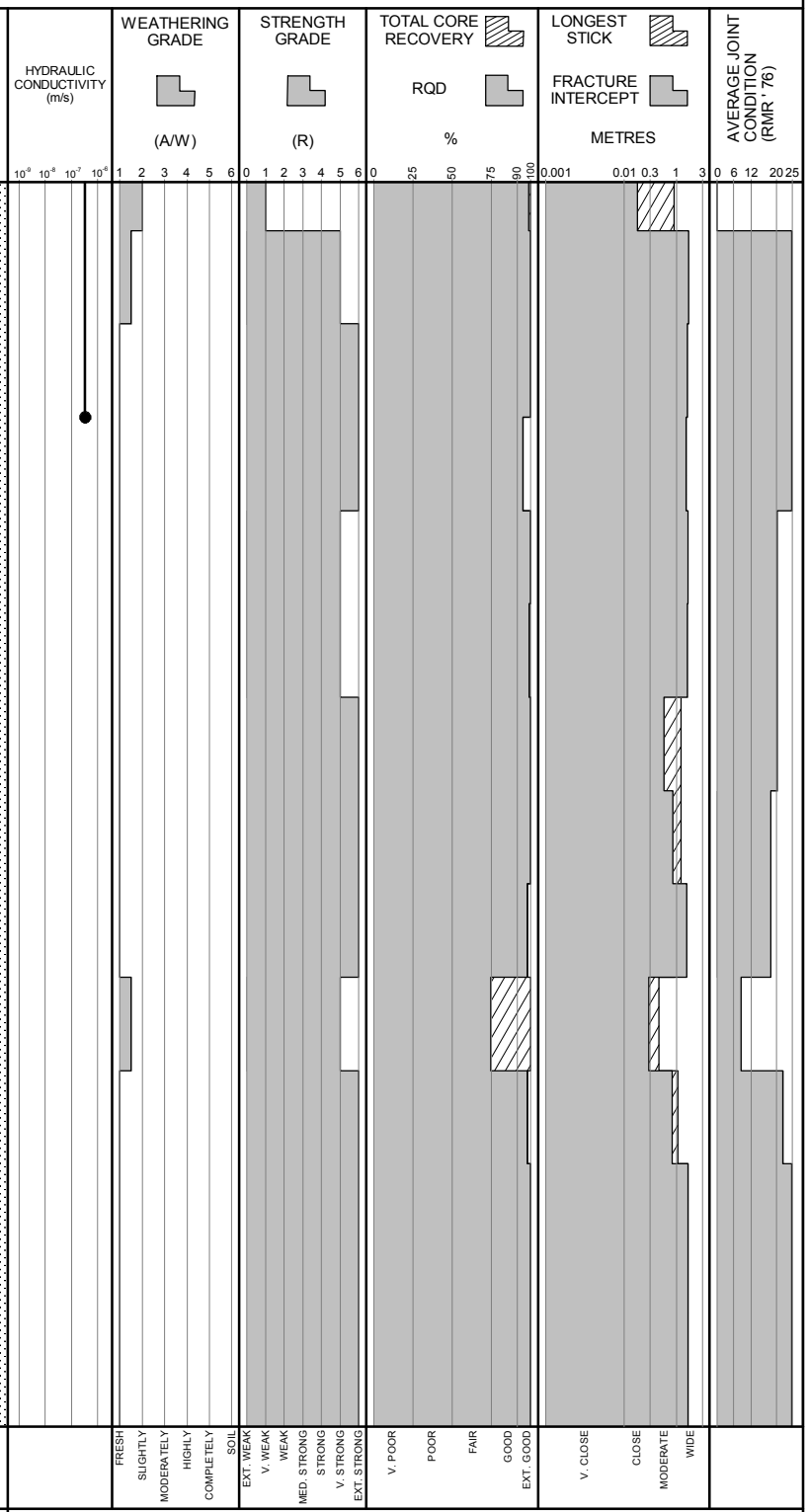
Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
160		At approximately 160 m: Minor loss of drilling fluid circulation.	
		At 160.25 m: Healed fault with angular fault fragments that are gouge-supported, sharp planar contacts, 70 mm aperture.	
162			
164			
166			
168			
170			
172			
174			
176			
178			
180			



BGC ENGINEERING INC.
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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

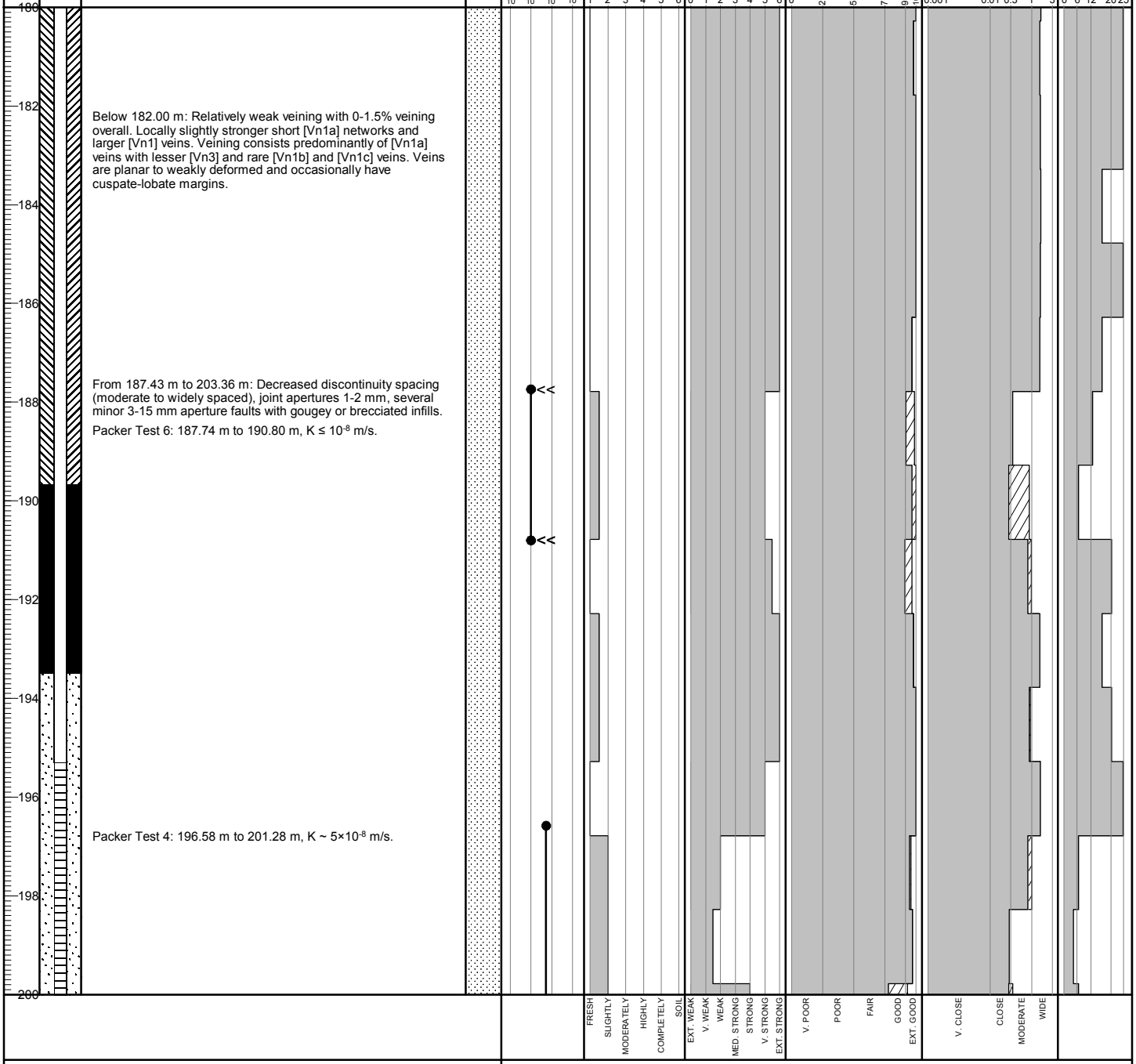
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Below 182.00 m: Relatively weak veining with 0-1.5% veining overall. Locally slightly stronger short [Vn1a] networks and larger [Vn1] veins. Veining consists predominantly of [Vn1a] veins with lesser [Vn3] and rare [Vn1b] and [Vn1c] veins. Veins are planar to weakly deformed and occasionally have cuspate-lobate margins.

From 187.43 m to 203.36 m: Decreased discontinuity spacing (moderate to widely spaced), joint apertures 1-2 mm, several minor 3-15 mm aperture faults with gougey or brecciated infills.

Packer Test 6: 187.74 m to 190.80 m, K ≤ 10^{-8} m/s.

Packer Test 4: 196.58 m to 201.28 m, K ~ 5×10^{-8} m/s.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-21A

Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP

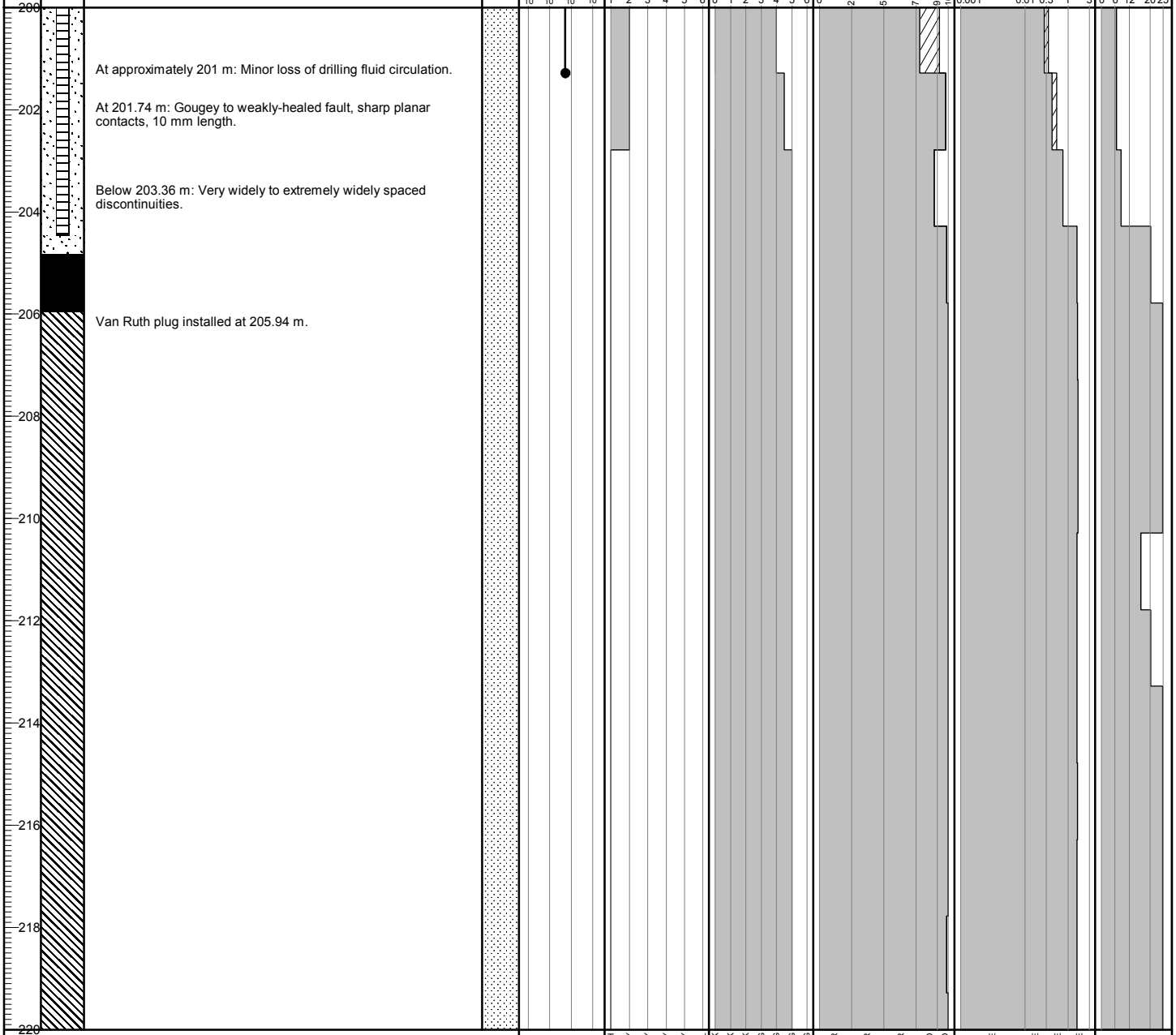
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

At approximately 201 m: Minor loss of drilling fluid circulation.

At 201.74 m: Gougey to weakly-healed fault, sharp planar contacts, 10 mm length.

Below 203.36 m: Very widely to extremely widely spaced discontinuities.

Van Ruth plug installed at 205.94 m.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
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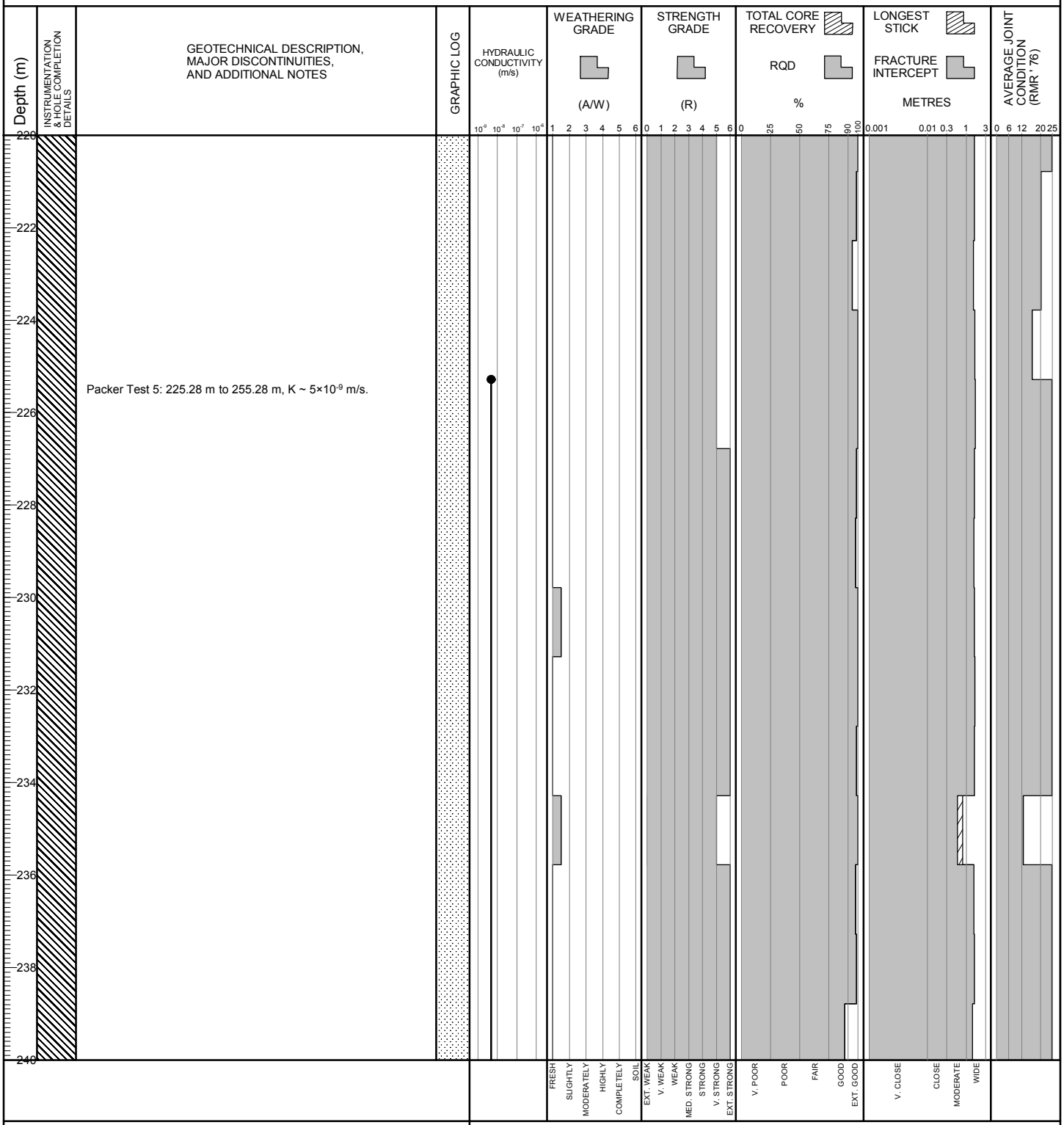

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21A

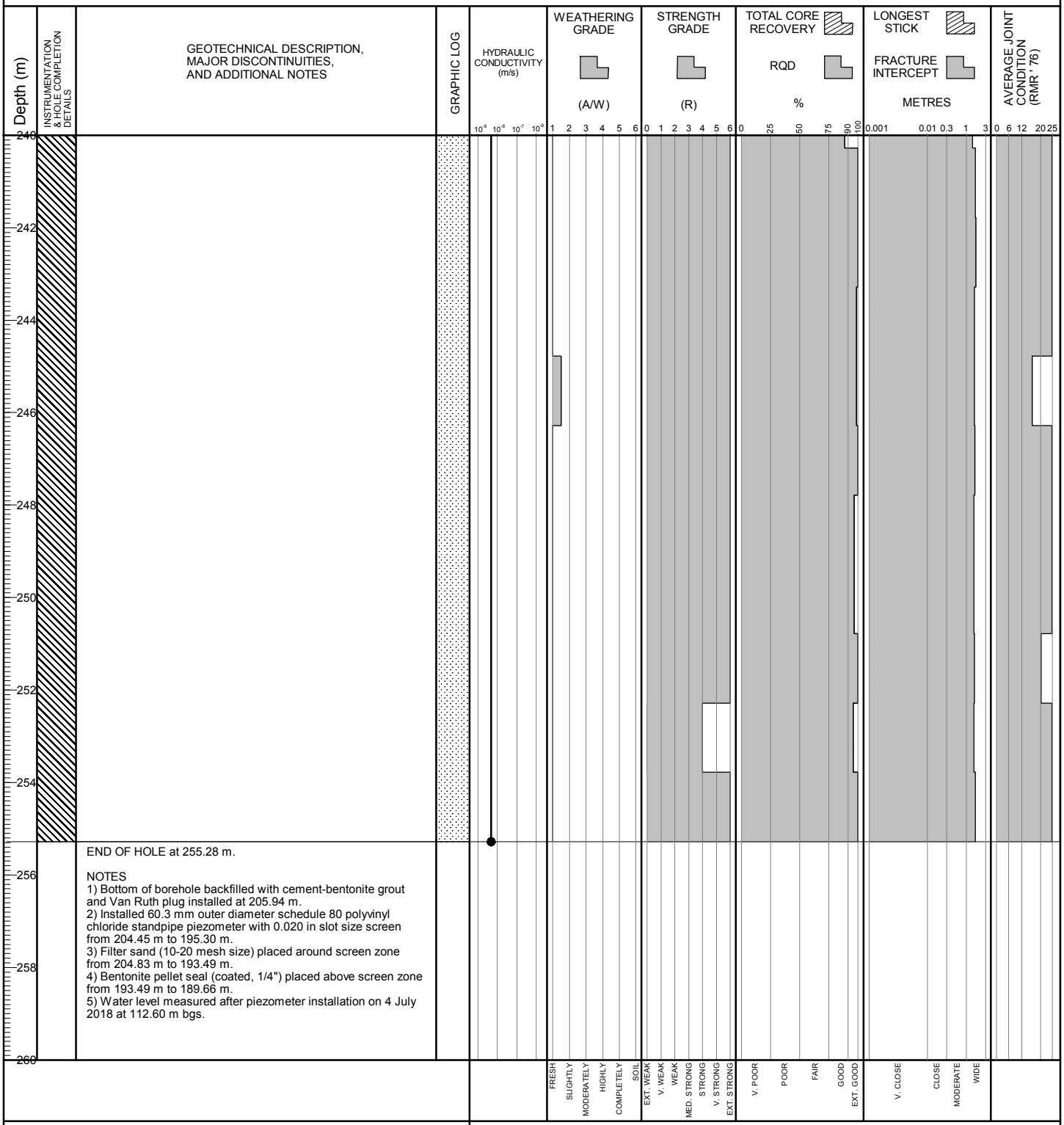
Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP



END OF HOLE at 255.28 m.

NOTES
1) Bottom of borehole backfilled with cement-bentonite grout and Van Ruth plug installed at 205.94 m.
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 204.45 m to 195.30 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 204.83 m to 193.49 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 193.49 m to 189.66 m.
5) Water level measured after piezometer installation on 4 July 2018 at 112.60 m bgs.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21B

Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

OVERBURDEN (0.00 m to 2.77 m)

INTENSELY-SILICIFIED CONGLOMERATE [H8] (2.77 m to 8.20 m)
Grey, strongly silicified interval. Ghosted textures suggest original rock type was [S3]. Approximately 5% quartz veins as disarticulated [Vn1a] veins. Strong silicification of host and most fragments, minor sericite alteration of clasts.

Close to moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, very strong to extremely strong, slightly weathered.

Discontinuity apertures generally < 1 mm, commonly with iron oxide staining on joint surfaces, some sand infill, primary joint orientations approximately 30° and 60° to core axis.

At 3.75 m: Weakly developed fault zone with minor fault gouge, 20 mm length.

At 6.17 m: Moderately developed fault zone with minor fault gouge, 170 mm length.

CONGLOMERATE [S3] (8.20 m to 29.80 m)
Grey-green, matrix-supported conglomerate with sub-rounded to rounded coarse, granular to pebble sized clasts. Clasts range from 2-100 mm and are commonly strongly sericite altered. Quartz veining, mostly disarticulated [Vn1a] veins and disarticulated and deformed [Vn1c]/[Vn1b] vein networks. Moderate vein associated silicification, with sericite alteration of fragments/clasts and chlorite alteration that is patchy throughout host matrix.

Moderately spaced discontinuities, slightly rough joint surfaces with variable but mostly highly weathered walls, very strong to extremely strong, slightly weathered to fresh.

Discontinuity apertures generally 0.5-5 mm, some iron oxide staining on joint surfaces in shallower part of unit, some crushed/disintegrated rock (clayey or sandy) infill, minor calcite coatings, variable joint orientations.

From 11.40 m to 19.14 m: Four minor to moderately developed fault zones with some fault gouge, 15-140 mm length.

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

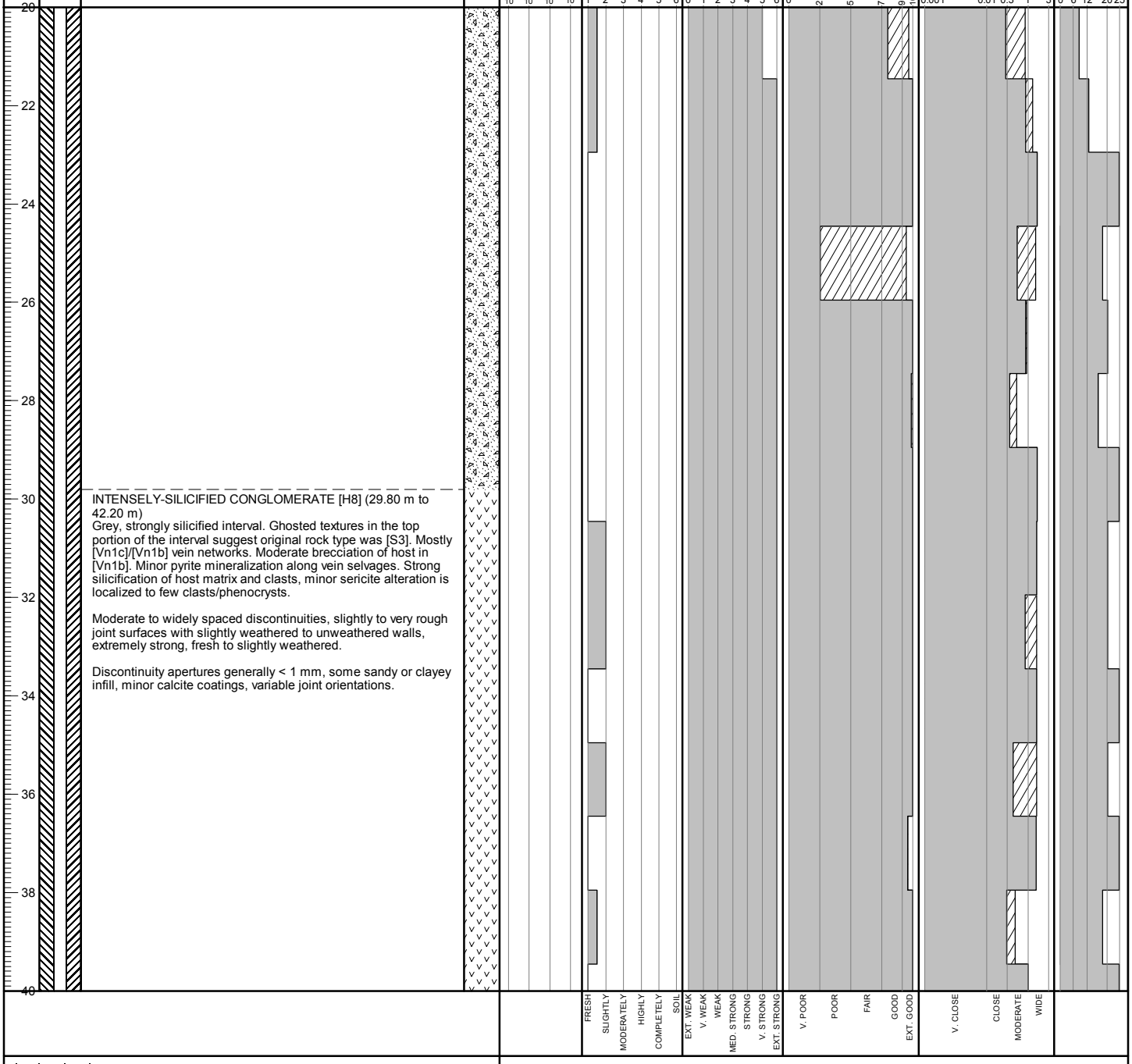
Co-ordinates (m): 426,660E - 6,257,807N	**Drill Designation:** Tech 5000	**Start Date:** 24 JUN 18
Ground Elevation (m): 1,550.34	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 29 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 159.45
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.77
Plunge (°): -90	**Fluid:** Water	**Logged By:** LS/HM/BM
Trend (°): 000	**Cased To (m) :** 4.50	**Reviewed By:** HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

INTENSELY-SILICIFIED CONGLOMERATE [H8] (29.80 m to 42.20 m)
Grey, strongly silicified interval. Ghosted textures in the top portion of the interval suggest original rock type was [S3]. Mostly [Vn1c]/[Vn1b] vein networks. Moderate brecciation of host in [Vn1b]. Minor pyrite mineralization along vein selvages. Strong silicification of host matrix and clasts, minor sericite alteration is localized to few clasts/phenocrysts.

Moderate to widely spaced discontinuities, slightly to very rough joint surfaces with slightly weathered to unweathered walls, extremely strong, fresh to slightly weathered.

Discontinuity apertures generally < 1 mm, some sandy or clayey infill, minor calcite coatings, variable joint orientations.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
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Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

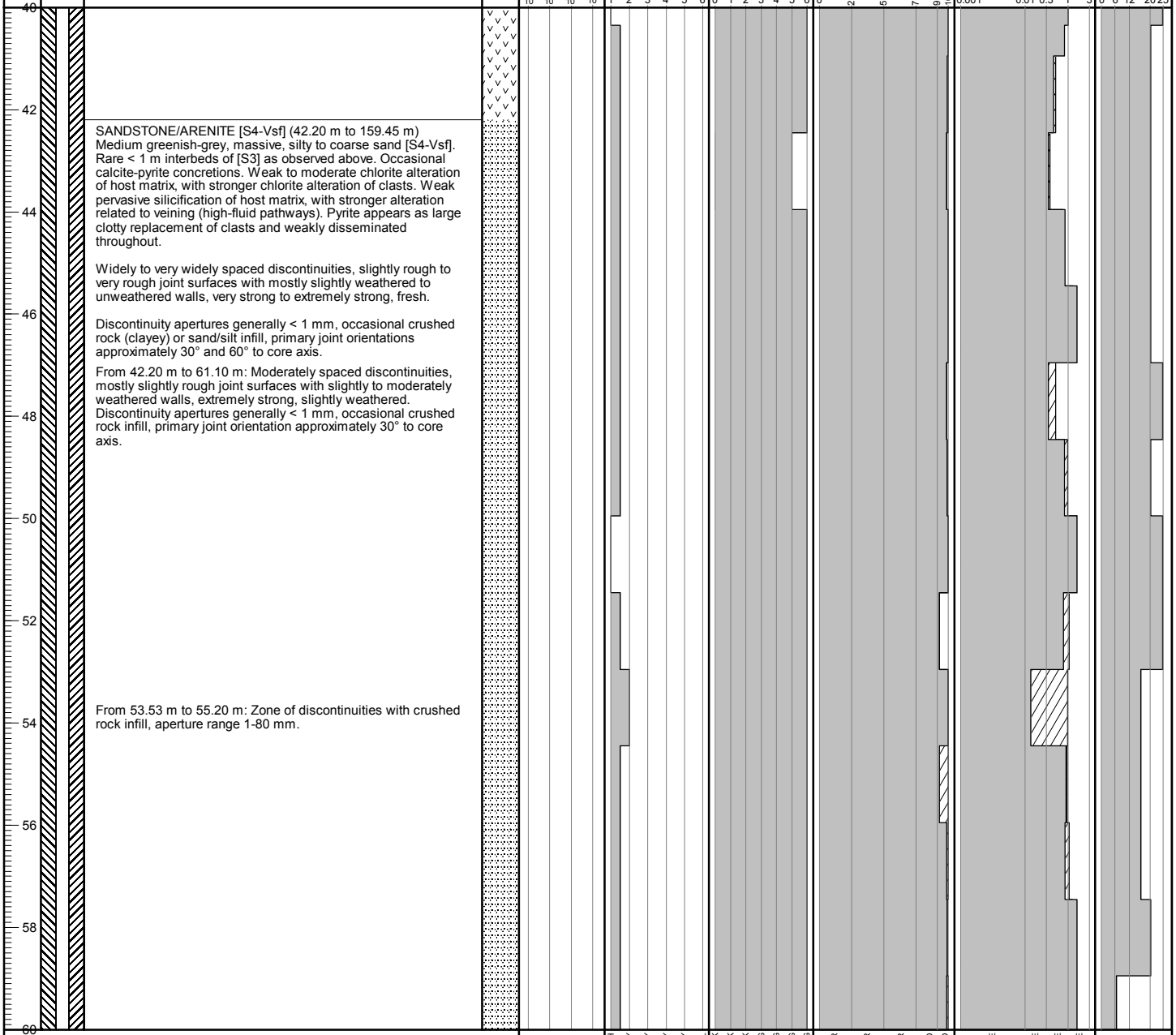
SANDSTONE/ARENITE [S4-Vsf] (42.20 m to 159.45 m)
Medium greenish-grey, massive, silty to coarse sand [S4-Vsf]. Rare < 1 m interbeds of [S3] as observed above. Occasional calcite-pyrite concretions. Weak to moderate chlorite alteration of host matrix, with stronger chlorite alteration of clasts. Weak pervasive silicification of host matrix, with stronger alteration related to veining (high-fluid pathways). Pyrite appears as large clotty replacement of clasts and weakly disseminated throughout.

Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with mostly slightly weathered to unweathered walls, very strong to extremely strong, fresh.

Discontinuity apertures generally < 1 mm, occasional crushed rock (clayey) or sand/silt infill, primary joint orientations approximately 30° and 60° to core axis.

From 42.20 m to 61.10 m: Moderately spaced discontinuities, mostly slightly rough joint surfaces with slightly to moderately weathered walls, extremely strong, slightly weathered. Discontinuity apertures generally < 1 mm, occasional crushed rock infill, primary joint orientation approximately 30° to core axis.

From 53.53 m to 55.20 m: Zone of discontinuities with crushed rock infill, aperture range 1-80 mm.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
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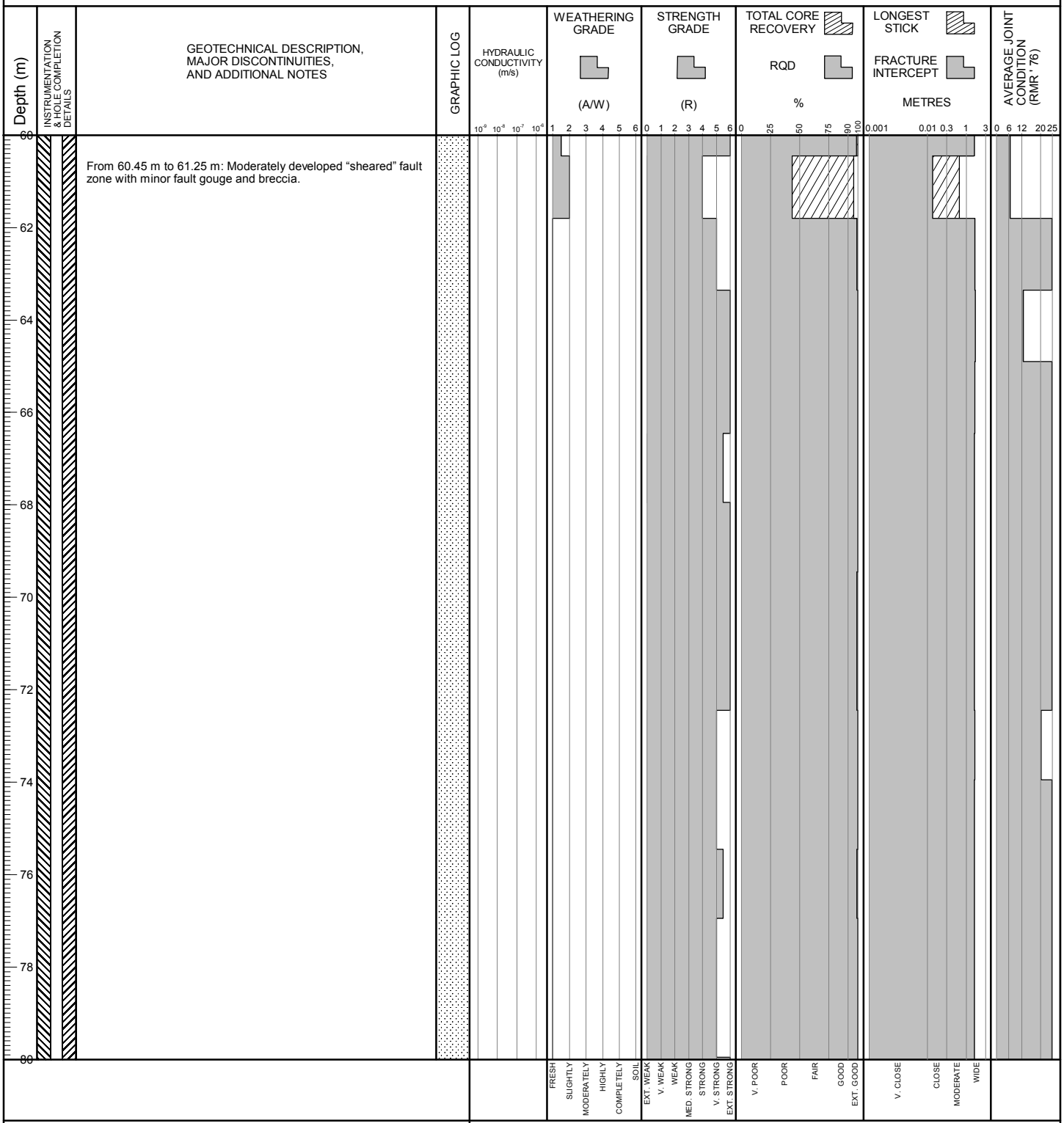
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
60–80	From 60.45 m to 61.25 m: Moderately developed "sheared" fault zone with minor fault gouge and breccia.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

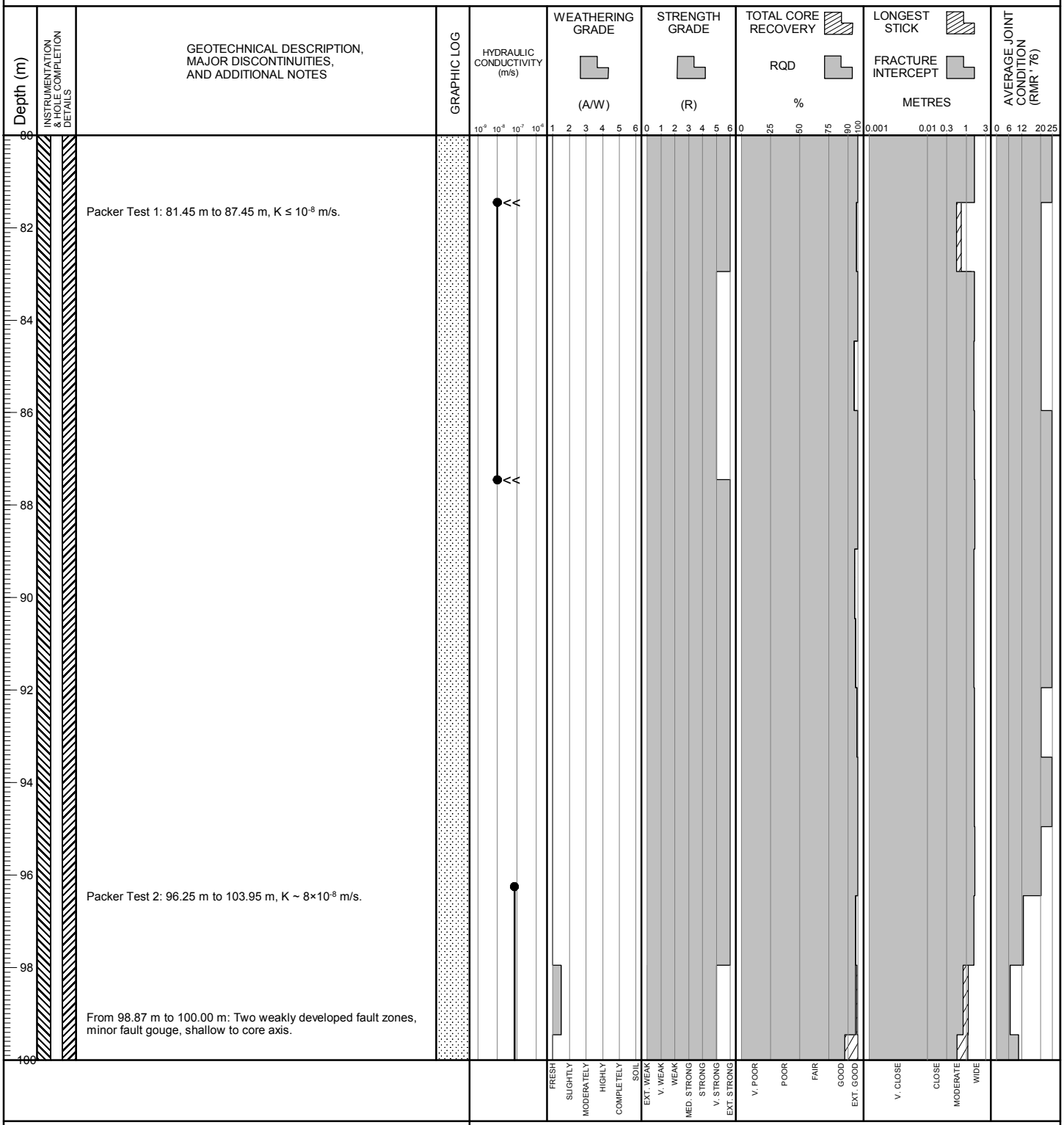
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Drilling Contractor: Hy-Tech Drilling Ltd.
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Start Date: 24 JUN 18
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Final Depth (m): 159.45
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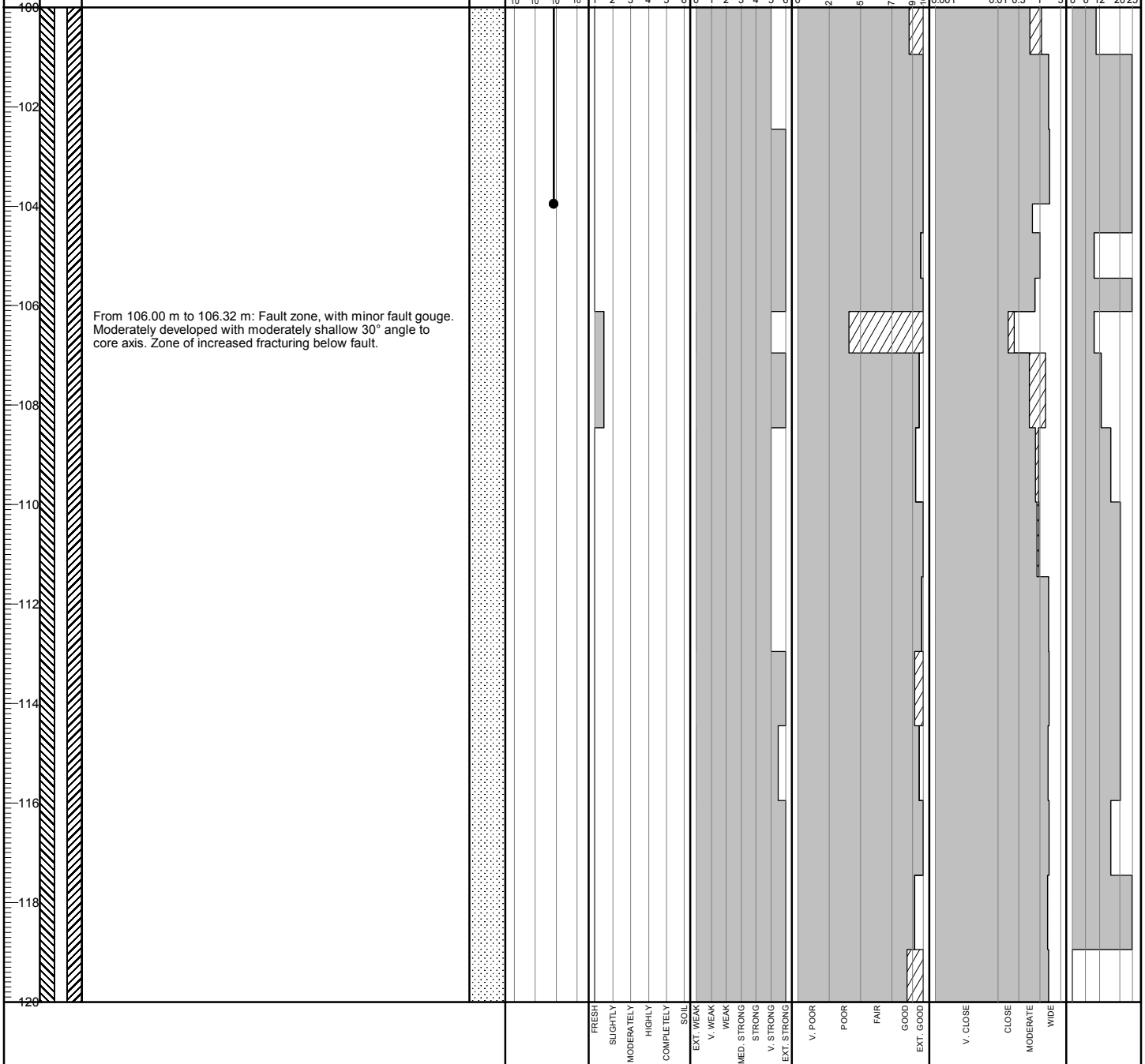
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
100–120		From 106.00 m to 106.32 m: Fault zone, with minor fault gouge. Moderately developed with moderately shallow 30° angle to core axis. Zone of increased fracturing below fault.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
120		From 120.12 m to 120.45 m: Moderately developed fault zone with fault gouge.
122		
124		
126		
128		
130		Packer Test 3: 130.75 m to 150.45 m, K ~ 2×10^{-9} m/s.
132		
134		
136		
138		
140		

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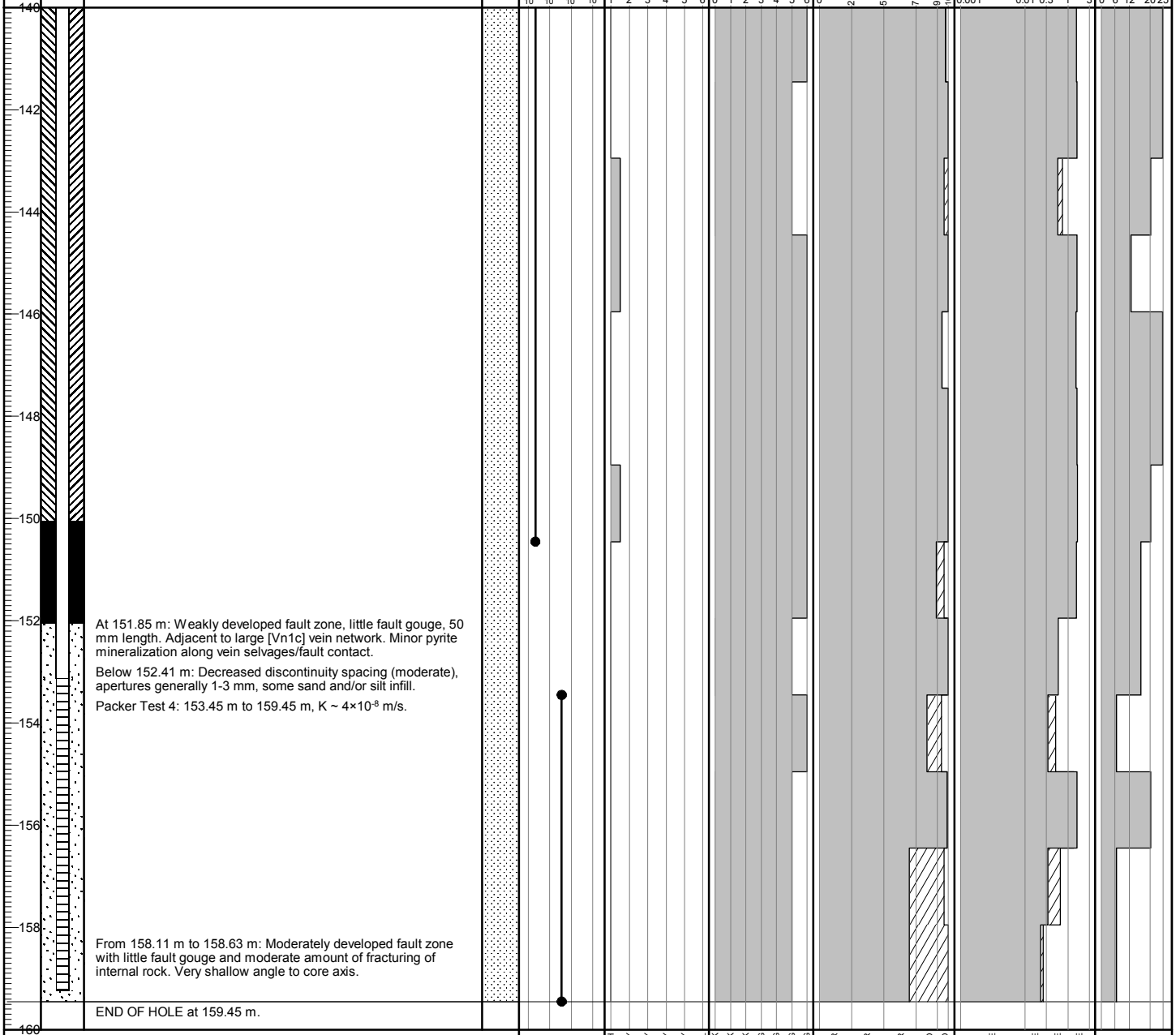
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21B

Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
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Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
160		NOTES 1) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 159.23 m to 153.13 m. 2) Filter sand (10-20 mesh size) placed around screen zone from 159.45 m to 152.05 m. 3) Bentonite pellet seal (coated, 1/4") placed above screen zone from 152.05 m to 150.05 m. 4) Water level measured after piezometer installation on 4 July 2018 at 122.70 m bgs.							
162									
164									
166									
168									
170									
172									
174									
176									
178									
180									

Hydraulic conductivity: 10^{-9} 10^{-8} 10^{-7} 10^{-6}
Weathering grade (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept metres: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

FILL and OVERBURDEN (0.00 m to 3.10 m)

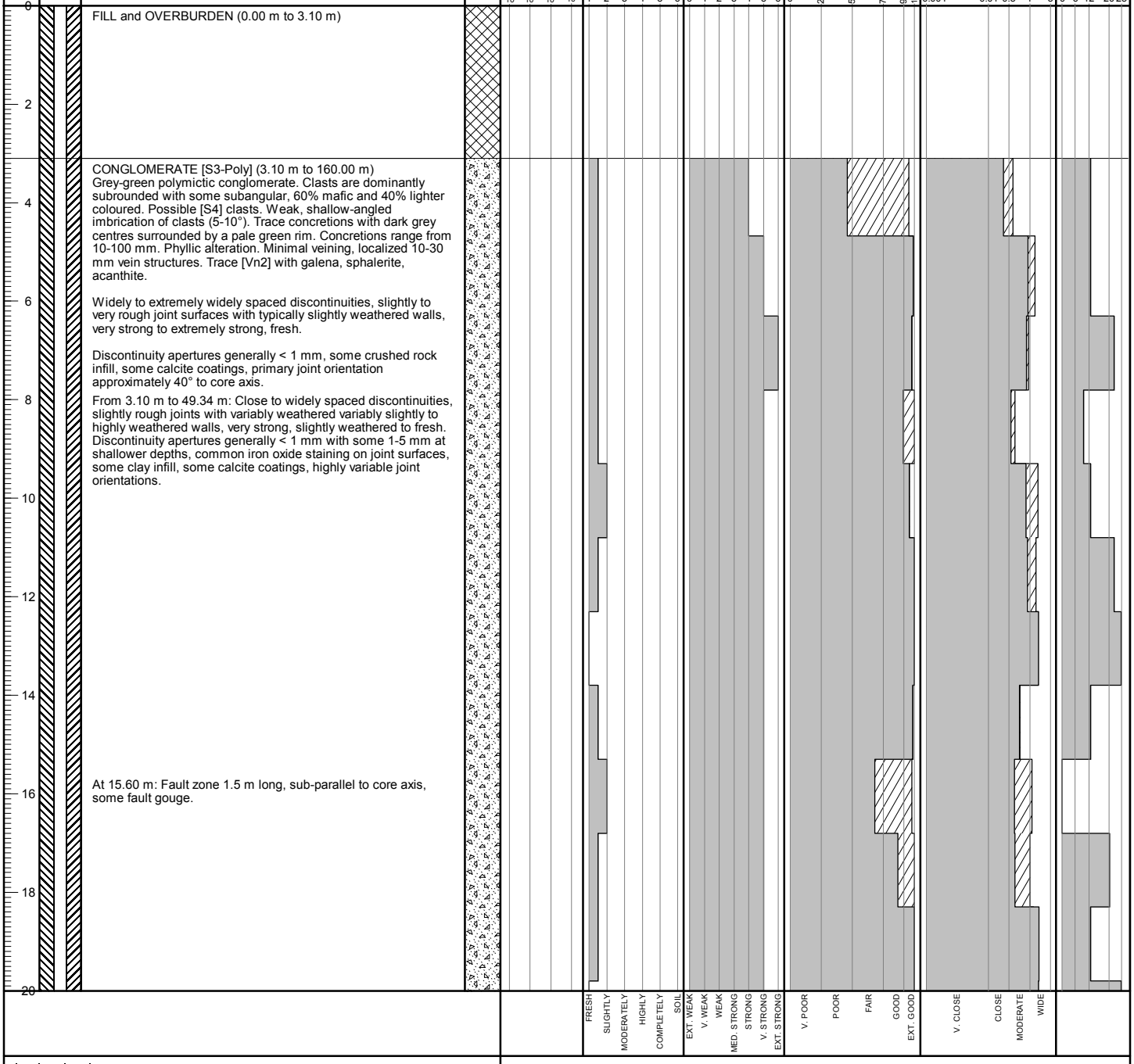
CONGLOMERATE [S3-Poly] (3.10 m to 160.00 m)
Grey-green polymictic conglomerate. Clasts are dominantly subrounded with some subangular, 60% mafic and 40% lighter coloured. Possible [S4] clasts. Weak, shallow-angled imbrication of clasts (5-10°). Trace concretions with dark grey centres surrounded by a pale green rim. Concretions range from 10-100 mm. Phyllic alteration. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with typically slightly weathered walls, very strong to extremely strong, fresh.

Discontinuity apertures generally < 1 mm, some crushed rock infill, some calcite coatings, primary joint orientation approximately 40° to core axis.

From 3.10 m to 49.34 m: Close to widely spaced discontinuities, slightly rough joints with variably weathered variably slightly to highly weathered walls, very strong, slightly weathered to fresh. Discontinuity apertures generally < 1 mm with some 1-5 mm at shallower depths, common iron oxide staining on joint surfaces, some clay infill, some calcite coatings, highly variable joint orientations.

At 15.60 m: Fault zone 1.5 m long, sub-parallel to core axis, some fault gouge.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
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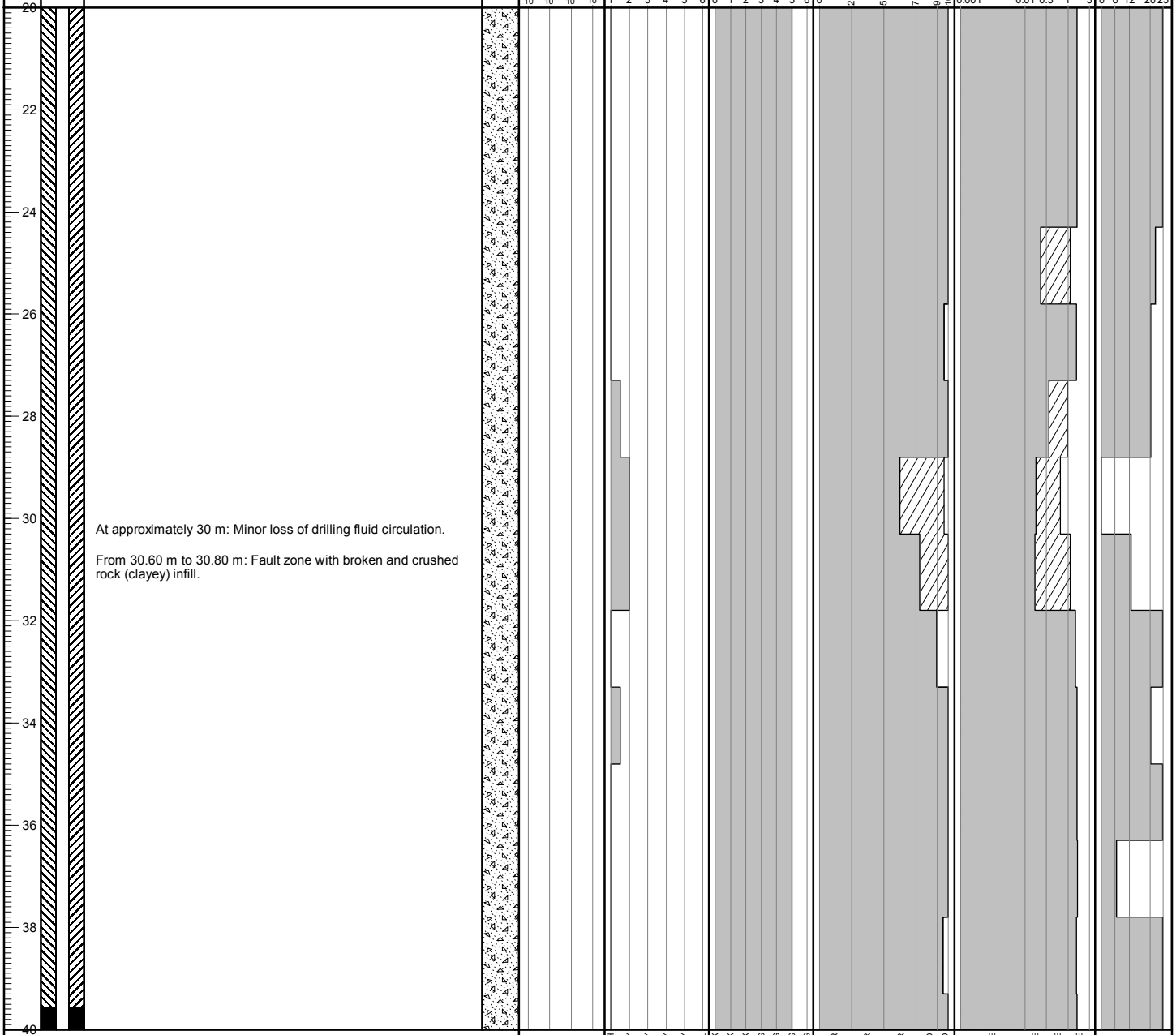
At approximately 30 m: Minor loss of drilling fluid circulation.

From 30.60 m to 30.80 m: Fault zone with broken and crushed rock (clayey) infill.



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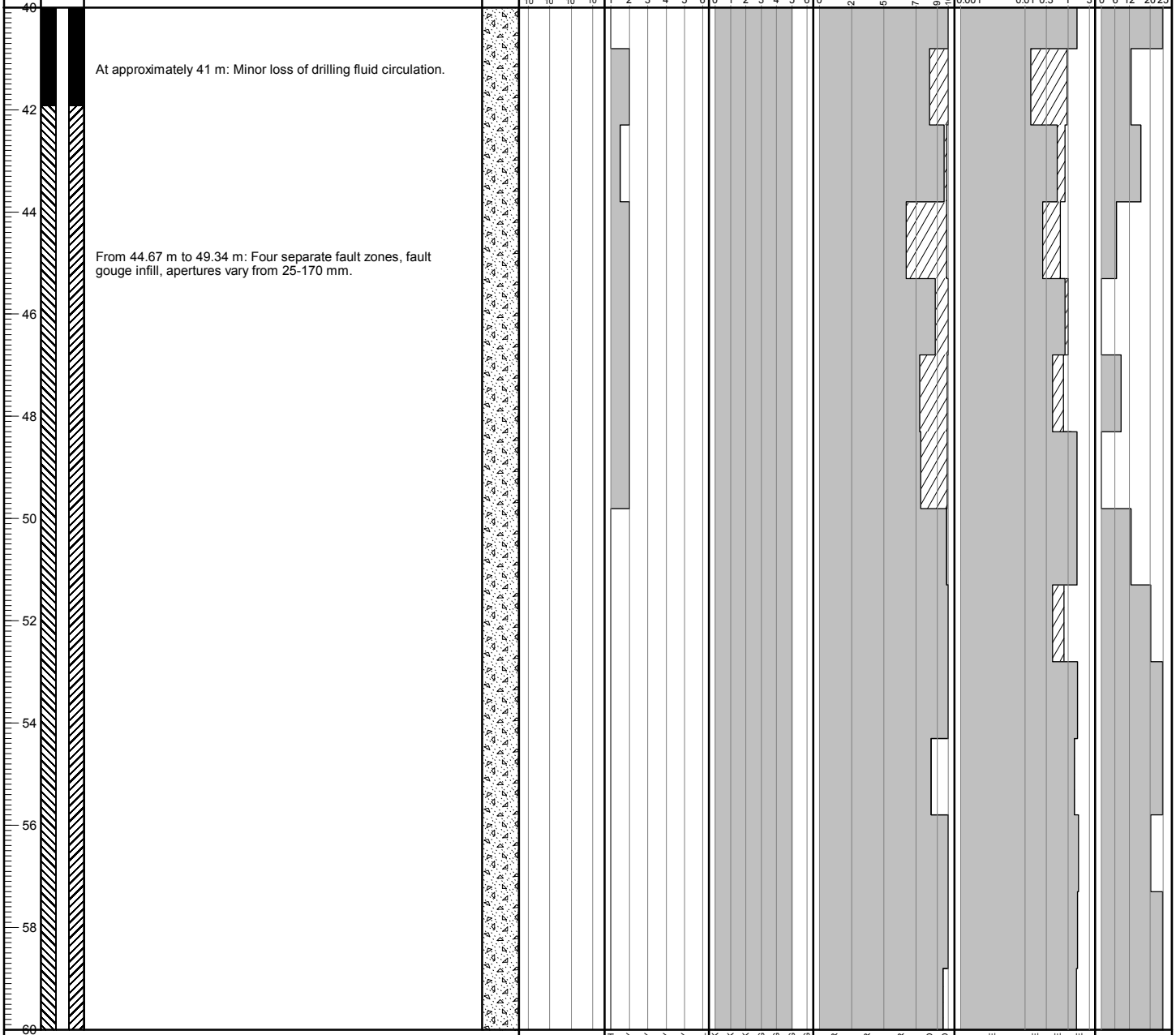
At approximately 41 m: Minor loss of drilling fluid circulation.

From 44.67 m to 49.34 m: Four separate fault zones, fault gouge infill, apertures vary from 25-170 mm.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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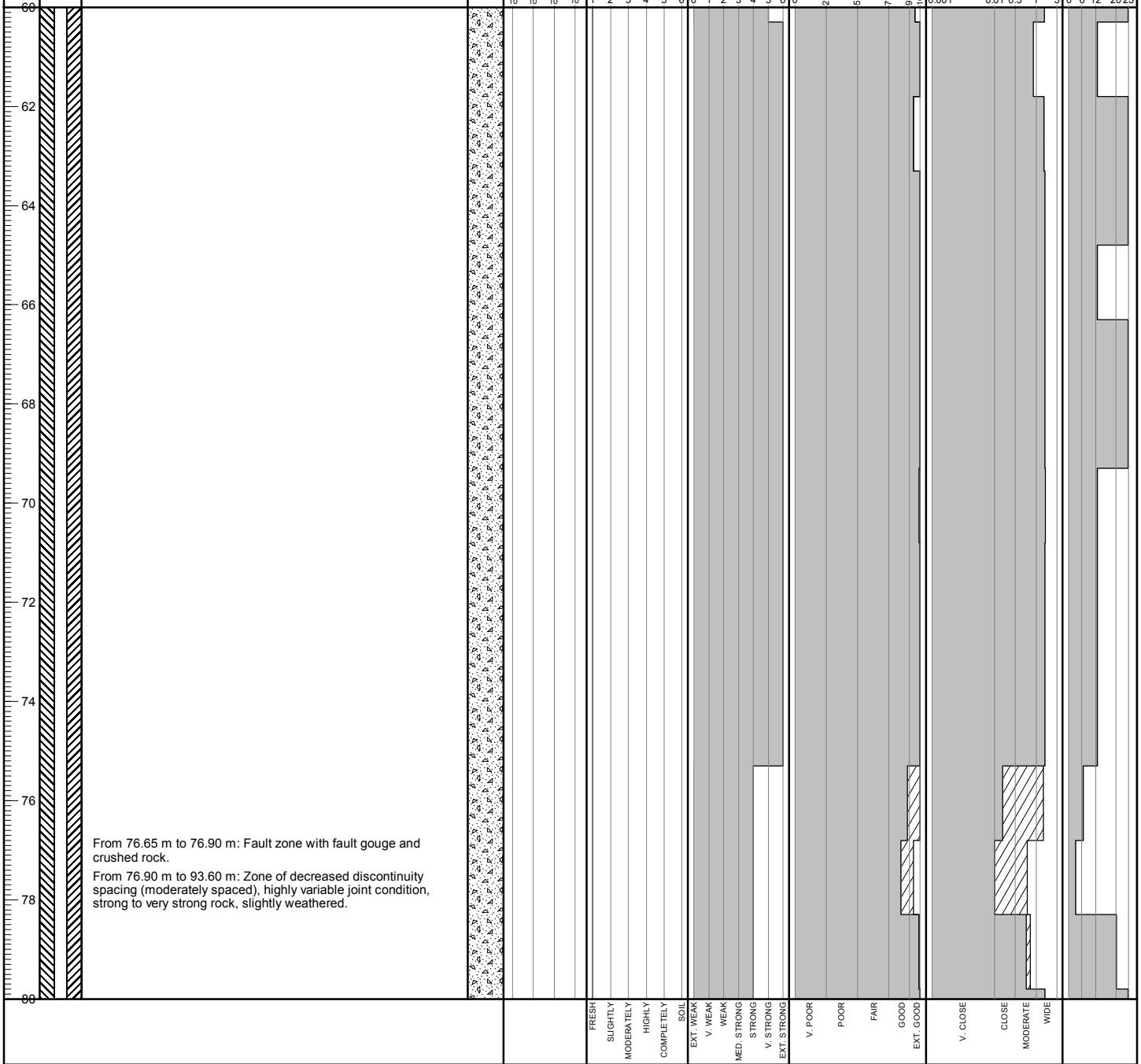

From 76.65 m to 76.90 m: Fault zone with fault gouge and crushed rock.

From 76.90 m to 93.60 m: Zone of decreased discontinuity spacing (moderately spaced), highly variable joint condition, strong to very strong rock, slightly weathered.

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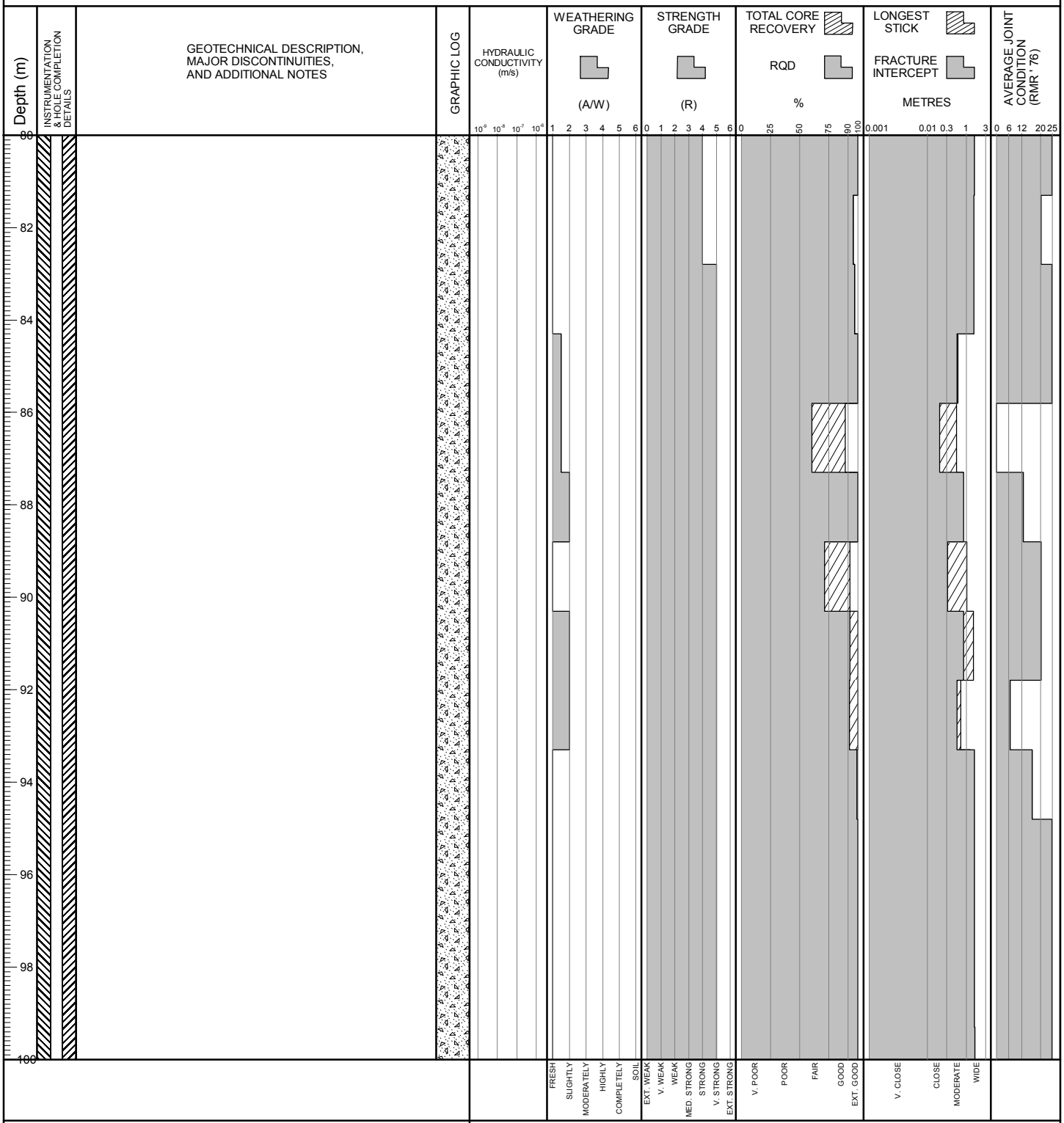

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029

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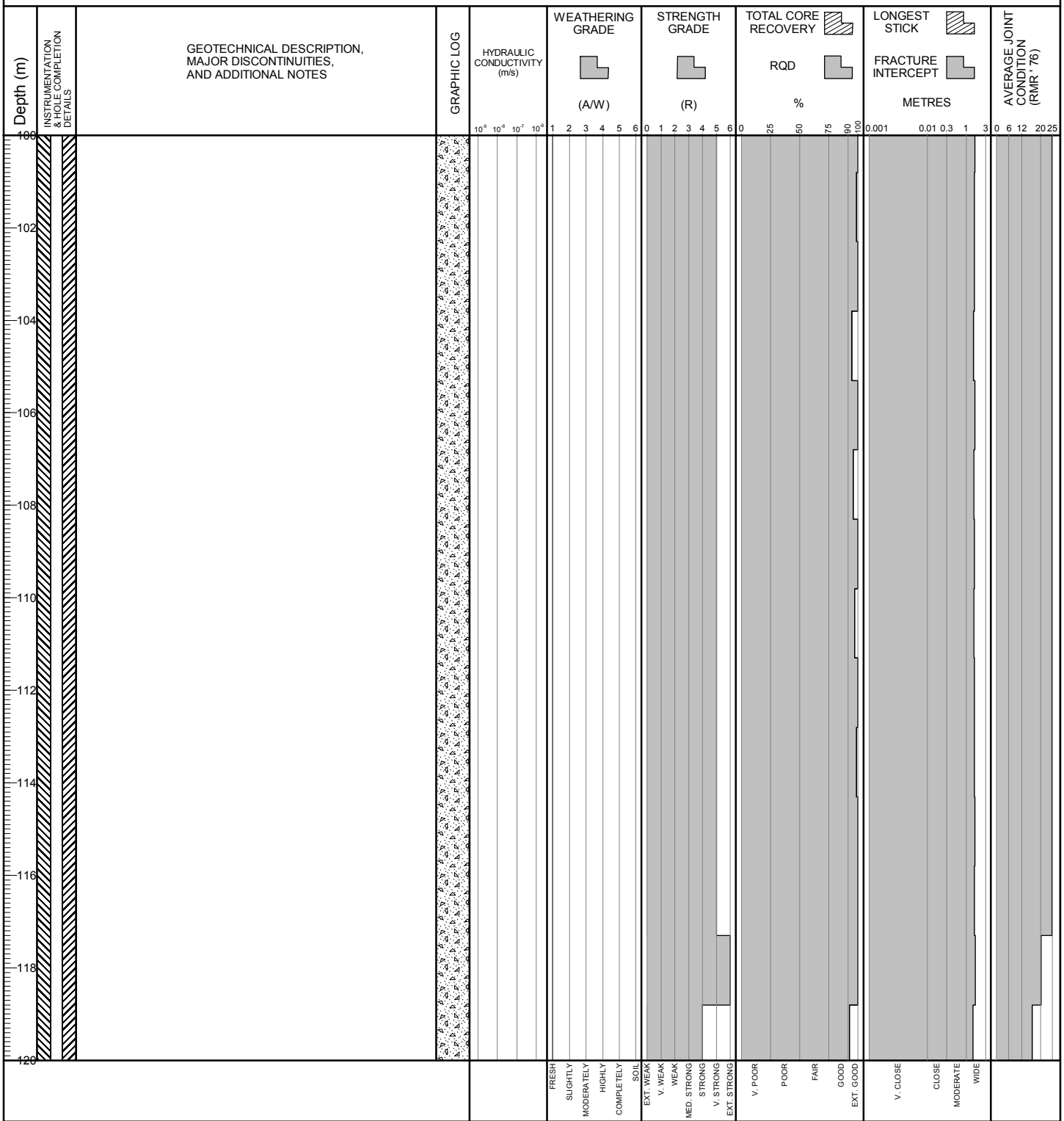

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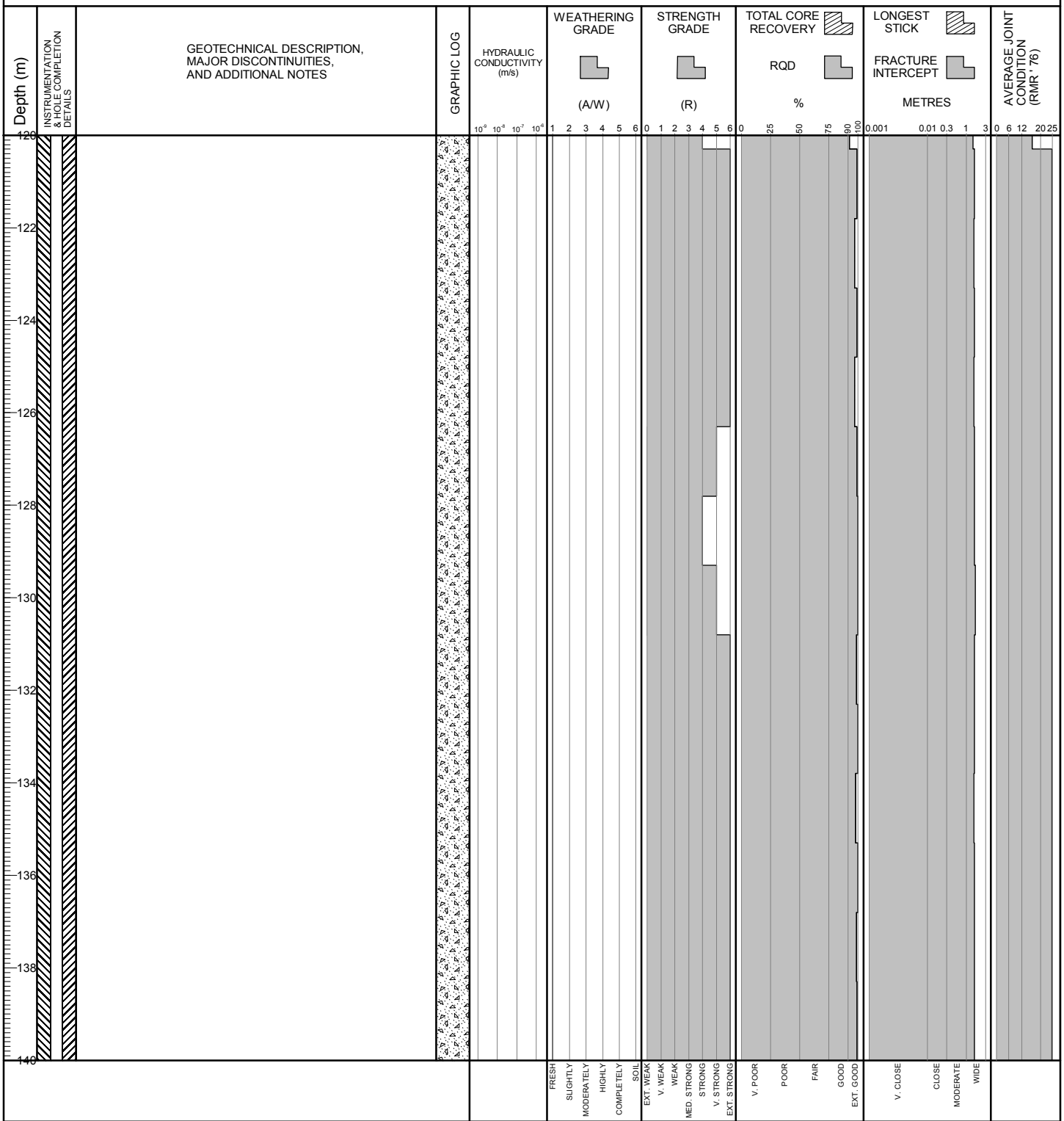

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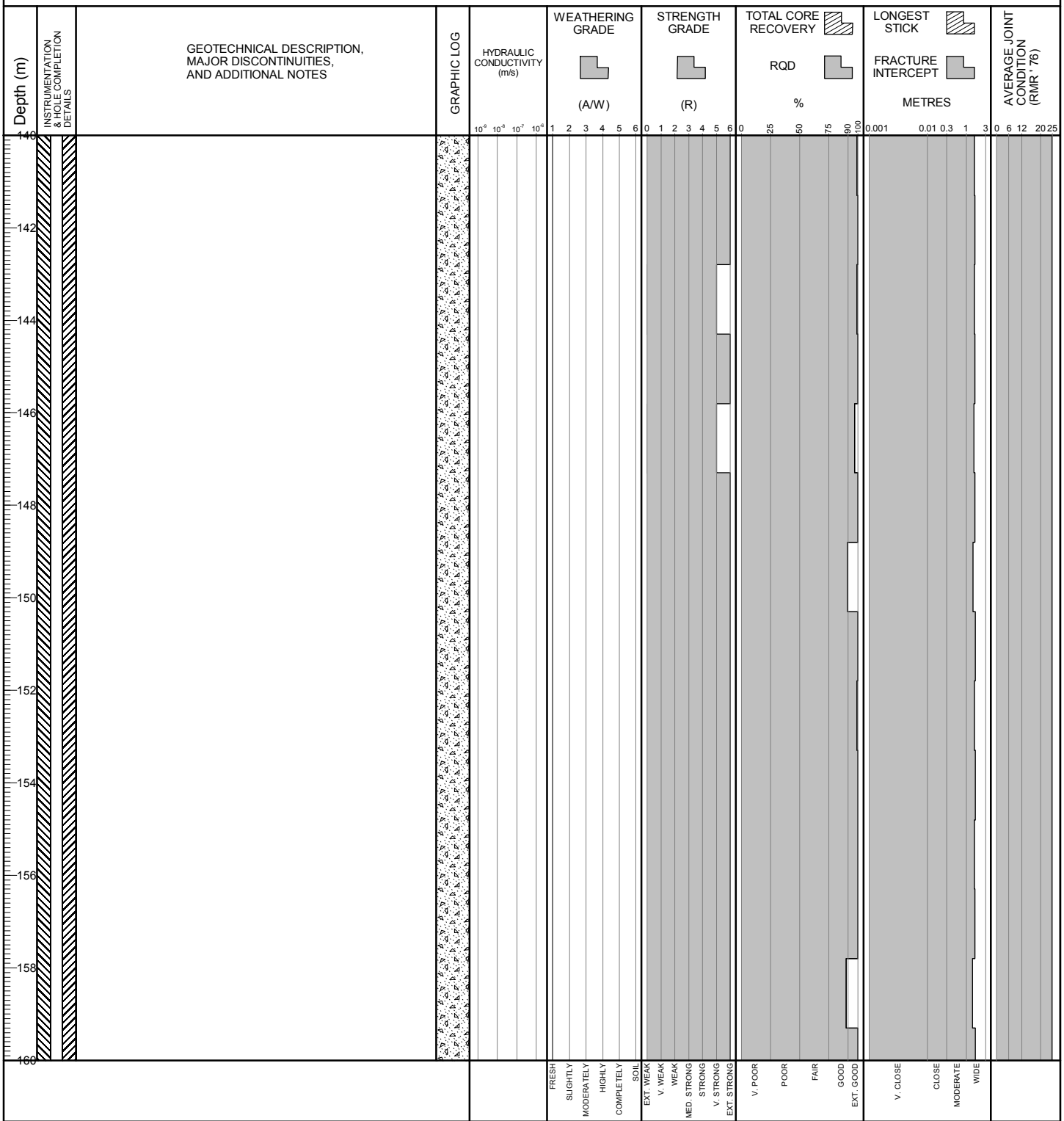

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Logged By: FP/KB
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes	Graphic Log	Hydraulic Conductivity (m/s)	Weathering Grade (A/W)	Strength Grade (R)	Total Core Recovery / RQD (%)	Longest Stick / Fracture Intercept (Metres)	Average Joint Condition (RMR' 76)
160		SANDSTONE/ARENITE [S4-Vsf] (160.00 m to 195.00 m) Light to medium green, fine to medium grained sandstone. Interbedded with intervals of polymictic conglomerate up to 1.5 m. Phyllic alteration. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite. Extremely strong, fresh.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
162									
164									
166									
168									
170									
172									
174									
176									
178									
180					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

Project No.: 1008-029 **Location:** Twin Towers

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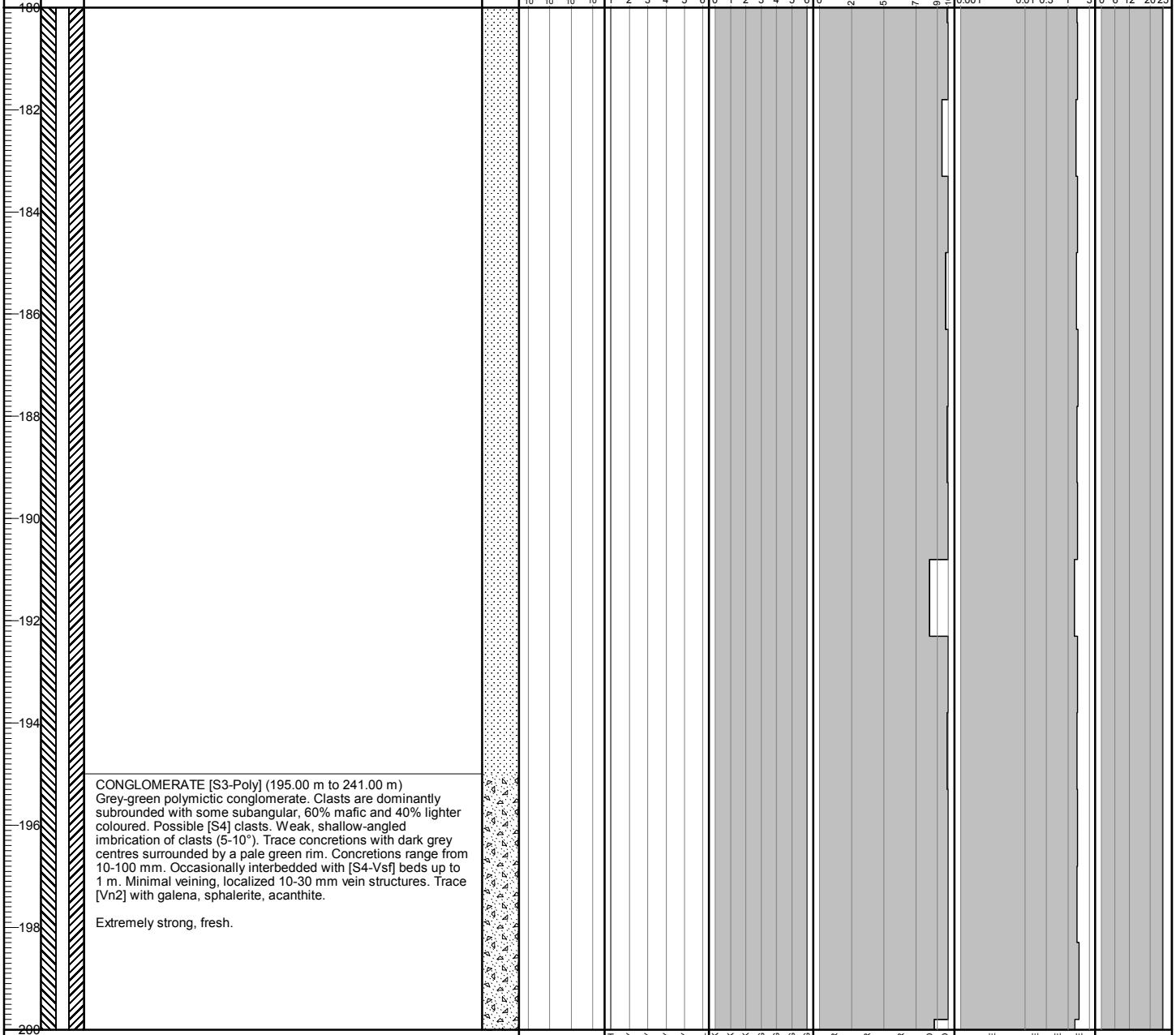
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



CONGLOMERATE [S3-Poly] (195.00 m to 241.00 m)
Grey-green polymictic conglomerate. Clasts are dominantly subrounded with some subangular, 60% mafic and 40% lighter coloured. Possible [S4] clasts. Weak, shallow-angled imbrication of clasts (5-10°). Trace concretions with dark grey centres surrounded by a pale green rim. Concretions range from 10-100 mm. Occasionally interbedded with [S4-Vsf] beds up to 1 m. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite.

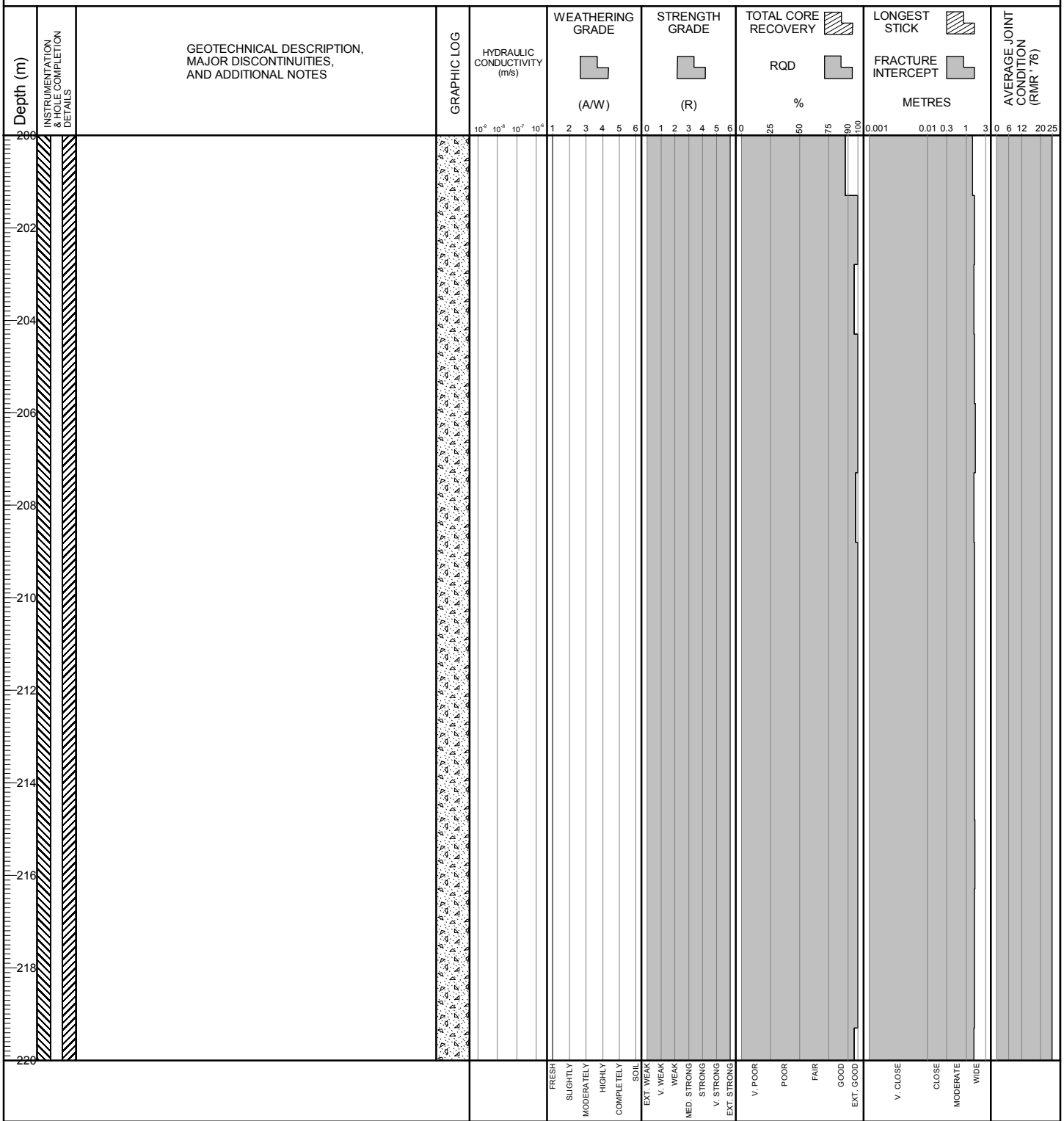
Extremely strong, fresh.

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

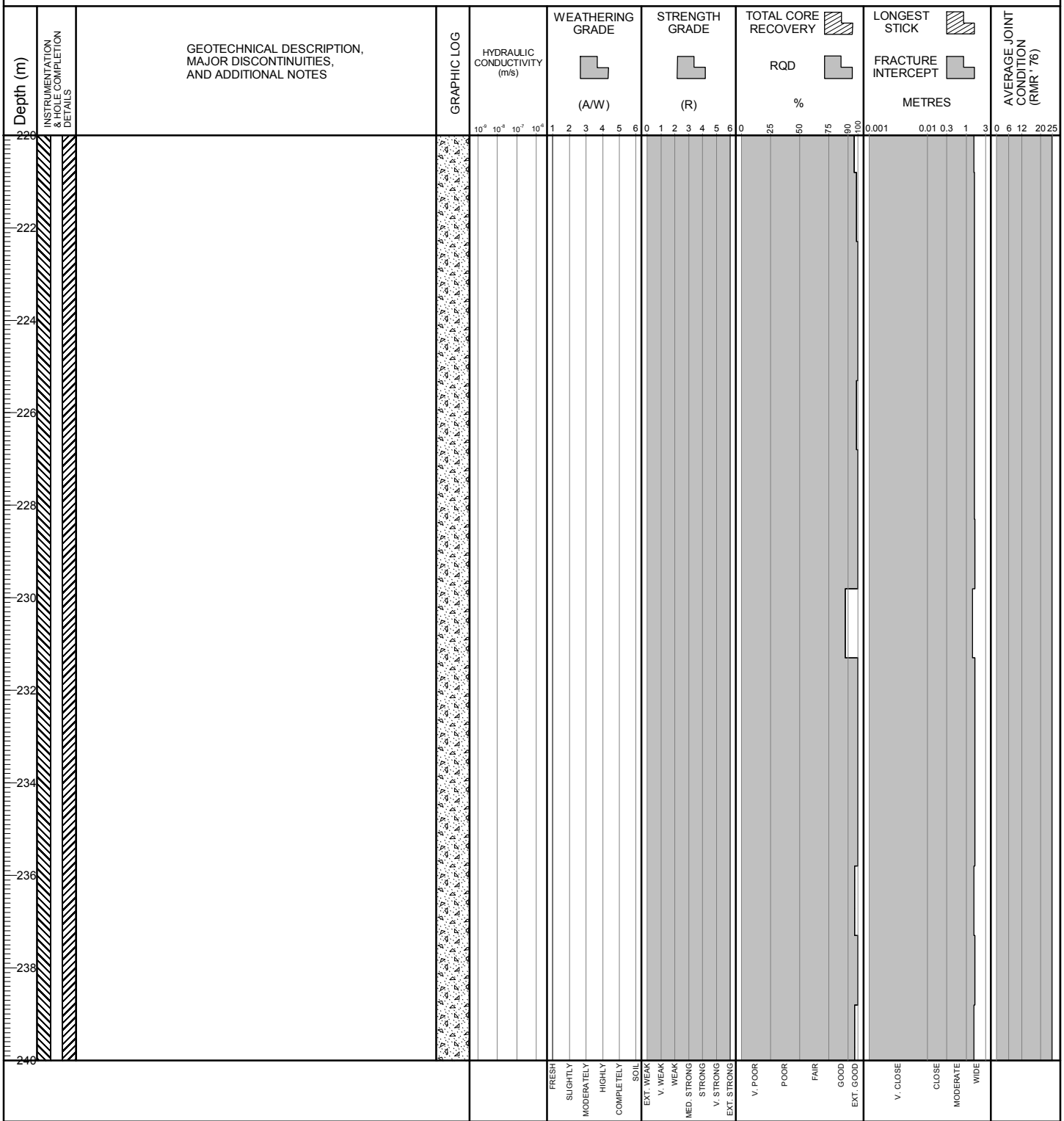
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

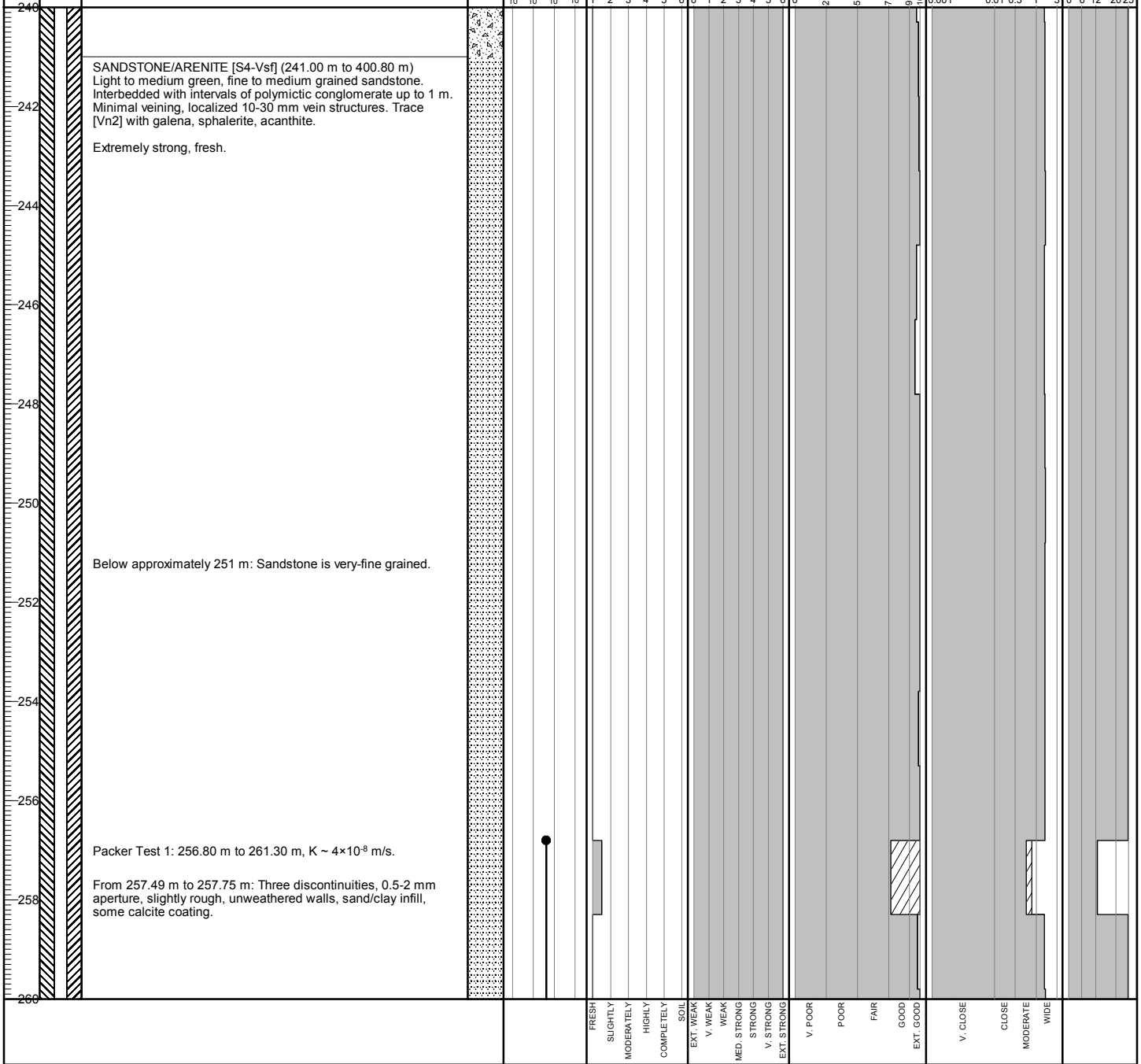
SANDSTONE/ARENITE [S4-Vsf] (241.00 m to 400.80 m)
Light to medium green, fine to medium grained sandstone. Interbedded with intervals of polymictic conglomerate up to 1 m. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite.

Extremely strong, fresh.

Below approximately 251 m: Sandstone is very-fine grained.

Packer Test 1: 256.80 m to 261.30 m, K ~ 4×10^{-8} m/s.

From 257.49 m to 257.75 m: Three discontinuities, 0.5-2 mm aperture, slightly rough, unweathered walls, sand/clay infill, some calcite coating.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 2: 292.80 m to 297.30 m, K ~ 2×10^{-8} m/s.

From 293.59 m to 293.87 m: Two discontinuities, 2 mm aperture, smooth, unweathered walls, clay and sand infill, calcite coatings, some shearing along veins.

Below approximately 295 m: No conglomerate interbeds.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD %	LONGEST STICK METRES / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
300				10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
302									
304									
306									
308									
310									
312									
314									
316									
318		From 317.80 m to 349.60 m: Slightly elevated veining with 0.5-2% veining overall. Veining is predominantly quartz-calcite [Vn3] veins with lesser [Vn1] generations. Sporadic [Vn0] and [Vn4] veins.							
320					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

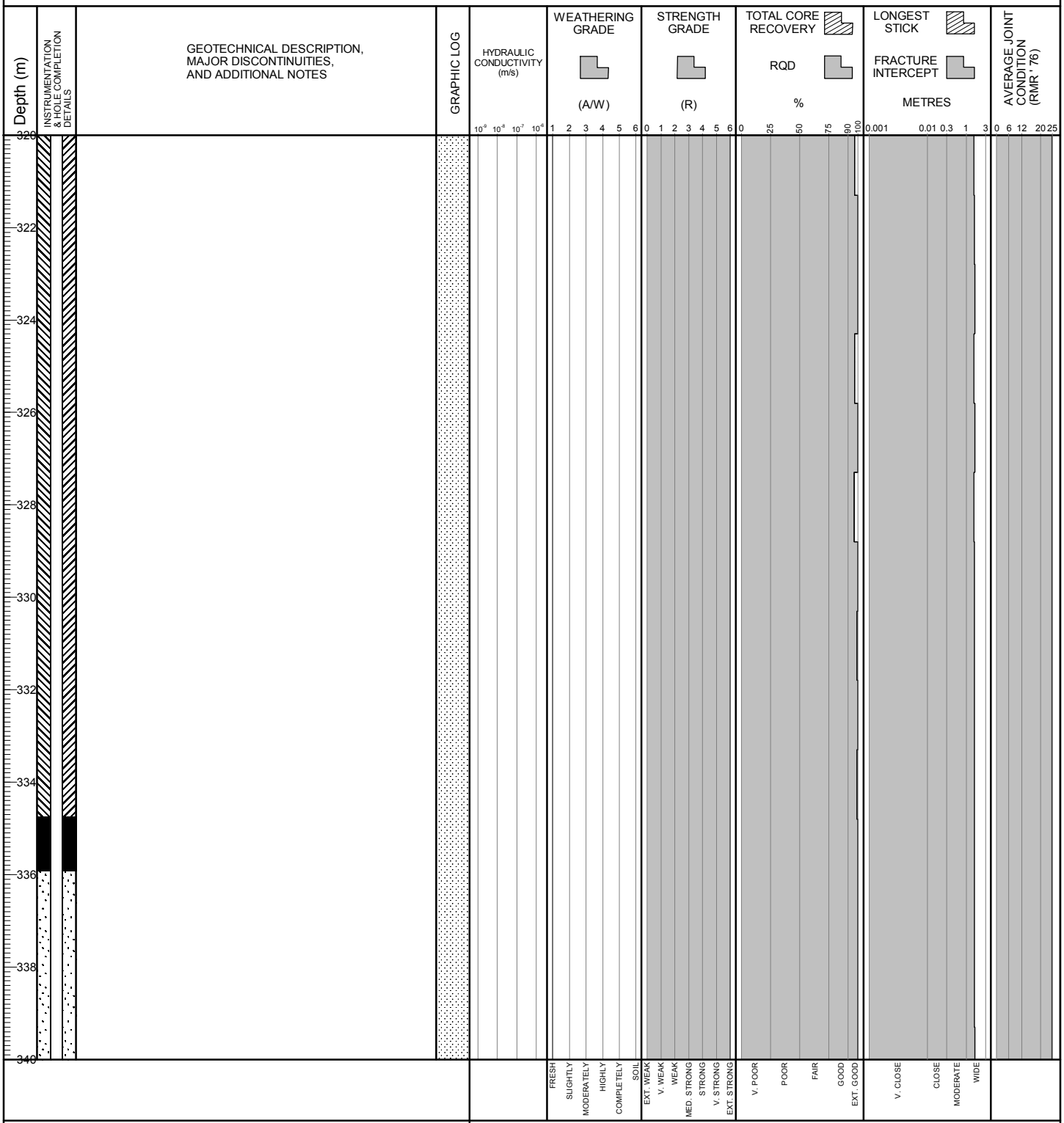
Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
340		
342		
344		
346		
348		
350		From 349.60 m to 383.85 m: Minimal veining 0-1%, localized 10-30 mm vein structures consisting of [Vn1] and [Vn3] veins with [Vn3] veins being slightly more dominant.
352		
354		
356		
358		
360		

Graphic Log

Hydraulic Conductivity (m/s): 10^{-9} 10^{-8} 10^{-7} 10^{-6}

Weathering Grade (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL

Strength Grade (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG

Total Core Recovery / RQD (%): 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90, 100 EXT. GOOD

Longest Stick / Fracture Intercept (METRES): 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1, 3 WIDE

Average Joint Condition (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
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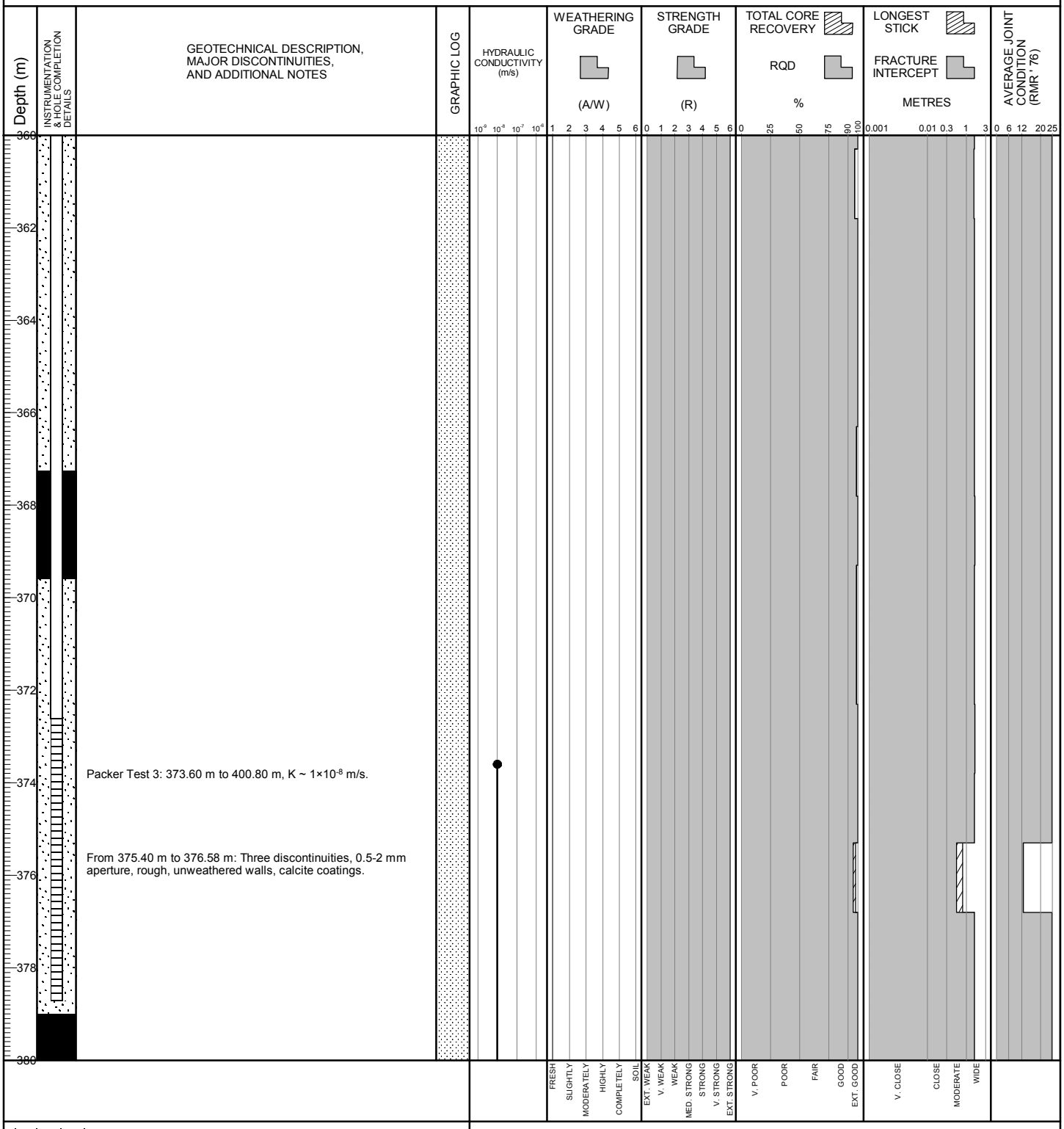


BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
380				10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
382									
384		Below 383.85 m: Zone of elevated veining (2-4%) that is predominantly quartz-calcite [Vn3] and quartz-calcite and chlorite [Vn4b] veins. Veins range from 5-80 mm in width.							
386									
388									
390									
392									
394									
396									
398									
400					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD %	LONGEST STICK METRES / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
400				10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
402		END OF HOLE at 400.80 m. NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 378.71 m to 372.61 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 379.00 m to 369.58 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 369.58 m to 367.24 m. 5) Unstabilized water level measured after piezometer installation on 2 July 2018 06:35 at 64.20 m bgs.								
404									
406									
408									
410									
412									
414									
416									
418									
420					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

FILL and OVERBURDEN (0.00 m to 3.80 m)

CONGLOMERATE [S3-Poly] (3.80 m to 91.92 m)
Grey-green polymictic conglomerate. Clasts are dominantly subrounded with some subangular, 60% mafic and 40% lighter coloured. Possible [S4] clasts. Weak, shallow-angled imbrication of the clasts (5-10°). Trace concretions with dark grey centres surrounded by a pale green rim. Concretions range from 10-100 mm. Phyllic alteration. Overall hole has weak veining with 0-1% veining consisting of 10-30 mm [Vn1a] and [Vn3] veinlets/veins. Veins are weakly deformed and occasionally have cuspate-lobate margins.

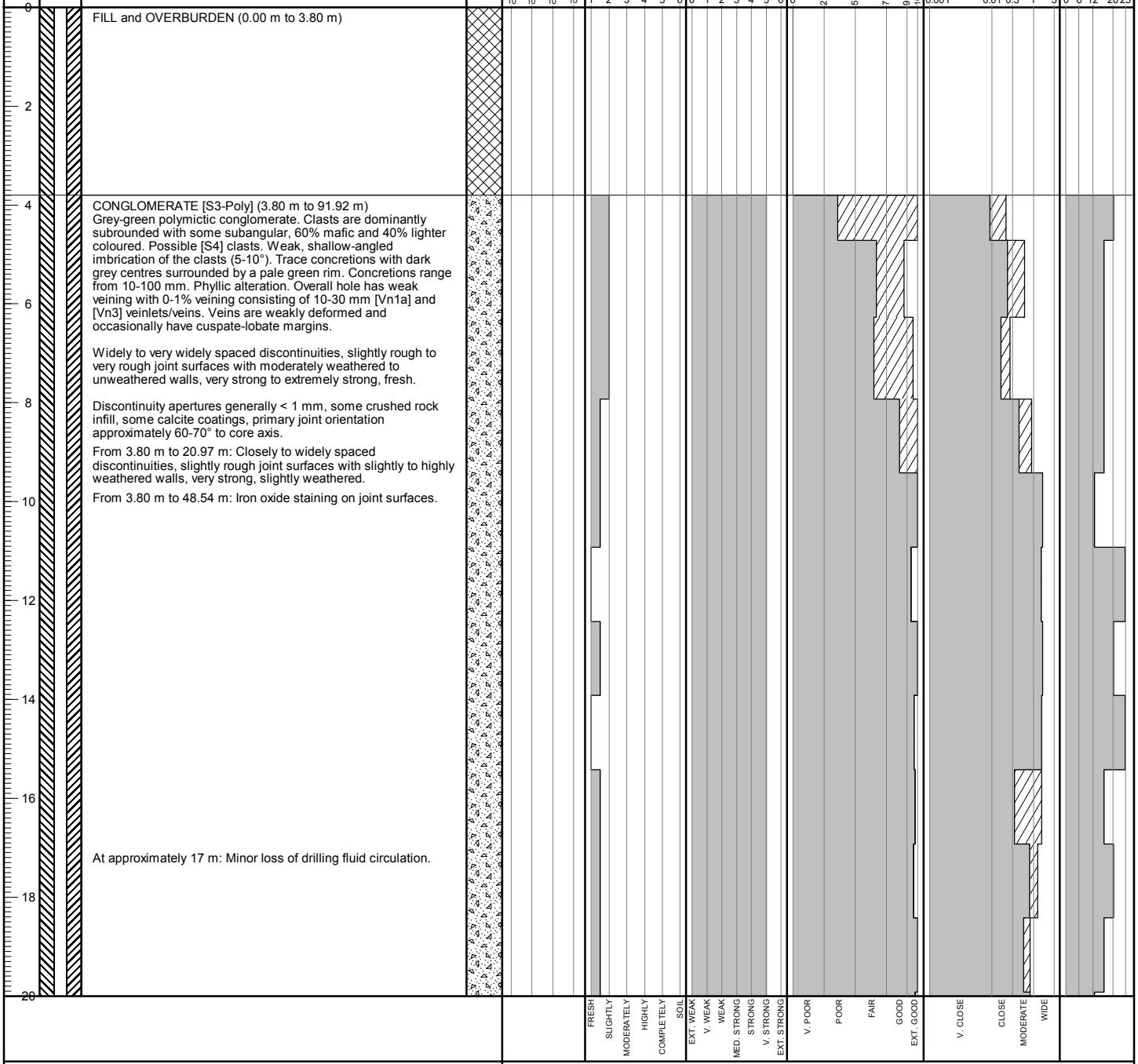
Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with moderately weathered to unweathered walls, very strong to extremely strong, fresh.

Discontinuity apertures generally < 1 mm, some crushed rock infill, some calcite coatings, primary joint orientation approximately 60-70° to core axis.

From 3.80 m to 20.97 m: Closely to widely spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, very strong, slightly weathered.

From 3.80 m to 48.54 m: Iron oxide staining on joint surfaces.

At approximately 17 m: Minor loss of drilling fluid circulation.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

Location: Twin Towers

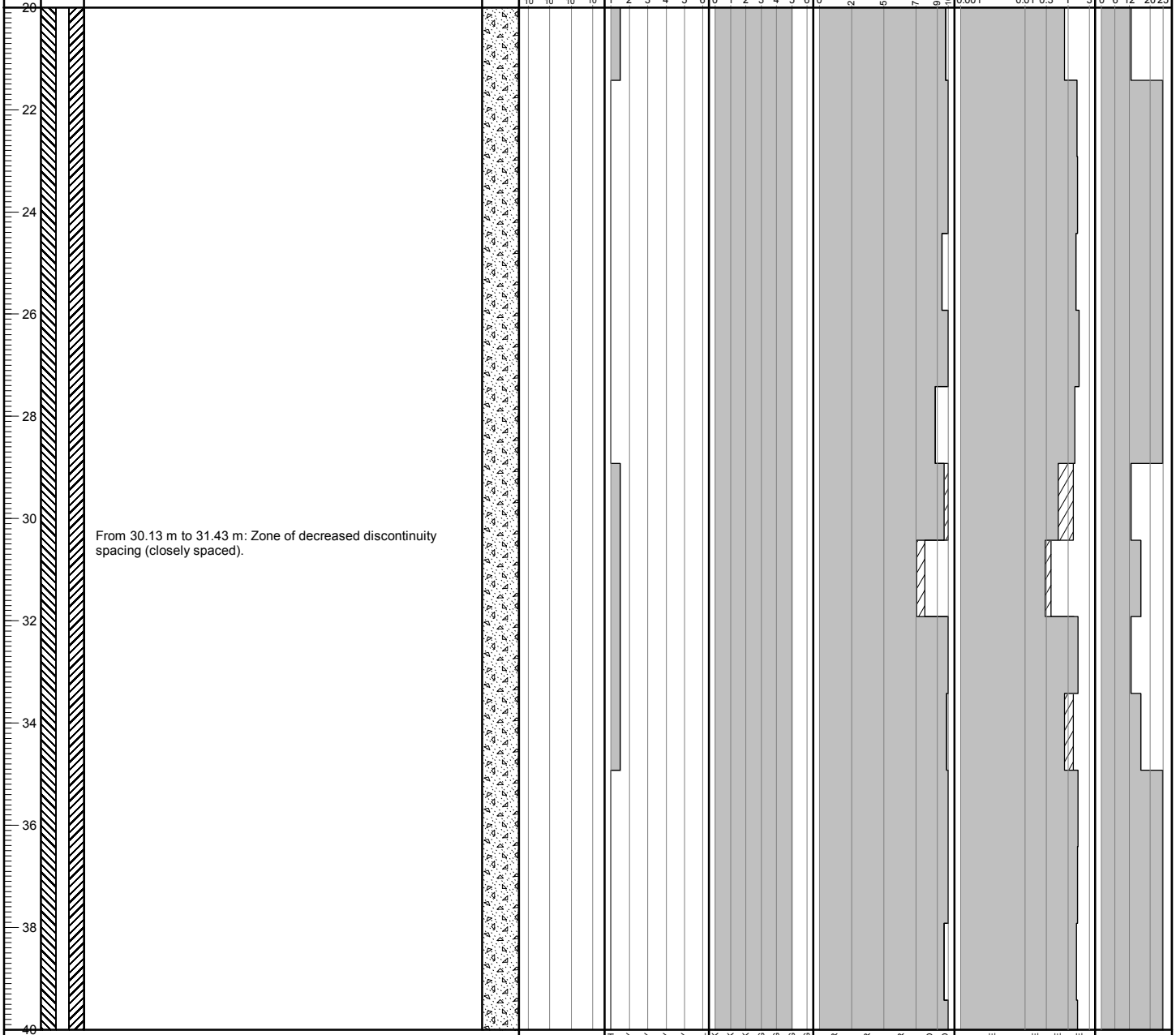
Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 30.13 m to 31.43 m: Zone of decreased discontinuity spacing (closely spaced).



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

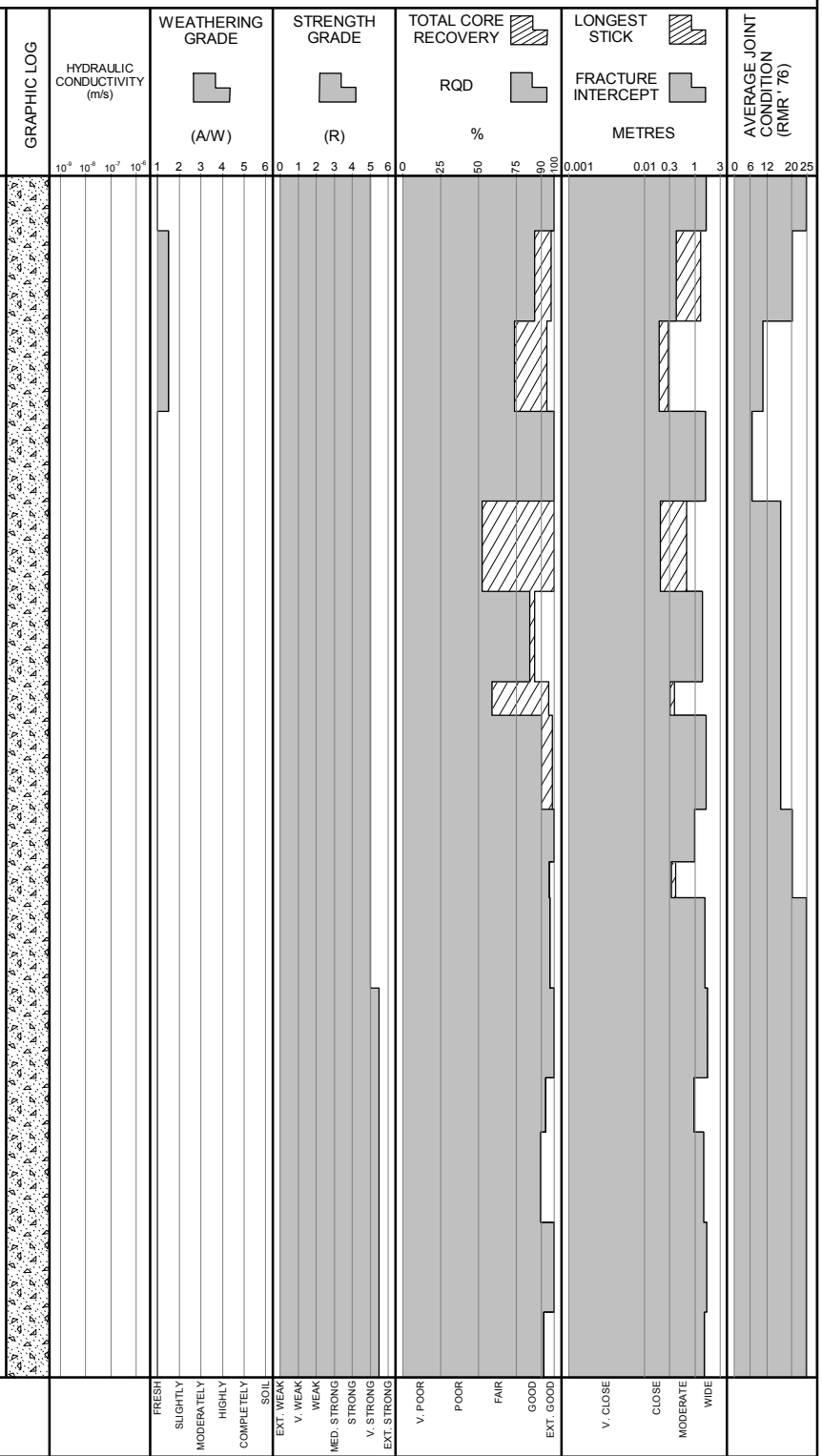
Location: Twin Towers

Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
40		
42		
44		From 43.48 m to 43.69 m: Fault, planar, gouge infill, 10 mm aperture. Zone of decreased discontinuity spacing (closely spaced) above and below fault.
46		
48		
50		
52		
54		
56		
58		
60		



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

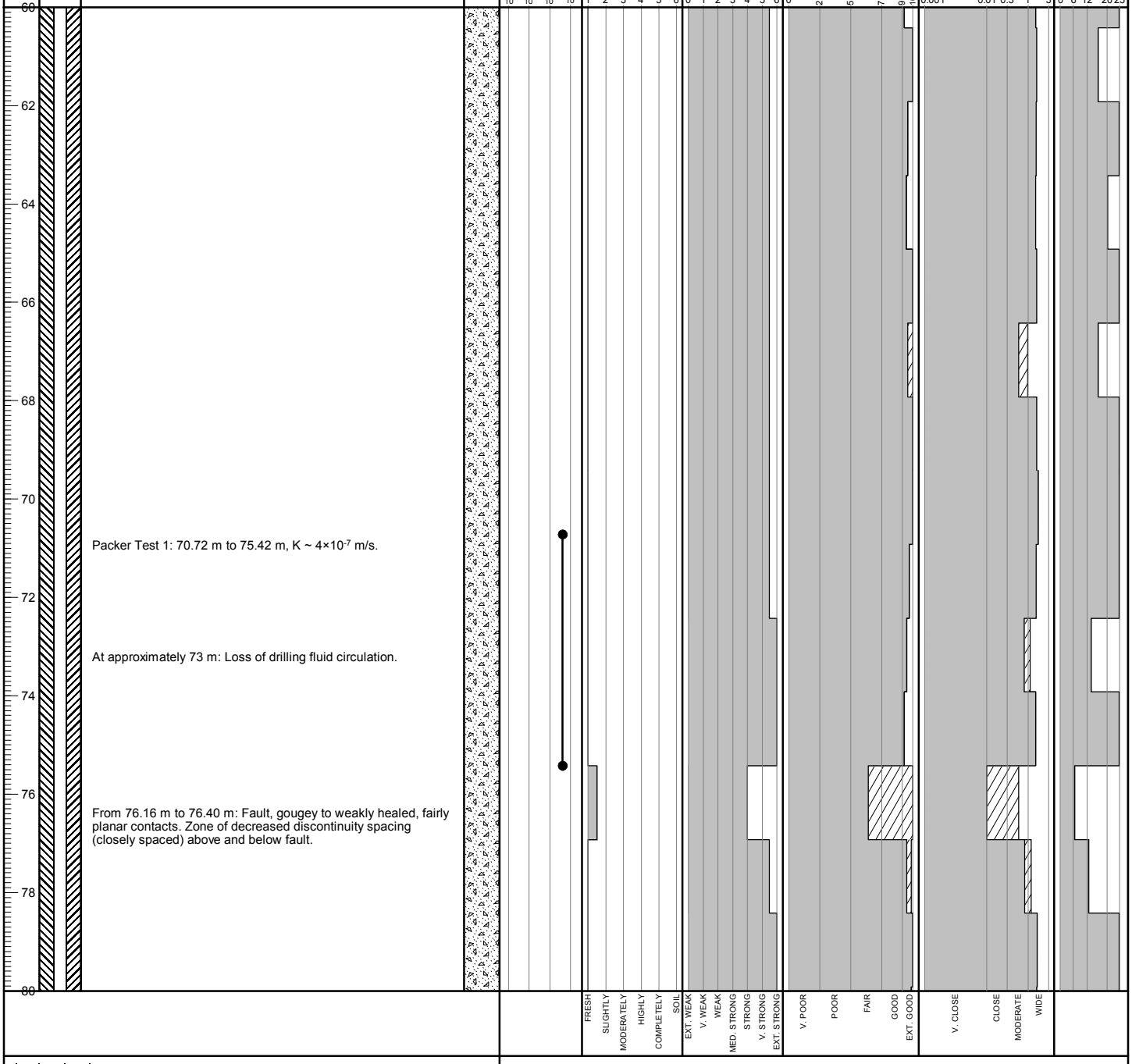
Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 1: 70.72 m to 75.42 m, K ~ 4×10^{-7} m/s.

At approximately 73 m: Loss of drilling fluid circulation.

From 76.16 m to 76.40 m: Fault, gougey to weakly healed, fairly planar contacts. Zone of decreased discontinuity spacing (closely spaced) above and below fault.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

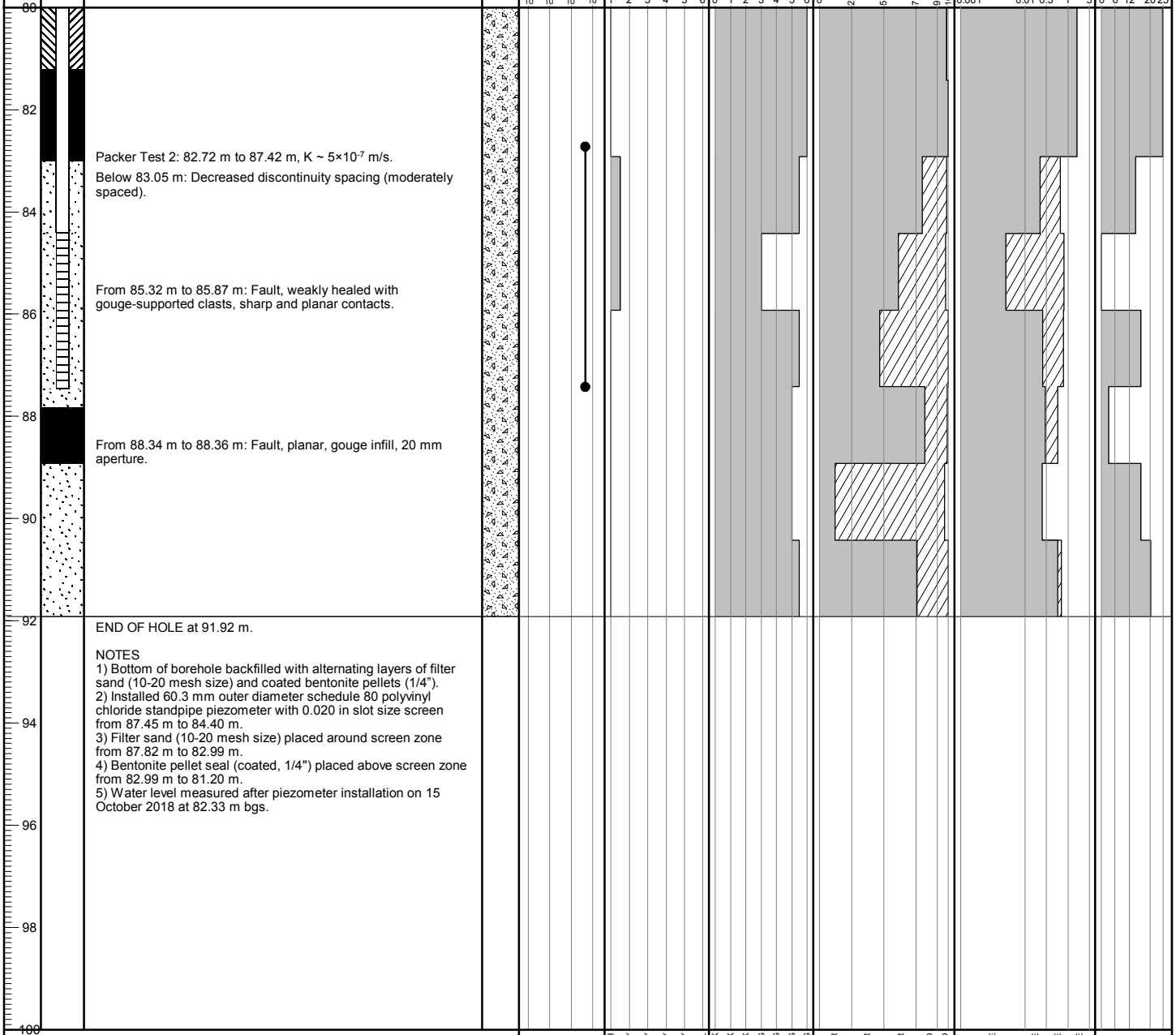
Location: Twin Towers

Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



END OF HOLE at 91.92 m.

NOTES
1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4").
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 87.45 m to 84.40 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 87.82 m to 82.99 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 82.99 m to 81.20 m.
5) Water level measured after piezometer installation on 15 October 2018 at 82.33 m bgs.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-23A

Project No.: 1008-029

Location: Contact Water Pond

Co-ordinates (m): 427,091E - 6,258,751N
Ground Elevation (m): 1,370.84
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.24

Start Date: 30 JUN 18
Finish Date: 01 JUL 18
Final Depth (m): 35.20
Depth To Top Of Rock (m): 2.96
Logged By: BM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

OVERBURDEN (0.00 m to 2.96 m)

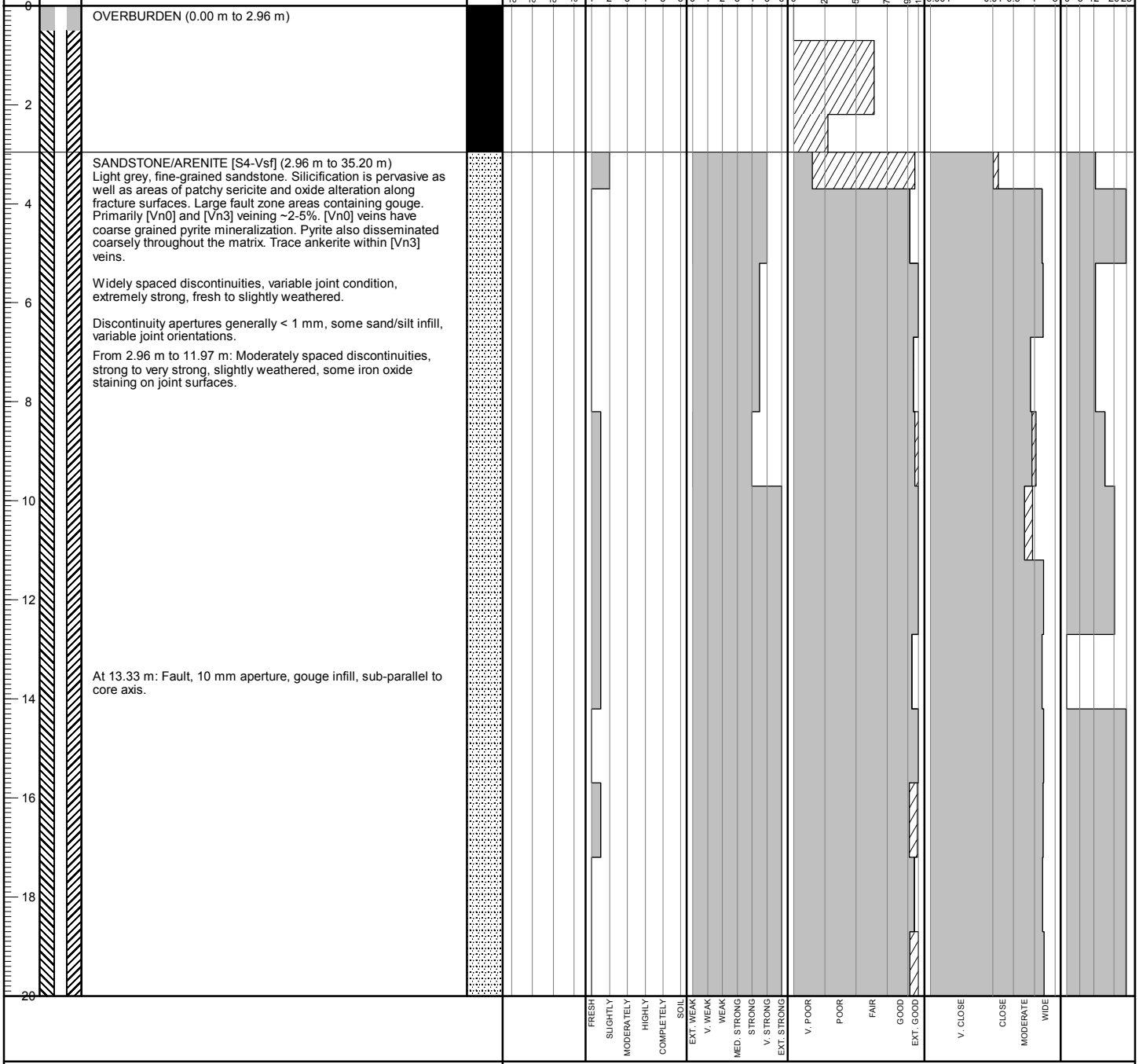
SANDSTONE/ARENITE [S4-Vsf] (2.96 m to 35.20 m)
Light grey, fine-grained sandstone. Silicification is pervasive as well as areas of patchy sericite and oxide alteration along fracture surfaces. Large fault zone areas containing gouge. Primarily [Vn0] and [Vn3] veining ~2-5%. [Vn0] veins have coarse grained pyrite mineralization. Pyrite also disseminated coarsely throughout the matrix. Trace ankerite within [Vn3] veins.

Widely spaced discontinuities, variable joint condition, extremely strong, fresh to slightly weathered.

Discontinuity apertures generally < 1 mm, some sand/silt infill, variable joint orientations.

From 2.96 m to 11.97 m: Moderately spaced discontinuities, strong to very strong, slightly weathered, some iron oxide staining on joint surfaces.

At 13.33 m: Fault, 10 mm aperture, gouge infill, sub-parallel to core axis.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-23A

Project No.: 1008-029

Location: Contact Water Pond

Co-ordinates (m): 427,091E - 6,258,751N
Ground Elevation (m): 1,370.84
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.24

Start Date: 30 JUN 18
Finish Date: 01 JUL 18
Final Depth (m): 35.20
Depth To Top Of Rock (m): 2.96
Logged By: BM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

At 20.75 m: Fault, 80 mm aperture, along vein, sub-parallel to core axis.

Packer Test 2: 26.00 m to 35.20 m, K ~ 1×10^{-8} m/s.

At 27.05 m: Fault, 5 mm aperture, gouge infill.

Packer Test 1: 30.50 m to 35.20 m, K ≤ 10^{-8} m/s.

Below 32.08 m: Zone of decreased discontinuity spacing (moderately spaced), some clay infill.

END OF HOLE at 35.20 m.

NOTES
1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4").
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 28.96 m to 25.91 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 29.70 m to 25.32 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 25.32 m to 24.04 m.
5) Water level measured after piezometer installation on 4 July 2018 at 4.07 m bgs.

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-23B

Project No.: 1008-029

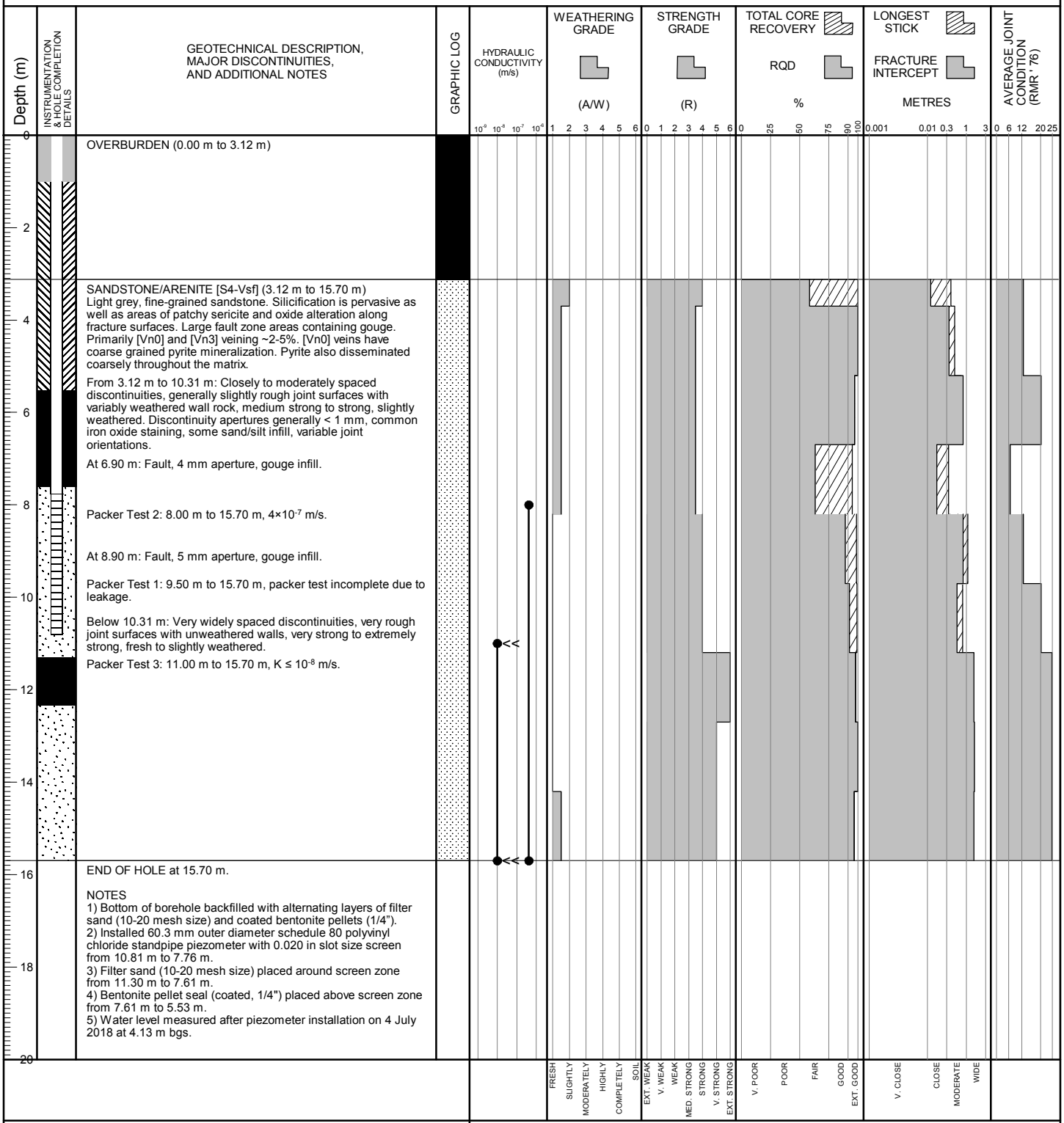
Location: Contact Water Pond

Co-ordinates (m): 427,091E - 6,258,752N
Ground Elevation (m): 1,370.81
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.30

Start Date: 01 JUL 18
Finish Date: 01 JUL 18
Final Depth (m): 15.70
Depth To Top Of Rock (m): 3.12
Logged By: BM/LS
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
0		OVERBURDEN (0.00 m to 3.12 m)
3.12		SANDSTONE/ARENITE [S4-Vsf] (3.12 m to 15.70 m) Light grey, fine-grained sandstone. Silicification is pervasive as well as areas of patchy sericite and oxide alteration along fracture surfaces. Large fault zone areas containing gouge. Primarily [Vn0] and [Vn3] veining ~2-5%. [Vn0] veins have coarse grained pyrite mineralization. Pyrite also disseminated coarsely throughout the matrix. From 3.12 m to 10.31 m: Closely to moderately spaced discontinuities, generally slightly rough joint surfaces with variably weathered wall rock, medium strong to strong, slightly weathered. Discontinuity apertures generally < 1 mm, common iron oxide staining, some sand/silt infill, variable joint orientations. At 6.90 m: Fault, 4 mm aperture, gouge infill. Packer Test 2: 8.00 m to 15.70 m, 4×10^{-7} m/s. At 8.90 m: Fault, 5 mm aperture, gouge infill. Packer Test 1: 9.50 m to 15.70 m, packer test incomplete due to leakage. Below 10.31 m: Very widely spaced discontinuities, very rough joint surfaces with unweathered walls, very strong to extremely strong, fresh to slightly weathered. Packer Test 3: 11.00 m to 15.70 m, $K \leq 10^{-8}$ m/s.
15.70		END OF HOLE at 15.70 m. NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 10.81 m to 7.76 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 11.30 m to 7.61 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 7.61 m to 5.53 m. 5) Water level measured after piezometer installation on 4 July 2018 at 4.13 m bgs.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.2	INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, grey, minor hydrothermal breccias (H15), moderate to strong phyllic/QSP alteration.
2.14	At 2.14m - Joint, 4mm aperture, with surface staining
2.18	At 2.18m - Joint, 1mm aperture, with surface staining
2.75	At 2.75m - Joint, 1mm aperture, with surface staining
4.52	At 4.52m - Joint, 4mm aperture, with surface staining
5.4	TRANSITIONAL UNIT BETWEEN POLYLITHIC CONGLOMERATE (S3-Poly) and INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine to coarse grained, grey, minor hydrotehermal breccias (H15), moderate to strong phyllic/QSP alteration.
5.51	At 5.51m - Joint, 1mm aperture, with surface staining
5.94	At 5.94m - Joint (curved), 1mm aperture, with surface staining
6.22	At 6.22m - Joint, 1mm aperture, with surface staining
6.38	At 6.38m - Joint, 1mm aperture, with surface staining
7.65	At 7.65m - Joint, 1mm aperture, with surface staining
8	

Columns: Depth (m); Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Geotechnical Description, Major Discontinuities, and Additional Notes; Graphic Log; Weathering Grade (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept Metres 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N	**Drill Designation:** Heliportable	**Start Date:** 02 JUL 16
Ground Elevation (m): 1,376.9	**Drilling Contractor:** HY TECH	**Finish Date:** 03 JUL 16
Survey Method: Surveyed coordinates	**Drill Method:** DIAMOND CORING	**Final Depth (m):** 27.4
Datum: UTM NAD 83 Zone 9	**Core:** PQ	**Depth To Top Of Rock (m):** 1.2
Plunge (°): -90	**Fluid:** Polymer	**Logged By:** JRW, SH
Trend (°): 000	**Cased To (m) :** 1.2	**Reviewed By:** TWC

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES:

At 8.05m - Joint, 1mm aperture, with surface staining

At 9.65m - Joint, 1mm aperture, with orange brown staining

At 9.71 m - Joint, 1mm aperture, with trace light brown clay infill

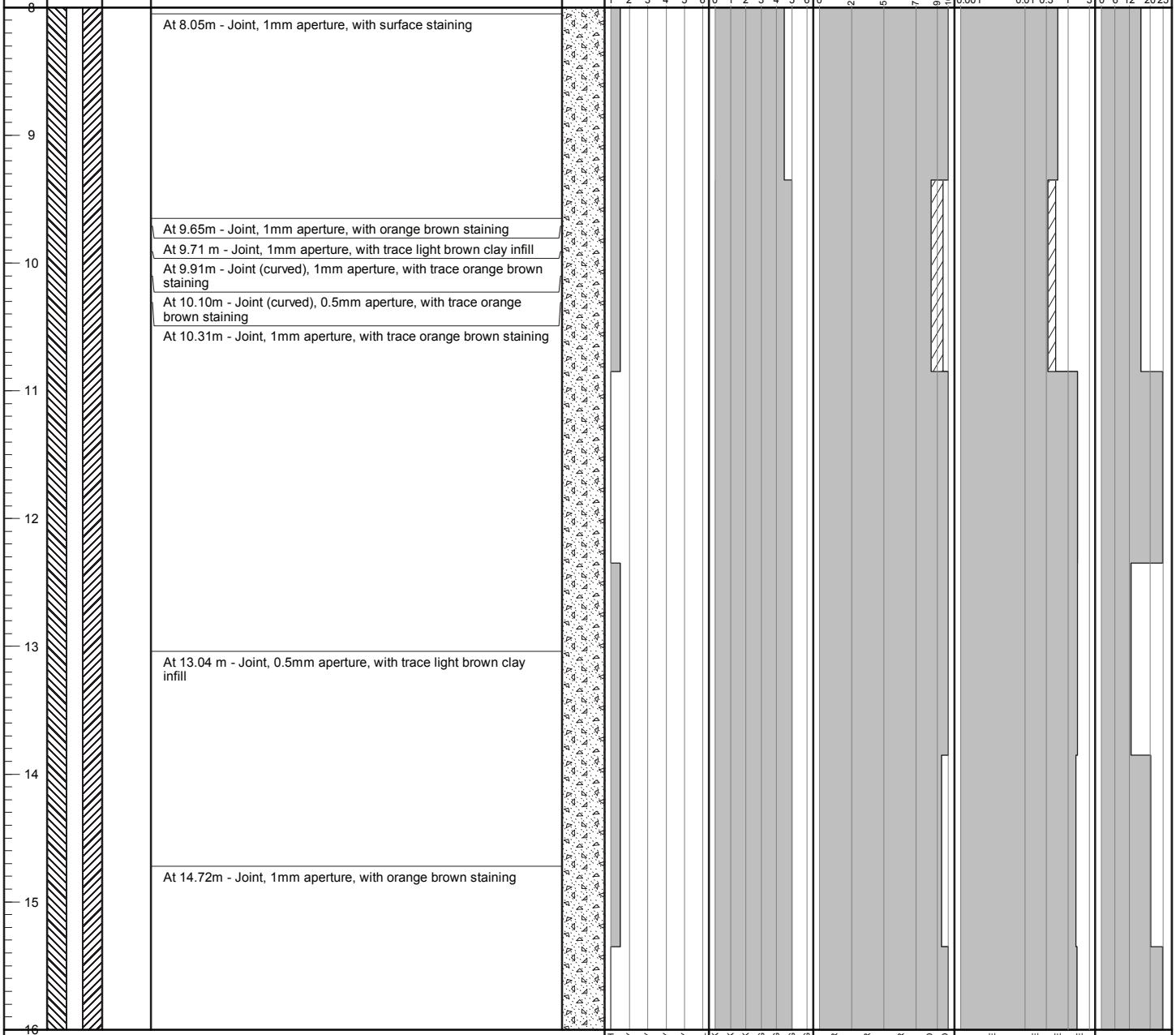
At 9.91m - Joint (curved), 1mm aperture, with trace orange brown staining

At 10.10m - Joint (curved), 0.5mm aperture, with trace orange brown staining

At 10.31m - Joint, 1mm aperture, with trace orange brown staining

At 13.04 m - Joint, 0.5mm aperture, with trace light brown clay infill

At 14.72m - Joint, 1mm aperture, with orange brown staining



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack 2016-2017
Project No.: 1008-022

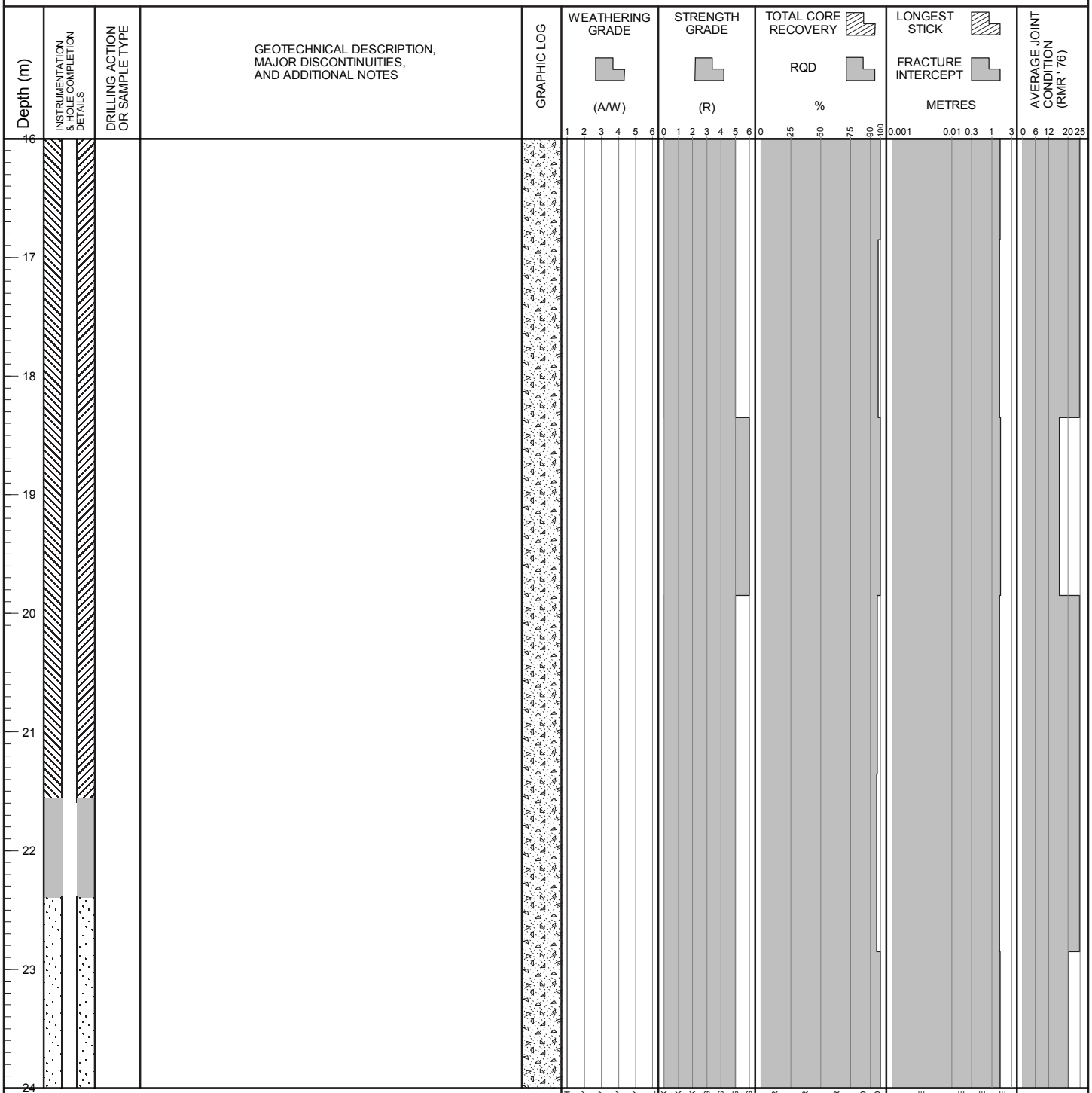
DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

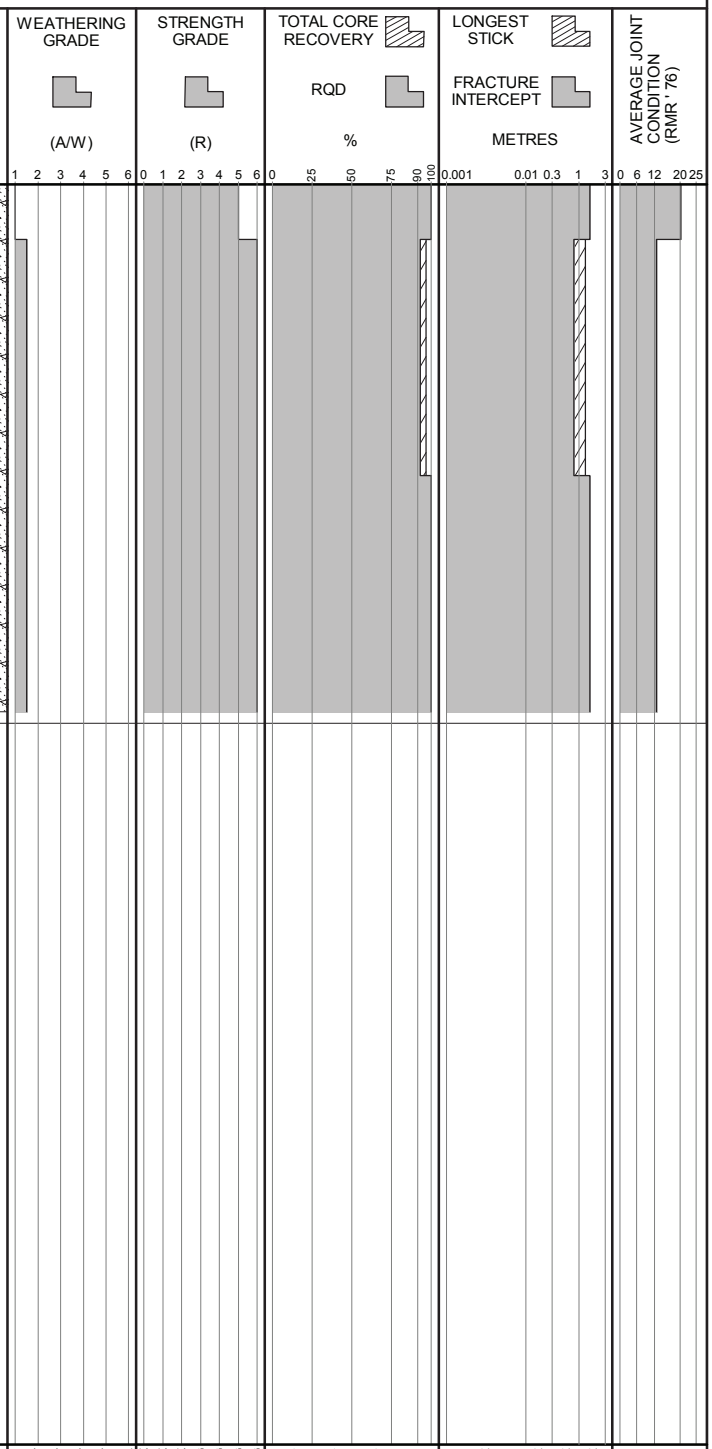
Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
24				
			At 24.53 m - Joint, 1mm aperture, with trace light brown clay infill	
			At 24.57 m - Joint, 1mm aperture, with trace white grey clay infill	
25				
26				
			At 26.70m - Joint (on vein), 1mm aperture, with orange staining	
27				
			END OF HOLE AT: 27.42 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 24.37 to 27.42 m on July 3, 2016. 2) Filter sand placed around screen zone from 22.39 to 27.42 m. 3) Lithology descriptions by Pretium geologists.	
28				
29				
30				
31				
32				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01B

Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.37	INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, light grey, weak to moderate phyllic/QSP alteration.
1.37	At 1.37 m - Joint, 5mm aperture, with coarse sand infill and staining on joint surfaces
1.50	At 1.50m - Joint (stepped), 1mm aperture, with staining on surfaces
2.03	At 2.03m - Joint (undulating smooth), 1mm aperture, with surface staining
3.27	At 3.27m - Joint (rough planar), 1mm aperture, with surface staining
4.00	At 4.00 m - Joint, 3mm aperture, with sand infill and staining on joint surfaces
4.20	At 4.20m - Joint, 1mm aperture, with surface staining
4.53	At 4.53m - Joint (curved), 1mm aperture, with surface staining
4.64	At 4.64 m - Joint, 1mm aperture, with sand infill and staining on joint surfaces
5.70	At 5.70m - Joint, 1mm aperture, with surface staining
5.75	At 5.75 m - Joint, 4mm aperture, with staining on joint surfaces

Columns: Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Graphic Log; Weathering Grade (A/W) — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD (%) — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept (metres) — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76)

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-01B

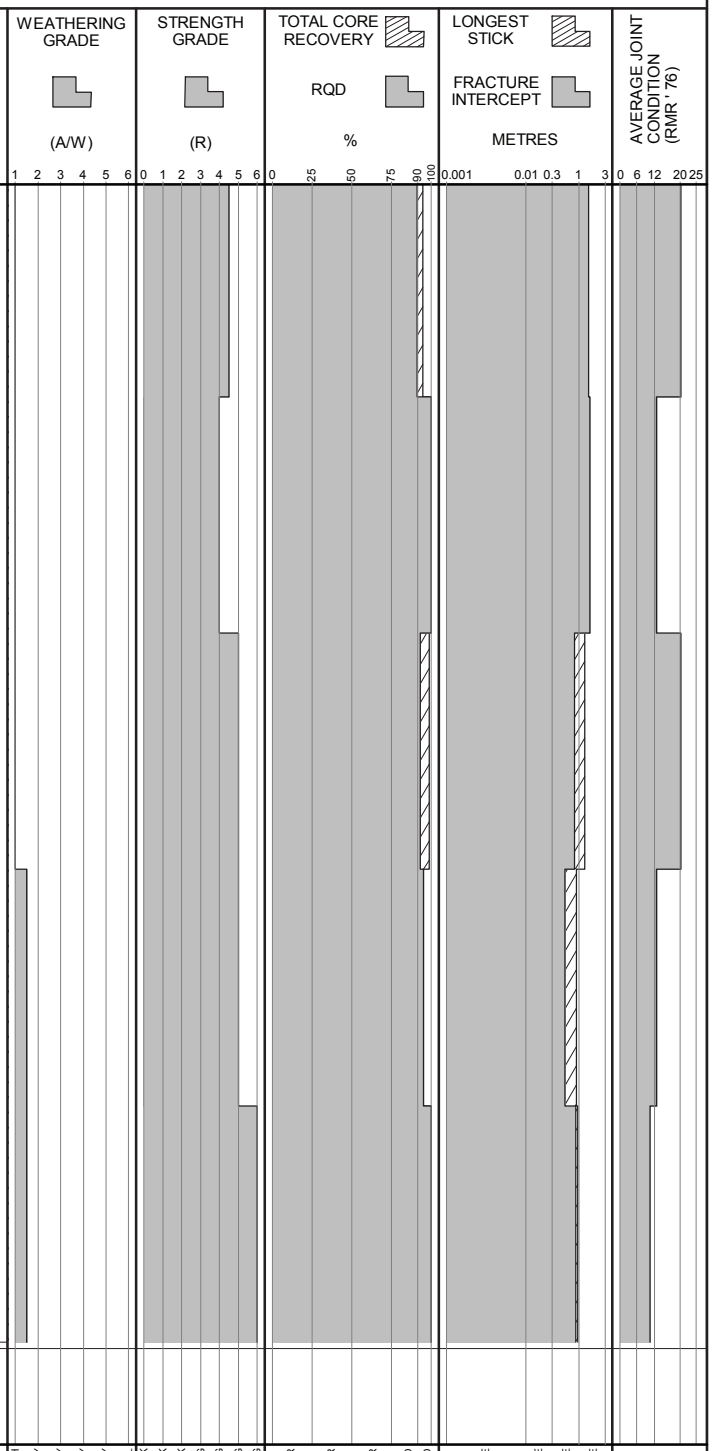
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
			At 10.58 m - Joint (on vein), 0.5mm aperture, with trace grey clay infill
11			
12			
			At 12.41 m - Joint, 1mm aperture, with grey clay infill
13			
14			
			At 14.47 m - Joint, 1mm aperture, with grey clay infill, yellow brown staining, dark brown staining
15			
			At 15.34 m - Joint, aperture unknown (second half of joint not recovered) with grey white clay infill
			END OF HOLE AT: 15.39 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-01B

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR' 76) 0 6 12 20 25
16			slotted screen from 13.87 to 15.37 m on July 7, 2016. 2) Filter sand placed around screen zone from 13.44 to 15.37 m. 3) Lithology descriptions by Pretium geologists.						
17									
18									
19									
20									
21									
22									
23									
24									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02A

Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.2	INTERMEDIATE VOLCANICS (V4) Medium grained, greenish blue, pyroclastic, weak to moderate chlorite-sericite alteration.
	At 1.30m - Joint, 0.5mm aperture, with dark brown stain
	At 1.36m - Joint, 0.5mm aperture, with dark brown stain
	At 1.40m - Joint, 1mm aperture, with dark brown stain
	At 1.52m - Joint, 1mm aperture, with dark brown stain
	At 1.70 - Joint, 1mm aperture, with dark brown stain
	At 2.03 m - Joint, 2mm aperture, with trace orange brown clay infill
	At 2.30m - Joint, 1mm aperture, with dark brown stain
	At 2.37m - Joint, 1.5mm aperture, with dark brown stain
	At 2.49 m - Joint, 0.5mm aperture, with trace orange brown clay infill
	At 2.73 m - Joint, 1mm aperture, with trace orange brown clay infill
	At 3.00 m - Fault, 220mm aperture, with fault gouge and broken rock infill. Circulation lost during drilling.
	At 3.48 m - Joint, 1mm aperture, with trace dark brown clay infill
	At 5.21m - Joint, 1mm aperture, with dark brown stain
	At 7.11 m - Joint, 1mm aperture, with trace light brown clay infill
8	

Columns: Depth (m); Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Geotechnical Description, Major Discontinuities, and Additional Notes; Graphic Log; Weathering Grade (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept Metres 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-02A

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			At 10.08 m - Joint, 1mm aperture, with trace white grey clay infill
11			
12			At 11.89 m - Joint, 1mm aperture, with trace white clay infill
13			At 12.80 m - Joint, 1mm aperture, with trace white clay infill
14			At 14.14 m - Joint, 0.5mm aperture, with trace white grey clay infill
15			At 15.57 m - Joint, 1mm aperture, with trace grey clay infill
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02A

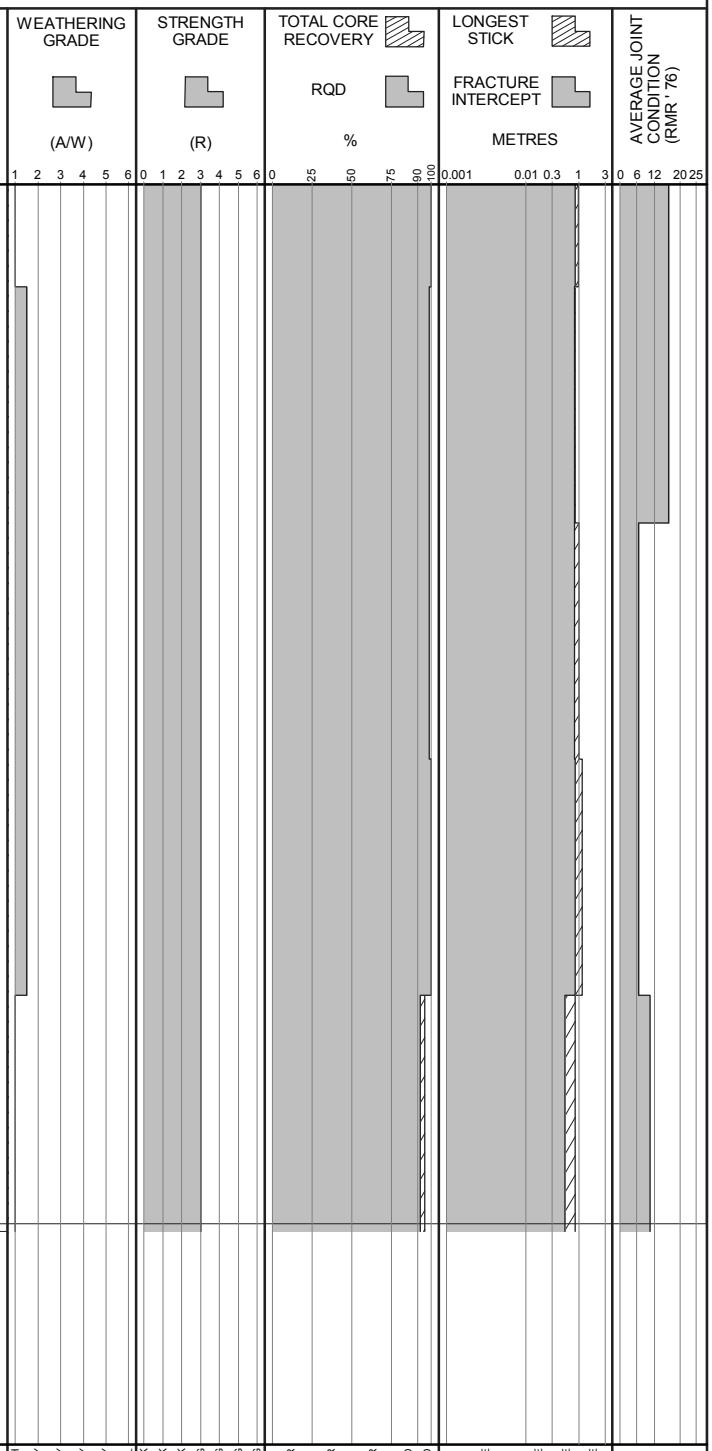
Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
			At 16.77 m - Joint, 1mm aperture, with trace white grey clay infill
17			
			At 17.39 m - Joint, 0.5mm aperture, with trace white grey clay infill
18			
19			
			At 19.36 m - Joint, 1mm aperture, with trace white grey clay infill
20			
21			At 20.94 m - Bedding Joint, 1mm aperture, with trace white grey clay infill
			At 21.24 m - Joint, 1mm aperture, with trace white grey clay infill
22			
23			END OF HOLE AT: 22.60 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 19.55 to 22.60 m on July 5, 2016. 2) Filter sand placed around screen zone from 19.16 to 22.60 m. 3) Lithology descriptions by Pretium geologists.
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02B

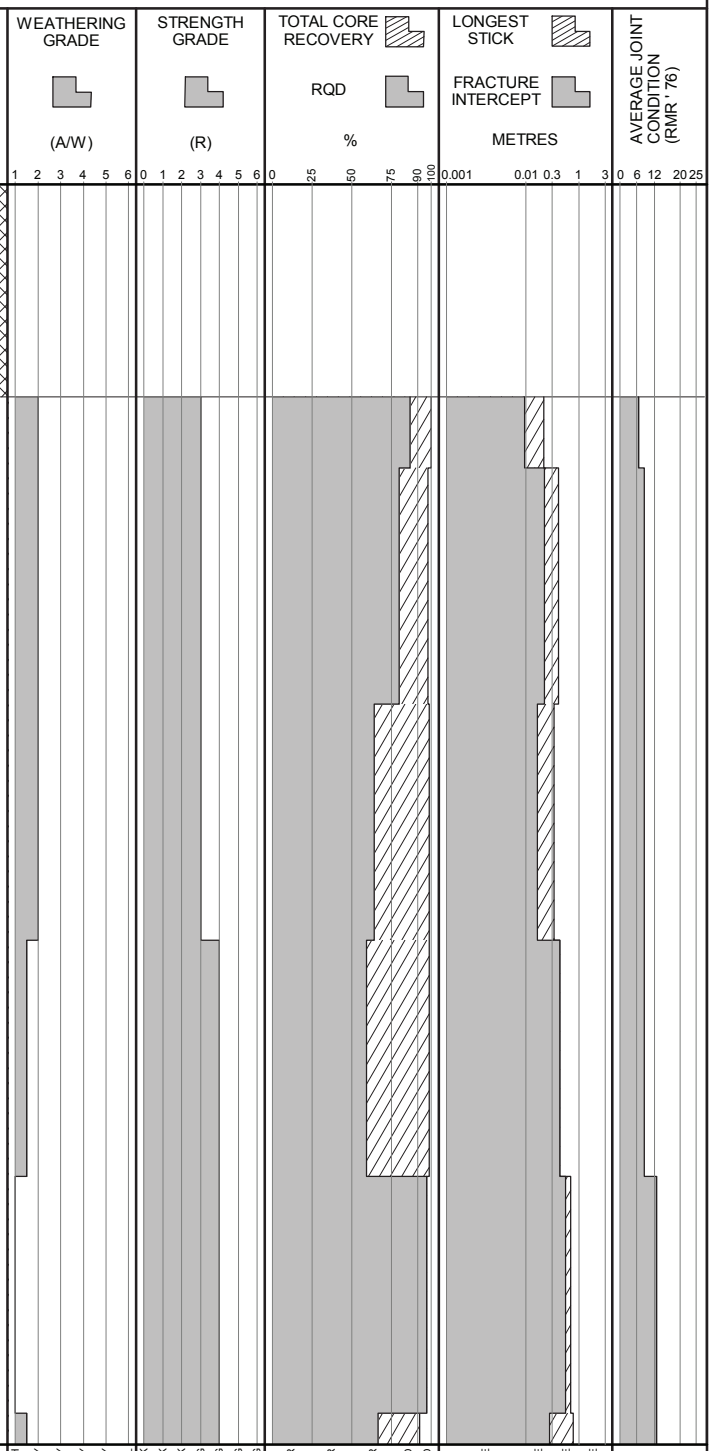
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
1			
2			INTERMEDIATE VOLCANICS (V4) Fine grained, greenish grey, porphyritic, weak to moderate phyllic/QSP alteration.
			At 1.43 m - Joint, 3mm aperture, with trace green grey clay infill and dark brown staining
			At 1.44 m - Joint, aperture size unknown (second half of joint missing), with trace brown clay infill and dark brown staining
			At 1.62m - Joint, 1mm aperture, with dark brown stain
			At 1.80 m - Joint, aperture size unknown (second half of joint missing), with green grey clay infill, trace brown clay infill and dark brown staining
3			At 2.18 m - Joint, 90mm aperture, with broken rock infill and dark brown staining
			At 2.58 m - Joint, 1mm aperture, with green grey clay infill and dark brown staining
			At 2.75m - Joint, 1mm aperture, with dark brown stain
			At 3.29 m - Joint, 2mm aperture, with trace brown clay infill, trace green grey clay infill and dark brown staining
			At 3.30 m - Joint, (aperture size could not be determined), with trace brown clay infill and dark brown staining
4			At 3.34 m - Joint, 1 to 4mm aperture, with brown clay and green grey clay infill and dark brown staining
			At 3.49m - Joint, 0.5mm aperture, with dark brown stain
			At 3.56 m - Joint, aperture size could not be determined (joint too broken), with brown clay infill and green grey clay infill, and dark brown staining
			At 3.87 m - Joint, 1.5mm aperture, with trace dark brown clay infill
5			At 3.88m - Joint, 0.5mm aperture, with dark brown stain
			At 4.01 m - Joint, 1.5mm aperture, with trace dark brown clay infill, dark brown staining
			At 4.15 m - Joint, 1mm aperture, with trace dark brown clay infill, dark brown staining
			At 4.19m - Joint, 1mm aperture, with dark brown stain
			At 4.38 m - Joint, 1mm aperture, with trace dark brown clay infill, dark brown staining
6			At 4.53 m - Joint (on vein), 1mm aperture, with trace dark brown clay infill, dark brown staining, on 8mm white vein
			At 4.64 m - Joint, 1mm aperture, with trace brown clay infill, dark brown staining
			At 4.99m - Joint, 1mm aperture, with dark brown stain
			At 5.18 m - Joint, 1mm aperture, with trace green grey clay infill
7			At 5.71m - Joint, 1mm aperture, with orange brown stain
			At 5.89 m - Joint, 1mm aperture, with grey white clay infill
			At 6.65m - Joint, 0.5mm aperture, with yellow brown stain
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # MW-BGC16-BJ-02B

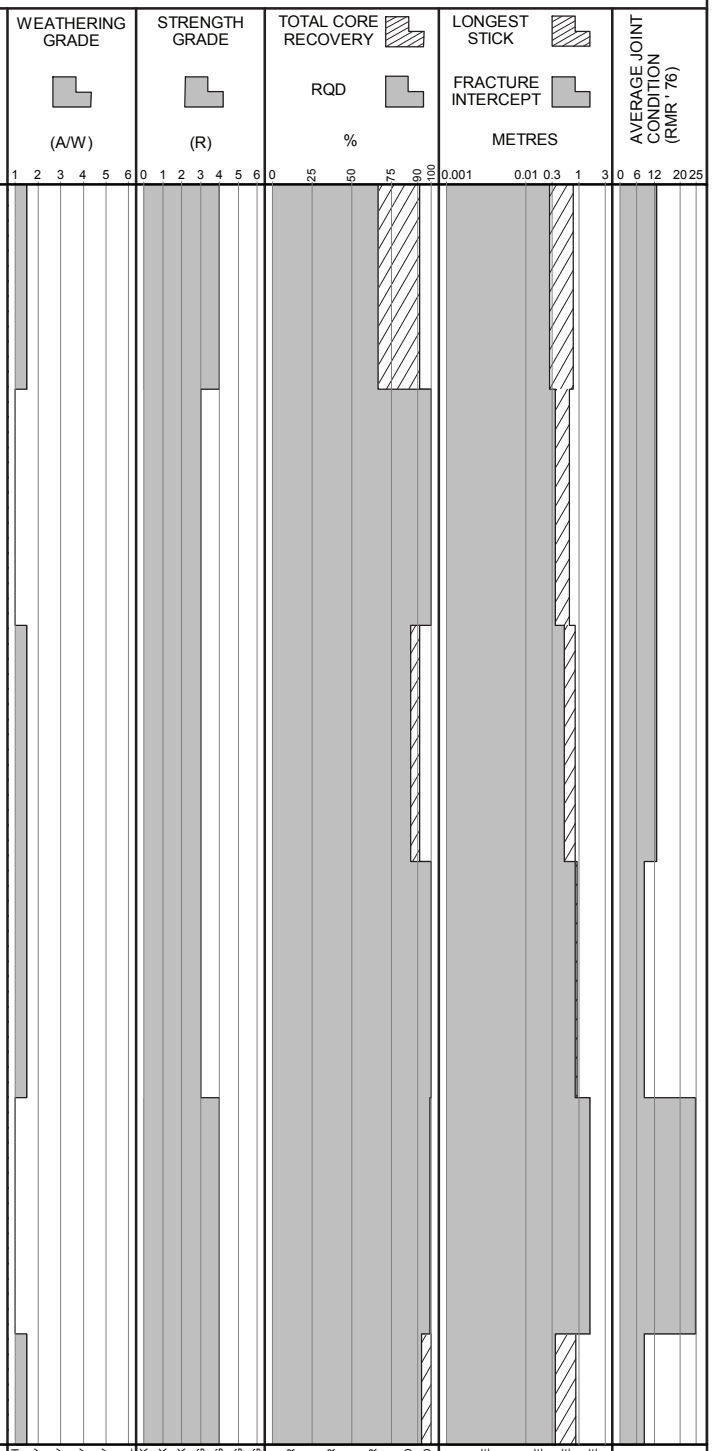
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
			At 8.75 m - Joint, 0.5mm aperture, with trace green grey clay infill
9			At 8.76 m - Joint, 1mm aperture, with green grey clay infill, dark brown staining
			At 9.65m - Joint, 0.5mm aperture, with yellow brown stain
			At 9.84m - Joint, 0.5mm aperture, with yellow brown stain
10			At 9.86m - Joint, 0.5mm aperture, with yellow brown stain
11			
			At 11.29 m - Joint, 1mm aperture, with trace white clay infill
12			
			At 12.63m - Joint, 0.5mm aperture, with trace white clay infill
13			
			At 13.45m - Joint, 1mm aperture, with trace grey clay infill
14			
15			
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02B

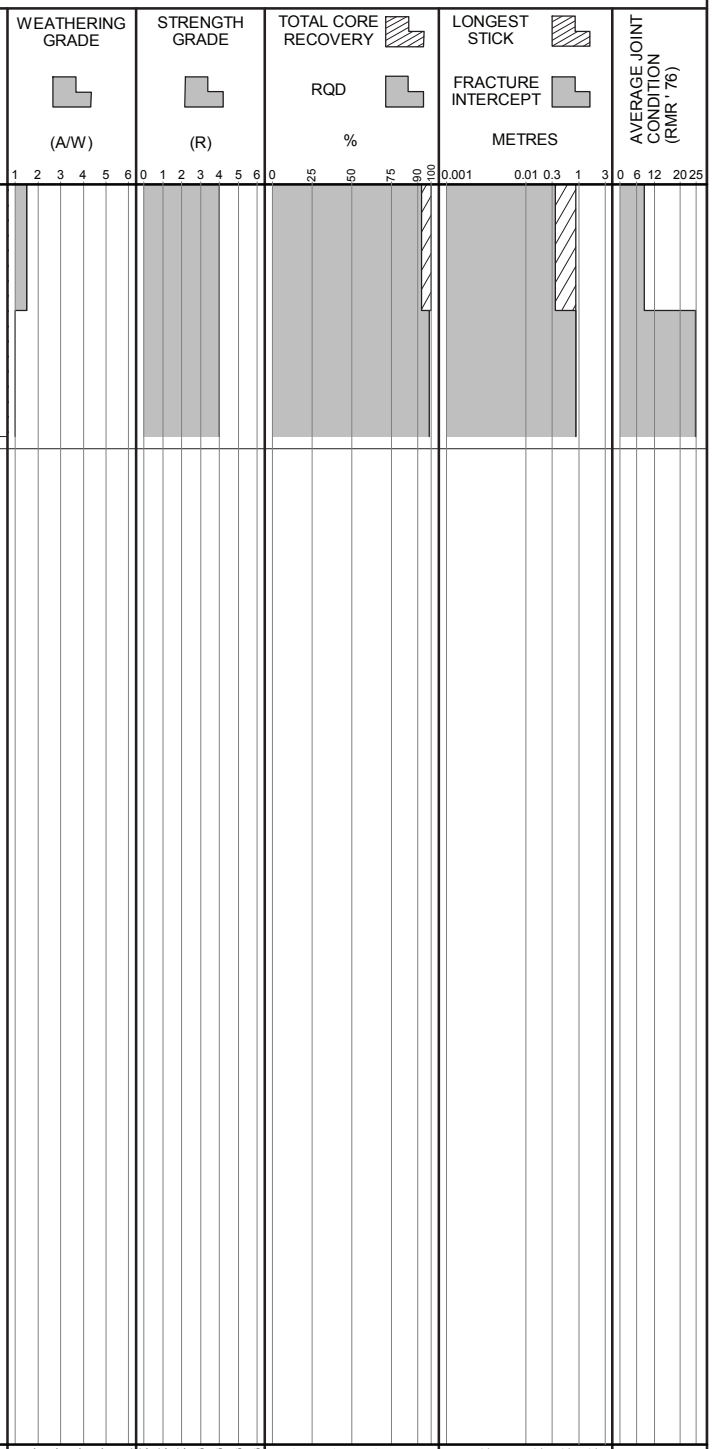
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
16									
17			At 16.69m - Joint, 1mm aperture, with grey clay and decomposed rock infill At 16.70m - Joint, aperture size could not be determined (couldn't fit joint together properly), with trace grey clay and decomposed rock infill At 16.75m - Joint, 1.5mm aperture, with trace grey white clay infill						
18			END OF HOLE AT: 17.68 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 16.16 to 17.68 m on July 7, 2016. 2) Filter sand placed around screen zone from 15.66 to 17.68 m. 3) Lithology descriptions by Pretium geologists.						
19									
20									
21									
22									
23									
24									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

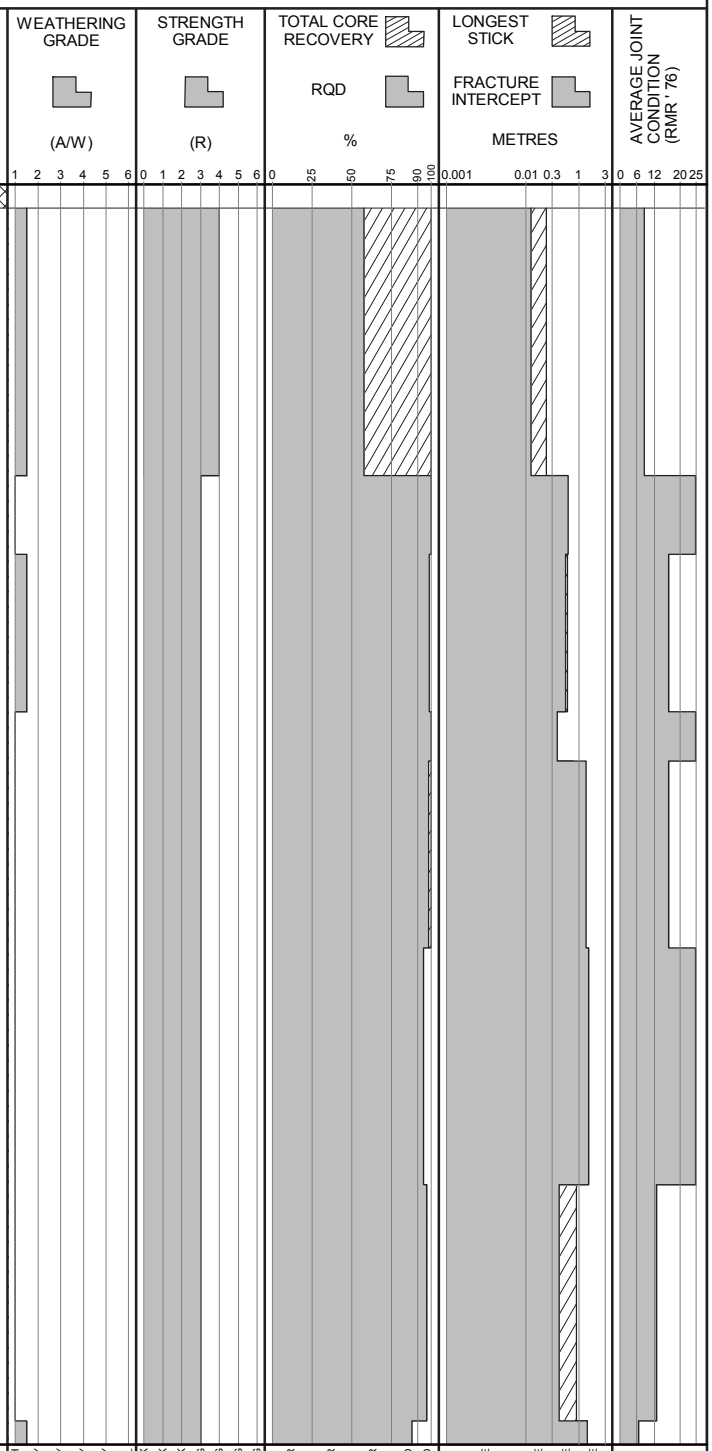
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, greenish grey, minor hydrothermal breccias (H15) from 6.58 to 6.71 m, moderate to strong phyllic/QSP alteration.
			At 0.34 m - Joint, 1mm aperture, with grey clay and crushed rock infill
1			At 0.58 m - Joint, 2mm aperture, with grey clay and crushed rock infill
			At 0.82 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.05 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.37 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.42 m - Joint, 1mm aperture, with trace light brown clay infill
2			At 1.68 m - Joint, aperture size unknown (other joint face too broken up), with trace light brown clay infill
3			At 3.21 m - Joint, 0.5mm aperture, with trace grey clay infill
4			
5			
6			
			At 6.42 m - Joint, 0.5mm aperture, with grey clay infill
7			
			At 7.20 m - Joint, 1mm aperture, with white grey clay infill
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

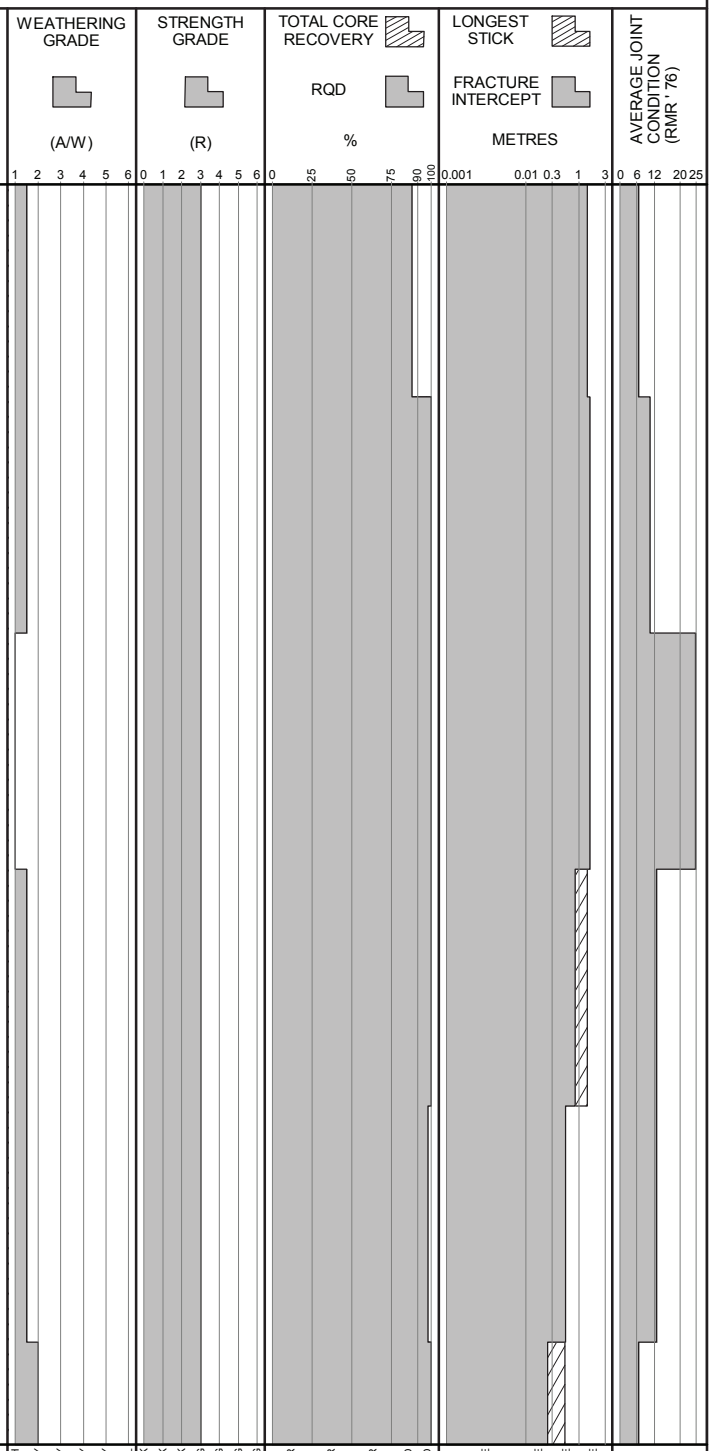
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			At 9.35 m - Joint, 2mm aperture, with grey white clay infill
10			At 10.26 m - Joint, 0.5mm aperture, with grey white clay infill
11			
12			
13			
14			At 13.77 m - Joint, 1mm aperture, with grey white clay infill At 14.33 m - Joint (with vein), 1mm aperture, with grey white clay infill
15			
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-03A

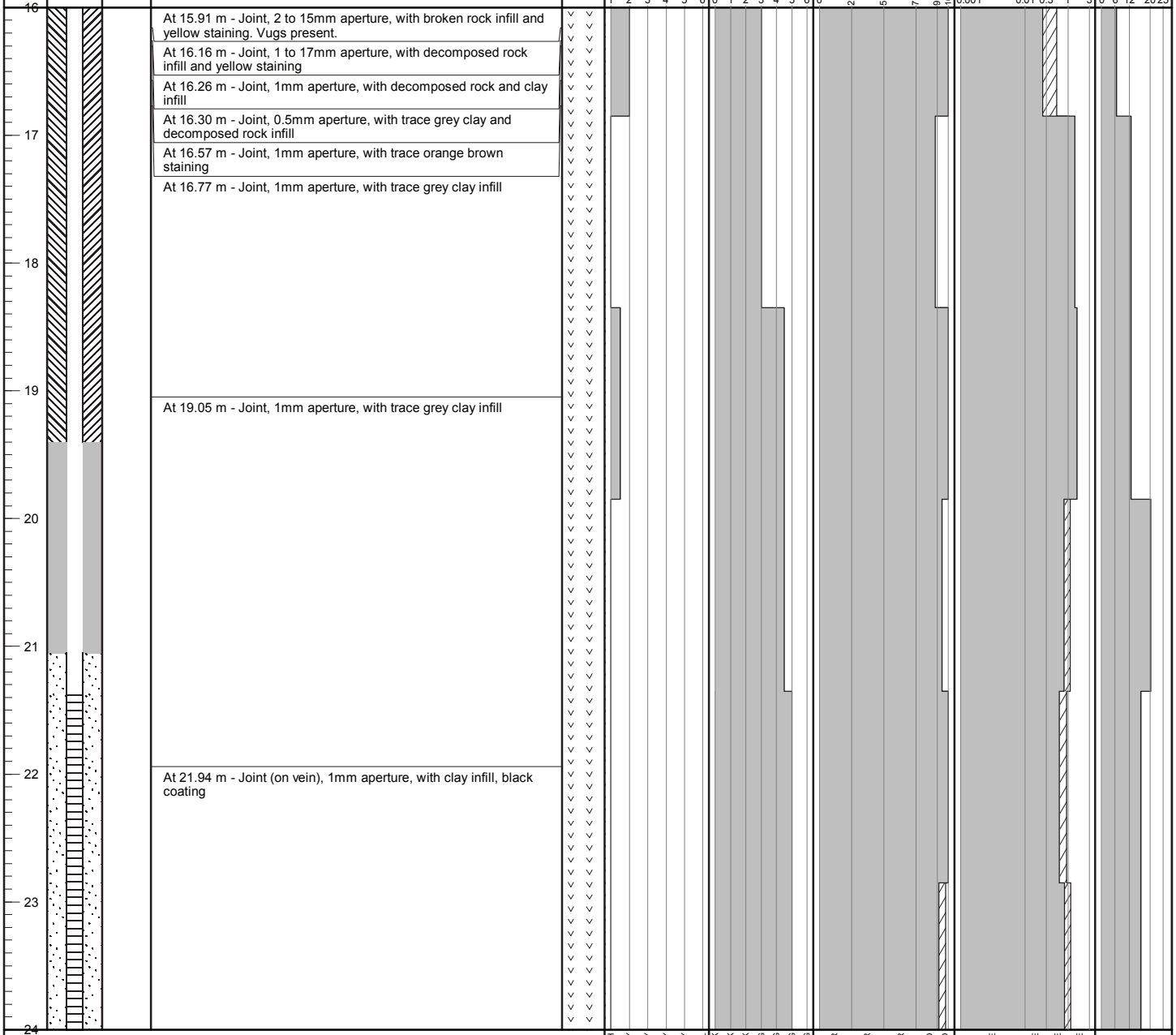
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16	At 15.91 m - Joint, 2 to 15mm aperture, with broken rock infill and yellow staining. Vugs present.
	At 16.16 m - Joint, 1 to 17mm aperture, with decomposed rock infill and yellow staining
	At 16.26 m - Joint, 1mm aperture, with decomposed rock and clay infill
	At 16.30 m - Joint, 0.5mm aperture, with trace grey clay and decomposed rock infill
17	At 16.57 m - Joint, 1mm aperture, with trace orange brown staining
	At 16.77 m - Joint, 1mm aperture, with trace grey clay infill
18	
19	At 19.05 m - Joint, 1mm aperture, with trace grey clay infill
20	
21	
22	At 21.94 m - Joint (on vein), 1mm aperture, with clay infill, black coating
23	
24	



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
24									
25			END OF HOLE AT: 24.43 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 21.38 to 24.43 m on July 6, 2016. 2) Filter sand placed around screen zone from 21.05 to 24.43 m. 3) Lithology descriptions by Pretium geologists.						
26									
27									
28									
29									
30									
31									
32									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03B

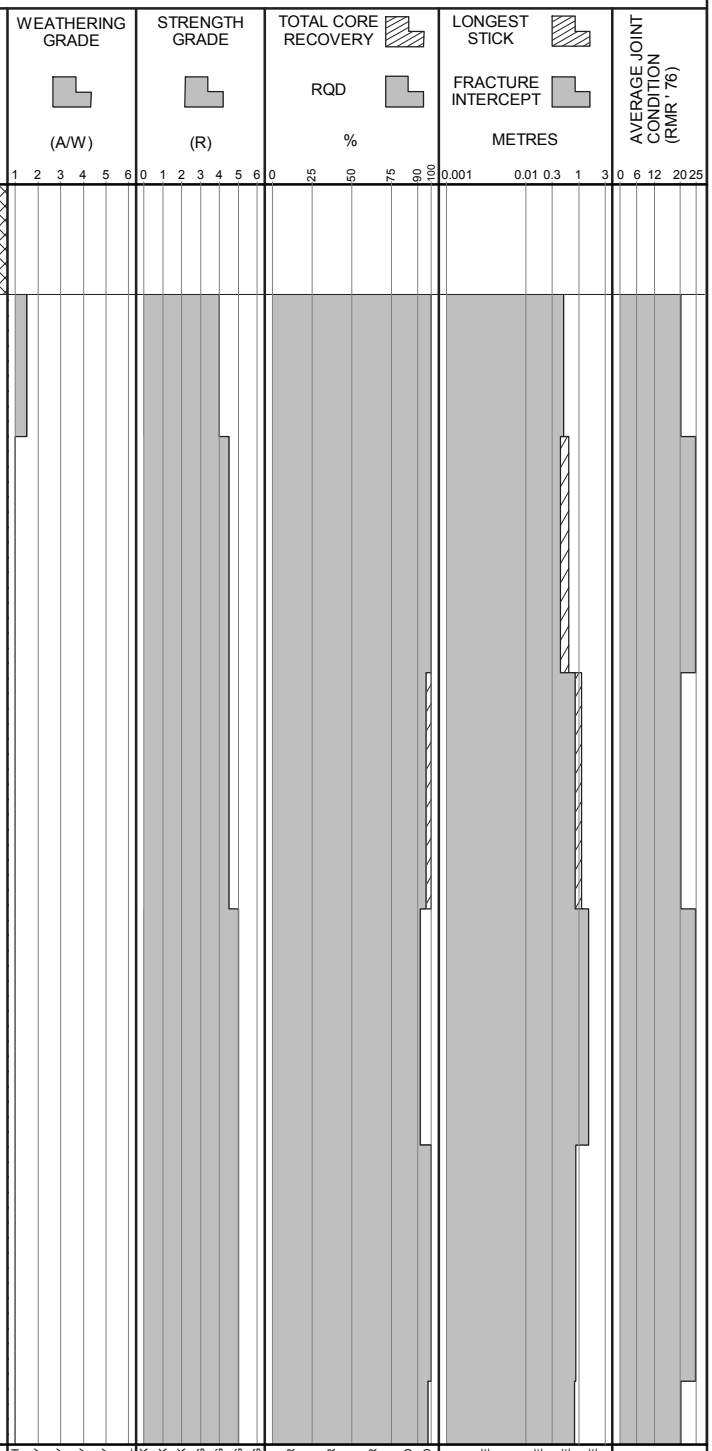
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,707N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 08 JUL 16
Finish Date: 08 JUL 16
Final Depth (m): 13.7
Depth To Top Of Rock (m): 0.7
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
1			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, light grey, laminated, moderate to strong phyllic/QSP alteration. At 1.06 m - Joint, 1mm aperture, with surface staining
2			
3			
4			
5			
6			
7			
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03B

Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,707N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 08 JUL 16
Finish Date: 08 JUL 16
Final Depth (m): 13.7
Depth To Top Of Rock (m): 0.7
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
11			
12			
13			At 13.30 m - Joint (on vein), 8mm aperture, with clay, calcite infill
14			END OF HOLE AT: 13.67 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 12.17 to 13.67 m on July 8, 2016. 2) Filter sand placed around screen zone from 11.15 to 13.67 m. 3) Lithology descriptions by Pretium geologists.
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04A

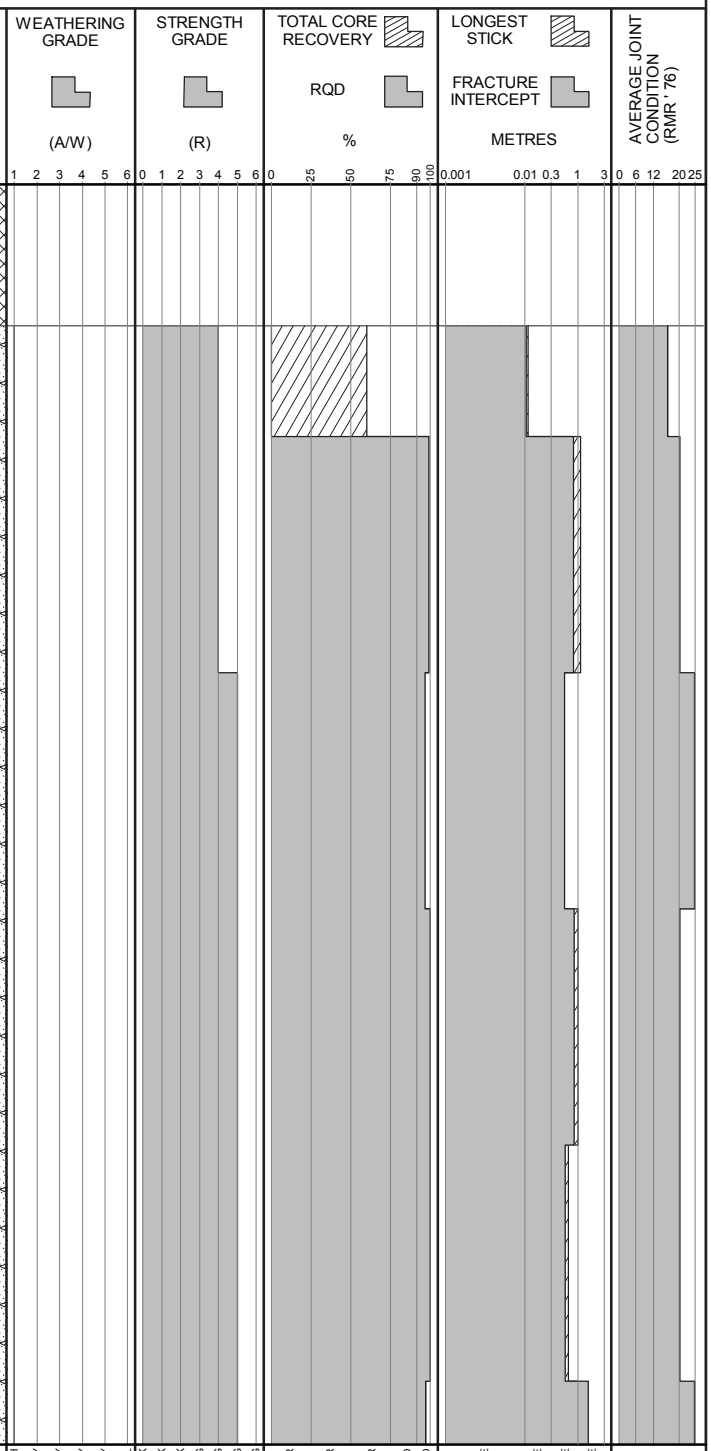
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
0			FILL	
1			CONGLOMERATE (S3-VSF) Coarse grained, dark grey, polymyctic, >90% reworked volcano-sedimentary facies sediments, moderate to strong sericite alteration.	
2				
3				
4				
5				
6				
7				
8				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04A

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
11			At 11.00 m - Joint (on vein), 10mm aperture, with broken rock infill
13			At 13.03 m - Joint, 3mm aperture, with decomposed rock infill

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04A

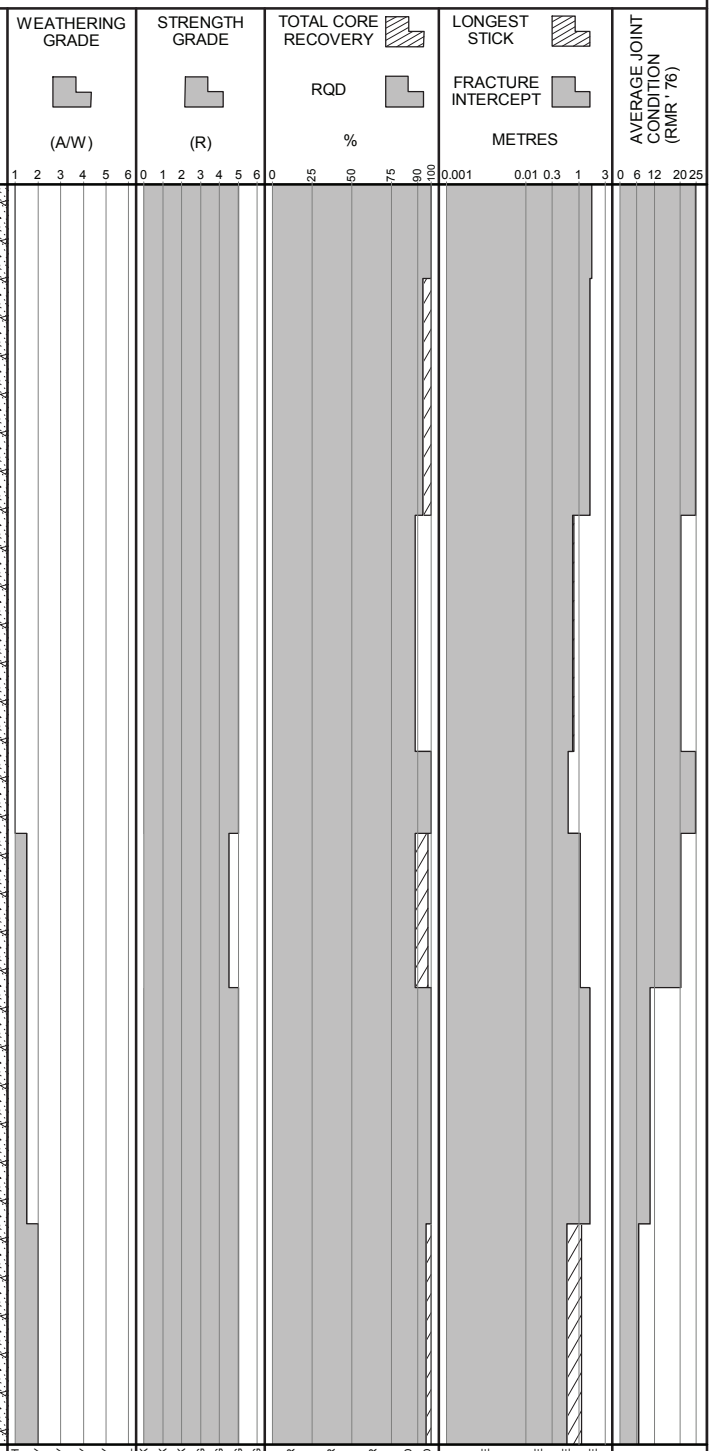
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			
20			
			At 20.22 m - Joint, 1mm aperture, with trace grey clay infill, potential vugs on Joint
21			
22			
			At 22.25 m - Joint (on vein), 1mm aperture, with trace grey clay infill. Curved joint.
23			
			At 23.60 m - Joint, 1mm aperture, with grey clay and decomposed rock infill
24			At 23.80 m - Joint, 90mm aperture, with apparent broken rock infill



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04A

Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
24			(potentially was very weak/fractured, and not broken, in-situ)						
			At 23.89 m - Joint (on vein), 1mm aperture, with trace grey clay and decomposed rock infill						
			END OF HOLE AT: 24.17 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 22.65 to 24.12 m on July 10, 2016. 2) Filter sand placed around screen zone from 22.28 to 24.12 m. 3) Lithology descriptions by Pretium geologists.						
25									
26									
27									
28									
29									
30									
31									
32									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY % / RQD: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04B

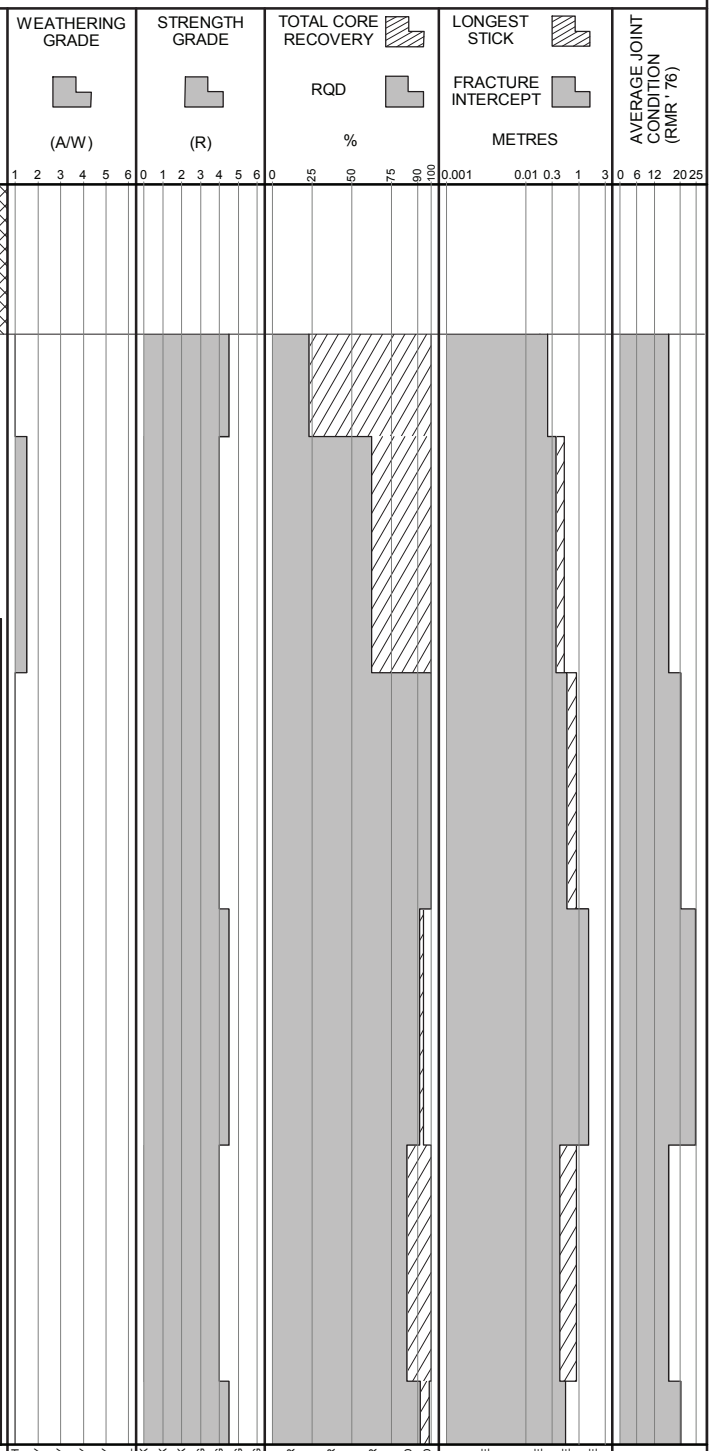
Location: CWP Pad A

Co-ordinates (m): 426,997E - 6,258,792N
Ground Elevation (m): 1,377.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 10 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 14.2
Depth To Top Of Rock (m): 1.0
Logged By: JRW
Reviewed By: TWC

Depth (m)	Instrumentation & Hole Completion Details	Drilling Action or Sample Type	Geotechnical Description, Major Discontinuities, and Additional Notes
0			FILL
1			VOLCANO-SEDIMENTARY FACIES SERIES SANDSTONES (S4-VSF) Fine grained, dark grey, polymyctic, moderate to strong phyllic/QSP alteration.
			At 1.75 m - Joint, 1mm aperture, with oxides/staining
2			At 2.25 m - Joint, 2mm aperture, with decomposed rock infill
3			VOLCANO-SEDIMENTARY FACIES SERIES SILT AND MUDSTONES (S5-VSF) Fine grained, dark grey to black, sheared, moderate to strong phyllic/QSP alteration.
4			
5			
6			
7			At 7.15 m - Joint (on contact), 5mm aperture, with decomposed rock infill
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04B

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,997E - 6,258,792N
Ground Elevation (m): 1,377.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 10 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 14.2
Depth To Top Of Rock (m): 1.0
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
8					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
9									
10									
11									
12									
13									
14									
15			END OF HOLE AT: 14.15 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 12.65 to 14.15 m on July 10, 2016. 2) Filter sand placed around screen zone from 12.07 to 14.15 m. 3) Lithology descriptions by Pretium geologists.						
16									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05A

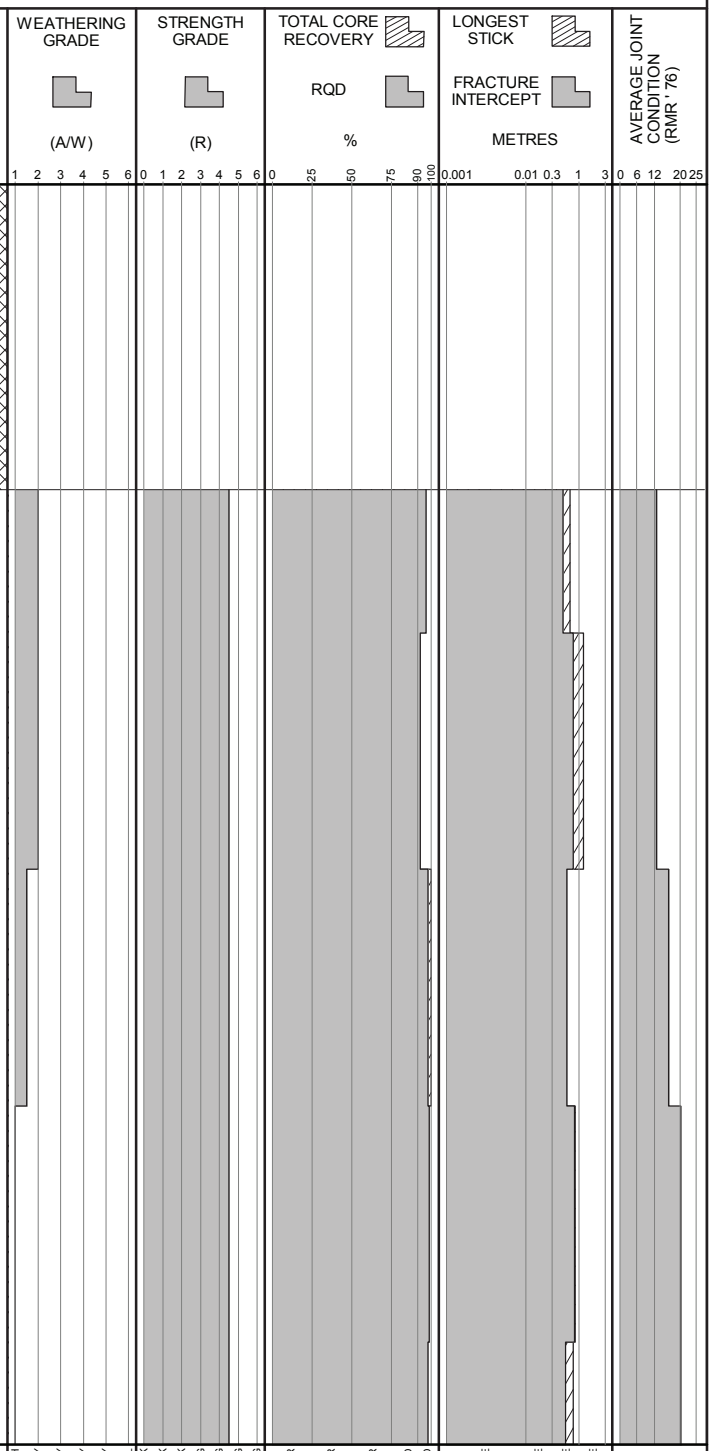
Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
2			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, light greenish grey, minor hydrothermal breccias (H15), moderate to strong sericite-chlorite alteration.
			At 2.55 m - Joint, 1mm aperture, with orange staining
			At 2.76 m - Joint, 1mm aperture, with dark orange brown staining
3			At 2.95 m - Joint, 1mm aperture, with surface staining
4			At 4.16 m - Joint, 1mm aperture, with surface staining
5			
			At 5.54 m - Joint, 1mm aperture, with surface staining
6			
7			
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05A

Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
11			At 11.33 m - Joint, 1mm aperture, with surface staining
12			
13			
14			At 13.55 m - Joint, 2mm aperture, with decomposed rock infill, and oxidizes/surface staining
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-05A

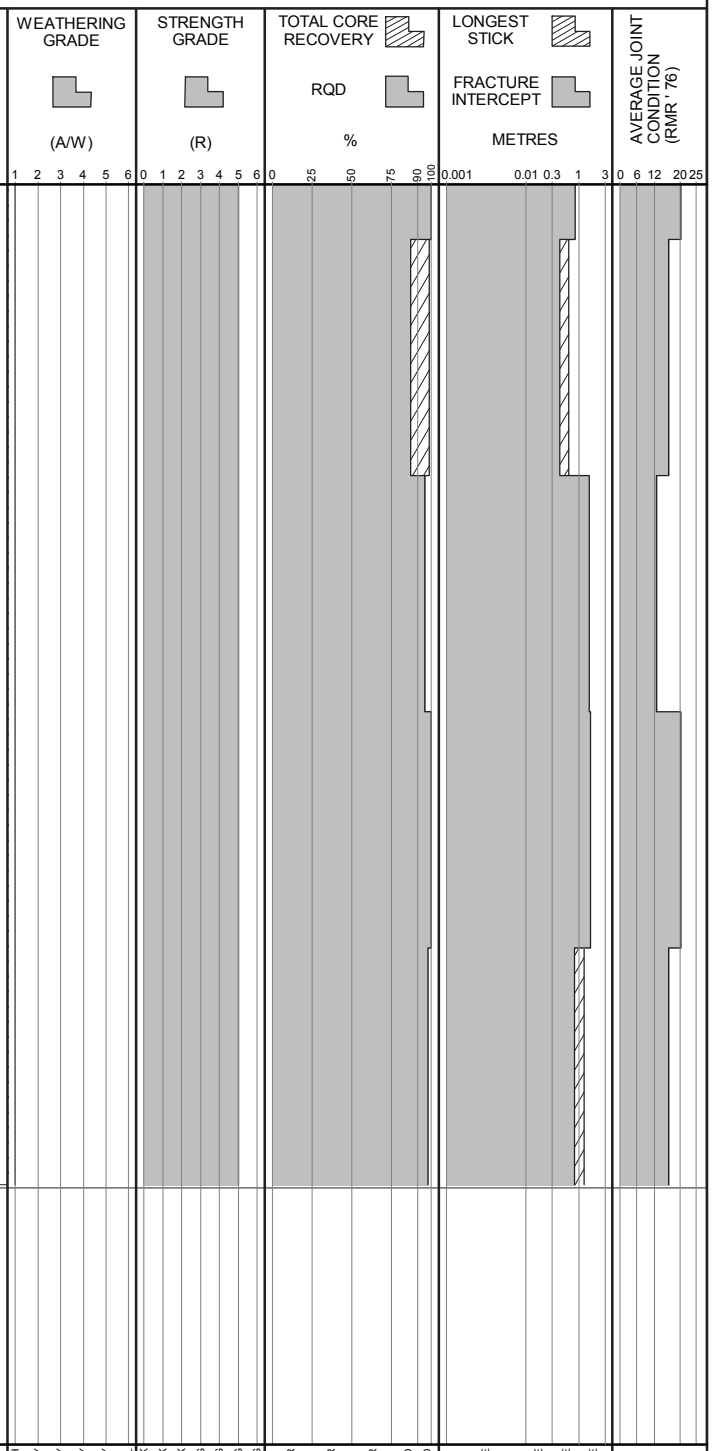
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			At 19.00 m - Joint, 2mm aperture, with decomposed rock infill
20			
21			
22			
23			END OF HOLE AT: 22.37 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 19.32 to 22.37 m on July 11, 2016. 2) Filter sand placed around screen zone from 18.65 to 22.37 m. 3) Lithology descriptions by Pretium geologists.
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05B

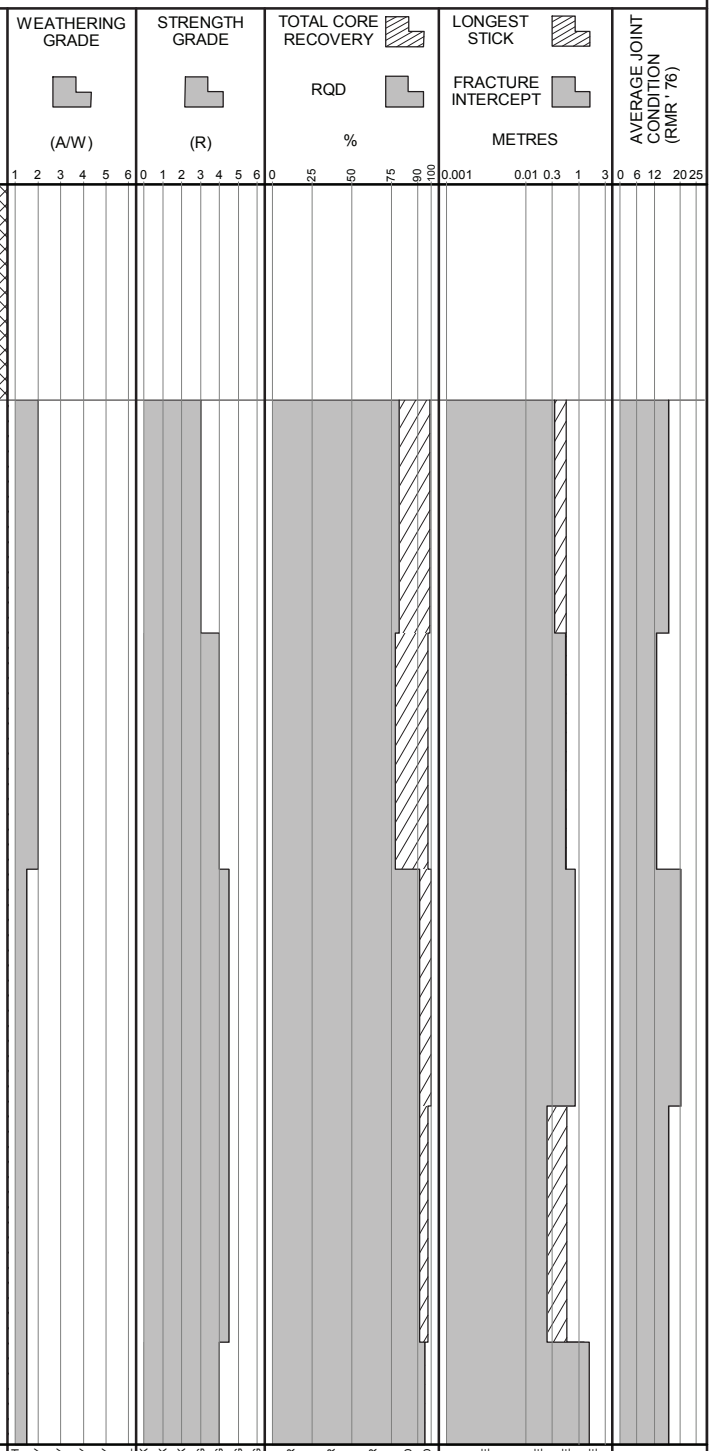
Location: CWP Pad B

Co-ordinates (m): 427,014E - 6,258,838N
Ground Elevation (m): 1,372.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 11 JUL 16
Finish Date: 12 JUL 16
Final Depth (m): 13.3
Depth To Top Of Rock (m): 1.4
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Instrumentation & Hole Completion Details	Drilling Action or Sample Type	Geotechnical Description, Major Discontinuities, and Additional Notes
0			FILL
1			
2			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, pale blue-green, locally weakly silicified. At 1.37 m - Joint, 1mm aperture, with grey clay infill At 1.83 m - Joint, 1.5mm aperture, with grey clay and decomposed rock infill and dark brown staining At 1.91 m - Joint, 1mm aperture, with grey clay infill and dark brown staining At 2.22 m - Joint, 1mm aperture, with orange brown staining At 2.34 m - Joint, 1.5mm aperture, with orange brown staining
3			At 3.17 m - Joint, 1mm aperture, with orange staining At 3.29 m - Joint, 0.5mm aperture, with orange staining. Curved joint.
4			At 3.90 m - Joint, 1mm aperture, with orange staining. Very long, undulating joint.
5			At 5.07 m - Joint, 0.5mm aperture, with orange staining
6			At 6.00 m - Joint, 1mm aperture, with surface staining At 6.10 m - Joint, 1mm aperture, with surface staining At 6.20 m - Joint, 1mm aperture, with surface staining At 6.33 m - Joint, 1mm aperture, with surface staining
7			
8			At 7.64 m - Joint, 1mm aperture, with surface staining



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05B

Location: CWP Pad B

Co-ordinates (m): 427,014E - 6,258,838N
Ground Elevation (m): 1,372.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 11 JUL 16
Finish Date: 12 JUL 16
Final Depth (m): 13.3
Depth To Top Of Rock (m): 1.4
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			At 9.40 m - Joint, 1mm aperture, with surface staining
10			At 10.00 m - Joint, 1mm aperture, with surface staining
			At 10.56 m - Joint (on vein), 1mm aperture, with waxy coating of decomposed rock
11			
			At 11.47 m - Joint, 1mm aperture, with waxy coating of decomposed rock
12			
13			
			END OF HOLE AT: 13.25 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 9.00 to 10.50 m on July 12, 2016. 2) Filter sand placed around screen zone from 8.50 to 10.50 m. 3) Backfilled from end of hole to 10.50m with bentonite chips. 4) Lithology descriptions by Pretium geologists.
14			
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Appendix B
Groundwater Monitoring and Sampling Field Protocol

NEWCREST

GROUNDWATER MONITORING AND SAMPLING PROTOCOL – BRUCEJACK MINE

VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
1	14 April 2015 - internal		DRAFT for Pretium Review and Comment
2	24 April 2015 - internal		Incorporated M. Holtby and L. Tate review comments; added version tracking sheet
3	June 2015		Revised to include MA and EMA Permit Review comments and recommendations
4	August 2015		Revised to include the wells to be added to the program during Operations and Closure
5	February 2017		Revised to include updated monitoring program details
6	January 2019		Revised to include updates to monitoring program details and CWP Monitoring Wells, update well purge methods.
7	February 2020		Revised to match the low-flow field sampling protocol employed in 2019
8	March 2022		Revised to add direct read cable and sonic water level measurement SOPs

1. INTRODUCTION

The following document describes the procedures and equipment associated with groundwater level monitoring, groundwater sampling, field documentation and quality assurance/quality control (QA/QC) protocols for the Brucejack Mine Site.

This document is strictly a guideline and procedures may vary when in the field to suit field conditions at the time of sampling.

1.1 Brucejack Groundwater Monitoring Program

The wells included in the current groundwater monitoring program at Brucejack are listed in Table 1 along with screening information. Table 2 provides a list of monitoring wells to be constructed later in Operations or prior to Closure, to satisfy requirements outlined in the *Mines Act* and *Environmental Management Act* Permits (i.e., M-243 and PE-107835, respectively). A map showing current and proposed well locations is provided in Appendix A, while detailed well construction information for existing wells is provided in Appendix B.

Table 1. Monitoring Well Locations and Sampling Method.

Well ID	Area	Top of Screen (m btoc)	Bottom of Screen (m btoc)	Water Level Monitoring	Sampling Method (s)	Suggested Pumping Rate (mL/min)[a]	Sampling Frequency
BJ-GW11-1A	WZ	78.6	84.8	C	Submersible	200 - 400	Q
BJ-GW11-1B	WZ	35.3	38.4	C	Submersible	200 - 400	Q
BJ-GW11-3A	WZ	83.0	88.3	C	Submersible	200 - 400	Q
BJ-GW11-3B	WZ	5.8	8.8	C	Peristaltic	200 - 400	Q
BJ-GW11-5A	VOK	68.6	77.7	C	Dry	-	Q
BJ-GW11-5B	VOK	41.0	50.2	C	Dry	-	Q
BJ-GW11-6A	Shore Zone	21.2	30.3	C	Not Required	-	-
BJ-GW12-6B	Shore Zone	100.3	103.3	C	Not Required	-	-
BJ-GW12-8A	PV	86.2	92.3	C	Submersible	200 - 400	Q
BJ-GW12-8B	PV	44.8	50.9	C	Submersible	200 - 400	Q
BJ-GW12-9A	VOK	72.9	79.0	C	Dry	-	Q
BJ-GW12-9B	VOK	40.6	46.7	C	Submersible[c]	200 - 400	Q
BJ-GW12-11A	VOK	26.5	29.5	C	Bailer	-	Q
BJ-GW12-11B	VOK	50.7	53.8	C	Submersible	200 - 400	Q
BJ-GW12-12A	VOK	87.8	93.9	C	Dry	-	Q
BJ-GW12-12B	VOK	46.7	52.8	C	Dry	-	Q
BJ-GW14-13A[b]	BJ Fault	41.0	99.2	C	Not Required	-	-
BJ-GW14-13B[b]	BJ Fault	58.2	73.6	C	Not Required	-	-
BJ-GW14-14A[b]	BJ Fault	18.2	30.7	C	Submersible	<250	Q
BJ-GW14-14B	BJ Fault (OVB)	1.5	4.4	C	Peristaltic	200 - 400	Q
BJ-GW16-5A	CWP	19.3	22.4	C	Submersible	<250	Q
BJ-GW16-5B	CWP	9.8	11.3	C	Peristaltic	<250	Q

Well ID	Area	Top of Screen (m btoc)	Bottom of Screen (m btoc)	Water Level Monitoring	Sampling Method (s)	Suggested Pumping Rate (mL/min)[a]	Sampling Frequency
BJ-GW18-17A	Camp Pad	144.7	147.7	C	Bennett	500 - 2000	Q
BJ-GW18-17B	Camp Pad	72.2	75.3	C	Submersible / bailer[d]	200 - 300	Q
BJ-GW18-18A	Camp Pad	97.9	101.0	C	Development in progress	-	Q
BJ-GW18-18B	Camp Pad	61.9	64.9	C	Submersible	500	Q
BJ-GW18-19A	VOK	193.5	196.6	C	Development in progress	-	Q
BJ-GW18-19B	VOK	155.5	158.5	C	Bennett sample	200 - 500	Q
BJ-GW18-20A	BJ Fault	161.0	167.1	C	Development in progress	-	B
BJ-GW18-20B	BJ Fault	114.6	117.7	C	Development in progress	-	B
BJ-GW18-21A	VOK	195.3	204.5	C	Development in progress	-	B
BJ-GW18-21B	VOK	153.1	159.2	C	Development in progress	-	B
BJ-GW18-22A	VOK	372.6	378.7	C	Not Required	-	-
BJ-GW18-22B	VOK	84.4	87.5	C	Not Required	-	-
BJ-GW18-23A	CWP	25.9	28.9	C	Submersible	<250	Q
BJ-GW18-23B	CWP	7.8	10.8	C	Peristaltic	<250	Q

Notes:
C = Continuous (automatically recorded on a 6-hr interval) monitoring using pressure transducer; Q = Quarterly sampling; B = Biannual sampling
WZ – West Zone; VOK – Valley of Kings; PV – Pilsner Valley; OVB – Overburden; CWP – Contact Water Pond
[a]Pumping rate ranges are listed. The lower rate should be used if turbidity readings are elevated.
[b]Monitoring wells where flowing artesian conditions are observed.
[c]If well access is improved, otherwise bailer can be used
[d]At high water levels a submersible pump is feasible, at low water levels a bailer may have to be used.

Table 2. Additional Compliance Monitoring Wells.

Well ID Amended Permit 107835 (December 14, 2018)	Water Level Monitoring	Chemistry Monitoring	Installation Date
New well @ B	-	-	Submit installation plan 2 years prior to closure
New Well @ P1	-	-	Submit installation plan 2 years prior to closure
New Well @ P2	-	-	Submit installation plan 2 years prior to closure
New Well @ P3	-	-	Submit installation plan 2 years prior to closure
New Well @ P5	-	-	Install timing to be assessed during 2020 Five Year Mine Plan update

2. FIELD EQUIPMENT AND CALIBRATION

2.1. Equipment Check List

The equipment needed for sampling of the wells is listed in Table 3.

Table 3. Groundwater Sampling Equipment

Equipment	Purpose	Equipment Source
Personal Protective Equipment (PPE) – Safety glasses, vinyl gloves, hard hat, safety boots, high-visibility safety vest, hearing protection, as required	Health and safety concerns, limit exposure to noise and chemical preservatives	On-site stock
Water level meter and spare battery	To manually measure the groundwater level	On-site stock
Alconox soap and distilled water	To rinse the monitoring equipment between wells	On-site stock
YSI multi-probe (with a flow cell) capable of measuring pH, Temperature, Specific Conductivity (SC), Dissolved Oxygen (DO), Oxidation Reduction Potential (ORP), and Turbidity.	To measure field temperature, pH, SC, DO, ORP and turbidity.	On-site stock
Calibration solutions for pH 4, 7 and 10; 1413 µS/cm conductivity solution, Zobell solution for ORP, 0 FNU and 124 FNU Turbidity standards).	To evaluate and adjust the precision and accuracy of the YSI meter and probes.	On-site stock, Hoskin Environmental
HACH Digital Titrator Model 16900 with sulfuric acid (1.6 and 0.16 N) cartridges, Phenolphthalein and Bromcresol Green-Methyl Red powder pillow packets	To measure field alkalinity	On-site, HACH Sales and Services
Poly-weighted bailers	To sample groundwater wells with poor recovery or deep wells with short water columns.	On-site stock, Pine Environmental
Geotech peristaltic pump, 12V battery, 5/8" Silicone Tubing, 1/4" polyethylene tubing, power cable	To sample shallow (<10 m deep) groundwater wells	On-site stock, Pine Environmental
Grundfos Redi-Flo2 submersible pump, Redi-Flo variable frequency drive controller, 3000W	To sample groundwater wells with depths ranging from 10m to 90m.	On-site stock, Pine Environmental

Equipment	Purpose	Equipment Source
generator, hose clamps, 1/2" polyethylene tubing, extension cord (generator), power cord (VFD to pump), jerry can of gasoline for generator		
Bennett sample pump, propane tanks (seacan heat source), jerry can of gasoline for generators, three 20L pails of water (to prime the pump)	To sample groundwater wells with depths greater than 100m	On-site Bennett Sample Pump seacan.
QED bladder pump, QED pump controller, disposable bladders, Makita portable air compressor, polyethylene tubing, generator, power cord, jerry can of gasoline for generator.	Back-up pump capable of sampling wells that utilize the Bennett sample pump and the Grundfos submersible pump	On-site stock, Pine Environmental
45 micron filter and syringes or High Capacity Waterra inline filters	To field filter the groundwater samples	Pine Environmental or on-site stock
String/ 100 m nylon cable reel	Attach to Poly-weighted bailer to collect groundwater sample	On-site stock
Graduated 20 litre pail	To measure flowrate, and clean water level tape and pump	On-site stock
Laboratory supplied sample bottles	To collect groundwater samples	ALS Laboratories
Preservatives (if any)	To preserve various samples	ALS Laboratories
Cooler(s) with bubble wrap	To protect samples and provide a temperature controlled environment for transport	On-site stock or ALS laboratories
Frozen ice-pack(s)	To provide a temperature controlled environment for transport of groundwater samples to laboratory	ALS Laboratories
Chain of custody (COC)	To track samples and ensure integrity/provide a record of samples from collection to reporting	ALS Laboratories
Stopwatch, graduated cylinder	To determine purge rate	On-site stock
Field Forms	To record field measurements	Field laptop or printed on Rite in Rain Paper
Computer with HOBOware and Diver-Office software and optical reading cables	To download and reset dataloggers and barologgers	Free software download available at Onsetcomp.com and vanessen.com

2.2. Calibrations and Equipment Checks

Prior to heading to the field ensure that all equipment is working properly and complete with required accessories (power cables, flow cell, etc) as outlined in Table 3.

- Test the water level meter function by pushing the test button and listening for the tone or observing the flashing light which indicates that the water level tape is functioning correctly.
- Ensure that battery for peristaltic pump is fully charged and/or bring a spare.
- The YSI calibration should be checked every day, prior to its use in the field and recalibrated if required.

- Record the calibration data on the Brucejack master calibration tracking spreadsheet (Appendix C).
- Check the YSI multi-probe calibration for pH, specific conductance (SC), Oxidation Reduction Potential (ORP), Dissolved Oxygen (DO) and turbidity using the appropriate calibration solutions (i.e., pH 4, 7 and 10; 1413 µS/cm conductivity solution at reference temperature 25 ºC; Zobell solution for ORP, and 0 FNU and 124 FNU solutions for turbidity). If parameters report outside of range, the probe should be re-calibrated. Calibration procedures should follow instrument manual instructions.
- The YSI should be stored covered and protected from freezing conditions while not in use. The sonde should be stored in the calibration cup with a damp sponge to ensure pH and DO sensors do not dry out.

3. METHODOLOGY

3.1. Groundwater Level Monitoring Procedures

- Remove well cap and check the PVC stick-up for damage; repair if necessary.
- Wait five minutes before lowering the clean water level meter into the well until the tone is heard or the light illuminates. This delay allows the water level to equilibrate with barometric pressure. Wells that have vented pipe (holes drilled on the side) do not require the five minute delay for water level measurement.
- Measure depth-to-water (using the water level meter) below the notch on the PVC pipe prior to sampling (i.e., static level). Water levels should be recorded on the *Groundwater Monitoring Well Field Sampling Form* (Appendix C) in meters to the nearest mm, which will provide a groundwater level in meters below top of PVC casing (m bTOC). Include the well ID, date and time.
    - Note: The notch on the PVC pipe is the standard survey point from which all water levels in the well are measured.
- Measure the height of the PVC pipe (at the notch level) above ground (stickup) using a measuring tape. Record this value on the *Groundwater Monitoring Well Field Sampling Form* (Appendix D) and compare to the well record (provided in Appendix B) to identify changes in these values. Document any changes in stickup on the *Groundwater Monitoring Well Field Sampling Form*.
- Clean the submerged portion of the water level meter between locations with a phosphate free detergent like Alconox and rinse with distilled water.
- The elevation of the water level can be calculated by subtracting the depth to water from the top of the PVC (m bTOC) from the surveyed elevation of the top of the PVC (found in Appendix B).

3.2. Datalogger and Barologger Download and Reset

All monitoring wells at Brucejack are equipped with Onset Industries HOBO dataloggers or Van Essen Instruments TD-Diver dataloggers to remotely record the groundwater level and temperature on a 6-hr interval (i.e., at 12 AM, 6 AM, 12 PM, and 6 PM). A barometric logger is also used and placed in a safe and dry location on site to record barometric pressure at the same time intervals. The barometric logger data is used for barometric compensation of the groundwater level data.

Prior to deploying tubing or equipment in a well:

- Measure and record water level below the top of the PVC pipe utilizing a water level meter. Note date and time.
- Retrieve cable with datalogger from the well.
- Download the datalogger using the optical reader connected to a computer with a USB plug-in. The computer will need the HOBOware software for Onset HOBO dataloggers and Diver-Office for Van Essen TD-Diver dataloggers
- Review the status of the logger by confirming logger function, battery life and available internal memory. Ensure the logger internal clocks are synchronized with the computer clock. If the battery level is less than 20%, remove the logger from service. If the memory level is greater than 80%, download the data and reset the logger. Do NOT reset the dataloggers, unless a setup issue (e.g. off-set internal clock, logging frequency error, internal memory almost at full capacity) is identified.
- Save the downloaded data to the appropriate subfolder within the master Groundwater folder on the server. Save the raw data file and export (and save) the data as a .csv file.
- Ensure the dataloggers are stored in a safe place while they are not in the wells.
- Once groundwater sampling is complete, redeploy the datalogger in the well to the same depth using the well-specific attached cable.
- Measure and record water level below the PVC pipe utilizing a water level meter after the logger has been redeployed. Note date and time.
- Download the barometric datalogger at the end of the sampling quarter.

3.3. Sampling

Low-Flow Sampling

Groundwater samples will be collected from wells using the sampling equipment listed in Table 1. Low-flow sampling protocols will be followed for all wells where the peristaltic pump, submersible pump, Bennett sample pump or bladder pump are utilized. Standard Operating Procedures for the submersible pump, Bennett Sample Pump and bladder pump are presented in Appendix E, Appendix F, and Appendix G, respectively. General low-flow sampling procedures are as follows:

- Deploy pump and/or tubing using clean gloves. The intakes for the pump/tubing should be within the screened area of the well (Table 1)
- Initiate pumping. Connect pump discharge line to flow through cell of YSI. Allow outlet of YSI to drain into graduated bucket.
- Throttle pump settings to recommended ranges provided in Table 1. Typical low flow sampling rates range between 0.1 and 0.5 L/min, although some wells can support higher rates. In slower recharging wells, it may be advantageous to pump the well at a slightly higher rate to obtain some drawdown (i.e. forcing higher gradients towards the well) and then throttling the pump rates back to recommended levels to achieve stable water levels.
- Measure and record groundwater level, sampling flow rate and field parameters (pH, ORP, SC, Turbidity, DO) at regular intervals on the well sampling form provided in Appendix C. Suggested time intervals are on the order of 5 to 10 minutes, more frequent for faster pump rates and less frequent for slower pumping rates.
- As monitoring progresses, prepare sample bottles with waterproof labels provided by the laboratory. Use indelible ink or pencil to fill in the information.

- Observed trends in water levels and field parameters to determine if the well discharge has stabilized. Stabilization of parameters is considered achieved when turbidity is minimal (<50 NTU) and three consecutive readings change within the following limits:
    - Water level (within ± 2 mm)
    - pH ± 0.1
    - Specific Conductance ±3%
    - Dissolved Oxygen ±10% for values >0.5 mg/L (three values less than 0.5 mg/L are considered stabilized);
    - Oxidation Reduction Potential ±10 mV
    - Turbidity ±10%
- Collection of groundwater sample can occur when the above criteria are met. Disconnect the YSI flow- through cell and measure the flow rate. Sometimes flow rates increase when the flow-through cell is disconnected, which will cause the water level to drop, introducing stagnant well water into the sample stream. Adjust flow rate downwards so that it matches or is lower than the stabilized flow rate when the flow-through cell was attached.
- A clean set of vinyl gloves must be used during sample collection. Care should be taken to avoid touching the inside of the sample bottle and cap with sampling tubing, filters, syringes or gloves.
- Samples bottles are taken for the analyses outlined in Table 4. Bottles that do not require field filtering can be filled in sequence with appropriate laboratory supplied preservatives added as the bottles are filled.
- For dissolved parameters, the groundwater sample should be field-filtered using a 0.45 micron filter. Typically, a syringe is filled with groundwater and a filter is attached to the end of the syringe. Alternatively, an inline high-capacity filter may be used. The filtered groundwater should be dispensed directly into the appropriate laboratory bottle and preserved with prescribed preservative.
- Prior to turning off the pump, review Appendix H to select the appropriate sample volume and titration cartridge based on the expected alkalinity range of the well water. Alkalinity can be done in the field if conditions permit, or inside the site environmental office promptly after sampling. More detailed instructions on how to measure field alkalinity are found in Appendix H.
    - Transfer the sample into a clean 250-mL Erlenmeyer flask and dilute with DI water to the 100 mL mark if necessary.
    - Add one packet of Phenolphthalein and swirl the flask. If the solution turns pink, titrate to a colorless end point while recording the number of digits required. Calculate the $CaCa_3$ P alkalinity and record the value on the well data sheet.
    - Add one Bromcresol Green-Methyl Red packet and swirl to mix. Continue titrating while recording the digits to either a light green-blue-gray, a light violet-gray, or a light pink (the color depends on the sample composition). Calculate the total alkalinity and record it on the field sheet.
- Place filled sample bottles in a cooler with ice-packs and fill out the chain-of-custody (COC) for each cooler. Ensure samples are tightly capped. Sample cooler temperature should be maintained between 4 °C and 10 °C.
- If samples are not shipped immediately, refrigerate samples immediately and maintain refrigerated conditions until the cooler is ready for shipment to the analytical laboratory.
- When ready to ship the samples to the selected laboratory:

- Put sample bottles in coolers with (fresh or newly frozen) ice-packs located above and below samples.
- Place enough bubble wrap in the cooler to protect the samples from impact.
- Include COC form for each cooler in ZipLoc bag.

Table 4: Groundwater Analytes and Preservatives

Bottle	Volume/Material	Parameters	Filtered	Preservative
1	500 mL HDPE	General Parameters + Anions: pH, conductivity, total dissolved solids (TDS), total suspended solids (TSS), turbidity, hardness, total alkalinity, acidity, sulphate, chloride, fluoride, nitrate, nitrite	No	None
2	120 mL Amber Glass	Nutrients: Total Kjeldahl Nitrogen (TKN), ammonia, orthophosphate – dissolved, phosphorous - total, total nitrogen	No	H_2SO_4
3	60 mL HDPE	Total Metals: Aluminum (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Bismuth (Bi), Cadmium (Cd), Calcium (Ca), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead(Pb), Lithium (Li), Manganese (Mn), Magnesium (Mg), Molybdenum (Mo), Nickel (Ni), Phosphorous (P), Potassium (K), Selenium (Se), Silver (Ag), Sodium (Na), Strontium (Sr), Thallium (Tl), Tin (Sn), Uranium (U), Vanadium (V), Zinc (Zn).	No	HNO_3
4	60 mL HDPE	Dissolved Metals: (as per total metals suite)	Yes	HNO_3
5	40 mL glass vial	Mercury (Total)	No	HCl
6	40 mL glass vial	Mercury (Dissolved)	Yes	HCl
7	145 mL HDPE	Sulfide (Total)	No	Zn Acetate; NaOH

Grab Sampling (Bailers)

Poly-weighted bailers (i.e., 1.6” x 36”) are used in deep wells with short water columns (insufficient head pressure to operate the submersible pump or Bennett sample pump) and wells with very poor recovery. General procedures for sampling with bailers are as follows:

- The poly-weighted bailer is lowered down the well using a cable until the bailer is submerged.
- Bailers are raised to the surface as smoothly as possible, which allows the ball valves to seal, trapping water in the bailers on the way up.
- The cumulative volume withdrawn by the bailers is tracked by emptying the bailer into an appropriate receptacle (e.g., 20-litre bucket) to record purge volumes and measure field parameters (temperature, pH, SC, DO, ORP and turbidity). Field parameters and water levels should be measured over 5L increments to monitor the stabilization of parameters and water level. Once three consecutive stable readings are obtained, a groundwater sample can be collected.
- For sampling, use the pourer (supplied with the poly-weighted bailer), by inserting into the bottom of the poly-weighted bailer to dislodge the ball valve and allow the water to flow either directly into the sampling bottles for unfiltered parameters or into a syringe for filtering prior to filling the dissolved parameter bottle (Table 4).

Equipment Decontamination

Any portable pumps (submersible or Bennett pump) must be decontaminated between monitoring wells using an Alconox solution or similar followed by a rinse with de-ionized water. Any pump motor leads that are submerged must also be wiped prior to re-deployment. When not in use, the submersible pump shall be stored in a dust free environment (or bagged). The seacan containing the Bennett pump should have its doors closed while not in use to inhibit dust incursion.

3.4. Artesian Conditions

Artesian (or "flowing") conditions occur when a confined aquifer is under positive pressure, which causes the water level in a monitoring well to rise above ground surface to achieve hydrostatic equilibrium. The monitoring wells BJ-GW14-13A/B and BJ-GW14-14A present artesian conditions and are fitted with packer plugs to control the artesian flow and satisfy Part 8 of BC's Groundwater Protection Regulation under the *Water Sustainability Act.*

All three monitoring wells contain dataloggers that are deployed below the packer plugs to record pressure. The packers will have to be removed prior to downloading the dataloggers at BJ-GW14-13A/B and prior to the monitoring, sampling and data logger download at BJ-GW14-14A. The packers will be reinstalled in the wells upon completing of the monitoring and/or sampling tasks. To prevent water from freezing in the well above the packer, any standing water above the packer seal should be expelled (using a peristaltic pump).

BJ-GW14-14A is seasonally artesian which can impact the sampling procedure:

- If the water level in the well resides within the casing upon removal of the packer plug, then the well should be sampled via low flow methods outlined in Section 3.3.
- If the well flows upon removal of the packer plug, the flow rate should be estimated and the well allowed to 'self-purge' one to three bore volumes prior to collection of the sample. One bore volume is approximately 88 L. Upon purging of this water, the well can be sampled using a peristaltic pump, the sample tubing need not be deployed to the bottom of the well. The sampler should connect the YSI flow through cell and record three readings (every 5 minutes) prior to collecting the sample as per the procedures outline in Section 3.3.

3.5. Quality Assurance/Quality Control (QA/QC) Procedures

Quality Assurance/Quality Control (QA/QC) procedures are important to ensure that representative data are obtained.

- Collect field duplicate samples for analyses for the same analytical parameters as the primary samples:
    - The field duplicate sample provides an indication of the precision of the analytical methodology as well as sampling methodology and sample matrix variability.
    - Collect one duplicate per ten primary samples in a quarterly sampling event. If more than one duplicate is collected in a quarterly sampling event (i.e. primary samples exceed ten), then duplicates should be collected at wells using different sampling methods. Ideally, a duplicate for each sampling method (peristaltic pump, submersible pump, Bennett sample pump, bailer and bladder pump) should be collected over the course of one year.
    - The duplicate should be taken for all parameters listed in Table 4.
    - The field duplicate is given the name of the primary sample, followed by the suffix "-98" (for example, BJ-GW18-23B-98).

- At least one field blank should be collected during each quarterly sampling event.
    - The field blank will be collected by directly pouring recently prepared (within one month) deionized water (DI) supplied from the laboratory into the same sample bottles as a typical groundwater sample set (Table 4).
    - DI water will be field-filtered using a syringe and disc filter for the dissolved metals and dissolved mercury samples.
    - All field blank bottles should be preserved in the field.
    - The field blank is given the name of the well site where the sample was collected, followed by the suffix "-99" (for example, BJ-GW18-23B-99).
- One equipment blank should be collected during each quarterly sampling event. This sample should be collected using one of the main sampling methods used during the sampling rounds.
    - The DI water should be field-filtered using an inline filter for the dissolved metals and dissolved mercury samples.
    - The field blank is given the name of the well site where the sample was collected, followed by the suffix "-99" (for example, BJ-GW18-23B-99).
- Record QA/QC samples on COC submissions.

4. FIELD DOCUMENTATION

Complete required field documentation for each monitoring well/sample. These field data include (but are not limited to) the following, as appropriate:

- Date and time of groundwater monitoring, data logger withdrawal/deployment and sample collection.
- Sampling equipment used.
- Specific notes regarding the sample collection and QA/QC samples.
- References, such as maps or photographs, of the sampling site.
- Field measurements, such as color/clarity, temperature, pH, SC, DO, ORP, turbidity and alkalinity (starting in sQ1 2020).

5. SITE SPECIFIC CONSIDERATIONS

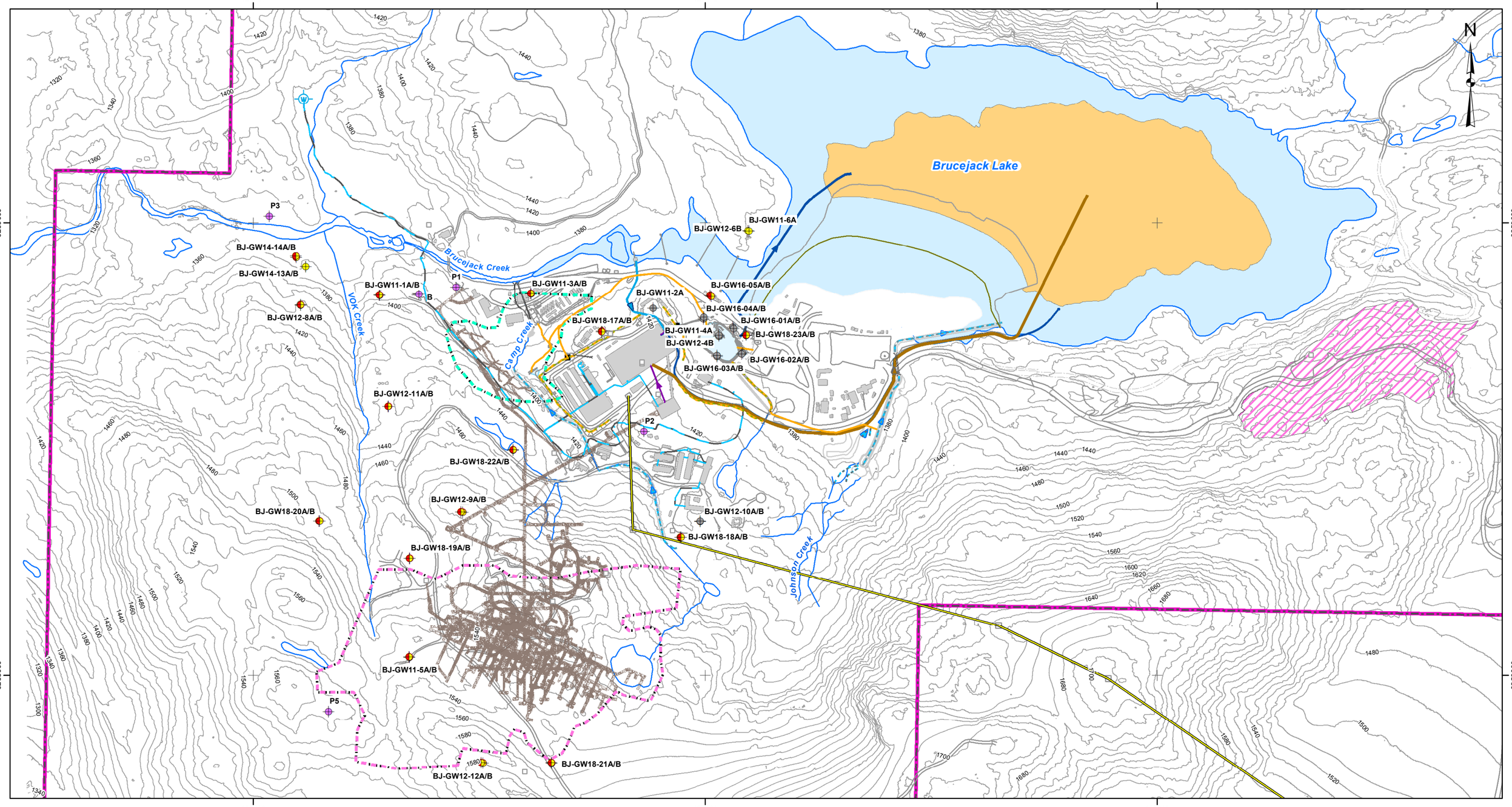
In the winter, keep the YSI meter and probes warm to avoid damage from freezing. Prevent groundwater samples from freezing, as sample bottles could crack with the change in volume.

5.1. Wells with Slow Recovery

Some wells experience slow recovery during purging and sampling necessitating multiple trips to purge the required well volumes prior to sampling. For wells where the water level is within the screened interval, purging should be conducted such that the water level does not reach the bottom of the screen. The well should be allowed to recover, then purging may resume.

Appendix A

Groundwater Monitoring Well Site Map



- Decommissioned/Destroyed Monitoring Well
- Permit Required Monitoring Well (Delayed Installation or Installation for Closure)
- Existing Monitoring Well (Level and Quality)
- Existing Monitoring Well (Water Level Only)
- Drainage Manhole
- Water Well & Pump
- Furthest Edge of Waste Rock Dump Toe
- Crest of Waste Rock Dump
- Ultimate Waste Rock Dump Design
- CWP Direct Discharge Line
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Relcaim Water Line
- Tailings Discharge Lines
- Untreated or Off-Spec Water Line
- WTP/STP Effluent Line
- Culverts
- Potable Water Line
- Transmission Line
- Road Permitted (Not Built)
- EOM VOK U/G Stopes Surface Projection
- EOM WZ U/G Stopes Surface Projection
- Underground Development
- NPAG Quarry
- Tailings Deposition
- Pretivm Mining Lease

0 125 250 500
Meters

PRETIVM

2300–1055 Dunsmuir Street
Vancouver, BC V7X 1L4
Canada
(604) 558–1784

PRETIUM RESOURCES INC.
Brucejack Gold Mine

Site Plan D
Groundwater Monitoring Sites

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_BJ_4000_PE-107835-Plan_D_11x17_20180914		1:8,000	19 Sept 2018	PE-107835	

PROJECTION: NAD 1983 UTM Zone 9N

Appendix B

Detailed Table of Monitoring Wells for the Brucejack Groundwater Monitoring Program

Monitoring Site Identifier (PE-107835 Mar. 31, 2017)		Monitoring Site Identifier (PE-107835 Dec. 14, 2018)		Permit-Required Monitoring[4]		Installation Date	Easting[1] (m)	Northing[1] (m)	Elevation[1] (m)	Sand Pack Interval		Lithological Unit	Decommissioned Date
Project ID	EMS ID	Project ID	EMS ID	Groundwater Levels	Groundwater Sampling					Top (mbgs)	Bottom (mbgs)		
MW-BGC11-BJ-1A	E303054	BJ-GW11-1A	E303054	C	sQ	Oct 02, 2011	426,281	6,258,840	1,385.72	77.1	85.3	Office P1	-
MW-BGC11-BJ-1B	E303054	BJ-GW11-1B	E314692	C	sQ	Oct 02, 2011	426,280	6,258,841	1,385.72	31.3	38.7	Office P1	-
MW-BGC11-BJ-2A		-	-	-	-	Oct 03, 2011	426,885	6,258,812	1,423.17	64.9	80.3	P2	Jan 21, 2016
MW-BGC11-BJ-3A	E303056	BJ-GW11-3A	E303056	C	sQ	Oct 03, 2011	426,615	6,258,844	1,367.63	79.3	88.4	P2	-
MW-BGC11-BJ-3B	E303056	BJ-GW11-3B	E314693	C	sQ	Oct 04, 2011	426,615	6,258,844	1,367.53	4.5	9.1	P2	-
MW-BGC11-BJ-4A	-	-	-	-	-	Oct 04, 2011	427,031	6,258,750	1,390.46	18	31	VSF	Sep 14, 2015
MW-BGC12-BJ-4B	-	-	-	-	-	Jun 20, 2012	427,031	6,258,752	1,390.43	91.6	98.1	VSF	Sep 14, 2015
MW-BGC11-BJ-5A	E303058	BJ-GW11-5A	E303058	C	sQ	Sep 29, 2011	426,347	6,258,040	1,526.14	65.7	78	VSF	-
MW-BGC11-BJ-5B	E303058	BJ-GW11-5B	E314694	C	sQ	Sep 30, 2011	426,346	6,258,042	1,526.16	39.6	50.9	VSF	-
MW-BGC11-BJ-6A	-	-	-	-	-	Oct 04, 2011	427,095	6,258,983	1,379.81	98.2	103.2	VSF	-
MW-BGC12-BJ-6B	-	-	-	-	-	Jun 16, 2012	427,097	6,258,982	1,379.56	86	95.1	VSF	-
MW-BGC12-BJ-8A	E303059	BJ-GW12-8A	E303059	C	sQ	Jun 18, 2012	426,106	6,258,818	1,403.38	86	95.1	Office P1	-
MW-BGC12-BJ-8B	E303059	BJ-GW12-8B	E314695	C	sQ	Jun 19, 2012	426,106	6,258,819	1,403.30	44.3	51	Office P1	-
MW-BGC12-BJ-9A	E303060	BJ-GW12-9A	E303060	C	sQ	Aug 04, 2012	426,465	6,258,361	1,514.40	70.8	80	Office P1	-
MW-BGC12-BJ-9B	E303060	BJ-GW12-9B	E314696	C	sQ	Aug 01, 2012	426,461	6,258,362	1,514.56	38.4	47.4	Office P1	-
MW-BGC12-BJ-10A	-	-	-	-	-	Jun 22, 2012	426,989	6,258,341	1,445.59	51.6	60.1	VSF	Sep 14, 2015
MW-BGC12-BJ-10B	-	-	-	-	-	Jun 22, 2012	426,989	6,258,341	1,445.64	35.6	41.4	VSF	Sep 14, 2015
MW-BGC12-BJ-11A	E303062	BJ-GW12-11A	E303062	C	sQ	Jun 26, 2012	426,300	6,258,595	1,433.57	25.8	29.5	Office P1	-
MW-BGC12-BJ-11B	E303062	BJ-GW12-11B	E314697	C	sQ	Jun 28, 2012	426,299	6,258,595	1,432.96	48.2	53.8	Office P1	-
MW-BGC12-BJ-12A	E303063	BJ-GW12-12A	E303063	C	sQ	Aug 08, 2012	426,509	6,257,807	1,579.19	84.3	97	Bridge P1	-
MW-BGC12-BJ-12B	E303063	BJ-GW11-12B	E314698	C	sQ	Aug 10, 2012	426,505	6,257,807	1,579.16	45.2	53.1	Bridge P1	-
MW-BGC14-BJ-13A	E303064	BJ-GW14-13A	E303064	C	-	Sep 09, 2014	426,118	6,258,904	1,362.49	20.7	100.9	Office P1	-
MW-BGC14-BJ-13B	E303064	BJ-GW14-13B	E314699	C	-	Sep 13, 2014	426,118	6,258,904	1,362.76	21.2	75.4	Office P1	-
MW-BGC14-BJ-14A	E303065	BJ-GW14-14A	E303065	C	sQ	Sep 11, 2014	426,096	6,258,924	1,351.10	14.9	34.9	Office P1	-
MW-BGC14-BJ-14B [3]	E303065	BJ-GW14-14B	E314700	C	sQ	Sep 23, 2014	426,095	6,258,927	1,355	0.5	4.6	Office P1	-
New well @ A	E303560	BJ-GW18-17A	E303066	C	sQ	Jun 05, 2018	426,771	6,258,761	1404.21	142.07	148.12	V12/V6b	-
New well @ A	E303560	BJ-GW18-17B	E314701	C	sQ	Jun 08, 2018	426,772	6,258,760	1404.24	72.1	75.76	Office P1	-
New well @ C	E303068	BJ-GW18-18A	E303069	C	sQ	Jun 12, 2018	426,946	6,258,306	1445.35	95.53	101.27	Office P1	-
New well @ C	E303068	BJ-GW18-18B	E314702	C	sQ	Jun 09, 2018	426,947	6,258,306	1445.32	61.54	65.57	Office P1	-
New well @ D	E303069	BJ-GW18-19A	E303070	C	sQ	Jun 14, 2018	426,347	6,258,259	1495.6	191.78	196.89	Office P1	-
New well @ D	E303069	BJ-GW18-19B	E314703	C	sQ	Jun 17, 2018	426,346	6,258,259	1495.45	154.92	159.54	Office P1	-
New well @ E	E303070	BJ-GW18-20A	E303559	C	B	Jun 17, 2018	426,147	6,258,341	1494.02	159.92	167.53	Office P1	-
New well @ E	E303070	BJ-GW18-20B	E314704	C	B	Jun 20, 2018	426,148	6,258,342	1494.07	113.27	118.45	Office P1	-
New well @ F	E303071	BJ-GW18-21A	E303071	C	B	Jun 24, 2018	426,661	6,257,806	1550.41	193.49	204.83	S4-VSF	-
New well @ F	E303071	BJ-GW18-21B	E314705	C	B	Jun 29, 2018	426,660	6,257,807	1550.43	152.05	159.45	S4-VSF	-
New Well @ P4	E303559	BJ-GW18-22A	E303068	C	-	Jul 01, 2018	426,575	6,258,498	1444.73	369.58	379	S4-VSF	-
New Well @ P4	E303559	BJ-GW18-22B	E314706	C	-	Jul 06, 2018	426,576	6,258,499	1444.91	82.99	87.82	S3-Poly	-
-	-	BJ-GW18-23A	E314690	C	sQ	Jul 01, 2018	427,091	6,258,751	1370.92	25.32	29.7	S4-VSF	-
-	-	BJ-GW18-23B	E314691	C	sQ	Jul 02, 2018	427,091	6,258,752	1370.94	7.61	11.3	S4-VSF	-

Notes:

1. Monitoring well top of pipe coordinates determined by RTK GPS, horizontal datum UTM Zone 9N NAD 83, Project vertical datum.
2. "-" indicates the well was not sampled in 2018. Both Hydrolift and Manual purge methods use 1" Waterra tubing and associated foot valves (i.e., inertial pumps).
3. Coordinates of MW-BGC-BJ-14B are from a handheld GPS in UTM NAD 83 Zone 9N. Vertical datum is unknown.
4. Permit-required monitoring as specified in Mines Act Permit MA-253, Environmental Management Act Permit 107835, and documents referenced by the permits. C = continuous, sQ = each Smart Quarter

Appendix C

Brucejack Field Parameter Probe Calibration Record

Calibration Log

Calibration

Date	Time	YSI Instrument	Serial No.	Calibrated by	barometer	Temperature (˚C)	1413µS Spec. Cond.	4.00 pH	4 pH mV	7.00 pH	7 pH mV	10.00 pH	10 pH mV	Slope	slope %	DO (%)	Turbidity 0 FNU	Turbidity 124 FNU	ORP +125 mV

Appendix D

Groundwater Monitoring Well Field Sampling Form

BRUCEJACK GW SAMPLING FORM

NEWCREST

Well ID:
XXXXXXXXXXXXX

Water Level (mbTOC @ time):	Date:
Stick-up (m ags):	Personnel:
Bottom of well (mbTOC):	Weather:
Well Casing Diameter (mm):	Air Temperature (°C):
Minimum Purge Volume (L):	Sampling Method:

Purging Record - Field measurements

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	Temp. % change from previous reading	SC (mS/cm)	SC % change from previous reading	DO (mg/L)	DO % change from previous reading	pH (s.u.)	pH % change from previous reading	Redox Potential (mV)	Redox Potential % change from previous reading	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
					-		-		-		-		-		

Time sample collected:		Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Total Volume Purged (L):		Equipment Used (Model, SN):	
Average Purge Rate (L/min):		Date multimeter (e.g., YSI) last calibrated:	
Notes:			

cells with calculations in them, do not type inside them

Sampling criteria

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

drawdown	<10 cm
Temperature:	+/- 0.1°C
Electrical Conductivity:	+/- 3%
Dissolved Oxygen:	+/- 10%
pH:	+/- 0.1 units
Reduction/Oxidation Potential:	+/- 10%

Appendix E

Submersible Pump Standard Operating Procedure

NEWCREST		BJ-ENV-SOP-XXX Groundwater Sampling with Submersible Pump	
Owner:	**Approver**:	**Revision Number**: 1	**Creation Date**: June 13 2019
			Revision Date: Dec 14, 2019

Objective

Safe and effective operation of the Grundfos Redioflo 2 submersible pump for collection of groundwater samples from standpipe monitoring wells.

Scope

Installing the pump in a well, operating the pump, recovering the pump from a well, storage and maintenance. Other aspects of groundwater sampling and working at Brucejack more generally are discussed in other SOPs.

Health, Safety & Reclamation Code of BC

- 1.11.1 – Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 – Personal Protective Equipment
- 4.9.01, 4.9.1, 4.9.3 – Heavy Equipment

Training

Personnel should be familiar with the safe operation and limitations of the equipment before using it. When using the submersible pump system for the first time, personnel with previous experience using the equipment should be leading the work and providing hands-on guidance on the risks.

Preparation

Hazards

- Electric shock
- Back and muscle strain (forearms, shoulders)
- Property damage (Loss of well and pump)

Tools

- Vinyl gloves
- ½ inch inner diameter (ID) tubing (high-density polyethylene or low-density polyethylene)
- Submersible pump and 300 ft cable reel
- Pump variable frequency drive (VFD) controller
- Tubing cutters
- Hose clamps (1 x ¾ or 1 inch, 1 x 2½ or 3 inch)
- 2 ft Cord, 2 mm diameter or greater
- Water level tape
- Multi-parameter probe with flow-through cell
- PVC tape
- Zip ties
- Medium or large vice grips
- Nut drive fitted to the hose clamps
- Flathead screw driver
- Graduated bucket (1 or 2 L graduations, 1 or 2 buckets)

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Job Step

1. **Measure groundwater level in the well and remove pressure transducer**
    - Well should be clear of all obstructions before lowering the pump
2. **Prepare to lower pump**
    - Stage pump, cable reel, and tubing next to the well collar'
    - Pump motor chamber should be filled with water. This should be inspected and topped up as required before each use of the pump
    - Connect tubing to barb fitting at top of pump. Use hose clamp to tighten tubing onto fitting
3. **Lower the pump**
    - Fix the tubing and cable together approximately 1 m above the pump using PVC tape or zip ties. Continue to fix the cable and tubing together at approximately 10 m intervals as the pump is lowered. The cable should be kept under light tension while lowering, particularly when fixing it to the tubing. This task step serves to prevent the cable from bunching up during recovery of the assembly. **Bunching up cable presents a risk of considerable property damage, the worst case being loss of both the pump and monitoring well.**
    - If an obstruction is encountered before reaching the bottom of the well, do not apply force to advance the pump past it. **Applying force against an obstruction may result in the pump becoming stuck at or below it, presenting a risk of considerable property damage, the worst case being loss of both the pump and monitoring well.**
    - This is a two person task. One person is positioned at the collar, guiding the tubing and cable into the well. The second person unspools the tubing. The cable reel is allowed to unspool cable with light resistance applied by the mechanical break (preventing free-wheeling).
    - Vice grips may be used to suspect the assembly part-way down the well temporarily, providing personnel with the opportunity to take breaks to minimize muscle fatigue and prevent strain. Set the vice grips to an appropriate size to grip the tubing without damaging it before starting to lower the pump, so that they are available with minimal disruption when needed.
    - Vinyl gloves should be worn to lower tubing to minimize cross-contamination of the water in the monitoring well and to maximize dexterity for holding the tubing.
4. **Set the pump at the center of the well screen**
    - The center of the well screen is most easily identified by lowering the pump to the bottom of the well (where the weight of the assembly is supported), then raising by a distance equal to half the length of the well screen. Most well screens are 3 m long (verify for each specific well by reviewing well construction details table).
5. **Prepare to start the pump**
    - Cut the tubing to length, if required, using tubing cutters. Connect the flow cell with multi-parameter probe to the end of the tubing, use a short additional length of tubing to direct flow into a graduated bucket.
    - Plug the pump cable lead into the VFD controller.
    - Plug the controller into the generator.
    - Prepare to start the generator: fuel up (using standard protocol with gloves, spill kit, containment), turn breather valve on fuel filler cap to On position, open fuel valve, turn power to on position, turn choke on. Start the generator, turn choke off.
    - The controller will immediately power up once the generator starts to produce power. Wait around one minute before starting pump to verify power supplied to the controller is appropriate (an error message will display if not).
6. **Start the Pump**
    - Slowly turn the VFD knob on the controller clockwise to increase the pump motor frequency (increase controller output voltage).

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- The motor frequency required to sustain flow to the well depends on the depth to water in the well, and may need to be adjusted depending how rapidly the water level drops in response to pumping. Determining the optimal motor frequency and adjustments will require familiarity with both the pump and the recharge and sediment load characteristics of the specific well.
- VFD controllers are sometimes not compatible with the ground fault circuit interrupters on some generators.

7. Purge and sample

- Conduct groundwater sampling in accordance with the groundwater sampling SOP. Purging should be conducted until groundwater level stabilization can be demonstrated followed by hydrochemical parameter stabilization. Additionally, the flow rate should be maintained adequately low to minimize entrainment of suspended sediments (as assessed by turbidity measurements).
- The practical lower threshold flow rate for the Redi Flo 2 submerisble pump is around 200 mL/min. Lower flow rates may be achieved but may not be consistent, particularly in the presence of higher sediment loads and as pump impeller and motor wear progresses.
- Sediment load should be minimized with use of a submersible pump. A slug of suspended sediment shortly after starting to pump and enduring less than one well volume is common and should not cause undue wear on the pump. Sustained elevated sediment loads will reduce pump lifespan due to the abrasion on components contacting the water.
- Water level measurements should be recorded at regular intervals while purging. Care should be taken to avoid the water level dropping to the pump (e.g. maintain a water column at least a couple meters above the pump).
- Flow should remain continuous at a consistent flow rate while sampling with the submersible pump. This pump is not equipped with a check valve, and as such when the pump is stopped all water in the tubing will return to the standpipe column.

8. Stop the pump and remove the assembly from the well

- The pump may be stopped either using the stop button on the controller or by turning off the generator.
- Disconnect the materials used to suspend the pump at the well collar.
- Raise the tubing and cable using a hand-over-hand motion, cutting the PVC tape or zip ties as they daylight from the well.
- Raising the tubing and cable is a two person task.

9. Tubing will not be re-used. Dispose the tubing in the General Waste bin at the Waste Sorting Facility. Return equipment to storage

- Controller box should be left open to allow any moisture accumulation to dry. Care should be taken to avoid any direct water contact with the controller itself at all times.

DRAFT

Photo 1. Submersible pump with 300 ft cable on reel

Photo 2. VFD Pump Controller (top-down view)

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Environment Superintendent	Torence Sandhals		
Assistant Environment Manager	Robin McCall		
JOHSC Co-chair or Member			

Appendix F

Bennett Sample Pump Standard Operating Procedure

Objective

To provide operational guidance when using the Bennett Sample Pump (BSP) during groundwater sampling at the Brucejack mine.

Scope

The document covers the transport of the BSP along with instructions on start-up, operation and shut-down. Troubleshooting, safety tips and decontamination procedures are also provided.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5, 1.8.7 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- BSP – Bennett Sample Pump
- PPE – Personal Protective Equipment (hard hat, steel toed boots, high visibility vest, hearing protection, cut resistant gloves and safety glasses)
- PSI – Pounds per square inch

Preparation

Hazards

- Work near heavy equipment (loaders and snowcat)
- Gasoline exhaust fumes
- Pressurized air compressor tank and pressurized air lines
- Propane lines and tanks
- Gasoline tanks and generators
- Slips, trips and falls
- Tight working space
- Noise
- Excessive vibration
- Work in a remote field environment
- Avalanche hazards
- Deep snow
- Wildlife

Training Requirements

- Avalanche training.
- Bear aware training.

Tools

- BSP seacan:
  - Ingersoll Rand gasoline powered air compressor (Photograph 1),

    - BE 9000W gasoline generator (Photograph 2),
    - BSP motorized tubing reel and detachable tube reel arm (Photograph 3),
    - Super-Dry air dryer unit (Photograph 4),
    - Detachable airline (Photograph 5), and;
    - Propane heater (Photograph 6).
- Toolkit (adjustable pipe wrench, small wrenches for reel tubing and screwdrivers).
- Super-dry desiccant
- Three 20 L pails full of clean water (to prime the BSP and tubing)
- Electrical tape
- Rubber bungie cables
- Two twenty pound propane tanks (cold weather conditions)
- Gasoline jerry can
- Large spill tray
- Hydrocarbon spill pads
- Wildlife deterrent (bear bangers and bear spray)
- Snow shovels

Job Step

1. Pump Movement/Relocation

- Coordinate with the Surface Operations department in advance to plan the transport of the BSP seacan. A loader will be required in the summer. In the winter, the seacan must be loaded and fastened onto a snowcat trailer.
- Personnel familiar with the safe operation of the BSP should lead the pre-operational check of the seacan. Inspect the exterior and interior of the seacan for any visible damage to the structure of the seacan (including interior insulation) and its contents, including the propane heater and exhaust, propane lines, air compressor, generator and tubing reel.
- Ensure that any loose equipment (tools, pails, spill kits, snow shovels, etc.) are secured to minimize any movement during transport of the seacan.
- Propane tanks must be disconnected, and along with gasoline jerry cans, must be transported separately to prevent any spills and minimize safety risks.
- Close and lock the man-door and the roll up door.
- In the summer, provide guidance to the loader operator regarding the transport of the seacan, and accompany the loader (and seacan) to the well site. In the winter, provide guidance to the snowcat operator regarding the transport of the seacan to the well site. Environmental team members should accompany the loader/snowcat operators to serve as a spotter and to confirm the correct placement of the seacan.
- At the well site, direct the heavy equipment operator to position the seacan approximately 1 to 2 m away from the well/well shack, with the reel lined up with the well stickup being sampled(Photograph 7).

NOTE: Positioning the pump in the winter can be significantly more challenging. Depending on the thickness of the snow, there may be a considerable amount of shoveling around the well shack doors. This should be completed prior to mobilizing the seacan to minimize the snowcat operator's down time. Additionally, the trailer should be placed as flat as possible. The trailer MAY ROLL if left on a slope. If necessary, dunnage/wooden blocks can be placed under the tracks before the trailer is detached from the snowcat. DO NOT rely on the dunnage to prevent a roll.

2. Assembling and priming the pump

- Using a small adjustable wrench, attach the Bennett pump head to the pump reel tubing. First, attach the steel wire to the centre of the Bennett pump head. Next, the three tubes within the tubing reel (Air Inlet, Air Exhaust, and Water) will have to be attached to the labelled ports on the pump head. The Air Inlet and Exhaust are similar in size and are located on either side of and

below the Water line, which is located in the centre of three lines. The lines create a triangle. Finally, ensure the pressure transducer line is fitted into the associated slot on the Bennett pump head.

- Remove the generator from the seacan, and orient the generator exhaust downwind and/or away from the work area. Turn the generator on and run for about two minutes to allow the generator to warm up. Plug in the electrical cable from the tubing reel motor into the generator.
- Advance the reel forward using the reel toggle switch, allowing enough slack in the tubing to place the pump in a 20L pail full of clean water. The pump and entire reel of tubing needs to be primed prior to advancing the pump downhole.
- Check to ensure that the air compressor outlet valve is closed (perpendicular to the air line). Close the air compressor drain valve located at the base of the air compressor tank. Check the engine oil and fuel tank level. DO NOT operate the air compressor if the engine oil level is low. Start the air compressor by turning the key to the ON position. Turn the fuel lever to the open position and open the choke. Toggle the grey metal wire below the choke so that the small metal plate is parallel to the floor (horizontal). This will aid in helping the air compressor to turn over (Photograph 8). Start the air compressor engine with the pull cord. Slowly close the choke.
- Once the air compressor tank is full, the engine will switch to idle mode. To minimize noise, it is preferable to turn the engine off. Monitor the pressure gauge on top of the tank every 3 to 5 minutes. Close the moisture filter valve, located behind the tubing reel flow controller and close the drain valve located below the air dryer unit.
- Slowly open the air compressor outlet valve to allow air flow into the Super-dry air dryer unit. There are two pressure gauges, one at the inlet and one at the outlet of the Super-dry air dryer unit. The inlet (bottom) pressure gauge and the outlet (top) pressure gauge should read the same pressure during operation. If there is a discrepancy in the readings between the inlet and outlet pressure gauges, the internal desiccant will need to be replaced. The air dryer unit is rated to handle a maximum air pressure of 150 psi. Monitor the pressure gauges and ensure that the pressure does not exceed 130 psi (this allows a 20 psi buffer).
- Open the air dryer outlet air valve and open the flow controller on the front face of the tubing reel (Photograph 9) to allow air to flow through the tubing and the pump. As the air pressure increases, the pump will engage (identified by a clicking sound) and will begin pumping water from the 20L pail. Approximately 40L of water will be required to completely fill the tubing reel and pump. Monitor the discharge, noting the frequency of air bubbles. Once the discharge of air bubbles ceases, the pump is ready for deployment into the well. While priming the pump on surface, 40 psi of air pressure will be adequate to pump water out of a 20L pail. Ideally, pump three 20L pails of water through the tubing to ensure the pump is primed and flushed. After one and a half pails (~30L), the pump outlet should start to produce water, which should be discharged into an empty pail.
- The air pressure in the air compressor tank will gradually reduce. In order to fill up the compressor tanks, close the outlet valve on the air compressor tank, turn on the engine, allow the tank to fill up, and then open the outlet valve on the air compressor tank. Alternatively, the outlet valve can be adjusted and left open such that the air compressor fills the compressor tank and the desiccator to the desired psi.
- Once the pump is primed, close the outlet air valve on the air dryer unit and allow the pump to slow down the pumping rate. Once the pump stops cycling, turn off the flow controller. Allowing the pump to slow down reduces the air pressure within the tubing, thus applying less pressure on pump fittings and connections. Ideally, no air should be pumped while lowering the tubing down the well. By releasing pressure in the system, it reduces the likelihood of pumping or water loss during deployment.

3. Deploying the pump in the monitoring well. TWO PERSON TASK.

- Advance the tubing reel forward using the toggle switch, and gently guide the pump into the well. One person will control the reel toggle switch, while the other person guides the tubing into the well. Ensure the pump head enters the well directly so that it is not damaged and does not damage the well.
- Place the detachable reel arm between the monitoring well and the reel, using the arm to support the weight of the tubing. The reel arm will reduce the load on the well stick-up and will minimize

surface abrasion to the tubing (Photograph 10). At the start of the tubing deployment, the tubing will likely have to be pushed down the well.

- While lowering the tubing, complete repairs to the tubing bundle by applying thick electrical tape on exposed areas of the tubing bundle and/or removing brittle tape.
- Lower the pump to the bottom of the well and then withdraw it up to the desired target depth for the pump head. The pump should be deployed midway into the well screen (confirm screen length from well fact sheets).
- Turn off the generator and unplug the electrical cable.
- Wait 5-10 mins to allow disturbed silt to settle.

4. Purging and sampling the monitoring well

- Pressurize the system again to begin pumping. The air compressor can remain turned off while pumping. Re-engage the air compressor only when the pressure drops below the minimum pressure needed to pump the well. This will minimize unnecessary noise and vibration.
- The air pressure as measured by the air dryer pressure gauges should be maintained below 130 psi. Initially, the air compressor outlet valve may need to be adjusted each time it is turned on to adjust to a steady pressure of ~80-120 psi, however, after repeated adjustments the air compressor should pressurize to the set pressure before dropping to idle automatically.
- Follow the low flow sampling guidelines provided in the Groundwater Sampling Protocol document. Generally, a flow rate of 1000 mL/min or less should be maintained, filling one 20L pail in 20 minutes.
- Once field parameters have stabilized, the sample can be collected following standard sampling procedures outlined in the groundwater sampling SOP.

5. Removing the pump from the monitoring well. TWO PERSON TASK.

- Close the valve at the air compressor outlet, thus slowing the pumping rate and eventually stopping the pump from cycling. Turn off the flow controller.
- Connect the electrical cable from the BSP reel motor to the generator.
- Retrieve the pump and tubing by using the toggle switch and by gently guiding the tubing onto the reel by spreading it in an even manner. One person will control the toggle switch, while the other person will direct the tubing onto the reel. Proper communication and eye contact is vital to complete this task safely. Use the detachable reel arm to aid in guiding the tubing out of the well and onto the reel.
- When the pump head is close to the top of the well, lower the rate of tubing withdrawal, to prevent the pump head from getting wedged at the top of the well stickup.
- Repair any damage to the tubing bundle with thick electrical tape, as the pump is raised out of the well.
- Turn off the generator and unplug the electrical cable once the tubing and pump head are at surface.

6. Draining water from the BSP tubing and pump.

- Turn off the air compressor and shut the air compressor outlet valve.
- Open the air dryer inlet valve, air dryer outlet valve and air dryer drain valve, which will drain the air pressure in the tubing bundle. **HEARING PROTECTION** is mandatory due to the high pitch of the air exiting the tubing.
- Once the BSP air line is drained, detach the pump screen using small a small adjustable wrench. Disconnect the BSP air line (black hose) from the outlet end of the air dryer.
- Close the inlet, outlet and drain valves of the air dryer. Attach the snap fitting of the detachable air line (yellow hose) to the outlet end of the air dryer and attach the threaded end to the base of the Bennett pump head (the screen will have to be removed as mentioned above).
- Open the inlet and outlet valves of the air dryer. Gently crack the air compressor outlet valve, thus allowing a slow stream of air into the pump head. This air stream will displace all the water in the BSP tubing. Approximately 30L of water will drain from the tubing, equivalent to the volume required to prime the pump and tubing.

- Once all the water has been drained from the tubing, close the air compressor outlet valve. Open the air dryer inlet, outlet and drain valves, thus allowing all the air in the yellow detachable air line to drain. Unscrew the yellow detachable air line from the base of the pump head.

7. Shutdown and equipment storage

- Open the drain valve located at the base of the air compressor. This will drain the air pressure and will drain any accumulated moisture in the compressor tank.
- Open all air line valves to drain them completely.
- Drain the Speedaire water filter located behind the BSP flow controller panel (Photograph 11)
- Close the inlet, outlet and drain valves for the air dryer.
- Turn the propane tank off, turn the propane heater off, unhook the propane tank, and allow propane lines to drain. **Propane heater has been broken for several seasons and a portable heater is currently being used, or a FrostFighter.*
- Secure the generator in the seacan using bungee straps.
- Secure the man door and roll up door of the seacan.
- Transport gasoline jerry cans and propane tanks separately.
- Contact the Surface Operations department regarding the transport of the seacan, if required.

8. Cold weather considerations

The pump head must be removed during above zero temperatures to prevent water from freezing within the pump head. The pump seals and piston will get damaged by water freezing within the pump chambers. During the winter, the BSP seacan should be heated (using the internal propane heater) prior to use. The heater should be run for at least 24 hours to allow residual water in the tubing to thaw, and to melt any frost/ice on the seacan floor. **Propane heater has been broken for several seasons and a portable heater is currently being used, or a FrostFighter.*

Troubleshooting

If the BSP is operational but no water is discharging, there could be an air lock in the system. To rectify this issue:

- Adjust the air pressure into the pump, but do not exceed 140 psi.
- Close the flow controller, thus allowing the system to pressurize.
- Try lowering and raising the pump within the water column.

If these steps do not rectify the issue, withdraw the pump, re-prime at surface and reinstate the pump down the well.

Photographs

Photo 1. Ingersoll Rand air compressor

Photo 2. BE 9000W gasoline generator

Photo 3. Bennett Sample Pump reel

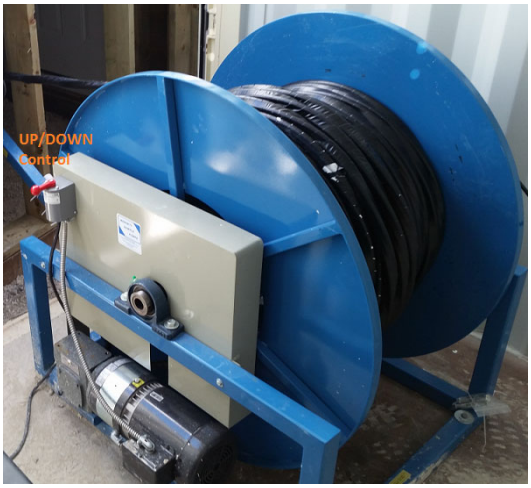

Photo 4. Super-Dry air dryer

Photo 5. Detachable yellow air line

Photo 6. Propane heater

Photo 7. BSP seacan placement

Photo 8: Toggle switch for air compressor.

Photo 9. Flow controller

Photo 10. BSP tubing supported by a detachable arm

Photo 11. Speedaire moisture filter

Closed - in use

Open - draining

Decoupled for cleaning

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
March 31, 2020	Updates to the procedure and additional photographs	Lionel Sequeira	Entire document
November 27, 2021	Updates to the procedure and additional photographs	Nathan Glas & Richelle Sussbauer	Entire document

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate			
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix G

Bladder Pump Standard Operating Procedure

NEWCREST		BJ-ENV-SOP-XXX Groundwater Sampling with High-Pressure Bladder Pumps	
Owner:	**Approver**:	**Revision Number**:	**Creation Date**: June 15 2019
			Revision Date:

Objective

Safe and effective operation of a bladder pump system for collection of groundwater samples from standpipe monitoring wells.

Scope

Installing the pump in a well, operating the pump, recovering the pump from a well, storage and maintenance. Other aspects of groundwater sampling and working at Brucejack more generally are discussed in other SOPs.

Health, Safety & Reclamation Code of BC

- 1.11.1 – Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 – Personal Protective Equipment
- 4.9.01, 4.9.1, 4.9.3 – Heavy Equipment

Training

Personnel should be familiar with the safe operation and limitations of the equipment before using it. When using the bladder pump system for the first time, personnel with previous experience using the equipment should be leading the work and providing hands-on guidance on the safety risks, particularly in relation to the high air pressure that is not involved in the day-to-day work of the environment department. There is also a low-probability high-magnitude risk of property damage associated with using down-well pumps. These risks can be controlled with the information included in this SOP.

Preparation

Hazards

- Energized equipment (compressed air) – fitting or tubing failures causing energized release
- Hearing trauma (compressed air)
- Property damage – loss of pump and use of monitoring well

Tools

- Vinyl gloves
- PVC Tape
- Tubing cutters
- 3/8 inch outer diameter tubing – bladder pump water discharge tube
- ¼ inch outer diameter tubing – bladder pump air tube
- Polyethylene bladder (disposable or dedicated)
- Bladder pump – QED model no. ST1102PM
- Bladder pump controller – QED model no. MP10UH
- Support cable (e.g., motorized winch with 1/8 inch PTFE-coated cable) – stainless steel (refer to cable winch SOP for equipment needed to operate the cable winch)
- ¼ inch and 3/8 inch stainless steel nut and ferule compression fitting unions
- Air compressor (oil-less, 400 psi max pressure)
- Appropriately-rated fittings adapting air compressor outlet to controller, and controller to ¼ inch HDPE air tubing
- Various crescent wrenches

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- Teflon thread tape
- Multi-parameter probe with flow through cell
- Graduated bucket (1 or 2 L graduations, 1 or 2 buckets)
- Generator with 15 amp power supply
- Whip-checks for all couplings at surface

Job Step

1. **Assemble equipment, prepare to go to the field**
    - Required equipment is listed under tools above
    - Use of a stainless steel support cable is required for pump depths greater than 50 m.
    - Polyethylene bladders are disposable and should not be used between wells.
    - Install a new bladder in the pump before going to the field. Wear new, clean vinyl gloves when handling the bladder. Use the task-specific clamp plyers to remove the bladder retainer clamps. Practice installing and removing bladders using a waste bladder.
    - Ensure the Teflon thread tape is applied to all threaded couplings in the bladder pump when re-assembling.
    - Select the appropriate tubing for the expected water levels (Table 1). Be sure to obtain specifications for tubing when ordering to **confirm working pressures are adequate for the expected pressures.** Some common tubing working pressures are included in Table 1.

Table 1. Common tubing working pressures (confirm manufacturer specifications when ordering)

Tubing	Maximum working pressure	Maximum depth to water
¼” OD x 0.17” ID HDPE	250 psi	150 m
3/8” OD x ¼” ID HDPE	250 psi	150 m
5/16 OD Teflon bonded with 3/8” OD (QED # DW5000)	500 psi	300 m

2. **Measure groundwater level, remove pressure transducer from the well**
    - All equipment should be removed from the well before lowering the pump
3. **Prepare to lower the pump in the well**
    - Couple air (1/4 inch) and water (3/8 inch) tubing into the top of the pump (Photo X). These are nut and ferule stainless steel Swagelok compression fittings. Review Swagelok tubing installation videos to familiarize with correct installation methods.
    - Connect support cable to eye loop at top of pump (Photo X).
    - Ensure all couplings are tight.
4. **Lower the pump down the well**
    - Fix the tubing (air and water lines) and cable together at intervals of around 10 m using PVC tape or zip ties.
    - Maintain tension on the cable to avoid it bunching up down the well.
    - Control the lowering rate using the cable winch – this will be especially helpful for deep wells where the weight of the pump, cable, and tubing down the well may exceed 50 lbs.

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- Tip! This is a two person task. One person unspools the tubing, while the second controls the cable winch. The mechanical brake on the cable winch may be used to take micro breaks and switch tasks
- If an obstruction is encountered before reaching the bottom of the well, do not apply force to advance the pump past it. **Applying force against an obstruction may result in the pump becoming stuck at or below it, presenting a risk of considerable property damage, the worst case being loss of both the pump and monitoring well.**
- Vinyl gloves should be worn to lower tubing to minimize cross-contamination of the water in the monitoring well and to maximize dexterity for holding the tubing.
- For deep wells multiple lengths of tubing will need to be coupled together to reach the bottom of the well. Couple the tubing using stainless steel nut and ferule compression fittings. Review the online materials from Swagelok to familiarize with the appropriate manufacturer-recommended methods for coupling tubing together in a manner that ensures maximum fitting strength.

5. Set the pump at the center of the well screen

- The center of the well screen is most easily identified by lowering the pump to the bottom of the well (where the weight of the assembly is supported), then raising by a distance equal to half the length of the well screen. Most well screens are 3 m long (verify for each specific well by reviewing well construction details table).
- Support the pump assembly down the well. If using the cable winch, the mechanical break would provide the simplest means of securing the assembly. If not using cable, the tubing may be secured to the standpipe collar using hose clamps and cord.

6. Prepare to Start the Pump

- Cut the tubing to the appropriate lengths using tubing cutters.
- Couple the air line from the pump into the controller “Air Out” port using an adaptor with one end consisting of a 3/8 inch stainless steel nut and ferule compression fitting and the other end standard NPT threading connected to the quick coupler.
- Connect the controller “Air In” port to the air compressor using the hosing and fittings assembly.
- **All airline couplings at surface are secured with appropriately sized whip checks.**
- Couple the water line into the flow cell and use an additional short length of tubing to direct flow into a graduated bucket.
- Plug the air compressor into the generator
- Start up the generator and wait for the air compressor to pressurize the tank.
- Slowly pressurize the controller by turning the pressure knob clockwise to the required pressure (minimum pressure is the head pressure from static water level to top of pipe plus at least 10 psi).
- Set the recharge/discharge cycling parameters to the desired setting. A common start point for an unfamiliar well is 45 seconds recharge / 15 seconds discharge. The optimal setting depends on the rate required to attain a stable water level, minimizing turbidity, and minimizing the time required to purge volume. Higher pressure and a greater pump submergence depth maximize the achievable flow rate. Lower pressure and, shorter discharge time (not completely emptying the bladder), and longer refill time (time for complete bladder refill plus additional stationary time to allow for water level recovery) reduces the flow rate. The optimal settings will be different for each well, and operators will become familiar with the specifications required for each well following initial use of the pump at the well. This topic is discussed further in the pump user manual.

7. Start the pump

- Recharge/discharge cycling will begin on pressing the start button on the controller.
- It may take several minutes to achieve flow at surface in wells with deeper water levels after starting the pump. Proper function of the pump can be confirmed by submerging the water line outlet in water and observing bubbling during the discharge cycle.
- If flow does not reach surface within a few minutes and there is no bubbling from the water line outlet, double check the pressure gauge readings on the air compressor and controller, and ensure the pressure is high enough to overcome static pressure. Check for leaks in the air line at

surface (listen for hissing). If the air compressor is running continuously this is a good indicator of a leak in the air supply. A leak in the water line may also prevent flow. It may be necessary to remove the assembly from the well and re-inspect the couplings, tubing, and pump for leaks.

8. Purge and sample

- Conduct groundwater sampling in accordance with the Ground Water Monitoring and Sampling Protocol.
- Bladder pumps are effective low-flow sampling tools that minimize entrainment of suspended sediments. A slug of suspended sediment shortly after starting to pump and enduring less than one well volume is common and may clear up. Bladder pumps are well-suited to elevated sediment loads, however the check valve that prevents water backflow may lose effectiveness at high sediment loads and low flow rates.
- Water level measurements and field parameters should be recorded at regular intervals (approximately 5 to 10 minutes) while purging. Air pressure may need to be increased as the water level drops.
- Collect a sample once field parameters have stabilized and water level is constant.
- Disconnect the flow cell prior to collecting a sample. Measure the flow rate and ensure that it hasn't increased. Disconnecting the flow cell may cause the water level to drop during sampling, invalidating the low flow method.
- After collecting the sample, take a final water level measurement prior to stopping the pump.

9. Stop the pump and remove the assembly from the well

- Press the stop button on the controller, turn off the generator, and bleed the pressure from the air compressor. Hearing and eye protection should be worn while bleeding the pressure, and personnel should be positioned outside the line of fire should any debris be energized by the air flow.
- Confirm pressure in the airline has been relieved before beginning to raise the assembly – check gauge pressures on the air compressor and controller read zero.
- Raise the tubing, cable and pump from the well. The cable winch is used to coil in the cable and lift the weight of the assembly. One person coils up the tubing as it raises, removing the zip ties or tape connecting the tubing to the cable.
- Following recovery of the pump, loosen the compression fittings at the top to remove the tubing – the nut and ferule stay with the tubing if it is dedicated (not being discarded).
- The bladder should be changed prior to using the pump on another well location or going into storage.
- The pump housing should be cleaned with an Alconox solution prior to being used in another well or going into storage

10. Return the equipment to storage

- Dedicated tubing should be stored in labelled plastic bags to prevent cross-contamination.
- The pump should be cleaned with Alcanox and the bladder replaced with a new bladder. The pump should be stored in the PVC sleeve between uses.
- Controller box should be left open to allow any moisture accumulation to dry. Care should be taken to avoid any direct water contact with the controller itself at all times.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
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Assistant Environment Manager	Robin McCall		

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Water Treatment Plant Supervisor			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

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Appendix H

Field Alkalinity Measurement Procedure

GENERAL DESCRIPTION

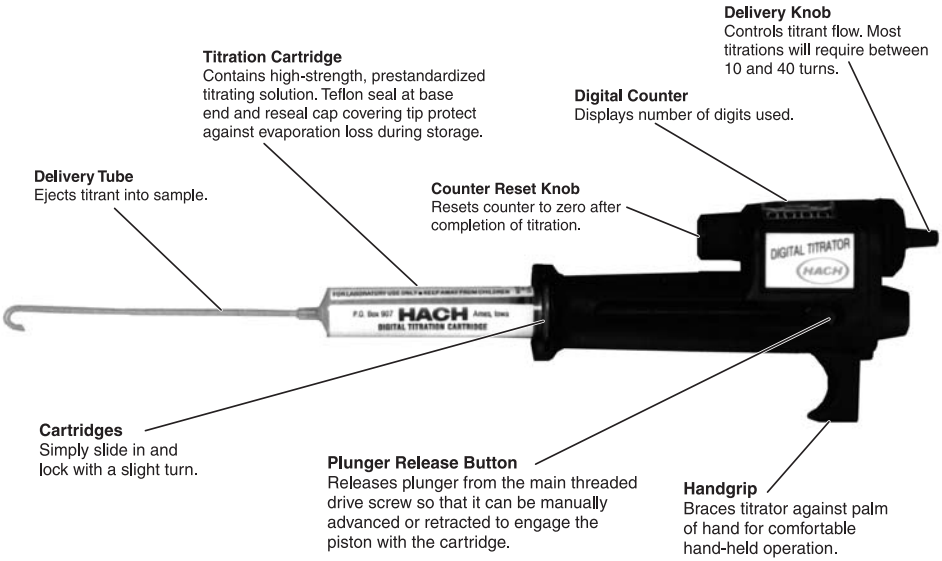
1.1 Introduction

Hach's Digital Titrator is a new concept in titrimetric analysis. It is a precision dispensing device fitted with compact cartridges that contain concentrated titrants. Accurate titrations are made without the bulk and fragility of conventional burets.

A main drive screw in the Digital Titrator controls a plunger which forces the concentrated titrant from a titration cartridge in a carefully regulated flow. The titrator body is constructed of precision-molded, heavy-duty, chemical- and impact-resistant acetal plastic. Accuracy is rated at ± 1% or better for a titration of more than 100 digits. For titrations less than 100, accuracy is ± 1 digit.

Titration solutions (titrants) are packaged in disposable polypropylene or Kynar® containers with Teflon-covered neoprene seals and polyethylene resealable closures to cover the cartridge tips. Each cartridge contains approximately 13 mL of titrating solution, enough for 50–100 average titrations. Titrant solutions are typically controlled to ± 0.5% concentration with normality and tolerances listed on the label. Titrant concentrations are designed for titrations of 10 to 40 turns
(100 to 400 digits) of the delivery knob. For the most commonly used concentration ranges, the digits appearing in the counter window correspond to the sample concentration.

Figure 1 Hach Digital Titrator



Both portable and fixed-position titrations are possible with the Digital Titrator. The instrument has a grip for hand-held operation or it can be clamped to a TitraStir® Stir Plate or laboratory stand for stationary setups. See *Figure 1*.

Each Digital Titrator comes with five delivery tubes and a methods manual, which covers the most commonly tested parameters and the corresponding titrant cartridges. Right-angle (ninety-degree) delivery tubes for stationary setups are available as an optional accessory.

1.1.1 Following a Procedure for the First Time

Each method is divided into five sections: Procedure, Accuracy Check, Interferences, Summary of Method, and Reagents and Apparatus. For more information about how to select a procedure or for answers to chemical questions, see Hach's *Water Analysis Handbook* (literature 8376). For more information about chlorine measurement, also see the technical booklet titled, *Current Technology of Chlorine Analysis for Water and Wastewater* (literature 7019).

The **Procedure** details how to perform the method step-by-step. To select the appropriate sample volume and titration cartridge based on expected sample concentration, use the

tables provided in each procedure. If the expected sample concentration is not known, start with one of the smaller sample volumes and determine its approximate concentration. Retest with the appropriate sample size.

The ranges in the table overlap to offer more flexibility. In most procedures, the number of digits used for each concentration range will be 100 to 400 digits.

To determine the actual concentration of the sample, use the correct digit multiplier for the sample volume and titration cartridge used.

Throughout the procedure, the notes will provide additional information.

The **Accuracy Check** provides a way to verify the results and determine if interferences are present. It also provides a method for checking the performance of reagents, the Digital Titrator and the operator's technique. Further information is provided in *Appendix A, Accuracy Check and Standard Additions*.

The **Interferences** section identifies common interferences causing inaccurate results and describes how to eliminate their effects. The interference levels are based on the sample volume that has 1.0 as the digit multiplier. Higher interference levels may be tolerated if a smaller sample is used.

The **Summary of Method** section discusses the chemical reaction taking place and information that applies to the entire procedure.

The **Reagents and Apparatus** list concludes the procedure. All the items required to perform the test are listed first and are available from Hach. The items listed in the notes or interferences sections are included in the optional listings.

1.2 Step-By-Step

1. Select a sample volume and titration cartridge corresponding to the expected sample concentration from the table given in each procedure.

If the expected sample concentration is not known, start with one of the smaller sample volumes and determine

its approximate concentration. Retest with the appropriate sample size.

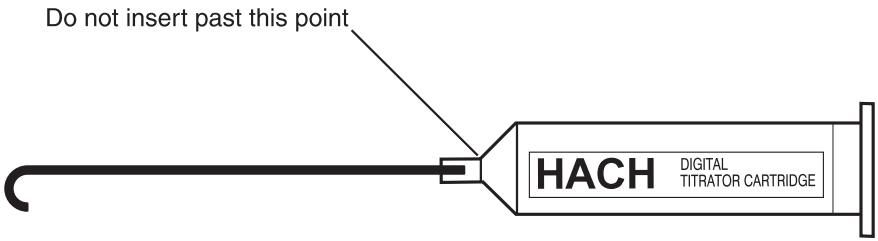
2. Slide the cartridge into the titrator receptacle and lock in position with a slight turn. See *Figure 2.*

Figure 2 Sliding the Cartridge into Place

3. Remove the polyethylene cap and insert a clean delivery tube into the end of the cartridge until it is tight. See *Figure 3.* Use a straight tube with a hook at the end for hand-held titrations; use a 90° tube with a hook at the end for stationary setups.

   Do not insert tube past cartridge extension; see illustration below. In some instances, it might be necessary to remove a small burr on the leading edge of the tube before insertion.

Figure 3 Inserting the Delivery Tube



4. For stationary titrations, use a TitraStir Stir Plate or a clamp holder and clamp to attach the titrator to a laboratory stand. See *Figure 4* and *Figure 5.*

   The TitraStir Stir Plate holds the Digital Titrator during the titration and also stirs the sample at a constant speed, leaving the analyst free to detect the end point.

When a TitraStir Stir Plate is used, substitute or add the following Optional Apparatus.

APPARATUS

Description	Quantity Required Per Test	Unit	Cat. No.
Delivery Tubes, 90° with hook for TitraStir® Stir Plate	1	5/pkg	41578-00
Flask, Erlenmeyer, 125 mL	1	each	505-43
Flask, Erlenmeyer, 250 mL	1	each	505-46
Stir Bar, 28.6 x 7.9 mm	1	each	20953-52
TitraStir® Stir Plate, 115 Vac	1	each	19400-00
TitraStir® Stir Plate, 230 Vac	1	each	19400-10

5. To start titrant flowing and flush the delivery tube, hold the tip of the cartridge up. Advance the plunger release button to engage the piston with the cartridge (push the button in and toward the cartridge). Do not expel solution when pushing the piston toward the cartridge. Turn the delivery knob until air is expelled and several drops of solution flow from the tip. As you turn the knob a drive screw pushes a piston against the cartridge seal and forces liquid out through the delivery tube. Then use the counter reset knob to turn the digital counter back to zero and wipe the tip. The tip can be rinsed with deionized water rather than wiped, if desired.

Figure 4 Using the TitraStir® Stir Plate

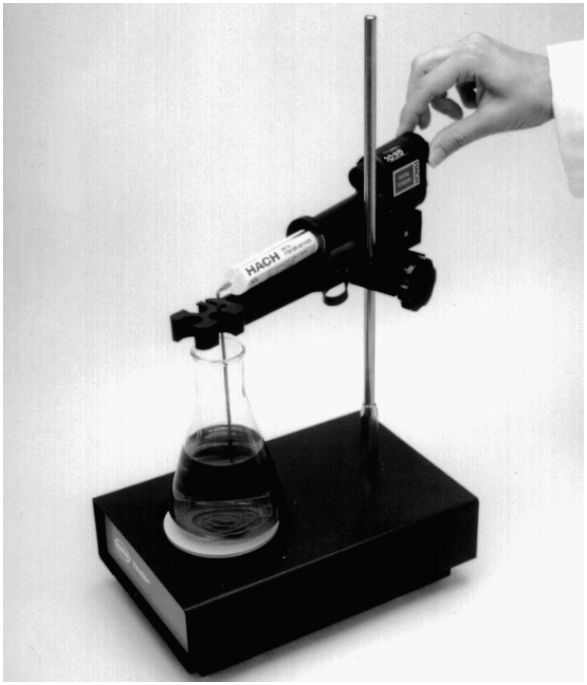


Figure 5 Using a Laboratory Stand

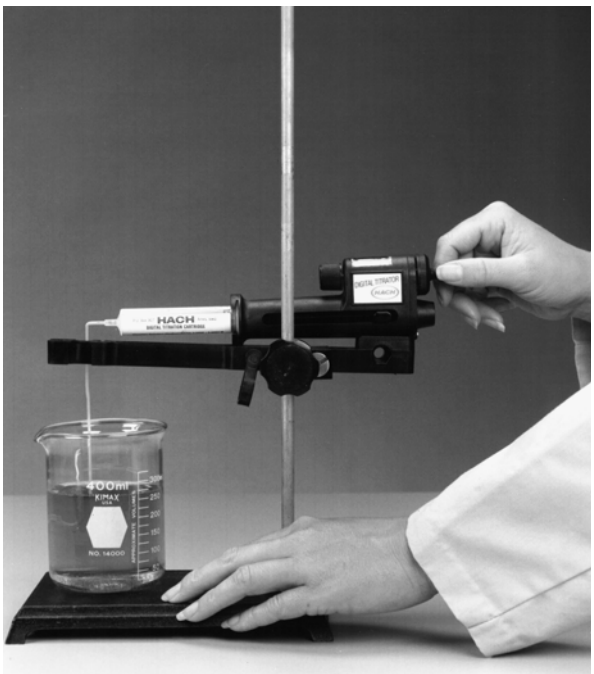


Figure 6 Titrating the Sample

6. Use the smallest appropriate graduated cylinder or pipet to measure the sample volume from the given table. Transfer the sample into a 125-mL or 250-mL Erlenmeyer flask. Dilute to the appropriate total volume with deionized water if necessary.

Note: *Sample volume measurements and dilutions (if required) must be made accurately. However, final total volume of titrated solution is not critical.*

7. Add the necessary reagents to the sample and swirl to mix.

8. Immerse the delivery tube tip in the solution and swirl the flask while titrating. Titrate by turning the delivery knob. Keep turning the knob and swirling the sample until the end point is reached. Record the number of

digits that appear in the digital counter window. See *Figure 6*.

Note: *The number of digits required will usually range from 100 to 400. In nearly all of the procedures if the digits required is less than 100 or more than 400, an alternate sample volume or titrant cartridge should be used.*

Note: *Inaccurate results will occur if the delivery tube tip is held out of the solution rather than under the solution surface.*

9. Calculate the concentration of your sample by using the following formula:

Digits Required × Digit Multiplier = Sample Concentration

Where:

Digits Required = the number that appeared in the digital counter window in Step 8.

Digit Multiplier = the number from the table given in the procedure. It takes into account the sample dilution and titrant strength.

10. After completing testing for the day, press the plunger release button and manually retract the plunger into the body of the titrator. Remove the cartridge. Remove the delivery tube and reseal the cartridge with the polyethylene cap. See *Figure 7.*

Figure 7 **Retracting the Plunger**

11. Discard or clean the delivery tube immediately after use. To clean, force water, then air, into the tube opening with a syringe or wash bottle.

1.3 Helpful Hints

1.3.1 To Reuse a Partially Emptied Cartridge

1. With the plunger fully retracted, attach cartridge to the titrator.
2. Press the plunger release; then manually push the plunger against the cartridge seal.
3. Attach a delivery tube. Hold the tip of the cartridge up. Eject air and a few drops of titrant, zero the counter, and wipe the tip.
4. Titrate as usual.

1.3.2 To Calculate Titrant Volume Used

Normalities of many Hach titration cartridge solutions have been designed so that the number of digits used in a titration corresponds to the sample concentration in mg/L. To determine the volume used in mL, divide the Digital Titrator reading by 800.

1.3.3 To Fill Your Own Titration Cartridges

Cartridges may be cleaned and refilled, or new empty cartridges, Cat. No. 14495-01, can be purchased from Hach Company. See *Figure 8*. When preparing to refill old cartridges, push the cartridge seal out of the cartridge with air pressure applied through the tip. Cap the tip, fill with solution and reinsert the cartridge seal using care to avoid wrinkling the Teflon sheath. Filling also can be accomplished at the tip with a syringe.

Figure 8 Digital Titrator Cartridges

1.3.4 Verifying Technique

Whenever procedures are changed or new equipment is used, it is helpful to run a sample of known concentration. This technique will confirm the operator is following the procedure correctly and the new equipment is working properly. One objective important to Hach Company is making our tests self-verifying. This means Hach makes the tools available so the operator can check their own work for accurate results without relying on an outside lab or chemist.

For most of the tests in this manual, *Table 1* on page *21* lists each procedure, the suggested standard, the volume of standard needed, the titration cartridge used, and the number of expected digits when the test is performed correctly. The suggested standards are Voluette® or PourRite™ Ampules whenever possible because of their superior accuracy and stability.

To use titration standards follow these steps:

1. Select the procedure of interest and order the appropriate standard. Use the given catalog numbers.
2. Measure the volume of standard to be used as the sample in the procedure using a TenSette® Pipet or Class A pipet.
3. Perform the procedure as written, adding deionized water as necessary.

4. After titrating, the required number of digits should approximately equal the expected digits.

Call Hach Technical and Customer Service (1-800-227-4224) for additional help.

.

Table 1 Titration Standards

Procedure (Parameter)	Standard Description (Cat. No.)	Volume of Standard (mL)	Titration Cartridge (Cat. No.)	Expected Digits
Acid-Base: Acid	0.500 N H_2SO_4 (2121-26)	1.0 5.0	1.600 N NaOH (14379-01) 8.00 N NaOH (14381-01)	250 250
Base	0.500 N Na_2CO_3 (14278-10)	1.0 5.0	1.600 N H_2SO_4 (14389-01) 8.00 N H_2SO_4 (14391-01)	250 250
Acidity	0.500 N H_2SO_4 (2121-26)	0.1 1.0	0.1600 N NaOH (14377-01) 1.600 N NaOH (14379-01)	250 250
Alkalinity	0.500 N Na_2CO_3 (14278-10)	0.1 1.0	0.1600 N H_2SO_4 (14388-01) 1.600 N H_2SO_4 (14389-01)	250 250
Calcium*: mg/L $CaCO_3$	10,000 mg/L $CaCO_3$ (2187-10)	0.1 1.0	0.0800 M EDTA (14364-01) 0.800 M EDTA (14399-01)	100 100
G.d.h.	10,000 mg/L $CaCO_3$ (2187-10)	0.2 1.0	0.1428 M EDTA (14960-01) 0.714 M EDTA (14959-01)	112 112
Carbon Dioxide	10,000 mg/L CO_2 (14275-10)	0.2 2.0	0.3636 N NaOH (14378-01) 3.636 N NaOH (14380-01)	100

Table 1 Titration Standards (Continued)

Procedure (Parameter)	Standard Description (Cat. No.)	Volume of Standard (mL)	Titration Cartridge (Cat. No.)	Expected Digits
Chloride	12,500 mg/L Cl (14250-10)	0.1	0.2256 N $Hg(NO_3)_2$ (14393-01)	125
		0.1	0.2256 N $AgNO_3$ (14396-01)	125
		1.0	1.128 N $AgNO_3$ (14397-01)	250
		1.0	2.256 N $Hg(NO_3)_2$ (921-01)	125
Chlorine	~50 mg/L Cl_2 (14268-20) (see certificate)	2.0	0.02256 N $Na_2S_2O_3$ (24091-01)	varies**
	~25 mg/L Cl_2 (26300-20)	0.5	0.00564 N FEAS (22923-01)	varies***
Chromate	1000 mg/L Cr (2231 mg/L CrO_4) (14664-42)	1.0	0.2068 N $Na_2S_2O_3$ (22676-01)	223
Hardness: mg/L $CaCO_3$	10,000 mg/L $CaCO_3$ (2187-10)	0.1	0.0800 M EDTA (14364-01)	100
		0.1	0.0800 M CDTA (14402-01)	100
		1.0	0.800 M EDTA (14399-01)	100
		1.0	0.800 M CDTA (14403-01)	100
G.d.h.	10,000 mg/L $CaCO_3$ (2187-10)	0.2	0.1428 M EDTA (14960-01)	112
		1.0	0.714 M EDTA (14959-01)	112
Iron	50 mg/L Fe (14254-10)	10.0	0.0716 M TitraVer (20817-01)	200
	1000 mg/L Fe (2271-42)	10.0	0.716 M TitraVer (20818-01)	100
Oxygen, Dissolved****	10 mg/L as DO (401-11)	100	0.2000 N $Na_2S_2O_3$ (22675-01)	500
		200	2.00 N $Na_2S_2O_3$ (14401-01)	100
Sulfite	5000 mg/L SO_3 (22674-10)	1.0	0.3998 N KIO_3–KI (14961-01)	250

* One to two drops of Magnesium Standard Solution (10 g/L as $CaCO_3$) must be added to get a sharp end point. These added drops will not change the results.

** The expected digits equal the volume of standard times the concentration on the certificate (e.g., 2 mL x 50 mg/L = 100 digits).
*** The expected digits equals the volume of standard times the concentration on the certificate times the constant, 4. (Example: 0.5 mL x 50 mg/L x 4 = 100 digits)
**** Add one Sulfamic Acid Powder Pillow to the volume of standard and follow Steps 10 to 12 in the Dissolved Oxygen Procedure. It is not necessary to add the first two reagents.

1.4 Adapting a Buret Titration to the Digital Titrator

Adapt any standard titration procedure using a buret to the Digital Titrator by using the following procedure.

1. Determine the approximate number of digits required. The Digital Titrator dispenses 1 mL per 800 digits on the counter. Using the following equation, determine the digits required for your buret method.

$$\text{Digits Required} = \frac{N_t \times mL_t \times 800}{N_c}$$

Where:

N_t = Normality of buret titrant
mL_t = milliliters of buret titrant required for an average titration
N_c = Normality of Digital Titrator cartridge

2. If the number of digits required is within the range of 70 to 350, you can use the procedure as written, substituting the Digital Titrator directly for the buret. Or, if the number of digits is outside of this range, make the following modifications:

a. If the number of digits required is more than 350, reduce the sample size to save titrant.

b. If the number of digits required is less than 70, increase the sample size to increase precision.

c. If the sample size is altered, adjust the amount of buffering or indicating reagents by the same proportion.

3. When using the Digital Titrator for your buret method, note the number of digits required for a sample titration.

To convert the digits required to the equivalent number of milliliters if the buret method was used, calculate:

$$\text{Equivalent Buret Milliliters} = \text{Digits Required} \times \frac{N_c}{800 \times N_t}$$

If the sample size was changed, adjust the equivalent buret milliliters accordingly. If the sample size was increased, reduce the equivalent buret milliliters; if the sample size was reduced increase the equivalent buret milliliters. Multiply the equivalent buret milliliters by any normally used factors to calculate concentration in oz/gal, g/L, etc.

Example: Adapt a buret procedure, which normally requires about 20 mL of a 0.4 N titrant, to the Digital Titrator. Try an 8.0 N titration cartridge. The first equation above gives:

$$\text{Digits Required} = \frac{0.4 \times 20 \times 800}{8.0} = 800 \text{ digits}$$

Because this would use excessive titrant, reduce the sample size to one fourth its normal size to reduce the digits required to 200, well within the recommended range.

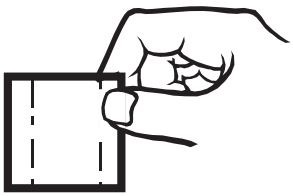
Upon completion of the titration using the smaller sample size, calculate the equivalent buret milliliters by the second equation above. If 205 were the digits required:

$$\text{Equivalent Buret Milliliters} = \frac{205 \times 8.0}{800 \times 0.4} = 5.13 \text{ mL}$$

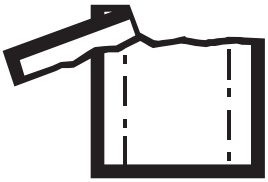
Multiply the 5.13 mL by 4 to account for the reduction in sample size to give the true equivalent buret milliliters of 20.5 mL. If the buret method called for multiplying the number of milliliters of titrant by a factor to calculate the concentration of a sample component, then multiply 20.5 by that factor.

1.5 Using PermaChem® Powder Pillows

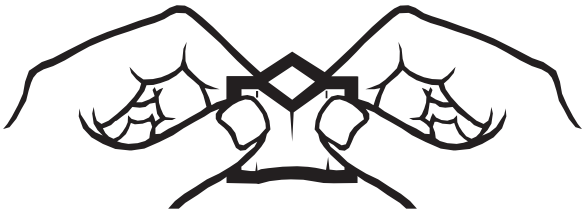
1. **Tap** the PermaChem on a hard surface to collect the powdered reagent in the bottom.



2. **Tear** across on the dotted pillow line marked “TEAR” holding the pillow away from your face.



3. Using two hands, **Push** both sides toward each other until thumbs and forefingers form a diamond. Make sure to **Crease** the foil pack, so that it forms a spout.



4. **Pour** the pillow contents into the sample. The polyfilm lining is specially formulated to deliver all the powder necessary for accurate results (no tapping on the vessel edge is necessary).

1.6 Safety

Safety is the responsibility of each individual when performing analysis procedures, and the analyst must develop and maintain good safety habits. Because many of the procedures in this methods handbook use potentially hazardous chemicals and apparatus, it is important that the analyst practice good laboratory techniques to minimize accidents. The following paragraphs present several techniques applicable to water analysis in the laboratory and in the field. They are not all inclusive, of course, nor do

they apply only to the procedures provided in this handbook. They are general in nature but emphasize practices that are often key factors in personal injury incidents.

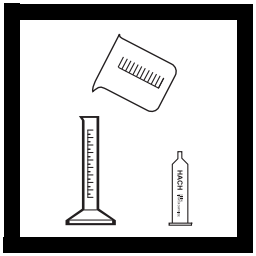
- Read labels carefully. Never remove the label from a reagent container. When preparing a reagent or standard solution, be sure to label the container clearly and date it.
- A Material Safety Data Sheet (MSDS) comes with each reagent. This sheet contains helpful information on first aid, spill and disposal procedures, and precautionary measures and should be read before using the product.
- Warning labels also appear on some of the apparatus used with the test procedures.
- Wear protective clothing when handling chemicals that cause irritation or burns. Eye protection in particular is important to guard against spattering and splashes from accidental spills when caustic materials are being used.
- Use tongs or finger cots when transferring apparatus that is hot.
- Use mechanical pipetters: Mouth pipetting could result in accidentally ingesting dangerous chemicals. Make a habit of using mechanical pipet fillers for all pipetting. This will avoid mistakes that could cause serious injury.
- Use special care with dangerous chemicals and apparatus.
- Follow the test procedure steps carefully and observe all precautionary measures. It is good practice to read the entire procedure carefully before beginning the procedure. Use safety equipment, such as pipet fillers, protective clothing, and ventilating hoods, appropriate for the test being conducted. Wipe up all spills promptly. Do not smoke or eat in an area where toxic or irritating chemicals are used. Use reagents and apparatus only as they were meant to be used and use them only as

directed in the test procedure. Do not use damaged labware and malfunctioning equipment.

TITRATION PROCEDURES

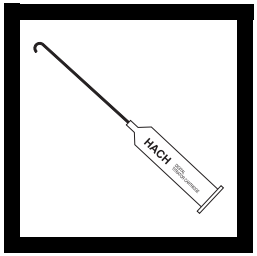
ALKALINITY (10 to 4000 mg/L as $CaCO_3$)

Phenolphthalein and Total Method

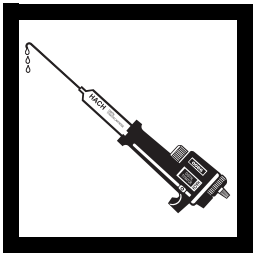


1. Select the sample volume and Sulfuric Acid (H_2SO_4) Titration Cartridge corresponding to the expected alkalinity concentration as mg/L calcium carbonate ($CaCO_3$) from *Table 1*.

Note: *See Sampling and Storage following these steps.*



2. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator body. See *General Description, Step-by-Step* for assembly instructions, if necessary.



3. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

Note: *For added convenience use the TitraStir® Stir Plate. See General Description, Step 3 in Step-by-Step.*

4. Use a graduated cylinder or pipet to measure the sample volume from *Table 1*. Transfer the sample into a clean 250-mL Erlenmeyer flask. Dilute to about the 100-mL mark with deionized water, if necessary.

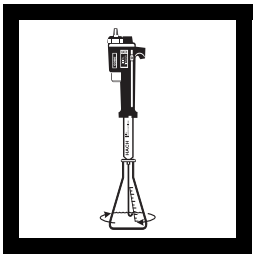
Table 1

Range (mg/L as $CaCO_3$)	Sample Volume (mL)	Titration Cartridge (H_2SO_4)	Catalog Number	Digit Multiplier
10-40	100	0.1600	14388-01	0.1
40-160	25	0.1600	14388-01	0.4
100-400	100	1.600	14389-01	1.0
200-800	50	1.600	14389-01	2.0
500-2000	20	1.600	14389-01	5.0
1000-4000	10	1.600	14389-01	10.0

5. Add the contents of one Phenolphthalein Indicator Powder Pillow and swirl to mix.

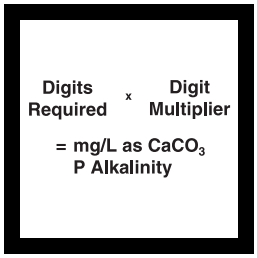
Note: *A solution of one pH 8.3 Buffer Powder Pillow and one Phenolphthalein Powder Pillow in 50 mL of deionized water is recommended as a comparison for determining the proper end point color.*

Note: *Four drops of Phenolphthalein Indicator Solution may be substituted for the Phenolphthalein Indicator Powder Pillow.*



6. If the solution turns pink, titrate to a colorless end point. Place the delivery tube tip into the solution and swirl the flask while titrating with sulfuric acid. Record the number of digits required.

Note: *If the solution is colorless before titrating with sulfuric acid, the Phenolphthalein (P) Alkalinity is zero; proceed with step 8.*



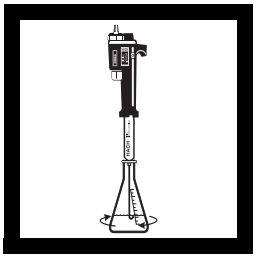
7. Calculate:

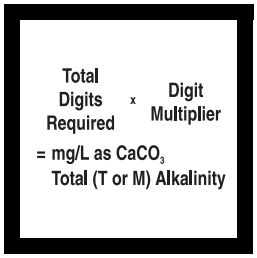
Digits Required x Digit Multiplier = mg/L $CaCO_3$ P Alkalinity

8. Add the contents of one Bromcresol Green-Methyl Red Indicator Powder Pillow to the flask and swirl to mix.

Note: *Four drops of Methyl Purple Indicator Solution may be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow. Titrate from green to a gray end point (pH 5.1).*

Note: *Four drops of Bromcresol Green-Methyl Red Indicator Solution may be substituted for the Bromcresol Green-Methyl Red Indicator Powder Pillow.*





9. Continue the titration with sulfuric acid to a light greenish blue-gray (pH 5.1), a light violet-gray (pH 4.8), or a light pink (pH 4.5) color, as required by the sample composition; see *Table 2.* Record the number of digits required.

Note: *A solution of one Bromcresol Green-Methyl Red Powder Pillow and one pillow of the appropriate pH buffer in 50 mL of deionized water is recommended as a comparison for judging the proper end point color. If the pH 3.7 end point is used, use a Bromphenol Blue Powder Pillow instead of a Bromcresol Green-Methyl Red and titrate to a green end point.*

10. Calculate:

Total Digits Required x Digit Multiplier = mg/L as CaCO3 Total (T or M) Alkalinity

Note: *Carbonate, bicarbonate and hydroxide concentrations may be expressed individually using the relationships shown in Table 3.*

Note: *meq/L Alkalinity = mg/L as $CaCO_3$ ÷ 50.*

Table 2

Sample Composition	End Point
Alkalinity about 30 mg/L	pH 4.9
Alkalinity about 150 mg/L	pH 4.6
Alkalinity about 500 mg/L	pH 4.3
Silicates or Phosphates present	pH 4.5
Industrial waste or complex system	pH 4.5

Sampling and Storage

Collect samples in clean plastic or glass bottles. Fill completely and cap tightly. Avoid excessive agitation or prolonged exposure to air. Samples should be analyzed as soon as possible after collection but can be stored at least 24 hours by cooling to 4 °C (39 °F) or below. Warm to room temperature before analyzing.

Alkalinity Relationship Table

Total alkalinity primarily includes hydroxide, carbonate and bicarbonate alkalinities. The concentration of these alkalinities in a sample may be determined when the phenolphthalein and total alkalinities are known (see *Table 3*).

Table 3 Alkalinity Relationship

Row	Result of Titration	Hydroxide Alkalinity is equal to:	Carbonate Alkalinity is equal to:	Bicarbonate Alkalinity is equal to:
1	Phenolphthalein Alkalinity = 0	0	0	Total Alkalinity
2	Phenolphthalein Alkalinity equal to Total Alkalinity	Total Alkalinity	0	0
3	Phenolphthalein Alkalinity less than one half of Total Alkalinity	0	2 times the Phenolphthalein Alkalinity	Total Alkalinity minus two times Phenolphthalein Alkalinity
4	Phenolphthalein Alkalinity equal to one half of Total Alkalinity	0	Total Alkalinity	0

Table 3 Alkalinity Relationship

Row	Result of Titration	Hydroxide Alkalinity is equal to:	Carbonate Alkalinity is equal to:	Bicarbonate Alkalinity is equal to:
5	Phenolphthalein Alkalinity greater than one half of Total Alkalinity	2 times the Phenolphthalein minus Total Alkalinity	2 times the difference between Total and Phenolphthalein Alkalinity	0

To use the table follow these steps:

a. Does the phenolphthalein alkalinity equal zero? If yes, use Row 1.

b. Does the phenolphthalein alkalinity equal total alkalinity? If yes, use Row 2.

c. Multiply the phenolphthalein alkalinity by 2.

d. Select Row 3, 4, or 5 based on comparing the result of *step c* with the total alkalinity.

e. Perform the required calculations in the appropriate row, if any.

f. Check your results. The sum of the three alkalinity types will equal the total alkalinity.

For example:
A sample has 170 mg/L as $CaCO_3$ phenolphthalein alkalinity and 250 mg/L as $CaCO_3$ total alkalinity. What is the concentration of hydroxide, carbonate and bicarbonate alkalinities?

The phenolphthalein alkalinity does not equal 0 (it is 170 mg/L), see *step a*.

The phenolphthalein alkalinity does not equal total alkalinity (170 mg/L vs. 250 mg/L), see *step b*.

The phenolphthalein alkalinity multiplied by 2 = 340 mg/L, see *step c*.

Because 340 mg/L is greater than 250 mg/L, select Row 5, see *step d*.

The hydroxide alkalinity is equal to: (see *step e*).

340 – 250 = 90 mg/L hydroxide alkalinity

The carbonate alkalinity is equal to:

250 – 170 = 80
80 x 2 = 160 mg/L carbonate alkalinity

The bicarbonate alkalinity equals 0 mg/L.

Check: (see *step f*).

90 mg/L hydroxide alkalinity + 160 mg/L carbonate alkalinity +
0 mg/L bicarbonate alkalinity = 250 mg/L

The above answer is correct; the sum of each type equals the total alkalinity.

Accuracy Check

Standard Additions Method
This accuracy check should be performed when interferences are suspected or to verify analytical technique.

1. Snap the neck off an Alkalinity Standard Solution Voluette® Ampule, 0.500 N.
2. Use a TenSette® Pipet to add 0.1 mL of standard to the sample titrated in Steps 6 or 9. Resume titration back to the same end point. Record the number of digits needed.
3. Repeat, using two more additions of 0.1 mL. Titrate to the end point after each addition.
4. Each 0.1 mL addition of standard should require 25 additional digits of 1.600 N titrant or 250 digits of 0.1600 N titrant. If these uniform increases do not occur, refer to *Appendix A, Accuracy Check and Standard Additions*.

Interferences

- Highly colored or turbid samples may mask the color change at the end point. Use a pH meter for these samples.
- Chlorine may interfere with the indicators. Add one drop of 0.1 N Sodium Thiosulfate to eliminate this interference.

Summary of Method

The sample is titrated with sulfuric acid to a colorimetric end point corresponding to a specific pH. Phenolphthalein alkalinity is determined by titration to a pH of 8.3, as evidenced by the color change of phenolphthalein indicator, and indicates the total hydroxide and one half the carbonate present. M (methyl orange) or T (total) alkalinity is determined by titration to a pH between 3.7 and 5.1, and includes all carbonate, bicarbonate and hydroxide.

REQUIRED REAGENTS
(varies with sample characteristics)

Description	Unit	Cat. No
Alkalinity Reagent Set (about 100 tests)		22719-00
Includes: (1) 942-99, (1) 943-99, (1) 14388-01, (1) 14389-01		
Bromcresol Green-Methyl Red Powder Pillows	100/pkg	943-99
Phenolphthalein Powder Pillows	100/pkg	942-99
Sulfuric Acid Titration Cartridge, 1.600 N	each	14389-01
Sulfuric Acid Titration Cartridge, 0.1600 N	each	14388-01
Water, deionized	4 L	272-56

REQUIRED APPARATUS

Digital Titrator	each	16900-01
Flask, Erlenmeyer, 250-mL	each	505-46
Select one or more based on sample concentration:		
Cylinder, graduated, 10-mL	each	508-38
Cylinder, graduated, 25-mL	each	508-40
Cylinder, graduated, 50-mL	each	508-41
Cylinder, graduated, 100-mL	each	508-42

OPTIONAL REAGENTS

Alkalinity Standard Solution Voluette® Ampules, 0.500 N Na_2CO_3, 10-mL	16/pkg	14278-10
Bromcresol Green-Methyl Red Indicator Solution	100 mL MDB	23292-32
Bromphenol Blue Indicator Solution	100 mL MDB	14552-32
Bromphenol Blue Powder Pillows	100/pkg	14550-99
Buffer Powder Pillows, pH 3.7	25/pkg	14551-68
Buffer Powder Pillows, pH 4.5	25/pkg	895-68
Buffer Powder Pillows, pH 4.8	25/pkg	896-68
Buffer Powder Pillows, pH 5.1	25/pkg	897-68
Buffer Powder Pillows, pH 8.3	25/pkg	898-68
Methyl Purple Indicator Solution	100 mL MDB	21934-32
Phenolphthalein Indicator Solution, 5 g/L	100 mL MDB*	162-32
Sodium Thiosulfate Standard Solution, 0.1 N	100 mL MDB	323-32

* Contact Hach for larger sizes.

OPTIONAL APPARATUS

Description	Unit	Cat. No
Bottle, wash, poly, 500-mL	each	620-11
Clamp, 2-prong extension, 38-mm	each	21145-00
Clamp Holder	each	326-00
Demineralizer Assembly, 473-mL	each	21846-00
Delivery Tubes, with 180° hook	5/pkg	17205-00
Delivery Tubes, 90° with hook for TitraStir® Stir Plate	5/pkg	41578-00
Pipet, TenSette® 0.1 to 1.0 mL	each	19700-01
Pipet Tips for 19700-01 TenSette® Pipet	50/pkg	21856-96
Pipet, volumetric, Class A, 10-mL	each	14515-38
Pipet, volumetric, Class A, 20-mL	each	14515-20
Pipet, volumetric, Class A, 25-mL	each	14515-40
Pipet, volumetric, Class A, 50-mL	each	14515-41
Pipet, volumetric, Class A, 100-mL	each	14515-42
Pipet Filler, safety bulb	each	14651-00
sension™1 Basic Portable pH Meter with electrode	each	51700-10
Support Ring Stand	each	563-00
TitraStir® Stir Plate, 115 Vac	each	19400-00
TitraStir® Stir Plate, 230 Vac	each	19400-10
Voluette® Ampule Breaker Kit	each	21968-00

APPENDIX A
ACCURACY CHECK AND STANDARD ADDITIONS

Most of the procedures in this manual have an accuracy check based on the standard additions method. Standard additions is a widely accepted technique for checking the validity of test results. Also known as “spiking” and “known additions,” the technique adds a small amount of the component (parameter) being measured to an analyzed sample and the analysis is repeated. The increase in the test results should equal the amount of the standard added. The results can be used to check the performance of the reagents, the apparatus, and the procedure.

First Step - The Accuracy Check

Perform the procedure and accuracy check as described in this manual. In each accuracy check the number of digits expected for each increment is given. If the actual number of digits required is within 1% of the expected number of digits, the analyst can conclude the answer for the sample is accurate and the reagents, apparatus, and method used are working properly.

Second Step - The Decision Tree

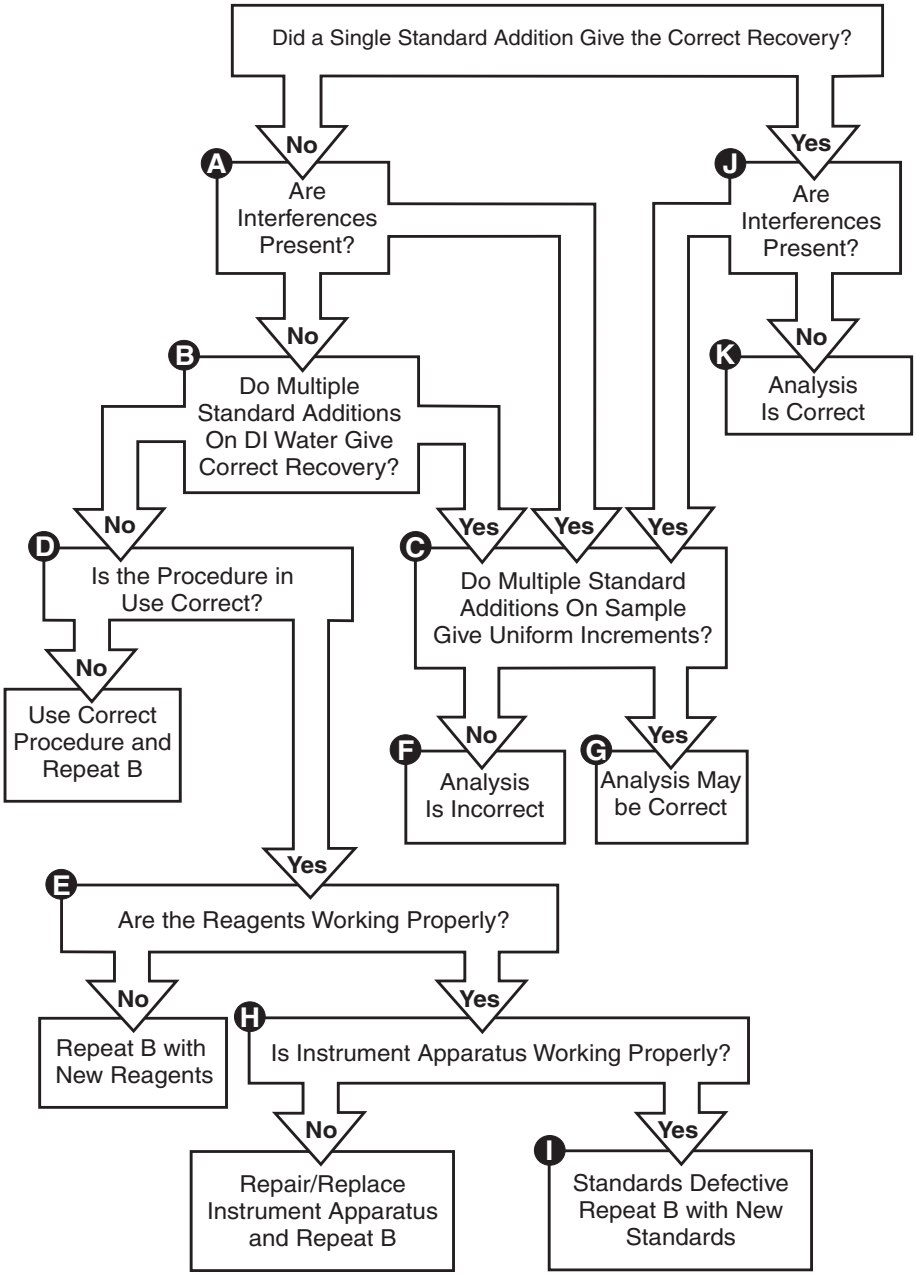
If the actual number of digits varies noticeably, then it must be concluded the problem was caused by either the reagents, the apparatus, the procedure or an interfering substance. By following a logical troubleshooting approach, the source of the problem can be systematically determined. Using the step-by-step decision tree in *Figure 1* will greatly ease identifying the problem. An explanation of each step in the decision tree follows.

Third Step - The Branches

Branch A

Suppose the first, or all three standard additions to the sample did not give the correct incremental digit increase. A possible cause for this could be the presence of interferences. Other causes could be defective reagents, an incorrect procedure, defective apparatus or a defective standard used for standard addition. If interferences are

Figure 1
Decision Tree



either absent or assumed to be absent, proceed to Branch B. If interferences are present, proceed to Branch C. The Chloride Procedure, Silver Nitrate Method, is used as an example throughout these steps.

Branch B

Repeat the Accuracy Check given in the procedure substituting the same volume of deionized water for the sample. For example, using the Chloride Procedure, Silver Nitrate Method:

1. Take a 50.0-mL sample of deionized water and follow the Chloride Procedure, Silver Nitrate Method. Record the number of digits required for the titration.

2. Add 0.10 mL of Chloride Standard Solution, 12,500 mg/L, and titrate to the end point. Record the number of digits required for the titration.

3. Repeat, using two more additions of 0.1 mL of 12,500 chloride standard, titrating to the end point after each addition. Record the number of digits required.

4. Tabulate the date as shown below:

Table 1

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	_____	0	_____
0.1	_____	_____	_____
0.2	_____	_____	_____
0.3	_____	_____	_____

The **Total Standard Added (mL)** will vary depending on the procedure used.

The **Total Number of Digits Used** are the total digits recorded after each titration.

The **Total Standard Added (mg/L)** is determined for each addition by the following equation:

$$\frac{\text{Total Standard Added (mL)}}{\text{Sample Volume (mL)}} \times \text{Standard Concentration (mg/L)}$$

$$= \text{Total Standard Added (mg/L)}$$

The **Total Parameter Found (mg/L)** is determined by following the calculation step of the procedure used. Use the same volume of deionized water as used for the sample. The addition of standard will not change the digit multiplier.

Performing the above procedure, the completed table would look like this:

Table 2

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	0	0	0
0.1	25	25	25
0.2	50	50	50
0.3	75	75	75

To complete the table the following calculations were made based on the above formula:

First Addition

$$\frac{0.1}{50} \times 12{,}500 = \text{Total Standard Added (mg/L)} = 25 \text{ mg/L}$$

Second Addition

$$0.1 + 0.1 = 0.2 \text{ mL} = \text{Total Standard Added (mL)}$$

0.2 mL in the above formula gives 50 mg/L total standard added.

Third Addition

$$0.1 + 0.1 + 0.1 = 0.3 \text{ mL} = \text{Total Standard Added (mL)}$$

0.3 mL in the above formula gives 75 mg/L total standard added.

The data shown above reveals several points:

- The chemicals, apparatus, procedures and standards are in good working condition. This conclusion is made because chloride added to the deionized water sample

was recovered entirely in the same uniform steps of addition.

- Because chloride added to deionized water was recovered, but was not recovered during the Accuracy Check, one may conclude the sample contains interferences which prevent the test reagents from operating properly.
- The first analysis of the water sample gave an incorrect result.

If the above results gave the expected increments between additions, proceed to Branch C. If the results did not give the expected increments, proceed to Branch D.

Branch C

If interfering ions are present, it may be concluded the analysis is incorrect. However, with the completed accuracy check it may be possible to arrive at an approximation of the correct result. Tabulate the results as follows:

Table 3

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	_____	0	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

The **Total Standard Added (mL)** will vary depending on the procedure used.

The **Total Number of Digits Used** are the total digits recorded after each addition of standard as specified in the accuracy check.

The **Total Standard Added (mg/L)** is determined for each addition by the following equation:

$$\frac{\text{Total Standard Added (mL)}}{\text{Sample Volume (mL)}} \times \text{Standard Concentration (mg/L)} = \text{Total Standard Added (mg/L)}$$

The **Total Parameter Found (mg/L)** is determined by following the calculation step of the procedure used. Use the same volume of deionized water as used for the sample. The addition of standard will not change the digit multiplier.

If steps between each addition are roughly uniform (i.e., 25 digits or 25 mg/L difference between each addition), proceed to Branch G. If the results are not uniform (i.e., 13, 10, and 6 mg/L), proceed to Branch F.

For example, a sample of water was analyzed for chloride with the result being 100 mg/L. The analyst, suspecting interferences, made one standard addition of 0.10 mL of 12,500-mg/L chloride standard to 50.0 mL of sample. Rather than an increase of 25 mg/L as expected, the analyst found an increase of 13 mg/L.

The analyst added a second and third addition of 0.1 mL of standard. The titrations were made and the results tabulated. The increments were 10 (123 minus 113) and 6 (129 minus 123) mg/L, respectively. The analyst proceeded to Branch F.

Table 4

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L
0	100	0	100
0.1	113	25	113
0.2	123	50	123
0.3	129	75	129

To complete the table the following calculations were made based on the above formula:

First Addition

$$\frac{0.1}{50} \times 12{,}500 = \text{Total Standard Added (mg/L)} = 25 \text{ mg/L}$$

Second Addition

$$0.1 + 0.1 = 0.2 \text{ mL} = \text{Total Standard Added (mL)}$$

0.2 mL in the above formula gives 50 mg/L Total Standard Added.

Third Addition

0.1 + 0.1 + 0.1 = 0.3 mL = Total Standard Added (mL)

0.3 mL in the above formula gives 75 mg/L Total Standard Added.

Branch D
Carefully check the instructions or directions for use of the procedure, making sure the proper techniques, reagents, titrant, sample volume, and digit multiplier were used. Verify there is no air or liquid, other than the titrant being used, in the delivery tube by ejecting several drops of solution. If the procedure in use is found to be in error, repeat Branch B using the correct procedure. If the procedure is found to be correct, proceed to Branch E.

Branch E
Check the performance of the reagents. This may be done easily by using a known standard solution to run the test or by obtaining a new fresh lot of the reagent. A list of known standard solutions is given in *Table 1* on page *21*. If it is determined reagents are defective, repeat Branch B with new reagents. If the reagents are proven in good condition, proceed with Branch H.

Branch F
Examples of non-uniform increments between standard additions on a sample are shown below in *Table 5*, *Table 6* and *Figure 2* on page 201. These plots illustrate the effect of interferences upon the standard addition and upon substances in the sample. The plots were made by graphing the Total Standard Added (mg/L) on the X axis and the Total Parameter Found (mg/L) on the Y axis as shown in *Figure 2* on page 201.

Table 5 Plot A

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	100	0	100
0.1	113	25	113
0.2	123	50	123
0.3	129	75	129

Table 6 Plot B

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	0	0	0
0.1	25	25	0
0.2	50	50	25
0.3	75	75	50

Both of these plots show that the four data points do not lie on a straight line. Plot A illustrates an interference which becomes progressively worse as the concentration of the standard increases. This type of interference is not common and may be caused by an error or malfunction of the procedure, reagents or apparatus. Perform Branch B to ensure that the supposed interference is present.

Plot B illustrates a common chemical interference which becomes less or even zero as the concentration of the standard increases. The plot shows the first standard addition was consumed by the interference and the remaining additions gave the correct increase of 25 mg/L for each additional 0.1 mL of standard added. The apparent interference in Plot B could be the result of an error made in the standard addition, and the analysis should be repeated with a fresh portion of sample.

The two examples illustrate chemical interferences which most certainly mean the result of the first analysis of the water sample was incorrect. When this type of interference is encountered, review the Interference section for the procedure for corrective steps. If this fails, the analyst should attempt to analyze the sample with an alternate method which, if possible, uses a different type of chemistry.

Branch G

Examples of uniform increments between standard additions on a sample are shown below in *Table 7* and *Table 8* on page 200. These plots illustrate the effect of interferences upon the standard addition and upon substances in the sample. The plots were made by graphing the Total Standard Added (mg/L) on the X axis

and the Total Parameter Found (mg/L) on the Y axis as shown in *Figure 2* on page 201.

Table 7 Plot C

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	50	0	50
0.1	63	25	63
0.2	75	50	75
0.3	88	75	88

Plot C illustrates a common interference with a uniform effect upon the standard and the substances in the sample. The four data points form a straight line, but the titration increments between the additions is not correct. The straight line between the additions may be extrapolated back through the horizontal axis. The point of intersect of the line with the horizontal axis gives a more accurate estimate of the concentration of the substance in question for the sample. In the example, the first analysis of the sample gave 50 mg/L. The result located graphically (100 mg/L) using the accuracy check should be much closer to the correct result. Other interference effects may also be present, or interferences may not be consistent in all samples. Use of another method not subject to the interference, or elimination of the interference is preferred over extrapolation or use of the percent recovery calculation.

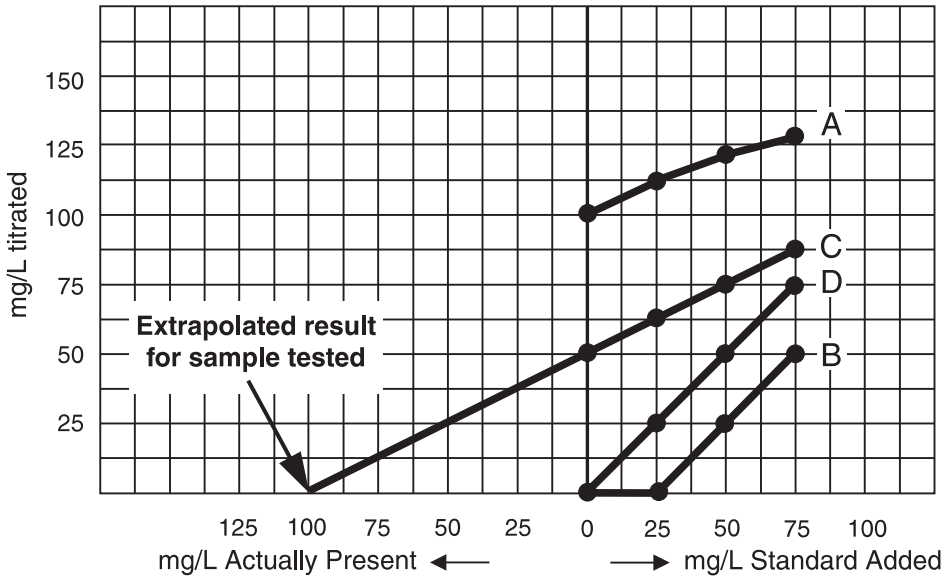
Apparent interferences also may be caused by errors in the method, a defect in the apparatus or standards. Before assuming the interference is chemical in nature, perform Branch B.

Table 8 Plot D

Total Standard Added (mL)	Total Number of Digits Used	Total Standard Added (mg/L)	Total Parameter Found (mg/L)
0	0	0	0
0.1	25	25	25
0.2	50	50	50
0.3	75	75	75

Plot D illustrates correct results but may hide a problem for the analyst. The increments found are uniform and the recovery of the standard was complete. The result of the first analysis was 0 mg/L and the plot graphs back through 0 mg/L. If interfering species are present, the interference may be sufficient to change the sample result but not sufficient to prevent the analyst from finding uniform increments and complete recovery of the additions. This would be an uncommon situation and results are probably correct unless unusual interferences are possible. Refer to the Interferences section in the specific procedure.

Figure 2
Multiple Standard Additions Graph



Branch H
Check operation of the apparatus used in the performance of the test. Verify the correct volumes of sample and standard were used. Check glassware used in the procedure, making sure that it is scrupulously cleaned. Dirty pipets and graduated cylinders are a source of

contamination and will not deliver the correct volume. If a defect is found in the apparatus, repeat Branch B after repair or replacement of apparatus. If the apparatus is found to be in good working order, proceed with Branch I.

Branch I

After demonstrating that the procedure, reagents, and apparatus are correct and operating properly, the only possible cause for standard additions not functioning properly in deionized water is the standard used in performing the standard additions. Prepare or obtain a new set of standards and repeat Branch B.

Branch J
If the standard addition gave the correct result, the analyst must then determine if interfering substances are present. If interfering substances are not present, the result of the analysis prior to the standard addition is correct. If interfering substances are present, proceed to Branch C.

One of the greatest aids to the analyst is knowledge of the water sample's composition. An analyst need not know the exact composition of each sample but should be aware of potential interferences in the method of analysis to be used. When performing a particular method, the analyst should know if those interferences are present or not in order to have confidence in the accuracy of the results. Once the interferences are known, the Interference section of each procedure describes how to correct for many common interferences.

If the correct result is obtained with one standard addition when no interfering species are present, the chance of an error in sample results is very small. Possible sources of error not revealed include: sample quality, sample quantity (unless the sample and standard volume used is equal), and inconsistent end point determinations.

Call Hach Technical and Customer Support (1-800-227-4224) for additional help.

REPLACEMENT PARTS FOR MODEL 16900 DIGITAL TITRATOR

Description	Unit	Cat. No.
Digital Titrator including delivery tubes, manual, and case	each	16900-01
Delivery Tubes, 180° hook	5/pkg	17205-00
Case	each	46602-00
Digital Titrator Manual	each	16900-08

Appendix I

Direct Read Cable Installation and Download

Objective

To outline a procedure to ensure proper installation of direct read cables in groundwater monitoring wells and associated data logger downloads.

Scope

Proper installation of and downloads from direct read cables.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

-

Roles and Responsibilities

The General Manager or Designate shall ensure that:

- Ensuring this procedure is implemented and followed.
- Ensuring this procedure has been reviewed and the appropriate signatures acquired.

The Health and Safety Manager or Designate shall ensure that:

- Ensuring this procedure complies with H&S regulation.
- Ensuring this procedure has been reviewed and the appropriate signatures acquired.

The Area Manager or Designate shall ensure that:

- Ensuring this procedure is followed.
- Ensuring that the Worker(s) has read, understood, and signed off on this procedure prior to beginning the work.
- Ensuring that this procedure is reviewed and updated as necessary, at minimum annually.

The Worker(s) are responsible for:

- Following the methodology outlined in this SOP and reporting deficiencies in the procedure to Brett DeHay-Turner (Hydrogeochemist), Nathan Glas (Hydrogeologist), Richelle Sussbauer (Environmental Scientist) and/or Jason Gabora/Torence Sandhals (Environmental Coordinator/Environmental Superintendent).

Preparation

Hazards

- Repetitive motion from reeling data logger to surface
- Potential risk of hand injury when cutting notch in well casing

Tools

- Electrical tape
- Leatherman or designated cutting tool as required by site policy
- Tablet
- Direct read cable
- USB connector
- Data logger from well
- Groundwater field sheets

Requirements

- Personnel familiar with well location, typical water levels and well construction (see Well Fact Sheets)
- Functional knowledge of Diver Office software for downloading data loggers

Job Step

Direct Read Cable Installation and Data Downloads

1. Reel the data logger that is already installed in the well up to surface. Remove the end cap and store in the groundwater cupboard in the office for future use.
2. Unwrap the correct length reel with the direct read cable and screw the end onto the top of the data logger, ensuring the cable attachment and logger are dry and free of moisture (Photo 1).
3. Use electrical tape to seal the connection point between the direct read cable and logger to ensure no moisture or water can seep in and disrupt the optical sensor reading (Photo 2). The optical sensor is within the cable end and sends data up to surface, meaning it remains downhole at all times, making a firm connection and well taped seal important to prevent leakage and ensure proper data downloads.
4. Lower the logger down the well such that the entirety of the cable is down the well, the cable is 1 m off the bottom of the well, or the cable matches the previous depth within the well. The logger elevation within the well will vary between wells. Contact Nathan Glas, Richelle Sussbauer or Brett DeHay-Turner if unsure about the situation at a specific well. Additional cable can be kept at surface on the reel (Photo 3). If the entirety of the cable is down the well, the cap on the end of the direct read cable can be used as a well cap (Photo 4), though it is recommended that an additional seal is made (either using tape, a plastic cap, etc.) to ensure the well remains tightly sealed.
5. At the surface end of the direct read cable there is a port with a cap on it (Photo 4). This cap screws off and the port access is below (Photo 5).
6. Instead of an optical sensor, the data logger is downloaded using a USB cable that plugs into the surface port (Photo 6). The USB cable end has four pins (Photo 7) that plug into the port on the end of the direct read cable.
7. Once connected, plug the USB cable into the tablet and open Diver Office. Hit the Diver icon along the top toolbar to connect to the Diver (third from left) (Photo 8).
8. Once the status window opens (Photo 9), collect a screenshot for internal records. It is recommended to create a folder on the tablet desktop to save all relevant screenshots and exports from the well. Ensure the logger reads as 'started', that there is sufficient space and battery left and that the date and time shown under Actual Data are reading correctly. Hit the Data icon (second from left along the top toolbar) to download the logger data.
9. The logger data will be downloaded, and a window will open showing the pressure and temperature

fluctuation graphed over time (Photo 10). Ensure that the data graphed continues to the current date. Collect a screenshot of the graphs for internal records.

10. Next, on the left-hand side of the screen, select the relevant logger and date range and export the data by right clicking the selection (or holding it for a second) and hitting export. Ensure to save the data to the associated desktop folder and select Mon; CSV under export file types and uncompensated (Photo 11). Hit okay. Once exported, it is recommended to open the .csv file and ensure the last point collected corresponds to the current date and time (most recent six-hour interval).
11. If the status window reads incorrectly or the data graphs do not show current data, close and re-open Diver Office. If they persist, unplug the USB and try again. The USB cable has a diagnostic function (Photo 12) that will alert the user to potential issues with the cable or diver and detail when the logger is sending data or is ready.
12. Once the data download is complete, the USB can be unplugged from the tablet and detached from the cable port. Screw the cap back on to the port to ensure no debris or moisture enters the port (Photo 13). Properly stow and store the USB cable to ensure no debris or moisture enters the USB or cable attachment.
13. If the direct read cable is fully extended down the well, the logger cap can act as a well cap and be set into the well (Photo 13). It is recommended to further seal the well to ensure the cap does not become dislodged and provides a good seal over the well.
14. If there is still some cable on the reel, lower the direct read cable to the desired depth and leave a tape mark to record this depth for future field visits. Seal the well with a j-plug. A slot may need to be cut in the casing to ensure the direct read cable does not become pinched, crimped or damaged when inserting the j-plug. Cover any cut section of the well casing with electrical tape to ensure there are no sharp edges. It is recommended that the remaining direct read cable and reel be hung towards the well shack roof where possible to ensure that they do not become buried, damaged or lost due to excessive snow in the winter (Photo 14).
15. Pack up any remaining equipment and leave the well site. Back in the office, transfer the downloaded data to the proper folder (select proper year and quarter) within the Groundwater section of the Monitoring Programs folder. Pathway: J:\Environmental\03 Monitoring Programs\Groundwater.
16. For all future field visits after initial cable installation, follow steps 5-15.

Table 1 below outlines monitoring wells with direct read installations. This table should be updated as deployment depths are adjusted to account for seasonal fluctuations and mine dewatering influence on water levels.

Table 1: Well ID's with Completed Direct Read Installs

Well ID	Estimated Deployment Depth (m)	Water Level Notes
BJ-GW11-5A	72	
BJ-GW11-5B	44	
BJ-GW11-6A	22	
BJ-GW11-6B	100	
BJ-GW12-9A	74	
BJ-GW12-12A	89	
BJ-GW12-12B	48	
BJ-GW14-14A	23	
BJ-GW14-14B	2	
BJ-GW18-18A	98	
BJ-GW18-19A	194	
BJ-GW18-20A	149	

BJ-GW18-20B	99	
BJ-GW18-21A	199	
BJ-GW18-21B	149	
BJ-GW18-22A	374	
BJ-GW18-22B	99	

Photo 1: Data logger attached to the direct read cable end.

Photo 2: Direct read cable and data logger connection sealed using electrical tape.

Photo 3: Direct read cables lowered down the well, with extra cable at surface.

Photo 4: Direct read cable end with port cap.

Photo 5: Direct read cable port after end cap removed. Note four holes and notch.

Photo 6: USB cable for data logger downloads.

Photo 7: USB cable end with four pins and notch for connection to direct read cable end port.

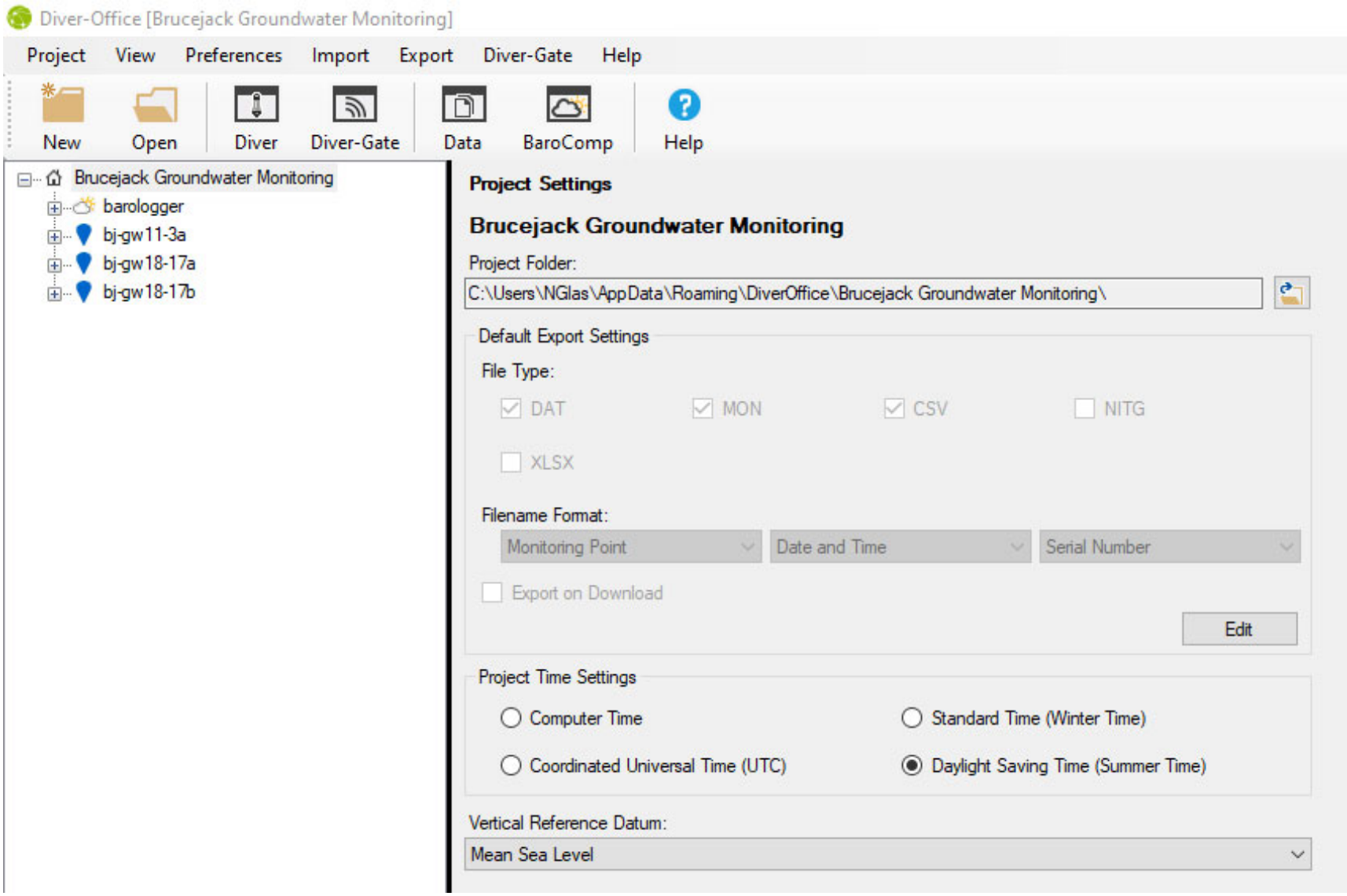


Photo 8: Diver Office main window. Diver icon located on top toolbar (third from left).

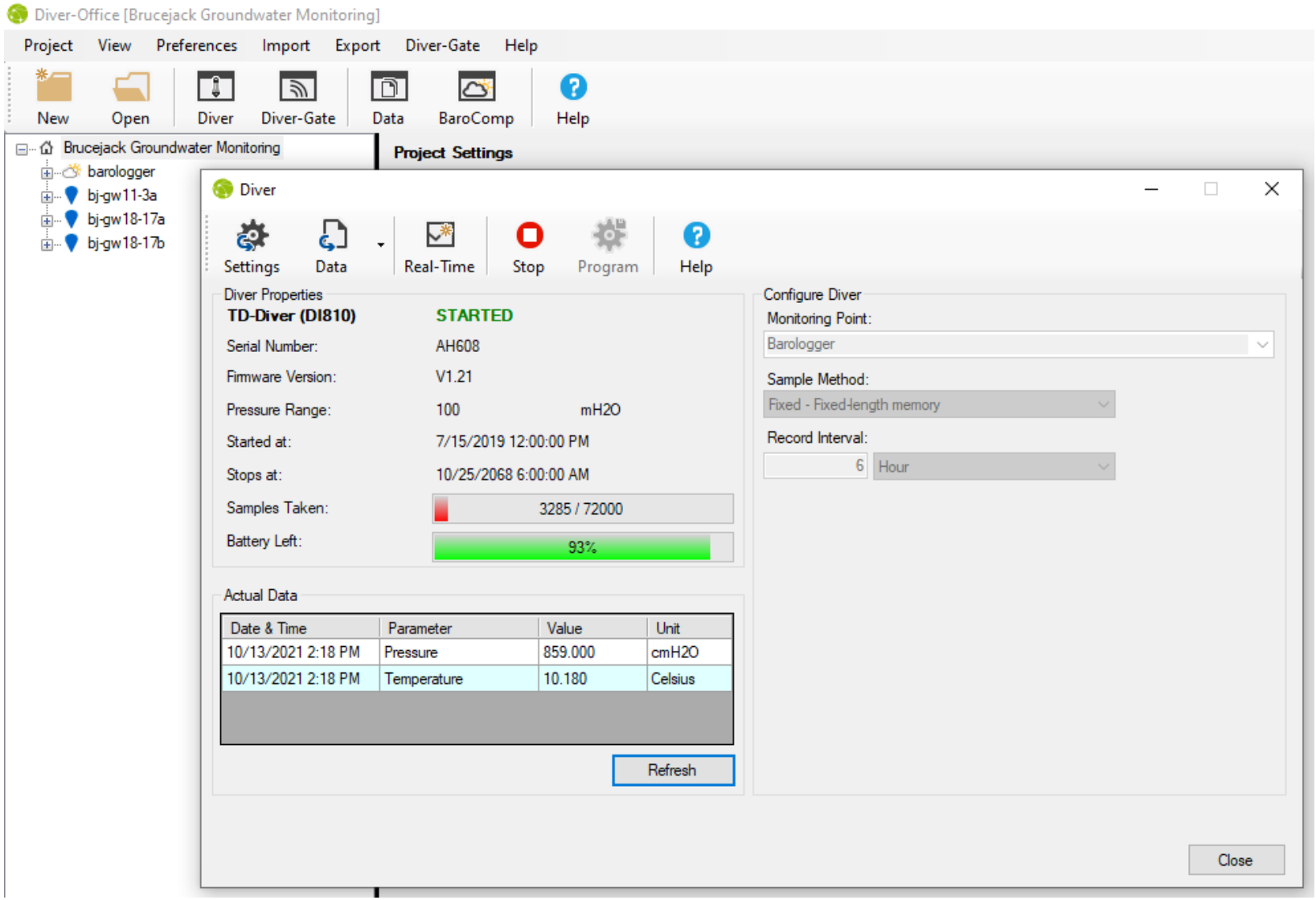


Photo 9: Diver status window detailing status, storage, battery life and current date and time. Data icon in top left for downloads.

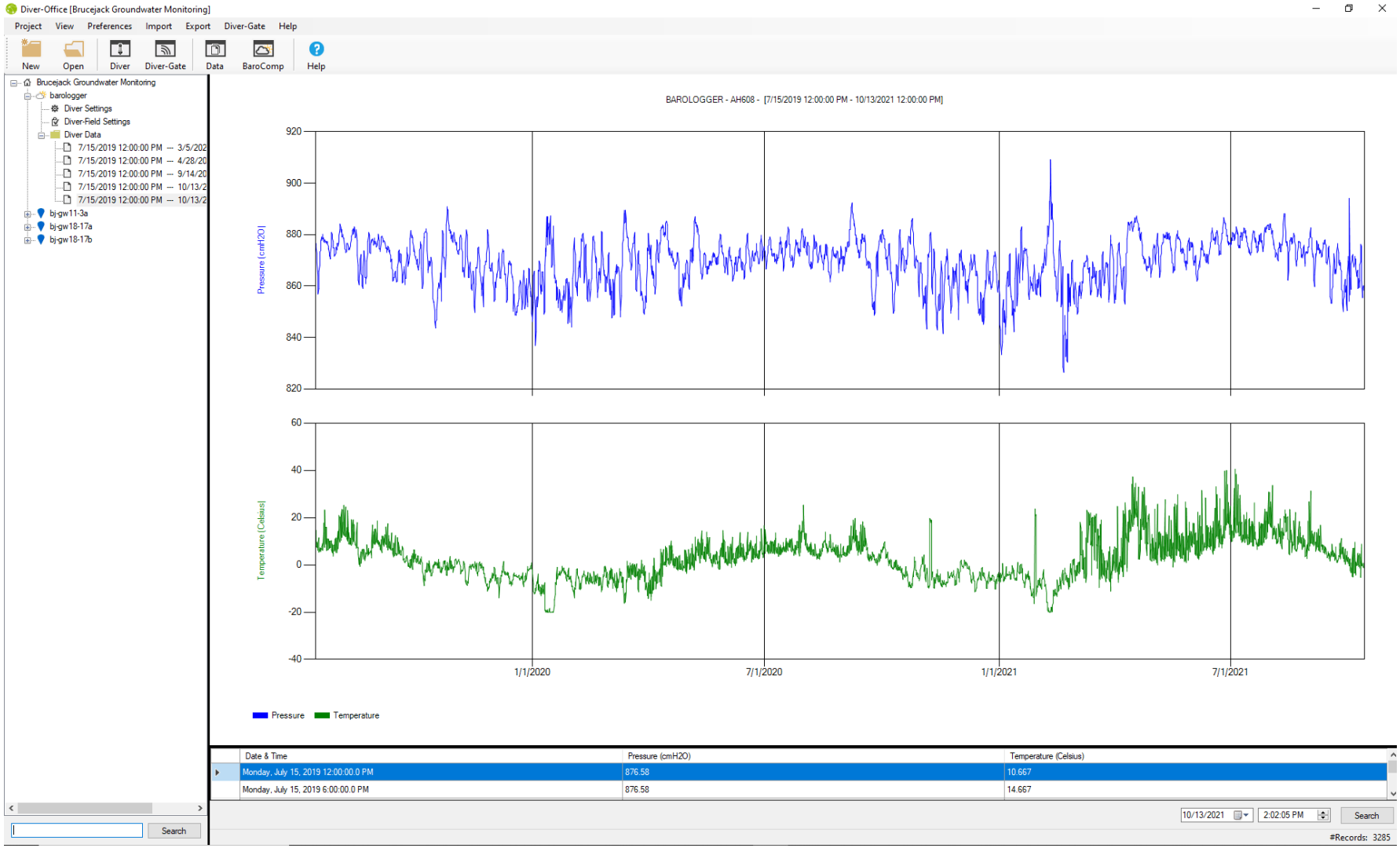


Photo 10: Data logger data downloaded and graphed. Right click the selected file on the left hand window to export data.

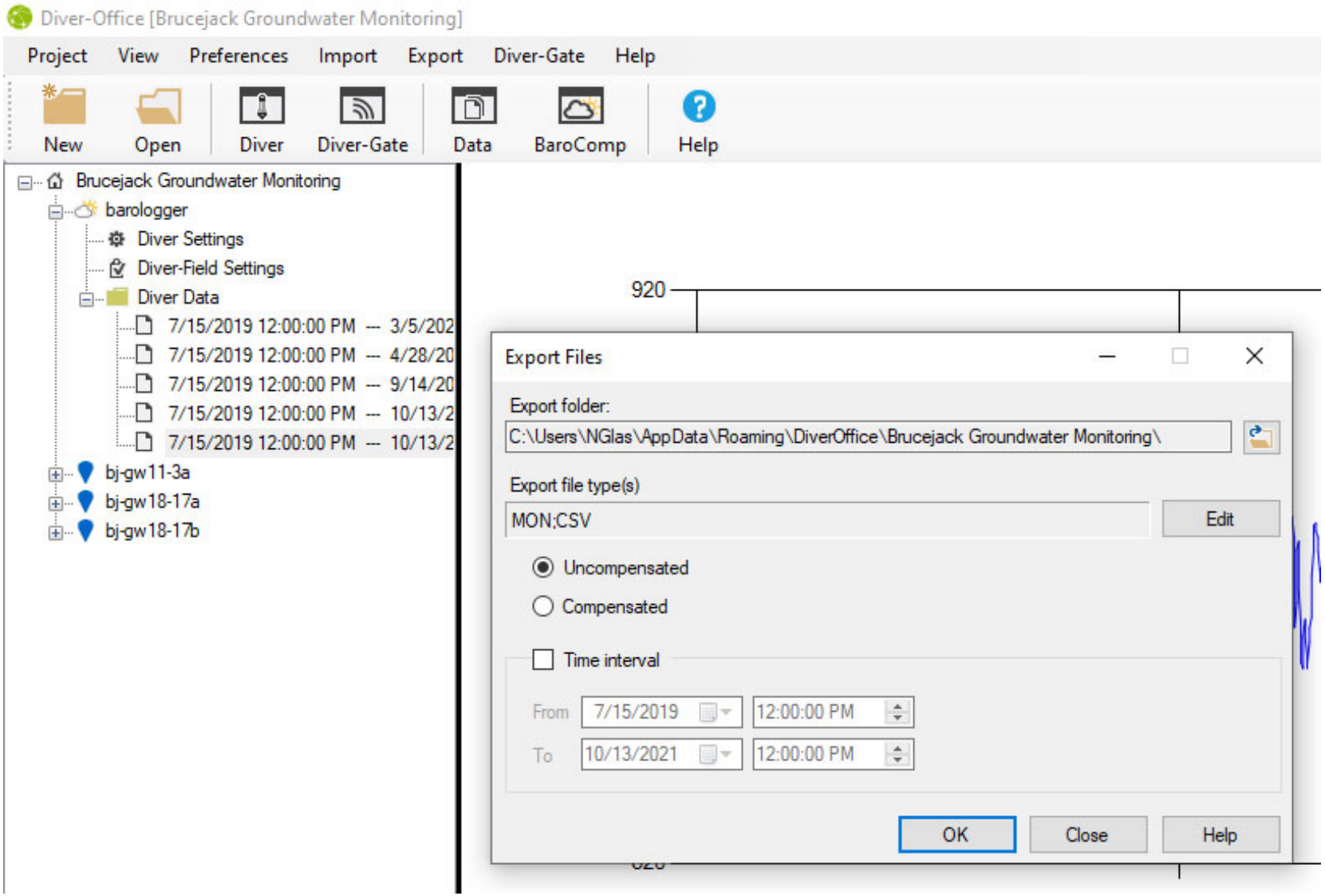


Photo 11: Export file window. Export to appropriate desktop folder with MON; CSV file types selected, along with uncompensated data.

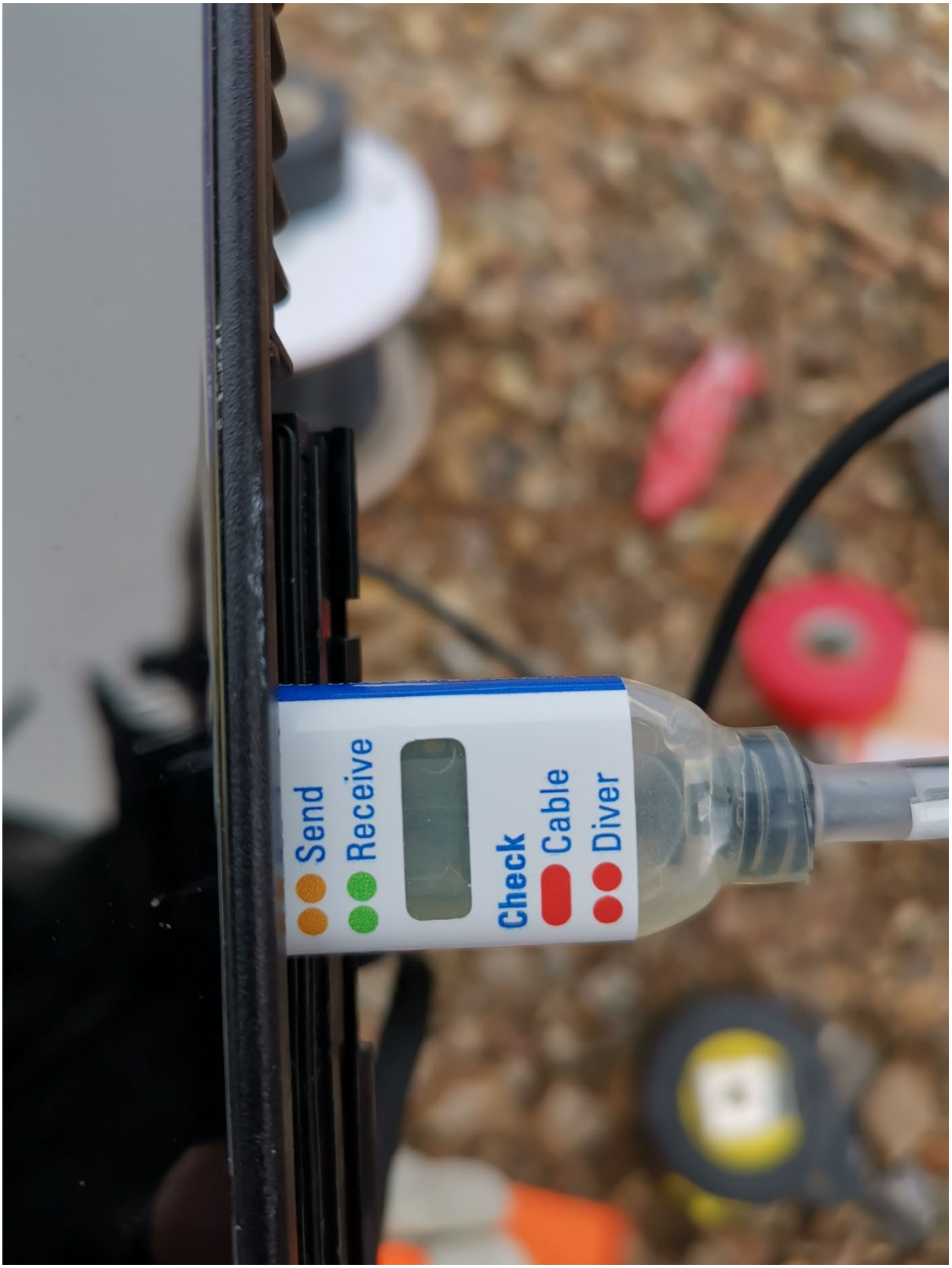


Photo 12: USB cable diagnostic feature with associated status readouts that will show in status window.

Photo 13: Direct read cable well cap that can be used when direct read cable is completely deployed. It is recommended that an additional cap/seal is used to ensure the well top is properly sealed from the environment.

Photo 14: Direct read excess cable on reels hung towards well shack roof to reduce likelihood or burial under snow in winter conditions. Slack left in cables to reduce strain on cables from snow load.

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Will move to the approver role, and approve only the SOP'S only their department SOP'S	You can add the supervisors, superintendents under the review role.	
Health & Safety Manager / Designate			
JOHSC Co-chair or Member			
APPROVER ROLE	NAME	SIGNATURE	DATE
Mine Manager / Designate	Will sign for all site wide documents		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE

SOP Review Sign Off	PRETIVM
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Completed copy to be forwarded to the Safety/Training Department

Appendix J

Sonic Water Level Measurement SOP

Objective

Properly utilize the Solinst Sonic Water Level Meter for water level measurements within groundwater monitoring wells on site.

Scope

Provide details to properly use the Sonic Water Level Meter to obtain water levels on site.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- WLM: Water Level Meter

Roles and Responsibilities

The General Manager or Designate shall ensure that:

- Ensuring this procedure is implemented and followed.
- Ensuring this procedure has been reviewed and the appropriate signatures acquired.

The Health and Safety Manager or Designate shall ensure that:

- Ensuring this procedure complies with H&S regulation.
- Ensuring this procedure has been reviewed and the appropriate signatures acquired.

The Area Manager or Designate shall ensure that:

- Ensuring this procedure is followed.
- Ensuring that the Worker(s) has read, understood, and signed off on this procedure prior to beginning the work.
- Ensuring that this procedure is reviewed and updated as necessary, at minimum annually.

The Worker are responsible for:

- Following the methodology outlined in this SOP and reporting deficiencies in the procedure to Brett DeHay-Turner (Hydrogeochemist), Nathan Glas (Hydrogeologist) and/or Jason Gabora/Torence Sandhals (Environmental Coordinator/Environmental Superintendent).

Preparation

Hazards

- Sonic pulse should be kept away from ears

Tools

- Sonic water level meter

- Well cover disc
- Field sheets/notebook
- Gloves or other material to seal well
- 6 spare AA batteries, preferably lithium for winter conditions

Requirements

- Trained and qualified to conduct water level sampling.
- Familiar with well location, typical water levels and well construction (see Well Fact Sheets)

Job Step

Operating Principles

1. The Solinst Sonic Water Level Meter (WLM) consists of a Control Unit (Photo 1) and Probe (Photo 2). The Control Unit has a display, keypad, and comes with 6 AA alkaline batteries. The Probe contains a sound/pulse generator, microphone and temperature sensor.
2. The Sonic Water Level Meter works by the Probe transmitting a sound wave into the pipe, tube, or well and measuring the time it takes for the pulse to return after making contact with water. The depth to water is calculated using the speed of sound and time. Since the speed of sound varies with temperature, the temperature sensor located in the Probe adjusts for variations.
3. View the attached link for additional details: https://www.solinst.com/products/level-measurement-devices/104-sonic-water-level-meter/instructions/instructions.php

Equipment Check and Setup

1. Connect the Probe to the Control Unit by plugging the Probe cable connector into the connection on the side of the Control Unit. Ensure the connector is completely pushed in, with the arrow facing inwards and towards the front of the control unit (Photo 3).
2. Press the ON button. The Sonic WLM Version number should briefly display and then show "Depth* Searching". There should be a popping sound from the Probe, if not, ensure the Probe is plugged in properly. Turn the Sonic Water Level Meter OFF by pressing the button.
3. Insert the Probe into the open well casing, and then cover any open area around the Probe to stop the sound pulse from leaving the well. For example, use the plastic disc that is supplied with the Solinst Sonic Water Level Meter (Photo 4). A glove also works to fill gaps where the plastic disc cannot be used to create a seal within the casing stickup.
    a. The seal around the probe does not need to be airtight, but the signal works better if there is a proper seal keeping the pulse inside the well. It also helps keep out external noise, including wind.
    b. If the top of the well or pipe is open, then it should be covered with a cap with a hole for the probe to access. The included plastic disc from Solinst is a good option.

Water Level Measurement

1. Press the ON button on the Control Unit. "Depth* Searching" will be displayed as it obtains a stable depth to water reading. The depth to water measurement will be displayed after a few seconds.
2. To ensure the accuracy of the reading, use the Control Unit to enter specific well details such as drop tube diameter (review Setting Measurement Parameters below) and the minimum and maximum water level measurement range (review Well Fact Sheets). See the following sections for setting up these, and other parameters. It should be noted that it is very tedious and inefficient to change the minimum and maximum depths – it is recommended to check these ranges but not adjust them if the general water level falls within them. If issues reading the signal are encountered, consider narrowing the range.

   a. Temperature is generally set at 4 degrees Celsius as an estimate, but can be adjusted seasonally if water level values seem incorrect.

3. Press the ON button (or the Read button if already on). During or after "Depth* Searching" is displayed, press the down arrow to show the battery voltage.
   a. Batteries should be replaced at 6.5 volts.

Setting Measurement Parameters

1. Press the Set button repeatedly to scroll through the various settings (see below for available set modes).
2. Use the up and down arrow buttons to change a setting.
3. When the desired setting is reached, press the Set button to save and advance to the next setting, or press Read to display the depth to water measurement.

Available Set Modes:

When the Set button is pressed, the Sonic WLM version number is displayed. Press the down arrow to read the Serial Number of the Sonic Water Level Meter.

WL Range Min (m): Sets the minimum range to start detecting. Setting a minimum range can also help ignore interferences at a specific depth. E.g. if the well casing ends at 10 m and your water level is below that at about 20 m, then the minimum range could be set to 15 m to ignore any reflection at 10 m. See "Well Obstruction" and "Depth to Water" considerations on Page 5.

WL Range Max (m): Sets the maximum depth from which the Probe will listen for a returning pulse. If the approximate depth to water is known, don't set the Meter to listen for the returning pulse longer/deeper than required. A longer range gives less frequent returning pulses and increases the possibility of interference. A shorter range means more frequent pulses returning to the probe. See "Depth to Water" considerations.

Water Temp (ºC): Manually set the estimated temperature of the water inside your well. With the air temperature automatically detected by the sensor in the Probe, the two temperatures are used to calculate the speed of sound and therefore, the distance. Note: The distance error is small for variations in temperature, about 1% for a 5.6 ºC temperature error.

Drop Tube Diameter (cm): Set the drop tube diameter. This compensates for a reduced sound speed in tubes smaller than 5 cm (2") in diameter. The options for this setting are: >5 cm, 5 cm, 4.4 cm, 3.8 cm, 3.2 cm, 2.5 cm, 1.9 cm and 1.3 cm (>2", 2", 1.75", 1.5", 1.25", 1", 0.75", 0.50"). The following are the recommended maximum depths for each drop tube diameter: 1.3 cm to 120 m, 1.9 cm to 180 m, 2.5 cm to 300 m, 5 cm to 600 m (0.50" to 400 ft, 0.75" to 600 ft, 1" to 1,000 ft, 2" to 2,000 ft). This setting should not be changed as all our wells are ~5 cm.

MP Offset (cm): Set the offset of the probe position from ground level – the zero point is the tip of the Probe. E.g. if the probe is inserted into a well cap that extends 75 cm above the ground. Then enter 75 cm for the offset. This will automatically be deducted from the depth reading. The value can be negative if the probe is installed on a casing below ground level. **We will not complete this step as our measurements are made from Top of Casing.*

Units: Select the measurement system for the data. The options are Metric for meters, centimeters, and degrees Celsius, or Eng ft for feet, inches, and degrees Fahrenheit. **Leave measurements in Metric.*

Power Mode: Set in Normal or Power save mode. When in Normal mode there is an auto off after 15 minutes. When in Power save mode, there is an auto off after 3 minutes.

Contrast: Set the contrast level on the LCD screen from 0 (brightest) to 10 (dimmest).

Factory Reset: Sets the Control Unit back to the factory default configuration. Press the up button to make the selection. All settings will be set to the default values in Metric.

Maintenance

Batteries and power: The 6 AA batteries should be replaced at 6.5 V. Old batteries should be removed as soon as possible to prevent damage from leaking. To access the batteries, undo the screw from the back of the Control Unit and remove the battery cover and batteries. Ensure the new batteries are installed in the correct polarity, as labeled. Do not kink or damage the ribbon cable inside the Control Unit and be careful when reinstalling the battery cover. If the Control Unit is going to be stored for longer than a two month period, the 6 alkaline batteries should be removed to avoid any potential leakage.

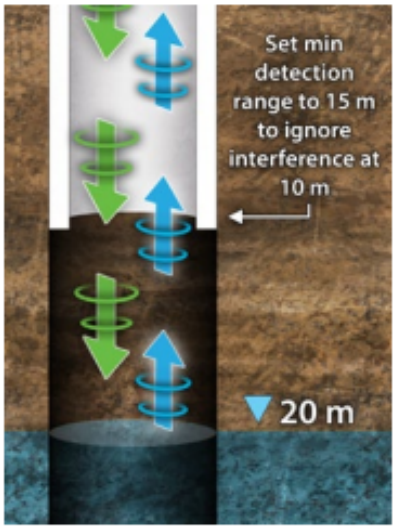
Factory Reset: It is good practice to perform a Factory Reset before starting a new application, or at a minimum, once a month. A Factory Reset will default measurements to Metric.

Troubleshooting

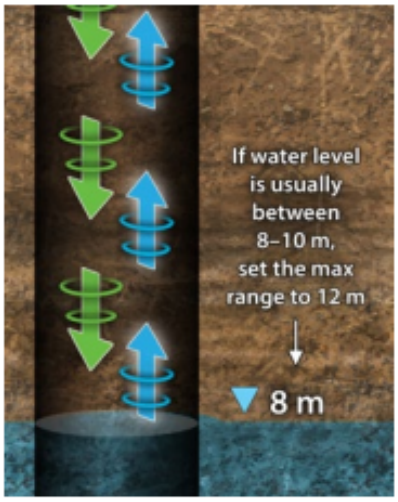
SYMPTOM	CAUSE	REMEDY
Will not power on / Display is blank	Contrast of the Control Unit is too low.	If the Probe makes the normal "popping" sound when powered on, but nothing is displayed, check the contrast of the Control Unit screen. You may be able to see the screen in a different lighting condition to adjust it. If this still does not work, a hard reset can be done by removing one of the AA batteries and waiting a few minutes before reinstalling.
	Control Unit needs a reset.	Remove the Probe connector, reconnect and try again.
	Batteries need replacing.	Replace the 6 AA batteries in the Control Unit.
Powers up, but no Probe "pop"	A bent connector pin, damaged cable or Probe.	Check the Probe cable connection first, then contact Solinst for more options.
Erratic depth, an asterisk beside the depth reading, or reads "Depth* Searching" for more than 15 seconds.	Probe not connected properly, a bent connector pin, damaged cable or Probe.	If there is no Probe "pop' heard, check the Probe cable connection first, then contact Solinst for more options.
	The well is not closed tightly enough.	Ensure the well is closed and that there is a good seal around the Probe.
	There is perforated casing, incomplete inner casing, excessive pump noise.	Try using a drop tube, or adjusting the parameter settings.
	The maximum or minimum range settings are not set properly.	Try resetting the parameters.
	Other parameters or settings are incorrect.	Try a Factory Reset.
The depth reading seems too small.	You set the minimum range too small.	Try adjusting the minimum range parameter.
	There is an obstruction or opening in the well.	Set a minimum range to ignore the obstruction or opening at that depth.
Display reads "no probe"	Probe not connected properly, a bent connector pin, damaged cable or Probe.	Check the Probe cable connection first, then contact Solinst for more options.

Other Operating Considerations

Well Openings



Well Obstructions



Depth to Water

Well Opening

The pulse generated by the Probe is an air pressure wave/low frequency sound wave. This is why there should be a good seal around the probe to prevent the air pressure from escaping an opening, which would result in not enough of the pulse going down the well. A good seal also prevents external noise, such as wind, from interfering with the signal.

Well Obstructions

The sound wave travels until it is disturbed. Each time it is disturbed by an imperfection in the well, some of the pulse is reflected, making the main pulse a little weaker. A complete imperfection, like the surface of the water, will reflect the entire remaining wave. Smaller obstructions, like tubing or wires, will not obstruct the pulse enough to affect the water level reading. However, larger interferences such as a small change in casing diameter, could reflect enough of the pulse to generate an erroneous reading. Setting a minimum detection range is helpful to ignore such interferences.

A drop tube should be used if there are more significant disturbances in the well, such as a large step-down in well casing diameter or perforated casing sections.

Depth to Water

The sound wave loses energy as it travels, and even more if the well casing is rough or porous. To compensate for this, the Probe increases its gain with time to listen for fainter signals. This can cause problems if the Probe listens for too long. The gain will get so high that pump noise or noise outside the well could outweigh the pulse. Therefore, the maximum range setting is available to tell the Probe how long to listen. E.g. if a pump is installed at 50 m, then set a maximum range of less than 50 m to avoid any interference from that depth.

In shallow wells, the sound wave bounces off the top and bottom of the well, so the pulse can bounce back and forth many times. E.g. in a well where the water level is at 2 m, the Probe would hear a reflection at 2 m, then again at 4 m, then 6 m etc., until the pulse gets weak enough to ignore. In this example, you would be able to see the multiple reflections by increasing the minimum range. When set to 3 m, the depth would read 4 m. When set to 5 m, it would read 6 m, etc. In this case, it may be helpful to leave a small leak at the probe to help dissipate the pulse.

Well Diameter

As well diameter increases, the strength of the sounds pulse weakens, therefore it is more susceptible to pump noise or interference from other imperfections. As such, wells larger than 8" in diameter should use a drop tube from top of well, to just below the depth to water for measurement.

Photo 1: Solinst Sonic Water Level Meter Control Unit.

Photo 2: Solinst Sonic Water Level Meter Probe with cable.

Photo 3: Cable connected to control unit, with arrow pointed inwards and facing the front of the control unit.

Photo 4: Solinst disc with hole for sealing well opening. If the disc does not create a tight seal, the probe can be inserted directly in the well, with a glove or other material acting to seal off the well opening.

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Will move to the approver role, and approve only the SOP'S only their department SOP'S	You can add the supervisors, superintendents under the review role.	
Health & Safety Manager / Designate			
JOHSC Co-chair or Member			
APPROVER ROLE	NAME	SIGNATURE	DATE
Mine Manager / Designate	Will sign for all site wide documents		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE

SOP Review Sign Off	PRETIVM
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Completed copy to be forwarded to the Safety/Training Department

Appendix C
Groundwater Quality Field Data

NEWCREST

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: / AB	Water Level (mbTOC @ time):	Date:	Personnel:
	Bottom of well (mbTOC):	Weather:	Air Temperature (°C):
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Spent two hours with a shovel trying to dig out area but could not find the well or rock -> dug down ~3.5-4 m over a ~ 20m² area

tripping of bottles impossible - will purge line again before redeploy

WL after pulled out was 18.035 mbTOC @ 14:30

going to sample = SP now and do snaps later, not paired just to ensure sample is collected -> sulfur smell at start

purged sample line again after reset bottles and set it back down

BRUCEJACK GROUNDWWATER SAMPLING FORM

Mar. 26, 2021

PRETIVM

Well ID: 3A	Water Level (mbTOC @ time): 17.945 @ 14:00	Date: ~~Mar 27/21~~	Personnel: NG/RO
	Bottom of well (mbTOC):	Weather: Snow	Air Temperature (°C): -3
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
14:30	18.035	0	open well							
14:55	17.455	0	submersible down		well					
15:00	18.708	2.5	500	2.5	358.5	0.87	7.49	-94.8	4.74	clear, sulfur smell
15:05	18.74	5.0	500	2.5	367.9	0.59	7.55	-121.5	5.82	" "
15:10	18.68	7.5	500	2.3	383.4	0.53	7.63	-133.3	11.6	" "
15:15	18.683	(1.875)	375	2.4	387.6	0.46	7.68	-140.4	11.95	clear
15:20	18.70	(1.875)	375	2.5	389.0	0.42	7.7	-148.0	14.49	" "
15:25	18.702	(1.875)	375	2.5	395.1	0.41	7.72	-149.8	17.2	" "
~~15:30~~										

open (SP in bag)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
15:30	18.702	13.125	375

Datalogger remove time (dd/mm/yr hr:mm): 26-Mar-21 @ 14:10	WL (mbTOC): 17.945		
Datalogger redeployment time (dd/mm/yr hr:mm): " " 16:20	WL (mbTOC): 18.595		
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):		
Field Alkalinity:	QA/QC Sample (FB, TB, DUP):		

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

ice in snap sampler air line, melted w/ heater before attaching compressor

Snap @ 3:10 max PSI 70

↳ must have still had some ice in line so bottles didn't trip - had to redeploy and will wait 2 weeks

↳ date of Feb 27, 2021 -> initial WL @ 17.934 (-8°C for day & snowy)

Groundwater Sampling Field Form v3 BDT 2020

Mar 26-2021 2nd attempt to sample - tripped @ 14:10 and stabilized @ 70 psi

bottles did not trip again - pulled and ran air compressor at surface and it closed bottles (see top)

18.035

borehole depth at 9.4, bottom of screen @ 8.0
so is below screened interval

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 3B	Water Level (mbTOC @ time): 9.235	Date: Feb 25, 2021 @ 10:50	Personnel: NG/RS
	Bottom of well (mbTOC): ~10.67	Weather: light snow	Air Temperature (°C): -3
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Feb 25, 2021 @ 10:55	WL (mbTOC): 9.235
				Datalogger redeployment time (dd/mm/yr hr:mm): Feb 25, 2021 @ 11:00	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

depth of well has increased by 1.27 m? Washing away bentonite below seal plug somehow?
↳ should look at well construction to see bottom completion to try to figure out how well could be getting significantly deeper

DRY

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): ~~[illegible]~~	Date: Feb 26, 2021 @ 15:30	Personnel: NG/RS	
Bottom of well (mbTOC): 77.34	Weather: Clear skies & sunny	Air Temperature (°C): -2	
Well ID: 5A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (mL/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Feb 26, 2021 @ 15:30	WL (mbTOC): ~~[illegible]~~ DRY
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:55	WL (mbTOC): DRY
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

pvc casing broken at surface

↳ water level measured from bottom of broken - roughly 30 cm?

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): DRY @ 16:05	Date: Feb 26, 2021	Personnel: NG/RS	
Bottom of well (mbTOC): 52.00	Weather: Clear skies/sunny	Air Temperature (°C): -2	
Well ID: SB	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Feb 26, 2021 @ 16:00	WL (mbTOC): DRY @ 16:05
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 16:15	WL (mbTOC): DRY
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: GBA	Water Level (mbTOC @ time): 15.365	Date: 19-Apr-21	Personnel: RS/AB
	Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 19-Apr-21 @10:05	WL (mbTOC): 15.365
				Datalogger redeployment time (dd/mm/yr hr:mm): / / ' @ 10:23	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: GB	Water Level (mbTOC @ time): 15.900	Date: 19-Apr-21	Personnel: RS/AB
	Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 19-Apr-21 @ 10:12	WL (mbTOC): 15.900
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 10:22	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

LL ~ 37
dpr ~ 91.5

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 8A	Water Level (mbTOC @ time): 35.27 @ 09:15	Date: 23-Apr-21	Personnel: NG/RS
	Bottom of well (mbTOC): —	Weather: sunny, windy!	Air Temperature (°C): -3
	Stick-up (m ags):	Sampling Method: snap, submersible	Minimum Purge Volume (L):

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
snap	09:55	—	1.5		1.6	220.1	4.00	8.10	191.0	8.62	clear
sub	10:25	35.244	0								
	10:30	35.365	2.5	~500	1.4	210.5	4.97	8.00	161.3	6.48	clear
	10:35	35.357	~~5~~ 5	~500	1.6	211.9	3.88	8.03	162.5	17.53	" "
	10:40	35.362	~~7.5~~ 10	~~1000~~	1.6	214.0	2.27	8.14	153.4	30.27	" "
	10:45	35.374	15	1800	1.7	214.4	1.92	8.17	125.3	25.49	beige
	10:50	35.383	20	1800	1.9	214.5	1.74	8.18	104.8	19.77	" "
	10:55	35.395	24	800	2.2	214.7	1.63	8.17	82.6	13.96	clear
	11:00	35.395	28	800	2.3	214.8	1.57	8.19	70.3	9.5	"
	11:05	35.395	32	800	2.5	215.0	1.50	8.19	55.6	7.16	"
	11:10	35.395	36	800	2.5	215.3	1.49	8.19	47.3	6.23	"
	11:15	35.395	~~40~~	800	~~2.6~~ 2.6	215.3	1.48	8.18	~~42~~ 41.8	6.65	"
	11:20	35.395	44	800	2.6	215.6	1.46	8.18	36.9	5.85	"
	11:25	35.395	48	800	2.7	215.7	1.45	8.18	33.4	4.06	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:30	35.395	52	800

Datalogger remove time (dd/mm/yr hr:mm): 23-Apr-21 @ 09:30	WL (mbTOC): 35.27	
Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 12:00	WL (mbTOC): —	
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):	
Field Alkalinity:	QA/QC Sample (FB, TB, DUP):	

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

pressure to 70 psi and then released out check valve - held stable there → tripped @ 09:20

Slight sheen on water surface in bucket @ ~10:45

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 8B	Water Level (mbTOC @ time): 38.895 @ 13:45	Date: 22-Apr-21	Personnel: NG/RS
	Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method: Snap/SP	Minimum Purge Volume (L):

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Snap	14:10	38.895	1.5	—	1.8	215.6	5.03	8.07	187.9	3.63	clear light sediment
SP	14:15	38.856	0	open well							
	14:35	38.784	0	~ snap in							
	14:40	39.432	1	500	1.5	216.1	4.27	8.11	167.9	206.33	large, murky
	14:45	39.418	3.5	500	1.8	216.5	2.67	8.08	156.8	174.68	" "
	14:50	39.418	6 → 22.4 L	500	2.5	214.5	2.34	8.09	94.2 ↔	130.9	" "
	14:55 *	39.335			3.9	214.9	3.05	8.11	109.6	74.6	"
	15:00	39.32			4.3	214.2	2.64	8.11	98.0	59.70	"
	15:05	39.32			4.5	214.0	2.52	8.12	85.6	57.01	"
	15:10	39.315	20L		4.3	213.9	2.56	8.11	75.2	35.49	clear
	15:15	39.342	22.5	500	4.5	213.5	2.14	8.12	67.5	41.31	" "
	15:20	39.355	25	500	4.9	213.3	1.96	8.13	60.4	57.19	" "
	15:25	39.370	27.5	500	5.1	213.2	2.00	8.13	58.0	51.48	" "
	15:30	39.368	30	500	5.3	212.9	2.09	8.13	57.4	10.34	" " **
	15:35	39.376	32.5	500	5.4	213.2	2.04	8.13	56.4	10.2	" "
	15:40	39.406 → after sampled									
	~~15:45~~										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 22-Apr-21 @ 13:55	WL (mbTOC): 38.895
15:40	39.376	35	500	Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:50	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP): EB		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Pressure up to 46 psi, sharp drop to 20 psi & stable → @ 13:50 was tripped

light sediment in some of snap bottles → most not readable in highest bottle

oily sheen in bucket ~ SP @ 14:50

Groundwater Sampling Field Form v3 BDT 2020

* flow decreased

** turb dropped rapidly when jostled

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): DRY @ 11:15	Date: Feb 27 2021	Personnel: NG ~~[illegible]~~ RS	
Bottom of well (mbTOC): 79.92	Weather: Snow, cloudy	Air Temperature (°C): -5	
Well ID: 9A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Feb 27, 2021 @ 11:05	WL (mbTOC): DRY
				Datalogger redeployment time (dd/mm/yr hr:mm): " " " @ 11:20	WL (mbTOC): DRY
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 46.237 @ 11:05	Date: Feb 27, 2021	Personnel: NG/RS	
Bottom of well (mbTOC): 47.233	Weather: snow, cloudy	Air Temperature (°C): -5	
Well ID: 9B	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 27-Feb-21 @ 11:00	WL (mbTOC): 46.237
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 11:15	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

depth ~29.5
WL ~23-24

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 11A	Water Level (mbTOC @ time): 21.16 @ 14:10	Date: 21-Apr-21	Personnel: NG/RS
	Bottom of well (mbTOC): 29.51	Weather: partly cloudy	Air Temperature (°C): -5
	Stick-up (m ags):	Sampling Method: bailer	Minimum Purge Volume (L):

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Apr 21	14:15	21.16	1	/	4.4	187.1	4.41	8.41	182.3	4.79	clear
	14:20	24.185	5	/	2.6	188.6	5.95	8.47	185.4	9.30	" "
	14:30	25.000	8.25	/							
	14:30	25.85	10.25	/	2.5	189.7	5.84	8.58	185.7	19.60	" "
Apr. 23	08:45	20.01	—	/							
	08:50	22.05	15.25	/	3.5	186.8	6.24	8.43	193.1	10.14	clear
	09:00	24.82	20.25	/	2.4	183.2	6.23	8.59	196.7	17.69	" "
	09:05	26.96	25.25	/	2.2	190.4	6.75	8.63	198.6	22.78	" "
Apr 24	14:55	20.09	—	/							
	1500	22.344	30.00	/	3.0	177.2	6.85	8.70	125.1	13.67	"
	1510	24.465	35	/	3.0	177.8	8.72	8.70	129.1	26.25	"
	1520	26.85	40	—	2.9	191.5	7.15	8.63	134.9	26.40	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 21-Apr-21 @ 14:10	WL (mbTOC): 21.16
1525	26.85	40		Datalogger redeployment time (dd/mm/yr hr:mm): 24 apr/21 1530	WL (mbTOC): 26.85
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

@ 8.25 L purged had trouble getting bailer all way down so did WL to check, water is well, must be getting caught

↳ once it hits water it doesn't want to go further

depth ~58.8
WL ~54

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 54.36 @ 14:05	Date: 21-Apr-21	Personnel: NG/RS	
Bottom of well (mbTOC): 54.84	Weather: partly cloudy	Air Temperature (°C): -5	
Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):	

Well ID: 11B

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 21-Apr-21 @ 14:05	WL (mbTOC): 54.36
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC): DRY
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

well is dry

Frozen at 9:00

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 12A	Water Level (mbTOC @ time): 0:00	Date: 23-Apr-21	Personnel: NG/RS
	Bottom of well (mbTOC):	Weather:	Air Temperature (°C):
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (mL/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

frozen - could not get an probe through
→ similar to last quarter

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 12 AB	Water Level (mbTOC @ time): Dry @15:55	Date: 25-Apr-21	Personnel: NG/RS
	Bottom of well (mbTOC): —	Weather: Sunny	Air Temperature (°C): 5
	Stick-up (m ags):	Sampling Method: —	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 25-Apr-21 @15:55	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): 25-Apr-21 @16:05	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

had to break well cap to get in to well. Should bring well cap housing up next time & lid.

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 17A (before snap removal)	Water Level (mbTOC @ time): 113.996 @ 09:05	Date: 31-Mar-21	Personnel: NG/RS
	Bottom of well (mbTOC): —	Weather: slight snow, wind	Air Temperature (°C): -5
	Stick-up (m ags): —	Sampling Method: snap / Bennett	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
09:~~45~~	~~113.996~~	0	before snap	0.7	878	4.86	~~9.99~~ 9.49	168.3	95	clear/light grey

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 31-Mar-21 09:30	WL (mbTOC): 113.996
09:10				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap tripped @ 09:10 - steady climb to 52 psi then slow drop to 50 psi
Snap & settle @ 09:30 -> Sample time is 09:35 for dissolved metals & Hg had a piece of e-tape flow Bennett in sample bottle

Groundwater Sampling Field Form v3 BDT 2020

attempted to sample = Bennett but tubing still foam - big air leaks

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: BB 17A	Water Level (mbTOC @ time): 103.252	Date: Apr 27/21	Personnel: RS M
	Bottom of well (mbTOC): ~152.0	Weather: Snow	Air Temperature (°C): -3
	Stick-up (m ags):	Sampling Method: Bennet	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	/DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:07	103.252	–	–							
10:32	start									
10:50		20L	1000	3.7	2.7	13.06	7.60	142.2	-2	DI
11:00		30L	1000	3.4	877	2.53	10.04	140.1	142	grey
11:10		40L	1000	3.2	858	1.10	9.90	133.7	64.4	"
11:20		50L	1000	3.2	809	0.77	9.64	-70.0	53.7	light grey
11:30		60L	1000	3.1	765	0.64	9.36	-127.3	62.8	" " " sulfur smell
11:40		70	1000	2.9	739	0.58	9.10	-152.3	27.00	"
11:50		80	1000	2.8	725	0.50	8.95	-165.6	19.7	clear * sulphur
11:55		85	1000	2.8	720	0.66	8.86	-166.5	10.77	"
12:00		90	1000	2.8	715	0.50	8.83	-168.9	8.12	"
12:05		95	1000	2.8	713	0.6	8.79	-173.5	6.37	"
12:10		100	1000	2.8	710	0.6	8.74	-173.8	5.46	"
12:15		105	1000	2.8	708	0.5	8.7	-178.1	11.48	"
12:20		110	1000	2.8	705	0.5	8.66	-180.5	4.04	"
12:25		115	1000	2.8	704	0.51	8.63	-181.6	3.76	"
12:30		120	1000	2.8	703	0.51	8.62	-183.7	2.94	"
12:35		125	1000	2.8	705	0.52	8.63	-184.7	3.78	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
13:05	–	150	1000	Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Eq blank
40L alconox
60L tap
60L DI
eq @ 9:30

* difficulty tagging bottom of well

Sulfur smell @ 11:30

2/2

17A

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 103.252	Date: 27-Apr-21	Personnel: NG/RS	
Bottom of well (mbTOC): ~152.8	Weather: Snow	Air Temperature (°C): -3	
Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):	

Well ID: 04

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
1240		130	1000	2.8	702	0.51	8.59	-185.6	7.18	clear, sulphur
1245		135	1000	2.8	701	0.50	8.57	-186.1	4.96	"
1250		140	1000	2.8	701	0.5	8.57	-187.3	6.98	"
1255		145	1000	2.9	699	0.7	8.53	-184.0	2.65	"
1300		150	1000	2.0	701	0.65	8.52	-188.5	4.64	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
13:05		150	1000	Datalogger redeployment time (dd/mm/yr hr:mm): 28-Apr-21 @08:55	WL (mbTOC): 103.135
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

attempted to take final water level but seemed to be getty stuck @ ~106m. will check again upon snap re-install.

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 17B	Water Level (mbTOC @ time): 65.766 @ 11:00	Date: 31-Mar-21	Personnel: NG/RS
	Bottom of well (mbTOC):	Weather: Sunny/windy	Air Temperature (°C): -5
	Stick-up (m ags): —	Sampling Method: Snap/Bailer	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (mL/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:35		0		-0.1	~~453.2~~	~~5.02~~	~~8.38~~	~~-49.1~~	64.5	sulphur smell, lightly cloudy
					~~345.2~~	~~4.80~~	8.06	-69.9		
					~~1146.3~~	4.62				
					933					

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 31-Mar-21 11:05	WL (mbTOC): 65.766
11:05				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Compressor on @ 11:05 left to 38 psi then down to 26 psi

up @ 11:15 - Strong sulphur smell

1/2

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 65.742 @ 10:25	Date: 04-Mar-21	Personnel: NG/BM	
Bottom of well (mbTOC): 75.8 @ 13:55	Weather: Sturdy snow	Air Temperature (°C): -5	
Stick-up (m ags):	Sampling Method: Submersible	Minimum Purge Volume (L):	

Well ID: 17B

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
snap	13:50	66.555	–	–	1.8	867	3.55	7.9	-197.6	77	light grey ✱
											strong rotten egg
sub	14:10	66.09	–								
	14:20	68.6	0								
	14:23	69.5	0								
	14:25	70.3	0								
	14:30	70.55	1	200	1.5	842	4.80	8.76	-176.2	422	Grey
	14:35	70.98	2	200	1.6	831	5.25	8.79	-171.8	350.6	" "
	14:38	71.1	2.7		1.4	822	5.94	8.91	-157.0	357.2	" "
	14:41	71.33	3.4		1.6	817	6.26	9.00	-150.1	345.2	" "
	14:44	71.435	3.7	100	1.6	816	6.39	9.08	-143.7	338.6	" "
	14:47	71.51	4	100	1.3	814	6.63	9.22	-133.8	294.3	" "
	14:50	71.57	4.2		1.1	815	7.35	9.19	-130.9	417.76	" "
	14:53	71.62	4.5	100	1.2	812	7.5	9.31	-133.0	375	" "
	14:56	all of a sudden dropped all water. Had to restart									
	~~14:59~~										
	~~15:02~~										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
15:25	72.5	7.5	100

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): Mar 4 @ 13:05

Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:55

Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): 66.555

WL (mbTOC):

Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap pressure hit ~ 38psi & stabilized @ 24 psi -> @ 13:05 snap tripped closed

Sulfur smell from well

✱ Snap sampler parameters first line

Groundwater Sampling Field Form v3 BDT 2020

Slundfas dry @ 2:10 to ~74 mbTOC

↳ WL dropping too = slowest possible flow rate

@ 14:44 water level drop slowed to a crawl, almost stable but barely dripping from flow through cell - pH still stabilizing though

Ground.

Sulfur visible water was dark gray - got light brown over time but recharge too slow

Snap bottles had sulfur smell, some suspended particles and a slight yellow brown color to them

2/2

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time):	Date: Mar 4, 2021	Personnel: NG/BM	
Bottom of well (mbTOC): 75.8	Weather: Snowy Stedily	Air Temperature (°C): -5	
Stick-up (m ags):	Sampling Method: Snap & Submersible	Minimum Purge Volume (L):	

Well ID: 17B Cont

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
15:05	71.70	5	—	2.7	800	9.53	9.38	-110.8	438.63	Gray
15:08	71.76	5.3	100	2.6	800	8.79	9.40	-115.9	382.11	" "
15:11	71.955	6.0	200	3.2	793	8.33	9.44	-121.0	373.51	" "
15:14	72.1	6.3	100	3.4	791					
15:17	dropped	all water again								
15:23	72.111	6.5	100	3.1	794	10.79	9.41	-96.8	333.12	" "
15:25	72.12	6.7	100	2.8	796	9.36	9.42	-102.2	336.2	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Mar 4 @ 13:05	WL (mbTOC): 66.555
15:25	72.5	7.5	100	Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:55	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap redeployed @ 15:55 during snap decanting a spring became dislodged so all water fell out of bottle so were able to get all samples and field parameters except for sulfides

Groundwater Sampling Field Form v3 BDT 2020

Snap bottles kept dropping water and read code 0-1. Too slow at pumping rate? still couple inches of water above pump

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 65.716 @ 09:50	Date: 02-Apr-21	Personnel: NG / LF	
Bottom of well (mbTOC): 75.83	Weather: snowy, gusty	Air Temperature (°C): -5	
Stick-up (m ags): —	Sampling Method: Bailer	Minimum Purge Volume (L): 60	

Well ID: 17B

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
	10:20		0								
Apr. 2	10:35		7.5		1.7	814	6.51	9.05		63.1	grey, sulfur smell
	10:55		16.5		1.0	781	8.89	9.84		92.37	" "
	11:10	70.320	22.5		1.0	774	11.02	10.02		138.12	grey
	14:10	66.985	22.5		~~3.3~~	~~884~~	~~4.43~~	~~8.07~~	~~-32.8~~	~~54.22~~	~~beige, light sulfur smell~~
Apr. 3	14:30		30		3.3	884	4.43	8.07	-32.8	54.22	beige, light sulfur smell
	14:45		37.5		2.1	834	5.24	8.58	-78.9	83.11	grey, light sulfur smell
	15:00		45		1.9	821	7.63	8.74	-66.4	261.17	dark grey, light sulfur smell
	09:15	68.728	45								
Apr. 4	09:30		52.5		3.0	899	4.16	7.83	-23.6	151.39	grey, sulfur smell
	09:45	72.62	60		1.8	886	3.80	7.86	-74.1	506.67	" "
Apr. 5	9:30	68.343	60		—	—	—	—	—	—	—
	9:35		61.5		2.5	905	2.81	7.52	-5.8	20.52	clear, sulfur smell
	9:45	69.60	64.5		1.8	895	3.83	7.66	-49.4	117.16	grey, sulfur smell

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): previously removed	WL (mbTOC):
Apr 5/21 9:40		63		Datalogger redeployment time (dd/mm/yr hr:mm): ☐ Snap see after	WL (mbTOC): 69.60
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

forgot to take ORP readings on Apr. 2

Half generals from 1st pull (Apr 5 @ 09:35), rest samples from 2nd pull (Apr 5 @ 09:40). Parameters 1st + 3rd pull (09:35, 09:45) second times

took params before and after sample to see variation

Snap & logger redeployed @ 10:10 - since issue with sampler all the way down & bit back column and stopped, went down after lifting & dropping

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 55.42 @15:00	Date: 30-Mar-21	Personnel: NG/RS	
Bottom of well (mbTOC): —	Weather: slight snow	Air Temperature (°C): -5	
Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —	

Well ID: 18A

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 30-Mar-21 @15:00	WL (mbTOC): 55.42
				Datalogger redeployment time (dd/mm/yr hr:mm): " " 15:10	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

j-plug frozen to well - had to pour boiling water to defrost and remove
minimal DI used to redeploy logger

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 64.900	Date: 30-Mar-21	Personnel: NG/RS	
Bottom of well (mbTOC): 65.360	Weather: slight snow	Air Temperature (°C): -5	
Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —	

Well ID: 18B

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 30-Mar-21 @ 14:15	WL (mbTOC): 64.900
				Datalogger redeployment time (dd/mm/yr hr:mm): 30-Mar-21 @ 14:50	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap tripped @ 14:15 -> pressure went to 40 psi and then dropped and stabilized @ ~20-21 psi
pulled up and all bottles were empty and outside had some silt built up on outside of bottles
rinsed bottles w DI and reset to send back down after data logger downloaded

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1st time well dry - looks like it went dry couple weeks back

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 184.938	Date: 03-Apr-21	Personnel: NG/BM	
Bottom of well (mbTOC): ~199	Weather: light snow	Air Temperature (°C): -5	
Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):	

Well ID: 1A

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 03-Apr-21 @ 09:30	WL (mbTOC): 184.938
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 09:40	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

found knot in logger string when retrieving, ~15cm of line caught up & another knot further down ~30cm & another @ ~50cm, another @ 50cm that could not be undone, and another @ 50cm

Groundwater Sampling Field Form v3 BDT 2020

String should be replaced

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): DRY @ 09:50	Date: 03-Apr-21	Personnel: NG/BM	
Bottom of well (mbTOC): —	Weather: light snow	Air Temperature (°C): -5	
Well ID: 9B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 03-Apr-21 @ 10:20	WL (mbTOC): DRY
				Datalogger redeployment time (dd/mm/yr hr:mm): ~ ~ 10:50	WL (mbTOC): DRY
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

data logger downloaded

used the human reel technique

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 94.000	Date: 05-Apr-21	Personnel: NG/LE	
Bottom of well (mbTOC):	Weather: Ad light, light snow	Air Temperature (°C): -5	
Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):	

Well ID: 20A

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 05-Apr-21 @14:20	WL (mbTOC): 94.000
				Datalogger redeployment time (dd/mm/yr hr:mm): 17:40	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 92.26 @14:15	Date: 05-Apr-20	Personnel: NG/LF	
Bottom of well (mbTOC): 118.22	Weather: flt 1,0, 1,0 snow	Air Temperature (°C): -5	
Well ID: 20B	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 05-Apr-21 @ 14:05	WL (mbTOC): 92.26
				Datalogger redeployment time (dd/mm/yr hr:mm): 14:35	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

logger downloaded & redeployed
hard to gauge water level, very light water

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 163.29	Date: Feb 26/21	Personnel: AG/RS	
Bottom of well (mbTOC): 201.	Weather: Sunny -10	Air Temperature (°C): -10	
Well ID: 21A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 26/02/21 1400	WL (mbTOC): 163.29
				Datalogger redeployment time (dd/mm/yr hr:mm): 27-Feb-21 @10:30	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 213	Water Level (mbTOC @ time): 150.695	Date: Feb 25/21	Personnel: RJ/NA
	Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): -10
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 28/02/21 12:45	WL (mbTOC): 150.695
				Datalogger redeployment time (dd/mm/yr hr:mm): 27-Feb-21 @ 10:30	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Well ID: 22A	Water Level (mbTOC @ time): 134.22 @ 16:00	Date: 28-Mar-21	Personnel: NG/RS
	Bottom of well (mbTOC): \	Weather: Windy, partial sun	Air Temperature (°C): -5
	Stick-up (m ags): \	Sampling Method: \	Minimum Purge Volume (L): \

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 27-Mar-21 @ 16:00	WL (mbTOC): 134.22
				Datalogger redeployment time (dd/mm/yr hr:mm): 27-Mar-21 @ 16:10	WL (mbTOC): \
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated: \	Equipment Used (Model, SN): \

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Lot of snow in well shack

No DI needed to get logger back down well

BRUCEJACK GROUNDWWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 87.204 @ 15:45	Date: 28-Mar-21	Personnel: NG/RS	
Bottom of well (mbTOC): ~~15.4~~	Weather: Windy, partial sun	Air Temperature (°C): -5	
Well ID: ~~BJ-GW18-17A~~ 22B	Stick-up (m ags): —	Sampling Method: \	Minimum Purge Volume (L): \

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 28-Mar-21 @ 15:40	WL (mbTOC): 87.204
				Datalogger redeployment time (dd/mm/yr hr:mm): 28-Mar-21 @ 15:50	WL (mbTOC): —
				Date multimeter (e.g., YSI) last calibrated: \	Equipment Used (Model, SN): \
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Lot of snow in well shack

No DI needed to get logger back down well

depth - ~29.4
WL - ~3.67

1/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 23A	Water Level (mbTOC @ time): 3.625 @ 09:40	Date: 24-Apr-21	Personnel: NG/RS
	Bottom of well (mbTOC): 29.06	Weather: sunny sunny	Air Temperature (°C): ~~0~~ 5
	Stick-up (m ags): –	Sampling Method: submers	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:00	2.63									
10:05	3.86	trying to	get flow	rate sorted	– keeps	dropping				
10:10	4.08	1	200	2.8	1181	1.15	7.63	185.8	6.79	Clear
10:15	4.54	2	200	2.3	1173	0.79	7.64	175.5	34.85	" "
10:20	5.44	3	200	2.4	1171	0.58	7.67	140.5	21.11	" "
10:25	5.72	4	200	2.7	1176	0.69	7.67	108.4	17.31	" "
10:30	5.91	5	200	2.5	1176	0.65	7.67	92.9	13.75	" "
10:35	6.18	6	200	2.7	1176	0.73	7.68	84.8	13.58	" "
10:40	6.28	7	200	2.6	1172	1.54	7.78	104.2	7.3	" " ☆
10:45	6.59	8	200	2.4	1174	0.96	7.69	91.8	13.68	" "
10:50	7.03	9	200	2.6	1171	0.76	7.68	67.8	15.01	beige
10:55	7.45	10	200	2.8	1165	0.73	7.71	26.4	15.46	" "
11:00	7.47	10.5	800/5	3.0	1164	0.73	7.71	15.4	12.76	" "
11:05	7.88	11.6		3.1	1165	0.75	7.71	9.6	12.74	" "
11:10	7.945	12.4		3.1	1164	0.72	7.71	8.0	12.74	" "
11:15	8.03	13.2		3.1	1163	0.74	7.72	~~8.0~~ 7.1	12.34	" "
11:18	8.04	14.0		3.1	1165	0.74	7.72	7.1	11.92	" "
11:21	8.04	~~15~~ 14.8		3.2	1163	0.79	7.72	7.2	11.83	" "

slowed low-flow

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 24-Apr-21 @ 09:45	WL (mbTOC): 3.625
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 12:10	WL (mbTOC): —
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

☆ lost flow for a minute so put of flow through empty & changing pumps

having to pump @ an extremely miniscule rate to stop drawdown in well

depth - ~11
WL - ~3.7

2/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 23A out	Water Level (mbTOC @ time): See	Date: See	Personnel: NG/RS
	Bottom of well (mbTOC): Sheet	Weather: Sheet	Air Temperature (°C):
	Stick-up (m ags): 1/2	Sampling Method: 1/2	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:24	8.04	15.6		3.0	1166	0.83	7.72	8.5	11.24	beige
11:27	8.04	16.4		3.1	1164	0.48	7.72	8.4	11.27	" "
11:30	8.04	17.2		3.0	1166	0.47	7.73	8.6	11.11	" "
—										
11:57	12.19	10 (30)		6.8	1155	0.34	7.69	-3.0	6.78	beige
11:58	15.16	20 (40)		5.8	1159	0.33	7.68	-0.1	4.27	" "
11:59	19.77	35 (45)		5.7	1160	0.34	7.66	-0.4	3.8	clear
12:00	19.73	30 (50)		5.3	1161	0.44	7.63	0.5	3.5	" "
12:05	21.51	40 (60)		5.5	1159	0.6	7.63	3.1	4.5	" "
12:08	25	50 (70)		6.6	~~19.8~~ 1165	1.44	7.64	6.8	8.15	~final values
										as pumped ~~[illegible]~~
										then stopped

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
11:30		20		Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

took sample & then pumped well down to see change & found ORP dropped quickly and other params were similar → likely need to resample and complete 3 well volume purge before sample to ensure getting fresh groundwater

Groundwater Sampling Field Form v3 BDT 2020

↳ values @ 11:50 are representative of this

depth = 11
LC = 2.7

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 23B	Water Level (mbTOC @ time): 3.47 @ 12:15	Date: 24-Apr-21	Personnel: NG/RO
	Bottom of well (mbTOC):	Weather: sunny 5°C	Air Temperature (°C): 5
	Stick-up (m ags):	Sampling Method: peristaltic	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume V: Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:25	3.55		250							
12:30	3.685	1.25	"	2.5	2514	0.55	7.29	109.6	17.81	clear
12:35	3.758	2.5	"	2.5	2505	0.37	7.33	107.8	19.2	"
12:40	3.812	3.75	"	2.5	2449	0.33	7.36	106.0	17.82	"
12:45	3.84	5.00		2.5	2391	0.31	7.38	104.8	14.31	"
12:50	3.873	6.25	"	2.5	2349	0.29	7.39	103.7	12.14	"
12:55	3.894	7.50	"	2.5	2325	0.28	7.39	102.9	10.77	"
	3.88									

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 24-Apr-21 @ 12:15	WL (mbTOC): 3.47
13:00	3.88	7.50	250	Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

dup @ 13:05

depth - ~23.3
WL - ~8.5

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 6.42 @ 09:00	Date: 25-Apr-21	Personnel: NG/RS	
Bottom of well (mbTOC):	Weather: sunny	Air Temperature (°C): 5	
Well ID: SA CVP	Stick-up (m ags):	Sampling Method: Submers	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
09:10	5.89	—	200							
*9:20	6.968			2.0	701	2.56	7.61	193.8	6.52	clear
9:25	7.08			2.0	701	2.88	7.59	180.6	6.08	"
9:30	7.342			1.9	701	2.40	7.59	160.0	7.20	"
** 9:35	7.507	3.0	200	2.0	700	2.28	7.57	110.4	5.56	"
9:40	9.41	10.00		4.9	695	0.89	7.57	83.2	4.48	"
9:45	11.70	20.00		3.8	692	0.49	7.57	60.3	5.44	"
9:50	15.68	30.00		3.7	687	0.45	7.58	33.4	1.67	"
9:55	15.103	38		3.6	682	0.40	7.59	20.8	1.43	"
1000	15.006	42		4.2	682	0.33	7.61	-0.2	1.63	"
1005	15.257	47		4.6	688	0.31	7.60	-12.3	0.62	"
1010	15.144	50		4.6	692	0.31	7.60	-17.5	0.22	"
10:15	15.156	54		4.9	692	0.29	7.60	-22.3	0.3	"
1020	15.2	58		5.0	695	0.27	7.60	-25.3	0.31	"
1025	15.185	62		5.0	698	0.27	7.60	-27.8	0.45	"
10:30	15.208	65		5.1	697	0.26	7.60	-29.3	0.8	"
10:35	15.202	68		5.1	697	0.26	7.61	-30.7	0.44	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 25-Apr-21 @ 08:55	WL (mbTOC): 6.42
10:40	15.167	68	755	Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 10:50	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

*small sheen on water surface at initial flow

** increased flow

when lowered data logger back down well it hit bottom before the end of the string
↳ removed 1 m of line to ensure not sitting at bottom

depth - ~11.3
WL - ~7.8-8.2

actually 2.13

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 1.465 @ 10:50	Date: 25-Apr-21	Personnel: NG / RS
Bottom of well (mbTOC): 10.67	Weather: sunny	Air Temperature (°C): 5
Stick-up (m ags): actually 11.335	Sampling Method: peristaltic	Minimum Purge Volume (L):

Well ID: 5B CWP

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:50	1.465	0								
10:58	stack		333							
11:05	2.55	2.33	"	1.8	931	9.74	7.43	120.3	8.75	clear
11:10	2.556	4.00	"	1.8	933	9.96	7.43	130.8	16.98	"
1115	2.82	5.67	"	1.8	955	10.72	7.43	143.5	9.22	"
1120	2.836	6.67	200	1.9	957	10.84	7.44	150.9	12.31	"
1125	2.848	8.00	200	1.9	957	11.32	7.44	158.7	5.99	"
1130	2.862	9.00		1.9	989	12.02	7.44	167.9	17.60	"
1135	2.867	10.00		1.9	992	12.22	7.44	172.6	11.46	"
1140	2.874	11.5		1.9	993	12.15	7.44	176.8	21.03	"
1145	2.878	13.0		1.9	993	12.06	7.44	181.0	12.76	"
1150	2.880									
		+0.665 = 3.543								
							actually 2.13			

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
1145	2.848	15	
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):	

Datalogger remove time (dd/mm/yr hr:mm): 25-Apr-21 @ 09:00
Datalogger redeployment time (dd/mm/yr hr:mm): //
Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): 1.465 @ 10:50
WL (mbTOC):
Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Casing was broken during snow moving during winter
→ 0.665 m water at should be added

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 26.078 @ 13:40	Date: 17-Jul-21	Personnel: NG/RS	
Bottom of well (mbTOC): ~~[illegible]~~ 81.160	Weather: Overcast, windy	Air Temperature (°C): 5	
Well ID: 1A	Stick-up (m ags): 0.503	Sampling Method: submersible	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
14:05	26.011	0								
14:10	26.088	2.5	500	3.8	126.6	12.01	7.85	185.0	4.60	Clear
14:15	26.088	5.0		3.3	127.0	11.91	7.80	140.0	6.72	"
14:20	26.088	7.5		3.1	128.9	11.75	7.69	119.0	78.15	
14:25	26.088	~~10.00~~ *		2.7	136.8	11.70	7.74	111.2	93.7	
14:30	26.092	1000		2.4	139.3	11.45	7.77	118.9	100.5	light brown
14:35	26.116	1500		2.2	139.2	11.43	7.77	122.21	48.31	"
14:40	26.116	2000		3.2	139.0	11.21	7.77	126.7	38.20	clear
14:45	26.120	25		3.1	139.5	11.52	7.77	128.41	23.59	"
14:50	26.120	32		3.1	139.5	11.53	7.77	130.3	26.66	
14:55	26.120	40		3.1	139.3	11.56	7.77	131.6	29.50	
1500										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 16-Jul-21 @ 14:00	WL (mbTOC): —
15:00				Datalogger redeployment time (dd/mm/yr hr:mm): 17-Jul-21 @	WL (mbTOC): 26.06
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

* increased flow

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 26.116 @ 13:45	Date: 17-Jul-21	Personnel: NG/RS	
Bottom of well (mbTOC): 38.82	Weather: overcast, windy	Air Temperature (°C): 5	
Stick-up (m ags): 0.570	Sampling Method: Surbers	Minimum Purge Volume (L): —	

Well ID: 1B

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
1345	26.116									
1520	27.75		750							
1528	27.710	2.5		2.4	159.9	10.73	7.91	156.7	18.63	clear
15:30	27.714	10		3.6	173.2	10.35	7.93	156.2	61.96	orange-brown
15:35	27.742	15		4.9	172.7	10.54	7.97	155.6	33.26	"
15:40	27.771	20		4.9	170.7	10.61	7.97	154.3	21.97	
1545	27.653	22.5		5.2	169.6	10.72	7.90	149.0	20.10	Clear
1550	27.653	25		5.4	168.9	10.73	7.93	143.3	16.22	"
1555	27.646	30		5.4	168.2	10.74	7.98	141.2	17.17	"
1600	27.646	35		5.4	167.7	10.73	7.90	139.5	19.63	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 17-Jul-21 @ 13:40	WL (mbTOC):
1600				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Stickup is leaning on marked side measures 0.570, on other side is 0.600

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 3A	Water Level (mbTOC @ time): 8.474m 13:55	Date: 20-June-2021	Personnel: CM & NG
	Bottom of well (mbTOC):	Weather: Clear, sunny, 15°C	Air Temperature (°C): 15°C
	Stick-up (m ags):	Sampling Method: Snap & Submersible	Minimum Purge Volume (L): N/A

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
snap	14:30	8.474	—	/	12.7	361	3.72	7.78	121.2	41.1	clear, some TSS
BP	14:55	8.630	0								
	15:00	8.756	2.5	500	5.3	362.3	0.80	7.64	77.1	5.7	Clear
	15:05	8.811	5	500	5.6	362.1	0.65	7.66	34.2	9.9	Clear
	15:10	8.835	7.5	500	6.0	360.1	0.57	7.67	9.2	14.6	" "
	15:15	8.900	10	500	5.5	361.5	0.52	7.68	-7.3	22.58	" "
	15:20	9.010	11.25	250	5.0	358.6	0.48	7.69	-27.6	11.88	" "
	15:25	9.021	12.50	250	5.0	358.6	0.50	7.70	-44.5	8.33	" "
	15:30	9.015	13.75	250	5.2	358.7	0.48	7.71	-51.1	5.67	" "
	15:35	9.010	15.00	250	5.0	359.4	0.48	7.72	-57.3	6.06	" "
	15:40	9.010	17.25	250	4.8	357.6	0.46	7.73	-59.9	5.60	" "
	15:45	9.010	19.00	250	4.8	358.3	0.46	7.73	-59.9	3.84	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
15:50	9.010	20.25	250
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):	

Datalogger remove time (dd/mm/yr hr:mm): 20-June-2021 @ 14:00	WL (mbTOC): 8.474		
Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 17:10	WL (mbTOC): 8.475		
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):		

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap → Pressure stabilized at 70 psi, did not drop
→ Tripped at 14:00 (Sample time)
→ line full of water, but still tripped

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): flowing artesian	Date: 20-Jun-21	Personnel: NG/CM	
Bottom of well (mbTOC): 10.640	Weather: Overcast	Air Temperature (°C): 10	
Well ID: 3B	Stick-up (m ags): —	Sampling Method: peristaltic	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
16:05	artesian	0	—							
16:10	" "	1.25	250	3.4	325	1.10	7.44	44.1	27.95	Clear
16:15	" "	2.5	250	3.4	360.6	0.91	7.63	43.4	20.23	" "
16:20	" "	3.75	250	3.4	351.3	0.82	7.68	48.6	41.26	" "
16:25	" "	5	250	3.4	350.5	0.80	7.69	52.7	19.51	" "
16:30	" "	6.25	250	3.4	349.5	0.79	7.69	57.0	29.38	" "
16:35	" "	7.50	250	3.4	348.8	0.79	7.70	60.4	23.41	" "
~~16:40~~										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 20-Jun-21 @ 16:00	WL (mbTOC): artesian
16:40	artesian	8.25	250	Datalogger redeployment time (dd/mm/yr hr:mm): 20-Jun-21 @ 16:45	WL (mbTOC): Artesian
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

flowing artesian which time

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 5A	Water Level (mbTOC @ time): DRY @ 11:20	Date: 20-May-21	Personnel: NG/RS
	Bottom of well (mbTOC): 78.05	Weather: sunny	Air Temperature (°C): 5
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 11:15 20-May-21

Datalogger redeployment time (dd/mm/yr hr:mm): 11:35 " "

Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): DRY

WL (mbTOC): DRY

Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

big knot in data logger string when pulled up - untangled and redeployed

poured some DI to redeploy

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): DRY @ 11:35	Date: 20-May-21	Personnel: NG/RS	
Bottom of well (mbTOC): 39.67	Weather: Sunny	Air Temperature (°C): 5	
Well ID: 5B	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11:35 @ 20-May-21	WL (mbTOC): DRY
				Datalogger redeployment time (dd/mm/yr hr:mm): 11:45 " "	WL (mbTOC): DRY
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

ice plug near top - poured some DI to clear out

~~poured some DI to redeploy~~

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 9.11 @ 10:30	Date: 30-May-21	Personnel: NG/CF	
Bottom of well (mbTOC): 30.876	Weather: foggy/cloudy	Air Temperature (°C): -2	
Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):	

Well ID: CA

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 30-May-21 @ 10:30	WL (mbTOC): 9.11
Datalogger redeployment time (dd/mm/yr hr:mm): 30-May-21 @ 10:34	WL (mbTOC):
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 6B	Water Level (mbTOC @ time): 12.772 @10:25	Date: 30-My-21	Personnel: NG/LF
	Bottom of well (mbTOC):	Weather: foggy, cloudy	Air Temperature (°C): -2
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 30-My-21 @ 10:25	WL (mbTOC): 12.772
				Datalogger redeployment time (dd/mm/yr hr:mm): " " " @ 10:35	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 8A	Water Level (mbTOC @ time): 13.133 @09:30	Date: 21-Jun-21	Personnel: NG/CM
	Bottom of well (mbTOC):	Weather: lig rain, cloudy	Air Temperature (°C): 10
	Stick-up (m ags):	Sampling Method: Snap, Submersible	Minimum Purge Volume (L): —

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Snap	10:05	13.133	1.5	—	8.0	216.1	5.93	8.04	198.5	21.10	clear, suspended sed
	—	—	—	—	—	—	—	—	—	—	—
SP	10:30	13.181	—								
	10:35	13.184	2.86	572	2.7	214.8	5.74	7.87	189.7	9.60	clear
	10:40	13.206	5.72	572	2.4	215.5	4.23	7.90	191.4	20.81	" "
	10:45	13.217	8.58	572	2.2	215.1	3.75	7.99	184.0	99.98	pale yellow, some particles
	10:50	13.223	11.44	572	2.2	215.0	3.70	8.04	93.9	86.31	" "
	10:55	13.225	14.3	572	2.2	214.6	3.57	8.06	61.1	70.04	yellow / lig beige
	11:00	13.230	17.16	572	2.2	214.3	3.54	8.07	50.6	68.74	" "
	11:05	13.230	20	572	2.2	214.2	3.41	8.08	47.5	52.91	" "
	11:10	13.230	22.5	500	2.3	214.4	3.76	8.08	48.1	19.96	lig beige
	11:15	13.230	25	500	2.3	214.3	3.77	8.08	49.7	19.10	" "
	~~11:20~~ 11:25	13.200									
	~~11:25~~										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 21-Jun-21 @09:50	WL (mbTOC): 13.133
11:20	13.230	27.5	570	Datalogger redeployment time (dd/mm/yr hr:mm): 21-Jun-21 @11:30	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

tripped @ 09:35 - stable @ 70psi
↳ one bottle half full
for bit of suspended sediment in bottles, some brown water around o-rings (seems to be water ≈ abundance of suspended part

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 23.786 @ 09:45	Date: May 27, 2021	Personnel: NG / BM	
Bottom of well (mbTOC): 50.754	Weather: Sunny, clear	Air Temperature (°C): 5	
Well ID: 8B	Stick-up (m ags):	Sampling Method: Snap & SP	Minimum Purge Volume (L):

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Snap	10:15		–	–	5.3	224.6	5.76	8.10	188.2	4.84	Clear
SP	10:35	23.623	0								
	10:40	24.537	4	800	2.0	217.7	5.55	7.99	176.7	143.2	light Brown
	10:45	24.579	8	800	2.3	217.7	7.96	8.01	150.3	77.81	Beige "
	10:50	24.628	12	800	2.7	217.2	2.64	8.04	116.0	49.23	" "
	10:55	24.522	16	800	3.0	216.9	2.55	8.05	88.0	40.18	" "
	11:00	24.480	20	800	3.1	216.9	2.58	8.05	68.1	14.15	" "
	11:05	24.464	22.5	500	3.1	216.8	2.66	8.05	52.3	9.97	Clear
	11:10	24.460	25	500	3.1	216.6	2.63	8.06	44.7	10.17	Clear
	11:15	24.455	27.5	500	3.2	216.6	2.61	8.06	39.6	10.77	Clear
	11:20	24.446	30	500	3.2	216.3	2.58	8.06	33.8	12.52	Very light grey
	11:25	24.456	32.5	500	3.2	216.2	2.57	8.06	30.4	3.34	" "
	11:30	24.444	35	500	3.3	216.1	2.59	8.05	28.1	2.21	" "
	11:35	24.436	37.5	500	3.3	216.1	2.60	8.05	25.0	1.83	" "
	11:40	24.407	40	500	3.3	216.2	2.62	8.06	23.5	1.54	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:45	24.407	42.5	500
Field Alkalinity:		QA/QC Sample (FB, TB, DUP): Dup	

Datalogger remove time (dd/mm/yr hr:mm): 27-May-21 @ 10:00	WL (mbTOC): 23.786
Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 12:05	WL (mbTOC): 23.655
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap tripped @ 09:50
Max Pressure = 57 psi
Dropped + stabilized @ 38 psi
Snap sampler brought to surface @ 10:00

after Snap sample taken & before sliders down well WL @ 23.976

Dup sampled @ 11:50

Groundwater Sampling Field Form v3 BDT 2020

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 09BA	Water Level (mbTOC @ time): Dry	Date: 21-May-21	Personnel: NG/RS
	Bottom of well (mbTOC): 79.94	Weather: Cloudy	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11:00 - 21-May-21	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): 1105 " "	WL (mbTOC): —
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 09B	Water Level (mbTOC @ time): ~~46.255~~ Dry @ 10:55	Date: 21-May-21	Personnel: NGM/RS
	Bottom of well (mbTOC): 46.255	Weather: Cloudy	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 21-May-21 @ 10:48	WL (mbTOC): ~~46.255~~ Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): ~ @ 11:00	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 13.59 @ 14:05	Date: 25-May-21	Personnel: NG/RS/BM	
Bottom of well (mbTOC): 25.255	Weather: overcast	Air Temperature (°C): -2	
Stick-up (m ags):	Sampling Method: Bailer	Minimum Purge Volume (L):	

Well ID: 11A

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
May 25	14:08	13.59	5		3.9	170	9.15	9.87	168.8	0.57	clear
	14:15		10		3.0	81.5	10.07	9.31	169.0	4.05	" "
	14:20	20.78	15		2.8	160.5	9.73	9.00	175.0	4.91	" "
	14:30	23.29	20		2.7	161.8	9.67	8.92	176.0	4.46	" "
May 26	11:00	13.623	25		3.6	167.4	9.96	9.07	101.5	4.43	" "
	11:04	16.046	25		2.7	165.7	10.77	8.96	109.6	9.08	" "
	11:10	18.386	30		2.6	165.2	10.50	8.89	114.7	8.01	" "
	11:16	20.60	35								
May 27	12:20	13.674	-								
	12:27		40		3.2	167.5	11.11	9.01	106.7	3.37	" "
	12:33		45		2.6	164.7	10.71	9.12	103.2	4.23	" "
	12:38	20.968	50		2.6	165.1	10.48	9.12	103.7	8.61	" "
May 29	11:14	13.587	–	–	–	–	–	–	–	–	–
	11:18	16.74	55	–	3.6	168.7	10.56	9.18	182.0	1.58	Clear
	11:25	19.114	60	–	2.7	164.7	10.87	9.23	183.0	4.77	Clear
	11:32	20.883	64	–	2.7	164.5	11.14	9.25	178.9	8.58	Clear
	11:42	21.402	66	–	2.8	164.5	11.33	9.25	174.8	9.77	Clear

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:33	20.883	65	–

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 25-May-21 @ 14:05

Datalogger redeployment time (dd/mm/yr hr:mm): 29 May 21 @ 11:44

Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): 13.59

WL (mbTOC): 21.402

Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 51.695	Date: 25-May-21	Personnel: NGJ/RS	
Bottom of well (mbTOC): 54.405	Weather: Overcast	Air Temperature (°C): -2	
Well ID: 11B	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 25-May-21 @ 13:55	WL (mbTOC): 51.695
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 14:00	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

~~51.11~~ water in screen, too low to sample

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): / 11:10	Date: 17-Jun-21	Personnel: NG/CM	
Bottom of well (mbTOC): /	Weather: Sunny	Air Temperature (°C): 10	
Well ID: 12A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

plug ~~of~~ of snow & ice frozen 1-2 ft. down well
↳ could get an. probe through at poured some DI but could not break through enough for probe to go down well - could try boiling water
↳ crack in PVC? or snow got in when well might have been uncovered?

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 12b	Water Level (mbTOC @ time): 53.28 @ 10:55	Date: June 17 2021	Personnel: CM + NG
	Bottom of well (mbTOC): 53.39 @ 10:55	Weather: Clear, light wind, 15°	Air Temperature (°C): 18°C
	Stick-up (m ags): /	Sampling Method: /	Minimum Purge Volume (L): /

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Not enough water in well to sample										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):	

Datalogger remove time (dd/mm/yr hr:mm): 17-Jun-21 @ 11:00	WL (mbTOC): 5328
Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 11:10	WL (mbTOC): —
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

~~13B - Artesian @ 15:15 - 15-Jul-21 - ~20L/5 min flow but slowed quickly - stick up @ 0.720 m ags - redeploy @ 15:25 → artesian - animal has been living in well shack - was 14A in software so will relabel~~

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Artesian @ 15:05	Date: 15-Jul-21	Personnel: NG/CM/RS	
Bottom of well (mbTOC): —	Weather: Overcast, windy	Air Temperature (°C): 5	
Well ID: 13A	Stick-up (m ags): 0.876	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 15-Jul-21 @ 15:05	WL (mbTOC): Artesian
				Datalogger redeployment time (dd/mm/yr hr:mm): " " 15:15	WL (mbTOC): Artesian
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

~20L/5 min of flow @ start - substantial slowdown after 15 mins

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 13B	Water Level (mbTOC @ time): Artesian @ 15:05	Date: 15-Jul-21	Personnel: NG/CM/RS
	Bottom of well (mbTOC): —	Weather: overcast, windy	Air Temperature (°C): 5
	Stick-up (m ags): 0.920	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 15-Jul-21 @ 15:15	WL (mbTOC): Artesian
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:25	WL (mbTOC): Artesian
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

~20L/5min flow but slowed down significantly after ~5 minutes

Animal has been living in well shaft

Logger file was titled 14B in DiverOffice software so re-labelled files back in office

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 17A	Water Level (mbTOC @ time): 80.02 8:43	Date: 26-May-21	Personnel: NGI/RS/BM
	Bottom of well (mbTOC):	Weather: Sunny, crisp	Air Temperature (°C): 2
	Stick-up (m ags):	Sampling Method: Snap, grundfos	Minimum Purge Volume (L):

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Snap	09:20	—	—	—	4.6	831	4.58	9.94	91.0	31.26	slightly cloudy
	~	~	~	~	~	~	~	~	~	~	~
SP	10:38	start									
	10:40		20L								
	11:00		40								
	11:17		60								
	11:35		80	1000	3.3	697	1.37	8.97	30.6	20.63	light grey
	11:55		100	1000	3.0	695	0.50	8.90	-115.4	25.06	clear / surfacing
	12:00		105	1000	2.9	692	0.47	8.81	-132.7	12.07	" clear "
	12:05		110	1000	2.9	686	0.46	8.73	-143.7	9.57	" "
	12:10		115	1000	3.0	683	0.46	8.66	-154.7	8.83	" "
	12:15		120	1000	3.0	681	0.45	8.59	-165.5	7.12	clear
	12:20		125	1000	3.1	680	0.44	8.54	-168.2	6.01	"
	12:25		130	1000	3.2	678	0.43	8.49	-173.1	5.09	"
	12:30		135	1000	3.2	675	0.42	8.38	-174.0	4.32	"
	12:35		140	"	3.3	677	0.41	8.33	-175.0	3.50	
	12:40		145	"	3.3	673	0.39	8.36	-178.5	3.10	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 26-May-21 @ 08:43	WL (mbTOC): 80.02
1245	81.81	145	1000	Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 13:40	WL (mbTOC): 81.81
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Shep tripped @ 08:45 → up to 80 psi with pressure on check valve, once released popped up & dropped and held @ 71 psi

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 45.111 @ 09:55	Date: 26-Jul-21	Personnel: NG/CM	
Bottom of well (mbTOC): 75.845	Weather: overcast	Air Temperature (°C): 5	
Well ID: 17B	Stick-up (m ags): 0.213	Sampling Method: Snap/Submers	Minimum Purge Volume (L): 180

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
Snap 10:35	45.111 m	0.75	N/A	7.9	754	4.01	8.13	-138.6	70.51	cloudy, odourless
SP 11:05	44.904	0								v. dark grey
11:10	49.495	5	1000	2.8	803	6.90	8.59	-152.1	1070	
11:15	50.730	10	1000	2.7	788	5.63	8.37	-142.3	1449.5	dark grey
11:20	52.930	15	1000	4.0	777	5.55	8.38	-131.2	~~1880.54~~	" grey "
11:25	54.720	20	1000	5.2	777	6.20	8.52	-133.8	372	grey
11:30	56.500	25	1000	5.6	771	5.74	8.81	-150.9	~~[illegible]~~ 240.93	grey
11:35	58.520	30	1000	6.4	768	5.76	9.38	-161.2	254.8	grey
11:40	60.140	40	1000	6.5	770	5.80	9.73	-161.6	278.52	grey
11:45	61.73	45	1000	6.7	775	5.61	9.93	-161.4	475.84	" " c/ cobbles/foam
11:50	63.95	50	1000	7.0	768	5.27	9.96	-163.2	481.73	" "
11:55	64.98	55	1000	7.7	771	4.91	10.03	-164.3	445.56	" "
12:00	65.94	60	1000	7.9	770	4.88	10.09	-162.4	383.94	" "
12:05	68.555	65	1000	8.4	760	4.77	9.98	-166.4	367.15	grey
12:10	70.48	70	1000	8.4	794	6.43	10.40	-159.5	480.54	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 26-Jul-21 @ 10:15	WL (mbTOC): 45.111
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap tripped @ 10cm - up to 63psi, dropped and stalled @ 48psi

outside of snap very dirty - lots of black/grey sediment settled in bottles, under had sulfury smell

at 10:40 WL @ 46.064 -> slow recharge from snap removal

c SP clear water for first two mins and then v. dark grey @ 30-40 < started to see some foam

17B snap install
50.57 m ▽ on Aug 6/2021 @ 15:00
After install: 49.895 ▽ after install

→ 15:00 29-Jul-21

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 17B	Water Level (mbTOC @ time): 48.365	Date: 29-Jul-21	Personnel: BDT
	Bottom of well (mbTOC): 75.845	Weather: Clear + sun	Air Temperature (°C): 10-15°C
	Stick-up (m ags): 0.213	Sampling Method: Grundfos	Minimum Purge Volume (L): 180

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
15:00	48.365	140								
July 30										
16:00	50.300									
17:00	50.040	200								
July 31st										
9:30	51.62									
9:47	55.65	203		3.6	629	1.27	8.39	-105.7	303.01	
9:55	56.385	205		3.3	620	0.93	8.42	-144.8	319	
10:00	56.620	210		3.5	626	0.83	8.42	-159.2	~200	
10:05	57.505	212		3.7	629	0.69	8.48	-190.0	252	
10:10	58.245	215		4.0	622	0.58	8.53	-203.4	220	
10:15	58.640	218		4.6			8.52	-209.9	220	overload on generator + to take break
13:01	53.210	Start again		3.4	616	<0.84	8.50	-139		
13:14	56.002	228		→ generator starter fouling again... sampled on the last leg						

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

@ 10:15 July 31 measurement: overload alarm on generator. Had to stop to give it ~ break.

@ 10:43 July 31 got new generator. variac had some troubles @ first but recovered. Purged to 220L to get parameters back to normal. 10:46 → second generator overheats? T-1 error code on variac. stopping for now

* possible problems w/ pump. – sediment? – overheat? } but it really got – starter or

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 15A	Water Level (mbTOC @ time): 60.51 @ 14:45	Date: 21-May-21	Personnel: NG/RS
	Bottom of well (mbTOC): 62.04	Weather: cloudy/windy	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14:40 21-May-21	WL (mbTOC): ~~60.5~~ 60.51
				Datalogger redeployment time (dd/mm/yr hr:mm): 14:55 " "	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

well depth is actually closer to 100m, so must have got stuck on sandbag?

12

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 54.515C 10:10	Date: 23-May-21	Personnel: NG/DS	
Bottom of well (mbTOC): 65.67	Weather: Snowy, foggy	Air Temperature (°C): -1	
Well ID: 08B	Stick-up (m ags):	Sampling Method: snap/grundfos	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:05	snap			4.1	685	~~4.22~~ 3.68	7.89	211.2	47.61	clear/slightly cloudy
—										
10:45	54.46	0								
11:05	54.70	0	water at surface							cloudy, dark brown/gray
11:10	54.675	2.5	500	1.4	693	3.32	7.79	165.4	974.2	" " "
11:15	54.68	5	500	1.6	685	2.93	7.76	138.2	695	" "
11:20	54.655	7.5	500	1.8	684	2.42	7.77	75.5	586	" "
11:25	54.66	10	500	2.0	682	1.95	7.77	3.2	472	brown/gray
11:30	54.62	12.5	500	2.4	681	1.87	7.77	-16.5	365	" "
11:35	54.695	15	500	4.1	678	1.77	7.76	-27.3	240	light brown/gray
11:40	54.80	~~25~~	1000	7.6	674	1.72	7.80	-23.6	140	" "
11:45	54.77	25	1000	8.3	674	1.74	7.83	-7.7	128	light brown
11:50	54.72	~~30~~	1000	7.8	677	1.57	7.82	-8.2	203	" "
11:55	54.715	35	1000	7.1	676	1.40	7.81	-19.5	188	" "
12:00	54.75	40	1000	6.7	672	1.15	7.79	-24.8	170	" "
12:05	54.75	43.3		7.3	673	1.33	7.82	-16.5	107	" "
12:10	54.735	46.6		7.1	672	1.38	7.82	-12.2	94	" "
12:15	54.705	50		6.5	672	1.33	7.82	-10.4	86	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 23-May-21 @ 09:45	WL (mbTOC): 54.515
				Datalogger redeployment time (dd/mm/yr hr:mm): " "	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Checked WL on 21-May-21 and was 55.705 mbTOC, will come back to sample

Snap tripped @ 09:35 -> up to 62psi then dropped to 26 psi & stabilized up to surface around 09:45. all bottles full

had some hiccups getting started, but eventually got going

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 54.515 @ 10:10	Date: 23-May-21	Personnel: NG/RS	
Bottom of well (mbTOC): 65.67	Weather: Cloudy	Air Temperature (°C): 0	
Well ID: 18B	Stick-up (m ags):	Sampling Method: Grundfos	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:20	54.77			6.2	674	1.28	7.81	-16.8	89	light brown
12:25	54.80	60		6.8	673	1.33	7.81	-25.7	140	" "
12:30	54.89			8.6	672	0.79	7.79	-56.7	295	" "
12:35	54.81			8.2	673	0.62	7.77	-56.8	160	brown
12:40	54.91			7.5	673	0.50	7.74	-53	107	brown/gray
12:45	54.93	80		7.2	674	0.47	7.74	-49	64	light brown/gray
12:50	54.91			7.1	673	0.44	7.74	-49.2	53	" "
12:55	54.89	95		7.2	672	0.47	7.75	-47.1	66	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 23-May-21 @ 09:45	WL (mbTOC): 54.515
13:00	54.89	100		Datalogger redeployment time (dd/mm/yr hr:mm): " " " 13:20	WL (mbTOC): 54.57
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Continued from previous page

Pump took a very long time to stabilize!

185.196 @ 14:10

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): ~~184.72~~	Date: 18-Jul-21	Personnel: NG/RS	
Bottom of well (mbTOC): 199.6	Weather: cloudy	Air Temperature (°C): 8	
Stick-up (m ags): 0.568	Sampling Method:	Minimum Purge Volume (L):	

Well ID: 19A

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 18-Jul-21 @ 13:55	WL (mbTOC): 185.196
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 14:45	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 19B	Water Level (mbTOC @ time): 148.298 @ 11:50	Date: July 18/21	Personnel: NG/RS
	Bottom of well (mbTOC): 0.456	Weather: cloudy	Air Temperature (°C): 8
	Stick-up (m ags): 162.668	Sampling Method: Snap/BSP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:10	148.955	0								
13:25	down well	and pumping								
13:50		20	- still all priming water							
14:10		30		13.4	408.4	6.20	8.24	162.2	584	grey - lots of bubbles
14:30		40		11.9	409.3	3.89	8.27	140.1	400	"
14:40		50		9.9	418.4	2.37	8.37	141.8	62.00	light grey - bubbles
14:48		60		8.6	420.1	1.83	8.28	145.6	43.50	"
14:55		65		7.9	420.2	1.67	8.33	144.2	35	bubbles - clear
15:00		70		7.7	419.3	2.02	8.42	141.9	32	"
1505		75		7.5	424.7	2.10	8.47	138.6	60.56	"
1510		80		6.7	438.3	1.72	8.40	140.2	45.0	"
15:15		85		6.5	434.6	1.63	8.40	134.3	46.29	"
15:20		90		6.3	442.3	1.70	8.43	132.5	31.67	"
15:25		95		6.0	445.0	1.53	8.41	127.3	98.0	lgt grey
15:30		100		6.0	443.5	2.31	8.47	118.8	49.0	"
15:35		110		6.1	450.1	1.98	8.42	119.6	30.35	"
15:40		115		6.1	457.3	1.97	8.42	119.6	32.75	"
15:45		120		6.1	461.9	1.96	8.36	120.0	48.62	clear

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
1545				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap tripped @ 11:55, stable @ 34 psi

Snap bottles did not trip, not enough pressure build up - unsure why, no obvious issues

WL @ 147.98 mbTOC after snap off

+0.485 m from stickup (was removed => so is 148.565

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 96.93	Date: 21-May-21	Personnel: NG/RS	
Bottom of well (mbTOC): 168.93	Weather: cloudy	Air Temperature (°C): 3°C	
Well ID: 20A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 21-May-21 @ 10:15	WL (mbTOC): 96.93
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 10:30	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): ~101	Date: May 21/21	Personnel: RS NG	
Bottom of well (mbTOC): 119.86	Weather: Cloudy	Air Temperature (°C): 3°C	
Well ID: 20B	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 09:45 21-May-21	WL (mbTOC): ~101
				Datalogger redeployment time (dd/mm/yr hr:mm): 10:00 21-May-21	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Water level beeped at then died off - might need to replace battery - could only get rough approx of ~~well depth~~ water level

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 21A	Water Level (mbTOC @ time): 168.704 08:40	Date: 22-May-21	Personnel: NG/RS
	Bottom of well (mbTOC): 203.236	Weather: Cloudy, light snow (wet)	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 22-May-21 08:40	WL (mbTOC): 168.704
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Will raise logger 30m to keep in water while trying to ensure it has 100m for flood

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 21B	Water Level (mbTOC @ time): 151.318 @ 09:20	Date: 22-May-21	Personnel: NG/RS
	Bottom of well (mbTOC): 164.296	Weather: cloudy, with light snow	Air Temperature (°C): 0
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 22-May-21 @ 09:35	WL (mbTOC): 151.318
				Datalogger redeployment time (dd/mm/yr hr:mm): " " 09:55	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 135.2	Date: May 20/21	Personnel: RS / NG	
Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): 5C	
Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):	

Well ID: 22A

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14:15	WL (mbTOC): 135.12
				Datalogger redeployment time (dd/mm/yr hr:mm): 1450	WL (mbTOC): 0
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

* 2" water on top of well, ~~[illegible]~~ frozen

* need to fix door
+ add an extension for flooding

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 223	Water Level (mbTOC @ time): 86.922	Date: May 20/21	Personnel: NG/RS
	Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): 5°C
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14:56	WL (mbTOC): 86.922
				Datalogger redeployment time (dd/mm/yr hr:mm): 15:00	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

26m × 2 × 3 = 156 min purge 1/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 3.356 @09:00	Date: 23-Jun-21	Personnel: NG	
Bottom of well (mbTOC): 29.088	Weather: Overcast,	Air Temperature (°C): 10	
Well ID: 23A	Stick-up (m ags):	Sampling Method: Submers	Minimum Purge Volume (L): 156

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
09:20	3.356	0								
09:25	7.012	10	2000	3.0	1195	0.43	7.59	184.1	44.55	beige/light gray
09:30	11.000	20	2000	3.5	1190	0.37	7.61	133.7	13.91	grey
09:35	15.076	25	1000	3.7	1184	0.34	7.63	104.8	25.80	clear / cloudy
09:40	16.780	30	1000	4.5	1176	0.34	7.64	60.0	18.25	light gray
09:45	19.902	40	2000	5.1	1165	0.34	7.65	-9.4	8.99	beige
09:50	23.015	50	2000	5.3	1147	0.90	7.64	-25.9	6.60	
09:51	20.740	after pump off								
11:10	12.052	50	–							
11:15	17.3	60	2000	3.8	1202	0.32	7.63	71.1	6.60	light gray
11:20	21.14	70	2000	4.7	1171	0.48	7.67	49.6	3.84	" "
11:25	29.51	80	2000	4.7	1154	0.79	7.68	40.3	4.93	cloudy
11:27	32.72	after pump off and		cleaning						
15:58	5.005	80		BSA						
16:05	11.095	90	2400	3.4	1215	0.44	7.55	114.9	2.05	" "
16:10	14.700	100	1600	3.9	1200	0.40	7.58	94.5	0.77	" "
16:15	19.655	110	2000	4.1	1189	0.54	7.61	78.2	1.39	" "
16:20	24.060	120	2000	4.5	1177	0.82	7.62	66.6	2.44	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 23-Jun-21 @09:00	WL (mbTOC): 3.356
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

going to pump 3 well volumes

Some surface sheen on water - breaks at right angles - film from water level in well potentially? natural?

23-Jun-21
25-Jun-21

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 23A	Water Level (mbTOC @ time): See sheet 1	Date: ~~23-Jun-21~~ to 24-Jun-21	Personnel: NG
	Bottom of well (mbTOC):	Weather: Overcast, muggy	Air Temperature (°C): 15
	Stick-up (m ags):	Sampling Method: Submersible	Minimum Purge Volume (L): 156

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
23-Jun-21	16:25	25.400	~~50~~ 125	1000	5.3	1174	0.98	7.62	60.3	8.28	" "
25-Jun-21	14:25	3.230	125	—							
	14:30	7.042	130	1000	3.3	1247	0.55	7.53	119.4	30.67*	clear
	14:35	8.443	135	1000	3.5	1242	0.49	7.52	103.6	2.49	" "
	14:40	11.053	140	1000	3.9	1232	0.44	7.56	86.9	0.90	" "
	14:45	13.376	145	1000	4.6	1220	0.48	7.59	74.1	8.13	" "
	14:50	15.276	150	1000	4.5	1214	0.46	7.61	61.8	~~40.11~~ 2.37	" "
	14:55	17.408	155	1000	5.0	1209	0.51	7.63	48.6	22.17	" "
	15:00	18.127	158.5	500	5.0	1205	0.54	7.63	43.6	7.85	" "
	15:05	18.818	160	500	6.0	1206	0.51	7.63	31.3	5.50	" "
	15:10	19.440	162.5	500	6.1	1208	0.54	7.63	25.5	1.97	" "
	15:15	20.346	165	500	7.3	1205	1.47	7.64	15.4	7.50	" "
	15:20	22.683	167.5	500	8.8	1198	0.77	7.65	13.7	4.90	" "
	15:25	24.692	172.5	1000	8.3	1201	0.95	7.59	14.7	4.40	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): See sheet 1	WL (mbTOC):
15:30	24.6~~42~~	~180	2000	Datalogger redeployment time (dd/mm/yr hr:mm): 25-Jun-21 @ 15:40	WL (mbTOC): 26.604
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

* after tapped YSI Turbidity dropped rapidly

pump is having a lot of issues pumping at end - would have to crank pump up to maintain pumping rate and then 10-30 seconds later would shoot out water at very high pressure so then could drop pump rate for a bit before having to slowly increase pumping rate to avoid water sputtering -> in end took sample as 3 volumes purged and max. becoming very unpredictable

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 3.37 @ 09:55	Date: 23-Jun-21	Personnel: NG	
Bottom of well (mbTOC): 11.02	Weather: cloudy	Air Temperature (°C): 10	
Well ID: 23B	Stick-up (m ags):	Sampling Method: peristaltic	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:00	3.37	0								
10:05	3.662	1.5	300	3.3	827	0.83	7.59	103.0	3.98	clear
10:10	3.660	3	300	3.5	818	0.59	7.57	101.1	4.24	" "
10:15	3.692	4.5	300	3.6	831	0.55	7.57	100.0	4.69	" "
10:20	3.688	5.5	300	3.9	837	0.44	7.57	98.9	3.99	" "
10:25	3.668	6.5	300	4.4	843	0.45	7.57	98.0	2.48	" "
10:30	3.658	7.5	200	4.6	849	0.43	7.57	97.3	2.08	" "
10:35	3.650	8	100	5.5	853	0.45	7.57	96.4	1.94	" "
10:40	3.788	9.5	300	3.2	856	1.13	7.56	98.6	3.73	" "
10:45	3.899	11	300	3.4	843	0.71	7.56	99.2	9.94	" "
10:50	3.922	12.5	300	3.4	819	0.62	7.59	98.7	7.80	" "
10:53	3.948	14	300	3.4	813	0.64	7.60	98.9	7.60	" "
10:56	3.962	15.5	300	3.3	816	0.67	7.60	99.2	7.63	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:00	3.979	17	300

Datalogger remove time (dd/mm/yr hr:mm): 23-Jun-21 @ 09:50	WL (mbTOC): 3.37
Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 11:05	WL (mbTOC): 3.831
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:	QA/QC Sample (FB, TB, DUP):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

battery died @ 10:35 - switched to generator battery, parameters reset

slight sheen on water surface

17 x 2 x 3 = 10:

1/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 6.41 @ 15:55	Date: 25-Jun-21	Personnel: NG/CM	
Bottom of well (mbTOC): 23.265	Weather: partly cloudy	Air Temperature (°C): 15	
Well ID: 5A-CLIP	Stick-up (m ags): ✓	Sampling Method: submersible	Minimum Purge Volume (L): 102

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
16:10	5.835	0								
16:15	8.463	5	1000	3.4	635	0.48	7.59	109.6	12.09	clear
16:20	9.266	10	1000	3.9	635	0.37	7.60	61.8	18.40	" "
16:25	10.461	15	1000	4.5	640	0.34	7.59	15.8	10.91	" "
16:30	11.164	20	1000	4.8	653	0.31	7.59	-11.2	8.38	" "
16:35	11.840	25	1000	4.4	671	0.29	7.58	-22.3	5.70	" "
16:40	13.182	30	1000	4.6	671	0.28	7.58	-26.2	2.29	" "
16:45	14.243	35	1000	4.7	684	0.28	7.57	-28.2	1.54	" "
16:50	14.571	40	1000	5.1	710	0.27	7.56	-30.2	0.88	" "
16:55	15.272	45	1000	5.3	693	0.35	7.70	-32.7	0.93	" "
17:00	15.906	50	1000	5.4	705	0.34	7.56	-32.8	0.44	" "
17:05	16.621	55	1000	5.3	703	0.38	7.56	-29.6	0.55	" "
17:10	16.668	60	1000	5.6	730	0.27	7.55	-30.8	0.20	" "
17:15	16.668	65	1000	6.1	737	0.23	7.54	-37.3	-0.20	" "
09:50	6.313	65	—							
10:00	8.428	70	1000	3.8	732	0.47	7.48	35.1	1.38	Clear
10:05	9.142	75	1000	3.2	726	0.37	7.51	12.2	-0.80	" "
10:10	10.404	80	1000	4.4	727	0.34	7.50	-3.5	-0.09	" "

25-Jun-21

26-Jun-21

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 25-Jun-21 @ 15:55	WL (mbTOC): 6.41
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

2/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): See sheet 1	Date: 26-Jun-21	Personnel: NG/KM	
Bottom of well (mbTOC): 23.265	Weather: Sunny	Air Temperature (°C): 15	
Well ID: SA-CWP	Stick-up (m ags): —	Sampling Method: Submers	Minimum Purge Volume (L): 102

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:15	10.960	85	1000	4.3	719	0.30	7.51	-12.3	0.01	Clear
10:20	Transducer this									
10:25	13.985	95	1000	4.0	740	0.36	7.49	-19.1	0.00	" "
10:30	14.355	100	1000	4.7	752	0.29	7.49	-21.1	0.00	" "
10:35	14.410	102.5	500	5.2	761	0.28	7.49	-25.6	0.14	" "
10:40	14.400	105	500	5.5	769	0.25	7.48	-30.6	0.28	" "
10:45	14.646	107.5	500	5.9	766	0.25	7.48	-35.0	3.23	" "
10:50	14.674	110	500	5.8	771	0.25	7.48	-36.1	1.85	" "
10:55	14.690	112.5	500	5.8	780	0.23	7.48	-38.9	2.09	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:00	14.690	115	500

Datalogger remove time (dd/mm/yr hr:mm): See sheet 1	WL (mbTOC): " "
Datalogger redeployment time (dd/mm/yr hr:mm): 26-Jun-21 @ 11:10	WL (mbTOC): 14.066
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:	QA/QC Sample (FB, TB, DUP):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 5B CWP	Water Level (mbTOC @ time): 2.782 @ 14:35	Date: 23-Jun-21	Personnel: NG
	Bottom of well (mbTOC): 11.368	Weather: overcast	Air Temperature (°C): 5
	Stick-up (m ags):	Sampling Method: peristaltic	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
14:50	2.782	—								
14:55	3.501	1.5	300	3.0	940	8.64	7.48	131.6	6.22	clear
15:00	3.770	3	300	2.9	1021	7.02	7.31	141.3	8.50	" "
15:05	3.893	4.25	250	3.0	1072	6.16	7.26	145.8	6.34	" "
15:10	3.969	5.5	250	3.1	1102	5.76	7.25	150.3	8.79	" "
15:15	4.007	6.75	250	3.2	1122	5.49	7.25	152.5	11.29	" "
15:20	4.034	8.00	250	3.3	1129	5.33	7.26	154.1	15.17	" "
15:25	4.047	9.25	250	3.2	1133	5.24	7.26	154.9	23.33	" "
15:30	4.054	10.5	250	3.2	1137	5.08	7.26	155.1	25.47	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
15:35	4.054	11.75	250

Datalogger remove time (dd/mm/yr hr:mm): 23-Jun-21 @ 14:35	WL (mbTOC): 2.782	
Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:45	WL (mbTOC):	
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):	
Field Alkalinity:	QA/QC Sample (FB, TB, DUP):	

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

very slight sheen on water - few specks

stick up broken but taped back together

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 68.265	Date: Oct 30/21	Personnel: RD	
Bottom of well (mbTOC): 81.32	Weather: sun, 35 km/hr	Air Temperature (°C): -10	
Stick-up (m ags):	Sampling Method: bailing	Minimum Purge Volume (L):	

Well ID: 1A

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
950	68.19									
1100	*	15		1.5	125.2	12.85	8.06	40.74	37.8	light beer
1130		20		0.4	124.2	11.53	7.67	160.7	30	"
1150		25		0.9	125.5	11.61	7.69	157.3	29.12	"
1210		30		0.7	127.7	11.51	7.72	129.5	46	clear
1230		35		0.7	129.1	11.00	7.71	91.2	35.1	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Oct 31/21 1305	WL (mbTOC):
Oct 31 1300		35		Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

*water level broke, in well

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): ~37	Date: 12-Oct-21	Personnel: NGA/RS	
Bottom of well (mbTOC): —	Weather: windy, overcast	Air Temperature (°C): -5	
Well ID: 1B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 12-Oct-21 11:40	WL (mbTOC): ~37
				Datalogger redeployment time (dd/mm/yr hr:mm): " ~12:00	WL (mbTOC): ~37
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

1m of water on top of logger - so insufficient volume for sampling

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 3.513 @ 09:50	Date: 22-Sep-21	Personnel: NG/BM	
Bottom of well (mbTOC):	Weather: snow	Air Temperature (°C): 0	
Well ID: 3A	Stick-up (m ags): —	Sampling Method: snap / SP	Minimum Purge Volume (L): —

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
snap	10:15	—	0.75	—	1.9	352.0	4.54	7.67	-10.1	9.63	clear, some suspended particle
SP	09:35	3.655	0								
SP Sept-23	09:40	4.46	2.5	500	2.7	349.7	2.62	7.57	183.6	1.46	clear
	9:45	4.552	5	500	2.7	349.6	2.26	7.59	181.7	2.18	"
	9:50	4.665	7.5	500	2.6	349.6	1.99	7.63	37.2	5.80	"
	9:55	4.746	10	500	2.6	350.5	1.21	7.69	-65.4	12.47	"
	10:00	4.814	12.5	500	2.7	350.2	0.95	7.76	-107.1	~~17.78~~ 3.90	"
	10:05	4.834	15	500	2.6	350.3	0.84	7.77	-112.1	6.06	"
	10:10	4.882	17.5	500	2.6	350.4	0.88	7.80	-123.8	8.60	"
	10:15	4.900	20	500	2.6	350.4	0.78	7.82	-121.8	10.02	"
	10:20	4.958	22.5	500	2.7	350.4	0.64	7.84	-138.6	12.99	"
	10:25	4.987	25	500	2.7	350.4	0.57	7.86	-145.9	16.46	"
	10:30	4.990	27.5	500	2.7	350.4	0.54	7.86	-144.3	11.50	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
10:35	4.990	30	500

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 22-Sep-21 09:50

Datalogger redeployment time (dd/mm/yr hr:mm): 23-Sep-21 @ 11:15

Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): 3.513

WL (mbTOC): —

Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst Sonic level read 3.85
pressure stable @ 7 psi 09:55
pump down well @ 10:40 but had to leave for a spill

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Artesian @09:50	Date: 23-Sep-21	Personnel: NG/BM	
Bottom of well (mbTOC):	Weather: Snow	Air Temperature (°C): 0	
Well ID: 3B	Stick-up (m ags): —	Sampling Method: PP	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:50	Artesian	0								
10:55	"	2	400	2.7	331.9	0.44	7.81	-20.3	10.94	Clear
11:00	"	4	400	2.6	331.9	0.32	7.49	-26.9	3.96	"
11:05	"	6	400	2.5	332.5	0.30	7.79	-26.6	5.48	"
11:10	"	8	400	2.3	332.1	0.29	7.80	-26.4	1.58	"
~~11:15~~										
~~11:20~~										
~~11:25~~										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:15	Artesian	10	400

Datalogger remove time (dd/mm/yr hr:mm): 23-Sep-21 @09:50	WL (mbTOC): Artesian		
Datalogger redeployment time (dd/mm/yr hr:mm): " " 11:20	WL (mbTOC): "		
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):		
Field Alkalinity:	QA/QC Sample (FB, TB, DUP):		

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Dry @ 15:40	Date: 14-Aug-21	Personnel: NG	
Bottom of well (mbTOC): 76.92	Weather: cloudy	Air Temperature (°C): 10	
Well ID: SA	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Aug-21 @ 15:25	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:55	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): BN340

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

top of stickup broken (+ 30cm to bottom of well)

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 50.98 @ 15:36	Date: 14-Aug-21	Personnel: NG	
Bottom of well (mbTOC): 51.00	Weather: cloudy	Air Temperature (°C): 10	
Well ID: 5B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Aug-21 @ 15:30	WL (mbTOC): 50.98
				Datalogger redeployment time (dd/mm/yr hr:mm): 14-Aug-21 @ 15:45	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): BN329

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 9.630	Date: 22-Aug-21	Personnel: NG/XP	
Bottom of well (mbTOC): 30.89	Weather: overcast	Air Temperature (°C): 5	
Well ID: 6A	Stick-up (m ags): –	Sampling Method: –	Minimum Purge Volume (L): –

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (mL/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 13.55 @ 13:55	Date: 22-Aug-21	Personnel: NGI / KP	
Bottom of well (mbTOC):	Weather: overcast	Air Temperature (°C): 5	
Well ID: GB	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap tripped at 10:40 am
Max + stable pressure = 69 psi
Snap sampler not redeployed

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 18.600 @ 11:55	Date: Oct 17, 2021	Personnel: BM/LF	
Bottom of well (mbTOC): 90.70	Weather: Sunny	Air Temperature (°C): -9	
Well ID: 8A	Stick-up (m ags):	Sampling Method: Submersible	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:35	18.66	10	500	1.3	142.6	4.91	8.10	198.5	44.83	Clear
12:40	18.685	15	"	1.3	205.7	4.59	8.15	187.5	52.30	"
12:45	18.71	20	"	1.6	204.7	4.75	8.18	162.0	34.26	"
13:05	18.715	25	"	1.8	204.4	4.66	8.20	148.6	48.72	Slightly grey
13:15	18.725	30	"	2.0	204.3	4.73	8.21	142.2	6.30	Clear
13:20	18.730	32.5	"	2.0	204.0	4.76	8.21	138.5	2.39	"
13:25	18.740	35	"	2.1	203.8	4.73	8.21	132.7	1.54	Clear
13:30	18.745	37.5	"	2.1	204.0	4.70	8.21	129.7	1.10	Clear
13:35										
Snap										
10:40				-0.2	150.1	10.45	8.09	247.0	254.02?	

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 17/10/21 10:40	WL (mbTOC):
13:30	18.745	37.5	500	Datalogger redeployment time (dd/mm/yr hr:mm): 17/10/21 16:15 *	WL (mbTOC): 18.62
Field Alkalinity: /		QA/QC Sample (FB, TB, DUP): /		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

* Data logger redeployed to approx 1m above bottom of well

NTU for snap is likely wrong due to probe being too far in-effect from bottom

Snap @ 11:20
Max psi = 58
Stable @ 37 psi
Snap sampler not redeployed

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 27.823@11:58	Date: Oct 17	Personnel: BM/LF	
Bottom of well (mbTOC): 51.373	Weather: Sunny	Air Temperature (°C): -9	
Well ID: 8B	Stick-up (m ags):	Sampling Method: Submersible	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
14:45	28.355	4	400	1.2	210.2	5.30	8.16	210.1	43.80	Clear
14:55	28.325	8	400	1.4	208.5	5.04	8.17	180.0	24.96	"
15:05	28.38	12	400	2.0	208.7	4.91	8.18	143.4	14.65	"
15:15	28.41	16	400	2.7	206.1	4.81	8.18	129.5	7.23	"
15:20	28.48	18	400	3.0	207.4	4.81	8.18	129.1	7.45	"
15:25	28.50	20	400	3.0	206.5	4.89	8.18	129.1	3.53	"
15:30	28.53	22	400	3.3	208.9	4.82	8.18	130.7	3.81	"
15:35	28.555	24	400	3.4	207.6	4.76	8.18	132.6	5.15	"
Snap										
11:20				-0.2	150.7	12.97	8.59	247.3	5207	

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
15:35	28.555	24	400
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):	

Datalogger remove time (dd/mm/yr hr:mm): 17/10/21 11:20
Datalogger redeployment time (dd/mm/yr hr:mm): 17/10/21 16:00 *
Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC):
WL (mbTOC): 27.89
Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

*Data logger redeployed to approx 1m above bottom of well

NTU for snap is likely wrong from probe being in wrong location (too far in) effect from bottom

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 77.502 @ 10:40	Date: 17-Sep-21	Personnel: NG/CM	
Bottom of well (mbTOC): 79.900	Weather: snow	Air Temperature (°C): -5	
Well ID: 9A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 17-Sep-21 @ 10:40	WL (mbTOC): 77.502
				Datalogger redeployment time (dd/mm/yr hr:mm): 17-Sep-21 @ 11:00	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst level sound 73.32? for WL - off

~~9A 10:40 laser out 77.502 mbTOC WL 73.32 for solinst~~
~~79.900 mbTOC~~ dupm

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 9B	Water Level (mbTOC @ time): 36.612	Date: 17-Sep-21	Personnel: NGM/CM
	Bottom of well (mbTOC): 46.50	Weather: snowy	Air Temperature (°C): -5
	Stick-up (m ags):	Sampling Method: Bailer	Minimum Purge Volume (L): 60

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:15	36.612	10		1.4	231.2	7.12	8.02	204.8	41.99	cloudy
11:30		20		1.5	233.1	6.82	8.12	135.3	84.00	"
11:55	36.805	30		1.6	231.3	8.22	8.14	130.3	71.28	"
12:11		40		1.5	231.7	7.68	7.98	144	75.74	" "
12:31	36.972	50		1.5	231.7	8.19	8.08	145.3	69.57	"
12:38		55		1.4	231.4	8.45	8.05	128.8	60.85	"
12:42	36.865	60		1.5	231.5	8.66	8.00	127.2	66.52	" "
		-								

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 17-Sep-21 @ 10:40	WL (mbTOC): 36.612
12:45	36.865	61		Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 12:55	WL (mbTOC): 36.865
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst ~~36.48~~

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 17.56 1030	Date: Oct 11/21	Personnel: RS/NG/LF	
Bottom of well (mbTOC):	Weather: Sun	Air Temperature (°C): -4	
Well ID: 11A ~~17A~~	Stick-up (m ags):	Sampling Method: bailer	Minimum Purge Volume (L):

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11-oct	1045	21.27	10		2.6	219.6	10.65	10.70	194.2	53.77	clear
	1056	24.49	18		2.1	226.5	9.55	10.01	148.0	29.88	"
14-oct	14:25	18.76	18 (0)		~~2.8~~	~~150.7~~	~~11.09~~	~~9.70~~	~~193.6~~	~~16.88~~	~~" "~~
		22.46	28 (10)		2.8	150.7	11.09	9.70	193.6	16.88	" "
	14:50	27.25	33 (15)		2.6	145.8	10.78	9.79	181.4	16.20	"
oct15	15:55	18.82	33 (0)		—	—	—	—	—	—	—
	16:09	22.78	43 (10)		2.9	146.3	9.99	9.26	210.1	7.16	clear
	16:10	24.50	48 (5)		2.3	152.0	11.45	9.07	212.9	10.22	"
oct16	13:30	18.84	48 (0)		—	—	—	—	—	—	—
	13:37	21.23	53 (5)		3.6	161.8	11.20	8.92	191.2	3.06	clear
	13:45	23.63	58 (5)		2.5	156.5	10.75	8.91	135.9	0.92	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Oct 11/21 1030	WL (mbTOC): 17.56
13:45	23.63	58		Datalogger redeployment time (dd/mm/yr hr:mm): Oct 16/21 13:48	WL (mbTOC): 23.78
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 11B	Water Level (mbTOC @ time): dry	Date: oct 11/21	Personnel: NG/RS
	Bottom of well (mbTOC): —	Weather: Sun	Air Temperature (°C): -4
	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): oct 11/21 1035	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): " 1045	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): DRY @11:10	Date: 14-Aug-21	Personnel: NG/RS	
Bottom of well (mbTOC): 96.194	Weather: Sunny	Air Temperature (°C): 10	
Well ID: 12A	Stick-up (m ags):	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Aug-21 @11:20	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @11:40	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 53.235 @ 11:20	Date: 14-Aug-21	Personnel: NG/RS	
Bottom of well (mbTOC): 53.39	Weather: sunny	Air Temperature (°C): 10	
Well ID: 12B	Stick-up (m ags):	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Aug-21 @ 11:20	WL (mbTOC): 53.235
				Datalogger redeployment time (dd/mm/yr hr:mm): " " 11:35	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Artesian	Date: 14-Sep-21	Personnel: NG/RS	
Bottom of well (mbTOC): —	Weather: overcast	Air Temperature (°C): 2	
Well ID: 13A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Sep-21 @10:55	WL (mbTOC): Artesian
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 10:40	WL (mbTOC): "
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Artesian	Date: 14-Sep-21	Personnel: NGI/RS	
Bottom of well (mbTOC): —	Weather: Overcast	Air Temperature (°C): 2	
Well ID: 13B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Sep-21 @ 10:35	WL (mbTOC): Artesian
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 10:40	WL (mbTOC): " "
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

I labelled as 14 on logger

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Artesian	Date: 14-Sep-21	Personnel: NG/RS	
Bottom of well (mbTOC): 31.158	Weather: overcast	Air Temperature (°C): 2	
Well ID: 14A	Stick-up (m ags):	Sampling Method: PP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:00	0									
11:15	0.78	1.5	~~5~~ 300	2.5	273.1	0.91	8.16	-20.6	3.02	Clear
11:20	1.09	2.0	100	2.6	273.7	0.50	8.19	-71.6	3.00	"
11:25	1.45	2.5	100	2.7	273.6	0.45	8.19	-95.1	3.48	"
11:30	1.686	3.0	100	2.6	273.6	0.40	8.19	-101.3	3.20	"
11:35	1.86	3.5	100	2.5	273.3	0.39	8.19	-96.0	3.42	"
11:38	1.999	4.0	100	2.5	273.3	0.37	8.19	-100.8	3.59	"
11:41	2.167	4.5	100	2.4	273.4	0.37	8.20	-104.8	3.59	"
11:44	2.265	5.0	100	2.4	273.3	0.36	8.20	-101.7	4.19	"
11:47	2.390	5.5	100	2.4	273.4	0.36	8.20	-100.2	4.98	"
11:50	2.508	6.0	100	2.4	273.4	0.35	8.20	-100.7	6.09	"
~~11:53~~		~~6.5~~	~~100~~							

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Sep-21 @ 10:40	WL (mbTOC): Artesian
11:50	2.508	6.0	100	Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 12:05	WL (mbTOC): 3.055
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 2.210	Date: 14-Sep-21	Personnel: NG/RS	
Bottom of well (mbTOC): 5.270	Weather: overcast	Air Temperature (°C): 2	
Well ID: 14B	Stick-up (m ags):	Sampling Method: PP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:20	1.005									
10:25	1.010	2.5	500	2.1	233.8	0.47	7.87	-103.0	4.67	clear
10:30	1.015	5.0	500	2.1	234.1	0.41	7.92	-128.7	3.39	"
10:35	1.013	7.5	500	2.1	234.0	0.37	7.96	-137.5	2.83	"
10:40	1.013	10	500	2.1	234.1	0.34	7.99	-142.9	2.74	"
10:45	1.015	12.5	500	2.1	234.1	0.34	8.01	-147.9	3.13	"
10:50	1.015	15.0	500	2.1	234.1	0.34	8.03	-150.6	3.32	"
10:55										
11:00										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Sep-21 @10:05	WL (mbTOC): 2.210 → lose to 1.005
1055	1.015	15.0	500	Datalogger redeployment time (dd/mm/yr hr:mm): " " @11:40	WL (mbTOC): 1.015
Field Alkalinity:		QA/QC Sample (FB, TB, DUP): 1100		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

after logger pulled WL lose to 1.005

Casing is secure but

1/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 85.184	Date: 08-Oct-21	Personnel: NG/RS	
Bottom of well (mbTOC): 147.970	Weather: Overcast, light snow	Air Temperature (°C): -5	
Well ID: 17A	Stick-up (m ags): —	Sampling Method: Bennett	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
13:00	—	0								
13:08		20								
13:25		40								
13:37		60		4.4	548	1.04	11.44	67.8	34.79	Clear
13:45		70		3.8	703	0.83	10.94	26.4	23.36	"
13:52		80		3.7	642	0.72	10.40	~~[illegible]~~ 8.7	21.39	"
14:02		90		3.6	602	0.63	9.73	-56.5	17.25	"
14:08		100		3.5	596	0.59	9.51	-77.5	14.66	"
14:13		113		3.4	~~695~~ 583	~~1.09~~ 0.57	~~4.0~~ 9.40	-107.4	18.16	"
14:19		120		3.4	585	0.59	9.17	-105.5	9.95	"
14:35		125		3.3	590	0.51	9.06	-111.5	11.ok	"
14:40		135		3.3	593	0.47	9.09	-128.1	6.77	"
14:45		140		3.2	590	0.46	9.01	-134.8	5.48	"
14:55		150		3.2	589	0.50	9.08	-144.1	7.46	"
15:00		160		3.2	592	0.47	8.90	-145.9	5.44	"
15:06		170		3.3	592	0.46	8.75	-145.1	4.02	"
15:10		185		3.3	593	0.46	8.64	-141.6	5.60	"
15:15		188		3.3	594	0.44	8.55	-145.5	4.65	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11:45 oct 8, 2021	WL (mbTOC): 85.184
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst Sonic WL @ 85.07 mbTOC

Gas tripped @ 11:35 -> stable @ 72psi but did not trip for some reason?

Bennett had very hard time going down @ bottom of well -> tape jam? likely not completely @ bottom

2/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 85.184	Date: 08-Oct-21	Personnel: NG/RS	
Bottom of well (mbTOC): 147.990	Weather: overcast, light snow	Air Temperature (°C): -5	
Well ID: 17A	Stick-up (m ags):	Sampling Method: Bennett	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
15:20		200		3.3	596	0.44	8.62	-158.1	6.25	Clear
15:25		205		3.4	595	0.45	8.58	-162.3	6.85	"
15:30		207		3.4	594	0.42	8.54	-168.2	5.81	"
15:35										
15:40										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 08-Oct-21 @ 11:45	WL (mbTOC): 85.184
15:35		210		Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

weirdly clear water
88.0 mbTOC after sampled

1/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 173	Water Level (mbTOC @ time): 42.82 14:25	Date: Sep 1/21	Personnel: 88 BM
	Bottom of well (mbTOC): 76.54	Weather: light snow	Air Temperature (°C): 3
	Stick-up (m ags):	Sampling Method: submersible	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
snap 1430				5.4	633	3.32	7.90	112.8	21.42	clear
1520	42.46									
start 1545	start									dark gray
1552	48.055	1.0 L		2.6	654	5.76	8.07	-83.7	678	"
1600	50.82	20		3.7	652	5.02	8.24	-114.0	778	"
1605	53.97	30		6.0	647	4.28	8.59	-153.7	329.0	"
1610	56.59	40		6.0	645	3.07	8.69	-167.8	852	"
1615	60.61	60		6.3	645	3.00	9.11	-194.9	562.8	"
1425	65.24	80		7.2	652	2.90	9.60	-191.6	576.4	"
1435	70.51	100		8.6	653	2.47	9.63	-195.8	398.6	"
Sep 15 08:20	45.00	~~40~~								
08:25	51.68	110	2000	2.6	619	0.65	8.41	-148.3	499.11	dark gray
8:32	53.05	120	~2000	3.8	618	0.53	8.58	-200.0	260.66	" gray
8:38	55.42	130		5.7	622	0.56	8.66	-227.1	249.44	"
8:47	56.75	140		5.7	627	0.58	8.71	-235.5	109.91	"
8:58	58.45	150		6.5	630	0.50	8.75	-249.2	226.78	grey
9:05	59.84	160		7.0	635	0.48	8.73	-256.3	211.81	grey
9:15	61.51	170		7.8	629	0.50	8.78	-251.6	164.82	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Snap @ ~~52~~ psi, settled to 52
64 14:30

2/2

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): See Sheet 1	Date: 15-Sep-21	Personnel: NG/RS	
Bottom of well (mbTOC): See sheet 1	Weather:	Air Temperature (°C):	
Well ID: 17B	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
07:20	63.21	180		8.5	631	0.50	8.83	-253.4	134.72	"
09:30	65.04	190		8.6	624	0.65	8.96	-240.8	232.76	grey
09:35	67.06	200		9.1	625	0.72	8.97	-239.6	265.42	"
09:40	68.32	210		9.6	626	0.85	9.00	-232.5	226.39	"
09:46	70.05	220		9.4	631	0.83	8.96	-238.2	506.1	"
15:15	47.50	—	—							
15:25	51.33	225		2.5	622	2.26	8.46	-135.1	82590	dark grey
15:30	51.602	225		2.6	623	1.78	8.44	-167.4	607.5	"
15:35	51.82	227.5		2.7	622	1.70	8.42	-175.4	487.4	"
15:40	52.435	230		2.6	623	1.30	8.38	-188.2	337.82	"
15:45	52.75	232.5		2.7	622	1.20	8.36	-188.1	332.9	"
15:50	53.02	235		3.2	623	1.15	8.36	-189.8	283.4	"
15:55	53.15	237.5		3.5	622	1.08	8.37	-191.8	316.06	"
16:00	53.78	240		4.3	622	1.40	8.35	-180.1	319.07	"
16:05	54.21	242.5		4.6	622	0.81	8.35	-197.7	360.1	"
16:15	55.11	245		5.9	622	0.43	8.33	-198.6	186.4	grey
16:20	56.65	250		6.4	620	0.71	8.38	-209.6	160.5	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
16:25	56.65	250		Datalogger redeployment time (dd/mm/yr hr:mm): 15-Sep-21 @ 16:00	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Sulfur Smut

Solinst @ 39.15

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 39.15	Date: 11-sep-21	Personnel: NG/RS	
Bottom of well (mbTOC): —	Weather: Rain	Air Temperature (°C): 5	
Well ID: 189	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-sep-21 @ 15:25	WL (mbTOC): 39.15
				Datalogger redeployment time (dd/mm/yr hr:mm): 11-sep-21	WL (mbTOC): 39.12
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

~1.5m of line never went down well for data logger

Solinist 29.23m

NA 40.27m

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 28.905 @14:15	Date: 11-Sep-21	Personnel: S	
Bottom of well (mbTOC): 65.74	Weather: Rain	Air Temperature (°C): N/A/RS	
Well ID: 18B	Stick-up (m ags): —	Sampling Method: Snap / SP	Minimum Purge Volume (L): —

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
snap	14:50	28.905	0.75	—	6.3	387.4	3.35	9.29	194.5	47.06	light grey
SP	15:15	28.835	—	—							
	15:20	29.20	~~1000~~ 5	1000	2.7	411.4	0.64	9.11	63.3	610.54	grey
	15:25	29.24	10	1000	2.9	419.1	0.58	8.69	12.3	384.86	dark grey
	15:30	29.275	15	1000	3.2	432.0	0.53	8.41	-45.3	227.15	" "
	15:35	29.28	20	1000	3.8	450.1	0.48	8.26	-67.3	177.10	light grey
	15:40	29.31	25	1000	4.0	464.0	0.45	8.15	-76.2	89.76	" "
	15:45	29.33	30	1000	4.2	477.4	0.41	8.09	-80.0	60.58	" "
	15:50	29.36	35	1000	4.3	486.2	0.37	8.05	-82.8	67.46	" "
	15:55	29.37	40	1000	4.4	494.0	0.36	8.02	-84.2	53.66	clear/light grey
	16:00	29.37	45	1000	4.4	497.8	0.34	8.02	-85.6	31.39	clear
	16:05	29.395	50	1000	4.4	502	0.31	8.01	-89.4	35.08	"
	16:10	29.39	55	1000	4.5	506	0.30	8.00	-94.2	33.16	"
	16:15										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-Sep-21 @14:35	WL (mbTOC): 28.905
16:15	29.39	55	1000	Datalogger redeployment time (dd/mm/yr hr:mm): 11-Sep-21 @ 16:35	WL (mbTOC): 28.63
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): PU 679

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

tripped @14:20 up to 70psi & stalle WL @ 28.91 mbTOC after snap out
28.63 WL after snap reinstall @ 16:35

184.218

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 183.65 @ 11:45	Date: 18-Aug-21	Personnel: NCM/RS	
Bottom of well (mbTOC): ~~[illegible]~~ 196.34	Weather: rain/fog	Air Temperature (°C): 5	
Well ID: 19A	Stick-up (m ags): – 196.9[illegible]	Sampling Method: –	Minimum Purge Volume (L): –

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (mL/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 18-Aug-21 @ 11:45	WL (mbTOC): 183.65 → 184.218
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): BM581

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 147.743 @10:00	Date: 18-Aug-21	Personnel: NG/RS	
Bottom of well (mbTOC):	Weather: rain/fog	Air Temperature (°C): 5	
Well ID: 19B	Stick-up (m ags): —	Sampling Method: Snap, Bennett	Minimum Purge Volume (L): 180 if not low flow

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:05		0								
11:20		20								
11:45		40								grey
12:00		60		6	396.5	2.8	8.39	145.7	128.7	light grey
12:21		70		5.4	400.2	4.10	8.63	142.4	48.5	"
12:26		80		5.0	409.5	2.33	8.41	143.0	82.11	"
12:30		85		4.8	408.7	1.94	8.36	146.8	36.59	"
12:35		90		4.7	406.7	1.95	8.38	149.0	78.41	"
12:40		95		4.6	405.0	2.00	8.40	147.1	72.1	"
12:45		100		4.5	408.2	1.97	8.42	145.8	96.3	"
12:50		105		4.6	401.6	3.00	8.66	141.4	36.6	"
12:55		110		4.7	408.2	3.08	8.67	137.7	46.6	"
13:00		115		4.7	416.4	2.71	8.59	139.6	35.6	"
13:05		120		4.8	423.0	2.11	8.45	141.4	32.43	"
13:10		125		4.9	426.3	1.72	8.36	143.7	32.3	"
13:15		130		4.9	422.3	1.38	8.29	145.6	27.56	clear
13:20		135		5.0	419.0	1.37	8.30	146.0	34.42	"
13:25		140		5.1	418.2	1.15	8.24	148.1	23.80	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 18-Aug-21 @ 10:20	WL (mbTOC): 147.743
13:35		150		Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC): 153.718 @13:35
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): BJ387

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

10:10 snap pressurized to 34psi, no light - likely a hole in the line?

1330		145							
1335	153.718	150		5.0	417.3	1.15	8.24	149.1	24.19	"
				5.0	417.3	1.20	8.27	149.0	19.18	"

installed data logger on string due to snap not being redeployed

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 58.485 @15:05	Date: 14-Aug-21	Personnel: NG	
Bottom of well (mbTOC): 165.98	Weather: Sunny	Air Temperature (°C): 10	
Well ID: 20A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Aug-21 @ 14:58	WL (mbTOC): 58.485
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:25	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Over pressured -> raised logger 15m

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 56.64@14:30	Date: 14-Aug-21	Personnel: NG	
Bottom of well (mbTOC): 118.226	Weather: Sunny	Air Temperature (°C): 10	
Well ID: 20B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Aug-21@14:20	WL (mbTOC): 56.64
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @14:40	WL (mbTOC):
				Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): BM577
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):			

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

logger covered in fine white/grey Clay/bentonite - slimy

192.526

195.716

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 191.492	Date: 19-Aug-21	Personnel: NG/CM	
Bottom of well (mbTOC): 194.680	Weather: overcast	Air Temperature (°C): 10	
Well ID: TC 21A	Stick-up (m ags): ~~[illegible]~~	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 19-Aug-21 @ 15:10	WL (mbTOC): 192.526
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:48	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN): BU683

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

tip of logger fell off - taped up and set down, change for next time

152.904

160.880

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 152.900 @15:10	Date: 19-Aug-21	Personnel: NG/CM	
Bottom of well (mbTOC): 159.876	Weather: Overcast	Air Temperature (°C): 10	
Well ID: 21B	Stick-up (m ags):	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 19-Aug-21 @15:10	WL (mbTOC): 152.704
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 15:45	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 125.514	Date: 14-Sep-21	Personnel: NG/CM	
Bottom of well (mbTOC): –	Weather: Overcast	Air Temperature (°C): 5	
Well ID: 22A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Sep-21 @ 15:40	WL (mbTOC): 125.514
				Datalogger redeployment time (dd/mm/yr hr:mm): " "	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Sonic Solinst level read 124.81 mbTOC

matched logger depth to past reading when installed direct read cable → should be @ 155.32 mbTOC

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): ~~14-Sep-21~~ 80.635 @15:30	Date: 14-Sep-21	Personnel: NG/CM	
Bottom of well (mbTOC): 89.82	Weather: overcast	Air Temperature (°C): 5	
Well ID: 22B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst sonic level read 80.02 mbTOC

direct read cable installed to a depth of 87.40 mbTOC

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 3.160 @ 14:45	Date: 11-Oct-21	Personnel: NG/RS	
Bottom of well (mbTOC): 29.740	Weather: overcast	Air Temperature (°C): -5	
Well ID: 23A	Stick-up (m ags):	Sampling Method: SP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
14:55	2.890	0								
15:05	7.070	7	1000	3.0	1252	0.49	7.68	164.6	22.40	Clear
15:10	10.456	12	1000	3.4	1250	0.44	7.66	148.9	24.88	"
15:15	14.175	17	1000	3.7	1247	0.41	7.66	136.4	13.69	"
15:20	15.064	19.5	500	3.6	1245	0.42	7.67	128.1	8.22	"
15:25	16.530	24.5	1000	5.0	1221	0.39	7.73	103.7	9.04	"
15:30	18.97	29.5	1000	4.9	1225	0.48	7.69	96.5	21.68	"
15:35	18.900	32	500	4.3	1222	0.55	7.67	97.8	6.22	"
15:40	19.774	34.5	500	4.7	1201	0.47	7.74	74.7	8.70	"
15:45	20.880	37.0	500	6.0	1220	0.52	7.71	36.5	131.70	grey
15:50	21.34	39.5	500	6.1	1224	0.57	7.66	39.1	94.86	"
15:55	21.45	42.0	500	5.5	1209	0.56	7.66	42.1	73.44	"
16:00	22.17	44.5	500	4.9	1237	0.62	7.67	40.0	27.38	grey
16:05	22.435	47	500	8.1	1214	0.56	7.69	26.5	23.54	light beige
16:10	22.610	49.5	500	8.0	1202	0.46	7.70	19.7	26.50	"
16:15	22.680	52.0	500	8.0	1214	0.50	7.70	25.6	45.19	"
16:16	22.690	54.5	500	6.5	1214	0.52	7.67	27.8	26.05	"
16:19	22.670	57.0	500	6.0	1214	0.52	7.68	29.1	35.05	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
16:25	22.67	57	500

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 11-Oct-21 @ 14:45	WL (mbTOC): 3.160		
Datalogger redeployment time (dd/mm/yr hr:mm): " @ 16:30	WL (mbTOC): -		
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):		

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst sonic WL @ 3.74 mbTOC

Issues w flow rate dropping off -> sometimes plugging pump -> moved pump up a meter or so to see if that helped

↳ every so often shoots out as unplugs or clears momentarily

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 3.202 @ 10:25	Date: 07-Oct-21	Personnel: NGn/RS	
Bottom of well (mbTOC): 11.020	Weather: partly cloudy	Air Temperature (°C): -2	
Well ID: 23B	Stick-up (m ags):	Sampling Method: PP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:35	3.202	0								
10:40	3.41	1.25	250	3.6	755	1.03	7.49	226.8	6.68	Clear
10:45	3.51	2.5	250	3.4	761	0.80	7.44	220.3	11.79	"
10:50	3.56	3.75	250	3.4	762	0.57	7.44	212.3	10.03	"
10:55	3.61	5.0	250	3.5	764	0.46	7.44	198.7	9.08	"
11:00	3.65	6.25	250	3.4	765	0.40	7.45	186.5	6.54	"
11:05	3.68	7.5	250	3.3	767	0.37	7.45	178.0	5.72	"
11:10	3.703	8.75	250	3.4	767	0.37	7.45	173.1	5.17	"
11:15	3.725	10.0	250	3.4	767	0.36	7.45	168.6	4.12	"
~~11:20~~		~~11.25~~	~~250~~							

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 07-Oct-21 @ 10:25	WL (mbTOC): 3.202
11:20	3.725	11.25	250	Datalogger redeployment time (dd/mm/yr hr:mm): " @ 11:20	WL (mbTOC): 3.750
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

3.10 LL for S.limit SMIL

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 5.940 @ 10:05	Date: 10-Oct-21	Personnel: NG/RS	
Bottom of well (mbTOC):	Weather: ~~Sunny~~ cloudy	Air Temperature (°C): -4	
Well ID: SA CWP	Stick-up (m ags):	Sampling Method: SP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:20	5.94		500							
10:25	7.104	2.5	500	1.9	707	0.89	7.55	14.5	3.52	clear
10:30	7.460	5.0	500	2.5	703	0.54	7.56	-20.7	3.81	"
10:35	7.910	7.5	500	2.9	703	0.45	7.57	-45.7	3.95	"
10:40	9.430	12.5	1000	4.0	703	0.38	7.59	-65.6	5.63	"
10:45	10.490	17.5	1000	3.8	721	0.35	7.59	-75.0	4.38	"
10:50	11.56	22.5	1000	4.0	755	0.33	7.59	-76.3	2.15	"
10:55	12.52	27.5	1000	4.1	770	0.32	7.58	-74.6	1.83	"
11:00	12.49	30	500	3.8	768	0.33	7.59	-71.8	1.68	"
11:05	12.47	32.5	500	3.9	829	0.29	7.57	-73.0	1.11	"
11:10	12.525	35	500	4.3	840	0.29	7.57	-74.8	0.91	"
11:15	12.540	37.5	500	4.3	842	0.29	7.57	-74.3	0.78	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 10-Oct-21 @ 09:40	WL (mbTOC): 5.940
11:20	12.540	40	500	Datalogger redeployment time (dd/mm/yr hr:mm): @ 11:30	WL (mbTOC): 12.580
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 2.430 @ 9:05	Date: 10-Oct-21	Personnel: NG/RS	
Bottom of well (mbTOC): 11.300	Weather: cloudy, light snow	Air Temperature (°C): -4	
Well ID: SB CWP	Stick-up (m ags):	Sampling Method: PP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
09:10	2.43	0	250							
920	3.172	1.25		2.9	896	6.63	7.32	225.4	10.19	clear
925	3.415	2.5		2.9	868	6.61	7.32	217.9	5.97	
930	3.56	3.75		2.9	853	6.55	7.34	215.2	6.31	"
935	3.64	5.00		2.8	853	6.46	7.35	213.6	6.05	"
940	3.70	6.25		2.8	844	6.40	7.35	213.2	5.59	"
945	3.76	7.50		2.8	836	6.29	7.36	212.2	5.77	
950	3.74	8.00		2.7	823	6.21	7.37	211.2	4.48	"
955	3.67	9.00		2.7	822	6.22	7.36	210.0	4.66	"
10:00	3.635	10.00		2.7	820	6.23	7.30	209.1	4.77	"
10:05	3.68	11.00		2.7	818	6.20	7.38	209.5	6.32	"
	3.63									

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 10-Oct-21 @9:05	WL (mbTOC): 2.430
10:10	3.63	11		Datalogger redeployment time (dd/mm/yr hr:mm): " @10:15	WL (mbTOC): 3.630
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Solinst Sonic WL @2.87 mbTOC

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 74.16 @10:20	Date: Jun 26/22	Personnel: RS/EU	
Bottom of well (mbTOC): 80.4	Weather: cloudy	Air Temperature (°C): -10	
Well ID: 1A	Stick-up (m ags):	Sampling Method: Somersible	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
1100	74.8			-0.1	291.4	1.1	8.28	118.2	271.1	Brown
1103	74.7			0.5	291.3	1.39	8.14	112.6	213.3	"
1110	74.66			0.9	287.8	1.26	8.05	108	177	"
1115	74.64			1.1	287.6	1.22	8.01	108.2	172.03	"
1120	74.64	10		1.6	286.4	1.15	8.01	90.2	345.5	"
1125	74.63									
1130	74.65			3.7	283.0	1.07	8.01	76.9	1350	"
1135	74.71	20		7.3	270.5	1.03	8.03	65.9	481	"
1140	74.75			8.9	273.7	1.05	8.03	57.6	289	"
1145	74.76			9.8	269.3	1.11	8.02	56.2	254	"
1150	74.76			9.4	262.5	1.16	8.02	56.8	234	"
1155	74.78			9.9	265.7	1.15	8.00	57.3	248	
1200	74.78	40		10.6	265.2	1.17	8.01	60.9	118	"
12:05	74.79			10.02	264.8	1.17	8.01	63.9	100	"
12:10	74.79			10.01	265.5	1.13	8.01	66.5	78	Clearing up.
12:15	74.79			9.9	266.6	1.16	8.02	67.9	74	"
12:20	74.78			9.6	267.1	1.10	8.03	69.7	75	
12:25	74.78	60		9.3	268.1	1.06	8.03	70.3	49	Clear now

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 26/1/22 @ 10:05	WL (mbTOC): 74.16
12:30	74.78	60	~~250~~ 500	Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:30	WL (mbTOC): 74.15
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

note: stick up broken

1 min 155/round

1:30 = 12

Groundwater Sampling Field Form v3 BDT 2020

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): — 12:40	Date: 26/1/22	Personnel: RS/U.U	
Bottom of well (mbTOC): 35.23	Weather:	Air Temperature (°C): – 10	
Well ID: 17A 1B	Stick-up (m ags):	Sampling Method: DATA logger record	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:40	74.1	–	–	–10	–	–	–	–	–	–

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Dec. 4, 2021

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 11.20 @ 15:25	Date: ~~11/26/21~~	Personnel: ~~BDT/RS~~ NG/KE	
Bottom of well (mbTOC): ~~88~~	Weather: ~~Snow~~ clear	Air Temperature (°C): -25	
Well ID: BJ-GW11-3A	Stick-up (m ags):	Sampling Method: SP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
15:25	11.20	0	—							
15:30	12.305	2.0	400	0.5	355.7	0.38	7.75	-182.7	5.44	clear sulphur smell
15:35	12.46	4.0	400	0.3	355.7	0.18	7.73	-188.9	5.17	clear
15:40	12.535	6.0	400	0.2	355.8	0.09	7.74	-205.4	5.44	Clear
15:45	12.58	8.0	410	0.1	357.2	0.04	7.75	-218.9	5.44	Clear
15:50			400	0						
15:55	12.59	12.0	400	0.1	360.2	0.06	7.73	-220.7	7.52	
16:00	13.00	14.5	500	1.3	357.1	0.55	7.88	-175.1	8.20	higher flow decreased 21 g
16:05	13.215	17.0	500	1.3	357.8	-0.02	7.89	-214.6	6.46	
16:10	13.35	19.5	500	1.5	360.3	-0.05	7.92	-217.4	5.35	clear
16:15	13.40	21.5	400	1.2	365.0	-0.08	7.98	-217.2	5.10	clear, sulfur smell
16:20	13.45	23.5	400	1.3	364.7	-0.0	7.99	-216.8	5.14	
16:25	13.46	25.5	400	1.2	365.3	-0.12	7.99	-218.7	5.79	Clear

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 4-Dec-21 @ 15:20	WL (mbTOC): 11.20
16:30	13.48			Datalogger redeployment time (dd/mm/yr hr:mm): " @ 16:45	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): —	Date: ~~11/26/21~~ 4-Dec-21	Personnel: ~~BDT/RS~~ NCI/KE	
Bottom of well (mbTOC): ~~10~~	Weather: ~~snow~~ clear	Air Temperature (°C): -25	
Well ID: BJ-GW11-3B	Stick-up (m ags):	Sampling Method: PP?	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

well frozen to surface → likely was still flowing artesian when snow hit and froze up quickly before it could experience drop in WL → due to fast onset of winter

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Dry	Date: 6-Nov-21	Personnel: NG/RS&CM	
Bottom of well (mbTOC): —	Weather: Sunny periods	Air Temperature (°C): -5	
Well ID: SA	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 6-Nov-21 @ 13:05	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): 11 @ 13:15	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

replace line = 2nd red

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Dry	Date: 6-Nov-21	Personnel: NG/RS/CM	
Bottom of well (mbTOC): —	Weather: Sunny periods	Air Temperature (°C): -5	
Well ID: 5B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 6-Nov-21 12:50	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): 6/12:55	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

installed direct read cable

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 6A	Water Level (mbTOC @ time): —	Date: Jan 18, 2022	Personnel: LF/XP
	Bottom of well (mbTOC): —	Weather: windy/snowy	Air Temperature (°C): -10
	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Jan 18, 2022 @ 12:00	WL (mbTOC): —
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:15	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Water level not taken & field notes not recorded, data downloaded around noon

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: GB	Water Level (mbTOC @ time): —	Date: Jan 18, 2022	Personnel: LF/XP
	Bottom of well (mbTOC): —	Weather: windy/snowy	Air Temperature (°C): -10
	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 18-Jan-22 @ 12:10	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:25	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Water level not taken & field notes not recorded, data downloaded around 12:15

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 5A	Water Level (mbTOC @ time): 34.485	Date: 27-Jan-21	Personnel: NG/KV
	Bottom of well (mbTOC): 38.920	Weather: Partly Cloudy	Air Temperature (°C): -5
	Stick-up (m ags): —	Sampling Method: SP	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:25	34.485	0								
10:30	34.560	1.25	250	1.0	209.0	4.97	8.19	164.6	7.74	clear
10:35	34.540	2.5	~~250~~	0.6	209.0	4.44	7.95	172.6	7.44	"
10:40	34.535	3.75	250	0.6	208.9	4.25	7.95	173.3	7.75	"
10:45	34.565	5.0	250	1.5	209.5	3.52	7.99	173.3	22.80	"
10:50	34.575	7.25	250	1.5	211.8	2.63	8.07	169.0	63.45	light yellow
10:55	34.580	~~8.50~~ 9.75	~~250~~ 500	1.5	212.6	2.36	8.10	147.3	67.44	"
11:00	34.585	11.25	500	1.6	211.9	2.25	8.13	141.5	57.77	"
11:05	34.575	13.75	500	1.5	211.6	2.23	8.14	134.6	47.15	"
11:10	34.575	16.25	500	1.6	211.4	2.19	8.15	128.3	46.25	"
11:15	34.575	18.75	500	1.5	211.5	2.16	8.15	124.7	46.33	"
11:20										
11:25										
11:30										
11:35										
11:40										
11:45										
11:50										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
11:20	34.575	18.75	500

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 27-Jan-21 @ 10:00

Datalogger redeployment time (dd/mm/yr hr:mm): " @ 11:45

Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): 34.485

WL (mbTOC): 34.575

Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 8B	Water Level (mbTOC @ time): 38.240	Date: 27-Jan-21	Personnel: NG/KU
	Bottom of well (mbTOC): 50.820	Weather: partly cloudy	Air Temperature (°C): -5
	Stick-up (m ags): —	Sampling Method: SP	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:05	38.160									
12:10	38.940	2.5	500	1.1	213.7	4.75	8.19	177.2	130.70	clear
12:15	38.750	5.0	500	1.6	216.5	2.01	8.16	170.7	121.95	light yellow
12:20	38.750	7.5	500	2.5	214.4	1.97	8.16	165.1	100.13	lt. gy
12:25	38.74	10.0	500	4.0	213.6	1.97	8.16	158.4	64.91	
12:30	38.73	12.5	500	4.6	213.4	1.98	8.16	152.9	61.20	Clearing up, slight tint
12:35	38.72	15.0	500	4.8	213.1	1.97	8.16	148.0	56.29	
12:40	38.73	17.5	500	5.1	212.5	1.97	8.15	140.5	33.50	
12:45	38.77	20	500	5.4	212.5	1.95	8.15	131.2	19.38	Light grey, transparent
12:50	38.76	22.5	500	5.6	212.5	1.93	8.15	121.7	14.7	
12:55	38.73	25	500	5.4	212.4	1.93	8.15	115.5	12.22	
13:00	38.75	27.5	500	5.5	212.1	1.93	8.15	108.5	9.51	
13:05										
13:10										
13:15										
13:20										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 27-Jan-21 @ 11:45	WL (mbTOC): 38.240
13:05	38.75	27.5	500	Datalogger redeployment time (dd/mm/yr hr:mm): " @ 13:20	WL (mbTOC): 38.75
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated: /	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Dry @ 11:40	Date: 4-Dec-21	Personnel: NA/CM	
Bottom of well (mbTOC): 82.455?	Weather: Sunny	Air Temperature (°C): -15	
Well ID: SA	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 4-Dec-21 @ 11:40	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 11:55	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

installed direct red cable + 70 m pipe

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 46.249 @ 11:35	Date: 4-Dec-21	Personnel: NG/CM	
Bottom of well (mbTOC): 46.265	Weather: clear	Air Temperature (°C): -15	
Well ID: 9B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 4-Dec-21 @ 11:35	WL (mbTOC): 46.249
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 11:50	WL (mbTOC): 46.249
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Dry

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 23.88 @ 14:30	Date: 7-Jan-2022	Personnel: -20 ↑	
Bottom of well (mbTOC): 29.30	Weather: ~~cle~~ Sunny	Air Temperature (°C): NG/LF	
Well ID: 11A	Stick-up (m ags): —	Sampling Method: Bailer	Minimum Purge Volume (L): 35

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
7	14:30	23.88									
Jan	14:40	26.275	.5		0.7	182.3	6.63	10.61	94.8	10.96	Clear

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 7-Jan-22 @ 14:40	WL (mbTOC): 23.88
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 15:00	WL (mbTOC): 26.275
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Water level lower than normal & immediately into screen after 5 pulls

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 1B	Water Level (mbTOC @ time): Dry	Date: 7-Jan-21	Personnel: NG/LF
	Bottom of well (mbTOC): 54.45	Weather: Sunny	Air Temperature (°C): -20
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)

Datalogger remove time (dd/mm/yr hr:mm): 14:30 07-Jan-21	WL (mbTOC): Dry
Datalogger redeployment time (dd/mm/yr hr:mm): 14:55 " "	WL (mbTOC): Dry
Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): frozen @ 13:20	Date: 11-Dec-21	Personnel: NG/KV	
Bottom of well (mbTOC): —	Weather: light snow	Air Temperature (°C): -10	
Well ID: 12A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): —	WL (mbTOC): —
				Datalogger redeployment time (dd/mm/yr hr:mm): —	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Well frozen @ surface - must be some crack in casing allowing snow to blow in -> tried to get probe down well to clear but could not

12A frozen again

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 53.25 @ 13:20	Date: 11-Dec-21	Personnel: NG/KU	
Bottom of well (mbTOC): 54.12	Weather: light snow	Air Temperature (°C): -10	
Well ID: 12B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-Dec-21 @ 13:15	WL (mbTOC): 53.25
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 13:35	WL (mbTOC): —
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

installed direct read cable to 50 mbTOC

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 17A	Water Level (mbTOC @ time): 116.830	Date: 28-Jan-21	Personnel: NG/RS/MW
	Bottom of well (mbTOC): —	Weather: Snow	Air Temperature (°C): -5
	Stick-up (m ags): —	Sampling Method: bailer	Minimum Purge Volume (L): 200

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
	11:05	~~[illegible]~~	15								
28-Jan	11:55		35								
	13:30		55								light grey
	14:25		75								"
	15:25		95								very light grey
	16:00		115								light grey
	9:20	113.59	~~115.59~~		0.3	760	4.32	9.65	-31.8	75.43	"
29-Jan	10:15		135		3.8	707	4.10	8.70	-31	55.12	light grey
	11:05		155		2.8	398.1	5.63	8.95	-70.4	59.99	
	11:55		175		2.5	703	5.36	8.93	-68.7	89.76	light grey
	1445	113.87	200		0.8	694	8.40	9.82	-65.7	151.20	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 28-Jan-21 @ 10:00	WL (mbTOC): 116.830
1445	113.87	200	N/A	Datalogger redeployment time (dd/mm/yr hr:mm): 29-Jan 15:06	WL (mbTOC): 113.87
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 17B	Water Level (mbTOC @ time): 69.00	Date: Jan 25/22	Personnel: RS/KU/NG
	Bottom of well (mbTOC): 76.95	Weather: Sun + cloud	Air Temperature (°C): -5
	Stick-up (m ags):	Sampling Method: bailer	Minimum Purge Volume (L): 48

	Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
25 Jan	11:18	70.39	3.5	N/A	3.3	841	4.65	11.07	-195.3	415.00	Grey, silty, turbid
	1145	72.13	8.5	—	2.1	796	4.30	10.01	+178.5	871	dark gr
	12:10	72.83	11.5	—	1.8	755	5.15	9.86	-176.1	1311.72	dark gray
26 Jan	14:15	69.59	11.5 (0)								
	14:35	71.11	16.5 (5)								
	14:45	—	18.5 (7)		2.0	842	3.95	8.84	30.0	1287.36	sludge
	14:55	72.565	21.5 (10)		1.2	802	3.65	9.18	-41.8	1294.07	dark gray
	15:15		22.5								
	Jan 27 1330	70.21	~~27.5 (5)~~		2.9	821	4.03	8.77	-64.5	800	dark grey
	1400	71.75	27.5 (5)		↓	↓	↓	↓	↓	↓	dark grey
	1415	73.01	32.5 (5)		2.0	807	5.44	9.08	-86.9	647.86	"
28 Jan	9:15	70.55									
	10:00	72.31	37.5 (5)		2.2	844	9.49	8.75	141.0	446.96	light grey
	16:20	72.68	42.5 (5)		1.4	845	7.15	8.72	-49.3	163.30	light grey
29	910	70.628									
	9:20	—	45.5		—	—	—	—	—	—	—
	12:05	—	48.5 (3)		2.1	870	5.00	8.32	-55.6	92.31	"
	15:10	72.71	48.5		1.5	866	7.07	8.39	-9.8	89.06	light grey

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): Jan 25/22 1030	WL (mbTOC): 69.00
15:10	72.71	48.5	N/A	Datalogger redeployment time (dd/mm/yr hr:mm): Jan 28 15:20	WL (mbTOC): 72.71
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated: Jan 29	Equipment Used (Model, SN): 21K

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 39.495	Date: 7-Nov-21	Personnel: NG/RS	
Bottom of well (mbTOC): —	Weather: slight clouds	Air Temperature (°C): -5	
Well ID: 18B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 7-Nov-21 @ 11:00	WL (mbTOC): 39.495
				Datalogger redeployment time (dd/mm/yr hr:mm): 8-Nov-21 @ 12:20	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

data logger broken? since mid-october has been reading max pressure — taking back to office to check
39.15 from solinst reader
↳ downloaded again and back date went back to april & then back to Jan

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 18B	Water Level (mbTOC @ time): 38.420	Date: 7-Nov-21	Personnel: NG/RS
	Bottom of well (mbTOC): —	Weather: slight clouds	Air Temperature (°C): -5
	Stick-up (m ags): —	Sampling Method: SP	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:15	38.420	0	—							
11:20	38.640	2.5	500	0.8	447.6	1.96	10.48	169.3	580.99	grey
11:25	38.605	5	500	0.8	449.6	1.37	9.65	67.5	412.89	dark grey
11:30	38.640	7.5	500	1.4	513	0.89	8.91	135.8	311.51	"
11:35	38.675	10	500	1.7	538	0.65	8.70	13.9	274.74	"
11:40	38.720	12.5	500	3.2	547	0.54	8.50	-92.5	164.38	"
11:45	38.750	15	500	3.9	553	0.46	8.33	-127.1	157.09	"
11:50	38.775	17.5	500	4.3	557	0.40	8.20	-141.0	124.52	"
11:55	38.778	20	500	4.4	560	0.37	8.13	-142.4	99.28	"
12:00	38.789	22.5	500	4.3	561	0.35	8.07	-145.4	136.95	beige
12:05	38.78	25	500	4.4	562	0.34	8.04	-147.6	156.90	"
12:10	38.91	27.5	500	4.9	563	0.32	7.99	-145.0	111.08	"
12:15	38.94	30	500	5.0	555	0.32	8.09	-157.6	42.08	"
12:20	38.94	32.5	500	4.8	561	0.29	7.99	-153.0	30.29	"
12:25	38.94	35	500	4.8	561	0.29	7.99	-151.3	23.51	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)
12:30	38.94	35	500

Field Alkalinity:

QA/QC Sample (FB, TB, DUP):

Datalogger remove time (dd/mm/yr hr:mm): 7-Nov-21 @ 10:30

Datalogger redeployment time (dd/mm/yr hr:mm): 7-Nov-21 @ 12:55

Date multimeter (e.g., YSI) last calibrated:

WL (mbTOC): 38.420

WL (mbTOC):

Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

38.01 from Solinst Sonic Reader

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 183.37 @ 10:20	Date: 11-Dec-21	Personnel: NG/KU	
Bottom of well (mbTOC): 195.69	Weather: Light snow	Air Temperature (°C): -10	
Well ID: ~~20A~~ 19A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-Dec-21 @ 10:15	WL (mbTOC): 183.37
				Datalogger redeployment time (dd/mm/yr hr:mm): " " @ 10:50	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

installed direct read cable to 194 m

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 157.78 @ 10:10	Date: 11-Dec-21	Personnel: NG/KV	
Bottom of well (mbTOC): 159.500	Weather: light snow	Air Temperature (°C): -10	
Well ID: ~~22B~~ 19B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-Dec-21 @ 10:10	WL (mbTOC): 157.78
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 10:40	WL (mbTOC): "
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 70.26 12:30	Date: 11-Dec-21	Personnel: NG/KU	
Bottom of well (mbTOC): 166.01	Weather: Light snow	Air Temperature (°C): -10	
Well ID: 20A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-Dec-21 @ 12:10	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:40	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

installed direct read cable to 150 mbTOC

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 58.38	Date: 11-Dec-21	Personnel: NCH/KV	
Bottom of well (mbTOC): 118.12	Weather: light snow	Air Temperature (°C): -10	
Well ID: 20B	Stick-up (m ags): –	Sampling Method: –	Minimum Purge Volume (L): –

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (mL/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 11-Dec-21@12:10	WL (mbTOC): 58.38
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:40	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

installed direct read cable to 100 mbTOC.

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): ~~119.307~~ Dry	Date: 6-Nov-21	Personnel: NM/RS/CM	
Bottom of well (mbTOC): —	Weather: overcast	Air Temperature (°C): -5	
Well ID: 21A	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 6-Nov-21 11:45	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): " @12:00	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

replaced w direct read cable 1m off bottom

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): Dry	Date: 6-Nov-21	Personnel: NG/RS/KM	
Bottom of well (mbTOC): —	Weather: Overcast	Air Temperature (°C): -5	
Well ID: 21B	Stick-up (m ags): —	Sampling Method: —	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 6-Nov-21 @ 12:00	WL (mbTOC): Dry
				Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:15	WL (mbTOC): Dry
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

replaced ~ direct read cable ~1m off bottom

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 123.86 12:30	Date: 4-DEC-2021	Personnel: OM & NG	
Bottom of well (mbTOC): —	Weather: Sunny	Air Temperature (°C): -15	
Well ID: 22A	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm):	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm):	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Used direct read cable for downloads

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Well ID: 22B	Water Level (mbTOC @ time): 83.56m @ 12:25	Date: 4-DEC-2021	Personnel: CM & NG
	Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): -15
	Stick-up (m ags):	Sampling Method:	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 4-Dec-21 @ 12:25	WL (mbTOC):
				Datalogger redeployment time (dd/mm/yr hr:mm): 11-Dec-21 @ 12:00	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Removed direct read cable for repairs → re-installed at working on 11-Dec-21

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 2.83 @ 09:40	Date: 14-Nov-21	Personnel: NG/CM	
Bottom of well (mbTOC): —	Weather: Snow	Air Temperature (°C): -5	
Well ID: 23A	Stick-up (m ags): —	Sampling Method: SP	Minimum Purge Volume (L):

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
10:05	2.83	0								
10:10	6.00	5L	1000	2.4	1219	0.48	7.57	185.0	17.78	Clear, no odors
10:15	8.70	10	1000	3.3	1216	0.43	7.63	135.5	24.7	" "
10:20	10.85	15	1000	3.5	1215	0.41	7.63	102.0	16.32	Beige, light
10:25	12.88	20	1000	3.8	1216	0.39	7.61	70	18.77	" "
10:30	15.4	25	1000	4.2	1212	0.39	7.61	43.3	17.58	" "
10:35	17.46	30	1000	4.4	1211	0.39	7.60	28.1	17.52	" "
10:40	17.48	31.25	250	3.5	1215	0.42	7.60	24.3	19.28	" "
10:45	17.00	32.50	250	3.6	1218	0.45	7.64	12.3	14.55	" "
10:50	18.60	33.75	250	6.8	1204	0.41	7.69	-112.8	20.12	" "
10:55	18.49	35	250	4.8	1200	0.42	7.69	-118.7	16.66	" "
11:00	18.78	36.25	250	5.0	1206	0.44	7.70	-88.0	14.43	" "
11:03	18.68	37	250	4.8	1199	0.40	7.70	-95.0	15.46	" "
11:06	18.49	37.75	250	4.4	1199	0.39	7.72	-115	19.06	" "
11:09	18.79	38.5	250	6.3	1193	0.39	7.73	-126.8	12.5	" "
11:12	18.78	39.25	250	5.4	1202	0.4	7.71	-118	11.77	" "
11:15	18.75	40	250	6.0	1182	0.43	7.72	-105.2	13.34	" "

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Nov-21 @ 09:40	WL (mbTOC): 2.83
11:20	18.75	40		Datalogger redeployment time (dd/mm/yr hr:mm): @ 11:30	WL (mbTOC): 18.75
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

Notes

Same issue with no flow, pressure build up, and then very high flow. This started occuring at the 40 minute mark, approximately 17.5 - 18.00 m.

downloaded logger on 15-Nov-21

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 2.875 @ 10:50	Date: 15-Nov-21	Personnel: YS/GT	
Bottom of well (mbTOC):	Weather: Sunny	Air Temperature (°C): -5°C	
Well ID: ~~SB CUP~~ 23B	Stick-up (m ags): —	Sampling Method: pp	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
11:20	2.875	0								
11:25	3.450	2.5	500	2.7	1093	0.56	7.57	188.1	19.95	Clear
11:30	3.520	5	500	2.7	1120	0.46	7.55	188.4	48.72	Clear
11:35	3.61	7.5	500	2.7	1134	0.61	7.52	178.1	50.94	"
11:40	3.515	~~[illegible]~~ 9.0	300	2.4	1166	0.42	7.53	145.7	26.02	"
11:45	3.500	10.5	300	2.4	1168	0.44	7.53	179.0	49.10	"
11:50	3.485	12	300	2.4	1167	0.37	7.53	112.6	17.53	"
11:55	3.515	13.5	300	2.4	1164	0.34	7.53	102.8	17.74	"
12:00	3.505	15	300	2.4	1164	0.34	7.54	93.8	15.54	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 15-Nov-21 @ 10:50	WL (mbTOC): 2.875
12:05	3.505	15	300	Datalogger redeployment time (dd/mm/yr hr:mm): " @ 12:10	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

lots of issues c tubing freezing

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 7.00 @ 12:25	Date: 14-Nov-21	Personnel: NG/CM	
Bottom of well (mbTOC): –	Weather: Snow	Air Temperature (°C): -10	
Well ID: SA CWP	Stick-up (m ags): –	Sampling Method: SP	Minimum Purge Volume (L): –

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:30	7.00	0								
12:35	9.33	5L	1000	1.1	775	0.61	7.64	6.1	5.94	Clear
12:40	10.57	10	1000	2.8	772	0.48	7.61	-23.5	8.42	" "
12:45	11.32	15	1000	2.8	769	0.43	7.61	-38.4	13.35	" "
12:50	12.20	20	1000	3.3	774	0.39	7.61	-52.6	11.83	" "
12:55	~~12.3~~ 12.30	22.5	500	2.8	788	0.38	~~7.61~~ 7.61	-56.9	8.72	" "
13:00	12.41	25	500	3.1	810	0.35	7.60	-62.0	6.81	" "
13:05	12.47	27.5	500	3.0	814	0.36	7.60	-64.9	5.03	" "
13:10	12.50	30.0	500	3.0	825	0.35	7.59	-65.5	4.07	" "
13:15	12.50	32.5		3.0	834	0.34	7.59	-66.2	3.50	" "
13:20										

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 14-Nov-21 @ 12:25	WL (mbTOC): 7.00
13:20	12.50	32.5	500	Datalogger redeployment time (dd/mm/yr hr:mm): 15 @ 13:30	WL (mbTOC):
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

downloaded logger on 15-Nov-21

BRUCEJACK GROUNDWATER SAMPLING FORM

PRETIVM

Water Level (mbTOC @ time): 4.540 @ 12:25	Date: 15-Nov-21	Personnel: NG	
Bottom of well (mbTOC): —	Weather: sunny	Air Temperature (°C): -5	
Well ID: ~~SB CWP~~ ~~238~~ SB CWP	Stick-up (m ags): —	Sampling Method: PP	Minimum Purge Volume (L): —

Time	Depth to Water (mbTOC)	Cumulative Volume Produced (L)	Flow (ml/min)	Temp. (°C)	SC (mS/cm)	DO (mg/L)	pH (s.u.)	Redox Potential (mV)	Turbidity (NTU)	Appearance/Odor (Colour, Clarity)
12:30	4.540	0								
12:35	5.12	2.5	500	2.6	680	7.01	7.46	146.3	26.61	clear
12:40	5.23	4.0	306	2.7	783	5.65	7.43	152.3	2.23	"
12:45	5.34	5.2	250	2.8	799	5.79	7.42	157.6	2.71	"
12:50	5.375	6.4	250	2.6	803	5.88	7.42	162.1	3.51	"
12:55	5.390	7.6	250	2.6	806	5.90	7.42	166.6	3.74	"
13:00	5.440	8.8	250	2.6	802	5.87	7.43	171.1	4.26	"
13:05	5.500	10	250	2.5	799	5.81	7.43	174.2	4.39	"
13:10	5.560	11.2	250	2.5	798	5.84	7.43	177.8	4.99	"
13:15	5.620	12.4	250	2.5	777	5.86	7.43	180.4	5.39	"

Time sample collected	Sample Depth to Water (mbTOC)	Total Volume Purged (L)	Average Purge Rate (mL/min)	Datalogger remove time (dd/mm/yr hr:mm): 15-Nov-21 @ 12:25	WL (mbTOC): 4.540
13:20	5.620	12.4	250	Datalogger redeployment time (dd/mm/yr hr:mm): " @ 13:30	WL (mbTOC): 5.620
Field Alkalinity:		QA/QC Sample (FB, TB, DUP):		Date multimeter (e.g., YSI) last calibrated:	Equipment Used (Model, SN):

SAMPLING CRITERIA

Record field parameters, including water elevation, until they have stabilized for three consecutive readings, three to five minutes apart.

Drawdown:	<10 cm	pH:	+/- 0.1
Temperature:	+/- 0.1°C	ORP:	+/- 10%
SPC:	+/- 3%	Turbidity:	<50 NTU
DO:	+/- 10%		

tubing v close to bottom but not quite there
↳ ~9m of tubing so should still be in screen as did not pull it up 1m as usual
↳ only 20cm sticking up above well

Appendix D
Quality Assurance and Quality Control

Appendix D1: Smart Quarter 1 QA/QC

Appendix D2: Smart Quarter 2 QA/QC

Appendix D3: Smart Quarter 3 QA/QC

Appendix D4: Smart Quarter 4 QA/QC

Appendix D5: YSI ProDDS Calibration Record

NEWCREST

Table D1-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW18-23A	BJ-GW18-23A-98	RPD
Date Sampled			24-Apr-2021	24-Apr-2021	
ALS Sample ID			VA21A7804-006	VA21A7804-007	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Duplicate	
Physical Tests (Matrix: Water)					
conductivity	µS/cm	2.0	2240	2250	0%
acidity (as CaCO3)	mg/L	1.00	4.7	5.1	-
alkalinity, total (as CaCO3)	mg/L	2.00	96.8	96.8	0%
hardness (as CaCO3), dissolved	mg/L	0.6	544	553	2%
hardness (as CaCO3), from total Ca/Mg	mg/L	1	596	596	0%
pH	pH units	0.10	7.88	7.88	0%
solids, total dissolved [TDS]	mg/L	10.0	1330	1350	1%
solids, total suspended [TSS]	mg/L	3.00	19.7	21.1	7%
turbidity	NTU	0.10	7.55	6.89	9%
Anions and Nutrients (Matrix: Water)					
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	7.4	7.6	3%
ammonia, total (as N)	mg/L	0.005	2.69	2.66	1%
bromide	mg/L	0.05	<1.00	<1.00	-
chloride	mg/L	0.5	339	341	1%
fluoride	mg/L	0.02	<0.400	<0.400	-
nitrate (as N)	mg/L	0.005	38.4	38.2	1%
nitrate + nitrite (as N)	mg/L	0.005	38.5	38.3	1%
nitrite (as N)	mg/L	0.001	0.119	0.116	3%
nitrogen, total	mg/L	0.03	45.9	45.9	0%
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.0010	<0.0010	-
phosphorus, total	mg/L	0.002	0.011	0.0075	-
sulfate (as SO4)	mg/L	0.3	465	465	0%
sulfide, total (as S)	mg/L	0.0015	<0.0015	<0.0015	-
sulfide, total (as H2S)	mg/L	0.0016	<0.0016	<0.0016	-
Total Metals (Matrix: Water)					
aluminum, total	mg/L	0.003	0.284	0.263	8%
antimony, total	mg/L	0.0001	0.00323	0.00308	5%
arsenic, total	mg/L	0.0001	0.00079	0.00083	5%
barium, total	mg/L	0.0001	0.0256	0.0241	6%
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	-
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	-
boron, total	mg/L	0.01	0.268	0.273	2%
cadmium, total	mg/L	0.000005	0.0000288	0.0000227	-
calcium, total	mg/L	0.05	212	212	0%
chromium, total	mg/L	0.0005	<0.00050	<0.00050	-
cobalt, total	mg/L	0.0001	0.00023	0.00024	-
copper, total	mg/L	0.0005	0.00059	0.00111	-
iron, total	mg/L	0.01	0.149	0.15	1%
lead, total	mg/L	0.00005	0.000472	0.000446	6%
lithium, total	mg/L	0.001	0.398	0.399	0%
magnesium, total	mg/L	0.1	16.3	16.2	1%
manganese, total	mg/L	0.0001	0.176	0.175	1%
mercury, total	mg/L	0.000005	0.0000059	0.0000053	-
molybdenum, total	mg/L	0.00005	0.00425	0.00415	2%
nickel, total	mg/L	0.0005	<0.00050	<0.00050	-
phosphorus, total	mg/L	0.3	<0.300	<0.300	-
potassium, total	mg/L	0.05	15.3	15.2	1%
selenium, total	mg/L	0.00005	0.000712	0.000661	7%
silicon, total	mg/L	0.1	2.64	2.57	3%
silver, total	mg/L	0.00001	0.000018	0.000016	-
sodium, total	mg/L	0.05	251	247	2%
strontium, total	mg/L	0.0002	2.69	2.66	1%
thallium, total	mg/L	0.00001	0.000078	0.000072	8%
tin, total	mg/L	0.0001	<0.00010	<0.00010	-
titanium, total	mg/L	0.01	<0.0100	<0.0100	-
uranium, total	mg/L	0.00001	0.00222	0.00224	1%
vanadium, total	mg/L	0.0005	<0.00050	<0.00050	-
zinc, total	mg/L	0.003	0.0057	0.0083	-

Table D1-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW18-23A	BJ-GW18-23A-98	RPD
Date Sampled			24-Apr-2021	24-Apr-2021	
ALS Sample ID			VA21A7804-006	VA21A7804-007	
Dissolved Metals (Matrix: Water)					
aluminum, dissolved	mg/L	0.001	0.0025	0.004	-
antimony, dissolved	mg/L	0.0001	0.00297	0.00303	2%
arsenic, dissolved	mg/L	0.0001	0.00048	0.00046	-
barium, dissolved	mg/L	0.0001	0.0244	0.022	**10%**
beryllium, dissolved	mg/L	0.0001	<0.000200	<0.000200	-
bismuth, dissolved	mg/L	0.00005	<0.000100	<0.000100	-
cadmium, dissolved	mg/L	0.000005	0.0000198	0.0000223	-
calcium, dissolved	mg/L	0.05	192	196	2%
chromium, dissolved	mg/L	0.0005	<0.00100	<0.00100	-
cobalt, dissolved	mg/L	0.0001	<0.00020	<0.00020	-
copper, dissolved	mg/L	0.0002	0.00066	<0.00040	-
iron, dissolved	mg/L	0.01	<0.020	<0.020	-
lead, dissolved	mg/L	0.00005	<0.000100	<0.000100	-
lithium, dissolved	mg/L	0.001	0.377	0.375	1%
magnesium, dissolved	mg/L	0.1	15.8	15.5	2%
manganese, dissolved	mg/L	0.0001	0.158	0.157	1%
mercury, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	-
molybdenum, dissolved	mg/L	0.00005	0.00392	0.004	2%
nickel, dissolved	mg/L	0.0005	<0.00100	<0.00100	-
phosphorus, dissolved	mg/L	0.3	<0.600	<0.600	-
potassium, dissolved	mg/L	0.05	14.4	14	3%
selenium, dissolved	mg/L	0.00005	0.000517	0.00061	**17%**
silicon, dissolved	mg/L	0.05	1.92	1.94	1%
silver, dissolved	mg/L	0.00001	<0.000020	<0.000020	-
sodium, dissolved	mg/L	0.05	238	232	3%
strontium, dissolved	mg/L	0.0002	2.63	2.68	2%
thallium, dissolved	mg/L	0.00001	0.000063	0.000064	2%
tin, dissolved	mg/L	0.0001	<0.00020	<0.00020	-
titanium, dissolved	mg/L	0.01	<0.0200	<0.0200	-
uranium, dissolved	mg/L	0.00001	0.0023	0.00226	2%
vanadium, dissolved	mg/L	0.0005	<0.00100	<0.00100	-
zinc, dissolved	mg/L	0.001	0.0065	0.0025	-
Aggregate Organics (Matrix: Water)					
Chemical Oxygen Demand [COD]	mg/L	20	<20	<20	-

Notes:

1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.

Table D1-3. Field blank and trip blank analytical results

Client Sample ID			BJ-GW18-23A-99
Date Sampled			24-Apr-2021
Time Sampled			11:35
ALS Sample ID			VA21A7804-005
Analyte	Units	Lowest Detection Limit	Sub-Matrix: Groundwater
Physical Tests (Matrix: Water)			
conductivity	µS/cm	2	<2.0
acidity (as CaCO3)	mg/L	2	<2.0
alkalinity, total (as CaCO3)	mg/L	1	**1.2**
hardness (as CaCO3), dissolved	mg/L	0.5	1.6
hardness (as CaCO3), from total Ca/M	mg/L	0.5	<0.50
pH	pH units	0.1	5.88
solids, total dissolved [TDS]	mg/L	10	<10
solids, total suspended [TSS]	mg/L	3	<3.0
turbidity	NTU	0.1	<0.10
Anions and Nutrients (Matrix: Water)			
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050
ammonia, total (as N)	mg/L	0.005	<0.0050
bromide	mg/L	0.05	<0.050
chloride	mg/L	0.5	<0.50
fluoride	mg/L	0.02	<0.020
nitrate (as N)	mg/L	0.005	<0.0050
nitrate + nitrite (as N)	mg/L	0.005	<0.0051
nitrite (as N)	mg/L	0.001	<0.0010
nitrogen, total	mg/L	0.03	<0.030
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.0010
phosphorus, total	mg/L	0.002	<0.0020
sulfate (as SO4)	mg/L	0.3	<0.30
sulfide, total (as S)	mg/L	0.0015	<0.0015
sulfide, total (as H2S)	mg/L	0.0016	<0.0016
Total Metals (Matrix: Water)			
aluminum, total	mg/L	0.003	<0.0030
antimony, total	mg/L	0.0001	<0.00010
arsenic, total	mg/L	0.0001	<0.00010
barium, total	mg/L	0.0001	<0.00010
beryllium, total	mg/L	0.0001	<0.000100
bismuth, total	mg/L	0.00005	<0.000050
boron, total	mg/L	0.01	<0.010
cadmium, total	mg/L	0.000005	<0.0000050
calcium, total	mg/L	0.05	<0.050
chromium, total	mg/L	0.0005	<0.00050
cobalt, total	mg/L	0.0001	<0.00010
copper, total	mg/L	0.0005	<0.00050
iron, total	mg/L	0.01	<0.010
lead, total	mg/L	0.00005	<0.000050
lithium, total	mg/L	0.001	<0.0010
magnesium, total	mg/L	0.1	<0.100
manganese, total	mg/L	0.0001	<0.00010
mercury, total	mg/L	0.000005	<0.0000050
molybdenum, total	mg/L	0.00005	<0.000050
nickel, total	mg/L	0.0005	<0.00050
phosphorus, total	mg/L	0.3	<0.300
potassium, total	mg/L	0.05	<0.050
selenium, total	mg/L	0.00005	<0.000050
silicon, total	mg/L	0.1	<0.10
silver, total	mg/L	0.00001	<0.000010
sodium, total	mg/L	0.05	<0.050
strontium, total	mg/L	0.0002	<0.00020
thallium, total	mg/L	0.00001	<0.000010
tin, total	mg/L	0.0001	<0.00010
titanium, total	mg/L	0.01	<0.0100
uranium, total	mg/L	0.00001	<0.000010
vanadium, total	mg/L	0.0005	<0.00050
zinc, total	mg/L	0.003	<0.0030

Table D1-3. Field blank and trip blank analytical results

Client Sample ID			BJ-GW18-23A-99
Date Sampled			24-Apr-2021
Time Sampled			11:35
ALS Sample ID			VA21A7804-005
Dissolved Metals (Matrix: Water)			
aluminum, dissolved	mg/L	0.001	**0.0011**
antimony, dissolved	mg/L	0.0001	<0.00010
arsenic, dissolved	mg/L	0.0001	<0.00010
barium, dissolved	mg/L	0.0001	<0.00010
beryllium, dissolved	mg/L	0.0001	<0.000100
bismuth, dissolved	mg/L	0.00005	<0.000050
cadmium, dissolved	mg/L	0.000005	<0.0000050
calcium, dissolved	mg/L	0.05	0.641
chromium, dissolved	mg/L	0.0005	<0.00050
cobalt, dissolved	mg/L	0.0001	<0.00010
copper, dissolved	mg/L	0.0002	<0.00020
iron, dissolved	mg/L	0.01	<0.010
lead, dissolved	mg/L	0.00005	<0.000050
lithium, dissolved	mg/L	0.001	<0.0010
magnesium, dissolved	mg/L	0.1	<0.100
manganese, dissolved	mg/L	0.0001	<0.00010
mercury, dissolved	mg/L	0.000005	<0.0000050
molybdenum, dissolved	mg/L	0.00005	<0.000050
nickel, dissolved	mg/L	0.0005	<0.00050
phosphorus, dissolved	mg/L	0.3	<0.300
potassium, dissolved	mg/L	0.05	<0.050
selenium, dissolved	mg/L	0.00005	<0.000050
silicon, dissolved	mg/L	0.05	<0.050
silver, dissolved	mg/L	0.00001	<0.000010
sodium, dissolved	mg/L	0.05	<0.050
strontium, dissolved	mg/L	0.0002	**0.00036**
thallium, dissolved	mg/L	0.00001	<0.000010
tin, dissolved	mg/L	0.0001	<0.00010
titanium, dissolved	mg/L	0.01	<0.0100
uranium, dissolved	mg/L	0.00001	<0.000010
vanadium, dissolved	mg/L	0.0005	<0.00050
zinc, dissolved	mg/L	0.001	<0.0010
dissolved mercury filtration location			Field
dissolved metals filtration location			Field
Aggregate Organics (Matrix: Water)			
chemical oxygen demand [COD]	mg/L	20	<20
Notes:			

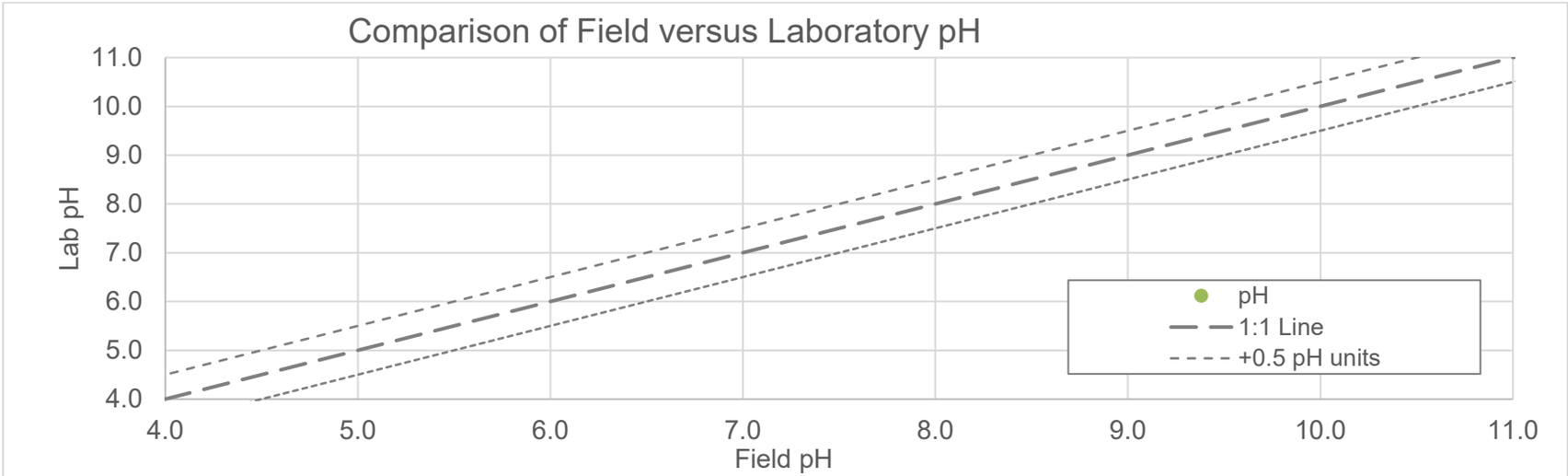
Bolded values indicate a detected value <2x the LDL.
White text on black fill indicates that the detected value is ≥2x the LDL.

Table D1-4. Samples with Ratios of Dissolved to Total Metals Concentrations Greater than 120%

Sample ID	Date Sample	Time Sampled	Matrix	Parameter C	Ratio of D/T
BJ-GW18-17B-SNAP	04-Mar-2021	13:05	Water	SE-D	1971%

Notes:

Ratio of dissolved concentration to total concentration (D/T) greater than 120% for metals parameters with dissolved or total concentration >5x RDL for metal



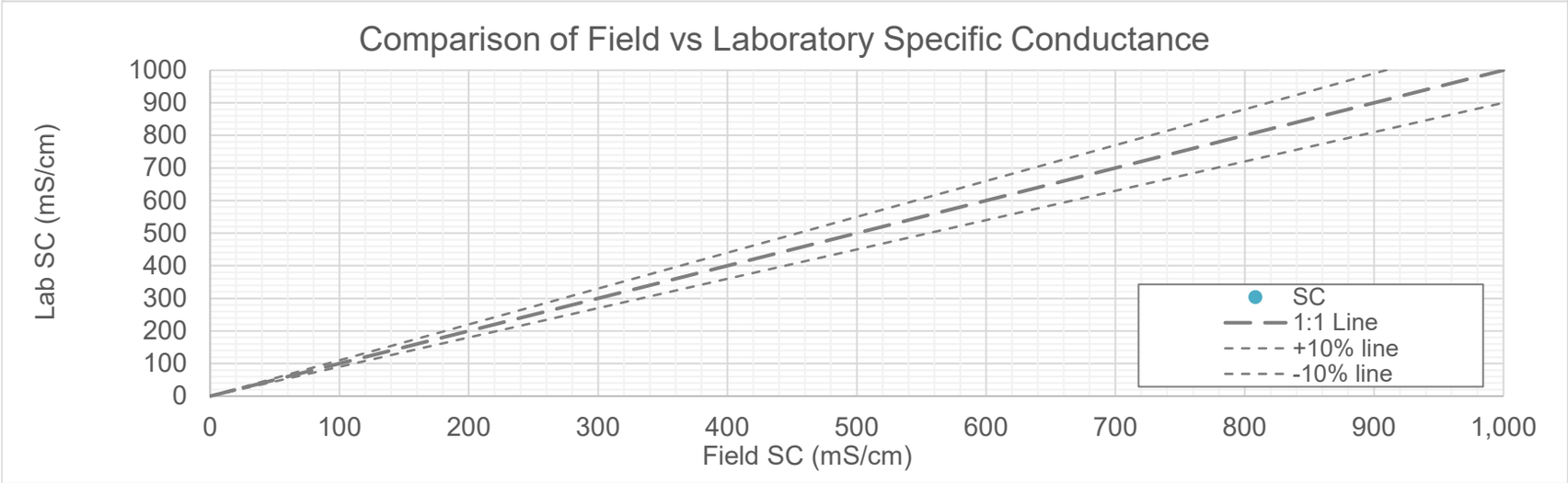


Figure D1-1: Comparison of field versus laboratory pH and specific conductance for sQ1 samples.

Table D2-1. Charge Balance Error

Lab Sample ID	Sample ID	Sample Date	Charge Balance Error (%)	Comments
VA21B0116-001	BJ-GW18-18B-snap	23-May-2021	0%	SNAP
VA21B0116-002	BJ-GW18-18B-E314702	23-May-2021	-3%	
VA21B0395-001	BJ-GW18-17A-Snap	23-May-2021	1%	SNAP
VA21B0395-002	BJ-GW18-17A-E303066	23-May-2021	1%	
VA21B0558-001	BJ-GW12-8B - Snap	27-May-2021	-1%	SNAP
VA21B0558-002	BJ-GW12-8B - E314695	27-May-2021	0%	
VA21B0558-003	BJ-GW12-8B - 98	27-May-2021	-1%	Duplicate
VA21B0672-001	BJ-GW12-11A-E303062	29-May-2021	0%	
VA21B2508-001	BJ-GW11-3A-snap	20-Jun-2021	-3%	SNAP
VA21B2508-002	BJ-GW11-3A-E303056	20-Jun-2021	-4%	
VA21B2508-003	BJ-GW11-3B-E314693	20-Jun-2021	-3%	
VA21B2626-001	BJ-GW11-8A- snap	21-Jun-2021	-1%	SNAP
VA21B2626-002	BJ-GW11-8A- E303059	21-Jun-2021	-1%	
VA21B2897-001	BJ-GW18-23B - E314691	23-Jun-2021	2%	
VA21B2897-002	BJ-GW18-5B - CWP	23-Jun-2021	-3%	
VA21B3123-001	BJ-GW18-23A - E314690	25-Jun-2021	2%	
VA21B3123-002	BJ-GW18-5A-CWP	26-Jun-2021	**-5%**	
VA21B4774-001	Equipment Blank-94	16-Jul-2021	**-30%**	Equip Blank
VA21B4774-002	BJ-GW11-1A - E303054	17-Jul-2021	-1%	
VA21B4774-003	BJ-GW11-1B - E314692	17-Jul-2021	1%	
VA21B4774-004	Travel Blank	17-Jul-2021	#N/A	Travel Blank
VA21B4774-005	BJ-GW18-19B - E314703	18-Jul-2021	-1%	
VA21B5926-001	BJ-GW18-17B - E314703	31-Jul-2021	**-7%**	
VA21B5469-001	BJ-GW18-17B - snap	26-Jul-2021	-3%	SNAP

Notes:

1. Bold red text indicates charge balance error is greater than 5% or less than -5%.
2. Red text with red background indicates charge balance error is greater than 10% or less than -10%.

Table D2-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW12-8B - E314695	BJ-GW12-8B - 98	RPD
Date Sampled			27-May-2021	27-May-2021	
ALS Sample ID			VA21B0558-002	VA21B0558-003	
Parameter	**Units**	**Lowest Detection Limit**	Sub-Matrix: Groundwater	Sub-Matrix: Groundwater	
pH	pH units	0.10	7.99	7.98	0%
solids, total dissolved [TDS]	mg/L	10.0	121	128	6%
solids, total suspended [TSS]	mg/L	3.00	9.6	14.4	-
alkalinity, total (as CaCO3)	mg/L	2.00	69.6	69.7	0%
hardness (as CaCO3), dissolved	mg/L	0.6	106	104	2%
hardness (as CaCO3), from total Ca/Mg	mg/L	1	101	104	3%
turbidity	NTU	0.10	3.74	3.59	4%
Anions and Nutrients (Matrix: Water)					
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050	<0.050	-
ammonia, total (as N)	mg/L	0.005	<0.0050	<0.0050	-
bromide	mg/L	0.05	<0.050	<0.050	-
chloride	mg/L	0.5	<0.50	<0.50	-
fluoride	mg/L	0.02	0.024	0.022	-
nitrate (as N)	mg/L	0.005	0.0253	0.0244	-
nitrate + nitrite (as N)	mg/L	0.005	0.0253	0.0244	-
nitrite (as N)	mg/L	0.001	<0.0010	<0.0010	-
nitrogen, total	mg/L	0.03	<0.030	<0.030	-
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.0010	<0.0010	-
phosphorus, total	mg/L	0.002	0.0079	0.0168	-
sulfate (as SO4)	mg/L	0.3	39.9	39.9	0%
sulfide, total (as S)	mg/L	0.0015	<0.0015	<0.0015	-
sulfide, total (as H2S)	mg/L	0.0016	<0.0016	<0.0016	-
Total Metals (Matrix: Water)					
aluminum, total	mg/L	0.003	0.173	0.189	
antimony, total	mg/L	0.0001	0.00088	0.00086	9%
arsenic, total	mg/L	0.0001	0.0172	0.0178	2%
barium, total	mg/L	0.0001	0.0320	0.0314	3%
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	2%
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	-
boron, total	mg/L	0.01	<0.010	<0.010	-
cadmium, total	mg/L	0.000005	0.0000089	0.0000084	-
calcium, total	mg/L	0.05	33.1	34.1	-
chromium, total	mg/L	0.0005	0.00913	0.0124	3%
cobalt, total	mg/L	0.0001	0.00236	0.00239	**30%**
copper, total	mg/L	0.0005	0.00208	0.00210	1%
iron, total	mg/L	0.01	0.325	0.345	-
lead, total	mg/L	0.00005	0.000367	0.000392	6%
lithium, total	mg/L	0.001	0.0066	0.0067	7%
magnesium, total	mg/L	0.1	4.56	4.52	2%
manganese, total	mg/L	0.0001	0.0794	0.0816	1%
mercury, total	mg/L	0.000005	<0.0000050	<0.0000050	3%
molybdenum, total	mg/L	0.00005	0.00224	0.00251	-
nickel, total	mg/L	0.0005	0.00496	0.00700	**11%**
phosphorus, total	mg/L	0.3	<0.300	<0.300	**34%**
potassium, total	mg/L	0.05	0.531	0.528	-
selenium, total	mg/L	0.00005	0.000290	0.000320	1%
silicon, total	mg/L	0.1	2.10	2.19	10%
silver, total	mg/L	0.00001	0.000388	0.000406	4%
sodium, total	mg/L	0.05	2.42	2.45	5%
strontium, total	mg/L	0.0002	0.571	0.541	1%
thallium, total	mg/L	0.00001	0.000010	<0.000010	5%
tin, total	mg/L	0.0001	<0.00010	<0.00010	-
titanium, total	mg/L	0.01	<0.0100	<0.0100	-
uranium, total	mg/L	0.00001	0.000193	0.000186	-
vanadium, total	mg/L	0.0005	<0.00050	<0.00050	4%
zinc, total	mg/L	0.003	<0.0030	0.0031	-

Table D2-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW12-8B - E314695	BJ-GW12-8B - 98	RPD
Date Sampled			27-May-2021	27-May-2021	
ALS Sample ID			VA21B0558-002	VA21B0558-003	
Parameter	**Units**	**Lowest Detection Limit**	Sub-Matrix: Groundwater	Sub-Matrix: Groundwater	
Dissolved Metals (Matrix: Water)					-
aluminum, dissolved	mg/L	0.001	0.0013	0.0011	
antimony, dissolved	mg/L	0.0001	0.00084	0.00083	
arsenic, dissolved	mg/L	0.0001	0.0136	0.0127	-
barium, dissolved	mg/L	0.0001	0.0212	0.0214	1%
beryllium, dissolved	mg/L	0.0001	<0.000100	<0.000100	7%
bismuth, dissolved	mg/L	0.00005	<0.000050	<0.000050	1%
boron, dissolved	mg/L	0.01	<0.010	<0.010	-
cadmium, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	-
calcium, dissolved	mg/L	0.05	34.6	34.1	-
chromium, dissolved	mg/L	0.0005	0.00170	0.00154	-
cobalt, dissolved	mg/L	0.0001	0.00022	0.00020	1%
copper, dissolved	mg/L	0.0002	0.00069	0.00068	-
iron, dissolved	mg/L	0.01	0.015	<0.010	-
lead, dissolved	mg/L	0.00005	<0.000050	<0.000050	-
lithium, dissolved	mg/L	0.001	0.0062	0.0062	-
magnesium, dissolved	mg/L	0.1	4.64	4.58	-
manganese, dissolved	mg/L	0.0001	0.00502	0.00497	0%
mercury, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	1%
molybdenum, dissolved	mg/L	0.00005	0.00222	0.00209	1%
nickel, dissolved	mg/L	0.0005	0.00264	0.00262	-
phosphorus, dissolved	mg/L	0.3	<0.300	<0.300	6%
potassium, dissolved	mg/L	0.05	0.488	0.470	1%
selenium, dissolved	mg/L	0.00005	0.000342	0.000304	-
silicon, dissolved	mg/L	0.05	2.06	1.98	4%
silver, dissolved	mg/L	0.00001	<0.000010	<0.000010	**12%**
sodium, dissolved	mg/L	0.05	2.48	2.43	4%
strontium, dissolved	mg/L	0.0002	0.608	0.605	-
thallium, dissolved	mg/L	0.00001	<0.000010	<0.000010	2%
tin, dissolved	mg/L	0.0001	<0.00010	<0.00010	0%
titanium, dissolved	mg/L	0.01	<0.0100	<0.0100	-
uranium, dissolved	mg/L	0.00001	0.000168	0.000162	-
vanadium, dissolved	mg/L	0.0005	<0.00050	<0.00050	-
zinc, dissolved	mg/L	0.001	0.0016	0.0014	4%
Aggregate Organics (Matrix: Water)			Field	Field	-
Chemical Oxygen Demand [COD]	mg/L	20	Field	Field	-

Notes:

1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less

2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%. -

3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.

Table D2-3. Field blank and trip blank analytical results

Client Sample ID			
Date Sampled			
Time Sampled			
ALS Sample ID			
Analyte	Units	Lowest Detection Limit	
Physical Tests (Matrix: Water)			
conductivity	µS/cm	2	
solids, total suspended [TSS]	mg/L	3	
turbidity	NTU	0.1	
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	
pH	pH units	0.1	
solids, total dissolved [TDS]	mg/L	10	
Anions and Nutrients (Matrix: Water)			
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	
ammonia, total (as N)	mg/L	0.005	
bromide	mg/L	0.05	
chloride	mg/L	0.5	
fluoride	mg/L	0.02	
nitrate (as N)	mg/L	0.005	
nitrate + nitrite (as N)	mg/L	0.005	
nitrite (as N)	mg/L	0.001	
nitrogen, total	mg/L	0.03	
phosphate, ortho-, dissolved (as P)	mg/L	0.001	
phosphorus, total	mg/L	0.002	
sulfate (as SO4)	mg/L	0.3	
sulfide, total (as S)	mg/L	0.0015	
sulfide, total (as H2S)	mg/L	0.0016	
Total Metals (Matrix: Water)			
aluminum, total	mg/L	0.003	
antimony, total	mg/L	0.0001	
arsenic, total	mg/L	0.0001	
barium, total	mg/L	0.0001	
beryllium, total	mg/L	0.0001	
bismuth, total	mg/L	0.00005	
boron, total	mg/L	0.01	
cadmium, total	mg/L	0.000005	
calcium, total	mg/L	0.05	
chromium, total	mg/L	0.0005	
cobalt, total	mg/L	0.0001	
copper, total	mg/L	0.0005	
iron, total	mg/L	0.01	
lead, total	mg/L	0.00005	
lithium, total	mg/L	0.001	
magnesium, total	mg/L	0.1	
manganese, total	mg/L	0.0001	
mercury, total	mg/L	0.000005	
molybdenum, total	mg/L	0.00005	
nickel, total	mg/L	0.0005	
phosphorus, total	mg/L	0.3	
potassium, total	mg/L	0.05	
selenium, total	mg/L	0.00005	
silicon, total	mg/L	0.1	
silver, total	mg/L	0.00001	
sodium, total	mg/L	0.05	
strontium, total	mg/L	0.0002	
thallium, total	mg/L	0.00001	
tin, total	mg/L	0.0001	
titanium, total	mg/L	0.01	
uranium, total	mg/L	0.00001	
vanadium, total	mg/L	0.0005	
zinc, total	mg/L	0.003	

Table D2-3. Field blank and trip blank analytical results

Client Sample ID			
Date Sampled			
Time Sampled			
ALS Sample ID			
Dissolved Metals (Matrix: Water)			
aluminum, dissolved	mg/L	0.001	
antimony, dissolved	mg/L	0.0001	
arsenic, dissolved	mg/L	0.0001	
barium, dissolved	mg/L	0.0001	
beryllium, dissolved	mg/L	0.0001	
bismuth, dissolved	mg/L	0.00005	
boron, dissolved	mg/L	0.01	
cadmium, dissolved	mg/L	0.000005	
calcium, dissolved	mg/L	0.05	
chromium, dissolved	mg/L	0.0005	
cobalt, dissolved	mg/L	0.0001	
copper, dissolved	mg/L	0.0002	
iron, dissolved	mg/L	0.01	
lead, dissolved	mg/L	0.00005	
lithium, dissolved	mg/L	0.001	
magnesium, dissolved	mg/L	0.1	
manganese, dissolved	mg/L	0.0001	
mercury, dissolved	mg/L	0.000005	
molybdenum, dissolved	mg/L	0.00005	
nickel, dissolved	mg/L	0.0005	
phosphorus, dissolved	mg/L	0.3	
potassium, dissolved	mg/L	0.05	
selenium, dissolved	mg/L	0.00005	
silicon, dissolved	mg/L	0.05	
silver, dissolved	mg/L	0.00001	
sodium, dissolved	mg/L	0.05	
strontium, dissolved	mg/L	0.0002	
thallium, dissolved	mg/L	0.00001	
tin, dissolved	mg/L	0.0001	
titanium, dissolved	mg/L	0.01	
uranium, dissolved	mg/L	0.00001	
vanadium, dissolved	mg/L	0.0005	
zinc, dissolved	mg/L	0.001	
dissolved mercury filtration location			
dissolved metals filtration location			
Aggregate Organics (Matrix: Water)			
chemical oxygen demand [COD]	mg/L	20	

Notes:

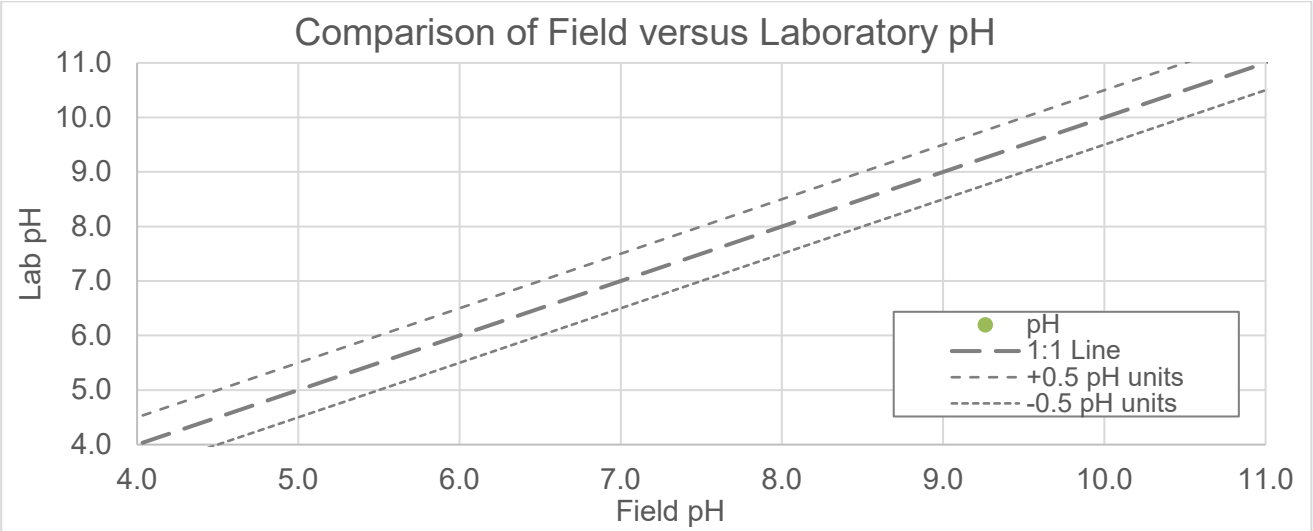
Bolded values indicate a detected value <2x the LDL.

White text on black fill indicates that the detected value is ≥2x the LDL.

Table D2-4. Samples with Ratios of Dissolved to Total Metals Concentrations Greater than 120%

Sample ID	Date Sample	Parameter Code	Ratio of D/T
BJ-GW18-17A-Snap	23-May-2021	K-D	130%

Notes:
Ratio of dissolved concentration to total concentration (D/T) greater than 120% for metals parameters with dissolved or total concentration >5x RDL for metal



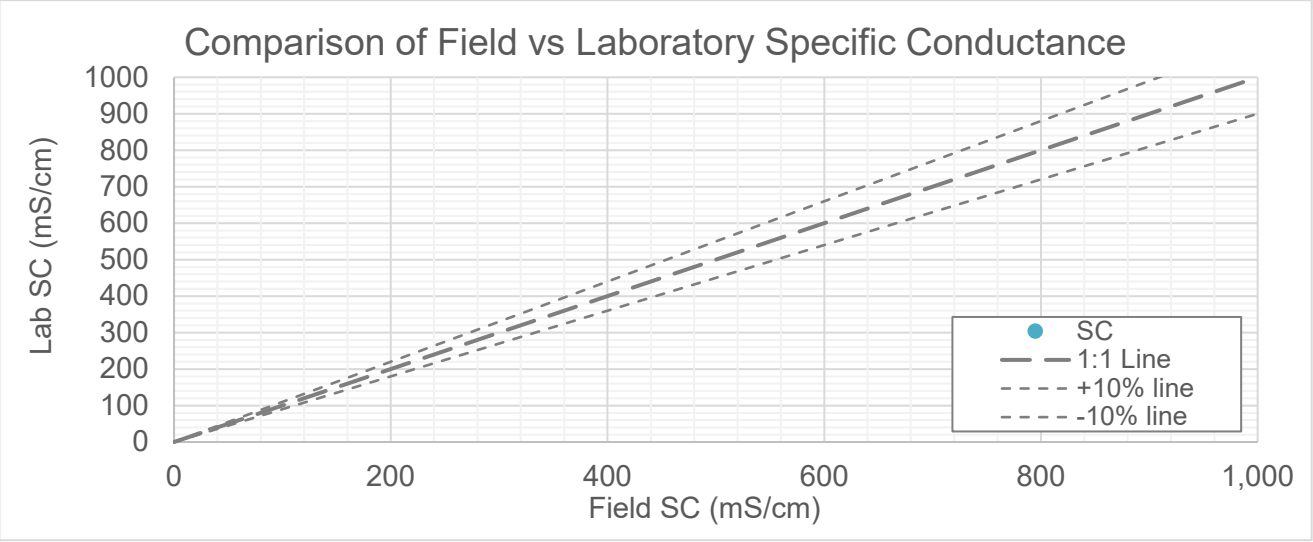


Figure D2-1: Comparison of field and laboratory pH and specific conductance for sQ2 samples

Table D3-1. Charge Balance Error

Lab Sample ID	Sample ID	Sample Date	Charge Balance Error (%)	Comments
VA21C4383-001	BJ-GW11-1A - E303054	31-Oct-2021	-2%	
VA21C3094-001	BJ-GW12-8A-snap	17-Oct-2021	0%	SNAP
VA21C3094-002	BJ-GW12-8A-E303059	17-Oct-2021	1%	
VA21C3094-003	BJ-GW12-8B-snap	17-Oct-2021	1%	SNAP
VA21C3094-004	BJ-GW12-8B-E314695	17-Oct-2021	0%	
VA21C3093-001	BJ-GW12-11A-E303062	16-Oct-2021	1%	
VA21C2526-001	BJ-GW18-17A-94	08-Oct-2021	**-37%**	Equip Blank
VA21C2526-002	BJ-GW18-17A-E303066	08-Oct-2021	4%	
VA21C2526-003	BJ-GW18-23B-E314691	09-Oct-2021	3%	
VA21C2526-004	BJ-GW18-23B-99	09-Oct-2021	**-49%**	Field Blank
VA21C2526-005	BJ-GW16-5B-CWP	10-Oct-2021	0%	
VA21C2526-006	BJ-GW16-5A-CWP	10-Oct-2021	-1%	
VA21C2526-007	BJ-GW18-23A-E314690	11-Oct-2021	3%	
VA21C1212-001	BJ-GW11-3A - E303056	23-Sep-2021	-4%	
VA21C1212-002	BJ-GW11-3B - E314693	23-Sep-2021	-4%	
VA21C0998-001	BJ-GW11-3A - Snap	22-Sep-2021	-4%	SNAP
VA21C0574-001	BJ-GW12-9B - E314696	17-Sep-2021	2%	
VA21C0275-001	BJ-GW18-17B - E314701	15-Sep-2021	**-5%**	
VA21C0111-001	BJ-GW18-17B - Snap	14-Sep-2021	0%	SNAP
VA21C0110-001	BJ-GW14-14B - E314700	14-Sep-2021	-4%	
VA21C0110-002	BJ-GW14-14B- 99	14-Sep-2021	**-47%**	Field Blank
VA21C0110-003	BJ-GW14-14A - E303065	14-Sep-2021	-2%	
VA21C0110-004	BJ-GW14-14A - 98	14-Sep-2021	-2%	Duplicate
VA21B9857-001	BJ-GW18-18B - snap	11-Sep-2021	2%	SNAP
VA21B9857-002	BJ-GW18-18B - E314702	11-Sep-2021	1%	
VA21B7639-001	BJ-GW18-19B - E314703	18-Aug-2021	-2%	

Notes:

1. Bold red text indicates charge balance error is greater than 5% or less than -5%.
2. Red text with red background indicates charge balance error is greater than 10% or less than -10%.

Table D3-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW12-8B - E314695	BJ-GW12-8B - 98	RPD
Date Sampled			27-May-2021	27-May-2021	
ALS Sample ID			VA21B0558-002	VA21B0558-003	
Parameter	**Units**	**Lowest Detection Limit**	Sub-Matrix: Groundwater	Sub-Matrix: Groundwater	
Physical Tests (Matrix: Water)					
conductivity	µS/cm	2.0	269	269	0%
acidity (as CaCO3)	mg/L	1.00	<2.0	<2.0	-
alkalinity, total (as CaCO3)	mg/L	2.00	90.4	89.3	1%
hardness (as CaCO3), dissolved	mg/L	0.6	81.6	81.5	0%
hardness (as CaCO3), from total Ca/Mg	mg/L	1	82.8	84.6	2%
pH	pH units	0.10	8.29	8.29	0%
solids, total dissolved [TDS]	mg/L	10.0	170	171	1%
solids, total suspended [TSS]	mg/L	3.00	9.2	3.8	-
turbidity	NTU	0.10	2.27	2.29	1%
Anions and Nutrients (Matrix: Water)					
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050	<0.050	-
ammonia, total (as N)	mg/L	0.005	0.0392	0.0408	4%
bromide	mg/L	0.05	<0.050	<0.050	-
chloride	mg/L	0.5	<0.50	<0.50	-
fluoride	mg/L	0.02	0.109	0.11	1%
nitrate (as N)	mg/L	0.005	<0.0050	<0.0050	-
nitrate + nitrite (as N)	mg/L	0.005	<0.0051	<0.0051	-
nitrite (as N)	mg/L	0.001	<0.0010	<0.0010	-
nitrogen, total	mg/L	0.03	0.045	0.045	-
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.003	0.003	-
phosphorus, total	mg/L	0.002	0.009	0.0095	-
sulfate (as SO4)	mg/L	0.3	45.2	45.2	0%
sulfide, total (as S)	mg/L	0.0015	0.0	0.0	6%
sulfide, total (as H2S)	mg/L	0.0016	0.0	0.0	5%
Total Metals (Matrix: Water)					
aluminum, total	mg/L	0.003	0.146	0.136	7%
antimony, total	mg/L	0.0001	0.0002	0.00019	-
arsenic, total	mg/L	0.0001	0.00424	0.00436	3%
barium, total	mg/L	0.0001	0.0254	0.0258	2%
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	-
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	-
boron, total	mg/L	0.01	0.087	0.089	2%
cadmium, total	mg/L	0.000005	0.0000077	0.0000092	-
calcium, total	mg/L	0.05	25.4	26.2	3%
chromium, total	mg/L	0.0005	0.00085	0.00082	-
cobalt, total	mg/L	0.0001	<0.00010	<0.00010	-
copper, total	mg/L	0.0005	<0.00050	<0.00050	-
iron, total	mg/L	0.01	0.178	0.177	1%
lead, total	mg/L	0.00005	0.000493	0.000566	**14%**
lithium, total	mg/L	0.001	0.0476	0.0479	1%
magnesium, total	mg/L	0.1	4.7	4.67	1%
manganese, total	mg/L	0.0001	0.0499	0.0494	1%
mercury, total	mg/L	0.000005	<0.0000050	<0.0000050	-
molybdenum, total	mg/L	0.00005	0.0016	0.00166	4%
nickel, total	mg/L	0.0005	<0.00050	<0.00050	-
phosphorus, total	mg/L	0.3	<0.300	<0.300	-
potassium, total	mg/L	0.05	1.56	1.56	0%
selenium, total	mg/L	0.00005	<0.000050	<0.000050	-
silicon, total	mg/L	0.1	3.98	3.96	1%
silver, total	mg/L	0.00001	<0.000010	<0.000010	-
sodium, total	mg/L	0.05	22.1	22.2	0%
strontium, total	mg/L	0.0002	2.49	2.54	2%
thallium, total	mg/L	0.00001	0.000025	0.000026	-
tin, total	mg/L	0.0001	0.000	0.000	-
titanium, total	mg/L	0.01	<0.0100	<0.0100	-
uranium, total	mg/L	0.00001	0.000152	0.000152	0%
vanadium, total	mg/L	0.0005	<0.00050	<0.00050	-
zinc, total	mg/L	0.003	<0.0030	<0.0030	-

Table D3-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW12-8B - E314695	BJ-GW12-8B - 98	RPD
Date Sampled			27-May-2021	27-May-2021	
ALS Sample ID			VA21B0558-002	VA21B0558-003	
Dissolved Metals (Matrix: Water)					
aluminum, dissolved	mg/L	0.001	0.0025	0.0023	-
antimony, dissolved	mg/L	0.0001	0.00013	0.00012	-
arsenic, dissolved	mg/L	0.0001	0.004	0.00388	3%
barium, dissolved	mg/L	0.0001	0.0214	0.0221	3%
beryllium, dissolved	mg/L	0.0001	<0.000100	<0.000100	-
bismuth, dissolved	mg/L	0.00005	<0.000050	<0.000050	-
boron, dissolved	mg/L	0.01	0.077	0.08	4%
cadmium, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	-
calcium, dissolved	mg/L	0.05	25	25.1	0%
chromium, dissolved	mg/L	0.0005	<0.00050	<0.00050	-
cobalt, dissolved	mg/L	0.0001	<0.00010	<0.00010	-
copper, dissolved	mg/L	0.0002	<0.00020	<0.00020	-
iron, dissolved	mg/L	0.01	0.02900	0.02800	-
lead, dissolved	mg/L	0.00005	<0.000050	<0.000050	-
lithium, dissolved	mg/L	0.001	0.0471	0.0481	2%
magnesium, dissolved	mg/L	0.1	4.65	4.57	2%
manganese, dissolved	mg/L	0.0001	0.048	0.0462	4%
mercury, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	-
molybdenum, dissolved	mg/L	0.00005	0.00156	0.00161	3%
nickel, dissolved	mg/L	0.0005	<0.00050	<0.00050	-
phosphorus, dissolved	mg/L	0.3	<0.300	<0.300	-
potassium, dissolved	mg/L	0.05	1.57	1.56	1%
selenium, dissolved	mg/L	0.00005	<0.000050	<0.000050	-
silicon, dissolved	mg/L	0.05	3.52	3.58	2%
silver, dissolved	mg/L	0.00001	<0.000010	<0.000010	-
sodium, dissolved	mg/L	0.05	23.1	22.7	2%
strontium, dissolved	mg/L	0.0002	2.44	2.51	3%
thallium, dissolved	mg/L	0.00001	<0.000010	<0.000010	-
tin, dissolved	mg/L	0.0001	<0.00010	<0.00010	-
titanium, dissolved	mg/L	0.01	<0.0100	<0.0100	-
uranium, dissolved	mg/L	0.00001	0.00009	0.000096	6%
vanadium, dissolved	mg/L	0.0005	<0.00050	<0.00050	-
zinc, dissolved	mg/L	0.001	<0.0010	<0.0010	-
Aggregate Organics (Matrix: Water)					
Chemical Oxygen Demand [COD]	mg/L	20	<20	<20	-

Notes:

1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less th

2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%. -

3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.

Table D3-3. Field blank and trip blank analytical results

Client Sample ID			BJ-GW14-14B- 99		BJ-GW18-23B-99
Date Sampled			14-Sep-2021		09-Oct-2021
Time Sampled			11:00		11:20
ALS Sample ID			VA21C0110-002		VA21C2526-004
Analyte	Units	Lowest Detection Limit	Sub-Matrix: Groundwater	Lowest Detection Limit	Sub-Matrix: Groundwater
Physical Tests (Matrix: Water)					
conductivity	µS/cm	2	<2.0	2.0	<2.0
acidity (as CaCO3)	mg/L	2	**2.1**	2.0	<2.0
alkalinity, total (as CaCO3)	mg/L	1	<1.0	1.0	1.1
hardness (as CaCO3), dissolved	mg/L	0.5	<0.50	0.50	<0.50
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	<0.50	0.50	<0.50
pH	pH units	0.1	5.83	0.10	6.19
solids, total dissolved [TDS]	mg/L	10	<10	10	<10
solids, total suspended [TSS]	mg/L	3	<3.0	3.0	<3.0
turbidity	NTU	0.1	<0.10	0.10	<0.10
Anions and Nutrients (Matrix: Water)					
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050	0.050	<0.050
ammonia, total (as N)	mg/L	0.005	<0.0050	0.0050	<0.0050
bromide	mg/L	0.05	<0.050	0.050	<0.050
chloride	mg/L	0.5	<0.50	0.50	<0.50
fluoride	mg/L	0.02	<0.020	0.020	<0.020
nitrate (as N)	mg/L	0.005	<0.0050	0.0050	<0.0050
nitrate + nitrite (as N)	mg/L	0.005	<0.0051	0.0050	<0.0051
nitrite (as N)	mg/L	0.001	<0.0010	0.0010	<0.0010
nitrogen, total	mg/L	0.03	<0.030	0.030	<0.030
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.0010	0.0010	<0.0010
phosphorus, total	mg/L	0.002	<0.0020	0.0020	<0.0020
sulfate (as SO4)	mg/L	0.3	<0.30	0.30	<0.30
sulfide, total (as S)	mg/L	0.0015	<0.0015	0.0015	<0.0015
sulfide, total (as H2S)	mg/L	0.0016	<0.0016	0.0016	<0.0016
Total Metals (Matrix: Water)					
aluminum, total	mg/L	0.003	<0.0030	0.0030	<0.0030
antimony, total	mg/L	0.0001	<0.00010	0.00010	<0.00010
arsenic, total	mg/L	0.0001	<0.00010	0.00010	<0.00010
barium, total	mg/L	0.0001	<0.00010	0.00010	<0.00010
beryllium, total	mg/L	0.0001	<0.000100	0.000100	<0.000100
bismuth, total	mg/L	0.00005	<0.000050	0.000050	<0.000050
boron, total	mg/L	0.01	<0.010	0.010	<0.010
cadmium, total	mg/L	0.000005	<0.0000050	0.0000050	<0.0000050
calcium, total	mg/L	0.05	<0.050	0.050	<0.050
chromium, total	mg/L	0.0005	<0.00050	0.00050	<0.00050
cobalt, total	mg/L	0.0001	<0.00010	0.00010	<0.00010
copper, total	mg/L	0.0005	<0.00050	0.00050	<0.00050
iron, total	mg/L	0.01	<0.010	0.010	<0.010
lead, total	mg/L	0.00005	<0.000050	0.000050	<0.000050
lithium, total	mg/L	0.001	<0.0010	0.0010	<0.0010
magnesium, total	mg/L	0.1	<0.100	0.100	<0.100
manganese, total	mg/L	0.0001	<0.00010	0.00010	<0.00010
mercury, total	mg/L	0.000005	<0.0000050	0.0000050	<0.0000050
molybdenum, total	mg/L	0.00005	<0.000050	0.000050	<0.000050
nickel, total	mg/L	0.0005	<0.00050	0.00050	<0.00050
phosphorus, total	mg/L	0.3	<0.300	0.300	<0.300
potassium, total	mg/L	0.05	<0.050	0.050	<0.050
selenium, total	mg/L	0.00005	<0.000050	0.000050	<0.000050
silicon, total	mg/L	0.1	<0.10	0.10	<0.10
silver, total	mg/L	0.00001	<0.000010	0.000010	<0.000010
sodium, total	mg/L	0.05	<0.050	0.050	<0.050
strontium, total	mg/L	0.0002	<0.00020	0.00020	<0.00020
thallium, total	mg/L	0.00001	<0.000010	0.000010	<0.000010
tin, total	mg/L	0.0001	<0.00010	0.00010	<0.00010
titanium, total	mg/L	0.01	<0.0100	0.0100	<0.0100
uranium, total	mg/L	0.00001	<0.000010	0.000010	<0.000010
vanadium, total	mg/L	0.0005	<0.00050	0.00050	<0.00050
zinc, total	mg/L	0.003	<0.0030	0.0030	<0.0030

Table D3-3. Field blank and trip blank analytical results

Client Sample ID			BJ-GW14-14B- 99		BJ-GW18-23B-99
Date Sampled			14-Sep-2021		09-Oct-2021
Time Sampled			11:00		11:20
ALS Sample ID			VA21C0110-002		VA21C2526-004
Analyte	Units	Lowest Detection Limit	Sub-Matrix: Groundwater	Lowest Detection Limit	Sub-Matrix: Groundwater
Dissolved Metals (Matrix: Water)					
aluminum, dissolved	mg/L	0.001	<0.0010	0.0010	<0.0010
antimony, dissolved	mg/L	0.0001	<0.00010	0.00010	<0.00010
arsenic, dissolved	mg/L	0.0001	<0.00010	0.00010	<0.00010
barium, dissolved	mg/L	0.0001	0.001	0.00010	<0.00010
beryllium, dissolved	mg/L	0.0001	<0.000100	0.000100	<0.000100
bismuth, dissolved	mg/L	0.00005	<0.000050	0.000050	<0.000050
boron, dissolved	mg/L	0.01	<0.010	0.010	<0.010
cadmium, dissolved	mg/L	0.000005	<0.0000050	0.0000050	<0.0000050
calcium, dissolved	mg/L	0.05	<0.050	0.050	<0.050
chromium, dissolved	mg/L	0.0005	<0.00050	0.00050	<0.00050
cobalt, dissolved	mg/L	0.0001	<0.00010	0.00010	<0.00010
copper, dissolved	mg/L	0.0002	0.00063	0.00020	<0.00020
iron, dissolved	mg/L	0.01	<0.010	0.010	<0.010
lead, dissolved	mg/L	0.00005	<0.000050	0.000050	<0.000050
lithium, dissolved	mg/L	0.001	<0.0010	0.0010	<0.0010
magnesium, dissolved	mg/L	0.1	<0.100	0.100	<0.100
manganese, dissolved	mg/L	0.0001	<0.00010	0.00010	<0.00010
mercury, dissolved	mg/L	0.000005	<0.0000050	0.0000050	<0.0000050
molybdenum, dissolved	mg/L	0.00005	<0.000050	0.000050	<0.000050
nickel, dissolved	mg/L	0.0005	<0.00050	0.00050	<0.00050
phosphorus, dissolved	mg/L	0.3	<0.300	0.300	<0.300
potassium, dissolved	mg/L	0.05	<0.050	0.050	<0.050
selenium, dissolved	mg/L	0.00005	<0.000050	0.000050	<0.000050
silicon, dissolved	mg/L	0.05	<0.050	0.050	<0.050
silver, dissolved	mg/L	0.00001	<0.000010	0.000010	<0.000010
sodium, dissolved	mg/L	0.05	<0.050	0.050	<0.050
strontium, dissolved	mg/L	0.0002	<0.00020	0.00020	<0.00020
thallium, dissolved	mg/L	0.00001	<0.000010	0.000010	<0.000010
tin, dissolved	mg/L	0.0001	<0.00010	0.00010	<0.00010
titanium, dissolved	mg/L	0.01	<0.0100	0.0100	<0.0100
uranium, dissolved	mg/L	0.00001	<0.000010	0.000010	<0.000010
vanadium, dissolved	mg/L	0.0005	<0.00050	0.00050	<0.00050
zinc, dissolved	mg/L	0.001	<0.0010	0.0010	<0.0010
dissolved mercury filtration location					
Aggregate Organics (Matrix: Water)					
chemical oxygen demand [COD]	mg/L	20	<20	20	<20

Notes:

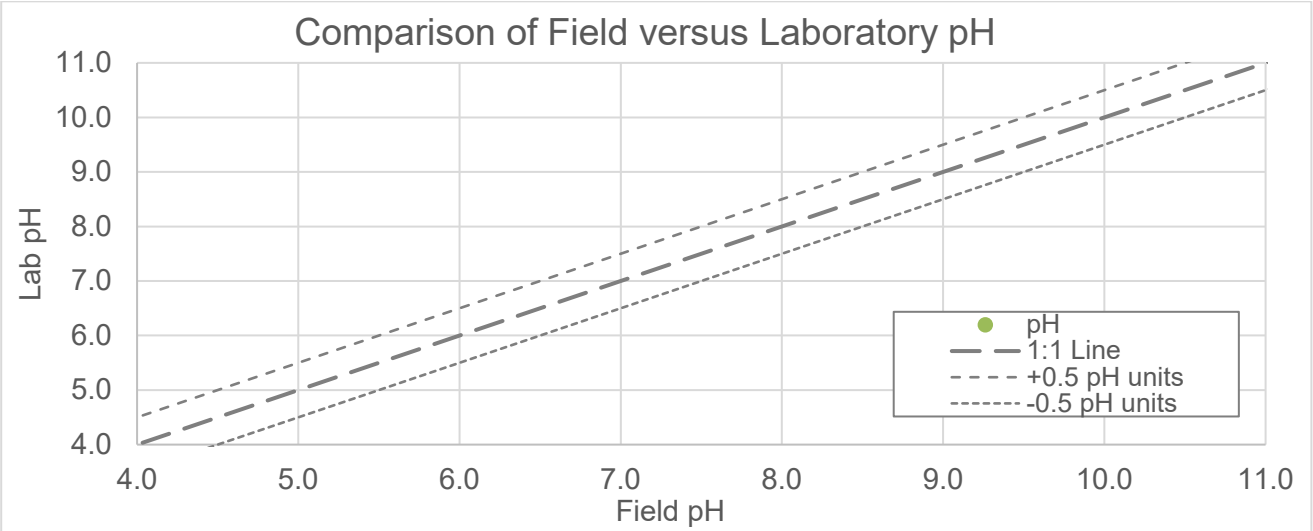
Bolded values indicate a detected value <2x the LDL.

White text on black fill indicates that the detected value is ≥2x the LDL.

Table D3-4. Samples with Ratios of Dissolved to Total Metals Concentrations Greater than 120%

Sample ID	Date Sample	Parameter Code	Ratio of D/T
None identified			

Notes:
Ratio of dissolved concentration to total concentration (D/T) greater than 120% for metals parameters with dissolved or total concentration >5x RDL for metal



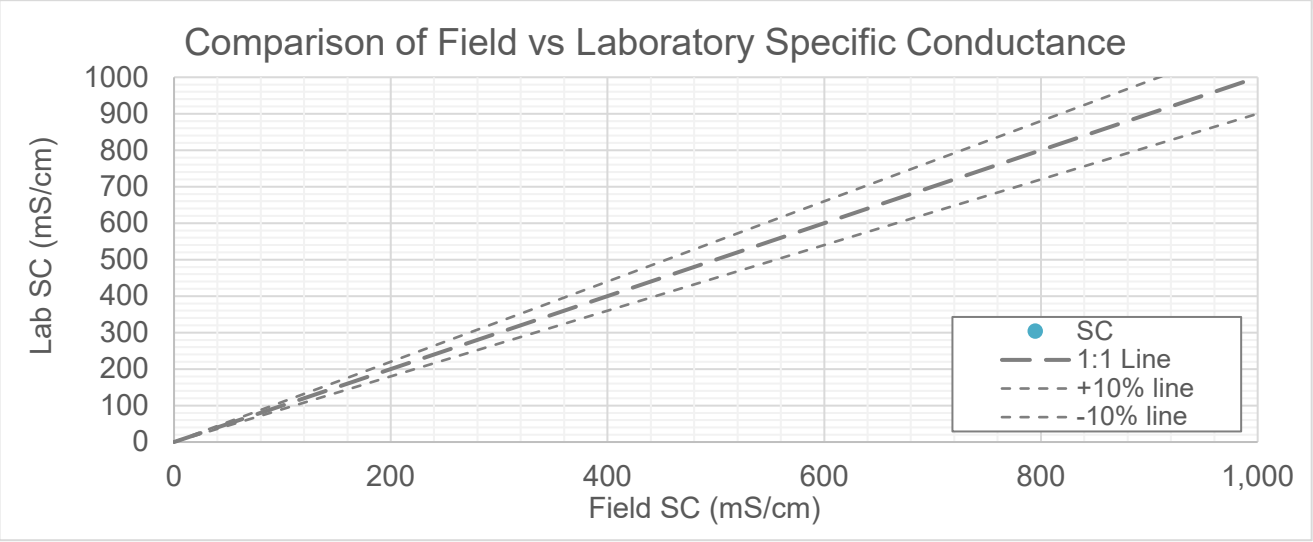


Figure D3-1: Comparison of field versus laboratory pH and specific conductance for sQ3 samples.

Table D4-1. Charge Balance Error

Lab Sample ID	Sample ID	Sample Date	Charge Balance Error (%)	Comments
VA21C5014-001	BJ-GW 18-18B -E314702	07-Nov-2021	-4%	
VA21C5536-001	BJ-GW18-23A-E314690	14-Nov-2021	-2%	
VA21C5536-002	BJ-GW16-5A-CWP	14-Nov-2021	-5%	
VA21C5605-001	BJ-GW18-23B-E314691	15-Nov-2021	-1%	
VA21C5605-002	BJ-GW16-5B-CWP	15-Nov-2021	-4%	
VA21C7213-001	BJ-GW11-3A-E303056	04-Dec-2021	-2%	
VA21C7213-002	BJ-GW11-3A-98	04-Dec-2021	-3%	Duplicate
VA22A1683-001	BJ-GW11-1A-99	26-Jan-2022	**-71%**	Field Blank
VA22A1683-002	BJ-GW11-1A-E303054	26-Jan-2022	-3%	
VA22A1795-001	BJ-GW12-8A-E303059	27-Jan-2022	4%	
VA22A1795-002	BJ-GW12-8B-E314695	27-Jan-2022	-1%	
VA22A1890-001	BJ-GW18-17A-E303066	29-Jan-2022	-4%	
VA22A1890-002	BJ-GW18-17B-E314701	29-Jan-2022	**-7%**	

Notes:

1. Bold red text indicates charge balance error is greater than 5% or less than -5%.
2. Red text with red background indicates charge balance error is greater than 10% or less than -10%.

Table D4-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW14-14A - E303065	BJ-GW14-14A - 98	RPD
Date Sampled			14-Sep-2021	14-Sep-2021	
ALS Sample ID			VA21C0110-003	VA21C0110-004	
Parameter	**Units**	**Lowest Detection Limit**	Sub-Matrix: Groundwater	Sub-Matrix: Groundwater	
Physical Tests (Matrix: Water)					
conductivity	µS/cm	2.0	365	361	1%
acidity (as CaCO3)	mg/L	1.00	<2.0	<2.0	<2xMDL
alkalinity, total (as CaCO3)	mg/L	2.00	97.8	99	1%
hardness (as CaCO3), dissolved	mg/L	0.6	164	162	1%
hardness (as CaCO3), from total Ca/Mg	mg/L	1	152	152	0%
pH	pH units	0.10	7.97	7.93	1%
solids, total dissolved [TDS]	mg/L	10.0	214	217	1%
solids, total suspended [TSS]	mg/L	3.00	20.9	<3.0	>2MDL
turbidity	NTU	0.10	5.8	3.96	38%
Anions and Nutrients (Matrix: Water)					
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050	<0.050	<2xMDL
ammonia, total (as N)	mg/L	0.005	0.0245	0.0246	<2xMDL
bromide	mg/L	0.05	<0.050	<0.050	<2xMDL
chloride	mg/L	0.5	<0.50	<0.50	<2xMDL
fluoride	mg/L	0.02	0.182	0.194	6%
nitrate (as N)	mg/L	0.005	<0.0050	<0.0050	<2xMDL
nitrate + nitrite (as N)	mg/L	0.005	<0.0051	<0.0051	<2xMDL
nitrite (as N)	mg/L	0.001	<0.0010	<0.0010	<2xMDL
nitrogen, total	mg/L	0.03	0.039	0.038	<2xMDL
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.0012	0.0014	<2xMDL
phosphorus, total	mg/L	0.002	0.0047	0.0078	<2xMDL
sulfate (as SO4)	mg/L	0.3	86.5	86.6	0%
sulfide, total (as S)	mg/L	0.0015	0.168	0.147	**13%**
sulfide, total (as H2S)	mg/L	0.0016	0.179	0.156	**14%**
Total Metals (Matrix: Water)					
aluminum, total	mg/L	0.003	0.0279	0.0176	45%
antimony, total	mg/L	0.0001	0.00158	0.00191	**19%**
arsenic, total	mg/L	0.0001	0.0188	0.0186	1%
barium, total	mg/L	0.0001	0.0256	0.0258	1%
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	<2xMDL
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	<2xMDL
boron, total	mg/L	0.01	0.042	0.041	<2xMDL
cadmium, total	mg/L	0.000005	0.0000086	0.0000098	<2xMDL
calcium, total	mg/L	0.05	53.8	53.9	0%
chromium, total	mg/L	0.0005	0.00061	0.00062	<2xMDL
cobalt, total	mg/L	0.0001	0.00022	0.00022	<2xMDL
copper, total	mg/L	0.0005	<0.00050	<0.00050	<2xMDL
iron, total	mg/L	0.01	0.582	0.565	3%
lead, total	mg/L	0.00005	0.000578	0.000567	2%
lithium, total	mg/L	0.001	0.0169	0.0166	2%
magnesium, total	mg/L	0.1	4.39	4.28	3%
manganese, total	mg/L	0.0001	0.302	0.288	5%
mercury, total	mg/L	0.000005	<0.0000050	<0.0000050	<2xMDL
molybdenum, total	mg/L	0.00005	0.000919	0.000892	3%
nickel, total	mg/L	0.0005	0.00071	0.00065	<2xMDL
phosphorus, total	mg/L	0.3	<0.300	<0.300	<2xMDL
potassium, total	mg/L	0.05	1.52	1.48	3%
selenium, total	mg/L	0.00005	<0.000050	<0.000050	<2xMDL
silicon, total	mg/L	0.1	3.69	3.77	2%
silver, total	mg/L	0.00001	<0.000010	0.000021	<2xMDL
sodium, total	mg/L	0.05	7.11	6.95	2%
strontium, total	mg/L	0.0002	1.13	1.14	1%
thallium, total	mg/L	0.00001	<0.000010	<0.000010	<2xMDL
tin, total	mg/L	0.0001	<0.00010	<0.00010	<2xMDL
titanium, total	mg/L	0.01	<0.0100	<0.0100	<2xMDL
uranium, total	mg/L	0.00001	0.000135	0.000131	3%
vanadium, total	mg/L	0.0005	<0.00050	<0.00050	<2xMDL
zinc, total	mg/L	0.003	0.0045	0.0041	<2xMDL

Table D4-2. Field duplicate Relative Percent Difference (RPD) Values

Sample ID			BJ-GW14-14A - E303065	BJ-GW14-14A - 98	**RPD**
Date Sampled			14-Sep-2021	14-Sep-2021	
ALS Sample ID			VA21C0110-003	VA21C0110-004	
Dissolved Metals (Matrix: Water)					
aluminum, dissolved	mg/L	0.001	0.0035	0.0032	<2xMDL
antimony, dissolved	mg/L	0.0001	0.00092	0.00096	4%
arsenic, dissolved	mg/L	0.0001	0.0176	0.0174	1%
barium, dissolved	mg/L	0.0001	0.026	0.0256	2%
beryllium, dissolved	mg/L	0.0001	<0.000100	<0.000100	<2xMDL
bismuth, dissolved	mg/L	0.00005	<0.000050	<0.000050	<2xMDL
boron, dissolved	mg/L	0.01	0.041	0.039	<2xMDL
cadmium, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	<2xMDL
calcium, dissolved	mg/L	0.05	58.2	57.6	1%
chromium, dissolved	mg/L	0.0005	0.00015	0.00013	<2xMDL
cobalt, dissolved	mg/L	0.0001	0.00013	0.00012	<2xMDL
copper, dissolved	mg/L	0.0002	<0.00020	<0.00020	<2xMDL
iron, dissolved	mg/L	0.01	0.549	0.54	2%
lead, dissolved	mg/L	0.00005	<0.000050	<0.000050	<2xMDL
lithium, dissolved	mg/L	0.001	0.0161	0.0156	3%
magnesium, dissolved	mg/L	0.1	4.5	4.38	3%
manganese, dissolved	mg/L	0.0001	0.293	0.285	3%
mercury, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	<2xMDL
molybdenum, dissolved	mg/L	0.00005	0.000902	0.00083	8%
nickel, dissolved	mg/L	0.0005	<0.00050	<0.00050	<2xMDL
phosphorus, dissolved	mg/L	0.3	<0.300	<0.300	<2xMDL
potassium, dissolved	mg/L	0.05	1.5	1.45	3%
selenium, dissolved	mg/L	0.00005	0.000166	0.00017	<2xMDL
silicon, dissolved	mg/L	0.05	3.62	3.66	1%
silver, dissolved	mg/L	0.00001	<0.000010	<0.000010	<2xMDL
sodium, dissolved	mg/L	0.05	7.4	7.21	3%
strontium, dissolved	mg/L	0.0002	1.13	1.13	0%
thallium, dissolved	mg/L	0.00001	<0.000010	<0.000010	<2xMDL
tin, dissolved	mg/L	0.0001	<0.00010	<0.00010	<2xMDL
titanium, dissolved	mg/L	0.01	<0.0100	<0.0100	<2xMDL
uranium, dissolved	mg/L	0.00001	0.000127	0.000127	0%
vanadium, dissolved	mg/L	0.0005	<0.00050	<0.00050	<2xMDL
zinc, dissolved	mg/L	0.001	0.0012	<0.0010	<2xMDL
Aggregate Organics (Matrix: Water)					
Chemical Oxygen Demand [COD]	mg/L	20	<20	<20	<2xMDL

Notes:

1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.

2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.

3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.

Table D4-3. Field blank and trip blank analytical results

Client Sample ID			BJ-GW11-1A-99		Travel Blank
Date Sampled			26-Jan-2022		27-Jan-2022
Time Sampled			12:35		08:30
ALS Sample ID			VA22A1683-001		VA22A1795-003
Analyte	Units	Lowest Detection Limit	Sub-Matrix: Groundwater	Lowest Detection Limit	Sub-Matrix: Water
Physical Tests (Matrix: Water)					
conductivity	µS/cm	2	<2.0	2	<2.0
acidity (as CaCO3)	mg/L	2	**2.3**	2	**2.7**
alkalinity, total (as CaCO3)	mg/L	1	<1.0	1	**1.1**
hardness (as CaCO3), dissolved	mg/L	0.5	<0.50	0.5	
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	<0.50	0.5	<0.50
pH	pH units	0.1	5.25	0.1	5.71
solids, total dissolved [TDS]	mg/L	10	<10	10	<10
solids, total suspended [TSS]	mg/L	3	<3.0	3	<3.0
turbidity	NTU	0.1	<0.10	0.1	<0.10
Anions and Nutrients (Matrix: Water)					
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050	0.05	<0.050
ammonia, total (as N)	mg/L	0.005	<0.0050	0.005	<0.0050
bromide	mg/L	0.05	<0.050	0.05	<0.050
chloride	mg/L	0.5	<0.50	0.5	<0.50
fluoride	mg/L	0.02	<0.020	0.02	<0.020
nitrate (as N)	mg/L	0.005	<0.0050	0.005	<0.0050
nitrate + nitrite (as N)	mg/L	0.005	<0.0051	0.005	<0.0051
nitrite (as N)	mg/L	0.001	<0.0010	0.001	<0.0010
nitrogen, total	mg/L	0.03	<0.030	0.03	<0.030
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.0010	0.001	<0.0010
phosphorus, total	mg/L	0.002	<0.0020	0.002	<0.0020
sulfate (as SO4)	mg/L	0.3	<0.30	0.3	<0.30
sulfide, total (as S)	mg/L	0.0015	<0.010	0.0015	<0.0015
sulfide, total (as H2S)	mg/L	0.0016	<0.011	0.0016	<0.0016
Total Metals					
aluminum, total	mg/L	0.003	<0.0030	0.003	<0.0030
antimony, total	mg/L	0.0001	<0.00010	0.0001	<0.00010
arsenic, total	mg/L	0.0001	<0.00010	0.0001	<0.00010
barium, total	mg/L	0.0001	<0.00010	0.0001	<0.00010
beryllium, total	mg/L	0.0001	<0.000020	0.00002	<0.000020
bismuth, total	mg/L	0.00005	<0.000050	0.00005	<0.000050
boron, total	mg/L	0.01	<0.010	0.01	<0.010
cadmium, total	mg/L	0.000005	<0.0000050	0.000005	<0.0000050
calcium, total	mg/L	0.05	<0.050	0.05	<0.050
chromium, total	mg/L	0.0005	<0.00010	0.0001	<0.00010
cobalt, total	mg/L	0.0001	<0.00010	0.0001	<0.00010
copper, total	mg/L	0.0005	<0.00050	0.0005	<0.00050
iron, total	mg/L	0.01	<0.010	0.01	<0.010
lead, total	mg/L	0.00005	<0.000050	0.00005	<0.000050
lithium, total	mg/L	0.001	<0.0010	0.001	<0.0010
magnesium, total	mg/L	0.1	<0.0050	0.005	<0.0050
manganese, total	mg/L	0.0001	<0.00010	0.0001	<0.00010
mercury, total	mg/L	0.000005	<0.0000050	0.000005	
molybdenum, total	mg/L	0.00005	<0.000050	0.00005	<0.000050
nickel, total	mg/L	0.0005	<0.00050	0.0005	<0.00050
phosphorus, total	mg/L	0.3	<0.050	0.05	<0.050
potassium, total	mg/L	0.05	<0.050	0.05	<0.050
selenium, total	mg/L	0.00005	<0.000050	0.00005	<0.000050
silicon, total	mg/L	0.1	<0.10	0.1	<0.10
silver, total	mg/L	0.00001	<0.000010	0.00001	<0.000010
sodium, total	mg/L	0.05	<0.050	0.0002	<0.050
strontium, total	mg/L	0.0002	<0.00020	0.5	<0.00020
thallium, total	mg/L	0.00001	<0.000010	0.00001	<0.000010
tin, total	mg/L	0.0001	<0.00010	0.0001	<0.00010
titanium, total	mg/L	0.01	<0.00030	0.0003	<0.00030
uranium, total	mg/L	0.00001	<0.000010	0.00001	<0.000010
vanadium, total	mg/L	0.0005	<0.00050	0.0005	<0.00050
zinc, total	mg/L	0.003	<0.0030	0.003	<0.0030

Table D4-3. Field blank and trip blank analytical results

Client Sample ID			BJ-GW11-1A-99		Travel Blank
Date Sampled			26-Jan-2022		27-Jan-2022
Time Sampled			12:35		08:30
ALS Sample ID			VA22A1683-001		VA22A1795-003
dissolved metals					
aluminum, dissolved	mg/L	0.001	<0.0010		
antimony, dissolved	mg/L	0.0001	<0.00010		
arsenic, dissolved	mg/L	0.0001	<0.00010		
barium, dissolved	mg/L	0.0001	<0.00010		
beryllium, dissolved	mg/L	0.0001	<0.000020		
bismuth, dissolved	mg/L	0.00005	<0.000050		
boron, dissolved	mg/L	0.01	<0.010		
cadmium, dissolved	mg/L	0.000005	<0.0000050		
calcium, dissolved	mg/L	0.05	<0.050		
chromium, dissolved	mg/L	0.0005	<0.00010		
cobalt, dissolved	mg/L	0.0001	<0.00010		
copper, dissolved	mg/L	0.0002	<0.00020		
iron, dissolved	mg/L	0.01	<0.010		
lead, dissolved	mg/L	0.00005	<0.000050		
lithium, dissolved	mg/L	0.001	<0.0010		
magnesium, dissolved	mg/L	0.1	<0.0050		
manganese, dissolved	mg/L	0.0001	<0.00010		
mercury, dissolved	mg/L	0.000005	<0.0000050		
molybdenum, dissolved	mg/L	0.00005	<0.000050		
nickel, dissolved	mg/L	0.0005	<0.00050		
phosphorus, dissolved	mg/L	0.3	<0.050		
potassium, dissolved	mg/L	0.05	<0.050		
selenium, dissolved	mg/L	0.00005	<0.000050		
silicon, dissolved	mg/L	0.05	<0.050		
silver, dissolved	mg/L	0.00001	<0.000010		
sodium, dissolved	mg/L	0.05	<0.050		
strontium, dissolved	mg/L	0.0002	<0.00020		
thallium, dissolved	mg/L	0.00001	<0.000010		
tin, dissolved	mg/L	0.0001	<0.00010		
titanium, dissolved	mg/L	0.01	<0.00030		
uranium, dissolved	mg/L	0.00001	<0.000010		
vanadium, dissolved	mg/L	0.0005	<0.00050		
zinc, dissolved	mg/L	0.001	<0.0010		
dissolved mercury filtration location					
dissolved metals filtration location					
Aggregate Organics (Matrix: Water)					
chemical oxygen demand [COD]	mg/L	20	<20	20	<20

Notes:

Bolded values indicate a detected value <2x the LDL.

White text on black fill indicates that the detected value is ≥2x the LDL.

Table D4-4. Samples with Ratios of Dissolved to Total Metals Concentrations Greater than 120%

Sample ID	Date Sample	Parameter Code	Ratio of D/T
BJ-GW18-23A-E314690	14-Nov-2021	SE-D	201%
BJ-GW16-5A-CWP	14-Nov-2021	MO-D	123%
BJ-GW16-5B-CWP	15-Nov-2021	ZN-D	129%
BJ-GW12-8B-E314695	27-Jan-2022	CU-D	124%
BJ-GW18-17A-E303066	29-Jan-2022	SE-D	630%

Notes:
Ratio of dissolved concentration to total concentration (D/T) greater than 120% for metals parameters with dissolved or total concentration >5x RDL for metal

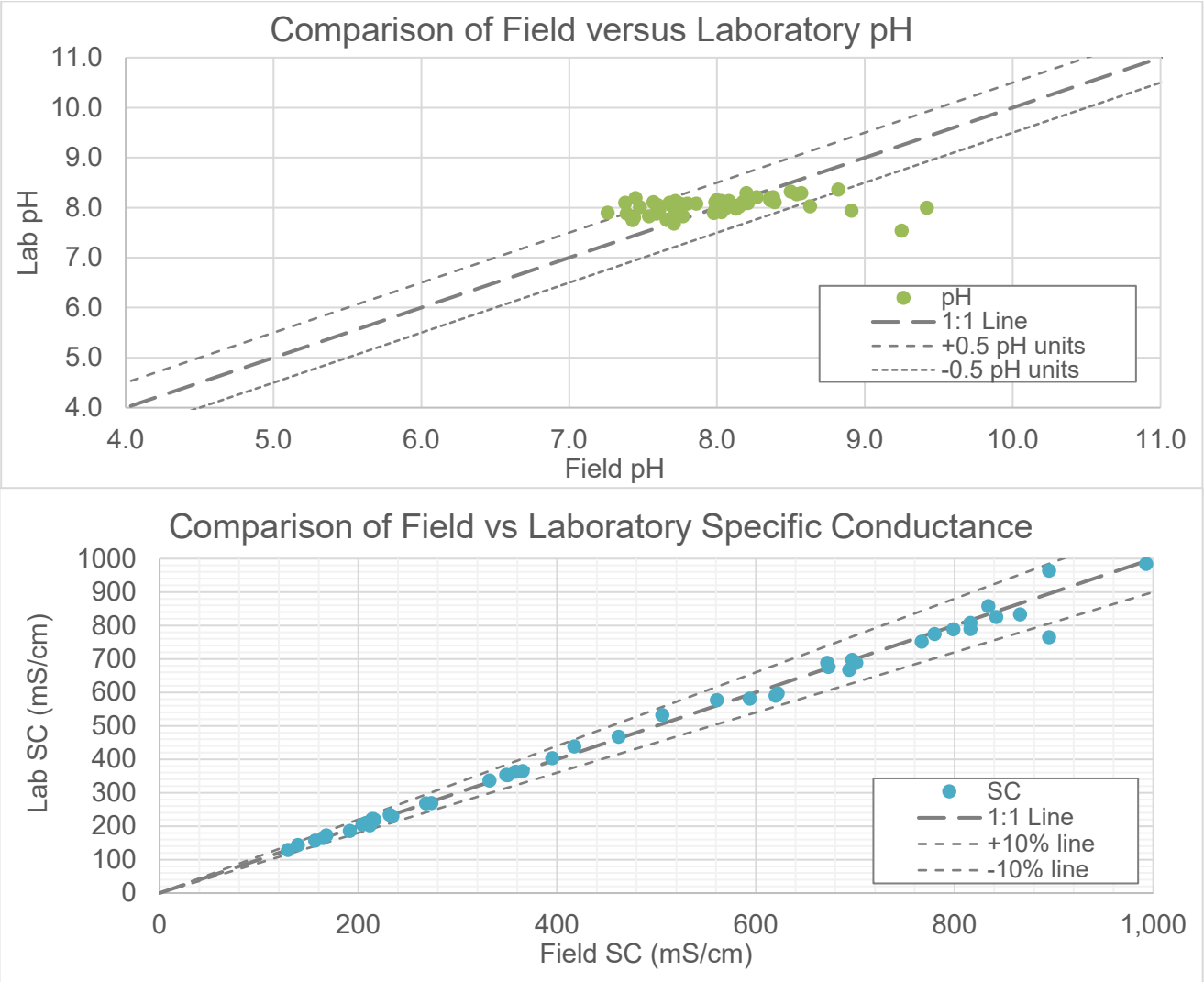


Figure D4-1: Comparison of field and laboratory pH and specific conductance for sQ4 samples.

Appendix D5 2021 Groudwater Calibration

Date	Time	YSI Instrument	serial no.	Calibrated by	barometer	Temperature (˚C)	1413µS Spec. Cond.	4.00 pH	4 pH mV	7.00 pH
4-Mar-21	6:30	ProDss	19B100228	NG	752.0	21.7	-	4.02	157.0	7.04
5-Apr-21	6:00	ProDSS	19B100228	NG	761.0	22.0	1425	3.99	154.1	7.05
22-Apr-21	6:15	ProDSS	19B100228	NG	763.9	22.7		3.88	155.6	6.99
23-Apr-21	6:00	ProDSS	19B100228	NG	758.7	22.5		4.02	153.2	7.06
24-Apr-21	6:20	ProDSS	19B100228	NG	757.7	22.1		4.01	151.6	7.06
25-Apr-21	6:40	ProDSS	19B100228	NG	757.7	22.3		3.94	154.4	7.04
27-Apr-21	6:00	ProDSS	19B100228	NG	755.0	22.2		3.98	153.3	7.00
23-May-21	6:20	ProDSS	19B100228	NG	760.5	22.0	-	4.16	142.5	7.08
26-May-21	6:15	ProDSS	19B100228	NG	758.3	22.0	-	4.00	148.4	7.06
27-May-21	6:25	ProDSS	19B100228	NG	755.4	22.3	-	3.98	148.8	7.06
29-May-21	6:20	ProDSS	19B100228	NG	763.8	22.7	-	3.96	150.4	7.02
20-Jun-21	11:20	ProDSS	19B100228	NG	766.1	23.2	-	3.83	150.3	6.94
21-Jun-21	6:05	ProDSS	19B100228	NG	762.3	23.8	1416	4.00	149.7	7.03
23-Jun-21	6:20	ProDSS	19B100228	NG	760.0	23.7	-	4.14	140.2	7.06
25-Jun-21	12:50	ProDSS	19B100228	CM/NG	769.8	24.0	-	3.98	1453.7	7.03
26-Jun-21	6:25	ProDSS	19B100228	NG	769.5	24.1	-	4.11	138.3	7.02
17-Jul-21										
18-Jul-21	6:15	ProDSS	19B100228	NG	764.9	23.4	-	3.93	143.2	6.85
31-Jul-21	8:00	ProDSS	19B100228	BDT	766.5	24.9	1409	4.03	137.9	7.02
18-Aug-21	6:15	ProDSS	19B100228	NG	762.3	23.9	-	4.14	158.8	7.04
11-Sep-21	11:05	ProDSS	19B100228	NG	760.8	22.7	-	4.07	153.2	7.00
14-Sep-21	6:30	ProDSS	19B100228	NG	756.7	22.3	-	4.05	151.8	7.02
15-Sep-21	6:45	ProDSS	19B100228	NG	758.9	22.6	-	4.05	149.9	6.98
17-Sep-21	6:00	ProDSS	19B100228	NG	748.1	22.6	-	4.00	151.7	6.97
23-Sep-21	6:40	ProDSS	19B100228	NG	762.3	22.4	-	3.97	151.6	6.96
7-Oct-21										
10-Oct-21	6:50	ProDSS	19B100228	CM	762.3	21.9	1409	3.92	150.8	6.92
11-Oct-21										
16-Oct-21	8:10	ProDSS	19B100228	NG	752.7	22.9	-	4.02	149.0	7.01
17-Oct-21	8:00	ProDSS	19B100228	BM	754.6	23.0	-	3.97	151.6	6.98
30-Oct-21		ProDSS	19B100228	RS	766.5	23.5	1414	3.89	149.1	6.87
7-Nov-21	7:40	ProDSS	19B100228	NG	751.4	22.8	-	4.02	148.7	7.03
14-Nov-21	6:30	ProDSS	19B100228	NG	748.7	20.9	-	4.01	144.3	6.94
15-Nov-21	6:00	ProDSS	19B100228	NG	748.7	20.8	-	4.04	143.0	7.01
4-Dec-21	6:05	ProDSS	21K100504	NG	647.9	21.0	-	4.01	148.6	6.97
26-Jan-22	8:30:00 AM	ProDSS	19B100228	KU	659	22.40	-	4.06	139.9	7.03
27-Jan-22	7:45:00 AM	ProDSS	21K100504	NG	657	22.00	-	4.03	143.8	7.02
29-Jan-22	0.336805556	ProDSS	21K100504	NG	646	22.60	-	4.01	140.8	7.02

Appendix D5 2021 Groudwater Calibration

Date	Time	7 pH mV	10.00 pH	10 pH mV	Slope	slope %	DO (%)	Turbidity 0 FNU	Turbidity 124 FNU	ORP +125 mV
4-Mar-21	6:30	-22.6	10.03	-200.8	60.0	98.5	99.5	-	-	236.1
5-Apr-21	6:00	-29.0	9.97	-204.3	60.0	98.5	100.1	-0.4	127.1	226.9
22-Apr-21	6:15	-30.3	9.95	-207.3	60.7	97.3	101.1			227.8
23-Apr-21	6:00	-30.1	10.00	-207.2	60.3	98.0	99.8			227.7
24-Apr-21	6:20	-30.9	10.04	-208.5	60.3	98.0	99.6			229.0
25-Apr-21	6:40	-30.7	9.99	-206.9	60.5	97.7	100.8			227.8
27-Apr-21	6:00	-28.5	9.95	-206.3	60.1	98.3	99.4			220.7
23-May-21	6:20	-33.3	10.07	-213.8	59.7	99.1	101.0			229.0
26-May-21	6:15	-35.5	10.00	-212.8	60.5	97.7	99.7			227.4
27-May-21	6:25	-35.5	10.01	-212.5	60.4	97.8	99.4			226.3
29-May-21	6:20	-33.4	10.03	-213.9	60.9	96.9	101.0			225.6
20-Jun-21	11:20	-35.2	9.94	-213.4	60.8	97.2	100.2	-	-	234.5
21-Jun-21	6:05	-34.1	10.00	-214.0	60.7	97.2	101.8	0.8	120.8	219.5
23-Jun-21	6:20	-36.8	10.03	-217.1	59.7	99.0	99.7	-	-	224.6
25-Jun-21	12:50	-38.4	9.99	-217.4	60.6	97.4	101.4	-	-	224.0
26-Jun-21	6:25	-37.6	10.02	-218.7	59.6	99.1	101.4	-	-	224.0
17-Jul-21										
18-Jul-21	6:15	-30.8	10.00	-212.1	60.6	97.5	100.6	-	-	225.0
31-Jul-21	8:00	-39.6	10.08	-220.9	59.8	98.8	100.9	-1.2	125.8	221.2
18-Aug-21	6:15	-13.5	10.07	-193.2	58.8	99.5	101.4	-	-	252.3
11-Sep-21	11:05	-18.5	10.05	-196.7	58.6	99.1	100.0	-	-	225.9
14-Sep-21	6:30	-20.8	10.07	198.0	58.6	99.1	99.4	-	-	226.4
15-Sep-21	6:45	-20.3	10.09	-200.7	58.7	99.3	100.3	-	-	224.3
17-Sep-21	6:00	-21.0	10.08	-202.4	59.9	99.7	98.1	-	-	227.4
23-Sep-21	6:40	-20.7	10.10	-202.0	59.2	99.8	100.2	-	-	227.3
7-Oct-21										
10-Oct-21	6:50	-23.0	10.01	-202.2	59.0	99.8	98.7	-0.2	118.9	223.7
11-Oct-21										
16-Oct-21	8:10	-26.2	9.98	-201.0	58.6	99.2	99.6	-	-	225.4
17-Oct-21	8:00	-24.0	10.08	-205.1	59.6	99.2	99.2	-	-	223.8
30-Oct-21		-26.5	10.02	-210.3	60.1	98.3	108.8	0.4	128.1	231.1
7-Nov-21	7:40	-27.1	10.09	-204.7	59.0	99.8	99.5	-	-	235.3
14-Nov-21	6:30	-27.0	9.49	-206.0	58.7	99.3	97.7	-	-	230.4
15-Nov-21	6:00	-29.0	10.09	-207.1	58.8	99.4	98.1	-	-	228.8
4-Dec-21	6:05	-25.9	9.94	-196.8	57.9	97.9	87.2	-	-	235.6
26-Jan-22	8:30:00 AM	-32.1	10.1	-207.0	58.0	98.2	99.4	-	-	220.2
27-Jan-22	7:45:00 AM	-30.0	10.0	-204.7	58.3	98.6	86.7	-	-	236.7
29-Jan-22	0.336805556	-33.3	10.0	-206.9	58.2	98.3	84.7	-	-	232.8

Appendix E
Snap Sampler Manual

NEWCREST

SNAP SAMPLER® ZERO
PASSIVE SAMPLING SYSTEM

STANDARD OPERATING PROCEDURE FOR THE SNAP SAMPLER® PASSIVE GROUNDWATER SAMPLING METHOD (NOVEMBER 2019)

2019 UPDATE

The 2019 update includes minor additions to reflect further technical validation of the Snap Sampler® method add and clarifications to some sample and equipment handling procedures, including the PFAS-Zero™ version of the Snap Sampler passive groundwater sampler. The update includes reference to the ASTM Standard Guide for Passive Sampling, D7929-14 (ASTM, 2014).

This Standard Operating Procedure (SOP) should be used to familiarize the user with the application and protocol for use the Snap Sampler® passive groundwater monitoring system. *The laminated picture instruction cards contain step-by-step field instructions. The picture instructions in the Appendices, rather than the SOP itself, should be the primary tool for Snap Sampler® operation in the field.* The SOP is designed for overall understanding and rationale for passive groundwater sampling with the Snap Sampler®, and for regulatory submittal with Sampling and Analysis Plans. Should the user require information beyond that included in this SOP, additional information can be found on the Snap Sampler® website **www.SnapSampler.com, www.qedenv.com/global** or by contacting your Snap Sampler representative at **QED Environmental Systems, Inc.**

FORWARD

This SOP was adapted from SOPs in USEPA's groundwater guidance for RCRA and Superfund project managers (U.S. Environmental Protection Agency 2002). Portions of the applicable text are included here. With this forward, the authors and USEPA are acknowledged in sincerest appreciation. Edited and supplemental text is added to detail application information and procedures for use and deployment of the Snap Sampler® passive groundwater sampling device and method.

INTRODUCTION

The goal of groundwater sampling is to collect samples that are representative of *in situ* groundwater conditions and to minimize changes in groundwater chemistry during sample collection and handling. Experience has shown that groundwater sample collection and handling procedures can be a source of variability in water quality concentrations due to differences in sampling personnel, sampling procedures, and equipment (U.S. Environmental Protection Agency 1995; McHugh *et al.* 2010; Parker and Britt, 2012).

Traditionally, the collection of representative water samples from wells is neither straightforward nor easily accomplished. Groundwater sample collection through pumping or bailing can be a source of variability through differences in sampling personnel and their individual sampling procedures, the equipment used, and ambient temporal variability in subsurface and environmental conditions. Many site inspections and remedial investigations require the sampling at groundwater monitoring wells within a defined criterion of data confidence or data quality, which necessitates that the personnel collecting the samples are trained and aware of proper sample collection procedures.

The purpose of this SOP is to provide a description of the Snap Sampler® passive groundwater sampling method. The method and specialized equipment is designed to minimize the impact the sampling process on groundwater chemistry. This is accomplished through deployment and passive re-equilibration of the monitoring well to ambient groundwater flow and/or diffusive contaminant flux within the well/aquifer system. The Snap Sampler® method eliminates well purging prior to sample collection.

As a passive groundwater sampling device, the Snap Sampler® is a proven, cost-effective alternative to well purge and low-flow sampling (Parker *et al*. 2011; Britt *et al*. 2010). Historical and recent research shows that most if not virtually all well screen zones exhibit ambient flow-through under natural groundwater gradients (Gillham

1982; Pankow *et al.* 1985; Robin and Gillham 1987; Powell and Puls 1993; Puls and Barcelona 1996; Vroblesky *et al.* 2001a; ASTM 2002; ITRC 2004, 2007, ASTM 2014). The screen sections of these wells naturally exchange formation water without pumping. Ongoing research suggests that natural ambient flow-through induces a contaminant redistribution effect within wells (Britt *et al.* 2011; Britt 2005, 2006; Martin-Hayden and Britt 2006; Vroblesky *et al.* 2006; Britt and Calabria 2008). This redistribution regularly results in a flow-weighted averaging effect in the well *without purging*. Though not all wells are thoroughly mixed, many wells show relatively narrow ranges of vertical concentrations when vertically profiled (Vroblesky *et al.* 2001b; Parsons 2003; Britt and Calabria 2008). These studies and others indicate flow-weighted contaminant concentration averaging within wells is common. The Snap Sampler® takes advantage of these "naturally purged" wells by capturing a whole water sample after a period of sampler deployment in the well.

Wells in poor yielding formations with slow recharge during pumping have always been problematic for pumping methods. Wells with short water columns are also problematic for some of the same reasons. Passive sampling of poorly yielding wells has been suggested as a better method than purging to dryness in VOC impacted wells (McAlary and Barker 1987; Puls and Powell 1993; Puls and Barcelona 1996). *The Snap Sampler® can be deployed in low yield and short water column wells to take advantage of this passive sampling approach*.

The Snap Sampler® (Figure 1) passive groundwater sampling method limits sample collection variables by sealing the sample while it is still in the well, at the same position in the well during each sampling event. Where appropriate, the sample is maintained in the same sample container that is transmitted to the laboratory rather than pouring into sample bottles at the ground surface. Using this approach, sampling personnel are essentially prevented from introducing error, variability, or bias during the sample collection process. Sample collection is virtually the same for any user because the sample is captured downhole the same way every event, without impact from user technique, and in many cases, not exposed to the ambient air from the well to the laboratory. Research shows that variability reduction may improve long-term data trend analysis (Britt *et al.* 2011; McHugh *et al.* 2010; Britt *et al.* 2010; Britt 2008).

SCOPE AND APPLICATION

This SOP should be used primarily for monitoring wells that have a screen or an open interval large enough to

FIGURE 1, example with 2 of the VOA-size Snap Sampler Modules. Up to 6 modules can be assembled in any combination of sizes.

accept a downhole device of 1.8 inches (46mm) in diameter or larger. Long screen interval sampling may be conducted, but stratification testing may be warranted if previous information about aquifer and/or well contaminant stratification is not available. Vertical profiling requirements depend on site-specific data quality objectives (DQO's) and site-specific requirements (ASTM 2014, Vroblesky 2001a; ITRC 2004, 2007).

Groundwater samples that are collected using this procedure are useable for the analyses of groundwater contaminants that may be found at Superfund and RCRA contamination sites, as well as sites with a variety of contamination types. The analytes may be volatile organic compounds, semi-volatile organic compounds, pesticides, PCBs, metals, and other inorganic compounds, including perchlorate and other emerging contaminants

such as explosive compounds, 1,4-dioxane, 1,2,3-TCP, NDMA and others. No analyte limitations have been found for the Snap Sampler® (Parker and Mulherin, 2007, Parker *et al*. 2008, 2009, 2011a and 2011b; Britt *et al*. 2010). Sufficient sample volume is the only practical analyte limiting factor for the method. When sampling for Per- and Polyfluoroalkonated compounds (PFAS), the user should choose the PFAS Zero™ versions of the Snap Sampler product line. These components contain no fluorinated compounds. The user should note that bottles and pneumatic actuator devices not specifically marked as "PFAS Zero™" items may contain fluoropolymers. Lot testing shows these tested items to be PFAS free, but some sampling plans prohibit use of any fluoropolymers regardless of testing status.

For contaminant plume monitoring, the sampler should be placed within the screened interval of the well. For consistency and comparability of results over time, the sampler should be placed in same location and depth for each subsequent sampling event. To accommodate this preference, dedicated sampling devices with dedicated trigger lines should be used whenever possible. The Snap Sampler® should not be placed resting on the bottom well to avoid disturbing any sediment at the bottom of the well during deployment or when the sampler is triggered.

The Snap Sampler® relies on natural flow-through and/or diffusion of contaminants from the aquifer to the well (Powell and Puls 1993; ASTM 2002; ITRC 2004, 2007). Well purging is not conducted before sampling, therefore, measurement of water-quality-indicator parameters is not a prerequisite to sample collection. If parameters are required for certain monitoring programs independent of sampling method (e.g. for monitored natural attenuation assessment), parameters can be collected by utilizing one of the deployed Snap Sampler® bottles or post-sampling by another method (*e.g.* a downhole probe).

Samples collected for metals, semi-volatile organic compounds, pesticides, and other analytes may be impacted by sample turbidity. They also may be subject to transport by colloidal flow in the natural groundwater regime (Kearl *et al.* 1992; Puls and Powell 1992). Deployment and re-equilibrium of the Snap Sampler® allows natural colloidal flow to be monitored within the well. This is a distinct advantage over sampling methods such as the polyethylene diffusion bag (PDB), where colloidal particles are excluded from the sample; and an advantage over purge methods where colloids may be artificially mobilized (Britt *et al.* 2010). Field filtering is not required for samples collected with the Snap Sampler® but can be conducted if required by the site Sampling and Analysis Plan.

Proper well construction, development, and maintenance are essential for any groundwater sampling procedure. Prior to conducting field work, information on the construction of the well and well development should be obtained and that information factored into the site specific sampling procedure. This SOP is not to be used where non-aqueous phase liquids (NAPL) (immiscible fluids) are present in the monitoring well.

MATERIALS AND EQUIPMENT

- Field Sampling and Quality Assurance Project Plan.
- Site Health and Safety Plan with specifications for personal protective equipment and air monitoring equipment.
- Personal protective equipment in good working order as specified in the site Health and Safety Plan.
- Air monitoring equipment in good working order as specified in the Site Health and Safety Plan.
- Site access/permission documentation for site entry.
- Well keys and map of well locations.
- Tool box - All needed tools for all site equipment used.
- Snap Sampler® Modules - Dedicated samplers are recommended in most applications.
- Snap Sampler® Trigger lines, – Dedicated trigger lines are recommended in most applications. Trigger lines may be manual, with a mechanical wire connection from surface to sampler; or pneumatic, with an airline from surface to sampler.
- Snap Sampler® Well Caps – Lockable well caps for Snap Sampler® -deployed wells—includes a support ring to hang Snap Sampler equipment.
- Sample bottles, sample preservation supplies, sample tags or labels, and chain-of-custody forms.
- Well construction, field, and water quality data from the previous sampling event.
- Field notebook, groundwater sampling logs, and calculator.
- Polyethylene sheeting placed on ground around the well head.
- Depth-to-water measuring device - An electronic water-level indicator or steel tape and chalk, with marked intervals of 0.01 foot. Interface probe for determination of liquid products (NAPL) presence, if needed.

- Steel tape and weight - Used for measuring total depth of well.

- Multi-parameter meter, if required. The water-quality-indicator parameters that may be monitored under common monitoring programs include pH, ORP/Eh, (ORP) dissolved oxygen (DO), turbidity, specific conductance, and temperature. Turbidity readings, if required, must be collected from a sacrificed Snap Sampler® bottle because retrieving the sampler may agitate the well, increasing turbidity values not present in the actual samples. Calibration fluids for all instruments should be traceable and there should be enough for daily calibration throughout the sampling event.

- Decontamination supplies, including a reliable and documented source of distilled water and any solvents (if used). Pressure sprayers, buckets or decontamination tubes for pumps, brushes and non-phosphate soap will be needed for non-dedicated equipment that is moved from well to well.

- A suitable container for excess sample and decontamination water, as needed or required.

Construction materials of non-dedicated sampling equipment (samplers, tubing, and other equipment that comes in contact with the sample) should be limited to inert materials. This will reduce the chance that sampling materials alter the groundwater where concentrations of the site contaminants are expected to be near the detection limits. The tendency of organics to sorb into and desorb out of plastic materials makes dedicated equipment preferable where possible.

It should be noted that plastic materials used in the Snap Sampler® are not usually problematic for sorption. Using methods described in this SOP, the sampler is deployed for one to two weeks (or more). This deployment period allows materials prone to sorption to achieve equilibrium with groundwater before the sample is collected (Parker, et al. 2007).

DEPLOYMENT/SAMPLING PROCEDURES

The following describes the deployment and sampling procedures for the Snap Sampler® passive groundwater sampling method. These procedures describe steps for dedicated and non-dedicated systems.

Pre-Sampling Activities

1. Well location maps, construction information, keys and sampling equipment should be assembled and transported to the site.

2. Water level monitoring and sampling must begin at the monitoring well with the least contamination, generally up-gradient or farthest from the site or suspected source. Then proceed systematically to the monitoring wells with the most contaminated ground water.

3. Check and record the condition of the monitoring well for damage or evidence of tampering. Lay out polyethylene sheeting around the well to minimize the likelihood of contamination of sampling equipment from the soil and exposure of soil to liquids dripping from the sampling equipment.

4. Unlock well head. Record location, time, date, and appropriate information in a field logbook or on the groundwater sampling log.

5. Remove inner casing cap.

6. If required, monitor the headspace of the monitoring well at the rim of the casing for volatile organic compounds (VOC) with a photo-ionization detector (PID) or flame ionization detector (FID) and record in the logbook. If the existing monitoring well currently has or has a history of positive headspace readings, then the sampling must be conducted in accordance with the Health and Safety Plan.

7. Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference measuring point on the well casing with an electronic water level indicator or other appropriate measuring device and record in logbook or groundwater sampling log. If no reference point is found, measure relative to the top of the inner casing, then mark that reference point and note that location in the field logbook. Record information on depth to ground water in the field logbook or groundwater sampling log. Measure the depth to water a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

8. Check the available well information or field check for the total depth of the monitoring well.

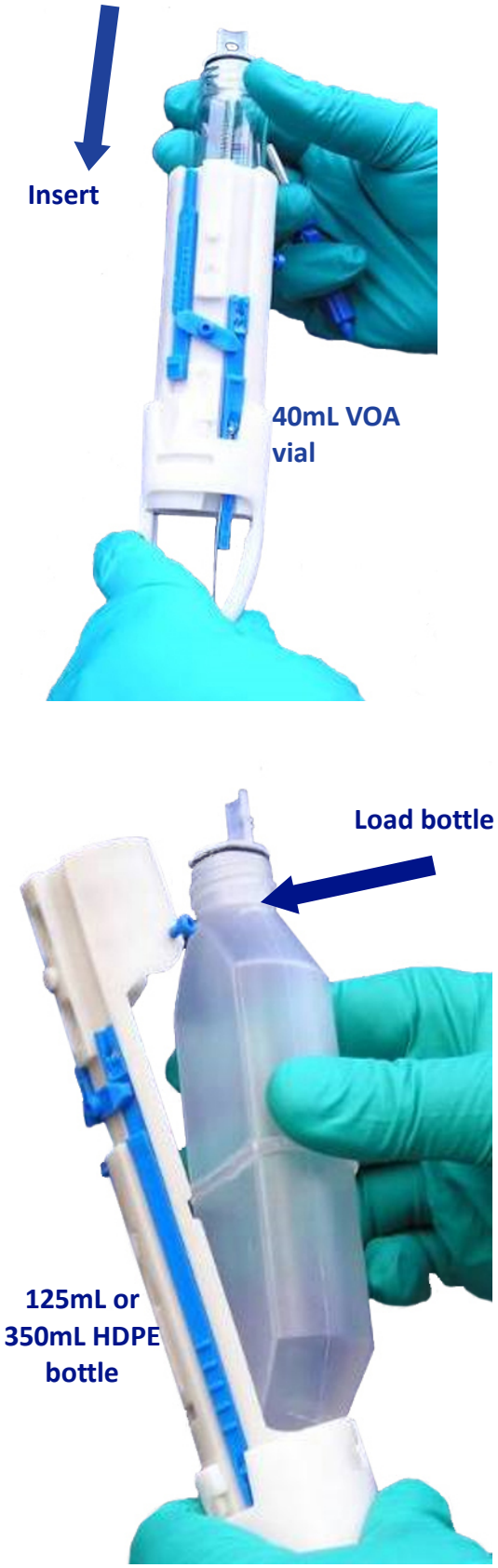


FIGURE 2

Deployment Activities

Selection of the deployment depth within the screen interval is dependent on site specific DQO's. Normally, deployment depth is targeted at the center of the well screen. If depth-specific monitoring is desired, multiple samplers may be deployed at intervals appropriate for the sampling objective.

If multiple sample zones within a well, zone isolation using a packer or baffle device to limit in-well mixing can be used (Britt 2006; Britt and Calabria 2008). These can be attached to the Snap Sampler® trigger line or deployed separately. Installation of an upper baffle designed to isolate the unscreened well casing or well headspace may be desired. The upper baffle will limit mixing of "stagnant" casing water with screen-interval water, an/or gas exchange with the headspace air.

1. Remove the Snap Sampler bottle(s) from its packaging.

2. Turn the translucent "Snap Cap" on each end of the bottle slightly to release any sticking of the o-ring.

3. Insert the bottle into the upper end of the sampler as shown in Figure 2.

4. Place the sampler twist-on connector onto each end of the sampler; turn clockwise to align the set pins/screw (Figure 3); then gently tighten the set screw with the Snap Driver Tool (Figure 4).

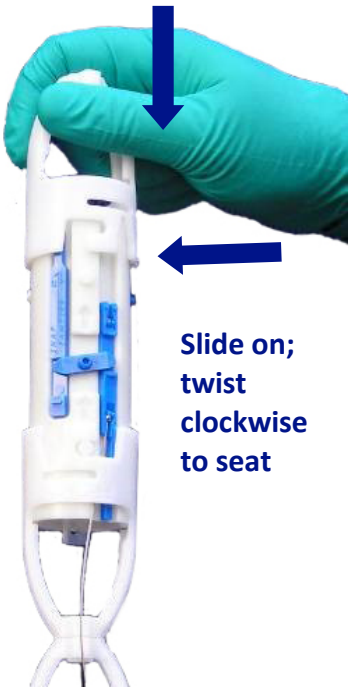


FIGURE 3

FIGURE 4

5. Pivot the vial cap (Snap Cap) into its seat with the Snap driver. Push up the retainer pin through the lower hole in the vial cap. Repeat for all Snap Caps (Figure 5). If an o-ring should dislodge from its seat during setting, remove the sample bottle and carefully replace it in the o-ring groove; repeat setting procedure.

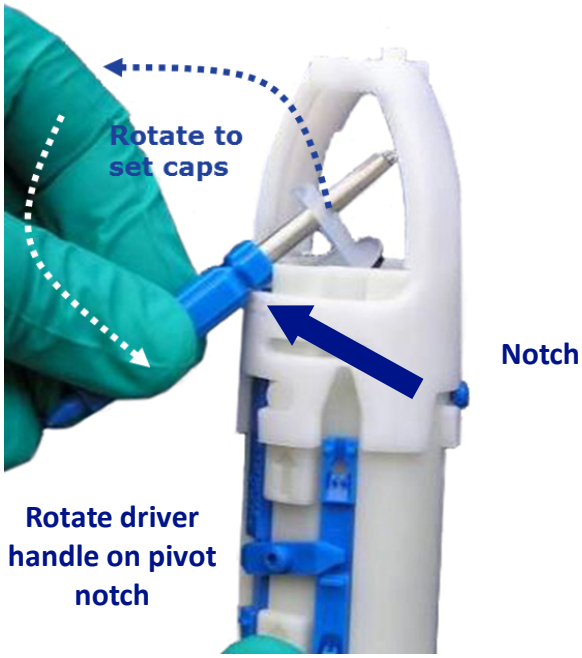


FIGURE 5

6. For the manual trigger, feed ball-fitting end of trigger cable through lower release pin groove; click tube fitting into connector (Figure 6).

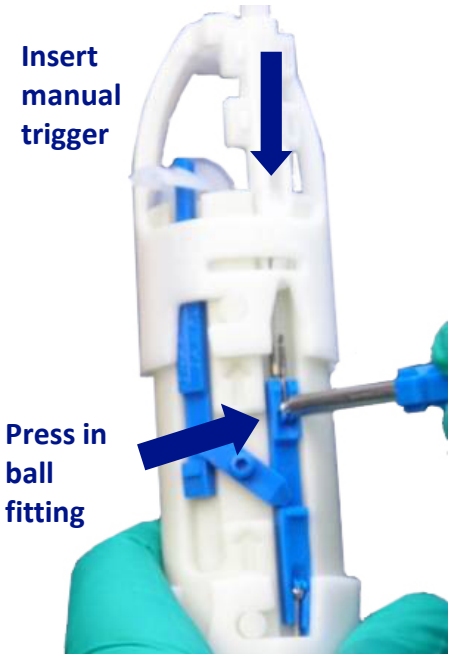


FIGURE 6

7. Press in the ball fitting to attach to lower release pin (Figure 6).

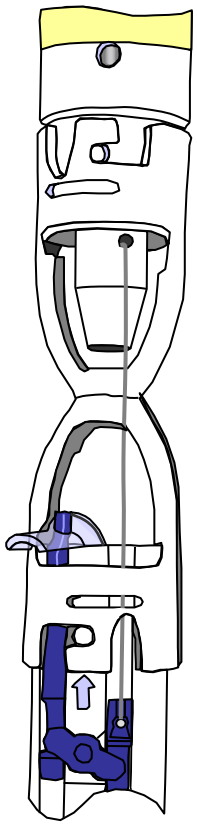


FIGURE 7

8. For the pneumatic trigger system, attach the wireline from the plunger (Figure 7).

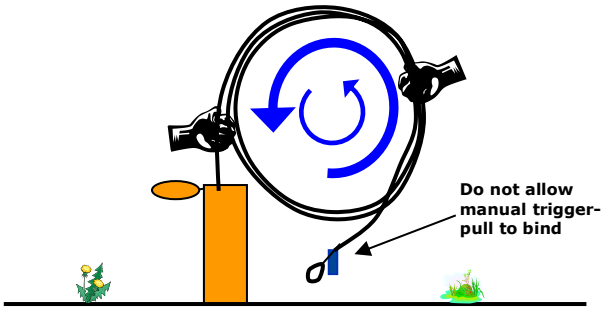


Figure 8

9. Deploy to selected depth with trigger cable/tubing and attach to well head docking station (Figure 8, Figure 9).

10. Additional Snap Samplers® can be deployed with separate trigger lines or in series with a single trigger. If separate triggers are used, the ID tags should be marked at the surface for later reference.

FIGURE 9

11. The recommended deployment period is one to two weeks. There may be hydrogeologic conditions where a shorter deployment is possible, but one to two weeks would generally assure a return of the well to its steady-state condition (Vroblesky, 2001a, 2001b). Parker et al (2009) found that a 72 hour submergence time was sufficient for most analytes tested, but this does not account for well disturbance or other-well-specific factors. The user may determine that shorter or longer deployment times than the standard 1-2 weeks are appropriate for a specific application.

12. The Snap Sampler® can be deployed for extended periods. No upper bound for sampler deployment has been found. Rather, conditions at individual wells seem to control the applicability of deployments lasting a year or longer.

Sample Collection Activities

When the deployment period is completed, the sampler should be triggered at the well head without disturbing the sampler position. For the manual trigger, the cable end should be pulled with sufficient force to move the cable up the tubing. Depending on the length of the cable, closure of the samplers usually can be felt through the trigger line when the samplers trip. For the pneumatic trigger system, pressure is added to the downhole air line to trigger the Snap Samplers to close. If more than one triggering line is present, closure should proceed from the deepest to the shallowest sampler position to limit capture of sediment potentially re-suspended by closure of the first sampler. Additional details on collection activities are included in the Appendices and "Quick Check" instructions.

After the sampler is triggered and retrieved, the upper connector should be removed by loosening the blue retainer screw and turning the white cover piece. The bottom connector piece does not need to be disassembled to remove the bottles.

While the bottles should not leak with reasonable handling, they should not be agitated (to check for headspace, for example) until after the screw caps are tightened. Under most circumstances there will be no air in the vials at retrieval. However, some field conditions—including deep groundwater, natural effervescence, or other causes—may cause some small air bubbles to be present in the bottle or on the spring when retrieved. This is not a concern if the air was entrained while deployed. Air adhering to the vial during deployment would be in equilibrium with the sample water upon sampler closure. Therefore it is not "headspace air" into which sample VOCs could volatilize. Deployment air could be attached to the spring or cap, and should not be larger than 1-2 mm upon retrieval. Pankow (1986) showed that small headspace gas from these or other causes do not substantially impact results for most

common volatiles. If gas bubbles are larger than 5 mm before placing the screw cap, or water is clearly leaking from the vial, the sample may not have sealed properly. There are three options for addressing bubbles: 1) the bottle can be submitted to the laboratory with the headspace bubble, noting the occurrence; 2) the cap can be opened slightly and sample water from another bottle added to fill the vial; or 3) the bottle can be discarded. The user can determine which approach is most appropriate depending on the size of the bubble. For a 1mm bubble, option #1 may be most appropriate; for a 5mm bubble, #2 may be appropriate, while #3 may be appropriate for a 50% full bottle.

There are no special laboratory preparation procedures for Snap Sample bottles. The bottles can be analyzed using common 40-ml autosamplers. The spring inside the VOAs is polymer-coated and will deflect away from the autosampler extraction needle during insertion.

The appendices include step-by-step instructions for deployment and bottle preparation procedures.

Appendix A contains step-by-step field procedures for deployment of both 40 ml Snap Sampler VOAs and 125 ml Snap Sampler POLY bottles.

Appendix B contains step-by-step procedures for preparation of both 40 ml Snap Sampler VOAs and 125 ml Snap Sampler POLY bottles.

DECONTAMINATION PROCEDURES

The electronic water level indicator probe/steel tape, the water-quality field parameter sensors and any *non-dedicated* Snap Sampler® groundwater sampling equipment should be decontaminated by the following procedures:

1. The water level meter will be hand washed with phosphate-free detergent and a scrubber, then thoroughly rinsed with distilled water.

2. Water quality field parameter sensors with distilled water between sampling locations where utilized. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the sensors must be cleaned and maintained per the manufacturer's requirements.

3. For *non-dedicated* applications, the Snap Sampler® and trigger tubing must be pressure-sprayed or bristle-brush scrubbed with soapy water, tap water, and distilled water prior to use in a different well. Depending on the condition of the Snap Sampler®, the release pin mechanism may need to be disassembled to effectively clean the pins and grooves. Disassembly can be accomplished by removing the lever screw.

FIELD QUALITY CONTROL

Quality control (QC) samples must be collected to verify that sample collection and handling procedures were performed adequately and that they have not compromised the quality of the groundwater samples. The appropriate EPA or other appropriate program guidance must be consulted in preparing the field QC sample requirements for the site-specific Quality Assurance Project Plan (QAPP).

There are five primary areas of concern for quality assurance (QA) in the collection of representative groundwater samples:

1. Obtaining a groundwater sample that is representative of the aquifer or zone of interest in the aquifer. Verification is based on the field log documenting that the field procedures were followed appropriately during sample deployment and collection.

2. Ensuring that the sampling devices are made of materials, and utilized in a manner that will not interact with or alter the analyses.

3. Ensuring that results generated by these procedures are reproducible; therefore, the sampling scheme should incorporate co-located samples (duplicates).

4. Preventing cross-contamination. Sampling should proceed from least to most contaminated wells, if known. Field equipment blanks should be incorporated for all sampling, and decontamination of the equipment is therefore required.

5. Properly preserving, packaging, and shipping samples.

All field QC samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The chain-of custody procedures for the QC samples will be identical to the field groundwater samples. The following are QC samples that should be collected during the sampling event:

Field duplicates	See QAPP/SAP
Matrix spike	See QAPP/SAP
Matrix spike dup.	See QAPP/SAP
Equipment blank	See QAPP/SAP
Trip blank (VOCs)	See QAPP/SAP
Temperature blank	See QAPP/SAP

HEALTH AND SAFETY CONSIDERATIONS

Depending on the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site Health and Safety Plan should be reviewed with specific emphasis placed on the protection program planned for the sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the liquid and vapor phase through the use of appropriate personal protective equipment.

Depending on the type of contaminants expected or determined in previous sampling efforts, the following safe work practices should be employed:

Particulate or metals contaminants

1. Avoid skin contact with, and incidental ingestion of sample water.

2. Use protective gloves and splash protection.

Volatile organic contaminants

1. Avoid breathing constituents venting from well.

2. Pre-survey the well head space with an appropriate device as specified in the site Health and Safety Plan.

3. If monitoring results indicate elevated organic constituents, sampling activities may be conducted in elevated protective equipment (e.g. level C protection). At a minimum, skin protection will be afforded by disposable protective clothing, such as Tyvek®, appropriate gloves and face protection.

General practices should include avoiding skin contact with water from preserved sample bottles, as this water will have pH less than 2 or greater than 10. Also, when field acidifying VOA bottles, hydrochloric acid fumes may be released and should not be inhaled. Acid should not contact skin, eyes, or unprotected clothing.

POST-SAMPLING ACTIVITIES

Several activities need to be completed and documented once groundwater sampling has been completed.

These activities include, but are not limited to the following:

1. Ensuring that all field equipment has been decontaminated and returned to proper storage location. Once the individual field equipment has been decontaminated, tag it with date of cleaning, site name, and name of individual responsible.

2. Processing all sample paperwork, including copies provided to the appropriate sample handling and tracking facility.

3. Compiling all field data for site records.

4. Verifying all analytical data processed by the analytical laboratory against field sheets to ensure all data has been returned to sampler.

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Technology websites: www.QEDENV.com
www.SnapSampler.com

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QED Environmental Systems Ltd.

Cyan Park – Unit 3
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CV2 4QP
UNITED KINGDOM

THE SNAP SAMPLER

for Passive Groundwater Sampling

The Snap Sampler—a Passive Groundwater Sampling Technology for Any Analyte

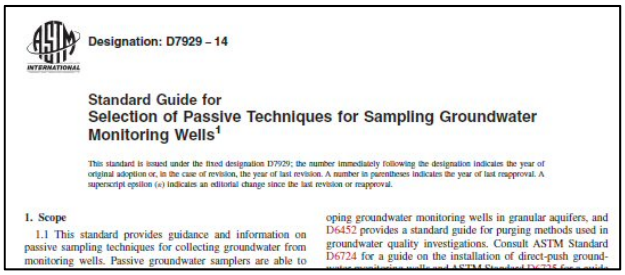
What is a Snap Sampler and how does it work?

The Snap Sampler is a passive grab sampler. A passive sampler is any device that is left in place for an "equilibration" period that allows the analytes of concern to enter the sampling device and equilibrate with the surrounding sample environment. Unlike diffusion- or sorption-based passive samplers, Snap Sampler containers are simply open to the sampled environment. There is no diffusion through a membrane or sorption onto special media. Snap Sampler bottles have openings on both ends, allowing advective or diffusive analyte exchange with the surrounding environment.

The equilibration period for the Snap Sampler depends on the installation environment and the analytes of concern. For many inorganic analytes, Snap Samplers have been shown by the US Army Corps of Engineers to be in an equilibrium state within the shortest timeframe measured in their tests—24 hours. For organic analytes, including VOCs, equilibration periods could be longer—up to 72 hours or so. We recommend a deployment period of 1-2 weeks in many cases to allow extra time for the well to re-establish natural flow-through and water exchange after the disturbance of inserting the Snap Sampler into the well. For routine sampling, Snap Samplers are left in the sample position for the entire time between sampling events, so this equilibration period is not a concern. It is mainly a consideration for initial or one-time deployments.

To capture the sample, Snap Sampler bottles are activated to close mechanically from the surface, either through a manual pull trigger system for shallow applications (less than 40-50ft, 12-15m) or using a pneumatic triggering system that can be used an any depth (the current record is approximately 2500ft, 760m). Photos show the "Snap Caps" in the set position. Caps are left in the open position during the deployment period, then "snapped" shut immediately prior to retrieval and preparation for laboratory submittal. Typically, Snap Samplers are then redeployed into the well in preparation for the subsequent sampling event.

ASTM Standard D7929-14 includes the Snap Sampler as a "passive" sampling device by defining passive grab sampling differently from "active" grab sampling. "Active" grab sampling requires motion of the sampling device to "grab" the sample from the environment, while a "passive" grab sampler already contains the sample within the sampler. For the Snap Sampler, simple closure of the device retains the sample. A bailer, a bailer-type pull-filling device, or a pressure/vacuum-based sampler actively moves sample from the environment into the sampling device during collection. For these devices, there is no real equilibration. Sampler materials are not truly equilibrated with the surrounding environment as they may be exposed to that water for the first time at the time of collection. Further, there may be substantial disturbance of the water column during collection and the precise sample position may not be known. Some research suggests strong bias and data variability can occur when the sampling position is not known. Water may come from beyond the screen zone of the well in the case of a pull-filling device, causing such bias and variability.



Designation: D7929 – 14

Standard Guide for
Selection of Passive Techniques for Sampling Groundwater Monitoring Wells[1]

This standard is issued under the fixed designation D7929; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

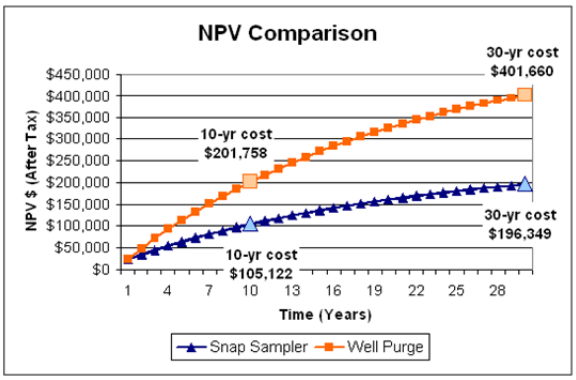
1.1 This standard provides guidance and information on passive sampling techniques for collecting groundwater from monitoring wells. Passive groundwater samplers are able to

oping groundwater monitoring wells in granular aquifers, and D6452 provides a standard guide for purging methods used in groundwater quality investigations. Consult ASTM Standard D6724 for a guide on the installation of direct-push ground-

Snap Samplers can be configured to collect samples in 40ml VOA vials designed to be used directly in commercial laboratory testing equipment. Snap VOA vials allow the user to collect samples in the same container that is analyzed at the lab, never exposing the sample. These samples can be field-preserved after collection without exposing sample. This is just about the perfect sample—sealed downhole, never exposed, analyzed in the same container that was deployed in the well. Snap Samplers can also be configured with 125ml or 350ml HDPE bottles for larger volume requirements. Snap Sampler modules can be stacked in any combination up to 6 in a "string" of Snap Samplers. The 40ml VOA and 125ml Poly bottles will fit into 2-inch (50mm) or larger wells, while the 350ml bottle can fit into wells that are 4-inch (100mm) or larger. Samples collected in the Poly bottles can be prepared for direct submittal to the analytical laboratory, or samples can be transferred into appropriate lab-supplied containers as needed.

Why use a Snap Sampler?

Cost savings is usually the main reason users consider passive sampling generally. Snap Samplers are passive devices, which means you can avoid the time-consuming purge process and the associated waste generation, handing, paperwork and liability. If you generate no wastewater, you don't have to deal with it. It's smart



and it's sustainable. It also allows you to avoid equipment rentals, meter calibrations, and potential failures. Of course, if you need parameter readings for purposes other than purge "stability" measurements, you can use collected Snap Sampler water to take hand held meter measurements. Typical cost savings from Snap Sampling ranges widely, but a good rule of thumb is a 50% cost savings on physical sample collection. Savings results from reduced time in the field, avoidance of waste handling and disposal, and avoidance of equipment rentals.

Data Quality is another primary reason for choosing the Snap Sampler. The US Department of Defense funded a number of SERDP and ESTCP studies that show the Snap Sampler met data quality criteria for equivalence to low flow sampling for both concentration and data variability. The bottom line is that Snap Sampling is technically equivalent to low flow sampling. Sealed VOC samples mean that in addition to technical equivalence, the effect of field conditions and personnel is minimized or even eliminated. This can't be said for other no-purge devices that are highly reliant on user technique, or have analyte limitations. These key factors set the Snap Sampler apart from other approaches.

Discrete depth sampling is a common use for Snap Samplers. Because Snap Samplers are deployed in a fixed position, you can be as sure as you can be about where the sample comes from within a well. For multiple depth sampling, that is a key feature. Zone isolation devices can be inserted between Snap Samplers to improve vertical profile results. This approach allows a user to utilize existing infrastructure for characterization, or may allow dual purpose well construction.

Very deep wells are traditionally difficult to sample. With Snap Samplers, deep wells are much less of a problem. The Snap Sampler pneumatic trigger system operates on tire pump air pressure. There is no need to overcome submergence pressure, therefore you no longer need nitrogen bottles to sample from hundreds or even thousands of feet depth.

Technology Websites: www.QEDENV.com www.SnapSampler.com

QED Environmental Systems, Inc.

2355 Bishop Circle West
Dexter, MI 48130
800-624-2026
www.qedenv.com

References:

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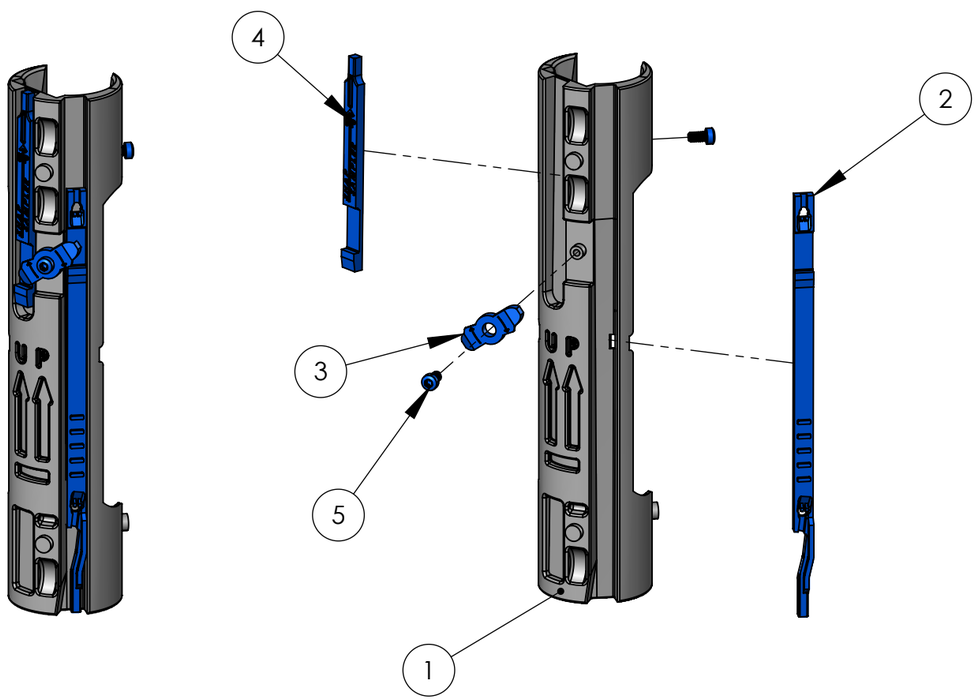
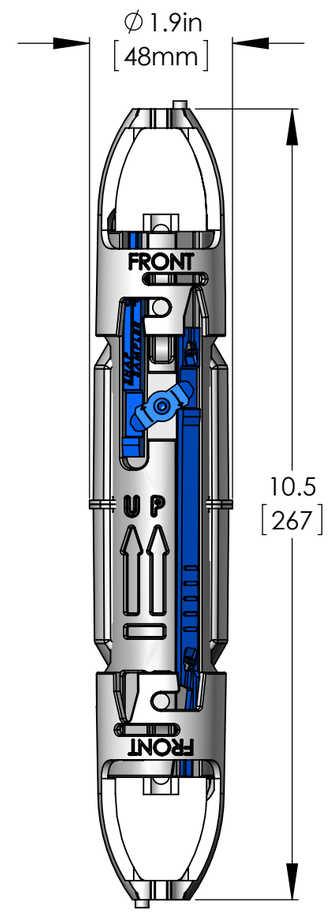
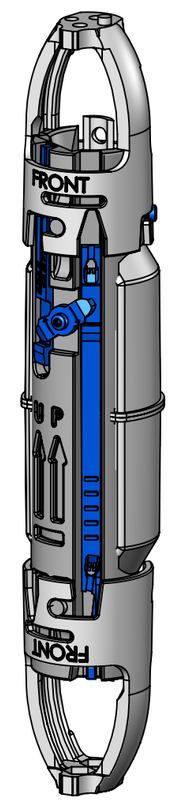
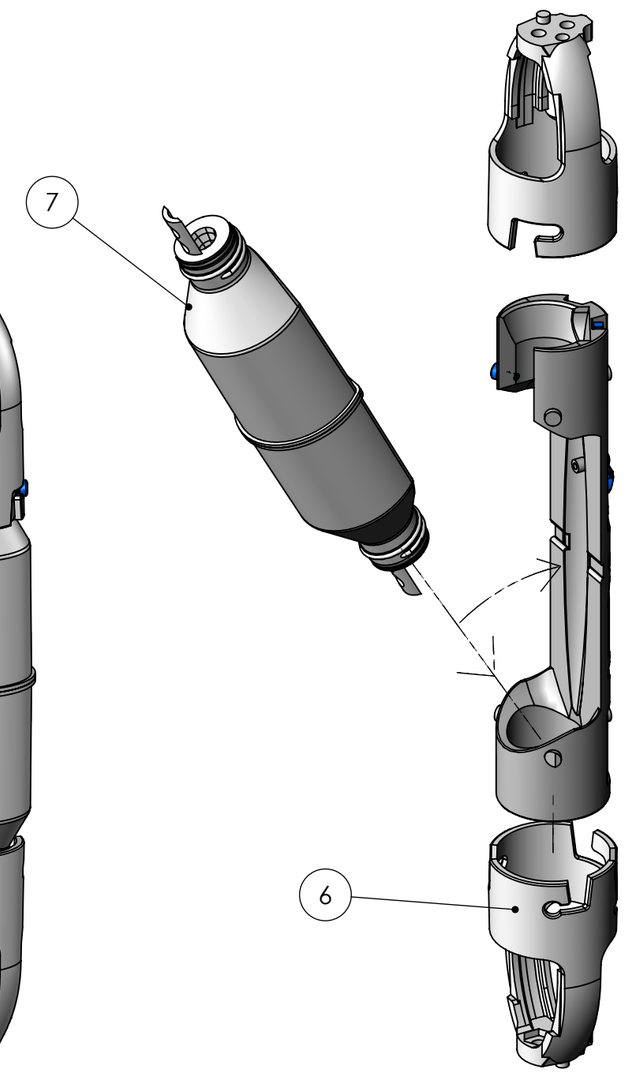
ITEM NO.	DESCRIPTION	STACKED/QTY.
1	125mL/350mL SAMPLER BODY	1
2	LOWER RELEASE PIN (LONG)	1
3	RELEASE PIN LEVER	1
4	UPPER RELEASE PIN	1
5	4-40 SCREW (PLASTIC)	2
6	TWIST-ON CONNECTOR	2
7	125mL BOTTLE	1









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THREE PLACE DECIMAL ± 0.005
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ASME Y14.5-2009

MATERIAL

FINISH

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	NAME	DATE
DRAWN	MAB	01/02/13
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
1in
[25.4mm]

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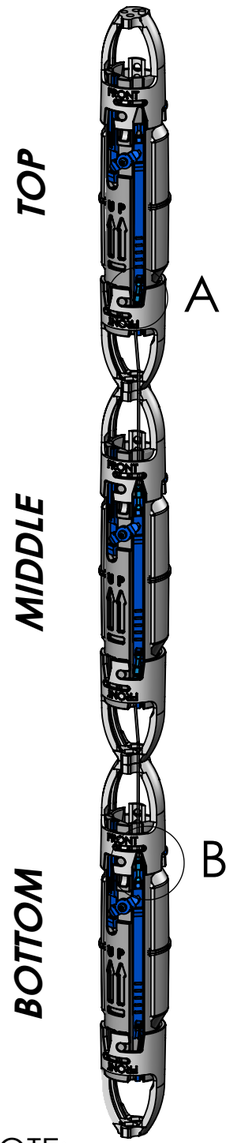
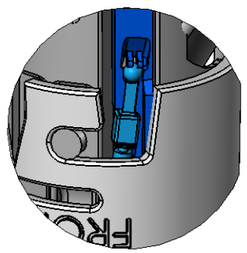
TITLE:
125mL SNAP SAMPLER

SIZE B | PART NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 2

ITEM NO.	DESCRIPTION	QTY.
1	BALL END CONNECTOR (PLASTIC)	2
2	BALL END CONNECTOR (S.S.)	2
3	125mL SNAP SAMPLER	3
4	SCREW (PLASTIC)	4
5	HEX NUT (PLASTIC)	4





DETAIL A
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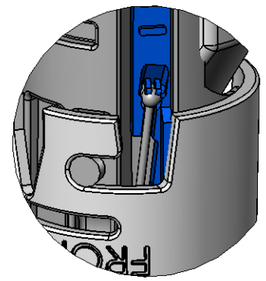

DETAIL A'
S.S. CONNECTOR
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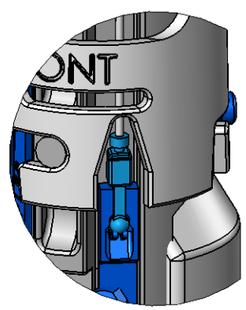

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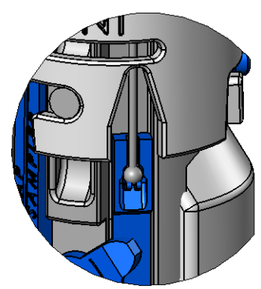
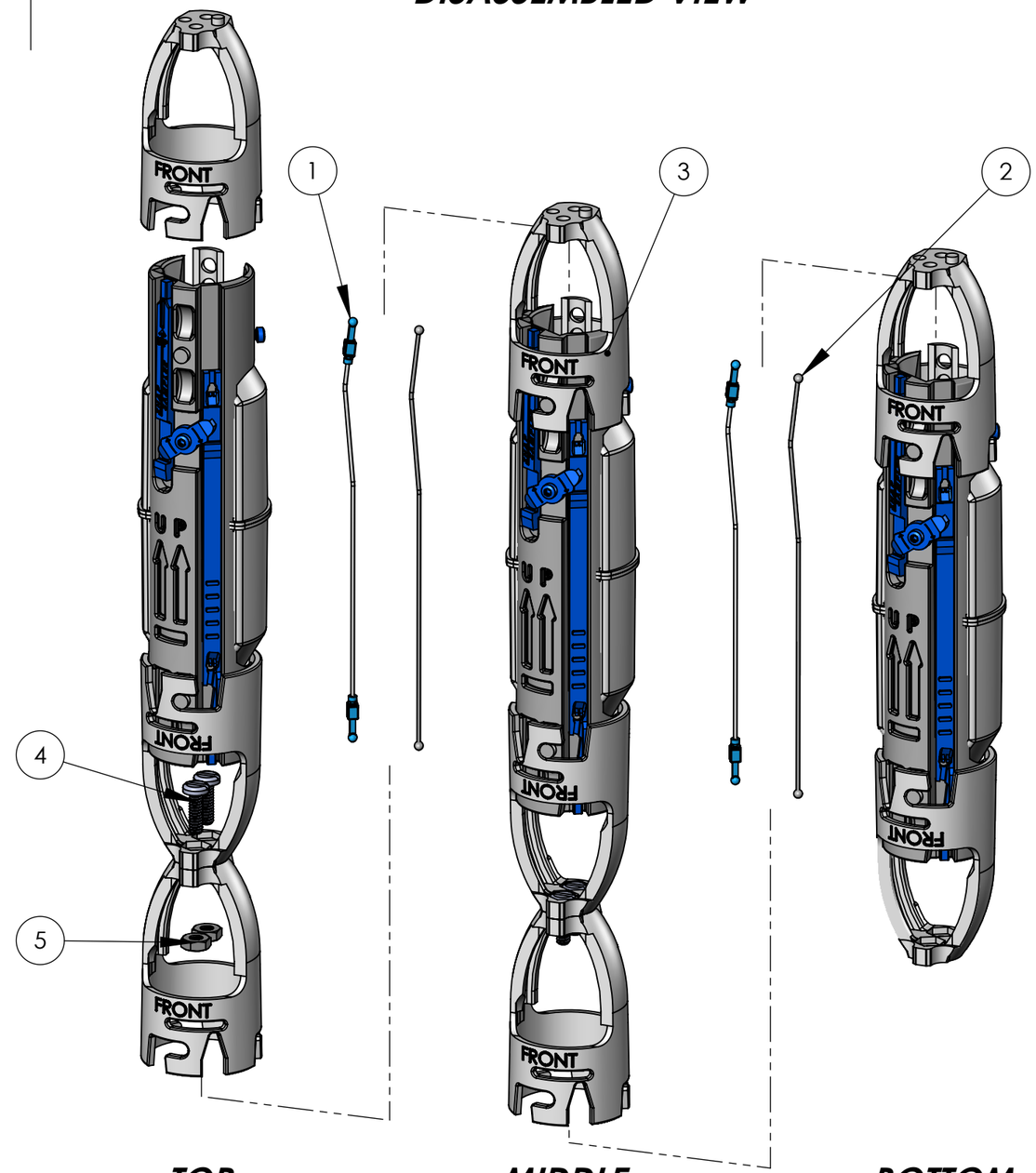
CABLE INSERTION



DETAIL B'
S.S. CONNECTOR
CABLE INSERTION

DISASSEMBLED VIEW



NOTE:

- 40mL AND 125mL SNAP SAMPLERS ARE INTERCHANGEABLE AND CAN BE ASSEMBLED IN ANY COMBINATION UP TO 6 IN SERIES.
- EITHER CABLE CONNECTOR(S) (PLASTIC OR STAINLESS STEEL) CAN BE USED

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ASME Y14.5-2009

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MAB	01/02/13
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
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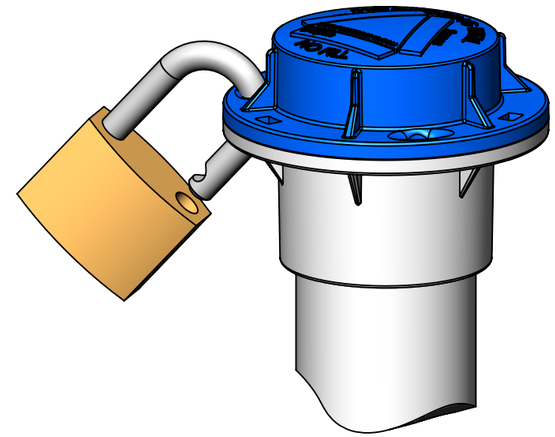
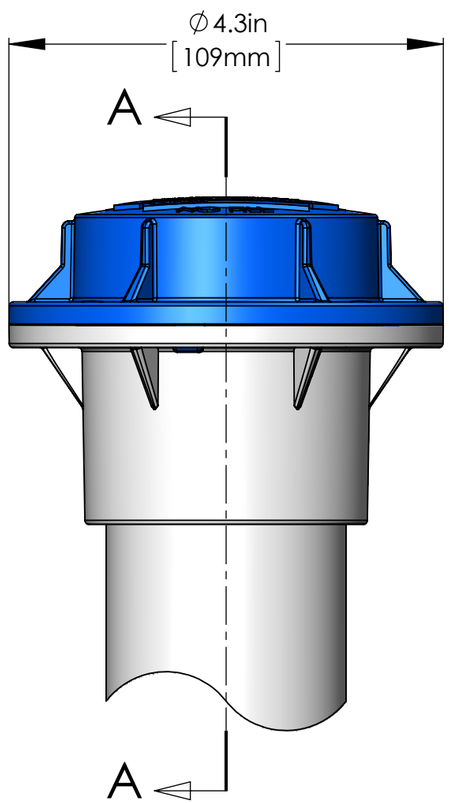
TITLE:
125mL SNAP SAMPLER

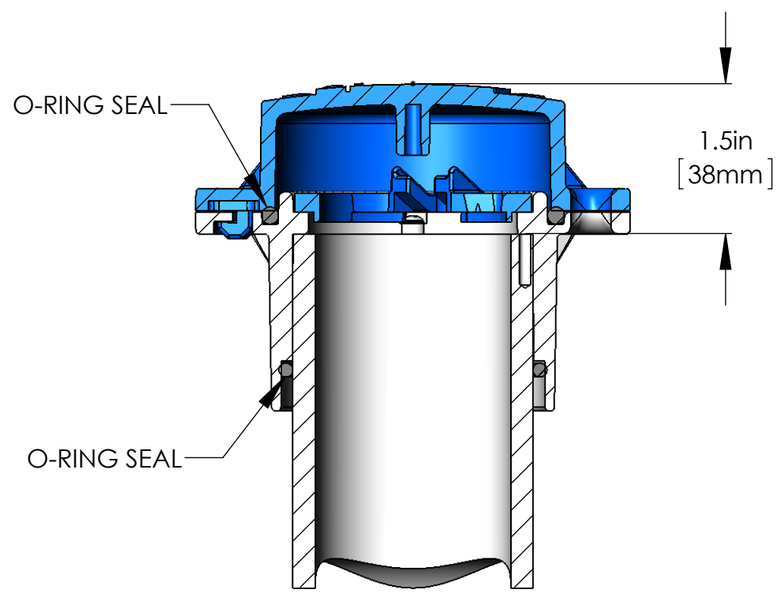
SIZE B | PART NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 2 OF 2

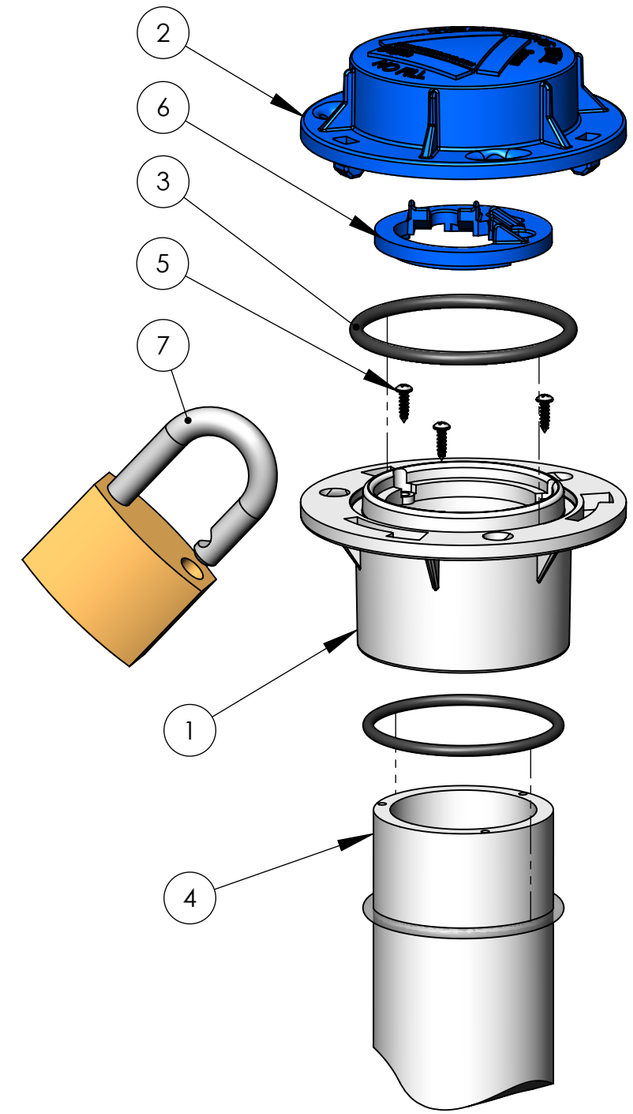
ITEM NO.	DESCRIPTION	QTY.
1	2" WELL DOCK BASE	1
2	2" WELL DOCK CAP	1
3	VITON O-RING	2
4	2" WELL RISER PIPE	1
5	410 SS SCREW (MAGNETIC)	3
6	2" WELL DOCK EQUIPMENT SUPPORT RING	1
7	PADLOCK (EXAMPLE; NOT INCLUDED)	1







SECTION A-A
SCALE 1 : 1.5



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ANGULAR: 1°
TWO PLACE DECIMAL ± 0.01
THREE PLACE DECIMAL ± 0.005
INTERPRET GEOMETRIC TOLERANCING PER:
ASME Y14.5-2009

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MAB	01/02/13
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
1in
[25.4mm]

ProHydro, Inc.

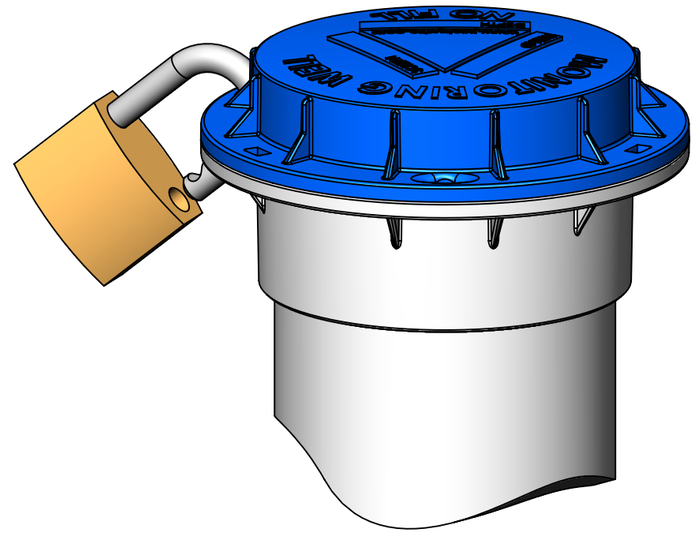
MADE IN THE USA | 585-385-0023 | www.prohydro.com

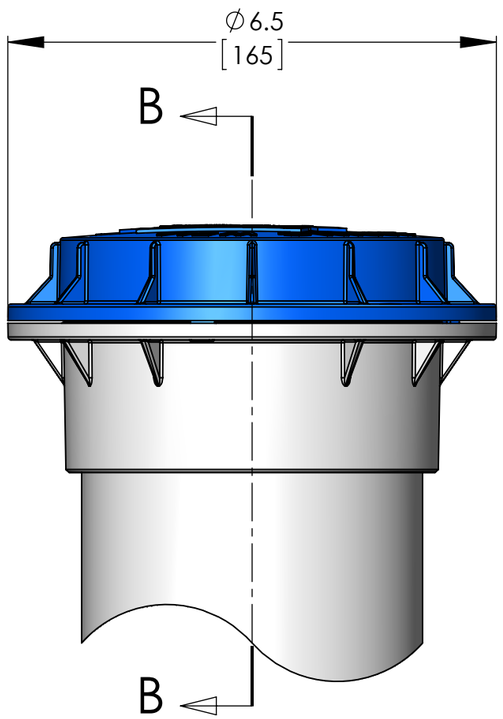
TITLE:
2" WELL CAP ASSEMBLY

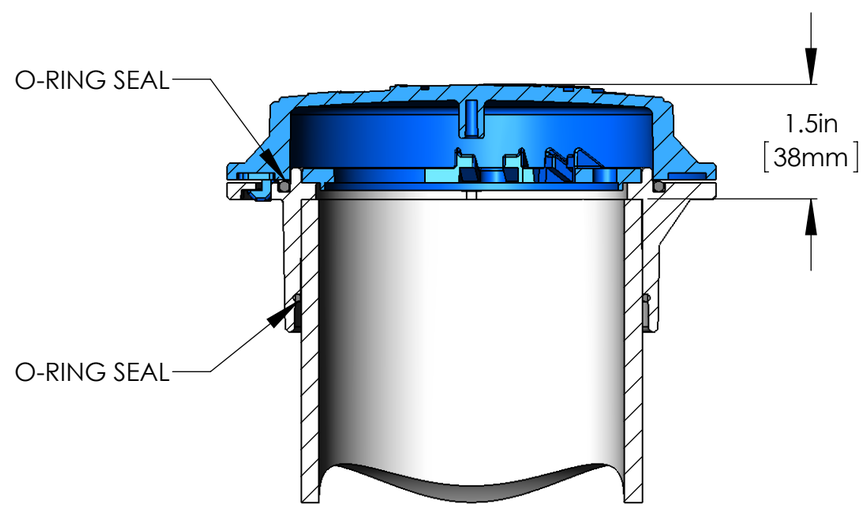
SIZE **B** | PART NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 1 OF 2

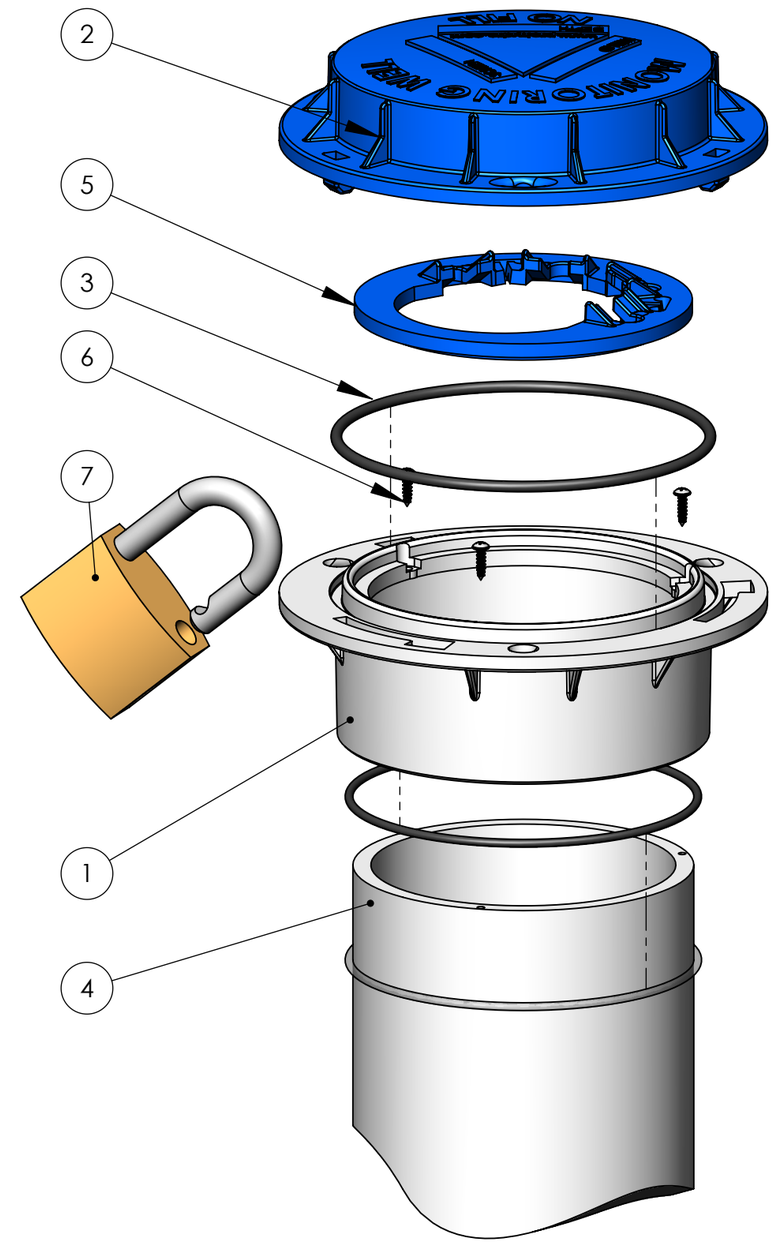
ITEM NO.	DESCRIPTION	QTY.
1	4" WELL DOCK BASE	1
2	4" WELL DOCK CAP	1
3	VITON O-RING	2
4	4" WELL RISER PIPE	1
5	4" WELL DOCK EQUIPMENT SUPPORT RING	1
6	410 SS SCREW (MAGNETIC)	3
7	PADLOCK (EXAMPLE; NOT INCLUDED)	1







SECTION B-B



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ANGULAR: 1°
TWO PLACE DECIMAL ± 0.01
THREE PLACE DECIMAL ± 0.005
INTERPRET GEOMETRIC TOLERANCING PER:
ASME Y14.5-2009

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MAB	01/02/13
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
1in
[25.4mm]

ProHydro, Inc.

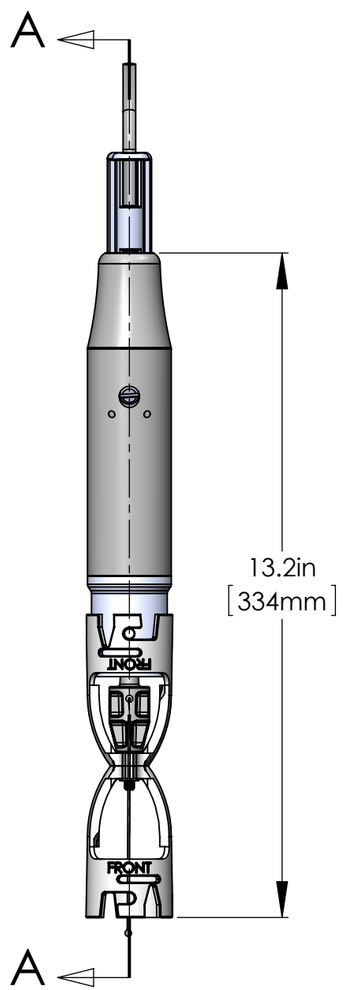
MADE IN THE USA | 585-385-0023 | www.prohydro.com

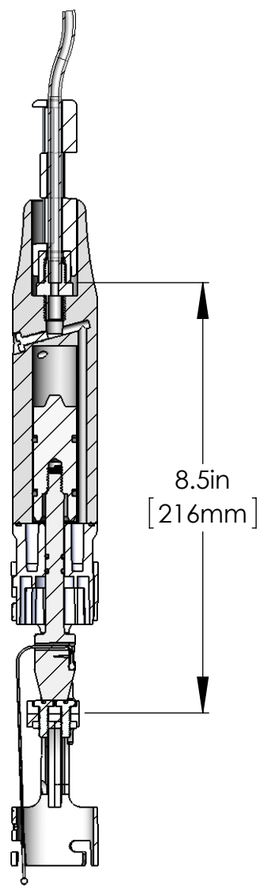
TITLE:
4" WELL CAP ASSEMBLY

SIZE **B** | PART NO. | REV

SCALE: 1:2 | WEIGHT: | SHEET 2 OF 2

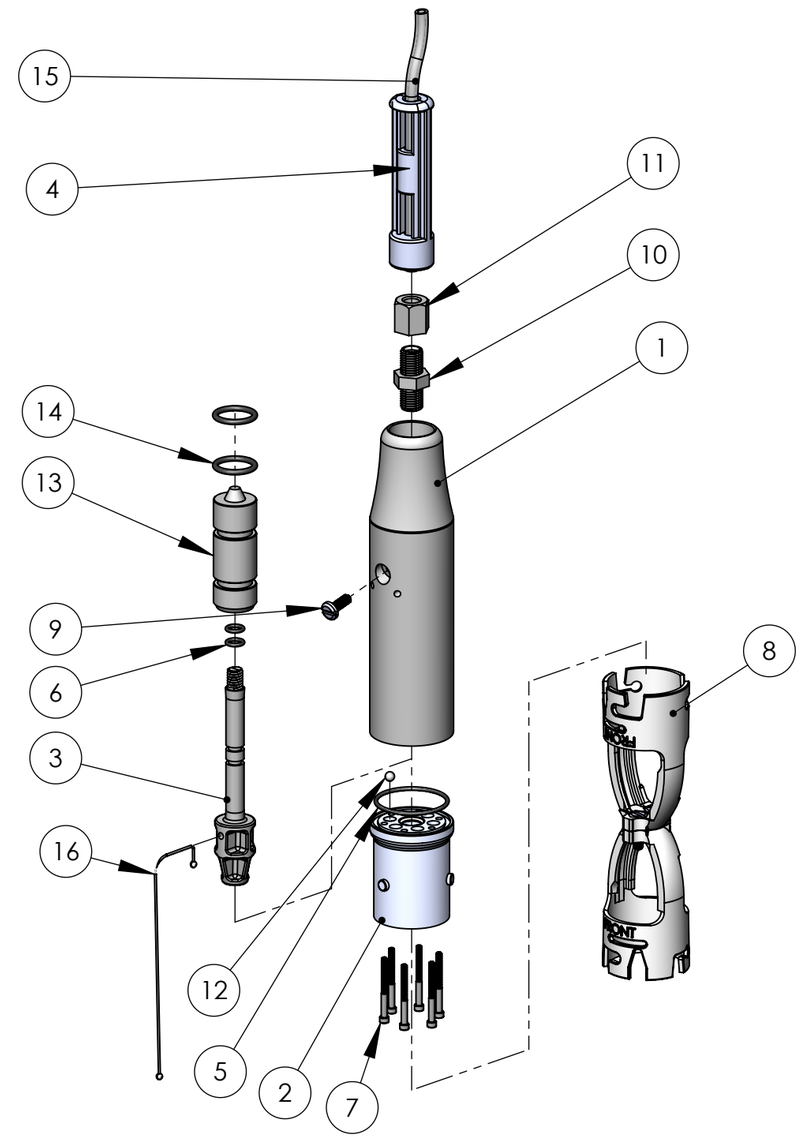
ITEM NO.	DESCRIPTION	QTY.
1	PNEUMATIC CYLINDER (MACHINED)	1
2	PNEUMATIC BASE	1
3	MOLDED PLUNGER	1
4	AIR-LINE WRENCH TOOL	1
5	PNEUMATIC BASE O-RING	1
6	PLUNGER STEM O-RING	2
7	4-40 SHCS (S.S.)	6
8	TWIST-ON CONNECTOR	2
9	MACHINE SCREW (VENT PLUG)	1
10	CONNECTOR TUBE FITTING (BODY)	1
11	CONNECTOR TUBE FITTING (NUT)	1
12	CHECK VALVE BALL (VITON)	1
13	MACHINED PLUNGER	1
14	MACHINED PLUNGER O-RING	2
15	AIR-LINE TUBE	1
16	CONNECTOR CABLE (S.S. OR PLASTIC)	1





SECTION A-A

FOR ILLUSTRATION ONLY
NO USER DISASSEMBLY REQUIRED. AIRTUBE ATTACHMENT (PARTS 4, 11, & 15) IS THE ONLY ASSEMBLY REQUIRED FOR USE.



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INTERPRET GEOMETRIC TOLERANCING PER:
ASME Y14.5-2009

MATERIAL

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	MAB	01/02/13
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:
1in
[25.4mm]

ProHydro, Inc.

MADE IN THE USA | 585-385-0023 | www.prohydro.com

TITLE:
PNEUMATIC ACTUATOR

SIZE B | PART NO. | REV

SCALE: 1:3 | WEIGHT: | SHEET 1 OF 1

Appendix F
Groundwater Level Hydrographs

NEWCREST

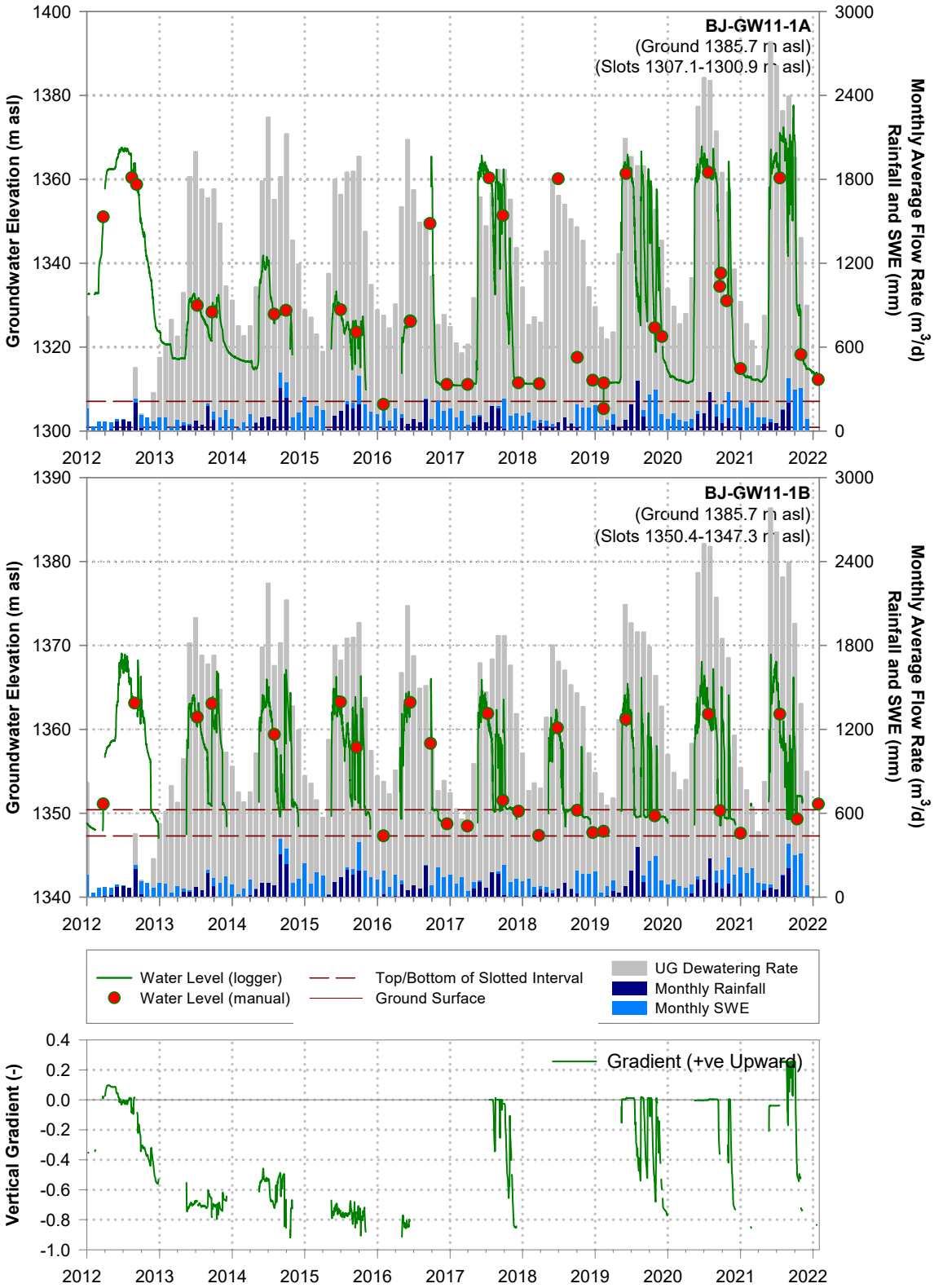

Figure 1: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-1A/B

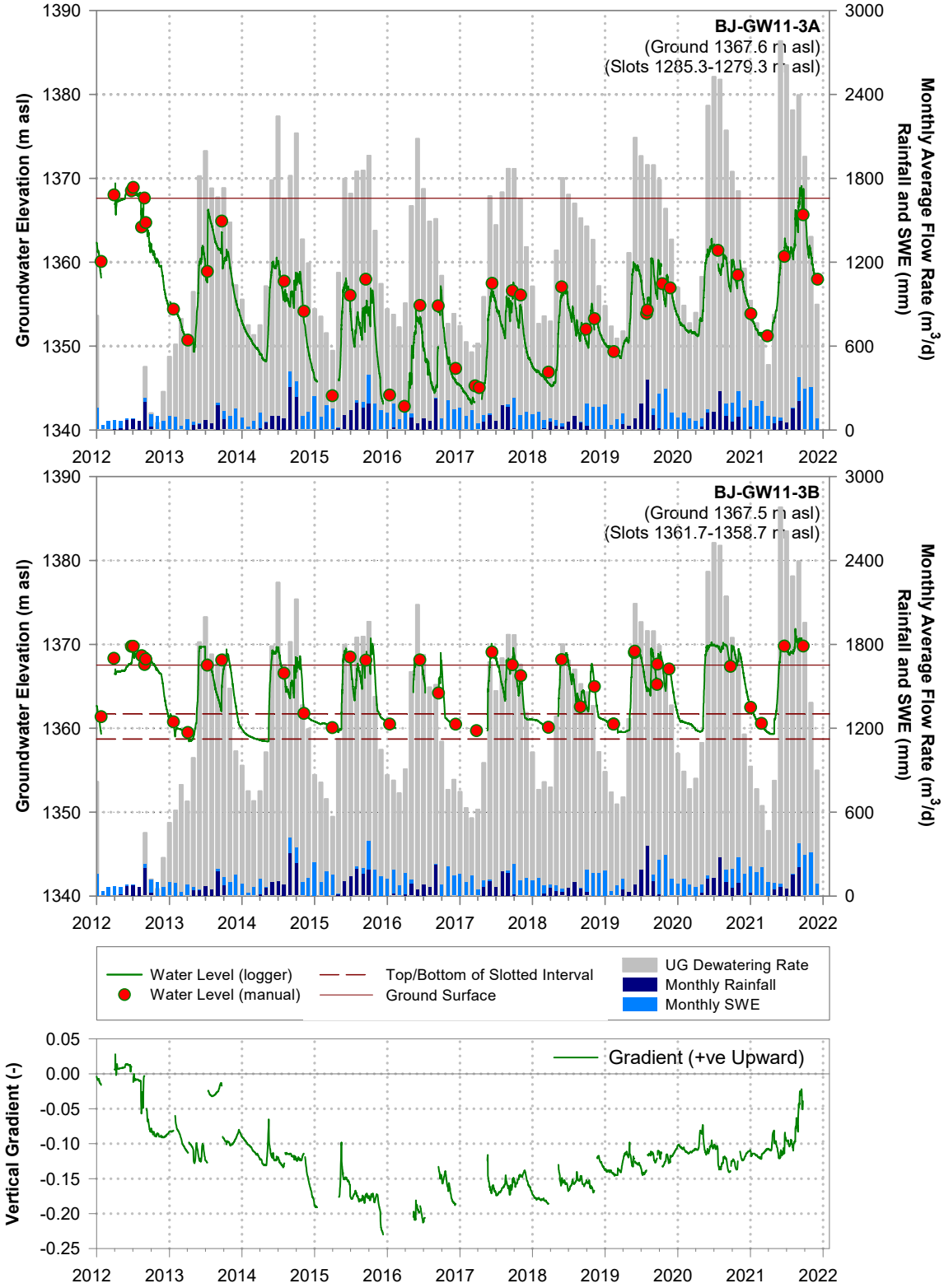

Figure 2: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-3A/B

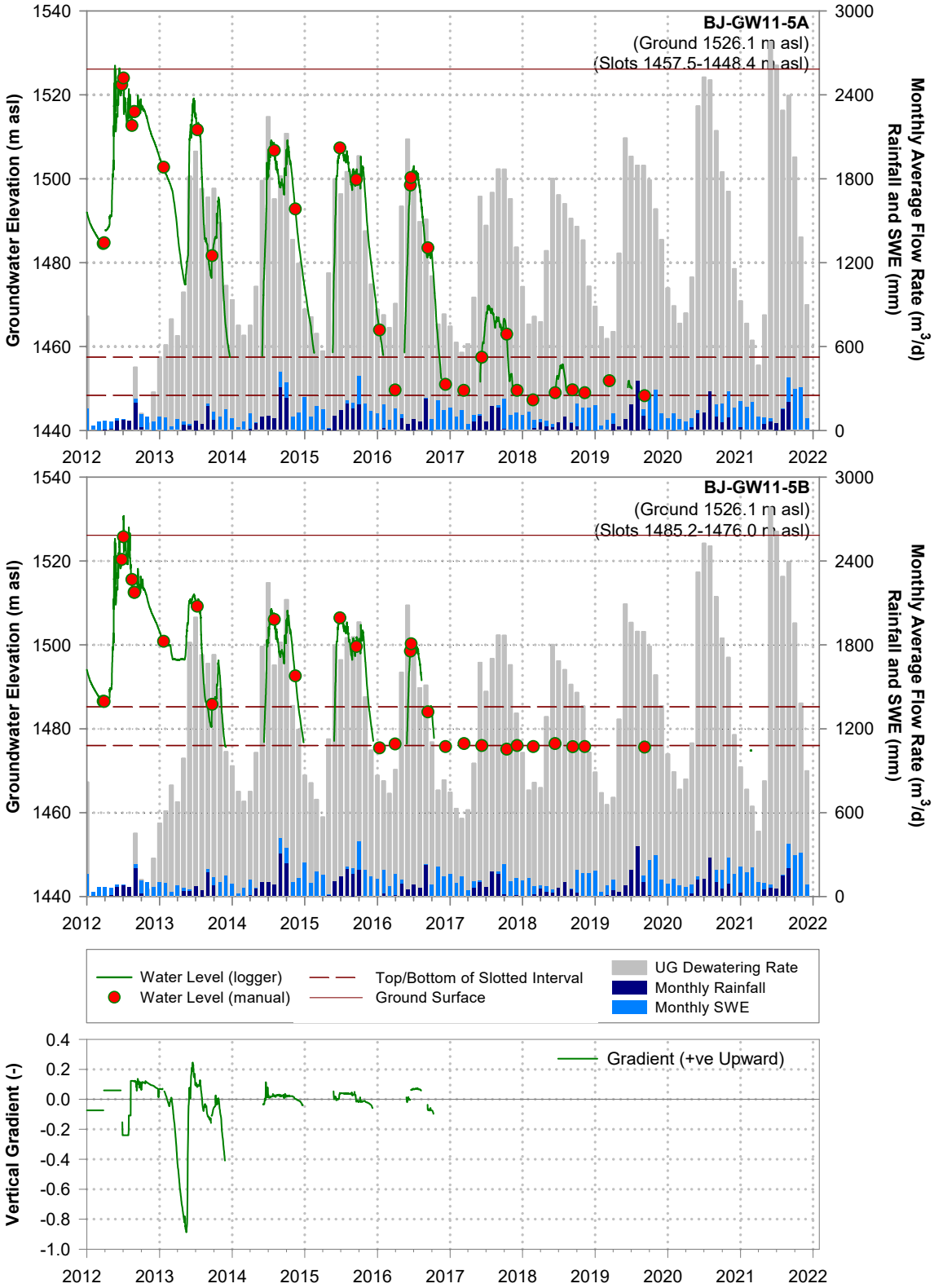

Figure 3: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-5A/B

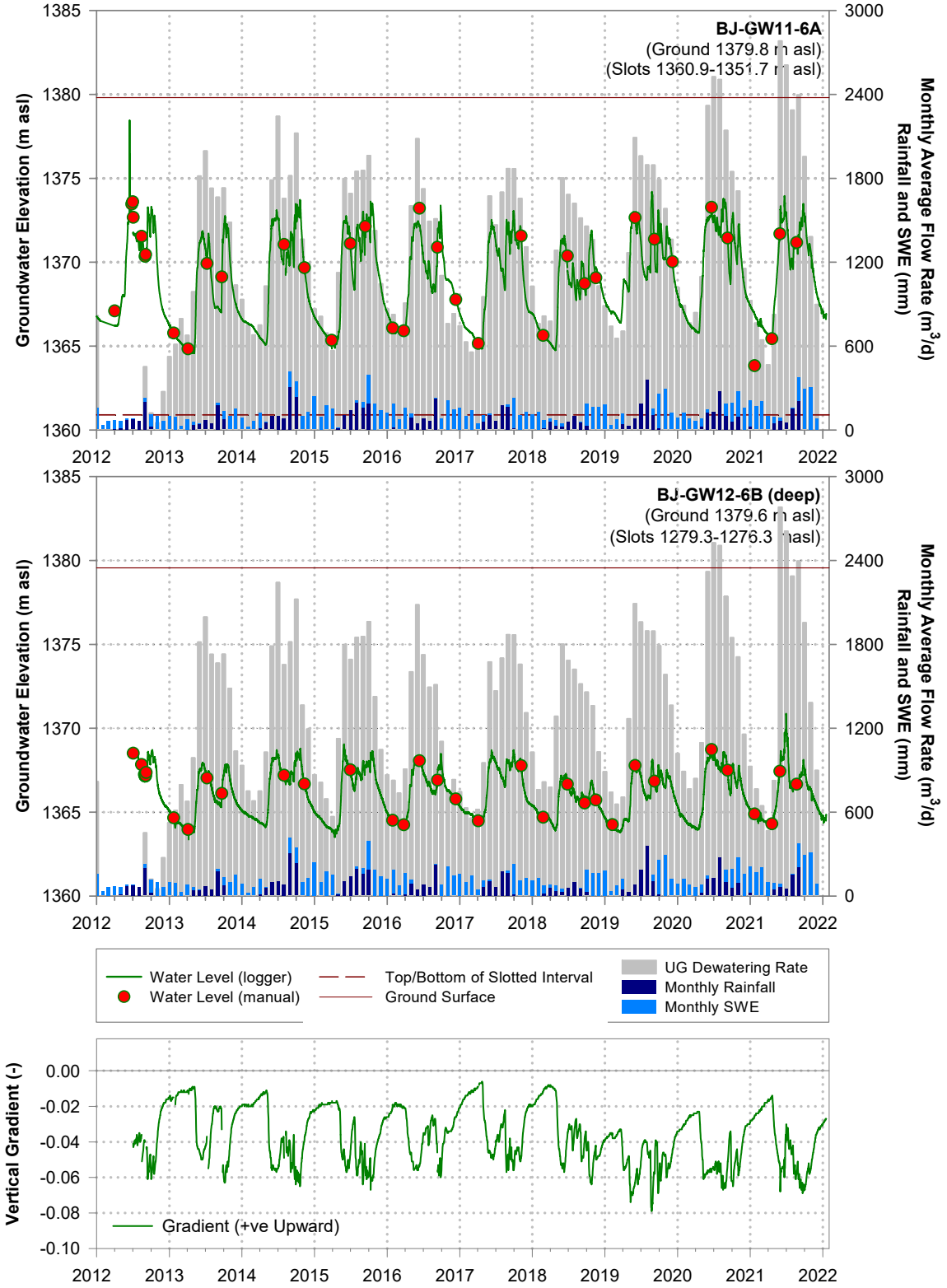

Figure 4: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-6A/BJ-GW12-6B

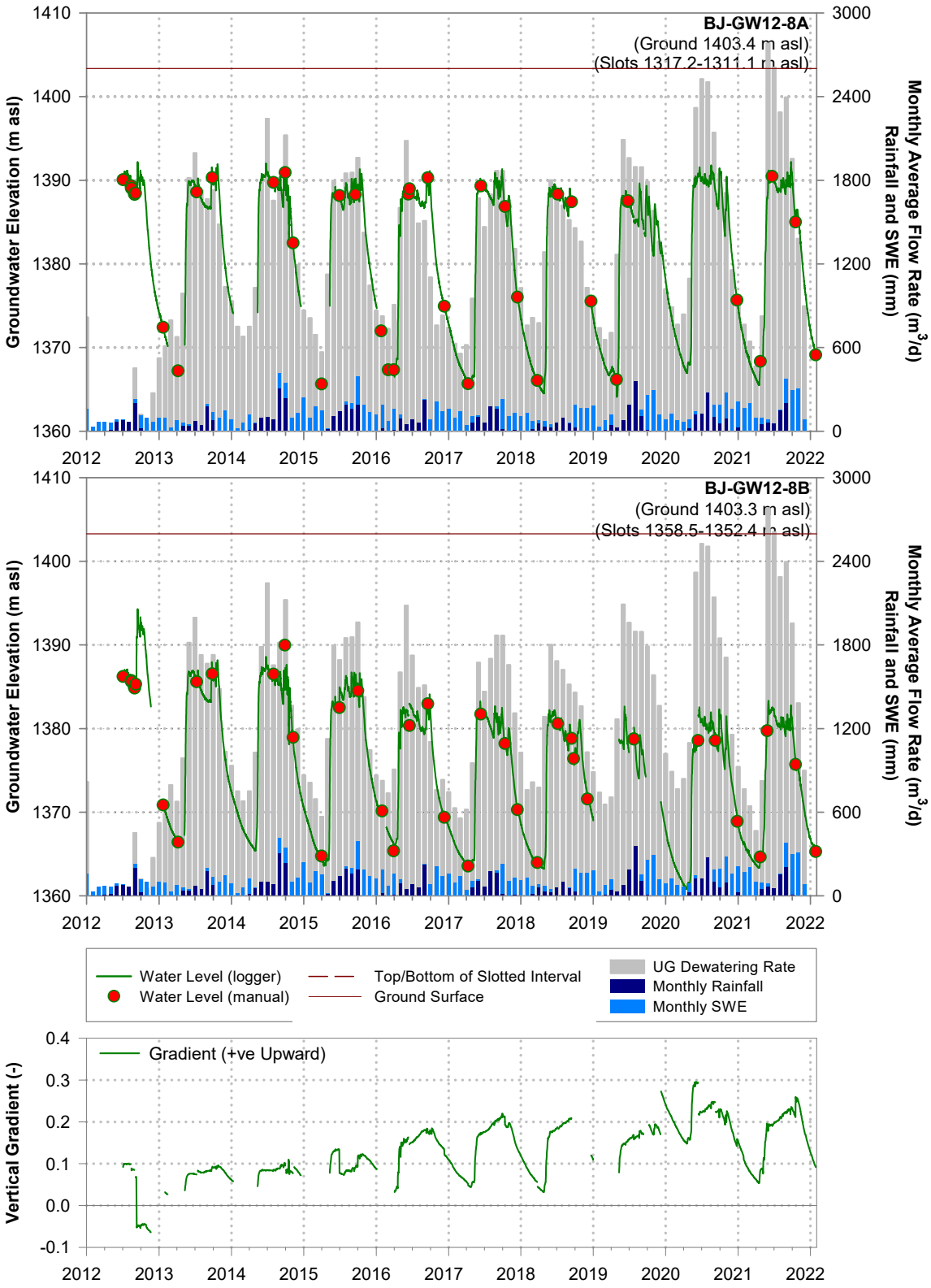

Figure 5: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-8A/B

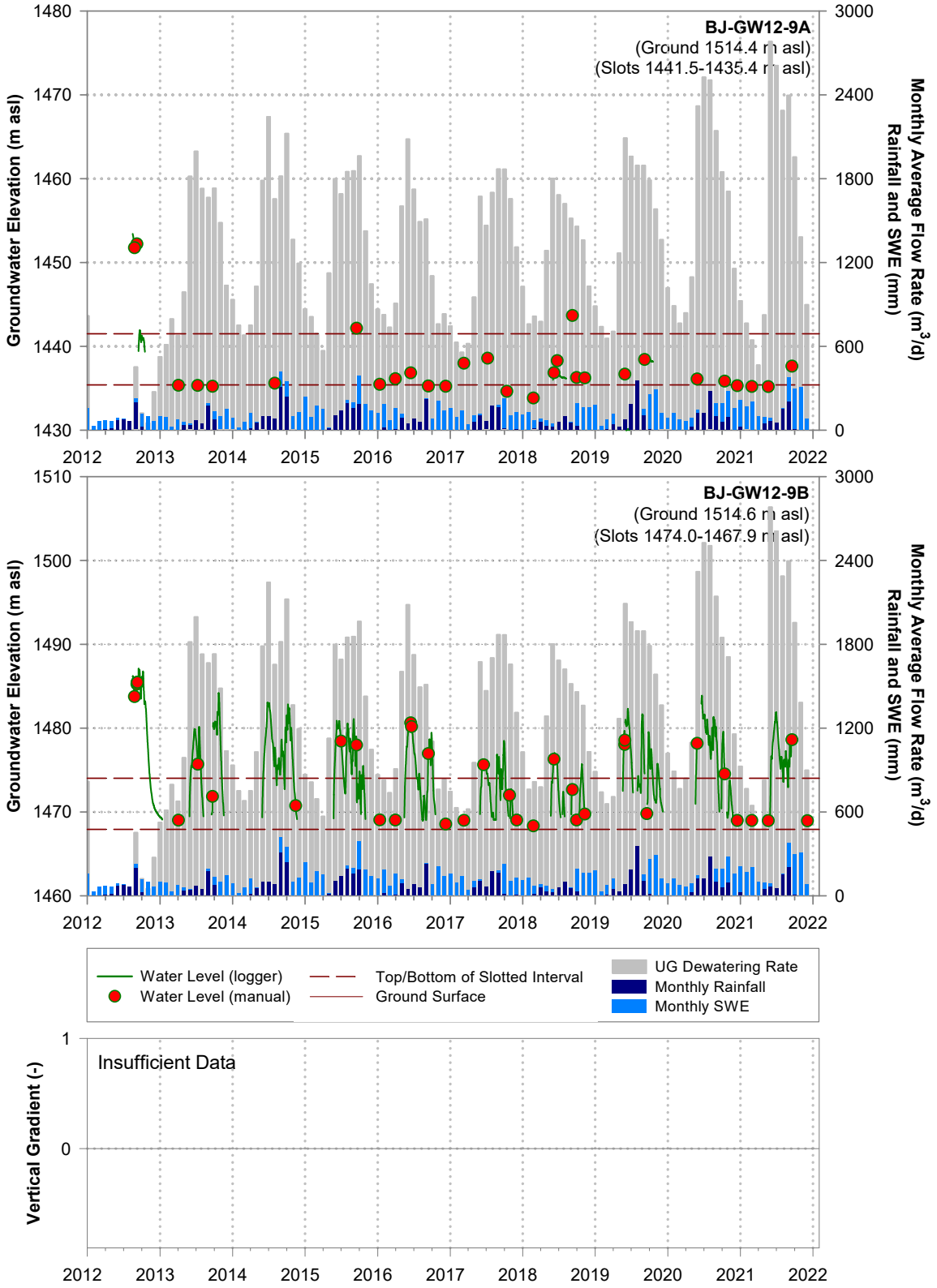

Figure 6: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-9A/B

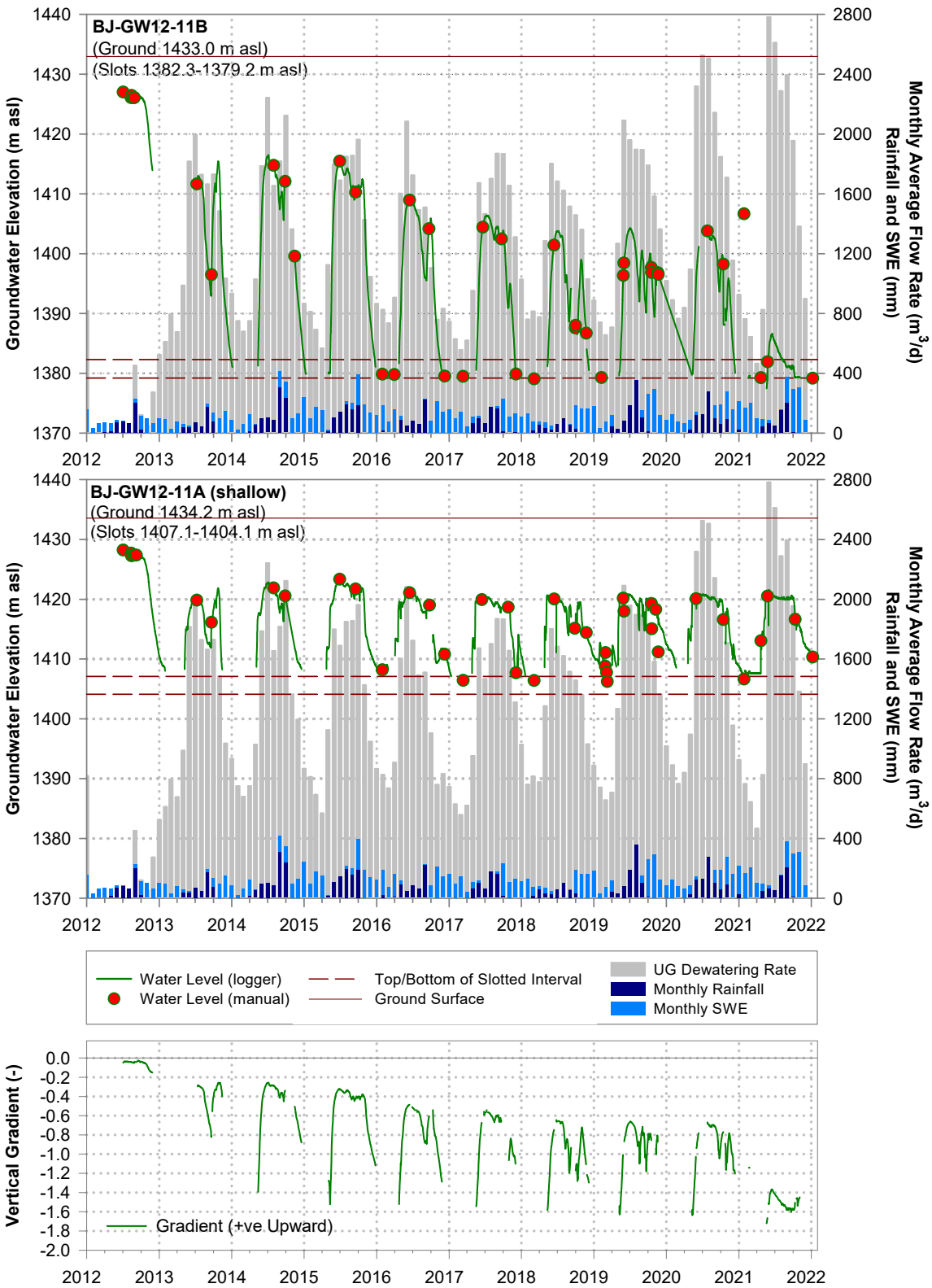

Figure 7: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-11A/B

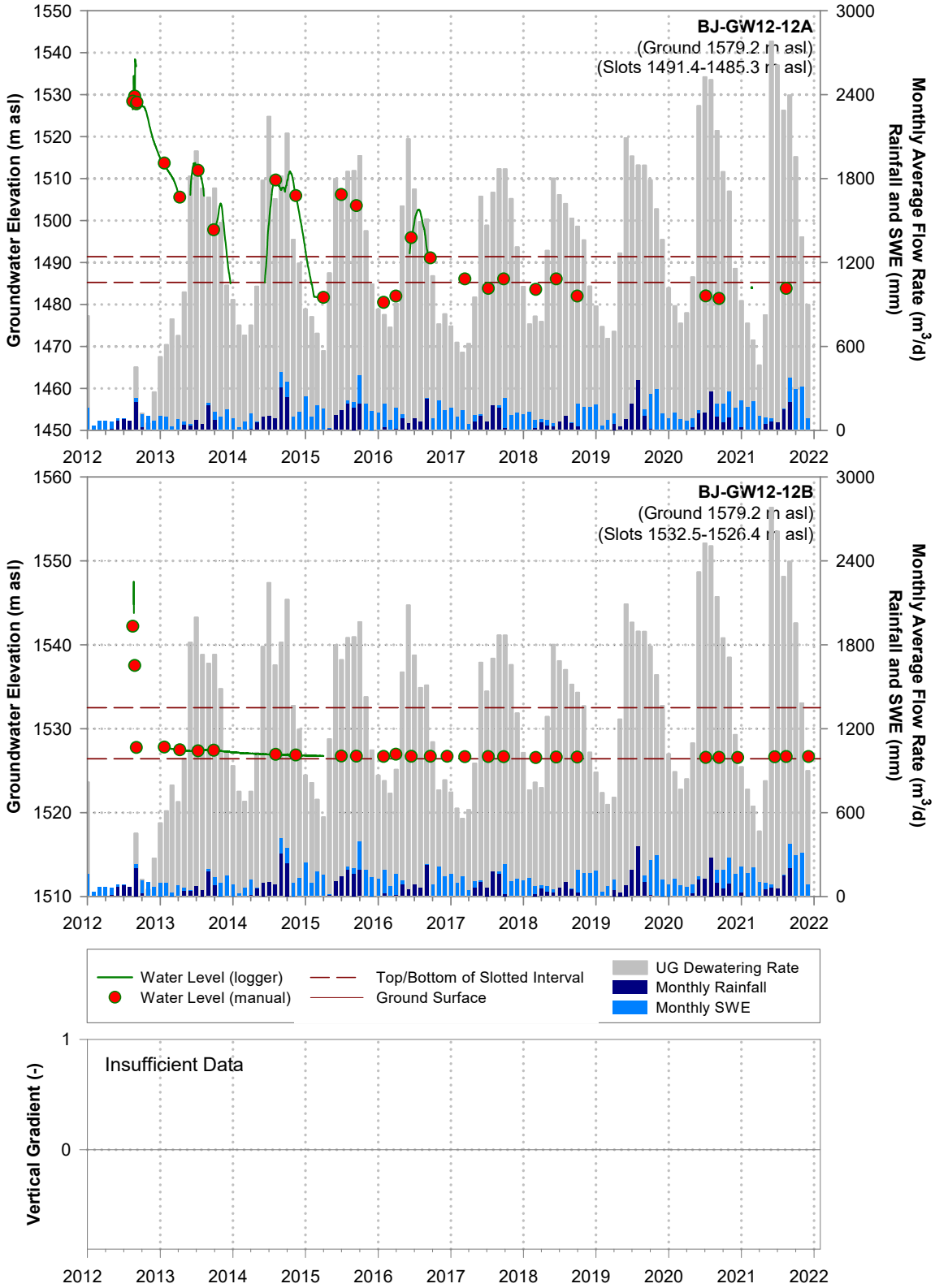

Figure 8: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-12A/B

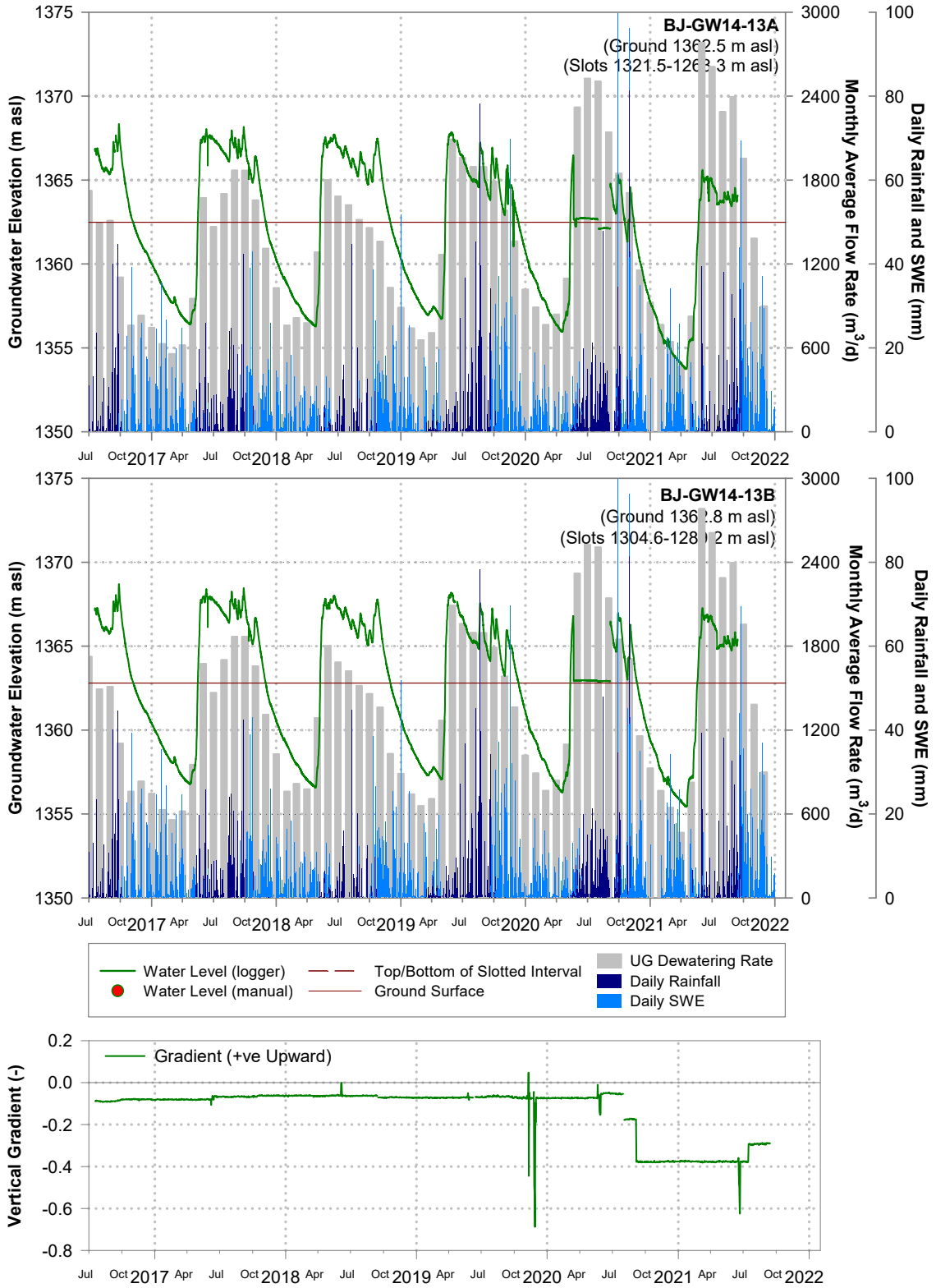

Figure 9: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW14-13A/B

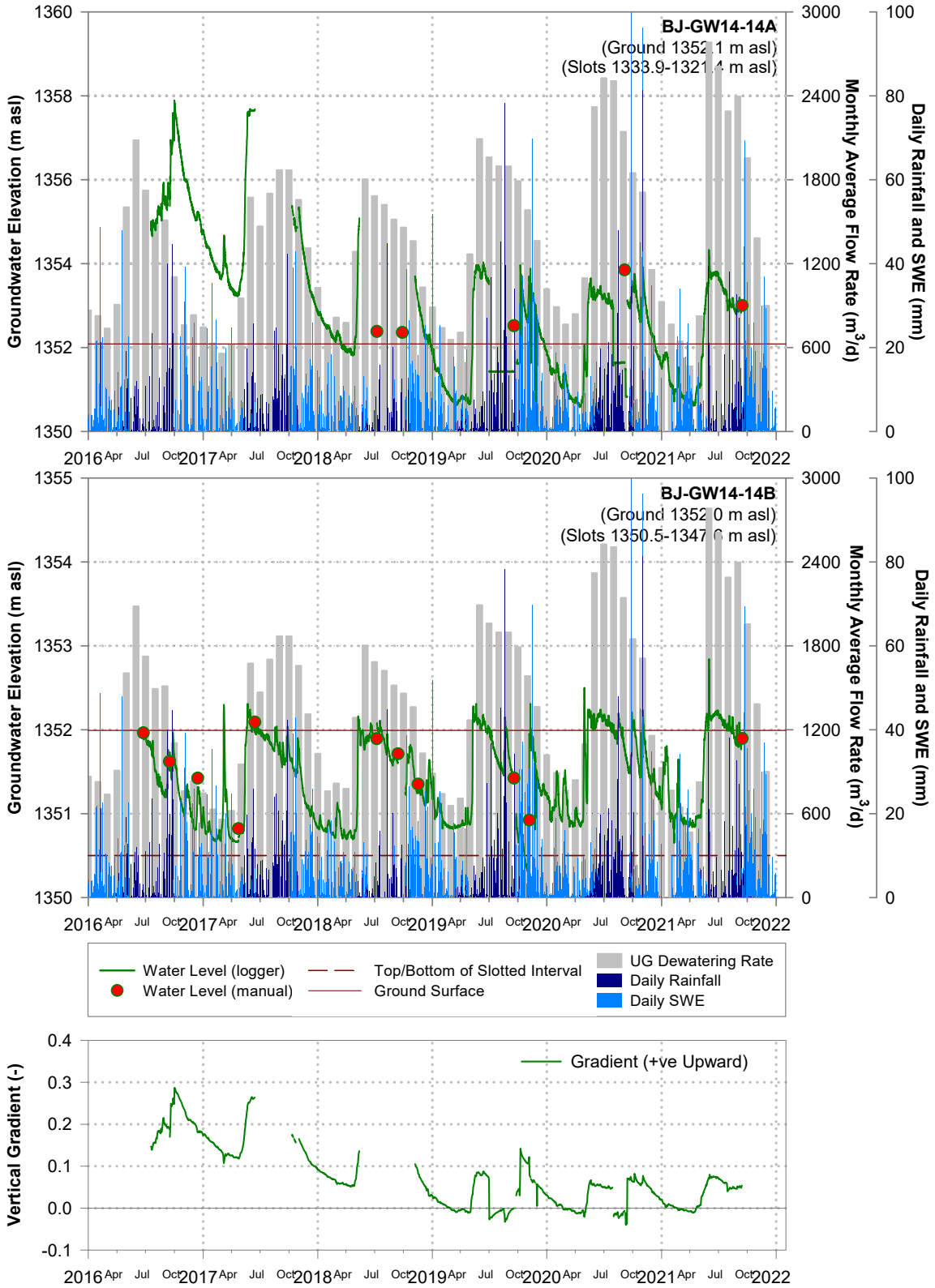

Figure 10: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW14-14A/B

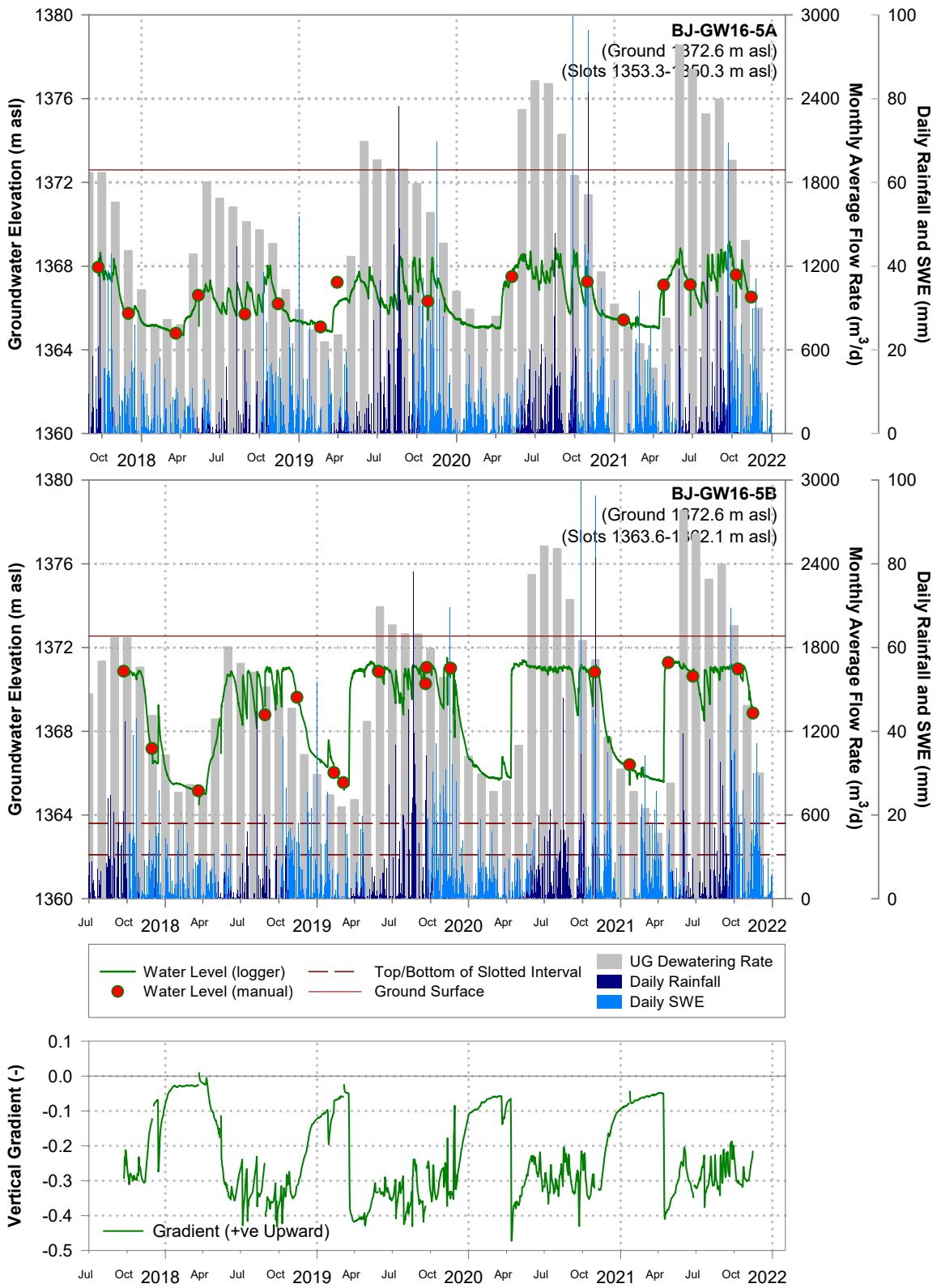

Figure 11: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW16-5A/B

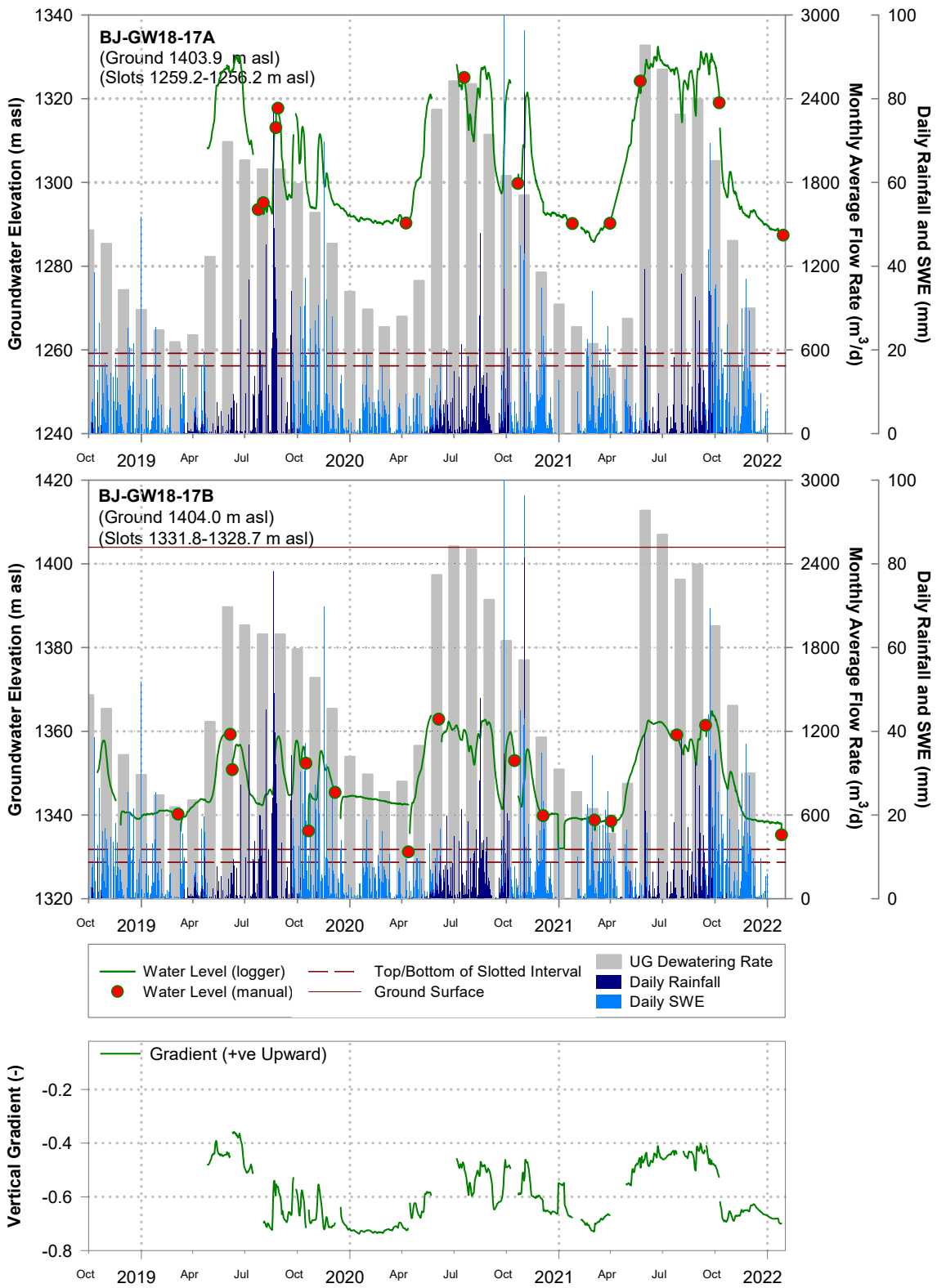

Figure 12: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-17A/B

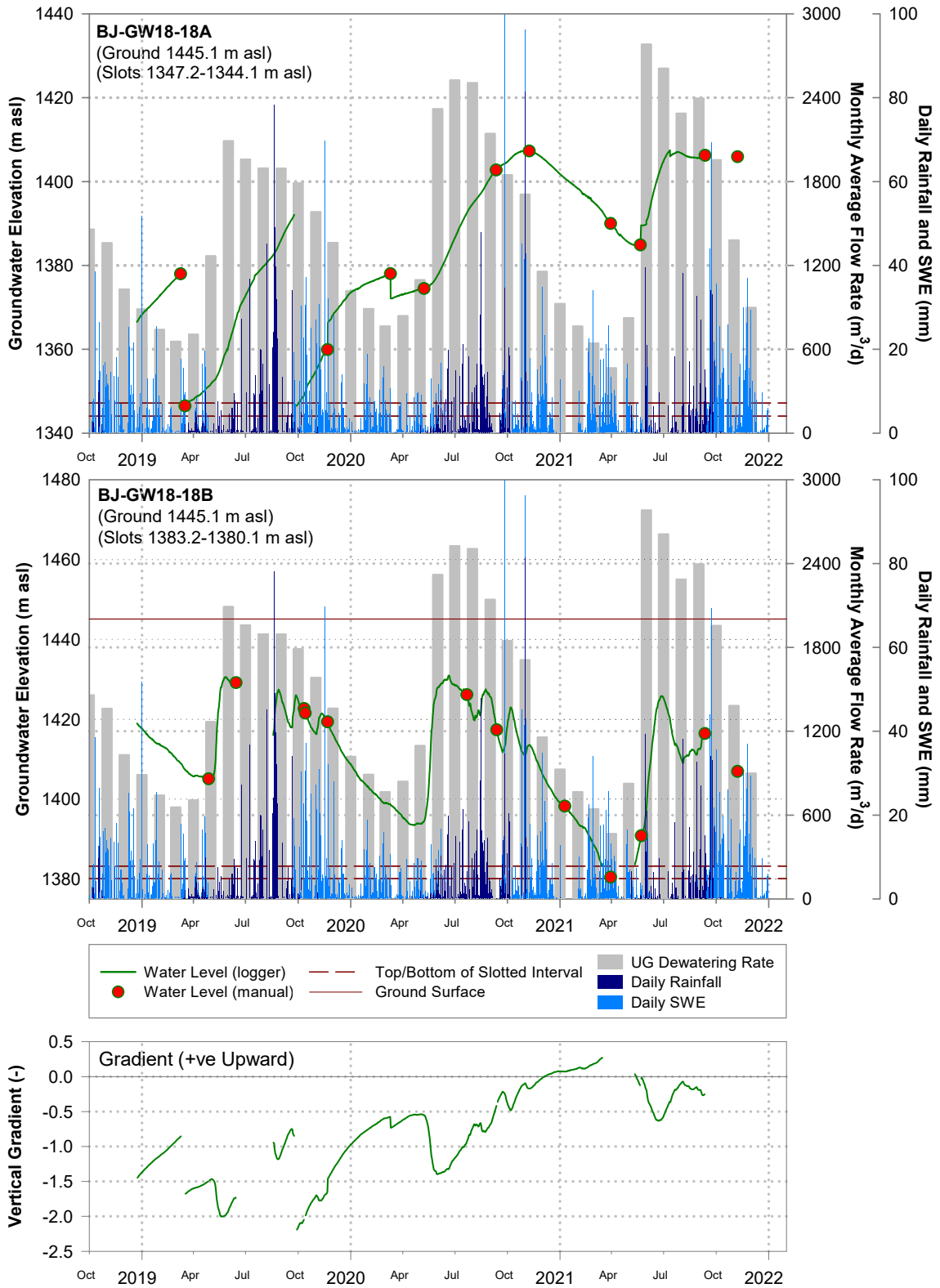

Figure 13: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-18A/B

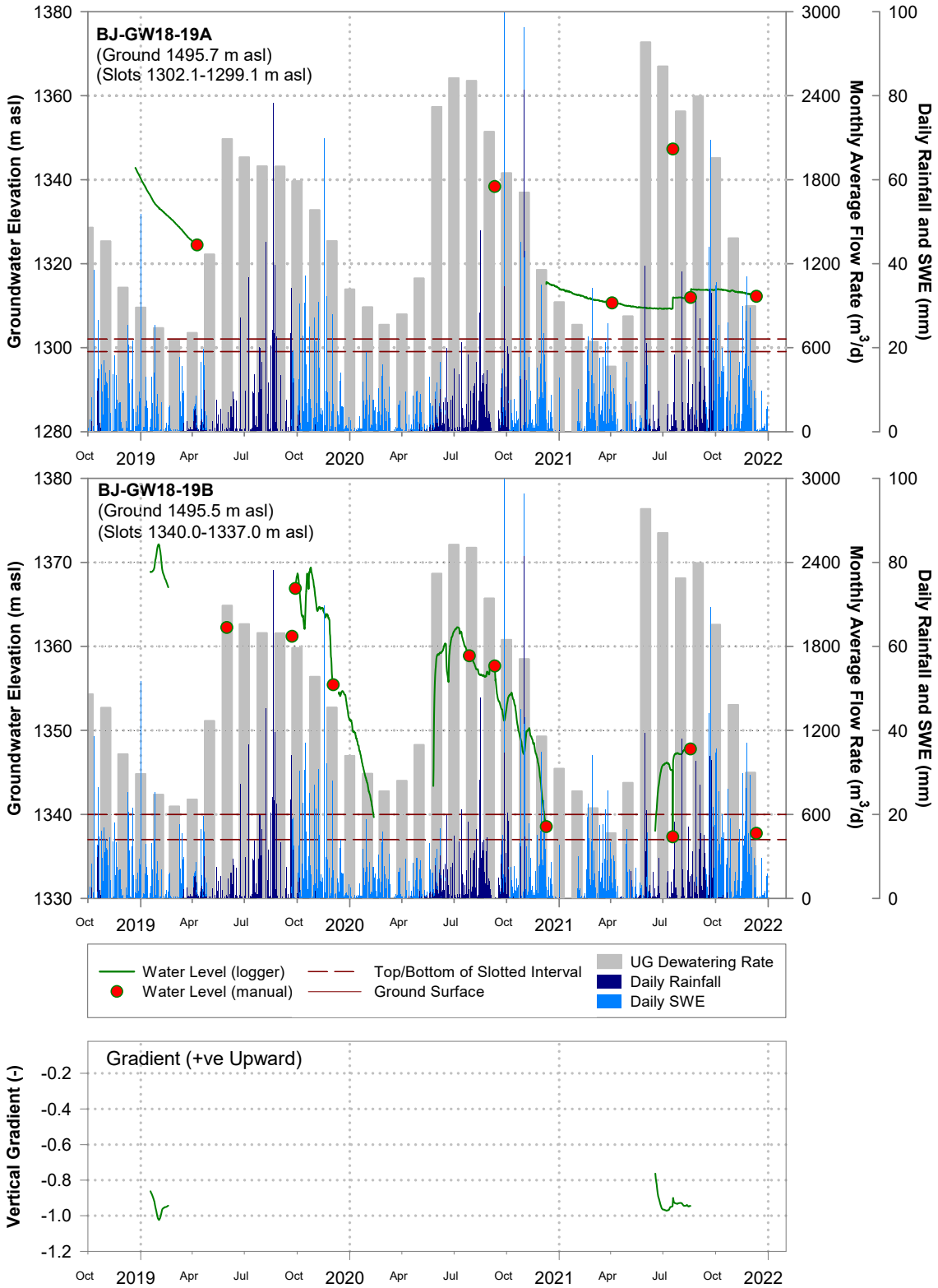

Figure 14: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-19A/B

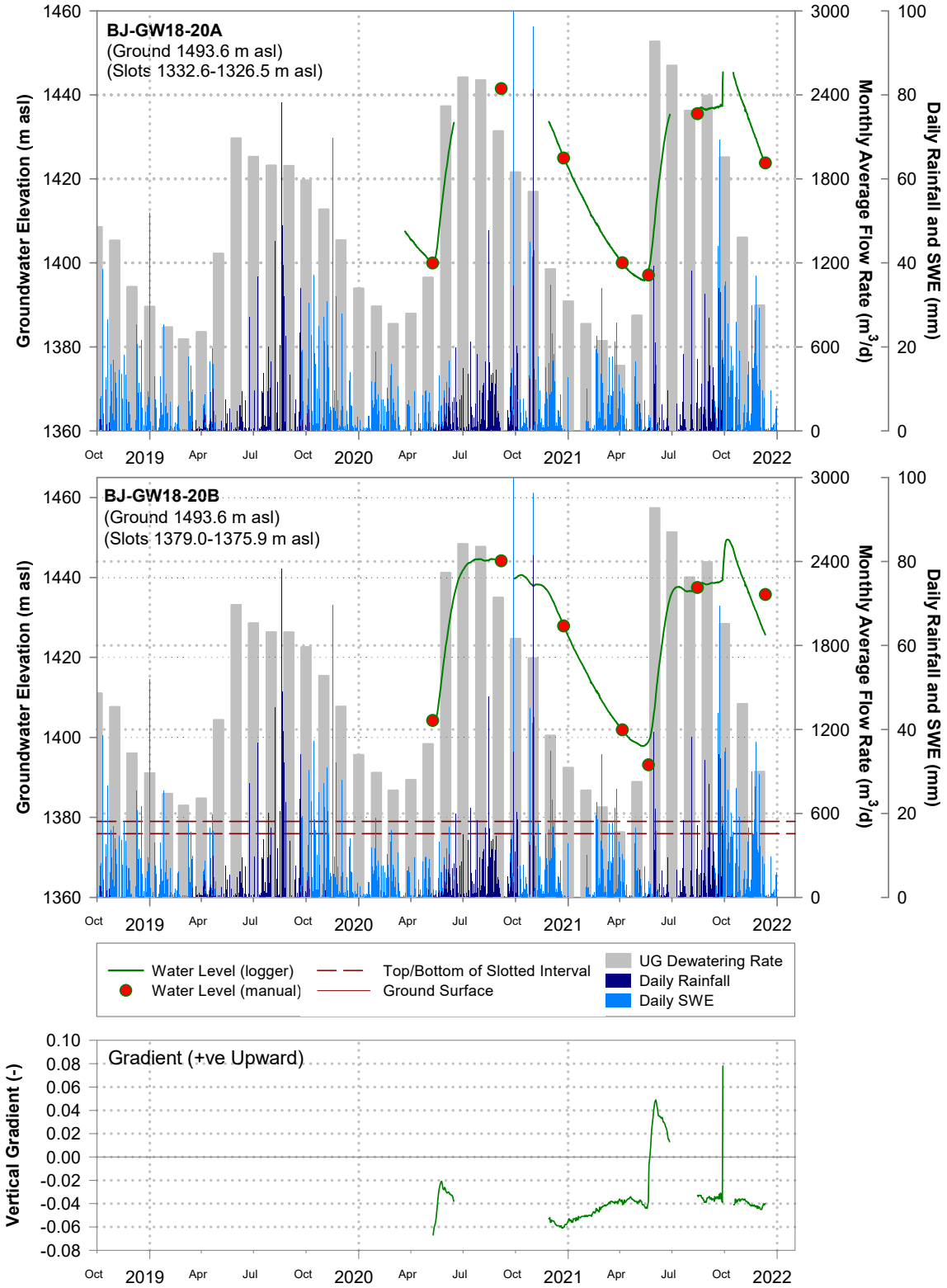

Figure 15: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-20A/B

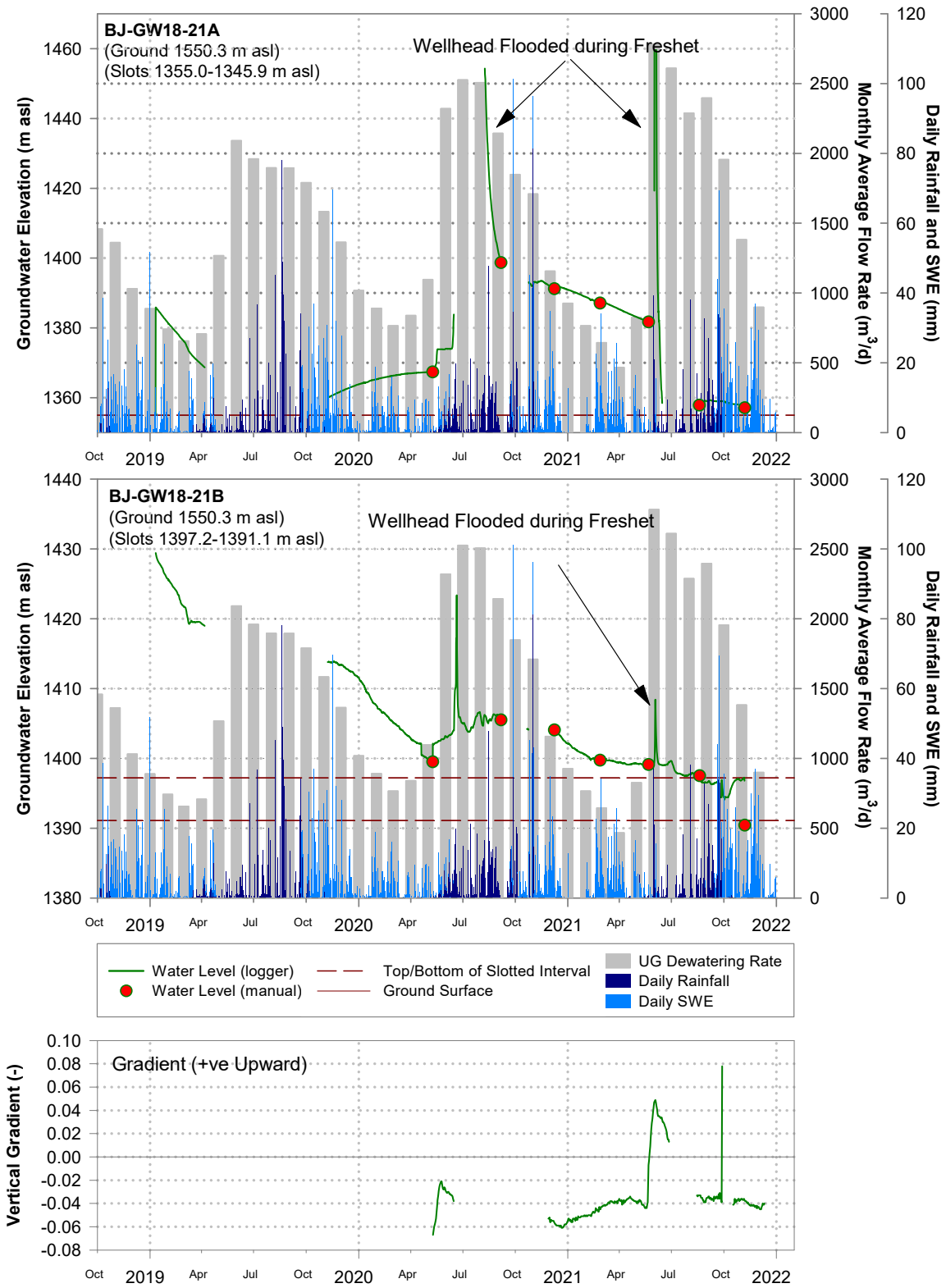

Figure 16: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-21A/B

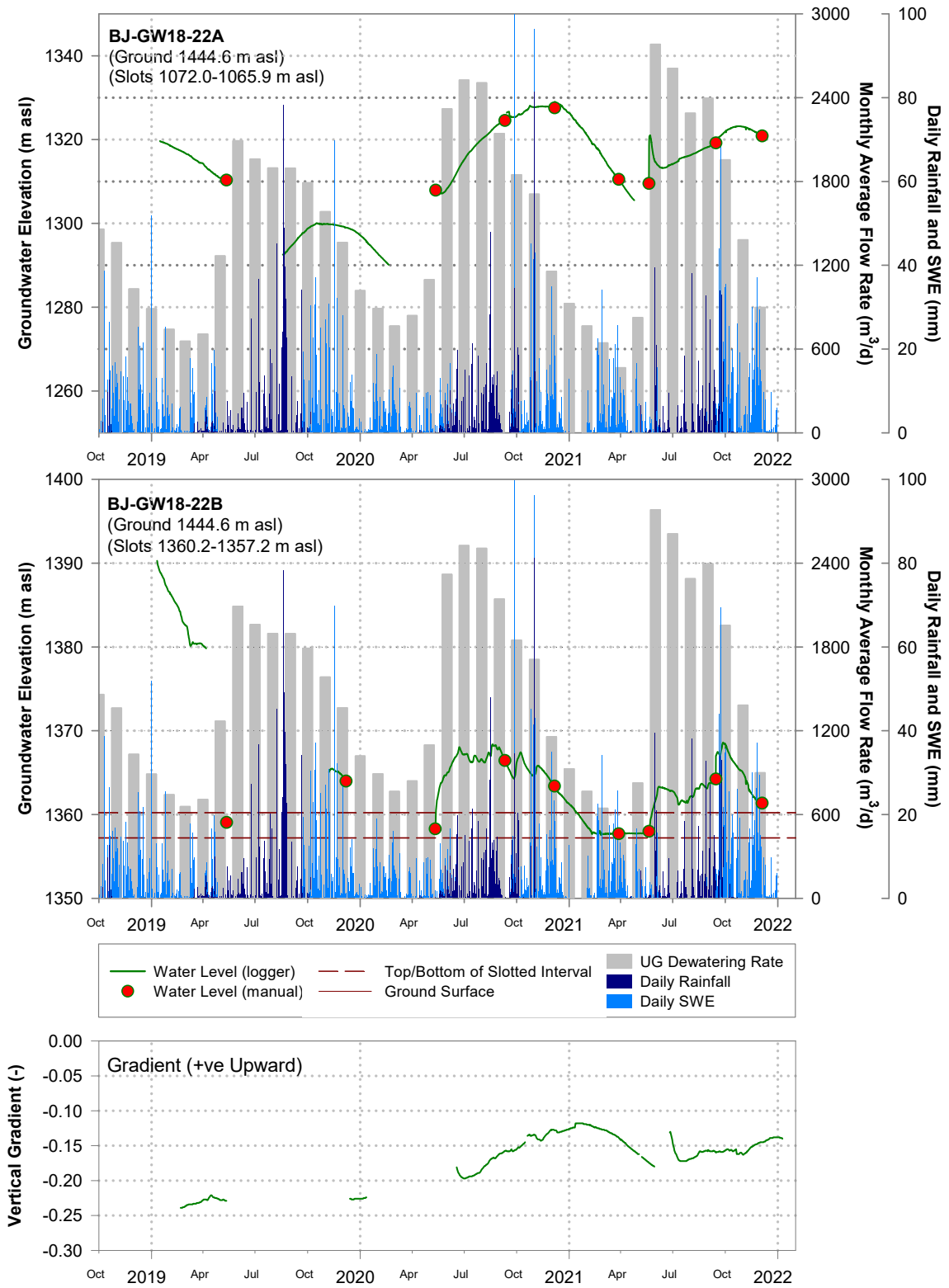

Figure 17: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-22A/B

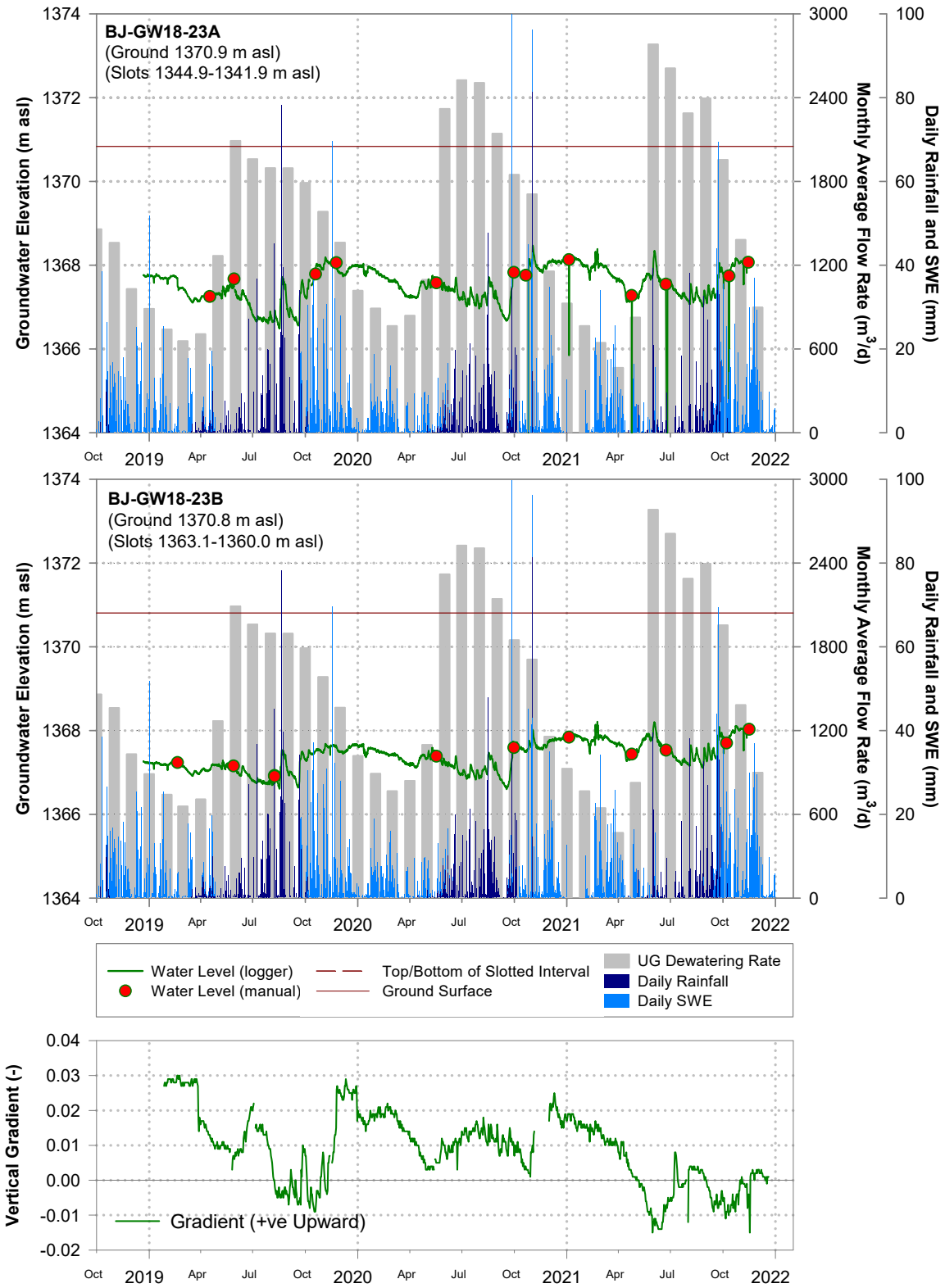

Figure 18: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-23A/B

Appendix G
Summary of Groundwater Quality Analytical Results

NEWCREST

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW11-1A		Date																					
		Oct 10, 2011	Jun 17, 2016	Sep 23, 2016	Dec 15, 2016	Mar 30, 2017	Jul 16, 2017	Sep 24, 2017	Dec 11, 2017	Mar 25, 2018	Jul 01, 2018	Oct 02, 2018	Dec 19, 2018	Feb 13, 2019	Jun 05, 2019	Oct 27, 2019	Dec 05, 2019	23-Jul-2020	28-Oct-2020	31-Dec-2020	Jul 17, 2021	Oct 31, 2021	Jan 26, 2022
ALS COA Sample ID		L1071509-9	L1786020-1	**L1834821-1**	**L1871461-1**	L1907867-1	L1959792-1	L1997397-1	**L2034710-1**	**L2072721-3**	L2122534-1	**L2176163-1**	L2214132-1	L2233559-1	L2287749-1	L2373056-1	VA19A0405-001	VA20B1157-001	VA20B9590-001	VA21A0051-001	VA21B4774-002	VA21C4383-001	VA22A1683-002
Field Parameters	**Unit**																						
Temperature	°C	-	2.5	**2**	**0.4**	1.6	2.6	2.6	**2.5**	**1.6**	2.2	**2.9**	**0.7**	0.1	2.3	5.6	7	3	1.2	6.2	3.1	0.7	9.3
pH	pH	-	7.8	**7.8**	**8**	8.1	7.9	7.9	**8.2**	**7.7**	7.8	**7.8**	**7.9**	7.96	7.66	7.7	7.71	7.56	7.7	8.09	7.77	7.71	8.03
Specific Sonductance	µS/cm	-	196	**219**	**247**	246	245	230	**245**	**298**	234	**216**	223	292	198.6	308.9	288.3	222.9	257.1	241.1	139.3	129.1	268.1
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.86	6.84	8.41	8.8	2.56	11.56	11	1.06
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	125.5	99.4	126.1	83.6	133.7	27.4	131.6	91.2	70.3
Turbidity	NTU	-	-	-	-	73.6	20.5	23.5	**985**	-	-	**626**	60	-	4.88	8.1	45	10.73	59	31.77	29.5	35.1	49
Physical Tests																							
Conductivity	uS/cm	45	166	**222**	**245**	244	231	231	**242**	**298**	227	**242**	248	273	196	316	284	236	259	243	144	129	268
Acidity (as $CaCO_3$)	mg/L	yah	1.7	**1.5**	**1.4**	1.1	2.1	2.4	**2**	**2.1**	2.8	**<1.0**	1.6	2.3	1.4	2.2	2.7	<2.0	<2.0	<2.0	<2.0	2.3	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	29	48	**92**	**76**	77	69	66	**76**	**91**	69	**74**	74	82.1	55.6	104	84.3	67.6	80.3	67.9	43.2	41.1	72.3
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	110	139	106	69.5	55.4	99.1
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	160	84	**104**	**102**	87	103	93	**95**	**111**	109	**114**	109	113	92.5	146	139	106	124	93.2	67.6	58.2	95.2
pH	pH	8	8	**8**	**7.8**	8.1	8	7.9	**8.1**	**8**	8	**7.8**	8.1	8.13	8.03	8.13	7.94	7.95	8	8.05	7.83	7.68	7.91
Total Dissolved Solids (TDS)	mg/L	59	106	**152**	**170**	163	145	143	**179**	**242**	154	**232**	154	180	123	205	176	151	177	154	81	94	182
Total Suspended Solids (TSS)	mg/L	32	42	**694**	**1740**	126	18	14	**998**	**1080**	12	**521**	45	34.8	11.4	5.5	37.3	4.9	133	19.2	24.7	52.8	63.4
Turbidity	NTU	34	22	**287**	**1940**	108	13	7.6	**867**	**2690**	10	**304**	56	37.6	7.3	7.82	36.5	4.4	72.7	24.7	8.86	59.4	66.7
Anions and Nutrients																							
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.085	<0.050	0.198	<0.600
Total Ammonia (as N)	mg/L	0.028	<0.0050	**<0.0050**	**<0.0050**	<0.0050	<0.0050	<0.0050	**<0.0050**	**0.007**	<0.0050	**<0.0050**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0204	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	0.66	<0.50	**<0.50**	**<0.50**	<0.50	<0.50	<0.50	**<0.50**	**0.76**	<0.50	**<0.50**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	0.72
Fluoride (F)	mg/L	0.039	0.032	**0.037**	**0.09**	0.17	0.041	0.035	**0.12**	**0.12**	0.037	**0.05**	0.078	0.114	0.033	0.047	0.048	0.045	0.043	0.103	0.039	0.028	0.119
Nitrate (as N)	mg/L	0.014	0.022	**0.067**	**0.11**	0.39	0.028	0.065	**0.24**	**0.39**	0.052	**0.088**	0.25	0.554	0.0498	0.0405	0.0544	0.0205	0.0368	0.881	0.0246	0.0585	1.31
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.881	0.0246	0.0585	1.31
Nitrite (as N)	mg/L	<0.0010	<0.0010	**<0.0010**	**<0.0010**	<0.0010	<0.0010	<0.0010	**<0.0010**	**0.0028**	0.0011	**<0.0010**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L																	0.032	0.058	0.85	<0.030	0.256	1.25
Dissolved Orthophosphate (as P)	mg/L	<0.0010	0.0014	**0.0014**	**0.0012**	0.0021	<0.0010	0.0014	**0.0015**	**<0.0010**	0.0019	**0.0019**	<0.0010	0.0015	<0.0010	0.0012	<0.0010	0.0013	0.0016	<0.0010	0.0011	<0.0010	0.0026
Total Phosphorus (P)	mg/L	0.032	0.019	**0.14**	**1.8**	0.096	0.025	0.0066	**1.1**	**0.72**	0.015	**0.67**	0.059	0.0419	0.0222	0.0068	0.0266	0.006	0.0846	0.0206	0.0057	0.0271	0.0571
Sulfate (SO_4)	mg/L	19	32	**44**	**51**	46	47	46	**48**	**58**	48	**54**	53	59.9	41.1	68.4	61.3	46.8	50.4	48.1	25	22.4	55.3
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.019	0.023	<0.019	<0.0016	<0.0016	<0.011
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	0.022	<0.018	<0.0015	<0.0015	<0.010
Total Metals																							
Aluminum (Al)-Total	mg/L	0.8	1	**7.5**	**20**	0.57	0.43	0.25	**11**	**19**	0.45	**11**	1.9	0.727	0.178	0.343	0.791	0.0723	2.73	0.774	0.124	1	1.06
Antimony (Sb)-Total	mg/L	0.00086	0.0015	**0.0028**	**0.011**	0.0024	0.0018	0.0016	**0.011**	**0.011**	0.0016	**0.0013**	0.0025	0.00206	0.00156	0.00138	0.00226	0.00141	0.00661	0.0024	0.0015	0.00717	0.00354
Arsenic (As)-Total	mg/L	0.0059	0.011	**0.077**	**0.62**	0.027	0.016	0.0073	**0.33**	**0.27**	0.0098	**0.012**	0.025	0.016	0.00501	0.00522	0.0199	0.00303	0.0964	0.0145	0.00574	0.0248	0.0249
Barium (Ba)-Total	mg/L	0.061	0.058	**0.46**	**3.5**	0.29	0.1	0.048	**1.3**	**9.1**	0.06	**1.4**	0.11	0.0682	0.0249	0.0543	0.159	0.0332	1.16	0.0785	0.026	0.0778	0.0836
Beryllium (Be)-Total	mg/L	<0.0010	<0.00010	**0.00097**	**0.0022**	0.00015	<0.00010	<0.00010	**0.00084**	**0.0012**	<0.00010	**0.0003**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	0.000076
Bismuth(Bi)- Total	mg/L	<0.20	<0.000050	**0.00024**	**0.0005**	<0.000050	<0.000050	<0.000050	**0.00017**	**0.00018**	<0.000050	**0.00012**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000091	<0.000050
Boron(B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	0.028	<0.010	<0.010	0.035
Cadmium (Cd)-Total	mg/L	0.000061	0.000036	**0.00048**	**0.012**	0.00037	0.00016	0.000048	**0.0032**	**0.0038**	0.000092	**0.00051**	0.00018	0.000116	0.0000939	0.0000401	0.000228	0.0000256	0.00157	0.0000996	0.0000405	0.000227	0.000138
Calcium (Ca)-Total	mg/L	17	29	**51**	**63**	30	35	36	**36**	**43**	38	**313**	38	39	34.1	51.2	46.4	36.4	40.5	31.8	25.1	19.2	33.4
Chromium (Cr)-Total	mg/L	0.0013	0.00059	**0.0026**	**0.014**	0.00055	0.00038	0.00045	**0.005**	**0.014**	0.00036	**0.028**	0.0014	0.002	<0.00080	0.00584	0.00876	0.00453	0.0014	0.0292	0.00382	0.0161	0.0122
Cobalt (Co)-Total	mg/L	0.00049	0.00066	**0.0049**	**0.049**	0.0028	0.00068	0.00034	**0.02**	**0.021**	0.00041	**0.02**	0.0013	0.00082	0.00016	0.00026	0.001	0.00016	0.00499	0.00094	0.00153	0.00181	0.00158
Copper (Cu)-Total	mg/L	0.012	0.0016	**0.014**	**0.17**	0.0057	0.0025	0.00081	**0.063**	**0.075**	0.0013	**0.046**	0.005	0.00453	0.0012	0.00203	0.00584	0.00174	0.0183	0.00312	0.00117	0.0129	0.00616
Iron (Fe)-Total	mg/L	1	0.98	**8.6**	**59**	1.2	0.98	0.44	**31**	**40**	0.55	**22**	2.3	1.43	0.265	0.332	1.47	0.118	6	1.1	0.262	1.98	2.37
Lead (Pb)-Total	mg/L	0.0017	0.0016	**0.017**	**0.16**	0.0039	0.0022	0.00077	**0.067**	**0.056**	0.0013	**0.015**	0.0043	0.00298	0.0007	0.000588	0.00318	0.000232	0.0172	0.00378	0.000718	0.00615	0.0044
Lithium (Li)-Total	mg/L	0.0073	0.002	**0.0095**	**0.055**	0.043	0.0049	0.0036	**0.046**	**0.071**	0.005	**0.014**	0.023	0.0335	0.0026	0.0101	0.0117	0.0039	0.0088	0.0282	0.0013	0.0029	0.032
Magnesium (Mg)-Total	mg/L	1.2	2.4	**6**	**12**	3.3	4.6	4.1	**6.9**	**14**	4.7	**179**	3.7	4.3	2.59	7.28	5.69	3.77	5.58	3.34	1.66	1.8	3.81
Manganese (Mn)-Total	mg/L	0.08	0.1	**1.2**	**28**	0.7	0.38	0.13	**7.7**	**8.6**	0.2	**10**	0.41	0.216	0.0807	0.0657	0.544	0.0236	4.21	0.218	0.0786	0.371	0.341
Mercury (Hg)-Total	mg/L	0.000011	<0.0000050	**0.000027**	**0.00015**	<0.0000050	<0.0000050	<0.0000050	**0.000098**	**0.00016**	<0.0000050	**0.00012**	<0.000025	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000243	<0.0000050	<0.0000050	0.0000122	0.0000102
Molybdenum (Mo)-Total	mg/L	<0.0010	0.00029	**0.00059**	**0.0019**	0.00034	0.00042	0.00038	**0.0017**	**0.0022**	0.00042	**0.004**	0.00063	0.000657	0.000245	0.00118	0.00147	0.000772	0.000898	0.00433	0.000855	0.00092	0.0026
Nickel (Ni)-Total	mg/L	0.0012	<0.00050	**0.0031**	**0.024**	0.00077	<0.00050	<0.00050	**0.009**	**0.014**	<0.00050	**0.16**	0.00088	0.00078	<0.00050	0.00383	0.0057	0.00288	0.00226	0.0182	0.00247	0.00547	0.00842
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	0.059
Potassium (K)-Total	mg/L	<2.0	0.78	**2.1**	**5**	1.8	0.75	0.72	**3.3**	**4.9**	0.83	**16**	1.9	1.48	0.576	1.15	1.23	0.638	1.87	1.74	0.414	0.921	1.71
Selenium (Se)-Total	mg/L	<0.0010	0.00026	**0.00037**	**0.00063**	0.00011	0.00025	0.00037	**0.00037**	**0.00037**	0.0003	**0.00036**	0.00034	0.000185	0.000369	0.00032	0.000379	0.000291	0.000474	0.000304	0.000342	0.000254	0.000248
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.02	5.74	3	1.47	2.35	3.58
Silver (Ag)-Total	mg/L	0.00011	0.00032	**0.0013**	**0.019**	0.00052	0.0004	0.000083	**0.0075**	**0.0065**	0.0001	**0.00017**	0.0004	0.00026	0.000067	0.000067	0.000387	0.000034	0.00211	0.000221	0.000144	0.000698	0.000469
Sodium (Na)-Total	mg/L	2.6	0.76	**1.8**	**9.4**	16	1.7	1.5	**10**	**15**	1.9	**327**	8	12.1	1.19	3.99	4.07	1.62	2.75	11.7	0.333	2	13.3
Strontium (Sr)-Total	mg/L	0.21	0.27	**0.55**	**0.97**	0.75	0.54	0.46	**0.76**	**1**	0.55	**3.3**	0.7	0.724	0.319	1	0.807	0.499	0.739	0.699	0.143	0.146	0.739
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	<0.00020	0.000031	**0.00022**	**0.0016**	0.000022	0.000037	0.000015	**0.00075**	**0.00099**	0.000026	**0.000097**	0.000077	0.000037	0.00001	0.000014	0.000059	<0.000010	0.00036	0.000038	<0.000010	0.000043	0.000048
Tin (Sn)-Total	mg/L	0.004	0.00024	**0.00039**	**0.00077**	<0.00010	<0.00010	<0.00010	**0.00047**	**0.0016**	0.00019	**0.0016**	0.0012	0.00081	0.00022	<0.00010	0.00032	<0.00010	<0.00010	<0.00010	<0.00010	0.00494	0.00011
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	0.0534	0.011	<0.0100	0.0124	0.0184
Uranium (U)-Total	mg/L	<0.00020	0.00011	**0.0016**	**0.0024**	0.00019	0.000055	0.000049	**0.00051**	**0.00066**	0.000055	**0.0072**	0.000096	0.000101	0.00004	0.000063	0.000075	0.000043	0.000128	0.00007	0.000025	0.000061	0.000084
Vanadium (V)-Total	mg/L	0.0011	0.0014	**0.0072**	**0.03**	0.00098	0.00084	<0.00050	**0.018**	**0.034**	0.00091	**0.036**	0.0035	0.00133	<0.00050	0.0007	0.00144	<0.00050	0.00481	0.00157	<0.00050	0.00171	0.0021
Zinc (Zn)-Total	mg/L	0.039	0.012	**0.089**	**2**	0.057	0.032	0.011	**0.54**	**0.74**	0.017	**0.11**	0.039	0.0253	0.0157	0.0139	0.047	0.0084	0.253	0.0305	0.0094	0.0591	0.0369
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																							
Aluminum (Al)-Dissolved	mg/L	0.034	0.41	**0.018**	**0.0015**	0.0049	0.0023	0.0019	**0.0012**	**0.0024**	0.0022	**0.0016**	0.0061	0.0037	0.0035	0.0011	0.0022	<0.0010	0.0021	0.0018	<0.0010	0.0572	0.0026
Antimony (Sb)-Dissolved	mg/L	0.0008	0.0011	**0.0012**	**0.0014**	0.002	0.0011	0.0012	**0.0015**	**0.0014**	0.0013	**0.0013**	0.0012	0.00144	0.00121	0.00109	0.00132	0.00136	0.00124	0.00186	0.00131	0.00307	0.00234
Arsenic (As)-Dissolved	mg/L	0.0011	0.0038	**0.0027**	**0.0033**	0.0029	0.0025	0.0028	**0.003**	**0.0028**	0.0031	**0.003**	0.0039	0.00304	0.00209	0.00241	0.00298	0.00189	0.00313	0.00341	0.00276	0.00426	0.00291
Barium (Ba)-Dissolved	mg/L	0.028	0.037	**0.021**	**0.021**	0.021	0.016	0.016	**0.017**	**0.024**	0.017	**0.016**	0.019	0.0226	0.0147	0.0196	0.0201	0.0176	0.0191	0.0202	0.0116	0.0208	0.0223
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.00010	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	**<0.00010**	**<0.00010**	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000020
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.000050	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	**<0.000050**	**<0.000050**	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron(B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	0.029	<0.010	<0.010	0.031
Cadmium (Cd)-Dissolved	mg/L	0.000027	0.000013	**0.000014**	**<0.0000050**	<0.0000050	0.0000068	0.0000057	**<0.0000050**	**0.0000072**	0.0000071	**<0.0000050**	<0.0000050	0.000006	0.0000077	0.0000089	0.0000107	0.0000091	0.0000059	0.0000101	0.0000063	0.0000308	0.0000079
Calcium (Ca)-Dissolved	mg/L	16	30	**36**	**35**	29	34	31	**33**	**38**	36	**40**	38	38.4	32.9	47.7	46.6	37.6	46.4	37.4	24.4	20.9	32.6
Chromium (Cr)-Dissolved	mg/L	<0.0010	0.00015	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	**<0.00010**	**0.00017**	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	0.00061	0.00039	0.00183	<0.00010	0.00044	0.0009	0.00139	0.00083
Cobalt (Co)-Dissolved	mg/L	<0.00030	0.00014	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	**<0.00010**	**<0.00010**	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00014	0.00076	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	0.009	0.00036	**<0.00020**	**0.00038**	<0.00050	<0.00020	<0.00020	**<0.00020**	**0.0011**	<0.00020	**<0.00020**	0.00024	0.00021	<0.00020	0.00083	0.00117	0.00296	<0.00020	<0.00020	0.00022	0.00257	0.00075
Iron (Fe)-Dissolved	mg/L	<0.030	0.18	**<0.010**	**<0.010**	<0.010	<0.010	<0.010	**<0.010**	**<0.010**	<0.010	**<0.010**	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	<0.010	<0.010	<0.010	0.048	<0.010
Lead (Pb)-Dissolved	mg/L	<0.00050	0.00031	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	**<0.000050**	**<0.000050**	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000076	<0.000050	<0.000050	<0.000050	0.000195	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0073	0.0027	**0.004**	**0.03**	0.045	0.0042	0.0033	**0.035**	**0.042**	0.0046	**0.0085**	0.022	0.0351	0.0023	0.0095	0.0108	0.0039	0.0071	0.028	0.0012	0.0024	0.0299
Magnesium (Mg)-Dissolved	mg/L	1	2.2	**3.5**	**3.5**	3.2	4.2	3.7	**3.1**	**3.7**	4.6	**3.7**	3.6	4.05	2.54	6.63	5.14	3.85	5.54	3.18	1.62	1.46	3.36
Manganese (Mn)-Dissolved	mg/L	0.033	0.022	**0.0047**	**0.00025**	0.00055	0.0014	0.00067	**0.00023**	**0.00053**	0.00066	**0.00016**	0.00051	0.0005	0.00044	0.00142	0.00159	0.00085	0.00014	0.00684	0.00061	0.00586	0.00242
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.0000050	**<0.0000050**	**<0.0000050**	0.0000091	<0.0000050	<0.0000050	**<0.0000050**	**<0.0000050**	<0.0000050	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	<0.0010	0.00023	**0.00035**	**0.00088**	0.0012	0.0003	0.00026	**0.00073**	**0.00078**	0.00037	**0.00039**	0.00049	0.000631	0.000209	0.00107	0.00115	0.000795	0.00039	0.00251	0.000845	0.000612	0.00174
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.00050	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	**<0.00050**	**<0.00050**	<0.00050	**<0.00050**	<0.00050	<0.00050	<0.00050	0.00238	0.00262	0.00237	<0.00050	0.00526	0.00146	0.00092	0.00249
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.050
Potassium (K)-Dissolved	mg/L	<2.0	0.58	**0.65**	**1.4**	1.6	0.57	0.6	**1.2**	**1.6**	0.63	**0.82**	1.2	1.58	0.522	0.981	0.96	0.637	0.832	1.41	0.376	0.512	1.42
Selenium (Se)-Dissolved	mg/L	<0.0010	0.00025	**0.00036**	**0.00022**	0.00011	0.00027	0.00036	**0.00017**	**0.0001**	0.00028	**0.00043**	0.00036	0.000363	0.000405	0.000346	0.000355	0.000265	0.00032	0.000307	0.000286	0.000208	0.000205
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.85	1.97	1.82	1.31	1.16	1.85
Silver (Ag)-Dissolved	mg/L	<0.000020	0.000028	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	**<0.000010**	**<0.000010**	<0.000010	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000044	<0.000010
Sodium (Na)-Dissolved	mg/L	2.9	0.78	**1.6**	**12**	16	1.6	1.4	**11**	**14**	1.8	**2.7**	8.4	13.9	1.07	4.03	3.97	1.58	2.88	11.8	0.333	1.59	13
Strontium (Sr)-Dissolved	mg/L	0.21	0.28	**0.61**	**0.68**	0.74	0.52	0.39	**0.63**	**0.83**	0.53	**0.57**	0.67	0.887	0.303	0.952	0.8	0.511	0.748	0.783	0.148	0.152	0.732
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.00020	0.000011	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	**<0.000010**	**<0.000010**	<0.000010	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	0.0016	<0.00010	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	**<0.00010**	**0.00019**	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00032	<0.00010	<0.00010	<0.00010	0.00049	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.00030
Uranium (U)-Dissolved	mg/L	<0.00020	0.000049	**0.000046**	**0.000062**	0.000067	0.000043	0.000032	**0.000056**	**0.000078**	0.000045	**0.000051**	0.000059	0.000063	0.000034	0.000063	0.000059	0.000042	0.000055	0.000055	0.000022	0.000027	0.000054
Vanadium (V)-Dissolved	mg/L	<0.0010	0.00059	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	**<0.00050**	**<0.00050**	<0.00050	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.017	0.0038	**0.0012**	**0.0012**	<0.0030	0.0025	0.0029	**0.0012**	**0.0057**	0.0028	**0.0013**	<0.0030	0.0022	0.0039	0.0064	0.0046	0.0063	0.002	0.005	0.0024	0.0078	0.0016
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																							
Chemical Oxygen Deman (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<20	<20	<20	<20	98	<20

Notes:

Sample results in red indicate turbidity measured between 50 and 200 NTU

Sample results in **red bold** indicated turbidity measured above 200 NTU

Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW11-1B		Date										
		Oct 10, 2011	**Jun 17, 2016**	**Sep 25, 2016**	**Jul 10, 2017**	**Sep 24, 2017**	**Nov 05, 2017**	**Jun 25, 2018**	**Oct 18, 2018**	**05-Jun-19**	**23-Jul-2020**	**17-Jul-21**
ALS COA Sample ID		L1071509-10	**L1786020-2**	**L1834828-1**	**L1957233-1**	**L1997397-2**	**L2019853-1**	L2119969-1	L2184584-1	L2287749-2	VA20B1157-002	VA21B4774-003
Field Parameters	**Unit**											
Temperature	°C	-	**2.1**	**1.8**	**2.4**	**2.8**	**0**	1.7	1.4	1.7	5.2	5.4
pH	pH	-	**8.1**	**8**	**8.1**	**8**	**7.9**	8	7.7	7.78	7.58	7.98
Specific conductance	µS/cm	-	**269**	**239**	**269**	**243**	**297**	247	302	210.2	243.2	167.7
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	7.62	10.73
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	131.3	126	139.5
Turbidity	NTU	-	-	-	**160**	**717**	-	-	-	37.96	4.04	19.63
Physical Tests												
Conductivity	uS/cm	289	**217**	**241**	**253**	**243**	**292**	180	313	210	257	173
Acidity (as $CaCO_3$)	mg/L	2.4	**<1.0**	**1.5**	**1.3**	**2**	**2.7**	2	1.7	1.2	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	86	**65**	**87**	**71**	**70**	**88**	68	83	58.5	71.2	48.8
Hardness (as $CaCO_3$), as dissolved	mg/L	-	-	-	-	-	-	-	-	-	113	**76**
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	90	**102**	**113**	**107**	**107**	**132**	110	129	95.6	116	81.1
pH	pH	8	**8.1**	**8**	**8.1**	**8**	**8.1**	7.7	8.1	8.1	7.97	7.89
Total Dissolved Solids (TDS)	mg/L	187	**273**	**393**	**287**	**180**	**235**	214	216	135	154	97
Total Suspended Solids (TSS)	mg/L	86	**1690**	**1480**	**315**	**166**	**173**	92	160	17.4	<3.0	14.5
Turbidity	NTU	100	**2770**	**2010**	**372**	**222**	**208**	144	150	22.6	2.08	4.52
Anions and Nutrients												
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	<0.050	<0.050
Total Ammonia (as N)	mg/L	0.023	**<0.0050**	**<0.0050**	**<0.0050**	**<0.0050**	**<0.0050**	<0.0050	0.006	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	**<0.50**	**<0.50**	**<0.50**	**<0.50**	**<0.50**	<0.50	0.65	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.25	**0.061**	**0.052**	**0.048**	**0.045**	**0.056**	0.051	0.048	0.04	0.049	0.045
Nitrate (as N)	mg/L	0.026	**0.041**	**0.058**	**0.036**	**0.069**	**0.065**	0.046	0.11	0.0641	0.0241	0.0268
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	0.0307
Nitrite (as N)	mg/L	0.0036	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	<0.0010	<0.0010	<0.0010	<0.0010	0.0039
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	0.034	<0.030
Dissolved Orthophosphate (as P)	mg/L	<0.0010	**0.0017**	**0.0014**	**<0.0010**	**0.0012**	**0.0013**	0.0012	0.0015	<0.0010	0.0012	0.0013
Total Phosphorus (P)	mg/L	0.072	**1.4**	**0.7**	**0.14**	**0.014**	**0.15**	0.2	0.23	0.0119	0.0038	0.0039
Sulfate (SO_4)	mg/L	60	**44**	**49**	**55**	**49**	**62**	53	65	44.9	54.3	34.3
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	<0.019	<0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	<0.018	<0.0015
Total Metals												
Aluminum (Al)-Total	mg/L	2.4	**29**	**18**	**3**	**4.4**	**1.8**	4.8	2.9	0.764	0.044	0.11
Antimony (Sb)-Total	mg/L	0.0014	**0.012**	**0.0067**	**0.0039**	**0.0039**	**0.0022**	0.0041	0.0035	0.0015	0.00121	0.00121
Arsenic (As)-Total	mg/L	0.029	**1.2**	**0.8**	**0.14**	**0.17**	**0.059**	0.18	0.13	0.0114	0.00394	0.00535
Barium (Ba)-Total	mg/L	0.11	**6.1**	**4.5**	**0.86**	**0.71**	**0.31**	0.92	2.5	0.0588	0.0243	0.0307
Beryllium (Be)-Total	mg/L	<0.0010	**0.0022**	**0.0015**	**0.00028**	**0.00034**	**0.00014**	0.00038	0.00024	<0.00010	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	<0.20	**0.0002**	**0.00012**	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	0.000032	**0.0002**	**0.00013**	**0.000022**	**0.000026**	**0.000029**	0.000053	0.000084	0.0000443	0.0000053	0.0000098
Calcium (Ca)-Total	mg/L	30	**41**	**48**	**37**	**36**	**45**	41	47	33.6	40	27
Chromium (Cr)-Total	mg/L	0.0012	**0.015**	**0.0099**	**0.0013**	**0.0021**	**0.0035**	0.0034	0.0053	0.00096	0.0008	0.00432
Cobalt (Co)-Total	mg/L	0.001	**0.057**	**0.04**	**0.0059**	**0.007**	**0.0028**	0.0076	0.0066	0.00042	<0.00010	0.00133
Copper (Cu)-Total	mg/L	0.0047	**0.064**	**0.043**	**0.0059**	**0.0083**	**0.0049**	0.0099	0.011	0.00217	0.00136	0.0009
Iron (Fe)-Total	mg/L	1.9	**67**	**43**	**6.5**	**9**	**3.6**	9.5	6.4	0.717	0.054	0.162
Lead (Pb)-Total	mg/L	0.0019	**0.07**	**0.045**	**0.0076**	**0.0073**	**0.0034**	0.0081	0.0078	0.00106	0.000089	0.000328
Lithium (Li)-Total	mg/L	0.082	**0.067**	**0.043**	**0.016**	**0.015**	**0.023**	0.02	0.018	0.008	0.0099	0.0071
Magnesium (Mg)-Total	mg/L	4.2	**18**	**13**	**4.6**	**6**	**5.4**	6.1	5.9	3.07	3.99	2.09
Manganese (Mn)-Total	mg/L	0.13	**5.9**	**4.3**	**0.59**	**0.67**	**0.22**	0.65	0.68	0.0501	0.00503	0.0199
Mercury (Hg)-Total	mg/L	<0.000010	**0.00023**	**0.00013**	**0.000026**	**0.000035**	**<0.000050**	0.000028	<0.000050	0.0000067	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.0024	**0.002**	**0.00088**	**0.0005**	**0.00055**	**0.00057**	0.00068	0.00076	0.0003	0.000368	0.000927
Nickel (Ni)-Total	mg/L	0.001	**0.021**	**0.014**	**0.002**	**0.0027**	**0.0015**	0.0032	0.0026	<0.00050	0.00063	0.00293
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	<0.300	<0.300
Potassium (K)-Total	mg/L	3.2	**7**	**4.5**	**1.7**	**2.3**	**1.8**	2.6	2	1.09	0.894	0.658
Selenium (Se)-Total	mg/L	<0.0010	**0.00061**	**0.00056**	**0.00029**	**0.00043**	**0.00047**	0.00043	0.00054	0.000348	0.000388	0.0003
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	2.04	1.58
Silver (Ag)-Total	mg/L	0.000073	**0.0022**	**0.0012**	**0.00058**	**0.00025**	**0.00019**	0.00035	0.00035	0.000077	<0.000010	0.000096
Sodium (Na)-Total	mg/L	25	**5.3**	**3.7**	**3.3**	**3.1**	**6**	5.6	5	2.76	3.78	2.28
Strontium (Sr)-Total	mg/L	0.9	**0.73**	**0.71**	**0.65**	**0.61**	**0.96**	0.73	0.93	0.484	0.616	0.324
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	<0.00020	**0.00059**	**0.00034**	**0.0001**	**0.00011**	**0.000052**	0.00012	0.000085	0.000027	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	0.0017	**0.00031**	**0.00013**	**<0.00010**	**0.00015**	**0.0012**	0.00042	0.00059	0.00031	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100
Uranium (U)-Total	mg/L	<0.00020	**0.00057**	**0.00036**	**0.00011**	**0.00013**	**0.00011**	0.00018	0.00019	0.000062	0.000052	0.000034
Vanadium (V)-Total	mg/L	0.002	**0.054**	**0.033**	**0.0054**	**0.0079**	**0.0034**	0.0084	0.0051	0.00132	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	0.018	**0.36**	**0.21**	**0.039**	**0.049**	**0.025**	0.054	0.05	0.0105	<0.0030	0.0035
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals												
Aluminum (Al)-Dissolved	mg/L	0.015	**0.067**	**0.47**	**0.0033**	**0.0012**	**0.003**	0.0014	0.0021	0.0067	0.0013	0.007
Antimony (Sb)-Dissolved	mg/L	0.00093	**0.0011**	**0.0012**	**0.0011**	**0.0012**	**0.001**	0.0011	0.0012	0.00106	0.00113	0.00119
Arsenic (As)-Dissolved	mg/L	0.008	**0.0068**	**0.0088**	**0.0027**	**0.0035**	**0.0063**	0.004	0.0053	0.00351	0.00299	0.00342
Barium (Ba)-Dissolved	mg/L	0.022	**0.047**	**0.06**	**0.018**	**0.016**	**0.019**	0.02	0.017	0.02	0.0211	0.024
Beryllium (Be)-Dissolved	mg/L	<0.0010	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.20	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	<0.000017	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	30	**35**	**39**	**37**	**37**	**45**	38	43	33.6	38.8	29.1
Chromium (Cr)-Dissolved	mg/L	<0.0010	**<0.00010**	**0.00013**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	0.00034	<0.00010	0.00027	0.00118
Cobalt (Co)-Dissolved	mg/L	<0.00030	**<0.00010**	**0.00023**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	0.00062
Copper (Cu)-Dissolved	mg/L	<0.0010	**<0.00020**	**0.00035**	**<0.00020**	**<0.00020**	**0.00023**	0.0004	0.0014	0.00053	0.00116	0.00102
Iron (Fe)-Dissolved	mg/L	<0.030	**0.027**	**0.23**	**<0.010**	**<0.010**	**<0.010**	<0.010	<0.010	<0.010	<0.010	0.012
Lead (Pb)-Dissolved	mg/L	<0.00050	**<0.000050**	**0.00033**	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.078	**0.019**	**0.01**	**0.011**	**0.0095**	**0.015**	0.012	0.014	0.0067	0.0099	0.0073
Magnesium (Mg)-Dissolved	mg/L	3.8	**3.3**	**3.7**	**3.7**	**3.7**	**5.1**	3.9	5.2	2.83	3.99	2.05
Manganese (Mn)-Dissolved	mg/L	0.031	**0.0015**	**0.025**	**0.00069**	**0.00034**	**0.0015**	0.0006	0.00032	0.00101	0.00024	0.00111
Mercury (Hg)-Dissolved	mg/L	<0.000010	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.0023	**0.00036**	**0.00024**	**0.00024**	**0.0003**	**0.0003**	0.00036	0.0004	0.000237	0.000445	0.000956
Nickel (Ni)-Dissolved	mg/L	<0.0010	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	0.00198
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	2.5	**1.3**	**1.1**	**0.79**	**0.86**	**1.3**	0.98	1.3	0.829	0.865	0.66
Selenium (Se)-Dissolved	mg/L	<0.0010	**0.0003**	**0.00035**	**0.00027**	**0.00041**	**0.00047**	0.00034	0.00056	0.000426	0.000295	0.000331
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	1.95	1.43
Silver (Ag)-Dissolved	mg/L	<0.000020	**<0.000010**	**0.000015**	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	26	**5.4**	**3.5**	**3.4**	**2.9**	**5.6**	4.9	4.8	2.93	3.82	2.46
Strontium (Sr)-Dissolved	mg/L	0.9	**0.64**	**0.64**	**0.65**	**0.59**	**0.9**	0.66	0.86	0.45	0.628	0.342
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.00020	**<0.000010**	**0.000014**	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	0.0012	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	**0.00011**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	<0.00020	**0.000046**	**0.000073**	**0.000051**	**0.000046**	**0.00007**	0.000086	0.00011	0.000039	0.000048	0.000033
Vanadium (V)-Dissolved	mg/L	<0.0010	**<0.00050**	**0.0008**	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	<0.0050	**0.0012**	**0.0015**	**<0.0010**	**<0.0010**	**0.001**	0.0021	0.0022	0.0021	0.0018	0.0042
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics												
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	<20	22

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW11-3A		Date																																				
		Oct 08, 2011	Mar 28, 2012	Jun 27, 2012	Sep 04, 2012	Jan 28, 2013	Apr 07, 2013	Jul 13, 2013	Sep 25, 2013	Aug 05, 2014	Nov 10, 2014	Mar 30, 2015	Jun 28, 2015	Sep 15, 2015	Jan 13, 2016	Mar 27, 2016	Jun 13, 2016	Sep 14, 2016	Dec 10, 2016	Mar 25, 2017	Jun 11, 2017	Sep 21, 2017	Nov 02, 2017	Mar 26, 2018	May 27, 2018	Sep 27, 2018	Nov 21, 2018	Apr 18, 2019	Jul 28, 2019	Oct 15, 2019	Nov 24, 2019	21-Jul-2020	29-Oct-2020	02-Jan-2021	Mar 26, 2021	Jun 20, 2021	Sep 23, 2021	Dec 04, 2021
ALS COA Sample ID		L1071509-6	L1129695-1	L1171422-2	L1207447-1	L1263921-2	L1287525-2	L1333226-2	L1370058-1	L1498121-1	L1545769-1	L1594284-2	L1634560-4	L1674145-1	L1724154-1	L1750582-1	L1784010-1	L1830196-1	L1869371-4	L1905630-1	L1941920-3	L1996356-1	L2018184-1	L2073429-1	L2102081-1	L2173270-1	L2201198-1	L2260746-2	L2319511-1	L2368320-1	VA19A0100-001	VA20B0922-001	VA20B9681-002	VA21A0051-004	VA21A5837-001	VA21B2508-002	VA21C1212-001	VA21C7213-001
Field Parameters	**Unit**																																					
Temperature	°C	2.2	1.8	2.7	2.8	2.5	3.2	3.5	4.3	5	3.4	4.1	4.5	4.4	4.3	3.3	3.6	3.5	2.5	3	4.2	4.2	2.6	2.7	3.1	3.6	2.8	3	3.7	2.7	2.4	4.5	2.6	2.6	2.5	4.8	2.7	1.2
pH	pH	7	7.9	8	8.3	8	8	8	8.2	8	7.3	7.8	8.2	8.1	7.9	7	7.8	7.5	7.9	7.9	7.8	7.8	7.8	7.9	7.9	7.8	7.8	7.79	7.55	7.85	7.71	7.6	7.72	7.71	7.72	7.73	7.86	7.99
Specific conductance	µS/cm	355	358	210	186	405	408	223	424	470	320	315	275	307	330	340	322	361	359	373	334	340	363	391	359	334	326	409	359.3	367.4	350.6	336.8	372.7	375.8	395.1	358.3	350.4	365.3
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	-	0.03	0.2	0.96	4.22	0.38	0.41	0.46	0.54	-0.12
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	69	-100.9	-90.7	-180	-161.6	-73.1	-101.8	-149.8	-59.9	-144.3	-217.8
Turbidity	NTU		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1478	-	263	-	-	80	100	85	23	10.43	2.85	12.6	14.86	80.08	14.51	17.2	3.84	11.5	5.79
Physical Tests																																						
Conductivity	uS/cm	358	355	343	351	349	348	329	345	344	349	332	300	341	340	365	326	372	357	366	317	339	355	393	353	363	349	414	366	346	371	352	383	376	403	363	352	365
Acidity (as $CaCO_3$)	mg/L	1.1	2.2	<1.0	1.9	2.9	1.8	4	1.5	1.8	1.6	-	-	-	-	-	3.6	1.2	1.9	2.5	0	1.1	12	1.4	2.2	1.9	<1.0	1.1	<1.0	2.2	3	2.5	<2.0	<2.0	2.2	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	93	94	89	95	102	97	94	100	95	103	66	87	96	64	65	90	105	79	69	85	94	103	60	91	93	84	94	105	96.3	105	92.6	98.4	98.9	92.7	97.6	95.6	97.8
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	163	166	192	197	156	152	152
Hardness (as $CaCO_3$), from total	mg/L	135	167	89	137	167	156	150	155	150	159	143	146	165	147	154	149	173	167	158	149	148	166	175	153	164	154	189	162	169	182	169	189	172	180	155	150	164
pH	pH	8.2	8.1	8.2	8.2	8.1	8.1	8	8.1	8.1	8.1	8.1	7.9	7.9	7.9	7.9	8	8.2	8	7.9	8	8.1	7.4	8.2	8.1	8	8	8.06	8.32	8.05	8.18	7.53	8	8.18	8.13	8.04	8.08	7.97
Total Dissolved Solids (TDS)	mg/L	212	247	230	240	238	230	220	235	246	222	241	217	235	213	227	197	305	254	326	244	260	271	264	257	258	242	283	251	233	239	230	260	242	258	234	238	214
Total Suspended Solids (TSS)	mg/L	<3.0	328	55	155	520	11	49	1550	144	107	1150	342	26	225	3490	1800	466	1210	1010	223	162	1220	32	263	174	815	23.3	8.2	<3.0	5.6	86.8	61.7	5.5	21.8	9.4	<3.0	20.9
Turbidity	NTU	2.9	270	40	138	199	31	40	2130	62	58	1240	377	40	268	>4000	3000	435	1260	1140	229	181	1400	46	152	121	255	29	1.63	0.68	2.7	4.79	81.9	4.45	7.04	3.47	3.13	5.8
Anions and Nutrients																																						
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	0.095	<0.050	<0.050	<0.050	<0.050	<0.050
Total Ammonia (as N)	mg/L	0.028	0.029	0.07	0.034	0.031	0.033	0.029	0.034	0.032	0.024	0.071	0.04	0.027	0.061	0.096	0.043	0.03	0.073	0.062	0.028	0.03	0.031	0.11	0.032	0.023	0.026	0.04	0.0298	0.0298	0.0271	0.0226	0.0296	0.0307	0.0419	0.0296	0.0274	0.0245
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	0.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	2.6	<0.50	<0.50	3	3.5	<0.50	<0.50	1.3	2.1	0.68	<0.50	<0.50	5.3	1.1	1.4	<0.50	2.86	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	2.08	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.21	0.19	0.22	0.18	0.19	0.2	0.19	0.2	0.2	0.2	0.14	0.17	0.18	0.14	0.15	0.18	0.2	0.14	0.13	0.17	0.18	0.18	0.14	0.19	0.19	0.18	0.169	0.172	0.175	0.209	0.189	0.18	0.182	0.176	0.178	0.185	0.182
Nitrate (as N)	mg/L	<0.0050	0.0059	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0068	<0.0050	0.018	0.062	0.025	0.0073	0.11	0.092	<0.0050	0.024	0.023	0.1	0.013	<0.0050	0.0089	0.037	<0.0050	0.042	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0191	<0.0050	0.0205	<0.0050	0.0318	<0.0050
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0051	0.0224	<0.0051	0.0318	<0.0051
Nitrite (as N)	mg/L	<0.0010	0.0024	0.0023	0.0021	<0.0010	<0.0010	<0.0010	0.0019	0.0011	0.0023	0.0025	0.0029	0.0018	0.0023	0.0044	0.0021	0.0028	0.0024	0.0019	0.0039	0.0011	0.0012	<0.0010	0.0045	0.0034	<0.0010	0.0012	<0.0010	<0.0010	<0.0010	0.0014	0.0067	<0.0010	0.0019	0.0024	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.048	0.121	0.049	0.048	<0.030	0.067	0.039
Dissolved Orthophosphate (as P)	mg/L	<0.0010	<0.0010	0.003	<0.0010	<0.0010	<0.0010	0.0011	0.0017	0.0017	<0.0010	0.0014	0.0025	0.0017	0.002	0.0015	0.0025	0.0011	0.0026	0.0024	0.0018	0.0016	0.0019	0.0033	0.0029	0.0016	0.0017	0.0016	<0.0010	<0.0010	<0.0010	<0.0010	0.0017	<0.0010	<0.0010	0.0017	0.0014	0.0012
Total Phosphorus (P)	mg/L	<0.0020	0.11	0.028	0.12	0.29	0.027	0.059	1.6	0.14	0.14	1.3	0.32	0.044	0.19	3.3	1.3	0.41	1.2	0.81	0.21	0.12	0.89	0.032	0.091	0.076	0.099	0.0433	0.0068	0.003	0.0046	0.011	0.0592	0.0057	0.0049	0.0054	0.0064	0.0047
Sulfate (SO_4)	mg/L	84	89	90	89	89	90	81	89	85	88	93	72	82	92	102	79	85	100	117	82	81	87	119	86	93	89	109	86	86.9	87.6	82.8	91.9	92.3	112	86.2	82.8	86.5
Sulfide (as H2S0	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.597	0.04	0.026	0.030	0.0036	<0.0016	0.179
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.561	0.038	0.024	0.028	0.0034	<0.0015	0.168
Total Metals																																						
Aluminum (Al)-Total	mg/L	0.52	7.2	0.98	3.6	11	1.4	1.6	22	4.3	2.4	23	13	1.7	13	56	40	4.1	14	17	2.9	2.7	12	0.9	4.1	3.2	7.7	0.562	0.0357	0.0094	0.0513	0.15	2	0.275	0.109	0.0732	0.0169	0.0279
Antimony (Sb)-Total	mg/L	0.005	0.0045	0.002	0.0027	0.021	0.0059	0.018	0.047	0.028	0.022	0.037	0.036	0.018	0.02	0.059	0.079	0.012	0.079	0.011	0.027	0.028	0.09	0.0086	0.0071	0.02	0.009	0.0238	0.00173	0.00189	0.00116	0.0036	0.0306	0.00295	0.00353	0.00318	0.00197	0.00158
Arsenic (As)-Total	mg/L	0.024	0.053	0.03	0.023	0.087	0.013	0.016	0.13	0.041	0.023	0.37	0.11	0.02	0.074	0.84	0.36	0.048	0.37	0.1	0.1	0.027	0.14	0.019	0.026	0.043	0.025	0.0439	0.00689	0.00638	0.00596	0.00914	0.0226	0.00642	0.00582	0.00566	0.0215	0.0188
Barium (Ba)-Total	mg/L	0.04	0.18	0.043	0.13	0.44	0.057	0.064	0.8	0.15	0.091	0.95	0.41	0.069	0.39	2	1.3	0.21	0.64	0.44	0.13	0.092	0.5	0.058	0.093	0.082	0.13	0.0458	0.0179	0.0182	0.0191	0.0216	0.0716	0.024	0.0252	0.0202	0.0201	0.0256
Beryllium (Be)-Total	mg/L	<0.0010	<0.0010	<0.00010	0.00014	0.00069	<0.00010	<0.00010	0.0012	0.00022	0.00015	0.00099	0.00048	<0.00010	0.0003	0.0043	0.0022	0.00037	0.0013	0.0014	0.00028	0.00026	0.0011	<0.00010	0.00058	0.00047	0.001	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	0.000162	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00053	<0.00050	<0.00050	0.00055	0.00017	<0.000050	0.000088	0.0017	0.00084	0.0001	0.00052	0.00042	0.00007	0.000068	0.00038	<0.000050	0.00012	0.0001	0.00021	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.041	0.041	0.037	0.036	0.04	0.04	0.042
Cadmium (Cd)-Total	mg/L	<0.000017	0.00026	0.000024	0.00013	0.00055	0.000037	0.000097	0.002	0.00029	0.00027	0.0015	0.00045	0.00011	0.00043	0.005	0.0028	0.00038	0.0016	0.00077	0.00057	0.00042	0.0025	0.00012	0.00037	0.00077	0.00036	0.000541	0.0000129	0.0000089	0.0000258	0.000231	0.00121	0.0000684	0.0000494	0.0000439	0.0000258	0.0000086
Calcium (Ca)-Total	mg/L	51	59	32	49	65	56	53	68	54	58	57	55	60	55	73	61	71	70	69	54	53	62	63	57	61	63	66.6	63.5	60.6	65.8	60.2	66.8	61.1	71.2	55.2	53.8	53.8
Chromium (Cr)-Total	mg/L	<0.0010	0.0033	0.00046	0.0016	0.019	0.0016	0.0086	0.02	0.0039	0.0044	0.018	0.0065	0.0013	0.0067	0.048	0.025	0.0028	0.012	0.0081	0.0022	0.0015	0.0093	0.00058	0.0012	0.0012	0.0017	0.00036	0.00076	0.00029	0.00137	0.00191	0.00092	0.00424	0.00369	0.00271	<0.00050	0.00061
Cobalt (Co)-Total	mg/L	<0.00030	0.0023	0.00022	0.001	0.006	0.00043	0.00071	0.015	0.0014	0.0012	0.012	0.0035	0.0004	0.0025	0.034	0.018	0.0026	0.01	0.0076	0.0016	0.0012	0.0078	0.00042	0.0011	0.00099	0.0013	0.00015	<0.00010	<0.00010	<0.00010	0.00012	0.00131	0.00053	0.00121	0.00203	0.00044	0.00019	0.00022
Copper (Cu)-Total	mg/L	<0.0010	0.0091	0.0011	0.0051	0.035	0.0027	0.0029	0.063	0.007	0.005	0.059	0.016	0.0022	0.011	0.19	0.094	0.013	0.051	0.029	0.011	0.0064	0.042	0.0018	0.0047	0.0051	0.0051	0.00181	<0.00050	<0.00050	0.00072	0.00069	0.00483	0.00052	<0.00050	0.00188	<0.00050	<0.00050
Iron (Fe)-Total	mg/L	0.067	7.8	0.62	3.2	16	0.98	1.9	43	5.1	3.5	39	13	1.8	6.6	117	56	7.5	38	25	6.9	4	26	1.4	3.4	4	4.3	1.98	0.145	0.121	0.173	0.35	2.68	0.306	0.199	0.162	0.453	0.582
Lead (Pb)-Total	mg/L	<0.00050	0.0093	0.0013	0.0052	0.027	0.0037	0.011	0.12	0.02	0.017	0.085	0.051	0.021	0.038	0.36	0.23	0.03	0.16	0.039	0.059	0.065	0.31	0.01	0.021	0.04	0.024	0.0321	0.000597	0.000461	0.000846	0.00511	0.0482	0.00245	0.00169	0.00137	0.00161	0.000578
Lithium (Li)-Total	mg/L	0.045	0.025	0.075	0.038	0.031	0.02	0.016	0.047	0.02	0.017	0.034	0.021	0.016	0.024	0.095	0.058	0.022	0.048	0.044	0.026	0.021	0.032	0.021	0.026	0.02	0.021	0.0199	0.0171	0.0149	0.0147	0.0163	0.0187	0.015	0.0174	0.0165	0.0171	0.0169
Magnesium (Mg)-Total	mg/L	4.2	5.8	2.6	4.6	6.8	4.5	4.1	11	4.9	4.5	7.8	5.9	4.4	4.8	21	14	5.2	8.8	10	5.1	4.8	8.5	4	5.1	5.3	6	4.65	4	4.48	4.29	4.6	5.41	4.72	4.78	4.52	4.24	4.39
Manganese (Mn)-Total	mg/L	0.22	0.64	0.25	0.37	1.6	0.22	0.22	1.3	0.27	0.2	5.5	1.3	0.22	0.71	5.1	2.6	0.63	1.7	1.6	0.5	0.28	0.97	0.67	0.33	0.3	0.35	0.332	0.121	0.119	0.126	0.149	0.192	0.137	0.251	0.149	0.191	0.302
Mercury (Hg)-Total	mg/L	<0.000010	0.000022	<0.000010	0.000013	0.000053	<0.000010	<0.000010	0.00012	<0.000010	<0.000010	0.00019	0.000068	<0.0000050	-	0	0.00028	0.000054	0.00018	0.0001	<0.000050	<0.000025	<0.0000050	<0.000025	<0.000050	<0.00010	<0.00010	0.0000063	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000500	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.003	0.0019	0.0024	0.0016	0.004	0.0013	0.0031	0.005	0.0013	0.0015	0.0058	0.0021	0.00099	0.0021	0.0087	0.0045	0.0012	0.0033	0.0017	0.0011	0.00088	0.0023	0.00054	0.00084	0.00069	0.00063	0.000633	0.000809	0.000722	0.000864	0.00108	0.00079	0.0015	0.0012	0.0012	0.000975	0.000919
Nickel (Ni)-Total	mg/L	<0.0010	0.002	<0.00050	0.00095	0.011	0.0011	0.0018	0.012	0.0019	0.0029	0.01	0.0036	0.00084	0.004	0.024	0.013	0.0025	0.0079	0.0072	0.0016	0.0013	0.0065	<0.00050	0.0011	0.00099	0.0015	<0.00050	0.00065	<0.00050	0.00106	0.00154	<0.00050	0.00367	0.00265	0.00203	0.00056	0.00071
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	2.1	3.1	1.8	2.7	6	2	1.9	8.5	3.2	2.3	11	6.2	2	4.5	18	15	2.7	5.9	4.9	2.3	2.3	4.6	1.6	2.3	2.1	2.8	1.65	1.38	1.41	1.36	1.54	2.22	1.4	1.47	1.4	1.5	1.52
Selenium (Se)-Total	mg/L	<0.0010	<0.0010	<0.00010	0.00032	0.0014	<0.00010	<0.00010	0.0039	0.00029	0.00025	0.0025	0.00076	0.000063	0.00054	0.0089	0.0041	0.00059	0.0029	0.002	0.00036	0.0002	0.002	0.000097	0.00014	0.00021	0.00018	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000153	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.8	6.79	4.03	3.96	3.69	3.71	3.69
Silver (Ag)-Total	mg/L	<0.000020	0.0011	0.000092	0.0012	0.0052	0.00034	0.00052	0.015	0.0014	0.0012	0.013	0.0039	0.00033	0.0029	0.049	0.019	0.0015	0.0093	0.0034	0.0011	0.00066	0.0066	0.00019	0.00029	0.00034	0.00029	0.000097	<0.000010	<0.000010	<0.000010	0.000016	0.000446	0.000037	0.000018	0.000042	0.000012	<0.000010
Sodium (Na)-Total	mg/L	21	9.6	37	16	10	9.4	8.2	10	7.9	7.1	8.9	7.3	7.1	8.9	11	10	6.4	9.8	10	9.2	7.9	7.1	9.2	10	8.5	7.7	9.18	6.68	6.7	6.13	7.58	8.2	6.68	8.23	7.1	7.15	7.11
Strontium (Sr)-Total	mg/L	1.5	1.2	1	1.2	1.3	1.1	1.1	1.2	1.1	1	1.4	1	1	1.3	1.8	1.3	1.1	1.6	1.8	1.2	1.1	1.2	1.5	1.2	1.3	1.3	1.39	1.05	1.06	1.1	1.17	1.32	1.11	1.3	1.07	1.06	1.13
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	<0.00020	0.00023	0.000025	0.00017	0.00067	0.000089	0.00025	0.002	0.00027	0.00021	0.0012	0.0006	0.00013	0.00034	0.0018	0.0016	0.00019	0.00085	0.00037	0.00018	0.00023	0.00095	0.000064	0.00011	0.00013	0.00016	0.000085	<0.000010	<0.000010	<0.000010	0.000023	0.000146	0.000019	0.000013	0.000011	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	<0.00050	<0.00050	<0.00010	0.00012	0.00031	<0.00010	<0.00010	0.00044	0.00011	<0.00010	0.00039	0.00018	<0.00010	0.00013	0.00059	0.00064	0.00013	0.00032	0.00037	0.00012	0.00012	0.00026	<0.00010	0.00019	0.00015	0.00034	<0.00010	<0.00010	<0.00010	0.00024	0.00013	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	0.0322	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Total	mg/L	<0.00020	0.00033	0.00024	0.00023	0.00053	0.00019	0.0002	0.00086	0.00023	0.00022	0.00095	0.00045	0.00018	0.00028	0.002	0.0012	0.00033	0.00063	0.0013	0.00023	0.00032	0.00049	0.00011	0.00075	0.00068	0.0013	0.000173	0.000158	0.000136	0.000157	0.000157	0.000196	0.000165	0.000145	0.000134	0.000184	0.000135
Vanadium (V)-Total	mg/L	<0.0010	0.011	0.0013	0.0053	0.017	0.0021	0.0033	0.034	0.0069	0.0038	0.04	0.019	0.0026	0.011	0.084	0.061	0.006	0.023	0.021	0.0046	0.0039	0.018	0.0017	0.0042	0.0039	0.0067	0.00097	<0.00050	<0.00050	<0.00050	<0.00050	0.00336	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	<0.0050	0.029	0.0051	0.013	0.068	0.012	0.044	0.32	0.06	0.061	0.18	0.095	0.035	0.071	0.68	0.46	0.05	0.36	0.1	0.086	0.11	0.5	0.029	0.039	0.088	0.052	0.113	0.0031	0.0036	0.0071	0.0296	0.19	0.0152	0.0119	0.0123	0.005	0.0045
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																						
Aluminum (Al)-Dissolved	mg/L	0.024	0.014	0.016	0.02	0.021	0.0065	0.0088	0.015	0.013	0.016	0.023	0.011	0.0021	0.013	0.13	0.012	0.15	0.0032	0.011	0.031	0.0077	0.048	0.0026	0.0026	0.0011	0.0028	0.0012	0.0012	0.0012	0.0025	0.0022	0.0034	0.0014	0.0015	0.0015	0.0045	0.0035
Antimony (Sb)-Dissolved	mg/L	0.0047	0.0013	0.0018	0.0013	0.012	0.0033	0.0094	0.032	0.0099	0.011	0.0043	0.0091	0.0044	0.0066	0.0098	0.02	0.0034	0.0026	0.0018	0.0031	0.008	0.0078	0.0029	0.002	0.0034	0.002	0.00197	0.00141	0.00162	0.00077	0.00067	0.00138	0.00178	0.00219	0.00198	0.00184	0.00092
Arsenic (As)-Dissolved	mg/L	0.023	0.0076	0.028	0.0087	0.006	0.0069	0.0055	0.004	0.0038	0.0026	0.005	0.0051	0.0038	0.0059	0.0064	0.013	0.0045	0.0066	0.0068	0.0067	0.0074	0.005	0.0054	0.005	0.0036	0.0058	0.0044	0.00689	0.00652	0.00608	0.00523	0.00615	0.00578	0.00506	0.00423	0.0206	0.0176
Barium (Ba)-Dissolved	mg/L	0.029	0.031	0.024	0.029	0.03	0.025	0.022	0.032	0.022	0.021	0.039	0.023	0.019	0.034	0.039	0.03	0.031	0.03	0.035	0.023	0.023	0.025	0.031	0.027	0.026	0.032	0.0265	0.0184	0.0184	0.0181	0.0179	0.0185	0.0233	0.0253	0.0192	0.0191	0.026
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00020	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW11-3B		Date																										
		08-Oct-11	Mar 28, 2012	Jun 27, 2012	Sep 04, 2012	Jan 28, 2013	Jul 11, 2013	Sep 25, 2013	Aug 05, 2014	Nov 10, 2014	Jun 28, 2015	Sep 15, 2015	Jun 12, 2016	Sep 14, 2016	Jun 11, 2017	Sep 21, 2017	Nov 02, 2017	May 27, 2018	Aug 29, 2018	Nov 08, 2018	May 28, 2019	Sep 19, 2019	Nov 18, 2019	27-May-2020	22-Sep-2020	02-Jan-2021	Jun 20, 2021	Sep 23, 2021
ALS COA Sample ID		L1071509-5	L1129695-2	L1171422-3	L1207447-2	L1263921-3	L1331947-3	L1370058-2	L1498121-2	L1545769-2	L1634560-3	L1674145-2	L1784010-2	L1830196-2	L1941920-2	L1996356-2	L2018184-2	L2102081-2	L2156736-1	L2195168-1	L2282541-1	L2352491-1	L2384942-1	VA20A7334-001	VA20B6161-001	VA21A0051-003	VA21B2508-003	VA21C1212-002
Field Parameters	**Unit**																											
Temperature	°C	2	0.6	1.7	2.4	-	1.9	3.3	3.6	1.6	4.4	3	2.9	3.1	2.4	3.8	2.1	1.9	3.2	2.2	2.9	4.3	2.4	3.5	3.3	2.5	3.4	2.3
pH	pH	7	7.8	7.6	8.2	-	7.8	7.8	7.9	7.9	7.9	7.5	7.4	7	7.3	7.5	7.6	7.5	7.4	7.3	7.58	7.47	7.54	7.53	7.57	7.69	7.7	7.8
Specific conductance	µS/cm	380	367	193	176	-	249	482	550	494	392	435	293	792	311	482	552	614	866	602	379.1	455.7	406.5	408.2	369.7	502	348.8	332.1
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.18	0.15	0.18	0.26	5.99	0.79	0.29
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	244.2	105.1	221.1	187.5	91.4	226.7	60.4	-26.4
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	112	-	18.8	16.7	25.2	3.05	0.35	0.75	1.92	19.96	35.38	23.41	1.58
Physical Tests																												
Conductivity	uS/cm	339	312	331	340	382	352	386	409	496	407	476	518	794	519	478	521	659	867	585	379	466	400	409	394	498	353	337
Acidity (as $CaCO_3$)	mg/L	1.7	2.7	1.5	2.3	5	<1.0	1.4	2	2	-	-	5.6	2.8	0	1.5	5.4	2.9	2.9	2.5	1	1.4	2.2	2.6	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	86	43	86	88	76	95	93	107	105	98	112	109	124	109	112	111	105	106	106	93.2	105	110	109	104	90.4	95	93.3
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	190	172	244	160	148
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	167	156	157	156	188	164	182	188	238	211	241	264	420	258	224	253	306	354	256	159	204	184	184	192	219	157	148
pH	pH	8.1	7.9	8.1	8.1	7.9	8.2	8.1	8.1	8.1	7.7	7.7	8	8.1	7.9	8.1	7.8	8.1	7.6	8	8.08	8.18	8.06	8.07	8.09	8.09	8.02	8.08
Total Dissolved Solids (TDS)	mg/L	212	215	229	236	267	223	276	299	345	300	336	356	593	386	355	386	427	676	393	260	304	280	274	276	358	217	214
Total Suspended Solids (TSS)	mg/L	<3.0	275	326	1930	675	493	189	212	106	28	225	454	72	13	75	232	25	23	44	<3.0	<3.0	<3.0	<3.0	<3.0	63.5	<3.0	<3.0
Turbidity	NTU	2	204	288	2540	777	346	156	132	15	22	184	297	40	13	69	154	22	20	42	1.16	0.22	<0.10	0.29	<0.10	37.3	0.16	0.23
Anions and Nutrients																												
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	0.096	<0.050	<0.050
Total Ammonia (as N)	mg/L	0.032	0.015	0.03	0.033	0.032	0.027	0.024	0.017	0.012	0.012	0.01	0.0054	<0.0050	0.005	0.0082	0.009	0.0079	0.011	0.024	0.0246	0.0154	0.0145	0.0131	0.0152	0.0248	0.026	0.024
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	1.2	<0.50	2.4	0.59	1.5	0.95	6.5	3.4	15	6.5	3.2	15	19	93	41	5.97	24.1	7.87	7.82	1.79	25.9	1.22	<0.50
Fluoride (F)	mg/L	0.13	0.091	0.11	0.14	0.11	0.16	0.11	0.16	0.1	0.12	0.099	0.12	<0.10	0.09	0.13	0.12	0.095	<0.10	0.15	0.172	0.159	0.178	0.174	0.17	0.148	0.179	0.183
Nitrate (as N)	mg/L	<0.0050	0.02	<0.0050	<0.0050	<0.0050	0.0052	0.21	0.067	0.82	<0.0050	0.45	<0.0050	3.2	0.02	0.0088	0.12	0.032	0.14	0.014	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0129	<0.0050	<0.0050
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0129	<0.0051	<0.0051
Nitrite (as N)	mg/L	<0.0010	0.0018	0.0016	<0.0010	0.0013	<0.0010	0.044	0.0057	0.01	0.0016	0.049	0.0015	0.069	<0.0010	<0.0010	0.0081	0.001	0.0066	<0.0010	<0.0010	<0.0010	<0.0010	0.001	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.030	<0.030	0.109	<0.030	0.048
Dissolved Orthophosphate (as P)	mg/L	<0.0010	0.0021	0.0012	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	0.0012	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	0.0012	<0.0010	0.0013	0.0017
Total Phosphorus (P)	mg/L	<0.0020	0.045	0.29	1.2	0.51	0.23	0.18	0.14	0.088	0.015	0.23	0.17	0.043	0.0088	0.041	0.21	0.025	0.019	0.037	0.0024	0.0031	<0.0020	<0.0020	<0.0020	0.0519	0.0023	0.004
Sulfate (SO_4)	mg/L	83	108	90	92	125	87	112	115	161	116	131	161	256	167	143	146	190	197	132	84.9	103	94.5	95	94	122	81.9	75.5
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.019	<0.019	<0.0016	<0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.018	<0.0015	<0.0015
Total Metals																												
Aluminum (Al)-Total	mg/L	0.017	6.7	8.5	28	10	9.3	2.8	4.3	2.2	0.76	6.2	7.5	0.18	0.19	1.3	2.9	0.86	0.54	0.53	0.0327	<0.0030	0.0032	0.0033	<0.0030	2.09	<0.0030	0.008
Antimony (Sb)-Total	mg/L	0.0011	0.006	0.0039	0.0061	0.019	0.011	0.0048	0.0053	0.0047	0.0023	0.0084	0.0081	0.0027	0.0024	0.004	0.0082	0.0028	0.002	0.0019	0.00101	0.00071	0.00074	0.00127	0.00106	0.00257	0.00105	0.00089
Arsenic (As)-Total	mg/L	0.016	0.057	0.038	0.16	0.064	0.11	0.034	0.038	0.027	0.011	0.059	0.056	0.011	0.008	0.023	0.058	0.011	0.0082	0.01	0.00284	0.0025	0.0028	0.00258	0.0026	0.0193	0.00253	0.0046
Barium (Ba)-Total	mg/L	0.044	0.17	0.34	1.3	0.4	0.41	0.2	0.19	0.14	0.05	0.28	0.24	0.05	0.035	0.073	0.17	0.061	0.057	0.048	0.0231	0.0254	0.0239	0.0201	0.0229	0.0768	0.0186	0.0219
Beryllium (Be)-Total	mg/L	<0.0010	<0.0010	0.00033	0.0017	0.00056	0.00088	0.00023	0.00027	0.00014	<0.00010	0.00044	0.00049	<0.00010	<0.00010	0.00013	0.00037	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	<0.00050	0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	0.00015	0.00016	<0.000050	<0.000050	0.000066	0.00017	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.028	0.027	0.024	0.033	0.028
Cadmium (Cd)-Total	mg/L	<0.000017	0.00019	0.00043	0.0027	0.00049	0.00059	0.00016	0.00014	0.000084	0.00007	0.00028	0.00028	0.000087	0.00006	0.00013	0.00032	0.000063	0.00011	0.00011	0.000038	0.000041	0.0000277	0.0000128	0.0000274	0.0000972	0.0000249	0.0000195
Calcium (Ca)-Total	mg/L	62	58	68	84	74	76	70	69	90	75	97	97	159	97	83	104	112	138	103	60.4	75.5	70.7	67.2	70.4	79.1	58.2	53.6
Chromium (Cr)-Total	mg/L	<0.0010	0.0023	0.0027	0.018	0.0035	0.0045	0.0013	0.0013	0.0011	0.0003	0.0022	0.002	0.00011	0.00011	0.00072	0.0016	0.00088	0.00065	0.00034	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00636	<0.00050	<0.00050
Cobalt (Co)-Total	mg/L	<0.00030	0.0017	0.0021	0.013	0.003	0.0052	0.0012	0.0013	0.00082	0.00021	0.0026	0.0026	0.00031	0.00012	0.00076	0.0026	0.00027	0.0002	0.00029	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00037	<0.00010	<0.00010
Copper (Cu)-Total	mg/L	<0.0010	0.0073	0.013	0.083	0.024	0.021	0.0052	0.006	0.0027	0.0014	0.011	0.011	0.0014	0.00081	0.0039	0.011	0.0014	0.0012	0.0015	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00342	<0.00050	<0.00050
Iron (Fe)-Total	mg/L	0.055	6	7.8	43	8	16	3.7	3.6	2.4	0.53	7.3	7.2	0.41	0.25	2.1	7.2	0.68	0.44	0.84	0.02	<0.010	<0.010	<0.010	<0.010	1.54	<0.010	<0.010
Lead (Pb)-Total	mg/L	<0.00050	0.0061	0.0061	0.089	0.012	0.02	0.0052	0.006	0.003	0.0012	0.0089	0.0086	0.0013	0.00064	0.0035	0.0088	0.0013	0.00074	0.0015	0.000128	<0.000050	<0.000050	<0.000050	<0.000050	0.00162	<0.000050	0.000271
Lithium (Li)-Total	mg/L	0.013	0.01	0.024	0.047	0.02	0.028	0.013	0.019	0.013	0.012	0.019	0.022	0.011	0.013	0.014	0.017	0.013	0.013	0.012	0.0128	0.0112	0.0095	0.0114	0.011	0.0121	0.0125	0.0102
Magnesium (Mg)-Total	mg/L	3.9	4.5	6.7	12	7.4	7.3	4.9	5.6	5.9	4.3	7	7.5	8	5.9	5.5	7	6.8	7.8	5.3	3.7	4.59	4.21	3.97	3.85	5.16	3.56	3.57
Manganese (Mn)-Total	mg/L	0.42	0.39	0.74	2.3	0.65	1.1	0.42	0.31	0.27	0.073	0.68	0.78	0.13	0.032	0.23	0.79	0.077	0.091	0.21	0.0545	0.1	0.122	0.00604	0.0944	0.298	0.115	0.224
Mercury (Hg)-Total	mg/L	<0.000010	0.000012	0.000031	0.00022	0.000046	0.000072	0.00002	<0.000010	<0.000010	<0.0000050	0.000033	0.000021	0.00001	<0.0000050	<0.000025	0.000039	0.0000079	0.0000059	0.0000097	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000109	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	<0.0010	<0.0010	0.00097	0.0076	0.0022	0.0019	0.00075	0.00092	0.00059	0.00062	0.00093	0.0011	0.00014	0.00035	0.00072	0.0011	0.00033	0.00041	0.00062	0.000547	0.000615	0.000647	0.000426	0.000806	0.00105	0.000682	0.000845
Nickel (Ni)-Total	mg/L	<0.0010	0.0019	0.002	0.0097	0.0026	0.0033	0.0011	0.001	0.00074	<0.00050	0.0021	0.0021	<0.00050	<0.00050	0.00071	0.0017	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00057	<0.00050	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	<2.0	2.1	2.8	9.6	5.3	3.6	1.8	2.5	2	1.2	2.9	3.4	1.5	1.3	1.6	1.9	1.6	1.7	1.3	1.13	1.18	1.22	1.13	1.17	2	1.13	1.18
Selenium (Se)-Total	mg/L	<0.0010	<0.0010	0.0012	0.0055	0.0021	0.0019	0.00046	0.00064	0.00043	0.00017	0.00086	0.0006	0.00037	0.0002	0.00027	0.00063	0.0003	0.00012	0.00014	0.00006	<0.000050	<0.000050	0.000088	<0.000050	0.000175	<0.000050	<0.000050
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.22	3.31	6.79	3.33	3.5
Silver (Ag)-Total	mg/L	<0.000020	0.00039	0.0029	0.028	0.0043	0.0023	0.00041	0.00047	0.00037	0.000076	0.00052	0.00039	0.000034	0.000033	0.0002	0.00037	0.000059	0.000036	0.00006	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.00007	<0.000010	<0.000010
Sodium (Na)-Total	mg/L	5.6	3.2	5.7	7	5	6.6	5.7	6.7	6.1	5.7	6.7	6.5	7.7	7.2	6.4	7.4	10	23	13	8.28	9.3	8.22	8.66	4.99	11	6.41	5.08
Strontium (Sr)-Total	mg/L	1.7	1	1.7	1.8	3	1.6	1.8	2	2.6	1.9	2.3	2.5	3.5	2.5	2.4	2.5	2.9	3.3	2.1	1.37	1.67	1.45	1.54	1.37	1.6	1.06	0.998
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	<0.00020	0.00023	0.00024	0.0013	0.00042	0.00038	0.00013	0.00016	0.00011	0.000054	0.00023	0.00029	0.000054	0.000042	0.000089	0.00022	0.000062	0.000063	0.000059	0.000026	0.000028	0.000029	0.000025	0.000029	0.000094	0.00002	0.000016
Tin (Sn)-Total	mg/L	<0.00050	<0.00050	0.00016	0.00018	0.00032	0.00032	0.00018	0.00018	0.00028	<0.00010	0.00025	0.00013	<0.00010	<0.00010	0.00015	0.00012	<0.00010	0.00015	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00017	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0400	<0.0100	<0.0100
Uranium (U)-Total	mg/L	0.00025	0.00046	0.00085	0.0021	0.00095	0.00098	0.00072	0.00052	0.00057	0.0003	0.00056	0.00047	0.00047	0.0003	0.00037	0.00048	0.00033	0.00059	0.00034	0.00016	0.000244	0.00023	0.00022	0.000206	0.00027	0.000161	0.000186
Vanadium (V)-Total	mg/L	<0.0010	0.011	0.011	0.039	0.015	0.016	0.0048	0.0068	0.0037	0.0012	0.01	0.012	0.00053	<0.00050	0.0023	0.0061	0.0015	0.00096	0.00092	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00315	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	<0.0050	0.029	0.034	0.2	0.041	0.055	0.017	0.016	0.01	0.0039	0.028	0.026	0.0036	0.0031	0.01	0.029	0.0054	0.0049	0.0042	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0094	<0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																												
Aluminum (Al)-Dissolved	mg/L	0.0075	0.016	0.025	0.049	0.015	0.047	0.013	0.0083	0.011	0.006	0.013	0.0016	0.0051	<0.0010	0.0021	0.057	0.0012	<0.0010	<0.0010	<0.0010	0.001	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	0.0019
Antimony (Sb)-Dissolved	mg/L	0.0011	0.0025	0.0033	0.0051	0.019	0.0028	0.0019	0.0019	0.003	0.0016	0.0016	0.0013	0.002	0.0018	0.0015	0.0016	0.0017	0.0011	0.00095	0.00096	0.00071	0.00072	0.00123	0.00102	0.0012	0.00111	0.00089
Arsenic (As)-Dissolved	mg/L	0.017	0.02	0.0077	0.0054	0.028	0.013	0.0096	0.0089	0.0097	0.0064	0.0063	0.0061	0.0047	0.0047	0.0044	0.0064	0.0043	0.0031	0.0034	0.00271	0.00265	0.00278	0.0024	0.00285	0.00367	0.00276	0.00439
Barium (Ba)-Dissolved	mg/L	0.042	0.034	0.038	0.051	0.052	0.053	0.043	0.048	0.049	0.031	0.042	0.034	0.042	0.027	0.025	0.036	0.029	0.034	0.029	0.0206	0.0264	0.0229	0.0193	0.0237	0.0274	0.0203	0.0252
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.029	0.027	0.024	0.031	0.026
Cadmium (Cd)-Dissolved	mg/L	<0.000017	0.00006	0.000081	0.000075	0.000057	0.00003	0.000046	0.000039	0.000022	0.000045	0.000071	0.00013	0.000055	0.000047	0.000055	0.000079	0.000032	0.000055	0.00009	0.000038	0.0000472	0.0000296	0.0000087	0.0000205	0.0000357	0.0000259	0.0000113
Calcium (Ca)-Dissolved	mg/L	61	58	57	57	67	60	66	68	87	77	89	97	154	94	82	92	111	131	93	57.8	74.4	66.5	69.3	62.2	90.6	57	53.9
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	<0.00010	<0.00010	<0.00010	0.0001	<0.00010	<0.00010	0.00014	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00056	<0.00050	<0.00050
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	0.00018	0.00027	0.0005	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.0010	<0.0010	<0.00050	<0.00050	0.00089	<0.00050	<0.00050	<0.00050	<0.00050	0.0002	0.00036	<0.00020	<0.00020	0.0003	<0.00020	0.0006	0.00088	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	0.00029	0.0002	0.00074
Iron (Fe)-Dissolved	mg/L	0.036	<0.030	<0.030	<0.030	<0.030	<0.030	0.076	<0.030	<0.030	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.13	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.000050	0.00009	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000076	<0.000050	<0.000050	0.00039	0.000055	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000112
Lithium (Li)-Dissolved	mg/L	0.012	<0.0050	0.0094	0.013	0.011	0.015	0.0095	0.014	0.011	0.011	0.0098	0.012	0.01	0.012	0.012	0.012	0.012	0.01	0.011	0.0128	0.0105	0.0096	0.0126	0.0105	0.0101	0.0123	0.01
Magnesium (Mg)-Dissolved	mg/L	3.8	2.8	3.5	3.4	5.3	3.8	4	4.4	5.2	4.3	4.8	5.6	8.3	5.6	4.8	5.8	6.9	6.4	5.5	3.55	4.39	4.28	4.05	4.09	4.45	3.63	3.32
Manganese (Mn)-Dissolved	mg/L	0.4	0.083	0.25	0.49	0.32	0.041	0.13	0.037	0.013	0.018	0.046	0.27	0.025	0.0069	0.047	0.085	0.0037	0.01	0.13	0.0533	0.1	0.12	0.00212	0.102	0.112	0.125	0.225
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.0000050	<0.0000050	<0.0000005	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	<0.0010	<0.0010	0.00058	0.0018	0.0012	0.00088	0.00061	0.00075	0.00055	0.00058	0.00057	0.00069	0.00014	0.00033	0.00057	0.00057	0.00028	0.00032	0.00059	0.00055	0.00061	0.0111	0.000414	0.00084	0.000747	0.000713	0.000895
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.0010	<0.00050	0.00078	0.00083	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	<2.0	<2.0	0.98	1.5	1.8	1.2	1.1	1.1	1.3	1	1.1	1.2	1.5	1.2	1.2	1.2	1.4	1.4	1.3	1.15	1.23	1.2	1.12	1.34	1.29	1.2	1.14
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	0.00059	0.001	0.0012	0.00029	0.00017	0.00012	0.00022	0.000081	0.00016	0.00012	0.00033	0.00019	<0.000050	0.000064	0.00019	0.000089	<0.000050	0.000186	<0.000050	0.000083	0.000143	0.000052	<0.000050	<0.000050	<0.000050
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.85	3.45	3.3	3.19	3.15
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000010	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	5.5	3.1	5	6.3	4.7	6.4	5.2

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW11-5A		Date						
		Oct 11, 2011	Mar 12, 2012	Jun 12, 2012	Jun 16, 2016	Sep 16, 2016	Jul 17, 2017	Oct 17, 2017
ALS COA Sample ID		L1071509-3	L1129695-3	L1171422-5	L1786525-1	L1828019-1	L1959234-2	L2007771-1
Field Parameters	**Unit**							
Temperature	°C	-	-	-	2.2	2.7	3	1.6
pH	pH	-	-	-	7.5	7.23	7.5	7.77
Specific conductance	µS/cm	-	-	-	738.2	766	652	593.4
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-	-	3846
Physical Tests								
Conductivity	uS/cm	249	484	460	831	732	637	578
Acidity (as CaCO3)	mg/L	2.9	1.1	1.5	8.7	7.2	3.5	4.3
Total Alkalinity (as $CaCO_3$)	mg/L	39.5	83.1	98.8	173	201	164	167
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	91.5	100	198	405	407	274	224
pH	pH	7.96	8.2	8.1	7.75	7.88	8.05	7.94
Total Dissolved Solids (TDS)	mg/L	149	323	328	610	504	500	379
Total Suspended Solids (TSS)	mg/L	62.2	5380	4980	3440	3640	878	2260
Turbidity	NTU	66.6	>4000	>4000	>4000	3270	978	2800
Anions and Nutrients								
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-
Total Ammonia (as N)	mg/L	0.102	0.283	0.371	0.374	0.235	0.218	0.282
Bromide (Br)	mg/L	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	1.47	1.47	3.27	<2.5	<2.5	<0.50	<0.50
Fluoride (F)	mg/L	0.152	0.221	0.194	<0.10	<0.10	0.075	0.096
Nitrate (as N)	mg/L	0.0057	<0.0050	<0.0050	<0.025	<0.025	0.0074	0.0783
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	0.0011	<0.0010	<0.0010	<0.0050	<0.0050	<0.0010	0.0023
Nitrogen, total	mg/L	-	-	-	-	-	-	-
Dissolved Orthophosphate (as P)	mg/L	<0.0010	<0.0010	<0.0010	0.0011	0.001	<0.0010	<0.0010
Total Phosphorus (P)	mg/L	<0.30	1.51	2.22	2.59	1.9	0.87	1.44
Sulfate (as SO_4)	mg/L	73.6	155	130	310	237	201	172
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-
Sulfide (as S)	mg/L	-	-	-	-	-	-	-
Total Metals								
Aluminum (Al)-Total	mg/L	1.04	52.5	32.1	36.7	40.2	12.3	21.4
Antimony (Sb)-Total	mg/L	0.00319	0.0029	0.0122	0.0109	0.00677	0.00887	0.0129
Arsenic (As)-Total	mg/L	0.0126	0.311	0.798	0.85	0.738	0.295	0.74
Barium (Ba)-Total	mg/L	0.072	0.76	1.37	1.33	0.942	0.459	0.802
Beryllium (Be)-Total	mg/L	<0.0010	0.0091	0.00345	0.00304	0.00605	0.00069	0.00197
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	0.0024	0.00242	0.00268	0.000805	0.00141
Boron (B)-Total	mg/L	-	-	-	-	-	-	-
Cadmium (Cd)-Total	mg/L	0.00023	0.0021	0.00809	0.00385	0.00344	0.0017	0.00292
Calcium (Ca)-Total	mg/L	32.4	164	162	221	235	116	131
Chromium (Cr)-Total	mg/L	0.002	0.0264	0.0481	0.0446	0.0349	0.0196	0.0269
Cobalt (Co)-Total	mg/L	0.00435	0.0239	0.0337	0.0333	0.0328	0.0131	0.0304
Copper (Cu)-Total	mg/L	0.0091	0.12	0.198	0.189	0.164	0.075	0.112
Iron (Fe)-Total	mg/L	1.5	54.8	82.3	84.3	56.9	27.9	55.9
Lead (Pb)-Total	mg/L	0.00245	0.121	0.139	0.112	0.123	0.0293	0.0805
Lithium (Li)-Total	mg/L	0.0229	0.111	0.1	0.113	0.058	0.05	0.0665
Magnesium (Mg)-Total	mg/L	3.6	24.5	21.8	38.2	31.4	20.1	22.3
Manganese (Mn)-Total	mg/L	0.654	1.94	3.8	3.84	3.31	1.46	5.1
Mercury (Hg)-Total	mg/L	<0.000010	0.000124	<0.00010	0.00014	0.00149	0.000052	0.00016
Molybdenum (Mo)-Total	mg/L	0.0063	0.0058	0.0172	0.00764	0.00379	0.00512	0.00634
Nickel (Ni)-Total	mg/L	0.0038	0.0422	0.0749	0.0651	0.0624	0.0303	0.0441
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-
Potassium (K)-Total	mg/L	3.3	13.8	15.8	19.3	15.3	9.59	11.3
Selenium (Se)-Total	mg/L	<0.0010	<0.0050	0.00594	0.0033	0.00216	0.00212	0.00328
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-
Silver (Ag)-Total	mg/L	0.000524	0.0189	0.0412	0.0368	0.0261	0.0179	0.0266
Sodium (Na)-Total	mg/L	12.4	62.5	29.9	26.2	15.4	20.8	22.8
Strontium (Sr)-Total	mg/L	0.842	4.65	3.47	7.43	5.85	4.95	5.39
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	<0.00020	0.0018	0.00407	0.00251	0.00228	0.000923	0.00162
Tin (Sn)-Total	mg/L	0.00193	<0.0025	0.00066	0.0007	0.00055	0.00075	0.00128
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-
Uranium (U)-Total	mg/L	0.00028	0.0175	0.00561	0.0106	0.0132	0.00256	0.00509
Vanadium (V)-Total	mg/L	0.0015	0.039	0.0478	0.0529	0.0423	0.0201	0.0327
Zinc (Zn)-Total	mg/L	0.0317	0.321	0.461	0.351	0.441	0.124	0.254
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-
Dissolved Metals								
Aluminum (Al)-Dissolved	mg/L	0.0566	0.148	5.8	0.0036	0.0062	0.0055	0.0028
Antimony (Sb)-Dissolved	mg/L	0.00277	0.00501	0.01	0.00655	0.00335	0.0051	0.00238
Arsenic (As)-Dissolved	mg/L	0.00641	0.0144	0.0958	0.0216	0.0324	0.0104	0.00789
Barium (Ba)-Dissolved	mg/L	0.027	0.021	0.285	0.0986	0.0597	0.0515	0.0385
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	0.00047	<0.00020	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.0010	<0.00010	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-
Cadmium (Cd)-Dissolved	mg/L	0.000112	<0.000017	0.0012	0.000021	0.0000067	0.0000088	0.0000077
Calcium (Ca)-Dissolved	mg/L	31.3	30.1	63.9	128	137	84.9	67
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	0.00811	<0.00020	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Dissolved	mg/L	0.00331	<0.00030	0.00437	0.00099	0.00093	0.0016	0.00044
Copper (Cu)-Dissolved	mg/L	0.0024	<0.0010	0.0165	<0.00040	0.00023	0.00078	0.00033
Iron (Fe)-Dissolved	mg/L	0.072	0.038	9.15	0.424	1.08	0.072	<0.010
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	0.0186	<0.00010	0.000101	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0214	0.0865	0.0655	0.0746	0.0234	0.0353	0.045
Magnesium (Mg)-Dissolved	mg/L	3.22	6.1	9.37	20.6	15.7	15	13.7
Manganese (Mn)-Dissolved	mg/L	0.569	0.0576	0.831	0.598	0.859	0.389	0.138
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.00010	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.0058	0.0054	0.0141	0.00291	0.0017	0.00291	0.00194
Nickel (Ni)-Dissolved	mg/L	0.0026	<0.0010	0.0119	0.0045	0.00305	0.00666	0.00278
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-
Potassium (K)-Dissolved	mg/L	2.5	5	8.49	6.62	5.47	5.91	5.11
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	0.00072	<0.00010	<0.000050	0.000053	<0.000050
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	0.00503	<0.000020	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	12.3	65.2	29.2	25.3	10.9	20.2	21.6
Strontium (Sr)-Dissolved	mg/L	0.811	2.16	2.54	6.22	4.45	4.71	3.9
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	0.000746	<0.000020	<0.000010	0.000021	0.000031
Tin (Sn)-Dissolved	mg/L	0.00091	<0.00050	<0.00020	<0.00020	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	<0.010	<0.010	0.102	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	mg/L	0.00022	0.00167	0.00156	0.0028	0.0026	0.00115	0.000813
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	0.0094	<0.0010	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.0102	<0.0050	0.0425	<0.0020	0.0023	0.0017	0.0011
Zirconium (Zr)-Dissolved	mg/L							
Aggregate Organics								
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW11-5B		Date				
		Oct 10, 2011	Mar 28, 2012	Jun 26, 2012	Jun 19, 2016	Sep 11, 2016
ALS COA Sample ID		L1071509-2	L1129695-4	L1171422-6	L1786525-2	L1828019-2
Field Parameters	**Unit**					
Temperature	°C	-	-	-	3.1	5.3
pH	pH	-	-	-	7.53	7.45
Specific conductance	µS/cm	-	-	-	675.2	603
Dissolved Oxygen	mg/L	-	-	-	-	-
Oxidation Reduction Potential	mV	-	-	-	-	-
Turbidity	NTU	-	-	-	-	-
Physical Tests						
Conductivity	uS/cm	335	338	427	770	607
Acidity (as CaCO3)	mg/L	2.4	1.5	1.7	8.9	4.6
Total Alkalinity (as $CaCO_3$)	mg/L	70.8	75.6	89.3	160	163
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	171	145	168	400	299
pH	pH	8.12	8.13	8.05	7.72	7.91
Total Dissolved Solids (TDS)	mg/L	255	237	290	580	451
Total Suspended Solids (TSS)	mg/L	34400	6220	3830	651	1230
Turbidity	NTU	>4000	>4000	>4000	635	1410
Anions and Nutrients						
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-
Total Ammonia (as N)	mg/L	0.393	0.121	0.225	0.0598	0.0873
Bromide (Br)	mg/L	-	-	-	-	-
Chloride (Cl)	mg/L	0.76	2.97	4.31	<2.5	<2.5
Fluoride (F)	mg/L	0.239	0.184	0.256	<0.10	0.1
Nitrate (as N)	mg/L	<0.0050	<0.0050	<0.0050	0.737	0.11
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-
Nitrite (as N)	mg/L	0.0011	<0.0010	<0.0010	0.084	0.0074
Nitrogen, total	mg/L	-	-	-	-	-
Dissolved Orthophosphate (as P)	mg/L	<0.0010	<0.0010	<0.0010	0.0014	0.0027
Total Phosphorus (P)	mg/L	12.5	9.74	2.51	0.49	0.95
Sulfate (as SO_4)	mg/L	96.3	89.2	121	274	219
Sulfide (as H2S)	mg/L	-	-	-	-	-
Sulfide (as S)	mg/L	-	-	-	-	-
Total Metals						
Aluminum (Al)-Total	mg/L	240	158	38.3	11.2	17.7
Antimony (Sb)-Total	mg/L	<0.010	0.013	0.0128	0.018	0.0176
Arsenic (As)-Total	mg/L	5.04	3.52	0.937	0.201	0.435
Barium (Ba)-Total	mg/L	6.33	3.44	2.08	0.365	0.672
Beryllium (Be)-Total	mg/L	<0.020	<0.020	0.00253	0.00047	0.00077
Bismuth(Bi)- Total	mg/L	<0.20	<0.20	0.0016	0.000255	0.000432
Boron (B)-Total	mg/L	-	-	-	-	-
Cadmium (Cd)-Total	mg/L	0.0109	0.00641	0.0113	0.000682	0.00139
Calcium (Ca)-Total	mg/L	620	460	171	148	139
Chromium (Cr)-Total	mg/L	0.241	0.146	0.0673	0.0142	0.0254
Cobalt (Co)-Total	mg/L	0.202	0.152	0.038	0.0109	0.0233
Copper (Cu)-Total	mg/L	1.52	1.04	0.294	0.0398	0.0909
Iron (Fe)-Total	mg/L	460	344	92.6	16.4	30
Lead (Pb)-Total	mg/L	0.518	0.267	0.127	0.017	0.0347
Lithium (Li)-Total	mg/L	0.3	0.22	0.0794	0.0645	0.0467
Magnesium (Mg)-Total	mg/L	118	94.3	21.9	20.1	19.8
Manganese (Mn)-Total	mg/L	24.4	17.9	5.06	1.02	1.88
Mercury (Hg)-Total	mg/L	0.0015	0.000351	<0.00010	0.0000197	0.000072
Molybdenum (Mo)-Total	mg/L	0.03	<0.020	0.0254	0.00676	0.0139
Nickel (Ni)-Total	mg/L	0.357	0.251	0.0755	0.035	0.0529
Phosphorus (P)-Total	mg/L	-	-	-	-	-
Potassium (K)-Total	mg/L	74.8	48.1	16.3	9.09	10.6
Selenium (Se)-Total	mg/L	<0.020	<0.020	0.00759	0.000875	0.00154
Silicon (Si)-Total	mg/L	-	-	-	-	-
Silver (Ag)-Total	mg/L	0.244	0.136	0.0567	0.00885	0.0205
Sodium (Na)-Total	mg/L	14.3	11.1	15	13.3	10.5
Strontium (Sr)-Total	mg/L	3.83	4.33	2.35	4.31	3.54
Sulfur (S)-Total	mg/L	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.0105	0.0091	0.00329	0.000716	0.00105
Tin (Sn)-Total	mg/L	<0.010	<0.010	0.00043	0.00029	0.00043
Titanium (Ti)-Total	mg/L	-	-	-	-	-
Uranium (U)-Total	mg/L	0.0526	0.0132	0.00393	0.0032	0.003
Vanadium (V)-Total	mg/L	0.341	0.221	0.0598	0.0195	0.0321
Zinc (Zn)-Total	mg/L	1.63	1.27	0.5	0.069	0.161
Zirconium (Zr)-Total	mg/L	-	-	-	-	-
Dissolved Metals						
Aluminum (Al)-Dissolved	mg/L	0.0868	0.0297	0.0747	0.0064	0.0065
Antimony (Sb)-Dissolved	mg/L	0.0113	0.00722	0.00457	0.016	0.00984
Arsenic (As)-Dissolved	mg/L	0.0102	0.012	0.00533	0.0162	0.0194
Barium (Ba)-Dissolved	mg/L	0.042	0.024	0.0492	0.0542	0.0334
Beryllium (Be)-Dissolved	mg/L	<0.0010	<0.0010	<0.00020	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.20	<0.20	<0.0010	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-
Cadmium (Cd)-Dissolved	mg/L	<0.000017	<0.000017	0.00033	0.0000582	0.0000464
Calcium (Ca)-Dissolved	mg/L	58.5	48.6	56.9	133	98.3
Chromium (Cr)-Dissolved	mg/L	<0.0010	<0.0010	<0.00020	<0.00010	<0.00010
Cobalt (Co)-Dissolved	mg/L	<0.00030	<0.00030	0.00037	0.00151	0.0013
Copper (Cu)-Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.00020	0.0002
Iron (Fe)-Dissolved	mg/L	<0.030	<0.030	<0.030	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	<0.00050	<0.00050	<0.00010	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0094	0.0151	0.0232	0.0527	0.0273
Magnesium (Mg)-Dissolved	mg/L	5.91	5.74	6.38	16.5	13.1
Manganese (Mn)-Dissolved	mg/L	0.134	0.262	0.554	0.183	0.292
Mercury (Hg)-Dissolved	mg/L	<0.000010	<0.000010	<0.00010	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.0075	0.0055	0.0158	0.00497	0.00997
Nickel (Ni)-Dissolved	mg/L	<0.0010	<0.0010	0.0017	0.0185	0.0112
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-
Potassium (K)-Dissolved	mg/L	7.4	3.7	5.53	5.45	5.07
Selenium (Se)-Dissolved	mg/L	<0.0010	<0.0010	<0.00020	0.00015	0.000062
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-
Silver (Ag)-Dissolved	mg/L	<0.000020	<0.000020	<0.000020	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	12.7	9.8	14.5	13.1	9.91
Strontium (Sr)-Dissolved	mg/L	0.747	1.55	1.66	4.33	3.39
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.00020	<0.00020	0.000129	0.0001	0.000104
Tin (Sn)-Dissolved	mg/L	0.00116	<0.00050	<0.00020	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-
Uranium (U)-Dissolved	mg/L	0.00146	0.00082	0.00107	0.00263	0.0027
Vanadium (V)-Dissolved	mg/L	<0.0010	<0.0010	<0.0020	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	<0.0050	<0.0050	<0.0060	0.0026	0.0019
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-
Aggregate Organics						
Chemical Ozygen Demand (COD)	mg/L	-	-	-	-	-

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-8A		Date																																	
		Jun 28, 2012	Sep 04, 2012	Jan 28, 2013	Apr 08, 2013	Jul 14, 2013	Sep 26, 2013	Aug 07, 2014	Nov 12, 2014	Mar 31, 2015	Jun 29, 2015	Sep 18, 2015	Jan 30, 2016	Mar 28, 2016	Jun 16, 2016	Sep 17, 2016	Dec 09, 2016	Apr 09, 2017	Jun 13, 2017	Oct 12, 2017	Dec 14, 2017	Mar 25, 2018	Jul 05, 2018	Sep 13, 2018	Dec 20, 2018	Apr 28, 2019	Jul 24, 2019	Sep 15, 2019	Dec 10, 2019	14-Jun-2020	07-Sep-2020	Jan 27, 2021	Apr 23, 2021	Jun 21, 2021	Oct 17, 2021	Jan 27, 2022
ALS COS Sample ID		L1174115-1	L1207447-3	L1263921-8	L1288325-1	L1333226-4	L1370207-2	L1499651-1	L1546455-2	L1594284-4	L1636861-4	L1676019-1	L1729910-1	L1750649-1	L1785971-1	L1831646-1	L1869371-1	L1911676-1	L1942896-1	L2007251-2	L2036305-1	L2072721-1	L2125409-1	L2164992-1	L2214131-1	L2265042-2	L2317986-1	L2349152-1	VA19A0481-002	VA20A8336-001	VA20B4636-001	VA21A1647-002	VA21A7804-002	VA21B2626-002	VA21C3094-002	VA22A1795-001
Field Parameters	**Unit**																																			
Temperature	°C	3.5	4.9	1.9	2.2	3.1	2.7	3.8	2.1	3.3	3.2	3	3.7	2.2	2.7	2.4	1.3	2.1	2.6	2.3	2.3	1.3	3.5	2.6	1.9	2.5	4.3	3.4	1.8	2.6	2.7	3.3	2.7	2.3	2.1	1.5
pH	pH	8.1	7.3	8.1	8	8.7	6.7	8.2	8.3	8.1	8.3	8.2	8.2	8.3	8.3	8.1	8.1	8.6	8	8.3	8.3	8.1	8	8	8.1	8.1	8.05	8.16	8.1	8.02	8.09	8.17	8.18	8.08	8.21	8.15
Specific conductance	µS/cm	130	246	333	253	341	222	290	192	213	190	201	208	221	245	202	206	220	213	203	205	218	204	200	181	214.9	196.8	200.2	202.4	211.2	206.4	208.3	215.7	214.3	204	211.5
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.66	4	3.4	4.64	3.12	1.45	3.77	4.7	2.16
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101.2	58	151.2	85.9	156.7	139.8	84.9	33.4	49.7	129.7	124.7
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43.1	119	84.1	-	17.5	-	62	55.7	7.65	7.24	23.08	8.4	10.33	1.56	4.06	19.1	1.1	46.33
Physical Tests																																				
Conductivity	uS/cm	203	200	209	213	200	196	200	201	216	209	201	213	225	220	206	202	217	207	198	189	219	207	198	205	216	201	212	210	217	210	212	219	222	205	202
Acidity (as $CaCO_3$)	mg/L	<1.0	<1.0	1.4	1.2	1.8	11	1	<1.0	-	-	-	-	-	<1.0	1.2	1.1	<1.0	1.1	1.6	<1.0	1	1.8	1.4	1.2	1.3	1.3	1.8	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	76	74	74	76	73	74	70	76	77	74	76	72	83	89	80	80	87	73	77	77	103	70	70	76	77	74	75.2	72.3	72.2	70.5	68.6	72.3	73	72.4	60.7
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	102	93.2	106	104	98.2	97.9	99.9
Hardness (as $CaCO_3$), from	mg/L	90	86	98	100	91	91	89	88	103	101	96	105	103	100	99	98	93	99	99	96	108	93	92	96	102	94.3	92.4	99.8	98.8	99.2	114	98.5	98.6	100	96.6
pH	pH	8.2	8.3	8.2	8.2	8.1	7	8.2	8.1	8.2	8.1	8	8	8.1	8.2	8.1	8.1	8.3	8.2	8.1	8.2	8.1	8.2	8.1	8.1	8.17	8.12	8.16	8.11	8.14	7.89	8.08	8.12	8.13	8.09	8.05
Total Dissolved Solids (TDS)	mg/L	145	123	131	130	127	117	121	125	139	125	132	121	140	161	133	138	151	133	161	138	141	141	122	148	143	122	144	110	144	127	131	132	123	106	141
Total Suspended Solids (TSS)	mg/L	212	7.1	114	16	22	7.9	<3.0	36	10	125	594	30	771	715	1050	812	3200	154	264	462	1510	41	12	172	74.8	6.4	6.3	9.1	13.3	12.3	<3.0	28.9	16.8	5.2	15.4
Turbidity	NTU	118	4.4	44	11	8.2	3.3	0.7	11	7.7	43	139	14	410	634	525	346	2420	84	123	236	923	36	16	101	55.1	5.34	1.38	5.71	6.49	10	1.28	14.2	12.4	1.76	12.4
Anions and Nutrients																																				
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Ammonia (as N)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.006	<0.0050	<0.0050	0.0058	<0.0050	0.01	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (B)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.03	0.031	0.029	0.03	0.027	0.027	0.028	0.026	0.024	0.026	0.028	0.027	0.035	0.039	0.03	0.021	0.034	0.024	0.024	0.024	0.029	0.022	0.024	0.023	0.026	0.025	0.025	0.03	0.026	0.022	0.023	0.024	0.023	0.026	0.029
Nitrate (as N)	mg/L	0.027	0.0065	0.0072	0.0092	0.019	0.018	0.018	0.016	0.017	0.022	0.018	0.013	0.014	0.019	0.017	0.02	0.014	0.027	0.019	0.022	0.014	0.027	0.024	0.03	0.0254	0.023	0.0199	0.0298	0.0272	0.0184	0.0187	0.0149	0.0258	0.0157	0.0154
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0187	0.0149	0.0258	0.0157	0.0154
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.032	<0.030	<0.030	<0.030	<0.030	<0.030	0.03
Dissolved Orthophosphate (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0013	0.0012	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0014	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus (P)	mg/L	0.1	0.0034	0.022	0.0058	0.0058	0.0021	<0.0020	0.0023	0.0021	0.025	0.13	0.0029	0.14	0.032	0.51	0.43	3.5	0.071	0.22	0.12	1.1	0.044	0.01	0.15	0.0477	0.0032	0.0086	0.0046	0.0049	0.0119	0.0032	0.0033	0.0103	0.0024	0.01
Sulfate (SO_4)	mg/L	34	31	36	37	32	30	32	32	37	35	32	35	37	35	32	33	37	36	32	33	35	32	30	34	37	31.7	32.9	35.5	37.5	33.2	35.1	38.2	34.8	31.4	33.4
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.019	<0.019	<0.0016	<0.0016	<0.0016	<0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.018	<0.0015	<0.0015	<0.0015	<0.0015
Total Metals																																				
Aluminum (Al)-Total	mg/L	5.1	0.79	3.9	0.87	0.91	0.3	0.04	0.76	0.48	2.3	10	1.6	16	13	9.9	8.4	41	2.2	6.5	6.7	19	0.67	0.34	2.6	1.14	0.0913	2.45	0.169	0.246	0.272	0.0544	0.084	0.306	0.0585	0.407
Antimony (Sb)-Total	mg/L	0.0016	0.00098	0.00074	0.00081	0.00088	0.00082	0.00084	0.0008	0.00089	0.00075	0.00057	0.00082	0.00059	0.0034	0.0033	0.0022	0.0077	0.0021	0.0022	0.0022	0.0059	0.0016	0.0011	0.003	0.00214	0.00104	0.00322	0.001	0.00101	0.00103	0.00082	0.00093	0.0011	0.00093	0.0012
Arsenic (As)-Total	mg/L	0.032	0.0076	0.0084	0.0074	0.0087	0.0089	0.008	0.0086	0.0095	0.0082	0.01	0.0087	0.021	0.21	0.26	0.15	1.6	0.071	0.068	0.14	0.69	0.029	0.022	0.12	0.0571	0.0103	0.158	0.0118	0.013	0.0152	0.00964	0.0115	0.0155	0.0105	0.02
Barium (Ba)-Total	mg/L	0.1	0.022	0.042	0.026	0.027	0.021	0.02	0.025	0.026	0.035	0.17	0.051	0.18	0.33	0.45	0.25	2.7	0.13	0.13	0.2	1	0.049	0.035	0.17	0.0769	0.0226	0.18	0.0275	0.0282	0.029	0.0222	0.025	0.0313	0.0237	0.0372
Beryllium (Be)-Total	mg/L	0.00044	<0.00010	0.00073	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00026	0.0018	0.00017	0.0024	0.001	0.0016	0.0012	0.0049	0.00032	0.00038	0.0008	0.0029	<0.00010	<0.00010	0.00024	<0.00010	<0.00010	0.00032	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	0.000029
Bismuth(Bi)- Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	0.000079	0.00045	0.000052	0.00061	0.00026	0.00024	0.00032	0.00073	0.000052	0.000071	0.0002	0.00052	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000053	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	0.00024	0.000014	0.000037	0.000015	0.000018	0.000012	0.000012	0.000015	0.000015	0.000025	0.0001	0.000038	0.00021	0.0027	0.0015	0.00072	0.0055	0.00034	0.00022	0.0004	0.0035	0.00017	0.00008	0.00069	0.000344	0.0000204	0.00213	0.0000269	0.000031	0.0000484	0.0000128	0.0000235	0.0000386	0.0000147	0.0000618
Calcium (Ca)-Total	mg/L	41	27	34	32	29	26	26	28	33	33	57	34	65	47	56	52	192	34	32	43	103	33	30	33	31.6	32	36.3	30.3	29.3	29.5	35.1	31.4	29.9	30.6	30.4
Chromium (Cr)-Total	mg/L	0.0046	0.00027	0.0067	0.0011	0.00068	0.00019	0.00028	0.00088	0.0005	0.00094	0.008	0.022	0.0038	0.014	0.009	0.0066	0.099	0.002	0.0026	0.0039	0.03	0.00081	0.00047	0.004	0.00115	0.0102	0.0153	0.00557	0.00398	0.00376	0.00098	0.00394	0.00942	0.00157	0.00927
Cobalt (Co)-Total	mg/L	0.0016	<0.00010	0.00057	0.00016	0.00016	<0.00010	<0.00010	0.0001	<0.00010	0.00025	0.0013	0.00056	0.0021	0.0076	0.011	0.0069	0.08	0.0026	0.0029	0.0057	0.031	0.00082	0.00048	0.0044	0.00192	0.00039	0.00522	0.00035	0.00074	0.00058	<0.00010	0.0004	0.00128	0.00023	0.00101
Copper (Cu)-Total	mg/L	0.0074	<0.00050	0.018	0.0025	0.00053	<0.00050	<0.00050	<0.00050	<0.00050	0.002	0.0044	0.0016	0.0068	0.027	0.026	0.017	0.3	0.0062	0.0084	0.014	0.096	0.0022	0.0016	0.014	0.00452	0.00071	0.0217	0.00289	0.00162	0.00262	<0.00050	0.00153	0.00266	0.00126	0.00415
Iron (Fe)-Total	mg/L	5	0.18	1.3	0.33	0.34	0.092	<0.030	0.22	0.21	0.56	3	0.62	5.3	20	18	12	120	4.7	5.8	10	55	1.7	0.94	7.6	3.61	0.168	10.1	0.247	0.36	0.529	0.056	0.187	0.588	0.091	0.874
Lead (Pb)-Total	mg/L	0.0075	0.00045	0.003	0.00049	0.00061	0.00013	0.00007	0.00058	0.00049	0.0021	0.013	0.0014	0.017	0.04	0.029	0.018	0.16	0.0054	0.0062	0.011	0.069	0.0023	0.00097	0.0097	0.00501	0.000297	0.012	0.000676	0.000646	0.000978	0.00017	0.000516	0.000964	0.000206	0.00146
Lithium (Li)-Total	mg/L	0.011	0.0082	0.01	0.011	0.009	0.009	0.0082	0.0077	0.0074	0.0095	0.012	0.0094	0.014	0.015	0.018	0.015	0.058	0.011	0.011	0.011	0.027	0.01	0.0081	0.0099	0.0092	0.009	0.0108	0.0076	0.0083	0.0082	0.0086	0.0083	0.0087	0.0081	0.0087
Magnesium (Mg)-Total	mg/L	6.9	5	6.4	5.6	5.5	5.9	5.2	5.2	6.2	6.1	8.2	6	9.5	9.8	8.9	8.2	24	6.4	7.2	8	15	5.8	5.8	7.4	6.32	5.81	7.07	5.85	6.24	6.21	6.46	6.11	5.71	5.23	5.83
Manganese (Mn)-Total	mg/L	0.28	0.01	0.042	0.025	0.017	0.0049	0.0024	0.0082	0.013	0.026	0.17	0.026	0.29	2.6	2.8	1.3	16	0.72	0.55	1.2	6.4	0.21	0.11	1.1	0.434	0.0139	0.805	0.0345	0.0326	0.0565	0.00493	0.022	0.0474	0.00908	0.0848
Mercury (Hg)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000050	<0.0000050	0.000032	-	-	0.000025	0.000053	0.000018	0.00017	<0.000025	<0.000025	<0.00010	0.000099	<0.0000050	<0.0000050	<0.000025	<0.000025	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.0026	0.0016	0.002	0.0017	0.0014	0.0013	0.0013	0.0014	0.0013	0.0012	0.0016	0.004	0.0009	0.0025	0.0022	0.0015	0.014	0.0015	0.0017	0.0018	0.0021	0.0015	0.0013	0.0015	0.00144	0.00295	0.0023	0.00192	0.00175	0.00169	0.00131	0.00184	0.0025	0.00155	0.00244
Nickel (Ni)-Total	mg/L	0.0012	<0.00050	0.0042	0.00077	<0.00050	<0.00050	<0.00050	0.0006	<0.00050	0.00069	0.0057	0.014	0.0024	0.0046	0.0042	0.0027	0.026	0.001	0.0012	0.0022	0.011	<0.00050	<0.00050	0.0015	0.00066	0.00676	0.00736	0.00376	0.0025	0.00244	0.00061	0.0029	0.0047	0.00114	0.00636
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300	<0.050
Potassium (K)-Total	mg/L	1.9	0.61	0.99	0.59	0.56	0.49	0.43	0.52	0.54	0.69	1.9	0.64	2.5	3.8	3	2.4	8.3	1.1	2	1.8	4.2	0.73	0.57	1.4	0.974	0.489	1.18	0.509	0.568	0.522	0.45	0.53	0.619	0.495	0.639
Selenium (Se)-Total	mg/L	0.00023	0.00018	0.00019	0.00017	0.00016	0.00017	0.00018	0.00017	0.00022	0.0002	0.00018	0.00019	0.00026	0.00027	0.00026	0.00025	0.00074	0.00022	0.00019	0.00025	0.0004	0.0002	0.00018	0.00026	0.000234	0.000191	0.00025	0.000211	0.000218	0.000225	0.000221	0.000224	0.000188	0.000177	0.000183
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.46	2.71	2.04	2.28	2.54	2.17	2.65
Silver (Ag)-Total	mg/L	0.00022	0.000021	0.00021	0.000075	0.000022	<0.000010	<0.000010	0.000012	0.000035	0.000022	0.000036	0.000049	0.00019	0.0015	0.0014	0.0015	0.021	0.00022	0.00038	0.00073	0.0056	0.000092	0.00023	0.0005	0.000184	0.000019	0.00347	0.000034	0.000052	0.000068	<0.000010	0.00003	0.000312	0.000028	0.000192
Sodium (Na)-Total	mg/L	6	7	6.8	5.2	4.2	4.2	3.6	3.5	3.6	4	3.8	3.7	7.5	7	4.4	3.5	7.2	3.4	3.7	3.6	4.6	3.3	3.2	3.4	3.74	3.47	3.39	3.36	3.25	3.31	3.32	3.61	3.29	3.6	3.33
Strontium (Sr)-Total	mg/L	0.76	0.63	0.72	0.75	0.75	0.63	0.67	0.68	0.73	0.74	0.89	0.72	1.1	0.87	0.93	0.94	1.7	0.75	0.76	0.95	1.1	0.79	0.66	0.74	0.778	0.727	0.749	0.704	0.745	0.704	0.707	0.737	0.744	0.704	0.71
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.00013	<0.000010	0.000059	0.000014	0.000014	<0.000010	<0.000010	<0.000010	<0.000010	0.000033	0.00018	0.000022	0.00024	0.00077	0.00046	0.0003	0.0017	0.00011	0.00015	0.00019	0.00081	0.000063	0.000021	0.00018	0.000089	<0.000010	0.000092	<0.000010	<0.000010	0.000012	<0.000010	<0.000010	0.000012	<0.000010	0.000016
Tin (Sn)-Total	mg/L	0.00047	0.00029	0.00039	0.00012	<0.00010	<0.00010	<0.00010	<0.00010	0.00014	0.00015	0.00037	0.00026	0.00036	0.00047	0.00041	0.00027	0.002	0.00023	0.00051	0.001	0.0012	<0.00010	0.00026	0.0016	0.00034	<0.00010	0.00091	0.0002	0.00011	0.00017	<0.00010	<0.00010	0.00017	<0.00010	0.00026
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.00360
Uranium (U)-Total	mg/L	0.0012	0.00037	0.0011	0.00036	0.00032	0.0002	0.00018	0.00035	0.00027	0.00069	0.0038	0.00059	0.0049	0.0022	0.002	0.002	0.0058	0.00053	0.00087	0.0014	0.0038	0.00024	0.00017	0.00044	0.000275	0.000186	0.000532	0.000182	0.0002	0.000199	0.000181	0.000194	0.000207	0.00017	0.000206
Vanadium (V)-Total	mg/L	0.0048	<0.0010	0.0023	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	0.0012	0.0055	0.0011	0.0083	0.015	0.01	0.0078	0.051	0.0026	0.0064	0.0055	0.021	0.00099	0.00051	0.0034	0.00165	<0.00050	0.00349	<0.00050	<0.00050	0.0006	<0.00050	<0.00050	<0.00050	<0.00050	0.00078
Zinc (Zn)-Total	mg/L	0.034	<0.0030	0.014	0.0041	0.0041	<0.0030	<0.0030	0.0033	0.0047	0.0059	0.018	0.005	0.035	0.29	0.16	0.085	0.77	0.042	0.039	0.069	0.5	0.022	0.011	0.085	0.043	0.0036	0.0802	0.0061	0.0084	0.0072	0.0033	0.006	0.0075	0.0033	0.0098
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																				
Aluminum (Al)-Dissolved	mg/L	0.02	0.012	0.016	0.014	0.014	0.013	<0.0030	0.0055	0.014	0.029	0.0068	0.028	1.6	0.0042	1.1	0.007	0.015	0.033	0.0056	0.013	0.0069	0.0013	0.0028	0.0076	0.005	0.0021	0.0035	0.0031	0.0019	0.0019	0.0015	0.0044	0.0079	0.0014	0.0039
Antimony (Sb)-Dissolved	mg/L	0.0014	0.0009	0.00081	0.00085	0.00086	0.00086	0.00085	0.00078	0.00083	0.00085	0.00086	0.00081	0.00082	0.001	0.00097	0.00084	0.00087	0.00085	0.00082	0.00089	0.00087	0.00086	0.00082	0.00082	0.00082	0.00088	0.00087	0.0009	0.00086	0.00087	0.00095	0.00086	0.00085	0.00086	0.00089
Arsenic (As)-Dissolved	mg/L	0.0069	0.007	0.0069	0.0071	0.0078	0.0083	0.0083	0.0085	0.0083	0.0077	0.0075	0.0078	0.0082	0.0091	0.031	0.0097	0.025	0.0092	0.019	0.0089	0.0099	0.0084	0.0089	0.0089	0.0081	0.00793	0.00882	0.00837	0.00854	0.00905	0.00889	0.00832	0.00836	0.00905	0.00812
Barium (Ba)-Dissolved	mg/L	0.022	0.019	0.021	0.022	0.02	0.019	0.02	0.021	0.02	0.021	0.023	0.022	0.04	0.024	0.08	0.032	0.041	0.028	0.02	0.029	0.031	0.021	0.02	0.023	0.0245	0.0202	0.0215	0.0227	0.0224	0.0222	0.0232	0.0233	0.0243	0.0211	0.0211
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00014	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000020
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.000012	<0.000010	<0.000010	0.000011	<0.000010	<0.000010	0.00001	<0.000010	0.0000087	<0.000050

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-8B		Date																																		
		Jun 28, 2012	Sep 04, 2012	Jan 28, 2013	Apr 08, 2013	Jul 14, 2013	Sep 26, 2013	Aug 07, 2014	Nov 12, 2014	Mar 31, 2015	Sep 18, 2015	Jan 30, 2016	Mar 28, 2016	Jun 16, 2016	Sep 17, 2016	Dec 09, 2016	Apr 09, 2017	Jun 12, 2017	Oct 12, 2017	Dec 14, 2017	Mar 25, 2018	Jul 05, 2018	Sep 13, 2018	Dec 06, 2018	Apr 28, 2019	Jul 24, 2019	Oct 08, 2019	Dec 10, 2019	14-Jun-2020	07-Sep-2020	28-Jan-2021	Apr 22, 2021	May 27, 2021	Oct 17, 2021	Jan 27, 2022
ALS COA Sample ID		L1174115-2	L1207447-4	L1263921-9	L1288325-2	L1333226-5	L1370207-3	L1499651-2	L1546455-3	L1594284-5	L1676019-2	L1729910-2	L1750649-2	L1785971-2	L1831646-2	L1869371-3	L1911676-2	L1941960-1	L2007251-3	L2036305-2	L2072721-2	L2125409-2	L2164992-2	L2207927-1	L2265042-3	L2317986-2	L2364052-1	VA19A0481-003	VA20A8336-002	VA20B4636-002	VA21A1808-002	VA21A7683-003	VA21B0558-002	VA21C3094-004	VA22A1795-002
Field Parameters	**Unit**																																			
Temperature	°C	4.9	3.6	1	1.4	2.6	1.9	3.2	2.6	3.6	2.9	4.1	1	3.6	2.1	0.5	1.2	2.7	1.7	1.7	1	3.6	2	0	2	4.7	3.6	2.9	2.9	3.7	4.9	5.4	3.3	3.4	5.5
pH	pH	8.3	8.5	7.7	8.2	8.7	7.7	8.4	8.3	8.1	7.6	8.1	8.4	8.3	8.2	8	8.2	8.1	8.3	8.3	8.1	8	8	8.2	8.12	7.98	7.96	8.07	8.02	8.07	8.17	8.13	8.06	8.18	8.15
Specific conductance	µS/cm	131	242	211	240	188	213	210	196	222	198	206	215	233	207	215	219	210	215	214	220	211	210	193	220.9	204.8	208.3	206.6	214.7	212.5	211.6	213.2	216.2	207.6	212.1
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.57	4.29	4.43	4.8	2.97	2.04	2.62	4.76	1.93
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	148.7	76.5	169.9	68.7	142.5	107	47.3	56.4	23.5	132.6	108.5
Turbidity	NTU	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3286	-	2249	2830	-	1707	-	-	-	13.9	6.26	30	16.77	9.75	8.66	10.2	1.54	5.15	9.51
Physical Tests																																				
Conductivity	uS/cm	187	197	200	201	200	194	200	200	211	201	209	221	207	209	217	224	201	202	193	225	219	210	252	219	210	210	213	222	217	219	217	219	209	208
Acidity (as $CaCO_3$)	mg/L	<1.0	1	1.6	<1.0	2.4	<1.0	1.3	<1.0	-	-	-	-	<1.0	1.1	1.3	<1.0	2.1	2.1	1.4	1.1	1.8	1.4	1.6	1.4	1.4	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	55	73	73	68	68	70	63	71	72	69	64	79	72	76	79	106	109	107	78	116	71	102	103	78	72.9	70.1	70.3	69.7	70.6	69	72.9	69.6	71.1	70.1
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	101	94.5	110	103	101	93.5	102
Hardness (as $CaCO_3$), from	mg/L	64	91	98	100	94	91	94	94	103	99	107	120	103	101	139	101	98	91	95	106	100	100	120	109	96.1	97.9	102	112	102	100	102	106	102	99.1
pH	pH	8.3	8.3	8.2	8.2	8.1	8	8.1	8.1	8.1	8	7.9	8.1	8.1	8.1	8.1	7.8	8.1	8.1	8.1	8.2	8.1	8.1	8.2	8.15	8.12	8.06	8.12	8.13	7.99	8.12	7.98	7.99	8.09	8.02
Total Dissolved Solids (TDS)	mg/L	142	147	128	133	131	121	130	131	140	132	137	145	147	166	163	185	120	241	163	171	418	184	301	277	127	116	119	143	132	122	136	121	120	132
Total Suspended Solids (TSS)	mg/L	5340	984	193	281	182	17	26	5.3	182	30	11	1380	2030	1100	3610	1950	2670	1840	1460	3320	762	3640	879	1610	5.4	<3.0	159	145	<3.0	7.4	13.2	9.6	3.4	4.6
Turbidity	NTU	>4000	969	174	281	266	53	53	14	109	47	29	1550	2150	1060	>4000	2690	2880	3470	1750	>4000	757	90	1120	3140	3.19	1.47	38.4	11.1	4.84	7	7.14	3.74	1.96	3.16
Anions and Nutrients																																				
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Total Ammonia (as N)	mg/L	0.008	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0071	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.061	0.027	0.023	0.03	0.021	0.023	0.025	0.023	0.02	0.02	0.022	0.024	<0.020	0.023	<0.020	0.02	0.021	0.023	0.022	0.022	0.02	<0.020	0.028	0.024	0.022	0.024	0.027	0.025	<0.020	0.025	0.024	0.024	0.022	0.027
Nitrate (as N)	mg/L	<0.0050	<0.0050	0.015	0.018	0.022	0.02	0.019	0.022	0.021	0.019	0.015	0.013	0.023	0.02	0.021	0.018	0.031	0.023	0.022	0.022	0.029	0.033	0.038	0.0246	0.0271	0.0264	0.0371	0.0343	0.0196	0.0205	0.0155	0.0253	0.0169	0.0165
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0205	0.0155	0.0253	0.0169	0.0165
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.034	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Dissolved Orthophosphate (as P)	mg/L	0.0082	0.0012	<0.0010	<0.0010	<0.0010	<0.0010	0.0016	0.0015	<0.0010	0.0011	<0.0010	0.0012	0.002	0.0017	0.0013	0.0013	0.0018	0.0014	<0.0010	0.0011	0.001	0.0013	0.0023	<0.0010	0.0012	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	0.0018	<0.0010	<0.0010	<0.0010
Total Phosphorus (P)	mg/L	1.3	0.33	0.091	0.15	0.093	0.0096	0.018	0.0034	0.16	0.015	0.0098	0.43	1.3	1.2	1.8	1.9	1.7	2.1	0.98	2.3	0.73	2.4	0.63	1.2	0.0021	0.0031	0.0179	0.0284	0.0057	0.0066	0.0115	0.0079	0.0024	0.0063
Sulfate (SO_4)	mg/L	40	33	36	37	35	32	35	36	40	35	38	39	35	35	38	39	38	37	36	40	36	36	45	40.1	35.7	35.5	37.6	40.4	36.7	37.3	39.3	39.9	33.7	35.7
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.019	<0.019	<0.011	<0.0016	<0.0016	<0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.018	<0.010	<0.0015	<0.0015	<0.0015
Total Metals																																				
Aluminum (Al)-Total	mg/L	50	17	7	13	12	2.8	2.5	0.57	5.6	2.4	1.3	16	47	6.1	63	20	32	48	28	41	14	56	16	36	0.118	0.0694	1.13	0.63	0.122	0.411	0.473	0.173	0.0822	0.339
Antimony (Sb)-Total	mg/L	0.0025	0.0027	0.0018	0.0017	0.0018	0.00097	0.0011	0.00075	0.0023	0.001	0.00094	0.0046	0.0036	0.0019	0.006	0.0043	0.0051	0.0045	0.0053	0.0052	0.0046	0.005	0.0043	0.00515	0.00084	0.00081	0.00105	0.00101	0.00079	0.00081	0.0009	0.00088	0.00083	0.0009
Arsenic (As)-Total	mg/L	0.53	0.34	0.069	0.067	0.082	0.03	0.034	0.02	0.097	0.032	0.024	0.26	0.71	0.18	1.5	0.46	0.77	1.1	0.69	1.1	0.4	1.3	0.36	0.994	0.0136	0.0125	0.0235	0.026	0.0146	0.0158	0.0173	0.0172	0.015	0.0179
Barium (Ba)-Total	mg/L	0.91	0.49	0.16	0.19	0.28	0.079	0.074	0.028	0.14	0.077	0.046	0.64	1.1	0.46	1.9	0.55	1	1.2	0.75	1.3	0.43	1.6	0.47	1.19	0.0199	0.0175	0.0468	0.0514	0.0217	0.0279	0.032	0.032	0.0236	0.0309
Beryllium (Be)-Total	mg/L	0.0073	0.0016	0.00031	0.00028	0.00017	<0.00010	<0.00010	<0.00010	0.00037	<0.00010	<0.00010	0.00092	0.0055	0.0016	0.0061	0.0014	0.0023	0.0028	0.0015	0.0032	0.00073	0.0029	0.00078	0.00225	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	0.00002
Bismuth(Bi)- Total	mg/L	0.0016	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.000092	<0.000050	0.000091	0.00016	0.0014	<0.000050	0.0012	0.00017	0.00033	0.00047	0.00027	0.00053	0.00014	0.00048	0.00012	0.000299	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	0.0006	0.00018	0.00004	0.000042	0.000033	<0.000010	0.000015	<0.000010	0.000064	0.0000095	0.0000066	0.00042	0.00075	0.00047	0.0018	0.0004	0.0013	0.00091	0.00055	0.0013	0.00037	0.0014	0.00034	0.000762	<0.0000050	<0.0000050	0.0000084	0.0000286	<0.0000050	<0.0000050	0.0000062	0.0000089	<0.0000050	0.0000097
Calcium (Ca)-Total	mg/L	118	50	39	34	32	30	30	32	43	33	35	59	117	87	198	69	110	86	62	129	51	103	54	70.8	35.3	34.5	33.2	36.7	32.9	32.6	33.6	33.1	31	33.1
Chromium (Cr)-Total	mg/L	0.028	0.0068	0.016	0.014	0.0023	0.0008	0.0026	0.00058	0.0086	0.003	0.0038	0.01	0.028	0.004	0.06	0.013	0.032	0.04	0.02	0.039	0.014	0.056	0.014	0.0252	0.00383	0.00058	0.0077	0.00405	0.00574	0.00597	0.00717	0.00913	0.00182	0.00432
Cobalt (Co)-Total	mg/L	0.033	0.018	0.0033	0.0033	0.003	0.00056	0.0008	0.00013	0.0071	0.00077	0.00052	0.022	0.047	0.019	0.092	0.021	0.049	0.054	0.032	0.06	0.017	0.065	0.018	0.0602	0.0001	<0.00010	0.00082	0.00197	0.0002	0.00032	0.00051	0.00236	0.00027	0.00044
Copper (Cu)-Total	mg/L	0.1	0.036	0.0098	0.0091	0.0077	0.0018	0.0024	<0.00050	0.017	0.0025	0.0012	0.049	0.1	0.031	0.22	0.052	0.12	0.15	0.079	0.14	0.046	0.18	0.045	0.111	<0.00050	0.00052	0.00329	0.0039	0.00209	0.00063	0.00178	0.00208	0.00128	0.00118
Iron (Fe)-Total	mg/L	52	25	5.1	5.3	6.8	1.4	1.6	0.27	6.3	1.4	0.8	20	57	6.8	114	32	55	85	44	78	26	98	26	69.1	0.062	0.033	0.828	0.762	0.114	0.282	0.339	0.325	0.084	0.319
Lead (Pb)-Total	mg/L	0.07	0.02	0.0042	0.0039	0.0057	0.001	0.0016	0.0002	0.0065	0.0012	0.0006	0.015	0.083	0.017	0.14	0.024	0.063	0.08	0.043	0.075	0.025	0.099	0.024	0.0596	0.000175	<0.000050	0.000728	0.000904	0.000132	0.000406	0.000332	0.000367	0.000175	0.000347
Lithium (Li)-Total	mg/L	0.053	0.023	0.0096	0.0085	0.0096	0.0066	0.006	0.005	0.0071	0.0058	0.0062	0.018	0.053	0.016	0.093	0.031	0.053	0.064	0.036	0.059	0.022	0.077	0.025	0.0548	0.0067	0.0068	0.007	0.007	0.0067	0.0065	0.0068	0.0066	0.0064	0.0069
Magnesium (Mg)-Total	mg/L	19	10	5.3	5.7	4.8	4.1	3.9	3.5	5.1	4	4	8.5	24	6.3	35	13	18	26	16	23	10	29	11	19.3	4.48	3.99	4.74	4.94	4.84	4.52	4.68	4.56	3.92	4.63
Manganese (Mn)-Total	mg/L	3.2	2	0.29	0.29	0.33	0.061	0.091	0.012	0.46	0.076	0.044	2.7	5	2.7	11	2.5	5.7	5.6	3.5	7	1.9	7.5	2	7.39	0.00355	0.00259	0.094	0.156	0.00674	0.0219	0.04	0.0794	0.0227	0.0458
Mercury (Hg)-Total	mg/L	0.00048	0.00014	0.00004	<0.000010	0.000056	<0.000010	<0.000010	<0.000010	<0.000050	0.0000096	-	-	0.00024	0.0003	0.0006	0.00036	0.00031	0.00042	0.00018	0.00037	0.00014	0.00065	<0.00050	0.00031	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.0015	0.0017	0.0031	0.0031	0.0019	0.0016	0.0017	0.0017	0.002	0.0017	0.002	0.0026	0.0016	0.00072	0.0028	0.0019	0.0022	0.0029	0.0023	0.0021	0.0021	0.0024	0.0023	0.00167	0.00183	0.00136	0.00215	0.00157	0.00214	0.00189	0.00215	0.00224	0.0014	0.00169
Nickel (Ni)-Total	mg/L	0.021	0.007	0.0087	0.0089	0.0025	0.00051	0.0014	<0.00050	0.0058	0.0018	0.0025	0.008	0.023	0.005	0.04	0.0094	0.022	0.027	0.014	0.025	0.0083	0.033	0.0083	0.0211	0.00249	<0.00050	0.0044	0.00271	0.00376	0.00354	0.00488	0.00496	0.00117	0.00267
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300	<0.050
Potassium (K)-Total	mg/L	7.9	4.1	3.1	3.1	2.1	1.3	1.5	0.77	2	1.5	1.1	4.5	8.7	2.2	9.1	4.8	5.6	8.2	5.1	6.6	3.4	8.1	3.6	5.6	0.489	0.469	0.88	0.72	0.487	0.648	0.691	0.531	0.498	0.625
Selenium (Se)-Total	mg/L	0.00061	0.00039	0.00028	0.00027	0.00028	0.00022	0.00026	0.00024	0.00035	0.00038	0.00044	0.00042	0.0005	0.0003	0.00096	0.00038	0.00052	0.00062	0.00053	0.00057	0.00036	0.00062	0.00047	0.0005	0.00026	0.000271	0.000352	0.000301	0.000387	0.000362	0.000376	0.00029	0.000291	0.000312
Silicion (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.66	2.39	2.48	2.73	2.1	2.21	2.53
Silver (Ag)-Total	mg/L	0.0016	0.00046	0.00077	0.00089	0.00023	0.000036	0.000069	<0.000010	0.00041	0.000047	0.000047	0.0055	0.0022	0.0025	0.0088	0.0018	0.0044	0.006	0.0025	0.0051	0.0019	0.0068	0.0015	0.00267	<0.000010	<0.000010	0.000034	0.000026	<0.000010	0.000018	0.00002	0.000388	<0.000010	0.000018
Sodium (Na)-Total	mg/L	13	3.3	2.6	2.7	2.8	2.5	2.4	2.1	1.9	2	2.1	2.8	3	2.6	4.1	3	2.8	3.5	3.1	3.4	2.8	2.9	3	2.98	2.72	2.45	2.62	2.45	2.57	2.52	2.56	2.42	2.5	2.57
Strontium (Sr)-Total	mg/L	0.96	0.59	0.49	0.56	0.46	0.43	0.44	0.44	0.47	0.46	0.45	0.62	0.95	0.74	1.4	0.68	0.89	0.81	0.74	0.92	0.65	0.81	0.72	0.807	0.558	0.554	0.566	0.582	0.587	0.552	0.594	0.571	0.564	0.558
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.00091	0.0004	0.00017	0.00016	0.00012	0.000045	0.000061	0.000014	0.00014	0.000056	0.000039	0.0004	0.0011	0.00015	0.0015	0.00041	0.0007	0.00091	0.00057	0.0009	0.00035	0.0009	0.00034	0.00088	<0.000010	<0.000010	0.000032	0.000026	<0.000010	0.00001	<0.000010	0.00001	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	0.0013	0.00029	0.00065	0.00029	0.00034	<0.00010	0.00019	<0.00010	0.00086	<0.00010	<0.00010	0.0019	0.0015	0.00021	0.0011	0.00051	0.0007	0.00073	0.00061	0.0015	0.00062	0.00068	0.00055	0.00072	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.00450
Uranium (U)-Total	mg/L	0.012	0.0021	0.00052	0.0004	0.00023	0.00018	0.0002	0.00017	0.00078	0.00018	0.00018	0.0012	0.0076	0.0011	0.0057	0.0011	0.0019	0.0021	0.0011	0.0027	0.00067	0.0018	0.00062	0.00144	0.000176	0.000173	0.000195	0.000221	0.000173	0.000169	0.000188	0.000193	0.000158	0.000177
Vanadium (V)-Total	mg/L	0.049	0.024	0.011	0.012	0.0081	0.0033	0.0041	0.0011	0.0086	0.0038	0.0022	0.022	0.059	0.0094	0.088	0.03	0.049	0.075	0.041	0.059	0.023	0.081	0.024	0.0531	<0.00050	<0.00050	0.00174	0.00124	<0.00050	0.00075	0.00077	<0.00050	<0.00050	0.0008
Zinc (Zn)-Total	mg/L	0.36	0.088	0.031	0.027	0.034	0.0082	0.0097	<0.0030	0.046	0.0082	0.0052	0.12	0.32	0.078	0.64	0.15	0.34	0.46	0.23	0.41	0.13	0.51	0.13	0.293	<0.0030	<0.0030	0.0068	0.0088	<0.0030	0.0039	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																				
Aluminum (Al)-Dissolved	mg/L	2.1	0.05	0.017	3.6	0.035	0.031	0.011	0.0092	0.047	0.032	0.069	9.8	0.011	0.0033	0.0081	0.022	0.018	0.0061	0.039	0.0057	0.0053	0.14	0.0035	0.0025	0.0013	0.0012	0.0201	0.0012	0.0016	0.0018	0.0072	0.0013	0.0015	0.0023
Antimony (Sb)-Dissolved	mg/L	0.0015	0.00074	0.00072	0.00092	0.00067	0.00067	0.00069	0.00068	0.00076	0.00067	0.00069	0.0016	0.00076	0.00072	0.0011	0.00075	0.0008	0.00089	0.00081	0.0008	0.00081	0.0008	0.00094	0.00079	0.00082	0.00076	0.00078	0.00076	0.00079	0.00081	0.00078	0.00084	0.00078	0.0008
Arsenic (As)-Dissolved	mg/L	0.049	0.02	0.016	0.024	0.017	0.017	0.016	0.017	0.017	0.016	0.016	0.047	0.016	0.018	0.021	0.017	0.021	0.0094	0.015	0.016	0.016	0.02	0.017	0.0154	0.0129	0.0145	0.0136	0.0138	0.0137	0.013	0.0129	0.0136	0.014	0.0131
Barium (Ba)-Dissolved	mg/L	0.058	0.021	0.017	0.079	0.016	0.015	0.016	0.015	0.02	0.019	0.018	0.25	0.018	0.019	0.028	0.023	0.021	0.026	0.019	0.021	0.022	0.024	0.023	0.0209	0.0183	0.0197	0.0203	0.0208	0.0193	0.0206	0.022	0.0212	0.0204	0.0192
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.0002	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000020
Bismuth(Bi)- Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	0.000012	<0.000010	<0.000010	<0.000010	<0.000010	<0.0000050	<0.0000050	<0.0000050	0.000021	<0.000010	<0.000050	<0.000050	<0.000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	22	31	33	33	32	30	32	32	35	34	37	39	35	34	48	34	32	28	31	36	33	34	39	36.7	31.2	31.1	32.2	33	30.8	36.8	33.3	34.6	33.1	32.4
Chromium (Cr)-Dissolved	mg/L	0.0015	0.00016	<0.00010	0.0029	0.00013	<0.00010	0.00013	<0.00010	<0.00010	<0.00010	0.00022	0.0015	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00012	0.

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-9A		Date
		Jul 16, 2017
ALS COA Sample ID		L1959792-2
Field Parameters	**Unit**	
Temperature	°C	3.7
pH	pH	12.9
Specific conductance	µS/cm	>4000
Dissolved Oxygen	mg/L	-
Oxidation Reduction Potential	mV	-
Turbidity	NTU	-
Physical Tests		
Conductivity	uS/cm	7720
Acidity (as CaCO3)	mg/L	<1.0
Total Alkalinity (as $CaCO_3$)	mg/L	1700
Hardness (as $CaCO_3$), dissolved	mg/L	-
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	1740
pH	pH	12.5
Total Dissolved Solids (TDS)	mg/L	1550
Total Suspended Solids (TSS)	mg/L	138
Turbidity	NTU	111
Anions and Nutrients		
Kjeldahl nitrogen, total [TKN]	mg/L	-
Total Ammonia (as N)	mg/L	0.0896
Bromide (Br)	mg/L	-
Chloride (Cl)	mg/L	<25
Fluoride (F)	mg/L	<1.0
Nitrate (as N)	mg/L	<0.25
Nitrate + Nitrite (as N)	mg/L	-
Nitrite (as N)	mg/L	<0.050
Nitrogen, total	mg/L	-
Dissolved Orthophosphate (as P)	mg/L	<0.0010
Total Phosphorus (P)	mg/L	<0.30
Sulfate (as SO_4)	mg/L	<15
Sulfide (as H2S)	mg/L	-
Sulfide (as S)	mg/L	-
Total Metals		
Aluminum (Al)-Total	mg/L	1.75
Antimony (Sb)-Total	mg/L	0.00086
Arsenic (As)-Total	mg/L	0.0187
Barium (Ba)-Total	mg/L	0.795
Beryllium (Be)-Total	mg/L	<0.00050
Bismuth(Bi)- Total	mg/L	<0.00025
Boron (B)-Total	mg/L	-
Cadmium (Cd)-Total	mg/L	0.000196
Calcium (Ca)-Total	mg/L	746
Chromium (Cr)-Total	mg/L	0.0136
Cobalt (Co)-Total	mg/L	0.0014
Copper (Cu)-Total	mg/L	0.0112
Iron (Fe)-Total	mg/L	4.67
Lead (Pb)-Total	mg/L	0.00514
Lithium (Li)-Total	mg/L	0.041
Magnesium (Mg)-Total	mg/L	0.68
Manganese (Mn)-Total	mg/L	0.183
Mercury (Hg)-Total	mg/L	0.0000077
Molybdenum (Mo)-Total	mg/L	0.00492
Nickel (Ni)-Total	mg/L	0.0029
Phosphorus (P)-Total	mg/L	-
Potassium (K)-Total	mg/L	10.1
Selenium (Se)-Total	mg/L	<0.00025
Silicon (Si)-Total	mg/L	-
Silver (Ag)-Total	mg/L	0.000725
Sodium (Na)-Total	mg/L	13
Strontium (Sr)-Total	mg/L	0.985
Sulfur (S)-Total	mg/L	-
Thallium (Tl)-Total	mg/L	0.000059
Tin (Sn)-Total	mg/L	0.00316
Titanium (Ti)-Total	mg/L	-
Uranium (U)-Total	mg/L	0.000308
Vanadium (V)-Total	mg/L	0.0031
Zinc (Zn)-Total	mg/L	0.034
Zirconium (Zr)-Total	mg/L	-
Dissolved Metals		
Aluminum (Al)-Dissolved	mg/L	0.087
Antimony (Sb)-Dissolved	mg/L	<0.00050
Arsenic (As)-Dissolved	mg/L	<0.00050
Barium (Ba)-Dissolved	mg/L	0.677
Beryllium (Be)-Dissolved	mg/L	<0.00050
Bismuth(Bi)- Dissolved	mg/L	<0.00025
Boron (B)-Dissolved	mg/L	-
Cadmium (Cd)-Dissolved	mg/L	<0.000025
Calcium (Ca)-Dissolved	mg/L	698
Chromium (Cr)-Dissolved	mg/L	0.00668
Cobalt (Co)-Dissolved	mg/L	<0.00050
Copper (Cu)-Dissolved	mg/L	0.0034
Iron (Fe)-Dissolved	mg/L	<0.050
Lead (Pb)-Dissolved	mg/L	0.00069
Lithium (Li)-Dissolved	mg/L	0.0366
Magnesium (Mg)-Dissolved	mg/L	<0.10
Manganese (Mn)-Dissolved	mg/L	<0.00050
Mercury (Hg)-Dissolved	mg/L	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00424
Nickel (Ni)-Dissolved	mg/L	<0.0025
Phosphorus (P)-Dissolved	mg/L	-
Potassium (K)-Dissolved	mg/L	9.55
Selenium (Se)-Dissolved	mg/L	<0.00025
Silicon (Si)-Dissolved	mg/L	-
Silver (Ag)-Dissolved	mg/L	<0.000050
Sodium (Na)-Dissolved	mg/L	12.4
Strontium (Sr)-Dissolved	mg/L	0.817
Sulfur (S)-Dissolved	mg/L	-
Thallium (Tl)-Dissolved	mg/L	<0.000050
Tin (Sn)-Dissolved	mg/L	0.001
Titanium (Ti)-Dissolved	mg/L	-
Uranium (U)-Dissolved	mg/L	<0.000050
Vanadium (V)-Dissolved	mg/L	<0.0025
Zinc (Zn)-Dissolved	mg/L	0.0062
Zirconium (Zr)-Dissolved	mg/L	-
Aggregate Organics		
Chemical Oxygen Demand (COD)	mg/L	-

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-9B		Date								
		Jun 20, 2016	**Sep 12, 2016**	**Jun 18, 2017**	**Jun 07, 2018**	**May 29, 2019**	**Sep 18, 2019**	**17-Jun-2020**	**13-Oct-2020**	**17-Sep-21**
ALS COA Sample ID		L1787362-1	L1829454-1	L1945185-1	L2109387-1	L2283159-1	L2351836-1	VA20A8663-001	VA20B8101-001	VA21C0574-001
Field Parameters	**Unit**									
Temperature	°C	3.4	2.3	5	1.9	3.2	2.6	6.5	1.6	1.5
pH	pH	7.9	7.4	7.8	7.7	7.75	7.7	7.74	7.92	8.05
Specific conductance	µS/cm	324	306	322	314	317	286.5	244.3	254.4	231.5
Dissolved Oxygen	mg/L	-	-	-	-	-	5.57	4.56	6.14	8.66
Oxidation Reduction Potential	mV	-	-	-	-	163.8	197	92	175.5	132.2
Turbidity	NTU	-	-	13.6	63	55.8	40	9.8	94.61	66.52
Physical Tests										
Conductivity	uS/cm	257	297	320	317	326	295	249	240	234
Acidity (as CaCO3)	mg/L	1.7	1.3	2	<1.0	1	1.6	<2.0	2.1	3.2
Total Alkalinity (as $CaCO_3$)	mg/L	84	86	86	87	92.7	89.2	79.7	77	71.6
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	117	110	103
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	133	149	152	139	165	143	116	146	115
pH	pH	8.1	8.1	8.1	8.2	8.16	8.11	7.99	8.03	8.01
Total Dissolved Solids (TDS)	mg/L	178	207	217	209	211	197	170	154	129
Total Suspended Solids (TSS)	mg/L	148	11	22	87	123	99.2	<3.0	104	19.9
Turbidity	NTU	70	8.3	17	50	87.4	69.1	0.77	69.2	11.7
Anions and Nutrients										
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	<0.050	0.551	0.092
Total Ammonia (as N)	mg/L	<0.0050	<0.0050	<0.0050	0.0059	<0.0050	<0.0050	<0.0050	0.0112	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	<0.50	<0.50	<0.50	0.67	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.027	0.029	0.029	0.031	<0.040	0.036	0.033	0.038	0.028
Nitrate (as N)	mg/L	0.014	0.025	0.025	0.026	0.0418	0.0137	0.0144	0.0108	0.0153
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	0.0153
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.0027	0.0013	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	<0.030	0.562	0.107
Dissolved Orthophosphate (as P)	mg/L	<0.0010	<0.0010	<0.0010	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus (P)	mg/L	0.016	0.011	0.018	0.077	0.152	0.0662	<0.0020	0.0884	0.0228
Sulfate (as SO_4)	mg/L	50	71	79	70	74.8	61.1	46.6	48.2	40.4
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	<0.018	<0.019	<0.011
Sulfide (as S)	mg/L	-	-	-	-	-	-	<0.018	<0.018	<0.010
Total Metals										
Aluminum (Al)-Total	mg/L	0.85	0.089	0.37	2.3	1.62	1.22	0.036	4.03	0.321
Antimony (Sb)-Total	mg/L	0.0011	0.0012	0.0012	0.0016	0.00129	0.00167	0.00099	0.00102	0.00106
Arsenic (As)-Total	mg/L	0.004	0.0012	0.0024	0.013	0.0122	0.00715	0.00072	0.0062	0.00169
Barium (Ba)-Total	mg/L	0.069	0.033	0.042	0.16	0.0841	0.0775	0.0196	0.112	0.0337
Beryllium (Be)-Total	mg/L	<0.00010	<0.00010	<0.00010	0.00015	<0.00010	<0.00010	<0.000100	0.00028	<0.000100
Bismuth(Bi)- Total	mg/L	<0.000050	<0.000050	<0.000050	0.000061	<0.000050	<0.000050	<0.000050	0.000054	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	0.000079	0.000034	0.000052	0.00013	0.000124	0.00015	<0.0000100	0.000135	0.0000227
Calcium (Ca)-Total	mg/L	54	61	65	71	54.6	63.1	44.1	55.3	39.4
Chromium (Cr)-Total	mg/L	0.0012	0.00038	0.00057	0.0041	0.00322	0.00455	0.00155	0.00647	0.00392
Cobalt (Co)-Total	mg/L	0.00051	0.00018	0.00028	0.0015	0.0009	0.00107	0.0001	0.00181	0.00027
Copper (Cu)-Total	mg/L	0.0025	0.00086	0.0019	0.011	0.0143	0.00958	0.00133	0.0089	0.00269
Iron (Fe)-Total	mg/L	1.6	0.39	0.89	4.7	3.3	3.23	0.074	3.9	0.636
Lead (Pb)-Total	mg/L	0.0016	0.00053	0.00096	0.0065	0.00587	0.0119	0.000124	0.00684	0.000988
Lithium (Li)-Total	mg/L	0.0057	0.0055	0.0069	0.0075	0.006	0.0062	0.0046	0.0075	0.0036
Magnesium (Mg)-Total	mg/L	2.1	2.4	2.3	2.7	2.24	2.32	1.45	1.96	1.18
Manganese (Mn)-Total	mg/L	0.045	0.016	0.028	0.24	0.16	0.137	0.00393	0.173	0.0297
Mercury (Hg)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.000025	0.0000113	<0.0000050	<0.0000050	0.0000167	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.0027	0.0023	0.0022	0.0024	0.00192	0.0361	0.00296	0.00371	0.00322
Nickel (Ni)-Total	mg/L	0.00062	<0.00050	<0.00050	0.0023	0.00149	0.00191	0.00186	0.00213	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	1.2	0.93	1.1	1.5	1.47	1.44	0.848	2.04	0.866
Selenium (Se)-Total	mg/L	0.00098	0.0017	0.0015	0.00091	0.000746	0.00116	0.000586	0.000712	0.000622
Silicion (Si)-Total	mg/L	-	-	-	-	-	-	2.26	10.9	2.7
Silver (Ag)-Total	mg/L	0.00015	<0.000010	0.00034	0.00043	0.000301	0.000277	<0.000010	0.000248	0.000056
Sodium (Na)-Total	mg/L	2.1	2.4	2.5	2.6	3.28	2.99	1.83	3.93	1.59
Strontium (Sr)-Total	mg/L	0.42	0.34	0.41	0.53	0.339	0.401	0.268	0.348	0.249
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000033	<0.000010	0.000018	0.000066	0.000038	0.000043	<0.000010	0.000081	0.000013
Tin (Sn)-Total	mg/L	0.00039	0.00015	0.00034	0.0019	0.0015	0.00177	<0.00010	0.00184	0.00038
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	<0.0100	0.0782	<0.0100
Uranium (U)-Total	mg/L	0.00057	0.00065	0.00066	0.00086	0.000597	0.000731	0.000402	0.000753	0.000329
Vanadium (V)-Total	mg/L	0.0021	<0.00050	0.00098	0.0042	0.00282	0.00294	<0.00050	0.00492	0.00074
Zinc (Zn)-Total	mg/L	0.007	<0.0030	0.0057	0.1	0.0385	0.0227	<0.0030	0.0798	0.0076
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-
Dissolved Metals										
Aluminum (Al)-Dissolved	mg/L	0.0043	0.0047	0.003	0.0075	0.0103	0.0079	0.0032	0.0042	0.0071
Antimony (Sb)-Dissolved	mg/L	0.001	0.0012	0.001	0.00092	0.00084	0.0012	0.00097	0.0006	0.00082
Arsenic (As)-Dissolved	mg/L	0.00053	0.00044	0.00044	0.00053	0.00063	0.00061	0.00051	0.00074	0.00069
Barium (Ba)-Dissolved	mg/L	0.026	0.029	0.025	0.032	0.0285	0.0256	0.0187	0.0246	0.019
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	<0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.0000058	0.0000066	0.0000067	0.0000088	0.000012	<0.000040	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	50	56	57	53	63.1	54.1	44.6	41.8	44.3
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	0.00014	0.00111	0.00016	0.00015	0.00052
Cobalt (Co)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.00020	<0.00020	0.00041	0.00067	0.00374	0.0013	0.0007	0.00059	0.0006
Iron (Fe)-Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	0.000066	0.000058	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0046	0.0049	0.0055	0.0052	0.0055	0.0052	0.0045	0.004	0.0037
Magnesium (Mg)-Dissolved	mg/L	1.9	2.2	2	1.9	1.88	2.02	1.39	1.24	1.1
Manganese (Mn)-Dissolved	mg/L	0.00027	0.00056	0.0008	0.0048	0.00569	0.00156	0.00086	0.00354	0.00104
Mercury (Hg)-Dissolved	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.0024	0.0022	0.0021	0.002	0.00208	0.0342	0.00267	0.00328	0.00332
Nickel (Ni)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00104	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	0.9	0.93	0.96	1	1.2	1.12	0.849	0.894	0.75
Selenium (Se)-Dissolved	mg/L	0.0009	0.0017	0.0015	0.00072	0.000703	0.000933	0.000545	0.000596	0.000562
Silicion (Si)-Dissolved	mg/L	-	-	-	-	-	-	2.25	2.4	2.01
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	2	2.4	2.4	2.4	3.33	2.98	1.84	3.06	1.54
Strontium (Sr)-Dissolved	mg/L	0.32	0.33	0.35	0.36	0.363	0.321	0.27	0.263	0.23
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	0.00028	0.00033	0.00035	<0.00010	0.00054	0.00013
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	0.0005	0.00061	0.00057	0.00059	0.000502	0.000608	0.000373	0.000344	0.000308
Vanadium (V)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	<0.0010	<0.0010	0.0021	0.021	0.0066	0.0019	0.0018	0.0035	0.0016
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-
Aggregate Organics										
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-11A		Date																			
		Jul 19, 2016 11:15	Jul 19, 2016 17:30	Oct 10, 2016	Dec 17, 2016	Jul 13, 2017	Oct 28, 2017	Dec 12, 2017	Jun 25, 2018	Sep 30, 2018	Nov 25, 2018	Mar 09, 2019	Jun 02, 2019	Oct 19, 2019	Nov 21, 2019	31-May-2020	16-Oct-2020	30-Jan-2021	Apr 24, 2021	May 29, 2021	Oct 16, 2021
ALS COA Sample ID		**L1801880-1**	**L1842071-4**	L1871867-1	L1959234-1	L2015211-1	L2036155-1	L2036155-2	**L2119969-3**	L2175351-1	L2202265-1	L2243027-1	L2284783-1	L2369526-1	VA19A0099-001	VA20A7427-001	VA20B8506-001	VA21A1807-001	VA21A7804-003	VA21B0672-001	VA21C3093-001
Field Parameters	**Unit**																				
Temperature	°C	**7**	**16**	2.4	0.5	3.2	2.7	2	**2**	2.6	3.3	2.3	2.8	2.5	2.3	4	2	1.2	2.9	2.7	2.5
pH	pH	**9.5**	**9.5**	10	9.2	10	9.3	8.7	**12**	9.2	9.5	8.5	9.04	9.04	8.77	8.79	8.84	8.84	8.63	9.25	8.91
Specific conductance	µS/cm	**128**	**125**	171	-	109	182	202	**3150**	115	174	210.4	130	191.9	218.7	171.1	150.1	173.1	191.5	164.5	156.5
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	11.79	10.88	11.03	11.42	8.1	7.15	11.14	10.75
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-	-	200.8	155.5	104.4	132.3	236.6	69.6	220.9	134.9	178.9	135.9
Turbidity	NTU	-	-	-	-	35.4	835	-	**6.86**	96	-	23	7.46	1.3	9.15	7.5	71	18.34	26.4	8.58	0.92
Physical Tests																					
Conductivity	uS/cm	**134**	**130**	180	193	101	173	204	**671**	115	174	206	139	196	229	174	158	181	186	165	157
Acidity (as CaCO3)	mg/L	**<1.0**	**<1.0**	-	<1.0	<1.0	<1.0	<1.0	**<1.0**	<1.0	1.7	<1.0	1.1	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	**46**	**31**	22	41	29	43	40	**1400**	30	30	37.4	31.3	25.1	33	29.9	35.7	30.2	34.7	24.9	28.8
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71.5	62.9	70.1	92	74.3	68.8
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	**48**	**40**	62	79	38	71	86	**190**	48	70	88.5	50.3	90.5	100	76.9	92.8	89.5	79.3	70.2	70.4
pH	pH	**9.6**	**9.6**	7.8	8	8.8	8.6	8.4	**12**	8.6	7.9	7.99	8.19	8.29	7.89	7.66	8.16	8.29	8.03	7.54	7.94
Total Dissolved Solids (TDS)	mg/L	**96**	**86**	-	135	59	143	130	**424**	84	138	124	89	118	149	105	113	109	113	87	97
Total Suspended Solids (TSS)	mg/L	**1350**	**981**	130	144	19	227	67	**4680**	49	216	39.2	28.9	6.4	8.6	11.1	154	124	18.9	17.7	3.6
Turbidity	NTU	**1080**	**640**	82	100	13	190	52	**2830**	35	193	31.5	5.63	4.07	1.44	6.83	116	82.2	11.6	3.07	3.42
Anions and Nutrients																					
Kjeldahl nitrogen, total [TKN]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.053	<0.150	0.142	0.432	0.142	0.062
Total Ammonia (as N)	mg/L	**<0.0050**	**0.0054**	<0.0050	0.0057	<0.0050	<0.0050	<0.0050	**0.0063**	0.0056	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0083	0.0067	<0.0050	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	**<0.50**	**<0.50**	<0.50	0.93	<0.50	<0.50	<0.50	**<2.5**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	**0.024**	**0.034**	0.022	0.02	0.023	0.023	0.021	**<0.10**	0.024	0.021	<0.020	0.024	<0.020	0.022	0.023	0.022	0.025	0.023	0.026	0.02
Nitrate (as N)	mg/L	**0.025**	**0.038**	0.086	0.068	0.17	0.23	0.14	**0.16**	0.077	0.11	0.0477	0.188	0.071	0.142	0.211	0.0787	0.056	0.0481	0.216	0.0498
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.056	0.0481	0.216	0.0498
Nitrite (as N)	mg/L	**<0.0010**	**<0.0010**	<0.0010	0.0019	<0.0010	<0.0010	<0.0010	**<0.0050**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.264	0.223	0.198	0.48	0.358	0.112
Dissolved Orthophosphate (as P)	mg/L	**0.0028**	**0.0021**	-	<0.0010	0.0021	<0.0010	<0.0010	**<0.0010**	0.0023	0.002	0.0019	<0.0010	<0.0010	<0.0010	0.0026	0.0018	0.0034	<0.0010	<0.0010	0.0019
Total Phosphorus (P)	mg/L	**0.86**	**0.18**	0.11	0.15	0.022	0.16	0.027	**2.1**	0.047	0.13	0.0058	0.0278	0.0039	0.0127	0.0112	0.141	0.0633	0.0218	0.0208	0.0085
Sulfate (SO_4)	mg/L	**23**	**33**	56	58	19	57	62	**47**	28	49	63.6	32.3	69.5	72.5	50.1	41	53	53.6	49.2	43.6
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.019	<0.019	<0.0016	<0.011	<0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.018	<0.0015	<0.010	<0.0015
Total Metals																					
Aluminum (Al)-Total	mg/L	**20**	**24**	1	0.93	0.26	4.6	2.6	**75**	1.7	3.9	0.132	0.237	0.0697	0.0598	0.135	2.13	1.22	0.284	0.126	0.0465
Antimony (Sb)-Total	mg/L	**0.0078**	**0.0074**	0.0022	0.002	0.0014	0.0021	0.0016	**0.013**	0.0023	0.0071	0.00093	0.00102	0.00164	0.00126	0.00117	0.00235	0.00231	0.00154	0.00114	0.00089
Arsenic (As)-Total	mg/L	**0.17**	**0.22**	0.022	0.019	0.012	0.033	0.021	**0.29**	0.021	0.041	0.00801	0.00901	0.00915	0.0078	0.00829	0.0278	0.0206	0.0111	0.0086	0.00988
Barium (Ba)-Total	mg/L	**0.97**	**1.4**	0.099	0.086	0.035	0.29	0.14	**0.85**	0.085	0.22	0.0333	0.0481	0.0374	0.0394	0.0354	0.162	0.0953	0.0534	0.0398	0.0326
Beryllium (Be)-Total	mg/L	**0.00059**	**0.00067**	<0.00010	<0.00010	<0.00010	0.0001	<0.00010	**0.002**	<0.00010	0.00011	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	**0.00013**	**0.00011**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**0.001**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	**0.00054**	**0.00078**	0.000066	0.000037	0.00001	0.000077	0.000039	**0.00099**	0.000041	0.0001	0.0000101	0.0000108	0.0000059	0.000007	0.0000106	0.0000939	0.0000437	0.0000319	0.0000089	<0.0000050
Calcium (Ca)-Total	mg/L	**90**	**77**	27	35	15	32	41	**812**	20	30	27.8	19.7	31.3	32.9	25.7	30.7	28.9	30.1	24.3	23.1
Chromium (Cr)-Total	mg/L	**0.022**	**0.019**	0.0016	0.0031	0.00034	0.0026	0.0017	**0.15**	0.0013	0.0023	0.00021	0.00121	0.00085	0.00042	0.00032	0.00237	0.00495	0.00583	0.00258	0.00329
Cobalt (Co)-Total	mg/L	**0.014**	**0.017**	0.0021	0.00065	0.00013	0.0026	0.00066	**0.043**	0.0008	0.0039	<0.00010	0.00015	<0.00010	<0.00010	<0.00010	0.0015	0.00109	0.0003	<0.00010	<0.00010
Copper (Cu)-Total	mg/L	**0.089**	**0.076**	0.007	0.0057	0.0014	0.01	0.0056	**0.6**	0.0034	0.0085	0.00053	0.00279	0.00064	0.00094	0.00121	0.011	0.00621	0.00301	0.00176	0.0006
Iron (Fe)-Total	mg/L	**31**	**42**	1.6	1.1	0.35	5.7	1.5	**85**	1.7	5	0.095	0.293	0.047	0.086	0.162	3.2	1.83	0.407	0.147	0.049
Lead (Pb)-Total	mg/L	**0.032**	**0.057**	0.0041	0.0019	0.0006	0.0043	0.0018	**0.11**	0.0017	0.0057	0.000138	0.0006	0.000163	0.000305	0.000329	0.00389	0.00246	0.000959	0.000287	0.000184
Lithium (Li)-Total	mg/L	**0.021**	**0.03**	0.0073	0.004	0.003	0.0076	0.0036	**0.023**	0.0034	0.0054	0.0023	0.0034	0.003	0.0026	0.0026	0.0041	0.0067	0.0034	0.0029	0.0024
Magnesium (Mg)-Total	mg/L	**11**	**14**	3.5	3.4	1.5	5	4.6	**22**	2.9	4.5	3.86	2.49	3.91	4.37	3.09	3.89	4.22	4.1	3.3	2.7
Manganese (Mn)-Total	mg/L	**1.5**	**2.6**	0.23	0.078	0.011	0.28	0.077	**2.8**	0.1	0.31	0.00442	0.0108	0.00322	0.00416	0.00624	0.2	0.11	0.0238	0.00577	0.00293
Mercury (Hg)-Total	mg/L	**0.000059**	**<0.000050**	0.000014	0.0000054	<0.0000050	0.0000069	<0.0000050	**0.000025**	0.000009	<0.000050	<0.0000050	0.0000077	<0.0000050	<0.0000050	<0.0000050	0.0000185	0.0000063	0.0000064	0.0000064	<0.0000050
Molybdenum (Mo)-Total	mg/L	**0.0046**	**0.0049**	0.002	0.0017	0.0016	0.0018	0.0016	**0.031**	0.0021	0.0024	0.00102	0.00106	0.00201	0.00156	0.00141	0.00192	0.00276	0.00189	0.00158	0.00155
Nickel (Ni)-Total	mg/L	**0.013**	**0.012**	0.001	0.0012	<0.00050	0.0019	0.0015	**0.07**	0.00064	0.0016	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00188	0.00139	0.00086	<0.00050	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	**8.9**	**12**	1.9	1.3	0.73	3.6	2.1	**6.9**	1.7	2.4	0.549	0.832	0.69	0.626	0.6	1.81	2.06	1.02	0.806	0.641
Selenium (Se)-Total	mg/L	**0.0016**	**0.0016**	0.00048	0.00071	0.00017	0.00054	0.00056	**0.006**	0.00039	0.00058	0.000703	0.000318	0.000546	0.000492	0.000319	0.000445	0.000648	0.000462	0.000349	0.000361
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.89	5.09	3.72	2.22	1.72	1.73
Silver (Ag)-Total	mg/L	**0.013**	**0.02**	0.00019	0.00028	0.000075	0.0025	0.00058	**0.029**	0.00069	0.0014	0.000039	0.000145	0.000026	0.000115	0.000183	0.000861	0.000848	0.000156	0.000106	0.00002
Sodium (Na)-Total	mg/L	**6.3**	**8.8**	6.7	3.4	2.2	4.1	2.7	**3.1**	2.8	2.6	2.09	2.56	2.34	2.24	2.02	3.08	5.71	2.67	2.51	2.12
Strontium (Sr)-Total	mg/L	**0.79**	**0.93**	0.43	0.43	0.25	0.41	0.5	**0.76**	0.25	0.37	0.333	0.339	0.387	0.406	0.316	0.4	0.449	0.394	0.353	0.284
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	**0.00098**	**0.0013**	0.000064	0.000064	0.000015	0.00026	0.000098	**0.0012**	0.0001	0.00021	<0.000010	0.00001	<0.000010	<0.000010	<0.000010	0.000122	0.000081	0.000016	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	**0.0043**	**0.0021**	0.00012	0.0005	0.00045	0.0003	0.0015	**0.011**	0.00022	0.00022	<0.00010	0.00044	0.00026	0.00016	0.00039	0.00054	0.00077	0.00043	0.0003	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	0.0297	0.0172	<0.0100	<0.0100	<0.0100
Uranium (U)-Total	mg/L	**0.0021**	**0.0017**	0.00049	0.0004	0.000094	0.00051	0.00051	**0.0092**	0.00025	0.00042	0.000223	0.000117	0.0002	0.00022	0.000143	0.000339	0.000358	0.000338	0.000137	0.000173
Vanadium (V)-Total	mg/L	**0.039**	**0.047**	0.0018	0.0016	0.00053	0.0078	0.0044	**0.14**	0.0028	0.0062	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00344	0.00222	0.00054	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	**0.28**	**0.19**	0.019	0.021	0.0064	0.025	0.032	**2.3**	0.012	0.034	<0.0030	0.0058	<0.0030	0.0046	0.0035	0.0547	0.0214	0.0378	0.0051	0.0045
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																					
Aluminum (Al)-Dissolved	mg/L	**0.28**	**0.16**	0.069	0.039	0.04	0.065	0.021	**0.15**	0.021	0.026	0.0114	0.0291	0.0148	0.0203	0.0129	0.027	0.0248	0.0156	0.0216	0.0125
Antimony (Sb)-Dissolved	mg/L	**0.0034**	**0.003**	0.0017	0.0017	0.0012	0.0015	0.00096	**0.0017**	0.0015	0.002	0.00085	0.00094	0.00142	0.00128	0.00098	0.00164	0.00205	0.0012	0.00104	0.00084
Arsenic (As)-Dissolved	mg/L	**0.017**	**0.014**	0.011	0.0096	0.011	0.008	0.0081	**0.00059**	0.01	0.0092	0.00785	0.00699	0.00738	0.0063	0.00648	0.00845	0.0101	0.00648	0.00701	0.00889
Barium (Ba)-Dissolved	mg/L	**0.025**	**0.037**	0.03	0.027	0.024	0.038	0.032	**0.04**	0.015	0.025	0.0281	0.035	0.0313	0.0331	0.0233	0.0278	0.0326	0.0323	0.0348	0.0273
Beryllium (Be)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	**0.0000073**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000083	<0.0000050	0.0000054	<0.0000050	0.0000051	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	**16**	**12**	20	26	13	23	28	**75**	16	23	28.7	16.3	29.9	30.5	23.5	20.3	22.2	25.4	22.5	23.2
Chromium (Cr)-Dissolved	mg/L	**0.00023**	**0.00024**	0.00021	0.00019	0.00012	0.00019	0.00013	**0.0003**	0.00011	<0.00010	<0.00010	0.00032	0.0001	0.00019	<0.00010	0.00013	0.00024	<0.00050	0.00071	<0.00050
Cobalt (Co)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	**0.0002**	**0.00026**	<0.00020	0.00096	0.00035	0.0017	0.0012	**0.00041**	0.0005	<0.00020	<0.00020	0.00221	<0.00020	0.00112	<0.00020	0.00211	0.00087	0.00113	0.00056	0.00031
Iron (Fe)-Dissolved	mg/L	**<0.010**	**<0.010**	<0.010	<0.010	<0.010	<0.010	<0.010	**<0.010**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	**0.0061**	**0.0084**	0.0059	0.0037	0.0034	0.0039	0.0028	**0.0029**	0.0023	0.0026	0.0021	0.0035	0.0028	0.003	0.0025	0.0032	0.0064	0.0031	0.0028	0.0026
Magnesium (Mg)-Dissolved	mg/L	**2.1**	**2.2**	3.1	3.6	1.6	3.5	3.9	**0.41**	2.2	3.2	4.11	2.34	3.87	4.2	3.13	2.96	3.56	3.85	3.4	3.04
Manganese (Mn)-Dissolved	mg/L	**0.00033**	**0.0003**	0.00063	0.0014	0.00089	0.00067	0.00088	**<0.00020**	0.00027	0.0019	0.00018	0.00109	0.00063	0.0013	0.00051	0.00187	0.00125	0.0011	0.00087	0.0006
Mercury (Hg)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000052
Molybdenum (Mo)-Dissolved	mg/L	**0.0037**	**0.0037**	0.0023	0.0017	0.0015	0.0017	0.0013	**0.0073**	0.002	0.0021	0.000968	0.0011	0.00186	0.00141	0.00118	0.00216	0.00305	0.0018	0.00146	0.00159
Nickel (Ni)-Dissolved	mg/L	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	**1.4**	**2.1**	1.6	0.9	0.78	0.96	0.73	**0.76**	0.66	0.66	0.506	0.895	0.682	0.722	0.533	0.826	1.46	0.921	0.838	0.682
Selenium (Se)-Dissolved	mg/L	**0.00044**	**0.00035**	0.00036	0.00065	0.00019	0.00041	0.00043	**0.00078**	0.00028	0.00048	0.000761	0.000299	0.000405	0.000374	0.000303	0.000402	0.000566	0.000482	0.00033	0.000275
Silicion (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.52	1.56	2.16	1.81	1.55	1.52
Silver (Ag)-Dissolved	mg/L	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	**5.3**	**7.5**	6.3	3.7	2.5	3.7	2.5	**2.3**	2.4	2.5	2.2	2.8	2.34	2.61	1.86	3.02	6.24	2.62	2.6	2.12
Strontium (Sr)-Dissolved	mg/L	**0.33**	**0.45**	0.39	0.36	0.23	0.35	0.35	**0.28**	0.21	0.31	0.327	0.349	0.354	0.394	0.288	0.341	0.425	0.361	0.355	0.285
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	**0.000023**	**0.000026**	0.000017	0.000012	<0.000010	0.000012	<0.000010	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	0.0002	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	0.0002	<0.00010	0.00015	<0.00010	0.0002	0.00011	0.00011	0.00029	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	**0.000073**	**0.000094**	0.00029	0.00025	0.000073	0.00031	0.00028	**<0.000010**	0.00016	0.00026	0.000197	0.000102	0.000174	0.00022	0.000112	0.0002	0.000255	0.000304	0.000128	0.000173
Vanadium (V)-Dissolved	mg/L	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	**<0.0010**	**<0.0010**	<0.0010	<0.0010	0.0012	0.0058	0.0029	**0.0017**	0.0027	<0.0010	<0.0010	<0.0010	<0.0010	0.0026	<0.0010	0.0024	0.0012	0.0064	0.0019	0.001
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																					
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<20	<20	<20	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-11B		Date											
		Jun 21, 2016	**Sep 24, 2016**	**Jun 20, 2017**	**Sep 22, 2017**	**Jun 14, 2018**	**Sep 30, 2018**	**Nov 25, 2018**	**Jun 02, 2019**	**Oct 18, 2019**	**Nov 21, 2019**	**26-Jul-2020**	**14-Oct-2020**
ALS COA Sample ID		L1788755-1	**L1834821-2**	**L1946850-1**	**L1996612-3**	**L2113620-1**	L2175351-2	L2202265-2	L2284783-2	L2369526-2	VA19A0099-002	VA20B1263-001	VA20B8238-001
Field Parameters	**Unit**												
Temperature	°C	2.4	**2.6**	**2**	**2.3**	**2.5**	1.9	1.3	2.5	2	5.4	4.9	2
pH	pH	7.8	**7.9**	**7.6**	**8.3**	**7.7**	8	8.2	7.61	8.09	7.82	7.68	7.98
Specific conductance	µS/cm	407	**285**	**455**	**319**	**409**	276	347	434.7	273.6	303.4	309.8	255.4
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	3.63	1.07	0.33	3.99
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	182	96.3	16.1	-65.4	126.3
Turbidity	NTU	-	-	**194**	**955**	**178.6**	58.5	-	41.5	2.35	9.05	31.89	32.42
Physical Tests													
Conductivity	uS/cm	400	**286**	**461**	**306**	**401**	321	331	448	279	311	312	250
Acidity (as CaCO3)	mg/L	2	**1.7**	**1.5**	**1.7**	**2**	1.1	1.3	<1.0	<2.0	2.1	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	95	**120**	**113**	**91**	**107**	88	97	107	72.3	67.3	80.1	68.4
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	162	115
Hardness (as $CaCO_3$), from total	mg/L	206	**135**	**220**	**145**	**191**	146	159	194	140	150	153	123
pH	pH	8.1	**8**	**8.1**	**8.1**	**8.2**	8.2	8.1	8.1	8.18	8.04	8.01	8.02
Total Dissolved Solids (TDS)	mg/L	257	**200**	**342**	**241**	**256**	214	252	277	183	206	212	143
Total Suspended Solids (TSS)	mg/L	162	**833**	**892**	**798**	**1340**	101	228	51.3	34.2	13.8	66.7	17.4
Turbidity	NTU	85	**356**	**351**	**403**	**391**	62	99	25.3	20.1	5.32	28.9	10.4
Anions and Nutrients													
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050
Total Ammonia (as N)	mg/L	<0.0050	**<0.0050**	**<0.005**	**<0.0050**	**<0.0050**	<0.0050	0.0057	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	**<0.50**	**<0.50**	**<0.50**	**<0.50**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.037	**0.043**	**0.037**	**0.042**	**0.038**	0.042	0.043	0.042	0.038	0.047	0.047	0.039
Nitrate (as N)	mg/L	0.0077	**<0.0050**	**0.028**	**0.0092**	**0.013**	0.016	<0.0050	0.0088	0.0123	<0.0050	<0.0050	0.0072
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	<0.0010	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	<0.030	<0.030
Dissolved Orthophosphate (as P)	mg/L	<0.0010	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0021
Total Phosphorus (P)	mg/L	0.065	**0.43**	**0.44**	**0.43**	**0.23**	0.05	0.068	0.06	0.003	0.0061	0.0418	0.0031
Sulfate (SO_4)	mg/L	113	**69**	**131**	**80**	**110**	85	96	122	73.2	86.3	74.7	58.6
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	<0.019	<0.019
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018
Total Metals													
Aluminum (Al)-Total	mg/L	3.8	**9**	**8.1**	**6.8**	**10**	0.98	2.2	0.866	0.107	0.359	0.978	0.0714
Antimony (Sb)-Total	mg/L	0.0036	**0.014**	**0.0078**	**0.015**	**0.0025**	0.003	0.003	0.00296	0.00203	0.00188	0.00301	0.00172
Arsenic (As)-Total	mg/L	0.028	**0.19**	**0.18**	**0.24**	**0.032**	0.015	0.0091	0.00702	0.003	0.00689	0.0125	0.00258
Barium (Ba)-Total	mg/L	0.12	**0.71**	**0.84**	**0.65**	**0.2**	0.093	0.12	0.0686	0.0341	0.0342	0.0673	0.0194
Beryllium (Be)-Total	mg/L	0.00023	**0.0011**	**0.0016**	**0.0011**	**0.0019**	<0.00010	0.00029	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	0.000063	**0.00016**	**0.00039**	**0.00021**	**0.00057**	<0.000050	0.00011	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	0.000045	**0.00033**	**0.0027**	**0.00027**	**0.00014**	0.000069	0.0001	0.0000415	0.0000221	0.0000159	0.0000301	0.0000072
Calcium (Ca)-Total	mg/L	67	**70**	**117**	**61**	**110**	64	76	66.6	50.9	48.8	48.8	40.3
Chromium (Cr)-Total	mg/L	0.00089	**0.0052**	**0.0027**	**0.0032**	**0.0022**	0.0029	0.0025	0.0142	0.00086	0.00187	0.0134	<0.00010
Cobalt (Co)-Total	mg/L	0.0015	**0.0091**	**0.0087**	**0.011**	**0.003**	0.00091	0.00078	0.00056	<0.00010	0.00032	0.00079	<0.00010
Copper (Cu)-Total	mg/L	0.011	**0.078**	**0.085**	**0.078**	**0.016**	0.01	0.0087	0.0104	0.00197	0.00317	0.00832	0.00083
Iron (Fe)-Total	mg/L	3.5	**28**	**21**	**26**	**5.4**	1.7	1.4	1.37	0.143	0.675	1.45	0.139
Lead (Pb)-Total	mg/L	0.0053	**0.032**	**0.032**	**0.038**	**0.02**	0.0035	0.0044	0.00209	0.000296	0.000919	0.00202	0.00028
Lithium (Li)-Total	mg/L	0.013	**0.014**	**0.015**	**0.015**	**0.015**	0.01	0.012	0.0114	0.0086	0.0087	0.0093	0.0077
Magnesium (Mg)-Total	mg/L	9.7	**8.8**	**14**	**8.4**	**14**	7.6	8.7	10.3	6.19	6.8	7.51	5.51
Manganese (Mn)-Total	mg/L	0.16	**0.7**	**0.78**	**0.75**	**0.38**	0.19	0.16	0.0515	0.0223	0.0494	0.0606	0.018
Mercury (Hg)-Total	mg/L	0.000019	**0.000078**	**0.000023**	**0.000069**	**0.000031**	<0.000050	<0.000050	0.0000096	<0.0000050	<0.0000050	0.0000077	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00091	**0.0016**	**0.00097**	**0.0014**	**0.00047**	0.0013	0.0014	0.000773	0.00141	0.00162	0.0026	0.00162
Nickel (Ni)-Total	mg/L	0.00095	**0.0059**	**0.004**	**0.0048**	**0.0026**	0.0012	0.0017	0.00077	<0.00050	0.00171	0.0074	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300
Potassium (K)-Total	mg/L	2.6	**5.6**	**4.1**	**4.8**	**2.7**	1.4	1.6	1.54	1.02	1.1	1.45	0.903
Selenium (Se)-Total	mg/L	0.0014	**0.004**	**0.0031**	**0.0039**	**0.0022**	0.0013	0.0016	0.00187	0.000965	0.000848	0.0017	0.000856
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	4.18	1.88
Silver (Ag)-Total	mg/L	0.0025	**0.023**	**0.012**	**0.015**	**0.0023**	0.00084	0.0008	0.00162	0.000262	0.000305	0.000967	0.000083
Sodium (Na)-Total	mg/L	4.7	**4.5**	**4.9**	**4.5**	**4.7**	4	4.5	4.3	3.32	3.28	3.48	2.82
Strontium (Sr)-Total	mg/L	1.6	**1.4**	**2.2**	**1.4**	**1.9**	1.5	1.6	1.71	1.17	1.17	1.15	0.954
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.00015	**0.00054**	**0.00043**	**0.00052**	**0.00022**	0.000056	0.000089	0.000054	0.000022	0.000033	0.000062	0.000018
Tin (Sn)-Total	mg/L	0.00026	**0.00084**	**0.00037**	**0.00056**	**0.0006**	0.0022	0.0027	0.0011	0.00048	<0.00010	0.00016	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	0.0146	<0.0100
Uranium (U)-Total	mg/L	0.0011	**0.0015**	**0.0032**	**0.0019**	**0.004**	0.0006	0.001	0.000764	0.000322	0.000366	0.000446	0.000303
Vanadium (V)-Total	mg/L	0.0044	**0.013**	**0.0093**	**0.011**	**0.0057**	0.0013	0.0016	0.00116	<0.00050	<0.00050	0.00149	<0.00050
Zinc (Zn)-Total	mg/L	0.013	**0.081**	**0.072**	**0.085**	**0.032**	0.024	0.026	0.0151	0.0041	0.005	0.0098	<0.0030
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals													
Aluminum (Al)-Dissolved	mg/L	0.0031	**0.03**	**0.0016**	**0.01**	**0.001**	0.0044	0.0039	0.0044	0.0074	0.0037	0.002	0.0109
Antimony (Sb)-Dissolved	mg/L	0.0016	**0.0014**	**0.002**	**0.0015**	**0.0019**	0.0016	0.0014	0.00226	0.0018	0.00142	0.002	0.00153
Arsenic (As)-Dissolved	mg/L	0.001	**0.0024**	**0.00073**	**0.0012**	**0.00089**	0.0016	0.0015	0.00092	0.00195	0.00143	0.00169	0.00153
Barium (Ba)-Dissolved	mg/L	0.018	**0.026**	**0.022**	**0.021**	**0.021**	0.023	0.024	0.0254	0.0232	0.0148	0.0179	0.0165
Beryllium (Be)-Dissolved	mg/L	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.000050	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	<0.010	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.000011	**0.0000091**	**0.0000099**	**<0.0000050**	**<0.0000050**	0.0000082	0.0000085	0.0000124	0.0000124	0.0000061	<0.0000100	0.0000066
Calcium (Ca)-Dissolved	mg/L	68	**45**	**72**	**47**	**62**	47	51	61.6	45.9	45.3	52.7	37.3
Chromium (Cr)-Dissolved	mg/L	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	0.00016	0.00016	0.0006	0.00017	0.00025	0.00031	0.00012
Cobalt (Co)-Dissolved	mg/L	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00016	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.00020	**0.00024**	**<0.00020**	**<0.00020**	**<0.00020**	0.0015	0.0004	0.0014	0.00191	0.00041	0.00033	0.00041
Iron (Fe)-Dissolved	mg/L	<0.010	**0.028**	**<0.010**	**0.022**	**<0.010**	<0.010	<0.010	<0.010	<0.010	<0.010	0.013	0.011
Lead (Pb)-Dissolved	mg/L	<0.000050	**0.000077**	**<0.00005**	**0.00006**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000157
Lithium (Li)-Dissolved	mg/L	0.012	**0.0093**	**0.012**	**0.011**	**0.01**	0.0089	0.011	0.0101	0.0087	0.009	0.0082	0.0074
Magnesium (Mg)-Dissolved	mg/L	9.1	**5.5**	**10**	**6.8**	**8.8**	6.9	8.1	9.85	6.09	6.14	7.38	5.28
Manganese (Mn)-Dissolved	mg/L	0.031	**0.016**	**0.013**	**0.024**	**0.0067**	0.013	0.027	0.00506	0.0138	0.0273	0.0227	0.0143
Mercury (Hg)-Dissolved	mg/L	<0.0000050	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00077	**0.0012**	**0.00066**	**0.0011**	**0.00066**	0.0013	0.0013	0.000626	0.00143	0.00166	0.00219	0.00144
Nickel (Ni)-Dissolved	mg/L	<0.00050	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	0.00077	0.00337	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	1.2	**1.1**	**1.3**	**1.3**	**1.2**	1	1.2	1.23	1.06	0.877	1.05	0.844
Selenium (Se)-Dissolved	mg/L	0.0011	**0.00028**	**0.00096**	**0.00063**	**0.0013**	0.001	0.00038	0.00158	0.000882	0.000523	0.00083	0.00101
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	1.66	1.64
Silver (Ag)-Dissolved	mg/L	<0.000010	**0.000014**	**<0.00001**	**0.000028**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	4.7	**4.3**	**4.9**	**4.5**	**4**	3.7	4.4	4.31	3.38	3.1	3.71	2.85
Strontium (Sr)-Dissolved	mg/L	1.6	**1.1**	**1.8**	**1.2**	**1.6**	1.2	1.3	1.68	1.1	1.13	1.23	0.93
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	0.000017	**0.000013**	**0.000017**	**0.000022**	**0.000013**	0.000015	0.000024	0.000014	0.000019	0.000015	0.000014	0.000012
Tin (Sn)-Dissolved	mg/L	<0.00010	**<0.00010**	**<0.0001**	**<0.00010**	**<0.00010**	0.00015	0.00014	0.0002	0.00031	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	0.00076	**0.00039**	**0.00075**	**0.0005**	**0.00059**	0.0004	0.00046	0.000664	0.000316	0.000323	0.000354	0.000283
Vanadium (V)-Dissolved	mg/L	<0.00050	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.0011	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	0.0023	0.0044	0.0031	0.0021	0.0026	0.0028	0.0045
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics													
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-12A		Date							
		Sep 05, 2012	**Jul 15, 2013**	**Sep 30, 2013**	**Aug 04, 2014**	**Nov 13, 2014**	**Sep 14, 2015**	**Jun 18, 2016**	**Sep 19, 2016**
ALS COA Sample ID		**L1206550-1**	L1335562-1	L1372080-1	L1498408-3	L1547077-3	L1673255-2	L1786020-3	L1833162-1
Field Parameters	**Unit**								
Temperature	°C	**3**	2.5	1.3	4.4	0.6	2.3	2.8	2.5
pH	pH	**8.17**	8.41	8.5	7.52	-	7.75	7.49	7.23
Specific conductance	µS/cm	**252**	540	555	970	650	553	751	873
Dissolved Oxygen	mg/L	**-**	-	-	-	-	-	-	-
Oxidation Reduction Potential	mV	**-**	-	-	-	-	-	-	-
Turbidity	NTU	**-**	-	-	-	-	-	-	-
Physical Tests									
Conductivity	uS/cm	**455**	485	557	691	591	598	728	871
Acidity (as CaCO3)	mg/L	**2.3**	3.1	8	2.3	2.5	-	6.2	12.5
Total Alkalinity (as $CaCO_3$)	mg/L	**81.8**	98.8	109	118	129	112	119	152
Hardness (as $CaCO_3$), dissolved	mg/L	**-**	-	-	-	-	-	-	-
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	**220**	224	267	360	290	302	392	466
pH	pH	**8.14**	8.06	7.69	7.95	7.96	7.68	7.78	7.53
Total Dissolved Solids (TDS)	mg/L	**330**	338	400	497	421	416	547	681
Total Suspended Solids (TSS)	mg/L	**842**	183	488	203	74.1	25.9	15.4	163
Turbidity	NTU	**272**	2.4	164	66.4	22.3	14.5	10.5	70.6
Anions and Nutrients									
Kjeldahl nitrogen, total [TKN]	mg/L	**-**	-	-	-	-	-	-	-
Total Ammonia (as N)	mg/L	**0.125**	0.169	0.152	0.17	0.153	0.178	0.103	0.132
Bromide (Br)	mg/L	**-**	-	-	-	-	-	-	-
Chloride (Cl)	mg/L	**1.07**	1.05	0.71	<2.5	<0.50	<0.50	<2.5	<2.5
Fluoride (F)	mg/L	**0.204**	0.16	0.149	0.21	0.177	0.15	0.12	0.12
Nitrate (as N)	mg/L	**<0.0050**	<0.0050	0.0088	0.026	<0.0050	<0.0050	0.205	0.152
Nitrate + Nitrite (as N)	mg/L	**-**	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	**<0.0010**	<0.0010	<0.0010	<0.0050	<0.0010	0.0015	<0.0050	<0.0050
Nitrogen, total	mg/L	**-**	-	-	-	-	-	-	-
Dissolved Orthophosphate (as P)	mg/L	**<0.0010**	<0.0010	<0.0010	<0.0010	0.0018	<0.0010	<0.0010	<0.0010
Total Phosphorus (P)	mg/L	**0.46**	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Sulfate (as SO_4)	mg/L	**153**	159	195	265	214	207	272	343
Sulfide (as H2S)	mg/L	**-**	-	-	-	-	-	-	-
Sulfide (as S)	mg/L	**-**	-	-	-	-	-	-	-
Total Metals									
Aluminum (Al)-Total	mg/L	**5.93**	1.48	4.39	1.57	0.604	0.125	0.135	0.899
Antimony (Sb)-Total	mg/L	**0.00716**	0.00501	0.00318	0.0088	0.00454	0.00135	0.00453	0.00413
Arsenic (As)-Total	mg/L	**0.326**	0.192	0.0825	0.13	0.0646	0.0278	0.0134	0.112
Barium (Ba)-Total	mg/L	**0.641**	0.3	0.234	0.219	0.082	0.0757	0.0513	0.122
Beryllium (Be)-Total	mg/L	**0.00057**	<0.00010	0.0005	0.00011	<0.00010	<0.00010	<0.00010	0.00012
Bismuth(Bi)- Total	mg/L	**0.00056**	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	0.000053
Boron (B)-Total	mg/L	**-**	-	-	-	-	-	-	-
Cadmium (Cd)-Total	mg/L	**0.00108**	0.00029	0.000521	0.000615	0.000258	0.000114	0.000375	0.000489
Calcium (Ca)-Total	mg/L	**87.7**	74.5	95.3	118	93	99.2	129	157
Chromium (Cr)-Total	mg/L	**0.00853**	0.158	0.0285	0.0633	0.0201	0.00124	0.00103	0.00275
Cobalt (Co)-Total	mg/L	**0.00662**	0.0022	0.00255	0.00435	0.00107	0.00087	0.00133	0.00171
Copper (Cu)-Total	mg/L	**0.00662**	0.0022	0.00255	0.00435	0.00107	0.00087	0.00133	0.00171
Iron (Fe)-Total	mg/L	**0.0246**	0.0139	0.0155	0.0219	0.00751	0.00321	0.00631	0.0184
Lead (Pb)-Total	mg/L	**23.7**	8.02	5.36	7.36	1.64	0.404	0.726	3.46
Lithium (Li)-Total	mg/L	**0.00837**	0.0107	0.0156	0.0138	0.011	0.0103	0.0125	0.0183
Magnesium (Mg)-Total	mg/L	**11.5**	10.5	14	16.7	13	13.3	17.4	21.2
Manganese (Mn)-Total	mg/L	**0.554**	0.366	0.434	0.85	0.568	0.53	0.566	1.31
Mercury (Hg)-Total	mg/L	**0.000011**	<0.000010	0.000012	0.000011	<0.000010	<0.0000050	<0.0000050	0.0000096
Molybdenum (Mo)-Total	mg/L	**0.00385**	0.00524	0.00279	0.00358	0.00196	0.00118	0.00108	0.00197
Nickel (Ni)-Total	mg/L	**0.00419**	0.0592	0.013	0.0336	0.0085	0.00102	0.00209	0.00371
Phosphorus (P)-Total	mg/L	**-**	-	-	-	-	-	-	-
Potassium (K)-Total	mg/L	**7.68**	5.33	5.28	6.34	4.72	4.63	5.53	6.38
Selenium (Se)-Total	mg/L	**0.00241**	0.0007	0.00031	0.00071	0.00016	0.000055	0.000169	0.000231
Silicon (Si)-Total	mg/L	**-**	-	-	-	-	-	-	-
Silver (Ag)-Total	mg/L	**0.00464**	0.00165	0.000871	0.00478	0.00124	0.000216	0.000221	0.00128
Sodium (Na)-Total	mg/L	**5.7**	6.4	9.2	6.7	5.5	5.75	5.67	7.23
Strontium (Sr)-Total	mg/L	**1.24**	1.41	1.87	2.28	1.92	1.83	2.33	2.79
Sulfur (S)-Total	mg/L	**-**	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	**0.000782**	0.000146	0.000236	0.00102	0.000674	0.000327	0.000431	0.000664
Tin (Sn)-Total	mg/L	**0.00046**	0.00283	0.0014	0.00312	0.0013	0.00039	0.00076	0.0011
Titanium (Ti)-Total	mg/L	**-**	-	-	-	-	-	-	-
Uranium (U)-Total	mg/L	**0.00449**	0.000545	0.00164	0.00505	0.00306	0.00135	0.00189	0.00322
Vanadium (V)-Total	mg/L	**0.0042**	0.0024	0.0029	0.0025	<0.0010	<0.00050	<0.00050	0.00105
Zinc (Zn)-Total	mg/L	**0.171**	0.0474	0.0608	0.168	0.048	0.0252	0.106	0.0977
Zirconium (Zr)-Total	mg/L	**-**	-	-	-	-	-	-	-
Dissolved Metals									
Aluminum (Al)-Dissolved	mg/L	**0.0281**	0.0119	0.005	<0.0030	0.0142	0.0042	0.0024	<0.0010
Antimony (Sb)-Dissolved	mg/L	**0.00289**	0.00055	0.0013	0.00311	0.00263	0.0007	0.00381	0.00081
Arsenic (As)-Dissolved	mg/L	**0.0609**	0.00433	0.0252	0.0131	0.0268	0.0174	0.00227	0.0298
Barium (Ba)-Dissolved	mg/L	**0.0412**	0.0706	0.0398	0.0364	0.0369	0.0355	0.0262	0.0308
Beryllium (Be)-Dissolved	mg/L	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bismuth(Bi)- Dissolved	mg/L	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	**-**	-	-	-	-	-	-	-
Cadmium (Cd)-Dissolved	mg/L	**0.000156**	0.000039	<0.000010	0.000054	0.000034	<0.0000050	0.000291	0.0000848
Calcium (Ca)-Dissolved	mg/L	**72.1**	73.1	85.4	117	94.4	99.2	129	154
Chromium (Cr)-Dissolved	mg/L	**<0.00010**	0.00186	0.00012	<0.00010	0.00025	<0.00010	<0.00010	<0.00010
Cobalt (Co)-Dissolved	mg/L	**0.00067**	0.00072	0.00033	0.00167	0.00053	0.00078	0.00116	0.00119
Copper (Cu)-Dissolved	mg/L	**0.00097**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	0.00204	0.00222
Iron (Fe)-Dissolved	mg/L	**<0.030**	<0.030	<0.030	<0.030	<0.030	<0.010	0.264	0.281
Lead (Pb)-Dissolved	mg/L	**0.000053**	<0.000050	<0.000050	0.000085	0.000161	<0.000050	0.000058	<0.000050
Lithium (Li)-Dissolved	mg/L	**0.00638**	0.01	0.0131	0.0114	0.0105	0.0103	0.0122	0.0164
Magnesium (Mg)-Dissolved	mg/L	**9.83**	10.1	13	16.4	13.1	13.1	17.3	19.8
Manganese (Mn)-Dissolved	mg/L	**0.361**	0.314	0.344	0.832	0.52	0.517	0.539	1.21
Mercury (Hg)-Dissolved	mg/L	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	**0.0023**	0.00297	0.00212	0.00202	0.00162	0.00111	0.000961	0.00187
Nickel (Ni)-Dissolved	mg/L	**0.00091**	0.00716	0.00213	0.0035	0.00237	0.00054	0.00147	0.00186
Phosphorus (P)-Dissolved	mg/L	**-**	-	-	-	-	-	-	-
Potassium (K)-Dissolved	mg/L	**4.88**	4.53	4.47	5.55	4.65	4.62	5.32	6.14
Selenium (Se)-Dissolved	mg/L	**<0.00010**	0.0001	<0.00010	<0.00010	<0.00010	<0.000050	0.000165	<0.000050
Silicon (Si)-Dissolved	mg/L	**-**	-	-	-	-	-	-	-
Silver (Ag)-Dissolved	mg/L	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	**5.5**	6.2	9.2	5.8	5.5	5.58	5.57	7.12
Strontium (Sr)-Dissolved	mg/L	**1.08**	1.37	1.78	2.25	1.9	1.82	2.29	2.58
Sulfur (S)-Dissolved	mg/L	**-**	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	**0.000075**	0.000024	0.000018	0.000561	0.000572	0.000286	0.000407	0.000466
Tin (Sn)-Dissolved	mg/L	**<0.00010**	0.00018	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	**-**	-	-	-	-	-	-	-
Uranium (U)-Dissolved	mg/L	**0.00245**	0.000257	0.000364	0.00517	0.00283	0.00129	0.00175	0.00198
Vanadium (V)-Dissolved	mg/L	**<0.0010**	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	**0.0059**	0.0057	0.003	0.0514	0.0164	0.0095	0.0941	0.0509
Zirconium (Zr)-Dissolved	mg/L	**-**	-	-	-	-	-	-	-
Aggregate Organics									
Chemical Oxygen Demand (COD)	mg/L	**-**	-	-	-	-	-	-	-

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW12-12B		Date
		Jun 30, 2015
ALS COA Sample ID		L1636861-3
Field Parameters	**Unit**	
Temperature	°C	2.3
pH	pH	7.31
Specific conductance	µS/cm	712.4
Dissolved Oxygen	mg/L	-
Oxidation Reduction Potential	mV	-
Turbidity	NTU	-
Physical Tests		
Conductivity	uS/cm	789
Acidity (as CaCO3)	mg/L	-
Total Alkalinity (as $CaCO_3$)	mg/L	123
Hardness (as $CaCO_3$), dissolved	mg/L	-
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	438
pH	pH	7.6
Total Dissolved Solids (TDS)	mg/L	585
Total Suspended Solids (TSS)	mg/L	48.7
Turbidity	NTU	30.4
Anions and Nutrients		
Kjeldahl nitrogen, total [TKN]	mg/L	-
Total Ammonia (as N)	mg/L	0.142
Bromide (Br)	mg/L	-
Chloride (Cl)	mg/L	<1.0
Fluoride (F)	mg/L	0.102
Nitrate (as N)	mg/L	0.011
Nitrate + Nitrite (as N)	mg/L	-
Nitrite (as N)	mg/L	0.0026
Nitrogen, total	mg/L	-
Dissolved Orthophosphate (as P)	mg/L	<0.0010
Total Phosphorus (P)	mg/L	<0.30
Sulphate (SO_4)	mg/L	310
Sulfide (as H2S)	mg/L	-
Sulfide (as S)	mg/L	-
Total Metals		
Aluminum (Al)-Total	mg/L	0.167
Antimony (Sb)-Total	mg/L	0.00247
Arsenic (As)-Total	mg/L	0.0336
Barium (Ba)-Total	mg/L	0.0666
Beryllium (Be)-Total	mg/L	<0.00010
Bismuth(Bi)- Total	mg/L	<0.000050
Boron (B)-Total	mg/L	-
Cadmium (Cd)-Total	mg/L	0.000184
Calcium (Ca)-Total	mg/L	139
Chromium (Cr)-Total	mg/L	0.00187
Cobalt (Co)-Total	mg/L	0.00335
Copper (Cu)-Total	mg/L	0.0053
Iron (Fe)-Total	mg/L	1.54
Lead (Pb)-Total	mg/L	0.00378
Lithium (Li)-Total	mg/L	0.0138
Magnesium (Mg)-Total	mg/L	18.7
Manganese (Mn)-Total	mg/L	1.18
Mercury (Hg)-Total	mg/L	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00155
Nickel (Ni)-Total	mg/L	0.00425
Phosphorus (P)-Total	mg/L	-
Potassium (K)-Total	mg/L	5.8
Selenium (Se)-Total	mg/L	0.000107
Silicon (Si)-Total	mg/L	-
Silver (Ag)-Total	mg/L	0.000247
Sodium (Na)-Total	mg/L	6.41
Strontium (Sr)-Total	mg/L	2.45
Sulfur (S)-Total	mg/L	-
Thallium (Tl)-Total	mg/L	0.00051
Tin (Sn)-Total	mg/L	0.00094
Titanium (Ti)-Total	mg/L	-
Uranium (U)-Total	mg/L	0.00265
Vanadium (V)-Total	mg/L	<0.00050
Zinc (Zn)-Total	mg/L	0.149
Zirconium (Zr)-Total	mg/L	-
Dissolved Metals		
Aluminum (Al)-Dissolved	mg/L	0.0024
Antimony (Sb)-Dissolved	mg/L	0.00158
Arsenic (As)-Dissolved	mg/L	0.00404
Barium (Ba)-Dissolved	mg/L	0.0457
Beryllium (Be)-Dissolved	mg/L	<0.00010
Bismuth(Bi)- Dissolved	mg/L	<0.000050
Boron (B)-Dissolved	mg/L	-
Cadmium (Cd)-Dissolved	mg/L	0.000123
Calcium (Ca)-Dissolved	mg/L	144
Chromium (Cr)-Dissolved	mg/L	<0.00010
Cobalt (Co)-Dissolved	mg/L	0.00322
Copper (Cu)-Dissolved	mg/L	0.00168
Iron (Fe)-Dissolved	mg/L	<0.010
Lead (Pb)-Dissolved	mg/L	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0144
Magnesium (Mg)-Dissolved	mg/L	19
Manganese (Mn)-Dissolved	mg/L	1.17
Mercury (Hg)-Dissolved	mg/L	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00152
Nickel (Ni)-Dissolved	mg/L	0.00376
Phosphorus (P)-Dissolved	mg/L	-
Potassium (K)-Dissolved	mg/L	6.06
Selenium (Se)-Dissolved	mg/L	0.00005
Silicon (Si)-Dissolved	mg/L	-
Silver (Ag)-Dissolved	mg/L	<0.000010
Sodium (Na)-Dissolved	mg/L	6.58
Strontium (Sr)-Dissolved	mg/L	2.52
Sulfur (S)-Dissolved	mg/L	-
Thallium (Tl)-Dissolved	mg/L	0.000492
Tin (Sn)-Dissolved	mg/L	<0.00010
Titanium (Ti)-Dissolved	mg/L	-
Uranium (U)-Dissolved	mg/L	0.00266
Vanadium (V)-Dissolved	mg/L	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.131
Zirconium (Zr)-Dissolved	mg/L	-
Aggregate Organics		
Chemical Oxygen Demand (COD)	mg/L	-

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW14-14A		Date							
		Jun 26, 2016	**Sep 16, 2016**	**Jun 15, 2017**	**Jul 15, 2018**	**Sep 27, 2018**	**Sep 18, 2019**	**06-Sep-2020**	**Sep 14, 2021**
ALS COA Sample ID		**L1792221-1**	**L1830196-5**	**L1943975-1**	**L2131467-1**	**L2173270-3**	L2351836-2	VA20B4585-001	VA21C0110-003
Field Parameters	**Unit**								
Temperature	°C	**2.5**	**2.6**	**2.5**	**3**	**2.7**	2	5.4	2.4
pH	pH	**8.2**	**8**	**8.1**	**8.2**	**8.1**	8.13	8.12	8.2
Specific conductance	µS/cm	**266**	**265**	**271**	**264**	**235**	257.6	265	273.4
Dissolved Oxygen	mg/L	**-**	**-**	**-**	**-**	**-**	8.16	0.35	0.35
Oxidation Reduction Potential	mV	**-**	**-**	**-**	**-**	**-**	113.8	-109.6	-100.7
Turbidity	NTU	**-**	**-**	**2959**	**2135**	**758**	36.7	22.39	6.09
Physical Tests									
Conductivity	uS/cm	**263**	**272**	**257**	**262**	**252**	267	262	269
Acidity (as CaCO3)	mg/L	**<1.0**	**<1.0**	**<1.0**	**<1.1**	**<1.0**	<1.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	**93**	**98**	**114**	**112**	**92**	93.5	89.6	90.4
Hardness (as $CaCO_3$), dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	91.8	82.8
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	**84**	**84**	**78**	**88**	**85**	90.4	83.7	81.6
pH	pH	**8.2**	**8.2**	**8.1**	**8.3**	**8.1**	8.25	8.12	8.29
Total Dissolved Solids (TDS)	mg/L	**216**	**342**	**181**	**202**	**286**	180	157	170
Total Suspended Solids (TSS)	mg/L	**457**	**834**	**2230**	**2270**	**702**	77.6	53.7	9.2
Turbidity	NTU	**462**	**938**	**3180**	**2610**	**399**	37.4	12	2.27
Anions and Nutrients									
Kjeldahl nitrogen, total [TKN]	mg/L	**-**	**-**	**-**	**-**	**-**	-	0.124	<0.050
Total Ammonia (as N)	mg/L	**0.036**	**0.042**	**0.056**	**0.08**	**0.038**	0.0348	0.0453	0.0392
Bromide (Br)	mg/L	**-**	**-**	**-**	**-**	**-**	-	<0.050	<0.050
Chloride (Cl)	mg/L	**<0.50**	**<0.50**	**<0.50**	**<0.50**	**<0.50**	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	**0.12**	**0.12**	**0.12**	**0.12**	**0.13**	0.122	0.12	0.109
Nitrate (as N)	mg/L	**<0.0050**	**<0.0050**	**<0.0050**	**<0.0050**	**<0.0050**	<0.0050	<0.0050	<0.0050
Nitrate + Nitrite (as N)	mg/L	**-**	**-**	**-**	**-**	**-**	-	-	<0.0051
Nitrite (as N)	mg/L	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	**<0.0010**	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	**-**	**-**	**-**	**-**	**-**	-	0.125	0.045
Dissolved Orthophosphate (as P)	mg/L	**0.0055**	**0.0019**	**0.0013**	**0.0038**	**0.012**	<0.0010	0.0038	0.0033
Total Phosphorus (P)	mg/L	**0.3**	**0.38**	**0.66**	**0.99**	**0.28**	0.0477	0.0246	0.009
Sulfate (SO_4)	mg/L	**44**	**44**	**45**	**43**	**44**	44.4	45.4	45.2
Sulfide (as H2S)	mg/L	**-**	**-**	**-**	**-**	**-**	-	<0.019	0.0145
Sulfide (as S)	mg/L	**-**	**-**	**-**	**-**	**-**	-	<0.018	0.0136
Total Metals									
Aluminum (Al)-Total	mg/L	**11**	**22**	**28**	**27**	**12**	0.543	1.04	0.146
Antimony (Sb)-Total	mg/L	**0.0022**	**0.0037**	**0.0022**	**0.0022**	**0.0023**	0.00066	0.00034	0.0002
Arsenic (As)-Total	mg/L	**0.048**	**0.098**	**0.11**	**0.11**	**0.042**	0.00673	0.00561	0.00424
Barium (Ba)-Total	mg/L	**0.36**	**0.67**	**0.72**	**0.88**	**0.51**	0.048	0.0411	0.0254
Beryllium (Be)-Total	mg/L	**0.00078**	**0.0014**	**0.0031**	**0.0047**	**0.0012**	<0.00010	0.000118	<0.000100
Bismuth(Bi)- Total	mg/L	**0.00018**	**0.0003**	**0.00063**	**0.0013**	**0.00032**	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	**-**	**-**	**-**	**-**	**-**	-	0.081	0.087
Cadmium (Cd)-Total	mg/L	**0.000088**	**0.0001**	**0.00016**	**0.00043**	**0.00025**	0.000036	0.0000189	0.0000077
Calcium (Ca)-Total	mg/L	**35**	**42**	**50**	**64**	**36**	32.5	26.5	25.4
Chromium (Cr)-Total	mg/L	**0.0041**	**0.0062**	**0.009**	**0.016**	**0.0063**	0.00291	0.00772	0.00085
Cobalt (Co)-Total	mg/L	**0.0066**	**0.012**	**0.019**	**0.018**	**0.0071**	0.00043	0.00023	<0.00010
Copper (Cu)-Total	mg/L	**0.014**	**0.023**	**0.042**	**0.04**	**0.019**	0.00357	0.00194	<0.00050
Iron (Fe)-Total	mg/L	**16**	**28**	**43**	**52**	**20**	1.41	2.14	0.178
Lead (Pb)-Total	mg/L	**0.011**	**0.022**	**0.035**	**0.067**	**0.02**	0.00601	0.00506	0.000493
Lithium (Li)-Total	mg/L	**0.059**	**0.069**	**0.078**	**0.075**	**0.061**	0.0452	0.0501	0.0476
Magnesium (Mg)-Total	mg/L	**8.5**	**11**	**16**	**16**	**9.3**	5.02	4.28	4.7
Manganese (Mn)-Total	mg/L	**0.83**	**1.7**	**1.9**	**2.7**	**0.75**	0.12	0.108	0.0499
Mercury (Hg)-Total	mg/L	**0.000066**	**0.000095**	**0.00019**	**0.00017**	**<0.00010**	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	**0.0025**	**0.0032**	**0.0017**	**0.0027**	**0.0038**	0.00201	0.00253	0.0016
Nickel (Ni)-Total	mg/L	**0.0047**	**0.0074**	**0.011**	**0.012**	**0.0055**	0.00148	0.00067	<0.00050
Phosphorus (P)-Total	mg/L	**-**	**-**	**-**	**-**	**-**	-	<0.300	<0.300
Potassium (K)-Total	mg/L	**5.1**	**8.7**	**7.3**	**8.2**	**4.5**	1.67	1.84	1.56
Selenium (Se)-Total	mg/L	**0.00045**	**0.00071**	**0.0013**	**0.00096**	**0.00047**	<0.000050	<0.000050	<0.000050
Silicon (Si)-Total	mg/L	**-**	**-**	**-**	**-**	**-**	-	6.29	3.98
Silver (Ag)-Total	mg/L	**0.00072**	**0.0012**	**0.0024**	**0.0019**	**0.00069**	0.000084	0.000029	<0.000010
Sodium (Na)-Total	mg/L	**20**	**22**	**25**	**23**	**22**	20.5	23.4	22.1
Strontium (Sr)-Total	mg/L	**2.2**	**2.6**	**2.9**	**4**	**2.5**	2.24	2.5	2.49
Sulfur (S)-Total	mg/L	**-**	**-**	**-**	**-**	**-**	-	-	-
Thallium (Tl)-Total	mg/L	**0.00025**	**0.00048**	**0.00039**	**0.00054**	**0.00031**	0.00002	0.00003	0.000025
Tin (Sn)-Total	mg/L	**0.00045**	**0.00065**	**0.00032**	**0.00061**	**0.00039**	0.0004	0.00028	0.00011
Titanium (Ti)-Total	mg/L	**-**	**-**	**-**	**-**	**-**	-	0.0138	<0.0100
Uranium (U)-Total	mg/L	**0.0016**	**0.0026**	**0.0041**	**0.0097**	**0.0029**	0.000424	0.000583	0.000152
Vanadium (V)-Total	mg/L	**0.016**	**0.03**	**0.03**	**0.025**	**0.015**	0.00094	0.00092	<0.00050
Zinc (Zn)-Total	mg/L	**0.044**	**0.072**	**0.12**	**0.15**	**0.054**	0.0165	0.0065	<0.0030
Zirconium (Zr)-Total	mg/L	**-**	**-**	**-**	**-**	**-**	-	-	-
Dissolved Metals									
Aluminum (Al)-Dissolved	mg/L	**0.0033**	**0.086**	**0.0026**	**<0.0010**	**0.0026**	0.0067	0.0023	0.0025
Antimony (Sb)-Dissolved	mg/L	**0.0002**	**0.00029**	**0.00025**	**0.00036**	**0.00033**	0.00022	0.00014	0.00013
Arsenic (As)-Dissolved	mg/L	**0.0022**	**0.0024**	**0.0025**	**0.0017**	**0.0026**	0.00286	0.00375	0.004
Barium (Ba)-Dissolved	mg/L	**0.028**	**0.027**	**0.023**	**0.027**	**0.026**	0.0239	0.0233	0.0214
Beryllium (Be)-Dissolved	mg/L	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	0.077	0.077
Cadmium (Cd)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	**0.0000082**	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	**26**	**25**	**24**	**28**	**26**	28	28.2	25
Chromium (Cr)-Dissolved	mg/L	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	0.00015	<0.00010	<0.00050
Cobalt (Co)-Dissolved	mg/L	**0.00011**	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	**<0.00020**	**<0.00020**	**0.0024**	**0.00022**	**<0.00020**	0.00033	<0.00020	<0.00020
Iron (Fe)-Dissolved	mg/L	**<0.010**	**0.036**	**<0.010**	**<0.010**	**<0.010**	<0.010	0.025	0.029
Lead (Pb)-Dissolved	mg/L	**<0.000050**	**0.00005**	**0.00013**	**<0.000050**	**<0.000050**	0.000061	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	**0.049**	**0.047**	**0.047**	**0.047**	**0.048**	0.0434	0.0511	0.0471
Magnesium (Mg)-Dissolved	mg/L	**4.9**	**5**	**4.5**	**4.7**	**4.7**	4.95	5.19	4.65
Manganese (Mn)-Dissolved	mg/L	**0.058**	**0.046**	**0.06**	**0.058**	**0.068**	0.0479	0.0536	0.048
Mercury (Hg)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	**0.002**	**0.002**	**0.0019**	**0.0023**	**0.0018**	0.00192	0.00173	0.00156
Nickel (Ni)-Dissolved	mg/L	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	**1.6**	**1.6**	**1.4**	**1.5**	**1.6**	1.54	1.82	1.57
Selenium (Se)-Dissolved	mg/L	**<0.000050**	**<0.000050**	**<0.000050**	**0.000068**	**<0.000050**	<0.000050	<0.000050	<0.000050
Silicon (Si)-Dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	3.69	3.52
Silver (Ag)-Dissolved	mg/L	**<0.000010**	**<0.000010**	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	**20**	**19**	**25**	**21**	**21**	21.3	23.5	23.1
Strontium (Sr)-Dissolved	mg/L	**2**	**2**	**1.7**	**2**	**2.2**	2.19	2.54	2.44
Sulfur (S)-Dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	-	-
Thallium (Tl)-Dissolved	mg/L	**0.000012**	**0.000011**	**<0.000010**	**<0.000010**	**0.000022**	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	**0.0003**	**0.00023**	**0.00026**	**0.00032**	**0.00033**	0.000235	0.00015	0.00009
Vanadium (V)-Dissolved	mg/L	**<0.00050**	**<0.00050**	**<0.00050**	**<0.00050**	**0.00057**	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	**<0.0010**	**<0.0010**	**0.0015**	**<0.0010**	**<0.0010**	0.0012	0.0018	<0.0010
Zirconium (Zr)-Dissolved	mg/L	**-**	**-**	**-**	**-**	**-**	-	-	-
Aggregate Organics									
Chemical Oxygen Demand (COD)	mg/L	**-**	**-**	**-**	**-**	**-**	-	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW14-14B		Date											
		Jun 26, 2016	**Sep 15, 2016**	**Dec 14, 2016**	**Apr 23, 2017**	**Jun 14, 2017**	**Jul 08, 2018**	**Sep 27, 2018**	**Nov 26, 2018**	**Sep 18, 2019**	**29-Jul-2020**	**05-Sep-2020**	**29-Jul-2020**
ALS COA Sample ID		L1792221-2	**L1830196-3**	**L1871461-2**	**L1917088-1**	L1943976-1	L2126636-1	L2173270-5	L2202547-1	L2351836-3	VA20B1627-001	VA20B4588-001	VA20B1627-001
Field Parameters	**Unit**												
Temperature	°C	<1	**>10**	**0**	**2.1**	2	2.6	3	2	3.6	3.7	3.5	2.1
pH	pH	7.7	**7.6**	**8.3**	**7.8**	7.8	8	8	8	7.99	7.98	7.88	8.03
Specific conductance	µS/cm	153	**183**	**246**	**232**	211	178	194	235	224.4	230.1	228.6	234.1
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	4.54	3.69	0.29	0.34
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	-68.3	-106.3	-174.8	-150.6
Turbidity	NTU	-	-	-	**707**	33.6	43.4	49.2	-	0.2	0.3	8.1	3.32
Physical Tests													
Conductivity	uS/cm	155	**179**	**238**	**239**	198	166	214	224	231	233	223	230
Acidity (as CaCO3)	mg/L	1.9	**1.1**	**2.3**	**2.2**	1.1	1.8	1.6	1.7	1.7	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	47	**53**	**70**	**63**	56	49	59	62	60.1	61.3	59.6	56.9
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	102	105	94.8
Hardness (as $CaCO_3$), from total	mg/L	107	**103**	**95**	**97**	93	74	97	105	101	111	97.7	95.1
pH	pH	7.9	**8**	**7.6**	**8**	7.8	7.9	7.9	8	8.04	7.9	7.93	8.13
Total Dissolved Solids (TDS)	mg/L	97	**122**	**165**	**167**	129	108	138	141	162	147	160	156
Total Suspended Solids (TSS)	mg/L	183	**322**	**1880**	**837**	33	261	273	<3.0	<3.0	<3.0	<3.0	<3.0
Turbidity	NTU	138	**216**	**518**	**512**	26	102	70	1.5	1.51	1.56	1.94	0.99
Anions and Nutrients													
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050
Total Ammonia (as N)	mg/L	0.0079	**0.015**	**0.019**	**0.023**	0.0093	0.006	0.013	0.012	0.0118	0.015	0.0165	0.0166
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	**<0.50**	**<0.50**	**<0.50**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.037	**0.042**	**0.051**	**0.059**	0.048	0.044	0.06	0.065	0.071	0.071	0.068	0.061
Nitrate (as N)	mg/L	0.011	**0.036**	**0.037**	**<0.0050**	0.016	0.011	0.0091	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-		<0.0051
Nitrite (as N)	mg/L	<0.0010	**<0.0010**	**0.0025**	**<0.0010**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	<0.030	<0.030	<0.030
Dissolved Orthophosphate (as P)	mg/L	<0.0010	**<0.0010**	**0.0013**	**<0.0010**	<0.0010	<0.0010	0.0019	0.0011	<0.0010	<0.0010	0.0013	0.0016
Total Phosphorus (P)	mg/L	0.16	**0.28**	**2.4**	**1**	0.042	0.14	0.11	<0.0020	<0.0020	0.0023	0.0042	0.0034
Sulphate (SO_4)	mg/L	28	**34**	**51**	**55**	45	33	49	51	53.1	52.6	53.3	53.1
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	<0.019	<0.019	<0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.0015
Total Metals													
Aluminum (Al)-Total	mg/L	4.4	**2.3**	**38**	**15**	0.79	2.3	3.4	0.0043	0.0056	0.0042	0.0063	0.0048
Antimony (Sb)-Total	mg/L	0.0017	**0.00041**	**0.0067**	**0.0047**	0.00056	0.0016	0.0015	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Total	mg/L	0.014	**0.0082**	**0.15**	**0.063**	0.0061	0.03	0.037	0.0027	0.0031	0.00277	0.00309	0.00257
Barium (Ba)-Total	mg/L	0.15	**0.29**	**1.9**	**0.82**	0.065	0.14	0.23	0.027	0.0248	0.0277	0.0243	0.0243
Beryllium (Be)-Total	mg/L	0.00047	**0.00084**	**0.0065**	**0.0028**	0.00011	0.00032	0.00047	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	0.00016	**<0.000050**	**0.0012**	**0.00044**	<0.000050	0.00007	0.000082	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	0.00037	**0.00078**	**0.0071**	**0.0029**	0.00017	0.00041	0.00078	0.0000053	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L	26	**33**	**57**	**42**	34	29	39	35	40.1	40.5	35.8	34.2
Chromium (Cr)-Total	mg/L	0.0031	**0.00048**	**0.023**	**0.0067**	0.00044	0.0016	0.002	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Total	mg/L	0.0037	**0.0028**	**0.039**	**0.014**	0.00092	0.0024	0.0048	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	mg/L	0.015	**0.013**	**0.15**	**0.053**	0.0038	0.013	0.017	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)-Total	mg/L	8.1	**4.9**	**90**	**35**	1.8	8.3	13	0.19	0.243	0.233	0.256	0.164
Lead (Pb)-Total	mg/L	0.009	**0.011**	**0.097**	**0.035**	0.0017	0.0064	0.0092	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L	0.0073	**0.0052**	**0.045**	**0.018**	0.0038	0.0052	0.007	0.0034	0.0037	0.0037	0.0038	0.0034
Magnesium (Mg)-Total	mg/L	2.9	**2**	**12**	**6.1**	2.2	2.4	3.6	2.4	2.32	2.4	1.98	2.28
Manganese (Mn)-Total	mg/L	0.37	**0.46**	**3.4**	**1.5**	0.5	1.1	0.67	0.37	0.365	0.382	0.365	0.385
Mercury (Hg)-Total	mg/L	0.000072	**0.000065**	**0.00027**	**0.0002**	0.0000088	0.000031	0.0000089	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00071	**0.00013**	**0.0031**	**0.0023**	0.00028	0.0005	0.00058	0.00015	0.000152	0.000177	0.000163	0.000161
Nickel (Ni)-Total	mg/L	0.005	**0.0019**	**0.042**	**0.013**	0.0008	0.0023	0.0035	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	1.6	**0.85**	**6.3**	**3.4**	0.76	1	1.2	0.6	0.607	0.639	0.597	0.576
Selenium (Se)-Total	mg/L	0.00025	**<0.000050**	**0.002**	**0.001**	0.000073	0.00012	0.00046	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silicion (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	3.09	2.93	2.97
Silver (Ag)-Total	mg/L	0.00035	**0.000024**	**0.0037**	**0.0017**	0.000074	0.0002	0.00024	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	mg/L	3.2	**3**	**9.3**	**7.1**	3.3	3.4	4.9	4.4	4.46	4.67	4.66	4.16
Strontium (Sr)-Total	mg/L	0.18	**0.2**	**0.39**	**0.29**	0.21	0.18	0.25	0.22	0.222	0.241	0.229	0.219
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000079	**0.00007**	**0.00083**	**0.00037**	0.000023	0.000056	0.00013	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	0.00042	**0.0001**	**0.0039**	**0.0025**	0.00015	0.00053	0.0004	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100
Uranium (U)-Total	mg/L	0.00032	**0.00038**	**0.0036**	**0.0015**	0.000095	0.00026	0.00048	0.000026	0.000026	0.000023	0.000030	0.000022
Vanadium (V)-Total	mg/L	0.0076	**0.0014**	**0.057**	**0.019**	0.0012	0.0042	0.0079	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	0.049	**0.081**	**0.61**	**0.26**	0.012	0.035	0.048	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals													
Aluminum (Al)-Dissolved	mg/L	0.0029	**0.042**	**0.0072**	**0.01**	0.0055	0.0022	0.0039	0.0016	0.0022	0.0024	0.0024	0.0027
Antimony (Sb)-Dissolved	mg/L	0.00012	**0.00015**	**0.00027**	**0.00049**	0.00013	0.00013	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Arsenic (As)-Dissolved	mg/L	0.0018	**0.0016**	**0.0019**	**0.0015**	0.0014	0.0013	0.0027	0.0027	0.00318	0.00271	0.00326	0.00269
Barium (Ba)-Dissolved	mg/L	0.03	**0.033**	**0.03**	**0.028**	0.028	0.02	0.027	0.028	0.0267	0.0276	0.0245	0.0277
Beryllium (Be)-Dissolved	mg/L	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.000050	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	<0.010	0.022	<0.010
Cadmium (Cd)-Dissolved	mg/L	0.0000062	**0.00001**	**0.0000066**	**<0.0000050**	0.000012	0.0000085	0.0000058	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	39	**37**	**34**	**35**	33	27	35	38	36.4	37	38.4	34.4
Chromium (Cr)-Dissolved	mg/L	<0.00010	**0.00063**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	0.00015	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050
Cobalt (Co)-Dissolved	mg/L	<0.00010	**0.00012**	**0.00013**	**0.00017**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	<0.00020	**0.00026**	**<0.00020**	**0.0054**	<0.00020	0.00056	<0.00020	<0.00020	<0.00020	0.00209	<0.00020	0.00077
Iron (Fe)-Dissolved	mg/L	0.039	**0.094**	**<0.010**	**<0.010**	0.027	<0.010	0.14	0.17	0.234	0.154	0.207	0.142
Lead (Pb)-Dissolved	mg/L	<0.000050	**0.00016**	**<0.000050**	**0.00029**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000074	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0037	**0.004**	**0.0036**	**0.0033**	0.0032	0.0031	0.0036	0.0038	0.0034	0.0038	0.0036	0.0037
Magnesium (Mg)-Dissolved	mg/L	2.5	**2.4**	**2.3**	**2.2**	2.2	1.8	2.3	2.6	2.4	2.34	2.26	2.24
Manganese (Mn)-Dissolved	mg/L	0.33	**0.29**	**0.27**	**0.29**	0.28	0.21	0.36	0.38	0.361	0.38	0.358	0.37
Mercury (Hg)-Dissolved	mg/L	<0.0000050	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00017	**0.00028**	**0.0002**	**0.00021**	0.00014	0.0002	0.00016	0.00014	0.000164	0.000189	0.000159	0.000192
Nickel (Ni)-Dissolved	mg/L	<0.00050	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	0.61	**0.64**	**0.62**	**0.58**	0.58	0.51	0.62	0.67	0.635	0.653	0.604	0.598
Selenium (Se)-Dissolved	mg/L	<0.000050	**<0.000050**	**0.00011**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silicion (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	2.98	2.94	2.74
Silver (Ag)-Dissolved	mg/L	<0.000010	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	3.7	**3.4**	**3.8**	**3.8**	3.6	3.1	4.4	4.9	4.84	4.75	4.68	4.21
Strontium (Sr)-Dissolved	mg/L	0.23	**0.21**	**0.22**	**0.22**	0.2	0.17	0.23	0.22	0.222	0.227	0.244	0.211
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.000010	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00039	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	0.000036	**0.000037**	**0.000055**	**0.000053**	0.000027	0.000023	0.000033	0.000028	0.000025	0.000027	0.000025	0.000026
Vanadium (V)-Dissolved	mg/L	<0.00050	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	<0.0010	**0.0011**	**<0.0010**	**0.0036**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0025	0.0011	0.0029
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics													
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-17A		Date											
		Mar 31, 2019	**Jul 25, 2019**	**Sep 24, 2019**	**Dec 09, 2019**	**08-Apr-2020**	**19-Jul-2020**	**08-Oct-2020**	**24-Jan-2021**	**Apr 27, 2021**	**May 23, 2021**	**Oct 08, 2021**	**Jan 29, 2022**
ALS COA Sample ID		L2252178-1	L2318885-1	L2354404-1	VA19A0524-001	VA20A4687-001	VA20B0745-001	VA20B7855-001	VA21A1383-001	VA21A8275-002	VA21B0395-002	VA21C2526-002	VA22A1890-001
Field Parameters	**Unit**												
Temperature	°C	3.5	5.4	4.6	2.8	6.1	5.3	2.6	2.5	2	3.3	3.4	0.8
pH	pH	9.17	9.16	8.89	9.07	9.21	8.4	8.84	9.02	8.57	8.36	8.54	8.82
Specific conductance	µS/cm	871	834	779	822	886	599	644	770	701	673	594	694
Dissolved Oxygen	mg/L	-	-	0.09	0.46	3.29	0.21	0.33	0.93	0.65	0.39	0.42	8.4
Oxidation Reduction Potential	mV	-250.4	-226.6	-237.5	-217.8	-179.3	-225.1	-223.8	-156	-187.5	-178.5	-168.2	-65.7
Turbidity	NTU	2.77	13.5	0.18	9	5.9	34.1	9.67	6.67	4.64	3.1	5.81	151.2
Physical Tests													
Conductivity	uS/cm	928	854	841	830	886	627	623	754	688	676	581	667
Acidity (as CaCO3)	mg/L	<1.0	<1.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	146	130	170	149	117	141	118	108	135	124	124	122
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	11.9	144	133	49.5	129	147	146	96.9
Hardness (as $CaCO_3$), from total	mg/L	13.5	13.1	14.9	16.8	12.8	146	142	56	122	143	156	56.3
pH	pH	9.44	8.52	8.75	8.51	8.79	8.28	8.29	8.74	8.29	8.2	8.27	8.36
Total Dissolved Solids (TDS)	mg/L	576	597	550	533	562	408	380	482	436	426	355	485
Total Suspended Solids (TSS)	mg/L	14.8	4.5	<3.0	<3.0	<3.0	26.5	7.9	9.6	10.7	3.9	<3.0	126
Turbidity	NTU	7.23	1.37	4.37	3.08	0.41	42.7	3.56	4.6	3.95	2.74	1.41	140
Anions and Nutrients													
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	-	0.221	0.089	0.147	0.172	0.096	0.083	0.096	0.206
Total Ammonia (as N)	mg/L	0.149	0.131	0.0905	0.144	0.125	0.104	0.145	0.102	0.0824	0.105	0.0929	0.079
Bromide (Br)	mg/L	-	-	-	-	<0.250	<0.050	<0.050	<0.250	<0.250	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	5.5	6.7	5.5	5.46	7.03	2.41	2.22	4.39	4.84	4.86	1.82	3.29
Fluoride (F)	mg/L	<0.10	0.2	0.18	0.231	0.189	0.234	0.207	0.234	0.179	0.19	0.208	0.218
Nitrate (as N)	mg/L	0.155	<0.025	<0.025	<0.0250	<0.0250	0.0077	0.0952	<0.0250	<0.0250	0.127	0.177	<0.0050
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	<0.0255	<0.0255	0.178	0.218	<0.0051
Nitrite (as N)	mg/L	0.177	<0.0050	0.0055	0.0116	<0.0050	0.0371	0.068	0.0085	<0.0050	0.0512	0.0414	<0.0010
Total Nitrogen	mg/L	-	-	-	-	0.227	0.134	0.31	0.172	0.096	0.261	0.314	0.206
Dissolved Orthophosphate (as P)	mg/L	0.0293	<0.0010	0.0019	0.001	0.0088	0.0012	0.0016	0.0068	0.0024	0.0023	0.0017	0.0052
Total Phosphorus (P)	mg/L	0.0572	0.028	0.0183	0.0186	0.0262	0.0376	0.0122	0.0142	0.0086	0.0068	0.0042	0.154
Sulfate (SO_4)	mg/L	264	264	232	232	290	177	191	241	216	205	169	207
Sulfide (as H_2S)	mg/L	-	-	-	-	2.74	0.215	0.268	0.523	0.524	0.123	0.116	0.284
Sulfide (as S)	mg/L	-	-	-	-	2.58	0.202	0.252	0.492	0.493	0.116	0.109	0.267
Total Metals													
Aluminum (Al)-Total	mg/L	0.153	0.0844	0.0768	0.0869	0.0676	0.592	0.093	0.162	0.0528	0.0379	0.0276	3.25
Antimony (Sb)-Total	mg/L	0.0442	0.00571	0.00501	0.0119	0.00726	0.00545	0.00626	0.0211	0.0026	0.00475	0.00322	0.0156
Arsenic (As)-Total	mg/L	0.469	0.181	0.121	0.209	0.21	0.0462	0.038	0.182	0.0492	0.0374	0.0208	0.102
Barium (Ba)-Total	mg/L	0.0592	0.0343	0.0348	0.0319	0.0253	0.0755	0.0721	0.0629	0.0925	0.0588	0.0366	0.149
Beryllium (Be)-Total	mg/L	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000020	<0.000100	<0.000100	<0.000100	0.000077
Bismuth(Bi)- Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	0.07	0.06	0.052	0.073	0.057	0.056	0.046	0.062
Cadmium (Cd)-Total	mg/L	0.0000108	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000067	0.0000068	<0.0000050	<0.0000050	0.000028
Calcium (Ca)-Total	mg/L	8.47	5.9	6.22	6.14	4.67	55.9	54.4	21.2	48.6	56.2	56	34.2
Chromium (Cr)-Total	mg/L	0.00378	0.0003	0.00011	0.0002	0.00011	0.00041	0.00031	0.00024	<0.00050	<0.00050	<0.00050	0.0236
Cobalt (Co)-Total	mg/L	0.00014	<0.00010	<0.00010	<0.00010	0.00011	0.00011	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00078
Copper (Cu)-Total	mg/L	0.00219	<0.00050	<0.00050	0.0005	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00089	0.00052	0.00404
Iron (Fe)-Total	mg/L	0.117	0.029	0.021	0.031	0.013	0.591	0.118	0.05	0.044	0.1	0.019	3.62
Lead (Pb)-Total	mg/L	0.000568	0.000182	0.000336	0.000218	0.000082	0.000289	0.00011	0.000181	0.000102	0.000086	0.000076	0.00152
Lithium (Li)-Total	mg/L	0.461	0.474	0.484	0.477	0.438	0.22	0.218	0.359	0.248	0.221	0.168	0.303
Magnesium (Mg)-Total	mg/L	0.27	0.33	0.39	0.366	0.266	1.61	1.63	0.741	1.87	1.58	1.44	2.79
Manganese (Mn)-Total	mg/L	0.0156	0.0108	0.0124	0.00989	0.00679	0.074	0.0432	0.0233	0.055	0.0401	0.0175	0.182
Mercury (Hg)-Total	mg/L	<0.000025	0.0000052	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00447	0.00293	0.0027	0.00238	0.00355	0.00131	0.00128	0.00302	0.00157	0.00115	0.000659	0.00194
Nickel (Ni)-Total	mg/L	0.00226	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00193	<0.00050	0.00262
Phosphorus (P)-Total	mg/L	-	-	-	-	<0.300	<0.300	<0.300	<0.050	<0.300	<0.300	<0.300	0.175
Potassium (K)-Total	mg/L	3.7	1.81	1.82	1.67	1.57	1.7	2.26	1.73	1.78	1.48	1.82	2.47
Selenium (Se)-Total	mg/L	0.000154	0.000082	0.000088	0.000096	<0.000050	0.000136	0.000197	0.000187	<0.000050	0.000258	0.000206	0.000125
Silicon (Si)-Total	mg/L	-	-	-	-	3.43	3.57	3.02	3.13	2.97	2.78	2.76	6.99
Silver (Ag)-Total	mg/L	0.00004	<0.000010	0.000017	0.00001	<0.000010	0.000068	<0.000010	0.00001	<0.000010	<0.000010	<0.000010	0.00101
Sodium (Na)-Total	mg/L	195	184	184	183	183	83.6	85.1	138	103	95.2	72.8	131
Strontium (Sr)-Total	mg/L	0.383	0.378	0.435	0.408	0.382	1.18	1.19	0.824	1.66	1.3	0.869	1.12
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	85.7				77.6
Thallium (Tl)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000054
Tin (Sn)-Total	mg/L	0.00144	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00044
Titanium (Ti)-Total	mg/L	-	-	-	-	<0.0100	<0.0100	<0.0100	0.00122	<0.0100	<0.0100	<0.0100	0.0479
Uranium (U)-Total	mg/L	0.00018	0.000167	0.00028	0.000269	0.000153	0.000229	0.000206	0.000221	0.000206	0.00017	0.000199	0.000235
Vanadium (V)-Total	mg/L	0.00051	<0.00050	<0.00050	<0.00050	<0.00050	0.00056	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00266
Zinc (Zn)-Total	mg/L	0.0107	0.0059	<0.0030	<0.0030	<0.0030	0.007	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0303
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	0.00068				
Dissolved Metals													
Aluminum (Al)-Dissolved	mg/L	0.0613	0.0498	0.0519	0.0376	0.0475	0.0382	0.0074	0.0413	0.0092	0.021	0.0156	0.0182
Antimony (Sb)-Dissolved	mg/L	0.0448	0.00296	0.00423	0.00424	0.00512	0.00498	0.00649	0.0181	0.00125	0.00446	0.00298	0.00728
Arsenic (As)-Dissolved	mg/L	0.453	0.129	0.123	0.135	0.165	0.0505	0.0372	0.167	0.0411	0.0358	0.02	0.0704
Barium (Ba)-Dissolved	mg/L	0.0372	0.0291	0.0299	0.0295	0.024	0.0671	0.0617	0.0544	0.0845	0.0541	0.0375	0.0425
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000020	<0.000100	<0.000100	<0.000100	<0.000020
Bismuth(Bi)- Dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	0.071	0.052	0.05	0.065	0.056	0.053	0.045	0.058
Cadmium (Cd)-Dissolved	mg/L	<0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.000006	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	5.02	4.73	5.33	5.82	4.33	55	50.6	18.5	45.8	54.7	59.8	21
Chromium (Cr)-Dissolved	mg/L	0.00077	0.00018	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00050	<0.00050	<0.00050	0.00027
Cobalt (Co)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	0.00139	<0.00020	<0.00020	<0.00020	0.00027	<0.00020	<0.00020	0.00038	<0.00020	0.00042	0.00025	<0.00020
Iron (Fe)-Dissolved	mg/L	0.016	0.016	0.013	0.017	0.015	0.097	0.013	0.015	0.015	0.045	<0.010	0.01
Lead (Pb)-Dissolved	mg/L	0.000228	0.000089	0.000163	0.000088	0.000052	<0.000050	<0.000050	0.000138	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.509	0.396	0.435	0.441	0.458	0.246	0.2	0.345	0.243	0.223	0.179	0.299
Magnesium (Mg)-Dissolved	mg/L	0.23	0.31	0.38	0.356	0.26	1.6	1.68	0.811	1.78	1.6	1.52	0.936
Manganese (Mn)-Dissolved	mg/L	0.00581	0.00889	0.0116	0.00858	0.00595	0.053	0.0369	0.0224	0.0535	0.0391	0.0178	0.0102
Mercury (Hg)-Dissolved	mg/L	<0.0000050	<0.0000050	<0.0000050	0.0000055	<0.0000050	<0.0000050	<0.0000050	<0.0000050		<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00414	0.00191	0.00255	0.00145	0.0019	0.00133	0.00124	0.00278	0.00157	0.00111	0.000639	0.00165
Nickel (Ni)-Dissolved	mg/L	0.0006	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	<0.300	<0.300	<0.300	<0.050	<0.300	<0.300	<0.300	<0.050
Potassium (K)-Dissolved	mg/L	3.51	1.8	1.74	1.68	1.55	1.84	2.3	1.82	1.88	1.48	1.81	1.84
Selenium (Se)-Dissolved	mg/L	0.000462	0.00326	0.00197	0.0014	0.000537	0.00124	0.000511	0.00212	0.000293	0.000224	0.000169	0.000788
Silicon (Si)-Dissolved	mg/L	-	-	-	-	3.25	2.74	2.74	3.17	2.83	2.66	2.71	2.9
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	188	162	185	172	183	96.6	89.1	150	107	93.5	77.3	118
Strontium (Sr)-Dissolved	mg/L	0.337	0.335	0.396	0.398	0.345	1.31	1.18	0.845	1.80	1.25	0.946	1
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	97.7				76.3
Thallium (Tl)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	0.00091	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00159	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.00030	<0.0100	<0.0100	<0.0100	<0.00030
Uranium (U)-Dissolved	mg/L	0.000183	0.000173	0.00026	0.000271	0.000153	0.000213	0.000184	0.000224	0.000217	0.00017	0.000185	0.000181
Vanadium (V)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.0052	0.0028	<0.0010	<0.0010	0.0036	0.0014	0.0015	0.0051	0.0026	<0.0010	<0.0010	<0.0010
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	<0.00020			0.0015	
Aggregate Organics													
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	<20	<20	<20	<20	<20	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-17B		Date														
		Jul 18, 2018	**Aug 30, 2018**	**Nov 25, 2018**	**Mar 10, 2019**	**Jun 09, 2019**	**Oct 20, 2019**	**Dec 15, 2019**	**14-Apr-2020**	**09-Jun-2020**	**19-Oct-2020**	**09-Jan-2021**	**Apr 05, 2021**	**Jul 31, 2021**	Sep 15, 2021	Jan 29, 2022
ALS COA Sample ID		**L2133200-2**	L2157339-1	**L2202266-1**	L2243027-2	L2289366-1	L2369526-3	VA19A0679-001	**VA20A4840-001**	**VA20A8023-001**	VA20B8669-001	**VA21A0475-001**	**VA21A6365-001**	**VA21B5926-001**	VA21C0275-001	VA22A1890-002
Field Parameters	**Unit**															
Temperature	°C	**3.8**	4.5	**1.0**	2.4	2.6	4	3.1	**2.5**	**4.5**	1.4	**0.9**	**1.87**	**3.4**	6.4	1.5
pH	pH	**8.68**	8.64	**8.84**	8.46	8.74	9.88	8.25	**8.2**	**8.32**	8.73	**8.55**	**7.66**	**8.5**	8.38	8.39
Specific conductance	µS/cm	**740**	1048	**922**	926	676	695	864	**946**	**659**	609	**764**	**895**	**622**	620	866
Dissolved Oxygen	mg/L	**-**	-	**-**	-	160.3	2	4.93	**3.8**	**3.3**	2.42	**4.33**	**3.83**	**<0.84**	0.71	7.07
Oxidation Reduction Potential	mV	**-**	-	**-**	27.1	3.98	-150.4	-85.2	**-52.1**		-165.7	**21**	**-49.4**	**-139**	-204.6	-9.8
Turbidity	NTU	**973**	1019	**>4000**	27	51	89	94	**1656**	**113**	59.89	**263.2**	**117.16**	**220**	166.5	89.06
Physical Tests																
Conductivity	uS/cm	**757**	786	**869**	912	681	657	837	**961**	**669**	643	**768**	**964**	**597**	590	833
Acidity (as CaCO3)	mg/L	**-**	<1.0	**1.6**	<1.0	<1.0	<2.0	<2.0	**7.3**	**<2.0**	<2.0	**<2.0**	**<2.0**	**<2.0**	<2.0	2.7
Total Alkalinity (as $CaCO_3$)	mg/L	**<1.0**	119	**95.4**	112	126	123	137	**327**	**130**	122	**150**	**117**	**121**	112	120
Hardness (as $CaCO_3$), dissolved	mg/L								**324**	**190**	113	**179**	**374**	**161**	181	303
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	**137**	209	**198**	305	168	84.4	288	**554**	**222**	130	**233**	**332**	**130**	161	255
pH	pH	**8.34**	8.27	**8.37**	8.28	8.4	9.44	8.2	**7.83**	**8.18**	8.45	**7.99**	**7.76**	**8.32**	8.21	8.11
Total Dissolved Solids (TDS)	mg/L	**524**	545	**459**	675	460	429	592	**691**	**592**	384	**532**	**652**	**493**	397	616
Total Suspended Solids (TSS)	mg/L	**701**	2020	**256**	50.4	74.1	229	153	**584**	**235**	69.3	**473**	**263**	**468**	104	91.3
Turbidity	NTU	**843**	189	**347**	48	64	96.7	171	**>4000**	**430**	78.7	**540**	**293**	**613**	166	117
Anions and Nutrients																
Total Kjeldahl Nitrogen (TKN)	mg/L								**1.29**	**0.304**	0.407	**0.93**	**0.451**	**0.209**	0.155	0.662
Total Ammonia (as N)	mg/L	**105**	0.174	**0.275**	0.125	0.121	0.326	0.124	**0.227**	**0.11**	0.121	**0.116**	**0.0757**	**0.112**	0.0848	0.171
Bromide (B)	mg/L	**-**	-	**-**	-	-	-	-	**<0.250**	**<0.050**	<0.050	**<0.250**	**<0.250**	**<0.050**	<0.050	<0.050
Chloride (Cl)	mg/L	**<0.25**	9.2	**7.2**	6.7	8.83	5.96	8.99	**12.6**	**5.03**	3.67	**4.44**	**5.02**	**3.31**	4.72	4.65
Fluoride (F)	mg/L	**7.4**	0.19	**0.21**	0.14	0.264	0.225	0.232	**0.18**	**0.214**	0.283	**0.228**	**0.138**	**0.344**	0.26	0.24
Nitrate (as N)	mg/L	**0.31**	0.199	**0.092**	0.858	0.13	0.0568	0.0859	**0.0257**	**0.058**	0.121	**0.0785**	**0.172**	**<0.0050**	<0.0050	<0.0050
Nitrate + Nitrite (as N)	mg/L	**-**	-	**-**	-	-	-	-	**-**	**-**	-	**0.0905**	**0.2**	**<0.0051**	<0.0051	<0.0051
Nitrite (as N)	mg/L	**0.147**	0.0268	**0.0429**	0.177	0.0041	0.0149	0.0248	**0.0155**	**0.0097**	0.0054	**0.012**	**0.0277**	**<0.0010**	<0.0010	0.0021
Total Nitrogen (n)	mg/L	**-**	-	**-**	-	-	-	-	**1.33**	**0.372**	0.533	**1.02**	**0.651**	**0.209**	0.155	0.662
Dissolved Orthophosphate (as P)	mg/L	**0.89**	<0.0010	**0.0017**	<0.0010	0.0045	0.0049	<0.0010	**0.0018**	**0.0085**	0.0014	**0.031**	**<0.0010**	**0.0114**	<0.0010	0.0436
Total Phosphorus (P)	mg/L	**0.33**	1.37	**<0.30**	0.0388	0.0583	0.111	0.112	**1.61**	**0.379**	0.077	**0.435**	**0.267**	**0.293**	0.0976	0.13
Sulfate (SO_4)	mg/L	**256**	297	**344**	365	213	208	304	**373**	**200**	179	**253**	**395**	**190**	188	321
Sulfide (as H_2S)	mg/L	**-**	-	**-**	-	-	-	-	**4.28**	**<0.018**	0.996	**0.329**	**0.145**	**0.554**	0.42	0.174
Sulfide (as S)	mg/L	**-**	-	**-**	-	-	-	-	**4.02**	**<0.018**	0.936	**0.309**	**0.136**	**0.521**	0.395	0.164
Total Metals																
Aluminum (Al)-Total	mg/L	**8.46**	36.6	**3.5**	0.326	0.579	0.61	1.66	**37.6**	**11.8**	0.448	**4.48**	**3.1**	**6.39**	1.94	0.601
Antimony (Sb)-Total	mg/L	**0.00601**	0.00535	**0.00579**	0.00282	0.00331	0.00481	0.00387	**0.00615**	**0.00397**	0.00162	**0.00581**	**0.00295**	**0.00326**	0.002	0.00395
Arsenic (As)-Total	mg/L	**0.06**	0.172	**0.037**	0.0155	0.0459	0.0351	0.0237	**0.194**	**0.0947**	0.0432	**0.0498**	**0.0276**	**0.0808**	0.0636	0.0243
Barium (Ba)-Total	mg/L	**0.205**	0.857	**0.105**	0.0512	0.0613	0.0414	0.0883	**1.11**	**0.292**	0.0289	**0.185**	**0.124**	**0.16**	0.078	0.0692
Beryllium (Be)-Total	mg/L	**0.00066**	0.00336	**0.00028**	<0.00010	<0.00010	<0.00010	0.00011	**0.00347**	**0.00109**	<0.000100	**0.000365**	**0.000236**	**0.000586**	0.000151	0.000049
Bismuth(Bi)- Total	mg/L	**0.000246**	0.00119	**0.000081**	<0.000050	<0.000050	<0.000050	<0.000050	**0.00143**	**0.000304**	<0.000050	**0.000166**	**0.000103**	**0.000192**	0.000053	<0.000050
Boron (B)-Total	mg/L	**-**	-	**-**	-	-	-	-	**0.078**	**0.052**	0.057	**0.057**	**0.053**	**0.046**	0.036	0.052
Cadmium (Cd)-Total	mg/L	**0.0000713**	0.000407	**0.0000435**	0.0000311	0.0000254	0.0000229	0.0000557	**0.000913**	**0.000105**	0.000034	**0.000205**	**0.0000956**	**0.000106**	0.0000402	0.0000233
Calcium (Ca)-Total	mg/L	**51.2**	107	**75.2**	116	65.2	34.1	107	**182**	**75.7**	49.1	**84**	**138**	**55.5**	66.1	113
Chromium (Cr)-Total	mg/L	**0.00372**	0.0217	**0.0015**	0.00086	0.00049	0.0106	0.00668	**0.188**	**0.0099**	0.0005	**0.0958**	**0.0150**	**0.0501**	0.015	0.0176
Cobalt (Co)-Total	mg/L	**0.0033**	0.0157	**0.00134**	0.00037	0.00038	0.00142	0.00104	**0.0313**	**0.00872**	0.0003	**0.00514**	**0.00264**	**0.0136**	0.00163	0.00074
Copper (Cu)-Total	mg/L	**0.0132**	0.0639	**0.0047**	0.00349	0.00138	0.00201	0.00632	**0.113**	**0.016**	0.00129	**0.0161**	**0.00649**	**0.0148**	0.00356	0.00256
Iron (Fe)-Total	mg/L	**9.29**	45.2	**3.38**	0.511	0.643	0.689	1.87	**53.6**	**12.2**	0.377	**6.27**	**4.49**	**7.96**	2.62	0.83
Lead (Pb)-Total	mg/L	**0.01**	0.0494	**0.0033**	0.00215	0.000802	0.000836	0.00211	**0.0652**	**0.0144**	0.000544	**0.0087**	**0.00476**	**0.00844**	0.00244	0.0012
Lithium (Li)-Total	mg/L	**0.21**	0.24	**0.16**	0.103	0.161	0.207	0.139	**0.236**	**0.177**	0.26	**0.162**	**0.109**	**0.189**	0.147	0.131
Magnesium (Mg)-Total	mg/L	**6.21**	23.1	**5.39**	5.33	3.31	2.18	4.82	**24.1**	**7.92**	1.78	**5.76**	**7.27**	**5.35**	3.82	5.1
Manganese (Mn)-Total	mg/L	**0.432**	1.91	**0.238**	0.274	0.379	0.109	0.233	**2.52**	**0.801**	0.0682	**0.33**	**0.328**	**0.561**	0.732	0.146
Mercury (Hg)-Total	mg/L	**0.000069**	<0.0025	**<0.00010**	0.0000086	0.0000128	<0.0000050	0.0000242	**0.000265**	**0.0000708**	<0.0000050	**0.0000776**	**0.0000234**	**0.000071**	0.0000284	<0.0000050
Molybdenum (Mo)-Total	mg/L	**0.00548**	0.00345	**0.00534**	0.00242	0.00414	0.00475	0.00136	**0.0196**	**0.0036**	0.00208	**0.00551**	**0.00181**	**0.0108**	0.00486	0.00414
Nickel (Ni)-Total	mg/L	**0.0047**	0.0214	**0.00241**	0.00109	0.0007	0.0072	0.00182	**0.128**	**0.00915**	0.0006	**0.0297**	**0.00613**	**0.045**	0.0103	0.00607
Phosphorous (P)-Total	mg/L	**-**	-	**-**	-	-	-	-	**1.96**	**0.471**	<0.300	**0.343**	**<0.300**	**<0.300**	<0.300	0.138
Potassium (K)-Total	mg/L	**6.9**	11.8	**8.33**	4.35	2.78	11	2.75	**10.1**	**4.03**	1.76	**4.87**	**3.11**	**3.02**	2.14	3.95
Selenium (Se)-Total	mg/L	**0.00231**	0.00616	**0.00164**	0.000881	0.000614	0.000733	0.000741	**0.00644**	**0.00198**	0.00044	**0.00141**	**0.0011**	**0.00112**	0.000297	0.000458
Silicon (Si)-Total	mg/L	**-**	-	**-**	-	-	-	-	**50.1**	**19.1**	3.72	**9.06**	**6.9**	**10.6**	5.9	3.79
Silver (Ag)-Total	mg/L	**0.000888**	0.0044	**0.00035**	0.000037	0.000062	0.000143	0.000198	**0.0078**	**0.000638**	0.000021	**0.000797**	**0.000402**	**0.00671**	0.000175	0.000097
Sodium (Na)-Total	mg/L	**92.8**	75.1	**105**	75	72.3	104	63.1	**75.2**	**58.2**	102	**83**	**55.6**	**68.8**	55.2	73
Strontium (Sr)-Total	mg/L	**1.79**	2.93	**2.92**	3.77	2.22	1.58	3.2	**4.87**	**2.13**	1.8	**2.76**	**4.44**	**1.78**	1.91	3.54
Sulfur (S)-Total	mg/L	**-**	-	**-**	-	-	-	-	**-**	**-**	-	**-**	**-**	**-**	-	115
Thallium (Tl)-Total	mg/L	**0.000195**	0.000826	**0.000067**	<0.000010	0.000011	0.000017	0.000045	**0.00136**	**0.000354**	<0.000010	**0.000177**	**0.000109**	**0.000162**	0.000041	0.000017
Tin (Sn)-Total	mg/L	**0.00028**	0.00261	**0.0002**	0.00079	0.00055	0.00088	0.00077	**0.0025**	**0.00013**	<0.00010	**0.00142**	**0.00034**	**0.00017**	<0.00010	0.00046
Titanium (Ti)-Total	mg/L	**-**	-	**-**	-	-	-	-	**0.132**	**0.0706**	<0.0100	**0.0329**	**0.0275**	**0.0428**	0.0278	0.00828
Uranium (U)-Total	mg/L	**0.000872**	0.0021	**0.00208**	0.000679	0.000208	0.000192	0.00042	**0.00929**	**0.000472**	0.000211	**0.0035**	**0.000834**	**0.00038**	0.000194	0.00229
Vanadium (V)-Total	mg/L	**0.0136**	0.0558	**0.0057**	0.00084	0.00109	0.00133	0.00269	**0.0623**	**0.0187**	0.00082	**0.00881**	**0.00509**	**0.0103**	0.00342	0.00158
Zinc (Zn)-Total	mg/L	**0.0438**	0.226	**0.018**	0.0101	0.0075	0.0058	0.0166	**0.311**	**0.0571**	0.0043	**0.0473**	**0.0208**	**0.0364**	0.0114	0.0079
Zirconium (Zr)-Total	mg/L	**-**	-	**-**	-	-	-	-	**-**	**-**	-	**-**	**-**	**-**	-	-
Dissolved Metals																
Aluminum (Al)-Dissolved	mg/L	**0.0228**	0.0398	**0.014**	0.0154	0.017	0.0217	0.0078	**0.01**	**0.205**	0.0124	**0.023**	**0.0034**	**0.0075**	1.03	0.0067
Antimony (Sb)-Dissolved	mg/L	**0.00514**	0.00383	**0.0055**	0.00243	0.00244	0.0039	0.0028	**0.00717**	**0.00114**	0.0015	**0.00335**	**0.0019**	**0.0009**	0.00078	0.00357
Arsenic (As)-Dissolved	mg/L	**0.023**	0.0121	**0.0263**	0.0125	0.0402	0.0306	0.0164	**0.0109**	**0.0306**	0.0452	**0.0271**	**0.0124**	**0.0418**	0.0472	0.0171
Barium (Ba)-Dissolved	mg/L	**0.0258**	0.0373	**0.0368**	0.0374	0.0289	0.0256	0.0363	**0.0498**	**0.0333**	0.0173	**0.0324**	**0.0449**	**0.0249**	0.052	0.0413
Beryllium (Be)-Dissolved	mg/L	**<0.00010**	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.000100	**<0.000100**	**<0.000100**	<0.000100	**<0.000100**	**<0.000100**	**<0.000100**	<0.000100	<0.000020
Bismuth(Bi)- Dissolved	mg/L	**<0.000050**	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	**<0.000050**	**<0.000050**	<0.000050	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	**-**	-	**-**	-	-	-	-	**0.051**	**0.045**	0.05	**0.047**	**0.044**	**0.043**	0.036	0.044
Cadmium (Cd)-Dissolved	mg/L	**0.0000197**	0.0000091	**<0.0000050**	<0.0000050	0.0000072	0.0000086	<0.0000050	**<0.0000050**	**<0.0000050**	0.0000288	**<0.0000050**	**<0.0000050**	**<0.0000050**	0.0000055	<0.0000050
Calcium (Ca)-Dissolved	mg/L	**50.1**	76.9	**72.8**	113	62.5	30.7	108	**120**	**70.7**	42.7	**66.3**	**124**	**48.3**	59.7	95.1
Chromium (Cr)-Dissolved	mg/L	**<0.00010**	0.00026	**<0.00010**	0.00023	<0.00010	0.00128	<0.00010	**<0.00010**	**<0.00010**	<0.00010	**0.00037**	**0.00032**	**<0.00050**	0.00285	0.00061
Cobalt (Co)-Dissolved	mg/L	**0.00018**	0.00016	**0.00014**	0.00021	0.00016	0.00017	0.00029	**0.0005**	**0.00011**	0.00012	**0.00013**	**0.0002**	**0.00019**	0.00035	0.00021
Copper (Cu)-Dissolved	mg/L	**0.00027**	0.00058	**<0.00020**	0.00023	<0.00020	<0.00020	<0.00020	**0.00117**	**<0.00020**	<0.00020	**<0.00020**	**<0.00020**	**<0.00020**	0.00057	<0.00020
Iron (Fe)-Dissolved	mg/L	**<0.010**	<0.010	**<0.010**	0.015	<0.010	0.017	0.115	**0.049**	**0.068**	0.03	**0.015**	**0.193**	**0.074**	0.415	<0.010
Lead (Pb)-Dissolved	mg/L	**0.000169**	0.000058	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	**0.000101**	**0.000052**	0.00007	**<0.000050**	**<0.000050**	**<0.000050**	0.000403	<0.000050
Lithium (Li)-Dissolved	mg/L	**0.217**	0.126	**0.161**	0.108	0.152	0.188	0.132	**0.135**	**0.149**	0.2	**0.177**	**0.119**	**0.17**	0.14	0.122
Magnesium (Mg)-Dissolved	mg/L	**2.77**	4.05	**4**	5.23	2.87	1.86	5.05	**5.85**	**3.2**	1.64	**3.27**	**5.41**	**2.22**	2.98	4.37
Manganese (Mn)-Dissolved	mg/L	**0.0909**	0.128	**0.102**	0.199	0.343	0.0496	0.123	**0.381**	**0.305**	0.0373	**0.0856**	**0.174**	**0.224**	0.603	0.084
Mercury (Hg)-Dissolved	mg/L	**0.0000056**	<0.0000050	**<0.0000050**	<0.0000050	0.0000067	0.0000092	0.0000053	**<0.0000050**	**<0.0000050**	<0.0000050	**0.000006**	**<0.0000050**	**<0.0000050**	0.0000055	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	**0.00557**	0.00328	**0.0052**	0.00235	0.00383	0.00426	0.00128	**0.0126**	**0.00267**	0.00206	**0.00392**	**0.00159**	**0.00539**	0.00366	0.00382
Nickel (Ni)-Dissolved	mg/L	**0.00077**	0.00113	**0.00075**	0.00054	<0.00050	0.00088	0.00051	**0.00725**	**0.0005**	<0.00050	**0.00109**	**0.00124**	**0.00074**	0.0026	0.00272
Phosphorous (P)-Dissolved	mg/L	**-**	-	**-**	-	-	-	-	**<0.300**	**<0.300**	<0.300	**<0.300**	**<0.300**	**<0.300**	<0.300	0.064
Potassium (K)-Dissolved	mg/L	**5.92**	6.71	**7.77**	4.37	2.77	10.8	2.87	**3.95**	**1.76**	1.72	**3.92**	**2.77**	**1.88**	1.97	3.46
Selenium (Se)-Dissolved	mg/L	**0.00116**	0.00134	**0.00152**	0.000955	0.000691	0.00182	0.000548	**0.000535**	**0.000903**	0.00523	**0.000599**	**0.000538**	**0.000221**	0.000369	0.000366
Silicon (Si)-Dissolved	mg/L								**2.62**	**3.47**	2.96	**2.94**	**3.06**	**3.37**	4.6	2.66
Silver (Ag)-Dissolved	mg/L	**<0.000010**	<0.000010	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	**<0.000010**	**<0.000010**	<0.000010	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	**107**	83.1	**111**	83	71.3	103	67.6	**80.4**	**65.1**	85	**88.1**	**60.7**	**67.3**	54	65.8
Strontium (Sr)-Dissolved	mg/L	**1.7**	2.8	**2.77**	3.65	2.05	1.55	3.62	**4.22**	**2.37**	1.48	**2.55**	**4.14**	**1.66**	1.82	3.24
Sulfur (S)-Dissolved	mg/L	**-**	-	**-**	-	-	-	-	**-**	**-**	-	**-**	**-**	**-**	-	102
Thallium (Tl)-Dissolved	mg/L	**0.000015**	0.000026	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	**<0.000010**	**<0.000010**	<0.000010	**<0.000010**	**<0.000010**	**<0.000010**	0.000017	<0.000010
Tin (Sn)-Dissolved	mg/L	**<0.00010**	<0.00010	**<0.00010**	0.00021	0.00016	0.00035	0.0001	**0.00018**	**<0.00010**	0.00022	**0.0004**	**0.00019**	**<0.00010**	<0.00010	0.00013
Titanium (Ti)-Dissolved	mg/L	**-**	-	**-**	-	-	-	-	**<0.0100**	**<0.0100**	<0.0100	**<0.0100**	**<0.0100**	**<0.0100**	0.0129	<0.00030
Uranium (U)-Dissolved	mg/L	**0.000742**	0.00133	**0.002**	0.000551	0.000172	0.00016	0.000396	**0.00783**	**0.000236**	0.000161	**0.00312**	**0.000966**	**0.000186**	0.000161	0.0021
Vanadium (V)-Dissolved	mg/L	**<0.00050**	<0.00050	**0.00053**	<0.00050	<0.00050	<0.00050	<0.00050	**<0.00050**	**<0.00050**	<0.00050	**0.00074**	**<0.00050**	**<0.00050**	0.00159	<0.00050
Zinc (Zn)-Dissolved	mg/L	**<0.0010**	0.0015	**<0.0010**	0.0017	0.0014	<0.0010	0.0016	**0.0046**	**<0.0010**	0.0012	**<0.0010**	**0.002**	**0.0028**	0.0036	0.0012
Zirconium (Zr)-Dissolved	mg/L	**-**	-	**-**	-	-	-	-	**-**	**-**	-	**-**	**-**	**-**	-	-
Aggregate Organics																
Chemical Oxygen Demand (COD)	mg/L	**-**	-	**-**	-	-	-	-	**-**	**33**	40	**61**	**51**	**37**	40	43

Notes:

Sample results in red indicate turbidity measured between 50 and 200 NTU

Sample results in **red bold** indicated turbidity measured above 200 NTU

Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-18A		Date
		Mar 17, 2019
ALS COA Sample ID		**L2245926-1**
Field Parameters	**Unit**	
Temperature	°C	**2.7**
pH	pH	**12.63**
Specific conductance	µS/cm	**5011**
Dissolved Oxygen	mg/L	**-**
Oxidation Reduction Potential	mV	**-32.2**
Turbidity	NTU	**430**
Physical Tests		
Conductivity	uS/cm	**4220**
Acidity (as CaCO3)	mg/L	**<1.0**
Total Alkalinity (as $CaCO_3$)	mg/L	**1320**
Hardness (as $CaCO_3$), dissolved	mg/L	**-**
Hardness (as $CaCO_3$), total as Ca/Mg	mg/L	**177**
pH	pH	**11.85**
Total Dissolved Solids (TDS)	mg/L	**2290**
Total Suspended Solids (TSS)	mg/L	**12400**
Turbidity	NTU	**>4000**
Anions and Nutrients		
Kjeldahl nitrogen, total [TKN]		**-**
Total Ammonia (as N)	mg/L	**2.04**
Bromide (Br)	mg/L	**-**
Chloride (Cl)	mg/L	**94**
Fluoride (F)	mg/L	**0.6**
Nitrate (as N)	mg/L	**0.2**
Nitrate + Nitrite (as N)	mg/L	**-**
Nitrite (as N)	mg/L	**0.13**
Nitrogen, total	mg/L	**-**
Dissolved Orthophosphate (as P)	mg/L	**0.0041**
Total Phosphorus (P)	mg/L	**7.41**
Sulfate (as SO_4)	mg/L	**896**
Sulfide (as H2S)	mg/L	**-**
Sulfide (as S)	mg/L	**-**
Total Metals		
Aluminum (Al)-Total	mg/L	**31.4**
Antimony (Sb)-Total	mg/L	**0.0106**
Arsenic (As)-Total	mg/L	**0.212**
Barium (Ba)-Total	mg/L	**2.25**
Beryllium (Be)-Total	mg/L	**0.00503**
Bismuth(Bi)- Total	mg/L	**<0.00025**
Boron (B)-Total	mg/L	**-**
Cadmium (Cd)-Total	mg/L	**0.00181**
Calcium (Ca)-Total	mg/L	**299**
Chromium (Cr)-Total	mg/L	**0.0276**
Cobalt (Co)-Total	mg/L	**0.029**
Copper (Cu)-Total	mg/L	**0.218**
Iron (Fe)-Total	mg/L	**62.2**
Lead (Pb)-Total	mg/L	**0.0587**
Lithium (Li)-Total	mg/L	**0.421**
Magnesium (Mg)-Total	mg/L	**13.5**
Manganese (Mn)-Total	mg/L	**2.84**
Mercury (Hg)-Total	mg/L	**0.00015**
Molybdenum (Mo)-Total	mg/L	**0.0235**
Nickel (Ni)-Total	mg/L	**0.0413**
Phosphorus (P)-Total	mg/L	**-**
Potassium (K)-Total	mg/L	**79.2**
Selenium (Se)-Total	mg/L	**0.00299**
Silicon (Si)-Total	mg/L	**-**
Silver (Ag)-Total	mg/L	**0.0337**
Sodium (Na)-Total	mg/L	**531**
Strontium (Sr)-Total	mg/L	**4.81**
Sulfur (S)-Total	mg/L	**-**
Thallium (Tl)-Total	mg/L	**0.00123**
Tin (Sn)-Total	mg/L	**0.00668**
Titanium (Ti)-Total	mg/L	**-**
Uranium (U)-Total	mg/L	**0.0167**
Vanadium (V)-Total	mg/L	**0.0574**
Zinc (Zn)-Total	mg/L	**0.578**
Zirconium (Zr)-Total	mg/L	**-**
Dissolved Metals		
Aluminum (Al)-Dissolved	mg/L	**0.935**
Antimony (Sb)-Dissolved	mg/L	**0.00214**
Arsenic (As)-Dissolved	mg/L	**0.0342**
Barium (Ba)-Dissolved	mg/L	**0.171**
Beryllium (Be)-Dissolved	mg/L	**<0.00050**
Bismuth(Bi)- Dissolved	mg/L	**<0.00025**
Boron (B)-Dissolved	mg/L	**-**
Cadmium (Cd)-Dissolved	mg/L	**<0.000025**
Calcium (Ca)-Dissolved	mg/L	**70.8**
Chromium (Cr)-Dissolved	mg/L	**0.00407**
Cobalt (Co)-Dissolved	mg/L	**<0.00050**
Copper (Cu)-Dissolved	mg/L	**0.0237**
Iron (Fe)-Dissolved	mg/L	**<0.050**
Lead (Pb)-Dissolved	mg/L	**<0.00025**
Lithium (Li)-Dissolved	mg/L	**0.365**
Magnesium (Mg)-Dissolved	mg/L	**<0.10**
Manganese (Mn)-Dissolved	mg/L	**0.00223**
Mercury (Hg)-Dissolved	mg/L	**0.0000055**
Molybdenum (Mo)-Dissolved	mg/L	**0.0269**
Nickel (Ni)-Dissolved	mg/L	**0.0044**
Phosphorus (P)-Dissolved	mg/L	**-**
Potassium (K)-Dissolved	mg/L	**72.7**
Selenium (Se)-Dissolved	mg/L	**0.00301**
Silicon (Si)-Total	mg/L	**-**
Silver (Ag)-Dissolved	mg/L	**<0.000050**
Sodium (Na)-Dissolved	mg/L	**607**
Strontium (Sr)-Dissolved	mg/L	**2.51**
Sulfur (S)-Dissolved	mg/L	**-**
Thallium (Tl)-Dissolved	mg/L	**<0.000050**
Tin (Sn)-Dissolved	mg/L	**<0.00050**
Titanium (Ti)-Dissolved	mg/L	**-**
Uranium (U)-Dissolved	mg/L	**0.000057**
Vanadium (V)-Dissolved	mg/L	**0.0164**
Zinc (Zn)-Dissolved	mg/L	**<0.0050**
Zirconium (Zr)-Dissolved	mg/L	**-**
Aggregate Organics		
Chemical Oxygen Demand (COD)	mg/L	**-**

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-18B		Date												
		Aug 12, 2018	**Aug 26, 2018**	**Nov 20, 2018**	**Apr 28, 2019**	**Jun 15, 2019**	**Oct 13, 2019**	**Nov 21, 2019**	**23-Jul-2020**	**12-Sep-2020**	**09-Jan-2021**	**May 23, 2021**	**Sep 11, 2021**	**Nov 07, 2021**
ALS COA Sample ID		**L2147510-1**	**L2154319-1**	L2200641-1	L2265042-1	L2293090-1	L2365137-1	VA19A0099-003	VA20B1046-001	VA20B5183-001	VA21A0475-003	VA21B0116-002	VA21B9857-002	VA21C5014-001
Field Parameters	**Unit**													
Temperature	°C	**3.3**	**2.8**	2	2.6	3.3	3.4	4	4.2	4.3	5.1	7.2	4.5	4.8
pH	pH	**8.12**	**8.3**	8.23	7.76	7.99	8.56	7.77	8.13	7.97	7.89	7.75	8	7.99
Specific conductance	µS/cm	**498**	**514**	501	797	622	579	573	562	577	600	672	506	561
Dissolved Oxygen	mg/L	**-**	**-**	-	-	0.01	0.25	0.1	0.2	0.2	0.45	0.47	0.3	0.29
Oxidation Reduction Potential	mV	**-**	**-**	-	-	12	-44.9	22.8	-18.7	-70.9	-12.8	-47.1	-94.2	-151.3
Turbidity	NTU	**200**	**635**	145	118.2	8.2	29	4.17	9.92	2.85	15.63	66	33.16	23.31
Physical Tests														
Conductivity	uS/cm	**500**	**462**	536	766	627	549	581	570	575	602	688	532	577
Acidity (as CaCO3)	mg/L	**<1.0**	**<1.0**	<1.0	1.7	<1.0	<2.0	2.7	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	**108**	**114**	107	117	98.9	97.5	108	90.3	99.9	111	118	96.6	107
Hardness (as $CaCO_3$), dissolved	mg/L	**-**	**-**	-	-	-	-	-	174	204	216	213	165	170
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	**148**	**165**	187	273	207	189	201	181	195	224	210	167	168
pH	pH	**8.2**	**8.21**	8.11	8.14	8.23	8.31	8.17	8.11	8.13	8.08	8.08	8.15	8.11
Total Dissolved Solids (TDS)	mg/L	**381**	**398**	402	539	435	406	375	373	409	356	438	387	300
Total Suspended Solids (TSS)	mg/L	**384**	**553**	113	207	5.5	6.5	6.2	5.5	6.1	5.3	27	43.1	13.8
Turbidity	NTU	**334**	**472**	138	155	1.33	1.67	1.14	4.49	3.51	4	54.4	26.2	0.3
Anions and Nutrients														
Kjeldahl nitrogen, total [TKN]	mg/L	**-**	**-**	-	-	-	-	-	0.134	0.076	0.082	0.137	0.162	0.13
Total Ammonia (as N)	mg/L	**0.0983**	**0.0981**	0.0907	0.06	0.0764	0.0402	0.0243	0.117	0.0726	0.06	0.106	0.151	0.126
Bromide (Br)	mg/L	**-**	**-**	-	-	-	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	**3.17**	**3.17**	2.34	19.7	8.58	3.8	2.85	4.36	4.23	3.75	17.3	4.66	8.8
Fluoride (F)	mg/L	**0.114**	**-**	0.093	<0.10	0.1	0.103	0.107	0.126	0.103	0.094	0.084	0.133	0.107
Nitrate (as N)	mg/L	**0.152**	**0.108**	0.0264	0.066	0.028	0.0462	0.041	0.0131	0.0201	<0.0050	0.0073	<0.0050	<0.0050
Nitrate + Nitrite (as N)	mg/L	**-**	**-**	-	-	-	-	-	-	-	<0.0051	0.0086	<0.0051	<0.0051
Nitrite (as N)	mg/L	**0.0117**	**0.141**	0.0012	0.0073	0.0015	0.0015	0.0018	<0.0010	<0.0010	<0.0010	0.0013	<0.0010	<0.0010
Nitrogen, total	mg/L	**-**	**-**	-	-	-	-	-	0.147	0.097	0.082	0.146	0.162	0.13
Dissolved Orthophosphate (as P)	mg/L	**<0.0010**	**0.34**	0.0012	<0.0010	<0.0010	<0.0010	<0.0010	0.0034	0.0038	0.0011	<0.0010	0.0019	0.0023
Total Phosphorus (P)	mg/L	**<0.30**	**<0.30**	<0.30	0.0496	0.0028	0.0085	0.0033	0.0059	0.0069	0.0052	0.0276	0.0107	0.0161
Sulfate (SO_4)	mg/L	**144**	**151**	180	278	210	190	187	181	186	197	206	152	168
Sulfide (as H2S)	mg/L	**-**	**-**	-	-	-	-	-	<0.019	<0.019	<0.019	<0.0016	<0.0016	<0.011
Sulfide (as S)	mg/L	**-**	**-**	-	-	-	-	-	<0.018	<0.018	<0.018	<0.0015	0.0015	<0.010
Total Metals														
Aluminum (Al)-Total	mg/L	**5.8**	**6.88**	3.67	1.63	0.0458	0.0593	0.0135	0.0679	0.0694	0.146	2.28	0.123	0.429
Antimony (Sb)-Total	mg/L	**0.00135**	**0.00141**	0.00045	0.00104	0.00012	0.00016	0.00012	<0.00010	0.00011	0.00012	0.00076	0.00022	0.00024
Arsenic (As)-Total	mg/L	**0.02**	**0.0271**	0.0142	0.0055	0.00096	0.00073	0.00045	0.00096	0.0009	0.00072	0.00333	0.00181	0.00205
Barium (Ba)-Total	mg/L	**0.148**	**0.2**	0.127	0.116	0.022	0.0285	0.0191	0.0254	0.0282	0.0238	0.0873	0.0264	0.031
Beryllium (Be)-Total	mg/L	**0.00069**	**0.00074**	0.00021	0.00023	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	**0.000085**	**0.000081**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	**-**	**-**	-	-	-	-	-	0.036	0.036	0.035	0.041	0.029	0.031
Cadmium (Cd)-Total	mg/L	**0.0000275**	**0.0000368**	0.0000136	0.0000144	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000122	0.0000065	<0.0000050
Calcium (Ca)-Total	mg/L	**60**	**62.3**	65	97.6	68.3	67.5	64.8	57.2	62.2	72.2	66.4	51.3	52.9
Chromium (Cr)-Total	mg/L	**0.00122**	**0.00138**	<0.00040	0.00109	0.0009	0.00224	0.00094	0.00058	0.00303	0.00296	0.018	0.00354	0.00611
Cobalt (Co)-Total	mg/L	**0.00329**	**0.00436**	0.00088	0.0009	<0.00010	0.00014	<0.00010	0.00012	0.00019	0.00022	0.00356	0.00301	0.00032
Copper (Cu)-Total	mg/L	**0.00764**	**0.00989**	0.00253	0.00314	<0.00050	0.00069	0.00084	0.00086	0.00116	<0.00050	0.00229	0.00104	0.00069
Iron (Fe)-Total	mg/L	**9.93**	**13.1**	5.92	2.25	0.035	0.048	0.015	0.032	0.149	0.116	1.26	0.164	0.454
Lead (Pb)-Total	mg/L	**0.00446**	**0.00487**	0.00149	0.00149	0.000058	0.000092	<0.000050	0.000055	0.000101	0.000488	0.000574	0.000186	0.000271
Lithium (Li)-Total	mg/L	**0.0689**	**0.0769**	0.0717	0.0724	0.0789	0.0754	0.0653	0.0793	0.0921	0.066	0.111	0.0825	0.0916
Magnesium (Mg)-Total	mg/L	**9.38**	**9.7**	9.74	16	10.4	9.4	9.5	9.3	9.71	10.5	11.4	8.94	9.34
Manganese (Mn)-Total	mg/L	**0.271**	**0.37**	0.177	0.0834	0.0267	0.0223	0.0224	0.0243	0.0265	0.0262	0.05	0.0559	0.0476
Mercury (Hg)-Total	mg/L	**<0.00010**	**<0.000025**	<0.000050	<0.000025	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	**0.000966**	**0.0011**	0.000596	0.000617	0.000614	0.000755	0.000417	0.000591	0.000902	0.00073	0.00271	0.00154	0.00121
Nickel (Ni)-Total	mg/L	**0.00127**	**0.0014**	0.00056	0.0011	0.00059	0.00166	0.00061	0.0005	0.0024	0.00177	0.01	0.00415	0.00389
Phosphorus (P)-Total	mg/L	**-**	**-**	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	**5.97**	**5.5**	4.13	4.57	3.62	3.8	2.82	3.23	3.24	2.73	4.7	3.31	3.48
Selenium (Se)-Total	mg/L	**0.000099**	**0.00014**	<0.000050	0.000051	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000074	<0.000050	<0.000050
Silicon (Si)-Total	mg/L	**-**	**-**	-	-	-	-	-	3.41	3.53	3.55	7.56	3.62	3.99
Silver (Ag)-Total	mg/L	**0.000959**	**0.00158**	0.000315	0.000214	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000023	0.000469	0.000036	0.000138
Sodium (Na)-Total	mg/L	**38.6**	**36.3**	39.9	47.7	47.9	43.3	36.2	46.8	47	38.5	57.2	42.5	46
Strontium (Sr)-Total	mg/L	**1.24**	**1.3**	1.37	2.13	1.55	1.48	1.41	1.42	1.57	1.6	1.67	1.44	1.54
Sulfur (S)-Total	mg/L	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	**0.000133**	**0.000165**	0.000054	0.000041	0.000015	0.000012	0.00001	0.000014	0.000012	0.000015	0.000087	0.000022	0.000031
Tin (Sn)-Total	mg/L	**0.00019**	**0.0003**	<0.00010	0.00121	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00016	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	**-**	**-**	-	-	-	-	-	<0.0100	<0.0100	<0.0100	0.0161	<0.0100	<0.0100
Uranium (U)-Total	mg/L	**0.00115**	**0.00135**	0.000647	0.00105	0.000383	0.000385	0.000403	0.00037	0.0004	0.000401	0.00138	0.00124	0.000974
Vanadium (V)-Total	mg/L	**0.00721**	**0.009**	0.00197	0.00179	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.004	<0.00050	0.00096
Zinc (Zn)-Total	mg/L	**0.0216**	**0.0282**	0.0071	0.0079	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0033	0.0064	0.0037	<0.0030
Zirconium (Zr)-Total	mg/L	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals														
Aluminum (Al)-Dissolved	mg/L	**0.0153**	**0.0086**	0.0077	0.0022	0.0042	0.0032	0.0032	0.0037	0.0045	0.0036	0.0018	0.0029	0.002
Antimony (Sb)-Dissolved	mg/L	**0.00048**	**0.00051**	0.00022	0.00039	0.00012	0.00015	0.00013	<0.00010	<0.00010	0.00011	0.00056	0.00019	0.00018
Arsenic (As)-Dissolved	mg/L	**0.00114**	**0.00119**	0.00134	0.00063	0.00086	0.00057	0.00043	0.00085	0.00068	0.00049	0.0007	0.00158	0.0009
Barium (Ba)-Dissolved	mg/L	**0.0244**	**0.0261**	0.0228	0.0294	0.0209	0.0241	0.0162	0.0214	0.0239	0.0194	0.0222	0.0178	0.0194
Beryllium (Be)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	**-**	**-**	-	-	-	-	-	0.032	0.038	0.03	0.04	0.028	0.032
Cadmium (Cd)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	<0.0000050	<0.000010	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Dissolved	mg/L	**47.3**	**52.8**	59.7	81.9	65.3	60.4	63.4	54.7	65.3	68.8	65.8	51.6	52.4
Chromium (Cr)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	0.00014	0.00034	0.0003	0.00042	0.00012	0.00108	0.00061	<0.00050	<0.00050	0.00056
Cobalt (Co)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00011	<0.00010	0.00038	0.002	0.00014
Copper (Cu)-Dissolved	mg/L	**<0.00020**	**<0.00020**	<0.00020	0.00109	<0.00020	<0.00020	0.00067	<0.00020	0.00072	0.00058	0.00035	<0.00020	<0.00020
Iron (Fe)-Dissolved	mg/L	**<0.010**	**<0.010**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.01	0.017	0.016	0.014	0.019
Lead (Pb)-Dissolved	mg/L	**<0.000050**	**<0.000050**	<0.000050	0.000065	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000103	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	**0.0618**	**0.0674**	0.0694	0.0765	0.0782	0.0731	0.0696	0.0904	0.0997	0.0701	0.114	0.0807	0.0932
Magnesium (Mg)-Dissolved	mg/L	**7.17**	**8.09**	9.17	16.7	10.7	9.38	9.08	9.15	9.88	10.7	11.1	9.35	9.12
Manganese (Mn)-Dissolved	mg/L	**0.0275**	**0.0279**	0.0323	0.0223	0.0248	0.0195	0.0206	0.0221	0.0225	0.0236	0.0245	0.0471	0.0378
Mercury (Hg)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	**0.000683**	**0.000726**	0.000581	0.000524	0.000582	0.000685	0.00045	0.000617	0.000728	0.000648	0.00156	0.00125	0.000776
Nickel (Ni)-Dissolved	mg/L	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	0.00085	<0.00050	<0.00050	0.00118	0.00117	0.0042	0.00179	0.00145
Phosphorus (P)-Dissolved	mg/L	**-**	**-**	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	**4.51**	**4.85**	3.69	4.65	3.62	3.55	2.79	3.21	3.5	3.17	3.82	3.39	3.14
Selenium (Se)-Dissolved	mg/L	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000059	<0.000050	<0.000050
Silicion (Si)-Dissolved	mg/L	**-**	**-**	-	-	-	-	-	3.2	3.02	3.34	3.27	3.45	3.13
Silver (Ag)-Dissolved	mg/L	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	**37.1**	**41**	40.3	48.5	46.8	38.8	34.9	46.1	48.7	40.9	57	44.6	46.5
Strontium (Sr)-Dissolved	mg/L	**1.09**	**1.2**	1.36	2.07	1.64	1.47	1.43	1.48	1.41	1.63	1.66	1.52	1.48
Sulfur (S)-Dissolved	mg/L	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	**0.000019**	**0.000018**	0.000017	<0.000010	0.000011	0.000012	0.00001	0.000011	0.00001	0.000011	0.000027	0.000015	0.000021
Tin (Sn)-Dissolved	mg/L	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	**-**	**-**	-	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	**0.000493**	**0.000491**	0.000505	0.000675	0.000356	0.000363	0.00041	0.000355	0.00035	0.000377	0.00126	0.0011	0.000877
Vanadium (V)-Dissolved	mg/L	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	**<0.0010**	**0.0017**	<0.0010	0.0038	<0.0010	0.0011	0.0018	0.0015	0.0028	0.0039	0.0024	0.0021	<0.0010
Zirconium (Zr)-Dissolved	mg/L	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics														
Chemical Oxygen Demand (COD)	mg/L	**-**	**-**	-	-	-	-	-	<20	<20	<20	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-19B		Date							
		Oct 08, 2018	**Jun 02, 2019**	**Sep 22, 2019**	**Dec 12, 2019**	**28-Jul-2020**	**10-Sep-2020**	**Jul 18, 2021**	**Aug 18, 2021**
ALS COA Sample ID		L2178537-1	L2284783-3	L2352492-1	**VA19A0634-001**	VA20B1507-001	VA20B5181-001	VA21B4774-005	VA21B7639-001
Field Parameters	**Unit**								
Temperature	°C	3.1	3.2	3.1	**2.2**	5.4	5.7	6.1	5
pH	pH	8.42	8.08	7.97	**8.07**	8.9	8.47	8.36	8.27
Specific conductance	µS/cm	328	576	400	**475.6**	438.9	401.4	461.9	417.3
Dissolved Oxygen	mg/L	-	-	0.16	**1.11**	2.96	0.47	1.96	1.2
Oxidation Reduction Potential	mV	-	182.8	87.3	**-8.7**	66.1	197.8	120	149
Turbidity	NTU	109.7	74.31	23	**34**	38.2	25	48.62	19.18
Physical Tests									
Conductivity	uS/cm	409	589	412	**481**	454	411	467	438
Acidity (as CaCO3)	mg/L	<1.0	<1.0	<1.0	**<2.0**	<2.0	<2.0	<2.0	<2.0
Total Alkalinity (as $CaCO_3$)	mg/L	86.9	106	79.4	**77.9**	78.8	74	87.1	84.4
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	**-**	-	-	143	121
Hardness (as $CaCO_3$), total from Ca/Mg	mg/L	107	164	119	**204**	150	129	125	111
pH	pH	8.44	8.16	8.17	**7.79**	8.4	8.26	8.15	8.21
Total Dissolved Solids (TDS)	mg/L	315	395	280	**443**	311	284	274	254
Total Suspended Solids (TSS)	mg/L	91.1	75.3	6.6	**258**	32.1	17.8	38.5	17.6
Turbidity	NTU	108	80.7	24	**418**	40.5	26.3	44.8	23.8
Anions and Nutrients									
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	**-**	0.097	0.063	0.075	<0.050
Total Ammonia (as N)	mg/L	0.045	0.0392	0.043	**0.0378**	0.0579	0.0484	0.0369	0.0323
Bromide (Br)	mg/L	-	-	-	**-**	-	-	<0.050	<0.050
Chloride (Cl)	mg/L	<0.50	0.5	<0.50	**<0.50**	<0.50	<0.50	<0.50	<0.50
Fluoride (F)	mg/L	0.156	0.141	0.132	**0.132**	0.125	0.14	0.138	0.129
Nitrate (as N)	mg/L	0.0084	<0.0050	0.0221	**<0.0050**	<0.0050	<0.0050	0.0082	<0.0050
Nitrate + Nitrite (as N)	mg/L	-	-	-	**-**	-	-	0.0122	<0.0051
Nitrite (as N)	mg/L	0.0011	<0.0010	0.0081	**0.0017**	0.0011	0.0014	0.004	0.0036
Total Nitrogen	mg/L	-	-	-	**-**	0.099	-	0.087	0.039
Dissolved Orthophosphate (as P)	mg/L	0.0038	<0.0010	0.0023	**0.0043**	0.0016	<0.0010	0.0017	0.0027
Total Phosphorus (P)	mg/L	<0.30	0.0609	0.0109	**0.155**	0.0247	0.0152	0.032	0.0079
Sulphate (SO_4)	mg/L	115	189	128	**152**	144	122	141	120
Sulfide (as H_2S)	mg/L	-	-	-	**-**	<0.019	<0.019	<0.0016	<0.0016
Sulfide (as S)	mg/L	-	-	-	**-**	<0.018	<0.018	<0.0015	<0.0015
Total Metals									
Aluminum (Al)-Total	mg/L	1.85	3.8	1.06	**12.4**	1.27	0.0118	0.712	0.394
Antimony (Sb)-Total	mg/L	0.00169	0.0102	0.00689	**0.008**	0.00428	0.00349	0.00504	0.0042
Arsenic (As)-Total	mg/L	0.0309	0.0203	0.0266	**0.0551**	0.0398	0.0335	0.0192	0.0184
Barium (Ba)-Total	mg/L	0.107	0.213	0.0478	**0.318**	0.0815	0.0256	0.0591	0.036
Beryllium (Be)-Total	mg/L	0.00011	<0.00010	<0.00010	**0.000231**	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	<0.000050	<0.000050	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	**-**	0.038	0.035	0.043	0.046
Cadmium (Cd)-Total	mg/L	0.0000896	0.0000634	0.0000179	**0.000139**	0.0000246	<0.0000050	0.00003	0.0000157
Calcium (Ca)-Total	mg/L	40.7	58.9	37.2	**61.4**	46	40	45.8	38.7
Chromium (Cr)-Total	mg/L	0.00376	0.0101	0.00053	**0.00444**	0.00099	<0.00010	0.00085	<0.00050
Cobalt (Co)-Total	mg/L	0.0009	0.00184	0.00073	**0.00416**	0.00102	0.00037	0.00175	0.00103
Copper (Cu)-Total	mg/L	0.00564	0.0117	0.00062	**0.0104**	0.0026	<0.00050	0.00834	0.00292
Iron (Fe)-Total	mg/L	2.67	2.26	0.658	**7.37**	1.16	<0.010	1.21	0.398
Lead (Pb)-Total	mg/L	0.0295	0.00274	0.000528	**0.00593**	0.00124	<0.000050	0.00209	0.00105
Lithium (Li)-Total	mg/L	0.0682	0.0853	0.0613	**0.067**	0.0614	0.056	0.0779	0.0807
Magnesium (Mg)-Total	mg/L	7.36	11.2	6.43	**12.2**	8.6	7.13	6.89	5.95
Manganese (Mn)-Total	mg/L	0.202	0.282	0.134	**0.42**	0.177	0.117	0.151	0.118
Mercury (Hg)-Total	mg/L	<0.000050	0.0000075	<0.0000050	**0.0000156**	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00268	0.00581	0.00197	**0.00191**	0.0019	0.00198	0.00393	0.00344
Nickel (Ni)-Total	mg/L	0.00176	0.00183	0.00054	**0.00284**	0.00127	<0.00050	0.00075	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	**-**	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	4.89	7.13	3.33	**8.04**	3.96	2.84	3.52	3.25
Selenium (Se)-Total	mg/L	<0.000050	0.000137	<0.000050	**0.000099**	<0.000050	<0.000050	<0.000050	<0.000050
Silicon (Si)-Total	mg/L	-	-	-	**-**	5.71	3.42	4.03	3.6
Silver (Ag)-Total	mg/L	0.000471	0.000327	0.000083	**0.00172**	0.00021	<0.000010	0.000339	0.000291
Sodium (Na)-Total	mg/L	39.6	51.5	33.6	**35.8**	38.2	31.4	44.1	44
Strontium (Sr)-Total	mg/L	2.06	2.93	2.08	**3.04**	2.6	2.43	2.14	1.94
Sulfur (S)-Total	mg/L	-	-	-	**-**	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000081	0.000192	0.000117	**0.000371**	0.000108	0.000061	0.000097	0.000087
Tin (Sn)-Total	mg/L	0.00251	0.00163	<0.00010	**0.00059**	0.00024	<0.00010	0.00037	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	**-**	<0.0200	<0.0100	<0.0100	<0.0100
Uranium (U)-Total	mg/L	0.000393	0.00318	0.0007	**0.000694**	0.00034	0.000233	0.000851	0.00066
Vanadium (V)-Total	mg/L	0.0032	0.0062	0.00205	**0.02**	0.00242	<0.00050	0.00135	0.0009
Zinc (Zn)-Total	mg/L	0.0234	0.0247	0.0032	**0.0385**	0.0072	<0.0030	0.0083	0.0037
Zirconium (Zr)-Total	mg/L	-	-	-	**-**	-	-	-	-
Dissolved Metals									
Aluminum (Al)-Dissolved	mg/L	0.0187	0.0105	0.0105	**0.0147**	0.0389	0.014	0.0049	0.0119
Antimony (Sb)-Dissolved	mg/L	0.00109	0.00927	0.00648	**0.00528**	0.0036	0.00335	0.00426	0.00391
Arsenic (As)-Dissolved	mg/L	0.0216	0.0113	0.0267	**0.0268**	0.0317	0.0347	0.0134	0.017
Barium (Ba)-Dissolved	mg/L	0.0251	0.0473	<0.00010	**0.0272**	0.0369	0.0282	0.0327	0.0271
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.000050	**<0.000100**	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.000050	<0.000050	0.036	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	**-**	0.036	0.035	0.042	0.042
Cadmium (Cd)-Dissolved	mg/L	0.00001	0.0000079	0.0000073	**0.0000059**	<0.0000050	<0.0000050	<0.0000100	0.0000077
Calcium (Ca)-Dissolved	mg/L	31.9	50	36.2	**46.8**	43.3	38.5	39.3	34.4
Chromium (Cr)-Dissolved	mg/L	0.00094	0.00046	<0.00010	**<0.00010**	0.00012	<0.00010	<0.00050	<0.00050
Cobalt (Co)-Dissolved	mg/L	<0.00010	0.00069	0.00047	**0.00053**	0.00036	0.00036	0.00055	0.00063
Copper (Cu)-Dissolved	mg/L	0.00311	0.00336	<0.00020	**0.00039**	0.00055	0.00044	0.00188	0.0012
Iron (Fe)-Dissolved	mg/L	<0.010	<0.010	<0.010	**0.011**	0.023	<0.010	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	0.000193	<0.000050	<0.000050	**<0.000050**	0.000055	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0634	0.0786	0.0558	**0.059**	0.0615	0.0554	0.0792	0.0705
Magnesium (Mg)-Dissolved	mg/L	6.65	9.39	6.99	**9.64**	7.55	7.16	6.64	6.03
Manganese (Mn)-Dissolved	mg/L	0.0735	0.161	0.121	**0.134**	0.122	0.124	0.0943	0.105
Mercury (Hg)-Dissolved	mg/L	<0.0000050	<0.0000050	<0.0000050	**0.0000052**	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00324	0.00545	0.00193	**0.00157**	0.00175	0.00181	0.00412	0.00351
Nickel (Ni)-Dissolved	mg/L	0.00084	0.00056	<0.00050	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	**-**	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	5.2	4.98	3.13	**3.14**	3.24	2.98	3.43	3
Selenium (Se)-Dissolved	mg/L	<0.000050	0.000114	<0.000050	**<0.000050**	<0.000050	<0.000050	<0.000050	0.00009
Silicon (Si)-Dissolved	mg/L	-	-	-	**-**	3.29	3.31	2.94	2.98
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	39.6	47.1	36.1	**35.4**	36.7	32.7	45.6	40.8
Strontium (Sr)-Dissolved	mg/L	1.95	2.83	2.01	**2.82**	2.37	2.23	2.28	1.99
Sulfur (S)-Dissolved	mg/L	-	-	-	**-**	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	0.000081	0.000093	0.00008	**0.000068**	0.000048	0.000056	0.000063	0.000076
Tin (Sn)-Dissolved	mg/L	0.00083	0.00027	<0.00010	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010
Titantium (Ti)-Dissolved	mg/L	-	-	-	**-**	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	0.000294	0.00301	0.00067	**0.000466**	0.000282	0.00022	0.00084	0.000672
Vanadium (V)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.0065	0.003	<0.0010	**0.0012**	0.0018	0.0017	0.0028	0.002
Zirconium (Zr)-Dissolved	mg/L	-	-	-	**-**	-	-	-	-
Aggregate Organics									
Chemical Oxygen Demand (COD)	mg/L	-	-	-	**-**	<20	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-23A		Date														
		Jul 15, 2018	**Oct 21, 2018**	**Nov 15, 2018**	**Apr 18, 2019**	**May 29, 2019**	**Oct 09, 2019**	**Nov 24, 2019**	**07-Apr-2020**	**17-May-2020**	**25-Oct-2020**	**04-Jan-2021**	**Apr 24, 2021**	**Jun 25, 2021**	**Oct 11, 2021**	**Nov 14, 2021**
ALS COA Sample ID		L2131469-1	L2185677-1	L2198095-1	L2260746-1	L2283159-2	L2364051-1	VA19A0100-002	VA20A4588-004	VA20A6598-001	VA20B9148-001	VA21A0115-001	VA21A7804-004	VA21B3123-001	VA21C2526-007	VA21C5536-001
Field Parameters	**Unit**															
Temperature	°C	-	2.6	2.4	3.4	4.1	2.7	1.6	-0.1	3.9	3.6	2.8	3	8.3	6	6
pH	pH	-	7.99	7.84	7.84	7.89	7.55	7.86	7.47	7.62	7.63	7.8	7.73	7.59	7.68	7.72
Specific conductance	µS/cm	-	888	771	1046	1032	1103	1026	1076	1088	1157	1181	1166	1201	1214	1182
Dissolved Oxygen	mg/L	-	-	-	2.3	-	0.13	0.17	0.27	0.17	5.19	1.56	0.77	0.95	0.52	0.43
Oxidation Reduction Potential	mV	-	-	-	168	150.1	130.8	11.7	82.3	114.6	98.7	57.5	8.6	14.7	29.1	-105.2
Turbidity	NTU	-	43	55	12	39	70.4	26	45.3	130.3	29.53	18.1	11.11	4.4	35.05	13.34
Physical Tests																
Conductivity	uS/cm	736	883	908	1040	1050	1090	1070	1040	1120	1170	1170	1150	1190	1200	1240
Acidity (as CaCO3)	mg/L	<1.0	2.5	3.3	2	1.3	2.3	2	2.2	2.8	2.6	2.9	2.6	2.3	<2.0	2.6
Total Alkalinity (as $CaCO_3$)	mg/L	108	98	95.2	86.7	87.8	89.6	90.9	105	96.1	96.9	92.9	91.6	89.8	93.3	95.7
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	284	270	353	326	319	333	362	341
Hardness (as CaCO3), from total Ca/Mg	mg/L	153	265	281	303	305	342	260	285	281	364	304	285	336	355	340
pH	pH	8.72	7.94	8.09	8.02	8.15	7.85	8.15	7.88	7.92	7.98	8.07	8.02	8.05	8.1	7.88
Total Dissolved Solids (TDS)	mg/L	498	620	598	762	748	744	730	740	762	908	827	773	904	753	806
Total Suspended Solids (TSS)	mg/L	141	322	63.6	17.7	44.1	<3.0	12.4	54.8	32.4	92.4	25.6	15.9	51.2	111	8.9
Turbidity	NTU	132	176	45.1	14.1	18.9	0.34	3.39	31	11.5	53.3	11.1	5.86	19	66.5	5.43
Anions and Nutrients																
Total Kjeldahl Nitrogen (TKN)	mg/L	-	-	-	-	-	-	-	0.194	9.71	1.06	<0.627	1.71	<1.11	<0.895	<0.743
Total Ammonia (as N)	mg/L	0.496	0.456	0.452	0.522	0.561	0.593	0.594		0.529	0.58	0.572	0.357	0.539	0.417	0.319
Bromide (Br)	mg/L	-	-	-	-	-	-	-	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250
Chloride (Cl)	mg/L	10.2	16.3	17.7	21.6	23.5	31.6	24.8	24.2	23.8	31.2	29.5	27.4	27.9	29.4	28.4
Fluoride (F)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.100	0.117	<0.100	0.12	0.103	<0.100	0.123	0.114	0.113
Nitrate (as N)	mg/L	4.5	4.83	5.57	8.49	7.38	6.65	4.08	4.99	6.35	7.33	6.08	5.58	11.6	9.32	7.87
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	6.14	5.75	11.6	9.47	7.9
Nitrite (as N)	mg/L	0.353	0.427	0.412	0.529	0.612	0.522	0.34	0.205	0.324	0.118	0.0608	0.174	0.0546	0.148	0.034
Total Nitrogen	mg/L	-	-	-	-	-	-	-	5.39	16.4	8.51	6.66	7.46	11.8	9.49	7.86
Dissolved Orthophosphate (as P)	mg/L	0.0037	0.0073	0.0072	0.0083	0.0069	0.0065	0.0071	0.0059	0.0073	0.0052	0.0034	0.0042	0.0036	0.0037	0.0036
Total Phosphorus (P)	mg/L	<0.30	<0.30	<0.30	0.0124	0.145	0.0189	0.012	0.022	0.0292	0.0376	0.0162	0.0135	0.0501	0.0416	0.0083
Sulphate (as SO_4)	mg/L	272	323	322	358	382	408	391	395	394	439	444	445	442	456	464
Sulfide (as H_2S)	mg/L	-	-	-	-	-	-	-	0.021	<0.018	<0.019	<0.019	0.0026	<0.0016	0.002	<0.011
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	0.02	<0.018	<0.018	<0.018	0.0024	<0.0015	0.0019	<0.010
Total Metals																
Aluminum (Al)-Total	mg/L	0.574	3.63	1.9	0.479	0.468	0.0143	0.117	0.682	0.0821	1.77	0.417	0.343	0.475	2.12	0.209
Antimony (Sb)-Total	mg/L	0.102	0.0678	0.0635	0.0561	0.0544	0.0423	0.0446	0.0321	0.043	0.0312	0.033	0.0323	0.0336	0.0302	0.0319
Arsenic (As)-Total	mg/L	0.0374	0.0568	0.0486	0.061	0.075	0.0611	0.0477	0.028	0.052	0.0419	0.0357	0.0287	0.0373	0.0468	0.0408
Barium (Ba)-Total	mg/L	0.13	0.128	0.0976	0.0476	0.0734	0.0387	0.0526	0.0611	0.0496	0.0784	0.0525	0.0554	0.0624	0.0553	0.0393
Beryllium (Be)-Total	mg/L	<0.00010	0.00057	0.00014	<0.00010	<0.00010	<0.00010	<0.000100	0.000111	<0.000100	0.00032	<0.000100	<0.000200	<0.000100	0.000411	<0.000200
Bismuth(Bi)- Total	mg/L	<0.000050	0.000119	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000061	<0.000050	<0.000100	<0.000050	0.000085	<0.000100
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	0.063	0.067	0.106	0.093	0.09	0.119	0.115	0.106
Cadmium (Cd)-Total	mg/L	0.0000186	0.0000908	0.000029	0.0000168	0.0000725	0.0000083	0.0000153	0.0000277	0.0000208	0.0000678	0.0000175	0.0000205	0.000044	0.0000786	0.0000272
Calcium (Ca)-Total	mg/L	65.9	92.4	93.3	95.9	93.5	118	84.4	92.9	91.3	120	99	104	107	119	112
Chromium (Cr)-Total	mg/L	0.00216	0.00304	0.00076	0.0005	0.00071	<0.00010	0.0034	0.0108	0.00382	0.0007	0.00974	0.00945	0.0222	0.0138	0.00508
Cobalt (Co)-Total	mg/L	0.00029	0.00087	0.00034	0.00018	0.00058	0.00013	0.00022	0.0006	0.00029	0.00076	0.00121	0.00045	0.0047	0.00467	0.0032
Copper (Cu)-Total	mg/L	0.00122	<0.0040	0.00166	0.00081	0.00434	<0.00050	0.00196	0.00396	0.00267	0.00234	0.00135	0.00253	0.00234	0.00488	0.00152
Iron (Fe)-Total	mg/L	0.672	1.95	0.782	0.207	1.56	0.037	0.181	0.584	0.158	1.25	0.256	0.253	0.438	0.974	0.135
Lead (Pb)-Total	mg/L	0.00126	0.00373	0.00128	0.000676	0.00277	0.000272	0.000869	0.00104	0.000802	0.00238	0.00107	0.000761	0.000874	0.00288	0.000472
Lithium (Li)-Total	mg/L	0.134	0.142	0.156	0.18	0.2	0.206	0.199	0.205	0.227	0.243	0.24	0.238	0.251	0.256	0.253
Magnesium (Mg)-Total	mg/L	12.7	14.5	12.6	13.4	13.2	14	12	12.9	12.9	15.6	13.7	14.5	16.1	15.8	15
Manganese (Mn)-Total	mg/L	0.128	0.296	0.242	0.277	0.3	0.265	0.171	0.149	0.191	0.31	0.0869	0.148	0.289	0.272	0.22
Mercury (Hg)-Total	mg/L	0.0000104	<0.00010	0.0000176	<0.0000050	0.0000148	<0.0000050	<0.0000050	0.0000053	<0.0000050	<0.000100	<0.0000050	<0.0000050	0.0000117	0.0000128	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00328	0.00168	0.00148	0.00208	0.00222	0.00192	0.00285	0.00392	0.00325	0.00281	0.00459	0.00507	0.00778	0.0051	0.00467
Nickel (Ni)-Total	mg/L	0.0007	0.00218	0.00107	0.00054	0.0009	<0.00050	0.00286	0.00724	0.0033	0.00101	0.0067	0.00638	0.0178	0.00984	0.00636
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.600	<0.300	<0.300	<0.600
Potassium (K)-Total	mg/L	21.4	4.1	3.6	3.34	3.53	3.29	3.28	3.83	3.82	4.04	3.89	3.8	4.22	4.1	3.93
Selenium (Se)-Total	mg/L	0.000674	0.000679	0.000561	0.000899	0.000691	0.000656	0.000498	0.000336	0.000527	0.000724	0.000543	0.000402	0.00065	0.000707	0.000582
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	4.44	2.97	6.11	3.83	3.78	3.9	6.7	3.15
Silver (Ag)-Total	mg/L	0.000147	0.000175	0.000131	0.000024	0.000159	0.000012	0.000037	0.000079	0.000022	0.000093	0.000047	0.00003	0.000442	0.000198	0.000147
Sodium (Na)-Total	mg/L	93.3	87.8	81	101	104	96.7	112	120	128	117	128	135	124	130	124
Strontium (Sr)-Total	mg/L	4.67	5.24	5.29	5.34	5.91	6.13	5.26	5.58	6.22	6.9	6.34	6.42	6.36	6.53	6.53
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000125	0.000143	0.000112	0.000107	0.000084	0.000105	0.000044	0.00004	0.000054	0.000108	0.000053	0.000036	0.000108	0.000109	0.000083
Tin (Sn)-Total	mg/L	0.00105	0.00061	0.00039	0.00047	0.00057	<0.00010	0.0002	0.00047	0.00023	0.00012	0.00013	0.00021	0.00022	0.00029	0.00028
Titanium (Ti)- Total	mg/L	-	-	-	-	-	-	-	<0.0100	<0.0100	0.015	<0.0100	<0.0200	<0.0100	0.0117	<0.0200
Uranium (U)-Total	mg/L	0.000915	0.00215	0.00118	0.00128	0.0012	0.00141	0.0014	0.00176	0.00137	0.00263	0.00197	0.00178	0.0021	0.00262	0.00209
Vanadium (V)-Total	mg/L	0.00104	0.00279	0.00199	0.00052	0.001	<0.00050	<0.00050	0.0007	<0.00050	0.00186	0.00054	<0.00100	0.00063	0.00164	<0.00100
Zinc (Zn)-Total	mg/L	0.0084	0.0155	0.0152	0.0043	0.0129	<0.0030	0.011	0.0162	0.0107	0.0063	0.0068	0.0139	0.0096	0.0118	0.006
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																
Aluminum (Al)-Dissolved	mg/L	0.0012	0.0028	0.0041	0.0022	0.0035	0.0036	0.0034	0.0032	0.003	0.0021	0.0026	0.0076	0.0021	0.002	0.0011
Antimony (Sb)-Dissolved	mg/L	0.1	0.081	0.0655	0.0578	0.0552	0.0425	0.0512	0.034	0.04	0.0325	0.0314	0.0326	0.0344	0.0337	0.0337
Arsenic (As)-Dissolved	mg/L	0.012	0.0511	0.0478	0.0589	0.0698	0.0639	0.0508	0.0252	0.0441	0.0394	0.0297	0.0258	0.0324	0.0427	0.0387
Barium (Ba)-Dissolved	mg/L	0.14	0.0444	0.0428	0.0404	0.0429	0.0424	0.0421	0.054	0.0505	0.0475	0.0471	0.0508	0.0455	0.0424	0.0336
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00020	<0.00010	<0.00010	<0.00020	<0.000200	<0.000100	<0.000100	<0.000100	<0.000100	<0.000200	<0.000100	<0.000200	<0.000200
Bismuth(Bi)- Dissolved	mg/L	<0.000050	<0.000050	<0.00010	<0.000050	<0.000050	<0.00010	<0.000100	<0.000050	<0.000050	<0.000050	<0.000050	<0.000100	<0.000050	<0.000100	<0.000100
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	0.066	0.055	0.104	0.09	0.084	0.12	0.105	0.103
Cadmium (Cd)-Dissolved	mg/L	<0.0000050	0.0000107	<0.000010	0.0000127	0.0000138	<0.000010	<0.0000100	0.0000148	0.0000079	0.0000086	<0.0000050	<0.0000100	0.000023	0.0000183	0.0000142
Calcium (Ca)-Dissolved	mg/L	45.3	85.5	89.9	99.4	99	111	87.8	92	86.2	114	108	92	109	116	113
Chromium (Cr)-Dissolved	mg/L	0.00125	0.00013	<0.00020	0.00013	<0.00010	<0.00020	0.00143	0.00047	0.00066	<0.00010	0.00034	<0.00100	<0.00050	<0.00100	0.00044
Cobalt (Co)-Dissolved	mg/L	<0.00010	0.00012	<0.00020	0.00012	0.00011	<0.00020	<0.00020	0.00014	0.00013	0.00021	0.0003	0.00021	0.0004	0.00073	0.00025
Copper (Cu)-Dissolved	mg/L	<0.00020	0.00039	<0.00040	0.00023	0.00162	0.00044	0.00102	0.00126	0.00064	<0.00020	0.00036	<0.00040	0.0006	0.00103	0.00042
Iron (Fe)-Dissolved	mg/L	<0.010	0.03	<0.020	<0.010	<0.010	<0.020	<0.020	0.013	0.012	<0.010	<0.010	<0.020	0.011	<0.020	<0.020
Lead (Pb)-Dissolved	mg/L	8.72	7.94	8.09	0.000224	0.000208	0.00022	0.000138	<0.000050	0.000123	0.0002	0.000097	0.00013	0.000288	0.000172	0.000177
Lithium (Li)-Dissolved	mg/L	0.127	0.149	0.158	0.197	0.201	0.187	0.216	0.21	0.226	0.251	0.228	0.222	0.26	0.282	0.261
Magnesium (Mg)-Dissolved	mg/L	9.72	12.5	13.7	13.3	14.1	15.6	12.1	13.1	13.3	16.7	13.7	13.4	15.5	15.9	14.1
Manganese (Mn)-Dissolved	mg/L	<0.00010	0.204	0.219	0.249	0.205	0.285	0.131	0.104	0.143	0.265	0.0258	0.0828	0.235	0.214	0.182
Mercury (Hg)-Dissolved	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.00368	0.00175	0.00149	0.00217	0.00212	0.00178	0.00299	0.00358	0.00333	0.00292	0.00345	0.00487	0.0056	0.00435	0.00429
Nickel (Ni)-Dissolved	mg/L	<0.00050	<0.00050	<0.0010	<0.00050	<0.00050	<0.0010	0.00223	0.00321	0.00225	<0.00050	0.00147	0.00405	0.00373	0.00396	0.0033
Phosphorus (P)- Dissolved	mg/L	-	-	-	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.600	<0.300	<0.600	<0.600
Potassium (K)-Dissolved	mg/L	30.5	3.53	3.15	3.23	3.32	3.39	3.34	3.82	3.78	4.05	3.4	3.68	4.23	3.63	3.39
Selenium (Se)-Dissolved	mg/L	0.000659	0.00059	0.00062	0.000761	0.000706	0.00061	0.000436	0.000408	0.000503	0.000667	0.000671	0.000419	0.000793	0.000544	0.00117
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	2.88	2.84	2.74	2.68	2.84	2.82	2.6	2.48
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000020	<0.000010	<0.000010	<0.000020	<0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000020	<0.000010	<0.000020	<0.000020
Sodium (Na)-Dissolved	mg/L	98.9	88.2	85.2	101	114	101	117	116	127	122	115	129	128	136	117
Strontium (Sr)-Dissolved	mg/L	4.09	5.26	5.49	5.13	6.19	5.93	5.32	5.64	5.84	6.61	6.39	6.28	6.5	6.62	6.65
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	0.000093	0.000076	0.000091	0.00009	0.000072	0.000096	0.000046	0.000026	0.00004	0.000054	0.000038	<0.000020	0.000089	0.000058	0.000076
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00020	<0.00010	<0.00010	<0.00020	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00020	<0.00010	<0.00020	<0.00020
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0200	<0.0100	<0.0200	<0.0200
Uranium (U)-Dissolved	mg/L	0.000239	0.00112	0.001	0.00111	0.00109	0.00134	0.0014	0.00144	0.00133	0.00204	0.00192	0.00173	0.00199	0.00192	0.0019
Vanadium (V)-Dissolved	mg/L	<0.00050	<0.00050	<0.0010	<0.00050	<0.00050	<0.0010	<0.00100	<0.00050	<0.00050	<0.00050	<0.00050	<0.00100	<0.00050	<0.00100	<0.00100
Zinc (Zn)-Dissolved	mg/L	<0.0010	0.0026	0.0083	0.0017	0.0034	0.0022	0.0094	0.01	0.0075	0.0014	0.0044	0.0107	0.0081	0.0073	0.0048
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	<20	<20	<20	<20	<20	<20	28	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW18-23B		Date														
		Aug 12, 2018	**Aug 26, 2018**	**Nov 14, 2018**	**Feb 19, 2019**	**May 28, 2019**	**Aug 08, 2019**	**Nov 13, 2019**	**07-Apr-2020**	**17-May-2020**	**30-Sep-2020**	**04-Jan-2021**	**Apr 24, 2021**	**Jun 23, 2021**	**Oct 09, 2021**	**Nov 15, 2021**
ALS COA Sample ID		**L2147510-2**	**L2154319-2**	**L2197889-2**	L2235495-1	L2282541-2	L2326407-1	L2383198-1	VA20A4588-001	VA20A6598-002	VA20B6993-001	VA21A0115-003	VA21A7804-006	VA21B2897-001	VA21C2526-003	VA21C5605-001
Field Parameters	**Unit**															
Temperature	°C	**4.3**	**3.1**	**2.9**	1.8	7.9	6.6	2.9	3.4	5.3	4.3	1.8	2.5	3.3	3.4	2.4
pH	pH	**7.43**	**8.42**	**7.88**	7.65	7.7	7.07	7.29	7.28	7.44	7.26	7.66	7.39	7.6	7.45	7.54
Specific conductance	µS/cm	**946**	**1036**	**1140**	1534	764	1320	1202	1536	769	836	1292	2325	816	767	1164
Dissolved Oxygen	mg/L	**-**	**-**	**-**	-	-	0.13	0.14	1.59	1.48	0.31	0.57	0.28	0.67	0.36	0.34
Oxidation Reduction Potential	mV	**-**	**-**	**-**	-	260.3	207.8	177.1	57.4	75.7	93.2	107.1	102.9	99.2	168.6	93.8
Turbidity	NTU	**802**	**130**	**1212**	2.4	1.54	23.49	0.12	7	4.01	4.54	21.6	10.77	7.63	4.12	19.54
Physical Tests																
Conductivity	uS/cm	**936**	**943**	**1180**	1490	737	1310	1200	1560	778	852	1290	2240	808	752	1140
Acidity (as CaCO3)	mg/L	**5.1**	**2**	**3.3**	4.7	1.9	1.4	3.2	3.4	2.5	-	3.6	4.7	3	<2.0	3.9
Total Alkalinity (as $CaCO_3$)	mg/L	**143**	**123**	**107**	85.9	69.4	123	90.7	105	77.7	130	90.4	96.8	88.2	121	98.2
Hardness (as CaCO3), dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	402	226	334	345	596	228	261	347
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	**344**	**364**	**361**	316	245	471	341	406	232	327	326	544	236	278	318
pH	pH	**7.82**	**8.21**	**7.98**	7.79	8	8.18	8.1	7.77	7.84	7.86	8.06	7.88	8.05	8.19	7.83
Total Dissolved Solids (TDS)	mg/L	**672**	**747**	**900**	979	483	943	856	1110	492	572	872	1330	518	423	724
Total Suspended Solids (TSS)	mg/L	**787**	**1270**	**1410**	<3.0	<3.0	<3.0	<3.0	137	72.8	3.8	5.4	19.7	8.6	4.3	10.7
Turbidity	NTU	**507**	**769**	**853**	0.22	0.54	0.39	0.17	47.6	4.06	0.61	1.58	7.55	3.06	2.59	2.36
Anions and Nutrients																
Total Kjeldahl Nitrogen (TKN)	mg/L	**-**	**-**	**-**	-	-	-	-	<1.50	1.5	<0.600	<3.26	7.4	0.38	<0.519	<2.13
Total Ammonia (as N)	mg/L	**0.41**	**0.627**	**0.79**	2.43	0.412	0.904	1.03	-	0.905	0.3	1.89	2.69	0.459	0.264	0.907
Bromide (Br)		**-**	**-**	**-**	-	-	-	-	<0.250	<0.050	<0.250	<0.250	<1.00	0.061	<0.250	<0.250
Chloride (Cl)	mg/L	**4.83**	**12.7**	**28.7**	39.6	62.3	87.1	34.6	44.5	44.8	53.3	28.4	339	75.8	30.4	23.9
Fluoride (F)	mg/L	**0.19**	**-**	**0.33**	0.69	0.27	0.34	0.38	0.584	0.342	0.204	0.459	<0.400	0.278	0.241	0.328
Nitrate (as N)	mg/L	**5.39**	**0.17**	**20.8**	40.3	3.69	11.3	27.9	42.4	5.18	3.24	32.4	38.4	3.69	5.4	23.1
Nitrate + Nitrite (as N)	mg/L	**-**	**-**	**-**	-	-	-	-	-	-	-	32.5	38.5	3.7	5.4	23.1
Nitrite (as N)	mg/L	**0.151**	**10.3**	**0.248**	0.0995	0.072	0.293	0.171	0.274	0.117	0.0236	0.113	0.119	0.0105	0.0052	0.0126
Total Nitrogen	mg/L	**-**	**-**	**-**	-	-	-	-	43.2	6.79	3.56	34.4	45.9	4.08	5.54	22.4
Dissolved Orthophosphate (as P)	mg/L	**0.0013**	**11.6**	**<0.0010**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus (P)	mg/L	**0.57**	**0.72**	**0.59**	0.0025	<0.0020	<0.0020	<0.0020	0.0352	0.0235	0.0046	0.0056	0.011	0.0082	0.0044	0.004
Sulphate (as SO_4)	mg/L	**335**	**346**	**342**	466	209	383	358	487	210	214	399	465	181	205	392
Sulfide (as H_2S)	mg/L	**-**	**-**	**-**	-	-	-	-	<0.018	0.02	<0.019	<0.019	<0.0016	<0.0016	0.0017	<0.011
Sulfide (as S)	mg/L	**-**	**-**	**-**	-	-	-	-	<0.018	0.019	<0.018	<0.018	<0.0015	<0.0015	0.0016	<0.010
Total Metals																
Aluminum (Al)-Total	mg/L	**12.2**	**11.9**	**19.9**	0.0037	0.0225	0.0077	0.007	3.11	0.518	0.0832	0.0966	0.284	0.114	0.0615	0.11
Antimony (Sb)-Total	mg/L	**0.00483**	**0.00695**	**0.00428**	0.00235	0.00168	0.00229	0.00219	0.00185	0.00204	0.00216	0.00221	0.00323	0.0023	0.00217	0.00216
Arsenic (As)-Total	mg/L	**0.0302**	**0.0395**	**0.0357**	0.00073	0.00038	0.00051	0.00043	0.00341	0.00117	0.00042	0.00062	0.00079	0.00046	0.00046	0.00045
Barium (Ba)-Total	mg/L	**0.207**	**0.388**	**0.391**	0.0172	0.0134	0.0159	0.016	0.0682	0.02	0.014	0.0166	0.0256	0.0131	0.0126	0.0167
Beryllium (Be)-Total	mg/L	**0.00221**	**0.00248**	**0.00452**	<0.00010	<0.00010	<0.00010	<0.00010	0.000582	0.00017	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	**0.00042**	**0.000475**	**0.000921**	<0.000050	<0.000050	<0.000050	<0.000050	0.000105	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	**-**	**-**	**-**	-	-	-	-	0.283	0.143	0.109	0.225	0.268	0.111	0.1	0.136
Cadmium (Cd)-Total	mg/L	**0.000244**	**0.000338**	**0.000265**	0.0000094	0.0000121	0.0000111	<0.000020	0.0000401	0.0000156	0.0000116	0.0000148	0.0000288	0.0000102	0.0000073	0.0000101
Calcium (Ca)-Total	mg/L	**167**	**153**	**156**	116	95.3	163	124	144	83.5	118	117	212	82.8	94	125
Chromium (Cr)-Total	mg/L	**0.00537**	**0.00524**	**0.00507**	<0.00010	<0.00010	<0.00010	<0.00010	0.0114	0.00064	<0.00010	<0.00010	<0.00050	<0.00050	<0.00050	<0.00010
Cobalt (Co)-Total	mg/L	**0.00569**	**0.0098**	**0.00667**	0.00014	<0.00010	0.00011	0.00014	0.00121	0.00022	0.0001	0.00017	0.00023	<0.00010	<0.00010	0.00013
Copper (Cu)-Total	mg/L	**0.0173**	**0.026**	**0.0241**	<0.00050	<0.00050	<0.00050	<0.00050	0.00427	0.00158	<0.00050	<0.00050	0.00059	<0.00050	<0.00050	<0.00050
Iron (Fe)-Total	mg/L	**18.4**	**34.3**	**20.4**	<0.010	0.013	<0.010	<0.010	1.54	0.26	0.031	0.042	0.149	0.057	0.037	0.049
Lead (Pb)-Total	mg/L	**0.0209**	**0.026**	**0.0363**	0.000064	0.000086	0.000078	0.000073	0.00391	0.00164	0.000115	0.000205	0.000472	0.000184	0.000161	0.000217
Lithium (Li)-Total	mg/L	**0.102**	**0.163**	**0.291**	0.446	0.095	0.181	0.236	0.5	0.161	0.0806	0.329	0.398	0.115	0.0905	0.227
Magnesium (Mg)-Total	mg/L	**15.3**	**14**	**14.5**	8.54	5.99	10.4	8.45	11.4	5.76	7.76	8.12	16.3	5.23	6.32	8.43
Manganese (Mn)-Total	mg/L	**0.828**	**1.13**	**0.863**	0.0831	0.0902	0.106	0.112	0.214	0.089	0.101	0.0884	0.176	0.0642	0.0767	0.0846
Mercury (Hg)-Total	mg/L	**0.00026**	**0.00023**	**<0.00050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000141	0.0000205	<0.0000050	<0.0000050	0.0000059	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	**0.00114**	**0.00239**	**0.00205**	0.00327	0.00161	0.00178	0.0221	0.00616	0.00256	0.0018	0.00342	0.00425	0.00318	0.00212	0.00267
Nickel (Ni)-Total	mg/L	**0.0071**	**0.00804**	**0.0065**	<0.00050	<0.00050	<0.00050	<0.00050	0.00744	0.00068	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Total	mg/L	**-**	**-**	**-**	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	**6.96**	**10.2**	**10.4**	12.8	5.31	7.15	8.16	14.4	6.65	5.21	11.4	15.3	5.85	5.86	9.58
Selenium (Se)-Total	mg/L	**0.0013**	**0.00175**	**0.00198**	0.00134	0.000828	0.000523	0.00134	0.000938	0.00112	0.000681	0.00158	0.000712	0.000563	0.000525	0.000911
Silicon (Si)-Total	mg/L	**-**	**-**	**-**	-	-	-	-	8.52	2.48	2.35	1.79	2.64	1.78	1.97	1.97
Silver (Ag)-Total	mg/L	**0.00133**	**0.00275**	**0.00185**	<0.000010	<0.000010	<0.000010	<0.000010	0.000074	0.000028	<0.000010	<0.000010	0.000018	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	mg/L	**46.5**	**69.9**	**131**	186	43.5	98.8	111	193	54.4	56.9	133	251	64.5	56.7	104
Strontium (Sr)-Total	mg/L	**2.16**	**2.45**	**2.1**	1.38	0.944	1.85	1.22	1.74	0.956	1.21	1.3	2.69	0.902	0.914	1.28
Sulfur (S)-Total	mg/L	**-**	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	**0.000256**	**0.000307**	**0.000403**	0.000062	0.000036	0.000056	0.000055	0.000113	0.000041	0.00003	0.000057	0.000078	0.000028	0.000027	0.000045
Tin (Sn)-Total	mg/L	**0.00051**	**0.00044**	**0.00038**	<0.00010	<0.00010	<0.00010	<0.00010	0.00035	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	**-**	**-**	**-**	-	-	-	-	0.0141	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Total	mg/L	**0.00426**	**0.00443**	**0.009**	0.00105	0.000399	0.00189	0.000794	0.00256	0.00078	0.00168	0.00139	0.00222	0.000721	0.00118	0.00126
Vanadium (V)-Total	mg/L	**0.0102**	**0.0106**	**0.0118**	<0.00050	<0.00050	<0.00050	<0.00050	0.00196	0.00053	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	**0.0416**	**0.0836**	**0.06**	<0.0030	<0.0030	<0.0030	<0.0030	0.0137	0.0041	<0.0030	<0.0030	0.0057	<0.0030	<0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	**-**	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																
Aluminum (Al)-Dissolved	mg/L	**0.0023**	**0.0053**	**0.0025**	<0.0010	0.0013	<0.0010	0.0014	0.0051	<0.0010	<0.0010	<0.0010	0.0025	0.001	0.0012	<0.0010
Antimony (Sb)-Dissolved	mg/L	**0.005**	**0.00887**	**0.00595**	0.00238	0.00163	0.00219	0.00216	0.00201	0.00193	0.00214	0.00215	0.00297	0.00216	0.00211	0.00241
Arsenic (As)-Dissolved	mg/L	**0.00084**	**0.00124**	**0.00093**	0.00076	0.00031	0.00049	0.00042	0.0005	0.00038	0.00038	0.00044	0.00048	0.00034	0.0003	0.00039
Barium (Ba)-Dissolved	mg/L	**0.0263**	**0.0273**	**0.0206**	0.018	0.0122	0.0159	0.0167	0.0181	0.0105	0.0132	0.0151	0.0244	0.0127	0.0125	0.016
Beryllium (Be)-Dissolved	mg/L	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000100	<0.000200	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000100	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	0.314	0.121	0.108	0.233	0.261	0.111	0.098	0.123
Cadmium (Cd)-Dissolved	mg/L	**0.000016**	**0.0000091**	**0.0000114**	0.0000088	0.0000056	0.0000069	0.0000118	0.000016	0.0000092	0.0000066	0.0000078	0.0000198	0.0000081	0.0000092	0.0000118
Calcium (Ca)-Dissolved	mg/L	**121**	**129**	**129**	113	88.6	168	122	144	80.2	121	125	192	84.6	102	114
Chromium (Cr)-Dissolved	mg/L	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	0.00015	<0.00010	0.00024	0.0002	<0.00010	<0.00010	<0.00100	<0.00050	<0.00050	<0.00010
Cobalt (Co)-Dissolved	mg/L	**0.00016**	**0.0001**	**0.00013**	0.00014	<0.00010	0.00011	0.00014	0.00015	<0.00010	<0.00010	0.00014	<0.00020	<0.00010	<0.00010	0.00011
Copper (Cu)-Dissolved	mg/L	**0.00096**	**0.00042**	**0.00028**	0.00026	<0.00020	0.00112	0.00023	0.00254	0.00042	<0.00020	0.00023	0.00066	0.00025	<0.00020	0.00055
Iron (Fe)-Dissolved	mg/L	**<0.010**	**<0.010**	**<0.010**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.010	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	**0.000084**	**0.00007**	**0.00006**	0.000063	<0.000050	0.000055	0.000051	0.000147	<0.000050	<0.000050	<0.000050	<0.000100	<0.000050	<0.000050	0.000056
Lithium (Li)-Dissolved	mg/L	**0.0903**	**0.149**	**0.282**	0.441	0.0937	0.188	0.216	0.51	0.163	0.0857	0.324	0.377	0.127	0.0952	0.209
Magnesium (Mg)-Dissolved	mg/L	**9.96**	**10.3**	**9.23**	8.12	5.79	12.4	8.8	10.7	6.18	7.81	7.96	15.8	6.15	5.77	8.03
Manganese (Mn)-Dissolved	mg/L	**0.163**	**0.142**	**0.111**	0.0809	0.0862	0.108	0.108	0.106	0.0708	0.103	0.0858	0.158	0.0686	0.0723	0.0852
Mercury (Hg)-Dissolved	mg/L	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	**0.000762**	**0.00206**	**0.00237**	0.00321	0.00152	0.00176	0.00178	0.00582	0.00344	0.0019	0.00331	0.00392	0.00308	0.00209	0.00277
Nickel (Ni)-Dissolved	mg/L	**0.00083**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00100	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	<0.300	<0.300	<0.300	<0.300	<0.600	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	**4.97**	**9.66**	**8.57**	11.6	5.17	7.82	8.54	12.9	7.13	5.59	11.1	14.4	6.52	5.39	8.74
Selenium (Se)-Dissolved	mg/L	**0.000664**	**0.000673**	**0.000952**	0.00253	0.00109	0.000525	0.00128	0.00118	0.00104	0.000689	0.00217	0.000517	0.000528	0.000799	0.00105
Silicon (Si)-Dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	1.74	1.4	1.91	1.52	1.92	1.5	1.74	1.59
Silver (Ag)-Dissolved	mg/L	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	2.11	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000020	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	**44.8**	**78.1**	**134**	172	43.6	108	111	183	62.1	58	131	238	72.5	54.4	99.8
Strontium (Sr)-Dissolved	mg/L	**1.86**	**2.24**	**2.04**	1.41	0.931	1.68	1.28	1.82	0.976	1.22	1.31	2.63	0.924	1.03	1.31
Sulfur (S)-Dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	**0.000043**	**0.000045**	**0.000047**	0.000065	0.000031	0.000048	0.000054	0.000057	0.000038	0.000031	0.00005	0.000063	0.000029	0.000024	0.000039
Tin (Sn)-Dissolved	mg/L	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	0.00015	<0.00010	<0.00010	<0.00010	<0.00020	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	<0.0100	<0.0100	<0.0100	<0.0100	<0.0200	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	**0.00162**	**0.00134**	**0.00208**	0.00104	0.000409	0.00163	0.000819	0.0017	0.000664	0.00178	0.00124	0.0023	0.000812	0.00116	0.00115
Vanadium (V)-Dissolved	mg/L	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00100	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	**0.0042**	**0.0021**	**<0.0010**	<0.0010	<0.0010	0.0011	<0.0010	0.0044	0.004	0.0012	<0.0010	0.0065	<0.0010	<0.0010	0.0022
Zirconium (Zr)-Dissolved	mg/L	**-**	**-**	**-**	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																
Chemical Oxygen Demand (COD)	mg/L	**-**	**-**	**-**	-	-	-	-	<20	<20	<20	<20	<20	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW16-5A		Date																	
		Aug 04, 2016	**Sep 22, 2017**	**Dec 03, 2017**	**Mar 21, 2018**	**May 13, 2018**	**Aug 28, 2018**	**Nov 14, 2018**	**Feb 24, 2019**	**May 28, 2019**	**Sep 19, 2019**	**04-Dec-2019**	**03-Jun-2020**	**31-Oct-2020**	**22-Jan-2021**	**Apr 25, 2021**	**Jun 26, 2021**	**Oct 10, 2021**	**Nov 14, 2021**
ALS COA Sample ID		L1809476-1	L1996612-1	L2030932-1	L2071981-2	L2094675-1	L2156735-1	L2197889-1	L2237095-1	L2282542-1	L2352491-2	VA19A0405-00	VA20A7728-00	VA20B9840-00	VA21A1383-00	VA21A7804-00	VA21B3123-00	VA21C2526-00	VA21C5536-00
Field Parameters	**Unit**																		
Temperature	°C	-	2.8	1.6	1.3	3.8	3.7	1.5	1.5	3.5	3	0.8	4.4	1.4	1.7	5.1	5.8	4.3	3
pH	pH	-	7.76	7.74	7.67	7.64	7.62	7.60	7.52	7.57	7.59	7.55	7.57	7.47	7.51	7.61	7.48	7.57	7.59
Specific conductance	µS/cm	-	924	951	883	652	947	895	989	786	819	842	656	763	758	697	780	842	834
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	0.16	0.24	0.26	4.8	0.41	0.26	0.23	0.29	0.34
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	-	23.2	-179.4	-108	-82.3	51.5	-35.2	-30.7	-38.9	-74.3	-66.2
Turbidity	NTU	-	183	-	14.4	2.77	23	3.30	7.03	4.5	3.16	6.20	1.5	11.76	5.23	0.44	2.04	0.78	3.5
Physical Tests																			
Conductivity	uS/cm	807	847	872	898	641	962	951	960	784	964	819	678	811	729	697	774	825	858
Acidity (as CaCO3)	mg/L	4.5	2.1	3.6	3	1	2.6	5.3	3.7	1.4	2.6	5.2	3	<2.0	2.6	3.5	3.3	<2.0	3.2
Total Alkalinity (as $CaCO_3$)	mg/L	106	110	112	109	99.7	102	93.4	98.5	96	105	104	100	103	94.6	97	96	92.1	96.5
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	338	455	385	386	382	451	449
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	435	438	499	482	338	565	612	564	402	496	450	364	414	394	359	394	456	425
pH	pH	7.8	8.04	7.98	8.02	7.9	7.67	7.77	7.77	8.04	8.1	7.89	7.91	7.83	7.91	7.95	8.01	8.11	7.88
Total Dissolved Solids (TDS)	mg/L	599	668	702	667	471	773	807	770	593	679	576	512	562	534	468	625	598	576
Total Suspended Solids (TSS)	mg/L	148	227	39.3	21.5	7.5	33.5	19.6	10.6	5.6	<3.0	4.7	5.1	12.6	11.6	<3.0	<3.0	<3.0	17.5
Turbidity	NTU	83.8	137	13.3	13	4.62	8.19	3.64	4.41	2.42	0.84	3.70	1.38	6.64	8.26	0.39	0.36	0.82	6.24
Anions and Nutrients																			
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.399	0.116	0.154	0.106	0.137	0.123	0.127
Total Ammonia (as N)	mg/L	0.253	0.161	0.138	0.15	0.0839	0.0739	0.0561	0.102	0.0811	<0.0050	0.120	0.103	0.0924	0.132	0.0946	0.0974	0.105	0.104
Bromide (Br)	mg/L												<0.250	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250
Chloride (Cl)	mg/L	4.8	7.7	7.2	6.4	3.3	4.4	2.8	2.7	<2.5	<2.5	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50
Fluoride (F)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Nitrate (as N)	mg/L	1	1.31	0.074	0.1	0.042	0.107	0.054	<0.025	<0.025	1.17	<0.0250	<0.0250	<0.0250	<0.0250	<0.0250	<0.0250	<0.0250	<0.0250
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.0255	<0.0255	<0.0255	<0.0255	<0.0255
Nitrite (as N)	mg/L	0.0345	0.0224	<0.0050	<0.0050	<0.0050	0.0092	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.006	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrogen, Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.416	0.133	0.154	0.106	0.137	0.123	0.127
Dissolved Orthophosphate (as P)	mg/L	<0.0010	0.0061	0.0043	0.005	0.003	0.0032	0.0031	0.0037	<0.0010	0.0018	<0.0010	0.0014	0.003	0.0016	0.0013	0.0013	0.0012	0.0028
Total Phosphorus (P)	mg/L	0.0424	0.193	0.0388	0.0191	0.0093	0.028	0.0147	0.0129	0.0081	0.0048	0.0085	0.0146	0.0263	0.0176	<0.0020	<0.0020	0.003	0.0299
Sulfate (as SO_4)	mg/L	309	385	397	379	242	439	441	448	317	435	355	266	346	303	287	340	367	370
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.019	<0.019	<0.0016	<0.0016	<0.0016	<0.011
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.018	<0.0015	<0.0015	<0.0015	<0.010
Total Metals																			
Aluminum (Al)-Total	mg/L	0.405	2.54	0.414	0.204	0.107	0.305	0.163	0.137	0.0273	0.0204	0.0364	0.0344	0.191	0.11	0.0042	0.0039	0.0056	0.0348
Antimony (Sb)-Total	mg/L	0.00407	0.00326	0.00381	0.00197	0.00286	0.00273	0.00276	0.0019	0.00171	0.0006	0.00069	0.00117	0.00094	0.00049	0.00106	0.00098	0.00099	0.00085
Arsenic (As)-Total	mg/L	0.0011	0.00384	0.00101	0.00085	0.00076	0.00086	0.00067	0.00073	0.00102	0.00055	0.00093	0.0008	0.00105	0.00113	0.00089	0.00086	0.00092	0.00114
Barium (Ba)-Total	mg/L	0.048	0.0903	0.0495	0.0471	0.0261	0.0349	0.0329	0.0304	0.0207	0.0331	0.0234	0.0219	0.0288	0.0296	0.017	0.0193	0.0198	0.0225
Beryllium (Be)-Total	mg/L	<0.00010	0.00016	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000020	<0.000100	<0.000100	<0.000100	<0.000200
Bismuth(Bi)- Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000100
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.036	0.034	0.039	0.037	0.036	0.034	0.032
Cadmium (Cd)-Total	mg/L	0.0000263	0.000236	0.0000261	0.0000238	0.0000097	0.0000137	0.0000084	0.0000178	<0.0000050	<0.0000050	0.0000059	0.0000056	0.0000183	0.0000107	<0.0000050	<0.0000050	<0.0000050	<0.0000100
Calcium (Ca)-Total	mg/L	141	153	158	152	101	149	179	173	128	188	142	115	132	127	125	122	147	147
Chromium (Cr)-Total	mg/L	0.00157	0.00673	0.00151	0.00059	0.00038	0.00082	0.00049	0.00134	0.00012	0.00019	0.00374	0.00703	0.00084	0.0098	0.00116	0.00059	0.00117	0.00191
Cobalt (Co)-Total	mg/L	0.00082	0.00408	0.00104	0.00069	0.00043	0.0008	0.00067	0.00062	0.00035	<0.00010	0.00044	0.00052	0.00073	0.00078	0.00032	0.00063	0.00037	0.00042
Copper (Cu)-Total	mg/L	0.00171	0.00875	0.00151	0.00115	0.00056	0.0009	0.00067	0.00062	<0.00050	0.00058	0.00493	0.00234	0.00069	0.00078	0.00051	<0.00050	0.00144	<0.00100
Iron (Fe)-Total	mg/L	0.728	3.96	0.579	0.299	0.165	0.465	0.263	0.284	0.132	0.023	0.212	0.144	0.417	0.351	0.052	0.053	0.081	0.193
Lead (Pb)-Total	mg/L	0.00168	0.00327	0.000507	0.000251	0.000304	0.000295	0.000173	0.000166	0.00111	0.000067	0.000313	0.000258	0.000299	0.00105	0.000081	0.000086	0.000175	0.00019
Lithium (Li)-Total	mg/L	0.0164	0.0187	0.0152	0.0129	0.0123	0.0136	0.0163	0.0136	0.0136	0.0123	0.0147	0.0134	0.0127	0.0125	0.0127	0.0131	0.0129	0.0137
Magnesium (Mg)-Total	mg/L	23.1	24.2	26.6	26	17	24.7	28.7	26.8	20.6	7.23	23.1	18.5	20.3	18.7	18	18.9	20.4	19.9
Manganese (Mn)-Total	mg/L	0.211	0.548	0.294	0.289	0.152	0.193	0.201	0.195	0.143	0.00315	0.172	0.17	0.165	0.186	0.102	0.115	0.131	0.135
Mercury (Hg)-Total	mg/L	<0.0000050	<0.000025	0.0000071	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.00103	0.00137	0.000816	0.00114	0.000294	0.000314	0.000291	0.000346	0.000232	0.000271	0.000958	0.0014	0.000259	0.00204	0.000312	0.000294	0.000352	0.000452
Nickel (Ni)-Total	mg/L	0.00098	0.00463	0.00126	0.00116	<0.00050	0.00092	0.00064	0.00064	<0.00050	<0.00050	0.00343	0.00495	0.00062	0.00701	0.00092	0.00084	0.0011	0.00197
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.050	<0.300	<0.300	<0.300	<0.600
Potassium (K)-Total	mg/L	1.85	2.18	1.83	1.87	1.46	1.58	1.77	1.68	1.52	2.76	1.64	1.56	1.51	1.6	1.51	1.59	1.6	1.63
Selenium (Se)-Total	mg/L	0.000065	0.000188	0.000104	0.000054	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000221	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000100
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	2.73	2.87	2.78	2.74	2.9	2.65	2.67
Silver (Ag)-Total	mg/L	0.000017	0.000088	0.000022	0.000016	0.000014	0.000016	0.000011	0.000013	0.000011	<0.000010	<0.000010	<0.000010	0.000014	<0.000010	<0.000010	<0.000010	<0.000010	<0.000020
Sodium (Na)-Total	mg/L	7.54	8.23	8.32	8.35	6.46	6.93	8.32	7.97	7.55	15.2	7.88	7.26	6.92	6.59	6.58	6.46	6.75	6.77
Strontium (Sr)-Total	mg/L	5.27	5.51	6.03	5.84	3.76	5.42	6.71	5.88	4.86	1.02	5.85	4.94	5.23	5.07	4.4	4.58	4.96	5.16
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	104	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000016	0.000103	0.000027	0.000025	0.000016	0.000018	0.000015	0.000016	<0.000010	<0.000010	<0.000010	0.000012	0.000015	0.000015	<0.000010	<0.000010	<0.000010	<0.000020
Tin (Sn)-Total	mg/L	<0.00010	0.00019	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00052	0.00028	<0.00010	0.0001	<0.00010	<0.00010	<0.00010	<0.00020
Titanium (T)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	0.00114	<0.0100	<0.0100	<0.0100	<0.0200
Uranium (U)-Total	mg/L	0.000309	0.000983	0.000578	0.000671	0.000268	0.000419	0.000439	0.000401	0.000262	0.00138	0.000372	0.000299	0.000332	0.000373	0.000275	0.000278	0.000334	0.000348
Vanadium (V)-Total	mg/L	0.0008	0.00369	0.00073	0.0005	<0.00050	0.00052	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00100
Zinc (Zn)-Total	mg/L	0.0182	0.0487	0.0091	0.0133	0.0031	0.0064	0.0091	0.0032	<0.0030	<0.0030	0.0134	0.0156	0.0036	0.0292	0.0052	0.0036	<0.0030	<0.0060
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.00020	-	-	-	-
Dissolved Metals																			
Aluminum (Al)-Dissolved	mg/L	0.0072	0.0048	0.0267	0.0029	0.003	0.0022	0.002	0.0022	0.0026	0.0012	0.0032	0.0072	0.0025	0.0045	0.0024	0.0015	0.0015	0.0025
Antimony (Sb)-Dissolved	mg/L	0.00405	0.00345	0.00312	0.00203	0.00275	0.00287	0.00278	0.00194	0.00171	0.00059	0.00045	0.00093	0.00096	0.00042	0.00102	0.00094	0.00089	0.00075
Arsenic (As)-Dissolved	mg/L	0.00058	0.00047	0.00057	0.00057	0.00051	0.00046	0.00044	0.00053	0.00094	0.00048	0.00079	0.00071	0.00087	0.00099	0.0008	0.00084	0.00081	0.00084
Barium (Ba)-Dissolved	mg/L	0.0361	0.048	0.0448	0.0422	0.0247	0.0322	0.0278	0.0271	0.0197	0.0339	0.0239	0.021	0.0234	0.0276	0.0192	0.0197	0.0196	0.0209
Beryllium (Be)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000100	<0.000020	<0.000100	<0.000100	<0.000100	<0.000200
Bismuth(Bi)- Dissolved	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000100
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.039	0.036	0.037	0.035	0.037	0.032	0.032
Cadmium (Cd)-Dissolved	mg/L	0.0000055	0.0000281	0.0000193	0.0000188	0.0000054	<0.0000050	<0.0000050	0.0000095	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000100
Calcium (Ca)-Dissolved	mg/L	137	140	158	152	108	182	196	181	128	187	141	106	145	120	115	127	149	140
Chromium (Cr)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00019	0.00099	0.0033	<0.00010	0.00128	<0.00050	<0.00050	0.00069	0.00081
Cobalt (Co)-Dissolved	mg/L	0.00035	0.00076	0.00065	0.00045	0.00032	0.00043	0.00044	0.00044	0.00031	<0.00010	0.00036	0.00041	0.00037	0.00057	0.00027	0.00047	0.00032	0.0003
Copper (Cu)-Dissolved	mg/L	0.00022	0.00025	0.00059	0.00042	0.00039	<0.00020	0.00021	0.0004	<0.00020	0.00041	0.00075	0.00096	<0.00020	0.00021	0.00052	0.00023	0.00085	<0.00040
Iron (Fe)-Dissolved	mg/L	0.111	0.011	0.048	<0.010	0.017	0.035	0.031	0.024	0.09	<0.010	0.111	0.079	0.052	0.156	0.048	0.045	0.064	0.059
Lead (Pb)-Dissolved	mg/L	0.000054	0.00006	0.000125	<0.000050	0.000057	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000056	0.000076	<0.000050	0.000092	<0.000050	0.000088	0.000146	<0.000100
Lithium (Li)-Dissolved	mg/L	0.0148	0.0134	0.0136	0.0123	0.0128	0.0143	0.0153	0.0162	0.0133	0.011	0.0147	0.0132	0.0131	0.0123	0.0125	0.0137	0.0136	0.0136
Magnesium (Mg)-Dissolved	mg/L	22.7	21.4	25.8	25.1	16.7	26.6	30.1	27.1	19.7	7.05	22.7	18	22.5	20.8	17.4	18.6	20.3	18.4
Manganese (Mn)-Dissolved	mg/L	0.142	0.314	0.266	0.257	0.155	0.194	0.186	0.179	0.139	0.00072	0.174	0.16	0.159	0.179	0.098	0.115	0.127	0.136
Mercury (Hg)-Dissolved	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Dissolved	mg/L	0.000869	0.00103	0.000789	0.00119	0.000386	0.000277	0.000201	0.000277	0.000203	0.000259	0.000637	0.00113	0.000199	0.00145	0.000297	0.000263	0.000354	0.000558
Nickel (Ni)-Dissolved	mg/L	<0.00050	0.00084	0.00075	0.00079	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00181	0.0036	<0.00050	0.00393	0.00071	0.00066	0.00078	0.00134
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.050	<0.300	<0.300	<0.300	<0.600
Potassium (K)-Dissolved	mg/L	1.73	1.8	1.78	1.82	1.49	1.89	1.77	1.7	1.61	2.81	1.66	1.61	1.75	1.7	1.6	1.65	1.5	1.5
Selenium (Se)-Dissolved	mg/L	0.000051	0.00008	0.00006	0.000096	<0.000050	<0.000050	<0.000050	<0.000050	0.000515	0.00024	0.000124	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000100
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	2.78	2.66	2.66	2.71	2.81	2.49	2.6
Silver (Ag)-Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	0.000014	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000020
Sodium (Na)-Dissolved	mg/L	7.02	7.82	7.64	7.9	6.98	7.6	8.69	8.24	7.73	15.1	7.48	7.4	7.43	7.02	6.38	6.65	7	6.35
Strontium (Sr)-Dissolved	mg/L	5	5.17	5.81	6.19	4.12	6.54	7.7	6.65	4.88	1.01	5.62	4.34	5.3	5.24	4.47	4.69	5.13	5.09
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	107	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.000010	0.000036	0.00002	0.00002	0.000012	0.000012	0.000011	0.000011	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000020
Tin (Sn)-Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00020
Titanium (T)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.00030	<0.0100	<0.0100	<0.0100	<0.0200
Uranium (U)-Dissolved	mg/L	0.000267	0.000592	0.000553	0.000685	0.000262	0.000399	0.000375	0.000387	0.000273	0.00142	0.000338	0.000268	0.000344	0.000365	0.000283	0.000285	0.000311	0.000348
Vanadium (V)-Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00100
Zinc (Zn)-Dissolved	mg/L	0.0027	0.003	0.0045	0.0087	0.0036	0.001	0.0031	0.0018	<0.0010	<0.0010	0.0045	0.0152	0.0012	0.0306	0.0065	0.0047	0.0021	0.0039
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.00020	-	-	-	-
Aggregate Organics																			
Chemical Oxygen Demand	mg/L	-	-	-	-	-	-	-	-	-	-	-	<20	<20	<20	<20	<20	<20	<20

Notes:
Sample results in red indicate turbidity measured between 50 and 200 NTU
Sample results in **red bold** indicated turbidity measured above 200 NTU
Sample results highlighted yellow have pH values measured above 8.5

Appendix G: Summary of Groundwater Quality Analytical Results

BJ-GW16-5B		Date																	
		Aug 04, 2016	**Sep 22, 2017**	**Nov 30, 2017**	**Mar 21, 2018**	**May 14, 2018**	**Aug 28, 2018**	**Nov 13, 2018**	**Mar 05, 2019**	**May 28, 2019**	**Oct 26, 2019**	**Nov 18, 2019**	**27-May-2020**	**30-Oct-2020**	**22-Jan-2021**	**Apr 25, 2021**	**Jun 23, 2021**	**Oct 10, 2021**	**Nov 15, 2021**
ALS COA Sample ID		L1809476-2	**L1996612-2**	L2030148-1	L2071981-1	**L2095665-1**	**L2156735-2**	**L2197248-1**	L2241458-1	L2282542-2	L2373056-3	L2384942-2	VA20A7334-00	VA20B9840-00	VA21A1383-00	VA21A7804-00	VA21B2897-00	VA21C2526-00	VA21C5605-002
Field Parameters	**Unit**																		
Temperature	°C	-	**3.1**	0.2	1.1	**2.8**	**3.8**	**1.0**	2.7	2.8	4.4	2.4	2.7	2	1.1	1.9	3.2	2.7	2.5
pH	pH	-	**7.67**	7.67	7.64	**7.58**	**7.55**	**7.32**	7.52	7.41	7.24	7.24	7.47	7.14	7.32	7.44	7.26	7.38	7.43
Specific conductance	µS/cm	-	**824.3**	896	883	**1004**	**1167**	**1021**	1223	1161	954	780	623	797	963	993	1137	816	799
Dissolved Oxygen	mg/L	-	-	-	-	-	-	-	-	-	6.98	7.97	9.76	7.14	2.4	12.06	5.08	6.22	5.86
Oxidation Reduction Potential	mV	-	-	-	-	-	-	-	211.6	1507	155.7	288.1	78	138.6	172.2	181	155.1	209.5	180.4
Turbidity	NTU	-	**378**	34	13.9	**770**	**832**	**150**	29	9.26	7.20	0.52	0.99	4.86	10.11	12.76	25.47	6.32	5.39
Physical Tests																			
Conductivity	uS/cm	1010	**751**	839	889	**975**	**1120**	**1130**	1230	1150	864	751	617	794	929	984	1110	789	788
Acidity (as CaCO3)	mg/L	5.8	**3.8**	3.9	4.2	**3.6**	**3.2**	**4.6**	5.6	2.7	3.2	3.8	3.1	3.1	3.4	4.2	4.3	2.2	4.6
Total Alkalinity (as $CaCO_3$)	mg/L	98.7	**107**	109	106	**105**	**103**	**91.1**	92.6	81	98	111	92.8	87.1	96.4	73.8	87.8	91.8	92.1
Hardness (as $CaCO_3$), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	305	441	512	562	592	420	403
Hardness (as $CaCO_3$), as total Ca/Mg	mg/L	532	**363**	462	477	**509**	**664**	**619**	651	581	426	354	292	404	525	533	606	430	393
pH	pH	7.67	**7.94**	7.94	7.9	**8.01**	**7.58**	**7.92**	7.69	7.93	8.05	7.94	7.98	7.94	7.81	7.8	7.9	8.1	7.75
Total Dissolved Solids (TDS)	mg/L	764	**560**	672	659	**794**	**956**	**1000**	986	949	641	586	440	592	742	753	871	531	598
Total Suspended Solids (TSS)	mg/L	304	**274**	117	23.9	**1150**	**544**	**281**	53.1	13.8	5.5	<3.0	<3.0	<3.0	6.4	<3.0	4.6	<3.0	<3.0
Turbidity	NTU	63.6	**226**	119	16	**1050**	**312**	**323**	55.6	7.62	2.63	0.4	0.32	0.3	1.41	0.15	0.61	1.72	0.41
Anions and Nutrients																			
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.133	<0.050	<0.050	0.146	<0.078	<0.063	<0.057
Total Ammonia (as N)	mg/L	0.124	**0.052**	0.0793	0.0527	**0.023**	**0.015**	**0.0122**	0.0097	<0.0050	0.106	<0.0050	0.0078	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.050	<0.250	<0.250	<0.250	<0.250	<0.250	<0.250
Chloride (Cl)	mg/L	3.5	**9.5**	5.7	5.8	**3.1**	**3.1**	**2.5**	<2.5	<2.5	0.94	<2.5	3.2	<2.50	<2.50	<2.50	<2.50	<2.50	<2.50
Fluoride (F)	mg/L	<0.10	**<0.10**	<0.10	<0.10	**<0.10**	**<0.10**	**<0.10**	<0.10	<0.10	0.026	<0.10	0.066	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Nitrate (as N)	mg/L	9.96	**4.98**	2.15	1.35	**2.78**	**3.25**	**2.26**	0.722	1.71	<0.0050	0.418	1.28	0.643	0.384	0.254	0.807	0.638	0.552
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	0.391	0.254	0.807	0.638	0.552
Nitrite (as N)	mg/L	0.0372	**0.0288**	0.0524	0.0173	**0.0061**	**0.0066**	**0.0088**	<0.0050	<0.0050	<0.0010	<0.0050	0.0028	<0.0050	0.0067	<0.0050	<0.0050	<0.0050	<0.0050
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	1.42	0.645	0.403	0.4	0.801	0.635	0.575
Dissolved Orthophosphate (as P)	mg/L	<0.0010	**0.0021**	0.0079	0.0077	**0.0015**	**0.0022**	**0.0025**	0.0069	<0.0010	<0.0010	<0.0010	0.0036	0.0025	0.0035	0.0027	0.0026	0.0031	0.0031
Total Phosphorus (P)	mg/L	0.435	**0.12**	0.06	0.0121	**0.619**	**0.344**	**0.135**	0.0194	0.0218	0.0084	0.0052	0.0062	<0.0020	0.0053	0.0038	0.0036	0.0061	0.0046
Sulfate (as SO_4)	mg/L	398	**288**	364	365	**444**	**540**	**547**	599	548	379	319	222	346	435	310	557	341	339
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.019	<0.019	<0.0016	<0.0016	<0.0016	<0.011
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.018	<0.018	<0.018	<0.0015	<0.0015	<0.0015	<0.010
Total Metals																			
Aluminum (Al)-Total	mg/L	4.38	**3.67**	1.57	0.0171	**13.9**	**7.24**	**4.53**	0.461	0.184	0.099	0.0115	0.0061	0.006	0.0534	0.0065	0.0109	0.0196	0.0077
Antimony (Sb)-Total	mg/L	0.00302	**0.00307**	0.00115	0.00028	**0.00642**	**0.00507**	**0.0037**	0.00045	0.00052	0.00096	0.00063	0.00058	0.00058	0.00055	0.00051	0.00054	0.00071	0.00062
Arsenic (As)-Total	mg/L	0.0832	**0.0656**	0.0199	0.00082	**0.273**	**0.144**	**0.0962**	0.0043	0.00141	0.00091	0.00058	0.00062	0.00043	0.00067	0.00044	0.0005	0.00068	0.00065
Barium (Ba)-Total	mg/L	0.239	**0.173**	0.0999	0.0374	**0.861**	**0.428**	**0.233**	0.0583	0.0565	0.0246	0.0279	0.0245	0.0328	0.0396	0.0376	0.0413	0.03	0.0295
Beryllium (Be)-Total	mg/L	0.00053	**0.0005**	0.00019	<0.00010	**0.0016**	**0.00089**	**0.00058**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000020	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Total	mg/L	0.000166	**0.000139**	<0.000050	<0.000050	**0.000549**	**0.000314**	**0.00017**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.022	0.028	0.027	0.024	0.025	0.028	0.025
Cadmium (Cd)-Total	mg/L	0.0000613	**0.0000419**	0.0000509	0.0000128	**0.000204**	**0.000135**	**0.0000557**	0.0000299	0.0000422	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000095
Calcium (Ca)-Total	mg/L	193	**137**	168	175	**191**	**207**	**219**	266	241	152	148	111	152	198	213	224	159	152
Chromium (Cr)-Total	mg/L	0.00245	**0.00231**	0.00111	0.00014	**0.00905**	**0.00561**	**0.0033**	0.00062	0.00043	0.00278	0.00068	<0.00010	<0.00010	<0.00010	<0.00050	<0.00050	<0.00050	0.00024
Cobalt (Co)-Total	mg/L	0.0249	**0.0198**	0.00697	0.00015	**0.0836**	**0.0453**	**0.0252**	0.00103	0.0002	0.00052	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	0.00011	<0.00010
Copper (Cu)-Total	mg/L	0.082	**0.0684**	0.0221	0.00057	**0.284**	**0.137**	**0.0796**	0.00367	0.00161	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00057	0.00064
Iron (Fe)-Total	mg/L	10.9	**9.89**	3.4	0.018	**41**	**21.2**	**14.1**	0.551	0.188	0.235	0.012	0.01	<0.010	0.029	<0.010	0.019	0.041	0.021
Lead (Pb)-Total	mg/L	0.0135	**0.00993**	0.00284	<0.000050	**0.0418**	**0.0236**	**0.0125**	0.000601	0.000531	0.000149	<0.000050	<0.000050	<0.000050	0.000052	<0.000050	<0.000050	0.000054	0.000068
Lithium (Li)-Total	mg/L	0.0146	**0.0148**	0.0095	0.0066	**0.0264**	**0.0218**	**0.0181**	0.0106	0.0104	0.0146	0.0103	0.0076	0.0094	0.0104	0.0097	0.0108	0.0103	0.0099
Magnesium (Mg)-Total	mg/L	11.4	**7.14**	8.46	8.99	**13.4**	**11.6**	**11.1**	13.1	8.43	24.2	5.84	3.88	5.91	7.45	7.37	8	5.61	5.6
Manganese (Mn)-Total	mg/L	1.99	**1.56**	0.796	0.0633	**8.39**	**4.01**	**2.07**	0.0837	0.0208	0.195	0.00172	0.0309	0.00042	0.00499	0.00111	0.00609	0.0121	0.00207
Mercury (Hg)-Total	mg/L	0.00009	**0.000248**	0.0000858	<0.0000050	**0.00085**	**0.0005**	**0.0003**	0.0000127	0.0000064	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.000962	**0.00125**	0.00291	0.00114	**0.00486**	**0.00261**	**0.00215**	0.000583	0.00027	0.00069	0.000281	0.00201	0.000325	0.000490	0.00027	0.000401	0.000394	0.000352
Nickel (Ni)-Total	mg/L	0.012	**0.00917**	0.0037	0.00058	**0.0381**	**0.0202**	**0.0122**	0.00117	<0.00050	0.00317	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.050	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Total	mg/L	2	**1.78**	1.43	0.991	**3.34**	**2.78**	**3.09**	1.82	2.47	1.7	2.62	1.95	2.4	2.42	2.67	3.14	3.13	2.67
Selenium (Se)-Total	mg/L	0.000377	**0.000193**	0.000131	0.000065	**0.000555**	**0.00035**	**0.000326**	0.000153	0.000411	<0.000050	0.000115	0.000258	0.000217	0.000224	0.000201	0.000315	0.000266	0.000195
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	2.25	2.49	2.53	2.45	2.58	2.7	2.51
Silver (Ag)-Total	mg/L	0.000144	**0.000121**	0.000058	<0.000010	**0.000478**	**0.000341**	**0.000209**	0.000019	0.000032	0.000013	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	mg/L	13.2	**13.7**	17.2	11.9	**12.5**	**15**	**18.2**	13.8	15	8.02	11.2	13.1	8.71	9.82	7.71	10.2	8.34	7.78
Strontium (Sr)-Total	mg/L	1.12	**0.821**	1.03	1.05	**1.06**	**1.2**	**1.31**	1.6	1.19	6.29	0.823	0.603	0.874	1.09	1.12	1.26	0.839	0.807
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	153	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000134	**0.000106**	0.000054	0.000015	**0.000353**	**0.000214**	**0.000114**	0.000029	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	mg/L	0.00012	**0.00022**	<0.00010	<0.00010	**0.00021**	**0.00042**	**0.00015**	<0.00010	0.00016	0.00025	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	0.00051	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Total	mg/L	0.000654	**0.00067**	0.000922	0.000733	**0.0014**	**0.0015**	**0.0014**	0.00114	0.0013	0.000354	0.00117	0.000824	0.000988	0.00138	0.0011	0.00158	0.00112	0.00108
Vanadium (V)-Total	mg/L	0.00742	**0.00637**	0.00279	<0.00050	**0.0239**	**0.0134**	**0.00826**	0.00084	0.00051	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	0.0323	**0.0305**	0.0133	<0.0030	**0.113**	**0.0654**	**0.0411**	0.0038	0.0038	0.0137	0.0052	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0116
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.00020	-	-	-	-
Dissolved Metals																			
Aluminum (Al)-Dissolved	mg/L	0.0012	**0.0046**	0.0013	0.0017	**0.002**	**0.0015**	**0.0011**	0.0023	0.0012	0.0034	0.0033	0.0012	0.0012	0.0018	0.0011	0.001	<0.0010	0.0016
Antimony (Sb)-Dissolved	mg/L	0.0003	**0.00029**	0.00026	0.00027	**0.00028**	**0.00032**	**0.00039**	0.0003	0.00044	0.00063	0.00056	0.00056	0.00057	0.00056	0.0005	0.00056	0.00067	0.00068
Arsenic (As)-Dissolved	mg/L	0.00047	**0.00051**	0.0006	0.00062	**0.00065**	**0.00058**	**0.00056**	0.00072	0.00037	0.00081	0.00043	0.00059	0.0005	0.00054	0.00037	0.00048	0.0004	0.00053
Barium (Ba)-Dissolved	mg/L	0.0536	**0.029**	0.0367	0.0354	**0.0416**	**0.0486**	**0.0488**	0.0383	0.0441	0.0225	0.0263	0.0238	0.0328	0.0400	0.0401	0.0423	0.0297	0.0304
Beryllium (Be)-Dissolved	mg/L	<0.00010	**<0.00010**	<0.00010	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000100	<0.000100	<0.000020	<0.000100	<0.000100	<0.000100	<0.000100
Bismuth(Bi)- Dissolved	mg/L	<0.000050	**<0.000050**	<0.000050	<0.000050	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	0.023	0.03	0.028	0.023	0.028	0.026	0.023
Cadmium (Cd)-Dissolved	mg/L	0.0000084	**0.0000061**	0.000014	0.0000141	**0.0000061**	**0.0000103**	**0.0000076**	0.0000136	0.0000073	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000113
Calcium (Ca)-Dissolved	mg/L	197	**135**	171	177	**190**	**250**	**232**	242	219	136	133	116	166	192	201	229	164	148
Chromium (Cr)-Dissolved	mg/L	0.00019	**0.00019**	<0.00010	<0.00010	**<0.00010**	**<0.00010**	**0.00011**	<0.00010	<0.00010	0.00081	0.00108	<0.00010	<0.00010	<0.00010	<0.00050	<0.00050	<0.00050	0.00013
Cobalt (Co)-Dissolved	mg/L	0.00019	**<0.00010**	0.00019	0.00011	**<0.00010**	**0.00032**	**0.00029**	0.00018	<0.00010	0.00032	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Dissolved	mg/L	0.00074	**0.00074**	0.00065	0.00039	**0.00103**	**0.00082**	**0.00066**	0.00043	0.00057	<0.00020	0.00046	0.00025	0.0003	0.00098	0.00035	0.00037	0.00027	0.00081
Iron (Fe)-Dissolved	mg/L	0.02	**<0.010**	<0.010	<0.010	**<0.010**	**<0.010**	**<0.010**	<0.010	<0.010	0.13	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lead (Pb)-Dissolved	mg/L	<0.000050	**<0.000050**	<0.000050	<0.000050	**<0.000050**	**<0.000050**	**<0.000050**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Dissolved	mg/L	0.0086	**0.0088**	0.0075	0.0056	**0.0076**	**0.0114**	**0.0107**	0.0101	0.01	0.0135	0.0097	0.0083	0.0102	0.0100	0.0094	0.0114	0.0109	0.0096
Magnesium (Mg)-Dissolved	mg/L	9.9	**6.16**	8.42	8.67	**8.71**	**9.79**	**9.87**	11.1	8.27	21	5.46	4.06	6.27	7.95	7.65	8.25	5.04	5.62
Manganese (Mn)-Dissolved	mg/L	0.0268	**0.0223**	0.105	0.0615	**0.0255**	**0.0902**	**0.111**	0.055	0.00241	0.181	0.00067	0.0309	<0.00010	0.00453	0.00012	0.00278	0.00127	0.0004
Mercury (Hg)-Dissolved	mg/L	<0.0000050	**<0.0000050**	<0.0000050	<0.0000050	**<0.0000050**	**<0.0000050**	**<0.0000050**	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000074
Molybdenum (Mo)-Dissolved	mg/L	0.000487	**0.000575**	0.00176	0.00119	**0.00191**	**0.000721**	**0.00145**	0.000917	0.000257	0.000454	0.000364	0.002	0.000317	0.000536	0.000283	0.000378	0.000396	0.00042
Nickel (Ni)-Dissolved	mg/L	0.00077	**<0.00050**	<0.00050	<0.00050	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	0.00098	<0.00050	<0.00050	<0.00050	0.00051	<0.00050	<0.00050	<0.00050	<0.00050
Phosphorus (P)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.300	<0.300	<0.050	<0.300	<0.300	<0.300	<0.300
Potassium (K)-Dissolved	mg/L	1.09	**1.12**	0.945	0.999	**1.2**	**1.91**	**2.08**	1.54	2.53	1.61	2.44	2.07	2.79	2.50	2.83	3.22	2.86	2.66
Selenium (Se)-Dissolved	mg/L	0.000277	**0.000191**	0.00012	0.000097	**0.000553**	**0.00027**	**0.000258**	0.000144	0.000576	0.00115	0.000199	0.000351	0.000235	0.000189	0.000223	0.000351	0.000191	0.000218
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	2.03	2.43	2.43	2.35	2.72	2.46	2.34
Silver (Ag)-Dissolved	mg/L	<0.000010	**<0.000010**	<0.000010	<0.000010	**<0.000010**	**<0.000010**	**<0.000010**	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Dissolved	mg/L	13	**14.8**	14.6	11.2	**13.1**	**16.4**	**19.2**	13.7	15	7.68	10.6	13.6	9.3	10.4	7.63	10.1	8.4	7.88
Strontium (Sr)-Dissolved	mg/L	1.09	**0.798**	0.955	1.08	**1.05**	**1.37**	**1.39**	1.54	1.16	5.2	0.766	0.606	0.881	1.14	1.14	1.23	0.864	0.866
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	155	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	<0.000010	**<0.000010**	0.000016	0.000016	**<0.000010**	**0.000016**	**0.000014**	0.000016	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Dissolved	mg/L	<0.00010	**<0.00010**	<0.00010	<0.00010	**<0.00010**	**<0.00010**	**<0.00010**	<0.00010	<0.00010	0.00015	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	<0.0100	<0.0100	<0.00030	<0.0100	<0.0100	<0.0100	<0.0100
Uranium (U)-Dissolved	mg/L	0.000519	**0.000542**	0.00068	0.000764	**0.000884**	**0.00105**	**0.00117**	0.00108	0.00137	0.000319	0.00107	0.000799	0.00106	0.00142	0.00118	0.00146	0.00106	0.00109
Vanadium (V)-Dissolved	mg/L	<0.00050	**<0.00050**	<0.00050	<0.00050	**<0.00050**	**<0.00050**	**<0.00050**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Dissolved	mg/L	0.0021	**<0.0010**	0.0013	0.001	**0.0029**	**0.0012**	**0.002**	0.0012	0.0011	0.0046	<0.0010	<0.0010	<0.0010	0.0075	<0.0010	<0.0010	<0.0010	0.015
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.00020	-	-	-	-
Aggregate Organics																			
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	<20	<20	<20	<20	<20	<20	<20

Notes:

Sample results in red indicated turbidity measured between 50 and 200 NTU

Sample results in **red bold** indicated turbidity measured above 200 NTU

Sample results highlighted yellow have pH values measured above 8.5

Appendix H
Groundwater Quality Statistics

NEWCREST

BJ-GW11-1A		Baseline Period (2011 - 2014)						2016						2017						2018						2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																										
Temperature	°C	0	0	-	-	-	-	3	3	0.4	2.5	1.6	2	4	4	1.6	2.6	2.3	2.55	4	4	0.7	2.9	1.9	1.9	4	4	0.1	7	4.2	5.6	3	3	1.2	6.2	3.5	3	3	3	0.7	9.3	4.4	3.1
pH	pH	0	0	-	-	-	-	3	3	7.8	8	7.87	7.8	4	4	7.9	8.2	8.03	8	4	4	7.7	7.9	7.8	7.8	4	4	7.7	7.96	7.79	7.71	3	3	7.56	8.09	7.8	7.7	3	3	7.71	8.03	7.84	7.77
Specific Sonductance	µS/cm	0	0	-	-	-	-	3	3	196	247	220.7	219	4	4	230	246	241.5	245	4	4	216	298	242.8	228.5	4	4	288.3	308.9	296.4	292	3	3	222.9	257.1	240	241.1	3	3	129.1	268.1	178.8	139.3
Dissolved Oxygen	mg/L	0	0	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	2	2	4.86	6.84	5.85	5.85	3	3	2.56	8.8	6.6	8.41	3	3	1.06	11.56	7.9	11
Oxidation Reduction Potential	mV	0	0	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	3	3	99.4	126.1	117	125.5	3	3	27.4	133.7	82	83.6	3	3	70.3	131.6	97.7	91.2
Turbidity	NTU	0	0	-	-	-	-	0	-	-	-	-	-	4	4	20.5	985	275.7	48.55	2	2	60	626	343	343	3	3	4.88	45	19.33	8.1	3	3	10.73	59	34	31.77	3	3	29.5	49	37.87	35.1
Physical Tests																																											
Conductivity	uS/cm	1	1	45	45	45	45	3	3	166	245	211	222	4	4	231	244	237	236.5	4	4	227	298	253.8	245	4	4	196	316	267.3	278.5	3	3	236	259	250	243	3	3	129	268	180	144
Acidity (as CaCO3)	mg/L	1	1	1.8	1.8	1.8	1.8	3	3	1.4	1.7	1.533	1.5	4	4	1.1	2.4	1.9	2.05	4	3	1	2.8	1.875	1.85	4	4	1.4	2.7	2.15	2.25	3	0	2	2	2	2	3	1	2	2.3	2.1	2
Total Alkalinity (as $CaCO_3$)	mg/L	1	1	29	29	29	29	3	3	48	92	72	76	4	4	66	77	72	72.5	4	4	69	91	77	74	4	4	55.6	104	81.5	83.2	3	3	67.6	80.3	72	67.9	3	3	41.1	72.3	52	43.2
hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	106	139	120	110	3	3	55.4	99.1	74.7	69.5
Hardness (as $CaCO_3$), from total Ca/Mg	mg/L	1	1	160	160	160	160	3	3	84	104	96.67	102	4	4	87	103	94.5	94	4	4	109	114	110.8	110	4	4	92.5	146	122.6	126	3	3	93.2	124	110	106	3	3	58.2	95.2	73.67	67.6
pH	pH	1	1	8	8	8	8	3	3	7.8	8	7.93	8	4	4	7.9	8.1	8.03	8.05	4	4	7.8	8.1	7.98	8	4	4	7.94	8.13	8.06	8.08	3	3	7.95	8.05	8	8	3	3	7.68	7.91	7.8	7.83
Total Dissolved Solids (TDS)	mg/L	1	1	59	59	59	59	3	3	106	170	142.7	152	4	4	143	179	157.5	154	4	4	154	242	195.5	193	4	4	123	205	171	178	3	3	151	177	160	154	3	3	81	182	119	94
Total Suspended Solids (TSS)	mg/L	1	1	32	32	32	32	3	3	42	1740	825.3	694	4	4	14	998	289	72	4	4	12	1080	414.5	283	4	4	5.5	37.3	22.25	23.1	3	3	4.9	133	52	19.2	3	3	24.7	63.4	46.97	52.8
Turbidity	NTU	1	1	34	34	34	34	3	3	22	1940	749.7	287	4	4	7.6	867	248.9	60.5	4	4	10	2690	765	180	4	4	7.3	37.6	22.31	22.16	3	3	4.4	72.7	34	24.7	3	3	8.86	66.7	45	59.4
Anions and Nutrients																																											
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.085	0.062	0.05	3	1	0.05	0.6	0.2827	0.198
Total Ammonia (as N)	mg/L	1	1	0.028	0.028	0.028	0.028	3	0	0.005	0.005	0.005	0.005	4	0	0.005	0.005	0.005	0.005	4	1	0.005	0.007	0.0055	0.005	4	0	0.005	0.005	0.005	0.005	3	0	0.005	0.005	0.005	0.005	3	1	0.005	0.0204	0.01	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	3	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	1	1	0.66	0.66	0.66	0.66	3	0	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	4	1	0.5	0.76	0.565	0.5	4	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	3	1	0.5	0.72	0.5733	0.5
Fluoride (F)	mg/L	1	1	0.039	0.039	0.039	0.039	3	3	0.032	0.09	0.053	0.037	4	4	0.035	0.17	0.092	0.0805	4	4	0.037	0.12	0.071	0.064	4	4	0.033	0.114	0.061	0.048	3	3	0.043	0.103	0.064	0.045	3	3	0.028	0.119	0.062	0.039
Nitrate (as N)	mg/L	1	1	0.014	0.014	0.014	0.014	3	3	0.022	0.11	0.07	0.067	4	4	0.028	0.39	0.18	0.1525	4	4	0.052	0.39	0.20	0.169	4	4	0.0405	0.554	0.18	0.05	3	3	0.0205	0.881	0.31	0.0368	3	3	0.0246	1.31	0.464	0.0585
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.881	0.881	0.88	0.881	3	3	0.0246	1.31	0.4644	0.0585
Nitrite (as N)	mg/L	1	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	4	2	0.001	0.0028	0.001	0.00105	4	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.032	0.85	0.31	0.058	3	2	0.03	1.25	0.512	0.256
Dissolved Orthophosphate (as P)	mg/L	1	0	0.001	0.001	0.001	0.001	3	3	0.0012	0.0014	0.0013	0.0014	4	3	0.001	0.0021	0.0015	0.00145	4	2	0.001	0.0019	0.0015	0.00145	4	2	0.001	0.0015	0.0012	0.0011	3	2	0.001	0.0016	0.0013	0.0013	3	2	0.001	0.0026	0.001567	0.0011
Total Phosphorus (P)	mg/L	1	1	0.032	0.032	0.032	0.032	3	3	0.019	1.8	0.65	0.14	4	4	0.0066	1.1	0.31	0.0605	4	4	0.015	0.72	0.37	0.3645	4	4	0.0068	0.0419	0.024	0.024	3	3	0.006	0.0846	0.037	0.0206	3	3	0.0057	0.0571	0.03	0.0271
Sulphate (SO_4)	mg/L	1	1	19	19	19	19	3	3	32	51	42.3	44	4	4	46	48	46.8	46.5	4	4	48	58	53.3	53.5	4	4	41.1	68.4	57.7	60.6	3	3	46.8	50.4	48	48.1	3	3	22.4	55.3	34.2	25
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.019	0.023	0.02	0.019	3	0	0.0016	0.011	0.004733	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.018	0.022	0.019	0.018	3	0	0.0015	0.01	0.0043	0.0015
Total Metals																																											
Aluminum (Al)-Total	mg/L	1	1	0.8	0.8	0.8	0.8	3	3	1	20	9.50	7.5	4	4	0.25	11	3.06	0.5	4	4	0.45	19	8.09	6.45	4	4	0.178	0.791	0.51	0.54	3	3	0.0723	2.73	1.2	0.774	3	3	0.124	1.06	0.728	1
Antimony (Sb)-Total	mg/L	1	1	0.00086	0.00086	0.00086	0.00086	3	3	0.0015	0.011	0.0051	0.0028	4	4	0.0016	0.011	0.0042	0.0021	4	4	0.0013	0.011	0.0041	0.00205	4	4	0.00138	0.00226	0.0018	0.002	3	3	0.00141	0.00661	0.0035	0.0024	3	3	0.0015	0.00717	0.0041	0.00354
Arsenic (As)-Total	mg/L	1	1	0.0059	0.0059	0.0059	0.0059	3	3	0.011	0.62	0.24	0.077	4	4	0.0073	0.33	0.095	0.0215	4	4	0.0098	0.27	0.079	0.0185	4	4	0.00501	0.0199	0.012	0.011	3	3	0.00303	0.0964	0.038	0.0145	3	3	0.00574	0.0249	0.0185	0.0248
Barium (Ba)-Total	mg/L	1	1	0.058	0.058	0.058	0.058	3	3	0.058	3.5	1.3	0.46	4	4	0.048	1.3	0.43	0.195	4	4	0.06	9.1	2.7	0.755	4	4	0.0249	0.159	0.077	0.061	3	3	0.0332	1.16	0.42	0.0785	3	3	0.026	0.0836	0.06247	0.0778
Beryllium (Be)-Total	mg/L	1	0	0.001	0.001	0.001	0.001	3	2	0.0001	0.0022	0.0011	0.00097	4	2	0.0001	0.00084	0.0003	0.000125	4	2	0.0001	0.0012	0.00043	0.0002	4	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	1	0.00076	0.0021	0.00092	0.0001
Bismuth(Bi)- Total	mg/L	1	0	0.2	0.2	0.2	0.2	3	2	0.00005	0.0005	0.00026	0.00024	4	1	0.00005	0.00017	0.00008	0.00005	4	2	0.00005	0.00018	0.0001	0.000085	4	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	1	0.00005	0.000091	0.0006637	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.01	0.028	0.016	0.01	3	1	0.01	0.035	0.01833	0.01
Cadmium (Cd)-Total	mg/L	1	1	0.000061	0.000061	0.000061	0.000061	3	3	0.000036	0.012	0.0042	0.00048	4	4	0.000048	0.0032	0.00094	0.000265	4	4	0.000092	0.0038	0.0011	0.000345	4	4	0.0000401	0.000228	0.00012	0.00010	3	3	0.0000256	0.00157	0.00057	0.0000996	3	3	0.0000405	0.000227	0.00014	0.000138
Calcium (Ca)-Total	mg/L	1	1	17	17	17	17	3	3	29	63	47.7	51	4	4	30	36	34.3	35.5	4	4	38	313	108	40.5	4	4	34.1	51.2	42.7	42.7	3	3	31.8	40.5	36	36.4	3	3	19.2	33.4	25.9	25.1
Chromium (Cr)-Total	mg/L	1	1	0.0013	0.0013	0.0013	0.0013	3	3	0.00059	0.014	0.0057	0.0026	4	4	0.00038	0.005	0.0016	0.0005	4	4	0.00036	0.028	0.011	0.0077	4	3	0.0008	0.00876	0.00444	0.0039	3	3	0.0014	0.0292	0.012	0.00453	3	3	0.00382	0.0161	0.01071	0.0122
Cobalt (Co)-Total	mg/L	1	1	0.00049	0.00049	0.00049	0.00049	3	3	0.00066	0.049	0.018	0.0049	4	4	0.00034	0.02	0.006	0.00174	4	4	0.00041	0.021	0.011	0.01065	4	4	0.00016	0.001	0.00056	0.00054	3	3	0.00016	0.00499	0.002	0.00094	3	3	0.00153	0.00181	0.0016	0.00158
Copper (Cu)-Total	mg/L	1	1	0.012	0.012	0.012	0.012	3	3	0.0016	0.17	0.062	0.014	4	4	0.00081	0.063	0.018	0.0041	4	4	0.0013	0.075	0.032	0.0255	4	4	0.0012	0.00584	0.0034	0.0033	3	3	0.00174	0.0183	0.0077	0.00312	3	3	0.00117	0.0129	0.00674	0.00616
Iron (Fe)-Total	mg/L	1	1	1	1	1	1	3	3	0.98	59	23	8.6	4	4	0.44	31	8.4	1.09	4	4	0.55	40	16	12.15	4	4	0.265	1.47	0.87	0.88	3	3	0.118	6	2.4	1.1	3	3	0.262	2.37	1.537	1.98
Lead (Pb)-Total	mg/L	1	1	0.0017	0.0017	0.0017	0.0017	3	3	0.0016	0.16	0.06	0.017	4	4	0.00077	0.067	0.018	0.00305	4	4	0.0013	0.056	0.019	0.00965	4	4	0.000588	0.00318	0.0019	0.002	3	3	0.000232	0.0172	0.0071	0.00378	3	3	0.000718	0.00615	0.0038	0.0044
Lithium (Li)-Total	mg/L	1	1	0.0073	0.0073	0.0073	0.0073	3	3	0.002	0.055	0.022	0.0095	4	4	0.0036	0.046	0.024	0.02395	4	4	0.005	0.071	0.028	0.0185	4	4	0.0026	0.0335	0.014	0.011	3	3	0.0039	0.0282	0.014	0.0088	3	3	0.0013	0.032	0.0121	0.0029
Magnesium (Mg)-Total	mg/L	1	1	1.2	1.2	1.2	1.2	3	3	2.4	12	6.8	6	4	4	3.3	6.9	4.7	4.35	4	4	3.7	179	50	9.35	4	4	2.59	7.28	5	5.00	3	3	3.34	5.58	4.2	3.77	3	3	1.66	3.81	2.423	1.8
Manganese (Mn)-Total	mg/L	1	1	0.08	0.08	0.08	0.08	3	3	0.1	28	9.8	1.2	4	4	0.13	7.7	2.2	0.54	4	4	0.2	10	4.8	4.505	4	4	0.0657	0.544	0.23	0.15	3	3	0.0236	4.21	1.5	0.218	3	3	0.0786	0.371	0.26	0.341
Mercury (Hg)-Total	mg/L	1	1	0.000011	0.000011	0.000011	0.000011	3	2	0.000005	0.00015	0.000061	0.000027	4	1	0.000005	0.000098	0.000028	0.000005	4	2	0.000005	0.00016	0.000078	0.0000725	4	0	0.000005	0.000005	0.000005	0.000005	3	1	0.000005	0.0000243	0.000011	0.000005	3	2	0.000005	0.0000122	0.00000913	0.0000102
Molybdenum (Mo)-Total	mg/L	1	0	0.001	0.001	0.001	0.001	3	3	0.00029	0.0019	0.00093	0.00059	4	4	0.00034	0.0017	0.00071	0.0004	4	4	0.00042	0.004	0.0018	0.001415	4	4	0.000245	0.00147	0.00089	0.00092	3	3	0.000772	0.00433	0.002	0.000898	3	3	0.000805	0.0026	0.001458	0.00092
Nickel (Ni)-Total	mg/L	1	1	0.0012	0.0012	0.0012	0.0012	3	2	0.0005	0.024	0.0092	0.0031	4	2	0.0005	0.009	0.0027	0.000635	4	3	0.0005	0.16	0.044	0.00744	4	3	0.0005	0.0057	0.0027	0.0023	3	3	0.00226	0.0182	0.0078	0.00288	3	3	0.00247	0.00842	0.0055	0.00547
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	3	1	0.059	0.3	0.22	0.3
Potassium (K)-Total	mg/L	1	0	2	2	2	2	3	3	0.78	5	2.6	2.1	4	4	0.72	3.3	1.6	1.275	4	4	0.83	16	5.9	3.4	4	4	0.576	1.48	1.1	1.19	3	3	0.638	1.87	1.4	1.74	3	3	0.414	1.71	1.015	0.921
Selenium (Se)-Total	mg/L	1	0	0.001	0.001	0.001	0.001	3	3	0.00026	0.00063	0.00042	0.00037	4	4	0.00011	0.00037	0.00028	0.00031	4	4	0.0003	0.00037	0.00034	0.00035	4	4	0.000185	0.000379	0.00031	0.00034	3	3	0.000291	0.000474	0.00036	0.000304	3	3	0.000248	0.000342	0.00028	0.000254
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	2.02	5.74	3.6	3	3	3	1.47	3.58	2.47	2.35
Silver (Ag)-Total	mg/L	1	1	0.00011	0.00011	0.00011	0.00011	3	3	0.00032	0.019	0.0069	0.0013	4	4	0.000083	0.0075	0.0021	0.00046	4	4	0.0001	0.0065	0.0018	0.000285	4	4	0.000067	0.000387	0.0002	0.00016	3	3	0.000034	0.00211	0.00079	0.000221	3	3	0.000144	0.000698	0.000437	0.000469
Sodium (Na)-Total	mg/L	1	1	2.6	2.6	2.6	2.6	3	3	0.76	9.4	4	1.8	4	4	1.5	16	7.3	5.85	4	4	1.9	327	88	11.5	4	4	1.19	12.1	5.3	4.03	3	3	1.62	11.7	5.4	2.75	3	3	0.333	13.3	5.2	2
Strontium (Sr)-Total	mg/L	1	1	0.21	0.21	0.21	0.21	3	3	0.27	0.97	0.6	0.55	4	4	0.46	0.76	0.63	0.645	4	4	0.55	3.3	1.4	0.85	4	4	0.319	1	0.71	0.77	3	3	0.499	0.739	0.65	0.699	3	3	0.143	0.739	0.343	0.146
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	1	0	0.0002	0.0002	0.0002	0.0002	3	3	0.000031	0.0016	0.00062	0.00022	4	4	0.000015	0.00075	0.00021	0.0000295	4	4	0.000026	0.00099	0.0003	0.000087	4	4	0.00001	0.000059	0.00003	0.000026	3	2	0.00001	0.00036	0.00014	0.000038	3	2	0.00001	0.000048	0.00003367	0.000043
Tin (Sn)-Total	mg/L	1	1	0.004	0.004	0.004	0.004	3	3	0.00024	0.00077	0.00047	0.00039	4	1	0.0001	0.00047	0.00019	0.0001	4	4	0.00019	0.0016	0.0011	0.0014	4	3	0.0001	0.00081	0.00036	0.00027	3	0	0.0001	0.0001	0.0001	0.0001	3	2	0.0001	0.00494	0.0017	0.00011
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0.01	0.0534	0.025	0.011	3	2	0.01	0.0184	0.0136	0.0124
Uranium (U)-Total	mg/L	1	0	0.0002	0.0002	0.0002	0.0002	3	3	0.00011	0.0024	0.0014	0.0016	4	4	0.000049	0.00051	0.0002	0.0001225	4	4	0.000055	0.0072	0.002	0.000378	4	4	0.00004	0.000101	0.00007	0.000069	3	3	0.000043	0.000128	0.00008	0.00007	3	3	0.000025	0.000084	0.00005667	0.000061
Vanadium (V)-Total	mg/L	1	1	0.0011	0.0011	0.0011	0.0011	3	3	0.0014	0.03	0.013	0.0072	4	3	0.0005	0.018	0.0051	0.00091	4	4	0.00091	0.036	0.019	0.01875	4	3	0.0005	0.00144	0.00099	0.0010	3	2	0.0005	0.00481	0.0023	0.00157	3	2	0.0005	0.0021	0.0014	0.00171
Zinc (Zn)-Total	mg/L	1	1	0.039	0.039	0.039	0.039	3	3	0.012	2	0.7	0.089	4	4	0.011	0.54	0.16	0.0445	4	4	0.017	0.74	0.23	0.0745	4	4	0.0139	0.047	0.025	0.021	3	3	0.0084	0.253	0.097	0.0305	3	3	0.0094	0.0591	0.0351	0.0369
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																											
Aluminum (Al)-Dissolved	mg/L	1	1	0.034	0.034	0.034	0.034	3	3	0.0015	0.41	0.143	0.018	4	4	0.0012	0.0049	0.003	0.0021	4	4	0.0016	0.0061	0.003	0.0023	4	4	0.0011	0.0037	0.003	0.0029	3	2	0.001	0.0021	0.0016	0.0018	3	2	0.001	0.0572	0.02	0.0026
Antimony (Sb)-Dissolved	mg/L	1	1	0.0008	0.0008	0.0008	0.0008	3	3	0.0011	0.0014	0.0012	0.0012	4	4	0.0011	0.002	0.0015	0.00135	4	4	0.0012	0.0014	0.0013	0.0013	4	4	0.00109	0.00144	0.0013	0.0013	3	3	0.00124	0.00186	0.0015	0.00136	3	3	0.00131	0.00307	0.00224	0.00234
Arsenic (As)-Dissolved	mg/L	1	1	0.0071	0.0011	0.0011	0.0011	3	3	0.0027	0.0038	0.0033	0.0033	4	4	0.0025	0.003	0.0028	0.00285	4	4	0.0028	0.0039	0.0032	0.00305	4	4	0.00209	0.00304	0.0026	0.0027	3	3	0.00189	0.00341	0.0028	0.00313	3	3	0.00276	0.00426	0.00331	0.00291
Barium (Ba)-Dissolved	mg/L	1	1	0.028	0.028	0.028	0.028	3	3	0.021	0.037	0.026	0.021	4	4	0.016	0.021	0.018	0.0165	4	4	0.016	0.024	0.019	0.018	4	4	0.0147	0.0226	0.019	0.020	3	3	0.0176	0.0202	0.019	0.0191	3	3	0.0116	0.0223	0.018	0.0208
Beryllium (Be)-Dissolved	mg/L	1	0	0.001	0.001	0.001	0.001	3	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	0

BJ-GW11-1B		Baseline Period (2011 - 2014)						2016							2017							2018						2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																												
Temperature	°C	0	0	-	-	-	-	2	2	1.8	2.1	1.95	2	1.95	3	3	0	2.8	1.733333333	1.7	2.4	2	2	1.4	1.7	1.6	1.55	1	1	1.7	1.7	1.7	1.7	1	1	5.2	5.2	5.2	5.2	5.2	1	1	5.4	5.4	5.4	5.4
pH	pH	0	0	-	-	-	-	2	2	8	8.1	8.05	8.05	8.05	3	3	8	8.1	8	8	8	2	2	7.7	8	7.85	7.85	1	1	7.78	7.78	7.78	7.78	1	1	7.58	7.58	7.58	7.6	7.58	1	1	7.98	7.98	7.98	7.98
Specific Sonductance	µS/cm	0	0	-	-	-	-	2	2	239	269	254	254	254	3	3	243	297	269.6666667	269.7	269	2	2	247	302	274.5	274.5	1	1	210.2	210.2	210.2	210.2	1	1	243.2	243.2	243.2	240	243.2	1	1	167.7	167.7	167.7	167.7
Dissolved Oxygen	mg/L	0	0	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	1	1	7.62	7.62	7.62	7.6	7.62	1	1	10.73	10.73	11	10.73
Oxidation Reduction Potential	mV	0	0	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	1	1	131.3	131.3	131.3	131.3	1	1	126	126	126	130	126	1	1	139.5	139.5	140	139.5
Turbidity	NTU	0	0	-	-	-	-	0	-	-	-	-	-	-	2	2	160	717	438.5	438.5	438.5	0	-	-	-	-	-	1	1	37.96	37.96	37.96	37.96	1	1	4.04	4.04	4.04	4	4.04	1	1	19.63	19.63	19.63	19.63
Physical Tests																																													
Conductivity	uS/cm	1	1	289	289	289	289	2	2	217	241	229	229	229	3	3	243	292	262.6666667	262.7	253	2	2	180	313	246.5	246.5	1	1	210	210	210	210	1	1	257	257	257	260	257	1	1	173	173	173	173
Acidity (as CaCO3)	mg/L	1	1	2.4	2.4	2.4	2.4	2	1	1	1.5	1.25	1.25	1.25	3	3	1	2.7	2	2	2	2	2	1.7	2	1.85	1.85	1	1	1.2	1.2	1.2	1.2	1	0	2	2	2	2	2	1	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	1	1	86	86	86	86	2	2	65	87	76	76	76	3	3	70	88	76.33333333	76.33	71	2	2	68	83	75.5	75.5	1	1	58.5	58.5	58.5	58.5	1	1	71.2	71.2	71.2	71	71.2	1	1	48.8	48.8	49	48.8
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	113	113	113	110	113	1	1	76	76	76	76
Hardness (as CaCO3), from total Ca/Mg	mg/L	1	1	90	90	90	90	2	2	102	113	107.5	107.5	107.5	3	3	107	132	115.3333333	115.3	107	2	2	110	129	119.5	119.5	1	1	95.6	95.6	95.6	95.6	1	1	116	116	116	120	116	1	1	81.1	81.1	81.1	81.1
pH	pH	1	1	8	8	8	8	2	2	8	8.1	8.05	8.05	8.05	3	3	8	8.1	8.066666667	8.07	8.1	2	2	7.7	8.1	7.9	7.9	1	1	8.1	8.1	8.1	8.1	1	1	7.97	7.97	7.97	8	7.97	1	1	7.89	7.89	7.9	7.89
Total Dissolved Solids (TDS)	mg/L	1	1	187	187	187	187	2	2	273	393	333	333	333	3	3	180	287	234	234	235	2	2	214	216	215	215	1	1	135	135	135	135	1	1	154	154	154	150	154	1	1	97	97	97	97
Total Suspended Solids (TSS)	mg/L	1	1	86	86	86	86	2	2	1480	1690	1585	1585	1585	3	3	166	315	218	218	173	2	2	92	160	126	126	1	1	17.4	17.4	17.4	17.4	1	0	3	3	3	3	3	1	1	14.5	14.5	14.5	14.5
Turbidity	NTU	1	1	100	100	100	100	2	2	2010	2770	2390	2390	2390	3	3	208	372	267.3333333	267.3	222	2	2	144	150	147	147	1	1	22.6	22.6	22.6	22.6	1	1	2.08	2.08	2.08	2.1	2.08	1	1	4.52	4.52	4.5	4.52
Anions and Nutrients																																													
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.05	0.05	0.05	0.05	0.05	1	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	1	1	0.023	0.023	0.023	0.023	2	0	0.005	0.005	0.005	0.005	0.005	3	0	0	0.005	0.005	0.005	0.005	2	1	0.005	0.006	0.0055	0.0055	1	0	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.05	0.05	0.05	0.05	0.05	1	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	1	0	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5	0.5	3	0	1	0.5	0.5	0.5	0.5	2	1	0.5	0.65	0.575	0.575	1	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	1	1	0.25	0.25	0.25	0.25	2	2	0.052	0.061	0.0565	0.057	0.0565	3	3	0	0.056	0.049666667	0.05	0.048	2	2	0.048	0.051	0.05	0.0495	1	1	0.04	0.04	0.04	0.04	1	1	0.049	0.049	0.049	0.049	0.049	1	1	0.045	0.045	0.045	0.045
Nitrate (as N)	mg/L	1	1	0.026	0.026	0.026	0.026	2	2	0.041	0.058	0.0495	0.05	0.0495	3	3	0	0.069	0.056666667	0.06	0.065	2	2	0.046	0.11	0.08	0.078	1	1	0.0641	0.0641	0.0641	0.0641	1	1	0.0241	0.0241	0.0241	0.024	0.0241	1	1	0.0268	0.0268	0.0268	0.0268
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0307	0.0307	0.0307	0.0307
Nitrite (as N)	mg/L	1	1	0.0036	0.0036	0.0036	0.0036	2	0	0.001	0.001	0.001	0.001	0.001	3	0	0	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	0.001	1	1	0.0039	0.0039	0.0039	0.0039
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.034	0.034	0.034	0.034	0.034	1	0	0.03	0.03	0.03	0.03
Dissolved Orthophosphate (as P)	mg/L	1	0	0.001	0.001	0.001	0.001	2	2	0.0014	0.0017	0.00155	0.0016	0.00155	3	2	0	0.0013	0.001166667	0.0012	0.0012	2	2	0.0012	0.0015	0.0014	0.00135	1	0	0.001	0.001	0.001	0.001	1	1	0.0012	0.0012	0.0012	0.0012	0.0012	1	1	0.0013	0.0013	0.0013	0.0013
Total Phosphorus (P)	mg/L	1	1	0.072	0.072	0.072	0.072	2	2	0.7	1.4	1.05	1.1	1.05	3	3	0	0.15	0.101333333	0.1	0.14	2	2	0.2	0.23	0.22	0.215	1	1	0.0119	0.0119	0.0119	0.0119	1	1	0.0038	0.0038	0.0038	0.0038	0.0038	1	1	0.0039	0.0039	0.0039	0.0039
Sulphate (SO4)	mg/L	1	1	60	60	60	60	2	2	44	49	46.5	46.5	46.5	3	3	49	62	55.33333333	55.3	55	2	2	53	65	59	59	1	1	44.9	44.9	44.9	44.9	1	1	54.3	54.3	54.3	54	54.3	1	1	34.3	34.3	34.3	34.3
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.019	0.019	0.019	0.019	0.019	1	0	0.0016	0.0016	0.0016	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.018	0.018	0.018	0.018	0.018	1	0	0.0015	0.0015	0.0015	0.0015
Total Metals																																													
Aluminum (Al)-Total	mg/L	1	1	2.4	2.4	2.4	2.4	2	2	18	29	23.5	23.50	23.5	3	3	2	4.4	3.066666667	3.07	3	2	2	2.9	4.8	3.85	3.85	1	1	0.764	0.764	0.764	0.764	1	1	0.044	0.044	0.044	0.044	0.044	1	1	0.11	0.11	0.11	0.11
Antimony (Sb)-Total	mg/L	1	1	0.0014	0.0014	0.0014	0.0014	2	2	0.0067	0.012	0.00935	0.0094	0.00935	3	3	0	0.0039	0.003333333	0.0033	0.0039	2	2	0.0035	0.0041	0.0038	0.0038	1	1	0.0015	0.0015	0.0015	0.0015	1	1	0.00121	0.00121	0.00121	0.0012	0.00121	1	1	0.00121	0.00121	0.0012	0.00121
Arsenic (As)-Total	mg/L	1	1	0.029	0.029	0.029	0.029	2	2	0.8	1.2	1	1	1	3	3	0	0.17	0.123	0.12	0.14	2	2	0.13	0.18	0.16	0.155	1	1	0.0114	0.0114	0.0114	0.0114	1	1	0.00394	0.00394	0.00394	0.0039	0.00394	1	1	0.00535	0.00535	0.00535	0.00535
Barium (Ba)-Total	mg/L	1	1	0.11	0.11	0.11	0.11	2	2	4.5	6.1	5.3	5.3	5.3	3	3	0	0.86	0.626666667	0.63	0.71	2	2	0.92	2.5	1.7	1.71	1	1	0.0588	0.0588	0.0588	0.0588	1	1	0.0243	0.0243	0.0243	0.024	0.0243	1	1	0.0307	0.0307	0.0307	0.0307
Beryllium (Be)-Total	mg/L	1	0	0.001	0.001	0.001	0.001	2	2	0.0015	0.0022	0.00185	0.0019	0.00185	3	3	0	0.0034	0.000253333	0.0025	0.00028	2	2	0.00024	0.00038	0.00031	0.00031	1	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	1	0	0.2	0.2	0.2	0.2	2	2	0.00012	0.0002	0.00016	0.00016	0.00016	3	3	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.01	0.01	0.01	0.01	0.01	1	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	1	1	0.000032	0.000032	0.000032	0.000032	2	2	0.00013	0.0002	0.000165	0.00017	0.000165	3	3	0	0.000029	2.56667E-05	0.000026	0.000026	2	2	0.000053	0.000084	0.000069	0.0000685	1	1	0.0000443	0.0000443	0.0000443	0.0000443	1	1	0.0000053	0.0000053	0.0000053	0.0000053	0.0000053	1	1	0.0000098	0.0000098	0.0000098	0.0000098
Calcium (Ca)-Total	mg/L	1	1	30	30	30	30	2	2	41	48	44.5	44.5	44.5	3	3	36	45	39.33333333	39.3	37	2	2	41	47	44	44	1	1	33.6	33.6	33.6	33.6	1	1	40	40	40	40	40	1	1	27	27	27	27
Chromium (Cr)-Total	mg/L	1	1	0.0012	0.0012	0.0012	0.0012	2	2	0.0099	0.015	0.01245	0.012	0.01245	3	3	0	0.0035	0.0023	0.0023	0.0021	2	2	0.0034	0.0053	0.0044	0.00435	1	1	0.00096	0.00096	0.00096	0.00096	1	1	0.0008	0.0008	0.0008	0.0008	0.0008	1	1	0.00432	0.00432	0.00432	0.00432
Cobalt (Co)-Total	mg/L	1	1	0.001	0.001	0.001	0.001	2	2	0.04	0.057	0.0485	0.049	0.0485	3	3	0	0.007	0.005233333	0.0052	0.0059	2	2	0.0066	0.0076	0.0071	0.0071	1	1	0.00042	0.00042	0.00042	0.00042	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	1	0.00133	0.00133	0.0013	0.00133
Copper (Cu)-Total	mg/L	1	1	0.0047	0.0047	0.0047	0.0047	2	2	0.043	0.064	0.0535	0.054	0.0535	3	3	0	0.0083	0.006366667	0.0064	0.0059	2	2	0.0099	0.011	0.01	0.01045	1	1	0.00217	0.00217	0.00217	0.00217	1	1	0.00136	0.00136	0.00136	0.0014	0.00136	1	1	0.0009	0.0009	0.0009	0.0009
Iron (Fe)-Total	mg/L	1	1	1.9	1.9	1.9	1.9	2	2	43	67	55	55	55	3	3	4	9	6.366666667	6.4	6.5	2	2	6.4	9.5	8	7.95	1	1	0.717	0.717	0.717	0.717	1	1	0.054	0.054	0.054	0.054	0.054	1	1	0.162	0.162	0.162	0.162
Lead (Pb)-Total	mg/L	1	1	0.0019	0.0019	0.0019	0.0019	2	2	0.045	0.07	0.0575	0.058	0.0575	3	3	0	0.0076	0.0061	0.0061	0.0073	2	2	0.0078	0.0081	0.008	0.00795	1	1	0.00106	0.00106	0.00106	0.00106	1	1	0.000089	0.000089	0.000089	0.000089	0.000089	1	1	0.000328	0.000328	0.00033	0.000328
Lithium (Li)-Total	mg/L	1	1	0.082	0.082	0.082	0.082	2	2	0.043	0.067	0.055	0.055	0.055	3	3	0	0.023	0.018	0.018	0.016	2	2	0.018	0.02	0.019	0.019	1	1	0.008	0.008	0.008	0.008	1	1	0.0099	0.0099	0.0099	0.0099	0.0099	1	1	0.0071	0.0071	0.0071	0.0071
Magnesium (Mg)-Total	mg/L	1	1	4.2	4.2	4.2	4.2	2	2	13	18	15.5	16	15.5	3	3	5	6	5.333333333	5.3	5.4	2	2	5.9	6.1	6	6	1	1	3.07	3.07	3.07	3.07	1	1	3.99	3.99	3.99	4	3.99	1	1	2.09	2.09	2.09	2.09
Manganese (Mn)-Total	mg/L	1	1	0.13	0.13	0.13	0.13	2	2	4.3	5.9	5.1	5.1	5.1	3	3	0	0.67	0.493333333	0.49	0.59	2	2	0.65	0.68	0.67	0.665	1	1	0.0501	0.0501	0.0501	0.0501	1	1	0.00503	0.00503	0.00503	0.005	0.00503	1	1	0.0199	0.0199	0.02	0.0199
Mercury (Hg)-Total	mg/L	1	0	0.00001	0.00001	0.00001	0.00001	2	2	0.00013	0.00023	0.00018	0.00018	0.00018	3	2	0	0.00005	0.000037	0.000037	0.000035	2	1	0.000028	0.00005	0.000039	0.000039	1	1	0.0000067	0.0000067	0.0000067	0.0000067	1	0	0.000005	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	1	1	0.0024	0.0024	0.0024	0.0024	2	2	0.00088	0.002	0.00144	0.0014	0.00144	3	3	0	0.00057	0.00054	0.00054	0.00055	2	2	0.00068	0.00076	0.00072	0.00072	1	1	0.0003	0.0003	0.0003	0.0003	1	1	0.000268	0.000268	0.000268	0.00037	0.000268	1	1	0.000927	0.000927	0.000927	0.000927
Nickel (Ni)-Total	mg/L	1	1	0.001	0.001	0.001	0.001	2	2	0.014	0.021	0.0175	0.018	0.0175	3	3	0	0.0027	0.002666667	0.0021	0.002	2	2	0.0026	0.0032	0.0029	0.0029	1	0	0.0005	0.0005	0.0005	0.0005	1	1	0.00063	0.00063	0.00063	0.00063	0.00063	1	1	0.00293	0.00293	0.0029	0.00293
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.3	0.3	0.3	0.3	0.3	1	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	1	1	3.2	3.2	3.2	3.2	2	2	4.5	7	5.75	5.8	5.75	3	3	2	2.3	1.933333333	1.9	1.8	2	2	2	2.6	2.3	2.3	1	1	1.09	1.09	1.09	1.09	1	1	0.894	0.894	0.894	0.89	0.894	1	1	0.658	0.658	0.658	0.658
Selenium (Se)-Total	mg/L	1	0	0.001	0.001	0.001	0.001	2	2	0.00056	0.00061	0.000585	0.00059	0.000585	3	3	0	0.00047	0.000396667	0.0004	0.00043	2	2	0.00043	0.00054	0.00049	0.000485	1	1	0.000348	0.000348	0.000348	0.000348	1	1	0.000388	0.000388	0.000388	0.00039	0.000388	1	1	0.0003	0.0003	0.0003	0.0003
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2.04	2.04	2.04	2	2.04	1	1	1.58	1.58	1.58	1.58
Silver (Ag)-Total	mg/L	1	1	0.000073	0.000073	0.000073	0.000073	2	2	0.0012	0.0022	0.0017	0.0017	0.0017	3	3	0	0.00058	0.00034	0.00034	0.00025	2	2	0.00035	0.00035	0.00035	0.00035	1	1	0.000077	0.000077	0.000077	0.000077	1	0	0.00001	0.00001	0.00001	0.00001	0.00001	1	1	0.000096	0.000096	0.000096	0.000096
Sodium (Na)-Total	mg/L	1	1	25	25	25	25	2	2	3.7	5.3	4.5	4.5	4.5	3	3	3	6	4.133333333	4.1	3.3	2	2	5	5.6	5.3	5.3	1	1	2.76	2.76	2.76	2.76	1	1	3.78	3.78	3.78	3.8	3.78	1	1	2.28	2.28	2.3	2.28
Strontium (Sr)-Total	mg/L	1	1	0.9	0.9	0.9	0.9	2	2	0.71	0.73	0.72	0.72	0.72	3	3	1	0.96	0.74	0.74	0.65	2	2	0.73	0.93	0.83	0.83	1	1	0.484	0.484	0.484	0.484	1	1	0.616	0.616	0.616	0.62	0.616	1	1	0.324	0.324	0.324	0.324
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	1	0	0.0002	0.0002	0.0002	0.0002	2	2	0.00034	0.00059	0.000465	0.00047	0.000465	3	3	0	0.00011	8.73333E-05	0.000087	0.0001	2	2	0.000085	0.00012	0.0001	0.0001025	1	1	0.000027	0.000027	0.000027	0.000027	1	0	0.00001	0.00001	0.00001	0.00001	0.00001	1	1	0.00001	0.00001	0.00001	0.00001
Tin (Sn)-Total	mg/L	1	1	0.0017	0.0017	0.0017	0.0017	2	2	0.00013	0.00031	0.00022	0.00022	0.00022	3	2	0	0.0012	0.000483333	0.00048	0.00015	2	2	0.00042	0.00059	0.00051	0.000505	1	1	0.00031	0.00031	0.00031	0.00031	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	1	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.01	0.01	0.01	0.01	0.01	1	0	0.01	0.01	0.01	0.01
Uranium (U)-Dissolved	mg/L	1	0	0.0002	0.0002	0.0002	0.0002	2	2	0.00036	0.00057	0.000465	0.00047	0.000465	3	3	0	0.00013	0.000116667	0.00012	0.00011	2	2	0.00018	0.00019	0.00019	0.000185	1	1	0.000062	0.000062	0.000062	0.000062	1	1	0.000052	0.000052	0.000052	0.000052	0.000052	1	1	0.000034	0.000034	0.000034	0.000034
Vanadium (V)-Total	mg/L	1	1	0.002	0.002	0.002	0.002	2	2	0.033	0.054	0.0435	0.044	0.0435	3	3	0	0.0079	0.005566667	0.0056	0.0054	2	2	0.0051	0.0084	0.0068	0.00675	1	1	0.00132	0.00132	0.00132	0.00132	1	0	0.0005	0.0005	0.0005	0.0005	0.0005	1	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Total	mg/L	1	1	0.018	0.018	0.018	0.018	2	2	0.21	0.36	0.285	0.29	0.285	3	3	0	0.049	0.037666667	0.038	0.039	2	2	0.05	0.054	0.052	0.052	1	1	0.0105	0.0105	0.0105	0.0105	1	0	0.003	0.003	0.003	0.003	0.003	1	1	0.0035	0.0035	0.0035	0.0035
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																													
Aluminum (Al)-Dissolved	mg/L	1	1	0.015	0.015	0.015	0.015	2	2	0.067	0.47	0.2685	0.269	0.2685	3	3	0	0.0033	0.0025	0.003	0.003	2	2	0.0014	0.0021	0.002	0.00175	1	1	0.0067	0.0067	0.0067	0.0067	1	1	0.0013	0.0013	0.0013

BJ-GW11-3A		Baseline Period (2011 - 2014)						2015					2016							2017								2018								2019								2020								2021					
		Sample Count	Min	Max	Mean raw	Mean	Median	Sample Count	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																																										
Temperature	°C	10	1.8	5	3.14	3.1	3	3	4.1	4.5	4.3	4.4	5	5	2.5	4.3	3.44	3.4	3.5	4	4	2.6	4.2	3.5	3.5	3.6	4	4	2.7	3.6	3.1	2.95	4	4	2.4	3.7	3	2.85	3	3	2.6	4.5	3.233333333	3.2	2.6	4	4	1.2	4.8	2.8	2.6
pH	pH	10	7	8.3	7.87	7.87	8	3	7.8	8.2	8.03	8.1	5	5	7	7.9	7.62	7.62	7.8	4	4	7.8	7.9	7.825	7.83	7.8	4	4	7.8	7.9	7.85	7.85	4	4	7.55	7.85	7.73	7.75	3	3	7.6	7.72	7.676666667	7.7	7.71	4	4	7.72	7.99	7.8	7.795
Specific Sonductance	µS/cm	10	186	470	335.9	335.9	356.5	3	275	315	299	307	5	5	322	361	342.4	342.4	340	4	4	334	373	352.5	352.5	351.5	4	4	326	391	352.5	346.5	4	4	350.6	409	371.6	363.35	3	3	336.8	375.8	361.7666667	360	372.7	4	4	350.4	395.1	370	361.8
Dissolved Oxygen	mg/L	0	-	-	-	-	-	0	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	3	0.03	1.7	0.6433	0.2	3	3	0.38	4.22	1.853333333	1.9	0.96	4	4	-0.12	0.54	0.32	0.435
Oxidation Reduction Potential	mV	0	-	-	-	-	-	0	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	4	-180	69	-75.65	-95.8	3	3	-161.6	-73.1	-112.1666667	-110	-101.8	4	4	-217.8	-59.9	-140	-147.05
Turbidity	NTU	1	-	-	-	-	-	0	-	-	-	-	0	-	-	-	-	-	-	2	2	263	1478	870.5	870.5	870.5	3	3	80	100	88.33	85	4	4	2.85	23	12.22	11.52	3	3	14.51	80.08	36.48333333	36	14.86	4	4	3.84	17.2	9.6	8.645
Physical Tests																																																											
Conductivity	uS/cm	10	329	358	347.1	347.1	348.5	3	300	341	324.3	332	5	5	326	372	352	352	357	4	4	317	366	344.25	344.3	347	4	4	349	393	364.5	358	4	4	346	414	374.3	368.5	3	3	352	383	370.3333333	370	376	4	4	352	403	370	364
Acidity (as CaCO3)	mg/L	10	1	4	1.98	1.98	1.8	0					3	3	1.2	3.6	2.233333333	2.233	1.9	4	4	0	12	3.9	3.9	1.8	4	3	1	2.2	1.625	1.65	4	3	1	3	1.825	1.65	3	1	2	2.5	2.166666667	2.2	2	4	1	2	2.2	2.1	2
Total Alkalinity (as CaCO3)	mg/L	10	89	103	96.2	96.2	95	3	66	96	83	87	5	5	64	105	80.6	80.6	79	4	4	69	103	87.75	87.75	89.5	4	4	60	93	82	87.5	4	4	94	105	100.1	100.65	3	3	92.6	98.9	96.63333333	97	98.4	4	4	92.7	97.8	96	96.6
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	163	192	173.6666667	170	166	4	4	152	197	160	154
Hardness (as CaCO3)	mg/L	10	89	167	146.5	146.5	152.5	3	143	165	151.3	146	5	5	147	173	158	158	154	4	4	148	166	155.25	155.3	153.5	4	4	153	175	161.5	159	4	4	162	189	175.5	175.5	3	3	169	189	176.6666667	180	172	4	4	150	180	160	159.5
pH	pH	10	8	8.2	8.12	8.12	8.1	3	7.9	8.1	7.97	7.9	5	5	7.9	8.2	8	8	8	4	4	7.4	8.1	7.85	7.85	7.95	4	4	8	8.2	8.08	8.05	4	4	8.05	8.32	8.15	8.12	3	3	7.53	8.18	7.903333333	7.9	8	4	4	7.97	8.13	8.1	8.06
Total Dissolved Solids (TDS)	mg/L	10	212	247	232	232	232.5	3	217	241	231	235	5	5	197	305	239.2	239.2	227	4	4	244	326	275.25	275.3	265.5	4	4	242	264	255.3	257.5	4	4	233	283	251.5	245	3	3	230	260	244	240	242	4	4	214	258	240	236
Total Suspended Solids (TSS)	mg/L	10	3	1550	292.2	292.2	125.5	3	26	1150	506	342	5	5	225	1490	1438.2	1438	1210	4	4	162	1220	653.75	653.8	616.5	4	4	32	815	321	218.5	4	3	3	23.3	10.03	6.9	3	3	5.5	86.8	51.33333333	51	61.7	4	3	3	21.8	14	15.15
Turbidity	NTU	10	2.9	2130	297.09	297.1	60	3	40	1240	552.3	377	5	5	268	4000	1792.6	1793	1260	4	4	181	1400	737.5	737.5	684.5	4	4	46	255	143.5	136.5	4	4	0.68	29	8.503	2.17	3	3	4.45	81.9	30.38	30	4.79	4	4	3.13	7.04	4.9	4.635
Anions and Nutrients																																																											
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.05	0.095	0.065	0.065	0.05	4	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	10	0.024	0.07	0.0344	0.034	0.032	3	0.027	0.071	0.046	0.04	5	5	0.03	0.096	0.0606	0.061	0.061	4	4	0.028	0.062	0.03775	0.038	0.0305	4	4	0.023	0.11	0.048	0.029	4	4	0.0271	0.04	0.032	0.030	3	3	0.0226	0.0307	0.027633333	0.028	0.0296	4	4	0.0245	0.0419	0.031	0.0285
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0.05	0.05	0.05	0.05	0.05	4	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	10	0.5	0.6	0.51	0.51	0.5	3	0.5	2.6	1.2	0.5	5	3	0.5	3.5	1.76	1.76	1.3	4	2	0.5	2.1	0.945	0.945	0.59	4	3	0.5	5.3	2.08	1.25	4	1	0.5	2.86	1.09	0.5	3	0	0	0.5	0.5	0.5	0.5	4	1	0.5	2.08	0.9	0.5
Fluoride (F)	mg/L	10	0.18	0.22	0.198	0.2	0.2	3	0.14	0.24	0.18	0.16	5	5	0.14	0.2	0.162	0.16	0.15	4	4	0.13	0.18	0.165	0.17	0.175	4	4	0.14	0.19	0.18	0.185	4	4	0.169	0.209	0.18	0.17	3	3	0.18	0.189	0.18366667	0.18	0.182	4	4	0.176	0.185	0.18	0.18
Nitrate (as N)	mg/L	10	0.005	0.018	0.00657	0.0066	0.005	3	0.0073	0.062	0.03	0.025	5	4	0.005	0.11	0.0508	0.05	0.024	4	3	0.005	0.1	0.031725	0.03	0.01095	4	2	0.005	0.042	0.02	0.021	4	0	0.005	0.005	0.01	0.005	3	1	0.005	0.0191	0.0097	0.0097	0.005	4	2	0.005	0.0318	0.016	0.01275
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0	0.0051	0.0017	0.0017	0	4	2	0.0051	0.0318	0.016	0.01375
Nitrite (as N)	mg/L	10	0.001	0.0024	0.00161	0.0016	0.0015	3	0.0018	0.0029	0.002	0.0025	5	5	0.0021	0.0044	0.0028	0.003	0.0024	4	4	0.0011	0.0039	0.002025	0.002	0.00155	4	2	0.001	0.0045	0.002	0.0022	4	1	0.001	0.0012	0.001	0.001	3	2	0.001	0.0067	0.003033333	0.003	0.0014	4	2	0.001	0.0024	0.0016	0.00145
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.048	0.121	0.07266667	0.073	0.049	4	3	0.03	0.067	0.046	0.0435
Dissolved Orthophosphate (as P)	mg/L	10	0.001	0.003	0.00135	0.0014	0.001	3	0.0014	0.0025	0.0019	0.0017	5	5	0.0011	0.0026	0.00194	0.0019	0.002	4	4	0.0016	0.0024	0.001925	0.0019	0.00185	4	4	0.0016	0.0033	0.0024	0.0023	4	1	0.001	0.0016	0.0012	0.001	3	1	0.001	0.0017	0.001233333	0.0012	0.001	4	3	0.001	0.0017	0.0013	0.0013
Total Phosphorus (P)	mg/L	10	0.002	1.6	0.2516	0.25	0.115	3	0.044	1.3	0.55	0.32	5	5	0.19	3.3	1.28	1.3	1.2	4	4	0.12	0.89	0.5075	0.51	0.51	4	4	0.032	0.099	0.075	0.0835	4	4	0.003	0.0433	0.014	0.0057	3	3	0.0057	0.0592	0.0253	0.025	0.011	4	4	0.0047	0.0064	0.0054	0.00515
Sulphate (SO4)	mg/L	10	81	90	87.4	87.4	89	3	72	93	82.3	82	5	5	79	102	91.6	91.6	92	4	4	81	117	91.75	91.8	84.5	4	4	86	119	96.8	91	4	4	86	109	92.4	87.25	3	3	82.8	92.3	89	89	91.9	4	4	82.8	112	92	86.35
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.026	0.597	0.221	0.22	0.04	4	3	0.0016	0.179	0.054	0.0168
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.024	0.561	0.207666667	0.21	0.038	4	3	0.0015	0.168	0.05	0.0157
Total Metals																																																											
Aluminum (Al)-Total	mg/L	10	0.52	22	5.5	5.5	3	3	1.7	23	12.60	13	5	5	4.1	56	25.42	25.40	14	4	4	2.7	17	8.65	8.65	7.45	4	4	0.9	7.7	3.98	3.65	4	4	0.0094	0.562	0.17	0.044	3	3	0.15	2	0.808333333	0.81	0.275	4	4	0.0169	0.109	0.057	0.05055
Antimony (Sb)-Total	mg/L	10	0.002	0.047	0.01561	0.016	0.012	3	0.018	0.037	0.03	0.036	5	5	0.012	0.079	0.0498	0.05	0.059	4	4	0.011	0.09	0.039	0.039	0.0275	4	4	0.0071	0.02	0.011	0.0088	4	4	0.00116	0.0238	0.0071	0.0018	3	3	0.00295	0.0306	0.012383333	0.012	0.0036	4	4	0.00158	0.00353	0.0026	0.002575
Arsenic (As)-Total	mg/L	10	0.013	0.13	0.044	0.044	0.027	3	0.02	0.37	0.17	0.11	5	5	0.048	0.84	0.3384	0.34	0.36	4	4	0.027	0.14	0.09175	0.092	0.1	4	4	0.019	0.043	0.028	0.0255	4	4	0.00596	0.0439	0.016	0.0066	3	3	0.00642	0.0226	0.01272	0.013	0.00914	4	4	0.00566	0.0215	0.013	0.01231
Barium (Ba)-Total	mg/L	10	0.04	0.8	0.1995	0.2	0.11	3	0.069	0.95	0.48	0.41	5	5	0.21	2	0.908	0.91	0.64	4	4	0.092	0.5	0.2905	0.29	0.285	4	4	0.058	0.13	0.091	0.0875	4	4	0.0179	0.0458	0.025	0.019	3	3	0.0216	0.0716	0.039666667	0.039	0.024	4	4	0.0201	0.0256	0.023	0.0227
Beryllium (Be)-Total	mg/L	10	0.0001	0.0012	0.00047	0.00047	0.00019	3	0.0001	0.0009	0.0052	0.00048	5	5	0.0003	0.0043	0.001694	0.0017	0.0013	4	4	0.00026	0.0014	0.00076	0.00076	0.00069	4	3	0.0001	0.001	0.00054	0.00125	4	0	0.0001	0.0001	0.0001	0.0001	3	1	0.0001	0.00126	0.000126667	0.0012	0.0001	4	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	10	0.0005	0.2	0.040403	0.04	0.0005	3	0.00005	0.0055	0.00026	0.00017	5	5	0.000088	0.0017	0.0006496	0.00065	0.00052	4	4	0.000068	0.00042	0.002345	0.00023	0.000225	4	3	0.00005	0.00021	0.00012	0.00011	4	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.037	0.041	0.039666667	0.04	0.041	4	4	0.036	0.042	0.04	0.04
Cadmium (Cd)-Total	mg/L	10	0.000017	0.002	0.0003675	0.00037	0.00020	3	0.00011	0.0015	0.00069	0.00045	5	5	0.00038	0.005	0.002042	0.002	0.0016	4	4	0.00042	0.0025	0.001065	0.0011	0.00067	4	4	0.00012	0.00077	0.00041	0.000365	4	4	0.0000089	0.000541	0.00015	0.000019	3	3	0.0000684	0.00121	0.000503133	0.0005	0.000231	4	4	0.000006	0.000494	0.00032	0.000034485
Calcium (Ca)-Total	mg/L	10	32	68	54.5	54.5	55	3	55	60	57.3	57	5	5	55	73	66	66	70	4	4	53	69	59.5	59.5	58	4	4	57	63	61	62	4	4	60.6	66.6	64.1	64.7	3	3	60.2	66.8	62.7	63	61.1	4	4	53.8	71.2	59	54.5
Chromium (Cr)-Total	mg/L	10	0.00046	02	0.006386	0.0064	0.0036	3	0.0013	0.018	0.0086	0.0065	5	5	0.0028	0.048	0.0189	0.019	0.012	4	4	0.0015	0.0093	0.005275	0.0053	0.00515	4	4	0.00058	0.0017	0.0012	0.0012	4	4	0.00029	0.00137	0.0007	0.00056	3	3	0.00092	0.00424	0.002356667	0.0024	0.00191	4	3	0.0005	0.00369	0.0019	0.00166
Cobalt (Co)-Total	mg/L	10	0.00022	0.015	0.002856	0.0029	0.0011	3	0.0004	0.012	0.0053	0.0035	5	5	0.0025	0.034	0.01342	0.013	0.01	4	4	0.0012	0.0078	0.00455	0.0046	0.00446	4	4	0.00042	0.0013	0.00095	0.001045	4	2	0.0001	0.00015	0.00012	0.00011	3	3	0.00053	0.00131	0.001016667	0.001	0.00121	4	4	0.00019	0.00203	0.00072	0.00033
Copper (Cu)-Total	mg/L	10	0.001	0.063	0.01319	0.0118	0.0055	3	0.0022	0.059	0.026	0.016	5	5	0.011	0.19	0.0718	0.072	0.051	4	4	0.0064	0.042	0.0221	0.022	0.02	4	4	0.0018	0.051	0.0042	0.0049	4	4	0.0005	0.0181	0.00888	0.0061	3	3	0.00052	0.00483	0.002033333	0.002	0.00069	4	4	0.0005	0.00188	0.00085	0.0005
Iron (Fe)-Total	mg/L	10	0.067	43	8.2167	8.2	3.35	3	1.8	39	18	13	5	5	6.6	117	45.02	45	38	4	4	4	26	15.475	15	15.95	4	4	1.4	4.3	3.3	3.7	4	4	0.121	1.98	0.6	0.16	3	3	0.306	2.68	1.112	1.1	0.35	4	4	0.162	0.582	0.35	0.326
Lead (Pb)-Total	mg/L	10	0.0005	0.12	0.0215	0.022	0.010	3	0.021	0.085	0.052	0.051	5	5	0.03	0.36	0.1636	0.16	0.16	4	4	0.039	0.31	0.1125	0.12	0.062	4	4	0.01	0.04	0.024	0.0225	4	4	0.000461	0.0321	0.0085	0.00072	3	3	0.00245	0.0482	0.018586667	0.019	0.00511	4	4	0.000578	0.00169	0.0013	0.00149
Lithium (Li)-Total	mg/L	10	0.016	0.075	0.0334	0.033	0.028	3	0.016	0.034	0.024	0.021	5	5	0.022	0.095	0.0494	0.049	0.048	4	4	0.021	0.044	0.03075	0.031	0.029	4	4	0.02	0.026	0.022	0.021	4	4	0.0147	0.0199	0.017	0.016	3	3	0.015	0.0187	0.016666667	0.017	0.0163	4	4	0.0165	0.0174	0.017	0.017
Magnesium (Mg)-Total	mg/L	10	2.6	11	5.3	5.3	4.55	3	4.4	7.8	6	5.9	5	5	4.8	21	10.76	11	9.8	4	4	4.3	10	7	7.1	6.8	4	4	4	6	5.1	4.85	4	4	4	4.7	4.5	4.4	4.39	3	3	4.6	5.41	4.91	4.9	4.7	4	4	4.24	4.78	4.5	4.455
Manganese (Mn)-Total	mg/L	10	0.2	1.6	0.529	0.53	0.26	3	0.22	5.5	2.3	1.3	5	5	0.63	5.1	2.148	2.1	1.7	4	4	0.28	1.6	0.8375	0.84	0.735	4	4	0.3	0.67	0.41	0.34	4	4	0.119	0.332	0.17	0.12	3	3	0.137	0.192	0.159333333	0.16	0.149	4	4	0.149	0.302	0.22	0.221
Mercury (Hg)-Total	mg/L	10	0.00001	0.00012	0.000268	0.000027	0.00001	3	0.000005	0.00019	0.000088	0.000068	4	4	0	0.00028	0.0001285	0.00013	0.000117	4	1	0.000005	0.0001	0.000045	0.000045	0.0000375	4	0	0.000025	0.0001	0.000069	0.000075	4	1	0.000005	0.0000063	0.0000053	0.000005	3	0	0.000005	0.00005	0.00002	0.00002	0.000005	4	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	10	0.0013	0.005	0.00251	0.0025	0.0022	3	0.00099	0.0058	0.003	0.0021	5	5	0.0012	0.0087	0.00396	0.004	0.0033	4	4	0.00068	0.0023	0.001495	0.0015	0.0014	4	4	0.00054	0.00084	0.00068	0.00066	4	3	0.000633	0.000864	0.00076	0.00077	3	3	0.00079	0.0015	0.001123333	0.0011	0.00108	4	4	0.000053	0.00127	0.0008	0.0010875
Nickel (Ni)-Total	mg/L	10	0.0005	0.012	0.003515	0.0035	0.0019	3	0.00084	0.01	0.0048	0.0036	5	5	0.0025	0.024	0.01028	0.01	0.0079	4	4	0.0013	0.0072	0.00415	0.0042	0.00405	4	3	0.0005	0.0015	0.001	0.001045	4	2	0.0005	0.00106	0.00068	0.00058	3	2	0.0005	0.00367	0.001903333	0.0019	0.00154	4	4	0.00056	0.00265	0.0015	0.00137
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	0.3	4	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	10	1.8	8.5	3.36	3.4	2.5	3	2	11	6.4	6.2	5	5	2.7	18	9.22	9.2	5.9	4	4	2.3	4.9	3.525	3.5	3.45	4	4	1.6	2.8	2.2	2.2	4	4	1.36	1.65	1.5	1.49	3	3	1.4	2.22	1.72	1.7	1.54	4	4	1.4	1.52	1.5	1.485
Selenium (Se)-Total	mg/L	10	0.0001	0.0039	0.000846	0.00085	0.00031	3	0.000063	0.0025	0.0014	0.0006	5	5	0.00054	0.0089	0.003406	0.0034	0.0029	4	4	0.0002	0.002	0.00114	0.0011	0.00118	4	4	0.000097	0.00021	0.00016	0.00016	4	4	0.00005	0.0029	0.0005	0.00005	3	1	0.00005	0.00153	8.43333E-05	0.00004	0.00005	4	4	0.00005	0.00005	0.00005	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3.8	6.79	4.87333333	4.9	4.03	4	4	3.69	3.96	3.8	3.7
Silver (Ag)-Total	mg/L	10	0.00002	0.015	0.0026072	0.0026	0.0012	3	0.00033	0.013	0.0057	0.0039	5	5	0.0015	0.049	0.01634	0.016	0.0093	4	4	0.00066	0.0066	0.00294	0.0029	0.00225	4	4	0.00019	0.00034	0.00028	0.00029	4	1	0.00001	0.00097	0.000032	0.00001	3	3	0.000016	0.000446	0.000166333	0.00017	0.000037	4	3	0.000001	0.000047	0.00003	0.000001
Sodium (Na)-Total	mg/L	10	7.1	37	13.62	14	9.8	3	7.1	8.9	7.8	7.3	5	5	6.4	11	9.22	9.2	9.8	4	4	7.1	10	8.55	8.6	8.55	4	4	7.7	10	8.9	8.85	4	4	6.13	9.18	7.2	6.69	3	3	6.68	8.2	7.466666667	7.5	7.58	4	4	7.1	8.23	7.4	7.13
Strontium (Sr)-Total	mg/L	10	1	1.5	1.17	1.2	1.15	3	1	1.4	1.1	1	5	5	1.1	1.8	1.42	1.4	1.3	4	4	1.1	1.8	1.325	1.3	1.2	4	4	1.2	1.5	1.3	1.3	4	4	1.05	1.39	1.2	1.08	3	3	1.11	1.32	1.2	1.2	1.17	4	4	1.06	1.3	1.1	1.1
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	10	0.000025	0.002	0.0004114	0.00041

BJ-GW11-3B		Baseline Period (2011 - 2014)							2015							2016							2017							2018							2019							2020							2021						
		Sample Count	Sample Count > DL.	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean	Median	Sample Count	Sample Count > DL.	Min	Max	Mean	Median
Field Parameters	Unit																																																							
Temperature	°C	8	8	0.6	3.6	2.1375	2.1	1.95	2	2	3	4.4	3.7	3.7	3.7	2	2	2.9	3.1	3	3	3	3	2.1	3.8	2.766666667	2.8	2.4	3	3	1.9	3.2	2.4	2.2	3	3	2.4	4.3	3.2	2.9	3	3	2.5	3.5	3.1	3.3	2	2	2.3	3.4	2.9	2.85
pH	pH	8	8	7	8.2	7.75	7.75	7.8	2	2	7.5	7.9	7.7	7.7	7.7	2	2	7	7.4	7.2	7.2	3	3	7.3	7.6	7.466666667	7.47	7.5	3	3	7.3	7.5	7.4	7.4	3	3	7.47	7.58	7.53	7.54	3	3	7.53	7.69	7.6	7.57	2	2	7.7	7.8	7.8	7.75
Specific Sonductance	µS/cm	8	8	176	550	361.375	361.4	373.5	2	2	392	435	413.5	413.5	413.5	2	2	293	792	542.5	542.5	3	3	311	552	448.3333333	448.3	482	3	3	602	866	694	614	3	3	379.1	455.7	413.8	406.5	3	3	369.7	502	430	408.2	2	2	332.1	348.8	340	340.45
Dissolved Oxygen	mg/L	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	2	2	0.15	0.18	0.165	0.17	3	3	0.18	5.99	2.1	0.26	2	2	0.29	0.79	0.54	0.54
Oxidation Reduction Potential	mV	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	3	3	105.1	244.2	190.1	221.1	3	3	91.4	226.7	170	187.5	2	2	-26.4	60.4	17	17
Turbidity	NTU	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	1	1	112	112	112	112	112	3	3	16.7	25.2	20.23	18.8	3	3	0.35	3.05	1.383	0.75	3	3	1.92	35.38	19	19.96	2	2	1.58	23.41	12	12.495
Physical Tests																																																								
Conductivity	uS/cm	9	9	312	496	371.8888889	379.11	352	2	2	407	476	441.5	441.5	441.5	2	2	518	794	656	656	3	3	478	521	506	506	519	3	3	585	867	703.7	659	3	3	379	466	415	400	3	3	394	498	430	409	2	2	337	353	350	345
Acidity (as CaCO3)	mg/L	9	8	1	5	2.177777778	2.178	2	0	-	-	-	-	-	-	2	2	2.8	5.6	4.2	4.2	3	3	0	5.4	2.3	2.3	1.5	3	3	2.5	2.9	2.767	2.9	3	3	1	2.2	1.533	1.4	3	1	2	2.6	2.2	2	2	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	9	9	43	107	86.55555556	86.56	88	2	2	98	112	105	105	105	2	2	109	124	116.5	116.5	3	3	109	112	110.6666667	110.7	111	3	3	105	106	105.7	106	3	3	93.2	110	102.7	105	3	3	90.4	109	100	104	2	2	93.3	95	94	94.15
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	172	244	200	190	2	2	148	160	150	154
Hardness (as CaCO3), total from Ca/Mg	mg/L	9	9	156	238	177.3333333	177.3	167	2	2	211	241	226	226	226	2	2	264	420	342	342	3	3	224	258	245	245	253	3	3	256	354	305.3	306	3	3	159	204	182.3	184	3	3	184	219	200	192	2	2	148	157	150	152.5
pH	pH	9	9	7.9	8.2	8.066666667	8.07	8.1	2	2	7.7	7.7	7.7	7.7	7.7	2	2	8	8.1	8.05	8.05	3	3	7.8	8.1	7.933333333	7.93	7.9	3	3	7.6	8.1	7.9	8	3	3	8.06	8.18	8.11	8.08	3	3	8.07	8.09	8.1	8.09	2	2	8.02	8.08	8.1	8.05
Total Dissolved Solids (TDS)	mg/L	9	9	212	345	255.7777778	255.8	236	2	2	300	336	318	318	318	2	2	356	593	474.5	474.5	3	3	355	386	375.6666667	375.7	386	3	3	393	676	498.7	427	3	3	260	304	281.3	280	3	3	274	358	300	276	2	2	214	217	220	215.5
Total Suspended Solids (TSS)	mg/L	9	8	3	1930	467.6666667	467.7	275	2	2	28	225	126.5	126.5	126.5	2	2	72	454	263	263	3	3	13	232	106.6666667	106.7	75	3	3	23	44	30.67	25	3	0	3	3	3	3	3	1	3	63.5	23	3	2	0	3	3	3	3
Turbidity	NTU	9	9	2	2540	495.5555556	495.6	204	2	2	22	184	103	103	103	2	2	40	297	168.5	168.5	3	3	13	154	78.66666667	78.67	69	3	3	20	42	28	22	3	2	0.1	1.16	0.4933	0.22	3	2	0.1	37.3	13	0.29	2	2	0.16	0.23	0.2	0.195
Anions and Nutrients																																																								
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.05	0.096	0.065	0.05	2	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	9	9	0.012	0.033	0.024666667	0.025	0.027	2	2	0.01	0.012	0.011	0.011	0.011	2	1	0.005	0.0054	0.0052	0.0052	3	3	0.005	0.009	0.0074	0.0074	0.0082	3	3	0.0079	0.024	0.014	0.011	3	3	0.015	0.025	0.018	0.015	3	3	0.0131	0.0248	0.018	0.0152	2	2	0.024	0.026	0.025	0.025
Bromide (Br)	mg/L	9	4	0.5	2.4	0.91	0.91	0.5	2	2	0.95	6.5	3.725	3.73	3.725	2	2	3.4	15	9.2	9.2	3	3	3.2	15	8.233333333	8.23	6.5	3	3	19	93	51	41	3	3	5.97	24.1	12.6	7.87	3	0	0.05	0.05	0.05	0.05	2	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	9	9	0.091	0.16	0.123444444	0.12	0.11	2	2	0.099	0.12	0.1095	0.11	0.1095	-	-	-	-	-	-	3	3	0.09	0.13	0.113333333	0.11	0.12	3	3	0.095	0.15	0.12	0.1	3	3	0.16	0.18	0.17	0.17	3	3	1.79	25.9	12	7.82	2	1	0.5	1.22	0.86	0.86
Fluoride (F)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.148	0.174	0.16	0.17	2	2	0.179	0.183	0.18	0.181
Nitrate (as N)	mg/L	9	5	0.005	0.82	0.126911111	0.127	0.0052	2	1	0.005	0.45	0.2275	0.23	0.2275	2	1	0.005	3.2	1.60	1.6025	3	3	0.0088	0.12	0.0496	0.05	0.02	3	3	0.014	0.14	0.06	0.032	3	0	0.005	0.005	0.01	0.005	3	1	0.005	0.0129	0.0076	0.005	2	0	0.005	0.005	0.005	0.005
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0	0.0129	0.0043	0	2	0	0.0051	0.0051	0.0051	0.0051
Nitrite (as N)	mg/L	9	6	0.001	0.044	0.007488889	0.0075	0.00165	2	2	0.0016	0.049	0.0253	0.025	0.0253	2	2	0.0015	0.069	0.035	0.03525	3	1	0.001	0.0081	0.003366667	0.003	0.001	3	2	0.001	0.0066	0.003	0.001	3	0	0.001	0.001	0.001	0.001	3	1	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.03	0.109	0.056	0.03	2	1	0.03	0.048	0.039	0.039
Dissolved Orthophosphate (as P)	mg/L	9	3	0.001	0.0021	0.001177778	0.0012	0.001	2	2	0.0011	0.0012	0.00115	0.0012	0.00115	2	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	0.001	3	2	0.001	0.0011	0.0011	0.0011	3	0	0.001	0.001	0.001	0.001	3	1	0.001	0.0012	0.001	0.001	2	2	0.0013	0.0017	0.0015	0.0015
Total Phosphorus (P)	mg/L	9	8	0.002	1.2	0.29833333	0.3	0.18	2	2	0.015	0.23	0.1225	0.12	0.1225	2	2	0.043	0.17	0.11	0.1065	3	3	0.0088	0.21	0.0866	0.087	0.041	3	3	0.019	0.037	0.027	0.025	3	2	0.002	0.0031	0.0025	0.0024	3	1	0.002	0.0519	0.019	0.002	2	2	0.0023	0.004	0.0032	0.00315
Sulphate (SO4)	mg/L	9	9	83	161	108.1111111	108	108	2	2	116	131	123.5	124	123.5	2	2	161	256	209	208.5	3	3	143	167	152	152	146	3	3	132	197	173	190	3	3	84.9	103	94.1	94.5	3	3	94	122	100	95	2	2	75.5	81.9	79	78.7
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.019	0.019	0.019	2	0	0.0016	0.0016	0.0016	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	2	0	0.0015	0.0015	0.0015	0.0015
Total Metals																																																								
Aluminum (Al)-Total	mg/L	9	9	0.017	28	7.979666667	7.98	6.7	2	2	0.76	6.2	3.48	3.48	3.48	2	2	0.18	7.5	3.84	3.84	3	3	0.19	2.9	1.463333333	1.46	1.3	3	3	0.53	0.86	0.64	0.54	3	2	0.003	0.0327	0.01	0.0032	3	2	0.003	2.09	0.7	0.0033	2	1	0.003	0.008	0.0055	0.0055
Antimony (Sb)-Total	mg/L	9	9	0.0011	0.019	0.006877778	0.0069	0.0053	2	2	0.0023	0.0084	0.00535	0.0054	0.00535	2	2	0.0027	0.0081	0.0054	0.0054	3	3	0.0024	0.0082	0.004866667	0.0049	0.004	3	3	0.0019	0.0028	0.0022	0.002	3	3	0.00071	0.00101	0.00082	0.00074	3	3	0.00106	0.00257	0.0016	0.00127	2	2	0.00089	0.00105	0.00097	0.00097
Arsenic (As)-Total	mg/L	9	9	0.016	0.16	0.060444444	0.06	0.038	2	2	0.011	0.059	0.035	0.035	0.035	2	2	0.0011	0.056	0.0334	0.0335	3	3	0.0066	0.058	0.029666667	0.03	0.023	3	3	0.0082	0.011	0.0097	0.01	3	3	0.0025	0.00284	0.0027	0.0028	3	3	0.00258	0.0193	0.0082	0.0026	2	2	0.0053	0.0046	0.0036	0.001565
Barium (Ba)-Total	mg/L	9	9	0.044	1.3	0.354888889	0.35	0.2	2	2	0.05	0.28	0.165	0.17	0.165	2	2	0.05	0.24	0.15	0.145	3	3	0.035	0.17	0.092666667	0.093	0.073	3	3	0.048	0.061	0.055	0.057	3	3	0.023	0.025	0.024	0.024	3	3	0.0201	0.0768	0.04	0.0229	2	2	0.0186	0.0219	0.02	0.02025
Beryllium (Be)-Total	mg/L	9	7	0.00014	0.0017	0.000678889	0.00068	0.00056	2	1	0.0001	0.00044	0.00027	0.00027	0.00027	2	1	0.0001	0.00049	0.0003	0.000295	3	2	0.0001	0.00037	0.0002	0.0002	0.00013	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	9	1	0.0005	0.2	0.044888889	0.045	0.0005	2	1	0.00005	0.00015	0.0001	0.0001	0.0001	2	1	0.00005	0.00016	0.00011	0.000105	3	2	0.00005	0.00017	0.953333E-05	0.000095	0.000066	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.024	0.028	0.026	0.027	2	2	0.028	0.033	0.031	0.0305
Cadmium (Cd)-Total	mg/L	9	8	0.000017	0.0027	0.000533444	0.00053	0.00019	2	2	0.00007	0.00028	0.000175	0.00018	0.000175	2	2	0.000087	0.00028	0.00018	0.0001835	3	3	0.00006	0.00032	0.00017	0.00017	0.00013	3	3	0.000063	0.00011	0.000094	0.00011	3	3	0.000028	0.000041	0.000036	0.000038	3	3	0.0000128	0.0000972	0.000046	0.0000274	2	2	0.0000195	0.0000249	0.000022	0.0000222
Calcium (Ca)-Total	mg/L	9	9	58	90	72.3333333	72.3	70	2	2	75	97	86	86	86	2	2	97	159	128	128	3	3	83	104	94.66666667	94.7	97	3	3	103	138	118	112	3	3	60.4	75.5	68.9	70.7	3	3	67.2	79.1	72	70.4	2	2	53.6	58.2	56	55.9
Chromium (Cr)-Total	mg/L	9	8	0.001	0.018	0.003966667	0.004	0.0023	2	2	0.0003	0.0022	0.00125	0.0013	0.00125	2	2	0.00011	0.002	0.0011	0.001055	3	3	0.00011	0.0016	0.00081	0.00081	0.00072	3	3	0.00034	0.00088	0.00062	0.00065	3	0	0.0001	0.0001	0.0001	0.0001	3	1	0.0001	0.00636	0.0022	0.0001	2	0	0.0005	0.0005	0.0005	0.0005
Cobalt (Co)-Total	mg/L	9	8	0.0003	0.013	0.00318	0.0032	0.0017	2	2	0.00021	0.0026	0.00145	0.0015	0.00145	2	2	0.00031	0.0026	0.0015	0.001455	3	3	0.00012	0.0026	0.0016	0.0012	0.00076	3	3	0.00029	0.00049	0.00025	0.00027	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.00037	0.0019	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Copper (Cu)-Total	mg/L	9	8	0.001	0.083	0.018133333	0.018	0.0073	2	2	0.0014	0.011	0.0062	0.0062	0.0062	2	2	0.0014	0.011	0.0062	0.0062	3	3	0.00081	0.011	0.005236667	0.0052	0.0039	3	3	0.0012	0.0015	0.0014	0.0014	3	0	0.0005	0.0005	0.0005	0.0005	3	1	0.0005	0.00342	0.0015	0.0005	2	0	0.0005	0.0005	0.0005	0.0005
Iron (Fe)-Total	mg/L	9	9	0.055	43	10.06166667	10	6	2	2	0.53	7.3	3.915	3.9	3.915	2	2	0.41	7.2	3.8	3.805	3	3	0.25	7.2	3.183333333	3.2	2.1	3	3	0.44	0.84	0.65	0.68	3	1	0.01	0.02	0.013	0.01	3	1	0.01	1.54	0.52	0.01	2	0	0.01	0.01	0.01	0.01
Lead (Pb)-Total	mg/L	9	8	0.0005	0.089	0.016433333	0.016	0.0061	2	2	0.0012	0.0089	0.00505	0.0051	0.00505	2	2	0.0013	0.0086	0.005	0.00495	3	3	0.00064	0.0088	0.004313333	0.0043	0.0035	3	3	0.00074	0.0015	0.0012	0.0013	3	1	0.00005	0.000128	0.000076	0.00005	3	1	0.00005	0.00162	0.00057	0.00005	2	1	0.00005	0.000271	0.00016	0.0001605
Lithium (Li)-Total	mg/L	9	9	0.01	0.047	0.020777778	0.021	0.019	2	2	0.012	0.019	0.0155	0.016	0.0155	2	2	0.011	0.022	0.017	0.0165	3	3	0.013	0.017	0.014666667	0.015	0.014	3	3	0.012	0.013	0.013	0.013	3	3	0.005	0.0128	0.011	0.011	3	3	0.011	0.0123	0.012	0.0114	2	2	0.012	0.015	0.013	0.01135
Magnesium (Mg)-Total	mg/L	9	9	3.9	12	6.466666667	6.5	5.9	2	2	4.3	7	5.65	5.7	5.65	2	2	7.5	8	7.8	7.75	3	3	5.5	7	6.133333333	6.1	5.9	3	3	5.3	7.8	6.6	6.8	3	3	3.7	4.9	4.2	4.21	3	3	3.85	5.16	4.3	3.97	2	2	3.56	3.57	3.6	3.565
Manganese (Mn)-Total	mg/L	9	9	0.27	2.3	0.733333333	0.73	0.42	2	2	0.073	0.68	0.3765	0.38	0.3765	2	2	0.13	0.78	0.46	0.455	3	3	0.032	0.79	0.350666667	0.35	0.23	3	3	0.077	0.21	0.13	0.091	3	3	0.0545	0.122	0.092	0.1	3	3	0.00604	0.298	0.13	0.0944	2	2	0.115	0.224	0.17	0.1695
Mercury (Hg)-Total	mg/L	9	0	0.00001	0.00022	4.78889E-05	0.000048	0.000022	2	1	0.000005	0.000033	0.000019	0.000019	0.000019	2	2	0.00001	0.000021	0.000016	0.000155	3	1	0.000005	0.00039	0.000023	0.000023	0.000025	3	3	0.000009	0.000007	0.000008	0.000007	3	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000109	0.00007	0.000005	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	9	7	0.00059	0.0076	0.001881111	0.0019	0.001	2	2	0.00062	0.00093	0.000775	0.00078	0.000775	2	2	0.00014	0.0011	0.00062	0.00062	3	3	0.00035	0.0011	0.000723333	0.00072	0.00072	3	3	0.00033	0.00062	0.00045	0.00041	3	3	0.00055	0.00065	0.0006	0.00062	3	3	0.000426	0.00105	0.00076	0.000806	2	2	0.000682	0.000845	0.00076	0.0007635
Nickel (Ni)-Total	mg/L	9	8	0.00074	0.0097	0.002593333	0.0026	0.0019	2	1	0.0005	0.0021	0.0013	0.0013	0.0013	2	1	0.0005	0.0021	0.0013	0.0013	3	2	0.0005	0.0017	0.00097	0.00097	0.00071	3	0	0.0005	0.0005	0.0005	0.0005	3	0	0.0005	0.0005	0.0005	0.0005	3	1	0.0005	0.00057	0.00052	0.0005	2	0	0.0005	0.0005	0.0005	0.0005
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	2	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	9	8	1.8	9.6	3.522222222	3.5	2.5	2	2	1.2	1.2	2.9	2.05	2.1	2.05	2.1	1.5	3.4	2.5	2.45	3	3	1.3	1.9	1.6	1.6	1.6	3	3	1.3	1.7	1.5	1.6	3	2.5	1.13	1.22	1.2	1.18	3	1	1.13	2	1.4	1.17	2	2	1.13	1.18	1.2	1.155
Selenium (Se)-Total	mg/L	9	7	0.00043	0.0055	0.001581111	0.0016	0.001	2	2	0.00017	0.00086	0.000515	0.00052	0.000515	2	2	0.00037	0.0006	0.00049	0.000485	3	3	0.0002	0.00063	0.000366667	0.00037	0.00027	3	3	0.00012	0.0003	0.00019	0.00014	3	1	0.00005	0.00006	0.000053	0.00005	3	2	0.00005	0.000175	0.0001	0.000088	2	0	0.00005	0.00005	0.00005	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3.22	6.79	4.4	3.31	2	2	3.33	3.5	3.4	3.415
Silver (Ag)-Total	mg/L	9	8	0.00002	0.028	0.004351111	0.0044	0.00047	2	2	0.000076	0.00052	0.000298	0.0003	0.000298	2	2	0.000034	0.00039	0.00021	0.000212	3	3	0.000033	0.00037	0.000201	0.0002	0.0002	3	3	0.000036	0.00006	0.000052	0.000059	3	0	0.00001	0.00001	0.00001	0.00001	3	1	0.00001	0.00007	0.00003	0.00001	2	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Total	mg/L	9	9	3.2	7	5.733333333	5.7	5.7	2	2	5.7	6.7	6.2	6.2	6.2	2	2	6.5	7.7	7.1	7.1	3	3	6.4	7.4	7	7	7.2	3	3	10	23	15	13	3	3	8.22	9.3	8.6	8.28	3	3	4.99	11	8.2	8.66	2	2	5.08	6.41	5.7	5.745
Strontium (Sr)-Total	mg/L	9	9	1	3	1.911111111	1.9	1.8	2	2	1.9	2.3	2.1	2.1	2.1	2	2	2.5	3.5	3	3	3	3	2.4	2.5	2.466666667	2.5	2.5	3	3	2.1	3.3	2.8	2.9	3	3	1.37	1.67	1.5	1.45	3	3	1.37	1.6	1.5	1.54	2	2	0.998	1.06	1	1.029
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	9	8	0.00011	0.0013	0.000352222	0.00035	0.00023	2	2	0.000054	0.00023	0.000142	0.00014	0.000142	2	2	0.000054	0.00029	0.00017	0.000172	3	3	0.000042

BJ-GW11-5A		Baseline Period (2011 - 2014)						2016						2017					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																		
Temperature	°C	0	0					2	2	2.2	2.7	2.5	2.45	2	2	1.6	3	2.3	2.3
pH	pH	0	0					2	2	7.23	7.5	7.37	7.365	2	2	7.5	7.77	7.64	7.635
Specific Sonductance	µS/cm	0	0					2	2	738.2	766	752.1	752.1	2	2	593.4	652	622.7	622.7
Dissolved Oxygen	mg/L	0	0					0						0					
Oxidation Reduction Potential	mV	0	0					0						0					
Turbidity	NTU	0	0					0						1	1	3846	3846	3846	3846
Physical Tests																			
Conductivity	uS/cm	3	3	249	484	398	460	2	2	732	831	781.5	781.5	2	2	578	637	607.5	607.5
Hardness (as $CaCO_3$)	mg/L	3	3	91.5	198	130	100	2	2	405	407	406	406	2	2	224	274	249	249
pH	pH	3	3	7.96	8.2	8	8.1	2	2	7.75	7.88	7.82	7.815	2	2	7.94	8.05	8	7.995
Total Suspended Solids (TSS)	mg/L	3	3	62.2	5380	3474	4980	2	2	3440	3640	3540	3540	2	2	878	2260	1569	1569
Total Dissolved Solids (TDS)	mg/L	3	3	149	328	267	323	2	2	504	610	557	557	2	2	379	500	439.5	439.5
Turbidity	NTU	3	3	66.6	4000	2689	4000	2	2	3270	4000	3635	3635	2	2	978	2800	1889	1889
Anions and Nutrients																			
Acidity (as CaCO3)	mg/L	3	3	1.1	2.9	1.8	1.5	2	2	7.2	8.7	7.95	7.95	2	2	3.5	4.3	3.9	3.9
Total Alkalinity (as $CaCO_3$)	mg/L	3	3	39.5	98.8	73.8	83.1	2	2	173	201	187	187	2	2	164	167	165.5	165.5
Total Ammonia (as N)	mg/L	3	3	0.102	0.371	0.252	0.283	2	2	0.235	0.374	0.3	0.3045	2	2	0.218	0.282	0.25	0.25
Chloride (Cl)	mg/L	3	3	1.47	3.27	2.07	1.47	2	0	2.5	2.5	2.5	2.5	2	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	3	3	0.152	0.221	0.189	0.194	2	0	0.1	0.1	0.1	0.1	2	2	0.075	0.096	0.086	0.0855
Nitrate (as N)	mg/L	3	1	0.005	0.0057	0.01	0.005	2	0	0.025	0.025	0.03	0.025	2	2	0.0074	0.0783	0.04	0.04285
Nitrite (as N)	mg/L	3	1	0.001	0.0011	0.001	0.001	2	0	0.005	0.005	0.005	0.005	2	1	0.001	0.0023	0.002	0.00165
Dissolved Orthophosphate (as P)	mg/L	3	0	0.001	0.001	0.001	0.001	2	2	0.001	0.0011	0.0011	0.00105	2	0	0.001	0.001	0.001	0.001
Total Phosphorus (P)	mg/L	3	2	0.3	2.22	1.34	1.51	2	2	1.9	2.59	2.2	2.245	2	2	0.87	1.44	1.2	1.155
Sulphate (SO_4)	mg/L	3	3	73.6	155	120	130	2	2	237	310	274	273.5	2	2	172	201	187	186.5
Total Metals																			
Aluminum (Al)-Total	mg/L	3	3	1.04	52.5	28.55	32.1	2	2	36.7	40.2	38.50	38.45	2	2	12.3	21.4	16.90	16.85
Antimony (Sb)-Total	mg/L	3	3	0.0029	0.012	0.006096667	0.0032	2	2	0.00677	0.0109	0.0088	0.008835	2	2	0.00887	0.0129	0.011	0.010885
Arsenic (As)-Total	mg/L	3	3	0.013	0.80	0.373866667	0.31	2	2	0.738	0.85	0.79	0.794	2	2	0.295	0.74	0.52	0.5175
Barium (Ba)-Total	mg/L	3	3	0.072	1.37	0.734	0.76	2	2	0.942	1.33	1.1	1.136	2	2	0.459	0.802	0.63	0.6305
Beryllium (Be)-Total	mg/L	3	2	0.001	0.0091	0.004516667	0.0035	2	2	0.00304	0.00605	0.0045	0.004545	2	2	0.00069	0.00197	0.0013	0.00133
Bismuth(Bi)- Total	mg/L	3	1	0.0024	0.2	0.134133333	0.2	2	2	0.00242	0.00268	0.0026	0.00255	2	2	0.000805	0.00141	0.0011	0.0011075
Cadmium (Cd)-Total	mg/L	3	3	0.00023	0.0081	0.003473333	0.0021	2	2	0.00344	0.00385	0.0036	0.003645	2	2	0.0017	0.00292	0.0023	0.00231
Calcium (Ca)-Total	mg/L	3	3	32.4	164	119.4666667	162	2	2	221	235	228	228	2	2	116	131	124	123.5
Chromium (Cr)-Total	mg/L	3	3	0.002	0.048	0.0255	0.026	2	2	0.0349	0.0446	0.04	0.03975	2	2	0.0196	0.0269	0.023	0.02325
Cobalt (Co)-Total	mg/L	3	3	0.0044	0.034	0.02065	0.024	2	2	0.0328	0.0333	0.033	0.03305	2	2	0.0131	0.0304	0.022	0.02175
Copper (Cu)-Total	mg/L	3	3	0.0091	0.20	0.109033333	0.12	2	2	0.164	0.189	0.18	0.1765	2	2	0.075	0.112	0.094	0.0935
Iron (Fe)-Total	mg/L	3	3	1.5	82.3	46.2	54.8	2	2	56.9	84.3	71	70.6	2	2	27.9	55.9	42	41.9
Lead (Pb)-Total	mg/L	3	3	0.0025	0.14	0.087483333	0.12	2	2	0.112	0.123	0.12	0.1175	2	2	0.0293	0.0805	0.055	0.0549
Lithium (Li)-Total	mg/L	3	3	0.023	0.111	0.077966667	0.1	2	2	0.058	0.113	0.086	0.0855	2	2	0.05	0.0665	0.058	0.05825
Magnesium (Mg)-Total	mg/L	3	3	3.6	24.5	16.63333333	21.8	2	2	31.4	38.2	35	34.8	2	2	20.1	22.3	21	21.2
Manganese (Mn)-Total	mg/L	3	3	0.65	3.8	2.131333333	1.94	2	2	3.31	3.84	3.6	3.575	2	2	1.46	5.1	3.3	3.28
Mercury (Hg)-Total	mg/L	3	1	0.00001	0.00012	0.000078	0.0001	2	2	0.00014	0.00149	0.00082	0.000815	2	2	0.000052	0.00016	0.00011	0.000106
Molybdenum (Mo)-Total	mg/L	3	3	0.0058	0.017	0.009766667	0.0063	2	2	0.00379	0.00764	0.0057	0.005715	2	2	0.00512	0.00634	0.0057	0.00573
Nickel (Ni)-Total	mg/L	3	3	0.0038	0.075	0.0403	0.0422	2	2	0.0624	0.0651	0.064	0.06375	2	2	0.0303	0.0441	0.037	0.0372
Potassium (K)-Total	mg/L	3	3	3.3	15.8	10.96666667	13.8	2	2	15.3	19.3	17	17.3	2	2	9.59	11.3	10	10.445
Selenium (Se)-Total	mg/L	3	1	0.001	0.0059	0.00398	0.005	2	2	0.00216	0.0033	0.0027	0.00273	2	2	0.00212	0.00328	0.0027	0.0027
Silver (Ag)-Total	mg/L	3	3	0.00052	0.041	0.020208	0.019	2	2	0.0261	0.0368	0.031	0.03145	2	2	0.0179	0.0266	0.022	0.02225
Sodium (Na)-Total	mg/L	3	3	12.4	62.5	34.93333333	29.9	2	2	15.4	26.2	21	20.8	2	2	20.8	22.8	22	21.8
Strontium (Sr)-Total	mg/L	3	3	0.842	4.65	2.987333333	3.47	2	2	5.85	7.43	6.6	6.64	2	2	4.95	5.39	5.2	5.17
Thallium (Tl)-Total	mg/L	3	2	0.0002	0.0041	0.002023333	0.0018	2	2	0.00228	0.00251	0.0024	0.002395	2	2	0.000923	0.00162	0.0013	0.0012715
Tin (Sn)-Total	mg/L	3	2	0.00066	0.0025	0.001696667	0.0019	2	2	0.00055	0.0007	0.00063	0.000625	2	2	0.00075	0.00128	0.001	0.001015
Uranium (U)-Total	mg/L	3	3	0.00028	0.018	0.007796667	0.0056	2	2	0.0106	0.0132	0.012	0.0119	2	2	0.00256	0.00509	0.0038	0.003825
Vanadium (V)-Total	mg/L	3	3	0.0015	0.048	0.029433333	0.039	2	2	0.0423	0.0529	0.048	0.0476	2	2	0.0201	0.0327	0.026	0.0264
Zinc (Zn)-Total	mg/L	3	3	0.032	0.461	0.271233333	0.321	2	2	0.351	0.441	0.4	0.396	2	2	0.124	0.254	0.19	0.189
Dissolved Metals																			
Aluminum (Al)-Dissolved	mg/L	3	3	0.057	5.8	2.002	0.15	2	2	0.0036	0.0062	0.005	0.0049	2	2	0.0028	0.0055	0.004	0.00415
Antimony (Sb)-Dissolved	mg/L	3	3	0.0028	0.01	0.005926667	0.0050	2	2	0.00335	0.00655	0.005	0.00495	2	2	0.00238	0.0051	0.0037	0.00374
Arsenic (As)-Dissolved	mg/L	3	3	0.0064	0.0958	0.03887	0.014	2	2	0.0216	0.0324	0.027	0.027	2	2	0.00789	0.0104	0.0091	0.009145
Barium (Ba)-Dissolved	mg/L	3	3	0.021	0.285	0.111	0.027	2	2	0.0597	0.0986	0.079	0.07915	2	2	0.0385	0.0515	0.045	0.045
Beryllium (Be)-Dissolved	mg/L	3	1	0.00047	0.001	0.000823333	0.001	2	0	0.0001	0.0002	0.00015	0.00015	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	3	0	0.001	0.2	0.133666667	0.2	2	0	0.00005	0.0001	0.000075	0.000075	2	0	0.00005	0.00005	0.00005	0.00005
Cadmium (Cd)-Dissolved	mg/L	3	2	0.000017	0.0012	0.000443	0.00011	2	2	0.0000067	0.000021	0.000014	0.00001385	2	2	0.0000077	0.0000088	0.0000083	0.00000825
Calcium (Ca)-Dissolved	mg/L	3	3	30.1	63.9	41.76666667	31.3	2	2	128	137	133	132.5	2	2	67	84.9	76	75.95
Chromium (Cr)-Dissolved	mg/L	3	1	0.001	0.0081	0.00337	0.001	2	0	0.0001	0.0002	0.00015	0.00015	2	0	0.0001	0.0001	0.0001	0.0001
Cobalt (Co)-Dissolved	mg/L	3	2	0.0003	0.0044	0.00266	0.0033	2	2	0.00093	0.00099	0.00096	0.00096	2	2	0.00044	0.0016	0.001	0.00102
Copper (Cu)-Dissolved	mg/L	3	2	0.001	0.017	0.006633333	0.0024	2	1	0.00023	0.0004	0.00032	0.000315	2	2	0.00033	0.00078	0.00056	0.000555
Iron (Fe)-Dissolved	mg/L	3	3	0.038	9.15	3.086666667	0.072	2	2	0.424	1.08	0.75	0.752	2	1	0.01	0.072	0.041	0.041
Lead (Pb)-Dissolved	mg/L	3	1	0.0005	0.019	0.006533333	0.0005	2	1	0.0001	0.000101	0.0001	0.0001005	2	0	0.00005	0.00005	0.00005	0.00005
Lithium (Li)-Dissolved	mg/L	3	3	0.021	0.087	0.0578	0.066	2	2	0.0234	0.0746	0.049	0.049	2	2	0.0353	0.045	0.04	0.04015
Magnesium (Mg)-Dissolved	mg/L	3	3	3.22	9.37	6.23	6.1	2	2	15.7	20.6	18	18.15	2	2	13.7	15	14	14.35
Manganese (Mn)-Dissolved	mg/L	3	3	0.058	0.831	0.485866667	0.57	2	2	0.598	0.859	0.73	0.7285	2	2	0.138	0.389	0.26	0.2635
Mercury (Hg)-Dissolved	mg/L	3	0	0.00001	0.0001	0.00004	0.00001	2	0	0.000005	0.000005	0.000005	0.000005	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	3	3	0.0054	0.014	0.008433333	0.0058	2	2	0.0017	0.00291	0.0023	0.002305	2	2	0.00194	0.00291	0.0024	0.002425
Nickel (Ni)-Dissolved	mg/L	3	2	0.001	0.012	0.005166667	0.0026	2	2	0.00305	0.0045	0.0038	0.003775	2	2	0.00278	0.00666	0.0047	0.00472
Potassium (K)-Dissolved	mg/L	3	3	2.5	8.49	5.33	5	2	2	5.47	6.62	6	6.045	2	2	5.11	5.91	5.5	5.51
Selenium (Se)-Dissolved	mg/L	3	1	0.00072	0.001	0.000906667	0.001	2	0	0.00005	0.0001	0.000075	0.000075	2	1	0.00005	0.000053	0.000052	0.0000515
Silver (Ag)-Dissolved	mg/L	3	1	0.00002	0.0050	0.00169	0.00002	2	0	0.00001	0.00002	0.000015	0.000015	2	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	3	3	12.3	65.2	35.56666667	29.2	2	2	10.9	25.3	18	18.1	2	2	20.2	21.6	21	20.9
Strontium (Sr)-Dissolved	mg/L	3	3	0.811	2.54	1.837	2.16	2	2	4.45	6.22	5.3	5.335	2	2	3.9	4.71	4.3	4.305
Thallium (Tl)-Dissolved	mg/L	3	1	0.0002	0.00075	0.000382	0.0002	2	0	0.00001	0.00002	0.000015	0.000015	2	2	0.000021	0.000031	0.000026	0.000026
Tin (Sn)-Dissolved	mg/L	3	1	0.0002	0.00091	0.000536667	0.0005	2	0	0.0001	0.0002	0.00015	0.00015	2	0	0.0001	0.0001	0.0001	0.0001
Uranium (U)-Dissolved	mg/L	3	3	0.00022	0.0017	0.00115	0.0016	2	2	0.0026	0.0028	0.0027	0.0027	2	2	0.000813	0.00115	0.00098	0.0009815
Vanadium (V)-Dissolved	mg/L	3	3	0.001	0.0094	0.0038	0.001	2	0	0.0005	0.001	0.00075	0.00075	2	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	3	1	0.005	0.043	0.019233333	0.010	2	1	0.002	0.0023	0.0022	0.00215	2	2	0.0011	0.0017	0.0014	0.0014

BJ-GW11-5B		Baseline Period (2011 - 2014)						2016					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**												
Temperature	°C	0						2	2	3.1	5.3	4.2	4.2
pH	pH	0						2	2	7.45	7.53	7.49	7.49
Specific Sonductance	µS/cm	0						2	2	603	675.2	639.1	639.1
Dissolved Oxygen	mg/L	0						0					
Oxidation Reduction Potential	mV	0						0					
Turbidity	NTU	0						0					
Physical Tests													
Conductivity	uS/cm	3	3	335	427	366.7	338	2	2	607	770	688.5	688.5
Hardness (as $CaCO_3$)	mg/L	3	3	145	171	161.3	168	2	2	299	400	349.5	349.5
pH	pH	3	3	8.05	8.13	8.1	8.12	2	2	7.72	7.91	7.82	7.815
Total Suspended Solids (TSS)	mg/L	3	3	3830	34400	14820	6220	2	2	651	1230	940.5	940.5
Total Dissolved Solids (TDS)	mg/L	3	3	237	290	260.7	255	2	2	451	580	515.5	515.5
Turbidity	NTU	3	3	4000	4000	4000	4000	2	2	635	1410	1023	1022.5
Anions and Nutrients													
Acidity (as CaCO3)	mg/L	3	3	1.5	2.4	1.87	1.7	2	2	4.6	8.9	6.75	6.75
Total Alkalinity (as $CaCO_3$)	mg/L	3	3	70.8	89.3	78.57	75.6	2	2	160	163	161.5	161.5
Total Ammonia (as N)	mg/L	3	3	0.12	0.39	0.25	0.23	2	2	0.0598	0.0873	0.074	0.07355
Chloride (Cl)	mg/L	3	3	0.76	4.31	2.68	2.97	2	0	2.5	2.5	2.5	2.5
Fluoride (F)	mg/L	3	3	0.18	0.26	0.23	0.24	2	1	0.1	0.1	0.1	0.1
Nitrate (as N)	mg/L	3	0	0.005	0.005	0.005	0.005	2	2	0.11	0.737	0.42	0.4235
Nitrite (as N)	mg/L	3	1	0.001	0.0011	0.0010	0.001	2	2	0.0074	0.084	0.046	0.0457
Dissolved Orthophosphate (as P)	mg/L	3	0	0.001	0.001	0.001	0.001	2	2	0.0014	0.0027	0.0021	0.00205
Total Phosphorus (P)	mg/L	3	3	2.51	12.5	8.3	9.74	2	2	0.49	0.95	0.72	0.72
Sulphate (SO_4)	mg/L	3	3	89.2	121	102	96.3	2	2	219	274	247	246.5
Total Metals													
Aluminum (Al)-Total	mg/L	3	3	38.3	240	145	158	2	2	11.2	17.7	14.50	14.45
Antimony (Sb)-Total	mg/L	3	2	0.01	0.013	0.012	0.013	2	2	0.0176	0.018	0.018	0.0178
Arsenic (As)-Total	mg/L	3	3	0.94	5.04	3.2	3.52	2	2	0.201	0.435	0.32	0.318
Barium (Ba)-Total	mg/L	3	3	2.08	6.33	4	3.44	2	2	0.365	0.672	0.52	0.5185
Beryllium (Be)-Total	mg/L	3	1	0.0025	0.02	0.014	0.02	2	2	0.00047	0.00077	0.00062	0.00062
Bismuth(Bi)- Total	mg/L	3	1	0.0016	0.2	0.13	0.2	2	2	0.000255	0.000432	0.00034	0.0003435
Cadmium (Cd)-Total	mg/L	3	3	0.0064	0.0113	0.0095	0.0109	2	2	0.000682	0.00139	0.001	0.001036
Calcium (Ca)-Total	mg/L	3	3	171	620	417	460	2	2	139	148	144	143.5
Chromium (Cr)-Total	mg/L	3	3	0.0673	0.241	0.15	0.146	2	2	0.0142	0.0254	0.02	0.0198
Cobalt (Co)-Total	mg/L	3	3	0.038	0.202	0.13	0.152	2	2	0.0109	0.0233	0.017	0.0171
Copper (Cu)-Total	mg/L	3	3	0.294	1.52	0.95	1.04	2	2	0.0398	0.0909	0.065	0.06535
Iron (Fe)-Total	mg/L	3	3	92.6	460	300	344	2	2	16.4	30	23	23.2
Lead (Pb)-Total	mg/L	3	3	0.127	0.518	0.3	0.267	2	2	0.017	0.0347	0.026	0.02585
Lithium (Li)-Total	mg/L	3	3	0.0794	0.3	0.2	0.22	2	2	0.0467	0.0645	0.056	0.0556
Magnesium (Mg)-Total	mg/L	3	3	21.9	118	78	94.3	2	2	19.8	20.1	20	19.95
Manganese (Mn)-Total	mg/L	3	3	5.06	24.4	16	17.9	2	2	1.02	1.88	1.5	1.45
Mercury (Hg)-Total	mg/L	3	2	0.0001	0.0015	0.00065	0.000351	2	2	0.0000197	0.000072	0.000046	0.00004585
Molybdenum (Mo)-Total	mg/L	3	2	0.02	0.03	0.025	0.0254	2	2	0.00676	0.0139	0.01	0.01033
Nickel (Ni)-Total	mg/L	3	3	0.0755	0.357	0.23	0.251	2	2	0.035	0.0529	0.044	0.04395
Potassium (K)-Total	mg/L	3	3	16.3	74.8	46	48.1	2	2	9.09	10.6	9.8	9.845
Selenium (Se)-Total	mg/L	3	1	0.00759	0.02	0.016	0.02	2	2	0.000875	0.00154	0.0012	0.0012075
Silver (Ag)-Total	mg/L	3	3	0.0567	0.244	0.15	0.136	2	2	0.00885	0.0205	0.015	0.014675
Sodium (Na)-Total	mg/L	3	3	11.1	15	13	14.3	2	2	10.5	13.3	12	11.9
Strontium (Sr)-Total	mg/L	3	3	2.35	4.33	3.5	3.83	2	2	3.54	4.31	3.9	3.925
Thallium (Tl)-Total	mg/L	3	3	0.00329	0.0105	0.0076	0.0091	2	2	0.000716	0.00105	0.00088	0.000883
Tin (Sn)-Total	mg/L	3	1	0.00043	0.01	0.0068	0.01	2	2	0.00029	0.00043	0.00036	0.00036
Uranium (U)-Total	mg/L	3	3	0.00393	0.0526	0.023	0.0132	2	2	0.003	0.0032	0.0031	0.0031
Vanadium (V)-Total	mg/L	3	3	0.0598	0.341	0.21	0.221	2	2	0.0195	0.0321	0.026	0.0258
Zinc (Zn)-Total	mg/L	3	3	0.5	1.63	1.1	1.27	2	2	0.069	0.161	0.12	0.115
Dissolved Metals													
Aluminum (Al)-Dissolved	mg/L	3	3	0.0297	0.0868	0.0637	0.0747	2	2	0.0064	0.0065	0.006	0.00645
Antimony (Sb)-Dissolved	mg/L	3	3	0.00457	0.0113	0.0077	0.00722	2	2	0.00984	0.016	0.013	0.01292
Arsenic (As)-Dissolved	mg/L	3	3	0.00533	0.012	0.0092	0.0102	2	2	0.0162	0.0194	0.018	0.0178
Barium (Ba)-Dissolved	mg/L	3	3	0.024	0.0492	0.038	0.042	2	2	0.0334	0.0542	0.044	0.0438
Beryllium (Be)-Dissolved	mg/L	3	0	0.0002	0.001	0.00073	0.001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	3	0	0.001	0.2	0.13	0.2	2	0	0.00005	0.00005	0.00005	0.00005
Cadmium (Cd)-Dissolved	mg/L	3	1	0.000017	0.00033	0.00012	0.000017	2	2	0.0000464	0.0000582	0.000052	0.0000523
Calcium (Ca)-Dissolved	mg/L	3	3	48.6	58.5	54.7	56.9	2	2	98.3	133	116	115.65
Chromium (Cr)-Dissolved	mg/L	3	0	0.0002	0.001	0.00073	0.001	2	0	0.0001	0.0001	0.0001	0.0001
Cobalt (Co)-Dissolved	mg/L	3	1	0.0003	0.00037	0.00032	0.0003	2	2	0.0013	0.00151	0.0014	0.001405
Copper (Cu)-Dissolved	mg/L	3	0	0.001	0.001	0.001	0.001	2	1	0.0002	0.0002	0.0002	0.0002
Iron (Fe)-Dissolved	mg/L	3	0	0.03	0.03	0.03	0.03	2	0	0.01	0.01	0.01	0.01
Lead (Pb)-Dissolved	mg/L	3	0	0.0001	0.0005	0.00037	0.0005	2	0	0.00005	0.00005	0.00005	0.00005
Lithium (Li)-Dissolved	mg/L	3	3	0.0094	0.0232	0.016	0.0151	2	2	0.0273	0.0527	0.04	0.04
Magnesium (Mg)-Dissolved	mg/L	3	3	5.74	6.38	6	5.91	2	2	13.1	16.5	15	14.8
Manganese (Mn)-Dissolved	mg/L	3	3	0.134	0.554	0.32	0.262	2	2	0.183	0.292	0.24	0.2375
Mercury (Hg)-Dissolved	mg/L	3	0	0.00001	0.0001	0.00004	0.00001	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	3	3	0.0055	0.0158	0.0096	0.0075	2	2	0.00497	0.00997	0.0075	0.00747
Nickel (Ni)-Dissolved	mg/L	3	1	0.001	0.0017	0.0012	0.001	2	2	0.0112	0.0185	0.015	0.01485
Potassium (K)-Dissolved	mg/L	3	3	3.7	7.4	5.5	5.53	2	2	5.07	5.45	5.3	5.26
Selenium (Se)-Dissolved	mg/L	3	0	0.0002	0.001	0.00073	0.001	2	2	0.000062	0.00015	0.00011	0.000106
Silver (Ag)-Dissolved	mg/L	3	0	0.00002	0.00002	0.00002	0.00002	2	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	3	3	9.8	14.5	12	12.7	2	2	9.91	13.1	12	11.505
Strontium (Sr)-Dissolved	mg/L	3	3	0.747	1.66	1.3	1.55	2	2	3.39	4.33	3.9	3.86
Thallium (Tl)-Dissolved	mg/L	3	1	0.000129	0.0002	0.00018	0.0002	2	2	0.0001	0.000104	0.0001	0.000102
Tin (Sn)-Dissolved	mg/L	3	1	0.0002	0.00116	0.00062	0.0005	2	0	0.0001	0.0001	0.0001	0.0001
Uranium (U)-Dissolved	mg/L	3	3	0.00082	0.00146	0.0011	0.00107	2	2	0.00263	0.0027	0.0027	0.002665
Vanadium (V)-Dissolved	mg/L	3	0	0.001	0.002	0.0013	0.001	2	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	3	0	0.005	0.006	0.0053	0.005	2	2	0.0019	0.0026	0.0023	0.00225

BJ-GW12-8A		Baseline Period (2011 - 2014)						2015						2016						2017						2018						2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																																		
Temperature	°C	8	8	1.9	4.9	3	2.9	3	3	3	3.3	3.2	3.2	5	5	1.3	3.7	2.46	2.5	2.4	4	4	2.1	2.6	2.3	2.3	4	4	1.3	3.5	2.325	2.3	2.25	4	4	1.8	4.3	3	2.95	3	3	2.6	3.3	2.9	2.7	4	4	1.5	2.7	2.2	2.2
pH	pH	8	8	6.7	8.7	7.93	8.1	3	3	8.1	8.3	8.2	8.2	5	5	8.1	8.3	8.2	8.2	8.2	4	4	8	8.6	8.3	8.3	4	4	8	8.1	8.05	8.1	8.05	4	4	8.05	8.16	8.1	8.1	3	3	8.02	8.17	8.1	8.09	4	4	8.08	8.21	8.2	8.165
Specific conductance	µS/cm	8	8	130	341	250.9	249.5	3	3	190	213	201.3	201	5	5	202	245	216.4	220	208	4	4	203	220	210	209	4	4	181	218	200.75	200	202	4	4	196.8	214.9	203.6	201.3	3	3	206.4	211.2	210	208.3	4	4	204	215.7	210	212.9
Dissolved Oxygen	mg/L	0	0	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	2	2	3.66	4	3.83	3.83	3	3	3.12	4.64	3.7	3.4	4	4	1.45	4.7	3	2.965
Oxidation Reduction Potential	mV	0	0	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	4	4	58	151.2	99.08	93.55	3	3	84.9	156.7	130	139.8	4	4	33.4	129.7	84	87.2
Turbidity	NTU	0	0	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	-	3	3	43.1	119	82	84.1	2	2	17.5	62	39.75	40	39.75	4	4	7.24	55.7	23.42	15.37	3	3	1.56	10.33	6.8	8.4	4	4	1.1	46.33	18	11.58
Physical Tests																																																			
Conductivity	uS/cm	8	8	196	213	202.8	200.5	3	3	201	216	208.7	209	5	5	202	225	213.2	210	213	4	4	189	217	200	202.5	4	4	198	219	207.25	210	206	4	4	201	216	209.8	211	3	3	210	217	213	212	4	4	202	222	210	212
Acidity (as CaCO3)	mg/L	8	5	1	11	2.425	1.1	0	-	-	-	-	-	3	2	1	1.2	1.1	1.1	1.1	4	2	1	1.6	1.2	1.05	4	4	1	1.8	1.35	1.4	1.3	4	3	1.3	2	1.6	1.55	3	3	2	2	2	2	4	4	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	8	8	70	76	74.13	74	3	3	74	77	75.67	76	5	5	72	89	80.8	81	80	4	4	73	87	79	77	4	4	70	103	79.75	80	73	4	4	72.3	77	74.63	74.6	3	3	68.6	72.2	70	70.5	4	4	60.7	73	70	72.35
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	93.2	106	100	102	4	4	97.9	104	100	99.05
Hardness (as CaCO3), total from Ca/Mg	mg/L	8	8	86	100	91.63	90.5	3	3	96	103	100	101	5	5	98	105	101	100	100	4	4	93	99	97	97.5	4	4	92	108	97.25	97	94.5	4	4	92.4	102	97.13	97.05	3	3	98.8	114	100	99.2	4	4	96.6	100	98	98.55
pH	pH	8	8	7	8.3	8.04	8.2	3	3	8	8.2	8.1	8.1	5	5	8	8.2	8.1	8.1	8.1	4	4	8.1	8.3	8.2	8.2	4	4	8.1	8.2	8.125	8.1	8.1	4	4	8.11	8.17	8.14	8.14	3	3	7.89	8.14	8	8.08	4	4	8.05	8.13	8.1	8.105
Total Dissolved Solids (TDS)	mg/L	8	8	117	145	127.4	126	3	3	125	139	132	132	5	5	121	161	138.6	140	138	4	4	133	161	150	144.5	4	4	122	148	138	140	141	4	4	110	144	129.8	132.5	3	3	127	144	130	131	4	4	106	141	130	127.5
Total Suspended Solids (TSS)	mg/L	8	7	3	212	52.25	19	3	3	10	594	243	125	5	5	30	1050	675.6	680	771	4	4	154	3200	1000	363	4	4	12	1510	433.75	430	106.5	4	4	6.3	74.8	24.15	7.75	3	2	3	13.3	9.5	12.3	4	4	5.2	28.9	17	16.1
Turbidity	NTU	8	8	0.7	118	25.08	9.6	3	3	7.7	139	63.23	43	5	5	14	634	385.8	390	410	4	4	84	2420	720	179.5	4	4	16	923	269	270	68.5	4	4	1.38	55.1	16.88	5.525	3	3	1.28	10	5.9	6.49	4	4	1.76	14.2	10	12.4
Anions and Nutrients																																																			
Kjeldahl nitrogen, total [TKN]														-	-	-	-	-	-	-														-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	4	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	8	0	0.005	0.005	0.005	0.005	3	0	0.005	0.005	0.005	0.005	5	0	0.005	0.005	0.005	0.005	0.005	4	2	0.005	0.006	0.0055	0.0054	4	1	0.005	0.01	0.00625	0.0063	0.005	4	0	0.005	0.005	0.005	0.005	3	0	0.005	0.005	0.005	0.005	4	0	0.005	0.005	0.005	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	4	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	8	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	5	0	0.5	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	8	8	0.026	0.031	0.029	0.0285	3	3	0.024	0.028	0.026	0.026	5	5	0.021	0.039	0.0304	0.03	0.03	4	4	0.024	0.034	0.027	0.024	4	4	0.022	0.029	0.0245	0.025	0.0235	4	4	0.025	0.03	0.027	0.026	3	3	0.022	0.026	0.024	0.023	4	4	0.023	0.029	0.026	0.025
Nitrate (as N)	mg/L	8	8	0.0065	0.0237	0.0151	0.017	3	3	0.017	0.022	0.02	0.018	5	5	0.013	0.02	0.0166	0.017	0.017	4	4	0.014	0.027	0.021	0.0205	4	4	0.014	0.03	0.02375	0.024	0.0255	4	4	0.0199	0.0298	0.02	0.024	3	3	0.0184	0.0272	0.021	0.0187	4	4	0.0149	0.0258	0.018	0.01555
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0	0.0187	0.0062	0	4	4	0.0149	0.0258	0.018	0.01555
Nitrite (as N)	mg/L	8	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	5	0	0.001	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.03	0.032	0.031	0.03	4	1	0.03	0.03	0.03	0.03
Dissolved Orthophosphate (as P)	mg/L	8	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	5	2	0.001	0.0013	0.0011	0.0011	0.001	4	1	0.001	0.0014	0.0011	0.001	4	0	0.001	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	3	1	0.001	0.0014	0.0011	0.001	4	0	0.001	0.001	0.001	0.001
Total Phosphorus (P)	mg/L	8	7	0.002	0.1	0.018	0.0046	3	3	0.0021	0.13	0.052	0.025	5	5	0.0029	0.51	0.22298	0.22	0.14	4	4	0.071	3.5	0.98	0.17	4	4	0.01	1.1	0.326	0.33	0.097	4	4	0.0032	0.0477	0.016	0.0066	3	3	0.0032	0.0119	0.0067	0.0049	4	4	0.0024	0.0103	0.0065	0.00665
Sulphate (SO4)	mg/L	8	8	30	37	33	32	3	3	32	37	34.7	35	5	5	32	37	34.4	34	35	4	4	32	37	35	34.5	4	4	30	35	32.75	33	33	4	4	31.7	37	34.3	34.2	3	3	33.2	37.5	35	35.1	4	4	31.4	38.2	34	34.1
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.019	0.019	0.019	4	0	0.0016	0.0016	0.0016	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	4	0	0.0015	0.0015	0.0015	0.0015
Total Metals																																																			
Aluminum (Al)-Total	mg/L	8	8	0.04	5.1	1.58	0.83	3	3	0.48	10	4.26	2.3	5	5	1.6	16	9.78	9.8	9.9	4	4	2.2	41	14	6.6	4	4	0.34	19	5.6525	5.7	1.635	4	4	0.0544	0.272	0.19	0.246	3	3	0.0544	0.272	0.19	0.246	4	4	0.0585	0.407	0.21	0.195
Antimony (Sb)-Total	mg/L	8	8	0.00074	0.0016	0.00093	0.00083	3	3	0.00057	0.00089	0.00074	0.00075	5	5	0.00059	0.0034	0.002062	0.0021	0.0022	4	4	0.0021	0.0077	0.0036	0.0022	4	4	0.0011	0.0059	0.0029	0.0029	0.0023	4	4	0.001	0.0032	0.0019	0.0016	3	3	0.00082	0.00103	0.00095	0.00103	4	4	0.00093	0.0012	0.001	0.001015
Arsenic (As)-Total	mg/L	8	8	0.0074	0.012	0.011	0.0085	3	3	0.0082	0.01	0.0092	0.0095	5	5	0.0087	0.26	0.12594	0.13	0.15	4	4	0.068	1.6	0.47	0.1055	4	4	0.022	0.69	0.21525	0.22	0.0745	4	4	0.0103	0.158	0.059	0.034	3	3	0.00964	0.0152	0.013	0.013	4	4	0.0105	0.02	0.014	0.0135
Barium (Ba)-Total	mg/L	8	8	0.02	0.1	0.035	0.0255	3	3	0.026	0.17	0.077	0.035	5	5	0.051	0.45	0.2522	0.25	0.25	4	4	0.13	2.7	0.79	0.165	4	4	0.035	1	0.3135	0.31	0.1095	4	4	0.026	0.18	0.077	0.052	3	3	0.0222	0.029	0.026	0.0282	4	4	0.0237	0.0372	0.029	0.02815
Beryllium (Be)-Total	mg/L	8	2	0.0001	0.00073	0.00022	0.0001	3	2	0.0001	0.0018	0.00072	0.00026	5	5	0.00017	0.0024	0.001274	0.0013	0.0012	4	4	0.00032	0.0049	0.0016	0.00059	4	2	0.0001	0.0029	0.000835	0.00084	0.00017	4	1	0.0001	0.00032	0.00016	0.0001	3	3	0.0001	0.0001	0.0001	0.0001	4	1	0.000029	0.0001	0.000082	0.0001
Bismuth(Bi)-Total	mg/L	8	0	0.0005	0.0005	0.0005	0.0005	3	2	0.00005	0.00045	0.00019	0.000079	5	5	0.000052	0.00061	0.0002964	0.0003	0.00026	4	4	0.000052	0.00073	0.00026	0.000155	4	1	0.00005	0.00052	0.0001675	0.00017	0.00005	4	1	0.00005	0.000553	0.000051	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.01	0.01	0.01	0.01	4	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	8	8	0.000012	0.00024	0.000045	0.000015	3	3	0.000015	0.0001	0.000047	0.000025	5	5	0.000038	0.0027	0.001036	0.001	0.00072	4	4	0.00022	0.0055	0.0016	0.00037	4	4	0.00008	0.0035	0.00111	0.0011	0.00043	4	4	0.000220	0.00213	0.00063	0.00019	3	3	0.000128	0.000484	0.000331	0.000331	4	4	0.000147	0.000658	0.00035	0.000310 5
Calcium (Ca)-Total	mg/L	8	8	26	31	28	27.5	3	3	30	32	31	31	5	5	34	65	51	52	52	4	4	32	192	75	38.5	4	4	30	103	45.75	50	33	4	4	30.3	37	31	31.8	3	3	29.3	35.1	31	29.5	4	4	29.9	34.4	31	30.5
Chromium (Cr)-Total	mg/L	8	8	0.00019	0.0067	0.0018	0.00078	3	3	0.0005	0.008	0.0031	0.00094	5	5	0.0038	0.022	0.01108	0.011	0.009	4	4	0.002	0.099	0.027	0.00325	4	4	0.0047	0.03	0.00882	0.0088	0.002405	4	4	0.00115	0.0583	0.0187	0.0079	3	3	0.00098	0.00398	0.0029	0.00376	4	4	0.00157	0.00942	0.0061	0.006405
Cobalt (Co)-Total	mg/L	8	5	0.0001	0.0016	0.00036	0.00013	3	2	0.0001	0.0013	0.00055	0.00025	5	5	0.00056	0.011	0.005632	0.0056	0.0069	4	4	0.0026	0.08	0.023	0.0043	4	4	0.00048	0.031	0.009175	0.0092	0.00261	4	4	0.00035	0.00522	0.002	0.0012	3	3	0.0001	0.00074	0.00047	0.00058	4	4	0.00023	0.00128	0.00073	0.000705
Copper (Cu)-Total	mg/L	8	8	0.0005	0.0044	0.0012	0.00065	3	3	0.0005	0.0044	0.0023	0.002	5	5	0.0016	0.027	0.01568	0.016	0.017	4	4	0.0062	0.03	0.082	0.0112	4	4	0.0016	0.09	0.02845	0.028	0.0081	4	4	0.00071	0.0217	0.0075	0.0037	3	2	0.0002	0.00262	0.0016	0.00162	4	4	0.00126	0.00415	0.0024	0.002095
Iron (Fe)-Total	mg/L	8	7	0.03	5	0.94	0.275	3	3	0.21	3	1.3	0.56	5	5	0.62	20	11.184	11	12	4	4	4.7	120	35	7.9	4	4	0.94	55	16.31	16	4.65	4	4	0.168	10.1	3.5	1.93	3	3	0.056	0.529	0.32	0.36	4	4	0.091	0.874	0.44	0.3875
Lead (Pb)-Total	mg/L	8	8	0.00007	0.0075	0.0016	0.000535	3	3	0.00049	0.013	0.0052	0.0021	5	5	0.0014	0.04	0.02108	0.021	0.018	4	4	0.0054	0.16	0.046	0.0086	4	4	0.00097	0.069	0.0204925	0.02	0.006	4	4	0.00030	0.012	0.0045	0.0028	3	3	0.00017	0.000978	0.0006	0.000646	4	4	0.000206	0.00146	0.00079	0.00074
Lithium (Li)-Total	mg/L	8	8	0.0077	0.011	0.0091	0.009	3	3	0.0074	0.012	0.0096	0.0095	5	5	0.0094	0.018	0.01428	0.014	0.015	4	4	0.011	0.058	0.023	0.011	4	4	0.001	0.027	0.0175	0.014	0.00995	4	4	0.0076	0.0108	0.0092	0.0091	3	3	0.0082	0.0086	0.0084	0.0083	4	4	0.0081	0.0087	0.0085	0.0085
Magnesium (Mg)-Total	mg/L	8	8	5	6.5	5.7	5.55	3	3	6.1	8.2	6.8	6.2	5	5	6	9.8	8.48	8.5	8.9	4	4	6.4	24	11	7.6	4	4	5.8	15	8.5	8.5	6.6	4	4	5.81	7.07	6.3	6.09	3	3	6.21	6.46	6.3	6.24	4	4	5.23	6.11	5.7	5.77
Manganese (Mn)-Total	mg/L	8	8	0.0024	0.28	0.049	0.0135	3	3	0.013	0.17	0.07	0.026	5	5	0.026	2.8	1.4032	1.4	1.3	4	4	0.55	16	4.6	0.96	4	4	0.11	6.4	1.955	2	0.655	4	4	0.0139	0.805	0.32	0.234	3	3	0.00493	0.0565	0.031	0.0326	4	4	0.00908	0.0848	0.041	0.0347
Mercury (Hg)-Total	mg/L	8	0	0.00001	0.00001	0.00001	0.00001	3	3	0.000005	0.00005	0.000029	0.000032	3	3	0.000018	0.000053	0.000032	0.000032	0.000025	4	1	0.000025	0.00017	0.00008	0.0000625	4	1	0.00005	0.000099	0.000035	0.000034	0.000015	4	0	0.000005	0.000025	0.00001	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005
Molybdenum(Mo)-Total	mg/L	8	8	0.0013	0.0023	0.0016	0.0015	3	3	0.0012	0.016	0.0014	0.0014	5	5	0.0009	0.004	0.00222	0.0021	0.0016	4	4	0.0013	0.0024	0.0018	0.00175	4	4	0.0013	0.0061	0.0016	0.0016	0.0015	4	4	0.00144	0.00295	0.0022	0.0021	3	3	0.00131	0.00176	0.0016	0.00169	4	4	0.00155	0.0025	0.0021	0.0022
Nickel (Ni)-Total	mg/L	8	4	0.0005	0.0042	0.0011	0.00055	3	2	0.0005	0.0057	0.0023	0.00069	5	5	0.0024	0.014	0.00558	0.0056	0.0042	4	4	0.001	0.026	0.0076	0.0017	4	2	0.0005	0.011	0.003375	0.0034	0.001	4	4	0.00066	0.00736	0.0046	0.0053	3	3	0.00061	0.0025	0.0019	0.00244	4	4	0.00114	0.00636	0.0038	0.0038
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	4	0	0.05	0.3	0.24	0.3
Potassium (K)-Total	mg/L	8	8	0.43	1.9	0.76	0.575	3	3	0.54	1.9	1	0.69	5	5	0.64	3.8	2.468	2.5	2.5	4	4	1.1	8.3	3.3	1.9	4	4	0.57	4.2	1.725	1.7	1.065	4	4	0.489	1.18	0.79	0.7415	3	3	0.45	0.568	0.51	0.522	4	4	0.495	0.639	0.57	0.5745
Selenium (Se)-Total	mg/L	8	8	0.00016	0.00023	0.00018	0.000175	3	3	0.00018	0.00022	0.0002	0.0002	5	5	0.00019	0.00027	0.000246	0.00025	0.00026	4	4	0.00019	0.00074	0.00035	0.000235	4	4	0.00018	0.0004	0.00026	0.00026	0.00023	4	4	0.000191	0.00025	0.00022	0.00022	3	3	0.000218	0.000225	0.00022	0.000221	4	4	0.000177	0.000224	0.00019	0.0001855
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	2.04	2.71	2.4	2.46	4	4	2.17	2.65	2.4	2.41
Silver (Ag)-Total	mg/L	8	6	0.00001	0.00022	0.000073	0.0000215	3	3	0.000022	0.000036	0.000031	0.000035	5	5	0.000049	0.0015	0.0009278	0.00093	0.0014	4	4	0.00022	0.021	0.0056	0.000555	4	4	0.000092	0.0056	0.0016055	0.0016	0.000365	4	4	0.000019	0.00347	0.00093	0.00011	3	2	0.00001	0.000068	0.000043	0.000052	4	4	0.000028	0.00312	0.00014	0.000111
Sodium (Na)-Total	mg/L	8	8	3.5	7	5.1	4.7	3	3	3.6	4	3.8	3.8	5	5	3.5	7.5	5.22	5.2	4.4	4	4	3.4	7.2	4.5	3.65	4	4	3.2	4.6	3.625	3.6	3.35	4	4	3.36	3.74	3.5	3.43	3	3	3.25	3.32	3.3	3.31	4	4	3.29	3.61	3.5	3.465
Strontium (Sr)-Total	mg/L	8	8	0.63	0.76	0.7	0.7	3	3	0.73	0.89	0.79	0.74	5	5	0.72	1.1	0.912	0.91	0.93	4	4	0.75	1.7	1	0.855	4	4	0.66	1.1	0.8225	0.82	0.765	4	4	0.704	0.778	0.74	0.74	3	3	0.704	0.745	0.72	0.707	4	4	0.704	0.744	0.72	0.7235
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	8	4	0.00001	0.00013	0.000032	0.000012	3	2	0.00001	0.00018	0.000074	0.000033	5	5	0.000022	0.00077	0.0003584	0.00036	0.0003	4	4	0.00011	0.0017	0.00054	0.00017	4	4	0.000021	0.00081	0.0002685	0.00027	0.0001215	4	2	0.00001	0.000092	0.00005	0.000050	3	1	0.00001	0.000012	0.000011	0.00001	4	2	0.00001	0.000016	0.000012	0.000011
Tin (Sn)-Total	mg/L	8	4	0.0001	0.00047	0.00021	0.00011	3	3	0.00014	0.00037	0.00022	0.00015	5	5	0.00026	0.00047	0.000354	0.00035	0.00036	4	4	0.00023	0.002	0.00094	0.000755	4	3	0.0001	0.0016	0.00079	0.00079	0.00073	4	3	0.0001	0.00091	0.00039	0.00027	3	2	0.0001	0.00017	0.00013	0.00011	4	2	0.0001

BJ-GW12-IB		Baseline Period (2011 - 2014)							2015						2016						2017						2018						2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																																			
Temperature	°C	8	8	1	4.9	2.65	2.7	2.6	2	2	2.9	3.6	3.3	3.25	5	5	0.5	4.1	2.3	2.1	4	4	1.2	2.7	1.8	1.7	4	4	0	3.6	1.7	1.5	4	4	2	4.7	3.3	3.25	3	3	2.9	4.9	3.8	3.7	4	4	3.3	5.5	4.4	4.4
pH	pH	8	8	7.7	8.7	8.225	8.23	8.3	2	2	7.6	8.1	7.9	7.85	5	5	8	8.4	8.2	8.2	4	4	8.1	8.3	8.2	8.25	4	4	8	8.2	8.1	8.05	4	4	7.96	8.12	8.03	8.025	3	3	8.02	8.17	8.1	8.07	4	4	8.06	8.18	8.1	8.14
Specific Sonductance	µS/cm	8	8	131	242	203.875	203.9	210.5	2	2	198	222	210	210	5	5	206	233	220	215	4	4	210	219	210	214.5	4	4	193	220	210	210.5	4	4	204.8	220.9	210.2	207.45	3	3	211.6	214.7	210	212.5	4	4	207.6	216.2	210	212.65
Dissolved Oxygen	mg/L	0	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	2	2	4.29	4.57	4.43	4.43	3	3	2.97	4.8	4.1	4.43	4	4	1.93	4.76	2.8	2.33
Oxidation Reduction Potential	mV	0	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	4	4	68.7	169.9	116	112.6	3	3	47.3	142.5	99	107	4	4	23.5	132.6	80	82.45
Turbidity	NTU	0	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	3	3	2249	3286	2800	2830	1	1	1707	1707	1700	1707	3	3	6.26	30	16.72	13.9	3	3	8.66	16.77	12	9.75	4	4	1.54	10.2	6.6	7.33
Physical Tests																																																				
Conductivity	uS/cm	8	8	187	201	197.375	197.4	200	2	2	201	211	210	206	5	5	207	221	210	209	4	4	193	224	210	201.5	4	4	210	252	230	222	4	4	210	219	213	211.5	3	3	217	222	219	219	4	4	208	219	210	213
Acidity (as CaCO3)	mg/L	8	4	1	2.4	1.2875	1.288	1	0	-	-	-	-	-	3	2	1	1.3	1.1	1.1	4	3	1	2.1	1.7	1.75	4	4	1.1	1.8	1.5	1.5	4	2	1.4	2	1.7	1.7	3	0	2	2	2	2	4	2	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	8	8	55	73	67.625	67.63	69	2	2	69	72	71	70.5	5	5	64	79	74	76	4	4	78	109	100	106.5	4	4	71	116	98	102.5	4	4	70.1	78	72.83	71.6	3	3	69	70.6	70	69.7	4	4	69.6	72.9	71	70.6
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	94.5	110	100	101	4	4	93.5	103	100	101.5
Hardness (as CaCO3), total from Ca/Mg	mg/L	8	8	64	100	90.75	90.75	94	2	2	99	103	100	101	5	5	139	110	107	107	4	4	91	101	96	96.5	4	4	100	120	110	103	4	4	96.1	109	101.3	99.95	3	3	100	112	100	102	4	4	99.1	106	100	102
pH	pH	8	8	8	8.3	8.1625	8.16	8.15	2	2	8	8.1	8.1	8.05	5	5	7.9	8.1	8.1	8.1	4	4	7.8	8.1	8	8.1	4	4	8.1	8.2	8.2	8.15	4	4	8.06	8.15	8.11	8.12	3	3	7.99	8.13	8.1	8.12	4	4	7.98	8.09	8	8.005
Total Dissolved Solids (TDS)	mg/L	8	8	121	147	132.875	132.9	131	2	2	132	140	140	136	5	5	137	166	150	147	4	4	120	241	180	174	4	4	171	418	270	242.5	4	4	116	277	139.8	123	3	3	122	143	130	132	4	4	120	136	130	126.5
Total Suspended Solids (TSS)	mg/L	8	8	5.3	5340	878.5375	878.5	187.5	2	2	30	182	110	106	5	5	11	3610	1600	1380	4	4	1460	2670	2000	1895	4	4	762	3640	2200	2099.5	4	3	3	1610	444.4	82.2	3	2	3	145	52	7.4	4	4	3.4	13.2	7.7	7.1
Turbidity	NTU	8	8	14	4000	726.25	726.3	220	2	2	47	109	78	78	5	5	29	4000	1800	1550	4	4	1750	3470	2700	2785	4	4	90	4000	1500	938.5	4	4	1.47	3140	795.8	20.80	3	3	4.84	11.1	7.6	7	4	4	1.96	7.14	4	3.45
Anions and Nutrients																																																				
Kjeldahl nitrogen, total [TKN]	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	4	2	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	8	1	0.005	0.008	0.005375	0.0054	0.005	2	0	0.005	0.005	0.005	0.005	5	1	0.005	0.0071	0.0054	0.005	4	0	0.005	0.005	0.005	0.005	4	0	0.005	0.005	0.005	0.005	4	0	0.005	0.005	0.005	0.005	3	0	0.005	0.005	0.005	0.005	4	2	0.005	0.005	0.005	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	4	2	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	8	0	0.5	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5	5	0	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	4	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	4	2	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	8	8	0.021	0.061	0.029125	0.029	0.024	2	2	0.02	0.02	0.02	0.02	5	3	0.02	0.024	0.022	0.022	4	4	0.02	0.023	0.022	0.0215	4	3	0.02	0.028	0.023	0.021	4	4	0.022	0.027	0.024	0.024	3	2	0.02	0.025	0.023	0.025	4	4	0.022	0.027	0.024	0.024
Nitrate (as N)	mg/L	8	6	0.005	0.022	0.01575	0.016	0.019	2	2	0.019	0.021	0.02	0.02	5	5	0.013	0.023	0.018	0.02	4	4	0.018	0.031	0.024	0.0225	4	4	0.022	0.038	0.031	0.031	4	4	0.0246	0.0371	0.029	0.027	3	3	0.0196	0.0343	0.025	0.0205	4	4	0.0153	0.0253	0.019	0.0167
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0	0.0205	0.0068	0	4	4	0.0155	0.0253	0.019	0.0167
Nitrite (as N)	mg/L	8	0	0.001	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001	5	0	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	4	2	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.03	0.034	0.031	0.03	4	2	0.03	0.03	0.03	0.03
Dissolved Orthophosphate (as P)	mg/L	8	4	0.001	0.0082	0.0020625	0.0021	0.001	2	1	0.001	0.0011	0.0011	0.00105	5	4	0.001	0.002	0.0014	0.0013	4	3	0.001	0.0018	0.0014	0.00135	4	4	0.001	0.0023	0.0014	0.0012	4	1	0.001	0.0012	0.0011	0.001	3	1	0.001	0.0013	0.0011	0.001	4	3	0.001	0.0018	0.0012	0.001
Total Phosphorus (P)	mg/L	8	8	0.0034	1.3	0.249375	0.25	0.092	2	2	0.015	0.16	0.088	0.0875	5	5	0.0098	1.8	0.95	1.2	4	4	0.98	2.1	1.7	1.8	4	4	0.63	2.4	1.5	1.515	4	4	0.0021	1.2	0.31	0.011	3	3	0.0057	0.0284	0.014	0.0066	4	4	0.0024	0.0115	0.007	0.0071
Sulphate (SO4)	mg/L	8	8	32	40	35.5	35.5	35.5	2	2	35	40	38	37.5	5	5	35	39	37	38	4	4	36	39	38	37.5	4	4	36	45	39	38	4	4	35.5	40.1	37.2	36.65	3	3	36.7	46.4	38	37.3	4	4	33.7	39.9	37	37.5
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.019	0.019	0.019	4	2	0.0016	0.011	0.004	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	4	2	0.0015	0.01	0.0036	0.0015
Total Metals																																																				
Aluminum (Al)-Total	mg/L	8	8	0.57	50	13.10875	13.1	9.5	2	2	2.4	5.6	4	4	5	5	1.3	63	27	16	4	4	20	48	32	30	4	4	14	56	32	28.5	4	4	0.0694	36	9.33	6.624	3	3	0.122	0.63	0.39	0.411	4	4	0.0822	0.473	0.27	0.256
Antimony (Sb)-Total	mg/L	8	8	0.00075	0.0027	0.001665	0.0017	0.0018	2	2	0.001	0.0023	0.0017	0.00165	5	5	0.00094	0.006	0.0034	0.0036	4	4	0.0043	0.0053	0.0048	0.0048	4	4	0.0043	0.0052	0.0048	0.0048	4	4	0.00081	0.00515	0.002	0.00095	3	3	0.00079	0.00101	0.00087	0.00081	4	4	0.00083	0.0009	0.00088	0.00089
Arsenic (As)-Total	mg/L	8	8	0.02	0.53	0.11465	0.15	0.068	2	2	0.032	0.097	0.065	0.0645	5	5	0.024	1.5	0.53	0.26	4	4	0.46	1.1	0.76	0.73	4	4	0.36	1.3	0.79	0.75	4	4	0.0125	0.994	0.26	0.019	3	3	0.0146	0.026	0.018	0.0158	4	4	0.015	0.0179	0.017	0.01725
Barium (Ba)-Total	mg/L	8	8	0.028	0.91	0.276375	0.28	0.175	2	2	0.077	0.14	0.11	0.1085	5	5	0.046	1.9	0.83	0.64	4	4	0.55	1.2	0.88	0.875	4	4	0.43	1.6	0.95	0.885	4	4	0.0175	1.19	0.32	0.033	3	3	0.0217	0.0514	0.029	0.0279	4	4	0.0236	0.032	0.03	0.03145
Beryllium (Be)-Total	mg/L	8	5	0.0001	0.0073	0.001245	0.0012	0.00023	2	1	0.0001	0.00037	0.00024	0.000235	5	4	0.0001	0.0061	0.0028	0.0016	4	4	0.0014	0.0028	0.002	0.0019	4	4	0.00073	0.0032	0.0019	0.00184	4	1	0.0001	0.00225	0.00064	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	4	2	0.00002	0.0001	0.00008	0.0001
Bismuth(Bi)- Total	mg/L	8	1	0.0005	0.0016	0.0006375	0.00064	0.0005	2	1	0.00005	0.00092	0.00071	0.000071	5	4	0.00005	0.0014	0.00058	0.00016	4	4	0.00017	0.00047	0.00031	0.0003	4	4	0.00012	0.00053	0.00032	0.00031	4	1	0.00005	0.000299	0.00011	0.00005	3	0	0.00005	0.0005	0.00005	0.00005	4	2	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.01	0.01	0.01	0.01	4	2	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	8	6	0.00001	0.0006	0.00011625	0.00012	0.000037	2	2	0.0000095	0.000064	0.000037	0.00003675	5	5	0.0000066	0.0018	0.00069	0.00047	4	4	0.0004	0.0013	0.00079	0.00073	4	4	0.00034	0.0014	0.00085	0.000835	4	2	0.000005	0.000762	0.0002	0.0000667	3	1	0.000005	0.0000286	0.000013	0.000005	4	4	0.000005	0.0000907	0.000075	0.0000755
Calcium (Ca)-Total	mg/L	8	8	30	118	45.625	45.6	33	2	2	33	43	38	38	5	5	35	198	99	87	4	4	62	110	82	77.5	4	4	51	129	84	78.5	4	4	33.2	78.8	43.5	34.9	3	3	32.6	36.7	34	32.9	4	4	31	33.6	33	33.1
Chromium (Cr)-Total	mg/L	8	8	0.00058	0.028	0.008885	0.0089	0.0047	2	2	0.003	0.086	0.0058	0.0058	5	5	0.0038	0.06	0.021	0.01	4	4	0.013	0.04	0.026	0.026	4	4	0.014	0.056	0.031	0.0265	4	4	0.00058	0.0252	0.0093	0.0058	3	3	0.0405	0.00597	0.0053	0.00574	4	4	0.00182	0.00913	0.0056	0.005745
Cobalt (Co)-Total	mg/L	8	8	0.00013	0.033	0.00776125	0.0078	0.0032	2	2	0.00077	0.0071	0.0039	0.003935	5	5	0.00052	0.092	0.036	0.022	4	4	0.021	0.054	0.039	0.0405	4	4	0.017	0.065	0.04	0.039	4	3	0.0001	0.0602	0.015	0.00046	3	3	0.0002	0.00197	0.00083	0.00032	4	4	0.00027	0.00236	0.0009	0.000475
Copper (Cu)-Total	mg/L	8	7	0.0005	0.1	0.0199125	0.021	0.0084	2	2	0.0025	0.017	0.0098	0.00975	5	5	0.0012	0.25	0.11	0.049	4	4	0.0152	0.11	0.0595	0.0995	4	4	0.045	0.18	0.1	0.093	4	4	0.0005	0.111	0.029	0.0019	3	3	0.00063	0.0039	0.0022	0.00209	4	4	0.00118	0.00208	0.0016	0.00153
Iron (Fe)-Total	mg/L	8	8	0.27	52	12.1875	12	5.2	2	2	1.4	6.3	3.9	3.85	5	5	0.8	114	40	20	4	4	0.52	85	54	49.5	4	4	26	98	57	52	4	4	0.033	69.1	18	0.45	3	3	0.114	0.762	0.39	0.282	4	4	0.084	0.339	0.27	0.322
Lead (Pb)-Total	mg/L	8	8	0.0002	0.07	0.013325	0.013	0.0041	2	2	0.0012	0.0065	0.0039	0.00385	5	5	0.0006	0.14	0.051	0.017	4	4	0.024	0.08	0.053	0.053	4	4	0.024	0.099	0.056	0.05	4	3	0.00005	0.0596	0.015	0.00045	3	3	0.000132	0.000904	0.00048	0.000406	4	4	0.000175	0.00367	0.00031	0.000395
Lithium (Li)-Total	mg/L	8	8	0.005	0.053	0.0115625	0.015	0.0091	2	2	0.0058	0.071	0.0065	0.00645	5	5	0.0062	0.093	0.037	0.018	4	4	0.031	0.064	0.046	0.0445	4	4	0.022	0.077	0.046	0.042	4	4	0.0067	0.058	0.019	0.0069	3	3	0.0067	0.007	0.007	0.0067	4	4	0.0064	0.0069	0.0067	0.0067
Magnesium (Mg)-Total	mg/L	8	8	3.5	19	7.0375	7	5.05	2	2	4	5.1	4.6	4.55	5	5	4	35	16	8.5	4	4	13	26	18	17	4	4	10	29	18	17	4	4	3.99	19.3	8.1	4.61	3	3	4.52	4.54	4.8	4.84	4	4	3.92	4.68	4.4	4.595
Manganese (Mn)-Total	mg/L	8	8	0.012	3.2	0.78425	0.78	0.29	2	2	0.076	0.46	0.27	0.268	5	5	0.044	11	4.3	2.7	4	4	2.5	5.7	4.3	4.55	4	4	1.9	7.5	4.6	4.5	4	4	0.00259	7.39	1.9	0.049	3	3	0.00674	0.156	0.062	0.0219	4	4	0.0227	0.0794	0.047	0.0429
Mercury (Hg)-Total	mg/L	8	4	0.00001	0.0048	0.0009045	0.00095	0.0002	2	1	0.0000996	0.0003	0.0001	0.0000298	3	3	0.00024	0.0006	0.00038	0.0003	4	3	0.00014	0.0006	0.00042	0.00035	4	3	0.00014	0.00065	0.00042	0.000435	4	1	0.000005	0.00031	0.00018	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	4	2	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	8	8	0.0015	0.0031	0.0020375	0.002	0.0017	2	2	0.0017	0.002	0.0019	0.00185	5	5	0.00072	0.0028	0.0019	0.002	4	4	0.0021	0.0024	0.0023	0.00225	4	4	0.0021	0.0024	0.0022	0.0022	4	4	0.00136	0.00215	0.0018	0.00189	3	3	0.00157	0.00214	0.0019	0.00189	4	4	0.0014	0.00224	0.0019	0.00192
Nickel (Ni)-Total	mg/L	8	7	0.0005	0.021	0.00631375	0.0063	0.0048	2	2	0.0018	0.0058	0.0038	0.0038	5	5	0.0025	0.04	0.016	0.008	4	4	0.0094	0.027	0.018	0.018	4	4	0.0083	0.033	0.019	0.01665	4	3	0.0005	0.0211	0.0071	0.0034	3	3	0.00271	0.00376	0.0033	0.00354	4	4	0.00117	0.00496	0.0034	0.003775
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	4	2	0.05	0.3	0.24	0.3
Potassium (K)-Total	mg/L	8	8	0.77	7.9	2.98375	3	2.6	2	2	1.5	2	1.8	1.75	5	5	1.1	9.1	5.1	4.5	4	4	4.8	8.2	5.9	5.35	4	4	3.4	8.1	5.4	5.1	4	4	0.469	5.6	1.9	0.68	3	3	0.487	0.72	0.62	0.648	4	4	0.498	0.691	0.59	0.578
Selenium (Se)-Total	mg/L	8	8	0.00022	0.00061	0.00031875	0.00032	0.00028	2	2	0.00035	0.00038	0.00037	0.000365	5	5	0.0003	0.001	0.00052	0.00044	4	4	0.00038	0.00062	0.00051	0.000525	4	4	0.00036	0.00062	0.00051	0.00052	4	4	0.00026	0.0005	0.00035	0.00031	3	3	0.000301	0.000387	0.00035	0.000362	4	4	0.00029	0.000376	0.00032	0.000301
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	2.39	2.66	2.5	2.48	4	4	2.1	2.73	2.4	2.37
Silver (Ag)-Total	mg/L	8	7	0.00001	0.0016	0.000598125	0.00051	0.00035	2	2	0.000047	0.0041	0.00023	0.0002285	5	5	0.000047	0.0088	0.0038	0.0025	4	4	0.0018	0.006	0.0037	0.00345	4	4	0.0015	0.0068	0.0038	0.0035	4	2	0.00001	0.00267	0.00068	0.000022	3	2	0.00001	0.000026	0.000018	0.000018	4	4	0.00001	0.000388	0.00011	0.000019
Sodium (Na)-Total	mg/L	8	8	2.1	13	3.925	3.9	2.65	2	2	1.9	2	2	1.95	5	5	2.1	4.1	2.9	2.8	4	4	2.8	3.5	3.1	3.05	4	4	2.8	3.4	3	2.95	4	4	2.45	2.98	2.7	2.67	3	3	2.45	2.57	2.5	2.52	4	4	2.42	2.57	2.5	2.53
Strontium (Sr)-Total	mg/L	8	8	0.43	56	5.6625	5.55	0.475	2	2	0.46	0.47	0.47	0.465	5	5	0.45	1.4	0.83	0.74	4	4	0.68	0.89	0.78	0.775	4	4	0.65	0.92	0.78	0.765	4	4	0.554	0.807	0.62	0.56	3	3	0.552	0.587	0.57	0.582	4	4	0.558	0.594	0.57	0.5675
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	8	8	0.000014	0.00091	0.000235	0.00024	0.00014	2	2	0.000056	0.00014	0.000098	0.000098	5	5	0.000039	0.0015	0.00064	0.0004	4	4	0.00041	0.00091	0.00065	0.000635	4	4	0.00034	0.0009	0.00062	0.000625	4	2	0.00001	0.00088	0.00023	0.000021	3	2	0.00001	0.000026	0.000015	0.00001	4	4	0.00001	0.00001	0.00001	0.00001
Tin (Sn)-Total	mg/L	8	6	0.0001	0.0013	0.0004075	0.00041	0.00029	2	1	0.0001	0.0086	0.00048	0.00048	5	4	0.0001	0.0019	0.00096	0.0011	4	4	0.00015	0.0073	0.00064	0.000655	4	4	0.00055	0.0015	0.00084	0.00065	4	1	0.0001	0.00072	0.00026	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	4	2	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.01	0.01	0.01	0.01	4	2	0.0045	0.01	0.0086	0.01
Uranium (U)-Total	mg/L	8	8	0.00017	0.012	0.001975	0.002	0.00032	2	2	0.00018	0.00078	0.00048	0.00048	5	5	0.00018	0.0076	0.0032	0.0012	4	4	0.0011	0.0021	0.0016	0.

BJ-GW12-9B		Operations (2015 - 2018)	2016						2017							2018						2019						2020						2021					
		Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																																						
Temperature	°C	2.85	2	2	2.3	3.4	2.9	2.85	1	1	5	5	5	5	5	1	1	1.9	1.9	1.9	1.9	2	2	2.6	3.2	2.9	2.9	2	2	1.6	6.5	4.1	4.05	1	1	1.5	1.5	1.5	1.5
pH	pH	7.75	2	2	7.4	7.9	7.7	7.65	1	1	7.8	7.8	7.8	7.8	7.8	1	1	7.7	7.7	7.7	7.7	2	2	7.7	7.75	7.73	7.725	2	2	7.74	7.92	7.8	7.83	1	1	8.05	8.05	8.1	8.05
Specific Sonductance	µS/cm	318	2	2	306	324	320	315	1	1	322	322	322	320	322	1	1	314	314	310	314	2	2	286.5	317	301.8	301.75	2	2	244.3	254.4	250	249.35	1	1	231.5	231.5	230	231.5
Dissolved Oxygen	mg/L	-	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	1	1	5.57	5.57	5.57	5.57	2	2	4.56	6.14	5.4	5.35	1	1	8.66	8.66	8.7	8.66
Oxidation Reduction Potential	mV	-	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	2	2	163.8	197	180.4	180.4	2	2	92	175.5	130	133.75	1	1	132.2	132.2	130	132.2
Turbidity	NTU	38.3	0	-	-	-	-	-	1	1	13.6	13.6	13.6	14	13.6	1	1	63	63	63	63	2	2	40	55.8	47.9	47.9	2	2	9.8	94.61	52	52.205	1	1	66.52	66.52	67	66.52
Physical Tests																																							
Conductivity	uS/cm	307	2	2	257	297	280	277	1	1	320	320	320	320	320	1	1	317	317	320	317	2	2	295	326	310.5	310.5	2	2	240	249	240	244.5	1	1	234	234	230	234
Acidity (as CaCO3)	mg/L	1.5	2	2	1.3	1.7	1.5	1.5	1	1	2	2	2	2	2	1	0	1	1	1	1	2	2	1	1.6	1.3	1.3	2	1	2	2.1	2.1	2.05	1	1	3.2	3.2	3.2	3.2
Total Alkalinity (as CaCO3)	mg/L	86	2	2	84	86	85	85	1	1	86	86	86	86	86	1	1	87	87	87	87	2	2	89.2	92.7	90.95	90.95	2	2	77	79.7	78	78.35	1	1	71.6	71.6	72	71.6
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	110	117	110	113.5	1	1	103	103	100	103
Hardness (as CaCO3), total from Ca/Mg	mg/L	144	2	2	133	149	140	141	1	1	152	152	152	150	152	1	1	139	139	140	139	2	2	143	165	154	154	2	2	116	146	130	131	1	1	115	115	120	115
pH	pH	8.1	2	2	8.1	8.1	8.1	8.1	1	1	8.1	8.1	8.1	8.1	8.1	1	1	8.2	8.2	8.2	8.2	2	2	8.11	8.16	8.14	8.135	2	2	7.99	8.03	8	8.01	1	1	8.01	8.01	8	8.01
Total Dissolved Solids (TDS)	mg/L	208	2	2	178	207	190	192.5	1	1	217	217	217	220	217	1	1	209	209	210	209	2	2	197	211	204	204	2	2	154	170	160	162	1	1	129	129	130	129
Total Suspended Solids (TSS)	mg/L	54.5	2	2	11	148	80	79.5	1	1	22	22	22	22	22	1	1	87	87	87	87	2	2	99.2	123	111.1	111.1	2	1	3	104	54	53.5	1	1	19.9	19.9	20	19.9
Turbidity	NTU	33.5	2	2	8.3	70	39	39.15	1	1	17	17	17	17	17	1	1	50	50	50	50	2	2	69.1	87.4	78.25	78.25	2	2	0.77	69.2	35	34.985	1	1	11.7	11.7	12	11.7
Anions and Nutrients																																							
Kjeldahl nitrogen, total [TKN]		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	0.05	0.551	0.3	0.3005	1	1	0.092	0.092	0.092	0.092
Total Ammonia (as N)	mg/L	0.005	2	0	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005	0.005	1	1	0.0059	0.0059	0.0059	0.0059	2	0	0.005	0.005	0.005	0.005	2	1	0.005	0.0112	0.0081	0.0081	1	0	0.005	0.005	0.005	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.05	0.05	0.05	0.05	1	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	0.5	2	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5	2	1	0.5	0.67	0.59	0.59	2	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	0.029	2	2	0.027	0.029	0.028	0.028	1	1	0.029	0.029	0.029	0.029	0.029	1	1	0.031	0.031	0.031	0.031	2	1	0.036	0.04	0.038	0.038	2	2	0.033	0.038	0.036	0.0355	1	1	0.028	0.028	0.028	0.028
Nitrate (as N)	mg/L	0.025	2	2	0.014	0.025	0.02	0.0195	1	1	0.025	0.025	0.025	0.025	0.025	1	1	0.026	0.026	0.026	0.026	2	2	0.0137	0.0418	0.028	0.028	2	2	0.0108	0.0144	0.013	0.0126	1	1	0.0153	0.0153	0.015	0.0153
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0153	0.0153	0.015	0.0153
Nitrite (as N)	mg/L	0.001	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	2	2	0.0013	0.0027	0.002	0.002	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	0.03	0.562	0.3	0.296	1	1	0.107	0.107	0.11	0.107
Dissolved Orthophosphate (as P)	mg/L	0.001	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	0.001	1	1	0.0011	0.0011	0.0011	0.0011	2	0	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001
Total Phosphorus (P)	mg/L	0.017	2	2	0.011	0.016	0.014	0.0135	1	1	0.018	0.018	0.018	0.018	0.018	1	1	0.077	0.077	0.077	0.077	2	2	0.0662	0.152	0.11	0.11	2	1	0.002	0.0884	0.045	0.0452	1	1	0.0228	0.0228	0.023	0.0228
Sulphate (SO4)	mg/L	70.5	2	2	50	71	61	60.5	1	1	79	79	79	79	79	1	1	70	70	70	70	2	2	61.1	74.8	68	67.95	2	2	46.6	48.2	47	47.4	1	1	40.4	40.4	40	40.4
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.018	0.019	0.019	0.0185	1	0	0.011	0.011	0.011	0.011
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.018	0.018	0.018	0.018	1	0	0.01	0.01	0.01	0.01
Total Metals																																							
Aluminum (Al)-Total	mg/L	0.61	2	2	0.089	0.85	0.47	0.4695	1	1	0.37	0.37	0.37	0.37	0.37	1	1	2.3	2.3	2.3	2.3	2	2	1.22	1.62	1.42	1.42	2	2	0.036	4.03	2	2.033	1	1	0.321	0.321	0.32	0.321
Antimony (Sb)-Total	mg/L	0.0012	2	2	0.0011	0.0012	0.0012	0.00115	1	1	0.0012	0.0012	0.0012	0.0012	0.0012	1	1	0.0016	0.0016	0.0016	0.0016	2	2	0.00129	0.00167	0.0015	0.0015	2	2	0.00099	0.00102	0.001	0.001005	1	1	0.00106	0.00106	0.0011	0.00106
Arsenic (As)-Total	mg/L	0.0032	2	2	0.0012	0.004	0.0026	0.0026	1	1	0.0024	0.0024	0.0024	0.0024	0.0024	1	1	0.013	0.013	0.013	0.013	2	2	0.00715	0.0122	0.0097	0.0097	2	2	0.00072	0.0062	0.0035	0.00346	1	1	0.00169	0.00169	0.0017	0.00169
Barium (Ba)-Total	mg/L	0.0555	2	2	0.033	0.069	0.051	0.051	1	1	0.042	0.042	0.042	0.042	0.042	1	1	0.16	0.16	0.16	0.16	2	2	0.0775	0.0841	0.081	0.081	2	2	0.0196	0.112	0.066	0.0658	1	1	0.0337	0.0337	0.034	0.0337
Beryllium (Be)-Total	mg/L	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.00015	0.00015	0.00015	0.00015	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.00028	0.00019	0.00019	1	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	0.00005	1	1	0.000061	0.000061	0.000061	0.000061	2	0	0.00005	0.00005	0.00005	0.00005	2	1	0.00005	0.000054	0.000052	0.000052	1	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.01	0.01	0.01	1	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	0.000066	2	2	3.4E-05	0.000079	0.000057	0.000565	1	1	0.000052	0.000052	0.000052	0.000052	0.000052	1	1	0.00013	0.00013	0.00013	0.00013	2	2	0.00012	0.00015	0.00014	0.00014	2	1	0.00001	0.000135	0.000073	0.0000725	1	1	0.0000227	0.0000227	0.000023	0.0000227
Calcium (Ca)-Total	mg/L	63	2	2	54	61	58	57.5	1	1	65	65	65	65	65	1	1	71	71	71	71	2	2	54.6	63.1	58.9	58.85	2	2	44.1	55.3	50	49.7	1	1	39.4	39.4	39	39.4
Chromium (Cr)-Total	mg/L	0.00089	2	2	0.00038	0.0012	0.00079	0.00079	1	1	0.0057	0.0057	0.0057	0.0057	0.0057	1	1	0.0041	0.0041	0.0041	0.0041	2	2	0.00322	0.00455	0.0039	0.0039	2	2	0.00155	0.00647	0.004	0.00401	1	1	0.00392	0.00392	0.0039	0.00392
Cobalt (Co)-Total	mg/L	0.00040	2	2	0.00018	0.00051	0.00035	0.000345	1	1	0.00028	0.00028	0.00028	0.00028	0.00028	1	1	0.0015	0.0015	0.0015	0.0015	2	2	0.0009	0.00107	0.00099	0.00099	2	2	0.0001	0.00181	0.00096	0.000955	1	1	0.00027	0.00027	0.00027	0.00027
Copper (Cu)-Total	mg/L	0.0022	2	2	0.00086	0.0025	0.0017	0.00168	1	1	0.0019	0.0019	0.0019	0.0019	0.0019	1	1	0.011	0.011	0.011	0.011	2	2	0.00958	0.0143	0.012	0.012	2	2	0.00133	0.0089	0.0051	0.005115	1	1	0.00269	0.00269	0.0027	0.00269
Iron (Fe)-Total	mg/L	1.245	2	2	0.39	1.6	1	0.995	1	1	0.89	0.89	0.89	0.89	0.89	1	1	4.7	4.7	4.7	4.7	2	2	3.23	3.3	3.3	3.27	2	2	0.074	3.9	2	1.987	1	1	0.636	0.636	0.64	0.636
Lead (Pb)-Total	mg/L	0.0013	2	2	0.00053	0.0016	0.0011	0.001065	1	1	0.00096	0.00096	0.00096	0.00096	0.00096	1	1	0.0065	0.0065	0.0065	0.0065	2	2	0.00587	0.0119	0.0089	0.0089	2	2	0.000124	0.00684	0.0035	0.003482	1	1	0.000988	0.000988	0.00099	0.000988
Lithium (Li)-Total	mg/L	0.0063	2	2	0.0055	0.0057	0.0056	0.0056	1	1	0.0069	0.0069	0.0069	0.0069	0.0069	1	1	0.0075	0.0075	0.0075	0.0075	2	2	0.006	0.0062	0.0061	0.0061	2	2	0.0046	0.0075	0.0061	0.00605	1	1	0.0036	0.0036	0.0036	0.0036
Magnesium (Mg)-Total	mg/L	2.35	2	2	2.1	2.4	2.3	2.25	1	1	2.3	2.3	2.3	2.3	2.3	1	1	2.7	2.7	2.7	2.7	2	2	2.24	2.32	2.3	2.28	2	2	1.45	1.96	1.7	1.705	1	1	1.18	1.18	1.2	1.18
Manganese (Mn)-Total	mg/L	0.0365	2	2	0.016	0.045	0.031	0.0305	1	1	0.028	0.028	0.028	0.028	0.028	1	1	0.24	0.24	0.24	0.24	2	2	0.137	0.16	0.15	0.149	2	2	0.00393	0.173	0.088	0.088465	1	1	0.0297	0.0297	0.03	0.0297
Mercury (Hg)-Total	mg/L	0.000005	2	0	5E-06	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005	0.000005	1	0	0.000025	0.000025	0.000025	0.000025	2	1	5E-06	0.0000113	0.0000082	0.0000082	2	1	0.000005	0.0000167	0.000011	0.00001085	1	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	0.0024	2	2	0.0023	0.0027	0.0025	0.0025	1	1	0.0022	0.0022	0.0022	0.0022	0.0022	1	1	0.0024	0.0024	0.0024	0.0024	2	2	0.00192	0.0361	0.019	0.01905	2	2	0.00296	0.00371	0.0033	0.003335	1	1	0.00322	0.00322	0.0032	0.00322
Nickel (Ni)-Total	mg/L	0.00056	2	1	0.0005	0.00062	0.00056	0.00056	1	0	0.0005	0.0005	0.0005	0.0005	0.0005	1	1	0.0023	0.0023	0.0023	0.0023	2	2	0.00149	0.00191	0.0017	0.0017	2	2	0.00186	0.00213	0.002	0.001995	1	0	0.0005	0.0005	0.0005	0.0005
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.3	0.3	0.3	0.3	1	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	1.15	2	2	0.93	1.2	1.1	1.065	1	1	1.1	1.1	1.1	1.1	1.1	1	1	1.5	1.5	1.5	1.5	2	2	1.44	1.47	1.5	1.46	2	2	0.848	2.04	1.4	1.444	1	1	0.866	0.866	0.87	0.866
Selenium (Se)-Total	mg/L	0.0012	2	2	0.00098	0.0017	0.0013	0.00134	1	1	0.0015	0.0015	0.0015	0.0015	0.0015	1	1	0.00091	0.00091	0.00091	0.00091	2	2	0.00075	0.00116	0.00095	0.00095	2	2	0.000586	0.000712	0.00065	0.000649	1	1	0.000622	0.000622	0.00062	0.000622
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2.26	10.9	6.6	6.58	1	1	2.7	2.7	2.7	2.7
Silver (Ag)-Total	mg/L	0.00025	2	1	0.00001	0.00015	0.00008	0.00008	1	1	0.00034	0.00034	0.00034	0.00034	0.00034	1	1	0.00043	0.00043	0.00043	0.00043	2	2	0.00028	0.000301	0.00029	0.00029	2	1	0.00001	0.000248	0.00013	0.000129	1	1	0.000056	0.000056	0.000056	0.000056
Sodium (Na)-Total	mg/L	2.45	2	2	2.1	2.4	2.3	2.25	1	1	2.5	2.5	2.5	2.5	2.5	1	1	2.6	2.6	2.6	2.6	2	2	2.99	3.28	3.1	3.14	2	2	1.83	3.93	2.9	2.88	1	1	1.59	1.59	1.6	1.59
Strontium (Sr)-Total	mg/L	0.34	2	2	0.34	0.42	0.38	0.38	1	1	0.41	0.41	0.41	0.41	0.41	1	1	0.53	0.53	0.53	0.53	2	2	0.339	0.401	0.37	0.37	2	2	0.268	0.348	0.31	0.308	1	1	0.249	0.249	0.25	0.249
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000026	2	1	0.00001	0.000033	0.000022	0.0000215	1	1	0.000018	0.000018	0.000018	0.000018	0.000018	1	1	0.000066	0.000066	0.000066	0.000066	2	2	3.8E-05	0.000043	0.000041	0.000041	2	1	0.00001	0.000081	0.000046	0.0000455	1	1	0.000013	0.000013	0.000013	0.000013
Tin (Sn)-Total	mg/L	0.00037	2	2	0.00015	0.00039	0.00027	0.00027	1	1	0.00034	0.00034	0.00034	0.00034	0.00034	1	1	0.0019	0.0019	0.0019	0.0019	2	2	0.0015	0.00177	0.0016	0.0016	2	1	0.0001	0.00184	0.00097	0.00097	1	1	0.00038	0.00038	0.00038	0.00038
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	0.01	0.0782	0.044	0.0441	1	0	0.01	0.01	0.01	0.01
Uranium (U)-Total	mg/L	0.00066	2	2	0.00057	0.00065	0.00061	0.00061	1	1	0.00066	0.00066	0.00066	0.00066	0.00066	1	1	0.00086	0.00086	0.00086	0.00086	2	2	0.0006	0.000731	0.00066	0.00066	2	2	0.000402	0.000753	0.00058	0.0005775	1	1	0.000329	0.000329	0.00033	0.000329
Vanadium (V)-Total	mg/L	0.0015	2	1	0.0005	0.0021	0.0013	0.0013	1	1	0.00098	0.00098	0.00098	0.00098	0.00098	1	1	0.0042	0.0042	0.0042	0.0042	2	2	0.00282	0.00294	0.0029	0.0029	2	1	0.0005	0.00492	0.0027	0.00271	1	1	0.00074	0.00074	0.00074	0.00074
Zinc (Zn)-Total	mg/L	0.0064	2	1	0.003	0.007	0.005	0.005	1	1	0.0057	0.0057	0.0057	0.0057	0.0057	1	1	0.1	0.1	0.1	0.1	2	2	0.0227	0.0385	0.031	0.031	2	1	0.003	0.0798	0.041	0.0414	1	1	0.0076	0.0076	0.0076	0.0076
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																							
Aluminum (Al)-Dissolved	mg/L	0.0045	2	2	0.0043	0.0047	0.0045	0.0045	1	1	0.003	0.003	0.003	0.003	0.003	1	1	0.0075	0.0075	0.0075	0.0075	2	2	0.0079	0.0103	0.0091	0.0091	2	2	0.0032	0.0042	0.0037	0.0037	1	1	0.0071	0.0071	0.0071	0.0071
Antimony (Sb)-Dissolved	mg/L	0.001	2	2	0.001	0.0012	0.0011	0.0011	1	1	0.001	0.001	0.001	0.001	0.001	1	1	0.00092	0.00092	0.00092	0.00092	2	2	0.00084	0.0012	0.001	0.0010	2	2	0.0006	0.00097	0.00079	0.000785	1	1	0.00082	0.00082	0.00082	0.00082
Arsenic (As)-Dissolved	mg/L	0.00049	2	2	0.00044	0.00053	0.00049	0.000485	1	1	0.00044	0.00044	0.00044	0.00044	0.00044	1	1	0.00053	0.00053	0.00053	0.00053	2	2	0.00061	0.00063	0.00062	0.00062	2	2	0.00051	0.00074	0.00063	0.000625	1	1	0.00069	0.00069	0.00069	0.00069
Barium (Ba)-Dissolved	mg/L	0.028	2	2	0.026	0.029	0.028	0.0275	1	1	0.025	0.025	0.025	0.025	0.025	1	1	0.032	0.032	0.032	0.032	2	2	0.0256	0.0285	0.027	0.02705	2	2	0.0187	0.0246	0.022	0.02165	1	1	0.019	0.019	0.019	0.019
Beryllium (Be)-Dissolved	mg/L	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	0.0000067	2	2	5.8E-06	0.0000066	0.0000062	0.0000062	1	1	0.0000067	0.0000067	0.0000067	0.0000067	0.0000067	1	1	0.0000088	0.0000088	0.0000088	0.0000088	2	1	1.2E-05	0.00004	0.000026	0.000026	2	0	0.01	0.01	0.01	0.01	1	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Dissolved	mg/L	54.5	2	2	50	56	53	53	1	1	57	57	57	57	57	1	1	53	53	53	53	2	2	54.1	63.1	58.6	58.6	2	0	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005
Calcium (Ca)-Dissolved	mg/L	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	2	2	0.00014	0.00111	0.00063	0.00063	2	2	41.8	44.6	43	43.2	1	1	44.3	44.3	44	44.3
Chromium (Cr)-Dissolved	mg/L	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	0.0001

BJ-GW12-11A		Operations (2015 - 2018)				2016							2017							2018							2019							2020							2021					
		Min	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																																														
Temperature	°C	0.5	4.17	4.2	2.65	4	4	0.5	16	6.475	6.5	4.7	3	3	2	3.2	2.633333333	2.6	2.7	3	3	2	3.3	2.6	2.6	4	4	2.3	2.8	2.475	2.5	2.4	3	3	1.2	4	2.4	2	3	3	2.5	2.9	2.7	2.7
pH	pH	8.7	9.69	9.69	9.5	4	4	9.2	10	9.55	9.6	9.5	3	3	8.7	10	9.333333333	9.3	9.3	3	3	9.2	12	10	9.5	4	4	8.5	9.04	8.8375	8.84	8.905	3	3	8.79	8.84	8.8	8.84	3	3	8.63	9.25	8.93	8.91
Specific Sonductance	µS/cm	109	484	484	171	3	3	125	171	141.3333333	140	128	3	3	109	202	164.3333333	160	182	3	3	115	3150	1100	174	4	4	130	218.7	187.75	187.8	201.15	3	3	150.1	173.1	160	171.1	3	3	156.5	191.5	170.8	164.5
Dissolved Oxygen	mg/L	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	2	2	10.88	11.79	11.335	11.34	11.335	3	3	8.1	11.42	10	11.03	3	3	7.15	11.14	9.7	10.75
Oxidation Reduction Potential	mV	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	4	4	104.4	200.8	148.25	148.3	143.9	3	3	69.6	236.6	180	220.9	3	3	134.9	178.9	150	135.9
Turbidity	NTU	6.86	243.315	243.3	65.7	0	-	-	-	-	-	-	2	2	35.4	835	435.2	440	435.2	2	2	6.86	96	51	51.43	4	4	1.3	23	10.2275	10.23	8.31	3	3	7.5	71	32	18.34	3	3	0.92	26.4	11.97	8.58
Physical Tests																																															
Conductivity	uS/cm	101	207.5	207.5	173.5	4	4	130	193	159.25	160	157	3	3	101	204	159.3333333	160	173	3	3	115	671	320	174	4	4	139	229	192.5	192.5	201	3	3	158	181	171	174	3	3	157	186	169	165
Acidity (as CaCO3)	mg/L	1	1.077777778	1.078	1	3	0	1	1	1	1	1	3	0	1	1	1	1	1	3	1	1	1.7	1.2	1	4	1	1	2	1.525	1.53	1.55	3	0	2	2	2	2	3	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	22	171.2	171.2	35.5	4	4	22	46	35	35	36	3	3	29	43	37.33333333	37	40	3	3	30	1400	490	30	4	4	25.1	37.4	31.7	31.7	32.15	3	3	29.9	35.7	32	30.2	3	3	24.9	34.7	29	28.8
Hardness (as CaCO3)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	62.9	71.5	68	70.1	3	3	68.8	92	78.4	74.3
Hardness (as CaCO3), total	mg/L	38	73.2	73.2	66	4	4	40	79	57.25	57	55	3	3	38	86	65	65	71	3	3	48	190	100	70	4	4	50.3	100	82.325	82.33	89.5	3	3	76.9	92.8	86	89.5	3	3	70.2	79.3	73.3	70.4
pH	pH	7.8	8.93	8.93	8.6	4	4	7.8	9.6	8.75	8.8	8.8	3	3	8.4	8.8	8.6	8.6	8.6	3	3	7.9	12	9.5	8.6	4	4	7.89	8.29	8.09	8.09	8.09	3	3	7.66	8.29	8	8.16	3	3	7.54	8.03	7.8	7.94
Total Dissolved Solids	mg/L	59	143.8888889	143.9	130	3	3	86	135	105.6666667	110	96	3	3	59	143	110.6666667	110	130	3	3	84	424	220	138	4	4	89	149	120	120	121	3	3	105	113	110	109	3	3	87	113	99	97
Total Suspended Solids	mg/L	19	786.3	786.3	180	4	4	130	1350	651.25	650	562.5	3	3	19	227	104.3333333	100	67	3	3	49	4680	1600	216	4	4	6.4	39.2	20.775	20.78	18.75	3	3	11.1	154	96	124	3	3	3.6	18.9	13.4	17.7
Turbidity	NTU	13	521.5	521.5	145	4	4	82	1080	475.5	480	370	3	3	13	190	85	85	52	3	3	35	2830	1000	193	4	4	1.44	31.5	10.66	10.66	4.85	3	3	6.83	116	68	82.2	3	3	3.07	11.6	6	3.42
Anions and Nutrients																																															
Kjeldahl nitrogen, total (TKN	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0.053	0.15	0.12	0.142	3	3	0.062	0.432	0.212	0.142
Total Ammonia (as N)	mg/L	0.005	0.0053	0.0053	0.005	4	2	0.005	0.0057	0.005275	0.0053	0.0052	3	0	0.005	0.005	0.005	0.005	0.005	3	2	0.005	0.0063	0.0056	0.0056	4	0	0.005	0.005	0.005	0.005	0.005	3	1	0.005	0.0083	0.0061	0.005	3	1	0.005	0.0067	0.0056	0.005
Bromide (Br)	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	3	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	0.5	0.743	0.743	0.5	4	1	0.5	0.93	0.6075	0.61	0.5	3	0	0.5	0.5	0.5	0.5	0.5	3	0	0.5	2.5	1.2	0.5	4	0	0.5	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	0.02	0.0312	0.031	0.023	4	4	0.02	0.034	0.025	0.025	0.023	3	3	0.021	0.023	0.022333333	0.022	0.023	3	2	0.021	0.1	0.048	0.024	4	2	0.02	0.024	0.0215	0.022	0.021	3	3	0.022	0.025	0.023	0.023	3	3	0.02	0.026	0.023	0.023
Nitrate (as N)	mg/L	0.025	0.1104	0.11	0.098	4	4	0.025	0.086	0.05425	0.054	0.053	3	3	0.14	0.23	0.18	0.18	0.17	3	3	0.077	0.16	0.12	0.11	4	4	0.0477	0.188	0.112175	0.11	0.11	3	3	0.056	0.211	0.12	0.0787	3	3	0.0481	0.216	0.105	0.0498
Nitrate + Nitrite (as N)	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0	0.056	0.019	0	3	3	0.0481	0.216	0.1046	0.0498
Nitrite (as N)	mg/L	0.001	0.00149	0.0015	0.001	4	1	0.001	0.0019	0.001225	0.0012	0.001	3	0	0.001	0.001	0.001	0.001	0.001	3	0	0.001	0.005	0.0023	0.001	4	1	0.001	0.0013	0.001075	0.0011	0.001	3	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.198	0.264	0.23	0.223	3	3	0.112	0.48	0.317	0.358
Orthophosphate	mg/L	0.001	0.0017	0.0017	0.002	3	2	0.001	0.0028	0.001966667	0.002	0.0021	3	1	0.001	0.0021	0.001366667	0.0014	0.001	3	2	0.001	0.0023	0.0018	0.002	4	1	0.001	0.0019	0.001225	0.0012	0.001	3	3	0.0018	0.0034	0.0026	0.0026	3	1	0.001	0.0019	0.0013	0.001
Total Phosphorus (P)	mg/L	0.022	0.3786	0.38	0.14	4	4	0.11	0.86	0.325	0.33	0.165	3	3	0.022	0.16	0.069666667	0.07	0.027	3	3	0.047	2.1	0.76	0.13	4	4	0.0039	0.0278	0.01255	0.013	0.0093	3	3	0.0112	0.141	0.072	0.0633	3	3	0.0085	0.0218	0.017	0.0208
Sulphate (SO4)	mg/L	19	43.2	43.2	48	4	4	23	58	42.5	43	44.5	3	3	19	62	46	46	57	3	3	28	49	41	47	4	4	32.3	72.5	59.475	59.5	66.55	3	3	41	53	48	50.1	3	3	43.6	53.6	48.8	49.2
Sulfide (as H2S)	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.019	0.019	0.019	3	0	0.0016	0.011	0.004733	0.0016
Sulfide (as S)	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	3	0	0.0015	0.01	0.0043	0.0015
Total Metals																																															
Aluminum (Al)-Total	mg/L	0.26	13.399	13.4	3.25	4	4	0.93	24	11.4825	11	10.5	3	3	0.26	4.6	2.486666667	2.5	2.6	3	3	1.7	75	27	3.9	4	4	0.0598	0.237	0.124625	0.125	0.101	3	3	0.135	2.13	1.2	1.22	3	3	0.0465	0.284	0.1522	0.126
Antimony (Sb)-Total	mg/L	0.0014	0.00469	0.0047	0.0023	4	4	0.002	0.0078	0.00485	0.0049	0.0048	3	3	0.0014	0.0021	0.0017	0.0017	0.0016	3	3	0.0023	0.013	0.0075	0.0071	4	4	0.00093	0.00164	0.0012125	0.0012	0.0011	3	3	0.00117	0.00235	0.0019	0.00231	3	3	0.00089	0.00154	0.0012	0.00114
Arsenic (As)-Total	mg/L	0.012	0.0849	0.085	0.028	4	4	0.019	0.22	0.10775	0.11	0.096	3	3	0.012	0.033	0.022	0.022	0.021	3	3	0.021	0.29	0.12	0.041	4	4	0.0078	0.00915	0.0084925	0.0085	0.0085	3	3	0.00829	0.0278	0.019	0.0206	3	3	0.0086	0.0111	0.00986	0.00988
Barium (Ba)-Total	mg/L	0.035	0.4175	0.42	0.18	4	4	0.086	1.4	0.63875	0.64	0.5345	3	3	0.035	0.29	0.155	0.16	0.14	3	3	0.085	0.85	0.39	0.22	4	4	0.0333	0.0481	0.03955	0.04	0.038	3	3	0.0354	0.162	0.098	0.0953	3	3	0.0326	0.0534	0.0493	0.0398
Beryllium (Be)-Total	mg/L	0.0001	0.00097	0.0004	0.0001	4	2	0.0001	0.0067	0.00365	0.00337	0.000345	3	1	0.0001	0.0001	0.0001	0.0001	0.0001	3	2	0.0001	0.002	0.00074	0.00011	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	0.00005	0.000159	0.00016	0.00005	4	2	0.00005	0.00013	0.000085	0.000085	0.00008	3	0	0.00005	0.00005	0.00005	0.00005	0.00005	3	1	0.00005	0.001	0.00037	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.01	0.01	0.01	0.01	3	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	0.00001	0.000268	0.00027	0.000072	4	4	0.000037	0.00078	0.00035575	0.00036	0.000303	3	3	0.00001	0.000077	0.000042	0.000042	0.000039	3	3	0.000041	0.00099	0.00038	0.0001	4	4	0.0000059	0.0000108	0.00000845	0.0000085	0.0000086	3	3	0.0000106	0.0000939	0.000049	0.0000437	3	2	0.000005	0.0000319	0.000015	0.0000089
Calcium (Ca)-Total	mg/L	15	117.9	118	33.5	4	4	27	90	57.25	57	56	3	3	15	41	29.33333333	29	32	3	3	20	812	290	30	4	4	19.7	32.9	27.925	27.9	29.55	3	3	25.7	30.7	28	28.9	3	3	23.1	30.1	25.8	24.3
Chromium (Cr)-Total	mg/L	0.00034	0.020394	0.02	0.0025	4	4	0.0016	0.022	0.011425	0.011	0.01105	3	3	0.00034	0.0026	0.001546667	0.0015	0.0017	3	3	0.0013	0.15	0.051	0.0023	4	4	0.00021	0.00121	0.0006725	0.00067	0.00064	3	3	0.00032	0.00495	0.0025	0.00237	3	3	0.00258	0.00583	0.0039	0.0029
Cobalt (Co)-Total	mg/L	0.00013	0.008484	0.0085	0.0024	4	4	0.00065	0.017	0.0084375	0.0084	0.00805	3	3	0.00013	0.0026	0.00113	0.0011	0.00066	3	3	0.0008	0.043	0.016	0.0039	4	1	0.0001	0.00015	0.0001125	0.00011	0.0001	3	2	0.0001	0.0015	0.0009	0.00109	3	1	0.0001	0.0003	0.00017	0.0001
Copper (Cu)-Total	mg/L	0.0014	0.08066	0.081	0.0078	4	4	0.0014	0.089	0.044425	0.044	0.0415	3	3	0.0014	0.01	0.005666667	0.0057	0.0056	3	3	0.0034	0.6	0.2	0.0085	4	4	0.00053	0.00279	0.001225	0.0012	0.00079	3	3	0.00121	0.011	0.0061	0.00621	3	3	0.0006	0.00301	0.00179	0.00176
Iron (Fe)-Total	mg/L	0.35	17.495	17	3.35	4	4	1.1	42	18.925	19	16.3	3	3	0.35	5.7	2.516666667	2.5	1.5	3	3	1.7	85	31	5	4	4	0.047	0.293	0.13025	0.13	0.091	3	3	0.162	3.2	1.7	1.83	3	3	0.049	0.407	0.201	0.147
Lead (Pb)-Total	mg/L	0.00046	0.02191	0.022	0.0042	4	4	0.0019	0.057	0.02375	0.024	0.01805	3	3	0.0005	0.0043	0.002233333	0.0022	0.0018	3	3	0.0017	0.11	0.039	0.0057	4	4	0.000138	0.0006	0.0003015	0.0003	0.00023	3	3	0.00329	0.00389	0.0022	0.00246	3	3	0.000184	0.000959	0.00048	0.000287
Lithium (Li)-Total	mg/L	0.003	0.01083	0.011	0.0064	4	4	0.004	0.03	0.015575	0.016	0.01415	3	3	0.003	0.006	0.004733333	0.0047	0.0036	3	3	0.0034	0.023	0.011	0.0054	4	4	0.0023	0.0034	0.002825	0.0028	0.0028	3	3	0.0026	0.0067	0.0045	0.0041	3	3	0.0024	0.0034	0.0029	0.0029
Magnesium (Mg)-Total	mg/L	1.5	7.24	7.2	4.55	4	4	3.4	14	7.975	8	7.25	3	3	1.5	5	3.7	3.7	4.6	3	3	2.9	22	9.8	4.5	4	4	2.49	4.37	3.6575	3.7	3.89	3	3	3.09	4.22	3.7	3.89	3	3	2.7	4.1	3.367	3.3
Manganese (Mn)-Total	mg/L	0.011	0.7986	0.8	0.26	4	4	0.078	2.6	1.102	1.1	0.865	3	3	0.011	0.28	0.122666667	0.12	0.077	3	3	0.1	2.8	1.1	0.31	4	4	0.00322	0.0108	0.00565	0.0057	0.0043	3	3	0.00624	0.2	0.11	0.11	3	3	0.00293	0.0238	0.011	0.00577
Mercury (Hg)-Total	mg/L	0.000005	0.00002293	0.000023	0.000012	4	3	0.000054	0.000059	0.0000321	0.000032	0.000032	3	1	0.000005	0.0000069	5.63333E-06	0.0000056	0.000005	3	2	0.000009	0.00005	0.000028	0.000025	4	1	0.000005	0.0000077	0.000005675	0.0000057	0.0000005	3	2	0.000005	0.0000185	0.0000999	0.0000063	3	2	0.000005	0.0000064	0.00000593	0.0000064
Molybdenum (Mo)-Total	mg/L	0.0016	0.00537	0.0054	0.0021	4	4	0.0017	0.0049	0.0033	0.0033	0.0033	3	3	0.0016	0.0018	0.001666667	0.0017	0.0016	3	3	0.0021	0.031	0.012	0.0024	4	4	0.00102	0.00201	0.0014125	0.0014	0.0013	3	3	0.00141	0.00276	0.002	0.00192	3	3	0.00155	0.00189	0.001673	0.00158
Nickel (Ni)-Total	mg/L	0.0005	0.010334	0.01	0.0016	4	4	0.001	0.013	0.0068	0.0068	0.0066	3	2	0.0005	0.0019	0.0013	0.0013	0.0015	3	3	0.00064	0.07	0.024	0.0016	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	3	2	0.0005	0.00188	0.0013	0.00139	3	1	0.0005	0.00086	0.00062	0.0005
Phosphorus (P)-Total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	3	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	0.73	4.153	4.2	2.25	4	4	1.3	12	6.025	6	5.4	3	3	0.73	3.6	2.143333333	2.1	2.1	3	3	1.7	6.9	3.7	2.4	4	4	0.549	0.832	0.67425	0.67	0.658	3	3	0.6	2.06	1.5	1.81	3	3	0.641	1.02	0.8223	0.806
Selenium (Se)-Total	mg/L	0.00017	0.001263	0.0013	0.00057	4	4	0.00048	0.0016	0.0010975	0.0011	0.001155	3	3	0.00017	0.00056	0.000423333	0.00042	0.00054	3	3	0.00039	0.006	0.0023	0.00058	4	4	0.000318	0.000703	0.00051475	0.00051	0.000519	3	3	0.000319	0.000648	0.00047	0.000445	3	3	0.000349	0.000462	0.00039	0.000361
Silicon (Si)-Total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	1.89	5.09	3.6	3.72	3	3	1.72	2.22	1.89	1.73
Silver (Ag)-Total	mg/L	0.000075	0.0067715	0.0068	0.0010	4	4	0.00019	0.02	0.0083675	0.0084	0.00664	3	3	0.000075	0.0025	0.001051667	0.0011	0.00058	3	3	0.00069	0.029	0.01	0.0014	4	4	0.000026	0.000145	0.00088125	0.000081	0.000077	3	3	0.000183	0.000861	0.00063	0.000848	3	3	0.00002	0.000156	0.000094	0.000106
Sodium (Na)-Total	mg/L	2.2	4.27	4.3	3.25	4	4	3.4	8.8	6.3	6.3	6.5	3	3	2.2	4.1	3	3	2.7	3	3	2.6	3.1	2.8	2.8	4	4	2.09	2.56	2.3075	2.3	2.29	3	3	2.02	5.71	3.6	3.08	3	3	2.12	2.67	2.4	2.51
Strontium (Sr)-Total	mg/L	0.25	0.512	0.51	0.43	4	4	0.43	0.93	0.645	0.65	0.61	3	3	0.25	0.5	0.386666667	0.39	0.41	3	3	0.25	0.76	0.46	0.37	4	4	0.333	0.406	0.36625	0.37	0.363	3	3	0.316	0.449	0.39	0.4	3	3	0.284	0.394	0.344	0.353
Sulfur (S)-Total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000015	0.0004291	0.00043	0.00016	4	4	0.000064	0.0013	0.000602	0.0006	0.000522	3	3	0.000015	0.00026	0.000124333	0.00012	0.000098	3	3	0.0001	0.0012	0.0005	0.00021	4	1	0.00001	0.00001	0.00001	0.00001	0.00001	3	2	0.00001	0.000122	0.000071	0.000081	3	1	0.00001	0.000016	0.000012	0.00001
Tin (Sn)-Total	mg/L	0.00012	0.002071	0.0021	0.00048	4	4	0.00012	0.0043	0.001755	0.0018	0.0013	3	3	0.0003	0.0015	0.00075	0.00075	0.00045	3	3	0.00022	0.011	0.0038	0.00022	4	3	0.0001	0.00044	0.00024	0.00024	0.00021	3	3	0.00039	0.00077	0.00057	0.00054	3	2	0.0001	0.00043	0.00028	0.0003
Titanium (Ti)-Total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0.01	0.0297	0.019	0.0172	3	0	0.01	0.01	0.01	0.01
Uranium (U)-Total	mg/L	0.000094	0.0015674	0.0016	0.0005	4	4	0.0004	0.0021	0.0011725	0.0012	0.001095	3	3	0.000094	0.00051	0.000371333	0.00037	0.00051	3	3	0.00025	0.0092	0.0033	0.00042	4	4	0.000117	0.000223	0.00019	0.00019	0.00021	3	3	0.000143	0.000358	0.00028	0.000339	3	3	0.000137	0.000338	0.000216	0.000173
Vanadium (V)-Total	mg/L	0.00053	0.025113	0.025	0.0053	4	4	0.0016	0.047	0.02235	0.022	0.0204	3	3	0.00053	0.0078	0.004243333	0.0042	0.0044	3	3	0.0028	0.14	0.05	0.0062	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	3	2	0.0005	0.00344	0.0021	0.00222	3	1	0.0005	0.00054	0.00051	0.0005
Zinc (Zn)-Total	mg/L	0.0064	0.29194	0.29	0.029	4	4	0.019	0.28	0.1275	0.13	0.1055	3	3	0.0064	0.032	0.021133333	0.021	0.025	3	3	0.012	2.3	0.78	0.034	4	2	0.003	0.0058	0.0041	0.0041	0.0038	3	3	0.0035	0.0547	0.027	0.0214	3	3	0.0045	0.0378	0.0158	0.0251
Zirconium (Zr)-Total	mg/L	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																															
Aluminum (Al)-Dissolved	mg/L	0.021	0.0871	0.087	0.053	4	4	0.039	0.28	0.137	0.14	0.1145	3	3	0.021	0.065	0.042	0.042	0.04	3	3	0.021	0.15	0.066	0.026	4	4	0.0114	0.0291	0.0189	0.019	0.018	3	3	0.0129	0.027	0.022	0.0248	3	3	0.0125	0.0216	0.017	0.0156
Antimony (Sb)-Dissolved	mg/L	0.00096	0.001866	0.0019	0.0017	4	4	0.0017	0.0034	0.00245	0.0025	0.00235	3	3	0.00096	0.0015	0.00122	0.0012	0.0012	3	3	0.0015	0.002	0.0017	0.0017	4	4	0.00085	0.00142	0.0011225	0.0011	0.0011	3

BJ-GW12-11B		2016						2017						2018						2019						2020					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																														
Temperature	°C	2	2	2.4	2.6	2.5	2.5	2	2	2	2.3	2.2	2.15	3	3	1.3	2.5	1.9	1.9	3	3	2	5.4	3.3	3.3	2.5	2	2	2	4.9	3.5	3.45
pH	pH	2	2	7.8	7.9	7.9	7.85	2	2	7.6	8.3	8	7.95	3	3	7.7	8.2	8	8	3	3	7.61	8.09	7.84	7.84	7.82	2	2	7.68	7.98	7.8	7.83
Specific Sonductance	µS/cm	2	2	285	407	350	346	2	2	319	455	390	387	3	3	276	409	340	347	3	3	273.6	434.7	337.2333333	337.2	303.4	2	2	255.4	309.8	280	282.6
Dissolved Oxygen	mg/L	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	2	2	1.07	3.63	2.35	2.35	2.35	2	2	0.33	3.99	2.2	2.16
Oxidation Reduction Potential	mV	0	-	-	-	-	-	0	-	-	-	-	-	0	-	-	-	-	-	3	3	16.1	182	98.13333333	98.13	96.3	2	2	-65.4	126.3	30	30.45
Turbidity	NTU	0	-	-	-	-	-	2	2	194	955	570	574.5	2	2	58.5	178.6	120	118.55	3	3	2.35	41.5	17.63333333	17.63	9.05	2	2	31.89	32.42	32	32.155
Physical Tests																															
Conductivity	uS/cm	2	2	286	400	340	343	2	2	306	461	380	383.5	3	3	321	401	350	331	3	3	279	448	346	346	311	2	2	250	312	280	281
Acidity (as CaCO3)	mg/L	2	2	1.7	2	1.9	1.85	2	2	1.5	1.7	1.6	1.6	3	3	1.1	2	1.5	1.3	3	1	1	2.1	1.7	1.7	2	2	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	2	2	95	120	110	107.5	2	2	91	113	100	102	3	3	88	107	97	97	3	3	67.3	107	82.2	82.2	72.3	2	2	68.4	80.1	74	74.25
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	115	162	140	138.5
Hardness (as CaCO3), total from Ca/Mg	mg/L	2	2	135	206	170	170.5	2	2	145	220	180	182.5	3	3	146	191	170	159	3	3	140	194	161.3333333	161.3	150	2	2	123	153	140	138
pH	pH	2	2	8	8.1	8.1	8.05	2	2	8.1	8.1	8.1	8.1	3	3	8.1	8.2	8.2	8.2	3	3	8.04	8.18	8.106666667	8.11	8.1	2	2	8.01	8.02	8	8.015
Total Dissolved Solids (TDS)	mg/L	2	2	200	257	230	228.5	2	2	241	342	290	291.5	3	3	214	256	240	252	3	3	183	277	222	222	206	2	2	143	212	180	177.5
Total Suspended Solids (TSS)	mg/L	2	2	162	833	500	497.5	2	2	798	892	850	845	3	3	101	1340	560	228	3	3	13.8	51.3	33.1	33.1	34.2	2	2	17.4	66.7	42	42.05
Turbidity	NTU	2	2	85	356	220	220.5	2	2	351	403	380	377	3	3	62	391	180	99	3	3	5.32	25.3	16.90666667	16.91	20.1	2	2	10.4	28.9	20	19.65
Anions and Nutrients																															
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	2	0	0.005	0.005	0.005	0.005	2	0	0.005	0.005	0.005	0.005	3	1	0.005	0.0057	0.0052	0.005	3	0	0.005	0.005	0.005	0.005	0.005	2	0	0.005	0.005	0.005	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	2	0	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	2	2	0.037	0.043	0.04	0.04	2	2	0.037	0.042	0.04	0.0395	3	3	0.038	0.043	0.041	0.042	3	3	0.038	0.047	0.042333333	0.042	0.042	2	2	0.039	0.047	0.043	0.043
Nitrate (as N)	mg/L	2	1	0.005	0.0077	0.0064	0.00635	2	2	0.0092	0.028	0.019	0.0186	3	2	0.005	0.016	0.011	0.013	3	2	0.005	0.0123	0.0087	0.0087	0.0088	2	1	0.005	0.0072	0.0061	0.0061
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	2	0	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001	3	1	0.001	0.0011	0.001	0.001	3	0	0.001	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.03	0.03	0.03	0.03
Dissolved Orthophosphate (as P)	mg/L	2	0	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	0.001	2	1	0.001	0.0021	0.0016	0.00155
Total Phosphorus (P)	mg/L	2	2	0.065	0.43	0.25	0.2475	2	2	0.43	0.44	0.44	0.435	3	3	0.05	0.23	0.12	0.068	3	3	0.003	0.06	0.023033333	0.023	0.0061	2	2	0.0031	0.0418	0.022	0.02245
Sulphate (SO4)	mg/L	2	2	69	113	91	91	2	2	80	131	110	105.5	3	3	85	110	97	96	3	3	73.2	122	93.83333333	93.8	86.3	2	2	58.6	74.7	67	66.65
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.019	0.019	0.019	0.019
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.018	0.018	0.018	0.018
Total Metals																															
Aluminum (Al)-Total	mg/L	2	2	3.8	9	6.4	6.4	2	2	6.8	8.1	7.5	7.45	3	3	0.98	10	4.4	2.2	3	3	0.107	0.866	0.444	0.444	0.36	2	2	0.0714	0.978	0.52	0.5247
Antimony (Sb)-Total	mg/L	2	2	0.0036	0.014	0.0088	0.0088	2	2	0.0078	0.015	0.011	0.0114	3	3	0.0025	0.003	0.0028	0.003	3	3	0.00188	0.00296	0.00229	0.0023	0.0020	2	2	0.00172	0.00301	0.0024	0.002365
Arsenic (As)-Total	mg/L	2	2	0.028	0.19	0.11	0.109	2	2	0.18	0.24	0.21	0.21	3	3	0.0091	0.032	0.019	0.015	3	3	0.003	0.00702	0.005636667	0.0056	0.0069	2	2	0.00258	0.0125	0.0075	0.00754
Barium (Ba)-Total	mg/L	2	2	0.12	0.71	0.42	0.415	2	2	0.65	0.84	0.75	0.745	3	3	0.093	0.2	0.14	0.12	3	3	0.0341	0.0686	0.045633333	0.046	0.034	2	2	0.0194	0.0673	0.043	0.04335
Beryllium (Be)-Total	mg/L	2	2	0.00023	0.0011	0.0007	0.000665	2	2	0.0011	0.0016	0.0014	0.00135	3	2	0.0001	0.0019	0.00076	0.00029	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	2	2	0.000063	0.00016	0.0001	0.0001115	2	2	0.00021	0.00039	0.0003	0.0003	3	2	0.00005	0.00057	0.00024	0.00011	3	0	0.00005	0.00005	0.00005	5E-05	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	2	2	0.000045	0.00033	0.0002	0.0001875	2	2	0.00027	0.0027	0.0015	0.001485	3	3	0.000069	0.00014	0.0001	0.0001	3	3	0.0000159	0.0000415	0.0000265	3E-05	0.0000221	2	2	0.0000072	0.0000301	0.000019	0.00001865
Calcium (Ca)-Total	mg/L	2	2	67	70	69	68.5	2	2	61	117	89	89	3	3	64	110	83	76	3	3	48.8	66.6	55.43333333	55.4	50.9	2	2	40.3	48.8	45	44.55
Chromium (Cr)-Total	mg/L	2	2	0.00089	0.0052	0.003	0.003045	2	2	0.0027	0.0032	0.003	0.00295	3	3	0.0022	0.0029	0.0025	0.0025	3	3	0.00086	0.0142	0.005643333	0.0056	0.0019	2	1	0.0001	0.0134	0.0068	0.00675
Cobalt (Co)-Total	mg/L	2	2	0.0015	0.0091	0.0053	0.0053	2	2	0.0087	0.011	0.0099	0.00985	3	3	0.00078	0.003	0.0016	0.00091	3	2	0.0001	0.00056	0.000326667	0.0003	0.00032	2	1	0.0001	0.00079	0.00045	0.000445
Copper (Cu)-Total	mg/L	2	2	0.011	0.078	0.045	0.0445	2	2	0.078	0.085	0.082	0.0815	3	3	0.0087	0.016	0.012	0.01	3	3	0.00197	0.0104	0.00518	0.0052	0.0032	2	2	0.00083	0.00832	0.0046	0.004575
Iron (Fe)-Total	mg/L	2	2	3.5	28	16	15.75	2	2	21	26	24	23.5	3	3	1.4	5.4	2.8	1.7	3	3	0.143	1.37	0.729333333	0.73	0.675	2	2	0.139	1.45	0.79	0.7945
Lead (Pb)-Total	mg/L	2	2	0.0053	0.032	0.019	0.01865	2	2	0.032	0.038	0.035	0.035	3	3	0.0035	0.02	0.0093	0.0044	3	3	0.000296	0.00209	0.001101667	0.0011	0.000092	2	2	0.00028	0.00202	0.0012	0.00115
Lithium (Li)-Total	mg/L	2	2	0.013	0.014	0.014	0.0135	2	2	0.015	0.015	0.015	0.015	3	3	0.01	0.015	0.012	0.012	3	3	0.0086	0.0114	0.009566667	0.0096	0.0087	2	2	0.0077	0.0093	0.0085	0.0085
Magnesium (Mg)-Total	mg/L	2	2	8.8	9.7	9.3	9.25	2	2	8.4	14	11	11.2	3	3	7.6	14	10	8.7	3	3	6.19	10.3	7.763333333	7.8	6.8	2	2	5.51	7.51	6.5	6.51
Manganese (Mn)-Total	mg/L	2	2	0.16	0.7	0.43	0.43	2	2	0.75	0.78	0.77	0.765	3	3	0.16	0.38	0.24	0.19	3	3	0.0223	0.0515	0.041066667	0.041	0.049	2	2	0.018	0.0606	0.039	0.0393
Mercury (Hg)-Total	mg/L	2	2	0.000019	0.000078	5E-05	0.0000485	2	2	0.000023	0.000069	0.000046	0.000046	3	1	0.000031	0.00005	0.000044	0.00005	3	1	0.000005	0.0000096	6.53333E-06	7E-06	0.000005	2	1	0.000005	0.000077	0.0000064	0.00000635
Molybdenum (Mo)-Total	mg/L	2	2	0.00091	0.0016	0.0013	0.001255	2	2	0.00097	0.0014	0.0012	0.001185	3	3	0.00047	0.0014	0.0011	0.0013	3	3	0.000773	0.00162	0.001267667	0.0013	0.00141	2	2	0.00162	0.0026	0.0021	0.00211
Nickel (Ni)-Total	mg/L	2	2	0.00095	0.0059	0.0034	0.003425	2	2	0.004	0.0048	0.0044	0.0044	3	3	0.0012	0.0026	0.0018	0.0017	3	2	0.0005	0.00171	0.000993333	0.001	0.00077	2	1	0.0005	0.0074	0.004	0.00395
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	2	2	2.6	5.6	4.1	4.1	2	2	4.1	4.8	4.5	4.45	3	3	1.4	2.7	1.9	1.6	3	3	1.02	1.54	1.22	1.2	1.1	2	2	0.903	1.45	1.2	1.1765
Selenium (Se)-Total	mg/L	2	2	0.0014	0.004	0.0027	0.0027	2	2	0.0031	0.0039	0.0035	0.0035	3	3	0.0013	0.0022	0.0017	0.0016	3	3	0.000848	0.00187	0.001227667	0.0012	0.00097	2	2	0.000856	0.0017	0.0013	0.001278
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1.88	4.18	3	3.03
Silver (Ag)-Total	mg/L	2	2	0.0025	0.023	0.013	0.01275	2	2	0.012	0.015	0.014	0.0135	3	3	0.0008	0.0023	0.0013	0.00084	3	3	0.000262	0.00162	0.000729	0.0007	0.00031	2	2	0.000083	0.000967	0.00053	0.000525
Sodium (Na)-Total	mg/L	2	2	4.5	4.7	4.6	4.6	2	2	4.5	4.9	4.7	4.7	3	3	4	4.7	4.4	4.5	3	3	3.28	4.3	3.633333333	3.6	3.32	2	2	2.82	3.48	3.2	3.15
Strontium (Sr)-Total	mg/L	2	2	1.4	1.6	1.5	1.5	2	2	1.4	2.2	1.8	1.8	3	3	1.5	1.9	1.7	1.6	3	3	1.17	1.71	1.35	1.4	1.17	2	2	0.954	1.15	1.1	1.052
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	2	2	0.00015	0.00054	0.0004	0.000345	2	2	0.00043	0.00052	0.00048	0.000475	3	3	0.000056	0.00022	0.00012	0.000089	3	3	0.000022	0.000054	3.63333E-05	4E-05	0.000033	2	2	0.000018	0.000062	0.00004	0.00004
Tin (Sn)-Total	mg/L	2	2	0.00026	0.00084	0.0006	0.00055	2	2	0.00037	0.00056	0.00047	0.000465	3	3	0.0006	0.0027	0.0018	0.0022	3	2	0.0001	0.0011	0.00056	0.0006	0.00048	2	1	0.0001	0.00016	0.00013	0.00013
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	0.01	0.0146	0.012	0.0123
Uranium (U)-Total	mg/L	2	2	0.0011	0.0015	0.0013	0.0013	2	2	0.0019	0.0032	0.0026	0.00255	3	3	0.0006	0.004	0.0019	0.001	3	3	0.000322	0.000764	0.000484	0.0005	0.00037	2	2	0.000303	0.000446	0.00037	0.0003745
Vanadium (V)-Total	mg/L	2	2	0.0044	0.013	0.0087	0.0087	2	2	0.0093	0.011	0.01	0.01015	3	3	0.0013	0.0057	0.0029	0.0016	3	1	0.0005	0.00116	0.00072	0.0007	0.0005	2	1	0.0005	0.00149	0.001	0.000995
Zinc (Zn)-Total	mg/L	2	2	0.013	0.081	0.047	0.047	2	2	0.072	0.085	0.079	0.0785	3	3	0.024	0.032	0.027	0.026	3	3	0.0041	0.0151	0.008666667	0.0081	0.005	2	1	0.003	0.0098	0.0064	0.0064
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																															
Aluminum (Al)-Dissolved	mg/L	2	2	0.0031	0.03	0.017	0.01655	2	2	0.0016	0.01	0.0058	0.0058	3	3	0.001	0.0044	0.0031	0.0039	3	3	0.0037	0.0074	0.005166667	0.0052	0.0044	2	2	0.002	0.0109	0.0065	0.00645
Antimony (Sb)-Dissolved	mg/L	2	2	0.0014	0.0016	0.0015	0.0015	2	2	0.0015	0.002	0.0018	0.00175	3	3	0.0014	0.0019	0.0016	0.0016	3	3	0.00142	0.00226	0.001826667	0.0018	0.0018	2	2	0.00153	0.002	0.0018	0.001765
Arsenic (As)-Dissolved	mg/L	2	2	0.001	0.0024	0.0017	0.0017	2	2	0.00073	0.0012	0.00097	0.000965	3	3	0.00089	0.0016	0.0013	0.0015	3	3	0.00092	0.00195	0.001433333	0.0014	0.0014	2	2	0.00153	0.00169	0.0016	0.00161
Barium (Ba)-Dissolved	mg/L	2	2	0.018	0.026	0.022	0.022	2	2	0.021	0.022	0.022	0.0215	3	3	0.021	0.024	0.023	0.023	3	3	0.0148	0.0254	0.021133333	0.021	0.023	2	2	0.0165	0.0179	0.017	0.0172
Beryllium (Be)-Dissolved	mg/L	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	2	0	0.00005	0.00005	5E-05	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	5E-05	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Dissolved	mg/L	2	2	0.0000091	0.000011	1E-05	0.00001005	2	1	0.000005	0.0000099	0.0000075	0.00000745	3	2	0.000005	0.0000085	0.0000072	0.0000082	3	3	0.0000061	0.0000124	0.0000103	1E-05	0.000012	2	1	0.0000066	0.00001	0.0000083	0.0000083
Calcium (Ca)-Dissolved	mg/L	2	2	45	68	57	56.5	2	2	47	72	60	59.5	3	3	47	62	53	51	3	3	45.3	61.6	50.93333333	50.9	45.9	2	2	37.3	52.7	45	45
Chromium (Cr)-Dissolved	mg/L	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	3	2	0.0001	0.00016	0.00014	0.00016	3	3	0.00017	0.0006	0.00034	0.0003	0.00025	2	2	0.00012	0.00031	0.00022	0.000215
Cobalt (Co)-Dissolved	mg/L	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	1	0.0001	0.00016	0.00013	0.00013
Copper (Cu)-Dissolved	mg/L	2	1	0.0002	0.00024	0.0002	0.00022	2	0	0.0002	0.0002	0.0002	0.0002	3	2	0.0002	0.0015	0.0007	0.0004	3	3	0.00041	0.00191	0.00124	0.0012	0.0014	2	2	0.00033	0.00041	0.00037	0.00037
Iron (Fe)-Dissolved	mg/L	2	1	0.01	0.028	0.019	0.019	2	1	0.01	0.022	0.016	0.016	3	0	0.01	0.01	0.01	0.01	3	0	0.01	0.01	0.01	0.01	0.01	2	2	0.011	0.013	0.012	0.012
Lead (Pb)-Dissolved	mg/L	2	1	0.00005	0.000077	6E-05	0.0000635	2	1	0.00005	0.00006	0.000055	0.000055	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	5E-05	0.00005	2	1	0.00005	0.000157	0.0001	0.0001035
Lithium (Li)-Dissolved	mg/L	2	2	0.0093	0.012	0.011	0.01065	2	2	0.011	0.012	0.012	0.0115	3	3	0.0089	0.011	0.01	0.01	3	3	0.0087	0.0101	0.009266667	0.0093	0.009	2	2	0.0074	0.0082	0.0078	0.0078
Magnesium (Mg)-Dissolved	mg/L	2	2	5.5	9.1	7.3	7.3	2	2	6.8	10	8.4	8.4	3	3	6.9	8.8	7.9	8.1	3	3	6.09	9.85	7.36	7.4	6.14	2	2	5.28	7.38	6.3	6.33
Manganese (Mn)-Dissolved	mg/L	2	2	0.016	0.031	0.024	0.0235	2	2	0.013	0.024	0.019	0.0185	3	3	0.0067	0.027	0.016	0.013	3	3	0.00506	0.0273	0.015386667	0.015	0.0138	2	2	0.0143	0.0227	0.019	0.0185
Mercury (Hg)-Dissolved	mg/L	2	0	0.000005	0.000005	5E-06	0.000005	2	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	5E-06	0.000005	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	2	2	0.00077	0.0012	0.001	0.000985	2	2	0.00066	0.0011	0.00088	0.00088	3	3	0.00066	0.0013	0.0011	0.0013	3	3	0.000626	0.00166	0.001238667	0.0012	0.0014	2	2	0.00144	0.00219	0.0018	0.001815
Nickel (Ni)-Dissolved	mg/L	2	0	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005	3	0	0.0005	0.0005	0.0005	0.0005	3	1	0.0005	0.00077	0.00059	0.0006	0.0005	2	1	0.0005	0.00337	0.0019	0.001935
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.3	0.3	0.3	0.3
Phosphorus-Dissolved	mg/L	2	2	1.1	1.2	1.2	1.15	2	2	1.3	1.3	1.3	1.3	3	3	1	1.2	1.1	1.2	3	3	0.877	1.23	1.055666667	1.1	1.06	2	2	0.844	1.05	0.95	0.947
Selenium (Se)-Dissolved	mg/L	2	2	0.00028	0.0011	0.0007	0.00069	2	2	0.00063	0.00096	0.0008	0.000795	3	3	0.00038	0.0013	0.00089	0.001	3	3	0.000523	0.00158	0.000995	0.001	0.000882	2	2	0.00083	0.00101	0.00092	0.00092
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1.64	1.66	1.7	1.65
Silver (Ag)-Dissolved	mg/L	2	1	0.00001	0.000014	1E-05	0.000012	2	1	0.00001	0.000028	0.000019	0.000019	3	0	0.00001	0.00001	0.00001	0.00001	3	0	0.00001	0.00001	0.00001	1E-05	0.00001	2	0	0.00001	0.

BJ-GW12-12A		Baseline Period (2011 - 2014)						2015						2016					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																		
Temperature	°C	5	5	0.6	4.4	2.4	2.5	1	1	2.3	2.3	2.3	2.3	2	2	2.5	2.8	2.7	2.65
pH	pH	4	4	7.52	8.5	8.15	8.29	1	1	7.75	7.75	7.8	7.75	2	2	7.23	7.49	7.4	7.36
Specific Sonductance	µS/cm	5	5	252	970	593.4	555	1	1	553	553	550	553	2	2	751	873	810	812
Physical Tests																			
Conductivity	uS/cm	5	5	455	691	555.8	557	1	1	598	598	600	598	2	2	728	871	800	799.5
Hardness (as $CaCO_3$)	mg/L	5	5	220	360	272.2	267	1	1	302	302	300	302	2	2	392	466	430	429
pH	pH	5	5	7.69	8.14	7.96	7.96	1	1	7.68	7.68	7.7	7.68	2	2	7.53	7.78	7.7	7.655
Total Suspended Solids (TSS)	mg/L	5	5	74.1	842	358	203	1	1	25.9	25.9	26	25.9	2	2	15.4	163	89	89.2
Total Dissolved Solids (TDS)	mg/L	5	5	330	497	397.2	400	1	1	416	416	420	416	2	2	547	681	610	614
Turbidity	NTU	5	5	2.4	272	105.4	66.4	1	1	14.5	14.5	15	14.5	2	2	10.5	70.6	41	40.55
Anions and Nutrients																			
Acidity (as CaCO3)	mg/L	5	5	2.3	8	3.64	2.5	0						2	2	6.2	12.5	9.4	9.35
Total Alkalinity (as $CaCO_3$)	mg/L	5	5	81.8	129	107.3	109	1	1	112	112	110	112	2	2	119	152	140	135.5
Total Ammonia (as N)	mg/L	5	5	0.125	0.17	0.15	0.153	1	1	0.178	0.178	0.18	0.178	2	2	0.103	0.132	0.12	0.1175
Chloride (Cl)	mg/L	5	3	0.5	2.5	1.17	1.05	1	0	0.5	0.5	0.5	0.5	2	0	2.5	2.5	2.5	2.5
Fluoride (F)	mg/L	5	5	0.149	0.21	0.18	0.177	1	1	0.15	0.15	0.15	0.15	2	2	0.12	0.12	0.12	0.12
Nitrate (as N)	mg/L	5	2	0.005	0.026	0.0100	0.005	1	0	0.005	0.005	0.005	0.005	2	2	0.152	0.205	0.18	0.1785
Nitrite (as N)	mg/L	5	0	0.001	0.005	0.0018	0.001	1	1	0.0015	0.0015	0.0015	0.0015	2	0	0.005	0.005	0.005	0.005
Dissolved Orthophosphate (as P)	mg/L	5	1	0.001	0.0018	0.0012	0.001	1	0	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001
Total Phosphorus (P)	mg/L	5	1	0.3	0.46	0.33	0.3	1	0	0.3	0.3	0.3	0.3	2	0	0.3	0.3	0.3	0.3
Sulphate (SO_4)	mg/L	5	5	153	265	197	195	1	1	207	207	210	207	2	2	272	343	310	307.5
Total Metals																			
Aluminum (Al)-Total	mg/L	5	5	0.604	5.93	2.79	1.57	1	1	0.125	0.125	0.13	0.125	2	2	0.135	0.899	0.52	0.517
Antimony (Sb)-Total	mg/L	5	5	0.00318	0.0088	0.0057	0.0050	1	1	0.00135	0.00135	0.0014	0.00135	2	2	0.00413	0.00453	0.0043	0.00433
Arsenic (As)-Total	mg/L	5	5	0.0646	0.326	0.16	0.13	1	1	0.0278	0.0278	0.028	0.0278	2	2	0.0134	0.112	0.063	0.0627
Barium (Ba)-Total	mg/L	5	5	0.082	0.641	0.3	0.23	1	1	0.0757	0.0757	0.076	0.0757	2	2	0.0513	0.122	0.087	0.08665
Beryllium (Be)-Total	mg/L	5	3	0.0001	0.00057	0.00028	0.00011	1	0	0.0001	0.0001	0.0001	0.0001	2	1	0.0001	0.00012	0.00011	0.00011
Bismuth(Bi)- Total	mg/L	5	1	0.0005	0.00056	0.00051	0.0005	1	0	0.00005	0.00005	0.00005	0.00005	2	1	0.00005	0.000053	0.000052	0.0000515
Cadmium (Cd)-Total	mg/L	5	5	0.000258	0.00108	0.00055	0.00052	1	1	0.000114	0.000114	0.00011	0.000114	2	2	0.000375	0.000489	0.00043	0.000432
Calcium (Ca)-Total	mg/L	5	5	74.5	118	93.7	93	1	1	99.2	99.2	99	99.2	2	2	129	157	140	143
Chromium (Cr)-Total	mg/L	5	5	0.00853	0.158	0.056	0.029	1	1	0.00124	0.00124	0.0012	0.00124	2	2	0.00103	0.00275	0.0019	0.00189
Cobalt (Co)-Total	mg/L	5	5	0.00107	0.00662	0.0034	0.0026	1	1	0.00087	0.00087	0.00087	0.00087	2	2	0.00133	0.00171	0.0015	0.00152
Copper (Cu)-Total	mg/L	5	5	0.00107	0.00662	0.0034	0.0026	1	1	0.00087	0.00087	0.00087	0.00087	2	2	0.00133	0.00171	0.0015	0.00152
Iron (Fe)-Total	mg/L	5	5	0.00751	0.0246	0.017	0.016	1	1	0.00321	0.00321	0.0032	0.00321	2	2	0.00631	0.0184	0.012	0.012355
Lead (Pb)-Total	mg/L	5	5	1.64	23.7	9.2	7.36	1	1	0.404	0.404	0.4	0.404	2	2	0.726	3.46	2.1	2.093
Lithium (Li)-Total	mg/L	5	5	0.00837	0.0156	0.012	0.011	1	1	0.0103	0.0103	0.01	0.0103	2	2	0.0125	0.0183	0.015	0.0154
Magnesium (Mg)-Total	mg/L	5	5	10.5	16.7	13	13	1	1	13.3	13.3	13	13.3	2	2	17.4	21.2	19	19.3
Manganese (Mn)-Total	mg/L	5	5	0.366	0.85	0.55	0.55	1	1	0.53	0.53	0.53	0.53	2	2	0.566	1.31	0.94	0.938
Mercury (Hg)-Total	mg/L	5	3	0.00001	0.000012	0.000011	0.000011	1	0	0.000005	0.000005	0.000005	0.000005	2	1	0.000005	0.0000096	0.0000073	0.0000073
Molybdenum (Mo)-Total	mg/L	5	5	0.00196	0.00524	0.0035	0.0036	1	1	0.00118	0.00118	0.0012	0.00118	2	2	0.00108	0.00197	0.0015	0.001525
Nickel (Ni)-Total	mg/L	5	5	0.00419	0.0592	0.024	0.013	1	1	0.00102	0.00102	0.001	0.00102	2	2	0.00209	0.00371	0.0029	0.0029
Potassium (K)-Total	mg/L	5	5	4.72	7.68	5.9	5.33	1	1	4.63	4.63	4.6	4.63	2	2	5.53	6.38	6	5.955
Selenium (Se)-Total	mg/L	5	5	0.00016	0.00241	0.00086	0.0007	1	1	0.000055	0.000055	0.000055	0.000055	2	2	0.000169	0.000231	0.0002	0.0002
Silver (Ag)-Total	mg/L	5	5	0.000871	0.00478	0.0026	0.0017	1	1	0.000216	0.000216	0.00022	0.000216	2	2	0.000221	0.00128	0.00075	0.0007505
Sodium (Na)-Total	mg/L	5	5	5.5	9.2	6.7	6.4	1	1	5.75	5.75	5.8	5.75	2	2	5.67	7.23	6.5	6.45
Strontium (Sr)-Total	mg/L	5	5	1.24	2.28	1.7	1.87	1	1	1.83	1.83	1.8	1.83	2	2	2.33	2.79	2.6	2.56
Thallium (Tl)-Total	mg/L	5	5	0.000146	0.00102	0.00057	0.00067	1	1	0.000327	0.000327	0.00033	0.000327	2	2	0.000431	0.000664	0.00055	0.0005475
Tin (Sn)-Total	mg/L	5	5	0.00046	0.00312	0.0018	0.0014	1	1	0.00039	0.00039	0.00039	0.00039	2	2	0.00076	0.0011	0.00093	0.00093
Uranium (U)-Total	mg/L	5	5	0.000545	0.00505	0.003	0.0031	1	1	0.00135	0.00135	0.0014	0.00135	2	2	0.00189	0.00322	0.0026	0.002555
Vanadium (V)-Total	mg/L	5	4	0.001	0.0042	0.0026	0.0025	1	0	0.0005	0.0005	0.0005	0.0005	2	1	0.0005	0.00105	0.00078	0.000775
Zinc (Zn)-Total	mg/L	5	5	0.0474	0.171	0.099	0.061	1	1	0.0252	0.0252	0.025	0.0252	2	2	0.0977	0.106	0.1	0.10185
Dissolved Metals																			
Aluminum (Al)-Dissolved	mg/L	5	4	0.003	0.0281	0.012	0.012	1	1	0.0042	0.0042	0.0042	0.0042	2	1	0.001	0.0024	0.0017	0.0017
Antimony (Sb)-Dissolved	mg/L	5	5	0.00055	0.00311	0.0021	0.0026	1	1	0.0007	0.0007	0.0007	0.0007	2	2	0.00081	0.00381	0.0023	0.00231
Arsenic (As)-Dissolved	mg/L	5	5	0.00433	0.0609	0.026	0.025	1	1	0.0174	0.0174	0.017	0.0174	2	2	0.00227	0.0298	0.016	0.016035
Barium (Ba)-Dissolved	mg/L	5	5	0.0364	0.0706	0.045	0.040	1	1	0.0355	0.0355	0.036	0.0355	2	2	0.0262	0.0308	0.029	0.0285
Beryllium (Be)-Dissolved	mg/L	5	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	5	0	0.0005	0.0005	0.0005	0.0005	1	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Cadmium (Cd)-Dissolved	mg/L	5	4	0.00001	0.000156	0.000059	0.000039	1	0	0.000005	0.000005	0.000005	0.000005	2	2	0.0000848	0.000291	0.00019	0.0001879
Calcium (Ca)-Dissolved	mg/L	5	5	72.1	117	88.4	85.4	1	1	99.2	99.2	99	99.2	2	2	129	154	140	141.5
Chromium (Cr)-Dissolved	mg/L	5	3	0.0001	0.00186	0.00049	0.00012	1	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Cobalt (Co)-Dissolved	mg/L	5	5	0.00033	0.00167	0.00078	0.00067	1	1	0.00078	0.00078	0.00078	0.00078	2	2	0.00116	0.00119	0.0012	0.001175
Copper (Cu)-Dissolved	mg/L	5	1	0.0005	0.00097	0.00059	0.0005	1	0	0.0002	0.0002	0.0002	0.0002	2	2	0.00204	0.00222	0.0021	0.00213
Iron (Fe)-Dissolved	mg/L	5	0	0.03	0.03	0.03	0.03	1	0	0.01	0.01	0.01	0.01	2	2	0.264	0.281	0.27	0.2725
Lead (Pb)-Dissolved	mg/L	5	3	0.00005	0.000161	0.00008	0.000053	1	0	0.00005	0.00005	0.00005	0.00005	2	1	0.00005	0.000058	0.000054	0.000054
Lithium (Li)-Dissolved	mg/L	5	5	0.00638	0.0131	0.01	0.0105	1	1	0.0103	0.0103	0.01	0.0103	2	2	0.0122	0.0164	0.014	0.0143
Magnesium (Mg)-Dissolved	mg/L	5	5	9.83	16.4	12	13	1	1	13.1	13.1	13	13.1	2	2	17.3	19.8	19	18.55
Manganese (Mn)-Dissolved	mg/L	5	5	0.314	0.832	0.47	0.36	1	1	0.517	0.517	0.52	0.517	2	2	0.539	1.21	0.87	0.8745
Mercury (Hg)-Dissolved	mg/L	5	0	0.00001	0.00001	0.00001	0.00001	1	0	0.000005	0.000005	0.000005	0.000005	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	5	5	0.00162	0.00297	0.0022	0.0021	1	1	0.00111	0.00111	0.0011	0.00111	2	2	0.000961	0.00187	0.0014	0.0014155
Nickel (Ni)-Dissolved	mg/L	5	5	0.00091	0.00716	0.0032	0.0024	1	1	0.00054	0.00054	0.00054	0.00054	2	2	0.00147	0.00186	0.0017	0.001665
Potassium (K)-Dissolved	mg/L	5	5	4.47	5.55	4.8	4.65	1	1	4.62	4.62	4.6	4.62	2	2	5.32	6.14	5.7	5.73
Selenium (Se)-Dissolved	mg/L	5	1	0.0001	0.0001	0.0001	0.0001	1	0	0.00005	0.00005	0.00005	0.00005	2	1	0.00005	0.000165	0.00011	0.0001075
Silver (Ag)-Dissolved	mg/L	5	0	0.00001	0.00001	0.00001	0.00001	1	0	0.00001	0.00001	0.00001	0.00001	2	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	5	5	5.5	9.2	6.4	5.8	1	1	5.58	5.58	5.6	5.58	2	2	5.57	7.12	6.3	6.345
Strontium (Sr)-Dissolved	mg/L	5	5	1.08	2.25	1.7	1.78	1	1	1.82	1.82	1.8	1.82	2	2	2.29	2.58	2.4	2.435
Thallium (Tl)-Dissolved	mg/L	5	5	0.000018	0.000572	0.00025	0.000075	1	1	0.000286	0.000286	0.00029	0.000286	2	2	0.000407	0.000466	0.00044	0.0004365
Tin (Sn)-Dissolved	mg/L	5	1	0.0001	0.00018	0.00012	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Uranium (U)-Dissolved	mg/L	5	5	0.000257	0.00517	0.0022	0.0025	1	1	0.00129	0.00129	0.0013	0.00129	2	2	0.00175	0.00198	0.0019	0.001865
Vanadium (V)-Dissolved	mg/L	5	0	0.001	0.001	0.001	0.001	1	0	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	5	5	0.003	0.0514	0.016	0.0059	1	1	0.0095	0.0095	0.0095	0.0095	2	2	0.0509	0.0941	0.073	0.0725

BJ-GW14-14A		2016						2017							2018						2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																																					
Temperature	°C	2	2	2.5	2.6	2.6	2.55	1	1	2.5	2.5	2.5	1	1	2	2	2.7	3	2.9	2.85	1	1	2	2	2	2	1	1	5.4	5.4	5.4	5.4	1	1	2.4	2.4	2.4	2.4
pH	pH	2	2	8	8.2	8.1	8.1	1	1	8.1	8.1	8.1	1	1	2	2	8.1	8.2	8.2	8.15	1	1	8.13	8.13	8.13	8.13	1	1	8.12	8.12	8.1	8.12	1	1	8.2	8.2	8.2	8.2
Specific Sonductance	µS/cm	2	2	265	266	270	265.5	1	1	271	271	271	1	1	2	2	235	264	250	249.5	1	1	257.6	257.6	257.6	257.6	1	1	265	265	270	265	1	1	273.4	273.4	270	273.4
Dissolved Oxygen	mg/L	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	1	1	8.16	8.16	8.16	8.16	1	1	0.35	0.35	0.35	0.35	1	1	0.35	0.35	0.35	0.35
Oxidation Reduction Potential	mV	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	1	1	113.8	113.8	113.8	113.8	1	1	-109.6	-109.6	-110	-109.6	1	1	-100.7	-100.7	-100	-100.7
Turbidity	NTU	0	-	-	-	-	-	1	1	2959	2959	2959	1	1	2	2	758	2135	1400	1446.5	1	1	36.7	36.7	36.7	36.7	1	1	22.39	22.39	22	22.39	1	1	6.09	6.09	6.1	6.09
Physical Tests																																						
Conductivity	uS/cm	2	2	263	272	270	267.5	1	1	257	257	257	1	1	2	2	252	262	260	257	1	1	267	267	267	267	1	1	262	262	260	262	1	1	269	269	270	269
Acidity (as CaCO3)	mg/L	2	0	1	1	1	1	1	0	1	1	1	1	1	2	0	1	1.1	1.1	1.05	1	0	1	1	1	1	1	0	2	2	2	2	1	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	2	2	93	98	96	95.5	1	1	114	114	114	1	1	2	2	92	112	100	102	1	1	93.5	93.5	93.5	93.5	1	1	89.6	89.6	90	89.6	1	1	90.4	90.4	90	90.4
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	91.8	91.8	92	91.8	1	1	82.8	82.8	83	82.8
Hardness (as CaCO3), total from Ca/Mg	mg/L	2	2	84	84	84	84	1	1	78	78	78	1	1	2	2	85	88	87	86.5	1	1	90.4	90.4	90.4	90.4	1	1	83.7	83.7	84	83.7	1	1	81.6	81.6	82	81.6
pH	pH	2	2	8.2	8.2	8.2	8.2	1	1	8.1	8.1	8.1	1	1	2	2	8.1	8.3	8.2	8.2	1	1	8.25	8.25	8.25	8.25	1	1	8.12	8.12	8.1	8.12	1	1	8.29	8.29	8.3	8.29
Total Dissolved Solids (TDS)	mg/L	2	2	216	342	280	279	1	1	181	181	181	1	1	2	2	202	286	240	244	1	1	180	180	180	180	1	1	157	157	160	157	1	1	170	170	170	170
Total Suspended Solids (TSS)	mg/L	2	2	457	834	650	645.5	1	1	2230	2230	2230	1	1	2	2	702	2270	1500	1486	1	1	77.6	77.6	77.6	77.6	1	1	53.7	53.7	54	53.7	1	1	9.2	9.2	9.2	9.2
Turbidity	NTU	2	2	462	938	700	700	1	1	3180	3180	3180	1	1	2	2	399	2610	1500	1504.5	1	1	37.4	37.4	37.4	37.4	1	1	12	12	12	12	1	1	2.27	2.27	2.3	2.27
Anions and Nutrients																																						
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.124	0.124	0.12	0.124	1	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	2	2	0.036	0.042	0.039	0.039	1	1	0.056	0.056	0.056	1	1	2	2	0.038	0.08	0.059	0.059	1	1	0.0348	0.0348	0.035	0.035	1	1	0.0453	0.0453	0.045	0.0453	1	1	0.0392	0.0392	0.039	0.0392
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.05	0.05	0.05	0.05	1	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	2	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	1	1	2	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	2	2	0.12	0.12	0.12	0.12	1	1	0.12	0.12	0.12	1	1	2	2	0.12	0.13	0.13	0.125	1	1	0.122	0.122	0.12	0.12	1	1	0.12	0.12	0.12	0.12	1	1	0.109	0.109	0.11	0.109
Nitrate (as N)	mg/L	2	0	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	1	1	2	0	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.0051	0.0051	0.0051	0.0051
Nitrite (as N)	mg/L	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	1	1	2	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.125	0.125	0.13	0.125	1	1	0.045	0.045	0.045	0.045
Dissolved Orthophosphate (as P)	mg/L	2	2	0.0019	0.0055	0.0037	0.0037	1	1	0.0013	0.0013	0.0013	1	1	2	2	0.0038	0.012	0.0079	0.0079	1	0	0.001	0.001	0.001	0.001	1	1	0.0038	0.0038	0.0038	0.0038	1	1	0.0033	0.0033	0.0033	0.0033
Total Phosphorus (P)	mg/L	2	2	0.3	0.38	0.34	0.34	1	1	0.66	0.66	0.66	1	1	2	2	0.28	0.99	0.64	0.635	1	1	0.0477	0.0477	0.048	0.048	1	1	0.0246	0.0246	0.025	0.0246	1	1	0.009	0.009	0.009	0.009
Sulphate (SO4)	mg/L	2	2	44	44	44	44	1	1	45	45	45	1	1	2	2	43	44	44	43.5	1	1	44.4	44.4	44.4	44.4	1	1	45.4	45.4	45	45.4	1	1	45.2	45.2	45	45.2
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.019	0.019	0.019	0.019	1	1	0.0145	0.0145	0.015	0.0145
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.018	0.018	0.018	0.018	1	1	0.0136	0.0136	0.014	0.0136
Total Metals																																						
Aluminum (Al)-Total	mg/L	2	2	11	22	17	16.5	1	1	28	28	28	1	1	2	2	12	27	20	19.5	1	1	0.543	0.543	0.543	0.543	1	1	1.04	1.04	1	1.04	1	1	0.146	0.146	0.15	0.146
Antimony (Sb)-Total	mg/L	2	2	0.0022	0.0037	0.003	0.00295	1	1	0.0022	0.0022	0.0022	1	1	2	2	0.0022	0.0023	0.0023	0.00225	1	1	0.00066	0.00066	0.00066	0.00066	1	1	0.00034	0.00034	0.00034	0.00034	1	1	0.0002	0.0002	0.0002	0.0002
Arsenic (As)-Total	mg/L	2	2	0.048	0.098	0.073	0.073	1	1	0.11	0.11	0.11	1	1	2	2	0.042	0.11	0.076	0.076	1	1	0.00673	0.00673	0.0067	0.0067	1	1	0.00561	0.00561	0.0056	0.00561	1	1	0.00424	0.00424	0.0042	0.00424
Barium (Ba)-Total	mg/L	2	2	0.36	0.67	0.52	0.515	1	1	0.72	0.72	0.72	1	1	2	2	0.51	0.88	0.7	0.695	1	1	0.048	0.048	0.048	0.048	1	1	0.0411	0.0411	0.041	0.0411	1	1	0.0254	0.0254	0.025	0.0254
Beryllium (Be)-Total	mg/L	2	2	0.00078	0.0014	0.0011	0.00109	1	1	0.0031	0.0031	0.0031	1	1	2	2	0.0012	0.0047	0.003	0.00295	1	0	0.0001	0.0001	0.0001	0.0001	1	1	0.000118	0.000118	0.00012	0.000118	1	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	2	2	0.00018	0.0003	0.00024	0.00024	1	1	0.00063	0.00063	0.00063	1	1	2	2	0.00032	0.0013	0.00081	0.00081	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.081	0.081	0.081	0.081	1	1	0.087	0.087	0.087	0.087
Cadmium (Cd)-Total	mg/L	2	2	0.000088	0.0001	0.000094	0.000094	1	1	0.00016	0.00016	0.00016	1	1	2	2	0.00025	0.00043	0.00034	0.00034	1	1	0.000036	0.000036	0.000036	0.000036	1	1	0.0000189	0.0000189	0.000019	0.0000189	1	1	0.0000077	0.0000077	0.0000077	0.0000077
Calcium (Ca)-Total	mg/L	2	2	35	42	39	38.5	1	1	50	50	50	1	1	2	2	36	64	50	50	1	1	32.5	32.5	32.5	32.5	1	1	26.5	26.5	27	26.5	1	1	25.4	25.4	25	25.4
Chromium (Cr)-Total	mg/L	2	2	0.0041	0.0062	0.0052	0.00515	1	1	0.009	0.009	0.009	1	1	2	2	0.0063	0.016	0.011	0.01115	1	1	0.00291	0.00291	0.0029	0.00291	1	1	0.00772	0.00772	0.0077	0.00772	1	1	0.00085	0.00085	0.00085	0.00085
Cobalt (Co)-Total	mg/L	2	2	0.0066	0.012	0.0093	0.0093	1	1	0.019	0.019	0.019	1	1	2	2	0.0071	0.018	0.013	0.01255	1	1	0.00043	0.00043	0.00043	0.00043	1	1	0.00023	0.00023	0.00023	0.00023	1	0	0.0001	0.0001	0.0001	0.0001
Copper (Cu)-Total	mg/L	2	2	0.014	0.023	0.019	0.0185	1	1	0.042	0.042	0.042	1	1	2	2	0.019	0.04	0.03	0.0295	1	1	0.00357	0.00357	0.0036	0.0036	1	1	0.00194	0.00194	0.0019	0.00194	1	0	0.0005	0.0005	0.0005	0.0005
Iron (Fe)-Total	mg/L	2	2	16	28	22	22	1	1	43	43	43	1	1	2	2	20	52	36	36	1	1	1.41	1.41	1.4	1.41	1	1	2.14	2.14	2.1	2.14	1	1	0.178	0.178	0.18	0.178
Lead (Pb)-Total	mg/L	2	2	0.011	0.022	0.017	0.0165	1	1	0.035	0.035	0.035	1	1	2	2	0.02	0.067	0.044	0.0435	1	1	0.00601	0.00601	0.006	0.00601	1	1	0.00506	0.00506	0.0051	0.00506	1	1	0.000493	0.000493	0.00049	0.000493
Lithium (Li)-Total	mg/L	2	2	0.059	0.069	0.064	0.064	1	1	0.078	0.078	0.078	1	1	2	2	0.061	0.075	0.068	0.068	1	1	0.0452	0.0452	0.045	0.045	1	1	0.0501	0.0501	0.05	0.0501	1	1	0.0476	0.0476	0.048	0.0476
Magnesium (Mg)-Total	mg/L	2	2	8.5	11	9.8	9.75	1	1	16	16	16	1	1	2	2	9.3	16	13	12.65	1	1	5.02	5.02	5	5.02	1	1	4.28	4.28	4.3	4.28	1	1	4.7	4.7	4.7	4.7
Manganese (Mn)-Total	mg/L	2	2	0.83	1.7	1.3	1.265	1	1	1.9	1.9	1.9	1	1	2	2	0.75	2.7	1.7	1.725	1	1	0.12	0.12	0.12	0.12	1	1	0.108	0.108	0.11	0.108	1	1	0.0499	0.0499	0.05	0.0499
Mercury (Hg)-Total	mg/L	2	2	0.000066	0.000095	0.000081	0.0000805	1	1	0.00019	0.00019	0.00019	1	1	2	1	0.0001	0.00017	0.00014	0.000135	1	0	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	2	2	0.0025	0.0032	0.0029	0.00285	1	1	0.0017	0.0017	0.0017	1	1	2	2	0.0027	0.0038	0.0033	0.00325	1	1	0.00201	0.00201	0.002	0.0020	1	1	0.00253	0.00253	0.0025	0.00253	1	1	0.0016	0.0016	0.0016	0.0016
Nickel (Ni)-Total	mg/L	2	2	0.0047	0.0074	0.0061	0.00605	1	1	0.011	0.011	0.011	1	1	2	2	0.0055	0.012	0.0088	0.00875	1	1	0.00148	0.00148	0.0015	0.0015	1	1	0.00067	0.00067	0.00067	0.00067	1	0	0.0005	0.0005	0.0005	0.0005
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.3	0.3	0.3	0.3	1	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	2	2	5.1	8.7	6.9	6.9	1	1	7.3	7.3	7.3	1	1	2	2	4.5	8.2	6.4	6.35	1	1	1.67	1.67	1.7	1.67	1	1	1.84	1.84	1.8	1.84	1	1	1.56	1.56	1.6	1.56
Selenium (Se)-Total	mg/L	2	2	0.00045	0.00071	0.00058	0.00058	1	1	0.0013	0.0013	0.0013	1	1	2	2	0.00047	0.00096	0.00072	0.000715	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	6.29	6.29	6.3	6.29	1	1	3.98	3.98	4	3.98
Silver (Ag)-Total	mg/L	2	2	0.00072	0.0012	0.00096	0.00096	1	1	0.0024	0.0024	0.0024	1	1	2	2	0.00069	0.0019	0.0013	0.001295	1	1	0.000084	0.000084	0.000084	0.000084	1	1	0.000029	0.000029	0.000029	0.000029	1	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Total	mg/L	2	2	20	22	21	21	1	1	25	25	25	1	1	2	2	22	23	23	22.5	1	1	20.5	20.5	21	20.5	1	1	23.4	23.4	23	23.4	1	1	22.1	22.1	22	22.1
Strontium (Sr)-Total	mg/L	2	2	2.2	2.6	2.4	2.4	1	1	2.9	2.9	2.9	1	1	2	2	2.5	4	3.3	3.25	1	1	2.24	2.24	2.2	2.24	1	1	2.5	2.5	2.5	2.5	1	1	2.49	2.49	2.5	2.49
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	2	2	0.00025	0.00048	0.00037	0.000365	1	1	0.00039	0.00039	0.00039	1	1	2	2	0.00031	0.00054	0.00043	0.000425	1	1	0.00002	0.00002	0.00002	0.00002	1	1	0.00003	0.00003	0.00003	0.00003	1	1	0.000025	0.000025	0.000025	0.000025
Tin (Sn)-Total	mg/L	2	2	0.00045	0.00065	0.00055	0.00055	1	1	0.00032	0.00032	0.00032	1	1	2	2	0.00039	0.00061	0.0005	0.0005	1	1	0.0004	0.0004	0.0004	0.0004	1	1	0.00028	0.00028	0.00028	0.00028	1	1	0.00011	0.00011	0.00011	0.00011
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.0138	0.0138	0.014	0.0138	1	0	0.01	0.01	0.01	0.01
Uranium (U)-Total	mg/L	2	2	0.0016	0.0026	0.0021	0.0021	1	1	0.0041	0.0041	0.0041	1	1	2	2	0.0029	0.0097	0.0063	0.0063	1	1	0.000424	0.000424	0.00042	0.00042	1	1	0.000583	0.000583	0.00058	0.000583	1	1	0.000152	0.000152	0.00015	0.000152
Vanadium (V)-Total	mg/L	2	2	0.016	0.03	0.023	0.023	1	1	0.03	0.03	0.03	1	1	2	2	0.015	0.025	0.02	0.02	1	1	0.00094	0.00094	0.00094	0.00094	1	1	0.00092	0.00092	0.00092	0.00092	1	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Total	mg/L	2	2	0.044	0.072	0.058	0.058	1	1	0.12	0.12	0.12	1	1	2	2	0.054	0.15	0.1	0.102	1	1	0.0165	0.0165	0.017	0.0165	1	1	0.0065	0.0065	0.0065	0.0065	1	0	0.003	0.003	0.003	0.003
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																																						
Aluminum (Al)-Dissolved	mg/L	2	2	0.0033	0.086	0.045	0.04465	1	1	0.0026	0.0026	0.0026	1	1	2	1	0.001	0.0026	0.0018	0.0018	1	1	0.0067	0.0067	0.0067	0.0067	1	1	0.0023	0.0023	0.0023	0.0023	1	1	0.0025	0.0025	0.0025	0.0025
Antimony (Sb)-Dissolved	mg/L	2	2	0.0002	0.00029	0.00025	0.000245	1	1	0.00025	0.00025	0.00025	1	1	2	2	0.00033	0.00036	0.00035	0.000345	1	1	0.00022	0.00022	0.00022	0.00022	1	1	0.00014	0.00014	0.00014	0.00014	1	1	0.00013	0.00013	0.00013	0.00013
Arsenic (As)-Dissolved	mg/L	2	2	0.0022	0.0024	0.0023	0.0023	1	1	0.0025	0.0025	0.0025	1	1	2	2	0.0017	0.0026	0.0022	0.00215	1	1	0.00286	0.00286	0.0029	0.0029	1	1	0.00375	0.00375	0.0038	0.00375	1	1	0.004	0.004	0.004	0.004
Barium (Ba)-Dissolved	mg/L	2	2	0.027	0.028	0.028	0.0275	1	1	0.023	0.023	0.023	1	1	2	2	0.026	0.027	0.027	0.0265	1	1	0.0239	0.0239	0.024	0.024	1	1	0.0233	0.0233	0.023	0.0233	1	1	0.0214	0.0214	0.021	0.0214
Beryllium (Be)-Dissolved	mg/L	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	1	1	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	2	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	1	1	2	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	0.077	0.077	0.077	0.077	1	1	0.077	0.077	0.077	0.077
Cadmium (Cd)-Dissolved	mg/L	2	0	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	1	1	2	1	0.000005	0.0000082	0.0000066	0.0000066	1	0	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005
Calcium (Ca)-Dissolved	mg/L	2	2	25	26	26	25.5	1	1	24	24	24	1	1	2	2	26	28	27	27	1	1	28	28	28	28	1	1	28.2	28.2	28	28.2	1	1	25	25	25	25
Chromium (Cr)-Dissolved	mg/L	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	1	1	2	0	0.0001	0.0001	0.0001	0.0001	1	1	0.00015	0.00015	0.00015	0.00015	1	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0005	0.0005	0.0005	0.0005
Cobalt (Co)-Dissolved	mg/L	2	1	0.0001	0.00011	0.00011	0.000105	1	0	0.0001	0.0001	0.0001	1	1	2	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Copper (Cu)-Dissolved	mg/L	2	0	0.0002	0.0002	0.0002	0.0002	1	1	0.0024	0.0024	0.0024	1	1	2	1	0.0002	0.00022	0.00021	0.00021	1	1	0.00033	0.00033	0.00033	0.00033	1	0	0.0002	0.0002	0.0002	0.0002	1	0	0.0002	0.0002	0.0002	0.0002
Iron (Fe)-Dissolved	mg/L	2	1	0.01	0.036	0.023	0.023	1	0	0.01	0.01	0.01	1	1	2	0	0.01	0.01	0.01	0.01	1	0	0.01	0.01	0.01	0.01	1	1	0.025	0.025	0.025	0.025	1	1	0.029	0.029	0.029	0.029
Lead (Pb)-Dissolved	mg/L	2	1	0.00005	0.00005	0.00005	0.00005	1

Uranium (U)-Dissolved	mg/L	2	2	0.00023	0.0003	0.00027	0.000265	1	1	0.00026	0.00026	0.00026	1	1	2	2	0.00032	0.00033	0.00033	0.000325	1	1	0.000235	0.000235	0.00024	0.00024	1	1	0.00015	0.00015	0.00015	0.00015	1	1	0.00009	0.00009	0.00009	0.00009
Vanadium (V)-Dissolved	mg/L	2	0	0.0005	0.0005	0.0005	0.0005	1	0	0.0005	0.0005	0.0005	1	1	2	1	0.0005	0.00057	0.00054	0.000535	1	0	0.0005	0.0005	0.0005	0.0005	1	0	0.0005	0.0005	0.0005	0.0005	1	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	2	0	0.001	0.001	0.001	0.001	1	1	0.0015	0.0015	0.0015	1	1	2	0	0.001	0.001	0.001	0.001	1	1	0.0012	0.0012	0.0012	0.0012	1	1	0.0018	0.0018	0.0018	0.0018	1	0	0.001	0.001	0.001	0.001
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																																							
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	20	20	20	20	1	0	20	20	20	20

BJ-GW14-14B		Operations (2015 - 2018)							2016							2017							2018							2019							2020							2021						
		Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																																		
Temperature	°C	8	8	0	10	2.8375	2.8	2.05	3	3	0	10	3.666666667	3.7	1	2	2	2	2.1	2.05	2.1	2.05	3	3	2	3	2.533333333	2.5	2.6	1	1	3.6	3.6	3.6	3.6	3.6	2	2	3.5	3.7	3.6	3.6	3.6	1	1	2.1	2.1	2.1	2.1
pH	pH	8	8	7.6	8.3	7.9	7.9	7.9	3	3	7.6	8.3	7.866666667	7.9	7.7	2	2	7.8	7.8	7.8	7.8	7.8	3	3	8	8	8	8	8	1	1	7.99	7.99	7.99	7.99	7.99	2	2	7.88	7.98	7.93	7.9	7.93	1	1	8.03	8.03	8	8.03
Specific Sonductance	µSi/cm	8	8	153	246	204	204	202.5	3	3	153	246	194	190	183	2	2	211	232	221.5	220	221.5	3	3	178	235	202.3333333	200	194	1	1	224.4	224.4	224.4	224.4	224.4	2	2	228.6	230.1	229.35	230	229.35	1	1	234.1	234.1	230	234.1
Dissolved Oxygen	mg/L	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	1	1	4.54	4.54	4.54	4.54	4.54	2	2	0.29	3.69	1.99	2	1.99	1	1	0.34	0.34	0.34	0.34
Oxidation Reduction Potential	mV	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	-	1	1	-68.3	-68.3	-68.3	-68.3	-68.3	2	2	-174.8	-106.3	-140.55	-140	-140.55	1	1	-150.6	-150.6	-150	-150.6
Turbidity	NTU	4	4	33.6	707	208.3	208.3	46.3	0	-	-	-	-	-	-	2	2	33.6	707	370.3	370	370.3	2	2	43.4	49.2	46.3	46	46.3	1	1	0.2	0.2	0.2	0.2	0.2	2	2	0.3	8.1	4.2	4.2	4.2	1	1	3.32	3.32	3.3	3.32
Physical Tests																																																			
Conductivity	uS/cm	8	8	155	239	201.625	201.6	206	3	3	155	238	190.6666667	190	179	2	2	198	239	218.5	220	218.5	3	3	166	224	201.3333333	200	214	1	1	231	231	231	231	231	2	2	223	233	228	230	228	1	1	230	230	230	230
Acidity (as CaCO3)	mg/L	8	8	1.1	2.3	1.7125	1.713	1.75	3	3	1.1	2.3	1.766666667	1.8	1.9	2	2	1.1	2.2	1.65	1.7	1.65	3	3	1.6	1.8	1.7	1.7	1.7	1	1	1.7	1.7	1.7	1.7	1.7	2	0	2	2	2	2	2	1	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	8	8	47	70	57.375	57.38	57.5	3	3	47	70	56.66666667	57	53	2	2	56	63	59.5	60	59.5	3	3	49	62	56.66666667	57	59	1	1	60.1	60.1	60.1	60.1	60.1	2	2	59.6	61.3	60.45	60	60.45	1	1	56.9	56.9	57	56.9
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	102	105	103.5	100	103.5	1	1	94.8	94.8	95	94.8
Hardness (as CaCO3), total from Ca/Mg	mg/L	8	8	74	107	96.375	96.38	97	3	3	95	107	101.6666667	100	103	2	2	93	97	95	95	95	3	3	74	105	92	92	97	1	1	101	101	101	101	101	2	2	97.7	111	104.35	100	104.35	1	1	95.1	95.1	95	95.1
pH	pH	8	8	7.6	8	7.8875	7.89	7.9	3	3	7.6	8	7.833333333	7.8	7.9	2	2	7.8	8	7.9	7.9	7.9	3	3	7.9	8	7.933333333	7.9	7.9	1	1	8.04	8.04	8.04	8.04	8.04	2	2	7.9	7.93	7.915	7.9	7.915	1	1	8.13	8.13	8.1	8.13
Total Dissolved Solids (TDS)	mg/L	8	8	97	167	133.375	133.4	133.5	3	3	97	165	128	130	122	2	2	129	167	148	150	148	3	3	108	141	129	130	138	1	1	162	162	162	162	162	2	2	147	160	153.5	150	153.5	1	1	156	156	160	156
Total Suspended Solids (TSS)	mg/L	8	7	3	1880	474	474	267	3	3	183	1880	795	800	322	2	2	33	837	435	440	435	3	2	3	273	179	180	261	1	0	3	3	3	3	3	2	0	3	3	3	3	3	1	0	3	3	3	3
Turbidity	NTU	8	8	1.5	518	197.9375	197.9	120	3	3	138	518	290.6666667	290	216	2	2	26	512	269	270	269	3	3	1.5	102	57.83333333	58	70	1	1	1.51	1.51	1.51	1.51	1.51	2	2	1.56	1.94	1.75	1.8	1.75	1	1	0.99	0.99	0.99	0.99
Anions and Nutrients																																																			
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.05	0.05	0.05	0.05	0.05	1	0	0.05	0.05	0.05	0.05
Total Ammonia (as N)	mg/L	8	8	0.006	0.023	0.01315	0.013	0.013	3	3	0.0079	0.019	0.013966667	0.014	0.015	2	2	0.0093	0.023	0.01615	0.016	0.01615	3	3	0.006	0.013	0.010333333	0.01	0.012	1	1	0.0118	0.0118	0.0118	0.012	0.012	2	2	0.015	0.0165	0.01575	0.016	0.01575	1	1	0.0166	0.0166	0.017	0.0166
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.05	0.05	0.05	0.05	0.05	1	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	8	0	0.5	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5	0.5	3	0	0.5	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5	0.5	1	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	8	8	0.037	0.065	0.05075	0.051	0.050	3	3	0.037	0.051	0.043333333	0.043	0.042	2	2	0.048	0.059	0.0535	0.054	0.0535	3	3	0.044	0.065	0.056333333	0.056	0.06	1	1	0.071	0.071	0.071	0.071	0.071	2	2	0.068	0.071	0.0695	0.07	0.0695	1	1	0.061	0.061	0.061	0.061
Nitrate (as N)	mg/L	8	6	0.005	0.037	0.0162625	0.016	0.011	3	3	0.011	0.037	0.028	0.028	0.036	2	1	0.005	0.016	0.0105	0.011	0.0105	3	2	0.005	0.011	0.008366667	0.0084	0.0091	1	0	0.005	0.005	0.005	0.005	0.005	2	0	0.005	0.005	0.005	0.005	0.005	1	0	0.005	0.005	0.005	0.005
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0.0051	0.0051	0.0051	0.0051
Nitrite (as N)	mg/L	8	1	0.001	0.0025	0.0011875	0.0012	0.001	3	1	0.001	0.0025	0.0015	0.0015	0.001	2	0	0.001	0.001	0.001	0.001	0.001	3	0	0.001	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001	0.001	2	0	0.001	0.001	0.001	0.001	0.001	1	0	0.001	0.001	0.001	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.03	0.03	0.03	0.03	0.03	1	0	0.03	0.03	0.03	0.03
Dissolved Orthophosphate (as P)	mg/L	8	3	0.001	0.0019	0.0011625	0.0012	0.001	3	1	0.001	0.0013	0.0011	0.0011	0.001	2	0	0.001	0.001	0.001	0.001	0.001	3	2	0.001	0.0019	0.001333333	0.0013	0.0011	1	0	0.001	0.001	0.001	0.001	0.001	2	1	0.001	0.0013	0.00115	0.0012	0.00115	1	1	0.0016	0.0016	0.0016	0.0016
Total Phosphorus (P)	mg/L	8	7	0.002	2.4	0.51675	0.52	0.15	3	3	0.16	2.4	0.946666667	0.95	0.28	2	2	0.042	1	0.521	0.52	0.521	3	2	0.002	0.14	0.084	0.084	0.11	1	0	0.002	0.002	0.002	0.002	0.002	2	2	0.0023	0.0042	0.00325	0.0033	0.00325	1	1	0.0034	0.0034	0.0034	0.0034
Sulphate (SO4)	mg/L	8	8	28	55	43.25	43.3	47	3	3	28	51	37.66666667	38	34	2	2	45	55	50	50	50	3	3	33	51	44.33333333	44	49	1	1	53.1	53.1	53.1	53.1	53.1	2	2	52.6	53.1	52.95	53	52.95	1	1	53.1	53.1	53	53.1
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.019	0.019	0.019	0.019	0.019	1	0	0.0016	0.0016	0.0016	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.018	0.018	0.018	0.018	0.018	1	0	0.0015	0.0015	0.0015	0.0015
Total Metals																																																			
Aluminum (Al)-Total	mg/L	8	8	0.0043	38	8.2742875	8.27	2.85	3	3	2.3	38	14.9	15	4.4	2	2	0.79	15	7.895	7.9	7.895	3	3	0.0043	3.4	1.901433333	1.9	2.3	1	1	0.0056	0.0056	0.0056	0.0056	0.0056	2	2	0.0042	0.0063	0.00525	0.0053	0.00525	1	1	0.0048	0.0048	0.0048	0.0048
Antimony (Sb)-Total	mg/L	8	7	0.0001	0.0067	0.00215875	0.0022	0.0016	3	3	0.00041	0.0067	0.002936667	0.0029	0.0017	2	2	0.00056	0.0047	0.00263	0.0026	0.00263	3	2	0.0001	0.0016	0.001066667	0.0011	0.0015	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Arsenic (As)-Total	mg/L	8	8	0.0027	0.15	0.038875	0.039	0.022	3	3	0.0082	0.15	0.0574	0.057	0.014	2	2	0.0061	0.063	0.03455	0.035	0.03455	3	3	0.0027	0.037	0.023233333	0.023	0.03	1	1	0.0031	0.0031	0.0031	0.0031	0.0031	2	2	0.00277	0.00309	0.00293	0.0029	0.00293	1	1	0.00257	0.00257	0.0026	0.00257
Barium (Ba)-Total	mg/L	8	8	0.027	1.9	0.45275	0.45	0.19	3	3	0.15	1.9	0.78	0.78	0.29	2	2	0.065	0.82	0.4425	0.44	0.4425	3	3	0.027	0.23	0.112333333	0.13	0.14	1	1	0.0248	0.0248	0.0248	0.025	0.025	2	2	0.0243	0.0277	0.026	0.026	0.026	1	1	0.0243	0.0243	0.024	0.0243
Beryllium (Be)-Total	mg/L	8	7	0.0001	0.0065	0.00145125	0.0015	0.0047	3	3	0.00047	0.0065	0.002503333	0.0026	0.0084	2	2	0.00011	0.0025	0.001455	0.0015	0.001455	3	2	0.0001	0.00047	0.000296667	0.0003	0.00032	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	8	5	0.00005	0.0012	0.00026275	0.00026	0.00076	3	2	0.00005	0.0012	0.00047	0.00047	0.00016	2	1	0.00005	0.00044	0.00245	0.00025	0.00245	3	2	0.00005	0.000082	6.73333E-05	0.000067	0.00007	1	0	0.00005	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.01	0.01	0.01	0.01	1	0	0.01	0.01	0.01	0.01
Cadmium (Cd)-Total	mg/L	8	8	0.0000053	0.0071	0.001564413	0.0016	0.00060	3	3	0.00037	0.0071	0.00275	0.0028	0.00078	2	2	0.00017	0.0029	0.001535	0.0015	0.001535	3	3	0.000053	0.00078	0.000398433	0.0004	0.00041	1	0	0.000005	0.000005	0.000005	0.000005	0.000005	2	0	0.000005	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005
Calcium (Ca)-Total	mg/L	8	8	26	57	36.875	36.9	34.5	3	3	26	57	38.66666667	39	33	2	2	34	42	38	38	38	3	3	29	39	34.33333333	34	35	1	1	40.1	40.1	40.1	40.1	40.1	2	2	35.8	40.5	38.15	38	38.15	1	1	34.2	34.2	34	34.2
Chromium (Cr)-Total	mg/L	8	7	0.0001	0.023	0.0046775	0.0047	0.0018	3	3	0.00048	0.023	0.00886	0.0089	0.0031	2	2	0.00044	0.0067	0.00357	0.0036	0.00357	3	2	0.0001	0.002	0.001233333	0.0012	0.0016	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0005	0.0005	0.0005	0.0005
Cobalt (Co)-Total	mg/L	8	7	0.0001	0.039	0.008465	0.0085	0.0033	3	3	0.0028	0.039	0.015666667	0.015	0.0037	2	2	0.00092	0.014	0.00746	0.0075	0.00746	3	2	0.0001	0.0048	0.002433333	0.0024	0.0024	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Copper (Cu)-Total	mg/L	8	7	0.0005	0.15	0.0331625	0.033	0.014	3	3	0.013	0.15	0.059333333	0.059	0.015	2	2	0.0038	0.053	0.0284	0.028	0.0284	3	2	0.0005	0.017	0.010166667	0.01	0.0113	1	0	0.0005	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005	0.0005	1	0	0.0005	0.0005	0.0005	0.0005
Iron (Fe)-Total	mg/L	8	8	0.19	90	20.16125	20	8.2	3	3	4.9	90	34.33333333	34	8.1	2	2	1.8	35	18.4	18	18.4	3	3	0.19	13	7.163333333	7.2	8.3	1	1	0.243	0.243	0.243	0.24	0.24	2	2	0.233	0.256	0.2445	0.24	0.2445	1	1	0.164	0.164	0.16	0.164
Lead (Pb)-Total	mg/L	8	7	0.00005	0.097	0.021875	0.021	0.0091	3	3	0.009	0.097	0.039	0.039	0.0111	2	2	0.0017	0.035	0.01835	0.018	0.01835	3	2	0.00005	0.0092	0.005216667	0.0052	0.0064	1	0	0.00005	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Lithium (Li)-Total	mg/L	8	8	0.0034	0.045	0.0118625	0.012	0.0061	3	3	0.0052	0.045	0.019166667	0.019	0.0073	2	2	0.0038	0.018	0.0109	0.011	0.0109	3	3	0.0034	0.007	0.0052	0.0052	0.0052	1	1	0.0037	0.0037	0.0037	0.0037	0.0037	2	2	0.0037	0.0038	0.00375	0.0038	0.00375	1	1	0.0034	0.0034	0.0034	0.0034
Magnesium (Mg)-Total	mg/L	8	8	2	128	42	42	2.65	3	3	2	128	54.33333333	5.6	2.9	2	2	2.2	6.1	4.15	4.2	4.15	3	3	2.4	3.6	2.8	2.8	2.4	1	1	2.32	2.32	2.32	2.32	2.32	2	2	1.98	2.4	2.19	2.2	2.19	1	1	2.28	2.28	2.28	2.28
Manganese (Mn)-Total	mg/L	8	8	0.37	3.4	1.0425	1.04	0.57	3	3	0.37	3.4	1.41	1.4	0.46	2	2	0.5	1.5	1	1	1	3	3	0.37	1.1	0.713333333	0.71	0.67	1	1	0.365	0.365	0.365	0.37	0.37	2	2	0.365	0.382	0.3735	0.37	0.3735	1	1	0.385	0.385	0.39	0.385
Mercury (Hg)-Total	mg/L	8	7	0.000005	0.00027	0.25875E-05	0.000083	0.000048	3	3	0.000065	0.00027	0.000135667	0.00014	0.000072	2	2	0.0000088	0.0002	0.0001044	0.0001	0.0001044	3	2	0.000005	0.000031	1.49667E-05	0.000015	8.9E-06	1	0	0.000005	0.000005	0.000005	0.000005	0.000005	2	0	0.000005	0.000005	0.000005	0.000005	0.000005	1	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	8	8	0.00013	0.0031	0.00098875	0.0009	0.00054	3	3	0.00013	0.0031	0.001313333	0.0013	0.00071	2	2	0.00028	0.0023	0.00129	0.0013	0.00129	3	3	0.00015	0.00058	0.00041	0.00041	0.0005	1	1	0.000152	0.000152	0.000152	0.00015	0.00015	2	2	0.000163	0.000177	0.00017	0.00017	0.00017	1	1	0.000161	0.000161	0.00016	0.000161
Nickel (Ni)-Total	mg/L	8	7	0.0005	0.042	0.008625	0.0086	0.0029	3	3	0.0019	0.042	0.0163	0.016	0.005	2	2	0.0008	0.013	0.0069	0.0069	0.0069	3	2	0.0005	0.0035	0.0021	0.0021	0.0023	1	0	0.0005	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005	0.0005	1	0	0.0005	0.0005	0.0005	0.0005
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.3	0.3	0.3	0.3	0.3	1	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	8	8	0.6	6.3	1.96375	2	1.1	3	3	0.85	6.3	2.916666667	2.9	1.6	2	2	0.76	3.4	2.08	2.1	2.08	3	3	0.6	1.2	0.933333333	0.93	1	1	1	0.607	0.607	0.607	0.61	0.61	2	2	0.597	0.639	0.618	0.62	0.618	1	1	0.576	0.576	0.58	0.576
Selenium (Se)-Total	mg/L	8	6	0.00005	0.002	0.000500375	0.0005	0.00019	3	2	0.00005	0.002	0.000766667	0.00077	0.00025	2	2	0.000073	0.001	0.000565	0.00054	0.000565	3	2	0.00005	0.00046	0.00021	0.00021	0.00012	1	0	0.00005	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	0.00005	1	0	0.00005	0.00005	0.00005	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	2.93	3.09	3.01	3	3.01	1	1	2.97	2.97	3	2.97
Silver (Ag)-Total	mg/L	8	7	0.00001	0.0037	0.00078725	0.00079	0.00022	3	3	0.000024	0.0037	0.001358	0.0014	0.00035	2	2	0.000074	0.0017	0.00887	0.00089	0.00887	3	2	0.00001	0.00024	0.00015	0.00015	0.00012	1	0	0.00001	0.00001	0.00001	0.00001	0.00001	2	0	0.00001	0.00001	0.00001	0.00001	0.00001	1	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Total	mg/L	8	8	3	9.3	4.825	4.8	3.9	3	3	3	9.3	5.166666667	5.2	3.2	2	2	3.3	7.1	5.2	5.2	5.2	3	3	3.4	4.9	4.233333333	4.2	4.4	1	1	4.46	4.46	4.46	4.5	4.46	2	2	4.66	4.67	4.665	4.7	4.665	1	1	4.16	4.16	4.2	4.16
Strontium (Sr)-Total	mg/L	8	8	0.18	0.39	0.24	0.24	0.215	3	3	0.18	0.39	0.256666667	0.26	0.2	2	2	0.21	0.29	0.25	0.25	0.25	3	3	0.18	0.25	0.216666667	0.22	0.22	1	1	0.222	0.222	0.222	0.22	0.22	2	2	0.229	0.241	0.235	0.24	0.235	1	1	0.219	0.219	0.22	0.219
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	8	7	0.00001	0.00083	0.000196	0.0002	0.000075	3	3	0.00007	0.00083	0.000326333	0.00033	0.000079	2	2	0.000023	0.00037	0.0001965	0.0002	0.0001965	3	2	0.00001	0.00013	6.53333E-05	0.000065	5.6E-05	1	0	0.00001	0.00001	0.00001	0.00001	0.00001	2	0	0.00001	0.00001	0.00001	0.00001	0.00001	1	0	0.00001	0.00001	0.00001	0.00001
Tin (Sn)-Total	mg/L	8	7	0.0001	0.0039	0.0010125	0.001	0.00041	3	3	0.0001	0.0039	0.001473333	0.0015	0.00042	2	2	0.00015	0.0025	0.001325	0.0013	0.001325	3	2	0.0001	0.00053	0.000343333	0.00034	0.00034	1	0	0.0001	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	1	0	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.01	0.01	0.01	0.01

BJ-GW18-17A		2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																		
Temperature	°C	4	4	2.8	5.4	4.1	4.05	4	4	2.5	6.1	4.1	3.95	4	4	0.8	3.4	2.4	2.65
pH	pH	4	4	8.89	9.17	9.07	9.12	4	4	8.4	9.21	8.9	8.93	4	4	8.36	8.82	8.57	8.555
Specific Sonductance	µS/cm	4	4	779	871	826.5	828	4	4	599	886	720	707	4	4	594	701	665.5	683.5
Dissolved Oxygen	mg/L	2	2	0.09	0.46	0.28	0.28	4	4	0.21	3.29	1.2	0.63	4	4	0.39	8.4	2.5	0.535
Oxidation Reduction Potential	mV	4	4	-250.4	-217.8	-233.1	-232.05	4	4	-225.1	-156	-200	-201.55	4	4	-187.5	-65.7	-150	-173.35
Turbidity	NTU	4	4	0.18	13.5	6.36	5.89	4	4	5.9	34.1	14	8.17	4	4	3.1	151.2	41.19	5.225
Physical Tests																			
Conductivity	uS/cm	4	4	830	928	863.3	847.5	4	4	623	886	720	690.5	4	4	581	688	653	671.5
Acidity (as CaCO3)	mg/L	4	0	1	2	1.5	1.5	4	0	2	2	2	2	4	1	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	4	4	130	170	148.8	147.5	4	4	108	141	120	117.5	4	4	122	135	130	124
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	4	4	11.9	144	85	91.25	4	4	96.9	147	130	137.5
Hardness (as CaCO3), total from Ca/Mg	mg/L	4	4	13.1	16.8	14.58	14.2	4	4	12.8	146	89	99	4	4	56.3	156	119.3	132.5
pH	pH	4	4	8.51	9.44	8.81	8.64	4	4	8.28	8.79	8.5	8.515	4	4	8.2	8.36	8.3	8.28
Total Dissolved Solids (TDS)	mg/L	4	4	533	597	564	563	4	4	380	562	460	445	4	4	355	485	426	431
Total Suspended Solids (TSS)	mg/L	4	2	3	14.8	6.33	3.75	4	3	3	26.5	12	8.75	4	3	3	126	35.9	7.3
Turbidity	NTU	4	4	1.37	7.23	4.01	3.73	4	4	0.41	42.7	13	4.08	4	4	1.41	140	37	3.345
Anions and Nutrients																			
Kjeldahl nitrogen, total (TKN)	mg/L							4	4	0.089	0.221	0.16	0.1595	4	4	0.083	0.206	0.1203	0.096
Total Ammonia (as N)	mg/L	4	4	0.0905	0.149	0.13	0.14	4	4	0.102	0.145	0.12	0.1145	4	4	0.079	0.105	0.09	0.08765
Bromide (Br)	mg/L							4	0	0.05	0.25	0.15	0.15	4	1	0.05	0.25	0.1	0.05
Chloride (Cl)	mg/L	4	4	5.46	6.7	5.79	5.5	4	4	2.22	7.03	4	3.4	4	4	1.82	4.86	3.703	4.065
Fluoride (F)	mg/L	4	3	0.1	0.231	0.18	0.19	4	4	0.189	0.234	0.22	0.2205	4	4	0.179	0.218	0.2	0.199
Nitrate (as N)	mg/L	4	1	0.025	0.155	0.0575	0.025	4	2	0.0077	0.0952	0.038	0.025	4	3	0.005	0.177	0.0835	0.076
Nitrate + Nitrite (as N)	mg/L							4	3	0	0.0255	0.0064	0	4	3	0.0051	0.218	0.1067	0.10175
Nitrite (as N)	mg/L	4	3	0.005	0.177	0.050	0.0086	4	3	0.005	0.068	0.03	0.0228	4	3	0.001	0.0512	0.025	0.0232
Nitrogen, total	mg/L							4	4	0.134	0.31	0.21	0.1995	4	4	0.096	0.314	0.219	0.2335
Dissolved Orthophosphate (as P)	mg/L	4	3	0.001	0.0293	0.0083	0.0015	4	4	0.0012	0.0088	0.0046	0.0042	4	4	0.0017	0.0052	0.0029	0.00235
Total Phosphorus (P)	mg/L	4	4	0.0183	0.0572	0.031	0.023	4	4	0.0122	0.0376	0.023	0.0202	4	4	0.0042	0.154	0.043	0.0077
Sulphate (SO4)	mg/L	4	4	232	264	248	248	4	4	177	290	220	216	4	4	169	216	199	206
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	4	4	0.215	2.74	0.94	0.3955	4	4	0.116	0.524	0.2618	0.2035
Sulfide (as S)	mg/L	-	-	-	-	-	-	4	4	0.202	2.58	0.88	0.372	4	4	0.109	0.493	0.25	0.1915
Total Metals																			
Aluminum (Al)-Total	mg/L	4	4	0.0768	0.153	0.1	0.086	4	4	0.0676	0.592	0.23	0.1275	4	4	0.0276	3.25	0.8421	0.04535
Antimony (Sb)-Total	mg/L	4	4	0.00501	0.0442	0.017	0.0088	4	4	0.00545	0.0211	0.01	0.00676	4	4	0.0026	0.0156	0.0065	0.003985
Arsenic (As)-Total	mg/L	4	4	0.121	0.469	0.25	0.20	4	4	0.038	0.21	0.12	0.1141	4	4	0.0208	0.102	0.0524	0.0433
Barium (Ba)-Total	mg/L	4	4	0.0319	0.0592	0.04	0.035	4	4	0.0253	0.0755	0.059	0.0675	4	4	0.0366	0.149	0.08423	0.07565
Beryllium (Be)-Total	mg/L	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.00002	0.0001	0.00008	0.0001	4	1	0.000077	0.0001	0.000094	0.0001
Bismuth(Bi)- Total	mg/L	4	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	4	1	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	4	4	0.052	0.073	0.064	0.065	4	4	0.046	0.062	0.05525	0.0565
Cadmium (Cd)-Total	mg/L	4	1	0.000005	0.0000108	0.0000065	0.000005	4	1	0.000005	0.0000067	0.0000054	0.000005	4	2	0.000005	0.000028	0.000013	0.000005
Calcium (Ca)-Total	mg/L	4	4	5.9	8.47	6.68	6.18	4	4	4.67	55.9	34	37.8	4	4	34.2	56.2	48.8	56
Chromium (Cr)-Total	mg/L	4	4	0.00011	0.00378	0.0011	0.00025	4	4	0.00011	0.00041	0.00027	0.000275	4	1	0.0005	0.0236	0.006275	0.0005
Cobalt (Co)-Total	mg/L	4	1	0.0001	0.00014	0.00011	0.0001	4	2	0.0001	0.00011	0.00011	0.000105	4	1	0.0001	0.00078	0.00027	0.0001
Copper (Cu)-Total	mg/L	4	2	0.0005	0.00219	0.00092	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	4	3	0.0005	0.00404	0.00149	0.000705
Iron (Fe)-Total	mg/L	4	4	0.021	0.117	0.05	0.03	4	4	0.013	0.591	0.19	0.084	4	4	0.019	3.62	0.9458	0.072
Lead (Pb)-Total	mg/L	4	4	0.000182	0.000568	0.00033	0.00028	4	4	0.000082	0.000289	0.00017	0.0001455	4	4	0.000076	0.00152	0.00045	0.000094
Lithium (Li)-Total	mg/L	4	4	0.461	0.484	0.47	0.48	4	4	0.218	0.438	0.31	0.2895	4	4	0.168	0.303	0.235	0.2345
Magnesium (Mg)-Total	mg/L	4	4	0.27	0.39	0.34	0.35	4	4	0.266	1.63	1.1	1.1755	4	4	1.44	2.79	1.92	1.725
Manganese (Mn)-Total	mg/L	4	4	0.00989	0.0156	0.012	0.012	4	4	0.00679	0.074	0.037	0.03325	4	4	0.0175	0.182	0.074	0.04755
Mercury (Hg)-Total	mg/L	4	1	0.000005	0.000025	0.00001	0.0000051	4	0	0.000005	0.000005	0.000005	0.000005	4	1	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	4	4	0.00238	0.00447	0.0031	0.0028	4	4	0.00128	0.00355	0.0023	0.002165	4	4	0.000659	0.00194	0.00133	0.00136
Nickel (Ni)-Total	mg/L	4	1	0.0005	0.00226	0.00094	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	4	2	0.0005	0.00262	0.0014	0.001215
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	4	0	0.05	0.3	0.24	0.3	4	1	0.175	0.3	0.269	0.3
Potassium (K)-Total	mg/L	4	4	1.67	3.7	2.3	1.82	4	4	1.57	2.26	1.8	1.715	4	4	1.48	2.47	1.888	1.8
Selenium (Se)-Total	mg/L	4	4	0.000082	0.000154	0.00011	0.000092	4	3	0.00005	0.000197	0.00014	0.0001615	4	3	0.00005	0.000258	0.00016	0.0001655
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	4	4	3.02	3.57	3.3	3.28	4	4	2.76	6.99	3.88	2.875
Silver (Ag)-Total	mg/L	4	3	0.00001	0.00004	0.000019	0.000014	4	2	0.00001	0.000068	0.000025	0.00001	4	1	0.00001	0.00101	0.00026	0.00001
Sodium (Na)-Total	mg/L	4	4	183	195	190	184	4	4	83.6	183	120	111.55	4	4	72.8	131	100	99.1
Strontium (Sr)-Total	mg/L	4	4	0.378	0.435	0.4	0.40	4	4	0.382	1.19	0.89	1.002	4	4	0.869	1.66	1.24	1.21
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	4	4	0	85.7	21	0	4	4	0	77.6	19.4	0
Thallium (Tl)-Total	mg/L	4	0	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	4	1	0.00001	0.000054	0.000021	0.00001
Tin (Sn)-Total	mg/L	4	1	0.0001	0.00144	0.00044	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	1	0.0001	0.00044	0.00019	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	4	1	0.00122	0.01	0.0078	0.01	4	1	0.01	0.0479	0.0195	0.01
Uranium (U)-Total	mg/L	4	4	0.000167	0.00028	0.00022	0.00022	4	4	0.000153	0.000229	0.0002	0.0002135	4	4	0.00017	0.000235	0.0002025	0.0002025
Vanadium (V)-Total	mg/L	4	1	0.0005	0.00051	0.0005	0.0005	4	1	0.0005	0.00056	0.00052	0.0005	4	1	0.0005	0.00266	0.001	0.0005
Zinc (Zn)-Total	mg/L	4	2	0.003	0.0107	0.0057	0.0045	4	1	0.003	0.007	0.004	0.003	4	1	0.003	0.0303	0.00983	0.003
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	4	4	0	0.00068	0.00017	0	-	-	-	-	-	-
Dissolved Metals																			
Aluminum (Al)-Dissolved	mg/L	4	4	0.0376	0.0613	0.0502	0.051	4	4	0.0074	0.0475	0.034	0.03975	4	4	0.0092	0.021	0.016	0.0169
Antimony (Sb)-Dissolved	mg/L	4	4	0.00296	0.0448	0.014	0.0042	4	4	0.00498	0.0181	0.0087	0.005805	4	4	0.00125	0.00728	0.00399	0.00372
Arsenic (As)-Dissolved	mg/L	4	4	0.123	0.453	0.21	0.132	4	4	0.0372	0.167	0.1	0.10775	4	4	0.02	0.0704	0.04183	0.03845
Barium (Ba)-Dissolved	mg/L	4	4	0.0291	0.0372	0.031	0.030	4	4	0.024	0.0671	0.052	0.05805	4	4	0.0375	0.0845	0.055	0.0483
Beryllium (Be)-Dissolved	mg/L	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.00002	0.0001	0.00008	0.0001	4	1	0.00002	0.0001	0.00008	0.0001
Bismuth(Bi)- Dissolved	mg/L	4	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	4	1	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	4	4	0.05	0.071	0.06	0.0585	4	4	0.045	0.058	0.053	0.0545
Cadmium (Cd)-Dissolved	mg/L	4	1	0.000005	0.0000052	0.0000051	0.000005	4	1	0.000005	0.000006	0.0000053	0.000005	4	1	0.000005	0.000005	0.000005	0.000005
Calcium (Ca)-Dissolved	mg/L	4	4	4.73	5.82	5.23	5.18	4	4	4.33	55	32	34.55	4	4	21	59.8	45.33	50.25
Chromium (Cr)-Dissolved	mg/L	4	2	0.0001	0.00077	0.00029	0.00014	4	0	0.0001	0.0001	0.0001	0.0001	4	1	0.00027	0.0005	0.00044	0.0005
Cobalt (Co)-Dissolved	mg/L	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	1	0.0001	0.0001	0.0001	0.0001
Copper (Cu)-Dissolved	mg/L	4	1	0.0002	0.00139	0.0005	0.0002	4	2	0.0002	0.00038	0.00026	0.000235	4	3	0.0002	0.00042	0.0002675	0.000225
Iron (Fe)-Dissolved	mg/L	4	4	0.013	0.017	0.016	0.016	4	4	0.013	0.097	0.035	0.015	4	3	0.01	0.045	0.02	0.0125
Lead (Pb)-Dissolved	mg/L	4	4	0.000088	0.000228	0.00014	0.00013	4	2	0.00005	0.000138	0.000073	0.000051	4	1	0.00005	0.00005	0.00005	0.00005
Lithium (Li)-Dissolved	mg/L	4	4	0.396	0.509	0.45	0.44	4	4	0.2	0.458	0.31	0.2955	4	4	0.179	0.299	0.236	0.233
Magnesium (Mg)-Dissolved	mg/L	4	4	0.23	0.38	0.32	0.33	4	4	0.26	1.68	1.1	1.2055	4	4	0.936	1.78	1.5	1.56
Manganese (Mn)-Dissolved	mg/L	4	4	0.00581	0.0116	0.0087	0.0087	4	4	0.00595	0.053	0.03	0.02965	4	4	0.0102	0.0535	0.0302	0.02845
Mercury (Hg)-Dissolved	mg/L	4	1	0.000005	0.0000055	0.0000051	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	4	2	0	0.000005	0.00000375	0.000005
Molybdenum (Mo)-Dissolved	mg/L	4	4	0.00145	0.00414	0.0025	0.0022	4	4	0.00124	0.00278	0.0018	0.001615	4	4	0.000639	0.00165	0.0012	0.00134
Nickel (Ni)-Dissolved	mg/L	4	1	0.0005	0.0006	0.00053	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	4	1	0.0005	0.0005	0.0005	0.0005
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	4	0	0.05	0.3	0.24	0.3	4	1	0.05	0.3	0.2375	0.3
Phosphorus-Dissolved	mg/L	4	4	1.68	3.51	2.2	1.77	4	4	1.55	2.3	1.9	1.83	4	4	1.48	1.88	1.8	1.825
Selenium (Se)-Dissolved	mg/L	4	4	0.000082	0.000154	0.00011	0.0001	4	4	0.000511	0.00212	0.0011	0.0008885	4	4	0.000169	0.000788	0.000369	0.0002585
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	4	4	2.74	3.25	3	2.955	4	4	2.66	2.9	2.775	2.77
Silver (Ag)-Dissolved	mg/L	4	0	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	4	1	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	4	4	162	188	180	178.5	4	4	89.1	183	130	123.3	4	4	77.3	118	96.3	93.5
Strontium (Sr)-Dissolved	mg/L	4	4	0.335	0.398	0.37	0.37	4	4	0.345	1.31	0.92	1.0125	4	4	0.946	1.25	1.065	1
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	4	4	0	97.7	24	0	4	4	0	76.3	19	0
Thallium (Tl)-Dissolved	mg/L	4	0	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	4	1	0.00001	0.00001	0.00001	0.00001
Tin (Sn)-Dissolved	mg/L	4	1	0.0001	0.00091	0.0003	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	2	0.0001	0.00159	0.000473	0.0001
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	4	0	0.0003	0.01	0.0076	0.01	4	1	0.0003	0.01	0.007575	0.01
Uranium (U)-Dissolved	mg/L	4	4	0.000173	0.000271	0.00022	0.00022	4	4	0.000153	0.000224	0.00019	0.0001985	4	4	0.00017	0.000217	0.00019	0.000183
Vanadium (V)-Dissolved	mg/L	4	0	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	4	1	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	4	2	0.001	0.0052	0.0025	0.0019	4	4	0.0014	0.0051	0.0029	0.00255	4	2	0.001	0.0026	0.0014	0.001
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	4	3	0	0.0002	0.00005	0	4	4	0	0.0015	0.00038	0
Aggregate Organics																			
chemical oxygen demand [COD]	mg/L	-	-	-	-	-	-	4	0	20	20	20	20	4	1	20	20	20	20

BJ-GW18-17B		2018							2019							2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																										
Temperature	°C	3	3	1	4.5	3.1	3.1	3.8	4	4	2.4	4	3.025	3	2.85	4	4	0.9	4.5	2.3	1.95	4	4	1.5	6.4	3.3	2.635
pH	pH	3	3	8.64	8.84	8.72	8.7	8.68	4	4	8.25	9.88	8.8325	8.83	8.6	4	4	8.2	8.73	8.5	8.435	4	4	7.66	8.5	8.2	8.385
Specific Sonductance	µS/cm	3	3	740	1048	903.3333333	900	922	4	4	676	926	790.25	790.3	779.5	4	4	609	946	740	711.5	4	4	620	895	750	744
Dissolved Oxygen	mg/L	0	-	-	-	-	-	-	3	3	2	160.3	55.74333333	55.74	4.93	4	4	2.42	4.33	3.5	3.55	4	3	0.71	7.07	3.1	2.335
Oxidation Reduction Potential	mV	0	-	-	-	-	-	-	4	4	-150.4	27.1	-51.13	-51.13	-40.61	4	4	-165.7	21	-49	-26.05	4	4	-204.6	-9.8	-100	-94.2
Turbidity	NTU	3	3	973	1019	996	1000	996	4	4	27	94	65.25	65.25	70	4	4	59.89	1656	520	188.1	4	4	89.06	220	150	141.83
Physical Tests																											
Conductivity	uS/cm	3	3	757	869	804	800	786	4	4	657	912	771.75	771.8	759	4	4	643	961	760	718.5	4	4	590	964	750	715
Acidity (as CaCO3)	mg/L	2	1	1	1.6	1.3	1.3	1.3	4	0	1	2	1.5	1.5	1.5	4	1	2	7.3	3.3	2	4	1	2	2.7	2.2	2
Total Alkalinity (as CaCO3)	mg/L	3	2	1	119	71.8	72	95.4	4	4	112	137	124.5	124.5	124.5	4	4	122	327	180	140	4	4	112	121	120	118.5
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	113	324	200	184.5	4	4	161	374	250	242
Hardness (as CaCO3), from total Ca/Mg	mg/L	3	3	137	209	181.3333333	180	198	4	4	84.4	305	211.35	211.4	228	4	4	130	554	280	227.5	4	4	130	332	220	208
pH	pH	3	3	8.27	8.37	8.326666667	8.3	8.34	4	4	8.2	9.44	8.58	8.58	8.34	4	4	7.83	8.45	8.1	8.085	4	4	7.76	8.32	8.1	8.16
Total Dissolved Solids (TDS)	mg/L	3	3	459	545	509.3333333	510	524	4	4	429	675	539	539	526	4	4	384	691	550	562	4	4	397	652	540	554.5
Total Suspended Solids (TSS)	mg/L	3	3	256	2020	992.3333333	990	701	4	4	50.4	229	126.625	126.6	113.55	4	4	69.3	584	340	354	4	4	91.3	468	230	183.5
Turbidity	NTU	3	3	189	843	459.6666667	460	347	4	4	48	171	94.925	94.93	80.35	4	4	78.7	540	350	430	4	4	117	613	300	229.5
Anions and Nutrients																											
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.304	1.29	0.73	0.6685	4	4	0.155	0.662	0.37	0.33
Total Ammonia (as N)	mg/L	3	3	0.174	105	35.14966667	35	0.275	4	4	0.121	0.326	0.174	0.17	0.12	4	4	0.11	0.227	0.14	0.1185	4	4	0.0757	0.171	0.11	0.0984
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.05	0.25	0.15	0.15	4	0	0.05	0.25	0.1	0.05
Chloride (Cl)	mg/L	3	2	0.25	9.2	5.55	5.6	7.2	4	4	5.96	8.99	7.62	7.62	7.77	4	4	3.67	12.6	6.4	4.735	4	4	3.31	5.02	4.4	4.685
Fluoride (F)	mg/L	3	3	0.19	7.4	2.6	2.6	0.21	4	4	0.14	0.264	0.21525	0.22	0.23	4	4	0.18	0.283	0.23	0.221	4	4	0.138	0.344	0.25	0.25
Nitrate (as N)	mg/L	3	3	0.092	0.31	0.200333333	0.2	0.199	4	4	0.0568	0.858	0.282675	0.28	0.11	4	4	0.0257	0.121	0.071	0.06825	4	1	0.005	0.172	0.047	0.005
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	0.0905	0.023	0	4	1	0.0051	0.2	0.054	0.0051
Nitrite (as N)	mg/L	3	3	0.0268	0.147	0.072233333	0.072	0.0429	4	4	0.0041	0.177	0.0552	0.055	0.020	4	4	0.0054	0.0155	0.011	0.01085	4	2	0.001	0.0277	0.008	0.00155
Nitrogen, total	mg/L	3	2	0.001	0.89	0.297566667	0.3	0.0017	4	2	0.001	0.0049	0.00285	0.0029	0.0028	4	4	0.372	1.33	0.81	0.7765	4	4	0.155	0.662	0.42	0.43
Dissolved Orthophosphate (as P)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.0014	0.031	0.011	0.00515	4	2	0.001	0.0436	0.014	0.0062
Total Phosphorus (P)	mg/L	3	2	0.3	1.37	0.666666667	0.67	0.33	4	4	0.0388	0.112	0.080025	0.08	0.085	4	4	0.077	1.61	0.63	0.407	4	4	0.0976	0.293	0.2	0.1985
Sulphate (SO4)	mg/L	3	3	256	344	299	300	297	4	4	208	365	272.5	273	258.5	4	4	179	373	250	226.5	4	4	188	395	270	255.5
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	0.018	4.28	1.4	0.6625	4	4	0.145	0.554	0.32	0.297
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	0.018	4.02	1.3	0.6225	4	4	0.136	0.521	0.3	0.2795
Total Metals																											
Aluminum (Al)-Total	mg/L	3	3	3.5	36.6	16.18666667	16	8.46	4	4	0.326	1.66	0.79375	0.79	0.59	4	4	0.448	37.6	14	8.14	4	4	0.601	6.39	3	2.52
Antimony (Sb)-Total	mg/L	3	3	0.00535	0.00601	0.005716667	0.0057	0.00579	4	4	0.00282	0.00481	0.0037025	0.0037	0.0036	4	4	0.00162	0.00615	0.0044	0.00489	4	4	0.002	0.00395	0.003	0.003105
Arsenic (As)-Total	mg/L	3	3	0.037	0.172	0.089666667	0.09	0.06	4	4	0.0155	0.0459	0.03005	0.03	0.029	4	4	0.0432	0.194	0.095	0.07225	4	4	0.0243	0.0808	0.049	0.0456
Barium (Ba)-Total	mg/L	3	3	0.105	0.857	0.389	0.39	0.205	4	4	0.0414	0.0883	0.06055	0.061	0.056	4	4	0.0289	1.11	0.4	0.2385	4	4	0.0692	0.16	0.11	0.101
Beryllium (Be)-Total	mg/L	3	3	0.00028	0.00336	0.001433333	0.0014	0.00066	4	1	0.0001	0.00011	0.0001025	0.0001	0.0001	4	3	0.0001	0.000347	0.0013	0.0007275	4	4	0.00049	0.0057586	0.00026	0.0001935
Bismuth(Bi)- Total	mg/L	3	3	0.000081	0.00119	0.000505667	0.00051	0.000246	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	3	0.00005	0.00143	0.00049	0.000235	4	3	0.00005	0.000192	0.0001	0.000078
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.052	0.078	0.061	0.057	4	4	0.036	0.053	0.047	0.049
Cadmium (Cd)-Total	mg/L	3	3	0.0000435	0.000407	0.000173933	0.00017	0.0000713	4	4	0.0000229	0.0000557	0.000033775	0.000034	0.000028	4	4	0.000034	0.000913	0.00031	0.000155	4	4	0.0000233	0.000106	0.000057	0.0000402
Calcium (Ca)-Total	mg/L	3	3	51.2	107	77.8	78	75.2	4	4	34.1	116	80.575	80.6	86.1	4	4	49.1	182	98	79.85	4	4	55.5	113	78	66.1
Chromium (Cr)-Total	mg/L	3	3	0.0015	0.0217	0.008973333	0.009	0.00372	4	4	0.00049	0.0106	0.0046575	0.0047	0.0038	4	4	0.0005	0.188	0.074	0.05285	4	4	0.015	0.0501	0.028	0.0176
Cobalt (Co)-Total	mg/L	3	3	0.00134	0.0157	0.00678	0.0068	0.0033	4	4	0.00037	0.00142	0.0008025	0.0008	0.00071	4	4	0.0003	0.0313	0.011	0.00693	4	4	0.00074	0.0136	0.0053	0.00163
Copper (Cu)-Total	mg/L	3	3	0.0047	0.0639	0.027266667	0.027	0.0132	4	4	0.00138	0.00632	0.0033	0.0033	0.0028	4	4	0.00129	0.113	0.037	0.01605	4	4	0.00256	0.0148	0.0069	0.005025
Iron (Fe)-Total	mg/L	3	3	3.38	45.2	19.29	19	9.29	4	4	0.511	1.87	0.92825	0.93	0.67	4	4	0.377	53.6	18	9.235	4	4	0.83	7.96	4	3.555
Lead (Pb)-Total	mg/L	3	3	0.0033	0.0494	0.0209	0.021	0.01	4	4	0.000802	0.00215	0.0014745	0.0015	0.0015	4	4	0.000544	0.0652	0.022	0.01155	4	4	0.0012	0.00844	0.0042	0.0036
Lithium (Li)-Total	mg/L	3	3	0.16	0.24	0.203333333	0.2	0.21	4	4	0.103	0.207	0.1525	0.15	0.15	4	4	0.162	0.26	0.21	0.2065	4	4	0.109	0.189	0.14	0.139
Magnesium (Mg)-Total	mg/L	3	3	5.39	23.1	11.56666667	12	6.21	4	4	2.18	5.33	3.91	3.9	4.07	4	4	1.78	24.1	9.9	6.84	4	4	3.82	7.27	5.4	5.225
Manganese (Mn)-Total	mg/L	3	3	0.238	1.91	0.86	0.86	0.432	4	4	0.109	0.379	0.24875	0.25	0.25	4	4	0.0682	2.52	0.93	0.5655	4	4	0.146	0.732	0.44	0.4445
Mercury (Hg)-Total	mg/L	3	1	0.000069	0.0025	0.000889667	0.00089	0.0001	4	3	0.000005	0.0000242	0.00001265	0.000013	0.000011	4	3	0.000005	0.000265	0.0001	0.0000742	4	3	0.000005	0.000071	0.000032	0.0000259
Molybdenum (Mo)-Total	mg/L	3	3	0.00345	0.00548	0.004756667	0.0048	0.00534	4	4	0.00136	0.00475	0.0031675	0.0032	0.0033	4	4	0.00208	0.0196	0.0077	0.004555	4	4	0.00181	0.0108	0.0054	0.0045
Nickel (Ni)-Total	mg/L	3	3	0.00241	0.0214	0.009503333	0.0095	0.0047	4	4	0.0007	0.0072	0.0027025	0.0027	0.0015	4	4	0.0006	0.128	0.042	0.019425	4	4	0.00607	0.045	0.017	0.008215
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	0.3	1.96	0.77	0.407	4	1	0.138	0.3	0.26	0.3
Potassium (K)-Total	mg/L	3	3	6.9	11.8	9.01	9	8.33	4	4	2.75	11	5.22	5.2	3.565	4	4	1.76	10.1	5.2	4.45	4	4	2.14	3.95	3.1	3.065
Selenium (Se)-Total	mg/L	3	3	0.00164	0.00616	0.00337	0.0034	0.00231	4	4	0.000614	0.000881	0.0007422 5	0.00074	0.0007	4	4	0.00044	0.00644	0.0026	0.001695	4	4	0.000297	0.00112	0.00074	0.000779
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	3.72	50.1	20	14.08	4	4	3.79	10.6	6.8	6.4
Silver (Ag)-Total	mg/L	3	3	0.00035	0.0044	0.001879333	0.0019	0.000888	4	4	0.000037	0.000198	0.00011	0.00011	0.00010	4	4	0.000021	0.0078	0.0023	0.0007175	4	4	0.000097	0.00671	0.0018	0.0002885
Sodium (Na)-Total	mg/L	3	3	75.1	105	90.96666667	91	92.8	4	4	63.1	104	78.6	79	73.65	4	4	58.2	102	80	79.1	4	4	55.2	73	63	62.2
Strontium (Sr)-Total	mg/L	3	3	1.79	2.93	2.546666667	2.5	2.92	4	4	1.58	3.77	2.6925	2.7	2.71	4	4	1.8	4.87	2.9	2.445	4	4	1.78	4.44	2.9	2.725
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	115	29	0
Thallium (Tl)-Total	mg/L	3	3	0.000067	0.000826	0.000362667	0.00036	0.000195	4	3	0.00001	0.000045	0.00002075	0.000021	0.000014	4	3	0.00001	0.00136	0.00048	0.0002655	4	4	0.000017	0.000162	0.000082	0.000075
Tin (Sn)-Total	mg/L	3	3	0.0002	0.00261	0.00103	0.001	0.00028	4	4	0.00055	0.00088	0.0007475	0.00075	0.00078	4	3	0.0001	0.0025	0.001	0.000775	4	3	0.0001	0.00046	0.00027	0.000255
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	0.01	0.132	0.061	0.05175	4	4	0.00828	0.0428	0.027	0.02765
Uranium (U)-Total	mg/L	3	3	0.000872	0.0021	0.001684	0.0017	0.00208	4	4	0.000192	0.000679	0.00037475	0.00037	0.00031	4	4	0.000211	0.00929	0.0034	0.001986	4	4	0.000194	0.00229	0.00092	0.000607
Vanadium (V)-Total	mg/L	3	3	0.0057	0.0558	0.025033333	0.025	0.0136	4	4	0.00084	0.00269	0.0014875	0.0015	0.0012	4	4	0.00082	0.0623	0.023	0.013755	4	4	0.00158	0.0103	0.0051	0.004255
Zinc (Zn)-Total	mg/L	3	3	0.018	0.226	0.095933333	0.096	0.0438	4	4	0.0058	0.0166	0.01	0.01	0.0088	4	4	0.0043	0.311	0.1	0.0522	4	4	0.0079	0.0364	0.019	0.0161
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																											
Aluminum (Al)-Dissolved	mg/L	3	3	0.014	0.0398	0.025533333	0.026	0.0228	4	4	0.0078	0.0217	0.015475	0.016	0.016	4	4	0.01	0.205	0.063	0.0177	4	4	0.0034	1.03	0.26	0.0071
Antimony (Sb)-Dissolved	mg/L	3	3	0.00383	0.0055	0.004823333	0.0048	0.00514	4	4	0.00243	0.0039	0.0028925	0.0029	0.0026	4	4	0.00114	0.00717	0.0033	0.002425	4	4	0.00078	0.00357	0.0018	0.0014
Arsenic (As)-Dissolved	mg/L	3	3	0.0121	0.0263	0.020466667	0.02	0.023	4	4	0.0125	0.0402	0.024925	0.025	0.024	4	4	0.0109	0.0452	0.028	0.02885	4	4	0.0124	0.0472	0.03	0.02945
Barium (Ba)-Dissolved	mg/L	3	3	0.0258	0.0373	0.0333	0.033	0.0368	4	4	0.0256	0.0374	0.03205	0.032	0.0326	4	4	0.0173	0.0498	0.033	0.03285	4	4	0.0249	0.052	0.041	0.0431
Beryllium (Be)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.00002	0.0001	0.00008	0.0001
Bismuth(Bi)- Dissolved	mg/L	3	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.045	0.051	0.048	0.0485	4	4	0.036	0.044	0.042	0.0435
Cadmium (Cd)-Dissolved	mg/L	3	2	0.000005	0.0000197	1.12667E-05	0.000011	0.0000091	4	2	0.000005	0.0000086	0.00000645	0.0000065	0.0000061	4	1	0.000005	0.0000288	0.000011	0.000005	4	1	0.000005	0.0000055	0.0000051	0.000005
Calcium (Ca)-Dissolved	mg/L	3	3	50.1	76.9	66.6	67	72.8	4	4	30.7	113	78.55	78.6	85.25	4	4	42.7	120	75	68.5	4	4	48.3	124	82	77.4
Chromium (Cr)-Dissolved	mg/L	3	1	0.0001	0.00026	0.000153333	0.00015	0.0001	4	2	0.0001	0.00128	0.0004275	0.00043	0.00017	4	1	0.0001	0.00037	0.00017	0.0001	4	3	0.00032	0.00285	0.0011	0.000555
Cobalt (Co)-Dissolved	mg/L	3	3	0.00014	0.00018	0.00016	0.00016	0.00016	4	4	0.00016	0.00029	0.0002075	0.00021	0.00019	4	4	0.00011	0.0005	0.00022	0.000125	4	4	0.00019	0.00035	0.00024	0.000205
Copper (Cu)-Dissolved	mg/L	3	2	0.0002	0.00058	0.00035	0.00035	0.00027	4	1	0.0002	0.00023	0.0002075	0.00021	0.0002	4	1	0.0002	0.00117	0.00044	0.0002	4	1	0.0002	0.00057	0.00029	0.0002
Iron (Fe)-Dissolved	mg/L	3	0	0.01	0.01	0.01	0.01	0.01	4	3	0.01	0.115	0.03925	0.039	0.016	4	4	0.015	0.068	0.041	0.0395	4	3	0.01	0.415	0.17	0.1335
Lead (Pb)-Dissolved	mg/L	3	2	0.00005	0.000169	9.23333E-05	0.000092	0.000058	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	3	0.00005	0.000101	0.000068	0.000061	4	1	0.00005	0.000403	0.00014	0.00005
Lithium (Li)-Dissolved	mg/L	3	3	0.126	0.217	0.168	0.17	0.161	4	4	0.108	0.188	0.145	0.15	0.14	4	4	0.135	0.2	0.17	0.163	4	4	0.119	0.17	0.14	0.131
Magnesium (Mg)-Dissolved	mg/L	3	3	2.77	4.05	3.606666667	3.6	4	4	4	1.86	5.23	3.7525	3.8	3.96	4	4	1.64	5.85	3.5	3.235	4	4	2.22	5.41	3.7	3.675
Manganese (Mn)-Dissolved	mg/L	3	3	0.0909	0.128	0.106966667	0.11	0.102	4	4	0.0496	0.343	0.17865	0.18	0.161	4	4	0.0373	0.381	0.2	0.1953	4	4	0.084	0.603	0.27	0.199
Mercury (Hg)-Dissolved	mg/L	3	1	0.000005	0.0000056	0.0000052	0.0000052	0.000005	4	3	0.000005	0.0000092	0.00000655	0.0000066	0.000006	4	1	0.000005	0.000006	0.0000053	0.000005	4	1	0.000005	0.0000055	0.0000051	0.000005
Molybdenum (Mo)-Dissolved	mg/L	3	3	0.00328	0.00557	0.004683333	0.0047	0.0052	4	4	0.00128	0.00426	0.00293	0.0029	0.0031	4	4	0.00206	0.0126	0.0053	0.003295	4	4	0.00159	0.00539	0.0036	0.00374
Nickel (Ni)-Dissolved	mg/L	3	3	0.00075	0.00113	0.000883333	0.00088	0.00077	4	3	0.0005	0.00088	0.0006075	0.00061	0.00053	4	3	0.0005	0.00725	0.0023	0.000795	4	4	0.00074	0.00272	0.0018	0.00192
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.3	0.3	0.3	0.3	4	1	0.064	0.3	0.24	0.3
Phosphorus-Dissolved	mg/L	3	3	5.92	7.77	6.8	6.8	6.71	4	4	2.77	10.8	5.2025	5.2	3.62	4	4	1.72	3.95	2.8	2.84	4	4	1.88	3.46	2.5	2.37
Selenium (Se)-Dissolved	mg/L	3	3	0.00116	0.00152	0.00134	0.0013	0.00134	4	4	0.000548	0.000955	0.00073175	0.00073	0.00071	4	4	0.000535	0.00523	0.0018	0.000751	4	4	0.000221	0.000538	0.00037	0.0003675
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	2.62	3.47	3	2.95	4	4	2.66	4.6	3.4	3.215
Silver (Ag)-Dissolved	mg/L	3	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	3	3	83.1	111	100.3666667	100	107	4	4	67.6	103	81.225	81	77.15	4	4	65.1	88.1	80	82.7	4	4	54	67.3	62	65.8
Strontium (Sr)-Dissolved	mg/L	3	3	1.7	2.8	2.423333333	2.4	2.77	4	4	1.55	3.65	2.7175	2.7	2.835	4	4	1.48	4.22	2.7	2.46	4	4	1.66	3.24	2.2	1.82
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	102	26	0
Thallium (Tl)-Dissolved	mg/L	3	2	0.00001	0.000026	0.000017	0.000017	0.000015	4	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	4	1	0.00001	0.000017	0.000012	0.00001
Tin (Sn)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	4	0.0001	0.00035	0.000205	0.00021	0.00019	4	3	0.0001	0.0004	0.00023	0.0002	4	2	0.0001	0.00019	0.00013	0.000115
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.01	0.01	0.01	0.01	4	1	0.0003	0.0129	0.0083	0.01
Uranium (U)-Dissolved	mg/L	3	3	0.000742	0.002	0.001357333	0.0014	0.00133	4	4	0.00016	0.000551	0.00031975	0.00032	0.00028	4	4	0.000161	0.00783	0.0028	0.001678	4	4	0.000161	0.0021	0.000085	0.000576
Vanadium (V)-Dissolved	mg/L	3	1	0.0005	0.00053	0.00051	0.00051	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	1	0.0005	0.00074	0.00056	0.0005	4	1	0.0005	0.00159	0.00077	0.0005
Zinc (Zn)-Dissolved	mg/L	3	1	0.001	0.0015	0.001166667	0.0012	0.001	4	3	0.001	0.0017	0.001425	0.0014	0.0015	4	2	0.001	0.0046	0.002	0.0011	4	4	0.0012	0.0036	0.0024	0.0024
Zirconium (Zr)-Dissolved		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																											
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	61	34	36.5	4	4	37	51	43	41.5

BJ-GW18-18B		2018							2019							2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																										
Temperature	°C	3	3	2	3.3	2.7	2.7	2.8	4	4	2.6	4	3.325	3.3	3.35	3	3	4.2	5.1	4.5	4.3	3	3	4.5	7.2	5.5	4.8
pH	pH	3	3	8.12	8.3	8.216666667	8.2	8.23	4	4	7.76	8.56	8.02	8.02	7.88	3	3	7.89	8.13	8	7.97	3	3	7.75	8	7.91	7.99
Specific Sonductance	µS/cm	3	3	498	514	504.3333333	500	501	4	4	573	797	642.75	642.8	600.5	3	3	562	600	580	577	3	3	506	672	579.7	561
Dissolved Oxygen	mg/L	0	-	-	-	-	-	-	3	3	0.01	0.25	0.12	0.12	0.1	3	3	0.2	0.45	0.28	0.2	3	3	0.29	0.47	0.35	0.3
Oxidation Reduction Potential	mV	0	-	-	-	-	-	-	3	3	-44.9	22.8	-3.366666667	-3.367	12	3	3	-70.9	-12.8	-34	-18.7	3	3	-151.3	-47.1	-97.5	-94.2
Turbidity	NTU	3	3	145	635	326.6666667	330	200	4	4	4.17	118.2	39.8925	39.89	18.6	3	3	2.85	15.63	9.5	9.92	3	3	23.31	66	40.82	33.16
Physical Tests																											
Conductivity	uS/cm	3	3	462	536	499.3333333	500	500	4	4	549	766	630.75	630.8	604	3	3	570	602	580	575	3	3	532	688	599	577
Acidity (as CaCO3)	mg/L	3	0	1	1	1	1	1	4	2	1	2.7	1.85	1.85	1.85	3	0	2	2	2	2	3	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	3	3	107	114	109.6666667	110	108	4	4	97.5	117	105.35	105.4	103.45	3	3	90.3	111	100	99.9	3	3	96.6	118	110	107
hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	174	216	200	204	3	3	165	213	183	170
hardness (as CaCO3), from total Ca/Mg	mg/L	3	3	148	187	166.6666667	170	165	4	4	189	273	217.5	217.5	204	3	3	181	224	200	195	3	3	167	210	181.7	168
pH	pH	3	3	8.11	8.21	8.173333333	8.2	8.2	4	4	8.14	8.31	8.2125	8.21	8.2	3	3	8.08	8.13	8.1	8.11	3	3	8.08	8.15	8.1	8.11
Total Dissolved Solids (TDS)	mg/L	3	3	381	402	393.6666667	390	398	4	4	375	539	438.75	438.8	420.5	3	3	356	409	380	373	3	3	300	438	375	387
Total Suspended Solids (TSS)	mg/L	3	3	113	553	350	350	384	4	4	5.5	207	56.3	56.3	6.35	3	3	5.3	6.1	5.6	5.5	3	3	13.8	43.1	27.97	27
Turbidity	NTU	3	3	138	472	314.6666667	310	334	4	4	1.14	155	39.785	39.79	1.5	3	3	3.51	4.49	4	4	3	3	0.3	54.4	27	26.2
Anions and Nutrients																											
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.076	0.134	0.097	0.082	3	3	0.13	0.162	0.143	0.137
Total Ammonia (as N)	mg/L	3	3	0.0907	0.0983	0.0957	0.096	0.0981	4	4	0.0243	0.0764	0.050225	0.05	0.05	3	3	0.06	0.117	0.083	0.0726	3	3	0.106	0.151	0.13	0.126
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.05	0.05	0.05	3	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	3	3	2.34	3.17	2.893333333	2.9	3.17	4	4	2.85	19.7	8.7325	8.73	6.19	3	3	3.75	4.36	4.1	4.23	3	3	4.66	17.3	10.25	8.8
Fluoride (F)	mg/L	2	2	0.093	0.114	0.1035	0.1	0.1035	4	3	0.1	0.107	0.1025	0.1	0.10	3	3	0.094	0.126	0.11	0.103	3	3	0.084	0.133	0.11	0.107
Nitrate (as N)	mg/L	3	3	0.0264	0.152	0.095466667	0.095	0.108	4	4	0.028	0.066	0.0453	0.045	0.04	3	2	0.005	0.0201	0.013	0.0131	3	1	0.005	0.0073	0.00577	0.005
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0	0.0051	0.0017	0	3	1	0.0051	0.0086	0.006267	0.0051
Nitrite (as N)	mg/L	3	3	0.0012	0.141	0.0513	0.051	0.0117	4	4	0.0015	0.0073	0.003025	0.0030	0.0017	3	0	0.001	0.001	0.001	0.001	3	1	0.001	0.0013	0.0011	0.001
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.082	0.147	0.11	0.097	3	3	0.13	0.162	0.146	0.146
Dissolved Orthophosphate (as P)	mg/L	3	2	0.001	0.34	0.114066667	0.11	0.0012	4	0	0.001	0.001	0.001	0.001	0.001	3	3	0.0011	0.0038	0.0028	0.0034	3	2	0.001	0.0023	0.001733	0.0019
Total Phosphorus (P)	mg/L	3	0	0.3	0.3	0.3	0.3	0.3	4	4	0.0028	0.0496	0.01605	0.016	0.0059	3	3	0.0052	0.0069	0.006	0.0059	3	3	0.0107	0.0276	0.018	0.0161
Sulphate (SO4)	mg/L	3	3	144	180	158.3333333	160	151	4	4	187	278	216.25	216	200	3	3	181	197	190	186	3	3	152	206	175	168
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.019	0.019	0.019	0.019	3	0	0.0016	0.011	0.004733	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	3	1	0.0015	0.01	0.0043	0.0015
Total Metals																											
Aluminum (Al)-Total	mg/L	3	3	3.67	6.88	5.45	5.5	5.8	4	4	0.0135	1.63	0.43715	0.44	0.053	3	3	0.0679	0.146	0.094	0.0694	3	3	0.123	2.28	0.944	0.429
Antimony (Sb)-Total	mg/L	3	3	0.00045	0.00141	0.00107	0.0011	0.00135	4	4	0.00012	0.00104	0.00036	0.00036	0.00014	3	2	0.0001	0.00012	0.00011	0.00011	3	3	0.00022	0.00076	0.00041	0.00024
Arsenic (As)-Total	mg/L	3	3	0.0142	0.0271	0.020433333	0.02	0.02	4	4	0.00045	0.0055	0.00191	0.0019	0.00085	3	3	0.00072	0.00096	0.00086	0.0009	3	3	0.00181	0.00333	0.0024	0.00205
Barium (Ba)-Total	mg/L	3	3	0.127	0.2	0.158333333	0.16	0.148	4	4	0.0191	0.116	0.0464	0.046	0.025	3	3	0.0238	0.0282	0.026	0.0254	3	3	0.0264	0.0873	0.04823	0.031
Beryllium (Be)-Total	mg/L	3	3	0.00021	0.00074	0.000546667	0.00055	0.00069	4	1	0.0001	0.00023	0.0001325	0.00013	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	3	2	0.00005	0.000085	0.000072	0.000072	0.000081	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.035	0.036	0.036	0.036	3	3	0.029	0.041	0.03367	0.031
Cadmium (Cd)-Total	mg/L	3	3	0.0000136	0.0000368	2.59667E-05	0.000026	0.0000275	4	1	0.000005	0.0000144	0.00000735	0.0000074	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	3	2	0.000005	0.0000122	0.0000079	0.0000065
Calcium (Ca)-Total	mg/L	3	3	60	65	62.43333333	62	62.3	4	4	64.8	97.6	74.55	74.6	67.9	3	3	57.2	72.2	64	62.2	3	3	51.3	66.4	56.9	52.9
Chromium (Cr)-Total	mg/L	3	2	0.0004	0.00138	0.001	0.001	0.00122	4	4	0.0009	0.00224	0.0012925	0.0013	0.0010	3	3	0.00058	0.00303	0.0022	0.00296	3	3	0.00354	0.018	0.009217	0.00611
Cobalt (Co)-Total	mg/L	3	3	0.00088	0.00436	0.002843333	0.0028	0.00329	4	2	0.0001	0.0009	0.00031	0.00031	0.00012	3	3	0.00012	0.00022	0.00018	0.00019	3	3	0.00032	0.00356	0.0023	0.00301
Copper (Cu)-Total	mg/L	3	3	0.00253	0.00989	0.006686667	0.0067	0.00764	4	3	0.0005	0.00314	0.0012925	0.0013	0.00077	3	2	0.0005	0.00116	0.00084	0.00086	3	3	0.00069	0.00229	0.00134	0.00104
Iron (Fe)-Total	mg/L	3	3	5.92	13.1	9.65	9.7	9.93	4	4	0.015	2.25	0.587	0.59	0.042	3	3	0.032	0.149	0.099	0.116	3	3	0.164	1.26	0.626	0.454
Lead (Pb)-Total	mg/L	3	3	0.00149	0.00487	0.003606667	0.0036	0.00446	4	3	0.00005	0.00149	0.0004225	0.00042	0.000075	3	3	0.000055	0.000488	0.00021	0.000101	3	3	0.000186	0.000574	0.00034	0.000271
Lithium (Li)-Total	mg/L	3	3	0.0689	0.0769	0.0725	0.073	0.0717	4	4	0.0653	0.0789	0.073	0.073	0.074	3	3	0.066	0.0921	0.079	0.0793	3	3	0.0825	0.111	0.095	0.0916
Magnesium (Mg)-Total	mg/L	3	3	9.38	9.74	9.606666667	9.6	9.7	4	4	9.4	16	11.325	11	9.95	3	3	9.3	10.5	9.8	9.71	3	3	8.94	11.4	9.893	9.34
Manganese (Mn)-Total	mg/L	3	3	0.177	0.37	0.272666667	0.27	0.271	4	4	0.0223	0.0834	0.0387	0.039	0.025	3	3	0.0243	0.0265	0.026	0.0262	3	3	0.0476	0.0559	0.051	0.05
Mercury (Hg)-Total	mg/L	3	0	0.000025	0.0001	5.83333E-05	0.000058	0.00005	4	0	0.000005	0.000025	0.00001	0.00001	0.0000050	3	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	3	3	0.000596	0.0011	0.000887333	0.00089	0.000966	4	4	0.000417	0.000755	0.00060075	0.0006	0.00062	3	3	0.000591	0.000902	0.00074	0.00073	3	3	0.00121	0.00271	0.00182	0.00154
Nickel (Ni)-Total	mg/L	3	3	0.00056	0.0014	0.001076667	0.0011	0.00127	4	4	0.00059	0.00166	0.00099	0.00099	0.00086	3	3	0.0005	0.0024	0.0016	0.00177	3	3	0.00389	0.01	0.006	0.00415
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	3	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	3	3	4.13	5.97	5.2	5.2	5.5	4	4	2.82	4.57	3.7025	3.7	3.71	3	3	2.73	3.24	3.1	3.23	3	3	3.31	4.7	3.83	3.48
Selenium (Se)-Total	mg/L	3	2	0.00005	0.00014	9.63333E-05	0.000096	0.000099	4	1	0.00005	0.000051	0.00005025	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	1	0.00005	0.000074	0.000058	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3.41	3.55	3.5	3.53	3	3	3.62	7.56	5.06	3.99
Silver (Ag)-Total	mg/L	3	3	0.000315	0.00158	0.000951333	0.00095	0.000959	4	1	0.00001	0.000214	0.000061	0.000061	0.00001	3	1	0.00001	0.000023	0.000014	0.00001	3	3	0.000036	0.000469	0.0002143	0.000138
Sodium (Na)-Total	mg/L	3	3	36.3	39.9	38.26666667	38	38.6	4	4	36.2	47.9	43.775	44	45.5	3	3	38.5	47	44	46.8	3	3	42.5	57.2	49	46
Strontium (Sr)-Total	mg/L	3	3	1.24	1.37	1.303333333	1.3	1.3	4	4	1.41	2.13	1.6425	1.6	1.52	3	3	1.42	1.6	1.5	1.57	3	3	1.44	1.67	1.55	1.54
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	3	3	0.000054	0.000165	0.000117333	0.00012	0.000133	4	4	0.00001	0.000041	0.0000195	0.00002	0.000014	3	3	0.000012	0.000015	0.000014	0.000014	3	3	0.000022	0.000087	0.00004667	0.000031
Tin (Sn)-Total	mg/L	3	2	0.0001	0.0003	0.000196667	0.0002	0.00019	4	1	0.0001	0.00121	0.0003775	0.00038	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	1	0.0001	0.00016	0.00012	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.01	0.01	0.01	0.01	3	1	0.01	0.0161	0.012	0.01
Uranium (U)-Total	mg/L	3	3	0.000647	0.00135	0.001049	0.001	0.00115	4	4	0.000383	0.00105	0.00055525	0.00056	0.00039	3	3	0.00037	0.000401	0.00039	0.0004	3	3	0.000974	0.00138	0.001198	0.00124
Vanadium (V)-Total	mg/L	3	3	0.00197	0.009	0.00606	0.0061	0.00721	4	1	0.0005	0.00179	0.0008225	0.00082	0.0005	3	0	0.0005	0.0005	0.0005	0.0005	3	2	0.0005	0.004	0.0018	0.00096
Zinc (Zn)-Total	mg/L	3	3	0.0071	0.0282	0.018966667	0.019	0.0216	4	1	0.003	0.0079	0.004225	0.0042	0.003	3	1	0.003	0.0033	0.0031	0.003	3	2	0.003	0.0064	0.00437	0.0037
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																											
Aluminum (Al)-Dissolved	mg/L	3	3	0.0077	0.0153	0.010533333	0.011	0.0086	4	4	0.0022	0.0042	0.0032	0.0032	0.0032	3	3	0.0036	0.0045	0.0039	0.0037	3	3	0.0018	0.0029	0.0022	0.002
Antimony (Sb)-Dissolved	mg/L	3	3	0.00022	0.00051	0.000403333	0.0004	0.00048	4	4	0.00012	0.00039	0.0001975	0.0002	0.00014	3	1	0.0001	0.00011	0.0001	0.0001	3	3	0.00018	0.00056	0.00031	0.00019
Arsenic (As)-Dissolved	mg/L	3	3	0.00114	0.00134	0.001223333	0.0012	0.00119	4	4	0.00043	0.00086	0.0006225	0.00062	0.0006	3	3	0.00049	0.00085	0.00067	0.00068	3	3	0.0007	0.00158	0.00106	0.0009
Barium (Ba)-Dissolved	mg/L	3	3	0.0228	0.0261	0.024433333	0.024	0.0244	4	4	0.0162	0.0294	0.02265	0.023	0.023	3	3	0.0194	0.0239	0.022	0.0214	3	3	0.0178	0.0222	0.02	0.0194
Beryllium (Be)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	3	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.03	0.038	0.033	0.032	3	3	0.028	0.04	0.033	0.032
Cadmium (Cd)-Dissolved	mg/L	3	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.00001	0.00000625	0.0000063	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	0.000005
Calcium (Ca)-Dissolved	mg/L	3	3	47.3	59.7	53.26666667	53	52.8	4	4	60.4	81.9	67.75	67.8	64.35	3	3	54.7	68.8	63	65.3	3	3	51.6	65.8	56.6	52.4
Chromium (Cr)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	4	0.00014	0.00042	0.0003	0.0003	0.00032	3	3	0.00012	0.00108	0.0006	0.00061	3	1	0.0005	0.00056	0.00052	0.0005
Cobalt (Co)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	3	1	0.0001	0.00011	0.0001	0.0001	3	3	0.00014	0.002	0.00084	0.00038
Copper (Cu)-Dissolved	mg/L	3	0	0.0002	0.0002	0.0002	0.0002	0.0002	4	2	0.0002	0.00109	0.00054	0.00054	0.00044	3	2	0.0002	0.00072	0.0005	0.00058	3	1	0.0002	0.00035	0.00025	0.0002
Iron (Fe)-Dissolved	mg/L	3	0	0.01	0.01	0.01	0.01	0.01	4	0	0.01	0.01	0.01	0.01	0.01	3	2	0.01	0.017	0.012	0.01	3	3	0.014	0.019	0.016	0.016
Lead (Pb)-Dissolved	mg/L	3	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	1	0.00005	0.000065	0.00005375	0.000054	0.00005	3	1	0.00005	0.000103	0.000068	0.00005	3	0	0.00005	0.00005	0.00005	0.00005
Lithium (Li)-Dissolved	mg/L	3	3	0.0618	0.0694	0.0662	0.066	0.0674	4	4	0.0696	0.0782	0.07435	0.074	0.075	3	3	0.0701	0.0997	0.087	0.0904	3	3	0.0807	0.114	0.09597	0.0932
Magnesium (Mg)-Dissolved	mg/L	3	3	7.17	9.17	8.143333333	8.1	8.09	4	4	9.08	16.7	11.465	11	10.04	3	3	9.15	10.7	9.9	9.88	3	3	9.12	11.1	9.9	9.35
Manganese (Mn)-Dissolved	mg/L	3	3	0.0275	0.0323	0.029233333	0.029	0.0279	4	4	0.0195	0.0248	0.0218	0.022	0.021	3	3	0.0221	0.0236	0.023	0.0225	3	3	0.0245	0.0471	0.0365	0.0378
Mercury (Hg)-Dissolved	mg/L	3	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	3	3	0.000581	0.000726	0.000663333	0.000666	0.000683	4	4	0.00045	0.000685	0.00056025	0.00056	0.00055	3	3	0.000617	0.000728	0.00066	0.000648	3	3	0.000776	0.00156	0.0012	0.00125
Nickel (Ni)-Dissolved	mg/L	3	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	1	0.0005	0.00085	0.0005875	0.00059	0.0005	3	2	0.0005	0.00118	0.00095	0.00117	3	3	0.00145	0.0042	0.00248	0.00179
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.3	0.3	0.3	0.3	3	0	0.3	0.3	0.3	0.3
Phosphorus-Dissolved	mg/L	3	3	3.69	4.85	4.35	4.4	4.51	4	4	2.79	4.65	3.6525	3.7	3.59	3	3	3.17	3.5	3.3	3.21	3	3	3.14	3.82	3.5	3.39
Selenium (Se)-Dissolved	mg/L	3	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	3	1	0.00005	0.000059	0.000053	0.00005
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	3.02	3.34	3.2	3.2	3	3	3.13	3.45	3.283	3.27
Silver (Ag)-Dissolved	mg/L	3	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	0.00001	3	0	0.00001	0.00001	0.00001	0.00001	3	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	3	3	37.1	41	39.46666667	39	40.3	4	4	34.9	48.5	42.25	42	42.8	3	3	40.9	48.7	45	46.1	3	3	44.6	57	49.4	46.5
Strontium (Sr)-Dissolved	mg/L	3	3	1.09	1.36	1.216666667	1.2	1.2	4	4	1.43	2.07	1.6525	1.7	1.56	3	3	1.41	1.63	1.5	1.48	3	3	1.48	1.66	1.553	1.52
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	3	3	0.000017	0.000019	0.000018	0.000018	0.000018	4	3	0.00001	0.000012	0.00001075	0.000011	0.000011	3	3	0.00001	0.000011	0.000011	0.000011	3	3	0.000015	0.000027	0.000021	0.000021
Tin (Sn)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001	3	0	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.01	0.01	0.01	0.01	3	0	0.01	0.01	0.01	0.01
Uranium (U)-Dissolved	mg/L	3	3	0.000491	0.000505	0.000496333	0.0005	0.000493	4	4	0.000356	0.000675	0.000451	0.00045	0.00039	3	3	0.00035	0.000377	0.00036	0.000355	3	3	0.000877	0.00126	0.0011	0.00011
Vanadium (V)-Dissolved	mg/L	3	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	3	0	0.0005	0.0005	0.0005	0.0005	3	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	3	1	0.001	0.0017	0.001233333	0.0012	0.001	4	3	0.001	0.0038	0.001925	0.0019	0.0015	3	3	0.0015	0.0039	0.0027	0.0028	3	2	0.001	0.0024	0.001833	0.0021
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																											
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	20	20	20	20	3	0	20	20	20

BJ-GW18-19B		2018						2019						2020						2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																								
Temperature	°C	1	1	3.1	3.1	3.1	3.1	3	3	2.2	3.2	2.8	3.1	2	2	5.4	5.7	5.6	5.55	2	2	5	6.1	5.6	5.55
pH	pH	1	1	8.42	8.42	8.42	8.42	3	3	7.97	8.08	8.04	8.07	2	2	8.47	8.9	8.7	8.685	2	2	8.27	8.36	8.3	8.315
Specific Sonductance	µS/cm	1	1	328	328	328	328	3	3	400	576	483.9	475.6	2	2	401.4	438.9	420	420.15	2	2	417.3	461.9	440	439.6
Dissolved Oxygen	mg/L	0	0	-	-	-	-	2	2	0.16	1.11	0.635	0.635	2	2	0.47	2.36	1.7	1.715	2	2	1.2	1.96	1.6	1.58
Oxidation Reduction Potential	mV	0	0	-	-	-	-	3	3	-8.7	182.8	87.13	87.3	2	2	66.1	197.8	130	131.95	2	2	120	149	130	134.5
Turbidity	NTU	1	1	109.7	109.7	109.7	109.7	3	3	23	74.31	43.77	34	2	2	25	38.2	32	31.6	2	2	19.18	48.62	34	33.9
Physical Tests																									
Conductivity	uS/cm	1	1	409	409	409	409	3	3	412	589	494	481	2	2	411	454	430	432.5	2	2	438	467	450	452.5
Acidity (as CaCO3)	mg/L	1	0	1	1	1	1	3	0	1	2	1.33	1	2	0	2	2	2	2	2	0	2	2	2	2
Total Alkalinity (as CaCO3)	mg/L	1	1	86.9	86.9	86.9	86.9	3	3	77.9	106	87.77	79.4	2	2	74	78.8	76	76.4	2	2	84.4	87.1	86	85.75
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	126	139	130	132.5	2	2	121	143	130	132
Hardness (as CaCO3), from total Ca/Mg	mg/L	1	1	107	107	107	107	3	3	119	204	162.3	164	2	2	129	150	140	139.5	2	2	111	125	120	118
pH	pH	1	1	8.44	8.44	8.44	8.44	3	3	7.79	8.17	8.04	8.16	2	2	8.26	8.4	8.3	8.33	2	2	8.15	8.21	8.2	8.18
Total Dissolved Solids (TDS)	mg/L	1	1	315	315	315	315	3	3	280	443	372.7	395	2	2	284	311	300	297.5	2	2	254	274	260	264
Total Suspended Solids (TSS)	mg/L	1	1	91.1	91.1	91.1	91.1	3	3	6.6	258	113.3	75.3	2	2	17.8	32.1	25	24.95	2	2	17.6	38.5	28	28.05
Turbidity	NTU	1	1	108	108	108	108	3	3	24	418	174.2	80.7	2	2	26.3	40.5	33	33.4	2	2	23.8	44.8	34	34.3
Anions and Nutrients																									
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.063	0.097	0.08	0.08	2	1	0.05	0.075	0.063	0.0625
Total Ammonia (as N)	mg/L	1	1	0.045	0.045	0.045	0.045	3	3	0.0378	0.043	0.04	0.039	2	2	0.0484	0.0579	0.053	0.05315	2	2	0.0323	0.0369	0.035	0.0346
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.05	0.05	0.05	0.05	2	0	0.05	0.05	0.05	0.05
Chloride (Cl)	mg/L	1	0	0.5	0.5	0.5	0.5	3	1	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5	2	0	0.5	0.5	0.5	0.5
Fluoride (F)	mg/L	1	1	0.156	0.156	0.16	0.156	3	3	0.132	0.141	0.14	0.13	2	2	0.125	0.14	0.13	0.1325	2	2	0.129	0.138	0.13	0.1335
Nitrate (as N)	mg/L	1	1	0.0084	0.0084	0.0084	0.0084	3	1	0.005	0.0221	0.0107	0.005	2	0	0.005	0.005	0.005	0.005	2	1	0.005	0.0082	0.0066	0.0066
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	0.0051	0.0122	0.0087	0.00865
Nitrite (as N)	mg/L	1	1	0.0011	0.0011	0.0011	0.0011	3	2	0.001	0.0081	0.0036	0.0017	2	2	0.0011	0.0014	0.0013	0.00125	2	2	0.0036	0.004	0.0038	0.0038
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.066	0.099	0.083	0.0825	2	2	0.039	0.087	0.063	0.063
Dissolved Orthophosphate (as P)	mg/L	1	1	0.0038	0.0038	0.0038	0.0038	3	2	0.001	0.0043	0.0025	0.0023	2	1	0.001	0.0016	0.0013	0.0013	2	2	0.0017	0.0027	0.0022	0.0022
Total Phosphorus (P)	mg/L	1	0	0.3	0.3	0.3	0.3	3	3	0.0109	0.155	0.076	0.061	2	2	0.0152	0.0247	0.02	0.01995	2	2	0.0079	0.032	0.02	0.01995
Sulphate (SO4)	mg/L	1	1	115	115	115	115	3	3	128	189	156	152	2	2	122	144	130	133	2	2	120	141	130	130.5
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.019	0.019	0.019	0.019	2	0	0.0016	0.0016	0.0016	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.018	0.018	0.018	0.018	2	0	0.0015	0.0015	0.0015	0.0015
Total Metals																									
Aluminum (Al)-Total	mg/L	1	1	1.85	1.85	1.85	1.85	3	3	1.06	12.4	5.75	3.8	2	2	0.0118	1.27	0.64	0.6409	2	2	0.394	0.712	0.55	0.553
Antimony (Sb)-Total	mg/L	1	1	0.00169	0.00169	0.0017	0.00169	3	3	0.00689	0.0102	0.0084	0.008	2	2	0.00349	0.00428	0.0039	0.003885	2	2	0.0042	0.00504	0.0046	0.00462
Arsenic (As)-Total	mg/L	1	1	0.0309	0.0309	0.031	0.0309	3	3	0.0203	0.0551	0.034	0.027	2	2	0.0335	0.0398	0.037	0.03665	2	2	0.0184	0.0192	0.019	0.0188
Barium (Ba)-Total	mg/L	1	1	0.107	0.107	0.11	0.107	3	3	0.0478	0.318	0.19	0.21	2	2	0.0256	0.0815	0.054	0.05355	2	2	0.036	0.0591	0.048	0.04755
Beryllium (Be)-Total	mg/L	1	1	0.00011	0.00011	0.00011	0.00011	3	1	0.0001	0.000231	0.00014	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	1	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.035	0.038	0.037	0.0365	2	2	0.043	0.046	0.045	0.0445
Cadmium (Cd)-Total	mg/L	1	1	0.0000896	0.0000896	0.00009	0.000090	3	3	0.0000179	0.000139	0.000073	0.000063	2	1	0.000005	0.0000246	0.000015	0.0000148	2	2	0.0000157	0.00003	0.000023	0.00002285
Calcium (Ca)-Total	mg/L	1	1	40.7	40.7	40.7	40.7	3	3	37.2	61.4	52.5	58.9	2	2	40	46	43	43	2	2	38.7	45.8	42	42.25
Chromium (Cr)-Total	mg/L	1	1	0.00376	0.00376	0.0038	0.0038	3	3	0.00053	0.0101	0.005	0.0044	2	1	0.0001	0.00099	0.00055	0.000545	2	1	0.0005	0.00085	0.00068	0.000675
Cobalt (Co)-Total	mg/L	1	1	0.0009	0.0009	0.0009	0.0009	3	3	0.00073	0.00416	0.0022	0.0018	2	2	0.00037	0.00102	0.0007	0.000695	2	2	0.00103	0.00175	0.0014	0.00139
Copper (Cu)-Total	mg/L	1	1	0.00564	0.00564	0.0056	0.0056	3	3	0.00062	0.0117	0.0076	0.010	2	1	0.0005	0.0026	0.0016	0.00155	2	2	0.00292	0.00834	0.0056	0.00563
Iron (Fe)-Total	mg/L	1	1	2.67	2.67	2.7	2.67	3	3	0.658	7.37	3.4	2.26	2	1	0.01	1.16	0.59	0.585	2	2	0.398	1.21	0.8	0.804
Lead (Pb)-Total	mg/L	1	1	0.0295	0.0295	0.03	0.030	3	3	0.000528	0.00593	0.0031	0.0027	2	1	0.00005	0.00124	0.00065	0.000645	2	2	0.00105	0.00209	0.0016	0.00157
Lithium (Li)-Total	mg/L	1	1	0.0682	0.0682	0.068	0.068	3	3	0.0613	0.0853	0.071	0.067	2	2	0.056	0.0614	0.059	0.0587	2	2	0.0779	0.0807	0.079	0.0793
Magnesium (Mg)-Total	mg/L	1	1	7.36	7.36	7.4	7.36	3	3	6.43	12.2	9.9	11.2	2	2	7.13	8.6	7.9	7.865	2	2	5.95	6.89	6.4	6.42
Manganese (Mn)-Total	mg/L	1	1	0.202	0.202	0.2	0.202	3	3	0.134	0.42	0.28	0.28	2	2	0.117	0.177	0.15	0.147	2	2	0.118	0.151	0.13	0.1345
Mercury (Hg)-Total	mg/L	1	0	0.00005	0.00005	0.00005	0.00005	3	2	0.000005	0.0000156	0.0000094	0.0000075	2	0	0.000005	0.000005	0.000005	0.000005	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	1	1	0.00268	0.00268	0.0027	0.0027	3	3	0.00191	0.00581	0.0032	0.0020	2	2	0.0019	0.00198	0.0019	0.00194	2	2	0.00344	0.00393	0.0037	0.003685
Nickel (Ni)-Total	mg/L	1	1	0.00176	0.00176	0.0018	0.0018	3	3	0.00054	0.00284	0.0017	0.0018	2	1	0.0005	0.00127	0.00089	0.000885	2	1	0.0005	0.00075	0.00063	0.000625
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.3	0.3	0.3	0.3	2	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	1	1	4.89	4.89	4.9	4.89	3	3	3.33	8.04	6.2	7.13	2	2	2.84	3.96	3.4	3.4	2	2	3.25	3.52	3.4	3.385
Selenium (Se)-Total	mg/L	1	0	0.00005	0.00005	0.00005	0.00005	3	2	0.00005	0.000137	0.000095	0.000099	2	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3.42	5.71	4.6	4.565	2	2	3.6	4.03	3.8	3.815
Silver (Ag)-Total	mg/L	1	1	0.000471	0.000471	0.00047	0.00047	3	3	0.000083	0.00172	0.00071	0.00033	2	1	0.00001	0.00021	0.00011	0.00011	2	2	0.000291	0.000339	0.00032	0.000315
Sodium (Na)-Total	mg/L	1	1	39.6	39.6	40	39.6	3	3	33.6	51.5	40	35.8	2	2	31.4	38.2	35	34.8	2	2	44	44.1	44	44.05
Strontium (Sr)-Total	mg/L	1	1	2.06	2.06	2.1	2.06	3	3	2.08	3.04	2.7	2.93	2	2	2.43	2.6	2.5	2.515	2	2	1.94	2.14	2	2.04
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	1	1	0.000081	0.000081	0.000081	0.000081	3	3	0.000117	0.000371	0.00023	0.00019	2	2	0.000061	0.000108	0.000085	0.0000845	2	2	0.000087	0.000097	0.000092	0.000092
Tin (Sn)-Total	mg/L	1	1	0.00251	0.00251	0.0025	0.0025	3	2	0.0001	0.00163	0.00077	0.00059	2	1	0.0001	0.00024	0.00017	0.00017	2	1	0.0001	0.00037	0.00024	0.000235
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.02	0.015	0.015	2	0	0.01	0.01	0.01	0.01
Uranium (U)-Total	mg/L	1	1	0.000393	0.000393	0.00039	0.00039	3	3	0.000694	0.00318	0.0015	0.0007	2	2	0.000233	0.00034	0.00029	0.0002865	2	2	0.00066	0.000851	0.00076	0.0007555
Vanadium (V)-Total	mg/L	1	1	0.0032	0.0032	0.0032	0.0032	3	3	0.00205	0.02	0.0094	0.0062	2	1	0.0005	0.00242	0.0015	0.00146	2	2	0.0009	0.00135	0.0011	0.001125
Zinc (Zn)-Total	mg/L	1	1	0.0234	0.0234	0.023	0.023	3	3	0.0032	0.0385	0.022	0.025	2	1	0.003	0.0072	0.0051	0.0051	2	2	0.0037	0.0083	0.006	0.006
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																									
Aluminum (Al)-Dissolved	mg/L	1	1	0.0187	0.0187	0.0187	0.0187	3	3	0.0105	0.0147	0.012	0.011	2	2	0.014	0.0389	0.026	0.02645	2	2	0.0049	0.0119	0.0084	0.0084
Antimony (Sb)-Dissolved	mg/L	1	1	0.00109	0.00109	0.0011	0.0011	3	3	0.00528	0.00927	0.007	0.0065	2	2	0.00335	0.0036	0.0035	0.003475	2	2	0.00391	0.00426	0.0041	0.004085
Arsenic (As)-Dissolved	mg/L	1	1	0.0216	0.0216	0.022	0.0216	3	3	0.0113	0.0268	0.022	0.027	2	2	0.0317	0.0347	0.033	0.0332	2	2	0.0134	0.017	0.015	0.0152
Barium (Ba)-Dissolved	mg/L	1	1	0.0251	0.0251	0.025	0.0251	3	2	0.0001	0.0473	0.025	0.027	2	2	0.0282	0.0369	0.033	0.03255	2	2	0.0271	0.0327	0.03	0.0299
Beryllium (Be)-Dissolved	mg/L	1	0	0.0001	0.0001	0.0001	0.0001	3	0	0.00005	0.0001	0.000083	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	1	0	0.00005	0.00005	0.00005	0.00005	3	1	0.00005	0.036	0.012	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	2	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	0.035	0.036	0.036	0.0355	2	2	0.042	0.042	0.042	0.042
Cadmium (Cd)-Dissolved	mg/L	1	1	0.00001	0.00001	0.00001	0.00001	3	3	0.0000059	0.0000079	0.000007	0.0000073	2	0	0.000005	0.000005	0.000005	0.000005	2	1	0.0000077	0.00001	0.0000089	0.00000885
Calcium (Ca)-Dissolved	mg/L	1	1	31.9	31.9	31.9	31.9	3	3	36.2	50	44.3	46.8	2	2	38.5	43.3	41	40.9	2	2	34.4	39.3	37	36.85
Chromium (Cr)-Dissolved	mg/L	1	1	0.00094	0.00094	0.00094	0.00094	3	1	0.0001	0.00046	0.00022	0.0001	2	1	0.0001	0.00012	0.00011	0.00011	2	0	0.0005	0.0005	0.0005	0.0005
Cobalt (Co)-Dissolved	mg/L	1	0	0.0001	0.0001	0.0001	0.0001	3	3	0.00047	0.00069	0.00056	0.00053	2	2	0.00036	0.00036	0.00036	0.00036	2	2	0.00055	0.00063	0.00059	0.00059
Copper (Cu)-Dissolved	mg/L	1	1	0.00311	0.00311	0.0031	0.00311	3	2	0.0002	0.00336	0.0013	0.00039	2	2	0.00044	0.00055	0.0005	0.000495	2	2	0.0012	0.00188	0.0015	0.00154
Iron (Fe)-Dissolved	mg/L	1	0	0.01	0.01	0.01	0.01	3	1	0.01	0.011	0.01	0.01	2	1	0.01	0.023	0.017	0.0165	2	0	0.01	0.01	0.01	0.01
Lead (Pb)-Dissolved	mg/L	1	1	0.000193	0.000193	0.00019	0.000193	3	0	0.00005	0.00005	0.00005	0.00005	2	1	0.00005	0.000055	0.000053	0.0000525	2	0	0.00005	0.00005	0.00005	0.00005
Lithium (Li)-Dissolved	mg/L	1	1	0.0634	0.0634	0.063	0.0634	3	3	0.0558	0.0786	0.064	0.059	2	2	0.0554	0.0615	0.058	0.05845	2	2	0.0705	0.0792	0.075	0.07485
Magnesium (Mg)-Dissolved	mg/L	1	1	6.65	6.65	6.7	6.65	3	3	6.99	9.64	8.7	9.39	2	2	7.16	7.55	7.4	7.355	2	2	6.03	6.64	6.3	6.335
Manganese (Mn)-Dissolved	mg/L	1	1	0.0735	0.0735	0.074	0.0735	3	3	0.121	0.161	0.14	0.134	2	2	0.122	0.124	0.12	0.123	2	2	0.0943	0.105	0.1	0.09965
Mercury (Hg)-Dissolved	mg/L	1	0	0.000005	0.000005	0.000005	0.000005	3	1	0.000005	0.0000052	0.0000051	0.000005	2	0	0.000005	0.000005	0.000005	0.000005	2	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	1	1	0.00324	0.00324	0.0032	0.00324	3	3	0.00157	0.00545	0.003	0.0019	2	2	0.00175	0.00181	0.0018	0.00178	2	2	0.00351	0.00412	0.0038	0.003815
Nickel (Ni)-Dissolved	mg/L	1	1	0.00084	0.00084	0.00084	0.00084	3	1	0.0005	0.00056	0.00052	0.0005	2	0	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.3	0.3	0.3	0.3	2	0	0.3	0.3	0.3	0.3
Phosphorus-Dissolved	mg/L	1	1	5.2	5.2	5.2	5.2	3	3	3.13	4.98	3.8	3.14	2	2	2.98	3.24	3.1	3.11	2	2	3	3.43	3.2	3.215
Selenium (Se)-Dissolved	mg/L	1	0	0.00005	0.00005	0.00005	0.00005	3	1	0.00005	0.000114	0.000071	0.00005	2	0	0.00005	0.00005	0.00005	0.00005	2	1	0.00005	0.00009	0.00007	0.00007
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3.29	3.31	3.3	3.3	2	2	2.94	2.98	3	2.96
Silver (Ag)-Dissolved	mg/L	1	0	0.00001	0.00001	0.00001	0.00001	3	0	0.00001	0.00001	0.00001	0.00001	2	0	0.00001	0.00001	0.00001	0.00001	2	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Dissolved	mg/L	1	1	39.6	39.6	40	39.6	3	3	35.4	47.1	40	36.1	2	2	32.7	36.7	35	34.7	2	2	40.8	45.6	43	43.2
Strontium (Sr)-Dissolved	mg/L	1	1	1.95	1.95	2	1.95	3	3	2.01	2.83	2.6	2.82	2	2	2.23	2.37	2.3	2.3	2	2	1.99	2.28	2.1	2.135
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	1	1	0.000081	0.000081	0.000081	0.000081	3	3	0.000068	0.000093	0.00008	0.00008	2	2	0.000048	0.000056	0.000052	0.000052	2	2	0.000063	0.000076	0.00007	0.0000695
Tin (Sn)-Dissolved	mg/L	1	1	0.00083	0.00083	0.00083	0.00083	3	1	0.0001	0.00027	0.00016	0.0001	2	0	0.0001	0.0001	0.0001	0.0001	2	0	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	0.01	0.01	0.01	0.01	2	0	0.01	0.01	0.01	0.01
Uranium (U)-Dissolved	mg/L	1	1	0.000294	0.000294	0.00029	0.000294	3	3	0.000466	0.00301	0.0014	0.00067	2	2	0.00022	0.000282	0.00025	0.000251	2	2	0.000672	0.00084	0.00076	0.000756
Vanadium (V)-Dissolved	mg/L	1	0	0.0005	0.0005	0.0005	0.0005	3	0	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005	2	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Dissolved	mg/L	1	1	0.0065	0.0065	0.0065	0.0065	3	2	0.001	0.003	0.0017	0.0012	2	2	0.0017	0.0018	0.0018	0.00175	2	2	0.002	0.0028	0.0024	0.0024
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																									
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	2	0	20	20	20	20	2	0	20	20	20	20

BJ-GW18-23A		2018						2019							2020							2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																										
Temperature	°C	2	2	2.4	2.6	2.5	2.5	4	4	1.6	4.1	2.95	3	3.05	4	4	-0.1	3.9	2.55	2.6	3.2	4	4	3	8.3	5.8	6
pH	pH	2	2	7.84	7.99	7.92	7.915	4	4	7.55	7.89	7.785	7.79	7.85	4	4	7.47	7.8	7.63	7.6	7.625	4	4	7.59	7.73	7.68	7.7
Specific Sonductance	µS/cm	2	2	771	888	829.5	829.5	4	4	1026	1103	1051.75	1052	1039	4	4	1076	1181	1125.5	1100	1122.5	4	4	1166	1214	1191	1191.5
Dissolved Oxygen	mg/L	0	0	-	-	-	-	3	3	0.13	2.3	0.866666667	0.8667	0.17	4	4	0.17	5.19	1.7975	1.8	0.915	4	4	0.43	0.95	0.67	0.645
Oxidation Reduction Potential	mV	0	0	-	-	-	-	4	4	11.7	168	115.15	115.2	140.45	4	4	57.5	114.6	88.275	88	90.5	4	4	-105.2	29.1	-13.2	11.65
Turbidity	NTU	2	2	43	55	49	49	4	4	12	70.4	36.85	36.85	32.5	4	4	18.1	130.3	55.8075	56	37.415	4	4	4.4	35.05	15.98	12.225
Physical Tests																											
Conductivity	uS/cm	3	3	736	908	842.3	883	4	4	1040	1090	1062.5	1063	1060	4	4	1040	1170	1125	1100	1145	4	4	1150	1240	1200	1195
Acidity (as CaCO3)	mg/L	3	2	1	3.3	2.267	2.5	4	4	1.3	2.3	1.9	1.9	2	4	4	2.2	2.9	2.625	2.6	2.7	4	3	2	2.6	2.375	2.45
Total Alkalinity (as CaCO3)	mg/L	3	3	95.2	108	100.4	98	4	4	86.7	90.9	88.75	88.75	88.7	4	4	92.9	105	97.725	98	96.5	4	4	89.8	95.7	93	92.45
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	270	353	308.25	310	305	4	4	319	362	339	337
Hardness (as CaCO3), from total Ca/Mg	mg/L	3	3	153	281	233	265	4	4	260	342	302.5	302.5	304	4	4	281	364	308.5	310	294.5	4	4	285	355	329	338
pH	pH	3	3	7.94	8.72	8.25	8.09	4	4	7.85	8.15	8.0425	8.04	8.09	4	4	7.88	8.07	7.9625	8	7.95	4	4	7.88	8.1	8	8.035
Total Dissolved Solids (TDS)	mg/L	3	3	498	620	572	598	4	4	730	762	746	746	746	4	4	740	908	809.25	810	794.5	4	4	753	904	809	789.5
Total Suspended Solids (TSS)	mg/L	3	3	63.6	322	175.5	141	4	3	3	44.1	19.3	19.3	15.05	4	4	25.6	92.4	51.3	51	43.6	4	4	8.9	111	46.75	33.55
Turbidity	NTU	3	3	45.1	176	117.7	132	4	4	0.34	18.9	9.1825	9.183	8.75	4	4	11.1	53.3	26.725	27	21.25	4	4	5.43	66.5	24	12.43
Anions and Nutrients																											
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	3	0.194	9.71	2.89775	2.9	0.8435	4	1	0.743	1.71	1.115	1.0025
Total Ammonia (as N)	mg/L	3	3	0.452	0.496	0.47	0.46	4	4	0.522	0.594	0.5675	0.57	0.58	4	4	0	0.58	0.42025	0.42	0.5505	4	4	0.319	0.539	0.41	0.387
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.25	0.25	0.25	0.25	0.25	4	0	0.25	0.25	0.25	0.25
Chloride (Cl)	mg/L	3	3	10.2	17.7	14.7	16.3	4	4	21.6	31.6	25.375	25.4	24.15	4	4	23.8	31.2	27.175	27	26.85	4	4	27.4	29.4	28.28	28.15
Fluoride (F)	mg/L	3	0	0.1	0.1	0.1	0.1	4	0	0.1	0.1	0.1	0.1	0.1	4	3	0.1	0.12	0.11	0.11	0.11	4	3	0.1	0.123	0.11	0.1135
Nitrate (as N)	mg/L	3	3	4.5	5.57	4.97	4.83	4	4	4.08	8.49	6.65	6.65	7.02	4	4	4.99	7.33	6.1875	6.2	6.215	4	4	5.58	11.6	8.59	8.595
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	6.14	1.535	1.5	0	4	4	5.75	11.6	8.68	8.685
Nitrite (as N)	mg/L	3	3	0.353	0.427	0.40	0.41	4	4	0.34	0.612	0.50075	0.50	0.526	4	4	0.0608	0.324	0.17695	0.18	0.1615	4	4	0.034	0.174	0.1	0.1013
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	5.39	16.4	9.24	9.2	7.585	4	4	7.46	11.8	9.15	8.675
Dissolved Orthophosphate (as P)	mg/L	3	3	0.0037	0.0073	0.0061	0.0072	4	4	0.0065	0.0083	0.0072	0.0072	0.007	4	4	0.0034	0.0073	0.00545	0.0055	0.00555	4	4	0.0036	0.0042	0.003775	0.00365
Total Phosphorus (P)	mg/L	3	0	0.3	0.3	0.3	0.3	4	4	0.012	0.145	0.047075	0.047	0.016	4	4	0.0162	0.0376	0.02625	0.026	0.0256	4	4	0.0083	0.0501	0.028	0.02755
Sulphate (SO4)	mg/L	3	3	272	323	306	322	4	4	358	408	384.75	385	386.5	4	4	394	444	418	420	417	4	4	442	464	452	450.5
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.018	0.021	0.01925	0.019	0.019	4	2	0.0016	0.011	0.0043	0.0023
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.018	0.02	0.0185	0.019	0.018	4	2	0.0015	0.01	0.004	0.00215
Total Metals																											
Aluminum (Al)-Total	mg/L	3	3	0.574	3.63	2.03	1.9	4	4	0.0143	0.479	0.269575	0.27	0.29	4	4	0.0821	1.77	0.737775	0.74	0.5495	4	4	0.209	2.12	0.7868	0.409
Antimony (Sb)-Total	mg/L	3	3	0.0635	0.102	0.078	0.068	4	4	0.0423	0.0561	0.04935	0.049	0.050	4	4	0.0312	0.043	0.034825	0.035	0.03255	4	4	0.0302	0.0336	0.032	0.0321
Arsenic (As)-Total	mg/L	3	3	0.0374	0.0568	0.048	0.049	4	4	0.0477	0.075	0.0612	0.061	0.061	4	4	0.028	0.052	0.0394	0.039	0.0388	4	4	0.0287	0.0468	0.0384	0.03905
Barium (Ba)-Total	mg/L	3	3	0.0976	0.13	0.12	0.128	4	4	0.0387	0.0734	0.053075	0.053	0.05	4	4	0.0496	0.0784	0.0604	0.06	0.0568	4	4	0.0393	0.0624	0.0531	0.05535
Beryllium (Be)-Total	mg/L	3	2	0.0001	0.00157	0.00027	0.00014	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	2	0.0001	0.00032	0.00015775	0.0016	0.0001055	4	1	0.0001	0.000411	0.00023	0.0002
Bismuth(Bi)- Total	mg/L	3	1	0.00005	0.000119	0.000073	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	1	0.00005	0.000061	0.00005275	0.000053	0.00005	4	1	0.00005	0.0001	0.0000838	0.0000925
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.063	0.106	0.08225	0.082	0.08	4	4	0.09	0.119	0.1075	0.1105
Cadmium (Cd)-Total	mg/L	3	3	0.0000186	0.0000908	0.000046	0.000029	4	4	0.0000083	0.0000725	0.000028225	0.000028	0.000016	4	4	0.0000175	0.0000678	0.00003345	0.000033	0.00002425	4	4	0.0000205	0.0000786	0.000043	0.0000356
Calcium (Ca)-Total	mg/L	3	3	65.9	93.3	83.9	92.4	4	4	84.4	118	97.95	98	94.7	4	4	91.3	120	100.8	100	95.95	4	4	104	119	111	109.5
Chromium (Cr)-Total	mg/L	3	3	0.00076	0.00304	0.002	0.0022	4	3	0.0001	0.0034	0.0011775	0.0012	0.00061	4	4	0.0007	0.0108	0.006265	0.0063	0.00678	4	4	0.00508	0.0222	0.01263	0.011625
Cobalt (Co)-Total	mg/L	3	3	0.00029	0.00087	0.0005	0.00034	4	4	0.00013	0.00058	0.0002775	0.00028	0.0002	4	4	0.00029	0.00121	0.000715	0.00072	0.00068	4	4	0.00045	0.0047	0.0033	0.003935
Copper (Cu)-Total	mg/L	3	2	0.00122	0.004	0.0023	0.0017	4	3	0.0005	0.00434	0.0019025	0.0019	0.0014	4	4	0.00135	0.00396	0.00258	0.0026	0.002505	4	4	0.00152	0.00488	0.00282	0.002435
Iron (Fe)-Total	mg/L	3	3	0.672	1.95	1.1	0.78	4	4	0.037	1.56	0.49625	0.5	0.19	4	4	0.158	1.25	0.562	0.56	0.42	4	4	0.135	0.974	0.45	0.3455
Lead (Pb)-Total	mg/L	3	3	0.00126	0.00373	0.0021	0.0013	4	4	0.000272	0.00277	0.00114675	0.0011	0.00077	4	4	0.000802	0.00238	0.001323	0.0013	0.001055	4	4	0.000472	0.00288	0.0012	0.0008175
Lithium (Li)-Total	mg/L	3	3	0.134	0.156	0.14	0.142	4	4	0.18	0.206	0.19625	0.2	0.20	4	4	0.205	0.243	0.22875	0.23	0.2335	4	4	0.238	0.256	0.25	0.252
Magnesium (Mg)-Total	mg/L	3	3	12.6	14.5	13	12.7	4	4	12	14	13.15	13	13.3	4	4	12.9	15.6	13.775	14	13.3	4	4	14.5	16.1	15.35	15.4
Manganese (Mn)-Total	mg/L	3	3	0.128	0.296	0.22	0.24	4	4	0.171	0.3	0.25325	0.25	0.27	4	4	0.0869	0.31	0.184225	0.18	0.17	4	4	0.148	0.289	0.23	0.246
Mercury (Hg)-Total	mg/L	3	2	0.0000104	0.0001	0.000043	0.000018	4	1	0.000005	0.0000148	0.00000745	0.0000075	0.000005	4	1	0.000005	0.0001	0.000028825	0.000029	0.00000515	4	2	0.000005	0.0000128	0.00000863	0.00000835
Molybdenum (Mo)-Total	mg/L	3	3	0.00148	0.00328	0.0021	0.0017	4	4	0.00192	0.00285	0.0022675	0.0023	0.00215	4	4	0.00281	0.00459	0.0036425	0.0036	0.003585	4	4	0.00467	0.00778	0.005655	0.005085
Nickel (Ni)-Total	mg/L	3	3	0.0007	0.00218	0.0013	0.0011	4	3	0.0005	0.00286	0.0012	0.0012	0.00072	4	4	0.00101	0.00724	0.0045625	0.0046	0.005	4	4	0.00636	0.0178	0.01	0.00811
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.3	0.3	0.3	0.3	0.3	4	0	0.3	0.6	0.45	0.45
Potassium (K)-Total	mg/L	3	3	3.6	21.4	9.7	4.1	4	4	3.28	3.53	3.36	3.4	3.32	4	4	3.82	4.04	3.895	3.9	3.86	4	4	3.8	4.22	4.013	4.015
Selenium (Se)-Total	mg/L	3	3	0.000561	0.000679	0.00064	0.00067	4	4	0.000498	0.000899	0.000686	0.00069	0.00067	4	4	0.000336	0.000724	0.0005325	0.00053	0.000535	4	4	0.000402	0.000707	0.00059	0.000616
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	2.97	6.11	4.3375	4.3	4.135	4	4	3.15	6.7	4.38	3.84
Silver (Ag)-Total	mg/L	3	3	0.000131	0.000175	0.00015	0.00015	4	4	0.000012	0.000159	0.000058	0.000058	0.000031	4	4	0.000022	0.000093	0.00006025	0.00006	0.000063	4	4	0.00003	0.000442	0.0002043	0.0001725
Sodium (Na)-Total	mg/L	3	3	81	93.3	87	87.8	4	4	96.7	112	103.425	100	102.5	4	4	117	128	123.25	120	124	4	4	124	135	130	127
Strontium (Sr)-Total	mg/L	3	3	4.67	5.29	5.1	5.24	4	4	5.26	6.13	5.66	5.7	5.63	4	4	5.58	6.9	6.26	6.3	6.28	4	4	6.36	6.53	6.46	6.475
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	3	3	0.000112	0.000143	0.00013	0.00013	4	4	0.000044	0.000107	0.000085	0.000085	0.000095	4	4	0.00004	0.000108	0.00006375	0.000064	0.0000535	4	4	0.000036	0.000109	0.000084	0.0000955
Tin (Sn)-Total	mg/L	3	3	0.00039	0.00105	0.00068	0.00061	4	3	0.0001	0.00057	0.000335	0.00034	0.00034	4	4	0.00012	0.00047	0.0002375	0.00024	0.00018	4	4	0.00021	0.00029	0.00025	0.00025
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.01	0.015	0.01125	0.011	0.01	4	1	0.01	0.02	0.0154	0.01585
Uranium (U)-Total	mg/L	3	3	0.000915	0.00215	0.0014	0.0012	4	4	0.0012	0.00141	0.0013225	0.0013	0.0013	4	4	0.00137	0.00263	0.0019325	0.0019	0.001865	4	4	0.00178	0.00262	0.002148	0.002095
Vanadium (V)-Total	mg/L	3	3	0.00104	0.00279	0.0019	0.0020	4	2	0.0005	0.001	0.00063	0.00063	0.00051	4	3	0.0005	0.00186	0.0009	0.0009	0.00062	4	2	0.00063	0.00164	0.0011	0.001
Zinc (Zn)-Total	mg/L	3	3	0.0084	0.0155	0.013	0.0152	4	3	0.003	0.0129	0.0078	0.0078	0.0077	4	4	0.0063	0.0162	0.01	0.01	0.00875	4	4	0.006	0.0139	0.0103	0.0107
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																											
Aluminum (Al)-Dissolved	mg/L	3	3	0.0012	0.0041	0.0027	0.0028	4	4	0.0022	0.0036	0.003175	0.00318	0.0035	4	4	0.0021	0.0032	0.002725	0.0027	0.0028	4	4	0.0011	0.0076	0.0032	0.00205
Antimony (Sb)-Dissolved	mg/L	3	3	0.0655	0.1	0.082	0.081	4	4	0.0425	0.0578	0.051675	0.052	0.053	4	4	0.0314	0.04	0.034475	0.034	0.03325	4	4	0.0326	0.0344	0.0336	0.0337
Arsenic (As)-Dissolved	mg/L	3	3	0.012	0.0511	0.037	0.048	4	4	0.0508	0.0698	0.06085	0.061	0.061	4	4	0.0252	0.0441	0.0346	0.035	0.03455	4	4	0.0258	0.0427	0.0349	0.03555
Barium (Ba)-Dissolved	mg/L	3	3	0.0428	0.14	0.076	0.044	4	4	0.0404	0.0429	0.04195	0.042	0.042	4	4	0.0471	0.054	0.049775	0.05	0.049	4	4	0.0336	0.0508	0.043	0.04395
Beryllium (Be)-Dissolved	mg/L	3	0	0.0001	0.0002	0.00013	0.0001	4	0	0.0001	0.0002	0.00015	0.00015	0.00015	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0002	0.000175	0.0002
Bismuth(Bi)- Dissolved	mg/L	3	0	0.00005	0.0001	0.000067	0.00005	4	0	0.00005	0.0001	0.000075	0.000075	0.000075	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.0001	0.0000875	0.0001
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.055	0.104	0.07875	0.079	0.078	4	4	0.084	0.12	0.1	0.104
Cadmium (Cd)-Dissolved	mg/L	3	1	0.000005	0.0000107	0.0000086	0.00001	4	2	0.00001	0.0000138	0.000011625	0.000012	0.000011	4	3	0.000005	0.0000148	0.000009075	0.0000091	0.00000825	4	3	0.00001	0.000023	0.0000164	0.00001625
Calcium (Ca)-Dissolved	mg/L	3	3	45.3	89.9	73.6	85.5	4	4	87.8	111	99.3	99.3	99.2	4	4	86.2	114	100.05	100	100	4	4	92	116	107.5	111
Chromium (Cr)-Dissolved	mg/L	3	2	0.00013	0.00125	0.00053	0.0002	4	2	0.0001	0.00143	0.000465	0.00047	0.00017	4	3	0.0001	0.00066	0.0003925	0.00039	0.000405	4	1	0.00044	0.001	0.00074	0.00075
Cobalt (Co)-Dissolved	mg/L	3	1	0.0001	0.0002	0.00014	0.00012	4	2	0.00011	0.0002	0.0001575	0.00016	0.00016	4	4	0.00013	0.0003	0.000195	0.0002	0.000175	4	4	0.00021	0.00073	0.000398	0.000325
Copper (Cu)-Dissolved	mg/L	3	1	0.0002	0.0004	0.00033	0.00039	4	4	0.00023	0.00162	0.0008275	0.00083	0.00073	4	3	0.0002	0.00126	0.000615	0.00062	0.0005	4	3	0.0004	0.00103	0.0006125	0.00051
Iron (Fe)-Dissolved	mg/L	3	1	0.01	0.03	0.02	0.02	4	0	0.01	0.02	0.015	0.015	0.015	4	2	0.01	0.013	0.01125	0.011	0.011	4	1	0.011	0.02	0.018	0.02
Lead (Pb)-Dissolved	mg/L	3	3	7.94	8.72	8.3	8.09	4	4	0.000138	0.000224	0.0001975	0.0002	0.00021	4	3	0.00005	0.0002	0.0001175	0.00012	0.00011	4	4	0.00013	0.000288	0.000192	0.0001745
Lithium (Li)-Dissolved	mg/L	3	3	0.127	0.158	0.14	0.15	4	4	0.187	0.216	0.20025	0.2	0.20	4	4	0.21	0.251	0.22875	0.23	0.227	4	4	0.222	0.282	0.2563	0.2605
Magnesium (Mg)-Dissolved	mg/L	3	3	9.72	13.7	12	12.5	4	4	12.1	15.6	13.775	14	13.7	4	4	13.1	16.7	14.2	14	13.5	4	4	13.4	15.9	15	14.8
Manganese (Mn)-Dissolved	mg/L	3	2	0.0001	0.219	0.14	0.20	4	4	0.131	0.285	0.2175	0.22	0.227	4	4	0.0258	0.265	0.13445	0.13	0.1235	4	4	0.0828	0.235	0.178	0.198
Mercury (Hg)-Dissolved	mg/L	3	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	3	3	0.00149	0.00368	0.0023	0.0018	4	4	0.00178	0.00299	0.002265	0.0023	0.0021	4	4	0.00292	0.00358	0.00332	0.0033	0.00339	4	4	0.00429	0.0056	0.0048	0.00461
Nickel (Ni)-Dissolved	mg/L	3	0	0.0005	0.001	0.00067	0.0005	4	1	0.0005	0.00223	0.0010575	0.0011	0.00075	4	3	0.0005	0.00321	0.0018575	0.0019	0.00186	4	4	0.0033	0.00405	0.00376	0.003845
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.3	0.3	0.3	0.3	0.3	4	0	0.3	0.6	0.525	0.6
Phosphorus-Dissolved	mg/L	3	3	3.15	30.5	12	3.53	4	4	3.23	3.39	3.32	3.3	3.33	4	4	3.4	4.05	3.7625	3.8	3.8	4	4	3.39	4.23	3.7	3.655
Selenium (Se)-Dissolved	mg/L	3	3	0.00059	0.000659	0.00062	0.00062	4	4	0.000436	0.000761	0.00062825	0.00063	0.000658	4	4	0.000408	0.000671	0.00056225	0.00056	0.000585	4	4	0.000419	0.00117	0.000732	0.0006685
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	2.68	2.88	2.785	2.8	2.79	4	4	2.48	2.84	2.685	2.71
Silver (Ag)-Dissolved	mg/L	3	0	0.00001	0.00002	0.000013	0.00001	4	0	0.00001	0.00002	0.000015	0.000015	0.000015	4	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00002	0.000018	0.00002
Sodium (Na)-Dissolved	mg/L	3	3	85.2	98.9	91	88.2	4	4	101	117	108.25	110	107.5	4	4	115	127	120	120	119	4	4	117	136	128	128.5
Strontium (Sr)-Dissolved	mg/L	3	3	4.09	5.49	4.9	5.26	4	4	5.13	6.19	5.6425	5.6	5.63	4	4	5.64	6.61	6.12	6.1	6.115	4	4	6.28	6.65	6.513	6.56
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	3	3	0.000076	0.000093	0.000087	0.000091	4	4	0.000046	0.000096	0.000076	0.000076	0.000081	4	4	0.000026	0.000054	0.0000395	0.00004	0.000039	4	3	0.00002	0.000089	0.000061	0.000067
Tin (Sn)-Dissolved	mg/L	3	0	0.0001	0.0002	0.00013	0.0001	4	0	0.0001	0.0002	0.00015	0.00015	0.00015	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0002	0.000175	0.0002
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.01	0.01	0.01	0.01	0.01	4	0	0.01	0.02	0.0175	0.02
Uranium (U)-Dissolved	mg/L	3	3	0.000239	0.00112	0.00079	0.001	4	4	0.00109	0.0014	0.001235	0.0012	0.0012	4	4	0.00133	0.00204	0.0016825	0.0017	0.00168	4	4	0.00173	0.00199	0.0019	0.00191
Vanadium (V)-Dissolved	mg/L	3	0	0.0005	0.001	0.00067	0.0005	4	0	0.0005	0.001	0.00075	0.00075	0.00075	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.001	0.000875	0.001
Zinc (Zn)-Dissolved	mg/L	3	2	0.001	0.0083	0.004	0.0026	4	4	0.0017	0.0094	0.004175	0.0042	0.0028	4	4	0.0014	0.01	0.005825	0.0058	0.00595	4	4	0.0048	0.0107	0.007725	0.0077
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																											
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	20	20	20	20	20	4	1	20	28	22	20

BJ-GW18-23B		2018						2019							2020							2021					
		Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	**Unit**																										
Temperature	°C	3	3	2.9	4.3	3.4	3.1	4	4	1.8	7.9	4.8	4.8	4.75	4	4	1.8	5.3	3.7	3.7	3.85	4	4	2.4	3.4	2.9	2.9
pH	pH	3	3	7.43	8.42	7.91	7.88	4	4	7.07	7.7	7.4275	7.43	7.47	4	4	7.26	7.66	7.41	7.4	7.36	4	4	7.39	7.6	7.5	7.495
Specific Sonductance	µS/cm	3	3	946	1140	1041	1036	4	4	764	1534	1205	1205	1261	4	4	769	1536	1108.25	1100	1064	4	4	767	2325	1268	990
Dissolved Oxygen	mg/L	0	0	-	-	-	-	2	2	0.13	0.14	0.135	0.14	0.14	4	4	0.31	1.59	0.9875	0.99	1.025	4	4	0.28	0.67	0.41	0.35
Oxidation Reduction Potential	mV	0	0	-	-	-	-	3	3	177.1	260.3	215.0666667	215.1	207.8	4	4	57.4	107.1	83.35	83	84.45	4	4	93.8	168.6	116	101.05
Turbidity	NTU	3	3	130	1212	714.7	802	4	4	0.12	23.49	6.8875	6.89	1.97	4	4	4.01	21.6	9.2875	9.3	5.77	4	4	4.12	19.54	10.52	9.2
Physical Tests																											
Conductivity	uS/cm	3	3	936	1180	1020	943	4	4	737	1490	1184.25	1184	1255	4	4	778	1560	1120	1100	1071	4	4	752	2240	1240	974
Acidity (as CaCO3)	mg/L	3	3	2	5.1	3.467	3.3	4	4	1.4	4.7	2.8	2.8	2.55	4	4	0	3.6	2.375	2.4	2.95	4	3	2	4.7	3.4	3.45
Total Alkalinity (as CaCO3)	mg/L	3	3	107	143	124.3	123	4	4	69.4	123	92.25	92.25	88.3	4	4	77.7	130	100.775	100	97.7	4	4	88.2	121	100	97.5
Hardness (as CaCO3), dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	226	402	326.75	330	339.5	4	4	228	596	358	304
Hardness (as CaCO3), from total Ca/Mg	mg/L	3	3	344	364	356.3	361	4	4	245	471	343.25	343.3	328.5	4	4	232	406	322.75	320	326.5	4	4	236	544	344	298
pH	pH	3	3	7.82	8.21	8	7.98	4	4	7.79	8.18	8.0175	8.02	8.05	4	4	7.77	8.06	7.8825	7.9	7.85	4	4	7.83	8.19	8	7.965
Total Dissolved Solids (TDS)	mg/L	3	3	672	900	773	747	4	4	483	979	815.25	815.3	899.5	4	4	492	1110	761.5	760	722	4	4	423	1330	749	621
Total Suspended Solids (TSS)	mg/L	3	3	787	1410	1156	1270	4	0	3	3	3	3	3	4	4	3.8	137	54.75	55	39.1	4	4	4.3	19.7	10.83	9.65
Turbidity	NTU	3	3	507	853	709.7	769	4	4	0.17	0.54	0.33	0.33	0.305	4	4	0.61	47.6	13.4625	13	2.82	4	4	2.36	7.55	3.9	2.825
Anions and Nutrients																											
Kjeldahl nitrogen, total (TKN)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.6	3.26	1.715	1.7	1.5	4	2	0.38	7.4	2.607	1.3245
Total Ammonia (as N)	mg/L	3	3	0.41	0.79	0.61	0.627	4	4	0.412	2.43	1.194	1.2	0.97	4	4	0	1.89	0.77375	0.77	0.6025	4	4	0.264	2.69	1.1	0.683
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.05	0.25	0.2	0.2	0.25	4	1	0.061	1	0.39	0.25
Chloride (Cl)	mg/L	3	3	4.83	28.7	15.4	12.7	4	4	34.6	87.1	55.9	55.9	50.95	4	4	28.4	53.3	42.75	43	44.65	4	4	23.9	339	117.3	53.1
Fluoride (F)	mg/L	2	2	0.19	0.33	0.26	0.26	4	4	0.27	0.69	0.42	0.42	0.36	4	4	0.204	0.584	0.39725	0.4	0.4005	4	3	0.241	0.4	0.31	0.303
Nitrate (as N)	mg/L	3	3	0.17	20.8	8.79	5.39	4	4	3.69	40.3	20.7975	20.8	19.6	4	4	3.24	42.4	20.805	21	18.79	4	4	3.69	38.4	17.6	14.25
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0	32.5	8.125	8.1	0	4	4	3.7	38.5	17.68	14.25
Nitrite (as N)	mg/L	3	3	0.151	10.3	3.57	0.248	4	4	0.072	0.293	0.158875	0.16	0.14	4	4	0.0236	0.274	0.1319	0.13	0.115	4	4	0.0052	0.119	0.037	0.01155
Nitrogen, total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	3.56	43.2	21.9875	22	20.595	4	4	4.08	45.9	19.5	13.97
Dissolved Orthophosphate (as P)	mg/L	3	2	0.001	11.6	3.9	0.0013	4	0	0.001	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001	0.001	4	0	0.001	0.001	0.001	0.001
Total Phosphorus (P)	mg/L	3	3	0.57	0.72	0.63	0.59	4	1	0.002	0.0025	0.002125	0.0021	0.002	4	4	0.0046	0.0352	0.017225	0.017	0.01455	4	4	0.004	0.011	0.0069	0.0063
Sulphate (SO4)	mg/L	3	3	335	346	341	342	4	4	209	466	354	354	370.5	4	4	210	487	327.5	330	306.5	4	4	181	465	311	298.5
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.018	0.02	0.019	0.019	0.019	4	1	0.0016	0.011	0.003975	0.00165
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.018	0.019	0.01825	0.018	0.018	4	1	0.0015	0.01	0.0037	0.00155
Total Metals																											
Aluminum (Al)-Total	mg/L	3	3	11.9	19.9	14.7	12.2	4	4	0.0037	0.0225	0.010225	0.0102	0.0074	4	4	0.0832	3.11	0.95195	0.95	0.3073	4	4	0.0615	0.284	0.1424	0.112
Antimony (Sb)-Total	mg/L	3	3	0.00428	0.00695	0.0054	0.0048	4	4	0.00168	0.00235	0.0021275	0.0021	0.0022	4	4	0.00185	0.00221	0.002065	0.0021	0.0021	4	4	0.00216	0.00323	0.0025	0.002235
Arsenic (As)-Total	mg/L	3	3	0.0302	0.0395	0.035	0.036	4	4	0.00038	0.00073	0.0005125	0.00051	0.00047	4	4	0.00042	0.00341	0.001405	0.0014	0.000895	4	4	0.00045	0.00079	0.00054	0.00046
Barium (Ba)-Total	mg/L	3	3	0.207	0.391	0.33	0.39	4	4	0.0134	0.0172	0.015625	0.016	0.016	4	4	0.014	0.0682	0.0297	0.03	0.0183	4	4	0.0126	0.0256	0.017	0.0149
Beryllium (Be)-Total	mg/L	3	3	0.00221	0.00452	0.0031	0.0025	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	2	0.0001	0.000582	0.000238	0.00024	0.000135	4	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	3	3	0.00042	0.000921	0.00061	0.00048	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	1	0.00005	0.000105	0.00006375	0.000064	0.00005	4	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.109	0.283	0.19	0.19	0.184	4	4	0.1	0.268	0.1538	0.1235
Cadmium (Cd)-Total	mg/L	3	3	0.000244	0.000338	0.00028	0.00027	4	3	0.0000094	0.00002	0.00001315	0.000013	0.000012	4	4	0.0000116	0.0000401	0.000020525	0.000021	0.0000152	4	4	0.0000073	0.0000288	0.000014	0.00001015
Calcium (Ca)-Total	mg/L	3	3	153	167	159	156	4	4	95.3	163	124.575	125	120	4	4	83.5	144	115.625	120	117.5	4	4	82.8	212	128	109.5
Chromium (Cr)-Total	mg/L	3	3	0.00507	0.00537	0.0052	0.0052	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	2	0.0001	0.0114	0.00306	0.0031	0.00037	4	0	0.0001	0.0005	0.0004	0.0005
Cobalt (Co)-Total	mg/L	3	3	0.00569	0.0098	0.0074	0.0067	4	3	0.0001	0.00014	0.0001225	0.00012	0.00013	4	4	0.0001	0.00121	0.000425	0.00043	0.000195	4	2	0.0001	0.00023	0.00014	0.000115
Copper (Cu)-Total	mg/L	3	3	0.0173	0.026	0.022	0.0241	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	2	0.0005	0.00427	0.0017125	0.0017	0.00104	4	1	0.0005	0.00059	0.000523	0.0005
Iron (Fe)-Total	mg/L	3	3	18.4	34.3	24	20.4	4	1	0.01	0.013	0.01075	0.011	0.01	4	4	0.031	1.54	0.46825	0.47	0.151	4	4	0.037	0.149	0.073	0.053
Lead (Pb)-Total	mg/L	3	3	0.0209	0.0363	0.028	0.026	4	4	0.000064	0.000086	0.00007525	0.000075	0.000076	4	4	0.000115	0.00391	0.0014675	0.0015	0.0009225	4	4	0.000161	0.000472	0.00026	0.0002005
Lithium (Li)-Total	mg/L	3	3	0.102	0.291	0.19	0.16	4	4	0.095	0.446	0.2395	0.24	0.21	4	4	0.0806	0.5	0.26765	0.27	0.245	4	4	0.0905	0.398	0.208	0.171
Magnesium (Mg)-Total	mg/L	3	3	14	15.3	15	14.5	4	4	5.99	10.4	8.345	8.3	8.50	4	4	5.76	11.4	8.26	8.3	7.94	4	4	5.23	16.3	9.07	7.375
Manganese (Mn)-Total	mg/L	3	3	0.828	1.13	0.94	0.86	4	4	0.0831	0.112	0.097825	0.098	0.098	4	4	0.0884	0.214	0.1231	0.12	0.095	4	4	0.0642	0.176	0.1	0.08065
Mercury (Hg)-Total	mg/L	3	2	0.00023	0.0005	0.00033	0.00026	4	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	2	0.000005	0.0000205	0.00001115	0.000011	0.00000955	4	1	0.000005	0.0000059	0.00000523	0.000005
Molybdenum (Mo)-Total	mg/L	3	3	0.00114	0.00239	0.0019	0.0021	4	4	0.00161	0.0221	0.00719	0.0072	0.0025	4	4	0.0018	0.00616	0.003485	0.0035	0.00299	4	4	0.00212	0.00425	0.003055	0.002925
Nickel (Ni)-Total	mg/L	3	3	0.0065	0.00804	0.0072	0.0071	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	2	0.0005	0.00744	0.00228	0.0023	0.00059	4	0	0.0005	0.0005	0.0005	0.0005
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.3	0.3	0.3	0.3	0.3	4	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	3	3	6.96	10.4	9.2	10.2	4	4	5.31	12.8	8.355	8.4	7.66	4	4	5.21	14.4	9.415	9.4	9.025	4	4	5.85	15.3	9.148	7.72
Selenium (Se)-Total	mg/L	3	3	0.0013	0.00198	0.0017	0.0018	4	4	0.000523	0.00134	0.00100775	0.001	0.0011	4	4	0.000681	0.00158	0.00107975	0.0011	0.001029	4	4	0.000525	0.000911	0.00068	0.0006375
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	1.79	8.52	3.785	3.8	2.415	4	4	1.78	2.64	2.09	1.97
Silver (Ag)-Total	mg/L	3	3	0.00133	0.00275	0.002	0.0019	4	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	2	0.00001	0.000074	0.0000305	0.000031	0.000019	4	1	0.00001	0.000018	0.000012	0.00001
Sodium (Na)-Total	mg/L	3	3	46.5	131	82	69.9	4	4	43.5	186	109.825	110	104.9	4	4	54.4	193	109.325	110	94.95	4	4	56.7	251	120	84.25
Strontium (Sr)-Total	mg/L	3	3	2.1	2.45	2.2	2.16	4	4	0.944	1.85	1.3485	1.3	1.3	4	4	0.956	1.74	1.3015	1.3	1.255	4	4	0.902	2.69	1.45	1.097
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	3	3	0.000256	0.000403	0.00032	0.00031	4	4	0.000036	0.000062	0.00005225	0.000052	0.000056	4	4	0.00003	0.000113	0.00006025	0.00006	0.000049	4	4	0.000027	0.000078	0.0000445	0.0000365
Tin (Sn)-Total	mg/L	3	3	0.00038	0.00051	0.00044	0.00044	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	1	0.0001	0.00035	0.0001625	0.00016	0.0001	4	0	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	0.01	0.0141	0.011025	0.011	0.01	4	0	0.01	0.01	0.01	0.01
Uranium (U)-Total	mg/L	3	3	0.00426	0.009	0.0059	0.0044	4	4	0.000399	0.00189	0.00103325	0.001	0.00092	4	4	0.00078	0.00256	0.0016025	0.0016	0.001535	4	4	0.000721	0.00222	0.001345	0.00122
Vanadium (V)-Total	mg/L	3	3	0.0102	0.0118	0.011	0.0106	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	2	0.0005	0.00196	0.0008725	0.00087	0.000515	4	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Total	mg/L	3	3	0.0416	0.0836	0.062	0.06	4	0	0.003	0.003	0.003	0.003	0.003	4	2	0.003	0.0137	0.00595	0.006	0.00355	4	1	0.003	0.0057	0.00368	0.003
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dissolved Metals																											
Aluminum (Al)-Dissolved	mg/L	3	3	0.0023	0.0053	0.00337	0.0025	4	2	0.001	0.0014	0.001175	0.0012	0.0012	4	1	0.001	0.0051	0.002025	0.002	0.001	4	3	0.001	0.0025	0.0014	0.0011
Antimony (Sb)-Dissolved	mg/L	3	3	0.005	0.00887	0.0066	0.0060	4	4	0.00163	0.00238	0.00209	0.0021	0.0022	4	4	0.00193	0.00215	0.0020575	0.0021	0.002075	4	4	0.00211	0.00297	0.00241	0.002285
Arsenic (As)-Dissolved	mg/L	3	3	0.00084	0.00124	0.001	0.00093	4	4	0.00031	0.00076	0.000495	0.0005	0.00046	4	4	0.00038	0.0005	0.000425	0.00043	0.00041	4	4	0.0003	0.00048	0.0003775	0.000365
Barium (Ba)-Dissolved	mg/L	3	3	0.0206	0.0273	0.025	0.026	4	4	0.0122	0.018	0.0157	0.016	0.0163	4	4	0.0105	0.0181	0.014225	0.014	0.01415	4	4	0.0125	0.0244	0.016	0.01435
Beryllium (Be)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0002	0.000125	0.0001
Bismuth(Bi)- Dissolved	mg/L	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.0001	0.0000625	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	0.108	0.314	0.194	0.19	0.177	4	4	0.098	0.261	0.15	0.117
Cadmium (Cd)-Dissolved	mg/L	3	3	0.0000091	0.000016	0.000012	0.000011	4	4	0.0000056	0.0000118	0.000008275	0.0000083	0.0000079	4	4	0.0000066	0.000016	0.0000099	0.0000099	0.0000085	4	4	0.0000081	0.0000198	0.0000122	0.0000105
Calcium (Ca)-Dissolved	mg/L	3	3	121	129	126	129	4	4	88.6	168	122.9	123	117.5	4	4	80.2	144	117.55	120	123	4	4	84.6	192	123.2	108
Chromium (Cr)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	4	1	0.0001	0.00015	0.0001125	0.00011	0.0001	4	2	0.0001	0.00024	0.00016	0.00016	0.00015	4	0	0.0001	0.001	0.00053	0.0005
Cobalt (Co)-Dissolved	mg/L	3	3	0.0001	0.00016	0.00013	0.00013	4	3	0.0001	0.00014	0.0001225	0.00012	0.00013	4	2	0.0001	0.00015	0.0001225	0.00012	0.00012	4	1	0.0001	0.0002	0.000128	0.000105
Copper (Cu)-Dissolved	mg/L	3	3	0.00028	0.00096	0.00055	0.00042	4	3	0.0002	0.00112	0.0004525	0.00045	0.00025	4	3	0.0002	0.00254	0.0008475	0.00085	0.000325	4	3	0.0002	0.00066	0.000415	0.0004
Iron (Fe)-Dissolved	mg/L	3	0	0.01	0.01	0.01	0.01	4	0	0.01	0.01	0.01	0.01	0.01	4	0	0.01	0.01	0.01	0.01	0.01	4	0	0.01	0.02	0.013	0.01
Lead (Pb)-Dissolved	mg/L	3	3	0.00006	0.000084	0.000071	0.00007	4	3	0.00005	0.000063	0.00005475	0.000055	0.000053	4	1	0.00005	0.000147	0.00007425	0.000074	0.00005	4	1	0.00005	0.0001	0.000064	0.000053
Lithium (Li)-Dissolved	mg/L	3	3	0.0903	0.282	0.17	0.149	4	4	0.0937	0.441	0.234675	0.23	0.20	4	4	0.0857	0.51	0.270675	0.27	0.2435	4	4	0.0952	0.377	0.2021	0.168
Magnesium (Mg)-Dissolved	mg/L	3	3	9.23	10.3	9.8	9.96	4	4	5.79	12.4	8.7775	8.8	8.46	4	4	6.18	10.7	8.1625	8.2	7.885	4	4	5.77	15.8	8.9	7.09
Manganese (Mn)-Dissolved	mg/L	3	3	0.111	0.163	0.14	0.142	4	4	0.0809	0.108	0.095775	0.096	0.097	4	4	0.0708	0.106	0.0914	0.091	0.0944	4	4	0.0686	0.158	0.096	0.07875
Mercury (Hg)-Dissolved	mg/L	3	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Dissolved	mg/L	3	3	0.000762	0.00237	0.0017	0.0021	4	4	0.00152	0.00321	0.0020675	0.0021	0.0018	4	4	0.0019	0.00582	0.0036175	0.0036	0.003375	4	4	0.00209	0.00392	0.003	0.002925
Nickel (Ni)-Dissolved	mg/L	3	1	0.0005	0.00083	0.00061	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.001	0.000625	0.0005
Potassium (K)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.3	0.3	0.3	0.3	0.3	4	0	0.3	0.6	0.375	0.3
Phosphorus-Dissolved	mg/L	3	3	4.97	9.66	7.7	8.57	4	4	5.17	11.6	8.2825	8.3	8.18	4	4	5.59	12.9	9.18	9.2	9.115	4	4	5.39	14.4	8.8	7.63
Selenium (Se)-Dissolved	mg/L	3	3	0.000664	0.000952	0.00076	0.00067	4	4	0.000525	0.00134	0.00099325	0.00099	0.0011	4	4	0.000689	0.00217	0.00126975	0.0013	0.00111	4	4	0.000517	0.00105	0.000724	0.0006635
Silicon (Si)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	1.4	1.91	1.6425	1.6	1.63	4	4	1.5	1.92	1.688	1.665
Silver (Ag)-Dissolved	mg/L	3	0	0.00001	0.00001	0.00001	0.00001	4	1	0.00001	2.11	0.5275075	0.53	0.00001	4	0	0.00001	0.00001	0.00001	0.00001	0.00001	4	0	0.00001	0.00002	0.000013	0.00001
Sodium (Na)-Dissolved	mg/L	3	3	44.8	134	86	78.1	4	4	43.6	172	108.65	110	109.5	4	4	58	183	108.525	110	96.55	4	4	54.4	238	116	86.15
Strontium (Sr)-Dissolved	mg/L	3	3	1.86	2.24	2	2.04	4	4	0.931	1.68	1.32525	1.3	1.35	4	4	0.976	1.82	1.3315	1.3	1.265	4	4	0.924	2.63	1.474	1.17
Sulfur (S)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thallium (Tl)-Dissolved	mg/L	3	3	0.000043	0.000047	0.000045	0.000045	4	4	0.000031	0.000065	0.0000495	0.00005	0.000051	4	4	0.000031	0.000057	0.000044	0.000044	0.000044	4	4	0.000024	0.000063	0.000039	0.000034
Tin (Sn)-Dissolved	mg/L	3	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	1	0.0001	0.00015	0.0001125	0.00011	0.0001	4	0	0.0001	0.0002	0.000125	0.0001
Titanium (Ti)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	0.01	0.01	0.01	0.01	0.01	4	0	0.01	0.02	0.0125	0.01
Uranium (U)-Dissolved	mg/L	3	3	0.00134	0.00208	0.0017	0.00162	4	4	0.000409	0.00163	0.0009745	0.00097	0.00093	4	4	0.000664	0.00178	0.001346	0.0013	0.00147	4	4	0.000812	0.0023	0.0014	0.001155
Vanadium (V)-Dissolved	mg/L	3	0	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.001	0.000625	0.0005
Zinc (Zn)-Dissolved	mg/L	3	2	0.001	0.0042	0.0024	0.0021	4	1	0.001	0.0011	0.001025	0.001	0.001	4	3	0.001	0.0044	0.00265	0.0027	0.0026	4	2	0.001	0.0065	0.002675	0.0016
Zirconium (Zr)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aggregate Organics																											
Chemical Oxygen Demand (COD)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	20	20	20	20	20	4	0	20	20	20

BJ-GW16-5A		Operations (2015 - 2018)	2016							2017							2018							2019							2020							2021						
		Mean	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																											
Temperature	°C	2.5	0	0	-	-	-	-	-	2	2	1.6	2.8	2.2	2.2	2.2	4	4	1.3	3.8	2.6	2.6	4	4	0.8	3.5	2.2	2.25	3	3	1.4	4.4	2.5	1.7	4	4	3	5.8	4.6	4.7
pH	pH	7.67	0	0	-	-	-	-	-	2	2	7.74	7.76	7.75	7.8	7.75	4	4	7.6	7.67	7.6	7.63	4	4	7.52	7.59	7.56	7.56	3	3	7.47	7.57	7.5	7.51	4	4	7.48	7.61	7.6	7.58
Specific Sonductance	µS/cm	875.3	0	0	-	-	-	-	-	2	2	924	951	937.5	940	937.5	4	4	652	947	840	889	4	4	786	989	859	830.5	3	3	656	763	730	758	4	4	697	842	790	807
Dissolved Oxygen	mg/L	-	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	2	2	0.16	0.24	0.2	0.2	3	3	0.26	4.8	1.8	0.41	4	4	0.23	0.34	0.28	0.275
Oxidation Reduction Potential	mV	-	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	3	3	-179.4	23.2	-88.07	-108	3	3	-82.3	51.5	-22	-35.2	4	4	-74.3	-30.7	-53	-52.55
Turbidity	NTU	45.29	0	0	-	-	-	-	-	1	1	183	183	183	180	183	4	4	2.77	23	11	8.85	4	4	3.16	7.03	5.22	5.35	3	3	1.5	11.76	6.2	5.23	4	4	0.44	3.5	1.7	1.41
Physical Tests																																												
Conductivity	uS/cm	854	1	1	807	807	-	-	-	2	2	847	872	859.5	860	859.5	4	4	641	962	860	924.5	4	4	784	964	881.8	889.5	3	3	678	811	740	729	4	4	697	858	790	799.5
Acidity (as CaCO3)	mg/L	3.157	1	1	4.5	4.5	-	-	-	2	2	2.1	3.6	2.85	2.9	2.85	4	4	1	5.3	3	2.8	4	4	1.4	5.2	3.225	3.15	3	2	2	3	2.5	2.6	4	3	2	3.5	3	3.25
Total Alkalinity (as CaCO3)	mg/L	104.6	1	1	106	106	-	-	-	2	2	110	112	111	110	111	4	4	93.4	109	100	100.85	4	4	96	105	100.9	101.25	3	3	94.6	103	99	100	4	4	92.1	97	95	96.25
Hardness (as CaCO3), dissolved		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	338	455	390	385	4	4	382	451	420	417.5
Hardness (as CaCO3), from total Ca/Mg	mg/L	481.3	1	1	435	435	-	-	-	2	2	438	499	468.5	470	468.5	4	4	338	612	500	523.5	4	4	402	564	478	473	3	3	364	414	390	394	4	4	359	456	410	409.5
pH	pH	7.88	1	1	7.8	7.8	-	-	-	2	2	7.98	8.04	8.01	8	8.01	4	4	7.67	8.02	7.8	7.835	4	4	7.77	8.1	7.95	7.97	3	3	7.83	7.91	7.9	7.91	4	4	7.88	8.11	8	7.98
Total Dissolved Solids (TDS)	mg/L	669.6	1	1	599	599	-	-	-	2	2	668	702	685	690	685	4	4	471	807	680	720	4	4	576	770	654.5	636	3	3	512	562	540	534	4	4	468	625	570	587
Total Suspended Solids (TSS)	mg/L	70.91	1	1	148	148	-	-	-	2	2	39.3	227	133.15	130	133.15	4	4	7.5	33.5	21	20.55	4	3	3	10.6	5.98	5.15	3	3	5.1	12.6	9.8	11.6	4	1	3	17.5	6.6	3
Turbidity	NTU	37.65	1	1	83.8	83.8	-	-	-	2	2	13.3	137	75.15	75	75.15	4	4	3.64	13	7.4	6.405	4	4	0.84	4.41	2.843	3.06	3	3	1.38	8.26	5.4	6.64	4	4	0.36	6.24	2	0.605
Anions and Nutrients																																												
Kjeldahl nitrogen, total (TKN)							-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.116	0.399	0.22	0.154	4	4	0.106	0.137	0.12	0.125
Total Ammonia (as N)	mg/L	0.13	1	1	0.253	0.253	-	-	-	2	2	0.138	0.161	0.1495	0.15	0.1495	4	4	0.0561	0.15	0.091	0.0789	4	3	0.005	0.12	0.077	0.092	3	3	0.0924	0.132	0.11	0.103	4	4	0.0946	0.105	0.1	0.1007
Bromide (Br)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.25	0.25	0.25	0.25	4	0	0.25	0.25	0.25	0.25
Chloride (Cl)	mg/L	5.23	1	1	4.8	4.8	-	-	-	2	2	7.2	7.7	7.45	7.5	7.45	4	4	2.8	6.4	4.2	3.85	4	1	2.5	2.7	2.55	2.5	3	0	2.5	2.5	2.5	2.5	4	0	2.5	2.5	2.5	2.5
Fluoride (F)	mg/L	0.1	1	0	0.1	0.1	-	-	-	2	0	0.1	0.1	0.1	0.1	0.1	4	0	0.1	0.1	0.1	0.1	4	0	0.1	0.1	0.1	0.1	3	0	0.1	0.1	0.1	0.1	4	0	0.1	0.1	0.1	0.1
Nitrate (as N)	mg/L	0.38	1	1	1	1	-	-	-	2	2	0.074	1.31	0.692	0.69	0.692	4	4	0.042	0.107	0.076	0.077	4	1	0.025	1.17	0.311	0.025	3	0	0.025	0.025	0.025	0.025	4	0	0.025	0.025	0.025	0.025
Nitrate + Nitrite (as N)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0	0.0255	0.0085	0	4	0	0.0255	0.0255	0.026	0.0255
Nitrite (as N)	mg/L	0.012	1	1	0.0345	0.0345	-	-	-	2	1	0.005	0.0224	0.0137	0.014	0.0137	4	1	0.005	0.0092	0.0061	0.005	4	0	0.005	0.005	0.005	0.005	3	1	0.005	0.006	0.0053	0.005	4	0	0.005	0.005	0.005	0.005
Nitrogen, total		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.133	0.416	0.23	0.154	4	4	0.106	0.137	0.12	0.125
Dissolved Orthophosphate (as P)	mg/L	0.0037	1	0	0.001	0.001	-	-	-	2	2	0.0043	0.0061	0.0052	0.0052	0.0052	4	4	0.003	0.005	0.0036	0.00315	4	2	0.001	0.0037	0.0019	0.0014	3	3	0.0014	0.003	0.002	0.0016	4	4	0.0012	0.0028	0.0017	0.0013
Total Phosphorus (P)	mg/L	0.049	1	1	0.0424	0.0424	-	-	-	2	2	0.0388	0.193	0.1159	0.12	0.1159	4	4	0.0093	0.028	0.018	0.0169	4	4	0.0048	0.0129	0.0086	0.0083	3	3	0.0146	0.0263	0.02	0.0176	4	2	0.002	0.0299	0.0092	0.0025
Sulphate (SO4)	mg/L	370	1	1	309	309	-	-	-	2	2	385	397	391	390	391	4	4	242	441	380	409	4	4	317	448	389	395	3	3	266	346	310	303	4	4	287	370	340	353.5
Sulfide (as H2S)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.019	0.019	0.019	4	0	0.0016	0.011	0.004	0.0016
Sulfide (as S)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	4	0	0.0015	0.01	0.0036	0.0015
Total Metals																																												
Aluminum (Al)-Total	mg/L	0.59	1	1	0.405	0.405	-	-	-	2	2	0.414	2.54	1.477	1.5	1.477	4	4	0.107	0.305	0.19	0.1835	4	4	0.0204	0.137	0.055	0.032	3	3	0.0344	0.191	0.11	0.11	4	4	0.0039	0.0348	0.012	0.0049
Antimony (Sb)-Total	mg/L	0.0031	1	1	0.00407	0.00407	-	-	-	2	2	0.00326	0.00381	0.003535	0.0035	0.003535	4	4	0.00197	0.00286	0.0026	0.002745	4	4	0.0006	0.0019	0.0012	0.0012	3	3	0.00049	0.00117	0.00087	0.00094	4	4	0.00085	0.00106	0.00097	0.000985
Arsenic (As)-Total	mg/L	0.0013	1	1	0.0011	0.0011	-	-	-	2	2	0.00101	0.00384	0.002425	0.0024	0.002425	4	4	0.00067	0.00086	0.00079	0.000805	4	4	0.00055	0.00102	0.00081	0.00083	3	3	0.0008	0.00113	0.00099	0.00105	4	4	0.00086	0.00114	0.00095	0.000905
Barium (Ba)-Total	mg/L	0.047	1	1	0.048	0.048	-	-	-	2	2	0.0495	0.0903	0.0699	0.07	0.0699	4	4	0.0261	0.0471	0.035	0.0339	4	4	0.0207	0.0331	0.027	0.027	3	3	0.0219	0.0296	0.027	0.0288	4	4	0.017	0.0225	0.02	0.01955
Beryllium (Be)-Total	mg/L	0.00011	1	0	0.0001	0.0001	-	-	-	2	1	0.0001	0.00016	0.00013	0.00013	0.00013	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	3	0	0.00002	0.0001	0.000073	0.0001	4	0	0.0001	0.0002	0.00013	0.0001
Bismuth(Bi)- Total	mg/L	0.00005	1	0	0.00005	0.00005	-	-	-	2	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.0001	0.000063	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.034	0.039	0.036	0.036	4	4	0.032	0.037	0.035	0.035
Cadmium (Cd)-Total	mg/L	0.000049	1	1	0.0000263	0.0000263	-	-	-	2	2	0.0000261	0.000236	0.00013105	0.00013	0.00013105	4	4	0.0000084	0.0000238	0.000014	0.0000117	4	2	0.000005	0.0000178	0.0000084	0.0000055	3	3	0.0000056	0.0000183	0.000012	0.0000107	4	0	0.000005	0.00001	0.0000063	0.000005
Calcium (Ca)-Total	mg/L	148	1	1	141	141	-	-	-	2	2	153	158	155.5	160	155.5	4	4	101	179	150	150.5	4	4	128	188	158	157.5	3	3	115	132	120	127	4	4	122	147	140	136
Chromium (Cr)-Total	mg/L	0.0017	1	1	0.00157	0.00157	-	-	-	2	2	0.00151	0.00673	0.00412	0.0041	0.00412	4	4	0.00038	0.00082	0.00057	0.000554	4	4	0.00012	0.00374	0.00113	0.00077	3	3	0.00084	0.0098	0.0059	0.00703	4	4	0.00059	0.00191	0.0012	0.001165
Cobalt (Co)-Total	mg/L	0.0012	1	1	0.00082	0.00082	-	-	-	2	2	0.00104	0.00408	0.00256	0.0026	0.00256	4	4	0.00043	0.0008	0.00065	0.00068	4	3	0.0001	0.00062	0.00038	0.00040	3	3	0.00052	0.00078	0.00068	0.00073	4	4	0.00032	0.00063	0.00044	0.000395
Copper (Cu)-Total	mg/L	0.0022	1	1	0.00171	0.00171	-	-	-	2	2	0.00151	0.00875	0.00513	0.0051	0.00513	4	4	0.00056	0.00115	0.00082	0.000785	4	3	0.0005	0.00493	0.0017	0.0006	3	3	0.00069	0.00234	0.0013	0.00078	4	2	0.0005	0.00144	0.00086	0.000755
Iron (Fe)-Total	mg/L	0.92	1	1	0.728	0.728	-	-	-	2	2	0.579	3.96	2.2695	2.3	2.2695	4	4	0.165	0.465	0.3	0.281	4	4	0.023	0.284	0.16	0.17	3	3	0.144	0.417	0.3	0.351	4	4	0.052	0.193	0.095	0.067
Lead (Pb)-Total	mg/L	0.00093	1	1	0.00168	0.00168	-	-	-	2	2	0.000507	0.00327	0.0018885	0.0019	0.0018885	4	4	0.000173	0.000304	0.00026	0.000273	4	4	0.000067	0.00111	0.00041	0.00024	3	3	0.000258	0.00105	0.00054	0.000299	4	4	0.000081	0.00019	0.00013	0.0001305
Lithium (Li)-Total	mg/L	0.015	1	1	0.0164	0.0164	-	-	-	2	2	0.0152	0.0187	0.01695	0.017	0.01695	4	4	0.0123	0.0163	0.014	0.01325	4	4	0.0123	0.0147	0.014	0.014	3	3	0.0125	0.0134	0.013	0.0127	4	4	0.0127	0.0137	0.013	0.013
Magnesium (Mg)-Total	mg/L	24	1	1	23.1	23.1	-	-	-	2	2	24.2	26.6	25.4	25	25.4	4	4	17	28.7	24	25.35	4	4	7.23	26.8	19	21.85	3	3	18.5	20.3	19	18.7	4	4	18	20.4	19	19.4
Manganese (Mn)-Total	mg/L	0.27	1	1	0.211	0.211	-	-	-	2	2	0.294	0.548	0.421	0.42	0.421	4	4	0.152	0.289	0.21	0.197	4	4	0.00315	0.195	0.13	0.16	3	3	0.165	0.186	0.17	0.17	4	4	0.102	0.135	0.12	0.123
Mercury (Hg)-Total	mg/L	0.0000082	1	0	0.000005	0.000005	-	-	-	2	1	0.0000071	0.000025	0.00001605	0.000016	0.00001605	4	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	0.00075	1	1	0.00103	0.00103	-	-	-	2	2	0.00816	0.00137	0.001093	0.0011	0.001093	4	4	0.000291	0.00114	0.0051	0.000304	4	4	0.000232	0.00958	0.00045	0.00031	3	3	0.000259	0.00204	0.0012	0.00014	4	4	0.000294	0.000452	0.00035	0.00032
Nickel (Ni)-Total	mg/L	0.0014	1	1	0.00098	0.00098	-	-	-	2	2	0.00126	0.00463	0.002945	0.0029	0.002945	4	3	0.0005	0.00116	0.00081	0.00078	4	2	0.0005	0.00343	0.0013	0.00057	3	3	0.00062	0.00701	0.0042	0.00495	4	4	0.00084	0.00197	0.0012	0.00101
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.3	0.22	0.3	4	0	0.3	0.6	0.38	0.3
Potassium (K)-Total	mg/L	1.8	1	1	1.85	1.85	-	-	-	2	2	1.83	2.18	2.005	2	2.005	4	4	1.46	1.87	1.7	1.675	4	4	1.52	2.76	1.9	1.66	3	3	1.51	1.6	1.6	1.56	4	4	1.51	1.63	1.6	1.595
Selenium (Se)-Total	mg/L	0.00008	1	1	0.000065	0.000065	-	-	-	2	2	0.000104	0.000188	0.000146	0.00015	0.000146	4	1	0.00005	0.000054	0.000051	0.00005	4	1	0.00005	0.000221	0.000093	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.0001	0.000063	0.00005
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	2.73	2.87	2.8	2.78	4	4	2.65	2.9	2.7	2.705
Silver (Ag)-Total	mg/L	0.000026	1	1	0.000017	0.000017	-	-	-	2	2	0.000022	0.000088	0.000055	0.000055	0.000055	4	4	0.000011	0.000016	0.000014	0.000015	4	4	0.00001	0.000013	0.000011	0.000011	3	1	0.00001	0.000014	0.000011	0.00001	4	0	0.00001	0.000002	0.000013	0.00001
Sodium (Na)-Total	mg/L	7.7	1	1	7.54	7.54	-	-	-	2	2	8.23	8.32	8.275	8.3	8.275	4	4	6.46	8.35	7.5	7.625	4	4	7.55	15.2	9.7	7.93	3	3	6.59	7.26	6.9	6.92	4	4	6.46	6.77	6.6	6.665
Strontium (Sr)-Total	mg/L	5.5	1	1	5.27	5.27	-	-	-	2	2	5.51	6.03	5.77	5.8	5.77	4	4	3.76	6.71	5.4	5.63	4	4	1.02	5.88	4.4	5.36	3	3	4.94	5.23	5.1	5.07	4	4	4.4	5.16	4.8	4.77
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0	104	35	0	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.000031	1	1	0.000016	0.000016	-	-	-	2	2	0.000027	0.000103	0.000065	0.000065	0.000065	4	4	0.000015	0.000025	0.000019	0.000017	4	1	0.00001	0.000016	0.000012	0.00001	3	3	0.000012	0.000015	0.000014	0.000015	4	0	0.00001	0.00002	0.000013	0.00001
Tin (Sn)-Total	mg/L	0.00011	1	0	0.0001	0.0001	-	-	-	2	1	0.0001	0.00019	0.000145	0.00015	0.000145	4	0	0.0001	0.0001	0.0001	0.0001	4	1	0.0001	0.00052	0.00021	0.0001	3	2	0.0001	0.00028	0.00016	0.0001	4	0	0.0001	0.0002	0.00013	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.00114	0.01	0.007	0.01	4	0	0.01	0.02	0.013	0.01
Uranium (U)-Total	mg/L	0.00052	1	1	0.000309	0.000309	-	-	-	2	2	0.000578	0.000983	0.0007805	0.0008	0.0007805	4	4	0.000268	0.000671	0.00045	0.000429	4	4	0.000262	0.00138	0.0006	0.00039	3	3	0.000299	0.000373	0.00033	0.000332	4	4	0.000275	0.000348	0.00031	0.000306
Vanadium (V)-Total	mg/L	0.001	1	1	0.0008	0.0008	-	-	-	2	2	0.00073	0.00369	0.00221	0.0022	0.00221	4	2	0.0005	0.00052	0.00051	0.0005	4	0	0.0005	0.0005	0.0005	0.0005	3	3	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.001	0.00063	0.0005
Zinc (Zn)-Total	mg/L	0.015	1	1	0.0182	0.0182	-	-	-	2	2	0.0091	0.0487	0.0289	0.029	0.0289	4	4	0.0031	0.0133	0.008	0.00775	4	2	0.003	0.0134	0.0057	0.0031	3	3	0.0036	0.0292	0.016	0.0156	4	2	0.003	0.006	0.0045	0.0044
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0	0.0002	0.000067	0	-	-	-	-	-	-
Dissolved Metals																																												
Aluminum (Al)-Dissolved	mg/L	0.0070	1	1	0.0072	0.0072	-	-	-	2	2	0.0048	0.0267	0.01575	0.016	0.01575	4	4	0.002	0.003	0.0025	0.00255	4	4	0.0012	0.0032	0.0023	0.0024	3	3	0.0025	0.0072	0.0047	0.0045	4	4	0.0015	0.0025	0.002	0.00195
Antimony (Sb)-Dissolved	mg/L	0.003	1	1	0.00405	0.00405	-	-	-	2	2	0.00312	0.00345	0.003285	0.0033	0.003285	4	4	0.00203	0.00287	0.0026	0.002765	4	4	0.00045	0.00194	0.0012	0.0012	3	3	0.00042	0.00096	0.00077	0.00093	4	4	0.00075	0.00102	0.0009	0.000915
Arsenic (As)-Dissolved	mg/L	0.00051	1	1	0.00058	0.00058	-	-	-	2	2	0.00047	0.00057	0.00052	0.00052	0.00052	4	4	0.00044	0.00057	0.0005	0.000485	4	4	0.00048	0.00094	0.00069	0.00066	3	3	0.00071	0.00099	0.00086	0.00087	4	4	0.0008	0.00084	0.00082	0.000825
Barium (Ba)-Dissolved	mg/L	0.037	1	1	0.0361	0.0361	-	-	-	2	2	0.0448	0.048	0.0464	0.046	0.0464	4	4	0.0247	0.0422	0.032	0.03	4	4	0.0197	0.0339	0.026	0.026	3	3	0.021	0.0276	0.024	0.0234	4	4	0.0192	0.0209	0.02	0.01965
Beryllium (Be)-Dissolved	mg/L	0.0001	1	0	0.0001	0.0001	-	-	-	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	3	0	0.00002	0.0001	0.000073	0.0001	4	0	0.0001	0.0002	0.00013	0.0001
Bismuth(Bi)- Dissolved	mg/L	0.00005	1	0	0.00005	0.00005	-	-	-	2	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.0001	0.000063	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.036	0.039	0.037	0.037	4	4	0.032	0.037	0.034	0.0335
Cadmium (Cd)-Dissolved	mg/L	0.000012	1	1	0.0000055	0.0000055	-	-	-	2	2	0.0000193	0.0000281	0.0000237	0.000024	0.0000237	4	2	0.000005	0.0000188	0.0000086	0.0000052	4	1	0.000005	0.0000095	0.0000061	0.000005	3	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.00001	0.0000063	0.000005
Calcium (Ca)-Dissolved	mg/L	153	1	1	137	137	-	-	-	2	2	140	158	149	150	149	4	4	108	196	160	167	4	4	128	187	159	161	3	3	106	145	120	120	4	4	115	149	130	133.5
Chromium (Cr)-Dissolved	mg/L	0.0001	1	0	0.0001	0.0001	-	-	-	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	2	0.0001	0.00099	0.00035	0.00015	3	2	0.0001	0.0033	0.0016	0.00128	4	2	0.0005	0.00081	0.00063	0.000595
Cobalt (Co)-Dissolved	mg/L	0.00049	1	1	0.00035	0.00035	-	-	-	2	2	0.00065	0.00076	0.000705	0.00071	0.000705	4	4	0.00032	0.00045	0.00041	0.000435	4	3	0.0001	0.00044	0.0003	0.00034	3	3	0.00037

BJ-GW16-5B		Operations (2015 - 2018)		2016							2017							2018						2019						2020						2021					
		Mean raw	Mean	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean raw	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median	Sample Count	Sample Count > DL	Min	Max	Mean	Median
Field Parameters	Unit																																								
Temperature	°C	2	2	0	0	-	-	-	-	-	2	2	0.2	3.1	1.65	1.7	1.65	4	4	1	3.8	2.2	1.95	4	4	2.4	4.4	3.1	2.75	3	3	1.4	4.4	2.5	1.7	4	4	1.9	3.2	2.6	2.6
pH	pH	7.57167	7.57	0	0	-	-	-	-	-	2	2	7.67	7.67	7.67	7.7	7.67	4	4	7.32	7.64	7.5	7.565	4	4	7.24	7.52	7.35	7.325	3	3	7.47	7.57	7.5	7.51	4	4	7.26	7.44	7.4	7.405
Specific Sonductance	uS/cm	965.883	965.9	0	0	-	-	-	-	-	2	2	824.3	896	860.15	860	860.15	4	4	883	1167	1000	1012.5	4	4	780	1223	1030	1057.5	3	3	656	763	730	758	4	4	799	1137	940	904.5
Dissolved Oxygen	mg/L	-	-	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	2	2	6.98	7.97	7.475	7.475	3	3	0.26	4.8	1.8	0.41	4	4	5.08	12.06	7.3	6.04
Oxidation Reduction Potential	mV	-	-	0	0	-	-	-	-	-	0	-	-	-	-	-	-	0	-	-	-	-	-	4	4	155.7	1507	540.6	249.85	3	3	-82.3	51.5	-22	-35.2	4	4	155.1	209.5	180	180.7
Turbidity	NTU	362.983	363	0	0	-	-	-	-	-	2	2	34	378	206	210	206	4	4	13.9	832	440	460	4	4	0.52	29	11.5	8.23	3	3	1.5	11.76	6.2	5.23	4	4	5.39	25.47	12	9.54
Physical Tests																																									
Conductivity	uS/cm	959.143	959.1	1	1	1010	1010	-	-	-	2	2	751	839	795	800	795	4	4	889	1130	1000	1047.5	4	4	751	1230	998.8	1007	3	3	678	811	740	729	4	4	788	1110	920	886.5
Acidity (as CaCO3)	mg/L	4.15714	4.157	1	1	5.8	5.8	-	-	-	2	2	3.8	3.9	3.85	3.9	3.85	4	4	3.2	4.6	3.9	3.9	4	4	2.7	5.6	3.825	3.5	3	2	2	3	2.5	2.6	4	4	2.2	4.6	3.8	4.25
Total Alkalinity (as CaCO3)	mg/L	102.829	102.8	1	1	98.7	98.7	-	-	-	2	2	107	109	108	110	108	4	4	91.1	106	100	104	4	4	81	111	95.65	95.3	3	3	94.6	103	99	100	4	4	73.8	92.1	86	89.8
Hardness (as CaCO3), dissolved		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	338	455	390	385	4	4	403	592	490	491
Hardness (as CaCO3), from total Ca/Mg	mg/L	518	518	1	1	532	532	-	-	-	2	2	363	462	412.5	410	412.5	4	4	477	564	570	564	4	4	354	651	503	503.5	3	3	364	414	390	394	4	4	393	606	490	481.5
pH	pH	7.85143	7.85	1	1	7.67	7.67	-	-	-	2	2	7.94	7.94	7.94	7.9	7.94	4	4	7.58	8.01	7.9	7.91	4	4	7.69	8.05	7.9	7.94	3	3	7.83	7.91	7.9	7.91	4	4	7.75	8.1	7.9	7.85
Total Dissolved Solids (TDS)	mg/L	772.143	772.1	1	1	764	764	-	-	-	2	2	560	672	616	620	616	4	4	659	1000	850	875	4	4	586	986	790.5	795	3	3	512	562	540	534	4	4	531	871	690	675.5
Total Suspended Solids (TSS)	mg/L	384.843	384.8	1	1	304	304	-	-	-	2	2	117	274	195.5	200	195.5	4	4	23.9	1150	500	412.5	4	3	3	53.1	18.85	9.65	3	3	5.1	12.6	9.8	11.6	4	1	3	4.6	3.4	3
Turbidity	NTU	301.371	301.4	1	1	63.6	63.6	-	-	-	2	2	119	226	172.5	170	172.5	4	4	16	1050	430	317.5	4	4	0.4	55.6	16.56	5.13	3	3	1.38	8.26	5.4	6.64	4	4	0.15	1.72	0.72	0.51
Anions and Nutrients																																									
Kjeldahl nitrogen, total (TKN)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.116	0.399	0.22	0.154	4	1	0.057	0.146	0.086	0.0705
Total Ammonia (as N)	mg/L	0.05117	0.051	1	1	0.124	0.124	-	-	-	2	2	0.052	0.0793	0.06565	0.066	0.06565	4	4	0.0122	0.0527	0.026	0.019	4	2	0.005	0.106	0.031	0.0074	3	3	0.0924	0.132	0.11	0.103	4	0	0.005	0.005	0.005	0.005
Bromide (Br)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.25	0.25	0.25	0.25	4	0	0.25	0.25	0.25	0.25
Chloride (Cl)	mg/L	4.74286	4.74	1	1	3.5	3.5	-	-	-	2	2	5.7	9.5	7.6	7.6	7.6	4	4	2.5	5.8	3.6	3.1	4	1	0.94	2.5	2.11	2.5	3	0	2.5	2.5	2.5	2.5	4	0	2.5	2.5	2.5	2.5
Fluoride (F)	mg/L	0.1	0.1	1	0	0.1	0.1	-	-	-	2	0	0.1	0.1	0.1	0.1	0.1	4	0	0.1	0.1	0.1	0.1	4	1	0.026	0.1	0.082	0.1	3	0	0.1	0.1	0.1	0.1	4	0	0.1	0.1	0.1	0.1
Nitrate (as N)	mg/L	3.81857	3.82	1	1	9.96	9.96	-	-	-	2	2	2.15	4.98	3.565	3.6	3.565	4	4	1.35	3.25	2.4	2.52	4	3	0.005	1.71	0.714	0.57	3	0	0.025	0.025	0.025	0.025	4	4	0.254	0.807	0.56	0.595
Nitrate + Nitrite (as N)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0	0.0255	0.0085	0	4	4	0.254	0.807	0.56	0.595
Nitrite (as N)	mg/L	0.02246	0.023	1	1	0.0372	0.0372	-	-	-	2	2	0.0288	0.0524	0.0406	0.041	0.0406	4	4	0.0061	0.0173	0.0097	0.0077	4	0	0.001	0.005	0.004	0.005	3	1	0.005	0.006	0.0053	0.005	4	0	0.005	0.005	0.005	0.005
Nitrogen, total		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.133	0.416	0.23	0.154	4	4	0.4	0.801	0.6	0.605
Dissolved Orthophosphate (as P)	mg/L	0.00356	0.0036	1	0	0.001	0.001	-	-	-	2	2	0.0021	0.0079	0.005	0.005	0.005	4	4	0.0015	0.0077	0.0035	0.00235	4	1	0.001	0.0069	0.0025	0.001	3	3	0.0014	0.003	0.002	0.0016	4	4	0.0026	0.0031	0.0029	0.0029
Total Phosphorus (P)	mg/L	0.24644	0.25	1	1	0.435	0.435	-	-	-	2	2	0.06	0.12	0.09	0.09	0.09	4	4	0.0121	0.619	0.28	0.2395	4	4	0.0052	0.0218	0.014	0.014	3	3	0.0146	0.0263	0.02	0.0176	4	4	0.0036	0.0061	0.0045	0.0042
Sulphate (SO4)	mg/L	420.857	421	1	1	398	398	-	-	-	2	2	288	364	326	330	326	4	4	365	547	470	492	4	4	319	599	461	463.5	3	3	266	346	310	303	4	4	310	557	390	340
Sulfide (as H2S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.019	0.019	0.019	4	0	0.0016	0.011	0.004	0.0016
Sulfide (as S)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.018	0.018	0.018	0.018	4	0	0.0015	0.01	0.0036	0.0015
Total Metals																																									
Aluminum (Al)-Total	mg/L	5.04387	5.04	1	1	4.38	4.38	-	-	-	2	2	1.57	3.67	2.62	2.6	2.62	4	4	0.0171	13.9	6.4	5.885	4	4	0.0115	0.461	0.19	0.14	3	3	0.0344	0.191	0.11	0.11	4	4	0.0065	0.0196	0.011	0.0093
Antimony (Sb)-Total	mg/L	0.00324	0.0032	1	1	0.00302	0.00302	-	-	-	2	2	0.00115	0.00307	0.00211	0.0021	0.00211	4	4	0.00028	0.00642	0.0039	0.004385	4	4	0.00045	0.00096	0.00064	0.00058	3	3	0.00049	0.00117	0.00087	0.00094	4	4	0.00051	0.00071	0.0006	0.00058
Arsenic (As)-Total	mg/L	0.09753	0.098	1	1	0.0832	0.0832	-	-	-	2	2	0.0199	0.0656	0.04275	0.043	0.04275	4	4	0.00082	0.273	0.13	0.1201	4	4	0.00058	0.0043	0.0018	0.0012	3	3	0.0008	0.00113	0.00099	0.00105	4	4	0.00044	0.00068	0.00057	0.000575
Barium (Ba)-Total	mg/L	0.2959	0.3	1	1	0.239	0.239	-	-	-	2	2	0.0999	0.173	0.13645	0.14	0.13645	4	4	0.0374	0.861	0.39	0.3305	4	4	0.0246	0.0583	0.042	0.042	3	3	0.0219	0.0296	0.027	0.0288	4	4	0.0295	0.0413	0.035	0.0338
Beryllium (Be)-Total	mg/L	0.00063	0.00063	1	1	0.00053	0.00053	-	-	-	2	2	0.00019	0.0005	0.000345	0.00035	0.000345	4	3	0.0001	0.0016	0.00079	0.000735	4	1	0.0001	0.0001	0.0001	0.0001	3	0	0.0002	0.0001	0.000073	0.0001	4	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Total	mg/L	0.00021	0.00021	1	1	0.000166	0.000166	-	-	-	2	1	0.00005	0.000139	0.0000945	0.000095	0.0000945	4	3	0.00005	0.000549	0.00027	0.000242	4	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.034	0.039	0.036	0.036	4	4	0.024	0.028	0.026	0.025
Cadmium (Cd)-Total	mg/L	8E-05	0.00008	1	1	0.0000613	0.0000613	-	-	-	2	2	0.0000419	0.0000509	0.0000464	0.000046	0.0000464	4	4	0.0000128	0.000204	0.0001	0.00009535	4	2	0.000005	0.0000422	0.000021	0.000017	3	3	0.0000056	0.0000183	0.000012	0.0000107	4	1	0.000005	0.0000095	0.0000061	0.000005
Calcium (Ca)-Total	mg/L	184.286	184	1	1	193	193	-	-	-	2	2	137	168	152.5	150	152.5	4	4	175	219	200	199	4	4	148	266	202	196.5	3	3	115	132	120	127	4	4	152	224	190	186
Chromium (Cr)-Total	mg/L	0.00342	0.0034	1	1	0.00245	0.00245	-	-	-	2	2	0.00111	0.00231	0.00171	0.0017	0.00171	4	4	0.00014	0.00905	0.0045	0.004455	4	4	0.00043	0.0078	0.001	0.00055	3	3	0.00084	0.0098	0.0059	0.00703	4	1	0.0034	0.0005	0.00144	0.0005
Cobalt (Co)-Total	mg/L	0.02942	0.029	1	1	0.0249	0.0249	-	-	-	2	2	0.00697	0.0198	0.013385	0.013	0.013385	4	4	0.00015	0.0836	0.039	0.03525	4	3	0.0001	0.00103	0.00046	0.00036	3	3	0.00052	0.00078	0.00068	0.00073	4	1	0.0001	0.00011	0.0001	0.0001
Copper (Cu)-Total	mg/L	0.09624	0.096	1	1	0.082	0.082	-	-	-	2	2	0.0221	0.0684	0.04525	0.045	0.04525	4	4	0.00057	0.284	0.13	0.1083	4	2	0.0005	0.00317	0.0013	0.00084	3	3	0.00069	0.00234	0.0013	0.00078	4	2	0.0005	0.00064	0.00055	0.000535
Iron (Fe)-Total	mg/L	14.3583	14	1	1	10.9	10.9	-	-	-	2	2	3.4	9.89	6.645	6.6	6.645	4	4	0.018	41	19	17.65	4	4	0.012	0.551	0.25	0.21	3	3	0.144	0.417	0.3	0.351	4	3	0.01	0.041	0.023	0.02
Lead (Pb)-Total	mg/L	0.01489	0.015	1	1	0.0135	0.0135	-	-	-	2	2	0.00284	0.00993	0.006385	0.0064	0.006385	4	3	0.00005	0.0418	0.019	0.01805	4	3	0.00005	0.000601	0.00038	0.00034	3	3	0.000258	0.00105	0.00054	0.000299	4	2	0.00005	0.000068	0.000056	0.000052
Lithium (Li)-Total	mg/L	0.01597	0.016	1	1	0.0146	0.0146	-	-	-	2	2	0.0095	0.0148	0.01215	0.012	0.01215	4	4	0.0066	0.0264	0.018	0.01995	4	4	0.0103	0.0146	0.011	0.011	3	3	0.0125	0.0134	0.013	0.0127	4	4	0.0097	0.0108	0.01	0.0101
Magnesium (Mg)-Total	mg/L	10.2986	10	1	1	11.4	11.4	-	-	-	2	2	7.14	8.46	7.8	7.8	7.8	4	4	8.99	13.4	11	11.35	4	4	5.84	24.2	13	10.77	3	3	18.5	20.3	19	18.7	4	4	5.6	8	6.6	6.49
Manganese (Mn)-Total	mg/L	2.69704	2.7	1	1	1.99	1.99	-	-	-	2	2	0.796	1.56	1.178	1.2	1.178	4	4	0.0633	8.39	3.6	3.04	4	4	0.00172	0.195	0.075	0.052	3	3	0.165	0.186	0.17	0.17	4	4	0.00111	0.0121	0.0053	0.00408
Mercury (Hg)-Total	mg/L	0.0003	0.0003	1	1	0.00009	0.00009	-	-	-	2	2	0.0000858	0.000248	0.0001669	0.00017	0.0001669	4	3	0.000005	0.00085	0.00041	0.0004	4	2	0.000005	0.0000127	0.0000073	0.0000057	3	0	0.000005	0.000005	0.000005	0.000005	4	0	0.000005	0.000005	0.000005	0.000005
Molybdenum (Mo)-Total	mg/L	0.00227	0.0023	1	1	0.00962	0.00962	-	-	-	2	2	0.00125	0.00291	0.00208	0.0021	0.00208	4	4	0.00114	0.00486	0.0027	0.00238	4	4	0.00027	0.00069	0.00046	0.00043	3	3	0.000259	0.00204	0.0012	0.0014	4	4	0.00027	0.00401	0.00035	0.000373
Nickel (Ni)-Total	mg/L	0.01371	0.014	1	1	0.012	0.012	-	-	-	2	2	0.0037	0.00917	0.006435	0.0064	0.006435	4	4	0.00058	0.0381	0.018	0.0162	4	2	0.0005	0.00317	0.0013	0.00084	3	3	0.00062	0.00701	0.0042	0.00495	4	0	0.0005	0.0005	0.0005	0.0005
Phosphorus (P)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0	0.05	0.3	0.22	0.3	4	0	0.3	0.3	0.3	0.3
Potassium (K)-Total	mg/L	2.20157	2.2	1	1	2	2	-	-	-	2	2	1.43	1.78	1.605	1.6	1.605	4	4	0.991	3.34	2.6	2.935	4	4	1.7	2.62	2.2	2.15	3	3	1.51	1.6	1.6	1.56	4	4	2.67	3.14	2.9	2.9
Selenium (Se)-Total	mg/L	0.00029	0.00029	1	1	0.000377	0.000377	-	-	-	2	2	0.000131	0.000193	0.000162	0.00016	0.000162	4	4	0.000065	0.000555	0.00032	0.000338	4	3	0.00005	0.000411	0.00018	0.000134	3	0	0.00005	0.00005	0.00005	0.00005	4	4	0.000195	0.000315	0.00024	0.0002335
Silicon (Si)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.8	-	2.7	-	-	-	-	-	-	3	3	2.73	2.87	2.8	2.78	4	4	2.45	2.7	2.6	2.545
Silver (Ag)-Total	mg/L	0.00019	0.00019	1	1	0.000144	0.000144	-	-	-	2	2	0.000058	0.000121	0.0000895	0.00009	0.0000895	4	3	0.00001	0.000478	0.00026	0.000275	4	3	0.00001	0.000032	0.000019	0.000016	3	1	0.00001	0.000014	0.000011	0.00001	4	0	0.00001	0.00001	0.00001	0.00001
Sodium (Na)-Total	mg/L	14.5286	15	1	1	13.2	13.2	-	-	-	2	2	13.7	17.2	15.45	15	15.45	4	4	11.9	18.2	14	13.75	4	4	8.02	15	12	12.5	3	3	6.59	7.26	6.9	6.92	4	4	7.71	10.2	8.5	8.06
Strontium (Sr)-Total	mg/L	1.08443	1.1	1	1	1.12	1.12	-	-	-	2	2	0.821	1.03	0.9255	0.93	0.9255	4	4	1.05	1.31	1.2	1.13	4	4	0.823	6.29	2.5	1.395	3	3	4.94	5.23	5.1	5.07	4	4	0.807	1.26	1	0.9795
Sulfur (S)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0	104	35	0	-	-	-	-	-	-
Thallium (Tl)-Total	mg/L	0.00014	0.00014	1	1	0.000134	0.000134	-	-	-	2	2	0.000054	0.000106	0.00008	0.00008	0.00008	4	4	0.000015	0.000353	0.00017	0.000164	4	1	0.00001	0.000029	0.000015	0.00001	3	3	0.000012	0.000015	0.000014	0.000015	4	0	0.00001	0.00001	0.00001	0.00001
Tin (Sn)-Total	mg/L	0.00019	0.00019	1	1	0.00012	0.00012	-	-	-	2	1	0.0001	0.00022	0.00016	0.00016	0.00016	4	3	0.0001	0.00042	0.00022	0.00018	4	2	0.0001	0.00025	0.00015	0.00013	3	2	0.0001	0.00028	0.00016	0.0001	4	0	0.0001	0.0001	0.0001	0.0001
Titanium (Ti)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	0.00114	0.01	0.007	0.01	4	0	0.01	0.01	0.01	0.01
Uranium (U)-Total	mg/L	0.00104	0.001	1	1	0.000654	0.000654	-	-	-	2	2	0.00067	0.000922	0.000796	0.0008	0.000796	4	4	0.000733	0.0015	0.0013	0.0014	4	4	0.000354	0.0013	0.00099	0.0012	3	3	0.000299	0.000373	0.00033	0.000332	4	4	0.00108	0.00158	0.0012	0.00111
Vanadium (V)-Total	mg/L	0.00895	0.0089	1	1	0.00742	0.00742	-	-	-	2	2	0.00279	0.00637	0.00458	0.0046	0.00458	4	3	0.0005	0.0239	0.012	0.01083	4	2	0.0005	0.00084	0.00059	0.00051	3	0	0.0005	0.0005	0.0005	0.0005	4	0	0.0005	0.0005	0.0005	0.0005
Zinc (Zn)-Total	mg/L	0.04266	0.043	1	1	0.0323	0.0323	-	-	-	2	2	0.0133	0.0305	0.0219	0.022	0.0219	4	3	0.003	0.113	0.056	0.05325	4	4	0.0038	0.0137	0.0066	0.0045	3	3	0.0036	0.0292	0.016	0.0156	4	1	0.003	0.0116	0.0052	0.003
Zirconium (Zr)-Total	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	0	0.0002	0.000067	0	-	-	-	-	-	-
Dissolved Metals								-	-	-																															
Aluminum (Al)-Dissolved	mg/L	0.00191	0.0019	1	1	0.0012	0.0012	-	-	-	2	2	0.0013	0.0046	0.00295	0.003	0.00295	4	4	0.0011	0.002	0.0016	0.0016	4	4	0.0012	0.0034	0.00255	0.0028	3	3	0.0025	0.0072	0.0047	0.0045	4	3	0.001	0.0016	0.0012	0.00105
Antimony (Sb)-Dissolved	mg/L	0.0003	0.0003	1	1	0.0003	0.0003	-	-	-	2	2	0.00026	0.00029	0.000275	0.00028	0.000275	4	4	0.00027	0.00039	0.00032	0.0003	4	4	0.0003	0.00063	0.00048	0.0005	3	3	0.00042	0.00096	0.00077	0.00093	4	4	0.0005	0.00068	0.0006	0.000615
Arsenic (As)-Dissolved	mg/L	0.00057	0.00057	1	1	0.00047	0.00047	-	-	-	2	2	0.00051	0.0006	0.000555	0.00056	0.000555	4	4	0.00056	0.00065	0.0006	0.0006	4	4	0.00037	0.00081	0.00058	0.00058	3	3	0.00071	0.00099	0.00086	0.00087	4	4	0.00037	0.00053	0.00045	0.00044
Barium (Ba)-Dissolved	mg/L	0.04196	0.042	1	1	0.0536	0.0536	-	-	-	2	2	0.029	0.0367	0.03285	0.033	0.03285	4	4	0.0354	0.0488	0.044	0.0451	4	4	0.0225	0.0441	0.033	0.032	3	3	0.021	0.0276	0.024	0.0234	4	4	0.0297	0.0423	0.036	0.03525
Beryllium (Be)-Dissolved	mg/L	0.0001	0.0001	1	0	0.0001	0.0001	-	-	-	2	0	0.0001	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	4	0	0.0001	0.0001	0.0001	0.0001	3	0	0.00002	0.0001	0.000073	0.0001	4	0	0.0001	0.0001	0.0001	0.0001
Bismuth(Bi)- Dissolved	mg/L	0.00005	0.00005	1	0	0.00005	0.00005	-	-	-	2	0	0.00005	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005	3	0	0.00005	0.00005	0.00005	0.00005	4	0	0.00005	0.00005	0.00005	0.00005
Boron (B)-Dissolved	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3	0.036	0.039	0.037	0.037	4	4	0.023	0.028	0.025	0.0245
Cadmium (Cd)-Dissolved	mg/L	9.5E-06	0.0000095	1	1	0.0000084	0.0000084	-	-	-	2	2	0.0000061	0.000014	0.00001005	0.00001	0.00001005	4	4	0.0000061	0.0000141	0.0000095	0.00000895	4	2	0.000005	0.0000136	0.0000077	0.0000062	3	0	0.000005	0.000005	0.000005	0.000005	4	1	0.000005	0.0000113	0.0000066	0.000005
Calcium (Ca)-Dissolved	mg/L	193.143	193	1	1	197	197	-	-	-	2	2	135	171	153	150	153	4	4	177	250	210	211	4	4	133	242	183	177.5	3	3	106	145	120	120	4	4	148	229	190	182.5
Chromium (Cr)-

Appendix I
Groundwater Quality Plots

NEWCREST

Appendix I1: Piper Plots of Major Ion Chemistry

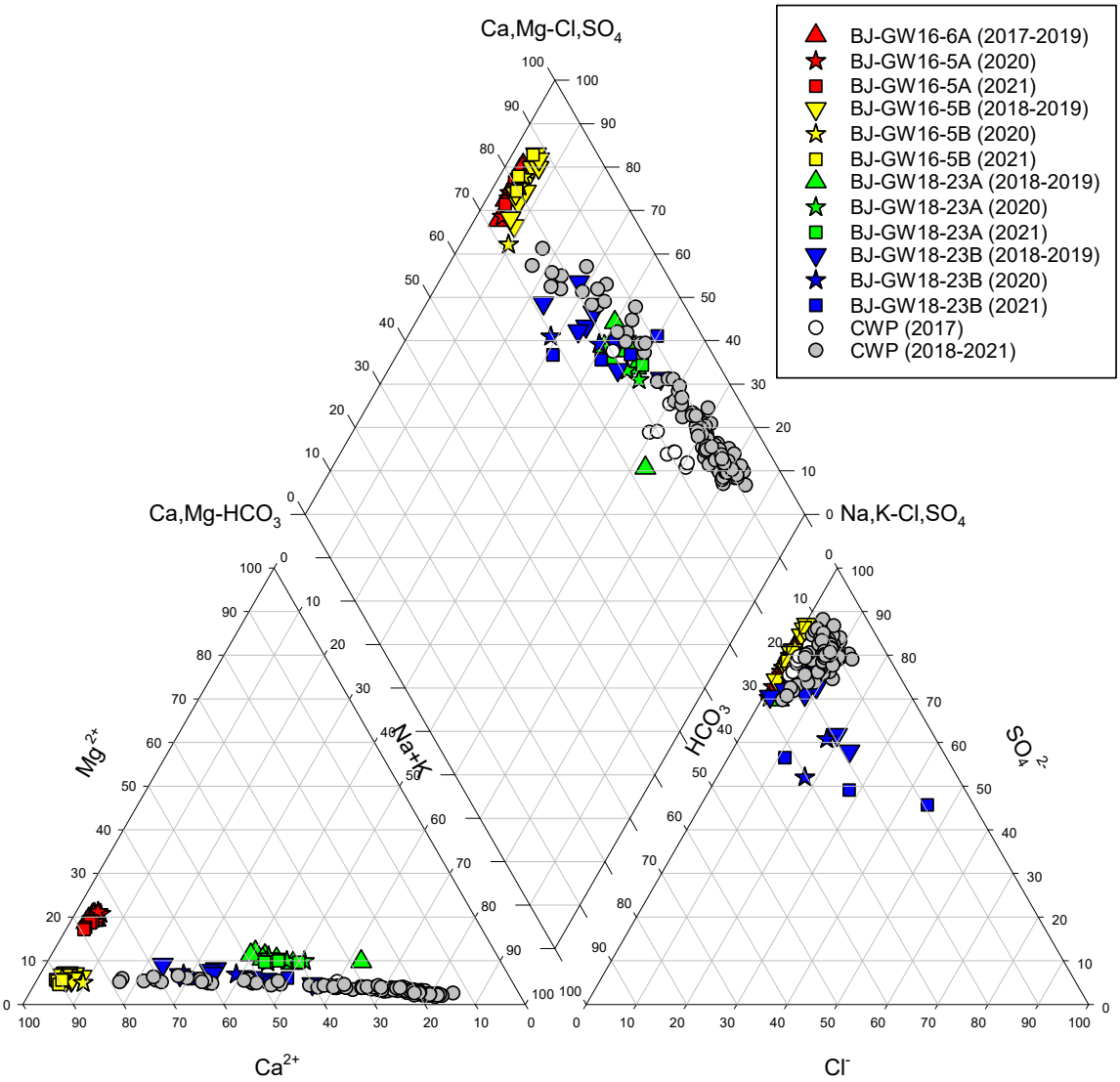

Figure 1: Piper plot of major ion chemistry of the CWP and at wells downgradient of the CWP (BJ-GW16-5A/B, BJ-GW18-23A/B)

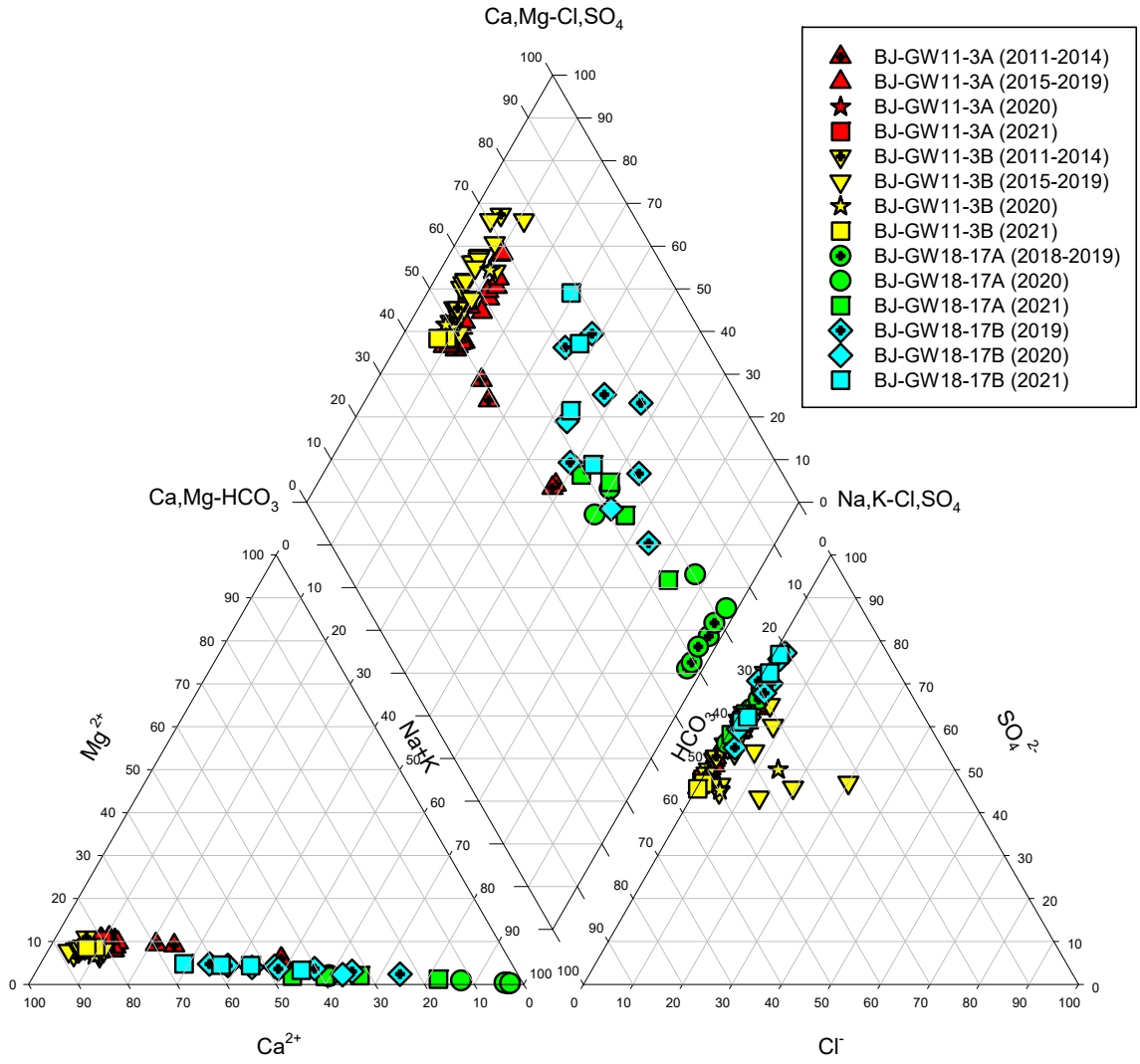

Figure 2: Piper plot of major ion chemistry at wells east of the West Zone Portal (BJ-GW11-3A/B, BJ-GW18-17A/B)

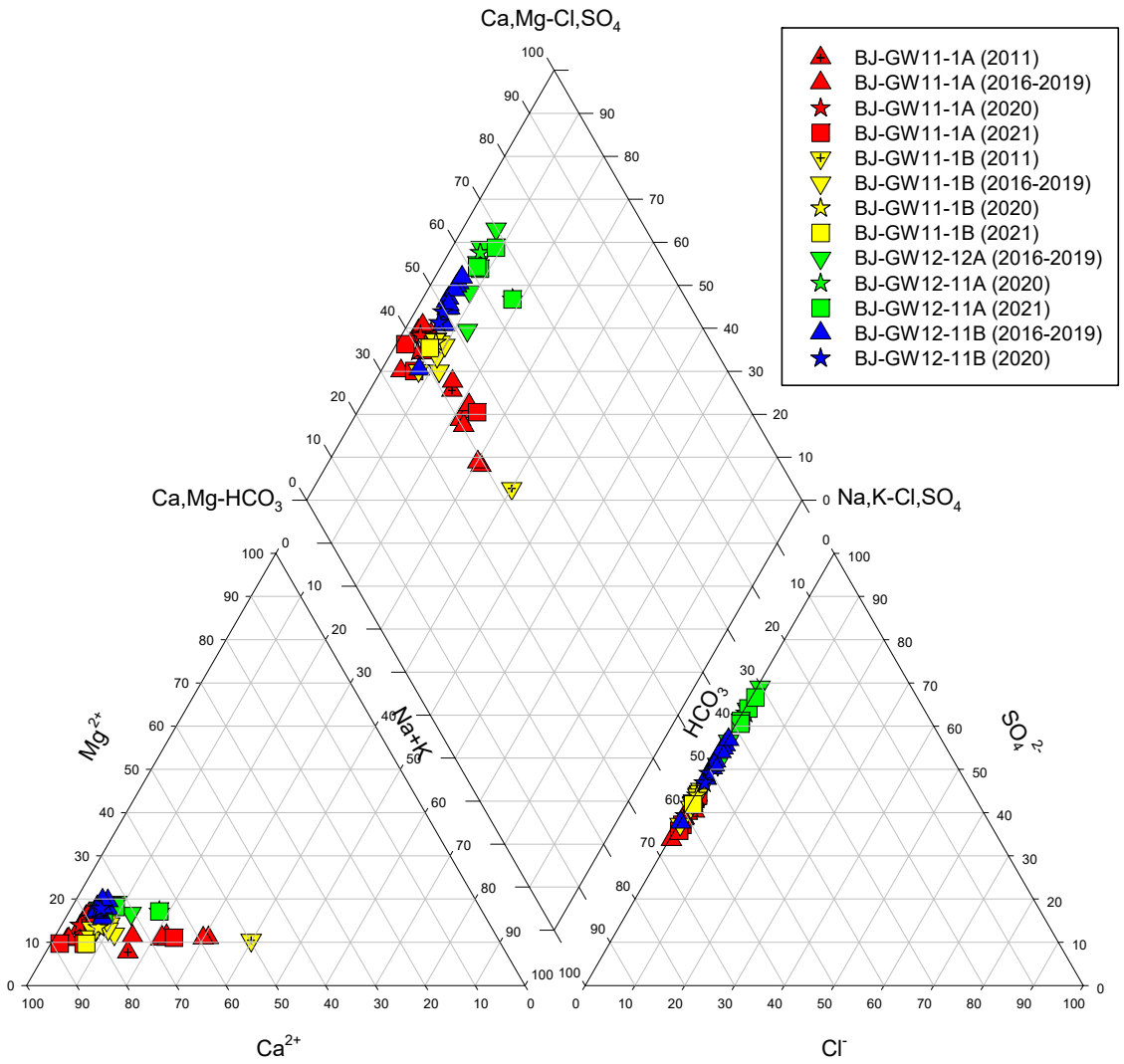

Figure 3: Piper plot of major ion chemistry at wells west of the West Zone Portal (BJ-GW11-1A/B, BJ-GW12-11A/B)

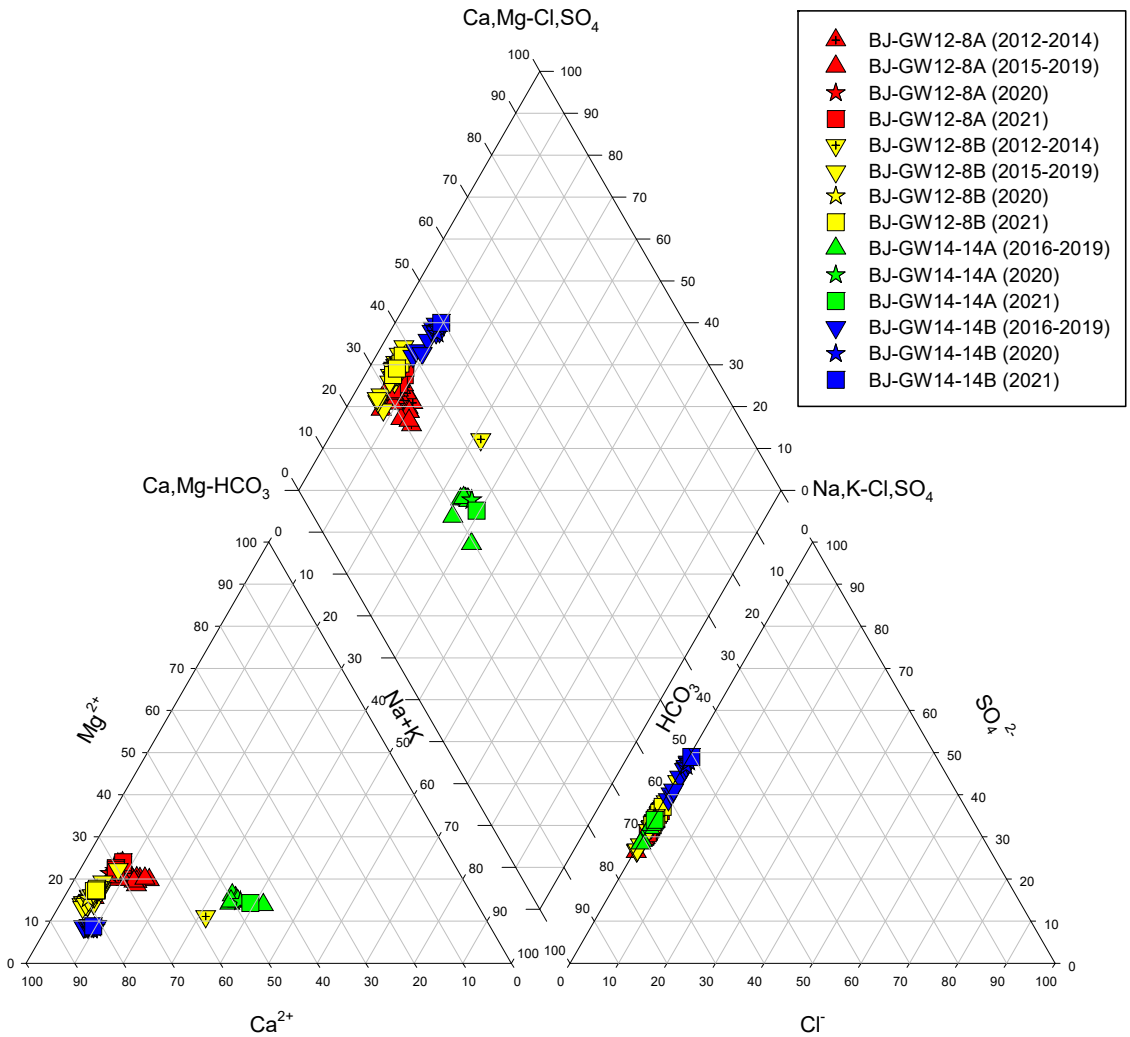

Figure 4: Piper plot of major ion chemistry at wells west of the Brucejack Fault (BJ-GW12-8A/B, BJ-GW14-14A/B)

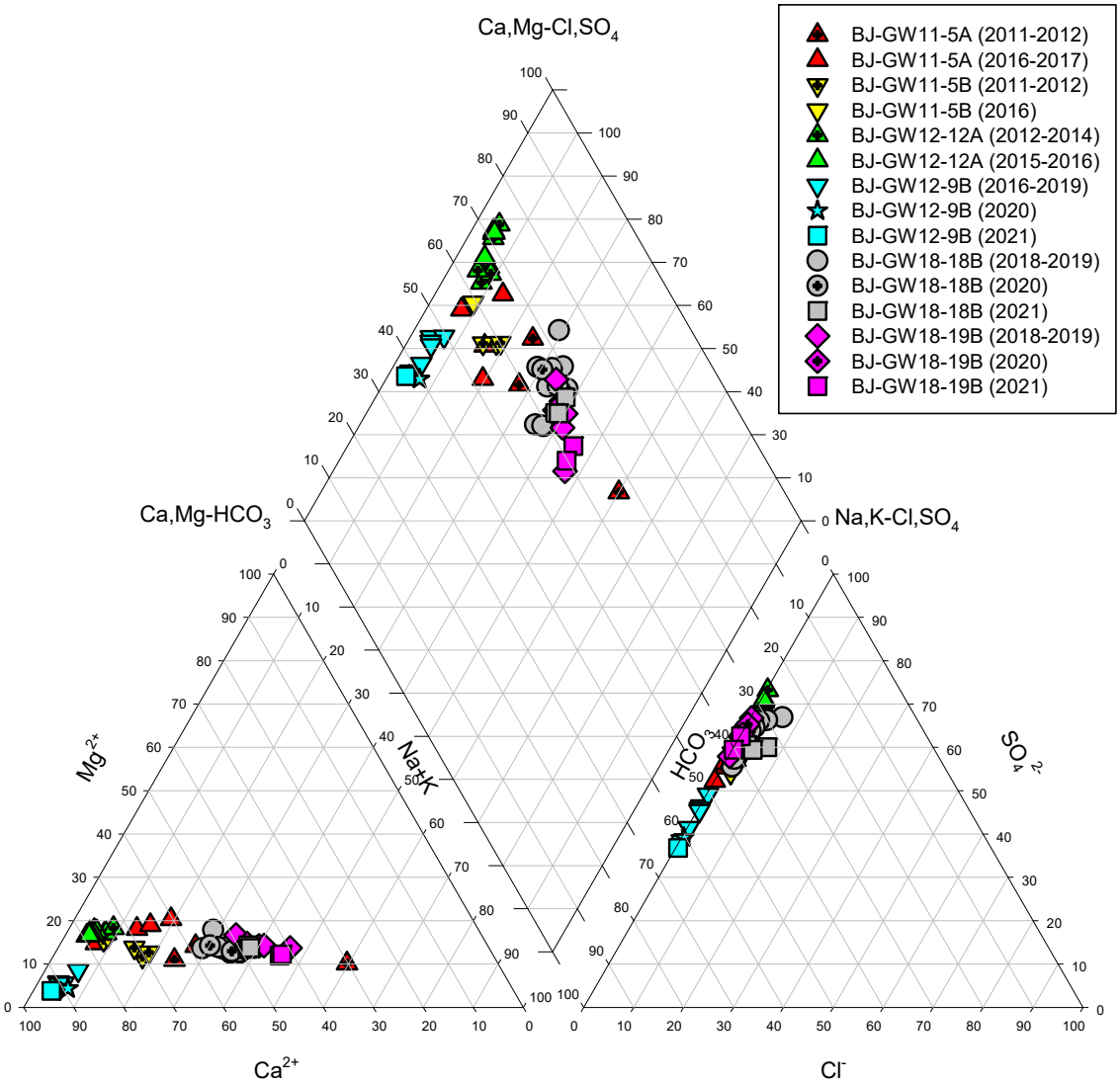

Figure 5: Piper plot of major ion chemistry at wells peripheral to the VOK Zone (BJ-GW11-5A/B, BJ-GW12-12A, BJ-GW12-9B, BJ-GW18-18B, BJ-GW18-19B)

Appendix I2: Bar Charts of Average Concentrations

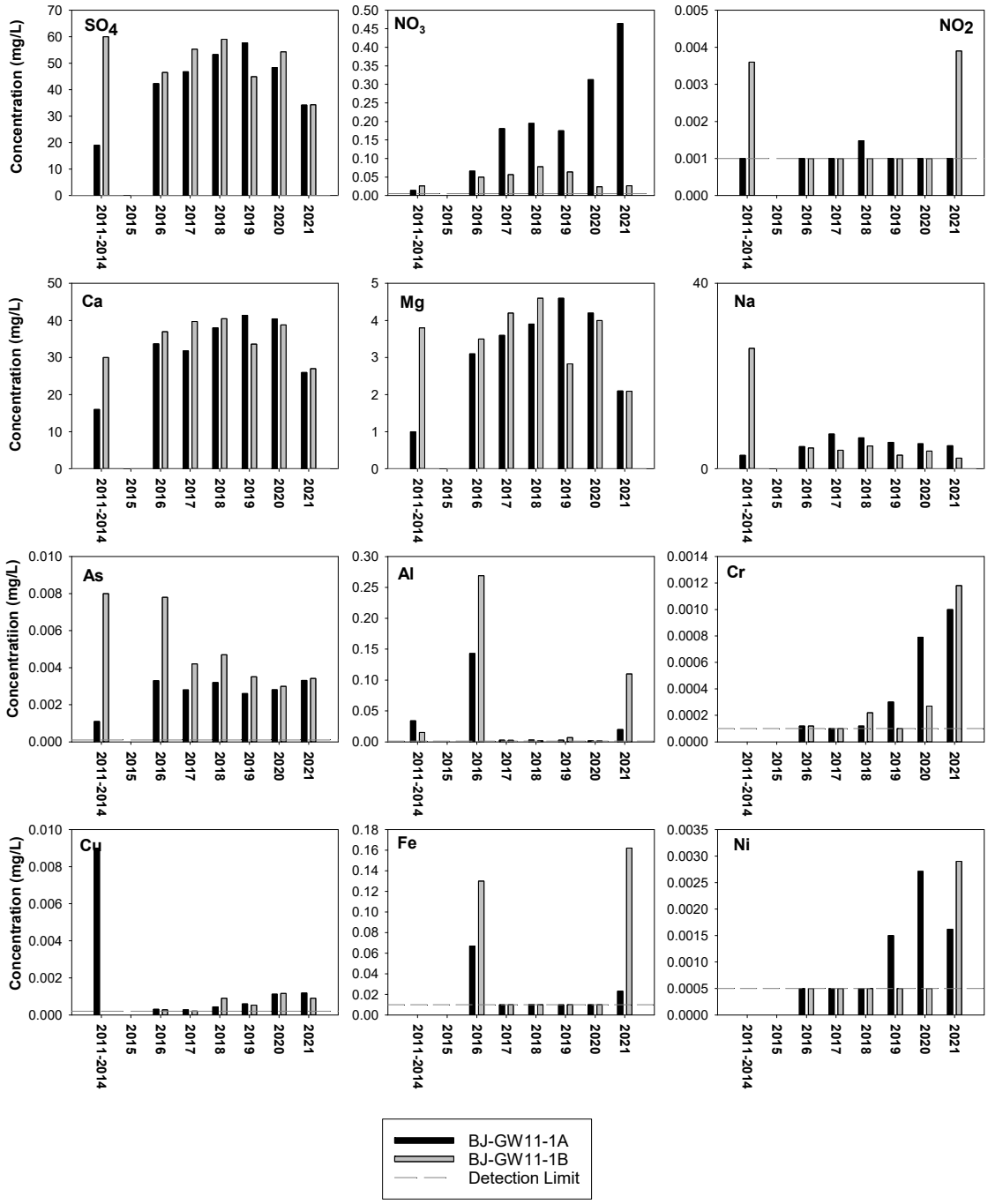

Figure 6: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW11-1A/B

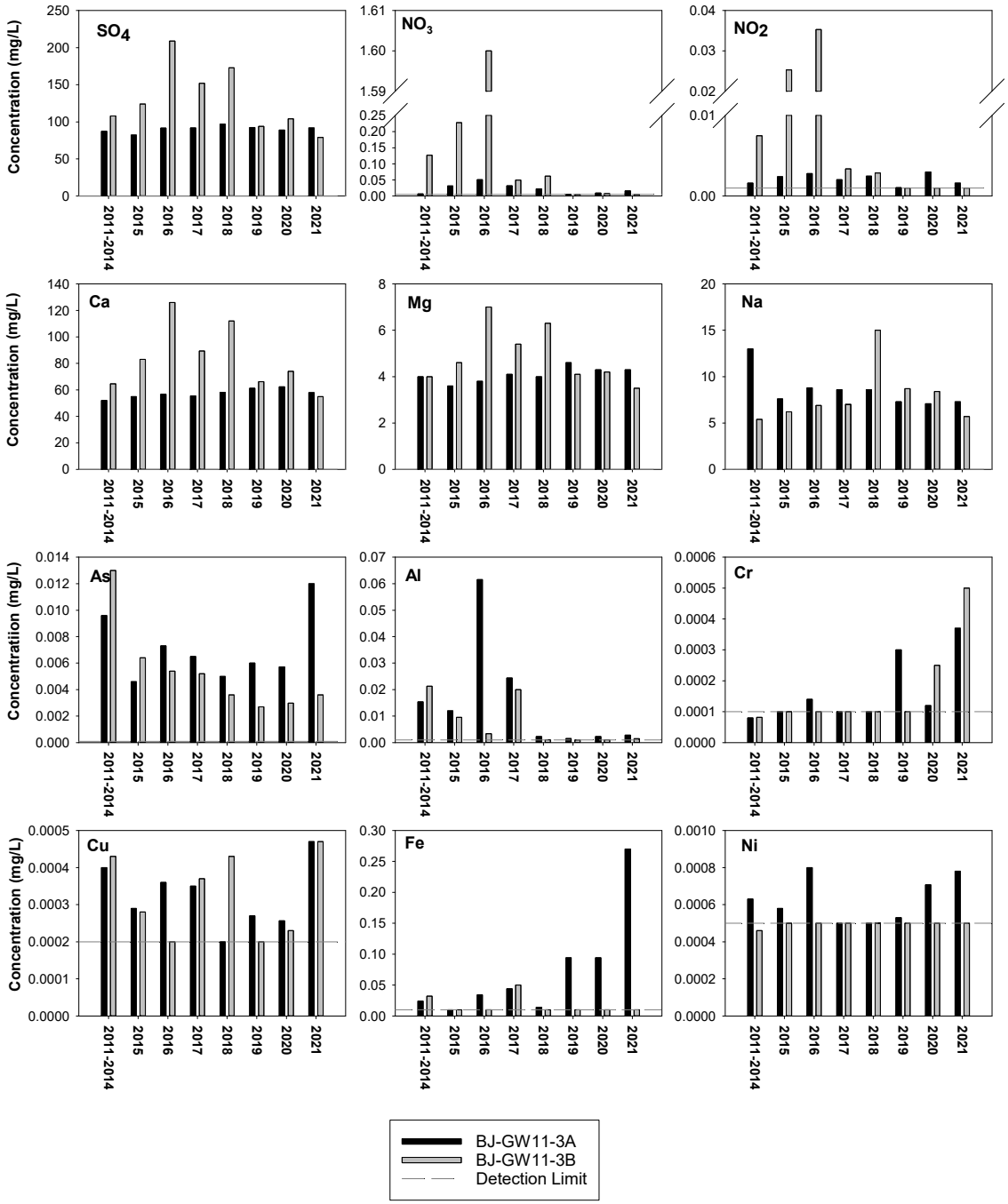

Figure 7: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW11-3A/B

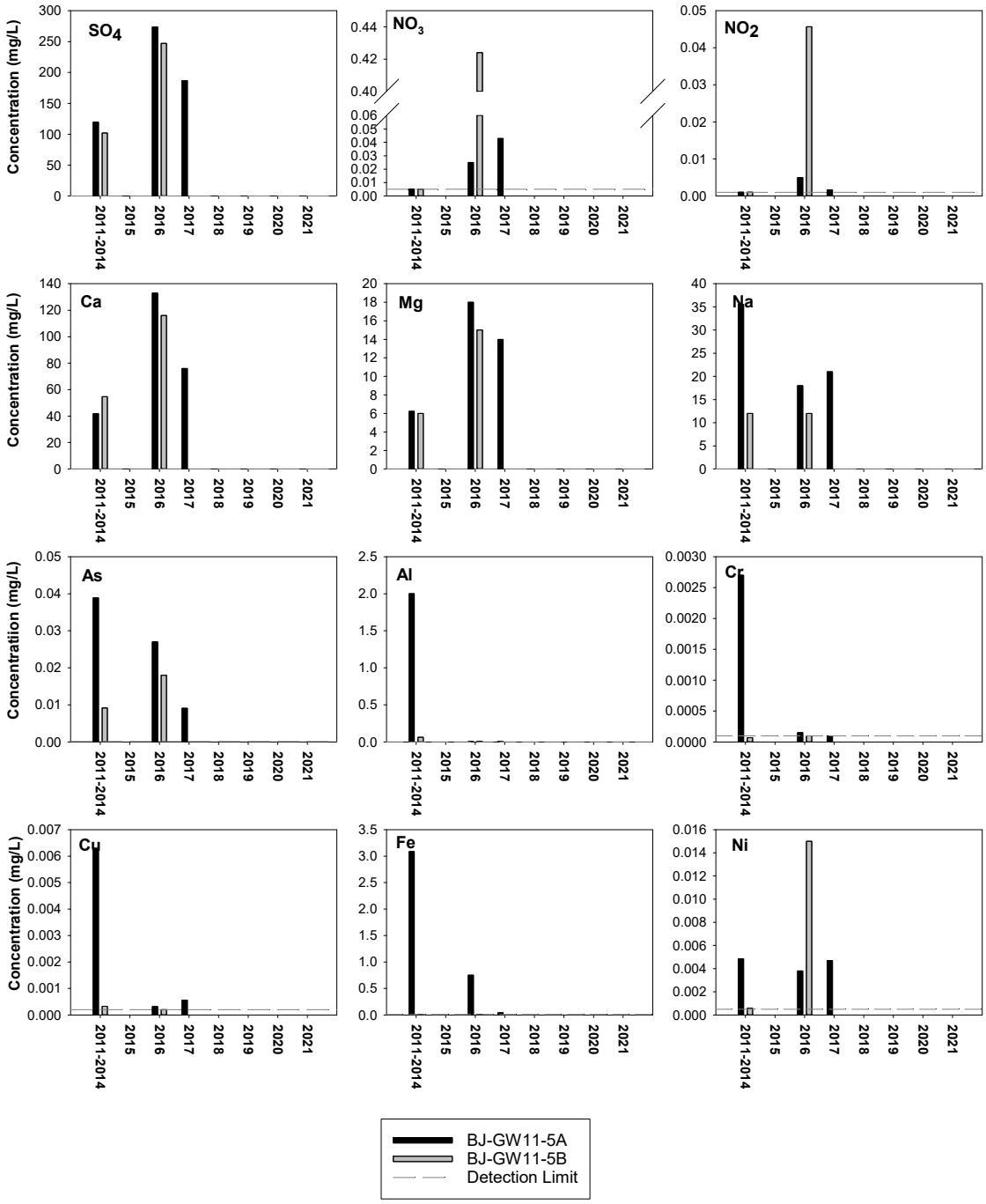

Figure 8: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW11-5A/B

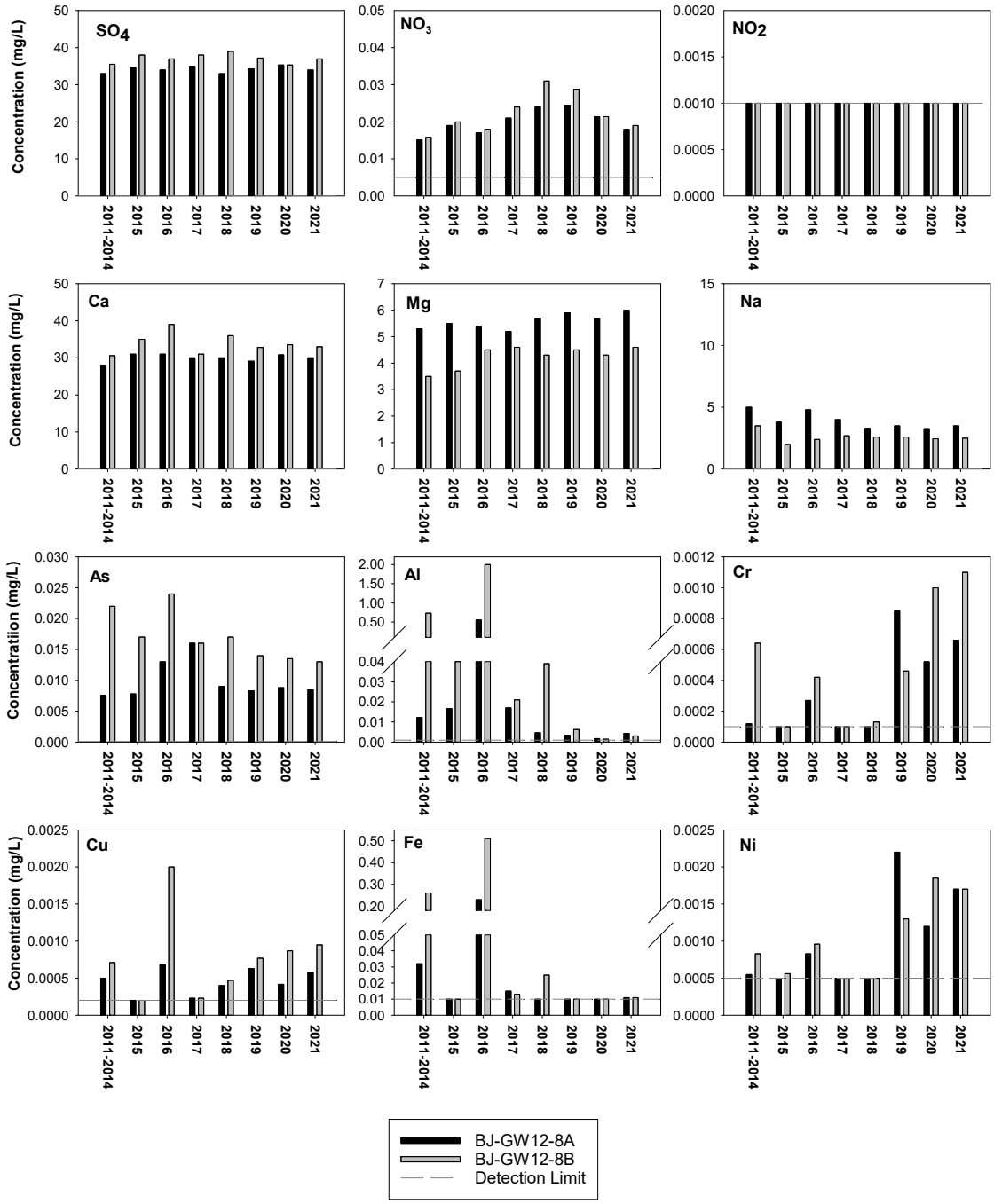

Figure 9: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW12-8A/B

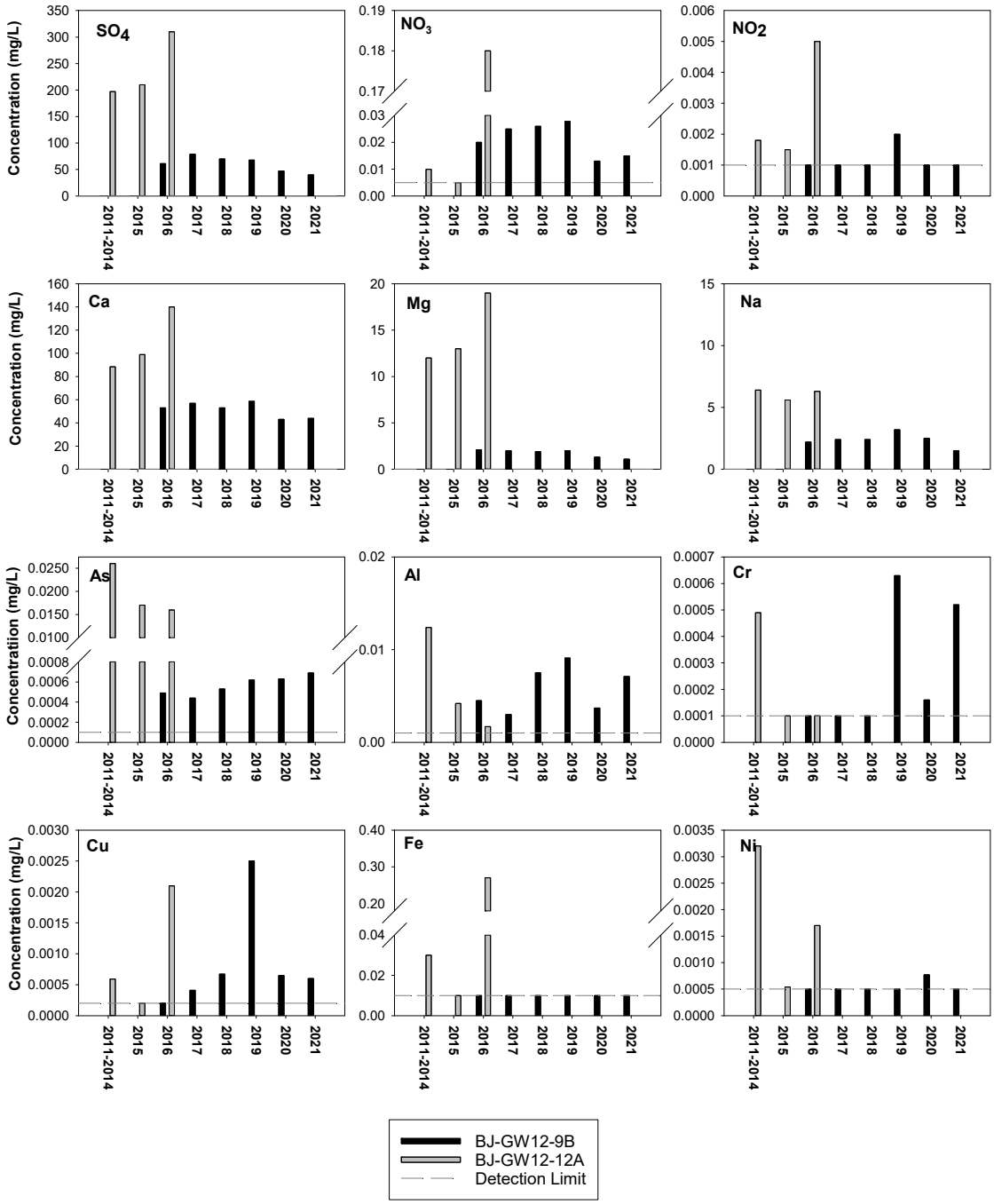

Figure 10: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW12-9B and BJ-GW12-12A

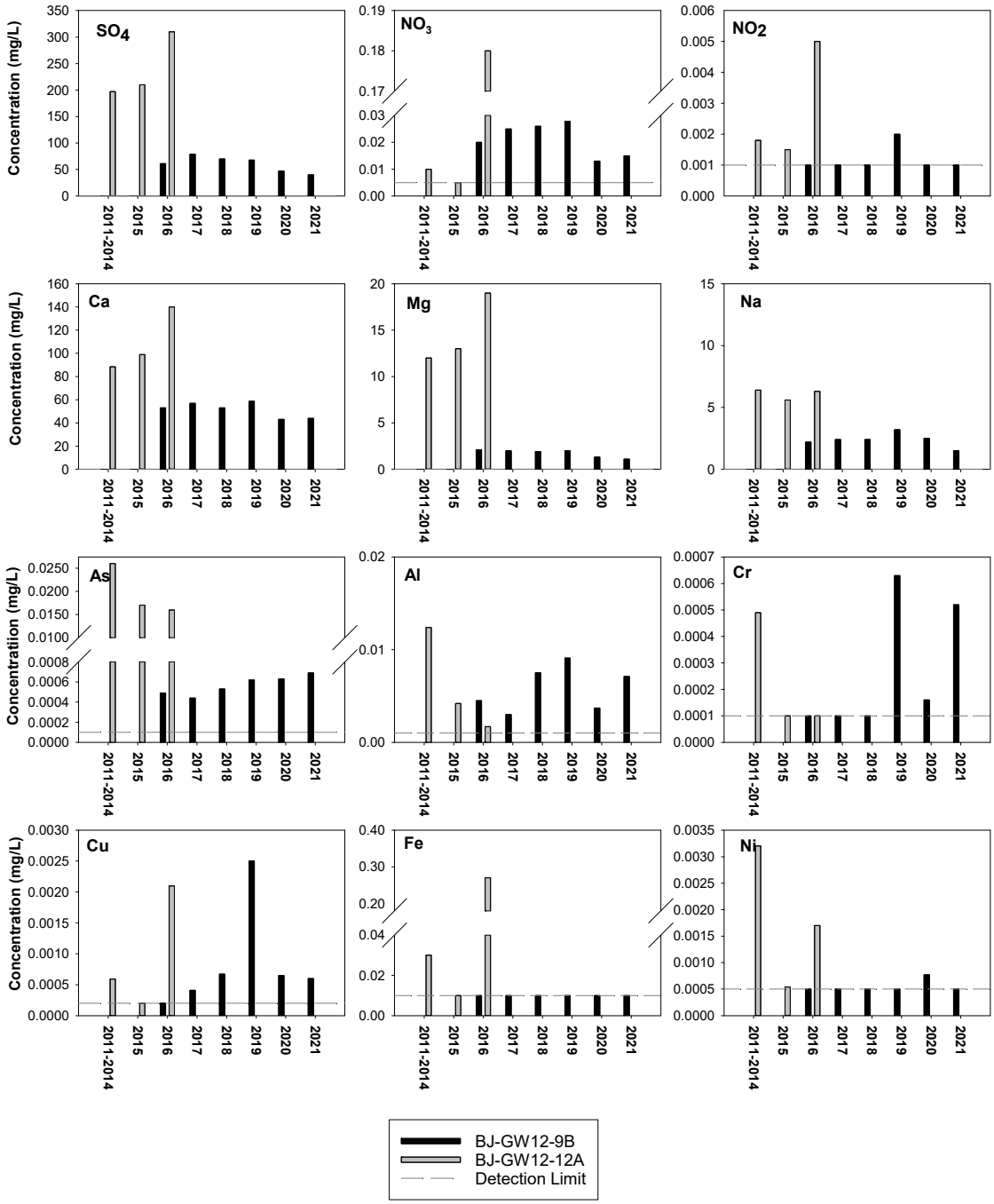

Figure 11: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW12-11A/B

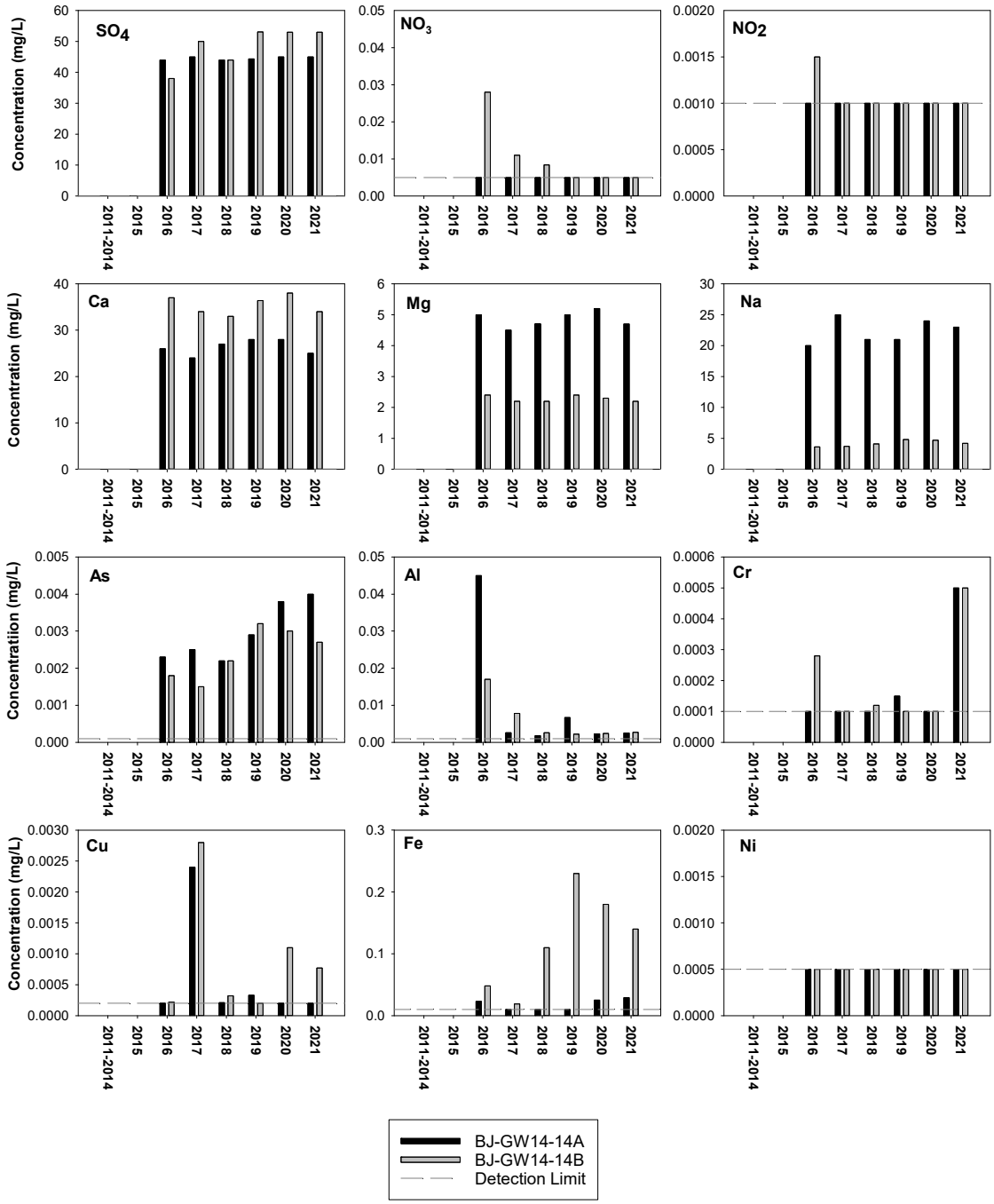

Figure 12: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW14-14A/B

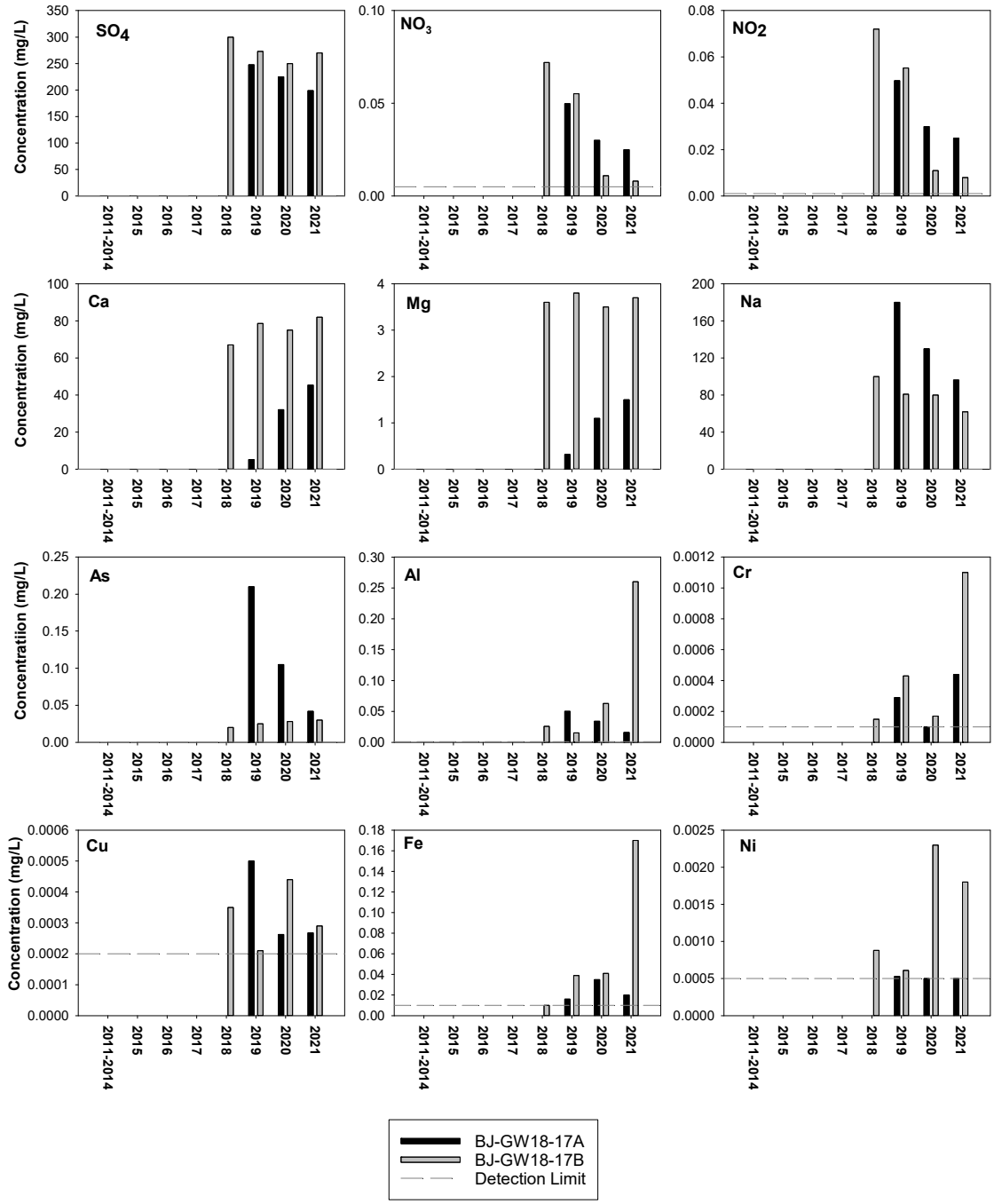

Figure 13: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW18-17A/B

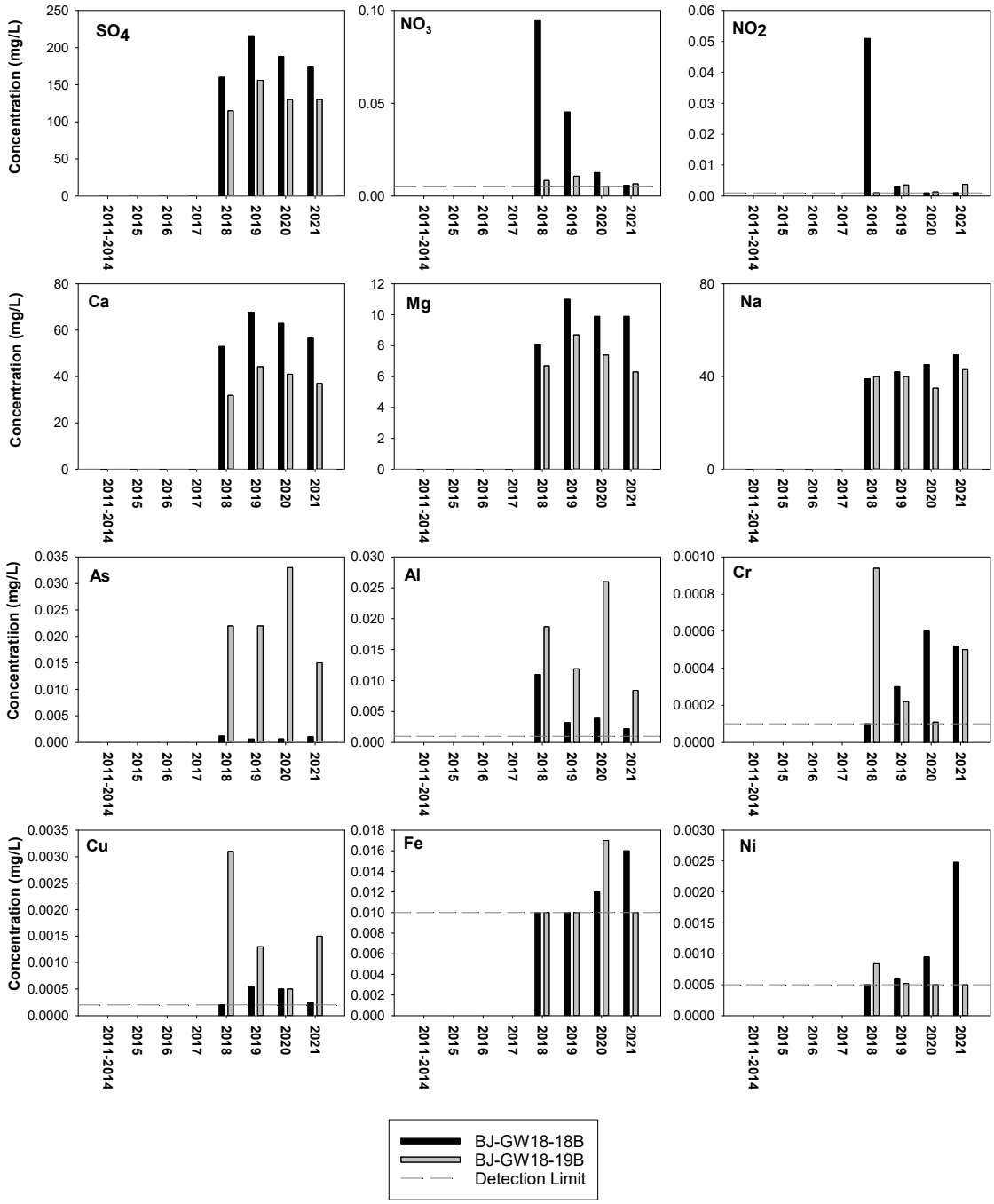

Figure 14: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW18-18B and BJ-GW18-19B

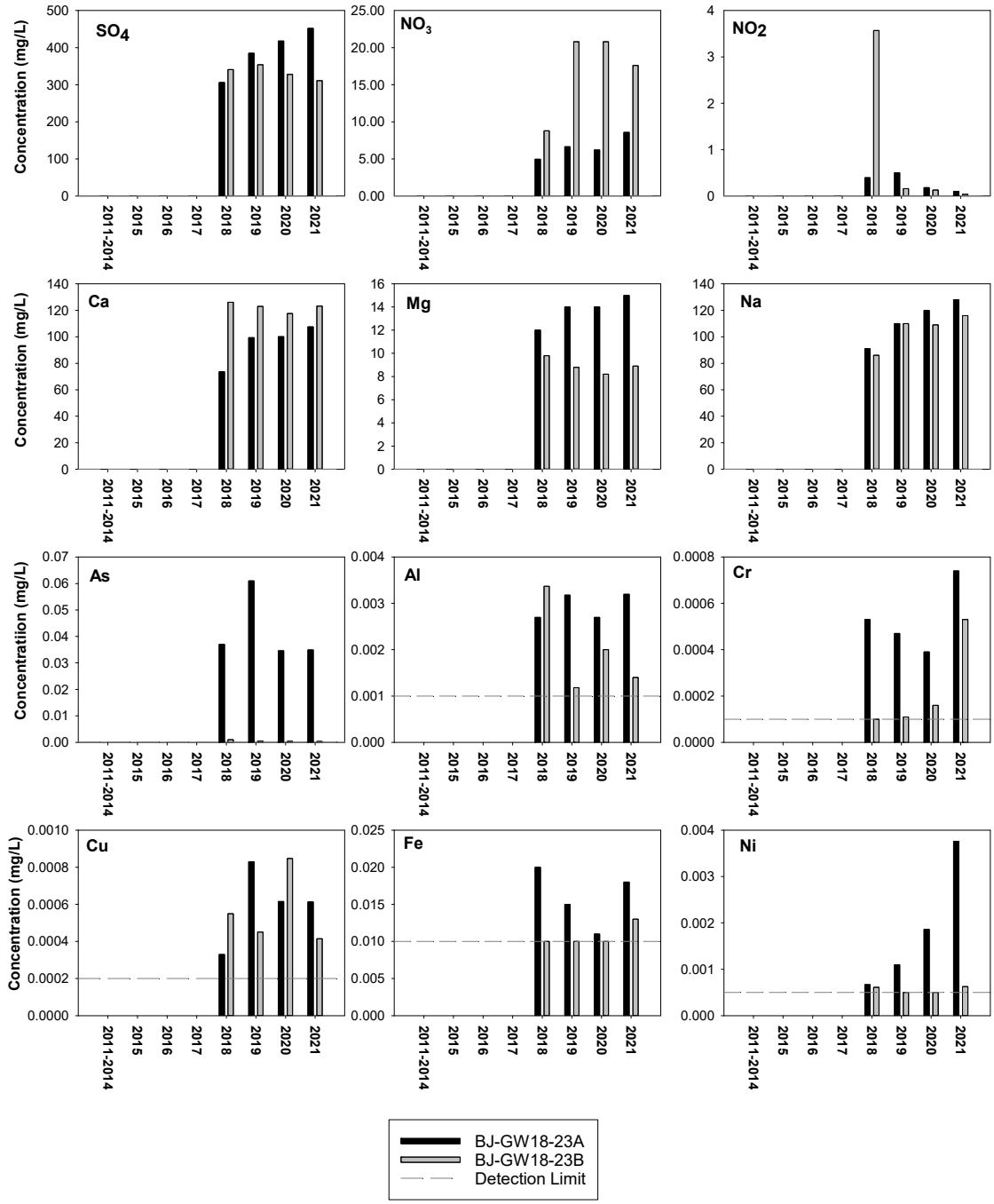

Figure 15: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW18-23A/B

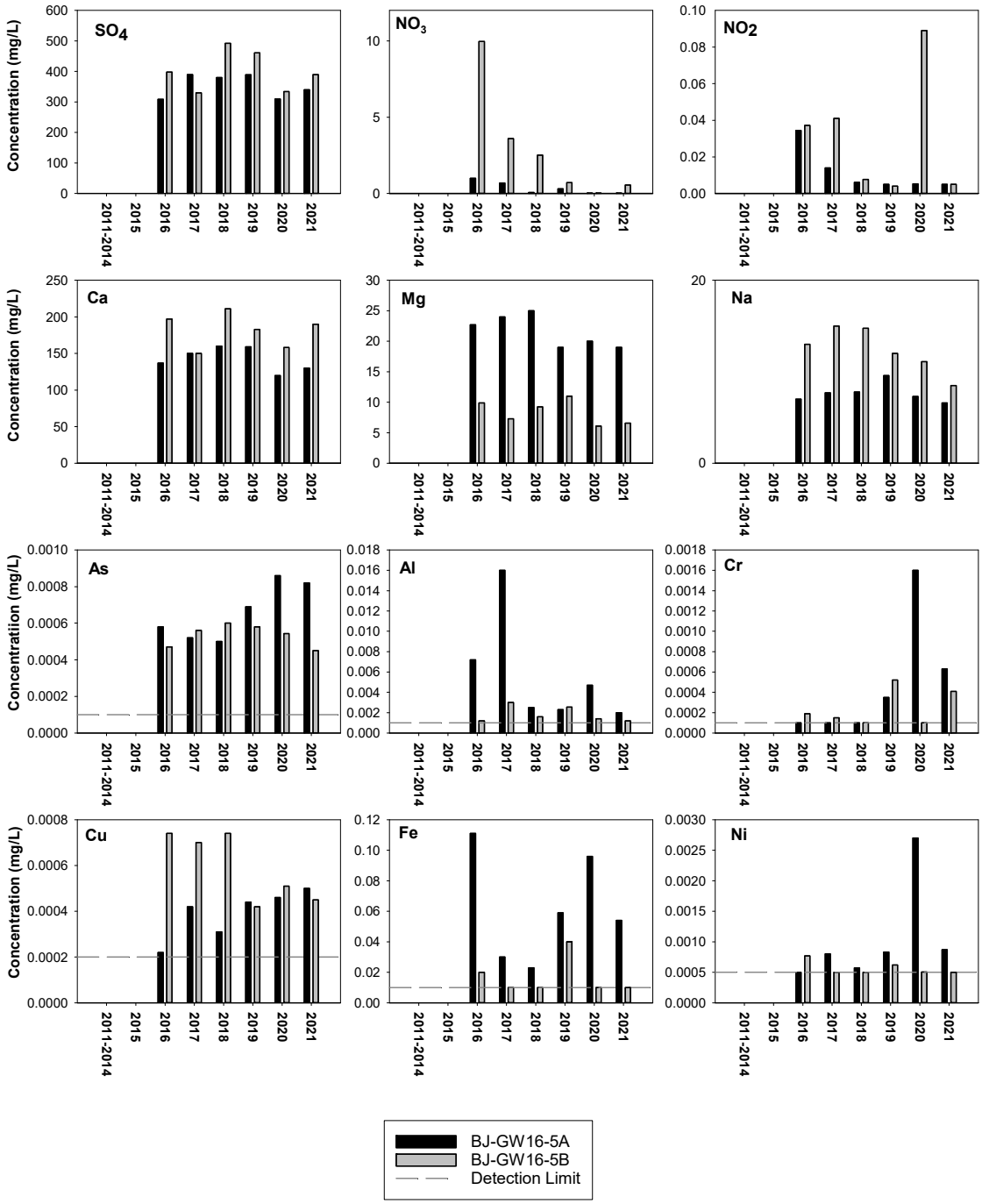

Figure 16: Bar charts of baseline (2011-2014) and average annual concentrations for selected parameters at BJ-GW16-5A/B

Appendix I3: Groundwater Quality Time Series

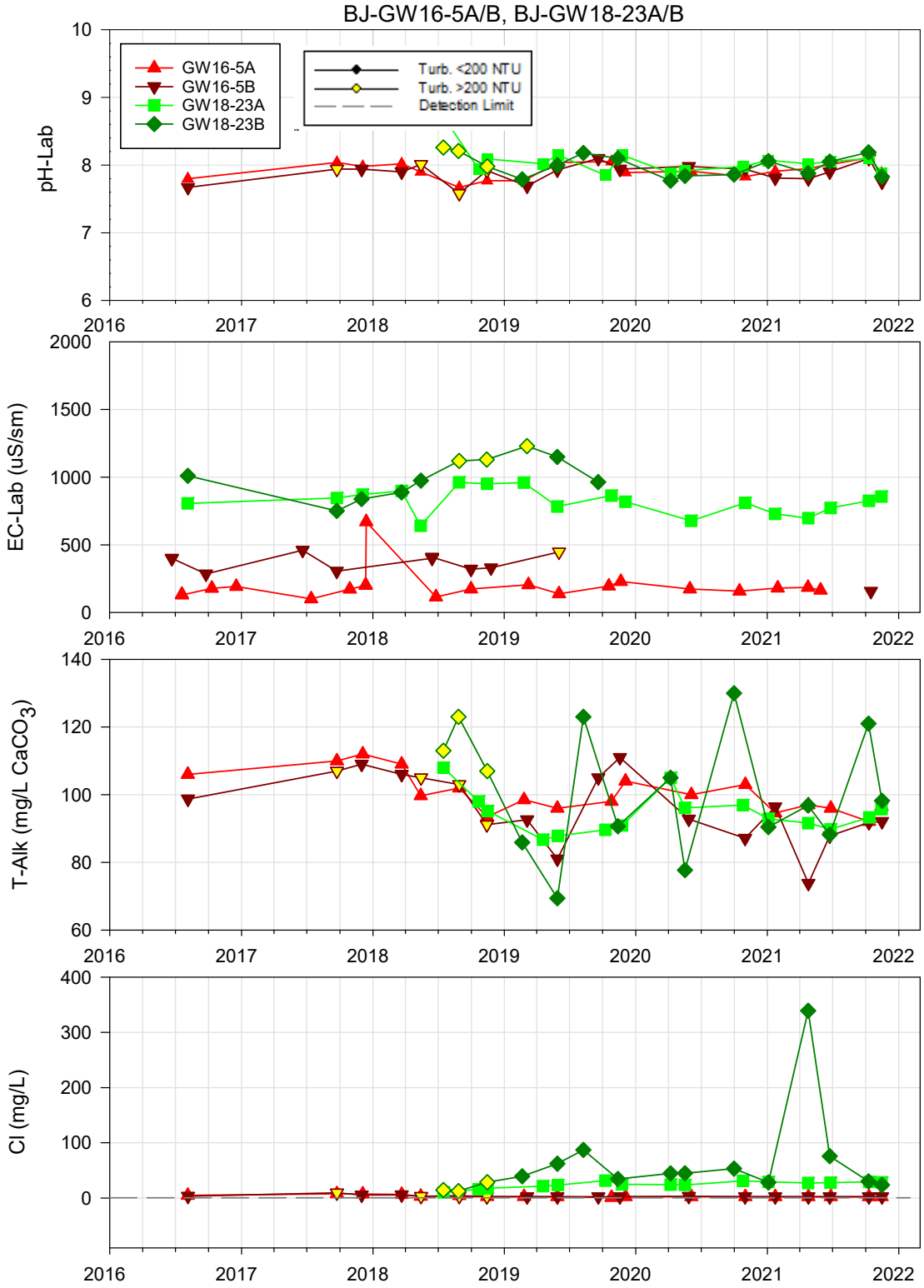

Figure 17: Time series of pH, EC, T-Alk and Cl at wells downgradient of the Contact Water Pond (BJ-GW16-5A/B, BJ-GW18-23A/B)

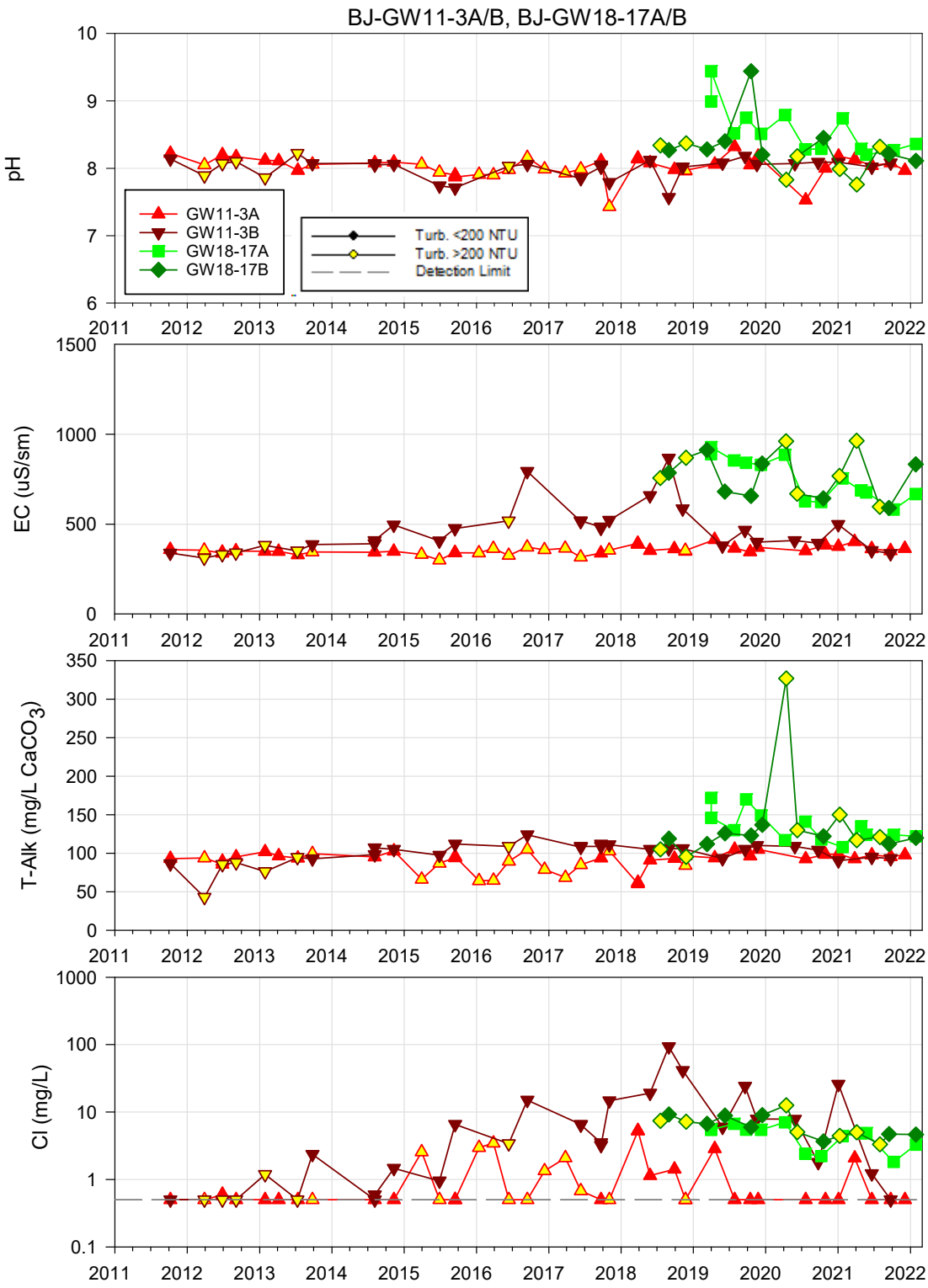

Figure 18: Time series of pH, EC, T-Alk and Cl at wells east of the West Zone Portal (BJ-GW11-3A/B, BJ-GW18-17A/B)

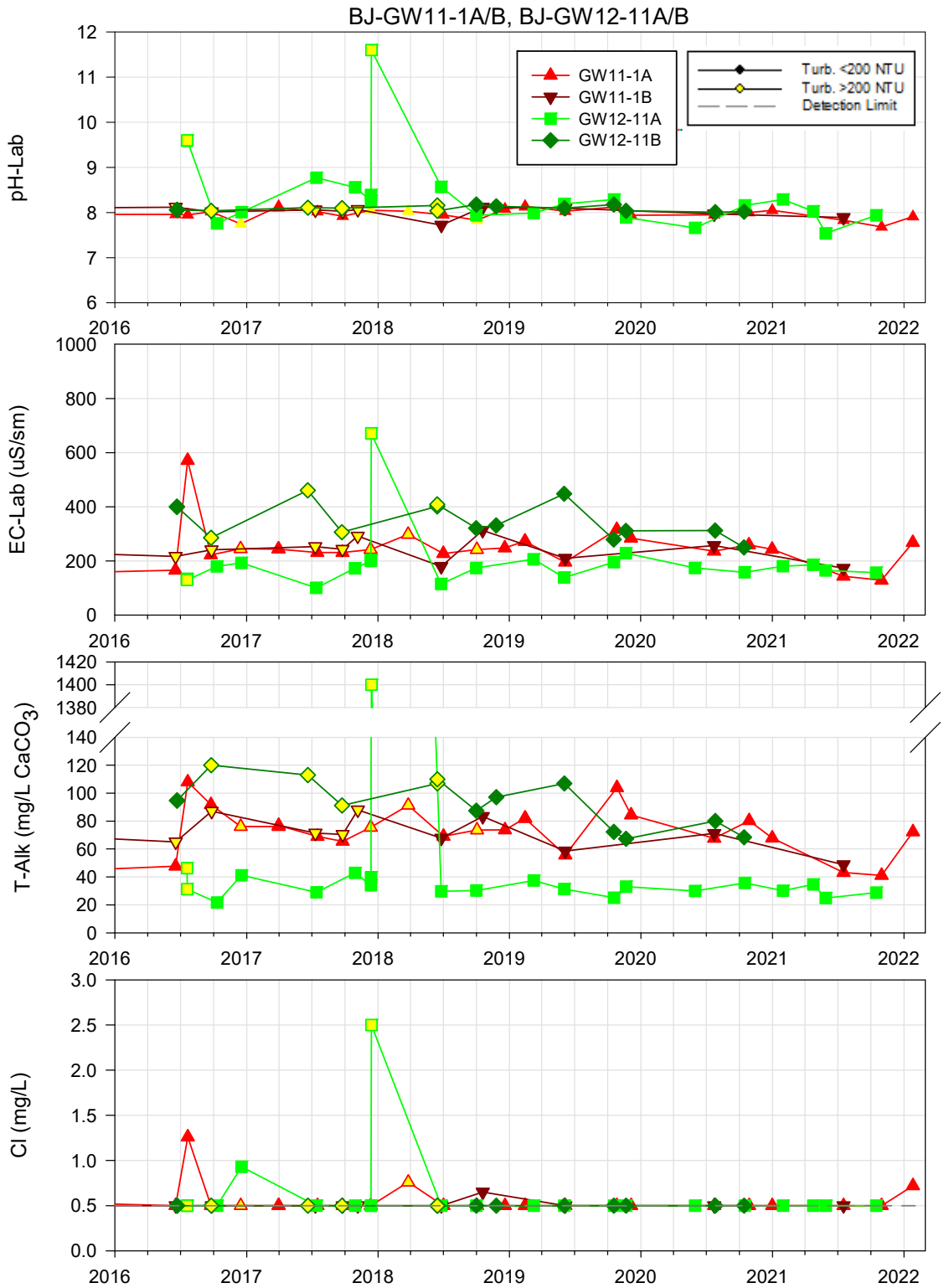

Figure 19: Time series of pH, EC, T-Alk and Cl at wells west of the West Zone Portal (BJ-GW11-1A/B, BJ-GW12-11A/B)

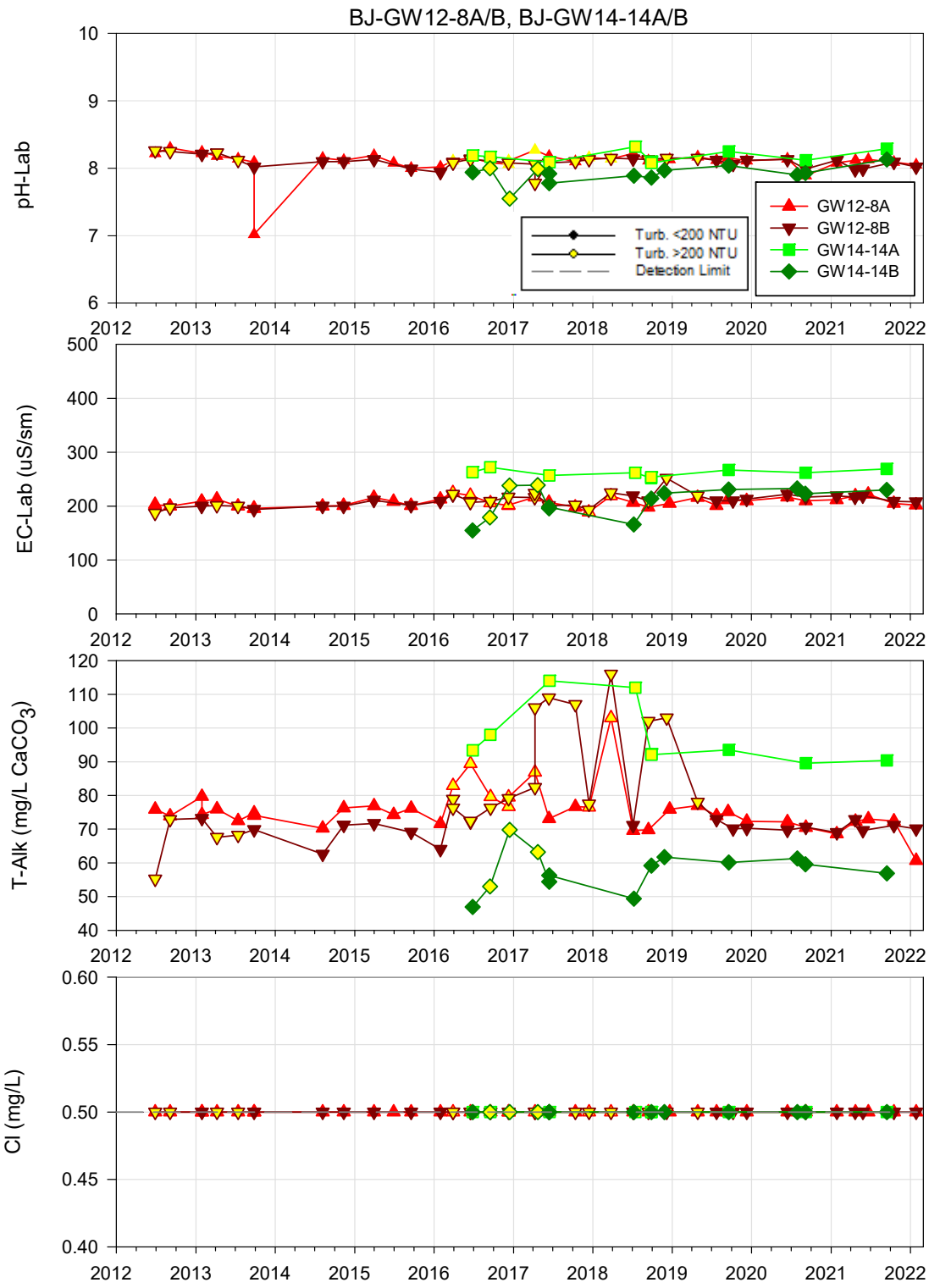

Figure 20: Time series of pH, EC, T-Alk and Cl at wells west of the Brucejack Fault (BJ-GW12-8A/B, BJ-GW14-14A/B)

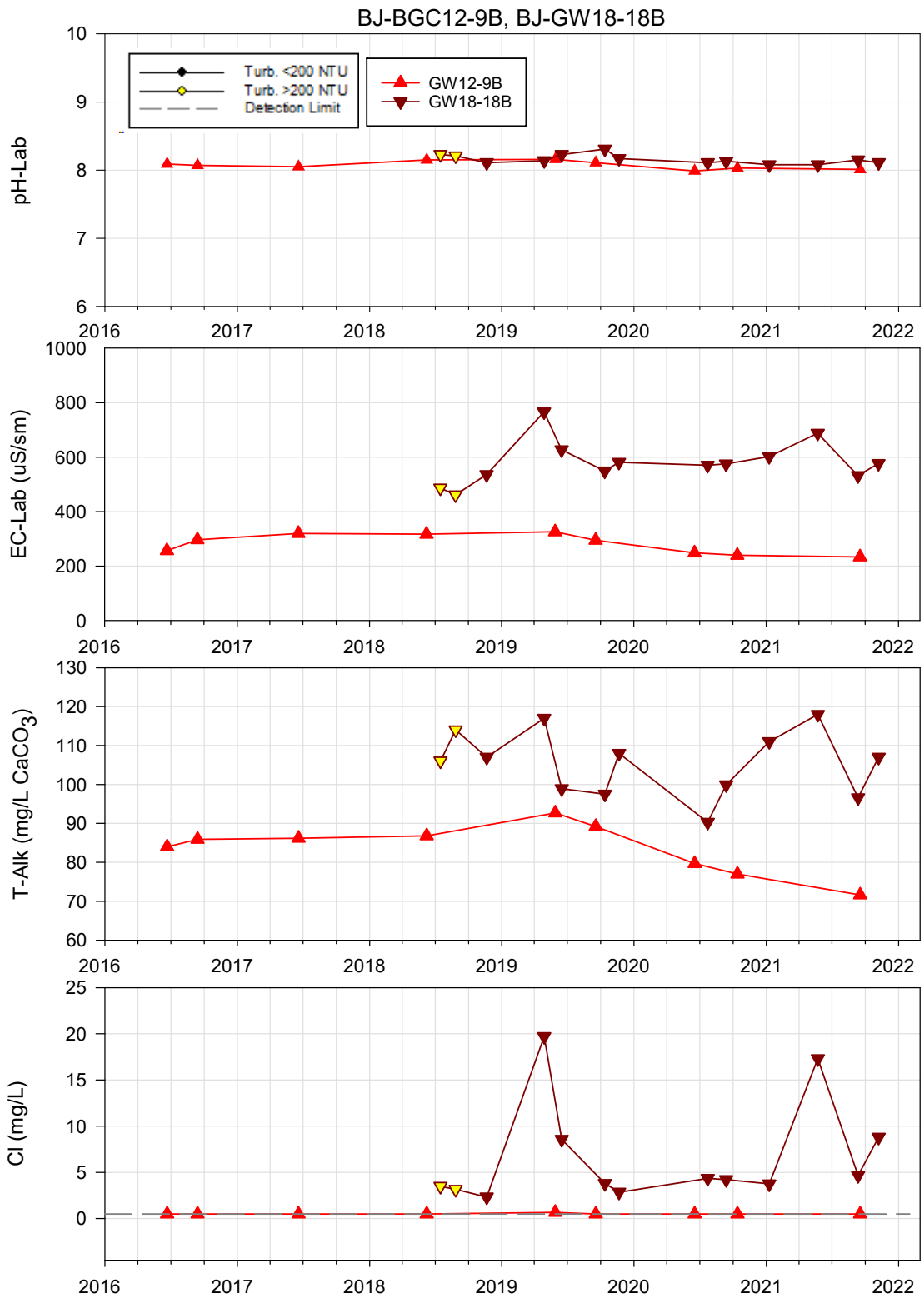

Figure 21: Time series of pH, EC, T-Alk and Cl at wells south and east of the VOK Zone (BJ-GW12-9B, BJ-GW18-18B)

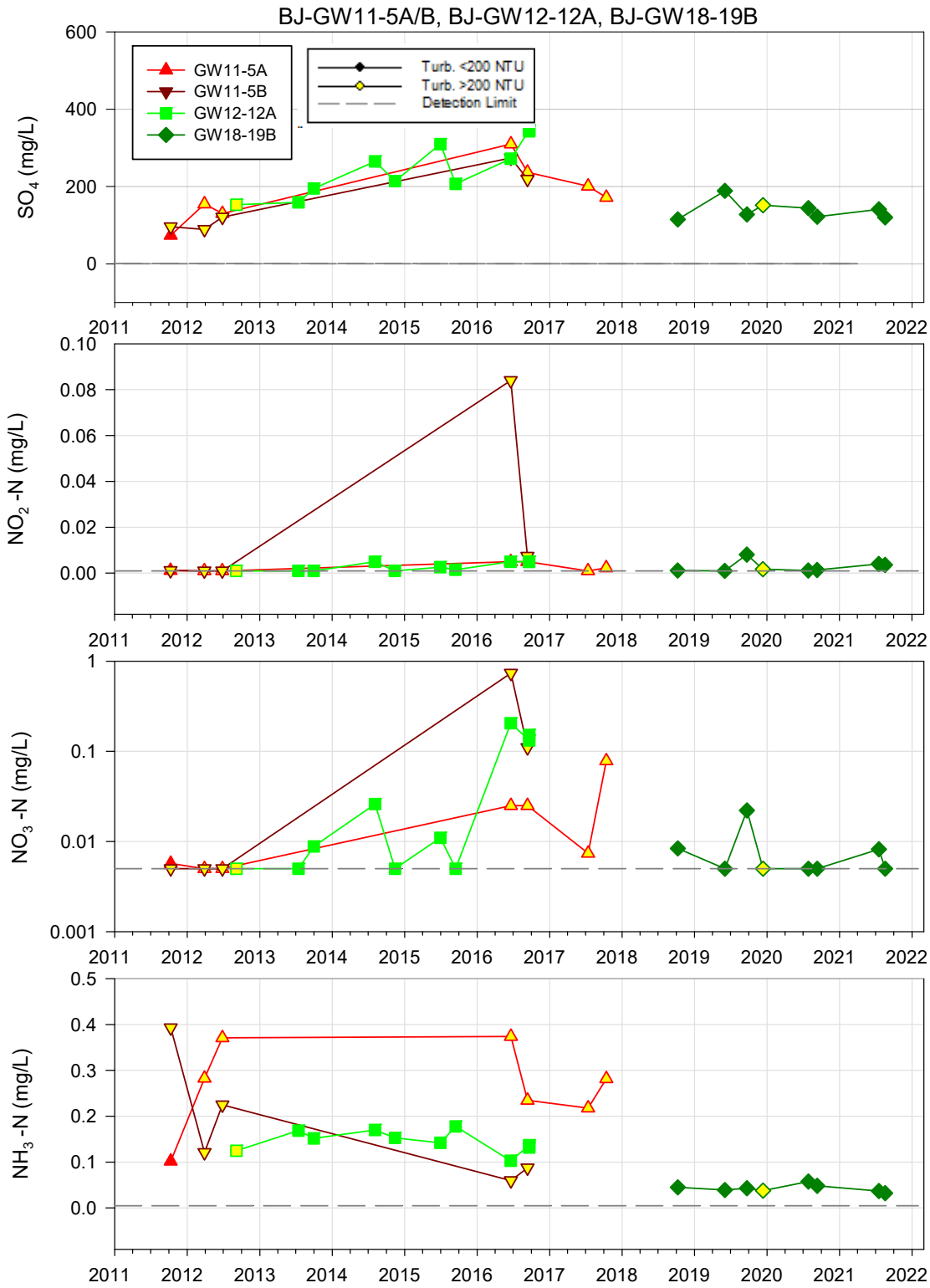

Figure 22: Time series of pH, EC, T-Alk and Cl at wells peripheral to the VOK Zone (BJ-GW11-5A/B, BJ-GW12-12A, BJ-GW18-19B)

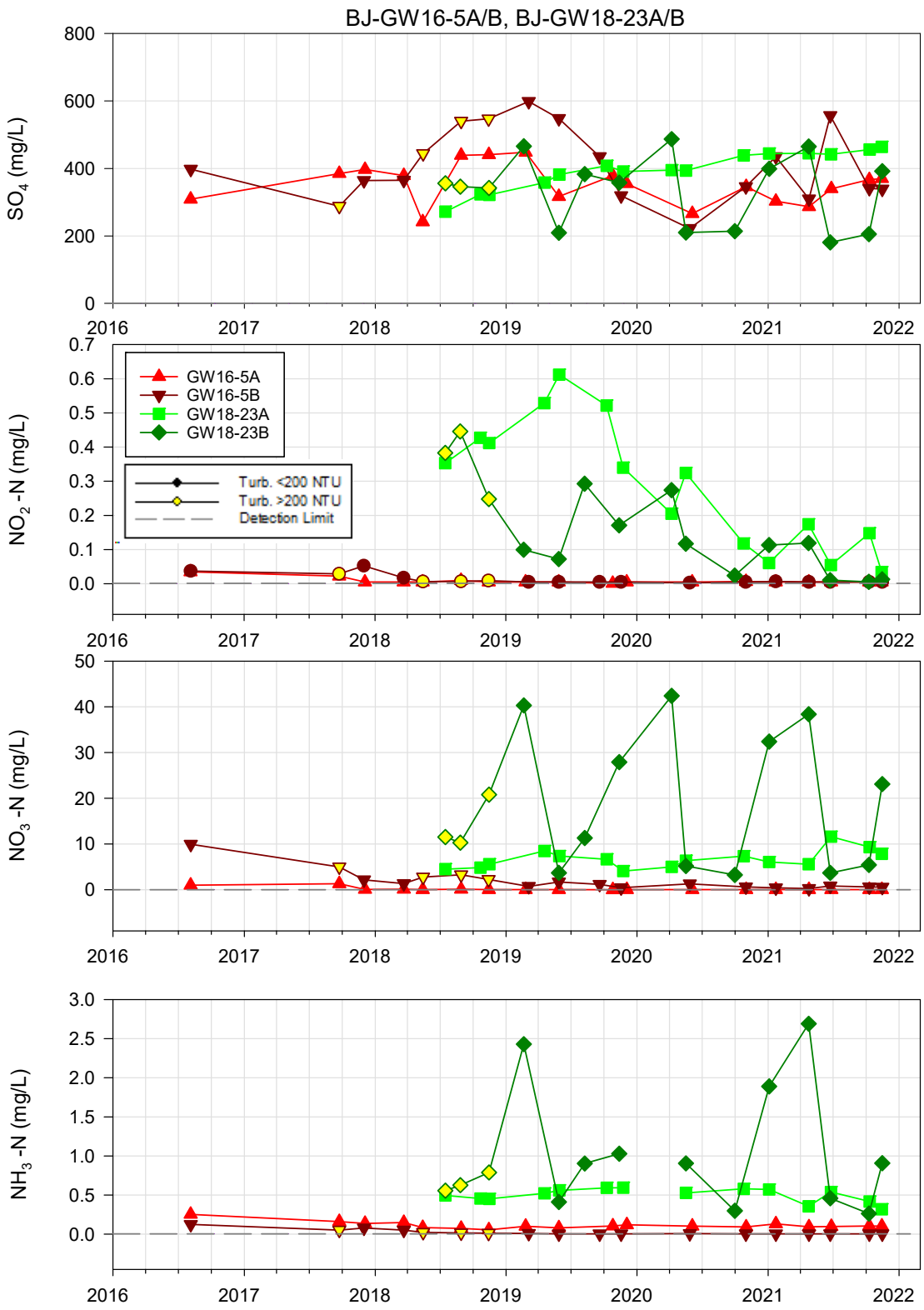

Figure 23: Time series of SO_4, NO_2, NO_3 and NH_3 at wells downgradient of the Contact Water Pond (BJ-GW16-5A/B, BJ-GW18-23A/B)

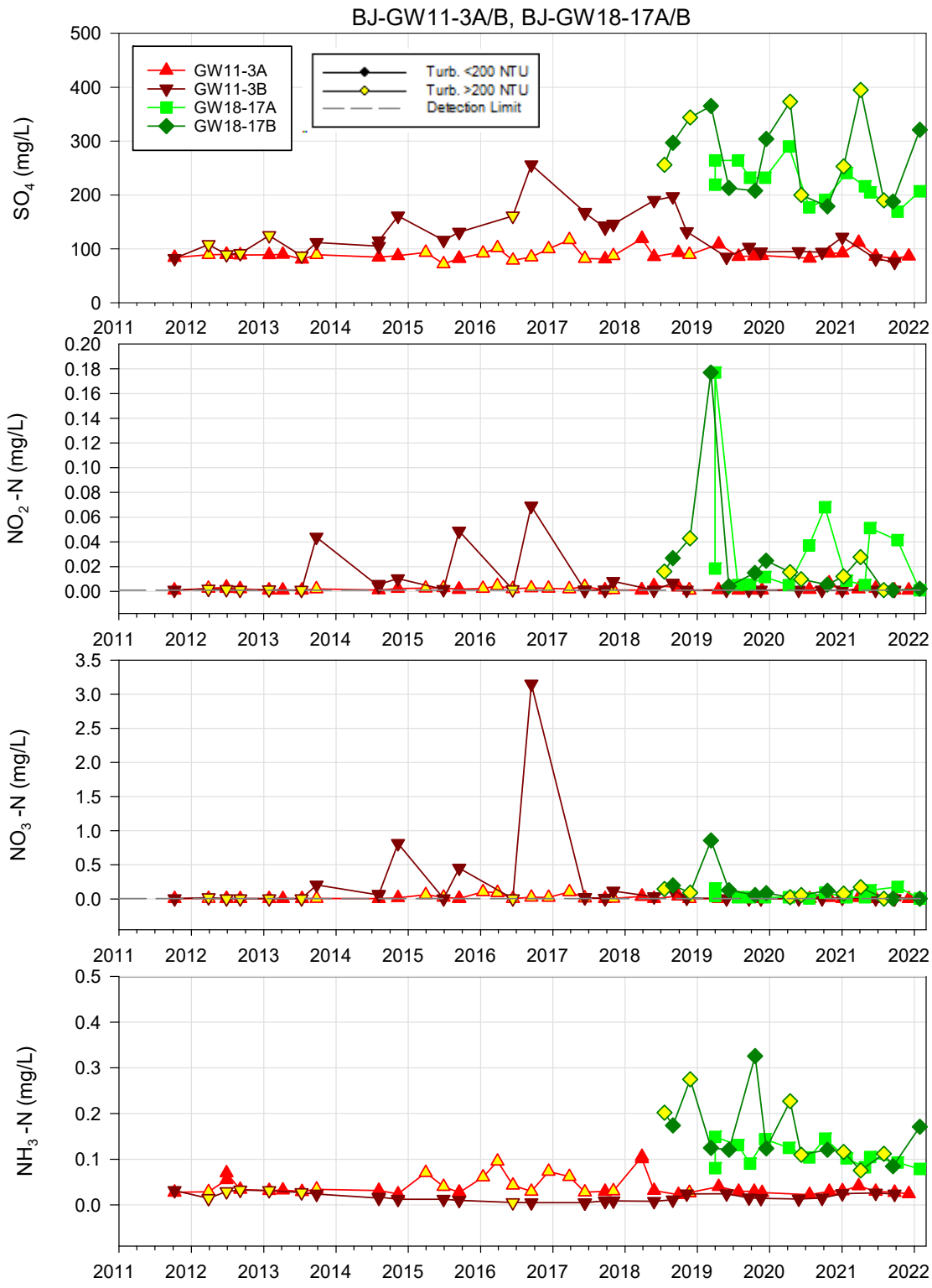

Figure 24: Time series of SO_4, NO_2, NO_3 and NH_3 at wells east of the West Zone Portal (BJ-GW11-3A/B, BJ-GW18-17A/B)

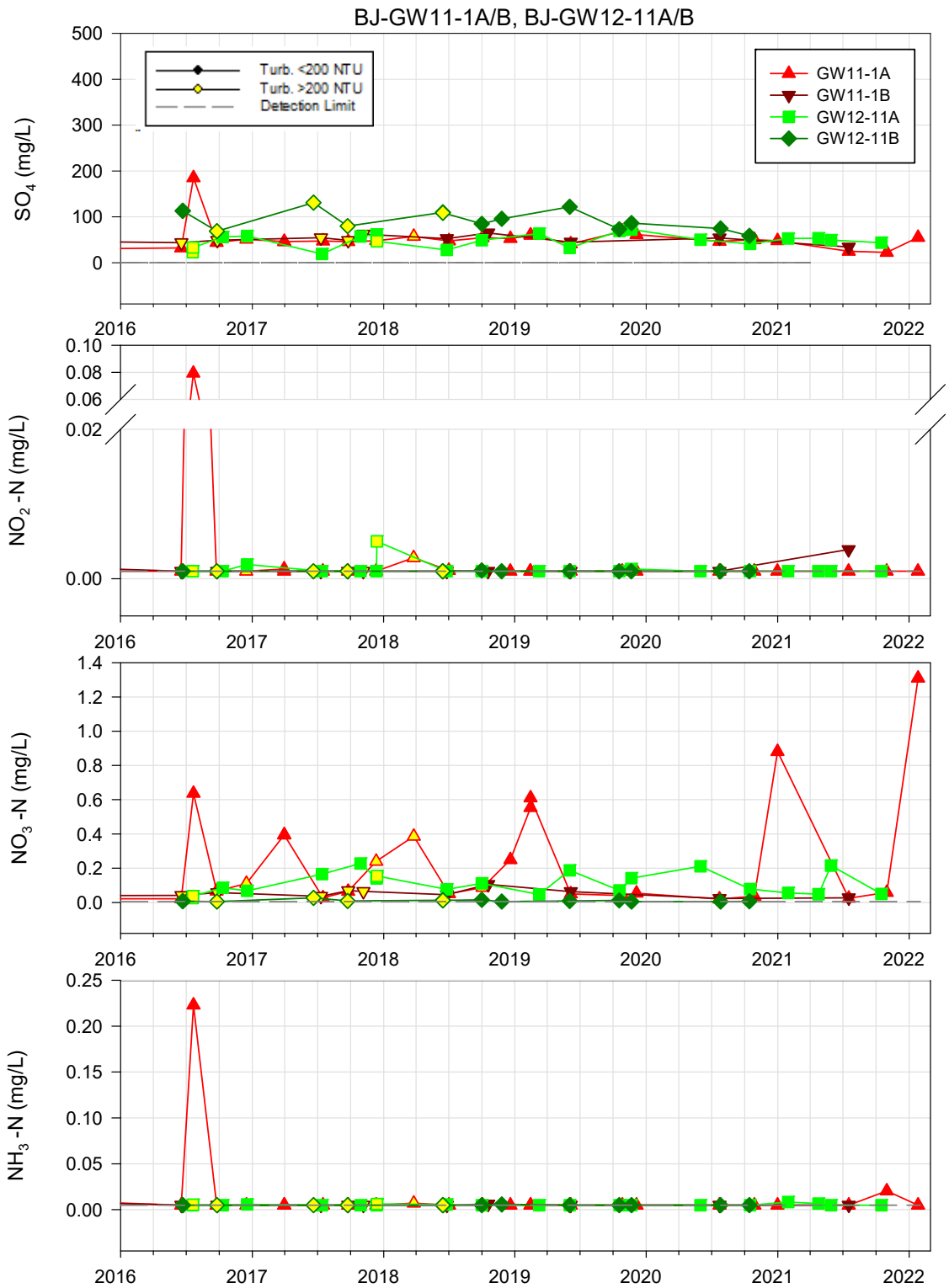

Figure 25: Time series of SO_4, NO_2, NO_3 and NH_3 at wells west of the West Zone Portal (BJ-GW11-1A/B, BJ-GW12-11A/B)

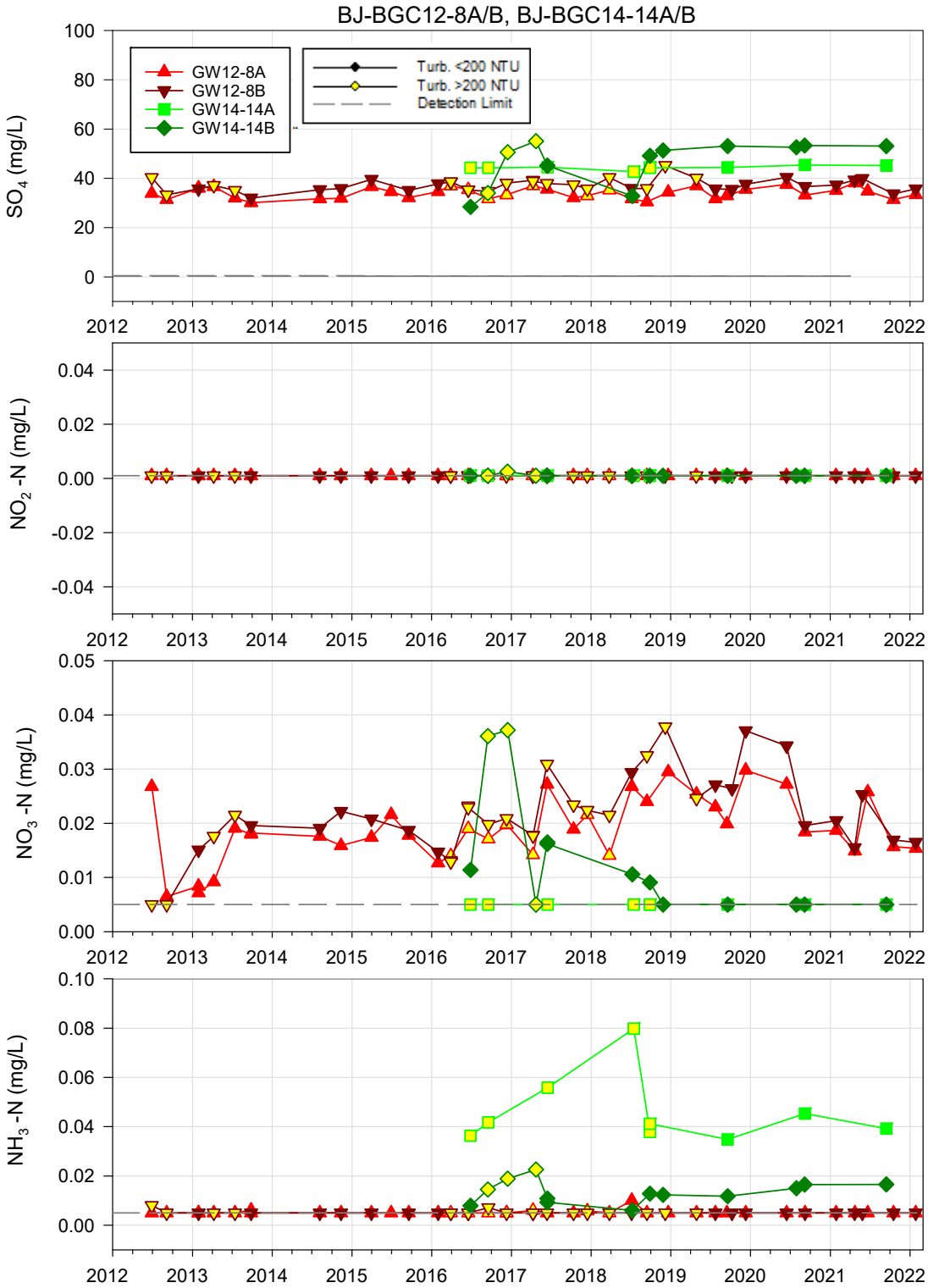

Figure 26: Time series of SO_4, NO_2, NO_3 and NH_3 at wells west of the Brucejack Fault (BJ-GW12-8A/B, BJ-GW14-14A/B)

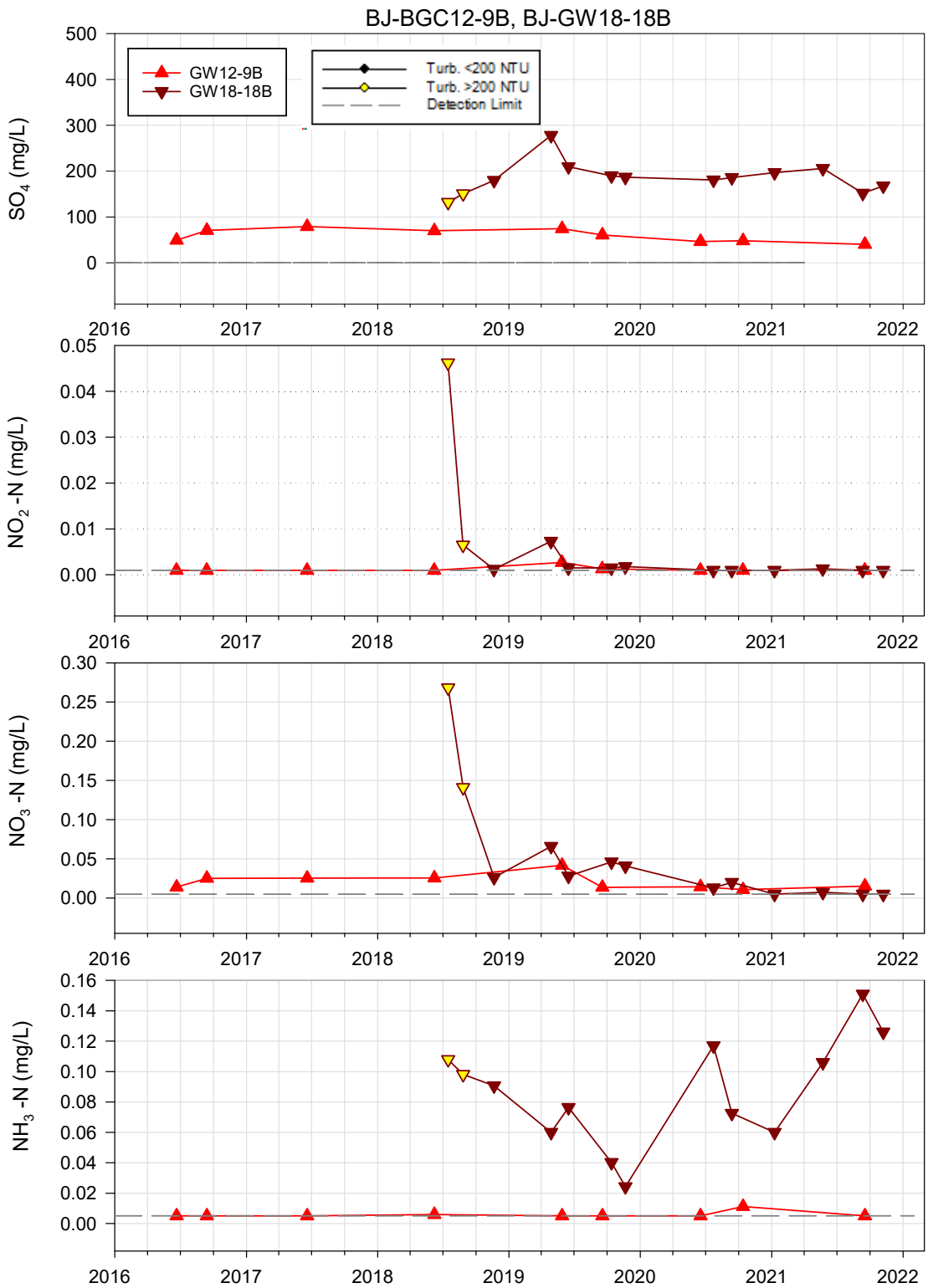

Figure 27: Time series of SO_4, NO_2, NO_3 and NH_3 at wells south and east of the VOK Zone (BJ-GW12-9B, BJ-GW18-18B)

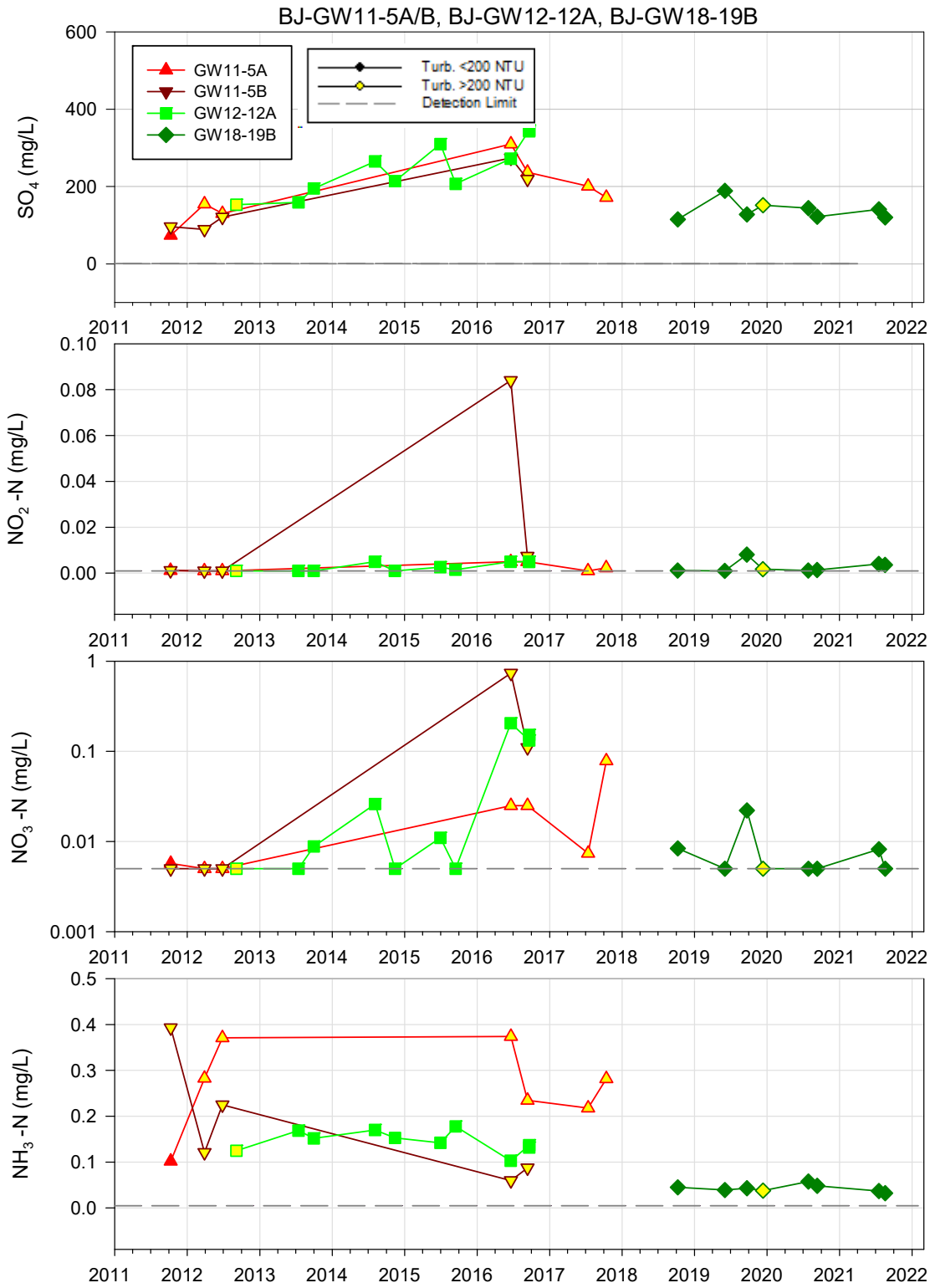

Figure 28: Time series of SO_4, NO_2, NO_3 and NH_3 at wells peripheral to the VOK Zone (BJ-GW11-5A/B, BJ-GW12-12A, BJ-GW18-19B)

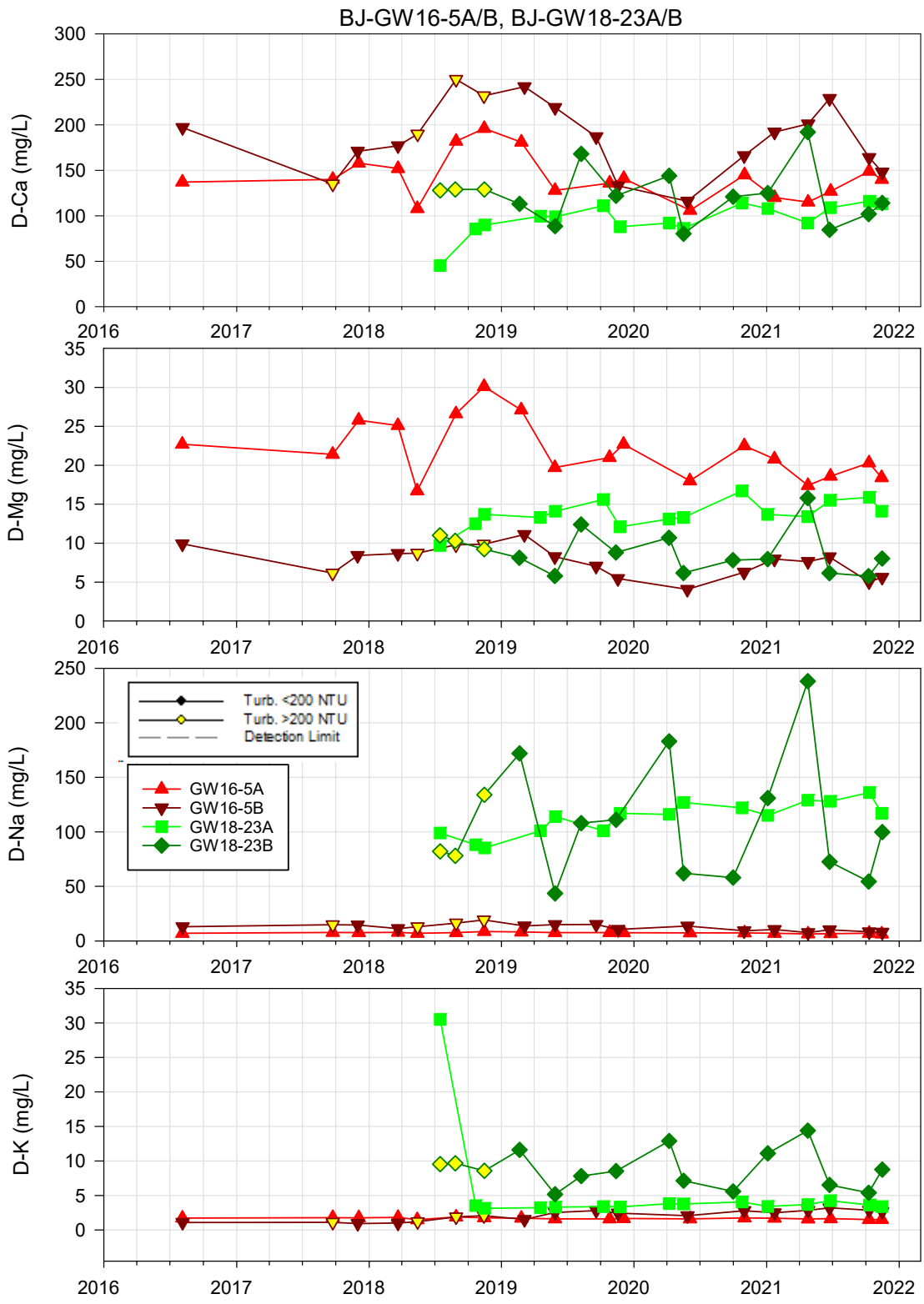

Figure 29: Time series of Ca, Mg, Na and K at wells downgradient of the Contact Water Pond (BJ-GW16-5A/B, BJ-GW18-23A/B)

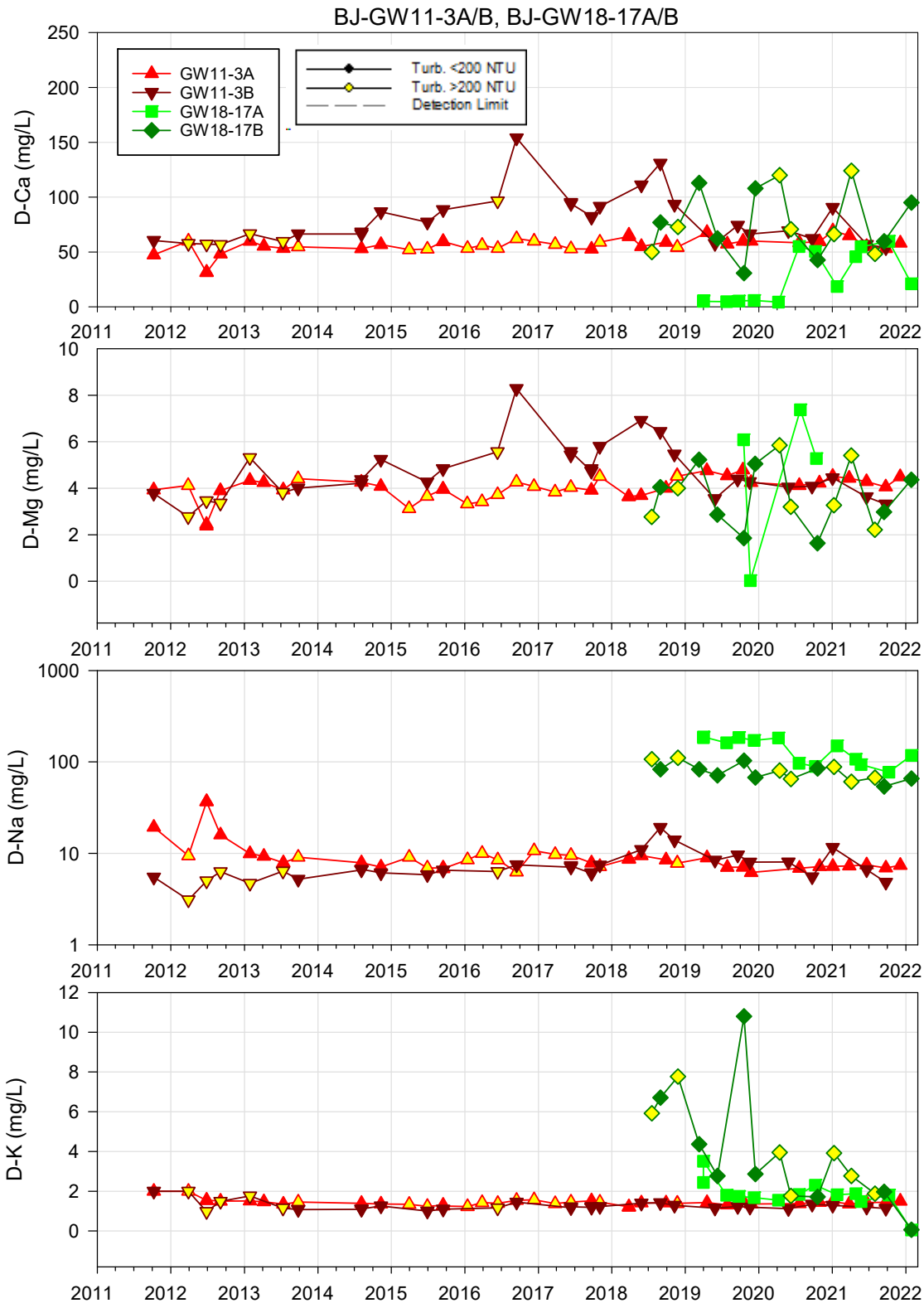

Figure 30: Time series of Ca, Mg, Na and K at wells east of the West Zone Portal (BJ-GW11-3A/B, BJ-GW18-17A/B)

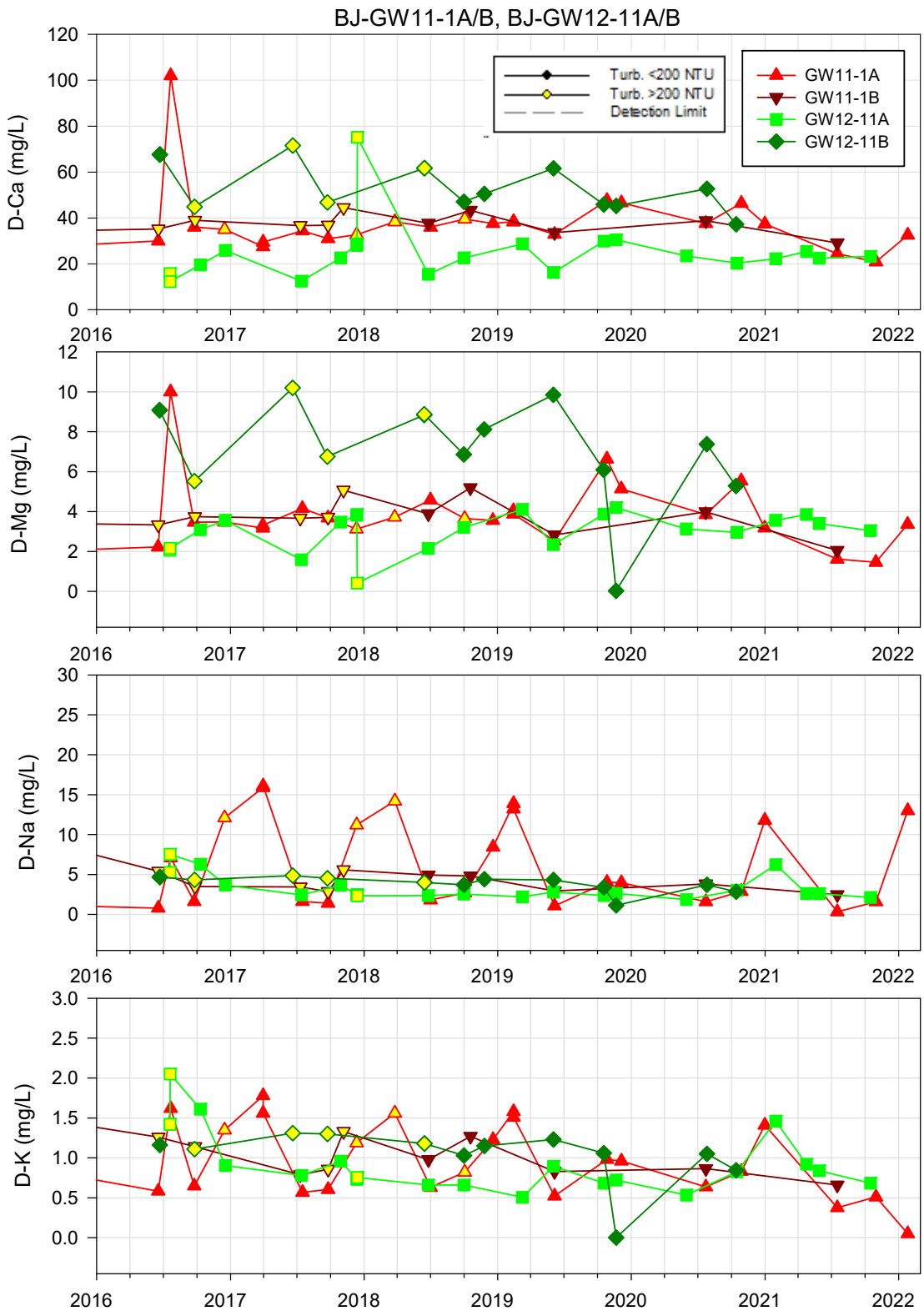

Figure 31: Time series of Ca, Mg, Na and K at wells west of the West Zone Portal (BJ-GW11-1A/B, BJ-GW12-11A/B)

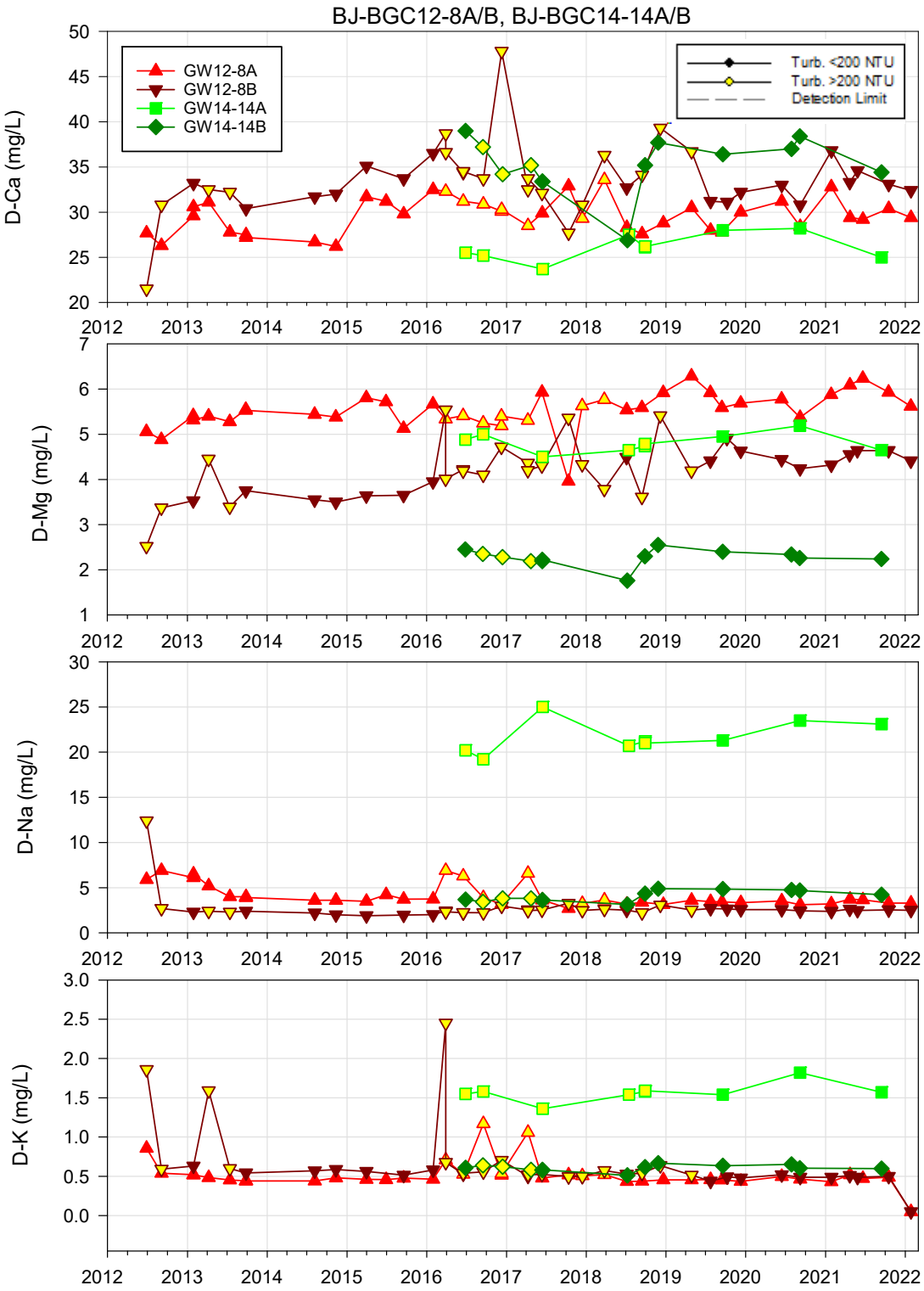

Figure 32: Time series of Ca, Mg, Na and K at wells west of the Brucejack Fault (BJ-GW12-8A/B, BJ-GW14-14A/B)

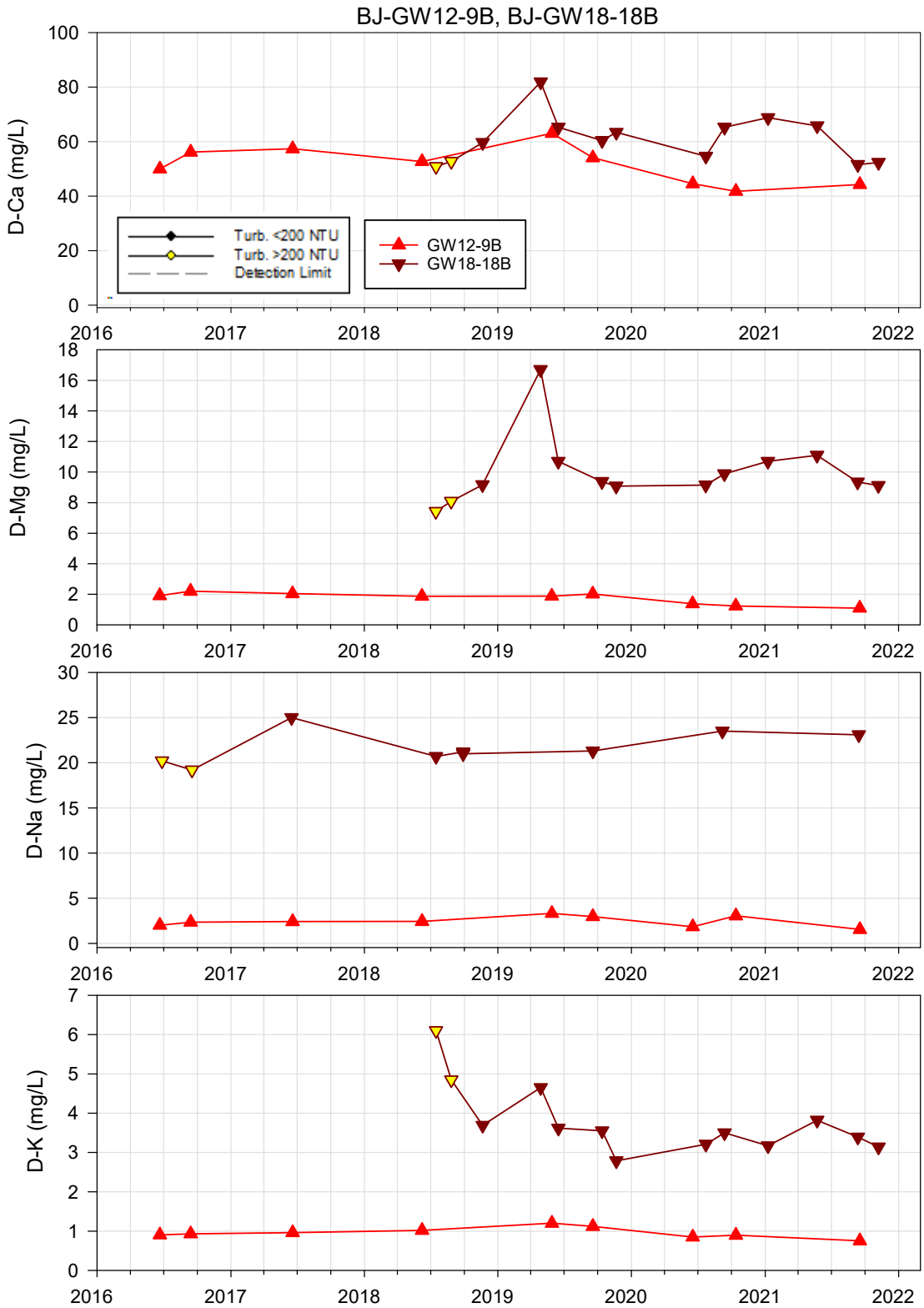

Figure 33: Time series of Ca, Mg, Na and K at wells south and east of the VOK Zone (BJ-GW12-9B, BJ-GW18-18B)

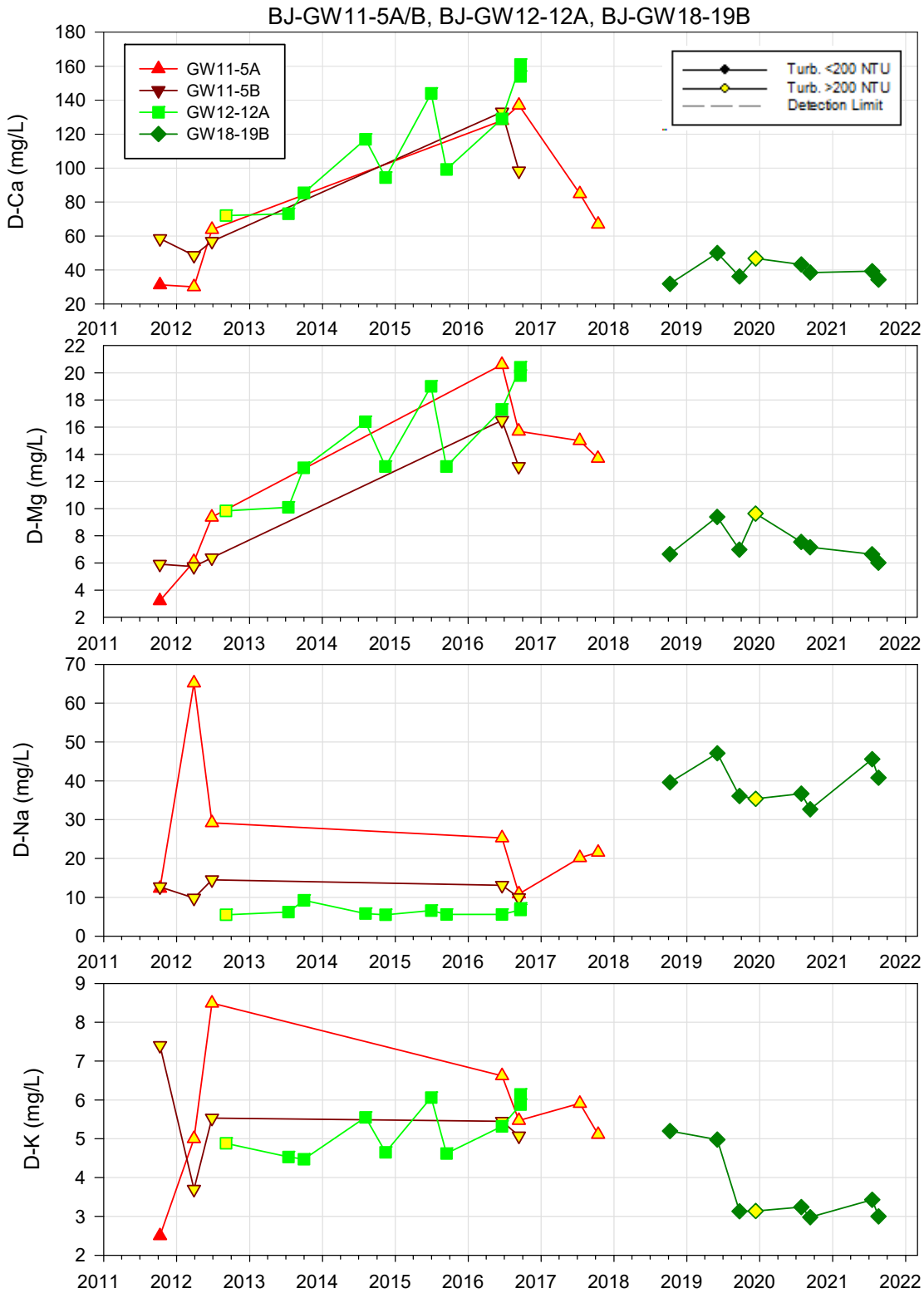

Figure 34: Time series of Ca, Mg, Na and K at wells peripheral to the VOK Zone (BJ-GW11-5A/B, BJ-GW12-12A, BJ-GW18-19B)

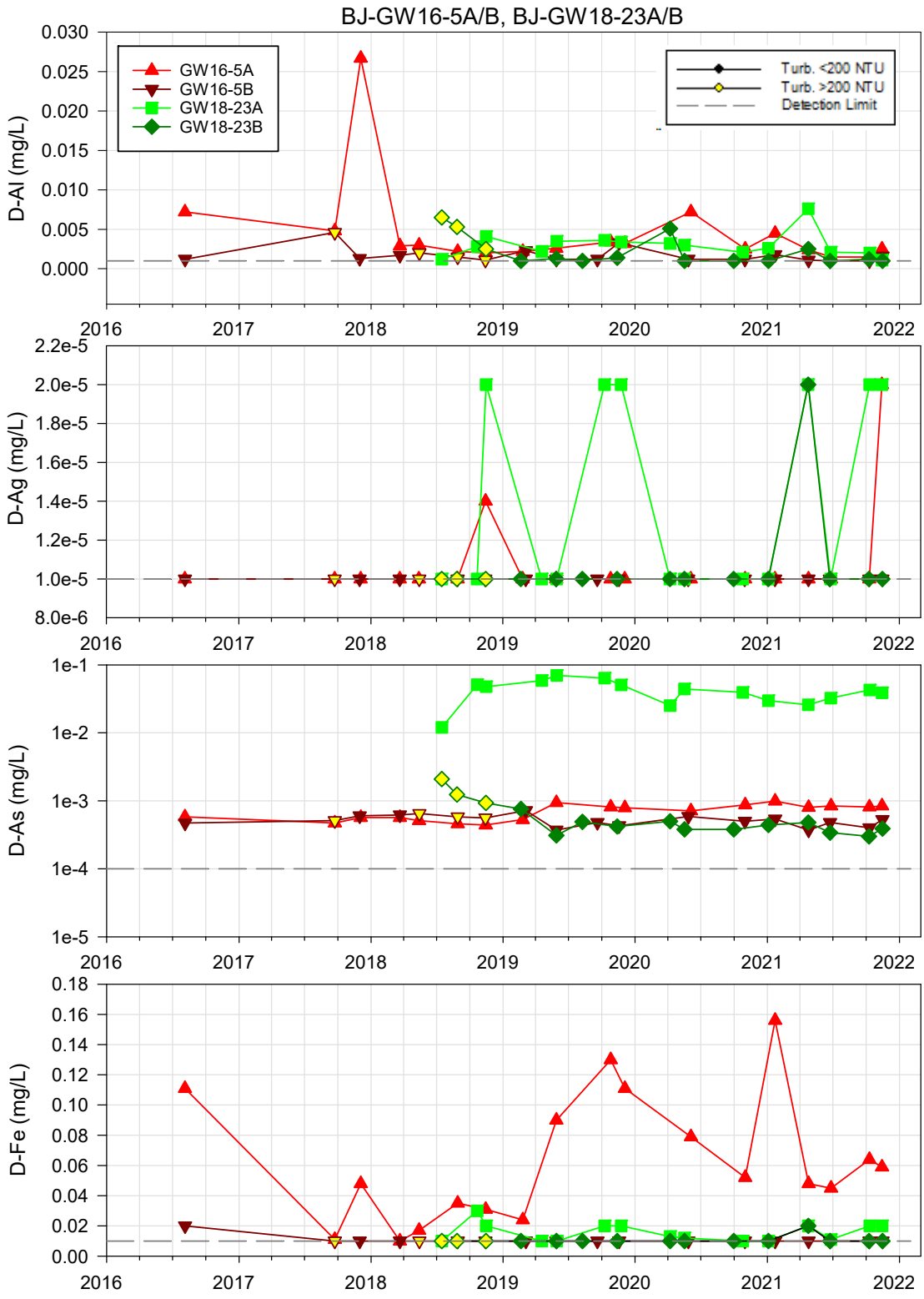

Figure 35: Time series of Al, Ag, As and Fe at wells downgradient of the Contact Water Pond (BJ-GW16-5A/B, BJ-GW18-23A/B)

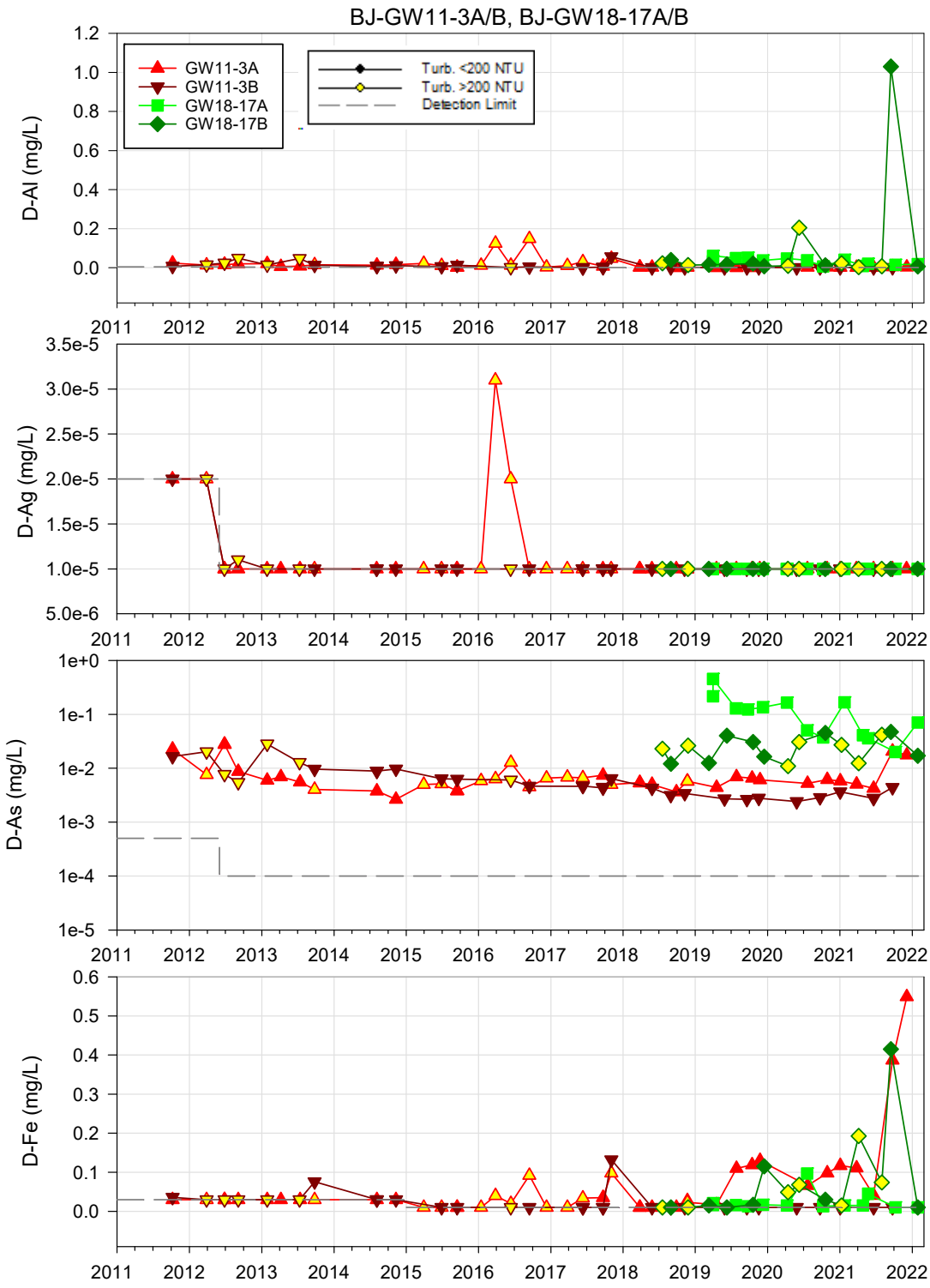

Figure 36: Time series of Al, Ag, As and Fe at wells east of the West Zone Portal (BJ-GW11-3A/B, BJ-GW18-17A/B)

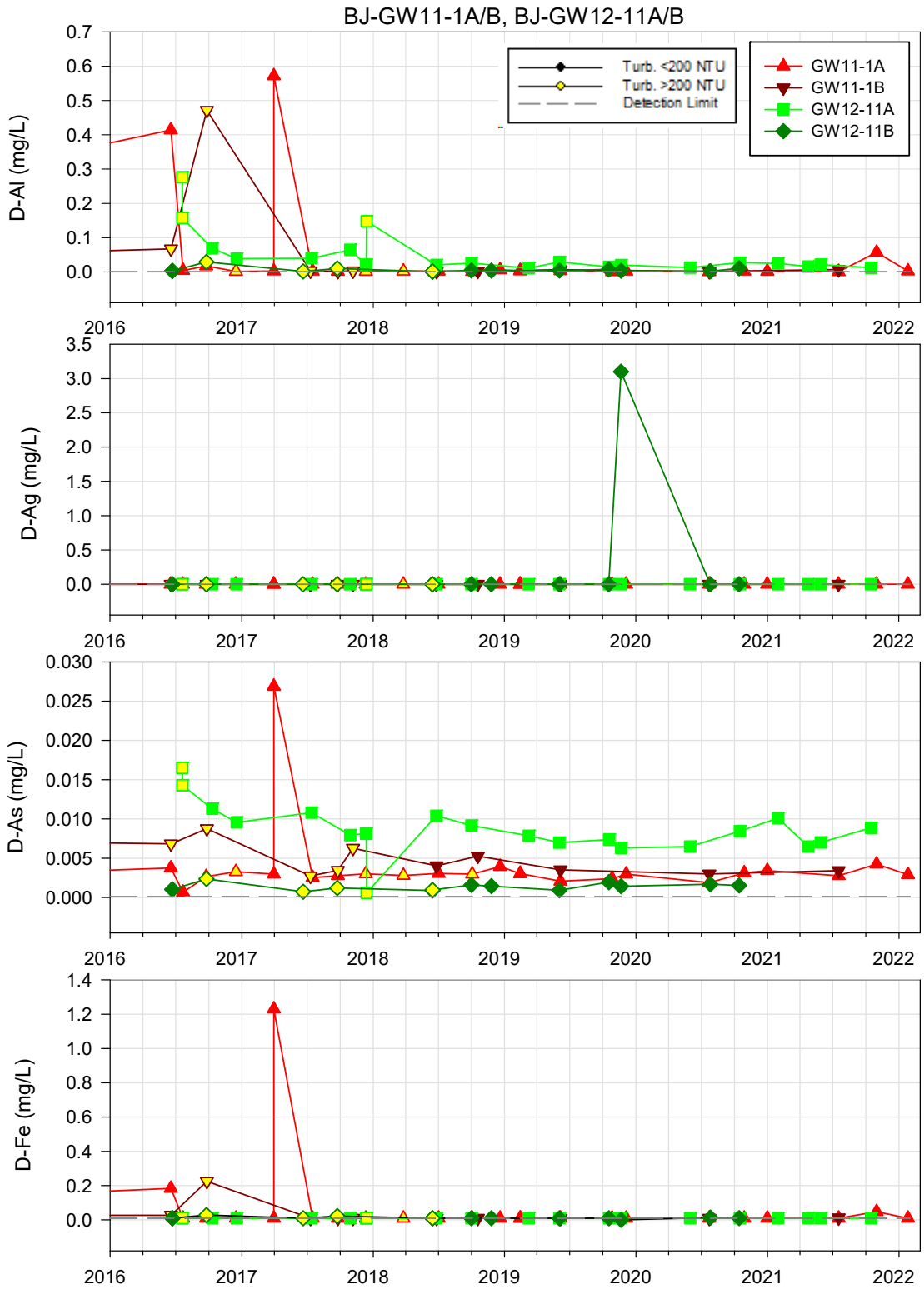

Figure 37: Time series of Al, Ag, As and Fe at wells west of the West Zone Portal (BJ-GW11-1A/B, BJ-GW12-11A/B)

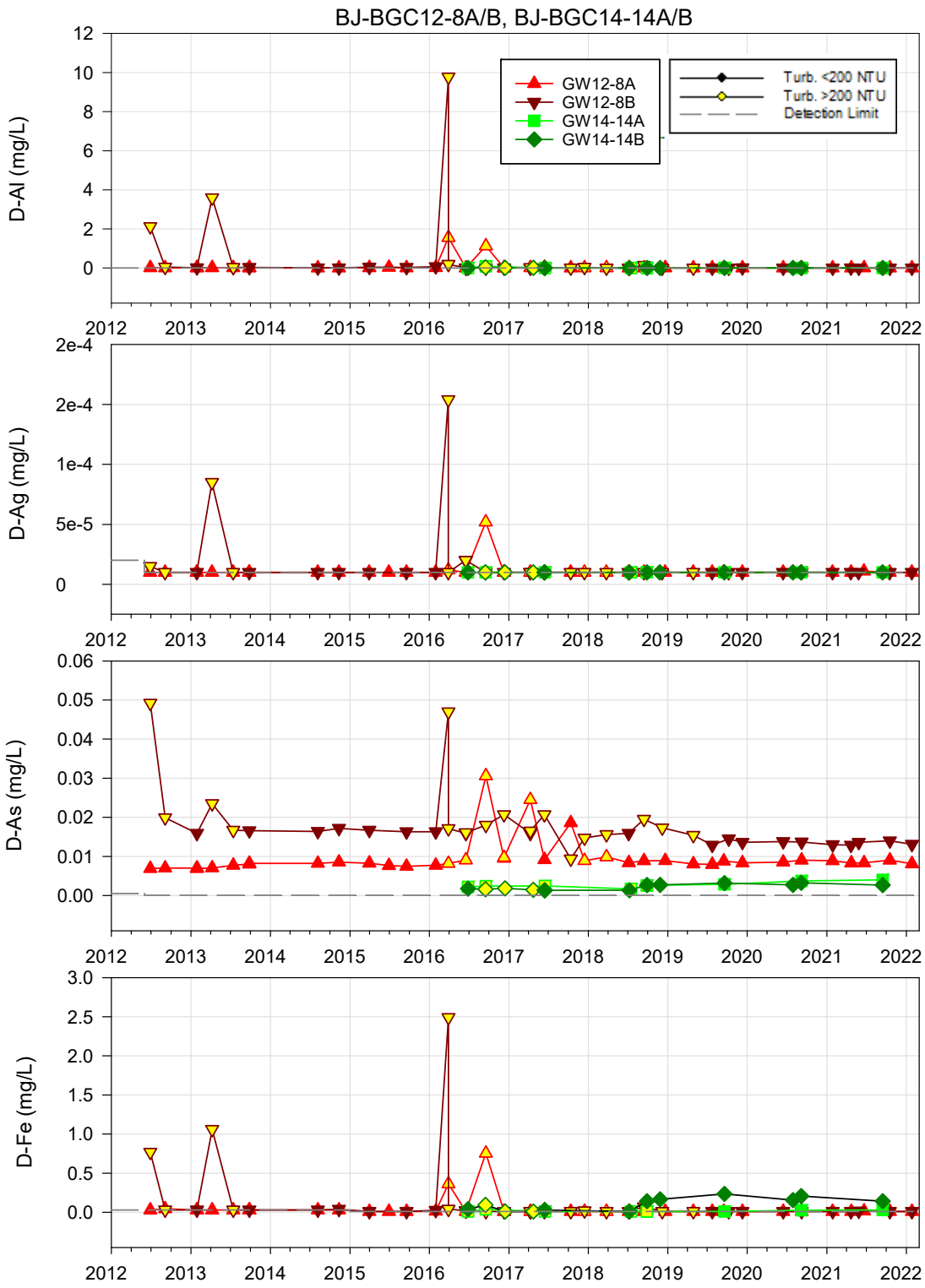

Figure 38: Time series of Al, Ag, As and Fe at wells west of the Brucejack Fault (BJ-GW12-8A/B, BJ-GW14-14A/B)

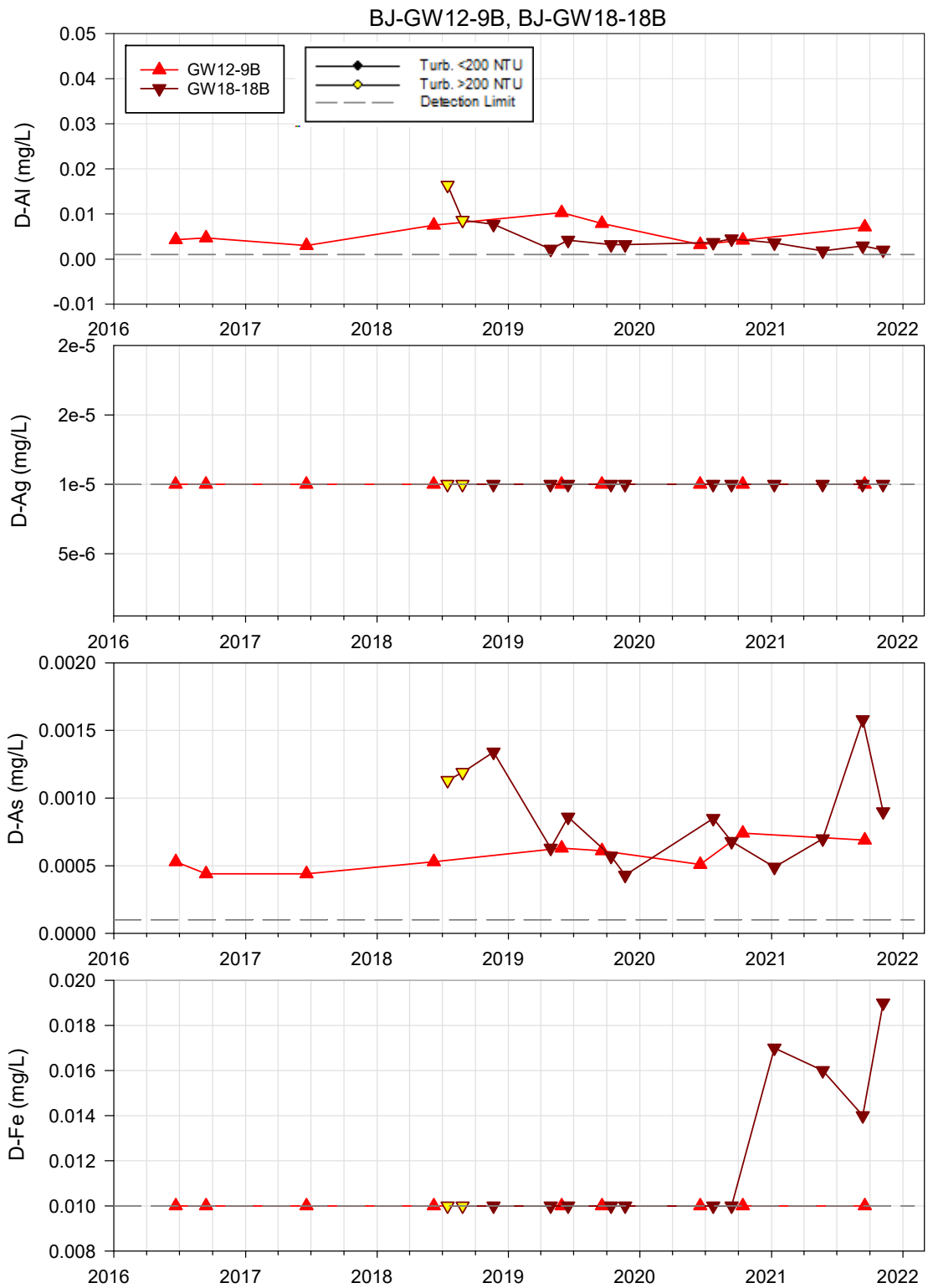

Figure 39: Time series of Al, Ag, As and Fe at wells south and east of the VOK Zone (BJ-GW12-9B, BJ-GW18-18B)

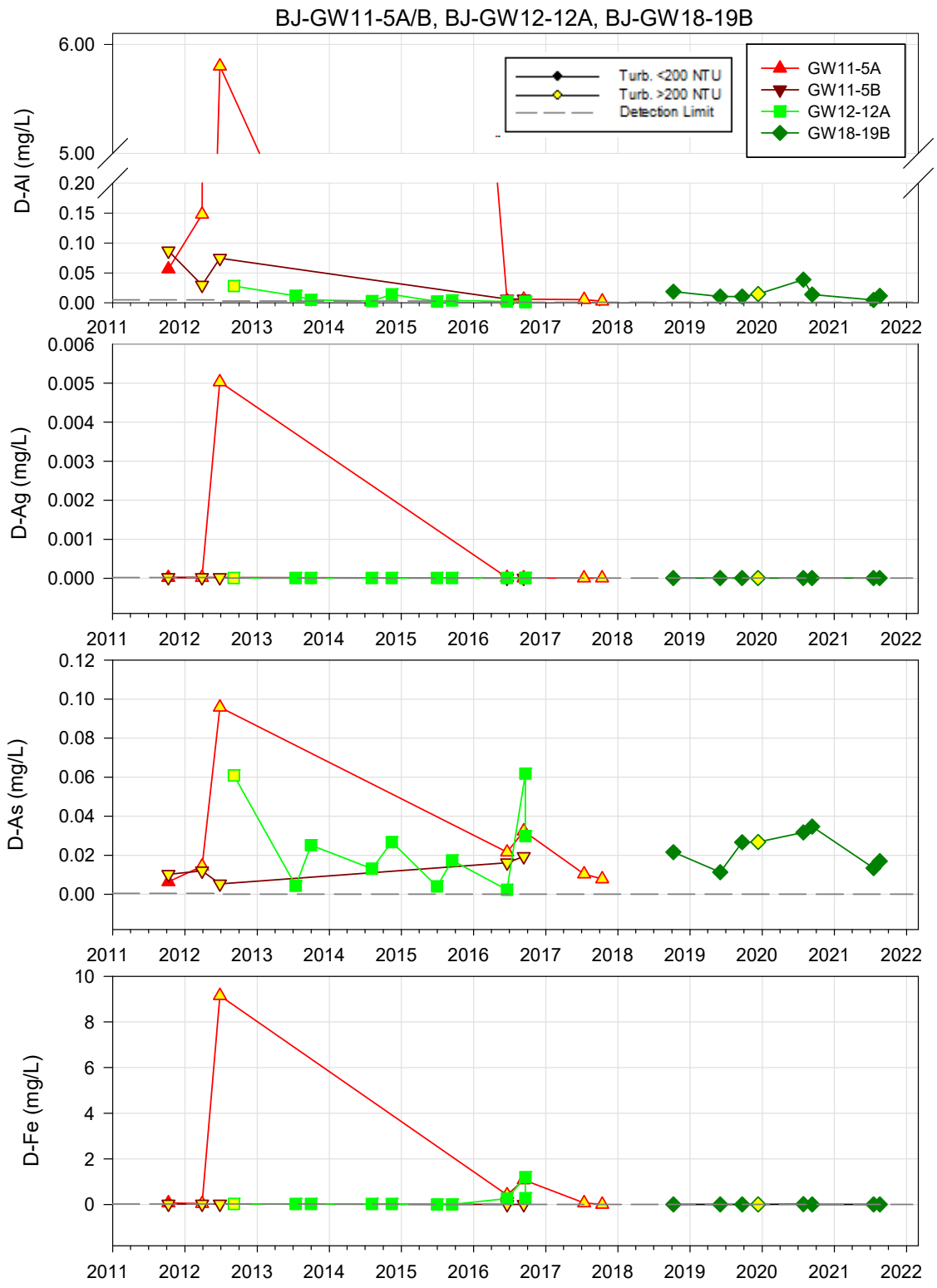

Figure 40: Time series of Al, Ag, As and Fe at wells peripheral to the VOK Zone (BJ-GW11-5A/B, BJ-GW12-12A, BJ-GW18-19B)

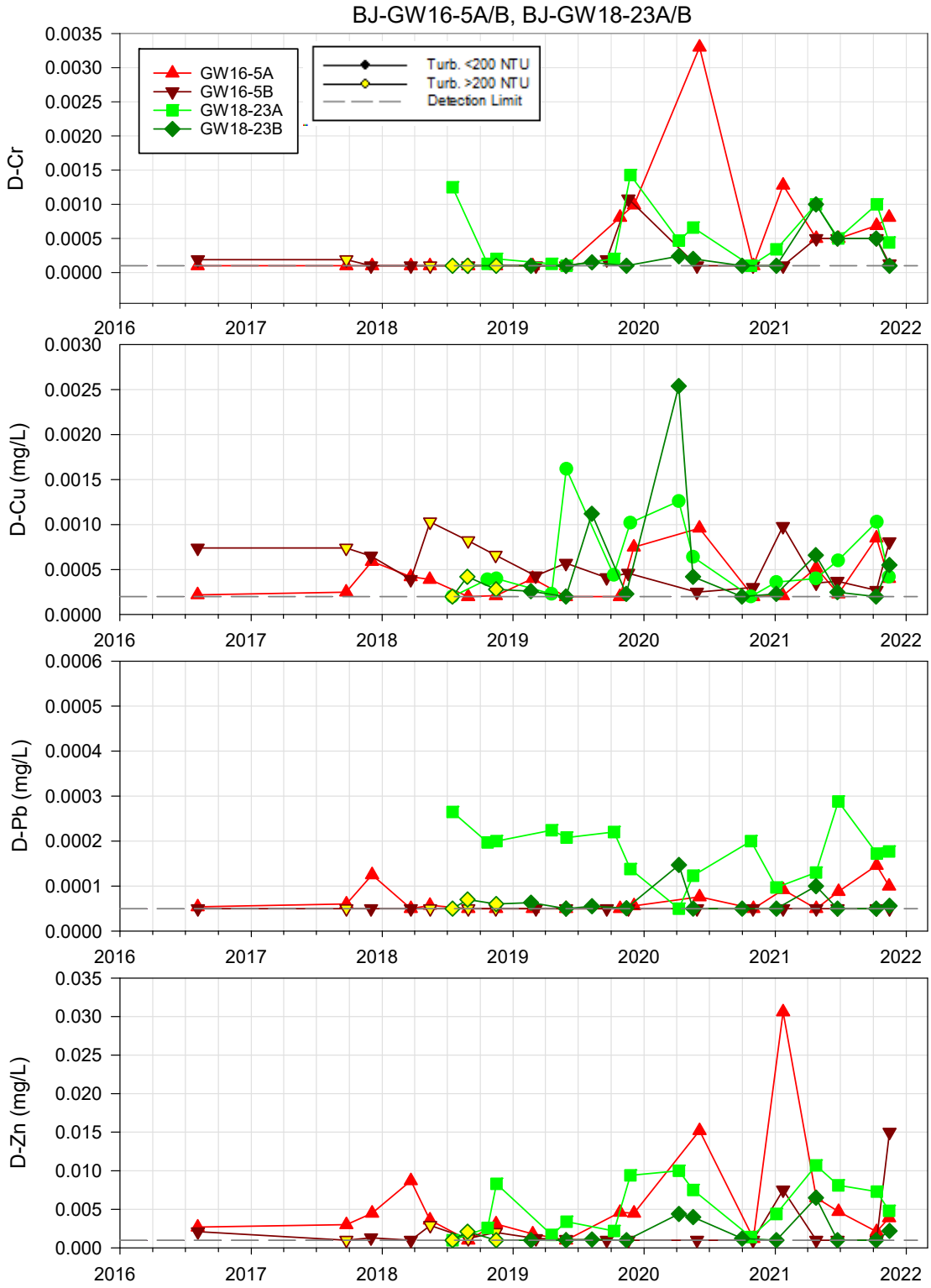

Figure 41: Time series of Cr, Cu, Pb and Zn at wells downgradient of the Contact Water Pond (BJ-GW16-5A/B, BJ-GW18-23A/B)

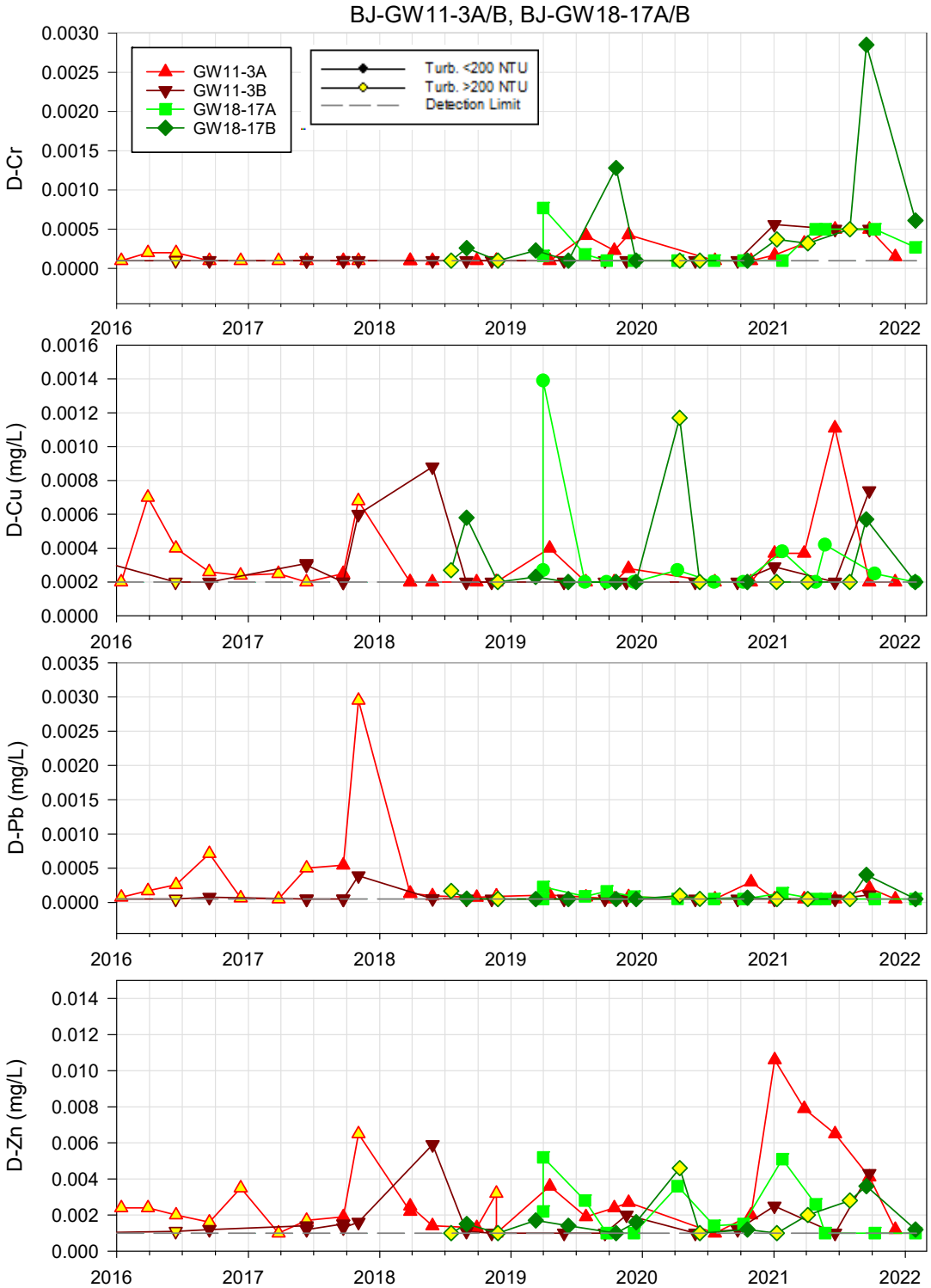

Figure 42: Time series of Cr, Cu, Pb and Zn at wells east of the West Zone Portal (BJ-GW11-3A/B, BJ-GW18-17A/B)

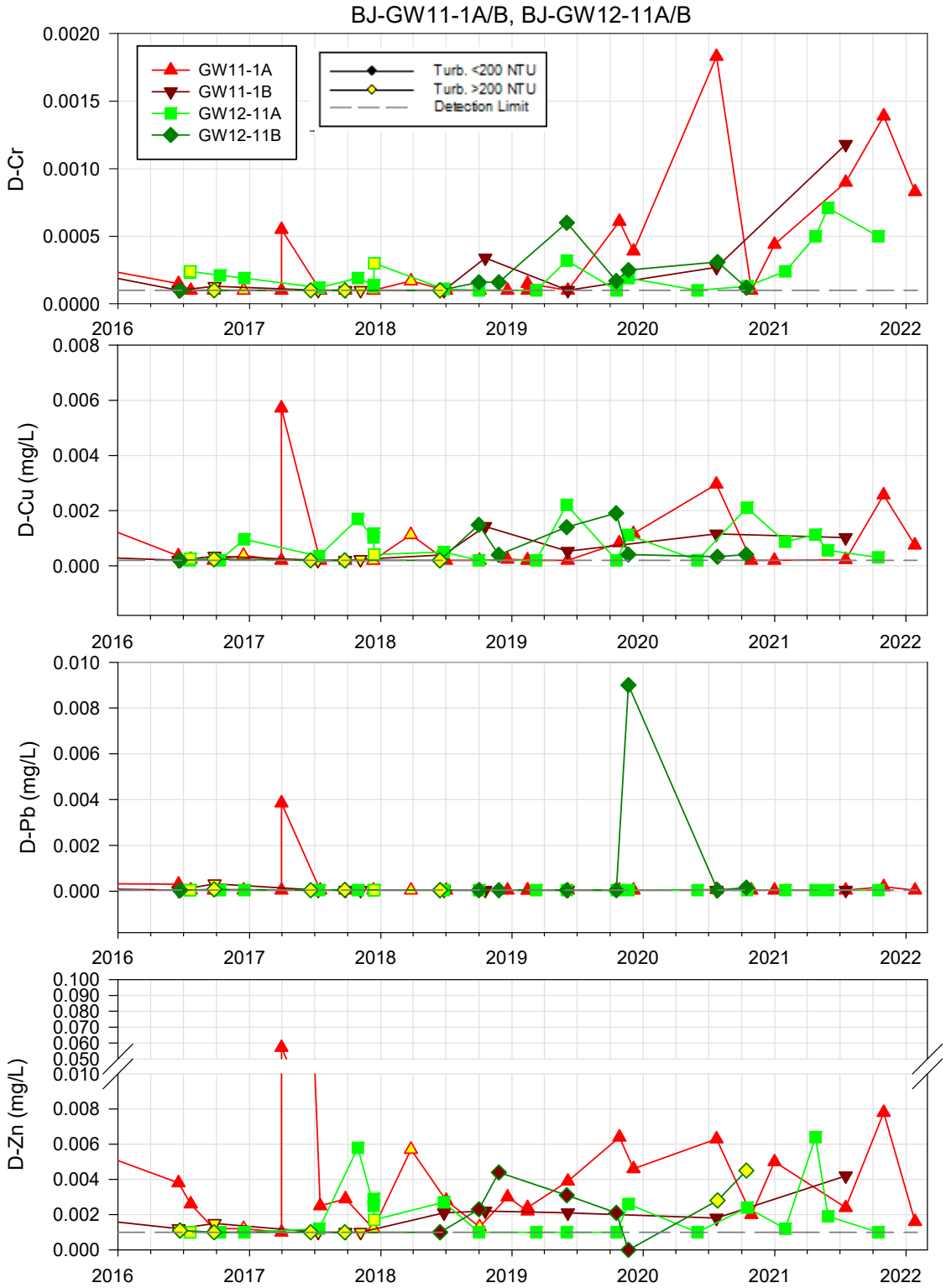

Figure 43: Time series of Cr, Cu, Pb and Zn at wells west of the West Zone Portal (BJ-GW11-1A/B, BJ-GW12-11A/B)

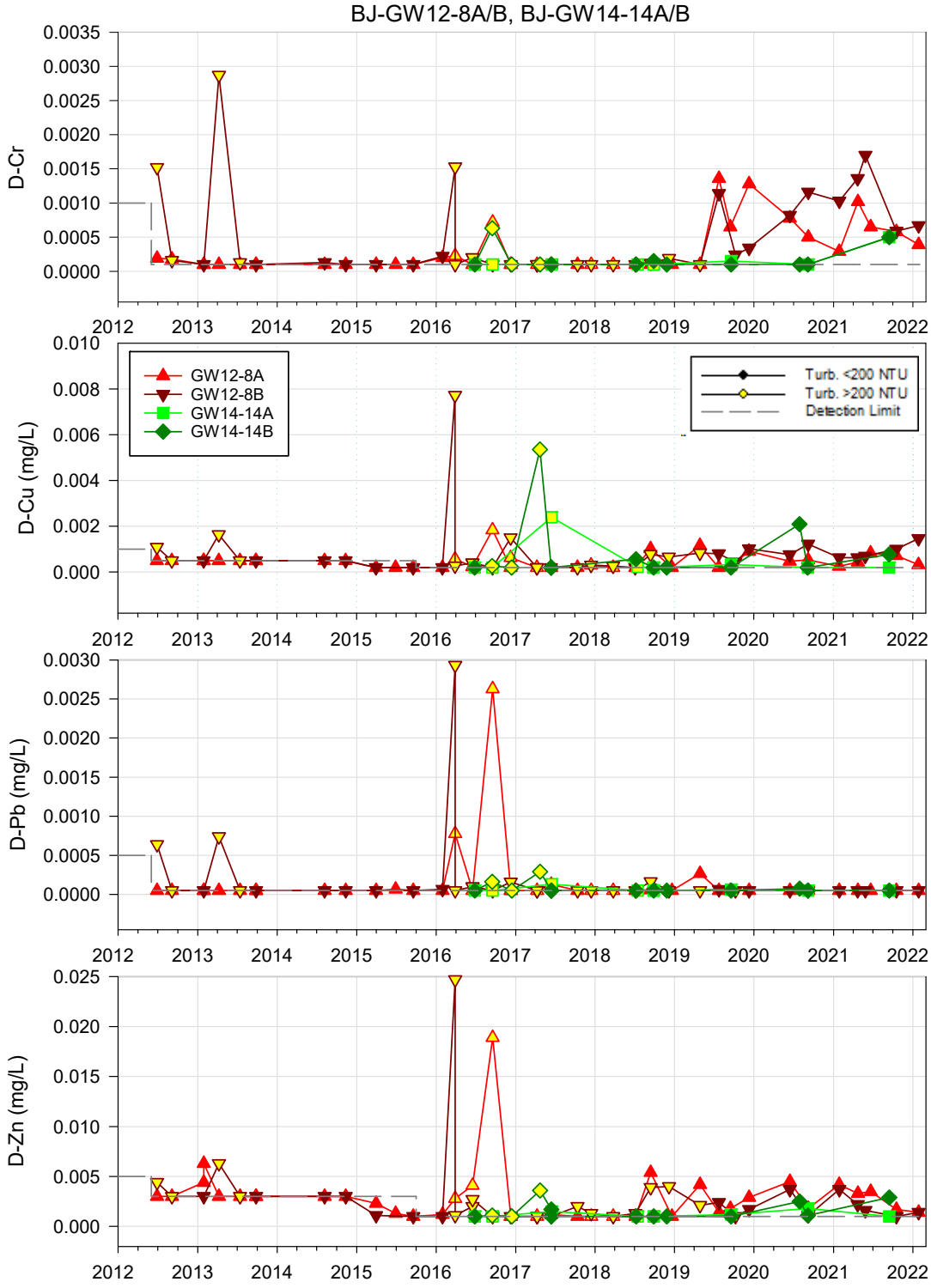

Figure 44: Time series of Cr, Cu, Pb and Zn at wells west of the Brucejack Fault (BJ-GW12-8A/B, BJ-GW14-14A/B)

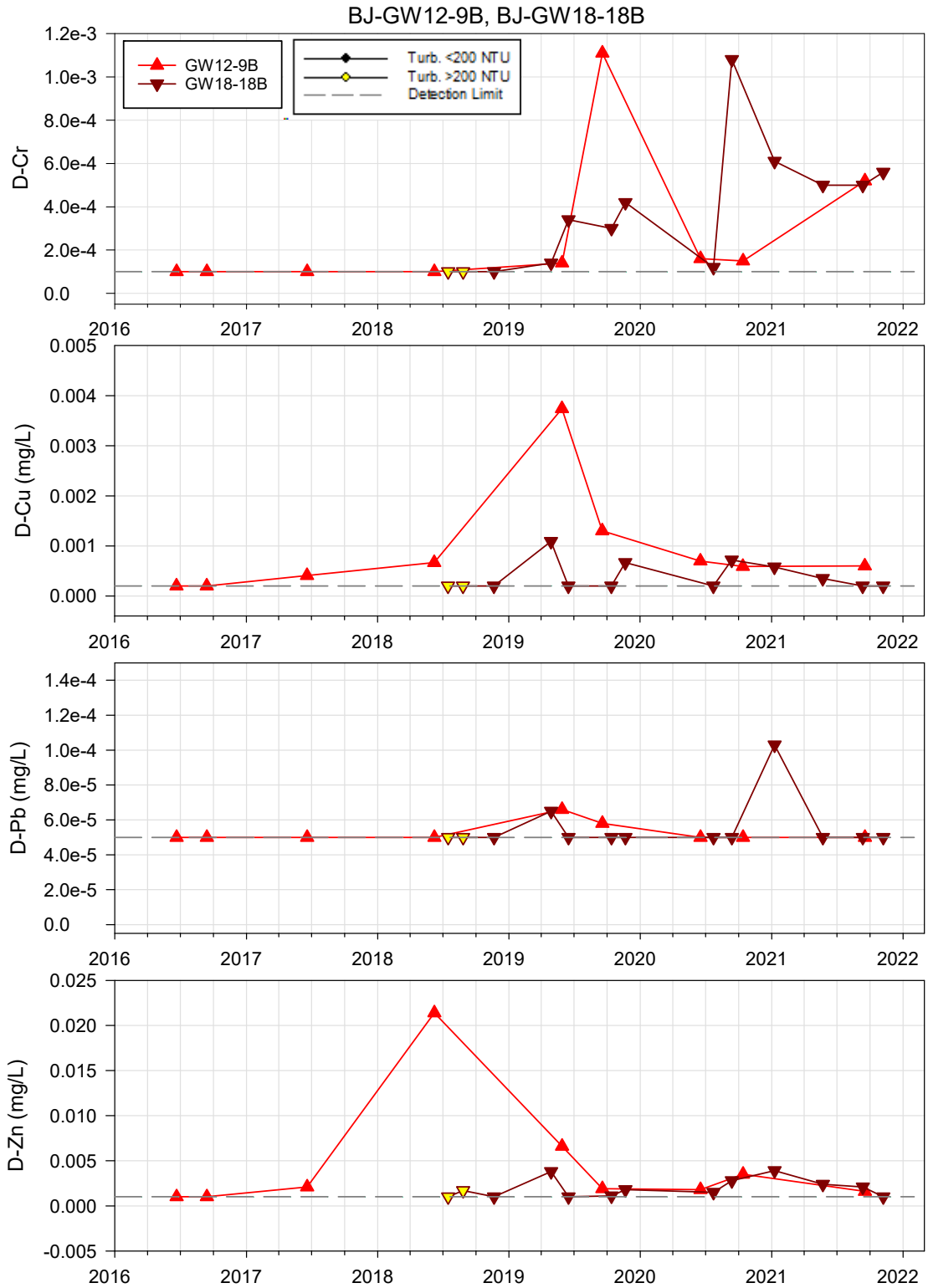

Figure 45: Time series of Cr, Cu, Pb and Zn at wells south and east of the VOK Zone (BJ-GW12-9B, BJ-GW18-18B)

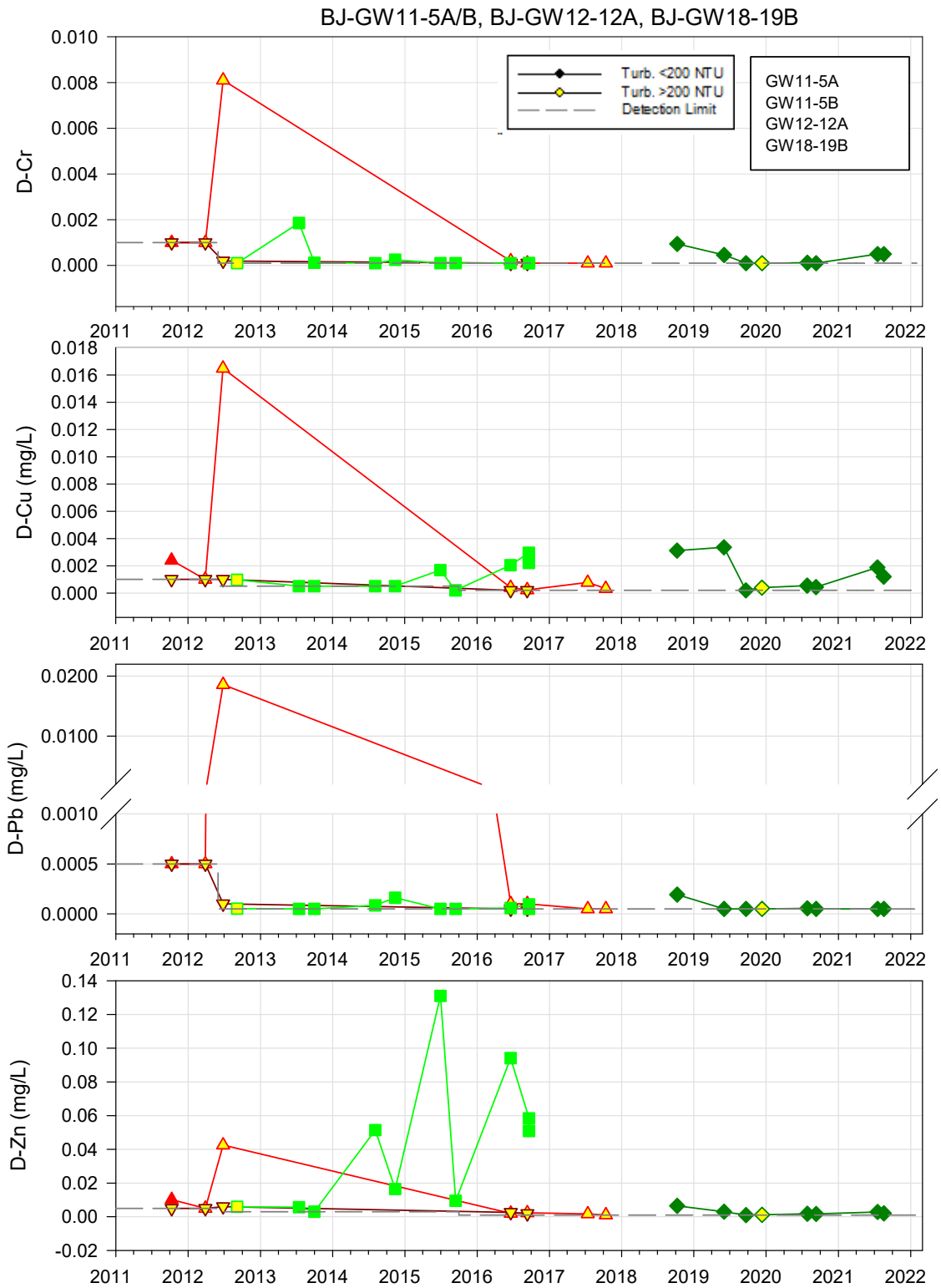

Figure 46: Time series of Cr, Cu, Pb and Zn at wells peripheral to the VOK Zone (BJ-GW11-5A/B, BJ-GW12-12A, BJ-GW18-19B)

Appendix J
Laboratory Certificates of Analysis

NEWCREST

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A4222**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Max Holtby	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 08-Mar-2021 14:45
PO	: 1025614	Date Analysis Commenced	: 08-Mar-2021
C-O-C number	: ----	Issue Date	: 15-Mar-2021 17:41
Sampler	: BM, NG		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Shaneel Dayal	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-17B-SNAP	BJ-GW18-17B-E 314701	----	----	----
				Client sampling date / time	04-Mar-2021 13:05	04-Mar-2021 15:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A4222-001	VA21A4222-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.4	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	241	108	----	----	----
conductivity	----	E100	2.0	µS/cm	847	765	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.60	mg/L	181	182	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.60	mg/L	161	239	----	----	----
pH	----	E108	0.10	pH units	8.44	8.00	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	641	514	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	24.5	348	----	----	----
turbidity	----	E121	0.10	NTU	30.2	385	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.128	0.293	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	4.84	4.15	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.199	0.245	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.612	0.961	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0584	0.0358	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0716	0.0593	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0132	0.0235	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.684	1.02	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.301	0.0040	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.509	0.322	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	194	272	----	----	----
sulfide, total (as H2S)	7783-06-4	E396	0.019	mg/L	----	0.073	----	----	----
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	----	0.069	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	2.07	14.2	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00096	0.00662	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0293	0.0635	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0818	0.433	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	0.000477	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17B-SNAP	BJ-GW18-17B-E 314701	----	----	----
				Client sampling date / time	04-Mar-2021 13:05	04-Mar-2021 15:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A4222-001	VA21A4222-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	0.000150	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.070	0.058	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000278	0.000142	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	58.3	85.7	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00374	0.0756	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00082	0.00722	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00150	0.0174	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	1.11	7.20	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00107	0.00884	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.168	0.167	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	3.84	6.10	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.363	0.537	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.000100 DLM	<0.000100 DLM	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00228	0.0136	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00262	0.0427	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	0.487	0.366	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	4.67	12.2	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000418	0.00120	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	7.85	23.0	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000096	0.000639	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	125	98.4	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	2.27	2.93	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000052	0.000355	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00040	0.00174	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	0.0328	0.161	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00306	0.00452	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00429	0.0226	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0060	0.0569	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0072	0.0859	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00046	0.00487	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17B-SNAP	BJ-GW18-17B-E 314701	----	----	----
				Client sampling date / time	04-Mar-2021 13:05	04-Mar-2021 15:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A4222-001	VA21A4222-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0244	0.0329	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0375	0.0442	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.066	0.050	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	66.4	67.6	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00040	0.00091	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00018	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.013	0.023	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.198	0.199	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	3.60	3.31	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.376	0.0592	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00183	0.00962	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00100	0.00374	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	0.460	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	4.83	9.17	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.00824 DTSE	0.000982	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	4.76	3.07	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	129	105	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	2.67	2.73	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	0.00026	0.00030	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00336	0.00419	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00133	0.00381	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	0.0016	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17B-SNAP**	**BJ-GW18-17B-E 314701**	**----**	**----**	**----**
				Client sampling date / time	04-Mar-2021 13:05	04-Mar-2021 15:25	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21A4222-001**	**VA21A4222-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	205	86	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A4222**	Page	: 1 of 16
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Max Holtby	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 08-Mar-2021 14:45
PO	: 1025614	Issue Date	: 15-Mar-2021 17:41
C-O-C number	: ----		
Sampler	: BM, NG		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Laboratory Control Sample (LCS) Recoveries								
Dissolved Metals	QC-MRG2-160456002	----	zinc, dissolved	7440-66-6	E421	123 % MES	80.0-120%	Recovery greater than upper control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 15:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 15:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-E314701	E559	04-Mar-2021	----	----	----		14-Mar-2021	28 days	9 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-SNAP	E559	04-Mar-2021	----	----	----		14-Mar-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-E314701	E298	04-Mar-2021	11-Mar-2021	28 days	6 days	✓	12-Mar-2021	21 days	0 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-SNAP	E298	04-Mar-2021	11-Mar-2021	28 days	6 days	✓	12-Mar-2021	21 days	0 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-E314701	E235.Br-L	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-SNAP	E235.Br-L	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B-E314701	E235.Cl	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B-SNAP	E235.Cl	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B-E314701	E378-U	04-Mar-2021	----	----	----		12-Mar-2021	3 days	8 days	✗ EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B-SNAP	E378-U	04-Mar-2021	----	----	----		12-Mar-2021	3 days	8 days	✗ EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B-E314701	E235.F	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B-SNAP	E235.F	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-E314701	E235.NO3-L	04-Mar-2021	----	----	----		12-Mar-2021	3 days	8 days	✗ EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-SNAP	E235.NO3-L	04-Mar-2021	----	----	----		12-Mar-2021	3 days	8 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-E314701	E235.NO2-L	04-Mar-2021	----	----	----		12-Mar-2021	3 days	8 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-SNAP	E235.NO2-L	04-Mar-2021	----	----	----		12-Mar-2021	3 days	8 days	✗ EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE BJ-GW18-17B-E314701	E235.SO4	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE BJ-GW18-17B-SNAP	E235.SO4	04-Mar-2021	----	----	----		12-Mar-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-17B-E314701	E366	04-Mar-2021	11-Mar-2021	28 days	6 days	✓	12-Mar-2021	21 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-17B-SNAP	E366	04-Mar-2021	11-Mar-2021	28 days	6 days	✓	12-Mar-2021	21 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-17B-E314701	E372-U	04-Mar-2021	11-Mar-2021	28 days	6 days	✓	11-Mar-2021	21 days	0 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-17B-SNAP	E372-U	04-Mar-2021	11-Mar-2021	28 days	6 days	✓	11-Mar-2021	21 days	0 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Manual)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17B-E314701	E396	04-Mar-2021	----	----	----		11-Mar-2021	7 days	7 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid) BJ-GW18-17B-E314701	E421.Cr-L	04-Mar-2021	08-Mar-2021	180 days	4 days	✓	09-Mar-2021	175 days	0 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid) BJ-GW18-17B-SNAP	E421.Cr-L	04-Mar-2021	08-Mar-2021	180 days	4 days	✓	09-Mar-2021	175 days	0 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B-E314701	E509	04-Mar-2021	10-Mar-2021	28 days	5 days	✓	10-Mar-2021	22 days	0 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B-SNAP	E509	04-Mar-2021	10-Mar-2021	28 days	5 days	✓	10-Mar-2021	22 days	0 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B-E314701	E421	04-Mar-2021	08-Mar-2021	180 days	4 days	✓	09-Mar-2021	175 days	0 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B-SNAP	E421	04-Mar-2021	08-Mar-2021	180 days	4 days	✓	09-Mar-2021	175 days	0 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B-E314701	E283	04-Mar-2021	----	----	----		10-Mar-2021	14 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B-SNAP	E283	04-Mar-2021	----	----	----		10-Mar-2021	14 days	5 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B-E314701	E290	04-Mar-2021	----	----	----		13-Mar-2021	14 days	8 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B-SNAP	E290	04-Mar-2021	----	----	----		13-Mar-2021	14 days	8 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B-E314701	E100	04-Mar-2021	----	----	----		13-Mar-2021	28 days	8 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B-SNAP	E100	04-Mar-2021	----	----	----		13-Mar-2021	28 days	8 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17B-E314701	E108	04-Mar-2021	----	----	----		13-Mar-2021	0.25 hrs	209 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17B-SNAP	E108	04-Mar-2021	----	----	----		13-Mar-2021	0.25 hrs	211 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-17B-E314701	E162	04-Mar-2021	----	----	----		10-Mar-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-17B-SNAP	E162	04-Mar-2021	----	----	----		10-Mar-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17B-E314701	E160-H	04-Mar-2021	----	----	----		10-Mar-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17B-SNAP	E160-H	04-Mar-2021	----	----	----		10-Mar-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17B-E314701	E121	04-Mar-2021	----	----	----		09-Mar-2021	3 days	4 days	✗ EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17B-SNAP	E121	04-Mar-2021	----	----	----		09-Mar-2021	3 days	4 days	✗ EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW18-17B-E314701	E420.Cr-L	04-Mar-2021	----	----	----		09-Mar-2021	180 days	4 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW18-17B-SNAP	E420.Cr-L	04-Mar-2021	----	----	----		09-Mar-2021	180 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B-E314701	E508	04-Mar-2021	----	----	----		12-Mar-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B-SNAP	E508	04-Mar-2021	----	----	----		12-Mar-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B-E314701	E420	04-Mar-2021	----	----	----		09-Mar-2021	180 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B-SNAP	E420	04-Mar-2021	----	----	----		09-Mar-2021	180 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	161163	1	13	7.6	5.0	✓
Alkalinity Species by Titration	E290	161792	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	161680	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	161788	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	163175	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	161787	1	11	9.0	5.0	✓
Conductivity in Water	E100	161791	1	7	14.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	160457	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	161229	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	160456	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	161793	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	161786	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	161784	1	6	16.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	161785	1	6	16.6	5.0	✓
pH by Meter	E108	161789	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	161783	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	161579	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	160436	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	162419	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	160435	1	17	5.8	5.0	✓
Total Nitrogen by Colourimetry	E366	161678	1	17	5.8	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	161679	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	162196	1	13	7.6	5.0	✓
TSS by Gravimetry	E160-H	161587	1	6	16.6	5.0	✓
Turbidity by Nephelometry	E121	160722	1	11	9.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	161163	1	13	7.6	5.0	✓
Alkalinity Species by Titration	E290	161792	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	161680	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	161788	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	163175	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	161787	1	11	9.0	5.0	✓
Conductivity in Water	E100	161791	1	7	14.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	160457	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	161229	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	160456	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	161793	1	6	16.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	161786	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	161784	1	6	16.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	161785	1	6	16.6	5.0	✓
pH by Meter	E108	161789	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	161783	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	161579	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	160436	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	162419	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	160435	1	17	5.8	5.0	✓
Total Nitrogen by Colourimetry	E366	161678	1	17	5.8	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	161679	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	162196	1	13	7.6	5.0	✓
TSS by Gravimetry	E160-H	161587	1	6	16.6	5.0	✓
Turbidity by Nephelometry	E121	160722	1	11	9.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	161163	1	13	7.6	5.0	✓
Alkalinity Species by Titration	E290	161792	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	161680	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	161788	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	163175	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	161787	1	11	9.0	5.0	✓
Conductivity in Water	E100	161791	1	7	14.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	160457	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	161229	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	160456	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	161793	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	161786	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	161784	1	6	16.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	161785	1	6	16.6	5.0	✓
Sulfate in Water by IC	E235.SO4	161783	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	161579	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	160436	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	162419	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	160435	1	17	5.8	5.0	✓
Total Nitrogen by Colourimetry	E366	161678	1	17	5.8	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	161679	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	162196	1	13	7.6	5.0	✓
TSS by Gravimetry	E160-H	161587	1	6	16.6	5.0	✓
Turbidity by Nephelometry	E121	160722	1	11	9.0	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	161680	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	161788	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	163175	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	161787	1	11	9.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	160457	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	161229	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	160456	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	161793	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	161786	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	161784	1	6	16.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	161785	1	6	16.6	5.0	✓
Sulfate in Water by IC	E235.SO4	161783	1	17	5.8	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	160436	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	162419	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	160435	1	17	5.8	5.0	✓
Total Nitrogen by Colourimetry	E366	161678	1	17	5.8	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	161679	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	162196	1	13	7.6	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Manual)	E396 Vancouver - Environmental	Water	APHA 4500-S2 D (mod)	Total Sulfide is determined by spectrophotometer using the methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S).
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A4222**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Max Holtby	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 08-Mar-2021 14:45
PO	: 1025614	Date Analysis Commenced	: 08-Mar-2021
C-O-C number	: ----	Issue Date	: 15-Mar-2021 17:41
Sampler	: BM, NG		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Shaneel Dayal	Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 160722)											
VA21A4204-001	Anonymous	turbidity	----	E121	0.10	NTU	0.56	0.63	0.07	Diff <2x LOR	----
Physical Tests (QC Lot: 161163)											
KS2100655-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	41.1	43.3	5.17%	20%	----
Physical Tests (QC Lot: 161579)											
VA21A4183-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	3020	3040	0.693%	20%	----
Physical Tests (QC Lot: 161587)											
VA21A4156-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	6.1	6.9	0.8	Diff <2x LOR	----
Physical Tests (QC Lot: 161789)											
VA21A4193-004	Anonymous	pH	----	E108	0.10	pH units	7.11	7.10	0.141%	4%	----
Physical Tests (QC Lot: 161791)											
VA21A4228-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1370	1370	0.219%	10%	----
Physical Tests (QC Lot: 161792)											
VA21A4228-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	226	227	0.308%	20%	----
Anions and Nutrients (QC Lot: 161678)											
VA21A4221-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 161679)											
VA21A4221-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 161680)											
VA21A4221-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 161783)											
VA21A4222-001	BJ-GW18-17B-SNAP	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	194	195	0.335%	20%	----
Anions and Nutrients (QC Lot: 161784)											
VA21A4222-001	BJ-GW18-17B-SNAP	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0584	0.0608	4.04%	20%	----
Anions and Nutrients (QC Lot: 161785)											
VA21A4222-001	BJ-GW18-17B-SNAP	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0132	0.0141	6.58%	20%	----
Anions and Nutrients (QC Lot: 161786)											
VA21A4222-001	BJ-GW18-17B-SNAP	fluoride	16984-48-8	E235.F	0.020	mg/L	0.199	0.200	0.001	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 161787)											
VA21A4222-001	BJ-GW18-17B-SNAP	chloride	16887-00-6	E235.Cl	0.50	mg/L	4.84	4.85	0.01	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 161788)											
VA21A4222-001	BJ-GW18-17B-SNAP	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 161793)											
VA21A4228-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0132	0.0128	2.61%	20%	----
Anions and Nutrients (QC Lot: 162196)											
VA21A4118-001	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	<0.018	<0.018	0	Diff <2x LOR	----
Total Metals (QC Lot: 160435)											
VA21A4213-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	2.58	2.41	6.84%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00070	0.00072	0.00002	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00139	0.00141	1.39%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0251	0.0245	2.42%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000112	0.000106	0.000006	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.049	0.050	0.002	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000302	0.0000332	0.0000031	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	50.1	53.5	6.57%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00035	0.00034	0.00001	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00376	0.00380	0.00004	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.653	0.613	6.31%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.00529	0.00528	0.0276%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0046	0.0045	0.00006	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	7.53	6.99	7.39%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.0501	0.0492	1.75%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00311	0.00317	2.02%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00135	0.00134	0.00001	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	0.360	0.342	0.018	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	1.84	1.82	1.39%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000194	0.000210	0.000016	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	5.62	5.09	9.82%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.000018	0.000014	0.000004	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	23.7	23.7	0.0988%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0904	0.0945	4.48%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000025	0.000022	0.000003	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.0275	0.0240	13.4%	20%	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000373	0.000374	0.445%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00280	0.00269	0.00010	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0073	0.0073	0.000010	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 160436)											
VA21A4213-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00079	0.00073	0.00006	Diff <2x LOR	----
Total Metals (QC Lot: 162419)											
VA21A4201-006	Anonymous	mercury, total	7439-97-6	E508	0.0050	mg/L	<0.0050 µg/L	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 160456)											
VA21A4221-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0025	0.0024	0.0001	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00027	0.00026	0.000003	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00171	0.00178	3.95%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0601	0.0603	0.299%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	26.0	26.1	0.663%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	0.555	0.576	0.0216	Diff <2x LOR	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000622	0.000630	1.34%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.106	0.114	0.008	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000374	0.000340	0.000034	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.50	1.51	0.789%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	0.966	1.00	3.90%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.150	0.152	1.73%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000064	0.000068	0.000004	Diff <2x LOR	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0011	0.0012	0.00008	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 160457)											
VA21A4221-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 161229)											
VA21A4202-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 163175)											
VA21A4221-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 160722)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 161163)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 161579)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 161587)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 161791)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 161792)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Anions and Nutrients (QCLot: 161678)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 161679)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 161680)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 161783)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 161784)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 161785)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 161786)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 161787)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 161788)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 161793)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 162196)						
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	<0.018	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 160435)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 160436)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 162419)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 160456)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 160456) - continued						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 160457)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 161229)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 163175)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 163175) - continued						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 160722)									
turbidity	----	E121	0.1	NTU	200 NTU	98.5	85.0	115	----
Physical Tests (QCLot: 161163)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	96.2	85.0	115	----
Physical Tests (QCLot: 161579)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	101	85.0	115	----
Physical Tests (QCLot: 161587)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	98.2	85.0	115	----
Physical Tests (QCLot: 161789)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 161791)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	98.6	90.0	110	----
Physical Tests (QCLot: 161792)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	98.7	85.0	115	----
Anions and Nutrients (QCLot: 161678)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 161679)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	104	80.0	120	----
Anions and Nutrients (QCLot: 161680)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.12 mg/L	99.0	85.0	115	----
Anions and Nutrients (QCLot: 161783)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 161784)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 161785)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 161786)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 161787)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 161788)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	103	85.0	115	----
Anions and Nutrients (QCLot: 161793)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 161793) - continued									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	101	80.0	120	----
Anions and Nutrients (QCLot: 162196)									
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	1 mg/L	93.9	75.0	125	----
Total Metals (QCLot: 160435)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	106	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	107	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	116	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	97.9	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	107	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	90.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	103	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	118	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	104	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	94.5	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	105	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	109	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	103	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	96.9	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	104	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	99.8	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	102	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	105	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	107	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	103	80.0	120	----
Total Metals (QCLot: 160436)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 160436) - continued									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
Total Metals (QCLot: 162419)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	102	80.0	120	----
Dissolved Metals (QCLot: 160456)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	106	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	118	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	109	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	110	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	108	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	92.9	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.6	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	105	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	110	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	95.4	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	95.7	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	101	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	111	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	115	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	107	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	110	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	108	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	97.9	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	114	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	96.3	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	109	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	95.6	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	103	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	102	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	94.1	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	107	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	# 123	80.0	120	MES
Dissolved Metals (QCLot: 160457)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 160457) - continued									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	96.1	80.0	120	----
Aggregate Organics (QCLot: 163175)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	108	85.0	115	----

Qualifiers

Qualifier	Description
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 161678)										
VA21A4222-001	BJ-GW18-17B-SNAP	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 161679)										
VA21A4222-001	BJ-GW18-17B-SNAP	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 161680)										
VA21A4222-001	BJ-GW18-17B-SNAP	ammonia, total (as N)	7664-41-7	E298	0.197 mg/L	0.2 mg/L	98.6	75.0	125	----
Anions and Nutrients (QCLot: 161783)										
VA21A4222-002	BJ-GW18-17B-E314701	sulfate (as SO4)	14808-79-8	E235.SO4	496 mg/L	500 mg/L	99.3	75.0	125	----
Anions and Nutrients (QCLot: 161784)										
VA21A4222-002	BJ-GW18-17B-E314701	nitrate (as N)	14797-55-8	E235.NO3-L	12.6 mg/L	12.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 161785)										
VA21A4222-002	BJ-GW18-17B-E314701	nitrite (as N)	14797-65-0	E235.NO2-L	2.47 mg/L	2.5 mg/L	98.8	75.0	125	----
Anions and Nutrients (QCLot: 161786)										
VA21A4222-002	BJ-GW18-17B-E314701	fluoride	16984-48-8	E235.F	5.10 mg/L	5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 161787)										
VA21A4222-002	BJ-GW18-17B-E314701	chloride	16887-00-6	E235.Cl	498 mg/L	500 mg/L	99.7	75.0	125	----
Anions and Nutrients (QCLot: 161788)										
VA21A4222-002	BJ-GW18-17B-E314701	bromide	24959-67-9	E235.Br-L	2.52 mg/L	2.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 161793)										
VA21A4228-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0318 mg/L	0.03 mg/L	106	70.0	130	----
Anions and Nutrients (QCLot: 162196)										
VA21A4118-002	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.094 mg/L	0.1 mg/L	93.9	65.0	135	----
Total Metals (QCLot: 160435)										
VA21A4213-001	Anonymous	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0205 mg/L	0.02 mg/L	102	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0417 mg/L	0.04 mg/L	104	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0101 mg/L	0.01 mg/L	101	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 160435) - continued										
VA21A4213-001	Anonymous	boron, total	7440-42-8	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00413 mg/L	0.004 mg/L	103	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0199 mg/L	0.02 mg/L	99.6	70.0	130	----
		copper, total	7440-50-8	E420	0.0193 mg/L	0.02 mg/L	96.7	70.0	130	----
		iron, total	7439-89-6	E420	1.95 mg/L	2 mg/L	97.5	70.0	130	----
		lead, total	7439-92-1	E420	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		lithium, total	7439-93-2	E420	0.0993 mg/L	0.1 mg/L	99.3	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		nickel, total	7440-02-0	E420	0.0390 mg/L	0.04 mg/L	97.5	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.8 mg/L	10 mg/L	108	70.0	130	----
		potassium, total	7440-09-7	E420	3.98 mg/L	4 mg/L	99.4	70.0	130	----
		selenium, total	7782-49-2	E420	0.0438 mg/L	0.04 mg/L	109	70.0	130	----
		silicon, total	7440-21-3	E420	8.70 mg/L	10 mg/L	87.0	70.0	130	----
		silver, total	7440-22-4	E420	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00382 mg/L	0.004 mg/L	95.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0203 mg/L	0.02 mg/L	101	70.0	130	----
		titanium, total	7440-32-6	E420	0.0381 mg/L	0.04 mg/L	95.3	70.0	130	----
		uranium, total	7440-61-1	E420	0.00415 mg/L	0.004 mg/L	104	70.0	130	----
		vanadium, total	7440-62-2	E420	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		zinc, total	7440-66-6	E420	0.391 mg/L	0.4 mg/L	97.6	70.0	130	----
Total Metals (QCLot: 160436)										
VA21A4213-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.0416 mg/L	0.04 mg/L	104	70.0	130	----
Total Metals (QCLot: 162419)										
VA21A4201-007	Anonymous	mercury, total	7439-97-6	E508	0.000519 mg/L	0.0005 mg/L	104	70.0	130	----
Dissolved Metals (QCLot: 160456)										
VA21A4221-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.194 mg/L	0.2 mg/L	97.2	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0211 mg/L	0.02 mg/L	106	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0199 mg/L	0.02 mg/L	99.5	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0423 mg/L	0.04 mg/L	106	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00853 mg/L	0.01 mg/L	85.3	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 160456) - continued										
VA21A4221-001	Anonymous	boron, dissolved	7440-42-8	E421	0.091 mg/L	0.1 mg/L	91.4	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00405 mg/L	0.004 mg/L	101	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.92 mg/L	2 mg/L	96.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0187 mg/L	0.02 mg/L	93.3	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	0.941 mg/L	1 mg/L	94.1	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0203 mg/L	0.02 mg/L	102	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.75 mg/L	10 mg/L	97.5	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.13 mg/L	4 mg/L	103	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0422 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.73 mg/L	10 mg/L	87.3	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00431 mg/L	0.004 mg/L	108	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.95 mg/L	2 mg/L	97.7	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00379 mg/L	0.004 mg/L	94.7	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0191 mg/L	0.02 mg/L	95.7	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0389 mg/L	0.04 mg/L	97.2	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00369 mg/L	0.004 mg/L	92.2	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0989 mg/L	0.1 mg/L	98.9	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.472 mg/L	0.4 mg/L	118	70.0	130	----
Dissolved Metals (QCLot: 160457)										
VA21A4221-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.0388 mg/L	0.04 mg/L	97.0	70.0	130	----
Dissolved Metals (QCLot: 161229)										
VA21A4202-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000946 mg/L	0.0001 mg/L	94.6	70.0	130	----
Aggregate Organics (QCLot: 163175)										
VA21A4222-001	BJ-GW18-17B-SNAP	chemical oxygen demand [COD]	----	E559	537 mg/L	500 mg/L	107	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Page 1 of 1

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		**ALS Contact:**	Dean Watt	**Sampler:** NG/BM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17B - snap	04-Mar-21	13:05	Groundwater	X	X		X	X			X	X	X			6
	BJ-GW18-17B - E314701	04-Mar-21	15:25	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21A4222

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	4-Mar-21	18:00				8/8/6/8°C		Mar 8/21	2:45	

5 coolers ice packs

NA-FM-0325d v06 Front / 22 May 2013

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A5837**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Vacant	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 29-Mar-2021 16:35
PO	: 1025614	Date Analysis Commenced	: 30-Mar-2021
C-O-C number	: ----	Issue Date	: 07-Apr-2021 16:30
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Bruna Botti	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-3A - E303056	Travel Blank	----	----	----
				Client sampling date / time	26-Mar-2021 15:30	26-Mar-2021 15:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A5837-001	VA21A5837-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.2	2.3	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	92.7	<1.0	----	----	----
conductivity	----	E100	2.0	µS/cm	403	<2.0	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	180	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	197	<0.50	----	----	----
pH	----	E108	0.10	pH units	8.13	5.54	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	258	<10	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	21.8	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	7.04	<0.10	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0419	<0.0050	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	2.08	<0.50	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.176	<0.020	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0205	<0.0050	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0224	<0.0051	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0019	<0.0010	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.048	<0.030	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0049	<0.0020	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	112	<0.30	----	----	----
sulfide, total (as H2S)	7783-06-4	E396	0.019	mg/L	0.030	<0.019	----	----	----
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	0.028	<0.018	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.109	<0.0030	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00353	<0.00010	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00582	<0.00010	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0252	<0.00010	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-3A - E303056	Travel Blank	----	----	----
				Client sampling date / time	26-Mar-2021 15:30	26-Mar-2021 15:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A5837-001	VA21A5837-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.036	<0.010	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000494	<0.0000050	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	71.2	<0.050	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00369	<0.00010	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00203	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.199	<0.010	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00169	<0.000050	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0174	<0.0010	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	4.78	<0.100	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.251	<0.00010	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00120	<0.000050	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00265	<0.00050	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.47	<0.050	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.96	<0.10	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000018	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	8.23	<0.050	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.30	<0.00020	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000013	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000145	<0.000010	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0119	<0.0030	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0015	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00219	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-3A - E303056	Travel Blank	----	----	----
				Client sampling date / time	26-Mar-2021 15:30	26-Mar-2021 15:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A5837-001	VA21A5837-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00506	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0253	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.040	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	64.9	----	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00032	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00026	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00037	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.111	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0172	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.43	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.260	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00101	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00129	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.36	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.65	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	7.29	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.27	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000138	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0079	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW11-3A - E303056**	**Travel Blank**	**----**	**----**	**----**
				Client sampling date / time	26-Mar-2021 15:30	26-Mar-2021 15:30	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21A5837-001**	**VA21A5837-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A5837**	Page	: 1 of 15
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Vacant	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 29-Mar-2021 16:35
PO	: 1025614	Issue Date	: 07-Apr-2021 16:30
C-O-C number	: ----		
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 15:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 15:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E559	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
Travel Blank	E559	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E298	26-Mar-2021	01-Apr-2021	28 days	5 days	✓	01-Apr-2021	22 days	0 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Travel Blank	E298	26-Mar-2021	01-Apr-2021	28 days	5 days	✓	01-Apr-2021	22 days	0 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - E303056	E235.Br-L	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.Br-L	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A - E303056	E235.Cl	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓

Matrix: **Water**

Evaluation: ✖ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Travel Blank	E235.Cl	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A - E303056	E378-U	26-Mar-2021	----	----	----		06-Apr-2021	3 days	10 days	✖ EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Travel Blank	E378-U	26-Mar-2021	----	----	----		06-Apr-2021	3 days	10 days	✖ EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A - E303056	E235.F	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Travel Blank	E235.F	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - E303056	E235.NO3-L	26-Mar-2021	----	----	----		05-Apr-2021	3 days	9 days	✖ EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.NO3-L	26-Mar-2021	----	----	----		05-Apr-2021	3 days	9 days	✖ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - E303056	E235.NO2-L	26-Mar-2021	----	----	----		05-Apr-2021	3 days	9 days	✖ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.NO2-L	26-Mar-2021	----	----	----		05-Apr-2021	3 days	9 days	✖ EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A - E303056	E235.SO4	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Travel Blank	E235.SO4	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E366	26-Mar-2021	01-Apr-2021	28 days	5 days	✓	05-Apr-2021	22 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Travel Blank	E366	26-Mar-2021	01-Apr-2021	28 days	5 days	✓	05-Apr-2021	22 days	4 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E372-U	26-Mar-2021	01-Apr-2021	28 days	5 days	✓	03-Apr-2021	22 days	2 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Travel Blank	E372-U	26-Mar-2021	01-Apr-2021	28 days	5 days	✓	03-Apr-2021	22 days	2 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Manual)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A - E303056	E396	26-Mar-2021	----	----	----		30-Mar-2021	7 days	3 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Manual)										
HDPE total (zinc acetate+sodium hydroxide)										
Travel Blank	E396	26-Mar-2021	----	----	----		30-Mar-2021	7 days	3 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW11-3A - E303056	E421.Cr-L	26-Mar-2021	30-Mar-2021	180 days	3 days	✓	31-Mar-2021	176 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A - E303056	E509	26-Mar-2021	03-Apr-2021	28 days	7 days	✓	03-Apr-2021	20 days	0 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A - E303056	E421	26-Mar-2021	30-Mar-2021	180 days	3 days	✓	31-Mar-2021	176 days	1 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3A - E303056	E283	26-Mar-2021	----	----	----		06-Apr-2021	14 days	10 days	✓
Physical Tests : Acidity by Titration										
HDPE										
Travel Blank	E283	26-Mar-2021	----	----	----		06-Apr-2021	14 days	10 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A - E303056	E290	26-Mar-2021	----	----	----		05-Apr-2021	14 days	9 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Travel Blank	E290	26-Mar-2021	----	----	----		05-Apr-2021	14 days	9 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A - E303056	E100	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Physical Tests : Conductivity in Water										
HDPE										
Travel Blank	E100	26-Mar-2021	----	----	----		05-Apr-2021	28 days	9 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-3A - E303056	E108	26-Mar-2021	----	----	----		05-Apr-2021	0.25 hrs	238 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE Travel Blank	E108	26-Mar-2021	----	----	----		05-Apr-2021	0.25 hrs	238 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-3A - E303056	E162	26-Mar-2021	----	----	----		30-Mar-2021	7 days	3 days	✓
Physical Tests : TDS by Gravimetry										
HDPE Travel Blank	E162	26-Mar-2021	----	----	----		30-Mar-2021	7 days	3 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-3A - E303056	E160-H	26-Mar-2021	----	----	----		30-Mar-2021	7 days	3 days	✓
Physical Tests : TSS by Gravimetry										
HDPE Travel Blank	E160-H	26-Mar-2021	----	----	----		30-Mar-2021	7 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-3A - E303056	E121	26-Mar-2021	----	----	----		30-Mar-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE Travel Blank	E121	26-Mar-2021	----	----	----		30-Mar-2021	3 days	3 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW11-3A - E303056	E420.Cr-L	26-Mar-2021	----	----	----		31-Mar-2021	180 days	4 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) Travel Blank	E420.Cr-L	26-Mar-2021	----	----	----		31-Mar-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3A - E303056	E508	26-Mar-2021	----	----	----		03-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
Travel Blank	E508	26-Mar-2021	----	----	----		03-Apr-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A - E303056	E420	26-Mar-2021	----	----	----		31-Mar-2021	180 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Travel Blank	E420	26-Mar-2021	----	----	----		31-Mar-2021	180 days	5 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	173872	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	173440	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	172194	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	173443	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	173603	2	33	6.0	5.0	✓
Chloride in Water by IC	E235.Cl	173442	1	20	5.0	5.0	✓
Conductivity in Water	E100	173439	1	18	5.5	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	170971	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	173147	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	170972	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173871	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	173441	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	173444	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	173445	1	11	9.0	5.0	✓
pH by Meter	E108	173438	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	173446	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	171026	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	170967	2	22	9.0	5.0	✓
Total Mercury in Water by CVAAS	E508	173134	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	170966	2	37	5.4	5.0	✓
Total Nitrogen by Colourimetry	E366	172191	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	172259	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	171222	1	6	16.6	5.0	✓
TSS by Gravimetry	E160-H	171023	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	171291	1	19	5.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	173872	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	173440	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	172194	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	173443	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	173603	2	33	6.0	5.0	✓
Chloride in Water by IC	E235.Cl	173442	1	20	5.0	5.0	✓
Conductivity in Water	E100	173439	1	18	5.5	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	170971	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	173147	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	170972	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173871	1	9	11.1	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	173441	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	173444	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	173445	1	11	9.0	5.0	✓
pH by Meter	E108	173438	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	173446	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	171026	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	170967	2	22	9.0	5.0	✓
Total Mercury in Water by CVAAS	E508	173134	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	170966	2	37	5.4	5.0	✓
Total Nitrogen by Colourimetry	E366	172191	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	172259	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	171222	1	6	16.6	5.0	✓
TSS by Gravimetry	E160-H	171023	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	171291	1	19	5.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	173872	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	173440	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	172194	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	173443	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	173603	2	33	6.0	5.0	✓
Chloride in Water by IC	E235.Cl	173442	1	20	5.0	5.0	✓
Conductivity in Water	E100	173439	1	18	5.5	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	170971	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	173147	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	170972	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173871	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	173441	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	173444	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	173445	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	173446	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	171026	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	170967	2	22	9.0	5.0	✓
Total Mercury in Water by CVAAS	E508	173134	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	170966	2	37	5.4	5.0	✓
Total Nitrogen by Colourimetry	E366	172191	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	172259	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	171222	1	6	16.6	5.0	✓
TSS by Gravimetry	E160-H	171023	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	171291	1	19	5.2	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	172194	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	173443	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	173603	2	33	6.0	5.0	✓
Chloride in Water by IC	E235.Cl	173442	1	20	5.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	170971	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	173147	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	170972	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173871	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	173441	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	173444	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	173445	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	173446	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	170967	2	22	9.0	5.0	✓
Total Mercury in Water by CVAAS	E508	173134	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	170966	2	37	5.4	5.0	✓
Total Nitrogen by Colourimetry	E366	172191	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	172259	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	171222	1	6	16.6	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Manual)	E396 Vancouver - Environmental	Water	APHA 4500-S2 D (mod)	Total Sulfide is determined by spectrophotometer using the methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S).
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A5837**	Page	: 1 of 22
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Vacant	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 29-Mar-2021 16:35
PO	: 1025614	Date Analysis Commenced	: 30-Mar-2021
C-O-C number	: ----	Issue Date	: 07-Apr-2021 16:30
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Bruna Botti	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 171023)											
VA21A5774-012	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	5.4	4.8	0.6	Diff <2x LOR	----
Physical Tests (QC Lot: 171026)											
VA21A5774-003	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	462	468	1.29%	20%	----
Physical Tests (QC Lot: 171291)											
FJ2100141-001	Anonymous	turbidity	----	E121	0.10	NTU	105	106	0.948%	15%	----
Physical Tests (QC Lot: 173438)											
VA21A5837-001	BJ-GW11-3A - E303056	pH	----	E108	0.10	pH units	8.13	8.15	0.246%	4%	----
Physical Tests (QC Lot: 173439)											
VA21A5837-001	BJ-GW11-3A - E303056	conductivity	----	E100	2.0	µS/cm	403	403	0.00%	10%	----
Physical Tests (QC Lot: 173440)											
VA21A5837-001	BJ-GW11-3A - E303056	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	92.7	92.3	0.432%	20%	----
Physical Tests (QC Lot: 173872)											
VA21A5837-002	Travel Blank	acidity (as CaCO3)	----	E283	2.0	mg/L	2.3	2.2	0.08	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 171222)											
FJ2100141-001	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	0.039	0.039	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 172191)											
KS2100898-001	Anonymous	nitrogen, total	7727-37-9	E366	0.600	mg/L	26.5	25.9	2.11%	20%	----
Anions and Nutrients (QC Lot: 172194)											
KS2100898-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.250	mg/L	13.9	13.8	0.310%	20%	----
Anions and Nutrients (QC Lot: 172259)											
KS2100898-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.470	0.439	6.84%	20%	----
Anions and Nutrients (QC Lot: 173441)											
VA21A5837-001	BJ-GW11-3A - E303056	fluoride	16984-48-8	E235.F	0.020	mg/L	0.176	0.174	0.002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 173442)											
VA21A5837-001	BJ-GW11-3A - E303056	chloride	16887-00-6	E235.Cl	0.50	mg/L	2.08	2.06	0.02	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 173443)											
VA21A5837-001	BJ-GW11-3A - E303056	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 173444)											
VA21A5837-001	BJ-GW11-3A - E303056	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0205	0.0204	0.00010	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 173445)											
VA21A5837-001	BJ-GW11-3A - E303056	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0019	0.0016	0.0003	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 173446)											
VA21A5837-001	BJ-GW11-3A - E303056	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	112	112	0.0504%	20%	----
Anions and Nutrients (QC Lot: 173871)											
VA21A5837-001	BJ-GW11-3A - E303056	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Total Metals (QC Lot: 170966)											
VA21A5747-002	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.195	0.184	5.42%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00336	0.00332	1.06%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00074	0.00066	0.00008	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.105	0.0982	7.16%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	0.000061	<0.000050	0.000011	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.386	0.369	4.51%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000810	0.0000769	5.20%	20%	----
		calcium, total	7440-70-2	E420	0.050	mg/L	55.7	54.4	2.40%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00110	0.00107	2.64%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00414	0.00383	0.00031	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	14.7	14.5	1.45%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.00577	0.00585	1.33%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0192	0.0197	2.44%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	2.74	2.74	0.00618%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.507	0.513	1.21%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00810	0.00808	0.215%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00803	0.00805	0.195%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	0.140	0.129	0.011	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	10.4	9.83	6.09%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000146	0.000140	0.000006	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	3.94	3.84	2.65%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.000011	0.000011	0.0000003	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	160	160	0.104%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.264	0.268	1.74%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	0.00019	<0.00010	0.00009	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00438	0.00376	15.2%	20%	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000049	0.000049	0.0000007	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00090	0.00087	0.00003	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0341	0.0329	3.53%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 170967)											
VA21A5747-002	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00226	0.00218	3.61%	20%	----
Total Metals (QC Lot: 171429)											
FJ2100143-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.10	mg/L	4.80 µg/L	0.00491	2.14%	20%	----
Total Metals (QC Lot: 171430)											
FJ2100143-001	Anonymous	aluminum, total	7429-90-5	E420	3.0	mg/L	2740 µg/L	2.74	0.0591%	20%	----
		antimony, total	7440-36-0	E420	0.10	mg/L	0.44 µg/L	0.00045	0.000005	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.10	mg/L	2.58 µg/L	0.00261	1.32%	20%	----
		barium, total	7440-39-3	E420	0.10	mg/L	256 µg/L	0.255	0.264%	20%	----
		beryllium, total	7440-41-7	E420	0.100	mg/L	0.191 µg/L	0.000197	0.000006	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.050	mg/L	<0.050 µg/L	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	10	mg/L	16 µg/L	0.016	0.0004	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0050	mg/L	0.266 µg/L	0.000269	1.37%	20%	----
		calcium, total	7440-70-2	E420	50	mg/L	29900 µg/L	31.2	4.26%	20%	----
		cobalt, total	7440-48-4	E420	0.10	mg/L	2.09 µg/L	0.00208	0.578%	20%	----
		copper, total	7440-50-8	E420	0.50	mg/L	8.73 µg/L	0.00867	0.679%	20%	----
		iron, total	7439-89-6	E420	10	mg/L	4750 µg/L	4.74	0.265%	20%	----
		lead, total	7439-92-1	E420	0.050	mg/L	3.10 µg/L	0.00317	2.36%	20%	----
		lithium, total	7439-93-2	E420	1.0	mg/L	5.4 µg/L	0.0056	0.0002	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	5.0	mg/L	5640 µg/L	5.45	3.45%	20%	----
		manganese, total	7439-96-5	E420	0.10	mg/L	59.1 µg/L	0.0590	0.155%	20%	----
		molybdenum, total	7439-98-7	E420	0.050	mg/L	4.43 µg/L	0.00441	0.350%	20%	----
		nickel, total	7440-02-0	E420	0.50	mg/L	9.95 µg/L	0.00975	2.05%	20%	----
		phosphorus, total	7723-14-0	E420	50	mg/L	228 µg/L	0.226	0.003	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	50	mg/L	5940 µg/L	5.90	0.649%	20%	----
		selenium, total	7782-49-2	E420	0.050	mg/L	0.510 µg/L	0.000572	11.5%	20%	----
		silicon, total	7440-21-3	E420	100	mg/L	5960 µg/L	5.97	0.244%	20%	----
		silver, total	7440-22-4	E420	0.010	mg/L	0.057 µg/L	0.000057	0.0000005	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	50	mg/L	9520 µg/L	9.43	0.929%	20%	----
		strontium, total	7440-24-6	E420	0.20	mg/L	101 µg/L	0.102	0.472%	20%	----
		thallium, total	7440-28-0	E420	0.010	mg/L	0.102 µg/L	0.000103	0.587%	20%	----
		tin, total	7440-31-5	E420	0.10	mg/L	0.11 µg/L	0.00010	0.000007	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.30	mg/L	25.1 µg/L	0.0253	1.08%	20%	----
		uranium, total	7440-61-1	E420	0.010	mg/L	0.961 µg/L	0.000991	3.04%	20%	----
		vanadium, total	7440-62-2	E420	0.50	mg/L	12.3 µg/L	0.0122	0.531%	20%	----
		zinc, total	7440-66-6	E420	3.0	mg/L	31.7 µg/L	0.0294	7.64%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 173134)											
FJ2100141-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 170971)											
VA21A5791-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 170972)											
VA21A5791-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0022	0.0017	0.0004	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00026	0.00026	0.000002	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00713	0.00711	0.278%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0119	0.0120	0.684%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.021	0.022	0.0008	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000297	0.0000362	0.0000065	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	125	126	0.670%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00026	0.00026	0.0000007	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00045	0.00042	0.00003	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.713	0.720	1.05%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	5.23	5.26	0.645%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0962	0.0982	2.02%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00426	0.00432	1.35%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.406	0.418	0.012	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000201	0.000160	0.000041	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.89	3.92	0.716%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	4.95	4.98	0.453%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.361	0.369	2.30%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00535	0.00537	0.370%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0022	0.0023	0.0001	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 173147)											
CG2100571-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 173603)											
VA21A5776-005	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	41	31	10	Diff <2x LOR	----
Aggregate Organics (QC Lot: 173972)											
VA21A4739-004	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 171023)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 171026)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 171291)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 173439)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 173440)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 173872)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Anions and Nutrients (QCLot: 171222)						
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	<0.018	----
Anions and Nutrients (QCLot: 172191)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 172194)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 172259)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 173441)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 173442)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 173443)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 173444)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 173445)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 173446)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 173871)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 170966)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 170967)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 171429)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 171430)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 171430) - continued						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 173134)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 170971)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 170972)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 170972) - continued						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 173147)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 173603)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----
Aggregate Organics (QCLot: 173972)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 173972) - continued						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 171023)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	106	85.0	115	----
Physical Tests (QCLot: 171026)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	96.8	85.0	115	----
Physical Tests (QCLot: 171291)									
turbidity	----	E121	0.1	NTU	200 NTU	99.5	85.0	115	----
Physical Tests (QCLot: 173438)									
pH	----	E108	----	pH units	7 pH units	99.7	98.0	102	----
Physical Tests (QCLot: 173439)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.5	90.0	110	----
Physical Tests (QCLot: 173440)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 173872)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	93.7	85.0	115	----
Anions and Nutrients (QCLot: 171222)									
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	1 mg/L	99.4	75.0	125	----
Anions and Nutrients (QCLot: 172191)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 172194)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	100	85.0	115	----
Anions and Nutrients (QCLot: 172259)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	97.8	80.0	120	----
Anions and Nutrients (QCLot: 173441)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 173442)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	106	90.0	110	----
Anions and Nutrients (QCLot: 173443)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	109	85.0	115	----
Anions and Nutrients (QCLot: 173444)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 173445)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 173446)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 173446) - continued									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	108	90.0	110	----
Anions and Nutrients (QCLot: 173871)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	104	80.0	120	----
Total Metals (QCLot: 170966)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	109	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	118	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	112	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	114	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	112	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	96.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	109	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	111	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	107	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	100	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	107	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	106	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	106	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	107	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	112	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	105	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	113	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	109	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	110	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	104	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	108	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	98.6	80.0	120	----
Total Metals (QCLot: 170967)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 170967) - continued									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
Total Metals (QCLot: 171429)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	98.5	80.0	120	----
Total Metals (QCLot: 171430)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	105	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	107	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	100	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	105	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	99.3	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	100	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.1	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	106	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	98.2	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	99.6	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	103	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	104	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	98.0	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	100	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	99.3	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	99.4	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	103	80.0	120	----
Total Metals (QCLot: 173134)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	100	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Dissolved Metals (QCLot: 170971)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	98.8	80.0	120	----
Dissolved Metals (QCLot: 170972)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	95.9	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	97.1	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.5	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	98.2	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.4	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	99.4	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	98.4	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	98.0	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	97.8	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.1	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	100	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.0	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	97.3	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	97.3	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	91.9	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	97.5	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	94.7	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	105	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	97.3	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	96.3	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	100	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	97.3	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	100	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	98.6	80.0	120	----
Aggregate Organics (QCLot: 173603)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	92.1	85.0	115	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 173972)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	96.2	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 171222)										
FJ2100142-002	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.098 mg/L	0.1 mg/L	98.3	65.0	135	----
Anions and Nutrients (QCLot: 172191)										
KS2100898-002	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 172194)										
KS2100898-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.2 mg/L	ND	75.0	125	MS-B
Anions and Nutrients (QCLot: 172259)										
KS2100898-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0516 mg/L	0.05 mg/L	103	70.0	130	----
Anions and Nutrients (QCLot: 173441)										
VA21A5837-002	Travel Blank	fluoride	16984-48-8	E235.F	1.12 mg/L	1 mg/L	112	75.0	125	----
Anions and Nutrients (QCLot: 173442)										
VA21A5837-002	Travel Blank	chloride	16887-00-6	E235.Cl	114 mg/L	100 mg/L	114	75.0	125	----
Anions and Nutrients (QCLot: 173443)										
VA21A5837-002	Travel Blank	bromide	24959-67-9	E235.Br-L	0.576 mg/L	0.5 mg/L	115	75.0	125	----
Anions and Nutrients (QCLot: 173444)										
VA21A5837-002	Travel Blank	nitrate (as N)	14797-55-8	E235.NO3-L	2.80 mg/L	2.5 mg/L	112	75.0	125	----
Anions and Nutrients (QCLot: 173445)										
VA21A5837-002	Travel Blank	nitrite (as N)	14797-65-0	E235.NO2-L	0.557 mg/L	0.5 mg/L	111	75.0	125	----
Anions and Nutrients (QCLot: 173446)										
VA21A5837-002	Travel Blank	sulfate (as SO4)	14808-79-8	E235.SO4	116 mg/L	100 mg/L	116	75.0	125	----
Anions and Nutrients (QCLot: 173871)										
VA21A5837-002	Travel Blank	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0321 mg/L	0.03 mg/L	107	70.0	130	----
Total Metals (QCLot: 170966)										
VA21A5747-002	Anonymous	aluminum, total	7429-90-5	E420	0.226 mg/L	0.2 mg/L	113	70.0	130	----
		antimony, total	7440-36-0	E420	0.0233 mg/L	0.02 mg/L	116	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0231 mg/L	0.02 mg/L	115	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0494 mg/L	0.04 mg/L	124	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00982 mg/L	0.01 mg/L	98.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	High	Qualifier
Total Metals (QCLot: 170966) - continued										
VA21A5747-002	Anonymous	boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00436 mg/L	0.004 mg/L	109	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0214 mg/L	0.02 mg/L	107	70.0	130	----
		copper, total	7440-50-8	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		iron, total	7439-89-6	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0207 mg/L	0.02 mg/L	103	70.0	130	----
		lithium, total	7439-93-2	E420	0.110 mg/L	0.1 mg/L	110	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0227 mg/L	0.02 mg/L	113	70.0	130	----
		nickel, total	7440-02-0	E420	0.0422 mg/L	0.04 mg/L	105	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.4 mg/L	10 mg/L	114	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0466 mg/L	0.04 mg/L	116	70.0	130	----
		silicon, total	7440-21-3	E420	10.7 mg/L	10 mg/L	107	70.0	130	----
		silver, total	7440-22-4	E420	0.00414 mg/L	0.004 mg/L	103	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00397 mg/L	0.004 mg/L	99.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0217 mg/L	0.02 mg/L	109	70.0	130	----
		titanium, total	7440-32-6	E420	0.0481 mg/L	0.04 mg/L	120	70.0	130	----
		uranium, total	7440-61-1	E420	0.00433 mg/L	0.004 mg/L	108	70.0	130	----
		vanadium, total	7440-62-2	E420	0.117 mg/L	0.1 mg/L	117	70.0	130	----
		zinc, total	7440-66-6	E420	0.407 mg/L	0.4 mg/L	102	70.0	130	----
Total Metals (QCLot: 170967)										
VA21A5747-002	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.0441 mg/L	0.04 mg/L	110	70.0	130	----
Total Metals (QCLot: 171429)										
FJ2100143-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.0383 mg/L	0.04 mg/L	95.8	70.0	130	----
Total Metals (QCLot: 171430)										
FJ2100143-001	Anonymous	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0393 mg/L	0.04 mg/L	98.3	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00954 mg/L	0.01 mg/L	95.4	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 171430) - continued										
FJ2100143-001	Anonymous	boron, total	7440-42-8	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00389 mg/L	0.004 mg/L	97.3	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		copper, total	7440-50-8	E420	0.0189 mg/L	0.02 mg/L	94.6	70.0	130	----
		iron, total	7439-89-6	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0195 mg/L	0.02 mg/L	97.4	70.0	130	----
		lithium, total	7439-93-2	E420	0.0943 mg/L	0.1 mg/L	94.3	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0201 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, total	7440-02-0	E420	0.0386 mg/L	0.04 mg/L	96.4	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.3 mg/L	10 mg/L	103	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, total	7440-21-3	E420	9.00 mg/L	10 mg/L	90.0	70.0	130	----
		silver, total	7440-22-4	E420	0.00409 mg/L	0.004 mg/L	102	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00383 mg/L	0.004 mg/L	95.8	70.0	130	----
		tin, total	7440-31-5	E420	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		titanium, total	7440-32-6	E420	0.0305 mg/L	0.04 mg/L	76.3	70.0	130	----
		uranium, total	7440-61-1	E420	0.00389 mg/L	0.004 mg/L	97.2	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0991 mg/L	0.1 mg/L	99.1	70.0	130	----
		zinc, total	7440-66-6	E420	0.370 mg/L	0.4 mg/L	92.5	70.0	130	----
Total Metals (QCLot: 173134)										
FJ2100142-001	Anonymous	mercury, total	7439-97-6	E508	0.0000965 mg/L	0.0001 mg/L	96.5	70.0	130	----
Dissolved Metals (QCLot: 170971)										
VA21A5791-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 170972)										
VA21A5791-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0199 mg/L	0.02 mg/L	99.6	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0412 mg/L	0.04 mg/L	103	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00918 mg/L	0.01 mg/L	91.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 170972) - continued										
VA21A5791-001	Anonymous	boron, dissolved	7440-42-8	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00389 mg/L	0.004 mg/L	97.2	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0190 mg/L	0.02 mg/L	95.2	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.90 mg/L	2 mg/L	95.3	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0192 mg/L	0.02 mg/L	96.1	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.105 mg/L	0.1 mg/L	105	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0200 mg/L	0.02 mg/L	99.8	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0387 mg/L	0.04 mg/L	96.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.4 mg/L	10 mg/L	104	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.95 mg/L	4 mg/L	98.6	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0384 mg/L	0.04 mg/L	96.1	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.88 mg/L	10 mg/L	88.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00340 mg/L	0.004 mg/L	85.1	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00394 mg/L	0.004 mg/L	98.4	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0192 mg/L	0.02 mg/L	96.1	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0391 mg/L	0.04 mg/L	97.7	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.399 mg/L	0.4 mg/L	99.8	70.0	130	----
Dissolved Metals (QCLot: 173147)										
CG2100571-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000954 mg/L	0.0001 mg/L	95.4	70.0	130	----
Aggregate Organics (QCLot: 173603)										
VA21A5776-006	Anonymous	chemical oxygen demand [COD]	----	E559	533 mg/L	500 mg/L	107	75.0	125	----
Aggregate Organics (QCLot: 173972)										
VA21A4739-005	Anonymous	chemical oxygen demand [COD]	----	E559	519 mg/L	500 mg/L	104	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	*Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.*

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Analysis Request
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	A5837	ALS Contact:	Dean Watt	Sampler: NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients (P)	EPH	Total Metals (P)	Dissolved Metals (F/P)			Total Mercury (P)	Dissolved Mercury (F/P)	Acidity	Total Sulphides (P)		Number of Containers
	BJ-GW11-3A - E303056	26-Mar-21	15:30	Groundwater	X	X		X	X			X	X	X	X		7
	Travel Blank	26-Mar-21	15:30	Groundwater	X	X		X				X		X	X		5

Environmental Division
Vancouver
Work Order Reference
VA21A5837

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	28-Mar-21	18:00	MB	Mar 29	4:35PM	8.6 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A6199**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 01-Apr-2021 18:55
PO	: 1025614	Date Analysis Commenced	: 02-Apr-2021
C-O-C number	: ----	Issue Date	: 12-Apr-2021 16:11
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-17A-snap	BJ-GW18-17B-snap	----	----	----
				Client sampling date / time	31-Mar-2021 09:10	31-Mar-2021 11:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A6199-001	VA21A6199-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	102	306	----	----	----
conductivity	----	E100	2.0	µS/cm	899	900	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	11.0	172	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	18.5	170	----	----	----
pH	----	E108	0.10	pH units	8.99	8.46	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	567	701	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	116	49.6	----	----	----
turbidity	----	E121	0.10	NTU	57.7	143	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0414	0.0613	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	5.21	5.68	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.219	0.200	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.102	0.383	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0250 DLDS	0.0737	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0255	0.0892	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0050 DLDS	0.0155	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.102	0.472	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0105	0.357	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0889	0.505	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	310	158	----	----	----
sulfide, total (as H2S)	7783-06-4	E396	0.019	mg/L	<0.019	6.48	----	----	----
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	<0.018	6.09	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0724	0.952	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.0203	0.00171	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.274	0.0316	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0415	0.0627	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-snap	BJ-GW18-17B-snap	----	----	----
				Client sampling date / time	31-Mar-2021 09:10	31-Mar-2021 11:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A6199-001	VA21A6199-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.082	0.074	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000050	0.0000368	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	6.98	61.3	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00070	0.0155	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	0.00134	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00316	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.077	1.32	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000213	0.00184	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.413	0.178	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	0.267	4.03	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0195	0.346	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000500 DLM	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00404	0.00393	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	0.00963	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	0.534	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.73	5.00	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000231	0.000328	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.12	5.78	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000011	0.000131	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	174	124	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.415	2.51	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	0.000028	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	0.00047	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	0.0117	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000185	0.00256	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	0.00350	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	0.0142	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0109	0.0057	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.0193	0.00058	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-snap	BJ-GW18-17B-snap	----	----	----
				Client sampling date / time	31-Mar-2021 09:10	31-Mar-2021 11:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A6199-001	VA21A6199-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.291	0.0234	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0340	0.0378	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.080	0.074	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	4.02	62.6	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00031	0.00131	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	0.011	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000121	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.449	0.192	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	0.243	3.70	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00667	0.280	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000500 DLM	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00364	0.00186	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00187	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	0.528	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.78	4.97	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000171	0.00583 DTSE	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.99	4.62	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	176	132	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.384	2.44	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	0.00024	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000179	0.00230	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	0.00170	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17A-snap**	**BJ-GW18-17B-snap**	**----**	**----**	**----**
				Client sampling date / time	31-Mar-2021 09:10	31-Mar-2021 11:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21A6199-001**	**VA21A6199-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	278	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A6199**	Page	: 1 of 16
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 01-Apr-2021 18:55
PO	: 1025614	Issue Date	: 12-Apr-2021 16:11
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Laboratory Control Sample (LCS) Recoveries								
Dissolved Metals	QC-MRG2-172814002	----	silver, dissolved	7440-22-4	E421	78.3 % MES	80.0-120%	Recovery less than lower control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 15:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 15:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-snap	E559	31-Mar-2021	----	----	----		07-Apr-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-snap	E559	31-Mar-2021	----	----	----		07-Apr-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-snap	E298	31-Mar-2021	07-Apr-2021	28 days	7 days	✓	08-Apr-2021	20 days	0 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-snap	E298	31-Mar-2021	07-Apr-2021	28 days	7 days	✓	08-Apr-2021	20 days	0 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-snap	E235.Br-L	31-Mar-2021	----	----	----		04-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-snap	E235.Br-L	31-Mar-2021	----	----	----		04-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B-snap	E235.Cl	31-Mar-2021	----	----	----		04-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE BJ-GW18-17A-snap	E235.Cl	31-Mar-2021	----	----	----		04-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW18-17A-snap	E378-U	31-Mar-2021	----	----	----		03-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW18-17B-snap	E378-U	31-Mar-2021	----	----	----		03-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW18-17B-snap	E235.F	31-Mar-2021	----	----	----		04-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW18-17A-snap	E235.F	31-Mar-2021	----	----	----		04-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE BJ-GW18-17B-snap	E235.NO3-L	31-Mar-2021	----	----	----		04-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE BJ-GW18-17A-snap	E235.NO3-L	31-Mar-2021	----	----	----		04-Apr-2021	3 days	4 days	✗ EHT
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE BJ-GW18-17B-snap	E235.NO2-L	31-Mar-2021	----	----	----		04-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE BJ-GW18-17A-snap	E235.NO2-L	31-Mar-2021	----	----	----		04-Apr-2021	3 days	4 days	✗ EHT

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17B-snap	E235.SO4	31-Mar-2021	----	----	----		04-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A-snap	E235.SO4	31-Mar-2021	----	----	----		04-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-snap	E366	31-Mar-2021	07-Apr-2021	28 days	7 days	✓	09-Apr-2021	20 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-snap	E366	31-Mar-2021	07-Apr-2021	28 days	7 days	✓	09-Apr-2021	20 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-snap	E372-U	31-Mar-2021	07-Apr-2021	28 days	7 days	✓	08-Apr-2021	20 days	0 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-snap	E372-U	31-Mar-2021	07-Apr-2021	28 days	7 days	✓	08-Apr-2021	20 days	0 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Manual)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17A-snap	E396	31-Mar-2021	----	----	----		05-Apr-2021	7 days	4 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Manual)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17B-snap	E396	31-Mar-2021	----	----	----		05-Apr-2021	7 days	4 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-snap	E421.Cr-L	31-Mar-2021	02-Apr-2021	180 days	1 days	✓	04-Apr-2021	178 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW18-17B-snap	E421.Cr-L	31-Mar-2021	02-Apr-2021	180 days	1 days	✓	04-Apr-2021	178 days	2 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B-snap	E509	31-Mar-2021	08-Apr-2021	28 days	7 days	✓	08-Apr-2021	20 days	0 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17A-snap	E509	31-Mar-2021	08-Apr-2021	28 days	8 days	✓	08-Apr-2021	19 days	0 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-snap	E421	31-Mar-2021	02-Apr-2021	180 days	1 days	✓	04-Apr-2021	178 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B-snap	E421	31-Mar-2021	02-Apr-2021	180 days	1 days	✓	04-Apr-2021	178 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A-snap	E283	31-Mar-2021	----	----	----		05-Apr-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B-snap	E283	31-Mar-2021	----	----	----		05-Apr-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A-snap	E290	31-Mar-2021	----	----	----		04-Apr-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B-snap	E290	31-Mar-2021	----	----	----		04-Apr-2021	14 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A-snap	E100	31-Mar-2021	----	----	----		04-Apr-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B-snap	E100	31-Mar-2021	----	----	----		04-Apr-2021	28 days	4 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17A-snap	E108	31-Mar-2021	----	----	----		04-Apr-2021	0.25 hrs	101 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17B-snap	E108	31-Mar-2021	----	----	----		04-Apr-2021	0.25 hrs	99 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-17A-snap	E162	31-Mar-2021	----	----	----		07-Apr-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-17B-snap	E162	31-Mar-2021	----	----	----		07-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17A-snap	E160-H	31-Mar-2021	----	----	----		07-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17B-snap	E160-H	31-Mar-2021	----	----	----		07-Apr-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17A-snap	E121	31-Mar-2021	----	----	----		03-Apr-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17B-snap	E121	31-Mar-2021	----	----	----		03-Apr-2021	3 days	2 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW18-17A-snap	E420.Cr-L	31-Mar-2021	----	----	----		04-Apr-2021	180 days	4 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW18-17B-snap	E420.Cr-L	31-Mar-2021	----	----	----		04-Apr-2021	180 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-17A-snap	E508	31-Mar-2021	----	----	----		07-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-17B-snap	E508	31-Mar-2021	----	----	----		07-Apr-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17A-snap	E420	31-Mar-2021	----	----	----		04-Apr-2021	180 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17B-snap	E420	31-Mar-2021	----	----	----		04-Apr-2021	180 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	173001	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	172992	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	175024	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	172999	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	174870	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	172998	1	20	5.0	5.0	✓
Conductivity in Water	E100	172993	1	20	5.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	172815	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175389	1	10	10.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	172814	2	20	10.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173000	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	172997	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	172995	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	172994	1	20	5.0	5.0	✓
pH by Meter	E108	172991	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	172996	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	174527	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	172805	1	3	33.3	5.0	✓
Total Mercury in Water by CVAAS	E508	174788	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	172804	1	9	11.1	5.0	✓
Total Nitrogen by Colourimetry	E366	175022	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	175023	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	173475	1	5	20.0	5.0	✓
TSS by Gravimetry	E160-H	174524	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	173039	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	173001	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	172992	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	175024	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	172999	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	174870	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	172998	1	20	5.0	5.0	✓
Conductivity in Water	E100	172993	1	20	5.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	172815	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175389	1	10	10.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	172814	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173000	1	2	50.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	172997	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	172995	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	172994	1	20	5.0	5.0	✓
pH by Meter	E108	172991	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	172996	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	174527	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	172805	1	3	33.3	5.0	✓
Total Mercury in Water by CVAAS	E508	174788	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	172804	1	9	11.1	5.0	✓
Total Nitrogen by Colourimetry	E366	175022	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	175023	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	173475	1	5	20.0	5.0	✓
TSS by Gravimetry	E160-H	174524	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	173039	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	173001	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	172992	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	175024	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	172999	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	174870	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	172998	1	20	5.0	5.0	✓
Conductivity in Water	E100	172993	1	20	5.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	172815	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175389	1	10	10.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	172814	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173000	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	172997	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	172995	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	172994	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	172996	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	174527	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	172805	1	3	33.3	5.0	✓
Total Mercury in Water by CVAAS	E508	174788	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	172804	1	9	11.1	5.0	✓
Total Nitrogen by Colourimetry	E366	175022	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	175023	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	173475	1	5	20.0	5.0	✓
TSS by Gravimetry	E160-H	174524	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	173039	1	20	5.0	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	175024	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	172999	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	174870	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	172998	1	20	5.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	172815	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175389	1	10	10.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	172814	2	20	10.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	173000	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	172997	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	172995	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	172994	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	172996	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	172805	1	3	33.3	5.0	✓
Total Mercury in Water by CVAAS	E508	174788	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	172804	1	9	11.1	5.0	✓
Total Nitrogen by Colourimetry	E366	175022	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	175023	1	17	5.8	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	173475	1	5	20.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Manual)	E396 Vancouver - Environmental	Water	APHA 4500-S2 D (mod)	Total Sulfide is determined by spectrophotometer using the methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S).
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A6199**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 01-Apr-2021 18:55
PO	: 1025614	Date Analysis Commenced	: 02-Apr-2021
C-O-C number	: ----	Issue Date	: 12-Apr-2021 16:11
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 172991)											
VA21A6146-001	Anonymous	pH	----	E108	0.10	pH units	7.11	7.11	0.00%	4%	----
Physical Tests (QC Lot: 172992)											
VA21A6146-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	13.1	12.9	1.54%	20%	----
Physical Tests (QC Lot: 172993)											
VA21A6146-001	Anonymous	conductivity	----	E100	2.0	µS/cm	24.9	25.0	0.1	Diff <2x LOR	----
Physical Tests (QC Lot: 173001)											
VA21A6203-001	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	7.3	7.6	0.3	Diff <2x LOR	----
Physical Tests (QC Lot: 173039)											
VA21A6074-006	Anonymous	turbidity	----	E121	0.10	NTU	<0.10	<0.10	0	Diff <2x LOR	----
Physical Tests (QC Lot: 174524)											
VA21A6062-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 174527)											
VA21A6091-010	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	994	1000	1.00%	20%	----
Anions and Nutrients (QC Lot: 172994)											
VA21A6146-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 172995)											
VA21A6146-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0209	0.0189	0.0020	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 172996)											
VA21A6146-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	2.25	2.22	0.04	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 172997)											
VA21A6146-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	<0.020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 172998)											
VA21A6146-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 172999)											
VA21A6146-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 173000)											
VA21A6199-001	BJ-GW18-17A-snap	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0105	0.0097	7.79%	20%	----
Anions and Nutrients (QC Lot: 173475)											
VA21A5911-001	Anonymous	sulfide, total (as S)	18496-25-8	E396	9.00	mg/L	93.9	93.9	0.00%	20%	----
Anions and Nutrients (QC Lot: 175022)											
VA21A6066-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.911	0.904	0.782%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 175023)											
VA21A4828-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0400	mg/L	1.23	1.14	7.64%	20%	----
Anions and Nutrients (QC Lot: 175024)											
VA21A4828-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.456	0.454	0.394%	20%	----
Total Metals (QC Lot: 172804)											
VA21A6199-001	BJ-GW18-17A-snap	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0724	0.0670	7.77%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.0203	0.0203	0.0760%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.274	0.284	3.41%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0415	0.0469	12.3%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.082	0.086	0.004	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000050	<0.0000050	0.00000006	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	6.98	7.23	3.51%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.077	0.071	0.005	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000213	0.000209	0.000004	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.413	0.416	0.826%	20%	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	0.267	0.266	0.0005	Diff <2x LOR	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.0195	0.0200	2.75%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00404	0.00391	3.16%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	1.73	1.80	4.29%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000231	0.000224	0.000007	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	3.12	3.22	3.15%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.000011	0.000016	0.000005	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	174	179	3.20%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.415	0.421	1.53%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000185	0.000184	0.415%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 172805)											
VA21A6199-001	BJ-GW18-17A-snap	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00070	0.00067	0.00004	Diff <2x LOR	----
Total Metals (QC Lot: 174788)											
VA21A6132-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 172814)											
KS2100930-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0587	0.0613	4.37%	20%	----
KS2100930-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0074	0.0067	0.0008	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00011	0.00011	0.000004	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00561	0.00582	3.66%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.011	0.011	0.0002	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	1.35	1.33	1.16%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00020	0.000003	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0077	0.0078	0.00007	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	0.334	0.327	0.0062	Diff <2x LOR	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0176	0.0174	1.49%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000881	0.000878	0.379%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	0.831	0.823	0.007	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	4.16	4.10	1.53%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	103	101	2.03%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.0591	0.0581	1.71%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000250	0.000247	1.32%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 172815)											
KS2100930-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 175389)											
VA21A6199-001	BJ-GW18-17A-snap	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 174870)											
VA21A6052-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 172992)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 172993)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 173001)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 173039)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 174524)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 174527)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 172994)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 172995)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 172996)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 172997)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 172998)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 172999)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 173000)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 173475)						
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	<0.018	----
Anions and Nutrients (QCLot: 175022)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 175023)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 175024)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 172804)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 172805)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 174788)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 172814)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 172814) - continued						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 172815)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 175389)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 174870)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 174870) - continued						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 172991)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 172992)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 172993)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	102	90.0	110	----
Physical Tests (QCLot: 173001)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	97.6	85.0	115	----
Physical Tests (QCLot: 173039)									
turbidity	----	E121	0.1	NTU	200 NTU	104	85.0	115	----
Physical Tests (QCLot: 174524)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	101	85.0	115	----
Physical Tests (QCLot: 174527)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	100.0	85.0	115	----
Anions and Nutrients (QCLot: 172994)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	106	90.0	110	----
Anions and Nutrients (QCLot: 172995)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	107	90.0	110	----
Anions and Nutrients (QCLot: 172996)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	108	90.0	110	----
Anions and Nutrients (QCLot: 172997)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 172998)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	107	90.0	110	----
Anions and Nutrients (QCLot: 172999)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	104	85.0	115	----
Anions and Nutrients (QCLot: 173000)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	103	80.0	120	----
Anions and Nutrients (QCLot: 173475)									
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	1 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 175022)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 175023)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 175023) - continued									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.6	80.0	120	----
Anions and Nutrients (QCLot: 175024)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.6	85.0	115	----
Total Metals (QCLot: 172804)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	98.1	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	96.9	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	97.8	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.6	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	97.8	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	96.5	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	97.0	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	98.2	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	97.0	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	96.0	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	96.4	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	98.6	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	96.7	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	94.6	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	98.8	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	99.8	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.6	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	113	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	98.8	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	98.6	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	95.5	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	99.2	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	98.4	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.4	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	99.1	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	97.1	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	94.6	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	98.6	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	93.9	80.0	120	----
Total Metals (QCLot: 172805)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 172805) - continued									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	95.1	80.0	120	----
Total Metals (QCLot: 174788)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	93.9	80.0	120	----
Dissolved Metals (QCLot: 172814)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	101	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	107	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	100	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	98.2	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	95.1	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	98.7	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	91.0	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.2	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	94.4	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.4	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	96.0	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	99.7	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	98.8	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	117	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	111	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	90.5	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	# 78.3	80.0	120	MES
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	97.8	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	103	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	91.0	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	98.2	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	102	80.0	120	----
Dissolved Metals (QCLot: 172815)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 172815) - continued									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	99.5	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	102	80.0	120	----
Aggregate Organics (QCLot: 174870)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	98.7	85.0	115	----

Qualifiers

Qualifier	Description
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 172994)										
VA21A6146-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.538 mg/L	0.5 mg/L	108	75.0	125	----
Anions and Nutrients (QCLot: 172995)										
VA21A6146-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.72 mg/L	2.5 mg/L	109	75.0	125	----
Anions and Nutrients (QCLot: 172996)										
VA21A6146-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	ND mg/L	100 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 172997)										
VA21A6146-002	Anonymous	fluoride	16984-48-8	E235.F	1.07 mg/L	1 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 172998)										
VA21A6146-002	Anonymous	chloride	16887-00-6	E235.Cl	109 mg/L	100 mg/L	109	75.0	125	----
Anions and Nutrients (QCLot: 172999)										
VA21A6146-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.544 mg/L	0.5 mg/L	109	75.0	125	----
Anions and Nutrients (QCLot: 173000)										
VA21A6199-002	BJ-GW18-17B-snap	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	ND mg/L	0.03 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 173475)										
VA21A6115-001	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.078 mg/L	0.1 mg/L	77.9	65.0	135	----
Anions and Nutrients (QCLot: 175022)										
VA21A6066-002	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 175023)										
VA21A6066-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0497 mg/L	0.05 mg/L	99.5	70.0	130	----
Anions and Nutrients (QCLot: 175024)										
VA21A6066-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.195 mg/L	0.2 mg/L	97.4	75.0	125	----
Total Metals (QCLot: 172804)										
VA21A6199-001	BJ-GW18-17A-snap	aluminum, total	7429-90-5	E420	0.173 mg/L	0.2 mg/L	86.3	70.0	130	----
		antimony, total	7440-36-0	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0394 mg/L	0.04 mg/L	98.4	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00934 mg/L	0.01 mg/L	93.4	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 172804) - continued										
VA21A6199-001	BJ-GW18-17A-snap	boron, total	7440-42-8	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00394 mg/L	0.004 mg/L	98.4	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0190 mg/L	0.02 mg/L	95.2	70.0	130	----
		copper, total	7440-50-8	E420	0.0187 mg/L	0.02 mg/L	93.6	70.0	130	----
		iron, total	7439-89-6	E420	1.83 mg/L	2 mg/L	91.5	70.0	130	----
		lead, total	7439-92-1	E420	0.0187 mg/L	0.02 mg/L	93.6	70.0	130	----
		lithium, total	7439-93-2	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, total	7439-95-4	E420	0.920 mg/L	1 mg/L	92.0	70.0	130	----
		manganese, total	7439-96-5	E420	0.0182 mg/L	0.02 mg/L	91.1	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, total	7440-02-0	E420	0.0386 mg/L	0.04 mg/L	96.5	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.5 mg/L	10 mg/L	105	70.0	130	----
		potassium, total	7440-09-7	E420	3.82 mg/L	4 mg/L	95.5	70.0	130	----
		selenium, total	7782-49-2	E420	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		silicon, total	7440-21-3	E420	9.08 mg/L	10 mg/L	90.8	70.0	130	----
		silver, total	7440-22-4	E420	0.00392 mg/L	0.004 mg/L	97.9	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00370 mg/L	0.004 mg/L	92.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0195 mg/L	0.02 mg/L	97.5	70.0	130	----
		titanium, total	7440-32-6	E420	0.0395 mg/L	0.04 mg/L	98.8	70.0	130	----
		uranium, total	7440-61-1	E420	0.00410 mg/L	0.004 mg/L	102	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0999 mg/L	0.1 mg/L	99.9	70.0	130	----
		zinc, total	7440-66-6	E420	0.386 mg/L	0.4 mg/L	96.6	70.0	130	----
Total Metals (QCLot: 172805)										
VA21A6199-001	BJ-GW18-17A-snap	chromium, total	7440-47-3	E420.Cr-L	0.0376 mg/L	0.04 mg/L	94.1	70.0	130	----
Total Metals (QCLot: 174788)										
VA21A6132-002	Anonymous	mercury, total	7439-97-6	E508	0.0000925 mg/L	0.0001 mg/L	92.5	70.0	130	----
Dissolved Metals (QCLot: 172814)										
KS2100930-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.413 mg/L	0.4 mg/L	103	70.0	130	----
KS2100930-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.196 mg/L	0.2 mg/L	98.2	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0214 mg/L	0.02 mg/L	107	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0400 mg/L	0.04 mg/L	99.9	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 172814) - continued										
KS2100930-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00777 mg/L	0.01 mg/L	77.7	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.096 mg/L	0.1 mg/L	96.3	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00391 mg/L	0.004 mg/L	97.7	70.0	130	----
		calcium, dissolved	7440-70-2	E421	3.87 mg/L	4 mg/L	96.8	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0194 mg/L	0.02 mg/L	96.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0187 mg/L	0.02 mg/L	93.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.86 mg/L	2 mg/L	93.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0178 mg/L	0.02 mg/L	89.0	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0968 mg/L	0.1 mg/L	96.8	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	0.951 mg/L	1 mg/L	95.1	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0184 mg/L	0.02 mg/L	91.9	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0371 mg/L	0.04 mg/L	92.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.0 mg/L	10 mg/L	110	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.94 mg/L	4 mg/L	98.6	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0420 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.86 mg/L	10 mg/L	88.6	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00368 mg/L	0.004 mg/L	92.0	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00359 mg/L	0.004 mg/L	89.7	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0185 mg/L	0.02 mg/L	92.4	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0409 mg/L	0.04 mg/L	102	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00397 mg/L	0.004 mg/L	99.2	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 172815)										
KS2100930-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.0379 mg/L	0.04 mg/L	94.8	70.0	130	----
Dissolved Metals (QCLot: 175389)										
VA21A6199-002	BJ-GW18-17B-snap	mercury, dissolved	7439-97-6	E509	0.000840 mg/L	0.001 mg/L	84.0	70.0	130	----
Aggregate Organics (QCLot: 174870)										
VA21A6052-002	Anonymous	chemical oxygen demand [COD]	----	E559	516 mg/L	500 mg/L	103	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17A - snap	31-Mar-21	9:10	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-17B - snap	31-Mar-21	11:05	Groundwater	X	X		X	X			X		X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21A6199

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	31-Mar-21	18:00	TC	APR - 1 2021	0551	7 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A6365**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 06-Apr-2021 20:45
PO	: 1025614	Date Analysis Commenced	: 07-Apr-2021
C-O-C number	: ----	Issue Date	: 13-Apr-2021 16:36
Sampler	: NG/BM/LF		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Bruna Botti	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B-E 314701	----	----	----	----
				Client sampling date / time	05-Apr-2021 09:40	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A6365-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	117	----	----	----	----
conductivity	----	E100	2.0	µS/cm	964	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	332	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	374	----	----	----	----
pH	----	E108	0.10	pH units	7.76	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	652	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	263	----	----	----	----
turbidity	----	E121	0.10	NTU	293	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0757	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	5.02	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.138	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.451	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.172	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.200	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0277	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.651 DLM	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.267	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	395	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E396	0.019	mg/L	0.145	----	----	----	----
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	0.136	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	3.10	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00295	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0276	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.124	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000236	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW18-17B-E 314701	----	----	----	----
					Client sampling date / time	05-Apr-2021 09:40	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21A6365-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
bismuth, total	7440-69-9	E420	0.000050	mg/L		0.000103	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L		0.053	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.0000956	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L		138	----	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L		0.0150	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00264	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.00649	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L		4.49	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L		0.00476	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L		0.109	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		7.27	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.328	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L		0.0000234	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.00181	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L		0.00613	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L		<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L		3.11	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L		0.00110	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L		6.90	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L		0.000402	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L		55.6	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L		4.44	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L		0.000109	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L		0.00034	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L		0.0275	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000834	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00509	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0208	----	----	----	----
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0034	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00190	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW18-17B-E 314701	----	----	----	----
					Client sampling date / time	05-Apr-2021 09:40	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21A6365-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.0124	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0449	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		0.044	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		124	----	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L		0.00032	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00020	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		0.193	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.119	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		5.41	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.174	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.00159	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		0.00124	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		2.77	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000538	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		3.06	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		60.7	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		4.14	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		0.00019	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000966	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L		0.0020	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17B-E 314701**	**----**	**----**	**----**	**----**
				Client sampling date / time	05-Apr-2021 09:40	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21A6365-001**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	51	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A6365**	Page	: 1 of 13
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 06-Apr-2021 20:45
PO	: 1025614	Issue Date	: 13-Apr-2021 16:36
C-O-C number	: ----		
Sampler	: NG/BM/LF		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 15:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 15:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-17B-E314701	E559	05-Apr-2021	----	----	----		08-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW18-17B-E314701	E298	05-Apr-2021	10-Apr-2021	28 days	5 days	✓	12-Apr-2021	22 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE BJ-GW18-17B-E314701	E235.Br-L	05-Apr-2021	----	----	----		07-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE BJ-GW18-17B-E314701	E235.Cl	05-Apr-2021	----	----	----		07-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW18-17B-E314701	E378-U	05-Apr-2021	----	----	----		07-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW18-17B-E314701	E235.F	05-Apr-2021	----	----	----		07-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE BJ-GW18-17B-E314701	E235.NO3-L	05-Apr-2021	----	----	----		07-Apr-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE BJ-GW18-17B-E314701	E235.NO2-L	05-Apr-2021	----	----	----		07-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE BJ-GW18-17B-E314701	E235.SO4	05-Apr-2021	----	----	----		07-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-17B-E314701	E366	05-Apr-2021	10-Apr-2021	28 days	5 days	✓	13-Apr-2021	22 days	2 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-17B-E314701	E372-U	05-Apr-2021	10-Apr-2021	28 days	5 days	✓	11-Apr-2021	22 days	0 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Manual)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17B-E314701	E396	05-Apr-2021	----	----	----		07-Apr-2021	7 days	1 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid) BJ-GW18-17B-E314701	E421.Cr-L	05-Apr-2021	07-Apr-2021	180 days	1 days	✓	07-Apr-2021	178 days	0 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) BJ-GW18-17B-E314701	E509	05-Apr-2021	08-Apr-2021	28 days	3 days	✓	08-Apr-2021	24 days	0 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW18-17B-E314701	E421	05-Apr-2021	07-Apr-2021	180 days	1 days	✓	07-Apr-2021	178 days	0 days	✓
Physical Tests : Acidity by Titration										
HDPE BJ-GW18-17B-E314701	E283	05-Apr-2021	----	----	----		07-Apr-2021	14 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE BJ-GW18-17B-E314701	E290	05-Apr-2021	----	----	----		07-Apr-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW18-17B-E314701	E100	05-Apr-2021	----	----	----		07-Apr-2021	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW18-17B-E314701	E108	05-Apr-2021	----	----	----		07-Apr-2021	0.25 hrs	51 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17B-E314701	E162	05-Apr-2021	----	----	----		11-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17B-E314701	E160-H	05-Apr-2021	----	----	----		11-Apr-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17B-E314701	E121	05-Apr-2021	----	----	----		07-Apr-2021	3 days	2 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW18-17B-E314701	E420.Cr-L	05-Apr-2021	----	----	----		07-Apr-2021	180 days	2 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B-E314701	E508	05-Apr-2021	----	----	----		09-Apr-2021	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B-E314701	E420	05-Apr-2021	----	----	----		07-Apr-2021	180 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	174695	1	11	9.0	5.0	✓
Alkalinity Species by Titration	E290	174693	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	176682	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	174690	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	175560	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	174686	1	20	5.0	5.0	✓
Conductivity in Water	E100	174694	1	14	7.1	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	174441	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175397	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	174440	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	174684	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	174685	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	174687	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	174688	1	20	5.0	5.0	✓
pH by Meter	E108	174692	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	174689	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	176889	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	174424	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	176123	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	174425	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	176681	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	176683	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	174536	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	176904	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	175027	1	19	5.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	174695	1	11	9.0	5.0	✓
Alkalinity Species by Titration	E290	174693	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	176682	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	174690	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	175560	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	174686	1	20	5.0	5.0	✓
Conductivity in Water	E100	174694	1	14	7.1	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	174441	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175397	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	174440	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	174684	1	14	7.1	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	174685	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	174687	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	174688	1	20	5.0	5.0	✓
pH by Meter	E108	174692	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	174689	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	176889	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	174424	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	176123	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	174425	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	176681	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	176683	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	174536	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	176904	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	175027	1	19	5.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	174695	1	11	9.0	5.0	✓
Alkalinity Species by Titration	E290	174693	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	176682	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	174690	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	175560	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	174686	1	20	5.0	5.0	✓
Conductivity in Water	E100	174694	1	14	7.1	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	174441	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175397	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	174440	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	174684	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	174685	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	174687	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	174688	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	174689	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	176889	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	174424	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	176123	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	174425	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	176681	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	176683	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	174536	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	176904	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	175027	1	19	5.2	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	176682	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	174690	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	175560	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	174686	1	20	5.0	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	174441	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	175397	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	174440	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	174684	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	174685	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	174687	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	174688	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	174689	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	174424	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	176123	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	174425	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	176681	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	176683	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Manual)	E396	174536	1	3	33.3	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Manual)	E396 Vancouver - Environmental	Water	APHA 4500-S2 D (mod)	Total Sulfide is determined by spectrophotometer using the methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S).
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A6365**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 06-Apr-2021 20:45
PO	: 1025614	Date Analysis Commenced	: 07-Apr-2021
C-O-C number	: ----	Issue Date	: 13-Apr-2021 16:36
Sampler	: NG/BM/LF		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Bruna Botti	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 174692)											
VA21A6362-001	Anonymous	pH	----	E108	0.10	pH units	7.79	7.77	0.257%	4%	----
Physical Tests (QC Lot: 174693)											
VA21A6362-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	54.3	54.6	0.551%	20%	----
Physical Tests (QC Lot: 174694)											
VA21A6362-001	Anonymous	conductivity	----	E100	2.0	µS/cm	333	333	0.00%	10%	----
Physical Tests (QC Lot: 174695)											
VA21A6366-001	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 175027)											
KS2100969-004	Anonymous	turbidity	----	E121	0.10	NTU	<0.10	<0.10	0	Diff <2x LOR	----
Physical Tests (QC Lot: 176889)											
VA21A6323-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	360	360	0.278%	20%	----
Physical Tests (QC Lot: 176904)											
VA21A6399-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	19.9	21.7	1.8	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 174536)											
VA21A6342-001	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.090	mg/L	0.203	0.201	0.002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 174684)											
VA21A6361-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	10.0	mg/L	243 µg/L	0.241	0.955%	20%	----
Anions and Nutrients (QC Lot: 174685)											
VA21A6360-001	Anonymous	fluoride	16984-48-8	E235.F	200	mg/L	<200 µg/L	<0.200	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 174686)											
VA21A6360-001	Anonymous	chloride	16887-00-6	E235.Cl	5000	mg/L	77600 µg/L	77.6	0.106%	20%	----
Anions and Nutrients (QC Lot: 174687)											
VA21A6360-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	50.0	mg/L	134 µg/L	0.126	0.0084	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 174688)											
VA21A6360-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	10.0	mg/L	111 µg/L	0.128	14.0%	20%	----
Anions and Nutrients (QC Lot: 174689)											
VA21A6360-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	3000	mg/L	37700 µg/L	37.5	0.697%	20%	----
Anions and Nutrients (QC Lot: 174690)											
VA21A6360-001	Anonymous	bromide	24959-67-9	E235.Br-L	500	mg/L	<500 µg/L	<0.500	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 176681)											
VA21A6362-001	Anonymous	nitrogen, total	7727-37-9	E366	0.300	mg/L	9.02	9.07	0.456%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 176682)											
VA21A6362-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0467	0.0469	0.0002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 176683)											
VA21A6362-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Total Metals (QC Lot: 174424)											
FJ2100156-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Total Metals (QC Lot: 174425)											
FJ2100156-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0077	0.0088	0.0011	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00279	0.00276	1.09%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00075	0.00077	0.00002	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.133	0.135	1.35%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.172	0.164	5.04%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000448	0.0000488	0.0000040	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	167	168	0.476%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00019	0.00021	0.00001	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00083	0.00087	0.00003	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.142	0.148	4.35%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000065	0.000064	0.0000004	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.244	0.239	2.15%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	61.0	62.6	2.60%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.0646	0.0666	3.05%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00966	0.00953	1.39%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00279	0.00284	0.00005	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	0.364	0.340	0.024	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	5.84	5.79	0.737%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.0132	0.0133	0.722%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	8.52	8.58	0.658%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	180	183	1.65%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.292	0.288	1.38%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00060	mg/L	<0.00060	<0.00030	0.00030	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.0130	0.0128	1.82%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 174425) - continued											
FJ2100156-001	Anonymous	vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0052	0.0053	0.00010	Diff <2x LOR	----
Total Metals (QC Lot: 176123)											
VA21A6365-001	BJ-GW18-17B-E314701	mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000234	0.0000211	0.0000023	Diff <2x LOR	----
Dissolved Metals (QC Lot: 174440)											
VA21A6242-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0050	0.0051	0.00007	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00011	0.00010	0.00001	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.102	0.101	0.411%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.081	0.083	0.002	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	27.2	27.9	2.44%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.172	0.171	0.950%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0092	0.0095	0.0003	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	5.81	5.89	1.38%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0860	0.0861	0.178%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000099	0.000094	0.000005	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.239	0.229	0.010	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	9.05	8.43	7.11%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	56.0	55.6	0.563%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.668	0.639	4.36%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000016	0.000018	0.000001	Diff <2x LOR	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 174440) - continued											
VA21A6242-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 174441)											
VA21A6242-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 175397)											
VA21A6270-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 175560)											
KS2100998-003	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	29	32	3	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 174693)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 174694)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 174695)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 175027)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 176889)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 176904)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 174536)						
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	<0.018	----
Anions and Nutrients (QCLot: 174684)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 174685)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 174686)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 174687)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 174688)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 174689)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 174690)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 176681)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 176682)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 176683)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 174424)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 174425)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 176123)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 174440)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 174440) - continued						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 174441)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 175397)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 175560)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 175560) - continued						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 174692)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 174693)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	106	85.0	115	----
Physical Tests (QCLot: 174694)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	102	90.0	110	----
Physical Tests (QCLot: 174695)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	99.8	85.0	115	----
Physical Tests (QCLot: 175027)									
turbidity	----	E121	0.1	NTU	200 NTU	100	85.0	115	----
Physical Tests (QCLot: 176889)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	102	85.0	115	----
Physical Tests (QCLot: 176904)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	108	85.0	115	----
Anions and Nutrients (QCLot: 174536)									
sulfide, total (as S)	18496-25-8	E396	0.018	mg/L	1 mg/L	95.6	75.0	125	----
Anions and Nutrients (QCLot: 174684)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	97.9	80.0	120	----
Anions and Nutrients (QCLot: 174685)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 174686)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 174687)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 174688)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 174689)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 174690)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	107	85.0	115	----
Anions and Nutrients (QCLot: 176681)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 176682)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 176682) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.9	85.0	115	----
Anions and Nutrients (QCLot: 176683)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	89.0	80.0	120	----
Total Metals (QCLot: 174424)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
Total Metals (QCLot: 174425)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	105	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	98.3	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	99.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.8	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	100	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	100	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.9	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	103	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	104	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	101	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	99.3	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	99.3	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	102	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	98.6	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	109	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	96.9	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	94.4	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 174425) - continued									
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	98.6	80.0	120	----
Total Metals (QCLot: 176123)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	103	80.0	120	----
Dissolved Metals (QCLot: 174440)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	105	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	97.6	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.2	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	104	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	96.6	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	97.6	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	95.2	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	96.6	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	98.4	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	102	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	93.9	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	103	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	93.5	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	98.4	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	97.6	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	96.3	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	97.9	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	101	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	98.0	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	97.4	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	95.4	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	97.5	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	99.3	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	101	80.0	120	----
Dissolved Metals (QCLot: 174441)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 174441) - continued									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	99.4	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	87.7	80.0	120	----
Aggregate Organics (QCLot: 175560)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	98.3	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 174536)										
VA21A6360-001	Anonymous	sulfide, total (as S)	18496-25-8	E396	0.096 mg/L	0.1 mg/L	96.0	65.0	135	----
Anions and Nutrients (QCLot: 174684)										
VA21A6362-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0328 mg/L	0.03 mg/L	109	70.0	130	----
Anions and Nutrients (QCLot: 174685)										
VA21A6361-001	Anonymous	fluoride	16984-48-8	E235.F	1.03 mg/L	1 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 174686)										
VA21A6361-001	Anonymous	chloride	16887-00-6	E235.Cl	102 mg/L	100 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 174687)										
VA21A6361-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.55 mg/L	2.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 174688)										
VA21A6361-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.501 mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 174689)										
VA21A6361-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	100 mg/L	100 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 174690)										
VA21A6361-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.530 mg/L	0.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 176681)										
VA21A6362-002	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 176682)										
VA21A6362-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.210 mg/L	0.2 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 176683)										
VA21A6362-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0497 mg/L	0.05 mg/L	99.4	70.0	130	----
Total Metals (QCLot: 174424)										
FJ2100156-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
Total Metals (QCLot: 174425)										
FJ2100156-001	Anonymous	aluminum, total	7429-90-5	E420	0.209 mg/L	0.2 mg/L	105	70.0	130	----
		antimony, total	7440-36-0	E420	0.0205 mg/L	0.02 mg/L	103	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 174425) - continued										
FJ2100156-001	Anonymous	beryllium, total	7440-41-7	E420	0.0418 mg/L	0.04 mg/L	104	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00914 mg/L	0.01 mg/L	91.4	70.0	130	----
		boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00379 mg/L	0.004 mg/L	94.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0193 mg/L	0.02 mg/L	96.3	70.0	130	----
		copper, total	7440-50-8	E420	0.0184 mg/L	0.02 mg/L	91.8	70.0	130	----
		iron, total	7439-89-6	E420	1.98 mg/L	2 mg/L	99.1	70.0	130	----
		lead, total	7439-92-1	E420	0.0184 mg/L	0.02 mg/L	92.1	70.0	130	----
		lithium, total	7439-93-2	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0216 mg/L	0.02 mg/L	108	70.0	130	----
		nickel, total	7440-02-0	E420	0.0368 mg/L	0.04 mg/L	92.0	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.3 mg/L	10 mg/L	113	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0421 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, total	7440-21-3	E420	10.2 mg/L	10 mg/L	102	70.0	130	----
		silver, total	7440-22-4	E420	0.00385 mg/L	0.004 mg/L	96.2	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00372 mg/L	0.004 mg/L	93.1	70.0	130	----
		tin, total	7440-31-5	E420	0.0198 mg/L	0.02 mg/L	99.2	70.0	130	----
		titanium, total	7440-32-6	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		uranium, total	7440-61-1	E420	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, total	7440-62-2	E420	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, total	7440-66-6	E420	0.357 mg/L	0.4 mg/L	89.2	70.0	130	----
Total Metals (QCLot: 176123)										
VA21A6366-001	Anonymous	mercury, total	7439-97-6	E508	0.0000974 mg/L	0.0001 mg/L	97.4	70.0	130	----
Dissolved Metals (QCLot: 174440)										
VA21A6242-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.198 mg/L	0.2 mg/L	98.8	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0196 mg/L	0.02 mg/L	98.0	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0196 mg/L	0.02 mg/L	98.3	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0397 mg/L	0.04 mg/L	99.4	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00912 mg/L	0.01 mg/L	91.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 174440) - continued										
VA21A6242-001	Anonymous	boron, dissolved	7440-42-8	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00380 mg/L	0.004 mg/L	95.0	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0197 mg/L	0.02 mg/L	98.6	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0194 mg/L	0.02 mg/L	97.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	2.00 mg/L	2 mg/L	100	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0184 mg/L	0.02 mg/L	92.2	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0199 mg/L	0.02 mg/L	99.4	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0384 mg/L	0.04 mg/L	96.1	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.74 mg/L	10 mg/L	97.4	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.89 mg/L	4 mg/L	97.2	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0401 mg/L	0.04 mg/L	100	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.28 mg/L	10 mg/L	82.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00397 mg/L	0.004 mg/L	99.2	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00363 mg/L	0.004 mg/L	90.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0193 mg/L	0.02 mg/L	96.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0396 mg/L	0.04 mg/L	99.0	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00391 mg/L	0.004 mg/L	97.8	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.405 mg/L	0.4 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 174441)										
VA21A6242-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.0395 mg/L	0.04 mg/L	98.6	70.0	130	----
Dissolved Metals (QCLot: 175397)										
VA21A6299-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000822 mg/L	0.0001 mg/L	82.2	70.0	130	----
Aggregate Organics (QCLot: 175560)										
KS2100998-004	Anonymous	chemical oxygen demand [COD]	----	E559	500 mg/L	500 mg/L	100.0	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		● Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	6365	ALS Contact:	Dean Watt	Sampler: NG/BM/LF

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients (P)	EPH	Total Metals (P)	Dissolved Metals (F/P)			Total Mercury (P)	Dissolved Mercury (F/P)	Acidity	Total Sulphides (P)		Number of Containers
	BJ-GW18-17B - E314701	05-Apr-21	9:40	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21A6365
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	5-Apr-21	18:00	TC	APR - 6 2021	8:41	8 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A7683**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 23-Apr-2021 16:20
PO	: 1025614	Date Analysis Commenced	: 24-Apr-2021
C-O-C number	: ----	Issue Date	: 03-May-2021 16:28
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	EB Test	Equipment Blank - 94	BJ-GW12-8B-E3 14695	BJ-GW12-8B-S nap	----
				Client sampling date / time	22-Apr-2021 11:30	22-Apr-2021 12:00	22-Apr-2021 15:40	22-Apr-2021 13:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21A7683-001	VA21A7683-002	VA21A7683-003	VA21A7683-004	--------
					Result	Result	Result	Result	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	<2.0	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	<1.0	<1.0	72.9	73.4	----
conductivity	----	E100	2.0	µS/cm	2.1	<2.0	217	224	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	1.28	<0.50	102	102	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	0.89	0.61	103	108	----
pH	----	E108	0.10	pH units	5.96	5.57	7.98	8.01	----
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	<10	136	147	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	13.2	6.7	----
turbidity	----	E121	0.10	NTU	0.44	<0.10	7.14	1.12	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	<0.0050	0.0052	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	<0.50	----
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	<0.020	0.024	0.022	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	0.091	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	0.0155	0.0146	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0051	0.0155	0.0146	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	<0.030	0.106	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0012	<0.0010	0.0018	0.0010	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	0.0028	0.0115	0.0622	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	<0.30	39.3	39.4	----
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	<0.011	<0.011	<0.011	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0132 RRV	0.0068 RRV	0.473	0.454	----
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0.00090	0.00110	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	<0.00010	0.0173	0.0296	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.00111 RRV	0.00077 RRV	0.0320	0.0499	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	EB Test	Equipment Blank - 94	BJ-GW12-8B-E3 14695	BJ-GW12-8B-S nap	----
				Client sampling date / time	22-Apr-2021 11:30	22-Apr-2021 12:00	22-Apr-2021 15:40	22-Apr-2021 13:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21A7683-001	VA21A7683-002	VA21A7683-003	VA21A7683-004	--------
					Result	Result	Result	Result	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0.0000062	0.0000208	----
calcium, total	7440-70-2	E420	0.050	mg/L	0.358 RRV	0.243 RRV	33.6	35.4	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00292 RRV	0.00148 RRV	0.00717	0.00098	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00017 RRV	<0.00010	0.00051	0.00104	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00208 RRV	0.00178	0.00302	----
iron, total	7439-89-6	E420	0.010	mg/L	0.024 RRV	0.013 RRV	0.339	0.874	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000290 RRV	0.000051 RRV	0.000332	0.00103	----
lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0.0068	0.0070	----
magnesium, total	7439-95-4	E420	0.100	mg/L	<0.100	<0.100	4.68	4.82	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00228 RRV	0.00107 RRV	0.0400	0.109	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000583 RRV	0.000133 RRV	0.00215	0.00112	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00286 RRV	0.00084 RRV	0.00488	<0.00050	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, total	7440-09-7	E420	0.050	mg/L	<0.050	<0.050	0.691	0.811	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0.000376	0.000352	----
silicon, total	7440-21-3	E420	0.10	mg/L	0.11 RRV	<0.10	2.73	2.85	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0.000020	0.000072	----
sodium, total	17341-25-2	E420	0.050	mg/L	<0.050	<0.050	2.56	2.84	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.00482 RRV	0.00360 RRV	0.594	0.628	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	0.000010	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	0.00020	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	<0.000010	0.000188	0.000245	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0.00077	0.00081	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	<0.0030	0.0064	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	<0.0010	0.0072	0.0012	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0.00078	0.00078	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	EB Test	Equipment Blank - 94	BJ-GW12-8B-E3 14695	BJ-GW12-8B-S nap	----
				Client sampling date / time	22-Apr-2021 11:30	22-Apr-2021 12:00	22-Apr-2021 15:40	22-Apr-2021 13:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21A7683-001	VA21A7683-002	VA21A7683-003	VA21A7683-004	--------
					Result	Result	Result	Result	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	<0.00010	0.0129	0.0134	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00051 RRV	0.00030 RRV	0.0220	0.0188	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	0.512 RRV	0.151 RRV	33.3	33.6	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0.00136	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00037 RRV	0.00059 RRV	0.00063	<0.00020	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000128 RRV	<0.000050	<0.000050	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0.0068	0.0065	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	<0.100	<0.100	4.55	4.52	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00202 RRV	0.00049 RRV	0.00586	<0.00010	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000316 RRV	0.000084 RRV	0.00190	0.00119	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0.00206	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	<0.050	0.511	0.548	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0.000327	0.000292	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	<0.050	<0.050	2.03	2.12	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	<0.050	<0.050	2.63	2.70	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.00744 RRV	0.00229 RRV	0.582	0.580	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	<0.000010	0.000161	0.000163	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0015 RRV	0.0015 RRV	0.0022	0.0017	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**EB Test**	**Equipment Blank - 94**	**BJ-GW12-8B-E3 14695**	**BJ-GW12-8B-S nap**	**----**
				Client sampling date / time	22-Apr-2021 11:30	22-Apr-2021 12:00	22-Apr-2021 15:40	22-Apr-2021 13:50	----
Analyte	CAS Number	Method	LOR	Unit	**VA21A7683-001**	**VA21A7683-002**	**VA21A7683-003**	**VA21A7683-004**	**--------**
					Result	Result	Result	Result	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	Field	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	<20	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A7683**	Page	: 1 of 19
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 23-Apr-2021 16:20
PO	: 1025614	Issue Date	: 03-May-2021 16:28
C-O-C number	: ----		
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E559	22-Apr-2021	----	----	----		28-Apr-2021	28 days	6 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-Snap	E559	22-Apr-2021	----	----	----		28-Apr-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
EB Test	E559	22-Apr-2021	----	----	----		28-Apr-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
Equipment Blank - 94	E559	22-Apr-2021	----	----	----		28-Apr-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E298	22-Apr-2021	24-Apr-2021	----	2 days	✓	24-Apr-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-Snap	E298	22-Apr-2021	24-Apr-2021	----	2 days	✓	24-Apr-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
EB Test	E298	22-Apr-2021	24-Apr-2021	----	2 days	✓	24-Apr-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Equipment Blank - 94	E298	22-Apr-2021	24-Apr-2021	----	2 days	✓	24-Apr-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.Br-L	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-Snap	E235.Br-L	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
EB Test	E235.Br-L	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Equipment Blank - 94	E235.Br-L	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.Cl	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B-Snap	E235.Cl	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
EB Test	E235.Cl	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Equipment Blank - 94	E235.Cl	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8B-E314695	E378-U	22-Apr-2021	----	----	----		24-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8B-Snap	E378-U	22-Apr-2021	----	----	----		24-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
EB Test	E378-U	22-Apr-2021	----	----	----		24-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Equipment Blank - 94	E378-U	22-Apr-2021	----	----	----		24-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.F	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8B-Snap	E235.F	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
EB Test	E235.F	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Equipment Blank - 94	E235.F	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.NO3-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-Snap	E235.NO3-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
EB Test	E235.NO3-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Equipment Blank - 94	E235.NO3-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.NO2-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-Snap	E235.NO2-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
EB Test	E235.NO2-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Equipment Blank - 94	E235.NO2-L	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.SO4	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B-Snap	E235.SO4	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
EB Test	E235.SO4	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Equipment Blank - 94	E235.SO4	22-Apr-2021	----	----	----		25-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E366	22-Apr-2021	24-Apr-2021	----	2 days	✓	27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-Snap	E366	22-Apr-2021	24-Apr-2021	----	2 days	✓	27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
EB Test	E366	22-Apr-2021	24-Apr-2021	----	2 days	✓	27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Equipment Blank - 94	E366	22-Apr-2021	24-Apr-2021	----	2 days	✓	27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E372-U	22-Apr-2021	24-Apr-2021	----	2 days	✓	26-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-Snap	E372-U	22-Apr-2021	24-Apr-2021	----	2 days	✓	26-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
EB Test	E372-U	22-Apr-2021	24-Apr-2021	----	2 days	✓	26-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Equipment Blank - 94	E372-U	22-Apr-2021	24-Apr-2021	----	2 days	✓	26-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B-E314695	E395-H	22-Apr-2021	----	----	----		28-Apr-2021	7 days	6 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B-Snap	E395-H	22-Apr-2021	----	----	----		28-Apr-2021	7 days	7 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
EB Test	E395-H	22-Apr-2021	----	----	----		28-Apr-2021	7 days	7 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
Equipment Blank - 94	E395-H	22-Apr-2021	----	----	----		28-Apr-2021	7 days	7 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B-E314695	E509	22-Apr-2021	29-Apr-2021	----	7 days	✓	29-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B-Snap	E509	22-Apr-2021	29-Apr-2021	----	7 days	✓	29-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
EB Test	E509	22-Apr-2021	29-Apr-2021	----	7 days	✓	29-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
Equipment Blank - 94	E509	22-Apr-2021	29-Apr-2021	----	7 days	✓	29-Apr-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B-E314695	E421	22-Apr-2021	26-Apr-2021	----	4 days	✓	26-Apr-2021	180 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
EB Test	E421	22-Apr-2021	26-Apr-2021	----	5 days	✓	26-Apr-2021	180 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Equipment Blank - 94	E421	22-Apr-2021	26-Apr-2021	----	5 days	✓	26-Apr-2021	180 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B-Snap	E421	22-Apr-2021	30-Apr-2021	----	8 days	✓	30-Apr-2021	180 days	1 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B-E314695	E283	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B-Snap	E283	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
EB Test	E283	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
Equipment Blank - 94	E283	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8B-E314695	E290	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8B-Snap	E290	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
EB Test	E290	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Equipment Blank - 94	E290	22-Apr-2021	----	----	----		26-Apr-2021	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-8B-E314695	E100	22-Apr-2021	----	----	----		26-Apr-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-8B-Snap	E100	22-Apr-2021	----	----	----		26-Apr-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
EB Test	E100	22-Apr-2021	----	----	----		26-Apr-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
Equipment Blank - 94	E100	22-Apr-2021	----	----	----		26-Apr-2021	28 days	4 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-8B-E314695	E108	22-Apr-2021	----	----	----		26-Apr-2021	0.25 hrs	89 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-8B-Snap	E108	22-Apr-2021	----	----	----		26-Apr-2021	0.25 hrs	91 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE										
Equipment Blank - 94	E108	22-Apr-2021	----	----	----		26-Apr-2021	0.25 hrs	92 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE										
EB Test	E108	22-Apr-2021	----	----	----		26-Apr-2021	0.25 hrs	93 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B-E314695	E162	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B-Snap	E162	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
EB Test	E162	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
Equipment Blank - 94	E162	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B-E314695	E160-H	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B-Snap	E160-H	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
EB Test	E160-H	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TSS by Gravimetry										
HDPE										
Equipment Blank - 94	E160-H	22-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B-E314695	E121	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B-Snap	E121	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
EB Test	E121	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
Equipment Blank - 94	E121	22-Apr-2021	----	----	----		25-Apr-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B-E314695	E508	22-Apr-2021	----	----	----		29-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B-Snap	E508	22-Apr-2021	----	----	----		29-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
EB Test	E508	22-Apr-2021	----	----	----		29-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
Equipment Blank - 94	E508	22-Apr-2021	----	----	----		29-Apr-2021	28 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B-E314695	E420	22-Apr-2021	----	----	----		29-Apr-2021	180 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B-Snap	E420	22-Apr-2021	----	----	----		29-Apr-2021	180 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
EB Test	E420	22-Apr-2021	----	----	----		29-Apr-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Equipment Blank - 94	E420	22-Apr-2021	----	----	----		29-Apr-2021	180 days	8 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	184779	1	4	25.0	5.0	✓
Alkalinity Species by Titration	E290	184771	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	184654	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	184777	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	187071	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	184776	1	20	5.0	5.0	✓
Conductivity in Water	E100	184769	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	187441	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	185380	2	22	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	184778	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	184775	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	184773	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	184774	1	20	5.0	5.0	✓
pH by Meter	E108	184770	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	184772	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	187301	2	39	5.1	5.0	✓
Total Mercury in Water by CVAAS	E508	187499	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	186918	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	184652	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	184653	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	187078	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	187302	2	30	6.6	5.0	✓
Turbidity by Nephelometry	E121	185023	1	10	10.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	184779	1	4	25.0	5.0	✓
Alkalinity Species by Titration	E290	184771	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	184654	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	184777	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	187071	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	184776	1	20	5.0	5.0	✓
Conductivity in Water	E100	184769	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	187441	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	185380	2	22	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	184778	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	184775	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	184773	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	184774	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	184770	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	184772	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	187301	2	39	5.1	5.0	✓
Total Mercury in Water by CVAAS	E508	187499	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	186918	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	184652	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	184653	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	187078	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	187302	2	30	6.6	5.0	✓
Turbidity by Nephelometry	E121	185023	1	10	10.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	184779	1	4	25.0	5.0	✓
Alkalinity Species by Titration	E290	184771	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	184654	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	184777	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	187071	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	184776	1	20	5.0	5.0	✓
Conductivity in Water	E100	184769	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	187441	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	185380	2	22	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	184778	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	184775	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	184773	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	184774	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	184772	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	187301	2	39	5.1	5.0	✓
Total Mercury in Water by CVAAS	E508	187499	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	186918	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	184652	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	184653	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	187078	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	187302	2	30	6.6	5.0	✓
Turbidity by Nephelometry	E121	185023	1	10	10.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	184654	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	184777	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	187071	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	184776	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	187441	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	185380	2	22	9.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	184778	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	184775	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	184773	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	184774	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	184772	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	187499	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	186918	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	184652	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	184653	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	187078	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A7683**	Page	: 1 of 21
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 23-Apr-2021 16:20
PO	: 1025614	Date Analysis Commenced	: 24-Apr-2021
C-O-C number	: ----	Issue Date	: 03-May-2021 16:28
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 184769)											
VA21A7683-003	BJ-GW12-8B-E314695	conductivity	----	E100	2.0	µS/cm	217	221	1.83%	10%	----
Physical Tests (QC Lot: 184770)											
VA21A7683-003	BJ-GW12-8B-E314695	pH	----	E108	0.10	pH units	7.98	8.01	0.375%	4%	----
Physical Tests (QC Lot: 184771)											
VA21A7683-003	BJ-GW12-8B-E314695	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	72.9	74.0	1.50%	20%	----
Physical Tests (QC Lot: 184779)											
VA21A7683-002	Equipment Blank - 94	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	2.0	0.02	Diff <2x LOR	----
Physical Tests (QC Lot: 185023)											
VA21A7672-001	Anonymous	turbidity	----	E121	0.10	NTU	338	345	2.05%	15%	----
Physical Tests (QC Lot: 187301)											
VA21A7687-016	Anonymous	solids, total dissolved [TDS]	----	E162	10	mg/L	2380	2350	0.930%	20%	----
Physical Tests (QC Lot: 187302)											
VA21A7687-016	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	55.3	53.5	3.31%	20%	----
Physical Tests (QC Lot: 187628)											
VA21A7678-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	3.4	0.4	Diff <2x LOR	----
Physical Tests (QC Lot: 187631)											
KS2101190-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	622	643	3.24%	20%	----
Anions and Nutrients (QC Lot: 184652)											
VA21A7683-001	EB Test	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184653)											
VA21A7683-001	EB Test	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184654)											
VA21A7683-001	EB Test	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184772)											
VA21A7683-001	EB Test	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	<0.30	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184773)											
VA21A7683-001	EB Test	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184774)											
VA21A7683-001	EB Test	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184775)											
VA21A7683-001	EB Test	fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	<0.020	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 184776)											
VA21A7683-001	EB Test	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184777)											
VA21A7683-001	EB Test	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 184778)											
VA21A7683-001	EB Test	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0012	<0.0010	0.0002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 187078)											
VA21A7575-002	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 186918)											
VA21A7673-083	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0209	0.0209	0.00006	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.00314	0.00318	1.54%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	4.82	4.98	3.18%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.119	0.125	4.79%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000696	0.000730	4.80%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	1.09	1.13	3.85%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00296	0.00274	7.42%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000060	0.000062	0.000002	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.154	0.163	0.009	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	2.15	2.13	1.08%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	3.36	3.43	2.11%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0150	0.0154	3.14%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 186918) - continued											
VA21A7673-083	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0059	0.0061	0.0002	Diff <2x LOR	----
Total Metals (QC Lot: 187499)											
KS2101190-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 185380)											
WR2100363-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0448	0.0447	0.267%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00056	0.00055	0.000009	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00603	0.00589	2.35%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0307	0.0315	2.42%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.000279	0.000271	3.02%	20%	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	37.3	36.5	2.14%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00042	0.00041	0.000003	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00265	0.00257	3.13%	20%	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.123	0.122	0.919%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000335	0.000321	0.000013	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	7.95	7.66	3.77%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.179	0.179	0.373%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000143	0.000143	0.0000002	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	3.68	3.65	0.644%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000064	0.000014	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.36	2.36	0.152%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	0.000018	0.000018	0.0000001	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	2.60	2.52	3.26%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.197	0.199	0.638%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000010	0.000011	0.000001	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	0.00118	0.00110	0.00007	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 185380) - continued											
WR2100363-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000339	0.000335	1.30%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0123	0.0119	2.81%	20%	----
Dissolved Metals (QC Lot: 187441)											
CG2101013-026	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 188252)											
VA21A7681-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0021	0.0022	0.00002	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00012	0.00016	0.00004	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0108	0.0109	0.304%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	18.2	16.8	7.80%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00278	0.00275	0.984%	20%	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	2.72	2.72	0.207%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00612	0.00614	0.207%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000086	0.000085	0.0000003	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.288	0.286	0.002	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000199	0.000228	0.000028	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.69	3.62	1.89%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	2.36	2.33	1.24%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.111	0.101	9.13%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 188252) - continued											
VA21A7681-002	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0023	0.0025	0.0002	Diff <2x LOR	----
Aggregate Organics (QC Lot: 187071)											
VA21A7571-001	Anonymous	chemical oxygen demand [COD]	----	E559	200	mg/L	2810	3000	6.49%	20%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 184769)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 184771)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 184779)						
acidity (as CaCO3)	----	E283	2	mg/L	2.4	----
Physical Tests (QCLot: 185023)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 187301)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 187302)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 187628)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 187631)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 184652)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 184653)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 184654)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 184772)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 184773)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 184774)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 184775)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 184776)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 184777)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 184778)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 187078)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----
Total Metals (QCLot: 186918)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 187499)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 185380)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 187441)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 188252)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 187071)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 184769)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	106	90.0	110	----
Physical Tests (QCLot: 184770)									
pH	----	E108	----	pH units	7 pH units	99.6	98.0	102	----
Physical Tests (QCLot: 184771)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	101	85.0	115	----
Physical Tests (QCLot: 184779)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	102	85.0	115	----
Physical Tests (QCLot: 185023)									
turbidity	----	E121	0.1	NTU	200 NTU	104	85.0	115	----
Physical Tests (QCLot: 187301)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	99.7	85.0	115	----
Physical Tests (QCLot: 187302)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	99.5	85.0	115	----
Physical Tests (QCLot: 187628)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	98.7	85.0	115	----
Physical Tests (QCLot: 187631)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 184652)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 184653)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	94.0	80.0	120	----
Anions and Nutrients (QCLot: 184654)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	98.9	85.0	115	----
Anions and Nutrients (QCLot: 184772)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 184773)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 184774)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 184775)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 184776)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 184776) - continued									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 184777)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	103	85.0	115	----
Anions and Nutrients (QCLot: 184778)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	97.5	80.0	120	----
Anions and Nutrients (QCLot: 187078)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	100	80.0	120	----
Total Metals (QCLot: 186918)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	102	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	98.7	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	100	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	102	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	96.9	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	98.6	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	97.9	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	99.7	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	96.4	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	98.9	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	98.9	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	98.9	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	99.6	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	103	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	99.1	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 186918) - continued									
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	98.3	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	104	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	99.9	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	98.1	80.0	120	----
Total Metals (QCLot: 187499)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	94.2	80.0	120	----
Dissolved Metals (QCLot: 185380)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	102	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	111	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	106	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	104	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.2	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	108	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	105	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	106	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	105	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	110	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	107	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	106	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	109	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	105	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	99.0	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 185380) - continued									
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	104	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	97.5	80.0	120	----
Dissolved Metals (QCLot: 188252)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	105	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	97.2	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	106	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.8	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	99.1	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	102	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	94.4	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	107	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	109	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	105	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	103	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	104	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	101	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	96.9	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	104	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 187071)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	102	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 184652)										
VA21A7683-002	Equipment Blank - 94	nitrogen, total	7727-37-9	E366	0.409 mg/L	0.4 mg/L	102	70.0	130	----
Anions and Nutrients (QCLot: 184653)										
VA21A7683-002	Equipment Blank - 94	phosphorus, total	7723-14-0	E372-U	0.0500 mg/L	0.05 mg/L	100.0	70.0	130	----
Anions and Nutrients (QCLot: 184654)										
VA21A7683-002	Equipment Blank - 94	ammonia, total (as N)	7664-41-7	E298	0.204 mg/L	0.2 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 184772)										
VA21A7683-002	Equipment Blank - 94	sulfate (as SO4)	14808-79-8	E235.SO4	117 mg/L	100 mg/L	117	75.0	125	----
Anions and Nutrients (QCLot: 184773)										
VA21A7683-002	Equipment Blank - 94	nitrate (as N)	14797-55-8	E235.NO3-L	2.88 mg/L	2.5 mg/L	115	75.0	125	----
Anions and Nutrients (QCLot: 184774)										
VA21A7683-002	Equipment Blank - 94	nitrite (as N)	14797-65-0	E235.NO2-L	0.565 mg/L	0.5 mg/L	113	75.0	125	----
Anions and Nutrients (QCLot: 184775)										
VA21A7683-002	Equipment Blank - 94	fluoride	16984-48-8	E235.F	1.14 mg/L	1 mg/L	114	75.0	125	----
Anions and Nutrients (QCLot: 184776)										
VA21A7683-002	Equipment Blank - 94	chloride	16887-00-6	E235.Cl	114 mg/L	100 mg/L	114	75.0	125	----
Anions and Nutrients (QCLot: 184777)										
VA21A7683-002	Equipment Blank - 94	bromide	24959-67-9	E235.Br-L	0.597 mg/L	0.5 mg/L	119	75.0	125	----
Anions and Nutrients (QCLot: 184778)										
VA21A7683-002	Equipment Blank - 94	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0302 mg/L	0.03 mg/L	101	70.0	130	----
Anions and Nutrients (QCLot: 187078)										
VA21A7577-002	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	8.90 mg/L	10 mg/L	89.0	75.0	125	----
Total Metals (QCLot: 186918)										
VA21A7673-083	Anonymous	aluminum, total	7429-90-5	E420	0.200 mg/L	0.2 mg/L	100.0	70.0	130	----
		antimony, total	7440-36-0	E420	0.0189 mg/L	0.02 mg/L	94.6	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0188 mg/L	0.02 mg/L	94.1	70.0	130	----
		barium, total	7440-39-3	E420	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0376 mg/L	0.04 mg/L	94.0	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00984 mg/L	0.01 mg/L	98.4	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 186918) - continued										
VA21A7673-083	Anonymous	cadmium, total	7440-43-9	E420	0.00384 mg/L	0.004 mg/L	95.9	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0384 mg/L	0.04 mg/L	96.1	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		copper, total	7440-50-8	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		lithium, total	7439-93-2	E420	0.0922 mg/L	0.1 mg/L	92.2	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0194 mg/L	0.02 mg/L	96.8	70.0	130	----
		nickel, total	7440-02-0	E420	0.0396 mg/L	0.04 mg/L	98.9	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.79 mg/L	10 mg/L	97.9	70.0	130	----
		potassium, total	7440-09-7	E420	4.05 mg/L	4 mg/L	101	70.0	130	----
		selenium, total	7782-49-2	E420	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		silicon, total	7440-21-3	E420	8.72 mg/L	10 mg/L	87.2	70.0	130	----
		silver, total	7440-22-4	E420	0.00395 mg/L	0.004 mg/L	98.6	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	0.0198 mg/L	0.02 mg/L	99.2	70.0	130	----
		thallium, total	7440-28-0	E420	0.00386 mg/L	0.004 mg/L	96.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0191 mg/L	0.02 mg/L	95.7	70.0	130	----
		titanium, total	7440-32-6	E420	0.0369 mg/L	0.04 mg/L	92.2	70.0	130	----
		uranium, total	7440-61-1	E420	0.00409 mg/L	0.004 mg/L	102	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0972 mg/L	0.1 mg/L	97.2	70.0	130	----
		zinc, total	7440-66-6	E420	0.407 mg/L	0.4 mg/L	102	70.0	130	----
Total Metals (QCLot: 187499)										
KS2101191-001	Anonymous	mercury, total	7439-97-6	E508	0.0000923 mg/L	0.0001 mg/L	92.3	70.0	130	----
Dissolved Metals (QCLot: 185380)										
WR2100363-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.195 mg/L	0.2 mg/L	97.5	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0417 mg/L	0.04 mg/L	104	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00884 mg/L	0.01 mg/L	88.4	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00390 mg/L	0.004 mg/L	97.5	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 185380) - continued										
WR2100363-001	Anonymous	chromium, dissolved	7440-47-3	E421	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0199 mg/L	0.02 mg/L	99.5	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.94 mg/L	2 mg/L	97.3	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0192 mg/L	0.02 mg/L	96.3	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0411 mg/L	0.04 mg/L	103	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.1 mg/L	10 mg/L	111	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.96 mg/L	4 mg/L	98.9	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0416 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.24 mg/L	10 mg/L	92.4	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00395 mg/L	0.004 mg/L	98.8	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00375 mg/L	0.004 mg/L	93.7	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0396 mg/L	0.04 mg/L	99.1	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00378 mg/L	0.004 mg/L	94.4	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.414 mg/L	0.4 mg/L	103	70.0	130	----
Dissolved Metals (QCLot: 187441)										
VA21A7656-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000927 mg/L	0.0001 mg/L	92.7	70.0	130	----
Dissolved Metals (QCLot: 188252)										
VA21A7681-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.193 mg/L	0.2 mg/L	96.4	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0194 mg/L	0.02 mg/L	97.1	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0188 mg/L	0.02 mg/L	94.2	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0396 mg/L	0.04 mg/L	99.1	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00935 mg/L	0.01 mg/L	93.5	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.097 mg/L	0.1 mg/L	96.6	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00399 mg/L	0.004 mg/L	99.8	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0395 mg/L	0.04 mg/L	98.8	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 188252) - continued										
VA21A7681-002	Anonymous	cobalt, dissolved	7440-48-4	E421	0.0198 mg/L	0.02 mg/L	98.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.98 mg/L	2 mg/L	98.8	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0967 mg/L	0.1 mg/L	96.7	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0191 mg/L	0.02 mg/L	95.6	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0396 mg/L	0.04 mg/L	99.0	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.4 mg/L	10 mg/L	104	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.12 mg/L	4 mg/L	103	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0416 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.37 mg/L	10 mg/L	93.7	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00388 mg/L	0.004 mg/L	97.0	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00385 mg/L	0.004 mg/L	96.3	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0191 mg/L	0.02 mg/L	95.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0378 mg/L	0.04 mg/L	94.4	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00404 mg/L	0.004 mg/L	101	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.1000 mg/L	0.1 mg/L	100.0	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.400 mg/L	0.4 mg/L	100.0	70.0	130	----
Aggregate Organics (QCLot: 187071)										
VA21A7582-001	Anonymous	chemical oxygen demand [COD]	----	E559	498 mg/L	500 mg/L	99.6	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		**Report Format / Distribution**	**Service Requested** (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	● Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	EB Test	22-Apr-21	11:30	Groundwater	X	X		X	X			X	X	X	X		7
	Equipment Blank - 94	22-Apr-21	12:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8B - E314695	22-Apr-21	15:40	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8B - snap	22-Apr-21	13:50	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21A7683

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	22-Apr-21	18:00	GA	4/23	4:20pm	6.16 °C				

icepacks

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A7804**	Page	: 1 of 10
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 26-Apr-2021 19:50
PO	: 1025614	Date Analysis Commenced	: 27-Apr-2021
C-O-C number	: ----	Issue Date	: 05-May-2021 16:41
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 9		
No. of samples analysed	: 9		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLA	*Detection Limit adjusted for required dilution.*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DTC	*Dissolved concentration exceeds total. Results were confirmed by re-analysis.*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-11A-E303062	BJ-GW18-23A-E314690	BJ-GW18-23A-99
				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-11A-E303062	BJ-GW18-23A-E314690	BJ-GW18-23A-99
				Client sampling date / time	23-Apr-2021 09:20	23-Apr-2021 11:30	24-Apr-2021 11:20	24-Apr-2021 11:30	24-Apr-2021 11:35
					VA21A7804-001	VA21A7804-002	VA21A7804-003	VA21A7804-004	VA21A7804-005
					Result	Result	Result	Result	Result
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	2.6	<2.0
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	72.4	72.3	34.7	91.6	1.2
conductivity	----	E100	2.0	µS/cm	221	219	186	1150	<2.0
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	104	98.5	79.3	285	1.60
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	108	104	92.0	319	<0.50
pH	----	E108	0.10	pH units	8.11	8.12	8.03	8.02	5.88
solids, total dissolved [TDS]	----	E162	10	mg/L	118	132	113	773	<10
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	89.2	28.9	18.9	15.9	<3.0
turbidity	----	E121	0.10	NTU	16.8	14.2	11.6	5.86	<0.10
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0.0067	0.357	<0.0050
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	<0.250 DLDS	<0.050
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	27.4	<0.50
fluoride	16984-48-8	E235.F	0.020	mg/L	0.025	0.024	0.023	<0.100 DLDS	<0.020
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.100	<0.050	0.432	1.71	<0.050
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0161	0.0149	0.0481	5.58	<0.0050
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0161	0.0149	0.0481	5.75	<0.0051
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	<0.0010	0.174	<0.0010
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.116	<0.030	0.480	7.46	<0.030
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	<0.0010	0.0042	<0.0010
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.117	0.0033	0.0218	0.0135	<0.0020
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	38.0	38.2	53.6	445	<0.30
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	<0.0015	0.0024	<0.0015
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	<0.0016	0.0026	<0.0016
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.286	0.0840	0.284	0.343	<0.0030
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00119	0.00093	0.00154	0.0323	<0.00010
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0317	0.0115	0.0111	0.0287	<0.00010
barium, total	7440-39-3	E420	0.00010	mg/L	0.0353	0.0250	0.0534	0.0554	<0.00010
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000200 DLA	<0.000100

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-11A-E303062	BJ-GW18-23A-E314690	BJ-GW18-23A-99
				Client sampling date / time	23-Apr-2021 09:20	23-Apr-2021 11:30	24-Apr-2021 11:20	24-Apr-2021 11:30	24-Apr-2021 11:35
Analyte	CAS Number	Method	LOR	Unit	VA21A7804-001	VA21A7804-002	VA21A7804-003	VA21A7804-004	VA21A7804-005
					Result	Result	Result	Result	Result
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000100 DLA	<0.000050
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	<0.010	0.090	<0.010
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000810	0.0000235	0.0000319	0.0000205	<0.0000050
calcium, total	7440-70-2	E420	0.050	mg/L	32.7	31.4	30.1	104	<0.050
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00077	0.00394	0.00583	0.00945	<0.00050
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00078	0.00040	0.00030	0.00045	<0.00010
copper, total	7440-50-8	E420	0.00050	mg/L	0.00265	0.00153	0.00301	0.00253	<0.00050
iron, total	7439-89-6	E420	0.010	mg/L	1.36	0.187	0.407	0.253	<0.010
lead, total	7439-92-1	E420	0.000050	mg/L	0.00170	0.000516	0.000959	0.000761	<0.000050
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0087	0.0083	0.0034	0.238	<0.0010
magnesium, total	7439-95-4	E420	0.100	mg/L	6.45	6.11	4.10	14.5	<0.100
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0735	0.0220	0.0238	0.148	<0.00010
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0.0000064	<0.0000050	<0.0000050
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00123	0.00184	0.00189	0.00507	<0.000050
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	0.00290	0.00086	0.00638	<0.00050
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.600 DLA	<0.300
potassium, total	7440-09-7	E420	0.050	mg/L	0.619	0.530	1.02	3.80	<0.050
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000219	0.000224	0.000462	0.000402	<0.000050
silicon, total	7440-21-3	E420	0.10	mg/L	2.62	2.28	2.22	3.78	<0.10
silver, total	7440-22-4	E420	0.000010	mg/L	0.000188	0.000030	0.000156	0.000030	<0.000010
sodium, total	17341-25-2	E420	0.050	mg/L	3.75	3.61	2.67	135	<0.050
strontium, total	7440-24-6	E420	0.00020	mg/L	0.755	0.737	0.394	6.42	<0.00020
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000011	<0.000010	0.000016	0.000036	<0.000010
tin, total	7440-31-5	E420	0.00010	mg/L	0.00017	<0.00010	0.00043	0.00021	<0.00010
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0200 DLA	<0.0100
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000216	0.000194	0.000338	0.00178	<0.000010
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0.00054	<0.00100 DLA	<0.00050
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0170	0.0060	0.0378	0.0139	<0.0030
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0015	0.0044	0.0156	0.0076	0.0011 RRV
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00085	0.00086	0.00120	0.0326	<0.00010

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-11A-E303062	BJ-GW18-23A-E314690	BJ-GW18-23A-99
				Client sampling date / time	23-Apr-2021 09:20	23-Apr-2021 11:30	24-Apr-2021 11:20	24-Apr-2021 11:30	24-Apr-2021 11:35
Analyte	CAS Number	Method	LOR	Unit	VA21A7804-001	VA21A7804-002	VA21A7804-003	VA21A7804-004	VA21A7804-005
					Result	Result	Result	Result	Result
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00836	0.00832	0.00648	0.0258	<0.00010
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0222	0.0233	0.0323	0.0508	<0.00010
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000200 DLA	<0.000100
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000100 DLA	<0.000050
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.010	<0.010	<0.010	0.084	<0.010
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000109	0.0000104	0.0000051	<0.0000100 DLA	<0.0000050
calcium, dissolved	7440-70-2	E421	0.050	mg/L	31.1	29.4	25.4	92.0	0.641 DTC, RRV
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	0.00102	<0.00050	<0.00100 DLA	<0.00050
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00013	<0.00010	0.00021	<0.00010
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00044	0.00113	<0.00040 DLA	<0.00020
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	<0.010	<0.020 DLA	<0.010
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	0.000130	<0.000050
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0087	0.0082	0.0031	0.222	<0.0010
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	6.34	6.09	3.85	13.4	<0.100
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00039	0.00507	0.00110	0.0828	<0.00010
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00121	0.00175	0.00180	0.00487	<0.000050
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00183	<0.00050	0.00405	<0.00050
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	<0.600 DLA	<0.300
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.543	0.521	0.921	3.68	<0.050
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000250	0.000230	0.000482	0.000419	<0.000050
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.14	2.10	1.81	2.84	<0.050
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000020 DLA	<0.000010
sodium, dissolved	17341-25-2	E421	0.050	mg/L	3.74	3.72	2.62	129	<0.050
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.761	0.754	0.361	6.28	0.00036 RRV
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000020 DLA	<0.000010
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0.00011	<0.00020 DLA	<0.00010
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0200 DLA	<0.0100
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000194	0.000187	0.000304	0.00173	<0.000010
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00100 DLA	<0.00050
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0029	0.0033	0.0064	0.0107	<0.0010

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-11A-E303062	BJ-GW18-23A-E314690	BJ-GW18-23A-99
				Client sampling date / time	23-Apr-2021 09:20	23-Apr-2021 11:30	24-Apr-2021 11:20	24-Apr-2021 11:30	24-Apr-2021 11:35
Analyte	CAS Number	Method	LOR	Unit	VA21A7804-001	VA21A7804-002	VA21A7804-003	VA21A7804-004	VA21A7804-005
					Result	Result	Result	Result	Result
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	Field	Field
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	<20	<20

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 8	BJ-GW16-5A CWP	BJ-GW16-5B CWP	----
				Client sampling date / time	24-Apr-2021 13:00	24-Apr-2021 13:05	25-Apr-2021 10:40	25-Apr-2021 11:45	----
Analyte	CAS Number	Method	LOR	Unit	VA21A7804-006	VA21A7804-007	VA21A7804-008	VA21A7804-009	--------
					Result	Result	Result	Result	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	4.7	5.1	3.5	4.2	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	96.8	96.8	97.0	73.8	----
conductivity	----	E100	2.0	µS/cm	2240	2250	697	984	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	544	553	359	533	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	596	596	386	562	----
pH	----	E108	0.10	pH units	7.88	7.88	7.95	7.80	----
solids, total dissolved [TDS]	----	E162	10	mg/L	1330	1350	468	753	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	19.7	21.1	<3.0	<3.0	----
turbidity	----	E121	0.10	NTU	7.55	6.89	0.39	0.15	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	2.69	2.66	0.0946	<0.0050	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<1.00 DLDS	<1.00 DLDS	<0.250 DLDS	<0.250 DLDS	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	339	341	<2.50 DLDS	<2.50 DLDS	----
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.400 DLDS	<0.400 DLDS	<0.100 DLDS	<0.100 DLDS	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	7.40	7.60	0.106	0.146	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	38.4	38.2	<0.0250 DLDS	0.254	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	38.5	38.3	<0.0255	0.254	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.119	0.116	<0.0050 DLDS	<0.0050 DLDS	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	45.9	45.9	0.106	0.400	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0.0013	0.0027	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0110	0.0075	<0.0020	0.0038	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	465	465	287	310	----
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	<0.0015	<0.0015	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	<0.0016	<0.0016	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.284	0.263	0.0042	0.0065	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00323	0.00308	0.00106	0.00051	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00079	0.00083	0.00089	0.00044	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0256	0.0241	0.0170	0.0376	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 8	BJ-GW16-5A CWP	BJ-GW16-5B CWP	----
				Client sampling date / time	24-Apr-2021 13:00	24-Apr-2021 13:05	25-Apr-2021 10:40	25-Apr-2021 11:45	----
Analyte	CAS Number	Method	LOR	Unit	VA21A7804-006	VA21A7804-007	VA21A7804-008	VA21A7804-009	--------
					Result	Result	Result	Result	----
Total Metals									
boron, total	7440-42-8	E420	0.010	mg/L	0.268	0.273	0.037	0.024	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000288	0.0000227	<0.0000050	<0.0000050	----
calcium, total	7440-70-2	E420	0.050	mg/L	212	212	125	213	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0.00116	<0.00050	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00023	0.00024	0.00032	<0.00010	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00059	0.00111	0.00051	<0.00050	----
iron, total	7439-89-6	E420	0.010	mg/L	0.149	0.150	0.052	<0.010	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000472	0.000446	0.000081	<0.000050	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.398	0.399	0.0127	0.0097	----
magnesium, total	7439-95-4	E420	0.100	mg/L	16.3	16.2	18.0	7.37	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.176	0.175	0.102	0.00111	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000059	0.0000053	<0.0000050	<0.0000050	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00425	0.00415	0.000312	0.000270	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0.00092	<0.00050	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, total	7440-09-7	E420	0.050	mg/L	15.3	15.2	1.51	2.67	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000712	0.000661	<0.000050	0.000201	----
silicon, total	7440-21-3	E420	0.10	mg/L	2.64	2.57	2.74	2.45	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000018	0.000016	<0.000010	<0.000010	----
sodium, total	17341-25-2	E420	0.050	mg/L	251	247	6.58	7.71	----
strontium, total	7440-24-6	E420	0.00020	mg/L	2.69	2.66	4.40	1.12	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000078	0.000072	<0.000010	<0.000010	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00222	0.00224	0.000275	0.00110	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0057	0.0083	0.0052	<0.0030	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0025	0.0040	0.0024	0.0011	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00297	0.00303	0.00102	0.00050	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00048	0.00046	0.00080	0.00037	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 8	BJ-GW16-5A CWP	BJ-GW16-5B CWP	----
				Client sampling date / time	24-Apr-2021 13:00	24-Apr-2021 13:05	25-Apr-2021 10:40	25-Apr-2021 11:45	----
Analyte	CAS Number	Method	LOR	Unit	VA21A7804-006	VA21A7804-007	VA21A7804-008	VA21A7804-009	--------
					Result	Result	Result	Result	----
Dissolved Metals									
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0244	0.0220	0.0192	0.0401	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000200 DLA	<0.000200 DLA	<0.000100	<0.000100	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000100 DLA	<0.000100 DLA	<0.000050	<0.000050	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.261	0.262	0.035	0.023	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000198	0.0000223	<0.0000050	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	192	196	115	201	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00100 DLA	<0.00100 DLA	<0.00050	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00020 DLA	<0.00020 DLA	0.00027	<0.00010	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00066	<0.00040 DLA	0.00052	0.00035	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.020 DLA	<0.020 DLA	0.048	<0.010	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000100 DLA	<0.000100 DLA	<0.000050	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.377	0.375	0.0125	0.0094	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	15.8	15.5	17.4	7.65	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.158	0.157	0.0980	0.00012	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00392	0.00400	0.000297	0.000283	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00100 DLA	<0.00100 DLA	0.00071	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.600 DLA	<0.600 DLA	<0.300	<0.300	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	14.4	14.0	1.60	2.83	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000517	0.000610	<0.000050	0.000223	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.92	1.94	2.71	2.35	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000020 DLA	<0.000020 DLA	<0.000010	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	238	232	6.38	7.63	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	2.63	2.68	4.47	1.14	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000063	0.000064	<0.000010	<0.000010	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00020 DLA	<0.00020 DLA	<0.00010	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0200 DLA	<0.0200 DLA	<0.0100	<0.0100	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00230	0.00226	0.000283	0.00118	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00100 DLA	<0.00100 DLA	<0.00050	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0065	0.0025	0.0065	<0.0010	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	Field	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-23B-E 314691**	**BJ-GW18-23B-9 8**	**BJ-GW16-5A CWP**	**BJ-GW16-5B CWP**	**----**
				Client sampling date / time	24-Apr-2021 13:00	24-Apr-2021 13:05	25-Apr-2021 10:40	25-Apr-2021 11:45	----
Analyte	CAS Number	Method	LOR	Unit	**VA21A7804-006**	**VA21A7804-007**	**VA21A7804-008**	**VA21A7804-009**	**--------**
					Result	Result	Result	Result	----
Dissolved Metals									
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	<20	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A7804**	Page	: 1 of 32
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 26-Apr-2021 19:50
PO	: 1025614	Issue Date	: 05-May-2021 16:41
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 9		
No. of samples analysed	: 9		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E559	24-Apr-2021	----	----	----		03-May-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-99	E559	24-Apr-2021	----	----	----		03-May-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E559	24-Apr-2021	----	----	----		03-May-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-98	E559	24-Apr-2021	----	----	----		03-May-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E559	24-Apr-2021	----	----	----		03-May-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E559	23-Apr-2021	----	----	----		03-May-2021	28 days	11 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-snap	E559	23-Apr-2021	----	----	----		03-May-2021	28 days	11 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW16-5A CWP	E559	25-Apr-2021	----	----	----		03-May-2021	28 days	9 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW16-5B CWP	E559	25-Apr-2021	----	----	----		03-May-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW12-11A-E303062	E298	24-Apr-2021	03-May-2021	----	10 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW18-23A-99	E298	24-Apr-2021	03-May-2021	----	10 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW18-23A-E314690	E298	24-Apr-2021	03-May-2021	----	10 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW12-8A-E303059	E298	23-Apr-2021	03-May-2021	----	11 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW12-8A-snap	E298	23-Apr-2021	03-May-2021	----	11 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW16-5B CWP	E298	25-Apr-2021	03-May-2021	----	8 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW16-5A CWP	E298	25-Apr-2021	03-May-2021	----	9 days	✓	03-May-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-98	E298	24-Apr-2021	03-May-2021	----	9 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E298	24-Apr-2021	03-May-2021	----	9 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A CWP	E235.Br-L	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B CWP	E235.Br-L	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.Br-L	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-99	E235.Br-L	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.Br-L	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-98	E235.Br-L	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.Br-L	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.Br-L	23-Apr-2021	----	----	----		27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-snap	E235.Br-L	23-Apr-2021	----	----	----		27-Apr-2021	28 days	5 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW16-5A CWP	E235.Cl	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW16-5B CWP	E235.Cl	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.Cl	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23A-99	E235.Cl	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.Cl	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23B-98	E235.Cl	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.Cl	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.Cl	23-Apr-2021	----	----	----		27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8A-snap	E235.Cl	23-Apr-2021	----	----	----		27-Apr-2021	28 days	5 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW16-5B CWP	E378-U	25-Apr-2021	----	----	----		27-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW16-5A CWP	E378-U	25-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23B-98	E378-U	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23B-E314691	E378-U	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-11A-E303062	E378-U	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23A-99	E378-U	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23A-E314690	E378-U	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8A-E303059	E378-U	23-Apr-2021	----	----	----		27-Apr-2021	3 days	5 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8A-snap	E378-U	23-Apr-2021	----	----	----		27-Apr-2021	3 days	5 days	× EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW16-5A CWP	E235.F	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW16-5B CWP	E235.F	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.F	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23A-99	E235.F	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.F	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23B-98	E235.F	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.F	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.F	23-Apr-2021	----	----	----		27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8A-snap	E235.F	23-Apr-2021	----	----	----		27-Apr-2021	28 days	5 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A CWP	E235.NO3-L	25-Apr-2021	----	----	----		27-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B CWP	E235.NO3-L	25-Apr-2021	----	----	----		27-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.NO3-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-99	E235.NO3-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.NO3-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-98	E235.NO3-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.NO3-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.NO3-L	23-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✗ EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-snap	E235.NO3-L	23-Apr-2021	----	----	----		27-Apr-2021	3 days	5 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A CWP	E235.NO2-L	25-Apr-2021	----	----	----		27-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B CWP	E235.NO2-L	25-Apr-2021	----	----	----		27-Apr-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.NO2-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-99	E235.NO2-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.NO2-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-98	E235.NO2-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.NO2-L	24-Apr-2021	----	----	----		27-Apr-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.NO2-L	23-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-snap	E235.NO2-L	23-Apr-2021	----	----	----		27-Apr-2021	3 days	5 days	✗ EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW16-5A CWP	E235.SO4	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW16-5B CWP	E235.SO4	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.SO4	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23A-99	E235.SO4	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.SO4	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23B-98	E235.SO4	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.SO4	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.SO4	23-Apr-2021	----	----	----		27-Apr-2021	28 days	4 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8A-snap	E235.SO4	23-Apr-2021	----	----	----		27-Apr-2021	28 days	5 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E366	24-Apr-2021	03-May-2021	----	10 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-99	E366	24-Apr-2021	03-May-2021	----	10 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E366	24-Apr-2021	03-May-2021	----	10 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E366	23-Apr-2021	03-May-2021	----	11 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-snap	E366	23-Apr-2021	03-May-2021	----	11 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5B CWP	E366	25-Apr-2021	03-May-2021	----	8 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5A CWP	E366	25-Apr-2021	03-May-2021	----	9 days	✓	04-May-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-23B-98	E366	24-Apr-2021	03-May-2021	----	9 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-23B-E314691	E366	24-Apr-2021	03-May-2021	----	9 days	✓	04-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW12-11A-E303062	E372-U	24-Apr-2021	03-May-2021	----	10 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-23A-99	E372-U	24-Apr-2021	03-May-2021	----	10 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-23A-E314690	E372-U	24-Apr-2021	03-May-2021	----	10 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW12-8A-E303059	E372-U	23-Apr-2021	03-May-2021	----	11 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW12-8A-snap	E372-U	23-Apr-2021	03-May-2021	----	11 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW16-5B CWP	E372-U	25-Apr-2021	03-May-2021	----	8 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW16-5A CWP	E372-U	25-Apr-2021	03-May-2021	----	9 days	✓	03-May-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-98	E372-U	24-Apr-2021	03-May-2021	----	9 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E372-U	24-Apr-2021	03-May-2021	----	9 days	✓	03-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW16-5A CWP	E395	25-Apr-2021	----	----	----		29-Apr-2021	7 days	5 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW16-5B CWP	E395	25-Apr-2021	----	----	----		29-Apr-2021	7 days	5 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-11A-E303062	E395	24-Apr-2021	----	----	----		29-Apr-2021	7 days	6 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23A-99	E395	24-Apr-2021	----	----	----		29-Apr-2021	7 days	6 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23A-E314690	E395	24-Apr-2021	----	----	----		29-Apr-2021	7 days	6 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23B-98	E395	24-Apr-2021	----	----	----		29-Apr-2021	7 days	6 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23B-E314691	E395	24-Apr-2021	----	----	----		29-Apr-2021	7 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8A-E303059	E395	23-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8A-snap	E395	23-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW16-5A CWP	E509	25-Apr-2021	30-Apr-2021	----	5 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW16-5B CWP	E509	25-Apr-2021	30-Apr-2021	----	5 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-11A-E303062	E509	24-Apr-2021	30-Apr-2021	----	6 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23A-99	E509	24-Apr-2021	30-Apr-2021	----	6 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23A-E314690	E509	24-Apr-2021	30-Apr-2021	----	6 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23B-98	E509	24-Apr-2021	30-Apr-2021	----	6 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23B-E314691	E509	24-Apr-2021	30-Apr-2021	----	6 days	✓	30-Apr-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8A-E303059	E509	23-Apr-2021	30-Apr-2021	----	7 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8A-snap	E509	23-Apr-2021	30-Apr-2021	----	7 days	✓	30-Apr-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW16-5A CWP	E421	25-Apr-2021	28-Apr-2021	----	4 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW16-5B CWP	E421	25-Apr-2021	28-Apr-2021	----	4 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-11A-E303062	E421	24-Apr-2021	28-Apr-2021	----	5 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23A-99	E421	24-Apr-2021	28-Apr-2021	----	5 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23A-E314690	E421	24-Apr-2021	28-Apr-2021	----	5 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23B-98	E421	24-Apr-2021	28-Apr-2021	----	5 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23B-E314691	E421	24-Apr-2021	28-Apr-2021	----	5 days	✓	29-Apr-2021	180 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8A-E303059	E421	23-Apr-2021	28-Apr-2021	----	6 days	✓	29-Apr-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8A-snap	E421	23-Apr-2021	28-Apr-2021	----	6 days	✓	29-Apr-2021	180 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW16-5B CWP	E283	25-Apr-2021	----	----	----		27-Apr-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-11A-E303062	E283	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW16-5A CWP	E283	25-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23A-99	E283	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23A-E314690	E283	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23B-98	E283	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23B-E314691	E283	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8A-E303059	E283	23-Apr-2021	----	----	----		27-Apr-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8A-snap	E283	23-Apr-2021	----	----	----		27-Apr-2021	14 days	5 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW16-5B CWP	E290	25-Apr-2021	----	----	----		27-Apr-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-11A-E303062	E290	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW16-5A CWP	E290	25-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23A-99	E290	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23A-E314690	E290	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23B-98	E290	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23B-E314691	E290	24-Apr-2021	----	----	----		27-Apr-2021	14 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8A-E303059	E290	23-Apr-2021	----	----	----		27-Apr-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8A-snap	E290	23-Apr-2021	----	----	----		27-Apr-2021	14 days	5 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW16-5B CWP	E100	25-Apr-2021	----	----	----		27-Apr-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-11A-E303062	E100	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW16-5A CWP	E100	25-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23A-99	E100	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23A-E314690	E100	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23B-98	E100	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23B-E314691	E100	24-Apr-2021	----	----	----		27-Apr-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8A-E303059	E100	23-Apr-2021	----	----	----		27-Apr-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8A-snap	E100	23-Apr-2021	----	----	----		27-Apr-2021	28 days	5 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW16-5B CWP	E108	25-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	46 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW16-5A CWP	E108	25-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	48 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-23B-98	E108	24-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	69 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-23B-E314691	E108	24-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	69 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW12-11A-E303062	E108	24-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	71 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-23A-99	E108	24-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	71 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-23A-E314690	E108	24-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	71 hrs	✗ EHTR-FM

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW12-8A-E303059	E108	23-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	95 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW12-8A-snap	E108	23-Apr-2021	----	----	----		27-Apr-2021	0.25 hrs	97 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW16-5A CWP	E162	25-Apr-2021	----	----	----		30-Apr-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW16-5B CWP	E162	25-Apr-2021	----	----	----		30-Apr-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW12-11A-E303062	E162	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23A-99	E162	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23A-E314690	E162	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23B-98	E162	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23B-E314691	E162	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8A-E303059	E162	23-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8A-snap	E162	23-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW16-5A CWP	E160-H	25-Apr-2021	----	----	----		30-Apr-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW16-5B CWP	E160-H	25-Apr-2021	----	----	----		30-Apr-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-11A-E303062	E160-H	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23A-99	E160-H	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23A-E314690	E160-H	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23B-98	E160-H	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23B-E314691	E160-H	24-Apr-2021	----	----	----		30-Apr-2021	7 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8A-E303059	E160-H	23-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8A-snap	E160-H	23-Apr-2021	----	----	----		29-Apr-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-11A-E303062	E121	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW16-5A CWP	E121	25-Apr-2021	----	----	----		28-Apr-2021	3 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW16-5B CWP	E121	25-Apr-2021	----	----	----		28-Apr-2021	3 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23A-99	E121	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23A-E314690	E121	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23B-98	E121	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23B-E314691	E121	24-Apr-2021	----	----	----		27-Apr-2021	3 days	4 days	✓

Matrix: **Water**

Evaluation: ✖ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8A-E303059	E121	23-Apr-2021	----	----	----		27-Apr-2021	3 days	5 days	✖ EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8A-snap	E121	23-Apr-2021	----	----	----		27-Apr-2021	3 days	5 days	✖ EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW16-5B CWP	E508	25-Apr-2021	----	----	----		30-Apr-2021	28 days	5 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW16-5A CWP	E508	25-Apr-2021	----	----	----		30-Apr-2021	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23B-98	E508	24-Apr-2021	----	----	----		30-Apr-2021	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23B-E314691	E508	24-Apr-2021	----	----	----		30-Apr-2021	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-11A-E303062	E508	24-Apr-2021	----	----	----		30-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23A-99	E508	24-Apr-2021	----	----	----		30-Apr-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23A-E314690	E508	24-Apr-2021	----	----	----		30-Apr-2021	28 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8A-E303059	E508	23-Apr-2021	----	----	----		30-Apr-2021	28 days	8 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8A-snap	E508	23-Apr-2021	----	----	----		30-Apr-2021	28 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW16-5A CWP	E420	25-Apr-2021	----	----	----		30-Apr-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW16-5B CWP	E420	25-Apr-2021	----	----	----		30-Apr-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-11A-E303062	E420	24-Apr-2021	----	----	----		30-Apr-2021	180 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23A-99	E420	24-Apr-2021	----	----	----		30-Apr-2021	180 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23A-E314690	E420	24-Apr-2021	----	----	----		30-Apr-2021	180 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23B-98	E420	24-Apr-2021	----	----	----		30-Apr-2021	180 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23B-E314691	E420	24-Apr-2021	----	----	----		30-Apr-2021	180 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8A-E303059	E420	23-Apr-2021	----	----	----		30-Apr-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8A-snap	E420	23-Apr-2021	----	----	----		30-Apr-2021	180 days	8 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	185816	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	185808	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	189612	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	185812	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	190225	1	16	6.2	5.0	✓
Chloride in Water by IC	E235.Cl	185811	1	20	5.0	5.0	✓
Conductivity in Water	E100	185809	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	188271	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	186871	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	185817	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	185810	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	185813	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	185814	1	20	5.0	5.0	✓
pH by Meter	E108	185807	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	185815	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	188118	2	39	5.1	5.0	✓
Total Mercury in Water by CVAAS	E508	188479	2	38	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	187582	1	16	6.2	5.0	✓
Total Nitrogen by Colourimetry	E366	189611	1	15	6.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	189610	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	187941	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	188119	2	39	5.1	5.0	✓
Turbidity by Nephelometry	E121	186196	3	57	5.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	185816	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	185808	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	189612	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	185812	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	190225	1	16	6.2	5.0	✓
Chloride in Water by IC	E235.Cl	185811	1	20	5.0	5.0	✓
Conductivity in Water	E100	185809	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	188271	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	186871	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	185817	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	185810	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	185813	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	185814	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	185807	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	185815	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	188118	2	39	5.1	5.0	✓
Total Mercury in Water by CVAAS	E508	188479	2	38	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	187582	1	16	6.2	5.0	✓
Total Nitrogen by Colourimetry	E366	189611	1	15	6.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	189610	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	187941	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	188119	2	39	5.1	5.0	✓
Turbidity by Nephelometry	E121	186196	3	57	5.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	185816	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	185808	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	189612	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	185812	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	190225	1	16	6.2	5.0	✓
Chloride in Water by IC	E235.Cl	185811	1	20	5.0	5.0	✓
Conductivity in Water	E100	185809	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	188271	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	186871	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	185817	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	185810	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	185813	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	185814	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	185815	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	188118	2	39	5.1	5.0	✓
Total Mercury in Water by CVAAS	E508	188479	2	38	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	187582	1	16	6.2	5.0	✓
Total Nitrogen by Colourimetry	E366	189611	1	15	6.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	189610	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	187941	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	188119	2	39	5.1	5.0	✓
Turbidity by Nephelometry	E121	186196	3	57	5.2	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	189612	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	185812	1	20	5.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	190225	1	16	6.2	5.0	✓
Chloride in Water by IC	E235.Cl	185811	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	188271	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	186871	1	14	7.1	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	185817	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	185810	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	185813	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	185814	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	185815	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	188479	2	38	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	187582	1	16	6.2	5.0	✓
Total Nitrogen by Colourimetry	E366	189611	1	15	6.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	189610	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	187941	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A7804**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 26-Apr-2021 19:50
PO	: 1025614	Date Analysis Commenced	: 27-Apr-2021
C-O-C number	: ----	Issue Date	: 05-May-2021 16:41
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 9		
No. of samples analysed	: 9		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 185807)											
VA21A7762-001	Anonymous	pH	----	E108	0.10	pH units	7.34	7.32	0.273%	4%	----
Physical Tests (QC Lot: 185808)											
VA21A7762-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	2.0	mg/L	40.3	40.1	0.498%	20%	----
Physical Tests (QC Lot: 185809)											
VA21A7762-001	Anonymous	conductivity	----	E100	2.0	µS/cm	101	103	1.37%	10%	----
Physical Tests (QC Lot: 185816)											
VA21A7804-002	BJ-GW12-8A-E303059	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 186196)											
VA21A7804-001	BJ-GW12-8A-snap	turbidity	----	E121	0.10	NTU	16.8	16.6	1.19%	15%	----
Physical Tests (QC Lot: 186296)											
VA21A7804-003	BJ-GW12-11A-E303062	turbidity	----	E121	0.10	NTU	11.6	11.9	2.54%	15%	----
Physical Tests (QC Lot: 186929)											
KS2101196-001	Anonymous	turbidity	----	E121	0.10	NTU	<0.10	<0.10	0	Diff <2x LOR	----
Physical Tests (QC Lot: 188118)											
VA21A7805-022	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	209	199	4.90%	20%	----
Physical Tests (QC Lot: 188119)											
VA21A7805-022	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	8.9	8.3	0.6	Diff <2x LOR	----
Physical Tests (QC Lot: 188404)											
VA21A7804-003	BJ-GW12-11A-E303062	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	18.9	18.9	0	Diff <2x LOR	----
Physical Tests (QC Lot: 188411)											
VA21A7804-003	BJ-GW12-11A-E303062	solids, total dissolved [TDS]	----	E162	13	mg/L	113	115	2	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 185810)											
VA21A7762-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.022	0.021	0.0005	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 185811)											
VA21A7762-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	5.86	5.86	0.0677%	20%	----
Anions and Nutrients (QC Lot: 185812)											
VA21A7762-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 185813)											
VA21A7762-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0935	0.0936	0.0588%	20%	----
Anions and Nutrients (QC Lot: 185814)											
VA21A7762-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 185815)											
VA21A7762-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	2.29	2.27	0.02	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 185817)											
VA21A7764-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0187	0.0194	3.85%	20%	----
Anions and Nutrients (QC Lot: 187941)											
CG2101054-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0750	mg/L	6.63	6.07	8.84%	20%	----
Anions and Nutrients (QC Lot: 189610)											
VA21A7804-001	BJ-GW12-8A-snap	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.117	0.112	0.0053	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 189611)											
VA21A7804-001	BJ-GW12-8A-snap	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.116	0.104	0.012	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 189612)											
VA21A7804-001	BJ-GW12-8A-snap	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Total Metals (QC Lot: 187582)											
VA21A7802-001	Anonymous	aluminum, total	7429-90-5	E420	0.0300	mg/L	0.374	0.389	4.14%	20%	----
		antimony, total	7440-36-0	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00100	mg/L	0.0816	0.0812	0.565%	20%	----
		beryllium, total	7440-41-7	E420	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.100	mg/L	0.588	0.617	0.028	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000500	mg/L	<0.0000500	<0.0000500	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.500	mg/L	78.2	81.7	4.40%	20%	----
		chromium, total	7440-47-3	E420	0.00500	mg/L	<0.00500	<0.00500	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00100	mg/L	0.00105	<0.00100	0.00005	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00500	mg/L	<0.00500	<0.00500	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.100	mg/L	1.34	1.36	1.15%	20%	----
		lead, total	7439-92-1	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0100	mg/L	0.0183	0.0187	0.0004	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	1.00	mg/L	190	193	1.81%	20%	----
		manganese, total	7439-96-5	E420	0.00100	mg/L	0.523	0.537	2.63%	20%	----
		molybdenum, total	7439-98-7	E420	0.000500	mg/L	0.00122	0.00116	0.000063	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00500	mg/L	<0.00500	<0.00500	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.500	mg/L	<0.500	<0.500	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	1.00	mg/L	56.1	56.9	1.39%	20%	----
		selenium, total	7782-49-2	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	1.00	mg/L	9.43	9.59	0.16	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 187582) - continued											
VA21A7802-001	Anonymous	silver, total	7440-22-4	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.500	mg/L	1460	1490	2.17%	20%	----
		strontium, total	7440-24-6	E420	0.00200	mg/L	1.20	1.21	0.561%	20%	----
		thallium, total	7440-28-0	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00300	mg/L	0.0167	0.0182	0.00142	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000100	mg/L	0.000291	0.000306	0.000016	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00500	mg/L	<0.00500	<0.00500	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0300	mg/L	<0.0300	<0.0300	0	Diff <2x LOR	----
Total Metals (QC Lot: 188479)											
VA21A7764-005	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 188480)											
VA21A7804-005	BJ-GW18-23A-99	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 186871)											
VA21A7783-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0040	0.0040	0.000006	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	0.00010	0.000002	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00920	0.00899	2.34%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	1.07	1.09	1.43%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	329	330	0.324%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.170	0.169	0.351%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0274	0.0272	0.925%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	68.8	67.9	1.34%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.902	0.899	0.286%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00544	0.00562	3.11%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	0.568	0.538	5.35%	20%	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	54.2	53.6	1.18%	20%	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 186871) - continued											
VA21A7783-001	Anonymous	selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000071	0.000063	0.000008	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	8.73	8.87	1.63%	20%	----
		silver, dissolved	7440-22-4	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	331	334	0.714%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	2.10	2.13	1.34%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	0.00046	0.00052	0.00006	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000569	0.000584	2.70%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00092	0.00095	0.00003	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 188271)											
VA21A7790-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000500	mg/L	<0.0000500	<0.0000500	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 190225)											
VA21A7802-001	Anonymous	chemical oxygen demand [COD]	----	E559	80	mg/L	<80	<80	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 185808)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 185809)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 185816)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 186196)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 186296)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 186929)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 188118)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 188119)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 188404)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 188411)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 185810)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 185811)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 185812)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 185813)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 185814)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 185815)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 185817)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 187941)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Anions and Nutrients (QCLot: 189610)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 189611)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 189612)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Metals (QCLot: 187582)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 187582) - continued						
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 188479)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 188480)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 186871)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 186871) - continued						
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 188271)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 190225)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 185807)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 185808)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 185809)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.4	90.0	110	----
Physical Tests (QCLot: 185816)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	104	85.0	115	----
Physical Tests (QCLot: 186196)									
turbidity	----	E121	0.1	NTU	200 NTU	103	85.0	115	----
Physical Tests (QCLot: 186296)									
turbidity	----	E121	0.1	NTU	200 NTU	103	85.0	115	----
Physical Tests (QCLot: 186929)									
turbidity	----	E121	0.1	NTU	200 NTU	99.5	85.0	115	----
Physical Tests (QCLot: 188118)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	109	85.0	115	----
Physical Tests (QCLot: 188119)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	98.8	85.0	115	----
Physical Tests (QCLot: 188404)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	95.9	85.0	115	----
Physical Tests (QCLot: 188411)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	95.5	85.0	115	----
Anions and Nutrients (QCLot: 185810)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 185811)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 185812)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	108	85.0	115	----
Anions and Nutrients (QCLot: 185813)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 185814)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 185815)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 185815) - continued									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 185817)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	98.8	80.0	120	----
Anions and Nutrients (QCLot: 187941)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	88.6	80.0	120	----
Anions and Nutrients (QCLot: 189610)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	91.3	80.0	120	----
Anions and Nutrients (QCLot: 189611)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 189612)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	104	85.0	115	----
Total Metals (QCLot: 187582)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	105	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	97.6	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	98.5	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	99.7	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	96.1	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	110	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	105	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	102	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	96.1	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	106	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	108	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	105	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	103	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	105	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Total Metals (QCLot: 187582) - continued									
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	109	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	117	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	103	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	102	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	99.4	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	106	80.0	120	----
Total Metals (QCLot: 188479)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Total Metals (QCLot: 188480)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	100	80.0	120	----
Dissolved Metals (QCLot: 186871)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	99.3	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	107	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	101	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	98.5	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	93.0	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.4	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.0	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	92.8	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	110	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	104	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 186871) - continued									
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	104	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	116	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	107	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	99.1	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	99.4	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	108	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	104	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	96.6	80.0	120	----
Aggregate Organics (QCLot: 190225)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	100	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 185810)										
VA21A7762-002	Anonymous	fluoride	16984-48-8	E235.F	1.07 mg/L	1 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 185811)										
VA21A7762-002	Anonymous	chloride	16887-00-6	E235.Cl	110 mg/L	100 mg/L	110	75.0	125	----
Anions and Nutrients (QCLot: 185812)										
VA21A7762-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.558 mg/L	0.5 mg/L	112	75.0	125	----
Anions and Nutrients (QCLot: 185813)										
VA21A7762-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.76 mg/L	2.5 mg/L	110	75.0	125	----
Anions and Nutrients (QCLot: 185814)										
VA21A7762-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.527 mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 185815)										
VA21A7762-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	111 mg/L	100 mg/L	111	75.0	125	----
Anions and Nutrients (QCLot: 185817)										
VA21A7764-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0276 mg/L	0.03 mg/L	92.0	70.0	130	----
Anions and Nutrients (QCLot: 187941)										
CG2101054-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	ND mg/L	0.2 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 189610)										
VA21A7804-002	BJ-GW12-8A-E303059	phosphorus, total	7723-14-0	E372-U	0.0471 mg/L	0.05 mg/L	94.3	70.0	130	----
Anions and Nutrients (QCLot: 189611)										
VA21A7804-002	BJ-GW12-8A-E303059	nitrogen, total	7727-37-9	E366	0.400 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 189612)										
VA21A7804-002	BJ-GW12-8A-E303059	ammonia, total (as N)	7664-41-7	E298	0.213 mg/L	0.2 mg/L	106	75.0	125	----
Total Metals (QCLot: 187582)										
VA21A7802-001	Anonymous	aluminum, total	7429-90-5	E420	2.07 mg/L	2 mg/L	103	70.0	130	----
		antimony, total	7440-36-0	E420	0.205 mg/L	0.2 mg/L	102	70.0	130	----
		arsenic, total	7440-38-2	E420	0.202 mg/L	0.2 mg/L	101	70.0	130	----
		barium, total	7440-39-3	E420	0.188 mg/L	0.2 mg/L	94.2	70.0	130	----
		beryllium, total	7440-41-7	E420	0.406 mg/L	0.4 mg/L	101	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0948 mg/L	0.1 mg/L	94.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 187582) - continued										
VA21A7802-001	Anonymous	boron, total	7440-42-8	E420	0.997 mg/L	1 mg/L	99.7	70.0	130	----
		cadmium, total	7440-43-9	E420	0.0390 mg/L	0.04 mg/L	97.6	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	40 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.409 mg/L	0.4 mg/L	102	70.0	130	----
		cobalt, total	7440-48-4	E420	0.195 mg/L	0.2 mg/L	97.7	70.0	130	----
		copper, total	7440-50-8	E420	0.191 mg/L	0.2 mg/L	95.6	70.0	130	----
		iron, total	7439-89-6	E420	20.1 mg/L	20 mg/L	100	70.0	130	----
		lead, total	7439-92-1	E420	0.188 mg/L	0.2 mg/L	94.1	70.0	130	----
		lithium, total	7439-93-2	E420	0.964 mg/L	1 mg/L	96.4	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	10 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.202 mg/L	0.2 mg/L	101	70.0	130	----
		nickel, total	7440-02-0	E420	0.380 mg/L	0.4 mg/L	94.9	70.0	130	----
		phosphorus, total	7723-14-0	E420	107 mg/L	100 mg/L	107	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	40 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.406 mg/L	0.4 mg/L	101	70.0	130	----
		silicon, total	7440-21-3	E420	99.7 mg/L	100 mg/L	99.7	70.0	130	----
		silver, total	7440-22-4	E420	0.0391 mg/L	0.04 mg/L	97.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	20 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.0376 mg/L	0.04 mg/L	94.1	70.0	130	----
		tin, total	7440-31-5	E420	0.197 mg/L	0.2 mg/L	98.6	70.0	130	----
		titanium, total	7440-32-6	E420	0.415 mg/L	0.4 mg/L	104	70.0	130	----
		uranium, total	7440-61-1	E420	0.0397 mg/L	0.04 mg/L	99.2	70.0	130	----
		vanadium, total	7440-62-2	E420	1.04 mg/L	1 mg/L	104	70.0	130	----
		zinc, total	7440-66-6	E420	3.92 mg/L	4 mg/L	97.9	70.0	130	----
Total Metals (QCLot: 188479)										
VA21A7764-006	Anonymous	mercury, total	7439-97-6	E508	0.0000994 mg/L	0.0001 mg/L	99.4	70.0	130	----
Total Metals (QCLot: 188480)										
VA21A7804-006	BJ-GW18-23B-E314691	mercury, total	7439-97-6	E508	0.000101 mg/L	0.0001 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 186871)										
VA21A7783-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.203 mg/L	0.2 mg/L	102	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0205 mg/L	0.02 mg/L	103	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0193 mg/L	0.02 mg/L	96.7	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0381 mg/L	0.04 mg/L	95.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 186871) - continued										
VA21A7783-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00900 mg/L	0.01 mg/L	90.0	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00376 mg/L	0.004 mg/L	94.0	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0393 mg/L	0.04 mg/L	98.3	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0184 mg/L	0.02 mg/L	91.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.92 mg/L	2 mg/L	96.0	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0182 mg/L	0.02 mg/L	90.8	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0893 mg/L	0.1 mg/L	89.3	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0209 mg/L	0.02 mg/L	105	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0376 mg/L	0.04 mg/L	93.9	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.1 mg/L	10 mg/L	111	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0423 mg/L	0.04 mg/L	106	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.90 mg/L	10 mg/L	99.0	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00701 mg/L	0.008 mg/L	87.6	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00371 mg/L	0.004 mg/L	92.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0416 mg/L	0.04 mg/L	104	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00414 mg/L	0.004 mg/L	103	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.374 mg/L	0.4 mg/L	93.6	70.0	130	----
Dissolved Metals (QCLot: 188271)										
VA21A7790-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000980 mg/L	0.0001 mg/L	98.0	70.0	130	----
Aggregate Organics (QCLot: 190225)										
VA21A7802-002	Anonymous	chemical oxygen demand [COD]	----	E559	1040 mg/L	1000 mg/L	104	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/RS	

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients (P)	EPH	Total Metals (P)	Dissolved Metals (F/P)			Total Mercury (P)	Dissolved Mercury (F/P)	Acidity	Total Sulphides (P)		Number of Containers
	BJ-GW12-8A - snap	23-Apr-21	9:20	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8A - E303059	23-Apr-21	11:30	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-11A - E303062	24-Apr-21	11;20	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-23A - E314690	24-Apr-21	11:30	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-23A - 99	24-Apr-21	11:35	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-23B - E314691	24-Apr-21	13:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-23B - 98	24-Apr-21	13:05	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW16-5A CWP	25-Apr-21	10:40	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW16-5B CWP	25-Apr-21	11:45	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21A7804
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	25-Apr-21	18:00	TL	4/26	750	8 °C Iced				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21A8275**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 01-May-2021 15:10
PO	: 1025614	Date Analysis Commenced	: 03-May-2021
C-O-C number	: ----	Issue Date	: 10-May-2021 18:03
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Bennett - 94	BJ-GW18-17A - E303066	----	----	----
				Client sampling date / time	27-Apr-2021 09:30	27-Apr-2021 13:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A8275-001	VA21A8275-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	<1.0	135	----	----	----
conductivity	----	E100	2.0	µS/cm	<2.0	688	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	0.70	122	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	0.64	129	----	----	----
pH	----	E108	0.10	pH units	5.95	8.29	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	436	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	10.7	----	----	----
turbidity	----	E121	0.10	NTU	<0.10	3.95	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	0.0824	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	4.84	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	0.179	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	0.096	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0250 DLDS	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0255	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0050 DLDS	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	0.096	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0024	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0020	0.0086	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	216	----	----	----
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	0.493	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	0.524	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	<0.0030	0.0528	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	0.00260	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00068 RRV	0.0492	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.00049 RRV	0.0925	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Bennett - 94	BJ-GW18-17A - E303066	----	----	----
				Client sampling date / time	27-Apr-2021 09:30	27-Apr-2021 13:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A8275-001	VA21A8275-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	0.057	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	0.0000068	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	0.256 RRV	48.6	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00497 RRV	<0.00050	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	<0.010	0.044	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	0.000102	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	0.248	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	<0.100	1.87	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00127 RRV	0.0550	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	<0.000050	0.00157	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	<0.050	1.78	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	<0.10	2.97	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000014 RRV	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	<0.050	103	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.00498 RRV	1.66	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	0.000206	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0046 RRV	<0.0030	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	0.0092	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	0.00125	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Bennett - 94	BJ-GW18-17A - E303066	----	----	----
				Client sampling date / time	27-Apr-2021 09:30	27-Apr-2021 13:05	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21A8275-001	VA21A8275-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00066 RRV	0.0411	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00053 RRV	0.0845	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	0.056	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	0.280 RRV	45.8	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00518 RRV	<0.00020	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	0.015	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	0.243	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	<0.100	1.78	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00132 RRV	0.0535	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	<0.000050	0.00157	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	1.88	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000293 DTSE	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	<0.050	2.83	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	<0.050	107	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.00498 RRV	1.80	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	0.000217	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0043 RRV	0.0026	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				Client sample ID	**Bennett - 94**	**BJ-GW18-17A - E303066**	**----**	**----**	**----**
				Client sampling date / time	27-Apr-2021 09:30	27-Apr-2021 13:05	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21A8275-001**	**VA21A8275-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21A8275**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 01-May-2021 15:10
PO	: 1025614	Issue Date	: 10-May-2021 18:03
C-O-C number	: ----		
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
Bennett - 94	E559	27-Apr-2021	----	----	----		10-May-2021	28 days	13 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A - E303066	E559	27-Apr-2021	----	----	----		10-May-2021	28 days	13 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A - E303066	E298	27-Apr-2021	07-May-2021	----	10 days	✓	07-May-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Bennett - 94	E298	27-Apr-2021	07-May-2021	----	11 days	✓	07-May-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Bennett - 94	E235.Br-L	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A - E303066	E235.Br-L	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Bennett - 94	E235.Cl	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17A - E303066	E235.Cl	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Bennett - 94	E378-U	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	✗ EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17A - E303066	E378-U	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	✗ EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Bennett - 94	E235.F	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17A - E303066	E235.F	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Bennett - 94	E235.NO3-L	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	✗ EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A - E303066	E235.NO3-L	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Bennett - 94	E235.NO2-L	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A - E303066	E235.NO2-L	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	✗ EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Bennett - 94	E235.SO4	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A - E303066	E235.SO4	27-Apr-2021	----	----	----		03-May-2021	28 days	7 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A - E303066	E366	27-Apr-2021	07-May-2021	----	10 days	✓	10-May-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Bennett - 94	E366	27-Apr-2021	07-May-2021	----	11 days	✓	10-May-2021	28 days	3 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Bennett - 94	E372-U	27-Apr-2021	07-May-2021	----	11 days	✓	07-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A - E303066	E372-U	27-Apr-2021	07-May-2021	----	11 days	✓	07-May-2021	28 days	1 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17A - E303066	E395	27-Apr-2021	----	----	----		03-May-2021	7 days	6 days	✓
Anions and Nutrients : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
Bennett - 94	E395	27-Apr-2021	----	----	----		03-May-2021	7 days	7 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
Bennett - 94	E509	27-Apr-2021	05-May-2021	----	9 days	✓	05-May-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Bennett - 94	E421	27-Apr-2021	03-May-2021	----	7 days	✓	03-May-2021	180 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17A - E303066	E421	27-Apr-2021	03-May-2021	----	7 days	✓	03-May-2021	180 days	1 days	✓
Physical Tests : Acidity by Titration										
HDPE										
Bennett - 94	E283	27-Apr-2021	----	----	----		04-May-2021	14 days	7 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A - E303066	E283	27-Apr-2021	----	----	----		04-May-2021	14 days	7 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Bennett - 94	E290	27-Apr-2021	----	----	----		04-May-2021	14 days	7 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A - E303066	E290	27-Apr-2021	----	----	----		04-May-2021	14 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE										
Bennett - 94	E100	27-Apr-2021	----	----	----		04-May-2021	28 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A - E303066	E100	27-Apr-2021	----	----	----		04-May-2021	28 days	7 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17A - E303066	E108	27-Apr-2021	----	----	----		04-May-2021	0.25 hrs	161 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE Bennett - 94	E108	27-Apr-2021	----	----	----		04-May-2021	0.25 hrs	164 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE Bennett - 94	E162	27-Apr-2021	----	----	----		03-May-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17A - E303066	E162	27-Apr-2021	----	----	----		04-May-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE Bennett - 94	E160-H	27-Apr-2021	----	----	----		03-May-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17A - E303066	E160-H	27-Apr-2021	----	----	----		03-May-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17A - E303066	E121	27-Apr-2021	----	----	----		03-May-2021	3 days	6 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE Bennett - 94	E121	27-Apr-2021	----	----	----		03-May-2021	3 days	7 days	× EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17A - E303066	E508	27-Apr-2021	----	----	----		05-May-2021	28 days	8 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) Bennett - 94	E508	27-Apr-2021	----	----	----		05-May-2021	28 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Bennett - 94	E420	27-Apr-2021	----	----	----		04-May-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17A - E303066	E420	27-Apr-2021	----	----	----		04-May-2021	180 days	8 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	190118	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	190115	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	192959	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	190085	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	194187	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	190084	1	12	8.3	5.0	✓
Conductivity in Water	E100	190117	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	191556	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190045	2	11	18.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	190119	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	190083	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	190086	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	190087	1	12	8.3	5.0	✓
pH by Meter	E108	190116	1	2	50.0	5.0	✓
Sulfate in Water by IC	E235.SO4	190088	1	12	8.3	5.0	✓
TDS by Gravimetry	E162	190342	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	191457	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190210	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	192961	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	192960	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	189935	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	190340	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	189921	1	15	6.6	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	190118	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	190115	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	192959	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	190085	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	194187	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	190084	1	12	8.3	5.0	✓
Conductivity in Water	E100	190117	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	191556	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190045	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	190119	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	190083	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	190086	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	190087	1	12	8.3	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	190116	1	2	50.0	5.0	✓
Sulfate in Water by IC	E235.SO4	190088	1	12	8.3	5.0	✓
TDS by Gravimetry	E162	190342	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	191457	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190210	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	192961	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	192960	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	189935	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	190340	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	189921	1	15	6.6	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	190118	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	190115	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	192959	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	190085	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	194187	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	190084	1	12	8.3	5.0	✓
Conductivity in Water	E100	190117	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	191556	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190045	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	190119	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	190083	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	190086	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	190087	1	12	8.3	5.0	✓
Sulfate in Water by IC	E235.SO4	190088	1	12	8.3	5.0	✓
TDS by Gravimetry	E162	190342	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	191457	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190210	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	192961	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	192960	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	189935	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	190340	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	189921	1	15	6.6	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	192959	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	190085	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	194187	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	190084	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	191556	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	190045	1	11	9.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	190119	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	190083	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	190086	1	12	8.3	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	190087	1	12	8.3	5.0	✓
Sulfate in Water by IC	E235.SO4	190088	1	12	8.3	5.0	✓
Total Mercury in Water by CVAAS	E508	191457	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	190210	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	192961	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	192960	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	189935	1	11	9.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21A8275**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 01-May-2021 15:10
PO	: 1025614	Date Analysis Commenced	: 03-May-2021
C-O-C number	: ----	Issue Date	: 10-May-2021 18:03
Sampler	: NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 189921)											
VA21A8213-001	Anonymous	turbidity	----	E121	0.10	NTU	17.3	16.3	5.94%	15%	----
Physical Tests (QC Lot: 190115)											
VA21A8231-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	80.4	79.4	1.25%	20%	----
Physical Tests (QC Lot: 190116)											
VA21A8275-001	Bennett - 94	pH	----	E108	0.10	pH units	5.95	5.98	0.503%	4%	----
Physical Tests (QC Lot: 190117)											
VA21A8275-001	Bennett - 94	conductivity	----	E100	2.0	µS/cm	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 190118)											
VA21A8275-002	BJ-GW18-17A - E303066	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 190340)											
VA21A7900-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	3.1	0.1	Diff <2x LOR	----
Physical Tests (QC Lot: 190342)											
VA21A8054-005	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	116	118	3	Diff <2x LOR	----
Physical Tests (QC Lot: 190713)											
VA21A7899-002	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	402	426	5.79%	20%	----
Anions and Nutrients (QC Lot: 189935)											
CG2101126-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 190083)											
VA21A8231-001	Anonymous	fluoride	16984-48-8	E235.F	0.400	mg/L	0.458	0.439	0.018	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 190084)											
VA21A8231-001	Anonymous	chloride	16887-00-6	E235.Cl	10.0	mg/L	579	579	0.0548%	20%	----
Anions and Nutrients (QC Lot: 190085)											
VA21A8231-001	Anonymous	bromide	24959-67-9	E235.Br-L	1.00	mg/L	1.18	1.16	0.018	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 190086)											
VA21A8231-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 190087)											
VA21A8231-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0200	mg/L	<0.0200	<0.0200	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 190088)											
VA21A8231-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	6.00	mg/L	134	134	0.278%	20%	----
Anions and Nutrients (QC Lot: 190119)											
VA21A8275-001	Bennett - 94	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 192959)											
VA21A8272-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0100	mg/L	0.0372	0.0391	0.0019	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 192960)											
KS2101285-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0337	0.0358	6.13%	20%	----
Anions and Nutrients (QC Lot: 192961)											
VA21A8275-001	Bennett - 94	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Total Metals (QC Lot: 190210)											
CG2101143-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0047	0.0045	0.0001	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00017	0.00015	0.00002	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0136	0.0142	3.76%	20%	----
		beryllium, total	7440-41-7	E420	0.020	mg/L	<0.020 µg/L	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0050	mg/L	0.0174 µg/L	0.0000171	0.0000003	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	44.4	44.2	0.465%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.10	mg/L	<0.10 µg/L	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0018	0.0018	0.000006	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	11.7	11.5	1.63%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00012	0.00011	0.000006	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000971	0.000961	1.06%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.259	0.242	0.017	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.050	mg/L	0.853 µg/L	0.000810	5.12%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.69	1.75	3.64%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	0.442	0.432	0.010	Diff <2x LOR	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.117	0.116	1.13%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 190210) - continued											
CG2101143-001	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	0.00103	0.00104	0.808%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0031	0.0033	0.0002	Diff <2x LOR	----
Total Metals (QC Lot: 191457)											
VA21A8217-005	Anonymous	mercury, total	7439-97-6	E508	0.0000100	mg/L	<0.0000100	<0.0000100	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 190045)											
CG2101126-027	Anonymous	zinc, dissolved	7440-66-6	E421	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
CG2101126-027	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0020	mg/L	0.0025	<0.0020	0.0005	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00020	mg/L	0.00033	0.00028	0.00005	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00020	mg/L	0.00950	0.00920	3.31%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.040	mg/L	<0.040 µg/L	<0.000040	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.020	mg/L	0.099	0.097	0.002	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0100	mg/L	<0.0100 µg/L	<0.0000100	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.100	mg/L	496	491	1.11%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00100	mg/L	0.00120	0.00108	0.00012	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.20	mg/L	26.4 µg/L	0.0252	4.56%	20%	----
		copper, dissolved	7440-50-8	E421	0.00040	mg/L	<0.00040	<0.00040	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.020	mg/L	2.76	2.60	5.97%	20%	----
		lead, dissolved	7439-92-1	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0020	mg/L	0.122	0.121	0.884%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0100	mg/L	266	249	6.66%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00020	mg/L	0.684	0.652	4.81%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000100	mg/L	0.000588	0.000614	0.000026	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00100	mg/L	0.129	0.122	5.04%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	12.8	12.3	4.42%	20%	----
		selenium, dissolved	7782-49-2	E421	0.100	mg/L	<0.100 µg/L	0.000144	0.000044	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	3.56	3.45	3.01%	20%	----
		silver, dissolved	7440-22-4	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.100	mg/L	8.27	7.76	6.29%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00040	mg/L	0.630	0.626	0.536%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 190045) - continued											
CG2101126-027	Anonymous	titanium, dissolved	7440-32-6	E421	0.00060	mg/L	<0.00060	<0.00060	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000020	mg/L	0.0338	0.0333	1.53%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 191556)											
CG2101126-025	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 194187)											
VA21A8275-001	Bennett - 94	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 189921)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 190115)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 190117)						
conductivity	----	E100	1	µS/cm	1.0	----
Physical Tests (QCLot: 190118)						
acidity (as CaCO3)	----	E283	2	mg/L	2.2	----
Physical Tests (QCLot: 190340)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 190342)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 190713)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 189935)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Anions and Nutrients (QCLot: 190083)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 190084)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 190085)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 190086)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 190087)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 190088)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 190119)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 192959)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 192960)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 192961)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Metals (QCLot: 190210)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 191457)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 190045)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 191556)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 194187)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 189921)									
turbidity	----	E121	0.1	NTU	200 NTU	100	85.0	115	----
Physical Tests (QCLot: 190115)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	106	85.0	115	----
Physical Tests (QCLot: 190116)									
pH	----	E108	----	pH units	7 pH units	99.7	98.0	102	----
Physical Tests (QCLot: 190117)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	98.4	90.0	110	----
Physical Tests (QCLot: 190118)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	115	85.0	115	----
Physical Tests (QCLot: 190340)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	92.5	85.0	115	----
Physical Tests (QCLot: 190342)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	97.4	85.0	115	----
Physical Tests (QCLot: 190713)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	94.9	85.0	115	----
Anions and Nutrients (QCLot: 189935)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	103	80.0	120	----
Anions and Nutrients (QCLot: 190083)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	98.7	90.0	110	----
Anions and Nutrients (QCLot: 190084)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 190085)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	107	85.0	115	----
Anions and Nutrients (QCLot: 190086)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 190087)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	99.8	90.0	110	----
Anions and Nutrients (QCLot: 190088)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 190119)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	96.9	80.0	120	----
Anions and Nutrients (QCLot: 192959)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 192959) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	96.8	85.0	115	----
Anions and Nutrients (QCLot: 192960)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 192961)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Total Metals (QCLot: 190210)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	105	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	99.7	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	100	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	98.7	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	99.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	98.2	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	92.1	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	94.8	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	99.8	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	98.2	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	95.3	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	97.6	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	103	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	99.5	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	97.4	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	98.1	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	100	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	99.6	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	100	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	98.4	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.6	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	98.3	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	92.9	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	102	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	99.7	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 190210) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	99.6	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	103	80.0	120	----
Total Metals (QCLot: 191457)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	105	80.0	120	----
Dissolved Metals (QCLot: 190045)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	101	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	98.9	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	98.0	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	109	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	97.3	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	95.7	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	95.6	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	98.5	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.6	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.8	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	96.9	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	111	70.0	130	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	98.5	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	99.0	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	110	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	104	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	95.9	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	103	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	98.9	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 190045) - continued									
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	101	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	96.6	80.0	120	----
Aggregate Organics (QCLot: 194187)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	101	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 189935)										
CG2101128-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.198 mg/L	0.2 mg/L	99.2	75.0	125	----
Anions and Nutrients (QCLot: 190083)										
VA21A8231-002	Anonymous	fluoride	16984-48-8	E235.F	5.05 mg/L	5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 190084)										
VA21A8231-002	Anonymous	chloride	16887-00-6	E235.Cl	512 mg/L	500 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 190085)										
VA21A8231-002	Anonymous	bromide	24959-67-9	E235.Br-L	2.62 mg/L	2.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 190086)										
VA21A8231-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	12.8 mg/L	12.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 190087)										
VA21A8231-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.48 mg/L	2.5 mg/L	99.4	75.0	125	----
Anions and Nutrients (QCLot: 190088)										
VA21A8231-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	520 mg/L	500 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 190119)										
VA21A8275-002	BJ-GW18-17A - E303066	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0294 mg/L	0.03 mg/L	98.0	70.0	130	----
Anions and Nutrients (QCLot: 192959)										
VA21A8275-001	Bennett - 94	ammonia, total (as N)	7664-41-7	E298	0.192 mg/L	0.2 mg/L	95.9	75.0	125	----
Anions and Nutrients (QCLot: 192960)										
VA21A8270-001	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 192961)										
VA21A8275-002	BJ-GW18-17A - E303066	nitrogen, total	7727-37-9	E366	0.416 mg/L	0.4 mg/L	104	70.0	130	----
Total Metals (QCLot: 190210)										
CG2101143-001	Anonymous	aluminum, total	7429-90-5	E420	0.212 mg/L	0.2 mg/L	106	70.0	130	----
		antimony, total	7440-36-0	E420	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		barium, total	7440-39-3	E420	0.0189 mg/L	0.02 mg/L	94.3	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00914 mg/L	0.01 mg/L	91.4	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 190210) - continued										
CG2101143-001	Anonymous	boron, total	7440-42-8	E420	0.096 mg/L	0.1 mg/L	96.3	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00386 mg/L	0.004 mg/L	96.6	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0395 mg/L	0.04 mg/L	98.7	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0192 mg/L	0.02 mg/L	96.0	70.0	130	----
		copper, total	7440-50-8	E420	0.0192 mg/L	0.02 mg/L	96.0	70.0	130	----
		iron, total	7439-89-6	E420	1.96 mg/L	2 mg/L	97.8	70.0	130	----
		lead, total	7439-92-1	E420	0.0182 mg/L	0.02 mg/L	91.0	70.0	130	----
		lithium, total	7439-93-2	E420	0.0960 mg/L	0.1 mg/L	96.0	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0197 mg/L	0.02 mg/L	98.3	70.0	130	----
		nickel, total	7440-02-0	E420	0.0381 mg/L	0.04 mg/L	95.2	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.6 mg/L	10 mg/L	106	70.0	130	----
		potassium, total	7440-09-7	E420	3.88 mg/L	4 mg/L	97.1	70.0	130	----
		selenium, total	7782-49-2	E420	0.0411 mg/L	0.04 mg/L	103	70.0	130	----
		silicon, total	7440-21-3	E420	9.04 mg/L	10 mg/L	90.4	70.0	130	----
		silver, total	7440-22-4	E420	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, total	17341-25-2	E420	1.87 mg/L	2 mg/L	93.5	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00365 mg/L	0.004 mg/L	91.3	70.0	130	----
		tin, total	7440-31-5	E420	0.0188 mg/L	0.02 mg/L	93.9	70.0	130	----
		titanium, total	7440-32-6	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		uranium, total	7440-61-1	E420	0.00370 mg/L	0.004 mg/L	92.6	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0993 mg/L	0.1 mg/L	99.3	70.0	130	----
		zinc, total	7440-66-6	E420	0.408 mg/L	0.4 mg/L	102	70.0	130	----
Total Metals (QCLot: 191457)										
VA21A8227-001	Anonymous	mercury, total	7439-97-6	E508	0.000105 mg/L	0.0001 mg/L	105	70.0	130	----
Dissolved Metals (QCLot: 190045)										
CG2101126-027	Anonymous	aluminum, dissolved	7429-90-5	E421	0.389 mg/L	0.4 mg/L	97.3	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0393 mg/L	0.04 mg/L	98.2	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0430 mg/L	0.04 mg/L	107	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0393 mg/L	0.04 mg/L	98.2	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0771 mg/L	0.08 mg/L	96.4	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0191 mg/L	0.02 mg/L	95.4	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.190 mg/L	0.2 mg/L	95.0	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 190045) - continued										
CG2101126-027	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00787 mg/L	0.008 mg/L	98.3	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0807 mg/L	0.08 mg/L	101	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0367 mg/L	0.04 mg/L	91.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0370 mg/L	0.04 mg/L	92.4	70.0	130	----
		iron, dissolved	7439-89-6	E421	3.82 mg/L	4 mg/L	95.6	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.183 mg/L	0.2 mg/L	91.3	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0402 mg/L	0.04 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	ND mg/L	0.08 mg/L	ND	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	22.7 mg/L	20 mg/L	114	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0906 mg/L	0.08 mg/L	113	70.0	130	----
		silicon, dissolved	7440-21-3	E421	18.0 mg/L	20 mg/L	90.3	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00665 mg/L	0.008 mg/L	83.2	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00768 mg/L	0.008 mg/L	96.0	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0393 mg/L	0.04 mg/L	98.2	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0853 mg/L	0.08 mg/L	107	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.008 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.208 mg/L	0.2 mg/L	104	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.779 mg/L	0.8 mg/L	97.4	70.0	130	----
Dissolved Metals (QCLot: 191556)										
CG2101126-026	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000969 mg/L	0.0001 mg/L	96.9	70.0	130	----
Aggregate Organics (QCLot: 194187)										
VA21A8275-002	BJ-GW18-17A - E303066	chemical oxygen demand [COD]	----	E559	460 mg/L	500 mg/L	92.1	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information	Analysis Request
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	Bennett - 94	27-Apr-21	9:30	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-17A - E303066	27-Apr-21	13:05	Groundwater	X	X		X	X			X		X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21A8275

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	27-Apr-21	18:00				18 °C	JCP	1 May	3:10 PM	

Ice Packs

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B0395**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-May-2021 16:50
PO	: 1025614	Date Analysis Commenced	: 28-May-2021
C-O-C number	: ----	Issue Date	: 04-Jun-2021 17:25
Sampler	: BM, NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ken Chan	Supervisor - Metals Prep & Mercury	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-17A-Snap	BJ-GW18-17A-E 303066	----	----	----
				Client sampling date / time	23-May-2021 08:45	23-May-2021 12:45	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0395-001	VA21B0395-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	153	124	----	----	----
conductivity	----	E100	2.0	µS/cm	795	676	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	6.74	143	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	39.7	147	----	----	----
pH	----	E108	0.10	pH units	8.66	8.20	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	506	426	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	52.1	3.9	----	----	----
turbidity	----	E121	0.10	NTU	31.8	2.74	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0855	0.105	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	4.72	4.86	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.251	0.190	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.168	0.083	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0250 DLDS	0.127	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0255	0.178	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0050 DLDS	0.0512	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.168	0.261	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0014	0.0023	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0809	0.0068	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	224	205	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	0.017	0.123	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	0.016	0.116	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.406	0.0379	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00502	0.00475	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.115	0.0374	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0504	0.0588	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-Snap	BJ-GW18-17A-E 303066	----	----	----
				Client sampling date / time	23-May-2021 08:45	23-May-2021 12:45	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0395-001	VA21B0395-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.119	0.056	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	15.4	56.2	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00105	<0.00050	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00012	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00136	0.00089	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.391	0.100	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000557	0.000086	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.489	0.221	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	0.307	1.58	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0458	0.0401	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00155	0.00115	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	0.00193	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.12	1.48	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	0.000258	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.90	2.78	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000110	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	189	95.2	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.362	1.30	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000010	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00011	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000200	0.000170	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0052	<0.0030	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0143	0.0210	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-Snap	BJ-GW18-17A-E 303066	----	----	----
				Client sampling date / time	23-May-2021 08:45	23-May-2021 12:45	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0395-001	VA21B0395-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00470	0.00446	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.103	0.0358	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0143	0.0541	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.105	0.053	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	2.46	54.7	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00042	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.010	0.045	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.467	0.223	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	0.144	1.60	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00720	0.0391	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00162	0.00111	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.46	1.48	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000224	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.16	2.66	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	181	93.5	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.214	1.25	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000172	0.000170	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17A-Snap**	**BJ-GW18-17A-E 303066**	**----**	**----**	**----**
				Client sampling date / time	23-May-2021 08:45	23-May-2021 12:45	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B0395-001**	**VA21B0395-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B0395**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-May-2021 16:50
PO	: 1025614	Issue Date	: 04-Jun-2021 17:25
C-O-C number	: ----		
Sampler	: BM, NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-Snap	E559	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E559	23-May-2021	----	----	----		01-Jun-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-Snap	E298	23-May-2021	03-Jun-2021	----	11 days	✓	03-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E298	23-May-2021	03-Jun-2021	----	12 days	✓	03-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.Br-L	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-Snap	E235.Br-L	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.Cl	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17A-Snap	E235.Cl	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17A-E303066	E378-U	23-May-2021	----	----	----		03-Jun-2021	3 days	12 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17A-Snap	E378-U	23-May-2021	----	----	----		03-Jun-2021	3 days	12 days	× EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.F	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17A-Snap	E235.F	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.NO3-L	23-May-2021	----	----	----		03-Jun-2021	3 days	12 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-Snap	E235.NO3-L	23-May-2021	----	----	----		03-Jun-2021	3 days	12 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.NO2-L	23-May-2021	----	----	----		03-Jun-2021	3 days	12 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-Snap	E235.NO2-L	23-May-2021	----	----	----		03-Jun-2021	3 days	12 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.SO4	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A-Snap	E235.SO4	23-May-2021	----	----	----		03-Jun-2021	28 days	12 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-Snap	E366	23-May-2021	03-Jun-2021	----	11 days	✓	04-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E366	23-May-2021	03-Jun-2021	----	12 days	✓	04-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-Snap	E372-U	23-May-2021	03-Jun-2021	----	11 days	✓	03-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E372-U	23-May-2021	03-Jun-2021	----	12 days	✓	04-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17A-E303066	E509	23-May-2021	03-Jun-2021	----	11 days	✓	03-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17A-Snap	E509	23-May-2021	03-Jun-2021	----	11 days	✓	03-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-E303066	E421	23-May-2021	28-May-2021	----	5 days	✓	31-May-2021	180 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-Snap	E421	23-May-2021	28-May-2021	----	6 days	✓	31-May-2021	180 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A-E303066	E283	23-May-2021	----	----	----		03-Jun-2021	14 days	12 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A-Snap	E283	23-May-2021	----	----	----		03-Jun-2021	14 days	12 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A-E303066	E290	23-May-2021	----	----	----		03-Jun-2021	14 days	11 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A-Snap	E290	23-May-2021	----	----	----		03-Jun-2021	14 days	11 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A-E303066	E100	23-May-2021	----	----	----		03-Jun-2021	28 days	11 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A-Snap	E100	23-May-2021	----	----	----		03-Jun-2021	28 days	11 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17A-E303066	E108	23-May-2021	----	----	----		03-Jun-2021	0.25 hrs	257 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17A-Snap	E108	23-May-2021	----	----	----		03-Jun-2021	0.25 hrs	261 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: ✖ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17A-E303066	E162	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17A-Snap	E162	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17A-E303066	E160-H	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17A-Snap	E160-H	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17A-E303066	E121	23-May-2021	----	----	----		28-May-2021	3 days	6 days	✖ EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17A-Snap	E121	23-May-2021	----	----	----		28-May-2021	3 days	6 days	✖ EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17A-E303066	E508	23-May-2021	----	----	----		02-Jun-2021	28 days	11 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17A-Snap	E508	23-May-2021	----	----	----		02-Jun-2021	28 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17A-E303066	E420	23-May-2021	----	----	----		31-May-2021	180 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17A-Snap	E420	23-May-2021	----	----	----		31-May-2021	180 days	9 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17A-E303066	E395-H	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17A-Snap	E395-H	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	212338	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	211361	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	211853	2	21	9.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	212323	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	210232	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	212321	1	11	9.0	5.0	✓
Conductivity in Water	E100	211359	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	211902	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	207574	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	212327	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	212322	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	212324	1	7	14.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	212319	1	11	9.0	5.0	✓
pH by Meter	E108	211360	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	212318	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	207697	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	207278	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	211857	2	6	33.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	211856	2	26	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	207818	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	207686	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	207906	1	6	16.6	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	212338	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	211361	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	211853	2	21	9.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	212323	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	210232	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	212321	1	11	9.0	5.0	✓
Conductivity in Water	E100	211359	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	211902	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	207574	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	212327	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	212322	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	212324	1	7	14.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	212319	1	11	9.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	211360	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	212318	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	207697	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	207278	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	211857	2	6	33.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	211856	2	26	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	207818	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	207686	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	207906	1	6	16.6	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	212338	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	211361	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	211853	2	21	9.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	212323	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	210232	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	212321	1	11	9.0	5.0	✓
Conductivity in Water	E100	211359	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	211902	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	207574	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	212327	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	212322	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	212324	1	7	14.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	212319	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	212318	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	207697	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	207278	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	211857	2	6	33.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	211856	2	26	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	207818	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	207686	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	207906	1	6	16.6	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	211853	2	21	9.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	212323	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	210232	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	212321	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	211902	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	207574	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	212327	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	212322	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	212324	1	7	14.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	212319	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	212318	1	11	9.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	207278	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	211857	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	211856	2	26	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	207818	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B0395**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-May-2021 16:50
PO	: 1025614	Date Analysis Commenced	: 28-May-2021
C-O-C number	: ----	Issue Date	: 04-Jun-2021 17:25
Sampler	: BM, NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ken Chan	Supervisor - Metals Prep & Mercury	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 207686)											
VA21B0279-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	178	192	7.66%	20%	----
Physical Tests (QC Lot: 207697)											
VA21B0130-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	637	624	2.14%	20%	----
Physical Tests (QC Lot: 207906)											
VA21B0375-001	Anonymous	turbidity	----	E121	0.10	NTU	1.24	1.26	0.02	Diff <2x LOR	----
Physical Tests (QC Lot: 211359)											
VA21B0405-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1820	1810	0.331%	10%	----
Physical Tests (QC Lot: 211360)											
VA21B0405-001	Anonymous	pH	----	E108	0.10	pH units	8.22	8.24	0.182%	4%	----
Physical Tests (QC Lot: 211361)											
VA21B0405-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	359	360	0.139%	20%	----
Physical Tests (QC Lot: 212338)											
VA21B0395-002	BJ-GW18-17A-E303066	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 211853)											
VA21B0349-004	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0093	0.0097	0.0004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 211856)											
VA21B0356-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0084	0.0084	0.000001	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 211857)											
VA21B0357-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.312	0.310	0.893%	20%	----
Anions and Nutrients (QC Lot: 212302)											
VA21B0276-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0286	0.0267	7.19%	20%	----
Anions and Nutrients (QC Lot: 212318)											
VA21B0357-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	5.41	5.42	0.205%	20%	----
Anions and Nutrients (QC Lot: 212319)											
VA21B0357-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212321)											
VA21B0357-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	1.05	1.04	0.008	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212322)											
VA21B0395-001	BJ-GW18-17A-Snap	fluoride	16984-48-8	E235.F	0.100	mg/L	0.251	0.272	0.021	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212323)											
VA21B0395-001	BJ-GW18-17A-Snap	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 212324)											
VA21B0395-001	BJ-GW18-17A-Snap	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	<0.0250	<0.0250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212327)											
VA21B0357-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0011	<0.0010	0.00008	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212669)											
VA21B0395-002	BJ-GW18-17A-E303066	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.261	0.266	0.005	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212670)											
VA21B0395-002	BJ-GW18-17A-E303066	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.105	0.105	0.0397%	20%	----
Total Sulfides (QC Lot: 207818)											
FJ2100306-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 207278)											
FJ2100306-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00045	0.00046	0.000002	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00010	<0.00010	0.000002	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0150	0.0144	3.61%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.082	0.084	0.002	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	108	111	2.80%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.139	0.142	2.20%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	169	165	2.27%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00314	0.00314	0.129%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00813	0.00792	2.66%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	0.532	0.488	8.61%	20%	----
		potassium, total	7440-09-7	E420	0.050	mg/L	3.01	2.99	0.823%	20%	----
		selenium, total	7782-49-2	E420	0.050	mg/L	133 µg/L	0.134	0.661%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.34	1.42	6.41%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	33.6	32.6	2.99%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 207278) - continued											
FJ2100306-001	Anonymous	strontium, total	7440-24-6	E420	0.00020	mg/L	0.682	0.698	2.30%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000015	0.000014	0.000001	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	0.00016	0.00016	0.000001	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00932	0.00932	0.0627%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0168	0.0159	0.0009	Diff <2x LOR	----
Total Metals (QC Lot: 211495)											
VA21B0327-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 207574)											
VA21B0271-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	0.0014	0.0004	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00462	0.00447	3.46%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0334	0.0328	1.94%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.125	0.124	0.778%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	83.8	82.4	1.65%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.658	0.649	1.52%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0036	0.0033	0.0003	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	82.3	82.2	0.0722%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	1.61	1.64	1.74%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00796	0.00818	2.73%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00181	0.00178	0.00004	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	0.114	0.135	0.021	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	8.48	8.41	0.869%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	13.2	12.9	1.72%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	45.3	45.0	0.664%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 207574) - continued											
VA21B0271-001	Anonymous	strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.345	0.347	0.614%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00312	0.00314	0.619%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 211902)											
FJ2100315-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 210232)											
VA21B0355-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	220	239	7.91%	20%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 207686)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 207697)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 207906)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 211359)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 211361)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 212338)						
acidity (as CaCO3)	----	E283	2	mg/L	2.6	----
Anions and Nutrients (QCLot: 211853)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 211856)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 211857)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 212302)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 212318)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 212319)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 212321)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 212322)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 212323)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 212324)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 212327)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 212669)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 212670)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 207818)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----
Total Metals (QCLot: 207278)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 207278) - continued						
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 211495)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 207574)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 207574) - continued						
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 211902)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 210232)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 207686)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	97.6	85.0	115	----
Physical Tests (QCLot: 207697)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	104	85.0	115	----
Physical Tests (QCLot: 207906)									
turbidity	----	E121	0.1	NTU	200 NTU	98.5	85.0	115	----
Physical Tests (QCLot: 211359)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	97.3	90.0	110	----
Physical Tests (QCLot: 211360)									
pH	----	E108	----	pH units	7 pH units	99.2	98.0	102	----
Physical Tests (QCLot: 211361)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.1	85.0	115	----
Physical Tests (QCLot: 212338)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	95.8	85.0	115	----
Anions and Nutrients (QCLot: 211853)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	94.2	85.0	115	----
Anions and Nutrients (QCLot: 211856)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	97.0	80.0	120	----
Anions and Nutrients (QCLot: 211857)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 212302)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	89.5	80.0	120	----
Anions and Nutrients (QCLot: 212318)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 212319)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 212321)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 212322)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 212323)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 212324)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 212324) - continued									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 212327)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	99.1	80.0	120	----
Anions and Nutrients (QCLot: 212669)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 212670)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	102	85.0	115	----
Total Sulfides (QCLot: 207818)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	93.1	80.0	120	----
Total Metals (QCLot: 207278)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	100	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	101	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	100	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	97.0	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	96.7	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.6	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	99.2	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	102	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	97.7	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	95.3	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	99.9	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	109	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	99.9	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	99.4	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	114	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 207278) - continued									
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	95.0	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	97.6	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	99.1	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	98.9	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	102	80.0	120	----
Total Metals (QCLot: 211495)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	89.4	80.0	120	----
Dissolved Metals (QCLot: 207574)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	100	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	101	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	101	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	96.5	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	81.1	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	100	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.0	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	97.7	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	98.6	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	98.3	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	97.6	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	96.5	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.4	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	98.2	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	99.4	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	97.5	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	100	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	98.6	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	98.6	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	96.1	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.0	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 207574) - continued									
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	93.1	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	95.8	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	99.4	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	99.1	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	98.8	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	108	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	96.6	80.0	120	----
Aggregate Organics (QCLot: 210232)									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	102	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 211853)										
VA21B0349-005	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.102 mg/L	0.1 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 211856)										
VA21B0356-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0523 mg/L	0.05 mg/L	105	70.0	130	----
Anions and Nutrients (QCLot: 211857)										
VA21B0357-002	Anonymous	nitrogen, total	7727-37-9	E366	0.400 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 212302)										
VA21B0283-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0476 mg/L	0.05 mg/L	95.2	70.0	130	----
Anions and Nutrients (QCLot: 212318)										
VA21B0357-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	107 mg/L	100 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 212319)										
VA21B0357-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.524 mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 212321)										
VA21B0357-002	Anonymous	chloride	16887-00-6	E235.Cl	107 mg/L	100 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 212322)										
VA21B0395-002	BJ-GW18-17A-E303066	fluoride	16984-48-8	E235.F	1.01 mg/L	1 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 212323)										
VA21B0395-002	BJ-GW18-17A-E303066	bromide	24959-67-9	E235.Br-L	0.475 mg/L	0.5 mg/L	94.9	75.0	125	----
Anions and Nutrients (QCLot: 212324)										
VA21B0395-002	BJ-GW18-17A-E303066	nitrate (as N)	14797-55-8	E235.NO3-L	2.50 mg/L	2.5 mg/L	99.9	75.0	125	----
Anions and Nutrients (QCLot: 212327)										
VA21B0357-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0332 mg/L	0.03 mg/L	111	70.0	130	----
Anions and Nutrients (QCLot: 212670)										
VA21B1014-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Total Sulfides (QCLot: 207818)										
FJ2100306-002	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.959 mg/L	1 mg/L	95.9	75.0	125	----
Total Metals (QCLot: 207278)										
FJ2100306-001	Anonymous	aluminum, total	7429-90-5	E420	0.199 mg/L	0.2 mg/L	99.6	70.0	130	----
		antimony, total	7440-36-0	E420	0.0197 mg/L	0.02 mg/L	98.7	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 207278) - continued										
FJ2100306-001	Anonymous	arsenic, total	7440-38-2	E420	0.0205 mg/L	0.02 mg/L	103	70.0	130	----
		barium, total	7440-39-3	E420	0.0180 mg/L	0.02 mg/L	90.3	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0388 mg/L	0.04 mg/L	96.9	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00871 mg/L	0.01 mg/L	87.1	70.0	130	----
		boron, total	7440-42-8	E420	0.096 mg/L	0.1 mg/L	96.5	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00383 mg/L	0.004 mg/L	95.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0192 mg/L	0.02 mg/L	96.1	70.0	130	----
		copper, total	7440-50-8	E420	0.0188 mg/L	0.02 mg/L	94.1	70.0	130	----
		iron, total	7439-89-6	E420	1.95 mg/L	2 mg/L	97.4	70.0	130	----
		lead, total	7439-92-1	E420	0.0176 mg/L	0.02 mg/L	88.1	70.0	130	----
		lithium, total	7439-93-2	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		nickel, total	7440-02-0	E420	0.0372 mg/L	0.04 mg/L	92.9	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.1 mg/L	10 mg/L	111	70.0	130	----
		potassium, total	7440-09-7	E420	4.10 mg/L	4 mg/L	103	70.0	130	----
		selenium, total	7782-49-2	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		silicon, total	7440-21-3	E420	9.48 mg/L	10 mg/L	94.8	70.0	130	----
		silver, total	7440-22-4	E420	0.00373 mg/L	0.004 mg/L	93.3	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00346 mg/L	0.004 mg/L	86.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0191 mg/L	0.02 mg/L	95.4	70.0	130	----
		titanium, total	7440-32-6	E420	0.0411 mg/L	0.04 mg/L	103	70.0	130	----
		uranium, total	7440-61-1	E420	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, total	7440-62-2	E420	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		zinc, total	7440-66-6	E420	0.382 mg/L	0.4 mg/L	95.6	70.0	130	----
Total Metals (QCLot: 211495)										
VA21B0327-002	Anonymous	mercury, total	7439-97-6	E508	0.0000898 mg/L	0.0001 mg/L	89.8	70.0	130	----
Dissolved Metals (QCLot: 207574)										
VA21B0271-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.202 mg/L	0.2 mg/L	101	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0201 mg/L	0.02 mg/L	101	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 207574) - continued										
VA21B0271-001	Anonymous	barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0397 mg/L	0.04 mg/L	99.3	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00785 mg/L	0.01 mg/L	78.5	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00381 mg/L	0.004 mg/L	95.2	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0397 mg/L	0.04 mg/L	99.2	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0189 mg/L	0.02 mg/L	94.7	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0186 mg/L	0.02 mg/L	93.1	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.88 mg/L	2 mg/L	93.8	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0183 mg/L	0.02 mg/L	91.5	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0998 mg/L	0.1 mg/L	99.8	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0210 mg/L	0.02 mg/L	105	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0374 mg/L	0.04 mg/L	93.4	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.6 mg/L	10 mg/L	106	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0421 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, dissolved	7440-21-3	E421	ND mg/L	10 mg/L	ND	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00298 mg/L	0.004 mg/L	74.5	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00358 mg/L	0.004 mg/L	89.5	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0198 mg/L	0.02 mg/L	98.8	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0426 mg/L	0.04 mg/L	106	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00368 mg/L	0.004 mg/L	91.9	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.398 mg/L	0.4 mg/L	99.4	70.0	130	----
Dissolved Metals (QCLot: 211902)										
KS2101590-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000963 mg/L	0.0001 mg/L	96.3	70.0	130	----
Aggregate Organics (QCLot: 210232)										
VA21B0395-001	BJ-GW18-17A-Snap	chemical oxygen demand [COD]	----	E559	537 mg/L	500 mg/L	107	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information	
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/RS/BM

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17A - snap	23-May-21	8:45	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-17A - E303066	23-May-21	12:45	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21B0395
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Ple... a, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIB...

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	26-May-21	18:00	HA	5/27	4:50P	9 °C				

icepack

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B0116**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 25-May-2021 18:00
PO	: 1025614	Date Analysis Commenced	: 26-May-2021
C-O-C number	: ----	Issue Date	: 03-Jun-2021 13:39
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Sristika Chand	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-18B-snap	BJ-GW18-18B-E314702	----	----	----
				Client sampling date / time	23-May-2021 09:35	23-May-2021 13:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0116-001	VA21B0116-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	114	118	----	----	----
conductivity	----	E100	2.0	µS/cm	679	688	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	221	210	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	243	213	----	----	----
pH	----	E108	0.10	pH units	8.11	8.08	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	430	438	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	31.6	27.0	----	----	----
turbidity	----	E121	0.10	NTU	25.8	54.4	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0878	0.106	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	17.5	17.3	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.084	0.084	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.136	0.137	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	0.0073	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	0.0086	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	0.0013	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.136	0.146	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0128	0.0276	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	201	206	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	2.12	2.28	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00063	0.00076	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00232	0.00333	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0965	0.0873	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-18B-snap	BJ-GW18-18B-E314702	----	----	----
				Client sampling date / time	23-May-2021 09:35	23-May-2021 13:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0116-001	VA21B0116-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.042	0.041	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000094	0.0000122	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	78.4	66.4	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00062	0.0180	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00038	0.00356	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00125	0.00229	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.735	1.26	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000323	0.000574	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.118	0.111	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	11.5	11.4	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0644	0.0500	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000510	0.00271	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	0.0100	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	4.66	4.70	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	0.000074	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	6.12	7.56	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000098	0.000469	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	55.0	57.2	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.81	1.67	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000062	0.000087	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00022	0.00016	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.600 DLM	0.0161	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00150	0.00138	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00344	0.00400	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0044	0.0064	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0044	0.0018	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-18B-snap	BJ-GW18-18B-E314702	----	----	----
				Client sampling date / time	23-May-2021 09:35	23-May-2021 13:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0116-001	VA21B0116-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00048	0.00056	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00078	0.00070	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0203	0.0222	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.039	0.040	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	69.8	65.8	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00038	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00051	0.00035	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	0.016	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.118	0.114	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	11.3	11.1	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0271	0.0245	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000371	0.00156	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00420	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	4.06	3.82	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000059	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.31	3.27	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	56.8	57.0	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.67	1.66	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000030	0.000027	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00112	0.00126	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-18B-snap**	**BJ-GW18-18B-E314702**	**----**	**----**	**----**
				Client sampling date / time	23-May-2021 09:35	23-May-2021 13:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B0116-001**	**VA21B0116-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	0.0024	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B0116**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 25-May-2021 18:00
PO	: 1025614	Issue Date	: 03-Jun-2021 13:39
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-E314702	E559	23-May-2021	----	----	----		31-May-2021	28 days	8 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-snap	E559	23-May-2021	----	----	----		31-May-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-E314702	E298	23-May-2021	01-Jun-2021	----	9 days	✓	01-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-snap	E298	23-May-2021	01-Jun-2021	----	9 days	✓	01-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B-E314702	E235.Br-L	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B-snap	E235.Br-L	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-18B-E314702	E235.Cl	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-18B-snap	E235.Cl	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-18B-E314702	E378-U	23-May-2021	----	----	----		01-Jun-2021	3 days	10 days	✗ EHTL
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-18B-snap	E378-U	23-May-2021	----	----	----		01-Jun-2021	3 days	10 days	✗ EHTL
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-18B-E314702	E235.F	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-18B-snap	E235.F	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B-E314702	E235.NO3-L	23-May-2021	----	----	----		01-Jun-2021	3 days	10 days	✗ EHTL
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B-snap	E235.NO3-L	23-May-2021	----	----	----		01-Jun-2021	3 days	10 days	✗ EHTL
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B-E314702	E235.NO2-L	23-May-2021	----	----	----		01-Jun-2021	3 days	10 days	✗ EHTL
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B-snap	E235.NO2-L	23-May-2021	----	----	----		01-Jun-2021	3 days	10 days	✗ EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-18B-E314702	E235.SO4	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-18B-snap	E235.SO4	23-May-2021	----	----	----		01-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-E314702	E366	23-May-2021	01-Jun-2021	----	9 days	✓	01-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-snap	E366	23-May-2021	01-Jun-2021	----	9 days	✓	01-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-E314702	E372-U	23-May-2021	01-Jun-2021	----	9 days	✓	01-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-18B-snap	E372-U	23-May-2021	01-Jun-2021	----	9 days	✓	01-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-18B-E314702	E509	23-May-2021	27-May-2021	----	5 days	✓	27-May-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-18B-snap	E509	23-May-2021	27-May-2021	----	5 days	✓	27-May-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-18B-E314702	E421	23-May-2021	26-May-2021	----	4 days	✓	27-May-2021	180 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW18-18B-snap	E421	23-May-2021	26-May-2021	----	4 days	✓	27-May-2021	180 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE BJ-GW18-18B-E314702	E283	23-May-2021	----	----	----		02-Jun-2021	14 days	10 days	✓
Physical Tests : Acidity by Titration										
HDPE BJ-GW18-18B-snap	E283	23-May-2021	----	----	----		02-Jun-2021	14 days	10 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE BJ-GW18-18B-E314702	E290	23-May-2021	----	----	----		02-Jun-2021	14 days	10 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE BJ-GW18-18B-snap	E290	23-May-2021	----	----	----		02-Jun-2021	14 days	10 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW18-18B-E314702	E100	23-May-2021	----	----	----		02-Jun-2021	28 days	10 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW18-18B-snap	E100	23-May-2021	----	----	----		02-Jun-2021	28 days	10 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW18-18B-E314702	E108	23-May-2021	----	----	----		02-Jun-2021	0.25 hrs	233 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-18B-snap	E108	23-May-2021	----	----	----		02-Jun-2021	0.25 hrs	236 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-18B-E314702	E162	23-May-2021	----	----	----		28-May-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-18B-snap	E162	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-18B-E314702	E160-H	23-May-2021	----	----	----		28-May-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-18B-snap	E160-H	23-May-2021	----	----	----		28-May-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-18B-E314702	E121	23-May-2021	----	----	----		26-May-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-18B-snap	E121	23-May-2021	----	----	----		26-May-2021	3 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-18B-E314702	E508	23-May-2021	----	----	----		26-May-2021	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-18B-snap	E508	23-May-2021	----	----	----		26-May-2021	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-18B-E314702	E420	23-May-2021	----	----	----		27-May-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-18B-snap	E420	23-May-2021	----	----	----		27-May-2021	180 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-18B-E314702	E395	23-May-2021	----	----	----		27-May-2021	7 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-18B-snap	E395	23-May-2021	----	----	----		27-May-2021	7 days	5 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	210574	1	8	12.5	5.0	✓
Alkalinity Species by Titration	E290	210564	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	209818	1	8	12.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	210569	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	209338	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	210568	1	16	6.2	5.0	✓
Conductivity in Water	E100	210566	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	207143	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	205922	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	210575	1	8	12.5	5.0	✓
Fluoride in Water by IC	E235.F	210567	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	210570	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	210571	1	16	6.2	5.0	✓
pH by Meter	E108	210565	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	210572	1	16	6.2	5.0	✓
TDS by Gravimetry	E162	207650	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	205981	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	205887	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	209814	1	8	12.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	209815	1	8	12.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	207091	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	207638	1	19	5.2	5.0	✓
Turbidity by Nephelometry	E121	205618	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	210574	1	8	12.5	5.0	✓
Alkalinity Species by Titration	E290	210564	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	209818	1	8	12.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	210569	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	209338	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	210568	1	16	6.2	5.0	✓
Conductivity in Water	E100	210566	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	207143	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	205922	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	210575	1	8	12.5	5.0	✓
Fluoride in Water by IC	E235.F	210567	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	210570	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	210571	1	16	6.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	210565	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	210572	1	16	6.2	5.0	✓
TDS by Gravimetry	E162	207650	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	205981	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	205887	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	209814	1	8	12.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	209815	1	8	12.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	207091	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	207638	1	19	5.2	5.0	✓
Turbidity by Nephelometry	E121	205618	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	210574	1	8	12.5	5.0	✓
Alkalinity Species by Titration	E290	210564	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	209818	1	8	12.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	210569	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	209338	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	210568	1	16	6.2	5.0	✓
Conductivity in Water	E100	210566	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	207143	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	205922	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	210575	1	8	12.5	5.0	✓
Fluoride in Water by IC	E235.F	210567	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	210570	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	210571	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	210572	1	16	6.2	5.0	✓
TDS by Gravimetry	E162	207650	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	205981	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	205887	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	209814	1	8	12.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	209815	1	8	12.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	207091	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	207638	1	19	5.2	5.0	✓
Turbidity by Nephelometry	E121	205618	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	209818	1	8	12.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	210569	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	209338	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	210568	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	207143	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	205922	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	210575	1	8	12.5	5.0	✓
Fluoride in Water by IC	E235.F	210567	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	210570	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	210571	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	210572	1	16	6.2	5.0	✓
Total Mercury in Water by CVAAS	E508	205981	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	205887	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	209814	1	8	12.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	209815	1	8	12.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	207091	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B0116**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
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Project	: Brucejack Ground Water	Date Samples Received	: 25-May-2021 18:00
PO	: 1025614	Date Analysis Commenced	: 26-May-2021
C-O-C number	: ----	Issue Date	: 03-Jun-2021 13:39
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Sristika Chand	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 205618)											
FJ2100227-001	Anonymous	turbidity	----	E121	0.10	NTU	3.21	3.38	5.16%	15%	----
Physical Tests (QC Lot: 207638)											
VA21B0060-015	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	3.0	3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 207650)											
VA21B0060-015	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	64	61	3	Diff <2x LOR	----
Physical Tests (QC Lot: 210564)											
KS2101583-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	269	269	0.260%	20%	----
Physical Tests (QC Lot: 210565)											
KS2101583-001	Anonymous	pH	----	E108	0.10	pH units	8.31	8.31	0.0963%	4%	----
Physical Tests (QC Lot: 210566)											
KS2101583-001	Anonymous	conductivity	----	E100	2.0	µS/cm	525	527	0.380%	10%	----
Physical Tests (QC Lot: 210574)											
VA21B0102-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	2.1	2.2	0.1	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209814)											
VA21B0109-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.094	0.091	0.003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209815)											
VA21B0109-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209818)											
VA21B0109-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 210567)											
KS2101583-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.066	0.064	0.001	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 210568)											
KS2101583-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	2.50	2.49	0.01	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 210569)											
KS2101583-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 210570)											
KS2101583-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.172	0.173	0.386%	20%	----
Anions and Nutrients (QC Lot: 210571)											
KS2101583-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0010	<0.0010	0.00004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 210572)											
KS2101583-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	23.4	23.4	0.0147%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 210575)											
VA21B0102-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 207091)											
CG2101572-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 205887)											
VA21B0102-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	19.9	19.6	1.57%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.0471	0.0473	0.570%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0380	0.0370	2.43%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.531	0.526	0.854%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000696	0.000667	4.29%	20%	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	0.000248	0.000240	0.000008	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.032	0.032	0.0007	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.00186	0.00190	2.05%	20%	----
		calcium, total	7440-70-2	E420	0.050	mg/L	94.5	91.0	3.84%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	0.0788	0.0765	3.04%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.0163	0.0160	2.33%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.144	0.141	1.83%	20%	----
		iron, total	7439-89-6	E420	0.010	mg/L	35.6	34.0	4.89%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.0186	0.0186	0.398%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0183	0.0180	1.55%	20%	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	18.2	18.3	0.207%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.967	0.939	2.91%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.0335	0.0331	1.03%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.0542	0.0526	3.00%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	1.08	0.995	8.41%	20%	----
		potassium, total	7440-09-7	E420	0.100	mg/L	3.06	2.89	5.79%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.00870	0.00828	4.90%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	35.4	35.0	1.12%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.00660	0.00681	3.13%	20%	----
		sodium, total	17341-25-2	E420	0.050	mg/L	17.7	16.8	5.03%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.558	0.568	1.78%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000451	0.000435	3.69%	20%	----
		tin, total	7440-31-5	E420	0.00010	mg/L	0.00088	0.00078	0.00010	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.312	0.286	8.74%	20%	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.0464	0.0469	1.00%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.0684	0.0646	5.67%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 205887) - continued											
VA21B0102-001	Anonymous	zinc, total	7440-66-6	E420	0.0030	mg/L	0.341	0.330	3.41%	20%	----
Total Metals (QC Lot: 205981)											
KS2101536-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 205922)											
VA21B0102-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0059	0.0052	0.0007	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00740	0.00736	0.532%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00574	0.00585	1.83%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0654	0.0661	0.992%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.029	0.028	0.001	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	73.8	74.1	0.292%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.651	0.682	4.58%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0062	0.0062	0.00004	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.00	4.11	2.60%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.286	0.296	3.09%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.0156	0.0158	0.731%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	0.890	0.910	0.020	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	9.63	9.70	0.810%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	15.3	15.6	1.92%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.422	0.428	1.38%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00959	0.00937	2.25%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 205922) - continued											
VA21B0102-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0010	<0.0010	0.00001	Diff <2x LOR	----
Dissolved Metals (QC Lot: 207143)											
FJ2100286-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 209338)											
KS2101573-005	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	33	30	3	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 205618)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 207638)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 207650)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 210564)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 210566)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 210574)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Anions and Nutrients (QCLot: 209814)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 209815)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 209818)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 210567)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 210568)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 210569)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 210570)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 210571)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 210572)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 210575)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Total Sulfides (QCLot: 207091)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 205887)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 205981)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 205922)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 205922) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 207143)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 209338)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 205618)									
turbidity	----	E121	0.1	NTU	200 NTU	103	85.0	115	----
Physical Tests (QCLot: 207638)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	101	85.0	115	----
Physical Tests (QCLot: 207650)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	98.4	85.0	115	----
Physical Tests (QCLot: 210564)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	98.8	85.0	115	----
Physical Tests (QCLot: 210565)									
pH	----	E108	----	pH units	7 pH units	99.9	98.0	102	----
Physical Tests (QCLot: 210566)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.0	90.0	110	----
Physical Tests (QCLot: 210574)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	104	85.0	115	----
Anions and Nutrients (QCLot: 209814)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 209815)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	90.0	80.0	120	----
Anions and Nutrients (QCLot: 209818)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 210567)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 210568)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 210569)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	104	85.0	115	----
Anions and Nutrients (QCLot: 210570)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 210571)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 210572)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 210575)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 210575) - continued									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	98.9	80.0	120	----
Total Sulfides (QCLot: 207091)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	103	80.0	120	----
Total Metals (QCLot: 205887)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	98.6	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	97.5	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	90.9	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	98.8	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	90.0	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	95.9	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	94.0	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	95.2	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	96.7	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	93.4	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	107	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	97.0	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	89.2	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	93.2	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	97.1	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	100	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.8	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	90.9	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	95.1	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	95.4	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	97.5	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	96.2	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	88.7	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.9	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	96.9	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	95.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	92.4	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	96.3	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	92.2	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 205981)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	97.0	80.0	120	----
Dissolved Metals (QCLot: 205922)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	102	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	100	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.0	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.7	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	99.7	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	101	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	92.6	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.0	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	99.6	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	96.1	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	101	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	98.9	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	99.2	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	99.0	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	98.0	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	99.0	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	96.2	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	94.9	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	95.1	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	98.1	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	95.7	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	94.7	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	94.6	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	96.7	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	99.9	80.0	120	----
Aggregate Organics (QCLot: 209338)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 209338) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	750 mg/L	102	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 209814)										
VA21B0110-001	Anonymous	nitrogen, total	7727-37-9	E366	0.402 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 209815)										
VA21B0110-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0463 mg/L	0.05 mg/L	92.5	70.0	130	----
Anions and Nutrients (QCLot: 209818)										
VA21B0110-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0991 mg/L	0.1 mg/L	99.1	75.0	125	----
Anions and Nutrients (QCLot: 210567)										
VA21B0102-001	Anonymous	fluoride	16984-48-8	E235.F	ND mg/L	1 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 210568)										
VA21B0102-001	Anonymous	chloride	16887-00-6	E235.Cl	103 mg/L	100 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 210569)										
VA21B0102-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.508 mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 210570)										
VA21B0102-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.58 mg/L	2.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 210571)										
VA21B0102-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.491 mg/L	0.5 mg/L	98.2	75.0	125	----
Anions and Nutrients (QCLot: 210572)										
VA21B0102-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	102 mg/L	100 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 210575)										
VA21B0102-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0311 mg/L	0.03 mg/L	104	70.0	130	----
Total Sulfides (QCLot: 207091)										
CG2101576-011	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.207 mg/L	0.2 mg/L	104	75.0	125	----
Total Metals (QCLot: 205887)										
VA21B0102-001	Anonymous	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0380 mg/L	0.04 mg/L	95.1	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00980 mg/L	0.01 mg/L	98.0	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 205887) - continued										
VA21B0102-001	Anonymous	boron, total	7440-42-8	E420	0.099 mg/L	0.1 mg/L	99.5	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00418 mg/L	0.004 mg/L	104	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0190 mg/L	0.02 mg/L	95.0	70.0	130	----
		copper, total	7440-50-8	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		iron, total	7439-89-6	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		lithium, total	7439-93-2	E420	0.0915 mg/L	0.1 mg/L	91.5	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		nickel, total	7440-02-0	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.96 mg/L	10 mg/L	99.6	70.0	130	----
		potassium, total	7440-09-7	E420	4.57 mg/L	4 mg/L	114	70.0	130	----
		selenium, total	7782-49-2	E420	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		silicon, total	7440-21-3	E420	ND mg/L	10 mg/L	ND	70.0	130	----
		silver, total	7440-22-4	E420	ND mg/L	0.004 mg/L	ND	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00389 mg/L	0.004 mg/L	97.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		titanium, total	7440-32-6	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		uranium, total	7440-61-1	E420	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0999 mg/L	0.1 mg/L	99.9	70.0	130	----
		zinc, total	7440-66-6	E420	0.383 mg/L	0.4 mg/L	95.7	70.0	130	----
Total Metals (QCLot: 205981)										
KS2101544-001	Anonymous	mercury, total	7439-97-6	E508	0.0000919 mg/L	0.0001 mg/L	91.9	70.0	130	----
Dissolved Metals (QCLot: 205922)										
VA21B0102-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.205 mg/L	0.2 mg/L	102	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0198 mg/L	0.02 mg/L	99.0	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0205 mg/L	0.02 mg/L	102	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0399 mg/L	0.04 mg/L	99.7	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00917 mg/L	0.01 mg/L	91.7	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.093 mg/L	0.1 mg/L	92.7	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 205922) - continued										
VA21B0102-001	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00391 mg/L	0.004 mg/L	97.8	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0406 mg/L	0.04 mg/L	102	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0198 mg/L	0.02 mg/L	99.0	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.95 mg/L	2 mg/L	97.7	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0189 mg/L	0.02 mg/L	94.6	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0953 mg/L	0.1 mg/L	95.3	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.3 mg/L	10 mg/L	113	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.15 mg/L	4 mg/L	104	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0424 mg/L	0.04 mg/L	106	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.48 mg/L	10 mg/L	94.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00371 mg/L	0.004 mg/L	92.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0384 mg/L	0.04 mg/L	96.0	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.397 mg/L	0.4 mg/L	99.2	70.0	130	----
Dissolved Metals (QCLot: 207143)										
VA21A9733-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.000963 mg/L	0.001 mg/L	96.3	70.0	130	----
Aggregate Organics (QCLot: 209338)										
KS2101573-006	Anonymous	chemical oxygen demand [COD]	----	E559	529 mg/L	500 mg/L	106	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-18B - snap	23-May-21	9:35	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-18B - E314702	23-May-21	13:00	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21B0116

Telephone : - 1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	24-May-21	18:00	PD	May 25	18:00	8 °C				

Ice packs Pa (Avg. of 8)

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B0558**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-May-2021 16:10
PO	: 1025614	Date Analysis Commenced	: 31-May-2021
C-O-C number	: ----	Issue Date	: 08-Jun-2021 17:24
Sampler	: NG/BM		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW12-8B - Snap	BJ-GW12-8B - E314695	BJ-GW12-8B - 98	----	----
				Client sampling date / time	27-May-2021 09:50	27-May-2021 11:45	27-May-2021 11:50	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0558-001	VA21B0558-002	VA21B0558-003	--------	--------
					Result	Result	Result	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	70.9	69.6	69.7	----	----
conductivity	----	E100	2.0	µS/cm	219	219	219	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	106	106	104	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	117	101	104	----	----
pH	----	E108	0.10	pH units	7.98	7.99	7.98	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	143	121	128	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	26.2	9.6	14.4	----	----
turbidity	----	E121	0.10	NTU	1.56	3.74	3.59	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	<0.0050	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.021	0.024	0.022	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0242	0.0253	0.0244	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0242	0.0253	0.0244	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	<0.0010	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.068	<0.030	<0.030	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	<0.0010	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.141	0.0079	0.0168	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	39.5	39.9	39.9	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0025	<0.0015	<0.0015	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.0026	<0.0016	<0.0016	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.704	0.173	0.189	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00125	0.00088	0.00086	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0415	0.0172	0.0178	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.101	0.0320	0.0314	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-8B - Snap	BJ-GW12-8B - E314695	BJ-GW12-8B - 98	----	----
				Client sampling date / time	27-May-2021 09:50	27-May-2021 11:45	27-May-2021 11:50	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0558-001	VA21B0558-002	VA21B0558-003	--------	--------
					Result	Result	Result	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	<0.010	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000314	0.0000089	0.0000084	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	38.2	33.1	34.1	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00284	0.00913	0.0124	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00241	0.00236	0.00239	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00914	0.00208	0.00210	----	----
iron, total	7439-89-6	E420	0.010	mg/L	1.85	0.325	0.345	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00214	0.000367	0.000392	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0076	0.0066	0.0067	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	5.16	4.56	4.52	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.228	0.0794	0.0816	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000080	<0.0000050	<0.0000050	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00123	0.00224	0.00251	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00121	0.00496	0.00700	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.687	0.531	0.528	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000369	0.000290	0.000320	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	2.85	2.10	2.19	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000171	0.000388	0.000406	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	2.46	2.42	2.45	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.554	0.571	0.541	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000026	0.000010	<0.000010	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00011	<0.00010	<0.00010	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000330	0.000193	0.000186	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00141	<0.00050	<0.00050	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0086	<0.0030	0.0031	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0012	0.0013	0.0011	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-8B - Snap	BJ-GW12-8B - E314695	BJ-GW12-8B - 98	----	----
				Client sampling date / time	27-May-2021 09:50	27-May-2021 11:45	27-May-2021 11:50	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0558-001	VA21B0558-002	VA21B0558-003	--------	--------
					Result	Result	Result	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00080	0.00084	0.00083	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0136	0.0136	0.0127	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0200	0.0212	0.0214	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	<0.010	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	34.8	34.6	34.1	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	0.00170	0.00154	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00022	0.00020	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00069	0.00068	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	0.015	<0.010	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0061	0.0062	0.0062	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.53	4.64	4.58	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	0.00502	0.00497	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00116	0.00222	0.00209	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00264	0.00262	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.500	0.488	0.470	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000262	0.000342	0.000304	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.06	2.06	1.98	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	2.45	2.48	2.43	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.594	0.608	0.605	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000166	0.000168	0.000162	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW12-8B - Snap**	**BJ-GW12-8B - E314695**	**BJ-GW12-8B - 98**	**----**	**----**
				Client sampling date / time	27-May-2021 09:50	27-May-2021 11:45	27-May-2021 11:50	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B0558-001**	**VA21B0558-002**	**VA21B0558-003**	**--------**	**--------**
					Result	Result	Result	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	0.0016	0.0014	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B0558**	Page	: 1 of 16
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-May-2021 16:10
PO	: 1025614	Issue Date	: 08-Jun-2021 17:24
C-O-C number	: ----		
Sampler	: NG/BM		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - 98	E559	27-May-2021	----	----	----		02-Jun-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - E314695	E559	27-May-2021	----	----	----		02-Jun-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - Snap	E559	27-May-2021	----	----	----		02-Jun-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - 98	E298	27-May-2021	04-Jun-2021	----	9 days	✓	04-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - E314695	E298	27-May-2021	04-Jun-2021	----	9 days	✓	04-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - Snap	E298	27-May-2021	04-Jun-2021	----	9 days	✓	04-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - 98	E235.Br-L	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - E314695	E235.Br-L	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - Snap	E235.Br-L	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B - 98	E235.Cl	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B - E314695	E235.Cl	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B - Snap	E235.Cl	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8B - 98	E378-U	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8B - E314695	E378-U	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8B - Snap	E378-U	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8B - 98	E235.F	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8B - E314695	E235.F	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8B - Snap	E235.F	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - 98	E235.NO3-L	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - E314695	E235.NO3-L	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - Snap	E235.NO3-L	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - 98	E235.NO2-L	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - E314695	E235.NO2-L	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B - Snap	E235.NO2-L	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B - 98	E235.SO4	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B - E314695	E235.SO4	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B - Snap	E235.SO4	27-May-2021	----	----	----		31-May-2021	28 days	5 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - 98	E366	27-May-2021	04-Jun-2021	----	9 days	✓	07-Jun-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - E314695	E366	27-May-2021	04-Jun-2021	----	9 days	✓	07-Jun-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - Snap	E366	27-May-2021	04-Jun-2021	----	9 days	✓	07-Jun-2021	28 days	3 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - 98	E372-U	27-May-2021	04-Jun-2021	----	9 days	✓	05-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - E314695	E372-U	27-May-2021	04-Jun-2021	----	9 days	✓	05-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B - Snap	E372-U	27-May-2021	04-Jun-2021	----	9 days	✓	05-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B - 98	E509	27-May-2021	03-Jun-2021	----	7 days	✓	03-Jun-2021	28 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B - E314695	E509	27-May-2021	03-Jun-2021	----	7 days	✓	03-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B - Snap	E509	27-May-2021	03-Jun-2021	----	7 days	✓	03-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B - 98	E421	27-May-2021	31-May-2021	----	5 days	✓	04-Jun-2021	180 days	4 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B - E314695	E421	27-May-2021	31-May-2021	----	5 days	✓	04-Jun-2021	180 days	4 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B - Snap	E421	27-May-2021	31-May-2021	----	5 days	✓	04-Jun-2021	180 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B - 98	E283	27-May-2021	----	----	----		31-May-2021	14 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B - E314695	E283	27-May-2021	----	----	----		31-May-2021	14 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B - Snap	E283	27-May-2021	----	----	----		31-May-2021	14 days	5 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8B - 98	E290	27-May-2021	----	----	----		03-Jun-2021	14 days	7 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE BJ-GW12-8B - E314695	E290	27-May-2021	----	----	----		03-Jun-2021	14 days	7 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE BJ-GW12-8B - Snap	E290	27-May-2021	----	----	----		03-Jun-2021	14 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8B - 98	E100	27-May-2021	----	----	----		03-Jun-2021	28 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8B - E314695	E100	27-May-2021	----	----	----		03-Jun-2021	28 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8B - Snap	E100	27-May-2021	----	----	----		03-Jun-2021	28 days	7 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW12-8B - 98	E108	27-May-2021	----	----	----		03-Jun-2021	0.25 hrs	162 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW12-8B - E314695	E108	27-May-2021	----	----	----		03-Jun-2021	0.25 hrs	162 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW12-8B - Snap	E108	27-May-2021	----	----	----		03-Jun-2021	0.25 hrs	164 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW12-8B - 98	E162	27-May-2021	----	----	----		03-Jun-2021	7 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B - E314695	E162	27-May-2021	----	----	----		03-Jun-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B - Snap	E162	27-May-2021	----	----	----		03-Jun-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B - 98	E160-H	27-May-2021	----	----	----		03-Jun-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B - E314695	E160-H	27-May-2021	----	----	----		03-Jun-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B - Snap	E160-H	27-May-2021	----	----	----		03-Jun-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B - 98	E121	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B - E314695	E121	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B - Snap	E121	27-May-2021	----	----	----		31-May-2021	3 days	5 days	× EHT
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B - 98	E508	27-May-2021	----	----	----		02-Jun-2021	28 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B - E314695	E508	27-May-2021	----	----	----		02-Jun-2021	28 days	7 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B - Snap	E508	27-May-2021	----	----	----		02-Jun-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B - 98	E420	27-May-2021	----	----	----		03-Jun-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B - E314695	E420	27-May-2021	----	----	----		03-Jun-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B - Snap	E420	27-May-2021	----	----	----		03-Jun-2021	180 days	8 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B - 98	E395	27-May-2021	----	----	----		01-Jun-2021	7 days	6 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B - E314695	E395	27-May-2021	----	----	----		01-Jun-2021	7 days	6 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B - Snap	E395	27-May-2021	----	----	----		01-Jun-2021	7 days	6 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	209161	1	7	14.2	5.0	✓
Alkalinity Species by Titration	E290	209160	1	19	5.2	5.0	✓
Ammonia by Fluorescence	E298	212979	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209168	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	211481	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	209167	1	19	5.2	5.0	✓
Conductivity in Water	E100	209158	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	212134	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	209597	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209170	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	209166	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209164	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209165	1	20	5.0	5.0	✓
pH by Meter	E108	209159	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	209163	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	211826	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211590	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209859	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	212977	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	212978	1	11	9.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	210500	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	211824	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	209416	1	5	20.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	209161	1	7	14.2	5.0	✓
Alkalinity Species by Titration	E290	209160	1	19	5.2	5.0	✓
Ammonia by Fluorescence	E298	212979	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209168	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	211481	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	209167	1	19	5.2	5.0	✓
Conductivity in Water	E100	209158	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	212134	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	209597	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209170	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	209166	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209164	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209165	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	209159	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	209163	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	211826	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211590	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209859	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	212977	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	212978	1	11	9.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	210500	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	211824	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	209416	1	5	20.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	209161	1	7	14.2	5.0	✓
Alkalinity Species by Titration	E290	209160	1	19	5.2	5.0	✓
Ammonia by Fluorescence	E298	212979	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209168	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	211481	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	209167	1	19	5.2	5.0	✓
Conductivity in Water	E100	209158	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	212134	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	209597	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209170	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	209166	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209164	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209165	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	209163	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	211826	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	211590	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209859	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	212977	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	212978	1	11	9.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	210500	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	211824	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	209416	1	5	20.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	212979	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209168	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	211481	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	209167	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	212134	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	209597	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209170	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	209166	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209164	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209165	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	209163	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	211590	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209859	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	212977	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	212978	1	11	9.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	210500	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B0558**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-May-2021 16:10
PO	: 1025614	Date Analysis Commenced	: 31-May-2021
C-O-C number	: ----	Issue Date	: 08-Jun-2021 17:24
Sampler	: NG/BM		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 209158)											
FJ2100328-001	Anonymous	conductivity	----	E100	2.0	µS/cm	215	216	0.464%	10%	----
Physical Tests (QC Lot: 209159)											
FJ2100328-001	Anonymous	pH	----	E108	0.10	pH units	8.15	8.15	0.0245%	4%	----
Physical Tests (QC Lot: 209160)											
FJ2100328-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	112	110	1.98%	20%	----
Physical Tests (QC Lot: 209161)											
KS2101617-001	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	2.2	2.0	0.2	Diff <2x LOR	----
Physical Tests (QC Lot: 209416)											
VA21B0514-001	Anonymous	turbidity	----	E121	0.10	NTU	0.26	0.27	0.006	Diff <2x LOR	----
Physical Tests (QC Lot: 211824)											
VA21B0566-004	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	163	157	3.88%	20%	----
Physical Tests (QC Lot: 211826)											
VA21B0566-004	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	56	57	2	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209163)											
FJ2100328-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	3.03	2.98	1.58%	20%	----
Anions and Nutrients (QC Lot: 209164)											
FJ2100328-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0817	0.0810	0.897%	20%	----
Anions and Nutrients (QC Lot: 209165)											
FJ2100328-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209166)											
FJ2100328-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.076	0.075	0.0004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209167)											
FJ2100328-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209168)											
FJ2100328-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209170)											
FJ2100328-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0016	0.0015	0.00009	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212977)											
FJ2100337-011	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 212978)											
VA21B0558-001	BJ-GW12-8B - Snap	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.141	0.141	0.0004	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 212979)											
FJ2100337-011	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 210500)											
CG2101670-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 209859)											
VA21B0550-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0269	0.0274	0.0005	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00120	0.00124	4.02%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00014	0.00016	0.00001	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.00951	0.00927	2.49%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000308	0.0000296	0.0000011	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	4.75	4.78	0.590%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.029	0.028	0.0006	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000156	0.000161	0.000005	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	0.988	1.00	1.48%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00368	0.00355	3.40%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000191	0.000190	0.0000005	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.095	0.097	0.002	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000107	0.000097	0.000010	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.10	1.10	0.0671%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	0.595	0.606	1.77%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0486	0.0498	2.29%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00051	0.00039	0.00012	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 209859) - continued											
VA21B0550-001	Anonymous	zinc, total	7440-66-6	E420	0.0030	mg/L	0.0045	0.0042	0.0002	Diff <2x LOR	----
Total Metals (QC Lot: 211590)											
KS2101617-010	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 211591)											
VA21B0558-002	BJ-GW12-8B - E314695	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 209597)											
CG2101645-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0089	0.0086	0.0003	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00018	0.00020	0.00002	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0603	0.0610	1.20%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.020	mg/L	<0.020 µg/L	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0050	mg/L	0.0275 µg/L	0.0000188	0.0000087	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	40.6	39.1	3.83%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.10	mg/L	0.12 µg/L	0.00012	0.000003	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00030	0.00050	0.00020	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0050	0.0049	0.00010	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	13.2	13.4	1.86%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00201	0.00201	0.265%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000704	0.000667	5.37%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00161	0.00156	0.00005	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.569	0.553	2.72%	20%	----
		selenium, dissolved	7782-49-2	E421	0.050	mg/L	3.11 µg/L	0.00331	6.15%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.96	2.00	1.92%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	2.49	2.48	0.301%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.112	0.106	5.07%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 209597) - continued											
CG2101645-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000566	0.000564	0.325%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 212134)											
CG2101665-007	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 211481)											
KS2101626-001	Anonymous	chemical oxygen demand [COD]	----	E559	80	mg/L	615	509	106	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 209158)						
conductivity	----	E100	1	µS/cm	1.2	----
Physical Tests (QCLot: 209160)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 209161)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 209416)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 211824)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 211826)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 209163)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 209164)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 209165)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 209166)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 209167)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 209168)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 209170)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 212977)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 212978)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 212979)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 210500)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 209859)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 211590)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 211591)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 209597)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 212134)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 211481)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 209158)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	98.9	90.0	110	----
Physical Tests (QCLot: 209159)									
pH	----	E108	----	pH units	7 pH units	99.3	98.0	102	----
Physical Tests (QCLot: 209160)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.8	85.0	115	----
Physical Tests (QCLot: 209161)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	102	85.0	115	----
Physical Tests (QCLot: 209416)									
turbidity	----	E121	0.1	NTU	200 NTU	98.0	85.0	115	----
Physical Tests (QCLot: 211824)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	96.0	85.0	115	----
Physical Tests (QCLot: 211826)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 209163)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 209164)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 209165)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	99.4	90.0	110	----
Anions and Nutrients (QCLot: 209166)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 209167)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 209168)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 209170)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 212977)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 212978)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	92.8	80.0	120	----
Anions and Nutrients (QCLot: 212979)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 212979) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	99.3	85.0	115	----
Total Sulfides (QCLot: 210500)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	106	80.0	120	----
Total Metals (QCLot: 209859)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	101	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	97.6	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	92.4	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	97.0	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	96.0	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	98.3	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	97.0	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	97.8	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.6	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	95.8	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	96.9	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	101	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	98.2	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	102	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	99.0	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	95.0	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	99.6	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	96.5	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	95.6	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	98.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	99.9	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	107	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	97.9	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	98.2	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 211590)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	93.2	80.0	120	----
Total Metals (QCLot: 211591)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	92.8	80.0	120	----
Dissolved Metals (QCLot: 209597)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	102	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	98.7	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.0	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.4	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	95.9	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	95.7	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.5	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	95.0	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	97.7	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	96.1	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	95.3	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	100	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	92.2	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.5	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	97.0	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	99.2	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	104	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	97.8	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	95.8	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	102	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	94.8	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.3	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	98.5	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	98.2	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	99.5	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	97.4	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	98.9	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 212134) - continued									
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	95.1	80.0	120	----
Aggregate Organics (QCLot: 211481)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	95.2	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 209163)										
FJ2100328-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 209164)										
FJ2100328-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.59 mg/L	2.5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 209165)										
FJ2100328-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.500 mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 209166)										
FJ2100328-002	Anonymous	fluoride	16984-48-8	E235.F	1.02 mg/L	1 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 209167)										
FJ2100328-002	Anonymous	chloride	16887-00-6	E235.Cl	103 mg/L	100 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 209168)										
FJ2100328-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.502 mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 209170)										
FJ2100328-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0301 mg/L	0.03 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 212977)										
VA21B0558-001	BJ-GW12-8B - Snap	nitrogen, total	7727-37-9	E366	0.404 mg/L	0.4 mg/L	101	70.0	130	----
Anions and Nutrients (QCLot: 212978)										
VA21B0558-002	BJ-GW12-8B - E314695	phosphorus, total	7723-14-0	E372-U	0.0527 mg/L	0.05 mg/L	105	70.0	130	----
Anions and Nutrients (QCLot: 212979)										
VA21B0558-001	BJ-GW12-8B - Snap	ammonia, total (as N)	7664-41-7	E298	0.0993 mg/L	0.1 mg/L	99.3	75.0	125	----
Total Sulfides (QCLot: 210500)										
CG2101688-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.226 mg/L	0.2 mg/L	113	75.0	125	----
Total Metals (QCLot: 209859)										
VA21B0550-001	Anonymous	aluminum, total	7429-90-5	E420	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		antimony, total	7440-36-0	E420	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0188 mg/L	0.02 mg/L	94.3	70.0	130	----
		barium, total	7440-39-3	E420	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0407 mg/L	0.04 mg/L	102	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0109 mg/L	0.01 mg/L	109	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 209859) - continued										
VA21B0550-001	Anonymous	boron, total	7440-42-8	E420	0.097 mg/L	0.1 mg/L	97.0	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00407 mg/L	0.004 mg/L	102	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0391 mg/L	0.04 mg/L	97.8	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		copper, total	7440-50-8	E420	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		iron, total	7439-89-6	E420	1.97 mg/L	2 mg/L	98.4	70.0	130	----
		lead, total	7439-92-1	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		lithium, total	7439-93-2	E420	0.111 mg/L	0.1 mg/L	111	70.0	130	----
		magnesium, total	7439-95-4	E420	0.934 mg/L	1 mg/L	93.4	70.0	130	----
		manganese, total	7439-96-5	E420	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0199 mg/L	0.02 mg/L	99.4	70.0	130	----
		nickel, total	7440-02-0	E420	0.0394 mg/L	0.04 mg/L	98.5	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.98 mg/L	10 mg/L	99.8	70.0	130	----
		potassium, total	7440-09-7	E420	3.90 mg/L	4 mg/L	97.5	70.0	130	----
		selenium, total	7782-49-2	E420	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, total	7440-21-3	E420	9.42 mg/L	10 mg/L	94.2	70.0	130	----
		silver, total	7440-22-4	E420	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		sodium, total	17341-25-2	E420	1.90 mg/L	2 mg/L	95.1	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00400 mg/L	0.004 mg/L	100.0	70.0	130	----
		tin, total	7440-31-5	E420	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		titanium, total	7440-32-6	E420	0.0397 mg/L	0.04 mg/L	99.3	70.0	130	----
		uranium, total	7440-61-1	E420	0.00436 mg/L	0.004 mg/L	109	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0981 mg/L	0.1 mg/L	98.1	70.0	130	----
		zinc, total	7440-66-6	E420	0.395 mg/L	0.4 mg/L	98.8	70.0	130	----
Total Metals (QCLot: 211590)										
KS2101617-011	Anonymous	mercury, total	7439-97-6	E508	0.0000926 mg/L	0.0001 mg/L	92.6	70.0	130	----
Total Metals (QCLot: 211591)										
VA21B0558-003	BJ-GW12-8B - 98	mercury, total	7439-97-6	E508	0.0000926 mg/L	0.0001 mg/L	92.6	70.0	130	----
Dissolved Metals (QCLot: 209597)										
CG2101645-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.195 mg/L	0.2 mg/L	97.7	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0203 mg/L	0.02 mg/L	102	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0395 mg/L	0.04 mg/L	98.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 209597) - continued										
CG2101645-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00797 mg/L	0.01 mg/L	79.7	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.096 mg/L	0.1 mg/L	96.4	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00398 mg/L	0.004 mg/L	99.6	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0384 mg/L	0.04 mg/L	96.1	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0189 mg/L	0.02 mg/L	94.7	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0186 mg/L	0.02 mg/L	93.0	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.92 mg/L	2 mg/L	96.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0194 mg/L	0.02 mg/L	97.3	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0964 mg/L	0.1 mg/L	96.4	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0188 mg/L	0.02 mg/L	94.2	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0203 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0377 mg/L	0.04 mg/L	94.2	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.6 mg/L	10 mg/L	106	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.82 mg/L	4 mg/L	95.6	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0414 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.70 mg/L	10 mg/L	97.0	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00411 mg/L	0.004 mg/L	103	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00386 mg/L	0.004 mg/L	96.6	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0377 mg/L	0.04 mg/L	94.3	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00386 mg/L	0.004 mg/L	96.6	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0990 mg/L	0.1 mg/L	99.0	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.421 mg/L	0.4 mg/L	105	70.0	130	----
Dissolved Metals (QCLot: 212134)										
CG2101665-008	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000936 mg/L	0.0001 mg/L	93.6	70.0	130	----
Aggregate Organics (QCLot: 211481)										
KS2101626-002	Anonymous	chemical oxygen demand [COD]	----	E559	ND mg/L	100 mg/L	ND	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information	
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	

Lab Work Order # (lab use only):

ALS Contact: Dean Watt

Sampler: NG/BM

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients (P)	EPH	Total Metals (P)	Dissolved Metals (F/P)			Total Mercury (P)	Dissolved Mercury (F/P)	Acidity	Total Sulphides (P)		Number of Containers
	BJ-GW12-8B - snap	27-May-21	9:50	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8B - E314695	27-May-21	11:45	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8B - 98	27-May-21	11:50	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21B0558

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	27-May-21	18:00	CC	MAY 2 9 2021	410	7 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B0672**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 31-May-2021 17:00
PO	: 1025614	Date Analysis Commenced	: 01-Jun-2021
C-O-C number	: ----	Issue Date	: 08-Jun-2021 17:13
Sampler	: BM, NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
				Client sampling date / time	29-May-2021 11:33	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0672-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	24.9	----	----	----	----
conductivity	----	E100	2.0	µS/cm	165	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	70.2	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	74.3	----	----	----	----
pH	----	E108	0.10	pH units	7.54	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	87	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	17.7	----	----	----	----
turbidity	----	E121	0.10	NTU	3.07	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.026	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.142	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.216	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.216	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.358	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0208	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	49.2	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.126	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00114	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00860	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0398	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
					Client sampling date / time	29-May-2021 11:33	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21B0672-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.0000089	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L		24.3	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L		0.00258	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		<0.00010	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.00176	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L		0.147	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L		0.000287	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L		0.0029	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		3.30	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.00577	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.00158	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L		<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L		0.806	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L		0.000349	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L		1.72	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L		0.000106	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L		2.51	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L		0.353	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L		<0.000010	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L		0.00030	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L		<0.0100	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000137	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		<0.00050	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0051	----	----	----	----
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0216	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00104	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00701	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0348	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)									
				Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
				Client sampling date / time	29-May-2021 11:33	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0672-001	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	22.5	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	0.00071	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00056	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0028	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	3.40	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00087	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00146	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.838	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000330	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.55	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	2.60	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.355	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	0.00029	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000128	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0019	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
				Client sampling date / time	29-May-2021 11:33	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B0672-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	----	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	----	----	----	----
Total Metals									
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000064	----	----	----	----
Dissolved Metals									
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B0672**	Page	: 1 of 12
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 31-May-2021 17:00
PO	: 1025614	Issue Date	: 08-Jun-2021 17:13
C-O-C number	: ----		
Sampler	: BM, NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Physical Tests	QC-209985-001	----	acidity (as CaCO3)	----	E283	3.3 mg/L [B]	3 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW12-11A-E303062	E559	29-May-2021	----	----	----		08-Jun-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) BJ-GW12-11A-E303062	E298	29-May-2021	07-Jun-2021	----	10 days	✓	07-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE BJ-GW12-11A-E303062	E235.Br-L	29-May-2021	----	----	----		01-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE BJ-GW12-11A-E303062	E235.Cl	29-May-2021	----	----	----		01-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW12-11A-E303062	E378-U	29-May-2021	----	----	----		01-Jun-2021	3 days	4 days	× EHTL
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW12-11A-E303062	E235.F	29-May-2021	----	----	----		01-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE BJ-GW12-11A-E303062	E235.NO3-L	29-May-2021	----	----	----		01-Jun-2021	3 days	4 days	× EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.NO2-L	29-May-2021	----	----	----		01-Jun-2021	3 days	4 days	× EHTL
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.SO4	29-May-2021	----	----	----		01-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E366	29-May-2021	07-Jun-2021	----	10 days	✓	08-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E372-U	29-May-2021	07-Jun-2021	----	10 days	✓	07-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-11A-E303062	E509	29-May-2021	04-Jun-2021	----	7 days	✓	04-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-11A-E303062	E421	29-May-2021	01-Jun-2021	----	4 days	✓	04-Jun-2021	180 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-11A-E303062	E283	29-May-2021	----	----	----		02-Jun-2021	14 days	5 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-11A-E303062	E290	29-May-2021	----	----	----		04-Jun-2021	14 days	6 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-11A-E303062	E100	29-May-2021	----	----	----		04-Jun-2021	28 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-11A-E303062	E108	29-May-2021	----	----	----		04-Jun-2021	0.25 hrs	138 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-11A-E303062	E162	29-May-2021	----	----	----		04-Jun-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-11A-E303062	E160-H	29-May-2021	----	----	----		04-Jun-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-11A-E303062	E121	29-May-2021	----	----	----		01-Jun-2021	3 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-11A-E303062	E508	29-May-2021	----	----	----		04-Jun-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-11A-E303062	E420	29-May-2021	----	----	----		01-Jun-2021	180 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-11A-E303062	E395-H	29-May-2021	----	----	----		01-Jun-2021	7 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	209985	0	1	0.0	5.0	✗
Alkalinity Species by Titration	E290	209976	1	9	11.1	5.0	✓
Ammonia by Fluorescence	E298	214832	1	16	6.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209980	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	215732	1	17	5.8	5.0	✓
Chloride in Water by IC	E235.Cl	209979	1	9	11.1	5.0	✓
Conductivity in Water	E100	209977	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	213622	1	6	16.6	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	210064	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209984	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	209978	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209981	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209982	1	9	11.1	5.0	✓
pH by Meter	E108	209975	1	9	11.1	5.0	✓
Sulfate in Water by IC	E235.SO4	209983	1	9	11.1	5.0	✓
TDS by Gravimetry	E162	212847	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	213523	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209866	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	214830	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	214831	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	210653	1	4	25.0	5.0	✓
TSS by Gravimetry	E160-H	212849	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	210241	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	209985	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	209976	1	9	11.1	5.0	✓
Ammonia by Fluorescence	E298	214832	1	16	6.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209980	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	215732	1	17	5.8	5.0	✓
Chloride in Water by IC	E235.Cl	209979	1	9	11.1	5.0	✓
Conductivity in Water	E100	209977	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	213622	1	6	16.6	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	210064	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209984	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	209978	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209981	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209982	1	9	11.1	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	209975	1	9	11.1	5.0	✓
Sulfate in Water by IC	E235.SO4	209983	1	9	11.1	5.0	✓
TDS by Gravimetry	E162	212847	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	213523	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209866	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	214830	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	214831	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	210653	1	4	25.0	5.0	✓
TSS by Gravimetry	E160-H	212849	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	210241	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	209985	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	209976	1	9	11.1	5.0	✓
Ammonia by Fluorescence	E298	214832	1	16	6.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209980	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	215732	1	17	5.8	5.0	✓
Chloride in Water by IC	E235.Cl	209979	1	9	11.1	5.0	✓
Conductivity in Water	E100	209977	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	213622	1	6	16.6	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	210064	1	18	5.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209984	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	209978	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209981	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209982	1	9	11.1	5.0	✓
Sulfate in Water by IC	E235.SO4	209983	1	9	11.1	5.0	✓
TDS by Gravimetry	E162	212847	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	213523	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209866	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	214830	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	214831	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	210653	1	4	25.0	5.0	✓
TSS by Gravimetry	E160-H	212849	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	210241	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	214832	1	16	6.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	209980	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	215732	1	17	5.8	5.0	✓
Chloride in Water by IC	E235.Cl	209979	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	213622	1	6	16.6	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	210064	1	18	5.5	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	209984	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	209978	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	209981	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	209982	1	9	11.1	5.0	✓
Sulfate in Water by IC	E235.SO4	209983	1	9	11.1	5.0	✓
Total Mercury in Water by CVAAS	E508	213523	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	209866	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	214830	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	214831	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	210653	1	4	25.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B0672**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 31-May-2021 17:00
PO	: 1025614	Date Analysis Commenced	: 01-Jun-2021
C-O-C number	: ----	Issue Date	: 08-Jun-2021 17:13
Sampler	: BM, NG, RS		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 209975)											
VA21B0664-003	Anonymous	pH	----	E108	0.10	pH units	8.56	8.56	0.00%	4%	----
Physical Tests (QC Lot: 209976)											
VA21B0664-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	271	267	1.48%	20%	----
Physical Tests (QC Lot: 209977)											
VA21B0664-003	Anonymous	conductivity	----	E100	2.0	µS/cm	1230	1230	0.163%	10%	----
Physical Tests (QC Lot: 210241)											
VA21B0566-001	Anonymous	turbidity	----	E121	0.10	NTU	0.41	0.43	0.02	Diff <2x LOR	----
Physical Tests (QC Lot: 212847)											
VA21B0664-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	1750	1730	1.44%	20%	----
Physical Tests (QC Lot: 212849)											
VA21B0664-004	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209978)											
VA21B0664-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.388	0.370	0.018	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209979)											
VA21B0664-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	<2.50	<2.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209980)											
VA21B0664-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209981)											
VA21B0664-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	1.10	1.10	0.208%	20%	----
Anions and Nutrients (QC Lot: 209982)											
VA21B0664-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 209983)											
VA21B0664-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	430	430	0.132%	20%	----
Anions and Nutrients (QC Lot: 209984)											
VA21B0664-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0018	0.0020	0.0002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 214830)											
VA21B0671-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 214831)											
FJ2100331-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0153	0.0134	0.0019	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 214832)											
FJ2100331-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0060	0.0066	0.0006	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Sulfides (QC Lot: 210653)											
VA21B0622-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.100	mg/L	0.367	0.357	0.010	Diff <2x LOR	----
Total Metals (QC Lot: 209866)											
FJ2100328-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0703	0.0818	15.0%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00014	0.00013	0.000005	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0792	0.0809	2.13%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.011	0.011	0.0002	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000414	0.0000464	0.0000050	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	33.6	34.2	1.85%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00056	0.00056	0.0000008	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.087	0.088	0.001	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000053	0.000056	0.000003	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0046	0.0046	0.00007	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	7.31	7.51	2.74%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00087	0.00088	0.000006	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000200	0.000202	0.000002	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00121	0.00123	0.00002	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.493	0.496	0.003	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000371	0.000348	0.000023	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.88	1.91	1.38%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	2.14	2.14	0.346%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0742	0.0728	1.88%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00087	0.00090	0.00003	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000118	0.000132	10.5%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 213523)											

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 213523) - continued											
VA21B0660-006	Anonymous	mercury, total	7439-97-6	E508	0.0000250	mg/L	<0.0000250	<0.0000250	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 210064)											
VA21B0626-032	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0151	0.0152	0.812%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00043	0.00042	0.000006	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00410	0.00390	5.07%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0138	0.0126	9.23%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.429	0.448	4.19%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000100	mg/L	<0.0000100	<0.0000100	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	75.1	76.2	1.41%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00018	0.00017	0.00002	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00154	0.00142	0.00012	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.024	0.024	0.0005	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000109	0.000109	0.0000004	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0028	0.0029	0.00007	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	47.2	44.8	5.20%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0170	0.0161	5.44%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00971	0.00949	2.35%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00164	0.00161	0.00003	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	47.7	45.6	4.52%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000193	0.000194	0.000001	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.01	1.03	1.78%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	365	345	5.62%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.86	1.80	2.98%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000010	0.000011	0.0000010	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	0.00035	0.00032	0.00003	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00110	0.00109	0.625%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00107	0.00098	0.00009	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0013	0.0012	0.00004	Diff <2x LOR	----
Dissolved Metals (QC Lot: 213622)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 213622) - continued											
VA21B0664-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 215732)											
KS2101649-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	658	653	0.705%	20%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 209976)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 209977)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 209985)						
acidity (as CaCO3)	----	E283	2	mg/L	# 3.3	B
Physical Tests (QCLot: 210241)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 212847)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 212849)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 209978)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 209979)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 209980)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 209981)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 209982)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 209983)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 209984)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 214830)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 214831)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 214832)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 210653)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 209866)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 213523)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 210064)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 210064) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 213622)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 215732)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 209975)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 209976)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.9	85.0	115	----
Physical Tests (QCLot: 209977)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	97.3	90.0	110	----
Physical Tests (QCLot: 209985)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	109	85.0	115	----
Physical Tests (QCLot: 210241)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 212847)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	102	85.0	115	----
Physical Tests (QCLot: 212849)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 209978)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 209979)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 209980)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	97.6	85.0	115	----
Anions and Nutrients (QCLot: 209981)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 209982)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 209983)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 209984)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	103	80.0	120	----
Anions and Nutrients (QCLot: 214830)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	99.1	75.0	125	----
Anions and Nutrients (QCLot: 214831)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	100	80.0	120	----
Anions and Nutrients (QCLot: 214832)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 214832) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	95.0	85.0	115	----
Total Sulfides (QCLot: 210653)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	98.6	80.0	120	----
Total Metals (QCLot: 209866)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	106	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	107	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	107	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	105	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	105	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	107	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	104	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	99.1	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	104	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	99.9	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	107	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	118	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	108	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	97.8	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	99.7	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	104	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	103	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	103	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	104	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	110	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Total Metals (QCLot: 213523)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	82.6	80.0	120	----
Dissolved Metals (QCLot: 210064)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	104	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.5	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	89.9	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	87.2	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	100	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	91.4	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	100	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	99.5	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	101	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	100	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	88.0	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	104	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	100	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	98.0	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	97.8	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	96.2	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	99.2	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	97.6	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	97.8	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	97.0	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	101	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	99.7	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	96.2	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	93.3	80.0	120	----
Aggregate Organics (QCLot: 215732)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 215732) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	96.1	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 209978)										
VA21B0664-002	Anonymous	fluoride	16984-48-8	E235.F	4.98 mg/L	5 mg/L	99.7	75.0	125	----
Anions and Nutrients (QCLot: 209979)										
VA21B0664-002	Anonymous	chloride	16887-00-6	E235.Cl	500 mg/L	500 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 209980)										
VA21B0664-002	Anonymous	bromide	24959-67-9	E235.Br-L	2.50 mg/L	2.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 209981)										
VA21B0664-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	12.6 mg/L	12.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 209982)										
VA21B0664-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.44 mg/L	2.5 mg/L	97.7	75.0	125	----
Anions and Nutrients (QCLot: 209983)										
VA21B0664-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	534 mg/L	500 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 209984)										
VA21B0664-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0314 mg/L	0.03 mg/L	105	70.0	130	----
Anions and Nutrients (QCLot: 214830)										
VA21B0671-002	Anonymous	nitrogen, total	7727-37-9	E366	0.405 mg/L	0.4 mg/L	101	70.0	130	----
Anions and Nutrients (QCLot: 214831)										
FJ2100331-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0511 mg/L	0.05 mg/L	102	70.0	130	----
Anions and Nutrients (QCLot: 214832)										
FJ2100331-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0991 mg/L	0.1 mg/L	99.1	75.0	125	----
Total Sulfides (QCLot: 210653)										
VA21B0672-001	BJ-GW12-11A-E303062	sulfide, total (as S)	18496-25-8	E395-H	0.250 mg/L	0.2 mg/L	125	75.0	125	----
Total Metals (QCLot: 209866)										
FJ2100328-001	Anonymous	aluminum, total	7429-90-5	E420	0.197 mg/L	0.2 mg/L	98.5	70.0	130	----
		antimony, total	7440-36-0	E420	0.0212 mg/L	0.02 mg/L	106	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0193 mg/L	0.02 mg/L	96.6	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0407 mg/L	0.04 mg/L	102	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00977 mg/L	0.01 mg/L	97.7	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 209866) - continued										
FJ2100328-001	Anonymous	boron, total	7440-42-8	E420	0.100 mg/L	0.1 mg/L	99.9	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00418 mg/L	0.004 mg/L	104	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0411 mg/L	0.04 mg/L	103	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0195 mg/L	0.02 mg/L	97.3	70.0	130	----
		copper, total	7440-50-8	E420	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		iron, total	7439-89-6	E420	1.92 mg/L	2 mg/L	96.2	70.0	130	----
		lead, total	7439-92-1	E420	0.0199 mg/L	0.02 mg/L	99.6	70.0	130	----
		lithium, total	7439-93-2	E420	0.0930 mg/L	0.1 mg/L	93.0	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0191 mg/L	0.02 mg/L	95.5	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0214 mg/L	0.02 mg/L	107	70.0	130	----
		nickel, total	7440-02-0	E420	0.0388 mg/L	0.04 mg/L	97.0	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.4 mg/L	10 mg/L	104	70.0	130	----
		potassium, total	7440-09-7	E420	3.87 mg/L	4 mg/L	96.8	70.0	130	----
		selenium, total	7782-49-2	E420	0.0422 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, total	7440-21-3	E420	9.05 mg/L	10 mg/L	90.5	70.0	130	----
		silver, total	7440-22-4	E420	0.00425 mg/L	0.004 mg/L	106	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00382 mg/L	0.004 mg/L	95.6	70.0	130	----
		tin, total	7440-31-5	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		titanium, total	7440-32-6	E420	0.0400 mg/L	0.04 mg/L	100	70.0	130	----
		uranium, total	7440-61-1	E420	0.00397 mg/L	0.004 mg/L	99.2	70.0	130	----
		vanadium, total	7440-62-2	E420	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		zinc, total	7440-66-6	E420	0.412 mg/L	0.4 mg/L	103	70.0	130	----
Total Metals (QCLot: 213523)										
VA21B0661-001	Anonymous	mercury, total	7439-97-6	E508	0.0000866 mg/L	0.0001 mg/L	86.6	70.0	130	----
Dissolved Metals (QCLot: 210064)										
VA21B0626-032	Anonymous	aluminum, dissolved	7429-90-5	E421	0.185 mg/L	0.2 mg/L	92.5	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0182 mg/L	0.02 mg/L	91.2	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0182 mg/L	0.02 mg/L	90.9	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0163 mg/L	0.02 mg/L	81.7	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0373 mg/L	0.04 mg/L	93.3	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00779 mg/L	0.01 mg/L	77.9	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 210064) - continued										
VA21B0626-032	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00341 mg/L	0.004 mg/L	85.2	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0358 mg/L	0.04 mg/L	89.5	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0174 mg/L	0.02 mg/L	86.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0164 mg/L	0.02 mg/L	81.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.76 mg/L	2 mg/L	88.1	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0164 mg/L	0.02 mg/L	82.0	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0918 mg/L	0.1 mg/L	91.8	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0160 mg/L	0.02 mg/L	80.1	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0189 mg/L	0.02 mg/L	94.6	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0334 mg/L	0.04 mg/L	83.4	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.29 mg/L	10 mg/L	92.9	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0398 mg/L	0.04 mg/L	99.6	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.74 mg/L	10 mg/L	97.4	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00304 mg/L	0.004 mg/L	76.0	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00331 mg/L	0.004 mg/L	82.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0181 mg/L	0.02 mg/L	90.7	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0354 mg/L	0.04 mg/L	88.5	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00333 mg/L	0.004 mg/L	83.3	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0935 mg/L	0.1 mg/L	93.5	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.338 mg/L	0.4 mg/L	84.4	70.0	130	----
Dissolved Metals (QCLot: 213622)										
VA21B0672-001	BJ-GW12-11A-E303062	mercury, dissolved	7439-97-6	E509	0.0000895 mg/L	0.0001 mg/L	89.5	70.0	130	----
Aggregate Organics (QCLot: 215732)										
KS2101649-002	Anonymous	chemical oxygen demand [COD]	----	E559	ND mg/L	100 mg/L	ND	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/RS/BM	

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW12-11A - E303062	29-May-21	11:33	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B0672
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	30-May-21	18:00	[illegible]	5/31	5pm	8 °C				

icepacks

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B2508**	Page	: 1 of 6
Amendment	: **1**		
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 21-Jun-2021 16:20
PO	: 1025614	Date Analysis Commenced	: 22-Jun-2021
C-O-C number	: ----	Issue Date	: 07-Jul-2021 11:30
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Workorder Comments

Turbidity results have been adjusted for QC blank correction.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-3A-snap	BJ-GW11-3A-E303056	BJ-GW11-3B-E314693	----	----
				Client sampling date / time	20-Jun-2021 14:00	20-Jun-2021 15:50	20-Jun-2021 16:40	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2508-001	VA21B2508-002	VA21B2508-003	--------	--------
					Result	Result	Result	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	95.9	97.6	95.0	----	----
conductivity	----	E100	2.0	µS/cm	362	363	353	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	158	155	157	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	165	156	160	----	----
pH	----	E108	0.10	pH units	8.07	8.04	8.02	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	204	234	217	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.1	9.4	<3.0	----	----
turbidity	----	E121	0.10	NTU	2.25	3.39	<0.10	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0301	0.0296	0.0260	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	1.22	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.173	0.178	0.179	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	<0.0050	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0051	<0.0051	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0017	0.0024	<0.0010	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.039	<0.030	<0.030	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0017	0.0013	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0098	0.0054	0.0023	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	86.2	86.2	81.9	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0078	0.0034	<0.0015	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.0083	0.0036	<0.0016	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.139	0.0732	<0.0030	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00434	0.00318	0.00105	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00777	0.00566	0.00253	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0203	0.0202	0.0186	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-3A-snap	BJ-GW11-3A-E303056	BJ-GW11-3B-E314693	----	----
				Client sampling date / time	20-Jun-2021 14:00	20-Jun-2021 15:50	20-Jun-2021 16:40	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2508-001	VA21B2508-002	VA21B2508-003	--------	--------
					Result	Result	Result	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.043	0.040	0.033	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000190	0.0000439	0.0000249	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	58.6	55.2	58.2	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	0.00271	<0.00050	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	0.00044	<0.00010	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00068	0.00188	<0.00050	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.298	0.162	<0.010	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00306	0.00137	<0.000050	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0180	0.0165	0.0125	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	4.45	4.52	3.56	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.145	0.149	0.115	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000745	0.00120	0.000682	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00218	0.00203	<0.00050	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.42	1.40	1.13	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.92	3.69	3.33	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000015	0.000042	<0.000010	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	7.13	7.10	6.41	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.09	1.07	1.06	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000018	0.000011	0.000020	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000163	0.000134	0.000161	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0204	0.0123	<0.0030	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0015	0.0015	<0.0010	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-3A-snap	BJ-GW11-3A-E303056	BJ-GW11-3B-E314693	----	----
				Client sampling date / time	20-Jun-2021 14:00	20-Jun-2021 15:50	20-Jun-2021 16:40	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2508-001	VA21B2508-002	VA21B2508-003	--------	--------
					Result	Result	Result	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00211	0.00198	0.00111	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00449	0.00423	0.00276	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0183	0.0192	0.0203	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.040	0.040	0.031	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000059	0.0000084	0.0000259	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	55.8	55.0	57.0	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00015	<0.00010	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00111	0.00020	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.040	0.041	<0.010	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0178	0.0173	0.0123	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.43	4.29	3.63	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.160	0.158	0.125	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000762	0.00108	0.000713	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00083	<0.00050	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.49	1.43	1.20	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.31	3.38	3.19	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	7.61	7.48	6.62	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.12	1.10	1.12	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0.000020	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000127	0.000125	0.000168	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW11-3A-snap**	**BJ-GW11-3A-E303056**	**BJ-GW11-3B-E314693**	**----**	**----**
				Client sampling date / time	20-Jun-2021 14:00	20-Jun-2021 15:50	20-Jun-2021 16:40	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B2508-001**	**VA21B2508-002**	**VA21B2508-003**	**--------**	**--------**
					Result	Result	Result	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0028	0.0065	<0.0010	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B2508**	Page	: 1 of 16
Amendment	: 1		
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 21-Jun-2021 16:20
PO	: 1025614	Issue Date	: 07-Jul-2021 11:30
C-O-C number	: ----		
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E559	20-Jun-2021	----	----	----		25-Jun-2021	28 days	5 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-snap	E559	20-Jun-2021	----	----	----		25-Jun-2021	28 days	5 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3B-E314693	E559	20-Jun-2021	----	----	----		25-Jun-2021	28 days	5 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E298	20-Jun-2021	26-Jun-2021	----	----		26-Jun-2021	28 days	6 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-snap	E298	20-Jun-2021	26-Jun-2021	----	----		26-Jun-2021	28 days	6 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3B-E314693	E298	20-Jun-2021	26-Jun-2021	----	----		26-Jun-2021	28 days	6 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-E303056	E235.Br-L	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-snap	E235.Br-L	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3B-E314693	E235.Br-L	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A-E303056	E235.Cl	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A-snap	E235.Cl	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3B-E314693	E235.Cl	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A-E303056	E378-U	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A-snap	E378-U	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3B-E314693	E378-U	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A-E303056	E235.F	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A-snap	E235.F	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3B-E314693	E235.F	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-E303056	E235.NO3-L	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-snap	E235.NO3-L	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3B-E314693	E235.NO3-L	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-E303056	E235.NO2-L	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-snap	E235.NO2-L	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3B-E314693	E235.NO2-L	20-Jun-2021	----	----	----		22-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A-E303056	E235.SO4	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A-snap	E235.SO4	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3B-E314693	E235.SO4	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E366	20-Jun-2021	25-Jun-2021	----	----		28-Jun-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-snap	E366	20-Jun-2021	25-Jun-2021	----	----		28-Jun-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3B-E314693	E366	20-Jun-2021	25-Jun-2021	----	----		28-Jun-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E372-U	20-Jun-2021	25-Jun-2021	----	----		26-Jun-2021	28 days	6 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-snap	E372-U	20-Jun-2021	25-Jun-2021	----	----		26-Jun-2021	28 days	6 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3B-E314693	E372-U	20-Jun-2021	25-Jun-2021	----	----		26-Jun-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A-E303056	E509	20-Jun-2021	24-Jun-2021	----	----		24-Jun-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A-snap	E509	20-Jun-2021	24-Jun-2021	----	----		24-Jun-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3B-E314693	E509	20-Jun-2021	24-Jun-2021	----	----		24-Jun-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A-E303056	E421	20-Jun-2021	22-Jun-2021	----	----		22-Jun-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A-snap	E421	20-Jun-2021	22-Jun-2021	----	----		22-Jun-2021	180 days	2 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3B-E314693	E421	20-Jun-2021	22-Jun-2021	----	----		22-Jun-2021	180 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3A-E303056	E283	20-Jun-2021	----	----	----		23-Jun-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3A-snap	E283	20-Jun-2021	----	----	----		23-Jun-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3B-E314693	E283	20-Jun-2021	----	----	----		23-Jun-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A-E303056	E290	20-Jun-2021	----	----	----		22-Jun-2021	14 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A-snap	E290	20-Jun-2021	----	----	----		22-Jun-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3B-E314693	E290	20-Jun-2021	----	----	----		22-Jun-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A-E303056	E100	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A-snap	E100	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3B-E314693	E100	20-Jun-2021	----	----	----		22-Jun-2021	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-3A-E303056	E108	20-Jun-2021	----	----	----		22-Jun-2021	0.25 hrs	51 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-3B-E314693	E108	20-Jun-2021	----	----	----		22-Jun-2021	0.25 hrs	51 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-3A-snap	E108	20-Jun-2021	----	----	----		22-Jun-2021	0.25 hrs	53 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-3A-E303056	E162	20-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-3A-snap	E162	20-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-3B-E314693	E162	20-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-3A-E303056	E160-H	20-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-3A-snap	E160-H	20-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-3B-E314693	E160-H	20-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-3A-E303056	E121	20-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-3A-snap	E121	20-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-3B-E314693	E121	20-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3A-E303056	E508	20-Jun-2021	----	----	----		24-Jun-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3A-snap	E508	20-Jun-2021	----	----	----		24-Jun-2021	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3B-E314693	E508	20-Jun-2021	----	----	----		24-Jun-2021	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A-E303056	E420	20-Jun-2021	----	----	----		24-Jun-2021	180 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A-snap	E420	20-Jun-2021	----	----	----		24-Jun-2021	180 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3B-E314693	E420	20-Jun-2021	----	----	----		24-Jun-2021	180 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A-E303056	E395	20-Jun-2021	----	----	----		22-Jun-2021	7 days	2 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A-snap	E395	20-Jun-2021	----	----	----		22-Jun-2021	7 days	2 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3B-E314693	E395	20-Jun-2021	----	----	----		22-Jun-2021	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	227168	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	227160	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	230534	1	10	10.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227164	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	229892	1	6	16.6	5.0	✓
Chloride in Water by IC	E235.Cl	227163	1	10	10.0	5.0	✓
Conductivity in Water	E100	227161	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	228949	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	227086	2	20	10.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227169	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	227162	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227165	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227166	1	10	10.0	5.0	✓
pH by Meter	E108	227159	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227167	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	230149	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229068	1	12	8.3	5.0	✓
Total Metals in Water by CRC ICPMS	E420	227871	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	230532	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	230533	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	227494	1	19	5.2	5.0	✓
TSS by Gravimetry	E160-H	230143	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	227731	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	227168	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	227160	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	230534	1	10	10.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227164	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	229892	1	6	16.6	5.0	✓
Chloride in Water by IC	E235.Cl	227163	1	10	10.0	5.0	✓
Conductivity in Water	E100	227161	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	228949	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	227086	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227169	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	227162	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227165	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227166	1	10	10.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	227159	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227167	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	230149	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229068	1	12	8.3	5.0	✓
Total Metals in Water by CRC ICPMS	E420	227871	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	230532	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	230533	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	227494	1	19	5.2	5.0	✓
TSS by Gravimetry	E160-H	230143	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	227731	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	227168	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	227160	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	230534	1	10	10.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227164	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	229892	1	6	16.6	5.0	✓
Chloride in Water by IC	E235.Cl	227163	1	10	10.0	5.0	✓
Conductivity in Water	E100	227161	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	228949	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	227086	2	20	10.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227169	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	227162	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227165	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227166	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227167	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	230149	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229068	1	12	8.3	5.0	✓
Total Metals in Water by CRC ICPMS	E420	227871	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	230532	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	230533	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	227494	1	19	5.2	5.0	✓
TSS by Gravimetry	E160-H	230143	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	227731	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	230534	1	10	10.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227164	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	229892	1	6	16.6	5.0	✓
Chloride in Water by IC	E235.Cl	227163	1	10	10.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	228949	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	227086	2	20	10.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227169	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	227162	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227165	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227166	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227167	1	10	10.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229068	1	12	8.3	5.0	✓
Total Metals in Water by CRC ICPMS	E420	227871	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	230532	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	230533	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	227494	1	19	5.2	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B2508**	Page	: 1 of 17
Amendment	: **1**		

Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 21-Jun-2021 16:20
PO	: 1025614	Date Analysis Commenced	: 22-Jun-2021
C-O-C number	: ----	Issue Date	: 07-Jul-2021 11:30
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 227159)											
VA21B2319-006	Anonymous	pH	----	E108	0.10	pH units	7.21	7.21	0.0694%	4%	----
Physical Tests (QC Lot: 227160)											
VA21B2319-006	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	15.5	15.4	0.647%	20%	----
Physical Tests (QC Lot: 227161)											
VA21B2319-006	Anonymous	conductivity	----	E100	2.0	µS/cm	55.0	54.9	0.182%	10%	----
Physical Tests (QC Lot: 227168)											
VA21B2319-007	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	2.0	<2.0	0.02	Diff <2x LOR	----
Physical Tests (QC Lot: 227731)											
FJ2100448-004	Anonymous	turbidity	----	E121	0.10	NTU	1.68	1.87	10.7%	15%	----
Physical Tests (QC Lot: 230143)											
FJ2100449-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	4.2	4.2	0	Diff <2x LOR	----
Physical Tests (QC Lot: 230149)											
FJ2100449-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	2140	2190	2.45%	20%	----
Anions and Nutrients (QC Lot: 227162)											
KS2101953-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.025	0.024	0.0007	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227163)											
KS2101953-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227164)											
KS2101953-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227165)											
KS2101953-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0339	0.0328	0.0010	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227166)											
KS2101953-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227167)											
KS2101953-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	6.24	6.24	0.0565%	20%	----
Anions and Nutrients (QC Lot: 227169)											
FJ2100449-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 230532)											
FJ2100440-002	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.320	0.320	0.00676%	20%	----
Anions and Nutrients (QC Lot: 230533)											
FJ2100440-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0189	0.0196	0.0008	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 230534)											
FJ2100440-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 227494)											
CG2102092-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 227871)											
VA21B2474-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0244	0.0256	0.0011	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00029	0.00030	0.000006	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.00471	0.00484	2.74%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000082	0.0000100	0.0000017	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	28.1	26.8	4.51%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00114	0.00111	0.00003	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.028	0.026	0.001	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	3.51	3.52	0.317%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00236	0.00233	1.17%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000469	0.000470	0.000002	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00083	<0.00050	0.00033	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.178	0.190	0.012	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000126	0.000181	0.000054	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	4.19	4.12	1.50%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	1.26	1.27	0.846%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.137	0.140	2.58%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00060	mg/L	<0.00060	<0.00060	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000043	0.000046	0.000003	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 227871) - continued											
VA21B2474-001	Anonymous	zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 229068)											
VA21B2474-014	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 227086)											
YL2100545-005	Anonymous	cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00199	0.00193	3.00%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000143	0.000146	0.000004	Diff <2x LOR	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.119	0.119	0.300%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	0.000152	0.000140	8.20%	20%	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0104	0.0101	2.48%	20%	----
YL2100545-005	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.194	0.198	2.43%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00017	0.00016	0.000004	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00671	0.00675	0.567%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.018	0.022	0.003	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000201	0.0000194	0.0000007	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	3.89	4.00	2.97%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	0.00068	0.00069	0.00001	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00178	0.00176	0.00001	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.183	0.184	0.487%	20%	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0028	0.0029	0.00009	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	1.96	2.00	1.99%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00199	0.00202	1.38%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00256	0.00260	0.00004	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.68	1.72	2.07%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.86	1.94	4.07%	20%	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	1.44	1.43	0.449%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.0202	0.0200	1.36%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	0.00223	0.00219	0.00004	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000328	0.000335	2.34%	20%	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 227086) - continued											
YL2100545-005	Anonymous	vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 228949)											
VA21B2455-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0050	mg/L	<0.0050 µg/L	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 229892)											
VA21B2447-001	Anonymous	chemical oxygen demand [COD]	----	E559	400	mg/L	29400	31000	5.58%	20%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 227160)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 227161)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 227168)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 227731)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 230143)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 230149)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 227162)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 227163)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 227164)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 227165)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 227166)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 227167)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 227169)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 230532)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 230533)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 230534)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 227494)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 227871)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 229068)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 227086)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	MBRR

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 227086) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 228949)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 229892)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
MBRR	Initial MB for this submission had positive results for flagged analyte (data not shown). Low level samples were repeated with new QC (2nd MB results shown). High level results (>5x initial MB level) and non-detect results were reported and are defensible

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 227159)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 227160)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	103	85.0	115	----
Physical Tests (QCLot: 227161)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	100	90.0	110	----
Physical Tests (QCLot: 227168)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	103	85.0	115	----
Physical Tests (QCLot: 227731)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 230143)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	103	85.0	115	----
Physical Tests (QCLot: 230149)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	100	85.0	115	----
Anions and Nutrients (QCLot: 227162)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	98.1	90.0	110	----
Anions and Nutrients (QCLot: 227163)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 227164)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 227165)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 227166)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	97.2	90.0	110	----
Anions and Nutrients (QCLot: 227167)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 227169)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	86.1	80.0	120	----
Anions and Nutrients (QCLot: 230532)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 230533)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.3	80.0	120	----
Anions and Nutrients (QCLot: 230534)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 230534) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	101	85.0	115	----
Total Sulfides (QCLot: 227494)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	99.8	80.0	120	----
Total Metals (QCLot: 227871)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	97.2	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	107	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	97.7	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	98.2	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	95.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	97.4	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	101	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	96.4	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	97.1	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	97.0	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	95.4	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	93.5	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	93.6	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	104	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	92.2	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	99.3	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	94.7	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	98.9	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	100	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	111	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	99.5	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	93.4	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	100	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 229068)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	102	80.0	120	----
Dissolved Metals (QCLot: 227086)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	102	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.2	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	100	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	102	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.3	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	96.5	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	108	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	99.2	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	111	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	95.9	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	94.5	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	104	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	105	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	99.5	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	99.9	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	97.1	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	100	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	96.6	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	99.9	80.0	120	----
Aggregate Organics (QCLot: 229892)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 229892) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	98.8	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 227162)										
KS2101953-002	Anonymous	fluoride	16984-48-8	E235.F	0.979 mg/L	1 mg/L	97.9	75.0	125	----
Anions and Nutrients (QCLot: 227163)										
KS2101953-002	Anonymous	chloride	16887-00-6	E235.Cl	101 mg/L	100 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 227164)										
KS2101953-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.524 mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 227165)										
KS2101953-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.52 mg/L	2.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 227166)										
KS2101953-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.482 mg/L	0.5 mg/L	96.4	75.0	125	----
Anions and Nutrients (QCLot: 227167)										
KS2101953-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	102 mg/L	100 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 227169)										
VA21B1925-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0329 mg/L	0.03 mg/L	110	70.0	130	----
Anions and Nutrients (QCLot: 230532)										
FJ2100441-001	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 230533)										
FJ2100442-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0539 mg/L	0.05 mg/L	108	70.0	130	----
Anions and Nutrients (QCLot: 230534)										
FJ2100442-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.104 mg/L	0.1 mg/L	104	75.0	125	----
Total Sulfides (QCLot: 227494)										
EO2101356-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.202 mg/L	0.2 mg/L	101	75.0	125	----
Total Metals (QCLot: 227871)										
VA21B2474-001	Anonymous	aluminum, total	7429-90-5	E420	0.183 mg/L	0.2 mg/L	91.3	70.0	130	----
		antimony, total	7440-36-0	E420	0.0191 mg/L	0.02 mg/L	95.6	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0188 mg/L	0.02 mg/L	93.8	70.0	130	----
		barium, total	7440-39-3	E420	0.0193 mg/L	0.02 mg/L	96.3	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0390 mg/L	0.04 mg/L	97.5	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00892 mg/L	0.01 mg/L	89.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 227871) - continued										
VA21B2474-001	Anonymous	boron, total	7440-42-8	E420	0.098 mg/L	0.1 mg/L	98.6	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00378 mg/L	0.004 mg/L	94.6	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0376 mg/L	0.04 mg/L	94.0	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0187 mg/L	0.02 mg/L	93.6	70.0	130	----
		copper, total	7440-50-8	E420	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		iron, total	7439-89-6	E420	1.88 mg/L	2 mg/L	94.2	70.0	130	----
		lead, total	7439-92-1	E420	0.0180 mg/L	0.02 mg/L	89.8	70.0	130	----
		lithium, total	7439-93-2	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0177 mg/L	0.02 mg/L	88.6	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0184 mg/L	0.02 mg/L	92.1	70.0	130	----
		nickel, total	7440-02-0	E420	0.0382 mg/L	0.04 mg/L	95.5	70.0	130	----
		phosphorus, total	7723-14-0	E420	8.95 mg/L	10 mg/L	89.5	70.0	130	----
		potassium, total	7440-09-7	E420	3.92 mg/L	4 mg/L	98.0	70.0	130	----
		selenium, total	7782-49-2	E420	0.0396 mg/L	0.04 mg/L	98.9	70.0	130	----
		silicon, total	7440-21-3	E420	8.79 mg/L	10 mg/L	87.9	70.0	130	----
		silver, total	7440-22-4	E420	0.00386 mg/L	0.004 mg/L	96.6	70.0	130	----
		sodium, total	17341-25-2	E420	2.08 mg/L	2 mg/L	104	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00342 mg/L	0.004 mg/L	85.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0184 mg/L	0.02 mg/L	91.9	70.0	130	----
		titanium, total	7440-32-6	E420	0.0350 mg/L	0.04 mg/L	87.5	70.0	130	----
		uranium, total	7440-61-1	E420	0.00368 mg/L	0.004 mg/L	92.0	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0975 mg/L	0.1 mg/L	97.5	70.0	130	----
		zinc, total	7440-66-6	E420	0.374 mg/L	0.4 mg/L	93.6	70.0	130	----
Total Metals (QCLot: 229068)										
VA21B2474-015	Anonymous	mercury, total	7439-97-6	E508	0.000101 mg/L	0.0001 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 227086)										
YL2100545-005	Anonymous	cobalt, dissolved	7440-48-4	E421	0.0207 mg/L	0.02 mg/L	103	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00404 mg/L	0.004 mg/L	101	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.412 mg/L	0.4 mg/L	103	70.0	130	----
YL2100545-005	Anonymous	aluminum, dissolved	7429-90-5	E421	0.199 mg/L	0.2 mg/L	99.5	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0210 mg/L	0.02 mg/L	105	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 227086) - continued										
YL2100545-005	Anonymous	arsenic, dissolved	7440-38-2	E421	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00929 mg/L	0.01 mg/L	92.9	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00400 mg/L	0.004 mg/L	100	70.0	130	----
		calcium, dissolved	7440-70-2	E421	4.03 mg/L	4 mg/L	101	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0397 mg/L	0.04 mg/L	99.2	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.92 mg/L	2 mg/L	95.8	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0395 mg/L	0.04 mg/L	98.7	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.0 mg/L	10 mg/L	100	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.07 mg/L	4 mg/L	102	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0422 mg/L	0.04 mg/L	106	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.31 mg/L	10 mg/L	93.1	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.90 mg/L	2 mg/L	95.0	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00405 mg/L	0.004 mg/L	101	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0390 mg/L	0.04 mg/L	97.5	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00407 mg/L	0.004 mg/L	102	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 228949)										
VA21B2455-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000993 mg/L	0.0001 mg/L	99.3	70.0	130	----
Aggregate Organics (QCLot: 229892)										
VA21B2447-002	Anonymous	chemical oxygen demand [COD]	----	E559	ND mg/L	400 mg/L	ND	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/CM	

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients (P)	EPH	Total Metals (P)	Dissolved Metals (F/P)			Total Mercury (P)	Dissolved Mercury (F/P)	Acidity	Total Sulphides (P)		Number of Containers
	BJ-GW11-3A - snap	20-Jun-21	14:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-3A - E303056	20-Jun-21	15:50	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-3B - E314693	20-Jun-21	16:40	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B2508
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	20-Jun-21	18:00	LAA	6/21	4:20pm	8 °C				

ice pack

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/CM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-3A - snap	20-Jun-21	14:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-3A - E303056	20-Jun-21	15:50	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-3B - E314693	20-Jun-21	16:40	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B2508

Telephone : + 1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
J Glas	20-Jun-21	18:00	LDA	6/21	4:20pm	8 °C				

ice pack

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B2626**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 22-Jun-2021 16:30
PO	: 1025614	Date Analysis Commenced	: 23-Jun-2021
C-O-C number	: ----	Issue Date	: 30-Jun-2021 18:33
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Sristika Chand	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-8A-snap	BJ-GW11-8A-E303059	----	----	----
				Client sampling date / time	21-Jun-2021 09:35	21-Jun-2021 11:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2626-001	VA21B2626-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	76.2	73.0	----	----	----
conductivity	----	E100	2.0	µS/cm	222	222	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	103	98.6	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	103	98.2	----	----	----
pH	----	E108	0.10	pH units	8.10	8.13	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	130	123	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	104	16.8	----	----	----
turbidity	----	E121	0.10	NTU	22.1	12.4	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.023	0.023	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0296	0.0258	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0296	0.0258	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.036	<0.030	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0059	0.0103	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	34.7	34.8	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0026	<0.0015	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.0028	<0.0016	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.748	0.306	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00164	0.00110	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0500	0.0155	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0684	0.0313	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-8A-snap	BJ-GW11-8A-E303059	----	----	----
				Client sampling date / time	21-Jun-2021 09:35	21-Jun-2021 11:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2626-001	VA21B2626-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000169	0.0000386	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	31.0	29.9	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00185	0.00942	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00161	0.00128	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00828	0.00266	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	2.65	0.588	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00467	0.000964	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0094	0.0087	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	6.23	5.71	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.184	0.0474	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000085	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00125	0.00250	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00065	0.00470	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.799	0.619	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000234	0.000188	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.14	2.54	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000454	0.000312	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	3.45	3.29	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.761	0.744	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000029	0.000012	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00067	0.00017	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000284	0.000207	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00099	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0244	0.0075	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0017	0.0079	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-8A-snap	BJ-GW11-8A-E303059	----	----	----
				Client sampling date / time	21-Jun-2021 09:35	21-Jun-2021 11:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2626-001	VA21B2626-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00084	0.00085	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00862	0.00836	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0216	0.0243	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000093	0.0000127	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	30.8	29.2	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	0.00065	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00025	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00083	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	0.015	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0086	0.0084	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	6.32	6.24	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	0.00618	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00121	0.00200	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00194	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.494	0.473	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000208	0.000188	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.05	2.09	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	0.000011	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	3.62	3.65	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.757	0.729	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000181	0.000173	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW11-8A-snap**	**BJ-GW11-8A-E303059**	**----**	**----**	**----**
				Client sampling date / time	21-Jun-2021 09:35	21-Jun-2021 11:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B2626-001**	**VA21B2626-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0018	0.0035	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B2626**	Page	: 1 of 15
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 22-Jun-2021 16:30
PO	: 1025614	Issue Date	: 30-Jun-2021 18:33
C-O-C number	: ----		
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Laboratory Control Sample (LCS) Recoveries								
Total Metals	QC-MRG3-228497002	----	phosphorus, total	7723-14-0	E420	122 % MES	80.0-120%	Recovery greater than upper control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- E303059	E559	21-Jun-2021	----	----	----		29-Jun-2021	28 days	8 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- snap	E559	21-Jun-2021	----	----	----		29-Jun-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- E303059	E298	21-Jun-2021	28-Jun-2021	----	8 days	✓	28-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- snap	E298	21-Jun-2021	28-Jun-2021	----	8 days	✓	28-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-8A- E303059	E235.Br-L	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-8A- snap	E235.Br-L	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-8A- E303059	E235.Cl	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-8A- snap	E235.Cl	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-8A- E303059	E378-U	21-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-8A- snap	E378-U	21-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-8A- E303059	E235.F	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-8A- snap	E235.F	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-8A- E303059	E235.NO3-L	21-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-8A- snap	E235.NO3-L	21-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-8A- E303059	E235.NO2-L	21-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-8A- snap	E235.NO2-L	21-Jun-2021	----	----	----		23-Jun-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-8A- E303059	E235.SO4	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-8A- snap	E235.SO4	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- E303059	E366	21-Jun-2021	28-Jun-2021	----	8 days	✓	29-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- snap	E366	21-Jun-2021	28-Jun-2021	----	8 days	✓	29-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- E303059	E372-U	21-Jun-2021	28-Jun-2021	----	8 days	✓	29-Jun-2021	28 days	1 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-8A- snap	E372-U	21-Jun-2021	28-Jun-2021	----	8 days	✓	29-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-8A- E303059	E509	21-Jun-2021	24-Jun-2021	----	4 days	✓	24-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-8A- snap	E509	21-Jun-2021	24-Jun-2021	----	4 days	✓	24-Jun-2021	28 days	1 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-8A- E303059	E421	21-Jun-2021	26-Jun-2021	----	6 days	✓	27-Jun-2021	180 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-8A- snap	E421	21-Jun-2021	26-Jun-2021	----	6 days	✓	27-Jun-2021	180 days	1 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-8A- E303059	E283	21-Jun-2021	----	----	----		23-Jun-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-8A- snap	E283	21-Jun-2021	----	----	----		23-Jun-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-8A- E303059	E290	21-Jun-2021	----	----	----		23-Jun-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-8A- snap	E290	21-Jun-2021	----	----	----		23-Jun-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-8A- E303059	E100	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-8A- snap	E100	21-Jun-2021	----	----	----		23-Jun-2021	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-8A- E303059	E108	21-Jun-2021	----	----	----		23-Jun-2021	0.25 hrs	42 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-8A- snap	E108	21-Jun-2021	----	----	----		23-Jun-2021	0.25 hrs	44 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-8A- E303059	E162	21-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-8A- snap	E162	21-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-8A- E303059	E160-H	21-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-8A- snap	E160-H	21-Jun-2021	----	----	----		25-Jun-2021	7 days	5 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-8A- E303059	E121	21-Jun-2021	----	----	----		24-Jun-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-8A- snap	E121	21-Jun-2021	----	----	----		24-Jun-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-8A- E303059	E508	21-Jun-2021	----	----	----		24-Jun-2021	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-8A- snap	E508	21-Jun-2021	----	----	----		24-Jun-2021	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-8A- E303059	E420	21-Jun-2021	----	----	----		25-Jun-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-8A- snap	E420	21-Jun-2021	----	----	----		25-Jun-2021	180 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-8A- E303059	E395	21-Jun-2021	----	----	----		29-Jun-2021	7 days	9 days	× EHT
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-8A- snap	E395	21-Jun-2021	----	----	----		29-Jun-2021	7 days	9 days	× EHT

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	227728	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	227719	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	231738	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227724	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	232616	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	227723	1	9	11.1	5.0	✓
Conductivity in Water	E100	227721	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	229388	1	9	11.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	231046	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227729	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	227722	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227725	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227726	1	10	10.0	5.0	✓
pH by Meter	E108	227720	1	5	20.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227727	1	9	11.1	5.0	✓
TDS by Gravimetry	E162	230628	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229391	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	228497	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	231736	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	231734	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	232809	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	230630	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	228798	2	24	8.3	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	227728	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	227719	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	231738	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227724	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	232616	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	227723	1	9	11.1	5.0	✓
Conductivity in Water	E100	227721	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	229388	1	9	11.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	231046	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227729	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	227722	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227725	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227726	1	10	10.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	227720	1	5	20.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227727	1	9	11.1	5.0	✓
TDS by Gravimetry	E162	230628	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229391	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	228497	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	231736	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	231734	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	232809	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	230630	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	228798	2	24	8.3	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	227728	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	227719	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	231738	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227724	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	232616	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	227723	1	9	11.1	5.0	✓
Conductivity in Water	E100	227721	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	229388	1	9	11.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	231046	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227729	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	227722	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227725	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227726	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227727	1	9	11.1	5.0	✓
TDS by Gravimetry	E162	230628	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	229391	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	228497	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	231736	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	231734	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	232809	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	230630	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	228798	2	24	8.3	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	231738	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	227724	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	232616	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	227723	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	229388	1	9	11.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	231046	1	11	9.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	227729	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	227722	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	227725	1	10	10.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	227726	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	227727	1	9	11.1	5.0	✓
Total Mercury in Water by CVAAS	E508	229391	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	228497	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	231736	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	231734	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	232809	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B2626**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 22-Jun-2021 16:30
PO	: 1025614	Date Analysis Commenced	: 23-Jun-2021
C-O-C number	: ----	Issue Date	: 30-Jun-2021 18:33
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Sristika Chand	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 227719)											
VA21B2626-001	BJ-GW11-8A- snap	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	76.2	74.5	2.26%	20%	----
Physical Tests (QC Lot: 227720)											
VA21B2626-001	BJ-GW11-8A- snap	pH	----	E108	0.10	pH units	8.10	8.11	0.123%	4%	----
Physical Tests (QC Lot: 227721)											
VA21B2626-001	BJ-GW11-8A- snap	conductivity	----	E100	2.0	µS/cm	222	223	0.449%	10%	----
Physical Tests (QC Lot: 227728)											
VA21B2626-002	BJ-GW11-8A- E303059	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 228798)											
VA21B2526-001	Anonymous	turbidity	----	E121	0.10	NTU	0.22	0.21	0.01	Diff <2x LOR	----
Physical Tests (QC Lot: 229049)											
VA21B2500-001	Anonymous	turbidity	----	E121	0.10	NTU	0.31	0.35	0.05	Diff <2x LOR	----
Physical Tests (QC Lot: 230628)											
FJ2100456-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	992	1020	2.34%	20%	----
Physical Tests (QC Lot: 230630)											
FJ2100456-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	9.0	8.4	0.6	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227722)											
VA21B2589-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	<0.020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227723)											
VA21B2589-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	1.45	1.44	0.004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227724)											
VA21B2589-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227725)											
VA21B2589-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0782	0.0784	0.146%	20%	----
Anions and Nutrients (QC Lot: 227726)											
VA21B2589-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227727)											
VA21B2589-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	0.61	0.64	0.03	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 227729)											
VA21B2589-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 231734)											
VA21B2500-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0084	0.0079	0.0005	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 231736)											
VA21B2607-003	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.142	0.144	0.002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 231738)											
VA21B2618-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	5.00	mg/L	256	264	2.70%	20%	----
Total Sulfides (QC Lot: 232809)											
CG2102133-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 228497)											
YL2100569-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.192	0.188	2.23%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00023	0.00024	0.000007	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0696	0.0704	1.08%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000032	0.000027	0.000005	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.212	0.213	0.369%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000248	0.000253	1.89%	20%	----
		calcium, total	7440-70-2	E420	0.050	mg/L	95.4	93.6	1.86%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.0104	0.0103	1.62%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00218	0.00212	0.00007	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.289	0.287	0.401%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000059	0.000058	0.0000007	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0213	0.0214	0.0943%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	20.9	20.7	0.773%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.630	0.630	0.0447%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00193	0.00193	0.0739%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.0387	0.0388	0.229%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	7.19	7.19	0.0382%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000069	<0.000050	0.000019	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.71	1.66	2.91%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	88.3	88.6	0.387%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.79	1.81	0.970%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000055	0.000057	0.000002	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00328	0.00297	10.00%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 228497) - continued											
YL2100569-001	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	0.000770	0.000779	1.14%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0352	0.0347	1.47%	20%	----
Total Metals (QC Lot: 229391)											
VA21B2589-005	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 229388)											
FJ2100452-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 231046)											
VA21B2626-001	BJ-GW11-8A- snap	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0017	0.0020	0.0004	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00084	0.00083	0.00001	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00862	0.00868	0.609%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0216	0.0211	2.27%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000093	0.0000104	0.0000011	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	30.8	30.5	0.949%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0086	0.0085	0.00008	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	6.32	6.43	1.83%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00121	0.00122	0.602%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.494	0.498	0.004	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000208	0.000239	0.000031	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.05	2.05	0.132%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	3.62	3.75	3.55%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.757	0.751	0.809%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 231046) - continued											
VA21B2626-001	BJ-GW11-8A- snap	tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000181	0.000185	2.36%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0018	0.0018	0.000002	Diff <2x LOR	----
Aggregate Organics (QC Lot: 232616)											
VA21B2598-004	Anonymous	chemical oxygen demand [COD]	----	E559	80	mg/L	3530	3480	1.38%	20%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 227719)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 227721)						
conductivity	----	E100	1	µS/cm	1.2	----
Physical Tests (QCLot: 227728)						
acidity (as CaCO3)	----	E283	2	mg/L	2.0	----
Physical Tests (QCLot: 228798)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 229049)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 230628)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 230630)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 227722)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 227723)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 227724)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 227725)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 227726)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 227727)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 227729)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 231734)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 231736)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 231738)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 232809)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 228497)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 229391)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 229388)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 231046)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 232616)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 227719)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100	85.0	115	----
Physical Tests (QCLot: 227720)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 227721)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	104	90.0	110	----
Physical Tests (QCLot: 227728)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	98.5	85.0	115	----
Physical Tests (QCLot: 228798)									
turbidity	----	E121	0.1	NTU	200 NTU	99.5	85.0	115	----
Physical Tests (QCLot: 229049)									
turbidity	----	E121	0.1	NTU	200 NTU	97.0	85.0	115	----
Physical Tests (QCLot: 230628)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	106	85.0	115	----
Physical Tests (QCLot: 230630)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	90.3	85.0	115	----
Anions and Nutrients (QCLot: 227722)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	97.6	90.0	110	----
Anions and Nutrients (QCLot: 227723)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 227724)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	99.8	85.0	115	----
Anions and Nutrients (QCLot: 227725)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 227726)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	99.6	90.0	110	----
Anions and Nutrients (QCLot: 227727)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 227729)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	96.8	80.0	120	----
Anions and Nutrients (QCLot: 231734)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	96.4	80.0	120	----
Anions and Nutrients (QCLot: 231736)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 231736) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 231738)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	103	85.0	115	----
Total Sulfides (QCLot: 232809)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	108	80.0	120	----
Total Metals (QCLot: 228497)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	108	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	109	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	106	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	103	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	102	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	104	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	105	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	105	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	106	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	109	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	# 122	80.0	120	MES
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	112	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	105	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	106	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	105	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	102	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	96.9	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	110	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 228497) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	107	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	106	80.0	120	----
Total Metals (QCLot: 229391)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	103	80.0	120	----
Dissolved Metals (QCLot: 231046)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	105	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	111	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	103	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	93.1	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	104	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	98.6	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	100	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	97.5	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	110	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.3	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	112	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	99.7	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	110	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	108	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	111	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	97.0	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 231046) - continued									
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	101	80.0	120	----
Aggregate Organics (QCLot: 232616)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	106	85.0	115	----

Qualifiers

Qualifier	Description
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 227722)										
VA21B2589-002	Anonymous	fluoride	16984-48-8	E235.F	0.980 mg/L	1 mg/L	98.0	75.0	125	----
Anions and Nutrients (QCLot: 227723)										
VA21B2589-002	Anonymous	chloride	16887-00-6	E235.Cl	102 mg/L	100 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 227724)										
VA21B2589-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.493 mg/L	0.5 mg/L	98.5	75.0	125	----
Anions and Nutrients (QCLot: 227725)										
VA21B2589-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.55 mg/L	2.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 227726)										
VA21B2589-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.497 mg/L	0.5 mg/L	99.4	75.0	125	----
Anions and Nutrients (QCLot: 227727)										
VA21B2589-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 227729)										
VA21B2589-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0284 mg/L	0.03 mg/L	94.6	70.0	130	----
Anions and Nutrients (QCLot: 231734)										
VA21B2607-003	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0491 mg/L	0.05 mg/L	98.2	70.0	130	----
Anions and Nutrients (QCLot: 231736)										
VA21B2607-004	Anonymous	nitrogen, total	7727-37-9	E366	0.419 mg/L	0.4 mg/L	105	70.0	130	----
Anions and Nutrients (QCLot: 231738)										
VA21B2626-001	BJ-GW11-8A- snap	ammonia, total (as N)	7664-41-7	E298	0.102 mg/L	0.1 mg/L	102	75.0	125	----
Total Sulfides (QCLot: 232809)										
CG2102133-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.220 mg/L	0.2 mg/L	110	75.0	125	----
Total Metals (QCLot: 228497)										
YL2100569-001	Anonymous	aluminum, total	7429-90-5	E420	0.175 mg/L	0.2 mg/L	87.3	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	99.9	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0407 mg/L	0.04 mg/L	102	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00975 mg/L	0.01 mg/L	97.5	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 228497) - continued										
YL2100569-001	Anonymous	boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00376 mg/L	0.004 mg/L	94.1	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0383 mg/L	0.04 mg/L	95.7	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0178 mg/L	0.02 mg/L	89.0	70.0	130	----
		copper, total	7440-50-8	E420	0.0179 mg/L	0.02 mg/L	89.4	70.0	130	----
		iron, total	7439-89-6	E420	1.78 mg/L	2 mg/L	89.2	70.0	130	----
		lead, total	7439-92-1	E420	0.0191 mg/L	0.02 mg/L	95.6	70.0	130	----
		lithium, total	7439-93-2	E420	0.0966 mg/L	0.1 mg/L	96.6	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		nickel, total	7440-02-0	E420	0.0335 mg/L	0.04 mg/L	83.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.8 mg/L	10 mg/L	108	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0396 mg/L	0.04 mg/L	99.1	70.0	130	----
		silicon, total	7440-21-3	E420	8.69 mg/L	10 mg/L	86.9	70.0	130	----
		silver, total	7440-22-4	E420	0.00391 mg/L	0.004 mg/L	97.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00382 mg/L	0.004 mg/L	95.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0188 mg/L	0.02 mg/L	94.0	70.0	130	----
		titanium, total	7440-32-6	E420	0.0346 mg/L	0.04 mg/L	86.6	70.0	130	----
		uranium, total	7440-61-1	E420	0.00410 mg/L	0.004 mg/L	102	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0989 mg/L	0.1 mg/L	98.9	70.0	130	----
		zinc, total	7440-66-6	E420	0.355 mg/L	0.4 mg/L	88.8	70.0	130	----
Total Metals (QCLot: 229391)										
VA21B2606-001	Anonymous	mercury, total	7439-97-6	E508	0.000101 mg/L	0.0001 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 229388)										
FJ2100452-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000997 mg/L	0.0001 mg/L	99.7	70.0	130	----
Dissolved Metals (QCLot: 231046)										
VA21B2626-001	BJ-GW11-8A- snap	aluminum, dissolved	7429-90-5	E421	0.195 mg/L	0.2 mg/L	97.7	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0183 mg/L	0.02 mg/L	91.7	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0200 mg/L	0.02 mg/L	99.9	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0394 mg/L	0.04 mg/L	98.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 231046) - continued										
VA21B2626-001	BJ-GW11-8A- snap	bismuth, dissolved	7440-69-9	E421	0.00993 mg/L	0.01 mg/L	99.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.100 mg/L	0.1 mg/L	99.7	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00405 mg/L	0.004 mg/L	101	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0383 mg/L	0.04 mg/L	95.8	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0193 mg/L	0.02 mg/L	96.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.94 mg/L	2 mg/L	96.9	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0984 mg/L	0.1 mg/L	98.4	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0190 mg/L	0.02 mg/L	95.1	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0185 mg/L	0.02 mg/L	92.6	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0383 mg/L	0.04 mg/L	95.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.5 mg/L	10 mg/L	105	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.93 mg/L	4 mg/L	98.2	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0422 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.92 mg/L	10 mg/L	89.2	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00386 mg/L	0.004 mg/L	96.5	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00388 mg/L	0.004 mg/L	97.1	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0176 mg/L	0.02 mg/L	88.1	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0385 mg/L	0.04 mg/L	96.2	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00410 mg/L	0.004 mg/L	102	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0987 mg/L	0.1 mg/L	98.7	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.407 mg/L	0.4 mg/L	102	70.0	130	----
Aggregate Organics (QCLot: 232616)										
VA21B2611-001	Anonymous	chemical oxygen demand [COD]	----	E559	942 mg/L	1000 mg/L	94.2	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/CM	

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-8A - snap	21-Jun-21	9:35	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-8A - E303059	21-Jun-21	11:20	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B2626

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	21-Jun-21	18:00	PD	Jun 22	10:30	5.5 °C				

Ice pk.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B2897**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 24-Jun-2021 21:35
PO	: 1025614	Date Analysis Commenced	: 25-Jun-2021
C-O-C number	: ----	Issue Date	: 07-Jul-2021 15:31
Sampler	: NG		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-23B - E314691	BJ-GW18-5B - CWP	----	----	----
				Client sampling date / time	23-Jun-2021 11:00	23-Jun-2021 15:35	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2897-001	VA21B2897-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	3.0	4.3	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	88.2	87.8	----	----	----
conductivity	----	E100	2.0	µS/cm	808	1110	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	236	606	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	228	592	----	----	----
pH	----	E108	0.10	pH units	8.05	7.90	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	518	871	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	8.6	4.6	----	----	----
turbidity	----	E121	0.10	NTU	3.06	0.61	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.459	<0.0050	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	0.061	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	75.8	<2.50 DLDS	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.278	<0.100 DLDS	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.380	<0.078	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	3.69	0.807	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	3.70	0.807	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0105	<0.0050 DLDS	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	4.08	0.801	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0026	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0082	0.0036	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	181	557	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.114	0.0109	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00230	0.00054	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00046	0.00050	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0131	0.0413	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-23B - E314691	BJ-GW18-5B - CWP	----	----	----
				Client sampling date / time	23-Jun-2021 11:00	23-Jun-2021 15:35	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2897-001	VA21B2897-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.111	0.025	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000102	<0.0000050	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	82.8	224	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.057	0.019	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000184	<0.000050	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.115	0.0108	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	5.23	8.00	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0642	0.00609	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00318	0.000401	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	5.85	3.14	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000563	0.000315	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	1.78	2.58	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	64.5	10.2	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.902	1.26	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000028	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000721	0.00158	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0010	0.0010	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-23B - E314691	BJ-GW18-5B - CWP	----	----	----
				Client sampling date / time	23-Jun-2021 11:00	23-Jun-2021 15:35	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B2897-001	VA21B2897-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00216	0.00056	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00034	0.00048	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0127	0.0423	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.111	0.028	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000081	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	84.6	229	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00025	0.00037	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.127	0.0114	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	6.15	8.25	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0686	0.00278	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00308	0.000378	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	6.52	3.22	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000528	0.000351	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.50	2.72	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	72.5	10.1	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.924	1.23	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000029	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000812	0.00146	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				Client sample ID	**BJ-GW18-23B - E314691**	**BJ-GW18-5B - CWP**	**----**	**----**	**----**
				Client sampling date / time	23-Jun-2021 11:00	23-Jun-2021 15:35	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21B2897-001**	**VA21B2897-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B2897**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 24-Jun-2021 21:35
PO	: 1025614	Issue Date	: 07-Jul-2021 15:31
C-O-C number	: ----		
Sampler	: NG		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B - E314691	E559	23-Jun-2021	----	----	----		03-Jul-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-5B - CWP	E559	23-Jun-2021	----	----	----		03-Jul-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23B - E314691	E298	23-Jun-2021	05-Jul-2021	----	----		05-Jul-2021	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-5B - CWP	E298	23-Jun-2021	05-Jul-2021	----	----		05-Jul-2021	28 days	12 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B - E314691	E235.Br-L	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-5B - CWP	E235.Br-L	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23B - E314691	E235.Cl	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-5B - CWP	E235.Cl	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23B - E314691	E378-U	23-Jun-2021	----	----	----		25-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-5B - CWP	E378-U	23-Jun-2021	----	----	----		25-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23B - E314691	E235.F	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-5B - CWP	E235.F	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B - E314691	E235.NO3-L	23-Jun-2021	----	----	----		25-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-5B - CWP	E235.NO3-L	23-Jun-2021	----	----	----		25-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B - E314691	E235.NO2-L	23-Jun-2021	----	----	----		25-Jun-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-5B - CWP	E235.NO2-L	23-Jun-2021	----	----	----		25-Jun-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23B - E314691	E235.SO4	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-5B - CWP	E235.SO4	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B - E314691	E366	23-Jun-2021	05-Jul-2021	----	----		06-Jul-2021	28 days	13 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-5B - CWP	E366	23-Jun-2021	05-Jul-2021	----	----		06-Jul-2021	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B - E314691	E372-U	23-Jun-2021	05-Jul-2021	----	----		06-Jul-2021	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-5B - CWP	E372-U	23-Jun-2021	05-Jul-2021	----	----		06-Jul-2021	28 days	13 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23B - E314691	E509	23-Jun-2021	26-Jun-2021	----	----		26-Jun-2021	28 days	3 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-5B - CWP	E509	23-Jun-2021	26-Jun-2021	----	----		26-Jun-2021	28 days	3 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23B - E314691	E421	23-Jun-2021	25-Jun-2021	----	----		28-Jun-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-5B - CWP	E421	23-Jun-2021	30-Jun-2021	----	----		30-Jun-2021	180 days	8 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23B - E314691	E283	23-Jun-2021	----	----	----		25-Jun-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-5B - CWP	E283	23-Jun-2021	----	----	----		25-Jun-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23B - E314691	E290	23-Jun-2021	----	----	----		25-Jun-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-5B - CWP	E290	23-Jun-2021	----	----	----		25-Jun-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23B - E314691	E100	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-5B - CWP	E100	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-5B - CWP	E108	23-Jun-2021	----	----	----		25-Jun-2021	0.25 hrs	46 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-23B - E314691	E108	23-Jun-2021	----	----	----		25-Jun-2021	0.25 hrs	51 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-23B - E314691	E162	23-Jun-2021	----	----	----		29-Jun-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-5B - CWP	E162	23-Jun-2021	----	----	----		30-Jun-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23B - E314691	E160-H	23-Jun-2021	----	----	----		29-Jun-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-5B - CWP	E160-H	23-Jun-2021	----	----	----		30-Jun-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23B - E314691	E121	23-Jun-2021	----	----	----		26-Jun-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-5B - CWP	E121	23-Jun-2021	----	----	----		26-Jun-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23B - E314691	E508	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-5B - CWP	E508	23-Jun-2021	----	----	----		25-Jun-2021	28 days	2 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23B - E314691	E420	23-Jun-2021	----	----	----		28-Jun-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-5B - CWP	E420	23-Jun-2021	----	----	----		30-Jun-2021	180 days	7 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23B - E314691	E395	23-Jun-2021	----	----	----		02-Jul-2021	7 days	9 days	× EHT
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-5B - CWP	E395	23-Jun-2021	----	----	----		02-Jul-2021	7 days	9 days	× EHT

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	230128	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	230120	1	7	14.2	5.0	✓
Ammonia by Fluorescence	E298	236087	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	230123	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	230122	1	15	6.6	5.0	✓
Conductivity in Water	E100	230119	1	7	14.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	231014	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	230322	2	40	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	230127	1	7	14.2	5.0	✓
Fluoride in Water by IC	E235.F	230121	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	230124	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	230125	1	16	6.2	5.0	✓
pH by Meter	E108	230118	1	7	14.2	5.0	✓
Sulfate in Water by IC	E235.SO4	230126	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	233273	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	230555	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	230903	2	40	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	236091	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	236089	1	12	8.3	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	233252	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	230827	2	40	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	230128	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	230120	1	7	14.2	5.0	✓
Ammonia by Fluorescence	E298	236087	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	230123	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	230122	1	15	6.6	5.0	✓
Conductivity in Water	E100	230119	1	7	14.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	231014	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	230322	2	40	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	230127	1	7	14.2	5.0	✓
Fluoride in Water by IC	E235.F	230121	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	230124	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	230125	1	16	6.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	230118	1	7	14.2	5.0	✓
Sulfate in Water by IC	E235.SO4	230126	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	233273	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	230555	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	230903	2	40	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	236091	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	236089	1	12	8.3	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	233252	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	230827	2	40	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	230128	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	230120	1	7	14.2	5.0	✓
Ammonia by Fluorescence	E298	236087	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	230123	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	230122	1	15	6.6	5.0	✓
Conductivity in Water	E100	230119	1	7	14.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	231014	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	230322	2	40	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	230127	1	7	14.2	5.0	✓
Fluoride in Water by IC	E235.F	230121	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	230124	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	230125	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	230126	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	233273	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	230555	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	230903	2	40	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	236091	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	236089	1	12	8.3	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	233252	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	230827	2	40	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	236087	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	230123	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	230122	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	231014	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	230322	2	40	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	230127	1	7	14.2	5.0	✓
Fluoride in Water by IC	E235.F	230121	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	230124	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	230125	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	230126	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	230555	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	230903	2	40	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	236091	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	236089	1	12	8.3	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B2897**	Page	: 1 of 25
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 24-Jun-2021 21:35
PO	: 1025614	Date Analysis Commenced	: 25-Jun-2021
C-O-C number	: ----	Issue Date	: 07-Jul-2021 15:31
Sampler	: NG		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 230118)											
VA21B2897-001	BJ-GW18-23B - E314691	pH	----	E108	0.10	pH units	8.05	8.06	0.124%	4%	----
Physical Tests (QC Lot: 230119)											
VA21B2897-001	BJ-GW18-23B - E314691	conductivity	----	E100	2.0	µS/cm	808	807	0.124%	10%	----
Physical Tests (QC Lot: 230120)											
VA21B2897-001	BJ-GW18-23B - E314691	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	88.2	89.2	1.13%	20%	----
Physical Tests (QC Lot: 230128)											
VA21B2897-002	BJ-GW18-5B - CWP	acidity (as CaCO3)	----	E283	2.0	mg/L	4.3	4.1	0.2	Diff <2x LOR	----
Physical Tests (QC Lot: 230827)											
FJ2100458-012	Anonymous	turbidity	----	E121	0.10	NTU	6.67	6.42	3.82%	15%	----
Physical Tests (QC Lot: 230931)											
FJ2100460-003	Anonymous	turbidity	----	E121	0.10	NTU	0.24	0.24	0.003	Diff <2x LOR	----
Physical Tests (QC Lot: 233252)											
FJ2100472-006	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	5.0	5.4	0.4	Diff <2x LOR	----
Physical Tests (QC Lot: 233273)											
VA21B2916-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	2450	2380	3.04%	20%	----
Physical Tests (QC Lot: 233511)											
FJ2100466-008	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 233514)											
KS2102022-003	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	303	290	4.22%	20%	----
Anions and Nutrients (QC Lot: 230121)											
VA21B2897-001	BJ-GW18-23B - E314691	fluoride	16984-48-8	E235.F	0.020	mg/L	0.278	0.278	0.0525%	20%	----
Anions and Nutrients (QC Lot: 230122)											
VA21B2897-001	BJ-GW18-23B - E314691	chloride	16887-00-6	E235.Cl	0.50	mg/L	75.8	76.2	0.608%	20%	----
Anions and Nutrients (QC Lot: 230123)											
VA21B2897-001	BJ-GW18-23B - E314691	bromide	24959-67-9	E235.Br-L	0.050	mg/L	0.061	0.066	0.004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 230124)											
VA21B2897-001	BJ-GW18-23B - E314691	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	3.69	3.71	0.501%	20%	----
Anions and Nutrients (QC Lot: 230125)											
VA21B2897-001	BJ-GW18-23B - E314691	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0105	0.0108	2.40%	20%	----
Anions and Nutrients (QC Lot: 230126)											
VA21B2897-001	BJ-GW18-23B - E314691	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	181	182	0.690%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 230127)											
VA21B2897-001	BJ-GW18-23B - E314691	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 236087)											
KS2102025-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.116	0.115	0.199%	20%	----
Anions and Nutrients (QC Lot: 236089)											
KS2102025-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0478	0.0511	6.67%	20%	----
Anions and Nutrients (QC Lot: 236091)											
KS2102030-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.136	0.135	0.001	Diff <2x LOR	----
Total Sulfides (QC Lot: 234998)											
CG2102202-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 230555)											
VA21B2851-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 230903)											
FJ2100462-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0056	0.0054	0.0002	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00957	0.00959	0.132%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	1.28	1.25	2.46%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.016	0.018	0.001	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	85.2	91.8	7.44%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00010	0.00010	0.000001	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	35.7	35.4	0.954%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0147	0.0156	5.58%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	24.2	24.5	1.30%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.398	0.395	0.884%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00185	0.00196	5.56%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.860	0.849	1.26%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000082	0.000095	0.000013	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	5.43	5.41	0.457%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 230903) - continued											
FJ2100462-001	Anonymous	silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	8.38	8.41	0.338%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.244	0.261	6.75%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000019	0.000022	0.000003	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00099	0.00099	0.000005	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 230907)											
FJ2100464-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0070	0.0064	0.0006	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00025	0.00025	0.000004	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0212	0.0205	3.60%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.617	0.600	2.74%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.033	0.033	0.0006	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	37.1	39.3	5.80%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00034	0.00033	0.00001	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.822	0.777	5.62%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0108	0.0109	1.29%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	12.3	11.1	10.1%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.196	0.185	5.89%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00353	0.00346	2.14%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	0.100	0.135	0.035	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.719	0.686	4.77%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	2.72	2.65	2.53%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	3.32	3.04	8.57%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 230907) - continued											
FJ2100464-001	Anonymous	strontium, total	7440-24-6	E420	0.00020	mg/L	0.206	0.204	1.04%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000322	0.000332	3.11%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 230322)											
VA21B2842-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0071	0.0058	0.0012	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00587	0.00576	1.95%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0281	0.0270	3.82%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0865	0.0874	0.982%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000123	0.0000148	0.0000025	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	60.0	57.8	3.80%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00201	0.00190	0.00011	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0084	0.0082	0.0002	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	20.2	19.2	5.19%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00040	0.00035	0.00004	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000619	0.000617	0.334%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00108	0.00101	0.00007	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	2.77	2.66	3.95%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000457	0.000438	0.000019	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	5.21	5.17	0.775%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	3.32	3.29	1.01%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.266	0.257	3.65%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 230322) - continued											
VA21B2842-001	Anonymous	tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00291	0.00285	2.16%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 231014)											
VA21B2882-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 233302)											
VA21B2897-002	BJ-GW18-5B - CWP	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0010	0.0015	0.0004	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00056	0.00055	0.000007	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00048	0.00043	0.00005	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0423	0.0423	0.0505%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.028	0.027	0.0006	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	229	227	1.04%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00037	0.00035	0.00003	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0114	0.0112	2.22%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.100	mg/L	8.25	8.21	0.552%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00278	0.00285	2.27%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000378	0.000377	0.0000003	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	3.22	3.17	1.48%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000351	0.000318	0.000032	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.72	2.66	2.47%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	10.1	10.0	0.830%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.23	1.22	0.543%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 233302) - continued											
VA21B2897-002	BJ-GW18-5B - CWP	tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00146	0.00145	0.422%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 235564)											
VA21B2897-001	BJ-GW18-23B - E314691	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 230119)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 230120)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	1.2	----
Physical Tests (QCLot: 230128)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 230827)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 230931)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 233252)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 233273)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 233511)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 233514)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 230121)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 230122)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 230123)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 230124)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 230125)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 230126)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 230127)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 236087)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 236089)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 236091)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Sulfides (QCLot: 234998)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 230555)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 230903)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 230903) - continued						
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 230907)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 230907) - continued						
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Dissolved Metals (QCLot: 230322)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 231014)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 233302)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 235564)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 230118)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 230119)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 230120)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	101	85.0	115	----
Physical Tests (QCLot: 230128)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	107	85.0	115	----
Physical Tests (QCLot: 230827)									
turbidity	----	E121	0.1	NTU	200 NTU	98.5	85.0	115	----
Physical Tests (QCLot: 230931)									
turbidity	----	E121	0.1	NTU	200 NTU	99.0	85.0	115	----
Physical Tests (QCLot: 233252)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	94.7	85.0	115	----
Physical Tests (QCLot: 233273)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	105	85.0	115	----
Physical Tests (QCLot: 233511)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	90.3	85.0	115	----
Physical Tests (QCLot: 233514)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	91.1	85.0	115	----
Anions and Nutrients (QCLot: 230121)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	97.2	90.0	110	----
Anions and Nutrients (QCLot: 230122)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 230123)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	105	85.0	115	----
Anions and Nutrients (QCLot: 230124)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 230125)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	99.2	90.0	110	----
Anions and Nutrients (QCLot: 230126)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 230127)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 230127) - continued									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	103	80.0	120	----
Anions and Nutrients (QCLot: 236087)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	100	85.0	115	----
Anions and Nutrients (QCLot: 236089)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	87.3	80.0	120	----
Anions and Nutrients (QCLot: 236091)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Total Sulfides (QCLot: 234998)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	105	80.0	120	----
Total Metals (QCLot: 230555)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	98.6	80.0	120	----
Total Metals (QCLot: 230903)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	101	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	107	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	99.5	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	94.5	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	92.4	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.6	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	98.6	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	99.3	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	99.9	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	99.6	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	107	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	101	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	104	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	99.4	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.8	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	103	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 230903) - continued									
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	105	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	96.4	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	96.2	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	102	80.0	120	----
Total Metals (QCLot: 230907)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	96.7	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	108	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	94.9	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	94.5	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	105	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	94.5	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.0	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	95.2	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	96.8	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	95.1	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	95.4	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	92.8	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	99.3	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	96.3	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	96.0	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	101	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	95.1	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	98.3	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	98.6	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	99.4	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	100	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	97.2	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	97.3	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 230907) - continued									
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	98.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	97.4	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	92.0	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	97.3	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	95.3	80.0	120	----
Dissolved Metals (QCLot: 230322)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	103	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.4	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	97.8	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	96.2	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	99.5	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.8	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	100.0	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	95.7	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.8	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.1	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	103	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	107	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	97.5	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	103	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	98.5	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	97.4	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 230322) - continued									
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	97.4	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	98.6	80.0	120	----
Dissolved Metals (QCLot: 233302)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	106	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.8	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.9	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	95.9	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	97.5	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	100	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	98.8	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	97.8	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	105	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	98.6	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	100	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	98.8	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	99.1	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	100	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	97.0	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	111	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	106	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	100	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	98.5	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.4	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	101	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	96.8	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	99.3	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	99.4	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	104	80.0	120	----
Aggregate Organics (QCLot: 235564)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 235564) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	106	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 230121)										
VA21B2897-002	BJ-GW18-5B - CWP	fluoride	16984-48-8	E235.F	5.06 mg/L	5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 230122)										
VA21B2897-002	BJ-GW18-5B - CWP	chloride	16887-00-6	E235.Cl	524 mg/L	500 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 230123)										
VA21B2897-002	BJ-GW18-5B - CWP	bromide	24959-67-9	E235.Br-L	2.60 mg/L	2.5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 230124)										
VA21B2897-002	BJ-GW18-5B - CWP	nitrate (as N)	14797-55-8	E235.NO3-L	13.1 mg/L	12.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 230125)										
VA21B2897-002	BJ-GW18-5B - CWP	nitrite (as N)	14797-65-0	E235.NO2-L	2.54 mg/L	2.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 230126)										
VA21B2897-002	BJ-GW18-5B - CWP	sulfate (as SO4)	14808-79-8	E235.SO4	ND mg/L	500 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 230127)										
VA21B2897-002	BJ-GW18-5B - CWP	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0310 mg/L	0.03 mg/L	103	70.0	130	----
Anions and Nutrients (QCLot: 236087)										
KS2102030-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.105 mg/L	0.1 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 236089)										
KS2102030-001	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 236091)										
KS2102030-002	Anonymous	nitrogen, total	7727-37-9	E366	0.392 mg/L	0.4 mg/L	98.0	70.0	130	----
Total Sulfides (QCLot: 234998)										
CG2102231-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.214 mg/L	0.2 mg/L	107	75.0	125	----
Total Metals (QCLot: 230555)										
VA21B2851-002	Anonymous	mercury, total	7439-97-6	E508	0.0000963 mg/L	0.0001 mg/L	96.3	70.0	130	----
Total Metals (QCLot: 230903)										
FJ2100462-001	Anonymous	aluminum, total	7429-90-5	E420	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0199 mg/L	0.02 mg/L	99.4	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 230903) - continued										
FJ2100462-001	Anonymous	beryllium, total	7440-41-7	E420	0.0401 mg/L	0.04 mg/L	100	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00927 mg/L	0.01 mg/L	92.7	70.0	130	----
		boron, total	7440-42-8	E420	0.093 mg/L	0.1 mg/L	93.3	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00401 mg/L	0.004 mg/L	100	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0199 mg/L	0.02 mg/L	99.5	70.0	130	----
		copper, total	7440-50-8	E420	0.0196 mg/L	0.02 mg/L	98.0	70.0	130	----
		iron, total	7439-89-6	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		lithium, total	7439-93-2	E420	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0205 mg/L	0.02 mg/L	102	70.0	130	----
		nickel, total	7440-02-0	E420	0.0384 mg/L	0.04 mg/L	96.1	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.5 mg/L	10 mg/L	105	70.0	130	----
		potassium, total	7440-09-7	E420	4.20 mg/L	4 mg/L	105	70.0	130	----
		selenium, total	7782-49-2	E420	0.0415 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, total	7440-21-3	E420	8.79 mg/L	10 mg/L	87.9	70.0	130	----
		silver, total	7440-22-4	E420	0.00413 mg/L	0.004 mg/L	103	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00371 mg/L	0.004 mg/L	92.8	70.0	130	----
		tin, total	7440-31-5	E420	0.0195 mg/L	0.02 mg/L	97.4	70.0	130	----
		titanium, total	7440-32-6	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		uranium, total	7440-61-1	E420	0.00421 mg/L	0.004 mg/L	105	70.0	130	----
		vanadium, total	7440-62-2	E420	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		zinc, total	7440-66-6	E420	0.386 mg/L	0.4 mg/L	96.5	70.0	130	----
Total Metals (QCLot: 230907)										
FJ2100464-001	Anonymous	aluminum, total	7429-90-5	E420	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	99.8	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00879 mg/L	0.01 mg/L	87.9	70.0	130	----
		boron, total	7440-42-8	E420	0.090 mg/L	0.1 mg/L	90.5	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 230907) - continued										
FJ2100464-001	Anonymous	cadmium, total	7440-43-9	E420	0.00389 mg/L	0.004 mg/L	97.2	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0368 mg/L	0.04 mg/L	92.1	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0186 mg/L	0.02 mg/L	93.0	70.0	130	----
		copper, total	7440-50-8	E420	0.0184 mg/L	0.02 mg/L	92.1	70.0	130	----
		iron, total	7439-89-6	E420	1.78 mg/L	2 mg/L	88.9	70.0	130	----
		lead, total	7439-92-1	E420	0.0178 mg/L	0.02 mg/L	89.2	70.0	130	----
		lithium, total	7439-93-2	E420	0.0968 mg/L	0.1 mg/L	96.8	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0193 mg/L	0.02 mg/L	96.7	70.0	130	----
		nickel, total	7440-02-0	E420	0.0367 mg/L	0.04 mg/L	91.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.2 mg/L	10 mg/L	102	70.0	130	----
		potassium, total	7440-09-7	E420	3.87 mg/L	4 mg/L	96.7	70.0	130	----
		selenium, total	7782-49-2	E420	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, total	7440-21-3	E420	8.69 mg/L	10 mg/L	86.9	70.0	130	----
		silver, total	7440-22-4	E420	0.00396 mg/L	0.004 mg/L	99.0	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00347 mg/L	0.004 mg/L	86.8	70.0	130	----
		tin, total	7440-31-5	E420	0.0190 mg/L	0.02 mg/L	95.1	70.0	130	----
		titanium, total	7440-32-6	E420	0.0374 mg/L	0.04 mg/L	93.6	70.0	130	----
		uranium, total	7440-61-1	E420	0.00347 mg/L	0.004 mg/L	86.8	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0953 mg/L	0.1 mg/L	95.3	70.0	130	----
		zinc, total	7440-66-6	E420	0.357 mg/L	0.4 mg/L	89.3	70.0	130	----
Dissolved Metals (QCLot: 230322)										
VA21B2842-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.208 mg/L	0.2 mg/L	104	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0198 mg/L	0.02 mg/L	99.0	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00879 mg/L	0.01 mg/L	87.9	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00407 mg/L	0.004 mg/L	102	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0407 mg/L	0.04 mg/L	102	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 230322) - continued										
VA21B2842-001	Anonymous	cobalt, dissolved	7440-48-4	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0198 mg/L	0.02 mg/L	99.2	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.92 mg/L	2 mg/L	96.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0193 mg/L	0.02 mg/L	96.6	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0203 mg/L	0.02 mg/L	102	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0191 mg/L	0.02 mg/L	95.6	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0398 mg/L	0.04 mg/L	99.5	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.5 mg/L	10 mg/L	115	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.80 mg/L	4 mg/L	95.0	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0398 mg/L	0.04 mg/L	99.4	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.46 mg/L	10 mg/L	84.6	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00396 mg/L	0.004 mg/L	99.1	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00388 mg/L	0.004 mg/L	97.0	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0196 mg/L	0.02 mg/L	98.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0405 mg/L	0.04 mg/L	101	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00370 mg/L	0.004 mg/L	92.4	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.105 mg/L	0.1 mg/L	105	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.387 mg/L	0.4 mg/L	96.7	70.0	130	----
Dissolved Metals (QCLot: 231014)										
VA21B2882-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000978 mg/L	0.0001 mg/L	97.8	70.0	130	----
Dissolved Metals (QCLot: 233302)										
VA21B2897-002	BJ-GW18-5B - CWP	aluminum, dissolved	7429-90-5	E421	0.227 mg/L	0.2 mg/L	113	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0221 mg/L	0.02 mg/L	110	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0226 mg/L	0.02 mg/L	113	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0425 mg/L	0.04 mg/L	106	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00972 mg/L	0.01 mg/L	97.2	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00427 mg/L	0.004 mg/L	107	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0440 mg/L	0.04 mg/L	110	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0217 mg/L	0.02 mg/L	109	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 233302) - continued										
VA21B2897-002	BJ-GW18-5B - CWP	copper, dissolved	7440-50-8	E421	0.0207 mg/L	0.02 mg/L	103	70.0	130	----
		iron, dissolved	7439-89-6	E421	2.14 mg/L	2 mg/L	107	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.105 mg/L	0.1 mg/L	105	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0219 mg/L	0.02 mg/L	110	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0223 mg/L	0.02 mg/L	111	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0425 mg/L	0.04 mg/L	106	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	12.6 mg/L	10 mg/L	126	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.16 mg/L	4 mg/L	104	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0484 mg/L	0.04 mg/L	121	70.0	130	----
		silicon, dissolved	7440-21-3	E421	10.1 mg/L	10 mg/L	101	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00422 mg/L	0.004 mg/L	105	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00429 mg/L	0.004 mg/L	107	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0221 mg/L	0.02 mg/L	110	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0452 mg/L	0.04 mg/L	113	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00430 mg/L	0.004 mg/L	107	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.113 mg/L	0.1 mg/L	113	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.436 mg/L	0.4 mg/L	109	70.0	130	----
Aggregate Organics (QCLot: 235564)										
VA21B2897-002	BJ-GW18-5B - CWP	chemical oxygen demand [COD]	----	E559	103 mg/L	100 mg/L	103	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-23B - E314691	23-Jun-21	11:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW16-5B - CWP	23-Jun-21	15:35	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21B2897

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	23-Jun-21	18:00				4.4 °C	RJ	JUN 24	21:35	

Scapule

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B3123**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-Jun-2021 15:25
PO	: 1025614	Date Analysis Commenced	: 29-Jun-2021
C-O-C number	: ----	Issue Date	: 12-Jul-2021 17:42
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
HTD	*Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-23A - E314690	BJ-GW18-5A-C WP	----	----	----
				Client sampling date / time	25-Jun-2021 15:30	26-Jun-2021 11:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B3123-001	VA21B3123-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.3	3.3	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	89.8	96.0	----	----	----
conductivity	----	E100	2.0	µS/cm	1190	774	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	336	394	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	333	382	----	----	----
pH	----	E108	0.10	pH units	8.05	8.01	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	904	625	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	51.2	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	19.0	0.36	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.539	0.0974	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	27.9	<2.50 DLDS	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.123	<0.100 DLDS	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<1.11	0.137	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	11.6	<0.0250 DLDS, HTD	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	11.6	<0.0255	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0546	<0.0050 DLDS, HTD	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	11.8	0.137	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0036	0.0013	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0501	<0.0020	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	442	340	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.475	0.0039	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.0336	0.00098	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0373	0.00086	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0624	0.0193	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23A - E314690	BJ-GW18-5A-C WP	----	----	----
				Client sampling date / time	25-Jun-2021 15:30	26-Jun-2021 11:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B3123-001	VA21B3123-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.119	0.036	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000440	<0.0000050	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	107	122	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.0222	0.00059	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00470	0.00063	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00234	<0.00050	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.438	0.053	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000874	0.000086	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.251	0.0131	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	16.1	18.9	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.289	0.115	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000117	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00778	0.000294	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.0178	0.00084	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	4.22	1.59	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000650	<0.000050	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.90	2.90	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000442	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	124	6.46	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	6.36	4.58	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000108	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00022	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00210	0.000278	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00063	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0096	0.0036	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0021	0.0015	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23A - E314690	BJ-GW18-5A-C WP	----	----	----
				Client sampling date / time	25-Jun-2021 15:30	26-Jun-2021 11:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B3123-001	VA21B3123-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.0344	0.00094	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0324	0.00084	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0455	0.0197	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.120	0.037	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000230	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	109	127	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00040	0.00047	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00060	0.00023	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.011	0.045	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000288	0.000088	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.260	0.0137	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	15.5	18.6	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.235	0.115	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00560	0.000263	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00373	0.00066	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	4.23	1.65	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000793	<0.000050	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.82	2.81	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	128	6.65	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	6.50	4.69	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000089	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00199	0.000285	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-23A - E314690**	**BJ-GW18-5A-C WP**	**----**	**----**	**----**
				Client sampling date / time	25-Jun-2021 15:30	26-Jun-2021 11:00	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B3123-001**	**VA21B3123-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0081	0.0047	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B3123**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-Jun-2021 15:25
PO	: 1025614	Issue Date	: 12-Jul-2021 17:42
C-O-C number	: ----		
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-5A-CWP	E559	26-Jun-2021	----	----	----		03-Jul-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A - E314690	E559	25-Jun-2021	----	----	----		03-Jul-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-5A-CWP	E298	26-Jun-2021	06-Jul-2021	----	----		06-Jul-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23A - E314690	E298	25-Jun-2021	06-Jul-2021	----	----		06-Jul-2021	28 days	11 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-5A-CWP	E235.Br-L	26-Jun-2021	----	----	----		29-Jun-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A - E314690	E235.Br-L	25-Jun-2021	----	----	----		29-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-5A-CWP	E235.Cl	26-Jun-2021	----	----	----		29-Jun-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23A - E314690	E235.Cl	25-Jun-2021	----	----	----		29-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-5A-CWP	E378-U	26-Jun-2021	----	----	----		29-Jun-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23A - E314690	E378-U	25-Jun-2021	----	----	----		29-Jun-2021	3 days	4 days	✗ EHTL
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-5A-CWP	E235.F	26-Jun-2021	----	----	----		29-Jun-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23A - E314690	E235.F	25-Jun-2021	----	----	----		29-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-5A-CWP	E235.NO3-L	26-Jun-2021	----	----	----		29-Jun-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A - E314690	E235.NO3-L	25-Jun-2021	----	----	----		29-Jun-2021	3 days	4 days	✗ EHTL
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-5A-CWP	E235.NO2-L	26-Jun-2021	----	----	----		29-Jun-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A - E314690	E235.NO2-L	25-Jun-2021	----	----	----		29-Jun-2021	3 days	4 days	✗ EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-5A-CWP	E235.SO4	26-Jun-2021	----	----	----		29-Jun-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23A - E314690	E235.SO4	25-Jun-2021	----	----	----		29-Jun-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-5A-CWP	E366	26-Jun-2021	06-Jul-2021	----	----		07-Jul-2021	28 days	11 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A - E314690	E366	25-Jun-2021	06-Jul-2021	----	----		07-Jul-2021	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-5A-CWP	E372-U	26-Jun-2021	06-Jul-2021	----	----		07-Jul-2021	28 days	11 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23A - E314690	E372-U	25-Jun-2021	06-Jul-2021	----	----		07-Jul-2021	28 days	12 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-5A-CWP	E509	26-Jun-2021	29-Jun-2021	----	----		29-Jun-2021	28 days	3 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23A - E314690	E509	25-Jun-2021	29-Jun-2021	----	----		29-Jun-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-5A-CWP	E421	26-Jun-2021	30-Jun-2021	----	----		30-Jun-2021	180 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23A - E314690	E421	25-Jun-2021	30-Jun-2021	----	----		30-Jun-2021	180 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-5A-CWP	E283	26-Jun-2021	----	----	----		29-Jun-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23A - E314690	E283	25-Jun-2021	----	----	----		29-Jun-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-5A-CWP	E290	26-Jun-2021	----	----	----		29-Jun-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23A - E314690	E290	25-Jun-2021	----	----	----		29-Jun-2021	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-5A-CWP	E100	26-Jun-2021	----	----	----		29-Jun-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23A - E314690	E100	25-Jun-2021	----	----	----		29-Jun-2021	28 days	4 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-5A-CWP	E108	26-Jun-2021	----	----	----		29-Jun-2021	0.25 hrs	66 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-23A - E314690	E108	25-Jun-2021	----	----	----		29-Jun-2021	0.25 hrs	86 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-5A-CWP	E162	26-Jun-2021	----	----	----		02-Jul-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-23A - E314690	E162	25-Jun-2021	----	----	----		02-Jul-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-5A-CWP	E160-H	26-Jun-2021	----	----	----		02-Jul-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23A - E314690	E160-H	25-Jun-2021	----	----	----		02-Jul-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-5A-CWP	E121	26-Jun-2021	----	----	----		29-Jun-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23A - E314690	E121	25-Jun-2021	----	----	----		29-Jun-2021	3 days	4 days	× EHTL
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-5A-CWP	E508	26-Jun-2021	----	----	----		29-Jun-2021	28 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23A - E314690	E508	25-Jun-2021	----	----	----		29-Jun-2021	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-5A-CWP	E420	26-Jun-2021	----	----	----		01-Jul-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23A - E314690	E420	25-Jun-2021	----	----	----		01-Jul-2021	180 days	6 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-5A-CWP	E395	26-Jun-2021	----	----	----		02-Jul-2021	7 days	6 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23A - E314690	E395	25-Jun-2021	----	----	----		02-Jul-2021	7 days	7 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	232112	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	232109	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	237047	1	3	33.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	232103	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	232102	1	10	10.0	5.0	✓
Conductivity in Water	E100	232108	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	232916	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	233392	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	232110	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	232101	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	232104	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	232105	1	10	10.0	5.0	✓
pH by Meter	E108	232107	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	232106	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	234920	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	233009	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	233765	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	237296	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	237048	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	234844	1	8	12.5	5.0	✓
Turbidity by Nephelometry	E121	232413	1	7	14.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	232112	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	232109	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	237047	1	3	33.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	232103	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	232102	1	10	10.0	5.0	✓
Conductivity in Water	E100	232108	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	232916	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	233392	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	232110	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	232101	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	232104	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	232105	1	10	10.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	232107	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	232106	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	234920	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	233009	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	233765	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	237296	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	237048	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	234844	1	8	12.5	5.0	✓
Turbidity by Nephelometry	E121	232413	1	7	14.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	232112	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	232109	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	237047	1	3	33.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	232103	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	232102	1	10	10.0	5.0	✓
Conductivity in Water	E100	232108	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	232916	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	233392	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	232110	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	232101	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	232104	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	232105	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	232106	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	234920	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	233009	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	233765	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	237296	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	237048	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	234844	1	8	12.5	5.0	✓
Turbidity by Nephelometry	E121	232413	1	7	14.2	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	237047	1	3	33.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	232103	1	7	14.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	235564	1	18	5.5	5.0	✓
Chloride in Water by IC	E235.Cl	232102	1	10	10.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	232916	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	233392	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	232110	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	232101	1	10	10.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	232104	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	232105	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	232106	1	10	10.0	5.0	✓
Total Mercury in Water by CVAAS	E508	233009	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	233765	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	237296	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	237048	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	234998	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B3123**	Page	: 1 of 16
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-Jun-2021 15:25
PO	: 1025614	Date Analysis Commenced	: 29-Jun-2021
C-O-C number	: ----	Issue Date	: 12-Jul-2021 17:42
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Gloria Chan	Lab Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 232107)											
FJ2100478-001	Anonymous	pH	----	E108	0.10	pH units	8.10	8.11	0.123%	4%	----
Physical Tests (QC Lot: 232108)											
FJ2100478-001	Anonymous	conductivity	----	E100	2.0	µS/cm	2620	2630	0.381%	10%	----
Physical Tests (QC Lot: 232109)											
FJ2100478-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	385	384	0.208%	20%	----
Physical Tests (QC Lot: 232112)											
VA21B3123-002	BJ-GW18-5A-CWP	acidity (as CaCO3)	----	E283	2.0	mg/L	3.3	2.8	0.5	Diff <2x LOR	----
Physical Tests (QC Lot: 232413)											
VA21B3097-004	Anonymous	turbidity	----	E121	0.10	NTU	0.48	0.48	0	Diff <2x LOR	----
Physical Tests (QC Lot: 234844)											
VA21B3122-007	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	13.2	15.0	1.8	Diff <2x LOR	----
Physical Tests (QC Lot: 234920)											
VA21B3111-002	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	225	221	1.79%	20%	----
Anions and Nutrients (QC Lot: 232101)											
FJ2100478-001	Anonymous	fluoride	16984-48-8	E235.F	0.400	mg/L	<0.400	<0.400	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 232102)											
FJ2100478-001	Anonymous	chloride	16887-00-6	E235.Cl	10.0	mg/L	18.5	18.6	0.07	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 232103)											
FJ2100478-001	Anonymous	bromide	24959-67-9	E235.Br-L	1.00	mg/L	<1.00	<1.00	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 232104)											
FJ2100478-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.100	mg/L	55.1	55.1	0.0192%	20%	----
Anions and Nutrients (QC Lot: 232105)											
FJ2100478-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0200	mg/L	0.132	0.139	0.0075	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 232106)											
FJ2100478-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	6.00	mg/L	983	983	0.0441%	20%	----
Anions and Nutrients (QC Lot: 232110)											
FJ2100478-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0013	<0.0010	0.0003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 237047)											
VA21B3027-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0090	0.0108	0.0018	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 237048)											
VA21B3027-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0195	0.0211	7.86%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 237296)											
VA21B3120-004	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	1.11	1.10	0.680%	20%	----
Total Sulfides (QC Lot: 234998)											
CG2102202-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 233009)											
VA21B3116-006	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 233765)											
FJ2100478-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0078	0.0077	0.0001	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00144	0.00136	5.63%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00030	0.00029	0.000002	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0650	0.0649	0.234%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.186	0.178	4.36%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000250	0.0000227	0.0000022	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	263	253	3.87%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00012	0.00011	0.000005	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.396	0.372	6.21%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	115	115	0.107%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00603	0.00600	0.389%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00343	0.00331	3.74%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.0425	0.0426	0.300%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	4.27	4.30	0.871%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.148	0.146	1.71%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	0.57	0.63	0.06	Diff <2x LOR	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	244	245	0.208%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.397	0.377	5.20%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000036	0.000032	0.000003	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 233765) - continued											
FJ2100478-001	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	0.0228	0.0223	1.89%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0033	<0.0030	0.0003	Diff <2x LOR	----
Dissolved Metals (QC Lot: 232916)											
VA21B3116-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 233392)											
FJ2100478-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0021	0.0024	0.0003	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00139	0.00138	0.854%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00030	0.00029	0.000008	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0700	0.0664	5.23%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.169	0.173	2.78%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000187	0.0000208	0.0000021	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	255	262	2.50%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00010	<0.00010	0.000001	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00040	0.00036	0.00004	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.374	0.384	2.61%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	120	116	3.91%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00420	0.00405	3.50%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00332	0.00335	0.776%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.0454	0.0429	5.61%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	4.45	4.36	2.15%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.162	0.163	0.272%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	0.481	0.492	0.011	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	268	254	5.03%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.376	0.385	2.51%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000034	0.000033	0.000001	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 233392) - continued											
FJ2100478-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.0222	0.0228	2.73%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0025	0.0023	0.0002	Diff <2x LOR	----
Aggregate Organics (QC Lot: 235564)											
VA21B2897-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 232108)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 232109)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 232112)						
acidity (as CaCO3)	----	E283	2	mg/L	2.0	----
Physical Tests (QCLot: 232413)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 234844)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 234920)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 232101)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 232102)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 232103)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 232104)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 232105)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 232106)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 232110)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 237047)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 237048)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 237296)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Sulfides (QCLot: 234998)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 233009)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 233765)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Dissolved Metals (QCLot: 232916)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 233392)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 235564)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 232107)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 232108)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.3	90.0	110	----
Physical Tests (QCLot: 232109)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	98.3	85.0	115	----
Physical Tests (QCLot: 232112)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	95.7	85.0	115	----
Physical Tests (QCLot: 232413)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 234844)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	95.3	85.0	115	----
Physical Tests (QCLot: 234920)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	106	85.0	115	----
Anions and Nutrients (QCLot: 232101)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 232102)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 232103)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	99.2	85.0	115	----
Anions and Nutrients (QCLot: 232104)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	99.7	90.0	110	----
Anions and Nutrients (QCLot: 232105)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 232106)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 232110)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	104	80.0	120	----
Anions and Nutrients (QCLot: 237047)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.6	85.0	115	----
Anions and Nutrients (QCLot: 237048)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	90.9	80.0	120	----
Anions and Nutrients (QCLot: 237296)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 237296) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	100	75.0	125	----
Total Sulfides (QCLot: 234998)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	105	80.0	120	----
Total Metals (QCLot: 233009)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	109	80.0	120	----
Total Metals (QCLot: 233765)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	108	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	100	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	95.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	96.2	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	91.3	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.7	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	99.1	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	98.9	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	105	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	98.7	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	98.1	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	115	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	110	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	105	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.4	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	99.6	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	103	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	99.0	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 233765) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	103	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Dissolved Metals (QCLot: 233392)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	105	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	100	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	98.6	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	96.6	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	102	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	99.9	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	108	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.4	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	102	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	103	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	115	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	112	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	111	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	102	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	110	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	98.9	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	104	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	105	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 235564)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	106	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 232101)										
FJ2100481-001	Anonymous	fluoride	16984-48-8	E235.F	4.92 mg/L	5 mg/L	98.4	75.0	125	----
Anions and Nutrients (QCLot: 232102)										
FJ2100481-001	Anonymous	chloride	16887-00-6	E235.Cl	482 mg/L	500 mg/L	96.4	75.0	125	----
Anions and Nutrients (QCLot: 232103)										
FJ2100481-001	Anonymous	bromide	24959-67-9	E235.Br-L	2.28 mg/L	2.5 mg/L	91.0	75.0	125	----
Anions and Nutrients (QCLot: 232104)										
FJ2100481-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	12.1 mg/L	12.5 mg/L	96.8	75.0	125	----
Anions and Nutrients (QCLot: 232105)										
FJ2100481-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.46 mg/L	2.5 mg/L	98.3	75.0	125	----
Anions and Nutrients (QCLot: 232106)										
FJ2100481-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	481 mg/L	500 mg/L	96.2	75.0	125	----
Anions and Nutrients (QCLot: 232110)										
FJ2100480-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	ND mg/L	30 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 237047)										
VA21B3123-001	BJ-GW18-23A - E314690	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Anions and Nutrients (QCLot: 237048)										
VA21B3051-001	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 237296)										
VA21B3123-001	BJ-GW18-23A - E314690	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Total Sulfides (QCLot: 234998)										
CG2102231-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.214 mg/L	0.2 mg/L	107	75.0	125	----
Total Metals (QCLot: 233009)										
VA21B3116-007	Anonymous	mercury, total	7439-97-6	E508	0.000106 mg/L	0.0001 mg/L	106	70.0	130	----
Total Metals (QCLot: 233765)										
FJ2100478-001	Anonymous	aluminum, total	7429-90-5	E420	0.216 mg/L	0.2 mg/L	108	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	99.9	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0205 mg/L	0.02 mg/L	102	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 233765) - continued										
FJ2100478-001	Anonymous	beryllium, total	7440-41-7	E420	0.0382 mg/L	0.04 mg/L	95.5	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00875 mg/L	0.01 mg/L	87.5	70.0	130	----
		boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00382 mg/L	0.004 mg/L	95.6	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0402 mg/L	0.04 mg/L	101	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0194 mg/L	0.02 mg/L	97.1	70.0	130	----
		copper, total	7440-50-8	E420	0.0183 mg/L	0.02 mg/L	91.6	70.0	130	----
		iron, total	7439-89-6	E420	1.98 mg/L	2 mg/L	99.1	70.0	130	----
		lead, total	7439-92-1	E420	0.0182 mg/L	0.02 mg/L	91.0	70.0	130	----
		lithium, total	7439-93-2	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0198 mg/L	0.02 mg/L	99.3	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, total	7440-02-0	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.8 mg/L	10 mg/L	118	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		silicon, total	7440-21-3	E420	10.3 mg/L	10 mg/L	103	70.0	130	----
		silver, total	7440-22-4	E420	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00370 mg/L	0.004 mg/L	92.6	70.0	130	----
		tin, total	7440-31-5	E420	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		titanium, total	7440-32-6	E420	0.0435 mg/L	0.04 mg/L	109	70.0	130	----
		uranium, total	7440-61-1	E420	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, total	7440-62-2	E420	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		zinc, total	7440-66-6	E420	0.371 mg/L	0.4 mg/L	92.8	70.0	130	----
Dissolved Metals (QCLot: 232916)										
VA21B3116-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.000101 mg/L	0.0001 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 233392)										
FJ2100478-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.220 mg/L	0.2 mg/L	110	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0213 mg/L	0.02 mg/L	106	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0389 mg/L	0.04 mg/L	97.3	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 233392) - continued										
FJ2100478-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00827 mg/L	0.01 mg/L	82.7	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00374 mg/L	0.004 mg/L	93.5	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0420 mg/L	0.04 mg/L	105	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0197 mg/L	0.02 mg/L	98.6	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0184 mg/L	0.02 mg/L	91.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	2.00 mg/L	2 mg/L	100	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0181 mg/L	0.02 mg/L	90.6	70.0	130	----
		lithium, dissolved	7439-93-2	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0212 mg/L	0.02 mg/L	106	70.0	130	----
		nickel, dissolved	7440-02-0	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	12.0 mg/L	10 mg/L	120	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		silicon, dissolved	7440-21-3	E421	10.4 mg/L	10 mg/L	104	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00365 mg/L	0.004 mg/L	91.3	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00364 mg/L	0.004 mg/L	91.1	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0199 mg/L	0.02 mg/L	99.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0443 mg/L	0.04 mg/L	111	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.109 mg/L	0.1 mg/L	109	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.380 mg/L	0.4 mg/L	95.0	70.0	130	----
Aggregate Organics (QCLot: 235564)										
VA21B2897-002	Anonymous	chemical oxygen demand [COD]	----	E559	103 mg/L	100 mg/L	103	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	*Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.*

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/CM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-23A - E314690	25-Jun-21	15:30	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW16-5A - CWP	26-Jun-21	11:00	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B3123
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	27-Jun-21	18:00		JUN 28 2021	3:29	8 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B4774**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 19-Jul-2021 21:30
PO	: 1025614	Date Analysis Commenced	: 20-Jul-2021
C-O-C number	: ----	Issue Date	: 27-Jul-2021 18:59
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 5		
No. of samples analysed	: 5		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*
DTC	*Dissolved concentration exceeds total. Results were confirmed by re-analysis.*
HTD	*Hold time exceeded for re-analysis or dilution, but initial testing was conducted within hold time.*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

Client sample ID					Equipment Blank-94	BJ-GW11-1A - E303054	BJ-GW11-1B - E314692	Travel Blank	BJ-GW18-19B - E314703
Client sampling date / time					16-Jul-2021 12:50	17-Jul-2021 15:00	17-Jul-2021 16:00	17-Jul-2021 16:00	18-Jul-2021 15:45
Analyte	CAS Number	Method	LOR	Unit	VA21B4774-001	VA21B4774-002	VA21B4774-003	VA21B4774-004	VA21B4774-005
					Result	Result	Result	Result	Result
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	<1.0	43.2	48.8	<1.0	87.1
conductivity	----	E100	2.0	µS/cm	2.1	144	173	<2.0	467
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	<0.50	67.6	81.1	----	125
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	<0.50	69.5	76.0	<0.50	143
pH	----	E108	0.10	pH units	5.22	7.83	7.89	5.23	8.15
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	81	97	<10	274
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	24.7	14.5	<3.0	38.5
turbidity	----	E121	0.10	NTU	0.44 RRV	8.86	4.52	<0.10	44.8
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	0.0369
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	0.039	0.045	<0.020	0.138
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	0.075
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	0.0246 HTD	0.0268 HTD	<0.0050 HTD	0.0082 HTD
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	0.0246	0.0307	<0.0051	0.0122
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010 HTD	0.0039	<0.0010	0.0040
nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	<0.030	<0.030	0.087
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0011	0.0013	<0.0010	0.0017
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0085 RRV	0.0057	0.0039	<0.0020	0.0320
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	25.0	34.3	<0.30	141
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	<0.0016	<0.0016	<0.0016
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0172 RRV	0.124	0.110	<0.0030	0.712
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	0.00150	0.00121	<0.00010	0.00504
arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	0.00574	0.00535	<0.00010	0.0192
barium, total	7440-39-3	E420	0.00010	mg/L	0.00147 RRV	0.0260	0.0307	<0.00010	0.0591
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: Equipment Blank-94	BJ-GW11-1A - E303054	BJ-GW11-1B - E314692	Travel Blank	BJ-GW18-19B - E314703
				Client sampling date / time	16-Jul-2021 12:50	17-Jul-2021 15:00	17-Jul-2021 16:00	17-Jul-2021 16:00	18-Jul-2021 15:45
					VA21B4774-001	VA21B4774-002	VA21B4774-003	VA21B4774-004	VA21B4774-005
					Result	Result	Result	Result	Result
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	0.043
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	0.0000405	0.0000098	<0.0000050	0.0000300
calcium, total	7440-70-2	E420	0.050	mg/L	0.171 RRV	25.1	27.0	<0.050	45.8
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00062 RRV	0.00382	0.00432	<0.00050	0.00085
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	0.00153	0.00133	<0.00010	0.00175
copper, total	7440-50-8	E420	0.00050	mg/L	0.00292 RRV	0.00117	0.00090	<0.00050	0.00834
iron, total	7439-89-6	E420	0.010	mg/L	<0.010	0.262	0.162	<0.010	1.21
lead, total	7439-92-1	E420	0.000050	mg/L	0.000060 RRV	0.000718	0.000328	<0.000050	0.00209
lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	0.0013	0.0071	<0.0010	0.0779
magnesium, total	7439-95-4	E420	0.100	mg/L	<0.100	1.66	2.09	<0.100	6.89
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00138 RRV	0.0786	0.0199	<0.00010	0.151
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000073 RRV	0.000855	0.000927	<0.000050	0.00393
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	0.00247	0.00293	<0.00050	0.00075
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	<0.300
potassium, total	7440-09-7	E420	0.050	mg/L	<0.050	0.414	0.658	<0.050	3.52
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	0.000342	0.000300	<0.000050	<0.000050
silicon, total	7440-21-3	E420	0.10	mg/L	<0.10	1.47	1.58	<0.10	4.03
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	0.000144	0.000096	<0.000010	0.000339
sodium, total	17341-25-2	E420	0.050	mg/L	0.120 RRV	0.333	2.28	<0.050	44.1
strontium, total	7440-24-6	E420	0.00020	mg/L	0.00313 RRV	0.143	0.324	<0.00020	2.14
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	0.000097
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	0.00037
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	0.000025	0.000034	<0.000010	0.000851
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	0.00135
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	0.0094	0.0035	<0.0030	0.0083
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0024	<0.0010	0.0070	----	0.0049
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	0.00131	0.00119	----	0.00426
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	0.00276	0.00342	----	0.0134

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	Equipment Blank-94	BJ-GW11-1A - E303054	BJ-GW11-1B - E314692	Travel Blank	BJ-GW18-19B - E314703
				Client sampling date / time	16-Jul-2021 12:50	17-Jul-2021 15:00	17-Jul-2021 16:00	17-Jul-2021 16:00	18-Jul-2021 15:45
Analyte	CAS Number	Method	LOR	Unit	VA21B4774-001	VA21B4774-002	VA21B4774-003	VA21B4774-004	VA21B4774-005
					Result	Result	Result	Result	Result
Dissolved Metals									
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00330 DTC	0.0116	0.0240	----	0.0327
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	----	<0.000100
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	<0.000050
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	<0.010	----	0.042
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	0.0000063	<0.0000050	----	<0.0000100 DLM
calcium, dissolved	7440-70-2	E421	0.050	mg/L	0.132	24.4	29.1	----	39.3
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	0.00090	0.00118	----	<0.00050
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00076	0.00062	----	0.00055
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00315	0.00022	0.00102	----	0.00188
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0.012	----	<0.010
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	<0.000050
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	0.0012	0.0073	----	0.0792
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	<0.100	1.62	2.05	----	6.64
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00068	0.00061	0.00111	----	0.0943
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	----	<0.0000050
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000085	0.000845	0.000956	----	0.00412
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00146	0.00198	----	<0.00050
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	----	<0.300
potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	0.376	0.660	----	3.43
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000286	0.000331	----	<0.000050
silicon, dissolved	7440-21-3	E421	0.050	mg/L	<0.050	1.31	1.43	----	2.94
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	----	<0.000010
sodium, dissolved	17341-25-2	E421	0.050	mg/L	0.125	0.333	2.46	----	45.6
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.00236	0.148	0.342	----	2.28
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	----	0.000063
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	----	<0.00010
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	----	<0.0100
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	0.000022	0.000033	----	0.000840
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	----	<0.00050
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0044 DTC	0.0024	0.0042	----	0.0028
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	----	Field
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	----	Field

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**Equipment Blank-94**	**BJ-GW11-1A - E303054**	**BJ-GW11-1B - E314692**	**Travel Blank**	**BJ-GW18-19B - E314703**
				Client sampling date / time	16-Jul-2021 12:50	17-Jul-2021 15:00	17-Jul-2021 16:00	17-Jul-2021 16:00	18-Jul-2021 15:45
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21B4774-001**	**VA21B4774-002**	**VA21B4774-003**	**VA21B4774-004**	**VA21B4774-005**
					Result	Result	Result	Result	Result
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	22	<20	<20

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B4774**	Page	: 1 of 21
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 19-Jul-2021 21:30
PO	: 1025614	Issue Date	: 27-Jul-2021 18:59
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 5		
No. of samples analysed	: 5		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E559	18-Jul-2021	----	----	----		24-Jul-2021	28 days	6 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E559	17-Jul-2021	----	----	----		24-Jul-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1B - E314692	E559	17-Jul-2021	----	----	----		24-Jul-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
Travel Blank	E559	17-Jul-2021	----	----	----		24-Jul-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
Equipment Blank-94	E559	16-Jul-2021	----	----	----		24-Jul-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E298	18-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	28 days	5 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E298	17-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	28 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-1B - E314692	E298	17-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	28 days	6 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Travel Blank	E298	17-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	28 days	6 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Equipment Blank-94	E298	16-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	28 days	7 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-19B - E314703	E235.Br-L	18-Jul-2021	----	----	----		20-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A - E303054	E235.Br-L	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-1B - E314692	E235.Br-L	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.Br-L	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Equipment Blank-94	E235.Br-L	16-Jul-2021	----	----	----		20-Jul-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-19B - E314703	E235.Cl	18-Jul-2021	----	----	----		20-Jul-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-1A - E303054	E235.Cl	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-1B - E314692	E235.Cl	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Travel Blank	E235.Cl	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Equipment Blank-94	E235.Cl	16-Jul-2021	----	----	----		20-Jul-2021	28 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-19B - E314703	E378-U	18-Jul-2021	----	----	----		20-Jul-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-1A - E303054	E378-U	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-1B - E314692	E378-U	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Travel Blank	E378-U	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Equipment Blank-94	E378-U	16-Jul-2021	----	----	----		20-Jul-2021	3 days	4 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-19B - E314703	E235.F	18-Jul-2021	----	----	----		20-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-1A - E303054	E235.F	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-1B - E314692	E235.F	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Travel Blank	E235.F	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Equipment Blank-94	E235.F	16-Jul-2021	----	----	----		20-Jul-2021	28 days	4 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-19B - E314703	E235.NO3-L	18-Jul-2021	----	----	----		20-Jul-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A - E303054	E235.NO3-L	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-1B - E314692	E235.NO3-L	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.NO3-L	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Equipment Blank-94	E235.NO3-L	16-Jul-2021	----	----	----		20-Jul-2021	3 days	4 days	✗ EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-19B - E314703	E235.NO2-L	18-Jul-2021	----	----	----		20-Jul-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A - E303054	E235.NO2-L	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-1B - E314692	E235.NO2-L	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.NO2-L	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Equipment Blank-94	E235.NO2-L	16-Jul-2021	----	----	----		20-Jul-2021	3 days	4 days	✗ EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-19B - E314703	E235.SO4	18-Jul-2021	----	----	----		20-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-1A - E303054	E235.SO4	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-1B - E314692	E235.SO4	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Travel Blank	E235.SO4	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Equipment Blank-94	E235.SO4	16-Jul-2021	----	----	----		20-Jul-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Equipment Blank-94	E366	16-Jul-2021	23-Jul-2021	----	----		26-Jul-2021	28 days	10 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E366	18-Jul-2021	23-Jul-2021	----	----		26-Jul-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E366	17-Jul-2021	23-Jul-2021	----	----		26-Jul-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1B - E314692	E366	17-Jul-2021	23-Jul-2021	----	----		26-Jul-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Travel Blank	E366	17-Jul-2021	23-Jul-2021	----	----		26-Jul-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E372-U	18-Jul-2021	23-Jul-2021	----	----		24-Jul-2021	28 days	6 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E372-U	17-Jul-2021	23-Jul-2021	----	----		24-Jul-2021	28 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW11-1B - E314692	E372-U	17-Jul-2021	23-Jul-2021	----	----		24-Jul-2021	28 days	7 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) Travel Blank	E372-U	17-Jul-2021	23-Jul-2021	----	----		24-Jul-2021	28 days	7 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) Equipment Blank-94	E372-U	16-Jul-2021	23-Jul-2021	----	----		24-Jul-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) BJ-GW18-19B - E314703	E509	18-Jul-2021	22-Jul-2021	----	----		22-Jul-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) BJ-GW11-1A - E303054	E509	17-Jul-2021	22-Jul-2021	----	----		22-Jul-2021	28 days	5 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) BJ-GW11-1B - E314692	E509	17-Jul-2021	22-Jul-2021	----	----		22-Jul-2021	28 days	5 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) Equipment Blank-94	E509	16-Jul-2021	22-Jul-2021	----	----		22-Jul-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW18-19B - E314703	E421	18-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	180 days	5 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW11-1A - E303054	E421	17-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	180 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-1B - E314692	E421	17-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	180 days	6 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Equipment Blank-94	E421	16-Jul-2021	23-Jul-2021	----	----		23-Jul-2021	180 days	7 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-19B - E314703	E283	18-Jul-2021	----	----	----		20-Jul-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-1A - E303054	E283	17-Jul-2021	----	----	----		20-Jul-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-1B - E314692	E283	17-Jul-2021	----	----	----		20-Jul-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
Travel Blank	E283	17-Jul-2021	----	----	----		20-Jul-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
Equipment Blank-94	E283	16-Jul-2021	----	----	----		20-Jul-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-19B - E314703	E290	18-Jul-2021	----	----	----		20-Jul-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-1A - E303054	E290	17-Jul-2021	----	----	----		20-Jul-2021	14 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-1B - E314692	E290	17-Jul-2021	----	----	----		20-Jul-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Travel Blank	E290	17-Jul-2021	----	----	----		20-Jul-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Equipment Blank-94	E290	16-Jul-2021	----	----	----		20-Jul-2021	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-19B - E314703	E100	18-Jul-2021	----	----	----		20-Jul-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-1A - E303054	E100	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-1B - E314692	E100	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
Travel Blank	E100	17-Jul-2021	----	----	----		20-Jul-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
Equipment Blank-94	E100	16-Jul-2021	----	----	----		20-Jul-2021	28 days	4 days	✓
Physical Tests : pH by Meter										
HDPE										
Equipment Blank-94	E108	16-Jul-2021	----	----	----		20-Jul-2021	0.25 hrs	100 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-19B - E314703	E108	18-Jul-2021	----	----	----		20-Jul-2021	0.25 hrs	49 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-1B - E314692	E108	17-Jul-2021	----	----	----		20-Jul-2021	0.25 hrs	73 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
Travel Blank	E108	17-Jul-2021	----	----	----		20-Jul-2021	0.25 hrs	73 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-1A - E303054	E108	17-Jul-2021	----	----	----		20-Jul-2021	0.25 hrs	74 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-19B - E314703	E162	18-Jul-2021	----	----	----		23-Jul-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-1A - E303054	E162	17-Jul-2021	----	----	----		23-Jul-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-1B - E314692	E162	17-Jul-2021	----	----	----		23-Jul-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
Travel Blank	E162	17-Jul-2021	----	----	----		23-Jul-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
Equipment Blank-94	E162	16-Jul-2021	----	----	----		23-Jul-2021	7 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-19B - E314703	E160-H	18-Jul-2021	----	----	----		23-Jul-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-1A - E303054	E160-H	17-Jul-2021	----	----	----		23-Jul-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-1B - E314692	E160-H	17-Jul-2021	----	----	----		23-Jul-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
Travel Blank	E160-H	17-Jul-2021	----	----	----		23-Jul-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
Equipment Blank-94	E160-H	16-Jul-2021	----	----	----		23-Jul-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-19B - E314703	E121	18-Jul-2021	----	----	----		20-Jul-2021	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-1A - E303054	E121	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-1B - E314692	E121	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
Travel Blank	E121	17-Jul-2021	----	----	----		20-Jul-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
Equipment Blank-94	E121	16-Jul-2021	----	----	----		20-Jul-2021	3 days	4 days	× EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-19B - E314703	E508	18-Jul-2021	----	----	----		23-Jul-2021	28 days	5 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-1A - E303054	E508	17-Jul-2021	----	----	----		23-Jul-2021	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-1B - E314692	E508	17-Jul-2021	----	----	----		23-Jul-2021	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
Travel Blank	E508	17-Jul-2021	----	----	----		23-Jul-2021	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
Equipment Blank-94	E508	16-Jul-2021	----	----	----		23-Jul-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-19B - E314703	E420	18-Jul-2021	----	----	----		23-Jul-2021	180 days	5 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-1A - E303054	E420	17-Jul-2021	----	----	----		23-Jul-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-1B - E314692	E420	17-Jul-2021	----	----	----		23-Jul-2021	180 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Travel Blank	E420	17-Jul-2021	----	----	----		23-Jul-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Equipment Blank-94	E420	16-Jul-2021	----	----	----		23-Jul-2021	180 days	7 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-19B - E314703	E395	18-Jul-2021	----	----	----		20-Jul-2021	7 days	2 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-1A - E303054	E395	17-Jul-2021	----	----	----		20-Jul-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-1B - E314692	E395	17-Jul-2021	----	----	----		20-Jul-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
Travel Blank	E395	17-Jul-2021	----	----	----		20-Jul-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
Equipment Blank-94	E395	16-Jul-2021	----	----	----		20-Jul-2021	7 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	247465	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	247464	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	250124	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	247468	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	250912	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	247467	1	20	5.0	5.0	✓
Conductivity in Water	E100	247463	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	249239	1	4	25.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	250113	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	247472	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	247466	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	247469	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	247470	1	15	6.6	5.0	✓
pH by Meter	E108	247462	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	247471	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	250035	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	250440	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	249689	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	250122	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	250123	1	19	5.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	247644	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	250032	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	247426	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	247465	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	247464	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	250124	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	247468	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	250912	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	247467	1	20	5.0	5.0	✓
Conductivity in Water	E100	247463	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	249239	1	4	25.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	250113	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	247472	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	247466	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	247469	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	247470	1	15	6.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	247462	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	247471	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	250035	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	250440	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	249689	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	250122	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	250123	1	19	5.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	247644	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	250032	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	247426	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	247465	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	247464	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	250124	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	247468	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	250912	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	247467	1	20	5.0	5.0	✓
Conductivity in Water	E100	247463	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	249239	1	4	25.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	250113	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	247472	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	247466	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	247469	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	247470	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	247471	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	250035	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	250440	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	249689	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	250122	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	250123	1	19	5.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	247644	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	250032	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	247426	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	250124	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	247468	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	250912	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	247467	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	249239	1	4	25.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	250113	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	247472	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	247466	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	247469	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	247470	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	247471	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	250440	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	249689	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	250122	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	250123	1	19	5.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	247644	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B4774**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 19-Jul-2021 21:30
PO	: 1025614	Date Analysis Commenced	: 20-Jul-2021
C-O-C number	: ----	Issue Date	: 27-Jul-2021 18:59
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 5		
No. of samples analysed	: 5		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Clarie Tejano	Laboratory Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 247426)											
VA21B4709-001	Anonymous	turbidity	----	E121	0.10	NTU	0.94	0.93	0.02	Diff <2x LOR	----
Physical Tests (QC Lot: 247462)											
VA21B4762-001	Anonymous	pH	----	E108	0.10	pH units	7.64	7.63	0.0917%	4%	----
Physical Tests (QC Lot: 247463)											
VA21B4762-001	Anonymous	conductivity	----	E100	2.0	µS/cm	158	158	0.190%	10%	----
Physical Tests (QC Lot: 247464)											
VA21B4762-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	30.7	30.8	0.325%	20%	----
Physical Tests (QC Lot: 247465)											
VA21B4771-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 250032)											
VA21B4722-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	5.7	5.3	0.4	Diff <2x LOR	----
Physical Tests (QC Lot: 250035)											
VA21B4722-001	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	181	188	3.61%	20%	----
Physical Tests (QC Lot: 250493)											
VA21B4730-004	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 250633)											
VA21B4730-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	1660	1590	3.72%	20%	----
Anions and Nutrients (QC Lot: 247466)											
VA21B4762-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.078	0.077	0.0008	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 247467)											
VA21B4762-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	1.04	1.02	0.01	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 247468)											
VA21B4762-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 247469)											
VA21B4762-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	3.47	3.50	0.763%	20%	----
Anions and Nutrients (QC Lot: 247470)											
VA21B4762-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0082	0.0079	0.0003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 247471)											
VA21B4762-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	26.6	26.7	0.0605%	20%	----
Anions and Nutrients (QC Lot: 247472)											
VA21B4762-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 250122)											
KS2102295-001	Anonymous	nitrogen, total	7727-37-9	E366	1.50	mg/L	48.9	48.8	0.289%	20%	----
Anions and Nutrients (QC Lot: 250123)											
VA21B4774-001	Equipment Blank-94	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0085	0.0090	0.0005	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 250124)											
VA21B4774-001	Equipment Blank-94	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 247644)											
CG2102612-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 249689)											
VA21B4879-003	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0244	0.0224	0.0021	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.00167	0.00157	6.20%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000062	0.0000064	0.0000003	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	1.22	1.20	0.917%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	0.161	0.158	2.10%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00063	0.00056	0.00007	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000199	0.000190	0.000009	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.109	0.106	0.002	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.39	1.38	0.957%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	0.546	0.539	1.30%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.00467	0.00472	1.21%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 249689) - continued											
VA21B4879-003	Anonymous	tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000021	0.000018	0.000003	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 250440)											
VA21B4774-001	Equipment Blank-94	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 249239)											
VA21B4774-001	Equipment Blank-94	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 250113)											
FJ2100573-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0094	0.0099	0.0004	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0471	0.0490	3.96%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.016	0.016	0.0006	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	88.6	88.6	0.0527%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.014	0.014	0.0001	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0347	0.0325	6.55%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	50.1	51.4	2.54%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00583	0.00561	3.86%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000312	0.000310	0.000002	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00065	0.00063	0.00002	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	0.059	0.070	0.011	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	2.07	2.11	1.82%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.00456	0.00439	3.88%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	0.236	0.232	0.004	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	11.6	11.6	0.932%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 250113) - continued											
FJ2100573-001	Anonymous	strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.173	0.181	4.60%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00265	0.00260	1.75%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 250912)											
FJ2100583-007	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 247426)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 247463)						
conductivity	----	E100	1	µS/cm	1.0	----
Physical Tests (QCLot: 247464)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 247465)						
acidity (as CaCO3)	----	E283	2	mg/L	2.0	----
Physical Tests (QCLot: 250032)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 250035)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 250493)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 250633)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 247466)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 247467)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 247468)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 247469)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 247470)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 247471)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 247472)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 250122)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 250123)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 250124)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 247644)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 249689)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 250440)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 249239)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 250113)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 250912)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 247426)									
turbidity	----	E121	0.1	NTU	200 NTU	100.0	85.0	115	----
Physical Tests (QCLot: 247462)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 247463)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	104	90.0	110	----
Physical Tests (QCLot: 247464)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100	85.0	115	----
Physical Tests (QCLot: 247465)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	97.9	85.0	115	----
Physical Tests (QCLot: 250032)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	88.2	85.0	115	----
Physical Tests (QCLot: 250035)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	112	85.0	115	----
Physical Tests (QCLot: 250493)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	88.2	85.0	115	----
Physical Tests (QCLot: 250633)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	94.5	85.0	115	----
Anions and Nutrients (QCLot: 247466)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	108	90.0	110	----
Anions and Nutrients (QCLot: 247467)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 247468)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	105	85.0	115	----
Anions and Nutrients (QCLot: 247469)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 247470)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	106	90.0	110	----
Anions and Nutrients (QCLot: 247471)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 247472)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	91.4	80.0	120	----
Anions and Nutrients (QCLot: 250122)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 250122) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 250123)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	98.4	80.0	120	----
Anions and Nutrients (QCLot: 250124)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	103	85.0	115	----
Total Sulfides (QCLot: 247644)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	88.3	80.0	120	----
Total Metals (QCLot: 249689)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	97.2	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	95.0	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	99.4	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	98.0	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	86.9	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	99.1	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	96.8	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	97.8	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	97.1	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	96.8	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.5	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	94.5	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	97.6	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	99.9	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	94.4	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	97.9	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	101	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	97.9	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	93.2	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	101	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	95.9	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	91.6	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	98.7	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 249689) - continued									
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	94.9	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	94.4	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	99.1	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	96.2	80.0	120	----
Total Metals (QCLot: 250440)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	93.2	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	106	80.0	120	----
Dissolved Metals (QCLot: 250113)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	96.2	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	97.1	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.6	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.2	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	94.3	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	93.2	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	100	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	98.3	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.3	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	98.5	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	95.6	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.9	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.1	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	96.1	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	99.0	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	99.8	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	96.5	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	111	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	96.5	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	99.8	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	97.9	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	100	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 250113) - continued									
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	97.7	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	94.8	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	94.2	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	99.0	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	98.5	80.0	120	----
Aggregate Organics (QCLot: 250912)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	105	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 247466)										
VA21B4762-002	Anonymous	fluoride	16984-48-8	E235.F	1.12 mg/L	1 mg/L	112	75.0	125	----
Anions and Nutrients (QCLot: 247467)										
VA21B4762-002	Anonymous	chloride	16887-00-6	E235.Cl	106 mg/L	100 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 247468)										
VA21B4762-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.532 mg/L	0.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 247469)										
VA21B4762-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	ND mg/L	2.5 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 247470)										
VA21B4762-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.546 mg/L	0.5 mg/L	109	75.0	125	----
Anions and Nutrients (QCLot: 247471)										
VA21B4762-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	106 mg/L	100 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 247472)										
VA21B4762-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0301 mg/L	0.03 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 250122)										
VA21B4774-001	Equipment Blank-94	nitrogen, total	7727-37-9	E366	0.418 mg/L	0.4 mg/L	105	70.0	130	----
Anions and Nutrients (QCLot: 250123)										
VA21B4774-002	BJ-GW11-1A - E303054	phosphorus, total	7723-14-0	E372-U	0.0487 mg/L	0.05 mg/L	97.5	70.0	130	----
Anions and Nutrients (QCLot: 250124)										
VA21B4774-002	BJ-GW11-1A - E303054	ammonia, total (as N)	7664-41-7	E298	0.107 mg/L	0.1 mg/L	107	75.0	125	----
Total Sulfides (QCLot: 247644)										
CG2102627-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.197 mg/L	0.2 mg/L	98.6	75.0	125	----
Total Metals (QCLot: 249689)										
VA21B4880-003	Anonymous	aluminum, total	7429-90-5	E420	0.186 mg/L	0.2 mg/L	93.2	70.0	130	----
		antimony, total	7440-36-0	E420	0.0195 mg/L	0.02 mg/L	97.6	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0185 mg/L	0.02 mg/L	92.6	70.0	130	----
		barium, total	7440-39-3	E420	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0398 mg/L	0.04 mg/L	99.4	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00939 mg/L	0.01 mg/L	93.9	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 249689) - continued										
VA21B4880-003	Anonymous	boron, total	7440-42-8	E420	0.088 mg/L	0.1 mg/L	88.0	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00399 mg/L	0.004 mg/L	99.7	70.0	130	----
		calcium, total	7440-70-2	E420	3.83 mg/L	4 mg/L	95.8	70.0	130	----
		chromium, total	7440-47-3	E420	0.0386 mg/L	0.04 mg/L	96.5	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		copper, total	7440-50-8	E420	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		iron, total	7439-89-6	E420	1.93 mg/L	2 mg/L	96.4	70.0	130	----
		lead, total	7439-92-1	E420	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		lithium, total	7439-93-2	E420	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		magnesium, total	7439-95-4	E420	0.938 mg/L	1 mg/L	93.8	70.0	130	----
		manganese, total	7439-96-5	E420	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0191 mg/L	0.02 mg/L	95.5	70.0	130	----
		nickel, total	7440-02-0	E420	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.52 mg/L	10 mg/L	95.2	70.0	130	----
		potassium, total	7440-09-7	E420	3.86 mg/L	4 mg/L	96.5	70.0	130	----
		selenium, total	7782-49-2	E420	0.0384 mg/L	0.04 mg/L	95.9	70.0	130	----
		silicon, total	7440-21-3	E420	9.66 mg/L	10 mg/L	96.6	70.0	130	----
		silver, total	7440-22-4	E420	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		sodium, total	17341-25-2	E420	1.96 mg/L	2 mg/L	97.8	70.0	130	----
		strontium, total	7440-24-6	E420	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		thallium, total	7440-28-0	E420	0.00360 mg/L	0.004 mg/L	90.0	70.0	130	----
		tin, total	7440-31-5	E420	0.0195 mg/L	0.02 mg/L	97.6	70.0	130	----
		titanium, total	7440-32-6	E420	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		uranium, total	7440-61-1	E420	0.00383 mg/L	0.004 mg/L	95.7	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0972 mg/L	0.1 mg/L	97.2	70.0	130	----
		zinc, total	7440-66-6	E420	0.386 mg/L	0.4 mg/L	96.6	70.0	130	----
Total Metals (QCLot: 250440)										
VA21B4774-002	BJ-GW11-1A - E303054	mercury, total	7439-97-6	E508	0.0000940 mg/L	0.0001 mg/L	94.0	70.0	130	----
Dissolved Metals (QCLot: 249239)										
VA21B4774-002	BJ-GW11-1A - E303054	mercury, dissolved	7439-97-6	E509	0.000105 mg/L	0.0001 mg/L	105	70.0	130	----
Dissolved Metals (QCLot: 250113)										
FJ2100573-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.196 mg/L	0.2 mg/L	97.9	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0426 mg/L	0.04 mg/L	106	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 250113) - continued										
FJ2100573-002	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00836 mg/L	0.01 mg/L	83.6	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00410 mg/L	0.004 mg/L	102	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0397 mg/L	0.04 mg/L	99.2	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0188 mg/L	0.02 mg/L	94.3	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0188 mg/L	0.02 mg/L	94.2	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.98 mg/L	2 mg/L	98.9	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0188 mg/L	0.02 mg/L	94.2	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0198 mg/L	0.02 mg/L	99.2	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0374 mg/L	0.04 mg/L	93.5	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.5 mg/L	10 mg/L	105	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.90 mg/L	4 mg/L	97.4	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0409 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.79 mg/L	10 mg/L	97.9	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00355 mg/L	0.004 mg/L	88.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0199 mg/L	0.02 mg/L	99.5	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0405 mg/L	0.04 mg/L	101	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00396 mg/L	0.004 mg/L	99.0	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.385 mg/L	0.4 mg/L	96.4	70.0	130	----
Aggregate Organics (QCLot: 250912)										
FJ2100583-008	Anonymous	chemical oxygen demand [COD]	----	E559	111 mg/L	100 mg/L	111	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	**Analysis Request**
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	Equipment Blank - 94	16-Jul-21	12:50	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-1A - E303054	17-Jul-21	15:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-1B - E314692	17-Jul-21	16:00	Groundwater	X	X		X	X			X	X	X	X		7
	Travel Blank	17-Jul-21	16:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-19B - E314703	18-Jul-21	15:45	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B4774
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	18-Jul-21	18:00				15.4 °C	RJ	JUL-19	21:30	

(Avg of 6 coolers) See page

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B5469**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-Jul-2021 21:20
PO	: 1025614	Date Analysis Commenced	: 28-Jul-2021
C-O-C number	: ----	Issue Date	: 06-Aug-2021 16:10
Sampler	: NG/CM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Ruby Pham	Lab Assistant	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17B - snap	----	----	----	----
				Client sampling date / time	26-Jul-2021 10:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B5469-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	137	----	----	----	----
conductivity	----	E100	2.0	µS/cm	768	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	229	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	243	----	----	----	----
pH	----	E108	0.10	pH units	8.53	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	548	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	92.2	----	----	----	----
turbidity	----	E121	0.10	NTU	116	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.164	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	2.68	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.139	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.267	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0264	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0264	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0050 DLDS	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.293	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0272	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.144	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	258	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	2.16	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	2.30	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	1.06	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00147	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0133	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0638	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17B - snap	----	----	----	----
				Client sampling date / time	26-Jul-2021 10:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B5469-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.052	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000399	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	89.3	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00990	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00136	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00266	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	2.33	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00188	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.105	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	4.80	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.208	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000131	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00133	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00267	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	4.98	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000404	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	4.68	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000165	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	72.3	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	3.33	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000041	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00053	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	0.0106	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000698	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00212	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0109	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0049	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00046	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00804	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17B - snap	----	----	----	----
				Client sampling date / time	26-Jul-2021 10:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B5469-001	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0354	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.045	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	84.5	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.048	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0986	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.30	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.150	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000835	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	4.30	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.00292 DTSE	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.34	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	71.0	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	3.13	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	0.00024	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000556	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0014	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)					Client sample ID	**BJ-GW18-17B - snap**	**----**	**----**	**----**	**----**
					Client sampling date / time	26-Jul-2021 10:00	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*		**VA21B5469-001**	**--------**	**--------**	**--------**	**--------**
						Result	----	----	----	----
Aggregate Organics										
chemical oxygen demand [COD]	----	E559	20	mg/L		68	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B5469**	Page	: 1 of 11
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-Jul-2021 21:20
PO	: 1025614	Issue Date	: 06-Aug-2021 16:10
C-O-C number	: ----		
Sampler	: NG/CM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - snap	E559	26-Jul-2021	----	----	----		04-Aug-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - snap	E298	26-Jul-2021	01-Aug-2021	----	----		03-Aug-2021	28 days	8 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - snap	E235.Br-L	26-Jul-2021	----	----	----		28-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B - snap	E235.Cl	26-Jul-2021	----	----	----		28-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B - snap	E378-U	26-Jul-2021	----	----	----		28-Jul-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B - snap	E235.F	26-Jul-2021	----	----	----		28-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - snap	E235.NO3-L	26-Jul-2021	----	----	----		28-Jul-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - snap	E235.NO2-L	26-Jul-2021	----	----	----		28-Jul-2021	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17B - snap	E235.SO4	26-Jul-2021	----	----	----		28-Jul-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - snap	E366	26-Jul-2021	01-Aug-2021	----	----		04-Aug-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - snap	E372-U	26-Jul-2021	01-Aug-2021	----	----		03-Aug-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B - snap	E509	26-Jul-2021	01-Aug-2021	----	----		01-Aug-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B - snap	E421	26-Jul-2021	29-Jul-2021	----	----		01-Aug-2021	180 days	6 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B - snap	E283	26-Jul-2021	----	----	----		28-Jul-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B - snap	E290	26-Jul-2021	----	----	----		28-Jul-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B - snap	E100	26-Jul-2021	----	----	----		28-Jul-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW18-17B - snap	E108	26-Jul-2021	----	----	----		28-Jul-2021	0.25 hrs	55 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17B - snap	E162	26-Jul-2021	----	----	----		29-Jul-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17B - snap	E160-H	26-Jul-2021	----	----	----		29-Jul-2021	7 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17B - snap	E121	26-Jul-2021	----	----	----		29-Jul-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B - snap	E508	26-Jul-2021	----	----	----		03-Aug-2021	28 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B - snap	E420	26-Jul-2021	----	----	----		30-Jul-2021	180 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17B - snap	E395	26-Jul-2021	----	----	----		29-Jul-2021	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	253850	0	1	0.0	5.0	✗
Alkalinity Species by Titration	E290	253840	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	256663	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	253844	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	257877	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	253843	1	15	6.6	5.0	✓
Conductivity in Water	E100	253839	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	256738	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	254967	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	253849	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	253842	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	253845	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	253846	1	15	6.6	5.0	✓
pH by Meter	E108	253838	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	253847	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	255195	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	257419	1	10	10.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	254691	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	256660	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	256661	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	255127	1	16	6.2	5.0	✓
TSS by Gravimetry	E160-H	255208	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	254215	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	253850	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	253840	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	256663	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	253844	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	257877	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	253843	1	15	6.6	5.0	✓
Conductivity in Water	E100	253839	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	256738	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	254967	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	253849	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	253842	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	253845	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	253846	1	15	6.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	253838	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	253847	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	255195	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	257419	1	10	10.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	254691	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	256660	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	256661	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	255127	1	16	6.2	5.0	✓
TSS by Gravimetry	E160-H	255208	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	254215	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	253850	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	253840	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	256663	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	253844	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	257877	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	253843	1	15	6.6	5.0	✓
Conductivity in Water	E100	253839	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	256738	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	254967	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	253849	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	253842	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	253845	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	253846	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	253847	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	255195	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	257419	1	10	10.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	254691	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	256660	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	256661	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	255127	1	16	6.2	5.0	✓
TSS by Gravimetry	E160-H	255208	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	254215	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	256663	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	253844	1	11	9.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	257877	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	253843	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	256738	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	254967	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	253849	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	253842	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	253845	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	253846	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	253847	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	257419	1	10	10.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	254691	1	18	5.5	5.0	✓
Total Nitrogen by Colourimetry	E366	256660	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	256661	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	255127	1	16	6.2	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B5469**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-Jul-2021 21:20
PO	: 1025614	Date Analysis Commenced	: 28-Jul-2021
C-O-C number	: ----	Issue Date	: 06-Aug-2021 16:10
Sampler	: NG/CM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Ruby Pham	Lab Assistant	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 253838)											
VA21B5461-001	Anonymous	pH	----	E108	0.10	pH units	8.01	8.01	0.00%	4%	----
Physical Tests (QC Lot: 253839)											
VA21B5461-001	Anonymous	conductivity	----	E100	2.0	µS/cm	45700	45900	0.437%	10%	----
Physical Tests (QC Lot: 253840)											
VA21B5461-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	107	108	0.744%	20%	----
Physical Tests (QC Lot: 254215)											
FJ2100597-001	Anonymous	turbidity	----	E121	0.10	NTU	53.4	60.1	11.8%	15%	----
Physical Tests (QC Lot: 255195)											
VA21B5446-002	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	81	85	4	Diff <2x LOR	----
Physical Tests (QC Lot: 255208)											
VA21B5302-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 253842)											
FJ2100603-023	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.134	0.131	0.003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 253843)											
FJ2100603-023	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 253844)											
FJ2100603-023	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 253845)											
FJ2100603-023	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.850	0.846	0.439%	20%	----
Anions and Nutrients (QC Lot: 253846)											
FJ2100603-023	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 253847)											
FJ2100603-023	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	114	114	0.199%	20%	----
Anions and Nutrients (QC Lot: 253849)											
FJ2100603-023	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0101	0.0102	1.16%	20%	----
Anions and Nutrients (QC Lot: 256660)											
VA21B5430-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.120	0.123	0.003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 256661)											
FJ2100597-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.598	0.572	4.44%	20%	----
Anions and Nutrients (QC Lot: 256663)											
KS2102393-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Sulfides (QC Lot: 255127)											
CG2102846-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 254691)											
FJ2100603-009	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0180	0.0172	0.0008	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00013	0.00014	0.000009	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00017	0.00018	0.00001	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.155	0.154	0.514%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000187	0.0000172	0.0000015	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	30.1	29.3	2.74%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.064	0.063	0.001	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0079	0.0078	0.0001	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	12.5	12.4	0.775%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00268	0.00264	1.62%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000723	0.000723	0.0618%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00114	0.00114	0.000004	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.690	0.685	0.651%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.00326	0.00347	6.18%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.53	1.54	0.873%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	4.28	4.21	1.68%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0735	0.0744	1.29%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000556	0.000564	1.52%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 257419)											

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 257419) - continued											
VA21B5456-001	Anonymous	mercury, total	7439-97-6	E508	0.0050	mg/L	<0.0050 µg/L	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 254967)											
VA21B5429-008	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00050	mg/L	0.00098	0.00100	0.00002	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00050	mg/L	0.0219	0.0216	1.16%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000250	mg/L	<0.0000250	<0.0000250	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.250	mg/L	970	947	2.34%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00100	mg/L	0.00116	0.00119	0.00003	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0050	mg/L	0.0481	0.0468	0.0012	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0250	mg/L	12.2	12.0	1.64%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000250	mg/L	0.00784	0.00802	2.24%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.250	mg/L	4.72	4.66	1.23%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000250	mg/L	3.64	3.66	0.344%	20%	----
		silicon, dissolved	7440-21-3	E421	0.250	mg/L	0.423	0.410	0.013	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.250	mg/L	4.04	4.02	0.553%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00100	mg/L	2.80	2.81	0.475%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00050	mg/L	0.00052	0.00053	0.000010	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00150	mg/L	<0.00150	<0.00150	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000050	mg/L	0.000103	0.000094	0.000009	Diff <2x LOR	----
		vanadium, dissolved	7440-62-2	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 256738)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 256738) - continued											
VA21B5427-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 257877)											
VA21B5468-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 253839)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 253840)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 253850)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 254215)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 255195)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 255208)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 253842)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 253843)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 253844)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 253845)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 253846)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 253847)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 253849)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 256660)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 256661)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 256663)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 255127)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 254691)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 257419)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 254967)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 254967) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 256738)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 257877)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 253838)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 253839)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	102	90.0	110	----
Physical Tests (QCLot: 253840)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.6	85.0	115	----
Physical Tests (QCLot: 253850)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	92.9	85.0	115	----
Physical Tests (QCLot: 254215)									
turbidity	----	E121	0.1	NTU	200 NTU	103	85.0	115	----
Physical Tests (QCLot: 255195)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	109	85.0	115	----
Physical Tests (QCLot: 255208)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	88.3	85.0	115	----
Anions and Nutrients (QCLot: 253842)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 253843)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 253844)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 253845)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 253846)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	98.6	90.0	110	----
Anions and Nutrients (QCLot: 253847)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 253849)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 256660)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 256661)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	90.5	80.0	120	----
Anions and Nutrients (QCLot: 256663)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 256663) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	102	85.0	115	----
Total Sulfides (QCLot: 255127)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	106	80.0	120	----
Total Metals (QCLot: 254691)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	99.0	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	101	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	95.1	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	98.7	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.2	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	97.2	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	95.3	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	89.4	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	97.8	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	98.0	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	98.6	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	96.4	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	98.8	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	96.0	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	95.0	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	95.9	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	103	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	97.6	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	92.0	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	97.0	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	97.1	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	98.2	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	96.3	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	93.2	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	90.5	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	96.6	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	98.0	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 257419)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	94.8	80.0	120	----
Dissolved Metals (QCLot: 254967)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	100	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	101	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	96.5	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	101	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	95.7	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	102	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	102	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	94.8	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	100	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	101	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	94.3	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	99.3	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	104	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	99.3	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	102	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	97.6	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	99.8	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	95.9	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	94.3	80.0	120	----
Aggregate Organics (QCLot: 257877)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 257877) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 253842)										
FJ2100603-024	Anonymous	fluoride	16984-48-8	E235.F	0.980 mg/L	1 mg/L	98.0	75.0	125	----
Anions and Nutrients (QCLot: 253843)										
FJ2100603-024	Anonymous	chloride	16887-00-6	E235.Cl	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 253844)										
FJ2100603-024	Anonymous	bromide	24959-67-9	E235.Br-L	0.464 mg/L	0.5 mg/L	92.8	75.0	125	----
Anions and Nutrients (QCLot: 253845)										
FJ2100603-024	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.57 mg/L	2.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 253846)										
FJ2100603-024	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.485 mg/L	0.5 mg/L	97.0	75.0	125	----
Anions and Nutrients (QCLot: 253847)										
FJ2100603-024	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	101 mg/L	100 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 253849)										
FJ2100603-024	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0292 mg/L	0.03 mg/L	97.3	70.0	130	----
Anions and Nutrients (QCLot: 256660)										
VA21B5468-001	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 256661)										
FJ2100597-002	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 256663)										
VA21B5430-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.107 mg/L	0.1 mg/L	107	75.0	125	----
Total Sulfides (QCLot: 255127)										
CG2102846-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.228 mg/L	0.2 mg/L	114	75.0	125	----
Total Metals (QCLot: 254691)										
FJ2100603-019	Anonymous	aluminum, total	7429-90-5	E420	0.188 mg/L	0.2 mg/L	94.0	70.0	130	----
		antimony, total	7440-36-0	E420	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0195 mg/L	0.02 mg/L	97.3	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0390 mg/L	0.04 mg/L	97.5	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00906 mg/L	0.01 mg/L	90.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 254691) - continued										
FJ2100603-019	Anonymous	boron, total	7440-42-8	E420	0.097 mg/L	0.1 mg/L	96.9	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00371 mg/L	0.004 mg/L	92.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0400 mg/L	0.04 mg/L	99.9	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0194 mg/L	0.02 mg/L	96.8	70.0	130	----
		copper, total	7440-50-8	E420	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		iron, total	7439-89-6	E420	1.94 mg/L	2 mg/L	97.3	70.0	130	----
		lead, total	7439-92-1	E420	0.0187 mg/L	0.02 mg/L	93.4	70.0	130	----
		lithium, total	7439-93-2	E420	0.0924 mg/L	0.1 mg/L	92.4	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, total	7440-02-0	E420	0.0391 mg/L	0.04 mg/L	97.7	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.86 mg/L	10 mg/L	98.6	70.0	130	----
		potassium, total	7440-09-7	E420	4.22 mg/L	4 mg/L	105	70.0	130	----
		selenium, total	7782-49-2	E420	0.0417 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, total	7440-21-3	E420	9.36 mg/L	10 mg/L	93.6	70.0	130	----
		silver, total	7440-22-4	E420	0.00399 mg/L	0.004 mg/L	99.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00373 mg/L	0.004 mg/L	93.3	70.0	130	----
		tin, total	7440-31-5	E420	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		titanium, total	7440-32-6	E420	0.0372 mg/L	0.04 mg/L	92.9	70.0	130	----
		uranium, total	7440-61-1	E420	0.00381 mg/L	0.004 mg/L	95.3	70.0	130	----
		vanadium, total	7440-62-2	E420	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, total	7440-66-6	E420	0.402 mg/L	0.4 mg/L	100	70.0	130	----
Total Metals (QCLot: 257419)										
VA21B5461-001	Anonymous	mercury, total	7439-97-6	E508	0.000100 mg/L	0.0001 mg/L	100	70.0	130	----
Dissolved Metals (QCLot: 254967)										
VA21B5429-009	Anonymous	aluminum, dissolved	7429-90-5	E421	1.01 mg/L	1 mg/L	101	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0998 mg/L	0.1 mg/L	99.8	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0990 mg/L	0.1 mg/L	99.0	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.186 mg/L	0.2 mg/L	93.0	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0460 mg/L	0.05 mg/L	92.0	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.433 mg/L	0.5 mg/L	86.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 254967) - continued										
VA21B5429-009	Anonymous	cadmium, dissolved	7440-43-9	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.201 mg/L	0.2 mg/L	100	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0974 mg/L	0.1 mg/L	97.4	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0933 mg/L	0.1 mg/L	93.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	9.34 mg/L	10 mg/L	93.4	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0968 mg/L	0.1 mg/L	96.8	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.486 mg/L	0.5 mg/L	97.2	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	5 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0994 mg/L	0.1 mg/L	99.4	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.190 mg/L	0.2 mg/L	95.3	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	50.8 mg/L	50 mg/L	102	70.0	130	----
		potassium, dissolved	7440-09-7	E421	20.3 mg/L	20 mg/L	101	70.0	130	----
		selenium, dissolved	7782-49-2	E421	ND mg/L	0.2 mg/L	ND	70.0	130	----
		silicon, dissolved	7440-21-3	E421	46.9 mg/L	50 mg/L	93.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.0189 mg/L	0.02 mg/L	94.5	70.0	130	----
		sodium, dissolved	17341-25-2	E421	10.2 mg/L	10 mg/L	102	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.0190 mg/L	0.02 mg/L	94.9	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0982 mg/L	0.1 mg/L	98.2	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.513 mg/L	0.5 mg/L	103	70.0	130	----
		zinc, dissolved	7440-66-6	E421	1.83 mg/L	2 mg/L	91.6	70.0	130	----
Dissolved Metals (QCLot: 256738)										
VA21B5427-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000967 mg/L	0.0001 mg/L	96.7	70.0	130	----
Aggregate Organics (QCLot: 257877)										
VA21B5468-002	Anonymous	chemical oxygen demand [COD]	----	E559	106 mg/L	100 mg/L	106	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	5469	ALS Contact:	Dean Watt	Sampler: NG/CM

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17B - snap	26-Jul-21	10:00	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21B5469
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	26-Jul-21	18:00				8.2 °C	RJ	JUL-27	21:20	

Sample

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B5926**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 03-Aug-2021 11:45
PO	: 1025614	Date Analysis Commenced	: 03-Aug-2021
C-O-C number	: ----	Issue Date	: 09-Aug-2021 16:41
Sampler	: BDT		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Shaneel Dayal	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B - E314703	----	----	----	----
				Client sampling date / time	31-Jul-2021 14:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B5926-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	121	----	----	----	----
conductivity	----	E100	2.0	µS/cm	597	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	130	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	161	----	----	----	----
pH	----	E108	0.10	pH units	8.32	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	493	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	468	----	----	----	----
turbidity	----	E121	0.10	NTU	613	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.112	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	3.31	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.344	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.209	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.209	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0114	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.293	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	190	----	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	0.554	----	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	0.521	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	6.39	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00326	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0808	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.160	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000586	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B - E314703	----	----	----	----
				Client sampling date / time	31-Jul-2021 14:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B5926-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	0.000192	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.046	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000106	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	55.5	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.0501	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.0136	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0148	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	7.96	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00844	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.189	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	5.35	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.561	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000710 DLM	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.0108	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.0450	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	3.02	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.00112	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	10.6	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.00671	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	68.8	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.78	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000162	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00017	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	0.0428	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000380	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.0103	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0364	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0075	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00090	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0418	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B - E314703	----	----	----	----
				Client sampling date / time	31-Jul-2021 14:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B5926-001	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0249	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.043	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	48.3	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00019	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.074	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.170	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	2.22	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.224	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00539	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00074	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.88	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000221	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.37	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	67.3	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.66	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000186	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0028	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)					Client sample ID	**BJ-GW18-17B - E314703**	**----**	**----**	**----**	**----**
					Client sampling date / time	31-Jul-2021 14:00	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*		**VA21B5926-001**	**--------**	**--------**	**--------**	**--------**
						Result	----	----	----	----
Aggregate Organics										
chemical oxygen demand [COD]	----	E559	20	mg/L		37	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B5926**	Page	: 1 of 12
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 03-Aug-2021 11:45
PO	: 1025614	Issue Date	: 09-Aug-2021 16:41
C-O-C number	: ----		
Sampler	: BDT		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Dissolved Metals	QC-260891-001	----	magnesium, dissolved	7439-95-4	E421	0.0053 B mg/L	0.005 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314703	E559	31-Jul-2021	----	----	----		09-Aug-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314703	E298	31-Jul-2021	04-Aug-2021	----	----		04-Aug-2021	28 days	4 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - E314703	E235.Br-L	31-Jul-2021	----	----	----		03-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B - E314703	E235.Cl	31-Jul-2021	----	----	----		03-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B - E314703	E378-U	31-Jul-2021	----	----	----		04-Aug-2021	3 days	3 days	✗ EHTL
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B - E314703	E235.F	31-Jul-2021	----	----	----		03-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - E314703	E235.NO3-L	31-Jul-2021	----	----	----		03-Aug-2021	3 days	3 days	✗ EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - E314703	E235.NO2-L	31-Jul-2021	----	----	----		03-Aug-2021	3 days	3 days	× EHTL
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17B - E314703	E235.SO4	31-Jul-2021	----	----	----		03-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314703	E366	31-Jul-2021	04-Aug-2021	----	----		05-Aug-2021	28 days	5 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314703	E372-U	31-Jul-2021	04-Aug-2021	----	----		05-Aug-2021	28 days	5 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B - E314703	E509	31-Jul-2021	07-Aug-2021	----	----		07-Aug-2021	28 days	7 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B - E314703	E421	31-Jul-2021	07-Aug-2021	----	----		08-Aug-2021	180 days	8 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B - E314703	E283	31-Jul-2021	----	----	----		04-Aug-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B - E314703	E290	31-Jul-2021	----	----	----		04-Aug-2021	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B - E314703	E100	31-Jul-2021	----	----	----		04-Aug-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW18-17B - E314703	E108	31-Jul-2021	----	----	----		04-Aug-2021	0.25 hrs	88 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17B - E314703	E162	31-Jul-2021	----	----	----		04-Aug-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17B - E314703	E160-H	31-Jul-2021	----	----	----		04-Aug-2021	7 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17B - E314703	E121	31-Jul-2021	----	----	----		03-Aug-2021	3 days	3 days	✗ EHTL
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B - E314703	E508	31-Jul-2021	----	----	----		08-Aug-2021	28 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B - E314703	E420	31-Jul-2021	----	----	----		05-Aug-2021	180 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17B - E314703	E395-H	31-Jul-2021	----	----	----		03-Aug-2021	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	257542	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	257544	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	257961	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	257550	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	261798	1	13	7.6	5.0	✓
Chloride in Water by IC	E235.Cl	257549	1	12	8.3	5.0	✓
Conductivity in Water	E100	257545	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	261192	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	260891	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	257555	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	257548	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	257551	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	257552	1	12	8.3	5.0	✓
pH by Meter	E108	257543	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	257547	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	258803	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	261490	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	257864	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	257962	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	257959	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	257613	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	258806	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	257719	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	257542	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	257544	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	257961	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	257550	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	261798	1	13	7.6	5.0	✓
Chloride in Water by IC	E235.Cl	257549	1	12	8.3	5.0	✓
Conductivity in Water	E100	257545	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	261192	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	260891	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	257555	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	257548	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	257551	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	257552	1	12	8.3	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	257543	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	257547	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	258803	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	261490	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	257864	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	257962	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	257959	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	257613	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	258806	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	257719	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	257542	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	257544	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	257961	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	257550	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	261798	1	13	7.6	5.0	✓
Chloride in Water by IC	E235.Cl	257549	1	12	8.3	5.0	✓
Conductivity in Water	E100	257545	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	261192	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	260891	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	257555	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	257548	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	257551	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	257552	1	12	8.3	5.0	✓
Sulfate in Water by IC	E235.SO4	257547	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	258803	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	261490	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	257864	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	257962	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	257959	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	257613	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	258806	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	257719	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	257961	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	257550	1	5	20.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	261798	1	13	7.6	5.0	✓
Chloride in Water by IC	E235.Cl	257549	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	261192	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	260891	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	257555	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	257548	1	12	8.3	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	257551	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	257552	1	12	8.3	5.0	✓
Sulfate in Water by IC	E235.SO4	257547	1	14	7.1	5.0	✓
Total Mercury in Water by CVAAS	E508	261490	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	257864	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	257962	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	257959	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	257613	1	3	33.3	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B5926**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 03-Aug-2021 11:45
PO	: 1025614	Date Analysis Commenced	: 03-Aug-2021
C-O-C number	: ----	Issue Date	: 09-Aug-2021 16:41
Sampler	: BDT		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Shaneel Dayal	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 257542)											
VA21B5926-001	BJ-GW18-17B - E314703	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 257543)											
VA21B5929-001	Anonymous	pH	----	E108	0.10	pH units	7.94	7.92	0.252%	4%	----
Physical Tests (QC Lot: 257544)											
VA21B5929-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	44.6	46.0	3.09%	20%	----
Physical Tests (QC Lot: 257545)											
VA21B5929-001	Anonymous	conductivity	----	E100	2.0	µS/cm	106	106	0.283%	10%	----
Physical Tests (QC Lot: 257719)											
FJ2100643-001	Anonymous	turbidity	----	E121	0.10	NTU	27.3	29.2	6.72%	15%	----
Physical Tests (QC Lot: 258803)											
VA21B5799-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	351	358	1.98%	20%	----
Physical Tests (QC Lot: 258806)											
VA21B5885-002	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	653	710	8.45%	20%	----
Anions and Nutrients (QC Lot: 257547)											
VA21B5904-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	39.5	39.5	0.0964%	20%	----
Anions and Nutrients (QC Lot: 257548)											
VA21B5904-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.079	0.079	0.0005	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 257549)											
VA21B5904-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 257550)											
VA21B5904-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 257551)											
VA21B5904-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0315	0.0302	0.0012	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 257552)											
VA21B5904-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 257555)											
VA21B5904-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0047	0.0050	0.0003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 257959)											
FJ2100646-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	5.86	5.89	0.612%	20%	----
Anions and Nutrients (QC Lot: 257961)											
FJ2100646-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0250	mg/L	2.68	2.70	0.761%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 257962)											
FJ2100646-001	Anonymous	nitrogen, total	7727-37-9	E366	0.300	mg/L	9.95	10.1	1.21%	20%	----
Total Sulfides (QC Lot: 257613)											
VA21B5926-001	BJ-GW18-17B - E314703	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	0.521	0.527	1.11%	20%	----
Total Metals (QC Lot: 257864)											
VA21B5904-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.593	0.597	0.531%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00167	0.00168	0.343%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00137	0.00146	6.60%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0409	0.0411	0.342%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000084	0.000087	0.000004	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.025	0.026	0.0005	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000352	0.0000347	0.0000005	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	42.4	42.6	0.418%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00037	0.00036	0.000002	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00113	0.00097	0.00016	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.339	0.339	0.0673%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000592	0.000591	0.122%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0038	0.0038	0.00008	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	35.4	35.7	0.593%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.0255	0.0259	1.29%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00634	0.00640	1.05%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00164	0.00159	0.00006	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	1.27	1.28	0.209%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000582	0.000640	9.53%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	4.06	3.97	2.28%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.000042	0.000049	0.000007	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	2.99	3.13	4.38%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.316	0.316	0.119%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000018	0.000017	0.0000005	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00427	0.00413	3.34%	20%	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.0120	0.0120	0.218%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00095	0.00092	0.00002	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 257864) - continued											
VA21B5904-001	Anonymous	zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 261490)											
VA21B5926-001	BJ-GW18-17B - E314703	mercury, total	7439-97-6	E508	0.0000500	mg/L	0.0000710	0.0000845	0.0000135	Diff <2x LOR	----
Dissolved Metals (QC Lot: 260891)											
VA21B5867-004	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.295	0.290	1.87%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00032	0.00032	0.000006	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00135	0.00133	1.54%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0781	0.0759	2.90%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.086	0.086	0.0003	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.000114	0.000110	3.38%	20%	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	47.5	46.6	1.90%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	0.00191	0.00193	0.00001	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00029	0.00030	0.000008	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00428	0.00429	0.149%	20%	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.038	0.035	0.003	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0058	0.0058	0.00005	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	25.6	25.4	0.989%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0688	0.0670	2.62%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00474	0.00481	1.51%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00082	0.00080	0.00001	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	9.03	8.66	4.15%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000306	0.000304	0.000002	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	7.06	6.90	2.37%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	237	238	0.318%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.429	0.429	0.0187%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000013	0.000013	0.0000006	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	0.00061	0.00059	0.00001	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00162	0.00159	1.86%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00437	0.00436	0.000002	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 260891) - continued											
VA21B5867-004	Anonymous	zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0053	0.0054	0.0001	Diff <2x LOR	----
Dissolved Metals (QC Lot: 261192)											
VA21B5805-024	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	0.0000124	0.0000120	0.0000004	Diff <2x LOR	----
Aggregate Organics (QC Lot: 261798)											
KS2102452-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	85	52	32	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 257542)						
acidity (as CaCO3)	----	E283	2	mg/L	2.7	----
Physical Tests (QCLot: 257544)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 257545)						
conductivity	----	E100	1	µS/cm	1.0	----
Physical Tests (QCLot: 257719)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 258803)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 258806)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 257547)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 257548)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 257549)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 257550)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 257551)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 257552)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 257555)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 257959)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 257961)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 257962)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Sulfides (QCLot: 257613)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 257864)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 261490)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 260891)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 260891) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	# 0.0053	B
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 261192)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 261798)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 257542)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	95.7	85.0	115	----
Physical Tests (QCLot: 257543)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 257544)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.6	85.0	115	----
Physical Tests (QCLot: 257545)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	95.6	90.0	110	----
Physical Tests (QCLot: 257719)									
turbidity	----	E121	0.1	NTU	200 NTU	103	85.0	115	----
Physical Tests (QCLot: 258803)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	102	85.0	115	----
Physical Tests (QCLot: 258806)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	91.5	85.0	115	----
Anions and Nutrients (QCLot: 257547)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 257548)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	107	90.0	110	----
Anions and Nutrients (QCLot: 257549)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 257550)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	104	85.0	115	----
Anions and Nutrients (QCLot: 257551)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 257552)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 257555)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 257959)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	96.2	80.0	120	----
Anions and Nutrients (QCLot: 257961)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	98.9	85.0	115	----
Anions and Nutrients (QCLot: 257962)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 257962) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Total Sulfides (QCLot: 257613)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	96.0	80.0	120	----
Total Metals (QCLot: 257864)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	98.9	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	94.3	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	97.8	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	99.8	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	98.3	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	88.3	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	97.4	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	95.1	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	96.9	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	97.1	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	95.6	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	101	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	97.2	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	93.7	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	97.7	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	95.6	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	94.8	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.9	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	92.3	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	95.3	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	97.5	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	92.5	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	98.9	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	93.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	94.0	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	96.7	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	95.2	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 261490)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	103	80.0	120	----
Dissolved Metals (QCLot: 260891)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	101	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	101	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	105	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	98.2	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	97.2	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	94.6	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	99.9	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.5	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	105	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.4	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	105	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	103	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	104	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	103	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	94.4	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	97.4	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	100	80.0	120	----
vanadium, dissolved	7440-62-2	E421	----	mg/L	0.5 mg/L	98.7	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	97.5	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Aggregate Organics (QCLot: 261798)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 261798) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	104	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 257547)										
VA21B5904-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	105 mg/L	100 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 257548)										
VA21B5904-002	Anonymous	fluoride	16984-48-8	E235.F	1.06 mg/L	1 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 257549)										
VA21B5904-002	Anonymous	chloride	16887-00-6	E235.Cl	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 257550)										
VA21B5904-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.525 mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 257551)										
VA21B5904-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.60 mg/L	2.5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 257552)										
VA21B5904-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.516 mg/L	0.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 257555)										
VA21B5904-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0343 mg/L	0.03 mg/L	114	70.0	130	----
Anions and Nutrients (QCLot: 257959)										
FJ2100646-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0483 mg/L	0.05 mg/L	96.6	70.0	130	----
Anions and Nutrients (QCLot: 257961)										
FJ2100646-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.102 mg/L	0.1 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 257962)										
FJ2100646-002	Anonymous	nitrogen, total	7727-37-9	E366	0.400 mg/L	0.4 mg/L	100.0	70.0	130	----
Total Sulfides (QCLot: 257613)										
VA21B5941-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.973 mg/L	1 mg/L	97.3	75.0	125	----
Total Metals (QCLot: 257864)										
VA21B5904-002	Anonymous	aluminum, total	7429-90-5	E420	0.202 mg/L	0.2 mg/L	101	70.0	130	----
		antimony, total	7440-36-0	E420	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0200 mg/L	0.02 mg/L	99.8	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0417 mg/L	0.04 mg/L	104	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00969 mg/L	0.01 mg/L	96.9	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 257864) - continued										
VA21B5904-002	Anonymous	boron, total	7440-42-8	E420	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00398 mg/L	0.004 mg/L	99.4	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0198 mg/L	0.02 mg/L	99.1	70.0	130	----
		copper, total	7440-50-8	E420	0.0200 mg/L	0.02 mg/L	99.8	70.0	130	----
		iron, total	7439-89-6	E420	1.97 mg/L	2 mg/L	98.6	70.0	130	----
		lead, total	7439-92-1	E420	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		lithium, total	7439-93-2	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, total	7440-02-0	E420	0.0401 mg/L	0.04 mg/L	100	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.2 mg/L	10 mg/L	102	70.0	130	----
		potassium, total	7440-09-7	E420	4.21 mg/L	4 mg/L	105	70.0	130	----
		selenium, total	7782-49-2	E420	0.0427 mg/L	0.04 mg/L	107	70.0	130	----
		silicon, total	7440-21-3	E420	9.52 mg/L	10 mg/L	95.2	70.0	130	----
		silver, total	7440-22-4	E420	0.00413 mg/L	0.004 mg/L	103	70.0	130	----
		sodium, total	17341-25-2	E420	2.11 mg/L	2 mg/L	106	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00383 mg/L	0.004 mg/L	95.8	70.0	130	----
		tin, total	7440-31-5	E420	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		titanium, total	7440-32-6	E420	0.0413 mg/L	0.04 mg/L	103	70.0	130	----
		uranium, total	7440-61-1	E420	0.00389 mg/L	0.004 mg/L	97.2	70.0	130	----
		vanadium, total	7440-62-2	E420	0.101 mg/L	0.1 mg/L	101	70.0	130	----
		zinc, total	7440-66-6	E420	0.384 mg/L	0.4 mg/L	96.1	70.0	130	----
Total Metals (QCLot: 261490)										
VA21B5936-001	Anonymous	mercury, total	7439-97-6	E508	0.000475 mg/L	0.0005 mg/L	94.9	70.0	130	----
Dissolved Metals (QCLot: 260891)										
VA21B5868-003	Anonymous	aluminum, dissolved	7429-90-5	E421	0.408 mg/L	0.4 mg/L	102	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0394 mg/L	0.04 mg/L	98.4	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0392 mg/L	0.04 mg/L	97.9	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0802 mg/L	0.08 mg/L	100	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0173 mg/L	0.02 mg/L	86.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.185 mg/L	0.2 mg/L	92.4	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 260891) - continued										
VA21B5868-003	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00740 mg/L	0.008 mg/L	92.5	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0787 mg/L	0.08 mg/L	98.4	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0384 mg/L	0.04 mg/L	96.0	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0377 mg/L	0.04 mg/L	94.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	3.86 mg/L	4 mg/L	96.4	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0371 mg/L	0.04 mg/L	92.8	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.186 mg/L	0.2 mg/L	92.9	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0748 mg/L	0.08 mg/L	93.5	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	22.2 mg/L	20 mg/L	111	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0782 mg/L	0.08 mg/L	97.8	70.0	130	----
		silicon, dissolved	7440-21-3	E421	19.9 mg/L	20 mg/L	99.4	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00750 mg/L	0.008 mg/L	93.7	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00735 mg/L	0.008 mg/L	91.9	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0770 mg/L	0.08 mg/L	96.2	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00784 mg/L	0.008 mg/L	98.0	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.744 mg/L	0.8 mg/L	92.9	70.0	130	----
Dissolved Metals (QCLot: 261192)										
VA21B5805-025	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000999 mg/L	0.0001 mg/L	99.9	70.0	130	----
Aggregate Organics (QCLot: 261798)										
KS2102452-002	Anonymous	chemical oxygen demand [COD]	----	E559	104 mg/L	100 mg/L	104	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** BDT

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17B - E314701	31-Jul-21	14:00	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B5926
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
BDEHAYTURNER	1-Aug-21	18:00	KS ice packs	Aug 3, 2021	11:45am	8, 5 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B7639**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 19-Aug-2021 20:50
PO	: 1025614	Date Analysis Commenced	: 21-Aug-2021
C-O-C number	: ----	Issue Date	: 01-Sep-2021 16:47
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-19B - E314703	----	----	----	----
				Client sampling date / time	18-Aug-2021 13:35	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B7639-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	84.4	----	----	----	----
conductivity	----	E100	2.0	µS/cm	438	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	111	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	121	----	----	----	----
pH	----	E108	0.10	pH units	8.21	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	254	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	17.6	----	----	----	----
turbidity	----	E121	0.10	NTU	23.8	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0323	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.129	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0036	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.039	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0027	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0079	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	120	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.394	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00420	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0184	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0360	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW18-19B - E314703	----	----	----	----
					Client sampling date / time	18-Aug-2021 13:35	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21B7639-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
beryllium, total	7440-41-7	E420	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L		<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L		0.046	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.0000157	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L		38.7	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L		<0.00050	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00103	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.00292	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L		0.398	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L		0.00105	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L		0.0807	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		5.95	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.118	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.00344	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L		<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L		3.25	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L		<0.000050	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L		3.60	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L		0.000291	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L		44.0	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L		1.94	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L		0.000087	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L		<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L		<0.0100	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000660	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00090	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0037	----	----	----	----
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0119	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW18-19B - E314703	----	----	----	----
					Client sampling date / time	18-Aug-2021 13:35	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21B7639-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00391	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.0170	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0271	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		0.042	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		0.0000077	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		34.4	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00063	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.00120	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0705	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		6.03	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.105	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.00351	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		3.00	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000090	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		2.98	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		40.8	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		1.99	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		0.000076	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000672	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-19B - E314703**	**----**	**----**	**----**	**----**
				Client sampling date / time	18-Aug-2021 13:35	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21B7639-001**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0020	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B7639**	Page	: 1 of 11
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 19-Aug-2021 20:50
PO	: 1025614	Issue Date	: 01-Sep-2021 16:46
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E559	18-Aug-2021	----	----	----		27-Aug-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E298	18-Aug-2021	26-Aug-2021	----	----		26-Aug-2021	28 days	8 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-19B - E314703	E235.Br-L	18-Aug-2021	----	----	----		21-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-19B - E314703	E235.Cl	18-Aug-2021	----	----	----		21-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-19B - E314703	E378-U	18-Aug-2021	----	----	----		21-Aug-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-19B - E314703	E235.F	18-Aug-2021	----	----	----		21-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-19B - E314703	E235.NO3-L	18-Aug-2021	----	----	----		21-Aug-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-19B - E314703	E235.NO2-L	18-Aug-2021	----	----	----		21-Aug-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-19B - E314703	E235.SO4	18-Aug-2021	----	----	----		21-Aug-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E366	18-Aug-2021	26-Aug-2021	----	----		27-Aug-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-19B - E314703	E372-U	18-Aug-2021	26-Aug-2021	----	----		26-Aug-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-19B - E314703	E509	18-Aug-2021	26-Aug-2021	----	----		26-Aug-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-19B - E314703	E421	18-Aug-2021	26-Aug-2021	----	----		26-Aug-2021	180 days	9 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-19B - E314703	E283	18-Aug-2021	----	----	----		21-Aug-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-19B - E314703	E290	18-Aug-2021	----	----	----		21-Aug-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-19B - E314703	E100	18-Aug-2021	----	----	----		21-Aug-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW18-19B - E314703	E108	18-Aug-2021	----	----	----		21-Aug-2021	0.25 hrs	67 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-19B - E314703	E162	18-Aug-2021	----	----	----		24-Aug-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-19B - E314703	E160-H	18-Aug-2021	----	----	----		24-Aug-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-19B - E314703	E121	18-Aug-2021	----	----	----		21-Aug-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-19B - E314703	E508	18-Aug-2021	----	----	----		26-Aug-2021	28 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-19B - E314703	E420	18-Aug-2021	----	----	----		27-Aug-2021	180 days	9 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-19B - E314703	E395	18-Aug-2021	----	----	----		25-Aug-2021	7 days	7 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	272694	0	1	0.0	5.0	✗
Alkalinity Species by Titration	E290	272692	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	276584	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	272681	1	6	16.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	277637	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	272680	1	19	5.2	5.0	✓
Conductivity in Water	E100	272691	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	276501	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	276342	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	272693	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	272679	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	272682	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	272683	1	19	5.2	5.0	✓
pH by Meter	E108	272690	1	13	7.6	5.0	✓
Sulfate in Water by IC	E235.SO4	272684	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	275231	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	277123	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	276471	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	276588	1	9	11.1	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	276583	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	275927	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	275234	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	273068	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	272694	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	272692	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	276584	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	272681	1	6	16.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	277637	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	272680	1	19	5.2	5.0	✓
Conductivity in Water	E100	272691	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	276501	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	276342	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	272693	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	272679	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	272682	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	272683	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	272690	1	13	7.6	5.0	✓
Sulfate in Water by IC	E235.SO4	272684	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	275231	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	277123	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	276471	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	276588	1	9	11.1	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	276583	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	275927	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	275234	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	273068	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	272694	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	272692	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	276584	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	272681	1	6	16.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	277637	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	272680	1	19	5.2	5.0	✓
Conductivity in Water	E100	272691	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	276501	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	276342	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	272693	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	272679	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	272682	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	272683	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	272684	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	275231	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	277123	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	276471	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	276588	1	9	11.1	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	276583	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	275927	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	275234	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	273068	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	276584	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	272681	1	6	16.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	277637	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	272680	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	276501	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	276342	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	272693	1	13	7.6	5.0	✓
Fluoride in Water by IC	E235.F	272679	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	272682	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	272683	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	272684	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	277123	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	276471	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	276588	1	9	11.1	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	276583	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	275927	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B7639**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 19-Aug-2021 20:50
PO	: 1025614	Date Analysis Commenced	: 21-Aug-2021
C-O-C number	: ----	Issue Date	: 01-Sep-2021 16:47
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 272690)											
VA21B7639-001	BJ-GW18-19B - E314703	pH	----	E108	0.10	pH units	8.21	8.23	0.243%	4%	----
Physical Tests (QC Lot: 272691)											
VA21B7639-001	BJ-GW18-19B - E314703	conductivity	----	E100	2.0	µS/cm	438	439	0.228%	10%	----
Physical Tests (QC Lot: 272692)											
VA21B7639-001	BJ-GW18-19B - E314703	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	84.4	85.1	0.826%	20%	----
Physical Tests (QC Lot: 273068)											
VA21B7610-001	Anonymous	turbidity	----	E121	0.10	NTU	<0.10	<0.10	0	Diff <2x LOR	----
Physical Tests (QC Lot: 275231)											
VA21B7627-001	Anonymous	solids, total dissolved [TDS]	----	E162	10	mg/L	11	12	0.8	Diff <2x LOR	----
Physical Tests (QC Lot: 275234)											
KS2102644-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	35.6	39.0	9.12%	20%	----
Anions and Nutrients (QC Lot: 272679)											
VA21B7634-002	Anonymous	fluoride	16984-48-8	E235.F	0.400	mg/L	<0.400	<0.400	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 272680)											
VA21B7634-002	Anonymous	chloride	16887-00-6	E235.Cl	10.0	mg/L	191	191	0.0914%	20%	----
Anions and Nutrients (QC Lot: 272681)											
VA21B7634-002	Anonymous	bromide	24959-67-9	E235.Br-L	1.00	mg/L	<1.00	<1.00	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 272682)											
VA21B7634-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.100	mg/L	10.8	11.0	1.60%	20%	----
Anions and Nutrients (QC Lot: 272683)											
VA21B7634-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0200	mg/L	0.0692	0.0673	0.0019	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 272684)											
VA21B7634-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	6.00	mg/L	1910	1910	0.0366%	20%	----
Anions and Nutrients (QC Lot: 272693)											
VA21B7639-001	BJ-GW18-19B - E314703	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0027	0.0027	0.000008	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 276583)											
VA21B7627-004	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 276584)											
VA21B7627-004	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 276588)											
VA21B7639-001	BJ-GW18-19B - E314703	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.039	0.043	0.004	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Sulfides (QC Lot: 275927)											
CG2103409-021	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0035	0.0038	0.0004	Diff <2x LOR	----
Total Metals (QC Lot: 276471)											
FJ2100764-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0098	0.0094	0.0004	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00017	0.00016	0.000002	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00021	0.00022	0.000009	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.121	0.118	3.07%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.020	0.020	0.0003	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000274	0.0000313	0.0000039	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	139	139	0.0351%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00070	0.00071	0.00002	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.014	0.016	0.003	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0356	0.0357	0.242%	20%	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	97.9	98.7	0.806%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00059	0.00063	0.00004	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000966	0.000980	1.51%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00165	0.00160	0.00005	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	2.64	2.64	0.00342%	20%	----
		selenium, total	7782-49-2	E420	0.050	mg/L	4.82 µg/L	0.00480	0.461%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	2.39	2.44	1.70%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	51.4	52.0	1.13%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.617	0.617	0.000554%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00439	0.00450	2.50%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 277123)											

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 277123) - continued											
VA21B7639-001	BJ-GW18-19B - E314703	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 276342)											
FJ2100763-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0046	0.0048	0.0002	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00168	0.00170	1.40%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00056	0.00053	0.00003	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0897	0.0927	3.29%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.153	0.150	1.90%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000459	0.0000479	0.0000020	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	157	158	0.597%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00073	0.00074	0.000006	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00085	0.00086	0.000010	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.254	0.254	0.238%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	69.3	69.9	0.882%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00550	0.00561	1.87%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00675	0.00684	1.21%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.0191	0.0191	0.134%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	4.00	4.00	0.110%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.0532	0.0500	6.16%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.70	2.71	0.268%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	182	183	0.550%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.261	0.264	1.14%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000037	0.000038	0.000001	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.0129	0.0129	0.0864%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00080	0.00081	0.000007	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0022	0.0024	0.0001	Diff <2x LOR	----
Dissolved Metals (QC Lot: 276501)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 276501) - continued											
VA21B7639-001	BJ-GW18-19B - E314703	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 277637)											
VA21B7611-005	Anonymous	chemical oxygen demand [COD]	----	E559	20000	mg/L	115000 µg/L	118	3	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 272691)						
conductivity	----	E100	1	µS/cm	1.0	----
Physical Tests (QCLot: 272692)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 272694)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 273068)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 275231)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 275234)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 272679)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 272680)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 272681)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 272682)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 272683)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 272684)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 272693)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 276583)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 276584)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 276588)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Sulfides (QCLot: 275927)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 276471)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 277123)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 276342)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 276342) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 276501)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 277637)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 272690)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 272691)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	103	90.0	110	----
Physical Tests (QCLot: 272692)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	96.0	85.0	115	----
Physical Tests (QCLot: 272694)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	93.0	85.0	115	----
Physical Tests (QCLot: 273068)									
turbidity	----	E121	0.1	NTU	200 NTU	103	85.0	115	----
Physical Tests (QCLot: 275231)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	90.4	85.0	115	----
Physical Tests (QCLot: 275234)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	94.0	85.0	115	----
Anions and Nutrients (QCLot: 272679)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	99.8	90.0	110	----
Anions and Nutrients (QCLot: 272680)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 272681)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	97.9	85.0	115	----
Anions and Nutrients (QCLot: 272682)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 272683)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	99.2	90.0	110	----
Anions and Nutrients (QCLot: 272684)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 272693)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 276583)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.4	80.0	120	----
Anions and Nutrients (QCLot: 276584)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	98.0	85.0	115	----
Anions and Nutrients (QCLot: 276588)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 276588) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Total Sulfides (QCLot: 275927)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	108	80.0	120	----
Total Metals (QCLot: 276471)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	97.5	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	109	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	105	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	112	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	89.6	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	106	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	105	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	100	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	102	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	94.5	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.7	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	102	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	99.8	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	112	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	111	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	99.5	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	94.7	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	95.6	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	104	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	111	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 277123)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	99.0	80.0	120	----
Dissolved Metals (QCLot: 276342)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	106	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	107	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	96.4	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	110	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	107	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	104	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.8	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	109	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	109	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	114	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	107	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	100	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	107	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	104	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	103	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	106	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	109	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	110	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Aggregate Organics (QCLot: 277637)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 277637) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	92.8	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 272679)										
VA21B7636-001	Anonymous	fluoride	16984-48-8	E235.F	20.4 mg/L	20 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 272680)										
VA21B7636-001	Anonymous	chloride	16887-00-6	E235.Cl	2020 mg/L	2000 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 272681)										
VA21B7636-001	Anonymous	bromide	24959-67-9	E235.Br-L	9.72 mg/L	10 mg/L	97.2	75.0	125	----
Anions and Nutrients (QCLot: 272682)										
VA21B7636-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	49.9 mg/L	50 mg/L	99.8	75.0	125	----
Anions and Nutrients (QCLot: 272683)										
VA21B7636-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	9.87 mg/L	10 mg/L	98.7	75.0	125	----
Anions and Nutrients (QCLot: 272684)										
VA21B7636-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1980 mg/L	2000 mg/L	98.8	75.0	125	----
Anions and Nutrients (QCLot: 272693)										
VA21B7692-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0323 mg/L	0.03 mg/L	108	70.0	130	----
Anions and Nutrients (QCLot: 276583)										
VA21B7638-001	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 276584)										
VA21B7639-001	BJ-GW18-19B - E314703	ammonia, total (as N)	7664-41-7	E298	0.103 mg/L	0.1 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 276588)										
VA21B7678-001	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Total Sulfides (QCLot: 275927)										
CG2103409-024	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.204 mg/L	0.2 mg/L	102	75.0	125	----
Total Metals (QCLot: 276471)										
FJ2100764-002	Anonymous	aluminum, total	7429-90-5	E420	0.196 mg/L	0.2 mg/L	98.2	70.0	130	----
		antimony, total	7440-36-0	E420	0.0210 mg/L	0.02 mg/L	105	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0205 mg/L	0.02 mg/L	102	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0458 mg/L	0.04 mg/L	114	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00940 mg/L	0.01 mg/L	94.0	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	High	Qualifier
Total Metals (QCLot: 276471) - continued										
FJ2100764-002	Anonymous	boron, total	7440-42-8	E420	0.115 mg/L	0.1 mg/L	115	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00414 mg/L	0.004 mg/L	104	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0413 mg/L	0.04 mg/L	103	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0200 mg/L	0.02 mg/L	100.0	70.0	130	----
		copper, total	7440-50-8	E420	0.0196 mg/L	0.02 mg/L	98.1	70.0	130	----
		iron, total	7439-89-6	E420	2.02 mg/L	2 mg/L	101	70.0	130	----
		lead, total	7439-92-1	E420	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		lithium, total	7439-93-2	E420	0.113 mg/L	0.1 mg/L	113	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		nickel, total	7440-02-0	E420	0.0395 mg/L	0.04 mg/L	98.9	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.0 mg/L	10 mg/L	100	70.0	130	----
		potassium, total	7440-09-7	E420	4.14 mg/L	4 mg/L	103	70.0	130	----
		selenium, total	7782-49-2	E420	0.0431 mg/L	0.04 mg/L	108	70.0	130	----
		silicon, total	7440-21-3	E420	9.76 mg/L	10 mg/L	97.6	70.0	130	----
		silver, total	7440-22-4	E420	0.00408 mg/L	0.004 mg/L	102	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00372 mg/L	0.004 mg/L	92.9	70.0	130	----
		tin, total	7440-31-5	E420	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		titanium, total	7440-32-6	E420	0.0427 mg/L	0.04 mg/L	107	70.0	130	----
		uranium, total	7440-61-1	E420	0.00402 mg/L	0.004 mg/L	100	70.0	130	----
		vanadium, total	7440-62-2	E420	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		zinc, total	7440-66-6	E420	0.419 mg/L	0.4 mg/L	105	70.0	130	----
Total Metals (QCLot: 277123)										
VA21B7673-001	Anonymous	mercury, total	7439-97-6	E508	0.0000947 mg/L	0.0001 mg/L	94.7	70.0	130	----
Dissolved Metals (QCLot: 276342)										
FJ2100763-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.208 mg/L	0.2 mg/L	104	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0213 mg/L	0.02 mg/L	106	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00883 mg/L	0.01 mg/L	88.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	High	Qualifier
Dissolved Metals (QCLot: 276342) - continued										
FJ2100763-002	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00402 mg/L	0.004 mg/L	101	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0410 mg/L	0.04 mg/L	102	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0201 mg/L	0.02 mg/L	101	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0194 mg/L	0.02 mg/L	96.9	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.97 mg/L	2 mg/L	98.5	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0185 mg/L	0.02 mg/L	92.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0213 mg/L	0.02 mg/L	106	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0386 mg/L	0.04 mg/L	96.5	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.4 mg/L	10 mg/L	114	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.00 mg/L	10 mg/L	90.0	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00382 mg/L	0.004 mg/L	95.6	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00363 mg/L	0.004 mg/L	90.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0412 mg/L	0.04 mg/L	103	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.109 mg/L	0.1 mg/L	109	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.399 mg/L	0.4 mg/L	99.8	70.0	130	----
Dissolved Metals (QCLot: 276501)										
VA21B7673-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000990 mg/L	0.0001 mg/L	99.0	70.0	130	----
Aggregate Organics (QCLot: 277637)										
VA21B7611-006	Anonymous	chemical oxygen demand [COD]	----	E559	99 mg/L	100 mg/L	98.8	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)	7639	ALS Contact: Dean Watt	Sampler: NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients (P)	EPH	Total Metals (P)	Dissolved Metals (F/P)			Total Mercury (P)	Dissolved Mercury (F/P)	Acidity	Total Sulphides (P)		Number of Containers
	BJ-GW18-19B - E314703	18-Aug-21	13:35	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B7639
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Morneyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	18-Aug-21	18:00		8/19	8:00	12.5 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B9857**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 13-Sep-2021 20:30
PO	: 1025614	Date Analysis Commenced	: 14-Sep-2021
C-O-C number	: ----	Issue Date	: 22-Sep-2021 18:04
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Shaneel Dayal	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-18B - snap	BJ-GW18-18B - E314702	----	----	----
				Client sampling date / time	11-Sep-2021 14:20	11-Sep-2021 16:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B9857-001	VA21B9857-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	69.7	96.6	----	----	----
conductivity	----	E100	2.0	µS/cm	411	532	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	139	167	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	163	165	----	----	----
pH	----	E108	0.10	pH units	8.04	8.15	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	246	387	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	19.1	43.1	----	----	----
turbidity	----	E121	0.10	NTU	26.1	26.2	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.167	0.151	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	4.66	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.183	0.133	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.160	0.162	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0051	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.160	0.162	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0019	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0181	0.0107	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	124	152	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0027	0.0015	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.0029	<0.0016	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	1.19	0.123	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00077	0.00022	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00782	0.00181	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0748	0.0264	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-18B - snap	BJ-GW18-18B - E314702	----	----	----
				Client sampling date / time	11-Sep-2021 14:20	11-Sep-2021 16:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B9857-001	VA21B9857-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000111	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.017	0.029	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000414	0.0000065	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	53.4	51.3	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.0143	0.00354	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00154	0.00301	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00425	0.00104	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	2.04	0.164	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00117	0.000186	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0505	0.0825	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	7.31	8.94	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0994	0.0559	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00169	0.00154	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00600	0.00415	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	3.39	3.31	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	5.22	3.62	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000402	0.000036	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	28.1	42.5	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.25	1.44	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000224	0.000022	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00042	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00130	0.00124	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00168	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0103	0.0037	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0036	0.0029	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-18B - snap	BJ-GW18-18B - E314702	----	----	----
				Client sampling date / time	11-Sep-2021 14:20	11-Sep-2021 16:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B9857-001	VA21B9857-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00012	0.00019	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00177	0.00158	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0198	0.0178	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.016	0.028	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	44.2	51.6	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00200	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	0.014	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0498	0.0807	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	7.04	9.35	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0363	0.0471	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000803	0.00125	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00179	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	3.15	3.39	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.07	3.45	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	29.0	44.6	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.27	1.52	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000050	0.000015	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000963	0.00110	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-18B - snap**	**BJ-GW18-18B - E314702**	**----**	**----**	**----**
				Client sampling date / time	11-Sep-2021 14:20	11-Sep-2021 16:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21B9857-001**	**VA21B9857-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	0.0021	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21B9857**	Page	: 1 of 15
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 13-Sep-2021 20:30
PO	: 1025614	Issue Date	: 22-Sep-2021 18:04
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Laboratory Control Sample (LCS) Recoveries								
Dissolved Metals	QC-294219-002	----	bismuth, dissolved	7440-69-9	E421	122 % MES	80.0-120%	Recovery greater than upper control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-18B - E314702	E559	11-Sep-2021	----	----	----		21-Sep-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-18B - snap	E559	11-Sep-2021	----	----	----		21-Sep-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-18B - E314702	E298	11-Sep-2021	21-Sep-2021	----	----		21-Sep-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-18B - snap	E298	11-Sep-2021	21-Sep-2021	----	----		21-Sep-2021	28 days	10 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B - E314702	E235.Br-L	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B - snap	E235.Br-L	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-18B - E314702	E235.Cl	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-18B - snap	E235.Cl	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-18B - E314702	E378-U	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	× EHTL
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-18B - snap	E378-U	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	× EHTL
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-18B - E314702	E235.F	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-18B - snap	E235.F	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B - E314702	E235.NO3-L	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	× EHTL
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B - snap	E235.NO3-L	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	× EHTL
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B - E314702	E235.NO2-L	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	× EHTL
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-18B - snap	E235.NO2-L	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	× EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE BJ-GW18-18B - E314702	E235.SO4	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE BJ-GW18-18B - snap	E235.SO4	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-18B - E314702	E366	11-Sep-2021	20-Sep-2021	----	----		21-Sep-2021	28 days	10 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ-GW18-18B - snap	E366	11-Sep-2021	20-Sep-2021	----	----		21-Sep-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-18B - E314702	E372-U	11-Sep-2021	20-Sep-2021	----	----		21-Sep-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ-GW18-18B - snap	E372-U	11-Sep-2021	20-Sep-2021	----	----		21-Sep-2021	28 days	10 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) BJ-GW18-18B - E314702	E509	11-Sep-2021	17-Sep-2021	----	----		17-Sep-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid) BJ-GW18-18B - snap	E509	11-Sep-2021	17-Sep-2021	----	----		17-Sep-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW18-18B - E314702	E421	11-Sep-2021	17-Sep-2021	----	----		17-Sep-2021	180 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-18B - snap	E421	11-Sep-2021	17-Sep-2021	----	----		17-Sep-2021	180 days	6 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-18B - E314702	E283	11-Sep-2021	----	----	----		14-Sep-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-18B - snap	E283	11-Sep-2021	----	----	----		14-Sep-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-18B - E314702	E290	11-Sep-2021	----	----	----		14-Sep-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-18B - snap	E290	11-Sep-2021	----	----	----		14-Sep-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-18B - E314702	E100	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-18B - snap	E100	11-Sep-2021	----	----	----		14-Sep-2021	28 days	3 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-18B - E314702	E108	11-Sep-2021	----	----	----		14-Sep-2021	0.25 hrs	73 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-18B - snap	E108	11-Sep-2021	----	----	----		14-Sep-2021	0.25 hrs	75 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-18B - snap	E162	11-Sep-2021	----	----	----		16-Sep-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-18B - E314702	E162	11-Sep-2021	----	----	----		17-Sep-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-18B - snap	E160-H	11-Sep-2021	----	----	----		16-Sep-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-18B - E314702	E160-H	11-Sep-2021	----	----	----		17-Sep-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-18B - E314702	E121	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-18B - snap	E121	11-Sep-2021	----	----	----		14-Sep-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-18B - E314702	E508	11-Sep-2021	----	----	----		16-Sep-2021	28 days	5 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-18B - snap	E508	11-Sep-2021	----	----	----		16-Sep-2021	28 days	5 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-18B - E314702	E420	11-Sep-2021	----	----	----		16-Sep-2021	180 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-18B - snap	E420	11-Sep-2021	----	----	----		16-Sep-2021	180 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-18B - E314702	E395	11-Sep-2021	----	----	----		16-Sep-2021	7 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-18B - snap	E395	11-Sep-2021	----	----	----		16-Sep-2021	7 days	5 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	291895	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	291883	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	297887	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	291891	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	297891	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	291889	1	12	8.3	5.0	✓
Conductivity in Water	E100	291884	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	295101	1	17	5.8	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	294219	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	291894	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	291890	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	291887	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	291888	1	15	6.6	5.0	✓
pH by Meter	E108	291882	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	291886	1	13	7.6	5.0	✓
TDS by Gravimetry	E162	294590	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	294500	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	292499	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	297501	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	297502	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	294153	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	294610	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	291922	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	291895	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	291883	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	297887	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	291891	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	297891	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	291889	1	12	8.3	5.0	✓
Conductivity in Water	E100	291884	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	295101	1	17	5.8	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	294219	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	291894	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	291890	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	291887	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	291888	1	15	6.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	291882	1	16	6.2	5.0	✓
Sulfate in Water by IC	E235.SO4	291886	1	13	7.6	5.0	✓
TDS by Gravimetry	E162	294590	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	294500	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	292499	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	297501	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	297502	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	294153	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	294610	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	291922	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	291895	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	291883	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	297887	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	291891	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	297891	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	291889	1	12	8.3	5.0	✓
Conductivity in Water	E100	291884	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	295101	1	17	5.8	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	294219	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	291894	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	291890	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	291887	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	291888	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	291886	1	13	7.6	5.0	✓
TDS by Gravimetry	E162	294590	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	294500	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	292499	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	297501	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	297502	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	294153	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	294610	2	40	5.0	5.0	✓
Turbidity by Nephelometry	E121	291922	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	297887	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	291891	1	10	10.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	297891	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	291889	1	12	8.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	295101	1	17	5.8	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	294219	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	291894	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	291890	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	291887	1	11	9.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	291888	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	291886	1	13	7.6	5.0	✓
Total Mercury in Water by CVAAS	E508	294500	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	292499	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	297501	1	10	10.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	297502	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	294153	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21B9857**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 13-Sep-2021 20:30
PO	: 1025614	Date Analysis Commenced	: 14-Sep-2021
C-O-C number	: ----	Issue Date	: 22-Sep-2021 18:04
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Shaneel Dayal	Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 291882)											
VA21B9759-008	Anonymous	pH	----	E108	0.10	pH units	5.23	5.29	1.14%	4%	----
Physical Tests (QC Lot: 291883)											
VA21B9759-008	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	<1.0	<1.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 291884)											
VA21B9759-008	Anonymous	conductivity	----	E100	2.0	µS/cm	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 291895)											
VA21B9857-001	BJ-GW18-18B - snap	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 291922)											
VA21B9712-001	Anonymous	turbidity	----	E121	0.10	NTU	2.95	3.18	7.51%	15%	----
Physical Tests (QC Lot: 294590)											
VA21B9789-005	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	38	38	0	Diff <2x LOR	----
Physical Tests (QC Lot: 294610)											
VA21B9789-015	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 295143)											
FJ2100935-015	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 295156)											
VA21B9839-007	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	1080	1150	5.96%	20%	----
Anions and Nutrients (QC Lot: 291886)											
VA21B9759-008	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	<0.30	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 291887)											
VA21B9759-008	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 291888)											
VA21B9759-008	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 291889)											
VA21B9759-008	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 291890)											
VA21B9759-008	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	<0.020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 291891)											
VA21B9759-008	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 291894)											
VA21B9539-005	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 297501)											
VA21B9694-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.248	0.241	0.007	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 297502)											
VA21B9694-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.136	0.127	0.0095	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 297887)											
VA21B9692-021	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0054	0.0056	0.0001	Diff <2x LOR	----
Total Sulfides (QC Lot: 294153)											
CG2103997-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0057	0.0057	0.00001	Diff <2x LOR	----
Total Metals (QC Lot: 292499)											
VA21B9819-020	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0188	0.0210	0.0022	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00538	0.00560	3.93%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0287	0.0291	1.44%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.00345	0.00333	3.48%	20%	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.091	0.089	0.002	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000075	0.0000104	0.0000030	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	273	274	0.0662%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00269	0.00274	1.87%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.011	0.010	0.001	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0461	0.0444	3.93%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	89.8	90.5	0.721%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	2.28	2.33	2.47%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000656	0.000687	4.54%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00500	0.00510	1.98%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	31.0	31.9	2.76%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000065	<0.000050	0.000015	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	13.6	13.8	0.763%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	56.4	57.9	2.68%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.334	0.342	2.29%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000010	0.000010	0.000000002	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 292499) - continued											
VA21B9819-020	Anonymous	tin, total	7440-31-5	E420	0.00010	mg/L	0.00039	0.00040	0.000006	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00366	0.00375	2.49%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0049	0.0047	0.0002	Diff <2x LOR	----
Total Metals (QC Lot: 294500)											
VA21B9839-009	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000133	0.0000117	0.0000016	Diff <2x LOR	----
Dissolved Metals (QC Lot: 294219)											
FJ2100914-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0018	0.0011	0.0007	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00018	0.00016	0.00002	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00011	0.00011	0.000003	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0670	0.0691	3.15%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.022	0.022	0.00002	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000082	0.0000124	0.0000041	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	178	174	2.23%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00029	0.00028	0.00001	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0342	0.0336	1.77%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	141	143	1.35%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00038	0.00031	0.00007	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000820	0.000819	0.166%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00330	0.00332	0.00002	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	3.44	3.50	1.63%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.0130	0.0129	0.885%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.99	2.01	1.01%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	41.4	42.9	3.47%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.07	1.07	0.145%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 294219) - continued											
FJ2100914-001	Anonymous	tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00658	0.00657	0.206%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0017	0.0015	0.0002	Diff <2x LOR	----
Dissolved Metals (QC Lot: 295101)											
VA21B9839-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 297891)											
VA21B9638-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 291883)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 291884)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 291895)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 291922)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 294590)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 294610)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 295143)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 295156)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 291886)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 291887)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 291888)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 291889)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 291890)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 291891)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 291894)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 297501)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 297502)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 297887)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 294153)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 292499)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 294500)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 294219)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 295101)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 297891)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 291882)									
pH	----	E108	----	pH units	7 pH units	99.7	98.0	102	----
Physical Tests (QCLot: 291883)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	105	85.0	115	----
Physical Tests (QCLot: 291884)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	105	90.0	110	----
Physical Tests (QCLot: 291895)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	101	85.0	115	----
Physical Tests (QCLot: 291922)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 294590)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	112	85.0	115	----
Physical Tests (QCLot: 294610)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	105	85.0	115	----
Physical Tests (QCLot: 295143)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	97.5	85.0	115	----
Physical Tests (QCLot: 295156)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	97.9	85.0	115	----
Anions and Nutrients (QCLot: 291886)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 291887)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 291888)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	96.4	90.0	110	----
Anions and Nutrients (QCLot: 291889)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 291890)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	97.2	90.0	110	----
Anions and Nutrients (QCLot: 291891)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 291894)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	99.3	80.0	120	----
Anions and Nutrients (QCLot: 297501)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 297501) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	99.2	75.0	125	----
Anions and Nutrients (QCLot: 297502)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.5	80.0	120	----
Anions and Nutrients (QCLot: 297887)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	99.2	85.0	115	----
Total Sulfides (QCLot: 294153)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	106	80.0	120	----
Total Metals (QCLot: 292499)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	101	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	97.9	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	98.4	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	95.0	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	95.2	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	100	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	97.2	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	97.3	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	97.4	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	95.2	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	96.4	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	96.9	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	93.9	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	95.6	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	99.4	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	99.2	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	108	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 292499) - continued									
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	97.0	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	97.9	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	106	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	101	80.0	120	----
Total Metals (QCLot: 294500)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Dissolved Metals (QCLot: 294219)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	112	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.4	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	# 122	80.0	120	MES
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	96.7	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	105	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	96.6	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	110	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	107	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	94.9	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	102	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.7	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	107	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	110	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	104	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	108	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	103	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	116	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 294219) - continued									
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	104	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	103	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	109	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	109	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	97.4	80.0	120	----
Aggregate Organics (QCLot: 297891)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	113	85.0	115	----

Qualifiers

Qualifier	Description
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 291886)										
VA21B9764-011	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1930 mg/L	2000 mg/L	96.4	75.0	125	----
Anions and Nutrients (QCLot: 291887)										
VA21B9764-011	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	ND mg/L	50 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 291888)										
VA21B9764-011	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	9.03 mg/L	10 mg/L	90.3	75.0	125	----
Anions and Nutrients (QCLot: 291889)										
VA21B9764-011	Anonymous	chloride	16887-00-6	E235.Cl	1880 mg/L	2000 mg/L	94.1	75.0	125	----
Anions and Nutrients (QCLot: 291890)										
VA21B9764-011	Anonymous	fluoride	16984-48-8	E235.F	19.0 mg/L	20 mg/L	95.0	75.0	125	----
Anions and Nutrients (QCLot: 291891)										
VA21B9764-011	Anonymous	bromide	24959-67-9	E235.Br-L	9.47 mg/L	10 mg/L	94.7	75.0	125	----
Anions and Nutrients (QCLot: 291894)										
VA21B9759-008	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0296 mg/L	0.03 mg/L	98.7	70.0	130	----
Anions and Nutrients (QCLot: 297501)										
VA21B9857-001	BJ-GW18-18B - snap	nitrogen, total	7727-37-9	E366	0.390 mg/L	0.4 mg/L	97.5	70.0	130	----
Anions and Nutrients (QCLot: 297502)										
VA21B9707-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0517 mg/L	0.05 mg/L	103	70.0	130	----
Anions and Nutrients (QCLot: 297887)										
VA21B9692-022	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.106 mg/L	0.1 mg/L	106	75.0	125	----
Total Sulfides (QCLot: 294153)										
CG2103997-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.236 mg/L	0.2 mg/L	118	75.0	125	----
Total Metals (QCLot: 292499)										
VA21B9819-021	Anonymous	aluminum, total	7429-90-5	E420	0.424 mg/L	0.4 mg/L	106	70.0	130	----
		antimony, total	7440-36-0	E420	0.0405 mg/L	0.04 mg/L	101	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0426 mg/L	0.04 mg/L	106	70.0	130	----
		barium, total	7440-39-3	E420	0.0412 mg/L	0.04 mg/L	103	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0768 mg/L	0.08 mg/L	96.0	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0193 mg/L	0.02 mg/L	96.5	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	High	Qualifier
Total Metals (QCLot: 292499) - continued										
VA21B9819-021	Anonymous	boron, total	7440-42-8	E420	0.187 mg/L	0.2 mg/L	93.4	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00825 mg/L	0.008 mg/L	103	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	8 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0832 mg/L	0.08 mg/L	104	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0405 mg/L	0.04 mg/L	101	70.0	130	----
		copper, total	7440-50-8	E420	0.0382 mg/L	0.04 mg/L	95.6	70.0	130	----
		iron, total	7439-89-6	E420	4.02 mg/L	4 mg/L	101	70.0	130	----
		lead, total	7439-92-1	E420	0.0387 mg/L	0.04 mg/L	96.7	70.0	130	----
		lithium, total	7439-93-2	E420	0.189 mg/L	0.2 mg/L	94.7	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0406 mg/L	0.04 mg/L	101	70.0	130	----
		nickel, total	7440-02-0	E420	0.0784 mg/L	0.08 mg/L	98.0	70.0	130	----
		phosphorus, total	7723-14-0	E420	21.4 mg/L	20 mg/L	107	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	8 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0924 mg/L	0.08 mg/L	116	70.0	130	----
		silicon, total	7440-21-3	E420	21.0 mg/L	20 mg/L	105	70.0	130	----
		silver, total	7440-22-4	E420	0.00785 mg/L	0.008 mg/L	98.2	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00773 mg/L	0.008 mg/L	96.6	70.0	130	----
		tin, total	7440-31-5	E420	0.0398 mg/L	0.04 mg/L	99.6	70.0	130	----
		titanium, total	7440-32-6	E420	0.0839 mg/L	0.08 mg/L	105	70.0	130	----
		uranium, total	7440-61-1	E420	0.00861 mg/L	0.008 mg/L	108	70.0	130	----
		vanadium, total	7440-62-2	E420	0.217 mg/L	0.2 mg/L	108	70.0	130	----
		zinc, total	7440-66-6	E420	0.817 mg/L	0.8 mg/L	102	70.0	130	----
Total Metals (QCLot: 294500)										
VA21B9839-010	Anonymous	mercury, total	7439-97-6	E508	0.000102 mg/L	0.0001 mg/L	102	70.0	130	----
Dissolved Metals (QCLot: 294219)										
FJ2100914-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.408 mg/L	0.4 mg/L	102	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0434 mg/L	0.04 mg/L	108	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0421 mg/L	0.04 mg/L	105	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0776 mg/L	0.08 mg/L	97.0	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0185 mg/L	0.02 mg/L	92.7	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.190 mg/L	0.2 mg/L	95.3	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 294219) - continued										
FJ2100914-002	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00799 mg/L	0.008 mg/L	99.8	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0826 mg/L	0.08 mg/L	103	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0394 mg/L	0.04 mg/L	98.6	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0371 mg/L	0.04 mg/L	92.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	3.97 mg/L	4 mg/L	99.4	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0390 mg/L	0.04 mg/L	97.5	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.199 mg/L	0.2 mg/L	99.4	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0414 mg/L	0.04 mg/L	104	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0432 mg/L	0.04 mg/L	108	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0774 mg/L	0.08 mg/L	96.7	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	22.7 mg/L	20 mg/L	113	70.0	130	----
		potassium, dissolved	7440-09-7	E421	9.32 mg/L	8 mg/L	116	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0869 mg/L	0.08 mg/L	109	70.0	130	----
		silicon, dissolved	7440-21-3	E421	19.7 mg/L	20 mg/L	98.6	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00780 mg/L	0.008 mg/L	97.5	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00792 mg/L	0.008 mg/L	99.0	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0418 mg/L	0.04 mg/L	104	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0837 mg/L	0.08 mg/L	105	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.008 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.217 mg/L	0.2 mg/L	108	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.777 mg/L	0.8 mg/L	97.1	70.0	130	----
Dissolved Metals (QCLot: 295101)										
VA21B9839-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.000103 mg/L	0.0001 mg/L	103	70.0	130	----
Aggregate Organics (QCLot: 297891)										
VA21B9639-001	Anonymous	chemical oxygen demand [COD]	----	E559	107 mg/L	100 mg/L	107	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(888) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	9857	ALS Contact:	Dean Watt	Sampler: NG/RS

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-18B - snap	11-Sep-21	14:20	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-18B - E314702	11-Sep-21	16:15	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21B9857

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh:mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
N Glas	11-Sep-21	18:00		9/13	8130P	12 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C0110**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 15-Sep-2021 16:00
PO	: 1025612	Date Analysis Commenced	: 16-Sep-2021
C-O-C number	: ----	Issue Date	: 24-Sep-2021 17:08
Sampler	: RS/NG		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Dion Chan	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DTC	*Dissolved concentration exceeds total. Results were confirmed by re-analysis.*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW14-14B - E314700	BJ-GW14-14B-99	BJ-GW14-14A - E303065	BJ-GW14-14A - 98	----
				Client sampling date / time	14-Sep-2021 10:55	14-Sep-2021 11:00	14-Sep-2021 11:50	14-Sep-2021 11:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0110-001	VA21C0110-002	VA21C0110-003	VA21C0110-004	--------
					Result	Result	Result	Result	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	2.1	<2.0	<2.0	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	56.9	<1.0	90.4	89.3	----
conductivity	----	E100	2.0	µS/cm	230	<2.0	269	269	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	95.1	<0.50	81.6	81.5	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	94.8	<0.50	82.8	84.6	----
pH	----	E108	0.10	pH units	8.13	5.83	8.29	8.29	----
solids, total dissolved [TDS]	----	E162	10	mg/L	156	<10	170	171	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	9.2	3.8	----
turbidity	----	E121	0.10	NTU	0.99	<0.10	2.27	2.29	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0166	<0.0050	0.0392	0.0408	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	<0.50	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.061	<0.020	0.109	0.110	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0051	<0.0051	<0.0051	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0.045	0.045	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0016	<0.0010	0.0033	0.0030	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0034	<0.0020	0.0090	0.0095	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	53.1	<0.30	45.2	45.2	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0.0136	0.0144	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	0.0145	0.0153	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0048	<0.0030	0.146	0.136	----
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0.00020	0.00019	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00257	<0.00010	0.00424	0.00436	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0243	<0.00010	0.0254	0.0258	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW14-14B - E314700	BJ-GW14-14B-99	BJ-GW14-14A - E303065	BJ-GW14-14A - 98	----
				Client sampling date / time	14-Sep-2021 10:55	14-Sep-2021 11:00	14-Sep-2021 11:50	14-Sep-2021 11:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0110-001	VA21C0110-002	VA21C0110-003	VA21C0110-004	--------
					Result	Result	Result	Result	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0.087	0.089	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0.0000077	0.0000092	----
calcium, total	7440-70-2	E420	0.050	mg/L	34.2	<0.050	25.4	26.2	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0.00085	0.00082	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
iron, total	7439-89-6	E420	0.010	mg/L	0.164	<0.010	0.178	0.177	----
lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0.000493	0.000566	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0034	<0.0010	0.0476	0.0479	----
magnesium, total	7439-95-4	E420	0.100	mg/L	2.28	<0.100	4.70	4.67	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.385	<0.00010	0.0499	0.0494	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000161	<0.000050	0.00160	0.00166	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.576	<0.050	1.56	1.56	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
silicon, total	7440-21-3	E420	0.10	mg/L	2.97	<0.10	3.98	3.96	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
sodium, total	17341-25-2	E420	0.050	mg/L	4.16	<0.050	22.1	22.2	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.219	<0.00020	2.49	2.54	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0.000025	0.000026	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0.00011	0.00010	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000022	<0.000010	0.000152	0.000152	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0027	<0.0010	0.0025	0.0023	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW14-14B - E314700	BJ-GW14-14B-99	BJ-GW14-14A - E303065	BJ-GW14-14A - 98	----
				Client sampling date / time	14-Sep-2021 10:55	14-Sep-2021 11:00	14-Sep-2021 11:50	14-Sep-2021 11:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0110-001	VA21C0110-002	VA21C0110-003	VA21C0110-004	--------
					Result	Result	Result	Result	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0.00013	0.00012	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00269	<0.00010	0.00400	0.00388	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0277	0.00100 DTC, RRV	0.0214	0.0221	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0.077	0.080	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	34.4	<0.050	25.0	25.1	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00077 DTC	0.00063 RRV	<0.00020	<0.00020	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.142	<0.010	0.029	0.028	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0037	<0.0010	0.0471	0.0481	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	2.24	<0.100	4.65	4.57	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.370	<0.00010	0.0480	0.0462	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000192	<0.000050	0.00156	0.00161	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.598	<0.050	1.57	1.56	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.74	<0.050	3.52	3.58	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	4.21	<0.050	23.1	22.7	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.211	<0.00020	2.44	2.51	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000026	<0.000010	0.000090	0.000096	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW14-14B - E314700	BJ-GW14-14B-99	BJ-GW14-14A - E303065	BJ-GW14-14A - 98	----
				Client sampling date / time	14-Sep-2021 10:55	14-Sep-2021 11:00	14-Sep-2021 11:50	14-Sep-2021 11:50	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0110-001	VA21C0110-002	VA21C0110-003	VA21C0110-004	--------
					Result	Result	Result	Result	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0029	<0.0010	<0.0010	<0.0010	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	Field	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	<20	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C0110**	Page	: 1 of 19
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 15-Sep-2021 16:00
PO	: 1025612	Issue Date	: 24-Sep-2021 17:08
C-O-C number	: ----		
Sampler	: RS/NG		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - 98	E559	14-Sep-2021	----	----	----		21-Sep-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - E303065	E559	14-Sep-2021	----	----	----		21-Sep-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14B - E314700	E559	14-Sep-2021	----	----	----		21-Sep-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14B- 99	E559	14-Sep-2021	----	----	----		21-Sep-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - 98	E298	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - E303065	E298	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW14-14B - E314700	E298	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW14-14B- 99	E298	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW14-14A - 98	E235.Br-L	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW14-14A - E303065	E235.Br-L	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW14-14B - E314700	E235.Br-L	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW14-14B- 99	E235.Br-L	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW14-14A - 98	E235.Cl	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW14-14A - E303065	E235.Cl	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW14-14B - E314700	E235.Cl	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW14-14B- 99	E235.Cl	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW14-14A - 98	E378-U	14-Sep-2021	----	----	----		16-Sep-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW14-14A - E303065	E378-U	14-Sep-2021	----	----	----		16-Sep-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW14-14B - E314700	E378-U	14-Sep-2021	----	----	----		16-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW14-14B- 99	E378-U	14-Sep-2021	----	----	----		16-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW14-14A - 98	E235.F	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW14-14A - E303065	E235.F	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW14-14B - E314700	E235.F	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW14-14B- 99	E235.F	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW14-14A - 98	E235.NO3-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW14-14A - E303065	E235.NO3-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW14-14B - E314700	E235.NO3-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW14-14B- 99	E235.NO3-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW14-14A - 98	E235.NO2-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW14-14A - E303065	E235.NO2-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW14-14B - E314700	E235.NO2-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW14-14B- 99	E235.NO2-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW14-14A - 98	E235.SO4	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW14-14A - E303065	E235.SO4	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW14-14B - E314700	E235.SO4	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW14-14B- 99	E235.SO4	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - 98	E366	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - E303065	E366	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14B - E314700	E366	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW14-14B- 99	E366	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - 98	E372-U	14-Sep-2021	21-Sep-2021	----	----		23-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW14-14A - E303065	E372-U	14-Sep-2021	21-Sep-2021	----	----		23-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW14-14B - E314700	E372-U	14-Sep-2021	21-Sep-2021	----	----		23-Sep-2021	28 days	8 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW14-14B- 99	E372-U	14-Sep-2021	21-Sep-2021	----	----		23-Sep-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW14-14A - 98	E509	14-Sep-2021	18-Sep-2021	----	----		18-Sep-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW14-14A - E303065	E509	14-Sep-2021	18-Sep-2021	----	----		18-Sep-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW14-14B - E314700	E509	14-Sep-2021	18-Sep-2021	----	----		18-Sep-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW14-14B- 99	E509	14-Sep-2021	18-Sep-2021	----	----		18-Sep-2021	28 days	4 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW14-14A - 98	E421	14-Sep-2021	22-Sep-2021	----	----		22-Sep-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW14-14A - E303065	E421	14-Sep-2021	22-Sep-2021	----	----		22-Sep-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW14-14B - E314700	E421	14-Sep-2021	22-Sep-2021	----	----		22-Sep-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW14-14B- 99	E421	14-Sep-2021	22-Sep-2021	----	----		22-Sep-2021	180 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW14-14A - 98	E283	14-Sep-2021	----	----	----		16-Sep-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW14-14A - E303065	E283	14-Sep-2021	----	----	----		16-Sep-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW14-14B - E314700	E283	14-Sep-2021	----	----	----		16-Sep-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW14-14B- 99	E283	14-Sep-2021	----	----	----		16-Sep-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW14-14A - 98	E290	14-Sep-2021	----	----	----		17-Sep-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW14-14A - E303065	E290	14-Sep-2021	----	----	----		17-Sep-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW14-14B - E314700	E290	14-Sep-2021	----	----	----		17-Sep-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW14-14B- 99	E290	14-Sep-2021	----	----	----		17-Sep-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW14-14A - 98	E100	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW14-14A - E303065	E100	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW14-14B - E314700	E100	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW14-14B- 99	E100	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW14-14A - 98	E108	14-Sep-2021	----	----	----		17-Sep-2021	0.25 hrs	70 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW14-14A - E303065	E108	14-Sep-2021	----	----	----		17-Sep-2021	0.25 hrs	70 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW14-14B - E314700	E108	14-Sep-2021	----	----	----		17-Sep-2021	0.25 hrs	71 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW14-14B- 99	E108	14-Sep-2021	----	----	----		17-Sep-2021	0.25 hrs	71 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW14-14A - 98	E162	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW14-14A - E303065	E162	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW14-14B - E314700	E162	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW14-14B- 99	E162	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW14-14A - 98	E160-H	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW14-14A - E303065	E160-H	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW14-14B - E314700	E160-H	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW14-14B- 99	E160-H	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW14-14A - 98	E121	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW14-14A - E303065	E121	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW14-14B - E314700	E121	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW14-14B- 99	E121	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW14-14A - 98	E508	14-Sep-2021	----	----	----		18-Sep-2021	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW14-14A - E303065	E508	14-Sep-2021	----	----	----		18-Sep-2021	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW14-14B - E314700	E508	14-Sep-2021	----	----	----		18-Sep-2021	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW14-14B- 99	E508	14-Sep-2021	----	----	----		18-Sep-2021	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW14-14A - 98	E420	14-Sep-2021	----	----	----		20-Sep-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW14-14A - E303065	E420	14-Sep-2021	----	----	----		20-Sep-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW14-14B - E314700	E420	14-Sep-2021	----	----	----		20-Sep-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW14-14B- 99	E420	14-Sep-2021	----	----	----		20-Sep-2021	180 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW14-14A - 98	E395	14-Sep-2021	----	----	----		17-Sep-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW14-14A - E303065	E395	14-Sep-2021	----	----	----		17-Sep-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW14-14B - E314700	E395	14-Sep-2021	----	----	----		17-Sep-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW14-14B- 99	E395	14-Sep-2021	----	----	----		17-Sep-2021	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	294539	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	294541	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Conductivity in Water	E100	294542	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	296156	1	11	9.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓
pH by Meter	E108	294540	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	298046	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	295972	1	5	20.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	295845	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	16	6.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	298042	2	31	6.4	5.0	✓
Turbidity by Nephelometry	E121	295222	2	37	5.4	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	294539	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	294541	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Conductivity in Water	E100	294542	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	296156	1	11	9.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	294540	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	298046	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	295972	1	5	20.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	295845	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	16	6.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	298042	2	31	6.4	5.0	✓
Turbidity by Nephelometry	E121	295222	2	37	5.4	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	294539	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	294541	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Conductivity in Water	E100	294542	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	296156	1	11	9.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	298046	2	40	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	295972	1	5	20.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	295845	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	16	6.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	298042	2	31	6.4	5.0	✓
Turbidity by Nephelometry	E121	295222	2	37	5.4	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	296156	1	11	9.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	295972	1	5	20.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	295845	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	16	6.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C0110**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 15-Sep-2021 16:00
PO	: 1025612	Date Analysis Commenced	: 16-Sep-2021
C-O-C number	: ----	Issue Date	: 24-Sep-2021 17:08
Sampler	: RS/NG		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Dion Chan	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 294539)											
VA21C0110-001	BJ-GW14-14B - E314700	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 294540)											
FJ2100939-001	Anonymous	pH	----	E108	0.10	pH units	6.83	6.83	0.00%	4%	----
Physical Tests (QC Lot: 294541)											
FJ2100939-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	567	576	1.63%	20%	----
Physical Tests (QC Lot: 294542)											
FJ2100939-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1140	1140	0.264%	10%	----
Physical Tests (QC Lot: 295222)											
VA21B9982-006	Anonymous	turbidity	----	E121	0.10	NTU	1.00	0.86	0.15	Diff <2x LOR	----
Physical Tests (QC Lot: 295449)											
KS2102965-001	Anonymous	turbidity	----	E121	0.10	NTU	4.79	4.91	2.39%	15%	----
Physical Tests (QC Lot: 298042)											
FJ2100944-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	24.5	21.3	3.2	Diff <2x LOR	----
Physical Tests (QC Lot: 298046)											
FJ2100944-001	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	479	474	1.19%	20%	----
Physical Tests (QC Lot: 298198)											
VA21C0067-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	634	630	0.554%	20%	----
Physical Tests (QC Lot: 298199)											
VA21C0110-003	BJ-GW14-14A - E303065	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	9.2	9.0	0.2	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294532)											
FJ2100939-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.913	0.897	0.016	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294533)											
FJ2100939-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	31.7	31.3	1.20%	20%	----
Anions and Nutrients (QC Lot: 294534)											
FJ2100939-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	0.945	0.963	0.018	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294535)											
FJ2100939-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.0312	0.0268	0.0044	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294536)											
FJ2100939-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294537)											
FJ2100939-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	34.7	34.3	1.06%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 294543)											
VA21C0105-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0043	0.0039	0.0004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298828)											
VA21C0110-001	BJ-GW14-14B - E314700	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298829)											
VA21C0110-001	BJ-GW14-14B - E314700	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0034	0.0027	0.0007	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298830)											
VA21C0110-001	BJ-GW14-14B - E314700	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0166	0.0156	0.0010	Diff <2x LOR	----
Total Sulfides (QC Lot: 295437)											
SK2103422-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0048	0.0048	0.00002	Diff <2x LOR	----
Total Metals (QC Lot: 295845)											
YL2101288-005	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0131	0.0111	0.0020	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	0.00011	0.000008	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0277	0.0278	0.293%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.564	0.559	0.906%	20%	----
		cadmium, total	7440-43-9	E420	0.0000150	mg/L	<0.0000150	<0.0000150	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	88.0	88.1	0.0128%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00018	0.00018	0.000006	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00143	0.00146	0.00003	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000052	<0.000050	0.000002	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0058	0.0058	0.00007	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	53.4	52.9	0.940%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00857	0.00846	1.34%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.0233	0.0235	0.972%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00689	0.00692	0.428%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	11.1	11.1	0.209%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000209	0.000206	0.000004	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.72	1.72	0.383%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	44.0	44.7	1.68%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 295845) - continued											
YL2101288-005	Anonymous	strontium, total	7440-24-6	E420	0.00020	mg/L	0.804	0.811	0.884%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000015	0.000014	0.000001	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00407	0.00399	1.93%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0053	0.0056	0.0002	Diff <2x LOR	----
Total Metals (QC Lot: 295972)											
VA21C0074-004	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 296156)											
VA21C0053-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 298750)											
VA21C0067-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0029	0.0026	0.0003	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00313	0.00317	1.14%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0507	0.0490	3.30%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.042	0.043	0.0008	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	78.4	80.1	2.24%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.362	0.377	4.10%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0028	0.0028	0.000010	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	50.9	51.2	0.692%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0504	0.0506	0.426%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00493	0.00496	0.609%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	6.37	6.20	2.81%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	9.54	9.50	0.434%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 298750) - continued											
VA21C0067-001	Anonymous	silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	35.6	36.3	1.90%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.656	0.616	6.32%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00217	0.00214	1.44%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0012	0.0012	0.00002	Diff <2x LOR	----
Aggregate Organics (QC Lot: 298223)											
VA21C0022-002	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	72	73	1	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 294539)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 294541)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 294542)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 295222)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 295449)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 298042)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 298046)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 298198)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 298199)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 294532)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 294533)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 294534)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 294535)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 294536)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 294537)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 294543)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 298828)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 298829)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 298830)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 295437)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 295845)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 295845) - continued						
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 295972)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 296156)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 298750)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 298750) - continued						
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 298223)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 294539)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	104	85.0	115	----
Physical Tests (QCLot: 294540)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 294541)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100	85.0	115	----
Physical Tests (QCLot: 294542)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.4	90.0	110	----
Physical Tests (QCLot: 295222)									
turbidity	----	E121	0.1	NTU	200 NTU	104	85.0	115	----
Physical Tests (QCLot: 295449)									
turbidity	----	E121	0.1	NTU	200 NTU	100.0	85.0	115	----
Physical Tests (QCLot: 298042)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	99.5	85.0	115	----
Physical Tests (QCLot: 298046)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	96.2	85.0	115	----
Physical Tests (QCLot: 298198)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	101	85.0	115	----
Physical Tests (QCLot: 298199)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	109	85.0	115	----
Anions and Nutrients (QCLot: 294532)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	95.1	90.0	110	----
Anions and Nutrients (QCLot: 294533)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 294534)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	100	85.0	115	----
Anions and Nutrients (QCLot: 294535)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 294536)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	93.5	90.0	110	----
Anions and Nutrients (QCLot: 294537)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 294543)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 294543) - continued									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 298828)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	99.5	75.0	125	----
Anions and Nutrients (QCLot: 298829)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	100	80.0	120	----
Anions and Nutrients (QCLot: 298830)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	96.8	85.0	115	----
Total Sulfides (QCLot: 295437)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	81.4	80.0	120	----
Total Metals (QCLot: 295845)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	107	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	108	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	103	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	108	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	104	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	107	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	108	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	103	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	109	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	100.0	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	107	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	110	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	101	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	107	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 295845) - continued									
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	109	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	107	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	102	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	104	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	105	80.0	120	----
Total Metals (QCLot: 295972)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	97.5	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	108	80.0	120	----
Dissolved Metals (QCLot: 298750)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	108	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	100	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.9	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	107	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	91.2	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.8	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.0	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	113	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	114	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	101	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 298750) - continued									
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	106	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	104	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	110	80.0	120	----
Aggregate Organics (QCLot: 298223)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 294532)										
FJ2100939-002	Anonymous	fluoride	16984-48-8	E235.F	19.5 mg/L	20 mg/L	97.7	75.0	125	----
Anions and Nutrients (QCLot: 294533)										
FJ2100939-002	Anonymous	chloride	16887-00-6	E235.Cl	2000 mg/L	2000 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 294534)										
FJ2100939-002	Anonymous	bromide	24959-67-9	E235.Br-L	10.2 mg/L	10 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 294535)										
FJ2100939-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	50.0 mg/L	50 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 294536)										
FJ2100939-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	9.44 mg/L	10 mg/L	94.4	75.0	125	----
Anions and Nutrients (QCLot: 294537)										
FJ2100939-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	2010 mg/L	2000 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 294543)										
VA21C0110-001	BJ-GW14-14B - E314700	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0318 mg/L	0.03 mg/L	106	70.0	130	----
Anions and Nutrients (QCLot: 298828)										
VA21C0110-002	BJ-GW14-14B- 99	nitrogen, total	7727-37-9	E366	0.401 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 298829)										
VA21C0110-002	BJ-GW14-14B- 99	phosphorus, total	7723-14-0	E372-U	0.0500 mg/L	0.05 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 298830)										
VA21C0110-002	BJ-GW14-14B- 99	ammonia, total (as N)	7664-41-7	E298	0.0985 mg/L	0.1 mg/L	98.5	75.0	125	----
Total Sulfides (QCLot: 295437)										
SK2103422-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.119 mg/L	0.1 mg/L	119	75.0	125	----
Total Metals (QCLot: 295845)										
VA21B9928-001	Anonymous	aluminum, total	7429-90-5	E420	0.196 mg/L	0.2 mg/L	97.8	70.0	130	----
		antimony, total	7440-36-0	E420	0.0197 mg/L	0.02 mg/L	98.7	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0378 mg/L	0.04 mg/L	94.6	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00943 mg/L	0.01 mg/L	94.3	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 295845) - continued										
VA21B9928-001	Anonymous	boron, total	7440-42-8	E420	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00380 mg/L	0.004 mg/L	95.0	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0392 mg/L	0.04 mg/L	97.9	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0188 mg/L	0.02 mg/L	93.9	70.0	130	----
		copper, total	7440-50-8	E420	0.0188 mg/L	0.02 mg/L	93.8	70.0	130	----
		iron, total	7439-89-6	E420	1.82 mg/L	2 mg/L	91.1	70.0	130	----
		lead, total	7439-92-1	E420	0.0195 mg/L	0.02 mg/L	97.5	70.0	130	----
		lithium, total	7439-93-2	E420	0.0937 mg/L	0.1 mg/L	93.7	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0199 mg/L	0.02 mg/L	99.6	70.0	130	----
		nickel, total	7440-02-0	E420	0.0366 mg/L	0.04 mg/L	91.4	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.39 mg/L	10 mg/L	93.9	70.0	130	----
		potassium, total	7440-09-7	E420	3.74 mg/L	4 mg/L	93.6	70.0	130	----
		selenium, total	7782-49-2	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		silicon, total	7440-21-3	E420	8.80 mg/L	10 mg/L	88.0	70.0	130	----
		silver, total	7440-22-4	E420	0.00376 mg/L	0.004 mg/L	94.0	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00372 mg/L	0.004 mg/L	93.1	70.0	130	----
		tin, total	7440-31-5	E420	0.0192 mg/L	0.02 mg/L	96.0	70.0	130	----
		titanium, total	7440-32-6	E420	0.0385 mg/L	0.04 mg/L	96.2	70.0	130	----
		uranium, total	7440-61-1	E420	0.00381 mg/L	0.004 mg/L	95.2	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0987 mg/L	0.1 mg/L	98.7	70.0	130	----
		zinc, total	7440-66-6	E420	0.387 mg/L	0.4 mg/L	96.6	70.0	130	----
Total Metals (QCLot: 295972)										
VA21C0110-001	BJ-GW14-14B - E314700	mercury, total	7439-97-6	E508	0.0000955 mg/L	0.0001 mg/L	95.5	70.0	130	----
Dissolved Metals (QCLot: 296156)										
VA21C0053-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000935 mg/L	0.0001 mg/L	93.5	70.0	130	----
Dissolved Metals (QCLot: 298750)										
VA21C0102-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.203 mg/L	0.2 mg/L	101	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0389 mg/L	0.04 mg/L	97.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 298750) - continued										
VA21C0102-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00938 mg/L	0.01 mg/L	93.8	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.090 mg/L	0.1 mg/L	90.1	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00402 mg/L	0.004 mg/L	100	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.78 mg/L	2 mg/L	89.1	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0193 mg/L	0.02 mg/L	96.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0966 mg/L	0.1 mg/L	96.6	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0395 mg/L	0.04 mg/L	98.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.81 mg/L	10 mg/L	98.1	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.92 mg/L	4 mg/L	97.9	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0413 mg/L	0.04 mg/L	103	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.77 mg/L	10 mg/L	87.7	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.91 mg/L	2 mg/L	95.4	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00390 mg/L	0.004 mg/L	97.6	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00400 mg/L	0.004 mg/L	100	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.428 mg/L	0.4 mg/L	107	70.0	130	----
Aggregate Organics (QCLot: 298223)										
VA21C0022-003	Anonymous	chemical oxygen demand [COD]	----	E559	110 mg/L	100 mg/L	110	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information	Analysis Request
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: RS/NG

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW14-14B - E314700	14-Sep-21	10:55	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW14-14B - 99	14-Sep-21	11:00	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW14-14A - E303065	14-Sep-21	11:50	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW14-14A - 98	14-Sep-21	11:50	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C0110

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Brittany Moore	14-Sep-21	18:00	TC	SEP 15 2021	4	10 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C0111**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 15-Sep-2021 16:00
PO	: 1025612	Date Analysis Commenced	: 16-Sep-2021
C-O-C number	: ----	Issue Date	: 23-Sep-2021 16:36
Sampler	: RS/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dion Chan	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B - Snap	----	----	----	----
				Client sampling date / time	14-Sep-2021 14:30	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0111-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.2	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	112	----	----	----	----
conductivity	----	E100	2.0	µS/cm	624	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	240	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	275	----	----	----	----
pH	----	E108	0.10	pH units	8.23	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	414	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	22.2	----	----	----	----
turbidity	----	E121	0.10	NTU	21.7	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0641	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	1.32	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.163	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.244	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.109	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.122	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0128	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.366	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0011	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0627	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	209	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0389	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.0414	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.823	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00189	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0140	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0451	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B - Snap	----	----	----	----
				Client sampling date / time	14-Sep-2021 14:30	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0111-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.038	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000231	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	104	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00348	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00060	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00201	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.799	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000507	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0787	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	3.74	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.124	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00160	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00194	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	2.92	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000418	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.91	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000277	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	39.3	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	2.74	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000026	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00022	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	0.0102	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000281	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00132	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0040	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0040	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW18-17B - Snap	----	----	----	----
					Client sampling date / time	14-Sep-2021 14:30	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C0111-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00148	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00802	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0221	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		0.037	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		90.2	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00011	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0650	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		3.52	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.0549	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.00149	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		2.55	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000305	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		2.68	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		40.2	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		2.73	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000194	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17B - Snap**	**----**	**----**	**----**	**----**
				Client sampling date / time	14-Sep-2021 14:30	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C0111-001**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C0111**	Page	: 1 of 11
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 15-Sep-2021 16:00
PO	: 1025612	Issue Date	: 23-Sep-2021 16:36
C-O-C number	: ----		
Sampler	: RS/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - Snap	E559	14-Sep-2021	----	----	----		21-Sep-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - Snap	E298	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - Snap	E235.Br-L	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B - Snap	E235.Cl	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B - Snap	E378-U	14-Sep-2021	----	----	----		16-Sep-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B - Snap	E235.F	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - Snap	E235.NO3-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - Snap	E235.NO2-L	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17B - Snap	E235.SO4	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - Snap	E366	14-Sep-2021	21-Sep-2021	----	----		22-Sep-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - Snap	E372-U	14-Sep-2021	21-Sep-2021	----	----		23-Sep-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B - Snap	E509	14-Sep-2021	20-Sep-2021	----	----		20-Sep-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B - Snap	E421	14-Sep-2021	22-Sep-2021	----	----		22-Sep-2021	180 days	8 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B - Snap	E283	14-Sep-2021	----	----	----		16-Sep-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B - Snap	E290	14-Sep-2021	----	----	----		17-Sep-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B - Snap	E100	14-Sep-2021	----	----	----		17-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17B - Snap	E108	14-Sep-2021	----	----	----		17-Sep-2021	0.25 hrs	67 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-17B - Snap	E162	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17B - Snap	E160-H	14-Sep-2021	----	----	----		21-Sep-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17B - Snap	E121	14-Sep-2021	----	----	----		17-Sep-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-17B - Snap	E508	14-Sep-2021	----	----	----		20-Sep-2021	28 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17B - Snap	E420	14-Sep-2021	----	----	----		21-Sep-2021	180 days	7 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17B - Snap	E395	14-Sep-2021	----	----	----		17-Sep-2021	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	294539	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	294541	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Conductivity in Water	E100	294542	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	297275	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓
pH by Meter	E108	294540	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	298198	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	297179	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	297671	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	298199	1	11	9.0	5.0	✓
Turbidity by Nephelometry	E121	295449	1	18	5.5	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	294539	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	294541	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Conductivity in Water	E100	294542	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	297275	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	294540	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	298198	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	297179	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	297671	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	298199	1	11	9.0	5.0	✓
Turbidity by Nephelometry	E121	295449	1	18	5.5	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	294539	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	294541	1	14	7.1	5.0	✓
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Conductivity in Water	E100	294542	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	297275	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	298198	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	297179	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	297671	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	298199	1	11	9.0	5.0	✓
Turbidity by Nephelometry	E121	295449	1	18	5.5	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	298830	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	294534	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	298223	1	12	8.3	5.0	✓
Chloride in Water by IC	E235.Cl	294533	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	297275	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298750	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	294543	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	294532	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	294535	1	9	11.1	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	294536	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	294537	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	297179	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	297671	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	298828	1	11	9.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	298829	1	15	6.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C0111**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 15-Sep-2021 16:00
PO	: 1025612	Date Analysis Commenced	: 16-Sep-2021
C-O-C number	: ----	Issue Date	: 23-Sep-2021 16:36
Sampler	: RS/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dion Chan	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 294539)											
VA21C0110-001	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 294540)											
FJ2100939-001	Anonymous	pH	----	E108	0.10	pH units	6.83	6.83	0.00%	4%	----
Physical Tests (QC Lot: 294541)											
FJ2100939-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	567	576	1.63%	20%	----
Physical Tests (QC Lot: 294542)											
FJ2100939-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1140	1140	0.264%	10%	----
Physical Tests (QC Lot: 295449)											
KS2102965-001	Anonymous	turbidity	----	E121	0.10	NTU	4.79	4.91	2.39%	15%	----
Physical Tests (QC Lot: 298198)											
VA21C0067-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	634	630	0.554%	20%	----
Physical Tests (QC Lot: 298199)											
VA21C0110-003	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	9.2	9.0	0.2	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294532)											
FJ2100939-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.913	0.897	0.016	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294533)											
FJ2100939-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	31.7	31.3	1.20%	20%	----
Anions and Nutrients (QC Lot: 294534)											
FJ2100939-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	0.945	0.963	0.018	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294535)											
FJ2100939-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.0312	0.0268	0.0044	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294536)											
FJ2100939-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 294537)											
FJ2100939-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	34.7	34.3	1.06%	20%	----
Anions and Nutrients (QC Lot: 294543)											
VA21C0105-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0043	0.0039	0.0004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298828)											
VA21C0110-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298829)											
VA21C0110-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0034	0.0027	0.0007	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 298830)											
VA21C0110-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0166	0.0156	0.0010	Diff <2x LOR	----
Total Sulfides (QC Lot: 295437)											
SK2103422-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0048	0.0048	0.00002	Diff <2x LOR	----
Total Metals (QC Lot: 297179)											
FJ2100937-004	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 297671)											
VA21C0102-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0303	0.0342	12.2%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00010	<0.00010	0.000005	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0137	0.0133	3.09%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000054	0.0000070	0.0000016	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	16.4	16.2	1.35%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.030	0.032	0.003	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000072	0.000074	0.000002	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	3.55	3.67	3.23%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00232	0.00253	8.56%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000380	0.000403	0.000023	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00060	0.00059	0.000004	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.612	0.615	0.548%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.41	1.51	6.58%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	0.635	0.649	2.09%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0929	0.0977	5.10%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00159	0.00169	0.00010	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 297671) - continued											
VA21C0102-001	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	0.000343	0.000341	0.477%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 297275)											
FJ2100937-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 298750)											
VA21C0067-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0029	0.0026	0.0003	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00313	0.00317	1.14%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0507	0.0490	3.30%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.042	0.043	0.0008	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	78.4	80.1	2.24%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.362	0.377	4.10%	20%	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0028	0.0028	0.000010	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	50.9	51.2	0.692%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0504	0.0506	0.426%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00493	0.00496	0.609%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	6.37	6.20	2.81%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	9.54	9.50	0.434%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	35.6	36.3	1.90%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.656	0.616	6.32%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 298750) - continued											
VA21C0067-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00217	0.00214	1.44%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0012	0.0012	0.00002	Diff <2x LOR	----
Aggregate Organics (QC Lot: 298223)											
VA21C0022-002	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	72	73	1	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 294539)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 294541)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 294542)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 295449)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 298198)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 298199)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 294532)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 294533)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 294534)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 294535)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 294536)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 294537)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 294543)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 298828)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 298829)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 298830)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 295437)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 297179)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 297671)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Dissolved Metals (QCLot: 297275)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 298750)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 298223)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 294539)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	104	85.0	115	----
Physical Tests (QCLot: 294540)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 294541)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100	85.0	115	----
Physical Tests (QCLot: 294542)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.4	90.0	110	----
Physical Tests (QCLot: 295449)									
turbidity	----	E121	0.1	NTU	200 NTU	100.0	85.0	115	----
Physical Tests (QCLot: 298198)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	101	85.0	115	----
Physical Tests (QCLot: 298199)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	109	85.0	115	----
Anions and Nutrients (QCLot: 294532)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	95.1	90.0	110	----
Anions and Nutrients (QCLot: 294533)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 294534)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	100	85.0	115	----
Anions and Nutrients (QCLot: 294535)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 294536)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	93.5	90.0	110	----
Anions and Nutrients (QCLot: 294537)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 294543)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 298828)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	99.5	75.0	125	----
Anions and Nutrients (QCLot: 298829)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	100	80.0	120	----
Anions and Nutrients (QCLot: 298830)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 298830) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	96.8	85.0	115	----
Total Sulfides (QCLot: 295437)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	81.4	80.0	120	----
Total Metals (QCLot: 297179)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	95.2	80.0	120	----
Total Metals (QCLot: 297671)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	99.9	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	101	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	98.2	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	96.5	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	104	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	100	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	100	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	97.4	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	97.5	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	98.3	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	97.4	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	96.8	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.7	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	113	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	98.7	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	92.4	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	97.1	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	106	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	100.0	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	97.3	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	95.8	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	96.0	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	93.4	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	93.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	98.2	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	99.2	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 297671) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	99.1	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	101	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	92.5	80.0	120	----
Dissolved Metals (QCLot: 298750)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	108	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	100	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.9	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	107	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	91.2	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.8	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.0	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	113	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	114	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	101	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	105	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	106	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	104	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	110	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 298223)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 294532)										
FJ2100939-002	Anonymous	fluoride	16984-48-8	E235.F	19.5 mg/L	20 mg/L	97.7	75.0	125	----
Anions and Nutrients (QCLot: 294533)										
FJ2100939-002	Anonymous	chloride	16887-00-6	E235.Cl	2000 mg/L	2000 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 294534)										
FJ2100939-002	Anonymous	bromide	24959-67-9	E235.Br-L	10.2 mg/L	10 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 294535)										
FJ2100939-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	50.0 mg/L	50 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 294536)										
FJ2100939-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	9.44 mg/L	10 mg/L	94.4	75.0	125	----
Anions and Nutrients (QCLot: 294537)										
FJ2100939-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	2010 mg/L	2000 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 294543)										
VA21C0110-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0318 mg/L	0.03 mg/L	106	70.0	130	----
Anions and Nutrients (QCLot: 298828)										
VA21C0110-002	Anonymous	nitrogen, total	7727-37-9	E366	0.401 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 298829)										
VA21C0110-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0500 mg/L	0.05 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 298830)										
VA21C0110-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0985 mg/L	0.1 mg/L	98.5	75.0	125	----
Total Sulfides (QCLot: 295437)										
SK2103422-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.119 mg/L	0.1 mg/L	119	75.0	125	----
Total Metals (QCLot: 297179)										
FJ2100937-005	Anonymous	mercury, total	7439-97-6	E508	0.000110 mg/L	0.0001 mg/L	110	70.0	130	----
Total Metals (QCLot: 297671)										
VA21C0102-002	Anonymous	aluminum, total	7429-90-5	E420	0.172 mg/L	0.2 mg/L	86.0	70.0	130	----
		antimony, total	7440-36-0	E420	0.0184 mg/L	0.02 mg/L	92.0	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0181 mg/L	0.02 mg/L	90.6	70.0	130	----
		barium, total	7440-39-3	E420	0.0171 mg/L	0.02 mg/L	85.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 297671) - continued										
VA21C0102-002	Anonymous	beryllium, total	7440-41-7	E420	0.0381 mg/L	0.04 mg/L	95.4	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00925 mg/L	0.01 mg/L	92.5	70.0	130	----
		boron, total	7440-42-8	E420	0.094 mg/L	0.1 mg/L	94.2	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00362 mg/L	0.004 mg/L	90.4	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0362 mg/L	0.04 mg/L	90.6	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0178 mg/L	0.02 mg/L	89.1	70.0	130	----
		copper, total	7440-50-8	E420	0.0178 mg/L	0.02 mg/L	89.3	70.0	130	----
		iron, total	7439-89-6	E420	1.81 mg/L	2 mg/L	90.7	70.0	130	----
		lead, total	7439-92-1	E420	0.0177 mg/L	0.02 mg/L	88.7	70.0	130	----
		lithium, total	7439-93-2	E420	0.105 mg/L	0.1 mg/L	105	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0185 mg/L	0.02 mg/L	92.4	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0172 mg/L	0.02 mg/L	86.1	70.0	130	----
		nickel, total	7440-02-0	E420	0.0357 mg/L	0.04 mg/L	89.2	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.28 mg/L	10 mg/L	92.8	70.0	130	----
		potassium, total	7440-09-7	E420	3.63 mg/L	4 mg/L	90.6	70.0	130	----
		selenium, total	7782-49-2	E420	0.0365 mg/L	0.04 mg/L	91.3	70.0	130	----
		silicon, total	7440-21-3	E420	8.90 mg/L	10 mg/L	89.0	70.0	130	----
		silver, total	7440-22-4	E420	0.00365 mg/L	0.004 mg/L	91.2	70.0	130	----
		sodium, total	17341-25-2	E420	1.87 mg/L	2 mg/L	93.4	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00352 mg/L	0.004 mg/L	87.9	70.0	130	----
		tin, total	7440-31-5	E420	0.0174 mg/L	0.02 mg/L	87.2	70.0	130	----
		titanium, total	7440-32-6	E420	0.0360 mg/L	0.04 mg/L	90.1	70.0	130	----
		uranium, total	7440-61-1	E420	0.00350 mg/L	0.004 mg/L	87.6	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0918 mg/L	0.1 mg/L	91.8	70.0	130	----
		zinc, total	7440-66-6	E420	0.370 mg/L	0.4 mg/L	92.4	70.0	130	----
Dissolved Metals (QCLot: 297275)										
FJ2100937-006	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000930 mg/L	0.0001 mg/L	93.0	70.0	130	----
Dissolved Metals (QCLot: 298750)										
VA21C0102-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.203 mg/L	0.2 mg/L	101	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0389 mg/L	0.04 mg/L	97.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 298750) - continued										
VA21C0102-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00938 mg/L	0.01 mg/L	93.8	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.090 mg/L	0.1 mg/L	90.1	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00402 mg/L	0.004 mg/L	100	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0408 mg/L	0.04 mg/L	102	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.78 mg/L	2 mg/L	89.1	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0193 mg/L	0.02 mg/L	96.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0966 mg/L	0.1 mg/L	96.6	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0395 mg/L	0.04 mg/L	98.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.81 mg/L	10 mg/L	98.1	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.92 mg/L	4 mg/L	97.9	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0413 mg/L	0.04 mg/L	103	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.77 mg/L	10 mg/L	87.7	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.91 mg/L	2 mg/L	95.4	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00390 mg/L	0.004 mg/L	97.6	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00400 mg/L	0.004 mg/L	100	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.428 mg/L	0.4 mg/L	107	70.0	130	----
Aggregate Organics (QCLot: 298223)										
VA21C0022-003	Anonymous	chemical oxygen demand [COD]	----	E559	110 mg/L	100 mg/L	110	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** RS/BM	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17B - snap	14-Sep-21	14:30	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C0111

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

- By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by: TC	Date: SEP 15 2027	Time: 4	Temperature: 10 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
R. Sussbauer	14-Sep-21	18:00								

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C0275**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 16-Sep-2021 17:00
PO	: 1025612	Date Analysis Commenced	: 17-Sep-2021
C-O-C number	: ----	Issue Date	: 27-Sep-2021 17:32
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Dion Chan	Lab Assistant	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-17B - E314701	----	----	----	----
				Client sampling date / time	15-Sep-2021 16:25	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0275-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	112	----	----	----	----
conductivity	----	E100	2.0	µS/cm	590	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	161	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	181	----	----	----	----
pH	----	E108	0.10	pH units	8.21	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	397	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	104	----	----	----	----
turbidity	----	E121	0.10	NTU	166	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0848	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	4.72	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.260	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.155	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.155	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0976	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	188	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.395	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.420	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	1.94	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00200	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0636	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0780	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17B - E314701	----	----	----	----
				Client sampling date / time	15-Sep-2021 16:25	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0275-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000151	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	0.000053	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.036	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000402	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	66.1	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.0150	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00163	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00356	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	2.62	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00244	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.147	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	3.82	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.732	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000284	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00486	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.0103	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	2.14	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000297	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	5.90	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000175	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	55.2	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.91	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000041	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	0.0278	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000194	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00342	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0114	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	1.03	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW18-17B - E314701	----	----	----	----
					Client sampling date / time	15-Sep-2021 16:25	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C0275-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00078	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.0472	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0520	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		0.036	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		0.0000055	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		59.7	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		0.00285	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00035	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.00057	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		0.415	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		0.000403	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.140	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		2.98	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.603	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		0.0000055	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.00366	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		0.00260	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		1.97	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000369	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		4.60	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		54.0	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		1.82	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		0.000017	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		0.0129	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000161	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		0.00159	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17B - E314701**	**----**	**----**	**----**	**----**
				Client sampling date / time	15-Sep-2021 16:25	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C0275-001**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0036	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C0275**	Page	: 1 of 12
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 16-Sep-2021 17:00
PO	: 1025612	Issue Date	: 27-Sep-2021 17:32
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Total Metals	QC-MRG3-298951001	----	arsenic, total	7440-38-2	E420	0.00011 mg/L MB-LOR	0.0001 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
MB-LOR	*Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314701	E559	15-Sep-2021	----	----	----		22-Sep-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314701	E298	15-Sep-2021	23-Sep-2021	----	----		24-Sep-2021	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - E314701	E235.Br-L	15-Sep-2021	----	----	----		17-Sep-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B - E314701	E235.Cl	15-Sep-2021	----	----	----		17-Sep-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B - E314701	E378-U	15-Sep-2021	----	----	----		17-Sep-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B - E314701	E235.F	15-Sep-2021	----	----	----		17-Sep-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - E314701	E235.NO3-L	15-Sep-2021	----	----	----		17-Sep-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B - E314701	E235.NO2-L	15-Sep-2021	----	----	----		17-Sep-2021	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17B - E314701	E235.SO4	15-Sep-2021	----	----	----		17-Sep-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314701	E366	15-Sep-2021	23-Sep-2021	----	----		24-Sep-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17B - E314701	E372-U	15-Sep-2021	23-Sep-2021	----	----		24-Sep-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B - E314701	E509	15-Sep-2021	21-Sep-2021	----	----		21-Sep-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B - E314701	E421	15-Sep-2021	21-Sep-2021	----	----		21-Sep-2021	180 days	6 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B - E314701	E283	15-Sep-2021	----	----	----		17-Sep-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B - E314701	E290	15-Sep-2021	----	----	----		18-Sep-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B - E314701	E100	15-Sep-2021	----	----	----		18-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW18-17B - E314701	E108	15-Sep-2021	----	----	----		18-Sep-2021	0.25 hrs	68 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17B - E314701	E162	15-Sep-2021	----	----	----		23-Sep-2021	7 days	7 days	× EHT
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17B - E314701	E160-H	15-Sep-2021	----	----	----		23-Sep-2021	7 days	7 days	× EHT
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17B - E314701	E121	15-Sep-2021	----	----	----		18-Sep-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B - E314701	E508	15-Sep-2021	----	----	----		21-Sep-2021	28 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B - E314701	E420	15-Sep-2021	----	----	----		22-Sep-2021	180 days	7 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17B - E314701	E395	15-Sep-2021	----	----	----		17-Sep-2021	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	295371	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	295368	1	7	14.2	5.0	✓
Ammonia by Fluorescence	E298	301075	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	295365	1	2	50.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	299467	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	295360	1	9	11.1	5.0	✓
Conductivity in Water	E100	295367	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	298292	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298499	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	295370	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	295363	1	4	25.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	295364	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	295361	1	14	7.1	5.0	✓
pH by Meter	E108	295366	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	295359	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	300064	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	298212	1	2	50.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	298951	1	14	7.1	5.0	✓
Total Nitrogen by Colourimetry	E366	301073	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	301074	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	300067	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	296125	1	19	5.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	295371	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	295368	1	7	14.2	5.0	✓
Ammonia by Fluorescence	E298	301075	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	295365	1	2	50.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	299467	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	295360	1	9	11.1	5.0	✓
Conductivity in Water	E100	295367	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	298292	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298499	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	295370	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	295363	1	4	25.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	295364	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	295361	1	14	7.1	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	295366	1	11	9.0	5.0	✓
Sulfate in Water by IC	E235.SO4	295359	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	300064	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	298212	1	2	50.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	298951	1	14	7.1	5.0	✓
Total Nitrogen by Colourimetry	E366	301073	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	301074	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	300067	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	296125	1	19	5.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	295371	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	295368	1	7	14.2	5.0	✓
Ammonia by Fluorescence	E298	301075	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	295365	1	2	50.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	299467	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	295360	1	9	11.1	5.0	✓
Conductivity in Water	E100	295367	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	298292	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298499	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	295370	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	295363	1	4	25.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	295364	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	295361	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	295359	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	300064	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	298212	1	2	50.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	298951	1	14	7.1	5.0	✓
Total Nitrogen by Colourimetry	E366	301073	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	301074	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓
TSS by Gravimetry	E160-H	300067	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	296125	1	19	5.2	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	301075	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	295365	1	2	50.0	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	299467	1	19	5.2	5.0	✓
Chloride in Water by IC	E235.Cl	295360	1	9	11.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	298292	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	298499	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	295370	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	295363	1	4	25.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	295364	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	295361	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	295359	1	14	7.1	5.0	✓
Total Mercury in Water by CVAAS	E508	298212	1	2	50.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	298951	1	14	7.1	5.0	✓
Total Nitrogen by Colourimetry	E366	301073	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	301074	1	4	25.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	295437	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C0275**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 16-Sep-2021 17:00
PO	: 1025612	Date Analysis Commenced	: 17-Sep-2021
C-O-C number	: ----	Issue Date	: 27-Sep-2021 17:32
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Dion Chan	Lab Assistant	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 295366)											
VA21C0247-001	Anonymous	pH	----	E108	0.10	pH units	7.41	7.43	0.270%	4%	----
Physical Tests (QC Lot: 295367)											
VA21C0247-001	Anonymous	conductivity	----	E100	2.0	µS/cm	3030	3040	0.329%	10%	----
Physical Tests (QC Lot: 295368)											
VA21C0247-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	19.4	19.0	2.08%	20%	----
Physical Tests (QC Lot: 295371)											
VA21C0275-001	BJ-GW18-17B - E314701	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 296125)											
VA21C0197-003	Anonymous	turbidity	----	E121	0.10	NTU	0.19	0.17	0.02	Diff <2x LOR	----
Physical Tests (QC Lot: 300064)											
VA21C0273-001	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	135	138	2.44%	20%	----
Physical Tests (QC Lot: 300067)											
VA21C0165-005	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 295359)											
VA21C0220-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	53.5	53.4	0.156%	20%	----
Anions and Nutrients (QC Lot: 295360)											
VA21C0220-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	5.92	5.92	0.0556%	20%	----
Anions and Nutrients (QC Lot: 295361)											
VA21C0220-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 295363)											
VA21C0220-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.201	0.200	0.366%	20%	----
Anions and Nutrients (QC Lot: 295364)											
VA21C0273-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 295365)											
VA21C0273-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 295370)											
VA21C0220-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0312	0.0309	1.10%	20%	----
Anions and Nutrients (QC Lot: 301073)											
VA21C0101-001	Anonymous	nitrogen, total	7727-37-9	E366	0.600	mg/L	6.62	6.57	0.716%	20%	----
Anions and Nutrients (QC Lot: 301074)											
VA21C0128-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	3.98	3.95	0.570%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 301075)											
VA21C0128-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0506	0.0497	1.77%	20%	----
Total Sulfides (QC Lot: 295437)											
SK2103422-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0048	0.0048	0.00002	Diff <2x LOR	----
Total Metals (QC Lot: 298212)											
VA21C0251-006	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 298951)											
VA21C0215-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0160	0.0184	0.0023	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0133	0.0138	3.71%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000085	0.0000074	0.0000011	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	14.8	14.7	0.369%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000196	0.000190	0.000006	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	2.89	3.01	4.03%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00113	0.00124	9.46%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000454	0.000476	0.000022	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.601	0.617	2.73%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000088	0.000084	0.000004	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.40	1.39	0.758%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	0.600	0.623	3.69%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0906	0.0910	0.462%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 298951) - continued											
VA21C0215-001	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	0.000309	0.000322	4.19%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 298292)											
VA21C0214-009	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 298499)											
VA21C0215-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0107	0.0119	11.1%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00010	<0.00010	0.000002	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0135	0.0134	0.487%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000080	0.0000059	0.0000020	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	14.6	14.0	4.18%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00067	0.00065	0.00002	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000343	0.000292	0.000051	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	2.88	2.88	0.121%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00058	0.00059	0.00002	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000487	0.000472	0.000015	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.589	0.595	0.995%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000071	0.000064	0.000008	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	1.27	1.30	2.16%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	0.612	0.611	0.197%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.0898	0.0873	2.84%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 298499) - continued											
VA21C0215-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000330	0.000325	1.76%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0015	0.0015	0.000010	Diff <2x LOR	----
Aggregate Organics (QC Lot: 299467)											
VA21C0023-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	70	70	0.06	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 295367)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 295368)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 295371)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 296125)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 300064)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 300067)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 295359)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 295360)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 295361)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 295363)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 295364)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 295365)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 295370)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 301073)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 301074)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 301075)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 295437)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 298212)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 298951)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	# 0.00011	MB-LOR
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Dissolved Metals (QCLot: 298292)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 298499)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 299467)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 295366)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 295367)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	96.2	90.0	110	----
Physical Tests (QCLot: 295368)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100	85.0	115	----
Physical Tests (QCLot: 295371)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	101	85.0	115	----
Physical Tests (QCLot: 296125)									
turbidity	----	E121	0.1	NTU	200 NTU	105	85.0	115	----
Physical Tests (QCLot: 300064)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	95.6	85.0	115	----
Physical Tests (QCLot: 300067)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	94.9	85.0	115	----
Anions and Nutrients (QCLot: 295359)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 295360)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 295361)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	95.3	90.0	110	----
Anions and Nutrients (QCLot: 295363)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	94.8	90.0	110	----
Anions and Nutrients (QCLot: 295364)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 295365)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	99.4	85.0	115	----
Anions and Nutrients (QCLot: 295370)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	99.8	80.0	120	----
Anions and Nutrients (QCLot: 301073)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	99.8	75.0	125	----
Anions and Nutrients (QCLot: 301074)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	92.6	80.0	120	----
Anions and Nutrients (QCLot: 301075)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 301075) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	101	85.0	115	----
Total Sulfides (QCLot: 295437)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	81.4	80.0	120	----
Total Metals (QCLot: 298212)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	93.1	80.0	120	----
Total Metals (QCLot: 298951)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	104	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	112	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	105	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	95.4	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	108	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	102	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	102	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	101	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	107	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	110	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	113	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	104	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	108	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	104	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	100	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	104	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 298951) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	104	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	83.8	80.0	120	----
Dissolved Metals (QCLot: 298499)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	97.1	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	97.4	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	96.3	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	96.9	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.0	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	96.3	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	94.8	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	96.6	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	96.6	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	101	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	100	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.0	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	97.9	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	96.2	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	104	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	95.4	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	100.0	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	96.1	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	98.7	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	97.8	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	95.7	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	90.9	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	99.2	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	95.4	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 299467)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	104	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 295359)										
VA21C0226-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	116 mg/L	100 mg/L	116	75.0	125	----
Anions and Nutrients (QCLot: 295360)										
VA21C0226-001	Anonymous	chloride	16887-00-6	E235.Cl	109 mg/L	100 mg/L	109	75.0	125	----
Anions and Nutrients (QCLot: 295361)										
VA21C0226-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.517 mg/L	0.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 295363)										
VA21C0275-001	BJ-GW18-17B - E314701	fluoride	16984-48-8	E235.F	1.07 mg/L	1 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 295364)										
VA21C0223-003	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	26.0 mg/L	25 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 295365)										
VA21C0275-001	BJ-GW18-17B - E314701	bromide	24959-67-9	E235.Br-L	0.501 mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 295370)										
VA21C0273-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0295 mg/L	0.03 mg/L	98.3	70.0	130	----
Anions and Nutrients (QCLot: 301073)										
VA21C0275-001	BJ-GW18-17B - E314701	nitrogen, total	7727-37-9	E366	0.393 mg/L	0.4 mg/L	98.2	70.0	130	----
Anions and Nutrients (QCLot: 301074)										
VA21C0128-002	Anonymous	phosphorus, total	7723-14-0	E372-U	6.16 mg/L	5 mg/L	123	70.0	130	----
Anions and Nutrients (QCLot: 301075)										
VA21C0128-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Total Sulfides (QCLot: 295437)										
SK2103422-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.119 mg/L	0.1 mg/L	119	75.0	125	----
Total Metals (QCLot: 298212)										
VA21C0275-001	BJ-GW18-17B - E314701	mercury, total	7439-97-6	E508	0.000456 mg/L	0.0005 mg/L	91.2	70.0	130	----
Total Metals (QCLot: 298951)										
VA21C0215-002	Anonymous	aluminum, total	7429-90-5	E420	0.192 mg/L	0.2 mg/L	96.2	70.0	130	----
		antimony, total	7440-36-0	E420	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0192 mg/L	0.02 mg/L	96.0	70.0	130	----
		barium, total	7440-39-3	E420	0.0198 mg/L	0.02 mg/L	99.1	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 298951) - continued										
VA21C0215-002	Anonymous	beryllium, total	7440-41-7	E420	0.0387 mg/L	0.04 mg/L	96.8	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00934 mg/L	0.01 mg/L	93.4	70.0	130	----
		boron, total	7440-42-8	E420	0.094 mg/L	0.1 mg/L	94.5	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00379 mg/L	0.004 mg/L	94.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0388 mg/L	0.04 mg/L	97.0	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0198 mg/L	0.02 mg/L	99.3	70.0	130	----
		copper, total	7440-50-8	E420	0.0192 mg/L	0.02 mg/L	96.3	70.0	130	----
		iron, total	7439-89-6	E420	1.91 mg/L	2 mg/L	95.4	70.0	130	----
		lead, total	7439-92-1	E420	0.0190 mg/L	0.02 mg/L	95.2	70.0	130	----
		lithium, total	7439-93-2	E420	0.0930 mg/L	0.1 mg/L	93.0	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0197 mg/L	0.02 mg/L	98.6	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		nickel, total	7440-02-0	E420	0.0394 mg/L	0.04 mg/L	98.4	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.93 mg/L	10 mg/L	99.3	70.0	130	----
		potassium, total	7440-09-7	E420	3.78 mg/L	4 mg/L	94.6	70.0	130	----
		selenium, total	7782-49-2	E420	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		silicon, total	7440-21-3	E420	9.20 mg/L	10 mg/L	92.0	70.0	130	----
		silver, total	7440-22-4	E420	0.00380 mg/L	0.004 mg/L	94.9	70.0	130	----
		sodium, total	17341-25-2	E420	2.07 mg/L	2 mg/L	103	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00381 mg/L	0.004 mg/L	95.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0195 mg/L	0.02 mg/L	97.7	70.0	130	----
		titanium, total	7440-32-6	E420	0.0377 mg/L	0.04 mg/L	94.2	70.0	130	----
		uranium, total	7440-61-1	E420	0.00376 mg/L	0.004 mg/L	93.9	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0985 mg/L	0.1 mg/L	98.5	70.0	130	----
		zinc, total	7440-66-6	E420	0.406 mg/L	0.4 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 298292)										
VA21C0214-010	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000928 mg/L	0.0001 mg/L	92.8	70.0	130	----
Dissolved Metals (QCLot: 298499)										
FJ2100941-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.187 mg/L	0.2 mg/L	93.6	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0196 mg/L	0.02 mg/L	98.1	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0189 mg/L	0.02 mg/L	94.7	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0384 mg/L	0.04 mg/L	96.1	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 298499) - continued										
FJ2100941-002	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00867 mg/L	0.01 mg/L	86.7	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.093 mg/L	0.1 mg/L	92.9	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00391 mg/L	0.004 mg/L	97.8	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0366 mg/L	0.04 mg/L	91.5	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0181 mg/L	0.02 mg/L	90.5	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0180 mg/L	0.02 mg/L	90.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.84 mg/L	2 mg/L	92.1	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0190 mg/L	0.02 mg/L	95.2	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0970 mg/L	0.1 mg/L	97.0	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0200 mg/L	0.02 mg/L	99.8	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0359 mg/L	0.04 mg/L	89.7	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.88 mg/L	10 mg/L	98.8	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.61 mg/L	4 mg/L	90.3	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0391 mg/L	0.04 mg/L	97.7	70.0	130	----
		silicon, dissolved	7440-21-3	E421	7.74 mg/L	10 mg/L	77.4	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00384 mg/L	0.004 mg/L	96.1	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.87 mg/L	2 mg/L	93.6	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00381 mg/L	0.004 mg/L	95.4	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0189 mg/L	0.02 mg/L	94.6	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0374 mg/L	0.04 mg/L	93.5	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00387 mg/L	0.004 mg/L	96.7	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0966 mg/L	0.1 mg/L	96.6	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.373 mg/L	0.4 mg/L	93.3	70.0	130	----
Aggregate Organics (QCLot: 299467)										
VA21C0024-001	Anonymous	chemical oxygen demand [COD]	----	E559	107 mg/L	100 mg/L	107	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	*Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.*

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17B - E314701	15-Sep-21	16:25	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C0275
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Nathan Glas	15-Sep-21	18:00	[illegible]	16/09/2021	5pm	9 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C0574**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 20-Sep-2021 18:45
PO	: 1025614	Date Analysis Commenced	: 21-Sep-2021
C-O-C number	: ----	Issue Date	: 07-Oct-2021 15:28
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-9B - E314696	----	----	----	----
				Client sampling date / time	17-Sep-2021 12:45	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0574-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	3.2 RRV	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	71.6	----	----	----	----
conductivity	----	E100	2.0	µS/cm	234	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	115	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	103	----	----	----	----
pH	----	E108	0.10	pH units	8.01	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	129	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	19.9	----	----	----	----
turbidity	----	E121	0.10	NTU	11.7	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.028	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.092	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0153	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0153	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.107	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0228	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	40.4	----	----	----	----
Organic / Inorganic Carbon									
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	0.74	----	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	----	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.321	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00106	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW12-9B - E314696	----	----	----	----
					Client sampling date / time	17-Sep-2021 12:45	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C0574-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.00169	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L		0.0337	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L		<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L		<0.010	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.0000227	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L		39.4	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L		0.00392	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00027	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.00269	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L		0.636	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L		0.000988	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L		0.0036	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		1.18	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.0297	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.00322	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L		<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L		0.866	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L		0.000622	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L		2.70	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L		0.000056	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L		1.59	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L		0.249	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L		0.000013	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L		0.00038	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L		<0.0100	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000329	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00074	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0076	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW12-9B - E314696	----	----	----	----
					Client sampling date / time	17-Sep-2021 12:45	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C0574-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0071	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00082	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00069	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0190	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		<0.010	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		44.3	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		0.00052	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.00060	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0037	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		1.10	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.00104	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.00332	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		0.750	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000562	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		2.01	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		1.54	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		0.230	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		0.00013	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000308	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)					Client sample ID	**BJ-GW12-9B - E314696**	**----**	**----**	**----**	**----**
					Client sampling date / time	17-Sep-2021 12:45	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*		**VA21C0574-001**	**--------**	**--------**	**--------**	**--------**
						Result	----	----	----	----
Dissolved Metals										
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L		0.0016	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-		Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-		Field	----	----	----	----
Aggregate Organics										
chemical oxygen demand [COD]	----	E559	20	mg/L		<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C0574**	Page	: 1 of 11
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 20-Sep-2021 18:45
PO	: 1025614	Issue Date	: 07-Oct-2021 15:28
C-O-C number	: ----		
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-9B - E314696	E559	17-Sep-2021	----	----	----		28-Sep-2021	28 days	11 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-9B - E314696	E298	17-Sep-2021	28-Sep-2021	----	----		29-Sep-2021	28 days	11 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-9B - E314696	E235.Br-L	17-Sep-2021	----	----	----		21-Sep-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-9B - E314696	E235.Cl	17-Sep-2021	----	----	----		21-Sep-2021	28 days	4 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-9B - E314696	E378-U	17-Sep-2021	----	----	----		21-Sep-2021	3 days	4 days	✗ EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-9B - E314696	E235.F	17-Sep-2021	----	----	----		21-Sep-2021	28 days	4 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-9B - E314696	E235.NO3-L	17-Sep-2021	----	----	----		21-Sep-2021	3 days	4 days	✗ EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-9B - E314696	E235.NO2-L	17-Sep-2021	----	----	----		21-Sep-2021	3 days	4 days	× EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-9B - E314696	E235.SO4	17-Sep-2021	----	----	----		21-Sep-2021	28 days	4 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-9B - E314696	E366	17-Sep-2021	28-Sep-2021	----	----		30-Sep-2021	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-9B - E314696	E372-U	17-Sep-2021	28-Sep-2021	----	----		30-Sep-2021	28 days	12 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-9B - E314696	E509	17-Sep-2021	25-Sep-2021	----	----		25-Sep-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-9B - E314696	E421	17-Sep-2021	27-Sep-2021	----	----		27-Sep-2021	180 days	10 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW12-9B - E314696	E355-L	17-Sep-2021	28-Sep-2021	----	----		29-Sep-2021	28 days	11 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-9B - E314696	E283	17-Sep-2021	----	----	----		21-Sep-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-9B - E314696	E290	17-Sep-2021	----	----	----		21-Sep-2021	14 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-9B - E314696	E100	17-Sep-2021	----	----	----		21-Sep-2021	28 days	4 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW12-9B - E314696	E108	17-Sep-2021	----	----	----		21-Sep-2021	0.25 hrs	104 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW12-9B - E314696	E162	17-Sep-2021	----	----	----		24-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW12-9B - E314696	E160-H	17-Sep-2021	----	----	----		24-Sep-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW12-9B - E314696	E121	17-Sep-2021	----	----	----		21-Sep-2021	3 days	4 days	× EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW12-9B - E314696	E508	17-Sep-2021	----	----	----		27-Sep-2021	28 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW12-9B - E314696	E420	17-Sep-2021	----	----	----		27-Sep-2021	180 days	10 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW12-9B - E314696	E395-H	17-Sep-2021	----	----	----		21-Sep-2021	7 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	298414	0	1	0.0	5.0	✗
Alkalinity Species by Titration	E290	298404	0	1	0.0	5.0	✗
Ammonia by Fluorescence	E298	305481	1	15	6.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	298410	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	304401	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	298409	1	20	5.0	5.0	✓
Conductivity in Water	E100	298403	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	302737	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	303292	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	298406	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	298407	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	298412	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	298411	1	20	5.0	5.0	✓
pH by Meter	E108	298402	1	8	12.5	5.0	✓
Sulfate in Water by IC	E235.SO4	298408	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	301509	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	303495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	302393	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	305478	1	9	11.1	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	305483	1	1	100.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	305479	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	298697	1	2	50.0	5.0	✓
TSS by Gravimetry	E160-H	301503	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	298293	1	14	7.1	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	298414	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	298404	1	1	100.0	5.0	✓
Ammonia by Fluorescence	E298	305481	1	15	6.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	298410	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	304401	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	298409	1	20	5.0	5.0	✓
Conductivity in Water	E100	298403	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	302737	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	303292	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	298406	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	298407	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	298412	1	16	6.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	298411	1	20	5.0	5.0	✓
pH by Meter	E108	298402	1	8	12.5	5.0	✓
Sulfate in Water by IC	E235.SO4	298408	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	301509	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	303495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	302393	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	305478	1	9	11.1	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	305483	1	1	100.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	305479	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	298697	1	2	50.0	5.0	✓
TSS by Gravimetry	E160-H	301503	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	298293	1	14	7.1	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	298414	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	298404	1	1	100.0	5.0	✓
Ammonia by Fluorescence	E298	305481	1	15	6.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	298410	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	304401	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	298409	1	20	5.0	5.0	✓
Conductivity in Water	E100	298403	1	11	9.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	302737	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	303292	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	298406	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	298407	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	298412	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	298411	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	298408	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	301509	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	303495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	302393	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	305478	1	9	11.1	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	305483	1	1	100.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	305479	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	298697	1	2	50.0	5.0	✓
TSS by Gravimetry	E160-H	301503	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	298293	1	14	7.1	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	305481	1	15	6.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	298410	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	304401	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Chloride in Water by IC	E235.Cl	298409	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	302737	1	16	6.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	303292	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	298406	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	298407	1	16	6.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	298412	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	298411	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	298408	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	303495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	302393	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	305478	1	9	11.1	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	305483	0	1	0.0	5.0	×
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	305479	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	298697	1	2	50.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H_2S concentration based on the total sulfide concentration in the sample. The H_2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C0574**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 20-Sep-2021 18:45
PO	: 1025614	Date Analysis Commenced	: 21-Sep-2021
C-O-C number	: ----	Issue Date	: 07-Oct-2021 15:28
Sampler	: C M, N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 298293)											
FJ2100962-001	Anonymous	turbidity	----	E121	0.10	NTU	1.49	1.39	6.94%	15%	----
Physical Tests (QC Lot: 298402)											
VA21C0541-001	Anonymous	pH	----	E108	0.10	pH units	7.51	7.46	0.668%	4%	----
Physical Tests (QC Lot: 298403)											
VA21C0541-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1040	1040	0.770%	10%	----
Physical Tests (QC Lot: 301503)											
VA21C0424-010	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	7.9	8.7	0.8	Diff <2x LOR	----
Physical Tests (QC Lot: 301509)											
FJ2100972-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	2760	2780	0.993%	20%	----
Anions and Nutrients (QC Lot: 298406)											
VA21B9413-022	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0298	0.0300	0.676%	20%	----
Anions and Nutrients (QC Lot: 298407)											
VA21C0541-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.219	0.216	0.002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298408)											
VA21C0541-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	15.8	15.8	0.109%	20%	----
Anions and Nutrients (QC Lot: 298409)											
VA21C0541-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	60.7	60.6	0.228%	20%	----
Anions and Nutrients (QC Lot: 298410)											
VA21C0541-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298411)											
VA21C0541-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 298412)											
VA21C0541-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.178	0.182	0.0039	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 305478)											
VA21C0501-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.133	0.135	0.001	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 305479)											
VA21C0501-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0109	0.0086	0.0024	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 305481)											
VA21C0409-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0250	mg/L	1.57	1.61	2.67%	20%	----
Organic / Inorganic Carbon (QC Lot: 305483)											
VA21C0574-001	BJ-GW12-9B - E314696	carbon, total organic [TOC]	----	E355-L	0.50	mg/L	0.74	1.01	0.26	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Sulfides (QC Lot: 298697)											
VA21C0574-001	BJ-GW12-9B - E314696	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 302393)											
VA21C0602-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0434	0.0424	2.35%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00016	0.00016	0.000001	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00080	0.00080	0.000008	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0236	0.0242	2.47%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.022	0.022	0.0004	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000098	0.0000110	0.0000012	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	32.2	32.3	0.351%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00703	0.00700	0.443%	20%	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000066	0.000066	0.00000004	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0018	0.0018	0.000007	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	8.33	8.27	0.678%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00126	0.00129	2.14%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00063	0.00066	0.00003	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	1.68	1.68	0.282%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000167	0.000143	0.000024	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	0.54	0.56	0.02	Diff <2x LOR	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	14.0	13.9	0.821%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.185	0.187	1.11%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000344	0.000344	0.0439%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0068	0.0067	0.0001	Diff <2x LOR	----
Total Metals (QC Lot: 303495)											

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 303495) - continued											
VA21C0563-005	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 302737)											
VA21C0563-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 303292)											
VA21C0581-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0011	<0.0010	0.0001	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00041	0.00038	0.00003	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0459	0.0472	2.86%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.015	0.015	0.0001	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	51.2	50.1	2.27%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00193	0.00187	0.00006	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000091	0.000087	0.000004	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	14.1	13.6	3.17%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00267	0.00262	1.59%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00158	0.00159	0.724%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.91	1.86	2.99%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000064	<0.000050	0.000014	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	6.24	6.39	2.43%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	12.0	11.8	1.96%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.303	0.296	2.22%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00116	0.00111	4.52%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00086	0.00081	0.00005	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 303292) - continued											
VA21C0581-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0029	0.0023	0.0006	Diff <2x LOR	----
Aggregate Organics (QC Lot: 304401)											
KS2103016-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	26	30	3	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 298293)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 298403)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 298404)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	1.0	----
Physical Tests (QCLot: 298414)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 301503)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 301509)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 298406)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 298407)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 298408)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 298409)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 298410)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 298411)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 298412)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 305478)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 305479)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 305481)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Organic / Inorganic Carbon (QCLot: 305483)						
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	<0.50	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 298697)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----
Total Metals (QCLot: 302393)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 303495)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 302737)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 303292)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Aggregate Organics (QCLot: 304401)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 298293)									
turbidity	----	E121	0.1	NTU	200 NTU	102	85.0	115	----
Physical Tests (QCLot: 298402)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 298403)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	100	90.0	110	----
Physical Tests (QCLot: 298404)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	94.3	85.0	115	----
Physical Tests (QCLot: 298414)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	99.7	85.0	115	----
Physical Tests (QCLot: 301503)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	95.5	85.0	115	----
Physical Tests (QCLot: 301509)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	94.8	85.0	115	----
Anions and Nutrients (QCLot: 298406)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	96.0	80.0	120	----
Anions and Nutrients (QCLot: 298407)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	96.6	90.0	110	----
Anions and Nutrients (QCLot: 298408)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 298409)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	99.2	90.0	110	----
Anions and Nutrients (QCLot: 298410)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	100	85.0	115	----
Anions and Nutrients (QCLot: 298411)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	96.4	90.0	110	----
Anions and Nutrients (QCLot: 298412)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	98.8	90.0	110	----
Anions and Nutrients (QCLot: 305478)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 305479)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	93.9	80.0	120	----
Anions and Nutrients (QCLot: 305481)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 305481) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	98.9	85.0	115	----
Organic / Inorganic Carbon (QCLot: 305483)									
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	8.57 mg/L	108	80.0	120	----
Total Sulfides (QCLot: 298697)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	94.6	80.0	120	----
Total Metals (QCLot: 302393)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	102	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	109	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	97.7	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	94.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	103	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	90.2	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	96.7	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	96.4	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	100.0	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	96.9	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	99.2	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	102	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	94.5	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	96.7	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	97.1	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	99.2	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	98.3	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	99.3	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	103	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	100	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	104	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	98.8	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 302393) - continued									
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	97.8	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	100	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	99.3	80.0	120	----
Total Metals (QCLot: 303495)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	97.0	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	97.5	80.0	120	----
Dissolved Metals (QCLot: 303292)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	99.2	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	98.8	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	95.9	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	113	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	99.9	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	112	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	108	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.1	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	110	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	105	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	106	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	101	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	99.6	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	107	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	106	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	103	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	94.8	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 303292) - continued									
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	114	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	107	80.0	120	----
Aggregate Organics (QCLot: 304401)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	102	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 298406)										
VA21C0574-001	BJ-GW12-9B - E314696	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0331 mg/L	0.03 mg/L	110	70.0	130	----
Anions and Nutrients (QCLot: 298407)										
VA21C0541-002	Anonymous	fluoride	16984-48-8	E235.F	9.71 mg/L	10 mg/L	97.1	75.0	125	----
Anions and Nutrients (QCLot: 298408)										
VA21C0541-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	982 mg/L	1000 mg/L	98.2	75.0	125	----
Anions and Nutrients (QCLot: 298409)										
VA21C0541-002	Anonymous	chloride	16887-00-6	E235.Cl	978 mg/L	1000 mg/L	97.8	75.0	125	----
Anions and Nutrients (QCLot: 298410)										
VA21C0541-002	Anonymous	bromide	24959-67-9	E235.Br-L	4.90 mg/L	5 mg/L	98.0	75.0	125	----
Anions and Nutrients (QCLot: 298411)										
VA21C0541-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	4.71 mg/L	5 mg/L	94.1	75.0	125	----
Anions and Nutrients (QCLot: 298412)										
VA21C0541-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	24.4 mg/L	25 mg/L	97.5	75.0	125	----
Anions and Nutrients (QCLot: 305478)										
VA21C0501-002	Anonymous	nitrogen, total	7727-37-9	E366	0.403 mg/L	0.4 mg/L	101	70.0	130	----
Anions and Nutrients (QCLot: 305479)										
VA21C0501-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0493 mg/L	0.05 mg/L	98.6	70.0	130	----
Anions and Nutrients (QCLot: 305481)										
VA21C0417-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Total Sulfides (QCLot: 298697)										
VA21C0648-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	ND mg/L	1 mg/L	ND	75.0	125	MS-B
Total Metals (QCLot: 302393)										
VA21C0389-002	Anonymous	aluminum, total	7429-90-5	E420	0.912 mg/L	1 mg/L	91.2	70.0	130	----
		antimony, total	7440-36-0	E420	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0955 mg/L	0.1 mg/L	95.5	70.0	130	----
		barium, total	7440-39-3	E420	0.0926 mg/L	0.1 mg/L	92.6	70.0	130	----
		beryllium, total	7440-41-7	E420	0.180 mg/L	0.2 mg/L	90.1	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0444 mg/L	0.05 mg/L	88.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 302393) - continued										
VA21C0389-002	Anonymous	boron, total	7440-42-8	E420	ND mg/L	0.5 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.0185 mg/L	0.02 mg/L	92.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	20 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.190 mg/L	0.2 mg/L	95.1	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0932 mg/L	0.1 mg/L	93.2	70.0	130	----
		copper, total	7440-50-8	E420	0.0887 mg/L	0.1 mg/L	88.7	70.0	130	----
		iron, total	7439-89-6	E420	9.16 mg/L	10 mg/L	91.6	70.0	130	----
		lead, total	7439-92-1	E420	0.0917 mg/L	0.1 mg/L	91.7	70.0	130	----
		lithium, total	7439-93-2	E420	0.454 mg/L	0.5 mg/L	90.8	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	5 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		nickel, total	7440-02-0	E420	0.182 mg/L	0.2 mg/L	91.2	70.0	130	----
		phosphorus, total	7723-14-0	E420	49.1 mg/L	50 mg/L	98.2	70.0	130	----
		potassium, total	7440-09-7	E420	18.2 mg/L	20 mg/L	91.1	70.0	130	----
		selenium, total	7782-49-2	E420	0.208 mg/L	0.2 mg/L	104	70.0	130	----
		silicon, total	7440-21-3	E420	44.4 mg/L	50 mg/L	88.9	70.0	130	----
		silver, total	7440-22-4	E420	0.0193 mg/L	0.02 mg/L	96.6	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	10 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.0182 mg/L	0.02 mg/L	91.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0962 mg/L	0.1 mg/L	96.2	70.0	130	----
		titanium, total	7440-32-6	E420	0.193 mg/L	0.2 mg/L	96.4	70.0	130	----
		uranium, total	7440-61-1	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		vanadium, total	7440-62-2	E420	0.491 mg/L	0.5 mg/L	98.2	70.0	130	----
		zinc, total	7440-66-6	E420	1.85 mg/L	2 mg/L	92.4	70.0	130	----
Total Metals (QCLot: 303495)										
VA21C0565-001	Anonymous	mercury, total	7439-97-6	E508	0.0000971 mg/L	0.0001 mg/L	97.1	70.0	130	----
Dissolved Metals (QCLot: 302737)										
VA21C0563-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000932 mg/L	0.0001 mg/L	93.2	70.0	130	----
Dissolved Metals (QCLot: 303292)										
VA21C0585-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.190 mg/L	0.2 mg/L	95.3	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0201 mg/L	0.02 mg/L	101	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0196 mg/L	0.02 mg/L	98.0	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0409 mg/L	0.04 mg/L	102	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 303292) - continued										
VA21C0585-001	Anonymous	bismuth, dissolved	7440-69-9	E421	0.00865 mg/L	0.01 mg/L	86.5	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.099 mg/L	0.1 mg/L	99.0	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00395 mg/L	0.004 mg/L	98.9	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0378 mg/L	0.04 mg/L	94.5	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0187 mg/L	0.02 mg/L	93.5	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0186 mg/L	0.02 mg/L	92.9	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.84 mg/L	2 mg/L	92.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0193 mg/L	0.02 mg/L	96.4	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0368 mg/L	0.04 mg/L	92.0	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.4 mg/L	10 mg/L	104	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.79 mg/L	4 mg/L	94.7	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0419 mg/L	0.04 mg/L	105	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.66 mg/L	10 mg/L	86.6	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00374 mg/L	0.004 mg/L	93.4	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0197 mg/L	0.02 mg/L	98.6	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0372 mg/L	0.04 mg/L	93.1	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00432 mg/L	0.004 mg/L	108	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0962 mg/L	0.1 mg/L	96.2	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.399 mg/L	0.4 mg/L	99.8	70.0	130	----
Aggregate Organics (QCLot: 304401)										
KS2103016-002	Anonymous	chemical oxygen demand [COD]	----	E559	ND mg/L	100 mg/L	ND	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	*Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.*

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/CM	

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW12-9B - E314696	17-Sep-21	12:45	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21C0574
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Nathan Glas	17-Sep-21	18:00	CC	SEP 20 2021	8:45	8 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C0998**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 23-Sep-2021 16:00
PO	: 1025614	Date Analysis Commenced	: 24-Sep-2021
C-O-C number	: ----	Issue Date	: 04-Oct-2021 17:42
Sampler	: NG/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ken Chan	Supervisor - Metals Prep & Mercury	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Workorder Comments

Sample "BJ-GW11-3A - Snap": 250mL plastic unpreserved bottle received approx. 2/5th full. All analyses still likely possible but if volume is insufficient, Account Manager will be in touch.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-3A - Snap	----	----	----	----
				Client sampling date / time	22-Sep-2021 09:55	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0998-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	102	----	----	----	----
conductivity	----	E100	2.0	µS/cm	349	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	157	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	165	----	----	----	----
pH	----	E108	0.10	pH units	8.19	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	235	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	24.8	----	----	----	----
turbidity	----	E121	0.10	NTU	14.2	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0294	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.182	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.060	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0020	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.060	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0185	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	83.5	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0404	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.0430	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0466	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00487	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0232	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0223	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-3A - Snap	----	----	----	----
				Client sampling date / time	22-Sep-2021 09:55	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0998-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.038	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000958	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	58.3	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00054	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.589	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00441	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0140	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	4.64	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.201	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000121	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000874	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.48	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.59	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000013	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	7.36	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.04	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000025	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000180	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0190	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0024	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00189	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-3A - Snap	----	----	----	----
				Client sampling date / time	22-Sep-2021 09:55	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C0998-001	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0221	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0208	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.037	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000057	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	55.4	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.490	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000358	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0144	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.55	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.200	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000884	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.52	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.32	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	7.52	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.12	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000177	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0017	----	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				Client sample ID	**BJ-GW11-3A - Snap**	----	----	----	----
				Client sampling date / time	22-Sep-2021 09:55	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C0998-001**	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C0998**	Page	: 1 of 10
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 23-Sep-2021 16:00
PO	: 1025614	Issue Date	: 04-Oct-2021 17:42
C-O-C number	: ----		
Sampler	: NG/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - Snap	E559	22-Sep-2021	----	----	----		29-Sep-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - Snap	E298	22-Sep-2021	30-Sep-2021	----	----		01-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - Snap	E235.Br-L	22-Sep-2021	----	----	----		25-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A - Snap	E235.Cl	22-Sep-2021	----	----	----		25-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A - Snap	E378-U	22-Sep-2021	----	----	----		25-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A - Snap	E235.F	22-Sep-2021	----	----	----		25-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - Snap	E235.NO3-L	22-Sep-2021	----	----	----		25-Sep-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - Snap	E235.NO2-L	22-Sep-2021	----	----	----		25-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A - Snap	E235.SO4	22-Sep-2021	----	----	----		25-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - Snap	E366	22-Sep-2021	30-Sep-2021	----	----		01-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - Snap	E372-U	22-Sep-2021	30-Sep-2021	----	----		02-Oct-2021	28 days	10 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A - Snap	E509	22-Sep-2021	30-Sep-2021	----	----		30-Sep-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A - Snap	E421	22-Sep-2021	29-Sep-2021	----	----		01-Oct-2021	180 days	9 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A - Snap	E290	22-Sep-2021	----	----	----		25-Sep-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A - Snap	E100	22-Sep-2021	----	----	----		25-Sep-2021	28 days	3 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW11-3A - Snap	E108	22-Sep-2021	----	----	----		25-Sep-2021	0.25 hrs	71 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW11-3A - Snap	E162	22-Sep-2021	----	----	----		29-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW11-3A - Snap	E160-H	22-Sep-2021	----	----	----		29-Sep-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW11-3A - Snap	E121	22-Sep-2021	----	----	----		25-Sep-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3A - Snap	E508	22-Sep-2021	----	----	----		29-Sep-2021	28 days	7 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A - Snap	E420	22-Sep-2021	----	----	----		30-Sep-2021	180 days	8 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A - Snap	E395	22-Sep-2021	----	----	----		24-Sep-2021	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	302368	1	17	5.8	5.0	✓
Ammonia by Fluorescence	E298	307780	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	302365	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	305639	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	302362	1	17	5.8	5.0	✓
Conductivity in Water	E100	302367	1	14	7.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	307623	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	306285	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	302371	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	302364	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	302359	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	302360	1	19	5.2	5.0	✓
pH by Meter	E108	302366	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	302361	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	306006	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	306260	1	13	7.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	306837	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	307778	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	307779	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	301529	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	305924	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	302568	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	302368	1	17	5.8	5.0	✓
Ammonia by Fluorescence	E298	307780	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	302365	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	305639	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	302362	1	17	5.8	5.0	✓
Conductivity in Water	E100	302367	1	14	7.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	307623	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	306285	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	302371	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	302364	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	302359	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	302360	1	19	5.2	5.0	✓
pH by Meter	E108	302366	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	302361	1	17	5.8	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
TDS by Gravimetry	E162	306006	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	306260	1	13	7.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	306837	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	307778	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	307779	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	301529	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	305924	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	302568	1	20	5.0	5.0	✓
Method Blanks (MB)							
Alkalinity Species by Titration	E290	302368	1	17	5.8	5.0	✓
Ammonia by Fluorescence	E298	307780	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	302365	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	305639	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	302362	1	17	5.8	5.0	✓
Conductivity in Water	E100	302367	1	14	7.1	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	307623	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	306285	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	302371	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	302364	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	302359	1	16	6.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	302360	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	302361	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	306006	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	306260	1	13	7.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	306837	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	307778	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	307779	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	301529	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	305924	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	302568	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	307780	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	302365	1	12	8.3	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	305639	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	302362	1	17	5.8	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	307623	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	306285	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	302371	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	302364	1	11	9.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	302359	1	16	6.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	302360	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	302361	1	17	5.8	5.0	✓
Total Mercury in Water by CVAAS	E508	306260	1	13	7.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	306837	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	307778	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	307779	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	301529	1	11	9.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C0998**	Page	: 1 of 16
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 23-Sep-2021 16:00
PO	: 1025614	Date Analysis Commenced	: 24-Sep-2021
C-O-C number	: ----	Issue Date	: 04-Oct-2021 17:42
Sampler	: NG/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Ken Chan	Supervisor - Metals Prep & Mercury	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 302366)											
VA21C0876-001	Anonymous	pH	----	E108	0.10	pH units	7.98	7.99	0.150%	4%	----
Physical Tests (QC Lot: 302367)											
VA21C0876-001	Anonymous	conductivity	----	E100	2.0	µS/cm	169	170	0.472%	10%	----
Physical Tests (QC Lot: 302368)											
VA21C0876-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	62.3	61.8	0.743%	20%	----
Physical Tests (QC Lot: 302568)											
VA21C0788-001	Anonymous	turbidity	----	E121	0.10	NTU	0.57	0.62	0.04	Diff <2x LOR	----
Physical Tests (QC Lot: 305924)											
FJ2100998-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 306006)											
FJ2100998-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	167	160	8	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 302359)											
VA21C0923-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0500	mg/L	<0.0500	<0.0500	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 302360)											
VA21C0923-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 302361)											
VA21C0876-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	7.67	7.65	0.172%	20%	----
Anions and Nutrients (QC Lot: 302362)											
VA21C0876-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	9.52	9.52	0.0480%	20%	----
Anions and Nutrients (QC Lot: 302364)											
VA21C0876-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.049	0.049	0.0002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 302365)											
VA21C0923-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.500	mg/L	1.47	1.52	0.058	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 302371)											
VA21C0878-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0100	mg/L	0.0942	0.0938	0.0004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 307778)											
VA21C0902-014	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	<0.030	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 307779)											
VA21C0902-014	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 307780)											
VA21C0902-014	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Sulfides (QC Lot: 301529)											
CG2104292-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0182	0.0175	3.70%	20%	----
Total Metals (QC Lot: 306260)											
VA21C0995-002	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 306837)											
VA21C0941-002	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0076	0.0064	0.0011	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00010	0.00012	0.00001	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.00723	0.00744	2.85%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	0.0000057	0.0000007	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	19.0	19.1	0.685%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00065	0.00066	0.00001	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	0.662	0.670	1.20%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00057	0.00058	0.000007	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000369	0.000377	0.000008	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	0.319	0.327	0.008	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000291	0.000249	0.000042	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.81	1.85	1.82%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	0.819	0.826	0.797%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.0491	0.0482	1.88%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000035	0.000036	0.000001	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 306837) - continued											
VA21C0941-002	Anonymous	zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 306285)											
VA21C0957-003	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00050	mg/L	0.00117	0.00116	0.00001	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00050	mg/L	0.0182	0.0188	3.18%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.050	mg/L	0.833	0.808	2.98%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000750	mg/L	<0.0000750	<0.0000750	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.250	mg/L	365	363	0.477%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00050	mg/L	0.00156	0.00162	0.00005	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00100	mg/L	0.00290	0.00313	0.00023	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0050	mg/L	0.0137	0.0134	0.0003	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0250	mg/L	238	246	3.39%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00050	mg/L	2.64	2.69	1.93%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000250	mg/L	0.0982	0.0964	1.91%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00250	mg/L	0.0138	0.0142	0.00042	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.250	mg/L	15.5	16.0	2.95%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000250	mg/L	0.00127	0.00137	0.000099	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.250	mg/L	6.64	6.64	0.0110%	20%	----
		silver, dissolved	7440-22-4	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.250	mg/L	833	838	0.664%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00100	mg/L	7.97	8.08	1.41%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00150	mg/L	<0.00150	<0.00150	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000050	mg/L	0.00453	0.00464	2.34%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 307623)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 307623) - continued											
VA21C0989-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	0.0000072	0.0000052	0.0000020	Diff <2x LOR	----
Aggregate Organics (QC Lot: 305639)											
VA21C0996-002	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 302367)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 302368)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 302568)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 305924)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 306006)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 302359)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 302360)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 302361)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 302362)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 302364)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 302365)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 302371)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 307778)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 307779)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 307780)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 301529)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 306260)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 306837)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Dissolved Metals (QCLot: 306285)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 306285) - continued						
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 307623)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 305639)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 302366)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 302367)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.6	90.0	110	----
Physical Tests (QCLot: 302368)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.8	85.0	115	----
Physical Tests (QCLot: 302568)									
turbidity	----	E121	0.1	NTU	200 NTU	99.2	85.0	115	----
Physical Tests (QCLot: 305924)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	92.3	85.0	115	----
Physical Tests (QCLot: 306006)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 302359)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 302360)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	97.2	90.0	110	----
Anions and Nutrients (QCLot: 302361)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 302362)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	99.6	90.0	110	----
Anions and Nutrients (QCLot: 302364)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	96.4	90.0	110	----
Anions and Nutrients (QCLot: 302365)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 302371)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	105	80.0	120	----
Anions and Nutrients (QCLot: 307778)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 307779)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	87.5	80.0	120	----
Anions and Nutrients (QCLot: 307780)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.9	85.0	115	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Sulfides (QCLot: 301529)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	102	80.0	120	----
Total Metals (QCLot: 306260)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	96.3	80.0	120	----
Total Metals (QCLot: 306837)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	92.8	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	96.2	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	99.8	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	92.7	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	97.3	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	95.0	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	98.6	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	96.0	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	96.9	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	98.6	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	97.0	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	93.6	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	87.4	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	95.8	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	92.6	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.4	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	103	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	98.2	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	99.3	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	94.8	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	97.4	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.8	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	97.3	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	95.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	94.7	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	95.4	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	97.5	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	94.9	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 306285)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	94.1	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	95.7	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	93.7	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	89.3	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	93.6	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	95.4	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	94.1	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	95.6	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	97.7	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	95.9	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	90.5	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	99.2	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	89.9	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	93.7	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	95.5	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	96.4	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	96.8	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	99.9	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	89.5	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	99.9	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	98.4	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	98.0	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	98.9	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	93.6	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	95.4	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	99.8	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	98.6	80.0	120	----
Aggregate Organics (QCLot: 305639)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	109	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 302359)										
VA21C0923-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.63 mg/L	2.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 302360)										
VA21C0923-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.508 mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 302361)										
VA21C0900-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	99.0 mg/L	100 mg/L	99.0	75.0	125	----
Anions and Nutrients (QCLot: 302362)										
VA21C0900-001	Anonymous	chloride	16887-00-6	E235.Cl	98.5 mg/L	100 mg/L	98.5	75.0	125	----
Anions and Nutrients (QCLot: 302364)										
VA21C0923-002	Anonymous	fluoride	16984-48-8	E235.F	1.02 mg/L	1 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 302365)										
VA21C0923-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.538 mg/L	0.5 mg/L	108	75.0	125	----
Anions and Nutrients (QCLot: 302371)										
VA21C0900-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0323 mg/L	0.03 mg/L	108	70.0	130	----
Anions and Nutrients (QCLot: 307778)										
VA21C0902-015	Anonymous	nitrogen, total	7727-37-9	E366	0.403 mg/L	0.4 mg/L	101	70.0	130	----
Anions and Nutrients (QCLot: 307779)										
VA21C0902-015	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0509 mg/L	0.05 mg/L	102	70.0	130	----
Anions and Nutrients (QCLot: 307780)										
VA21C0902-015	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.100 mg/L	0.1 mg/L	100	75.0	125	----
Total Sulfides (QCLot: 301529)										
CG2104292-004	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.213 mg/L	0.2 mg/L	106	75.0	125	----
Total Metals (QCLot: 306260)										
VA21C0996-001	Anonymous	mercury, total	7439-97-6	E508	0.0000968 mg/L	0.0001 mg/L	96.8	70.0	130	----
Total Metals (QCLot: 306837)										
VA21C0941-003	Anonymous	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0193 mg/L	0.02 mg/L	96.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 306837) - continued										
VA21C0941-003	Anonymous	barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0381 mg/L	0.04 mg/L	95.3	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00971 mg/L	0.01 mg/L	97.1	70.0	130	----
		boron, total	7440-42-8	E420	0.108 mg/L	0.1 mg/L	108	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00400 mg/L	0.004 mg/L	100	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0388 mg/L	0.04 mg/L	97.0	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		copper, total	7440-50-8	E420	0.0195 mg/L	0.02 mg/L	97.4	70.0	130	----
		iron, total	7439-89-6	E420	1.96 mg/L	2 mg/L	97.8	70.0	130	----
		lead, total	7439-92-1	E420	0.0195 mg/L	0.02 mg/L	97.6	70.0	130	----
		lithium, total	7439-93-2	E420	0.0915 mg/L	0.1 mg/L	91.5	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0187 mg/L	0.02 mg/L	93.7	70.0	130	----
		nickel, total	7440-02-0	E420	0.0394 mg/L	0.04 mg/L	98.6	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.76 mg/L	10 mg/L	97.6	70.0	130	----
		potassium, total	7440-09-7	E420	3.87 mg/L	4 mg/L	96.8	70.0	130	----
		selenium, total	7782-49-2	E420	0.0407 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, total	7440-21-3	E420	8.78 mg/L	10 mg/L	87.8	70.0	130	----
		silver, total	7440-22-4	E420	0.00397 mg/L	0.004 mg/L	99.3	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00376 mg/L	0.004 mg/L	93.9	70.0	130	----
		tin, total	7440-31-5	E420	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----
		titanium, total	7440-32-6	E420	0.0387 mg/L	0.04 mg/L	96.8	70.0	130	----
		uranium, total	7440-61-1	E420	0.00370 mg/L	0.004 mg/L	92.6	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0990 mg/L	0.1 mg/L	99.0	70.0	130	----
		zinc, total	7440-66-6	E420	0.394 mg/L	0.4 mg/L	98.4	70.0	130	----
Dissolved Metals (QCLot: 306285)										
VA21C0941-003	Anonymous	aluminum, dissolved	7429-90-5	E421	0.188 mg/L	0.2 mg/L	94.0	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0371 mg/L	0.04 mg/L	92.7	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00851 mg/L	0.01 mg/L	85.1	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 306285) - continued										
VA21C0941-003	Anonymous	boron, dissolved	7440-42-8	E421	0.092 mg/L	0.1 mg/L	91.8	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00383 mg/L	0.004 mg/L	95.9	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0387 mg/L	0.04 mg/L	96.9	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0198 mg/L	0.02 mg/L	99.0	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0195 mg/L	0.02 mg/L	97.5	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.86 mg/L	2 mg/L	93.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0194 mg/L	0.02 mg/L	96.9	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0935 mg/L	0.1 mg/L	93.5	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0187 mg/L	0.02 mg/L	93.6	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0391 mg/L	0.04 mg/L	97.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.2 mg/L	10 mg/L	102	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.93 mg/L	4 mg/L	98.3	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.25 mg/L	10 mg/L	82.5	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00399 mg/L	0.004 mg/L	99.7	70.0	130	----
		sodium, dissolved	17341-25-2	E421	2.13 mg/L	2 mg/L	106	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00376 mg/L	0.004 mg/L	94.0	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00359 mg/L	0.004 mg/L	89.7	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0982 mg/L	0.1 mg/L	98.2	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.404 mg/L	0.4 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 307623)										
VA21C0989-006	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000968 mg/L	0.0001 mg/L	96.8	70.0	130	----
Aggregate Organics (QCLot: 305639)										
VA21C0996-001	Anonymous	chemical oxygen demand [COD]	----	E559	100 mg/L	100 mg/L	99.6	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/BM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-3A - snap	22-Sep-21	9:55	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C0998

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Brittany Moore	22-Sep-21	18:00		23/09/2021	4pm	8 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C1212**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 25-Sep-2021 12:05
PO	: 1025614	Date Analysis Commenced	: 26-Sep-2021
C-O-C number	: ----	Issue Date	: 13-Oct-2021 14:10
Sampler	: BM, NG		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DTC	*Dissolved concentration exceeds total. Results were confirmed by re-analysis.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-3A - E303056	BJ-GW11-3B - E314693	----	----	----
				Client sampling date / time	23-Sep-2021 10:35	23-Sep-2021 11:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C1212-001	VA21C1212-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	95.6	93.3	----	----	----
conductivity	----	E100	2.0	µS/cm	352	337	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	150	148	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	152	148	----	----	----
pH	----	E108	0.10	pH units	8.08	8.08	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	238	214	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	3.13	0.23	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0274	0.0240	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.185	0.183	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0318	<0.0050	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0318	<0.0051	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.067	0.048	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0014	0.0017	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0064	0.0040	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	82.8	75.5	----	----	----
Organic / Inorganic Carbon									
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	<0.50	<0.50	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0169	0.0080	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00197	0.00089	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-3A - E303056	BJ-GW11-3B - E314693	----	----	----
				Client sampling date / time	23-Sep-2021 10:35	23-Sep-2021 11:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C1212-001	VA21C1212-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0215	0.00460	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0201	0.0219	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.040	0.028	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000258	0.0000195	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	53.8	53.6	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00019	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.453	<0.010	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00161	0.000271	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0171	0.0102	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	4.24	3.57	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.191	0.224	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000975	0.000845	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00056	<0.00050	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.50	1.18	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.71	3.50	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000012	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	7.15	5.08	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.06	0.998	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	0.000016	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000184	0.000186	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0050	<0.0030	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-3A - E303056	BJ-GW11-3B - E314693	----	----	----
				Client sampling date / time	23-Sep-2021 10:35	23-Sep-2021 11:15	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C1212-001	VA21C1212-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0045	0.0019	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00184	0.00089	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0206	0.00439	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0191	0.0252	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.036	0.026	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	0.0000113	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	53.2	53.9	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00012	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00074 DTC	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.387	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000210	0.000112	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0150	0.0100	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.06	3.32	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.190	0.225	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000998	0.000895	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.44	1.14	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.43	3.15	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	6.92	4.83	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.10	1.00	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	0.000015	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000181	0.000185	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW11-3A - E303056**	**BJ-GW11-3B - E314693**	**----**	**----**	**----**
				Client sampling date / time	23-Sep-2021 10:35	23-Sep-2021 11:15	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C1212-001**	**VA21C1212-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0041	0.0043 DTC	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C1212**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 25-Sep-2021 12:05
PO	: 1025614	Issue Date	: 13-Oct-2021 14:10
C-O-C number	: ----		
Sampler	: BM, NG		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E559	23-Sep-2021	----	----	----		06-Oct-2021	28 days	13 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3B - E314693	E559	23-Sep-2021	----	----	----		06-Oct-2021	28 days	13 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E298	23-Sep-2021	05-Oct-2021	----	----		06-Oct-2021	28 days	13 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3B - E314693	E298	23-Sep-2021	05-Oct-2021	----	----		06-Oct-2021	28 days	13 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - E303056	E235.Br-L	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3B - E314693	E235.Br-L	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A - E303056	E235.Cl	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3B - E314693	E235.Cl	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A - E303056	E378-U	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3B - E314693	E378-U	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A - E303056	E235.F	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3B - E314693	E235.F	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - E303056	E235.NO3-L	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3B - E314693	E235.NO3-L	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A - E303056	E235.NO2-L	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3B - E314693	E235.NO2-L	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A - E303056	E235.SO4	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3B - E314693	E235.SO4	23-Sep-2021	----	----	----		26-Sep-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E366	23-Sep-2021	05-Oct-2021	----	----		06-Oct-2021	28 days	13 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3B - E314693	E366	23-Sep-2021	05-Oct-2021	----	----		06-Oct-2021	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E372-U	23-Sep-2021	05-Oct-2021	----	----		07-Oct-2021	28 days	14 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3B - E314693	E372-U	23-Sep-2021	05-Oct-2021	----	----		07-Oct-2021	28 days	14 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A - E303056	E509	23-Sep-2021	06-Oct-2021	----	----		06-Oct-2021	28 days	13 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3B - E314693	E509	23-Sep-2021	06-Oct-2021	----	----		06-Oct-2021	28 days	13 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A - E303056	E421	23-Sep-2021	06-Oct-2021	----	----		06-Oct-2021	180 days	13 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3B - E314693	E421	23-Sep-2021	06-Oct-2021	----	----		06-Oct-2021	180 days	13 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A - E303056	E355-L	23-Sep-2021	05-Oct-2021	----	----		06-Oct-2021	28 days	12 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW11-3B - E314693	E355-L	23-Sep-2021	05-Oct-2021	----	----		06-Oct-2021	28 days	12 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3A - E303056	E283	23-Sep-2021	----	----	----		27-Sep-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3B - E314693	E283	23-Sep-2021	----	----	----		27-Sep-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A - E303056	E290	23-Sep-2021	----	----	----		27-Sep-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3B - E314693	E290	23-Sep-2021	----	----	----		27-Sep-2021	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A - E303056	E100	23-Sep-2021	----	----	----		27-Sep-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3B - E314693	E100	23-Sep-2021	----	----	----		27-Sep-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW11-3B - E314693	E108	23-Sep-2021	----	----	----		27-Sep-2021	0.25 hrs	90 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW11-3A - E303056	E108	23-Sep-2021	----	----	----		27-Sep-2021	0.25 hrs	91 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-3A - E303056	E162	23-Sep-2021	----	----	----		30-Sep-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-3B - E314693	E162	23-Sep-2021	----	----	----		30-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-3A - E303056	E160-H	23-Sep-2021	----	----	----		30-Sep-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-3B - E314693	E160-H	23-Sep-2021	----	----	----		30-Sep-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-3A - E303056	E121	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-3B - E314693	E121	23-Sep-2021	----	----	----		26-Sep-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW11-3A - E303056	E508	23-Sep-2021	----	----	----		05-Oct-2021	28 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3B - E314693	E508	23-Sep-2021	----	----	----		05-Oct-2021	28 days	12 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A - E303056	E420	23-Sep-2021	----	----	----		07-Oct-2021	180 days	14 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3B - E314693	E420	23-Sep-2021	----	----	----		07-Oct-2021	180 days	14 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A - E303056	E395	23-Sep-2021	----	----	----		27-Sep-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3B - E314693	E395	23-Sep-2021	----	----	----		27-Sep-2021	7 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	303071	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	303061	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	311891	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	303067	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	312144	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	303066	1	15	6.6	5.0	✓
Conductivity in Water	E100	303059	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	312017	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	312003	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	303069	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	303065	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	303063	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	303064	1	15	6.6	5.0	✓
pH by Meter	E108	303060	1	12	8.3	5.0	✓
Sulfate in Water by IC	E235.SO4	303062	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	307100	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	311495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	311984	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	311898	1	12	8.3	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	311893	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	311897	1	5	20.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	303409	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	307095	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	302974	1	10	10.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	303071	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	303061	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	311891	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	303067	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	312144	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	303066	1	15	6.6	5.0	✓
Conductivity in Water	E100	303059	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	312017	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	312003	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	303069	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	303065	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	303063	1	17	5.8	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	303064	1	15	6.6	5.0	✓
pH by Meter	E108	303060	1	12	8.3	5.0	✓
Sulfate in Water by IC	E235.SO4	303062	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	307100	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	311495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	311984	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	311898	1	12	8.3	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	311893	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	311897	1	5	20.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	303409	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	307095	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	302974	1	10	10.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	303071	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	303061	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	311891	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	303067	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	312144	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	303066	1	15	6.6	5.0	✓
Conductivity in Water	E100	303059	1	13	7.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	312017	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	312003	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	303069	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	303065	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	303063	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	303064	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	303062	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	307100	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	311495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	311984	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	311898	1	12	8.3	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	311893	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	311897	1	5	20.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	303409	1	3	33.3	5.0	✓
TSS by Gravimetry	E160-H	307095	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	302974	1	10	10.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	311891	1	14	7.1	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	303067	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	312144	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Chloride in Water by IC	E235.Cl	303066	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	312017	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	312003	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	303069	1	11	9.0	5.0	✓
Fluoride in Water by IC	E235.F	303065	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	303063	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	303064	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	303062	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	311495	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	311984	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	311898	1	12	8.3	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	311893	1	12	8.3	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	311897	1	5	20.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	303409	1	3	33.3	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H_2S concentration based on the total sulfide concentration in the sample. The H_2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C1212**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 25-Sep-2021 12:05
PO	: 1025614	Date Analysis Commenced	: 26-Sep-2021
C-O-C number	: ----	Issue Date	: 13-Oct-2021 14:10
Sampler	: BM, NG		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 302974)											
VA21C1150-008	Anonymous	turbidity	----	E121	0.10	NTU	0.11	0.10	0.007	Diff <2x LOR	----
Physical Tests (QC Lot: 303059)											
FJ2100999-001	Anonymous	conductivity	----	E100	2.0	µS/cm	253	253	0.00%	10%	----
Physical Tests (QC Lot: 303060)											
FJ2100999-001	Anonymous	pH	----	E108	0.10	pH units	8.12	8.13	0.160%	4%	----
Physical Tests (QC Lot: 303061)											
FJ2100999-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	90.4	85.9	5.10%	20%	----
Physical Tests (QC Lot: 303071)											
VA21C1212-001	BJ-GW11-3A - E303056	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 307095)											
VA21C1150-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	6.2	<3.0	3.2	Diff <2x LOR	----
Physical Tests (QC Lot: 307100)											
VA21C1150-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	1190	1100	7.80%	20%	----
Anions and Nutrients (QC Lot: 303062)											
FJ2100999-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	36.2	36.2	0.0522%	20%	----
Anions and Nutrients (QC Lot: 303063)											
FJ2100999-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.351	0.350	0.405%	20%	----
Anions and Nutrients (QC Lot: 303064)											
FJ2100999-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 303065)											
FJ2100999-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	1.03	1.02	0.359%	20%	----
Anions and Nutrients (QC Lot: 303066)											
FJ2100999-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 303067)											
FJ2100999-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 303069)											
FJ2100999-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 311891)											
KS2103175-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0079	0.0076	0.0003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 311897)											
VA21C0671-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	4.04	4.67	14.4%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 311898)											
KS2103175-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.080	0.077	0.002	Diff <2x LOR	----
Organic / Inorganic Carbon (QC Lot: 311893)											
KS2103175-001	Anonymous	carbon, total organic [TOC]	----	E355-L	0.50	mg/L	1.67	1.83	0.16	Diff <2x LOR	----
Total Sulfides (QC Lot: 303409)											
VA21C1083-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 311495)											
VA21C1074-005	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 311984)											
VA21C1211-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	3.73	4.05	8.25%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.0148	0.0149	0.503%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0439	0.0446	1.75%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.181	0.177	2.29%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000227	0.000210	0.000017	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	0.000141	0.000151	0.000011	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.091	0.091	0.0003	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000336	0.000362	7.62%	20%	----
		calcium, total	7440-70-2	E420	0.050	mg/L	25.6	25.6	0.330%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	0.00227	0.00223	0.00004	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00159	0.00163	2.40%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00642	0.00664	3.38%	20%	----
		iron, total	7439-89-6	E420	0.010	mg/L	2.89	2.94	2.02%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.0282	0.0281	0.268%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0454	0.0441	2.84%	20%	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	2.25	2.30	1.94%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.202	0.205	1.58%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00487	0.00489	0.517%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00267	0.00267	0.000008	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	6.40	6.43	0.324%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.00202	0.00208	3.11%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	5.46	5.46	0.0359%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.000807	0.000802	0.608%	20%	----
		sodium, total	17341-25-2	E420	0.050	mg/L	20.1	20.7	3.16%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.619	0.639	3.15%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000198	0.000197	0.541%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 311984) - continued											
VA21C1211-001	Anonymous	tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0100	mg/L	0.0252	0.0252	0.00002	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00164	0.00159	3.21%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00560	0.00569	1.48%	20%	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0237	0.0242	0.0006	Diff <2x LOR	----
Dissolved Metals (QC Lot: 312003)											
KS2103175-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0020	mg/L	0.0034	0.0029	0.0005	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00020	mg/L	0.00181	0.00175	0.00006	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00020	mg/L	0.00861	0.00863	0.208%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.020	mg/L	3.36	3.26	3.03%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000100	mg/L	<0.0000100	<0.0000100	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.100	mg/L	145	146	0.835%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00020	mg/L	0.00077	0.00078	0.00002	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00040	mg/L	<0.00040	<0.00040	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.020	mg/L	0.148	0.148	0.0006	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0020	mg/L	0.0479	0.0468	2.33%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0100	mg/L	324	326	0.542%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00020	mg/L	0.0168	0.0165	1.56%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000100	mg/L	0.0119	0.0117	1.82%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00100	mg/L	0.00844	0.00858	0.00015	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	13.8	14.0	1.36%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000100	mg/L	0.00306	0.00302	1.16%	20%	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	14.6	14.2	2.68%	20%	----
		silver, dissolved	7440-22-4	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.100	mg/L	204	205	0.472%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00040	mg/L	0.520	0.521	0.0563%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00060	mg/L	<0.00060	<0.00060	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 312003) - continued											
KS2103175-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000020	mg/L	0.0107	0.0108	0.565%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00100	mg/L	0.00130	0.00131	0.000008	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0020	mg/L	0.0020	<0.0020	0.00002	Diff <2x LOR	----
Dissolved Metals (QC Lot: 312017)											
FJ2100955-009	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 312144)											
FJ2101047-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 302974)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 303059)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 303061)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 303071)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 307095)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 307100)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 303062)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 303063)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 303064)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 303065)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 303066)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 303067)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 303069)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 311891)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 311897)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 311898)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Organic / Inorganic Carbon (QCLot: 311893)						
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	<0.50	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 303409)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 311495)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 311984)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 312003)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 312017)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 312144)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 302974)									
turbidity	----	E121	0.1	NTU	200 NTU	108	85.0	115	----
Physical Tests (QCLot: 303059)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 303060)									
pH	----	E108	----	pH units	7 pH units	99.7	98.0	102	----
Physical Tests (QCLot: 303061)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 303071)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	104	85.0	115	----
Physical Tests (QCLot: 307095)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	86.3	85.0	115	----
Physical Tests (QCLot: 307100)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	98.8	85.0	115	----
Anions and Nutrients (QCLot: 303062)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 303063)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 303064)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	96.2	90.0	110	----
Anions and Nutrients (QCLot: 303065)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	96.1	90.0	110	----
Anions and Nutrients (QCLot: 303066)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 303067)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	99.0	85.0	115	----
Anions and Nutrients (QCLot: 303069)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	109	80.0	120	----
Anions and Nutrients (QCLot: 311891)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 311897)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	91.2	80.0	120	----
Anions and Nutrients (QCLot: 311898)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 311898) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	99.7	75.0	125	----
Organic / Inorganic Carbon (QCLot: 311893)									
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	8.57 mg/L	102	80.0	120	----
Total Sulfides (QCLot: 303409)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	108	80.0	120	----
Total Metals (QCLot: 311495)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	96.4	80.0	120	----
Total Metals (QCLot: 311984)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	101	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	100	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	96.6	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	94.8	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	99.0	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	95.1	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	98.5	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	97.7	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	99.6	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	94.3	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	105	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	104	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	97.9	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	95.7	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.9	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	118	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	99.6	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	102	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	94.4	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.6	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	95.6	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 311984) - continued									
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	97.2	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	95.5	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	91.7	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	98.9	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	95.2	80.0	120	----
Dissolved Metals (QCLot: 312003)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	97.7	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	95.9	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	94.7	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	94.1	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	95.6	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	91.8	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	93.8	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	97.3	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	98.1	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	96.7	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	96.2	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	100	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	94.5	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	93.5	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	93.8	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	97.0	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	96.3	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	99.6	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	97.2	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	98.0	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	88.9	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	104	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	99.1	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	105	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	94.5	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	93.2	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	98.3	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	94.4	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	98.4	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Dissolved Metals (QCLot: 312003) - continued									
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	97.1	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	99.0	80.0	120	----
Aggregate Organics (QCLot: 312144)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	111	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 303062)										
FJ2100999-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	108 mg/L	100 mg/L	108	75.0	125	----
Anions and Nutrients (QCLot: 303063)										
FJ2100999-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.77 mg/L	2.5 mg/L	111	75.0	125	----
Anions and Nutrients (QCLot: 303064)										
FJ2100999-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.525 mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 303065)										
FJ2100999-002	Anonymous	fluoride	16984-48-8	E235.F	1.07 mg/L	1 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 303066)										
FJ2100999-002	Anonymous	chloride	16887-00-6	E235.Cl	111 mg/L	100 mg/L	111	75.0	125	----
Anions and Nutrients (QCLot: 303067)										
FJ2100999-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.546 mg/L	0.5 mg/L	109	75.0	125	----
Anions and Nutrients (QCLot: 303069)										
FJ2100999-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0330 mg/L	0.03 mg/L	110	70.0	130	----
Anions and Nutrients (QCLot: 311891)										
KS2103175-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.116 mg/L	0.1 mg/L	116	75.0	125	----
Anions and Nutrients (QCLot: 311897)										
VA21C1211-001	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 311898)										
KS2103175-002	Anonymous	nitrogen, total	7727-37-9	E366	1.92 mg/L	2 mg/L	96.3	70.0	130	----
Organic / Inorganic Carbon (QCLot: 311893)										
KS2103175-002	Anonymous	carbon, total organic [TOC]	----	E355-L	5.51 mg/L	5 mg/L	110	70.0	130	----
Total Sulfides (QCLot: 303409)										
VA21C1212-001	BJ-GW11-3A - E303056	sulfide, total (as S)	18496-25-8	E395	0.235 mg/L	0.2 mg/L	117	75.0	125	----
Total Metals (QCLot: 311495)										
VA21C1074-006	Anonymous	mercury, total	7439-97-6	E508	0.00100 mg/L	0.001 mg/L	100	70.0	130	----
Total Metals (QCLot: 311984)										
VA21C1212-001	BJ-GW11-3A - E303056	aluminum, total	7429-90-5	E420	0.200 mg/L	0.2 mg/L	100	70.0	130	----
		antimony, total	7440-36-0	E420	0.0207 mg/L	0.02 mg/L	103	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 311984) - continued										
VA21C1212-001	BJ-GW11-3A - E303056	arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0397 mg/L	0.04 mg/L	99.3	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0103 mg/L	0.01 mg/L	103	70.0	130	----
		boron, total	7440-42-8	E420	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00425 mg/L	0.004 mg/L	106	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0394 mg/L	0.04 mg/L	98.5	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0197 mg/L	0.02 mg/L	98.6	70.0	130	----
		copper, total	7440-50-8	E420	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		iron, total	7439-89-6	E420	1.96 mg/L	2 mg/L	98.3	70.0	130	----
		lead, total	7439-92-1	E420	0.0194 mg/L	0.02 mg/L	96.9	70.0	130	----
		lithium, total	7439-93-2	E420	0.0991 mg/L	0.1 mg/L	99.1	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0192 mg/L	0.02 mg/L	96.0	70.0	130	----
		nickel, total	7440-02-0	E420	0.0380 mg/L	0.04 mg/L	95.1	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.5 mg/L	10 mg/L	105	70.0	130	----
		potassium, total	7440-09-7	E420	4.03 mg/L	4 mg/L	101	70.0	130	----
		selenium, total	7782-49-2	E420	0.0412 mg/L	0.04 mg/L	103	70.0	130	----
		silicon, total	7440-21-3	E420	9.63 mg/L	10 mg/L	96.3	70.0	130	----
		silver, total	7440-22-4	E420	0.00380 mg/L	0.004 mg/L	95.0	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00373 mg/L	0.004 mg/L	93.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0189 mg/L	0.02 mg/L	94.3	70.0	130	----
		titanium, total	7440-32-6	E420	0.0387 mg/L	0.04 mg/L	96.7	70.0	130	----
		uranium, total	7440-61-1	E420	0.00402 mg/L	0.004 mg/L	100	70.0	130	----
		vanadium, total	7440-62-2	E420	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		zinc, total	7440-66-6	E420	0.384 mg/L	0.4 mg/L	96.1	70.0	130	----
Dissolved Metals (QCLot: 312003)										
KS2103175-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.984 mg/L	1 mg/L	98.4	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0930 mg/L	0.1 mg/L	93.0	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.191 mg/L	0.2 mg/L	95.5	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 312003) - continued										
KS2103175-002	Anonymous	bismuth, dissolved	7440-69-9	E421	0.0443 mg/L	0.05 mg/L	88.6	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.5 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.0191 mg/L	0.02 mg/L	95.4	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.200 mg/L	0.2 mg/L	100	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0932 mg/L	0.1 mg/L	93.2	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0928 mg/L	0.1 mg/L	92.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	9.59 mg/L	10 mg/L	95.9	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0919 mg/L	0.1 mg/L	91.9	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.484 mg/L	0.5 mg/L	96.7	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	5 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0969 mg/L	0.1 mg/L	96.9	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.183 mg/L	0.2 mg/L	91.7	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	51.4 mg/L	50 mg/L	103	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.215 mg/L	0.2 mg/L	107	70.0	130	----
		silicon, dissolved	7440-21-3	E421	42.9 mg/L	50 mg/L	85.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.0201 mg/L	0.02 mg/L	101	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	10 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.0184 mg/L	0.02 mg/L	92.2	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0952 mg/L	0.1 mg/L	95.2	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.201 mg/L	0.2 mg/L	100	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.0189 mg/L	0.02 mg/L	94.5	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.508 mg/L	0.5 mg/L	102	70.0	130	----
		zinc, dissolved	7440-66-6	E421	1.88 mg/L	2 mg/L	94.1	70.0	130	----
Dissolved Metals (QCLot: 312017)										
FJ2100955-010	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000979 mg/L	0.0001 mg/L	97.9	70.0	130	----
Aggregate Organics (QCLot: 312144)										
FJ2101047-002	Anonymous	chemical oxygen demand [COD]	----	E559	106 mg/L	100 mg/L	106	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/BM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-3A - E303056	23-Sep-21	10:35	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-3B - E314693	23-Sep-21	11:15	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C1212

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Brittany Moore	23-Sep-21	18:00	JA	25/09/2021	1205PM	16 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C2526**	Page	: 1 of 10
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 12-Oct-2021 21:30
PO	: 1025614	Date Analysis Commenced	: 13-Oct-2021
C-O-C number	: ----	Issue Date	: 26-Oct-2021 16:58
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 7		
No. of samples analysed	: 7		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLA	*Detection Limit adjusted for required dilution.*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DTMF	*Dissolved concentration exceeds total for field-filtered metals sample. Metallic contaminants may have been introduced to dissolved sample during field filtration.*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-17A-9 4	BJ-GW18-17A-E 303066	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 9	BJ-GW16-5B-C WP
				Client sampling date / time	08-Oct-2021 12:30	08-Oct-2021 15:35	09-Oct-2021 11:20	09-Oct-2021 11:20	10-Oct-2021 10:10
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-001	VA21C2526-002	VA21C2526-003	VA21C2526-004	VA21C2526-005
					Result	Result	Result	Result	Result
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	<2.0	2.2
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	1.1	124	121	1.1	91.8
conductivity	----	E100	2.0	µS/cm	<2.0	581	752	<2.0	789
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	<0.50	156	278	<0.50	430
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	<0.50	146	261	<0.50	420
pH	----	E108	0.10	pH units	6.16	8.27	8.19	6.19	8.10
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	355	423	<10	531
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	4.3	<3.0	<3.0
turbidity	----	E121	0.10	NTU	<0.10	1.41	2.59	<0.10	1.72
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	0.0929	0.264	<0.0050	<0.0050
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.250 DLDS	<0.050	<0.250 DLDS
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	1.82	30.4	<0.50	<2.50 DLDS
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	0.208	0.241	<0.020	<0.100 DLDS
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	0.096	<0.519	<0.050	<0.063
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	0.177	5.40	<0.0050	0.638
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	0.218	5.40	<0.0051	0.638
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	0.0414	0.0052	<0.0010	<0.0050 DLDS
nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	0.314	5.54	<0.030	0.635
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0017	<0.0010	<0.0010	0.0031
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	0.0042	0.0044	<0.0020	0.0061
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	169	205	<0.30	341
Organic / Inorganic Carbon									
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	0.54 RRV	<0.50	<0.50	<0.50	<0.50
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	0.109	0.0016	<0.0015	<0.0015
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	0.116	0.0017	<0.0016	<0.0016
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	<0.0030	0.0276	0.0615	<0.0030	0.0196
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	0.00322	0.00217	<0.00010	0.00071

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-9 4	BJ-GW18-17A-E 303066	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 9	BJ-GW16-5B-C WP
				Client sampling date / time	08-Oct-2021 12:30	08-Oct-2021 15:35	09-Oct-2021 11:20	09-Oct-2021 11:20	10-Oct-2021 10:10
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-001	VA21C2526-002	VA21C2526-003	VA21C2526-004	VA21C2526-005
					Result	Result	Result	Result	Result
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00069 RRV	0.0208	0.00046	<0.00010	0.00068
barium, total	7440-39-3	E420	0.00010	mg/L	0.00054 RRV	0.0366	0.0126	<0.00010	0.0300
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	0.046	0.100	<0.010	0.028
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0.0000073	<0.0000050	<0.0000050
calcium, total	7440-70-2	E420	0.050	mg/L	0.200 RRV	56.0	94.0	<0.050	159
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	0.00011
copper, total	7440-50-8	E420	0.00050	mg/L	0.0204 RRV	0.00052	<0.00050	<0.00050	0.00057
iron, total	7439-89-6	E420	0.010	mg/L	<0.010	0.019	0.037	<0.010	0.041
lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	0.000076	0.000161	<0.000050	0.000054
lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	0.168	0.0905	<0.0010	0.0103
magnesium, total	7439-95-4	E420	0.100	mg/L	<0.100	1.44	6.32	<0.100	5.61
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00124 RRV	0.0175	0.0767	<0.00010	0.0121
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, total	7439-98-7	E420	0.000050	mg/L	<0.000050	0.000659	0.00212	<0.000050	0.000394
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00059 RRV	<0.00050	<0.00050	<0.00050	<0.00050
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	<0.300
potassium, total	7440-09-7	E420	0.050	mg/L	<0.050	1.82	5.86	<0.050	3.13
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	0.000206	0.000525	<0.000050	0.000266
silicon, total	7440-21-3	E420	0.10	mg/L	<0.10	2.76	1.97	<0.10	2.70
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, total	17341-25-2	E420	0.050	mg/L	<0.050	72.8	56.7	<0.050	8.34
strontium, total	7440-24-6	E420	0.00020	mg/L	0.00465 RRV	0.869	0.914	<0.00020	0.839
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0.000027	<0.000010	<0.000010
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	0.000199	0.00118	<0.000010	0.00112
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0249 RRV	<0.0030	<0.0030	<0.0030	<0.0030

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-9 4	BJ-GW18-17A-E 303066	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 9	BJ-GW16-5B-C WP
				Client sampling date / time	08-Oct-2021 12:30	08-Oct-2021 15:35	09-Oct-2021 11:20	09-Oct-2021 11:20	10-Oct-2021 10:10
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-001	VA21C2526-002	VA21C2526-003	VA21C2526-004	VA21C2526-005
					Result	Result	Result	Result	Result
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	0.0156	0.0012	<0.0010	<0.0010
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	0.00298	0.00211	<0.00010	0.00067
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00074 RRV	0.0200	0.00030	<0.00010	0.00040
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00048 RRV	0.0375	0.0125	<0.00010	0.0297
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	<0.000100
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	0.045	0.098	<0.010	0.026
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0.0000092	<0.0000050	<0.0000050
calcium, dissolved	7440-70-2	E421	0.050	mg/L	0.153 RRV	59.8	102	<0.050	164
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0205 RRV	0.00025	<0.00020	<0.00020	0.00027
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	0.179	0.0952	<0.0010	0.0109
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	<0.100	1.52	5.77	<0.100	5.04
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00101 RRV	0.0178	0.0723	<0.00010	0.00127
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	<0.000050	0.000639	0.00209	<0.000050	0.000396
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	<0.300
potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	1.81	5.39	<0.050	2.86
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000169	0.000799 DTSE	<0.000050	0.000191
silicon, dissolved	7440-21-3	E421	0.050	mg/L	<0.050	2.71	1.74	<0.050	2.46
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
sodium, dissolved	17341-25-2	E421	0.050	mg/L	<0.050	77.3	54.4	<0.050	8.40
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.00350 RRV	0.946	1.03	<0.00020	0.864
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0.000024	<0.000010	<0.000010
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	0.00159 DTMF	<0.00010	<0.00010	<0.00010
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	0.000185	0.00116	<0.000010	0.00106

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-17A-9 4	BJ-GW18-17A-E 303066	BJ-GW18-23B-E 314691	BJ-GW18-23B-9 9	BJ-GW16-5B-C WP
				Client sampling date / time	08-Oct-2021 12:30	08-Oct-2021 15:35	09-Oct-2021 11:20	09-Oct-2021 11:20	10-Oct-2021 10:10
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-001	VA21C2526-002	VA21C2526-003	VA21C2526-004	VA21C2526-005
					Result	Result	Result	Result	Result
Dissolved Metals									
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0192 RRV	<0.0010	<0.0010	<0.0010	<0.0010
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	Field	Field
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	<20	<20

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW16-5A-C WP	BJ-GW18-23A-E 314690	----	----	----
				Client sampling date / time	10-Oct-2021 11:20	11-Oct-2021 16:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-006	VA21C2526-007	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	92.1	93.3	----	----	----
conductivity	----	E100	2.0	µS/cm	825	1200	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	456	355	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	451	362	----	----	----
pH	----	E108	0.10	pH units	8.11	8.10	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	598	753	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	111	----	----	----
turbidity	----	E121	0.10	NTU	0.82	66.5	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.105	0.417	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<2.50 DLDS	29.4	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.100 DLDS	0.114	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.123	<0.895	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0250 DLDS	9.32	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0255	9.47	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0050 DLDS	0.148	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.123	9.49	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0012	0.0037	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0030	0.0416	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	367	456	----	----	----
Organic / Inorganic Carbon									
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	<0.50	4.15	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	0.0019	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	0.0020	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0056	2.12	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00099	0.0302	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00092	0.0468	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW16-5A-CWP	BJ-GW18-23A-E314690	----	----	----
				Client sampling date / time	10-Oct-2021 11:20	11-Oct-2021 16:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-006	VA21C2526-007	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
barium, total	7440-39-3	E420	0.00010	mg/L	0.0198	0.0553	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	0.000411	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	0.000085	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.034	0.115	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	0.0000786	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	147	119	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00117	0.0138	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00037	0.00467	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00144	0.00488	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.081	0.974	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000175	0.00288	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0129	0.256	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	20.4	15.8	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.131	0.272	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	0.0000128	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000352	0.00510	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00110	0.00984	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.60	4.10	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	0.000707	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	2.65	6.70	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	0.000198	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	6.75	130	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	4.96	6.53	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	0.000109	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	0.00029	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	0.0117	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000334	0.00262	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	0.00164	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	0.0118	----	----	----
Dissolved Metals									

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW16-5A-C WP	BJ-GW18-23A-E 314690	----	----	----
				Client sampling date / time	10-Oct-2021 11:20	11-Oct-2021 16:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C2526-006	VA21C2526-007	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0015	0.0020	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00089	0.0337	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00081	0.0427	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0196	0.0424	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000200 DLA	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000100 DLA	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.032	0.105	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	0.0000183	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	149	116	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	0.00069	<0.00100 DLA	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00032	0.00073	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00085	0.00103	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.064	<0.020 DLA	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000146	0.000172	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0136	0.282	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	20.3	15.9	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.127	0.214	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000354	0.00435	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00078	0.00396	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.600 DLA	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.50	3.63	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000544	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.49	2.60	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000020 DLA	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	7.00	136	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	5.13	6.62	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	0.000058	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00020 DLA	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0200 DLA	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000311	0.00192	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW16-5A-CWP**	**BJ-GW18-23A-E 314690**	**----**	**----**	**----**
				Client sampling date / time	10-Oct-2021 11:20	11-Oct-2021 16:25	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21C2526-006**	**VA21C2526-007**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00100 DLA	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0021	0.0073	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	28	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C2526**	Page	: 1 of 27
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 12-Oct-2021 21:30
PO	: 1025614	Issue Date	: 26-Oct-2021 16:58
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 7		
No. of samples analysed	: 7		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E559	10-Oct-2021	----	----	----		20-Oct-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E559	10-Oct-2021	----	----	----		20-Oct-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-99	E559	09-Oct-2021	----	----	----		20-Oct-2021	28 days	11 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E559	09-Oct-2021	----	----	----		20-Oct-2021	28 days	11 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-94	E559	08-Oct-2021	----	----	----		20-Oct-2021	28 days	12 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E559	08-Oct-2021	----	----	----		20-Oct-2021	28 days	12 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E559	11-Oct-2021	----	----	----		20-Oct-2021	28 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-99	E298	09-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E298	09-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-94	E298	08-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	11 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E298	08-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	11 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E298	11-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E298	10-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E298	10-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.Br-L	11-Oct-2021	----	----	----		13-Oct-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A-CWP	E235.Br-L	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B-CWP	E235.Br-L	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-99	E235.Br-L	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.Br-L	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-94	E235.Br-L	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.Br-L	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.Cl	11-Oct-2021	----	----	----		13-Oct-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW16-5A-CWP	E235.Cl	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW16-5B-CWP	E235.Cl	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23B-99	E235.Cl	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.Cl	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17A-94	E235.Cl	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.Cl	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23A-E314690	E378-U	11-Oct-2021	----	----	----		13-Oct-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW16-5A-CWP	E378-U	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	× EHTL
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW16-5B-CWP	E378-U	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	× EHTL
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23B-99	E378-U	09-Oct-2021	----	----	----		13-Oct-2021	3 days	4 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23B-E314691	E378-U	09-Oct-2021	----	----	----		13-Oct-2021	3 days	4 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17A-94	E378-U	08-Oct-2021	----	----	----		13-Oct-2021	3 days	5 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17A-E303066	E378-U	08-Oct-2021	----	----	----		13-Oct-2021	3 days	5 days	× EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.F	11-Oct-2021	----	----	----		13-Oct-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW16-5A-CWP	E235.F	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW16-5B-CWP	E235.F	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23B-99	E235.F	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.F	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17A-94	E235.F	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.F	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.NO3-L	11-Oct-2021	----	----	----		13-Oct-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A-CWP	E235.NO3-L	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B-CWP	E235.NO3-L	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-99	E235.NO3-L	09-Oct-2021	----	----	----		13-Oct-2021	3 days	4 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.NO3-L	09-Oct-2021	----	----	----		13-Oct-2021	3 days	4 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-94	E235.NO3-L	08-Oct-2021	----	----	----		13-Oct-2021	3 days	5 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.NO3-L	08-Oct-2021	----	----	----		13-Oct-2021	3 days	5 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.NO2-L	11-Oct-2021	----	----	----		13-Oct-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A-CWP	E235.NO2-L	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B-CWP	E235.NO2-L	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-99	E235.NO2-L	09-Oct-2021	----	----	----		13-Oct-2021	3 days	4 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.NO2-L	09-Oct-2021	----	----	----		13-Oct-2021	3 days	4 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-94	E235.NO2-L	08-Oct-2021	----	----	----		13-Oct-2021	3 days	5 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.NO2-L	08-Oct-2021	----	----	----		13-Oct-2021	3 days	5 days	× EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.SO4	11-Oct-2021	----	----	----		13-Oct-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW16-5A-CWP	E235.SO4	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW16-5B-CWP	E235.SO4	10-Oct-2021	----	----	----		13-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23B-99	E235.SO4	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.SO4	09-Oct-2021	----	----	----		13-Oct-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A-94	E235.SO4	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.SO4	08-Oct-2021	----	----	----		13-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E366	10-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E366	10-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-99	E366	09-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	11 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E366	09-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	11 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-94	E366	08-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	12 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E366	08-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	12 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E366	11-Oct-2021	18-Oct-2021	----	----		20-Oct-2021	28 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-99	E372-U	09-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E372-U	09-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-94	E372-U	08-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	11 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E372-U	08-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E372-U	11-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E372-U	10-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E372-U	10-Oct-2021	18-Oct-2021	----	----		19-Oct-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW16-5A-CWP	E509	10-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	10 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW16-5B-CWP	E509	10-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	10 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23B-99	E509	09-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	11 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23B-E314691	E509	09-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	11 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17A-94	E509	08-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	12 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17A-E303066	E509	08-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	12 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23A-E314690	E509	11-Oct-2021	20-Oct-2021	----	----		20-Oct-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW16-5B-CWP	E421	10-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23B-99	E421	09-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23B-E314691	E421	09-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-94	E421	08-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	11 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW18-17A-E303066	E421	08-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW18-23A-E314690	E421	11-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ-GW16-5A-CWP	E421	10-Oct-2021	19-Oct-2021	----	----		19-Oct-2021	180 days	9 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) BJ-GW18-17A-94	E355-L	08-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	10 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) BJ-GW18-17A-E303066	E355-L	08-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	10 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) BJ-GW18-23A-E314690	E355-L	11-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	7 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) BJ-GW16-5A-CWP	E355-L	10-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	8 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) BJ-GW16-5B-CWP	E355-L	10-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	8 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) BJ-GW18-23B-99	E355-L	09-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E355-L	09-Oct-2021	18-Oct-2021	----	----		18-Oct-2021	28 days	9 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23A-E314690	E283	11-Oct-2021	----	----	----		14-Oct-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW16-5A-CWP	E283	10-Oct-2021	----	----	----		14-Oct-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW16-5B-CWP	E283	10-Oct-2021	----	----	----		14-Oct-2021	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23B-99	E283	09-Oct-2021	----	----	----		14-Oct-2021	14 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23B-E314691	E283	09-Oct-2021	----	----	----		14-Oct-2021	14 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A-94	E283	08-Oct-2021	----	----	----		14-Oct-2021	14 days	6 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A-E303066	E283	08-Oct-2021	----	----	----		14-Oct-2021	14 days	6 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23A-E314690	E290	11-Oct-2021	----	----	----		15-Oct-2021	14 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW16-5A-CWP	E290	10-Oct-2021	----	----	----		15-Oct-2021	14 days	5 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW16-5B-CWP	E290	10-Oct-2021	----	----	----		15-Oct-2021	14 days	5 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23B-99	E290	09-Oct-2021	----	----	----		15-Oct-2021	14 days	6 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23B-E314691	E290	09-Oct-2021	----	----	----		15-Oct-2021	14 days	6 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A-94	E290	08-Oct-2021	----	----	----		15-Oct-2021	14 days	7 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A-E303066	E290	08-Oct-2021	----	----	----		15-Oct-2021	14 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23A-E314690	E100	11-Oct-2021	----	----	----		15-Oct-2021	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW16-5A-CWP	E100	10-Oct-2021	----	----	----		15-Oct-2021	28 days	5 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW16-5B-CWP	E100	10-Oct-2021	----	----	----		15-Oct-2021	28 days	5 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23B-99	E100	09-Oct-2021	----	----	----		15-Oct-2021	28 days	6 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23B-E314691	E100	09-Oct-2021	----	----	----		15-Oct-2021	28 days	6 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A-94	E100	08-Oct-2021	----	----	----		15-Oct-2021	28 days	7 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A-E303066	E100	08-Oct-2021	----	----	----		15-Oct-2021	28 days	7 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW16-5A-CWP	E108	10-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	115 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW16-5B-CWP	E108	10-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	116 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-23B-99	E108	09-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	139 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-23B-E314691	E108	09-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	139 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-17A-E303066	E108	08-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	158 hrs	✗ EHTR-FM

Matrix: **Water**

Evaluation: ✖ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW18-17A-94	E108	08-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	161 hrs	✖ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-23A-E314690	E108	11-Oct-2021	----	----	----		15-Oct-2021	0.25 hrs	85 hrs	✖ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23A-E314690	E162	11-Oct-2021	----	----	----		15-Oct-2021	7 days	4 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW16-5A-CWP	E162	10-Oct-2021	----	----	----		15-Oct-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW16-5B-CWP	E162	10-Oct-2021	----	----	----		15-Oct-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23B-99	E162	09-Oct-2021	----	----	----		15-Oct-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23B-E314691	E162	09-Oct-2021	----	----	----		15-Oct-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17A-94	E162	08-Oct-2021	----	----	----		15-Oct-2021	7 days	7 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17A-E303066	E162	08-Oct-2021	----	----	----		15-Oct-2021	7 days	7 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23A-E314690	E160-H	11-Oct-2021	----	----	----		15-Oct-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW16-5A-CWP	E160-H	10-Oct-2021	----	----	----		15-Oct-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW16-5B-CWP	E160-H	10-Oct-2021	----	----	----		15-Oct-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23B-99	E160-H	09-Oct-2021	----	----	----		15-Oct-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23B-E314691	E160-H	09-Oct-2021	----	----	----		15-Oct-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17A-94	E160-H	08-Oct-2021	----	----	----		15-Oct-2021	7 days	7 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-17A-E303066	E160-H	08-Oct-2021	----	----	----		15-Oct-2021	7 days	7 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23A-E314690	E121	11-Oct-2021	----	----	----		14-Oct-2021	3 days	3 days	× EHT
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW16-5A-CWP	E121	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW16-5B-CWP	E121	10-Oct-2021	----	----	----		13-Oct-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23B-99	E121	09-Oct-2021	----	----	----		15-Oct-2021	3 days	6 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23B-E314691	E121	09-Oct-2021	----	----	----		15-Oct-2021	3 days	6 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17A-94	E121	08-Oct-2021	----	----	----		15-Oct-2021	3 days	7 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-17A-E303066	E121	08-Oct-2021	----	----	----		15-Oct-2021	3 days	7 days	× EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW16-5A-CWP	E508	10-Oct-2021	----	----	----		20-Oct-2021	28 days	10 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW16-5B-CWP	E508	10-Oct-2021	----	----	----		20-Oct-2021	28 days	10 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23B-99	E508	09-Oct-2021	----	----	----		20-Oct-2021	28 days	11 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23B-E314691	E508	09-Oct-2021	----	----	----		20-Oct-2021	28 days	11 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-17A-94	E508	08-Oct-2021	----	----	----		20-Oct-2021	28 days	12 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-17A-E303066	E508	08-Oct-2021	----	----	----		20-Oct-2021	28 days	12 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23A-E314690	E508	11-Oct-2021	----	----	----		20-Oct-2021	28 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW16-5A-CWP	E420	10-Oct-2021	----	----	----		20-Oct-2021	180 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW16-5B-CWP	E420	10-Oct-2021	----	----	----		20-Oct-2021	180 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23B-99	E420	09-Oct-2021	----	----	----		20-Oct-2021	180 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23B-E314691	E420	09-Oct-2021	----	----	----		20-Oct-2021	180 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17A-94	E420	08-Oct-2021	----	----	----		20-Oct-2021	180 days	12 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-17A-E303066	E420	08-Oct-2021	----	----	----		20-Oct-2021	180 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23A-E314690	E420	11-Oct-2021	----	----	----		20-Oct-2021	180 days	9 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW16-5B-CWP	E395	10-Oct-2021	----	----	----		13-Oct-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23A-E314690	E395	11-Oct-2021	----	----	----		14-Oct-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW16-5A-CWP	E395	10-Oct-2021	----	----	----		14-Oct-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23B-99	E395	09-Oct-2021	----	----	----		13-Oct-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23B-E314691	E395	09-Oct-2021	----	----	----		13-Oct-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17A-94	E395	08-Oct-2021	----	----	----		13-Oct-2021	7 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-17A-E303066	E395	08-Oct-2021	----	----	----		13-Oct-2021	7 days	5 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	318374	1	18	5.5	5.0	✓
Alkalinity Species by Titration	E290	318375	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	322861	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	318373	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	324354	2	29	6.9	5.0	✓
Chloride in Water by IC	E235.Cl	318372	1	18	5.5	5.0	✓
Conductivity in Water	E100	318376	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	324274	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	323691	3	40	7.5	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	318378	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	318371	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	318368	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	318369	1	18	5.5	5.0	✓
pH by Meter	E108	318377	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	318370	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	320492	1	17	5.8	5.0	✓
Total Mercury in Water by CVAAS	E508	324206	2	37	5.4	5.0	✓
Total Metals in Water by CRC ICPMS	E420	323572	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	322860	1	18	5.5	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	322859	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	322862	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	318628	3	60	5.0	5.0	✓
TSS by Gravimetry	E160-H	320437	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	318537	3	59	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	318374	1	18	5.5	5.0	✓
Alkalinity Species by Titration	E290	318375	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	322861	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	318373	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	324354	2	29	6.9	5.0	✓
Chloride in Water by IC	E235.Cl	318372	1	18	5.5	5.0	✓
Conductivity in Water	E100	318376	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	324274	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	323691	2	40	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	318378	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	318371	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	318368	1	18	5.5	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	318369	1	18	5.5	5.0	✓
pH by Meter	E108	318377	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	318370	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	320492	1	17	5.8	5.0	✓
Total Mercury in Water by CVAAS	E508	324206	2	37	5.4	5.0	✓
Total Metals in Water by CRC ICPMS	E420	323572	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	322860	1	18	5.5	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	322859	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	322862	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	318628	3	60	5.0	5.0	✓
TSS by Gravimetry	E160-H	320437	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	318537	3	59	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	318374	1	18	5.5	5.0	✓
Alkalinity Species by Titration	E290	318375	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	322861	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	318373	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	324354	2	29	6.9	5.0	✓
Chloride in Water by IC	E235.Cl	318372	1	18	5.5	5.0	✓
Conductivity in Water	E100	318376	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	324274	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	323691	2	40	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	318378	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	318371	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	318368	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	318369	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	318370	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	320492	1	17	5.8	5.0	✓
Total Mercury in Water by CVAAS	E508	324206	2	37	5.4	5.0	✓
Total Metals in Water by CRC ICPMS	E420	323572	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	322860	1	18	5.5	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	322859	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	322862	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	318628	3	60	5.0	5.0	✓
TSS by Gravimetry	E160-H	320437	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	318537	3	59	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	322861	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	318373	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	324354	2	29	6.9	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Chloride in Water by IC	E235.Cl	318372	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	324274	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	323691	2	40	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	318378	1	18	5.5	5.0	✓
Fluoride in Water by IC	E235.F	318371	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	318368	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	318369	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	318370	1	18	5.5	5.0	✓
Total Mercury in Water by CVAAS	E508	324206	2	37	5.4	5.0	✓
Total Metals in Water by CRC ICPMS	E420	323572	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	322860	1	18	5.5	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	322859	1	18	5.5	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	322862	1	18	5.5	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	318628	3	60	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H_2S concentration based on the total sulfide concentration in the sample. The H_2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C2526**	Page	: 1 of 22
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 12-Oct-2021 21:30
PO	: 1025614	Date Analysis Commenced	: 13-Oct-2021
C-O-C number	: ----	Issue Date	: 26-Oct-2021 16:58
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 7		
No. of samples analysed	: 7		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 318374)											
VA21C2505-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 318375)											
VA21C2505-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	172	172	0.407%	20%	----
Physical Tests (QC Lot: 318376)											
VA21C2505-001	Anonymous	conductivity	----	E100	2.0	µS/cm	704	710	0.849%	10%	----
Physical Tests (QC Lot: 318377)											
VA21C2505-001	Anonymous	pH	----	E108	0.10	pH units	8.45	8.44	0.118%	4%	----
Physical Tests (QC Lot: 318537)											
VA21C2455-001	Anonymous	turbidity	----	E121	0.10	NTU	1.25	1.42	12.9%	15%	----
Physical Tests (QC Lot: 319819)											
FJ2101102-001	Anonymous	turbidity	----	E121	0.10	NTU	19.6	20.8	5.74%	15%	----
Physical Tests (QC Lot: 320437)											
VA21C2439-024	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 320492)											
VA21C2439-024	Anonymous	solids, total dissolved [TDS]	----	E162	13	mg/L	67	55	12	Diff <2x LOR	----
Physical Tests (QC Lot: 320879)											
VA21C2524-002	Anonymous	turbidity	----	E121	0.10	NTU	0.53	0.55	0.01	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 318368)											
VA21C2505-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	<0.0250	<0.0250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 318369)											
VA21C2505-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 318370)											
VA21C2505-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	108	108	0.00682%	20%	----
Anions and Nutrients (QC Lot: 318371)											
VA21C2505-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.548	0.543	0.005	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 318372)											
VA21C2505-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	<2.50	<2.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 318373)											
VA21C2505-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 318378)											
VA21C2505-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 322860)											
VA21C2523-001	Anonymous	nitrogen, total	7727-37-9	E366	0.300	mg/L	7.92	7.92	0.0308%	20%	----
Anions and Nutrients (QC Lot: 322861)											
VA21C2523-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0977	0.0990	1.31%	20%	----
Anions and Nutrients (QC Lot: 322862)											
VA21C2523-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0032	0.0031	0.0001	Diff <2x LOR	----
Organic / Inorganic Carbon (QC Lot: 322859)											
VA21C2523-001	Anonymous	carbon, total organic [TOC]	----	E355-L	0.50	mg/L	0.79	0.51	0.29	Diff <2x LOR	----
Total Sulfides (QC Lot: 318628)											
EO2103106-010	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 319564)											
CG2104773-008	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0220	0.0223	1.67%	20%	----
Total Sulfides (QC Lot: 319569)											
CG2104799-004	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 323572)											
VA21C2507-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0509	0.0590	14.7%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00027	0.00026	0.00002	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00047	0.00051	0.00004	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0796	0.0828	3.96%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000085	0.0000068	0.0000016	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	60.5	62.7	3.48%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00171	0.00150	0.00021	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.096	0.101	0.004	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000051	0.000050	0.000001	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0016	0.0017	0.00004	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	31.2	32.5	4.08%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.00956	0.00946	0.982%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00118	0.00118	0.650%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00089	0.00084	0.00005	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.100	mg/L	1.34	1.41	5.60%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 323572) - continued											
VA21C2507-001	Anonymous	selenium, total	7782-49-2	E420	0.000050	mg/L	0.00111	0.00105	6.05%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	2.98	3.19	6.74%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	5.63	5.97	5.81%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	0.332	0.319	3.87%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00077	0.00068	0.00008	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000376	0.000382	1.36%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00056	0.00056	0.0000008	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 324206)											
VA21C2428-008	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000075	0.0000076	0.0000001	Diff <2x LOR	----
Total Metals (QC Lot: 324207)											
VA21C2526-004	BJ-GW18-23B-99	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 323691)											
KS2103328-021	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0050	mg/L	<0.0050	0.0051	0.00006	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00050	mg/L	0.0171	0.0174	1.91%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.050	mg/L	0.163	0.168	0.004	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000250	mg/L	0.000310	0.000325	4.76%	20%	----
		calcium, dissolved	7440-70-2	E421	0.250	mg/L	433	438	1.15%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00050	mg/L	0.00065	0.00064	0.00002	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0050	mg/L	0.0173	0.0169	0.0004	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0250	mg/L	599	633	5.52%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00050	mg/L	0.323	0.340	5.39%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000250	mg/L	0.0519	0.0522	0.647%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00250	mg/L	0.0452	0.0470	3.89%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 323691) - continued											
KS2103328-021	Anonymous	phosphorus, dissolved	7723-14-0	E421	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.250	mg/L	21.9	22.9	4.38%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000250	mg/L	0.00844	0.00876	3.76%	20%	----
		silicon, dissolved	7440-21-3	E421	0.250	mg/L	9.07	9.42	3.80%	20%	----
		silver, dissolved	7440-22-4	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.250	mg/L	154	161	4.65%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00100	mg/L	0.862	0.826	4.30%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000050	mg/L	0.000191	0.000190	0.0000008	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00150	mg/L	<0.00150	<0.00150	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000050	mg/L	0.0382	0.0379	0.672%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 324036)											
VA21C2548-001	Anonymous	barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00026	0.00018	0.00008	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	0.318	0.307	0.012	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	0.0147	0.0194	0.0047	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	0.266	0.277	0.011	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	0.446	0.415	0.031	Diff <2x LOR	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.00104	0.00104	0.000005	Diff <2x LOR	----
VA21C2548-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	0.0012	0.0002	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 324036) - continued											
VA21C2548-001	Anonymous	nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 324274)											
KS2103328-008	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 324354)											
VA21C1834-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 324355)											
VA21C2526-005	BJ-GW16-5B-CWP	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 318374)						
acidity (as CaCO3)	----	E283	2	mg/L	2.3	----
Physical Tests (QCLot: 318375)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 318376)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 318537)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 319819)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 320437)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 320492)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 320879)						
turbidity	----	E121	0.1	NTU	<0.10	----
Anions and Nutrients (QCLot: 318368)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 318369)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 318370)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 318371)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 318372)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 318373)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 318378)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 322860)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 322861)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Anions and Nutrients (QCLot: 322862)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Organic / Inorganic Carbon (QCLot: 322859)						
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	<0.50	----
Total Sulfides (QCLot: 318628)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Sulfides (QCLot: 319564)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Sulfides (QCLot: 319569)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 323572)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 323572) - continued						
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 324206)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 324207)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 323691)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 323691) - continued						
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 324036)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 324036) - continued						
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 324274)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 324354)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----
Aggregate Organics (QCLot: 324355)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 318374)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	101	85.0	115	----
Physical Tests (QCLot: 318375)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.7	85.0	115	----
Physical Tests (QCLot: 318376)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	97.5	90.0	110	----
Physical Tests (QCLot: 318377)									
pH	----	E108	----	pH units	7 pH units	99.7	98.0	102	----
Physical Tests (QCLot: 318537)									
turbidity	----	E121	0.1	NTU	200 NTU	99.8	85.0	115	----
Physical Tests (QCLot: 319819)									
turbidity	----	E121	0.1	NTU	200 NTU	99.5	85.0	115	----
Physical Tests (QCLot: 320437)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	91.1	85.0	115	----
Physical Tests (QCLot: 320492)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	91.3	85.0	115	----
Physical Tests (QCLot: 320879)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Anions and Nutrients (QCLot: 318368)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 318369)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 318370)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 318371)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 318372)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 318373)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	97.2	85.0	115	----
Anions and Nutrients (QCLot: 318378)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	99.9	80.0	120	----
Anions and Nutrients (QCLot: 322860)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 322860) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 322861)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 322862)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	92.8	80.0	120	----
Organic / Inorganic Carbon (QCLot: 322859)									
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	8.57 mg/L	102	80.0	120	----
Total Sulfides (QCLot: 318628)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	95.6	80.0	120	----
Total Sulfides (QCLot: 319564)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	104	80.0	120	----
Total Sulfides (QCLot: 319569)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	108	80.0	120	----
Total Metals (QCLot: 323572)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	104	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	98.2	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	96.9	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.8	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	95.5	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	90.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	97.0	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	99.9	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	98.4	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	96.4	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	94.6	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	98.0	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	96.8	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	93.2	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	94.5	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	97.1	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	101	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	97.1	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	98.2	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 323572) - continued									
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	97.7	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	87.8	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	87.7	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	94.6	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	95.2	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	94.0	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	97.0	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	96.6	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	97.4	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	97.6	80.0	120	----
Total Metals (QCLot: 324206)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	97.0	80.0	120	----
Total Metals (QCLot: 324207)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	98.8	80.0	120	----
Dissolved Metals (QCLot: 323691)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	104	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	99.3	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	100	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	109	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.5	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	105	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.5	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	99.8	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	99.0	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	97.3	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	98.4	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	95.0	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	96.5	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.8	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	95.8	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	98.6	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 323691) - continued									
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	109	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	98.2	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	105	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	87.0	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	97.9	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	95.7	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	97.5	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	98.3	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	98.9	80.0	120	----
Dissolved Metals (QCLot: 324036)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	103	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	108	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	111	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	106	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	105	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	96.1	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	103	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	108	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	105	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	98.4	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	99.5	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	106	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	119	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	110	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 324036) - continued									
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	92.9	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	105	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	100	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	102	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	107	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	101	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	97.4	80.0	120	----
Aggregate Organics (QCLot: 324354)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	111	85.0	115	----
Aggregate Organics (QCLot: 324355)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	109	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 318368)										
VA21C2505-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.40 mg/L	2.5 mg/L	96.0	75.0	125	----
Anions and Nutrients (QCLot: 318369)										
VA21C2505-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.468 mg/L	0.5 mg/L	93.7	75.0	125	----
Anions and Nutrients (QCLot: 318370)										
VA21C2505-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	91.9 mg/L	100 mg/L	91.9	75.0	125	----
Anions and Nutrients (QCLot: 318371)										
VA21C2505-002	Anonymous	fluoride	16984-48-8	E235.F	0.941 mg/L	1 mg/L	94.1	75.0	125	----
Anions and Nutrients (QCLot: 318372)										
VA21C2505-002	Anonymous	chloride	16887-00-6	E235.Cl	95.6 mg/L	100 mg/L	95.6	75.0	125	----
Anions and Nutrients (QCLot: 318373)										
VA21C2505-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.461 mg/L	0.5 mg/L	92.2	75.0	125	----
Anions and Nutrients (QCLot: 318378)										
VA21C2505-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0296 mg/L	0.03 mg/L	98.5	70.0	130	----
Anions and Nutrients (QCLot: 322860)										
VA21C2523-002	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 322861)										
VA21C2523-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.113 mg/L	0.1 mg/L	113	75.0	125	----
Anions and Nutrients (QCLot: 322862)										
VA21C2523-002	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0493 mg/L	0.05 mg/L	98.6	70.0	130	----
Organic / Inorganic Carbon (QCLot: 322859)										
VA21C2523-002	Anonymous	carbon, total organic [TOC]	----	E355-L	5.37 mg/L	5 mg/L	107	70.0	130	----
Total Sulfides (QCLot: 318628)										
EO2103124-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.199 mg/L	0.2 mg/L	99.5	75.0	125	----
Total Sulfides (QCLot: 319564)										
CG2104773-009	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.223 mg/L	0.2 mg/L	112	75.0	125	----
Total Sulfides (QCLot: 319569)										
CG2104799-005	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.228 mg/L	0.2 mg/L	114	75.0	125	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 323572)										
VA21C2507-002	Anonymous	aluminum, total	7429-90-5	E420	0.219 mg/L	0.2 mg/L	110	70.0	130	----
		antimony, total	7440-36-0	E420	0.0218 mg/L	0.02 mg/L	109	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0216 mg/L	0.02 mg/L	108	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0422 mg/L	0.04 mg/L	106	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0100 mg/L	0.01 mg/L	100	70.0	130	----
		boron, total	7440-42-8	E420	0.099 mg/L	0.1 mg/L	98.9	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00426 mg/L	0.004 mg/L	106	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0421 mg/L	0.04 mg/L	105	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		copper, total	7440-50-8	E420	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		iron, total	7439-89-6	E420	2.10 mg/L	2 mg/L	105	70.0	130	----
		lead, total	7439-92-1	E420	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		lithium, total	7439-93-2	E420	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0214 mg/L	0.02 mg/L	107	70.0	130	----
		nickel, total	7440-02-0	E420	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.9 mg/L	10 mg/L	119	70.0	130	----
		potassium, total	7440-09-7	E420	4.24 mg/L	4 mg/L	106	70.0	130	----
		selenium, total	7782-49-2	E420	0.0441 mg/L	0.04 mg/L	110	70.0	130	----
		silicon, total	7440-21-3	E420	9.76 mg/L	10 mg/L	97.6	70.0	130	----
		silver, total	7440-22-4	E420	0.00400 mg/L	0.004 mg/L	100.0	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00382 mg/L	0.004 mg/L	95.5	70.0	130	----
		tin, total	7440-31-5	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		titanium, total	7440-32-6	E420	0.0409 mg/L	0.04 mg/L	102	70.0	130	----
		uranium, total	7440-61-1	E420	0.00429 mg/L	0.004 mg/L	107	70.0	130	----
		vanadium, total	7440-62-2	E420	0.108 mg/L	0.1 mg/L	108	70.0	130	----
		zinc, total	7440-66-6	E420	0.415 mg/L	0.4 mg/L	104	70.0	130	----
Total Metals (QCLot: 324206)										
VA21C2428-009	Anonymous	mercury, total	7439-97-6	E508	0.0000994 mg/L	0.0001 mg/L	99.4	70.0	130	----
Total Metals (QCLot: 324207)										
VA21C2526-005	BJ-GW16-5B-CWP	mercury, total	7439-97-6	E508	0.0000988 mg/L	0.0001 mg/L	98.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 323691)										
KS2103328-022	Anonymous	aluminum, dissolved	7429-90-5	E421	1.01 mg/L	1 mg/L	101	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.101 mg/L	0.1 mg/L	101	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.105 mg/L	0.1 mg/L	105	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.211 mg/L	0.2 mg/L	105	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0447 mg/L	0.05 mg/L	89.4	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.472 mg/L	0.5 mg/L	94.4	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.198 mg/L	0.2 mg/L	99.3	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0986 mg/L	0.1 mg/L	98.6	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0964 mg/L	0.1 mg/L	96.4	70.0	130	----
		iron, dissolved	7439-89-6	E421	10.0 mg/L	10 mg/L	100	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0922 mg/L	0.1 mg/L	92.2	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.525 mg/L	0.5 mg/L	105	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	5 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.104 mg/L	0.1 mg/L	104	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.194 mg/L	0.2 mg/L	97.2	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	60.0 mg/L	50 mg/L	120	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.218 mg/L	0.2 mg/L	109	70.0	130	----
		silicon, dissolved	7440-21-3	E421	46.9 mg/L	50 mg/L	93.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.0191 mg/L	0.02 mg/L	95.4	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	10 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.0182 mg/L	0.02 mg/L	90.9	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.214 mg/L	0.2 mg/L	107	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.535 mg/L	0.5 mg/L	107	70.0	130	----
		zinc, dissolved	7440-66-6	E421	1.91 mg/L	2 mg/L	95.4	70.0	130	----
Dissolved Metals (QCLot: 324036)										
VA21C2306-003	Anonymous	aluminum, dissolved	7429-90-5	E421	0.187 mg/L	0.2 mg/L	93.4	70.0	130	----
		antimony, dissolved	7440-36-0	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0190 mg/L	0.02 mg/L	95.2	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 324036) - continued										
VA21C2306-003	Anonymous	barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0431 mg/L	0.04 mg/L	108	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00772 mg/L	0.01 mg/L	77.2	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.094 mg/L	0.1 mg/L	93.7	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00376 mg/L	0.004 mg/L	93.9	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0382 mg/L	0.04 mg/L	95.4	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0188 mg/L	0.02 mg/L	94.0	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0190 mg/L	0.02 mg/L	94.8	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.91 mg/L	2 mg/L	95.5	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0187 mg/L	0.02 mg/L	93.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.113 mg/L	0.1 mg/L	113	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0371 mg/L	0.04 mg/L	92.8	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.4 mg/L	10 mg/L	104	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.80 mg/L	4 mg/L	94.9	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0400 mg/L	0.04 mg/L	99.9	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.86 mg/L	10 mg/L	88.6	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00382 mg/L	0.004 mg/L	95.5	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.75 mg/L	2 mg/L	87.6	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00371 mg/L	0.004 mg/L	92.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0384 mg/L	0.04 mg/L	96.0	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00394 mg/L	0.004 mg/L	98.4	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0968 mg/L	0.1 mg/L	96.8	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.394 mg/L	0.4 mg/L	98.5	70.0	130	----
Dissolved Metals (QCLot: 324274)										
VA21C2507-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000999 mg/L	0.0001 mg/L	99.9	70.0	130	----
Aggregate Organics (QCLot: 324354)										
VA21C1834-002	Anonymous	chemical oxygen demand [COD]	----	E559	112 mg/L	100 mg/L	112	75.0	125	----
Aggregate Organics (QCLot: 324355)										
VA21C2526-006	BJ-GW16-5A-CWP	chemical oxygen demand [COD]	----	E559	112 mg/L	100 mg/L	112	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	2526	**ALS Contact:** Dean Watt	**Sampler:** NG/RS	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
1	BJ-GW18-17A-94	08-Oct-21	12:30	Groundwater	X	X		X	X			X	X	X	X		7
2	BJ-GW18-17A-E303066	08-Oct-21	15:35	Groundwater	X	X		X	X			X	X	X	X		7
3	BJ-GW18--23B-E314691	09-Oct-21	11:20	Groundwater	X	X		X	X			X	X	X	X		7
4	BJ-GW18-23B-99	09-Oct-21	11:20	Groundwater	X	X		X	X			X	X	X	X		7
5	BJ-GW16-5B-CWP	10-Oct-21	10:10	Groundwater	X	X		X	X			X	X	X	X		7
6	BJ-GW16-5A-CWP	10-Oct-21	11:20	Groundwater	X	X		X	X			X	X	X	X		7
7	BJ-GW18-23A-E314690	11-Oct-21	16:25	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA21C2526

Telephone : +1 604 253 4188

Special Instructions / R... ...E-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Richelle Sussbauer	11-Oct-21	18:00	DJS	Oct 12/21	9:30	5 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C3093**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 18-Oct-2021 21:20
PO	: 1025614	Date Analysis Commenced	: 19-Oct-2021
C-O-C number	: ----	Issue Date	: 27-Oct-2021 14:50
Sampler	: NG/RS/LF		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
				Client sampling date / time	16-Oct-2021 13:45	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C3093-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	28.8	----	----	----	----
conductivity	----	E100	2.0	µS/cm	157	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	70.4	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	68.8	----	----	----	----
pH	----	E108	0.10	pH units	7.94	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	97	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	3.6	----	----	----	----
turbidity	----	E121	0.10	NTU	3.42	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.020	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.062	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0498	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0498	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.112	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0019	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0085	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	43.6	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0465	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00089	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00988	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0326	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
				Client sampling date / time	16-Oct-2021 13:45	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C3093-001	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	23.1	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00329	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00060	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.049	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000184	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0024	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	2.70	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00293	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00155	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.641	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000361	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	1.73	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000020	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	2.12	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.284	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000173	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0045	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0125	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW12-11A-E 303062	----	----	----	----
					Client sampling date / time	16-Oct-2021 13:45	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C3093-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00084	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00889	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0273	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		<0.010	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		23.2	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.00031	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0026	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		3.04	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.00060	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		0.0000052	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.00159	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		0.682	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000275	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		1.52	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		2.12	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		0.285	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000173	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW12-11A-E 303062**	**----**	**----**	**----**	**----**
				Client sampling date / time	16-Oct-2021 13:45	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C3093-001**	**--------**	**--------**	**--------**	**--------**
					Result	----	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0010	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C3093**	Page	: 1 of 12
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 18-Oct-2021 21:20
PO	: 1025614	Issue Date	: 27-Oct-2021 14:50
C-O-C number	: ----		
Sampler	: NG/RS/LF		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Total Metals	QC-MRG3-329001001	----	magnesium, total	7439-95-4	E420	0.0070 mg/L [B]	0.005 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E559	16-Oct-2021	----	----	----		26-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E298	16-Oct-2021	22-Oct-2021	----	----		22-Oct-2021	28 days	6 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.Br-L	16-Oct-2021	----	----	----		19-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.Cl	16-Oct-2021	----	----	----		19-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-11A-E303062	E378-U	16-Oct-2021	----	----	----		19-Oct-2021	3 days	3 days	× EHTL
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.F	16-Oct-2021	----	----	----		19-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.NO3-L	16-Oct-2021	----	----	----		19-Oct-2021	3 days	3 days	× EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-11A-E303062	E235.NO2-L	16-Oct-2021	----	----	----		19-Oct-2021	3 days	3 days	× EHTL
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-11A-E303062	E235.SO4	16-Oct-2021	----	----	----		19-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E366	16-Oct-2021	22-Oct-2021	----	----		26-Oct-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-11A-E303062	E372-U	16-Oct-2021	22-Oct-2021	----	----		23-Oct-2021	28 days	7 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-11A-E303062	E509	16-Oct-2021	26-Oct-2021	----	----		26-Oct-2021	28 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-11A-E303062	E421	16-Oct-2021	25-Oct-2021	----	----		26-Oct-2021	180 days	10 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-11A-E303062	E283	16-Oct-2021	----	----	----		20-Oct-2021	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-11A-E303062	E290	16-Oct-2021	----	----	----		20-Oct-2021	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-11A-E303062	E100	16-Oct-2021	----	----	----		20-Oct-2021	28 days	4 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW12-11A-E303062	E108	16-Oct-2021	----	----	----		20-Oct-2021	0.25 hrs	98 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW12-11A-E303062	E162	16-Oct-2021	----	----	----		22-Oct-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW12-11A-E303062	E160-H	16-Oct-2021	----	----	----		22-Oct-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW12-11A-E303062	E121	16-Oct-2021	----	----	----		20-Oct-2021	3 days	4 days	✗ EHTL
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW12-11A-E303062	E508	16-Oct-2021	----	----	----		26-Oct-2021	28 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW12-11A-E303062	E420	16-Oct-2021	----	----	----		25-Oct-2021	180 days	9 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW12-11A-E303062	E395	16-Oct-2021	----	----	----		21-Oct-2021	7 days	5 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	324032	0	1	0.0	5.0	✗
Alkalinity Species by Titration	E290	324023	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324027	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	324026	1	15	6.6	5.0	✓
Conductivity in Water	E100	324024	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324031	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	324025	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324028	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324029	1	15	6.6	5.0	✓
pH by Meter	E108	324022	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	324030	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	327598	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	327601	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	324869	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	324032	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	324023	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324027	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	324026	1	15	6.6	5.0	✓
Conductivity in Water	E100	324024	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324031	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	324025	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324028	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324029	1	15	6.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	324022	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	324030	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	327598	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	327601	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	324869	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	324032	1	1	100.0	5.0	✓
Alkalinity Species by Titration	E290	324023	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324027	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	324026	1	15	6.6	5.0	✓
Conductivity in Water	E100	324024	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324031	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	324025	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324028	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324029	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	324030	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	327598	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	327601	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	324869	1	20	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324027	1	15	6.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	324026	1	15	6.6	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324031	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	324025	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324028	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324029	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	324030	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C3093**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 18-Oct-2021 21:20
PO	: 1025614	Date Analysis Commenced	: 19-Oct-2021
C-O-C number	: ----	Issue Date	: 27-Oct-2021 14:50
Sampler	: NG/RS/LF		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 324022)											
KS2103405-003	Anonymous	pH	----	E108	0.10	pH units	8.26	8.30	0.483%	4%	----
Physical Tests (QC Lot: 324023)											
KS2103405-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	170	172	0.934%	20%	----
Physical Tests (QC Lot: 324024)											
KS2103405-003	Anonymous	conductivity	----	E100	2.0	µS/cm	989	989	0.00%	10%	----
Physical Tests (QC Lot: 324869)											
KS2103409-001	Anonymous	turbidity	----	E121	0.10	NTU	0.15	0.15	0.001	Diff <2x LOR	----
Physical Tests (QC Lot: 327598)											
VA21C3092-002	Anonymous	solids, total dissolved [TDS]	----	E162	10	mg/L	26	27	1	Diff <2x LOR	----
Physical Tests (QC Lot: 327601)											
VA21C3029-006	Anonymous	solids, total suspended [TSS]	----	E160-H	15.0	mg/L	3320	3410	2.64%	20%	----
Anions and Nutrients (QC Lot: 324025)											
KS2103405-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.226	0.220	0.006	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324026)											
KS2103405-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	6.46	6.61	0.15	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324027)											
KS2103405-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324028)											
KS2103405-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.0895	0.0914	0.0019	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324029)											
KS2103405-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324030)											
KS2103405-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	163	167	2.54%	20%	----
Anions and Nutrients (QC Lot: 324031)											
KS2103405-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0293	0.0291	0.548%	20%	----
Anions and Nutrients (QC Lot: 327015)											
KS2103435-001	Anonymous	nitrogen, total	7727-37-9	E366	1.50	mg/L	42.3	43.0	1.70%	20%	----
Anions and Nutrients (QC Lot: 327016)											
KS2103435-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	6.68	6.70	0.354%	20%	----
Anions and Nutrients (QC Lot: 327017)											
KS2103435-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.500	mg/L	38.7	38.2	1.28%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Sulfides (QC Lot: 326399)											
CG2104979-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0056	0.0052	0.0004	Diff <2x LOR	----
Total Metals (QC Lot: 329001)											
YL2101539-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.233	0.252	7.49%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00043	0.00042	0.00001	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.225	0.232	3.19%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000027	0.000029	0.000002	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.916	0.960	4.71%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000340	0.000357	4.76%	20%	----
		calcium, total	7440-70-2	E420	0.050	mg/L	106	113	6.84%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.0109	0.0111	1.32%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00247	0.00243	0.00004	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.408	0.424	3.92%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000100	0.000101	0.0000008	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0112	0.0116	4.03%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	36.6	36.5	0.267%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.854	0.856	0.256%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00457	0.00463	1.41%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.0404	0.0406	0.519%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	25.4	25.7	1.14%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000133	0.000133	0.0000004	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	5.87	5.90	0.503%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	70.4	70.2	0.217%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.12	1.10	2.11%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000092	0.000087	0.000005	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00952	0.00930	2.36%	20%	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00105	0.00104	1.12%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00074	0.00076	0.00003	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0432	0.0427	1.24%	20%	----
Total Metals (QC Lot: 329385)											

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 329385) - continued											
CG2104995-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 329258)											
YL2101552-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0142	0.0138	2.78%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00012	0.00012	0.000003	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00015	0.00017	0.00002	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0230	0.0232	0.908%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.346	0.348	0.793%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000122	0.0000089	0.0000033	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	57.1	58.8	2.90%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00074	0.00075	0.000005	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00269	0.00276	2.50%	20%	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.016	0.016	0.0003	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0042	0.0041	0.0001	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	27.5	27.0	1.92%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0253	0.0247	2.48%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.0182	0.0187	2.71%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.0180	0.0180	0.475%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	6.38	6.37	0.116%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000189	0.000275	0.000085	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	4.36	4.43	1.60%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	16.8	17.0	1.16%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.349	0.360	3.13%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000011	0.000010	0.0000007	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00228	0.00224	1.91%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0020	0.0019	0.00009	Diff <2x LOR	----
Dissolved Metals (QC Lot: 329390)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 329390) - continued											
FJ2101136-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 329469)											
VA21C2959-005	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	74	74	0.5	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 324023)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 324024)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 324032)						
acidity (as CaCO3)	----	E283	2	mg/L	2.0	----
Physical Tests (QCLot: 324869)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 327598)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 327601)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 324025)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 324026)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 324027)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 324028)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 324029)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 324030)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 324031)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 327015)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 327016)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 327017)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 326399)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 329001)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	# 0.0070	B
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 329385)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 329258)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 329258) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 329390)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 329469)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 324022)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 324023)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	99.6	85.0	115	----
Physical Tests (QCLot: 324024)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	98.7	90.0	110	----
Physical Tests (QCLot: 324032)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	94.6	85.0	115	----
Physical Tests (QCLot: 324869)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 327598)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	99.8	85.0	115	----
Physical Tests (QCLot: 327601)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	92.7	85.0	115	----
Anions and Nutrients (QCLot: 324025)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 324026)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 324027)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	98.1	85.0	115	----
Anions and Nutrients (QCLot: 324028)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 324029)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 324030)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 324031)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	104	80.0	120	----
Anions and Nutrients (QCLot: 327015)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 327016)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.7	80.0	120	----
Anions and Nutrients (QCLot: 327017)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 327017) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.8	85.0	115	----
Total Sulfides (QCLot: 326399)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	97.6	80.0	120	----
Total Metals (QCLot: 329001)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	108	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	108	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	112	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	93.0	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	99.2	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	88.4	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	106	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	110	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	105	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	94.2	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	96.4	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	105	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	117	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	100	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	92.0	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	110	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	98.1	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	111	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	108	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 329385)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	97.1	80.0	120	----
Dissolved Metals (QCLot: 329258)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	100	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.5	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	97.7	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	105	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.3	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	100	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	98.3	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	97.5	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	93.9	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	102	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	98.5	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	99.4	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	97.6	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	94.0	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	94.7	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	89.4	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	99.2	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	105	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	96.8	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	92.8	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	105	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	92.6	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	97.0	80.0	120	----
Aggregate Organics (QCLot: 329469)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 329469) - continued									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 324025)										
KS2103405-002	Anonymous	fluoride	16984-48-8	E235.F	5.21 mg/L	5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 324026)										
KS2103405-002	Anonymous	chloride	16887-00-6	E235.Cl	497 mg/L	500 mg/L	99.5	75.0	125	----
Anions and Nutrients (QCLot: 324027)										
KS2103405-002	Anonymous	bromide	24959-67-9	E235.Br-L	2.40 mg/L	2.5 mg/L	96.2	75.0	125	----
Anions and Nutrients (QCLot: 324028)										
KS2103405-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	12.4 mg/L	12.5 mg/L	99.5	75.0	125	----
Anions and Nutrients (QCLot: 324029)										
KS2103405-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.55 mg/L	2.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 324030)										
KS2103405-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	494 mg/L	500 mg/L	98.8	75.0	125	----
Anions and Nutrients (QCLot: 324031)										
KS2103405-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0316 mg/L	0.03 mg/L	105	70.0	130	----
Anions and Nutrients (QCLot: 327015)										
KS2103435-002	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 327016)										
KS2103435-002	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	5 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 327017)										
KS2103435-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	----
Total Sulfides (QCLot: 326399)										
CG2104979-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.194 mg/L	0.2 mg/L	97.3	75.0	125	----
Total Metals (QCLot: 329001)										
YL2101540-001	Anonymous	aluminum, total	7429-90-5	E420	0.217 mg/L	0.2 mg/L	108	70.0	130	----
		antimony, total	7440-36-0	E420	0.0203 mg/L	0.02 mg/L	102	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0218 mg/L	0.02 mg/L	109	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00988 mg/L	0.01 mg/L	98.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 329001) - continued										
YL2101540-001	Anonymous	boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00404 mg/L	0.004 mg/L	101	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0422 mg/L	0.04 mg/L	106	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		copper, total	7440-50-8	E420	0.0195 mg/L	0.02 mg/L	97.5	70.0	130	----
		iron, total	7439-89-6	E420	2.07 mg/L	2 mg/L	103	70.0	130	----
		lead, total	7439-92-1	E420	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		lithium, total	7439-93-2	E420	0.0967 mg/L	0.1 mg/L	96.7	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0209 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, total	7440-02-0	E420	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.7 mg/L	10 mg/L	117	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0415 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, total	7440-21-3	E420	9.84 mg/L	10 mg/L	98.4	70.0	130	----
		silver, total	7440-22-4	E420	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00365 mg/L	0.004 mg/L	91.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		titanium, total	7440-32-6	E420	0.0433 mg/L	0.04 mg/L	108	70.0	130	----
		uranium, total	7440-61-1	E420	0.00410 mg/L	0.004 mg/L	103	70.0	130	----
		vanadium, total	7440-62-2	E420	0.111 mg/L	0.1 mg/L	111	70.0	130	----
		zinc, total	7440-66-6	E420	0.400 mg/L	0.4 mg/L	100	70.0	130	----
Total Metals (QCLot: 329385)										
CG2104995-002	Anonymous	mercury, total	7439-97-6	E508	0.0000988 mg/L	0.0001 mg/L	98.8	70.0	130	----
Dissolved Metals (QCLot: 329258)										
FJ2101136-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.206 mg/L	0.2 mg/L	103	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0198 mg/L	0.02 mg/L	99.1	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0215 mg/L	0.02 mg/L	107	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0411 mg/L	0.04 mg/L	103	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00874 mg/L	0.01 mg/L	87.4	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.088 mg/L	0.1 mg/L	88.4	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	High	Qualifier
Dissolved Metals (QCLot: 329258) - continued										
FJ2101136-002	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00415 mg/L	0.004 mg/L	104	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0414 mg/L	0.04 mg/L	103	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.87 mg/L	2 mg/L	93.6	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0410 mg/L	0.04 mg/L	102	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.3 mg/L	10 mg/L	103	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.07 mg/L	4 mg/L	102	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0400 mg/L	0.04 mg/L	99.9	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.92 mg/L	10 mg/L	89.2	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00381 mg/L	0.004 mg/L	95.3	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00372 mg/L	0.004 mg/L	93.0	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0193 mg/L	0.02 mg/L	96.6	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0396 mg/L	0.04 mg/L	99.0	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00397 mg/L	0.004 mg/L	99.3	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.395 mg/L	0.4 mg/L	98.8	70.0	130	----
Dissolved Metals (QCLot: 329390)										
FJ2101136-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000976 mg/L	0.0001 mg/L	97.6	70.0	130	----
Aggregate Organics (QCLot: 329469)										
VA21C2959-006	Anonymous	chemical oxygen demand [COD]	----	E559	109 mg/L	100 mg/L	109	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)	3093	**ALS Contact:** Dean Watt	**Sampler:** NG/RS/LF	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
1	BJ-GW12-11A-E303062	16-Oct-21	13:45	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C3093

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Nathan Glas	17-Oct-21	18:00				8.5 °C	PD	OCT 18 2021	21:20	

(JW)

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C3094**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 18-Oct-2021 21:20
PO	: 1025614	Date Analysis Commenced	: 20-Oct-2021
C-O-C number	: ----	Issue Date	: 27-Oct-2021 14:49
Sampler	: LF/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-8B-snap	BJ-GW12-8B-E314695	----
				Client sampling date / time	17-Oct-2021 10:40	17-Oct-2021 13:30	17-Oct-2021 11:20	17-Oct-2021 15:35	----
Analyte	CAS Number	Method	LOR	Unit	VA21C3094-001	VA21C3094-002	VA21C3094-003	VA21C3094-004	--------
					Result	Result	Result	Result	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	<2.0	<2.0	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	73.6	72.4	72.4	71.1	----
conductivity	----	E100	2.0	µS/cm	207	205	212	209	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	99.8	100	106	102	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	106	97.9	101	93.5	----
pH	----	E108	0.10	pH units	8.09	8.09	8.09	8.09	----
solids, total dissolved [TDS]	----	E162	10	mg/L	120	106	106	120	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	220	5.2	32.8	3.4	----
turbidity	----	E121	0.10	NTU	64.6	1.76	4.25	1.96	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	<0.50	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.031	0.026	0.022	0.022	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	<0.050	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0185	0.0157	0.0183	0.0169	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0185	0.0157	0.0183	0.0169	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.064	<0.030	<0.030	<0.030	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0934	0.0024	0.0517	0.0024	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	31.7	31.4	34.6	33.7	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	<0.0015	<0.0015	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	<0.0016	<0.0016	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	1.06	0.0585	0.186	0.0822	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00211	0.00093	0.00098	0.00083	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.104	0.0105	0.0222	0.0150	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.195	0.0237	0.0407	0.0236	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-8B-snap	BJ-GW12-8B-E314695	----
				Client sampling date / time	17-Oct-2021 10:40	17-Oct-2021 13:30	17-Oct-2021 11:20	17-Oct-2021 15:35	----
Analyte	CAS Number	Method	LOR	Unit	VA21C3094-001	VA21C3094-002	VA21C3094-003	VA21C3094-004	--------
					Result	Result	Result	Result	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	0.000107	<0.000100	<0.000100	<0.000100	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000290	0.0000147	0.0000106	<0.0000050	----
calcium, total	7440-70-2	E420	0.050	mg/L	32.8	30.6	33.0	31.0	----
chromium, total	7440-47-3	E420	0.00050	mg/L	0.00378	0.00157	0.00065	0.00182	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00257	0.00023	0.00080	0.00027	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0160	0.00126	0.00138	0.00128	----
iron, total	7439-89-6	E420	0.010	mg/L	5.77	0.091	0.475	0.084	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00805	0.000206	0.000541	0.000175	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0095	0.0081	0.0067	0.0064	----
magnesium, total	7439-95-4	E420	0.100	mg/L	5.86	5.23	4.46	3.92	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.284	0.00908	0.104	0.0227	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000116	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00126	0.00155	0.00129	0.00140	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00142	0.00114	<0.00050	0.00117	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.873	0.495	0.625	0.498	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000246	0.000177	0.000271	0.000291	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.73	2.17	2.32	2.21	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000791	0.000028	0.000031	<0.000010	----
sodium, total	17341-25-2	E420	0.050	mg/L	3.47	3.60	2.62	2.50	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.750	0.704	0.596	0.564	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000036	<0.000010	0.000013	<0.000010	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00098	<0.00010	0.00014	<0.00010	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000311	0.000170	0.000185	0.000158	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00154	<0.00050	<0.00050	<0.00050	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0420	0.0033	0.0063	<0.0030	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0012	0.0014	0.0016	0.0015	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW12-8A-snap	BJ-GW12-8A-E303059	BJ-GW12-8B-snap	BJ-GW12-8B-E314695	----
				Client sampling date / time	17-Oct-2021 10:40	17-Oct-2021 13:30	17-Oct-2021 11:20	17-Oct-2021 15:35	----
Analyte	CAS Number	Method	LOR	Unit	VA21C3094-001	VA21C3094-002	VA21C3094-003	VA21C3094-004	--------
					Result	Result	Result	Result	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00087	0.00086	0.00079	0.00078	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00877	0.00905	0.0138	0.0140	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0208	0.0211	0.0193	0.0204	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	<0.000100	<0.000100	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000112	0.0000107	<0.0000050	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	30.2	30.4	34.9	33.1	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	0.00058	<0.00050	0.00059	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00010	<0.00010	<0.00010	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00072	<0.00020	0.00100	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	<0.010	<0.010	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0086	0.0089	0.0070	0.0069	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	5.92	5.93	4.61	4.64	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	0.00041	<0.00010	0.00149	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00125	0.00144	0.00116	0.00129	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00082	<0.00050	0.00078	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	<0.300	<0.300	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.483	0.489	0.537	0.500	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000214	0.000194	0.000242	0.000281	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.00	1.94	2.06	1.94	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	3.29	3.28	2.56	2.55	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.719	0.696	0.558	0.564	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000175	0.000172	0.000170	0.000163	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW12-8A-snap**	**BJ-GW12-8A-E303059**	**BJ-GW12-8B-snap**	**BJ-GW12-8B-E314695**	**----**
				Client sampling date / time	17-Oct-2021 10:40	17-Oct-2021 13:30	17-Oct-2021 11:20	17-Oct-2021 15:35	----
Analyte	CAS Number	Method	LOR	Unit	**VA21C3094-001**	**VA21C3094-002**	**VA21C3094-003**	**VA21C3094-004**	**-------**
					Result	Result	Result	Result	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0015	0.0017	0.0014	0.0010	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	Field	Field	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	<20	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C3094**	Page	: 1 of 20
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 18-Oct-2021 21:20
PO	: 1025614	Issue Date	: 27-Oct-2021 14:49
C-O-C number	: ----		
Sampler	: LF/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Total Metals	QC-MRG3-329001001	----	magnesium, total	7439-95-4	E420	0.0070 mg/L [B]	0.005 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E559	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-snap	E559	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E559	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-snap	E559	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E298	17-Oct-2021	22-Oct-2021	----	----		22-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-snap	E298	17-Oct-2021	22-Oct-2021	----	----		22-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E298	17-Oct-2021	22-Oct-2021	----	----		22-Oct-2021	28 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-snap	E298	17-Oct-2021	22-Oct-2021	----	----		22-Oct-2021	28 days	5 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.Br-L	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-snap	E235.Br-L	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.Br-L	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-snap	E235.Br-L	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.Cl	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8A-snap	E235.Cl	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.Cl	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B-snap	E235.Cl	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW12-8A-E303059	E378-U	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW12-8A-snap	E378-U	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW12-8B-E314695	E378-U	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE BJ-GW12-8B-snap	E378-U	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW12-8A-E303059	E235.F	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW12-8A-snap	E235.F	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW12-8B-E314695	E235.F	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE BJ-GW12-8B-snap	E235.F	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE BJ-GW12-8A-E303059	E235.NO3-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-snap	E235.NO3-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.NO3-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-snap	E235.NO3-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.NO2-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-snap	E235.NO2-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.NO2-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-snap	E235.NO2-L	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.SO4	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8A-snap	E235.SO4	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.SO4	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B-snap	E235.SO4	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E366	17-Oct-2021	22-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-snap	E366	17-Oct-2021	22-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E366	17-Oct-2021	22-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-snap	E366	17-Oct-2021	22-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E372-U	17-Oct-2021	22-Oct-2021	----	----		23-Oct-2021	28 days	6 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-snap	E372-U	17-Oct-2021	22-Oct-2021	----	----		23-Oct-2021	28 days	6 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E372-U	17-Oct-2021	22-Oct-2021	----	----		23-Oct-2021	28 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-snap	E372-U	17-Oct-2021	22-Oct-2021	----	----		23-Oct-2021	28 days	6 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B-E314695	E509	17-Oct-2021	26-Oct-2021	----	----		26-Oct-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8A-E303059	E509	17-Oct-2021	26-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8A-snap	E509	17-Oct-2021	26-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B-snap	E509	17-Oct-2021	26-Oct-2021	----	----		26-Oct-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8A-snap	E421	17-Oct-2021	25-Oct-2021	----	----		26-Oct-2021	180 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B-snap	E421	17-Oct-2021	25-Oct-2021	----	----		26-Oct-2021	180 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8A-E303059	E421	17-Oct-2021	25-Oct-2021	----	----		26-Oct-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B-E314695	E421	17-Oct-2021	25-Oct-2021	----	----		26-Oct-2021	180 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8A-E303059	E283	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8A-snap	E283	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B-E314695	E283	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B-snap	E283	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8A-E303059	E290	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8A-snap	E290	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8B-E314695	E290	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8B-snap	E290	17-Oct-2021	----	----	----		20-Oct-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-8A-E303059	E100	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-8A-snap	E100	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-8B-E314695	E100	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW12-8B-snap	E100	17-Oct-2021	----	----	----		20-Oct-2021	28 days	3 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-8B-E314695	E108	17-Oct-2021	----	----	----		20-Oct-2021	0.25 hrs	72 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-8A-E303059	E108	17-Oct-2021	----	----	----		20-Oct-2021	0.25 hrs	74 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-8A-snap	E108	17-Oct-2021	----	----	----		20-Oct-2021	0.25 hrs	77 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW12-8B-snap	E108	17-Oct-2021	----	----	----		20-Oct-2021	0.25 hrs	77 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8A-E303059	E162	17-Oct-2021	----	----	----		22-Oct-2021	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B-E314695	E162	17-Oct-2021	----	----	----		22-Oct-2021	7 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8A-snap	E162	17-Oct-2021	----	----	----		22-Oct-2021	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B-snap	E162	17-Oct-2021	----	----	----		22-Oct-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8A-E303059	E160-H	17-Oct-2021	----	----	----		22-Oct-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B-E314695	E160-H	17-Oct-2021	----	----	----		22-Oct-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8A-snap	E160-H	17-Oct-2021	----	----	----		22-Oct-2021	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B-snap	E160-H	17-Oct-2021	----	----	----		22-Oct-2021	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8A-E303059	E121	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8A-snap	E121	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B-E314695	E121	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B-snap	E121	17-Oct-2021	----	----	----		20-Oct-2021	3 days	3 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8A-E303059	E508	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8A-snap	E508	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B-E314695	E508	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW12-8B-snap	E508	17-Oct-2021	----	----	----		26-Oct-2021	28 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8A-E303059	E420	17-Oct-2021	----	----	----		25-Oct-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B-E314695	E420	17-Oct-2021	----	----	----		25-Oct-2021	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8A-snap	E420	17-Oct-2021	----	----	----		25-Oct-2021	180 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW12-8B-snap	E420	17-Oct-2021	----	----	----		25-Oct-2021	180 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8A-E303059	E395	17-Oct-2021	----	----	----		21-Oct-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8A-snap	E395	17-Oct-2021	----	----	----		21-Oct-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B-E314695	E395	17-Oct-2021	----	----	----		21-Oct-2021	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW12-8B-snap	E395	17-Oct-2021	----	----	----		21-Oct-2021	7 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	324161	1	14	7.1	5.0	✓
Alkalinity Species by Titration	E290	324154	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324160	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	2	27	7.4	5.0	✓
Chloride in Water by IC	E235.Cl	324156	1	19	5.2	5.0	✓
Conductivity in Water	E100	324153	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324163	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	324159	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324157	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324158	1	18	5.5	5.0	✓
pH by Meter	E108	324152	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	324155	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	327598	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	327601	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	324827	2	40	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	324161	1	14	7.1	5.0	✓
Alkalinity Species by Titration	E290	324154	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324160	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	2	27	7.4	5.0	✓
Chloride in Water by IC	E235.Cl	324156	1	19	5.2	5.0	✓
Conductivity in Water	E100	324153	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324163	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	324159	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324157	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324158	1	18	5.5	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	324152	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	324155	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	327598	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	327601	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	324827	2	40	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	324161	1	14	7.1	5.0	✓
Alkalinity Species by Titration	E290	324154	1	18	5.5	5.0	✓
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324160	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	2	27	7.4	5.0	✓
Chloride in Water by IC	E235.Cl	324156	1	19	5.2	5.0	✓
Conductivity in Water	E100	324153	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324163	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	324159	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324157	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324158	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	324155	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	327598	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓
TSS by Gravimetry	E160-H	327601	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	324827	2	40	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	327017	1	20	5.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	324160	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	329469	2	27	7.4	5.0	✓
Chloride in Water by IC	E235.Cl	324156	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	329390	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	329258	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	324163	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	324159	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	324157	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	324158	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	324155	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	329385	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	329001	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	327015	1	20	5.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	327016	1	20	5.0	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	326399	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculaton)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C3094**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 18-Oct-2021 21:20
PO	: 1025614	Date Analysis Commenced	: 20-Oct-2021
C-O-C number	: ----	Issue Date	: 27-Oct-2021 14:49
Sampler	: LF/BM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 4		
No. of samples analysed	: 4		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 324152)											
KS2103409-001	Anonymous	pH	----	E108	0.10	pH units	7.31	7.33	0.178%	4%	----
Physical Tests (QC Lot: 324153)											
KS2103409-001	Anonymous	conductivity	----	E100	2.0	µS/cm	61.9	62.3	0.644%	10%	----
Physical Tests (QC Lot: 324154)											
KS2103409-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	16.7	16.2	3.04%	20%	----
Physical Tests (QC Lot: 324161)											
VA21C3073-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 324827)											
KS2102914-001	Anonymous	turbidity	----	E121	0.10	NTU	58.0	58.8	1.34%	15%	----
Physical Tests (QC Lot: 324869)											
KS2103409-001	Anonymous	turbidity	----	E121	0.10	NTU	0.15	0.15	0.001	Diff <2x LOR	----
Physical Tests (QC Lot: 327598)											
VA21C3092-002	Anonymous	solids, total dissolved [TDS]	----	E162	10	mg/L	26	27	1	Diff <2x LOR	----
Physical Tests (QC Lot: 327601)											
VA21C3029-006	Anonymous	solids, total suspended [TSS]	----	E160-H	15.0	mg/L	3320	3410	2.64%	20%	----
Anions and Nutrients (QC Lot: 324155)											
KS2103416-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	3.00	mg/L	475	475	0.0298%	20%	----
Anions and Nutrients (QC Lot: 324156)											
KS2103416-001	Anonymous	chloride	16887-00-6	E235.Cl	5.00	mg/L	174	175	0.156%	20%	----
Anions and Nutrients (QC Lot: 324157)											
KS2103416-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0500	mg/L	<0.0500	<0.0500	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324158)											
KS2103416-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324159)											
KS2103416-001	Anonymous	fluoride	16984-48-8	E235.F	0.200	mg/L	0.328	0.324	0.004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324160)											
KS2103416-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.500	mg/L	<0.500	<0.500	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 324163)											
VA21C3073-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0012	<0.0010	0.0002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 327015)											
KS2103435-001	Anonymous	nitrogen, total	7727-37-9	E366	1.50	mg/L	42.3	43.0	1.70%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 327016)											
KS2103435-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	6.68	6.70	0.354%	20%	----
Anions and Nutrients (QC Lot: 327017)											
KS2103435-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.500	mg/L	38.7	38.2	1.28%	20%	----
Total Sulfides (QC Lot: 326399)											
CG2104979-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.0056	0.0052	0.0004	Diff <2x LOR	----
Total Metals (QC Lot: 329001)											
YL2101539-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.233	0.252	7.49%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00043	0.00042	0.00001	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.225	0.232	3.19%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000027	0.000029	0.000002	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.916	0.960	4.71%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.000340	0.000357	4.76%	20%	----
		calcium, total	7440-70-2	E420	0.050	mg/L	106	113	6.84%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.0109	0.0111	1.32%	20%	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00247	0.00243	0.00004	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.408	0.424	3.92%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000100	0.000101	0.0000008	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0112	0.0116	4.03%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	36.6	36.5	0.267%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.854	0.856	0.256%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00457	0.00463	1.41%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.0404	0.0406	0.519%	20%	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	25.4	25.7	1.14%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000133	0.000133	0.0000004	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	5.87	5.90	0.503%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	70.4	70.2	0.217%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.12	1.10	2.11%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000092	0.000087	0.000005	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.00952	0.00930	2.36%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 329001) - continued											
YL2101539-001	Anonymous	uranium, total	7440-61-1	E420	0.000010	mg/L	0.00105	0.00104	1.12%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00074	0.00076	0.00003	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0432	0.0427	1.24%	20%	----
Total Metals (QC Lot: 329385)											
CG2104995-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 329258)											
YL2101552-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0142	0.0138	2.78%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00012	0.00012	0.000003	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00015	0.00017	0.00002	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0230	0.0232	0.908%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.346	0.348	0.793%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000122	0.0000089	0.0000033	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	57.1	58.8	2.90%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00074	0.00075	0.000005	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00269	0.00276	2.50%	20%	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.016	0.016	0.0003	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0042	0.0041	0.0001	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	27.5	27.0	1.92%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0253	0.0247	2.48%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.0182	0.0187	2.71%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.0180	0.0180	0.475%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	6.38	6.37	0.116%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000189	0.000275	0.000085	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	4.36	4.43	1.60%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	16.8	17.0	1.16%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.349	0.360	3.13%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000011	0.000010	0.0000007	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 329258) - continued											
YL2101552-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00228	0.00224	1.91%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0020	0.0019	0.00009	Diff <2x LOR	----
Dissolved Metals (QC Lot: 329390)											
FJ2101136-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 329469)											
VA21C2959-005	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	74	74	0.5	Diff <2x LOR	----
Aggregate Organics (QC Lot: 329470)											
VA21C3094-003	BJ-GW12-8B-snap	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 324153)						
conductivity	----	E100	1	µS/cm	1.0	----
Physical Tests (QCLot: 324154)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 324161)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 324827)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 324869)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 327598)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 327601)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 324155)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 324156)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 324157)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 324158)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 324159)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 324160)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 324163)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 327015)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 327016)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 327017)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 326399)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 329001)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	# 0.0070	B
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 329385)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 329258)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 329390)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 329469)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 329470)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 324152)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 324153)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.6	90.0	110	----
Physical Tests (QCLot: 324154)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 324161)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	96.2	85.0	115	----
Physical Tests (QCLot: 324827)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 324869)									
turbidity	----	E121	0.1	NTU	200 NTU	101	85.0	115	----
Physical Tests (QCLot: 327598)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	99.8	85.0	115	----
Physical Tests (QCLot: 327601)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	92.7	85.0	115	----
Anions and Nutrients (QCLot: 324155)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 324156)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 324157)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	99.5	90.0	110	----
Anions and Nutrients (QCLot: 324158)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 324159)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 324160)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 324163)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	102	80.0	120	----
Anions and Nutrients (QCLot: 327015)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 327016)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 327016) - continued									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.7	80.0	120	----
Anions and Nutrients (QCLot: 327017)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.8	85.0	115	----
Total Sulfides (QCLot: 326399)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	97.6	80.0	120	----
Total Metals (QCLot: 329001)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	108	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	108	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	112	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	93.0	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	99.2	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	88.4	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	106	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	104	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	110	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	105	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	94.2	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	96.4	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	105	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	105	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	117	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	100	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	92.0	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	110	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	98.1	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	111	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Total Metals (QCLot: 329001) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	108	80.0	120	----
Total Metals (QCLot: 329385)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	97.1	80.0	120	----
Dissolved Metals (QCLot: 329258)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	100	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	99.5	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	97.7	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	105	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	98.3	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	100	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	98.3	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	97.5	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	93.9	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	102	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	98.5	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	99.4	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	97.6	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	94.0	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	94.7	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	89.4	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	99.2	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	105	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	96.8	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	92.8	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	105	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 329258) - continued									
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	92.6	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	97.0	80.0	120	----
Aggregate Organics (QCLot: 329469)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----
Aggregate Organics (QCLot: 329470)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	106	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 324155)										
VA21C3073-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	ND mg/L	100 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 324156)										
VA21C3073-001	Anonymous	chloride	16887-00-6	E235.Cl	103 mg/L	100 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 324157)										
VA21C3073-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.57 mg/L	2.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 324158)										
VA21C3073-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.528 mg/L	0.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 324159)										
VA21C3073-001	Anonymous	fluoride	16984-48-8	E235.F	1.07 mg/L	1 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 324160)										
VA21C3073-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.525 mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 324163)										
VA21C3073-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0324 mg/L	0.03 mg/L	108	70.0	130	----
Anions and Nutrients (QCLot: 327015)										
KS2103435-002	Anonymous	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 327016)										
KS2103435-002	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	5 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 327017)										
KS2103435-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	----
Total Sulfides (QCLot: 326399)										
CG2104979-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.194 mg/L	0.2 mg/L	97.3	75.0	125	----
Total Metals (QCLot: 329001)										
YL2101540-001	Anonymous	aluminum, total	7429-90-5	E420	0.217 mg/L	0.2 mg/L	108	70.0	130	----
		antimony, total	7440-36-0	E420	0.0203 mg/L	0.02 mg/L	102	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0218 mg/L	0.02 mg/L	109	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00988 mg/L	0.01 mg/L	98.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 329001) - continued										
YL2101540-001	Anonymous	boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00404 mg/L	0.004 mg/L	101	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0422 mg/L	0.04 mg/L	106	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		copper, total	7440-50-8	E420	0.0195 mg/L	0.02 mg/L	97.5	70.0	130	----
		iron, total	7439-89-6	E420	2.07 mg/L	2 mg/L	103	70.0	130	----
		lead, total	7439-92-1	E420	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		lithium, total	7439-93-2	E420	0.0967 mg/L	0.1 mg/L	96.7	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0209 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, total	7440-02-0	E420	0.0399 mg/L	0.04 mg/L	99.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.7 mg/L	10 mg/L	117	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0415 mg/L	0.04 mg/L	104	70.0	130	----
		silicon, total	7440-21-3	E420	9.84 mg/L	10 mg/L	98.4	70.0	130	----
		silver, total	7440-22-4	E420	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00365 mg/L	0.004 mg/L	91.2	70.0	130	----
		tin, total	7440-31-5	E420	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		titanium, total	7440-32-6	E420	0.0433 mg/L	0.04 mg/L	108	70.0	130	----
		uranium, total	7440-61-1	E420	0.00410 mg/L	0.004 mg/L	103	70.0	130	----
		vanadium, total	7440-62-2	E420	0.111 mg/L	0.1 mg/L	111	70.0	130	----
		zinc, total	7440-66-6	E420	0.400 mg/L	0.4 mg/L	100	70.0	130	----
Total Metals (QCLot: 329385)										
CG2104995-002	Anonymous	mercury, total	7439-97-6	E508	0.0000988 mg/L	0.0001 mg/L	98.8	70.0	130	----
Dissolved Metals (QCLot: 329258)										
FJ2101136-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.206 mg/L	0.2 mg/L	103	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0198 mg/L	0.02 mg/L	99.1	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0215 mg/L	0.02 mg/L	107	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0411 mg/L	0.04 mg/L	103	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00874 mg/L	0.01 mg/L	87.4	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.088 mg/L	0.1 mg/L	88.4	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 329258) - continued										
FJ2101136-002	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00415 mg/L	0.004 mg/L	104	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0414 mg/L	0.04 mg/L	103	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.87 mg/L	2 mg/L	93.6	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0192 mg/L	0.02 mg/L	95.9	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.106 mg/L	0.1 mg/L	106	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0201 mg/L	0.02 mg/L	100	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0194 mg/L	0.02 mg/L	97.2	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0410 mg/L	0.04 mg/L	102	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.3 mg/L	10 mg/L	103	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.07 mg/L	4 mg/L	102	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0400 mg/L	0.04 mg/L	99.9	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.92 mg/L	10 mg/L	89.2	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00381 mg/L	0.004 mg/L	95.3	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00372 mg/L	0.004 mg/L	93.0	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0193 mg/L	0.02 mg/L	96.6	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0396 mg/L	0.04 mg/L	99.0	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00397 mg/L	0.004 mg/L	99.3	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.395 mg/L	0.4 mg/L	98.8	70.0	130	----
Dissolved Metals (QCLot: 329390)										
FJ2101136-004	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000976 mg/L	0.0001 mg/L	97.6	70.0	130	----
Aggregate Organics (QCLot: 329469)										
VA21C2959-006	Anonymous	chemical oxygen demand [COD]	----	E559	109 mg/L	100 mg/L	109	75.0	125	----
Aggregate Organics (QCLot: 329470)										
VA21C3094-004	BJ-GW12-8B-E314695	chemical oxygen demand [COD]	----	E559	119 mg/L	100 mg/L	119	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)	3094	**ALS Contact:** Dean Watt	**Sampler:** LF/BM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
1	BJ-GW12-8A-snap	17-Oct-21	10:40	Groundwater	X	X		X	X			X	X	X	X		7
2	BJ-GW12-8A-E303059	17-Oct-21	13:30	Groundwater	X	X		X	X			X	X	X	X		7
3	BJ-GW12-8B-snap	17-Oct-21	11:20	Groundwater	X	X		X	X			X	X	X	X		7
4	BJ-GW12-8B-E314695	17-Oct-21	15:35	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C3094

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Laura Fredrickson	17-Oct-21	18:00				8.5 °C	PD	OCT 18 2021	21:20	

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C4383**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 01-Nov-2021 21:15
PO	: 1025614	Date Analysis Commenced	: 02-Nov-2021
C-O-C number	: ----	Issue Date	: 15-Nov-2021 17:34
Sampler	: R S		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Courtney Cox	Analsyt	Inorganics, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW11-1A - E303054	----	----	----	----
				Client sampling date / time	31-Oct-2021 13:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C4383-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.3	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	41.1	----	----	----	----
conductivity	----	E100	2.0	µS/cm	129	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	58.2	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	55.4	----	----	----	----
pH	----	E108	0.10	pH units	7.68	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	94	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	52.8	----	----	----	----
turbidity	----	E121	0.10	NTU	59.4	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0204	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.028	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.198	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0585	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0585	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.256	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0271	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	22.4	----	----	----	----
Organic / Inorganic Carbon									
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	17.4	----	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	1.00	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00717	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW11-1A - E303054	----	----	----	----
					Client sampling date / time	31-Oct-2021 13:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C4383-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
arsenic, total	7440-38-2	E420	0.00010	mg/L		0.0248	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L		0.0778	----	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L		0.000091	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L		<0.010	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L		0.000227	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L		19.2	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L		0.0161	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00181	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.0129	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L		1.98	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L		0.00615	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L		0.0029	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		1.80	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.371	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L		0.0000122	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.000920	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L		0.00547	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L		<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L		0.921	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L		0.000254	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L		2.35	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L		0.000698	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L		2.00	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L		0.146	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L		0.000043	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L		0.00494	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L		0.0124	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000061	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00171	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L		0.0591	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW11-1A - E303054	----	----	----	----
					Client sampling date / time	31-Oct-2021 13:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C4383-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0572	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00307	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00426	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0208	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		<0.010	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		0.0000308	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		20.9	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		0.00139	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		0.00257	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		0.048	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		0.000195	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0024	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		1.46	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.00586	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.000612	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		0.00092	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		0.512	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		0.000208	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		1.16	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		0.000044	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		1.59	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		0.152	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		<0.000010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		0.00049	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000027	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW11-1A - E303054	----	----	----	----
					Client sampling date / time	31-Oct-2021 13:00	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C4383-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L		0.0078	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-		Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-		Field	----	----	----	----
Aggregate Organics										
chemical oxygen demand [COD]	----	E559	20	mg/L		98	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C4383**	Page	: 1 of 11
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 01-Nov-2021 21:15
PO	: 1025614	Issue Date	: 15-Nov-2021 17:34
C-O-C number	: ----		
Sampler	: R S		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E559	31-Oct-2021	----	----	----		09-Nov-2021	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E298	31-Oct-2021	09-Nov-2021	----	----		10-Nov-2021	28 days	10 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A - E303054	E235.Br-L	31-Oct-2021	----	----	----		02-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-1A - E303054	E235.Cl	31-Oct-2021	----	----	----		02-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-1A - E303054	E378-U	31-Oct-2021	----	----	----		02-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-1A - E303054	E235.F	31-Oct-2021	----	----	----		02-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A - E303054	E235.NO3-L	31-Oct-2021	----	----	----		02-Nov-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A - E303054	E235.NO2-L	31-Oct-2021	----	----	----		02-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-1A - E303054	E235.SO4	31-Oct-2021	----	----	----		02-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E366	31-Oct-2021	09-Nov-2021	----	----		10-Nov-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E372-U	31-Oct-2021	09-Nov-2021	----	----		12-Nov-2021	28 days	11 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-1A - E303054	E509	31-Oct-2021	08-Nov-2021	----	----		08-Nov-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-1A - E303054	E421	31-Oct-2021	06-Nov-2021	----	----		06-Nov-2021	180 days	6 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW11-1A - E303054	E355-L	31-Oct-2021	09-Nov-2021	----	----		09-Nov-2021	28 days	9 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-1A - E303054	E283	31-Oct-2021	----	----	----		03-Nov-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-1A - E303054	E290	31-Oct-2021	----	----	----		02-Nov-2021	14 days	2 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE BJ-GW11-1A - E303054	E100	31-Oct-2021	----	----	----		02-Nov-2021	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW11-1A - E303054	E108	31-Oct-2021	----	----	----		02-Nov-2021	0.25 hrs	51 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-1A - E303054	E162	31-Oct-2021	----	----	----		05-Nov-2021	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-1A - E303054	E160-H	31-Oct-2021	----	----	----		05-Nov-2021	7 days	5 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-1A - E303054	E121	31-Oct-2021	----	----	----		02-Nov-2021	3 days	2 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW11-1A - E303054	E508	31-Oct-2021	----	----	----		10-Nov-2021	28 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW11-1A - E303054	E420	31-Oct-2021	----	----	----		12-Nov-2021	180 days	12 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW11-1A - E303054	E395	31-Oct-2021	----	----	----		02-Nov-2021	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	335599	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	335598	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	341774	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	335594	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	341605	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	335590	1	20	5.0	5.0	✓
Conductivity in Water	E100	335597	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	340658	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	339593	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	335601	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	335593	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	335595	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	335591	1	20	5.0	5.0	✓
pH by Meter	E108	335596	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	335589	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	338797	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	342666	1	17	5.8	5.0	✓
Total Metals in Water by CRC ICPMS	E420	342848	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	341775	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	341777	1	7	14.2	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	341776	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	335942	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	338789	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	335776	1	19	5.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	335599	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	335598	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	341774	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	335594	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	341605	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	335590	1	20	5.0	5.0	✓
Conductivity in Water	E100	335597	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	340658	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	339593	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	335601	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	335593	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	335595	1	13	7.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	335591	1	20	5.0	5.0	✓
pH by Meter	E108	335596	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	335589	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	338797	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	342666	1	17	5.8	5.0	✓
Total Metals in Water by CRC ICPMS	E420	342848	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	341775	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	341777	1	7	14.2	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	341776	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	335942	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	338789	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	335776	1	19	5.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	335599	1	9	11.1	5.0	✓
Alkalinity Species by Titration	E290	335598	1	20	5.0	5.0	✓
Ammonia by Fluorescence	E298	341774	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	335594	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	341605	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	335590	1	20	5.0	5.0	✓
Conductivity in Water	E100	335597	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	340658	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	339593	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	335601	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	335593	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	335595	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	335591	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	335589	1	20	5.0	5.0	✓
TDS by Gravimetry	E162	338797	1	15	6.6	5.0	✓
Total Mercury in Water by CVAAS	E508	342666	1	17	5.8	5.0	✓
Total Metals in Water by CRC ICPMS	E420	342848	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	341775	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	341777	1	7	14.2	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	341776	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	335942	1	11	9.0	5.0	✓
TSS by Gravimetry	E160-H	338789	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	335776	1	19	5.2	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	341774	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	335594	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	341605	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Chloride in Water by IC	E235.Cl	335590	1	20	5.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	340658	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	339593	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	335601	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	335593	1	20	5.0	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	335595	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	335591	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	335589	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	342666	1	17	5.8	5.0	✓
Total Metals in Water by CRC ICPMS	E420	342848	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	341775	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	341777	1	7	14.2	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	341776	1	9	11.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	335942	1	11	9.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H_2S concentration based on the total sulfide concentration in the sample. The H_2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C4383**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 01-Nov-2021 21:15
PO	: 1025614	Date Analysis Commenced	: 02-Nov-2021
C-O-C number	: ----	Issue Date	: 15-Nov-2021 17:33
Sampler	: R S		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Courtney Cox	Analsyt	Inorganics, Burnaby, British Columbia
Jay Jang	Lab Assistant	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 335596)											
FJ2101222-001	Anonymous	pH	----	E108	0.10	pH units	8.71	8.72	0.115%	4%	----
Physical Tests (QC Lot: 335597)											
FJ2101222-001	Anonymous	conductivity	----	E100	2.0	µS/cm	2170	2170	0.00%	10%	----
Physical Tests (QC Lot: 335598)											
FJ2101222-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	944	946	0.201%	20%	----
Physical Tests (QC Lot: 335599)											
VA21C4380-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 335776)											
VA21C4362-001	Anonymous	turbidity	----	E121	0.10	NTU	0.74	0.75	0.01	Diff <2x LOR	----
Physical Tests (QC Lot: 338789)											
VA21C4451-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	25.6	23.6	2.0	Diff <2x LOR	----
Physical Tests (QC Lot: 338797)											
VA21C4451-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	276	275	0.363%	20%	----
Anions and Nutrients (QC Lot: 335589)											
FJ2101220-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	3.00	mg/L	143	143	0.340%	20%	----
Anions and Nutrients (QC Lot: 335590)											
FJ2101220-001	Anonymous	chloride	16887-00-6	E235.Cl	5.00	mg/L	<5.00	<5.00	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 335591)											
FJ2101220-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 335593)											
FJ2101220-001	Anonymous	fluoride	16984-48-8	E235.F	0.200	mg/L	0.762	0.709	0.052	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 335594)											
VA21C4371-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	0.074	0.080	0.007	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 335595)											
VA21C4371-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0496	0.0502	0.0006	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 335601)											
VA21C4380-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 341774)											
KS2103652-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.100	mg/L	13.7	13.8	0.746%	20%	----
Anions and Nutrients (QC Lot: 341775)											
VA21C4383-001	BJ-GW11-1A - E303054	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.256	0.253	0.003	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 341776)											
KS2103652-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	2.47	2.28	7.78%	20%	----
Organic / Inorganic Carbon (QC Lot: 341777)											
VA21C4139-001	Anonymous	carbon, total organic [TOC]	----	E355-L	0.50	mg/L	2.96	3.22	0.26	Diff <2x LOR	----
Total Sulfides (QC Lot: 335942)											
VA21C4338-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 342666)											
KS2103592-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 342848)											
VA21C4172-001	Anonymous	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.130	0.146	10.8%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00080	0.00081	0.000006	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00150	0.00149	0.189%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0421	0.0401	4.86%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.100	0.105	5.56%	20%	----
		cadmium, total	7440-43-9	E420	0.000160	mg/L	<0.000160	<0.000160	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	126	126	0.199%	20%	----
		chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00023	0.00023	0.000005	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.0299	0.0306	2.23%	20%	----
		iron, total	7439-89-6	E420	0.030	mg/L	0.102	0.110	0.009	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0064	0.0063	0.0001	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	21.6	22.1	2.43%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.0304	0.0307	1.11%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.171	0.172	0.400%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00088	0.00086	0.00002	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	4.84	4.94	2.05%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.0374	0.0362	3.23%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	5.24	5.10	2.61%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	34.3	34.6	0.598%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.31	1.29	1.84%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 342848) - continued											
VA21C4172-001	Anonymous	tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00198	0.00200	1.19%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00200	0.00194	0.00006	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 339593)											
KS2103595-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0050	mg/L	0.0056	<0.0050	0.0006	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00050	mg/L	0.00106	0.00104	0.00002	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00050	mg/L	0.00630	0.00643	2.14%	20%	----
		barium, dissolved	7440-39-3	E421	0.00050	mg/L	0.0154	0.0156	1.60%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.050	mg/L	0.495	0.516	4.18%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000600	mg/L	<0.0000600	<0.0000600	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.250	mg/L	133	140	5.14%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00100	mg/L	0.0440	0.0441	0.210%	20%	----
		iron, dissolved	7439-89-6	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0050	mg/L	0.0120	0.0124	0.0004	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0250	mg/L	272	278	2.14%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00050	mg/L	0.00058	<0.00050	0.00008	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000250	mg/L	0.144	0.144	0.358%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.250	mg/L	16.2	16.8	3.59%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000250	mg/L	0.114	0.115	0.475%	20%	----
		silicon, dissolved	7440-21-3	E421	0.250	mg/L	4.96	5.10	2.68%	20%	----
		silver, dissolved	7440-22-4	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.250	mg/L	740	748	1.07%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00100	mg/L	4.19	4.18	0.228%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00150	mg/L	<0.00150	<0.00150	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 339593) - continued											
KS2103595-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000050	mg/L	0.00532	0.00528	0.796%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00250	mg/L	0.00280	0.00267	0.00013	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 340658)											
CG2105467-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 341605)											
VA21C4129-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	35	42	7	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 335597)						
conductivity	----	E100	1	µS/cm	1.0	----
Physical Tests (QCLot: 335598)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 335599)						
acidity (as CaCO3)	----	E283	2	mg/L	2.8	----
Physical Tests (QCLot: 335776)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 338789)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 338797)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 335589)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 335590)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 335591)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 335593)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 335594)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 335595)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 335601)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 341774)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 341775)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 341776)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Organic / Inorganic Carbon (QCLot: 341777)						
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	<0.50	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 335942)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 342666)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 342848)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 339593)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 340658)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 341605)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 335596)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 335597)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 335598)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 335599)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	96.8	85.0	115	----
Physical Tests (QCLot: 335776)									
turbidity	----	E121	0.1	NTU	200 NTU	104	85.0	115	----
Physical Tests (QCLot: 338789)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	101	85.0	115	----
Physical Tests (QCLot: 338797)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	99.2	85.0	115	----
Anions and Nutrients (QCLot: 335589)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 335590)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 335591)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 335593)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	97.0	90.0	110	----
Anions and Nutrients (QCLot: 335594)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 335595)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 335601)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	101	80.0	120	----
Anions and Nutrients (QCLot: 341774)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	98.5	85.0	115	----
Anions and Nutrients (QCLot: 341775)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	98.8	75.0	125	----
Anions and Nutrients (QCLot: 341776)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 341776) - continued									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	94.0	80.0	120	----
Organic / Inorganic Carbon (QCLot: 341777)									
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	8.57 mg/L	105	80.0	120	----
Total Sulfides (QCLot: 335942)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	100	80.0	120	----
Total Metals (QCLot: 342666)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	96.2	80.0	120	----
Total Metals (QCLot: 342848)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	104	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	98.6	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	101	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	98.3	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	91.4	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	96.5	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	100	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	102	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	98.9	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	100.0	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	106	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	95.8	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	95.7	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	99.4	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	99.2	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	98.5	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	103	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	100	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	105	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	92.0	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	93.0	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	93.3	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 342848) - continued									
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	97.9	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	93.3	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	111	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	99.8	80.0	120	----
Dissolved Metals (QCLot: 339593)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	99.4	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	96.0	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	97.0	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	106	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	96.2	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	99.4	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.7	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	101	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	94.8	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	97.1	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	95.9	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	96.9	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	95.6	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	104	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	101	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	96.6	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	93.8	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	98.1	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	100	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	94.7	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	96.5	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	88.8	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	96.8	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	99.6	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	96.9	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	90.6	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	95.5	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	96.6	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Dissolved Metals (QCLot: 339593) - continued									
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	100	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	90.4	80.0	120	----
Aggregate Organics (QCLot: 341605)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	109	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 335589)										
FJ2101221-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	532 mg/L	500 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 335590)										
FJ2101221-001	Anonymous	chloride	16887-00-6	E235.Cl	513 mg/L	500 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 335591)										
FJ2101221-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.47 mg/L	2.5 mg/L	98.8	75.0	125	----
Anions and Nutrients (QCLot: 335593)										
FJ2101221-001	Anonymous	fluoride	16984-48-8	E235.F	4.95 mg/L	5 mg/L	99.0	75.0	125	----
Anions and Nutrients (QCLot: 335594)										
VA21C4371-002	Anonymous	bromide	24959-67-9	E235.Br-L	2.59 mg/L	2.5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 335595)										
VA21C4371-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	12.9 mg/L	12.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 335601)										
VA21C4380-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	ND mg/L	0.03 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 341774)										
VA21C4383-001	BJ-GW11-1A - E303054	ammonia, total (as N)	7664-41-7	E298	0.103 mg/L	0.1 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 341775)										
VA21C4438-001	Anonymous	nitrogen, total	7727-37-9	E366	0.400 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 341776)										
VA21C4383-001	BJ-GW11-1A - E303054	phosphorus, total	7723-14-0	E372-U	0.0543 mg/L	0.05 mg/L	108	70.0	130	----
Organic / Inorganic Carbon (QCLot: 341777)										
VA21C4139-002	Anonymous	carbon, total organic [TOC]	----	E355-L	4.94 mg/L	5 mg/L	98.8	70.0	130	----
Total Sulfides (QCLot: 335942)										
VA21C4338-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.124 mg/L	0.1 mg/L	124	75.0	125	----
Total Metals (QCLot: 342666)										
VA21C4362-001	Anonymous	mercury, total	7439-97-6	E508	0.0000970 mg/L	0.0001 mg/L	97.0	70.0	130	----
Total Metals (QCLot: 342848)										
VA21C4172-002	Anonymous	aluminum, total	7429-90-5	E420	0.231 mg/L	0.2 mg/L	116	70.0	130	----
		antimony, total	7440-36-0	E420	0.0197 mg/L	0.02 mg/L	98.5	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 342848) - continued										
VA21C4172-002	Anonymous	arsenic, total	7440-38-2	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0377 mg/L	0.04 mg/L	94.3	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00916 mg/L	0.01 mg/L	91.6	70.0	130	----
		boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00387 mg/L	0.004 mg/L	96.8	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0423 mg/L	0.04 mg/L	106	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0200 mg/L	0.02 mg/L	99.8	70.0	130	----
		copper, total	7440-50-8	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		iron, total	7439-89-6	E420	1.98 mg/L	2 mg/L	99.2	70.0	130	----
		lead, total	7439-92-1	E420	0.0177 mg/L	0.02 mg/L	88.5	70.0	130	----
		lithium, total	7439-93-2	E420	0.0901 mg/L	0.1 mg/L	90.1	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		nickel, total	7440-02-0	E420	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.3 mg/L	10 mg/L	103	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0398 mg/L	0.04 mg/L	99.6	70.0	130	----
		silicon, total	7440-21-3	E420	9.60 mg/L	10 mg/L	96.0	70.0	130	----
		silver, total	7440-22-4	E420	0.00368 mg/L	0.004 mg/L	92.1	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00352 mg/L	0.004 mg/L	87.9	70.0	130	----
		tin, total	7440-31-5	E420	0.0194 mg/L	0.02 mg/L	97.0	70.0	130	----
		titanium, total	7440-32-6	E420	0.0430 mg/L	0.04 mg/L	108	70.0	130	----
		uranium, total	7440-61-1	E420	0.00405 mg/L	0.004 mg/L	101	70.0	130	----
		vanadium, total	7440-62-2	E420	0.107 mg/L	0.1 mg/L	107	70.0	130	----
		zinc, total	7440-66-6	E420	0.380 mg/L	0.4 mg/L	95.0	70.0	130	----
Dissolved Metals (QCLot: 339593)										
KS2103595-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.946 mg/L	1 mg/L	94.6	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0989 mg/L	0.1 mg/L	98.9	70.0	130	----
		barium, dissolved	7440-39-3	E421	0.0981 mg/L	0.1 mg/L	98.1	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.192 mg/L	0.2 mg/L	95.8	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 339593) - continued										
KS2103595-002	Anonymous	bismuth, dissolved	7440-69-9	E421	0.0441 mg/L	0.05 mg/L	88.2	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.0191 mg/L	0.02 mg/L	95.4	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.192 mg/L	0.2 mg/L	96.1	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0962 mg/L	0.1 mg/L	96.2	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0919 mg/L	0.1 mg/L	91.9	70.0	130	----
		iron, dissolved	7439-89-6	E421	9.74 mg/L	10 mg/L	97.4	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0888 mg/L	0.1 mg/L	88.8	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.470 mg/L	0.5 mg/L	93.9	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0958 mg/L	0.1 mg/L	95.8	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.105 mg/L	0.1 mg/L	105	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.181 mg/L	0.2 mg/L	90.5	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	51.1 mg/L	50 mg/L	102	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		silicon, dissolved	7440-21-3	E421	48.1 mg/L	50 mg/L	96.3	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.0184 mg/L	0.02 mg/L	91.8	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.0179 mg/L	0.02 mg/L	89.5	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0984 mg/L	0.1 mg/L	98.4	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.191 mg/L	0.2 mg/L	95.6	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.493 mg/L	0.5 mg/L	98.7	70.0	130	----
		zinc, dissolved	7440-66-6	E421	1.92 mg/L	2 mg/L	95.8	70.0	130	----
Dissolved Metals (QCLot: 340658)										
CG2105467-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000915 mg/L	0.0001 mg/L	91.5	70.0	130	----
Aggregate Organics (QCLot: 341605)										
VA21C4129-002	Anonymous	chemical oxygen demand [COD]	----	E559	110 mg/L	100 mg/L	110	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: RS	

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-1A - E303054	31-Oct-21	13:00	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C4383
Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Richelle Sussbauer	31-Oct-21	18:00	CC	NOV 01 2021	915	15 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C5014**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 08-Nov-2021 21:00
PO	: 1025614	Date Analysis Commenced	: 09-Nov-2021
C-O-C number	: ----	Issue Date	: 18-Nov-2021 18:20
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	**BJ-GW 18-18B -E314702**	----	----	----	----
				Client sampling date / time	07-Nov-2021 12:30	----	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C5014-001**	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	----	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	107	----	----	----	----
conductivity	----	E100	2.0	µS/cm	577	----	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	168	----	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	170	----	----	----	----
pH	----	E108	0.10	pH units	8.11	----	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	300	----	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	13.8	----	----	----	----
turbidity	----	E121	0.10	NTU	0.30	----	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.126	----	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	----	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	8.80	----	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.107	----	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.130	----	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	----	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	----	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	----	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.130	----	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0023	----	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0161	----	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	168	----	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	----	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.429	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00024	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00205	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0310	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW 18-18B -E314702	----	----	----	----
					Client sampling date / time	07-Nov-2021 12:30	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C5014-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
beryllium, total	7440-41-7	E420	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L		<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L		0.031	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L		<0.0000050	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L		52.9	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L		0.00611	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L		0.00032	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L		0.00069	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L		0.454	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L		0.000271	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L		0.0916	----	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L		9.34	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L		0.0476	----	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L		0.00121	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L		0.00389	----	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L		<0.300	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L		3.48	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L		<0.000050	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L		3.99	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L		0.000138	----	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L		46.0	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L		1.54	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L		0.000031	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L		<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L		<0.0100	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L		0.000974	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L		0.00096	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L		<0.0030	----	----	----	----
Dissolved Metals										
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L		0.0020	----	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)					Client sample ID	BJ-GW 18-18B -E314702	----	----	----	----
					Client sampling date / time	07-Nov-2021 12:30	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit		VA21C5014-001	--------	--------	--------	--------
						Result	----	----	----	----
Dissolved Metals										
antimony, dissolved	7440-36-0	E421	0.00010	mg/L		0.00018	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L		0.00090	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L		0.0194	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L		<0.000100	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L		<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L		0.032	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L		<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L		52.4	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L		0.00056	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L		0.00014	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L		<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L		0.019	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L		<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L		0.0932	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L		9.12	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L		0.0378	----	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L		<0.0000050	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L		0.000776	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L		0.00145	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L		<0.300	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L		3.14	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L		<0.000050	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L		3.13	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L		<0.000010	----	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L		46.5	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L		1.48	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L		0.000021	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L		<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L		<0.0100	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L		0.000877	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L		<0.00050	----	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW 18-18B -E314702**	----	----	----	----
				Client sampling date / time	07-Nov-2021 12:30	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	**VA21C5014-001**	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	----	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C5014**	Page	: 1 of 12
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 08-Nov-2021 21:00
PO	: 1025614	Issue Date	: 18-Nov-2021 18:20
C-O-C number	: ----		
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Physical Tests	QC-MRG2-341505001	----	alkalinity, total (as CaCO3)	----	E290	1.8 mg/L [B]	1.5 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW 18-18B -E314702	E559	07-Nov-2021	----	----	----		17-Nov-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW 18-18B -E314702	E298	07-Nov-2021	16-Nov-2021	----	----		17-Nov-2021	28 days	10 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW 18-18B -E314702	E235.Br-L	07-Nov-2021	----	----	----		09-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW 18-18B -E314702	E235.Cl	07-Nov-2021	----	----	----		09-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW 18-18B -E314702	E378-U	07-Nov-2021	----	----	----		09-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW 18-18B -E314702	E235.F	07-Nov-2021	----	----	----		09-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW 18-18B -E314702	E235.NO3-L	07-Nov-2021	----	----	----		09-Nov-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW 18-18B -E314702	E235.NO2-L	07-Nov-2021	----	----	----		09-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW 18-18B -E314702	E235.SO4	07-Nov-2021	----	----	----		09-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW 18-18B -E314702	E366	07-Nov-2021	16-Nov-2021	----	----		17-Nov-2021	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW 18-18B -E314702	E372-U	07-Nov-2021	16-Nov-2021	----	----		17-Nov-2021	28 days	10 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW 18-18B -E314702	E509	07-Nov-2021	15-Nov-2021	----	----		15-Nov-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW 18-18B -E314702	E421	07-Nov-2021	15-Nov-2021	----	----		15-Nov-2021	180 days	8 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW 18-18B -E314702	E283	07-Nov-2021	----	----	----		09-Nov-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW 18-18B -E314702	E290	07-Nov-2021	----	----	----		09-Nov-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW 18-18B -E314702	E100	07-Nov-2021	----	----	----		09-Nov-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW 18-18B -E314702	E108	07-Nov-2021	----	----	----		09-Nov-2021	0.25 hrs	55 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW 18-18B -E314702	E162	07-Nov-2021	----	----	----		10-Nov-2021	7 days	3 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW 18-18B -E314702	E160-H	07-Nov-2021	----	----	----		10-Nov-2021	7 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW 18-18B -E314702	E121	07-Nov-2021	----	----	----		09-Nov-2021	3 days	2 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW 18-18B -E314702	E508	07-Nov-2021	----	----	----		16-Nov-2021	28 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW 18-18B -E314702	E420	07-Nov-2021	----	----	----		16-Nov-2021	180 days	9 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW 18-18B -E314702	E395-H	07-Nov-2021	----	----	----		10-Nov-2021	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	341503	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	341506	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	345969	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	341498	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	346433	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	341497	1	19	5.2	5.0	✓
Conductivity in Water	E100	341505	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	345315	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	344968	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	341495	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	341501	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	341502	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	341499	1	19	5.2	5.0	✓
pH by Meter	E108	341504	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	341496	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	342831	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	345429	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	345894	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	345971	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	345968	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	342576	1	14	7.1	5.0	✓
TSS by Gravimetry	E160-H	342833	1	18	5.5	5.0	✓
Turbidity by Nephelometry	E121	341616	1	19	5.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	341503	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	341506	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	345969	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	341498	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	346433	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	341497	1	19	5.2	5.0	✓
Conductivity in Water	E100	341505	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	345315	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	344968	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	341495	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	341501	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	341502	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	341499	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
pH by Meter	E108	341504	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	341496	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	342831	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	345429	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	345894	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	345971	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	345968	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	342576	1	14	7.1	5.0	✓
TSS by Gravimetry	E160-H	342833	1	18	5.5	5.0	✓
Turbidity by Nephelometry	E121	341616	1	19	5.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	341503	1	3	33.3	5.0	✓
Alkalinity Species by Titration	E290	341506	1	16	6.2	5.0	✓
Ammonia by Fluorescence	E298	345969	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	341498	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	346433	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	341497	1	19	5.2	5.0	✓
Conductivity in Water	E100	341505	1	18	5.5	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	345315	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	344968	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	341495	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	341501	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	341502	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	341499	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	341496	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	342831	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	345429	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	345894	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	345971	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	345968	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	342576	1	14	7.1	5.0	✓
TSS by Gravimetry	E160-H	342833	1	18	5.5	5.0	✓
Turbidity by Nephelometry	E121	341616	1	19	5.2	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	345969	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	341498	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	346433	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	341497	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	345315	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	344968	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	341495	1	14	7.1	5.0	✓
Fluoride in Water by IC	E235.F	341501	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	341502	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	341499	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	341496	1	19	5.2	5.0	✓
Total Mercury in Water by CVAAS	E508	345429	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	345894	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	345971	1	13	7.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	345968	1	13	7.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	342576	1	14	7.1	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P E (mod)	Dissolved Orthophosphate is determined colourimetrically on a water sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C5014**	Page	: 1 of 17
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 08-Nov-2021 21:00
PO	: 1025614	Date Analysis Commenced	: 09-Nov-2021
C-O-C number	: ----	Issue Date	: 18-Nov-2021 18:20
Sampler	: NG/RS		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 341503)											
VA21C5014-001	BJ-GW 18-18B -E314702	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 341504)											
VA21C5004-002	Anonymous	pH	----	E108	0.10	pH units	7.58	7.58	0.00%	4%	----
Physical Tests (QC Lot: 341505)											
VA21C5004-002	Anonymous	conductivity	----	E100	2.0	µS/cm	1660	1650	0.362%	10%	----
Physical Tests (QC Lot: 341506)											
VA21C5004-002	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	404	403	0.248%	20%	----
Physical Tests (QC Lot: 341616)											
KS2103672-001	Anonymous	turbidity	----	E121	0.10	NTU	16.6	16.8	1.19%	15%	----
Physical Tests (QC Lot: 342831)											
VA21C5014-001	BJ-GW 18-18B -E314702	solids, total dissolved [TDS]	----	E162	20	mg/L	300	337	11.4%	20%	----
Physical Tests (QC Lot: 342833)											
VA21C4876-018	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 341495)											
KS2103652-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.100	mg/L	2.07	2.02	2.76%	20%	----
Anions and Nutrients (QC Lot: 341496)											
VA21C4530-010	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	6.00	mg/L	1950	2040	4.82%	20%	----
Anions and Nutrients (QC Lot: 341497)											
VA21C4530-010	Anonymous	chloride	16887-00-6	E235.Cl	10.0	mg/L	11.5	11.9	0.45	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 341498)											
VA21C4530-010	Anonymous	bromide	24959-67-9	E235.Br-L	1.00	mg/L	<1.00	<1.00	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 341499)											
VA21C4530-010	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0200	mg/L	<0.0200	<0.0200	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 341501)											
VA21C4530-010	Anonymous	fluoride	16984-48-8	E235.F	0.400	mg/L	3.13	3.30	0.166	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 341502)											
VA21C4962-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.468	0.469	0.301%	20%	----
Anions and Nutrients (QC Lot: 345968)											
VA21C4824-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.970	0.996	2.62%	20%	----
Anions and Nutrients (QC Lot: 345969)											
FJ2101269-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 345971)											
FJ2101269-002	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.142	0.143	0.0005	Diff <2x LOR	----
Total Sulfides (QC Lot: 342576)											
FJ2101273-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 345429)											
VA21C4992-011	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000621	0.0000614	1.15%	20%	----
Total Metals (QC Lot: 345894)											
VA21C4992-001	Anonymous	aluminum, total	7429-90-5	E420	0.0150	mg/L	0.0933	0.0975	0.0042	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00050	mg/L	0.00224	0.00221	0.00003	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00050	mg/L	0.0172	0.0174	1.04%	20%	----
		barium, total	7440-39-3	E420	0.00050	mg/L	0.0498	0.0502	0.754%	20%	----
		beryllium, total	7440-41-7	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.050	mg/L	0.185	0.182	0.002	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000250	mg/L	<0.0000250	<0.0000250	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.250	mg/L	690	671	2.76%	20%	----
		chromium, total	7440-47-3	E420	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00050	mg/L	0.00084	0.00079	0.00005	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.050	mg/L	0.104	0.106	0.002	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000250	mg/L	0.000565	0.000563	0.000002	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0050	mg/L	0.0437	0.0428	0.0009	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0250	mg/L	67.9	68.8	1.34%	20%	----
		manganese, total	7439-96-5	E420	0.00050	mg/L	0.00386	0.00378	0.00008	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000250	mg/L	0.00200	0.00205	0.000047	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.250	mg/L	0.342	0.316	0.026	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.250	mg/L	2.88	2.87	0.417%	20%	----
		selenium, total	7782-49-2	E420	0.000250	mg/L	0.00494	0.00488	1.35%	20%	----
		silicon, total	7440-21-3	E420	0.50	mg/L	16.0	15.8	1.54%	20%	----
		silver, total	7440-22-4	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.250	mg/L	169	167	0.812%	20%	----
		strontium, total	7440-24-6	E420	0.00100	mg/L	5.53	5.51	0.378%	20%	----
		thallium, total	7440-28-0	E420	0.000050	mg/L	0.000079	0.000074	0.000004	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00150	mg/L	0.00227	0.00191	0.00037	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 345894) - continued											
VA21C4992-001	Anonymous	uranium, total	7440-61-1	E420	0.000050	mg/L	0.00780	0.00755	3.36%	20%	----
		vanadium, total	7440-62-2	E420	0.00250	mg/L	0.00632	0.00633	0.000009	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0150	mg/L	<0.0150	<0.0150	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 344968)											
VA21C5004-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0020	mg/L	0.0021	0.0021	0.00002	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00020	mg/L	0.00038	0.00036	0.00002	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00020	mg/L	0.0674	0.0698	3.60%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.020	mg/L	1.82	1.91	4.97%	20%	----
		cadmium, dissolved	7440-43-9	E421	0.0000100	mg/L	0.00172	0.00177	3.24%	20%	----
		calcium, dissolved	7440-70-2	E421	0.100	mg/L	311	322	3.27%	20%	----
		chromium, dissolved	7440-47-3	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00020	mg/L	0.00154	0.00159	0.00004	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00040	mg/L	0.00561	0.00571	1.74%	20%	----
		iron, dissolved	7439-89-6	E421	0.020	mg/L	<0.020	<0.020	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0020	mg/L	0.0083	0.0088	0.0005	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0100	mg/L	176	177	0.689%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00020	mg/L	0.187	0.194	3.83%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000100	mg/L	0.0128	0.0132	3.55%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00100	mg/L	0.0117	0.0122	4.43%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	8.03	8.31	3.36%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000100	mg/L	0.0171	0.0176	3.34%	20%	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	8.50	8.82	3.72%	20%	----
		silver, dissolved	7440-22-4	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.100	mg/L	414	423	2.23%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00040	mg/L	1.79	1.86	3.64%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00060	mg/L	<0.00060	<0.00060	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000020	mg/L	0.0786	0.0818	3.99%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00100	mg/L	0.00195	0.00205	0.00009	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 344968) - continued											
VA21C5004-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.0020	mg/L	<0.0020	<0.0020	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 345315)											
VA21C4992-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	0.0000446	0.0000422	0.0000025	Diff <2x LOR	----
Aggregate Organics (QC Lot: 346433)											
VA21C4924-002	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 341503)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 341505)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 341506)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	# 1.8	B
Physical Tests (QCLot: 341616)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 342831)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 342833)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 341495)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 341496)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 341497)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 341498)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 341499)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 341501)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 341502)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 345968)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 345969)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 345971)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Sulfides (QCLot: 342576)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 345429)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 345894)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Dissolved Metals (QCLot: 344968)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 344968) - continued						
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 345315)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 346433)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Qualifiers

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 341503)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	92.6	85.0	115	----
Physical Tests (QCLot: 341504)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 341505)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 341506)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	100	85.0	115	----
Physical Tests (QCLot: 341616)									
turbidity	----	E121	0.1	NTU	200 NTU	99.1	85.0	115	----
Physical Tests (QCLot: 342831)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	95.2	85.0	115	----
Physical Tests (QCLot: 342833)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	90.7	85.0	115	----
Anions and Nutrients (QCLot: 341495)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	100	80.0	120	----
Anions and Nutrients (QCLot: 341496)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	99.4	90.0	110	----
Anions and Nutrients (QCLot: 341497)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	97.9	90.0	110	----
Anions and Nutrients (QCLot: 341498)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	89.0	85.0	115	----
Anions and Nutrients (QCLot: 341499)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	97.1	90.0	110	----
Anions and Nutrients (QCLot: 341501)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	96.4	90.0	110	----
Anions and Nutrients (QCLot: 341502)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	97.9	90.0	110	----
Anions and Nutrients (QCLot: 345968)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.5	80.0	120	----
Anions and Nutrients (QCLot: 345969)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.6	85.0	115	----
Anions and Nutrients (QCLot: 345971)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 345971) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	103	75.0	125	----
Total Sulfides (QCLot: 342576)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	89.8	80.0	120	----
Total Metals (QCLot: 345429)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	104	80.0	120	----
Total Metals (QCLot: 345894)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	106	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	100	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	92.7	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	98.2	80.0	120	----
chromium, total	7440-47-3	E420	0.0005	mg/L	0.25 mg/L	102	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	102	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	98.9	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	97.5	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	102	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	103	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	103	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	105	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	92.2	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	98.1	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	98.7	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 345894) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	104	80.0	120	----
Dissolved Metals (QCLot: 344968)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	99.5	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	100	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	94.7	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	95.7	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	94.3	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	91.0	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	92.1	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	99.4	80.0	120	----
chromium, dissolved	7440-47-3	E421	0.0005	mg/L	0.25 mg/L	96.0	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	94.6	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	93.6	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	93.7	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	97.3	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	99.7	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.4	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	98.5	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	98.0	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	94.8	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	98.8	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	96.6	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	95.6	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	93.9	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	87.3	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	98.4	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	99.5	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	92.2	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	95.4	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	95.7	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	96.6	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	97.3	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	94.9	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Aggregate Organics (QCLot: 346433)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	104	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 341495)										
VA21C4977-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0368 mg/L	0.03 mg/L	122	70.0	130	----
Anions and Nutrients (QCLot: 341496)										
VA21C4977-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	120 mg/L	100 mg/L	120	75.0	125	----
Anions and Nutrients (QCLot: 341497)										
VA21C4977-001	Anonymous	chloride	16887-00-6	E235.Cl	114 mg/L	100 mg/L	114	75.0	125	----
Anions and Nutrients (QCLot: 341498)										
VA21C5014-001	BJ-GW 18-18B -E314702	bromide	24959-67-9	E235.Br-L	0.602 mg/L	0.5 mg/L	120	75.0	125	----
Anions and Nutrients (QCLot: 341499)										
VA21C4977-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.563 mg/L	0.5 mg/L	112	75.0	125	----
Anions and Nutrients (QCLot: 341501)										
VA21C4977-001	Anonymous	fluoride	16984-48-8	E235.F	1.19 mg/L	1 mg/L	119	75.0	125	----
Anions and Nutrients (QCLot: 341502)										
VA21C5014-001	BJ-GW 18-18B -E314702	nitrate (as N)	14797-55-8	E235.NO3-L	3.05 mg/L	2.5 mg/L	122	75.0	125	----
Anions and Nutrients (QCLot: 345968)										
VA21C4824-002	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 345969)										
FJ2101269-003	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0970 mg/L	0.1 mg/L	97.0	75.0	125	----
Anions and Nutrients (QCLot: 345971)										
FJ2101269-003	Anonymous	nitrogen, total	7727-37-9	E366	0.409 mg/L	0.4 mg/L	102	70.0	130	----
Total Sulfides (QCLot: 342576)										
FJ2101273-002	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.977 mg/L	1 mg/L	97.7	75.0	125	----
Total Metals (QCLot: 345429)										
VA21C4992-012	Anonymous	mercury, total	7439-97-6	E508	0.0000977 mg/L	0.0001 mg/L	97.7	70.0	130	----
Total Metals (QCLot: 345894)										
VA21C4992-002	Anonymous	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	High	Qualifier
Total Metals (QCLot: 345894) - continued										
VA21C4992-002	Anonymous	beryllium, total	7440-41-7	E420	0.0374 mg/L	0.04 mg/L	93.6	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00893 mg/L	0.01 mg/L	89.3	70.0	130	----
		boron, total	7440-42-8	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00396 mg/L	0.004 mg/L	99.0	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, total	7440-47-3	E420	0.0377 mg/L	0.04 mg/L	94.3	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0186 mg/L	0.02 mg/L	93.0	70.0	130	----
		copper, total	7440-50-8	E420	0.0177 mg/L	0.02 mg/L	88.5	70.0	130	----
		iron, total	7439-89-6	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0166 mg/L	0.02 mg/L	83.2	70.0	130	----
		lithium, total	7439-93-2	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		nickel, total	7440-02-0	E420	0.0367 mg/L	0.04 mg/L	91.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	9.93 mg/L	10 mg/L	99.3	70.0	130	----
		potassium, total	7440-09-7	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, total	7782-49-2	E420	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		silicon, total	7440-21-3	E420	ND mg/L	10 mg/L	ND	70.0	130	----
		silver, total	7440-22-4	E420	0.00366 mg/L	0.004 mg/L	91.6	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00342 mg/L	0.004 mg/L	85.4	70.0	130	----
		tin, total	7440-31-5	E420	0.0191 mg/L	0.02 mg/L	95.7	70.0	130	----
		titanium, total	7440-32-6	E420	0.0389 mg/L	0.04 mg/L	97.3	70.0	130	----
		uranium, total	7440-61-1	E420	0.00387 mg/L	0.004 mg/L	96.7	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0974 mg/L	0.1 mg/L	97.4	70.0	130	----
		zinc, total	7440-66-6	E420	0.384 mg/L	0.4 mg/L	96.0	70.0	130	----
Dissolved Metals (QCLot: 344968)										
VA21C5004-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.193 mg/L	0.2 mg/L	96.6	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0191 mg/L	0.02 mg/L	95.6	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0196 mg/L	0.02 mg/L	97.8	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0389 mg/L	0.04 mg/L	97.2	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00823 mg/L	0.01 mg/L	82.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.091 mg/L	0.1 mg/L	91.1	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Dissolved Metals (QCLot: 344968) - continued										
VA21C5004-002	Anonymous	cadmium, dissolved	7440-43-9	E421	0.00365 mg/L	0.004 mg/L	91.2	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		chromium, dissolved	7440-47-3	E421	0.0385 mg/L	0.04 mg/L	96.2	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0178 mg/L	0.02 mg/L	88.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0172 mg/L	0.02 mg/L	86.2	70.0	130	----
		iron, dissolved	7439-89-6	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0179 mg/L	0.02 mg/L	89.5	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0945 mg/L	0.1 mg/L	94.5	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0352 mg/L	0.04 mg/L	88.1	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.4 mg/L	10 mg/L	104	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0409 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.33 mg/L	10 mg/L	83.3	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00368 mg/L	0.004 mg/L	91.9	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00346 mg/L	0.004 mg/L	86.6	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0186 mg/L	0.02 mg/L	93.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0375 mg/L	0.04 mg/L	93.8	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0971 mg/L	0.1 mg/L	97.1	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.364 mg/L	0.4 mg/L	91.0	70.0	130	----
Dissolved Metals (QCLot: 345315)										
VA21C4992-006	Anonymous	mercury, dissolved	7439-97-6	E509	0.000481 mg/L	0.0005 mg/L	96.2	70.0	130	----
Aggregate Organics (QCLot: 346433)										
VA21C4924-001	Anonymous	chemical oxygen demand [COD]	----	E559	102 mg/L	100 mg/L	102	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG/RS

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-18B - E314702	07-Nov-21	12:30	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C5014

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Richelle Sussbauer	7-Nov-21	18:00	PO	NOV 08 2021	21:00	7 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C5536**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 15-Nov-2021 21:30
PO	: 1025614	Date Analysis Commenced	: 16-Nov-2021
C-O-C number	: ----	Issue Date	: 24-Nov-2021 18:59
Sampler	: NG/CM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLA	*Detection Limit adjusted for required dilution.*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*

Analytical Results

Sub-Matrix: **Groundwater**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-23A-E 314690	BJ-GW16-5A-C WP	----	----	----
				Client sampling date / time	14-Nov-2021 11:20	14-Nov-2021 13:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C5536-001	VA21C5536-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.6	3.2	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	95.7	96.5	----	----	----
conductivity	----	E100	2.0	µS/cm	1240	858	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	340	425	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	341	449	----	----	----
pH	----	E108	0.10	pH units	7.88	7.88	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	806	576	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	8.9	17.5	----	----	----
turbidity	----	E121	0.10	NTU	5.43	6.24	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.319	0.104	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	28.4	<2.50 DLDS	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.113	<0.100 DLDS	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.743	0.127	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	7.87	<0.0250 DLDS	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	7.90	<0.0255	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0340	<0.0050 DLDS	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	7.86	0.127	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0036	0.0028	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0083	0.0299	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	464	370	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	<0.011	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.209	0.0348	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.0319	0.00085	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0408	0.00114	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0393	0.0225	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23A-E 314690	BJ-GW16-5A-C WP	----	----	----
				Client sampling date / time	14-Nov-2021 11:20	14-Nov-2021 13:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C5536-001	VA21C5536-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000200 DLA	<0.000200 DLA	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000100 DLA	<0.000100 DLA	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.106	0.032	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000272	<0.0000100 DLA	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	112	147	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00508	0.00191	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00320	0.00042	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00152	<0.00100 DLA	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.135	0.193	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000472	0.000190	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.253	0.0137	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	15.0	19.9	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.220	0.135	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00467	0.000452	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00636	0.00197	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.600 DLA	<0.600 DLA	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	3.93	1.63	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000582	<0.000100 DLA	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.15	2.67	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000147	<0.000020 DLA	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	124	6.77	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	6.53	5.16	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000083	<0.000020 DLA	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00028	<0.00020 DLA	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0200 DLA	<0.0200 DLA	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00209	0.000348	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00100 DLA	<0.00100 DLA	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0060	<0.0060 DLA	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0011	0.0025	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23A-E 314690	BJ-GW16-5A-C WP	----	----	----
				Client sampling date / time	14-Nov-2021 11:20	14-Nov-2021 13:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C5536-001	VA21C5536-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.0337	0.00075	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0387	0.00084	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0336	0.0209	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000200 DLA	<0.000200 DLA	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000100 DLA	<0.000100 DLA	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.103	0.032	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000142	<0.0000100 DLA	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	113	140	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00044	0.00081	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00025	0.00030	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00042	<0.00040 DLA	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.020 DLA	0.059	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000177	<0.000100 DLA	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.261	0.0136	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	14.1	18.4	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.182	0.136	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00429	0.000558	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00330	0.00134	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.600 DLA	<0.600 DLA	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	3.39	1.50	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.00117 DTSE	<0.000100 DLA	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.48	2.60	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000020 DLA	<0.000020 DLA	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	117	6.35	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	6.65	5.09	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000076	<0.000020 DLA	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00020 DLA	<0.00020 DLA	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0200 DLA	<0.0200 DLA	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00190	0.000348	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00100 DLA	<0.00100 DLA	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-23A-E 314690**	**BJ-GW16-5A-C WP**	**----**	**----**	**----**
				Client sampling date / time	14-Nov-2021 11:20	14-Nov-2021 13:20	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C5536-001**	**VA21C5536-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0048	0.0039	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C5536**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 15-Nov-2021 21:30
PO	: 1025614	Issue Date	: 24-Nov-2021 18:59
C-O-C number	: ----		
Sampler	: NG/CM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E559	14-Nov-2021	----	----	----		22-Nov-2021	28 days	8 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E559	14-Nov-2021	----	----	----		22-Nov-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E298	14-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E298	14-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	28 days	8 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A-CWP	E235.Br-L	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.Br-L	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW16-5A-CWP	E235.Cl	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.Cl	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW16-5A-CWP	E378-U	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23A-E314690	E378-U	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW16-5A-CWP	E235.F	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.F	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A-CWP	E235.NO3-L	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.NO3-L	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW16-5A-CWP	E235.NO2-L	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23A-E314690	E235.NO2-L	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW16-5A-CWP	E235.SO4	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23A-E314690	E235.SO4	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E366	14-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E366	14-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW16-5A-CWP	E372-U	14-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23A-E314690	E372-U	14-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW16-5A-CWP	E421.Cr-L	14-Nov-2021	18-Nov-2021	----	----		19-Nov-2021	180 days	5 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW18-23A-E314690	E421.Cr-L	14-Nov-2021	18-Nov-2021	----	----		19-Nov-2021	180 days	5 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW16-5A-CWP	E509	14-Nov-2021	23-Nov-2021	----	----		23-Nov-2021	28 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23A-E314690	E509	14-Nov-2021	23-Nov-2021	----	----		23-Nov-2021	28 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW16-5A-CWP	E421	14-Nov-2021	18-Nov-2021	----	----		19-Nov-2021	180 days	5 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23A-E314690	E421	14-Nov-2021	18-Nov-2021	----	----		19-Nov-2021	180 days	5 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW16-5A-CWP	E283	14-Nov-2021	----	----	----		16-Nov-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23A-E314690	E283	14-Nov-2021	----	----	----		16-Nov-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW16-5A-CWP	E290	14-Nov-2021	----	----	----		16-Nov-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23A-E314690	E290	14-Nov-2021	----	----	----		16-Nov-2021	14 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW16-5A-CWP	E100	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23A-E314690	E100	14-Nov-2021	----	----	----		16-Nov-2021	28 days	2 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW16-5A-CWP	E108	14-Nov-2021	----	----	----		16-Nov-2021	0.25 hrs	50 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-23A-E314690	E108	14-Nov-2021	----	----	----		16-Nov-2021	0.25 hrs	52 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW16-5A-CWP	E162	14-Nov-2021	----	----	----		18-Nov-2021	7 days	4 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-23A-E314690	E162	14-Nov-2021	----	----	----		18-Nov-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW16-5A-CWP	E160-H	14-Nov-2021	----	----	----		18-Nov-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-23A-E314690	E160-H	14-Nov-2021	----	----	----		18-Nov-2021	7 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW16-5A-CWP	E121	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-23A-E314690	E121	14-Nov-2021	----	----	----		16-Nov-2021	3 days	2 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW16-5A-CWP	E420.Cr-L	14-Nov-2021	----	----	----		20-Nov-2021	180 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW18-23A-E314690	E420.Cr-L	14-Nov-2021	----	----	----		20-Nov-2021	180 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW16-5A-CWP	E508	14-Nov-2021	----	----	----		19-Nov-2021	28 days	5 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23A-E314690	E508	14-Nov-2021	----	----	----		19-Nov-2021	28 days	5 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW16-5A-CWP	E420	14-Nov-2021	----	----	----		20-Nov-2021	180 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23A-E314690	E420	14-Nov-2021	----	----	----		20-Nov-2021	180 days	6 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW16-5A-CWP	E395-H	14-Nov-2021	----	----	----		16-Nov-2021	7 days	2 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23A-E314690	E395-H	14-Nov-2021	----	----	----		16-Nov-2021	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	345742	1	15	6.6	5.0	✓
Alkalinity Species by Titration	E290	345745	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	349994	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	345739	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	345738	1	19	5.2	5.0	✓
Conductivity in Water	E100	345744	1	19	5.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	347931	1	3	33.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	347932	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	345746	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	345736	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	345740	1	19	5.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	345741	1	19	5.2	5.0	✓
pH by Meter	E108	345743	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	345737	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	347481	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348232	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	348904	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348231	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	349998	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	349995	1	14	7.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	346090	1	4	25.0	5.0	✓
TSS by Gravimetry	E160-H	347468	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	345997	2	40	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	345742	1	15	6.6	5.0	✓
Alkalinity Species by Titration	E290	345745	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	349994	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	345739	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	345738	1	19	5.2	5.0	✓
Conductivity in Water	E100	345744	1	19	5.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	347931	1	3	33.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	347932	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	345746	1	15	6.6	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	345736	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	345740	1	19	5.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	345741	1	19	5.2	5.0	✓
pH by Meter	E108	345743	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	345737	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	347481	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348232	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	348904	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348231	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	349998	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	349995	1	14	7.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	346090	1	4	25.0	5.0	✓
TSS by Gravimetry	E160-H	347468	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	345997	2	40	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	345742	1	15	6.6	5.0	✓
Alkalinity Species by Titration	E290	345745	1	15	6.6	5.0	✓
Ammonia by Fluorescence	E298	349994	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	345739	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	345738	1	19	5.2	5.0	✓
Conductivity in Water	E100	345744	1	19	5.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	347931	1	3	33.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	347932	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	345746	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	345736	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	345740	1	19	5.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	345741	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	345737	1	19	5.2	5.0	✓
TDS by Gravimetry	E162	347481	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348232	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	348904	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348231	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	349998	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	349995	1	14	7.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	346090	1	4	25.0	5.0	✓
TSS by Gravimetry	E160-H	347468	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	345997	2	40	5.0	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	349994	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	345739	1	19	5.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	345738	1	19	5.2	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	347931	1	3	33.3	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	347932	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	345746	1	15	6.6	5.0	✓
Fluoride in Water by IC	E235.F	345736	1	19	5.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	345740	1	19	5.2	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	345741	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	345737	1	19	5.2	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348232	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	348904	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348231	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	349998	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	349995	1	14	7.1	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	346090	1	4	25.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C5536**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Ground Water	Date Samples Received	: 15-Nov-2021 21:30
PO	: 1025614	Date Analysis Commenced	: 16-Nov-2021
C-O-C number	: ----	Issue Date	: 24-Nov-2021 18:59
Sampler	: NG/CM		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 345742)											
VA21C5527-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	2.4	2.5	0.1	Diff <2x LOR	----
Physical Tests (QC Lot: 345743)											
VA21C5527-001	Anonymous	pH	----	E108	0.10	pH units	7.98	7.98	0.0376%	4%	----
Physical Tests (QC Lot: 345744)											
VA21C5527-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1560	1560	0.128%	10%	----
Physical Tests (QC Lot: 345745)											
VA21C5527-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	148	148	0.541%	20%	----
Physical Tests (QC Lot: 345997)											
VA21C5484-001	Anonymous	turbidity	----	E121	0.10	NTU	48.2	48.0	0.541%	15%	----
Physical Tests (QC Lot: 345998)											
VA21C5536-002	BJ-GW16-5A-CWP	turbidity	----	E121	0.10	NTU	6.24	6.16	1.19%	15%	----
Physical Tests (QC Lot: 347468)											
VA21C5536-001	BJ-GW18-23A-E314690	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	8.9	9.9	1.0	Diff <2x LOR	----
Physical Tests (QC Lot: 347481)											
FJ2101298-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	4290	4650	7.92%	20%	----
Anions and Nutrients (QC Lot: 345736)											
VA21C5527-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	1.87	1.90	1.78%	20%	----
Anions and Nutrients (QC Lot: 345737)											
VA21C5527-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	501	511	1.98%	20%	----
Anions and Nutrients (QC Lot: 345738)											
VA21C5527-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	36.0	36.6	1.81%	20%	----
Anions and Nutrients (QC Lot: 345739)											
VA21C5527-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 345740)											
VA21C5527-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.982	0.998	1.62%	20%	----
Anions and Nutrients (QC Lot: 345741)											
VA21C5527-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	0.0718	0.0734	2.31%	20%	----
Anions and Nutrients (QC Lot: 345746)											
VA21C5527-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 349994)											
VA21C5326-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0067	0.0059	0.0008	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 349995)											
VA21C5327-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	1.46	1.49	0.0323	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 349998)											
VA21C5536-001	BJ-GW18-23A-E314690	nitrogen, total	7727-37-9	E366	0.300	mg/L	7.86	7.90	0.429%	20%	----
Total Sulfides (QC Lot: 346090)											
VA21C5502-021	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 348231)											
VA21C5536-001	BJ-GW18-23A-E314690	aluminum, total	7429-90-5	E420	0.0060	mg/L	0.209	0.223	6.82%	20%	----
		antimony, total	7440-36-0	E420	0.00020	mg/L	0.0319	0.0315	1.34%	20%	----
		arsenic, total	7440-38-2	E420	0.00020	mg/L	0.0408	0.0411	0.765%	20%	----
		barium, total	7440-39-3	E420	0.00020	mg/L	0.0393	0.0394	0.216%	20%	----
		beryllium, total	7440-41-7	E420	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.020	mg/L	0.106	0.106	0.0002	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000100	mg/L	0.0000272	0.0000262	0.0000009	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.100	mg/L	112	112	0.456%	20%	----
		cobalt, total	7440-48-4	E420	0.00020	mg/L	0.00320	0.00322	0.617%	20%	----
		copper, total	7440-50-8	E420	0.00100	mg/L	0.00152	0.00156	0.00003	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.020	mg/L	0.135	0.152	0.016	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000100	mg/L	0.000472	0.000485	0.000012	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0020	mg/L	0.253	0.252	0.578%	20%	----
		magnesium, total	7439-95-4	E420	0.200	mg/L	15.0	15.2	1.58%	20%	----
		manganese, total	7439-96-5	E420	0.00020	mg/L	0.220	0.223	1.24%	20%	----
		molybdenum, total	7439-98-7	E420	0.000100	mg/L	0.00467	0.00476	1.72%	20%	----
		nickel, total	7440-02-0	E420	0.00100	mg/L	0.00636	0.00648	0.00012	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.600	mg/L	<0.600	<0.600	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.100	mg/L	3.93	3.99	1.50%	20%	----
		selenium, total	7782-49-2	E420	0.000100	mg/L	0.000582	0.000660	0.000078	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.20	mg/L	3.15	3.20	1.48%	20%	----
		silver, total	7440-22-4	E420	0.000020	mg/L	0.000147	0.000154	0.000007	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.100	mg/L	124	124	0.554%	20%	----
		strontium, total	7440-24-6	E420	0.00040	mg/L	6.53	6.37	2.45%	20%	----
		thallium, total	7440-28-0	E420	0.000020	mg/L	0.000083	0.000077	0.000006	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00020	mg/L	0.00028	0.00032	0.00004	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0200	mg/L	<0.0200	<0.0200	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000020	mg/L	0.00209	0.00207	1.03%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 348231) - continued											
VA21C5536-001	BJ-GW18-23A-E314690	vanadium, total	7440-62-2	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0060	mg/L	0.0060	0.0063	0.0003	Diff <2x LOR	----
Total Metals (QC Lot: 348232)											
VA21C5536-001	BJ-GW18-23A-E314690	chromium, total	7440-47-3	E420.Cr-L	0.00020	mg/L	0.00508	0.00537	5.69%	20%	----
Total Metals (QC Lot: 348904)											
VA21C5528-001	Anonymous	mercury, total	7439-97-6	E508	0.0050	mg/L	0.0791 µg/L	0.0000881	10.8%	20%	----
Dissolved Metals (QC Lot: 347931)											
CG2105658-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 347932)											
CG2105658-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00063	0.00063	0.000006	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00014	0.00014	0.000006	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0868	0.0926	6.45%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.020	mg/L	<0.020 µg/L	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.016	0.016	0.00005	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0050	mg/L	0.110 µg/L	0.000109	1.06%	20%	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	167	175	4.68%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.10	mg/L	0.42 µg/L	0.00042	0.000002	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.015	0.015	0.0004	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0838	0.0842	0.460%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	82.3	84.4	2.52%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0143	0.0144	0.584%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00426	0.00427	0.216%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.0128	0.0129	0.544%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	3.27	3.32	1.51%	20%	----
		selenium, dissolved	7782-49-2	E421	0.050	mg/L	108 µg/L	0.105	2.53%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.04	1.94	4.94%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	2.87	2.74	4.52%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.256	0.260	1.60%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000021	0.000020	0.0000009	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 347932) - continued											
CG2105658-001	Anonymous	tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00504	0.00502	0.227%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0061	0.0059	0.0002	Diff <2x LOR	----
Dissolved Metals (QC Lot: 350308)											
KS2103732-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 349970)											
VA21C5536-001	BJ-GW18-23A-E314690	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 345742)						
acidity (as CaCO3)	----	E283	2	mg/L	2.2	----
Physical Tests (QCLot: 345744)						
conductivity	----	E100	1	µS/cm	1.1	----
Physical Tests (QCLot: 345745)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 345997)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 345998)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 347468)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 347481)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 345736)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 345737)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 345738)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 345739)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 345740)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 345741)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 345746)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 349994)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 349995)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 349998)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 346090)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----
Total Metals (QCLot: 348231)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 348232)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 348904)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 348904) - continued						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 347931)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 347932)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 350308)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 350308) - continued						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 349970)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 345742)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	98.5	85.0	115	----
Physical Tests (QCLot: 345743)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 345744)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	102	90.0	110	----
Physical Tests (QCLot: 345745)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 345997)									
turbidity	----	E121	0.1	NTU	200 NTU	106	85.0	115	----
Physical Tests (QCLot: 345998)									
turbidity	----	E121	0.1	NTU	200 NTU	105	85.0	115	----
Physical Tests (QCLot: 347468)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	93.8	85.0	115	----
Physical Tests (QCLot: 347481)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	103	85.0	115	----
Anions and Nutrients (QCLot: 345736)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 345737)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 345738)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 345739)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	103	85.0	115	----
Anions and Nutrients (QCLot: 345740)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 345741)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 345746)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	97.4	80.0	120	----
Anions and Nutrients (QCLot: 349994)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	98.6	85.0	115	----
Anions and Nutrients (QCLot: 349995)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 349995) - continued									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	91.0	80.0	120	----
Anions and Nutrients (QCLot: 349998)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	104	75.0	125	----
Total Sulfides (QCLot: 346090)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	102	80.0	120	----
Total Metals (QCLot: 348231)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	106	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	103	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	101	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	86.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	102	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	102	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	99.5	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	104	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.4	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	101	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	99.8	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	100	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	109	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	109	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	102	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	91.1	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	98.5	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	96.4	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	100	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	96.2	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 348231) - continued									
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	103	80.0	120	----
Total Metals (QCLot: 348232)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
Total Metals (QCLot: 348904)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	102	80.0	120	----
Dissolved Metals (QCLot: 347931)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	94.6	80.0	120	----
Dissolved Metals (QCLot: 347932)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	90.8	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	94.1	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	90.6	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	91.2	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	84.3	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	92.8	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	102	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	92.9	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	92.6	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	93.8	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	109	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	104	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	92.7	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	93.8	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	95.7	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	91.4	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	95.1	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	97.9	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	98.5	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	98.8	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	97.5	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	106	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	105	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	93.7	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	92.3	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 347932) - continued									
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	99.6	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	93.1	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	102	80.0	120	----
Aggregate Organics (QCLot: 349970)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 345736)										
VA21C5527-002	Anonymous	fluoride	16984-48-8	E235.F	1.03 mg/L	1 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 345737)										
VA21C5527-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	ND mg/L	100 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 345738)										
VA21C5527-002	Anonymous	chloride	16887-00-6	E235.Cl	104 mg/L	100 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 345739)										
VA21C5527-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.511 mg/L	0.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 345740)										
VA21C5527-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.63 mg/L	2.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 345741)										
VA21C5527-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.516 mg/L	0.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 345746)										
VA21C5527-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0322 mg/L	0.03 mg/L	107	70.0	130	----
Anions and Nutrients (QCLot: 349994)										
VA21C5326-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Anions and Nutrients (QCLot: 349995)										
VA21C5440-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0467 mg/L	0.05 mg/L	93.4	70.0	130	----
Anions and Nutrients (QCLot: 349998)										
VA21C5536-002	BJ-GW16-5A-CWP	nitrogen, total	7727-37-9	E366	0.413 mg/L	0.4 mg/L	103	70.0	130	----
Total Sulfides (QCLot: 346090)										
VA21C5536-001	BJ-GW18-23A-E314690	sulfide, total (as S)	18496-25-8	E395-H	0.956 mg/L	1 mg/L	95.6	75.0	125	----
Total Metals (QCLot: 348231)										
VA21C5536-002	BJ-GW16-5A-CWP	aluminum, total	7429-90-5	E420	0.412 mg/L	0.4 mg/L	103	70.0	130	----
		antimony, total	7440-36-0	E420	0.0389 mg/L	0.04 mg/L	97.2	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0396 mg/L	0.04 mg/L	99.0	70.0	130	----
		barium, total	7440-39-3	E420	0.0391 mg/L	0.04 mg/L	97.8	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0792 mg/L	0.08 mg/L	99.0	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0193 mg/L	0.02 mg/L	96.7	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 348231) - continued										
VA21C5536-002	BJ-GW16-5A-CWP	boron, total	7440-42-8	E420	0.170 mg/L	0.2 mg/L	85.2	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00814 mg/L	0.008 mg/L	102	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	8 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0402 mg/L	0.04 mg/L	100	70.0	130	----
		copper, total	7440-50-8	E420	0.0390 mg/L	0.04 mg/L	97.5	70.0	130	----
		iron, total	7439-89-6	E420	3.93 mg/L	4 mg/L	98.2	70.0	130	----
		lead, total	7439-92-1	E420	0.0384 mg/L	0.04 mg/L	95.9	70.0	130	----
		lithium, total	7439-93-2	E420	0.197 mg/L	0.2 mg/L	98.6	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
		nickel, total	7440-02-0	E420	0.0791 mg/L	0.08 mg/L	98.8	70.0	130	----
		phosphorus, total	7723-14-0	E420	20.8 mg/L	20 mg/L	104	70.0	130	----
		potassium, total	7440-09-7	E420	8.51 mg/L	8 mg/L	106	70.0	130	----
		selenium, total	7782-49-2	E420	0.0818 mg/L	0.08 mg/L	102	70.0	130	----
		silicon, total	7440-21-3	E420	19.8 mg/L	20 mg/L	99.1	70.0	130	----
		silver, total	7440-22-4	E420	0.00751 mg/L	0.008 mg/L	93.9	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00767 mg/L	0.008 mg/L	95.9	70.0	130	----
		tin, total	7440-31-5	E420	0.0382 mg/L	0.04 mg/L	95.6	70.0	130	----
		titanium, total	7440-32-6	E420	0.0788 mg/L	0.08 mg/L	98.5	70.0	130	----
		uranium, total	7440-61-1	E420	0.00783 mg/L	0.008 mg/L	97.8	70.0	130	----
		vanadium, total	7440-62-2	E420	0.205 mg/L	0.2 mg/L	102	70.0	130	----
		zinc, total	7440-66-6	E420	0.805 mg/L	0.8 mg/L	101	70.0	130	----
Total Metals (QCLot: 348232)										
VA21C5536-002	BJ-GW16-5A-CWP	chromium, total	7440-47-3	E420.Cr-L	0.0814 mg/L	0.08 mg/L	102	70.0	130	----
Total Metals (QCLot: 348904)										
VA21C5528-002	Anonymous	mercury, total	7439-97-6	E508	0.0000973 mg/L	0.0001 mg/L	97.3	70.0	130	----
Dissolved Metals (QCLot: 347931)										
VA21C5536-001	BJ-GW18-23A-E314690	chromium, dissolved	7440-47-3	E421.Cr-L	0.0762 mg/L	0.08 mg/L	95.3	70.0	130	----
Dissolved Metals (QCLot: 347932)										
VA21C5536-001	BJ-GW18-23A-E314690	aluminum, dissolved	7429-90-5	E421	0.146 mg/L	0.2 mg/L	73.2	70.0	130	----
		antimony, dissolved	7440-36-0	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 347932) - continued										
VA21C5536-001	BJ-GW18-23A-E314690	barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0726 mg/L	0.08 mg/L	90.8	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0188 mg/L	0.02 mg/L	94.1	70.0	130	----
		boron, dissolved	7440-42-8	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00775 mg/L	0.008 mg/L	96.8	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0378 mg/L	0.04 mg/L	94.6	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0371 mg/L	0.04 mg/L	92.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	3.86 mg/L	4 mg/L	96.4	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0407 mg/L	0.04 mg/L	102	70.0	130	----
		lithium, dissolved	7439-93-2	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0425 mg/L	0.04 mg/L	106	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0763 mg/L	0.08 mg/L	95.4	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	19.3 mg/L	20 mg/L	96.5	70.0	130	----
		potassium, dissolved	7440-09-7	E421	7.64 mg/L	8 mg/L	95.5	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0841 mg/L	0.08 mg/L	105	70.0	130	----
		silicon, dissolved	7440-21-3	E421	18.9 mg/L	20 mg/L	94.7	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00727 mg/L	0.008 mg/L	90.9	70.0	130	----
		sodium, dissolved	17341-25-2	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00718 mg/L	0.008 mg/L	89.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0802 mg/L	0.08 mg/L	100	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00770 mg/L	0.008 mg/L	96.2	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.204 mg/L	0.2 mg/L	102	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.774 mg/L	0.8 mg/L	96.8	70.0	130	----
Dissolved Metals (QCLot: 350308)										
KS2103732-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000998 mg/L	0.0001 mg/L	99.8	70.0	130	----
Aggregate Organics (QCLot: 349970)										
VA21C5536-002	BJ-GW16-5A-CWP	chemical oxygen demand [COD]	----	E559	121 mg/L	100 mg/L	121	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/CM

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-23A-E314690	14-Nov-21	11:20	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW16-5A-CWP	14-Nov-21	13:20	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C5536

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Nathan Glas	14-Nov-21	18:00	CC	NOV 15 2021	939	6 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C5605**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 16-Nov-2021 16:20
PO	: 1025614	Date Analysis Commenced	: 17-Nov-2021
C-O-C number	: ----	Issue Date	: 24-Nov-2021 18:59
Sampler	: N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Kelley Macdonald	Lab Assistant	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Tracy Harley	Supervisor - Water Quality Instrumentation	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23B-E 314691	BJ-GW16-5B-C WP	----	----	----
				Client sampling date / time	15-Nov-2021 12:05	15-Nov-2021 13:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C5605-001	VA21C5605-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	3.9	4.6	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	98.2	92.1	----	----	----
conductivity	----	E100	2.0	µS/cm	1140	788	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	318	393	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	347	403	----	----	----
pH	----	E108	0.10	pH units	7.83	7.75	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	724	598	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	10.7	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	2.36	0.41	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.907	<0.0050	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.250 DLDS	<0.250 DLDS	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	23.9	<2.50 DLDS	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.328	<0.100 DLDS	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<2.13	<0.057	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	23.1	0.552	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	23.1	0.552	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0126	<0.0050 DLDS	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	22.4	0.575	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0031	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0040	0.0046	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	392	339	----	----	----
Organic / Inorganic Carbon									
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	1.38	<0.50	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	<0.011	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.110	0.0077	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00216	0.00062	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23B-E 314691	BJ-GW16-5B-C WP	----	----	----
				Client sampling date / time	15-Nov-2021 12:05	15-Nov-2021 13:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C5605-001	VA21C5605-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00045	0.00065	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0167	0.0295	----	----	----
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.136	0.025	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000101	0.0000095	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	125	152	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	<0.00010	0.00024	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00013	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00064	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.049	0.021	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000217	0.000068	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.227	0.0099	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	8.43	5.60	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0846	0.00207	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00267	0.000352	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	9.58	2.67	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000911	0.000195	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	1.97	2.51	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, total	17341-25-2	E420	0.050	mg/L	104	7.78	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.28	0.807	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000045	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.00126	0.00108	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	0.0116	----	----	----

Analytical Results

Sub-Matrix: Groundwater (Matrix: Water)				Client sample ID	BJ-GW18-23B-E 314691	BJ-GW16-5B-C WP	----	----	----
				Client sampling date / time	15-Nov-2021 12:05	15-Nov-2021 13:20	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C5605-001	VA21C5605-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	0.0016	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00241	0.00068	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00039	0.00053	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0160	0.0304	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.123	0.023	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000118	0.0000113	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	114	148	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	0.00013	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00011	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00055	0.00081	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000056	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.209	0.0096	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	8.03	5.62	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0852	0.00040	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	0.0000074	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00277	0.000420	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	8.74	2.66	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.00105	0.000218	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.59	2.34	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	17341-25-2	E421	0.050	mg/L	99.8	7.88	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.31	0.866	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000039	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00115	0.00109	----	----	----

Analytical Results

Sub-Matrix: **Groundwater** (Matrix: **Water**)				Client sample ID	**BJ-GW18-23B-E 314691**	**BJ-GW16-5B-C WP**	**----**	**----**	**----**
				Client sampling date / time	15-Nov-2021 12:05	15-Nov-2021 13:20	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C5605-001**	**VA21C5605-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0022	0.0150	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C5605**	Page	: 1 of 15
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 16-Nov-2021 16:20
PO	: 1025614	Issue Date	: 24-Nov-2021 18:59
C-O-C number	: ----		
Sampler	: N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E559	15-Nov-2021	----	----	----		22-Nov-2021	28 days	7 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E559	15-Nov-2021	----	----	----		22-Nov-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E298	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	28 days	7 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E298	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	28 days	7 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B-CWP	E235.Br-L	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.Br-L	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW16-5B-CWP	E235.Cl	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.Cl	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW16-5B-CWP	E378-U	15-Nov-2021	----	----	----		17-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-23B-E314691	E378-U	15-Nov-2021	----	----	----		17-Nov-2021	3 days	2 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW16-5B-CWP	E235.F	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.F	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B-CWP	E235.NO3-L	15-Nov-2021	----	----	----		18-Nov-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.NO3-L	15-Nov-2021	----	----	----		18-Nov-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW16-5B-CWP	E235.NO2-L	15-Nov-2021	----	----	----		18-Nov-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-23B-E314691	E235.NO2-L	15-Nov-2021	----	----	----		18-Nov-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW16-5B-CWP	E235.SO4	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-23B-E314691	E235.SO4	15-Nov-2021	----	----	----		18-Nov-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E366	15-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	8 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E366	15-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E372-U	15-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	8 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E372-U	15-Nov-2021	22-Nov-2021	----	----		23-Nov-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW16-5B-CWP	E421.Cr-L	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	180 days	7 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW18-23B-E314691	E421.Cr-L	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	180 days	7 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW16-5B-CWP	E509	15-Nov-2021	23-Nov-2021	----	----		23-Nov-2021	28 days	8 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-23B-E314691	E509	15-Nov-2021	23-Nov-2021	----	----		23-Nov-2021	28 days	8 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW16-5B-CWP	E421	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	180 days	7 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-23B-E314691	E421	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	180 days	7 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW16-5B-CWP	E355-L	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	28 days	7 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ-GW18-23B-E314691	E355-L	15-Nov-2021	22-Nov-2021	----	----		22-Nov-2021	28 days	7 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW16-5B-CWP	E283	15-Nov-2021	----	----	----		17-Nov-2021	14 days	2 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-23B-E314691	E283	15-Nov-2021	----	----	----		17-Nov-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW16-5B-CWP	E290	15-Nov-2021	----	----	----		17-Nov-2021	14 days	2 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-23B-E314691	E290	15-Nov-2021	----	----	----		17-Nov-2021	14 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW16-5B-CWP	E100	15-Nov-2021	----	----	----		17-Nov-2021	28 days	2 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-23B-E314691	E100	15-Nov-2021	----	----	----		17-Nov-2021	28 days	2 days	✓
Physical Tests : pH by Meter										
HDPE										
BJ-GW16-5B-CWP	E108	15-Nov-2021	----	----	----		17-Nov-2021	0.25 hrs	53 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE										
BJ-GW18-23B-E314691	E108	15-Nov-2021	----	----	----		17-Nov-2021	0.25 hrs	54 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW16-5B-CWP	E162	15-Nov-2021	----	----	----		18-Nov-2021	7 days	3 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW18-23B-E314691	E162	15-Nov-2021	----	----	----		18-Nov-2021	7 days	3 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW16-5B-CWP	E160-H	15-Nov-2021	----	----	----		18-Nov-2021	7 days	3 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW18-23B-E314691	E160-H	15-Nov-2021	----	----	----		18-Nov-2021	7 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW16-5B-CWP	E121	15-Nov-2021	----	----	----		17-Nov-2021	3 days	2 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW18-23B-E314691	E121	15-Nov-2021	----	----	----		17-Nov-2021	3 days	2 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW16-5B-CWP	E420.Cr-L	15-Nov-2021	----	----	----		20-Nov-2021	180 days	5 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW18-23B-E314691	E420.Cr-L	15-Nov-2021	----	----	----		20-Nov-2021	180 days	5 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW16-5B-CWP	E508	15-Nov-2021	----	----	----		23-Nov-2021	28 days	8 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW18-23B-E314691	E508	15-Nov-2021	----	----	----		23-Nov-2021	28 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW16-5B-CWP	E420	15-Nov-2021	----	----	----		20-Nov-2021	180 days	5 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW18-23B-E314691	E420	15-Nov-2021	----	----	----		20-Nov-2021	180 days	5 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW16-5B-CWP	E395-H	15-Nov-2021	----	----	----		17-Nov-2021	7 days	2 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW18-23B-E314691	E395-H	15-Nov-2021	----	----	----		17-Nov-2021	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	347042	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	347041	1	6	16.6	5.0	✓
Ammonia by Fluorescence	E298	350151	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	347868	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	347867	1	18	5.5	5.0	✓
Conductivity in Water	E100	347040	1	6	16.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	349841	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	349842	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	347043	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	347866	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	347864	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	347865	1	18	5.5	5.0	✓
pH by Meter	E108	347039	1	6	16.6	5.0	✓
Sulfate in Water by IC	E235.SO4	347863	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	347548	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348848	1	6	16.6	5.0	✓
Total Mercury in Water by CVAAS	E508	350323	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348847	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	350155	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	350156	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	350153	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	347001	1	2	50.0	5.0	✓
TSS by Gravimetry	E160-H	347539	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	347095	2	40	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	347042	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	347041	1	6	16.6	5.0	✓
Ammonia by Fluorescence	E298	350151	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	347868	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	347867	1	18	5.5	5.0	✓
Conductivity in Water	E100	347040	1	6	16.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	349841	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	349842	1	19	5.2	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	347043	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	347866	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	347864	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	347865	1	18	5.5	5.0	✓
pH by Meter	E108	347039	1	6	16.6	5.0	✓
Sulfate in Water by IC	E235.SO4	347863	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	347548	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348848	1	6	16.6	5.0	✓
Total Mercury in Water by CVAAS	E508	350323	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348847	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	350155	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	350156	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	350153	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	347001	1	2	50.0	5.0	✓
TSS by Gravimetry	E160-H	347539	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	347095	2	40	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	347042	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	347041	1	6	16.6	5.0	✓
Ammonia by Fluorescence	E298	350151	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	347868	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	347867	1	18	5.5	5.0	✓
Conductivity in Water	E100	347040	1	6	16.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	349841	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	349842	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	347043	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	347866	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	347864	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	347865	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	347863	1	18	5.5	5.0	✓
TDS by Gravimetry	E162	347548	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348848	1	6	16.6	5.0	✓
Total Mercury in Water by CVAAS	E508	350323	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348847	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	350155	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	350156	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	350153	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	347001	1	2	50.0	5.0	✓
TSS by Gravimetry	E160-H	347539	1	20	5.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Method Blanks (MB) - Continued							
Turbidity by Nephelometry	E121	347095	2	40	5.0	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	350151	1	17	5.8	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	347868	1	18	5.5	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	349970	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	347867	1	18	5.5	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	349841	1	19	5.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	350308	1	19	5.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	349842	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	347043	1	6	16.6	5.0	✓
Fluoride in Water by IC	E235.F	347866	1	18	5.5	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	347864	1	18	5.5	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	347865	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	347863	1	18	5.5	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	348848	1	6	16.6	5.0	✓
Total Mercury in Water by CVAAS	E508	350323	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	348847	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	350155	1	5	20.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	350156	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	350153	1	7	14.2	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	347001	1	2	50.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H_2S concentration based on the total sulfide concentration in the sample. The H_2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C5605**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 16-Nov-2021 16:20
PO	: 1025614	Date Analysis Commenced	: 17-Nov-2021
C-O-C number	: ----	Issue Date	: 24-Nov-2021 18:59
Sampler	: N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

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General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 347039)											
VA21C5605-001	BJ-GW18-23B-E314691	pH	----	E108	0.10	pH units	7.83	7.62	2.72%	4%	----
Physical Tests (QC Lot: 347040)											
VA21C5605-001	BJ-GW18-23B-E314691	conductivity	----	E100	2.0	µS/cm	1140	1140	0.263%	10%	----
Physical Tests (QC Lot: 347041)											
VA21C5605-001	BJ-GW18-23B-E314691	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	98.2	90.3	8.38%	20%	----
Physical Tests (QC Lot: 347042)											
VA21C5605-002	BJ-GW16-5B-CWP	acidity (as CaCO3)	----	E283	2.0	mg/L	4.6	4.1	0.5	Diff <2x LOR	----
Physical Tests (QC Lot: 347095)											
VA21C5605-001	BJ-GW18-23B-E314691	turbidity	----	E121	0.10	NTU	2.36	2.42	2.34%	15%	----
Physical Tests (QC Lot: 347211)											
VA21C5605-002	BJ-GW16-5B-CWP	turbidity	----	E121	0.10	NTU	0.41	0.45	0.04	Diff <2x LOR	----
Physical Tests (QC Lot: 347539)											
VA21C5627-001	Anonymous	solids, total suspended [TSS]	----	E160-H	3000	mg/L	13700 µg/L	12.7	1.0	Diff <2x LOR	----
Physical Tests (QC Lot: 347548)											
VA21C5605-001	BJ-GW18-23B-E314691	solids, total dissolved [TDS]	----	E162	20	mg/L	724	791	8.91%	20%	----
Anions and Nutrients (QC Lot: 347043)											
VA21C5605-001	BJ-GW18-23B-E314691	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 347863)											
FJ2101304-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	506	507	0.348%	20%	----
Anions and Nutrients (QC Lot: 347864)											
FJ2101304-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	5.78	5.80	0.253%	20%	----
Anions and Nutrients (QC Lot: 347865)											
FJ2101304-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	0.0341	0.0342	0.00009	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 347866)											
FJ2101304-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 347867)											
FJ2101304-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	4.85	4.88	0.02	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 347868)											
FJ2101304-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 350151)											
VA21C5348-050	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0068	0.0058	0.0010	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 350153)											
VA21C5412-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0022	0.0022	0.00003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 350155)											
VA21C5348-050	Anonymous	nitrogen, total	7727-37-9	E366	1.50	mg/L	40.2	40.7	1.29%	20%	----
Organic / Inorganic Carbon (QC Lot: 350156)											
VA21C5412-001	Anonymous	carbon, total organic [TOC]	----	E355-L	0.50	mg/L	2.82	2.88	0.06	Diff <2x LOR	----
Total Sulfides (QC Lot: 347001)											
VA21C5605-001	BJ-GW18-23B-E314691	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 348847)											
VA21C5605-001	BJ-GW18-23B-E314691	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.110	0.121	9.27%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00216	0.00218	0.963%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00045	0.00046	0.000004	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0167	0.0166	0.248%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.136	0.135	0.402%	20%	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000101	0.0000120	0.0000019	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	125	122	2.92%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00013	0.00015	0.00002	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.049	0.051	0.002	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000217	0.000216	0.0000006	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.227	0.225	0.749%	20%	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	8.43	8.25	2.12%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.0846	0.0841	0.667%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00267	0.00270	0.947%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	9.58	9.69	1.07%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000911	0.000816	10.9%	20%	----
		silicon, total	7440-21-3	E420	0.10	mg/L	1.97	1.89	4.15%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	17341-25-2	E420	0.050	mg/L	104	105	1.76%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.28	1.28	0.512%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000045	0.000045	0.0000004	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 348847) - continued											
VA21C5605-001	BJ-GW18-23B-E314691	titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.00126	0.00120	4.35%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 348848)											
VA21C5605-001	BJ-GW18-23B-E314691	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Total Metals (QC Lot: 350323)											
VA21C5440-018	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000066	0.0000066	0.00000008	Diff <2x LOR	----
Dissolved Metals (QC Lot: 349841)											
CG2105741-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 349842)											
CG2105741-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0020	0.0018	0.0001	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00296	0.00300	1.51%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00059	0.00056	0.00003	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.121	0.119	1.44%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.020	mg/L	<0.020 µg/L	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.024	0.023	0.0006	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0050	mg/L	0.256 µg/L	0.000250	2.70%	20%	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	215	208	3.15%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.10	mg/L	5.44 µg/L	0.00542	0.336%	20%	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00065	0.00066	0.000008	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0530	0.0504	4.92%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	98.2	96.9	1.32%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0302	0.0303	0.499%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.0127	0.0129	1.82%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.0504	0.0501	0.657%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	6.91	6.77	2.05%	20%	----
		selenium, dissolved	7782-49-2	E421	0.050	mg/L	193 µg/L	0.192	0.692%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.49	2.44	1.99%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	17341-25-2	E421	0.050	mg/L	1.55	1.54	0.947%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 349842) - continued											
CG2105741-001	Anonymous	strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.263	0.263	0.137%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000143	0.000145	1.61%	20%	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.00718	0.00713	0.704%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0129	0.0131	0.924%	20%	----
Dissolved Metals (QC Lot: 350308)											
KS2103732-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 349970)											
VA21C5536-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 347040)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 347041)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 347042)						
acidity (as CaCO3)	----	E283	2	mg/L	2.3	----
Physical Tests (QCLot: 347095)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 347211)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 347539)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 347548)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 347043)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 347863)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 347864)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 347865)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 347866)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 347867)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 347868)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 350151)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 350153)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 350155)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Organic / Inorganic Carbon (QCLot: 350156)						
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	<0.50	----
Total Sulfides (QCLot: 347001)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----
Total Metals (QCLot: 348847)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	17341-25-2	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 348848)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 348848) - continued						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 350323)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 349841)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 349842)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 349842) - continued						
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 350308)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 349970)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 347039)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 347040)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 347041)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	101	85.0	115	----
Physical Tests (QCLot: 347042)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	99.0	85.0	115	----
Physical Tests (QCLot: 347095)									
turbidity	----	E121	0.1	NTU	200 NTU	105	85.0	115	----
Physical Tests (QCLot: 347211)									
turbidity	----	E121	0.1	NTU	200 NTU	111	85.0	115	----
Physical Tests (QCLot: 347539)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	102	85.0	115	----
Physical Tests (QCLot: 347548)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	96.8	85.0	115	----
Anions and Nutrients (QCLot: 347043)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	103	80.0	120	----
Anions and Nutrients (QCLot: 347863)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 347864)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 347865)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 347866)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 347867)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 347868)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	96.2	85.0	115	----
Anions and Nutrients (QCLot: 350151)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	104	85.0	115	----
Anions and Nutrients (QCLot: 350153)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 350153) - continued									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	90.4	80.0	120	----
Anions and Nutrients (QCLot: 350155)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Organic / Inorganic Carbon (QCLot: 350156)									
carbon, total organic [TOC]	----	E355-L	0.5	mg/L	8.57 mg/L	97.9	80.0	120	----
Total Sulfides (QCLot: 347001)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	113	80.0	120	----
Total Metals (QCLot: 348847)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	107	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	100.0	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	92.1	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	99.9	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	100	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	101	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	99.6	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	99.6	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	103	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	108	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	96.9	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	98.7	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	91.0	80.0	120	----
sodium, total	17341-25-2	E420	0.05	mg/L	50 mg/L	99.2	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	105	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	96.5	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 348847) - continued									
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	99.2	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	101	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	101	80.0	120	----
Total Metals (QCLot: 348848)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
Total Metals (QCLot: 350323)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	104	80.0	120	----
Dissolved Metals (QCLot: 349841)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
Dissolved Metals (QCLot: 349842)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	103	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	96.4	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	94.0	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	92.3	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	101	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	98.9	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	96.0	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	101	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	100	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	99.2	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	99.7	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	99.5	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	99.6	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	100	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	97.3	80.0	120	----
sodium, dissolved	17341-25-2	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	108	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 349842) - continued									
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	100	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	102	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	97.7	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	98.8	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	102	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	102	80.0	120	----
Aggregate Organics (QCLot: 349970)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	108	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 347043)										
VA21C5605-002	BJ-GW16-5B-CWP	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0320 mg/L	0.03 mg/L	106	70.0	130	----
Anions and Nutrients (QCLot: 347863)										
FJ2101304-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	528 mg/L	500 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 347864)										
FJ2101304-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	13.1 mg/L	12.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 347865)										
FJ2101304-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.55 mg/L	2.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 347866)										
FJ2101304-002	Anonymous	fluoride	16984-48-8	E235.F	5.20 mg/L	5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 347867)										
FJ2101304-002	Anonymous	chloride	16887-00-6	E235.Cl	524 mg/L	500 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 347868)										
FJ2101304-002	Anonymous	bromide	24959-67-9	E235.Br-L	2.53 mg/L	2.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 350151)										
VA21C5380-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Anions and Nutrients (QCLot: 350153)										
VA21C5605-001	BJ-GW18-23B-E314691	phosphorus, total	7723-14-0	E372-U	0.0458 mg/L	0.05 mg/L	91.7	70.0	130	----
Anions and Nutrients (QCLot: 350155)										
VA21C5605-001	BJ-GW18-23B-E314691	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Organic / Inorganic Carbon (QCLot: 350156)										
VA21C5597-001	Anonymous	carbon, total organic [TOC]	----	E355-L	5.21 mg/L	5 mg/L	104	70.0	130	----
Total Sulfides (QCLot: 347001)										
VA21C5605-002	BJ-GW16-5B-CWP	sulfide, total (as S)	18496-25-8	E395-H	0.122 mg/L	0.1 mg/L	122	75.0	125	----
Total Metals (QCLot: 348847)										
VA21C5605-002	BJ-GW16-5B-CWP	aluminum, total	7429-90-5	E420	0.200 mg/L	0.2 mg/L	100	70.0	130	----
		antimony, total	7440-36-0	E420	0.0189 mg/L	0.02 mg/L	94.3	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0197 mg/L	0.02 mg/L	98.4	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 348847) - continued										
VA21C5605-002	BJ-GW16-5B-CWP	beryllium, total	7440-41-7	E420	0.0385 mg/L	0.04 mg/L	96.3	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00950 mg/L	0.01 mg/L	95.0	70.0	130	----
		boron, total	7440-42-8	E420	0.090 mg/L	0.1 mg/L	89.7	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00395 mg/L	0.004 mg/L	98.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		copper, total	7440-50-8	E420	0.0188 mg/L	0.02 mg/L	93.9	70.0	130	----
		iron, total	7439-89-6	E420	1.92 mg/L	2 mg/L	95.8	70.0	130	----
		lead, total	7439-92-1	E420	0.0186 mg/L	0.02 mg/L	92.9	70.0	130	----
		lithium, total	7439-93-2	E420	0.0968 mg/L	0.1 mg/L	96.8	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		nickel, total	7440-02-0	E420	0.0377 mg/L	0.04 mg/L	94.2	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.6 mg/L	10 mg/L	106	70.0	130	----
		potassium, total	7440-09-7	E420	3.75 mg/L	4 mg/L	93.8	70.0	130	----
		selenium, total	7782-49-2	E420	0.0397 mg/L	0.04 mg/L	99.3	70.0	130	----
		silicon, total	7440-21-3	E420	9.43 mg/L	10 mg/L	94.3	70.0	130	----
		silver, total	7440-22-4	E420	0.00355 mg/L	0.004 mg/L	88.8	70.0	130	----
		sodium, total	17341-25-2	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00373 mg/L	0.004 mg/L	93.3	70.0	130	----
		tin, total	7440-31-5	E420	0.0186 mg/L	0.02 mg/L	93.0	70.0	130	----
		titanium, total	7440-32-6	E420	0.0393 mg/L	0.04 mg/L	98.2	70.0	130	----
		uranium, total	7440-61-1	E420	0.00386 mg/L	0.004 mg/L	96.6	70.0	130	----
		vanadium, total	7440-62-2	E420	0.100 mg/L	0.1 mg/L	100	70.0	130	----
		zinc, total	7440-66-6	E420	0.382 mg/L	0.4 mg/L	95.5	70.0	130	----
Total Metals (QCLot: 348848)										
VA21C5605-002	BJ-GW16-5B-CWP	chromium, total	7440-47-3	E420.Cr-L	0.0396 mg/L	0.04 mg/L	99.1	70.0	130	----
Total Metals (QCLot: 350323)										
VA21C5440-019	Anonymous	mercury, total	7439-97-6	E508	0.000101 mg/L	0.0001 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 349841)										
CG2105741-002	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.0405 mg/L	0.04 mg/L	101	70.0	130	----
Dissolved Metals (QCLot: 349842)										
CG2105741-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.203 mg/L	0.2 mg/L	102	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 349842) - continued										
CG2105741-002	Anonymous	antimony, dissolved	7440-36-0	E421	0.0215 mg/L	0.02 mg/L	108	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0211 mg/L	0.02 mg/L	105	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0380 mg/L	0.04 mg/L	95.1	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00875 mg/L	0.01 mg/L	87.5	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.095 mg/L	0.1 mg/L	95.5	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00385 mg/L	0.004 mg/L	96.3	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0188 mg/L	0.02 mg/L	94.1	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0178 mg/L	0.02 mg/L	89.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.90 mg/L	2 mg/L	95.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0187 mg/L	0.02 mg/L	93.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0919 mg/L	0.1 mg/L	91.9	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0201 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	11.3 mg/L	10 mg/L	113	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.78 mg/L	10 mg/L	87.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00395 mg/L	0.004 mg/L	98.7	70.0	130	----
		sodium, dissolved	17341-25-2	E421	1.81 mg/L	2 mg/L	90.6	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00361 mg/L	0.004 mg/L	90.2	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0203 mg/L	0.02 mg/L	101	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0415 mg/L	0.04 mg/L	104	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.004 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.377 mg/L	0.4 mg/L	94.2	70.0	130	----
Dissolved Metals (QCLot: 350308)										
KS2103732-003	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000998 mg/L	0.0001 mg/L	99.8	70.0	130	----
Aggregate Organics (QCLot: 349970)										
VA21C5536-002	Anonymous	chemical oxygen demand [COD]	----	E559	121 mg/L	100 mg/L	121	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: NG	

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-23B-E314691	15-Nov-21	12:05	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW16-5B-CWP	15-Nov-21	13:20	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C5605

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Nathan Glas	15-Nov-21	18:00	HA	11/16	4:20P	4 °C				

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C7213**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 06-Dec-2021 21:50
PO	: 1025614	Date Analysis Commenced	: 07-Dec-2021
C-O-C number	: ----	Issue Date	: 16-Dec-2021 17:59
Sampler	: NG/KE		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-3A-E3 03056	BJ-GW11-3A-98	----	----	----
				Client sampling date / time	04-Dec-2021 16:30	04-Dec-2021 16:35	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C7213-001	VA21C7213-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	97.8	99.0	----	----	----
conductivity	----	E100	2.0	µS/cm	365	361	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	164	162	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	152	152	----	----	----
pH	----	E108	0.10	pH units	7.97	7.93	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	214	217	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	20.9	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	5.80	3.96	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0245	0.0246	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.182	0.194	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0051	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.039	0.038	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0012	0.0014	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0047	0.0078	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	86.5	86.6	----	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.168	0.147	----	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	0.179	0.156	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0279	0.0176	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00158	0.00191	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0188	0.0186	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0256	0.0258	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-3A-E3 03056	BJ-GW11-3A-98	----	----	----
				Client sampling date / time	04-Dec-2021 16:30	04-Dec-2021 16:35	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C7213-001	VA21C7213-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.042	0.041	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000086	0.0000098	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	53.8	53.9	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00061	0.00062	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00022	0.00022	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.582	0.565	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000578	0.000567	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0169	0.0166	----	----	----
magnesium, total	7439-95-4	E420	0.100	mg/L	4.39	4.28	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.302	0.288	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000919	0.000892	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00071	0.00065	----	----	----
phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	1.52	1.48	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	3.69	3.77	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	0.000021	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	7.11	6.95	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.13	1.14	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000135	0.000131	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0045	0.0041	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0035	0.0032	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-3A-E3 03056	BJ-GW11-3A-98	----	----	----
				Client sampling date / time	04-Dec-2021 16:30	04-Dec-2021 16:35	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C7213-001	VA21C7213-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00092	0.00096	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0176	0.0174	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0260	0.0256	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000100	mg/L	<0.000100	<0.000100	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.041	0.039	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	58.2	57.6	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00015	0.00013	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00013	0.00012	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.549	0.540	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0161	0.0156	----	----	----
magnesium, dissolved	7439-95-4	E421	0.100	mg/L	4.50	4.38	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.293	0.285	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000902	0.000830	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.300	mg/L	<0.300	<0.300	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.50	1.45	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000166 DTSE	0.000170 DTSE	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	3.62	3.66	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	7.40	7.21	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.13	1.13	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.0100	mg/L	<0.0100	<0.0100	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000127	0.000127	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				Client sample ID	**BJ-GW11-3A-E3 03056**	**BJ-GW11-3A-98**	**----**	**----**	**----**
				Client sampling date / time	04-Dec-2021 16:30	04-Dec-2021 16:35	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA21C7213-001**	**VA21C7213-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0012	<0.0010	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C7213**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 06-Dec-2021 21:50
PO	: 1025614	Issue Date	: 16-Dec-2021 17:59
C-O-C number	: ----		
Sampler	: NG/KE		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-98	E559	04-Dec-2021	----	----	----		14-Dec-2021	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E559	04-Dec-2021	----	----	----		14-Dec-2021	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-98	E298	04-Dec-2021	10-Dec-2021	----	----		10-Dec-2021	28 days	6 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E298	04-Dec-2021	10-Dec-2021	----	----		10-Dec-2021	28 days	6 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-98	E235.Br-L	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-E303056	E235.Br-L	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A-98	E235.Cl	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-3A-E303056	E235.Cl	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A-98	E378-U	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-3A-E303056	E378-U	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A-98	E235.F	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-3A-E303056	E235.F	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-98	E235.NO3-L	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-E303056	E235.NO3-L	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-98	E235.NO2-L	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-3A-E303056	E235.NO2-L	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A-98	E235.SO4	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-3A-E303056	E235.SO4	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-98	E366	04-Dec-2021	10-Dec-2021	----	----		13-Dec-2021	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E366	04-Dec-2021	10-Dec-2021	----	----		13-Dec-2021	28 days	9 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-98	E372-U	04-Dec-2021	10-Dec-2021	----	----		11-Dec-2021	28 days	7 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-3A-E303056	E372-U	04-Dec-2021	10-Dec-2021	----	----		11-Dec-2021	28 days	7 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW11-3A-98	E421.Cr-L	04-Dec-2021	13-Dec-2021	----	----		13-Dec-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW11-3A-E303056	E421.Cr-L	04-Dec-2021	13-Dec-2021	----	----		13-Dec-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A-98	E509	04-Dec-2021	14-Dec-2021	----	----		14-Dec-2021	28 days	10 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-3A-E303056	E509	04-Dec-2021	14-Dec-2021	----	----		14-Dec-2021	28 days	10 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A-98	E421	04-Dec-2021	13-Dec-2021	----	----		13-Dec-2021	180 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-3A-E303056	E421	04-Dec-2021	13-Dec-2021	----	----		13-Dec-2021	180 days	9 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3A-98	E283	04-Dec-2021	----	----	----		07-Dec-2021	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-3A-E303056	E283	04-Dec-2021	----	----	----		07-Dec-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A-98	E290	04-Dec-2021	----	----	----		07-Dec-2021	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-3A-E303056	E290	04-Dec-2021	----	----	----		07-Dec-2021	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A-98	E100	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-3A-E303056	E100	04-Dec-2021	----	----	----		07-Dec-2021	28 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW11-3A-98	E108	04-Dec-2021	----	----	----		07-Dec-2021	0.25 hrs	72 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW11-3A-E303056	E108	04-Dec-2021	----	----	----		07-Dec-2021	0.25 hrs	72 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-3A-98	E162	04-Dec-2021	----	----	----		08-Dec-2021	7 days	4 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-3A-E303056	E162	04-Dec-2021	----	----	----		08-Dec-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-3A-98	E160-H	04-Dec-2021	----	----	----		08-Dec-2021	7 days	4 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-3A-E303056	E160-H	04-Dec-2021	----	----	----		08-Dec-2021	7 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-3A-98	E121	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-3A-E303056	E121	04-Dec-2021	----	----	----		07-Dec-2021	3 days	3 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW11-3A-98	E420.Cr-L	04-Dec-2021	----	----	----		14-Dec-2021	180 days	10 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW11-3A-E303056	E420.Cr-L	04-Dec-2021	----	----	----		14-Dec-2021	180 days	10 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3A-98	E508	04-Dec-2021	----	----	----		14-Dec-2021	28 days	10 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-3A-E303056	E508	04-Dec-2021	----	----	----		14-Dec-2021	28 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A-98	E420	04-Dec-2021	----	----	----		14-Dec-2021	180 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-3A-E303056	E420	04-Dec-2021	----	----	----		14-Dec-2021	180 days	10 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A-98	E395	04-Dec-2021	----	----	----		07-Dec-2021	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-3A-E303056	E395	04-Dec-2021	----	----	----		07-Dec-2021	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	361460	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	361452	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	365004	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	361459	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	367811	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	361458	1	17	5.8	5.0	✓
Conductivity in Water	E100	361450	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	366455	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	367148	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	366456	2	20	10.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	361453	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	361457	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	361455	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	361456	1	17	5.8	5.0	✓
pH by Meter	E108	361451	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	361454	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	362513	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	366894	1	5	20.0	5.0	✓
Total Mercury in Water by CVAAS	E508	367487	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	366893	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	365002	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	365003	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	361411	1	5	20.0	5.0	✓
TSS by Gravimetry	E160-H	362495	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	361795	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	361460	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	361452	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	365004	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	361459	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	367811	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	361458	1	17	5.8	5.0	✓
Conductivity in Water	E100	361450	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	366455	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	367148	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	366456	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	361453	1	12	8.3	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	361457	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	361455	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	361456	1	17	5.8	5.0	✓
pH by Meter	E108	361451	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	361454	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	362513	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	366894	1	5	20.0	5.0	✓
Total Mercury in Water by CVAAS	E508	367487	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	366893	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	365002	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	365003	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	361411	1	5	20.0	5.0	✓
TSS by Gravimetry	E160-H	362495	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	361795	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	361460	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	361452	1	12	8.3	5.0	✓
Ammonia by Fluorescence	E298	365004	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	361459	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	367811	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	361458	1	17	5.8	5.0	✓
Conductivity in Water	E100	361450	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	366455	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	367148	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	366456	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	361453	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	361457	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	361455	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	361456	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	361454	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	362513	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	366894	1	5	20.0	5.0	✓
Total Mercury in Water by CVAAS	E508	367487	1	20	5.0	5.0	✓
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Total Nitrogen by Colourimetry	E366	365002	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	365003	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	361411	1	5	20.0	5.0	✓
TSS by Gravimetry	E160-H	362495	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	361795	1	20	5.0	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	365004	1	6	16.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	361459	1	9	11.1	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	367811	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	361458	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	366455	1	16	6.2	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	367148	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	366456	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	361453	1	12	8.3	5.0	✓
Fluoride in Water by IC	E235.F	361457	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	361455	1	20	5.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	361456	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	361454	1	17	5.8	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	366894	1	5	20.0	5.0	✓
Total Mercury in Water by CVAAS	E508	367487	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	366893	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	365002	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	365003	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	361411	1	5	20.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA21C7213**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 06-Dec-2021 21:50
PO	: 1025614	Date Analysis Commenced	: 07-Dec-2021
C-O-C number	: ----	Issue Date	: 16-Dec-2021 17:59
Sampler	: NG/KE		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 361450)											
VA21C7185-003	Anonymous	conductivity	----	E100	2.0	µS/cm	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 361451)											
VA21C7185-003	Anonymous	pH	----	E108	0.10	pH units	5.46	5.45	0.183%	4%	----
Physical Tests (QC Lot: 361452)											
VA21C7185-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	1.1	1.2	0.1	Diff <2x LOR	----
Physical Tests (QC Lot: 361460)											
VA21C7213-002	BJ-GW11-3A-98	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 361795)											
KS2104025-001	Anonymous	turbidity	----	E121	0.10	NTU	110	103	6.95%	15%	----
Physical Tests (QC Lot: 362495)											
KS2104028-009	Anonymous	solids, total suspended [TSS]	----	E160-H	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 362513)											
FJ2101383-004	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	170	167	2	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 361453)											
VA21C7185-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 361454)											
VA21C7185-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	591	587	0.582%	20%	----
Anions and Nutrients (QC Lot: 361455)											
VA21C7185-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	3.84	3.82	0.666%	20%	----
Anions and Nutrients (QC Lot: 361456)											
VA21C7185-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	0.0636	0.0637	0.0393%	20%	----
Anions and Nutrients (QC Lot: 361457)											
VA21C7185-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.565	0.533	0.032	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 361458)											
VA21C7185-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	<2.50	<2.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 361459)											
VA21C7185-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 365002)											
FJ2101399-001	Anonymous	nitrogen, total	7727-37-9	E366	0.300	mg/L	6.14	6.26	1.84%	20%	----
Anions and Nutrients (QC Lot: 365003)											
FJ2101399-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0200	mg/L	0.126	0.127	0.0017	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 365004)											
FJ2101399-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.156	0.157	0.557%	20%	----
Total Sulfides (QC Lot: 361411)											
EO2104213-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.150	mg/L	0.243	0.268	0.0253	Diff <2x LOR	----
Total Metals (QC Lot: 366893)											
VA21C7213-001	BJ-GW11-3A-E303056	aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0279	0.0304	0.0026	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.00158	0.00161	1.78%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0188	0.0182	3.10%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.0256	0.0252	1.66%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.042	0.041	0.0010	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000086	0.0000107	0.0000022	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	53.8	52.8	1.82%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00022	0.00022	0.000003	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	0.582	0.577	0.889%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.000578	0.000578	0.00986%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.0169	0.0161	4.82%	20%	----
		magnesium, total	7439-95-4	E420	0.100	mg/L	4.39	4.40	0.223%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.302	0.298	1.58%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000919	0.000864	6.27%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00071	0.00070	0.00001	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.300	mg/L	<0.300	<0.300	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	1.52	1.49	2.12%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	3.69	3.68	0.213%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	7440-23-5	E420	0.050	mg/L	7.11	7.00	1.63%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.13	1.12	0.957%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0100	mg/L	<0.0100	<0.0100	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000010	mg/L	0.000135	0.000134	0.560%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0045	0.0046	0.00005	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 366894)											
VA21C7213-001	BJ-GW11-3A-E303056	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00061	0.00062	0.00001	Diff <2x LOR	----
Total Metals (QC Lot: 367487)											
KS2104044-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 366455)											
CG2106439-001	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 366456)											
CG2106439-001	Anonymous	zinc, dissolved	7440-66-6	E421	0.0020	mg/L	0.272	0.276	1.44%	20%	----
CG2106439-001	Anonymous	aluminum, dissolved	7429-90-5	E421	0.0020	mg/L	0.0022	0.0022	0.00003	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00020	mg/L	0.00424	0.00431	1.51%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00020	mg/L	0.0157	0.0155	1.49%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.040	mg/L	<0.040 µg/L	<0.000040	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.020	mg/L	0.104	0.099	0.005	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0100	mg/L	2.32 µg/L	0.00233	0.671%	20%	----
		calcium, dissolved	7440-70-2	E421	0.100	mg/L	590	556	5.88%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.20	mg/L	92.2 µg/L	0.0919	0.350%	20%	----
		copper, dissolved	7440-50-8	E421	0.00040	mg/L	<0.00040	<0.00040	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.020	mg/L	<0.020	<0.020	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0020	mg/L	1.01	0.950	5.78%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0100	mg/L	247	246	0.509%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00020	mg/L	0.345	0.342	0.893%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000100	mg/L	0.00946	0.00946	0.100%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00100	mg/L	0.498	0.501	0.495%	20%	----
		phosphorus, dissolved	7723-14-0	E421	0.100	mg/L	<0.100	<0.100	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.100	mg/L	17.8	17.8	0.0634%	20%	----
		selenium, dissolved	7782-49-2	E421	0.100	mg/L	5.13 µg/L	0.00496	3.47%	20%	----
		silicon, dissolved	7440-21-3	E421	0.100	mg/L	2.91	2.83	2.81%	20%	----
		silver, dissolved	7440-22-4	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		sodium, dissolved	7440-23-5	E421	0.100	mg/L	23.9	24.3	1.60%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00040	mg/L	1.03	1.04	1.07%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000020	mg/L	0.000517	0.000513	0.790%	20%	----
		tin, dissolved	7440-31-5	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00060	mg/L	<0.00060	<0.00060	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 366456) - continued											
CG2106439-001	Anonymous	uranium, dissolved	7440-61-1	E421	0.000020	mg/L	0.0416	0.0404	3.02%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 367148)											
VA21C7213-001	BJ-GW11-3A-E303056	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 367811)											
VA21C7213-001	BJ-GW11-3A-E303056	chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 361450)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 361452)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	1.1	----
Physical Tests (QCLot: 361460)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 361795)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 362495)						
solids, total suspended [TSS]	----	E160-H	3	mg/L	<3.0	----
Physical Tests (QCLot: 362513)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 361453)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 361454)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 361455)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 361456)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 361457)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 361458)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 361459)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 365002)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 365003)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 365004)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 361411)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 366893)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 366894)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Total Metals (QCLot: 367487)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 366455)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 366455) - continued						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 366456)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 367148)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Aggregate Organics (QCLot: 367811)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 367811) - continued						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 361450)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	99.6	90.0	110	----
Physical Tests (QCLot: 361451)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 361452)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	101	85.0	115	----
Physical Tests (QCLot: 361460)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	99.6	85.0	115	----
Physical Tests (QCLot: 361795)									
turbidity	----	E121	0.1	NTU	200 NTU	98.5	85.0	115	----
Physical Tests (QCLot: 362495)									
solids, total suspended [TSS]	----	E160-H	3	mg/L	150 mg/L	102	85.0	115	----
Physical Tests (QCLot: 362513)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	93.9	85.0	115	----
Anions and Nutrients (QCLot: 361453)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	98.8	80.0	120	----
Anions and Nutrients (QCLot: 361454)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 361455)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 361456)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 361457)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 361458)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 361459)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	109	85.0	115	----
Anions and Nutrients (QCLot: 365002)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 365003)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	90.7	80.0	120	----
Anions and Nutrients (QCLot: 365004)									

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 365004) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	96.2	85.0	115	----
Total Sulfides (QCLot: 361411)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	103	80.0	120	----
Total Metals (QCLot: 366893)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	102	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	108	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	94.6	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	101	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	106	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	108	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	95.3	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	106	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	106	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	109	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	107	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	99.8	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	108	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	98.1	80.0	120	----
sodium, total	7440-23-5	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	109	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	95.0	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	98.6	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	103	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	100	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	100.0	80.0	120	----
Total Metals (QCLot: 366894)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 366894) - continued									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
Total Metals (QCLot: 367487)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	96.7	80.0	120	----
Dissolved Metals (QCLot: 366455)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	95.5	80.0	120	----
Dissolved Metals (QCLot: 366456)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	106	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	103	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	103	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	99.0	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.7	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.0	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	99.2	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	103	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	97.8	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	102	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	98.5	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	101	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	106	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	108	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	92.3	80.0	120	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	100	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	98.6	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	98.6	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	96.4	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	101	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Dissolved Metals (QCLot: 366456) - continued									
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	102	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	98.9	80.0	120	----
Aggregate Organics (QCLot: 367811)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	104	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 361453)										
VA21C7185-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0350 mg/L	0.03 mg/L	117	70.0	130	----
Anions and Nutrients (QCLot: 361454)										
VA21C7185-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	100 mg/L	100 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 361455)										
VA21C7185-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	2.47 mg/L	2.5 mg/L	98.7	75.0	125	----
Anions and Nutrients (QCLot: 361456)										
VA21C7185-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.494 mg/L	0.5 mg/L	98.7	75.0	125	----
Anions and Nutrients (QCLot: 361457)										
VA21C7185-002	Anonymous	fluoride	16984-48-8	E235.F	1.00 mg/L	1 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 361458)										
VA21C7185-002	Anonymous	chloride	16887-00-6	E235.Cl	98.0 mg/L	100 mg/L	98.0	75.0	125	----
Anions and Nutrients (QCLot: 361459)										
VA21C7185-002	Anonymous	bromide	24959-67-9	E235.Br-L	0.529 mg/L	0.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 365002)										
VA21C7213-001	BJ-GW11-3A-E303056	nitrogen, total	7727-37-9	E366	0.381 mg/L	0.4 mg/L	95.3	70.0	130	----
Anions and Nutrients (QCLot: 365003)										
VA21C7213-001	BJ-GW11-3A-E303056	phosphorus, total	7723-14-0	E372-U	0.0497 mg/L	0.05 mg/L	99.4	70.0	130	----
Anions and Nutrients (QCLot: 365004)										
VA21C7213-001	BJ-GW11-3A-E303056	ammonia, total (as N)	7664-41-7	E298	0.101 mg/L	0.1 mg/L	101	75.0	125	----
Total Sulfides (QCLot: 361411)										
EO2104221-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	ND mg/L	0.2 mg/L	ND	75.0	125	MS-B
Total Metals (QCLot: 366893)										
VA21C7213-002	BJ-GW11-3A-98	aluminum, total	7429-90-5	E420	0.191 mg/L	0.2 mg/L	95.5	70.0	130	----
		antimony, total	7440-36-0	E420	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, total	7440-41-7	E420	0.0387 mg/L	0.04 mg/L	96.8	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00999 mg/L	0.01 mg/L	99.9	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 366893) - continued										
VA21C7213-002	BJ-GW11-3A-98	boron, total	7440-42-8	E420	0.099 mg/L	0.1 mg/L	99.3	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00403 mg/L	0.004 mg/L	101	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0196 mg/L	0.02 mg/L	98.1	70.0	130	----
		copper, total	7440-50-8	E420	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		iron, total	7439-89-6	E420	1.96 mg/L	2 mg/L	97.9	70.0	130	----
		lead, total	7439-92-1	E420	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		lithium, total	7439-93-2	E420	0.0954 mg/L	0.1 mg/L	95.4	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0205 mg/L	0.02 mg/L	103	70.0	130	----
		nickel, total	7440-02-0	E420	0.0388 mg/L	0.04 mg/L	97.0	70.0	130	----
		phosphorus, total	7723-14-0	E420	10.9 mg/L	10 mg/L	109	70.0	130	----
		potassium, total	7440-09-7	E420	4.02 mg/L	4 mg/L	101	70.0	130	----
		selenium, total	7782-49-2	E420	0.0398 mg/L	0.04 mg/L	99.5	70.0	130	----
		silicon, total	7440-21-3	E420	9.22 mg/L	10 mg/L	92.2	70.0	130	----
		silver, total	7440-22-4	E420	0.00408 mg/L	0.004 mg/L	102	70.0	130	----
		sodium, total	7440-23-5	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00363 mg/L	0.004 mg/L	90.7	70.0	130	----
		tin, total	7440-31-5	E420	0.0194 mg/L	0.02 mg/L	96.8	70.0	130	----
		titanium, total	7440-32-6	E420	0.0394 mg/L	0.04 mg/L	98.6	70.0	130	----
		uranium, total	7440-61-1	E420	0.00404 mg/L	0.004 mg/L	101	70.0	130	----
		vanadium, total	7440-62-2	E420	0.102 mg/L	0.1 mg/L	102	70.0	130	----
		zinc, total	7440-66-6	E420	0.377 mg/L	0.4 mg/L	94.2	70.0	130	----
Total Metals (QCLot: 366894)										
VA21C7213-002	BJ-GW11-3A-98	chromium, total	7440-47-3	E420.Cr-L	0.0396 mg/L	0.04 mg/L	99.0	70.0	130	----
Total Metals (QCLot: 367487)										
VA21C7197-001	Anonymous	mercury, total	7439-97-6	E508	0.0000915 mg/L	0.0001 mg/L	91.5	70.0	130	----
Dissolved Metals (QCLot: 366455)										
CG2106439-002	Anonymous	chromium, dissolved	7440-47-3	E421.Cr-L	0.0747 mg/L	0.08 mg/L	93.4	70.0	130	----
Dissolved Metals (QCLot: 366456)										
CG2106439-002	Anonymous	aluminum, dissolved	7429-90-5	E421	0.382 mg/L	0.4 mg/L	95.6	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0404 mg/L	0.04 mg/L	101	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0410 mg/L	0.04 mg/L	102	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 366456) - continued										
CG2106439-002	Anonymous	barium, dissolved	7440-39-3	E421	0.0384 mg/L	0.04 mg/L	96.0	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0772 mg/L	0.08 mg/L	96.5	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.0164 mg/L	0.02 mg/L	82.2	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.192 mg/L	0.2 mg/L	96.2	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00738 mg/L	0.008 mg/L	92.3	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0358 mg/L	0.04 mg/L	89.5	70.0	130	----
		iron, dissolved	7439-89-6	E421	3.81 mg/L	4 mg/L	95.3	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0364 mg/L	0.04 mg/L	91.0	70.0	130	----
		lithium, dissolved	7439-93-2	E421	ND mg/L	0.2 mg/L	ND	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0423 mg/L	0.04 mg/L	106	70.0	130	----
		nickel, dissolved	7440-02-0	E421	ND mg/L	0.08 mg/L	ND	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	20.5 mg/L	20 mg/L	102	70.0	130	----
		potassium, dissolved	7440-09-7	E421	ND mg/L	8 mg/L	ND	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0883 mg/L	0.08 mg/L	110	70.0	130	----
		silicon, dissolved	7440-21-3	E421	18.0 mg/L	20 mg/L	90.1	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00758 mg/L	0.008 mg/L	94.7	70.0	130	----
		sodium, dissolved	7440-23-5	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.04 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00711 mg/L	0.008 mg/L	88.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0393 mg/L	0.04 mg/L	98.3	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0805 mg/L	0.08 mg/L	100	70.0	130	----
		uranium, dissolved	7440-61-1	E421	ND mg/L	0.008 mg/L	ND	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.200 mg/L	0.2 mg/L	99.9	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.696 mg/L	0.8 mg/L	87.0	70.0	130	----
Dissolved Metals (QCLot: 367148)										
VA21C7213-002	BJ-GW11-3A-98	mercury, dissolved	7439-97-6	E509	0.0000987 mg/L	0.0001 mg/L	98.7	70.0	130	----
Aggregate Organics (QCLot: 367811)										
VA21C7213-002	BJ-GW11-3A-98	chemical oxygen demand [COD]	----	E559	111 mg/L	100 mg/L	111	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025614	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact:	Dean Watt	Sampler: NG/KE

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-3A-E303056	04-Dec-21	16:30	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-3A-98	04-Dec-21	16:35	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA21C7213

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Nathan Glas	5-Dec-21	18:00				5.5 °C	RJ	Dec-6	21:50	

Ice pack

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA22A1683**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-Jan-2022 21:20
PO	: 1025612	Date Analysis Commenced	: 28-Jan-2022
C-O-C number	: ----	Issue Date	: 08-Feb-2022 16:58
Sampler	: ----		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Ruby Pham	Lab Assistant	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW11-1A-99	BJ-GW11-1A-E3 03054	----	----	----
				Client sampling date / time	26-Jan-2022 12:35	26-Jan-2022 12:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1683-001	VA22A1683-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	2.3	<2.0	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	<1.0	72.3	----	----	----
conductivity	----	E100	2.0	µS/cm	<2.0	268	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	<0.50	95.2	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	<0.50	99.1	----	----	----
pH	----	E108	0.10	pH units	5.25	7.91	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	182	----	----	----
solids, total suspended [TSS]	----	E160	3.0	mg/L	<3.0	63.4	----	----	----
turbidity	----	E121	0.10	NTU	<0.10	66.7	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	0.72	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	<0.020	0.119	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.600	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	1.31	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	1.31	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	<0.030	1.25	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	0.0026	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	0.0571	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	<0.30	55.3	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	<0.011	<0.011	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	<0.0030	1.06	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	0.00354	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	0.0249	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	<0.00010	0.0836	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-1A-99	BJ-GW11-1A-E3 03054	----	----	----
				Client sampling date / time	26-Jan-2022 12:35	26-Jan-2022 12:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1683-001	VA22A1683-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	0.000076	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	0.035	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	0.000138	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	<0.050	33.4	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	<0.00010	0.0122	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	0.00158	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00616	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	<0.010	2.37	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	0.00440	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	0.0320	----	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	<0.0050	3.81	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	<0.00010	0.341	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	0.0000102	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	<0.000050	0.00260	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	0.00842	----	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	0.059	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	<0.050	1.71	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	0.000248	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	<0.10	3.58	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	0.000469	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	<0.050	13.3	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	<0.00020	0.739	----	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	<0.50	19.8	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	0.000048	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	0.00011	----	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	0.0184	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	0.000084	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	0.00210	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	0.0369	----	----	----
Dissolved Metals									

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-1A-99	BJ-GW11-1A-E3 03054	----	----	----
				Client sampling date / time	26-Jan-2022 12:35	26-Jan-2022 12:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1683-001	VA22A1683-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	0.0026	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	0.00234	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	0.00291	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	<0.00010	0.0223	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	0.031	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	0.0000079	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	<0.050	32.6	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	0.00083	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00075	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	0.0299	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	<0.0050	3.36	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	0.00242	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	<0.000050	0.00174	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00249	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	1.42	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	0.000205	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	<0.050	1.85	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	<0.050	13.0	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	<0.00020	0.732	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	<0.50	18.8	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW11-1A-99	BJ-GW11-1A-E3 03054	----	----	----
				Client sampling date / time	26-Jan-2022 12:35	26-Jan-2022 12:30	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1683-001	VA22A1683-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	0.000054	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	0.0016	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA22A1683**	Page	: 1 of 15
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-Jan-2022 21:20
PO	: 1025612	Issue Date	: 08-Feb-2022 16:58
C-O-C number	: ----		
Sampler	: ----		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Laboratory Control Sample (LCS) Recoveries								
Total Metals	QC-MRG2-401095002	----	phosphorus, total	7723-14-0	E420	124 % MES	80.0-120%	Recovery greater than upper control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-99	E559	26-Jan-2022	----	----	----		03-Feb-2022	28 days	8 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-E303054	E559	26-Jan-2022	----	----	----		03-Feb-2022	28 days	8 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-99	E298	26-Jan-2022	04-Feb-2022	----	----		04-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-E303054	E298	26-Jan-2022	04-Feb-2022	----	----		04-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A-99	E235.Br-L	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A-E303054	E235.Br-L	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-1A-99	E235.Cl	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW11-1A-E303054	E235.Cl	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-1A-99	E378-U	26-Jan-2022	----	----	----		29-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW11-1A-E303054	E378-U	26-Jan-2022	----	----	----		29-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-1A-99	E235.F	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW11-1A-E303054	E235.F	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A-99	E235.NO3-L	26-Jan-2022	----	----	----		29-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A-E303054	E235.NO3-L	26-Jan-2022	----	----	----		29-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A-99	E235.NO2-L	26-Jan-2022	----	----	----		29-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW11-1A-E303054	E235.NO2-L	26-Jan-2022	----	----	----		29-Jan-2022	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-1A-99	E235.SO4	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW11-1A-E303054	E235.SO4	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-99	E366	26-Jan-2022	04-Feb-2022	----	----		07-Feb-2022	28 days	12 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-E303054	E366	26-Jan-2022	04-Feb-2022	----	----		07-Feb-2022	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-99	E372-U	26-Jan-2022	04-Feb-2022	----	----		05-Feb-2022	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW11-1A-E303054	E372-U	26-Jan-2022	04-Feb-2022	----	----		05-Feb-2022	28 days	10 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW11-1A-99	E421.Cr-L	26-Jan-2022	04-Feb-2022	----	----		04-Feb-2022	180 days	9 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW11-1A-E303054	E421.Cr-L	26-Jan-2022	04-Feb-2022	----	----		04-Feb-2022	180 days	9 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-1A-E303054	E509	26-Jan-2022	31-Jan-2022	----	----		31-Jan-2022	28 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW11-1A-99	E509	26-Jan-2022	02-Feb-2022	----	----		02-Feb-2022	28 days	7 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-1A-99	E421	26-Jan-2022	04-Feb-2022	----	----		04-Feb-2022	180 days	9 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW11-1A-E303054	E421	26-Jan-2022	04-Feb-2022	----	----		04-Feb-2022	180 days	9 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-1A-99	E283	26-Jan-2022	----	----	----		29-Jan-2022	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW11-1A-E303054	E283	26-Jan-2022	----	----	----		29-Jan-2022	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-1A-99	E290	26-Jan-2022	----	----	----		29-Jan-2022	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW11-1A-E303054	E290	26-Jan-2022	----	----	----		29-Jan-2022	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-1A-99	E100	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW11-1A-E303054	E100	26-Jan-2022	----	----	----		29-Jan-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW11-1A-99	E108	26-Jan-2022	----	----	----		29-Jan-2022	0.25 hrs	67 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW11-1A-E303054	E108	26-Jan-2022	----	----	----		29-Jan-2022	0.25 hrs	68 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-1A-99	E162	26-Jan-2022	----	----	----		28-Jan-2022	7 days	2 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW11-1A-E303054	E162	26-Jan-2022	----	----	----		28-Jan-2022	7 days	2 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-1A-99	E160	26-Jan-2022	----	----	----		28-Jan-2022	7 days	2 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW11-1A-E303054	E160	26-Jan-2022	----	----	----		28-Jan-2022	7 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-1A-99	E121	26-Jan-2022	----	----	----		28-Jan-2022	3 days	2 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW11-1A-E303054	E121	26-Jan-2022	----	----	----		28-Jan-2022	3 days	2 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW11-1A-99	E420.Cr-L	26-Jan-2022	----	----	----		03-Feb-2022	180 days	8 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW11-1A-E303054	E420.Cr-L	26-Jan-2022	----	----	----		03-Feb-2022	180 days	8 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-1A-99	E508	26-Jan-2022	----	----	----		01-Feb-2022	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
BJ-GW11-1A-E303054	E508	26-Jan-2022	----	----	----		04-Feb-2022	28 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-1A-99	E420	26-Jan-2022	----	----	----		03-Feb-2022	180 days	8 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ-GW11-1A-E303054	E420	26-Jan-2022	----	----	----		03-Feb-2022	180 days	8 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-1A-99	E395-H	26-Jan-2022	----	----	----		28-Jan-2022	7 days	2 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
BJ-GW11-1A-E303054	E395-H	26-Jan-2022	----	----	----		28-Jan-2022	7 days	2 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	397650	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	397648	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	402355	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	397655	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	401575	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	397654	1	15	6.6	5.0	✓
Conductivity in Water	E100	397649	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	402203	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	398726	2	37	5.4	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	402202	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	397663	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	397653	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	397651	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	397652	1	19	5.2	5.0	✓
pH by Meter	E108	397647	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	397656	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	397240	1	5	20.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	401096	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	399869	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	401095	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	402352	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	402353	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	397454	1	20	5.0	5.0	✓
TSS by Gravimetry	E160	397236	1	5	20.0	5.0	✓
Turbidity by Nephelometry	E121	397307	1	20	5.0	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	397650	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	397648	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	402355	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	397655	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	401575	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	397654	1	15	6.6	5.0	✓
Conductivity in Water	E100	397649	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	402203	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	398726	2	37	5.4	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	402202	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	397663	1	9	11.1	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	397653	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	397651	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	397652	1	19	5.2	5.0	✓
pH by Meter	E108	397647	1	17	5.8	5.0	✓
Sulfate in Water by IC	E235.SO4	397656	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	397240	1	5	20.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	401096	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	399869	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	401095	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	402352	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	402353	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	397454	1	20	5.0	5.0	✓
TSS by Gravimetry	E160	397236	1	5	20.0	5.0	✓
Turbidity by Nephelometry	E121	397307	1	20	5.0	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	397650	1	6	16.6	5.0	✓
Alkalinity Species by Titration	E290	397648	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	402355	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	397655	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	401575	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	397654	1	15	6.6	5.0	✓
Conductivity in Water	E100	397649	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	402203	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	398726	2	37	5.4	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	402202	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	397663	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	397653	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	397651	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	397652	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	397656	1	15	6.6	5.0	✓
TDS by Gravimetry	E162	397240	1	5	20.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	401096	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	399869	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	401095	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	402352	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	402353	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	397454	1	20	5.0	5.0	✓
TSS by Gravimetry	E160	397236	1	5	20.0	5.0	✓
Turbidity by Nephelometry	E121	397307	1	20	5.0	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	402355	1	11	9.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	397655	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	401575	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	397654	1	15	6.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	402203	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	398726	2	37	5.4	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	402202	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	397663	1	9	11.1	5.0	✓
Fluoride in Water by IC	E235.F	397653	1	15	6.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	397651	1	15	6.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	397652	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	397656	1	15	6.6	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	401096	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	399869	2	40	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	401095	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	402352	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	402353	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	397454	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160 Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA22A1683**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 27-Jan-2022 21:20
PO	: 1025612	Date Analysis Commenced	: 28-Jan-2022
C-O-C number	: ----	Issue Date	: 08-Feb-2022 16:58
Sampler	: ----		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Dan Gebert	Laboratory Analyst	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Owen Cheng		Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Ruby Pham	Lab Assistant	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 397236)											
VA22A1657-005	Anonymous	solids, total suspended [TSS]	----	E160	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 397240)											
VA22A1657-005	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	128	128	0.5	Diff <2x LOR	----
Physical Tests (QC Lot: 397307)											
VA22A1425-001	Anonymous	turbidity	----	E121	0.10	NTU	0.32	0.28	0.04	Diff <2x LOR	----
Physical Tests (QC Lot: 397647)											
VA22A1632-003	Anonymous	pH	----	E108	0.10	pH units	7.37	7.37	0.00%	4%	----
Physical Tests (QC Lot: 397648)											
VA22A1632-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	306	308	0.814%	20%	----
Physical Tests (QC Lot: 397649)											
VA22A1632-003	Anonymous	conductivity	----	E100	2.0	µS/cm	713	722	1.25%	10%	----
Physical Tests (QC Lot: 397650)											
VA22A1657-004	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 397651)											
VA22A1632-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 397652)											
VA22A1632-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0050	0.0043	0.0007	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 397653)											
VA22A1632-001	Anonymous	fluoride	16984-48-8	E235.F	0.020	mg/L	0.103	0.103	0.0005	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 397654)											
VA22A1632-001	Anonymous	chloride	16887-00-6	E235.Cl	0.50	mg/L	21.6	22.7	5.10%	20%	----
Anions and Nutrients (QC Lot: 397655)											
VA22A1632-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 397656)											
VA22A1632-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	26.7	28.4	6.28%	20%	----
Anions and Nutrients (QC Lot: 397663)											
VA22A1657-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0017	0.0015	0.0002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 402352)											
VA22A1639-001	Anonymous	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.234	0.215	0.019	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 402353)											
VA22A1639-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0034	0.0032	0.0002	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 402355)											
VA22A1639-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 397454)											
CG2200901-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Total Metals (QC Lot: 399869)											
KS2200261-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 401095)											
VA22A1683-001	BJ-GW11-1A-99	aluminum, total	7429-90-5	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	<0.10	<0.10	0	Diff <2x LOR	----
		silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, total	7440-23-5	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		sulfur, total	7704-34-9	E420	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 401095) - continued											
VA22A1683-001	BJ-GW11-1A-99	uranium, total	7440-61-1	E420	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	<0.0030	0	Diff <2x LOR	----
Total Metals (QC Lot: 401096)											
VA22A1683-001	BJ-GW11-1A-99	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Total Metals (QC Lot: 402195)											
FJ2200298-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 398726)											
VA22A1657-005	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 400013)											
CG2200927-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 402202)											
VA22A1683-001	BJ-GW11-1A-99	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 402202) - continued											
VA22A1683-001	BJ-GW11-1A-99	sodium, dissolved	7440-23-5	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		sulfur, dissolved	7704-34-9	E421	0.50	mg/L	<0.50	<0.50	0	Diff <2x LOR	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 402203)											
VA22A1683-001	BJ-GW11-1A-99	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
Aggregate Organics (QC Lot: 401575)											
FJ2200236-001	Anonymous	chemical oxygen demand [COD]	----	E559	80	mg/L	2160	2170	0.212%	20%	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 397236)						
solids, total suspended [TSS]	----	E160	3	mg/L	<3.0	----
Physical Tests (QCLot: 397240)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 397307)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 397648)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 397649)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 397650)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Anions and Nutrients (QCLot: 397651)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 397652)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 397653)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 397654)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 397655)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 397656)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 397663)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 402352)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 402353)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 402355)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Total Sulfides (QCLot: 397454)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 399869)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 401095)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
sulfur, total	7704-34-9	E420	0.5	mg/L	<0.50	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 401096)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 402195)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 398726)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 400013)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 402202)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	<0.50	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 402202) - continued						
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 402203)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Aggregate Organics (QCLot: 401575)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 397236)									
solids, total suspended [TSS]	----	E160	3	mg/L	150 mg/L	94.7	85.0	115	----
Physical Tests (QCLot: 397240)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	100	85.0	115	----
Physical Tests (QCLot: 397307)									
turbidity	----	E121	0.1	NTU	200 NTU	108	85.0	115	----
Physical Tests (QCLot: 397647)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 397648)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	102	85.0	115	----
Physical Tests (QCLot: 397649)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	103	90.0	110	----
Physical Tests (QCLot: 397650)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	98.2	85.0	115	----
Anions and Nutrients (QCLot: 397651)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	99.7	90.0	110	----
Anions and Nutrients (QCLot: 397652)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 397653)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	102	90.0	110	----
Anions and Nutrients (QCLot: 397654)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	99.8	90.0	110	----
Anions and Nutrients (QCLot: 397655)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	91.3	85.0	115	----
Anions and Nutrients (QCLot: 397656)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 397663)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	98.2	80.0	120	----
Anions and Nutrients (QCLot: 402352)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	105	75.0	125	----
Anions and Nutrients (QCLot: 402353)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	95.8	80.0	120	----
Anions and Nutrients (QCLot: 402355)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Anions and Nutrients (QCLot: 402355) - continued									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	96.6	85.0	115	----
Total Sulfides (QCLot: 397454)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	100.0	80.0	120	----
Total Metals (QCLot: 399869)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	95.7	80.0	120	----
Total Metals (QCLot: 401095)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	104	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	117	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	106	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	96.9	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	98.3	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	93.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	106	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	103	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	105	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	99.5	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	95.7	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	104	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	114	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	# 124	80.0	120	MES
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	101	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	110	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	105	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	97.3	80.0	120	----
sodium, total	7440-23-5	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	105	80.0	120	----
sulfur, total	7704-34-9	E420	0.5	mg/L	50 mg/L	107	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	106	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	101	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	95.8	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 401095) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	99.5	80.0	120	----
Total Metals (QCLot: 401096)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
Total Metals (QCLot: 402195)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	94.3	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	100	80.0	120	----
Dissolved Metals (QCLot: 402202)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	95.8	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	98.0	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	98.6	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	99.8	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	92.8	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	94.7	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	87.6	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	97.1	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	95.8	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	96.6	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	95.6	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	98.3	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	92.4	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	91.9	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	96.1	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	99.2	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	99.6	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	96.2	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	111	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	98.7	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	100	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	97.4	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	90.3	80.0	120	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	50 mg/L	95.1	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	97.2	80.0	120	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	50 mg/L	92.5	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	93.5	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 402202) - continued									
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	97.0	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	94.2	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	90.0	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	96.5	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	96.7	80.0	120	----
Dissolved Metals (QCLot: 402203)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	96.7	80.0	120	----
Aggregate Organics (QCLot: 401575)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	110	85.0	115	----

Qualifiers

Qualifier	Description
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 397651)										
VA22A1632-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	13.0 mg/L	12.5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 397652)										
VA22A1632-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.59 mg/L	2.5 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 397653)										
VA22A1632-002	Anonymous	fluoride	16984-48-8	E235.F	5.22 mg/L	5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 397654)										
VA22A1632-002	Anonymous	chloride	16887-00-6	E235.Cl	529 mg/L	500 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 397655)										
VA22A1632-002	Anonymous	bromide	24959-67-9	E235.Br-L	2.44 mg/L	2.5 mg/L	97.6	75.0	125	----
Anions and Nutrients (QCLot: 397656)										
VA22A1632-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	534 mg/L	500 mg/L	107	75.0	125	----
Anions and Nutrients (QCLot: 397663)										
VA22A1657-004	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0298 mg/L	0.03 mg/L	99.3	70.0	130	----
Anions and Nutrients (QCLot: 402352)										
VA22A1683-001	BJ-GW11-1A-99	nitrogen, total	7727-37-9	E366	0.405 mg/L	0.4 mg/L	101	70.0	130	----
Anions and Nutrients (QCLot: 402353)										
VA22A1683-001	BJ-GW11-1A-99	phosphorus, total	7723-14-0	E372-U	0.0472 mg/L	0.05 mg/L	94.5	70.0	130	----
Anions and Nutrients (QCLot: 402355)										
VA22A1683-001	BJ-GW11-1A-99	ammonia, total (as N)	7664-41-7	E298	0.0970 mg/L	0.1 mg/L	97.0	75.0	125	----
Total Sulfides (QCLot: 397454)										
CG2200921-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	1.01 mg/L	1 mg/L	101	75.0	125	----
Total Metals (QCLot: 399869)										
KS2200261-002	Anonymous	mercury, total	7439-97-6	E508	0.0000904 mg/L	0.0001 mg/L	90.4	70.0	130	----
Total Metals (QCLot: 401095)										
VA22A1683-002	BJ-GW11-1A-E303054	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	0.0206 mg/L	0.02 mg/L	103	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 401095) - continued										
VA22A1683-002	BJ-GW11-1A-E303054	beryllium, total	7440-41-7	E420	0.0387 mg/L	0.04 mg/L	96.7	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00883 mg/L	0.01 mg/L	88.3	70.0	130	----
		boron, total	7440-42-8	E420	0.095 mg/L	0.1 mg/L	94.8	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00393 mg/L	0.004 mg/L	98.2	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0190 mg/L	0.02 mg/L	94.8	70.0	130	----
		copper, total	7440-50-8	E420	0.0187 mg/L	0.02 mg/L	93.4	70.0	130	----
		iron, total	7439-89-6	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		lead, total	7439-92-1	E420	0.0185 mg/L	0.02 mg/L	92.6	70.0	130	----
		lithium, total	7439-93-2	E420	0.0937 mg/L	0.1 mg/L	93.7	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0203 mg/L	0.02 mg/L	102	70.0	130	----
		nickel, total	7440-02-0	E420	0.0373 mg/L	0.04 mg/L	93.2	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.1 mg/L	10 mg/L	111	70.0	130	----
		potassium, total	7440-09-7	E420	3.67 mg/L	4 mg/L	91.8	70.0	130	----
		selenium, total	7782-49-2	E420	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
		silicon, total	7440-21-3	E420	9.56 mg/L	10 mg/L	95.6	70.0	130	----
		silver, total	7440-22-4	E420	0.00385 mg/L	0.004 mg/L	96.3	70.0	130	----
		sodium, total	7440-23-5	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, total	7704-34-9	E420	17.8 mg/L	20 mg/L	89.0	70.0	130	----
		thallium, total	7440-28-0	E420	0.00370 mg/L	0.004 mg/L	92.4	70.0	130	----
		tin, total	7440-31-5	E420	0.0204 mg/L	0.02 mg/L	102	70.0	130	----
		titanium, total	7440-32-6	E420	0.0358 mg/L	0.04 mg/L	89.4	70.0	130	----
		uranium, total	7440-61-1	E420	0.00372 mg/L	0.004 mg/L	92.9	70.0	130	----
		vanadium, total	7440-62-2	E420	0.0970 mg/L	0.1 mg/L	97.0	70.0	130	----
		zinc, total	7440-66-6	E420	0.376 mg/L	0.4 mg/L	94.1	70.0	130	----
Total Metals (QCLot: 401096)										
VA22A1683-002	BJ-GW11-1A-E303054	chromium, total	7440-47-3	E420.Cr-L	0.0372 mg/L	0.04 mg/L	92.9	70.0	130	----
Total Metals (QCLot: 402195)										
FJ2200298-002	Anonymous	mercury, total	7439-97-6	E508	0.0000944 mg/L	0.0001 mg/L	94.4	70.0	130	----
Dissolved Metals (QCLot: 398726)										
VA22A1657-006	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000832 mg/L	0.0001 mg/L	83.2	70.0	130	----
Dissolved Metals (QCLot: 400013)										

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 400013) - continued										
CG2200927-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000960 mg/L	0.0001 mg/L	96.0	70.0	130	----
Dissolved Metals (QCLot: 402202)										
VA22A1683-002	BJ-GW11-1A-E303054	aluminum, dissolved	7429-90-5	E421	0.186 mg/L	0.2 mg/L	92.9	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0196 mg/L	0.02 mg/L	98.2	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0190 mg/L	0.02 mg/L	94.8	70.0	130	----
		barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0364 mg/L	0.04 mg/L	90.9	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00833 mg/L	0.01 mg/L	83.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.086 mg/L	0.1 mg/L	86.3	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00381 mg/L	0.004 mg/L	95.4	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0184 mg/L	0.02 mg/L	92.2	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0185 mg/L	0.02 mg/L	92.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.84 mg/L	2 mg/L	92.2	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0180 mg/L	0.02 mg/L	90.2	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0877 mg/L	0.1 mg/L	87.7	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0189 mg/L	0.02 mg/L	94.3	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0369 mg/L	0.04 mg/L	92.2	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.7 mg/L	10 mg/L	107	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.69 mg/L	4 mg/L	92.3	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0403 mg/L	0.04 mg/L	101	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.38 mg/L	10 mg/L	93.8	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00373 mg/L	0.004 mg/L	93.3	70.0	130	----
		sodium, dissolved	7440-23-5	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, dissolved	7704-34-9	E421	21.7 mg/L	20 mg/L	109	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00361 mg/L	0.004 mg/L	90.2	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0191 mg/L	0.02 mg/L	95.6	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0375 mg/L	0.04 mg/L	93.7	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00358 mg/L	0.004 mg/L	89.4	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0945 mg/L	0.1 mg/L	94.5	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.384 mg/L	0.4 mg/L	96.0	70.0	130	----
Dissolved Metals (QCLot: 402203)										
VA22A1683-002	BJ-GW11-1A-E303054	chromium, dissolved	7440-47-3	E421.Cr-L	0.0372 mg/L	0.04 mg/L	93.1	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Aggregate Organics (QCLot: 401575)										
VA22A1632-001	Anonymous	chemical oxygen demand [COD]	----	E559	ND mg/L	100 mg/L	ND	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025612	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: RS/KU

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW11-1A - 99	26-Jan-22	12:35	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW11-1A - E303054	26-Jan-22	12:30	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division
Vancouver
Work Order Reference
VA22A1683

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Kevin Udema	26-Jan-21	18:00				9 °C	RJ	JAN-27	21:20	

NA-FM-0326d v06 Front / 22 May 2013

Icepack.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA22A1795**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-Jan-2022 21:15
PO	: 1025612	Date Analysis Commenced	: 30-Jan-2022
C-O-C number	: ----	Issue Date	: 09-Feb-2022 17:14
Sampler	: K U, N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW12-8A-E3 03059	BJ-GW12-8B-E3 14695	Travel Blank	----	----
				Client sampling date / time	27-Jan-2022 11:20	27-Jan-2022 13:05	27-Jan-2022 08:30	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1795-001	VA22A1795-002	VA22A1795-003	--------	--------
					Result	Result	Result	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	<2.0	2.7	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	60.7	70.1	1.1	----	----
conductivity	----	E100	2.0	µS/cm	202	208	<2.0	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	96.6	99.1	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	99.9	102	<0.50	----	----
pH	----	E108	0.10	pH units	8.05	8.02	5.71	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	141	132	<10	----	----
solids, total suspended [TSS]	----	E160	3.0	mg/L	15.4	4.6	<3.0	----	----
turbidity	----	E121	0.10	NTU	12.4	3.16	<0.10	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	<0.0050	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	<0.050	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	<0.50	<0.50	<0.50	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.029	0.027	<0.020	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	<0.050	<0.050	<0.050	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.0154	0.0165	<0.0050	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	0.0154	0.0165	<0.0051	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	<0.0010	<0.0010	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.030	<0.030	<0.030	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	<0.0010	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0100	0.0063	<0.0020	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	33.4	35.7	<0.30	----	----
Total Sulfides									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	<0.0015	----	----
sulfide, total (as H2S)	7783-06-4	E395	0.0016	mg/L	<0.0016	<0.0016	<0.0016	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.407	0.339	<0.0030	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00120	0.00090	<0.00010	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0200	0.0179	<0.00010	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0372	0.0309	<0.00010	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW12-8A-E3 03059	BJ-GW12-8B-E3 14695	Travel Blank	----	----
				Client sampling date / time	27-Jan-2022 11:20	27-Jan-2022 13:05	27-Jan-2022 08:30	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1795-001	VA22A1795-002	VA22A1795-003	--------	--------
					Result	Result	Result	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000029	0.000020	<0.000020	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	<0.000050	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	<0.010	<0.010	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000618	0.0000097	<0.0000050	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	30.4	33.1	<0.050	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.00927	0.00432	<0.00010	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00101	0.00044	<0.00010	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00415	0.00118	<0.00050	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.874	0.319	<0.010	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00146	0.000347	<0.000050	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0087	0.0069	<0.0010	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	5.83	4.63	<0.0050	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0848	0.0458	<0.00010	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00244	0.00169	<0.000050	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00636	0.00267	<0.00050	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	<0.050	<0.050	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.639	0.625	<0.050	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000183	0.000312	<0.000050	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	2.65	2.53	<0.10	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.000192	0.000018	<0.000010	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	3.33	2.57	<0.050	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.710	0.558	<0.00020	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	10.9	11.4	<0.50	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000016	<0.000010	<0.000010	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00026	<0.00010	<0.00010	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00360 DLM	<0.00450 DLM	<0.00030	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000206	0.000177	<0.000010	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00078	0.00080	<0.00050	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0098	<0.0030	<0.0030	----	----
Dissolved Metals									

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW12-8A-E3 03059	BJ-GW12-8B-E3 14695	Travel Blank	----	----
				Client sampling date / time	27-Jan-2022 11:20	27-Jan-2022 13:05	27-Jan-2022 08:30	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1795-001	VA22A1795-002	VA22A1795-003	--------	--------
					Result	Result	Result	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0039	0.0023	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00089	0.00080	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00812	0.0131	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0211	0.0192	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000095	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	29.4	32.4	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00039	0.00067	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00013	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00032	0.00146	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0080	0.0062	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	5.62	4.41	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00260	0.00381	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00213	0.00158	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00225	0.00116	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.452	0.484	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000182	0.000255	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.02	2.09	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	3.28	2.50	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.720	0.558	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	11.8	12.2	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW12-8A-E3 03059	BJ-GW12-8B-E3 14695	Travel Blank	----	----
				Client sampling date / time	27-Jan-2022 11:20	27-Jan-2022 13:05	27-Jan-2022 08:30	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1795-001	VA22A1795-002	VA22A1795-003	--------	--------
					Result	Result	Result	----	----
Dissolved Metals									
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000172	0.000193	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0014	0.0014	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	<20	<20	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA22A1795**	Page	: 1 of 17
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-Jan-2022 21:15
PO	: 1025612	Issue Date	: 09-Feb-2022 17:14
C-O-C number	: ----		
Sampler	: K U, N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E559	27-Jan-2022	----	----	----		07-Feb-2022	28 days	11 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E559	27-Jan-2022	----	----	----		07-Feb-2022	28 days	11 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
Travel Blank	E559	27-Jan-2022	----	----	----		07-Feb-2022	28 days	11 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E298	27-Jan-2022	05-Feb-2022	----	----		07-Feb-2022	28 days	11 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E298	27-Jan-2022	05-Feb-2022	----	----		07-Feb-2022	28 days	11 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Travel Blank	E298	27-Jan-2022	05-Feb-2022	----	----		07-Feb-2022	28 days	11 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.Br-L	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.Br-L	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.Br-L	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.Cl	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.Cl	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Travel Blank	E235.Cl	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8A-E303059	E378-U	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW12-8B-E314695	E378-U	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Travel Blank	E378-U	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.F	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.F	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Travel Blank	E235.F	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.NO3-L	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.NO3-L	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.NO3-L	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8A-E303059	E235.NO2-L	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW12-8B-E314695	E235.NO2-L	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Travel Blank	E235.NO2-L	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8A-E303059	E235.SO4	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW12-8B-E314695	E235.SO4	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Travel Blank	E235.SO4	27-Jan-2022	----	----	----		30-Jan-2022	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E366	27-Jan-2022	05-Feb-2022	----	----		09-Feb-2022	28 days	13 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E366	27-Jan-2022	05-Feb-2022	----	----		09-Feb-2022	28 days	13 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Travel Blank	E366	27-Jan-2022	05-Feb-2022	----	----		09-Feb-2022	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8A-E303059	E372-U	27-Jan-2022	05-Feb-2022	----	----		08-Feb-2022	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW12-8B-E314695	E372-U	27-Jan-2022	05-Feb-2022	----	----		08-Feb-2022	28 days	12 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Travel Blank	E372-U	27-Jan-2022	05-Feb-2022	----	----		08-Feb-2022	28 days	12 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW12-8A-E303059	E421.Cr-L	27-Jan-2022	07-Feb-2022	----	----		07-Feb-2022	180 days	11 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW12-8B-E314695	E421.Cr-L	27-Jan-2022	07-Feb-2022	----	----		07-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8A-E303059	E509	27-Jan-2022	03-Feb-2022	----	----		03-Feb-2022	28 days	7 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW12-8B-E314695	E509	27-Jan-2022	03-Feb-2022	----	----		03-Feb-2022	28 days	7 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8A-E303059	E421	27-Jan-2022	07-Feb-2022	----	----		07-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW12-8B-E314695	E421	27-Jan-2022	07-Feb-2022	----	----		07-Feb-2022	180 days	11 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8A-E303059	E283	27-Jan-2022	----	----	----		31-Jan-2022	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW12-8B-E314695	E283	27-Jan-2022	----	----	----		31-Jan-2022	14 days	4 days	✓
Physical Tests : Acidity by Titration										
HDPE										
Travel Blank	E283	27-Jan-2022	----	----	----		31-Jan-2022	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW12-8A-E303059	E290	27-Jan-2022	----	----	----		31-Jan-2022	14 days	4 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE BJ-GW12-8B-E314695	E290	27-Jan-2022	----	----	----		31-Jan-2022	14 days	4 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE Travel Blank	E290	27-Jan-2022	----	----	----		31-Jan-2022	14 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8A-E303059	E100	27-Jan-2022	----	----	----		31-Jan-2022	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ-GW12-8B-E314695	E100	27-Jan-2022	----	----	----		31-Jan-2022	28 days	4 days	✓
Physical Tests : Conductivity in Water										
HDPE Travel Blank	E100	27-Jan-2022	----	----	----		31-Jan-2022	28 days	4 days	✓
Physical Tests : pH by Meter										
HDPE BJ-GW12-8B-E314695	E108	27-Jan-2022	----	----	----		31-Jan-2022	0.25 hrs	89 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW12-8A-E303059	E108	27-Jan-2022	----	----	----		31-Jan-2022	0.25 hrs	91 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE Travel Blank	E108	27-Jan-2022	----	----	----		31-Jan-2022	0.25 hrs	93 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW12-8A-E303059	E162	27-Jan-2022	----	----	----		02-Feb-2022	7 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
BJ-GW12-8B-E314695	E162	27-Jan-2022	----	----	----		02-Feb-2022	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE										
Travel Blank	E162	27-Jan-2022	----	----	----		02-Feb-2022	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8A-E303059	E160	27-Jan-2022	----	----	----		02-Feb-2022	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
BJ-GW12-8B-E314695	E160	27-Jan-2022	----	----	----		02-Feb-2022	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE										
Travel Blank	E160	27-Jan-2022	----	----	----		02-Feb-2022	7 days	6 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8A-E303059	E121	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ-GW12-8B-E314695	E121	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE										
Travel Blank	E121	27-Jan-2022	----	----	----		30-Jan-2022	3 days	3 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid)										
BJ-GW12-8A-E303059	E420.Cr-L	27-Jan-2022	----	----	----		05-Feb-2022	180 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW12-8B-E314695	E420.Cr-L	27-Jan-2022	----	----	----		05-Feb-2022	180 days	9 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) Travel Blank	E420.Cr-L	27-Jan-2022	----	----	----		05-Feb-2022	180 days	9 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW12-8A-E303059	E508	27-Jan-2022	----	----	----		02-Feb-2022	28 days	6 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW12-8B-E314695	E508	27-Jan-2022	----	----	----		02-Feb-2022	28 days	6 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW12-8A-E303059	E420	27-Jan-2022	----	----	----		05-Feb-2022	180 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW12-8B-E314695	E420	27-Jan-2022	----	----	----		05-Feb-2022	180 days	9 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Travel Blank	E420	27-Jan-2022	----	----	----		05-Feb-2022	180 days	9 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW12-8A-E303059	E395	27-Jan-2022	----	----	----		31-Jan-2022	7 days	4 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW12-8B-E314695	E395	27-Jan-2022	----	----	----		31-Jan-2022	7 days	4 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide)										
Travel Blank	E395	27-Jan-2022	----	----	----		31-Jan-2022	7 days	4 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	398280	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	398272	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	403188	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	398276	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	404339	1	15	6.6	5.0	✓
Chloride in Water by IC	E235.Cl	398275	1	13	7.6	5.0	✓
Conductivity in Water	E100	398271	1	15	6.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	403193	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401362	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	403192	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	398281	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	398274	1	13	7.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	398277	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	398278	1	13	7.6	5.0	✓
pH by Meter	E108	398270	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	398279	1	13	7.6	5.0	✓
TDS by Gravimetry	E162	399992	1	13	7.6	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	403122	1	7	14.2	5.0	✓
Total Mercury in Water by CVAAS	E508	400918	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	403121	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	403186	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403187	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	398480	1	19	5.2	5.0	✓
TSS by Gravimetry	E160	399994	1	12	8.3	5.0	✓
Turbidity by Nephelometry	E121	398087	2	21	9.5	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	398280	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	398272	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	403188	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	398276	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	404339	1	15	6.6	5.0	✓
Chloride in Water by IC	E235.Cl	398275	1	13	7.6	5.0	✓
Conductivity in Water	E100	398271	1	15	6.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	403193	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401362	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	403192	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	398281	1	10	10.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	398274	1	13	7.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	398277	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	398278	1	13	7.6	5.0	✓
pH by Meter	E108	398270	1	15	6.6	5.0	✓
Sulfate in Water by IC	E235.SO4	398279	1	13	7.6	5.0	✓
TDS by Gravimetry	E162	399992	1	13	7.6	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	403122	1	7	14.2	5.0	✓
Total Mercury in Water by CVAAS	E508	400918	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	403121	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	403186	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403187	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	398480	1	19	5.2	5.0	✓
TSS by Gravimetry	E160	399994	1	12	8.3	5.0	✓
Turbidity by Nephelometry	E121	398087	2	21	9.5	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	398280	1	10	10.0	5.0	✓
Alkalinity Species by Titration	E290	398272	1	13	7.6	5.0	✓
Ammonia by Fluorescence	E298	403188	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	398276	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	404339	1	15	6.6	5.0	✓
Chloride in Water by IC	E235.Cl	398275	1	13	7.6	5.0	✓
Conductivity in Water	E100	398271	1	15	6.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	403193	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401362	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	403192	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	398281	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	398274	1	13	7.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	398277	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	398278	1	13	7.6	5.0	✓
Sulfate in Water by IC	E235.SO4	398279	1	13	7.6	5.0	✓
TDS by Gravimetry	E162	399992	1	13	7.6	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	403122	1	7	14.2	5.0	✓
Total Mercury in Water by CVAAS	E508	400918	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	403121	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	403186	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403187	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	398480	1	19	5.2	5.0	✓
TSS by Gravimetry	E160	399994	1	12	8.3	5.0	✓
Turbidity by Nephelometry	E121	398087	2	21	9.5	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	403188	1	18	5.5	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	398276	1	13	7.6	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	404339	1	15	6.6	5.0	✓
Chloride in Water by IC	E235.Cl	398275	1	13	7.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	403193	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401362	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	403192	1	19	5.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	398281	1	10	10.0	5.0	✓
Fluoride in Water by IC	E235.F	398274	1	13	7.6	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	398277	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	398278	1	13	7.6	5.0	✓
Sulfate in Water by IC	E235.SO4	398279	1	13	7.6	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	403122	1	7	14.2	5.0	✓
Total Mercury in Water by CVAAS	E508	400918	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	403121	1	19	5.2	5.0	✓
Total Nitrogen by Colourimetry	E366	403186	1	6	16.6	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403187	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395	398480	1	19	5.2	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160 Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395 Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA22A1795**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 28-Jan-2022 21:15
PO	: 1025612	Date Analysis Commenced	: 30-Jan-2022
C-O-C number	: ----	Issue Date	: 09-Feb-2022 17:14
Sampler	: K U, N G		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 3		
No. of samples analysed	: 3		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Monica Ko	Lab Assistant	Metals, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Woochan Song	Lab Analyst	Metals, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 398087)											
FJ2200265-001	Anonymous	turbidity	----	E121	0.10	NTU	3.26	3.17	2.80%	15%	----
Physical Tests (QC Lot: 398156)											
VA22A1667-001	Anonymous	turbidity	----	E121	0.10	NTU	0.26	0.26	0.003	Diff <2x LOR	----
Physical Tests (QC Lot: 398270)											
FJ2200263-001	Anonymous	pH	----	E108	0.10	pH units	8.28	8.28	0.00%	4%	----
Physical Tests (QC Lot: 398271)											
FJ2200263-001	Anonymous	conductivity	----	E100	2.0	µS/cm	1170	1170	0.342%	10%	----
Physical Tests (QC Lot: 398272)											
FJ2200263-001	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	184	182	0.982%	20%	----
Physical Tests (QC Lot: 398280)											
KS2200273-002	Anonymous	acidity (as CaCO3)	----	E283	2.0	mg/L	2.4	2.0	0.3	Diff <2x LOR	----
Physical Tests (QC Lot: 399992)											
KS2200276-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	185	193	8	Diff <2x LOR	----
Physical Tests (QC Lot: 399994)											
VA22A1795-001	BJ-GW12-8A-E303059	solids, total suspended [TSS]	----	E160	3.0	mg/L	15.4	17.8	2.4	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 398274)											
FJ2200263-001	Anonymous	fluoride	16984-48-8	E235.F	0.100	mg/L	0.177	0.178	0.002	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 398275)											
FJ2200263-001	Anonymous	chloride	16887-00-6	E235.Cl	2.50	mg/L	<2.50	<2.50	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 398276)											
FJ2200263-001	Anonymous	bromide	24959-67-9	E235.Br-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 398277)											
FJ2200263-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.0250	mg/L	0.206	0.206	0.0004	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 398278)											
FJ2200263-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 398279)											
FJ2200263-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	1.50	mg/L	501	503	0.303%	20%	----
Anions and Nutrients (QC Lot: 398281)											
KS2200273-001	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 403186)											
VA22A1795-001	BJ-GW12-8A-E303059	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.030	<0.030	0.0005	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 403187)											
VA22A1795-001	BJ-GW12-8A-E303059	phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.0100	0.0118	0.0017	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 403188)											
VA22A1795-001	BJ-GW12-8A-E303059	ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	<0.0050	<0.0050	0	Diff <2x LOR	----
Total Sulfides (QC Lot: 398480)											
CG2200927-001	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	<0.0015	0	Diff <2x LOR	----
Total Metals (QC Lot: 400918)											
KS2200273-001	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	0.0000054	0.0000063	0.0000010	Diff <2x LOR	----
Total Metals (QC Lot: 403121)											
FJ2200267-001	Anonymous	aluminum, total	7429-90-5	E420	0.0150	mg/L	<0.0150	<0.0150	0	Diff <2x LOR	----
		antimony, total	7440-36-0	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		arsenic, total	7440-38-2	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		barium, total	7440-39-3	E420	0.00050	mg/L	0.0254	0.0261	2.70%	20%	----
		beryllium, total	7440-41-7	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000250	mg/L	0.000392	0.000409	4.17%	20%	----
		calcium, total	7440-70-2	E420	0.250	mg/L	321	320	0.258%	20%	----
		cobalt, total	7440-48-4	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		lead, total	7439-92-1	E420	0.000250	mg/L	<0.000250	<0.000250	0	Diff <2x LOR	----
		lithium, total	7439-93-2	E420	0.0050	mg/L	0.106	0.108	0.981%	20%	----
		magnesium, total	7439-95-4	E420	0.500	mg/L	362	364	0.566%	20%	----
		manganese, total	7439-96-5	E420	0.00050	mg/L	0.00168	0.00163	0.00005	Diff <2x LOR	----
		molybdenum, total	7439-98-7	E420	0.000250	mg/L	0.00171	0.00166	0.000056	Diff <2x LOR	----
		nickel, total	7440-02-0	E420	0.00250	mg/L	0.0166	0.0165	0.00003	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.250	mg/L	7.86	7.80	0.820%	20%	----
		selenium, total	7782-49-2	E420	0.250	mg/L	19.9 µg/L	0.0186	6.62%	20%	----
		silicon, total	7440-21-3	E420	0.50	mg/L	1.82	1.80	0.02	Diff <2x LOR	----
		silver, total	7440-22-4	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		sodium, total	7440-23-5	E420	0.250	mg/L	171	171	0.0437%	20%	----
		strontium, total	7440-24-6	E420	0.00100	mg/L	2.20	2.12	3.31%	20%	----
		sulfur, total	7704-34-9	E420	2.50	mg/L	797	804	0.805%	20%	----
		thallium, total	7440-28-0	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 403121) - continued											
FJ2200267-001	Anonymous	tin, total	7440-31-5	E420	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.0500	mg/L	<0.0500	<0.0500	0	Diff <2x LOR	----
		uranium, total	7440-61-1	E420	0.000050	mg/L	0.0155	0.0155	0.241%	20%	----
		vanadium, total	7440-62-2	E420	0.00250	mg/L	<0.00250	<0.00250	0	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0150	mg/L	0.0207	0.0186	0.0020	Diff <2x LOR	----
Total Metals (QC Lot: 403122)											
FJ2200267-001	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 401362)											
FJ2200267-001	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 403192)											
VA22A1795-001	BJ-GW12-8A-E303059	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0039	0.0036	0.0002	Diff <2x LOR	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00089	0.00089	0.000004	Diff <2x LOR	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00812	0.00853	4.95%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0211	0.0217	2.99%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000095	0.0000115	0.0000020	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	29.4	29.5	0.357%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	0.00013	0.00014	0.000003	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00032	0.00032	0.000007	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0080	0.0078	0.0001	Diff <2x LOR	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	5.62	5.86	4.32%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00260	0.00263	1.19%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00213	0.00213	0.0874%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	0.00225	0.00242	0.00017	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.452	0.469	0.017	Diff <2x LOR	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000182	0.000169	0.000013	Diff <2x LOR	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.02	2.02	0.0960%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	7440-23-5	E421	0.050	mg/L	3.28	3.44	4.76%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.720	0.712	1.20%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Dissolved Metals (QC Lot: 403192) - continued											
VA22A1795-001	BJ-GW12-8A-E303059	sulfur, dissolved	7704-34-9	E421	0.50	mg/L	11.8	12.1	2.44%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000172	0.000176	2.06%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	0.0014	0.0015	0.00005	Diff <2x LOR	----
Dissolved Metals (QC Lot: 403193)											
VA22A1795-001	BJ-GW12-8A-E303059	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00039	0.00043	0.00004	Diff <2x LOR	----
Aggregate Organics (QC Lot: 404339)											
KS2200288-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	40	38	2	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 398087)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 398156)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 398271)						
conductivity	----	E100	1	µS/cm	<1.0	----
Physical Tests (QCLot: 398272)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 398280)						
acidity (as CaCO3)	----	E283	2	mg/L	2.1	----
Physical Tests (QCLot: 399992)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 399994)						
solids, total suspended [TSS]	----	E160	3	mg/L	<3.0	----
Anions and Nutrients (QCLot: 398274)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 398275)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 398276)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 398277)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 398278)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 398279)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 398281)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 403186)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Anions and Nutrients (QCLot: 403187)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 403188)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Sulfides (QCLot: 398480)						
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	<0.0015	----
Total Metals (QCLot: 400918)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 403121)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
sulfur, total	7704-34-9	E420	0.5	mg/L	<0.50	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 403122)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----
Dissolved Metals (QCLot: 401362)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 403192)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	<0.50	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 403193)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----
Aggregate Organics (QCLot: 404339)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 398087)									
turbidity	----	E121	0.1	NTU	200 NTU	105	85.0	115	----
Physical Tests (QCLot: 398156)									
turbidity	----	E121	0.1	NTU	200 NTU	102	85.0	115	----
Physical Tests (QCLot: 398270)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 398271)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	100	90.0	110	----
Physical Tests (QCLot: 398272)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	101	85.0	115	----
Physical Tests (QCLot: 398280)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	100	85.0	115	----
Physical Tests (QCLot: 399992)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	100	85.0	115	----
Physical Tests (QCLot: 399994)									
solids, total suspended [TSS]	----	E160	3	mg/L	150 mg/L	94.0	85.0	115	----
Anions and Nutrients (QCLot: 398274)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 398275)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 398276)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 398277)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	101	90.0	110	----
Anions and Nutrients (QCLot: 398278)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 398279)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	103	90.0	110	----
Anions and Nutrients (QCLot: 398281)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	96.3	80.0	120	----
Anions and Nutrients (QCLot: 403186)									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	100	75.0	125	----
Anions and Nutrients (QCLot: 403187)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Anions and Nutrients (QCLot: 403187) - continued									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	92.7	80.0	120	----
Anions and Nutrients (QCLot: 403188)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	97.5	85.0	115	----
Total Sulfides (QCLot: 398480)									
sulfide, total (as S)	18496-25-8	E395	0.0015	mg/L	0.08 mg/L	105	80.0	120	----
Total Metals (QCLot: 400918)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Total Metals (QCLot: 403121)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	100	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	112	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	102	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	99.3	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	98.9	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	104	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	99.8	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	101	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	103	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	103	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	102	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	106	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	103	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	101	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	108	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	102	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	101	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	92.0	80.0	120	----
sodium, total	7440-23-5	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	107	80.0	120	----
sulfur, total	7704-34-9	E420	0.5	mg/L	50 mg/L	98.3	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 403121) - continued									
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	99.7	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	95.8	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	98.1	80.0	120	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	95.1	80.0	120	----
Total Metals (QCLot: 403122)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	105	80.0	120	----
Dissolved Metals (QCLot: 403192)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	102	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	105	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	104	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	99.1	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	105	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	94.3	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	102	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	99.4	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	102	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	98.6	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	102	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	96.9	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	102	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	113	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	106	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	101	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	101	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	93.4	80.0	120	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	103	80.0	120	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	50 mg/L	92.0	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	107	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 403192) - continued									
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	104	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	100	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	104	80.0	120	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	106	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	99.9	80.0	120	----
Dissolved Metals (QCLot: 403193)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	103	80.0	120	----
Aggregate Organics (QCLot: 404339)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	113	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 398274)										
FJ2200263-003	Anonymous	fluoride	16984-48-8	E235.F	5.18 mg/L	5 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 398275)										
FJ2200263-003	Anonymous	chloride	16887-00-6	E235.Cl	509 mg/L	500 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 398276)										
FJ2200263-003	Anonymous	bromide	24959-67-9	E235.Br-L	2.49 mg/L	2.5 mg/L	99.6	75.0	125	----
Anions and Nutrients (QCLot: 398277)										
FJ2200263-003	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	12.8 mg/L	12.5 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 398278)										
FJ2200263-003	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	2.66 mg/L	2.5 mg/L	106	75.0	125	----
Anions and Nutrients (QCLot: 398279)										
FJ2200263-003	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	ND mg/L	500 mg/L	ND	75.0	125	----
Anions and Nutrients (QCLot: 398281)										
KS2200273-002	Anonymous	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0307 mg/L	0.03 mg/L	102	70.0	130	----
Anions and Nutrients (QCLot: 403186)										
VA22A1795-002	BJ-GW12-8B-E314695	nitrogen, total	7727-37-9	E366	0.401 mg/L	0.4 mg/L	100	70.0	130	----
Anions and Nutrients (QCLot: 403187)										
VA22A1795-002	BJ-GW12-8B-E314695	phosphorus, total	7723-14-0	E372-U	0.0498 mg/L	0.05 mg/L	99.6	70.0	130	----
Anions and Nutrients (QCLot: 403188)										
VA22A1795-002	BJ-GW12-8B-E314695	ammonia, total (as N)	7664-41-7	E298	0.0984 mg/L	0.1 mg/L	98.4	75.0	125	----
Total Sulfides (QCLot: 398480)										
CG2200927-002	Anonymous	sulfide, total (as S)	18496-25-8	E395	0.111 mg/L	0.1 mg/L	111	75.0	125	----
Total Metals (QCLot: 400918)										
KS2200273-002	Anonymous	mercury, total	7439-97-6	E508	0.000106 mg/L	0.0001 mg/L	106	70.0	130	----
Total Metals (QCLot: 403121)										
FJ2200267-002	Anonymous	aluminum, total	7429-90-5	E420	0.384 mg/L	0.4 mg/L	96.1	70.0	130	----
		antimony, total	7440-36-0	E420	0.0420 mg/L	0.04 mg/L	105	70.0	130	----
		arsenic, total	7440-38-2	E420	0.0418 mg/L	0.04 mg/L	104	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 403121) - continued										
FJ2200267-002	Anonymous	beryllium, total	7440-41-7	E420	0.0792 mg/L	0.08 mg/L	99.0	70.0	130	----
		bismuth, total	7440-69-9	E420	0.0173 mg/L	0.02 mg/L	86.7	70.0	130	----
		boron, total	7440-42-8	E420	0.202 mg/L	0.2 mg/L	101	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00821 mg/L	0.008 mg/L	103	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	8 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0379 mg/L	0.04 mg/L	94.8	70.0	130	----
		copper, total	7440-50-8	E420	0.0374 mg/L	0.04 mg/L	93.4	70.0	130	----
		iron, total	7439-89-6	E420	3.87 mg/L	4 mg/L	96.7	70.0	130	----
		lead, total	7439-92-1	E420	0.0385 mg/L	0.04 mg/L	96.4	70.0	130	----
		lithium, total	7439-93-2	E420	0.193 mg/L	0.2 mg/L	96.7	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0429 mg/L	0.04 mg/L	107	70.0	130	----
		nickel, total	7440-02-0	E420	0.0751 mg/L	0.08 mg/L	93.9	70.0	130	----
		phosphorus, total	7723-14-0	E420	20.7 mg/L	20 mg/L	103	70.0	130	----
		potassium, total	7440-09-7	E420	7.76 mg/L	8 mg/L	97.0	70.0	130	----
		selenium, total	7782-49-2	E420	0.0858 mg/L	0.08 mg/L	107	70.0	130	----
		silicon, total	7440-21-3	E420	19.6 mg/L	20 mg/L	97.8	70.0	130	----
		silver, total	7440-22-4	E420	0.00752 mg/L	0.008 mg/L	94.0	70.0	130	----
		sodium, total	7440-23-5	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.04 mg/L	ND	70.0	130	----
		sulfur, total	7704-34-9	E420	ND mg/L	40 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00736 mg/L	0.008 mg/L	92.0	70.0	130	----
		tin, total	7440-31-5	E420	0.0397 mg/L	0.04 mg/L	99.3	70.0	130	----
		titanium, total	7440-32-6	E420	0.0807 mg/L	0.08 mg/L	101	70.0	130	----
		uranium, total	7440-61-1	E420	ND mg/L	0.008 mg/L	ND	70.0	130	----
		vanadium, total	7440-62-2	E420	0.205 mg/L	0.2 mg/L	103	70.0	130	----
		zinc, total	7440-66-6	E420	0.725 mg/L	0.8 mg/L	90.6	70.0	130	----
Total Metals (QCLot: 403122)										
FJ2200267-002	Anonymous	chromium, total	7440-47-3	E420.Cr-L	0.0788 mg/L	0.08 mg/L	98.5	70.0	130	----
Dissolved Metals (QCLot: 401362)										
FJ2200267-002	Anonymous	mercury, dissolved	7439-97-6	E509	0.000105 mg/L	0.0001 mg/L	105	70.0	130	----
Dissolved Metals (QCLot: 403192)										
VA22A1795-002	BJ-GW12-8B-E314695	aluminum, dissolved	7429-90-5	E421	0.193 mg/L	0.2 mg/L	96.5	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0200 mg/L	0.02 mg/L	100	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0197 mg/L	0.02 mg/L	98.3	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 403192) - continued										
VA22A1795-002	BJ-GW12-8B-E314695	barium, dissolved	7440-39-3	E421	0.0190 mg/L	0.02 mg/L	94.9	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0378 mg/L	0.04 mg/L	94.4	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00883 mg/L	0.01 mg/L	88.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.092 mg/L	0.1 mg/L	92.5	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00388 mg/L	0.004 mg/L	96.9	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0194 mg/L	0.02 mg/L	96.8	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0188 mg/L	0.02 mg/L	94.3	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.94 mg/L	2 mg/L	97.3	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0187 mg/L	0.02 mg/L	93.7	70.0	130	----
		lithium, dissolved	7439-93-2	E421	0.0935 mg/L	0.1 mg/L	93.5	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	0.0195 mg/L	0.02 mg/L	97.6	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0197 mg/L	0.02 mg/L	98.7	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0400 mg/L	0.04 mg/L	100	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	10.1 mg/L	10 mg/L	101	70.0	130	----
		potassium, dissolved	7440-09-7	E421	4.10 mg/L	4 mg/L	102	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0400 mg/L	0.04 mg/L	99.9	70.0	130	----
		silicon, dissolved	7440-21-3	E421	9.25 mg/L	10 mg/L	92.5	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00373 mg/L	0.004 mg/L	93.3	70.0	130	----
		sodium, dissolved	7440-23-5	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, dissolved	7704-34-9	E421	19.9 mg/L	20 mg/L	99.7	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00375 mg/L	0.004 mg/L	93.8	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00380 mg/L	0.004 mg/L	94.9	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0995 mg/L	0.1 mg/L	99.5	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.378 mg/L	0.4 mg/L	94.4	70.0	130	----
Dissolved Metals (QCLot: 403193)										
VA22A1795-002	BJ-GW12-8B-E314695	chromium, dissolved	7440-47-3	E421.Cr-L	0.0388 mg/L	0.04 mg/L	97.0	70.0	130	----
Aggregate Organics (QCLot: 404339)										
KS2200288-002	Anonymous	chemical oxygen demand [COD]	----	E559	106 mg/L	100 mg/L	106	75.0	125	----

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To			
Company:	Pretivm Resources Inc.		
Contact:	Robin McCall		
Address:	2965 Tatlow Road		
	Smithers, BC V0J 2N5		
Phone:	(866) 214-9772	Fax:	(604) 558-4784
Invoice To	Same as Report ?	☑ Yes	☐ No
Hardcopy of Invoice with Report?		☑ Yes	☐ No
Company:			
Contact:			
Address:	invoices@pretivm.com		
Phone:		Fax:	

Report Format / Distribution

☑ Standard ☐ Other

☑ PDF ☑ Excel ☐ Digital ☐ Fax

Email 1: environmental@pretivm.com

Email 2: rmccall@pretivm.com

Email 3:

Client / Project Information

Job #: Brucejack Groundwater

PO / AFE: 1025612

LSD:

Quote #:

Service Requested (Rush for routine analysis subject to availability)

◉ Regular (Standard Turnaround Times - Business Days)

○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT

○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT

○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Lab Work Order # (lab use only):

ALS Contact: Dean Watt **Sampler:** KU/NG

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW12-8A-E303059	27-Jan-22	11:20	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8B-E314695	27-Jan-22	13:05	Groundwater	X	X		X	X			X	X	X	X		7
	Travel Blank	27-Jan-22	8:30	Groundwater	X	X		X				X		X	X		5

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Kevin Udema	27-Jan-22	18:00				°C				

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1:	environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2:	rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack Groundwater	
Company:		PO / AFE:	1025612	
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: KU/NG	

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW12-8A-E303059	27-Jan-22	11:20	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW12-8B-E314695	27-Jan-22	13:05	Groundwater	X	X		X	X			X	X	X	X		7
	Travel Blank	27-Jan-22	8:30	Groundwater	X	X		X	X					X	X		5

Environmental Division Vancouver
Work Order Reference
VA22A1795

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

~~Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered.~~ TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca, Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Kevin Udema	27-Jan-22	18:00				8 °C	RJ	JAN-28	21:15	

Ice pack.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA22A1890**	Page	: 1 of 6
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 31-Jan-2022 21:00
PO	: 1025614	Date Analysis Commenced	: 01-Feb-2022
C-O-C number	: ----	Issue Date	: 11-Feb-2022 16:45
Sampler	: NG/RS/KU		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DTSE	*Dissolved Se concentration exceeds total. Positive bias on D-Se suspected due to signal enhancement from volatile selenium species. Contact ALS if an alternative test to address this interference is needed.*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	BJ-GW18-17A-E 303066	BJ-GW18-17B-E 314701	----	----	----
				Client sampling date / time	29-Jan-2022 14:45	29-Jan-2022 15:10	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1890-001	VA22A1890-002	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
acidity (as CaCO3)	----	E283	2.0	mg/L	<2.0	2.7	----	----	----
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	122	120	----	----	----
conductivity	----	E100	2.0	µS/cm	667	833	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.50	mg/L	56.3	255	----	----	----
hardness (as CaCO3), from total Ca/Mg	----	EC100A	0.50	mg/L	96.9	303	----	----	----
pH	----	E108	0.10	pH units	8.36	8.11	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	485	616	----	----	----
solids, total suspended [TSS]	----	E160	3.0	mg/L	126	91.3	----	----	----
turbidity	----	E121	0.10	NTU	140	117	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0790	0.171	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	3.29	4.65	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.218	0.240	----	----	----
Kjeldahl nitrogen, total [TKN]	----	EC318	0.050	mg/L	0.206	0.662	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	<0.0050	<0.0050	----	----	----
nitrate + nitrite (as N)	----	EC235.N+N	0.0050	mg/L	<0.0051	<0.0051	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	0.0021	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.206	0.662	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0052	0.0436	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	0.154	0.130	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	207	321	----	----	----
Total Sulfides									
sulfide, total (as H2S)	7783-06-4	E395-H	0.011	mg/L	0.284	0.174	----	----	----
sulfide, total (as S)	18496-25-8	E395-H	0.010	mg/L	0.267	0.164	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	3.25	0.601	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.0156	0.00395	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.102	0.0243	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.149	0.0692	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17A-E 303066	BJ-GW18-17B-E 314701	----	----	----
				Client sampling date / time	29-Jan-2022 14:45	29-Jan-2022 15:10	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1890-001	VA22A1890-002	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000077	0.000049	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.062	0.052	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000280	0.0000233	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	34.2	113	----	----	----
chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.0236	0.0176	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00078	0.00074	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00404	0.00256	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	3.62	0.830	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.00152	0.00120	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.303	0.131	----	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	2.79	5.10	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.182	0.146	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00194	0.00414	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	0.00262	0.00607	----	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	0.175	0.138	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	2.47	3.95	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000125	0.000458	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	6.99	3.79	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	0.00101	0.000097	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	131	73.0	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	1.12	3.54	----	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	77.6	115	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000054	0.000017	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00044	0.00046	----	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	0.0479	0.00828	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000235	0.00229	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00266	0.00158	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	0.0303	0.0079	----	----	----
Dissolved Metals									

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ-GW18-17A-E 303066	BJ-GW18-17B-E 314701	----	----	----
				Client sampling date / time	29-Jan-2022 14:45	29-Jan-2022 15:10	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1890-001	VA22A1890-002	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0182	0.0067	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00728	0.00357	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0704	0.0171	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0425	0.0413	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.058	0.044	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	21.0	95.1	----	----	----
chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00027	0.00061	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	0.00021	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	0.010	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.299	0.122	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	0.936	4.37	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0102	0.0840	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00165	0.00382	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	0.00272	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	0.064	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.84	3.46	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000788 DTSE	0.000366	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.90	2.66	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	118	65.8	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.00	3.24	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	76.3	102	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	0.00013	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	----	----	----

Analytical Results

Sub-Matrix: **Water** (Matrix: **Water**)				Client sample ID	**BJ-GW18-17A-E 303066**	**BJ-GW18-17B-E 314701**	**----**	**----**	**----**
				Client sampling date / time	29-Jan-2022 14:45	29-Jan-2022 15:10	----	----	----
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	**VA22A1890-001**	**VA22A1890-002**	**--------**	**--------**	**--------**
					Result	Result	----	----	----
Dissolved Metals									
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000181	0.00210	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	0.0012	----	----	----
dissolved mercury filtration location	----	EP509	-	-	Field	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	----	----	----
Aggregate Organics									
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	43	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA22A1890**	Page	: 1 of 14
Client	: **Pretium Explorations Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 31-Jan-2022 21:00
PO	: 1025614	Issue Date	: 11-Feb-2022 16:45
C-O-C number	: ----		
Sampler	: NG/RS/KU		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- No Matrix Spike outliers occur.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E559	29-Jan-2022	----	----	----		08-Feb-2022	28 days	10 days	✓
Aggregate Organics : Chemical Oxygen Demand by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-E314701	E559	29-Jan-2022	----	----	----		08-Feb-2022	28 days	10 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E298	29-Jan-2022	06-Feb-2022	----	----		07-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-E314701	E298	29-Jan-2022	06-Feb-2022	----	----		07-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.Br-L	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-E314701	E235.Br-L	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.Cl	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ-GW18-17B-E314701	E235.Cl	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17A-E303066	E378-U	29-Jan-2022	----	----	----		02-Feb-2022	3 days	3 days	×
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ-GW18-17B-E314701	E378-U	29-Jan-2022	----	----	----		02-Feb-2022	3 days	3 days	×
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.F	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ-GW18-17B-E314701	E235.F	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.NO3-L	29-Jan-2022	----	----	----		01-Feb-2022	3 days	3 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-E314701	E235.NO3-L	29-Jan-2022	----	----	----		01-Feb-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17A-E303066	E235.NO2-L	29-Jan-2022	----	----	----		01-Feb-2022	3 days	3 days	✓
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
BJ-GW18-17B-E314701	E235.NO2-L	29-Jan-2022	----	----	----		01-Feb-2022	3 days	3 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17A-E303066	E235.SO4	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
BJ-GW18-17B-E314701	E235.SO4	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E366	29-Jan-2022	06-Feb-2022	----	----		09-Feb-2022	28 days	11 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-E314701	E366	29-Jan-2022	06-Feb-2022	----	----		09-Feb-2022	28 days	11 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17A-E303066	E372-U	29-Jan-2022	06-Feb-2022	----	----		08-Feb-2022	28 days	10 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
BJ-GW18-17B-E314701	E372-U	29-Jan-2022	06-Feb-2022	----	----		08-Feb-2022	28 days	10 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-E303066	E421.Cr-L	29-Jan-2022	08-Feb-2022	----	----		08-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Chromium in Water by CRC ICPMS (Low Level)										
HDPE dissolved (nitric acid)										
BJ-GW18-17B-E314701	E421.Cr-L	29-Jan-2022	08-Feb-2022	----	----		08-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17A-E303066	E509	29-Jan-2022	03-Feb-2022	----	----		03-Feb-2022	28 days	5 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
BJ-GW18-17B-E314701	E509	29-Jan-2022	03-Feb-2022	----	----		03-Feb-2022	28 days	5 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17A-E303066	E421	29-Jan-2022	08-Feb-2022	----	----		08-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
BJ-GW18-17B-E314701	E421	29-Jan-2022	08-Feb-2022	----	----		08-Feb-2022	180 days	11 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17A-E303066	E283	29-Jan-2022	----	----	----		01-Feb-2022	14 days	3 days	✓
Physical Tests : Acidity by Titration										
HDPE										
BJ-GW18-17B-E314701	E283	29-Jan-2022	----	----	----		01-Feb-2022	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17A-E303066	E290	29-Jan-2022	----	----	----		01-Feb-2022	14 days	3 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
BJ-GW18-17B-E314701	E290	29-Jan-2022	----	----	----		01-Feb-2022	14 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17A-E303066	E100	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓
Physical Tests : Conductivity in Water										
HDPE										
BJ-GW18-17B-E314701	E100	29-Jan-2022	----	----	----		01-Feb-2022	28 days	3 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : pH by Meter										
HDPE BJ-GW18-17B-E314701	E108	29-Jan-2022	----	----	----		01-Feb-2022	0.25 hrs	73 hrs	✗ EHTR-FM
Physical Tests : pH by Meter										
HDPE BJ-GW18-17A-E303066	E108	29-Jan-2022	----	----	----		01-Feb-2022	0.25 hrs	74 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17A-E303066	E162	29-Jan-2022	----	----	----		03-Feb-2022	7 days	5 days	✓
Physical Tests : TDS by Gravimetry										
HDPE BJ-GW18-17B-E314701	E162	29-Jan-2022	----	----	----		03-Feb-2022	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17A-E303066	E160	29-Jan-2022	----	----	----		03-Feb-2022	7 days	5 days	✓
Physical Tests : TSS by Gravimetry										
HDPE BJ-GW18-17B-E314701	E160	29-Jan-2022	----	----	----		03-Feb-2022	7 days	5 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17A-E303066	E121	29-Jan-2022	----	----	----		01-Feb-2022	3 days	3 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE BJ-GW18-17B-E314701	E121	29-Jan-2022	----	----	----		01-Feb-2022	3 days	3 days	✓
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW18-17A-E303066	E420.Cr-L	29-Jan-2022	----	----	----		08-Feb-2022	180 days	10 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Chromium in Water by CRC ICPMS (Low Level)										
HDPE total (nitric acid) BJ-GW18-17B-E314701	E420.Cr-L	29-Jan-2022	----	----	----		08-Feb-2022	180 days	10 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17A-E303066	E508	29-Jan-2022	----	----	----		02-Feb-2022	28 days	4 days	✓
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid) BJ-GW18-17B-E314701	E508	29-Jan-2022	----	----	----		02-Feb-2022	28 days	4 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17A-E303066	E420	29-Jan-2022	----	----	----		08-Feb-2022	180 days	10 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) BJ-GW18-17B-E314701	E420	29-Jan-2022	----	----	----		08-Feb-2022	180 days	10 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17A-E303066	E395-H	29-Jan-2022	----	----	----		01-Feb-2022	7 days	3 days	✓
Total Sulfides : Total Sulfide by Colourimetry (Automated Flow)										
HDPE total (zinc acetate+sodium hydroxide) BJ-GW18-17B-E314701	E395-H	29-Jan-2022	----	----	----		01-Feb-2022	7 days	3 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Acidity by Titration	E283	399727	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	399726	1	17	5.8	5.0	✓
Ammonia by Fluorescence	E298	403819	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	399721	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	405059	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	399720	1	17	5.8	5.0	✓
Conductivity in Water	E100	399724	1	6	16.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	404606	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401610	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	404605	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	399728	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	399719	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	399722	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	399717	1	20	5.0	5.0	✓
pH by Meter	E108	399725	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	399723	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	401349	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	404614	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	400638	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	404613	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	403823	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403821	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	399611	1	8	12.5	5.0	✓
TSS by Gravimetry	E160	401328	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	399757	1	7	14.2	5.0	✓
Laboratory Control Samples (LCS)							
Acidity by Titration	E283	399727	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	399726	1	17	5.8	5.0	✓
Ammonia by Fluorescence	E298	403819	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	399721	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	405059	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	399720	1	17	5.8	5.0	✓
Conductivity in Water	E100	399724	1	6	16.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	404606	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401610	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	404605	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	399728	1	2	50.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Fluoride in Water by IC	E235.F	399719	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	399722	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	399717	1	20	5.0	5.0	✓
pH by Meter	E108	399725	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	399723	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	401349	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	404614	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	400638	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	404613	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	403823	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403821	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	399611	1	8	12.5	5.0	✓
TSS by Gravimetry	E160	401328	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	399757	1	7	14.2	5.0	✓
Method Blanks (MB)							
Acidity by Titration	E283	399727	1	2	50.0	5.0	✓
Alkalinity Species by Titration	E290	399726	1	17	5.8	5.0	✓
Ammonia by Fluorescence	E298	403819	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	399721	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	405059	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	399720	1	17	5.8	5.0	✓
Conductivity in Water	E100	399724	1	6	16.6	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	404606	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401610	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	404605	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	399728	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	399719	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	399722	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	399717	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	399723	1	17	5.8	5.0	✓
TDS by Gravimetry	E162	401349	1	20	5.0	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	404614	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	400638	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	404613	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	403823	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403821	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	399611	1	8	12.5	5.0	✓
TSS by Gravimetry	E160	401328	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	399757	1	7	14.2	5.0	✓
Matrix Spikes (MS)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Ammonia by Fluorescence	E298	403819	1	13	7.6	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	399721	1	16	6.2	5.0	✓
Chemical Oxygen Demand by Colourimetry	E559	405059	1	20	5.0	5.0	✓
Chloride in Water by IC	E235.Cl	399720	1	17	5.8	5.0	✓
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L	404606	1	2	50.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	401610	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	404605	1	20	5.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	399728	1	2	50.0	5.0	✓
Fluoride in Water by IC	E235.F	399719	1	17	5.8	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	399722	1	17	5.8	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	399717	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	399723	1	17	5.8	5.0	✓
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L	404614	1	2	50.0	5.0	✓
Total Mercury in Water by CVAAS	E508	400638	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	404613	1	20	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	403823	1	2	50.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	403821	1	6	16.6	5.0	✓
Total Sulfide by Colourimetry (Automated Flow)	E395-H	399611	1	8	12.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160 Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Acidity by Titration	E283 Vancouver - Environmental	Water	APHA 2310 B (mod)	Acidity is determined by potentiometric titration to pH 8.3
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Sulfide by Colourimetry (Automated Flow)	E395-H Vancouver - Environmental	Water	APHA 4500 -S E-Auto-Colorimetry	Sulfide is determined using the gas dialysis automated methlyene blue colourimetric method. Results expressed "as H2S" if reported represent the maximum possible H2S concentration based on the total sulfide concentration in the sample. The H2S calculation converts Total Sulphide as (S2-) and reports it as Total Sulphide as (H2S)
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Chromium in Water by CRC ICPMS (Low Level)	E420.Cr-L Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Chromium in Water by CRC ICPMS (Low Level)	E421.Cr-L Vancouver - Environmental	Water	APHA 3030 B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Chemical Oxygen Demand by Colourimetry	E559 Vancouver - Environmental	Water	APHA 5220 D (mod)	Samples are analyzed using the closed reflux colourimetric method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), dissolved” is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.
Hardness (Calculated) from Total Ca/Mg	EC100A Vancouver - Environmental	Water	APHA 2340B	“Hardness (as CaCO3), from total Ca/Mg” is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. “Total Hardness” refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N Vancouver - Environmental	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Kjeldahl Nitrogen (Calculation)	EC318 Vancouver - Environmental	Water	BC MOE LABORATORY MANUAL (2005)	Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

QUALITY CONTROL REPORT

Work Order	: **VA22A1890**	Page	: 1 of 18
Client	: Pretium Explorations Inc.	Laboratory	: Vancouver - Environmental
Contact	: Robin McCall	Account Manager	: Dean Watt
Address	: Suite 2300, Four Bentall Centre 1055 Dunsmuir Street Vancouver BC Canada V7X1L4	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: 604 558 1784	Telephone	: +1 604 253 4188
Project	: Brucejack Groundwater	Date Samples Received	: 31-Jan-2022 21:00
PO	: 1025614	Date Analysis Commenced	: 01-Feb-2022
C-O-C number	: ----	Issue Date	: 11-Feb-2022 16:45
Sampler	: NG/RS/KU		
Site	: ----		
Quote number	: Standing Offer BC & Yukon 2021-2022		
No. of samples received	: 2		
No. of samples analysed	: 2		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits
- Reference Material (RM) Report; Recovery and Acceptance Limits
- Method Blank (MB) Report; Recovery and Acceptance Limits
- Laboratory Control Sample (LCS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Dee Lee	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percentage Difference
# = Indicates a QC result that did not meet the ALS DQO.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 399724)											
VA22A1871-001	Anonymous	conductivity	----	E100	2.0	µS/cm	374	376	0.533%	10%	----
Physical Tests (QC Lot: 399725)											
VA22A1871-001	Anonymous	pH	----	E108	0.10	pH units	7.18	7.14	0.559%	4%	----
Physical Tests (QC Lot: 399726)											
VA22A1885-003	Anonymous	alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	33.7	33.2	1.49%	20%	----
Physical Tests (QC Lot: 399727)											
VA22A1890-002	BJ-GW18-17B-E314701	acidity (as CaCO3)	----	E283	2.0	mg/L	2.7	2.0	0.6	Diff <2x LOR	----
Physical Tests (QC Lot: 399757)											
VA22A1890-001	BJ-GW18-17A-E303066	turbidity	----	E121	0.10	NTU	140	150	6.76%	15%	----
Physical Tests (QC Lot: 401328)											
VA22A1859-001	Anonymous	solids, total suspended [TSS]	----	E160	3.0	mg/L	<3.0	<3.0	0	Diff <2x LOR	----
Physical Tests (QC Lot: 401349)											
FJ2200281-001	Anonymous	solids, total dissolved [TDS]	----	E162	20	mg/L	562	552	1.88%	20%	----
Anions and Nutrients (QC Lot: 399717)											
VA22A1871-001	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	0.0595	0.0596	0.0722%	20%	----
Anions and Nutrients (QC Lot: 399719)											
VA22A1885-001	Anonymous	fluoride	16984-48-8	E235.F	1.00	mg/L	<1.00	<1.00	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 399720)											
VA22A1885-001	Anonymous	chloride	16887-00-6	E235.Cl	25.0	mg/L	1900	1900	0.419%	20%	----
Anions and Nutrients (QC Lot: 399721)											
VA22A1885-001	Anonymous	bromide	24959-67-9	E235.Br-L	2.50	mg/L	5.25	5.53	0.278	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 399722)											
VA22A1885-001	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	0.250	mg/L	<0.250	<0.250	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 399723)											
VA22A1885-001	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	15.0	mg/L	251	250	0.141%	20%	----
Anions and Nutrients (QC Lot: 399728)											
VA22A1890-001	BJ-GW18-17A-E303066	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0052	0.0042	0.0010	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 403819)											
KS2200305-001	Anonymous	ammonia, total (as N)	7664-41-7	E298	0.0500	mg/L	8.42	8.22	2.39%	20%	----
Anions and Nutrients (QC Lot: 403821)											
KS2200303-001	Anonymous	phosphorus, total	7723-14-0	E372-U	0.200	mg/L	1.38	1.54	0.166	Diff <2x LOR	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Anions and Nutrients (QC Lot: 403823)											
VA22A1890-001	BJ-GW18-17A-E303066	nitrogen, total	7727-37-9	E366	0.030	mg/L	0.206	0.203	0.003	Diff <2x LOR	----
Total Sulfides (QC Lot: 399611)											
VA22A1846-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	0.075	mg/L	1.28	1.41	9.35%	20%	----
Total Metals (QC Lot: 400638)											
VA22A1886-003	Anonymous	mercury, total	7439-97-6	E508	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Total Metals (QC Lot: 404613)											
VA22A1890-001	BJ-GW18-17A-E303066	aluminum, total	7429-90-5	E420	0.0030	mg/L	3.25	3.20	1.68%	20%	----
		antimony, total	7440-36-0	E420	0.00010	mg/L	0.0156	0.0158	1.44%	20%	----
		arsenic, total	7440-38-2	E420	0.00010	mg/L	0.102	0.0969	5.26%	20%	----
		barium, total	7440-39-3	E420	0.00010	mg/L	0.149	0.134	10.8%	20%	----
		beryllium, total	7440-41-7	E420	0.000020	mg/L	0.000077	0.000083	0.000006	Diff <2x LOR	----
		bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, total	7440-42-8	E420	0.010	mg/L	0.062	0.061	0.001	Diff <2x LOR	----
		cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000280	0.0000363	0.0000083	Diff <2x LOR	----
		calcium, total	7440-70-2	E420	0.050	mg/L	34.2	33.8	1.36%	20%	----
		cobalt, total	7440-48-4	E420	0.00010	mg/L	0.00078	0.00077	0.000008	Diff <2x LOR	----
		copper, total	7440-50-8	E420	0.00050	mg/L	0.00404	0.00380	0.00023	Diff <2x LOR	----
		iron, total	7439-89-6	E420	0.010	mg/L	3.62	3.56	1.78%	20%	----
		lead, total	7439-92-1	E420	0.000050	mg/L	0.00152	0.00156	2.17%	20%	----
		lithium, total	7439-93-2	E420	0.0010	mg/L	0.303	0.300	1.01%	20%	----
		magnesium, total	7439-95-4	E420	0.0050	mg/L	2.79	2.68	4.02%	20%	----
		manganese, total	7439-96-5	E420	0.00010	mg/L	0.182	0.173	4.83%	20%	----
		molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00194	0.00203	4.53%	20%	----
		nickel, total	7440-02-0	E420	0.00050	mg/L	0.00262	0.00264	0.00002	Diff <2x LOR	----
		phosphorus, total	7723-14-0	E420	0.050	mg/L	0.175	0.179	0.004	Diff <2x LOR	----
		potassium, total	7440-09-7	E420	0.050	mg/L	2.47	2.37	3.95%	20%	----
		selenium, total	7782-49-2	E420	0.000050	mg/L	0.000125	0.000217	0.000092	Diff <2x LOR	----
		silicon, total	7440-21-3	E420	0.10	mg/L	6.99	7.03	0.589%	20%	----
		silver, total	7440-22-4	E420	0.000010	mg/L	0.00101	0.00104	2.76%	20%	----
		sodium, total	7440-23-5	E420	0.050	mg/L	131	124	5.67%	20%	----
		strontium, total	7440-24-6	E420	0.00020	mg/L	1.12	1.11	0.253%	20%	----
		sulfur, total	7704-34-9	E420	0.50	mg/L	77.6	77.5	0.166%	20%	----
		thallium, total	7440-28-0	E420	0.000010	mg/L	0.000054	0.000053	0.0000008	Diff <2x LOR	----
		tin, total	7440-31-5	E420	0.00010	mg/L	0.00044	0.00042	0.00002	Diff <2x LOR	----
		titanium, total	7440-32-6	E420	0.00030	mg/L	0.0479	0.0480	0.384%	20%	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Laboratory Duplicate (DUP) Report						
					LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Total Metals (QC Lot: 404613) - continued											
VA22A1890-001	BJ-GW18-17A-E303066	uranium, total	7440-61-1	E420	0.000010	mg/L	0.000235	0.000236	0.236%	20%	----
		vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00266	0.00272	0.00006	Diff <2x LOR	----
		zinc, total	7440-66-6	E420	0.0030	mg/L	0.0303	0.0276	0.0028	Diff <2x LOR	----
Total Metals (QC Lot: 404614)											
VA22A1890-001	BJ-GW18-17A-E303066	chromium, total	7440-47-3	E420.Cr-L	0.00010	mg/L	0.0236	0.0225	4.76%	20%	----
Dissolved Metals (QC Lot: 401610)											
CG2200994-019	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 404605)											
VA22A1890-001	BJ-GW18-17A-E303066	aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0182	0.0172	6.22%	20%	----
		antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00728	0.00731	0.422%	20%	----
		arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0704	0.0724	2.89%	20%	----
		barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0425	0.0433	1.83%	20%	----
		beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	<0.000020	0	Diff <2x LOR	----
		bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		boron, dissolved	7440-42-8	E421	0.010	mg/L	0.058	0.057	0.0006	Diff <2x LOR	----
		cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	<0.0000050	0	Diff <2x LOR	----
		calcium, dissolved	7440-70-2	E421	0.050	mg/L	21.0	21.2	0.919%	20%	----
		cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	<0.00020	0	Diff <2x LOR	----
		iron, dissolved	7439-89-6	E421	0.010	mg/L	0.010	<0.010	0.0001	Diff <2x LOR	----
		lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	<0.000050	0	Diff <2x LOR	----
		lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.299	0.300	0.237%	20%	----
		magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	0.936	0.963	2.90%	20%	----
		manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0102	0.0101	0.963%	20%	----
		molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00165	0.00161	2.31%	20%	----
		nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	<0.050	0	Diff <2x LOR	----
		potassium, dissolved	7440-09-7	E421	0.050	mg/L	1.84	1.86	1.41%	20%	----
		selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000788	0.000719	9.17%	20%	----
		silicon, dissolved	7440-21-3	E421	0.050	mg/L	2.90	2.91	0.637%	20%	----
		silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----
		sodium, dissolved	7440-23-5	E421	0.050	mg/L	118	123	3.88%	20%	----
		strontium, dissolved	7440-24-6	E421	0.00020	mg/L	1.00	1.00	0.0975%	20%	----
		sulfur, dissolved	7704-34-9	E421	0.50	mg/L	76.3	76.5	0.251%	20%	----
		thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	<0.000010	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Dissolved Metals (QC Lot: 404605) - continued											
VA22A1890-001	BJ-GW18-17A-E303066	tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	<0.00010	0	Diff <2x LOR	----
		titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	<0.00030	0	Diff <2x LOR	----
		uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000181	0.000184	1.53%	20%	----
		vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	<0.00050	0	Diff <2x LOR	----
		zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Dissolved Metals (QC Lot: 404606)											
VA22A1890-001	BJ-GW18-17A-E303066	chromium, dissolved	7440-47-3	E421.Cr-L	0.00010	mg/L	0.00027	0.00024	0.00003	Diff <2x LOR	----
Aggregate Organics (QC Lot: 405059)											
VA22A1689-001	Anonymous	chemical oxygen demand [COD]	----	E559	20	mg/L	47	50	3	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 399724)						
conductivity	----	E100	1	µS/cm	1.3	----
Physical Tests (QCLot: 399726)						
alkalinity, total (as CaCO3)	----	E290	1	mg/L	<1.0	----
Physical Tests (QCLot: 399727)						
acidity (as CaCO3)	----	E283	2	mg/L	<2.0	----
Physical Tests (QCLot: 399757)						
turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 401328)						
solids, total suspended [TSS]	----	E160	3	mg/L	<3.0	----
Physical Tests (QCLot: 401349)						
solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 399717)						
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 399719)						
fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 399720)						
chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 399721)						
bromide	24959-67-9	E235.Br-L	0.05	mg/L	<0.050	----
Anions and Nutrients (QCLot: 399722)						
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 399723)						
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 399728)						
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 403819)						
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Anions and Nutrients (QCLot: 403821)						
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	<0.0020	----
Anions and Nutrients (QCLot: 403823)						
nitrogen, total	7727-37-9	E366	0.03	mg/L	<0.030	----
Total Sulfides (QCLot: 399611)						
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	<0.010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 400638)						
mercury, total	7439-97-6	E508	0.000005	mg/L	<0.0000050	----
Total Metals (QCLot: 404613)						
aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
sulfur, total	7704-34-9	E420	0.5	mg/L	<0.50	----
thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Total Metals (QCLot: 404614)						
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Dissolved Metals (QCLot: 401610)						
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	<0.0000050	----
Dissolved Metals (QCLot: 404605)						
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	<0.0010	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	<0.00010	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	<0.00010	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	<0.00010	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	<0.000050	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	<0.050	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	<0.00010	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	<0.00020	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	<0.010	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	<0.0050	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	<0.00010	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	<0.000050	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	<0.00050	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	<0.050	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	<0.050	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	<0.000050	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	<0.050	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	<0.000010	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	<0.050	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	<0.00020	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	<0.50	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	<0.000010	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	<0.00030	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	<0.000010	----
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	<0.0010	----
Dissolved Metals (QCLot: 404606)						
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Aggregate Organics (QCLot: 405059)						
chemical oxygen demand [COD]	----	E559	20	mg/L	<20	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 399724)									
conductivity	----	E100	1	µS/cm	146.9 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 399725)									
pH	----	E108	----	pH units	7 pH units	99.8	98.0	102	----
Physical Tests (QCLot: 399726)									
alkalinity, total (as CaCO3)	----	E290	1	mg/L	500 mg/L	103	85.0	115	----
Physical Tests (QCLot: 399727)									
acidity (as CaCO3)	----	E283	2	mg/L	50 mg/L	101	85.0	115	----
Physical Tests (QCLot: 399757)									
turbidity	----	E121	0.1	NTU	200 NTU	104	85.0	115	----
Physical Tests (QCLot: 401328)									
solids, total suspended [TSS]	----	E160	3	mg/L	150 mg/L	94.2	85.0	115	----
Physical Tests (QCLot: 401349)									
solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 399717)									
nitrite (as N)	14797-65-0	E235.NO2-L	0.001	mg/L	0.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 399719)									
fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 399720)									
chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 399721)									
bromide	24959-67-9	E235.Br-L	0.05	mg/L	0.5 mg/L	102	85.0	115	----
Anions and Nutrients (QCLot: 399722)									
nitrate (as N)	14797-55-8	E235.NO3-L	0.005	mg/L	2.5 mg/L	104	90.0	110	----
Anions and Nutrients (QCLot: 399723)									
sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	105	90.0	110	----
Anions and Nutrients (QCLot: 399728)									
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.03 mg/L	92.5	80.0	120	----
Anions and Nutrients (QCLot: 403819)									
ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	94.3	85.0	115	----
Anions and Nutrients (QCLot: 403821)									
phosphorus, total	7723-14-0	E372-U	0.002	mg/L	0.05 mg/L	92.4	80.0	120	----
Anions and Nutrients (QCLot: 403823)									

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Anions and Nutrients (QCLot: 403823) - continued									
nitrogen, total	7727-37-9	E366	0.03	mg/L	0.5 mg/L	102	75.0	125	----
Total Sulfides (QCLot: 399611)									
sulfide, total (as S)	18496-25-8	E395-H	0.01	mg/L	0.08 mg/L	91.6	80.0	120	----
Total Metals (QCLot: 400638)									
mercury, total	7439-97-6	E508	0.000005	mg/L	0.0001 mg/L	104	80.0	120	----
Total Metals (QCLot: 404613)									
aluminum, total	7429-90-5	E420	0.003	mg/L	2 mg/L	106	80.0	120	----
antimony, total	7440-36-0	E420	0.0001	mg/L	1 mg/L	101	80.0	120	----
arsenic, total	7440-38-2	E420	0.0001	mg/L	1 mg/L	101	80.0	120	----
barium, total	7440-39-3	E420	0.0001	mg/L	0.25 mg/L	99.0	80.0	120	----
beryllium, total	7440-41-7	E420	0.00002	mg/L	0.1 mg/L	102	80.0	120	----
bismuth, total	7440-69-9	E420	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, total	7440-42-8	E420	0.01	mg/L	1 mg/L	94.6	80.0	120	----
cadmium, total	7440-43-9	E420	0.000005	mg/L	0.1 mg/L	102	80.0	120	----
calcium, total	7440-70-2	E420	0.05	mg/L	50 mg/L	96.5	80.0	120	----
cobalt, total	7440-48-4	E420	0.0001	mg/L	0.25 mg/L	100	80.0	120	----
copper, total	7440-50-8	E420	0.0005	mg/L	0.25 mg/L	99.8	80.0	120	----
iron, total	7439-89-6	E420	0.01	mg/L	1 mg/L	92.7	80.0	120	----
lead, total	7439-92-1	E420	0.00005	mg/L	0.5 mg/L	98.8	80.0	120	----
lithium, total	7439-93-2	E420	0.001	mg/L	0.25 mg/L	100	80.0	120	----
magnesium, total	7439-95-4	E420	0.005	mg/L	50 mg/L	98.1	80.0	120	----
manganese, total	7439-96-5	E420	0.0001	mg/L	0.25 mg/L	101	80.0	120	----
molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.25 mg/L	99.2	80.0	120	----
nickel, total	7440-02-0	E420	0.0005	mg/L	0.5 mg/L	96.5	80.0	120	----
phosphorus, total	7723-14-0	E420	0.05	mg/L	10 mg/L	105	80.0	120	----
potassium, total	7440-09-7	E420	0.05	mg/L	50 mg/L	104	80.0	120	----
selenium, total	7782-49-2	E420	0.00005	mg/L	1 mg/L	96.5	80.0	120	----
silicon, total	7440-21-3	E420	0.1	mg/L	10 mg/L	104	80.0	120	----
silver, total	7440-22-4	E420	0.00001	mg/L	0.1 mg/L	96.2	80.0	120	----
sodium, total	7440-23-5	E420	0.05	mg/L	50 mg/L	103	80.0	120	----
strontium, total	7440-24-6	E420	0.0002	mg/L	0.25 mg/L	99.9	80.0	120	----
sulfur, total	7704-34-9	E420	0.5	mg/L	50 mg/L	98.7	80.0	120	----
thallium, total	7440-28-0	E420	0.00001	mg/L	1 mg/L	102	80.0	120	----
tin, total	7440-31-5	E420	0.0001	mg/L	0.5 mg/L	96.1	80.0	120	----
titanium, total	7440-32-6	E420	0.0003	mg/L	0.25 mg/L	95.1	80.0	120	----
uranium, total	7440-61-1	E420	0.00001	mg/L	0.005 mg/L	92.0	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report: Spike Concentration	Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High	Qualifier
Total Metals (QCLot: 404613) - continued									
vanadium, total	7440-62-2	E420	0.0005	mg/L	0.5 mg/L	103	80.0	120	----
zinc, total	7440-66-6	E420	0.003	mg/L	0.5 mg/L	96.4	80.0	120	----
Total Metals (QCLot: 404614)									
chromium, total	7440-47-3	E420.Cr-L	0.0001	mg/L	0.25 mg/L	98.9	80.0	120	----
mercury, dissolved	7439-97-6	E509	0.000005	mg/L	0.0001 mg/L	101	80.0	120	----
Dissolved Metals (QCLot: 404605)									
aluminum, dissolved	7429-90-5	E421	0.001	mg/L	2 mg/L	107	80.0	120	----
antimony, dissolved	7440-36-0	E421	0.0001	mg/L	1 mg/L	101	80.0	120	----
arsenic, dissolved	7440-38-2	E421	0.0001	mg/L	1 mg/L	106	80.0	120	----
barium, dissolved	7440-39-3	E421	0.0001	mg/L	0.25 mg/L	105	80.0	120	----
beryllium, dissolved	7440-41-7	E421	0.00002	mg/L	0.1 mg/L	97.2	80.0	120	----
bismuth, dissolved	7440-69-9	E421	0.00005	mg/L	1 mg/L	104	80.0	120	----
boron, dissolved	7440-42-8	E421	0.01	mg/L	1 mg/L	84.9	80.0	120	----
cadmium, dissolved	7440-43-9	E421	0.000005	mg/L	0.1 mg/L	103	80.0	120	----
calcium, dissolved	7440-70-2	E421	0.05	mg/L	50 mg/L	97.8	80.0	120	----
cobalt, dissolved	7440-48-4	E421	0.0001	mg/L	0.25 mg/L	104	80.0	120	----
copper, dissolved	7440-50-8	E421	0.0002	mg/L	0.25 mg/L	104	80.0	120	----
iron, dissolved	7439-89-6	E421	0.01	mg/L	1 mg/L	97.9	80.0	120	----
lead, dissolved	7439-92-1	E421	0.00005	mg/L	0.5 mg/L	101	80.0	120	----
lithium, dissolved	7439-93-2	E421	0.001	mg/L	0.25 mg/L	97.5	80.0	120	----
magnesium, dissolved	7439-95-4	E421	0.005	mg/L	50 mg/L	99.7	80.0	120	----
manganese, dissolved	7439-96-5	E421	0.0001	mg/L	0.25 mg/L	102	80.0	120	----
molybdenum, dissolved	7439-98-7	E421	0.00005	mg/L	0.25 mg/L	104	80.0	120	----
nickel, dissolved	7440-02-0	E421	0.0005	mg/L	0.5 mg/L	104	80.0	120	----
phosphorus, dissolved	7723-14-0	E421	0.05	mg/L	10 mg/L	109	80.0	120	----
potassium, dissolved	7440-09-7	E421	0.05	mg/L	50 mg/L	105	80.0	120	----
selenium, dissolved	7782-49-2	E421	0.00005	mg/L	1 mg/L	99.6	80.0	120	----
silicon, dissolved	7440-21-3	E421	0.05	mg/L	10 mg/L	108	80.0	120	----
silver, dissolved	7440-22-4	E421	0.00001	mg/L	0.1 mg/L	94.2	80.0	120	----
sodium, dissolved	7440-23-5	E421	0.05	mg/L	50 mg/L	104	80.0	120	----
strontium, dissolved	7440-24-6	E421	0.0002	mg/L	0.25 mg/L	101	80.0	120	----
sulfur, dissolved	7704-34-9	E421	0.5	mg/L	50 mg/L	89.0	80.0	120	----
thallium, dissolved	7440-28-0	E421	0.00001	mg/L	1 mg/L	101	80.0	120	----
tin, dissolved	7440-31-5	E421	0.0001	mg/L	0.5 mg/L	100	80.0	120	----
titanium, dissolved	7440-32-6	E421	0.0003	mg/L	0.25 mg/L	103	80.0	120	----
uranium, dissolved	7440-61-1	E421	0.00001	mg/L	0.005 mg/L	98.2	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Dissolved Metals (QCLot: 404605) - continued									
vanadium, dissolved	7440-62-2	E421	0.0005	mg/L	0.5 mg/L	109	80.0	120	----
zinc, dissolved	7440-66-6	E421	0.001	mg/L	0.5 mg/L	98.4	80.0	120	----
Dissolved Metals (QCLot: 404606)									
chromium, dissolved	7440-47-3	E421.Cr-L	0.0001	mg/L	0.25 mg/L	106	80.0	120	----
Aggregate Organics (QCLot: 405059)									
chemical oxygen demand [COD]	----	E559	20	mg/L	100 mg/L	111	85.0	115	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 399717)										
VA22A1871-002	Anonymous	nitrite (as N)	14797-65-0	E235.NO2-L	10.4 mg/L	10 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 399719)										
VA22A1885-002	Anonymous	fluoride	16984-48-8	E235.F	51.3 mg/L	50 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 399720)										
VA22A1885-002	Anonymous	chloride	16887-00-6	E235.Cl	5070 mg/L	5000 mg/L	101	75.0	125	----
Anions and Nutrients (QCLot: 399721)										
VA22A1885-002	Anonymous	bromide	24959-67-9	E235.Br-L	26.1 mg/L	25 mg/L	104	75.0	125	----
Anions and Nutrients (QCLot: 399722)										
VA22A1885-002	Anonymous	nitrate (as N)	14797-55-8	E235.NO3-L	127 mg/L	125 mg/L	102	75.0	125	----
Anions and Nutrients (QCLot: 399723)										
VA22A1885-002	Anonymous	sulfate (as SO4)	14808-79-8	E235.SO4	5160 mg/L	5000 mg/L	103	75.0	125	----
Anions and Nutrients (QCLot: 399728)										
VA22A1890-002	BJ-GW18-17B-E314701	phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	ND mg/L	0.03 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 403819)										
KS2200305-002	Anonymous	ammonia, total (as N)	7664-41-7	E298	ND mg/L	0.1 mg/L	ND	75.0	125	MS-B
Anions and Nutrients (QCLot: 403821)										
KS2200303-002	Anonymous	phosphorus, total	7723-14-0	E372-U	ND mg/L	0.05 mg/L	ND	70.0	130	----
Anions and Nutrients (QCLot: 403823)										
VA22A1890-002	BJ-GW18-17B-E314701	nitrogen, total	7727-37-9	E366	ND mg/L	0.4 mg/L	ND	70.0	130	----
Total Sulfides (QCLot: 399611)										
VA22A1885-001	Anonymous	sulfide, total (as S)	18496-25-8	E395-H	1.06 mg/L	1 mg/L	106	75.0	125	----
Total Metals (QCLot: 400638)										
VA22A1886-004	Anonymous	mercury, total	7439-97-6	E508	0.0000959 mg/L	0.0001 mg/L	95.9	70.0	130	----
Total Metals (QCLot: 404613)										
VA22A1890-002	BJ-GW18-17B-E314701	aluminum, total	7429-90-5	E420	ND mg/L	0.2 mg/L	ND	70.0	130	----
		antimony, total	7440-36-0	E420	0.0212 mg/L	0.02 mg/L	106	70.0	130	----
		arsenic, total	7440-38-2	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		barium, total	7440-39-3	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Total Metals (QCLot: 404613) - continued										
VA22A1890-002	BJ-GW18-17B-E314701	beryllium, total	7440-41-7	E420	0.0384 mg/L	0.04 mg/L	95.9	70.0	130	----
		bismuth, total	7440-69-9	E420	0.00953 mg/L	0.01 mg/L	95.3	70.0	130	----
		boron, total	7440-42-8	E420	0.100 mg/L	0.1 mg/L	100.0	70.0	130	----
		cadmium, total	7440-43-9	E420	0.00379 mg/L	0.004 mg/L	94.7	70.0	130	----
		calcium, total	7440-70-2	E420	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, total	7440-48-4	E420	0.0188 mg/L	0.02 mg/L	93.8	70.0	130	----
		copper, total	7440-50-8	E420	0.0176 mg/L	0.02 mg/L	88.2	70.0	130	----
		iron, total	7439-89-6	E420	1.88 mg/L	2 mg/L	93.9	70.0	130	----
		lead, total	7439-92-1	E420	0.0192 mg/L	0.02 mg/L	96.2	70.0	130	----
		lithium, total	7439-93-2	E420	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, total	7439-95-4	E420	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, total	7439-96-5	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, total	7439-98-7	E420	0.0208 mg/L	0.02 mg/L	104	70.0	130	----
		nickel, total	7440-02-0	E420	0.0362 mg/L	0.04 mg/L	90.5	70.0	130	----
		phosphorus, total	7723-14-0	E420	11.1 mg/L	10 mg/L	111	70.0	130	----
		potassium, total	7440-09-7	E420	3.93 mg/L	4 mg/L	98.2	70.0	130	----
		selenium, total	7782-49-2	E420	0.0410 mg/L	0.04 mg/L	102	70.0	130	----
		silicon, total	7440-21-3	E420	10.1 mg/L	10 mg/L	101	70.0	130	----
		silver, total	7440-22-4	E420	0.00373 mg/L	0.004 mg/L	93.3	70.0	130	----
		sodium, total	7440-23-5	E420	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, total	7440-24-6	E420	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, total	7704-34-9	E420	ND mg/L	20 mg/L	ND	70.0	130	----
		thallium, total	7440-28-0	E420	0.00360 mg/L	0.004 mg/L	90.0	70.0	130	----
		tin, total	7440-31-5	E420	0.0192 mg/L	0.02 mg/L	95.8	70.0	130	----
		titanium, total	7440-32-6	E420	0.0414 mg/L	0.04 mg/L	104	70.0	130	----
		uranium, total	7440-61-1	E420	0.00421 mg/L	0.004 mg/L	105	70.0	130	----
		vanadium, total	7440-62-2	E420	0.103 mg/L	0.1 mg/L	103	70.0	130	----
		zinc, total	7440-66-6	E420	0.363 mg/L	0.4 mg/L	90.8	70.0	130	----
Total Metals (QCLot: 404614)										
VA22A1890-002	BJ-GW18-17B-E314701	chromium, total	7440-47-3	E420.Cr-L	0.0392 mg/L	0.04 mg/L	98.1	70.0	130	----
Dissolved Metals (QCLot: 401610)										
CG2200994-020	Anonymous	mercury, dissolved	7439-97-6	E509	0.0000944 mg/L	0.0001 mg/L	94.4	70.0	130	----
Dissolved Metals (QCLot: 404605)										
VA22A1890-002	BJ-GW18-17B-E314701	aluminum, dissolved	7429-90-5	E421	0.192 mg/L	0.2 mg/L	95.8	70.0	130	----
		antimony, dissolved	7440-36-0	E421	0.0198 mg/L	0.02 mg/L	98.9	70.0	130	----
		arsenic, dissolved	7440-38-2	E421	0.0189 mg/L	0.02 mg/L	94.6	70.0	130	----

Sub-Matrix: **Water**

Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Matrix Spike (MS) Report: Spike Concentration	Spike Target	Recovery (%) MS	Recovery Limits (%) Low	Recovery Limits (%) High	Qualifier
Dissolved Metals (QCLot: 404605) - continued										
VA22A1890-002	BJ-GW18-17B-E314701	barium, dissolved	7440-39-3	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		beryllium, dissolved	7440-41-7	E421	0.0374 mg/L	0.04 mg/L	93.6	70.0	130	----
		bismuth, dissolved	7440-69-9	E421	0.00883 mg/L	0.01 mg/L	88.3	70.0	130	----
		boron, dissolved	7440-42-8	E421	0.094 mg/L	0.1 mg/L	93.6	70.0	130	----
		cadmium, dissolved	7440-43-9	E421	0.00384 mg/L	0.004 mg/L	96.1	70.0	130	----
		calcium, dissolved	7440-70-2	E421	ND mg/L	4 mg/L	ND	70.0	130	----
		cobalt, dissolved	7440-48-4	E421	0.0184 mg/L	0.02 mg/L	92.2	70.0	130	----
		copper, dissolved	7440-50-8	E421	0.0181 mg/L	0.02 mg/L	90.7	70.0	130	----
		iron, dissolved	7439-89-6	E421	1.81 mg/L	2 mg/L	90.3	70.0	130	----
		lead, dissolved	7439-92-1	E421	0.0188 mg/L	0.02 mg/L	94.1	70.0	130	----
		lithium, dissolved	7439-93-2	E421	ND mg/L	0.1 mg/L	ND	70.0	130	----
		magnesium, dissolved	7439-95-4	E421	ND mg/L	1 mg/L	ND	70.0	130	----
		manganese, dissolved	7439-96-5	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		molybdenum, dissolved	7439-98-7	E421	0.0202 mg/L	0.02 mg/L	101	70.0	130	----
		nickel, dissolved	7440-02-0	E421	0.0360 mg/L	0.04 mg/L	90.1	70.0	130	----
		phosphorus, dissolved	7723-14-0	E421	9.66 mg/L	10 mg/L	96.6	70.0	130	----
		potassium, dissolved	7440-09-7	E421	3.53 mg/L	4 mg/L	88.2	70.0	130	----
		selenium, dissolved	7782-49-2	E421	0.0400 mg/L	0.04 mg/L	100	70.0	130	----
		silicon, dissolved	7440-21-3	E421	8.86 mg/L	10 mg/L	88.6	70.0	130	----
		silver, dissolved	7440-22-4	E421	0.00350 mg/L	0.004 mg/L	87.6	70.0	130	----
		sodium, dissolved	7440-23-5	E421	ND mg/L	2 mg/L	ND	70.0	130	----
		strontium, dissolved	7440-24-6	E421	ND mg/L	0.02 mg/L	ND	70.0	130	----
		sulfur, dissolved	7704-34-9	E421	ND mg/L	20 mg/L	ND	70.0	130	----
		thallium, dissolved	7440-28-0	E421	0.00373 mg/L	0.004 mg/L	93.2	70.0	130	----
		tin, dissolved	7440-31-5	E421	0.0199 mg/L	0.02 mg/L	99.7	70.0	130	----
		titanium, dissolved	7440-32-6	E421	0.0388 mg/L	0.04 mg/L	97.1	70.0	130	----
		uranium, dissolved	7440-61-1	E421	0.00392 mg/L	0.004 mg/L	97.9	70.0	130	----
		vanadium, dissolved	7440-62-2	E421	0.0960 mg/L	0.1 mg/L	96.0	70.0	130	----
		zinc, dissolved	7440-66-6	E421	0.365 mg/L	0.4 mg/L	91.3	70.0	130	----
Dissolved Metals (QCLot: 404606)										
VA22A1890-002	BJ-GW18-17B-E314701	chromium, dissolved	7440-47-3	E421.Cr-L	0.0377 mg/L	0.04 mg/L	94.2	70.0	130	----
Aggregate Organics (QCLot: 405059)										
VA22A1689-002	Anonymous	chemical oxygen demand [COD]	----	E559	104 mg/L	100 mg/L	104	75.0	125	----

Qualifiers

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robin McCall	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2965 Tatlow Road	Email 1: environmental@pretivm.com	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Smithers, BC V0J 2N5	Email 2: rmccall@pretivm.com	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(866) 214-9772 Fax: (604) 558-4784	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack Groundwater	
Company:		PO / AFE: 1025614	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** NG/RS/KU

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients	EPH	Total Metals	Dissolved Metals			Total Mercury	Dissolved Mercury	Acidity	Total Sulphides		Number of Containers
						P		P	F/P			P	F/P		P		
	BJ-GW18-17A - E303066	29-Jan-22	14:45	Groundwater	X	X		X	X			X	X	X	X		7
	BJ-GW18-17B - E314701	29-Jan-22	15:10	Groundwater	X	X		X	X			X	X	X	X		7

Environmental Division Vancouver
Work Order Reference
VA22A1890

Telephone : +1 604 253 4188

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report results with 5 business day turnaround, no surcharge. Dissolved Metals and Dissolved Mercury are filtered. ~~TOC/DOC NOT required. Please CC report to Steven.Momeyer@lorax.ca,~~ Laura.Findlater@lorax.ca and bjwq@lorax.ca. EMS Upload Required (for samples with EMS number)

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
KU	30-Jan-22	18:00				6 °C	RJ	JAN 31	21:00	

Ice pack

Appendix K
Snap Sampler Trial Results

NEWCREST

Sample ID			**BJ-GW11-3A-E303056**	**BJ-GW11-3A-snap**	**RPD/Error**		**BJ-GW18-17B - E314701**	**BJ-GW18-17B-snap**	**RPD/Error**
Date Sampled			3-Jan-21	3-Jan-21			09-Jan-2021	30-Dec-2020	
ALS Sample ID			VA21A0051-004	VA21A0051-005			VA21A0475-001	VA21A0005-001	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	376	379	1%	2	768	650	17%
acidity (as CaCO3)	mg/L	2	<2.0	<2.0	<2MDL	2	<2.0	<2.0	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	98.9	98.5	0%	1	150	208	**32%**
hardness (as CaCO3), dissolved	mg/L	0.6	192	196	2%	0.6	179	64.4	**94%**
hardness (as CaCO3), from total Ca/Mg	mg/L	0.6	172	173	1%	0.6	233	81.8	**96%**
pH	pH units	0.1	8.18	8.23	1%	0.1	7.99	8.49	6%
solids, total dissolved [TDS]	mg/L	10	242	251	4%	10	532	500	6%
solids, total suspended [TSS]	mg/L	3	5.5	24.9	**>2MDL**	3	473	44.2	**166%**
turbidity	NTU	0.1	4.45	18.1	**121%**	0.1	540	59	**161%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	1.8	1.1	**48%**	0.05	0.93	0.606	**42%**
ammonia, total (as N)	mg/L	0.005	75.2	76.8	2%	0.005	0.116	0.29	**86%**
bromide	mg/L	0.05	<0.0050	<0.0050	<2MDL	0.05	<0.250	<0.050	**>2MDL**
chloride	mg/L	0.5	<0.050	<0.050	<2MDL	0.5	4.44	4.01	10%
fluoride	mg/L	0.02	<0.50	<0.50	0%	0.02	0.228	0.302	**28%**
nitrate (as N)	mg/L	0.005	0.025	0.024	<2MDL	0.005	0.0785	0.0477	**49%**
nitrate + nitrite (as N)	mg/L	0.005	0.0199	0.0219	<2MDL	0.0032	0.0905	0.0619	**38%**
nitrite (as N)	mg/L	0.001	<0.0010	<0.0010	<2MDL	0.001	0.012	0.0142	17%
nitrogen, total	mg/L	0.03	<0.050	0.1	<2MDL	0.03	1.02	0.668	**42%**
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.030	0.122	**121%**	0.001	0.031	0.437	**174%**
phosphorus, total	mg/L	0.002	<0.0010	<0.0010	<2MDL	0.002	0.435	0.589	**30%**
sulfate (as SO4)	mg/L	0.3	0.0086	0.0027	<2MDL	0.3	253	118	**73%**
sulfide, total (as H2S)	mg/L	0.019	32.9	33	0%	0.019	0.329	3.02	**161%**
sulfide, total (as S)	mg/L	0.018				0.018	0.309	2.84	**161%**
Total Metals (Water)									
aluminum, total	mg/L	0.003	0.275	0.648	**81%**	0.003	4.48	1.73	**89%**
antimony, total	mg/L	0.0001	0.00295	0.00817	**94%**	0.0001	0.00581	0.00136	**124%**
arsenic, total	mg/L	0.0001	0.00642	0.00813	**24%**	0.0001	0.0498	0.0314	**45%**
barium, total	mg/L	0.0001	0.024	0.036	**40%**	0.0001	0.185	0.0593	**103%**
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	<2MDL	0.0001	0.000365	<0.000100	**>2MDL**
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	0.000166	<0.000050	**>2MDL**
boron, total	mg/L	0.01	0.037	0.037	<2MDL	0.01	0.057	0.066	15%
cadmium, total	mg/L	0.000005	0.0000684	0.000318	**129%**	0.000005	0.000205	0.0000143	**>2MDL**
calcium, total	mg/L	0.05	61.1	61.6	1%	0.05	84	29.8	**95%**
chromium, total	mg/L	0.0001	0.00424	0.00056	**153%**	0.0001	0.0958	0.00155	**194%**
cobalt, total	mg/L	0.0001	0.00121	0.00018	**>2MDL**	0.0001	0.00514	0.00061	**158%**
copper, total	mg/L	0.0005	0.00052	0.00158	**>2MDL**	0.0005	0.0161	0.00802	**67%**
iron, total	mg/L	0.01	0.306	0.627	**69%**	0.01	6.27	0.806	**154%**
lead, total	mg/L	0.00005	0.00245	0.0114	**129%**	0.00005	0.0087	0.00107	**156%**
lithium, total	mg/L	0.001	0.015	0.0153	2%	0.001	0.162	0.167	3%
magnesium, total	mg/L	0.1	4.72	4.57	3%	0.1	5.76	1.8	**105%**
manganese, total	mg/L	0.0001	0.137	0.144	5%	0.0001	0.33	0.0834	**119%**
mercury, total	mg/L	0.000005	<0.0000050	<0.0000050	<2MDL	0.000005	0.0000776	<0.0000050	**>2MDL**
molybdenum, total	mg/L	0.00005	0.0015	0.000711	**71%**	0.00005	0.00551	0.00285	**64%**
nickel, total	mg/L	0.0005	0.00367	<0.00050	**>2MDL**	0.0005	0.0297	0.00155	**>2MDL**
phosphorus, total	mg/L	0.3	<0.300	<0.300	<2MDL	0.3	0.343	0.587	<2MDL
potassium, total	mg/L	0.05	1.4	1.57	11%	0.05	4.87	5.83	18%
selenium, total	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	0.00141	0.000324	**125%**
silicon, total	mg/L	0.1	4.03	4.66	14%	0.1	9.06	5.97	**41%**
silver, total	mg/L	0.00001	0.000037	0.000149	**>2MDL**	0.00001	0.000797	0.00006	**172%**
sodium, total	mg/L	0.05	6.68	6.73	1%	0.05	83	122	**38%**
strontium, total	mg/L	0.0002	1.11	1.06	5%	0.0002	2.76	1.14	**83%**
sulfur, total									
thallium, total	mg/L	0.00001	0.000019	0.000104	**>2MDL**	0.00001	0.000177	0.000038	**>2MDL**
tin, total	mg/L	0.0001	<0.00010	0.0004	**>2MDL**	0.0001	0.00142	0.00022	**>2MDL**
titanium, total	mg/L	0.01	<0.0100	0.0123	<2MDL	0.01	0.0329	0.0264	<2MDL
uranium, total	mg/L	0.00001	0.000165	0.000188	13%	0.00001	0.0035	0.000701	**133%**
vanadium, total	mg/L	0.0005	<0.00050	0.0011	<2MDL	0.0005	0.00881	0.00362	**84%**
zinc, total	mg/L	0.003	0.0152	0.0629	**122%**	0.003	0.0473	0.0069	**>2MDL**
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0014	0.002	<2MDL	0.001	0.023	0.021	9%
antimony, dissolved	mg/L	0.0001	0.00178	0.00232	**26%**	0.0001	0.00335	0.00063	**137%**
arsenic, dissolved	mg/L	0.0001	0.0058	0.0053	8%	0.0001	0.0271	0.0243	11%
barium, dissolved	mg/L	0.00010	0.02330	0.01860	**22%**	0.00010	0.03240	0.01920	**51%**
beryllium, dissolved	mg/L	0.00010	<0.000100	<0.000100	<2MDL	0.00010	<0.000100	<0.000100	<2MDL
bismuth, dissolved	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	<0.000050	<0.000050	<2MDL
boron, dissolved	mg/L	0.01000	0.04	0.037	<2MDL	0.01000	0.047	0.068	**>2MDL**
cadmium, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	<2MDL	0.000005	<0.0000050	<0.0000050	<2MDL
calcium, dissolved	mg/L	0.050	69.300	71.200	3%	0.050	66.300	23.600	**95%**
chromium, dissolved	mg/L	0.0001000	0.0001700	<0.00010	<2MDL	0.0001000	0.0003700	0.0002100	<2MDL
cobalt, dissolved	mg/L	0.0001	0.000650	<0.00010	**>2MDL**	0.0001	0.0	<0.00010	<2MDL
copper, dissolved	mg/L	0.00020	0.00037	<0.00020	<2MDL	0.00020	<0.00020	<0.00020	<2MDL
iron, dissolved	mg/L	0.01000	0.117	0.099	17%	0.01000	0.015	0.014	<2MDL
lead, dissolved	mg/L	0.00005	<0.000050	0.00012	<2MDL	0.00005	<0.000050	<0.000050	<2MDL
lithium, dissolved	mg/L	0.001	0.0162	0.016	1%	0.001	0.177	0.174	2%
magnesium, dissolved	mg/L	0.100000	4.52	4.39	3%	0.100000	3.27	1.34	**84%**
manganese, dissolved	mg/L	0.0001	0.1370	0.1300	5%	0.0001	0.0856	0.0380	**77%**
mercury, dissolved	mg/L	0.00	<0.0000050	<0.0000050	<2MDL	0.00	0.00	<0.0000050	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.00139	0.00070	**66%**	0.00005	0.00392	0.00256	**42%**
nickel, dissolved	mg/L	0.0005000	0.00112	<0.00050	<2MDL	0.0005000	0.00109	0.00068	<2MDL
phosphorus, dissolved	mg/L	0.300000	<0.300	<0.300	<2MDL	0.300000	<0.300	0.559000	<2MDL
potassium, dissolved	mg/L	0.05000	1.47	1.42	3%	0.05000	3.92	5.19	**28%**
selenium, dissolved	mg/L	0.00	<0.000050	<0.000050	<2MDL	0.00	0.000599	0.00176	**98%**
silicon, dissolved	mg/L	0.050	3.60	3.60	0%	0.050	2.94	3.51	18%
silver, dissolved	mg/L	0.000010	<0.000010	<0.000010	<2MDL	0.000010	<0.000010	<0.000010	<2MDL
sodium, dissolved	mg/L	0.050	7.19	7.36	2%	0.050	88.10	122.00	**32%**
strontium, dissolved	mg/L	0.000200	1.24	1.3	5%	0.000200	2.55	1.02	**86%**
sulfur, dissolved									
thallium, dissolved	mg/L	0.000	<0.000010	<0.000010	<2MDL	0.000	<0.000010	<0.000010	<2MDL
tin, dissolved	mg/L	0.00010	<0.00010	<0.00010	<2MDL	0.00010	0.00040	0.00016	**>2MDL**
titanium, dissolved	mg/L	0.010000	<0.0100	<0.0100	<2MDL	0.010000	<0.0100	<0.0100	<2MDL
uranium, dissolved	mg/L	0.00001	0.000145	0.000145	0%	0.00001	0.00312	0.00061	**135%**
vanadium, dissolved	mg/L	0.001	<0.00050	<0.00050	<2MDL	0.001	0.00074	0.00099	<2MDL
zinc, dissolved	mg/L	0.001000	0.010600	0.002000	**>2MDL**	0.001000	<0.0010	<0.0010	<2MDL
zirconium, dissolved									
dissolved mercury filtration location	-	-	Field	Field			Field	Field	
dissolved metals filtration location	-	-	Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	<20	<20	<2MDL	20	61	224	**>2MDL**

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW18-18B - E314702**	**BJ-GW18-18B - Snap**	**RPD/Error**		**BJ-GW18-17A-E303066**	**BJ-GW18-17A-Snap**	**RPD/Error**
Date Sampled			09-Jan-2021	09-Jan-2021			24-Jan-2021	24-Jan-2021	
ALS Sample ID			VA21A0475-003	VA21A0475-002			VA21A1383-001	VA21A1383-002	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	602	597	1%	2	754	815	8%
acidity (as CaCO3)	mg/L	2	<2.0	<2.0	<2MDL	2	<2.0	<2.0	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	111	148	**29%**	1	108	97.2	11%
hardness (as CaCO3), dissolved	mg/L	0.6	216	170	**24%**	0.6	49.5	11	**127%**
hardness (as CaCO3), from total Ca/Mg	mg/L	0.6	224	384	**53%**	0.6	56	20.7	**92%**
pH	pH units	0.1	8.08	8	1%	0.1	8.74	8.94	2%
solids, total dissolved [TDS]	mg/L	10	356	424	17%	10	482	491	2%
solids, total suspended [TSS]	mg/L	3	5.3	193	**>2MDL**	3	9.6	68.2	**>2MDL**
turbidity	NTU	0.1	4			0.1	4.6	37.9	**157%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.082	0.096	<2MDL	0.05	0.172	0.147	<2MDL
ammonia, total (as N)	mg/L	0.005	0.06	0.0569	5%	0.005	0.102	0.0482	**72%**
bromide	mg/L	0.05	<0.050	<0.050	<2MDL	0.05	<0.250	<0.250	<2MDL
chloride	mg/L	0.5	3.75	3.78	1%	0.5	4.39	4.83	10%
fluoride	mg/L	0.02	0.094	0.094	<2MDL	0.02	0.234	0.229	2%
nitrate (as N)	mg/L	0.005	<0.0050	<0.0050	<2MDL	0.005	<0.0250	0.0462	**>2MDL**
nitrate + nitrite (as N)	mg/L	0.0032	<0.0051	<0.0051	<2MDL	0.005	<0.0255	0.119	**129%**
nitrite (as N)	mg/L	0.001	<0.0010	<0.0010	<2MDL	0.001	0.0085	0.0732	**158%**
nitrogen, total	mg/L	0.03	0.082	0.096	<2MDL	0.03	0.172	0.266	**43%**
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.0011	0.0014	<2MDL	0.001	0.0068	0.01	**38%**
phosphorus, total	mg/L	0.002	0.0052	0.0109	**>2MDL**	0.002	0.0142	0.029	**69%**
sulfate (as SO4)	mg/L	0.3	197	198	1%	0.3	241	271	12%
sulfide, total (as H2S)	mg/L	0.019	<0.019	<0.019	<2MDL	0.019	0.523	<0.019	**>2MDL**
sulfide, total (as S)	mg/L	0.018	<0.018	<0.018	<2MDL	0.018	0.492	<0.018	**>2MDL**
Total Metals (Water)									
aluminum, total	mg/L	0.003	0.146	0.733	**134%**	0.003	0.162	0.0695	**80%**
antimony, total	mg/L	0.0001	0.00012	0.0003	<2MDL	0.0001	0.0211	0.0295	**33%**
arsenic, total	mg/L	0.0001	0.00072	0.00247	**110%**	0.0001	0.182	0.327	**57%**
barium, total	mg/L	0.0001	0.0238	0.184	**154%**	0.0001	0.0629	0.0501	**23%**
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	<2MDL	0.00002	<0.000020	<0.000020	<2MDL
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	<0.000050	<0.000050	<2MDL
boron, total	mg/L	0.01	0.035	0.034	<2MDL	0.01	0.073	0.082	12%
cadmium, total	mg/L	0.000005	<0.0000050	0.0000309	**>2MDL**	0.000005	0.0000067	<0.0000050	<2MDL
calcium, total	mg/L	0.05	72.2	136	**61%**	0.05	21.2	7.91	**91%**
chromium, total	mg/L	0.0001	0.00296	0.0016	**60%**	0.0001	0.00024	0.00058	**>2MDL**
cobalt, total	mg/L	0.0001	0.00022	0.00042	**>2MDL**	0.0001	<0.00010	<0.00010	<2MDL
copper, total	mg/L	0.0005	<0.00050	0.00212	**>2MDL**	0.0005	<0.00050	<0.00050	<2MDL
iron, total	mg/L	0.01	0.116	0.702	**143%**	0.01	0.05	0.053	<2MDL
lead, total	mg/L	0.00005	0.000488	0.000478	2%	0.00005	0.000181	0.000174	<2MDL
lithium, total	mg/L	0.001	0.066	0.0644	2%	0.001	0.359	0.418	15%
magnesium, total	mg/L	0.1	10.5	10.8	3%	0.1	0.741	0.24	**>2MDL**
manganese, total	mg/L	0.0001	0.0262	0.0674	**88%**	0.0001	0.0233	0.0158	**38%**
mercury, total	mg/L	0.000005	<0.0000050	<0.0000050	<2MDL	0.000005	<0.0000050	<0.0000050	<2MDL
molybdenum, total	mg/L	0.00005	0.00073	0.000466	**44%**	0.00005	0.00302	0.00417	**32%**
nickel, total	mg/L	0.0005	0.00177	0.00071	**>2MDL**	0.0005	<0.00050	<0.00050	<2MDL
phosphorus, total	mg/L	0.3	<0.300	<0.300	<2MDL	0.05	<0.050	<0.050	<2MDL
potassium, total	mg/L	0.05	2.73	3.13	14%	0.1	1.73	1.91	10%
selenium, total	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	0.000187	0.000328	**>2MDL**
silicon, total	mg/L	0.1	3.55	4.91	**32%**	0.1	3.13	3.04	3%
silver, total	mg/L	0.00001	0.000023	0.000095	**>2MDL**	0.00001	0.00001	<0.000010	<2MDL
sodium, total	mg/L	0.05	38.5	38.8	1%	0.05	138	160	15%
strontium, total	mg/L	0.0002	1.6	2	**22%**	0.0002	0.824	0.398	**70%**
sulfur, total						0.5	85.7	92.4	8%
thallium, total	mg/L	0.00001	0.000015	0.000029	<2MDL	0.00001	<0.000010	<0.000010	<2MDL
tin, total	mg/L	0.0001	<0.00010	0.00053	**>2MDL**	0.0001	<0.00010	<0.00010	<2MDL
titanium, total	mg/L	0.01	<0.0100	<0.0100	<2MDL	0.0003	0.00122	0.0009	<2MDL
uranium, total	mg/L	0.00001	0.000401	0.000602	**40%**	0.00001	0.000221	0.000197	11%
vanadium, total	mg/L	0.0005	<0.00050	0.00107	<2MDL	0.0005	<0.00050	<0.00050	<2MDL
zinc, total	mg/L	0.003	0.0033	0.0063	<2MDL	0.003	<0.0030	<0.0030	<2MDL
zirconium, total	mg/L					0.0002	0.00068	<0.00020	**>2MDL**
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0036	0.0032	<2MDL	0.001	0.0413	0.0123	**108%**
antimony, dissolved	mg/L	0.0001	0.00011	0.00011	<2MDL	0.0001	0.0181	0.0313	**53%**
arsenic, dissolved	mg/L	0.0001	0.0005	0.0005	<2MDL	0.0001	0.167	0.327	**65%**
barium, dissolved	mg/L	0.00010	0.01940	0.02560	**28%**	0.0001	0.0544	0.0387	**34%**
beryllium, dissolved	mg/L	0.00010	<0.000100	<0.000100	<2MDL	0.00002	<0.000020	<0.000020	<2MDL
bismuth, dissolved	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	<0.000050	<0.000050	<2MDL
boron, dissolved	mg/L	0.01000	0.03	0.027	<2MDL	0.01	0.065	0.079	19%
cadmium, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	<2MDL	0.000005	0.000006	<0.0000050	<2MDL
calcium, dissolved	mg/L	0.050	68.800	54.400	**23%**	0.05	18.5	4.05	**128%**
chromium, dissolved	mg/L	0.0001000	0.0006100	0.0003200	**>2MDL**	0.0001	<0.00010	0.0003700	**>2MDL**
cobalt, dissolved	mg/L	0.0001	<0.00010	<0.00010	<2MDL	0.0001	<0.00010	<0.00010	<2MDL
copper, dissolved	mg/L	0.00020	0.00058	<0.00020	<2MDL	0.0002	0.00038	<0.00020	<2MDL
iron, dissolved	mg/L	0.01000	0.017	<0.010	<2MDL	0.01	0.015	<0.010	<2MDL
lead, dissolved	mg/L	0.00005	0.00010	<0.000050	<2MDL	0.00005	0.00014	0.00012	<2MDL
lithium, dissolved	mg/L	0.001	0.0701	0.0755	7%	0.001	0.345	0.446	**26%**
magnesium, dissolved	mg/L	0.100000	10.7	8.37	**24%**	0.1	0.811	0.223	**>2MDL**
manganese, dissolved	mg/L	0.0001	0.0236	0.0140	**51%**	0.0001	0.0224	0.00599	**116%**
mercury, dissolved	mg/L	0.00	<0.0000050	<0.0000050	<2MDL	0.000005	<0.0000050	<0.0000050	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.00065	0.00053	19%	0.00005	0.00278	0.0039	**34%**
nickel, dissolved	mg/L	0.0005000	0.00117	<0.00050	<2MDL	0.0005	<0.00050	<0.00050	<2MDL
phosphorus, dissolved	mg/L	0.300000	<0.300	<0.300	<2MDL	0.05	<0.050	<0.050	<2MDL
potassium, dissolved	mg/L	0.05000	3.17	3.88	**20%**	0.1	1.82	2	9%
selenium, dissolved	mg/L	0.00	<0.000050	<0.000050	<2MDL	0.00005	0.00212	0.000336	**145%**
silicon, dissolved	mg/L	0.050	3.34	2.65	**23%**	0.05	3.17	2.92	8%
silver, dissolved	mg/L	0.000010	<0.000010	<0.000010	<2MDL	0.00001	<0.000010	<0.000010	<2MDL
sodium, dissolved	mg/L	0.050	40.90	41.60	2%	0.05	150	176	16%
strontium, dissolved	mg/L	0.000200	1.63	1.48	10%	0.0002	0.845	0.358	**81%**
sulfur, dissolved						0.500000	97.7	97.5	0%
thallium, dissolved	mg/L	0.000	0.0	<0.000010	<2MDL	0.00001	<0.000010	<0.000010	<2MDL
tin, dissolved	mg/L	0.00010	<0.00010	<0.00010	<2MDL	0.0001	<0.00010	<0.00010	<2MDL
titanium, dissolved	mg/L	0.010000	<0.0100	<0.0100	<2MDL	0.0003	<0.00030	<0.00030	<2MDL
uranium, dissolved	mg/L	0.00001	0.000377	0.000314	18%	0.00001	0.000224	0.000203	10%
vanadium, dissolved	mg/L	0.001	<0.00050	<0.00050	<2MDL	0.0005	<0.00050	<0.00050	<2MDL
zinc, dissolved	mg/L	0.001000	0.003900	<0.0010	**>2MDL**	0.001	0.0051	<0.0010	**>2MDL**
zirconium, dissolved						0.000200	<0.00020	<0.00020	<2MDL
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	<20	<20	<2MDL	20	<20	<20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW12-8A-E303059**	**BJ-GW12-8A-SNAP**	**RPD/Error**		**BJ-GW12-8B - E314695**	**BJ-GW12-8B - snap**	**RPD/Error**
Date Sampled			27-Jan-2021	27-Jan-2021			28-Jan-2021	28-Jan-2021	
ALS Sample ID			VA21A1647-002	VA21A1647-001			VA21A1808-002	VA21A1808-001	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	212	221	4%	2	219	223	2%
acidity (as CaCO3)	mg/L	2	<2.0	<2.0	<2MDL	2	<2.0	<2.0	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	68.6	73.6	7%	1	69	68.7	0%
hardness (as CaCO3), dissolved	mg/L	0.6	106	110	4%	0.6	110	106	4%
hardness (as CaCO3), from total Ca/Mg	mg/L	0.6	114	151	**28%**	0.6	100	97.5	3%
pH	pH units	0.1	8.08	8.07	0%	0.1	8.12	8.11	0%
solids, total dissolved [TDS]	mg/L	10	131	137	4%	10	122	126	3%
solids, total suspended [TSS]	mg/L	3	<3.0	30.4	**>2MDL**	3	7.4	5.4	<2MDL
turbidity	NTU	0.1	1.28	6.23	**132%**	0.1	7	0.81	**159%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	<0.050	0.087	<2MDL	0.05	<0.050	0.108	<2MDL
ammonia, total (as N)	mg/L	0.005	<0.0050	<0.0050	<2MDL	0.005	<0.0050	<0.0050	<2MDL
bromide	mg/L	0.05	<0.050	<0.050	<2MDL	0.05	<0.050	<0.050	<2MDL
chloride	mg/L	0.5	<0.50	<0.50	<2MDL	0.5	<0.50	<0.50	<2MDL
fluoride	mg/L	0.02	0.023	0.024	<2MDL	0.02	0.025	0.026	<2MDL
nitrate (as N)	mg/L	0.005	0.0187	0.0262	<2MDL	0.005	0.0205	0.0175	<2MDL
nitrate + nitrite (as N)	mg/L	0.005	0.0187	0.0262	<2MDL	0.005	0.0205	0.0175	<2MDL
nitrite (as N)	mg/L	0.001	<0.0010	<0.0010	<2MDL	0.001	<0.0010	<0.0010	<2MDL
nitrogen, total	mg/L	0.03	<0.030	0.113	**>2MDL**	0.03	<0.030	0.126	**>2MDL**
phosphate, ortho-, dissolved (as P)	mg/L	0.001	<0.0010	<0.0010	<2MDL	0.001	<0.0010	<0.0010	<2MDL
phosphorus, total	mg/L	0.002	0.0032	0.0776	**>2MDL**	0.002	0.0066	0.0237	**>2MDL**
sulfate (as SO4)	mg/L	0.3	35.1	36.2	3%	0.3	37.3	37.1	1%
sulfide, total (as H2S)	mg/L	0.019	<0.019			0.019	<0.019	<0.019	<2MDL
sulfide, total (as S)	mg/L	0.018	<0.018			0.018	<0.018	<0.018	<2MDL
Total Metals (Water)									
aluminum, total	mg/L	0.003	0.0544	0.921	**178%**	0.003	0.411	0.0426	**162%**
antimony, total	mg/L	0.0001	0.00082	0.0014	**52%**	0.0001	0.00081	0.0008	1%
arsenic, total	mg/L	0.0001	0.00964	0.0418	**125%**	0.0001	0.0158	0.015	5%
barium, total	mg/L	0.0001	0.0222	0.0902	**121%**	0.0001	0.0279	0.0197	**34%**
beryllium, total	mg/L	0.0001	<0.000100	<0.000100	<2MDL	0.0001	<0.000100	<0.000100	<2MDL
bismuth, total	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	<0.000050	<0.000050	<2MDL
boron, total	mg/L	0.01	<0.010	<0.010	<2MDL	0.01	<0.010	<0.010	<2MDL
cadmium, total	mg/L	0.000005	0.0000128	0.000128	**>2MDL**	0.000005	<0.0000050	<0.0000050	<2MDL
calcium, total	mg/L	0.05	35.1	49.3	**34%**	0.05	32.6	31.5	3%
chromium, total	mg/L	0.0001	0.00098	0.00197	**67%**	0.0001	0.00597	0.00011	**>2MDL**
cobalt, total	mg/L	0.0001	<0.00010	0.00116	**>2MDL**	0.0001	0.00032	<0.00010	**>2MDL**
copper, total	mg/L	0.0005	<0.00050	0.00816	**>2MDL**	0.0005	0.00063	<0.00050	<2MDL
iron, total	mg/L	0.01	0.056	2.38	**191%**	0.01	0.282	0.08	**112%**
lead, total	mg/L	0.00005	0.00017	0.00383	**>2MDL**	0.00005	0.000406	0.000102	**>2MDL**
lithium, total	mg/L	0.001	0.0086	0.0094	9%	0.001	0.0065	0.0062	5%
magnesium, total	mg/L	0.1	6.46	6.8	5%	0.1	4.52	4.57	1%
manganese, total	mg/L	0.0001	0.00493	0.146	**187%**	0.0001	0.0219	0.00664	**107%**
mercury, total	mg/L	0.000005	<0.0000050	0.0000057	<2MDL	0.000005	<0.0000050	<0.0000050	<2MDL
molybdenum, total	mg/L	0.00005	0.00131	0.00136	4%	0.00005	0.00189	0.00118	**46%**
nickel, total	mg/L	0.0005	0.00061	0.00088	<2MDL	0.0005	0.00354	<0.00050	**>2MDL**
phosphorus, total	mg/L	0.3	<0.300	<0.300	<2MDL	0.3	<0.300	<0.300	<2MDL
potassium, total	mg/L	0.05	0.45	0.739	**49%**	0.05	0.648	0.541	18%
selenium, total	mg/L	0.00005	0.000221	0.000254	<2MDL	0.00005	0.000362	0.000346	5%
silicon, total	mg/L	0.1	2.04	3.16	**43%**	0.1	2.48	1.95	**24%**
silver, total	mg/L	0.00001	<0.000010	0.000306	**>2MDL**	0.00001	0.000018	<0.000010	<2MDL
sodium, total	mg/L	0.05	3.32	3.76	12%	0.05	2.52	2.64	5%
strontium, total	mg/L	0.0002	0.707	0.746	5%	0.0002	0.552	0.559	1%
sulfur, total									
thallium, total	mg/L	0.00001	<0.000010	0.000025	<2MDL	0.00001	0.00001	<0.000010	<2MDL
tin, total	mg/L	0.0001	<0.00010	0.00084	**>2MDL**	0.0001	<0.00010	<0.00010	<2MDL
titanium, total	mg/L	0.01	<0.0100	<0.0100	<2MDL	0.01	<0.0100	<0.0100	<2MDL
uranium, total	mg/L	0.00001	0.000181	0.0003	**38%**	0.00001	0.000169	0.000163	4%
vanadium, total	mg/L	0.0005	<0.00050	0.00103	<2MDL	0.0005	0.00075	<0.00050	<2MDL
zinc, total	mg/L	0.003	0.0033	0.0191	**>2MDL**	0.003	0.0039	<0.0030	<2MDL
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0015	0.0334	**>2MDL**	0.001	0.0018	0.0015	<2MDL
antimony, dissolved	mg/L	0.0001	0.00095	0.00093	2%	0.0001	0.00081	0.00079	2%
arsenic, dissolved	mg/L	0.0001	0.00889	0.00892	0%	0.00010	0.0130	0.0134	3%
barium, dissolved	mg/L	0.0001	0.0232	0.021	10%	0.00010	0.02060	0.01910	8%
beryllium, dissolved	mg/L	0.0001	<0.000100	<0.000100	<2MDL	0.00010	<0.000100	<0.000100	<2MDL
bismuth, dissolved	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.00005	<0.000050	<0.000050	<2MDL
boron, dissolved	mg/L	0.01	<0.010	<0.010	<2MDL	0.010000	<0.010	<0.010	<2MDL
cadmium, dissolved	mg/L	0.000005	0.00001	0.0	<2MDL	0.000	<0.0000050	<0.0000050	<2MDL
calcium, dissolved	mg/L	0.05	32.8	33.8	3%	0.0500000	36.800	35.300	4%
chromium, dissolved	mg/L	0.0001	0.00029	<0.00010	<2MDL	0.000	0.0010300	<0.00010	**>2MDL**
cobalt, dissolved	mg/L	0.0001	<0.00010	<0.00010	<2MDL	0.00010	<0.00010	<0.00010	<2MDL
copper, dissolved	mg/L	0.0002	0.00025	0.0006	<2MDL	0.00020	0.00063	<0.00020	**>2MDL**
iron, dissolved	mg/L	0.01	<0.010	<0.010	<2MDL	0.01000	<0.010	<0.010	<2MDL
lead, dissolved	mg/L	0.00005	<0.000050	<0.000050	<2MDL	0.000	<0.000050	<0.000050	<2MDL
lithium, dissolved	mg/L	0.001	0.009	0.009	0%	0.001000	0.0069	0.007	1%
magnesium, dissolved	mg/L	0.1	5.88	6.32	7%	0.1000	4.32	4.33	0%
manganese, dissolved	mg/L	0.0001	0.00138	0.00032	**>2MDL**	0.00	0.0050	<0.00010	**>2MDL**
mercury, dissolved	mg/L	0.000005	<0.0000050	<0.0000050	<2MDL	0.00001	<0.0000050	<0.0000050	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.00137	0.00127	8%	0.0000500	0.00167	0.00116	**36%**
nickel, dissolved	mg/L	0.0005	<0.00050	<0.00050	<2MDL	0.000500	0.00178	<0.00050	**>2MDL**
phosphorus, dissolved	mg/L	0.3	<0.300	<0.300	<2MDL	0.30000	<0.300	<0.300	<2MDL
potassium, dissolved	mg/L	0.05	0.432	0.46	6%	0.05	0.488	0.476	2%
selenium, dissolved	mg/L	0.00005	0.000223	0.000207	<2MDL	0.000	0.000369	0.000319	15%
silicon, dissolved	mg/L	0.05	1.99	2.07	4%	0.050000	1.92	1.88	2%
silver, dissolved	mg/L	0.00001	<0.000010	<0.000010	<2MDL	0.000	<0.000010	<0.000010	<2MDL
sodium, dissolved	mg/L	0.05	3.21	3.5	9%	0.050000	2.38	2.40	1%
strontium, dissolved	mg/L	0.0002	0.758	0.767	1%	0.000	0.554	0.567	2%
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	<0.000010	<0.000010	<2MDL	0.00001	<0.000010	<0.000010	<2MDL
tin, dissolved	mg/L	0.0001	<0.00010	<0.00010	<2MDL	0.000100	<0.00010	<0.00010	<2MDL
titanium, dissolved	mg/L	0.01	<0.0100	<0.0100	<2MDL	0.01000	<0.0100	<0.0100	<2MDL
uranium, dissolved	mg/L	0.00001	0.000175	0.000186	6%	0.000	0.00016	0.000168	5%
vanadium, dissolved	mg/L	0.0005	<0.00050	<0.00050	<2MDL	0.000500	<0.00050	<0.00050	<2MDL
zinc, dissolved	mg/L	0.00100	0.0042	0.0015	**>2MDL**	0.00100	0.003700	<0.0010	**>2MDL**
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	<20	<20	<2MDL	20	<20	<20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW18-17B-E314701**	**BJ-GW18-17B-SNAP**	**RPD/Error**		**BJ-GW18-17A - E303066**	**BJ-GW18-17A-snap**	**RPD/Error**
Date Sampled			04-Mar-2021	04-Mar-2021			27-Apr-2021	31-Mar-2021	
ALS Sample ID			VA21A4222-002	VA21A4222-001			VA21A8275-002	VA21A6199-001	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	765	847	10%	2	688	899	**27%**
acidity (as CaCO3)	mg/L	2	2	2.4	<2MDL	2	2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	108	241	**76%**	1	135	102	**28%**
hardness (as CaCO3), dissolved	mg/L	0.6	182	181	1%	0.5	122	11	**167%**
hardness (as CaCO3), from total Ca/Mg	mg/L	0.6	239	161	**39%**	0.5	129	18.5	**150%**
pH	pH units	0.1	8	8.44	5%	0.1	8.29	8.99	8%
solids, total dissolved [TDS]	mg/L	10	514	641	**22%**	10	436	567	**26%**
solids, total suspended [TSS]	mg/L	3	348	24.5	**174%**	3	10.7	116	**>2MDL**
turbidity	NTU	0.1	385	30.2	**171%**	0.1	3.95	57.7	**174%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.961	0.612	**44%**	0.05	0.096	0.102	<2MDL
ammonia, total (as N)	mg/L	0.005	0.293	0.128	**78%**	0.005	0.0824	0.0414	**66%**
bromide	mg/L	0.05	0.25	0.05	**>2MDL**	0.05	0.25	0.25	<2MDL
chloride	mg/L	0.5	4.15	4.84	15%	0.5	4.84	5.21	7%
fluoride	mg/L	0.02	0.245	0.199	**21%**	0.02	0.179	0.219	**20%**
nitrate (as N)	mg/L	0.005	0.0358	0.0584	**48%**	0.005	0.025	0.025	<2MDL
nitrate + nitrite (as N)	mg/L	0.005	0.0593	0.0716	19%	0.005	0.0255	0.0255	0%
nitrite (as N)	mg/L	0.001	0.0235	0.0132	**56%**	0.001	0.005	0.005	<2MDL
nitrogen, total	mg/L	0.03	1.02	0.684	**39%**	0.03	0.096	0.102	<2MDL
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.004	0.301	**>2MDL**	0.001	0.0024	0.0105	**>2MDL**
phosphorus, total	mg/L	0.002	0.322	0.509	**45%**	0.002	0.0086	0.0889	**>2MDL**
sulfate (as SO4)	mg/L	0.3	272	194	**33%**	0.3	216	310	**36%**
sulfide, total (as H2S)	mg/L	0.019	0.073		**>2MDL**	0.019	0.493	0.019	**>2MDL**
sulfide, total (as S)	mg/L	0.018	0.069		**>2MDL**	0.018	0.524	0.018	**>2MDL**
Total Metals (Water)									
aluminum, total	mg/L	0.003	14.2	2.07	**149%**	0.003	0.0528	0.0724	**31%**
antimony, total	mg/L	0.0001	0.00662	0.00096	**149%**	0.0001	0.0026	0.0203	**155%**
arsenic, total	mg/L	0.0001	0.0635	0.0293	**74%**	0.0001	0.0492	0.274	**139%**
barium, total	mg/L	0.0001	0.433	0.0818	**136%**	0.0001	0.0925	0.0415	**76%**
beryllium, total	mg/L	0.0001	0.000477	0.0001	**>2MDL**	0.0001	0.0001	0.0001	<2MDL
bismuth, total	mg/L	0.00005	0.00015	0.00005	**>2MDL**	0.00005	0.00005	0.00005	<2MDL
boron, total	mg/L	0.01	0.058	0.07	19%	0.01	0.057	0.082	**36%**
cadmium, total	mg/L	0.000005	0.000142	0.0000278	**135%**	0.000005	0.0000068	0.000005	<2MDL
calcium, total	mg/L	0.05	85.7	58.3	**38%**	0.05	48.6	6.98	**150%**
chromium, total	mg/L	0.0001	0.0756	0.00374	**181%**	0.0001	0.0005	0.0007	**>2MDL**
cobalt, total	mg/L	0.0001	0.00722	0.00082	**159%**	0.0001	0.0001	0.0001	<2MDL
copper, total	mg/L	0.0005	0.0174	0.0015	**>2MDL**	0.0005	0.0005	0.0005	<2MDL
iron, total	mg/L	0.01	7.2	1.11	**147%**	0.01	0.044	0.077	**>2MDL**
lead, total	mg/L	0.00005	0.00884	0.00107	**157%**	0.00005	0.000102	0.000213	**>2MDL**
lithium, total	mg/L	0.001	0.167	0.168	1%	0.001	0.248	0.413	**50%**
magnesium, total	mg/L	0.1	6.1	3.84	**45%**	0.1	1.87	0.267	**>2MDL**
manganese, total	mg/L	0.0001	0.537	0.363	**39%**	0.0001	0.055	0.0195	**95%**
mercury, total	mg/L	0.000005	0.0001	0.0001	0%	0.000005	0.000005	0.000005	<2MDL
molybdenum, total	mg/L	0.00005	0.0136	0.00228	**143%**	0.00005	0.00157	0.00404	**88%**
nickel, total	mg/L	0.0005	0.0427	0.00262	**177%**	0.0005	0.0005	0.0005	<2MDL
phosphorus, total	mg/L	0.3	0.366	0.487	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	12.2	4.67	**89%**	0.05	1.78	1.73	3%
selenium, total	mg/L	0.00005	0.0012	0.000418	**97%**	0.00005	0.00005	0.000231	**>2MDL**
silicon, total	mg/L	0.1	23	7.85	**98%**	0.1	2.97	3.12	5%
silver, total	mg/L	0.00001	0.000639	0.000096	**148%**	0.00001	0.00001	0.000011	<2MDL
sodium, total	mg/L	0.05	98.4	125	**24%**	0.05	103	174	**51%**
strontium, total	mg/L	0.0002	2.93	2.27	**25%**	0.0002	1.66	0.415	**120%**
sulfur, total									
thallium, total	mg/L	0.00001	0.000355	0.000052	**149%**	0.00001	0.00001	0.00001	0%
tin, total	mg/L	0.0001	0.00174	0.0004	**125%**	0.0001	0.0001	0.0001	0%
titanium, total	mg/L	0.01	0.161	0.0328	**132%**	0.01	0.01	0.01	0%
uranium, total	mg/L	0.00001	0.00452	0.00306	<2MDL	0.00001	0.000206	0.000185	<2MDL
vanadium, total	mg/L	0.0005	0.0226	0.00429	**136%**	0.0005	0.0005	0.0005	0%
zinc, total	mg/L	0.003	0.0569	0.006	**162%**	0.003	0.003	0.003	0%
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0859	0.0072	**169%**	0.001	0.0092	0.0109	17%
antimony, dissolved	mg/L	0.0001	0.00487	0.00046	**>2MDL**	0.0001	0.00125	0.0193	**>2MDL**
arsenic, dissolved	mg/L	0.0001	0.0329	0.0244	**30%**	0.0001	0.0411	0.291	**150%**
barium, dissolved	mg/L	0.0001	0.0442	0.0375	16%	0.0001	0.0845	0.0340	**85%**
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.000050	0.000050	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0500	0.0660	**28%**	0.01	0.0560	0.0800	**35%**
cadmium, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.000005	0.000005	<2MDL
calcium, dissolved	mg/L	0.05	67.6	66.4	2%	0.05	45.8	4.02	**168%**
chromium, dissolved	mg/L	0.0001	0.00091	0.00040	<2MDL	0.0001	0.00050	0.00031	<2MDL
cobalt, dissolved	mg/L	0.0001	0.0001800	0.0001000	<2MDL	0.0001	0.00010	0.00010	<2MDL
copper, dissolved	mg/L	0.0002	0.00020	0.00020	<2MDL	0.0002	0.00020	0.00020	<2MDL
iron, dissolved	mg/L	0.01	0.02300	0.01300	**56%**	0.01	0.01500	0.01000	**40%**
lead, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.000121	<2MDL
lithium, dissolved	mg/L	0.001	0.19900	0.19800	1%	0.001	0.24300	0.44900	**60%**
magnesium, dissolved	mg/L	0.1	3.31	3.6	8%	0.1	1.78	0.243	**152%**
manganese, dissolved	mg/L	0.0001	0.0592	0.376	**>2MDL**	0.0001	0.0535	0.00667	<2MDL
mercury, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005		0.000005	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0096	0.0018	**136%**	0.00005	0.00157	0.00364	**79%**
nickel, dissolved	mg/L	0.0005	0.00374	0.00100	**116%**	0.0005	0.00050	0.00050	0%
phosphorus, dissolved	mg/L	0.3	0.3	0.46	**42%**	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	9.170000	4.830000	**62%**	0.05	1.880000	1.780000	5%
selenium, dissolved	mg/L	0.00005	0.000982	0.00824	<2MDL	0.00005	0.000293	0.000171	<2MDL
silicon, dissolved	mg/L	0.05	3.07	4.76	**43%**	0.05	2.83	2.99	5%
silver, dissolved	mg/L	0.00001	0.000010	0.000010	<2MDL	0.00001	0.000010	0.000010	<2MDL
sodium, dissolved	mg/L	0.05	105	129	**21%**	0.05	107	176	**49%**
strontium, dissolved	mg/L	0.0002	2.73	2.67	2%	0.0002	1.80	0.38	**130%**
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	0.0003	0.00026	14%	0.00001	0.00001	0.00001	0%
tin, dissolved	mg/L	0.0001	0.01	0.01	0%	0.0001	0.00010	0.00010	0%
titanium, dissolved	mg/L	0.01	0.004	0.003	**22%**	0.01	0.010	0.010	0%
uranium, dissolved	mg/L	0.00001	0.00381	0.00133	<2MDL	0.00001	0.000217	0.000179	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0016	0.001	**46%**	0.0005	0.0005	0.0005	0%
zinc, dissolved	mg/L	0.001				0.001	0.0026	0.001	**>2MDL**
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	86	205	**>2MDL**	20	20	20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW18-17B-E314701**	**BJ-GW18-17B-snap**	**RPD/Error**		**BJ-GW12-8B-E314695**	**BJ-GW12-8B-Snap**	**RPD/Error**
Date Sampled			05-Apr-2021	31-Mar-2021			22-Apr-2021	22-Apr-2021	
ALS Sample ID			VA21A6365-001	VA21A6199-002			VA21A7683-003	VA21A7683-004	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	964	900	7%	2	217	224	3%
acidity (as CaCO3)	mg/L	2	2	2	<2MDL	2	2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	117	306	**89%**	1	72.9	73.4	1%
hardness (as CaCO3), dissolved	mg/L	0.5	332	172	**63%**	0.5	102	102	0%
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	374	170	**75%**	0.5	103	108	5%
pH	pH units	0.1	7.76	8.46	9%	0.1	7.98	8.01	0%
solids, total dissolved [TDS]	mg/L	10	652	701	7%	10	136	147	8%
solids, total suspended [TSS]	mg/L	3	263	49.6	**137%**	3	13.2	6.7	**>2MDL**
turbidity	NTU	0.1	293	143	**69%**	0.1	7.14	1.12	**146%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.451	0.383	16%	0.05	0.05	0.091	<2MDL
ammonia, total (as N)	mg/L	0.005	0.0757	0.0613	**21%**	0.005	0.005	0.0052	<2MDL
bromide	mg/L	0.05	0.25	0.25	<2MDL	0.05	0.05	0.05	<2MDL
chloride	mg/L	0.5	5.02	5.68	12%	0.5	0.5	0.5	<2MDL
fluoride	mg/L	0.02	0.138	0.2	**37%**	0.02	0.024	0.022	<2MDL
nitrate (as N)	mg/L	0.005	0.172	0.0737	**80%**	0.005	0.0155	0.0146	<2MDL
nitrate + nitrite (as N)	mg/L	0.005	0.2	0.0892	**77%**	0.005	0.0155	0.0146	<2MDL
nitrite (as N)	mg/L	0.001	0.0277	0.0155	**56%**	0.001	0.001	0.001	<2MDL
nitrogen, total	mg/L	0.03	0.651	0.472	**32%**	0.03	0.03	0.106	**>2MDL**
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.001	0.357	**>2MDL**	0.001	0.0018	0.001	<2MDL
phosphorus, total	mg/L	0.002	0.267	0.505	**62%**	0.002	0.0115	0.0622	**138%**
sulfate (as SO4)	mg/L	0.3	395	158	**86%**	0.3	39.3	39.4	0%
sulfide, total (as H2S)	mg/L	0.019	0.145	6.48	**191%**	0.011	0.011	0.011	<2MDL
sulfide, total (as S)	mg/L	0.018	0.136	6.09	**191%**	0.01	0.01	0.01	<2MDL
Total Metals (Water)									
aluminum, total	mg/L	0.003	3.1	0.952	**106%**	0.003	0.473	0.454	4%
antimony, total	mg/L	0.0001	0.00295	0.00171	**53%**	0.0001	0.0009	0.0011	20%
arsenic, total	mg/L	0.0001	0.0276	0.0316	14%	0.0001	0.0173	0.0296	**52%**
barium, total	mg/L	0.0001	0.124	0.0627	**66%**	0.0001	0.032	0.0499	**44%**
beryllium, total	mg/L	0.0001	0.000236	0.0001	<2MDL	0.0001	0.0001	0.0001	<2MDL
bismuth, total	mg/L	0.00005	0.000103	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, total	mg/L	0.01	0.053	0.074	**33%**	0.01	0.01	0.01	<2MDL
cadmium, total	mg/L	0.000005	0.0000956	0.0000368	**89%**	0.000005	0.0000062	0.0000208	**>2MDL**
calcium, total	mg/L	0.05	138	61.3	**77%**	0.05	33.6	35.4	5%
chromium, total	mg/L	0.0001	0.015	0.0155	3%	0.0005	0.00717	0.00098	**>2MDL**
cobalt, total	mg/L	0.0001	0.00264	0.00134	**65%**	0.0001	0.00051	0.00104	**68%**
copper, total	mg/L	0.0005	0.00649	0.00316	**69%**	0.0005	0.00178	0.00302	**>2MDL**
iron, total	mg/L	0.01	4.49	1.32	**109%**	0.01	0.339	0.874	**88%**
lead, total	mg/L	0.00005	0.00476	0.00184	**88%**	0.00005	0.000332	0.00103	**102%**
lithium, total	mg/L	0.001	0.109	0.178	**48%**	0.001	0.0068	0.007	3%
magnesium, total	mg/L	0.1	7.27	4.03	**57%**	0.1	4.68	4.82	3%
manganese, total	mg/L	0.0001	0.328	0.346	5%	0.0001	0.04	0.109	**93%**
mercury, total	mg/L	0.000005	0.0000234	0.00005	**>2MDL**	0.000005	0.000005	0.000005	<2MDL
molybdenum, total	mg/L	0.00005	0.00181	0.00393	**74%**	0.00005	0.00215	0.00112	**63%**
nickel, total	mg/L	0.0005	0.00613	0.00963	**44%**	0.0005	0.00488	0.0005	**>2MDL**
phosphorus, total	mg/L	0.3	0.3	0.534	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	3.11	5	**47%**	0.05	0.691	0.811	16%
selenium, total	mg/L	0.00005	0.0011	0.000328	**108%**	0.00005	0.000376	0.000352	7%
silicon, total	mg/L	0.1	6.9	5.78	18%	0.1	2.73	2.85	4%
silver, total	mg/L	0.00001	0.000402	0.000131	**102%**	0.00001	0.00002	0.000072	**>2MDL**
sodium, total	mg/L	0.05	55.6	124	**76%**	0.05	2.56	2.84	10%
strontium, total	mg/L	0.0002	4.44	2.51	**56%**	0.0002	0.594	0.628	6%
sulfur, total									
thallium, total	mg/L	0.00001	0.000109	0.000028	**118%**	0.00001	0.00001	0.00001	0%
tin, total	mg/L	0.0001	0.00034	0.00047	**32%**	0.0001	0.0001	0.0002	**67%**
titanium, total	mg/L	0.01	0.0275	0.0117	**81%**	0.01	0.01	0.01	0%
uranium, total	mg/L	0.00001	0.000834	0.00256	<2MDL	0.00001	0.000188	0.000245	<2MDL
vanadium, total	mg/L	0.0005	0.00509	0.0035	**37%**	0.0005	0.00077	0.00081	5%
zinc, total	mg/L	0.003	0.0208	0.0142	**38%**	0.003	0.003	0.0064	**72%**
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0034	0.0057	**51%**	0.001	0.0072	0.0012	**143%**
antimony, dissolved	mg/L	0.0001	0.0019	0.00058	<2MDL	0.0001	0.00078	0.00078	<2MDL
arsenic, dissolved	mg/L	0.0001	0.0124	0.0234	**61%**	0.0001	0.0129	0.0134	4%
barium, dissolved	mg/L	0.0001	0.0449	0.0378	17%	0.0001	0.0220	0.0188	16%
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0440	0.0740	**51%**	0.01	0.0100	0.0100	0%
cadmium, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.000005	0.000005	<2MDL
calcium, dissolved	mg/L	0.05	124	62.6	**66%**	0.05	33.3	33.6	1%
chromium, dissolved	mg/L	0.0001	0.00032	0.00131	<2MDL	0.0005	0.0014	0.0005	<2MDL
cobalt, dissolved	mg/L	0.0001	0.00020	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
copper, dissolved	mg/L	0.0002	0.00020	0.00020	<2MDL	0.0002	0.00063	0.00020	**>2MDL**
iron, dissolved	mg/L	0.01	0.19300	0.01100	**178%**	0.01	0.01000	0.01000	0%
lead, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
lithium, dissolved	mg/L	0.001	0.11900	0.19200	**47%**	0.001	0.00680	0.00650	5%
magnesium, dissolved	mg/L	0.1	5.41	3.7	**38%**	0.1	4.55	4.52	1%
manganese, dissolved	mg/L	0.0001	0.174	0.28	<2MDL	0.0001	0.00586	0.0001	<2MDL
mercury, dissolved	mg/L	0.000005	0.000005	0.000050	<2MDL	0.000005	0.000005	0.000005	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0016	0.0019	16%	0.00005	0.0019	0.0012	**46%**
nickel, dissolved	mg/L	0.0005	0.00124	0.00187	**41%**	0.0005	0.00206	0.00050	**122%**
phosphorus, dissolved	mg/L	0.3	0.3	0.528	**55%**	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	2.770000	4.970000	**57%**	0.05	0.511000	0.548000	<2MDL
selenium, dissolved	mg/L	0.00005	0.000538	0.00583	<2MDL	0.00005	0.000327	0.000292	<2MDL
silicon, dissolved	mg/L	0.05	3.06	4.62	**41%**	0.05	2.03	2.12	4%
silver, dissolved	mg/L	0.00001	0.000010	0.000010	<2MDL	0.00001	0.000010	0.000010	<2MDL
sodium, dissolved	mg/L	0.05	60.700000	132.000000	**74%**	0.05	2.630000	2.700000	3%
strontium, dissolved	mg/L	0.0002	4.14	2.44	**52%**	0.0002	0.58	0.58	0%
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	0.00001	0.00001	0%	0.00001	0.00001	0.00001	0%
tin, dissolved	mg/L	0.0001	0.00019	0.00024	**23%**	0.0001	0.00010	0.00010	0%
titanium, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.010	0.010	0%
uranium, dissolved	mg/L	0.00001	0.000966	0.0023	<2MDL	0.00001	0.000161	0.000163	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0005	0.0017	**109%**	0.0005	0.0005	0.0005	0%
zinc, dissolved	mg/L	0.001	0.002	0.001	**>2MDL**	0.001	0.0022	0.0017	<2MDL
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	51	278	**>2MDL**	20	20	20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW12-8A-E303059**	**BJ-GW12-8A-snap**	**RPD/Error**		**BJ-GW18-18B-E314702**	**BJ-GW18-18B-snap**	**RPD/Error**
Date Sampled			23-Apr-2021	23-Apr-2021			23-May-2021	23-May-2021	
ALS Sample ID			VA21A7804-002	VA21A7804-001			VA21B0116-002	VA21B0116-001	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	219	221	1%	2	688	679	1%
acidity (as CaCO3)	mg/L	2	2	2	<2MDL	2	2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	72.3	72.4	0%	1	118	114	3%
hardness (as CaCO3), dissolved	mg/L	0.5	98.5	104	5%	0.5	210	221	5%
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	104	108	4%	0.5	213	243	13%
pH	pH units	0.1	8.12	8.11	0%	0.1	8.08	8.11	0%
solids, total dissolved [TDS]	mg/L	10	132	118	11%	10	438	430	2%
solids, total suspended [TSS]	mg/L	3	28.9	89.2	**102%**	3	27	31.6	16%
turbidity	NTU	0.1	14.2	16.8	17%	0.1	54.4	25.8	**71%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.05	0.1	<2MDL	0.05	0.137	0.136	<2MDL
ammonia, total (as N)	mg/L	0.005	0.005	0.005	<2MDL	0.005	0.106	0.0878	19%
bromide	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL
chloride	mg/L	0.5	0.5	0.5	<2MDL	0.5	17.3	17.5	1%
fluoride	mg/L	0.02	0.024	0.025	<2MDL	0.02	0.084	0.084	<2MDL
nitrate (as N)	mg/L	0.005	0.0149	0.0161	<2MDL	0.005	0.0073	0.005	<2MDL
nitrate + nitrite (as N)	mg/L	0.005	0.0149	0.0161	<2MDL	0.005	0.0086	0.0051	<2MDL
nitrite (as N)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.0013	0.001	<2MDL
nitrogen, total	mg/L	0.03	0.03	0.116	**>2MDL**	0.03	0.146	0.136	<2MDL
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.001	0.001	<2MDL
phosphorus, total	mg/L	0.002	0.0033	0.117	**>2MDL**	0.002	0.0276	0.0128	**73%**
sulfate (as SO4)	mg/L	0.3	38.2	38	1%	0.3	206	201	2%
sulfide, total (as H2S)	mg/L	0.0016	0.0016	0.0016	<2MDL	0.0016	0.0016	0.0016	<2MDL
sulfide, total (as S)	mg/L	0.0015	0.0015	0.0015	<2MDL	0.0015	0.0015	0.0015	<2MDL
Total Metals (Water)									
aluminum, total	mg/L	0.003	0.084	0.286	**109%**	0.003	2.28	2.12	7%
antimony, total	mg/L	0.0001	0.00093	0.00119	**25%**	0.0001	0.00076	0.00063	19%
arsenic, total	mg/L	0.0001	0.0115	0.0317	**94%**	0.0001	0.00333	0.00232	**36%**
barium, total	mg/L	0.0001	0.025	0.0353	**34%**	0.0001	0.0873	0.0965	10%
beryllium, total	mg/L	0.0001	0.0001	0.0001	<2MDL	0.0001	0.0001	0.0001	<2MDL
bismuth, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, total	mg/L	0.01	0.01	0.01	<2MDL	0.01	0.041	0.042	<2MDL
cadmium, total	mg/L	0.000005	0.0000235	0.000081	**>2MDL**	0.000005	0.0000122	0.0000094	<2MDL
calcium, total	mg/L	0.05	31.4	32.7	4%	0.05	66.4	78.4	17%
chromium, total	mg/L	0.0005	0.00394	0.00077	**>2MDL**	0.0005	0.018	0.00062	**>2MDL**
cobalt, total	mg/L	0.0001	0.0004	0.00078	**>2MDL**	0.0001	0.00356	0.00038	**>2MDL**
copper, total	mg/L	0.0005	0.00153	0.00265	**>2MDL**	0.0005	0.00229	0.00125	**>2MDL**
iron, total	mg/L	0.01	0.187	1.36	**152%**	0.01	1.26	0.735	**53%**
lead, total	mg/L	0.00005	0.000516	0.0017	**107%**	0.00005	0.000574	0.000323	**56%**
lithium, total	mg/L	0.001	0.0083	0.0087	5%	0.001	0.111	0.118	6%
magnesium, total	mg/L	0.1	6.11	6.45	5%	0.1	11.4	11.5	1%
manganese, total	mg/L	0.0001	0.022	0.0735	**108%**	0.0001	0.05	0.0644	**25%**
mercury, total	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.000005	0.000005	<2MDL
molybdenum, total	mg/L	0.00005	0.00184	0.00123	**40%**	0.00005	0.00271	0.00051	**137%**
nickel, total	mg/L	0.0005	0.0029	0.0005	**>2MDL**	0.0005	0.01	0.0005	**>2MDL**
phosphorus, total	mg/L	0.3	0.3	0.3	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	0.53	0.619	15%	0.05	4.7	4.66	1%
selenium, total	mg/L	0.00005	0.000224	0.000219	<2MDL	0.00005	0.000074	0.00005	<2MDL
silicon, total	mg/L	0.1	2.28	2.62	14%	0.1	7.56	6.12	**21%**
silver, total	mg/L	0.00001	0.00003	0.000188	**>2MDL**	0.00001	0.000469	0.000098	**131%**
sodium, total	mg/L	0.05	3.61	3.75	4%	0.05	57.2	55	4%
strontium, total	mg/L	0.0002	0.737	0.755	2%	0.0002	1.67	1.81	8%
sulfur, total									
thallium, total	mg/L	0.00001	0.00001	0.000011	10%	0.00001	0.000087	0.000062	**34%**
tin, total	mg/L	0.0001	0.0001	0.00017	**52%**	0.0001	0.00016	0.00022	**32%**
titanium, total	mg/L	0.01	0.01	0.01	0%	0.01	0.0161	0.6	**190%**
uranium, total	mg/L	0.00001	0.000194	0.000216	<2MDL	0.00001	0.00138	0.0015	<2MDL
vanadium, total	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.004	0.00344	15%
zinc, total	mg/L	0.003	0.006	0.017	**96%**	0.003	0.0064	0.0044	**37%**
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0044	0.0015	**98%**	0.001	0.0018	0.0044	**84%**
antimony, dissolved	mg/L	0.0001	0.00086	0.00085	<2MDL	0.0001	0.00056	0.00048	<2MDL
arsenic, dissolved	mg/L	0.0001	0.00832	0.00836	0%	0.0001	0.0007	0.00078	11%
barium, dissolved	mg/L	0.0001	0.0233	0.0222	5%	0.0001	0.0222	0.0203	9%
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0100	0.0100	0%	0.01	0.0400	0.0390	3%
cadmium, dissolved	mg/L	0.000005	0.0000104	0.0000109	<2MDL	0.000005	0.000005	0.000005	<2MDL
calcium, dissolved	mg/L	0.05	29.4	31.1	6%	0.05	65.8	69.8	6%
chromium, dissolved	mg/L	0.0005	0.0010	0.0005	<2MDL	0.0005	0.001	0.001	<2MDL
cobalt, dissolved	mg/L	0.0001	0.00013	0.00010	<2MDL	0.0001	0.0003800	0.0001000	<2MDL
copper, dissolved	mg/L	0.0002	0.00044	0.00020	**>2MDL**	0.0002	0.00035	0.00051	<2MDL
iron, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.01600	0.01000	**46%**
lead, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
lithium, dissolved	mg/L	0.001	0.00820	0.00870	6%	0.001	0.11400	0.11800	3%
magnesium, dissolved	mg/L	0.1	6.09	6.34	4%	0.1	11.1	11.3	2%
manganese, dissolved	mg/L	0.0001	0.00507	0.00039	<2MDL	0.0001	0.0245	0.0271	<2MDL
mercury, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.0000050	0.0000050	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0018	0.0012	**36%**	0.00005	0.00156	0.00037	**123%**
nickel, dissolved	mg/L	0.0005	0.00183	0.00050	**114%**	0.0005	0.00420	0.00050	**157%**
phosphorus, dissolved	mg/L	0.3	0.3	0.3	0%	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	0.521000	0.543000	<2MDL	0.05	3.820000	4.060000	6%
selenium, dissolved	mg/L	0.00005	0.00023	0.00025	<2MDL	0.00005	0.000059	0.00005	<2MDL
silicon, dissolved	mg/L	0.05	2.1	2.14	2%	0.05	3.27	3.31	1%
silver, dissolved	mg/L	0.00001	0.000010	0.000010	<2MDL	0.00001	0.000010	0.000010	<2MDL
sodium, dissolved	mg/L	0.05	3.720000	3.740000	1%	0.05	57.000000	56.800000	0%
strontium, dissolved	mg/L	0.0002	0.75	0.76	1%	0.0002	1.66	1.67	1%
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	0.00001	0.00001	0%	0.00001	0.000027	0.00003	11%
tin, dissolved	mg/L	0.0001	0.00010	0.00010	0%	0.0001	0.00010	0.00010	0%
titanium, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.010	0.010	0%
uranium, dissolved	mg/L	0.00001	0.000187	0.000194	<2MDL	0.00001	0.00126	0.00112	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.0005	0.0005	0%
zinc, dissolved	mg/L	0.001	0.0033	0.0029	13%	0.001	0.0024	0.001	**>2MDL**
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	20	20	<2MDL	20	20	20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW12-8B - E314695**	**BJ-GW12-8B - Snap**	**RPD/Error**		**BJ-GW11-3A-E303056**	**BJ-GW11-3A-snap**	**RPD/Error**
Date Sampled			27-May-2021	27-May-2021			20-Jun-2021	20-Jun-2021	
ALS Sample ID			VA21B0558-002	VA21B0558-001			VA21B2508-002	VA21B2508-001	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Sample	Snap Sampler	
Physical Tests (Water)									
conductivity	µS/cm	2	219	219	0%	2	363	362	0%
acidity (as CaCO3)	mg/L	2	2	2	<2MDL	2	2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	69.6	70.9	2%	1	97.6	95.9	2%
hardness (as CaCO3), dissolved	mg/L	0.5	106	106	0%	0.5	155	158	2%
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	101	117	15%	0.5	156	165	6%
pH	pH units	0.1	7.99	7.98	0%	0.1	8.04	8.07	0%
solids, total dissolved [TDS]	mg/L	10	121	143	17%	10	234	204	14%
solids, total suspended [TSS]	mg/L	3	9.6	26.2	**>2MDL**	3	9.4	3.1	**>2MDL**
turbidity	NTU	0.1	3.74	1.56	**82%**	0.1	3.47	2.33	**39%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL
ammonia, total (as N)	mg/L	0.005	0.005	0.005	<2MDL	0.005	0.0296	0.0301	2%
bromide	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL
chloride	mg/L	0.5	0.5	0.5	<2MDL	0.5	0.5	0.5	<2MDL
fluoride	mg/L	0.02	0.024	0.021	<2MDL	0.02	0.178	0.173	3%
nitrate (as N)	mg/L	0.005	0.0253	0.0242	<2MDL	0.005	0.005	0.005	<2MDL
nitrate + nitrite (as N)	mg/L	0.005	0.0253	0.0242	<2MDL	0.005	0.0051	0.0051	<2MDL
nitrite (as N)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.0024	0.0017	<2MDL
nitrogen, total	mg/L	0.03	0.03	0.068	<2MDL	0.03	0.03	0.039	<2MDL
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.0017	0.001	<2MDL
phosphorus, total	mg/L	0.002	0.0079	0.141	**>2MDL**	0.002	0.0054	0.0098	**>2MDL**
sulfate (as SO4)	mg/L	0.3	39.9	39.5	1%	0.3	86.2	86.2	0%
sulfide, total (as H2S)	mg/L	0.0016	0.0016	0.0026	<2MDL	0.0016	0.0036	0.0083	**>2MDL**
sulfide, total (as S)	mg/L	0.0015	0.0015	0.0025	<2MDL	0.0015	0.0034	0.0078	**>2MDL**
Total Metals (Water)									
aluminum, total	mg/L	0.003	0.173	0.704	**121%**	0.003	0.0732	0.139	**62%**
antimony, total	mg/L	0.0001	0.00088	0.00125	**35%**	0.0001	0.00318	0.00434	**31%**
arsenic, total	mg/L	0.0001	0.0172	0.0415	**83%**	0.0001	0.00566	0.00777	**31%**
barium, total	mg/L	0.0001	0.032	0.101	**104%**	0.0001	0.0202	0.0203	0%
beryllium, total	mg/L	0.0001	0.0001	0.0001	<2MDL	0.0001	0.0001	0.0001	<2MDL
bismuth, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, total	mg/L	0.01	0.01	0.01	<2MDL	0.01	0.04	0.043	<2MDL
cadmium, total	mg/L	0.000005	0.0000089	0.0000314	**>2MDL**	0.000005	0.0000439	0.00019	**125%**
calcium, total	mg/L	0.05	33.1	38.2	14%	0.05	55.2	58.6	6%
chromium, total	mg/L	0.0005	0.00913	0.00284	**105%**	0.0005	0.00271	0.0005	**>2MDL**
cobalt, total	mg/L	0.0001	0.00236	0.00241	2%	0.0001	0.00044	0.0001	**>2MDL**
copper, total	mg/L	0.0005	0.00208	0.00914	**>2MDL**	0.0005	0.00188	0.00068	**>2MDL**
iron, total	mg/L	0.01	0.325	1.85	**140%**	0.01	0.162	0.298	**59%**
lead, total	mg/L	0.00005	0.000367	0.00214	**141%**	0.00005	0.00137	0.00306	**76%**
lithium, total	mg/L	0.001	0.0066	0.0076	14%	0.001	0.0165	0.018	9%
magnesium, total	mg/L	0.1	4.56	5.16	12%	0.1	4.52	4.45	2%
manganese, total	mg/L	0.0001	0.0794	0.228	**97%**	0.0001	0.149	0.145	3%
mercury, total	mg/L	0.000005	0.000005	0.000008	<2MDL	0.000005	0.000005	0.000005	<2MDL
molybdenum, total	mg/L	0.00005	0.00224	0.00123	**58%**	0.00005	0.0012	0.000745	**47%**
nickel, total	mg/L	0.0005	0.00496	0.00121	**>2MDL**	0.0005	0.00203	0.00218	<2MDL
phosphorus, total	mg/L	0.3	0.3	0.3	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	0.531	0.687	**26%**	0.05	1.4	1.42	1%
selenium, total	mg/L	0.00005	0.00029	0.000369	**24%**	0.00005	0.00005	0.00005	<2MDL
silicon, total	mg/L	0.1	2.1	2.85	**30%**	0.1	3.69	3.92	6%
silver, total	mg/L	0.00001	0.000388	0.000171	**78%**	0.00001	0.000042	0.000015	**>2MDL**
sodium, total	mg/L	0.05	2.42	2.46	2%	0.05	7.1	7.13	0%
strontium, total	mg/L	0.0002	0.571	0.554	3%	0.0002	1.07	1.09	2%
sulfur, total									
thallium, total	mg/L	0.00001	0.00001	0.000026	**89%**	0.00001	0.000011	0.000018	**48%**
tin, total	mg/L	0.0001	0.0001	0.00011	10%	0.0001	0.0001	0.0001	0%
titanium, total	mg/L	0.01	0.01	0.01	0%	0.01	0.01	0.01	0%
uranium, total	mg/L	0.00001	0.000193	0.00033	<2MDL	0.00001	0.000134	0.000163	<2MDL
vanadium, total	mg/L	0.0005	0.0005	0.00141	**95%**	0.0005	0.0005	0.0005	0%
zinc, total	mg/L	0.003	0.003	0.0086	**97%**	0.003	0.0123	0.0204	**50%**
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0013	0.0012	8%	0.001	0.0015	0.0015	0%
antimony, dissolved	mg/L	0.0001	0.00084	0.0008	<2MDL	0.0001	0.00198	0.00211	<2MDL
arsenic, dissolved	mg/L	0.0001	0.0136	0.0136	0%	0.0001	0.00423	0.00449	6%
barium, dissolved	mg/L	0.0001	0.0212	0.0200	6%	0.0001	0.0192	0.0183	5%
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0100	0.0100	0%	0.01	0.0400	0.0400	0%
cadmium, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.0000084	0.0000059	<2MDL
calcium, dissolved	mg/L	0.05	34.6	34.8	1%	0.05	55	55.8	1%
chromium, dissolved	mg/L	0.0005	0.002	0.001	<2MDL	0.0005	0.001	0.001	<2MDL
cobalt, dissolved	mg/L	0.0001	0.0002200	0.0001000	<2MDL	0.0001	0.0001500	0.0001000	<2MDL
copper, dissolved	mg/L	0.0002	0.00069	0.00020	**>2MDL**	0.0002	0.0011	0.0002	**>2MDL**
iron, dissolved	mg/L	0.01	0.01500	0.01000	**40%**	0.01	0.04100	0.04000	2%
lead, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
lithium, dissolved	mg/L	0.001	0.00620	0.00610	2%	0.001	0.01730	0.01780	3%
magnesium, dissolved	mg/L	0.1	4.64	4.53	2%	0.1	4.29	4.43	3%
manganese, dissolved	mg/L	0.0001	0.00502	0.0001	<2MDL	0.0001	0.158	0.16	<2MDL
mercury, dissolved	mg/L	0.000005	0.0000050	0.0000050	<2MDL	0.000005	0.000005	0.000005	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0022	0.0012	**63%**	0.00005	0.00108	0.00076	**35%**
nickel, dissolved	mg/L	0.0005	0.00264	0.00050	**136%**	0.0005	0.00083	0.00050	**50%**
phosphorus, dissolved	mg/L	0.3	0.3	0.3	0%	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	0.488000	0.500000	<2MDL	0.05	1.430000	1.490000	<2MDL
selenium, dissolved	mg/L	0.00005	0.000342	0.000262	<2MDL	0.00005	0.00005	0.00005	<2MDL
silicon, dissolved	mg/L	0.05	2.06	2.06	0%	0.05	3.38	3.31	2%
silver, dissolved	mg/L	0.00001	0.000010	0.000010	<2MDL	0.00001	0.00001	0.00001	<2MDL
sodium, dissolved	mg/L	0.05	2.480000	2.450000	1%	0.05	7.480000	7.610000	2%
strontium, dissolved	mg/L	0.0002	0.61	0.59	2%	0.0002	1.10	1.12	2%
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	0.00001	0.00001	0%	0.00001	0.00001	0.00001	0%
tin, dissolved	mg/L	0.0001	0.00010	0.00010	0%	0.0001	0.00010	0.00010	0%
titanium, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.010	0.010	0%
uranium, dissolved	mg/L	0.00001	0.000168	0.000166	<2MDL	0.00001	0.000125	0.000127	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.0005	0.0005	0%
zinc, dissolved	mg/L	0.001	0.0016	0.001	<2MDL	0.001	0.0065	0.0028	**80%**
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	20	20	<2MDL	20	20	20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW11-8A-E303059**	**BJ-GW11-8A-snap**	**RPD/Error**		**BJ-GW18-17B - snap**	**BJ-GW18-17B - E314703**	**RPD/Error**
Date Sampled			21-Jun-2021	21-Jun-2021			26-Jul-2021	31-Jul-2021	
ALS Sample ID			VA21B2626-002	VA21B2626-001			VA21B5469-001	VA21B5926-001	
Parameter	**Units**	**Lowest Detection Limit**	Sample	Snap Sampler		**Lowest Detection Limit**	Snap Sampler	Sample	
Physical Tests (Water)									
conductivity	µS/cm	2	222	222	0%	2	768	597	**25%**
acidity (as CaCO3)	mg/L	2	2	2	<2MDL	2	2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	73	76.2	4%	1	137	121	12%
hardness (as CaCO3), dissolved	mg/L	0.5	98.6	103	4%	0.5	229	130	**55%**
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	98.2	103	5%	0.5	243	161	**41%**
pH	pH units	0.1	8.13	8.1	0%	0.1	8.53	8.32	2%
solids, total dissolved [TDS]	mg/L	10	123	130	6%	10	548	493	11%
solids, total suspended [TSS]	mg/L	3	16.8	104	**144%**	3	92.2	468	**134%**
turbidity	NTU	0.1	12.4	22.1	**56%**	0.1	116	613	**136%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.267	0.209	<2MDL
ammonia, total (as N)	mg/L	0.005	0.005	0.005	<2MDL	0.005	0.164	0.112	**38%**
bromide	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.25	0.05	**>2MDL**
chloride	mg/L	0.5	0.5	0.5	<2MDL	0.5	2.68	3.31	**21%**
fluoride	mg/L	0.02	0.023	0.023	<2MDL	0.02	0.139	0.344	**85%**
nitrate (as N)	mg/L	0.005	0.0258	0.0296	14%	0.005	0.0264	0.005	**>2MDL**
nitrate + nitrite (as N)	mg/L	0.005	0.0258	0.0296	14%	0.005	0.0264	0.0051	**>2MDL**
nitrite (as N)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.005	0.001	**>2MDL**
nitrogen, total	mg/L	0.03	0.03	0.036	<2MDL	0.03	0.293	0.209	**33%**
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.0272	0.0114	**82%**
phosphorus, total	mg/L	0.002	0.0103	0.0059	**>2MDL**	0.002	0.144	0.293	**68%**
sulfate (as SO4)	mg/L	0.3	34.8	34.7	0%	0.3	258	190	**30%**
sulfide, total (as H2S)	mg/L	0.0016	0.0016	0.0028	<2MDL	0.0016	2.3	0.554	**122%**
sulfide, total (as S)	mg/L	0.0015	0.0015	0.0026	<2MDL	0.0015	2.16	0.521	**122%**
Total Metals (Water)									
aluminum, total	mg/L	0.003	0.306	0.748	**84%**	0.003	1.06	6.39	**143%**
antimony, total	mg/L	0.0001	0.0011	0.00164	**39%**	0.0001	0.00147	0.00326	**76%**
arsenic, total	mg/L	0.0001	0.0155	0.05	**105%**	0.0001	0.0133	0.0808	**143%**
barium, total	mg/L	0.0001	0.0313	0.0684	**74%**	0.0001	0.0638	0.16	**86%**
beryllium, total	mg/L	0.0001	0.0001	0.0001	<2MDL	0.0001	0.0001	0.000586	**>2MDL**
bismuth, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.000192	**>2MDL**
boron, total	mg/L	0.01	0.01	0.01	<2MDL	0.01	0.052	0.046	<2MDL
cadmium, total	mg/L	0.000005	0.0000386	0.000169	**126%**	0.000005	0.0000399	0.000106	**91%**
calcium, total	mg/L	0.05	29.9	31	4%	0.05	89.3	55.5	**47%**
chromium, total	mg/L	0.0005	0.00942	0.00185	**>2MDL**	0.0005	0.0099	0.0501	**134%**
cobalt, total	mg/L	0.0001	0.00128	0.00161	**23%**	0.0001	0.00136	0.0136	**164%**
copper, total	mg/L	0.0005	0.00266	0.00828	**103%**	0.0005	0.00266	0.0148	**139%**
iron, total	mg/L	0.01	0.588	2.65	**127%**	0.01	2.33	7.96	**109%**
lead, total	mg/L	0.00005	0.000964	0.00467	**132%**	0.00005	0.00188	0.00844	**127%**
lithium, total	mg/L	0.001	0.0087	0.0094	8%	0.001	0.105	0.189	**57%**
magnesium, total	mg/L	0.1	5.71	6.23	9%	0.1	4.8	5.35	11%
manganese, total	mg/L	0.0001	0.0474	0.184	**118%**	0.0001	0.208	0.561	**92%**
mercury, total	mg/L	0.000005	0.000005	0.0000085	<2MDL	0.000005	0.0000131	0.000071	**>2MDL**
molybdenum, total	mg/L	0.00005	0.0025	0.00125	**67%**	0.00005	0.00133	0.0108	**156%**
nickel, total	mg/L	0.0005	0.0047	0.00065	**>2MDL**	0.0005	0.00267	0.045	**178%**
phosphorus, total	mg/L	0.3	0.3	0.3	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	0.619	0.799	**25%**	0.05	4.98	3.02	**49%**
selenium, total	mg/L	0.00005	0.000188	0.000234	<2MDL	0.00005	0.000404	0.00112	**94%**
silicon, total	mg/L	0.1	2.54	3.14	**21%**	0.1	4.68	10.6	**77%**
silver, total	mg/L	0.00001	0.000312	0.000454	**37%**	0.00001	0.000165	0.00671	**190%**
sodium, total	mg/L	0.05	3.29	3.45	5%	0.05	72.3	68.8	5%
strontium, total	mg/L	0.0002	0.744	0.761	2%	0.0002	3.33	1.78	**61%**
sulfur, total									
thallium, total	mg/L	0.00001	0.000012	0.000029	**83%**	0.00001	0.000041	0.000162	**119%**
tin, total	mg/L	0.0001	0.00017	0.00067	**119%**	0.0001	0.00053	0.00017	**103%**
titanium, total	mg/L	0.01	0.01	0.01	0%	0.01	0.0106	0.0428	**121%**
uranium, total	mg/L	0.00001	0.000207	0.000284	<2MDL	0.00001	0.000698	0.00038	<2MDL
vanadium, total	mg/L	0.0005	0.0005	0.00099	**66%**	0.0005	0.00212	0.0103	**132%**
zinc, total	mg/L	0.003	0.0075	0.0244	**106%**	0.003	0.0109	0.0364	**108%**
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0079	0.0017	**129%**	0.001	0.0049	0.0075	**42%**
antimony, dissolved	mg/L	0.0001	0.00085	0.00084	<2MDL	0.0001	0.00046	0.0009	<2MDL
arsenic, dissolved	mg/L	0.0001	0.00836	0.00862	3%	0.0001	0.00804	0.0418	**135%**
barium, dissolved	mg/L	0.0001	0.0243	0.0216	12%	0.0001	0.0354	0.0249	**35%**
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0100	0.0100	0%	0.01	0.0450	0.0430	5%
cadmium, dissolved	mg/L	0.000005	0.0000127	0.0000093	<2MDL	0.000005	0.000005	0.000005	<2MDL
calcium, dissolved	mg/L	0.05	29.2	30.8	5%	0.05	84.5	48.3	**55%**
chromium, dissolved	mg/L	0.0005	0.001	0.001	<2MDL	0.0005	0.001	0.001	<2MDL
cobalt, dissolved	mg/L	0.0001	0.0002500	0.0001000	<2MDL	0.0001	0.0001000	0.0001900	<2MDL
copper, dissolved	mg/L	0.0002	0.0008	0.0002	**>2MDL**	0.0002	0.00020	0.00020	<2MDL
iron, dissolved	mg/L	0.01	0.01500	0.01000	**40%**	0.01	0.04800	0.07400	**43%**
lead, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
lithium, dissolved	mg/L	0.001	0.00840	0.00860	2%	0.001	0.09860	0.17000	**53%**
magnesium, dissolved	mg/L	0.1	6.24	6.32	1%	0.1	4.3	2.22	**64%**
manganese, dissolved	mg/L	0.0001	0.00618	0.0001	<2MDL	0.0001	0.15	0.224	<2MDL
mercury, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.000005	0.000005	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0020	0.0012	**49%**	0.00005	0.001	0.005	**146%**
nickel, dissolved	mg/L	0.0005	0.00194	0.00050	**118%**	0.0005	0.00050	0.00074	**39%**
phosphorus, dissolved	mg/L	0.3	0.3	0.3	0%	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	0.473000	0.494000	<2MDL	0.05	4.300000	1.880000	**78%**
selenium, dissolved	mg/L	0.00005	0.000188	0.000208	<2MDL	0.00005	0.00292	0.000221	<2MDL
silicon, dissolved	mg/L	0.05	2.09	2.05	2%	0.05	3.34	3.37	1%
silver, dissolved	mg/L	0.00001	0.00001	0.00001	<2MDL	0.00001	0.00001	0.00001	<2MDL
sodium, dissolved	mg/L	0.05	3.650000	3.620000	1%	0.05	71.000000	67.300000	5%
strontium, dissolved	mg/L	0.0002	0.73	0.76	4%	0.0002	3.13	1.66	**61%**
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	0.00001	0.00001	0%	0.00001	0.00001	0.00001	0%
tin, dissolved	mg/L	0.0001	0.0001	0.0001	0%	0.0001	0.00024	0.00010	**82%**
titanium, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.010	0.010	0%
uranium, dissolved	mg/L	0.00001	0.000173	0.000181	<2MDL	0.00001	0.000556	0.000186	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.0005	0.0005	0%
zinc, dissolved	mg/L	0.001	0.0035	0.0018	**>2MDL**	0.001	0.0014	0.0028	**>2MDL**
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	20	20	<2MDL	20	68	37	**59%**

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW18-18B - snap**	**BJ-GW18-18B - E314702**	**RPD/Error**		**BJ-GW18-17B - Snap**	**BJ-GW18-17B - E314701**	**RPD/Error**
Date Sampled			11-Sep-2021	11-Sep-2021			14-Sep-2021	15-Sep-2021	
ALS Sample ID			VA21B9857-001	VA21B9857-002			VA21C0111-001	VA21C0275-001	
Parameter	**Units**	**Lowest Detection Limit**	Snap Sampler	Sample		**Lowest Detection Limit**	Snap Sampler	Sample	
Physical Tests (Water)									
conductivity	µS/cm	2	411	532	**26%**	2	624	590	6%
acidity (as CaCO3)	mg/L	2	2	2	<2MDL	2	2.2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	69.7	96.6	**32%**	1	112	112	0%
hardness (as CaCO3), dissolved	mg/L	0.5	139	167	18%	0.5	240	161	**39%**
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	163	165	1%	0.5	275	181	**41%**
pH	pH units	0.1	8.04	8.15	1%	0.1	8.23	8.21	0%
solids, total dissolved [TDS]	mg/L	10	246	387	**45%**	10	414	397	4%
solids, total suspended [TSS]	mg/L	3	19.1	43.1	**77%**	3	22.2	104	**130%**
turbidity	NTU	0.1	26.1	26.2	0%	0.1	21.7	166	**154%**
Anions and Nutrients (Water)									
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.16	0.162	<2MDL	0.05	0.244	0.155	<2MDL
ammonia, total (as N)	mg/L	0.005	0.167	0.151	10%	0.005	0.0641	0.0848	**28%**
bromide	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL
chloride	mg/L	0.5	0.5	4.66	**>2MDL**	0.5	1.32	4.72	**>2MDL**
fluoride	mg/L	0.02	0.183	0.133	**32%**	0.02	0.163	0.26	**46%**
nitrate (as N)	mg/L	0.005	0.005	0.005	<2MDL	0.005	0.109	0.005	**>2MDL**
nitrate + nitrite (as N)	mg/L	0.005	0.0051	0.0051	<2MDL	0.005	0.122	0.0051	**>2MDL**
nitrite (as N)	mg/L	0.001	0.001	0.001	<2MDL	0.001	0.0128	0.001	**>2MDL**
nitrogen, total	mg/L	0.03	0.16	0.162	1%	0.03	0.366	0.155	**81%**
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.001	0.0019	<2MDL	0.001	0.0011	0.001	<2MDL
phosphorus, total	mg/L	0.002	0.0181	0.0107	**51%**	0.002	0.0627	0.0976	**44%**
sulfate (as SO4)	mg/L	0.3	124	152	**20%**	0.3	209	188	11%
sulfide, total (as H2S)	mg/L	0.0016	0.0029	0.0016	<2MDL	0.0016	0.0414	0.42	**164%**
sulfide, total (as S)	mg/L	0.0015	0.0027	0.0015	<2MDL	0.0015	0.0389	0.395	**164%**
Total Metals (Water)									
aluminum, total	mg/L	0.003	1.19	0.123	**163%**	0.003	0.823	1.94	**81%**
antimony, total	mg/L	0.0001	0.00077	0.00022	**>2MDL**	0.0001	0.00189	0.002	6%
arsenic, total	mg/L	0.0001	0.00782	0.00181	**125%**	0.0001	0.014	0.0636	**128%**
barium, total	mg/L	0.0001	0.0748	0.0264	**96%**	0.0001	0.0451	0.078	**53%**
beryllium, total	mg/L	0.0001	0.000111	0.0001	<2MDL	0.0001	0.0001	0.000151	<2MDL
bismuth, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.000053	<2MDL
boron, total	mg/L	0.01	0.017	0.029	<2MDL	0.01	0.038	0.036	<2MDL
cadmium, total	mg/L	0.000005	0.0000414	0.0000065	**>2MDL**	0.000005	0.0000231	0.0000402	**>2MDL**
calcium, total	mg/L	0.05	53.4	51.3	4%	0.05	104	66.1	**45%**
chromium, total	mg/L	0.0005	0.0143	0.00354	**121%**	0.0005	0.00348	0.015	**125%**
cobalt, total	mg/L	0.0001	0.00154	0.00301	**65%**	0.0001	0.0006	0.00163	**92%**
copper, total	mg/L	0.0005	0.00425	0.00104	**>2MDL**	0.0005	0.00201	0.00356	**>2MDL**
iron, total	mg/L	0.01	2.04	0.164	**170%**	0.01	0.799	2.62	**107%**
lead, total	mg/L	0.00005	0.00117	0.000186	**>2MDL**	0.00005	0.000507	0.00244	**131%**
lithium, total	mg/L	0.001	0.0505	0.0825	**48%**	0.001	0.0787	0.147	**61%**
magnesium, total	mg/L	0.1	7.31	8.94	**20%**	0.1	3.74	3.82	2%
manganese, total	mg/L	0.0001	0.0994	0.0559	**56%**	0.0001	0.124	0.732	**142%**
mercury, total	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.000005	0.0000284	**>2MDL**
molybdenum, total	mg/L	0.00005	0.00169	0.00154	9%	0.00005	0.0016	0.00486	**101%**
nickel, total	mg/L	0.0005	0.006	0.00415	**36%**	0.0005	0.00194	0.0103	**>2MDL**
phosphorus, total	mg/L	0.3	0.3	0.3	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	3.39	3.31	2%	0.05	2.92	2.14	**31%**
selenium, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.000418	0.000297	**34%**
silicon, total	mg/L	0.1	5.22	3.62	**36%**	0.1	3.91	5.9	**41%**
silver, total	mg/L	0.00001	0.000402	0.000036	**>2MDL**	0.00001	0.000277	0.000175	**45%**
sodium, total	mg/L	0.05	28.1	42.5	**41%**	0.05	39.3	55.2	**34%**
strontium, total	mg/L	0.0002	1.25	1.44	14%	0.0002	2.74	1.91	**36%**
sulfur, total									
thallium, total	mg/L	0.00001	0.000224	0.000022	**164%**	0.00001	0.000026	0.000041	**45%**
tin, total	mg/L	0.0001	0.00042	0.0001	**123%**	0.0001	0.00022	0.0001	**75%**
titanium, total	mg/L	0.01	0.01	0.01	0%	0.01	0.0102	0.0278	**93%**
uranium, total	mg/L	0.00001	0.0013	0.00124	<2MDL	0.00001	0.000281	0.000194	<2MDL
vanadium, total	mg/L	0.0005	0.00168	0.0005	**108%**	0.0005	0.00132	0.00342	**89%**
zinc, total	mg/L	0.003	0.0103	0.0037	**94%**	0.003	0.004	0.0114	**96%**
zirconium, total	mg/L								
Dissolved Metals (Water)									
aluminum, dissolved	mg/L	0.001	0.0036	0.0029	**22%**	0.001	0.0040	1.0300	**198%**
antimony, dissolved	mg/L	0.0001	0.00012	0.00019	<2MDL	0.0001	0.00148	0.00078	<2MDL
arsenic, dissolved	mg/L	0.0001	0.00177	0.00158	11%	0.0001	0.00802	0.0472	**142%**
barium, dissolved	mg/L	0.0001	0.0198	0.0178	11%	0.0001	0.0221	0.0520	**81%**
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0160	0.0280	**55%**	0.01	0.0370	0.0360	3%
cadmium, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.000005	0.0000055	<2MDL
calcium, dissolved	mg/L	0.05	44.2	51.6	15%	0.05	90.2	59.7	**41%**
chromium, dissolved	mg/L	0.0005	0.001	0.001	<2MDL	0.0005	0.001	0.003	<2MDL
cobalt, dissolved	mg/L	0.0001	0.0001	0.0020	**>2MDL**	0.0001	0.0001100	0.0003500	<2MDL
copper, dissolved	mg/L	0.0002	0.00020	0.00020	<2MDL	0.0002	0.0002	0.0006	**>2MDL**
iron, dissolved	mg/L	0.01	0.01000	0.01400	**33%**	0.01	0.01000	0.41500	**191%**
lead, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.000403	<2MDL
lithium, dissolved	mg/L	0.001	0.04980	0.08070	**47%**	0.001	0.06500	0.14000	**73%**
magnesium, dissolved	mg/L	0.1	7.04	9.35	**28%**	0.1	3.52	2.98	17%
manganese, dissolved	mg/L	0.0001	0.0363	0.0471	<2MDL	0.0001	0.0549	0.603	**>2MDL**
mercury, dissolved	mg/L	0.000005	0.0000050	0.0000050	<2MDL	0.000005	0.000005	0.000006	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0008	0.0013	**44%**	0.00005	0.0015	0.0037	**84%**
nickel, dissolved	mg/L	0.0005	0.00050	0.00179	**113%**	0.0005	0.00050	0.00260	**135%**
phosphorus, dissolved	mg/L	0.3	0.3	0.3	0%	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	3.150000	3.390000	7%	0.05	2.550000	1.970000	**26%**
selenium, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.000305	0.000369	<2MDL
silicon, dissolved	mg/L	0.05	3.07	3.45	12%	0.05	2.68	4.6	**53%**
silver, dissolved	mg/L	0.00001	0.000010	0.000010	<2MDL	0.00001	0.00001	0.00001	<2MDL
sodium, dissolved	mg/L	0.05	29.000000	44.600000	**42%**	0.05	40.200000	54.000000	**29%**
strontium, dissolved	mg/L	0.0002	1.27	1.52	18%	0.0002	2.73	1.82	**40%**
sulfur, dissolved									
thallium, dissolved	mg/L	0.00001	0.00005	0.000015	**108%**	0.00001	0.00001	0.000017	**52%**
tin, dissolved	mg/L	0.0001	0.0001	0.0001	0%	0.0001	0.0001	0.0001	0%
titanium, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.010	0.013	**25%**
uranium, dissolved	mg/L	0.00001	0.000963	0.0011	<2MDL	0.00001	0.000194	0.000161	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.0005	0.00159	**104%**
zinc, dissolved	mg/L	0.001	0.001	0.0021	**>2MDL**	0.001	0.001	0.0036	**>2MDL**
zirconium, dissolved									
dissolved mercury filtration location	-		Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field	
Aggregate Organics (Water)									
COD	mg/L	20	20	20	<2MDL	20	20	20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Sample ID			**BJ-GW11-3A - Snap**	**BJ-GW11-3A - E303056**	**RPD/Error**		**BJ-GW12-8A-snap**	**BJ-GW12-8A-E303059**	**RPD/Error**		**BJ-GW12-8B-snap**	**BJ-GW12-8B-E314695**	**RPD/Error**
Date Sampled			22-Sep-2021	23-Sep-2021			17-Oct-2021	17-Oct-2021			17-Oct-2021	17-Oct-2021	
ALS Sample ID			VA21C0998-001	VA21C1212-001			VA21C3094-001	VA21C3094-002			VA21C3094-003	VA21C3094-004	
Parameter	**Units**	**Lowest Detection Limit**	Snap Sampler	Sample		**Lowest Detection Limit**	Snap Sampler	Sample		**Lowest Detection Limit**	Snap Sampler	Sample	
Physical Tests (Water)													
conductivity	µS/cm	2	349	352	1%	2	207	205	1%	2	212	209	1%
acidity (as CaCO3)	mg/L	2		2	<2MDL	2	2	2	<2MDL	2	2	2	<2MDL
alkalinity, total (as CaCO3)	mg/L	1	102	95.6	6%	1	73.6	72.4	2%	1	72.4	71.1	2%
hardness (as CaCO3), dissolved	mg/L	0.5	157	150	5%	0.5	99.8	100	0%	0.5	106	102	4%
hardness (as CaCO3), from total Ca/Mg	mg/L	0.5	165	152	8%	0.5	106	97.9	8%	0.5	101	93.5	8%
pH	pH units	0.1	8.19	8.08	1%	0.1	8.09	8.09	0%	0.1	8.09	8.09	0%
solids, total dissolved [TDS]	mg/L	10	235	238	1%	10	120	106	12%	10	106	120	12%
solids, total suspended [TSS]	mg/L	3	24.8	3	>2MDL	3	220	5.2	>2MDL	3	32.8	3.4	>2MDL
turbidity	NTU	0.1	14.2	3.13	128%	0.1	64.6	1.76	189%	0.1	4.25	1.96	74%
Anions and Nutrients (Water)													
Kjeldahl nitrogen, total [TKN]	mg/L	0.05	0.06	0.05	<2MDL	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL
ammonia, total (as N)	mg/L	0.005	0.0294	0.0274	7%	0.005	0.005	0.005	<2MDL	0.005	0.005	0.005	<2MDL
bromide	mg/L	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL	0.05	0.05	0.05	<2MDL
chloride	mg/L	0.5	0.5	0.5	<2MDL	0.5	0.5	0.5	<2MDL	0.5	0.5	0.5	<2MDL
fluoride	mg/L	0.02	0.182	0.185	2%	0.02	0.031	0.026	<2MDL	0.02	0.022	0.022	<2MDL
nitrate (as N)	mg/L	0.005	0.005	0.0318	>2MDL	0.005	0.0185	0.0157	<2MDL	0.005	0.0183	0.0169	<2MDL
nitrate + nitrite (as N)	mg/L	0.005	0.0051	0.0318	>2MDL	0.005	0.0185	0.0157	<2MDL	0.005	0.0183	0.0169	<2MDL
nitrite (as N)	mg/L	0.001	0.002	0.001	<2MDL	0.001	0.001	0.001	<2MDL	0.001	0.001	0.001	<2MDL
nitrogen, total	mg/L	0.03	0.06	0.067	<2MDL	0.03	0.064	0.03	<2MDL	0.03	0.03	0.03	<2MDL
phosphate, ortho-, dissolved (as P)	mg/L	0.001	0.001	0.0014	<2MDL	0.001	0.001	0.001	<2MDL	0.001	0.001	0.001	<2MDL
phosphorus, total	mg/L	0.002	0.0185	0.0064	>2MDL	0.002	0.0934	0.0024	>2MDL	0.002	0.0517	0.0024	>2MDL
sulfate (as SO4)	mg/L	0.3	83.5	82.8	1%	0.3	31.7	31.4	1%	0.3	34.6	33.7	3%
sulfide, total (as H2S)	mg/L	0.0016	0.043	0.0016	>2MDL	0.0016	0.0016	0.0016	<2MDL	0.0016	0.0016	0.0016	<2MDL
sulfide, total (as S)	mg/L	0.0015	0.0404	0.0015	>2MDL	0.0015	0.0015	0.0015	<2MDL	0.0015	0.0015	0.0015	<2MDL
Total Metals (Water)													
aluminum, total	mg/L	0.003	0.0466	0.0169	94%	0.003	1.06	0.0585	179%	0.003	0.186	0.0822	77%
antimony, total	mg/L	0.0001	0.00487	0.00197	85%	0.0001	0.00211	0.00093	78%	0.0001	0.00098	0.00083	17%
arsenic, total	mg/L	0.0001	0.0232	0.0215	8%	0.0001	0.104	0.0105	163%	0.0001	0.0222	0.015	39%
barium, total	mg/L	0.0001	0.0223	0.0201	10%	0.0001	0.195	0.0237	157%	0.0001	0.0407	0.0236	53%
beryllium, total	mg/L	0.0001	0.0001	0.0001	<2MDL	0.0001	0.000107	0.0001	<2MDL	0.0001	0.0001	0.0001	<2MDL
bismuth, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, total	mg/L	0.01	0.038	0.04	<2MDL	0.01	0.01	0.01	<2MDL	0.01	0.01	0.01	<2MDL
cadmium, total	mg/L	0.000005	0.0000958	0.0000258	115%	0.000005	0.00029	0.0000147	>2MDL	0.000005	0.0000106	0.000005	<2MDL
calcium, total	mg/L	0.05	58.3	53.8	8%	0.05	32.8	30.6	7%	0.05	33	31	6%
chromium, total	mg/L	0.0005	0.0005	0.0005	<2MDL	0.0005	0.00378	0.00157	>2MDL	0.0005	0.00065	0.00182	>2MDL
cobalt, total	mg/L	0.0001	0.0001	0.00019	<2MDL	0.0001	0.00257	0.00023	>2MDL	0.0001	0.0008	0.00027	>2MDL
copper, total	mg/L	0.0005	0.00054	0.0005	<2MDL	0.0005	0.016	0.00126	>2MDL	0.0005	0.00138	0.00128	<2MDL
iron, total	mg/L	0.01	0.589	0.453	26%	0.01	5.77	0.091	194%	0.01	0.475	0.084	140%
lead, total	mg/L	0.00005	0.00441	0.00161	93%	0.00005	0.00805	0.000206	>2MDL	0.00005	0.000541	0.000175	>2MDL
lithium, total	mg/L	0.001	0.014	0.0171	20%	0.001	0.0095	0.0081	16%	0.001	0.0067	0.0064	5%
magnesium, total	mg/L	0.1	4.64	4.24	9%	0.1	5.86	5.23	11%	0.1	4.46	3.92	13%
manganese, total	mg/L	0.0001	0.201	0.191	5%	0.0001	0.284	0.00908	188%	0.0001	0.104	0.0227	128%
mercury, total	mg/L	0.000005	0.0000121	0.000005	<2MDL	0.000005	0.0000116	0.000005	<2MDL	0.000005	0.000005	0.000005	<2MDL
molybdenum, total	mg/L	0.00005	0.000874	0.000975	11%	0.00005	0.00126	0.00155	21%	0.00005	0.00129	0.0014	8%
nickel, total	mg/L	0.0005	0.0005	0.00056	<2MDL	0.0005	0.00142	0.00114	<2MDL	0.0005	0.0005	0.00117	<2MDL
phosphorus, total	mg/L	0.3	0.3	0.3	<2MDL	0.3	0.3	0.3	<2MDL	0.3	0.3	0.3	<2MDL
potassium, total	mg/L	0.05	1.48	1.5	1%	0.05	0.873	0.495	55%	0.05	0.625	0.498	23%
selenium, total	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.000246	0.000177	<2MDL	0.00005	0.000271	0.000291	7%
silicon, total	mg/L	0.1	3.59	3.71	3%	0.1	3.73	2.17	53%	0.1	2.32	2.21	5%
silver, total	mg/L					0.00001	0.000791	0.000028	>2MDL	0.00001	0.000031	0.00001	>2MDL
sodium, total	mg/L	0.00001	0.000013	0.000012	<2MDL	0.05	3.47	3.6	4%	0.05	2.62	2.5	5%
strontium, total	mg/L	0.05	7.36	7.15	3%	0.0002	0.75	0.704	6%	0.0002	0.596	0.564	6%
sulfur, total		0.0002	1.04	1.06									
thallium, total	mg/L	0.00001	0.000025	0.00001	<2MDL	0.00001	0.000036	0.00001	113%	0.00001	0.000013	0.00001	26%
tin, total	mg/L	0.0001	0.0001	0.0001	0%	0.0001	0.00098	0.0001	163%	0.0001	0.00014	0.0001	33%
titanium, total	mg/L	0.01	0.01	0.01	0%	0.01	0.01	0.01	0%	0.01	0.01	0.01	0%
uranium, total	mg/L	0.00001	0.00018	0.000184	<2MDL	0.00001	0.000311	0.00017	<2MDL	0.00001	0.000185	0.000158	<2MDL
vanadium, total	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.00154	0.0005	102%	0.0005	0.0005	0.0005	0%
zinc, total	mg/L	0.003	0.019	0.005	117%	0.003	0.042	0.0033	171%	0.003	0.0063	0.003	71%
zirconium, total	mg/L												
Dissolved Metals (Water)													
aluminum, dissolved	mg/L	0.001	0.0024	0.0045	61%	0.001	0.0012	0.0014	15%	0.001	0.0016	0.0015	6%
antimony, dissolved	mg/L	0.0001	0.00189	0.00184	<2MDL	0.0001	0.00087	0.00086	<2MDL	0.0001	0.00079	0.00078	<2MDL
arsenic, dissolved	mg/L	0.0001	0.0221	0.0206	7%	0.0001	0.00877	0.00905	3%	0.0001	0.0138	0.014	1%
barium, dissolved	mg/L	0.0001	0.0208	0.0191	9%	0.0001	0.0208	0.0211	1%	0.0001	0.0193	0.0204	6%
beryllium, dissolved	mg/L	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL	0.0001	0.00010	0.00010	<2MDL
bismuth, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
boron, dissolved	mg/L	0.01	0.0370	0.0360	3%	0.01	0.0100	0.0100	0%	0.01	0.0100	0.0100	0%
cadmium, dissolved	mg/L	0.000005	0.0000057	0.000005	<2MDL	0.000005	0.0000112	0.0000107	<2MDL	0.000005	0.000005	0.000005	<2MDL
calcium, dissolved	mg/L	0.05	55.4	53.2	4%	0.05	30.2	30.4	1%	0.05	34.9	33.1	5%
chromium, dissolved	mg/L	0.0005	0.001	0.001	<2MDL	0.0005	0.001	0.001	<2MDL	0.0005	0.001	0.001	<2MDL
cobalt, dissolved	mg/L	0.0001	0.0001000	0.0001200	<2MDL	0.0001	0.0001000	0.0001000	<2MDL	0.0001	0.0001000	0.0001000	<2MDL
copper, dissolved	mg/L	0.0002	0.00020	0.00020	<2MDL	0.0002	0.0002	0.0007	>2MDL	0.0002	0.0002	0.0010	>2MDL
iron, dissolved	mg/L	0.01	0.49000	0.38700	23%	0.01	0.01000	0.01000	0%	0.01	0.01000	0.01000	0%
lead, dissolved	mg/L	0.00005	0.000358	0.00021	<2MDL	0.00005	0.00005	0.00005	<2MDL	0.00005	0.00005	0.00005	<2MDL
lithium, dissolved	mg/L	0.001	0.01440	0.01500	4%	0.001	0.00860	0.00890	3%	0.001	0.00700	0.00690	1%
magnesium, dissolved	mg/L	0.1	4.55	4.06	11%	0.1	5.92	5.93	0%	0.1	4.61	4.64	1%
manganese, dissolved	mg/L	0.0001	0.2	0.19	<2MDL	0.0001	0.0001	0.00041	<2MDL	0.0001	0.0001	0.00149	<2MDL
mercury, dissolved	mg/L	0.000005	0.000005	0.000005	<2MDL	0.000005	0.0000	0.0000	<2MDL	0.000005	0.0000050	0.0000050	<2MDL
molybdenum, dissolved	mg/L	0.00005	0.0009	0.0010	12%	0.00005	0.0013	0.0014	14%	0.00005	0.0011600	0.0012900	11%
nickel, dissolved	mg/L	0.0005	0.00050	0.00050	0%	0.0005	0.00050	0.00082	48%	0.0005	0.00050	0.00078	44%
phosphorus, dissolved	mg/L	0.3	0.3	0.3	0%	0.3	0.3	0.3	0%	0.3	0.3	0.3	0%
potassium, dissolved	mg/L	0.05	1.520000	1.440000	<2MDL	0.05	0.483000	0.489000	<2MDL	0.05	0.537000	0.500000	<2MDL
selenium, dissolved	mg/L	0.00005	0.00005	0.00005	<2MDL	0.00005	0.000214	0.000194	<2MDL	0.00005	0.000242	0.000281	<2MDL
silicon, dissolved	mg/L	0.05	3.32	3.43	3%	0.05	2	1.94	3%	0.05	2.06	1.94	6%
silver, dissolved	mg/L					0.00001	0.000010	0.000010	<2MDL	0.00001	0.000010	0.000010	<2MDL
sodium, dissolved	mg/L	0.00001	0.000010	0.000010	0%	0.05	3.290000	3.280000	0%	0.05	2.560000	2.550000	0%
strontium, dissolved	mg/L	0.05	7.52	6.92	8%	0.0002	0.72	0.70	3%	0.0002	0.56	0.56	1%
sulfur, dissolved		0.0002	1.12	1.1	2%								
thallium, dissolved	mg/L	0.00001	0.00001	0.00001	<2MDL	0.00001	0.00001	0.00001	0%	0.00001	0.00001	0.00001	0%
tin, dissolved	mg/L	0.0001	0.0001	0.0001	0%	0.0001	0.0001	0.0001	0%	0.0001	0.0001	0.0001	0%
titanium, dissolved	mg/L	0.01	0.010	0.010	0%	0.01	0.010	0.010	0%	0.01	0.010	0.010	0%
uranium, dissolved	mg/L	0.00001	0.000177	0.000181	<2MDL	0.00001	0.000175	0.000172	<2MDL	0.00001	0.00017	0.000163	<2MDL
vanadium, dissolved	mg/L	0.0005	0.0005	0.0005	0%	0.0005	0.0005	0.0005	0%	0.0005	0.0005	0.0005	0%
zinc, dissolved	mg/L	0.001	0.0017	0.0041	>2MDL	0.001	0.0015	0.0017	<2MDL	0.001	0.0014	0.001	<2MDL
zirconium, dissolved													
dissolved mercury filtration location	-		Field	Field			Field	Field			Field	Field	
dissolved metals filtration location	-		Field	Field			Field	Field			Field	Field	
Aggregate Organics (Water)													
COD	mg/L	20	20	20	<2MDL	20	20	20	<2MDL	20	20	20	<2MDL

Notes:
1." - " indicates that analyses were not performed, or RPD was not calculated for parameters where one or both of the concentrations were less than 5x the RDL.
2. Bolded values indicate that the sample and duplicate values are > 5x the RDL and the RPD is greater than 10%.
3. White text on black fill indicates that the sample and duplicate values are > 5x the RDL and the RPD is greater than 20%.
4. Yellow highlighting indicated Se-D>Se-T

Chapter 3 Appendices

Appendix 3-1: WRTSF Deposition Model for 4950 tpd Permit Amendment

TECHNICAL MEMORANDUM

DATE 31 January 2023 **Reference No.** 21507844-026-TM-Rev1-6000

TO Sylvia Van Zalingen
Newcrest Mining Ltd.

CC Cam MacKay-Stotesbury and Brett DeHay-Turner

FROM Caitlyn Cartwright and Jeffrey Kwok **EMAIL Caitlyn.Cartwright@wsp.com; Jeffrey.Kwok2@wsp.com**

DETAILED DEPOSITION MODEL FOR 4,950 TPD PERMIT AMENDMENT IN THE WASTE ROCK AND TAILINGS STORAGE FACILITY, BRUCEJACK MINE, BRITISH COLUMBIA

1.0 INTRODUCTION

Newcrest Mining Ltd. (Newcrest; formerly Pretium Resources Ltd.) retained Golder Associates Ltd. (Golder), now known as WSP Canada Inc. (WSP), to provide tailings and waste rock deposition planning and modelling for the waste rock and tailings storage facility (WRTSF) at Brucejack Mine. Deposition modelling was conducted for the proposed production rate of 4,950 tonnes per day (tpd) life of mine (LOM) material balance.

This technical memorandum presents the tailings and waste rock deposition planning and modelling work that has been completed to support the 4,950 tpd permit amendment and presents the predicted WRTSF configuration at various stages through the LOM. This revision 1 includes minor updates in scheduling taking into consideration input from Newcrest based on access road planned development schedule, mine plan update for years 2028 and 2029 and fully supersedes the revision 0 of this document.

2.0 BACKGROUND AND EXISTING CONDITIONS

The Brucejack mine site is an active underground mine that extracts gold and silver resources. The process concentrate is dewatered and transported to Stewart, British Columbia, for shipment to smelters.

Tailings are either discharged to the WRTSF or transported to the paste plant for backfilling the underground mine. Waste rock is either deposited in the Waste Rock Dump (WRD) within the WRTSF or is used to backfill the underground mine (not comingled with the tailings). Figure 1 includes the configuration of the WRTSF at the end of 2022.

2.1 Tailings Deposition

The tailings deposition system has evolved since the start of deposition in May 2017. Per the mine's effluent discharge permit issued by the BC Ministry of Environment and Climate Change Strategy, the tailings outfall to the WRTSF must never be positioned more than 7.5 m above the top of the natural lake bottom or deposited tailings, whichever is higher (Permit 107835, Section 1.3.2).

The full history and description of the tailings deposition lines are documented in the pipeline design and tailings deposition design basis (Golder 2022a).

The following are the tailings deposition lines currently in the water:

- Tails Line 1 was installed in 2017 at start-up, from a cable suspension line, and is currently inoperable.
- Tails Line 2 was installed in 2018, from a cable suspension line. Tails Line 2 was operated following the failure to deposit from Tails Line 4 in July 2021. In July 2022, following planned shutdown, Tails Line 2 appeared to be plugged and potentially may have reached end of operability as the current discharge elevation appears to be within the tailings beach mound. Tails Line 2 is planned to be decommissioned and removed in the future.
- Tails Line 3 was installed in 2017 at start-up, anchored to the lake bottom, and is operable but not used due to total suspended solids generation from lake bottom sediments and occasional observed plumes when the line was used. This line was used as an emergency discharge line following the failure of Tails Line 4 (Chong 2021).
- Tails Line 4 was installed in October 2020, anchored to the lake bottom until it was plugged and inoperable in July 2021.
- Tails Line 5 and 6 were installed in September 2021 and are anchored to the lake bottom.

A total of 3.56 million dry tonnes of tailings have been deposited in the WRTSF between the start of operations and the end of 2021 (summation of reported dry tonnages of tailings deposited in the WRTSF in the Annual Construction Reports [Pretium 2018a, 2019a, 2020a, 2021b] and MacKay-Stotesbury [2022a]). In 2022, a total of 0.44 million dry tonnes of tailings were deposited between January and mid-July (MacKay-Stotesbury 2022a).

2.2 Waste Rock Deposition

The waste rock deposition method has also undergone several changes since the start of deposition in 2015. An active mechanical screening system, used until 2021, separated materials passing through a 200 mm screen. Coarse rock is defined as screened material greater than 200 mm in diameter and temporarily stockpiled at the WRD. Fine material is defined as material nominally less than 200 mm in diameter.

2.2.1 Historical and Current Deposition Methods

The following main methods have been used to deposit waste rock into the WRTSF:

- **Remote-operated dozer push (as of May 2021 to date)**—A remote-operated dozer (no operator on board the equipment) is used to directly push run-of-mine waste muck into the WRTSF.
- **Telestacker conveyance (to May 2021)**—A telescoping radial conveyor stacker (Telestacker) was used to deposit 200 mm minus waste rock into the WRTSF from July 2017 until May 2021. The Telestacker was inoperable in May 2021 and has been removed from the immediate WRTSF area. There is no plan to resume Telestacker conveyance in the future.
- **Excavator bailing (to May 2021)**—A hydraulic excavator was used to place the coarse-size fraction from active screening and/or run-of-mine waste muck from October 2015 until May 2021. This method has ceased due to safety concerns.

- **Dozer push (start of Operations to October 2015)**—Dozer to directly push run-of-mine muck into the WRTSF, used until WRD partial crest sloughing failure on 11 October 2015.

The *Mines Act* Permit M-243 (recently amended 14 November 2022) includes the following conditions related to waste rock deposition:

- Condition D.3.(c)(iv)—all potentially acid generating (PAG) waste rock deposition in WRTSF is covered with a minimum 1 m water cover.
- Condition D.3.(c)(v)—waste rock stored temporarily on surface, within the mine contact water collection system for no longer than two years.

A total of approximately 5.6 million tonnes of waste rock (from both underground and surface development) have been deposited in the WRD between the start of operation and the end of 2021 (DeHay-Turner 2022a). In 2022, a total of 0.38 million tonnes of waste rock were deposited between January and mid-July (MacKay-Stotesbury 2022b).

Currently, there is additional waste rock stored in a temporary surface stockpile (WP1) on the crest of the WRD. The temporarily stockpiled material along with approximately 30,000 m^3 of the WRD crest above water (from elevation 1364.5 m to 1365 m) is to be subcut and replaced with fresh PAG to comply with condition D.3.(c)(v).

2.2.2 East Waste Rock Dump Historical *Mines Act* and *Environmental Management Act*

An east waste rock dump (EWRD) was initially part of the 2015 *Mines Act* and *Environmental Management Act* presented in Pretium (2015), as a contingency deposition site (Contingency Plan C), in case unacceptable water quality was detected at the outlet of the WRTSF. The EWRD was conceptually sized up to 2.18 million cubic metres (Mm^3) of waste rock. To date, no waste rock deposition has occurred at this location.

2.3 Bathymetry

The original base bathymetry was taken in 2013 prior to any waste rock or tailings deposition. The WRTSF deposition progress has been captured by annual bathymetry since 2017:

- August 2013 (Pretium 2013)
- 28 September 2017 (Pretium 2017b)
- 17 July 2018 (Pretium 2018c)
- 14 August 2019 (Pretium 2019c)
- 8 July 2020 (Pretium 2020b)
- 22, 25, and 26 July 2021 (Pretium 2021c)
- 23 August 2021 (Pretium 2021d), partial surface focusing on the WRD and tailings deposition lines
- 22 July 2022 (Newcrest 2022a)

This historical bathymetry is used to estimate the waste rock and tailings properties for deposition planning.

2.4 July 2022 Waste Rock Dump Failure

A circular failure (~150 m long and up to 40 m deep from the crest) occurred from the WRD crest around 10:00 a.m. on 16 July 2022. The failure mobilized approximately 236,100 m^3 of waste rock from the WRD into the WRTSF. The WRD was shut down and barricaded at the time of failure since 11 July 2022, as settlement exceeding the quantifiable performance objectives were observed, and settlement rates were accelerating. The failure was reported to the Ministry of Energy, Mines and Low Carbon Innovation (EMLI) (Newcrest 2022c).

As a result of the failure and subsequent deposition shutdown, gradual ramp-up to normal deposition, and operational limitations during the winter season, the temporary waste rock storage stockpile (WP1) was expanded from mid-July to mid-September and the volume of waste rock stored in WP1 is only predicted to be substantially reduced starting in May 2023.

2.5 2022 Geotechnical Investigation

WSP conducted a geotechnical investigation of the WRTSF with Gregg Drilling and Testing Canada (Gregg) from 13 September 2022 to 20 September 2022 (excluding mobilization and de-mobilization). The initial proposed investigation included seven cone penetration test (CPT) soundings to be carried out on a barge through 50 m to 60 m of water into tailings and lakebed sediments. Sampling was intended to be conducted in a targeted fashion using a MOSTAP sampler, which did not require drilling to the sample depth.

Due to the WRD partial crest failure on 16 July 2022 (Newcrest 2022c), it was recognized that the lakebed sediments at three of the sounding locations would be covered in at least 7 m of waste rock (per comparison between 2021 and 2022 bathymetry). Therefore, Gregg proposed bringing a sonic drill rig, instead of mud rotary, to allow for pre-drilling through waste rock and collection of samples. Furthermore, four of the planned CPT soundings were re-aligned to match with the back-analysis sections.

Due to difficult conditions (waste rock run-out in the WRTSF from the failure, subsequent loss of equipment, budget, and schedule constraints), only the following investigation locations were attempted:

- CPT22-01 (completed to refusal, part of the east back-analysis section)
- CPT22-02 (completed to refusal, part of the west back-analysis section)
- CPT22-04 (attempted, lost optical cone at ~4.9 m below mudline, part of the west back-analysis section)
- SCPT22-05 (completed to refusal, part of potential future WRD analysis section / tailings properties)
- CPT22-06 (completed to refusal, part of potential future WRD analysis section / tailings properties)
- BH22-06 (samples collected every ~10 ft [3 m], adjacent to CPT22-06)

3.0 DESIGN BASIS

Some key components of the mine production design basis and material properties are presented in the following sections.

3.1 Mine Waste Production Plan

The proposed 4,950 tpd mine waste production plan was provided by Newcrest and is summarized in Table 1.

Table 1: 4,950 tpd Mine Waste Schedule – Deposited in Waste Rock and Tailings Storage Facility

Year	Planned Tailings to WRTSF[(a)] (dry tonnes)	Planned Waste Rock to WRTSF[(a,b)] (tonnes)
2022[(c)]	389,000	265,000
2023	826,000	571,000
2024	1,076,000	630,000
2025	1,144,000	183,000
2026	1,144,000	33,000
2027	1,123,000	19,000
2028	940,000	3,000
2029	391,000	2,000
Total	**7,033,000**	**1,706,000**

(a) Values provided were rounded to the nearest thousand (DeHay-Turner 2022b).
(b) The waste rock quantity does not include waste rock currently stockpiled on surface.
(c) Tonnages for 2022 are for the period from mid-July to end of December.
WRTSF = waste rock and tailings storage facility; tpd = tonnes per day.

3.2 Allowable Waste Rock Deposition Rate

The preliminary WRD failure stability back-analysis (Golder 2022b) interpreted that a key control in managing the stability of the WRD going forward is the rate of loading (i.e., deposition of waste rock).

It is inferred that in the month prior to the failure, the average deposition rate from the crest was approximately 8 m^3/d/m of lineal crest frontage based on estimated daily volumes and deposition area tracking by Newcrest (2022b). Post-failure, the deposition (from post-July 2022 to Dec 2022) occurred over a limited front (~150 m) and was limited to approximately 9.5 m^3/d/m of lineal crest frontage. A higher deposition rate can be considered acceptable as the failure flattened the WRD slope slightly, runout waste rock had a small pre-loading effect on lakebed sediments, and settlement data does not show accelerating settlements.

An average rate of deposition of 7 m^3/d/m of lineal crest frontage is used to account for equipment downtime. Based on historical site experience, it is also assumed that no deposition would occur from 15 December to 1 May due to WRTSF surface freeze-up (MacKay-Stotesbury 2022d). Efforts would be made to deposit as late into the winter season as practical; but for the purposes of modelling, it would be assumed that deposition would only occur during 228 days of each year, which results in an average deposition rate of 1,596 m^3/yr/m of lineal crest frontage.

Waste rock produced between 15 December and 1 May is expected to be stockpiled at WP1. Throughout the remainder of the year, material depletion from WP1 occurs when waste rock production is less than the average rate of deposition. Waste rock that cannot be deposited at the WRD would be transported to a secondary stockpile, WP2, and deposited at the EWRD.

3.3 Existing Temporary Surface Stockpile (WP1)

At the time of the WRD failure (16 July 2022), the estimated amount of waste rock stored in WP1 was ~162,800 m^3 based on survey information as reported by Newcrest in daily WRD reports.

Newcrest developed two WP1 conceptual design options considering current constraints on the WRD and used as the basis for reconfiguration layout of WP1 in (Golder 2022c). The first option allows for an approximate additional storage capacity of 104,000 m^3, in addition to the volume estimated to be stored as of end of December 2022, providing an estimated maximum storage capacity of 332,225 m^3 within WP1. In preparation for an expected reduction in subaqueous waste rock deposition during winter operations of 2022/2023, a second contingency option with southern extension was developed to provide additional temporary storage capacity. The southern extension option allows for an additional 148,400 m^3 of storage over the volume estimated to be stored, as of end of December 2022, providing an estimated maximum storage capacity of 376,625 m^3 (MacKay- Stotesbury 2022c).

This 4,950 tpd deposition plan does not provide design concepts for WP1 beyond predicting the storage capacity of WP1 over time. A geotechnical assessment for WP1 temporary stockpile and the reconfiguration layout of WP1 is presented under separate cover (Golder 2022c).

3.4 Proposed East Temporary Surface Stockpile (WP2)

A second temporary surface stockpile (WP2) is expected to be developed at a separate location to the east of the WRTSF for the following reasons:

- requirement to completely subaqueously deposit the existing PAG waste rock stored above water in WP1 and replace the PAG waste rock beneath the footprint of WP1 to comply with Condition D.3.(c)(v)
- limited area to expand WP1 laterally
- stability concerns related to expanding WP1 vertically

WP2 is to be developed regardless of whether the production increase of 4950 tpd is granted. Notice of Departure from Approvals submission is anticipated to be provided to EMLI by Newcrest.

This document does not provide a specific location or design details for WP2 beyond predicting the required storage capacity of WP2 over time. It is assumed that this facility would be approved and developed by mid-September 2023.

3.5 Proposed East Waste Rock Dump

Waste rock stored at WP2 is proposed to be deposited in an EWRD. The EWRD would also be used to subaqueously deposit produced waste rock as an alternative to the existing WRD if monitoring shows increased settlement requiring a temporary halt to deposition at the existing WRD.

At the time of this report, it is assumed that the deposition into the EWRD is limited to 5,000 m^3/d due to equipment handling capacity. Estimate is expected to be further refined during detailed design of the facility.

The EWRD is to be developed regardless of whether the production increase of 4,950 tpd is granted. Notice of Departure from Approvals submission is anticipated to be provided to EMLI by Newcrest.

This document provides a conceptual location for the EWRD based on the 2015 *Mines Act* and *Environmental Management Act* application (Pretium 2015). The conceptual configuration is assumed based on maximizing the available deposition front. The final design configuration of the EWRD may be different than that shown in this document and will be approved by a qualified person. It is assumed this facility would be approved and developed by May 2024. The final design will be influenced by further geotechnical CPTs of the lakebed sediments and approved by a qualified person.

3.6 Waste Rock Properties

The waste rock properties used for deposition modelling are summarized in Table 2. It is noted that the properties are unchanged from 2021 due to the failure of the WRD on 16 July 2022 rendering it impracticable to re-assess densities and dump slopes.

Table 2: Waste Rock Properties

Criteria	Unit	Planning Value	Comment/Reference
Subaqueous waste rock in situ density	t/m^3	2.06[(a)]	Scarcelli-Casciola 2022
Subaqueous WRD slope	1.43H:1V[(a)]		average of five cross-sections from 2021 bathymetry (Pretium 2021c)

(a) Parameters are unchanged from 2021 waste rock properties for post failure of WRD slope on 16 July 2022.
H:V = horizontal distance to vertical rise; WRD = waste rock dump.

Density

The deposited (in situ) density of the waste rock was determined by comparing the reported waste rock quantities deposited in the WRTSF, between start of deposition in 2015 to mid-2019, to the 2013 bathymetric survey (Pretium 2013), and a composite surface generated from the 2019 LiDAR and bathymetric survey (Pretium 2019b,c). The waste rock quantities were obtained between 2015 and 2018 from the Annual Reclamation Reports for Ministry of Energy, Mines and Petroleum Resources (now EMLI; Pretium 2017a, 2018b, 2021a) and data to 19 August 2019 from the 2019 Annual Construction Reports (Pretium 2020a). The waste rock in situ density was calculated to be 2.08 t/m^3, which validates the assumed density of 2.06 t/m^3 used by Pretium for regulatory reporting and SRK Consulting Ltd. (SRK) for analysis and design works. The in situ density may be further validated with updated LiDAR information for the ground surface contours.

Slope

The WRD downstream slope was calculated by taking the average of five cross-sections around the existing WRD from the 2021 bathymetry. Only the 2021 bathymetry was implemented due to the change in waste rock deposition method in 2021 using the remote dozer push. Bathymetry from previous years generally showed a slightly flatter WRD downstream slope, likely due to the subsurface terrain and the stacker and bail method for deposition.

3.7 Tailings Properties

The tailings properties used for deposition modelling are summarized in Table 3.

Table 3: Tailings Properties

Criteria	Unit	Planning Value	Comment/Reference
Tailings in situ dry density	t/m^3	1.15	Estimated based on analysis of existing conditions and reported quantities.
Tailings beach slope (lakebed pipeline)	3% for 8 m; 10.5% for 90 m; 7% for 50 m; 3% for 35 m; 0.1% to the end		Determined through approximation and calibration of 2022 bathymetry surface compound slope with preliminary 2022 geotechnical investigation findings (slightly steeper than values in 2021 deposition model).
Tailings beach slope (suspended pipeline)	8% for 15 m; 11.5% for 60 m; 2% for 55 m; 0.1% to the end		Determined through approximation and calibration of 2022 bathymetry surface compound slope with preliminary 2022 geotechnical investigation findings (slightly steeper than values in 2021 deposition model).

Density

Previously, WSP estimated the in situ tailings dry density from bathymetry review and reported dry tonnages of tailings deposited in the WRTSF; the values typically increased from year to year ranging from 0.8 to 1.28 t/m^3. An in situ dry tailings density of 1.0 t/m^3 was used for the 2021 deposition model (Golder 2022a) as a conservative estimate.

This assumption was re-assessed based on the 2022 bathymetry and the reported dry tonnages of tailings deposited in the WRTSF between July 2021 and 2022 (MacKay-Stotesbury 2022a).

The deposited (in situ) dry density of the tailings was calculated using a method that involved creating a capacity-based volumetric deposition model. The model was created for lakebed and suspended deposition for 2022 over the 2021 bathymetric surface, using the beach slope parameters estimated from the bathymetry surface. The total volume generated by this model was then compared with the reported in situ dry tailings tonnages to estimate an approximate in situ tailings dry density of 1.18 t/m^3.

A secondary approach, which involved modifying the 2022 bathymetric surface to the approximate encountered mudline elevation at three locations to calculate a tailings volume, resulted in a slightly higher in situ dry density of 1.25 t/m^3.

Both of these methods relied on interpretation and approximation; therefore, an in situ dry density of 1.15 t/m^3 was determined to be a conservative estimate based on the analysis and would be used for this deposition model.

Slope

It is observed that in all of the bathymetry, there is a relatively steep slope (5% to 15%) for a distance (up to ~100 m) below the discharge point, followed by a relatively flat slope (~2%) for a short distance (~20 m) before flattening completely and appearing to fill the basin relatively uniformly. The uniform tailings surface was identified as a key uncertainty that may affect future tailings deposition modelling and planning. It was considered

that that the appearance of the long, flat run-out of the tailings surface may have been a factor of high turbidity impeding bathymetric measurements at the lake bottom, which did not accurately reflect actual conditions.

The results of the 2022 geotechnical investigation indicated that the mudline elevation at the lake bottom is approximately 1 to 1.5 m lower than the lake bottom visible in the 2022 bathymetry. The mudline elevation was fairly consistent across three CPT geotechnical investigation locations despite varying distances to the nearest deposition point. The greatest distance between the three CPT geotechnical investigation locations and a deposition point was 385 m. Therefore, it was assumed that bathymetry generally represents a relatively flat distribution of tailings across the bottom of the basin. The discrepancy between the mudline elevation and the bathymetry surface was considered when assessing the tailings beach slopes and the slopes were developed to match the mudline elevation instead of the bathymetry surface.

Future geotechnical investigations would confirm the beach slope assumptions as it remains a key parameter that may affect future tailings deposition modelling and planning.

The lakebed pipeline beach slope was assessed from 2022, when Tails Lines 5 and 6 were in operation. The measured mudline elevations at lake bottom obtained from the 2022 geotechnical investigation were used when approximating the tailings beach slopes. This was done to account for the discrepancy in lake bottom elevation between the 2022 bathymetry surface and the 2022 CPT geotechnical investigation measurements. The main beach slope estimated from the 2022 bathymetry was approximately 10.5% (plus flatter compound run-out slopes). This is the same as the slope that was previously approximated from the 2021 bathymetry (Golder 2022a). The 2022 bathymetry beach slope was therefore selected for the deposition model calibration as it is the most recent information and was assumed to best represent conditions at this time. The difference between the 10.5% subaqueous beach slope approximated for 2022 and the 5.5% beach slope that was previously approximated from the 2017 bathymetry (Golder 2022a) indicates there is a high level of uncertainty in beach slopes.

The suspended pipeline slope was assessed from the 2022 bathymetry surface. The measured mudline elevations at lake bottom obtained from the 2022 geotechnical investigation were used when approximating the tailings beach slopes. The suspended pipeline beach slope estimated from 2022 bathymetry was approximately 11.5% (plus flatter compound run-out slopes). This is slightly steeper than the 10% beach slope that was previously approximated from the 2021 bathymetry (Golder 2022a). The 2022 bathymetry beach slope was selected for the deposition model calibration as it is the most recent information and was assumed to best represent conditions at this time.

4.0 DEPOSITION MODEL

4.1 Approach

The Muk3D software application developed by MineBridge Software was used to model the tailings and waste rock deposition.

Detailed modelling was carried out in annual time steps except in 2022 when the modelling commenced from mid-July 2022 using the recent 2022 bathymetry (Newcrest 2022a) taken on 22 July 2022.

Waste rock was modelled in annual timesteps, starting in January and ending in December, based on the mine waste production plan and drawdown of temporary surface storage stockpiles. The WRD was modelled at the beginning of each timestep for the quantity expected to be deposited in that timestep. The existing temporarily stored surface waste rock and the planned produced waste rock to be deposited was tracked via spreadsheet to

account for required temporary storage in WP1 and WP2 due to deposition limits. The annual timesteps were subdivided to track growth of temporary storage due to winter conditions starting annually on 15 December and depletion of temporary storage during the summer season starting the following 1 May.

Tailings deposition was also modelled in annual timesteps, starting in January and ending in December, based on the mine waste production plan. As an approximation, the tailings deposition for the year was modelled overlying the waste rock deposition for the year.

The deposition model shows the tailings deposition and waste rock placement in annual increments until end of 2029 (LOM).

The model was developed with the design basis assumptions documented in Section 3.0.

The tailings deposition model and plan should be reviewed and updated periodically, with at minimum, annual bathymetry to determine whether tailings deposition and WRD development is occurring as expected.

4.2 Perimeter Tailings Pipelines

The tailings pipeline discharge outlet elevation is set to 7.5 m above the natural lakebed or tailings surface below the outlet (per PE-107835 Section 1.3.2). The perimeter tailings pipelines are located between the WRD and the snow dump located at the eastern extent of the plant site.

The discharge outlet is located 7.5 m above the natural lakebed slope just prior to meeting the tailings surface. Due to concerns regarding the potential for excess total suspended solids if the discharge outlets were located too close to the water surface, the discharge outlets were located at the lowest elevation providing a reasonable discharge capacity.

Pretium installed two new tailings pipelines, Lines 5 and 6, along the lakebed in September 2021 (Table 4). The design locations of the two recently installed pipelines are presented in the design drawings (Golder 2021) and the historical pipelines are shown in Figure 1.

Table 4: Newly Installed Perimeter Tailings Pipelines

ID	Northing (m)	Easting (m)	Discharge Elevation (m)
5	427712.87	6258838.04	1318.21
6	427791.05	6258801.20	1322.26

Table 5 outlines the locations of the future planned tailings pipelines. These are located based on the same deposition concept and assumptions. The locations of these pipelines are shown in Figure 1.

Table 5: Future Planned Tailings Pipelines

ID	Northing (m)	Easting (m)	Discharge Elevation (m)
A	427730.45	6258818.47	1329.49
B	427833.56	6258786.00	1334.95
C	427723.47	6258807.98	1341.95
D	427834.13	6258767.00	1345.60

4.3 Results

Figure 1 shows plan view snapshots of the projected WRTSF conditions at the end of 2022, end of 2024, end of 2026, and end of 2029 LOM. Figure 2 shows cross-sections for the tailings deposition, existing WRD, and proposed EWRD to show annual progress until the end of LOM.

Key results are highlighted:

- WP1 is expected to be depleted by end of year 2023.
- Waste rock stockpiling reoccurs in WP1 (to a significantly smaller size) when deposition into the WRTSF is halted due to winter conditions. WP1 is then fully depleted every year during the summer season (i.e., surface waste rock storage does not exceed two years).
- Waste rock stockpiling starts in WP2 in 2023 and is expected to be fully depleted by end of 2024 (i.e., surface waste rock storage does not exceed two years).
- The existing WRTSF has sufficient capacity for the predicted tailings and waste rock storage and will have excess additional capacity at the end of LOM.

Detailed results are presented in the following subsections.

4.3.1 Tailings

Table 6 presents the modelled tailings deposition volumes in comparison to the planned volumes.

Table 6: Tailings Deposition Model by Volume

Year	Maximum Tailings Elevation (m)	Minimum Tailings Elevation (m)	Modelled Deposited Volume[(a)] (m^3)	Cumulative Error (%)	Planned Incremental Tailings[(a,b)] (m^3)	Planned Cumulative Tailings[(a,b)] (m^3)
2022	1,321.92	1,307.32	338,000	0.0%	339,000	339,000
2023	1,324.73	1,310.13	718,000	0.0%	718,000	1,057,000
2024	1,328.09	1,313.43	935,000	0.0%	935,000	1,992,000
2025	1,331.21	1,316.41	995,000	0.0%	995,000	2,987,000
2026	1,334.36	1,319.58	994,000	0.0%	994,000	3,981,000
2027	1,337.17	1,322.45	977,000	0.0%	977,000	4,958,000
2028	1,339.52	1,324.74	817,000	0.0%	817,000	5,775,000
2029	1,340.45	1,325.66	337,000	-0.1%	340,000	6,115,000
Total	**N/A**	**N/A**	**6,111,000**	**N/A**	**6,115,000**	**N/A**

(a) Values rounded to the nearest thousand.
(b) The model begins in mid-July 2022 when the bathymetry was collected (DeHay-Turner 2022b).
N/A = not applicable.

The deposition model was completed by alternating deposition between two perimeter pipelines. The model was tested for sensitivity to alternating single versus multiple simultaneous deposition points, and the use of alternating single point was not found to significantly impact the resulting capacity or maximum tailings elevation. In some years, the deposition was split between two perimeter pipelines when one of the pipelines had reached maximum capacity. Table 7 summarizes the required tailings pipeline operation and construction schedule.

Table 7: Tailings Pipeline Operation and Construction Timeline

Year	Operating Line ID	Operating Line ID	Contingency Line ID
2022	5	6 (active)	A[(a)]
2023	A (active)	6 (active)	B
2024	A (active)	B	C
2025	A (active)	B (active)	C
2026	C	B (active)	D
2027	C (active)	B (active, minimal capacity remaining)	D
2028	C (active)	D	N/A[(b)]
2029	C (active)	D	N/A[(b)]

(a) Tails Line 5 and 6 are sized such that they cannot each independently pass the maximum flow rate; therefore, a contingency line is recommended. Currently, Newcrest has planned to construct Tails Line A in 2023 and would serve as contingency.

(b) A contingency Line E may not be required if Lines C and D are each sized to be able to independently pass the maximum flow rate. In which case, Line D can act as the contingency for Line C. A contingency Line E was not modelled.

N/A = not applicable.

4.3.2 Existing Waste Rock Dump

Advancement of the existing WRD is limited on the west and east sides to avoid blocking the outlet of the WRTSF and to avoid impacting the space available for the tailings deposition pipelines, respectively. Therefore, the majority of advancement is northward.

The model does not consider consolidation of the lakebed sediments or waste rock settlement into the tailings.

Table 8 presents the modelled WRD volumes in comparison to the planned volumes showing general verification and alignment of the model to the planned production.

4.3.3 Proposed East Waste Rock Dump

The proposed EWRD is conceptually located at the eastern end of the WRTSF (Figure 1). The original location and plan is provided in (Pretium 2015), which includes the Tertiary Waste Rock Contingency Plan in Appendix E-1 by SRK (2015). The waste rock would be advanced from one or two access points and deposition would occur following the shoreline before advancing into deeper parts of the WRTSF. It is possible the toe of the EWRD would interact with the subaqueous tailings deposit. The model does not consider consolidation of the lakebed sediments or waste rock settlement into the tailings.

Table 9 presents the modelled EWRD volumes compared to planned volumes showing general verification and alignment of the model to the planned production.

It is expected the final design for the EWRD may be produced for a higher storage capacity for contingency purposes.

Table 8: Existing Waste Rock Dump Model

Year	Modelled Waste Rock[a] (m^3)	Cumulative Error (%)	Available Deposition Front (m)	Deposited Rehandle from WP1[a,b,c] (m^3)	Deposited from Production (no rehandle)[a,c] (m^3)	Planned Deposited Waste Rock[a,b,c] (m^3)	Cumulative Planned Deposited Waste Rock[a,b,c] (m^3)
2022[d]	86,000	0.3%	142 to 207	15,000	71,000	86,000	86,000
2023	439,000	0.1%	290	346,000	93,000	439,000	525,000
2024	178,000	0.1%	350	0	178,000	178,000	703,000
2025	88,000	0.0%	280	37,000	51,000	89,000	791,000
2026	16,000	0.0%	190	7,000	9,000	16,000	807,000
2027	9,000	0.0%	190	4,000	5,000	9,000	816,000
2028	1,000	0.0%	90	1,000	0	1,000	817,000
2029	1,000	0.0%	50	0	1,000	1,000	818,000
Total	**819,000**	**N/A**	**N/A**	**410,000**	**408,000**	**819,000**	**N/A**

(a) Values rounded to the nearest thousand.

(b) Re-handle includes the ~162,800 m3 of WP1 stockpiled waste rock as of mid-July 2022.

(c) Planned waste rock deposited in the existing WRD does not track exactly with planned waste rock production as: 1) planned production is diverted to WP2 in 2023, and 2) deposition into the WRD is managed with an allowable deposition rate and excess is stored temporarily in WP1 then subsequently drawn down at a later time.

(d) Values provided are actual waste rock in the WRTSF occurring from mid-July to December 2022. The model begins in mid-July 2022 when the bathymetry was collected (Scarcelli-Casciola 2022).

WRTSF = waste rock and tailings storage facility; WRD = waste rock dump; N/A = not applicable.

Table 9: East Waste Rock Dump Model

Year	Modelled Waste Rock[a] (m^3)	Cumulative Error (%)	Available Deposition Front (m)	Deposited Rehandle from WP2[a,b] (m^3)	Deposited from Production (no rehandle)[a,b] (m^3)	Planned Total Waste Rock[a,b] (m^3)	Cumulative Waste Rock[a,b] (m^3)
2022	0	0.0%	n/a	0	0	0	0
2023	0	0.0%	n/a	0	0	0	0
2024	197,000	0.1%	n/a	197,000	0	197,000	197,000
2025	0	0.0%	n/a	0	0	0	197,000
2026	0	0.0%	n/a	0	0	0	197,000
2027	0	0.0%	n/a	0	0	0	197,000
2028	0	0.0%	n/a	0	0	0	197,000
2029	0	0.0%	n/a	0	0	0	197,000
Total	**197,000**	**N/A**	**N/A**	**197,000**	**0**	**197,000**	**N/A**

(a) Values rounded to the nearest thousand.

(b) Planned waste rock deposited in the EWRD does not track exactly with planned waste rock production as: 1) planned production is diverted to WP2 in 2023, and 2) deposition into the WRD is managed with an allowable deposition rate and excess is stored temporarily in WP2 then subsequently drawn down at a later time.

(c) Available deposition front is not examined for EWRD.

WRD = waste rock dump; EWRD = east waste rock dump; N/A = not applicable.

4.3.4 Temporary Surface Stockpiles

Waste rock that cannot be immediately deposited into the WRTSF would be stored in two temporary surface stockpiles. WP1 is currently located on the existing WRD platform, beyond the historical shoreline. Proposed WP2 stockpile(s) is expected to be located on land near the proposed EWRD and consist of multiple small stockpiles to facilitate first-in, first-out waste rock management.

Chart 1 presents the predicted change in volumes of WP1 and WP2 over time based on the mine waste production plan, existing WP1 storage, and assumed drawdown rates. To allow for the timely drawdown of WP1, all planned production is assumed to be diverted to WP2 stockpile(s) until 1 May 2024.

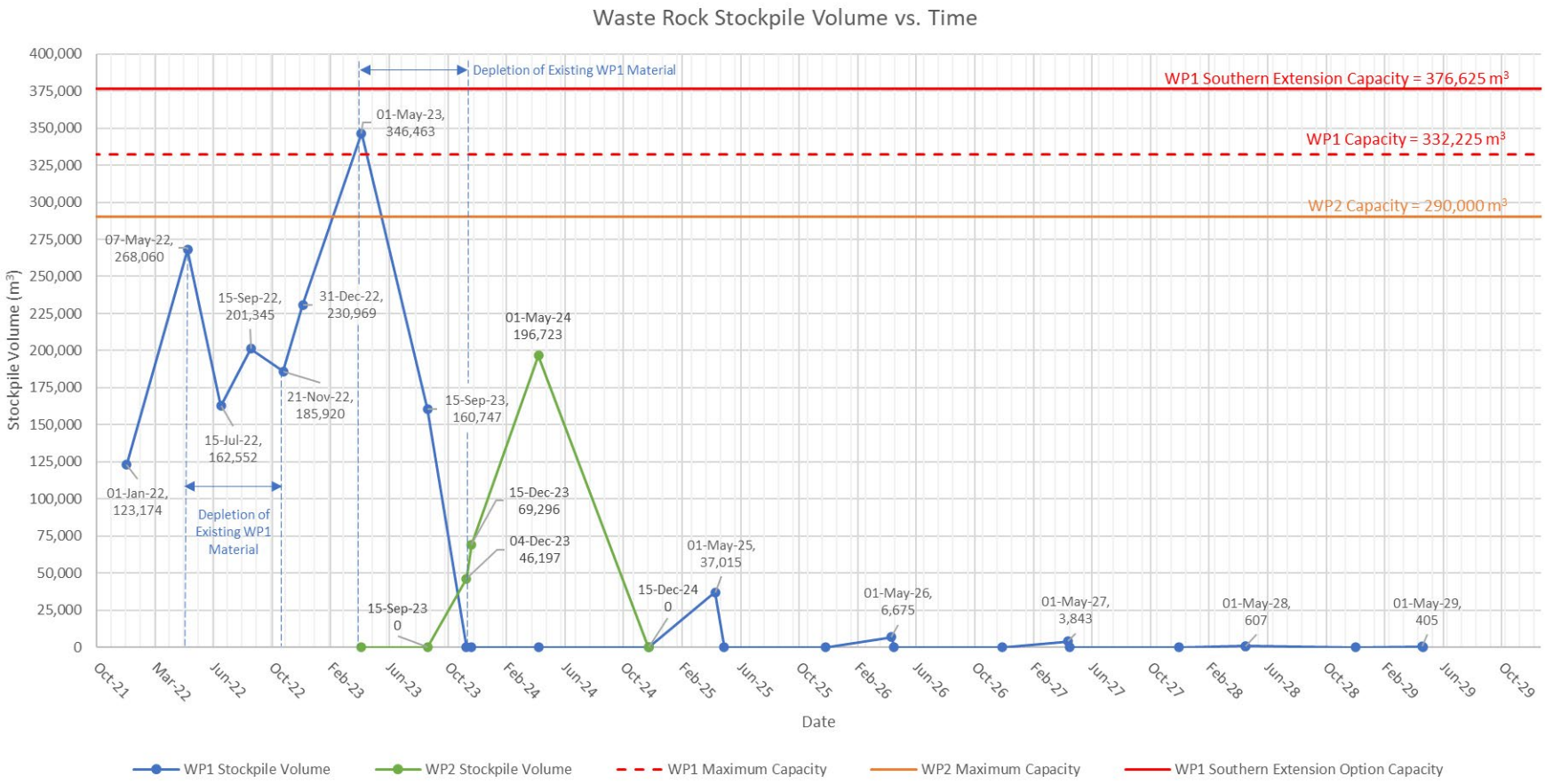

Chart 1: Temporary Waste Rock Surface Stockpile Volume over Time

4.3.4.1 WP1

Table 10 presents waste rock management at WP1 beginning from mid-July 2022. The maximum WP1 stockpile design size of approximately 332,225 m^3 would be exceeded in 2023 without the southern contingency extension design. If the WP1 southern extension option is utilized, the maximum capacity of 376,625 m^3 would not be exceeded in any year of production.

Table 10: Change in WP1 Volume over Time

Year	Received Waste Rock Volume[(a)] (m^3)	Withdrawn (Deposited) Waste Rock Volume[(a)] (m^3)	Maximum Stockpile Size[(a)] (m^3)	End of Year Stockpile Volume[(a,d)] (m^3)
2022[(b)]	84,000	15,000	268,000	231,000
2023	115,000	346,000	346,000	0
2024[(c)]	0	0	0	0
2025	37,000	37,000	37,000	0
2026	7,000	7,000	7,000	0
2027	4,000	4,000	4,000	0
2028	1,000	1,000	1,000	0
2029	0	0	0	0
Total	**248,000**	**410,000**	**N/A**	**N/A**

(a) Values rounded to the nearest thousand.

(b) Initial volume of WP1 on 15 July 2022 = 162,552 m3.

(c) Waste rock was assumed to be stockpiled at WP2 from September 2023 to May 2024.

(d) Following 2022, WP1 is predicted to be a seasonal structure, expanded during the winter season when deposition into the WRTSF is not operationally viable and fully drawn down during the summer season.

WRTSF = waste rock and tailings storage facility; N/A = not applicable.

4.3.4.2 WP2

Table 11 presents waste rock management at WP2 beginning from mid-July 2023.

Table 11: Change in WP2 Volume over Time

Year	Received Waste Rock Volume[(a)] (m^3)	Withdrawn (Deposited) Waste Rock Volume[(a)] (m^3)	Maximum Stockpile Size[(a)] (m^3)	End of Year Stockpile Volume[(a)] (m^3)
2022[(a)]	0	0	0	0
2023[(b)]	69,000	0	69,000	69,000
2024[(b)]	127,000	197,000	197,000	0
2025[(c)]	0	0	0	0
2026[(c)]	0	0	0	0
2027[(c)]	0	0	0	0
2028[(c)]	0	0	0	0
2029[(c)]	0	0	0	0
Total	**197,000**	**197,000**	**N/A**	**N/A**

(a) Values rounded to the nearest thousand.

(b) All planned produced waste rock hauled to surface was assumed to be stockpiled at WP2 from May 2023 to May 2024.

(c) Following 2024, WP2 is predicted to be fully depleted and not receive waste rock. Planned production is predicted to be received at the existing (Main) WRD following 2024, with WP1 being expanded and drawn down seasonally as described in Table 10.

WRD = waste rock dump; N/A = not applicable.

5.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this technical memorandum.

We trust the above meets your present requirements. If you have any questions or requirements, please contact the undersigned.

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Engineers & Geoscientists BC

EP/CEC/JEK/ca/ar

Attachment: Figures 1 and 2

https://golderassociates.sharepoint.com/sites/157185/project files/6 deliverables/3.0_issued/21507844-026-tm-rev1-6000/21507844-026-tm-rev1-6000-4950tpd deposition model 31jan_23.docx

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STUDY LIMITATIONS

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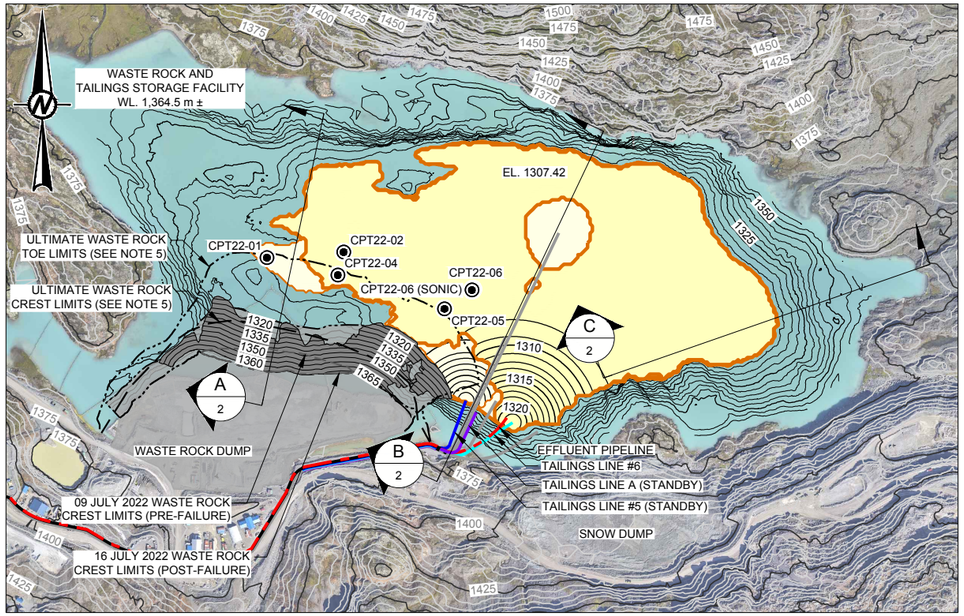
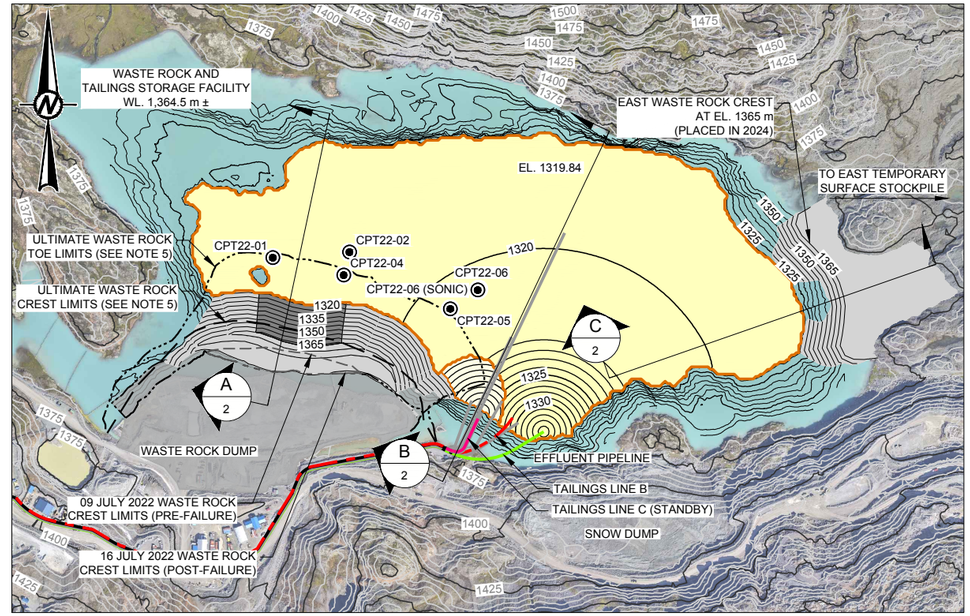


END OF 2022 CONDITIONS
SCALE 1:5 000 m



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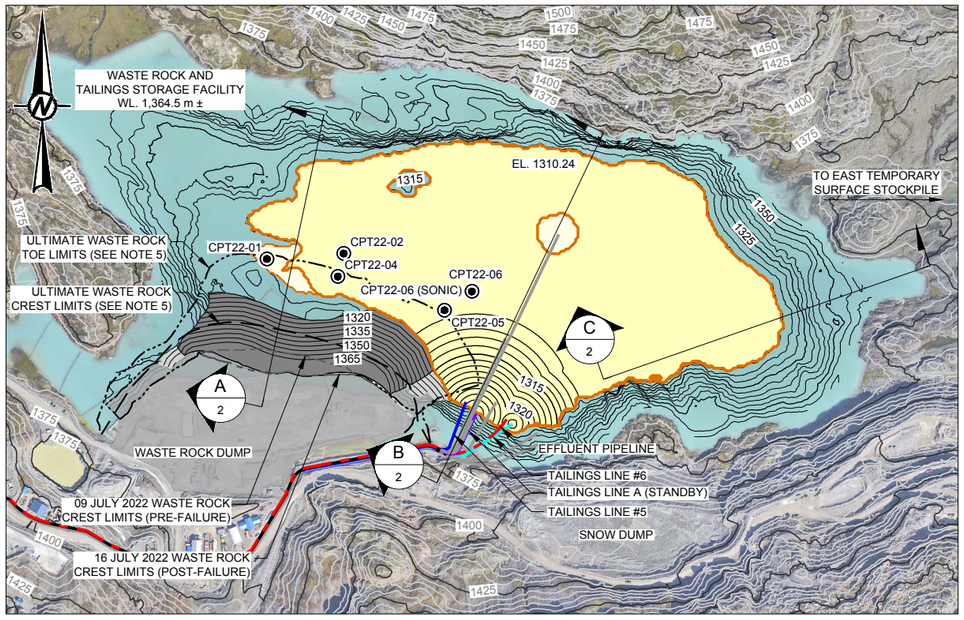
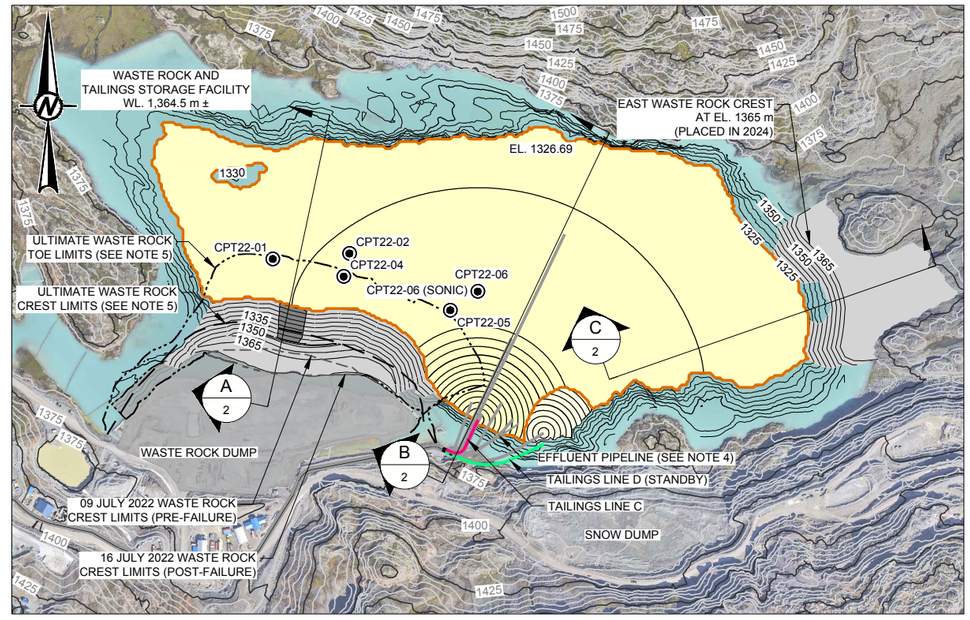


END OF 2023 CONDITIONS
SCALE 1:5 000 m



END OF 2029 CONDITIONS
SCALE 1:5 000 m

LEGEND

- 2019 EXISTING GROUND CONTOURS (SEE REFERENCE 1)
- 2022 BATHYMETRIC CONTOURS (SEE REFERENCE 2)
- PROPOSED WASTE ROCK AND DEPOSITION CONTOURS
- APPROXIMATE EFFLUENT LINE
- APPROXIMATE MILL LINE #2 AND #3
- HISTORIC INACTIVE PIPELINES
- APPROXIMATE TAILINGS LINE #5
- APPROXIMATE TAILINGS LINE #6
- APPROXIMATE TAILINGS LINE A
- APPROXIMATE TAILINGS LINE B
- APPROXIMATE TAILINGS LINE C
- APPROXIMATE TAILINGS LINE D
- APPROXIMATE ACTIVE TAILINGS DEPOSITION AREA
- APPROXIMATE INACTIVE TAILINGS DEPOSITION AREA
- CURRENT YEAR PROJECTED WASTE ROCK ADDITIONS
- PROJECTED WASTE ROCK AREA
- EXISTING JULY 2022 WASTE ROCK AREA
- 2022 CPT INVESTIGATION LOCATION

NOTES

1. ALL UNITS ARE IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES SHOWN IN UTM, NAD 83, ZONE 9. ELEVATIONS RELATIVE TO GEODETIC DATUM.
3. EXISTING GROUND AND BATHYMETRY CONTOURS SHOWN AT 25 m MAJOR AND 5 m MINOR INTERVAL. PROPOSED CONTOURS SHOWN AT 5 m MAJOR AND 1 m MINOR INTERVAL.
4. EFFLUENT PIPELINE OUTFALL ELEVATION ESTIMATED AT 1328 m AND IS EXPECTED TO BE BURIED BY TAILINGS IN 2029. REPLACEMENT EFFLUENT PIPELINE TO BE DESIGNED BEFORE 2027 AND INSTALLED IN 2028.
5. PREVIOUS "UPDATED SUBAQUEOUS WASTE ROCK DUMP DESIGN", SRK 2018 ASSUMED WASTE ROCK DUMP SLOPE OF 1.5H:1V.
6. RECORD SURVEY COORDINATES NOT AVAILABLE.
7. TAILINGS LINE #3 WAS PLUGGED JULY 2021, AND PARTIALLY REMOVED AS OF SEPTEMBER 2021.
8. SEDIMENT CURTAIN NOT SHOWN FOR CLARITY.

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2. 2022 BATHYMETRY SURVEY PROVIDED BY NEWCREST, SURVEYED: 22 JULY 2022, RECEIVED: 08 AUGUST 2022, FILE NAME: "20220722_adjusted_1.5x1.5 Brucejack Winghead Bathymetric Survey_median_UTMZ9_CGVD28.xyz".
3. 2019 AERIAL PHOTO PROVIDED BY PRETIUM RESOURCES LTD., RECEIVED: 18 MARCH 2021, FILE NAME: "Brucejack_2019_Clip.tif".

REDUCED SIZE

0 200 400
1:5,000 METRES

TABLE 1: TAILINGS PIPELINE DISCHARGE LOCATION AND TIMELINE

TAILINGS LINE ID	NORTHING (m)	EASTING (m)	DISCHARGE ELEVATION (m)	EARLIEST RECOMMENDED CONSTRUCTION YEAR	ACTIVE DISCHARGE YEARS
LINE #5 (SEE NOTE 6)	427712.87	6258838.04	1318.21	CONSTRUCTED	2022 TO 2023
LINE #6 (SEE NOTE 6)	427791.05	6258801.20	1322.26	CONSTRUCTED	2022 TO 2023
LINE A	427730.45	6258818.47	1329.49	2023	2023 TO 2025
LINE B	427833.56	6258786.00	1334.95	2023	2025 TO 2027
LINE C	427723.47	6258807.98	1341.95	2024	2026 TO 2029
LINE D	427834.13	6258767.00	1345.60	2026	STANDBY

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PROJECT
BRUCEJACK GOLD MINE
DETAILED DEPOSITION PLAN (4950 TPD)

TITLE
TAILINGS AND WASTE ROCK DEPOSITION SEQUENCE
END OF 2022 TO END OF 2029

PROJECT NO.	DOC.	REV.	FIGURE
21507844	026	1	1

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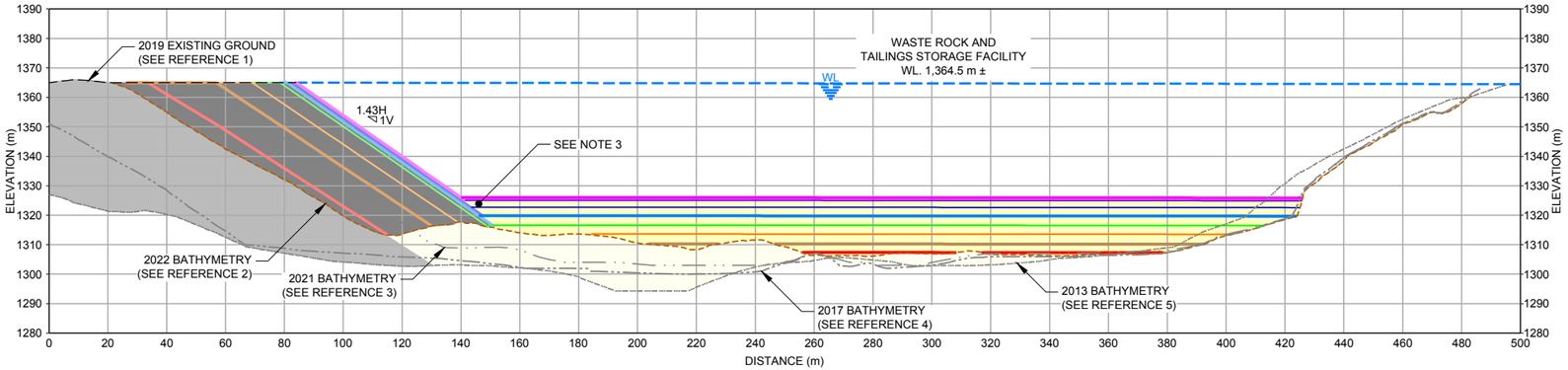

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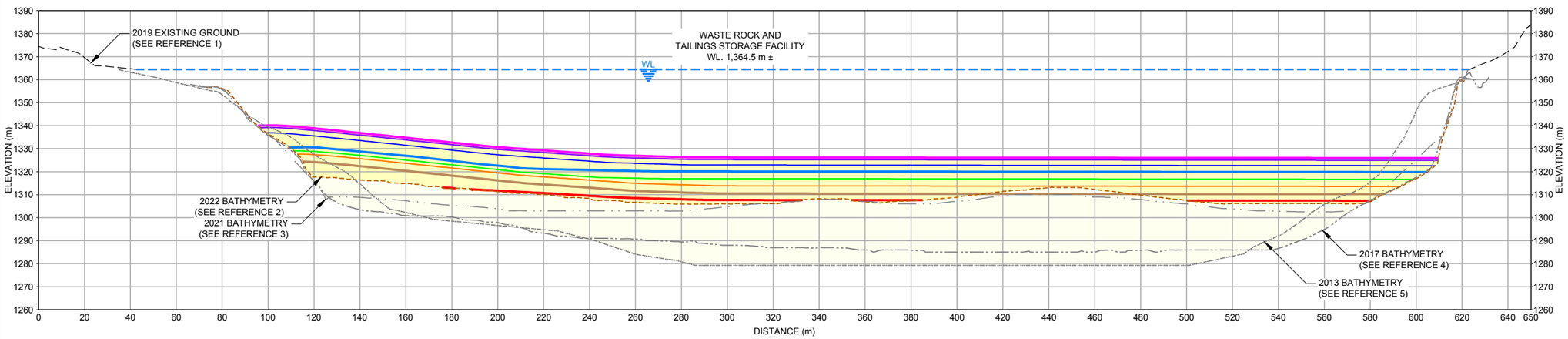

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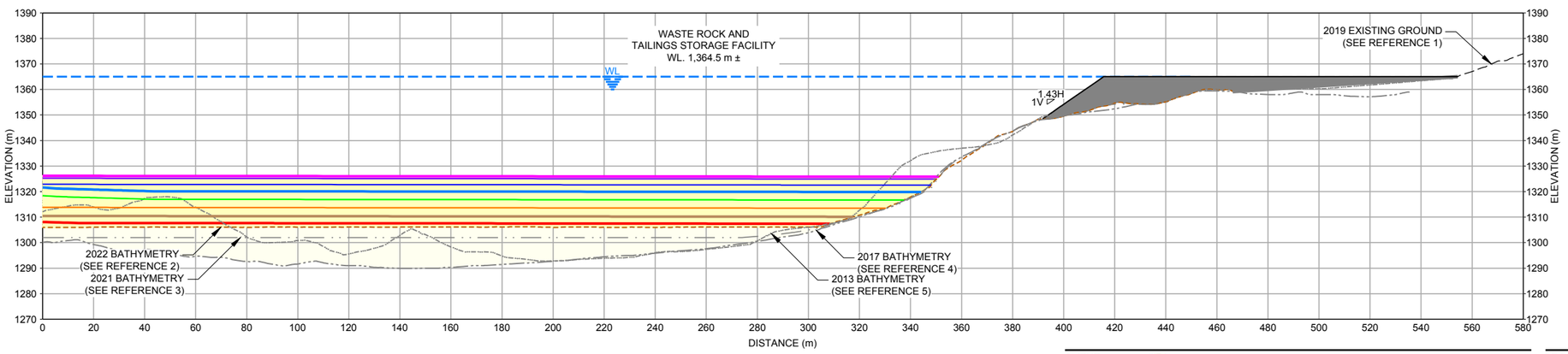

SCALE 1:1 000 m (C / 1) CROSS-SECTION - DEPOSITION SEQUENCE THROUGH EAST WASTE ROCK DUMP

LEGEND

- END OF 2022 DEPOSITION
- END OF 2023 DEPOSITION
- END OF 2024 DEPOSITION
- END OF 2025 DEPOSITION
- END OF 2026 DEPOSITION
- END OF 2027 DEPOSITION
- END OF 2028 DEPOSITION
- END OF 2029 DEPOSITION
- APPROXIMATE PROJECTED TAILINGS DEPOSITION
- EXISTING DEPOSITED TAILINGS AND RUNOUT WASTE ROCK
- EXISTING WASTE ROCK
- PROJECTED MAIN / EAST WASTE ROCK

NOTES

1. ALL UNITS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ELEVATIONS RELATIVE TO GEODETIC DATUM.
3. SIMPLIFIED AND IDEALIZED REPRESENTATION OF WASTE ROCK PLACEMENT OVER TAILINGS. ACTUAL CONDITIONS MAY DIFFER DEPENDING ON IN-SITU TAILINGS PROPERTIES. WASTE ROCK MAY LOCALLY DISPLACE TAILINGS DURING PLACEMENT.

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1. 2019 EXISTING GROUND SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 25 OCTOBER 2019, RECEIVED: 16 MARCH 2021, FILE NAME: "BJ_Lidar2019_Contour.shp".
2. 2022 BATHYMETRY SURVEY PROVIDED BY NEWCREST, SURVEYED: 22 JULY 2022, RECEIVED: 08 AUGUST 2022, FILE NAME: "20220722_adjusted_1.5x1.5 Brucejack Winghead Bathymetric Survey_median_UTMZ9_CGVD28.xyz".
3. 2021 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 22, 25-26 JULY 2021, RECEIVED: 09 AUGUST 2021, FILE NAME: "ACAD-21-282-1to3 REV2_2021 BruceJack Lake PRETIUM WINGHEAD Bathymetric Survey Geo.dwg".
4. 2017 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD.,SURVEYED: 28 SEPTEMBER 2017, RECEIVED: 16 MARCH 2021, FILE NAME: "BruceJack-1m-Contours-20170928.dxf".
5. 2013 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 25 OCTOBER 2013, RECEIVED: 6 APRIL 2021, FILE NAME: "P01_BJ_0000_Bathymetric_Contour_2013.shp".

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0 50 100
1:1,000 METRES

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APPROVED	J. KWOK

PROJECT
BRUCEJACK GOLD MINE
DETAILED DEPOSITION PLAN (4950 TPD)

TITLE
TAILINGS AND WASTE ROCK DEPOSITION SEQUENCE CROSS-SECTIONS

PROJECT NO.	DOC.	REV.	FIGURE
21507844	026	1	2

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Appendix 3-2: Brucejack WP1 Geotechnical Assessment Report

Report

Geotechnical Assessment for Waste Rock Pile WP1 Temporary Stockpile

Brucejack Mine

Submitted to:

Newcrest Mining Ltd.

Submitted by:

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Reference No. 21507844-029-R-Rev0-6000

16 December 2022

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APPENDIX C
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Drawings – Proposed WP1 Configuration

1.0 INTRODUCTION

Golder Associates Ltd., a member of WSP (WSP Golder) has been retained by Newcrest Mining Ltd. (Newcrest) to complete a geotechnical assessment, stability analysis, and setback analysis of the Waste Pile 1 (WP1) structure for Brucejack Mine, British Columbia.

A large temporary stockpile of waste rock has been stored on the surface of the waste rock dump (WRD) and is currently referred as WP1 and was previously known as Ore Pad 2. Due to safety and operational concerns at the waste rock and tailings storage facility (WRTSF) from the July 2022 WRD partial crest failure, waste rock placement was limited to the WP1 stockpile. Additional waste stockpile storage capacity is required for the winter of 2022/2023 as limited waste rock deposition expected during the winter. Taking this into consideration, the WP1 stockpile was reassessed and a design that meets the target factor of safety (FOS) criteria was developed.

This report presents a summary of geotechnical subsurface conditions at the site, stockpile design criteria, slope stability analyses, stockpile hazard classifications, and geotechnical stockpile construction monitoring and recommendations for the WP1 stockpile.

2.0 OBJECTIVE

The objective of the WP1 stockpile geotechnical assessment report is to provide geotechnical recommendations for the reconfiguration of the waste rock stockpile including expansion. The scope of the work presented in this report includes the following:

- Summary of subsurface conditions.
- Seismic site classification and seismic hazard parameters.
- Limit equilibrium slope stability analyses for static and seismic (pseudo-static) loading conditions.
- Recommendations for stockpile material placement and instrumentation monitoring.

3.0 SUBSURFACE CONDITIONS

The existing WP1 stockpile is located on the WRD which is underlaid by an assumed variable thickness of lakebed sediments over bedrock based on limited geophysical data from 2013 (Frontier Geosciences 2013). It is understood by WSP Golder that no geotechnical investigation has been conducted in the footprint of the WP1 stockpile. For modelling purposes, Newcrest provided WSP Golder with the most recent topography from an aerial LiDAR completed in July and August 2022 (Newcrest 2022a and 2022b) and lake bathymetric reconnaissance of the WRTSF collected in 2021.

Strata were assigned based on the review of the following surfaces:

- Top of bedrock (2013 geophysics depth to bedrock subtracted from 1,364.29 masl).
- Lakebed sediment thickness (Frontier Geosciences 2013).
- Top of lakebed sediment could be interpreted from one of the following:
  - 2013 bathymetry (Frontier Geosciences 2013).
  - 2013 geophysics thickness of sediment overlain on top of bedrock (Frontier Geosciences 2013).
  - 2017 (and later years) bathymetry (Pretium 2017, 2018, 2021).
- A composite surface of 2013, 2017, and 2021 bathymetries was used for the geometry of the top of the lakebed sediments unit.

As available data became less accurate and available towards the southern area of WP1, the following assumptions were made:

- Stratigraphy below the south area of WP1 presents an assumed and narrower thickness of lakebed sediment as bedrock was encountered at the southern perimeter of WP1.
- Flat surface along the base of WP1 is at constant elevation of 1,365 masl.
- Competent bedrock surface was assumed based on the geotechnical characterization of the rock mass of the Brucejack Mine area, which indicates that the rock unit near-surface presents good quality and moderate discontinuity spacing and the p-wave velocity ranging from 4,790 to 4,080 m/s in the geophysical survey of the Brucejack Lake property (Frontier Geosciences 2013).
- Uniform lakebed sediment unit presents homogeneous material properties.
- Constant water table is at 1,365 m elevation.

WSP Golder recommends completing additional investigation of the lakebed sediments and material properties of the subsurface conditions of the WP1 stockpile. Newcrest and WSP Golder are planning for a geotechnical subsurface investigation to understand and characterize the subsurface material properties.

4.0 STOCKPILE LOCATION AND CONFIGURATION

In 2020, due to resourcing and site conditions, waste rock was stockpiled at the southern end of the WRTSF in an area known as Ore Pad 2. Additional storage capacity was required due to waste rock deposition limitations which resulted in a waste rock stockpile up to 15 m constructed on the southern portion of the WRTSF, which is now known as the WP1 temporary stockpile. Currently the crest of WP1 is at approximate elevation of 1377.7 masl at its highest location and the north toe of WP1 is located at about 38 m from the crest of the WRD.

Newcrest plans to increase production to 4,950 tpd as part of the revised life of mine plan. As part of preparation for winter operations in 2022/2023 with the expected reduction in subaqueous waste rock deposition, a conceptual configuration of WP1 with south extension option was developed to provide additional temporary storage capacity. Table 1 summarizes the conceptual designs. The proposed design took into consideration the maximum extent limits and incorporated into the WP1 configuration with south expansion.

Table 1: Conceptual WP1 Design Volumes and Footprint Area.

WP1 Conceptual Designs ID Description	Estimated Additional Volumetric Capacity (m^3) Over August 2022 Survey	Surface Area (m^2)
Proposed WP1 configuration	104,000	18,000
Proposed WP1 configuration south expansion	132,000	19,900

WP1 = Waste Pile 1.

Based on stability analysis and input from the operations team on equipment loading, WP1 has been reconfigured slightly from the existing WP1 layout. The proposed WP1 configuration drawing list is presented in Drawing 1. The conceptual layout plan and cross-sections are presented in Drawings 2 and 3, respectively, in Appendix D.

Design geometry for WP1 is summarized below by main slope area of the temporary stockpile

Table 2: Temporary Stockpile WP1 Slope and Height Configuration

Slope face	Overall Slope Angle	Overall Maximum Height (m)
North	2H:1V (Constructed in stages of angle of repose 1.4H:1V as shown in Drawing 3)	13
East		13 (20 at the southern portion, refer to Drawings 2 and 3)
South		20
West		13 (20 at the southern portion, refer to Drawings 2 and 3)

5.0 SEISMIC SITE CLASSIFICATION

The level of importance of seismic loading at any site is related to factors such as the subsoil conditions and soil behaviour during an earthquake; the magnitude, duration, and frequency level of strong ground motion; and the probable intensity and likelihood of occurrence of an earthquake.

The *Canadian Foundation Engineering Manual* (CGS 2006) contains seismic analysis and design methodology. The seismic site class value, as defined in Table 6.1A (CGS 2006), depends on the average shear wave velocity and/or average standard penetration testing N-values of the upper 30 m of soil and/or rock below founding level. The *Canadian Foundation Engineering Manual* permits the site class to be specified based solely on the stratigraphy and in situ testing data.

No detailed geotechnical investigation was carried out within the general area of WP1 foundation. The subsurface conditions were interpreted from the 2013 bathymetry and geophysics survey (BGC 2014). As there are uncertainties in the thickness and properties of lakebed sediment within the area of WP1, and rock is predominantly present below the WP1 foundation, Site Class C was assigned to obtain preliminary seismic hazard calculations from 2020 National Building Code of Canada Seismic Hazard Tool.

Table 3 summarizes the seismic parameters for the site, based on a 2% probability of exceedance in 50 years and a 10% probability of exceedance in 50 years. For the stability assessment of WP1, a design earthquake with a 2% probability of exceedance in 50 years and a peak ground acceleration (PGA) of 0.0892 g (NBC 2020) was used. Appendix A presents a summary of the Seismic Hazard Calculation.

Table 3: 2020 National Building Code of Canada Seismic Hazard Calculation

Probability of Exceedance	PGA	Sa (0.05)	Sa (0.1)	Sa (0.2)	Sa (0.5)	Sa (1.0)	Sa (2.0)
2% in 50 years (2,475 AEP)	0.0892	0.103	0.16	0.199	0.207	0.162	0.114
10% in 50 years (475 AEP)	0.0344	0.0359	0.0527	0.0702	0.101	0.0846	0.0589

Note: Location based on Latitude 56.47º, Longitude -130.174 as shown in NBC 2020 for site location (Appendix A).
AEP = annual exceedance probability; g = acceleration due to gravity; PGA = peak ground acceleration; Sa = spectral acceleration.

6.0 GEOTECHNICAL ASSESSMENT AND DESIGN PARAMETERS

Geotechnical material properties used in the stability analysis of WP1 are summarized in Table 4. It was assumed that waste rock material from WP1 and the WRD are free draining and that no excess pore water pressure will develop. Therefore, the same material properties for waste rock from the previous WRD stability report were used (SRK 2015).

The bedrock foundation was characterized as a strong and competent material, and no failures were expected to occur through the bedrock unit; therefore, the infinite strength model was assigned for static and pseudo-static loading conditions.

The material properties for the lakebed sediment were based on the back-analysis assessment for the WRD failure completed on 17 October 2022 (WSP Golder 2022). For drained conditions, an effective friction angle of 27° and effective cohesion of 0 kPa was used based on consolidated undrained isotropic triaxial test results completed for material (BGC 2014) and mean value used in the probabilistic analysis (SRK 2020). FOS of 1.5 was estimated for the WRD under drained condition. For undrained conditions, the lakebed sediment was modelled using the range of 0.27 to 0.40 shear strength ratio model ($\frac{S_u}{\sigma_v'}$) based on consolidated undrained isotropic triaxial test results (BGC 2014) and back analysis of failure completed by Golder (WSP Golder 2022). The strength parameters under undrained conditions were estimated based on a FOS of approximately 1, which is a conservative assumption since there was no available information of the subsurface conditions of the WP1 stockpile.

A geotechnical investigation in the WRTSF was conducted by WSP Golder with Gregg Drilling and Testing Canada from 13 to 20 September 2022. The proposed investigation included seven cone penetration tests along tailings and lakebed sediments. Currently, the preliminary results of the investigation and interpretation have not been fully completed and incorporated into the stability analysis models. It should be noted that the 2022 geotechnical investigation extended north of the WRD platform in the WRTSF, and complementary testing along the WP1 area is to be considered to understand the material behaviour of the WP1 foundation.

Table 4: Material Properties

Material Name	Behaviour Type	Material Model	Unit Weight (kN/m³)[(a)]	Effective Cohesion c′ (kPa)	Effective Friction Angle	Undrained Shear Strength	Undrained Shear Strength Ratio	Minimum Shear Strength
Waste rock dump	Drained	Mohr-Coulomb	22	0	38[(a)]	N/A	N/A	N/A
WP1	Drained	Mohr-Coulomb	22	0	38[(a)]	N/A	N/A	N/A
Lakebed sediments	Drained	Mohr-Coulomb	16	0	27[(a)]	N/A	N/A	N/A
	Undrained	Undrained shear strength ratio	16[(a)]	N/A	N/A	N/A	0.32 assumed[(b)]	10 assumed[(b)]
Bedrock	Drained/ Undrained	Infinite strength	24	N/A	N/A	N/A	N/A	N/A

(a) SRK 2015.

(b) BGC 2014; WSP Golder 2022.

kN/m³ = kilonewtons per cubic metre; kPa = kilopascal; N/A = not applicable; WP1 = Waste Pile 1.

6.1 Stockpile Design Criteria and Hazard Classification

Based on the waste dump and stockpile stability rating and hazard classification system discussed in the *Guidelines for Mine Waste Dump and Stockpile Design* (Hawley and Cunning 2017), for the proposed WP1 stockpile was classified as a Moderate instability hazard.

The system takes into consideration 22 factors that affect the stability of the structure (Hawley and Cunning 2017); each factor has a numerical rating assigned that helps to characterize a hazard class for a waste dump or stockpile. The assessment of WP1 scored 50, suggesting an instability hazard class III – Moderate. Appendix B presents a detailed results summary of the stockpile stability rating and hazard classification assessment.

Table 5 summarizes the target and minimum FOS values that were used for the stockpile assessment. The target FOS values are suggested design values from the *Mined Rock and Overburden Piles Investigation and Design Manual – Interim Guidelines* (BCMWRPRC 1991) for Case A defined as:

- Low level of confidence in critical analysis parameters.
- Possibly unconservative interpretation of conditions, assumptions.
- Severe consequences of failure.
- Simplified stability analyses method (chart, simplified method of slices).
- Stability analysis method poorly simulates physical conditions.
- Poor understanding of potential failure mechanism(s).

The minimum FOS values from the *Guidelines for Mine Waste Dump and Stockpile Design* by Hawley and Cunning (2017) based on a low confidence and moderate consequence which are considered applicable to the WP1 stockpile are presented in Table 5.

Table 5: Target and Minimum Factors of Safety

Loading Condition	Target FOS Values – Case A (BCMWRPRC 1991)	Minimum FOS Values (Hawley and Cunning 2017)
Spoil surface stability – short-term	1	-
Spoil surface stability – long-term	1.2	-
Overall stability – short-term (static)	1.3	-
Overall stability – long-term (static)	1.5	-
Overall stability (static)	-	1.4
Overall stability – pseudo-static	1.1	1.1

FOS = factor of safety; - = not applicable

The WP1 is a temporary stockpile and the overall long term static long-term FOS criteria is not considered to be applicable. The selected stockpile design FOS criteria for stability have been selected using the most conservative of BCMWRPRC 1991 and Hawley and Cunning 2017. A FOS of 1.5 was selected, similar to case A long-long term, to accommodate some data gaps yet to be verified in the foundation conditions of the WRD platform that WP1 is founded on. The target FOS may be reassessed following new information from subsurface investigations and laboratory testing and analyses values.

6.2 Liquefaction Potential

Liquefaction is a phenomenon whereby seismically induced shaking generates shear stresses within the soil under undrained conditions. These stresses tend to densify the soil (i.e., leading to potentially large surface settlements) and under undrained conditions, generate excess pore pressures. The excess pore pressures can also lead to sudden temporary losses in strength. Where existing static shear stresses are present, the loss of strength can lead to significant lateral movements, also referred to as “lateral spreading,” or under certain conditions, even catastrophic slope failures referred to as “flow slides”. Understanding the soil liquefaction potential will provide input into the design and potential changes in the construction methods or procedures to prevent unwanted events.

A geotechnical investigation and instrumentation program is being planned for 2023 to provide input into a static and seismic liquefaction potential assessment which is also expected to be completed in 2023 as part of the detailed design for the waste rock stockpiles.

7.0 FOUNDATION CONDITIONS

Foundation of the existing WP1 is on the WRD crest which is assumed to be existing waste rock material placed over partially displaced lakebed sediments as the main WRD was developed. Expansion of WP1 to the design limits shown in Drawing 2 is expected to be on the main WRD rockfill crest and the southern rockfill access road.

Should additional storage be required for 2022/2023 winter season, an additional WP1 south expansion is also shown in Drawing 2 which will require ground preparation to remove some laydown materials and temporary structures to the base rockfill pad. The laydown pad foundation of this area is noted by Newcrest as non-acid generating rockfill. A separation barrier such as geotextile is to be placed to provide a visual barrier to aid in removal of the WP1 expansion potentially acid generating rockfill materials. WP1 will be remined at a future date and placed in the WRTSF.

Cross-sections of WP1 stockpile illustrating the proposed WP1 and south expansion are shown in Drawing 3.

8.0 SLOPE STABILITY ASSESSMENT

Slope stability analyses were completed for the WP1 stockpile using the program Slide2 V9.0, a two-dimensional limit equilibrium computer software developed by Rocscience Inc. The general limit equilibrium (GLE)/Morgenstern-Price and Spencer methods were employed to analyze potential failure surfaces through the stockpile slopes and underlying foundations. The slope stability analyses were conducted to locate the critical failure surfaces along the north and south side slopes of WP1 using the block and search and the non-circular auto-refine search method. Slope stability analyses were conducted using the effective stress analysis parameters. Slope stability analysis results for the WP1 stockpile are included in Appendix C.

Post-earthquake analyses (i.e., using residual shear strengths for liquefied foundation materials) were not carried out for WP1 because of limitations in available information for the in situ conditions. Pseudo-static analyses were carried out to confirm if WP1 meets the minimum and target FOS criteria discussed in Section 6.1.
The pseudo-static analyses were carried out in accordance with the method proposed by Hynes-Griffin and Franklin (1984). In this method, a horizontal acceleration coefficient of 0.045 g (equal to half of the bedrock PGA) was applied.

The slope stability of WP1 was completed for the WP1 conceptual design. The analysis considered the active load of a haul truck dumping waste rock at 6 m and 10 m distance from the WP1 crest, and a dozer pushing waste rock at the edge of the WP1 crest. It was concluded that the dozer scenario was the most critical condition, which suggested a flatter slope from 1.36H:1V (angle of repose) to a 2H:1V upper and lower slope in the WP1 conceptual design.

The selected cross-section for analysis corresponds to the greatest slope height and inferred maximum thickness of lakebed sediments. The static stability assessment of WP1 was initially checked for drained and undrained conditions at different failure depths from 5 m to 20 m using the block search and non-circular auto refine search method along the north and south side slopes of WP1. Once the critical slip failure surface was identified, a pseudo-static analysis was completed.

Table 6 summarizes the most conservative results of the slope stability analyses for WP1 under long-term, short-term, and pseudo-static conditions (when dozer pushing at edge of WP1). With revised geometry as shown in the drawings (Appendix D), the proposed WP1 configuration design meets the target FOS in all scenarios (long-term, short-term, and pseudo-static conditions).

Table 6: Slope Stability Results for WP1 Stockpile

Condition	Loading Condition	Target FOS	FOS GLE/ Morgenstern-Price Method	FOS Spencer Method	Figure (Appendix C)
South slope – Proposed WP1 conceptual design (2H:1V)	Long-term conditions	1.5	1.64	1.70	C-3
	Short-term conditions	1.3	2.06	2.03	C-4
	Pseudo-static drained conditions	1.1	1.53	1.58	C-3
	Pseudo-static undrained conditions	1.1	1.76	1.74	C-4
South slope – Proposed WP1 conceptual design south extension (2H:1V)	Long-term conditions	1.5	1.64	1.72	C-6
	Short-term conditions	1.3	2.03	2.01	C-7
	Pseudo-static drained conditions	1.1	1.55	1.58	C-6
	Pseudo-static undrained conditions	1.1	1.72	1.72	C-7
North slope – Proposed WP1 conceptual design (2H:1V)	Long-term conditions	1.5	1.66	1.70	C-5
	Pseudo-static drained conditions	1.1	1.60	1.55	C-5

Note: Green values meet criteria, red values do not meet criteria.

FOS = factor of safety; WP1 = Waste Pile 1; GLE= general limit equilibrium.

Setback distances between the north toe of WP1 and the crest of the WRD were assessed as part of the stability analysis of WP1. Stability analyses were performed setback distances of 38.2 m (current condition) and 60 m. The assessment only considered active loading from the dozer pushing waste rock at the crest of WP1 and no active load from heavy equipment working at the north side crest of the WRD. The Spencer and GLE/Morgenstern-Price methods were used in the setback distance assessment of WP1. For interpretation of results, the GLE/Morgenstern-Price method was used since the FOS was generally lower than Spencer method.

The results of the stability analyses for long-term conditions showed that a 38.2 m and 60 m set back distance between the north toe of WP1 and the WRD crest are enough to achieve a minimum FOS close to 1.3 for long-term static condition. However, the minimum FOS was not achieved when assessing the stability of the WRD under long-term (current condition) and pseudo-static undrained conditions and does not meet the FOS for long-term shallow slip surface condition with a 60 m setback of WP1 from the WRD crest edge. As earthquakes lead to pseudo-static conditions, an earthquake monitoring system is being considered by Newcrest which includes an alarm to trigger evacuation of personnel from the dump in the event of an earthquake.

Table 7 summarizes the setback FOS from the critical slip surface under long-term, short-term, and pseudo-static undrained conditions. Long term condition FOS of 1.3 for the WRD setback to WP1 for global stability of the WRD platform, consistent with design basis from SRK (2020) and is considered a reasonable basis along design approach of the observational method (Terzaghi and Peck 1967; Peck 1969). To confirm that the required level of stability is achieved, careful construction and monitoring are required to reduce undrained conditions of the lakebed sediments when excess pore pressure is generated from active loading at the WRD.

Table 7: WP1 Setback from Waste Rock Dump Platform Crest Analysis Results

Condition	Loading Condition	Target FOS	Lowest FOS GLE/ Morgenstern-Price Method	Distance from Crest (m)	Figure (Appendix C)
Setback analysis – current (Aug 2022) north toe of WP1	Long-term conditions	1.3	1.27	15.2	C-8
	Short-term conditions	1.1	1.15	32.3	C-11
	Pseudo-static undrained conditions	1.1	0.98	32.3	C-13
Setback analysis – 60 m setback from conceptual design north toe of WP1	Long-term conditions	1.3	1.26 (shallow slip surface)	15.2	C-9
	Long-term conditions	1.3	1.59 (deeper slip surface)	60.0	C-10
	Short-term conditions	1.1	1.15	32.3	C-12
	Pseudo-static undrained conditions	1.1	0.99	32.3	C-14

Note: Green values meet criteria, red values do not meet criteria.

FOS = factor of safety; WP1 = Waste Pile 1; GLE= general limit equilibrium.

The recommended minimum set back of WP1 is 60 m, which provides operational haulage equipment loading between 40 m and 60 m (meeting minimum distance for short term condition FOS) from the WRD crest.

9.0 WP1 STOCKPILE DEVELOPMENT

9.1 Surface Water Management

A surface water management plan is to be developed for the WP1 stockpile area that ties into the site-wide water management plan. Surface water management is to include surface diversion channels to prevent ponding of water at the crest of WP1. Water should be diverted from WP1 to a downstream water collection system and into the WRTSF. Surface water management and/or sediment control measures should be implemented prior to beginning stockpile foundation preparation and waste placement.

9.2 Stockpile WP1 Dumping Operations

The stockpile is to achieve a 2H:1V slope for the upper and lower bench as shown in Figure 3 by a series of four lifts of angle of repose (assumed to be 1.36H:1V) to elevation 1385 m at the south portion of the stockpile. Figure 3 illustrates cross-sections and typical bench dimensions. Both haul trucks and dozer are not expected to be on WP1 at the same time. The dumping sequence is to consider haul traffic.

Newcrest proposed operation for waste rock placed in WP1 is to be dumped at least 6 m (setback) from the 1377 m elevation crest and push with a dozer to the crest edge. Safety shoulder berms are to be maintained on all dump crests and haul roads of sufficient height to prevent the largest mine equipment from inadvertently driving over the crest. The height of the shoulder berms is to be no less than half the height of the largest haul truck tire. Shoulder berms are not to be used as a wheel stop when backing up to the dump.

The condition of the dump platform is to be monitored visually for any signs of instability. The operator responsible for spreading dumped waste materials and site geotechnical team is to confirm that the surface of the dump and dump platform is maintained in good condition. The dump platform is to be maintained with an uphill grade to the

crest, except for local areas to direct surface run off at a grade, of not less than 2% to facilitate surface water drainage away from the crest edge.

Stockpile stability is influenced by many factors, including dump height, dump materials, dump geometry, climatic conditions, foundation materials, and surface and groundwater conditions. However, the loading rate of the WRD crest edge advancement in the WRTSF also have an influence on global slope stability of the WRD which WP1 is founded on. Refer to the WRD back analysis and slope stability results in the back analysis report (WSP Golder 2022).

Downstream catch berms are to be placed at the toe of the WP1 stockpile, similar to the existing WP1, around the perimeter of WP1.

9.3 Geotechnical Inspections

Continuing routine scheduled inspections and survey monitoring of the WP1 stockpile and WRD, as identified in the most current operation, maintenance, and surveillance manual (Pretium 2021b), is a key component to the early detection of concerns relating to physical stability. The visual inspection program includes observations by operations staff, daily inspections by the geotechnical engineering team, and annual inspections by the Engineer of Record and qualified geotechnical engineer(s). Visual inspection of ramps and haul roads near dump crests or slopes are to be conducted frequently during stockpile development operations. Haul truck operators, dozer operators, and any others who routinely visit the WRD are to be trained in the recognition of hazards and reporting procedures.

Operations staff, equipment operators, surveyors, and other personnel that regularly visit the waste dumps are to be trained to recognize the following potential indications of instability:

- excessive or abnormal cracking
- excessive crest deformation or settlement
- excessive over-steepening of the crest
- abnormal platform tilting
- seepage breakout on the face
- bulging of the face
- toe spreading

Observations of any of these indicators are to be evaluated to determine if there is a developing slope instability issue.

9.4 Geotechnical Instrumentation Monitoring

Monitoring of the physical performance of the WP1 stockpile is recommended to confirm that performance is consistent with design assumptions and operations. The monitoring program is to consider potential failure mechanisms including foundation instability. Consideration is to be given to the installation of vibrating wire piezometers in the foundation materials in the WRD north of WP1, to assess the excess pore water pressure generation during loading (i.e., waste rock unloading and placement). In addition, the installation of slope inclinometers is to be considered to monitor the side slope and foundation deformation. A revised trigger action

response plan is to be established for future piezometers and slope inclinometers. It should be noted that Newcrest is looking into wireless subsurface monitoring systems to monitor porewater pressure.

9.5 Operational Guidelines

The operation of a waste dump or stockpile must be consistent with the design basis and assumptions. Operational guidelines and standard operating procedures are to be reviewed, updated, and included in the next revision of the operation, maintenance, and surveillance manual using the design basis presented in this document and reviewed by the design engineer and Engineer of Record in 2023.

10.0 CONCLUSION

We have assessed WP1, as presented in the drawings and stability of WP1, and it is expected to meet the FOS criteria with the following key recommendations and considerations:

- Complete an additional investigation of the lakebed sediments and material properties of the subsurface conditions of the WP1 stockpile.
- The minimum set back of WP1 is 60 m.
- Operational haulage equipment loading to be between 40 m and 60 m from the WRD platform crest.
- Monitoring of the physical performance of the WP1 stockpile to confirm that performance is consistent with design assumptions and operations.
    - Consideration is to be given to the installation of vibrating wire piezometers in the foundation materials in the WRD north of WP1 to assess the excess porewater pressure generation during loading.
    - Installation of slope inclinometers is to be considered to monitor the side slope and foundation deformation.
    - A revised trigger action response plan is to be established for the piezometers and slope inclinometers.
- Operational guidelines and standard operating procedures are to be reviewed, updated, and included in the next revision of the operation, maintenance, and surveillance manual.
- A surface water management plan is to be developed for the WP1 stockpile area that ties into the site-wide water management plan.

11.0 CLOSURE

The reader is referred to the Study Limitations, which precedes the text and forms an integral part of this report.

We trust the above meets your present requirements. If you have any questions or additional requirements, please contact the undersigned.

Signature Page

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https://golderassociates.sharepoint.com/sites/157185/project files/6 deliverables/3.0_issued/21507844-029-r-rev0-6000/21507844-029-r-rev0-6000-brucejack wp1 geotech assess report 16dec_22.docx

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.

APPENDIX A

Seismic Hazard Calculation

Government of Canada Gouvernement du Canada

Canada.ca > Natural Resources Canada > Earthquakes Canada

2020 National Building Code of Canada Seismic Hazard Tool

This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_S	X_C
Latitude (°)	56.47
Longitude (°)	-130.174

Please select one of the tabs below.

NBC 2020 | Additional Values | Plots | API | Background Information

The 5%-damped spectral acceleration ($S_a(T,X)$, where T is the period, in s, and X is the site designation) and peak ground acceleration (PGA(X)) values are given in units of acceleration due to gravity (g, 9.81 m/s^2). Peak ground velocity (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.199	0.207	0.162	0.114	0.0547	0.0356	0.0892	0.2

The log-log interpolated 2%/50 year $S_a(4.0, X_C)$ value is : **0.0654**

▼ Tables for 5% and 10% in 50 year values

NBC 2020 - 5%/50 years (0.001 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.109	0.138	0.113	0.0794	0.0374	0.0229	0.0513	0.14

The log-log interpolated 5%/50 year $S_a(4.0, X_C)$ value is : **0.0449**

NBC 2020 - 10%/50 years (0.0021 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.0702	0.101	0.0846	0.0589	0.0268	0.0154	0.0344	0.103

The log-log interpolated 10%/50 year $S_a(4.0, X_C)$ value is : **0.0325**

Download CSV

🡐 Go back to the seismic hazard calculator form

Date modified: 2021-04-06

APPENDIX B

Stockpile Hazard Classification

Appendix B
Slope Stability Analysis Results

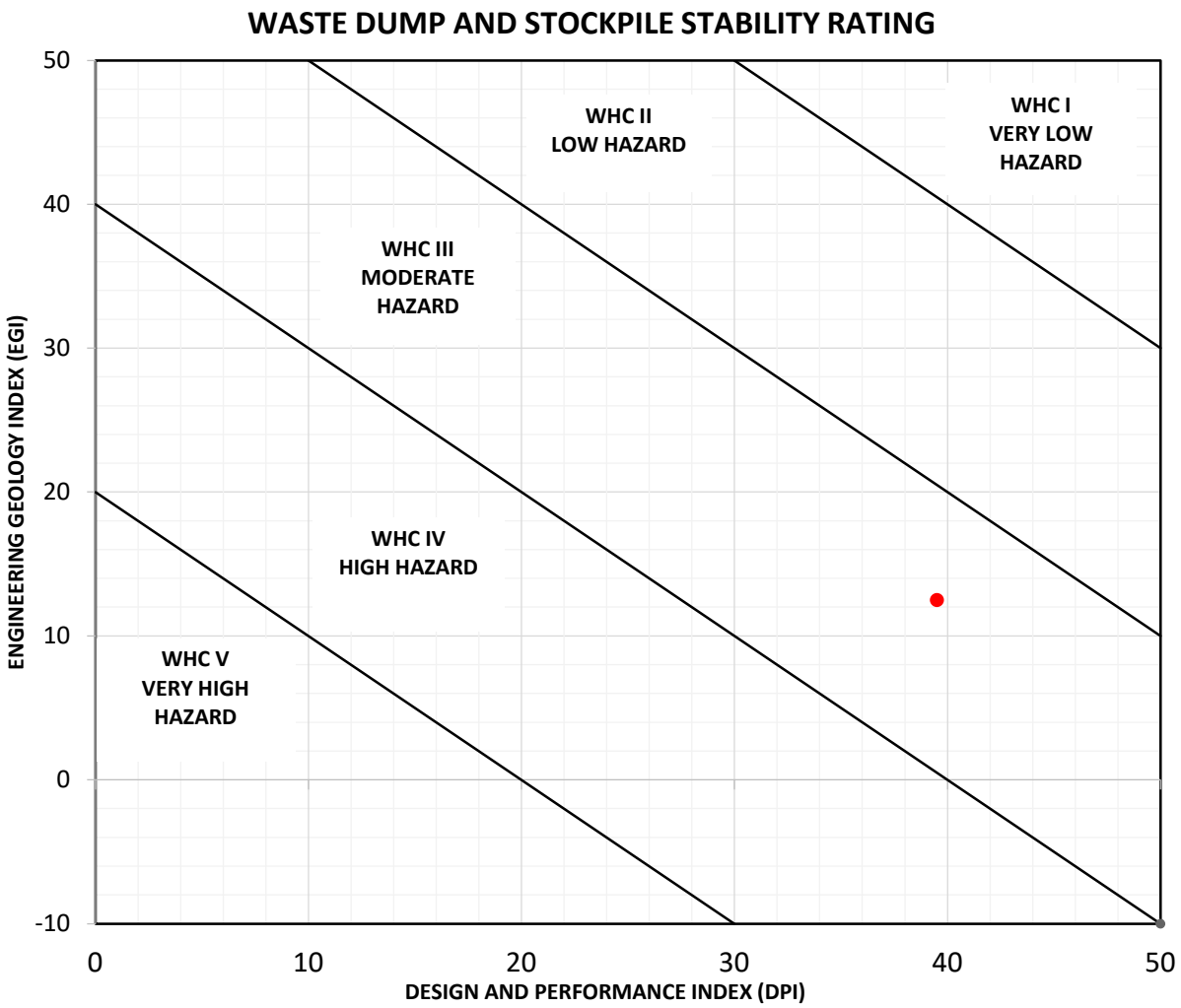
Waste Pile 1 (WP1)

Engineering Geology Index (EGI)

Group	Factor	Value	Index	Rating
Regional Setting	Seismicity	PGA= 0.03g (10% in 50 years) based on (NBC, 2020)	very Low	2
	Precipitation	Total annual precipitation ranged from 1,129 to 1,968 mm recorded from the Brucejack Lake climate station (SRK,2015)	High	2
Foundation Conditions	Foundation Slope	Based on CAD cross section	flat	5
	Foundation Shape	Convex on Gentle slopes; Planar or concave on moderate slopes	flat	2
	Overburden Type	Assumed Lacustrine deposits as WRD foundation located in lake	Type 2	1
	Overburden Thickness	Assumed thick unit of lakebed sediments	>5 m	0
	Undrained Failure Potential	Saturated Condition of Lakebed sediments with high potential of excess pore pressure	Moderate	-5
	Foundation Liquefaction Potential	Unknown Liquefaction Potential	Moderate	-5
	Bedrock	P-wave velocity from 4080 m/s to 4790 m/s which suggests Fair rock mass based on Q classification system	Type D	3
	Groundwater	Water Table at surface	High	0
Material Quality	Gradation	Assumed gradation - 10 to 25% fines and 25 to 50% greater than 75 mm	Mixed gradation	3.5
	Intact Strength and Durability	Medium strong rocks. Limited information are available and the rock quality cannnot be justified based on the available information	Type 3	4
	Material Liquefaction Potential	WP1 material is Waste rock	Negligible	0
	Chemical Stability	Neutralization Potential Ratio (NPR) ranging from 1 to 2.6 - (BGC, 2013)	Moderate reactive	0
			Total	12.5

Design and Performance Index (DPI)

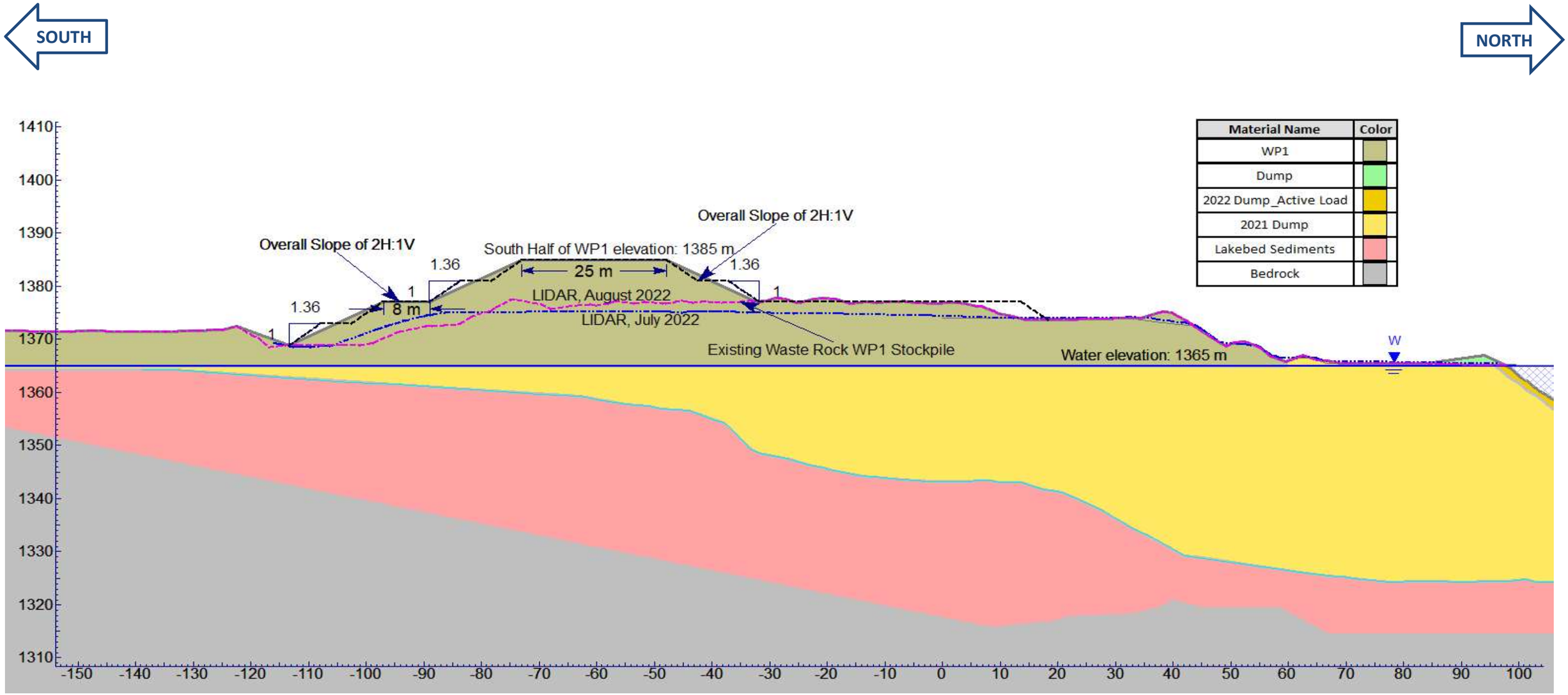
Group	Factor	Value	Index	Rating
Geometry & Mass	Height	WP1 height is 20 m	Very Low	4
	Slope Angle	Overall Slope is 22 degrees	Flat	3
	Volume and Mass	Volume <1 x 10^6	Very Small	2
Stability Analysis	Static Stability	FOS of 1.64 for drained conditions at south slope of WP1. There is low level of confidence in the input parameters.	> 1.5	7
	Dynamic Stability	FOS of 1.53 for pseudo-static condition at south slope of WP1	> 1.15	3
Construction	Construction Method	Lift Heights < 50 m	Method 5	8
	Loading Rate (m3/d/m)	based on Daily reports current November rate on average is 893 m3/day	Low	5
Performance	Stability Performance	Tension cracks along crest of WP1	Good	7.5
			Total	39.5



CLIENT			PROJECT			
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**			
CONSULTANT	YYYY-MM-DD	2022-12-15	TITLE			
WSP GOLDER	PREPARED	HOB	**Waste Dump and Stockpile Stability Rating**			
	REVIEWED	NNA	PROJECT NUMBER	PHASE	REV	FIGURE
	APPROVED	JEK	**21507844**	**6000**	**0**	**B-1**

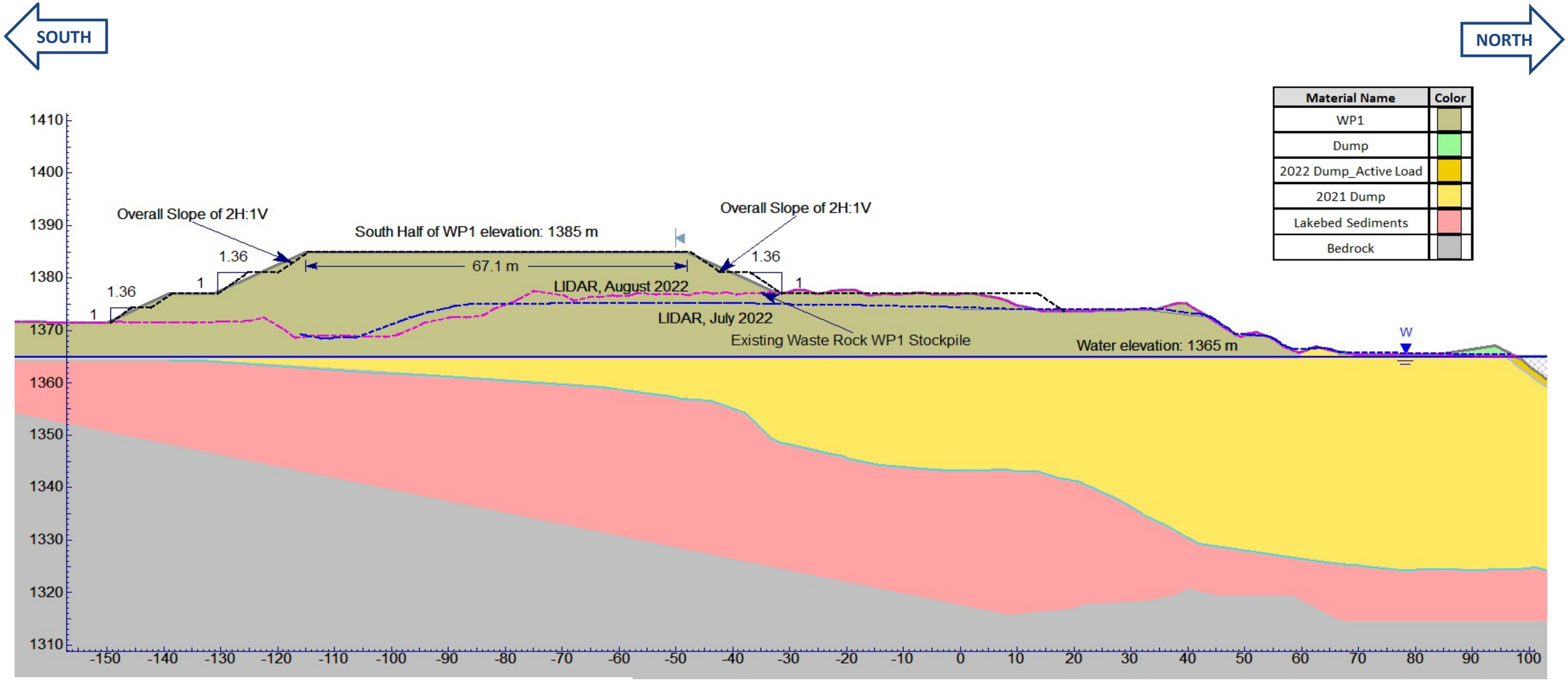
APPENDIX C

Slope Stability Analysis Results



Note:
- Magenta line represents LIDAR , August 2022 (existing ground surface based on August 2022 LIDAR)
- Blue line represents LIDAR , July 2022 (existing ground surface based on July 2022 LIDAR)
- Black line represents proposed conceptual design configuration
- Water elevation provided by Newcrest

CLIENT			PROJECT			
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**			
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE			
	PREPARED	HOB	**Waste Pile 1 - Proposed Conceptual Design Configuration (2.0H:1.0V)**			
WSP GOLDER	REVIEWED	NNA	PROJECT NUMBER	PHASE	REV	FIGURE
	APPROVED	JEK	**21507844**	**6000**	**0**	**C-1**



Note:
- Magenta line represents LIDAR , August 2022
- Blue line represents LIDAR , July 2022
- Black line represents proposed conceptual design south extension configuration
- Water elevation provided by Newcrest

CLIENT			PROJECT
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE
WSP GOLDER	PREPARED	HOB	**Waste Pile 1 - Proposed Conceptual Design South Extension Configuration (2.0H:1.0V)**
	REVIEWED	NNA	PROJECT NUMBER / PHASE / REV / FIGURE
	APPROVED	JEK	**21507844** / **6000** / **0** / **C-2**

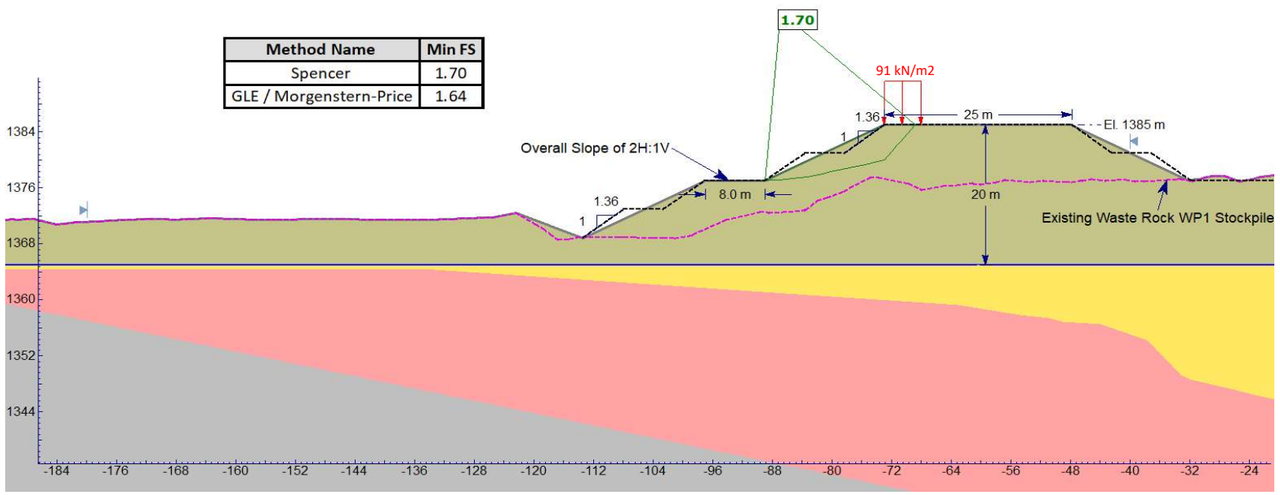
SOUTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

NORTH

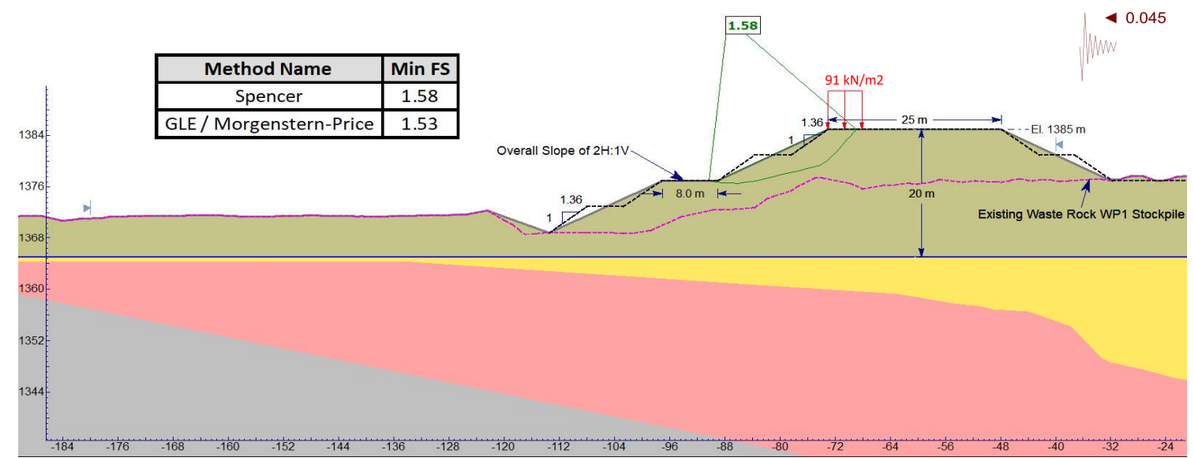
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

Method Name	Min FS
Spencer	1.70
GLE / Morgenstern-Price	1.64



Long Term Conditions - Proposed WP1 Conceptual Design

Method Name	Min FS
Spencer	1.58
GLE / Morgenstern-Price	1.53



Pseudo-static - Proposed WP1 Conceptual Design

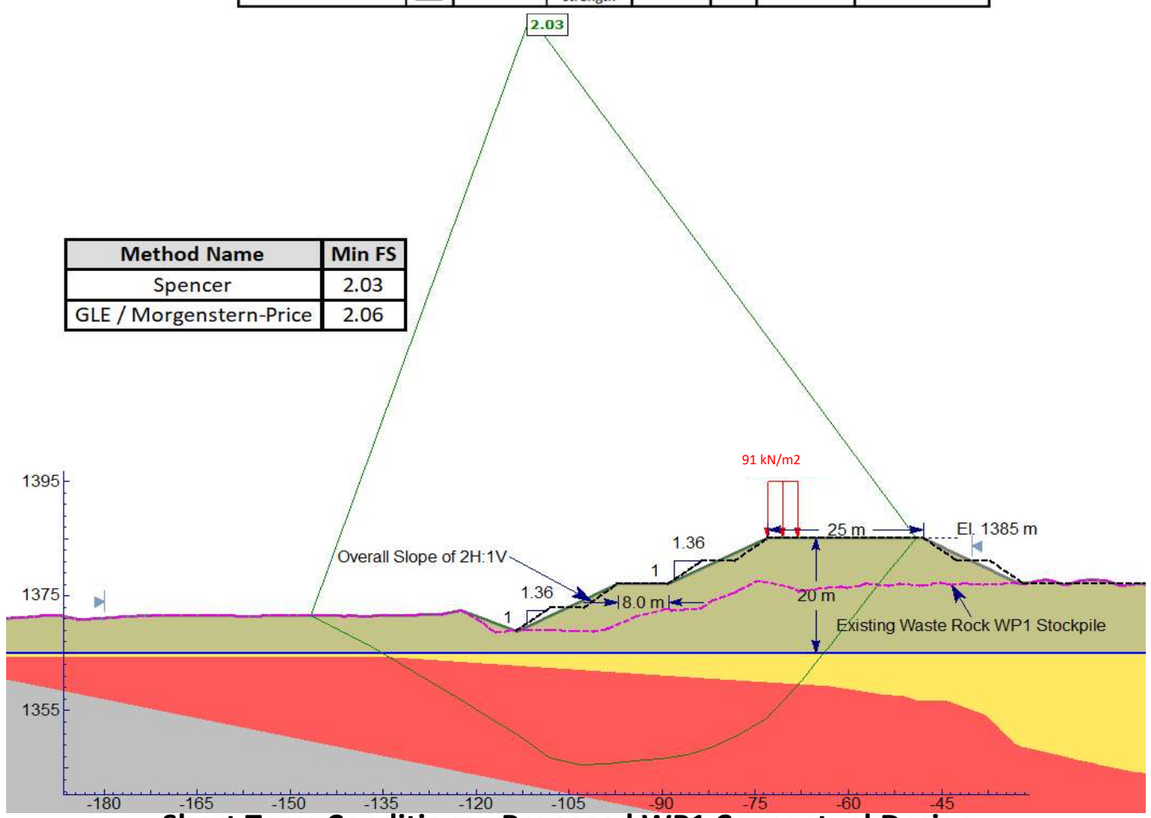
Note:
- Slip surfaces restricted to south slope of WP1
- Target Long Term FOS: 1.5
- Target Pseudo-static FOS: 1.1
- Estimated PGA for 1:2475 year return period on Site Class C is 0.089 according to National Building Code of Canada (NBC) - 2020
- Dozer D8T load: 91 kN/m^2

CLIENT		PROJECT	
Newcrest Mining Ltd.		**Waste Pile 1 - Slope Stability Analysis**	
CONSULTANT	YYYY-MM-DD 2022-12-16	TITLE	
WSP GOLDER	PREPARED HOB	**South Slope - Long Term and Pseudostatic Drained Conditions with Dozer D8T load**	
	REVIEWED NNA	PROJECT NUMBER / PHASE / REV	FIGURE
	APPROVED JEK	**21507844 / 6000 / 0**	**C-3**

SOUTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38		
Dump		22	Mohr-Coulomb	0	38		
2022 Dump_Active Load		22	Mohr-Coulomb	0	38		
2021 Dump		22	Mohr-Coulomb	0	38		
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio			0.32	10
Bedrock		24	Infinite strength				

Method Name	Min FS
Spencer	2.03
GLE / Morgenstern-Price	2.06

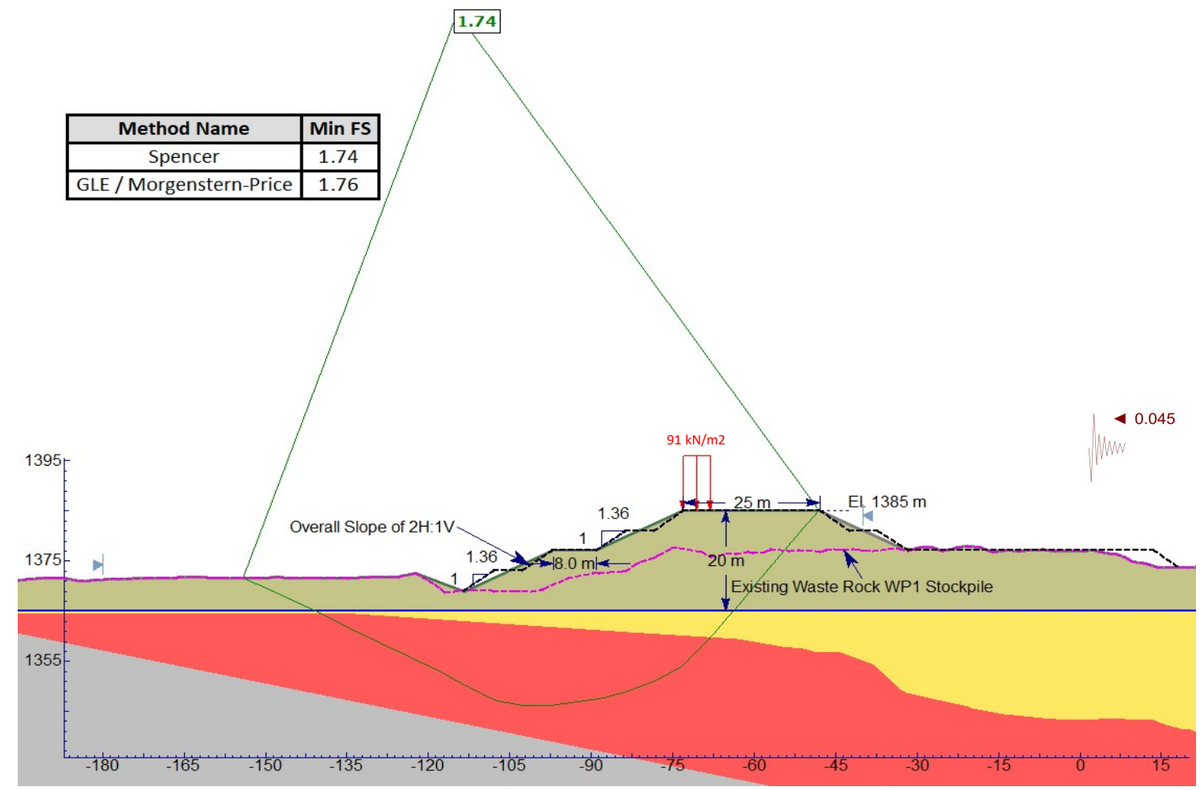


Short Term Conditions - Proposed WP1 Conceptual Design

NORTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38		
Dump		22	Mohr-Coulomb	0	38		
2022 Dump_Active Load		22	Mohr-Coulomb	0	38		
2021 Dump		22	Mohr-Coulomb	0	38		
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio			0.32	10
Bedrock		24	Infinite strength				

Method Name	Min FS
Spencer	1.74
GLE / Morgenstern-Price	1.76



Pseudo-static Conditions - Proposed WP1 Conceptual Design

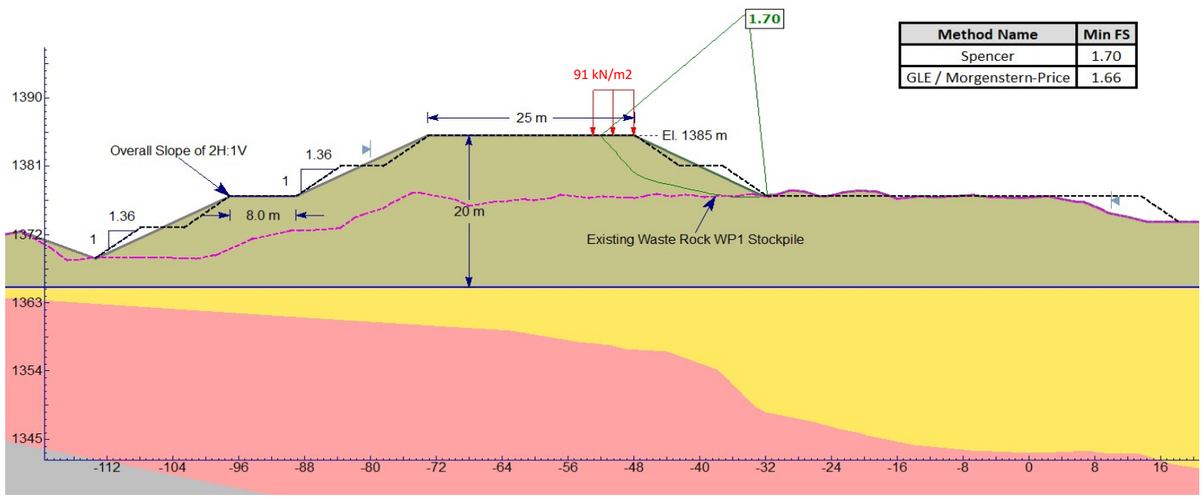
Note:

- Slip surfaces restricted to south slope of WP1
- Target Short Term FOS: 1.3
- Target Pseudo-static FOS: 1.1
- Estimated PGA for 1:2475 year return period on Site Class C is 0.089 according to National Building Code of Canada (NBC) - 2020
- Dozer D8T load: 91 kN/m^2

CLIENT		PROJECT	
Newcrest Mining Ltd.		**Waste Pile 1 - Slope Stability Analysis**	
CONSULTANT	YYYY-MM-DD 2022-12-16	TITLE	
WSP GOLDER	PREPARED HOB	**South Slope - Short Term and Pseudo-static Undrained Conditions with Dozer D8T load**	
	REVIEWED NNA	PROJECT NUMBER	PHASE / REV / FIGURE
	APPROVED JEK	**21507844**	**6000** / **0** / **C-4**

SOUTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

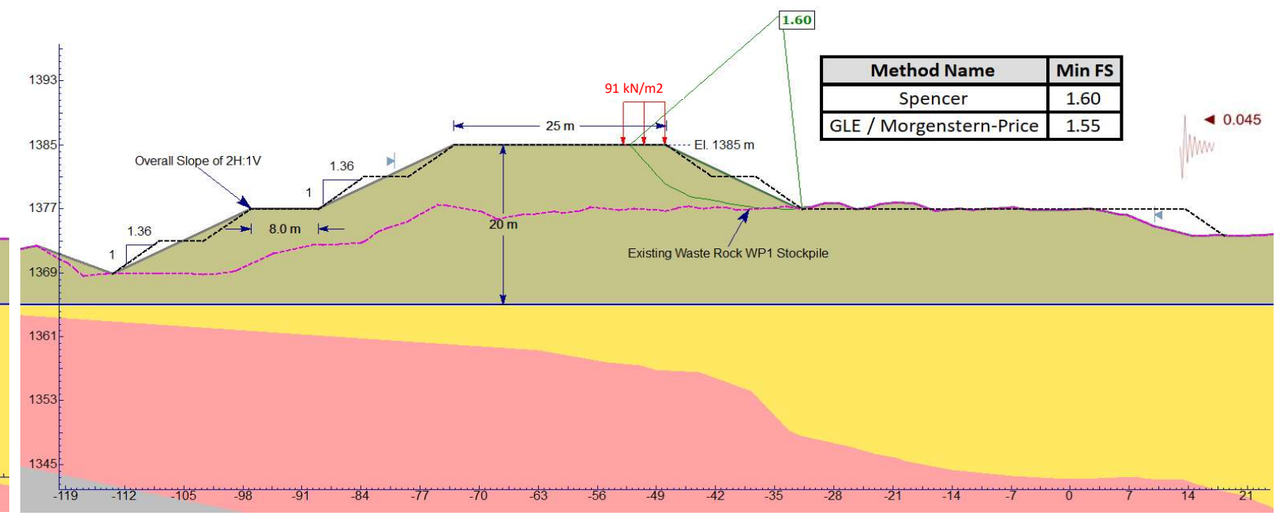


Method Name	Min FS
Spencer	1.70
GLE / Morgenstern-Price	1.66

Long Term Conditions - Proposed WP1 Conceptual Design

NORTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		



Method Name	Min FS
Spencer	1.60
GLE / Morgenstern-Price	1.55

Pseudo-static Conditions - Proposed WP1 Conceptual Design

Note:
- Slip surfaces restricted to north slope of WP1
- Target Long Term FOS: 1.5
- Target Pseudo-static FOS: 1.1
- Estimated PGA for 1:2475 year return period on Site Class C is 0.089 according to National Building Code of Canada (NBC) - 2020
- Dozer D8T load: 91 kN/m^2

CLIENT		PROJECT	
Newcrest Mining Ltd.		**Waste Pile 1 - Slope Stability Analysis**	
CONSULTANT	YYYY-MM-DD 2022-12-16	TITLE	
WSP GOLDER	PREPARED HOB	**North Slope - Long Term and Pseudo-static Drained Conditions with Dozer D8T load**	
	REVIEWED NNA	PROJECT NUMBER / PHASE / REV	FIGURE
	APPROVED JEK	**21507844 / 6000 / 0**	**C-5**

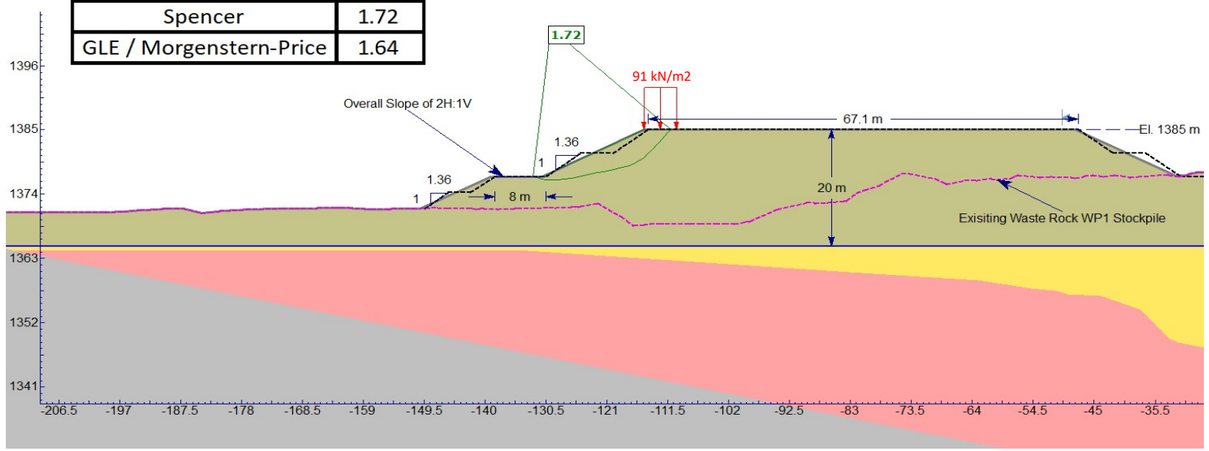
SOUTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

NORTH

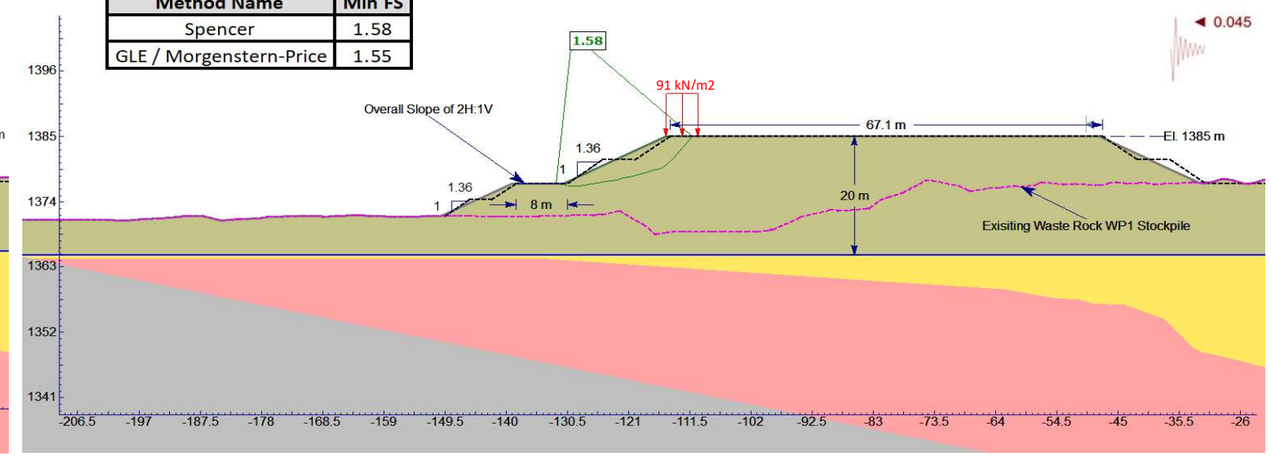
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

Method Name	Min FS
Spencer	1.72
GLE / Morgenstern-Price	1.64



Long Term Conditions - Proposed WP1 Conceptual Design South Extension

Method Name	Min FS
Spencer	1.58
GLE / Morgenstern-Price	1.55



Pseudo-static Conditions - Proposed WP1 Conceptual Design South Extension

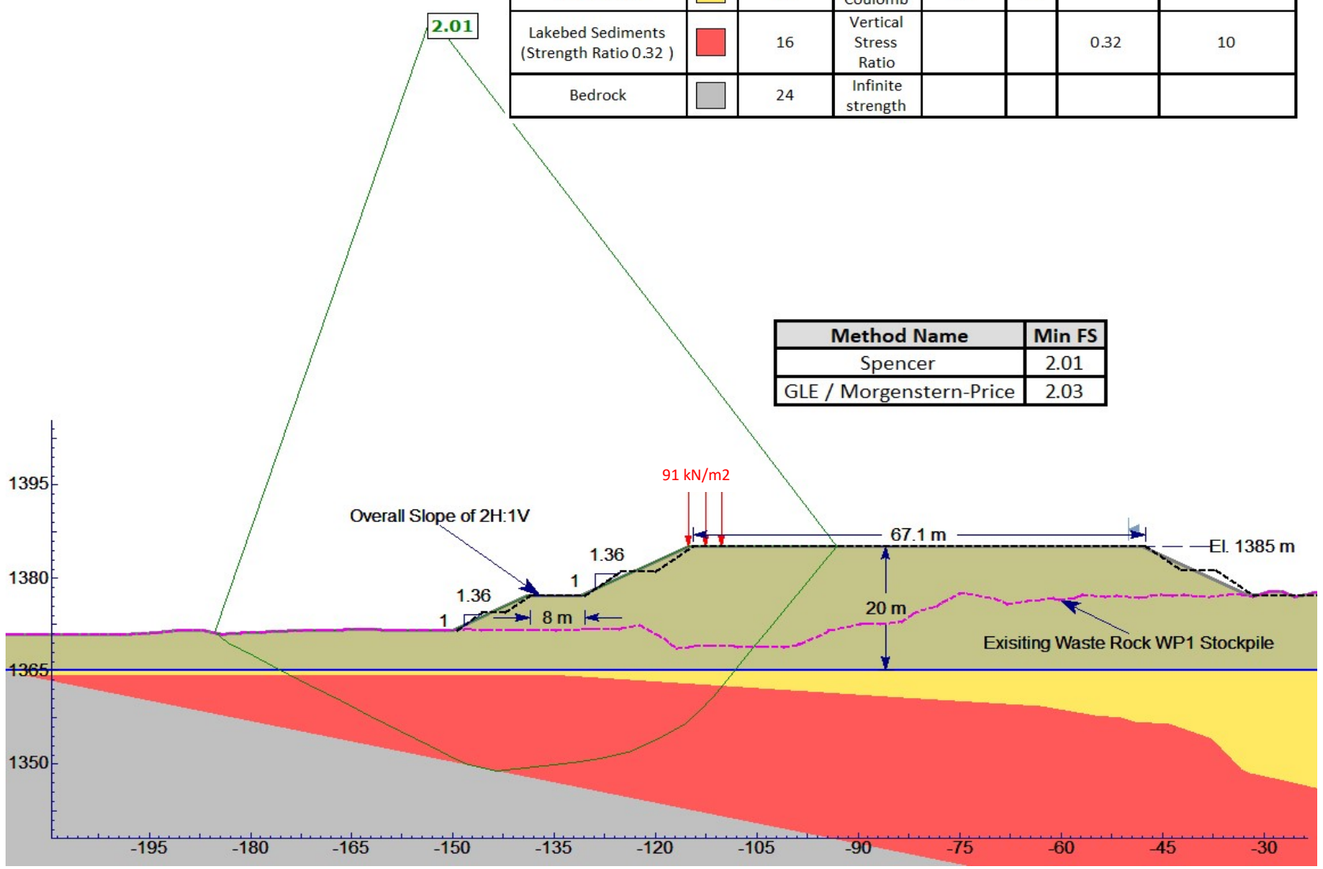
Note:
- Slip surfaces restricted to south slope of WP1
- Target Long Term FOS: 1.5
- Target Pseudo-static FOS: 1.1
- Estimated PGA for 1:2475 year return period on Site Class C is 0.089 according to National Building Code of Canada (NBC) - 2020
- Dozer D8T load: 91 kN/m^2

CLIENT			PROJECT
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE
WSP GOLDER	PREPARED	HOB	**South Slope - Long Term and Pseudo-static Drained Conditions with Dozer D8T load**
	REVIEWED	NNA	PROJECT NUMBER / PHASE / REV / FIGURE
	APPROVED	JEK	**21507844** / **6000** / **0** / **C-6**

SOUTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38		
Dump		22	Mohr-Coulomb	0	38		
2022 Dump_Active Load		22	Mohr-Coulomb	0	38		
2021 Dump		22	Mohr-Coulomb	0	38		
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio			0.32	10
Bedrock		24	Infinite strength				

Method Name	Min FS
Spencer	2.01
GLE / Morgenstern-Price	2.03

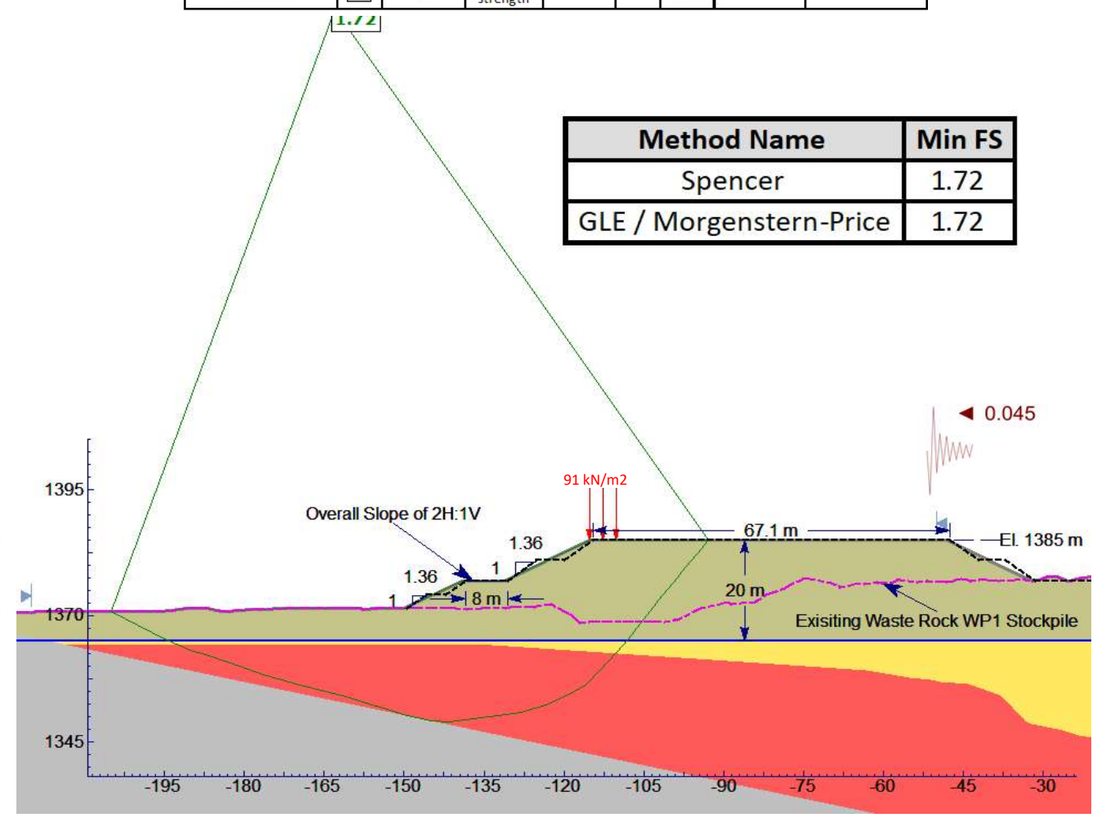


Short Term Conditions - Proposed WP1 Conceptual Design South Extension

NORTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38			
Dump		22	Mohr-Coulomb	0	38			
2022 Dump_Active Load		22	Mohr-Coulomb	0	38			
2021 Dump		22	Mohr-Coulomb	0	38			
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio				0.32	10
Bedrock		24	Infinite strength			Yes		

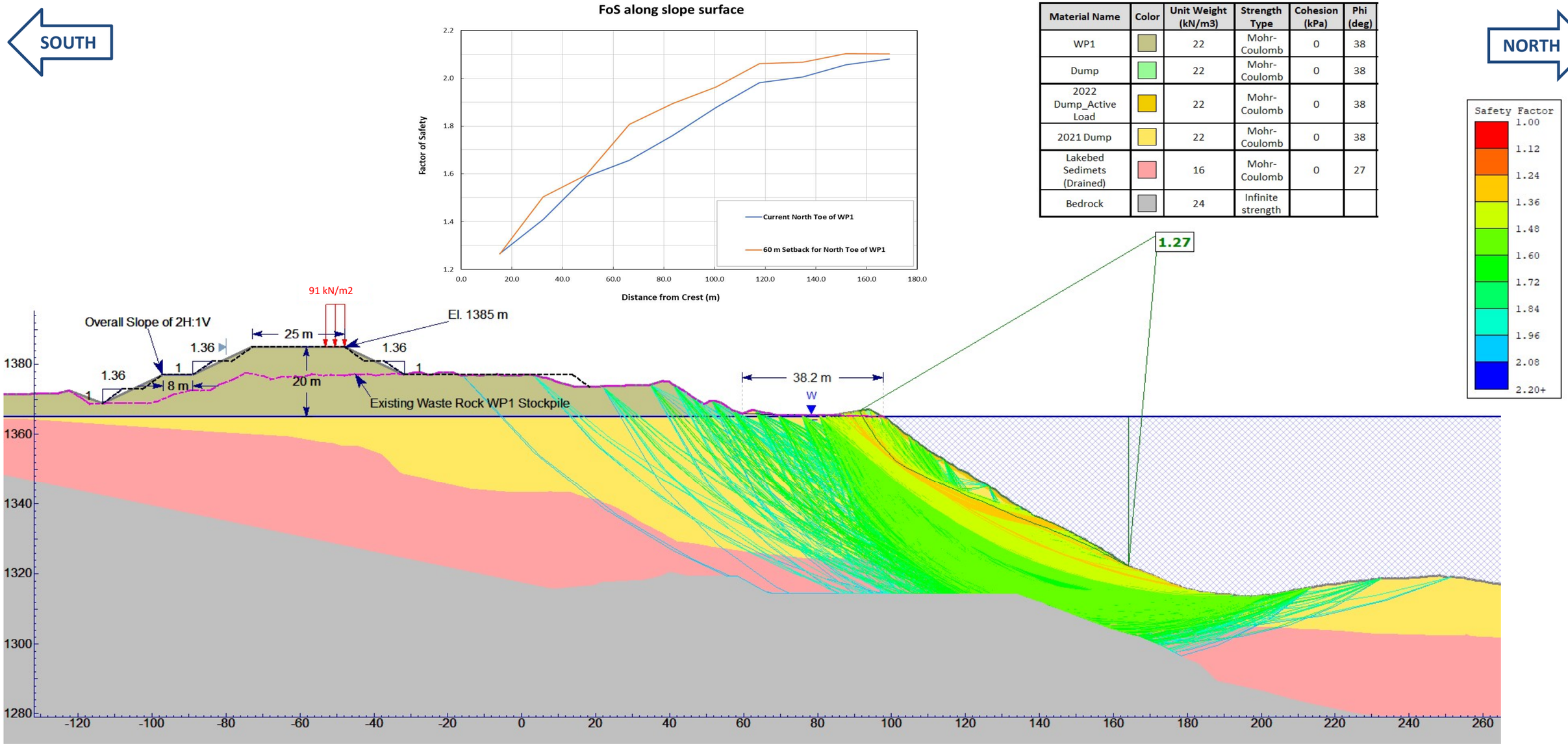
Method Name	Min FS
Spencer	1.72
GLE / Morgenstern-Price	1.72



Pseudo-static - Proposed WP1 Conceptual Design South Extension

Note:
- Slip surfaces restricted to south slope of WP1
- Target Short Term FOS: 1.3
- Target Pseudo-static FOS: 1.1
- Estimated PGA for 1:2475 year return period on Site Class C is 0.089 according to National Building Code of Canada (NBC) - 2020
- Dozer D8T load: 91 kN/m^2

CLIENT		PROJECT	
Newcrest Mining Ltd.		**Waste Pile 1 - Slope Stability Analysis**	
CONSULTANT	YYYY-MM-DD 2022-12-16	TITLE	
WSP GOLDER	PREPARED HOB	**South Slope - Short Term and Pseudo-static Undrained Conditions with Dozer D8T load**	
	REVIEWED NNA	PROJECT NUMBER / PHASE / REV	FIGURE
	APPROVED JEK	**21507844 / 6000 / 0**	**C-7**

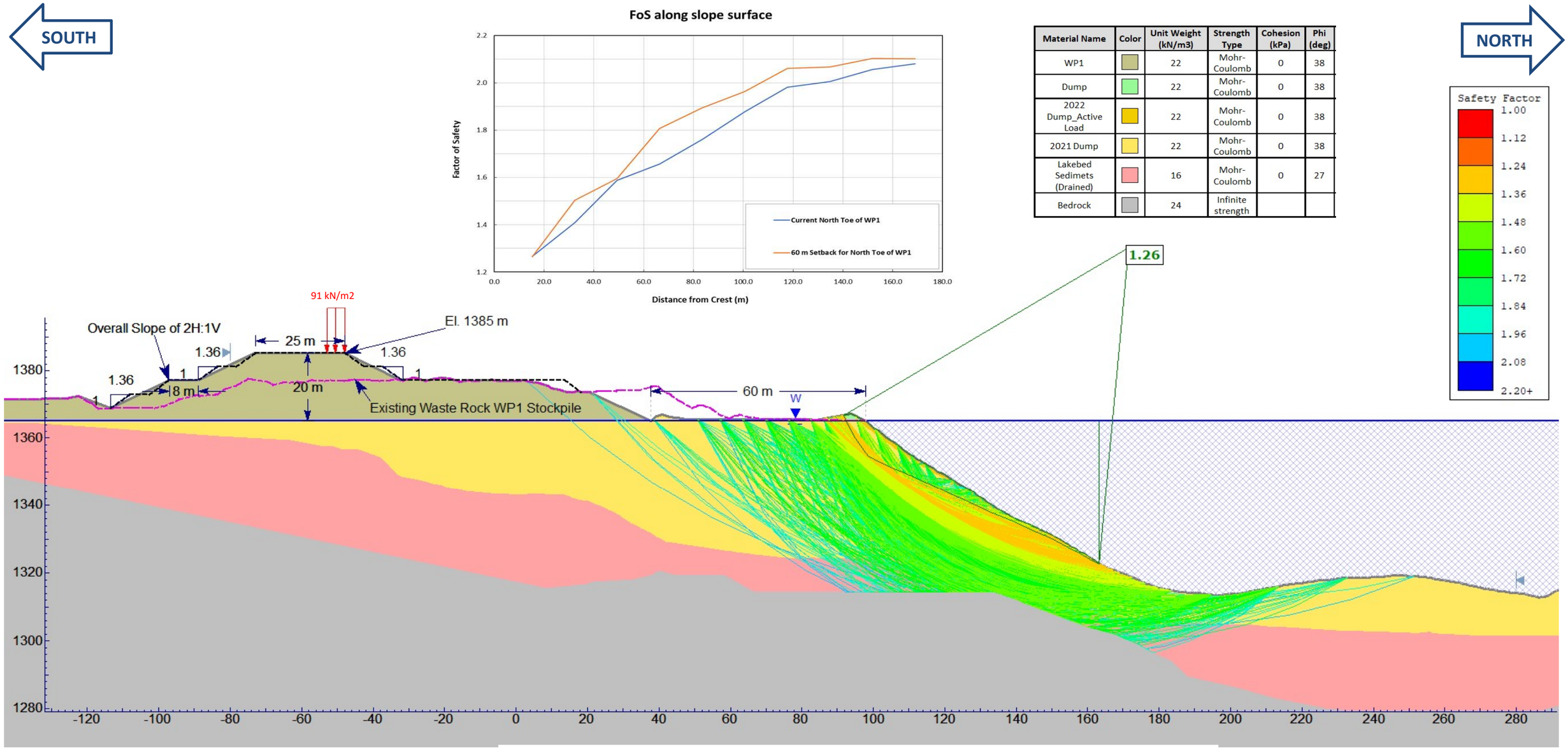


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

Long Term Conditions - GLE Morgenstern-Price Method

Note:
- FOS graph based on GLE Morgenstern-Price method
- Plot of FoS along slope surface shows variation of FoS for different slip surfaces passing at different distances from crest edge. Two presented curves were obtained from analysis shown in Figures C-8 and C-9

CLIENT			PROJECT
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE
wsp GOLDER	PREPARED	HOB	**Setback Analysis - Proposed WP1 Conceptual Design - Current North Toe of WP1**
	REVIEWED	NNA	PROJECT NUMBER / PHASE / REV / FIGURE
	APPROVED	JEK	**21507844** / **6000** / **0** / **C-8**



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		

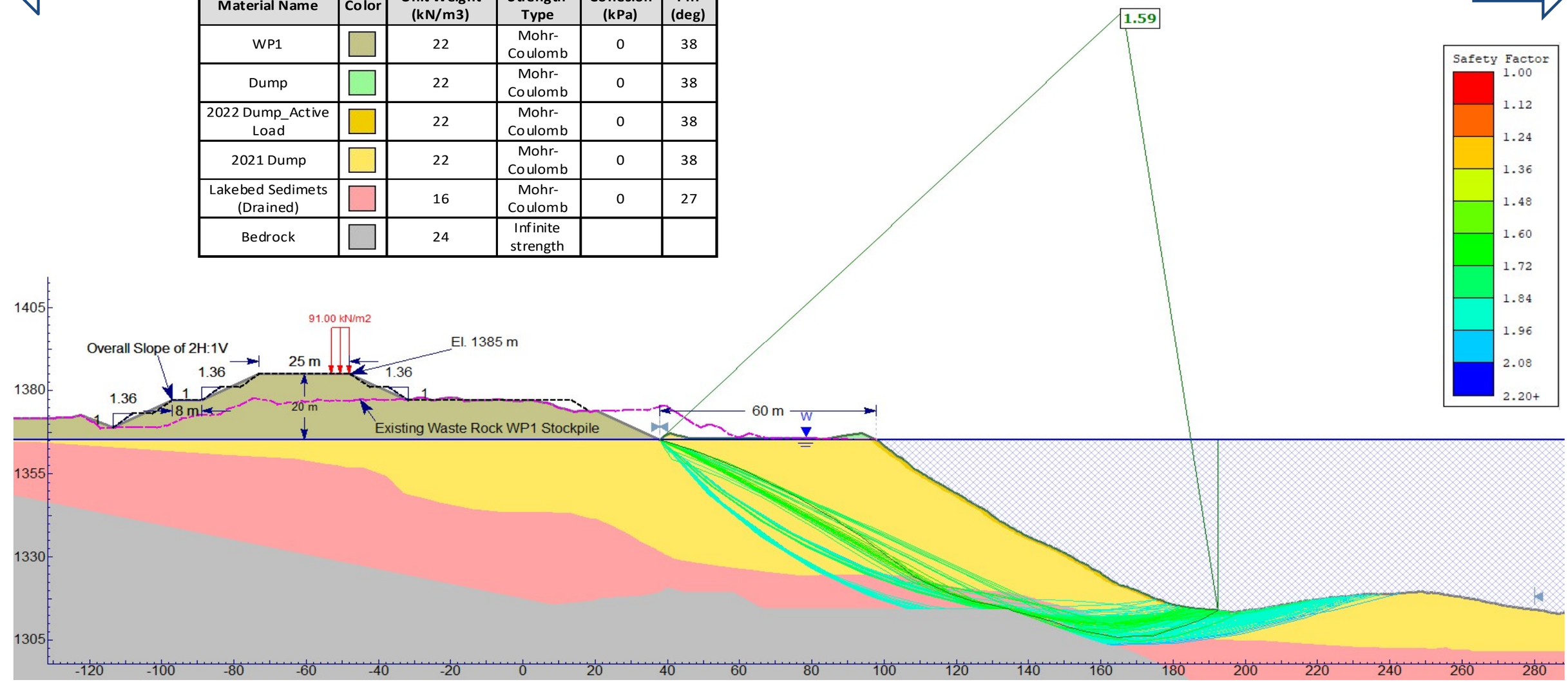
Long Term Conditions - GLE Morgenstern-Price Method

Note:

- FOS graph based on GLE Morgenstern-Price metho
- Plot of FoS along slope surface shows variation of FoS for different slip surfaces passing at different distances from crest edge. Two presented curves were obtained from analysis shown in Figures C-8 and C-9

CLIENT			PROJECT			
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**			
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE			
WSP GOLDER	PREPARED	HOB	**Setback Analysis - Proposed WP1 Conceptual Design - 60 m Setback for North Toe of WP1**			
	REVIEWED	NNA	PROJECT NUMBER	PHASE	REV	FIGURE
	APPROVED	JEK	**21507844**	**6000**	**0**	**C-9**

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
WP1		22	Mohr-Coulomb	0	38
Dump		22	Mohr-Coulomb	0	38
2022 Dump_Active Load		22	Mohr-Coulomb	0	38
2021 Dump		22	Mohr-Coulomb	0	38
Lakebed Sedimets (Drained)		16	Mohr-Coulomb	0	27
Bedrock		24	Infinite strength		



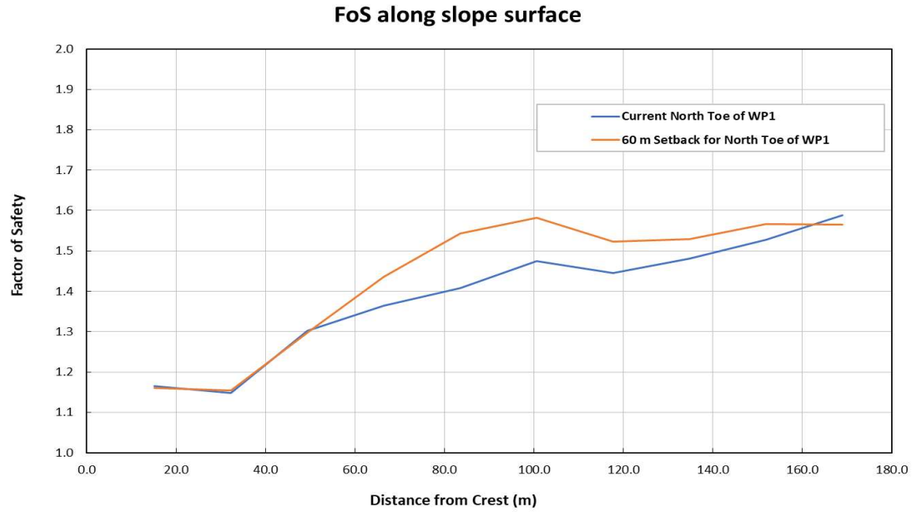
Long Term Conditions - GLE Morgenstern-Price Method

Note:
- FOS graph based on GLE Morgenstern-Price method

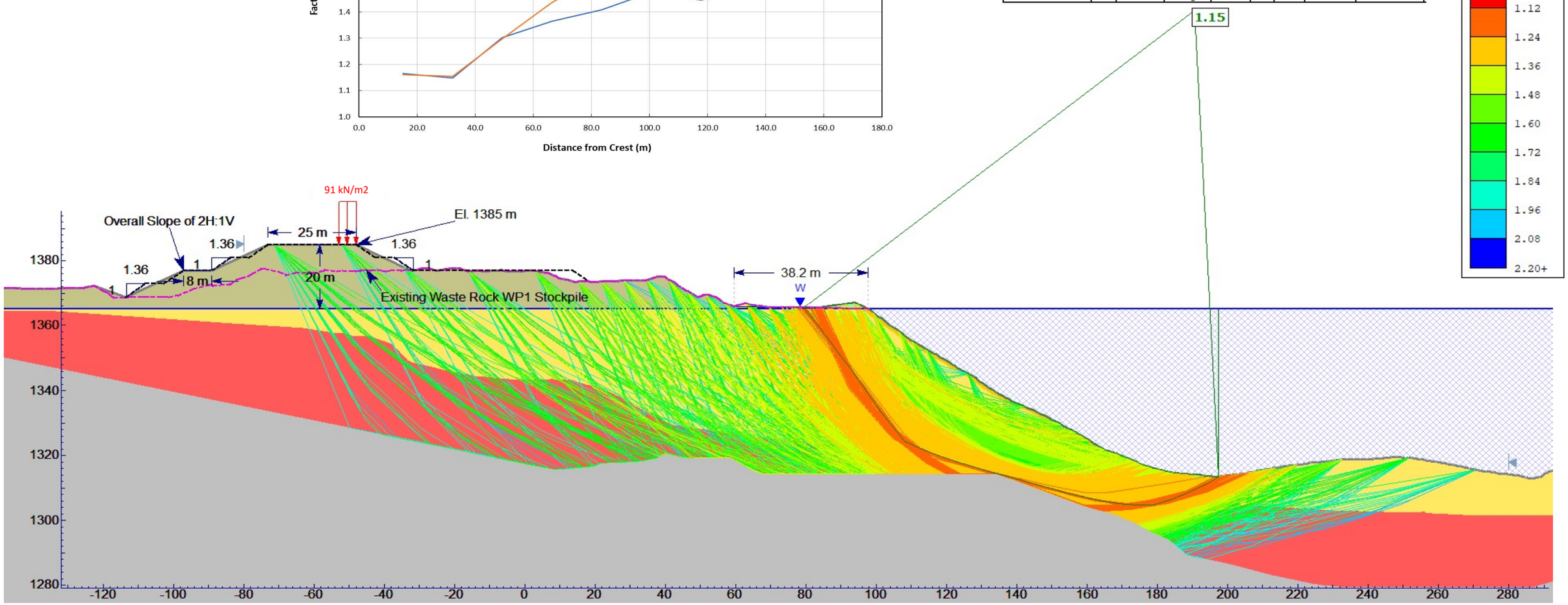
CLIENT			PROJECT			
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**			
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE			
WSP GOLDER	PREPARED	HOB	**Setback Analysis - Proposed WP1 Conceptual Design - 60 m Setback for North Toe of WP1**			
	REVIEWED	NNA	PROJECT NUMBER	PHASE	REV	FIGURE
	APPROVED	JEK	**21507844**	**6000**	**0**	**C-10**

SOUTH

NORTH



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38			
Dump		22	Mohr-Coulomb	0	38			
2022 Dump_Active Load		22	Mohr-Coulomb	0	38			
2021 Dump		22	Mohr-Coulomb	0	38			
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio				0.32	10
Bedrock		24	Infinite strength			Yes		



Short Term Conditions - GLE Morgenstern-Price Method

Note:

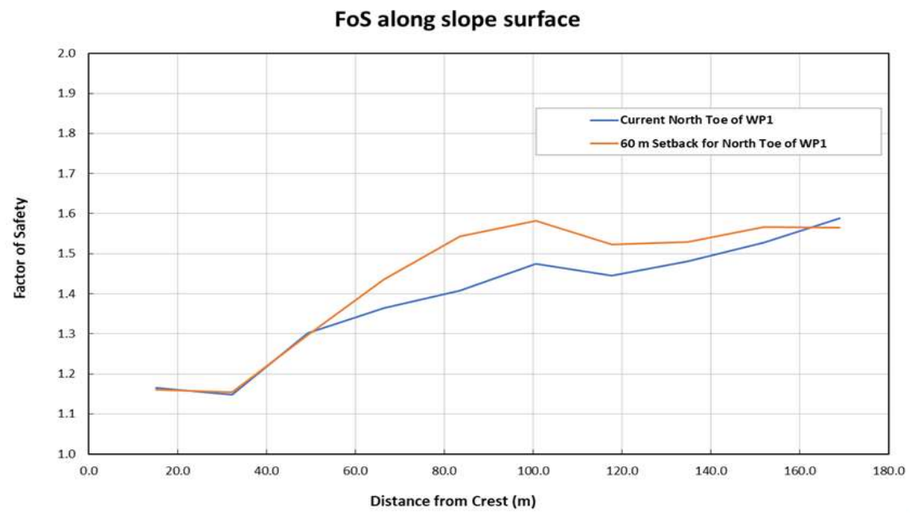
- FOS graph based on GLE Morgenstern-Price method
- Plot of FoS along slope surface shows variation of FoS for different slip surfaces passing at different distances from crest edge. Two presented curves were obtained from analysis shown in Figures C-11 and C-12.

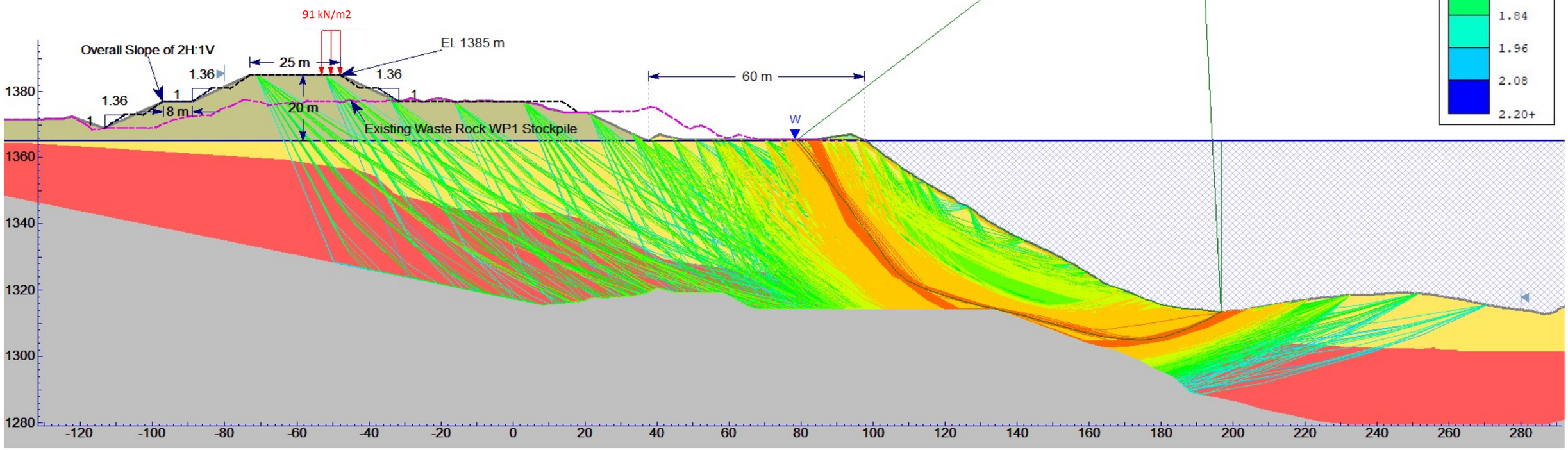
CLIENT			PROJECT
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE
WSP GOLDER	PREPARED	HOB	**Set Back Analysis - Proposed WP1 Conceptual Design - Current North Toe of WP1**
	REVIEWED	NNA	PROJECT NUMBER / PHASE / REV / FIGURE
	APPROVED	JEK	**21507844** / **6000** / **0** / **C-11**

SOUTH

NORTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38			
Dump		22	Mohr-Coulomb	0	38			
2022 Dump_Active Load		22	Mohr-Coulomb	0	38			
2021 Dump		22	Mohr-Coulomb	0	38			
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio				0.32	10
Bedrock		24	Infinite strength			Yes		





Note:
- FOS graph based on GLE Morgenstern-Price method
- Plot of FoS along slope surface shows variation of FoS for different slip surfaces passing at different distances from crest edge. Two presented curves were obtained from analysis shown in Figures C-11 and C-12.

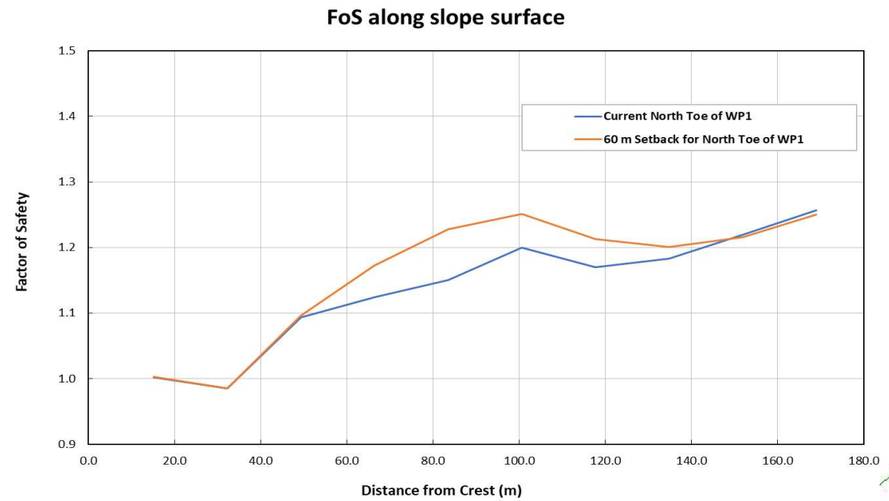
Short Term Conditions - GLE Morgenstern-Price Method

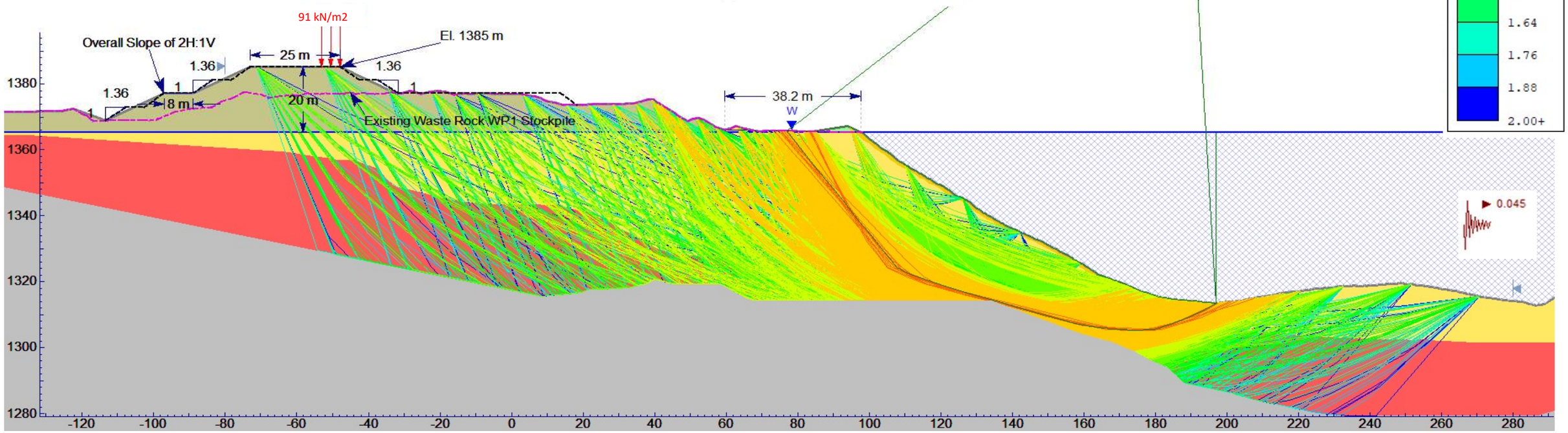
CLIENT		PROJECT	
Newcrest Mining Ltd.		**Waste Pile 1 - Slope Stability Analysis**	
CONSULTANT	YYYY-MM-DD 2022-12-16	TITLE	
WSP GOLDER	PREPARED HOB	**Setback Analysis - Proposed WP1 Conceptual Design - 60 m Setback for North Toe of WP1**	
	REVIEWED NNA	PROJECT NUMBER / PHASE / REV / FIGURE	
	APPROVED JEK	**21507844** / **6000** / **0** / **C-12**	

SOUTH

NORTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38			
Dump		22	Mohr-Coulomb	0	38			
2022 Dump_Active Load		22	Mohr-Coulomb	0	38			
2021 Dump		22	Mohr-Coulomb	0	38			
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio				0.32	10
Bedrock		24	Infinite strength			Yes		





Pseudo-static Undrained Conditions - GLE Morgenstern-Price Method

Note:

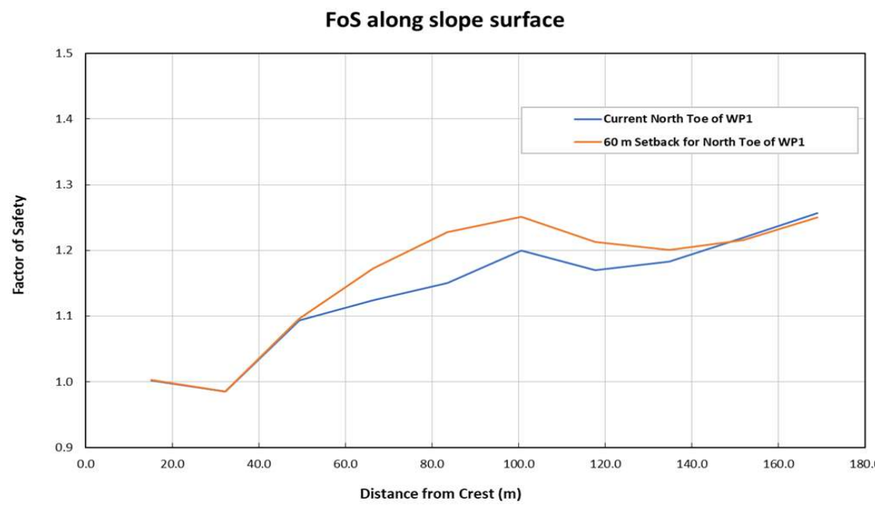
- FOS graph based on GLE Morgenstern-Price method
- Estimated PGA for 1:2475 year return period on Site Class C: 0.089 according to National Building Code of Canada (NBC) - 2020
- Plot of FoS along slope surface shows variation of FoS for different slip surfaces passing at different distances from crest edge. Two presented curves were obtained from analysis shown in Figures C-13 and C-14.

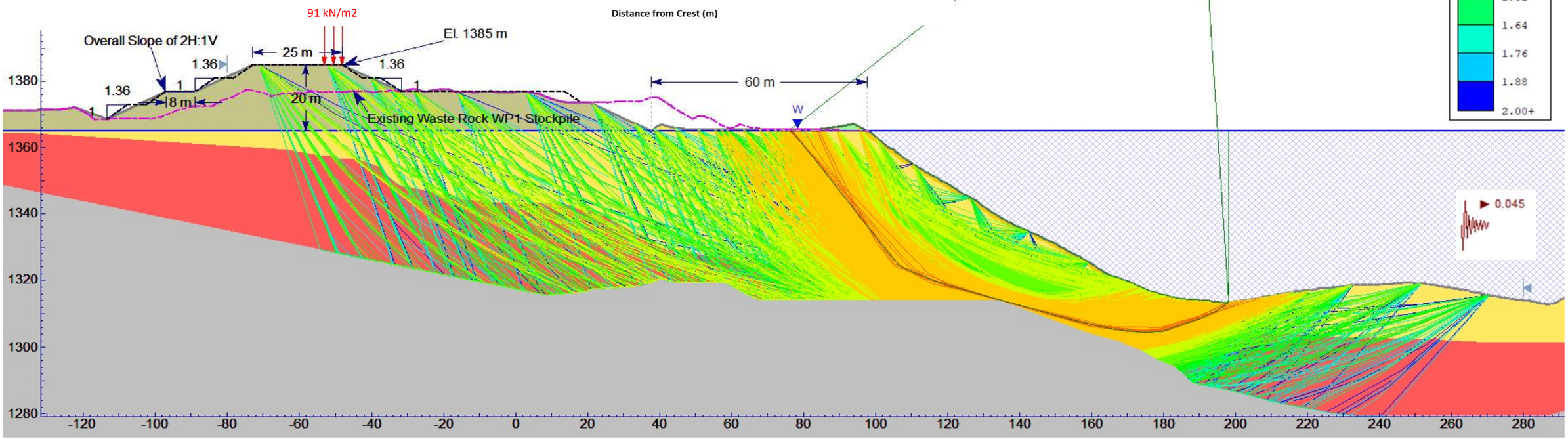
CLIENT			PROJECT
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE
WSP GOLDER	PREPARED	HOB	**Setback Analysis - Proposed WP1 Conceptual Design - Current North Toe of WP1**
	REVIEWED	NNA	PROJECT NUMBER / PHASE / REV / FIGURE
	APPROVED	JEK	**21507844** / **6000** / **0** / **C-13**

SOUTH

NORTH

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Vertical Strength Ratio	Minimum Shear Strength (kPa)
WP1		22	Mohr-Coulomb	0	38			
Dump		22	Mohr-Coulomb	0	38			
2022 Dump_Active Load		22	Mohr-Coulomb	0	38			
2021 Dump		22	Mohr-Coulomb	0	38			
Lakebed Sediments (Strength Ratio 0.32)		16	Vertical Stress Ratio				0.32	10
Bedrock		24	Infinite strength			Yes		





Pseudo-static Undrained Conditions - GLE Morgenstern-Price Method

Note:

- FOS graph based on GLE Morgenstern-Price method
- Estimated PGA for 1:2475 year return period on Site Class C: 0.089 according to National Building Code of Canada (NBC) - 2020
- Plot of FoS along slope surface shows variation of FoS for different slip surfaces passing at different distances from crest edge. Two presented curves were obtained from analysis shown in Figures C-13 and C-14.

CLIENT			PROJECT			
Newcrest Mining Ltd.			**Waste Pile 1 - Slope Stability Analysis**			
CONSULTANT	YYYY-MM-DD	2022-12-16	TITLE			
WSP GOLDER	PREPARED	HOB	**Setback Analysis - Proposed WP1 Conceptual Design - 60 m Setback for North Toe of WP1**			
	REVIEWED	NNA	PROJECT NUMBER	PHASE	REV	FIGURE
	APPROVED	JEK	**21507844**	**6000**	**0**	**C-14**

APPENDIX D

Drawings – Proposed WP1 Configuration

BRUCEJACK GOLD MINE
WASTE ROCK WP1 STOCKPILE

PROJECT LOCATION PLAN
NOT TO SCALE

DRAWING LIST				
DRAWING No.	DRAWING TITLE	REVISION No.	PURPOSE OF ISSUE	DATE OF ISSUE
1	TITLE SHEET AND PROJECT LOCATION PLAN	0	ISSUED FOR PERMITTING	2022-12-15
2	CONCEPTUAL DESIGN PLAN	0	ISSUED FOR PERMITTING	2022-12-15
3	TYPICAL CROSS-SECTIONS	0	ISSUED FOR PERMITTING	2022-12-15

ISSUED FOR
PERMITTING

THIS DRAWING IS INTENDED FOR CLIENT'S ONE TIME USE ONLY AND IT IS NOT INTENDED OR REPRESENTED BY GOLDER TO BE SUITABLE FOR REUSE BY ANY PARTY, INCLUDING, BUT NOT LIMITED TO, THE CLIENT, ITS EMPLOYEES, AGENTS, SUBCONTRACTORS OR SUBSEQUENT OWNERS ON ANY EXTENSION OF A SPECIFIC PROJECT OR FUTURE PROJECTS, WHETHER CLIENT'S OR OTHERWISE, WITHOUT GOLDER'S PRIOR WRITTEN PERMISSION. ANY MANIPULATION, ADAPTATION, MODIFICATION, ALTERATION, MISUSE OR REUSE UNAUTHORIZED BY GOLDER WILL BE AT CLIENT'S SOLE RISK. GOLDER EXPRESSLY DISCLAIMS ALL LIABILITY AGAINST ALL THIRD PARTIES RELYING, USING OR MAKING DECISIONS ON THIS DRAWING. THIRD PARTIES DO SO AT THEIR OWN RISK. EXCEPT WHERE WRITTEN AGREEMENT STATES OTHERWISE, THIS DRAWING IS THE PROPERTY OF GOLDER ASSOCIATES LTD.

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2022-12-15	ISSUED FOR PERMITTING	H.O.B./N.N.A.	T.A.K.	N.N.A.	J.E.K.

SEAL

PERMIT TO PRACTICE #1003064
Engineers & Geoscientists BC

CLIENT
NEWCREST
PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

CONSULTANT
WSP GOLDER
VANCOUVER OFFICE
SUITE 200 - 2920 VIRTUAL WAY
VANCOUVER, BC
CANADA
[+1] (604) 296 4200

PROJECT
BRUCEJACK GOLD MINE
WASTE ROCK WP1 STOCKPILE

TITLE
TITLE SHEET AND PROJECT LOCATION PLAN

PROJECT NO.	DOC.	REV.		DRAWING
21507844	029	0	1 of 3	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm

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LEGEND

- 1400 — EXISTING GROUND CONTOURS (SEE REFERENCE 1)
- 1350 — EXISTING BATHYMETRY CONTOURS (SEE REFERENCE 2)
- 1370 — PROPOSED WP1 CONCEPTUAL DESIGN CONTOURS
- PROPOSED WP1 CONCEPTUAL DESIGN SOUTHERN EXTENSION FOOTPRINT
- (WP1-14) PROPOSED WP1 CONCEPTUAL DESIGN SETOUT POINT
- (SE-05) PROPOSED WP1 CONCEPTUAL DESIGN SOUTHERN EXTENSION SETOUT POINT

NOTES

1. ALL UNITS ARE IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES SHOWS IN UTM, NAD 83, ZONE 9. ELEVATIONS ARE RELATIVE TO GEODETIC DATUM.
3. CONTOURS SHOWN AT 5 m MAJOR AND 1 m MINOR INTERVAL.
4. A WP1 CREST AT EL. 1377 m IS TO BE DEVELOPED WITH OVERALL GEOMETRY OF 2H:1V IN 2 LIFTS AT ANGLE OF REPOSE 1.36H:1V. UPPER WP1 CREST TO EL. 1385 m IS TO BE DEVELOPED WITH AN OVERALL GEOMETRY OF 2H:1V IN 2 LIFTS AT ANGLE OF REPOSE 1.36H:1V.

REFERENCES

1. 2022 LIDAR SURVEY PROVIDED BY NEWCREST, SURVEYED: 10 AUGUST 2022, RECEIVED: 17 OCTOBER 2022, FILE NAME: "20220810 - Surface Drone Flight_dsm.tif".
2. 2022 BATHYMETRY SURVEY PROVIDED BY NEWCREST, SURVEYED: 22 JULY 2022, RECEIVED: 08 AUGUST 2022, FILE NAME: "20220722_adjusted_1.5x1.5 Brucejack Winghead Bathymetry Survey_median_ UTMZ9_CGVD28.xyz".
3. 2022 AERIAL PHOTO PROVIDED BY NEWCREST AS MULTIPLE .tiff FILES, SURVEYED: 18 OCTOBER 2022, RECEIVED: 1 NOVEMBER 2022.

WP1 CONCEPTUAL DESIGN SETOUT TABLE

POINT ID	EASTING (m)	NORTHING (m)	ELEVATION (m)
WP1-01	427265.01	6258814.85	1377.00
WP1-02	427276.75	6258814.99	1377.00
WP1-03	427388.73	6258803.54	1377.00
WP1-04	427403.76	6258802.00	1377.00
WP1-05	427390.36	6258752.76	1377.00
WP1-06	427374.99	6258696.26	1377.00
WP1-07	427320.27	6258695.59	1377.00
WP1-08	427300.78	6258714.21	1377.00
WP1-09	427258.43	6258720.77	1377.00
WP1-10	427314.83	6258744.51	1385.00
WP1-11	427363.44	6258745.21	1385.00
WP1-12	427356.61	6258720.11	1385.00
WP1-13	427329.75	6258719.72	1385.00
WP1-14	427313.85	6258734.92	1385.00

WP1 SOUTHERN EXTENSION SETOUT TABLE

POINT ID	EASTING (m)	NORTHING (m)	ELEVATION (m)
SE-01	427371.01	6258651.88	1377.00
SE-02	427322.94	6258656.56	1377.00
SE-03	427310.58	6258699.51	1377.00
SE-04	427349.47	6258678.07	1385.00
SE-05	427341.50	6258678.85	1385.00

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0 50 100
1:1,000 METRES

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PROJECT
BRUCEJACK GOLD MINE
WASTE ROCK WP1 STOCKPILE

TITLE
CONCEPTUAL DESIGN PLAN

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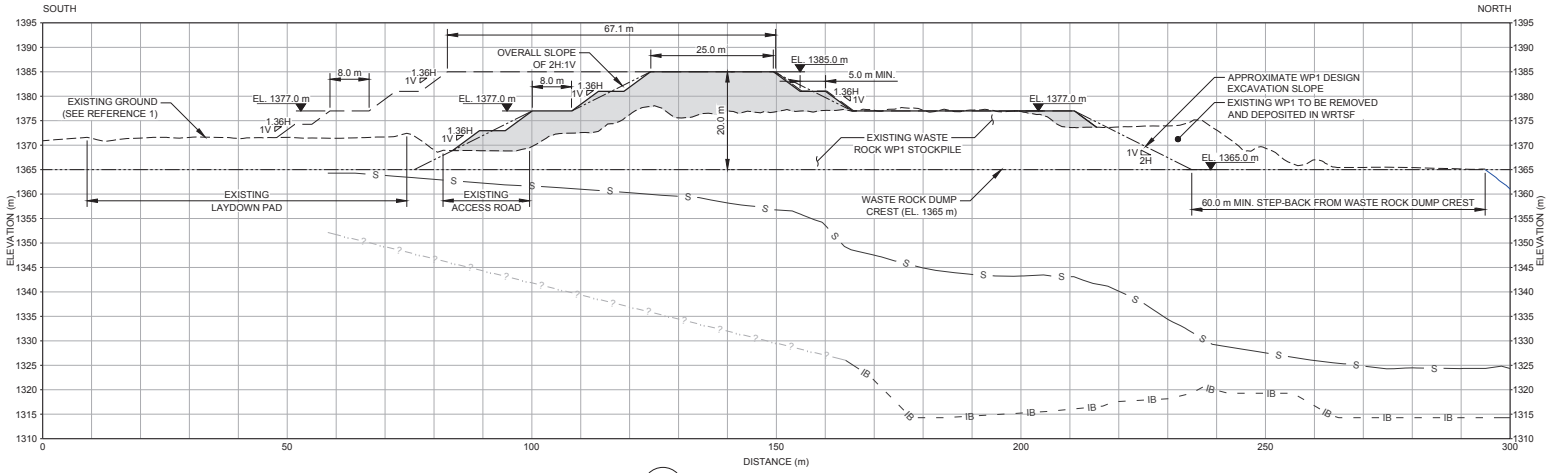
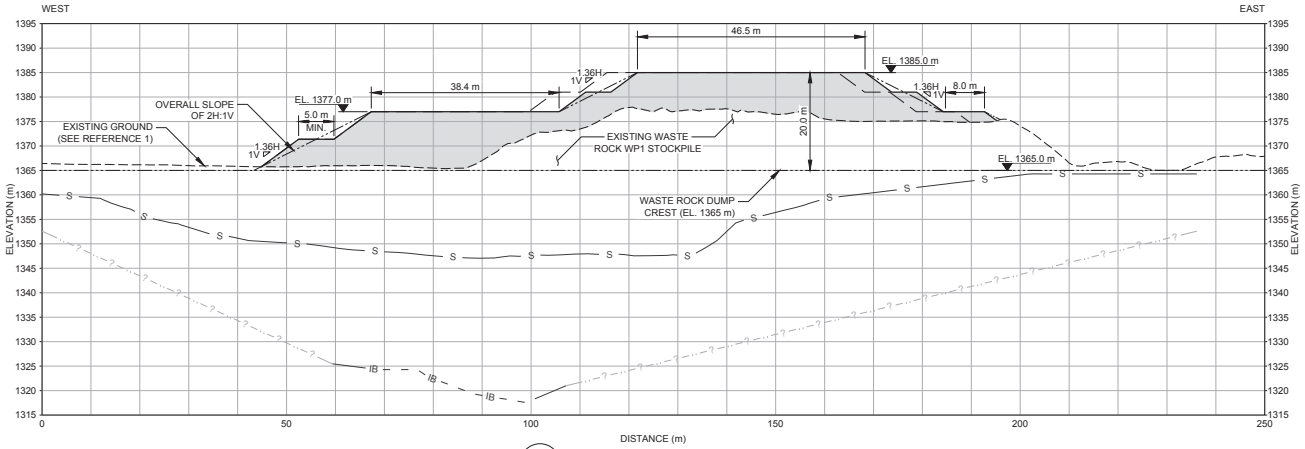


SCALE 1:500 m — A/2 TYPICAL SOUTH-NORTH CROSS-SECTION



SCALE 1:500 m — B/2 TYPICAL WEST-EAST CROSS-SECTION

LEGEND

- EXISTING GROUND SURFACE (SEE REFERENCE 1)
- EXISTING BATHYMETRY SURFACE (SEE REFERENCE 2)
- PROPOSED WP1 CONCEPTUAL DESIGN
- PROPOSED WP1 CONCEPTUAL DESIGN SOUTHERN EXPANSION
- S — INFERRED LAKEBED SEDIMENT (SEE NOTE 3)
- IB — INFERRED BEDROCK (SEE NOTE 4)
- ? — ASSUMED BEDROCK

NOTES

1. ALL UNITS ARE IN METRES UNLESS NOTED OTHERWISE.
2. ELEVATIONS ARE RELATIVE TO GEODETIC DATUM.
3. LAKEBED SEDIMENT INTERPRETED FROM 2013 BATHYMETRIC SURFACE (SEE REFERENCE 3).
4. BEDROCK INTERPRETED FROM SUBTRACTING DEPTH TO BEDROCK IN 2013 GEOPHYSICS FROM WATER ELEVATION AT TIME OF GEOPHYSICS.
5. SEQUENCE EXECUTION EXPECTED TO BE:
   A. EXCAVATION OF WP1 NORTH STOCKPILE AND EXISTING CATCH BERM FROM WASTE ROCK DUMP CREST TO BE 60 m BACK FROM THE WASTE ROCK DUMP CREST.
   B. A CATCH BERM TOE IS TO BE REINSTATED.
   C. A WP1 CREST AT EL. 1377 m IS TO BE DEVELOPED WITH OVERALL GEOMETRY OF 2H:1V IN 2 LIFTS AT ANGLE OF REPOSE 1.36H:1V.
   D. BENCH 8 m WIDE AT EL. 1377 m TO BE PROVIDED.
   E. UPPER WP1 CREST TO EL. 1385 m IS TO BE DEVELOPED WITH AN OVERALL GEOMETRY OF 2H:1V IN 2 LIFTS AT ANGLE OF REPOSE 1.36H:1V.

REFERENCES

1. 2022 LIDAR SURVEY PROVIDED BY NEWCREST, SURVEYED: 10 AUGUST 2022, RECEIVED: 17 OCTOBER 2022, FILE NAME: "20220810 - Surface Drone Flight_dsm.tif".
2. 2022 BATHYMETRY SURVEY PROVIDED BY NEWCREST, SURVEYED: 22 JULY 2022,RECEIVED: 08 AUGUST 2022, FILE NAME: "20220722_adjusted_1.5x1.5 BrucejackWinghead Bathymetry Survey_median_ UTMZ9_CGVD28.xyz".
3. 2013 BATHYMETRY SURVEY PROVIDED BY NEWCREST, SURVEYED: 25 OCTOBER 2013, RECEIVED: 06 APRIL 2021, FILE NAME: "P01_BJ_0000_Bathymetric_Contour_2013.shp".

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0 20 40
1:500 METRES

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PROJECT
BRUCEJACK GOLD MINE
WASTE ROCK WP1 STOCKPILE

TITLE
TYPICAL CROSS-SECTIONS

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Appendix 3-3: Brucejack Backfill Management Plan

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

Report

Brucejack Backfill Management Plan Rev-05

Pretium Resources Inc.

Revised by Brucejack Mine Geotechnical Engineering Team
10 March 2023

Revision history

Revision version	Title	Date	Comments
R0	Pretium Brucejack Backfill Management Plan Review Rev-0	7 March 2018	First Issue
R1	Pretium Brucejack Backfill Management Plan Review Rev-1	22 June 2018	Revised Golder barricade drawings in Section 8 and updated Appendix H
R2	Brucejack Backfill Management Plan Rev-2	18 October 2018	Added Appendix M Waste Fill Fence Design for Paste Fill
R3	Brucejack Backfill Management Plan Rev-3	18 November 2021	Updated with current SOPs in Section 4; Table 5.1 updated; Added Appendix N BJ-ENG-SOP-033 Rock Barricade Construction
R4	Brucejack Backfill Management Plan Rev-4	25 March 2022	Peer review of R3 document by AMC Mining Consultants (Canada) Ltd, with updates to target strengths, new paste recipes updated quality control analysis and fill barricades
R5	Brucejack Backfill Management Plan Rev-5	10 March 2023	Change target tonnage to 3800 tpd. Removed Horizontal belt filter section

Executive summary

This manual is the Brucejack Backfill Management Plan was collated by AMC Mining Consultants (Canada) Ltd (AMC) for Pretium Resources Inc. (Pretium). This document was developed in collaboration with Outotec (the plant designers), and Pretium's processing, mine operations, mine planning and geotechnical engineering staff. It contains a series of standard operating procedures (SOPs) in the form of task lists together with reference design and background information used to design and operate the Brucejack paste fill system.

British Columbia Ministry of Energy and Mines (BCMEM) has directed Pretium to provide the following information:

> *The Permittee shall develop a Mining-Backfill Standard Operating Procedure Manual that shall be available at any time at the mine site to any Mines Inspector. The Mining-Backfill Standard Operating Procedure manual shall include, but is not limited to, the following information:*

- *Barricade design for anticipated loading conditions.*
- *Procedures for determining suitable barricade location.*
- *QA/QC procedures for constructed barricades.*
- *Design rationale for minimum strength requirements for operating beside and underneath backfill at the design dimensions.*
- *Prescribed fill rates within stopes.*
- *Paste line flushing procedures.*
- *Procedures to ensure tight backfill has occurred.*
- *Safe filling procedures that include safe worker setback distance from active paste pours.*
- *QA/QC backfill testing requirements.*

The manual has been designed as a guide for employees working in paste fill related design and operations at Pretium Brucejack mine. It is also intended to serve as a reference manual for experienced users who interact with the paste fill system either at design or at operational level. The manual has been updated to final status following commissioning of the Brucejack Paste Fill System and has incorporated changes resulting from the commissioning process and the analysis of QC data.

The information contained herein is intended as a basis for design, but innovative solutions are encouraged when based on sound principles. In case of significant changes or discrepancies, please bring these to the attention of the Senior Geotechnical Engineer for resolution or correction.

All design documentation and drawings for the Brucejack paste fill system referenced in this document were supplied by Outotec and can be obtained from the Brucejack Reference files on the network. The Standard Operating procedures were developed in conjunction with mining and processing operations staff.

In June 2020 Outotec merged with Metso Minerals to form Metso Outotec, commonly referred to as MoGroup. This document retains references to supplied documentation in the original Outotec format.

The manual also refers to the Brucejack mining contractor, Procon.

Quality control

The signing of this statement confirms this report has been prepared and checked in accordance with the AMC Peer Review Process.

Project Manager	The signatory has given permission to use their signature in this AMC document	25 March 2022
	Tony Grice	Date
Peer Reviewer	The signatory has given permission to use their signature in this AMC document	25 March 2022
	Mo Molavi	Date
Author	The signatory has given permission to use their signature in this AMC document	25 March 2022
	Tony Grice	Date

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Certification

This document was reviewed and approved by the undersigned.

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Approved:

April 10, 2023

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Distribution list

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1 Introduction

This Paste Fill System Manual has been designed as a guide for employees working in paste fill related design and operations at Pretium's Brucejack mine. It is also intended to serve as a reference manual for users who interact with the paste fill system either at design or at operational level. The Manual contains details of Standard Operating Practices (SOPs) for key activities.

The information contained herein is intended as a basis for design, but innovative solutions are encouraged when based on sound principles. In case of significant changes or discrepancies, please bring these to the attention of the Senior Mining Engineer for resolution or correction.

All design documentation and drawings for the Brucejack paste fill system referenced in this document were supplied by Outotec and can be obtained from the Brucejack Reference files on the network.

The reader is referred to in the text as the "User".

The management of this manual is the responsibility of the **Senior Mining Engineer** who will ensure that copies in circulation are consistent with the master copy. The master copy will always be the latest edition and the starting point for any revisions. All revisions are to be suitably marked and dated and, where applicable, the older versions must be removed and destroyed.

This manual does not contain all the detailed information regarding the paste fill system, but references are given to other Pretium documentation, to published papers and various other useful sources of information.

All activities related to the paste fill system are subject to Pretium workplace Occupational Health and Safety requirements and conventions.

2 General backfill information

2.1 Objective

At Brucejack mine, paste fill is required as an integral part of underground mining operations in order to:

- Maximize ore recovery by eliminating the need for permanent ore pillars.
- Provide local and regional stability support.
- Serve as a working platform when mining the upper lifts of stopes.
- Enable tight filling of adjacent stopes to ensure stope back stability.
- Enable reduction of the volume of tailings stored in the Brucejack lake.

The objective of this technical manual is to provide an overview of the Brucejack paste backfill system to ensure safe and efficient backfill operations.

This manual is intended to provide background information and to detail the operating and control strategy for the paste backfill plant and underground distribution system. It has been designed for use in conjunction with the equipment operating / maintenance manuals. This technical manual is to be used by plant operators, supervisors, engineering staff, and maintenance personnel.

Paste fill operations are complex and involve interdependent activities that require interaction between mine planners, geotechnical engineers, mine operators and supervisors, plant operators and supervisors, mill operators and supervisors, and maintenance personnel.

It is imperative that all key stakeholders have a good common understanding of the key aspects of the entire backfill operations from the production stage on surface through to the final exposure of fill mass in open stopes underground. It is crucial that the key stakeholders operate within the guidelines given in this manual to make the right decisions during their involvement in filling operations.

Failure to operate within the technical and operating guidelines has the potential to lead to plant failures or substandard fill product that may lead to reticulation problems, pipeline blockages and ore loss or dilution. Barricade and large fill mass failures may in turn have far reaching consequences including endangering the safety of personnel and equipment or causing severe production losses and delays.

2.2 Paste fill system overview

All mill tailings are delivered to a Deep Cone Thickener (DCT). Tailings are thickened to a nominal 63%[1] w/w (solids by weight) and when not required for backfill purposes are pumped to the Brucejack Lake for underwater storage. When the paste fill plant is operating, thickened tailings are pumped to an agitated storage tank. The slurry density is consistently thickened to greater than or equal to 63%, the slurry is pumped directly to the paste mixer.

Tailings slurry, binder, and trim water is combined in the continuous paste mixer to produce the required paste recipe. The paste overflows the mixer and discharges to one of two Geho positive displacement (PD) pumps for transfer to the underground distribution system. The combined paste fill tailings, binder, and water will produce a nominal 125 m^3/hr of paste fill. The PD pumps and

[1] Percentage solids by weight = mass of solids / (mass of solids + mass water).

valving enable the delivery of paste fill through one of two parallel pipelines to the mine portal and down the decline, either directly to the stopes or via the UG pump booster station.

The paste fill system uses a blended cementitious binder consisting of ground blast furnace slag and general usage cement (Lafarge Terraflow product). The binder is commonly referred on site as cement and is transferred from stacked isotainers to a nominal 160 t binder silo (actual 100 t due to low density of Terraflow binder) and delivered via a weigh conveyor and augers to the paste mixer. The rate of binder addition varies depending upon the required paste fill strength and the defined recipe and typically ranges between 2% and 15% of total backfill solids. High strength paste is used in undercut sill pillars, medium strength in primary and secondary stopes and low strength in bulk fill where no future exposures are required.

With the mine operating at 3,800 tpd, the plant is designed to produce paste fill at approximately 140 m^3 per hour from 141 dry tonnes per hour (dtph) of dewatered tailings with a minimum slurry density of 63% w/w, and an average of 7.6 dtph of binder (at 5% of total dry solids dosing average). Where paste recipes call for different binder rates or milling is conducted at different rates, these values will change pro-rata.

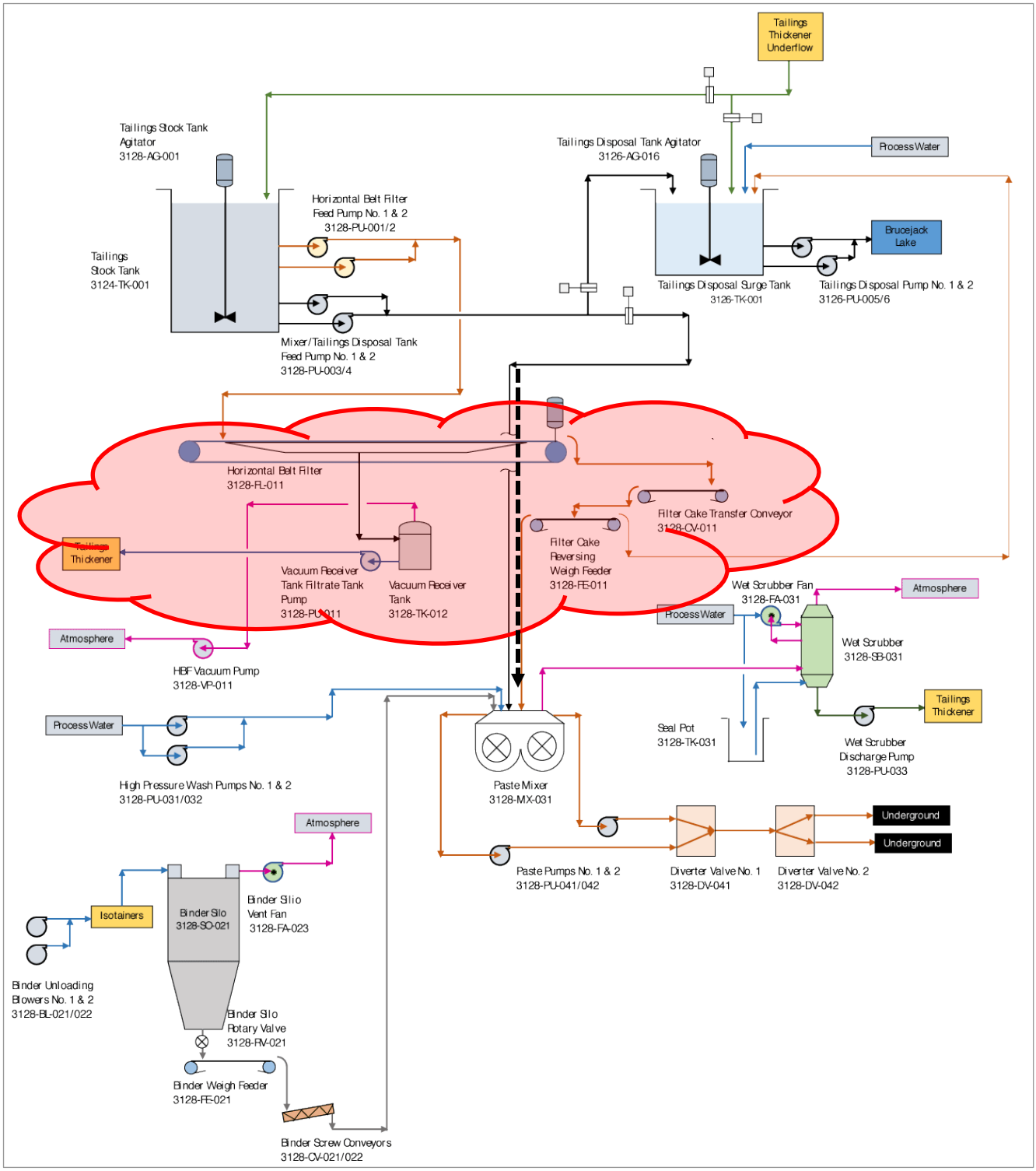
The wet bulk density of the paste fill slurry is approximately 1.68 t/m^3 and at an average 5% binder dosing contains 67 kg/m^3 of binder. Details of actual recipes are given later in the manual.

Assuming a monthly and annual utilization of 66% and 50%, the plant is designed to produce approximately 33,000 m^3 of paste per month and 400,000 m^3 per year, respectively. When the paste plant is not operating, thickened tailings are diverted to the Brucejack Lake for sub aqueous disposal. The paste plant is designed to process the full tailings stream when paste fill is being placed underground.

The Brucejack paste fill system combines thickened mill tailings mixed with binder to produce cemented paste backfill for stopes underground. The cured paste fill enables the extraction of adjacent ore in pillar stopes and reduces the quantity of sub aqueous tailings storage in the Brucejack Lake. Paste fill is produced in the surface plant and pumped underground in high-pressure piping either directly to stopes or via an underground pump booster station for stopes higher in the mine.

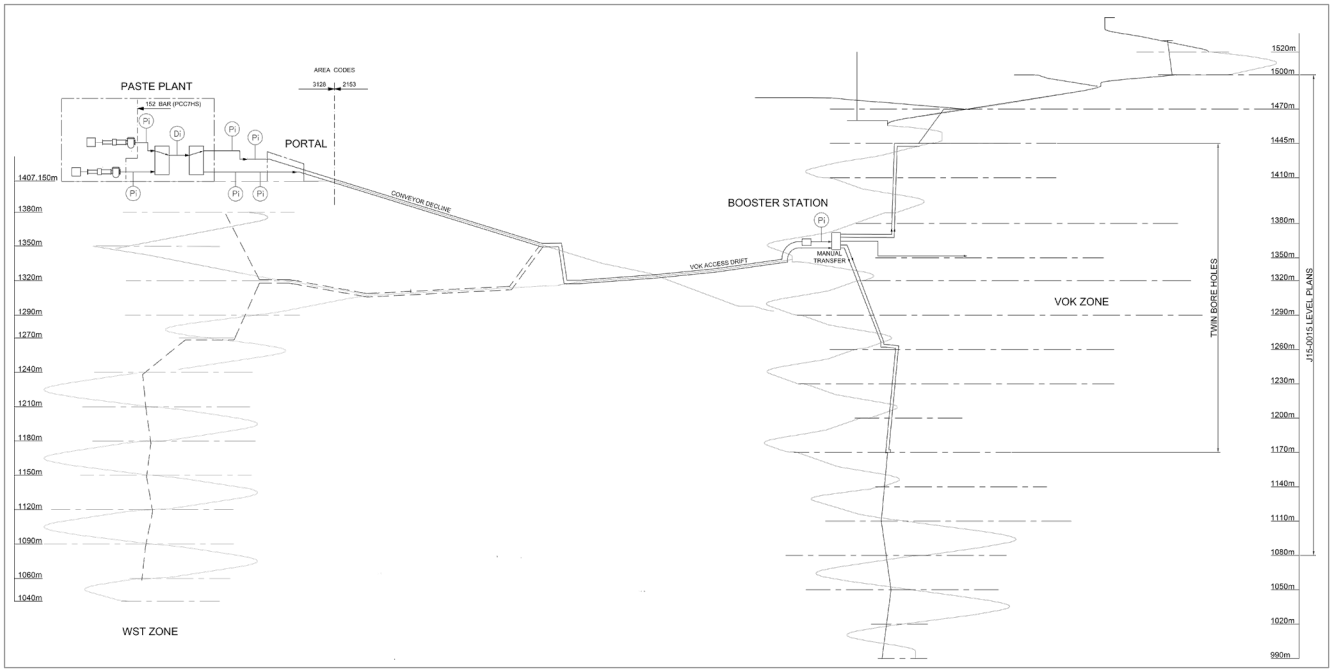
Figure 2.1 shows the paste fill plant process schematic.

Figure 2.1 Brucejack paste fill plant schematic



A schematic of the overall underground reticulation system is shown in Figure 2.2 including the Booster Pump Station. ***NOTE: The Horizontal Belt FLter has been removed from the operation. The slurry, at 63% solids, is pumped directly from the Tailings Stock Tank to the Past Mixer**

Figure 2.2 Schematic of underground reticulation system including Booster Station



Paste fill is delivered underground by pumping to the stoping areas via a pair of pipelines installed in the main access decline. The lines pass through the "dogleg borehole" and up to the booster pump station via the VOK incline. Paste can be pumped directly from surface to stopes underground or via the underground booster pump station to fill stopes higher in the mine.

The Booster Station is located at 1320 RL and consists of a feed hopper and provision for a pair of GEHO PD pumps with the same specifications as the surface unit. Initially, only one pump was installed due to low utilization rates. The second pump will be installed later when availability and utilization rates require it.

Table 2.1 illustrates the key operating parameters for the paste fill system.

Table 2.1 Paste fill system rates

Brucejack Paste Backfill System Rates Table - Mill at 3,300 tpd (150 tph @ 93% utilisation & 6% mass pull to cons)

Illustrating the linkage between short term and long term design and planning rates

Daily ore tonnes mined	3,348	tpd											
Ore tonnes milled	150.0	tph		Mill Utilisation	93%		SG tails	2.80	**Backfill Mix Calcs for 1,000 kg dry paste**				
Tonnes to Concentrate	9.0	tph		Mass pull to cons	6%		T90 Binder	2.9	1,000		wt (kg)	vol (l)	kg per m3
Tonnes to backfill system	141.0	tph					Average PC Rate	6.50%	OPC	6.50%	65.0	22.4	68.9
							Binder SG	3.14	Binder	0.00%	0.0	0.0	0.0
Percent tailings supplied to backfill plant	100%			**Total mined**	**1,222,020**	**tpa ore**	Binder Rate	0.0%	Tails	93.50%	935.0	333.9	990.8
Tailings supplied to backfill plant	141.0	tph								**Dry**	**1,000.0**	**356.3**	**1,059.7**
Percentage supplied tails used in backfill	84%			Ore Density	2.65				Water in backfill slurry		587.3	587.3	622.4
Tailings used in Backfill	117.8			Vol mined	461,140	m3/pa			**Slurry**	**Wet**	**1,587.3**	**943.6**	**1,682.1**
Average cement used in backfill	8.2	tph		**% to be filled**	**100%**				Water in consolidated backfill		548.1	548.1	606.0
Total Solids used in Backfill	125.9	tph		WT Vol Fill reqd	462,000	m3/pa			**Consolidated**	**Wet**	**1,548.1**	**904.5**	**1,711.6**
Fill Pulp Density	63.0%	by weight			Consolidated Density		64.6%	by weight		**Binder Dosing**			
Fill Pulp Density	37.8%	by volume			Fill Pulp Density		39.4%	by volume		Paste slurry	69	kg/m3	
Backfill Dry Bulk Density	1.0597	kg/l			Backfill Dry Bulk Density		1.1056	kg/l		Paste cured	72	kg/m3	
Backfill Pulp Relative Density	1.6821	tonnes/m3			Backfill Wet Bulk Density		1.7116	tonnes/m3					
Round Up Integer	0.1	0.1	0.1	10	10	10	1,000	1,000	1,000	1,000	1,000	1,000	
	Instant Slurry Design Placement Rate					These are the plant and component design throughput rates							
Factor	100%												
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d							
	126.0	200.0	118.9	3,030	4,800	2,860							
	Instant Consolidated Backfill Placement Rates					These are the backfill volume placement rates after consolidation							
Factor	100%												
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d							
	126.0	200.0	116.9	3,030	4,800	2,810							
	Daily Average Rate					These are the targets that the operators should achieve each day							
Factor	85%												
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d							
	107	170	99	2,580	4,080	2,390							
	Weekly and Monthly Scheduling Rates						These are the rates used for scheduling of fill placement						
Factor	66%												
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d	dtpm	wtpm	m3/m				
	83	132	77	2,000	3,180	1,860	61,000	97,000	57,000				
	Annual System Performance						These are the expected annual performance achievements						
Factor	47%												
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d	dtpm	wtpm	m3/m	dtpa	wtpa	m3pa	
	59	94	55	1,430	2,260	1,320	44,000	69,000	41,000	519,000	824,000	482,000	
									Tailings	**485,265**	**tpa**		
									Binder	**33,735**	**tpa**		

3 Outotec paste plant and operating philosophy

This section is a duplication of the Outotec document 177421-0000-DC00-PHL-0001-R0 Process Control Philosophy.pdf. This section is supplemented by the Outotec Training documentation.

3.1 Process overview

The related Process Flow Diagrams (PFD) and Piping and Instrumentation Diagrams (P&ID) in this area are listed below.

Table 3.1 PFD and P&ID drawings

Drawing no.	Title	Equipment
3128-A-0001 R3	Paste Plant Process Flow Diagram	Contains major equipment from area 3126 and 3128 P&IDs listed below.
2153-A-0001 RA	Underground Booster Station Process Flow Diagram	Contains major equipment from area 2153 P&IDs listed below.
3126-PID-0010 RH	Tailings Paste Thickener	Tailings Paste Thickener, Paste Thickener Underflow Pumps, Paste Thickener Recirculation Pumps
3128-PID-011 RH	Tailings Stock Tank	Tailings Stock Tank, Tailings Stock Tank Agitator, Horizontal Belt Filter Feed Pumps, Mixer / Tailings Disposal Feed Tank Pumps
3128-PID-0014 RH	Binder System	Binder Unloading Blowers, Binder Silo Aeration Air Receiver, Binder Silo, Binder Silo Bin Vent, Binder Silo Rotary Valve, Binder Weigh Feeder and Belt Scale, Binder Screw Conveyors, Binder Silo Bin Vent Fan
3128-PID-0015 RH	Paste Mixer	Higher Pressure Wash Pumps, Paste Mixer, Paste Mixer Lubrication System, Wet Scrubber, Wet Scrubber Fan, Wet Scrubber Discharge Pump, Seal Pot
3128-PID-0016 RH	Paste Pumps	Paste Pumps. Paste Pump Hydraulic Power Units, Mixer Overflow Chutes, Diverter Valves, Diverter Valve Hydraulic Power Unit
3128-PID-0017 RH	Gland Water	Paste Plant Gland Water Valves and Instrumentation
2153-PID-0020 RB	Underground Booster Station Flush Water Tank	Flush Water Tank, Flush Water Pumps
2153-PID-0021 RB	Underground Booster Station Live Bottom Hopper	Live Bottom Hopper, Booster Station Sump
2153-PID-0022 RB	Underground Booster Station Paste Pumps	Paste Pump, Paste Pump Hydraulic Power Unit, Diverter Valves, Diverter Vale Hydraulic Power Unit, Manual Transfer Stations

3.1.1 Overview – tailings backfill

Tailings are dewatered for either underground backfill or subaqueous deposition at rates up to 145 tonnes per hour (dry weight tailings). When challenging dewatering conditions occur, a stream of up to 20 tonnes per hour (dry weight tailings) may be diverted and additionally dewatered by vacuum filtration to maintain targeted slurry densities. When backfilling, the slurry and the filter cake are mixed with binder, tempered with water for slump and delivered to the Underground Delivery System (UDS) by a hydraulically powered paste pump.

The UDS will have a receiving hopper and an additional paste pump for pumping to various locations underground.

Before the mixer and paste pumps are put into operation the line should be “slicked” with water. This wets the inside surface and prevents the initial paste put down the pipe from being sucked of moisture. Underground should make provision for disposing this volume of water as well as an equal volume at the end of the pour to clean out the lines.

This also proves that the pipelines, valves and manual transfers have been orientated according to the deposition plan developed by mine personnel.

3.1.2 Tailings dewatering

Tailings need to be dewatered for use in either backfill or subaqueous disposal. Pumping to Brucejack Lake is permitted with "a solids content target of around 55 to 65% by weight (w/w)".

There is now a single stage of dewatering equipment at Brucejack. This stage is comprised of the Tailings Paste Thickener. The second stage Horizontal Vacuum Belt Filter has been removed from service and decommissioned.

Rougher scavenger tailings are pumped to the Tailings Thickener Feed Tank (3126-TK-003) of the Tailings Paste Thickener (3126-TH-001). Flocculant is added to the Tailings Thickener Feed Tank and injected into the feed line ahead of the feed well with dilution water to ensure proper mixing of the flocculant. The Tailings Paste Thickener is sized to provide 6 to 8 hours of retention time, which allows tailings to settle and densify / thicken. See Sections 3.2 and 3.3 for the Tailings Thickener Feed Tank, Tailings Paste Thickener, and flocculant addition.

Any spillage captured by the Tailings Dewatering Area Sump Pump (3126-PU-008) is also added to the Tailings Thickener Feed Tank, along with tailings filtrate, Paste Plant Sump Pump (3128-PU-013) contents, water from the Wet Scrubber (3128-SB-031), and any paste plant spillage obtained from downstream in the process. Also, if the thickener has to be drained or if there is a major spill, the sump pump can be directed to the Tailings Disposal Surge Tank (3126-TK-001). See Section 3.2.1 for the sump pumps. The thickener overflow flows by gravity to the Process Water Tank (3232-TK-001).

Depending on the minerology, testing has shown that if the thickener can produce tailings at 63% w/w solids, it can be used to produce paste. If the thickener underflow is between 63% and 65% w/w, and paste is not currently required, an operational decision will be made to pump it either to the Tailings Stock Tank (3128-TK-001) or directly to the Tailings Disposal Surge Tank (3126-TK-001). If not required for backfill, tailings are pumped to the Tailings Disposal Surge Tank. Underflow densities greater than 72% cannot be pumped from the Tailings Disposal Surge Tank due to the limitations of the pumping system. Dilution water is added to the Tailings Disposal Surge Tank if high density slurry occurs. The Tailings Disposal Surge Tank and pumping therefrom is outside of Outotec's responsibility.

The Tailings Stock Tank is a large, agitated tank with a full capacity of 1,145 m^3. The live capacity of this tank is roughly the top half of the tank, due to minimum slurry level requirements above the agitator blades. The Tailings Stock Tank Agitator (3128-AG-001) agitates the slurry keeping the tailings in suspension.

Two Recirculation Pumps (3126-PU-003 & 004) are designed to recirculate slurry within the thickener discharge cylinder in an attempt to shear the material and reduce the viscosity. During normal plant operation, it is anticipated these pumps will run continuously at a speed that is based on 100% to 150% of the flow of the underflow pumps. One of the recirculation pumps is also able to pump sheared material above the thickener knuckle if required.

Both the paste backfill process and tailings disposal (subaqueous) require thickened tailings. Both paste backfill and subaqueous disposal have tailings density requirements. When the tailings do not meet these density requirements, additional dewatering is required. The 20 tonnes/hour stream of thickened tailings is then pumped from the Tailings Stock Tank to the Horizontal Belt Filter (3128-FL-011) and vacuum filtered to ~80% w/w solids. The filter cake stream produced by the

Horizontal Belt Feeder is conveyed to the Paste Mixer (3128-MX-031) where it will merge with the thickened slurry stream and effectively increase the density of the slurry.

3.1.3 Sub-aqueous tailings disposal

When not placing paste backfill underground, Brucejack disposes the tailings under water. Thickened tailings are pumped through a pipeline to the nearby Brucejack Lake. In order to meet the Permit requirements, slurry densities of the tailings must be between 63% and 65% solids by weight. Dewatering equipment in the plant ensures discharged tailings satisfy the Permit requirements.

Tailings disposal pumps draw thickened slurry from the agitated Tailings Disposal Surge Tank. This tank is fed either from the Thickener Underflow Pumps or from the Tailings Stock Tank discharge pumps.

When tailings are being disposed, it is preferable to bypass the Tailings Stock Tank and pump tailings slurry directly to the Tailings Disposal Surge Tank from the Tailings Paste Thickener. This reduces the overall power consumption and equipment wear.

It may be necessary to send tailings slurry from the Tailings Stock Tank to disposal during challenging conditions or when maintenance is required. Tailings can be sent to disposal from the Tailings Stock Tank when paste production is occurring. The valves in these lines are configured to allow slurry to both the Disposal Tank and the Paste Mixer simultaneously.

When slurry densities are too high for pumping, process water will be added to the Tailings Disposal Surge Tank to decrease the density to be within acceptable capabilities. Water addition will be automatic and will be controlled by the process control system (PCS).

3.1.4 Paste backfill

The plant is designed as a continuous system. Continuous monitoring of the process by the PCS and on-stream instrumentation allows the plant control to adapt process flows and conditions in real-time, maintaining control of the final product. The paste plant is automated with a goal of operating at steady state as per a paste recipe entered by the operator and a production rate determined by underground.

The production rate will determine the flow rate of the slurry to the mixer. This is reduced by the flow to the Horizontal Belt Filter if the % solids is low. The paste recipe will determine the feed rate of binder added. Tempering water is added by recipe to start and varied as stated below.

Tailings is pumped to the Tailings Paste Thickener providing approximately 6 to 8 hours of residence time prior to feeding the Underflow Pumps and an agitated Tailings Stock Tank. The residence time of the Tailings Stock Tank will minimize fluctuations in density for various ore types. Minimizing fluctuations in density and flowrate are critical for paste production, as final paste quality and slump are sensitive to variations in density.

The slurry is pumped from the Tailings Stock Tank, using centrifugal pumps, to the Paste Mixer and the Horizontal Belt Filter (if required). The Horizontal Vacuum Belt Filter acts as a second stage of dewatering when thickening is insufficient to produce required product density. The belt filter transfers filter cake into the Paste Mixer by the Filter Cake Transfer Conveyor (3128-CV-011) followed by the Reversing Filter Cake Weigh Feeder (3128-FE-011). Water recovered from filtration will return to the feed box of the Tailings Thickener Feed Box.

Under normal circumstances, the thickener will provide sufficient dewatering for paste production when combined with the binder in the Paste Mixer. When challenging conditions occur and the thickener alone cannot dewater sufficiently, the Horizontal Belt Filter provides a second stage of dewatering.

Flow rates of thickened tailings slurry, binder, tempering water and filter cake are controlled such that the ratio provides a consistent slump within the Paste Mixer.

This is accomplished by measuring:

1. Pressure difference after the paste pumps.
2. Density measured after paste pumps.
3. Hydraulic pressure powering the paste pumps.
4. Amperage draw from the mixer motors.
5. If the values for 1 through 4 are increasing and / or manual measurements of slump indicates a lower slump than required, then the tempering water will be increased.
6. Conversely, if the values for 1 through 4 are decreasing and the slump is higher than required, then tempering water will be decreased.

Density measurement downstream of the Paste Mixer can be used to confirm and maintain the target density of the paste. Manual slump measurements on paste collected from the Paste Mixer are used to confirm that the density set-point is achieving the desired slump. If it is not, the set-point can be adjusted accordingly.

Dry binder is delivered from the Knipple Transfer Station to the paste plant in bulk isotainers. Storage and handling is provided inside the mill complex with a pneumatic transfer system capable of handling bulk binder isotainers. Binder is pneumatically conveyed into a binder silo for use in the plant. This is a manual system that will require an operator to switch air supply line to the isotainer to be off- loaded and the air / product line from the isotainer to the silo recharge line. Offloading the isotainer is done by manually operating butterfly valves on the belly of the isotainer to introduce binder into the conveying airstream. The binder silo is equipped with a bin vent for dust collection. The bin vent fan will only be used when the silo is being loaded.

Binder is metered on a continuous basis into the Paste Mixer using a rotary vane feeder and weigh-belt feeder. Two screw conveyors in series are used to transport the binder from the weigh-belt feeder into the Paste Mixer. Binder addition at the Paste Mixer is controlled based on the targeted binder content and the measured dry weight of tailings entering the Paste Mixer.

The Paste Mixer blends the filter cake, thickener underflow, trim water, and binder together, achieving a homogenous paste mix. Continuous monitoring of the flowrate and solids content of the material entering and exiting the process will allow a consistent mixture to be achieved.

A wet scrubber type dust collector is used at the mixer to prevent the release of any dry products from the Paste Mixer to the atmosphere. The same scrubber is be used to eliminate dusting at the weigh-belt feeder as required. The dust collected is recycled back to the Tailings Thickener Feed Tank as a dilute slurry.

Any spills resulting from the operation of the paste plant is directed to three (3) clean-up sumps located within the paste plant footprint. Material collected is pumped to the Tailings Thickener Feed Tank. Care must be taken to avoid introducing large quantities of cemented material into the sump which could potentially damage equipment downstream from the sump.

This overflow type mixer continuously discharges cemented paste to one of the paste pumps. From the paste pumps it flows into one of two lines of the underground distribution system through a pair of diverter valves in series. The first diverter valve allows for pig insertion for cleaning after a pour and the second diverts flow into one of the two lines to underground.

The underground distribution system is comprised of a network of 8” pipe and a booster pump station located near the VOK mining zone. The Booster Station includes a receiving hopper, flush water tank and pumps, valves, and a single paste pump. The paste pump located in the Booster Station is identical to the ones located in the surface plant with the exception of having air cooling instead of water cooling. It is similarly controlled by the PCS. Operation of the booster pump station is linked and coordinated with the surface pumps to avoid spills and damage to equipment.

After each paste campaign, the lines are flushed by supplying process water to the Paste Mixer and using the paste pumps to push water and a cleaning pig through the lines.

The paste plant Overhead Crane (3128-CK-001) services the area as needed.

3.1.5 Gland water for slurry pumps

To minimize the dilution of the slurry, all the GIW centrifugal slurry pumps have been fitted with type KE seals. These pump seals are fed with individual valve trains to each pump at a pressure of ~70 kPa (10 psi) higher than the discharge pressure of that pump. Gland water to any pump is proved to allow it to operate (FISL on each line).

3.2 Tailings thickener (3125-TH-001)

Table 3.2 Reference P&IDs, drawings, and documents P&IDs

Drawing no.	Title	Equipment
3126-PID-0010 RH	Tailings Paste Thickener	Tailings Thickener, Underflow Pumps, Recycle Pumps
177421-0000-DE20-PID-0031	Tailings Thickener (AMECFW)	Tailings Paste Thickener, Underflow Pumps, Recycle Pumps, Tailings Thickener Feed Tank, Tailings Dewatering Area Sump

Table 3.3 Vendor drawings

Supplier document no.	AMEC document no.	Title
1000209642 Rev. 1	177421-PJ020-C08-0002-001	P&ID Symbol Legend
1000209600 Rev. 1	177421-PJ020-C08-0003-001	P&ID – 5 m High Rate Thickener

3.2.1 Major equipment

The major equipment for the tailings thickening area is listed in the table below.

Table 3.4 Major equipment for the tailings thickening

Equipment No.	Description	P&ID No.
3126-TK-003	Tailings Thickener Feed Tank	0031
3126-TH-001	Tailings Thickener	0010
3126-PU-001/2	Tailings Thickener Underflow Pumps	0010
3126-PU-003/4	Tailings Thickener Recirculation Slurry Pumps	0010
3126-PU-008	Tailings Dewatering Area Sump	0031

3.2.2 Start-up sequence

For this thickener, refer to FLS document, Tailings Thickener, Control and Operating Philosophy 177421-PJ020-C03-0002_S1.

In general, the following start-up sequence is employed:

- Rake mechanism
- Recirculation pumps
- Feed from Thickener Feed Tank
- Flocculant addition
- Overflow pumps

3.2.3 Control description

3.2.3.1 Tailings Thickener Underflow Pumps (3126-PU-001/002)

The two Thickener Underflow Pumps (3126-PU-001 and 3126-PU-002) draw from the bottom of the discharge cylinder that is the lowest part of the paste thickener. Both pumps are isolated by automated knife gate valves on the pump inlet lines (3126-XV-5311/5321) and discharge lines (3126-XV-5315/5325). Additionally, manual gate valves are located between the thickener outlet flange and the pump inlet knife gate valve for maintenance.

During normal operation of the thickener, one of the two underflow pumps transports the thickened tailings to either the tailings stock tank or the tailings disposal surge tank. The thickener should be monitored for:

- Density
- Outflow in balance with incoming feed
- Rake torque
- Bed interface
- Bed pressure

If the density or the rake torque increases the amount of material pulled from the thickener should be increased.

Refer to Section 3.2.3 for the control of the thickener.

Both pumps are operated with variable frequency drives (VFDs). Flow and density are measured on the pump discharge line (3126-FE-5332 and 3126-RX-5331) and are used to control the pump speed. The target flow will depend on the current control philosophy for the thickener. Density and pressure are also measured and are used for the operation of the thickener and pump systems (3126-DI-5331 and 3126-PE-5333). Normally, thickeners are run where the dry solids mass flow out of the thickener equals the dry solids mass flow into the thickener and the bed is kept constant. When the backfill rate is drastically different from the thickener feed rate, the agitated stock tank can act as a buffer, so that the thickener is operated in “steady state”.

In the event the thickener underflow density is too low, the underflow pumps can be slowed and directed to either tank or returned to the Tailings Thickener Feed Tank. The underflow pump can even be stopped if required, however then the density measurement on the underflow is not available. In the event of upset conditions such as a power outage, the tailings can be recycled to the Tailings Thickener Feed Tank.

The inlet lines for all pumps have sample ports with manual plug valves.

Automated globe valves prior to each pump (3126-XV-5312/5322) are used for the flushing of the pumps and lines with water. Automated knife gate valves (3126-XV-5313/5323) are also located prior to the pumps for draining the pumps and pipes.

A series of automated knife gate valves are also used to direct the flow of slurry from the underflow pumps to the Tailings Stock Tank, Tailings Disposal Surge Tank, or back to the Tailings Thickener Feed Tank. These include 3126-XV-5334, 3126-XV-5336 and 3126-XV-5338, while 3126-XV-5335/3126-XV-5337/3126-XV-5339 are used to drain the respective lines when pumping to a specific location stops.

3.2.3.2 Tailings thickener recirculation slurry pumps

Similar to the two thickener underflow pumps, the two recirculation pumps will draw from the bottom of the discharge cylinder that is the lowest part of the paste thickener. These pumps are also isolated by automated gate valves on the pump inlet (3126-XV-5341/5351) and discharge lines (3126-XV-5348A/5348B/5355). Additionally, manual gate valves are located between the thickener outlet flange and the pump inlet knife gate valve for maintenance.

During normal operation of the thickener, one or two of the two recirculation pumps transports the thickened tailings from bottom of the discharge cylinder and reinjects it into the top of the same discharge cylinder. Both pumps are powered by VFDs. The volumetric flowrate of this recirculation is targeted at 1.25 to 1.5 times the flow through the underflow pump.

Both recirculation pump discharge lines are outfitted with flow meters (3126-FE-5340/5350), and both pumps are able to recirculate the tailings within the discharge cylinder.

One of the Recirculation Pumps (3126-PU-004) is only able to perform this recirculation duty while the other (3126-PU-003) is also able to pump tailings further up into the thickener (above the thickener knuckle). Item 3126-PU-003 can pump to the discharge cylinder or the nozzles above the knuckle, but not to both destinations at once. There are two inlets on the thickener for such recirculation, opposite each other. Three knife gate valves are opened to allow for the pumping of slurry above the knuckle (3126-XV-5345/5347A/5347B). This recirculation will only be employed when the thickener rake torque is abnormally high, when the underflow pumps are not in operation or during periods when tailings are not being introduced into the thickener.

During high torque events, the tailings can be recirculated to both the discharge cylinder and above the knuckle, or alternatively can be recirculated only to the upper lines.

Automated knife gate valves are used to help drain both pumps as well as the recirculation lines (3126-XV-5343/5353/5356/5349/5346).

Flush water for the recirculation pumping system is introduced with two automated globe valves prior to each pump (3126-XV-5342/5352).

Manual plug valves allow for sample collection prior to each recirculation pump.

3.2.3.3 Tailings dewatering area sump pump

The Tailings Dewatering Area Sump Pump (3126-PU-008) is turned on and off locally with the use of high and low-level switches (3126-LSL-5300 and 3126-LSH-5300), with a “high high” alarm (3126-LAHH-5300) displayed on the PCS screen which uses the standard HMI graphic template to monitor the status of the pump.

3.3 Tailings storage and disposal

3.3.1 Reference P&IDs, drawings, and documents

Table 3.5 P&IDs

Drawing no.	Title	Equipment
3128-PID-0011 RH	Tailings Stock Tank	Tailings Stock Tank, Tailings Stock Tank Agitator, Horizontal Belt Filter Feed Pump No. 1 and No. 2, Mixer / Tailings Disposal Tank Feed Pump No. 1 and No. 2
3128-PID-0011 RH	Disposal Tank	Update required

3.3.2 Major equipment

The major equipment for the tailings storage area is listed in the table below.

Table 3.6 Major equipment

Equipment no.	Description	P&ID no.
3126-TK-001	Tailings Disposal Surge Tank	Update required
3126-AG-016	Tailings Disposal Surge Tank Agitator	Update required
3126-PU-005/6	Tailings Disposal Pumps	Update required
3128-TK-001	Tailings Stock Tank	0011
3128-AG-001	Tailings Stock Tank Agitator	0011
3128-PU-001/2	Horizontal Belt Filter Feed Pumps	0011
3128-PU-003/4	Mixer / Tailings Disposal Feed Tank Pumps	0011

3.3.3 Control description

3.3.3.1 Tailings Disposal Tank Agitator (3126-AG-016)

The tailings stock tank agitator is powered by a VFD to assist in start-up with slurry in the tank. The tailings stock tank agitator is designed with a single set of 4 blades and will only agitate the bottom 1/2 of the material in a full tailings stock tank. Do not be concerned if the tailings stock tank agitator is operating and the visible material on top is not moving.

The tailings stock tank agitator should be operated whenever there are tailings in the tailings stock tank above the 19% level (see 3128-LE-5401 below). The signal back from the VFD will generate a "Permissive to run - Agitator Running".

It is possible to operate the agitator without liquid. The liquid level should be above the level of the slap ring that steadies the bottom of the agitator shaft.

3.3.3.2 Tailings Disposal Pumps (3126-PU-005/6)

There are four (4) pumps that empty the tailings stock tank. Two are the Horizontal Belt Filter (HBF) Feed Pumps 3128-PU-001 and 3128-PU-002, GIW 3x2 centrifugal pumps designed to pump a maximum of 20.5 m^3/hour at a design SG of 1.63 (at 60% w/w solids) against a head of 57.4 m. These HBF feed pumps are designed as redundant, one in operation and one as a standby. They pump from the tailings stock tank to HBF 3128-FL-011 (actually to the HBF Feed Splitter 3128-BN-001). The other two pumps are the Mixer / Tailings Disposal Surge Tank Feed Pumps 3128-PU-003 and 3128-PU-004, GIW 6x4 centrifugal pumps designed to pump a maximum of 148 m^3/hour at a design SG of 1.78 against a head of 26.2 m. These mixer / tailings disposal surge tank feed pumps are designed as redundant, one in operation and one as a standby. They pump from the tailings stock tank to either Paste Mixer 3128-MX-031 or the Tailings Disposal Surge Tank.

All these pumps are equipped with Type KE type stuffing boxes (gland) that require water under pressure control (usually at 0.7 bar (10 psi) above discharge pressure). Gland water must be proved before a pump can be turned on and if the gland water flow is low, the pump should be shut down.

The inlet piping to each pump is equipped with a flush water valve; during a routine shut down this valve is opened to allow the pump to flush itself and the discharge line to be flushed with process water.

The inlet piping to the HBF feed pumps is fitted with a 6" manual knife gate valve, while the two mixer / tailings disposal surge tank feed pumps are fitted with an 8" manual knife gate valve. These manual valves should always be open during operation. It is closed to do maintenance on the automated knife gate valve that feeds an individual pump.

3.3.3.3 Tailings Stock Tank (3128-TK-001)

The Tailings Stock Tank is a large, agitated tank that buffers the thickener from paste backfill production. This helps to minimize any variability in the slurry density to the mixer, the belt filter and the tailings disposal surge tank. It also allows the paste plant to continue operation during any interruptions in the thickener underflow. When not completely full, it offers buffering should backfill underground need to stop for short periods of time. This buffer also facilitates switching the underflow from the Thickener to the Tailings Disposal Surge Tank if the backfill rate is low without interfering with Thickener operation.

The Agitator (3126-AG-016) will operate continuously. Tank level is measured by a continuous level sensor (3128-LE-5401) while separate level switches are used for the high-level alarm (3128-LSHH-5402) and the low-level alarm (3128-LSLL-5402). The low level will protect the pumps from running dry.

The tank is connected to a pair of mixer feed pumps as well as a pair of filter feed pumps (one operating, one stand-by for both).

3.3.3.4 Horizontal Belt Filter Feed Pumps (3128-PU-001/2)

The Horizontal Belt Filter Feed pumps are similarly configured to the Tailings Thickener Underflow Pumps in terms of instrumentation and valving. This includes:

- Pump inlet – manual knife gate valves
- Pump inlet – automated knife gate valves (3128-XV-5411/5421)
- Water valves for flushing – globe valves (3128-XV-5412/5422)
- Draining of line – pump inlet – automated knife gate valves (3128-XV-5413/5423)
- Pump outlet – automated knife gate valves (3128-XV-5415/5425)
- Flow measurement (3128-FE-5432)
- Pressure measurement (3128-PE-5433)

If the slurry density is in the required range, the Horizontal Belt Filter as well as the Horizontal Belt Filter Feed Pumps will not be required. The Horizontal Belt Filter will only be operated when the slurry density is lower than the optimal range due to mineralogical variations.

If the density in the Tailings Stock Tank is not sufficient, then vacuum filtration will be required to increase the density of tailings. The flow and density measurements (3128-FE-5432 and 3128-DI-5461) will be used to control the pumps to maintain a target tailings feed rate to the filter. This target will be a set-point based on the slurry density that can be changed by the operator.

3.3.3.5 Mixer / Tailings Disposal Tank Feed Pumps (3128-PU-003/4)

The Mixer / Tailing Disposal Tank Feed Pumps are similarly configured to the Tailings Thickener Underflow Pumps and Horizontal Belt Filter Feed Pumps in terms of instrumentation and valving. This includes:

- Pump inlet – manual knife gate valves
- Pump inlet – automated knife gate valves (3128-XV-5441/5451)
- Water valves for flushing – globe valves (3128-XV-5442/5452)
- Draining of line – pump inlet – automated knife gate valves (3128-XV-5443/5453)
- Pump outlet – automated knife gate valves (3128-XV-5445/5455)
- Flow measurement (3128-FE-5462)
- Pressure measurement (3128-PE-5463)
- Density measurement (3128-DI-5461)

Using knife gate valves 3128-XV-5464 and 3128-XV-5466, the operating pump can pump tailings either to the Paste Mixer or to the Tailings Disposal Surge Tank. The system is only able to pump to one or the other, not to both at the same time. When pumping stops or when the location changes, the line no longer in use (to the mixer or tank) is drained by opening knife gate valves 3128-XV-5465 and 3128-XV-5467, respectively.

When paste backfill is being produced, the operating Mixer / Tailings Disposal Tank Feed Pump is controlled with the VFD such that the dry tailings in the slurry meet the set-point for plant throughput. If the Horizontal Belt Filter is operating, then the combined feed to the mixer and the filter are controlled to match the plant set-point.

When tailings are being pumped from the Tailings Stock Tank to the Tailings Disposal Surge Tank, the pump speed can be controlled based on the level of the Tailings Disposal Surge Tank.

3.4 Paste backfill and distribution

3.4.1 Reference P&IDs, drawings, and documents

Table 3.10 below shows a list of drawings.

Table 3.7 PFDs and P&ID drawings

Drawing no.	Title	Equipment
3128-A-0001	Paste Plant Process Flow Diagram	Contains major equipment from area 3126 and 3128 P&IDs
2153-A-0001	Underground Booster Station Process Flow Diagram	Contains major equipment from area 2153 P&IDs listed below
3128-PID-0014 RH	Binder System	Binder Unloading Blowers, Binder Silo Aeration Air Receiver, Binder Silo, Binder Silo Bin Vent, Binder Silo Rotary Valve, Binder Weigh Feeder and Belt Scale, Binder Screw Conveyors, Binder Silo Bin Vent Fan
3128-PID-0015 RH	Paste Mixer	Higher Pressure Wash Pumps, Paste Mixer, Paste Mixer Lubrication System, Wet Scrubber, Wet Scrubber Fan, Wet Scrubber Discharge Pump, Seal Pot
3128-PID-0016 RH	Paste Pumps	Paste Pumps. Paste Pump Hydraulic Power Units, Mixer Overflow Chutes, Diverter Valves, Diverter Valve Hydraulic Power Unit
3128-PID-0017 RH	Gland Water	Paste Plant Gland Water Valves and Instrumentation
2153-PID-0001	Underground Booster Station Flush Water Tank	Flush Water Tank, Flush Water Pumps
2153-PID-0002	Underground Booster Station Live Bottom Hopper	Live Bottom Hopper, Booster Station Sump
2153-PID-0003	Underground Booster Station Paste Pumps	Paste Pump, Paste Pump Hydraulic Power Unit, Diverter Valves, Diverter Vale Hydraulic Power Unit, Manual Transfer Stations

3.4.2 Major equipment

The major equipment for the tailings backfill area is listed in Table 3.11 below.

Table 3.8 Major equipment list

Equipment no.	Description	P&ID No.
3128-BL-021/022	Binder Unloading Blowers	0014
3128-TK-021	Binder Silo Aeration Air Receiver	0014
3128-SO-021	Binder Silo	0014
3128-BH-021	Binder Silo Bin Vent	0014
3128-RV-021	Binder Silo Rotary Valve	0014
3128-FE-021	Binder Weigh Feeder	0014
3128-CV-021/022	Binder Screw Conveyors	0014
3128-FA-023	Binder Silo Bin Vent Fan	0014
3128-PU-031/032	High-Pressure Wash Pumps	0015
3128-MX-031	Paste Mixer	0015
3128-LU-031	Paste Mixer Lubrication System	0015
3128-SB-031	Wet Scrubber	0015
3128-CA-031	Wet Scrubber Fan	0015
3128-PU-033	Wet Scrubber Discharge Pump	0015
3128-TK-031	Seal Pot	0015
3128-HY-041/042	Paste Pump Hydraulic Power Units	0016
3128-PU-041/042	Paste Pumps	0016
3128-CH-041/042	Mixer Overflow Chutes	0016
3128-HY-043	Diverter Valve Hydraulic Power Unit	0016
3128-DV-041/042	Diverter Valves	0016
2153-TK-001	Flush Water Tank	0020
2153-PU-001/002	Flush Water Pumps	0020
2153-HO-001	Live Bottom Hopper	0021
2153-PU-003	Underground Booster Station Sump	0021
2153-PU-020	Paste Pump	0022
2153-HY-020	Paste Pump Hydraulic Power Unit	0022
2153-HY-003	Diverter Valve Hydraulic Power Unit	0022
2153-DV-001/002	Diverter Valves	0022
2153-MT-002/003/004/005/006	Manual Transfer Stations	0022

3.4.3 Control description

3.4.3.1 Binder Silo (3128-SO-021)

The binder addition system includes a silo, a variable speed rotary feeder, a binder weigh feeder and a pair of screw conveyors in series to transfer the binder from the weigh feeder to the paste mixer.

Binder is delivered to Knipple Transfer Station in bulk trucks and stored in a dedicated silo. The binder will then be transferred into isotainers capable of holding 20 tonnes each, and subsequently weighed. These isotainers can then be transported to the Brucejack site.

At site, the isotainer is unloaded inside the mill building and moved with the overhead crane into position. There is space for 6 of the isotainers to be stored adjacent to the backfill binder system.

One of two Blowers (3128-BL-021 or 3128-BL-022) are used to transfer the binder from the isotainers into the binder silo. This will require that two hoses be connected to the isotainer, one from the blower to the isotainer to supply air and one from the isotainer to the silo piping which transports the binder into the silo.

A Bin Vent (3128-BH-021) with Fan (3128-FA-023) atop the silo filters and vents the pressurized air during charging of the silo to outside. The fan on the bin vent will only run when the silo is being charged.

Instrument air is used to pulse the filter to discharge any binder from the cartridges back into the silo. The pressure difference across the filter is also monitored (3128-PDIT-5525) and used to control pulsing to ensure good filter performance. The bin vent will allow air into the silo when binder is being drawn down.

While the binder system is operating, instrument air is used for aeration of the cone at the bottom of the silo (3128-XV-5527A/5527B/5527C) controlled by timer 3128-XC-5527 using Solimar fluidizers. This helps to avoid bridging and keeps the binder flowing into the binder silo rotary valve (3128-RV-021).

The silo is equipped with a continuous level sensor (3128-LI-5522). This will alarm if the level is too high, to prevent overfilling of the silo, will show when the silo is capable of receiving a full isotainer of binder, or too low to warn the operator that binder may run out during a pour.

A discreet level sensor 3128-LSHH-5523 will sense when the silo is full and will alarm the system which will turn on a horn (3128-YA-5522A) and a blue light (3128-YA-5522B) to warn the operator to shut down the silo filling system.

The binder silo storage capacity is 160 tons, in addition to six (6) isotainers which hold up to 20 tonnes each. This combines to a total capacity of 280 tonnes within the plant, sufficient to service approximately 36 hours (1.5 days) of continuous paste backfill plant operation at the design paste backfill rate of 145 dry t/h tailings, and at a binder consumption rate of 5% (7.7 t/h) (by dry weight paste backfill).

3.4.3.2 Binder Silo Rotary Valve (3128-RV-021)

The Binder Silo Rotary Valve serves to meter binder out of the silo and onto the Binder Weigh Feeder (3128-FE-021). It has a motor controlled by VFD, the speed of which is slaved to the head pulley of the weigh feeder.

The rotary valve is fitted with air purge seals and air is fed through 3128-XV-5528.

3.4.3.3 Binder Weigh Feeder (3128-FE-021)

The Binder Weigh Feeder receives binder from the Binder Silo Rotary Valve, and meters the binder based on the binder content specified in the recipe as well as the mass of tailings entering the Paste Mixer.

The Binder Weigh Feeder is equipped with a Speed Sensor (3128-SE-5533) and Load Cells (3128-WE-5533A/5533B) that measure the binder going across the weigh feeder. The Integrator (3128-WIT-5533) calculates binder added and varies it according to the recipe and the solids feed rate to control the VFD on the belt drive, which in turn will control the rotary valve.

During a normal shutdown of the binder addition system, the rotary valve should stop first and the binder weigh feeder run for a period of time to clear it of binder.

3.4.3.4 Binder Screw Conveyors (3128-CV-021/022)

The Binder Screw Conveyors simply transport the binder from the Binder Weigh Feeder into the Paste Mixer. They both operate at a fixed speed and should run whenever the weigh feeder is operating.

During a normal shutdown of the binder addition system, following the Binder Weigh Feeder stopping, the Binder Screw Conveyors should continue to run for a period of time to ensure they are empty.

The second Screw (3128-CV-022) is fitted with a sampling port for calibration purposes.

3.4.3.5 Paste Mixer (3128-MX-031)

The Paste Mixer is a twin shaft high shear mixer that operates in a continuous manner. The tailings slurry, filter cake, binder and water are all introduced into the top of the Mixer at one end.

At the opposite end of the Paste Mixer, there are two overflow ports and each goes to a separate chute that carries the mixed paste from the Mixer to one of two paste pumps. These chutes are isolated from the Mixer with automated square knife gate valves (3128-XV-5577/5581), so that the paste will only flow into the chute for the corresponding paste pump that is being used.

Each chute is outfitted with a level sensor (3128-LI-5574/5584). This sensor is used to control the stroke rate of the paste pump to maintain a constant head of material in the chute. It is backed up by pressure transmitters in each chute (3128-PIT-5573/5585). An inspection hatch is located on the chute for viewing as well as cleaning of the chutes at the end of every pour. A separate sampling chute is used for collection of paste that is required for slump tests during the pour, the results of which are used to tune the target density for the paste. Paste is also collected from the chute for casting cylinders that are stored and tested for strength after a certain amount of time as part of the QA/QC program for backfill.

The level in these chutes will be slightly lower than the level as the paste inside the Mixer and will be used to help control the speed of the paste pumps.

The inlet to each square valve 3128-XV-5571/5581 has a trash screen with 30 mm openings which will prevent large debris from entering the pumps or the UDS.

The initial cleaning of the Mixer is accomplished with process water that is piped to the Mixer by Valve 3128-XV-5556. When the Mixer has been flushed of product, the Mixer is emptied by Knife Gate Valves 3128-XV-5572 and 3128-XV-5582 opening and closing alternately so that the local sump is not overflowed. The mixer is 5 m^3 when full and can be emptied in ~15 seconds when both 10” drain valves are fully opened; the receiving sump has a capacity of 1 m^3. The drain valves will have to opened and closed several times to empty the mixer without overflowing the sump. After the mixer has been emptied, the high-pressure wash will run 6 wash heads in the mixer individually for ~2 minutes each. This wash water is pumped at 100 bar (1,450 psi) and is extremely dangerous. It must be stressed that access hatches to the Mixer must stay shut during mixing and especially during cleaning. Although these hatches have limit switches which will shut down the Mixer or the high-pressure water pumps, operators need to be advised of the potential hazard. When the cleaning cycle is complete, the water in the Mixer (~1.5 m^3) should be drained to the sump in the method described above.

When water no longer flows from the Mixer, water to the Paste Pump Chutes (3128-CH-041 or 3128-CH-042) is fed by Valves (3128-XV-5557/5558 and 3128-FCV-5555) for cleaning of the

system and flushing of the distribution system. The flow control valves are used based on level measurement in the chute to avoid overfilling while cleaning.

Following that, the cleaning of the Paste Mixer and Chutes is performed using a high-pressure washing system. Automatic, rotating nozzles allow the high-pressure water to wash down all the interior surfaces of the mixer after it has been drained. Six spray nozzles are mounted on the mixer with solenoids prior to each so they can be sequenced by the control panel located on the mixer. After the nozzles have finished their cycles, the water inside shall be emptied using the dump valves (3128-XV-5572 and 3128-XV-5582).

The clean-up sequence is designed to automatically clean and empty the mixer and the chutes once a pour is completed. This includes draining of the mixer with automated valves to a Sump (XV-5572/5582). The drain valves will have to be cycled throughout the clean-up and tied into the level of the sump as the volume and pumping capacity of the sump requires that the mixer be drained in stages. However, the chutes require manual cleaning with a high-pressure spray wand at the end of every pour.

Sensors on the Paste Mixer doors (ZY-5541A/5541B) will alarm if the doors are opened while the mixer is operating, and will interlock the mixer motors, shutting them down.

3.4.3.6 High-Pressure Wash Pumps (3128-PU-031/032)

The High-Pressure Wash Pumps is automated to turn on as part of the shutdown sequence in order to supply the spray nozzles within the Paste Mixer with high-pressure water.

The pumps also supply high-pressure water to wands that are used to clean up the mixer and chutes following a pour. The operator is required to manually turn a pump on prior to using the wands. These pumps produce water at a pressure of 100 bar (1,450 psi). These wands should be used with extreme caution.

Sensors on the Paste Mixer doors (ZY-5541A/5541B) will alarm if the doors are opened while the high-pressure wash system is operating, and will interlock the pump motors, shutting them down.

3.4.3.7 Wet Scrubber (3128-SB-031)

The Wet Scrubber is fed process water which passes through nozzles to make a fine mist inside the scrubber. The water feeding the scrubber is monitored for flow (FE-5562/5563) and pressure (PI-5565A/5565B) to ensure that the scrubber is operating properly.

The Wet Scrubber Fan (3128-FA-031) is attached to the body of the scrubber which pulls air from the Paste Mixer, through the scrubber and vents to outside the building. Air pressure measurement near the scrubber inlet and exit helps to monitor the scrubber's performance (3128-PI-5564A/5564B). Fan performance is monitored by pressure measurements (3128-PG-5565A/5565B).

The Seal Pot (3128-TK-031) helps to ensure that a seal is maintained at the bottom of the scrubber, by provided water against which the fan pulls. A valve on the process water into the Seal Pot (3128-XV-5568) helps to maintain a level of water inside the Seal Pot (3128-LS-5568). A low-level switch will alarm if the level in the Seal Pot drops (3128-LSLL-5699).

The primary reason for the scrubber is to minimize any airborne binder from escaping the paste mixer and ending up in the atmosphere.

A second line pulls a slight negative pressure on the binder weigh belt feeder.

A discharge pump (3128-PU-0330) is used to pump water and collected binder from the scrubber back to the Tailings Thickener Feed Tank. The VFD for this pump is controlled to maintain a target level of water inside the cone at the bottom of the scrubber, measured by 3128-LI-5566.

The Wet Scrubber is automated to run whenever the binder addition system or the mixer is in operation.

3.4.3.8 Paste Pumps (3128-PU-041/042)

Two hydraulic driven piston paste pumps are located underneath the mixer, one fed by each of the overflow chutes. One is operated when backfilling, with the other in standby mode.

Each pump has its own hydraulic power pack (3128-HY-041/042) that is used to drive the pump. The power pack uses the pressurized hydraulic fluid to alternately push paste from the two cylinders of the paste pump. The flow rate of the hydraulic fluid controls the paste pump speed, which in turn controls the flow rate of the cemented paste backfill. This is varied to maintain level in the overflow chute.

These pumps will normally run at 80 bar but are capable of 150 bar. There are progressive alarms at increasing pressure.

High-pressure reflects a reduction of flow that could have many causes; a pipe restriction, a partial plug in the line, an incorrectly chosen mix due to changes in minerology. Taking slump measurements on a regular basis is key to preventing pressure build-up due to mix irregularities. Communications between the paste pump(s) operator(s) and the pour site is essential. The pour site can confirm flow of slick water first, can confirm paste (by colour), and rate decrease during instances of higher than normal pressure.

Two manually operated diverter valves are located after the paste pumps. One to switch between the two pumps and also to allow for the insertion of pigs for cleaning the line (3128-DV-041), and a second one (3128-DV-042) to switch between the two trunk lines that connect the paste plant to the UDS and Booster Station. The diverter valves are powered by their own hydraulic power unit (3128-HY-043). The Paste Pumps are interlocked to stop pumping prior to actuation of either diverter valve. The Paste Pump should be locked out and tagged out and pressure proved to be zero before the pig insertion process is initiated.

Pressure sensors (3128-PI-5597/5598) following the paste pumps are used to monitor the operation of the pumps. The PCS will have to filter the pressure readings so that spikes associated with changes between paste pump strokes are not seen as high-pressure alarms. Additional pressure sensors (3128-PI-5601/5602 and PI-5603/5604) following the diverter valves are spaced 100 m apart in order to provide real time feedback on system pressure losses, which will help with the safe operation of the UDS.

Density measurement (3128-DI-5591) is performed between the diverter valves which will monitor the final density of the paste backfill leaving the plant. This, along with the strokes rate of the paste pump will give indication to the mass flow rate of paste.

4 Mill paste plant standard operating procedures

This section summarizes the SOPs developed to establish the mandatory requirements for the safe and responsible working standards for operating the Paste Plant.

4.1 List of SOPs

The following SOPs are summarized in this section:

- BJ-PBF-SOP-551 Paste Plant Start-up Procedure (Control Room)
- BJ-PBF-SOP-553 Paste Plant Shutdown Procedure
- BJ-PBF-SOP-555 Transfer of Binder from ISO-VEYOR to Bulk Storage Silo
- BJ-PBF-SOP-557 Casting of Cylinders for Strength Test - Underground
- BJ-PBF-SOP-558 Casting of Cylinders for Strength Test
- BJ-PBF-SOP-559 Determination of Unconfined Compressive Strength for Cylinders
- BJ-PBF-SOP-560 Diverter Gate Operation & Pigging Procedure
- BJ-PBF-SOP-562 Paste Plant Mixer Cleaning
- BJ-PRO-SOP-564 Operating Overhead Door with Safety Edge Bypassed

4.2 BJ-PBF-SOP-551 Paste plant start-up procedure (control room)

4.2.1 Objective

To establish mandatory requirements for the safe and responsible working standards for starting up the Paste Plant.

4.2.2 Scope

This SOP covers the process and procedures which are used to start up the Paste Plant.

4.2.3 Health, safety & reclamation code of BC

Section 1.11.1 (Training)

4.2.4 Definitions

- DCS
  - Distributed Control System: a computerized control system for a process or plant usually with a large number of control loops, in which autonomous controllers are distributed throughout the system, but are monitored by a central control operator.
- MAN
  - Manual mode: term used when the control parameters within the DCS are switched to operator (human) control.
- AUTO
  - Automatic mode: term used when the control parameters are monitored by the DCS.
- CAS
  - Cascade mode: term used in DCS control when one parameter or parameter dictates when another parameter is activated or deactivated.
- No.
  - Abbreviation for "number"
- CRO
  - Control Room Operator

- Paste Watcher
  - Person responsible for monitoring the paste fill UG.
- Paste Operator
  - Person responsible for monitoring the paste plant.
- TPH
  - Acronym for "Tonnes per hour"
- M^3/hr - abbreviation for flowrate: cubic meters per hour.

4.2.5 Preparation

- Hazards
  - No hazards.
- Tools
  - No additional tools required to complete task.
- Requirements
  - Must be trained to operate the DCS or work within close contact with a trained operator.

4.2.6 Job steps

1 Paste Discussion Telephone Meeting (Person Responsible – Mill Operations Supervisor, Procon Underground Supervisor, Mine Captain and Control Room Operator)
   - A discussion will be held by all parties to ensure everyone is aware and in agreement of the paste backfill plan.

2 Prestart Checks (Person Responsible – Control Room / Paste Operator)
   - Procon Supervisor or Paste Watcher will contact Mill Control Room when they are ready to receive paste as discussed in a telephone meeting.
   - Ensure stope fill, paste and binder information has been provided to the underground paste watcher and they are ready to accept paste. **NOTE: Contact Procon Paste Watcher on Channel 5 (BJC: Paste). If the Paste Watcher cannot be reached, the CRO will contact the Procon Supervisor on Channel #2 (Underground: Mine Ops).**
   - **NOTE: All advice and directives from the Underground Paste Watcher must be adhere too.**
   - Check the level in the Tailing Stock Tank (5401) to ensure there is adequate material for paste mixing.
   - Check the Binder Silo level (5522) to ensure there is adequate material for paste mixing.
   - Ensure the diverter gates on the underground paste distribution lines are in the correct positions.
   - Ensure the paste pump hydraulic system temperature is within operating range. If the paste pump hydraulic system temperature is not within operating range, contact Paste Plant Operator to resolve issue.
   - Call Paste Operator to verify manual rinsing chamber water is on.
   - Ensure that binder recipe is to set point per stope requirements.

3 Start Wet Scrubber (Person Responsible - Central Control Room Operator / Paste Operator)
   - Open Wet Scrubber Fresh Water Supply Valve (5561).
   - Start Wet Scrubber Exhaust Fan (FA031M) at 50% speed and adjust as needed for dust extraction.

4 Start Paste Mixer (Person Responsible - Central Control Room Operator)
- Close Paste Mixer drain valve (5572/5582).
- Open Paste Mixer overflow valve (5571/5581).
- Start Paste Mixer (MX031M1) and fill mixer with water until overflows into desired pump - will be indicated with the paste pump level sensor when it overflows or have the Paste Operator verify visually.

5 Start Binder Delivery System (Person Responsible- Central Control Room Operator)
- Start Binder Screw Conveyor No.2 (CV022).
- Start Binder Screw Conveyor No.1 (CV021).
- Start Binder Weigh Feeder (FE021) and set to auto.
- Ensure Binder Silo Vent (5527) and Binder Silo Aeration supply (5528) are in CAS mode.
- Ensure Rotary valve (RV021) in CSA mode. This will cause the Binder Silo Vent (5527) and Binder Silo Aeration supply (5528) to open automatically once tailing has been received to the mixer.
- Ensure Binder Weigh Feeder controller (WIC5533) is in CAS mode.

6 Start Paste Pump (Person Responsible- Central Control Room Operator)
- Ensure the correct paste pump duty is “Selected”.
- Start the hydraulic unit for the selected paste pump (PU41HU/PU042HU).
- Set Paste Mixer Chute Level (LIC5574/5584) to 90% set point in MAN mode.
- Open Paste Mixer and Chute Flush Water valve (FIC55555) and put the set point to 70 to 80 m^3/hour in AUTO mode.
- Start the selected Paste Pump (PU041DH/PU042DH) and set the speed to 10% in MAN mode.
- Open desired Paste Mixer Chute valve (5557/5558). Increase the paste pump speed accordingly to maintain level (90%) in the chute (40 to 50% speed).
- Flush / Slick underground distribution paste line until Paste Watcher confirms clear flow of water exiting the pipe and there are no leaks on the distribution paste line.
- Turn water off to chute and all contributing valves are close (5555/5556/5557/5558).

7 Start Tailings Stock Delivery System to Paste Mixer in "Manual" Mode (Person Responsible - Central Control Room Operator)
- Set Mix Feed Pump controller to 80 TPH of feed (FIC5462) in AUTO mode. This is to allow a “softer start” as requested by vender.
- Open Tailings Stock Tank Feed Pump to Mixer valve (5464).
- Open "Pump Select" faceplate and sure that the desired pump (5445/5455) is selected as duty.
- Ensure Drain valve and gland water is in CAS mode.
- Open the desired discharge valve and suction valve on mixer feed line.
- Start desired Mixer feed pump (5445/5455 in AUTO mode.

4.3 BJ-PBF-SOP-553 Paste plant shutdown procedure

4.3.1 Objective

To establish mandatory requirements for the safe and responsible working standards for shutting down the Paste Plant.

4.3.2 Scope

This SOP covers the process and procedures which are used to shut down the Paste Plant.

4.3.3 Health, safety & reclamation code of BC

Section 1.11.1 (Training)

4.3.4 Definitions

- DCS
  - Distributed Control System: a computerized control system for a process or plant usually with a large number of control loops, in which autonomous controllers are distributed throughout the system, but are monitored by a central control operator.
- MAN
  - Manual mode: term used when the control parameters within the DCS are switched to operator (human) control.
- AUTO
  - Automatic mode: term used when the control parameters are monitored by the DCS.
- CAS
  - Cascade mode: term used in DCS control when one parameter or parameter dictates when another parameter is activated or deactivated.
- No.
  - Abbreviation for "number".
- CRO
  - Control Room Operator.
- Paste Watcher
  - Person responsible for monitoring the paste fill UG.
- Paste Operator
  - Person responsible for monitoring the paste plant.
- TPH
  - Acronym for "Tonnes per hour".
- UG
  - Underground.
- Pig
  - A device to clean and scour pipes / lines.

4.3.5 Preparation

- Hazards
  - No hazards.
- Requirements
- Must be trained to operate the DCS or work within close contact with a trained operator.

4.3.6 Job steps

1 Stopping Tailings Stock Delivery to Paste Plant

2 All contact will be made on Paste Channel #5

- Inform Procon Underground Paste Watcher / Booster Station Operator that the Paste Plant will be shutting down and the flush will start.
- Dependent on Tails Stock Tank level requirements, switch Tails Paste Thickener U/F to Tails Disposal Surge Tank.

3 Stop Paste Mixer / Binder Delivery System

- Stop Paste Mixer Feed Pump (003/004).
- Close Paste Mixer Feed Pump suction valve (5441/5451).
- Open Paste Mixer Feed Pump flush valve and flush line and mixer for 15 min (5442/5452).
- Start Paste Mixer Feed Pump (003/004), run in manual at about 12 to 15% speed.
- Flush Mixer feed line for 15 minutes or until the density gauge (FI5462) reaches 0% solids.
- Stop Paste Mixer Feed Pump (003/004).
- Ensure Binder Rotary Valve (RV021) is down. (When in CAS will shut down on low mixer feed density).
- Ensure Binder Weigh Feeder (FE021) is run off by checking that Weightometer (WIC5533) is reading 0 TPH.
- Allow feeder and screws to run for 5 to 10 minutes to ensure all residual binder has been run off.
- Stop Binder Weigh Feeder (FE021).
- Stop Binder Screw Conveyor No.1 (CV021).
- Stop Binder Screw Conveyor No.2 (CV022).
- Close Paste Mixer Feed Pump flush valve (5442/5452).
- Open Paste Mixer Feed Pump drain valve (5443/5453).

4 Flush Paste Mixer

- Close Mixer Slump Control water valve (5551).
- Inform Paste Plant Operator to start High-Pressure Pump (PU31/32) and run a 15-minute wash cycle.
- Adjust Paste Pump in Man mode to achieve a level (90 to 93%) in chute and put paste pump into AUTO.
- Flush water through the Paste Mixer for a minimum of 5 minutes. Call the Paste Operator to verify that the mixer has had enough flush time.

5 Flush Paste Line

- Contact Procon Underground Paste Watcher and inform that the 1-hour flush of the paste line has been initiated.
- Once the mixer has been flushed. Open Chute Flush Water Valve (5557/5558)
- Close paste feed pump valve (5442/5452).
  - NOTE: Ensure all processes have been turned off to mixer before closing overflow valve.
- Close Mixer Overflow Valve (5571/5581). Verify with operator that the valve fully closed.
- Adjust Paste Mixer and Chute Flush Water Controller (FIC5555). Dependent on water availability aim for 50 m^3/hr.

- Adjust paste pump speed to 40% output in MAN to achieve a level (90 to 93%) in chute and put paste pump into AUTO.
- Line is to be flushed until Paste watcher confirms.
- Adjust Paste Mixer and Chute Flush Water Controller (FIC5555) in MAN mode to a flowrate of 0 m^3/hr.
- Draw down the Paste Mixer Pump Chute.
- De-energize Paste Pump (041DH/042DH).
- Pig the Paste Line to Underground.
- Contact Paste Plant Operator to insert the clean out pig. (Refer to: BJ-PBF-SOP-560-Diverter Gate Operation & Pigging Procedure). If the Booster Station is running contact the Booster Operator also. Refer to: (BJ-PRO-SOP-570 Operating Underground Booster Station) for the shutdown procedure of the Booster Station.
- Contact Procon Underground Paste Watcher and inform them that a hard pig has been inserted into the paste line and flushing will re-initiate and to make contact when pig has been received.
- Start Paste Pump (041DH/042DH) and adjust in MAN mode to 40% speed.
- Adjust Paste Mixer and Chute Flush Water Controller (FIC5555) dependent on water availability aim for 50 m^3/hr.
- Adjust paste pump speed to 40% output in MAN to achieve a level (90 to 93%) in chute and put paste pump into AUTO.
- When confirmation has been received from the Paste Watcher that the hard pig has exited the paste line: De-energize the paste pump and repeat the above steps for the soft pig. If there is a T valve installed have the Paste Watcher open after the soft pig exits for remainder of flush.
- Once the 1-hour flush has been completed adjust Paste Mixer and Chute Flush Water Controller (FIC5555) to 0 m^3/hr.
- Close Process Water to Paste Mixer Chute (5557/5558).
- Draw down the Paste Mixer Pump Chute and de-energize Paste Pump (041DH/042DH).
- De-energize the Paste Pump Hydraulic Unit.
- Emergency contacts in the event of paste line failure.
- In the event, that there is a diverter gate or pump failure and unable to flush the paste line, the CR operator will contact the Supervisor and / or Mill Operation Superintendent / Mill Manager, who will then notify, within 30 minutes, the Mine Captain and / or Mine Manager.
- The Control room operator will email the Paste Update group on the status of the paste line clearing as they receive updates or as required.

6 Stop Wet Scrubber System (Person Responsible - Control Room Operator)

- Commence Wet Scrubber System shutdown after the paste plant has been down for a minimum of 30 minutes.
- Close Water valve (5561).
- Stop Wet Scrubber Fan (FA031).

4.4 BJ-PBF-SOP-555 Transfer of binder from ISO-VEYOR to bulk storage silo

4.4.1 Objective

To establish mandatory requirements for the safe and responsible working standards for transferring Binder from the ISO-Veyor to the Bulk Storage Silo.

4.4.2 Scope

This SOP covers the process and procedures which are used to transfer binder from the ISO-Veyor to the Bulk Storage Silo.

4.4.3 Health, safety & reclamation code of BC

Section 1.11.1 (Training)

4.4.4 Definitions

- ISO – container
  - A tank container which is built to the ISO standard (International Organization for Standardization). ISO tanks are suitable for multiple transportation methods such as truck, rail, or ship.

4.4.5 Preparation

- Hazards
  - Elevated noise levels
  - Dust (binder)
  - Pinch points
  - Caustic material (binder)
  - Overhead load (crane operation)
  - Slip, trips, & falls
- Tools
  - Pretium standard PPE
  - Half mask or full-face respirator
  - Wire brush
  - Keeper pins
  - Whip stops
- Requirements
  - Must be trained or working within close contact with a trained operator.
  - Air Purifying Respirator Evaluation & Fit Test.

4.4.6 Job steps

1 Pre-Start Checks (Person Responsible- Paste Plant Operator)
  - Once the ISO-container is staged, ensure the following conditions are met:
    - Ensure the silo vent fan and baghouse air are on.
    - Ensure vent valve is open and there is no pressure in ISO-container.
    - Top air vent valve is closed.
    - Material discharge valves are closed.
    - Aeration valves (6) are closed.
    - Boost valve is fully closed.
    - Ring jet is closed.

2 Hose Connections
  - Remove the cap from the ISO-container connector ports (Both feed and discharge ends).
  - Ensure gasket is seated in coupler.

- Connect both air intake and binder discharge hoses to the corresponding ISO-container connections.
- **NOTE: All keeper pins and whip stops must be in place before progressing onto the next step.**

3 Pressurizing the ISO-container

- Close the vent valve.
- Ensure blower discharge valve is open.
- Air inlet and binder discharge valves opened at header.
- Open all (6) aeration valves.
- Energize the Binder Unloading Blower (021M/022M).
- Allow the ISO-container to pressurize to approximately 1.2 bar / 120 kPa.
- **NOTE: Do not exceed 2.0 bar / 200 kPa.**

4 Discharging ISO-container

- When the pressure within the ISO-container reaches operating pressure (approx. 1.2 bar / 120 kPa), open top air vent valve and open the boost valve ¼ of the way.
- Close the aeration valves for bay 1 and bay 3.
- Open the discharge valve for bay 2.
- **NOTE: If the pressure in the ISO-container is increasing, open the boost valve accordingly to maintain adequate pressure. (1.2 - 1.8 bar / 120 – 180 kPa).**
- Discharge is complete when a drop in tank pressure is indicated on the pressure gauge.
- Close the Discharge Valve for bay 2.
- Open aeration valves for bay 3.
- Open the Discharge valves for bay 3.
- Close the Aeration valve for bay 2.
- **NOTE: If the pressure in the ISO-container is increasing, open the boost valve accordingly to maintain adequate pressure. (1.2 - 1.8 bar / 120 - 180 kPa).**
- Discharge is complete when a drop in tank pressure is indicated on the pressure gauge.
- Close the discharge valve for bay 3.
- Open the aeration valve for bay 1.
- Close the Aeration valve for bay 3.
- **NOTE: If the pressure in the ISO-container is increasing, open the boost valve accordingly to maintain adequate pressure. (1.2 - 1.8 bar / 120 – 180 kPa).**
- Discharge is complete when a drop in tank pressure is indicated on the pressure gauge.
- Close the discharge valve for bay 1.
- Open the aeration valves for bay 2
- Close aeration valves for bay 1.
- Repeat process for bay 2 to empty the ISO-container.
- Discharge is complete when a drop in tank pressure is indicated on the pressure gauge.
- Close discharge valve for bay 2.
- Close aeration valves for bay 2.
- Fully open boost valve to purge material remaining in discharge line.
- De-energize the blower.

5 Depressurizing the ISO-container

- Open vent valve slowly to bleed off pressure.

- Ensure boost valve is open.
- When the ISO-container pressure gauge displays 0 bar and you can no longer hear air discharging from the vent, remove locking pins disconnect the discharge hose and the blower hose from the ISO-container.
- Install the shipping caps onto the ISO-container connector ports.

4.5 BJ-PBF-SOP-557 Casting of cylinders for strength test – underground

4.5.1 Objective

To establish mandatory requirements for the safe and responsible working standards for collecting paste samples and casting of cylinders for strength test.

4.5.2 Scope

This SOP covers the process and procedures which are used to determine the optimal binder ratios relative to strength of the backfill material.

4.5.3 Health, safety & reclamation code of BC

- Section 1.11.1 (Training)
- Sections 1.8.2, 1.8.3, 1.8.4, and 1.8.5 (Personal Protective Equipment)

4.5.4 Definitions

- UCS
  - Unconfined Compressive Strength.
- TAMP
  - To press down lightly in an up and down motion.
- QA/QC
  - Quality Assurance / Quality Control.
- UG
  - Underground Preparation.

4.5.5 Preparation

- Hazards
  - Noise
  - Respiratory
- Tools
  - Pretium Standard PPE
  - Recommended Half-Mask Respirator
  - Ensure all the following materials are available before proceeding:
    - Bucket or pail
    - Slump Cone & Tamping Rod
    - 3 x 3 Plywood Board
    - Ruler
    - Trowel
    - UCS Cylinders
    - Knife

- Duct tape
- Sharpie
- Plastic
- Elastics
- Milk crate

- Requirements
  - Must be trained to operate the Paste Plant or work within close contact with a trained operator.
  - Underground Orientation.

4.5.6 Job steps

1 Determination of Time Delay (Person Responsible - Control Room Operator)
   - Control Room Operator will determine the time delay it takes for paste to leave the mill and reach the stope. This time delay is communicated to the Surface and UG Paste Operators at the beginning of each stope and used for the entire length of the pour.

2 Communication (Person Responsible - Surface Paste Plant Operator)
   - When surface samples have to be taken, the Surface Paste Plant Operator must contact the UG Paste Operator and inform them the exact time of sampling.
   - The UG Paste Operator will use the time delay to determine what time to take the underground samples.

3 UCS Cylinder Preparation (Person Responsible - UG Paste Operator)
   - Cut each cylinder and using duct tape, seal each cylinder split seam.
   - Label each cylinder as follows: YYYY-MMM-DD HH:MM UG. Example: 2017- SEP-19 09:45 UG. The date (YYYY-MMM-DD) can be written in advance of sample collection, but the time (HH:MM) must be written just before sampling. Ensure that UG is specified on all the cylinders.

4 Sample Collection (Person Responsible - UG Paste Operator)
   - Sample collections are conducted using the information from the Surface Paste Operators and the time delay.
   - Underground samples are only to be taken on dayshift.
   - 1 sample set equals 4 cylinders (2 x 7 day and 2 x 28 day samples).
   - Ensure latex or rubber gloves are donned prior to collecting sample.
   - Place pail under sample pipe extending off the T-Valve.
   - Open the T-Valve and collect enough paste to perform a slump and pour 4 cylinders.
   - Procon Paste Watcher can assist with collection of samples as needed.

5 Slump Test (Person Responsible - UG Paste Operator)
   - Place the slump cone on the wetted 3'x3' plywood. Ensure the surfaces of both the plywood and the cone are clean and moistened with water to eliminate sample sticking to equipment.
   - Stand on the foot tabs of the cone to hold it firmly during filling, taking precaution to keep constant force with little to no movement.
   - Fill the cone in three layers, each approximately one third the volume of the cone. Each layer is tamped with 25 strokes and uniformly distributed over the cross section of the cone. The second and top layers each are tamped throughout their depth, so that the strokes penetrate into the previous underlying layer.

- After the top layer has been rodded, the surface of the backfill material is stricken off at the top of the cone with the steel rod, so that the cone is exactly full.
- Lift the cone straight up and away from the backfill material counting slowly to 5, taking precaution to lift uniformly. Invert the cone and place it next to the slumped pile of backfill material gently ensuring not to disturb the slumped material. Place the steel rod horizontally across the inverted cone, so that the rod extends over the slumped material.
- Measure the distance between the bottom of the steel rod and the top of the slumped pile of material at three intervals across the top of the pile using a meter stick or ruler in inches. Record the Slump on the raw data Casting Sheet.

6 Filling UCS Cylinders with Sample (Person Responsible - UG Paste Operator)

- Fill each UCS cylinder (4), to a height of approximately 1/3 of the total height of the UCS cylinder.
- Tamp each UCS cylinder 25 times.
- Fill each UCS cylinder (4) to a height of approximately 2/3 of the total height of the UCS cylinder.
- Tamp each UCS cylinder 25 times.
- Fill each UCS cylinder (4), so that each UCS cylinder is full to top.
- Tamp each UCS cylinder 25 times.
- Cover UCS cylinders (4) with plastic and secure with elastic bands.

7 Sample Collection and Storage (Person Responsible- UG Paste Operator)

- Transport all 4 UCS cylinders directly to the curing chamber using a milk crate or similar container in a timely manner. Note: Cylinders must directly be transferred to the humidity lab and cannot be temporarily stored in any location.
- Place two UCS cylinders into each curing time shelf.

8 Data Collection (Person Responsible- UG Paste Operator)

- Fill in the Paste Casting Sheets and document that the samples were taken underground.
- Hand in Casting Sheets to the Metallurgist Group upon completion.

9 Clean up (Person Responsible- Paste Plant Operator)

- Clean up work area and tools.
- Place tools in proper storage area.

4.6 BJ-PBF-SOP-558 Casting of cylinders for strength test

4.6.1 Objective

To establish mandatory requirements for the safe and responsible working standards for casting of cylinders for strength test.

4.6.2 Scope

This SOP covers the process and procedures which are used to determine the optimal binder ratios relative to strength of the backfill material.

4.6.3 Health, safety & reclamation code of BC

- Section 1.11.1 (Training)
- Sections 1.8.2, 1.8.3, 1.8.4, and 1.8.5 (Personal Protective Equipment)

4.6.4 Definitions

- UCS
  - Unconfined Compressive Strength.
- TAMP
  - To press down lightly in an up and down motion to achieve a homogenous solution without any air bubbles, deformities, etc.
- QA/QC
  - Quality Assurance / Quality Control.

4.6.5 Preparation

- Hazards
  - Noise
  - Corrosive material
- Tools
  - Ensure all the following materials are available before proceeding:
    - UCS Cylinders
    - Scoop
    - Slump Cone
    - Moisture Tins
    - Tampering Rod
    - Small Taming Rod
    - Oven
    - Curing Room
    - Duct tape
    - Marker Pen (Sharpie)
- Requirements
  - Must be trained to operate the Paste Plant or work within close contact with a trained operator.

4.6.6 Job steps

1 UCS Cylinder Preparation (Person Responsible - Paste Plant Operator)
  - Regular sample set include 2 cylinders for 7/14/28/365 Days.
    - Under special circumstances two cylinders for 21days may be required.
    - only cast these extra samples at the direction of the Geotechnical department.
  - Using duct tape, seal each cylinder split seam.
  - Label each cylinder as follows: YYYY-MMM-DD HH:MM. Example: 2017- SEP-19 09:45. The date (YYYY-MMM-DD) can be written in advance of sample collection, but the time (HH:MM) must be written just before sampling.

2 Sample Collection (Person Responsible - Paste Plant Operator)
  - Sample collections are conducted under the following conditions.
  - Sample collections are conducted under the following conditions.
    - At least 1 hour after start-up and circuit is stable.
      - Ensure water isn't being added.
      - if % solids, binder % ore fill rate is outside of normal operating parameters.

- If recipe changes during the shift.
- Ensure latex or rubber gloves are donned prior to collecting sample.
- Inform Control room that you will be taking a slump sample so they can put paste pump into manual mode as not to interfere with the level control of the paste hopper.
- Transfer the required amount of sample from the sample port into a clean collection pail to fill the required casting cylinders.

3 Filling UCS Cylinders with Sample (Person Responsible - Paste Plant Operator)

- Fill each UCS cylinder (8), to a height of approximately 1/3 of the total height of the UCS cylinder.
- Tamp each UCS cylinder 25 times.
- Fill each UCS cylinder (8) to a height of approximately 2'3 of the total height of the UCS cylinder.
- Tamp each UCS cylinder 25 times.
- Fill each UCS cylinder (8), so that each UCS cylinder is full to top.
- Tamp each UCS cylinder 25 times.

4 Sample Collection Storage (Person Responsible- Paste Plant Operator)

- Transport the 7 day / 14 day / 28 day UCS cylinders to the curing chamber located adjacent to the Paste Plant lab.
- Place two UCS cylinders into each curing time shelf
  - Starting at the left-hand side moving clockwise.
  - For each type of sample (7, 14, 21, and 28 day).
    - Ensure the new samples are placed at the end of the block of samples.
    - Each row will store 3 sets (6 cylinders deep).
    - Once the current shelf is full, move to the next shelf in sequence.
    - Once the last shelf is full, there should be room to restart storing samples at the upper left-hand shelf.
    - Remember 21 is a priority stope and is only cast at the direction of the Geotechnical Department).
- Please keep the cylinders in order, if you are unsure ask your supervisor for clarification.
- Transport the 365 cylinders to the new curing room (located beside the Met lab under the tails thickener).
  - Starting at the left-hand side spiralling down clockwise.
  - Samples are stored 2 sets (4 samples) per row.
  - The room is set up in similar fashion to the original curing room. The start is at the top left corner and spirals downward. Please keep the samples in order.

5 Data Input (Person Responsible- Paste Plant Operator)

- Fill out the Casting Paste Cylinders Log sheet.
  - A new sheet is required for each Set of Cylinders (8).
  - Ensure you record the actual date and time.
  - Hand in the sheet (along with all other Paste operator sheets) to the Metallurgists Office.

6 Data Input (Person Responsible – Metallurgy)

- Ensure all Casting sheets were handed in. If sheets are missing, contact the Mill Operations Supervisor or Paste operator for clarification.

- Scan and save the Casting Paste Cylinders Log sheet in the following folder, under the appropriate Year / Month.
- J:\Mill Tech Services\PASTE BACKFILL\99-Paste Lab - QAQC\Strength Testing\01 Casting Sheets

7 Clean up (Person Responsible- Paste Plant Operator)

- Clean up work area and tools.
- Place tools in proper storage area.

4.7 BJ-PBF-SOP-559 Determination of unconfined compressive strength for cylinders

4.7.1 Objective

To establish mandatory requirements for the safe and responsible working standards for determining the UCS for cylinders.

4.7.2 Scope

This SOP covers the process and procedures which are used to determine the optimal binder ratios relative to strength of the backfill material.

4.7.3 Health, safety & reclamation code of BC

- Section 1.11.1 (Training)
- Sections 1.8.2, 1.8.3, 1.8.4, and 1.8.5 (Personal Protective Equipment)

4.7.4 Definitions

- UCS
  - Unconfined Compressive Strength.
- ARD
  - Acid Rock Drainage.
- QA/QC
  - Quality Assurance / Quality Control.
- kN
  - Abbreviation for kilo newton. A newton is the Standard International (SI) unit of force. One Newton is the force required to cause a mass of one kilogram to accelerate at a rate of one meter per second squared.
- Failure Threshold
  - Defines the load at which the machine starts looking for a failure. The machine ignores any failures below this level.
- Loading Rate
  - The rate at which the machine applies force to the sample specimen.

4.7.5 Preparation

- Hazards
  - Noise
  - Corrosive material
- Tools
  - Karol Warner Compression Machine Core sample saw
  - Ruler (or callipers)

- Scale
- Dust mask (recommended)
- Computer with Unconfined software installed

4.7.6 Requirements

Must be trained to operate the Paste Plant or work within close contact with a trained operator.

4.7.7 Job steps

1 USC Cylinder Preparation and Collection (Person Responsible - Paste Plant Operator)

- Obtain the list of cylinders to be broken from Metallurgy or Geotechnical Department (usually 7-10 days worth of cylinders).
- Submit a UCS testing log sheet even if no samples are scheduled for the that day.
- Fill out the Paste UCS Testing Log sheet with the Cylinder ID and Design Cure time.
- Enter the Tester, Date, and shift.
- Relocate from the new curing room to the original curing room the new month's worth of 365 samples at the start of each month.
- Arrange the samples in chronological order to ensure adequate space and ease for breaking.
- Go to the original curing room (adjacent to the Paste Plant Lab).
- Collect the required 7/14/28/365-day samples.
- Remove the samples in the opposite order that they were placed.
- Get guidance from the supervisor if you are unsure.
- Record on the UCS Test sheet all missing cylinders.
- Place the cylinders on the workbench.

2 Sample Collection (Person Responsible - Paste Plant Operator)

- Remove the tape holding the cylinder together.
- Gently remove the sample from the cylinder and place it upright on the workbench.
- Use a Pretium approved knife to remove the cemented backfill by cutting the plastic cylinder mould's length.
- Note: Ensure all cylinders that cannot be re-used or broken pieces of cylinders are disposed of in the hard plastic bin and not the paste reject bin.
- Inspect the sample for damage or deformities (cracks, air bubbles).
- Record any deformations in the record / notes section of the Paste UCS testing Log sheet.
- Ensure the following tasks are conducted on the core saw before using:
  - Check safety guards are in place and functional.
  - Clear work area from debris.
  - Check core saw water discharge hose run into the floor drain.
  - Use core saw only when sample is hard.
  - Cut each sample with the core saw to make flat ends on each side.
  - Use a flat ruler or device to flatten the end by scraping when the sample is too soft.
  - Place each sample upright on the workbench.
  - Measure the sample's diameter in two locations using a callipers or ruler.
  - Calculate the average diameter in mm.

- Record the average diameter of the sample into the USC Test Sheet.
- Place each sample onto its side on the workbench.
- Measure the sample's length in two locations.
- Calculate the average length in mm.
- Record the average length of the sample into the UCS Test sheet.
- Weigh the sample on the scale.
- Record the mass of the sample to the nearest gram.
- Record any irregularities with the cylinder on the UCS Test sheet, like air pockets, oval or bent shape.

3 USC Test (Person Responsible- Paste Plant Operator)

- Turn on the power to the Compression test machine, data readout and computer.
- Open the Karol-Warner Unconfined Software.
- Check that the software read port is correctly selected and select "Connect".
- Set Auto-stop test when load fall below peak = 20.
- Set Run test to Record Every(s) = 1.
- Set Compression Machine Strain Rate = to 2 kN/s up to a maximum strain value of 7%.
- Check the compression machines fittings are tight.
- Click the new file button.

- Enter Project ID = Cylinder ID (MMM-DD-YYYY hh:mm AM/PM - Design Cure Time (d)).
- Example: MAR 02 2021 0105 AM- 28.
  - Enter Cylinder ID = Test 1 or 2.
  - Click Set File.
  - Set the file location to local drive, preventing issues of generating corrupt data.
  - C:\KW UCS Results\yyyy\mm mmm\dd.
- Example for yyyy\mm mmm\dd is 2021\05 May\01.
  - Input the average length and diameter of the sample (mm).
  - Place the sample upright into the compression test machine and, using the jog switch, raise the sample until a small gap of approximately one millimetre is achieved.
  - Click Tare and then Start test on the software.
  - Push the toggle up on the compression test machine. A green light should appear indicating the direction it is running.
  - Push the RED stop button on the compression machine when it done. The program stops by itself.
  - Record on the paper log sheet the peak stress and peak load.
  - Click Save.
- An example of the file name is below.
  - MAR 03 2021 0140 AM – 7 UC 1.
- Use the jog toggle switch on the compression machine to retract the hydraulics.
- Reserve a small piece of sample for moisture analysis.
- Discard the sample into the discarded sample chute.

4 Sample Data Entry (Person Responsible- Paste Plant Operator)
- Cut up the step 3.23 sample into very fine pieces (smaller than rice).
- Place a clean, dry pan into the moisture analyzer, zero the scale.
- Weigh between 5-10 g of sample on the tray.
- Spread it out so it will dry faster.
- Hit start.
- Record the moisture on the sheet, when the cycle is complete.
- **Note:** Moisture analysis may take up to 30 minutes per sample. If needed, you can stockpile the broken pieces on the bench (label the pieces, so you know which sample is which). All moisture samples must be completed on the shift that the cylinders were tested.

5 Sample Data Entry and Copying to Network folder (Person Responsible- Paste Plant Operator / Metallurgical Technician)
- Fill out the Paste UCS Testing Log sheet.
- Start a new sheet for the other cylinders if more than 10 cylinders are tested.
- Record the actual date and time.
- Make a note on the sheet if samples were not tested due to missing or not found on the shelf.
- Check the data file is saved to the appropriate file name and location.
- C:\KW UCS Results\yyyy\mm mmm\dd.
- File name: MMM DD YYYY HHMM AM/PM - Cure Days UC SAMPLE 1 or 2.
- Example: MAR 03 2021 0401 AM – 7 UC 2.
- Copy the data files to the network folder inside same yyyy/mm mmm/dd folder.
- J:\Mill Tech Services\PASTE BACKFILL\99-Paste Lab - QAQC\Strength Testing\09 KW UCS Results\yyyy\mm mmm\dd.
- Hand in the sheet (Along with all other paste operator sheets) to the Metallurgists Office.

6 Data Input (Person Responsible – Metallurgy)
- Scan and save the Paste UCS Testing Log sheet in the following folder, under the appropriate Year / Month.
- J:\Mill Tech Services\PASTE BACKFILL\99-Paste Lab - QAQC\Strength Testing\02 Paste UCS Sheets.

7 Clean up (Person Responsible- Paste Plant Operator)
- Clean up work areas and tools.
- Place tools in the proper storage area.
- Ensure that Pretium standard waste separation practices are followed, and that plastics and other debris ARE NOT mixed with cylinder sample waste.

4.8 BJ-PBF-SOP-560 Diverter gate operation & pigging procedure

4.8.1 Objective

To establish mandatory requirements for the safe and responsible working standards for operating the Paste Plant Diverter Gate and inserting clean-out pigs into the Paste Plant discharge lines.

4.8.2 Scope

This SOP covers the process and procedures which are used to standardize operation of the Paste Plant Diverter Gate and the insertion of clean-out pigs into the Paste Plant discharge lines.

4.8.3 Health, safety & reclamation code of BC

- Section 1.11.1 (Training)
- Sections 1.8.2, 1.8.3, 1.8.4, and 1.8.5 (Personal Protective Equipment)

4.8.4 Definitions

- Clean-Out Pig
  - Round shaped foam which is cut or poured out of an open cell polyurethane.
- Pigging
  - Refers to the practice of inserting a clean out pig into pipelines to clean / remove material build up within the pipeline.
- Pinch Point
  - A pinch point is any point at which it is possible for a person or part of a person's body to be caught between moving parts of a machine, or between the moving and stationary parts of a machine, or between material and any part of the machine. A pinch point does not have to cause injury to a limb or body part, although it might cause injury - it only has to trap or pinch the person to prevent them from escaping or removing the trapped part from the pinch point.

4.8.5 Preparation

- Hazards
  - Pinch Points
  - Noise
  - Pressure in Paste Line
- Tools
  - Broom handle
  - Clean-out Pig

4.8.6 Requirements

Must be trained to operate the Paste Plant or work within close contact with a trained operator.

4.8.7 Job steps

1 Diverter Gate Operation
  - Visually inspect the pressure gauge on the Paste Lines (Discharge side of Paste Pumps) and ensure the pressure is reading 0 kPa.
  - Check the Diverter Gate Hydraulic Pack for adequate oil; oil level can be checked by using the site glass.
  - Contact the Control Room Operator and have them start (HY043) Diverter Gate Hydraulic Pump.
  - NOTE: Before moving / repositioning the Diverter Gate, grease the Diverter Gate.
  - The Diverter Gate (Connected to the Paste Line) can be moved to three different positions.
    - Paste Pump 1 is the centre position.
    - Paste Pump 2 is the left position.
    - Pigging Port is the right position.

- Use the black lever (Mounted on the south side of the Diverter Gate Enclosure) to move the gate to the desired position.

2 Insertion of Clean-Out Pig into Paste Discharge Line

- Ensure the Diverter Gate is in the pig position.
- Insert the pig into the pipe opening. Do not push the pig into the line using any part of the body.
- Use a broom handle to push the pig past the Diverter Gate into the Paste Line**. Do not to allow any part of the body to enter the pipe.**
- Use the black hydraulic lever to position the Diverter Gate to the desired Paste Pump.
- Contact the Control Room Operator to notify them that the pig has been inserted and the Diverter Gate is in the correct position for the pump being used.

4.9 BJ-PBF-SOP-562 Paste plant mixer cleaning

4.9.1 Objective

To ensure the Paste Mixer has been flushed and thoroughly washed when paste production is complete.

4.9.2 Scope

This SOP covers the process and steps involved to flush out the paste mixer and thoroughly wash using the high-pressure washing system.

4.9.3 Health, safety & reclamation code of BC

- Section 1.11.1 (Training)
- Sections 1.8.2, 1.8.3, 1.8.4, and 1.8.5 (Personal Protective Equipment)

4.9.4 Definitions

- LOTO
  - Lockout / Tagout: a safety procedure which is used in industry to ensure that dangerous machines and equipment are properly shut off and not able to be started up again prior to the completion of maintenance or service work.

4.9.5 Preparation

- Hazards
  - Respiratory
  - Slips & Falls
  - Elevated Noise
  - High-Pressure Water
  - Equipment damage
- Tools
  - Pretium standard PPE
  - Pressure washer
  - Air hammer / chisel
  - Respiratory Protection (when entering the Paste Mixer)
  - Face Shield (when operating the pressure washer and / or air hammer / chisel)

- Requirements
  - Lockout / Tagout training.
  - Confined Space training when entering the Paste Mixer.
  - Qualified Paste Plant Operator or working within close contact with a qualified Paste Plant Operator.

4.9.6 Job steps

The Paste Mixer must be thoroughly cleaned as soon as a paste pour is complete or during extended interruptions.

1 Washing the Paste Mixer (Persons Responsible - Paste Plant Operator)

- Once a Paste Pour is complete and the Control Room operator has finished flushing the Paste Mixer with water, the Control Room operator will contact the Paste Plant operator to divert the paste area sump (PU-013) to the Paste Mixer chute.
- Control Room Operator will be contacted and asked to open the Paste Mixer Drain Valves (HS-5572/5582).
- Paste Plant Operator will check the flow from the Paste Mixer Drain Valves (HS-5572/5582) to ensure there is no obstruction plugging the line.
- If the Paste Mixer is not draining, the Paste Plant Operator must conduct the following tasks:
  - Close the Paste Mixer drain valves (HS-5572/5582).
  - Open the flush water valve located between the Paste Mixer and drain valves and back flush the material back into the Paste Mixer.
  - After back flushing, close the flush water valve and open the Paste Mixer drain valves.
  - Check for flow from the Paste Mixer drain valves.
  - **If the back flush did not dislodge the paste build up, the mixer agitator must be shut down and locked out to manually dislodge blockage.**
- While the Paste Mixer is draining, the high-pressure water pump (PU-031/032) can be started on the 15-minute wash cycle.
- Once the wash cycle completes and the basement is pumped down, contact the Control Room Operator and divert the sump back to the Tailings Disposal Surge Tank.
- The interior of the Paste Mixer and the Paste Mixer Agitators must be inspected for build-up of paste. **It is very critical to ensure that all build-up of paste is removed from the interior of the Paste Mixer and the Paste Mixer Agitators.**
- Paste Plant Operator will use the High-Pressure Washer wand and clean out the interior of the Paste Mixer the best they can before entering. **Face shield must be worn when using the pressure washer**.
- Before entering the Paste Mixer for inspection and further cleaning, the Paste Mixer Agitators (MX-031M1/M2) and all associated equipment must be locked out according to the Lockout Isolation Point Checklist located in the following directory: J:Mill/Mill Lockout & Tagout/LOTO Checklists/Completed/Paste Production & Pumping.
- Confined Space procedures must be followed when entering the Paste Mixer. **Half masked respirator fit with P100 cartridges must be worn when inside the Paste Mixer.**
- Paste Plant Operator will continue cleaning out the Paste Mixer with an air hammer/chisel and any other tools needed to remove all hardened paste build up. **Pressure Washer will not be used while any persons are inside the Paste Mixer.**

- Any chunks of paste that are too large to be washed down the drain will be lifted out. **All residual pieces must be removed before the agitators in the Paste Mixer can be started.**
- If maintenance is required, the Paste Mixer can now be turned over to the Maintenance Department.
- If maintenance was conducted, operator and maintenance personnel must both be at the Paste Mixer before it is started. The Paste Mixer will be started at 10% speed while testing agitators for proper function.

4.10 BJ-PRO-SOP-564 Operating overhead door with safety edge bypassed

4.10.1 Objective

To establish mandatory requirements for safe responsible working standards for operating an overhead door when the safety edge is bypassed.

4.10.2 Scope

This procedure covers the steps involved for operating an overhead door when the safety edge is bypassed. This includes opening the overhead door and closing the overhead door.

4.10.3 Health, safety & reclamation code of BC

Section 1.11.1 (Training)

4.10.4 Definitions

No definitions.

4.10.5 Preparation

- Hazards
  - Any obstruction that may interfere with opening or closing the overhead door.
- Tools
  - No additional tools required.
- Requirements
  - Trained in operating overhead door when safety edge is bypassed.

4.10.6 Job steps

1 Opening Overhead Door
- Ensure door entrance is clear of obstructions.
- Push Up / Down button (Black) to open door.
- Do not allow any vehicular traffic through the doorway until the overhead door is fully opened.
- Direct vehicular traffic through doorway.
- Closing Overhead Door.
- Ensure vehicle has passed through the doorway and is clear of the overhead door.
- Press Up / Down button (Black) to close door.
- Visually monitor doorway to ensure no vehicles try to drive through the doorway as door is being lowered.
- **Note:** When the Safety bump is bypassed there is no door protection for the door encountering obstructions. This why it is imperative that the operator pays strict attention to when the door is being lowered or raised. Failure to do so could render the door inoperative due to equipment damage.

5 Underground standard operating procedures

All SOP must conform to the relevant Mine Regulations and Pretium Health and Safety Policies.

Key areas for each SOP are:

- Objective
- Scope
- Health, safety & reclamation code of BC
- WorkSafe BC Regulations
- Definition
- Preparation – hazards, tools, and knowledge
- Responsibilities
- Job Steps
- Revisions
- Approval signature record

The key guideline information is provided in the following Outotec functional description documents:

- 177421-0000-DC00-PHL-0001-R0 Process Control Philosophy.pdf – Appendix A
- J15-0015-FD-010-R0-Underground Booster Station.pdf
- J15-0015-FD-009-R0-Paste Pumps to Underground.pdf

5.1 Stope fill design note SOP

The purpose of the stope fill design note is to determine the following parameters:

- Dimensions and volume of the as-built stope.
- Size and shape of future fill exposures to adjacent stopes alongside, below, and above.
- Determine the strength of cured paste fill required for stable vertical and undercut exposures.
- Determine the volume of and binder requirements for each strength zone for fill runs.
- Determine the filling rate and vertical rise rate of fill within the stope and any restrictions to duration of fill runs due to barricade load limitations.
- Location of fill barricade(s), personnel entry limits and waste rock catch bunds (if any).
- A summary sheet to be issued to the Paste Production for fill pouring instructions.
- Any special notes or cautions with regard to fill operations, access or local safety issues.

5.1.1 References

- Section 7 in this report – Paste fill duty and target strength design.
- Section 9.3 in this report – Paste strength test work.
- Section 8 in this report – Paste barricade design.

5.1.2 Stope fill design note procedure

The stope fill design note will be produced by the mining engineer in conjunction with the Geotech engineer. It can be started using design parameters and progressively updated with as-built survey information for access development, stope cavity monitoring survey (CMS) including any material (ore, waste or fill falloff) remaining in the stope at the end of production. Stopes will typically be mined and filled over one sub level – 30 m, floor to floor and up to 15 m wide, along strike. The main variable will be the stope length which could vary from a maximum of 30 m to as short as

10 m. Narrow and short stopes will have a high fill raise rate and will require restricted fill pour durations to limit barricade pressures.

- The responsible engineer will examine the design or as built shape of the stope to be filled and will load into the model all other stopes in close or direct proximity to the stope.
- If the stope will be exposed at the base by a stope mined from the level below, the engineer will note that a high strength fill sill beam will be required in the initial pour. The thickness of this sill beam will be a minimum of one half of the width of the stope (15 m wide stope will require minimum 7.5 m thick beam). Pretium has specified a 10 m thick high strength (1,100 kPa) beam in all initial stopes.
  - The shape and dimension of the sill will be recorded. This will apply to all primary and secondary stopes at a sill level.
- The shape and dimensions of each vertical exposure to directly adjacent stopes will be recorded.
  - Most Primary stopes will have up to three vertical wall exposures which will be exposed sequentially (never simultaneously) during mining of pillars in secondary stopes. The first exposure will be a narrow 15 m wide face on retreat. The two following exposures will be 30m on either side, exposed as the adjacent secondary stopes are mined. These stopes will require regular strength fill as follows:
    - First 15 m high (Regular Strength recipe A) 350 kPa.
    - Fill above 15 m high (Regular Strength recipe B) 250 kPa.
  - Most Secondary stopes will have only one vertical wall exposures which will be exposed as a narrow 15 m wide face on retreat. These stopes will require low strength fill up to 200 kPa.
  - Bulk fill stopes will have no vertical wall exposures (but may have a sill beam) and will only require liquefaction resistant fill up of 100 kPa throughout or above the sill beam.
- Current design practice is to place a one-metre-thick cap of high strength (800 kPa) paste on the top of the fill to form a strong mucking surface, typically also capped with broken rock for improved traction. This cap design has been proven successful at Brucejack Mine.
- Using the six paste strength types shown in Table 5.1, calculate the volumes of each strength type to be placed in the stope and note the elevations within the stope where these binder changes occur.

Table 5.1 Paste fill strength type and current binder* dosing (February 2022)

Paste type	Usage	Design 28-day strength (kPa)	QC Average 28-day strength (kPa)	Current binder dosage by (%)	Current binder dosage (kg/m³)	Minimum paste slurry density (% w/w)	In situ density dry paste (t/m³)	In situ density wet paste (t/m³)
High-strength Paste	Sill beams up to 15 m wide	1,100	1,252	11.0%	125.5	63%	1.11	1.71
High-strength Paste	Top of stope caps for mucking	800	965	9.8%	111.8	63%	1.11	1.71
Regular Strength A	Regular stope in the first 15 m high	350	340	6.4%	73	63%	1.11	1.71
Regular Strength B	Regular stope at 15 m or higher	250	206	5.5%	62.7	63%	1.11	1.71
Low Strength Paste	Secondary stopes with short wall exposure	200	171	4.3%	49.1	63%	1.11	1.71
Liquefaction resistant Paste	Secondary stopes with no future exposures	100	110	3.8%	43.4	63%	1.11	1.71

Note: *Binder specified is Lafarge Terraflow T90 containing 90% slag and 10% general usage limestone (GUL) cement. Product details are supplied in Appendix F.

Brucejack will use the six paste binder recipes specified in Table 5.1 for the six fill strength types. The QC strength results should be reviewed regularly to ensure that design target strengths are being achieved and recipes adjusted when required.

The target design strengths and paste fill recipes have been adjusted from initial designs based on continuous review of QC paste strength data and the introduction of zoned paste fill strengths as originally recommended in the original Backfill Management Plan.

The mining engineer will prepare the fill note to include:

- Stope name to be filled, filling level and barricade level.
- Nominate the stope as primary or secondary and whether a high strength sill beam pour will be required.
- Agreement on reticulation route, specify which pump and which trunk pipelines and the length of pipes and boreholes will be used for flushing volume calculation.
- Volume of stope to be filled and density, strength and binder recipes required. A table of stope plan areas in one metre increments.
- Specify width and depth of sill pour.
- Confirm filling rate in m³/hr and estimate fill rise rate in stope. If rate exceeds 11.6 m in any 24 hours, fill run will terminate at that elevation and not restart until the 24-hour period has completed.
- Confirm start date for filling not earlier than 72 hours after barricade shotcrete completed and stope released by Backfill Operations.
- Document all agreed points and include with stope file note along with any Special Instructions.

The following page shows the SOP with example data inserted for the first stope to be filled.

5.2 Stope fill reticulation note SOP

The purpose of the stope fill reticulation note is to determine the following parameters:

- Route of UDS including fill placement level and drawpoint level.
- Main trunk pipe connections from surface to stope.
- Length and volume of UDS for flush run calculations.
- Estimate of friction losses for this stope and expected pump pressures.

5.2.1 References

Section 9.2 in this report – Paste fill rheology.

5.2.2 Stope fill reticulation design procedure

- The mining engineer will review the Stope Fill Design Note and will determine the fill placement level and the drawpoint level.
- If currently accessible, the engineer will inspect the route of the UDS on the fill placement level from the base of the fill borehole, along the steel trunk lines and to the fill crosscut.
- The engineer will record where manual pipe transfer changes are required and the various steel and HDPE pipe and bend installations required.
- Using the mine design software, the engineer will prepare a UDS string file of the full length of UDS from the paste pump discharge via the declines and boreholes to the discharge into the stope.
  - The engineer will calculate the length and volume of the UDS and will record the flushing water volume as 2x (twice) that volume.
  - The engineer will measure the static head difference between the paste pump outlet and the discharge into the stope and calculate the hydraulic gradient (static head / UDS length).
  - Using the friction losses in Table 5.2, calculate the total friction loss along the UDS length and correct for (add or subtract) the static head difference using default values for 63% w/w solids and 1.71 t/m^3 slurry density.
    - Example calculation: Pump 1407 RL, UDS outlet 1350 RL, static head -57 m.
    - Slurry head = -57 * 1.71 * 9.81 = 956 kPa.
    - If total UDS length is 500, then friction losses are 10 * 500 = 5,000 kPa.
    - Pressure at pump exit is 5,000 + (-956) = 4,044 kPa (or 40.4 bar).
  - The pump working pressure is then recorded on the Fill Reticulation Design note.

Table 5.2 Flow model parameters

Slump (mm and inches)	Cemented paste fill (w/w % solids)	Friction losses (kPa/m)
175 mm (7”)	65%	15 kPa/m
210 mm (8.5”)	63%	10 kPa/m
250 mm (10”)	61%	4 kPa/m

5.3 Fill preparation SOP

The purpose of the fill preparation SOP is to ensure that the stope is ready to receive paste fill. This will include:

5.3.1 References

Section 7 in this report - Paste fill duty and target strength design.

5.3.2 Stope fill preparation procedure

- The mining engineer will review the Stope Fill Design Note and will determine the fill placement level and the drawpoint level.
- Check that UDS is correctly connected, and pressure sensors and pressure relief valves are present and correct.
- CMS survey of stope void to determine shape and volume to fill and stope plan area to determine fill rise rate.
- All entry points to the stope are inspected to be safe, and travel restriction barricades and signage installed.
- Fill Barricade location has been inspected, confirmed, and recorded.
- Waste rock bund walls and or travel restriction areas defined and recorded.
- All locations recorded on maps for filling level and drawpoint level.
- The stope has been released by production for fill preparation.
- At the end of production operations, the stope is signed off as completed and ready for fill preparation activities. This includes preparation of stope fill note containing:
  - Details of fill volume, limits to either fill pouring rate or duration of fill runs and resting periods, if any.
  - Details of future cured fill exposures including vertical and undercut exposures (if any) with strength requirements.
  - List of fill pour volumes, 28-day strength requirements and binder recipes for each volume increment.
  - Location and dimensions of all barricades.
  - Instruction on tight filling and or top dressing with waste rock for each stope.
  - Installation of level piping (steel) and crosscut piping (HDPE) and establishment of safe pouring location from upper level.
  - If filling via borehole into stope, ensure that breather hole is available to monitor tight filling and pressure break to ensure no excess pumping or static head pressure can be transmitted to barricade walls.
  - Installation of cameras for remote observation, if required.
  - Installation of safety barriers, access warning signs to manage or prevent access to stope filling activities.
  - Installation of pressure monitoring equipment in stope, if required.

5.4 Fill barricade construction SOP

The current design of fill barricades for Brucejack are limited to a maximum working wall capacity limit of 200 kPa. At a wet slurry density of 1.71 t/m^3. This is equivalent to a paste slurry height of 11.9 m behind the wall. Pretium has stated the maximum height of pour behind a wall in any 24 hours of paste filling will be 10 m. If the stope plan area is less than 250 m^2, this rate could be exceeded at 140 m^3/hr paste filling rate. In this case, the fill pour must be suspended and not restarted until the 24-hour time span from the start of the previous fill run has been reached.

The only exception to this rule is where a vertically oriented total pressure cell has been mounted behind the barricade and the remote readings continue to show less than 200 kPa horizontal stress and has been verified by the Geotechnical Engineer. In this case only, fill pouring may continue under advice from the Geotechnical Engineer.

5.4.1 References – Appendix H

- Ref Drawing – Golder 5 x 5 Barricade Design 1776046_S-03_R0.pdf
- Ref Drawing – Golder 5 x 6 Barricade Design 1776046_S-02_R0.pdf
- Ref Drawing – Golder Construction notes 1776046_S-01_R0.pdf

5.4.2 Arched shotcrete barricade construction procedure

- At the completion of production from a stope, the stope is signed off as complete and available for fill preparation activities.
- The drawpoint is inspected and made safe as per the Pretium Ground Control Management Plan. If space is available, a small bund of waste rock should be placed under the brow of the drawpoint to act as a catch bund in case of small rock falloff within the stope to protect construction activities.
- The wall and back will be inspected and a suitable location between 5.0 and 6.0 m back from the brow will be marked. A paint line arc with a radius of 4.5 m will be drawn on the floor from the centreline of the drive at this point and up the walls of the drive where they intersect. If a better location due to wall shape or poor ground the location of the wall can be moved along the drive on the direction of the Geotechnical Engineer or Supervisor.
- The walls and back will be cleaned of all loose rock and washed down to at least 1.0 m on either side (2.0 m total) of the paint line. This rubble and the floor will then be cleared to 2.0 m width to expose the rock floor and also cleaned of all loose rock.
- A series of shear pin holes will be drilled at 600mm intervals along the centreline of the barricade to a depth of 1.5 m and at least 25 mm diameter. Each hole will have a 2.7 m long #8 (20 mm) Dywidag bar inserted and grouted, or rock bolt resin installed to full depth.
- The wire mesh 400 mm x 400 mm channel frames will be erected vertically along the centre line of the barricade and clipped to the Dywidag shear pins. As the channel frames are being erected, the bedspring mesh and burlap backing will be installed, clipping to both the shear pins and channel frames.
- 6m long 20 mm diameter rebars bent to 4.5 m radius will then be installed horizontally across each wall Dywidag dowel and connected across the drift. Vertical straight 20 mm rebars will be installed vertically from back to floor.
- 825 mm long shotcrete thickness depth gauge bars will be installed parallel to the drawpoint axis, located 750 mm from the sidewall of the drive.
- The final task will be to install sheets of 100 mm x 100 mm mesh to the 20 mm rebars and channel frames. The construction framework should be inspected prior to the next stage of shotcreting.
- When the barricade framework has been completed, shotcrete can be applied. The shotcrete mix used will have an unconfined compressive strength (UCS) of 20 MPa at three days of curing. The shotcrete will be sprayed in multiple passes to ensure even thickness and complete penetration of the barricade to the burlap backing. The minimum thickness of the shotcrete will be 400 mm to completely embed the channel frames in the centre of the barricade. The thickness will be progressively increased outwards from the centre to be 825 mm thick at the outer depth gauges and to the wall. The objective is to achieve a wall contact of at 1,950 mm of shotcrete to minimize shear loading and improve the efficiency of the load bearing arch shape.
- When shotcreting is complete the wall will be inspected for complete full depth coverage. Any areas which are incomplete will be shotcreted to completion. The date and time of completion will be recorded by the supervisor, and it is recommended that this also be spray painted on the wall. The stope will not be released for paste filling until 7 days or until the shotcrete has reached 20 MPa, whichever is the sooner. after the shotcreting has been completed to ensure

the design UCS has been reached and the barricade has reached is design working load capacity.

- QC procedures will be carried out at all stages of barricade construction including:
  - Checking on the location of the wall with respect to the bow.
  - Condition of boundary interfaces.
  - Dimensions of all components within the wall.
  - Checking of pin spacing.
  - Checking correct installation of depth gauges.
  - Depth of shotcrete applied to the wall.
  - Collection of QC samples to confirm strength development.
  - Marking of date and stope name on completed wall.
- At the end of construction, a no travelling unless authorized sign will be placed at the entrance to the drawpoint from the level access drive. During filling activities only authorized persons will have access to the barricade for the purpose of inspection or data collection. If required, a waste rock bund will also be placed at the entrance to act as a catch berm in the event of fill leakage.

5.5 Starting a fill run directly to underground SOP

This SOP refers only to stopes being filled directly from surface pumping and bypassing the Booster Station. When filling via the Booster Station BJ-PRO-SOP-570 Operating the Underground Booster Station is to be used.

5.5.1 References

Outotec Functional Description - J15-0015-FD-009-R0-Paste Pumps to Underground.pdf.

5.5.2 Fill run start up procedure

- Stope Fill Design Note
- Stope Fill Pouring Note
- Pre-Pour Meeting
  - Backfill co-ordinator –surface and underground, mine planning and production, Geotech.
  - Stope name to be filled, filling level and barricade level.
  - Agreement on reticulation route, specify which pump and which trunk pipelines and the length of pipes and boreholes will be used for flushing volume calculation.
  - Volume of stope to be filled and density, strength and binder recipes required.
  - Specify whether high strength sill beam pour required and depth of sill pour.
  - Confirm filling rate in m^3/hr and estimate fill rise rate in stope. If rate exceeds 11.6 m in any 24 hours, fill run will terminate at that elevation and not restart until the 24-hour period has completed.
  - Confirm start date for filling not earlier than 72 hours after barricade shotcrete completed and stope released by Backfill Operations.
  - Document all agreed points and include with stope file note along with any Special Instructions.
- Stope Ready Permission
  - No water or paste will be delivered until permission has been received that the stope is ready to receive fill.

- Slick the Fill Line
  - Water will be pumped through the fill line for 10 minutes to ensure the line is wet and correctly routed to the stope.
  - The UG Pour Leader will signal the arrival of the water at the stope and will instruct the Paste operator to start making paste.
- Running Paste.
  - On receipt of permission to start making paste, the paste operator will combine thickened tailings slurry, tailings cake from the horizontal belt filter (if required), binder and any adjustment trim water to start producing the paste fill.
  - The paste operator will monitor paste slurry density, binder addition and the pressure sensor readings in the surface Utilidor and underground to manage the quality of the paste fill. The operator will aim to achieve the highest paste density within the limits of reticulation and pumping pressure and managing the risk of pipeline blockage.
  - The paste operator will record paste activities at hourly intervals into the shift record sheets or spreadsheets.
  - The paste operator will collect QC samples at least twice per shift as per the paste QC SOP.
  - The UG Pour Leader will monitor the paste placement into the stope from the pouring level and from the barricade level as required. If pressure instrumentation has been installed in the stope, this can be used as an additional monitoring tool.
  - In the event of an upset condition the Paste Operator can halt the paste fill production and commence a flushing cycle. If the upset event is minor and can be rectified within one hour, the paste line can be left full for one hour maximum and restarted when fixed. If the upset is still not fixed after one hour maximum, the line must be flushed clean.
  - In the absence of upset conditions, paste fill will be placed continuously using pressure and remote video monitoring to either an agreed volume for that run or until advised by the UG Pour Leader that the fill run is to be terminated. Paste can be placed during changes of shift using remote monitoring.

5.6 Stopping a fill run directly to stopes underground

This SOP refers only to stopes being filled directly from surface pumping and bypassing the Booster Station.

In the event of an upset condition the Paste Operator can halt the paste fill production and commence a flushing cycle. If the upset event is minor and can be rectified within one hour, the paste line can be left full for one hour maximum and restarted when fixed. If the upset is still not fixed after one hour maximum, the line must be flushed clean.

Stopping a fill run will require all of the paste currently in the mixer and the volume of the delivery system to be pumped into the stope. Due to the binder addition to the paste, the line must be thoroughly flushed with water to push a pig through the line.

Due to the design of the UDS, water will always be present in the dog leg section between the VOK borehole and the booster station to an elevation of 1360 RL after any flush run. Any maintenance work on this section of pipeline should assume the line has a static pressure of 60 m water head or 600 kPa and which must be relieved before work commences.

5.6.1 References

Outotec Functional Description - J15-0015-FD-009-R0-Paste Pumps to Underground.pdf.

5.6.2 Fill run stopping procedure

- Paste operator will shut down feeds to the paste mixer. The binder system will be shut down and if the Horizontal Belt Filter (HBF), is in use, the belt will be emptied, and tailings returned to the tailings storage tank. The HBF will be flushed clean.
- Water will be introduced to the mixer for flushing and will continue until the discharge is clear of cemented paste. The water and paste pump will continue for two minutes to commence the flushing of the pump system.
- The Paste operator will notify the UG Paste Leader that the line is being stopped to insert a pig.
- The pump will be turned off and the pressure will be confirmed at zero before adjusting the diverter valve to the middle position.
- The paste operator will insert the pig and return the diverter valve to the original position and notify the UG Paste leader that flushing is now commencing.
- The paste operator will now pump water and the pig through the line until the volume of water is two times the volume of the line to that stope.
- The UG Paste Leader will observe the discharge and will either see the pig and or the water behind the paste becoming progressively clear. If the line does not clear, the UG operator can instruct the Paste Operator to insert another pig or to keep flushing until advised. Extra flushing should be minimized.

5.7 Operating the Underground Booster Station

To establish mandatory requirements for the safe and responsible working standards for operating the Underground Booster Station.

5.7.1 Operating the Underground Booster Station Job Steps

NOTE: All advice and directives from the Underground Paste Watcher must be adhered to.

- Pre-start Checks (Person Responsible- Underground Paste Plant Operator)
  - Start Hydraulics (2153-HY-003) to Diverter Valves.
  - Set Diverter Valve to Paste Pump (PU-020).
  - Verify Destination Valve is correct for Destination: 1350 Level, Lower VOK or Upper VOK".
  - Stop Hydraulics to Diverter Valves.
  - Wet the Live Bottom Hopper.
- Pre-Start checks (Person Responsible - Control Room Operator and Underground Paste Booster Operator)
  - Close Hopper Discharge Valve (2153-HS-5613) to Booster Paste Pump (PU020}.
  - Start Bottom Hopper Augier Forward (2153-HO-001}.
  - Verify Flush Water Tank Level (2153-Ll-5621) is greater than 80% and set to CAS mode.
- Pre Wetting Live Bottom Hopper (Person Responsible - Control Room Operator)
  - Use slick water from surface paste plant.
  - If water from surface is not available, start selected Flush Water Pump (2153-PU-001 or 2153-PU-002}.
  - Set Live Bottom Hopper Level (2153-LIC-5611) to approximately 67% in AUTO mode.
- Prepare Booster Pumps for Start-up (Person Responsible- Control Room Operator)
  - Open Hopper Discharge Valve (2153-HS-5613) to Paste Pump (PU-020).

- Start Booster Paste Pump (Person Responsible - Control Room Operator)
  - When the Underground Paste Plant gives the confirmation that "Underground is ready for Start-up", the surface paste plant will be started using water.
  - The Underground Paste Plant Operator will inform the Control Room Operator when water is received into the Live Bottom Hopper.
  - The Underground Paste Plant Operator will inform the Control Room Operator that "Underground is ready for paste.
  - Allow the Live Bottom Hopper to attain a level of approximately 70%, then start Booster Paste Pump (PU-020).
  - Adjust pump stroke to maintain a level of 65%- 67% in the Live Bottom Hopper, then switch to AUTO mode.
  - The Surface Paste Plant Operator will start pumping paste underground.
  - The Underground Paste Plant Operator will inform the Control Room Operator when paste is discharging into the Live Bottom Hopper.
  - If the Booster Paste Pump (PU-020), was turned off, turn the pump back on and set to AUTO mode and set the level in the Live Bottom Hopper to around 67% on (2153-LIC-5611}.
- Shutdown and Clean Out Mode (Person Responsible - Control Room Operator)
  - After the pour of Paste is complete, the surface plant will go into cleanout mode. This process will send dirty water to Live Bottom Hopper and Booster Station.
  - The Underground Booster Paste Pump (PU-020} will remain running until the Underground Paste Plant Operator verifies that "clean11 water is discharging into the Live Bottom Hopper.
  - Stop Underground Paste Booster Pump (PU-20).
- Pigging the Surface Line (Person Responsible- Control Room Operator & Mill Surface Paste Plant Operator)
  - Surface Paste Plant Operator will prepare the surface line for pigging as per Pretium Pigging SOP1.
  - When confirmation from the Underground Paste Plant Operator has been given that the pig has arrived and the pig has been removed from the Live Bottom Hopper and the flow into the Live Bottom Hopper is clear, the surface paste pump can be shut down and the procedure for pigging the underground paste line from the booster pump to the stope can be conducted.
- Flush the Live Bottom Hopper (Person Responsible - Underground Paste Operator)
  - Close the drain on Live Bottom Hopper to catch any excess water for pigging the underground process. Remaining water will report to sump via Live Bottom Hopper overflow.
  - Start Underground Paste Booster Pump (PU-20}.
  - Flush the underground line for approximately two minutes with water from the Live Bottom Hopper.
  - Stop Booster Paste Pump (PU-020}.
  - Confirm a loss in line pressure at 2153-PI-5641 and 2153-PI-5646.
  - To prevent backflow, start the Diverter Hydraulic Power Pack 2153-HY-003 and move Diverter Valve No.1 (2153-DV-001} to the centre pigging port and verify with 2153-PI-5646.
- Pigging the Underground Line (Person Responsible-Underground Paste Operator)
  - Turn Diverter Valve Hydraulic Power Pak (2153-HY-003) on.

- Place both Diverter Gates to Neutral position.
- After the line pressure has been proven to be zero (2153-PI-5647 and 2153-PI-5646).
- Insert the pig into the line making sure it is beyond the rotating plate of the diverter plate.
- Return the Diverter Valves to previous position for Booster Paste Pump (PU-020) and verified by 2153-ZI-5643A.
- Turn Diverter Valve Hydraulic Power Pak (2153-HY-003} off.
- Start Paste Pump (2153-PU-020}.
- Once the UG Paste Plant Operator verifies that the Pig has been released and the UG Paste Watcher verifies clean water is exiting the pipe, stop Paste Booster Pump (2153-PU-020).
- Position Diverter Valve No. 1 slowly to the centre Pig Insertion Port (B) and allow remaining water to drain into the sump.
- Stop the Paste Pump Hydraulic Power Unit (2153-HY-020) allow for cool down period.
- Conduct general circuit clean up.

5.8 Paste line blockage

The Pretium paste system UDS has been designed with multiple pressure monitoring points and a high-capacity pump to enable operators to manage the paste density and react to and prevent potential blockage events before they occur. During commissioning, working pressure trends will be developed and guidelines for operators will be provided and updated in the SOP. The system allows for fine tuning of trim water addition to modify the paste rheology and manage paste line pressures and prevent blockages occurring.

This SOP applies when a major upset event occurs such as extended power loss or if the normal Stopping of the Fill Run SOP has failed to empty the line of paste.

In the event of a blockage occurring due to power loss, safe working practices around a potentially energized paste pipeline are paramount and careful, timely response to clearing the line during cement binder setting is important. Experience at other mines has shown that the paste line can be shut down and restarted within one hour in the event of an extended power loss or other short term breakdown event. If the returned power is emergency only, then the normal Stopping the Fill Run SOP applies.

The Pretium paste system UDS has been designed with two parallel lines available into the mine and twin pumps with the ability to use either pump on either line. Subject to safe working conditions, paste pumping underground may continue during clean out of the other blocked line.

5.8.1 References

- Outotec Functional Description - J15-0015-FD-009-R0-Paste Pumps to Underground.pdf
- Stopping the Fill Run SOP

5.8.2 Paste line blockage procedure

- The operator will carry out the Stopping the Fill Run SOP. If this cannot be completed due to loss of power or a blockage occurring, the operator will notify their supervisor and the UG Paste Leader that a blockage has occurred.
- The operator will ensure that all tailings and binder feed to the mixer has stopped and only water is being added.

- If power is available and under instruction by the paste plant supervisor, the normal peak pressure of the pump can be increased to the maximum operating limit of 150 Bar to attempt to clear the blockage with water.
- If this is unsuccessful, the pump will be shut down and depressurized and the UG Paste leader advised that the line is now blocked.
- If the line is blocked at the base of the VOK borehole or other vertical paste borehole, the UG Paste Leader will depressurize the line and open it to enable the paste to flow out of the borehole by gravity into the adjacent sump.
- If the pump is available actions may include:
  - Restarting the pump with water and flushing any remaining paste in the upper line section into the same sump.
  - Closing the line again at the base of the VOK borehole and opening the line by the 1350 Bypass sump and attempting a flush that section of the line up the VOK decline.
  - If that is successful, the line can be progressively broken and reconnected to pump and flush out each section until the line is completely clear to the stope.
- If the line cannot be cleared by pumping, or the pump is not available, then each pipe length or spool starting from the delivery end at the stope will be progressively opened. Using a pipe cap with a high-pressure water connector, the soft paste will be washed out of each pipe section.
- If any of the boreholes are blocked, a drill rig will be mobilized and the hardened paste will be drilled out.
- If the paste fill has set hard in the pipes, the blocked pipes will be dismantled and returned to surface to be drilled out and cleaned using a boring rig.

5.9 Tight filling a stope into an open void

In many circumstances, stopes will be tight filled to the shoulders of the original drill drive to ensure that the crown of each stope is adequately confined and that large unsupported spans do not occur during adjacent secondary stope extraction. This SOP covers activities required when filling into an open void from the upper level of the stope and the final fill surface is visible to the observer. The objective is to bring the elevation of the top surface of the fill to be in good contact with the shoulders of the stope up to the floor of the upper drill drive. This will ensure that the back of the stope is confined on either side of the drill drive and no void will be present when the secondary stopes alongside are mined. Extended back spans will be prevented.

This SOP does not cover tight filling a stope through a closed borehole and adjacent breather hole, either from the drawpoint elevation below or through rock or fill from alongside or above the stope. That SOP is the next section in the manual.

The key risks are both under filling (poor support to the back of the stope) and over filling (spillage of fill at that level). In some cases, the tight fill will be carried out with high strength fill to enable a good mucking surface.

5.9.1 References

Outotec Functional Description - J15-0015-FD-009-R0-Paste Pumps to Underground.pdf.

5.9.2 Tight filling a stope into an open void procedure

- During the design of the fill runs for the stope the Engineer will note whether the stope requires to be tight filled. This will be true in most cases.
- The Engineer will specify the volume of fill that will be placed as “tight fill”.

- The Engineer may specify a lower fill placement rate if required for level control.
- The binder recipes of the fill will be taken from the fill run design note and note that recipes may change during tight filling.
- Filling operations will take place for the lower part of the stope until the elevation of the tight fill is reached.
- The UG Paste Leader will advise the Operator and Engineer that tight filling is commencing and may continue filling operations.
- The UG Paste Leader will monitor the fill level visually at frequent intervals during the shift and when the fill run is within 200 m^3 of the tight fill volume will arrange for continuous monitoring for the last few hours of filling.
- When the observer sees that the fill has covered the shoulders of the stope and nearly reached the elevation of the level, they will inform the operator that the stope is now full and to commence a fill run shut down. The additional volume of fill in the reticulation will be placed into the stope and the line flushed.
- The UG Paste Leader will advise the Operator and Engineer that the stope is tight filled.

5.10 Tight filling a stope through a borehole and breather borehole

Tight filling is required in some stopes to ensure that the crown of each stope is adequately confined and that large unsupported spans do not occur during adjacent secondary stope extraction.

This SOP covers activities required when filling via boreholes from below or above the top of the stope and the final fill surface is not visible to the observer. The objective is to bring the elevation of the top surface of the fill to be in good contact with the shoulders of the stope up to the floor of the upper drill drive. This will ensure that the back of the stope is confined on either side of the drill drive and no void will be present when the secondary stopes alongside are mined. Extended back spans will be prevented.

When a stope is mined with retreating blind upholes and there is no physical access to the top of the stope, filling will take place via a pair of angled boreholes drilled from the drawpoint at a steep angle to intercept the top of the stope. One borehole will act as the fill hole and the other as a breather hole. During tight filling operations, the breather hole will be observed for displaced airflow and at the first sign of fill reaching the breather hole the fill run will be terminated.

An alternate situation where a stope can be accessed by boreholes from the upper level or above, sometimes through previously cured fill. Again, two boreholes will be used, one to fill and the other as a breather. If there is any positive static head available at the collars of the two boreholes it is recommended that a small launder be fitted to the filling borehole which is filled from the reticulation piping. This will eliminate the possibility of overpressure from static head.

The key risks are both under filling (poor support to the back of the stope) and over filling (over pressure of the fill in the stope, putting the drawpoint barricade at risk). There have been several recorded instances of barricade failure caused by applying excess static head pressure to the semi liquid fill from the fill line during these operations.

5.10.1 References

Outotec Functional Description - J15-0015-FD-009-R0-Paste Pumps to Underground.pdf.

5.10.2 Tight filling a stope through a borehole and breather borehole procedure

- During the design of the fill runs for the stope the Engineer will note whether the stope requires to be tight filled. This will be true in most cases.

- The Engineer will specify the volume of fill that will be placed as “tight fill”.
- The Engineer may specify a lower fill placement rate if required for level control.
- The binder recipes of the fill will be taken from the fill run design note and note that recipes may change during tight filling.
- Filling operations will take place for the lower part of the stope until the elevation of the tight fill is reached.
- The UG Paste Leader will advise the Operator and Engineer that tight filling is commencing and may continue filling operations.
- The UG Paste Leader will arrange to monitor the air flow from the breather hole at frequent intervals during the shift and when the fill run is within 200 m^3 of the tight fill volume will arrange for continuous monitoring for the last few hours of filling.
- When the observer sees any evidence that the fill has reached the breather hole, they will immediately inform the operator that the stope is now full and to commence a fill run shut down. If the additional volume of fill in the reticulation system can be diverted from the stope, this should be done.
- The UG Paste Leader will advise the Operator and Engineer that the stope is tight filled.

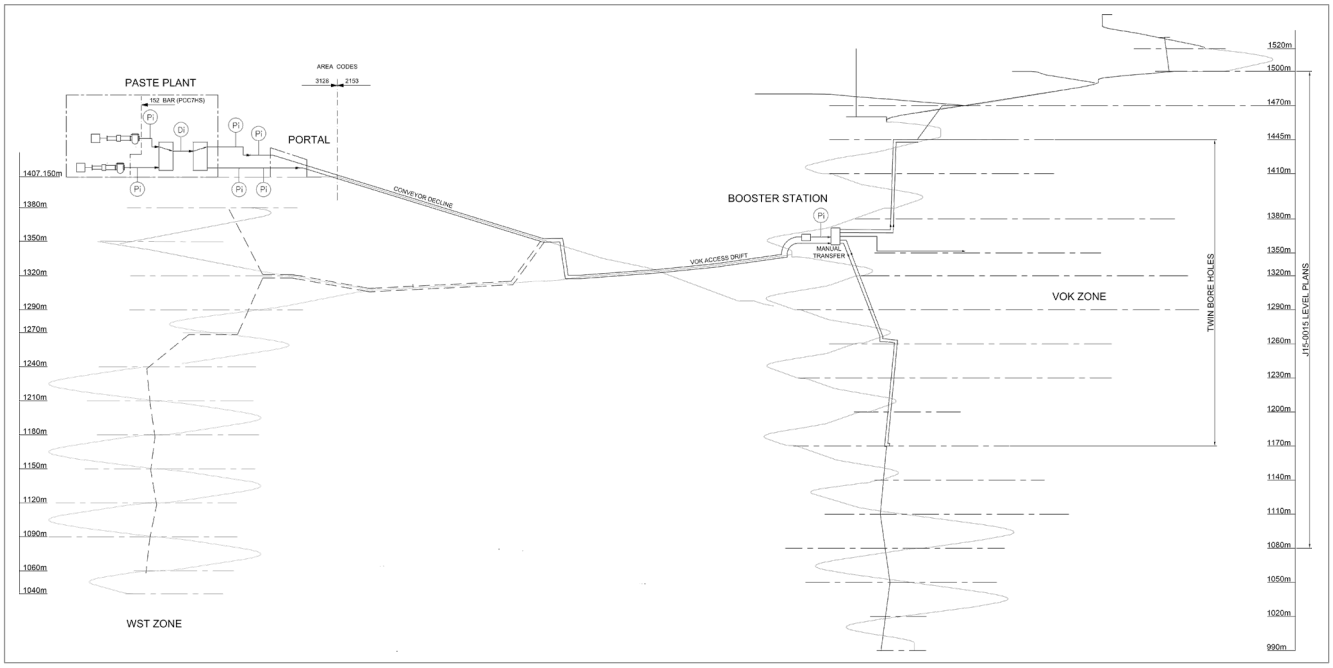
6 Underground paste distribution system

This section covers all underground activities related to the distribution of paste by pump and gravity to the stopes.

6.1 Reticulation system

A schematic of the overall reticulation system is shown in Figure 6.1 including the Booster pump station.

Figure 6.1 Schematic of underground reticulation



Paste fill is delivered underground by pumping to the stoping areas via a pair of pipelines installed in the main access decline. The lines pass through the "dogleg borehole" and up to the booster pump station via the VOK access drift. During commissioning and initial operations, paste will be pumped directly to the first few stopes to be filled. During this time, the booster pump station will be commissioned and used wherever higher density paste can be placed.

The Booster Station is located at 1320 RL and consists of a feed hopper and provision for a pair of GEHO PD pumps with the same specifications as the surface unit. To date, one pump has been installed due to the expected low utilization rates. The second pump will be installed if availability and utilization rates require it.

When the paste system is operating, the pressures will generally be much lower and controlled entirely by the balance of the total friction losses throughout the entire reticulation system and the static head developed in the boreholes and pipelines to overcome those friction losses. Table 6.1 and Figure 6.2 shows the expected pressure losses for surface pumping.

Table 6.1 Flow model parameters

Slump (mm & inches)	Cemented paste fill (w/w % solids)	Friction losses (kPa/m)
175 mm (7”)	65	15
210 mm (8.5”)	63	10
250 mm (10”)	61	4

Figure 6.2 Brucejack reticulation density and friction limits from surface pumping

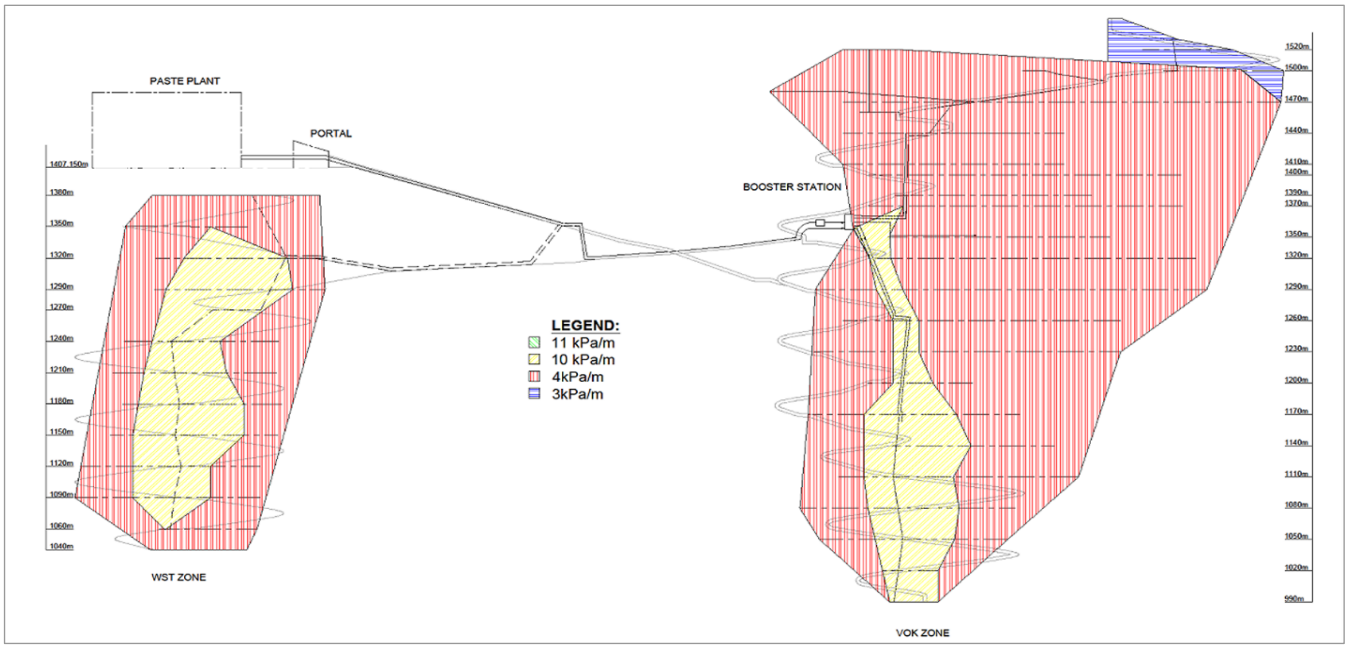
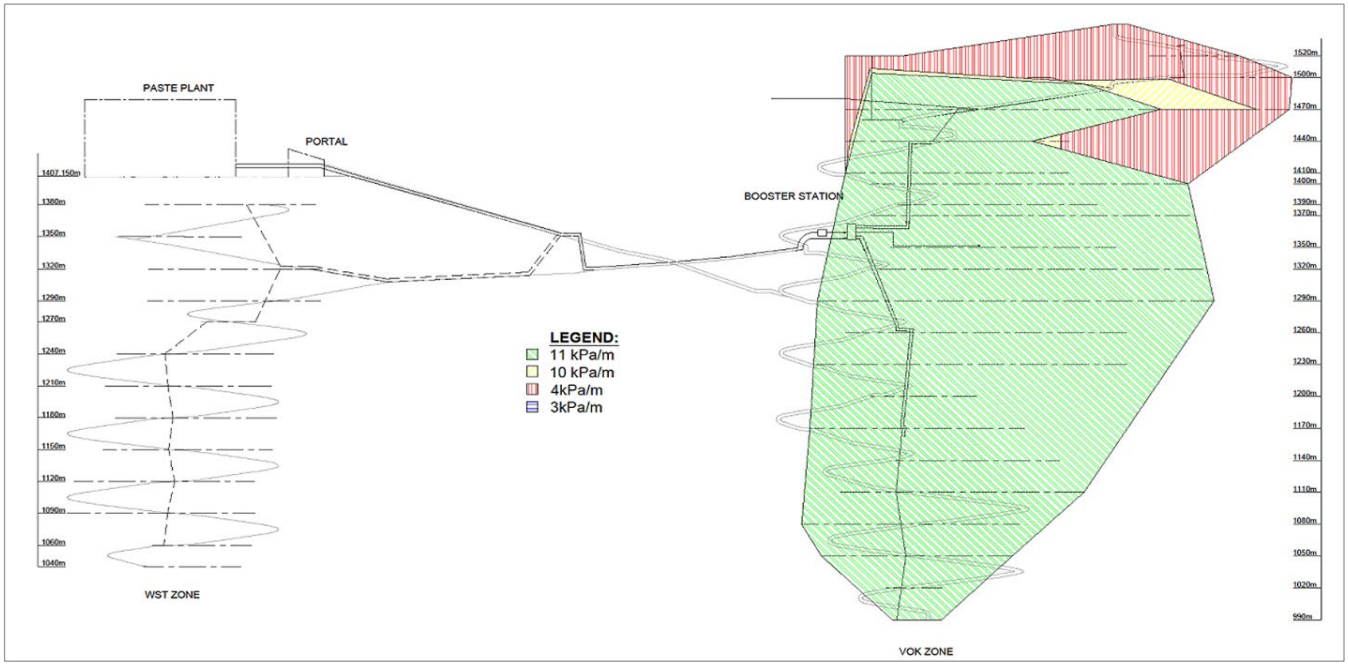


Figure 6.3 shows the expected pressure losses for underground booster station pumping.

Figure 6.3 Brucejack reticulation density and friction limits from booster station pumping



6.2 Piping design standards

All piping at Brucejack must comply to the Pretium Brucejack Design Specifications. These are shown in Table 6.2 though Table 6.5.

Table 6.2 Piping design standards

Piping design standard	Type	Material	Design pressure (kPa)	Application
PCC7FS	High-pressure piping	Ultratech 600	15,200	From paste plant to Booster Station to the level and borehole connections
PCC5HS	Level piping	Carbon steel		Sub levels from borehole connections to stope crosscuts
PPE2US	Cross cut piping	HDPE		Stope and levels where distance to pipe discharge is less than 90 m based on maximum design pressure of 1,380 kPa and design pressure loss of 15 kPa/m

Table 6.3 PCC7FS – high-pressure piping - Ultratech

Item	Size	Material	Mfg. method	Material spec	Pressure class	End prep	Spec
Pipe	8″	Induction hardened carbon steel	ERW	Ultra 600 (Ultratech) or approved eq.	Sch. 80	Plain end	UT600
	8″	Carbon steel	SMLS	ASTM A53 Gr. B Type 5.	Sch. 120	Plain end	ASME B36.10M
Fittings	8″	Induction hardened carbon steel	ERW	Ultra 600 (Ultratech) or approved eq.	Sch. 80	Plain end	UT600
	8″ - 10″	Carbon steel	SMLS	ASTM A234 Gr. B Type 5.	Sch. 120	Plain end	ASME B16.9
Couplings	8″	Ductile iron		Victaulic style 995N or approved equal. EPDM gasket, carbon steel bolts		Plain ends	
Joining method	8″	Polyethylene	Thermal fusion	PE 4710	DR9	Plain ends	ASTM D2657
Transition coupling	8″	Ductile iron		Victaulic style 997 or approved equal. EPDM gasket, carbon steel bolts		Plain / grooved	ASME B36.10M

Table 6.4 PPC5HS – level piping carbon steel

Item	Size	Material	Mfg. method	Material spec	Pressure class	End prep	Spec
Pipe	8″	Carbon steel	SMLS	ASTM A53 Gr. B Type S	Sch. 80	"ES" cut grooved	ASME 836.10M
Fittings	6″ & 8″	Carbon steel	SMLS	ASTM A234 Gr. B Type S	Sch. 80	Butt weld	ASME B16.9
Couplings	8″	Ductile iron		Victaulic style HP-70ES or approved equal. HMT gasket, carbon steel bolts			
Flanges	6″ & 8″	Forged steel, Raised face, slip-on or weld neck	Forged	ASTM A105	600	Welded	ASME B16.5
Nuts	All sizes″	Carbon steel, Semi finished heavy hex		ASTM A194 Gr 2H			ASME B18 2.2, B1.1 Class 2B
Studs	All sizes	Chrome moly steel, continuously threaded		ASTM A193 Gr B7			ASME B18 2.1, B1.1 Class 2A
Flange gaskets	6″ & 8″	Spiral wound, 304 SS & non-asbestos filler c/w 1/8″ thk CS integral centring ring		Flexitallic CG or app. Equiv	600		ASME B16.20
Instrument fittings	½″ to 2″	Forged steel, Half coupling	Forged	ASTM A105	3000	Threaded	ASME B16.11 and MSS SP-97

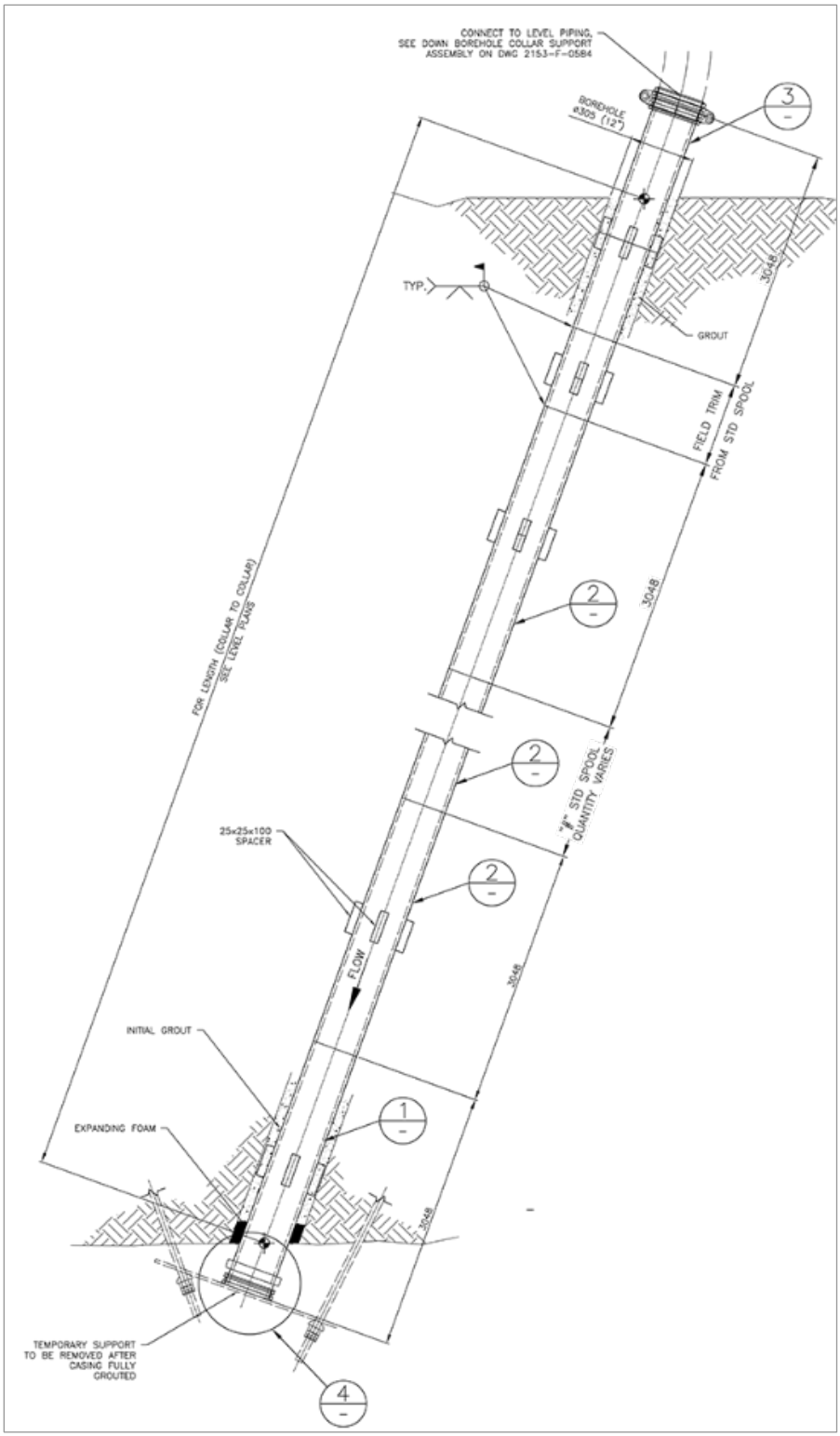
Table 6.5 PPE2US – HDPE low-pressure crosscut pipe

Item	Size	Material	Mfg. method	Material spec	Pressure class	End prep	Spec
Pipe	8″	HDPE	Pressure pipe	PE 4710	DR9	Plain	ASTM D2035/F714
Fittings	8″	HDPE	Pressure fittings, fabricated	PE 4710	DR9	Plain end – butt fusion	ASTM D2035/F714
Couplings	8″	Ductile iron		Victaulic style 995N or approved equal. EPDM gasket, carbon steel bolts		Plain ends	
Joining method	8″	Polyethylene	Thermal fusion	PE 4710	DR9	Plain ends	ASTM D2657
Transition coupling	8″	Ductile iron		Victaulic style 997 or approved equal. EPDM gasket, carbon steel bolts		Plain / grooved	

6.3 Internal borehole design details

Figure 6.4 shows a typical piping and borehole details.

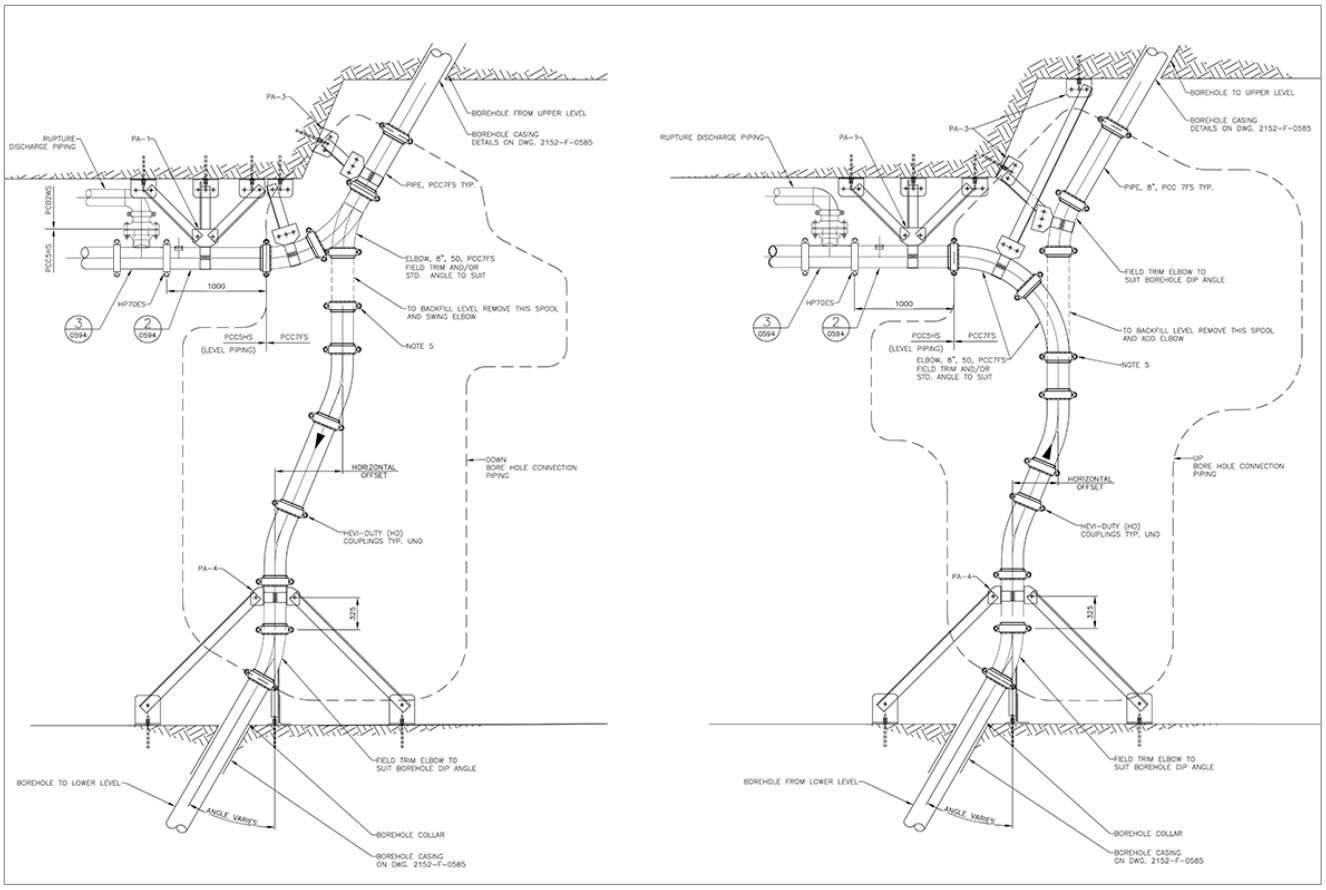
Figure 6.4 Schematic of borehole installation



6.4 Piping arrangements

Figure 6.5 shows borehole connections through to next borehole or to current filling level.

Figure 6.5 Borehole connection piping



6.5 Reticulation above and below booster station

A series of cased 200 mm boreholes have been drilled between each of the levels above and below the Booster Station, with take-off points on each level to permit paste reticulation wherever required.

7 Paste fill duty and target strength design

Paste fill placed underground at Brucejack is required to perform a number of stability functions. These functions include:

- Static strength requirements:
  - Stand open in vertical faces when exposed by adjacent pillar mining.
  - Support the weight of loading equipment when used as a mucking floor.
  - Permit mining underneath fill by production blasting for undercut ore extraction.
  - Permit mining through fill in development headings for the purposes of access or ventilation.
  - Confine the rock mass surrounding the stope to maintain local and regional stability within mining areas.
- Dynamic loading requirements:
  - Withstand the effects of proximity blasting from production stopes or development headings.
  - Withstand the effects of regional seismic events.

7.1 Vertical fill exposures

The transverse long hole open stoping method achieves a high resource recovery by the sequential extraction and filling of primary and secondary transverse long hole stopes, with a typical plan dimension of 30 mL x 15 mW x 30 mH. The mining of secondary stopes will expose the fill placed in most of these stopes, so it must be strong enough to remain stable when the confining rock pillar is removed.

AMC uses the strength design method by Terzaghi (1946)[2] as modified by Bloss (1997)[3] and Baldwin & Grice (2000)[4]. The technique is based on Terzaghi's arching method of stress estimation which allows calculation of backfill strength for fill masses with multiple sequential exposures (not simultaneous). From the input parameters, the average vertical stress in the fill can be calculated for each exposure. The design fill strength required is the largest of the calculated values, multiplied by the factor of safety (FoS) for each elevation zone in the stope. The method allows for variable strength zoning in the stope.

A wet fill bulk density of 1.71 kg/m^3 was used to represent high strength consolidated fill and a FoS of 1.25 applied.

Table 7.1 illustrates the design input parameters for vertical stope exposures and the geometry of the stope as a regular prism.

[2] K Terzaghi, *Rock Defects and Loads on Tunnel Supports*, (Youngstown: Harvard University, 1946).

[3] M L Bloss, *Fill Stability by Terzaghi*, (Brisbane, 1997).

[4] G Baldwin and A G Grice, "Engineering the New Olympic Dam Backfill System," (presented at the MassMin 2000, Brisbane, 2000), 1-15.

Table 7.1 Fill strength design inputs

AMC Backfill Design Strength Estimator V2.5

Using Terzaghi (1943) as modified by Bloss (1996) and Grice (1999) for multiple backfill exposures

General Assumptions

Geotechnical Data

Friction Angle ϕ	26	degrees	F/W Dip (deg)	90
Gravity g	9.81	ms-2		
Fill Density ρ	1.71	kg/m3	Wet PF 1.68 kg/m3	
Poisson's Ratio k	0.36			
Adjusted Factor of Safety	1.25		Default Factor of Safety	1.25
Depth zone increments	5.0	m		
Backfill mix increments	100	kPa	B' to W'	4

Stope Information

Stope Name

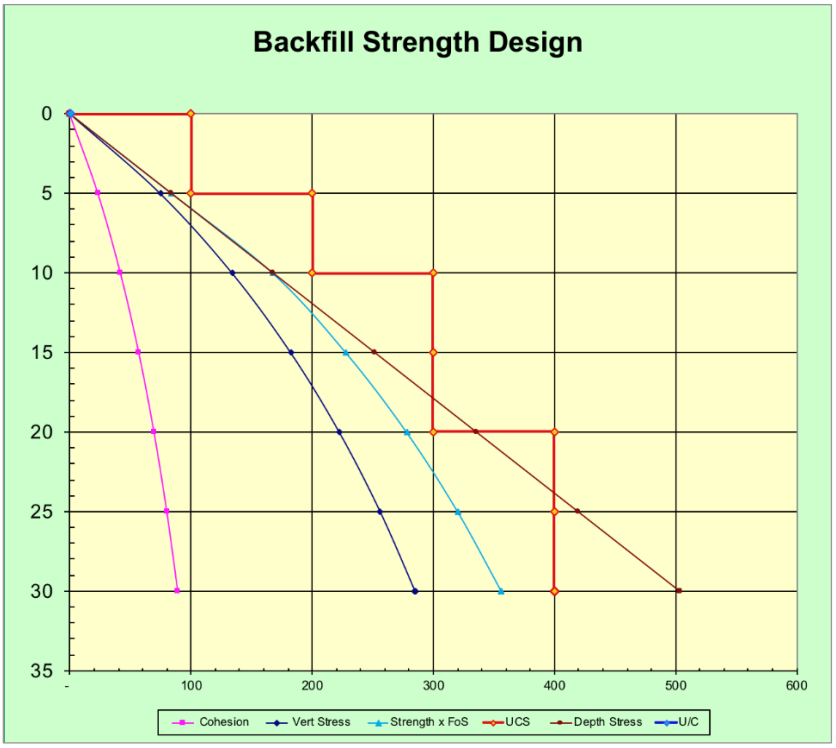
BJ Primary 15 x 30 x 30 Three Exposures

Stope Geometry

Length	30.0	m	Length is along strike
Width	15.0	m	Width is across strike
Height	30.0	m	
		Perimeter	90.0 m

Figure 7.1 plots the calculated average vertical stresses in the fill (shown in blue colour), progressively increasing in value with depth in the stope. A primary stope has three sequential exposures, 15 m wide x 30 m high and two exposures 30 m long and 30 m high. The peak average vertical stress after three exposures at the base of the stope is 285 kPa and multiplied by the FoS and rounded to the next 100 kPa gives 400 kPa. Note that the vertical stress diverges significantly from the linear depth stress line (shown in brown colour), illustrating the effect of arching within the fill. Inspecting the graph in 5m depth increments shows that optimized zoning of strengths can be carried out.

Figure 7.1 Charts of design strength of primary stope with three exposures (metres depth v stress kPa)



These graphs also show that it is possible to zone the strength of the fill within the stope. The cured strength of the fill need only meet the required strength at that elevation, permitting a reduction of cement dosing in the upper parts of stopes. However, for initial operations at Brucejack, the mine has elected to define three fill strength recipes. These are the high strength sill pour, the main fill zone of the stope and a thin high strength cap to finish the stope.

Table 7.2 summarizes the strength requirements for the various Brucejack stope geometries currently being planned using the above calculation method. Four stope cases are presented all of which are 15 m wide, 30 m long, and 30 m high. The cases are:

- Primary stope with no sill beam and three sequential exposures, 1 x 15 m wide and 2 x 30 m wide.
- Primary stope with sill beam and three sequential exposures, 1 x 15 m wide and 2 x 30 m wide.
- Secondary stope with no sill beam and one exposure, 1 x 15 m wide.
- Secondary stope with sill beam and one exposure, 1 x 15 m wide.

This table shows the optimized fill strengths that could be used to meet the stable exposure requirements. However, as discussed above, a simplified sill, main and cap zone system has been adopted for early paste fill operations until both extensive QC data and exposure experience has been gained.

Table 7.2 Optimized Vertical Exposures Strength Design using Fill Zoning

Optimised Strength Design

Depth (m)	Primary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)		Depth (m)	Primary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)		Depth (m)	Secondary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)		Depth (m)	Scondary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)	
1	Cap	1,100		0.5	Cap	1,100		0.5	Cap	1,100		0.5	Cap	1,100	
4	Main	100		5	Main	100		5	Main	100		5	Main	100	
10	Main	200		10	Main	200		10	Main	200		10	Main	200	
15	Main	300		15	Main	300		15	Main	200		15	Main	200	
20	Main	300		20	Main	300		20	Main	200		20	Main	200	
25	Main	350		25	Sill	1,100		25	Main	200		25	Sill	1,100	
30	Main	350		30	Sill	1,100		30	Main	200		30	Sill	1,100	
	average	250	kPa		average	500	kPa		average	167	kPa		average	467	kPa
	Width	Height			Width	Height			Width	Height			Width	Height	
Exposure 1	15	30		Exposure 1	15	30		Exposure 1	15	30		Exposure 1	15	30	
Exposure 2	30	BJ Primary 15 x 3		Exposure 2	30	30		Exposure 2	-	-		Exposure 2	-	-	
Exposure 3	30	30		Exposure 3	30	30		Exposure 3	-	-		Exposure 3	-	-	
Undercut	-	36		Undercut	15			Undercut	-			Undercut	15		

Table 7.3 details the updated current vertical exposures strength designs in use as of March 2022.

Table 7.3 Updated Vertical Exposures Strength Design using Fill Zoning

Zoned Paste Fill Strength Design

Depth (m)	Primary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)		Depth (m)	Primary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)		Depth (m)	Secondary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)		Depth (m)	Scondary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)
1	Cap	1,100		1	Cap	1,100		1	Cap	1,100		1	Cap	1,100
4	Regular B	250		4	Regular B	250		4	Low Strength	200		4	Low Strength	200
10	Regular B	250		10	Regular B	250		10	Low Strength	200		10	Low Strength	200
15	Regular B	250		15	Regular B	250		15	Low Strength	200		15	Low Strength	200
20	Regular A	350		20	Regular A	350		20	Low Strength	200		20	Low Strength	200
25	Regular A	350		25	Sill	1,100		25	Low Strength	200		25	Sill	1,100
30	Regular A	350		30	Sill	1,100		30	Low Strength	200		30	Sill	1,100
	average	328	kPa		average	578	kPa		average	230	kPa		average	530
	Width	Height			Width	Height			Width	Height			Width	Height
Exposure 1	15	30		Exposure 1	15	30		Exposure 1	15	30		Exposure 1	15	30
Exposure 2	30	30		Exposure 2	30	30		Exposure 2	-	-		Exposure 2	-	-
Exposure 3	30	30		Exposure 3	30	30		Exposure 3	-	-		Exposure 3	-	-
Undercut	-			Undercut	15			Undercut	-			Undercut	15	

7.2 Undercut sill exposures fill strength design

Undercut (sill) exposures will require higher strength backfill, primarily dependant on stope span. The first stopes mined on 1320 L will form a sill pillar to stopes below and high-strength fill will be required to ensure stable extraction of the resulting pillar. All of these stopes will require a high-strength beam of thick paste fill to ensure stable extraction with minimal dilution.

AMC has developed an undercut fill strength spreadsheet design tool based on the method described by Mitchell & Roetger (1989)[5]. This technique assesses stability of sills against five possible failure mechanisms of sliding, caving, flexural bending, crushing and rotation. Figure 7.2 illustrates each of these potential fill failure mechanisms. Each of the failure mechanisms are tested for the geometry in question and the target design strength is the maximum of each failure mechanism, multiplied by the FoS. It is a conservative two-dimensional approach.

[5] Mitchell, R.J. & Roetger, J., 1989. Analysis and modelling of sill pillars. In Innovations in Mining Backfill Technology, Hassani et al.(eds.). pp. 53–61.

Figure 7.2 Mitchell sill design method – failure mechanisms

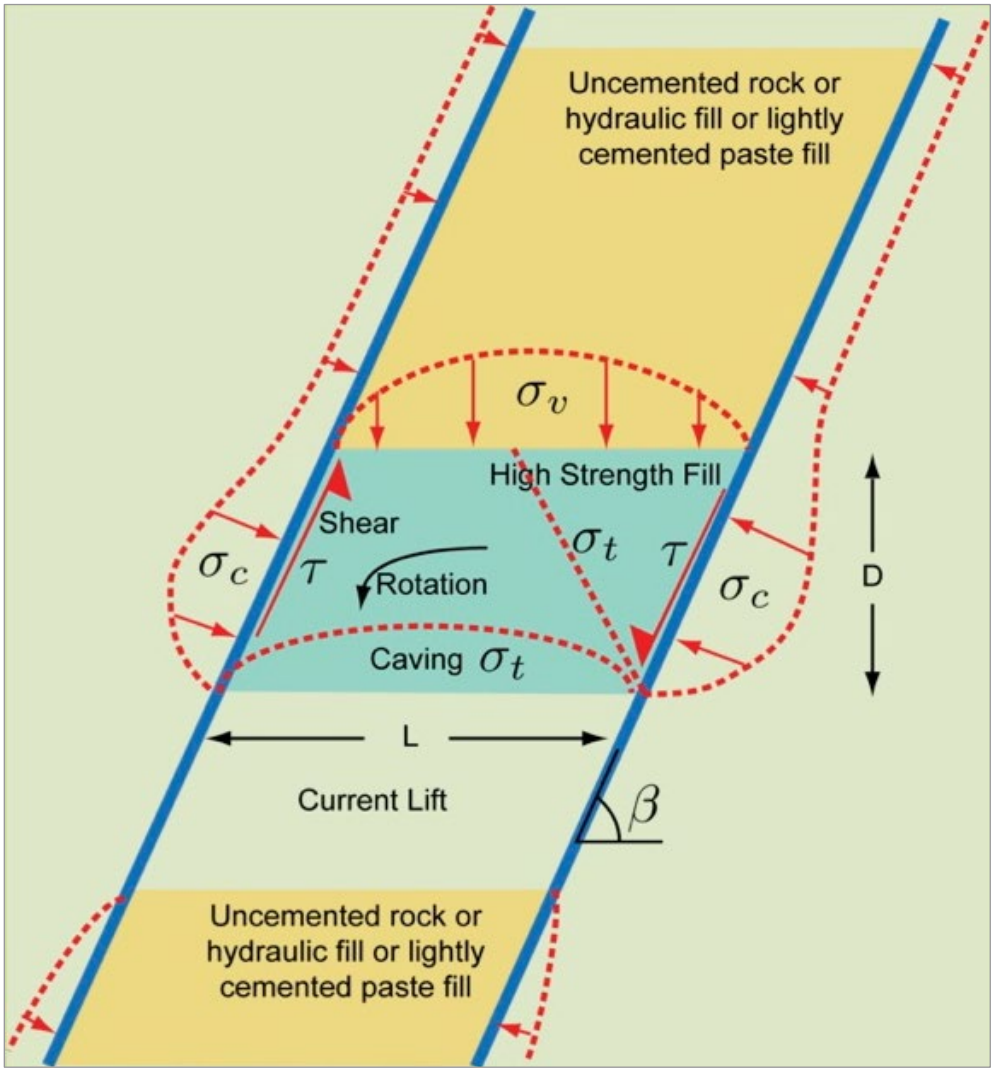


Table 7.4 shows the input parameters for the undercut sill designs.

Table 7.4 AMC Mitchell sill input parameters

General Assumptions			
Geotechnical Data			
Sill Pillar Fill Type	Paste		Non Entry Mining Method (FoS >= 1.25)
Elastic Modulus E MPa	200		
Ratio of Compressive to Tensile Strength	8.0		
Gravity g ms-2	9.81		
Wet Fill Density γ kg/m^3	1.71	Sill Pillar	
Wet Fill Density σ_v γ kN/m^3	16.8	Sill Pillar	
Wet Fill Density γ kg/m^3	1.71	Surcharge Load	
Wet Fill Density σ_v γ kN/m^3	16.8	Surcharge load	
Factor of safety FoS	1.25		FoS >= 3.0 for man entry
Backfill mix increments kPa	100		

Under Terzaghi's arching principles, for a sill of 30 m long and 15 m wide, the dominant arching effect occurs over the narrow span. The Mitchell design method produces a conservative design result, considering only the narrow span in a 2D analysis and ignoring the additional arching that does occur at the ends of the stope. Table 7.5 shows the calculation results for each exposed sill for a range of sill exposure widths. This table shows the required backfill strengths for each failure mechanism. The results show that for spans up to 15 m stope width the limiting failure mechanism will be caving failure (highlighted in red).

The model also calculates the minimum thickness of the high strength sill beam. The nominal thickness is one half of the span to accommodate a parabolic shaped caving surface of 7.5 m. For initial operations at Brucejack, AMC recommends that 10 m thickness of high strength cemented paste fill should be placed to ensure stability.

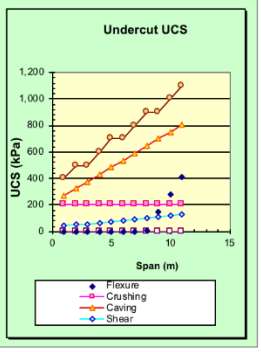
AMC concludes that all stopes undercut by future stoping with a span of 15 m will require a 10 m thick beam of 1,100 kPa paste fill to ensure stability during sill pillar recovery. The curing time available for these sill beams is in the order of months and years, again permitting efficient use of binders to minimize operating cost.

Table 7.5 Backfill strengths for undercut sills

Required Undercut Backfill Strength

Maximum of Flexure, Crushing, Caving, Shear and Rotational Stability Limits

Width of Sill (HW to FW) m	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
σ_c at flexural stability limit kPa	0	0	0	0	0	0	0	12	146	281	415
σ_c at crushing stability limit kPa	200	200	200	200	200	200	200	200	200	200	200
σ_c at caving stability limit kPa	269	322	376	430	484	537	591	645	698	752	806
σ_c at shear stability limit kPa	42	50	59	67	76	84	92	101	109	118	126
σ_c at rotational stability limit kPa	0	0	0	0	0	0	0	0	0	0	0
Minimum depth of cemented sill m	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
σ_c at stability limit kPa	269	322	376	430	484	537	591	645	698	752	806
Minimum Backfill UCS (inc FoS=1.25) kPa	400	500	500	600	700	700	800	900	900	1,000	1,100



7.3 QC data analysis

Figure 7.3 shows a subset of QC samples tested at 28 days curing time for a range of binder dosing rates plotted as percent solids by weight. The recipe dosing rates of 6.5%, 11%, and 12.5% can be clearly seen and the average strength trend line is included. Figure 7.4 shows the same data set but this time plotted as kg/m^3 of binder in the cured QC samples. This graph is more useful since it takes in to account the significant variable of paste density. In this example the binder doing rates for the above binder rates cluster around 70, 120, and 140 kg/m^3 respectively.

This analysis introduces the concept of characteristic strength whereby 95% of all samples tested are above that value. Comparison of the characteristic and average strengths validate the adoption of a FoS of 1.25.

Figure 7.3 28 day curing UCS QC samples plotted by binder addition by weight

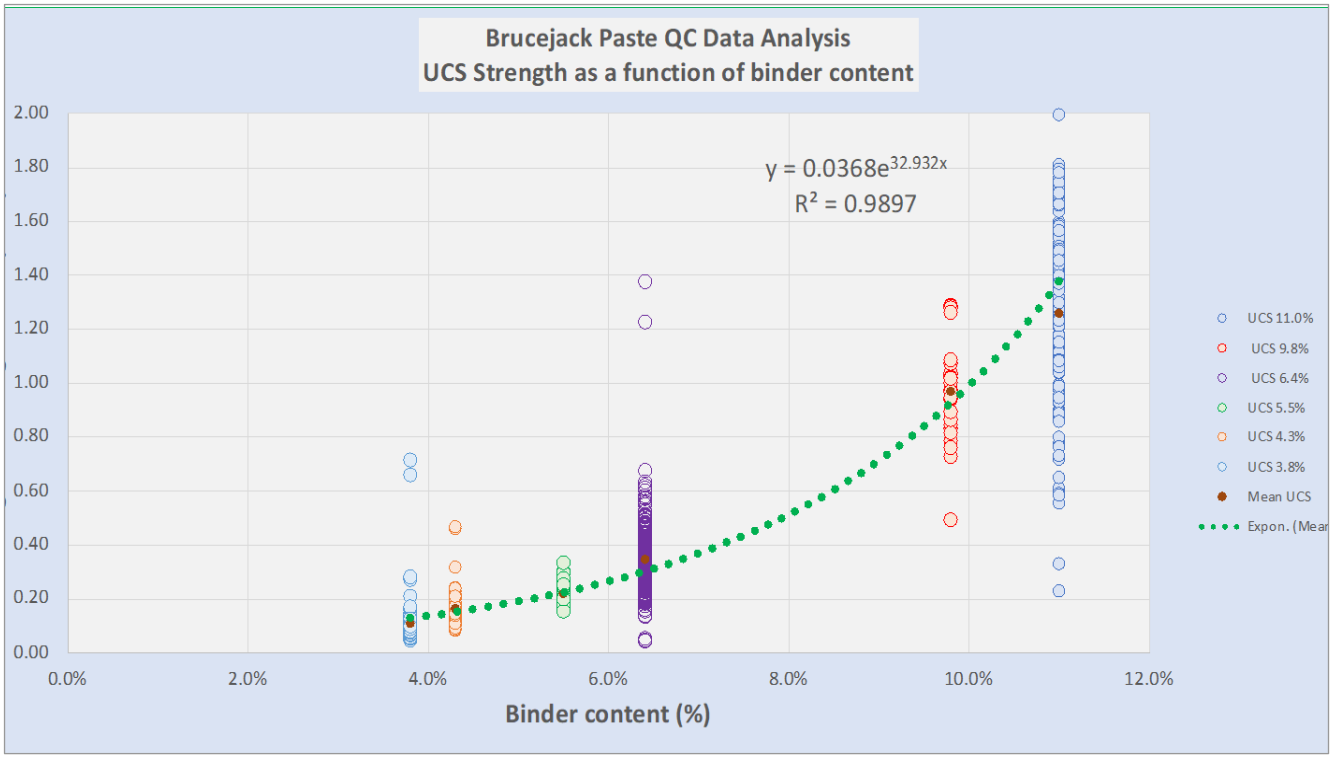
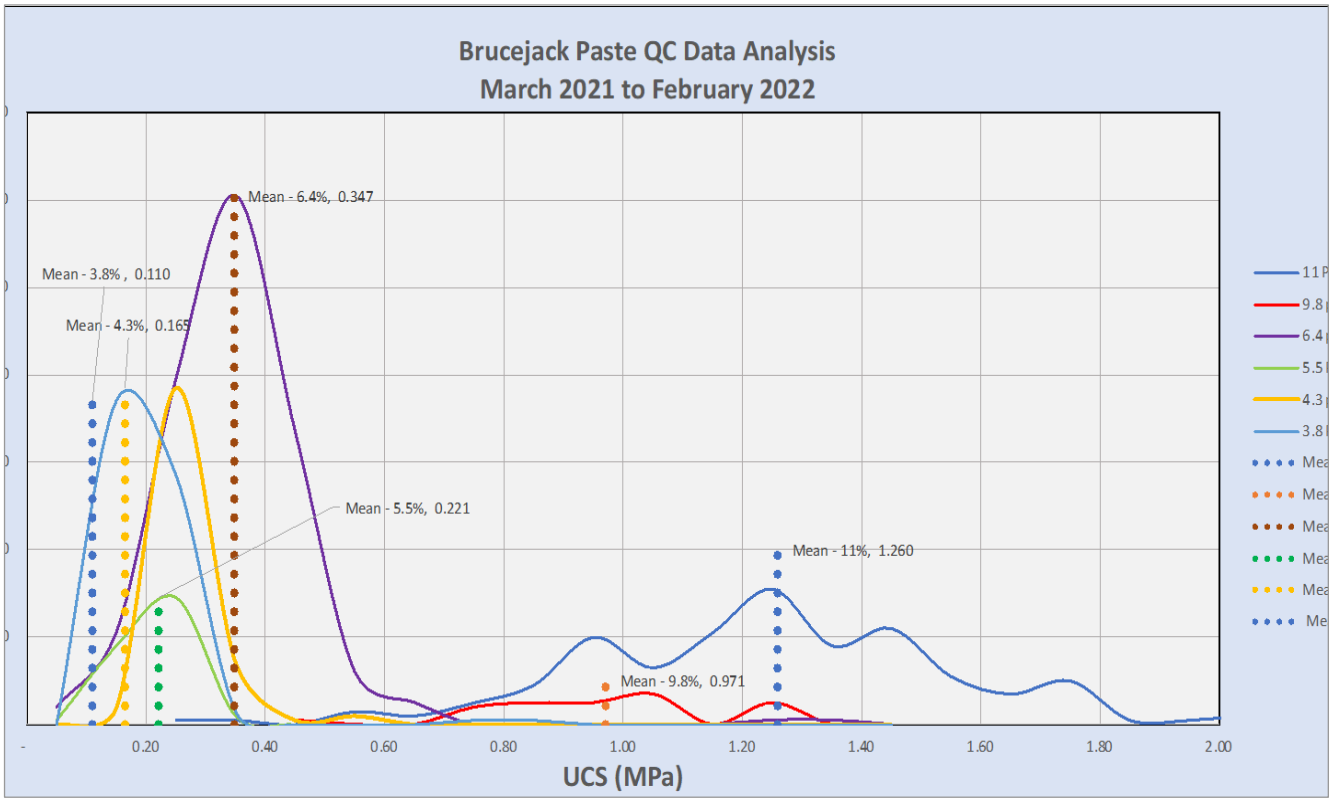


Figure 7.4 28 day curing UCS QC samples plotted by frequency



7.4 Binder dosing requirements and paste fill recipes

Using the simplified strength fill zone designs, the paste recipes can be determined from the original FS designs and updated with the latest QC data.

The design-strength-zone variations for all fill recipes are summarized in Table 7.6, repeated here from Table 5.1.

Table 7.6 Paste fill strength zones for each fill type application

Paste type	Usage	Design 28-day strength (kPa)	QC Average 28-day strength (kPa)	Current binder dosage by (%)	Current binder dosage (kg/m³)	Minimum paste slurry density (% w/w)	In situ density dry paste (t/m³)	In situ density wet paste (t/m³)
High-strength Paste	Sill beams up to 15 m wide	1,100	1,252	11.0%	125.5	63%	1.11	1.71
High-strength Paste	Top of stope caps for mucking	800	965	9.8%	111.8	63%	1.11	1.71
Regular Strength A	Regular stope in the first 15 m high	350	340	6.4%	73	63%	1.11	1.71
Regular Strength B	Regular stope at 15 m or higher	250	206	5.5%	62.7	63%	1.11	1.71
Low Strength Paste	Secondary stopes with short wall exposure	200	171	4.3%	49.1	63%	1.11	1.71
Liquefaction resistant Paste	Secondary stopes with no future exposures	100	110	3.8%	43.4	63%	1.11	1.71

7.5 Importance of QC data collection

The results of the previous test work have provided design binder recipes to achieve the required fill strengths at 28 days curing. The tests have shown that results are sensitive to binder content, clay content and paste slurry density. The test work carried out has reported strengths of tested samples and these values have been applied to the recommended binder recipes.

Brucejack has established a Paste QC lab as an integral part of the backfill plant and will generate strength results from paste samples collected each shift. As part of that QC work, the mine will also investigate and quantify the effect of the key variables of clay, density and binder dosing. These results are compiled and the trends of average strength and variability for each of the key parameters for the actual tailings and binder being used for the paste fill.

These results are used to continually refine the paste fill recipes to improve strength or optimize binder addition. In the event that average strength QC results start to trend below the design requirements, the initial response are to increase binder levels in all recipes until the source of the problem can be identified. Other responses include increasing slurry density where practical.

The Engineer will review the QC data and investigate whether large volumes of under strength fill has been placed into stopes prior to the identification of the problem. If low strength bands of fill or large volumes are identified at risk in individual stopes, remedial mine design will be undertaken. This will consist of evaluation of the future exposure dimensions and the required strength.

An example action could be for a secondary stope planned to be 30 m long and 30 m high on one of the side fill exposures not being to the required strength. In this case the Engineer will determine

the stable exposure at the lower strength and will reduce the number of rings to be drilled and fired, reducing the length of the stope and the size of the exposure. That stope would be filled and, after curing, the remaining stope taken and subsequently filled.

The Engineer may also choose to leave an ore pillar against the lower strength fill and not expose it to prevent failure and ore loss from unplanned dilution.

Assessment of fill QC records are a routine part of each stope design to anticipate fill performance problems and minimize the risk of dilution and ore loss.

8 Paste barricade designs

Historically, Brucejack has adopted two types of paste fill barricades to retain curing paste fill in stopes. These are:

- Shotcrete arched walls – Golder design
- Waste rock with shotcrete bunds – SRK design

Most commonly, Brucejack uses waste rock with shotcrete bunds as paste barricades due to the limited available space for barricade construction. Barricades are retaining structures that are constructed at the base of open stopes to retain paste fill until it gains sufficient strength to become self-supporting.

Prior to commencement of filling operations, barricades are constructed in the draw points of empty production stopes to retain the paste fill. Figure 8.1 shows an example of a shotcrete arched wall barricade.

Figure 8.1 Example of arched shotcrete barricade

It is important to prevent or divert any ground water or service water entering the stopes being filled. This will ensure that there is no build-up of pore water pressure behind these structures. Exploration boreholes intersecting stopes should be routinely grouted to eliminate or minimize inflow.

Risk and safety issues relating to barricade construction and operation are discussed in some detail in Section 10.11 and the user is directed there for further information.

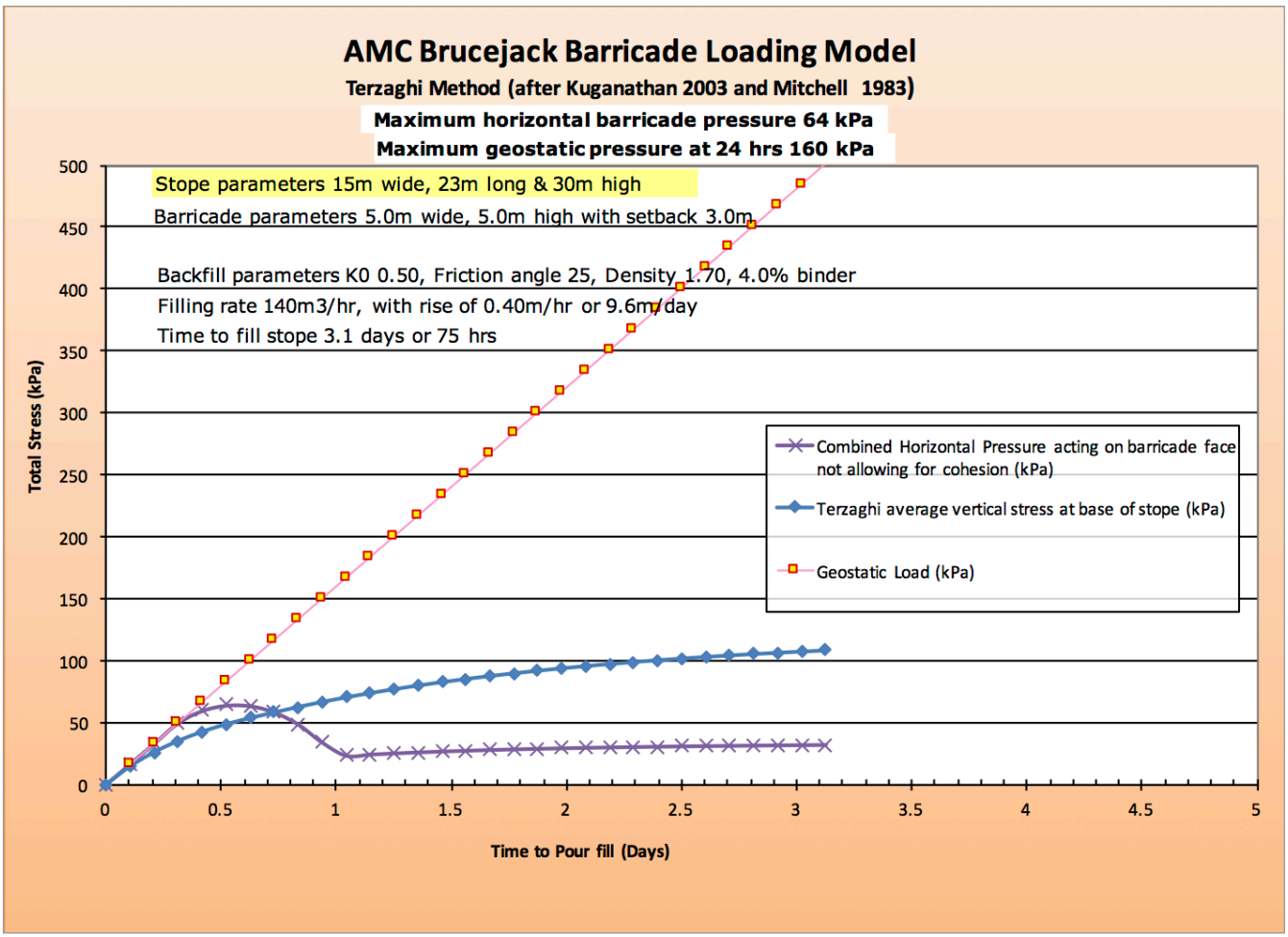
8.1 Barricade loading specification

Field measurements and modelling of stresses within early curing age paste fill at other mines has shown that barricade pressures typically reach a maximum around 24 hours after the start of filling. Paste fill behaves initially as a viscous liquid exhibiting geostatic loading conditions. Within 8 to 12 hours, consolidation commences as some of the pore water exudes and the tailings particles start to develop frictional shear strength. In uncemented fill types, the peak pressure is reached at 24 hours and remains at the value despite further fill placement above this elevation in the stope. More commonly, the fill is cemented and the development of cohesive strength from the curing binder causes the peak pressure to drop to residual levels.

AMC has developed a barricade loading model based on the calculations published by Kuganathan (2003) which allow for arching in the consolidating and curing fill in the stope and arching within the drawpoint, further reducing loading on the barricade. A binder curing model based on Mitchell (1983) is used to generate cohesive strength. The values for transition from initial geostatic loading to fully arched are manually input as 8 and 24 hours respectively based on papers by Hughes 2008, Yumlu & Guresci, 2007, and Veenstra, 2013.

Figure 8.2 shows the calculated loading result for a Brucejack stope filling at 140 m^3/hr in a stope with a base area of 15 m x 30 m or 450 m^2.

Figure 8.2 Barricade loading model – 140 m^3/hr



The chart shows depth stress increasing linearly over 30 m height of the stope and the expected Terzaghi arch vertical stress acting on the base of the stope. The blue line plots the pressure acting horizontally on the barricade as it transitions from geostatic to arched load, reducing below the vertical stress (as expected) and alongside the drawpoint walls. The peak arched barricade pressure is calculated as 50 kPa in this example and the maximum geostatic pressure at 24 hours is 160 kPa.

For Brucejack the stope fill runs have been designed to provide a high strength sill beam of up to 10 m thick in the base of the stope with the rest of the stope filled with normal strength fill for up to three sequential (never simultaneous) fill exposures. The last half metre will be capped with high strength fill to provide a clean mucking surface and prevent loss of grade into soft paste.

Brucejack has selected 10 m as the maximum height rise in 24 hours at the base of any sized stope. Table 8.1 lists the expected arch horizontal pressures on the barricades and peak geostatic loads for 24 hour pours or up to 10 m height, whichever occurs sooner. Table 8.2 illustrates the range of stope dimensions, rise rates and peak pressures that could be encountered. All stopes below 350 m^2 plan area will be limited to 10 m maximum height rise per 24 hours.

Table 8.1 Calculated arched and geostatic bulkhead pressures at 140 m^3/hr

Dimensions	Plan area	Estimated horizontal pressure (kPa)	Maximum geostatic pressure at 24 hours (kPa)	Barricade design working pressure (kPa)
30 mL x 15 mW x 30 mH	450 m^2	50 kPa	125	200
23.5 mL x 15 mW x 30 mH	350 m^2	64 kPa	168	200
Limit to 10 m rise per 24 hours	Less than 350 m^2	64 kPa	168	200

Table 8.2 Range of Brucejack stope dimensions and fill rise rates at 140 m^3/hr

	Brucejack Stope filling rates				Daily mining rate	3,300	tpd	
					Hourly tailings solids	141	tph	
Sub level interval		30	m		Filling rate	140	m3/hr	
Limit daily rise rate		10	m		Wet density	1.71	t/m3	
		Stope Plan Area (m2)						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	800	700	600	500	400	2	200
	15	600	525	450	375	300	225	150
	10	400	350	300	250	200	150	100
		Stope Volume (m3)						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	24,000	21,000	18,000	15,000	12,000	9,000	6,000
	15	18,000	15,750	13,500	11,250	9,000	6,750	4,500
	10	12,000	10,500	9,000	7,500	6,000	4,500	3,000
		Rise Rate per hour (m)						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	0.2	0.2	0.2	0.3	0.4	76.5	0.7
	15	0.2	0.3	0.3	0.4	0.5	0.6	0.9
	10	0.4	0.4	0.5	0.6	0.7	0.9	1.4
		Rise rate per 24 hrs (m)						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	4.2	4.8	5.6	6.7	8.4	10.0	10.0
	15	5.6	6.4	7.5	9.0	10.0	10.0	10.0
	10	8.4	9.6	10.0	10.0	10.0	10.0	10.0
		Hours to fill stope						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	171	150	129	107	86	64	43
	15	129	113	96	80	64	48	32
	10	86	75	64	54	43	32	21
		Days to fill stope						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	7.1	6.3	5.4	4.5	3.6	2.7	1.8
	15	5.4	4.7	4.0	3.3	2.7	2.0	1.3
	10	3.6	3.1	2.7	2.2	1.8	1.3	0.9
		24 hour Max Geostatic Load (kPa)						
Stope length (m)		40	35	30	25	20	15	10
Stope width (m)	20	70	81	94	113	141	168	168
	15	94	107	125	150	168	168	168
	10	141	161	168	168	168	168	168

Based on the above analysis, Brucejack arched barricades are designed for a maximum working load of 200 kPa to allow for geostatic limit conditions with the expectation that actual pressures will be considerably lower. This will be monitored by instrumentation in the first stopes using earth pressure cells and piezometers and in the case of significant variations during close monitoring, filling operations will be modified to ensure safe operations at all times.

8.2 Shotcrete arch barricade designs and location

Golder Associates was engaged to provide a design of reinforced compressive arch shotcrete barricades for a design working pressure of 200 kPa. Two barricade opening sizes were selected to cover largest possible dimension drawpoints. Current practice at Brucejack is to mine drawpoints at 5.0 m wide and 4.5 m high, which is smaller than the barricade design dimensions.

Barricade location is specified using common practice for most paste backfill operations around the world. The centre line of the barricade arch is located one drive width (usually 5.0 m) back from the brow of the stope. The barricade has an arch radius of 4.5 m with a thickness of 0.400 m the peak of the arch is located 3.9 m back from the brow. Based on work by Kuganathan (2008), this 5.0 m setback further reduces the peak arched loading on the wall from the curing paste fill and is a practical location for mining of the adjacent stope.

The location may be varied by an authorized person due to local ground conditions or drawpoint geometry. In the event that the barricade is moved closer to the brow, the filling rules relating to maximum fill height rise must be reviewed.

The current barricade designs for 5 x 5 m and 6 x 6 m sized drawpoint openings are shown in the following section. The reference drawings for these illustrations are taken from and are included in this report as Appendix H.

- Appendix H2 - Ref Drawing – Golder 5 x 5 Barricade 1776046_S-03_R0.pdf
- Appendix H3 - Ref Drawing – Golder 6 x 6 Barricade 1776046_S-02_R2.pdf
- Appendix H1 - Ref Drawing – Golder Construction notes 1776046_S-01_R2.pdf

The SOP for construction is given here is Section 5.4.

8.2.1 5 m x 5 m barricade design

Figure 8.3 and Figure 8.4 show the plan and section views of a 5 m x 5 m arched barricades and Table 8.3 shows the bill of materials for the same.

Figure 8.3 5 m x 5 m barricade plan

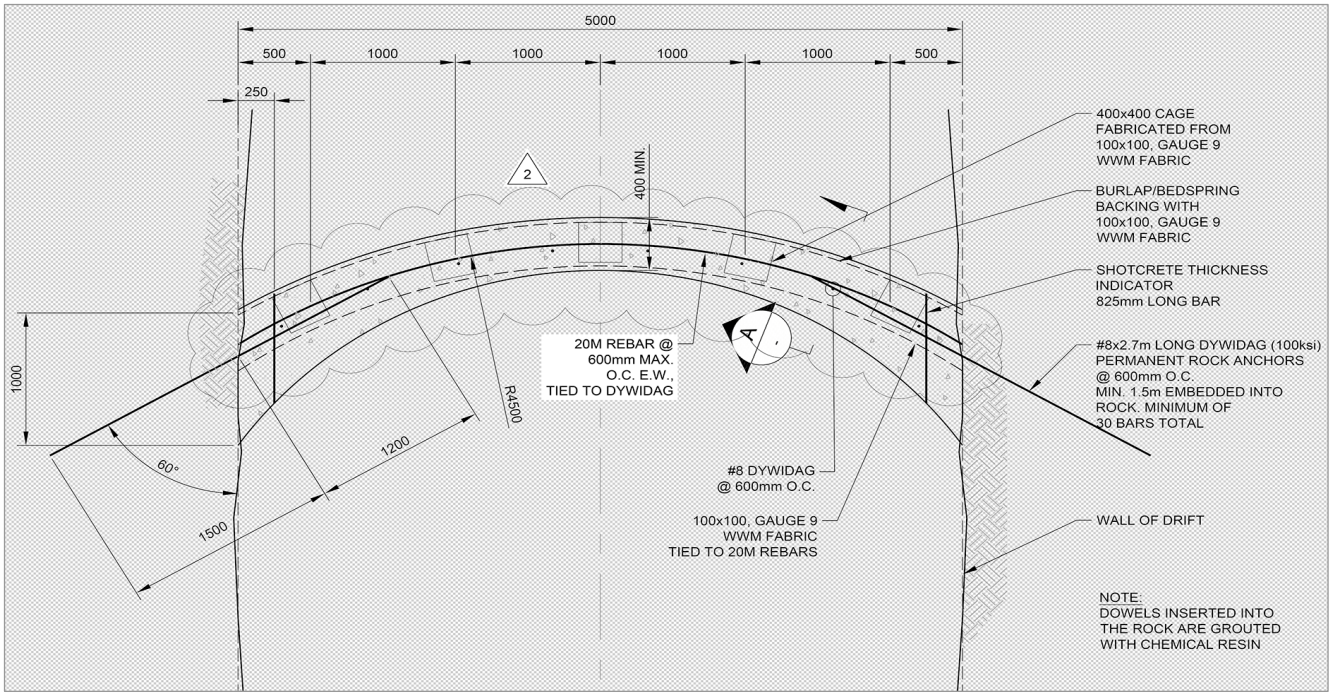


Figure 8.4 5 m x 5 m barricade section

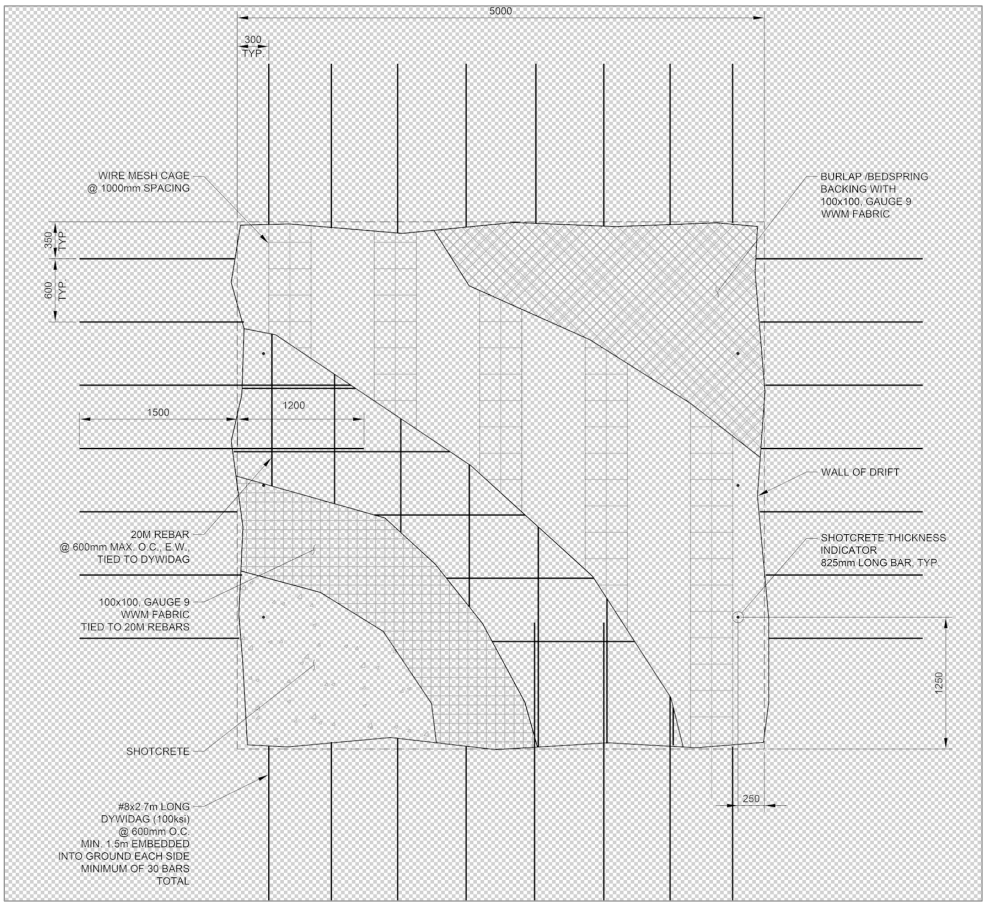


Table 8.3 5 m x 5 m barricade bill of materials

Item	Description	Qty.
1	#8 x 2.7 m long Dywidag permanent rock anchors (100 ski)	30
2	Shotcrete thickness indicator 825 mm bar	6
3	400 x 400 wire mesh channel frame	5
4	100 x 100 9 gauge wire mesh- approx. 28 m^2	1
5	Shotcrete depending on drift size - approx. 12 m^3 Min 28 day compressive strength = 28 MPa	1
6	20 mm x 5 m long rebar	16
7	20m x 5 m Long, 4.5 m Radius Rebar	14
8	Burlap / bedspring backing - approx. 28 m^2 100 mm x 100 mm, Gauge 9 Wire Mesh – Approx 40 m^2	1

8.2.2 6 m x 6 m barricade design

Figure 8.5 and Figure 8.6 show the plan and section views of a 6 m x 6 m arched barricades and Table 8.4 shows the bill of materials for the same.

Figure 8.5 6 m x 6 m barricade plan

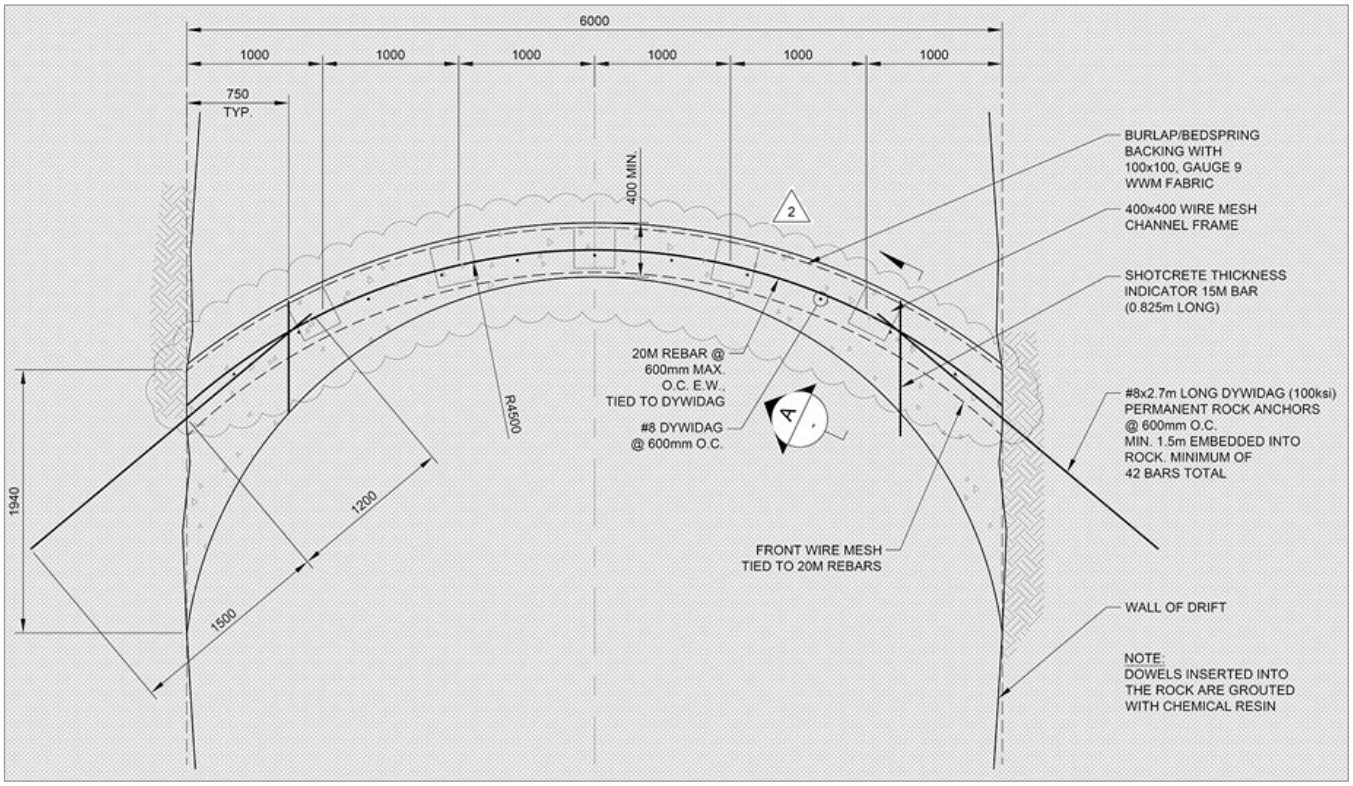


Figure 8.6 6 m x 6 m barricade section

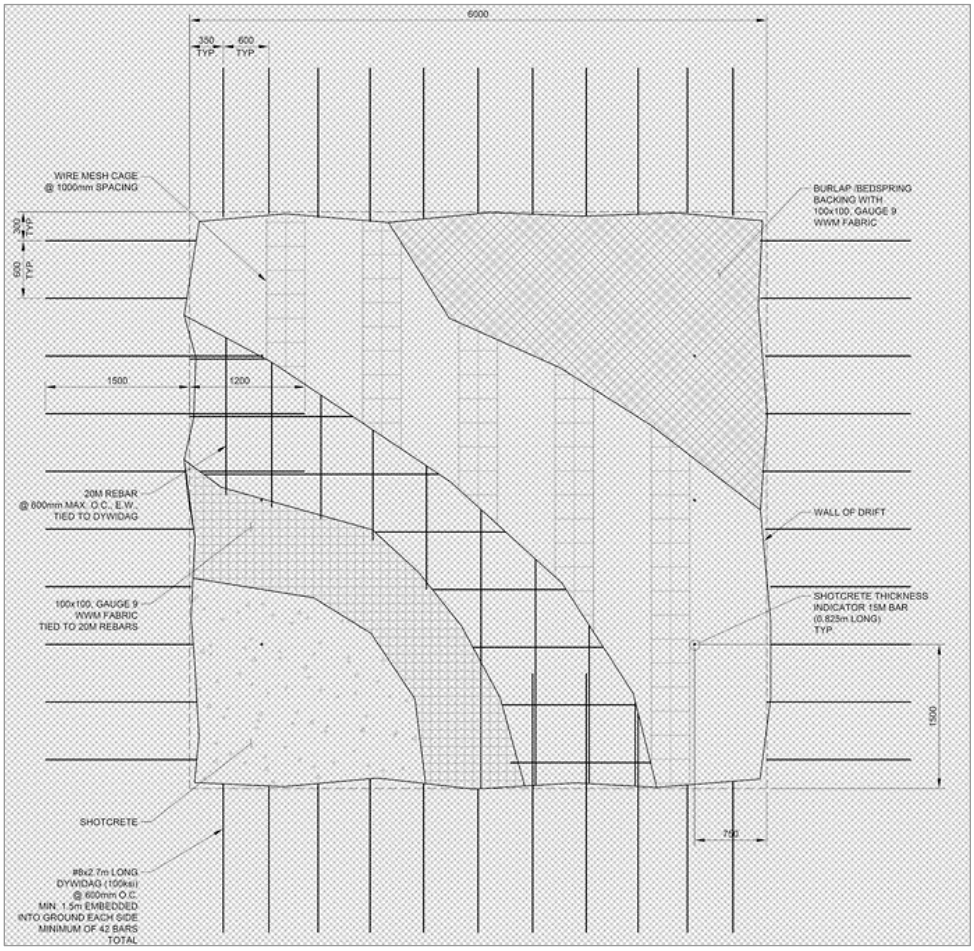


Table 8.4 6 m x 6 m barricade bill of materials

Item	Description	Qty.
1	#8 x 2.7 m long Dywidag permanent rock anchors (100 ski)	42
2	Shotcrete thickness indicator 825 mm bar	6
3	400 x 400 wire mesh channel frame	5
4	100 x 100 9 gauge wire mesh- approx. 28 m^2	1
5	Shotcrete depending on drift size - approx. 17 m^3 Min 28 day compressive strength = 28 MPa	1
6	20 mm x 6m long rebar	21
7	20m x 5 m Long, 4.5 m Radius Rebar	21
8	Burlap / bedspring backing - with 100 mm x 100 mm, Gauge 9 Wire Mesh – Approx 40 m^2	1

8.3 Rock Barricade designs and location

SRK Consulting was engaged to provide the design of a fill fence used as a barricade for paste backfill of mined stopes at Brucejack Mine. The fill fence will be constructed with waste rock material generated from development extraction. SRK provided a waste fill fence design as shown in Figure 8.7 to meet the current requirements for shotcrete fences when 200kPa of lateral pressure is applied.

The capacity of the waste fill fence will depend on the shear resistance of the waste material against the lateral pressure from the paste fill column. The resisting contributing force must take into account the shear against the floor and the walls of the drift. It is expected that the friction between the waste, and the walls, floor and back of the drift, will be greater than the internal friction of the waste due to drift profile irregularities, therefore the internal friction of the waste material will be assumed for the calculations.

According to Aubertin et al, 2009 considering a worst-case scenario of waste fence being fully saturated with water.

Equation 1: $L = \frac{\mathrm{P}}{\lambda}$

Where:

- L is the required length of waste fence.
- P is the maximum lateral pressure: 200 kPa.
- λ is equal to Equation 2.

Equation 2: $\lambda = Tan\varphi K_R \left(\gamma_\omega \mathrm{h} + \frac{\gamma_s - 2\gamma_\omega}{3}\mathrm{h}\right)\mathrm{h} + Tan\varphi \left(\gamma_\omega \mathrm{h} + \frac{\gamma_s - \gamma_\omega}{2}\mathrm{h}\right)\mathrm{w} + \mathrm{Tan}\varphi K_R \gamma_\omega (\frac{h^2}{3})$

Where:

- γ_ω is the unit weight of the waste fill: 2,200 N/m^3.
- γ_s is the unit weight of the saturated waste fill: 2,450 N/m^3 (assuming 23% void).
- φ is the internal friction angle of the waste material: 38°.
- K_R is a coefficient of friction = $\frac{1-sin\varphi}{1+sin\varphi}$.

Therefore, for a maximum lateral pressure of 200 kPa, the fill fence with a safety factor of 1.4 which is equivalent to 0.77 m.

SRK recommends the following:

- Use a minimum 5 m length waste fill fence from toe to toe.
- Ensure a minimum contact of 1 m in the back.
- Fill any gap between the back and the waste fill fence with shotcrete.
- To avoid leakage cover the toe of the barricade with shotcrete with a minimum thickness of 50 mm.

Reference – Appendix H

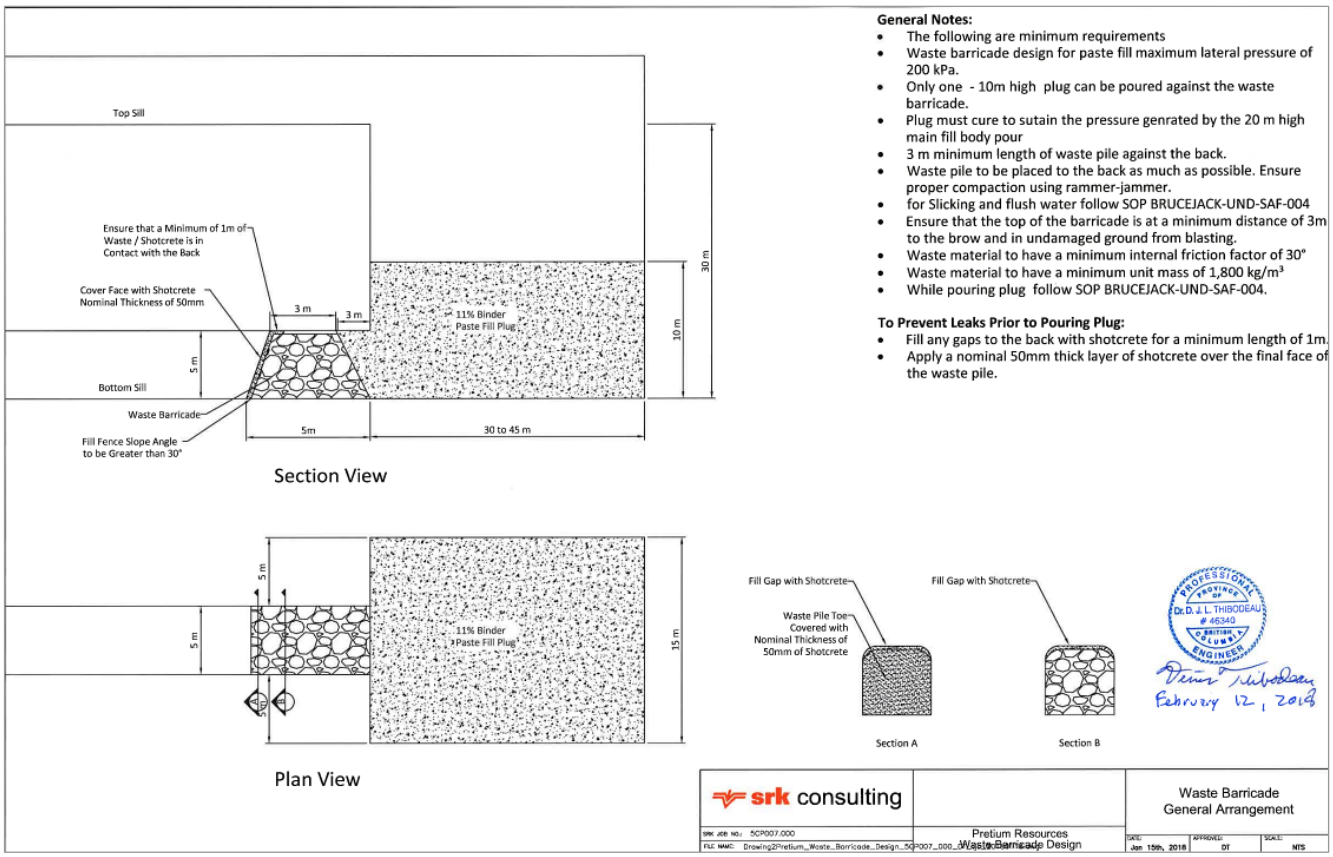
- Appendix H4 Ref Drawing – SRK Consulting - Waste Barricade General Arrangement SRK - Rockfill Barricade Design R3.pdf

The rock barricade should be located as close to the stope brow as possible in meeting the length requirement as the space for the scoop operation is the main concern for the waste rock barricade construction.

In addressing the potential paste leakage through the waste rock porosity, Pretium had chosen to have the waste rock barricade length longer than the design. This has been based on the understanding that the waste rock slope will be much shallower than the design. Instead of using the toe to toe 5 m long of the rock barricade, Pretium is using the 5 m tight back length to construct the waste rock barricade, which have been proved successful.

A copy of the Brucejack Muck Barricade Case Study Memo outlining the company's most recent practices can be found here.

Figure 8.7 SRK waste rock barricade design



8.4 Barricade monitoring and QC

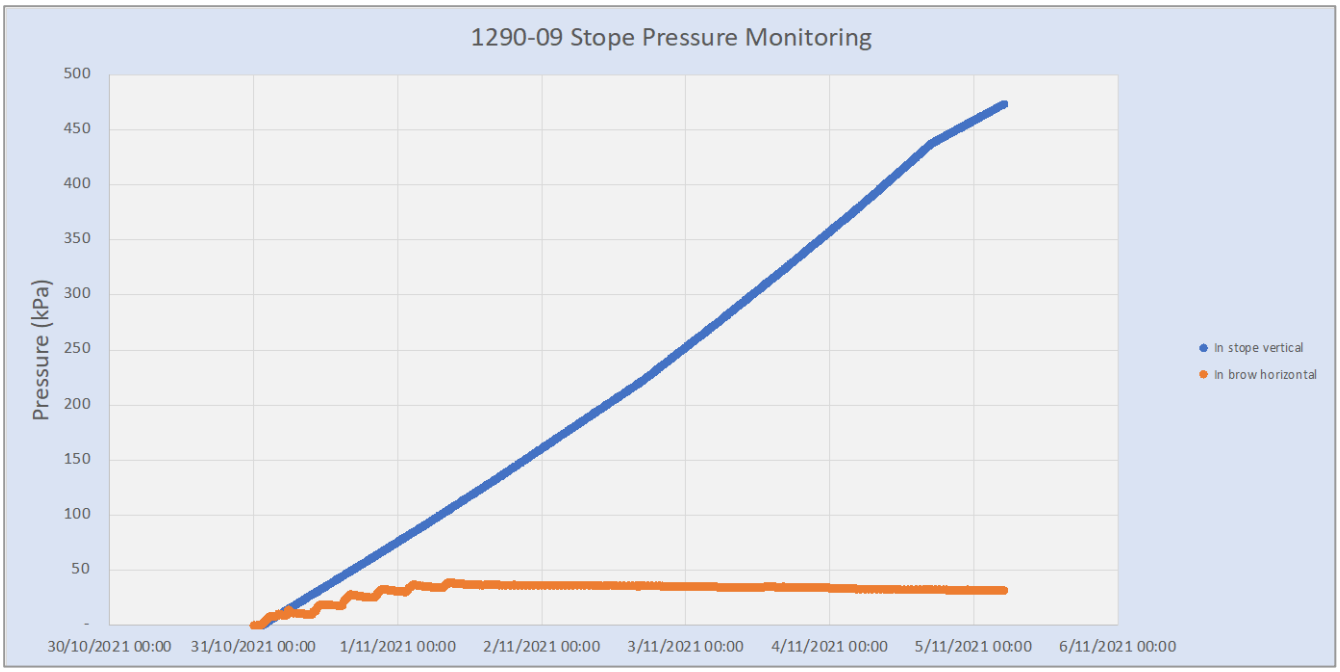
Detailed construction information is provided in the above description which will ensure the structural integrity of the barricade. This includes dimensions and spacing of components, material specifications, barricade location, and shotcrete standards and thickness.

Pretium is testing the shotcrete used in the barricade with samples collected from each barricade and tested in UCS mode at 1, 2, 3, 7, 14, and 28 days to confirm required strengths.

The initial fill pours at Brucejack were monitored to determine the stress regime within the early curing age fill. Both total pressure (flat jacks) and pore pressure (piezometers) instrumentation were installed to resolve the components of stress and vectors and compare with height of the fill.

Figure 8.8 plots the pressure data for a recent stope 1290-09 as a time series. The sensor measuring vertical stress within the stope reaches 475 kPa. However, the maximum horizontal stress at the brow, acting on the barricade does not exceed 35 kPa. The low-pressure conditions from consolidation can be seen and the pressures become decoupled from paste depth within one day indicating the onset of major binder hydration and curing.

Figure 8.8 Stope and Barricade pressure monitoring – 1290-09 Stope - time series



The data collected to date validate the working design capacity of the paste fill barricades of 200 kPa.

9 Reference sections

This section covers the background to the test work used to design the Brucejack paste fill system. This can be progressively updated with site data as it becomes available.

9.1 Paste fill characterization

This section will firstly cover the component materials and their characteristics that make up paste fill. This will be followed by an introduction to paste fill rheology and the various flow properties required to deliver cost effective paste underground. The section will conclude on the strength performance of paste fill. All three areas are heavily interdependent, and it will be shown that the prime objective is to design and produce a paste that will meet the design requirements at the lowest practical cost.

9.1.1 Mineralogy

The predominant minerals contained in the Brucejack tailings are shown in (Table 9.1).

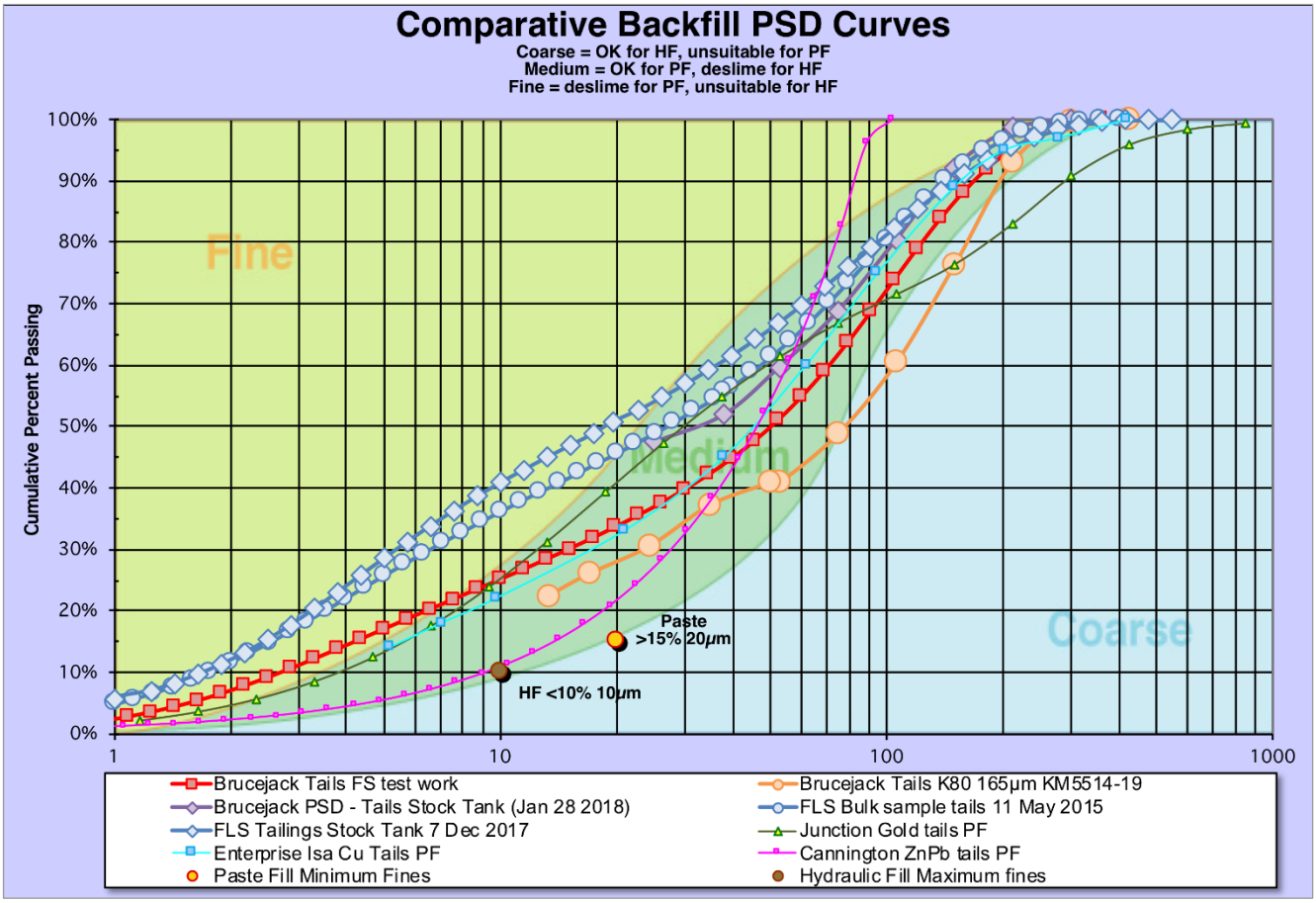
Table 9.1 Mineralogical characteristics of Brucejack tailings

Mineral	Bulk sample (%)
Quartz	46
Calcite	14
Illite	14
Kaolinite	11
Pyrite	6
Siderite	3
Plagioclase Feldspar	3
Aragonite	3

9.1.2 Sizing curves

The particle size distribution (PSD) curves for Brucejack full plant tailings together with simulated cyclone underflow and underflow PSD curves and predicted paste fill PSD are plotted in a chart in Figure 9.1. This data set also includes recent sampling of tailings after paste plant commissioning.

Figure 9.1 Comparative particle size distribution curve



The tailings are finer than the standard sizing criterion for paste fill of more than 15% passing 20 microns. Total Brucejack mill tailings can be classified as a fine grind.

9.1.3 Binder type and properties

The main cost driver in the manufacture of cemented backfill is the binder costs, which can account for between 50% and 75% of the operating cost. It is therefore important to determine the optimal binder type and content in order to meet the required design strength at the lowest operating cost.

Binder is supplied by Lafarge and delivered in isotainers to site. The binder consists of a 90% slag and 10% General Purpose (GP) cement blend which has shown to perform well with the clay rich tailings at Brucejack.

The SG and bulk density of binder are 3.14 and 0.95 t/m^3 respectively.

9.1.4 Water quality

The quality of water has a strong impact on the strength and rheology of paste fill. Water that has a low pH and a high total dissolved solids (TDS) content can be detrimental to the strength development of paste fill. Water with a pH of 5 or lower should be avoided. Similarly, water that contains ≥35,000 mg/L of TDS should be avoided.

Brucejack water quality is suitable for paste fill.

9.2 Paste rheological properties

Rheology is the study of the deformation and flow of matter. Knowledge of the flow properties of paste fill is critical to the design and successful operation of the paste fill system.

In general, the binder content required is reduced as the solids concentration and yield stress of the paste is increased. Therefore, the primary economic goal will always be to minimize the binder addition rate through maximizing the paste solids concentration.

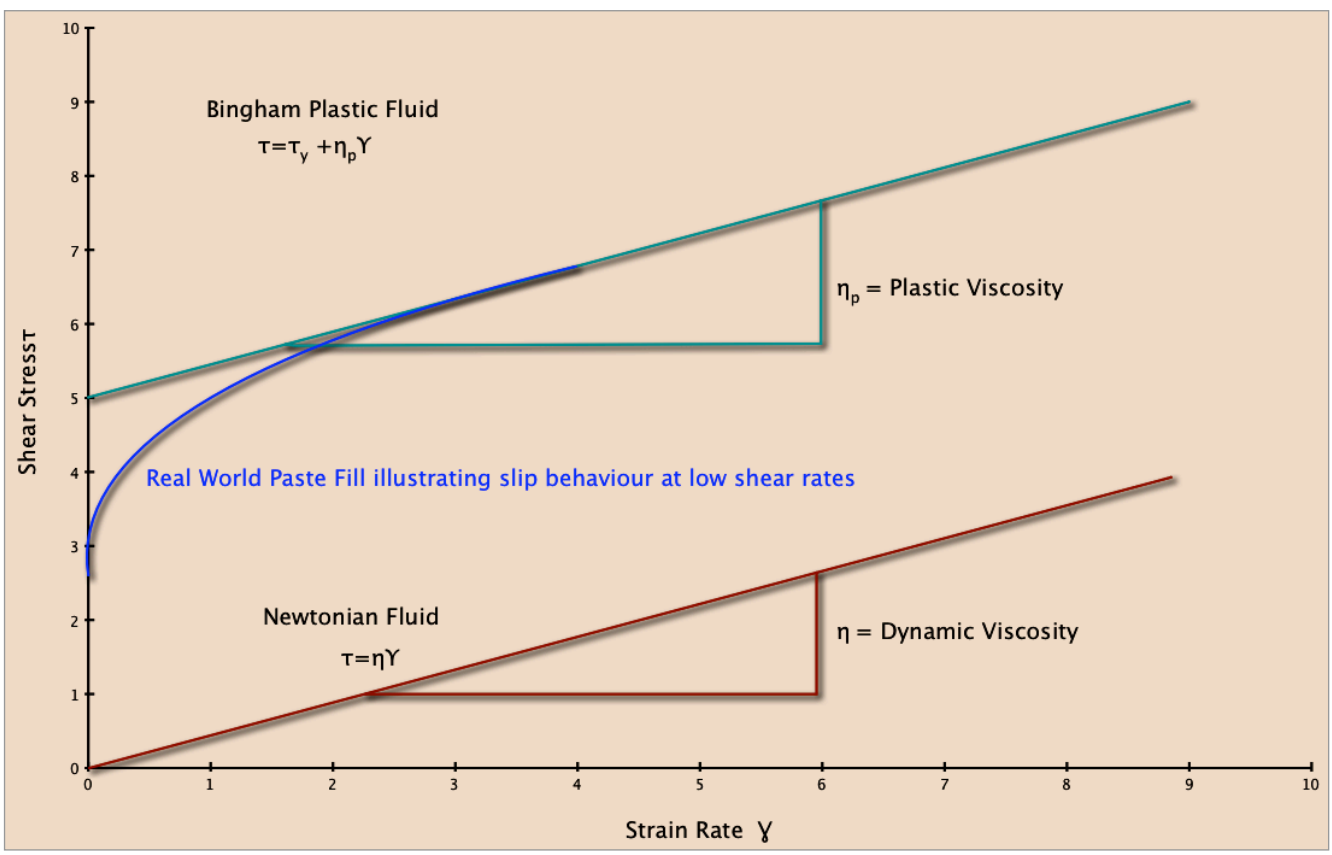
Constraining the achievement of this goal is the increased risk of borehole or pipe blockage with thicker paste densities. The system must be operated in a narrow band that produces an effective compromise.

This section discusses the issues of rheology that are pertinent to Brucejack paste fill. Flow will only occur when the driving head exceeds the wall shear stress. If the solids concentration of the paste is too high, flow will not occur and the paste will set in the borehole, which may result in line blockages. Conversely if the yield stress of the paste fill is too low, then the paste fill strength will be compromised due to the lower solids density.

9.2.1 Paste fill rheology

Paste fill rheology closely conforms to the Bingham Plastic flow model which is strongly non-Newtonian in its behaviour. Figure 9.2 shows Newtonian and non-Newtonian fluid models and plots the change in shear stress as a function of the shear rate. Water is the best example of a Newtonian fluid, exhibiting no shear strength at zero shear rates and linear increases in shear stress with increases in shear rate.

Figure 9.2 Definition of viscosity and yield stress parameters - index values



Bingham Plastics in general and paste fill in particular, exhibit a significant shear stress which must be overcome before movement (shearing) commences. This value of shear stress is commonly referred to as yield stress (or yield shear stress). Once shearing has commenced, the rate of rise of shear stress with shear rate is closely linear. The gradient of this line is the viscosity of the fluid.

Paste fill frequently exhibits slippage at low shear rates. This is caused by sliding of the paste fluid on a thin boundary film of water at the pipeline walls. This serves to reduce the friction losses and introduces non-linear behaviour for the typical delivery velocities of paste fill.

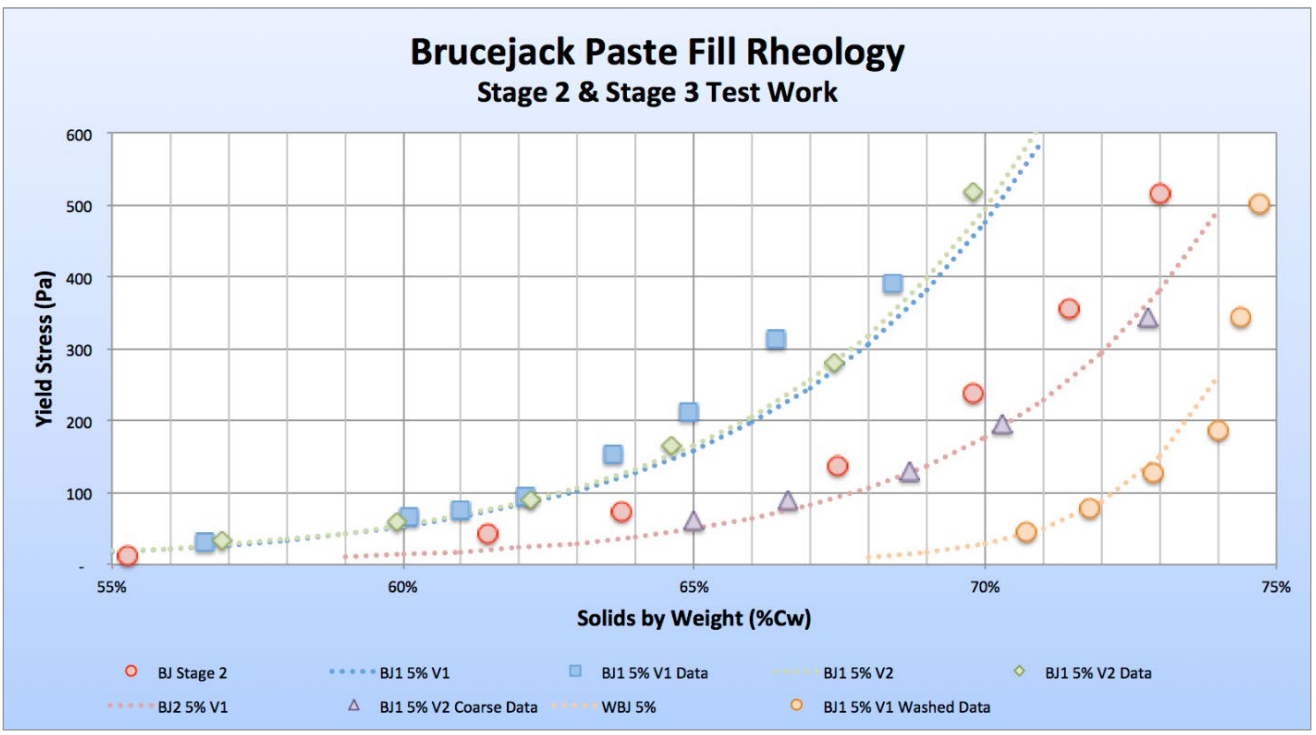
Rheological Consulting Services (RCS) conducted rheological test work on Brucejack Paste blends.

9.2.2 Yield stress versus solids concentration

The key determinant of paste fill rheological behaviour is the yield stress. For paste fill and other Bingham Plastics, the yield stress is exponentially proportional to the solids concentration of the fluid.

Figure 9.3 plots yield stress against solids concentration for the three blends tested.

Figure 9.3 Yield stress as a function of solids concentration



Using curve fitting software an empirical relationship between the variables can be written as:

Blend 1	$\tau_0 = 1.178\times10^{-6}\times e^{25.98x}$ $\tau_0 = 1.178\times10^{-6}\times e^{25.98x}$	0.5924<***x***<0.7759	Equation (4)
Blend 2	$\tau_0 = 3.321\times10^{-6}\times e^{25.52x}$ $\tau_0 = 3.321\times10^{-6}\times e^{25.52x}$	0.6054<***x***<0.7592	Equation (5)
Blend 3	$\tau_0 = 1.687\times10^{-5}\times e^{24.05x}$ $\tau_0 = 1.687\times10^{-5}\times e^{24.05x}$	0.5711<***x***<0.7288	Equation (6)

where τ_0 = yield stress (Pa)

x = Solids concentration % solids (expressed as a decimal)

9.2.3 Friction factors

Paste pipe friction loss can be determined most easily from the Buckingham equation, neglecting 4th order terms (not derived here). The pressure drop (P) per metre length (L) of pipe is given by:

$$P/L = 5.33\ \tau_0/D + 32\ \eta\ V/D2 \qquad \text{Equation (7)}$$

Where

τ_0 = Bingham Yield Stress

D = Inside pipe diameter

η = Bingham viscosity

V = Paste flow velocity

Viscosity can be calculated from the slope of the shear rate to shear stress curve. For paste fill at low shear rates in laminar flow, change in shear rate contributes only approximately 5% of the wall shear stress value. The yield stress value is the dominant variable for design consideration, whilst viscosity is usually ignored.

Other tables can be generated for different flow rates and pipe diameters using the above formulae. For Brucejack, the operating range of densities is between 63% and 68% solids by weight.

9.2.4 Flow control strategy

The Brucejack paste flow control strategy involves yield stress adjustment to maximize paste slurry density by measuring the pressure from the sensors installed on the reticulation system. For a stope of any given reticulation geometry to be filled in the mine, there will be a combination of flow rate, driving head and friction losses that will maximize the density. The key variable is that of the paste yield stress. This is determined mostly by the solids concentration of the paste. Therefore, a control strategy can be developed which modifies the solids concentration so as to maintain the paste column within a fixed range.

This control strategy will:

- Maximize the solids concentration for any given reticulation geometry and layout which in turn ensures the optimum binder addition rates are achieved.

9.3 Paste strength test work

AMC engaged McGill University to conduct the test work in their specialized backfill laboratory in Montréal. Pretium provided tailings samples from metallurgical test work on a new bulk sample. This report is an addendum to the AMC Brucejack Feasibility Study Update.

This study was Stage 3 of backfill testing of Brucejack tailings. Stages 1 and 2 were conducted in Australia using Brucejack tailings from drill core and equivalent Australian binders. Stage 3 testing was conducted on fresh bulk tailings using Canadian and Chinese binders.

9.3.1 Brucejack backfill system

The primary means of backfilling is paste fill, generated from unclassified mill tailings mixed with adequate cementitious binder to meet the strength requirements of re-exposure. Regular strength paste fill is commonly required where there will be re-exposure of vertical stope walls.

Stopes that will not be re-exposed by adjacent mining may be backfilled with unconsolidated waste and / or by paste fill with sufficient binder to remove any risk of future liquefaction (low-strength

paste fill). High-strength paste fill will be required in the lower portion of all primary and secondary stopes that will be undercut by sill extraction from below.

9.3.2 Previous paste backfill test work – Stages 1 & 2 (2013)

Pretium previously engaged AMC to undertake a high-level study on the suitability of using mill flotation tailings for paste fill at the Brucejack mine. Stage 1 and 2 tests were carried out in Australia.

Most of the samples were prepared at a yield stress of 250 Pa, which corresponds to a paste slurry density of around 66% solids by weight. Four batches were also prepared at 100 and 500 Pa (62% and 69%) to investigate the effect of slurry density on paste fill strength.

Stage 1 results carried out on initial metallurgical testing tailings showed a higher-than-expected cement requirement for the range of determined paste fill strengths. The pulp density of the paste was low and resulting strengths required higher-than-expected cement content to achieve the target strengths.

Stage 2 test work was then carried out to identify other classes of binders that would achieve target strengths at lower dosing rates. In particular, Stage 2 investigated the use of blended blast furnace slag and fly-ash with cement, as possibly better paste mix recipes.

The Stage 2 test work program included the following:

- Material characterization tests in areas such as specific gravity and particle size distribution.
- Determination of paste fill density at a yield stress of 250 Pa as the benchmark for the paste fill mix.

UCS tests of mixes using GP cement, slag, and fly-ash blend cements to look at the effect of adding fine-ground iron blast furnace slag and fly-ash to the GP cement binder. Two slag blends were tested; Minecem (MC) containing 55% slag and Sunstate Slag Blend (SS) containing 35% slag. Medium-size fly-ash (FA) was also used.

The Brucejack tailings paste fill mixes responded very favourably to the slag-based and fly-ash binders. The test program demonstrated a significant improvement in the strength values for the paste fill mix with slag-based (MC and SS) and FA binders compared to GP cement.

9.3.3 Stage 3 paste backfill test work

With the availability of bulk ore and tailings samples, Stage 3 test work was carried out in Canada using full plant tailings, clay washed tailings, Canadian slag / cement (M90:10) and Chinese slag / cement (C90:10). Most of the samples were prepared at a yield stress of 250 Pa, which corresponds to a paste slurry density of around 66% solids by weight. Four batches were also prepared at 100 and 500 Pa (62% and 69%) to investigate the effect of slurry density on paste fill strength.

9.3.4 Rheology testing

Rheological tests were carried out on various cemented Brucejack tailings to measure of yield stress vs. solids content. As expected, the shear yield stress of the Brucejack tailings increased exponentially with increasing solids concentration. For the full plant tailings, a shear yield stress of approximately 250 Pa corresponds to a solids concentration of approximately 67.0% w/w. For the washed tailings, 250 Pa yield stress corresponds to 74.0% w/w. The high clay content of the full plant tailings can explain the variable rheology. The clay traps water in the paste making a lower density product compared to the washed tailings. This behaviour is common in high clay tailings paste fill mixes and Figure 9.3 plots the same rheology data against two other paste fill materials

tested by AMC. The curve labelled Kencana represents an example of another mine with very high clay content and the curve labelled Lisheen has very low clay content. Brucejack paste fill lies between these two examples.

In AMC's opinion, the Brucejack tailings are suitable for paste fill delivery. The actual rheology will vary as a function of the density and clay content of the tailings and monitoring of this parameter will be required during operations. Where clay content is higher, paste density will be lower as the clay traps the water in the cured backfill. Where the clay content is lower, more will be removed during dewatering and higher densities will be achieved. In each of these cases, AMC expects there will be little or no bleed water from the paste.

Stage 3 strength test work results are summarized in Table 9.2.

Table 9.2 Summary of stage 3 UCS results

Batch	Tailings type	Tailings	Washed tails	GP cement	Canadian 90/10 Slag cement	Chinese 90/10 Slag cement	Yield stress (Pa)	7 days UCS (MPa)	14 days UCS (MPa)	28 days UCS (MPa)	56 days UCS (MPa)
1 (SC3-Y250)	BJ1	97.0%			3.0%		250	0.028	0.077	0.149	0.153
2 (SC5-Y250)	BJ1	95.0%			5.0%		250	0.188	0.334	0.577	0.856
3 (SC8-Y250)	BJ1	92.0%			8.0%		250	0.777	1.036	1.125	1.386
4 (C5-Y250)	BJ1	95.0%		5.0%			250	0.061	0.093	0.172	0.185
5 (W-SC3-Y250)	WBJ		97.0%		3.0%		250	0.174	0.375	0.454	0.770
6 (W-SC5-Y250)	WBJ		95.0%		5.0%		250	0.370	0.755	0.910	1.331
7 (W-SC8-Y250)	WBJ		92.0%		8.0%		250	0.818	1.311	1.548	1.986
8 (W-C5-Y250)	WBJ		95.0%	5.0%			250	0.101	0.133	0.173	0.254
9 (SC5-Y100)	BJ1	95.0%			5.0%		100	0.098	0.196	0.254	0.635
10 (SC5-Y500)	BJ1	95.0%			5.0%		500	0.255	0.462	0.712	1.155
CH1 (CC3-Y250)	BJ2	97.0%				3.0%	250	0.044	0.069	0.083	0.101
CH2 (CC5-Y250)	BJ2	95.0%				5.0%	250	0.077	0.102	0.156	0.212
CH3 (CC8-Y250)	BJ2	92.0%				8.0%	250	0.176	0.333	0.456	0.541
CH9 (CC5-Y100)	BJ2	95.0%				5.0%	100	0.035	0.072	0.087	0.096
CH10 (CC3-Y250)	BJ2	95.0%				5.0%	500	N.A.	N.A.	N.A.	N.A.

Brucejack high clay fine tailings showed good response to Canadian 90:10 slag binder prepared at 250 Pa yield stress (67.0%$_{CW}$). By comparison, BJ1 tailings prepared at 250 Pa yield stress with 5% normal Portland cement (NPC) showed poor response with a similar curing curve to 3% 90:10 slag binder. For the high clay fine BJ1 tailings, the slag based binders strongly outperform normal Portland cement binder.

As expected, increasing paste slurry density will result in higher strengths for a given binder content and curing time. At 28 days, 5% paste prepared at 100 Pa yield stress will achieve 400 kPa. At 250 Pa it will achieve 600 kPa and at 500 kPa will achieve 800 kPa.

AMC emphasizes that placing paste fill at the highest practical density commensurate with delivery requirements will produce the highest performing fill. Depending upon the stope being filled and the distance and elevation of that stope a range of paste slurry densities will be required. The binder content can be varied to ensure adequate strength performance.

The removal of clay makes a significant improvement to the strength of the paste fill. If clay is reduced or removed from paste fill then reductions in slag cement binder can be expected. By the

same token, variability in strength resulting from changes to clay content in full plant tailings will impact on paste fill performance during operations and should be closely monitored.

AMC would have expected better response to the BJ2 coarse tailings by the Chinese Slag. However, the Chinese slag significantly underperformed Canadian slag used on the finer BJ1 tailings sample. The Chinese slag was the worst performer achieving just under 100 kPa at 28 days compared to 180 kPa for NPC and 600 kPa for Lafarge slag. Based on these results, AMC advises against the importing of Chinese binder for Brucejack paste fill.

The Stage 3 test work has demonstrated the suitability of paste fill for the backfill system at Brucejack mine. Canadian sourced slag cement provides good performance at economic dosing rates and is the recommended binder.

10 Safety and risk assessment

Risks are discussed below with the important risks in each area of the paste fill system covered.

10.1 Liquefaction risk

The primary hazard of slurry based backfills such as paste fill is the potential for the fill mass to remobilize after placement, a process known as liquefaction. The quantity of backfill that could be remobilized and the proximity of personnel and equipment to the area govern the level of risk.

Paste fill requires a minimum of 15% -20 micron size fraction in order to achieve the flow behaviour and water retentive nature of a paste with a typical permeability in the order of 10^{-8} ms^{-1}.

There have been a number of failure events in paste fill operations involving uncontrolled in rush of fluid paste fill into mine workings. In each case the maximum amount of paste fill mobilized was placed less than 24 hours previously. Paste that had cured for longer periods did not liquefy.

There are three conditions relevant to liquefaction potential:

- The paste fill has a contractant behaviour under load.
- The paste fill is saturated.
- The loss or lack of cohesion.

In tri-axial testing, paste fill generally contracts under load, thereby meeting the first criterion.

Paste fill permanently maintains a state of near saturation since it is by nature a non-draining material thereby meeting the second criterion.

In order to minimize the risk of liquefaction, binder is always added to paste fill in order to generate inter particle cohesion.

Paste fill develops cohesive strength over time. Therefore, during early stages of filling and immediately after when the paste fill has not achieved sufficient strength to be self-supporting, there is still potential for paste liquefaction.

Only by using a combination of the correct fill recipe, filling regime and design of barricades, liquefaction of paste fill can be effectively controlled or eliminated.

Clough et al (1988)[6] tested weakly cemented sands with a range of cementation levels and unit weights in a cyclic tri-axial shear device. For the sands under investigation, a UCS of 100 kPa was enough to prevent liquefaction under cyclic loads typical of a very large earthquake.

AMC recommends that the minimum strength design of 100 kPa is used for all bulk paste fill. This strength can be achieved with approximately 2.8% binder.

10.2 High-pressure risk from blocked paste reticulation

High-pressure risks can exist in the case of blocked boreholes and or pipelines. If either of the two surface boreholes become blocked it is possible that geostatic pressures could occur at the base of

[6] Clough, GW, Iwabuchi, J, Rad, NS and Kuppusamy, T (1989) Influence of Cementation on liquefaction of sands, Journal of Geotechnical Engineering, 115(8):1107-1117 in Pierce et al (ibid).

the boreholes. For the paste fill design and geometry at Brucejack, it is possible to generate pressures of around 4.3 MPa in the case of a blockage.

The borehole casing, breastplates and pipes are rated above these values and in normal operations measurements taken underground indicate that normal working pressures in the pipeline are way below the geostatic pressures.

The hazard exists to personnel if the line is opened without some form of pressure relief. For breastplates and transition pipes above and below the Booster Station, remotely operated knife gate valves are recommended to enable pressure relief prior to unblocking operations.

10.3 Paste plant risk

Operations in the paste fill plant are covered by standard operating procedures. The paste fill plant is automated and many of the processes are controlled by PLC logic. Error conditions that can generate a safety hazard are discussed in some detail below. All of the hazards identified relate to the placement of fill underground rather than to the plant or operations itself. Operations in the surface plant could trigger these hazard conditions underground.

10.4 Low binder addition - high risk

It is possible to generate a process condition whereby insufficient binder could be added to the paste fill. If the resulting cured strength does not exceed 100 kPa then the paste may be subject to future liquefaction as a result of either a barricade failure, production blasting or from a regional seismic event.

Binder addition is controlled via the PLC system. Binder content can be varied to produce paste with differing strength targets if required.

Daily binder consumption and binder stock levels should be checked and reconciled with the binder supplier to identify any potential discrepancies in dosing.

Insufficient binder dosing leads to the substandard paste fill product that may in turn lead to potentially large-scale failures in primary stopes during secondary pillar extraction process. Results of laboratory and in-situ strength tests should be checked, analyzed, and compared to the fill design requirements before exposures are made.

10.5 No binder addition – substantial risk

It is standard practice to place an approximately 5 m^3 of uncemented paste at the start of each fill run in order to 'slick' or lubricate the line. A secondary benefit is that cemented paste fill is not in direct contact with the pipe walls reducing build up and the risk of pipe blockage.

At the end of each run it is also common practice to place a similar small volume of uncemented paste in order to ensure that effective flushing is achieved. These small quantities of uncemented paste represent a safe working practice and pose no concern.

It is possible to consider the sustained placement of uncemented paste fill but the PLC logic should prevent this from occurring.

Operators should ensure that excessive slick volumes (greater than 20 m^3) are not delivered at start up or shut down times.

10.6 Flushing water - moderate risk

The flushing water must be metered and controlled by PLC to deliver a fixed amount of water in order to avoid incidents where an excessive amount of water is inadvertently sent into the stope causing significant pore water pressures behind the barricades.

There is a major safety risk if the retaining barricade fails due to excessive water in the fill, releasing large quantities of water and paste into the mine. It is possible that all paste placed in the previous 24 hours can be mobilized with the barricade failure.

The manual flushing system has been replaced by an automated one that will deliver a fixed quantity.

Plant operators must ensure that excessive flushing quantities are not delivered underground.

10.7 Yield stress too high or too low - moderate risk

Paste fill prepared at a solid density or yield stress that is too high could result in borehole or pipe blockages. This, in turn could expose personnel to high-pressure paste during clean out operations.

Running the paste fill system at a yield stress that is too low could result in low strength fill and blocked lines.

For primary stopes this may cause low strength fill that may collapse during secondary mining potentially leading to fill dilution and / or production loss and delays. The hazard that could arise for secondary stopes would be either a slower than expected achievement of the 100 kPa minimum strength target and a longer susceptibility to liquefaction.

Regular control and monitoring of the key properties of the tailings material such as SG, PSD, mineralogy and slump consistency or yield stress of the mixed product is required in order to ensure that desired paste rheology is maintained at all times. Paste rheology is measured directly using the slump or vane shear viscometer and indirectly using the mixer drive power draw.

Rheological properties are strongly influenced by the yield stress of the paste fill. The impact of sudden changes in metallurgical processing operations should be considered.

10.8 Reticulation system risk

Safety hazards primarily relate to exposure of personnel to paste at high-pressure.

Paste fill is distributed via twin, steeply angled boreholes from surface and through high-pressure pipelines from the paste plant to the stopes under the force of gravity.

Generally speaking, the highest-pressure point occurs at the base of the surface borehole on 12 Level and the lowest pressure at the discharge point into the stope.

Brucejack runs the paste fill system with the surface borehole full to 50 m below the collar of the boreholes. This ensures that the maximum driving head is available to deliver the paste and that the minimum slump (stiffest paste) is achieved at all times.

10.9 Borehole blockage - low risk

The surface boreholes are vertical and are cased throughout. The casings and breastplates are rated for hydrostatic pressure, a condition that could arise if the pipeline is blocked.

In practice, working paste pressures are primarily a function of the downstream paste flow conditions and is generally much lower than static pressure due to the frictional losses in pipelines.

In order to prevent production loss and delays, some level of redundancy is required in the reticulation system. At Brucejack two boreholes were drilled to provide an alternative route in case of blockage.

In case of blockage of the surface borehole, it is imperative that the borehole is cleared as quickly as possible. Generally, there is less than two hours available to detect and clear a blockage before binder hardening makes the task very difficult.

Pressure relief for the boreholes is generally achieved by the use of remotely operated knife gate valves.

10.10 Pipeline blockage - low risk

The introduction of pressure relief valves enables the dissipation of the high gravity pressures in the system prior to the opening of the horizontal segments of the pipeline.

The highest pressures that are likely to be encountered are those resulting from line friction. These pressures will be largely dissipated through opening of the gate valves.

10.11 Stope placement

The primary hazard to personnel and equipment is an uncontrolled inrush of paste fill into the workings following the failure of a retaining barricade. The main danger would be if personnel or equipment are impacted by the flowing paste material.

Because paste fill is designed with binder to eliminate liquefaction risk, the likely consequences of a failure are comparatively much lower than that of a saturated uncemented hydraulic fill.

However, all mines operating paste fill tend to assume that paste fill less than 24 hours old has no cohesive strength. Retaining structures must therefore be designed to meet this loading condition and in the absence of field data, hydrostatic loading conditions must be assumed.

10.12 Barricade failure during tight filling - substantial risk

There is a substantial risk of barricade failure due to overloading during tight filling operations.

AMC is aware of several serious paste fill inrushes associated with barricade failures during tight filling activities.

Proper protocols for tight filling must be developed and implemented in order to control or eliminate this risk.

10.13 Barricade failure during normal filling - substantial risk

Stope filling is based on the following commonly accepted practices.

It is a common practice to fill stopes in two separate pours. In the first pour a plug of fill is placed behind the barricade. The paste fill is poured at a controlled rate to a depth (usually 2 m to 3 m

above the drawpoint) that adequately covers the barricade in a single pour. Filling is then suspended for a period of time to permit partial curing of this plug.

Paste filling then continues at the safest maximum rate until the next sub level is reached. On each level this process is repeated. In this method, the barricades need to be strong enough to withstand the hydrostatic loading of the plug in slurry form. In Brucejack's case this would be approximately 150 kPa. The rest time for curing is then determined as the time taken for the paste to achieve this strength (approximately three days). The reminder of the stope is then filled at such a controlled rate that the strength gain of the paste is at least equivalent to the induced hydrostatic loading from the height rise of the paste.

The second practice is to convert the curing rate into an instantaneous filling height limit. In this case, the strength gain in 24 hours is determined from laboratory test work. For a typical gain of 100 kPa in 24 hours this depth stress is reached in 5 m. As curing continues and shear strength increases, confinement and arching will become dominant factors and there will be a divergence between vertical and horizontal loadings on any retaining structure.

The majority of paste fill operations have designed their barricades to withstand a horizontal working load of 150 kPa. For Brucejack 200 kPa has been selected.

10.14 Paste leakage through drill holes - moderate risk

In an Australian paste fill operation, paste fill was observed entering a level from a stope and was flowing via adjacent production blast holes. As a result of this incident, the pre-start stope check list was revised to inspect for blast holes and diamond drill holes which may permit the transfer of paste from one stope to another and to sand bag these off where necessary. The safety risk here is minor but has production delay consequences if not detected early.

10.15 Water in stope - moderate risk

Excessive flushing of boreholes and pipelines with water should be avoided. AMC recommends approximately 50 m^3 of water should be used for flushing. If extensive line flushing is required to clean the blocked lines, then it should be diverted outside the stope.

Excessive ground water inflow though production or diamond drill holes should be avoided. Prior to filling the stope, all diamond drill holes should be grouted.

In an incident in an Australian paste fill operation, a large quantity of flushing water was released into a stope as a result of a valve being inadvertently left open. This water, along with very wet paste slurry, breached the barricade in the base of the stope and made its way to the lower levels, causing major problems with the main dewatering pumps. The flow rates were not great but the quantity of fine tailings that were mobilized was high enough to cause significant problems with both clean up and final disposal.

All inrush situations are very serious and the need to minimize flushing water placed in stopes is very important.

10.16 Liquefaction risk

The geotechnical issues relating to liquefaction have been covered in Section 10.1 in some detail. This part briefly considers the specific risk issues for Brucejack. They key issue is whether any dynamic vibration source will act upon the paste fill and induce liquefaction either:

- Prior to achieving strength greater than 100 kPa, or
- By damaging cohesive binder bonding and reducing strength to below 100 kPa.

10.16.1 Liquefaction by blasting - moderate risk

Lilley and Chitombo (1998)[7] note that little work has been carried out on the dynamic stability of backfill when exposed to blasting vibrations. They observed that backfill is a strong attenuator of blast vibration and calculated for a simple model that up to 0.4 m of damage (plastic deformation) could be expected in drained cemented hydraulic fills. Bloss (1992)[8] considered the issue in some detail and looked at the effect of blast energy on the rock to fill interfaces and within the fill mass itself. He notes that energy transmission across the interfaces is poor but suggested that failure would be possible if the compressive or tensile stresses induced were greater than the strength of the fill at that point.

All the researchers were concerned with blasting adjacent to cured fill masses. In the situations under consideration, the blasting events are at sufficient distance from the fill being placed (greater than 40 m) such that the magnitude of blast energy transferred to the fill is not considered to be significant.

In the pre-cured state, paste fill will only be susceptible to liquefaction if the strength is less than 100 kPa and with an age of less than 24 hours. Further, this would only present a risk situation if the liquefied paste could flow into the workings.

10.16.2 Liquefaction by seismic event - moderate risk

The scenario described above also applies to seismic events with the difference being the magnitude of the vibration is higher but the exposure of the mine is significantly lower. There has been considerable research into civil engineering aspects of soil and foundation stability in seismically prone areas and it is from this work that the seismically resistant strength of 100 kPa has been derived.

A secondary issue is the long-term strength of paste fill over the life of the mine. Since paste fill is effectively a non-draining material, it will remain at or close to saturation conditions for many years. It is important that the long-term strength of paste fill is assessed to ensure that significant deterioration does not occur.

Brucejack needs to carry out tests at a laboratory scale on paste fill to confirm that there are no long-term strength loss issues, which may pose a future risk of liquefaction as a result of a large regional seismic event. When these results become available, they need to be incorporated into this technical manual.

10.16.3 Disposal of spilled paste - moderate risk

Paste fill which has failed into a stope (dilution), spilled onto a drive floor or been mucked from a fired face will have lost most or all of its cohesive strength. When large quantities of dilution occur, caution is required to ensure that mixed ore and paste sludge will not flow uncontrollably.

A fatal accident involving the mucking of uncemented hydraulic fill occurred at Mount Isa Mines in the mid nineteen eighties. In this incident, spilled hydraulic fill was tipped into a short vertical pass and water was deliberately added to mobilize the fill and prevent it from hanging up. The saturated material rushed from the pass and buried the loader operator.

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[7] Lilley, CR & Chitombo, GPF (1998) Development of a near field damage model for cemented hydraulic fill, Sixth International Symposium on Mining with Backfill, AusIMM, Brisbane.

[8] Bloss, ML (1992) Prediction of cemented rockfill stability - Design procedures and modelling techniques, PhD Thesis, University of Queensland, Brisbane.

A more likely scenario is the contamination of ore or mullock with fill in passes which could make the material more susceptible to an inrush situation.

Brucejack is in the process of developing of operating procedures to ensure the safe storage and transfer of loose paste fill.

10.17 Failure of exposed paste - moderate risk

Fill mass wall / pillar failures in open stopes during mucking can lead to severe risks to people and equipment.

Large scale paste fill fall-off can cause backfill dilution, disrupt mining activities, and adversely affect local and regional ground stability and potential production delays and ore losses.

Smooth blasting practices should be implemented in order to minimize blast damage.

Undercutting of paste fill in stope sidewalls with loaders during mucking should be avoided.

Development ground support procedures have been developed in order to consider the hazards involved with mining through or alongside paste fill.

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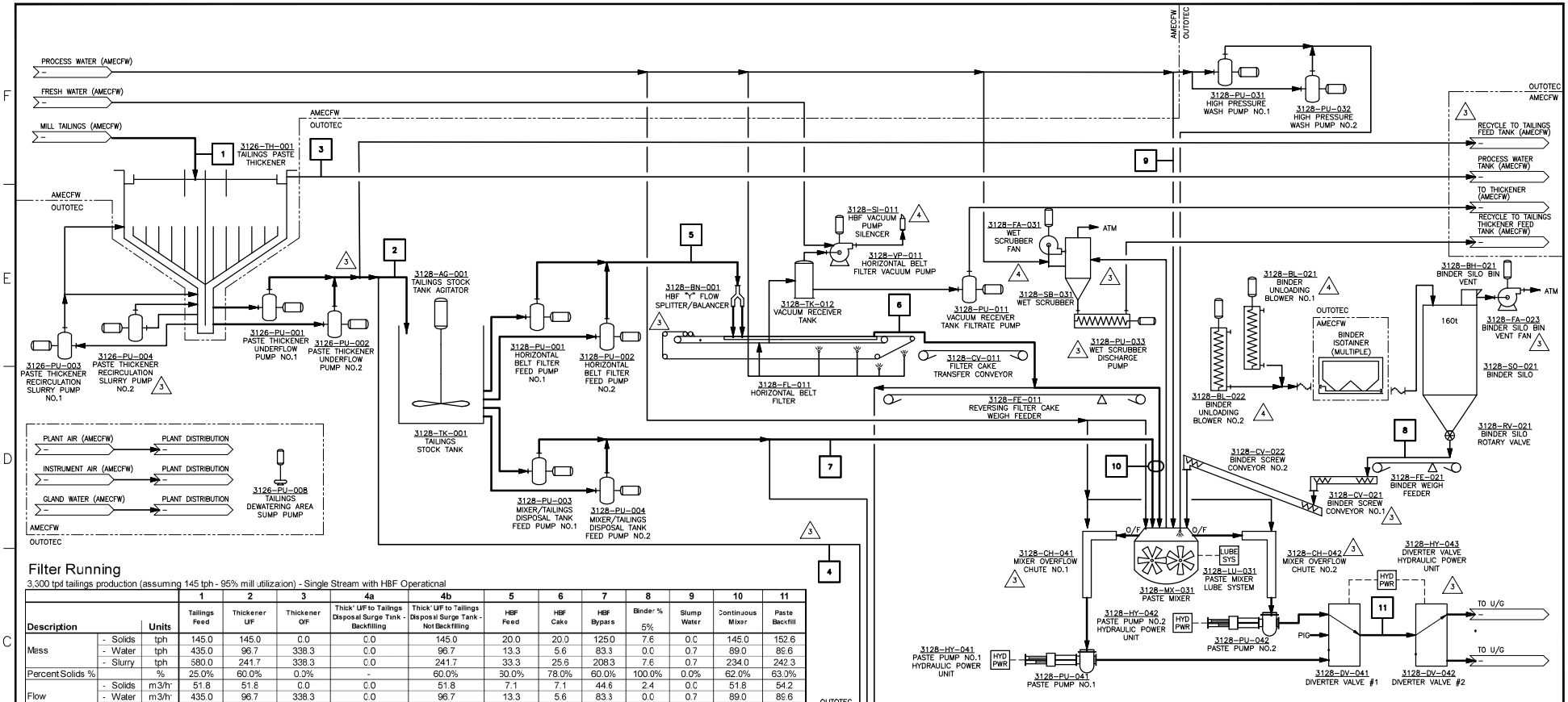
Appendix A
Brucejack Process Flow Diagram-Paste Plant R4 April 2017



Filter Running

3,300 tpd tailings production (assuming 145 tph - 95% mill utilization) - Single Stream with HBF Operational

Description		Units	1 Tailings Feed	2 Thickener U/F	3 Thickener O/F	4a Thick' U/F to Tailings Disposal Surge Tank - Backfilling	4b Thick' U/F to Tailings Disposal Surge Tank - Not Backfilling	5 HBF Feed	6 HBF Cake	7 HBF Bypass	8 Binder % 5%	9 Slump Water	10 Continuous Mixer	11 Paste Backfill
Mass	- Solids	tph	145.0	145.0	0.0	0.0	145.0	20.0	20.0	125.0	7.6	0.0	145.0	152.6
	- Water	tph	435.0	96.7	338.3	0.0	96.7	13.3	5.6	83.3	0.0	0.7	89.0	89.6
	- Slurry	tph	580.0	241.7	338.3	0.0	241.7	33.3	25.6	208.3	7.6	0.7	234.0	242.3
Percent Solids %		%	25.0%	60.0%	0.0%	-	60.0%	50.0%	78.0%	60.0%	100.0%	0.0%	62.0%	63.0%
Flow	- Solids	m3/h	51.8	51.8	0.0	0.0	51.8	7.1	7.1	44.6	2.4	0.0	51.8	54.2
	- Water	m3/h	435.0	96.7	338.3	0.0	96.7	13.3	5.6	83.3	0.0	0.7	89.0	89.6
	- Slurry	m3/h	486.8	148.5	338.3	0.0	148.5	20.5	12.3	128.0	2.4	0.7	140.8	143.9
Specific Gravity / Relative Density	- Solids	t/m3	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	3.14	2.80	2.80	2.82
	- Water	t/m3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	- Slurry	t/m3	1.19	1.63	1.00	-	1.63	1.63	2.01	1.63	3.14	1.00	1.66	1.68

Filter not in use

3,300 tpd tailings production (assuming 145 tph - 95% mill utilization) - Single Stream with HBF not in Operation

Description		Units	1 Tailings Feed	2 Thickener U/F	3 Thickener O/F	4a Thick' U/F to Tailings Disposal Surge Tank - Backfilling	4b Thick' U/F to Tailings Disposal Surge Tank - Not Backfilling	5 HBF Feed	6 HBF Cake	7 HBF Bypass	8 Binder % 5%	9 Slump Water	10 Continuous Mixer	11 Paste Backfill
Mass	- Solids	tph	145.0	145.0	0.0	0.0	145.0	0.0	0.0	145.0	7.6	0.0	145.0	152.6
	- Water	tph	435.0	85.2	349.8	0.0	85.2	0.0	0.0	85.2	0.0	4.5	85.2	89.6
	- Slurry	tph	580.0	230.2	349.8	0.0	230.2	0.0	0.0	230.2	7.6	4.5	230.2	242.3
Percent Solids %		%	25.0%	63.0%	0.0%	-	63.0%	33.0%	78.0%	63.0%	100.0%	0.0%	63.0%	63.0%
Flow	- Solids	m3/h	51.8	51.8	0.0	0.0	51.8	0.0	0.0	51.8	2.4	0.0	51.8	54.2
	- Water	m3/h	435.0	85.2	349.8	0.0	85.2	0.0	0.0	85.2	0.0	4.5	85.2	89.6
	- Slurry	m3/h	486.8	136.9	349.8	0.0	136.9	0.0	0.0	136.9	2.4	4.5	136.9	143.9
Specific Gravity / Relative Density	- Solids	t/m3	2.80	2.80	2.80	2.80	2.80	2.80	2.80	2.80	3.14	2.80	2.80	2.82
	- Water	t/m3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	- Slurry	t/m3	1.19	1.68	1.00	-	1.68	1.68	2.01	1.68	3.14	1.00	1.68	1.68

AMEC Foster Wheeler Limited
Pretivm - Brucejack - Project 177421

P.O.	DATE	LOG #
AMEC #		

- 1. NOT ACCEPTABLE- NOT RELEASED FOR PRODUCTION-REVISE AND RESUBMIT.
- 2. SUBJECT TO REVISION AS INDICATED, RELEASED FOR PRODUCTION - SUBMIT CERTIFIED DRAWING
- 3. NO EXCEPTION TAKEN - RELEASED FOR PRODUCTION - SUBMIT CERTIFIED DRAWING
- 4. CERTIFIED DRAWING ACCEPTED - RELEASED FOR PRODUCTION.
- 5. REVIEWED FOR INFORMATION ONLY. THIS DRAWING NOT REQUIRED BY CONSULTANT FOR ENGINEERING DESIGN.

BY _____ DATE

FOR THE GENERAL COMPLIANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND CONTRACT DOCUMENTS. NO RESPONSIBILITY IS ASSUMED FOR CORRECTNESS OF DIMENSIONS OR DETAILS.

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
4	09SEP16	ISSUED FOR CONSTRUCTION	EAN	VR				
3	15JUN16	ADD EQUIPMENT	K.R.	V.R.				
2	11DEC15	REVISED EQUIP # / 3126-PU-004	K.R.	V.R.				
1	27OCT15	FOR DESIGN	K.R.	V.R.				

REF	NUMBER	TITLE
-		

REFERENCES

STAMP/SEAL: PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, A.J. BOISSONNEAULT, 43026, 2016-09-13

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT: BRUCEJACK

PROJECT NO. 177421 | ACTIVITY NO. | SCALE NTS | PACKAGE CODE

	BY	DDMMMYY
DES	B.G.	–
DRN	K.R.	–
CHK	V.R	–
APP	A.B.	–

PRETIVM

SUBJECT: FLOW DIAGRAMS PROCESS FLOW DIAGRAM PASTE PLANT

Outotec

AREA 3128 PASTE PLANT

CLIENT DWG NO.

DRAWING NO. 3128-A-0001 REV 4

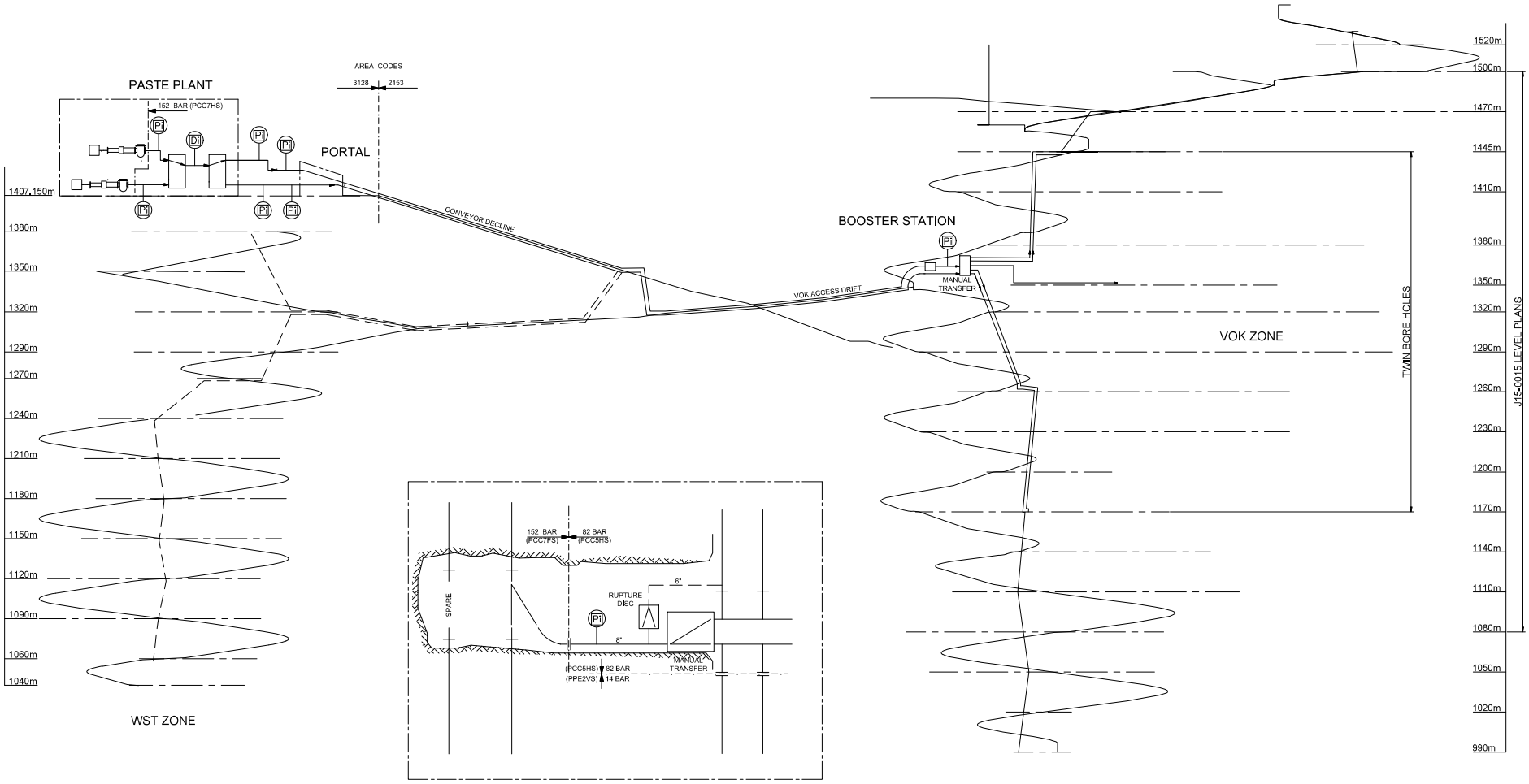
SAVED: 13-Nov-15 3:07 PM PLOTTED: 28-Oct-15 10:58 AM USER: KARL RANTALA

CAD FILE: J:\177-0015-PRETIVM BRUCEJACK PASTE PLANT DESIGN-SUPPLY\7.0 DRAWINGS\03 FLOWSHEETS\3128-A-0001.DWG

50 A1-594641

Appendix B
Brucejack Underground Distribution System
April 2017

NOTES:
NOTES: 1. FOR GENERAL NOTES, REFER TO DWG 2153-F-0550



TYPICAL LEVEL CUTOUT DETAIL

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
B	16NOV16	ISSUED FOR CLIENT REVIEW	EAN	VR	JR	AB	AB	
A	06JUN16	PRELIMINARY	D&L	JR				

REF	NUMBER	TITLE

REFERENCES

STAMP/SEAL

APPROVED FOR CONSTRUCTION

A. BOISSONNEAULT

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
		DES	J.R	26MAY16
		DRN	E.A.N./D.G.L.	26MAY16
SCALE: NTS	PACKAGE CODE	CHK	V.R	26MAY16
		APP	A.B	26MAY16

PRETIVM

SUBJECT: U/G PASTE BACKFILL SCHEMATIC
PASTE DISTRIBUTION SYSTEM

Outotec

AREA: 2153 | U/G PASTE BACKFILL

CLIENT DWG NO.:

DRAWING NO.: 2153-F-0551 | REV: B

SAVED: 24-Nov-16 2:37 PM PLOTTED: 29-Nov-16 1:44 PM USER: DEVIN LANGLEY

Appendix C
Combined Brucejack Mill SOPs November 2021

Objective

To establish mandatory requirements for the safe and responsible working standards for starting up the Paste Plant.

Scope

This SOP covers the process and procedures which will be used to start up the Paste Plant.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

Definitions

DCS – Distributed Control System : a computerized control system for a process or plant usually with a large number of control loops, in which autonomous controllers are distributed throughout the system, but are monitored by a central control operator.

MAN – Manual mode: term used when the control parameters within the DCS are switched to operator (human) control.

AUTO – Automatic mode: term used when the control parameters are monitored by the DCS.

CAS – Cascade mode: term used in DCS control when one parameter or parameter dictates when another parameter is activated or deactivated.

No. – abbreviation for "number".

TPH – acronym for "Tonnes per hour".

Preparation

Hazards

- No hazards

Tools

- No additional tools required to complete task

Requirements

- Must be trained to operate the DCS or work within close contact with a trained operator.

Job Step

1. **Prestart Checks (Person Responsible – Central Control Room Operator)**
   - Ensure stope fill, paste and binder information has been provided to the underground paste crew and they are ready to accept paste. Note: Contact Procon Paste Crew on channel 5 (BJC: PASTE).
   - Check the level in the Tailing Stock Tank (5401) to ensure there is adequate material for paste mixing.

- Check the Binder Silo level (5522) to ensure there is adequate material for paste mixing.
- Ensure the diverter gates on the underground paste distribution lines are in the correct positions.
- Ensure the paste pump hydraulic system temperature is within operating range. If the paste pump hydraulic system temperature is not within operating range, contact Paste Plant Operator to resolve issue.

2. **Start Wet Scrubber (Person Responsible – Central Control Room Operator)**
   - Open Wet Scrubber Fresh Water Supply Valve (5561).
   - Open Seal Pot Process Water Supply Valve (5568).
   - Start Wet Scrubber Exhaust Fan (FA031M).
   - Start Wet Scrubber Recirculating Pump (PU033VFD).
   - Set Wet Scrubber Cone (5566) to AUTO mode.

3. **Start Paste Pump (Person Responsible – Central Control Room Operator)**
   - Ensure the correct paste pump is enabled as duty on both paste mixer and paste pump details page.
   - Start the hydraulic unit for the selected paste pump (PU41HU/PU042HU).
   - Start the selected Paste Pump (PU041DH/PU042DH) and set the speed to 10% in MAN mode.

4. **Flush Underground Feed Line (Person Responsible – Central Control Room Operator)**
   - Set Paste Mixer Chute Level (LIC5574/5584) to 90% set point.
   - Open Process Mixer to Paste Mixer Chute valve (5557/5558).
   - Set Paste Plant speed to 100% in MAN mode.
   - Open Paste Mixer and Chute Flush Water valve (FIC5555) and put the set point to 130 m^3/h in MAN mode.
   - As Paste Mixer Chute Level (LIC5574/5584) reaches 90% set point, set pump speed to 90 % in MAN mode. As pump speed reaches 90%, switch pump speed to AUTO mode.
   - Flush underground distribution paste line until Procon Paste Crew confirms clear flow of water exiting the pipe and there are no leaks on the distribution paste line. (Approximately 5 minutes)

5. **Start Paste Mixer (Person Responsible- Central Control Room Operator)**
   - Close Paste Mixer drain valve (5572/5582).
   - Open Paste Mixer overflow valve (5571/5581).
   - Start Paste Mixer (MX031M1).
   - Open Paste Mixer Slump water control valve (5551).
   - Ensure Paste Mixer water controller (FIC5552) is in CAS mode.

6. **Start Binder Delivery System (Person Responsible- Central Control Room Operator)**
   - Start Binder Screw Conveyor No.2 (CV022).
   - Start Binder Screw Conveyor No.1 (CV021).

- Start Binder Weigh Feeder (FE021).
- Ensure Binder Silo Vent (5527) and Binder Silo Aeration supply (5528) are in CAS mode.
- Start Rotary Valve (RV021) in AUTO mode, and it will change itself to CAS mode. This will cause the Binder Silo Vent (5527) and Binder Silo Aeration supply (5528) to open automatically.
- Ensure Binder Weigh Feeder controller (WIC5533) is in CAS mode.

7. Start Tailings Stock Delivery System to Paste Mixer in "Manual" Mode (Person Responsible – Central Control Room Operator)

- Set Paste Pump into MAN mode.
- Set Mix Feed Pump TPH to 117 (FIC5462) in AUTO mode.
- Open Tailings Stock Tank Feed Pump to Mixer valve (5464).
- Open "Pump Select" faceplate and sure that the desired pump (5445 /5455) is selected as duty.
- Open Sequence faceplate and ensure Duty pump and all associated valves are in CAS mode. (Selected valves are indicated by green check marks beside the valve description).
- Press "START SEQ".

NOTE: If the line pressures in the Paste Lines are below target value and not further adjustments can be made on paste solids target, the Horizontal Belt Filter will need to be brought online. (Refer to Horizontal Belt Filter Startup Procedure)

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	[redacted]
Mill Supervisor	Cory Rouse		
JOHSC Rep	Don Stawski		
Mill Superintendent	David Towle		

PRETIVM	BJ-PBF-SOP-553 **Paste Plant Shutdown Procedure (Control Room)**		
Owner: Brent Bachewich Bryan Dodding	Approver: Peter Nelega	Revision Number:	Creation Date: Sept. 18, 2017 Revision Date:

Objective

To establish mandatory requirements for the safe and responsible working standards for shutting down the Paste Plant.

Scope

This SOP covers the process and procedures which will be used to shut down the Paste Plant.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

Definitions

DCS – Distributed Control System: a computerized control system for a process or plant usually with a large number of control loops, in which autonomous controllers are distributed throughout the system, but are monitored by a central control operator.

MAN – Manual mode: term used when the control parameters within the DCS are switch to operator (human) control.

AUTO – Automatic mode: term used when the control parameters are monitored by the DCS.

No. – Abbreviation for "number".

TPH – acronym for "Tonnes per hour".

Preparation

Hazards

- No hazards

Tools

- No additional tools required to complete task

Requirements

- Must be trained to operate the DCS or work within close contact with a trained operator.

Job Step

1. **Stopping Tailings Stock Delivery to Paste Plant in Manual Mode (Person Responsible – Central Control Room Operator)**
   - Inform Procon Underground Paste Crew that the Paste Plant will be shutting down.
   - If Horizontal Belt Filter is running, shut it down first. (Refer to Horizontal Belt Filter Shutdown Procedure.

- Open Paste Mixer Feed Pump flush valve (5442/5452).
- Close Paste Mixer Feed Pump suction valve (5441/5451).
- Flush Paste Mixer for a minimum of 5 minute.
- De-energize Paste Mixer Feed Pump (003/004).
- Close Paste Mixer Feed Pump flush valve (5442/5452).
- Close Paste Mixer Feed Pump discharge valve (5445/5455).
- Open Paste Mixer Feed Pump drain valve (5443/5452).

2. Stopping Tailings Stock Delivery to Paste Plant in Auto Mode (Person Responsible – Central Control Room Operator).

- Open Sequence Faceplate and press "STOP SEQ".

3. Flush Paste Mixer

- Close Mixer Slump Control water valve (5551).
- Open Paste Mixer Flush water valve (5556).
- Adjust Paste Pump in Man mode to 100%.
- Adjust Paste Mixer (5555) and Chute Flush Water Controller to a flowrate of approximately 130m^3/hr. – 145m^3/hr. to match the flowrate used during the paste pour.
- Flush water through the Paste Mixer for a minimum of 5 minutes.

4. Stop Binder Delivery System (Person Responsible- Central Control Room Operator)

- Verify Binder Rotary Valve (RV021) is down.
- Ensure Binder Weigh Feeder (FE021) has been run off by checking that Weightometer (WIC5533) is ready 0.
- Stop Binder Weigh Feeder (FE021).
- Stop Binder Screw Conveyor No.1 (CV021).
- Stop Binder Screw Conveyor No.2 (CV022).

5. Flush Paste Mixer and Paste Line (Person Responsible – Central Control Room Operator)

- Adjust Paste Mixer (5555) and Chute Flush Water Controller to 0 m^3/hr.
- Open Process Water valve (5557/5558) to Paste Mixer Chute. (Sump line is tied into the process water line for clean-up).
- Close Paste Mixer Flush valve (5556).
- Contact Paste Plant Operator to divert Paste Area Sump pump (013), to Paste Mixer Chute.
- Open Paste Mixer drain valves (5572/5582),
- Inform Paste Plant Operator to start High Pressure Pump (1032) and run for 15 minute flush cycle.
- Once the Paste Plant Operator has confirmed that the Paste Mixer has stopped draining and the cleanup is complete, inform the Paste Plant Operator to diver the sump back to the Tailings Disposal Surge Tank.

- Close Paste Mixer Overflow (5571/5581) to Paste Pump.
- As the Paste Pump reaches the set point (90%), switch Paste Pump speed to AUTO mode.
- Adjust Paste Mixer (5555) and Chute Flush Water Controller to a flowrate of approximately 130m³/hr. – 145m³/hr. to match the flowrate used during the paste pour.
- Set Paste Mixer (5555) to AUTO mode.
- As the level in the Paste Mixer chute reaches 90% set point, in MAN mode, adjust the Paste Pump speed to 90%
- **Contact** Procon Underground Paste Crew and inform them that flushing of the paste line has been initiated and they are to contact the Central Control Room operator when the paste line has completed flushing "**clean water**" is coming out of the end of the paste line.
- Adjust the Paste Mixer (5555) and Chute Flush Water controller in MAN mode to a flowrate of 0 m^m/h.
- Close Process Water valve (5557/5558) to Paste Mixer chute.
- Draw down the Paste Mixer Pump Chute
- De-energize the Paste Pump (041DH/042DH).

6. Pig the Paste Line to Underground (Person Responsible – Central Control Room Operator).

- Contact Paste Plant Operator to insert the clean out pig. (Refer to: BJ-PBF-SOP-56- Diverter Gate Operation & Pigging Procedure).
- **Contact** Procon Underground Paste Crew and inform them that a clean out pig has been inserted into the paste line and flushing will re-initiate.
- Inform the Procon Underground Paste Crew to notify the Central Control Room Operator when the clean out pig has discharged from the paste line and "**clean water**" is being discharged for the end of the paste line.
- Start Paste Pump (041DH/042DH) and adjust in MAN mode to 100%.
- Adjust Paste Mixer (5555) and Chute Flush Water Controller to a flowrate of approximately 130m³/hr. – 145m³/hr. to match the flowrate used during the paste pour.
- As the Paste Pump reaches the set point (90%), switch Paste Pump speed to AUTO mode.
- As the level in the Paste Mixer Chute reaches 90% switch control to AUTO mode.
- When confirmation has been received from the Procon Underground Paste Crew that the clean out pig has discharged from the paste line and "**clean water**" is being discharged for the end of the paste line, adjust the flowrate for Paste Mixer (5555) and Chute Flush Water Controller, in MAN mode, to 0 m³/hr.
- Close Process Water to Paste Mixer Chute (5557/5558).
- Draw down the Paste Mixer Pump Chute and de-energize Paste Pump (041DH/042DH).
- De-energize the Paste Pump Hydraulic Unit.

7. Stop Wet Scrubber System

- Commence Wet Scrubber System shutdown after the paste plant has been down for a minimum of 1 hour.
- Close Water valve (5561).
- Stop Pump (033VFD)
- Stop Wet Scrubber Fan (031M).

- **Approval Signatures Record**

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	[redacted]
Mill Supervisor	Cory Rouse		
JOHSC Rep	Don Stawski		
Mill Superintendent	David Towle		

PRETIVM	BJ-PBF-SOP-555 **Transfer of Binder from ISO-VEYOR to Bulk Storage Silo**		
Owner: Brent Bachewich Bryan Dodding	Approver: Peter Nelega	Revision Number:	Creation Date: Sept. 25, 2017 Revision Date:

Objective

SCANNED

To establish mandatory requirements for the safe and responsible working standards for transferring Binder from the ISO-Veyor to the Bulk Storage Silo.

Scope

This SOP covers the process and procedures which will be used to transfer binder from the ISO-Veyor to the Bulk Storage Silo.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

Definitions

ISO-Veyor– term used for containers where the material is introduced and extracted from the container by using air.

MT- abbreviation for the word "Empty."

Preparation

Hazards

- Dust
- Noise

Tools

- No additional tools are required to complete the tasks.

Requirements

- Must be trained to operate the Paste Plant or work within close contact with a trained operator.

Job Step

1. **Pre-Start Checks (Person Responsible- Paste Plant Operator)**
   - Ensure the following conditions are met on the Iso-Veyor:
     - Vent valve is open.
     - Top air vent is open.
     - Material discharge valves are closed.
     - Aeration valves (6) are closed.
     - Boost valve is fully open.

- Ring jet is closed.
- Correct valving from ISO-Veyor to bulk storage silo.

2. Discharge Hose Connection (Person Responsible- Paste Plant Operator)

- Remove the cap from the ISO-Veyor connector ports
- Ensure gasket is seated in coupler.
- Connect the discharge hose to the corresponding ISO-Veyor and delivery connection.

  NOTE: Locking pins must be in place before progressing onto next step.

3. Pressurizing the Iso-Veyor (Person Responsible- Paste Plant Operator)

- Close the Boost valve.
- Open all (6) aeration valves.
- Close the vent valve.
- Energize Binder Unloading Blower (021M/022M).
- Allow the ISO-Veyor to pressurize to approximately 1.9 bar.

  NOTE: Do not exceed 2.0 bar.

4. Discharging ISO-Veyor (Person Responsible – Paste Plant Operator)

- When the pressure within the ISO-Veyor reaches operating pressure (1.9 bar), open the boost valve ¼ of the way.
- Close the aeration valves for bay 1 and bay 3
- Open the discharge valves for bay 2.

  NOTE: If the pressure in the ISO-Veyor is increasing, open the boost valve to full open position.
- Discharge is completed when a drop in tank pressure is indicated on the pressure gauge.
- Open the boost valve to purge material in the discharge line.
- Close the discharge valve for bay 2.
- Close the boost valve
- When the pressure within the ISO-Veyor reaches operating pressure (1.9 bar), open the boost valve ¼ of the way.
- Open the aeration valves for bay 3.
- Open the discharge valve for bay 3.

  NOTE: If the pressure in the ISO-Veyor is increasing, open the boost valve to full open position.
- Discharge is completed when a drop in tank pressure is indicated on the pressure gauge.
- Open the boost valve to purge material in the discharge line.
- Close the discharge valve for bay 3.
- Close the boost valve.
- When the pressure within the ISO-Veyor reaches operating pressure (1.9 bar), open the boost valve ¼ of the way.
- Open the aeration valves for bay 1.

- Open the discharge valve for bay 1.

  NOTE: If the pressure in the ISO-Veyor is increasing, open the boost valve to full open position.
- Discharge is completed when a drop in tank pressure is indicated on the pressure gauge
- Open the boost valve to purge material in the discharge line.

5. Flushing Delivery System (Person Responsible – Paste Plant Operator)

- Close the boost valve.
- Allow the ISO-Veyor to pressurize to 1.9 bar.
- Open bay 1 discharge valve.
- Open one bay 1 aeration valve.
- When the pressure in the ISO-Veyor drops below 1 bar, close the aeration valve.
- Allow the ISO-Veyor to pressurize to 1.9 bar.
- Open the additional aeration valve for bay 1.
- When the pressure in the ISO-Veyor drops below 1 bar, close the aeration valve.
- Close bay 1 discharge valve.
- Allow the ISO-Veyor to pressurize to 1.9 bar.
- Open bay 2 discharge valve.
- Open one bay 2 aeration valve.
- When the pressure in the ISO-Veyor drops below 1 bar, close the aeration valve.
- Allow the ISO-Veyor to pressurize to 1.9 bar.
- Open the additional aeration valve for bay 2.
- When the pressure in the ISO-Veyor drops below 1 bar, close the aeration valve.
- Close bay 2 discharge valve.
- Allow the ISO-Veyor to pressurize to 1.9 bar.
- Open bay 3 discharge valve.
- Open one bay 3 aeration valve.
- When the pressure in the ISO-Veyor drops below 1 bar, close the aeration valve.
- Allow the ISO-Veyor to pressurize to 1.9 bar.
- Open the additional aeration valve for bay 3.
- When the pressure in the ISO-Veyor drops below 1 bar, close the aeration valve.
- Close bay 3 discharge valve.
- De-energize the blower.

6. Depressurizing the ISO-Veyor (Person Responsible- Paste Plant Operator)

- Open the vent valve fully.
- Open the boost valve fully.
- Close all aeration valves.

- Ensure the blower is de-energized.
- When the ISO-Veyor pressure gauge displays 0 bar, disconnect the discharge hose and the blower hose from the ISO-Veyor.
- Install caps onto the ISO-Veyor.
- Attach an "MT" tag onto bay 1 discharge valve.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	
Mill Supervisor	Cory Rouse		
JOHSC Rep	Don Stawski		
Mill Superintendent	David Towle		

PRETIVM		BJ-PBF-SOP-557 **Casting of Cylinders for Strength Test - Underground**	
Owner: Bryan Dodding Kayla Johnston Brent Bachewich	**Approver:** Ward Philips Peter Nelega Dave Archiblad	**Revision Number:**	**Creation Date:** Jan. 28, 2018 **Revision Date:**

Objective

To establish mandatory requirements for the safe and responsible working standards for collecting paste samples and casting of cylinders for strength test.

Scope

This SOP covers the process and procedures which will be used to determine the optimal binder ratios relative to strength of the backfill material

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

1.8.2, 1.8.3, 1.8.4, 1.8.5 (Personal Protective Equipment)

Definitions

UCS – Unconfined Compressive Strength

TAMP – To press down lightly in an up and down motion.

QAQC – Quality Assurance Quality Control

U/G – Underground

Preparation

Hazards

- Noise
- Respiratory

Tools

- Pretivm Standard PPE
- Recommended Half-Mask Respirator
- Ensure all the following materials are available before proceeding:
    - Bucket/pail
    - Slump Cone
    - Tamping Rod
    - 3x3 Plywood Board
    - Ruler
    - Trowel
    - UCS Cylinders
    - Knife
    - Duct tape
    - Sharpie
    - Plastic
    - Elastics
    - Milk crate

Requirements

- Must be trained to operate the Paste Plant or work within close contact with a trained operator.

- Underground Orientation

Job Step

1. **Determination of Time Delay (Person Responsible – Control Room Operator)**
   - Control Room Operator will determine the time delay it takes for paste to leave the mill and reach the stope. This time delay will be communicated to the Surface and U/G Paste Operators at the beginning of each stope, and used for the entire length of the pour.
2. **Communication (Person Responsible – Surface Paste Plant Operator)**
   - When surface samples have to be taken, the Surface Paste Plant Operator must contact the U/G Paste Operator and inform them the exact time of sampling.
   - The U/G Paste Operator will use the time delay to determine what time to take the underground samples.
3. **UCS Cylinder Preparation (Person Responsible – U/G Paste Operator)**
   - Cut each cylinder and using duct tape, seal each cylinder split seam.
   - Label each cylinder as follows: YYYY-MMM-DD HH:MM UG. Example: 2017- SEP-19 09:45 UG. The date (YYYY-MMM-DD) can be written in advance of sample collection, but the time (HH:MM) must be written just before sampling. Ensure that UG is specified on all the cylinders.
4. **Sample Collection (Person Responsible – U/G Paste Operator)**
   - Sample collections are conducted using the information from the Surface Paste Operators and the time delay.
   - Underground samples are only to be taken on dayshift
   - 1 sample set equals 4 cylinders (2x7day and 2x28day samples)
   - Ensure latex or rubber gloves are donned prior to collecting sample.
   - Place pail under sample pipe extending off the T-Valve.
   - Open the T-Valve and collect enough paste to perform a slump and pour 4 cylinders.
   - Procon Paste Watcher can assist with collection of samples as needed
5. **Slump Test (Person Responsible – U/G Paste Operator)**
   - Place the slump cone on the wetted 3'x3' plywood. Ensure the surfaces of both the plywood and the cone are clean and moistened with water to eliminate sample sticking to equipment.
   - Stand on the foot tabs of the cone to hold it firmly during filling, taking precaution to keep constant force with little to no movement.
   - Fill the cone in three layers, each approximately one third the volume of the cone. Each layer is tamped with 25 strokes and uniformly distributed over the cross section of the cone. The second and top layers each are tamped throughout their depth, so that the strokes penetrate into the previous underlying layer.
   - After the top layer has been rodded, the surface of the backfill material is stricken off at the top of the cone with the steel rod, so that the cone is exactly full.
   - Lift the cone straight up and away from the backfill material counting slowly to 5, taking precaution to lift uniformly. Invert the cone and place it next to the slumped pile of backfill material gently ensuring not to disturb the slumped material. Place the steel rod horizontally across the inverted cone, so that the rod extends over the slumped material.

- Measure the distance between the bottom of the steel rod and the top of the slumped pile of material at three intervals across the top of the pile using a meter stick or ruler in inches. Record the Slump on the raw data Casting Sheet.

6. Filling UCS Cylinders with Sample (Person Responsible – U/G Paste Operator)

- Fill each UCS cylinder (4), to a height of approximately $^1/_3$ of the total height of the UCS cylinder.
- Tamp each UCS cylinder 25 times.
- Fill each UCS cylinder (4) to a height of approximately $^2/_3$ of the total height of the UCS cylinder.
- Tamp each UCS cylinder 25 times.
- Fill each UCS cylinder (4), so that each UCS cylinder is full to top.
- Tamp each UCS cylinder 25 times.
- Cover UCS cylinders (4) with plastic and secure with elastic bands.

7. Sample Collection and Storage (Person Responsible- U/G Paste Operator)

- Transport all 4 UCS cylinders directly to the curing chamber using a milk crate or similar container in a timely manner. Note: Cylinders must directly be transferred to the humidity lab and cannot be temporarily stored in any location.
- Place two UCS cylinders into each curing time shelf.

8. Data Collection (Person Responsible- U/G Paste Operator)

- Fill in the Paste Casting Sheets and document that the samples were taken underground.
- Hand in Casting Sheets to the Metallurgist Group upon completion.

9. Clean up (Person Responsible- Paste Plant Operator)

- Clean up work area and tools.
- Place tools in proper storage area.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Bryan Dodding Brent Bachewich	[redacted]	
Mill Supervisor	Cory Rouse John MacDonald Mike Whitmarsh Kevin Topper		
JOHSC Rep	Don Stawski Robb Wilson Cody George Chad Hamblin Al Gauthier		
Mill Superintendent	Ward Philips Peter Nelega Dave Archibald		

PRETIVM		BJ-PBF-SOP-558 **Casting of Cylinders for Strength Test**	
Owner: Brent Bachewich Bryan Dodding	Approver: Peter Nelega	Revision Number:	Creation Date: Sept. 18, 2017 Revision Date:

Objective

To establish mandatory requirements for the safe and responsible working standards for casting of cylinders for strength test.

Scope

This SOP covers the process and procedures which will be used to determine the optimal binder ratios relative to strength of the backfill material

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

1.8.2, 1.8.3, 1.8.4, 1.8.5 (Personal Protective Equipment)

Definitions

USC – Unconfined Compressive Strength

TAMP – to press down lightly in an up and down motion.

QAQC – Quality Assurance Quality Control

Preparation

Hazards

- Noise
- Corrosive material

Tools

- Ensure all the following materials are available before proceeding:
  - USC Cylinders - Scoop
  - Slump Cone - Moisture Tins
  - Tampering Rod - Small Taming Rod
  - Oven - Curing Room
  - Duct tape - Marker Pen (Sharpie)

Requirements

- Must be trained to operate the Paste Plant or work within close contact with a trained operator.

Job Step

1. USC Cylinder Preparation (Person Responsible – Paste Plant Operator)

- 1 sample set equals 8 cylinders.
- By using duct tape, seal each cylinder split seam.
- Label each cylinder as follows: YYYY-MMM-DD HH:MM. Example: 2017- SEP-19 09:45. The date (YYYY-MMM-DD) can be written in advance of sample collection, but the time (HH:MM) must be written just before sampling.

2. **Sample Collection (Person Responsible – Paste Plant Operator)**
   - Sample collections are conducted under the following conditions
     - At least 1 hour after start up and circuit is stable (1 set = 8 cylinders)
     - If recipe changes during the shift (1 set = 8 cylinders)
   - Ensure latex or rubber gloves are donned prior to collecting sample.
   - Transfer the required amount of sample from the sample port into a clean collection pail to fill the required casting cylinders.
3. **Filling USC Cylinders with Sample (Person Responsible – Paste Plant Operator)**
   - Fill each USC cylinder (8), to a height of approximately $^1/_3$ of the total height of the USC cylinder.
   - Tamp each USC cylinder 25 times.
   - Fill each USC cylinder (8) to a height of approximately $^2/_3$ of the total height of the USC cylinder.
   - Tamp each USC cylinder 25 times.
   - Fill each USC cylinder (8), so that each USC cylinder is full to top.
   - Tamp each USC cylinder 25 times.
4. **Sample Collection Storage (Person Responsible- Paste Plant Operator)**
   - Transport all 8 USC cylinders to the curing chamber.
   - Place two USC cylinders into each curing time shelf.
5. **Data Input (Person Responsible- Paste Plant Operator)**
   - By using the computer located with the Paste Plant Lab, open the excel file "QAQC-Strength Testing Sheets and click the icon "INPUT CASTING DATA".
   - Input data in the cell highlighted in yellow.
   - Review data entries to confirm the entries are correct. It data is incorrect, input correct data. If data is correct, click "TRANSFER" button, then click "SAVE" button.
   - Close the excel file "QAQC-Strength Testing Sheets".
6. **Clean up (Person Responsible- Paste Plant Operator)**
   - Clean up work area and tools.
   - Place tools in proper storage area.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	
Mill Supervisor	John MacDonald		
JOHSC Rep	Robb Wilson		
Mill Superintendent	Peter Nelega		

PRETIVM	BJ-PBF-SOP-559 **Determination of Unconfined Compressive Strength for Cylinders**		
Owner: Brent Bachewich Bryan Dodding	Approver: David Towle	Revision Number:	Creation Date: Sept. 19, 2017 Revision Date:

Objective

To establish mandatory requirements for the safe and responsible working standards for determining the Unconfined Compressive Strength (UCS) for cylinders.

Scope

This SOP covers the process and procedures which will be used to determine the optimal binder ratios relative to strength of the backfill material

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

1.8.2, 1.8.3, 1.8.4, 1.8.5 (Personal Protective Equipment)

Definitions

UCS – Unconfined Compressive Strength

ARD - Acid Rock Drainage

QAQC – Quality Assurance Quality Control

KN – abbreviation for kilo newton. A newton is the Standard International (SI) unit of force. One newton it the force required to cause a mass of one kilogram to accelerate at a rate of one meter per second squared

Preparation

Hazards

- Noise
- Corrosive material

Tools

- Ensure all the following materials are available before proceeding:
  - Compression Test machine
  - Core Sample Saw
  - Ruler
  - Caliper
  - Dusk Mask (Recommended)
  - Calculator
  - Scale
  - Camera

Requirements

- Must be trained to operate the Paste Plant or work within close contact with a trained operator.

Job Step

1. **USC Cylinder Preparation (Person Responsible – Paste Plant Operator/Metallurgical Technician)**
   - Open the excel file "QAQC – Strength Testing Sheets."
   - Press "PRINT" to obtain a hard copy of the QAQC – Strength Testing Sheet.
   - Remove the required samples (cylinders) from the curing chamber and place onto the work bench.

- Remove all the tape holding each cylinder together.
- Remove the top collar from the cylinders if applicable.
- Remove the samples from the cylinders and place each sample upright on the work bench.
- Inspect each sample for damage or deformities (cracks, air bubbles). Record any deformities in the record/notes section in the QAQC file.

2. Sample Collection (Person Responsible – Paste Plant Operator/Metallurgical Technician)

- Ensure the following tasks are conducted on the core saw prior to using
  - Safety guards are in place and functional.
  - Work area is clear of debris.
  - Core saw water discharge hose is discharged into the floor drain.
- Cut each sample with the core saw to make flat ends on each side.
- Place each sample upright on the work bench.
- By using the calipers, measure the diameter of each sample in two locations and calculate the average diameter. Record the average diameter of the sample into the USC Test Sheet.
- Place each sample onto their side on the work bench.
- By using the calipers, measure the length of each sample in two and calculate the average length. Record the average length of the sample into the USC Test Sheet.
- Place sample upright on the work bench.

3. USC Test (Person Responsible – Paste Plant Operator/Metallurgical Technician)

- Turn on the power to the Compression test machine.
- Turn on the hydraulics for the Compression test machine.
- Input the length and diameter of the sample into the test program.
- Remove the sample from the work bench and place the sample upright into the Compression test machine.
- If the space between the top of the sample and the hydraulic ram is greater than 1 centimeter, lower the ram until a gap of approximately one centimeter is achieved.
- Start test by turning handle to "Meter Advanced"
- Lower the ram at a constant speed.
- Continue breaking the sample until failure. The Compression test machine will stop when sample failure is achieved.
- Retract the hydraulic ram.
- Press the magnifying glass on the display and record the following data onto the USC Test Sheet.
  - Maximum load (kN)
  - Machine Stress (MPa)
- Take a picture of the sample.
- Visually inspect the sample to determine the fracture type.
- Record fracture type onto the USC Test Sheet.

- Obtain a sample bag, and by using a sharpie, write the following data onto the sample bag
  - The sample ID (Date/Shift/Time of pouring)
  - Attach a label with the following description "ARD SAMPLE".
- Place the ARD sample into collection box.
- Conduct testing on all samples before performing next step.

4. Sample Data Entry (Person Responsible- Paste Plant Operator)

- Open the excel file QAQC – Strength Testing Sheets.
- Click "INPUT UCS STRENGTH DATA" and enter the data from the USC Test Sheet into the computer.
- Review data entry for accuracy.
- Once data is confirmed correct, click the "TRANSFER" and then click "SAVE".
- Hole punch the USC Test Sheet and place in the data records binder.

5. Clean up (Person Responsible- Paste Plant Operator)

- Clean up work area and tools.
- Place tools in proper storage area.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	
Mill Supervisor	Cory Rouse		
JOHSC Rep	Don Stawski		
Mill Superintendent	David Towle		

PRETIVM		BJ-PBF-SOP-560 **Diverter Gate Operation & Pigging Procedure**	
Owner: Brent Bachewich Bryan Dodding	Approver: David Towle	Revision Number:	Creation Date: Sept. 18, 2017 Revision Date:

Objective

To establish mandatory requirements for the safe and responsible working standards for operating the Paste Plant Diverter Gate and inserting clean-out pigs into the Paste Plant discharge lines.

Scope

This Standard Operating Procedure (SOP), covers the process and procedures which will be used to standardize operation of the Paste Plant Diverter Gate and the insertion of clean-out pigs into the Paste Plant discharge lines.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

1.8.2, 1.8.3, 1.8.4, 1.8.5 (Personal Protective Equipment)

Definitions

Clean-Out Pig - Round shaped foam which is cut or poured out of an open cell polyurethane.

Pigging – Refers to the practice of inserting a clean out pig into pipelines to clean/remove material buildup within the pipeline.

Pinch Point - A pinch point is any point at which it is possible for a person or part of a person's body to be caught between moving parts of a machine, or between the moving and stationary parts of a machine, or between material and any part of the machine. A pinch point does not have to cause injury to a limb or body part, although it might cause injury – it only has to trap or pinch the person to prevent them from escaping or removing the trapped part from the pinch point.

Preparation

Hazards

- Pinch Points
- Noise
- Pressure in Paste Line

Tools

- Broom handle
- Clean-out Pig

Requirements

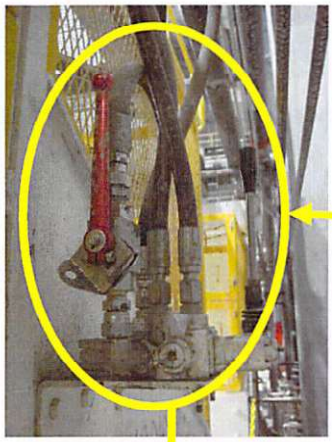
- Must be trained to operate the Paste Plant or work within close contact with a trained operator.

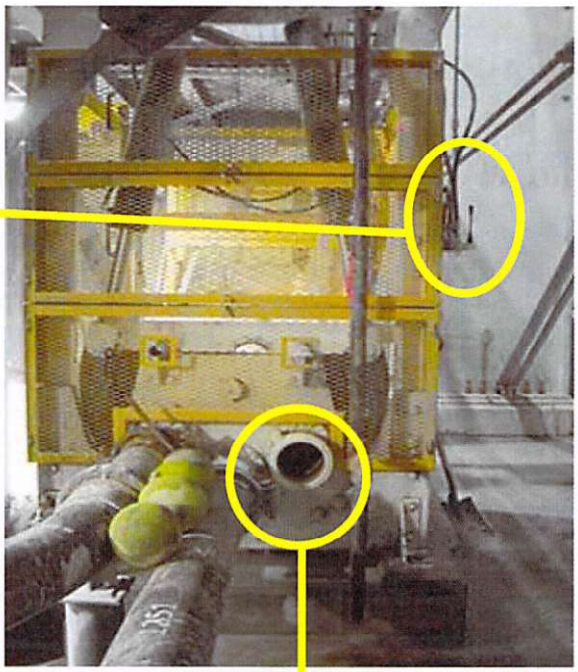
Job Step

1. **Diverter Gate (Person Responsible – Paste Plant Operator)**
   - Visually inspect the pressure gauge on the Paste Line (discharge side of the Paste Pumps) and ensure the line pressure is reading 0 kPa.
   - Check the Diverter Gate Hydraulic Pack for adequate oil; oil level can be checked by using the site glass.
   - Contact Central Control Room to energize the Diverter Gate Hydraulic Pump (HY043).

- Move the Diverter Gate to the desired position, by using the black lever (Mounted on the south side of the Diverter Gate Enclosure).The Diverter Gate (connected to the Paste Line) can be moved to three positions:
    - Paste Pump 1 is the center position
    - Paste pump 2 is the left position
    - Pigging port is the right position

2. **Insertion of Clean-Out Pig into Paste Discharge Line (Person Responsible – Paste Plant Operator)**
    - Ensure the Diverter Gate is in the pig position.
    - Insert the clean-out pig into the pipe opening. **Do not push the clean-out pig into the pipe using any part of your body.**
    - Push the clean-out pig past the Diverter Gate into the Paste Line by using a broom handle. Do not allow any part of your body to enter the pipeline opening.
    - Position the Diverter Gate to the desired Paste Pump by using the black hydraulic lever.
    - Contact the Central Control Room Operator to notify them that the clean-out pig has been inserted and the Diverter Gate is in the correct position.
    - Contact Central Control Room to de-energize the Diverter Gate Hydraulic Pump (HY043).





Black Lever: This lever is used to control the position of the Diverter Gate.

Red Lever: This lever is used to lock the hydraulics to the Diverter Gate. Pulling the lever to a horizontal position will cut off the hydraulic fluid to the cylinders.

Pig Port: This is where the clean out pig is inserted. Insert clean out pig into the line using a broom handle. Never place any part of your body inside the pig port.

The above picture shows the gate in the center position, which would connect the paste line to Paste Pump #1.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	
Mill Supervisor	Cory Rouse		
JOHSC Rep	Don Stawski		
Mill Superintendent	David Towle		

PRETIVM SCANNED		BJ-PBF-SOP-561 **Energizing/De-energizing the Paste Pumps (GeHo) Hydraulic System in Manual Mode**	
Owner: Brent Bachewich Bryan Dodding	Approver: Peter Nelega	Revision Number:	Creation Date: Sept. 18, 2017 Revision Date:

Objective

To establish mandatory requirements for the safe and responsible working standards for energizing the Paste Plant Pumps (GEHO) hydraulic system in manual mode.

Scope

This SOP covers the process and procedures which will be used to energize the Paste Pumps (GEHO) hydraulic system in manual mode.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

1.8.2, 1.8.3, 1.8.4, 1.8.5 (Personal Protective Equipment)

Definitions

GEHO – trade name for a diaphragm pump developed by Weir. The GEHO pump is a crankshaft driven high pressure piston diaphragm pump designed to handle abrasive tailings slurries and underground paste.

PLC- acronym for "Programmable Logic Controller". A PLC is an industrial computer that has been adapted for the control of manufacturing and has a high control reliability and ease of diagnosing process faults.

Local/Remote – refers to operator control of the PLC. Local refers to operating the PLC is the field. This is usually conducted in close proximity to the equipment controlled by the PLC. Remote refers to operating the PCL from a control room.

Preparation

Hazards

- Noise
- Electrical

Tools

- No additional tools required to complete task.

Requirements

- Must be trained to operate the Paste Plant or work within close contact with a trained operator.

Job Step

1. **Energizing the Paste Pump Hydraulic System in Manual Mode (Person Responsible – Paste Plant Operator)**
   - Visual inspect "TIA temperature" on PLC display screen. If temperature is below 50° Celsius, energize the Paste Plant hydraulic system.
   - Turn PLC control to "LOCAL".
   - Conducted the following steps using the touch screen located on the PLC cabinet in the following order:
     - Press "Service" to enter service mode screen

- Press "Yes" to acknowledge that you want to go into service mode.
  NOTE: When you press "YES", all safety features are overridden.
- Enter access code. Contact supervisor for access code.
- Press "START" to switch PLC into service mode. The status light will change from grey to green
- Press "START" to energize M6 motor.
- Press "START" to open Y21 valve.
- Press "START" to open Y35 valve
- Press "START" to energize M3 motor.
- Press "START" to energize M4 motor.
- Press "START" to energize M5 motor.
- Press "MAIN" to exit service screen and to display main display screen
- Monitor "TIA Temperature". When temperature reaches 60° Celsius, de-energize the paste pump hydraulic system.

2. De-energizing the Paste Pump Hydraulic System in Manual Mode (Person Responsible – Paste Plant Operator)

- Ensure PLC control is in "Local" mode.
- Conduct the following steps using the touch screen located on the PLC cabinet in the following order:
  - Press "Service" on main screen to enter service mode screen.
  - Press "Yes" to acknowledge that you want to go into service mode.
  - NOTE: When you press "YES", all safety features are disengaged
  - Enter access code. Contact supervisor for access code.
  - Press "STOP" to de-energize M5 motor.
  - Press "STOP" to de-energize M4 motor.
  - Press "STOP" to de-energize M3 motor.
  - Press "STOP" to close Y35 valve.
  - Press "STOP" to close Y21 valve.
  - Press "STOP" to de-energize M6 motor.
  - Press "STOP" to deactivate Service mode.
  - Press "MAIN" to exit service screen and to display main display screen.
  - Monitor "TIA Temperature". When temperature drops to 50° Celsius, energize the paste pump hydraulic system up.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Brent Bachewich	[redacted]	
Mill Supervisor	Cory Rouse		
JOHSC Rep	Don Stawski		
Mill Superintendent	David Towle		

PRETIVM		BJ-PBF-SOP-562 Paste Plant Mixer Cleaning	
Owner: Bryan Dodding Brent Bachewich	Approver: Peter Nelega	Revision Number:	Creation Date: Oct 12, 2017 Revision Date:

Objective

To ensure the Paste Mixer has been flushed and thoroughly washed when paste production is complete.

Scope

This SOP covers the process and steps involved to flush out the paste mixer and thoroughly wash using the high pressure washing system.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

Definitions

TDST – Tailings Disposal Surge Tank

Preparation

Hazards

- High Pressure Water
- Equipment starting

Tools

- Pressure Washer
- Face Shield

Job Steps

1. Washing the Paste Mixer (Persons Responsible – Paste Plant Operator)

- Once the Control Room operator has finished flushing the Paste Mixer with water, they will contact the Paste Plant operator to divert the paste area sump (PU-013) to the Paste Mixer chute.
- Control Room will open the Paste Mixer drain valves (HS-5572/5582).
- Check for flow from the drains to ensure there isn't a plug in the line.
- If the Paste Mixer doesn't drain, the line will be built up with hardened paste between the Paste Mixer discharge and drain valve. Close the Paste Mixer drain valves (HS-5572/5582) and open the flush water located in this section to try and flush the material back into the mixer. After flushing, shut off water and open the drain valves. Check for flow.
- If the water flush doesn't remove the buildup, maintenance will have to break the line so it can be cleaned out.
- Once the Paste Mixer has completed draining, the high pressure washer pump (PU-031/032) can be started on a 15 minute flush cycle.
- When flush has completed, the Paste Mixer will be inspected for buildup of hardened paste inside the tank and on the agitators. **It is very crucial to ensure that all buildup of paste is removed.**
- If further cleaning is required, the Paste Mixer agitators (MX-031M1/M2) must be locked out.
- Use the pressure washer to spray off all hardened build up.

  Note: Face Shield must be worn when using the pressure washer.

- If an Operator has to reach inside or enter the Paste Mixer, both lock-out and confined space procedures must be followed.
- Contact the Control Room operator when cleanup is complete and divert the sump back to TDST.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	Bryan Dodding	[redacted]	
Mill Supervisor	Kevin Topper		
JOHSC Rep	Chad Hamblin		
Mill Superintendent	Peter Nelega		

PRETIVM		BJ-PRO-SOP-564 **OPERATING OVERHEAD DOOR WITH SAFETY EDGE BYPASSED**	
Owner: Bryan Dodding Brent Bachewich	Approver: Dave Archibald Peter Nelega	Revision Number:	Creation Date: Jan. 11, 2018 Revision Date:

Objective

To establish mandatory requirements for safe responsible working standards for operating an overhead door when the safety edge is bypassed.

Scope

This procedure covers the steps involved for operating an overhead door when the safety edge is bypassed. This includes opening the overhead door and closing the overhead door.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

Definitions

No definitions

Preparation

Hazards

- Any obstruction that may interfere with opening or closing the overhead door.

Tools

- No additional tools required.

Requirements

- Trained in operating overhead door when safety edge is bypassed.

Job Steps

1. **Opening Overhead Door (Person Responsible – Mill Operator)**
   - Ensure door entrance is clear of obstructions.
   - Push Up/Down button (Black) to open door.
   - Do not allow any vehicular traffic through the doorway until the overhead door is fully opened.
   - Direct vehicular traffic through door way.
2. **Closing Overhead Door (Person Responsible – Mill Operator)**
   - Ensure vehicle has passed through the door way and is clear of the overhead door.
   - Press Up/Down button (Black) to close door.
   - Visually monitor doorway to ensure no vehicles try to drive through the door way as door is being lowered.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	[redacted]		
Mill Supervisor			
JOHSC Rep			
Mill Superintendent			

PRETIVM		BJ-PRO-SOP-570 **Operating Underground Booster Station**	
Owner: Brent Bachewich Bryan Dodding	**Approver:** David Archibald Peter Nelega	**Revision Number:**	**Creation Date:** Feb. 13, 2018 **Revision Date:**

Objective

To establish mandatory requirements for the safe and responsible working standards for operating the Underground Booster Station.

Scope

This procedure covers the steps required for starting the Underground Booster Station, operating the Underground Booster Station and shutting down the Underground Booster Station.

Health, Safety & Reclamation Code of BC

1.11.1 (Training)

1.8.2, 1.8.3, 1.8.4, 1.8.5 (Personal Protective Equipment)

Definitions

CAS – Cascade

UG –Underground

SOP- Safe Operation Procedure

Preparation

Hazards

- Noise
- Working underground.
- Pinch points
- Pressure in Paste lines, hydraulic lines, airlines and water lines

Requirements

- Underground Orientation
- Trained or working with a trained Underground Paste Plant Operator
- Trained in Lockout/tagout (LOTO).
- Trained & Signed off on BJ-PRO-SOP-560 Diverter Gate Operation & Pigging Procedure

Job Step

NOTE: All advice and directives from the Underground Paste Watcher must be adhered to.

1. Pre-start Checks (Person Responsible- Underground Paste Plant Operator)

- Start Hydraulics (2153-HY-003) to Diverter Valves.
- Set Diverter Valve to Paste Pump (PU-020).
- Verify Destination Valve is correct for Destination: 1350 Level, Lower VOK or Upper VOK".
- Stop Hydraulics to Diverter Valves.

- Wet the Live Bottom Hopper.

2. **Pre-Start checks (Person Responsible – Control Room Operator and Underground Paste Booster Operator)**
   - Close Hopper Discharge Valve (2153-HS-5613) to Booster Paste Pump (PU020).
   - Start Bottom Hopper Augier Forward (2153-HO-001).
   - Verify Flush Water Tank Level (2153-LI-5621) is greater than 80% and set to CAS mode.
3. **Pre Wetting Live Bottom Hopper (Person Responsible – Control Room Operator)**
   - Use slick water from surface paste plant.
   - If water from surface is not available, start selected Flush Water Pump (2153-PU-001 or 2153-PU-002).
   - Set Live Bottom Hoper Level (2153-LIC-5611) to approximately 67% in AUTO mode.
4. **Prepare Booster Pumps for Startup (Person Responsible- Control Room Operator)**
   - Open Hopper Discharge Valve (2153-HS-5613) to Paste Pump (PU-020).
5. **Start Booster Paste Pump (Person Responsible – Control Room Operator)**
   - When the Underground Paste Plant gives the confirmation that "Underground is ready for Startup", the surface paste plant will be started using water.
   - The Underground Paste Plant Operator will inform the Control Room Operator when water is received into the Live Bottom Hopper.
   - The Underground Paste Plant Operator will inform the Control Room Operator that "Underground is ready for paste.
   - Allow the Live Bottom Hopper to attain a level of approximately 70%, then start Booster Paste Pump (PU-020).
   - Adjust pump stroke to maintain a level of 65%- 67% in the Live Bottom Hopper, then switch to AUTO mode.
   - The Surface Paste Plant Operator will start pumping paste underground.
   - The Underground Paste Plant Operator will inform the Control Room Operator when paste is discharging into the Live Bottom Hopper.
   - If the Booster Paste Pump (PU-020), was turned off, turn the pump back on and set to AUTO mode and set the level in the Live Bottom Hopper to around 67% on (2153-LIC-5611).
6. **Shutdown and Clean Out Mode (Person Responsible – Control Room Operator)**
   - After the pour of Paste is complete, the surface plant will go into cleanout mode. This process will send dirty water to Live Bottom Hopper and Booster Station.
   - The Underground Booster Paste Pump (PU-020) will remain running until the Underground Paste Plant Operator verifies that "clean" water is discharging into the Live Bottom Hopper.
   - Stop Underground Paste Booster Pump (PU-20).
7. **Pigging the Surface Line (Person Responsible – Control Room Operator & Mill Surface Paste Plant Operator)**
   - Surface Paste Plant Operator will prepare the surface line for pigging as per Pretivm Pigging SOP[1]
   - When confirmation from the Underground Paste Plant Operator has been given that the pig has arrived and the pig has been removed from the Live Bottom Hopper and the flow into the Live Bottom Hopper is clear, the surface paste pump can be shut down and the procedure for pigging the underground paste line from the booster pump to the stope can be conducted.

8. Flush the Live Bottom Hopper (Person Responsible – Underground Paste Operator)

- Close the drain on Live Bottom Hopper to catch any excess water for pigging the underground process. Remaining water will report to sump via Live Bottom Hopper overflow.
- Start Underground Paste Booster Pump (PU-20).
- Flush the underground line for approximately 2 minutes with water from the Live Bottom Hopper.
- Stop Booster Paste Pump (PU-020).
- Confirm a loss in line pressure at 2153-PI-5641 and 2153-PI-5646.
- To prevent backflow, start the Diverter Hydraulic Power Pack 2153-HY-003 and move Diverter Valve No.1 (2153-DV-001) to the center pigging port and verify with 2153-PI-5646.

9. Pigging the Underground Line (Person Responsible- Underground Paste Operator)

- Turn Diverter Valve Hydraulic Power Pak (2153-HY-003) on.
- Place both Diverter Gates to Neutral position.
- After the line pressure has been proven to be zero (2153-PI-5647 and 2153-PI-5646).
- Insert the pig into the line making sure it is beyond the rotating plate of the diverter plate.
- Return the Diverter Valves to previous position for Booster Paste Pump (PU-020) and verified by 2153-ZI-5643A.
- Turn Diverter Valve Hydraulic Power Pak (2153-HY-003) off.
- Start Paste Pump (2153-PU-020).
- Once the UG Paste Plant Operator verifies that the Pig has been released and the UG Paste Watcher verifies clean water is exiting the pipe, stop Paste Booster Pump (2153-PU-020).
- Position Diverter Valve No. 1 slowly to the center Pig Insertion Port (B) and allow remaining water to drain into the sump.
- Stop the Paste Pump Hydraulic Power Unit (2153-HY-020) allow for cool down period.
- Conduct general circuit clean up.

Appendix

BJ-PRO-SOP-560 Diverter Gate Operation & Pigging Procedure

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mill Trainer	[redacted]		
Mill Supervisor			
JOHSC Rep			
Mill Superintendent			

Appendix D
Brucejack Fill System Rates February 2018

Brucejack Paste Backfill System Rates Table - Mill at 3,300 tpd (150 tph @ 93% utilisation & 6% mass pull to cons)

Illustrating the linkage between short term and long term design and planning rates

Daily ore tonnes mined	3,348	tpd											
Ore tonnes milled	150.0	tph	Mill Utilisation	93%	SG tails	2.80	**Backfill Mix Calcs for 1,000 kg dry paste**						
Tonnes to Concentrate	9.0	tph	Mass pull to cons	6%	T90 Binder	2.9	1,000			wt (kg)	vol (l)	kg per m3	
Tonnes to backfill system	141.0	tph			Average PC Rate	6.50%	OPC	6.50%		65.0	22.4	68.9	
					Binder SG	3.14	Binder	0.00%		0.0	0.0	0.0	
Percent tailings supplied to backfill plant	100%		**Total mined**	**1,222,020 tpa ore**	Binder Rate	0.0%	Tails	93.50%		935.0	333.9	990.8	
Tailings supplied to backfill plant	141.0	tph							**Dry**	**1,000.0**	**356.3**	**1,059.7**	
Percentage supplied tails used in backfill	84%		Ore Density	2.65			Water in backfill slurry			587.3	587.3	622.4	
Tailings used in Backfill	117.8		Vol mined	461,140 m3/pa					**Slurry**	**Wet**	**1,587.3**	**943.6**	**1,682.1**
Average cement used in backfill	8.2	tph	**% to be filled**	**100%**			Water in consolidated backfill			548.1	548.1	606.0	
Total Solids used in Backfill	125.9	tph	WT Vol Fill reqd	462,000 m3/pa					**Consolidated**	**Wet**	**1,548.1**	**904.5**	**1,711.6**

Fill Pulp Density	63.0%	by weight	Consolidated Density	64.6%	by weight	**Binder Dosing**	
Fill Pulp Density	37.8%	by volume	Fill Pulp Density	39.4%	by volume	Paste slurry	69 kg/m3
Backfill Dry Bulk Density	1.0597	kg/l	Backfill Dry Bulk Density	1.1056	kg/l	Paste cured	72 kg/m3
Backfill Pulp Relative Density	1.6821	tonnes/m3	Backfill Wet Bulk Density	1.7116	tonnes/m3		

Round Up Integer	0.1	0.1	0.1	10	10	10	1,000	1,000	1,000	1,000	1,000	1,000

Instant Slurry Design Placement Rate — These are the plant and component design throughput rates

Factor	100%					
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d
	126.0	200.0	118.9	3,030	4,800	2,860

Instant Consolidated Backfill Placement Rates — These are the backfill volume placement rates after consolidation

Factor	100%					
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d
	126.0	200.0	116.9	3,030	4,800	2,810

Daily Average Rate — These are the targets that the operators should achieve each day

Factor	85%					
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d
	107	170	99	2,580	4,080	2,390

Weekly and Monthly Scheduling Rates — These are the rates used for scheduling of fill placement

Factor	66%								
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d	dtpm	wtpm	m3/m
	83	132	77	2,000	3,180	1,860	61,000	97,000	57,000

Annual System Performance — These are the expected annual performance achievements

Factor	47%											
Plant Rate	dtph	wtph	m3/hr	dtpd	wtpd	m3/d	dtpm	wtpm	m3/m	dtpa	wtpa	m3pa
	59	94	55	1,430	2,260	1,320	44,000	69,000	41,000	519,000	824,000	482,000

Tailings	**485,265 tpa**
Binder	**33,735 tpa**

Appendix E
Brucejack Backfill Design V2.5 February 2018

AMC Backfill Design Strength Estimator V2.5

Using Terzaghi (1943) as modified by Bloss (1996) and Grice (1999) for multiple backfill exposures

General Assumptions

Geotechnical Data

Friction Angle ϕ	26	degrees	F/W Dip (deg)	90
Gravity g	9.81	ms-2		
Fill Density ρ	1.71	kg/m3	Wet PF 1.68 kg/m3	
Poisson's Ratio k	0.36			
Adjusted Factor of Safety	1.25		Default Factor of Safety	1.25
Depth zone increments	5.0	m		
Backfill mix increments	100	kPa	B' to W'	4

Stope Information

Stope Name

BJ Primary 15 x 30 x 30 Three Exposures

Stope Geometry

Length	30.0	m	Length is along strike
Width	30.0	m	Width is across strike
Height	30.0	m	
Perimeter	120.0	m	

Backfill Strength Calculator

Exposure Geometry

Exposure Number	1	2	3	4	
Width	15.0	30.0	30.0	-	
Fill to Fill Arching Factor	93.4%	84.0%	81.3%	46.0%	
Width	14.0	25.2	24.4	-	m
B'	4.78	6.85	6.73	0.00	
Perimeter Contact removed	15	44	69	64	m
Percent Perimeter Contact	88%	63%	42%	47%	%
Intact Walls	3.5	2.5	1.7	1.9	

Is the backfill undercut? FALSE — Not undercut

Backfill Strength - Top Section

Height	10		Depth Stress	168	kPa
Average vertical stress σ_z	96	122	134	0	kPa
cohesion	30	38	42	0	kPa
Design Strength (UCS)	120	153	167	0	kPa
Backfill Mix Strength - Top Section				200	kPa

Backfill Strength - 2nd Section

Height	15		Depth Stress	252	kPa
Average vertical stress σ_z	119	161	182	0	kPa
cohesion	37	50	57	0	kPa
Design Strength (UCS)	148	202	228	0	kPa
Backfill Mix Strength - 2nd Section				300	kPa

Backfill Strength - 3rd Section

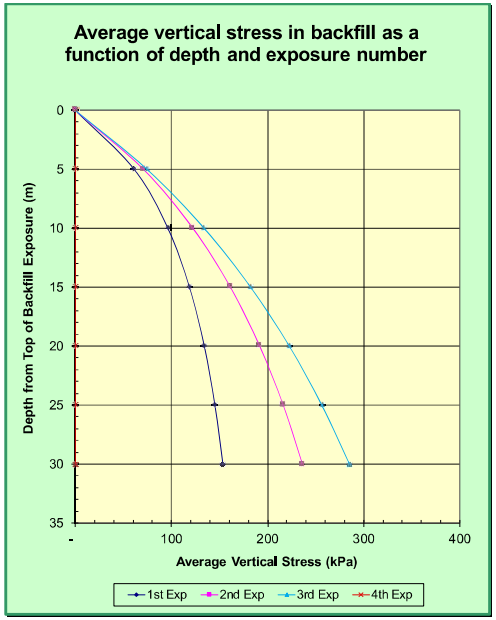
Height	30		Depth Stress	495	kPa
Average vertical stress σ_z	153	234	282	0	kPa
cohesion	48	73	88	0	kPa
Design Strength (UCS)	191	293	353	0	kPa
Backfill Mix Strength - 3rd Section				400	kPa

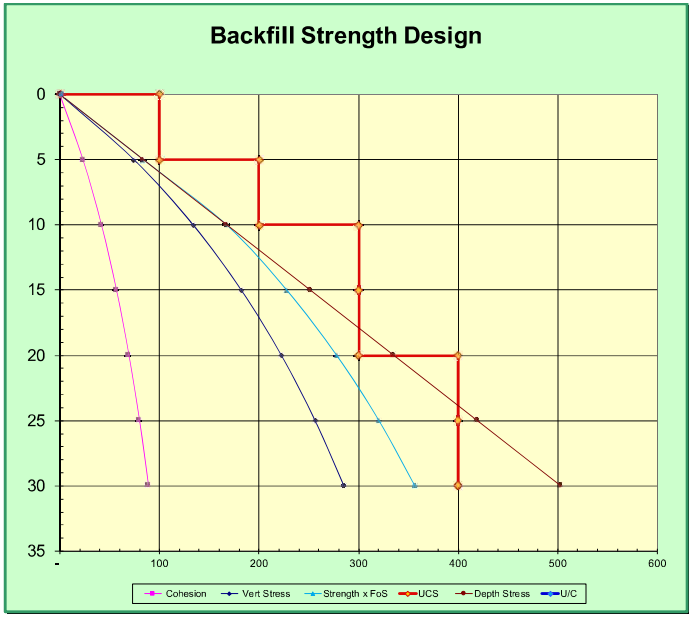
Backfill Strength - 4th Section

Height	30		Depth Stress	503	kPa
Average vertical stress σ_z	154	236	285	0	kPa
cohesion	48	74	89	0	kPa
Design Strength (UCS)	192	295	356	0	kPa
Backfill Mix Strength - 4th Section				400	kPa

Backfill Strength - Undercut

Base of Undercut zone	Not undercut	Depth Stress	kPa
Height of Undercut	m		
Design Strength (UCS)			kPa
Backfill Mix Strength - Undercut			kPa





Calculation of average vertical stress in backfill and UCS for each increment (kPa)

UCS values denote backfill mix strength at the base of each incremental zone

Depth	1st Exp	2nd Exp	3rd Exp	4th Exp	Max Average Vert Stress	Cohesion	Depth Stress	Min Strength x FoS	UCS
0	0	0	0	0	0	0	0	0	
5	61	71	74	0	74	23	84	84	100
10	96	122	134		134	42	168	167	200
15	119	161	182		182	57	252	228	300
20	134	192	223		223	70	336	278	300
25	145	216	256		256	80	419	320	400
30	154	236	285		285	89	503	356	400

Summary of backfill mix strength

UCS values for manually zoned backfill

Zone	Depth	σz	cohesion	UCS	Zoned UCS
	0	0	0	0	200
1st	10	134	42	167	200
2nd	15	182	57	228	300
3rd	29.5	282	88	353	400
4th	30	285	89	356	400
U/C	30			356	400

Calculation of average vertical stress in backfill (kPa)

Terzaghi 3D

$$\sigma_z = \frac{\frac{W}{N}\left(\rho_g - \frac{c}{W}\right)\left(1 - e^{-\frac{(N.k.z.\tan\phi)}{W}}\right)}{k.\tan\phi}$$

Key to Terzaghi 3D formula

σz	Average vertical stress	kPa
c	Cohesion	kPa
ρg	Bulk density of backfill	KN/m3
ϕ	Friction angle	degrees
k	Poisson's ratio	
W	Width of backfill exposure	m
Z	Depth of fill (Height of exposure)	m
N	Number of intact rock walls	

AMC Backfill Design Strength Estimator V2.5

Using Terzaghi (1943) as modified by Bloss (1996) and Grice (1999) for multiple backfill exposures

General Assumptions

Geotechnical Data

Friction Angle ϕ	26	degrees	F/W Dip (deg)	90
Gravity g	9.81	ms-2		
Fill Density ρ	1.71	kg/m3	Wet PF 1.68 kg/m3	
Poisson's Ratio k	0.36			
Adjusted Factor of Safety	1.25		Default Factor of Safety	1.25
Depth zone increments	5.0	m		
Backfill mix increments	100	kPa	B' to W'	4

Stope Information

Stope Name

BJ Primary 15 x 30 One Exposure

Stope Geometry

Length	30.0	m	Length is along strike
Width	30.0	m	Width is across strike
Height	30.0	m	
Perimeter	120.0	m	

Backfill Strength Calculator

Exposure Geometry

Exposure Number	1	2	3	4	
Width	15.0	-	-	-	
Fill to Fill Arching Factor	93.4%	84.0%	81.3%	46.0%	
Width	14.0	-	-	-	m
B'	4.78	0.00	0.00	0.00	
Perimeter Contact removed	15	14	14	14	m
Percent Perimeter Contact	88%	88%	88%	88%	%
Intact Walls	3.5	3.5	3.5	3.5	
Is the backfill undercut?	FALSE		Not undercut		

Backfill Strength - Top Section

Height	10		Depth Stress	168	kPa
Average vertical stress σ_z	96	0	0	0	kPa
cohesion	30	0	0	0	kPa
Design Strength (UCS)	120	0	0	0	kPa
Backfill Mix Strength - Top Section				200	kPa

Backfill Strength - 2nd Section

Height	15		Depth Stress	252	kPa
Average vertical stress σ_z	119	0	0	0	kPa
cohesion	37	0	0	0	kPa
Design Strength (UCS)	148	0	0	0	kPa
Backfill Mix Strength - 2nd Section				200	kPa

Backfill Strength - 3rd Section

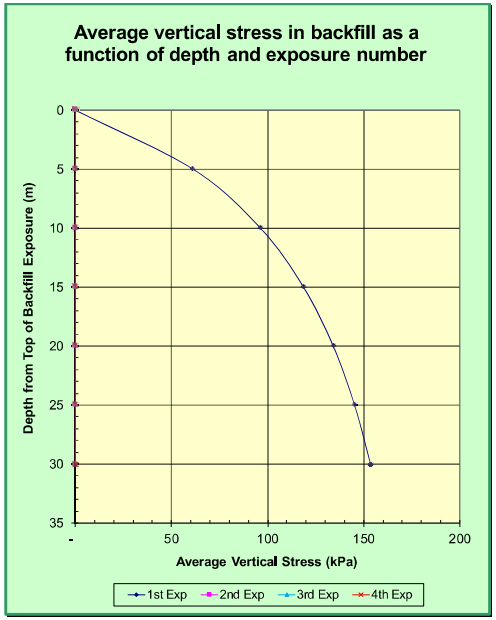
Height	30		Depth Stress	495	kPa
Average vertical stress σ_z	153	0	0	0	kPa
cohesion	48	0	0	0	kPa
Design Strength (UCS)	191	0	0	0	kPa
Backfill Mix Strength - 3rd Section				200	kPa

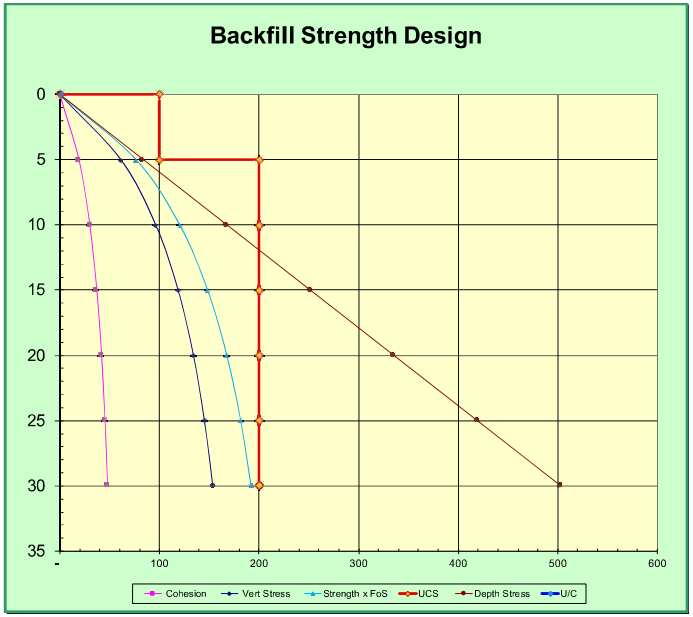
Backfill Strength - 4th Section

Height	30		Depth Stress	503	kPa
Average vertical stress σ_z	154	0	0	0	kPa
cohesion	48	0	0	0	kPa
Design Strength (UCS)	192	0	0	0	kPa
Backfill Mix Strength - 4th Section				200	kPa

Backfill Strength - Undercut

Base of Undercut zone	Not undercut	Depth Stress	kPa
Height of Undercut	m		
Design Strength (UCS)			kPa
Backfill Mix Strength - Undercut			kPa





Calculation of average vertical stress in backfill and UCS for each increment (kPa)

UCS values denote backfill mix strength at the base of each incremental zone

Depth	1st Exp	2nd Exp	3rd Exp	4th Exp	Max Average Vert Stress	Cohesion	Depth Stress	Min Strength x FoS	UCS
0	0	0	0	0	0	0	0	0	
5	61	0	0	0	61	19	84	77	100
10	96				96	30	168	120	200
15	119				119	37	252	148	200
20	134				134	42	336	168	200
25	145				145	45	419	182	200
30	154				154	48	503	192	200

Summary of backfill mix strength

UCS values for manually zoned backfill

Zone	Depth	σz	cohesion	UCS	Zoned UCS
	0	0	0	0	200
1st	10	96	30	120	200
2nd	15	119	37	148	200
3rd	29.5	153	48	191	200
4th	30	154	48	192	200
U/C	30			192	200

Calculation of average vertical stress in backfill (kPa)

Terzaghi 3D

$$\sigma_z = \frac{\frac{W}{N}\left(\rho_g - \frac{c}{W}\left(1 - e^{-\frac{(N.k.z.\tan\phi)}{W}}\right)\right)}{k.\tan\phi}$$

Key to Terzaghi 3D formula

σz	Average vertical stress	kPa
c	Cohesion	kPa
ρg	Bulk density of backfill	KN/m3
ϕ	Friction angle	degrees
k	Poisson's ratio	
W	Width of backfill exposure	m
Z	Depth of fill (Height of exposure)	m
N	Number of intact rock walls	

Brucejack Strength Design summary

Optimised Strength Design

	Depth (m)	Primary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	0.5	Cap	1,100
4.5	5	Main	100
5	10	Main	200
5	15	Main	300
5	20	Main	300
5	25	Main	400
5	30	Main	400

average	300	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	30	30
Exposure 3	30	30
Undercut	-	

Depth (m)	Primary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	Cap	1,100
5	Main	100
10	Main	200
15	Main	300
20	Main	300
25	Sill	1,100
30	Sill	1,100

average	533	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	30	30
Exposure 3	30	30
Undercut	15	

Depth (m)	Secondary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	Cap	1,100
5	Main	100
10	Main	200
15	Main	200
20	Main	200
25	Main	200
30	Main	200

average	200	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	-	-
Exposure 3	-	-
Undercut	-	

Depth (m)	Scondary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	Cap	1,100
5	Main	100
10	Main	200
15	Main	200
20	Main	200
25	Sill	1,100
30	Sill	1,100

average	500	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	-	-
Exposure 3	-	-
Undercut	15	

Current Simplified Strength Design

	Depth (m)	Primary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	0.5	Cap	1,100
4.5	5	Main	400
5	10	Main	400
5	15	Main	400
5	20	Main	400
5	25	Main	400
5	30	Main	400

average	412	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	30	30
Exposure 3	30	30
Undercut	-	

Depth (m)	Primary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	Cap	1,100
5	Main	400
10	Main	400
15	Main	400
20	Main	400
25	Sill	1,100
30	Sill	1,100

average	645	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	30	30
Exposure 3	30	30
Undercut	15	

Depth (m)	Secondary stope (no sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	Cap	1,100
5	Main	200
10	Main	200
15	Main	200
20	Main	200
25	Main	200
30	Main	200

average	215	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	-	-
Exposure 3	-	-
Undercut	-	

Depth (m)	Scondary stope (with sill)	Design Strength UCS in 1.25 FoS (kPa)
0.5	Cap	1,100
5	Main	200
10	Main	200
15	Main	200
20	Main	200
25	Sill	1,100
30	Sill	1,100

average	515	kPa

	Width	Height
Exposure 1	15	30
Exposure 2	-	-
Exposure 3	-	-
Undercut	15	

Appendix F
Brucejack Mitchell Sill V1.9 February 2018

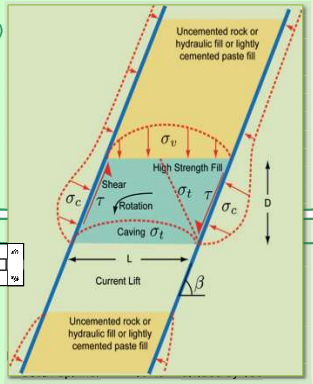
AMC Worksheet to estimate the strength and thickness of an undercut fill slab Version 1.9 - February 2010

Adapted from Mitchell & Roettger (1989) Analysis and Modelling of Sill Pillars, Innovations in Mining with Backfill, Montréal, Balkema

General Assumptions

Geotechnical Data

Sill Pillar Fill Type	Paste	Non Entry Mining Method (FoS >= 1.25)
Elastic Modulus E MPa	200	
Ratio of Compressive to Tensile Strength	8.0	
Gravity g ms-2	9.81	
Wet Fill Density γ kg/m^3	1.71	Sill Pillar
Wet Fill Density $\sigma_v \gamma$ kN/m^3	16.8	Sill Pillar
Wet Fill Density γ kg/m^3	1.71	Surcharge Load
Wet Fill Density $\sigma_v \gamma$ kN/m^3	16.8	Surcharge load
Factor of safety FoS	1.25	FoS >= 3.0 for man entry
Backfill mix increments kPa	100	



Stope Information

Stope Name

Brucejack Undercut Sills

Select closure method ==> Distance / Strain

and use spinner to adjust

Stope Geometry

Closure Spinners ==> 0.005 0.10%

Include surcharge load (Distance / Strain (%))

Length of Sill (Strike length) m	100										
Backfill lift height m	30.0										
Orebody Dip β degrees	90										
Width of Sill (HW to FW) m	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
Actual depth of cemented sill d m	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
Suggested sill depth values m	2.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50
Surcharge depth m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Suggested surcharge depth (1.6*span) m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Closure (HW to FW) m	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.015
Minimum Span (L) m	5.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00	13.00	14.00	15.00
Sill Self Weight kN/m	210	302	411	537	680	840	1,016	1,209	1,419	1,645	1,889
Surcharge load σ_v kN/m	0	0	0	0	0	0	0	0	0	0	0
Uniform Loading (Sill + Surcharge) kN/m	210	302	411	537	680	840	1,016	1,209	1,419	1,645	1,889
Uniform Loading (Sill + Surcharge) w kPa	42	50	59	67	76	84	92	101	109	118	126

Test for Flexure Failure

Calculation

Closure stress σ_c (Eδ/L) kPa	200	200	200	200	200	200	200	200	200	200	200
Tensile Strength (σ_t) kPa	0	0	0	0	0	0	0	1	18	35	52
Compressive strength kPa	0	0	0	0	0	0	0	12	146	281	415
UCS for Flexure Stability (inc FoS) kPa	0	0	0	0	0	0	0	100	200	400	600

$$\sigma_t = \frac{w}{2}\left(\frac{l}{d}\right)^2 - \sigma_c$$

Test for Crushing Failure

Calculation

Closure stress σ_c (Eδ/L) kPa	200	200	200	200	200	200	200	200	200	200	200
UCS for Crushing Stability (inc FoS) kPa	300	300	300	300	300	300	300	300	300	300	300

$$UCS = \sigma_c$$

Test for Caving Failure

Calculation

Tensile Strength (σ_t) kPa	34	40	47	54	60	67	74	81	87	94	101
Compressive strength kPa	269	322	376	430	484	537	591	645	698	752	806
UCS for Caving Stability (inc FoS) kPa	400	500	500	600	700	700	800	900	900	1,000	1,100

$$\sigma_t = \frac{\gamma l}{2.5}$$

Test for Shear Failure

Calculation

Shear Stress (τ_f) kPa	42	50	59	67	76	84	92	101	109	118	126
UCS for Shear Stability (inc FoS) kPa	100	100	100	100	100	200	200	200	200	200	200

$$\tau_f = \frac{sin^2\beta wl}{2d}$$

Test for Rotational Failure

Calculation

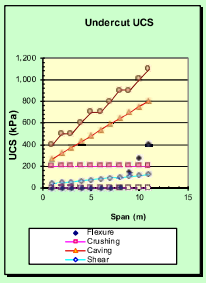
Test for dimensional stability	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable	Stable
Tensile Strength (σ_t) kPa	0	0	0	0	0	0	0	0	0	0	0
Compressive strength kPa	0	0	0	0	0	0	0	0	0	0	0
UCS for Rotational Stability (inc FoS) kPa	0	0	0	0	0	0	0	0	0	0	0

$$\sigma_t = \frac{w(2l(l - dcot\beta)(sin^2\beta))}{d^2}$$

Required Undercut Backfill Strength

Maximum of Flexure, Crushing, Caving, Shear and Rotational Stability Limits

Width of Sill (HW to FW) m	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0
σ_c at flexural stability limit kPa	0	0	0	0	0	0	0	12	146	281	415
σ_c at crushing stability limit kPa	200	200	200	200	200	200	200	200	200	200	200
σ_c at caving stability limit kPa	269	322	376	430	484	537	591	645	698	752	806
σ_c at shear stability limit kPa	42	50	59	67	76	84	92	101	109	118	126
σ_c at rotational stability limit kPa	0	0	0	0	0	0	0	0	0	0	0
Minimum depth of cemented sill m	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5
σ_c at stability limit kPa	269	322	376	430	484	537	591	645	698	752	806
Minimum Backfill UCS (inc FoS=1.25) kPa	**400**	**500**	**500**	**600**	**700**	**700**	**800**	**900**	**900**	**1,000**	**1,100**



Appendix G
Brucejack Stope Filling Rate Calculator

Brucejack Stope filling rates

Daily mining rate	2,900	tpd
Hourly tailings solids	127	tph
Filling rate	125	m3/hr
Wet density	1.83	t/m3

Sub level interval 30 m

Stope Plan Area (m2)

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	800	700	600	500	400	300	200
15	600	525	450	375	300	225	150
10	400	350	300	250	200	150	100

Stope Volume (m3)

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	24,000	21,000	18,000	15,000	12,000	9,000	6,000
15	18,000	15,750	13,500	11,250	9,000	6,750	4,500
10	12,000	10,500	9,000	7,500	6,000	4,500	3,000

Rise Rate per hour (m)

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	0.2	0.2	0.2	0.3	0.3	0.4	0.6
15	0.2	0.2	0.3	0.3	0.4	0.6	0.8
10	0.3	0.4	0.4	0.5	0.6	0.8	1.3

Rise rate per 24 hrs (m)

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	3.8	4.3	5.0	6.0	7.5	10.0	15.0
15	5.0	5.7	6.7	8.0	10.0	13.3	20.0
10	7.5	8.6	10.0	12.0	15.0	20.0	30.0

Hours to fill stope

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	192	168	144	120	96	72	48
15	144	126	108	90	72	54	36
10	96	84	72	60	48	36	24

Days to fill stope

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	8.0	7.0	6.0	5.0	4.0	3.0	2.0
15	6.0	5.3	4.5	3.8	3.0	2.3	1.5
10	4.0	3.5	3.0	2.5	2.0	1.5	1.0

24 hour Max Geostatic Load (kPa)

Stope width (m) \ Stope length (m)	40	35	30	25	20	15	10
20	67	77	90	108	135	180	269
15	90	103	120	144	180	239	359
10	135	154	180	215	269	359	539

Brucejack Stope filling rates

Sub level interval 30 m

Daily mining rate	3,300	tpd
Hourly tailings solids	144	tph
Filling rate	140	m3/hr
Wet density	1.83	t/m3

Stope Plan Area (m2)

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	800	700	600	500	400	2	200
15	600	525	450	375	300	225	150
10	400	350	300	250	200	150	100

Stope Volume (m3)

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	24,000	21,000	18,000	15,000	12,000	9,000	6,000
15	18,000	15,750	13,500	11,250	9,000	6,750	4,500
10	12,000	10,500	9,000	7,500	6,000	4,500	3,000

Rise Rate per hour (m)

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	0.2	0.2	0.2	0.3	0.4	76.5	0.7
15	0.2	0.3	0.3	0.4	0.5	0.6	0.9
10	0.4	0.4	0.5	0.6	0.7	0.9	1.4

Rise rate per 24 hrs (m)

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	4.2	4.8	5.6	6.7	8.4	11.2	16.8
15	5.6	6.4	7.5	9.0	11.2	14.9	22.4
10	8.4	9.6	11.2	13.4	16.8	22.4	30.0

Hours to fill stope

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	171	150	129	107	86	64	43
15	129	113	96	80	64	48	32
10	86	75	64	54	43	32	21

Days to fill stope

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	7.1	6.3	5.4	4.5	3.6	2.7	1.8
15	5.4	4.7	4.0	3.3	2.7	2.0	1.3
10	3.6	3.1	2.7	2.2	1.8	1.3	0.9

24 hour Max Geostatic Load (kPa)

Stope length (m)	40	35	30	25	20	15	10
Stope width (m) 20	75	86	101	121	151	201	302
15	101	115	134	161	201	268	402
10	151	172	201	241	302	402	539

Appendix H1
Golder Barricade Design Construction Notes

GENERAL REQUIREMENTS

1. CODE: ALL DESIGN WORK FOR THIS PROJECT SHALL CONFORM TO THE BRITISH COLUMBIA BUILDING CODE (BCBC), LATEST EDITION AND CONSTRUCTION WORK SHALL CONFORM TO CANADIAN STANDARDS.

2. FURNISH ALL LABOR, MATERIALS AND EQUIPMENT NECESSARY TO COMPLETE THE WORK SHOWN OR INFERRED BY THESE DRAWINGS.

3. THE CONTRACTOR SHALL REVIEW AND COMPARE THE STRUCTURAL DRAWINGS WITH ALL OTHER CONTRACT DOCUMENTS, VERIFYING ALL DIMENSIONS AND ELEVATIONS, AND REPORT ANY INCONSISTENCIES, ERRORS, OR OMISSIONS TO GOLDER'S STRUCTURAL ENGINEER BEFORE PROCEEDING WITH THE WORK.

4. THE CONTRACTOR SHALL TAKE FIELD MEASUREMENTS, VERIFY FIELD CONDITIONS AND SHALL COMPARE SUCH FIELD MEASUREMENTS AND CONDITIONS WITH THE STRUCTURAL DRAWINGS, AND REPORT INCONSISTENCIES TO THE ENGINEER BEFORE PROCEEDING WITH THE WORK.

5. THE DESIGN LOADS SHALL NOT BE EXCEEDED DURING CONSTRUCTION. THE CONTRACTOR SHALL MAKE ADEQUATE PROVISIONS FOR CONSTRUCTION LOADS AND PROVIDE ADEQUATE TEMPORARY BRACING TO KEEP THE STRUCTURE PLUMB AND IN TRUE ALIGNMENT AT ALL PHASES OF CONSTRUCTION.

6. GOLDER ASSOCIATES SHALL NOT BE RESPONSIBLE FOR CONSTRUCTION SAFETY, MEANS, TECHNIQUES AND CONSTRUCTION PROCEDURES, OR ANY TEMPORARY WORKS AS MAY BE REQUIRED BY THE CONTRACTOR TO BUILD AND COMPLETE THE STRUCTURE IN CONFORMITY WITH THE CONTRACT DOCUMENTS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OVERALL PROJECT SAFETY AND SHALL CONFORM TO BRITISH COLUMBIA REGULATION RESPECTING OCCUPATIONAL HEALTH AND SAFETY IN MINES.

ROCK

1. BARRICADE TO BE CONSTRUCTED AGAINST SOLID ROCK WITH A MIN. STRENGTH OF 25 MPa (TO BE VERIFIED AT SITE).

2. DESIGN OF ROCK ANCHORS TO BE REVIEWED AND CONFIRMED BY A GEOTECHNICAL PROFESSIONAL LICENSED IN THE JURISDICTION OF THE WORK AND FAMILIAR WITH THE ROCK STRUCTURE.

SHOTCRETE

1. COMPLY WITH THE PROVISIONS OF THE LATEST EDITION OF THE FOLLOWING EXCEPT WHERE MORE STRINGENT REQUIREMENTS ARE SHOWN OR SPECIFIED:

A. CSA-A23.1-09 / A23.2-09
- CONCRETE MATERIALS AND METHODS OF CONCRETE CONSTRUCTION
- METHODS OF TEST AND STANDARD PRACTICES FOR CONCRETE

B. CSA-A23.3-04.
- DESIGN OF CONCRETE STRUCTURES

2. REINFORCING MATERIALS:
WELDED WIRE FABRICS (WWF) SHALL CONFORM TO CSA G 30.5

3. SHOTCRETE MINIMUM 28-DAY COMPRESSIVE STRENGTH: 20 MPa

4. CEMENT: CAN/CSA-A3001, TYPE GU; GREY COLOUR

5. MAXIMUM AGGREGATE SIZE SHALL BE: 10mm.

6. MINIMUM CONCRETE COVER FOR REINFORCEMENT: 40mm.

FORMWORK

1. FORMWORK AND FALSEWORK SHALL CONFORM TO THE REQUIREMENTS OF CAN/CSA-S269.3-M92 & CSA-S269.1-1975 AND THE NATIONAL BUILDING CODE OF CANADA.

PRODUCTION AND PLACING OF CONCRETE

1. PLACING OF CONCRETE SHALL NOT COMMENCE UNTIL THE FRAMEWORK AND REINFORCEMENT HAS BEEN INSPECTED AND APPROVED BY THE OWNER'S INSPECTOR.

CURING AND PROTECTION

1. CONCRETE SHALL BE CURED AND PROTECTED IN ACCORDANCE WITH CAN/CSA A23.1 & A23.2 AND THE NATIONAL BUILDING CODE OF CANADA.

TESTING AND INSPECTION

1. TESTING AND INSPECTION SHALL CONFORM TO THE REQUIREMENTS OF PROJECT STANDARD SPECIFICATIONS FOR CONCRETE CONSTRUCTION.

SUBMITTALS

1. SUBMIT SHOP DRAWINGS FOR REVIEW. INDICATE REINFORCING BAR SIZE, GRADE, SPACING, LOCATIONS, QUANTITIES, LAP SPLICES, LENGTHS, BENDING AND CUTTING SCHEDULES AND ONE SPARE SUPPORTING AND SPACING DEVICES

2. SUBMIT CERTIFICATION THAT THE MIX PROPORTIONS SELECTED WILL PRODUCE CONCRETE OF QUALITY, YIELD AND STRENGTH AS SPECIFIED AND WILL COMPLY WITH CSA A23.3-04.

3. SUBMIT MANUFACTURER'S TEST DATA & CERTIFICATION BY QUALIFIED INDEPENDENT INSPECTION & TESTING LABORATORY THAT ALL MATERIALS USED IN THE PRODUCTION OF CONCRETE MEET CSA A23.3-04

ISSUED FOR
CONSTRUCTION

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2017-04-18	ISSUED FOR CONSTRUCTION	AM	CB	MA	MA

SEAL

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
34115
April 18, 2017

CLIENT
AMC MINING CONSULTANT (CANADA) LTD.
SUITE 202, 200 GRANVILLE STREET,
VANCOUVER, B.C. V6C 1S4

CONSULTANT
Golder Associates

GOLDER ASSOCIATES LTD.
6925 CENTURY AVE.
MISSISSAUGA, ON
CANADA L5N 7K2
905-567-4444
www.golder.com

PROJECT
PASTE BACKFILL BARRICADE DESIGN
BRUCEJACK MINE, B.C.

TITLE
GENERAL NOTES

PROJECT NO.	DISCIPLINE	REV.		DWG. NO.
1776046	STRUCTURAL	0	1 of 1	S-01

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm

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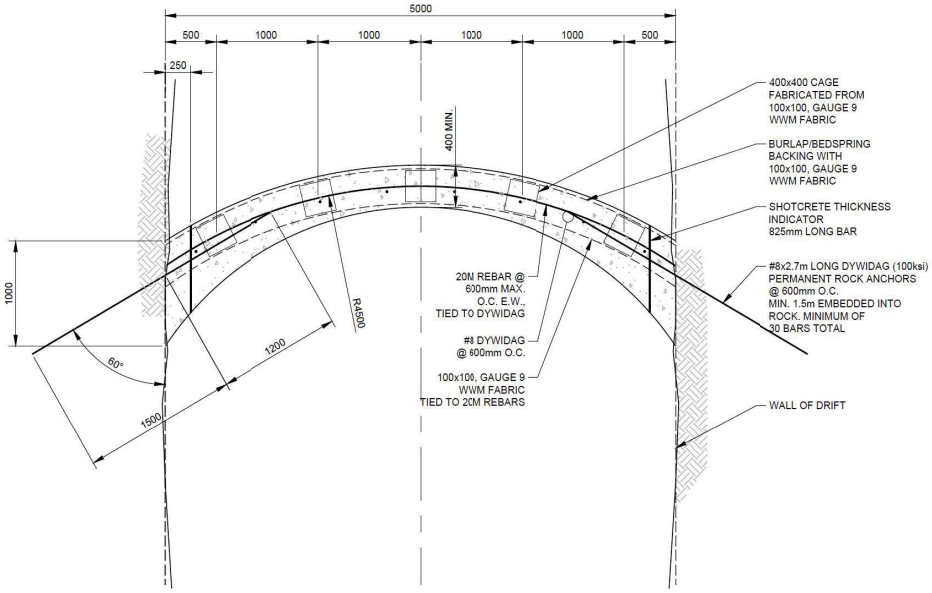
Appendix H2
Golder Barricade Design 5 m x 5 m



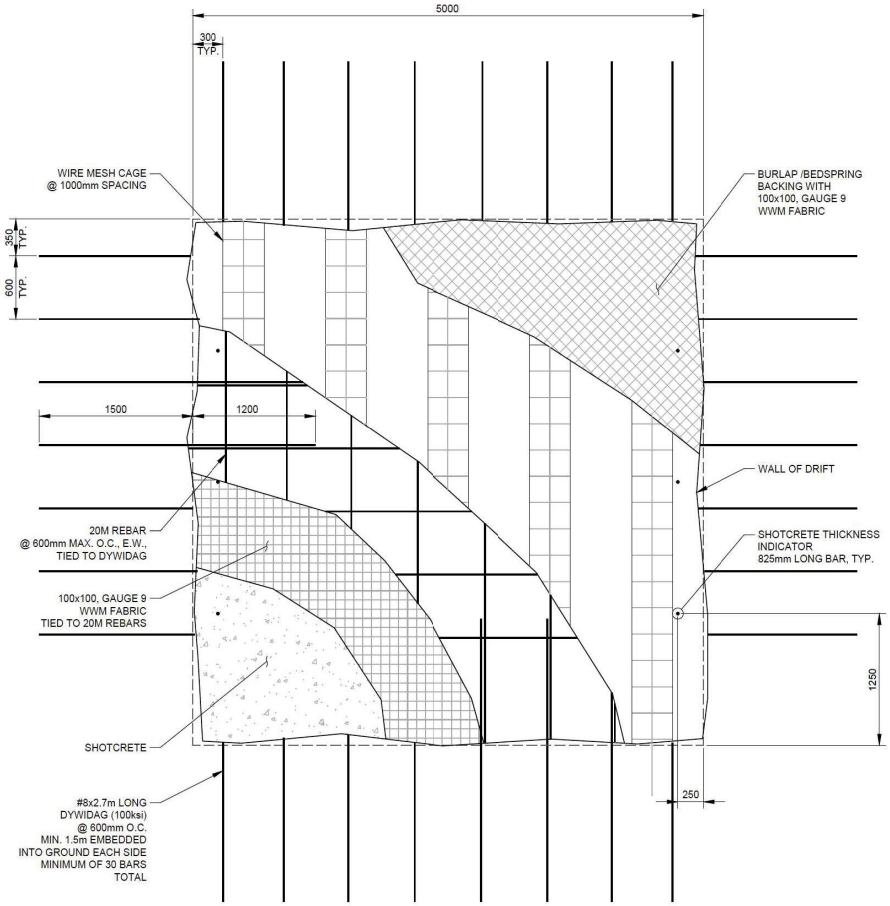
PLAN
SCALE 1:25

MATERIAL LIST FOR DRIFT WIDTH/HEIGHT 5m, RADIUS 4.5m		
ITEM	DESCRIPTION	QTY.
1	#8 x 2.7m LONG DYWIDAG PERMANENT ROCK ANCHORS (100ksi)	30
2	SHOTCRETE THICKNESS INDICATOR 825mm BAR	6
3	400x400 WIRE MESH CHANNEL FRAME	5
4	100x100, GAUGE 9 WIRE MESH- APPROX. 28m^2	1
5	SHOTCRETE DEPENDING ON DRIFT SIZE - APPROX. 12m^3 MIN. 28-DAY COMPRESSIVE STRENGTH = 20MPa	1
6	20mx5m LONG REBAR	16
7	20mx5m LONG, 4.5m RADUS REBAR	14
8	BURLAP/BEDSPRING BACKING WITH 100x100, GAUGE 9 WIRE MESH- APPROX. 40m^2	1

NOTE: THE ABOVE MATERIAL QUANTITIES DO NCT INCLUDE ANY CONTINGENCY.

DESIGN LOADS

1. BACKFILL MATERIAL UNIT WEIGHT: 18 kN/m^3.
2. HYDROSTATIC PRESSURE: MAX. 200 kPa FOR 11m HEAD HEIGHT FROM DRIFT FLOOR LEVEL



SECTION
SCALE 1:25

ISSUED FOR
CONSTRUCTION

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2017-04-18	ISSUED FOR CONSTRUCTION	AM	CB	MA	MA

SEAL

PROFESSIONAL ENGINEER PROVINCE OF ONTARIO 34115 ENGINEERING LICENSE April 18, 2017

CLIENT
AMC MINING CONSULTANT (CANADA) LTD.
SUITE 202, 200 GRANVILLE STREET,
VANCOUVER, B.C. V6C 1S4

CONSULTANT
Golder Associates
GOLDER ASSOCIATES LTD.
6925 CENTURY AVE.
MISSISSAUGA, ON
CANADA L5N 7K2
905-567-4444
www.golder.com

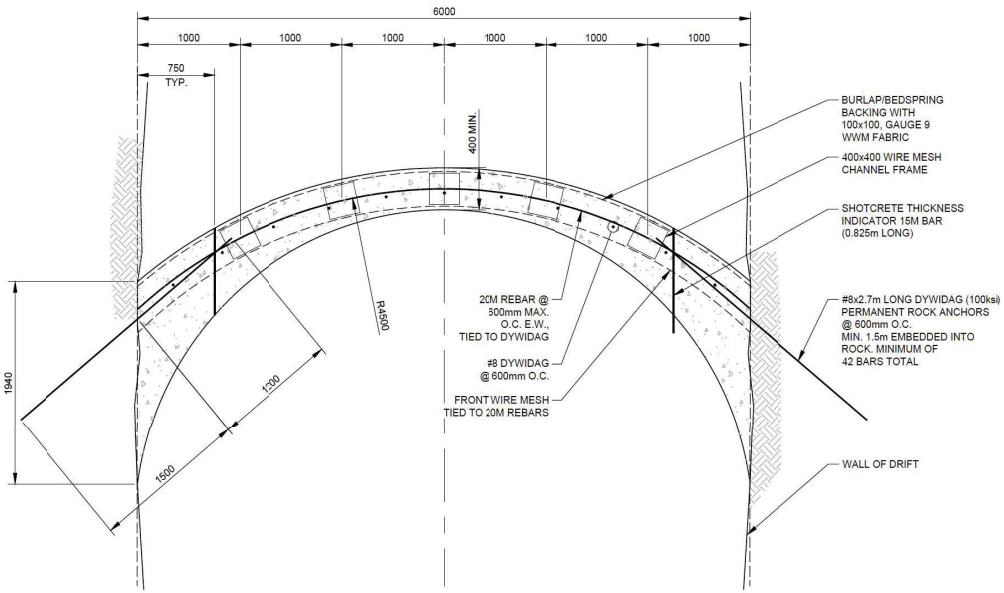
PROJECT
PASTE BACKFILL BARRICADE DESIGN
BRUCEJACK MINE, B.C.

TITLE
5M DRIFT WIDTH/HEIGHT
PLAN, SECTION AND DETAILS

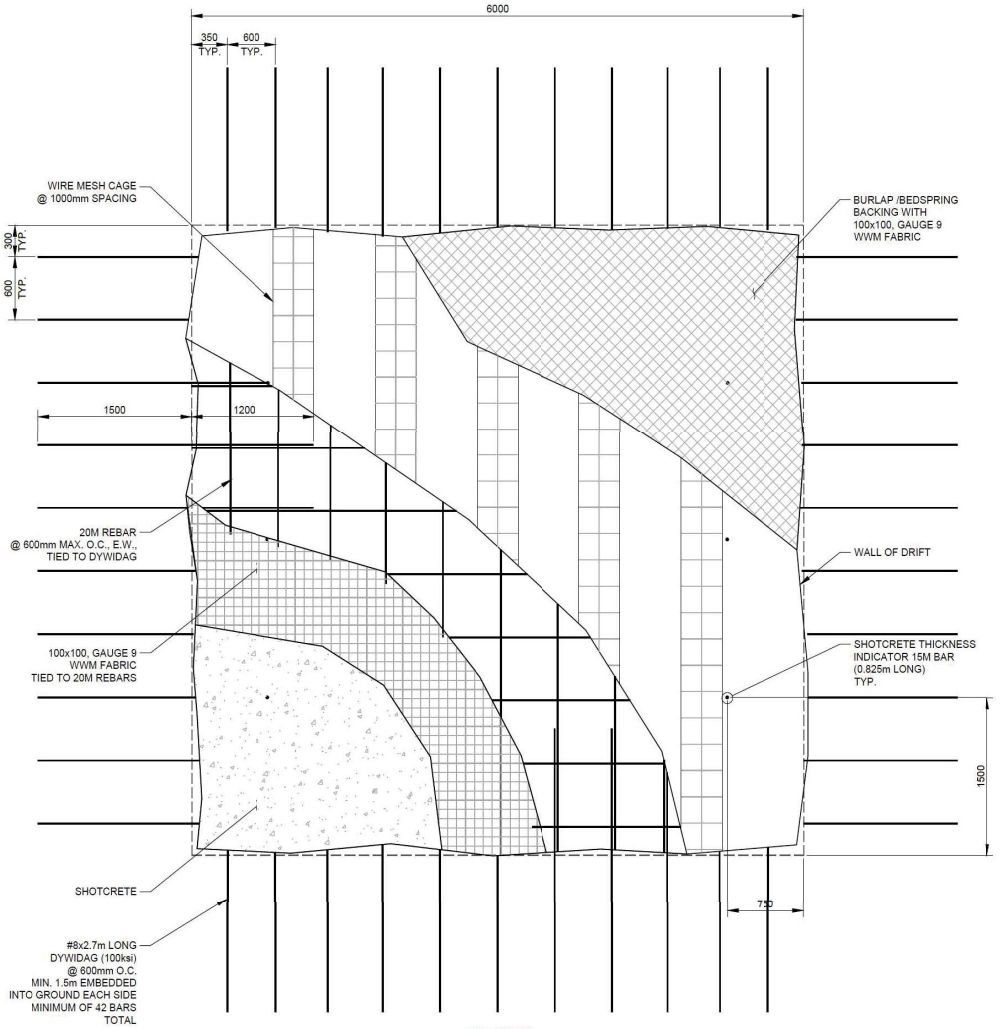
PROJECT NO.	DISCIPLINE	REV.		DWG. NO.
1776046	STRUCTURAL	0	1 of 1	S-03

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm

Appendix H3
Golder Barricade Design 6 m x 6 m



PLAN
SCALE 1:25



SECTION
SCALE 1:25

MATERIAL LIST FOR DRIFT WIDTH/HEIGHT 6m, RADIUS 4.5m		
ITEM	DESCRIPTION	QTY.
1	#8 x 2.7m LONG DYWIDAG PERMANENT ROCK ANCHORS (100ksi)	42
2	SHOTCRETE THICKNESS INDICATOR (825mm) BAR	6
3	400x400 WIRE MESH CHANNEL FRAME	5
4	100x100, GAUGE 9 WIRE MESH - APPROX. 40m^2	1
5	SHOTCRETE DEPENDING ON DRIFT SIZE - APPROX. 17m^3 MIN. 28-DAY COMPRESSIVE STRENGTH = 20MPa	1
6	20mx6m LONG REBAR	21
7	20mx6m LONG, 4.5m RADIUS REBAR	21
8	BURLAP/BEDSPRING BACKING WITH 100x100, GAUGE 9 WIRE MESH - APPROX. 40m^2	1

NOTE: THE ABOVE MATERIAL QUANTITIES DO NOT INCLUDE ANY CONTINGENCY.

DESIGN LOADS

1. BACKFILL MATERIAL UNIT WEIGHT: 18 kN/m^3.
2. HYDROSTATIC PRESSURE: MAX. 200 kPa FOR 11m HEAD HEIGHT FROM DRIFT FLOOR LEVEL

ISSUED FOR
CONSTRUCTION

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2017-04-18	ISSUED FOR CONSTRUCTION	AM	CB	MA	MA

SEAL

PROFESSIONAL ENGINEER
April 18, 2017

CLIENT
AMC MINING CONSULTANT (CANADA) LTD.
SUITE 202, 200 GRANVILLE STREET,
VANCOUVER, B.C. V6C 1S4

CONSULTANT
Golder Associates
GOLDER ASSOCIATES LTD.
6925 CENTURY AVE.
MISSISSAUGA, ON
CANADA L5N 7K2
905-567-4444
www.golder.com

PROJECT
PASTE BACKFILL BARRICADE DESIGN
BRUCEJACK MINE, B.C.

TITLE
6M DRIFT WIDTH/HEIGHT
PLAN, SECTION AND DETAILS

PROJECT NO.	DISCIPLINE	REV.		DWG. NO.
1776046	STRUCTURAL	0	1 of 1	S-02

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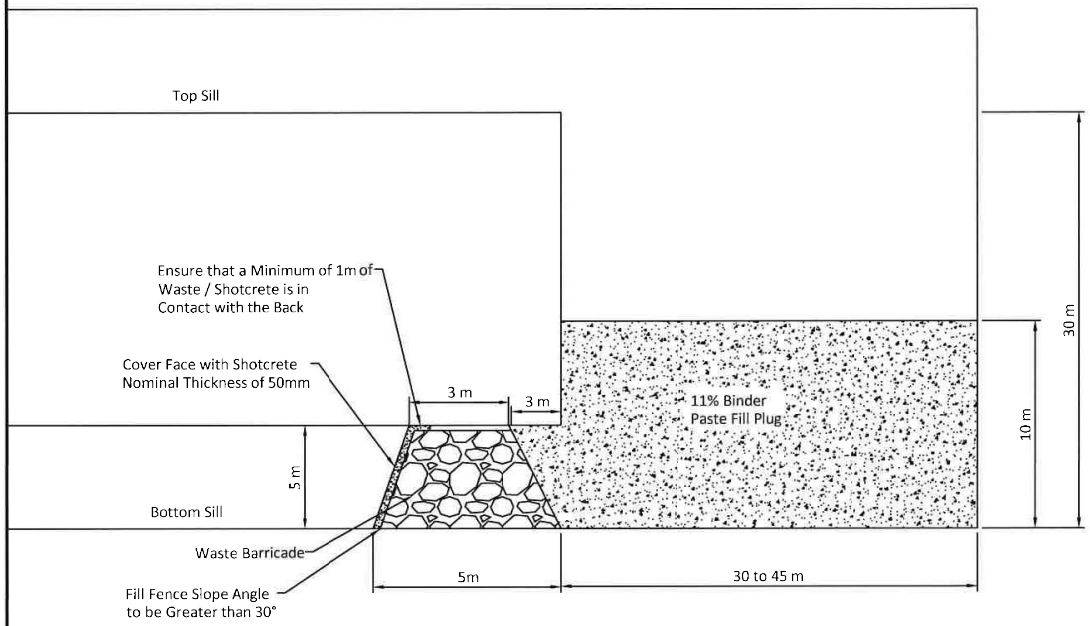
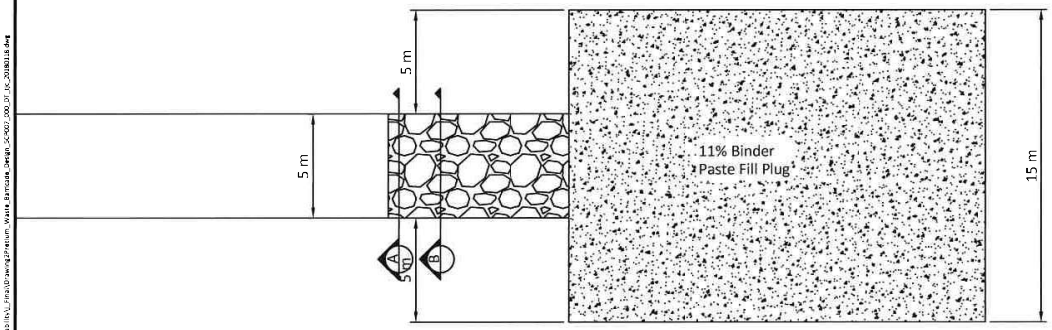
Appendix H4
SRK Consulting – Waste Barricade General Arrangement



Section View



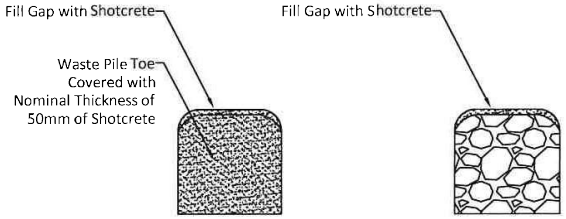
Plan View

General Notes:

- The following are minimum requirements
- Waste barricade design for paste fill maximum lateral pressure of 200 kPa.
- Only one - 10m high plug can be poured against the waste barricade.
- Plug must cure to sutain the pressure genrated by the 20 m high main fill body pour
- 3 m minimum length of waste pile against the back.
- Waste pile to be placed to the back as much as possible. Ensure proper compaction using rammer-jammer.
- for Slicking and flush water follow SOP BRUCEJACK-UND-SAF-004
- Ensure that the top of the barricade is at a minimum distance of 3m to the brow and in undamaged ground from blasting.
- Waste material to have a minimum internal friction factor of 30°
- Waste material to have a minimum unit mass of 1,800 kg/m³
- While pouring plug follow SOP BRUCEJACK-UND-SAF-004.

To Prevent Leaks Prior to Pouring Plug:

- Fill any gaps to the back with shotcrete for a minimum length of 1m.
- Apply a nominal 50mm thick layer of shotcrete over the final face of the waste pile.



Section A

Section B

PROFESSIONAL PROVINCE OF Dr. D. J. L. THIBODEAU # 46340 BRITISH COLUMBIA ENGINEER

February 12, 2018

srk consulting

SRK JOB NO.: SCP007.000

FILE NAME: Drawing2Pretium_Waste_Barricade_Design_SCP007_000_0

Pretium Resources
Waste Barricade Design

Waste Barricade
General Arrangement

DATE:	APPROVED:	SCALE:
Jan 15th, 2018	DT	NTS

Appendix I
Lafarge TerraFlow Binder Brochure

Product Data Sheet

Lafarge TerraFlow™

LAFARGE

An engineered solution for backfilling in underground mines.

LAFARGE

Product Data Sheet

LAFARGE TERRAFLOW™

Product Description

TerraFlow is a specialized blend of cementitious and other construction materials that allows for more efficient and cost effective backfilling in underground mines. It is formulated to work with mine backfill material to meet the unique needs of the underground mining industry and is not suitable for use in concrete or concrete product applications. TerraFlow can be custom blended for a given mine based on local conditions.

Benefits of TerraFlow:

- Allows for more efficient and cost effective backfilling in underground mines
- Optimizes use/reuse of material, including cementitious byproducts
- Pre-blended before arriving on site to promote maximum working efficiency
- Blend proportions may be varied according to specific requirements as determined by preliminary testing
- Saves energy and natural resources
- Cost savings

TerraFlow is produced using stringent quality control procedures. Product claims are based on proper use in accordance with recognized industry standards. Please contact your Lafarge representative for assistance.

Product Name
Lafarge TerraFlow

Manufacturer
Lafarge North America Inc.
12950 Worldgate Drive, Suite 500
Herndon, Virginia 20170

Lafarge Canada Inc.
606 Cathcart Street
Montréal, Québec H3B 1L7

www.lafarge-na.com

Precautions
Direct contact with wet cement should be avoided. If contact occurs, the skin should be washed with water as soon as possible. Exposure can cause serious, potentially irreversible tissue destruction in the form of chemical (caustic) burns. If cement gets into the eyes, immediately rinse thoroughly with water and seek medical attention. For more information, reference the applicable Lafarge Material Safety Data Sheet (MSDS). The MSDS should be consulted prior to use of this product and is available upon request and online at www.lafarge-na.com.

Contact your Lafarge Office for specific product information, availability and ordering.

Lakes and Seaway Business Unit
Bingham Farms, Michigan
Phone: 248-594-1991

River Business Unit
Lee's Summit, Missouri
Phone: 816-251-2100

U.S. East Business Unit
Alpharetta, Georgia
Phone: 678-746-2000

Western Business Unit
Calgary, Alberta
Phone: 403-271-9110

Limited Warranty
Lafarge makes no warranty, whether of merchantability or fitness for a particular purpose, with respect to Lafarge TerraFlow. Having no control over its use, Lafarge will not guarantee finished work in which Lafarge TerraFlow is used.

LAFARGE CEMENT

Printed on recycled paper

Appendix J
Baldwin & Grice 2000 - Engineering the New Olympic Dam Backfill System

Baldwin, G and Grice A G in *Proceedings Massmin 2000*, pp 705-711 (The Australasian Institute of Mining and Metalurgy: Melbourne). Reprinted with permission of The Australasian Institute of Mining and Metallurgy

Engineering the New Olympic Dam Backfill System

By G Baldwin [1] and A G Grice [2]

Abstract

WMC Resources Pty Ltd – Copper Uranium Division operates the large underground Olympic Dam Mine at Roxby Downs, South Australia. These operations mine and process the ore to produce refined copper, uranium oxide, gold and silver. In mid 1996, the company committed to the Olympic Dam Expansion Project (OEP) to expand production from 3.0 million tonnes per annum of ore (85,000 tonnes per annum of copper metal) to over 9.0 million tonnes per annum of ore (over 200,000 tonnes per annum of copper metal). Along with the increase in the ore production capacity of the underground mine and the surface ore handling and processing facilities, expansion of the backfill system was required. The target backfill placement rate was 2.0 million cubic metres of backfill per annum which was to be predominantly delivered as cemented aggregate fill (CAF). This paper discusses the engineering activities undertaken to assess and change the method of designing the required strength of fill exposures. In addition, the operational changes that were introduced to achieve the required fill quantities and the mix designs to meet the specified strengths, including the use of alternate binders, are discussed. This work resulted in a large increase in the fill placement rate and a reduction in the overall unit cost of fill.

Introduction

WMC Resources Pty Ltd – Copper Uranium Division operates the large underground Olympic Dam Mine at Roxby Downs, South Australia. These operations mine and process the ore to produce refined copper, uranium oxide, gold and silver. In mid 1996, the company committed to the Olympic Dam Expansion Project (OEP) to expand production from 3.0 million tonnes per annum of ore (85,000 tonnes per annum of copper metal) to over 9.0 million tonnes per annum of ore (over 200,000 tonnes per annum of copper metal). Along with the increase in the ore production capacity of the underground mine and the surface ore handling and processing facilities, expansion of the backfill system was required. The target backfill placement rate was 2.0 million cubic metres of backfill per annum which was to be predominantly delivered as cemented aggregate fill (CAF).

Historical practice at Olympic Dam had been placing a high strength CAF for around a decade. Fill was prepared in a surface mixing plant using various combinations of dewatered tailings, dune sand, crushed mine waste rock, cement, flyash and water. The fill was batched in standard concrete mixing bowls ($6m^3$ nominal capacity) and transported by open semi-tipper trucks to boreholes drilled vertically to each high-rise open stope. The hole depths varied between 350 and 500 metres depending on the stope crown location. Surface cylinder testing showed typical strengths in excess of 5 MPa and coring through fill in situ showed values over 12MPa. The upgraded CAF Mixing Plant as part of OEP was based on continuous CAF mixing in a pugmill that was process controlled with delivery using the existing semi-trailer tipper trucks.

Olympic Dam Operations undertook a further critical review of the backfill process in early 1998 and a project manager was appointed. The opportunity to review the strength requirements and mix designs for cemented fill was realised after literature searches and a visit to Mount Isa Mines in June 1998. The basis of the revised strategy was to "design the fill mass" for the geometry of each stope and to develop a delivery process utilising the continuously mixed and process controlled CAF mixing plant that satisfied the specified fill mass design, in particular the specified strength for cemented fill. The review of the CAF strength design and mixing processes was expected to yield the most significant cost savings due to the high cost of cement and flyash in CAF. Preliminary investigations of past practices and literature (internally and externally) identified the more cost effective strategy of using zoned strengths of CAF in each stope. In general, stronger CAF would be required at the base of the stope and progressively weaker CAF placed in zones in the upper sections of the stope.

The mine engaged Australian Mining Consultants (AMC) to conduct a technical review and develop a "fill mass design process" with particular emphasis on CAF strength design. A "design study project" was initiated to investigate the zoned strength requirements for the size and geometry of Olympic Dam stopes and to cope with the sequential multiple face exposures. This was carried out using numerical modelling software. At the same time, a spreadsheet based design tool was developed suitable for use by mine design - backfill engineers to permit design of individual fill stopes. The design study showed that the maximum strength required, with appropriate conservatism, was 4.5 MPa. The basis of the CAF strength

1. Manager, Engineering and Site Services, WMC, Olympic Dam Operations, P O Box 150, Roxby Downs SA 5725. E-mail: gary.baldwin@wmc.com
2. Principal Mining Engineer, AMC Consultants Pty Ltd, 19/114 William Street, Melbourne Vic 3000. E-mail: tgrice@amcconsultants.com.au

design spreadsheet was that CAF would be available in 0.5 MPa increments from 0.5 to 5.0 MPa.

In parallel with the design study, investigations were undertaken to evaluate the options for backfill mix designs. The objective was to determine the most economical mix recipes for the series of strengths ranging from 0.5 to 5.0 MPa in 0.5 MPa increments using all of the aggregate ingredients available at the mine site. This investigation required the testing of a wide range of cementitious and pozzolanic binders with the locally available aggregates consisting of underground mullock, quarried limestone, classified tailings (tails sand) and dune sand. A very recent development has been the elimination of dune sand, which has been replaced with limestone fines from the quarry.

Backfill Design

Backfill generally consists of assemblages of natural materials; fine ground mineral particles, sand, crushed rocks and a range of cementitious binder materials. These materials contain voids, which are filled with air and/or water.

There are two important properties to consider for the design of backfill.

- **Flow properties**, which enable the delivery and placement of backfill into the underground workings. This is achieved by adding water to form either thin or viscous slurries. The water is also used to hydrate cementitious binders and excess water, where present, drains off.
- **Strength properties,** which enable the fill to withstand the internal stresses generated by gravitational loading of fill caused either by exposure of free fill faces or from dynamic external sources such as blasting or seismicity.

This paper considers only the strength properties of backfill and will focus on the strength required for vertical, freestanding faces. The effects of dynamic loads on fill are not considered. There is little useful quantitative information in this area and this tends to support the opinion that well controlled stope blasting practices result in minor fill damage. Backfill is a good attenuator of blast energy and it is intended that dynamic loading conditions will be investigated in future work.

Aspects of Backfill Geomechanics

The fundamentals of soil mechanics are extensively described by Terzaghi & Peck (1967) and Lambe and Whitman (1979). The reader is directed to them for further detailed information. The following discussion is adapted for backfill from Lambe and Whitman (1979).

Relative sliding between particles is the most important mechanism of deformation within a fill mass. The resistance of fill to deformation is influenced strongly by the shear resistance at contacts between particles. Determining the magnitude of shear resistance and the factors that influence it are the keys to understanding the behaviour of backfill. A further critical aspect to consider is the interlocking of particles, which is a function of packing density.

Interparticle shear resistance is frictional in nature. In some situations, part of the shear resistance between particles is independent of the normal force pushing the particles together; i.e., even if the normal force is decreased to zero there is still a measurable shear resistance. In such cases, there is true cohesion between particles. In backfill, this property is achieved by the use of binders such as Portland cement and pozzolans.

The strength of soil is usually defined in terms of the stresses developed at the peak of the stress strain curve. The Mohr-Coulomb failure law simplifies the envelope to a straight line and can be expressed by:

$$\tau_f = c + \sigma_f \tan \phi \qquad (1)$$

where

τ_f = shear stress at failure along the failure plane

σ_f = normal stress perpendicular to the failure plane

c = cohesion

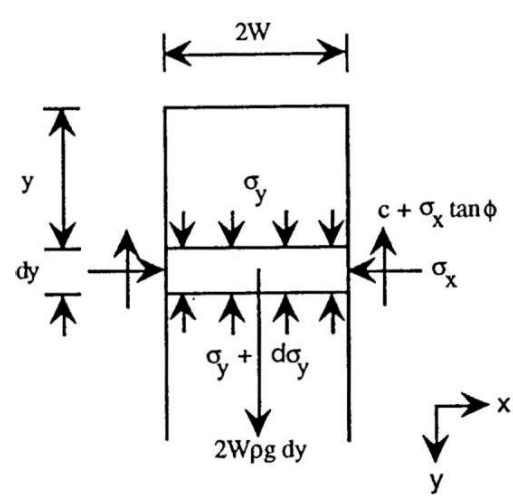
ϕ = friction angle

The strength of backfill can be therefore be described in terms of the cohesion and the friction angle of the material. The friction angle is a property of the backfill particulate make up and the degree of packing density. The cohesion is a function of the binder addition and the development of chemical bonds between particles. A backfill can be considered to be stable when the shear strength exceeds the current state of shear stress at any point in the fill.

Terzaghi (1943) described the mechanism of arching in a two dimensional column of soil. Terzaghi observed that the vertical stress induced by the self-weight of the soil is transferred to adjacent soil or containing walls. This phenomenon of pressure transfer is known as arching.

For a given prism of soil located above a void a stable condition exists when the self-weight of the soil is resisted by the shearing stresses along its lateral boundaries. He stated that the ultimate pressure on the base of the soil is practically independent of the depth of the layer of the soil. If the soil has a trace of cohesion, the soil will not fail into an underlying void.

Figure 1 – *Theoretical assessment pf arching mechanism*



Bloss (1992) describes the two-dimensional force equilibrium equation for a mass of fill in a stope as illustrated in Figure 1.

Solving, Bloss gives

$$\sigma_z = \left\{ \frac{(W\rho g - c)}{K \tan\phi} \right\} \left\{ 1 - e^{\frac{-k \tan\phi z}{W}} \right\} \qquad (2)$$

where

z = vertical coordinate (m)

σ_z = vertical stress (kPa)

σ_x = horizontal stress (kPa)

W = half width of stope (m)

ρ = material density (t/m^3)

g = gravitational constant (m/s^2)

k = ratio of horizontal to vertical stress (σ_x / σ_z)

c = material cohesion (kPa)

ϕ = friction angle (°)

Bloss notes that there are two assumptions:

- uniform stress distribution and
- full mobilisation of the shear strength of the fill (c + σ_x tan ϕ) at the wall contacts.

Askew *et al* (1978) caution that the use of the cohesion term is not referring to the cohesive strength of the backfill but the cohesion developed between the fill and stope wall contact. Where the walls are sub vertical and rough, this cohesion should not be less than the backfill cohesion. Where walls are inclined, however, this contact cohesion may be less than the backfill cohesion.

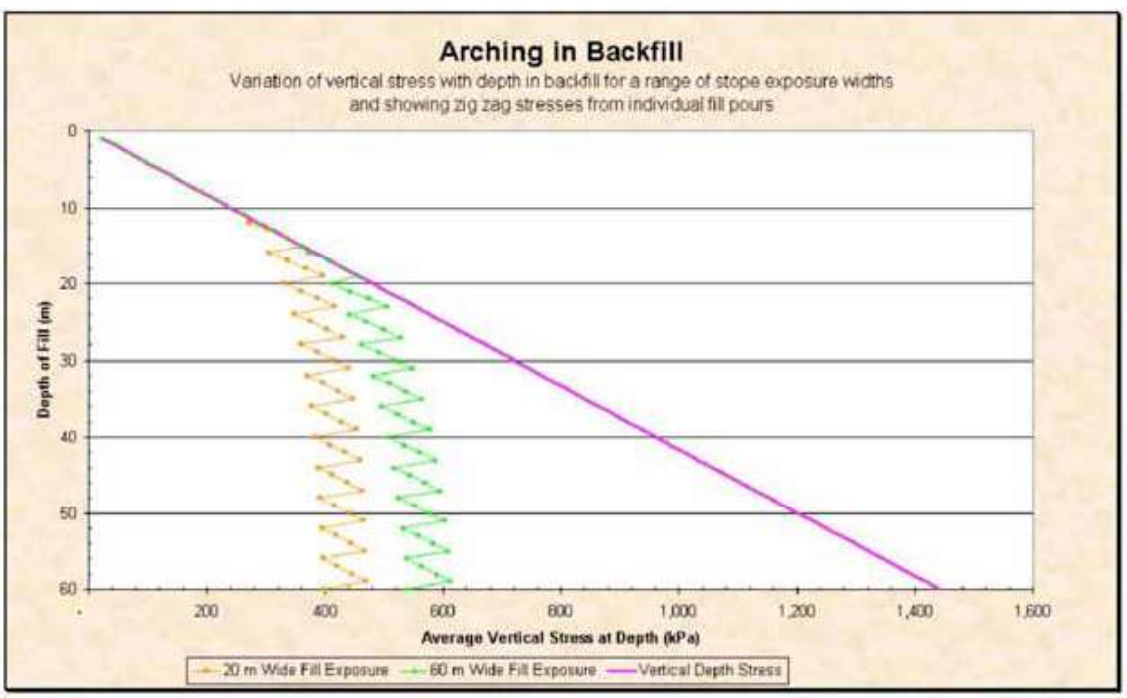
The effect of arching and the comparison with self-weight is plotted in Figure 2. The arched vertical stresses are considerably lower than the corresponding depth stress values.

Cowling (1983) describes the state of the initial stresses developed in backfill as a result of placement in stopes. He notes that when cemented fills are placed, they are in a liquid state and can have high water contents for some time after they have been placed. Hence, each fill pour shows an initial hydrostatic vertical stress profile. The fill commences curing and the stiffness increases linearly with time. This locks in the stress profile for the lift and the pattern is repeated with each discrete fill run. The modulus continues to increase with time. This generates a characteristic zigzag of shear and horizontal stresses down the centre line of the fill during modelling. This feature is noted by Barrett *et al* (1978) and Bloss (1992) and is illustrated schematically in Figure 2. The features shown are a function of the modelling process and would be different for discrete fill runs.

There are very few in-situ stress measurements to back these assumptions of backfill behaviour. Coulthard and Dight (1979) measured hydrostatic loading during fill placement but Cowling (1983) reported that depth stresses (in cured fill) have not been recorded in-situ and that arching effects substantially reduce the vertical stress values. Although the description of the zigzag loadings is generally accepted, Cowling comments that there is little direct evidence to support the notion.

In summary, the effect of arching significantly reduces the stress levels within fill. Since the stress at any point in the fill can be determined, it is therefore possible to zone the fill strength such that the cement content is varied through the height of the stope in order to match the required performance at that elevation. This then permits the design and placement of a cost optimised backfill.

Figure 2 – ***Comparison of vertical stress in arched and unarched modes***



Backfill Design Techniques

Various authors have published backfill design techniques and these are briefly reviewed in the following section. The techniques discussed are:

- freestanding vertical faces,
- vertical slopes,
- limit equilibrium wedge,
- arching.

Free standing Vertical Face

Mitchell *et al* (1982) note that the largest shear stresses in backfill are caused by self-weight. The cemented backfill can be designed as a freestanding vertical face. A freestanding wall where the unconfined compressive strength required at any depth in the fill is given as

$$\sigma_z \geq \rho g\, z \qquad (3)$$

where

σ_z =unconfined compressive strength (kPa)

ρg =bulk density of backfill (KN/m^3)

z =depth of backfill from the surface (m)

Vertical Slope

Mitchell *et al* (1982) discuss the vertical slope method where $\phi = 0$ for a constant strength fill

$$\sigma_z = \rho g\, H / 2 \qquad (4)$$

where:

H = overall height of exposed fill (m)

Limit Equilibrium Wedge– Mitchell

Mitchell *et al* (1982) used physical centrifuge modelling to develop a model for a single exposure, three-dimensional fill mass.

$$\sigma_z = \frac{\gamma H}{\left(1 + \frac{H}{L}\right)} \qquad (5)$$

where:

σ_z = design UCS

H = height of fill exposure and

L = width of fill exposure.

There are four assumptions with this model:

1. The mobilised wall shear stress is equal to the material cohesion.
2. The material friction angle is zero.
3. The fill height is much greater than fill depth.
4. Stresses are evenly distributed.

This formula is commonly applied to backfill design strength estimation. Stone (1993) presents a methodology for the design of backfill using the limit equilibrium approach in the form of standardised charts.

A limitation of this technique is that it only applies to single exposures of a fill mass. Even in small and narrow primary-pillar orebodies, most backfill masses are exposed on two opposing faces. The design technique must assume that two wedges are laid back to back and do not interfere with each other. The technique cannot cope with the exposure of adjacent faces, a common occurrence in large mines such as Olympic Dam.

Arching – Terzaghi

Askew (1982) and Bloss (1998, personal communication) independently adapted the Terzaghi equation for regular three dimensional square plan area stopes. Their solutions are shown below as equation 6.

$$\sigma_z = \frac{\frac{W}{N}\left(\rho_g - \frac{c}{W}\right)\left(1 - e^{-\frac{(N.k.z.\tan\phi)}{W}}\right)}{k.\tan\phi} \qquad (6)$$

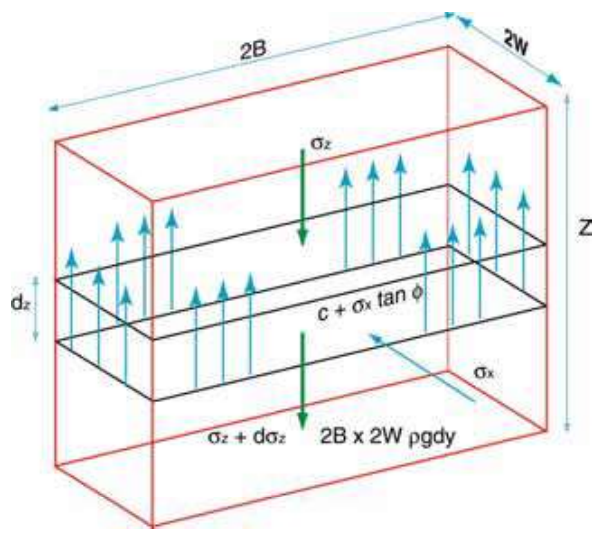
where

N = Number of exposed equal sized fill faces

W = Width of exposures (m)

AMC has further modified the equation to cope with irregular prismatic stopes as commonly encountered at Olympic Dam. The modification is illustrated in Figure 3.

Figure 3 – *Modification of Terzaghi analysis to incorporate prismatic stope shapes.*



For Olympic Dam, prismatic stope shapes are the normal design occurrence. It can also be seen that there will be a difference in stress estimation depending on the sequence of large and small face exposures made.

AMC therefore applied a further modification that changed the number and size of exposures to that of contact surface area. During initial fill placement and curing, the fill is confined by all the surrounding rock walls. As each face is successively exposed, the contact area is reduced progressively from 100% contact until all faces are open. This would imply that a stope which has been exposed on all four walls should be considered a free standing prism and therefore subject to depth stresses.

Bloss (1998) investigated this issue using numerical modelling techniques. He concluded that, for a regular set of stopes:

- The arching mechanism is still dominant in stabilising the fill even when adjacent extraction is complete.
- The effect of Poisson's ratio in developing confinement is significant in stabilising the fill.
- If the fill remains primarily elastic, the final stresses after complete extraction are similar even though the path to the final result may vary as a result of differing extraction sequences.
- For the stope geometries considered, plastic strain levels are close to or at the limit for stability proposed by Bloss (1992). This suggests that, even though vertical stresses are below that for failure, the arching mechanism is on the verge of breaking down due to excessive shear stress adjacent to the wall contacts. This can lead to complete failure of the fill.

AMC has therefore incorporated two factors into the calculation of average vertical stress.

- The loss of contact area due to successive fill exposures is modified in line with the results reported by Bloss (1998). The loss of arching is reduced to allow for the benefit from fill to fill arching.
- The resultant average vertical stress calculated at a particular elevation is multiplied by a factor of safety but limited by the maximum depth stress calculation at that elevation. The selection of the factor of safety is a function of the degree of conservatism that is required and a scaling component that converts small-scale test strengths to real world scale exposure performance. AMC currently recommends a factor of safety of 2.0 for the Olympic Dam situation. In the absence of failure data for ODC stopes this is considered to be conservative and it is expected that this can be relaxed with improved experience.

Design Tools Summary

Of the existing techniques, the only method suitable for development and application at Olympic Dam is Terzaghi's arching. This method can cope with the shape and multiple exposure issues and lends itself to a spreadsheet based design tool.

However, before the method was advanced further, numerical modelling was undertaken to investigate the distribution of stresses in Olympic Dam backfill. The results of the previous modelling and the current work were then compared with the Terzaghi results to ensure that the AMC Terzaghi Spreadsheet would provide a simple proxy solution to the complex real world problem.

Numerical Modelling

Numerical modelling was carried out using MAP3D boundary element software and validated and calibrated to earlier work conducted by Olympic Dam Operations.

Backfill material properties were not available from Olympic Dam backfill material at the start of the project. The material properties used in the preliminary analyses were therefore based on published data from Mount Isa by Cowling *et al* (1983), from Broken Hill by Askew *et al* (1978) and from Canada by Cundall *et al* (1978). These parameters are listed in Table 1.

Table 1 – *Backfill material properties*

Material Property	Symbol	Value	Unit
Friction angle	ϕ	34	degrees
Cohesion	c	250	kPa
Modulus	E	500	MPa

The initial modelling was conducted to repeat earlier work and this was used to validate and calibrate the model. Purple 54 was then selected as an example of a tall, slender Olympic Dam stope. The exposures modelled were cumulative in nature. No fill was placed back into the adjacent void and the benefit of fill to fill arching was not included. Therefore these results contain a degree of conservatism. The results of the modelling are shown in Figures 4a to 4d and are graphed in Figure 5.

Figure 4a shows the geometry of Purple 54 stope, 140m high by 15m long by 85m wide. The stope has been modelled in 7 segments, each 20m high. The stope is to be exposed on the two widest opposing faces.

Figure 4b shows vertical stress distribution prior to exposure of any fill faces. Note that significant arching is occurring which keeps stresses levels at around 300 kPa with a concentration at the toe of around 600 kPa. This is well below depth stress of around 3,350 kPa. The zigzag vertical stress profile has been locked into each of the 20m segment boundaries representing discrete fill pours.

In Figure 4c the first wide face has been exposed. There has been a small increase in stress at the toe of the exposure and a small decrease in the upper part. At this point, around 57% of the fill perimeter is in contact with rock and arching is significant.

In Figure 4d the second face has been exposed and only 15% of the fill perimeter is in contact with rock. Vertical stress has increased to 1,200 kPa but is still well below depth stress levels.

Comparison of Terzaghi Method with Numerical Modelling

The numerical modelling using MAP3D confirmed magnitudes of stress level development in the backfill as successive exposures were made. Figure 5 plots the vertical stress distribution in Purple 54 against the Terzaghi method and correlation in the distribution and magnitude of stresses can be seen. For the one and two exposure cases the maximum average vertical stress at the foot of the fill mass calculated by Terzaghi method and MAP3D are similar. At all other points Terzaghi estimates a higher value. It can be seen that in the case of the second exposure, arching is starting to break down and the maximum values are around one third of depth stress values.

Figure 4A, B, C and D – ***Results of numerical modelling of Purple 54 stope.***

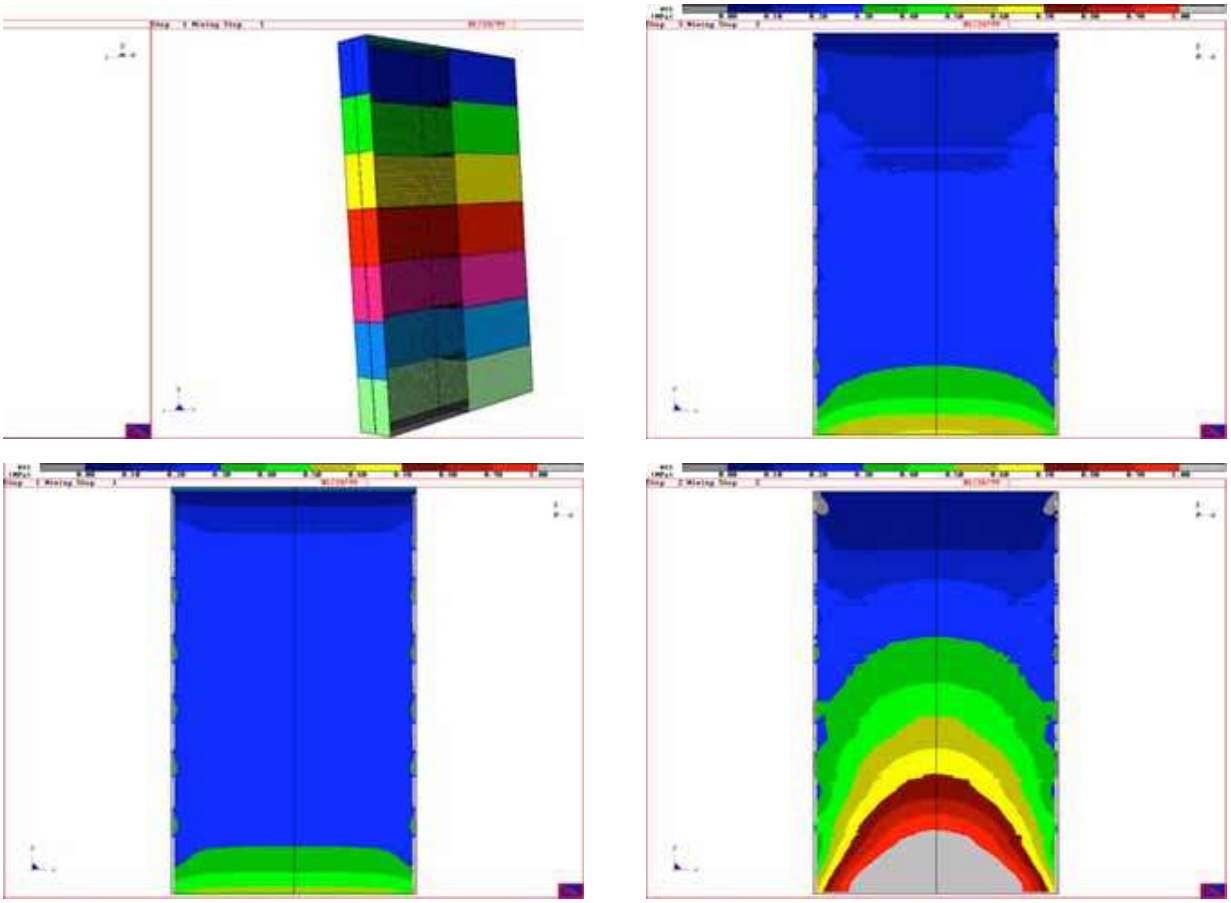
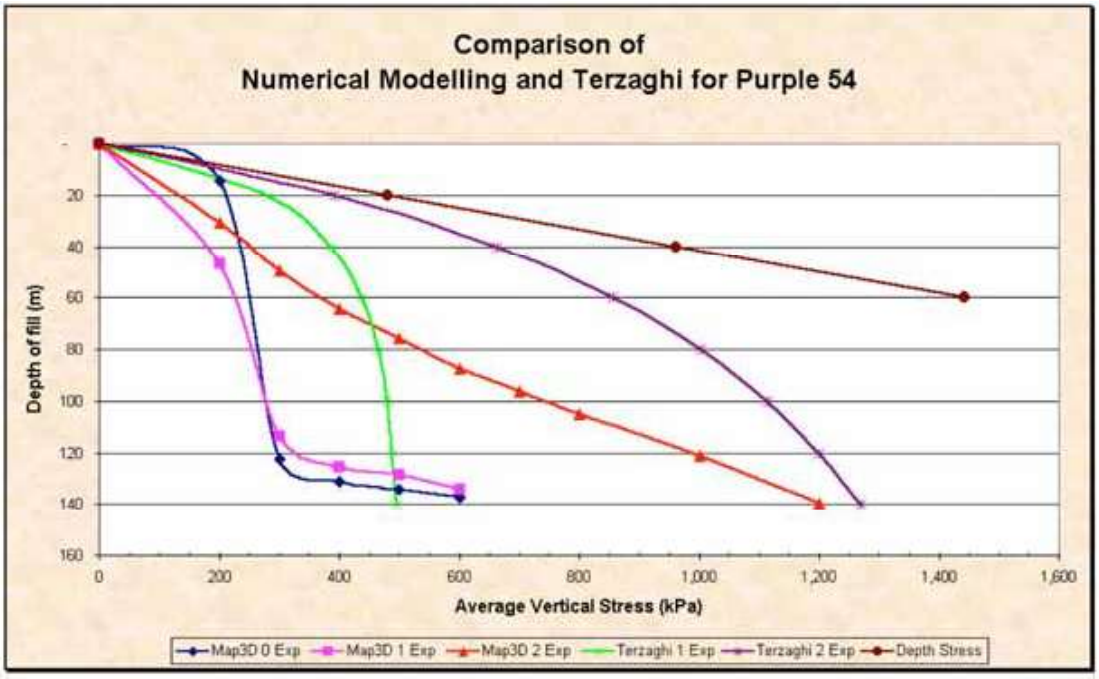


Figure 5 – ***Comparison of Terzaghi method with numerical modelling***



AMC concluded that the Terzaghi method provides a valid approximation to the distribution and magnitude of average vertical stresses in backfill. Since the values derived are conservative, it can therefore be used as the basis of a simplified design tool.

Development of the Backfill Design Strength Tool

The primary objective of this part of the project was to develop an effective method to determine the required strength of backfill for use in open stope mining at Olympic Dam. Most of the backfill design techniques described earlier do not allow for the complex geometry and sequencing of exposures of fill masses as experienced at Olympic Dam. Neither is it practical to run numerical modelling for every fill exposure option. The results of the study show that the Terzaghi method can meet all of the design requirements.

It was therefore decided to develop a spreadsheet based version of the 3D Terzaghi equation. The software was designed to run as a simple Excel worksheet without macros. The following sections document the underlying geomechanics assumptions and the software design criteria.

AMC Terzaghi Spreadsheet

The AMC Terzaghi Spreadsheet is designed to print out on a single landscape sheet of A4 paper and contains no macros. There are a number of calculation areas outside of the main print area. The sheet is split into several functional areas and each of these will be discussed in turn. In general, text in blue on an indented pale green background represents data entry. Text in black on an indented pale yellow background represents calculation results. Other numbers are intermediate, advisory calculations. Units are indicated where appropriate. Figure 6 illustrates the general assumptions.

The key geotechnical data entries are friction angle and Poisson's ratio. The fill density is the wet bulk density of the fully drained backfill. Depth zone increments permit the user to control the thickness of fill zones in the backfill strength model. The choice of this number is one of convenience and the practicality of control of fill placement into stopes. AMC would tend to recommend 10 metres as a lower limit and 25 metres as the upper limit.

CAF is prepared to a number of discrete recipes of generally increasing binder content with an increase in strength. Depending on the controls available it is possible to mix batches with incremental strengths of between 250 and 500 kPa UCS. For Olympic Dam the batch increment selected is 500 kPa, ranging up to 4,500 kPa maximum.

The final entry is the Factor of Safety, a term which loosely describes the degree of conservatism in the design process. AMC favours a probabilistic approach to failure assessment where the design process, the lab scale test data and their statistical variance and back analysis to a large data set of full sized fill exposures which exhibit various degrees of performance and failure are considered. Olympic Dam has no history of major fill failures. This, combined with evidence of very high test sample strengths, renders this approach unsuitable at this time. It was considered that a Factor of Safety of 2 should be applied until real performance data emerged. At some time in the future the Factor of Safety could then be adjusted or the process modified. Figure 7 shows the entry of stope information.

The geometry of the stope is entered in the stope information section. The geometry is designed to cope with regular prismatic vertical stopes. Length is defined as the stope plan distance along strike of the orebody and width is the plan distance in the perpendicular horizontal direction. Height is generally the full vertical stope height. Frequently however, the exposure of the fill mass is not over the full height of the stope. In this case, the height of the exposure can be entered. In the examples that follow a square plan stope, 40m wide by 160m high has been selected with four successive exposures. Figure 8 shows the exposure geometry.

Figure 6 – ***General assumptions***

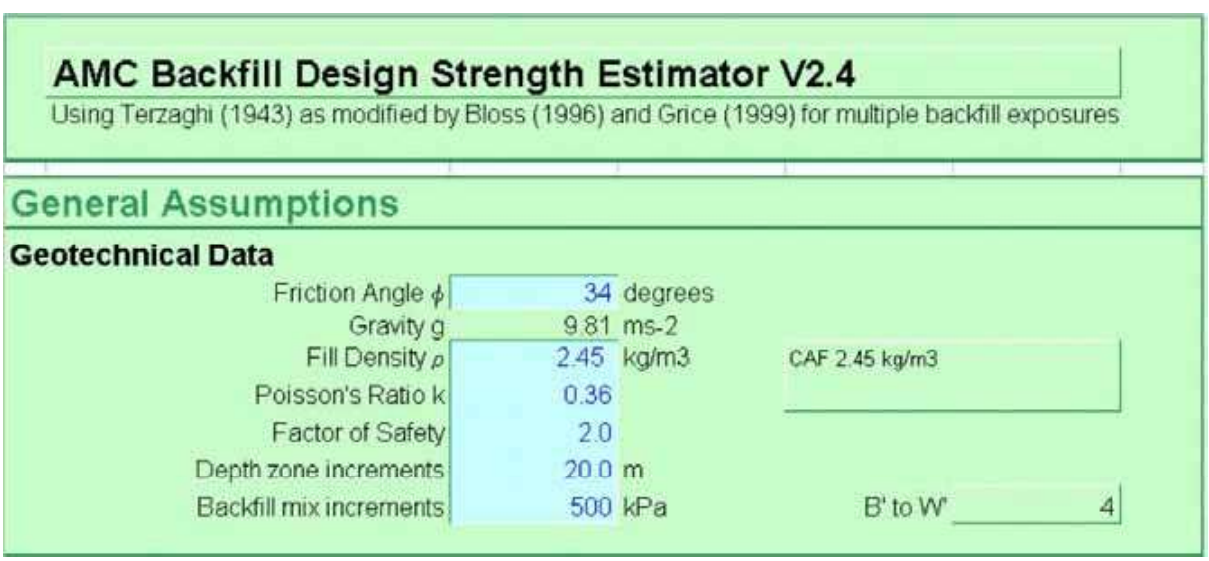


Figure 7 – ***Stope information***

Stope Information

Stope Name

MassMin 2000 Stope

Stope Geometry

Length	40.0 m		Length is along strike
Width	40.0 m		Width is across strike
Height	160.0 m		
		Perimeter	160.0 m

Figure 8 – ***Exposure geometry***

Backfill Strength Calculator

Exposure Geometry

Exposure Number	1	2	3	4
Width	40.0	40.0	40.0	40.0

Figure 9 – ***Calculation of average vertical stress***

Calculation of average vertical stress in backfill and UCS for each increment (kPa)

UCS values denote backfill mix strength at the base of each incremental zone

Depth	1st Exp	2nd Exp	3rd Exp	4th Exp	Max Average Vert Stress	Cohesion	Depth Stress	Min Strength x FoS	UCS
0	0	0	0	0	0	0	0	0	
20	298	333	379	426	426	113	481	481	500
40	427	506	625	765	765	204	961	961	1,000
60	496	608	795	1,041	1,041	277	1,442	1,442	1,500
80	536	674	918	1,268	1,268	337	1,923	1,923	2,000
100	561	719	1,010	1,459	1,459	388	2,403	2,403	2,500
120	577	750	1,080	1,620	1,620	431	2,884	2,884	3,000
140	587	772	1,136	1,758	1,758	467	3,365	3,365	3,500
160	594	788	1,179	1,877	1,877	499	3,846	3,754	4,000

Details of sequential fill exposures are entered in the exposure geometry section. For each of up to four exposure faces, the width is entered in sequence of exposure. This value is then adjusted to permit fill to fill arching modification in the following calculations and a value for the length to width factor (B`) is computed. The perimeter removed is then calculated as a percentage and factored back into the number of intact walls. Figure 9 shows the results of the calculations.

The average vertical stress is computed for each depth increment for successive exposures. The maximum average vertical stress at each depth increment is recorded along with a corresponding value for depth stress for comparative purposes. Figure 10 shows the computed average vertical stresses for each exposure plotted as a graph. Note that the fourth exposure is still exhibiting a curved shape that shows the continuance of fill to fill arching.

The strength required at that depth increment is then calculated as the lesser of the average vertical stress multiplied by the Factor of Safety and the depth stress. In order to determine the strength of the fill to be placed in that depth sector, this value is rounded up to the next fill strength increment.

Figures 11a to Figure 11d show the fill strength zones required for one, two three and four exposures stopes. Taking the height of each of the computed zones it is then possible to develop a schedule of fill placement and a cumulative volume of fill required to be placed in each zone.

Figure 10 – ***Graph of average vertical stress***

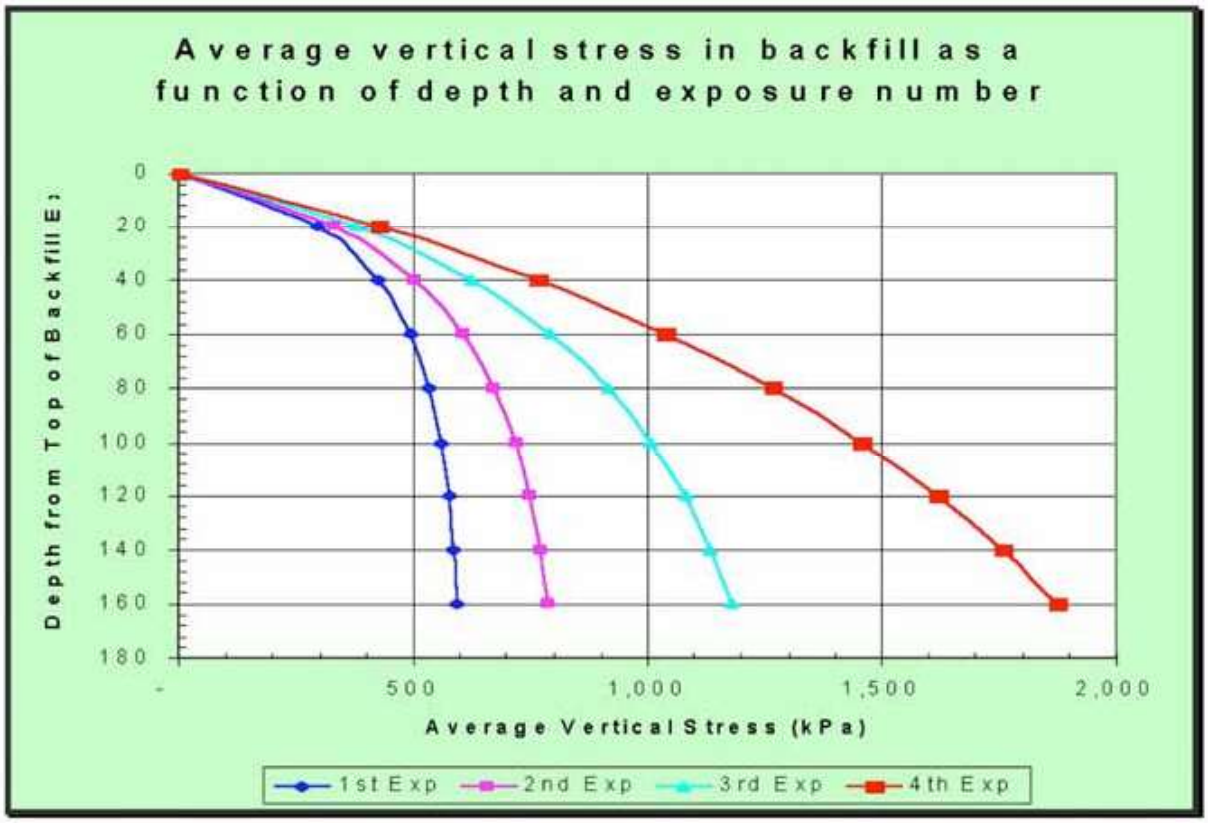
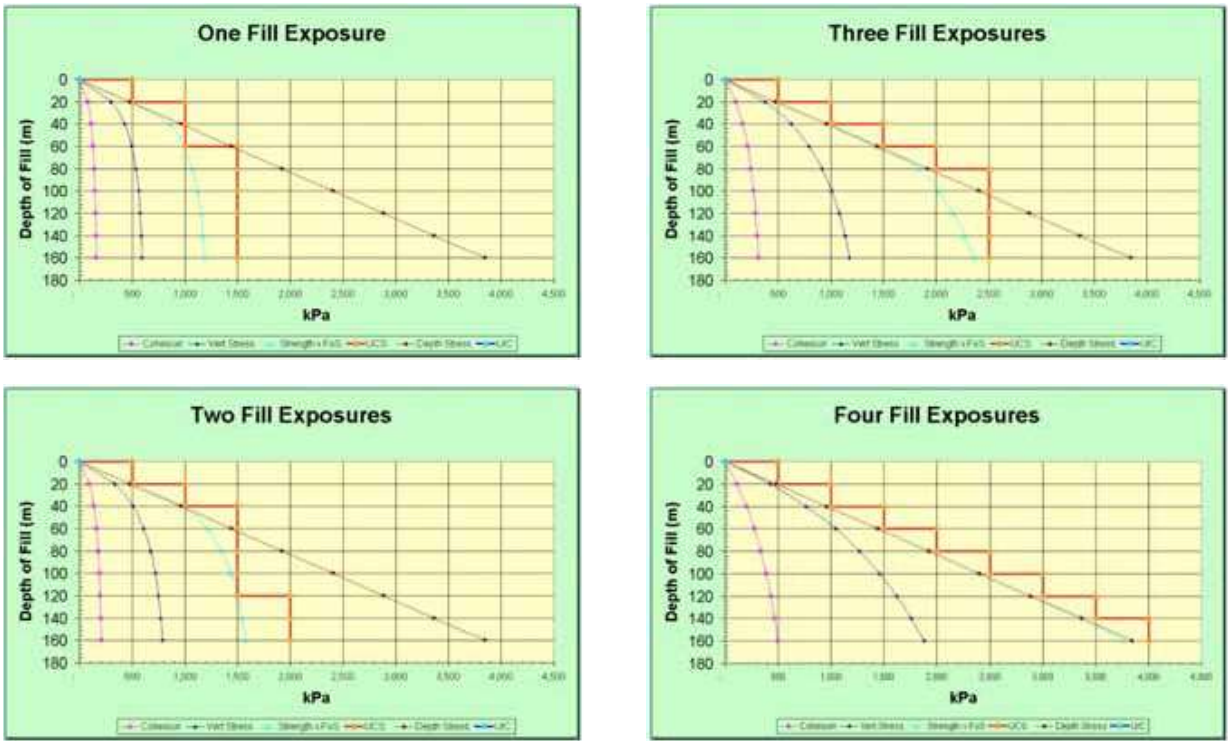


Figure 11A, B, C and D – ***Graphs of average vertical stress for one, two, three and four exposures***



Backfilling strategy and Mix Design development: Phase 1

Overview of the Olympic Dam Mining Method and Backfilling Requirements.

The expansion strategy for Olympic Dam has evolved from the proposals considered by a scoping study team in 1993 to the detail designs that have been constructed and commissioned by OEP in 1998 and subsequently put into operation by ODO.

Early in this review process, determination was reached that retained the long hole open stoping mining method. As a consequence, mining of ore continued with this historical practice, which similarly enshrined CAF as the predominant fill material. With this mining method, stopes are generally production drilled from access drives which are generally 50-60 metres apart vertically and allow both uphole and downhole drilling. A typical stope consists of a bottom level extraction drive which allows LHDs to "bog ore" from multiple extraction points and a top level drill drive which also allows the "slot" (internal rise) to be drilled which creates the void to allow the blasting of the ore to occur.

The typical geometry for a stope is an upside down milk carton except the stope is generally rectangular rather than square. Dimensions taper up from approximately 6 metres wide at the base (for extraction purposes) and attain a maximum stope width of say 35 metres, a length up to 40 metres and a height from 60 to 270 metres determined by ore body characteristics and mine design considerations. The "fill void" for a stope ranges in volume from a minimum of 50,000m^3 to the largest designed to date of approximately 250,000m^3 (270m high).
Traditionally stopes have been filled with CAF which were of a constant strength, mixed to attain at least 5.0 MPa and probably achieving in excess of 10 MPa (based on very limited in situ coring of one or two stopes). The predominant fill mass historically was CAF with some fill void being filled with underground development waste or mullock where there was no adjacent stope to be mined (and hence the stope face not being exposed). Wherever CAF is exposed by an adjacent mined stope, it is required to remain fully supported with no face fall off.

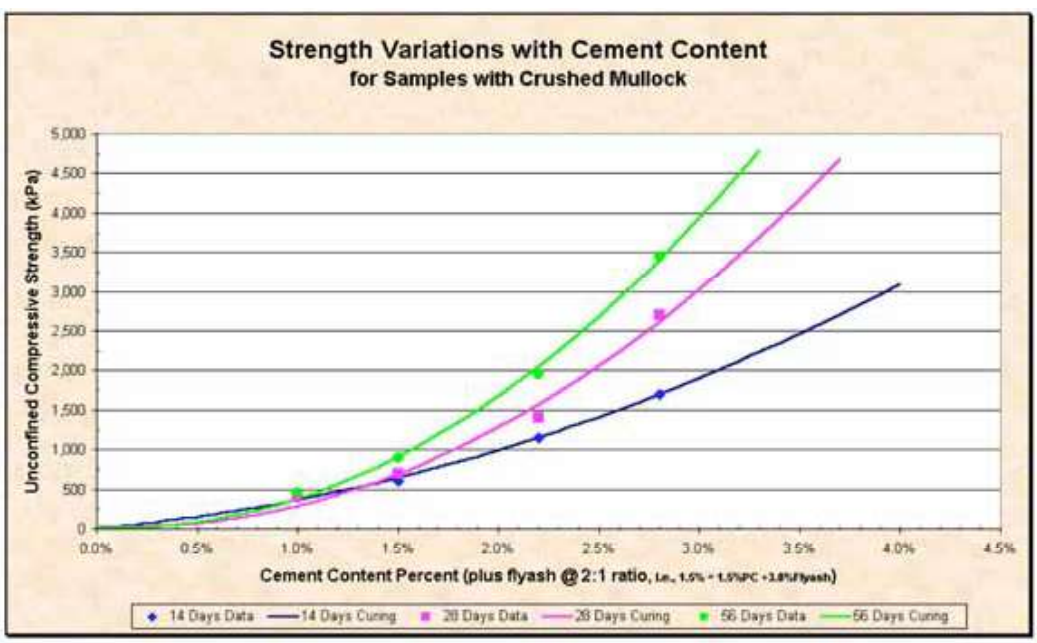
Summary and Observations: Phase 1

During the pre-feasibility and feasibility study stages for the expansion of Olympic Dam, particular emphasis was placed on defining CAF properties, utilising existing aggregates available on site. Particular emphasis was placed upon defining the CAF strength characteristics when utilising "tails sand" to replace dune sand as the regular fine aggregate and a significant amount of the coarse aggregate. A typical graphical representation of test results is given in Figure 12 where UCS (Uniaxial Compressive Strength) on the vertical axis is plotted against % binder (cement and flyash) on the horizontal axis.

In general the following observations can be made from Figure 12 and the Phase 1 investigations.

- Test work was undertaken with 30mm crushed mullock (and limestone where tested) which was not truly representative of the crushed rock used in the actual CAF mixing conducted in the old batch plant and planned for the new mixing plant. The aggregate top size was determined by the test cylinder size rather than investigating the intended process being utilised. The on site fixed crushing plant was operated in an open circuit configuration which resulted in maximum lump approaching 120-150mm. Whilst this top size is too big, it was important to understand the maximum lump size available from closed crushing and a properly graded aggregate - generally, the smaller the rock top size, the greater the crushed rock cost and this is a non-linear cost as rock size reduces.

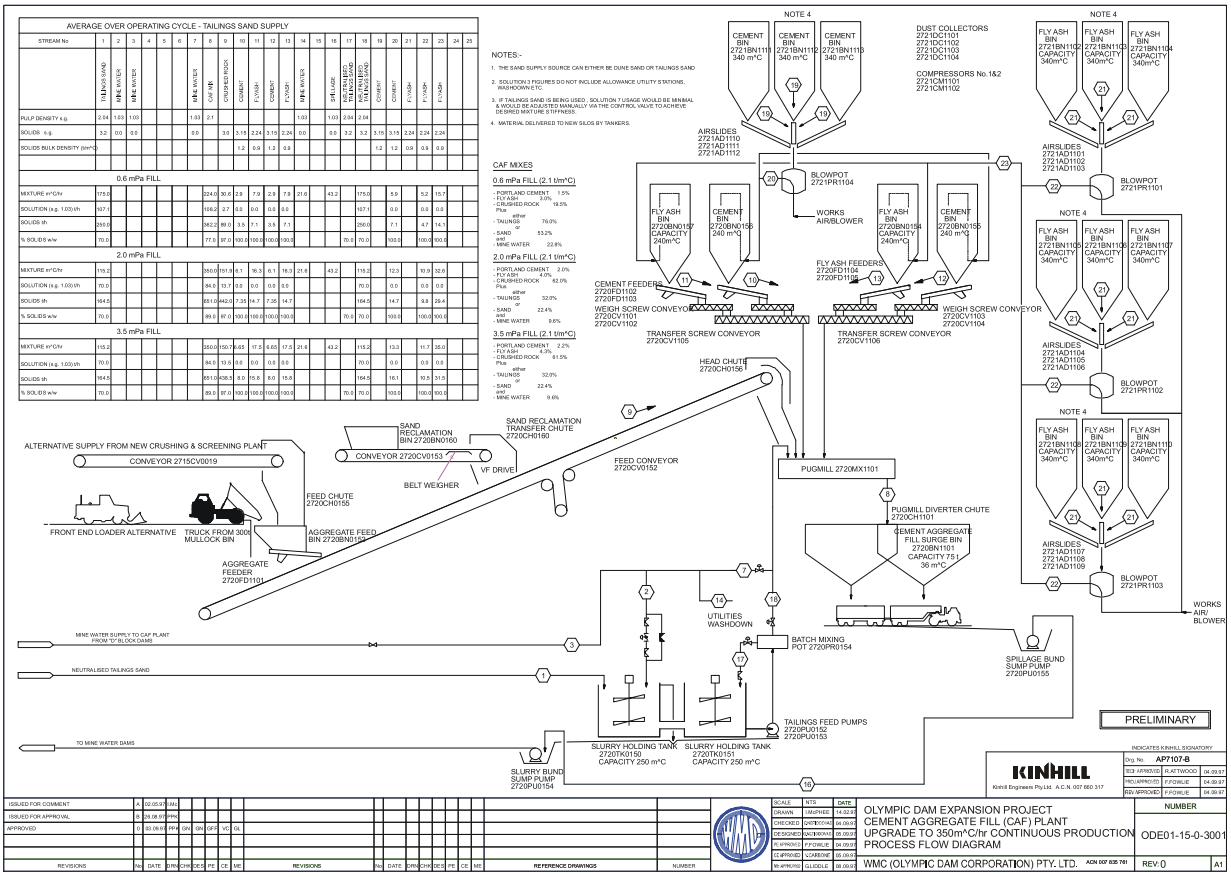
Figure 12 - ***Strength variations with cement content for samples with crushed mullock***



- All test work results were recorded and reported on a percentage dry basis. Simple test work using a small (builder's) concrete mixer revealed that water requirements varied considerably between crushed mullock and limestone as well as the grading of the course aggregates. It was apparent that "mix designs" required specification of all the ingredients inclusive of the water added (both directly and indirectly).
- All test work undertaken was on the basis of cement and flyash being used in the proportions of 1 to 2. No test work results/reports existed to substantiate this nor define an appropriate relationship of strength versus percentage binder (cement and flyash) with variable proportions e.g. 1 to 2, 1 to 3, 1 to 4 etc. The economics of landed cement and flyash cost meant that for a given CAF mix design strength, the quantity of flyash should be maximised to meet the strength requirement because the landed cost was 5 to 6 times cheaper.
- All test work strengths were for 56 days; 3 test cylinders were crushed at 14, 28 and 56 days and the results averaged to yield a single strength value for the elapsed curing time. There were no results/reports, which investigated and defined post "56 days" curing times. A literature search revealed that this was most probable and clearly required defining. The most appropriate way to represent this phenomenon was to graph UCS (MPa) versus curing time (days). This knowledge should have been established and defined.
- All test work was undertaken using traditionally available binders (cement and flyash); cement was supplied from Adelaide and flyash (Zone 1) ex the Port Augusta Power Station (coal fired). It is well documented that ground granulated blast furnace slag when processed correctly will develop pozzolanic properties. A well-established blast furnace exists at Whyalla (BHP) and no serious discussions had been entered into that resulted in an appropriate test program utilising GGBFS and the locally available aggregates at Olympic Dam.

The test work undertaken in 1995 had provided some valuable and useful information regarding mix designs, which had been carried forward to process and plant design. However, there seemed as many unanswered questions as those that were answered.

Figure 13 – ***CAF Plant process flow diagram***



The recommendations that were carried forward are in essence summarised in Figure 13. The main features are:

- CAF was to be mixed at the respective strengths of 2.0, and 3.5 MPa using readily available aggregates from site. Whilst a general strategy for selecting the CAF strength existed (i.e. stronger at stope bottom and weaker towards the top - depending upon number of exposed faces), there was no well-defined systematic design method for determining the minimum specified CAF strength for all stope mining situations.
- CAF mix designs to attain the minimum specified strengths did not differentiate between crushed mullock and crushed limestone. Simple test work with the concrete mixer had revealed that there was at least a 2–3% w/w (weight wet) difference in water requirements between CAF mixes with mullock compared to limestone.

The real concern was the over simplification of the mix designs and thus the subsequent process and actual plant design. These and other important factors revealed from critical review conducted in July 1998 prompted a rapid investigation and test work program. At that point in time the upgraded plant was being constructed, with commissioning planned for early to mid September 1998. The clock was well and truly ticking and the delivery of CAF to fill the underground fill (stope) voids was essential to the highly planned and well-coordinated mining at Olympic Dam. Any serious delay to the reliable delivery of CAF would have impacted significantly on the mining operations during the critical underground production ramp-up phase to meet the new production capability of the process plant. Any delay to a stope going into production due to late backfilling was untenable.

Backfilling Strategy and Mix Design Development: Phase 2

Overview: Phase 2

By early August 1998 the high level strategy was to:

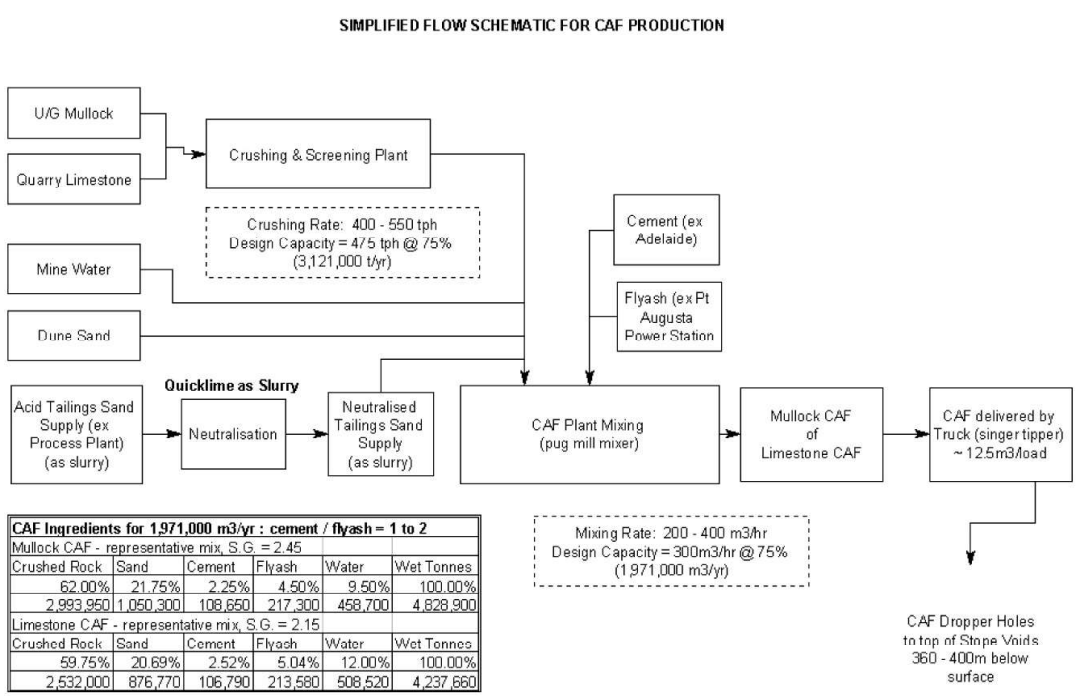
- Establish a clearly defined design process, which allowed the fill mass to be engineered. The outcome of the design process was to determine the minimum specified CAF strength.
- Develop mix designs that allowed CAF to be mixed continuously in a modern process controlled plant and delivered using semi-trailer tipper trucks.

The outcome of the test work was the development of mix designs using mullock as the main coarse aggregate ingredient due to the significant surface stockpiles available from the OEP mine development and normal mining operations. Preliminary work was commenced on mix design test work with limestone, which would be mined from a nearby quarry and required after the surface mullock stockpiles were exhausted. Similarly, test work was undertaken using the small concrete mixer.

- Define a stope filling strategy which attempts to maximize the uncemented fill mass relative to the cemented fill (CAF) mass.

The intent here would be to refine the stope filling design process so that uncemented fill could be maximized. Thus, utilisation of surface rockfill and hydraulic (sand) fill were potentially suitable uncemented fill types that could be delivered quickly and efficiently from the surface, in addition to the underground development waste.

Figure 14 – ***Simplified flow schematic for CAF production***



CAF Ingredients for 1,971,000 m3/yr : cement / flyash = 1 to 2					
Mullock CAF - representative mix, S.G. = 2.45					
Crushed Rock	Sand	Cement	Flyash	Water	Wet Tonnes
62.00%	21.75%	2.25%	4.50%	9.50%	100.00%
2,993,950	1,050,300	108,650	217,300	458,700	4,828,900
Limestone CAF - representative mix, S.G. = 2.15					
Crushed Rock	Sand	Cement	Flyash	Water	Wet Tonnes
59.75%	20.69%	2.52%	5.04%	12.00%	100.00%
2,532,000	876,770	106,790	213,580	508,520	4,237,660

These refinements were not the immediate priority due to the need to get the upgraded CAF mixing plant constructed and commissioned as quickly as possible. It was obvious that the promised completion dates would not be achieved and the work program was split into more sensible packages that gave greatest priority to completing all facilities directly associated with CAF mixing.

Operating Experience: November 1998 to April 2000.

A simplified flow schematic for CAF production is shown in Figure 14. This schematic is applicable to the time frame from November 1998 to April 2000. This was when the fixed crushing and screening plant was operational. From mid April 2000 an in-pit track mounted (mobile) two-stage crushing and screening plant has been operational. It was supplied by Nordberg and is owned by Brambles Industrial Services and supplies crushed rock under the "Backfill Services Contract" along with the mixing and delivering of CAF.

For the stated period of time, the following milestones and observations are relevant.

Upgraded Backfill (CAF Mixing) Plant Commissioning Milestones:

- CAF Mixing in pugmill: 1/9/99(plan), 1/11/98 (actual).
- New Binder (cement and flyash) Silos: 1/10/98 (plan), 15/1/99 (actual).
- Neutralised Tails Sand Supply System: 1/11/98 (plan), 20/8/99 actual).

The pugmill was re-designed and upgraded in April '99 with respect to wear materials for the mixing chamber. The pugmill was further redesigned and upgraded in August '99 with respect to bearings and mixing chamber sealing along with a complete overhaul. The mix designs are entered into a recipe menu in the process control system for the required CAF strength as specified by the "CAF delivery schedule"

Specific mix designs exist for CAF strengths from 0.5 MPa to 5.0 MPa in 0.5 MPa increments, utilising the following ingredients:

- Crushed mullock / dune sand / cement and flyash / water.
- Crushed mullock / dune sand and tails sand / cement and flyash / water.
- Crushed limestone / dune sand / cement and flyash / water.
- Crushed limestone / dune sand and tails sand / cement and flyash / water.

Tails sand is supplied as neutralised tailings sand slurry at around 50-53% solids (for the current single stage neutralisation circuit). Cement and flyash are normally mixed in the ratios of 1:2 or 1:3 depending upon the availability of flyash from the Port Augusta Power Station.

Properly graded crushed rock is essential to ensure the repeatability of CAF mixing using process control and delivery using semi-tipper trailers to dropper holes. The fixed crushing and screening plant was successfully operated in closed circuit from March 1999 onwards after the successful commissioning of a "trash removal facility" within the circuit. This capability is essential whenever underground waste mullock is used so as to remove the significant quantities of metallic and non-metallic rubbish that reports with the mullock from underground. The fact that the crushing and screening plant did not have this capability was a significant oversight.

Twelve test cylinders are taken on every shift so that testing can be conducted at 14, 28, 56 and 90 days elapsed curing time. These cylinders need to be cured in a controlled environment - water baths are preferred at Olympic Dam. The water bath temperature is controlled at 35°C to approximately represent the "in-stope temperature" where curing of the CAF occurs. The rock temperature is generally above 40°C in the ore zones and CAF is cured in a hot moist environment which is also affected by aquifer water running into the stopes (it is intersected by the CAF dropper hole).

Despite the benefits of a continuous, process-controlled CAF mixing plant, CAF consistency (hence water content) is best determined by the simple and reliable "slump test". This test is conducted on an hourly basis when CAF mixing occurs and the results logged - it is part of the contract key performance indicators (KPI) for the "Backfill Services Contract". Brambles Industrial Services were the successful tenderer for the new contract awarded in September 1999.

Slump of the CAF is specified to be 150-180 mm and when ingredients are mixed and controlled correctly, the slump of the CAF can be consistently between 160-170 mm. Water management against mix design is the most critical parameter to be controlled to ensure delivery of the minimum specified strength for CAF.

Due to the delivery of CAF in semi- tipper trailer trucks (payload currently 12-13m^3 per trailer), correct slump means no segregation occurs when the CAF is transported over gravel roads where a loaded one-way trip can be in excess of 2km. The purpose designed semi-tipper trailers (supplied under the new contract and owned by Brambles) are capable of a 15m^3 payload. This transport method is very flexible and effective when a prompt stop of CAF delivery to any stope is required for whatever reason.

Drilling of the "CAF/ Fill Dropper Holes" is now always an 8 inch percussion drilled hole from the surface, which is then reamed to 12.25 inch diameter. Wherever possible, holes are drilled directly into a stope to provide the simplest and most cost effective delivery method. Hole depth is between 350-500 metres and to an accuracy of +/- 1% of depth. For a period of 9 months dropper holes were drilled at 8 inch as a simpler and lower cost delivery hole. Despite the improvement in the crushed rock grading and quality from the closed circuit operation of the crushing and screening plant (implemented March 1999), some dropper holes continued to fail prematurely by blocking up and the practice was abandoned in June 1999.

The "CAF/ Fill Dropper Holes" are steel cased to hard rock from the surface (generally 40-50 m.) and a tundish (= a funnel with screening grates) is installed on the top of the casing into which the CAF delivery trucks tip directly. The tundish design is now at "mark 3" and is very reliable from a wear perspective. The dropper hole below the steel casing is in the natural rock and generally lasts between 80,000-100,000 m^3 of CAF and/ or surface rockfill delivery. The design of the new semi-tipper trailers and tundish allows both CAF and SRF (surface rockfill) to be delivered to the stope in accordance with the fill design and delivery schedule.

The "process control system" was upgraded in July/ August 1999 to accommodate the supply of the neutralised tailings sand as a slurry (NTSS). The basis of the process design was that a dry sand product would be available to supplement the NTSS supplied from the process plant. This was required due to the variable density and supply reliability from the process plant deslime circuit. The quantity of tails sand and neutralised liquor is calculated from the slurry flow and density and compared with the mix design values for "sand" and "water". The shortfall in tails sand is made up with a dry sand product and similarly with the water. There has been a "trim water" circuit added to allow the operator to adjust the water requirement set point due to change in the "slump" of the CAF.

Surface rockfill (SRF) was first delivered under the new design process to Purple 80 (stope designation) from October to December ' 99. The stope was filled to a defined level as per the fill design with CAF. Then, CAF and SRF were simultaneously delivered down separate fill dropper holes so that a CAF plug was created on one side of the stope and straight rockfill on the other. This was due to the stope only having a single face exposure. This method means stope fill void is filled with a significantly cheaper fill mass for the SRF (approximately 60-70% cheaper) compared with the CAF.

Operating Experience from April 2000 and Future Developments

To improve the quantity, quality and reliability of tailings sand supply from the process plant, the "deslime circuit" was redesigned and simplified. This was implemented and commissioned in May/ June 2000. The quantity of tails sand has now reached in excess of 50% of the sand requirement for the CAF mixes. The "process plant deslime circuit" supplies acid tailings sand slurry (ATSS) to the backfill plant where it is neutralised with a "milk of lime slurry" prepared in a dedicated lime slaking plant. The neutralised tailings sand slurry (NTSS) is then supplied to the pug mill on demand from storage tanks.

A plan has been developed to reduce the dune sand consumption to zero for cost and environmental reasons. This will ultimately require the "mix design sand %" to be supplied as tails sand at 0.75 and limestone fines at 0.25 which will replace the dune sand. The limestone fines will be produced by screening (scalping) out the fines in the quarried limestone drill and blast feed rock to the new mobile in-pit crusher. Field trials have confirmed around 30% by weight can be screened out which will sustain the intended replacement process. The new in-pit mobile crushing and screening plant was supplied by Nordberg to Brambles who are the owner. It is capable of 600 tph and utilises a Nordberg Lokotrak Configuration of LT 125 primary crusher and LT 1500 secondary crusher.

Mixing trials with the pug mill have also been conducted to confirm the process control and CAF mixing consistency using the limestone fines. To increase the tailings sand supply to the backfill plant so that the 0.75 proportion can be achieved, a new upgraded capacity pump station will be constructed and commissioned at the tailings disposal area. This pump station will supply tailings to the "deslime" circuit reliably and at the required rates, even at the upgraded CAF mixing rates required over the forthcoming years.

The CAF Mixing Plant production amounts on a per annum basis (actuals/ forecast) are given in Table 2.

Table 2 – *Fill schedule*

Year	Fill Volume m^3	Fill Tonnes
1999	1,256,000	2,888,000
2000	1,450,000	3,371,250
2001	1,850,000	4,347,500
2002	1,950,000	4,582,500
2003	2,050,000	4,817,500
2004	2,150,000	5,052,500
2005	2,200,000	5,170,000

It is believed that the CAF Mixing Plant maximum reliable production capacity is around 2,200,000m^3 per year. This equates to a continuous delivery of 335m^3 per hr at 75% use, which is considered a very achievable figure with the current redesigned pug mill and binder delivery feeders. It will be necessary to conduct some very minor upgrades to achieve this e.g. conveyor, feeder and pump speed-ups.

The current neutralisation process is single stage using "milk of lime slurry" produced from slaking quicklime. It is effective from a process perspective; however, the costs are high due to the cost of lime.

Waste products from a soda ash works in Adelaide, which have neutralisation properties, are available. Laboratory scale test work has revealed their effectiveness in neutralising ATSS (acid tailings sand slurry) from 1.0/ 1.5 pH to 4.0/ 5.0 pH. This will allow the neutralisation of the ATSS to be effected in a 2-stage process. The existing lime slaking facility will be used to trim the pH value up to the set point of 7.0 which is then classified as NTSS (neutralised tailings sand slurry) and ready to be supplied to the pug mill for CAF mixing.

Technical investigations have been conducted into the use of "ground granulated blast furnace slag (GGBFS)". An agreement has been entered into with BHP and test work conducted by the CSIRO on GGBFS from both Newcastle and Whyalla. This product will be able to in essence replace cement as the main binder in CAF mixes. Depending upon the economics, it may be possible to replace some or all of the flyash. The other application for this product is in neutralisation of acid tailings sand slurry and acid liquors. At the time of writing this paper, BHP - Whyalla and WMC-ODO have tendered for the supply of GGBFS on a contract basis. A final decision on the use of GGBFS will be made late in year 2000.

CAF Displacement Rockfill (CDR) is being developed for stopes which are currently planned to be 100% CAF. This method is based on the design requirement of only having a 10m CAF pillar. This need has been developed and defined for stopes where CAF is at one end and rockfill at the other (as was the case for Purple 80). Thus, it is possible to introduce SRF (surface rockfill) into the centre of a stope and generally have the SRF remain in the stope centre. SRF is delivered by semi-tipper truck along with CAF to a defined ratio e.g. 1 to 10. Whilst this method may only displace around 5% CAF, the cost savings are appreciable if this can be applied to only 50% of stopes currently receiving CAF. For 50,000m^3 of CAF displaced, the estimated savings would be $ 500,000-$ 600,000 per year.

Conclusions

The results of the design study project have been to define the required minimum CAF strengths and produce an interactive design spreadsheet able to be used by mine design/ backfill engineers on site. The CAF mix designs to meet the required minimum CAF strengths have been developed on site for a wide range of aggregates that are available. These have been mixed in the new CAF mixing plant and delivered to the U/G stopes by well proven methods developed at Olympic Dam This investigation and implementation process has generated some new insights into backfilling at Olympic Dam, especially for cemented fill (CAF) and for surface rockfill (uncemented fill).

The project has delivered a simple and effective design tool, which is used on a routine basis to determine zoned CAF fill strengths. The design mixes that have been developed ensure that these strengths are then achieved at the most economical cost. The unit cost of CAF as backfill has reduced approximately 15-20% since the new design, mixing and delivery processes have been optimised. Monitoring of the performance of the new backfill system is in progress.

Olympic Dam has successfully engineered the backfill system to meet the needs of the expanded mining operation. This has been achieved through improved design processes, rigorous investigations and the introduction of an innovative approach to backfill mixing and placement. As future mine fill needs increase in quantity and change in requirements, the knowledge base of personnel about the backfill system ensures that Olympic Dam is well positioned to meet those changes - and continue to deliver a cost effective fill mass at a reducing unit cost per cubic metre of void filled.

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Appendix K
Kuganathan 2004 A Model to Predict Bulkhead Pressures for Safe Design of Bulkheads

SECTION 6

A Model to Predict Bulkhead Pressures for Safe Design of Bulkheads

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Introduction

At present there is no procedure available to mine operators to estimate the expected bulkhead pressures to design a satisfactory bulkhead. Some mines are constructing bulkheads after their initial investigations carried out years ago. Other mines have simply borrowed the ideas from the pioneer mines and happily repeating in their areas. It is long overdue that we develop a rational approach to estimate the expected bulkhead pressures for the design of bulkheads. Numerical modelling of fill and bulkhead interaction is an interesting exercise, but not very easy to be handled by practicing mining engineers. We need a simple model that could be understood and used by the mine operators in a day-to-day basis. This paper presents a model to predict the bulkhead pressures for designing safe bulkheads.

The Bulkhead Pressure Model Development

The following conditions were assumed for the development of the theory for bulkhead pressure.

- The bulkhead is free draining or a shotcrete bulkhead with adequate wall drain system installed.
- The total lateral pressures acting on the bulkhead are made of two components namely the fill pressure through the inter-granular mechanism, and the pore water pressure or the seepage forces.
- The seepage forces transferred to the fill solids act like a body force similar to gravity body force, but in the horizontal direction.
- The granular skeleton of the fill solids in the stope and drive, develop shear strength and interact with the rock walls to promote arching.
- The saturated and loose nature of the fill in the access drive, cannot develop very high shear strength, hence arching in the drive is very minimal.
- The bulkhead structure prevents the fill solids from moving laterally as the result of fill and water pressures. This results in compaction and accumulation of fines in the fill near bulkhead.
- As we move from the stope in to the access drive, the seepage forces tend to increase the lateral stress whereas the shear resistance between the rock wall and the fill tend to reduce the lateral stresses.
- The fill in the drive undergoes creep, and progressively increases the lateral stress acting on the bulkhead especially at higher stress levels.
- The access drive is horizontal and the seepage takes place in horizontal direction only.
- The hydraulic backfill in the stope and in the access drive has settled and consolidated to equilibrium conditions.
- The seepage in the stope is predominantly in the vertical direction.
- The effective stresses both σ'_z and σ'_x in the stope and at the bulkhead level stabilised at the fully arched condition.

- Further filling will not appreciably change σ'_z and σ'_x at the bulkhead level. Only pore water pressure will increase and accordingly the σ'_z and σ'_x will change.
- The total stress σ_x at the entry to access drive is made of σ'_x and $\mathbf{U_0}$, where $\sigma'_x = \mathbf{k_0} . \sigma'_{z\,(stope)}$.
- The total stress σ_x at the bulkhead is equal to the effective stress σ'_x at the bulkhead, and this is only true if the pore water pressure at the bulkhead is zero or very small. If the bulkhead is blended then additional water pressure will (over 100kPa) act on the bulkhead.
- The unbalanced horizontal force of A. $(\sigma_x - \sigma_b)$ is balanced by the friction and cohesion forces along the rock fill interface in the drive.

Let the stope filling rate is **R** dtph, the area of stope be $\mathbf{A_s}$ m^2, the filling time be $\mathbf{T_1}$ hours, the resting time be $(24 - T_1)$ hours, the hydraulic fill slurry concentration be **S%** and the tailings solids specific gravity be $\mathbf{G_s}$. Let the final moisture content of the drained fill mass be **m%** of the dry mass and the final dry density of the fill mass is γ_d t/m^3.

The Amount of Water Entering the Stope

The water entering the stope in a 24 hour (m^3/day) $T_1 . R . (100 - S) / S$
The water retained in the fill after drainage is (m^3/day) $T_1 . R . m/100$
Hence excess water entering the stope is $I = T_1 . R . [(100-S)/S - m/100]$
Where the excess eater per tonne of hydraulic fill $W = [(100-S)/S - m/100]$

Vertical Filling Rate

Let the vertical filling rate is given by (m/day) $Y = T_1 . R / (A_s . \gamma_d)$

The Rate of Fill Drainage

Let the fill drainage rate be Q m^3/day

Pore Water Pressure Distribution in the Drive

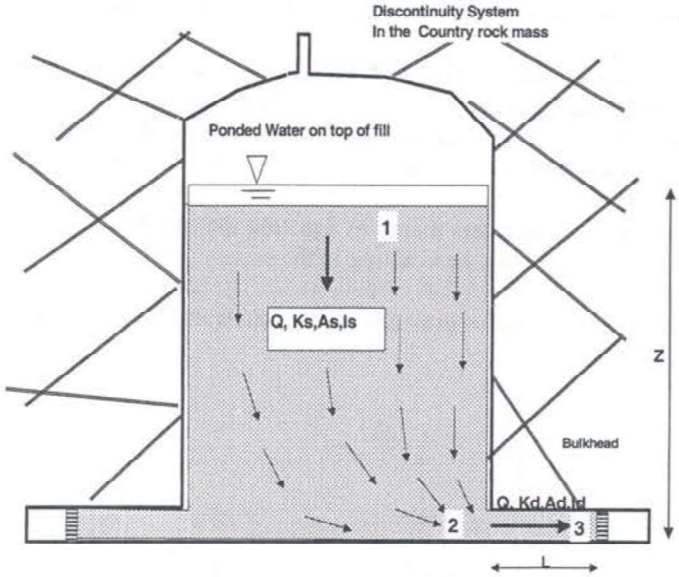
A simplified procedure has been developed for the pore water pressure calculations as follows. Let the flow parameters for the stope are as follows (Figure 1) :

K_s is the permeability of the fill in the stope
A_s is the plan area of the fill mass
I_s is the hydraulic gradient in the stope
H_1, H_2, and H_3 are the total potential for the seepage flow at locations 1 (top of fill mass), 2 (at the entry to the access drive), and 3 (at the free draining bulkhead)

Hence, the hydraulic gradient in the stope $I_s = (H_1 - H_2)/ Z = (Z-h)/Z$,
Where Z is the height of the water table, h is the hydraulic head at the entry to access drive.

The flow through the stope is given by:-

$$Q = k_s \cdot i_s \cdot A_s = k_s \cdot \left(\frac{(z-h)}{z} \right) \cdot A_s$$



A typical Hydraulic Fill in a Stope Durin Filling

Figure 1

Let the number of draining bulkheads be n. In most cases n = 1.

The total flow through all the n bulkheads is qual to the stope drainage rate as calculated above and will be given by

$$Q = n \cdot k_d \cdot i_d \cdot A_d \quad = \quad n \cdot k_d \cdot \left(\frac{h}{L}\right) \cdot A_d$$

Since the flow through the stope is equal to the flow through the n draining bulkheads,

$$Q \quad = \quad k_s \cdot \left(\frac{z-h}{z}\right) \cdot A_s \quad = \quad n \cdot k_d \left(\frac{h}{L}\right) \cdot A_d$$

Let $K_s . A_s = T_s$ which is the Transmissivity of the fill mass in stope, and
$K_d . A_d = T_d$ which is the Transmissivity of the fill in the access drive

Substituting T_s and T_d in the above equation we get:

$$T_s \cdot \left(\frac{z-h}{z}\right) \quad = \quad n \cdot T_d \left(\frac{h}{L}\right)$$

By simplifying the above equation we get

$$h \quad = \quad \frac{z}{\left[n \cdot \left(\frac{T_d}{T_s}\right)\left(\frac{z}{L}\right) + 1\right]} \quad (meters) \qquad (1)$$

Hence the hydraulic head at the entry to access drive could be calculated from the values of Z, n, T_s, T_d, and L. The following general observation can be made from the above equation for the hydraulic head h acting at the access drive entry.

- h will decrease a n increase, that is if we increase the number of bulkheads for a stope we can reduce the hydraulic head acting in the drive
- h will decrease as (T_d / T_s) increase, that is by increasing the transmissivity of the drive by incorporating the drainage systems we can reduce the hydraulic head acting in the drive
- h will decrease as L decrease, that is by locating the bulkhead closer to the stope we can reduce the hydraulic head acting in the drive

From the theory presented in the drainage model, the water flow rate per day through the bulkhead is given by

$$Q = 24.n.\frac{h}{L}.T_d = \frac{24.n.Z.T_d}{L.\left[n.\left(\frac{T_d}{T_s}\right)\left(\frac{Z}{L}\right)+1\right]} \quad tpd \qquad (2)$$

Where T_d is the transmissivity of the fill in the drive in m^3/h.

But the excess water inflow rate is given earlier as $T_1 . R .W = I$ tpd

Conditions for Water table to Rise, Fall or Stay constant

Hence if the excess water inflow rate is greater than the drainage rate (I >Q) then the water table in the stope will rise and if the excess water inflow rate is less than the drainage rate (I < Q) then the water table will fall. If I = Q then the water table will stabilise at constant height.

From the time a stope filling starts, the water table will continue to rise until the excess water inflow rate matches the stope drainage rate. The height of the water table at which the inflow matches the drainage is the maximum height for the water table.

$$\frac{24.n.Z.T_d}{L.\left[n.\left(\frac{T_d}{T_s}\right)\left(\frac{Z}{L}\right)+1\right].} = T_1.R.W \qquad ((3))$$

$$24.n.k_d.Z.A_d = T_1.R.W.L.n.\left(\left(\frac{T_d}{T_s}\right)\left(\frac{Z}{L}\right)\right) + T_1.R.W.L$$

$$Z.\left[24.n.k_d.A_d - T_1.R.W.n.\left(\frac{T_d}{T_s}\right)\right] = T_1.R.W.L$$

$$Z = \frac{T_1.R.W.L}{24.n.T_d - \dot{Y}.A_s.\gamma_d.W.n.\left(\frac{T_d}{T_s}\right)}$$

$$Z = \frac{\dot{Y}.A_s.\gamma_d.W.L}{24.n.T_d - \dot{Y}.A_s.\gamma_d.W.n.\left(\frac{T_d}{T_s}\right)} \qquad (4)$$

Where $\dot{Y}$ *is the vertical filling rate in* m/day

A_s *is the stope plan area in* m^2

L *is the bulkhead offset distance in m*

$T_d = k_d.A_d$

k_d *is the permeability of the fill in drive* (m/h)

The Equation (1) can be rewritten as:-

$$Z = \frac{T_1.R.L.W}{24.n.T_d - T_1.R.n.\left(\frac{T_d}{T_s}\right).W} \qquad (5)$$

in which the filling rate R, and the filling time T_1 could be used to calculate the final equilibrium height of the water table.

The following examples have been worked out to illustrate the effectiveness of the above formulas.

Case 1

A narrow and long stope with dimensions 100m long, 15m wide, is being filled with hydraulic fill at 175 dtph at 75% solids concentration. The filling is carried out for 12 hours followed by a resting time of 12 hours. The drained moisture content of the fill mass is 20%. The stope is provided with only one bulkhead at 15m off set at the lowest level (draw point). Assume the permeability for the fill in the stope and in the drive as 30mm/h, and estimate the height of water table in the stope.

First calculate T_d and T_s as follows:

T_d = (30mm/h)* (1m/1000mm) * 5m x 5m = 0.75 m^3/h

T_s = (30mm/h)* (1m/1000mm) * 15m x 100m = 45 m^3/h

Use equation (5) and substitute the values for T_d and T_s as follows:

$$Z = \frac{12 * 175 * 15 * \left(\frac{25}{75} - \frac{20}{100}\right)}{24 * 1 * .75 - 12 * 175 * \left(\frac{.75}{45}\right) * \left(\frac{25}{75} - \frac{20}{100}\right)} = 313.95\ m$$

Since the height of the water table Z = 313.95 meters is greater than the height of the stope, which is 50 meters, the water table will be always above the fill surface during the filling campaign as per the rates assumed (that is 12 hours filling daily at 175 dtph rate).

Case 2

We will consider a similar case to the previous one, but with the bulkhead is located at 3m off set, and the filling time is 6 hours in a 24 hour period in this case. All the other filling parameters are same as in the case 1.

The height of the water table Z is given by equation (5) as,

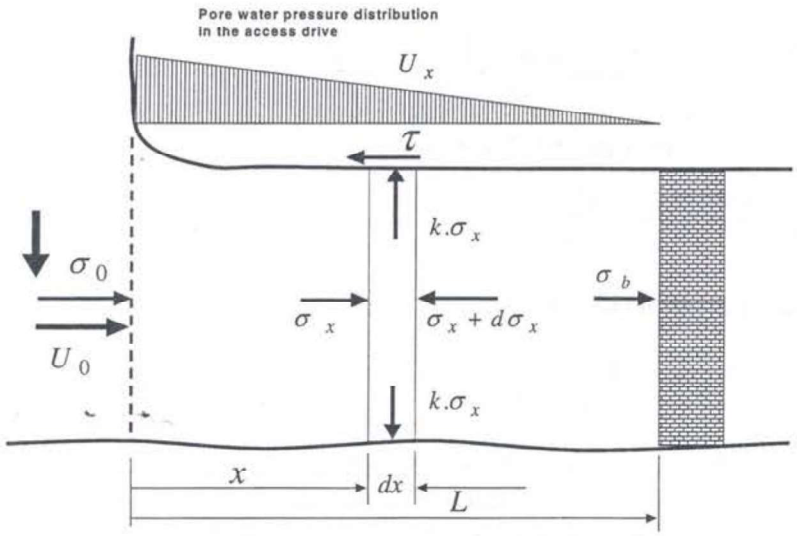
$$Z = \frac{6*175*3*\left(\frac{25}{75}-\frac{20}{100}\right)}{24*1*.75-6*175*\left(\frac{.75}{45}\right)*\left(\frac{25}{75}-\frac{20}{100}\right)} = 26.73m$$

Hence the equilibrium height of the water table in the stope is 23.73meters, if we provide a bulkhead at 3m away and reduce the filling time to 6 hours only.

The Bulkhead Pressure Model (MIM)

The lateral stresses acting on the bulkhead can be calculated in the following manner: Let the pore water pressure at x = 0 is U_0, at the entry to drive, the total fill and water pressure σ_x at x = 0 is σ_0, and the effective stress σ'_x at x = 0 is (σ_0 - U_0). Using equation (1)for the hydraulic head in the drive and multiplying by γ_w, we get,

$$u_0 = h.\gamma_w = \frac{Z.\gamma_w}{\left[n.\left(\frac{T_d}{T_s}\right).\left(\frac{Z}{L}\right)+1\right]} \qquad (6)$$



The Stressess acting in the Fill in the Access Drive

Figure 2

Assume the same permeability for the fill along the drive. In practice this may not be true. A compaction or accumulation (of fines) zone of 0.5 to 1.0m of fill will form near the bulkhead, and the pore water will develop steeper gradients in the compaction zone.

However, for the purpose of developing the present model, we have to assume the same permeability for the fill in the access drive from x = 0 to x = L. This will result in a linear pore water pressure distribution as shown in the above diagram.

Let U_x be the pore water pressure at distance x from the stope in the drive.
Hence,

$$U_x = \frac{U_0}{L}(L - x) \qquad (7)$$

Assume the lateral earth pressure coefficient for the fill in the access drive is K_0. Hence the mobilised shear strength S_x of the fill at the rock walls in the drive is given by,

$$S_x = \sigma'_y.\tan\phi + C \qquad (8)$$

$$but\ \sigma'_y = K_0 . \sigma'_x = K_0 . (\sigma_x - U_x) \qquad (9)$$

$$Therefore,\ S_x = K_0.(\sigma_x - U_x).\tan\phi + C \qquad (10)$$

$$Substituting\ U_x = \frac{U_0}{L}.(L-x)\quad in\quad equation(2)\ gives$$

$$S_x = K_0.\left(\sigma_x - \frac{U_0}{L}.(L-x)\right).\tan\phi + C \qquad (11)$$

Considering a slice of fill dx thick, and resolving the forces horizontally in X-X direction we get the following:

$$\frac{d\sigma_x}{dx} + \frac{P.K_0.\tan\phi.\sigma_x}{A} = \frac{P.K_0.\tan\phi.U_0.(L-x)}{A.L} - \frac{P.C}{A} \qquad (12)$$

Let $b = \frac{P.K_0.\tan\phi}{A}$, *the equation* (3) *can be rewritten as*

$$\frac{d\sigma_x}{dx} + b\sigma_x = \frac{b.U_0.(L-x)}{L} - \frac{P.C}{A} \qquad (13)$$

Upon integrating equation (13) we get

$$\sigma_x = U_0 - \frac{U_0 x}{L} + \frac{U_0}{bL} - \frac{P.C}{A.b} + d.e^{-bx} \qquad (14)$$

This is the formula to calculate the lateral stress at any section in the access drive, where d is a constant to be evaluated through the boundary conditions. By using the boundary condition that at x = 0, $\sigma_x = \sigma_0$, this is the total lateral stress acting at the stope boundary, U_0 is the pore water pressure at the stope boundary obtained from the drainage model, and the σ'_0 obtained by using Terzaghi's arching theory for the main fill mass in the stope, the value of the constant d is given by,

$$d = \sigma_0 - u_0\left(1 + \frac{1}{bL}\right) + \frac{P.C}{A.b} \qquad (15)$$

By substituting this in the equation (14), we get

$$\sigma_x = u_0 - \frac{u_0.x}{L} + \frac{u_0}{bL} - \frac{P.C}{A.b} + \left\{\sigma_0 - u_0\left(1 + \frac{1}{bL}\right) + \frac{P.C}{A.b}\right\}.e^{-bx} \qquad (16)$$

This is the final form of the bulkhead pressure model (formula). To find how much lateral pressure is transferred to the bulkhead, we substitute x = L, and get

$$\sigma_b = \sigma'_0.e^{-bL} + \frac{u_0}{bL}.\left(1 - e^{-bL}\right) - \frac{P.C}{A.b}.\left(1 - e^{-bL}\right) \qquad (17)$$

Where the first term is the contribution to the final bulkhead pressure through the tailings solids, and this quantity is decreasing as the L increases, the second term is the contribution from the seepage forces to the final bulkhead pressure, and the final term is accounting for the resistance provided by the cohesion of the fill.

A Recommended Procedure to Design a Hydraulic Fill Bulkhead

Seven Step Procedure

Step 1
Choose appropriate filling rate to control the height of the water table.

Step 2
Provide adequate number of bulkheads or drainage system to achieve adequate drainage rate. Step 1 and step 2 may be iterated few times to achieve the most optimum condition for fill drainage, at a specified site.

Step 3
Estimate the maximum water head h acting at the stope boundary using the drainage model presented in the paper.

Step 4
Using Terzaghi's arching theory estimate the vertical and horizontal fill pressures at the stope boundary at the bulkhead level.

Step 5
Use the bulkhead pressure model presented in this paper to estimate the expected maximum lateral stress that will act on the bulkhead.

Step 6
Use a factor of safety of 1.5 to 2 to get the design pressure for the bulkhead structure.

Step 7
Design the bulkhead structure to stand this pressure. The structural design of the bulkhead is not covered in this paper.

Example 1 – Bulkhead pressure calculation –Case A
Consider a case where, the stope dimensions are 40m x 40m x 120m, and provided with three bulkheads at the draw point level. The hydraulic fill is placed at 250dtph rate, at 70% solids concentration, 12 hours per day. The final drained moisture content of the fill mass is 25%, and the permeability of the fill is 50mm/h both in the stope and in the drive. The bulkheads are placed at 4m off set distance from the stope boundary, and the drives are of 5m x 5m size. Estimate the expected fill pressure for the bulkhead design.

Solution:

Filling time T_1 = 12 hrs,
Fill solids concentration S = 70%,
Fill permeability k_s = 50mm/h
Bulkhead off set L = 4m
Area of the stope A_s = 1600m^2

Filling rate R = 250dtph
Number of bulkheads n = 3
Fill permeability k_d = 50mm/h
Area of the drive A_d = 25m^2

The transmissivity of the drive $T_d = k_d \cdot A_d = 25 * .05 = 1.25$ m^3/h
The transmissivity of the stope $T_s = k_s \cdot A_s = 1600 * .05 = 80$m^3/h

$$z = \frac{12*250*4*\left(\frac{30}{70}-\frac{25}{100}\right)}{3*24*.05*25-12*250*3*\frac{1.25}{80}*\left(\frac{30}{70}-\frac{25}{100}\right)}$$

$$= 33.02\,m$$

Hence the equilibrium water table height is 33 meters
The hydraulic head at the stope boundary h is calculated as follows:

$$h = \frac{z}{n\left(\frac{T_d}{T_s}\right).\left(\frac{z}{L}\right)+1} = \frac{33.02}{3*\left(\frac{1.25}{80}\right)*\left(\frac{33}{4}\right)+1} = 23.81m$$

Hence the hydraulic head acting at the entry to the access drive is around 238 kPa.

The Calculation for the bulkhead pressure is carried out as follows:
The bulkhead pressure σ_b is calculated as follows:

$$\sigma_b = \sigma_0^{'} \cdot e^{-bL} + \frac{u_0}{bL} \cdot \left(1 - e^{-bL}\right)$$

$$b = \frac{p_d \cdot k_0 \cdot \tan\phi}{A_d} = \frac{20*.4*\tan 20}{25} = .1164$$

$$e^{-bL} = e^{-.1164*4} = .6275$$

$$\sigma_0^{'} = 339kPa \text{ from Terzaghi's } 3-D \text{ analysis, Hence } \sigma_b \text{ is given by}$$

$$\sigma_b = 339*e^{-.4656} + \frac{238.1*\left(1-e^{-.4656}\right)}{.4656} = 212.8+190.35 = 403.2kPa$$

This is the maximum bulkhead pressure that should be expected under the specified filling conditions. If the rock forming the stope void is jointed then the water may find easy passages through the rock, and it is not necessary to consider such a case for the design.

If the fill and water pressures in the stope and on the bulkheads experienced in the past are lower than the above values, we should thank Mother Nature for such a mercy. However, this will not allow us to design the bulkheads for lower pressures than the above-calculated values.

Hence the expected bulkhead pressure is around 400kPa, under the filling conditions considered.

For the design of bulkhead choose a factor safety of at least 2 and design the bulkhead to withstand a pressure not less than 800kPa. Lower factor of safety of 1.5 could be used if deep drainage systems installed.

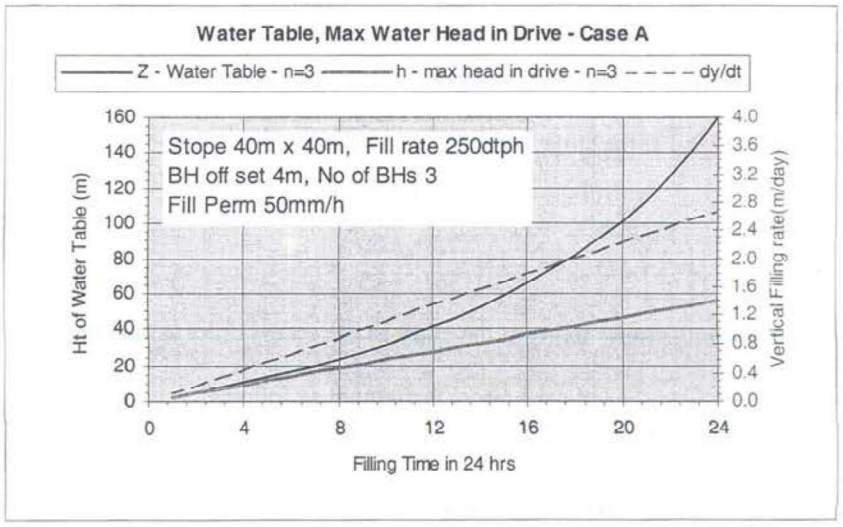


Figure 3 The filling time, height of water table, and the water head in the access drive – Case A

Example 2 – Bulkhead pressure calculation –Case B

Consider a case where, the stope dimensions are 60m x 20m x 60m, and provided with one bulkhead at the draw point level. The hydraulic fill is placed at 200dtph rate, at 75% solids concentration. The final drained moisture content of the fill mass is 18%, and the permeability of the fill is 30mm/h both in the stope and in the drive. The bulkheads are placed at 15m off set distance from the stope boundary, and the drives are of 5m x 5m size. Estimate the expected fill pressure for the bulkhead design.

Solution:

Filling time $T_1 = 12$ hrs,
Fill solids concentration $S = 75\%$,
Fill permeability $k_s = 30$mm/h
Bulkhead off set $L = 15$m
Area of the stope $A_s = 1200$m^2

Filling rate $R = 200$dtph
Number of bulkheads $n = 1$
Fill permeability $k_d = 30$mm/h
Area of the drive $A_d = 25$m^2

The transmissivity of the drive $T_d = k_d \cdot A_d = 25 * .03 = .75$ m^3/h
The transmissivity of the stope $T_s = k_s \cdot A_s = 1200 * .03 = 36$m^3/h

$$z = \frac{12*200*15*\left(\frac{25}{75}-\frac{18}{100}\right)}{1*24*.03*25-12*200*3*\frac{.75}{36}*\left(\frac{25}{75}-\frac{18}{100}\right)}$$

$$= 534\,m$$

Hence the equilibrium water table height is the fill height, which is 60m

The hydraulic head at the stope boundary h is calculated as follows:

$$h = \frac{z}{n\left(\frac{T_d}{T_s}\right).\left(\frac{z}{L}\right)+1} = \frac{60}{1*\left(\frac{.75}{36}\right)*\left(\frac{60}{15}\right)+1} = 55.38m$$

Hence the hydraulic head acting at the entry to the access drive is around 554kPa

Calculation of the bulkhead pressure is carried out as follows:
The bulkhead pressure σ_b is calculated as follows:

$$\sigma_b = \sigma_0^{'}.e^{-bL}+\frac{u_0}{bL}.\left(1-e^{-bL}\right)$$

$$b=\frac{p_d.k_0.\tan\phi}{A_d} = \frac{20*.4*\tan 15}{25} = .0857$$

$$e^{-bL} = e^{-.0857*15} = .2763$$

$$\sigma_0^{'} = 150kPa \text{ from Terzaghi's } 3-D \text{ analysis, Hence } \sigma_b \text{ is given by}$$

$$\sigma_b = 150*e^{-1.285}+\frac{554*\left(1-e^{-1.285}\right)}{1.285} = 41.4+400.9=442kPa$$

Hence the expected bulkhead pressure is around 442kPa, under the filling conditions considered.

For the design of bulkhead choose a factor safety of at least 2 and design the bulkhead to withstand a pressure not less than 880kPa, which will be a massive structure.

The major component of the bulkhead pressure is from the hydraulic head and this is 400kPa. The bulkhead pressure can be easily reduced to a value less than 200kPa by using deep drains. It is much safer to handle the reduced bulkhead pressure than designing a massive structure to withstand the design pressure of 880kPa .

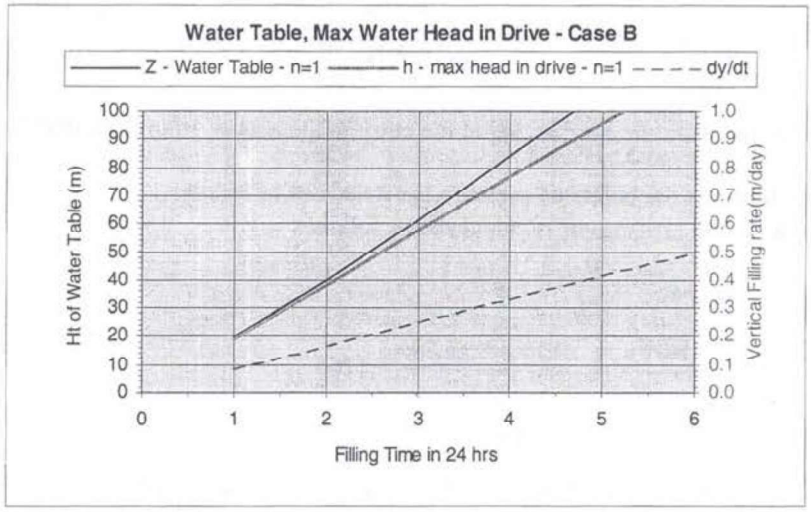


Figure 4 The filling time, height of water table, and the water head in the access drive – Case B

Example 3 – Bulkhead pressure calculation – Case C

Consider a case where, the stope dimensions are 50m x 20m x 80m, and provided with one bulkhead at the draw point level. The hydraulic fill is placed at 200dtph rate, at 70% solids concentration. The final drained moisture content of the fill mass is 25%, and the permeability of the fill is 30mm/h both in the stope and in the drive. The bulkheads are placed at 7.5m off set distance from the stope boundary, and the drives are of 5m x 5m size. Estimate the expected fill pressure for the bulkhead design.

Solution:

Filling time $T_1 = 12$ hrs,
Fill solids concentration S = 70%,
Fill permeability $k_s = 30$mm/h
Bulkhead off set L = 7.5m
Area of the stope $A_s = 1000$m^2

Filling rate R = 200dtph
Number of bulkheads n = 1
Fill permeability $k_d = 30$mm/h
Area of the drive $A_d = 25$m^2

The transmissivity of the drive $T_d = k_d \,.\, A_d = 25 * .03 = .75$ m^3/h
The transmissivity of the stope $T_s = k_s \,.\, A_s = 1000 * .03 = 30$m^3/h

$$z = \frac{12*200*7.5*\left(\frac{30}{70}-\frac{25}{100}\right)}{1*24*.03*25-12*200*3*\frac{.75}{30}*\left(\frac{30}{70}-\frac{25}{100}\right)}$$

$$= 441\,m$$

Hence the equilibrium water table height is the fill height, which is 70m

The hydraulic head at the stope boundary h is calculated as follows:

$$h = \frac{z}{n\cdot\left(\frac{T_d}{T_s}\right)\cdot\left(\frac{z}{L}\right)+1} = \frac{70}{1*\left(\frac{.75}{30}\right)*\left(\frac{70}{7.5}\right)+1} = 56.75m$$

Hence the hydraulic head acting at the entry to the access drive is around 568kPa

Calculation of the bulkhead pressure is carried out as follows:
The bulkhead pressure σ_b is calculated as follows:

$$\sigma_b = \sigma_0^{'}\cdot e^{-bL} + \frac{u_0}{bL}\cdot\left(1-e^{-bL}\right)$$

$$b = \frac{p_d\cdot k_0\cdot\tan\phi}{A_d} = \frac{20*.4*\tan 20}{25} \quad .1164$$

$$e^{-bL} = e^{-.1164*7.5} = .4174$$

$$\sigma_0^{'} = 150kPa \text{ from Terzaghi's } 3-D \text{ analysis, Hence } \sigma_b \text{ is given by}$$

$$\sigma_b = 150*e^{-.873} + \frac{568*\left(1-e^{-.873}\right)}{.873} = 62.6+379 = 441kPa$$

Hence the expected bulkhead pressure is around 441kPa, under the filling conditions considered.

For the design of bulkhead choose a factor safety of at least 2 and design the bulkhead to withstand a pressure not less than 880kPa, which will be a massive structure.

The major component of the bulkhead pressure is from the hydraulic head and this is 400kPa. The bulkhead pressure can be easily reduced to a value less than 200kPa by using deep drains. It is much safer to handle the reduced bulkhead pressure than designing a massive structure to withstand the design pressure of 880kPa .

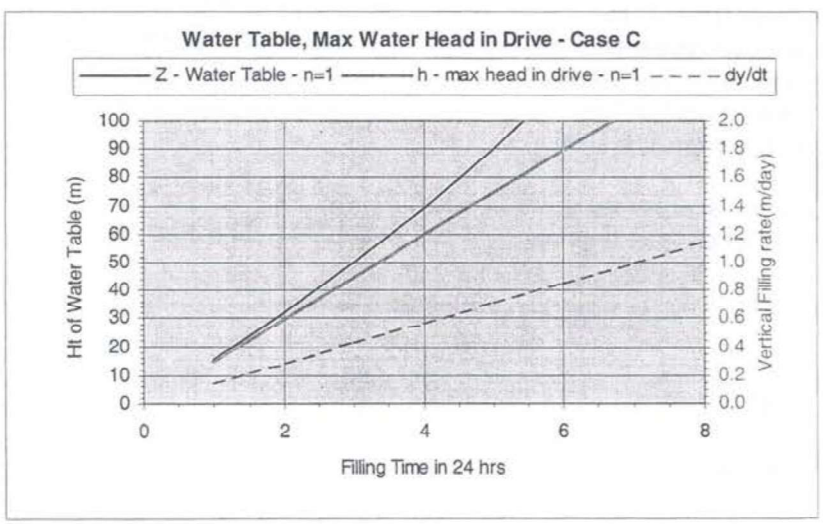


Figure 5 The filling time, height of water table, and the water head in the access drive – Case C

Conclusions

In this paper a rational approach to determining the bulkhead pressures has been presented. It is now possible to control the bulkhead pressures through the methods presented in this paper. Installing proper drainage systems will increase stope drainage by many times faster. Also installing deep drains in the drive will reduce the bulkhead pressures to easily manageable level. Bulkheads should then be designed to withstand the reduced pressures only. Most of the bulkhead failures are caused by the combined effect of the fill and seepage forces, and the model presented in this paper clearly identifies this.

By improving the drainage through engineered drainage systems, the bulkhead pressures are reduced and the safety in automatically increased could only achieve safety in hydraulic filling.

There is no rule of thumb for the safety of hydraulic filling. The free draining bulkheads on their own accord do not provide any improved safety, if not engineered drainage systems are incorporated with them. If the drainage is properly taken care of, then the type of bulkhead (porous brick or shotcrete) does not matter.

APPENDIX

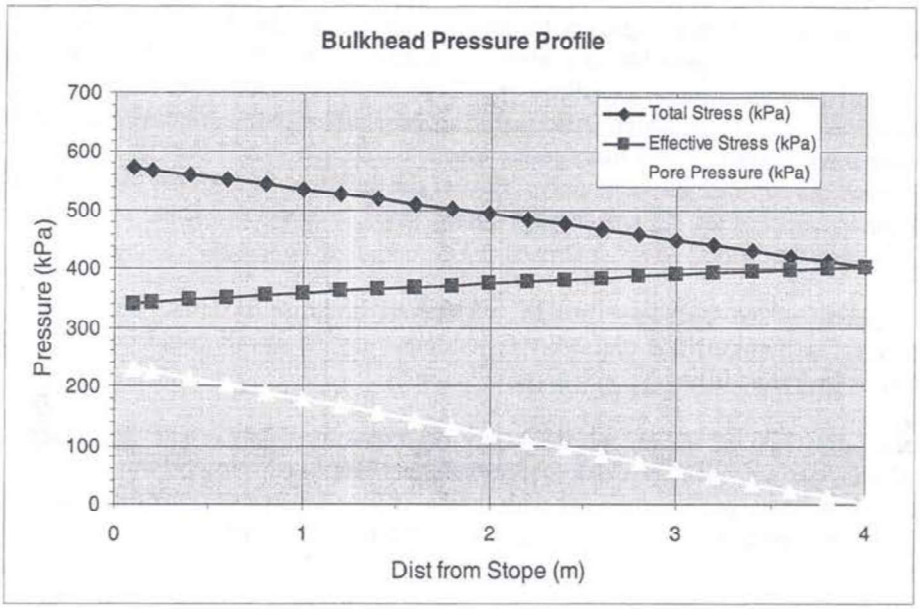


Figure 6 A typical pressure distribution in the access drive for Case A

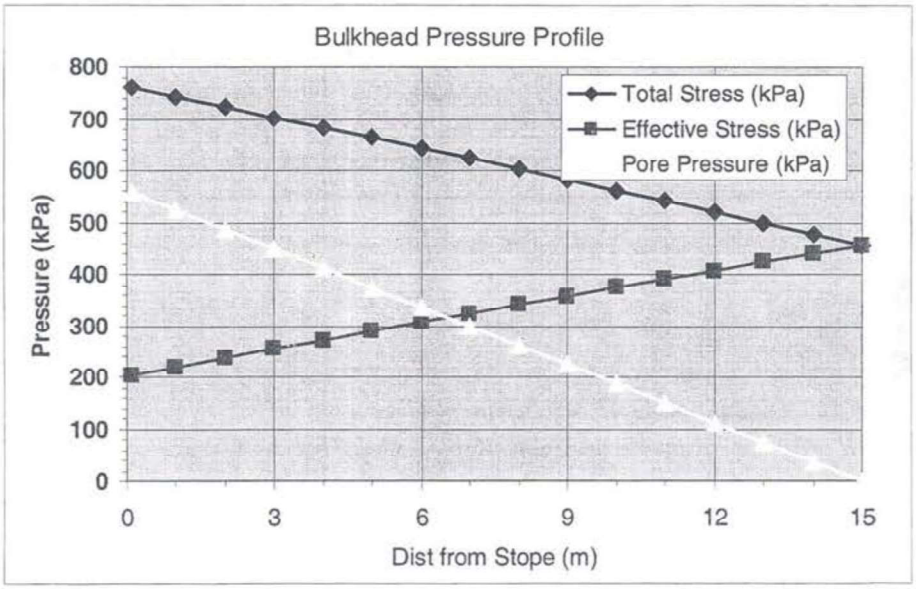


Figure 7 A typical pressure distribution in the access drive for Case B

APPENDIX

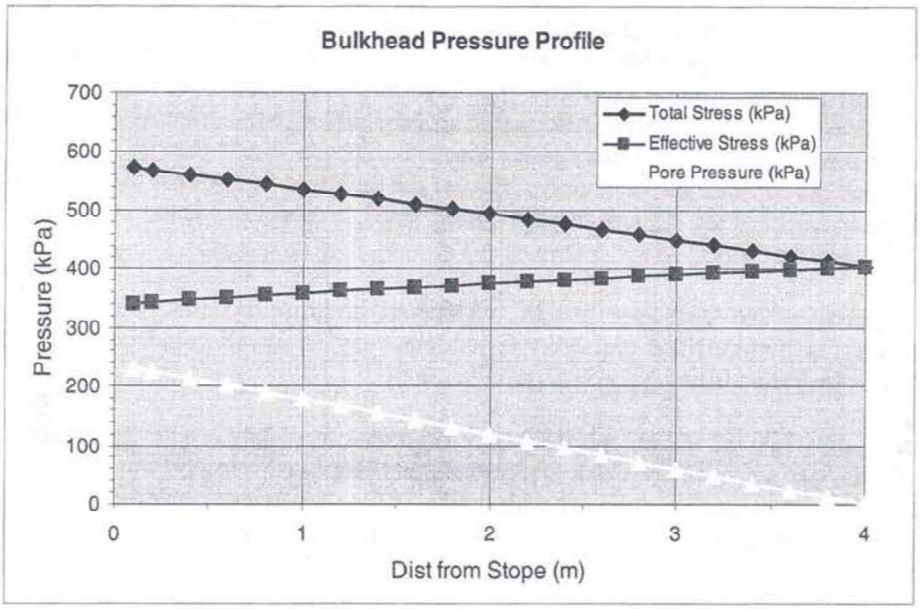


Figure 6 A typical pressure distribution in the access drive for Case A

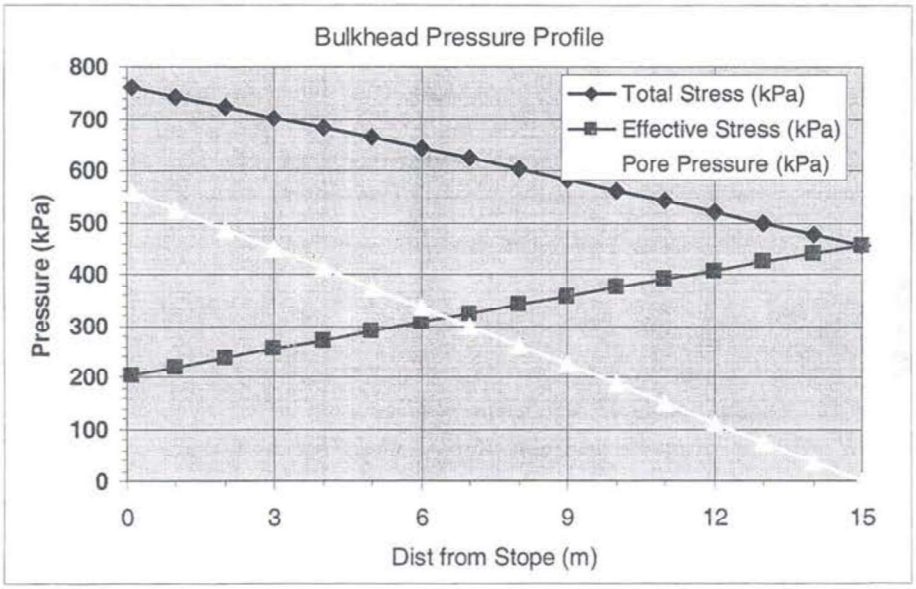


Figure 7 A typical pressure distribution in the access drive for Case B

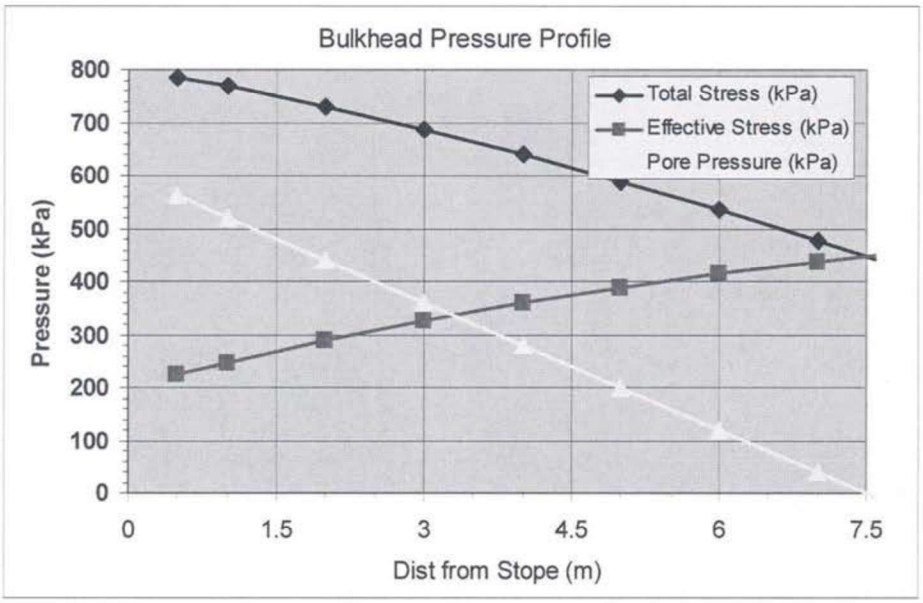


Figure 8 A typical pressure distribution in the access drive for Case C

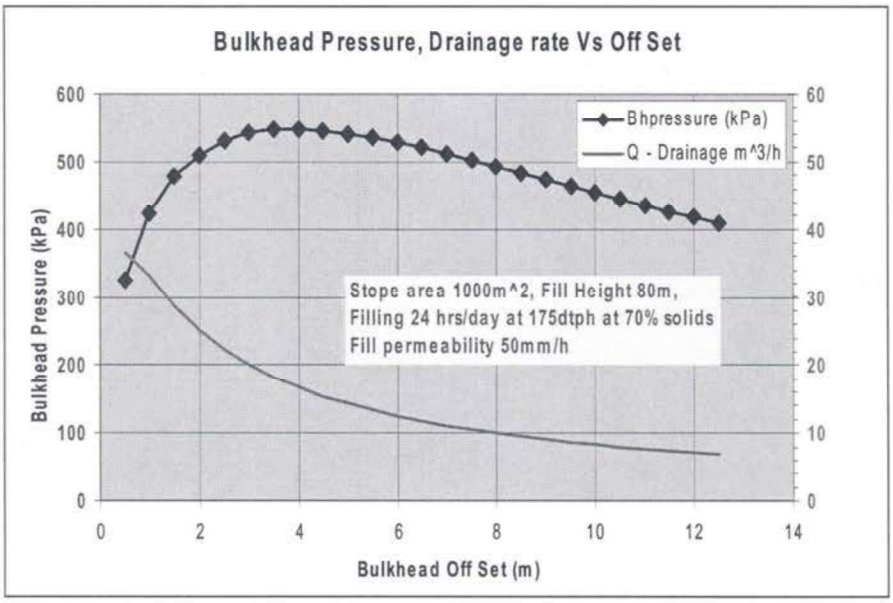


Figure 9 The variation in the bulkhead pressure and the drainage rate for a selected filling rate

Appendix L
Yumlu & Guresci 2007 - Paste backfill bulkhead failures and pressure monitoring at Cayeli Mine

Paste backfill bulkhead failures and pressure monitoring at Cayeli Mine

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M. Guresci, Inmet Mining Corporation (Cayeli Bakir Isletmeleri A.S.), Rize, Turkey

ABSTRACT The stability of bulkheads forms an integral part of a successful paste backfill system. Bulkheads are constructed at the draw points of open stopes to contain paste fill while the initial pour cures and forms a consolidated plug. Mobilization of uncured paste fill as a result of a bulkhead failure can lead to significant consequences, including endangering the safety of personnel, property damage and production losses and delays. This paper presents details of three paste fill bulkhead failures that have occurred during the late stage of tight filling transverse blind uphole retreat stopes in an underground base metal mine; the results of an in-situ instrumentation and monitoring program to ascertain the paste fill pressure loads acting on the bulkheads and to understand the pressure development mechanism within paste fill mass; and the subsequent changes made to the bulkhead design and paste fill placement sequence in order to prevent reoccurrence of bulkhead failures in the future.

The revised bulkhead design and fill placement management has been successful because, to date, Cayeli has filled more than 50 blind stopes without any failure. A significant outcome of this study is that it has been shown that only a combination of properly engineered bulkhead design, bulkhead construction, and better management of fill placement can provide safe and efficient filling practices. Furthermore, bulkhead pressures are very site-specific and any bulkhead design should be based on field pressure monitoring results carried out at the actual mine site.

KEYWORDS Cemented backfill, Paste fill, Bulkhead failure, Pressure monitoring, Tight fill, Shotcrete bulkheads, Barricades failure, Paste fill temperature measurements

INTRODUCTION

The Cayeli underground mine, operated by Cayeli Bakir Isletmeleri A.S., is a wholly owned subsidiary of Inmet Mining Corporation. Cayeli is located 8 km inland from the Black Sea coast and approximately 75 km to the east of the city of Trabzon (Fig. 1).

Construction of the mine started in 1992 and ore production began in 1994. The Cayeli Mine is the largest fully mechanized underground base metal mine in Turkey. The mine extracts about 1.0 Mt of ore per year, to produce a combined total of about 220,000 t of copper and zinc concentrates.

Fig. 1. Location map of Cayeli Mine.

DESCRIPTION OF THE MINING METHOD

The orebody is a steeply dipping volcanogenic massive sulphide deposit. The Cayeli Mine is accessed by a decline and serviced by a hoisting shaft.

The mining method applied at Cayeli has been designed for 100% recovery with complete pillar recovery. The mining method is transverse and longitudinal longhole, open and blind stoping with post-backfill. The mining method includes: driving sills for stope development; slotting and ring blasting; remote mucking; and bulkhead construction and filling (Fig. 2).

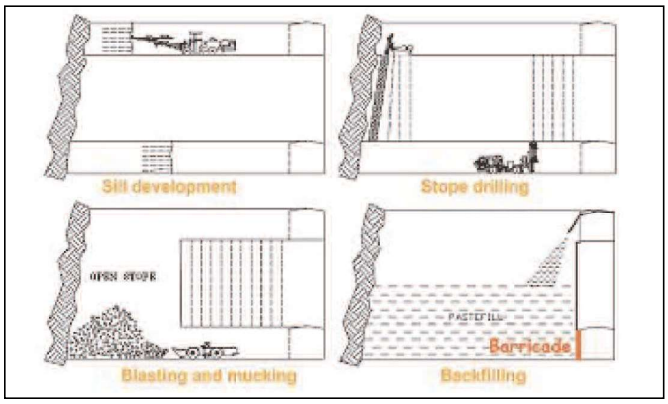

Fig. 2. Mining method at Cayeli Mine.

Cayeli stopes are small, averaging 6,000 t each with about 100 stopes being mined and backfilled each year. The stopes are generally 7.0 m to 10.0 m wide with stope lengths varying between 15.0 m and 30.0 m. The stopes are mined in single lifts between 15.0 m and 20.0 m high sublevels.

Backfill is an integral part of the mining method at Cayeli Mine. There are currently three types of backfill in use at Cayeli. These are waste fill using development waste rock, cemented waste fill, and paste fill. On average, Cayeli places about 250,000 m^3 of backfill annually. Paste fill constitutes about 150,000 m^3 per year.

PASTE FILL PROPERTIES

Cayeli uses full mill tailings to make paste fill. The tailings are very fine with a P90 of 63 microns. Depending on the mill feed rate and the ore blend, the material passing 20 microns can be 50% to 60%. Cayeli uses cement as a binder and fills primary stopes at an average cement content of 7% and secondary and tertiary stopes at 5% cement content. The slump varies between 175 mm and 190 mm, and the target design strength for vertical exposures is 1.0 MPa after 28 days curing using a safety factor of two.

BULKHEAD PROPERTIES AND FILL MANAGEMENT

Cayeli uses shotcrete bulkheads to contain freshly placed paste fill in open stopes. The bulkheads are large measuring 7 m wide and 5 m high. The bulkheads are made up of 300 mm thick shotcrete reinforced with 28 mm diameter rebars, which are tied to the 20 mm diameter rebar bolts.

There are limitations to the application of an arched shotcrete bulkhead at Cayeli due to the constraints imposed by the access geometry. The location of the sublevel haulage at the footwall/hangingwall contact provides a restricted area for the construction of a shotcrete arch. As a consequence, a planar, flat shotcrete bulkhead is required.

The original Cayeli shotcrete bulkheads were only designed for a maximum working pressure of 32 kPa. Fill placement was continuous and was managed by a restricting rate of fill rise to a maximum of 0.43 m per hour.

Subsequent to bulkhead failures that will be described later in this paper, significant changes were made to the barricade design and management of fill placement in order to ensure safe and efficient filling practices.

PASTE FILL BULKHEAD FAILURES

Since the start of paste backfill application, Cayeli Mine has built several hundred shotcrete bulkheads to retain paste fill in open stopes. To date, there have not been any shotcrete bulkhead failures in open stopes. In blind stopes, however, there have been a total of five bulkhead failures between 2003 and 2004. All of these failures were in relatively small blind stopes, i.e. stopes with no access at the top.

The first two failures occurred as a result of stope wall failure during filling. There was no injury, damage to property, or production loss.

The remaining three failures occurred during the late stage filling of blind stopes while they were being tight filled. The following sections will provide details of the last three failures.

BULKHEAD FAILURE 1

On December 28, 2003, a reinforced shotcrete bulkhead failed in stope S880 S07 (Fig. 3). Fortunately, there was no injury as there was nobody working in the vicinity when the failure occurred. The failure was very violent and resulted in severe damage to equipment and caused significant production delays.

The stope was a blind primary stope filled in two stages. The reinforced shotcrete bulkhead was constructed as per mine standards. The first stage was the plug containing about 347 m^3 of paste fill filled at a restricted rate of 31.4 m^3/h in order to limit height rise to 0.43 m/h (10 m/day). After two days of plug fill curing, the remaining 971 m^3 of paste was placed into the stope over 20 h of continuous filling at a rate of 45 m^3/h (0.62 m/h). The average cement content was 7.0% and the average slump

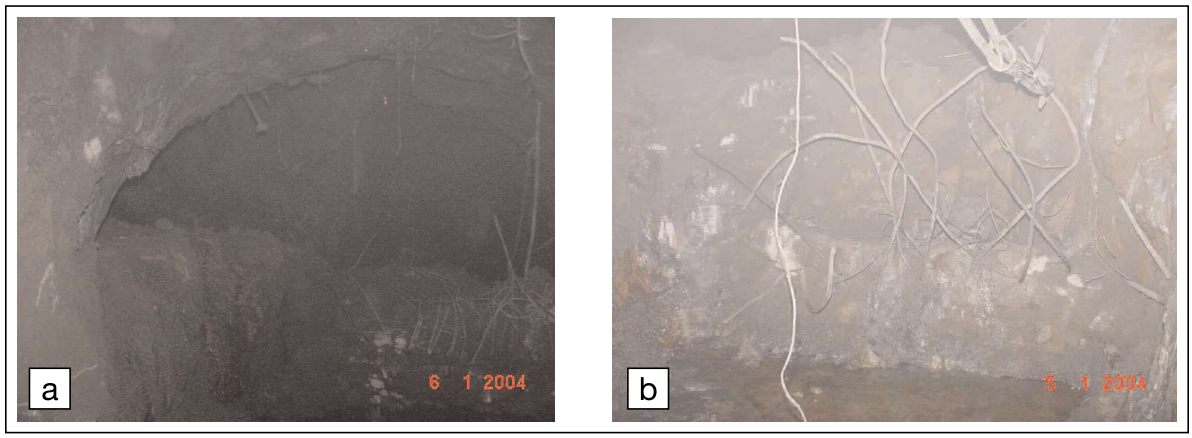

Fig. 3. Picture of bulkhead failure 1: a) looking into draw point; b) bulkhead remnants.

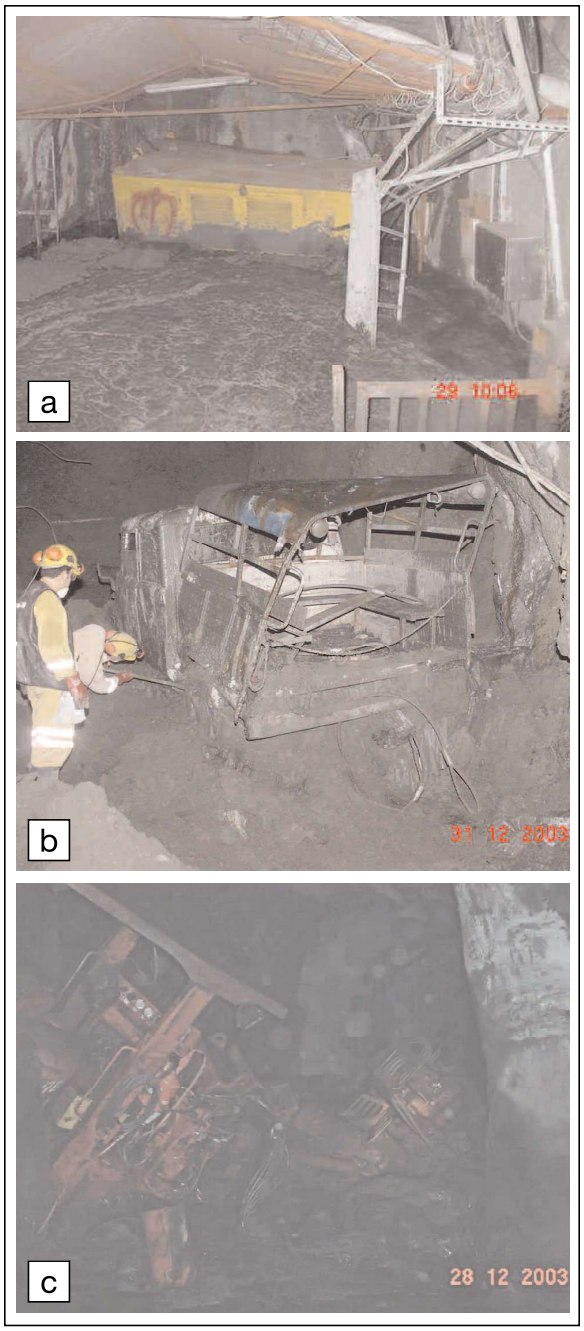

Fig. 4. Property damage caused by bulkhead failure 1: a) transformer; b) Fargo truck; c) Solomatic.

was 185 mm. The failure occurred at the final stage of tight filling. Filling was through a 102 mm diameter cased hole with no provision for a separate air breather hole.

Paste fill plant records showed that the stope was 'overfilled' by about 12%, based on a cavity monitoring survey (CMS), and adjusted production figures (it is normally difficult to reconcile excavated volumes and paste plant volumes). Furthermore, an increase in pipeline pressure was reported, indicating the likely presence of overpressure conditions during the tight filling stage.

The paste fill outflow caused major damage to a longhole drill parked 14 m away, in front of the S05 sill drift, to a pickup truck parked 35 m away, inside the S02 sill drift, and to a transformer located 50 m away, at the end of the 880 level cross-cut (Fig. 4).

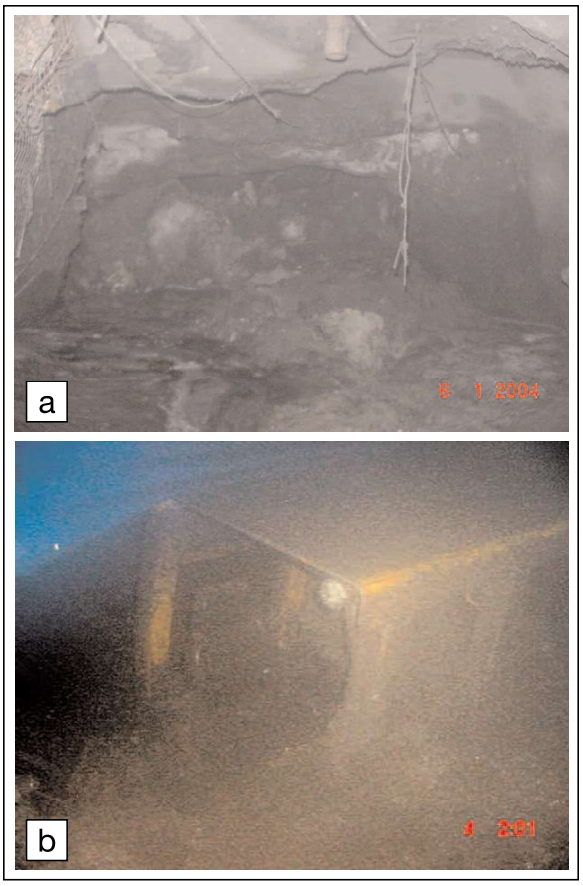

Fig. 5. Picture of the bulkhead failure 2: a) failed bulkhead b) truck caught up in paste fill inrush.

Post failure investigation concluded that the most likely cause of failure was overloading the bulkhead by 'overfilling' as a result of lack of a breather hole during tight filling of the stope.

BULKHEAD FAILURE 2

A paste fill bulkhead failed on January 3, 2004, in stope S900 CDN07E (Fig. 5). No people were injured but an ore truck was damaged and production delays occurred. The stope was a small blind primary stope with dimensions of 20 m long x 13 m high x 4 m wide. The bulkhead was constructed from a waste rock pile with shotcrete applied at the top and along the drift perimeter to prevent leakage.

A total of 1,370 m^3 of paste fill was pumped continuously into the stope with filling being completed in 30 h at an average fill rise rate of 0.56 m/h. The average cement content of the fill was 7.0% and the average slump was 185 mm.

Failure occurred at the final stage of tight filling. Paste returned from the breather hole indicating tight filling conditions.

Paste fill plant records showed that the stope was 'overfilled' by about 13%, based on CMS, and adjusted production figures. Also, an increase in

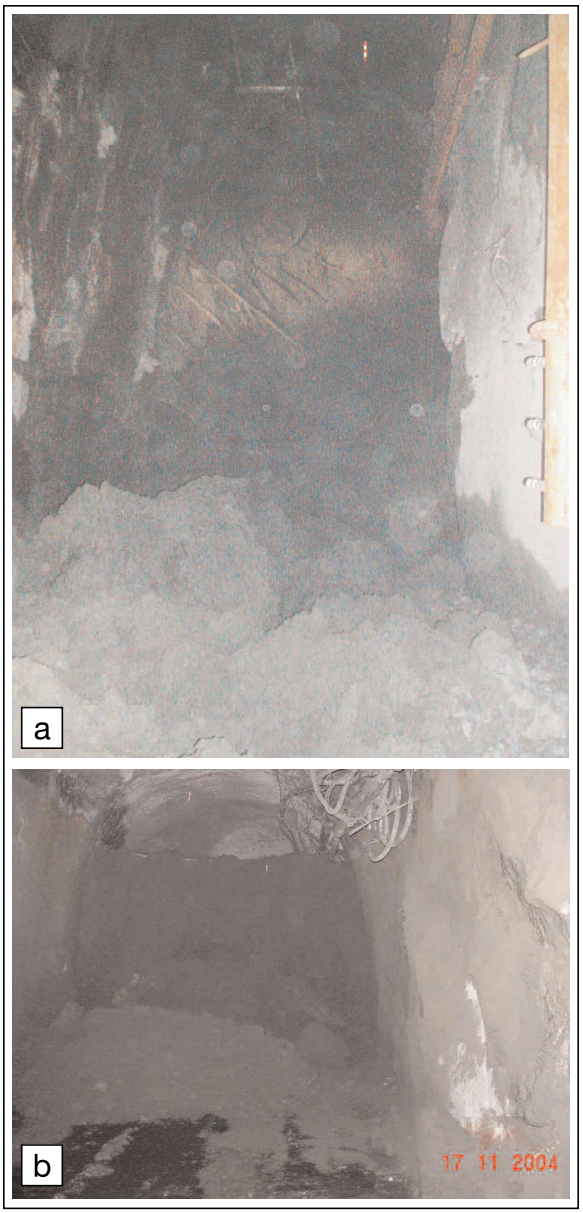

Fig. 6. Picture of the bulkhead failure 3: a) failed bulkhead b) height of paste fill inrush after cleaning.

pipeline pressure was reported, indicating likely overpressure conditions during the tight filling stage.

Post failure investigation concluded that the most likely cause of this failure was overpressure resulting from 'overfilling' due to a blocked air breather hole during the final stage of tight filling.

After these two consecutive failures, the filling strategy was changed to a safer practice. Filling is now staged, with the first stage being 2 m above the brow height (or to a 7 m fill height from the stope floor). Two days of curing time is required before the start of the second stage. The first stage plug acts as a bulkhead for the remainder of the fill and is intended to replace the bulkhead. A 127 mm diameter air relief hole cased with a 102 mm diameter steel pipe is drilled for blind stopes.

As well, the numbers of hitching rebars of the reinforced shotcrete bulkhead were increased. For waste muck pile bulkheads, the apex length was standardized to a minimum of 7 m with the face being shotcreted.

The strike access drifts were fenced off 50 m away from the bulkhead with a warning sign indicating ongoing paste filling.

BULKHEAD FAILURE 3

A shotcrete bulkhead failed on November 11, 2004, in blind secondary stope S880 S06 (Fig. 6). About two hours prior to failure, a roof bolter operator heard cracking noises from the bulkhead. He evacuated and fenced off the area and informed the shift engineer, but filling was continued and the bulkhead failed violently causing a major paste fill inrush. Nobody was injured but a roof bolter parked about 30 m away was dragged with the paste fill causing some minor damage. The inrush resulted in production delays due to blocked access to nearby active stope S860 S15.

The stope being filled was a relatively small blind secondary stope with a total volume of 1,393 m^3. The stope dimensions were 15 m long x 15 m height x 7.5 m wide. The filling was to be completed in three parts. The average paste fill rise rate was 0.43 m/h. Two 10 m long by 125 mm diameter holes were drilled for filling and air relief. First-stage filling was 700 m^3 for the 7 m high plug fill. Second-stage filling started after two days of plug fill curing. Final-stage filling started after two days of stage two curing. The average cement content of the fill was 5.4% and the average slump was 185 mm.

Post failure investigation revealed that the stope sidewalls and the stope brow were intact with some rebar anchors sticking out. The entire shotcrete bulkhead was ripped apart. The majority of the paste fill contained in the plug was not mobilized and was free-standing.

The air-breathing hole was choked with paste at about two metres away from the collar, indicating overpressure conditions. Paste fill plant records showed that the stope was 'overfilled' by about 9%, based on CMS and adjusted production figures.

It was concluded that the bulkhead was overloaded due to 'overfilling' during the tight filling stage. The observations indicated that the failure process was such that paste fill contained in the plug fill immediately adjacent to the bulkhead was progressively compressed during filling and was eventually squeezed out of the stope, subsequently pushing and ripping the bulkhead apart causing a sudden inrush of uncured paste fill.

Safety measures of filling procedures were firmed after that failure and a third stage was added to the fill placement sequence for the blind stopes. In order to eliminate the risk of over-pressurizing, the second stage was stopped at 90% of the stope volume and left for three weeks of curing before tight filling the stope at the third stage. The number of breather holes was increased to two.

More consideration is now given to monitoring the bulkhead and breather holes for the blind stopes. The bulkhead is monitored from the paste plant with a camera in addition to the one monitoring the draw point. A watchman was assigned to keep an eye on the air holes of blind stopes at the third stage.

Paste plant operators are instructed to stop when: there is a leakage from the bulkhead; paste comes out the air holes; 40 bar pipe pressure is observed; or when a 10 bar pipe pressure increase is monitored at the paste plant.

CAUSE OF BULKHEAD FAILURES

Bulkhead failure investigations revealed that in all cases, failure occurred in small and blind stopes during last stage of filling while tight filling. Furthermore, stopes were overfilled by about 10% and there were problems with air relief holes.

These bulkhead failures were attributed to one or a combination of the following factors: fast filling rate; continuous filling or inadequate plug fill cure time; 'overfilling' during the tight filling stage due to the absence, blockage, or inadequate use of air breather holes; lack of adequate fill management and fill monitoring controls; and inadequate bulkhead design.

PASTE FILL PRESSURE MONITORING TESTS

The Cayeli Mine initiated a paste fill instrumentation program after the bulkhead failures in order to ascertain bulkhead loads and to monitor the evolution of internal stresses in cemented paste fill during and after stope filling.

Three stopes were instrumented using total pressure cells and piezometers. The pressures induced in the paste fill (horizontal and vertical) and on the bulkhead (horizontal) were recorded during and after placement of paste fill.

DESCRIPTION OF PASTE FILL PRESSURE INSTRUMENTS

Instruments used for the tests consisted of total pressure cells, contact pressure cells, piezometers and a data logger. Total pressure cells were used to monitor stress change in the paste fill while the contact pressure cell was used to monitor load on the bulkheads. Piezometers were used to monitor pore water pressure in the paste fill.

The piezometers used for these tests were Geokon Model 4500S units. These piezometers had a filter head of 50 micron size and the pressure capacity was 350 kPa with an accuracy of ± 0.1% of full scale. The instrument had a built-in thermistor for measuring the temperature in the fill.

The total pressure cells used were Geokon Model 4800 units. The capacity of the total pressure cells used was 350 kPa with ± 0.1% of the full scale. They had built in thermistors for measuring the temperature during pressure recording.

These cells are designed to measure soil and backfill pressures on structures. The back plate of the cell, which bears against the external surface of the structure, is thick enough to prevent the cell from warping. The other plate is thin and is welded to the back plate in a manner that creates a flexible hinge to provide maximum sensitivity to changing soil or backfill pressures.

The contact pressure cells used were Geokon Model 4810 units. The capacity of the contact pressure cells used was 350 kPa ± 0.1% of full scale. They had built-in thermistors for measuring the temperature during pressure recording.

All of the instruments were connected to an eight-channel Canary Data Logging System for real-time recording. The sampling rate was set at five minutes and the readings were periodically downloaded to a lap top computer.

INSTRUMENTATION SETUP AND BULKHEAD CONSTRUCTION

In all tests, a 300 mm thick rebar-reinforced planar shotcrete bulkhead was constructed at the base of the open stopes. Figure 7 shows the instrumentation setup and Figure 8 shows the sequence for placement of instruments and construction of shotcrete bulkheads.

The pressure cells were placed at two locations within the stope—in the centre of the stope and behind the shotcrete bulkhead. Only horizontal pressure was monitored at the bulkhead. In the stope, vertical pressure and horizontal pressure along the length of the stope were monitored.

For pressure measurements in the stope, instruments were mounted on a rigid steel frame attached to a heavy metal box to prevent it from floating. The instrument frame was 1.2 m long, 0.60 m wide, and 0.60 m high.

A contact pressure cell was mounted at the back of a large steel plate (1 m wide, 1 m high, and 5 mm thick) in order to protect it from damage during shot-

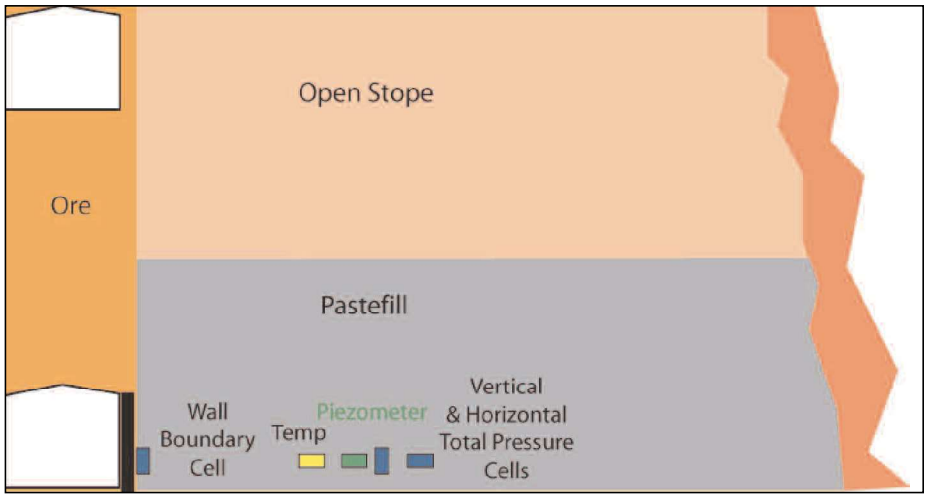

Fig. 7. Paste fill pressure instrumentation setup.

Fig, 8. Placement of instrumentation frame and construction of shotcrete bulkheads.

creting. The contact cell was installed in the centre of the shotcrete bulkhead at 0.5 m from the floor of the stope. No piezometer was installed at the bulkhead.

The stope floor was leveled and the frame was pushed into the stope in a bucket of a remote controlled LHD. All instrument lead wires were protected using 25 mm plastic hoses.

Table 1 lists summary information for the first three tests described in this paper.

TEST 1

The first instrumented stope was S860 S15, a primary transverse open stope exposing ore pillars on the north and south sidewalls. The stope was vertical in shape and was accessible from the overcut sill drift. The stope had an average width of 6.2 m, length of 19.5 m, and height of 19.5 m. About 5,000 t of ore were mucked from this stope in a period of 12 days.

TEST 2

Test 2 was conducted in stope S820 N07, a small blind secondary stope exposing paste fill at the back and on the sidewalls. The stope width was 8 m, the height was 17 m, and the length was 13.6 m. The total CMS stope volume was 2,185 m^3. Stope production was completed in eight days and about 3,000 t of ore were mined.

TEST 3

The third instrumented stope was S880 S13-P2, which is a part two primary transverse blind stope exposing ore pillars on the north and south sidewalls and paste fill on the footwall side. The stope had an average width of 7.0 m, length of 14.9 m, and height of 20.0 m.

PRESSURE MONITORING RESULTS

PRESSURE MEASUREMENTS

Table 2 lists a comparison of key parameters measured during all three tests. The peak pressure values were normalized maximum values recorded during the plug filling. In all three tests the filling rate was set at 0.35 m/h for direct comparison.

Table 1. Description of pressure monitoring tests

Description of the Tests	Test 1	Test 2	Test 3
Stope name	S860 S15	S820 N07	S880 S13P2
Stope type	Primary, open	Secondary, blind	Primary, blind
Average stope size	19.5 m L x 6.2 m W x 19.5 m H	13.6 m L x 8.0 m W x 17.0 m H	14.9 m L x 7.0 m W x 20.0 m H
Stope volume, CMS	2,185 m^3	1,862 m^3	1,546 m^3
Pressure instruments	Inside stope-middle	Inside stope-middle	Inside stope-3 m away
	Vertical cell @0.5 m	Vertical cell @0.7 m	Vertical cell @0.45 m
	Horizontal @0.8 m	Horizontal @0.45 m	Horizontal @0.45 m
	Piezometer @0.8 m	Piezometer @0.2 m	Bulkhead
	Bulkhead	Bulkhead	Contact cell @0.45 m
	Contact cell @1.8 m	Contact cell @0.45 m	Piezometer @0.45 m
Bulkhead size	7 m W x 5 m H	7 m W x 5m H	7 m W x 5m H
Bulkhead offset from brow	None	1 m	None
Bulkhead type	Shotcrete	Shotcrete	Shotcrete
Total paste fill pumped	2,500 m^3	2,044 m^3	1,778 m^3
Filling sequence	Single stage	Two stage	Two stage
		Two days plug cure	Seven days plug cure
Fill pausing time	8 hours	15 hours	1.5 hours
Total filling time	58 hours	54 hours	49 hours
Fill completion after	2.8 days	5 days	9 days
Average fill rate	42 m^3/h	37 m^3/h	36 m^3/h
Average fill rise rate	0.35 m/h	0.35 m/h	0.35 m/h
Slump	192 mm	192 mm	195 mm
Cement	7.43%	7.40%	7.05%

Table 2. Summary of pressure monitoring test results.

Measured Parameters	Test 1	Test 2	Test 3
Stope name	S860 S15	S820 N07	S880S13-P2
Stope type	Open	Blind	Blind
Peak bulkhead pressure	98 kPa	50 kPa	72 kPa
Peak vertical pressure	Not measured	90 kPa	90 kPa
Peak horizontal pressure	Not measured	75 kPa	90 kPa
Peak pore water pressure	100 kPa	53 kPa	53 kPa
Peak temp. - bulkhead	24-39°C (+15°C)	22-33°C (+11°C)	25-36°C (+11°C)
Peak temp. - stope	20-37°C (+17 °C)	21-37°C (+16 °C)	25-41°C (+16°C)
End of geostatic loading	10 hours (3.5 m)	6 hours (2.1 m)	4 hours (1.4 m)
Start of arching	20 hours (7.0 m)	12 hours (4.2 m)	18 hours (6.3 m)

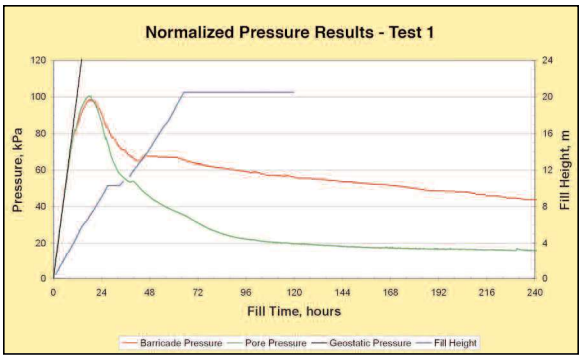

Fig. 9. Paste fill pressure results for test 1.

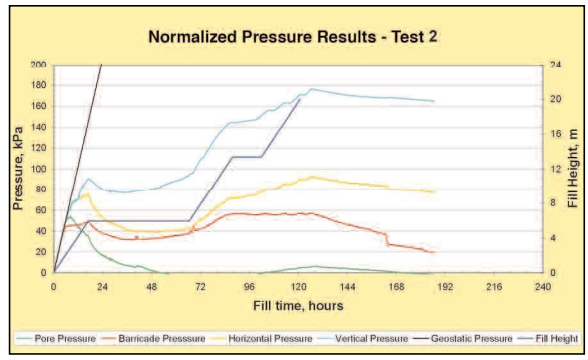

Fig. 10. Paste fill pressure results for test 2.

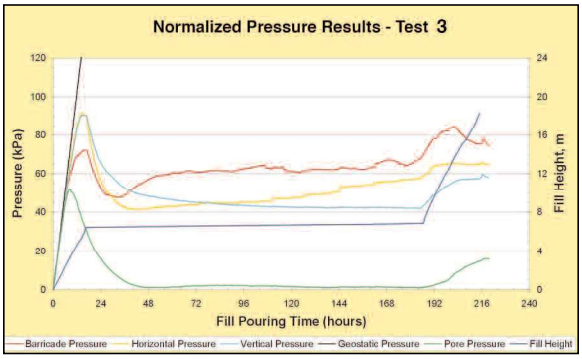

Fig. 11. Paste fill pressure results for test 3.

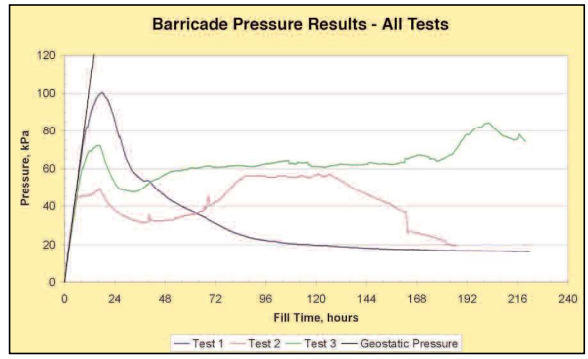

Fig. 12. Comparison of pressure results for all three tests.

Normalized bulkhead pressures for all three tests are plotted in Figures 9 to 12. Although the tailings, the slump, the cement content, and the vertical fill rise rates were the same for all three tests the measured bulkhead pressures were significantly different for each test.

From the three tests, the following common pressure development process can be noted:

- Initially measured paste fill pressures are equal and correspond to geostatic overburden load. This is observed during the first 4 h to 10 h corresponding to fill heights of 1.4 m to 3.5 m.
- Later pressures deviate from the geostatic pressures in response to dissipation of pore water pressure and continued cement hydration. This is through development of cohesive shear strength with time due to cement hydration.
- Continued filling pushes solids together creating effective stresses, which generates fill arching.
- Development of full arching starts after 12 h to 20 h corresponding to 4.2 m to 7.0 m fill height.

The bulkhead pressure in test 3 is lower than test 1 but higher than test 2. The marked difference could be due to a number of factors including different stope boundary conditions (primary or secondary), stope size and shape (stope height to width/length ratio), and geometry (bulkhead setback distance) and stope filling sequence.

Based on the test results, the following conclusions can be made:

- The filling regime has a significant effect on the bulkhead pressures.
- Continued single-stage filling generates higher bulkhead pressures.
- Staged filling with plug fill cure times generates lower bulkhead pressures.
- The longer the plug cure time, the lower the bulkhead pressures.
- Stope size has an effect on the bulkhead pressures.

The reasons for the relatively lower bulkhead pressures can be due to one or a combination of the following factors: stope boundary effects, i.e. shear resistance along fill-wall interface, lower pore water pressure due to limited drainage at the bulkhead, and temperature effects.

The stope aspect ratio (stope length divided by stope width) of test 3 is the average of the first two tests. Similarly, the measured bulkhead pressure is also the average of the first two tests. Stope size, therefore, plays a significant role in the bulkhead loads. The smaller the stope aspect ratio, the higher is the bulkhead pressure.

The following changes were made to the filling procedures in the light of the pressure monitoring tests, for safer and more efficient filling practice.

- Fill the 7 m (2 m above the brow) first-stage height (plug).
- Decrease the fill rate from 0.43 to 0.35 m/h in the first stage.
- Increase the curing time from two to seven days for the plug.
- Fill the rest of the stope omitting the third stage.

These rules are applied to all stopes regardless of type. The safety measures that were introduced for blind stopes to avoid over pressurizing continued to be effective. The Cayeli Mine also moved away from using any waste rock for constructing bulkheads. All bulkheads are now constructed from reinforced shotcrete.

The pressure generation process is very complex and site-specific. Paste fill pressures depend on many factors such as tailings properties (type, particle sizing, and specific gravity), paste fill recipe (slump, solids content, and cement type and content), filling rate, filling placement sequence, and stope size and geometry.

Prior to the bulkhead failures, Cayeli shotcrete bulkheads were only designed for a maximum working pressure of 32 kPa. Fill placement was continuous and was managed by restricting rate of fill rise to a maximum of 0.43 m/h. The pressure-monitoring results, however, indicated that bulkheads could in fact be subjected to up to 100 kPa, even at the restricted fill rise rate of only 0.35 m/h.

These pressure monitoring results and conclusions drawn may not be applicable to other mining conditions. Bulkhead pressures are very site-specific and any bulkhead design should be based on actual pressure monitoring results.

TEMPERATURE MEASUREMENTS

Each pressure instrument had a built-in thermistor, which measured temperature variations during and after filling. Figure 13 shows the paste fill temperature profiles at the bulkhead and inside stope for test 3. Based on the temperature measurements, the following general conclusions can be made:

- Except for the first test, the paste fill temperature inside the stope is higher than the one at the bulkhead.
- The rate of fill temperature increase at the bulkhead is lower than that measured inside the stope.
- The fill temperature inside the stope increases by about 16 degrees over five days.
- The fill temperature decrease after five days.
- The rate of temperature drop is slower and similar in magnitude both at the bulkhead and inside the stope.

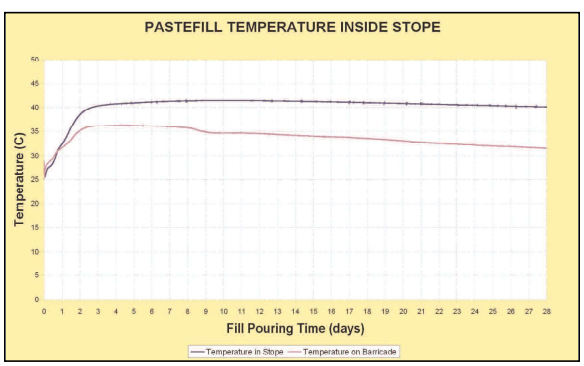

Fig. 13. Measured paste fill temperature profile for test 3.

Furthermore, ignoring the effect of nearby mining, the following temperature effects were observed from tests 2 and 3:

- During the plug cure time, pressures increase in response to temperature increase.
- After filling is completed, pressures drop in response to temperature drop.

Measured Cayeli paste fill uniaxial compressive strength values are typically less than 100 kPa at five days cure age. The temperature effects during the first five days will therefore be limited due to low deformation modulus of paste fill compared pressure cell stiffness. Measured pressure readings reported in this paper are therefore not corrected for temperature effects.

CONCLUSIONS

Paste backfill is an integral part of the mining method at the Cayeli Mine. Safe and efficient placement of paste fill requires a detailed understanding of paste fill characteristics, from the production stage to the final fill exposures.

Mobilization of uncured paste fill as a result of a bulkhead failure is a potential safety hazard and can lead to significant consequences, including endangering the safety of personnel, property damage, and production losses and delays.

Since inception of paste filling operations in 1999, there have been three major bulkhead failure incidents at Cayeli. Detailed descriptions of each of these incidents and their consequences have been provided in order to raise general awareness among backfill practitioners and mine operators about the potential risks associated with bulkhead failures.

Bulkhead failure investigations revealed that in all cases failure occurred in small and blind stopes during last stage of filling while tight filling. Furthermore, stopes were overfilled by about 10% and there were problems with air relief holes.

These bulkhead failures were attributed to one or a combination of the following factors: fast filling rate; continuous filling or inadequate plug fill cure time; 'overfilling' during the tight filling stage due to the absence, blockage or inadequate use of air breather holes; lack of adequate fill management and fill monitoring controls; and inadequate bulkhead design.

As a direct outcome of bulkhead failures, the Cayeli Mine moved away from using any waste rock for constructing bulkheads. All bulkheads are now constructed from reinforced shotcrete.

Cayeli Mine gained invaluable information about the development and magnitude of pressures inside and behind the bulkheads through a detailed field pressure-monitoring program. Cayeli instrumentation and monitoring program indicated that the loading conditions in the paste fill and the resultant lateral loads on the bulkheads are complex and are dependent on many factors, such as tailings properties (type, particle sizing, and specific gravity), paste fill recipe (slump, solids content, and cement type and content), filling rate, filling placement sequence, and stope size and geometry.

Based on the Cayeli pressure monitoring test results, the following general conclusions can be drawn:

- Despite the same fill recipes and fill rise rates used, bulkhead pressures were significantly different. The difference is attributed to different stope size and filling sequences.

- Continuous filling with no cure time leads to higher bulkhead pressures. This is due to the higher pore water pressure and slower pore water pressure dissipation with ongoing filling.
- At the same fill rise rate, staged filling results in lower bulkhead pressure. This is attributed to the higher fill strength in the plug fill. The rest time enables pore water pressure dissipation and longer fill cure times. The weight of ongoing filling is partially distributed to the stope sides as a result of arching.
- Temperature changes during cement hydration can have an impact on the pressure readings. Test results indicate that an increase in temperature increases pressure and a decrease in temperature decreases pressures.

Prior to the bulkhead failures, Cayeli shotcrete bulkheads were only designed for a maximum working pressure of 32 kPa. Fill placement was continuous and was managed by restricting rate of fill rise to a maximum of 0.43 m/h. The pressure-monitoring results, however, indicated that bulkheads could in fact be subjected to up to 100 kPa even at the restricted fill rise rate of only 0.35 m/h.

Based on the evaluation of pressure monitoring test results and findings from the bulkhead failures described in this paper, the Cayeli Mine has made the following design and operational changes in their paste fill system: revised shotcrete bulkhead design, new fill recipe, revised fill placement procedures, and new fill risk management and monitoring procedures. Site-specific new operating practices are now in place that allow safe and efficient fill placement.

To date, Cayeli has filled more than 50 blind stopes without any failure incidents. The new bulkhead design and fill placement sequence has therefore been proven to be successful.

Going forward, the Cayeli Mine is considering instrumenting every single bulkhead with a pressure cell, transferring the pressure data to the paste plant and filling until a threshold bulkhead pressure is reached. More pressure tests are planned for this purpose and they are ongoing. The mine is also looking to automatically monitor the airflow in blind stope breather holes as an indicator of potential over-pressuring.

In conclusion, this case study shows that only a combination of properly engineered bulkhead design, bulkhead construction, and better management of fill placement can provide safe and efficient filling practices. Furthermore, bulkhead pressures are very site-specific and any bulkhead design should be based on actual pressure monitoring results.

ACKNOWLEDGMENT

The authors would like to thank the management of the Cayeli Mine for allowing the use of the data and encouraging the publication of this paper. Thanks are also due to the mine and engineering staff for their help during the collection of the data. The authors are also grateful to the management of AMC Consultants for the motivation and help during the preparation of this paper.

Paper reviewed and approved for publication by the Minefill 2007 review committee.

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Murat Guresci received a B.Sc. degree in mining engineering from Hacettepe University, Ankara, Turkey, in 1999. After graduation, he worked as a shift engineer at Bauholding Strabag AG in the construction of the Muratli Dam & Hydro Electrical Power Plant in Artvin, Turkey, prior to joining Cayeli Bakir Isletmeleri A.S. (Inmet Mining Corporation) in 2003 as a rock mechanics engineer.

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Appendix M
SRK Consulting – Waste Fill Fence Design for Paste Fill (Rock Barricade)

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Memo

To:	Lyle Morgenthaler	**Date:**	February 12, 2018
Company:	Pretium Resources Inc.	**From:**	Denis Thibodeau
Copy to:		**Project #:**	5CP007.000
Subject:	Waste Fill Fence Design for Paste Fill		

Introduction

Pretium Resources Inc. (Pretium) requested SRK Consulting (Canada) Inc. (SRK)'s assistance in the design of a fill fence used as a barricade for paste fill of mined stopes at its operating Bruce Jack Mine. The fill fence would be constructed with waste rock material generated from development extraction. Pretium's mining method consists of either transverse or longitudinal long hole stoping. SRK is to provide a waste fill fence design to meet the current requirements for shotcrete fences when 200 KPa of lateral pressure is applied.

Methodology

To design a waste fill fence for application at the Bruce Jack Mine, the fence demand must first be understood. The demand consists of the lateral pressure applied by the paste fill column on the fence. Pretium's current practice is to pour a paste fill plug at 11 % binder reducing over time to original design specifications to a maximum height of 10 m and pour the remainder of the stope with 6.4% binder. The initial design for shotcrete fences considers a maximum lateral pressure of 200 KPa.

Therefore, calculation was made for 200 KPa lateral pressure (Pa).

The capacity of the waste fill fence will depend on the shear resistance of the waste material against the lateral pressure from the paste fill column. The resisting contributing force must take into account the shear against the floor and the walls of the drift. The friction against the back is not considered due to poor contact between the waste barricade and the back. It is expected that the friction between the waste, and the walls, floor and back of the drift, will be greater than the internal friction of the waste due to drift profile irregularities, therefore the internal friction of the waste material will be assumed for the calculations.

According to Aubertin et al, 2009 considering a worst case scenario of waste fence being fully saturated with water, the fill fence requirement is calculated as follows:

Equation 1: $\mathbf{L} = \frac{\mathbf{p}}{\boldsymbol{\lambda}}$

Where:

L is the required length of waste fence
P is the maximum lateral pressure: 200 KPa

l is equal to Equation

Equation 2: $\boldsymbol{\lambda = \mathrm{Tan}\varphi K_R\left(\gamma_\omega h + \frac{\gamma_s - 2\gamma w}{3} h\right) h}$

$$+ \mathrm{Tan}\varphi\left(\gamma_w h + \frac{\gamma s - y_w}{2} \cdot h\right) w$$

$$+ \mathrm{Tan}\varphi K_R \gamma w\left(\frac{h^2}{3}\right)$$

Where:

γw Is the unit mass of the waste fill: 1,800 kg/m^3 (Pretium internal communication)
γs Is the unit mass of the saturated waste fill: 2,050 kg/m^3 (assuming 25 percent void) – unit weight of water 1000n/m^3)

h is the height of waste material corresponding to drift height of 5 m (Pretium internal communication)
f is the internal friction angle of the waste material: 30°

K_R is a coefficient of friction $= \frac{1-\sin\varphi}{1+\sin\varphi}$

Therefore, for a maximum lateral pressure of 200 KPa the fill fence barricade with a safety factor of 1.4 = 0.77 m.

Conclusion

Based on the waste material characteristics, and the lateral pressure expected and/or measured on the current shotcrete fill fence provided by Pretium, the length of the waste fill fence was calculated for 200 kPa. The minimal length of waste fill fence calculated is 0.77 meter. The field length requirements are set to 5 meters from toe to toe. A minimum 1 meter length of waste and/or shotcrete must be in contact along the back of the drift due to variable inherent to the waste material. Shotcrete is required for gap filling between the waste pile used to create the fence and the back of the mucking drift. The provided waste fill length is valid only for a paste fill plug pour to a maximum height of 10 m above the stope floor. The plug must cure to withstand a 20 meters high fill pour for the remainder of the stope. To minimize leakage, the toe of the waste pile must be shotcreted with a minimum 50 mm thick coat. The plug pour is required since the waste fill fence design provided will not resist the lateral pressure generated by the full column height of the paste fill of 30 m. For the Bruce Jack Mine, the waste fill fence is designed for a maximum lateral pressure of 200 KPa.

Recommendations

SRK recommends the following:

1. Use a minimum 5 m length waste fill fence from toe to toe.
2. Ensure a minimum contact of 1 m in the back.
3. Fill any gap between the back and the waste fill fence with shotcrete
4. To avoid leakage cover the toe of the barricade with shotcrete with a minimum thickness of 50 mm.
5. While pouring plug follow SOP BRUCEJACK-UND-SAF-004.

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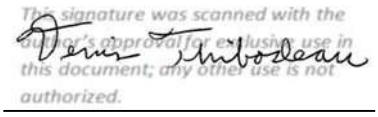
Regards

SRK Consulting (Canada) Inc.



Denis Thibodeau. PhD, PEng
Principal Consultant (Geomechanics)

Reviewed by: Tim Coleman, Principal Consultant

Appendix N
BJ-ENG-SOP-033 Rock Barricade Construction

Objective

The objective of this procedure is to provide direction, information, and controls for rock barricade construction to build and maintain the integrity of the earth fill structure throughout the stope paste backfilling process.

Ensure all workers understand the hazards and are qualified with the skill and competency needed to be working in a responsible and safe manner near the open stopes.

Scope

As longhole stopes are mined out, barricades are erected to dam stopes for paste backfill deposition. Rock barricades (also referred to as “muck barricades”) and Shotcrete Arch Fill Fence (SCAFF) barricades are the two methods employed at Brucejack mine. Rock barricades are chosen for most stopes, owing to the reduced time and cost required to construct them. The construction of these rock barricades is the subject of this SOP.

Additionally, monitoring instruments such as Total Earth Pressure Cells (TEPC) are occasionally installed in stopes with rock barricades specified for construction. The specific complications associated with the installation of these sensors is also covered in this procedure. Proper installation is critical to the collection of data to further our understanding of paste backfill pressures. This has potentially significant impacts on process improvement and cost savings.

This standard operating procedure will be applied by all personnel who are involved in the process of barricade design, material handling, preparation work, construction, and inspections, including both Pretivm employees and subcontractors, to ensure the construction of robust rock barricades.

Health, Safety & Reclamation Code of BC

- Working Conditions – 1.9.1
- Examination of Workings – 6.4.1
- Workplace to be Hazard Free – 2.2.1

Definitions

- Rock Barricade – the earth gravity structure which is constructed in front of draw points to contain the paste in stope.
- Open Brow – the interface between the stope void and the draw points
- LHD (scoop) – a machine used to load, haul and dump the muck into another location.
- PPE – Personal Protective Equipment
- CMS – Cavity Monitoring System
- TEPC – Total Earth Pressure Cells, an instrument to monitor the pressure of the paste.
- SCAFF – Shotcrete Arch Fill Fence, an alternative stope barricade option.
- Metal frame – a customized angle steel piece which is designed to accommodate TEPC instrument(s).
- Limited Zone – the area between 2m from the brow/edge and beginning of the respective safe zone for equipment only (no personnel).

Preparation

Hazards

- Energized equipment
- Poor visibility
- Potential bouncing rock from in-stope, sloughing rock from muck pile

- Poor ventilation
- Barricade failure
- Ground failure
- Tripping / slipping hazards

Tools

- Underground LHD loader
- Rammer Jammer
- Underground Rock Truck
- Telehandler
- Spray paint
- PPE – hardhat, safety glasses, miner's belt with W65, safety boots with metatarsal protection, and hi-visibility coveralls.

Requirements

- Underground operators, engineers, Procon supervisors must review this SOP and drawings issued by site geotechnical team before commencing rock barricade construction.

Responsibilities

Mine Manager

The Mine Manger is responsible for:

- Ensuring this procedure is implemented and maintained.

Geotechnical Engineer

The Onsite Geotechnical Engineer is responsible for:

- Inspecting the ground condition at the draw point and surrounding area.
- Marking up the location of the rock barricade(s).
- Developing a drawing with specifications for the rock barricade construction.
- Communicating the design drawing with the underground personnel and Procon supervisors.
- Implementing this procedure.
- Conducting field inspections after each stage is completed to ensure it meets specification.
- Working together with underground operations personnel as needed during TEPC installation.

Procon Supervisors

Procon Supervisors are responsible for:

- Ensuring that stope has been signed off as complete by Pretium geologists and CMS scan is also completed.
- Implementing this procedure with the combination of design drawing issued by onsite geotechnical engineer.
- Assigning this task to a more experienced operator, or spending adequate time training, checking up on, and verifying the work of less-experienced barricade construction operators.
- Reviewing the potential hazards with underground operations personnel.
- Checking that underground operations personnel are adhering to the procedures.

Underground Operations Personnel

Procon Underground Operations Personnel are responsible for:

- Adhering to this procedure at all times.
- Performing visual ground condition inspections, equipment pre-shift inspections, and PPE inspections.
- Safely operating LHD, Rammer Jammer and telehandler, when needed.
- Keeping all barricades and signage properly placed and maintained.
- Stopping work and retreating to a safe area if conditions are changed.
- Immediately reporting any substandard ground conditions to their supervisors.
- Asking for clarification from supervision if they have questions or concerns.
- Ensuring that the integrity and dimensions of the rock barricade built meets the standard of the design.
- Ensuring that the TEPC instrument wires are protected and undamaged during sensor installation and subsequent rock barricade construction.

Health and Safety Manager

The Health and Safety Manager and their designate(s) are responsible for:

- Monitoring the implementation of this procedure.
- Maintaining training records.

Job Step

Regular Rock Barricade Construction:

Step 1:

Onsite geotechnical engineer will inspect the walls, back, and open brow ground condition and break through holes from stope before marking up the location of the rock barricade. Figure 1 illustrates the example of how the location of the tight back and the toe line will be marked up in the field. A detailed and design-specific drawing for the rock barricade construction will be issued to Procon supervisors and underground operations personnel.

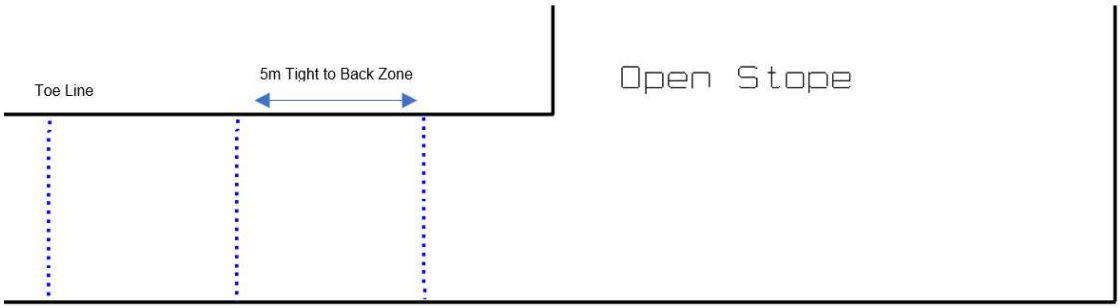


Figure 1

Step 2:

To start off the construction with waste rock as shown in Figure 2, use LHD scoop to dump muck close to the brow of stope and build up the pile; use rammer jammer to push muck towards the first line of the tight back.

Then dump some finer rocks or paste materials to build the thin layer against the initial muck pile. Ensure it is also tight to back as much as possible.

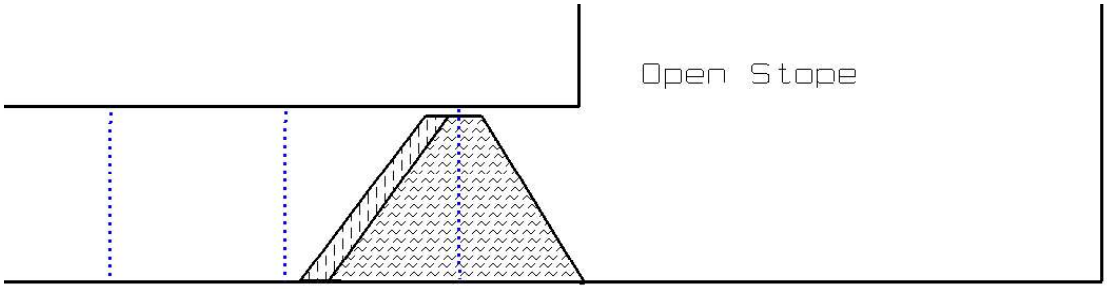


Figure 2

Step 3:

Continue with the rock barricade construction with waste rock. Use the rammer jammer to ensure the total distance of tight back is 5 m. Ensure the toe of the rock barricade has reached or slightly exceeded the toe line which was marked up by geotechnical engineer. The maximum gap distance between back and rock barricade is less then 6 inches. Onsite geotechnical engineer will conduct the first visual inspection once this step is completed.

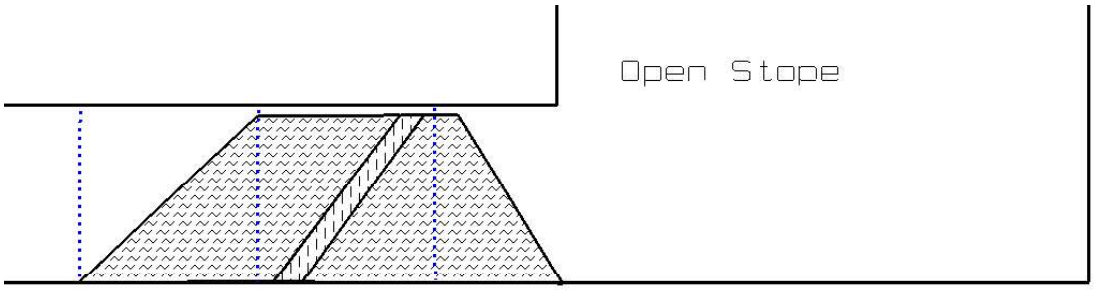


Figure 3

Step 4:

Upon approval from onsite geotechnical engineer, apply a 5 cm (2”) thick layer of shotcrete to cover the face and top gap of rock barricade. 24 hours curing time is required. Onsite geotechnical engineer will conduct the final visual inspection.

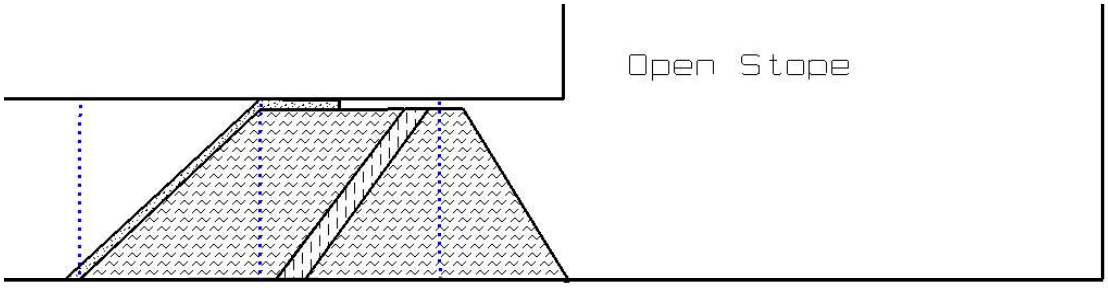


Figure 3

Step 5:

Ensure to place safety berm catchment as well as proper signage and barricade after rock barricade construction and shotcrete are complete. Only if both final inspection and cured shotcrete are met, paste filling can be started.

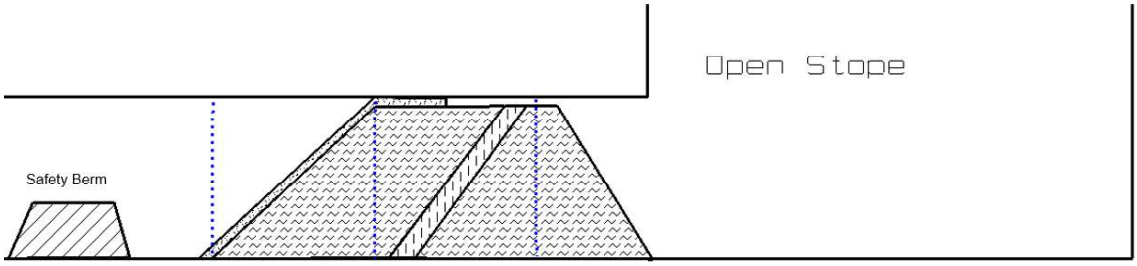


Figure 4

Step 6 (Optional Step 1):

In the case muck berm tight back is less than 3m due to short distance from stope brow to main drift, intersection for other cross cuts and/or hammer head drifts for resue drilling, initial muck berm should be built with tight back from brow to the intersection as much as possible then apply a 5 cm (2”) thick layer of shotcrete to cover the face and top gap of rock barricade. 24 hours curing time is required. Onsite geotechnical engineer will conduct the visual inspection on shotcrete condition. Minimum 200 ton of additional muck need to be placed in front of SC sprayed berm to provide additional load against paste fill pressure.

Step 7 (Optional Step 2):

In the case muck berm tight back is less than 3m and equipment resources are not available for Step 6 (Optional Step 1), maximum stand-off distance need to be estimated by Geotechnical Engineer based on estimated sill paste volume and Mine Production Engineer should check possible damage of underground infrastructure within stand-off distance. This step only can be conducted under approval by Pretivm Mine Superintendent.

Rock Barricade Construction with Total Earth Pressure Cell (TEPC) Instruments Installation:

Both underground operation personnel and onsite geotechnical engineer must establish good communication about materials handling, instrument installation and rock barricade construction process beforehand. In addition, both parties should be present during construction. The detailed steps are as follows:

Step 1:

Geotechnical engineer will check to see if the instruments planned for installation function in the main office with the data loggers. Ensure to record the instrument IDs as well as apply calibration factors as possible before leaving the office.

Step 2:

Instrument wires need to be covered with 1.5’’ yellow service hose or PVC pipe by connecting to the instrument wires with a master cord, then pulling out from the other end. The PVC pipe should be flushed against the instrument with some slack as do not want to apply too much tension on to the wires. The required length of PVC pipe is at least 15m. This is to prevent rock damage to the fragile instrument wires during the construction.

The data logger and wire spool should be situated in a safe location for readings away from the line of fire, and an area where it may not get damaged by equipment or personnel (labelling is key).

Place the metal frame with instrument about 4-5m passing the brow into the open stope by using a telehandler with forks and ensure the ground chosen for placement is solid and even. All installations and preparation work must be done in a safe zone.

Run the PVC pipe with caution through the back and extend it further to the toe line (Figure 6); hang it on the screens with straps, securing the pipe to the screen every 1-2 m. All wires should be protected, properly labelled and the metal frame sitting rigidly on the flat ground inside the stope. At this point, start pushing muck and build the first pile. It's important to build the initial pile with caution as muck rolling over and into the stope may hit the metal frame and/or damage the instrument. Use rammer jammer to push muck towards the first line of the tight back.

Dump some finer rocks or paste materials to build a thin layer of fines against the first stage of muck pile as shown in Figure 6. Ensure this and the coarser muck beyond it is as tight to the back as possible.

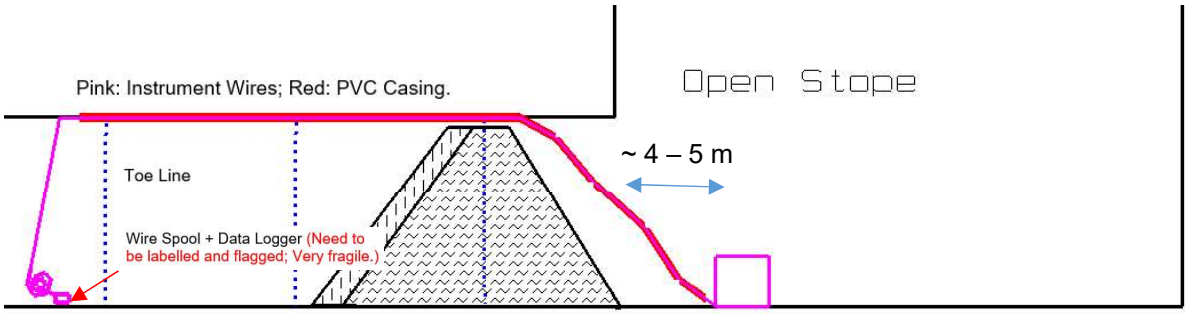


Figure 6

Step 3:

Continue with the rock barricade construction. Use the rammer jammer to ensure the total distance of tight back is 5 m or greater. Ensure the toe of the rock barricade has reached or slightly exceeded the toe line which was marked up by geotechnical engineer. The maximum gap between the back and the top of the rock barricade is 6 inches (Figure 7). Onsite geotechnical engineer will conduct the first visual inspection once this step is completed. If any worry exists, one can verify the sensor wire integrity with the datalogger(s) now as well.

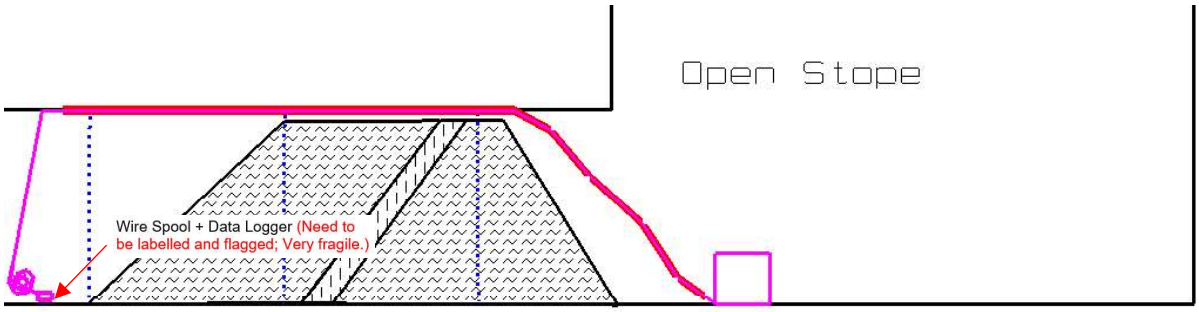


Figure 7

Step 4:

Upon approval from onsite geotechnical engineer, apply a 5 cm (2") thick layer of shotcrete to cover the face and top gap of rock barricade (Figure 8). Avoid spraying shotcrete to the exposed wires without PVC casing protected as they are fragile. 24 hours curing time is required. Ensure to place safety berm catchment as well as proper signage and barricade after rock barricade construction and shotcrete are complete.

Onsite geotechnical engineer will conduct the final visual inspection. Only if both final inspection and cured shotcrete are met, paste filling can be started. Geotechnical engineer will also ensure that the instruments are set to start the data collection by using data logger, including verifying that the correct unit and calibration factors are applied.

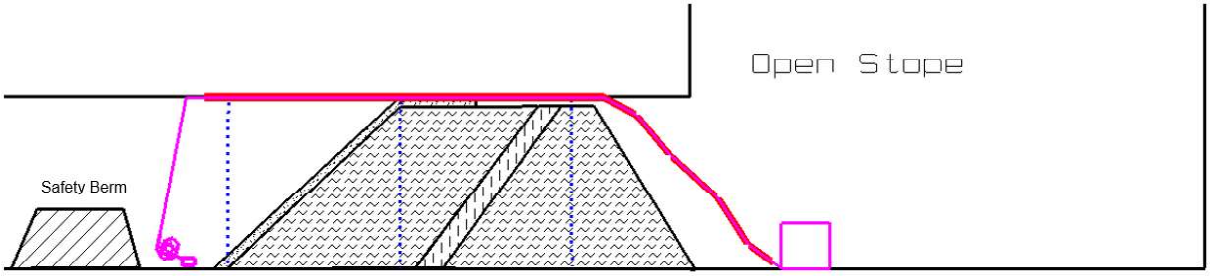
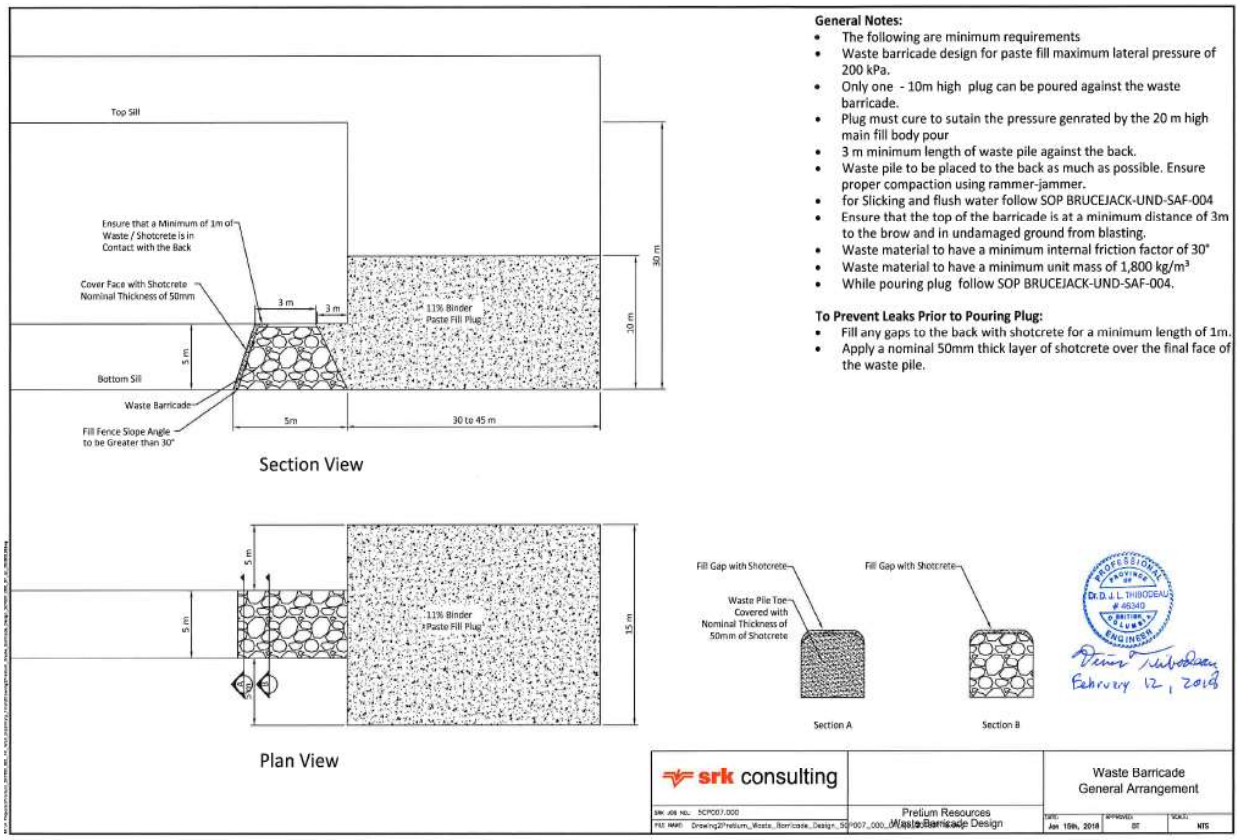


Figure 5

Engineering Design

Muck Berm Barricade Design:



Relate Documents

Manual

- Brucejack Backfill Management Plan Rev. 1 (AMC, 2018)

SOP

- BJ-PBF-SOP-553 Paste Plant Shutdown Procedure
- BJ-PBF-SOP-558 Casting of Cylinders for Strength Test
- BJ-PBF-SOP-559 Determination of Unconfined Compressive Strength for Cylinders
- Brucejack-UND-EXP-006 Underground Backfill Line Cleanout

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
Nov.19, 2020	Revised Job steps details and figures	YC	
Jan.29, 2021	Revised job steps and added design drawing and references following M-243 permit requirements	WS	

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Appendix 3-4: Brucejack Gold Mine: Updated Subaqueous Waste Rock Dump Design

Brucejack Gold Mine: Updated Subaqueous Waste Rock Dump Design

Prepared for

Pretium Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
1CP026.000
October 2018

Brucejack Gold Mine: Updated Subaqueous Waste Rock Dump Design

October 2018

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1 Introduction

1.1 Overview of Proposed Production Increase

Pretium Resources Inc. (Pretivm) is proposing to increase the authorized Brucejack Gold Mine ore production rate from an annual average 1.0 Mt to 1.4 Mt (i.e., average 2,700 tpd to average 3,800 tpd). The production increase application also reflects an increase in the mine ore reserves, from 16.5 Mt for the 2015 MA-EMA Permits Application, to 18.5 Mt. The increase in the ore production rate will reduce the mine life from 18 years as predicted in 2015, to approximately 14 years, with the ore reserve increase slightly offsetting the mine life reduction.

Also integral to the applications is that Pretivm is seeking authorizations for the flexibility to direct waste rock to either Brucejack Lake, or as backfill in the underground mine, depending upon operational needs. Specifically, Pretivm is applying for authorizations to deposit between 36% and 100% of future waste rock in Brucejack Lake, to provide operational flexibility for mine waste deposition. These percentages of waste rock to be deposited subaqueously are based on the following two scenarios:

- Scenario 1, which assumes that all waste rock going forward (5.3 Mt) and 50% of the tailings (8.7 Mt) would be deposited subaqueously in Brucejack Lake, with the remaining tailings (8.7 Mt) paste backfilled in the underground mine; and
- Scenario 2, which assumes maximum backfilling of waste rock in the underground mine (3.4 Mt), with the remaining 1.9 Mt deposited in Brucejack Lake. Consequently, significantly less tailings would be backfilled as paste in the underground mine (5.5 Mt; 32% of total generated).

The approach in evaluating these scenarios is that if both waste rock deposition extremes are acceptable for a given assessment, any ‘in-between’ waste rock deposition would also be acceptable. Build-out figures, illustrating both Scenario 1 and 2, are presented as Figure 1 and Figure 2 respectively.

1.2 Scope

SRK Consulting (Canada) Inc. completed the original subaqueous waste rock and tailings deposition design and management plan included as Appendix 6-O of the 2015 Brucejack Gold Mine MA/EMA Permits Application (Pretivm 2015). This management plan is consistent with the waste rock and tailings deposition design report produced by SRK (SRK 2016a). SRK has acted as Engineer-of-Record (EOR) for the waste rock dump (WRD) since the start of construction in 2016 and continues to act in that capacity at the time of writing this report.

This report provides a design update of the WRD taking into consideration the proposed production increase. It demonstrates that the proposed increased deposition scenarios would not impact the overall WRD performance, and that the WRD procedures as outlined in the current dumping Standard Operating Procedure (SOP) (SRK 2017, Appendix A-1) remain valid. It furthermore demonstrates that the current Quantifiable Performance Objectives (QPOs), as outlined in the current Operations, Maintenance and Surveillance (OMS) Manual (SRK 2017) remain appropriate to ensure safe operation and overall stability (short and long term) of the WRD.

2 Historic Waste Rock Dump Design

2.1 Previous Design

The previous WRD design is documented in SRK (2016a), which is a comprehensive tailings and WRD design report prepared by the EOR. Specifically, this design report includes an Appendix (Appendix C; SRK 2014) which documents the Brucejack WRD stability and settlement analysis. This analysis takes into consideration site specific physical characterization of the lake bed sediments, the lake bathymetry, and measured lake bed sediment thickness.

This design report also includes another Appendix (Appendix A, SRK 2015a) that describes the rheological properties of the tailings. These data confirm that based on physical characteristics of the tailings, the tailings is predominantly silty-sand, while the lake-bed sediments range from sands to fine clays, including silty-sands. Although WRD stability analysis was not completed assuming tailings as a foundation material, the range of lake bed sediment properties used in the analysis more than adequately covers the tailings material behaviour.

2.2 Design Criteria

No prescribed stability requirements are available for subaqueous waste rock deposition in British Columbia (or globally). However, the “Mined Rock and Overburden Piles Investigation and Design Manual” (BCMWRP 1991) can be used as a starting point to inform a possible minimum acceptable Factor of Safety (FoS).

Table 1 presents the recommended FoS, based on levels of confidence in the understanding of site conditions, material parameters and the consequences of instability in accordance with BCMWRP (1991). In the context of the Brucejack WRD, Case B is considered the most representative case.

Table 1: BC (Subaerial) Mined Rock and Overburden Pile Minimum FoS Guidelines

Stability Conditions	Suggested Minimum Design Values for FoS	
	Case A	Case B
Stability of Dump Surface		
Short-term (during construction)	1.0	1.0
Long-term (reclamation – abandonment)	1.2	1.1
Overall Stability (Deep Seated Stability)		
Short-term (static)	1.3 – 1.5	1.1 – 1.3
Long-term (static)	1.5	1.3
Pseudo-static (earthquake)	1.1 – 1.3	1.0
1. Case A • Low level of confidence in critical analysis parameters • Possibly non-conservative interpretation of conditions or assumptions • Severe consequence of failure • Simplified stability analysis method (charts, simplified method of slices, etc.) • Stability analysis method poorly simulates physical conditions • Poor understanding of potential failure mechanism(s)		
2. Case B • High level of confidence in critical analysis parameters • Conservative interpretation of conditions, assumptions • Minimal consequence of failure • Rigorous stability analysis method • Stability analysis method simulates physical conditions well • High level of confidence in critical failure mechanism(s)		

2.3 Previous Design Analysis Results

The previous design confirmed that physical stability of the Brucejack WRD results in inherently low FoS' when compared to BCMWRP (1991). Fundamentally, it was determined that the active dumping face of the Brucejack WRD remains in a quasi-stable state with a FoS near unity for a period of weeks to months depending on the thickness of the unconsolidated undrained and highly variable lake bed sediments, until sufficient pore pressure dissipation has occurred to allow the WRD foundation to carry the load of the WRD and remain stable.

2.4 Design Approach

Because the design analysis confirmed that a conventional FoS approach, based on numerical analysis would not allow for construction of the WRD, the observational method (Terzaghi and Peck 1967, Peck 1969) was adopted as the design approach for the Brucejack WRD. This method was developed from the need to avoid highly conservative assumptions about ground properties in geotechnical design when faced with unavoidable uncertainties of natural ground conditions. It takes advantage of observations and data gathered during construction to adapt the design to actual ground conditions in an orderly and planned way. Implementation of this approach in the context of the Brucejack WRD requires the following:

- Conduct numerical analysis to establish behavioral bookends;

- Develop monitoring requirements to allow behavioral tracking;
- Develop and implement safe operating procedures for WRD construction;
- Develop QPOs to inform safe operating procedures;
- Conduct ongoing monitoring and reanalysis as necessary; and
- Continuously revisit and update safe operating procedures as necessary.

As a result, strict operational controls were set to ensure safe WRD construction. This rigorous dumping procedure allows for sufficient safe preloading of the foundation, subject to continuous monitoring and review by a qualified geotechnical site engineer, with ongoing oversight by the EOR, and annual independent geotechnical inspections by an external geotechnical engineer. This dumping procedure is independent of the lake bed sediment thickness or strength, because it is based on the assumption that the foundation cannot initially carry the load whether it is due to sediment thickness or strength (or both). This is documented in the OMS Manual (SRK 2017) which includes the current SOP (SRK 2017, Appendix A-1).

3 Historic Waste Rock Dump Performance

Consistent with the observational approach, the OMS Manual and the dumping SOP are living documents which has been updated multiple times as the WRD behaviour understanding is improved. Specifically, three incidents, as described below has resulted in changes over the life of the WRD construction. Other factors that have resulted in changes to the dumping procedures include routine operational efficiency reviews, such introduction of the stacker system.

3.1 October 2015 Incident

On October 11, 2015 a substantial foundation failure occurred during construction of the WRD. A follow-up investigation (SRK 2015b) confirmed that failure was most likely a complete foundation (i.e. bearing capacity) failure as a result of loading the foundation too fast, thereby not allowing sufficient preloading time for pore pressures to dissipate. The dumping rate at the time was in excess of 10 times that recommended in the design.

A subsequent back analysis of the failure (SRK 2015c) confirmed the failure was a foundation failure and the foundation sediment types were a normally consolidated fine grained silty material. During rapid loading of the dumping face, the silty sediments reached their maximum shear strength under undrained conditions. Very importantly, the back-calculated material properties were in good agreement with the values of the undrained shear strength of the silty and clay materials used in original design (SRK 2014) providing confidence in the expected design performance.

3.2 April 2016 Incident

A fairly substantial outer slope sloughing failure of the WRD occurred on April 3, 2016. A thorough investigation of this failure (SRK 2016b) concluded that multiple different factors likely contributed to the failure, but that fundamentally the failure mode was expected and consistent with the original dump design (SRK 2014). Importantly, a crusher that was temporally installed and operated near the WRD face was believed to be at least in part responsible for the failure. The incident led to minor refinements of the dumping SOP, the most significant being increasing the overall crest setback distance.

3.3 June 2016 Incident

On June 6, 2016 a substantial portion of the WRD sloughed and almost breached the pre-loading berm that demarcates the deemed safe zone (i.e. setback distance) of the dump. Detailed analysis of the incident revealed (SRK 2016c) that because surface rock excavation for mine construction was almost complete by that time, the waste rock composition had changed to consisting predominantly of underground mine muck. The underground mine muck contains significantly more fines than the surface waste rock (partly due to different blasting techniques in the underground mine compared to surface), and those fines affect the overall dump behaviour. This incident resulted in Pretivm adjusting the dumping strategy to include a conveyor stacker, and subsequently adjusting the dumping SOP (SRK 2017, Appendix A-1) to allow mine muck smaller than 8 inches to be dumped using the stacker, while larger materials are dumped in accordance with the original dumping SOP. Pretivm continues to evaluate alternatives to stacker use, and if suitable alternatives are identified in future, Pretivm would seek to revise the OMS Manual (SRK 2017) as applicable.

4 Updated Waste Rock Dump Design

Consistent with the observational approach, SRK has revisited the WRD design to confirm whether the proposed expansion would result in any changes to the safe operation of the WRD, and whether the current OMS Manual, SOP and associated QPOs require modification. This section of the report describes the numerical analysis that was completed to assess the WRD stability in its current state, as well as in future as the dump extends further into the lake. Furthermore, this numerical analysis is evaluated against observational data of the WRD performance.

4.1 Stability Analysis

4.1.1 Objectives

A stability analysis of the WRD was completed at the most critical cross section to evaluate the risk during construction related to catastrophic dump failure. This approach inherently implies that the resultant outcome is conservative, as in every other location of the dump conditions are better. This numeric analysis should not be viewed in isolation, as it needs to be evaluated in the context of field observations (visual observations and displacement measurements), which are dicussed in the next chapter.

4.1.2 Geometry

The location and geometry of the adopted cross section for the stability analysis are shown as Section A in Figure 3. This cross section was selected as the critical section for the analysis based on the foundation conditions (inclination and thickness of the fine-grained materials). The downstream slope of the dump is approximated as 1.5H: 1.0V (Horizontal: Vertical).

It should be noted, that in reality the outer slope does undergo continuous sloughing and as a result in all likelihood the outer slope is expected to be flatter, but sufficiently detailed bathymetric survey to definitively confirm this is not available and therefore the analysis is completed with the more conservative steeper slope.

4.1.3 Material Properties

Table 2 lists the material properties used in the stability analysis. Friction angles were based on direct shear tests results (BGC 2014, as reported in SRK 2014). The undrained shear strength to effective stress ratio s_u/σ_v' obtained during triaxial testing (BGC 2014, as reported in SRK 2014). Failures are not expected to occur through bedrock as it has been characterized as strong and competent, especially in comparison to the weak, unconsolidated foundation materials, therefore it was assumed to have infinite strength.

The soil at the foundation was assumed to be composed of uniform clay, a conservative assumption when compared to the original stability analysis (SRK 2014). A sensitivity analysis was performed increasing the clay strength parameters as indicated by the values between parentheses in Table 2.

The presence of tailings at the toe of the dump was considered for the final expansion of the WRD. The material properties of these tailings were adopted in a conservative manner based on engineering judgment.

Table 2: Material Properties used in Stability Analysis

Geotechnical Unit	Unit Weight, γ (kN/m^3)	Cohesion, c (kPa)	Friction Angle, ϕ (º)	Undrained Shear Strength, s_u (kPa)
U1: Waste Dump	22.0	0.0	38.0	NA
U2: Clay	16.0	0.0 (0.0)	27.0 (30.0)	$0.27\times \sigma_v'$ $(0.30 \times \sigma_v')$
U3: Bedrock	26.0	Infinite Strength		
U4: Tailings	16.0	0.0	27.0	NA

Note:

Values in parenthesis are increased shear strength parameters of clay for sensitivity analysis purposes.

4.1.4 Results

Table 3 summarizes the result from the stability analysis. The first column refers to the geometric configuration of the dump used in the analysis. The dump configuration is defined as the advance distance of crest measured from the current position (e.g., a distance of 42 m indicates that the dump crest has advanced 42 m into the lake with respect to the position it had at the time of writing this report).

The second column indicates whether the shear strength of the clay was considered under drained or undrained conditions. The third column refers to the type of slip surface analyzed with the software, either circular (rotational) or non-circular (translational). Column (4) in Table 3 includes the calculated setback distance measured from the crest to get a FoS > 1.1; i.e., all slip surfaces of the analysis outcropping beyond this distance have a FoS > 1.1. Setback distances to get a FoS > 1.3 are included in column (5). Values in parenthesis in columns (4) and (5) are setback distances for the increased shear strength parameters of the clay included in Table 2.

The sixth column is the minimum factor of safety calculated for the corresponding scenario. The seventh column is a description of the critical slip surface (i.e. the one with the lowest FoS): in the “Shallow Slope” type, the slip surfaces is within the dump and does not include the foundation; in the “Shallow Slope-Toe” type, the slip surface does not go to the crest of dump and is concentrated between the foundation and the toe of the dump; in the “Slope-Foundation” type, the slip surface is a deep seated one involving the dump from the crest to its foundation; and the ”Slope-Tailings” type is the same as the “Slope-Foundation” type when the dump is founded in tailings. Figure 4 illustrates these failure types.

The values between parentheses in the fourth, fifth and sixth column are the corresponding results for the increased shear strength parameters of the clay (shown between parentheses in Table 2).

The failure mechanisms and setback distances for each of the analyzed scenarios are shown in Figures 5 to 12.

Table 3: Summary of Results from Stability Analysis

(1) Scenario	(2) Loading Condition	(3) Failure Mechanism	(4) Set Back (m) for FoS > 1.1	(5) Set Back (m) for FoS > 1.3	(6) Minimum FoS	(7) Failure Type at Minimum FoS
Current condition	Drained (Figure 5)	Rotational	8 (8)	25 (25)	0.91 (1.00)	Shallow Slope-Toe
		Translational	22 (13)	40 (31)	0.92 (1.01)	Shallow Slope-Toe
	Undrained (Figure 6)	Rotational	76 (59)	111 (76)	0.65 (0.71)	Shallow Slope-Toe
		Translational	95 (86)	125 (112)	0.65 (0.71)	Shallow Slope-Toe
Crest ~42 m from the current condition	Drained (Figure 7)	Rotational	0 (0)	13 (13)	1.01 (1.10)	Slope-Foundation
		Translational	12 (0)	33 (29)	1.01 (1.10)	Slope-Foundation
	Undrained (Figure 8)	Rotational	90 (13)	105 (105)	0.70 (0.76)	Slope-Foundation
		Translational	30 (27)	47 (43)	0.76 (0.81)	Slope-Foundation
Crest ~84 m from the current condition	Drained (Figure 9)	Rotational	0 (0)	20 (10)	1.18 (1.18)	Shallow Slope
		Translational	0 (0)	25 (11)	1.21 (1.27)	Slope-Foundation
	Undrained (Figure 10)	Rotational	26 (26)	49 (49)	0.82 (0.88)	Slope-Foundation
		Translational	75 (65)	103 (93)	0.78 (0.86)	Slope-Foundation
Crest ~162 m from the current condition	Drained (Figure 11)	Rotational	0 (0)	4 (4)	1.18 (1.18)	Shallow Slope
		Translational	0 (0)	0 (0)	1.38 (1.38)	Slope-Tailings
	Undrained (Figure 12)	Rotational	0 (0)	6 (6)	1.18 (1.18)	Shallow Slope
		Translational	0 (0)	0 (0)	1.31 (1.35)	Slope-Foundation

5 Field Observations

As part of the observational method, an interpretation of the observed displacements and conditions on site is presented next and is linked to the performed numeric stability analysis in the preceding chapter.

5.1 Field Observations

No cracks or sudden displacements have been observed on the dump surface in the vicinity of the analyzed cross section, and the dump does not show any signs of instability.

SRK conducted a review of displacement measurements, both vertical and horizontal, from monuments established in Zone 3 to Zone 7. Out of these measurements, monuments in Zone 3-1 and Zone 3-2 represent the longest and most continuous displacement data set. SRK believes these to be representative of the settlement conditions of the entire WRD due to the consolidation (dissipation of excess pore water pressure) of the fine-grained soil in the foundation. Settlement curves for monuments in Zones 3-1 and 3-2 are shown in Figure 13.

The time required to achieve 90% of consolidation (i.e. almost complete dissipation of pore pressure induced by the dump construction) was estimated from the interpretation of settlement curves, using Taylor's method (Taylor 1948). Several factors impact the time of consolidation, like local soil conditions, the geometry of the fine-grained soil layer, real applied stress, and measurement accuracy. The calculated time varies between a minimum of about 5 days and a maximum of about 90 days (Figure 14). The conservative estimate of the time required to achieve a consolidation degree of 80% from the current condition is about 60 days.

5.2 Current Dump Geometry

The last dump advancement at the studied cross section was completed about 60 days ago, and a consolidation degree of about 80% was achieved based on displacement measurements (Figure 14). The fine-grained soils can be considered practically consolidated under the dump load for the determined consolidation state.

Since the fine-grained soil is consolidated (i.e., excess pore water pressure has already dissipated) and no load is applied to the dump surface or in the foundation near to the toe of the submerged dump, stability analysis of the current condition should be performed with shear strength parameters for drained loading conditions and hydrostatic water level. However, results of stability analysis of current dump configuration (Table 3) under drained loading conditions do not meet the minimum FoS specified in the guidelines (BCMWRP 1991) for some distance from the crest.

While field observations confirm a stable dump in the current conditions, calculations predict a dump failure with slide surfaces outcropping at some distance from the crest. To remove the inconsistency between observation and calculations, the factors involved in the stability calculations (mainly shear strength parameters of the waste rock and fine-grained soil for drained load conditions, and thickness and slope of the fine-grained soil layer) may be adjusted or

determined more precisely. However, SRK intentionally presented the stability analysis results in Table 3 without any adjustment of the factors involved in the stability analysis so as not to influence the outcome based on numerical manipulation.

For the current condition, setback distances of 22 m and 40 m were determined to get a FoS greater than 1.1 and 1.3 respectively (Table 3). Results from sensitivity analysis show that an increase in the shear strength of the clay of around 13% leads to a reduction of the setback distances between 40% to 20%, and an increase in the minimum factor of safety by 10% approximately. An increase in shear strength of that range is entirely plausible and therefore it illustrates the conservatism in the numerical analysis when compared to observations of the dump performance.

It is important to note that setback distances as calculated is based on the outermost leading edge of the dump. In reality, most of the dump is constructed using the stacker, and therefore the actual working surface is normally at least 22 m away from the outer crest as illustrated in Figure 15.

5.3 Dump Expansion

Based on the stability analysis for drained loading condition, a setback of 12 m is required for an intermediate dump configuration with a dump advancement into the lake of 42 m beyond the current extent.

In general, the stability analysis shows that the setback distances associated with FoS below 1.1 decreases as the dump advances towards the lake. No set back is required for intermediate stages with dump crests over 84 m from the current condition. Also, the minimum FoS increases above 1.1 as the dump construction progresses. The increase of the minimum FoS can be explained mainly by the decrease in the inclination (i.e. the geometry) of the fine-grained layer in the foundation.

Under these conditions, and based on the results included in Table 3, the calculated operational setback distance (i.e. FoS > 1.1) is 12 m for the 42 m crest advancement, and 0 m for the 84 m and 162 m advancements. Results from the sensitivity analysis on clay strength parameters indicates a reduction on the setback distance to 0 m, for the 42 m crest advancement, and an increase in the minimum FoS by 10%.

Also, the setback distance for permanent structures and stockpiles (i.e. FoS > 1.3) is 33 m for the 42 m crest advancement, 25 m for the 84 m advancement, and 4 m for the 162 m advancement. Results from the sensitivity analysis on clay strength parameters reduce these setback distances between 30% to 50%. The minimum FoS increases, in general, by 10%, except for the “Shallow Slope” failure type, because these slip surfaces do not include the foundation.

5.4 Seismic Loading

Under seismic loading undrained conditions would be experienced, and as can be seen from the results in Table 3, much of the WRD, especially under current conditions would have a FoS

below 1. Therefore, to ensure safety of personnel, the OMS Manual and SOP needs to be updated with clear protocols for evacuation of the WRD area when seismic events are identified.

5.5 Summary of Findings

To overcome the difference between observations and calculation results, the following design principles should be adopted as best practice for ongoing WRD construction:

- The fined-grained foundation materials behave in a drained manner when sufficient pre-loading time has occurred (i.e. drained shear strength parameters should be used to do the stability calculations);
- The operational setback distance at the crest is defined with a FoS > 1.1 (BCMWRP recommends a minimum FoS between 1.1 to 1.3 for short-term analysis of deep-seated failures); and
- The setback distance for permanent structures and stockpiles is defined to get a FoS > 1.30 (BCMWRP recommends a minimum FoS of 1.3 for long-term analysis of deep-seated failures).

The operational setback distance should be interpreted as the definition of a high-risk zone as currently identified in the SOP as follows:

- The zone should be clearly marked on site;
- No person shall work alone within this zone; and
- A clear, unobstructed escape route for the equipment working within this zone must always be present.

The setback distance for permanent structures and stockpiles defines a zone at the crest of the WRD where no permanent structures or stockpiles can be placed.

The numeric stability analysis results as presented clearly demonstrate that there remains a safety reserve with the drained shear strength parameters based on the comparison with the real WRD stability in the current condition. The maximum operational calculated setback distance (i.e. required to get a FoS above 1.1) for the current condition is 22 m at the most critical section. Future WRD configuration required less set back. However, a minimum operational setback distance of 10 m is recommended at all times.

The setback distance for permanent structures and stockpiles (i.e. required to get a FoS above 1.3) was estimated at 40 m. This set back is required for the current condition. Future WRD configuration requires less set back.

The sensitivity analysis performed on the shear strength of the clay (i.e. an increase of about 13% in shear strength) showed a reduction in setback distances between 20% to 50%, and an increase in the minimum FoS of 10% approximately. The selected increased shear strength of the clay is in the range of expected shear strength for this type of material, based on engineering judgment. Note that the increased shear strength still retains some reserve since it would be excepted that the entire foundation is not made of uniform soft clay.

6 Dumping Procedures and QPOs

This chapter provides an operational summary of subaqueous waste rock deposition at the Brucejack Gold Mine. Pretivm's engineering team manages the day-to-day waste rock deposition, and follow-up monitoring and surveillance following procedures outlined in the OMS Manual. The OMS Manual has been developed in accordance with SRK's design recommendations and undergoes updates as necessary. SRK is the EOR for the WRD.

Specifically, waste rock deposition is governed by the standard operating procedure (Brucejack Lake Waste Rock Disposal, SOP 011), which is an Appendix to the OMS Manual. All employees working on the WRD are provided training on this SOP.

6.1 Summary of Waste Rock Dump Surveillance Procedures

Table 4 summarizes the surveillance procedures used for managing the WRD.

Table 4: Summary of Waste Rock Deposition Surveillance Procedures

Inspection	Frequency	Critical Observation
Stability Analysis	• Start of every new deposition area.	• Determine anticipated settlement of new crest advance. • Assess FoS of new crest advance. • Assess preloading time for new crest advance to achieve acceptable factor of safety.
Settlement Surveys	• Immediately upon the completion of a 3 m crest advance. • Frequency afterwards based on-site Geotechnical Engineers requirements.	• Capture the baseline crest elevation for comparison with subsequent settlement surveying. • Conduct ongoing settlement surveying until necessary settlement has been achieved.

Geotechnical Engineer's Inspections	• At the start of every shift
	• After each break
	• At least every 4 hours if no breaks have occurred
	• At the start of a new work area
	• After every blast near the WRD
		• Inspect for signs of instability such as:
		  • Cracking
		  • Settlement
		  • Slope movement
		  • Changes in material type and moisture content
		  • Surface deflection from equipment
		• Inspect for delineators that mark the dump zones and restricted areas, and for proximity of safety equipment.
		• Inspect for safety equipment and personal protective equipment (PPE) worn by operators.

Equipment Operators Inspection	• At the start of each shift and continually during normal WRD operations	• Inspect for signs of instability on working surface and WRD face. • Be aware of equipment position, locations of egress points, and visibility. • Be aware of location of delineator cones, overhead lighting, and settlement monuments.
Health and Safety Audits	• Weekly	• Assess availability and use of safety supplies and PPE. • Assess adherence to deposition plan and SOP.

Inspection	Frequency	Critical Observation
		• Develop suggestions to improve WRD conditions and safety.
Engineer-of-Record Audits	• As deemed by the EOR	• Assess the deposition planning, tracking, and documentation being carried out on-site. • Determine if procedures are being followed and if WRD is being operated and is performing as designed.

6.2 Summary of Quantifiable Performance Objectives

QPOs were developed to manage the stability of the WRD. Table 5 summarizes the QPOs and their foundational methodology, responsible authority for their management, frequency of performance monitoring, and mitigation actions.

Table 5: Quantifiable Performance Objectives for Waste Rock Dump Construction

Description	QPO	Methodology	Responsibility	Frequency	Mitigation Actions
Waste Rock Dump Exposure	• Potentially acid generating (PAG) waste rock is to be subaqueously deposited below 1.0 m of water cover (1363.5 masl) within a 2 year (24 month) allowable exposure period.	• Excavate exposed PAG waste rock to an elevation of greater than 1.0 m below the Brucejack Lake level of 1364.5 m. • This excavation results in a minimum of 1.0 m of water cover over PAG waste rock. All excavations are to be guarded by a 1 m tall and 3 m wide safety berm that is set back 3 m from the excavation. • Where needed, a trafficking layer of non-acid generating waste rock is placed over the excavated PAG waste rock. • Elevations are confirmed by engineering staff and recorded in a digital database.	• On-site Geotechnical Engineers with support from Environmental Superintendent and Coordinator under the guidance of the Environmental Manager	• Actions to complete QPOs are ongoing and a component of operations work. • Due to weather constraints, the majority of the PAG waste rock excavation occurs in the summer months.	• The on-site Geotechnical Engineers with the support of the surface operations team will prioritize the location of PAG waste rock excavation and develop construction schedules and survey records.
Waste Rock Dump Preloading Time and Settlement Rate	• Experiential and judgement-based determination based on results of settlement surveys. Results must show that settlement rates are less than 0.03 m/day over two consecutive days.	• Foundation characteristics, depth of the lake and height of the waste rock continuously vary and therefore, settlement rate and magnitude are variable. • Preloading times are therefore also variable and cannot be prescribed.	• On-site Geotechnical Engineers with support from EOR as necessary	• Ongoing daily review of settlement survey results. • EOR formally reviews database bi-annually.	• Continue monitoring until the threshold values are reached.

Waste Rock Dump Stability	• Geodetic surveys are required a minimum of two times per day on all settlement monuments. Surveying frequency and timing must include:
	  • Initial survey immediately after the preloading material is constructed to establish a baseline.
	  • An initial check survey within 6 to 12 hours of the baseline survey.
	  • Subsequent surveys at 12-hour intervals until the Geotechnical Engineer specifies otherwise.
		• The Geotechnical Engineer reviews settlement results and applies experiential judgement to determine when preloading has been completed and when it is safe to deposit more waste rock.
		• As necessary, the Geotechnical Engineer will conduct numerical modeling, stability analysis and settlement analysis to confirm his experiential judgement.
			• On-site Geotechnical Engineers with support from EOR as necessary	• Ongoing daily review of settlement survey results.
				• Ongoing daily review of WRD stability though numerical modeling, stability analysis and settlement analysis as necessary.
				• Visual assessment of WRD stability every 4 hours.
				• EOR formally reviews database bi-annually.
					• The Geotechnical Engineer and the Manager Technical services must be contacted if the survey frequency cannot be completed to determine an action plan.
					• The Geotechnical Engineer must track the date when the survey(s) were attempted and report on the daily reports when future surveys will be attempted.

Waste Rock Dump Inspections	• Site inspections to visually assess the stability of active and inactive deposition zones.
	• Site inspections are required to be documented.
	• Inspections can also include the observations of the equipment operators and supervisors.
		• Sloughing and slope movement (including from equipment traffic) is expected and considered normal, however, within the constraints identified in the design reports and the conditions set here:
		  • Visual inspections focussing on surface cracks or other signs of instability within the preloading area.
		  • Cracks which form within the safety berm or on the dump surface must result in the stoppage of work (including egress of workers and equipment from the area) until an assessment by the engineer is completed.
		  • A change in deflection magnitude resulting from equipment traffic must be addressed by the engineer.
			• On-site Geotechnical Engineers with support from EOR as necessary	• Visual assessment of WRD stability every 4 hours.
				• EOR formally reviews database bi-annually.
					• Cracks forming in the preloading berm are immediately communicated to the Geotechnical Engineer. They are photo documented in the daily reports and visually assessed during regular inspections.
					• Cracks/slumps forming in the safety berm or in the dump pad surface result in an immediate work stoppage on the entire dumpsite. All signs of instability are immediately communicated to the Geotechnical Engineer and the EOR and recorded in the daily reports.

Rate of Waste Rock Dump Construction and Crest Advance	• The upper limit of waste rock deposition is 75,000 m^3/week (10,715 m^3/day) provided that preloading settlement rates meet expectations. • During normal operations between 600 and 1,000 m^3/day of waste rock will be supplied to the waste dump from the underground mine, which is less than the upper limit. • The Geotechnical Engineer prescribes the deposition zones that have met the preloading requirements in the daily deposition plan.	• The rate of waste rock deposition is related to the rate that the crest advances during the preloading process. • The rate that the preloading is advanced is operationally limited to the reach of the hydraulic excavators and conveyor system (stacker) used to bail waste rock over the preloading zone and the preloading time discussed above. • Typically, the preloading zones are 6 m wide and the current equipment has an approximate reach of 12 m. With the excavator situated behind the 6 m wide preloading area the effective reach of waste rock placement is 6 m into the lake and therefore, the rate of waste rock crest advance is 6 m per preloading cycle.	• On-site Geotechnical Engineers with support from EOR as necessary	• Ongoing daily activity.	• Rate of WRD construction is determined by the rate of construction of the preloading berms and by rate of settlement during preloading in the lake bottom sediments – it cannot be a fixed value. • To decrease the rate of WRD construction, decrease the capacity of the equipment used to construct the preloading berm. • To increase the rate of WRD construction, increase the capacity of the equipment used to construct the preloading berms. However, the rate of WRD construction will be limited to the availability of rock and the time required to meet the preloading requirements.

6.3 Summary of Waste Rock Deposition Methods

6.3.1 Screening and Stacker Deposition (8-inch Minus Material)

Underground waste rock is screened using a vibrating shaker deck to separate 8-inch and larger rock that would damage the rubber conveyor belts. Screened 8-inch and smaller (minus) rock is conveyed into the lake using a stacker.

The dumping procedure using the stacker is presented in Figure 16. Step 1 entails positioning the stacker with its wheels and rig mat pads as illustrated in Figure 16. The purpose is to distance the point load of the stacker as far back as practical from the WRD crest until a buttress of waste rock (shown in pink) is deposited along the toe and face of the dump. Step 2 entails infilling the gap between the outer cone and the previous crest, before advancing the stacker. Step 3 entails establishing a new preloading monitoring station, and after the required settlement QPOs have been attained the stacker is advanced to repeat the process (Step 4).

6.3.2 Excavator Deposition (8-inch Plus Material)

Separated 8-inch and greater (plus) waste rock is conventionally deposited into Brucejack Lake using a hydraulic excavator assisted by a tracked dozer as illustrated in Figure 17. 8-inch plus rock is dumped a minimum of 10 m away from the excavator to maintain a safe working area as illustrated by Step 1 in Figure 17. Step 2 entails end dumping material outside of the safe zone. Step 3 entails use of a small dozer to push the stockpiles into the safe zone to allow the excavator to reach it. Step 4 entails completion of the preloading section and installation of the monitoring instrumentation. At all times a tracked dozer advances the waste rock to the excavator on the right-hand side of the equipment to maintain a clear egress path for the equipment operator. Equipment operators are in constant communication with one another.

7 Closing Comments

Pretivm is proposing to increase overall life-of-mine ore production of the Brucejack Gold Mine from 16.5 Mt to 18.5 Mt, which will result in increased tailings and waste rock deposition in Brucejack Lake. Pretivm is also seeking approval for the flexibility to maximize waste rock deposition to either Brucejack Lake or to secondary stopes in the underground mine. The higher overall ore production and/or maximizing waste rock deposition to the lake will result in an expanded surface footprint of the WRD, and a thicker subaqueous tailings deposit. Subsequently the waste rock may extend onto unconsolidated tailings.

Although the original design analysis for the Brucejack WRD (SRK 2014) did not consider deposition on tailings, characterization data confirm that tailings will have greater strength than some of the weaker clays analysed as a foundation material (SRK 2015a). Ongoing WRD construction for the last 2 years, including back-analysis of three dump failure incidents (SRK 2015b, 2016b, c), has confirmed that the original design was robust and remains appropriate. Notwithstanding this, additional numerical analysis was completed and correlated with observational data, which confirmed that the dump construction can be executed safely, provided the conditions stipulated in the OMS Manual and SOP are maintained.

The updated design as presented in this report has confirmed that the existing dumping SOP (SRK 2017, Appendix A-1) and QPOs as defined in the current OMS Manual (SRK 2017) remain valid and relevant to ensure safe dumping in Brucejack Lake. This dumping SOP is independent of sediment type or thickness as it is based on the fundamental understanding that the foundation of the dump cannot initially carry the load.

SRK, as the EOR is therefore satisfied that the proposed mine expansion and implementation of either the Scenario 1 or 2 waste dumping scenarios (or anything in-between) does not require any changes to the WRD design analysis, dumping SOP or QPOs at this time, and that following of the already established protocols will ensure ongoing safe dumping.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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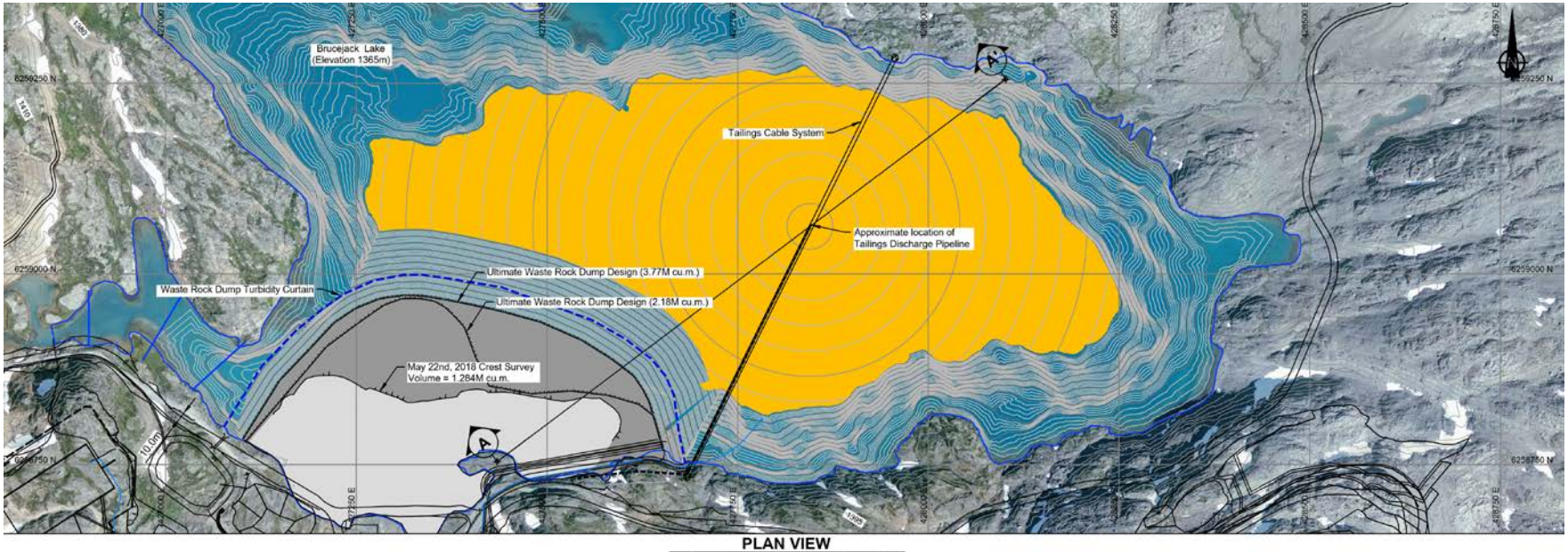
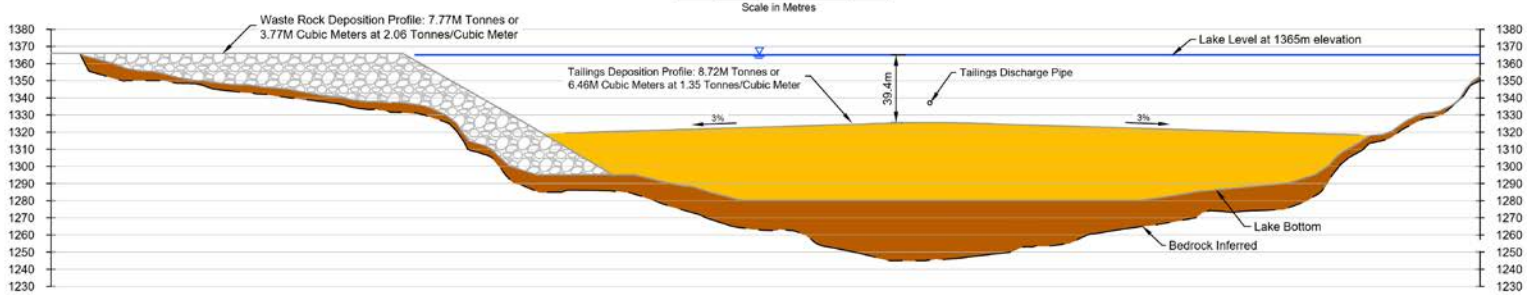
Terzaghi, K., Peck, R. B. 1967. Soil mechanics in engineering practice. 566-566.

Figures



PLAN VIEW

0 50 100 150 200 250
Scale in Metres



A SECTION A

0 20 40 60 80 100
Scale in Metres

- Subaqueous Waste Rock Deposition Area
- Subaqueous Tailings Deposition Area
- Lakebed Sediments
- Current Waste Rock Dump Area
- Additional Waste Rock Dump Area

NOTES

1. Contour interval 1m
2. Projection is UTM Zone 9, NAD83 datum.
3. Civil infrastructure layouts based on cad files received from AMEC Foster Wheeler.
3. Topography provided by Pretivm.

srk consulting

Job No: 1CP026.000

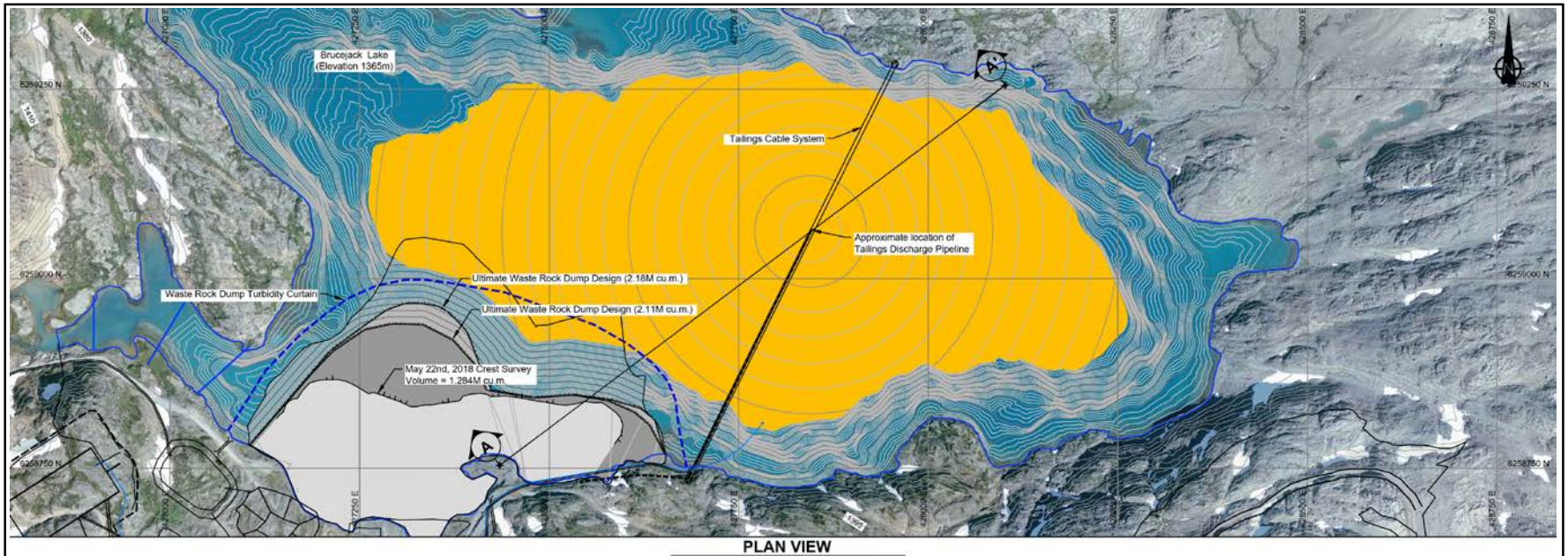
PRETIVM

Brucejack Gold Mine

Updated Waste Rock Dump Design

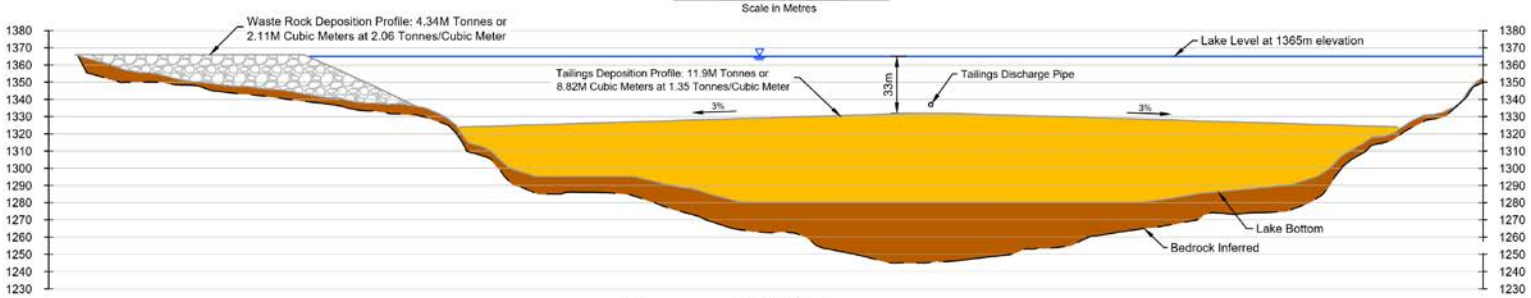
Scenario 1 Layout

Date:	Approved:	Figure:
09/28/2018	ONL	1



PLAN VIEW

0 50 100 150 200 250
Scale in Metres



SECTION A

A 0 20 40 60 80 100
Scale in Metres

LEGEND

- Subaqueous Waste Rock Deposition Area
- Subaqueous Tailings Deposition Area
- Lakebed Sediments
- Current Waste Rock Dump Area
- Additional Waste Rock Dump Area

NOTES

1. Contour interval 1m
2. Projection is UTM Zone 9, NAD83 datum.
3. Civil infrastructure layouts based on cad files received from AMEC Foster Wheeler.
3. Topography provided by Pretivm.

srk consulting

Job No: 1CP026.000

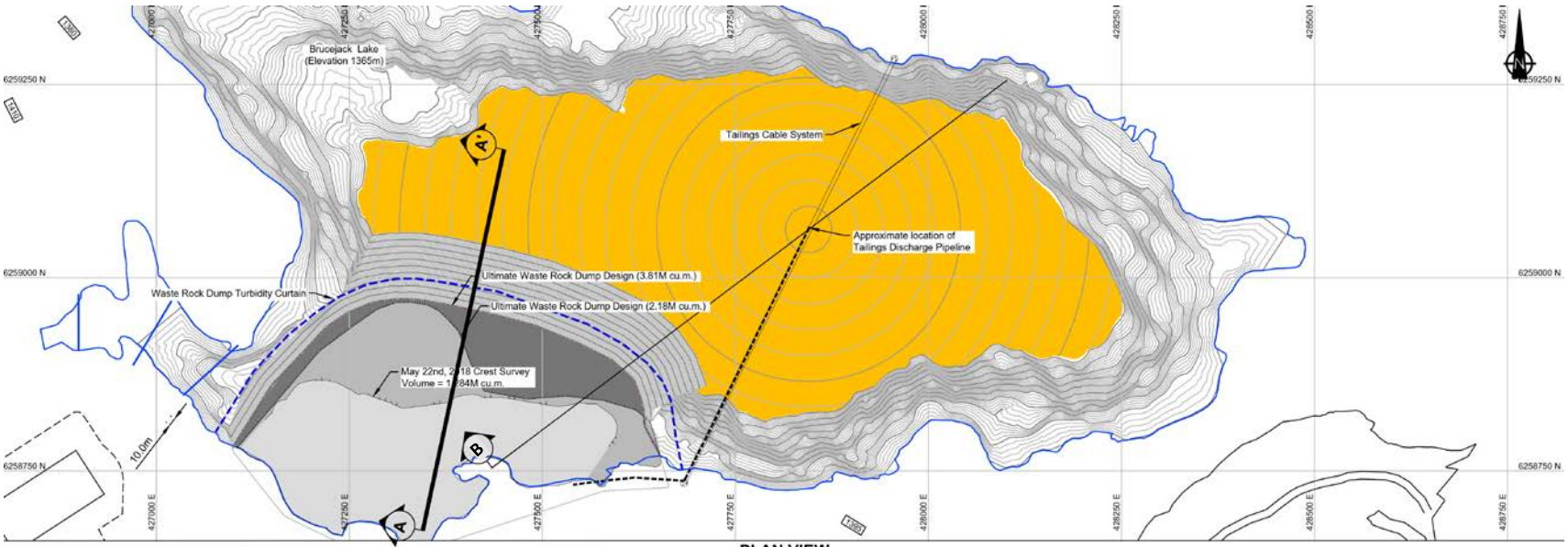
PRETIVM

Brucejack Gold Mine

Updated Waste Rock Dump Design

Scenario 2
Layout

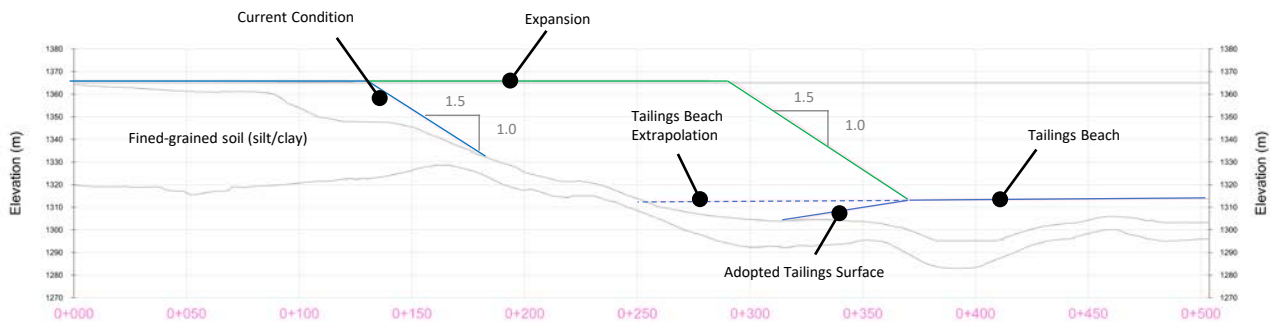
Date:	Approved:	Figure:
09/28/2018	ONL	2



PLAN VIEW

0 50 100 150 200 250

Scale in Metres



CROSS SECTION A

NOTES

1. Contour interval 1m
2. Projection is UTM Zone 9, NAD83 datum.
3. Civil infrastructure layouts based on cad files received from AMEC Foster Wheeler.
3. Topography provided by Pretivm.

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PRETIVM

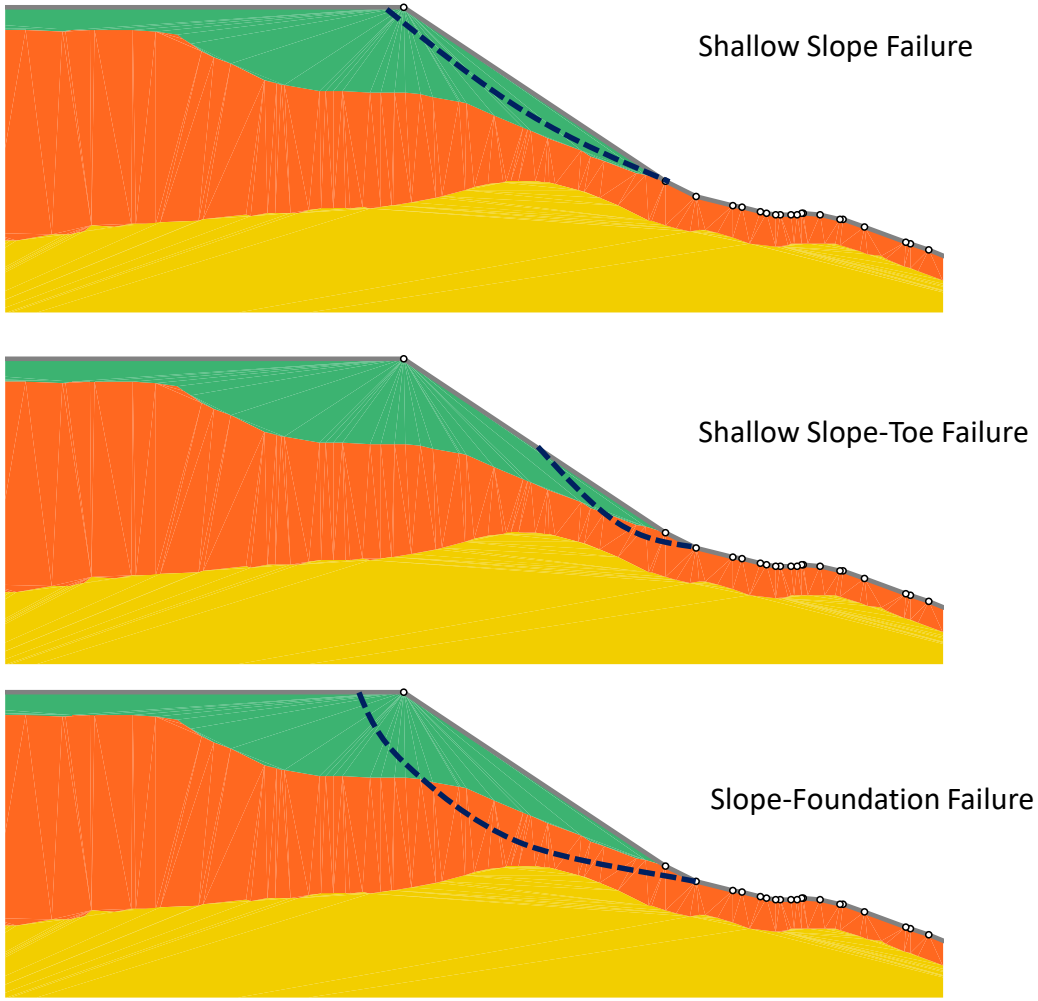
Job No: 1CP026.000

Brucejack Gold Mine

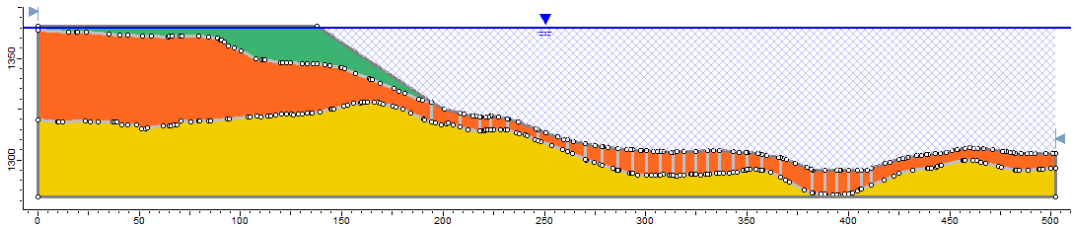
Updated Waste Rock Dump Design

Waste Rock Dump Geometry Plan View and Cross Section

Date:	Approved:	Figure:
09/28/2018	ONL	3



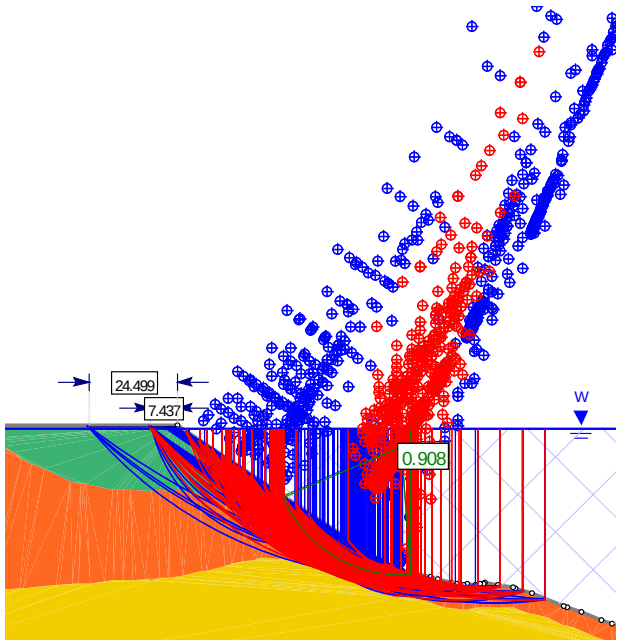
srk consulting	PRETIVM	Updated Waste Rock Dump Design **Failure Mechanisms Types**
Job No: 1CP026.000	Brucejack Gold Mine	Date: 09/28/2018 · Approved: ONL · Figure: **4**



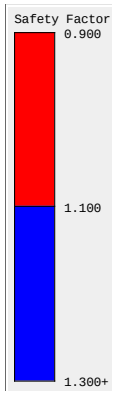
Geometry

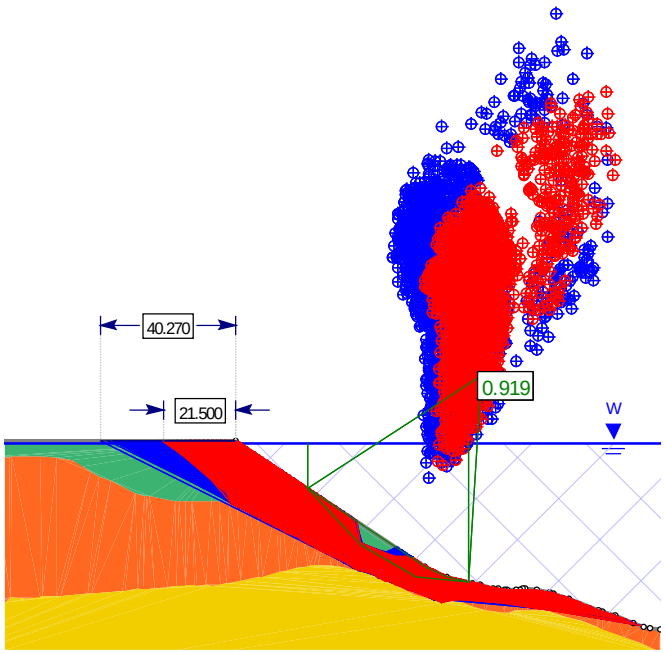
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
03 Bedrock		26	Infinite strength		
01 Waste Dump		22	Mohr-Coulomb	0	38
02A Clay (drained)		16	Mohr-Coulomb	0	27

Material Parameters



Rotational Failure Mechanism





Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

srk consulting

Job No: 1CP026.000

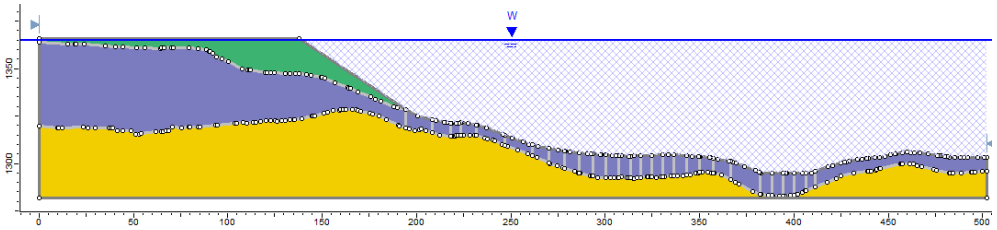
PRETIVM

Brucejack Gold Mine

Updated Waste Rock Dump Design

Failure Mechanisms
Current Condition - Drained

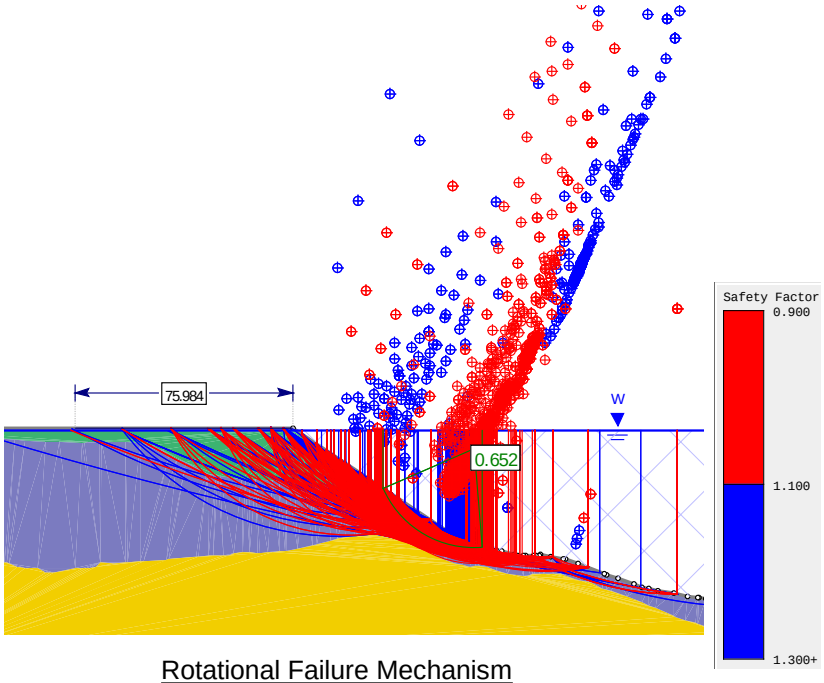
Date:	Approved:	Figure:
09/28/2018	ONL	5



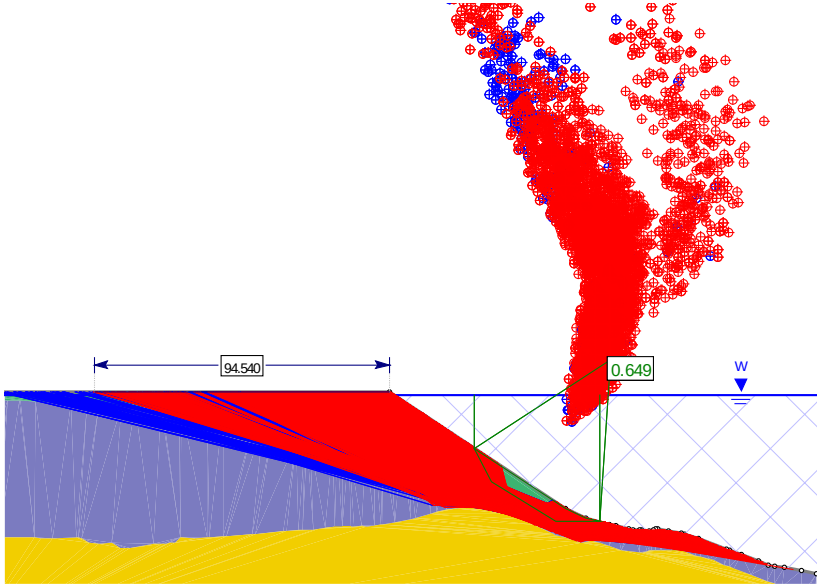
Geometry

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
03 Bedrock		26	Infinite strength				
01 Waste Dump		22	Mohr-Coulomb	0	38		
02B Clay (undrained)		16	Vertical Stress Ratio			0.27	0

Material Parameters



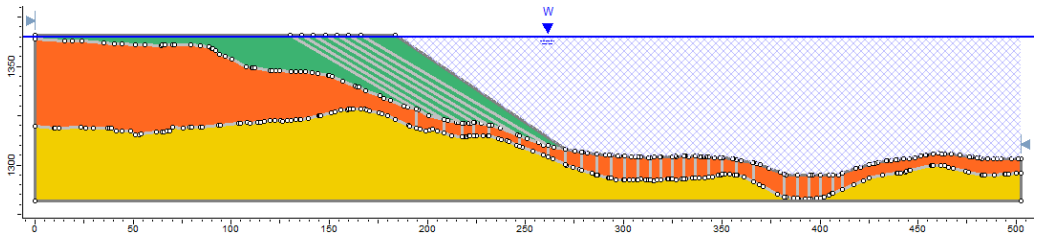
Rotational Failure Mechanism



Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

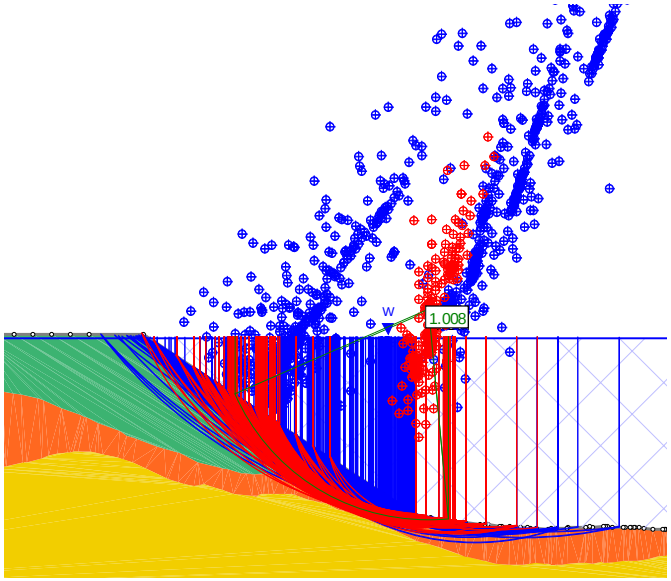
srk consulting	PRETIVM	Updated Waste Rock Dump Design
Job No: 1CP026.000	Brucejack Gold Mine	**Failure Mechanisms Current Condition - Undrained**
		Date: 09/28/2018 · Approved: ONL · Figure: 6



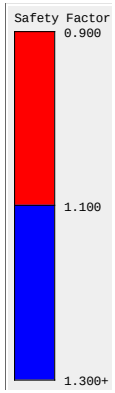
Geometry

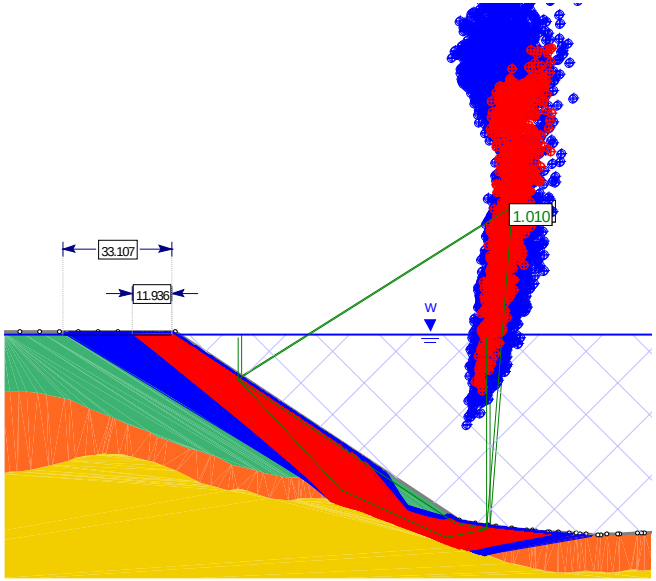
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
03 Bedrock		26	Infinite strength		
01 Waste Dump		22	Mohr-Coulomb	0	38
02A Clay (drained)		16	Mohr-Coulomb	0	27

Material Parameters



Rotational Failure Mechanism





Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

srk consulting

Job No: 1CP026.000

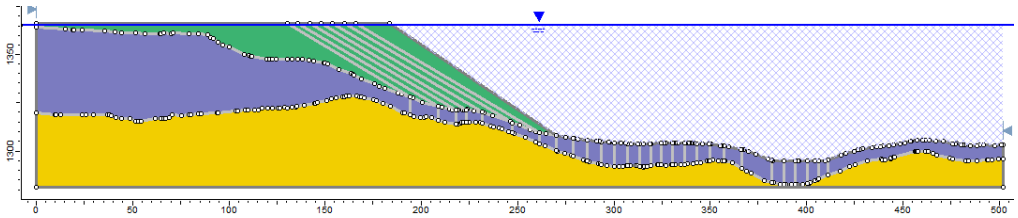
PRETIVM

Brucejack Gold Mine

Updated Waste Rock Dump Design

Failure Mechanisms
~42 m Advancement - Drained

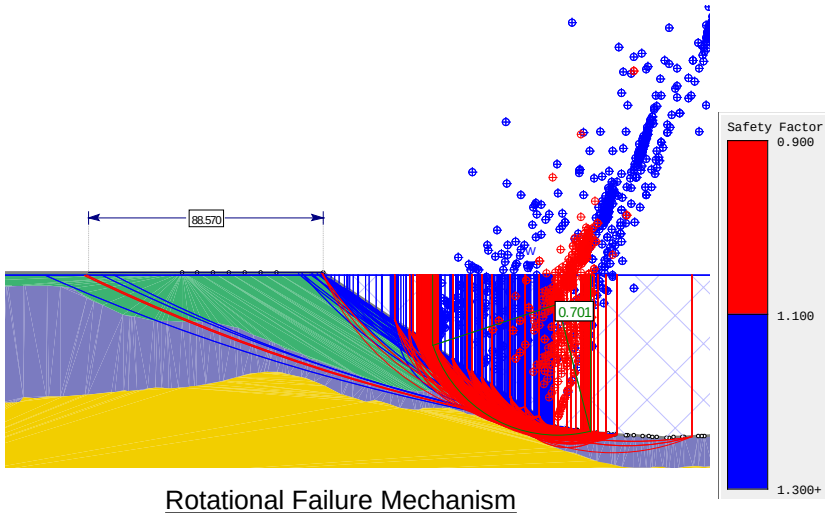
Date:	Approved:	Figure:
09/28/2018	ONL	7



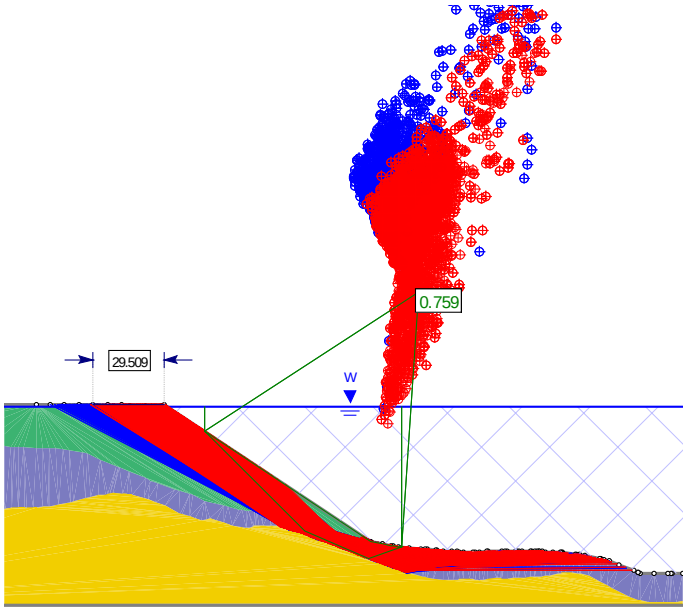
Geometry

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
03 Bedrock		26	Infinite strength				
01 Waste Dump		22	Mohr-Coulomb	0	38		
02B Clay (undrained)		16	Vertical Stress Ratio			0.27	0

Material Parameters



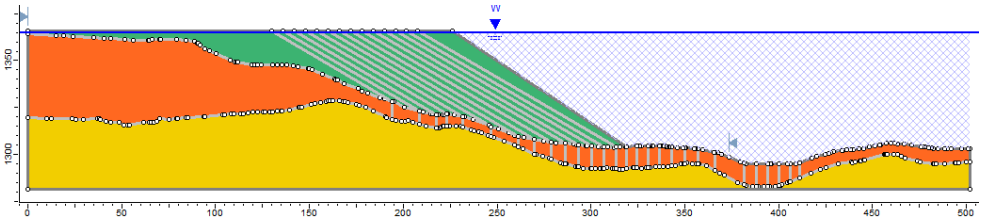
Rotational Failure Mechanism



Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

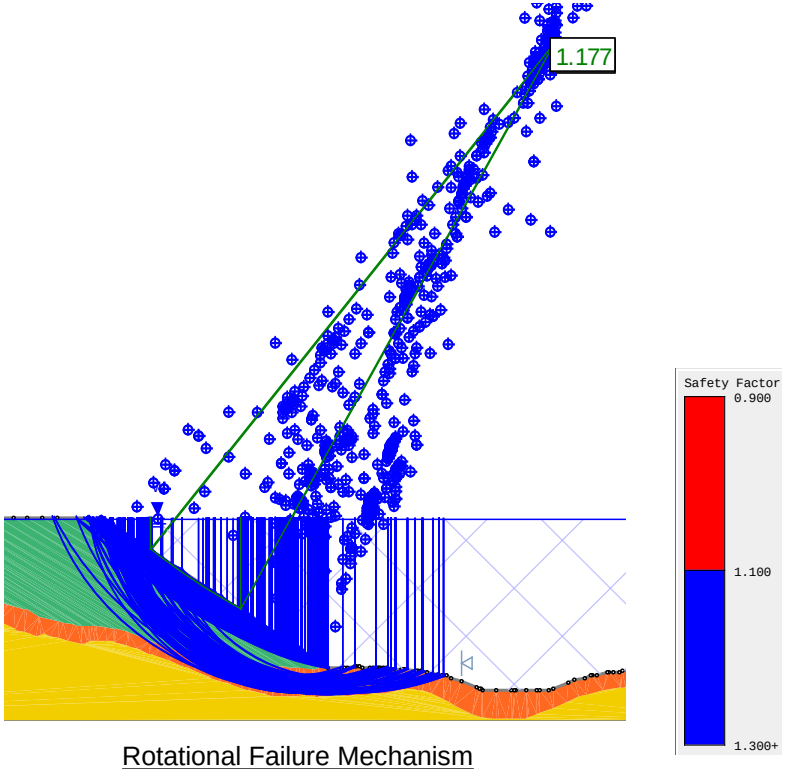
srk consulting	PRETIVM	Updated Waste Rock Dump Design
Job No: 1CP026.000	Brucejack Gold Mine	**Failure Mechanisms ~42 m Advancement - Undrained**
		Date: 09/28/2018 · Approved: ONL · Figure: 8



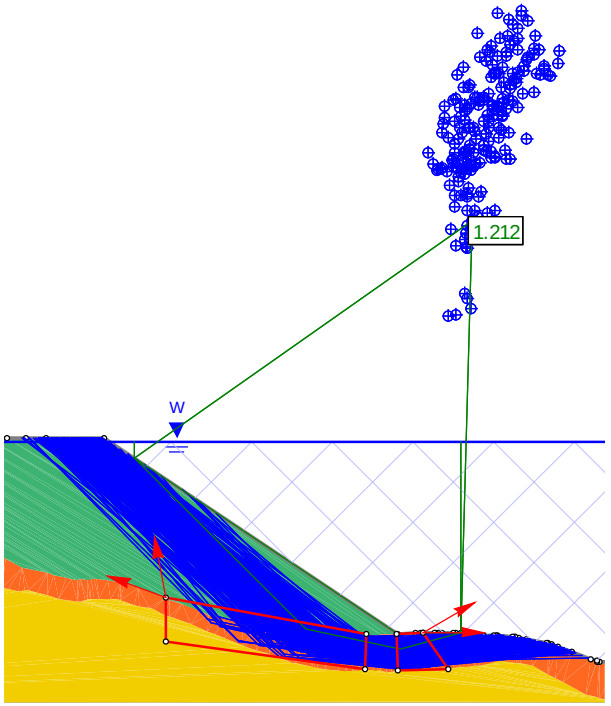
Geometry

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
03 Bedrock		26	Infinite strength		
01 Waste Dump		22	Mohr-Coulomb	0	38
02A Clay (drained)		16	Mohr-Coulomb	0	27

Material Parameters



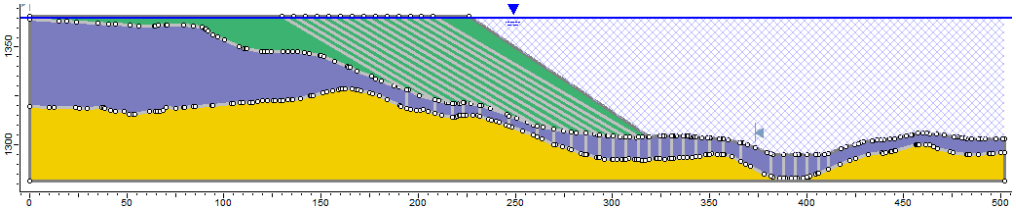
Rotational Failure Mechanism



Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

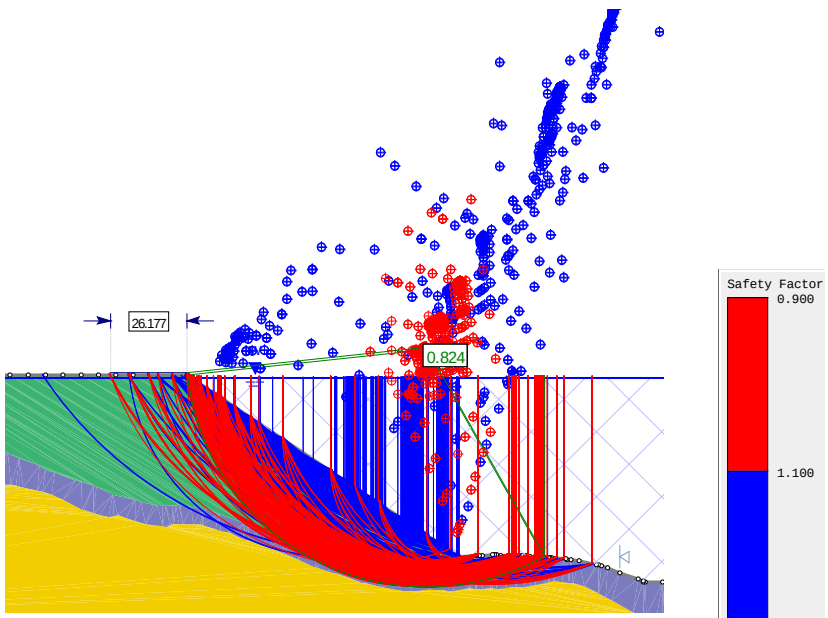
srk consulting	PRETIVM	Updated Waste Rock Dump Design
Job No: 1CP026.000	Brucejack Gold Mine	**Failure Mechanisms ~84 m Advancement - Drained**
		Date: 09/28/2018 · Approved: ONL · Figure: 9



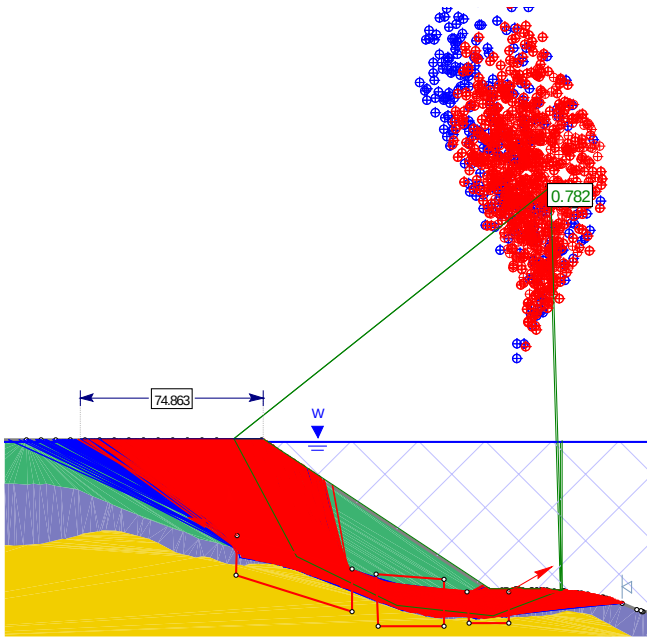
Geometry

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
03 Bedrock		26	Infinite strength				
01 Waste Dump		22	Mohr-Coulomb	0	38		
02B Clay (undrained)		16	Vertical Stress Ratio			0.27	0

Material Parameters



Rotational Failure Mechanism



Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

srk consulting

PRETIVM

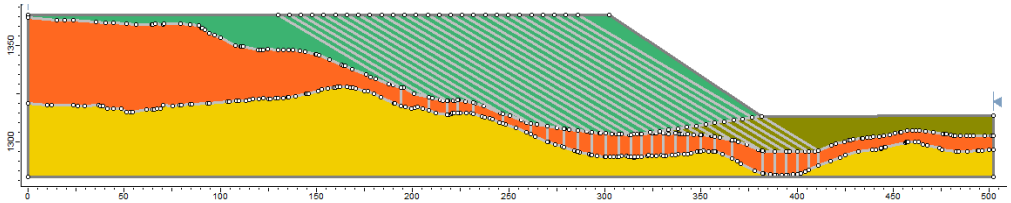
Job No: 1CP026.000

Brucejack Gold Mine

Updated Waste Rock Dump Design

Failure Mechanisms
~84 m Advancement - Undrained

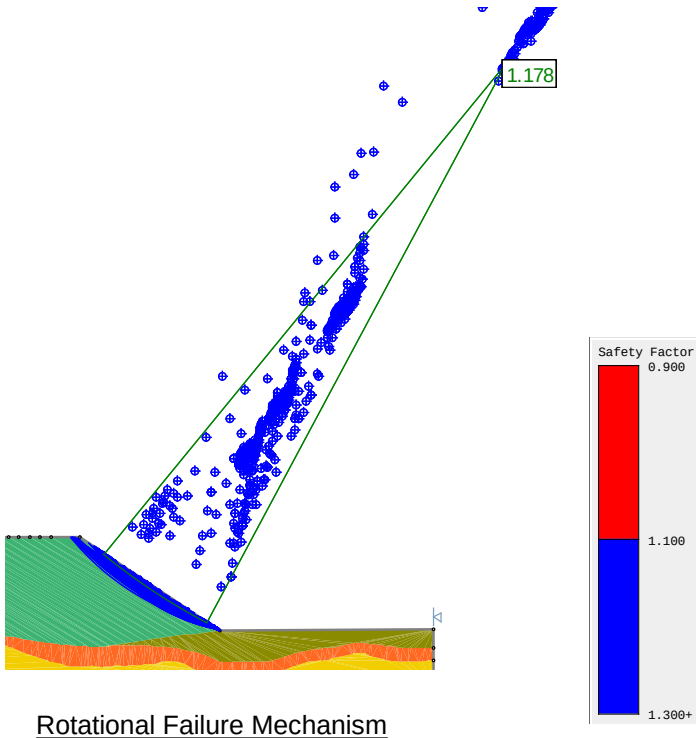
Date:	Approved:	Figure:
09/28/2018	ONL	10



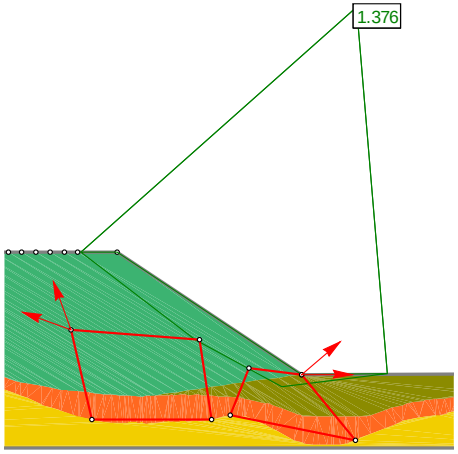
Geometry

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru
03 Bedrock		26	Infinite strength			None	0
01 Waste Dump		22	Mohr-Coulomb	0	38	None	0
02A Clay (drained)		16	Mohr-Coulomb	0	27	None	0
04 Tailings		16	Mohr-Coulomb	0	27	None	0

Material Parameters



Rotational Failure Mechanism



Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

srk consulting

PRETIVM

Job No: 1CP026.000

Brucejack Gold Mine

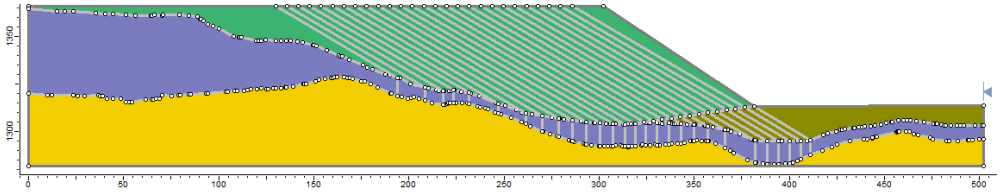
Updated Waste Rock Dump Design

Failure Mechanisms
~162 m Advancement - Drained

Date: 09/28/2018

Approved: ONL

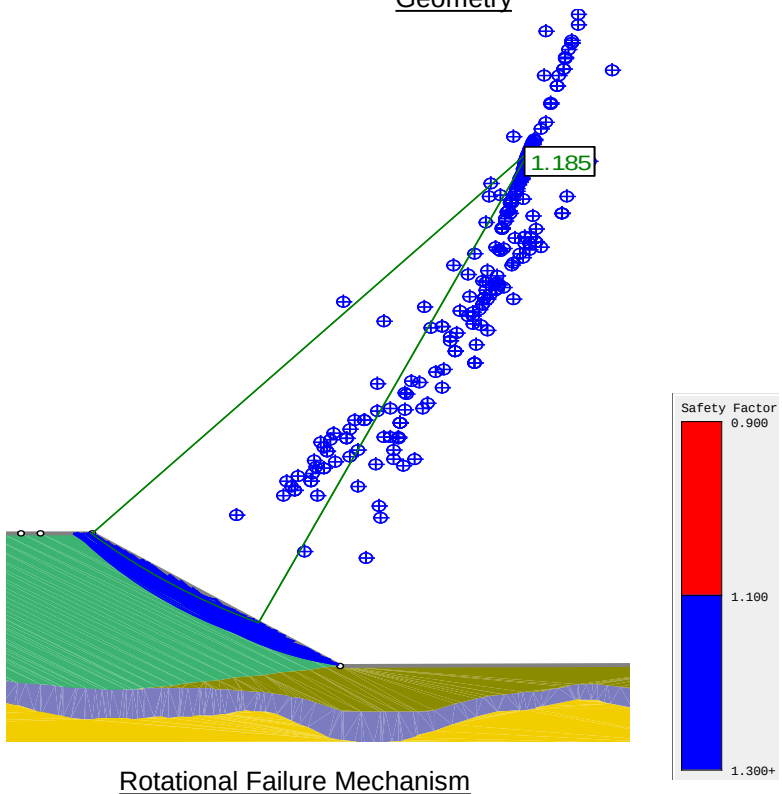
Figure: **11**



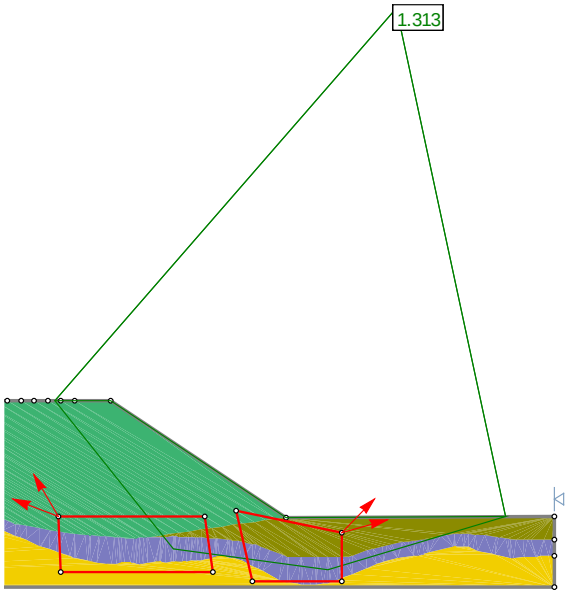
Geometry

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (kPa)
03 Bedrock		26	Infinite strength				
01 Waste Dump		22	Mohr-Coulomb	0	38		
02B Clay (undrained)		16	Vertical Stress Ratio			0.27	0
04 Tailings		16	Mohr-Coulomb	0	27		

Material Parameters



Rotational Failure Mechanism



Translational Failure Mechanism

Note: Results showing critical slip surface and all surfaces with FoS ≤ 1.3 (i.e. red means FoS ≤ 1.1; blue means 1.1 ≤ FoS ≤ 1.3)

srk consulting

PRETIVM

Job No: 1CP026.000

Brucejack Gold Mine

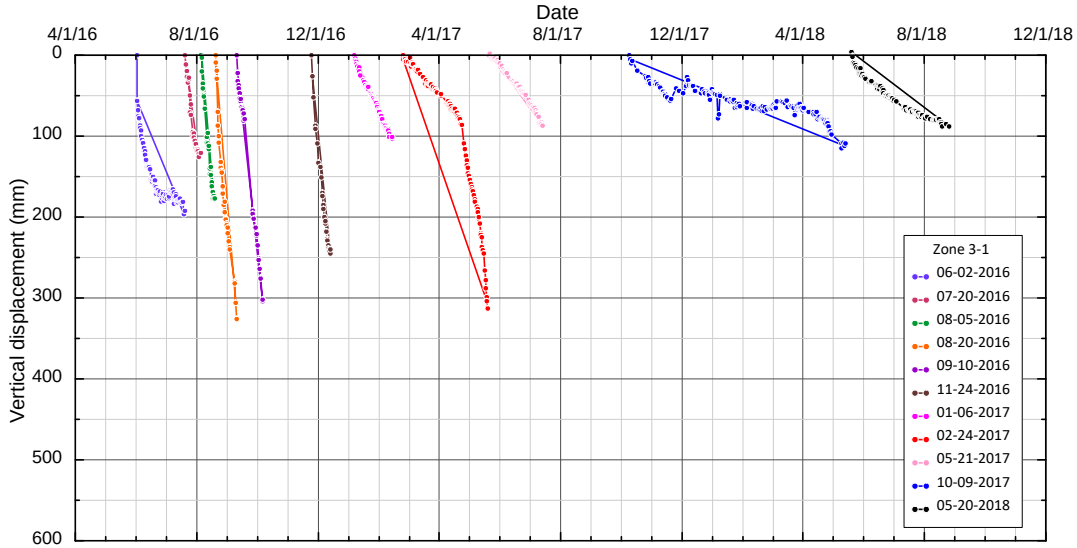
Updated Waste Rock Dump Design

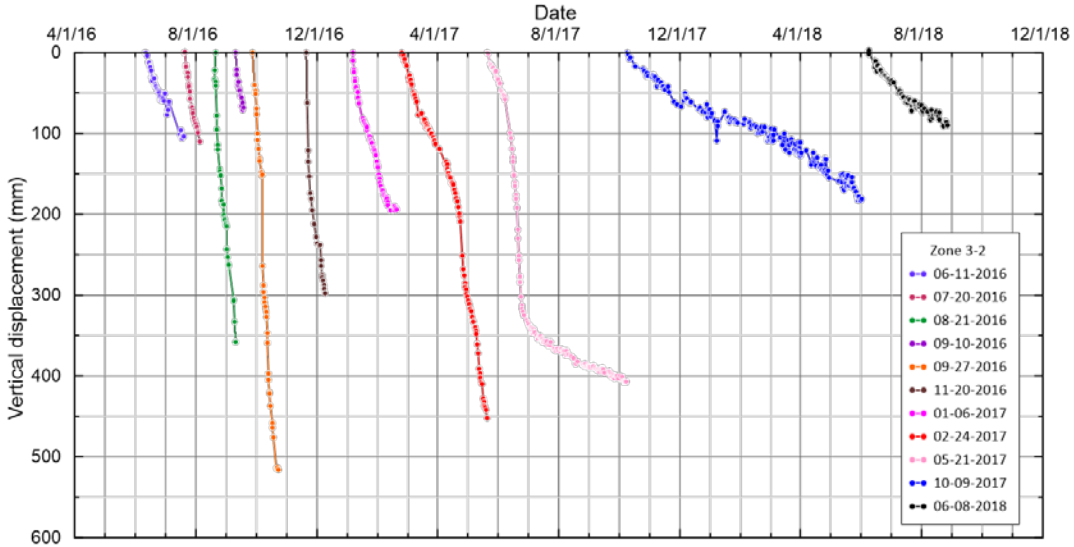
Failure Mechanisms
~162 m Advancement - Undrained

Date: 09/28/2018

Approved: ONL

Figure: **12**





srk consulting

PRETIVM

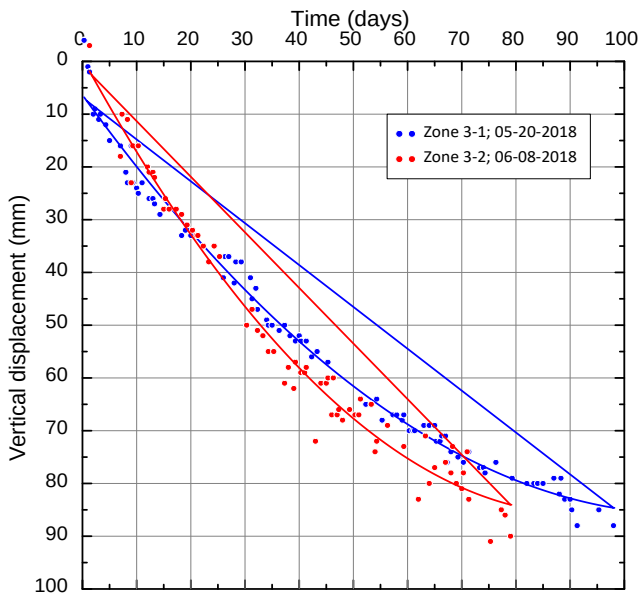
Job No: 1CP026.000

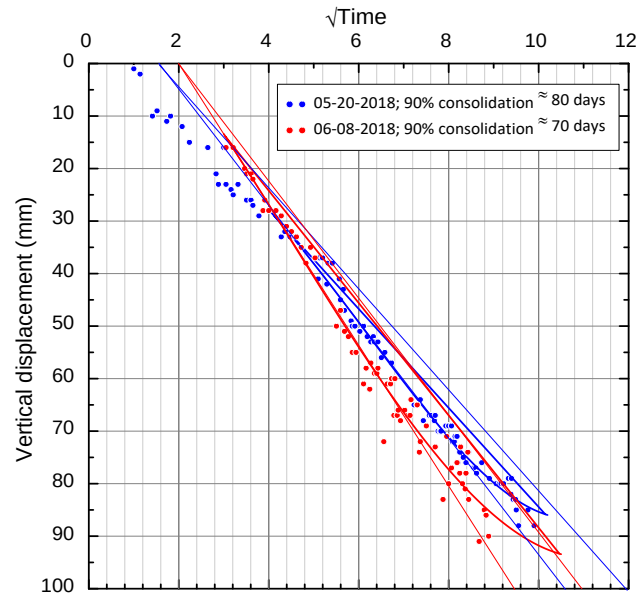
Brucejack Gold Mine

Updated Waste Rock Dump Design

Measured Displacements Zone 3-1 and Zone 3-2

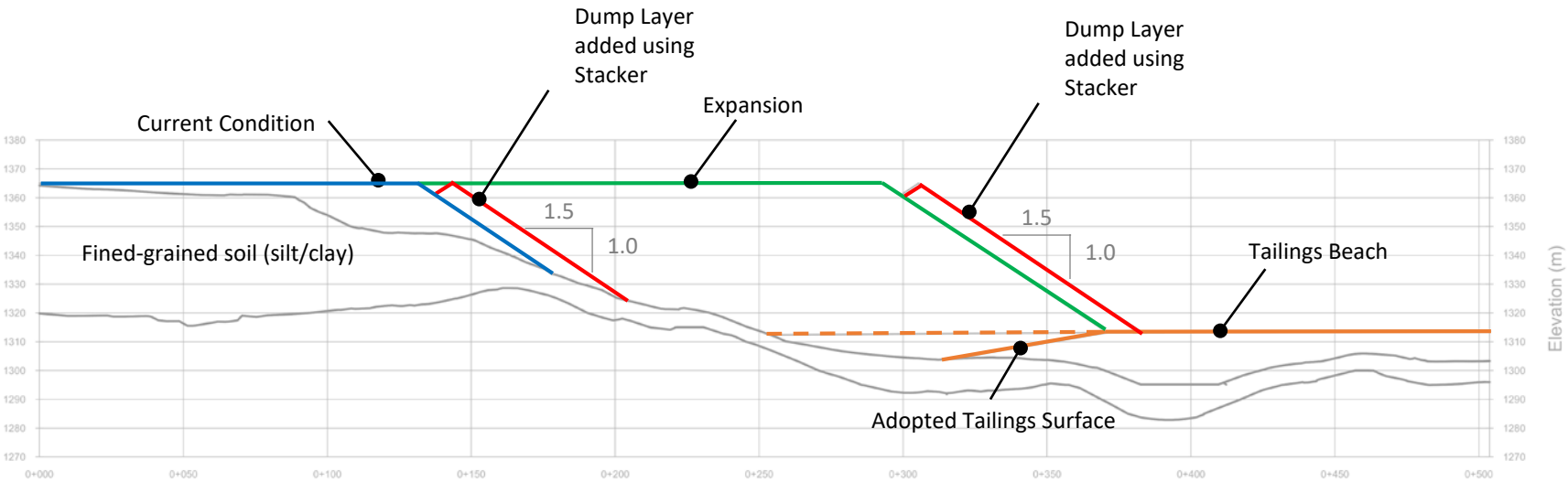
Date:	Approved:	Figure:
09/28/2018	ONL	13





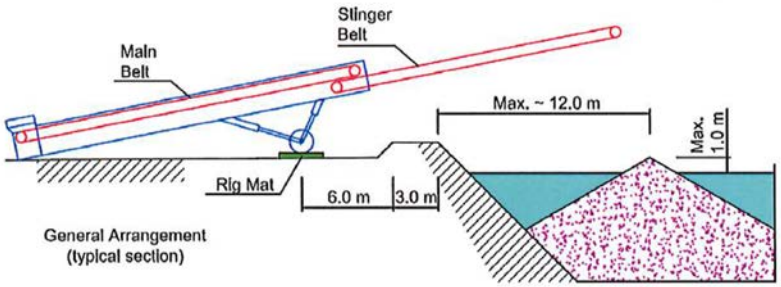
Note: A 15 m thick fined-grained soil layer with a coefficient of consolidation of about C_v =1.4E-06 requires ~75 days for 90% of consolidation

srk consulting	PRETIVM	Updated Waste Rock Dump Design
Job No: 1CP026.000	Brucejack Gold Mine	**Measured Displacements Degree of Consolidation**
		Date: 09/28/2018 · Approved: ONL · Figure: **14**



Cross Section

srk consulting	PRETIVM	Updated Waste Rock Dump Design
		Stacker Dump Construction Cross Section
Job No: 1CP026.000	Brucejack Gold Mine	Date: 09/28/2018 · Approved: ONL · Figure: **15**



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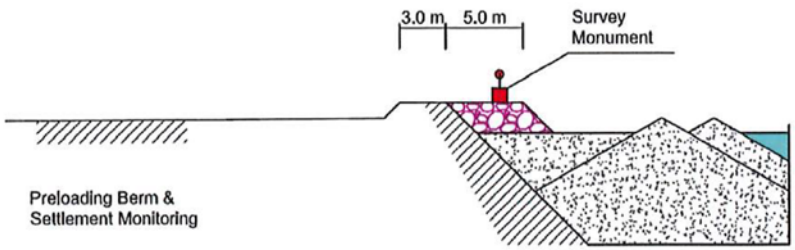

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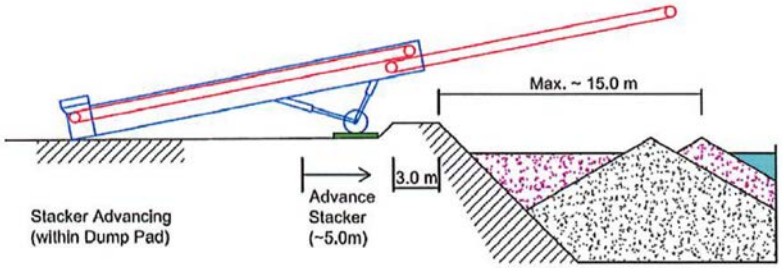

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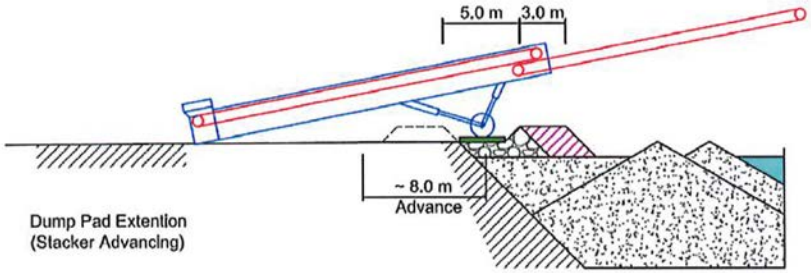
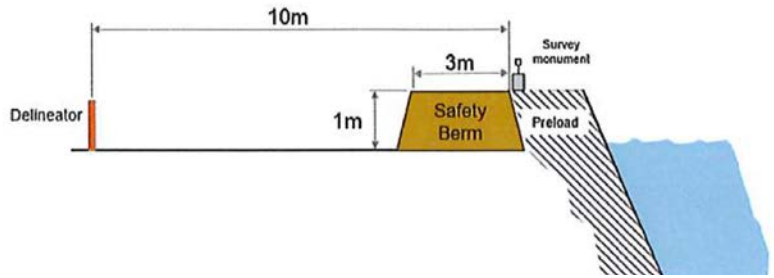


Step 4

srk consulting	PRETIVM	Updated Waste Rock Dump Design **Stacker Dump Construction Standard Operating Procedure**
Job No: 1CP026.000	Brucejack Gold Mine	Date: 09/28/2018 · Approved: ONL · Figure: **16**



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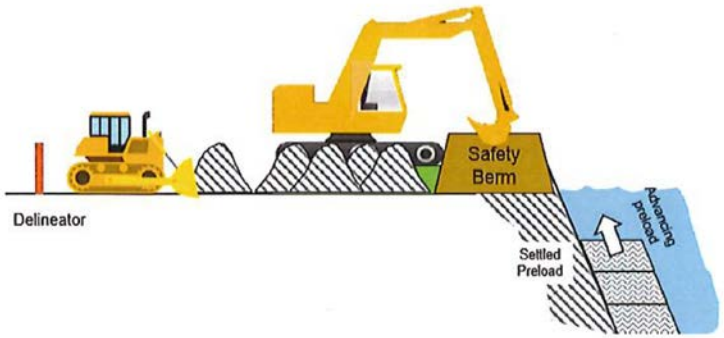

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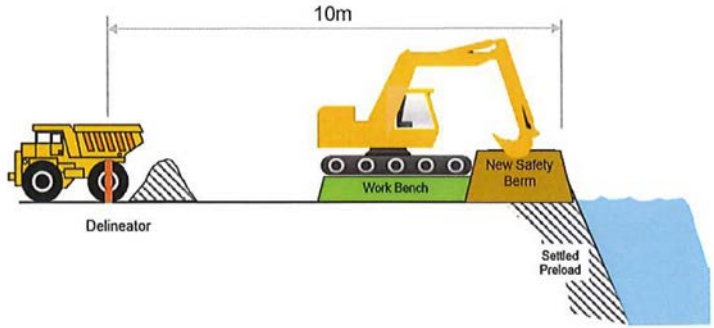

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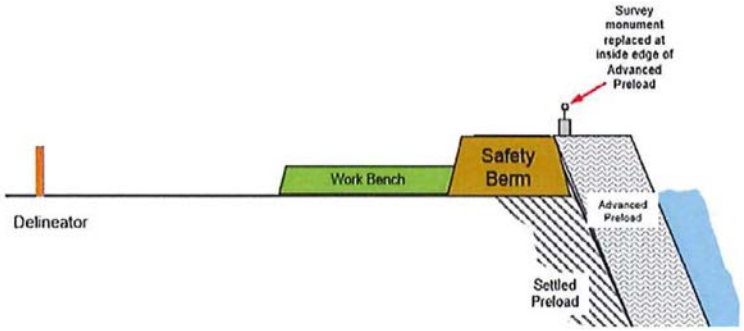

Step 4

srk consulting	PRETIVM	Updated Waste Rock Dump Design		
		Coarse Rock Placement Standard Operating Procedure		
Job No: 1CP026.000	Brucejack Gold Mine	Date: 09/28/2018	Approved: ONL	Figure: **17**

Chapter 4 Appendix

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Appendix 4-1
Reclamation and Closure Plan

March 2023

VERSION CONTROL

Revision #	Date Released	Revisions
1	May 2015	Initial issuance.
2	2018	Updated to reflect constructed infrastructure rather than proposed, and to separate infrastructure within the M-243 permitted area from ancillary infrastructure located outside of that area.
3	2020	Updated as Chapter 3 of the 2020 Mine Plan and Reclamation Program Update, including to address content requirements of *Mines Act* Permit M-243 Condition E.14.
4	2023	Updated areas of disturbance and figures to include infrastructure changes and updated PMA since 2020 (Amendment #8, approved November 2022), Five Year Mine Reclamation Plan to reflect closure in 2029, addition of east WRD and associated infrastructure, reclamation research program progress; and changes to closure approaches such as increased commitment to remove some types of waste materials. New content added to address EMLI information requirements (ecohydrological modeling considerations; landforms and drainage pre-mine, during operations, and post-mine; temporary closure content; and climate change).

ACKNOWLEDGEMENTS

The Brucejack Mine Reclamation and Closure Plan was originally prepared pre-mine for Pretium Resources Inc. by ERM as chapter 5 of the 2015 Applications for *Mines Act* and *Environmental Management Act* Permits (Pretium 2015). The plan was subsequently revised by Pretium Resources Inc. (Pretium) to reflect updates from construction and operations and to make it specific to the M-243 permitted area. Sylvia Van Zalingen, M.S., P.Ag. (Pretium Resources Inc.), has prepared sections 1, 2.1, 2.3, 3.2, 3.3, 3.4, 3.5, 3.6.1, 3.6.2, 5, 6, 7, 8, 9, 10, 11, 12.1, 12.6 and 12.7 of this updated Brucejack Mine Reclamation and Closure Plan. Justin Straker, M.Sc., P.Ag. (Integral Ecology Group (IEG)) has prepared the ecohydrological modeling discussion in section 2.2, and sections 3.1, 3.6.3, 3.7 and 4, including information on the mine's reclamation research program that is being lead by IEG. Jessica Lowey, M.Sc., P.Ag. (ERM) has prepared or approved soils and vegetation content in sections 2.2 (paragraphs 3 to 6) and 2.3 (paragraphs 2 and 4), and has prepared section 3.2 Climate Change Considerations. Wade Brunham, M.Sc., R.P.Bio. (ERM) has prepared or approved wildlife content within sections 2.2 (paragraphs 3 to 6) and 2.3 (paragraphs 2 and 4). Robert Goldblatt, B.Sc., R.P.Bio. has prepared Section 12.2. Laura Findlater, B.Sc., P.Geo. has prepared Section 12.3. Dinesh Devathasan, B.A.Sc., P.Eng. has prepared Sections 12.4 and 12.5.

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LIST OF ACRONYMS AND ABBREVIATIONS

Terminology used in this document is defined where it is first used in each chapter. The following list will assist readers who may choose to review only portions of the document.

ATV	All terrain vehicle
BC	British Columbia
BEC	Biogeoclimatic Ecosystem Classification
BJAR	Brucejack access road
CCME	Canadian Council of Ministers of the Environment
CMAun	Coastal Mountain-heather Alpine
CODE	Health, Safety and Reclamation Code for Mines in British Columbia (2022)
CSR	Contaminated Sites Regulation
CWP	Contact water pond
DPS	Diesel power station
EMA	BC *Environmental Management Act*
EMLI	Ministry of Energy, Mines and Low Carbon Innovation
HDPE	High-density polyethylene
ICP-MS	Inductively coupled plasma mass spectrometry
Knipple camp	Camp located at BJAR km 56, serving the Knipple transfer area and BJAR to km 71
Knipple transfer area	BJAR support area, including for transfer of supplies, equipment and personnel on and off the Knipple Glacier
Lakeshore Drive	BJAR km 71-73.3 (segment extending between the top of the Knipple Glacier (km 71) and the mine site (km 73.3)
LOO	Licence of Occupation
MA	BC *Mines Act*
M-243	BC *Mines Act* Permit M-243

masl	Meters above sea level
MECCS	BC Ministry of Environment and Climate Change Strategy
MEMPR	BC Ministry of Energy, Mines and Petroleum Resources
Mine Site	Core mine infrastructure area at the southwest end of WRTSF
Mine Site Area	Mine infrastructure west of upper Knipple Glacier (km 71.6), including the NPAG quarry, upper BJAR, and the mine site
ML/ARD	Metal leaching/acid rock drainage
Newhawk	Newhawk Gold Mines Ltd.
NP	Neutralization potential
NPAG	Non-potentially acid generating
NPK	Nitrogen, phosphorus and potassium
OMS	Operations, maintenance and surveillance
PA-107025	BC *Environmental Management Act* Air Permit 107025
P.Ag.	Professional Agrologist
PAG	Potentially acid generating
PE-107835	BC *Environmental Management Act* Effluent Permit 107835
PMA	Permitted mine area
Pretium	Pretium Resources Inc.
ROW	Right-of-way
RTV	Rugged terrain vehicle
SFE	Shake flask extraction
SOP	Standard operating procedure
STP	Sewage treatment plant
tpd	tonnes per day
TSS	Total suspended solids

UG	Underground
VOK	Valley of the Kings
Wildfire camp	Camp located at BJAR km 1, supporting Wildfire security and BJAR transport and operations
Wildfire security	Security gate and screening located at BJAR km 1
WRD	Waste rock dump
WRTSF	Waste rock and tailing storage facility
WT	Water treatment
WTP	Water treatment plant
WZ	West Zone

1 INTRODUCTION

This is the updated Reclamation and Closure Plan for the Brucejack Mine, originally presented as the Brucejack Reclamation and Closure Plan in the 2015 Brucejack Gold Mine Project Application for *Mines Act* and *Environmental Management Act* Permits (*MA & EMA* Permits) (Pretium 2015). It incorporates reclamation program information included in Annual Reports for *Mines Act* Permit M-243 (M-243), *Environmental Management Act* Effluent Permit 107835 (PE-107835), and Air Permit 107025 (PA-107025) (Pretium 2016, 2017, 2018, 2019, 2020a, 2021, and 2022a). Content includes end land use and capability objectives; reclamation approaches, prescriptions and research; reclamation planning for the next five years and at closure; and planned post-closure monitoring.

Brucejack Mine reclamation and closure planning has been integrated with mine planning and design since pre-construction environmental assessment and related pre-construction design work began in 2012 and 2013. The mine and its operations have been planned and designed to minimize the terrestrial development footprint and to prevent significant adverse effects on the downstream aquatic receiving environment, including both water quality and aquatic biota.

Based on the current mine plan [refer to 4950 tpd Joint M-243/PE-107835 Amendments Application (Pretium 2022b, Chapter 3)], the remaining mine life is approximately 7 years, with operations ceasing at the end of 2029. This will be followed by a closure phase estimated at three years that includes two years of closure and reclamation within the M-243 area, and a third year of reclaiming off-site mine related infrastructure [i.e., the Brucejack Access Road (BJAR) and adjacent infrastructure below Knipple Glacier and extending to the Highway 37 intersection, and the Statutory Right-of-Way (ROW) authorized portion of the transmission line]. A post-closure monitoring period of ten years is planned for the M-243 area following mine closure.

This updated Reclamation and Closure Plan addresses mine infrastructure components and site disturbance authorized under M-243, including mine development within the Permitted Mine Area (PMA) portion of the mining leases (Figure 1-1) and the portion of the mine's transmission line extending south from the mining leases to Pretium's Mineral Claim #1026976 (Figure 1-2). Permit M-243 authorizes the northernmost 19.5 km of the transmission line, whereas the 37.5 km segment located south of that is authorized under Statutory ROW #6408729.

Brucejack Mine surface disturbance areas are limited in extent due primarily to it being an underground mine. The M-243 approved PMA is 659.3 ha (Figure 1-1 and Figure 1-2), with approximately 195 ha covering a 100 m corridor along the northernmost 19.5 km of the transmission line, and the remaining approximately 464 ha being located within the mining leases. Actual disturbance at end of 2022 was calculated at 278 ha (terrestrial disturbance area total for mine site 55 ha, buffer from historical exploration 66 ha, transmission line 66 ha, Waste Rock and Tailings Storage Facility (WRTSF) and Waste Rock Platform 76 ha, and km 72 Non- Potentially Acid Generating (NPAG) quarry 14 ha), however the historical exploration buffer areas are minimally disturbed and have been partially reclaimed. The terrestrial disturbance area total for the mine site primary infrastructure area is 55 ha [lower and upper camps 5 ha, plant site 38 ha, pond 0.02 ha, roads 11 ha, overburden stockpile 0.4 ha, Contact Water Pond (CWP) 0.7 ha], which includes mine site infrastructure and related disturbance areas. The transmission line calculated surface disturbance is primarily within the 6.7 km southernmost segment that is below treeline. Most of the northernmost 12.8 km of the transmission line is comprised of clear spans over bedrock and ice; towers in this section are anchored in bedrock.

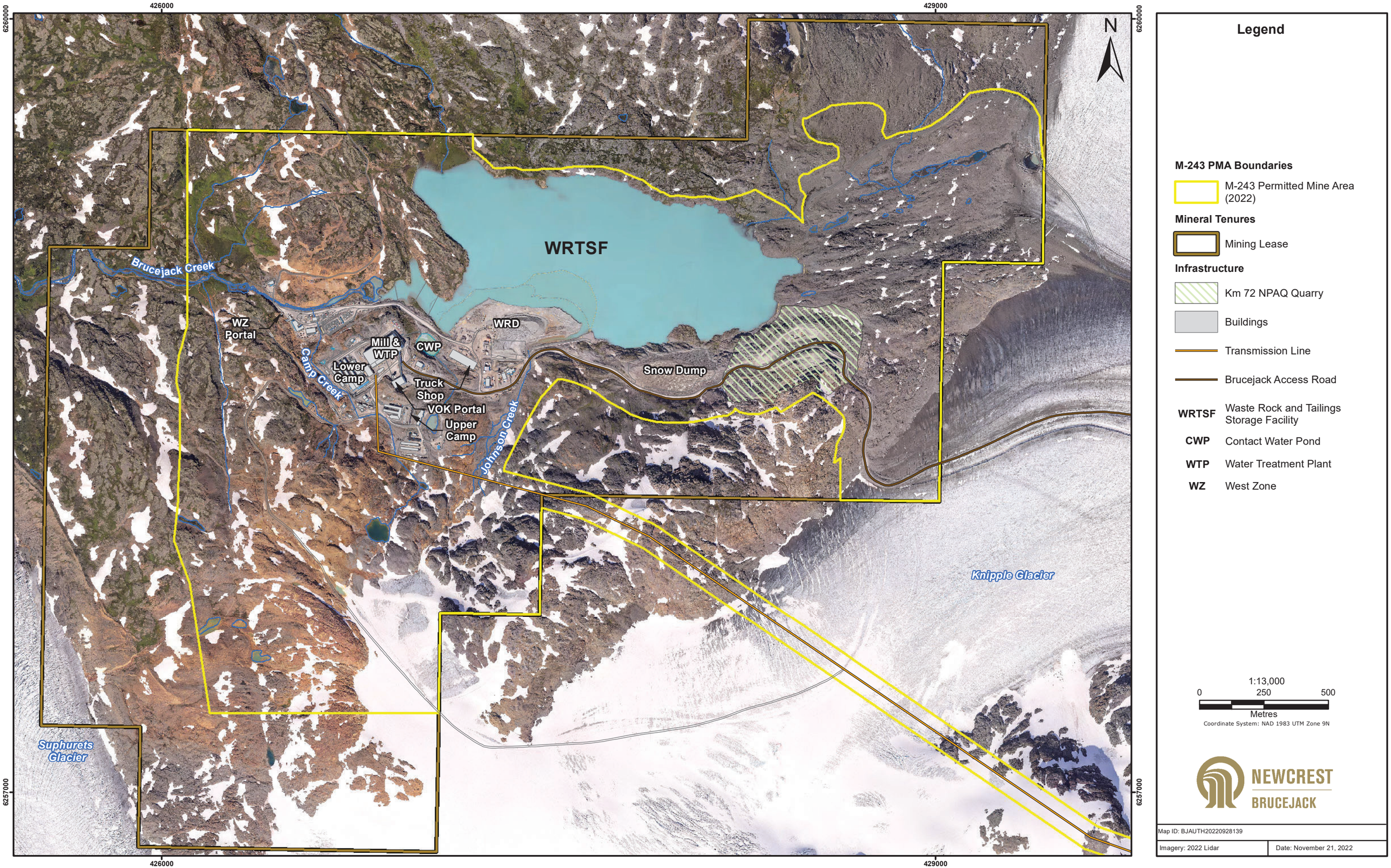


Figure 1-1. *Mines Act* Permit M-243 Permitted Mine Area Boundary within Mining Leases

Figure 1-2. *Mines Act* Permit M-243 Permitted Mine Area Boundary

Tree and shrub clearing within the M-243 portion of the transmission line right-of-way during construction was necessary for only the southern 6.7 km forested section, and mainly occurred to widths between 58 and 66 m. Access was almost entirely by helicopter, and trees were hand-felled and left in place with no disturbance of surficial soils and limited disturbance of existing vegetation over most of the cleared area. The tree felling approach was planned and approved, in part as an environmental protection/mitigation measure to limit ground-based access along the cleared ROW. Disturbance of surficial materials was limited, being primarily confined to tower bases. The tower sites were seeded with Pretium's native species seed mixes following completion of construction at each site. Post-construction, vegetation along the transmission line has continued to grow, undisturbed. Some mechanical vegetation control may be necessary in future if/when woody vegetation cover reaches heights that pose a safety and operational risk for the line.

2 END LAND USE AND CAPABILITY OBJECTIVES

2.1 BACKGROUND

End land use and capability objectives for Brucejack Mine components have been integrated with mine planning and design to promote successful reclamation and closure. Pre-development land use and conditions generally form the basis for identifying the end land use and capability objectives. The requirement to consider end land use for the mine site area is stated in Section 10.7.4 (Land Use) of the Health, Safety and Reclamation Code for Mines in British Columbia (Code) (EMLI 2022): "The land surface shall be reclaimed to an end land use approved by the chief permitting officer that considers previous and potential uses." The requirement to achieve an appropriate post-mine land capability is stated in Code Section 10.7.5 (Capability): "Excluding lands that are not to be reclaimed, the average land capability to be achieved on the remaining lands shall not be less than the average that existed prior to mining, unless the land capability is not consistent with the approved end land use or compromises long-term physical and/or geochemical stability."

These Code requirements are reflected in M-243. Condition E.3 requires Pretium to "reclaim the land with the intent of re-establishing average pre-mining capability to the following end land use objective: wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot on the mine site and high elevation sections of the transmission line, and moose and grizzly bear habitat at lower elevations of the transmission line. Achieving land capability objectives and habitat enhancement shall guide the reclamation program." Part E of M-243 contains additional reclamation related requirements.

This updated Reclamation and Closure Plan provides the plan of how end land use and land capability objectives will be achieved to the extent feasible, or site conditions created that will allow these to be achieved, by the end of the Brucejack Mine's closure period.

2.2 MINE SITE AREA

The Brucejack Mine site area encompasses all existing and proposed infrastructure within the mining leases, which are located west of the upper Knipple Glacier. Infrastructure in this area includes the underground mine and associated surface processing plant (mill) with Water Treatment Plant (WTP), camp, maintenance shop, water management infrastructure, WRTSF, BJAR ~km 71 to km 73.3, and the km 72 NPAG quarry (Figure 2.2-1). The mine is situated in rugged mountainous terrain at approximately 1,400 meters above sea level (masl). Surrounding peaks reach elevations exceeding 2,300 masl. Glaciers and ice fields surround the mine site area to the west, south and east. Recent and rapid deglaciation has resulted in over-steepened and unstable slopes in many locations. Recently deglaciated areas typically have limited, if any, soil development; where present, soils are derived from glacial till and colluvium.

The mine's primary surface infrastructure area is located along the southwest shore of the WRTSF in an area dominated by gossanous (mineralized materials to surface) bedrock outcropping with some slightly weathered parent materials occurring as pockets with alpine vegetation (Figure 2.2-1).

Prior to mine construction, the Brucejack Mine area was characterized as dominantly exposed bedrock, with approximately 80% of the mine site described as non-vegetated or sparsely vegetated

(Figure 2.2-2), with underlying limited extent and poor quality of soils (ERM Rescan 2014). The mine site area is located above the tree line in the Coastal Mountain-heather Alpine (undifferentiated; CMAun) Biogeoclimatic Ecosystem Classification (BEC) zone. This zone has the harshest climate of any biogeoclimatic zone in British Columbia (BC). Temperatures are low for most of the year, with much wind and snow. Temperatures remain low even during the growing season, which has an exceptionally short frost-free period. Mean annual temperatures range from 0°C to 4°C. Patches of snow, névé, and firn persist late into the year.

Figure 2.2-1. Brucejack Advanced Exploration 2013, Showing Mine Site Bedrock Outcrops and Pockets of Weathered Parent Materials.

Figure 2.2-2. Brucejack Mine Site 2012, Showing Bedrock Exposures and Limited Vegetation Extent.

Vegetation community development within the mine site and its vicinity was limited by the poor quality and limited availability of growth media, high snow pack, high winds and low temperatures. Vegetation classes of the Alpine Group (MacKenzie 2012) were present as a mosaic across the landscape, the distribution of which was determined by growth media depth, drainage and microclimate. The vegetation includes small shrubs, lichen and mosses. Most of the ecosystems within the mine site area are early seral, disclimax, or edaphic climax ecosystems. Early seral ecosystems, such as the areas mapped as alder thicket, are those early in the successional status chrono-sequence. These include non- and sparsely vegetated, pioneer seral and young seral communities. Edaphic ecosystems include those maintained by local climatic and soil conditions that enable an ecosystem to perpetuate itself.

The small areas of vegetation that were present (and which remain in some locations) include small shrubs, lichens and mosses. Alpine Tundra Class vegetation communities are dominated by hardy ericaceous shrubs that can withstand the desiccating winds common in alpine environments. Alpine vegetation classes include Alpine Fellfield, Heath, and Meadow classes. Detailed vegetation and terrain mapping and descriptions of the mine site and vicinity are provided in Appendix 5 of the 2012-2013 Terrestrial Ecosystem Baseline Studies (ERM Rescan 2014).

Pre-mine habitat assessments of the mine site classified the habitat as matrix habitat for wildlife species resident in the general vicinity: hoary marmot, grizzly bear, and, to a more limited extent,

mountain goat (ERM Rescan 2013). Aerial and ground surveys in 2012 and 2022 found hoary marmot colonies northwest and west of the mine site, along and near Brucejack Creek. Beginning during Pretium's advanced exploration activities in 2011, grizzly and/or black bears have been occasionally observed passing through the area north of Brucejack Creek and the (now) WRTSF, or south and high above the mine site along the winter access that traverses the upper Valley of the Kings (VOK) area.

An additional consideration pertinent to end land use is that growth media (unconsolidated overburden and soils) at the mine site have naturally elevated metals concentrations, including arsenic, due to being located on gossanous material. Additional details are provided below in Section 3.2.

At closure, the mine site will be reclaimed to matrix habitat for mountain goat, grizzly bear, and hoary marmot to facilitate movement by these target species and others, into better habitats. This will be achieved by reclamation measures that result in terrain that is free of mine related obstacles or hazards, thereby allowing free movement through the area by wildlife. The post-closure mine site will have low vegetation cover, consistent with its pre-mine condition and with surrounding areas, as most of the adjacent landscape is comprised of unvegetated bedrock exposures.

It is not currently possible to conduct ecohydrological modelling for the mine site and to present related tabular and spatial comparisons of pre-development and post-closure land use capabilities, for two reasons:

1. The Brucejack Mine site occurs in the CMAun BEC zone, for which a finer-resolution classification of site series does not exist. Thus pre-development (baseline) mapping of the mine-site area shows only five general ecosystem classes, listed here in rough order of prevalence: alpine ecosystem, glacier/permanent snow, moraine, water, and exposed soil. Of the alpine ecosystem class, as noted above, most of its area is sparsely or non-vegetated, as can be seen in Figure 2.2-1 and Figure 2.2-2. A pre-development table and map of ecosystems and capability therefore provides limited resolution (refer to Figure 2.2-3).
2. Objectives of the current Brucejack Mine reclamation research program include addressing three fundamental questions and limitations to reclamation at the mine site, as discussed in Section 3.6:

    a. What is the potential for metal uptake in vegetation that establishes on mine site surficial materials;

    b. Does any metal uptake that occurs pose or have the potential to pose concerns for any wildlife consuming this vegetation; and

    c. Given the acid generating or potentially acid generating (PAG), and metalliferous characteristics of mine site surficial materials and their unsuitability on that basis as reclamation material, should there be active revegetation of the mine site as part of the mine reclamation program (i.e., revegetation that would result in vegetation cover beyond what occurs naturally; potentially increasing the risk beyond what would occur naturally).

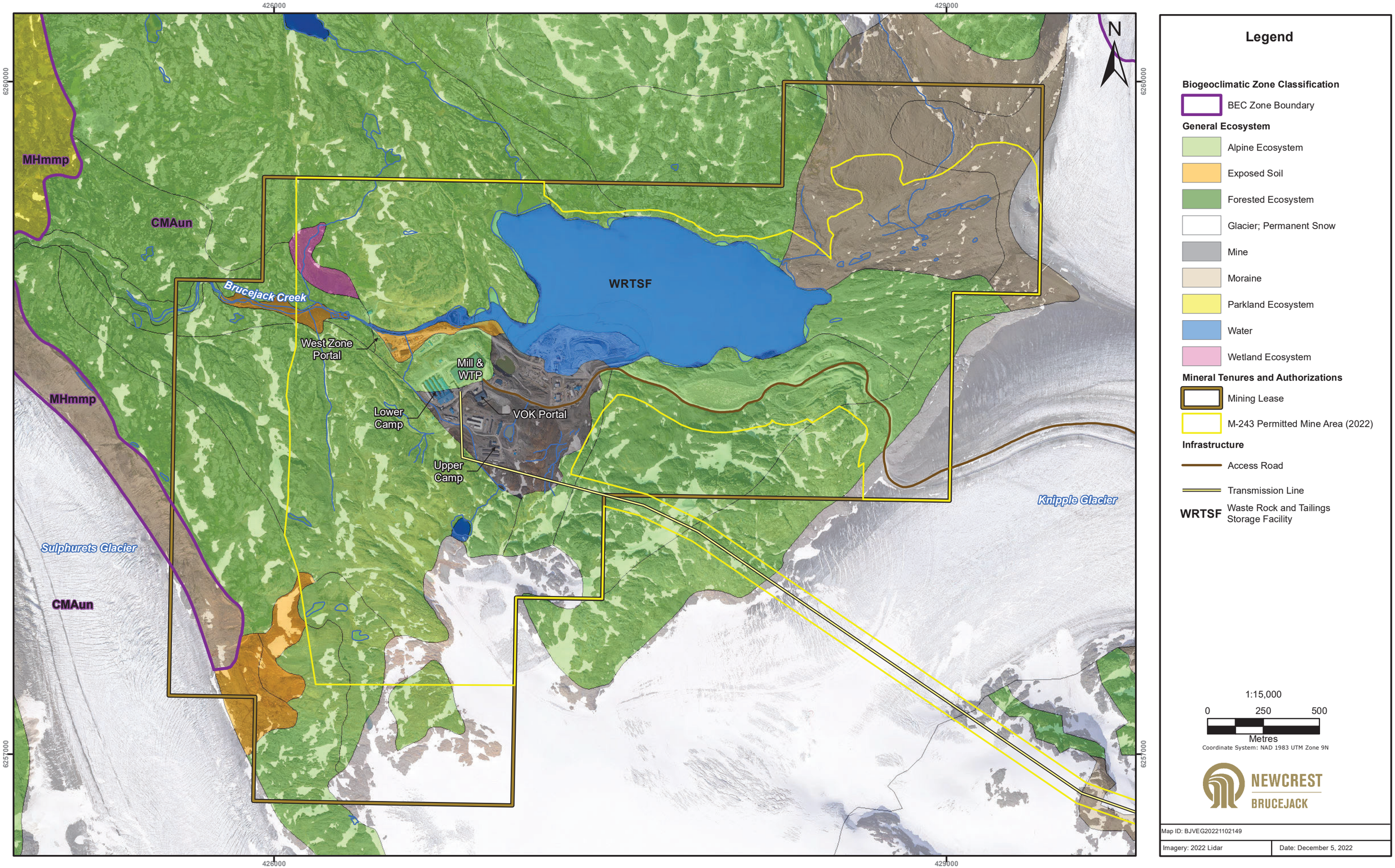


Figure 2.2-3. Brucejack Mine Site Terrestrial Ecosystem Map

2.3 BRUCEJACK TRANSMISSION LINE

Brucejack transmission line infrastructure will be removed during final reclamation. Due to the transmission line surface disturbance being primarily limited to tower base sites and effects to vegetation cover consequently being very limited, vegetation cover will have essentially the same extent at closure as it did pre-construction.

The M-243 portion of the Brucejack transmission line grades from old forest in the south to early seral ecosystems and non-vegetated areas in the north. Within the southern 6.7 km forested segment, mountain hemlock (*Tsuga mertensiana*) is a dominant species, with lesser presence of western hemlock (*Tsuga heterophylla*). Other tree species include subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*) and black cottonwood (*Populus trichocarpa*). Colluvium, moraine, rock, and ice are the dominant surficial materials mapped in the northernmost 12.8 km of the transmission line (ERM Rescan 2014).

As above, most of the M-243 portion of the transmission line route is located either above treeline or in high subalpine areas. Transmission line construction was helicopter supported, with road-based support within the M-243 section limited to a few towers near the BJAR. Transmission line tower base sizes vary with the tower type, with most being approximately 3 m in diameter. Towers were sited on bedrock as much as possible (Figure 2.3-1). Due to all of these factors, surface disturbance and effects on vegetation as a result of the transmission line are very limited.

At closure, the transmission line will be reclaimed to wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot in the high elevation sections, and moose and grizzly bear habitat at lower elevations of the transmission line. Transmission line development has not altered terrain except to a very limited extent (approximately 200 m length) at Knipple transfer area. Removal of the towers, conductors and Knipple substation will remove whatever limited obstacles to wildlife movement are posed by the transmission line. Due to the lack of soil disturbance between tower sites in the southern vegetated portion of the M-243 transmission line extent, the limited extent of tower sites on materials other than bedrock, and because where present, disturbed soils around tower bases have already been seeded, the end land use objectives for the transmission line are expected to be achieved.

Figure 2.3-1. Transmission Tower on Bedrock in M-243 Vegetated Section (Photo August 2019).

3 RECLAMATION APPROACHES

3.1 BACKGROUND

The Brucejack Mine site area has multiple unique or unusual characteristics that present substantial challenges for vegetation establishment and are not typical of mines in BC. As discussed above, these characteristics include the high elevation and harsh climatic conditions of the mine site area, the ubiquity of geochemically reactive gossanous materials throughout the mine site, and the pre-mine lack of soils and ecosystem development.

Because of these challenges, the general approach to reclamation planning for the mine has been to minimize surface disturbance through mine design and construction, and to then create post-mine topography and conditions that will achieve the matrix habitat end land use and support passive natural revegetation to the extent feasible. Key reclamation methods include recontouring to prevent barriers to movement of the target wildlife species and to create stable drainage features, and decompaction/scarification of potential growth media. Some limited additional measures are being investigated as a component of the reclamation research program, discussed below.

The following sections describe pre-development conditions and the approach to surficial materials use for reclamation within the Brucejack Mine site area and the M-243 portion of the transmission line. A key issue informing this approach is that overburden available as growth media within the mine site is predominantly PAG, with elevated element concentrations, particularly arsenic (Shaw and Simpson 2016) (Pretium 2020b, Appendix 3.3-1). This overburden is presently considered not suitable for use in reclamation and is instead recommended for handling in ways that will minimize potential for incremental acid rock drainage and metal leaching. It is not presently known if there are any areas within the mine site in which surficial materials may be amenable to revegetation – this question is being investigated as part of reclamation research described in 2020 Mine Plan and Reclamation Program Update (Pretium 2020b) and initiated in 2021.

Until the reclamation research program is sufficiently advanced to resolve active revegetation areas and methodologies, the reclamation plan and associated reclamation liability costing assume that mine site disturbances will generally be recontoured, de-compacted as feasible, seeded with the Brucejack high elevation native species seed mix, and fertilized (i.e. to supplement passive natural revegetation).

3.2 CLIMATE CHANGE CONSIDERATIONS

The BEC units across the province will inherently change as temperatures and precipitation amounts and types change into the future. The predictive changes in the BEC zones that overlap or are adjacent to the Project illustrate the effects associated with a predicted substantial raise in temperature and a predicted minor increase in precipitation amount, but a likely shift in precipitation type (BC Climate Explorer 2021). The lower elevation Mountain Hemlock (moist maritime parkland; MHmmp), with warmer mean annual temperatures, is predicted to begin replacing the higher elevation CMAun, which currently has much lower mean annual temperatures. These two ecosystems are predicted to overlap within 60 to 80 years (BC Climate Explorer 2021). The predicted differences in mean annual temperature and precipitation between the Engelmann Spruce - Subalpine Fir (undifferentiated parkland; ESSFunp) and the higher elevation Boreal Altai Fescue Alpine (undifferentiated parkland; BAFAun), are considerably less even now; thus, resulting in the possible replacement of the ESSFunp into higher elevations over time.

An understanding of climate change predictions and the associated effects on local ecosystems is intended to allow for the adaptation of final reclamation prescriptions to suit the current and predicted local climate.

3.3 SURFICIAL MATERIALS

3.3.1 Brucejack Mine Site Area

The Brucejack Mine site area is located in the high elevation, very cold CMAun BEC subzone. Prior to mine construction, vegetation was sparse, generally covering less than 20 percent of the plant site and vicinity and with little to no cover at km 72 NPAG quarry (ERM Rescan 2014) (Figure 2.2-2 and Figure 3.2-1). This sparseness is due to the extensive occurrence of bedrock, and the limited amount and poor quality of unconsolidated surficial materials.

Baseline surveys of mine site surficial materials (ERM Rescan 2014) determined that most of these materials are insufficiently weathered and developed to meet the definition of soils. Where soils are present, they are generally of poor quality for revegetation due to their high coarse fragment content, lack of development, and/or shallow depth to bedrock. Laboratory analyses indicate that most mine site surficial materials have metal exceedances based on Canadian Council of Ministers of the Environment (CCME) soil quality guidelines; these exceedances include arsenic (ERM Rescan 2014).

A thorough assessment of mine site overburden geochemical characteristics and suitability for use in reclamation was conducted in 2015 (Pretium 2020b, Appendix 3.3-1). This assessment indicated that mine site overburden is predominantly PAG. All overburden samples exceeded the CCME Industrial Soil Quality Guidelines for arsenic. The surficial materials characterization is consistent with the mine site's location in/on a gossan (mineralized, oxidized rock extending to surface; Figure 3.2-2).

In synthesis, the survey data indicate that soils and other surficial materials at the Brucejack Mine site are not suitable for use as reclamation growth media, and that overburden should not be spread as a reclamation cover but should be treated in a manner to minimize generation of acid rock drainage (Shaw and Simpson 2016). Although approximately 30,000 m^3 of this material was salvaged and stockpiled as required by the Ministry of Energy, Mines and Low Carbon Innovation (EMLI), there is currently no plan to use these materials as reclamation covers pending results from ongoing reclamation research. Amendment of these materials, such as attempting to add neutralizing compounds, is not a feasible option. Vegetation cover pre-mine was limited and implementing measures such as enhancing soil size materials to promote plant growth is currently considered to pose a risk to local wildlife in that it may attract wildlife to consume vegetation with potential to contain elevated metals concentrations.

Figure 3.2-1. Brucejack Mine Site 2008, Showing Sparse Vegetation Cover.

Shallow ripping will be conducted in areas of the mine site disturbance footprint as appropriate following decommissioning of structures to decompact surficial materials and facilitate any natural regeneration by native vegetation communities that may occur. These activities are consistent with the passive revegetation approach discussed below in Section 3.4.

Rock outcrops dominate the steep terrain at the km 72 NPAG quarry site and along the BJAR between the eastern boundary of the mining leases (~km 71) and the mine site (km 73.3). This section of the BJAR was pre-existing from prior exploration activities. It was widened and upgraded as required during mine construction to meet EMLI/Code safety requirements; this was primarily accomplished through placement of quarried NPAG rock from the km 72 NPAG quarry. No surficial materials salvage was feasible at these locations during mine construction. Shallow ripping will be conducted on the BJAR surface as feasible at closure, provided this does not compromise site stability and water management. The km 72 NPAG quarry will remain as exposed bedrock and boulders at closure.

Figure 3.2-2. Brucejack Mine Site Located On/In a Gossan (Photo August 2013).

3.3.2 Transmission Line

As described in Section 2.3, the northernmost 12.8 km of the Brucejack transmission line is comprised of clear spans over bedrock and ice dominated alpine terrain (Figure 3.2-4). Towers and lines were installed by helicopter. Towers are anchored in bedrock (Figure 3.2-3 and Figure 3.2-4). Reclamation of this section of the transmission line at closure will entail removal of towers and conductor line.

The southern 6.7 km of the M-243 transmission line section was mostly vegetated pre-construction, however even here there are extensive areas of bedrock exposure or shallow growth media over bedrock, and most towers in this section are also anchored in bedrock (Figure 2.3-1). Trees were hand felled, and soils and surficial materials were not disturbed except at the tower sites due to tower construction using helicopter support. The small, disturbed areas around tower sites with potential to support plant growth were seeded following transmission line construction. During mine closure, the towers and conductor along this portion of the transmission line will also be removed. No reclamation specific to surficial materials is planned at these tower sites at closure beyond minor recontouring, including covering concrete foundations to the extent feasible, and additional seeding as appropriate.

Figure 3.2-3. Transmission Line Tower, Northernmost Transmission Line Section (Photo July 2020).

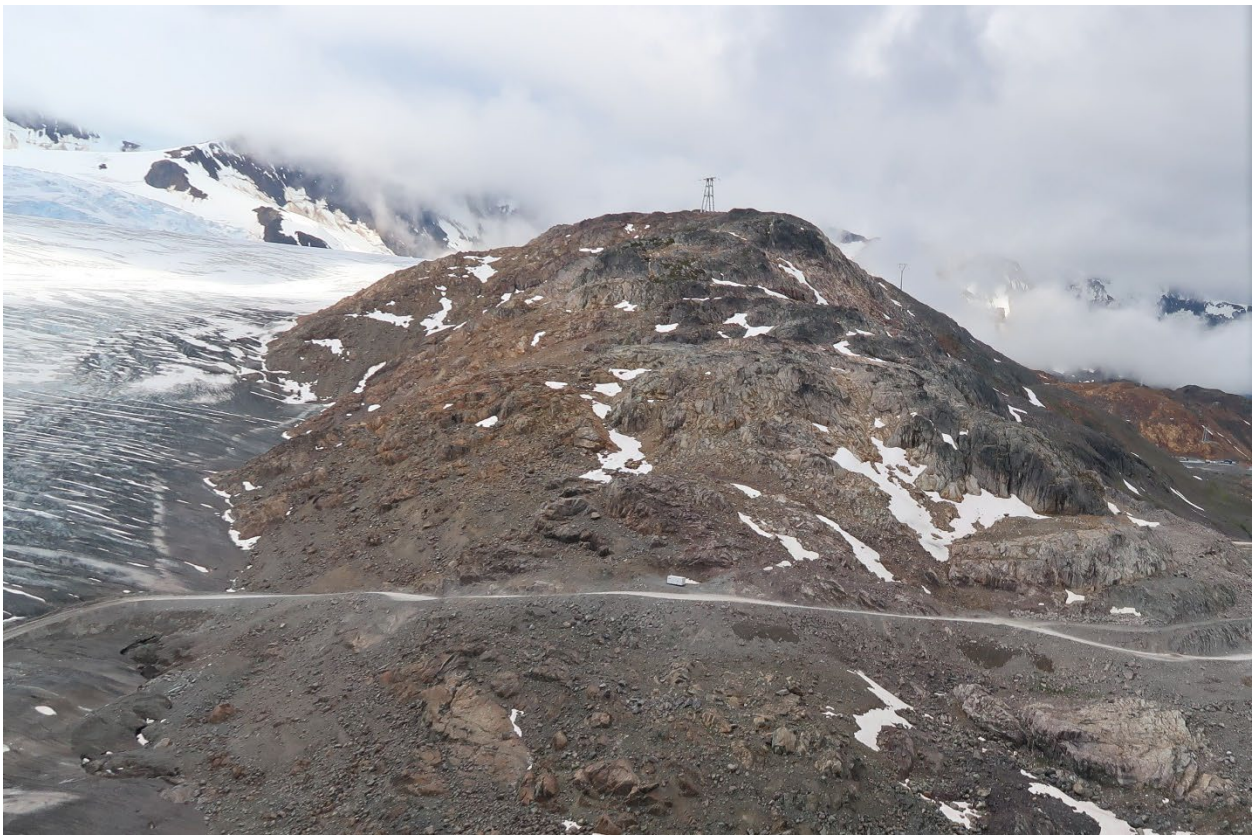


Figure 3.2-4. Transmission Line Towers in Northernmost Bedrock and Ice Section (Photo July 2018).

3.4 LANDFORM DESIGN AND EROSION CONTROL

3.4.1 Mine Site Area

3.4.1.1 Pre-Mine Landforms and Drainage

The Brucejack Mine site is located in a bedrock controlled, high elevation area (Figure 3.3-5.). Pre-mine, and in remaining undisturbed or minimally disturbed areas, the bedrock surface was/is irregular with rounded surfaces broken by crevices and depressions where snow accumulates. There were localized areas with shallow, slightly weathered overburden and limited areas with developed soil cover. Most of what is now the mine site drained to Brucejack Lake (now the WRTSF), with some areas draining to Camp Creek or directly to Brucejack Creek (Figure 3.3-1 and Figure 3.3-2). Bedrock and shallow overburden extended to the lake shoreline, with few level areas.

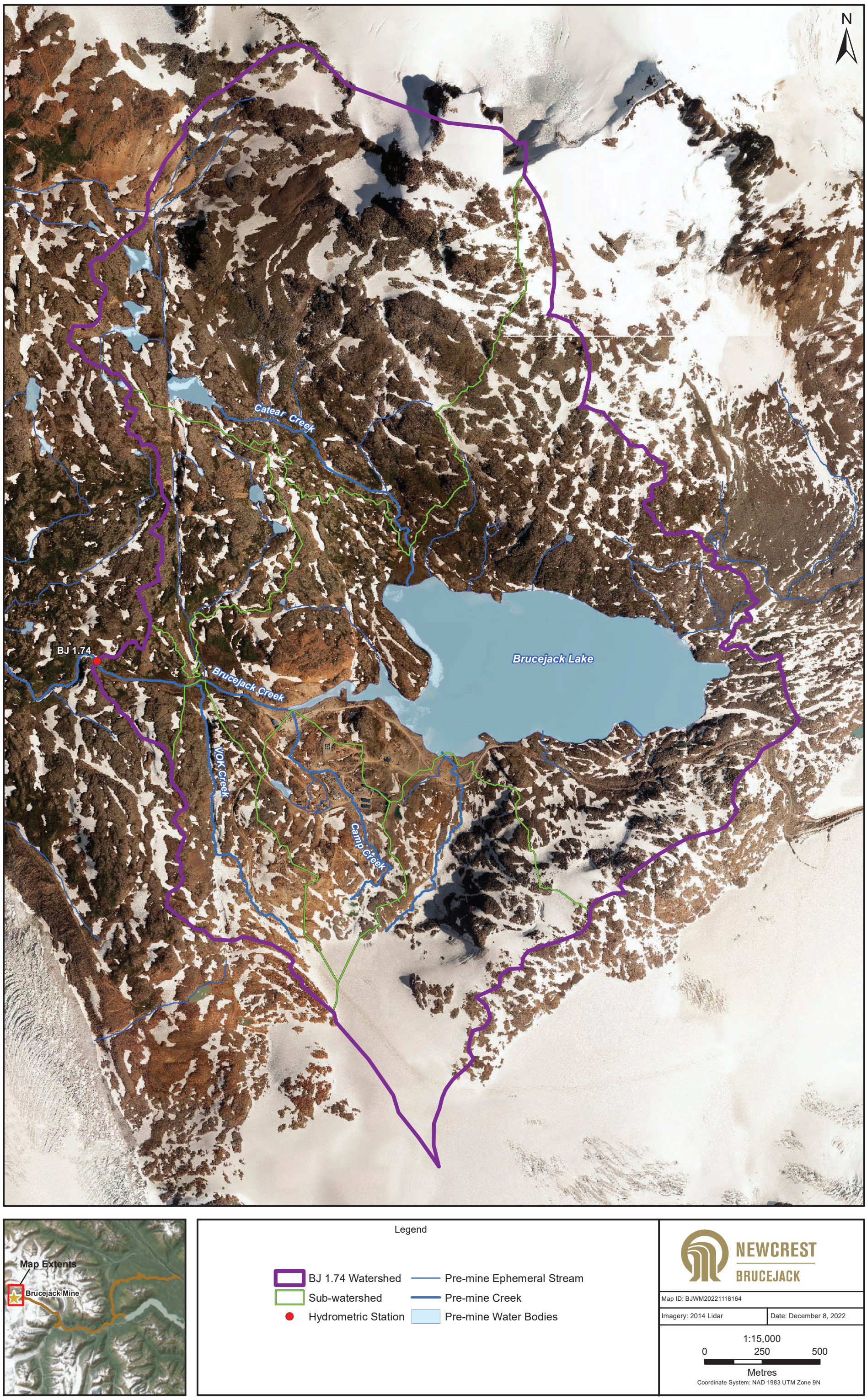


Figure 3.3-1. Pre-mine sub-watersheds within the Brucejack Creek Watershed

Figure 3.3-2. Pre-Mine Drainage Areas

3.4.1.2 Operations Landforms, Water Management and Erosion Control

Mine construction required development of level pads (Figure 3.3-6 and Figure 8.1-1) for surface infrastructure such as the mill and lower camp buildings. Parts of the pads were created by bedrock excavation; the remainder of the leveling was achieved by filling and compaction using excavated crushed rock sourced from the km 72 NPAG quarry. The pads are designed to be stable and resulted in approximately 20 ha of level area being created on the site (see also Figure 8.1-1, pads only).

A contact water collection system was constructed to collect runoff from the mine site pads bedrock excavations as had been planned and permitted pre-mine because this bedrock is or is assumed PAG, and in accordance with the metal leaching and acid rock drainage (ML/ARD) requirements of M-243 and the Brucejack ML/ARD Management Plan (Pretium 2021, Appendix 3-1-1-6). The contact water collection system collects water from an area of approximately 7 ha that pre-mine drained to Camp Creek and re-directs it to the WRTSF (Brucejack Lake) via the water collection and treatment system. It also collects water from an area of approximately 12 ha that pre-mine drained to the outlet section of Brucejack Lake or to Brucejack Creek and re-directs it to the WRTSF (Brucejack Lake) via the water collection system.

The WRTSF is authorized for the sub-aqueous deposition of mine waste rock and tailings and effectively settles suspended sediment resulting from this deposition. The contact water collection system actively and passively directs surface runoff from within the contact water collection portion of the mine site (most of the mine surface infrastructure areas; Figure 3.3-3) to the CWP. Water in the CWP is pumped to the WTP located in the mill, where it is treated prior to discharge to the WRTSF. Therefore, suspended sediment from any erosion within the contact water collection area is directed through the CWP and the WTP. Mine infrastructure areas east of the contact water collection system, including the waste management and other facilities near the East (Johnson Creek) diversion channel, the km 72 NPAG quarry, and the BJAR section from approximately km 72 westward, all drain passively to the WRTSF.

The West Zone pad and portal area is located outside of the contact water collection area. The portal itself drains inward into the underground mine. Water within the underground mine is collected and pumped to the mill and WTP. The West Zone pad is very level. A berm has been established between the West Zone Pad and the adjacent section of Brucejack Creek pad to provide physical separation of this infrastructure area from the creek.

Additional details on mine site water management and associated erosion control are provided in the Water Management Plan – Operations, Maintenance and Surveillance (OMS) Manual (Pretium 2021, Appendix 3-1-1-9).

The km 72 NPAG quarry east of the mine site is located in bedrock. The quarrying process results in excavated benches and walls in the sloping bedrock (Figure 3.3-7). The quarry is designed such that the final quarry faces will be stable.

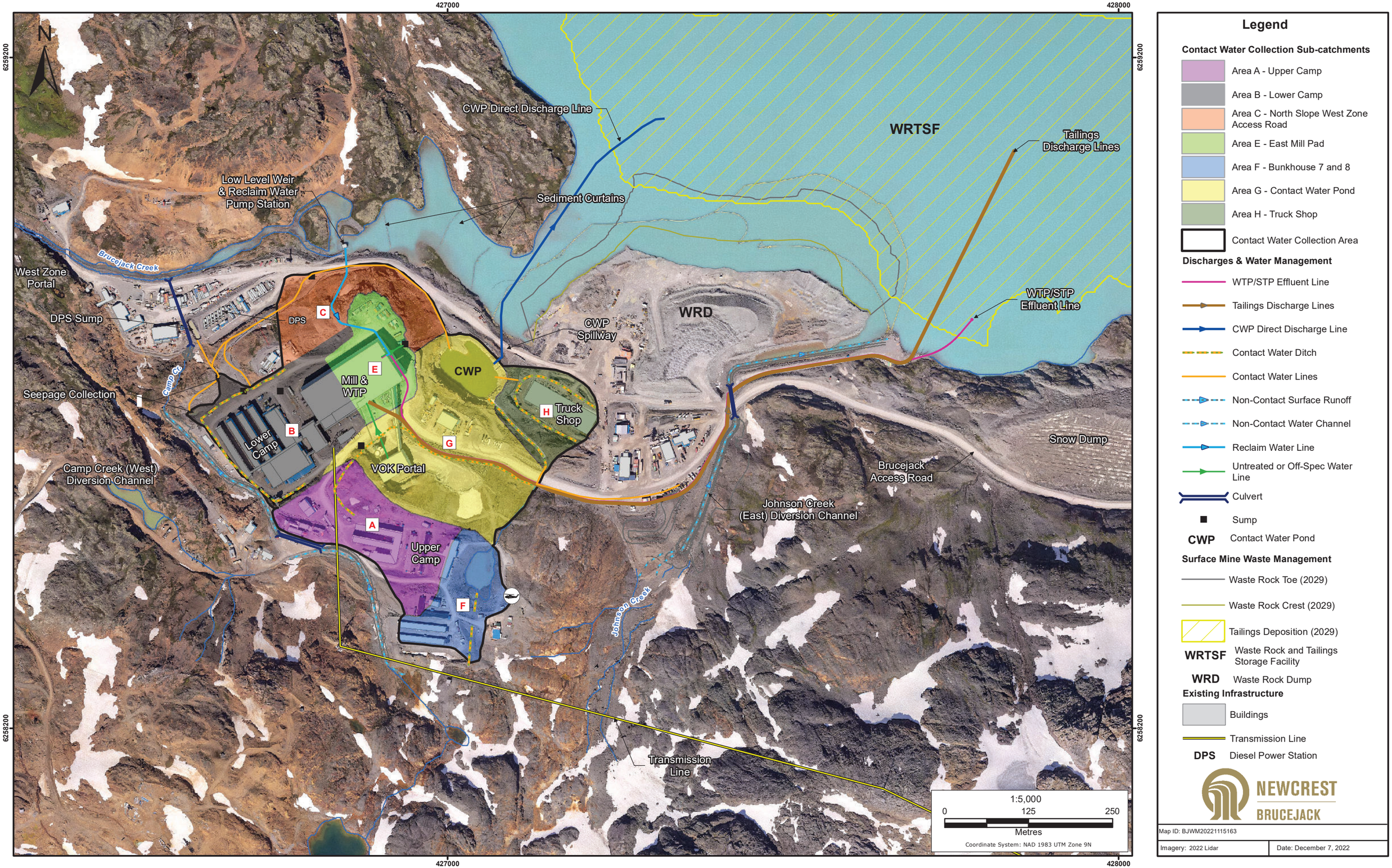
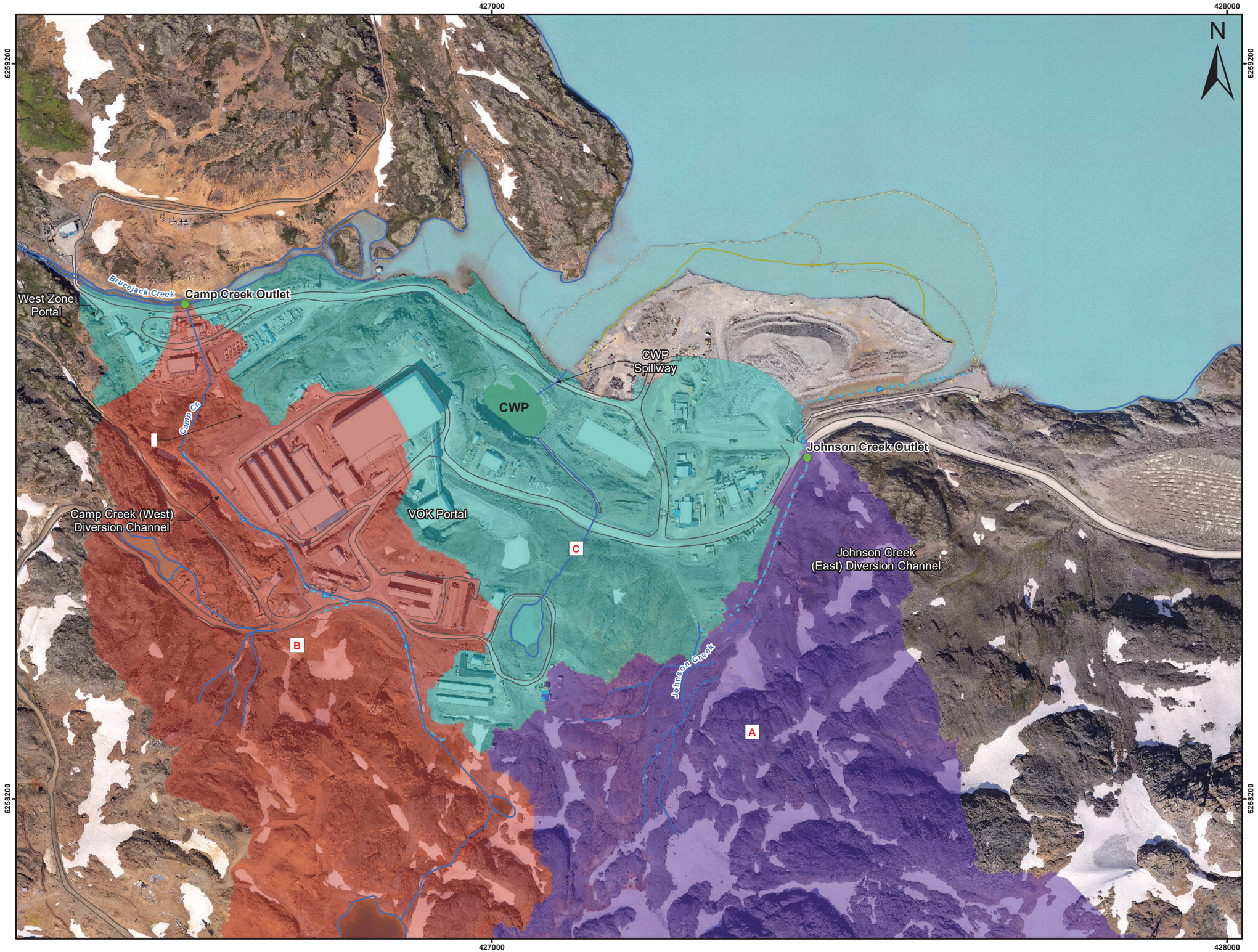


Figure 3.3-3.Brucejack Mine Operations Contact Water Collection Area

3.4.1.3 Post-Mine Landforms and Drainage

Post-mine drainage catchments based on current closure planning, including based on consideration of post-closure water quality and on stability requirements for remaining water management structures, are shown on Figure 3.3-5. Following the removal of the active portions of the contact water collection system, the camp pad will drain passively to Camp Creek and the slopes below the mill, along with a portion of the mill pad, will drain to lower Camp Creek or to Brucejack Creek. The remainder of the mill pad and the areas passively draining to the CWP during operations will drain to the CWP and from there to the WRTSF. The CWP will remain in place, with the spillway remaining intact, and allowed to spill passively via the current emergency spillway, to the WRTSF. All areas east of the operations contact water collection system that drained passively to the WRTSF during operations will continue to do so post-closure. Post-closure, much of the mine site will continue to drain to the WRTSF, which will continue to passively collect and settle sediment. The West Zone Pad area will continue to drain to Brucejack Creek post-closure. Section 8.4.2 provides additional details of contact water collection area closure planning.

Mine closure and reclamation has been planned to facilitate movement of wildlife through the post-mining landscape (discussed below).



Legend

Drainage Areas

- Area A - Johnson Creek
- Area B - Camp Creek Drainage
- Area C - Brucejack Creek Drainage
- Creek Outlets

Discharges & Water Management

- Non-Contact Surface Runoff
- Non-Contact Water Channel
- CWP Contact Water Pond

Surface Mine Waste Management

- Waste Rock Crest (2029)

Existing Infrastructure

- Buildings
- Roads

1:5,000

0 125 250

Metres

Coordinate System: NAD 1983 UTM Zone 9N

NEWCREST BRUCEJACK

Map ID: BJWM20221201167

Imagery: 2022 Lidar

Date: December 7, 2022

Figure 3.3-4. Post-Mine Drainage Areas

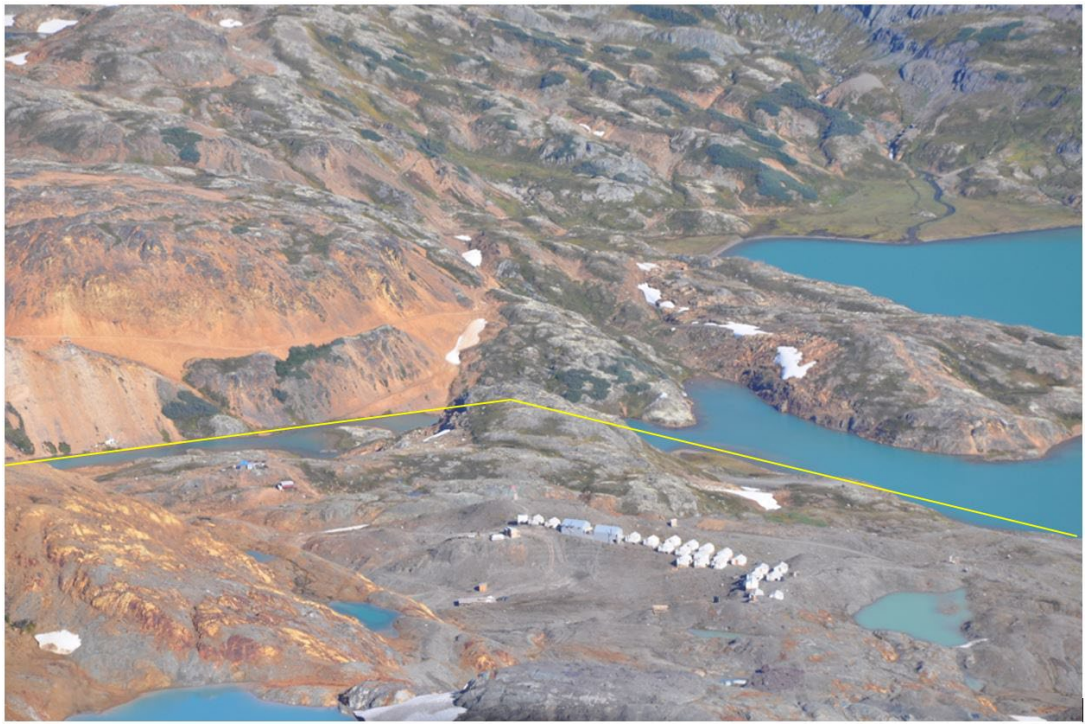


Figure 3.3-5. Mine Site 2008 During Exploration, Showing Bedrock Control.

Figure 3.3-6. Development of Mine Site Level Pads During Construction with PAG Bedrock Excavation and Quarried NPAG Rock Fill, October 2015.

Figure 3.3-7. Km 72 NPAG Quarry (Photo August 2022)

3.4.2 Transmission Line

Transmission line construction entailed very minimal surface disturbance and no significant effects on landforms. The Knipple substation was constructed on the pad (in gravel substrate) developed for Knipple transfer area and camp infrastructure (Figure 3.3-8). Much of this area had been previously leveled for the Granduc-Newcana joint venture use of this site for staging during the 1980s. The substation site is level, well drained (gravel and coarse textured materials substrate), stable and not subject to erosion.

Removal of the transmission line infrastructure at closure (towers, conductor, and Knipple substation) will result in the post- transmission line landforms being almost identical to the pre-mining landscape. There will be very minor and localized terrain changes compared to pre-development at some tower sites, but these are mainly limited to the vegetated southern portion of the line and are expected to become obscured by vegetation over time. The Knipple substation pad will be left level, in approximately the same topographical condition as existed prior to Pretium's use of this site. Erosion is not expected to be a significant consideration at any of the tower sites or at the substation.

Figure 3.3-8. Knipple Substation, July 2020.

3.5 REVEGETATION STRATEGY

3.5.1 Mine Site Area

Subject to the outcomes from ongoing reclamation research, the overall revegetation strategy for the Brucejack Mine site area is passive, and consistent both with the end land use objective of matrix habitat for mountain goat, grizzly bear, and hoary marmot, and with the challenges associated with local surficial materials. It entails creating, to the extent feasible and consistent with the pre-mine and adjacent landscapes, post-mine site and substrate conditions conducive to natural revegetation. Site disturbances will generally be recontoured and decompacted through shallow ripping as feasible and be allowed to regenerate naturally to locally endemic vegetation communities. Until the reclamation research program is sufficiently advanced to resolve active revegetation areas and methodologies, the reclamation plan and associated reclamation liability costing assume that mine site disturbances will generally be recontoured, de-compacted as feasible, seeded with the Brucejack high elevation native species seed mix, and fertilized (i.e. to supplement passive natural revegetation).

Most of the high elevation plant species that would be appropriate for an active revegetation program of the mine site are not commercially available and would likely present substantial propagation difficulties. Potentially suitable species that may be commercially available are very unlikely to have been sourced from near coastal northwest BC, and therefore, although the same species, may not necessarily be adapted to the site conditions at the Brucejack Mine site. These difficulties are further

exacerbated by the mine site surficial materials, which are acid generating or PAG, have elevated metals concentrations, and have been assessed as being unsuitable for use in reclamation (Section 3.2.1). The reclamation research program currently in progress is investigating the potential for revegetation of these materials to result in plant tissues with elevated metals concentrations, which, if these tissues are consumed by wildlife, could detract from the objective of providing suitable matrix habitat. Because of these limitations and challenges, passive or “leave-for-natural" revegetation approaches are more likely to yield acceptable long-term results than revegetation with non-local plant species. Further discussion on revegetation research and metal uptake is presented in Section 3.6 below on reclamation research.

The km 72 NPAG quarry and the BJAR segment between Knipple Glacier and the mine site (~km 71 to 73.3) were constructed mostly or entirely in rock. Natural revegetation is planned for these areas.

3.5.2 Transmission Line

During mine closure, the towers and conductor will be removed. As described in Section 3.2.2, transmission line towers within the northernmost 12.8 km of the transmission line are anchored into exposed bedrock. No revegetation is feasible or planned for these locations.

Most transmission line towers in the southern 6.7 km of the transmission line are also anchored in bedrock. The small, disturbed areas around tower sites with potential to support plant growth were seeded following transmission line construction. No reclamation specific to surficial materials is planned at these tower sites at closure beyond minor recontouring, including covering concrete foundations to the extent feasible, and additional seeding as appropriate. Wherever there are growth media available following removal of towers and lines at closure, these areas will be seeded with Pretium’s high elevation or low elevation seed mix (Table 3.4-1 and Table 3.4-2) as appropriate to the elevation (see Figure 3.4-1 as an example).

Because vegetation in the areas surrounding the towers has not been disturbed beyond felling trees (Figure 3.4-2), it is expected that any tower sites with surficial materials suitable for plant growth will revegetate naturally within a few years of transmission line removal, irrespective of any reclamation measures. The total area of tower bases and adjacent disturbed areas within the vegetated portion of the transmission line has been calculated at a total of 0.303 ha from analysis of site orthophotography. There are 13 towers in this section averaging 233 m^2 of surface disturbance per site (approximately 15 m by 15 m).

Table 3.4-1. Brucejack Low Elevation Seed Mix[1].

Low Elevation (sub 900 masl)	% by weight	Seeds/lb	% by Seed Count
Agrostis scabra, **hair bentgrass**	1.00	4,000,000	18.36
Bromus sitchensis, **Alaska (Sitka) brome[2]**	33.00	100,000	15.14
Elymus glaucus, **blue wildrye**	30.00	131,000	18.04
Elymus trachycaulus, **slender wheatgrass**	26.00	145,000	17.30
Festuca saximontana, **Rocky Mountain fescue**	10.00	679,000	31.16
	100.00		100.00

[1] Application rate 60 kg/ha with 16-16-16 NPK fertilizer at 40 kg/ha
[2] Alaska brome may be substituted for Mountain Brome

Table 3.4-2. Brucejack High Elevation Seed Mix[1].

High Elevation Seed Mix (above 900 masl)	% by weight	Seeds/lb	% by Seed Count
Elymus trachycaulus, **slender wheatgrass**	60.00	145,000	20.58
Festuca saximontana, **Rocky Mountain fescue**	20.00	679,000	32.12
Poa alpina, **alpine bluegrass**	10.00	1,000,000	23.65
Trisetum spicatum, **spike trisetum**	10.00	1,000,000	23.65
	100.00		100.00

[1] Application rate 60 kg/ha with 16-16-16 NPK fertilizer at 40 kg/ha

Figure 3.4-1. Seeded Transmission Line Tower Site (Photo July 2020).

Figure 3.4-2. Transmission Line Natural Vegetation Cover Following Clearing (Photo July 2020).

3.6 PROGRESSIVE RECLAMATION AND SEQUENCING

3.6.1 Mine Site

Design of the Brucejack Mine site has focussed on efficient and essential use of surface disturbances. The mine site surface disturbance area is small (mine site actual disturbance area totals approximately 55 ha), and the area is intensively used and needed for operations. Because Brucejack is an underground mine, incremental surface disturbances during mine life are very limited, and the site disturbance that is present is occupied by facilities and activities that will remain present throughout mine life.

An additional consideration within the small and intensively used mine site is the risk that revegetation efforts would pose to local wildlife. Establishing additional vegetation within the active mine site may attract hoary marmot and other small mammals, and possibly larger mammals such as bears. There is no feasible means to create barriers to prevent hoary marmot/small mammal ingress onto such areas, and this wildlife will be at increased risk of injury or mortality from traffic if present within the

active mine site. Further, as described in Section 3.7, results from the reclamation research in progress into metal uptake in vegetation is needed before there are efforts to establish vegetation within the gossanous area.

As a result of these factors, the opportunities for progressive reclamation within the primary facilities portion of mine site are currently mainly limited to those that will support reclamation research (see Section 3.7). This will be revisited as reclamation research proceeds and additional information becomes available. Areas within the M-243 PMA disturbed through surface exploration will continue to be reclaimed progressively (e.g., current Gossan Hill exploration areas north of Brucejack Creek, Figure 8.1-2). All other reclamation activities within the mine site will be completed during the closure phase.

3.6.2 Transmission Line

Tower sites within the southern 6.7 km vegetated portion of the M-243 authorized portion of the transmission line were seeded at the time each tower was completed. Vegetation disturbance between tower sites was limited to hand felling of trees due to use of helicopter support for line construction and absence of road access for all but a few tower sites within and near Knipple transfer area. Vegetation within the transmission line cleared width has been allowed to grow without further disturbance since the transmission line was completed (Figure 3.4-1).

Although vegetation regrowth at many tower sites has been excellent (Figure 3.4-2), there are small areas of limited growth at some tower sites. This appears in many cases to be related to bedrock presence at or near surface, or placement of compacted fill for certain tower sites (micro-piles) where tower anchoring to bedrock was not feasible.

The Knipple substation is located within the constructed gravel surface of the Knipple transfer area. The substation extent must remain vegetation free for as long as the substation remains active. M-243 portions of the Knipple pad outside of the substation will be active for life of mine as part of Knipple transfer area activities; this pad area is also tenured under License of Occupation (LOO) #6408836. Opportunities for progressive reclamation do not exist; all reclamation activities at this location will be completed during the closure phase.

3.7 RECLAMATION RESEARCH

3.7.1 Purpose and Objectives

The purpose of the Brucejack Mine reclamation research program is two-fold:

1. To address and reduce any identified uncertainties in the ability to achieve the objectives of the reclamation program, and
2. To test any key assumptions upon which successful reclamation is based.

Three primary and related uncertainties have been identified; these are the focus of the Brucejack reclamation research program over the next five years:

1. What is the potential for metal uptake in any vegetation that establishes on mine site surficial materials (i.e., naturally established or seeded vegetation);

2. Does any metal uptake that occurs pose or have the potential to pose concerns for any wildlife consuming this vegetation; and
3. Given the acid generating or PAG, and metalliferous characteristics of mine site surficial materials and their unsuitability on that basis as reclamation material, should there be active revegetation of the mine site as part of the mine-reclamation program (i.e., revegetation that would result in vegetation cover beyond what occurs naturally; potentially increasing the risk beyond what would occur naturally).

These uncertainties are inter-related in that findings from further research into metal uptake by plants could have implications for vegetation establishment on metalliferous mine site surficial materials. Reclamation research programs to address these uncertainties are discussed in more detail in the subsections below.

3.7.2 Trace Elements in Soils and Vegetation and Metal Uptake

Due to the mine site location on a gossan with mineralization to surface, trace elements in soils and growth media are elevated. Depending on the vegetation species and the trace elements that are present, metal uptake may occur. For example, soil size surficial materials (weathered parent material) and soils within the mine site are known to have elevated concentrations of arsenic. It is not expected that mine activities will significantly increase or change this. Surface stockpiling of excavated rock from the underground mine has been temporary and limited.

Waste rock is hauled directly to the shore of the WRTSF for subaqueous disposal, with stockpiling duration required to be maximum two years in accordance with M-243 Condition D.3(c)(v). Permanent disposal of waste rock on surface is not permitted. Snow cover and frozen conditions through most of the year and wet conditions through much of the remainder limits fugitive dust production and dispersal, as does the crushed NPAG rock surfacing of most site roads. Road watering is used as needed during the short summer season to limit road dust. Similar measures (road surfacing and watering) are used in the underground mine. There are pollution control works in the mill to manage dust sources there, in accordance with PA-107025 and the Air Quality Management Plan (Pretium 2022a, Appendix 3-1-1-2).

As noted above, surficial materials available as growth media within the mine site are PAG or acid generating, metalliferous, and have been recommended to not be used in reclamation. Research is in progress to provide more information on pre-mine conditions with respect to metals concentrations in vegetation, and to evaluate the implications and risks of revegetating site surficial materials.

As part of the terrestrial baseline program to support applications for mine authorizations, soils and vegetation were sampled at 11 sites in 2012 in the vicinity of the mine site area, and at six reference locations of similar elevation (ERM Rescan 2014) (Figure 3.6-1). Soil samples were collected at all sites, along with samples of the terrestrial lichen *Cladina stygia*. Samples of the blueberry *Vaccinium uliginosum* were also collected at one of the mine site sampling locations and at one reference site. Assessment of results from this sampling program indicate that all mine site soil samples and four of six of the reference sites had arsenic concentrations exceeding CCME industrial soil quality guidelines. There was some evidence of elevated arsenic concentrations in the lichen samples, although the occurrence of elevated levels was not as ubiquitous as in soil samples. Arsenic concentrations were below detection limits in the blueberry samples.

To advance understanding of the relationship between soil and vegetation element concentrations and the ability of vegetation to establish in metalliferous materials, a research program with five components is being conducted:

1. Sampling of surficial materials and vegetation once at the locations that were sampled in 2012, or where these sites no longer exist, at analogous locations (Figure 3.6-2).
2. Single-time sampling of surficial materials and vegetation co-located with the two historic dustfall canisters (Figure 3.6-2).
3. Opportunistic single-time sampling of surficial materials and vegetation at additional sites both within the gossanous surficial materials within/adjacent to the mine site area, and in adjacent non-gossanous areas for contrast (Figure 3.6-2).
4. Opportunistic single-time sampling of vegetation, and co-located sampling of surficial materials, that has established on disturbed materials within the mine site area [both gossanous and (thought to be) non-gossanous] (Figure 3.6-2).
5. Collection and removal of surficial materials for a greenhouse study using native grasses (the Brucejack Mine high elevation seed mix) to examine uptake in candidate species with potential for use in reclamation seeding within the mine site area.

Sampling programs 1 through 4 were completed during 2021, with results to be provided in the 2022 MA/EMA Permits Annual Report. Materials for the greenhouse study were collected from two locations in 2022 – the overburden stockpile and the vegetation establishment (i.e., seeding trial) area - and sent to Thompson Rivers University for initiation of research. In total, approximately 80 L of surficial materials were sent for testing and greenhouse propagation.

All surficial materials were, (or in the case of the greenhouse materials will be), analyzed for physical and chemical properties as described in Section 3.6.2.1 below. Vegetation sampling included re-sampling of *C. stygia* and *V. uliginosum* at sites previously sampled in 2012, and also included sampling of additional vascular species that could be consumed by hoary marmot. In total, 26 sites were sampled for vegetation in 2021, with a subset sampled for soils (Figure 3.6-2). Lichen samples were cleaned of non-lichen tissue and mineral materials prior to processing. All vegetation samples were analyzed for total element concentrations on a dry-weight basis by inductively coupled mass spectrometry (ICP-MS). This program is designed to be developed iteratively, so that results from initial sampling can be used to inform development of subsequent program phases as necessary.

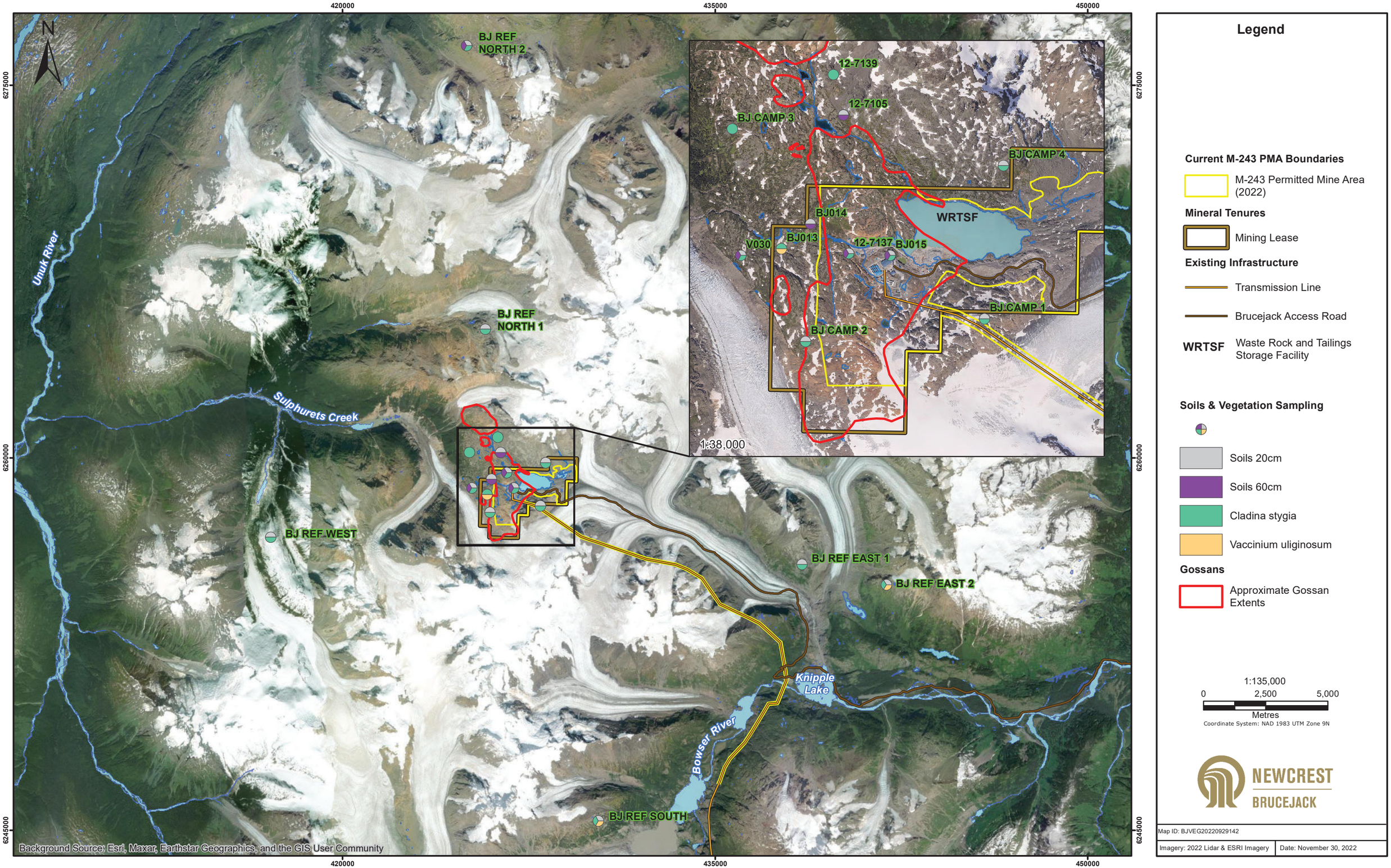


Figure 3.6-1. Baseline 2012 Soils and Vegetation Sampling Locations and Approximate Outlines of Gossanous Surficial Materials

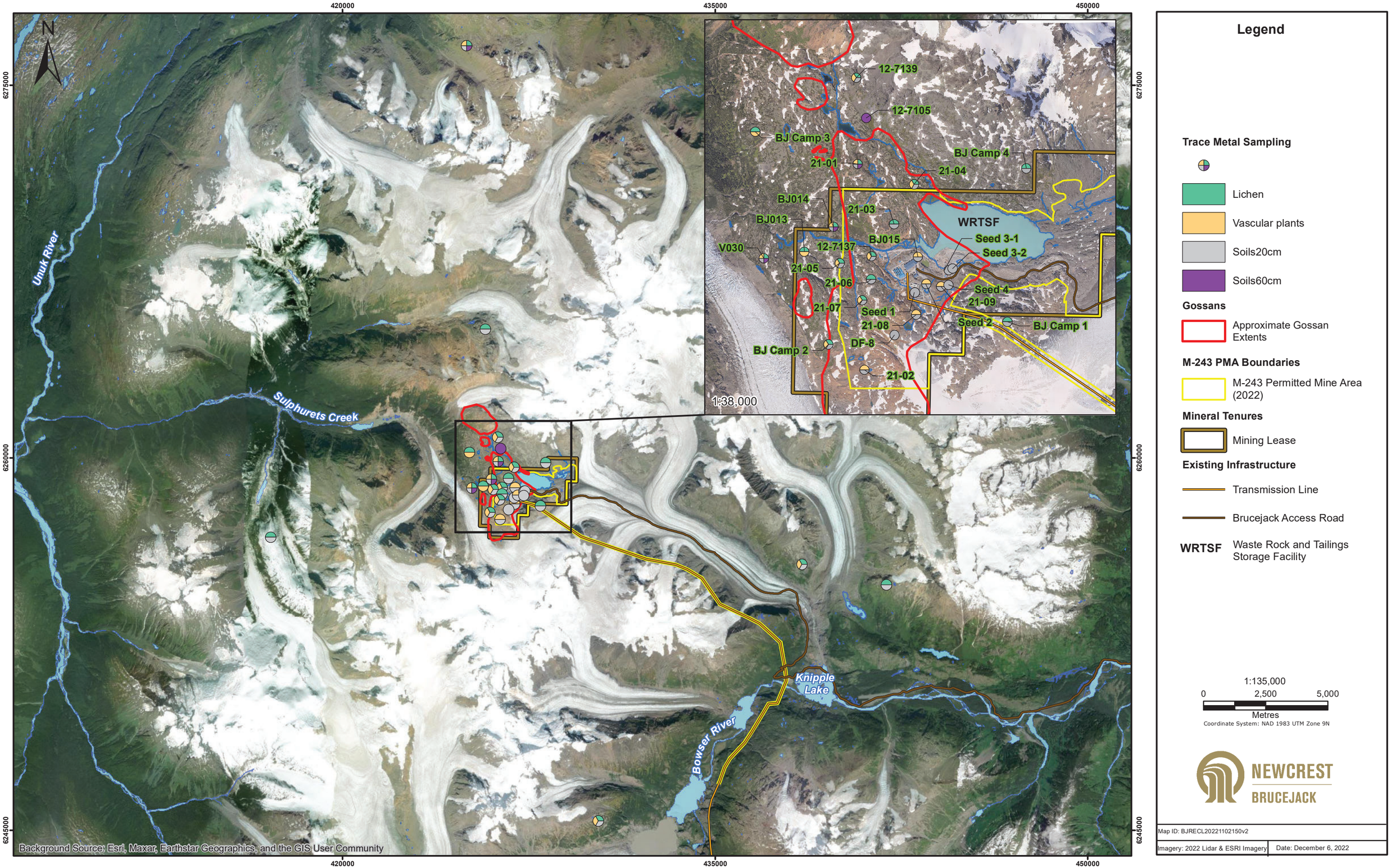


Figure 3.6-2. 2021 Trace Metal Sampling Locations and Approximate Outlines of Gossanous Surficial Materials

3.7.2.1 Vegetation Establishment

Research is in progress to identify opportunities to establish limited native vegetation cover on unamended local materials, such that any risks to wildlife due to metal uptake in vegetation are unlikely to exceed those present before mine development. As above, additional sampling of vegetation present within the gossan has been completed to improve the overall understanding of extent of risk. It is expected that as weathering and related acid production from surficial materials increases, the ability of the materials to support plant growth will decline until the acid has been depleted.

One study area, located south of the Brucejack upper camp, was identified to test revegetation establishment success and determine plant element uptake (Figure 3.6-3). Surficial materials were decompacted and the site was prepared for seeding. The site was then seeded with Pretium's high-elevation native seed mix (Table 3.4-2), which is tested for purity and to ensure lack of invasive species. The seed was applied at a rate of 60 kg/ha. As the disturbed soil had low organic-matter content and low fertility, fertilizer [16-16-16 nitrogen, phosphorus and potassium (NPK)] was applied at a rate of 40 kg/ha to promote plant establishment.

Approximately 40 L of surficial materials were composite-sampled from the seeding trial site and sent to Thompson Rivers University for analysis and inclusion in a greenhouse study (described in Section 3.6.2). Surficial materials will be described and tested for a range of physical and chemical parameters. Physical parameters will primarily consist of particle-size distribution. Chemical parameters will include pH, electrical conductivity, organic-matter content, total nitrogen, and a standard suite of analytes used for geochemical evaluation, including:

- total inorganic carbon,
- total carbon,
- sulphide sulphur,
- sulphate sulphur,
- total sulphur,
- insoluble sulphur (calculation),
- paste pH,
- modified neutralization potential (NP),
- acid production potential, carbonate acid NP and NP ratio (calculated),
- solid phase element by ICP-MS, and
- shake flask extraction (SFE).

The purpose of these analyses is to aid in interpretation of revegetation results, and to allow comparison to other materials that have been tested on site, including previously tested overburden and materials included in the metals uptake reclamation research program discussed in Section 3.6.2.

Results from the vegetation establishment study (i.e. plant establishment and element concentrations) will be monitored on an annual basis and reported in annual reclamation reports beginning with the 2023 annual report. Research trial approaches may be adjusted based on initial findings.

3.7.3 Implementation Schedule and Contingencies

As discussed above, repetition of the 2012 baseline soils and vegetation sampling was conducted in 2021, with results to be reported in the 2022 MA/EMA Permits Annual Report. Removal of materials for the greenhouse trial and installation of the vegetation-establishment trial was completed in August 2022, with initial results expected in 2023 and longer-term results expected for the establishment trial in subsequent years. This schedule is expected to meet reclamation needs, as opportunities for progressive reclamation are primarily limited to these areas; therefore, these research programs will provide information required for final reclamation at the end of mine life.

In terms of contingencies, there are two potential outcomes of the ongoing research:

1. Outcome 1: Research indicates that element uptake in vegetation remains below animal tolerance levels. In this case, active revegetation will be implemented on surface disturbances, using the high-elevation seed mix.
2. Outcome 2: Research indicates that element uptake in vegetation will pose a risk to animals consuming that vegetation due to the metalliferous nature of the gossanous surficial materials on site. In this case, surface disturbances will be left unvegetated, and allowed to revegetate naturally to the extent that may occur, to not magnify this risk.

Given the potentially acid-generating and metalliferous properties of the salvaged overburden, these materials are likely to be kept consolidated at surface and not spread as potential growth media. Active revegetation will be limited to residual materials in areas of surface disturbance and will consist of seeding of an appropriate seed mix (e.g., the current high-elevation seed mix, as adapted). No contingencies are proposed for revegetation success, as the mine-site area was sparsely or not vegetated prior to mining and passive revegetation will be the most successful mechanism for recovery of vegetated ecosystems and plant diversity on the post-mining landscape.

Figure 3.6-3. Site preparation completed at the vegetation-establishment trial, August 2022.

3.8 RECLAMATION MONITORING

3.8.1 Reclamation Success

Mines Act Permit M-243 directs that a reclamation success monitoring program be designed to evaluate the success of revegetation, landscape design, and erosion control, and that the program must specify sampling parameters and performance criteria. As noted, unlike most other mines in BC, the Brucejack Mine is an underground mine with small surface footprint that will remain active throughout the mine life. Also, atypical compared to other mines in the province, reclamation planning for the mine does not incorporate extensive ecological reclamation actions due to the harsh climate, lack of soils, and unsuitable nature of local surficial materials for supporting revegetation.

Thus, the reclamation monitoring program for Brucejack is focused on site specific reclamation objectives. The applicability of a revegetation monitoring program will be evaluated based on results from the metal uptake and revegetation research programs. Any modifications to objectives, and establishment of criteria applicable to reclamation monitoring, will be determined once interpreted results from the current reclamation research program yield more clarity on the most acceptable reclamation approach. As noted, soil salvage and replacement are not part of the reclamation program, as soil materials were extremely limited on the pre-mining landscape, and gossanous surficial materials are not suitable for use in reclamation cover systems.

Sediment from most of the mine site is well managed through mine design and implementation of the Water Management Plan – OMS Manual (Pretium 2021, Appendix 3-1-1-9). As described in Section 3.3.1.3, most of the mine site drains passively either directly to the WRTSF or to the WRTSF via the CWP and will continue to do so post-closure. A portion of the mine site is contained within the contact water management system, which captures runoff and ultimately directs it to treatment by the WTP prior to discharge to the WRTSF. Post-closure, some of the mine site drainage area will continue to report directly to the CWP, which will then discharge to the WRTSF. The remainder – primarily the mill and lower camp pads – will drain passively to Camp Creek or Brucejack Creek. These areas are dominantly bedrock or capped with NPAG crushed rock; erosion from these areas post-closure is not considered to be a significant consideration. Effectiveness of erosion control measures over the entire mine site is intensively monitored through the PE-107835 water quality monitoring program requirements, which include a stringent discharge limit for total suspended solids (TSS) at the WRTSF outlet and additional monitoring for TSS and other parameters in the downstream aquatic receiving environment. This monitoring provides rapid early warning of any significant erosion from locations not draining passively to the WRTSF or contained within the contact water management system. This monitoring program will continue through the closure period, thereby continuing to provide early warning of any significant site erosion during the active reclamation period.

Post-mine, pads, decommissioned roads (including drainage crossings), the km 72 NPAG quarry, the waste rock dump (WRD) pad, and other post-mine landscape features will be inspected for stability and performance. Repairs will be carried out if and as needed. This and other post-mine monitoring programs related to reclamation success are described in Section 12.

4 TRACE ELEMENT UPTAKE IN SOILS AND VEGETATION

Any ongoing monitoring of element uptake in soils and vegetation will be developed based on results from the current element uptake research program. The approach of this program, progress, implementation schedule, and contingencies are discussed in Section 3.6. Ongoing results will be provided in annual reclamation reports, and any required element uptake monitoring program will be presented as appropriate once an informed and robust approach can be developed from research program findings.

5 CONTAMINATED SITE REQUIREMENTS

There are no existing known or suspected areas of contamination at the Brucejack Mine site.

Hydrocarbon and chemical spill prevention at the Brucejack Mine is addressed through robust infrastructure spill prevention and secondary containment measures that include use of lined storage/dispensing facilities, secondary tank containment, routine inspection, and maintenance and other mitigation measures, as required and appropriate. Detailed storage and handling requirements and procedures for relevant substances at the mine are provided in Pretium's Chemicals and Materials Storage and Handling Plan (Pretium 2022a, Appendix 3-1-1-5).

In addition, Pretium implements its Spill Response Plan (Pretium 2022a, Appendix 3-1-1-7) through a rigorous site-wide spill response program. This program includes orientation in spill mitigation and response for all Pretium employees and contractors, distribution of spill response standard operating procedures (SOPs), augmented spill response training for select site personnel, equipping all vehicles and equipment with spill response kits and staging larger spill response equipment caches around the mine site area. Personnel are required and trained to clean up all spills that occur, and to report all spills internally, regardless of size. Dedicated collection and containment bins for hydrocarbon contaminated materials are sited at multiple locations at the mine site; these are processed and disposed of at an off site licensed facility. Spills exceeding prescribed quantities, or spills that enter, or are likely to enter a body of water, are reported externally in accordance with the *EMA* Spill Reporting Regulation (BC Reg. 221/2017). Water quality monitoring for hydrocarbons is conducted regularly at the final discharge point from the WRTSF (site BJ 3.10) and at the WTP. With these measures in place, the potential for significant residual spill-contaminated material presence at the mine during closure is considered to be low.

At closure, fuel, chemicals and other related substances no longer required will be returned to suppliers or disposed off-site at licensed facilities as appropriate, in accordance with Pretium's Chemicals and Materials Storage and Handling Plan (Pretium 2022a, Appendix 3-1-1-5). Following removal of liners beneath the Diesel Power Station (DPS) Pad and Sump, and beneath other fuel or chemicals storage or dispensing areas, Preliminary Site Investigations will be conducted in accordance with the Contaminated Sites Regulations (CSR) (BC Reg. 375/96) which includes sampling of relevant environmental media. Following the Preliminary Site Investigations, detailed Site Investigation(s) will be conducted if required. Remediation Plan(s) will be prepared and executed for any areas that the Detailed Site Investigation(s) deemed necessary as per the CSR (BC Reg. 375/96). Following this assessment process will ensure that reclamation success objectives and water quality requirements are satisfied, as per M-243 Condition E.6.

6 DISPOSAL OF TOXIC CHEMICALS, REAGENTS, HAZARDOUS MATERIALS, CONTAMINATED MATERIALS

Handling and storage of chemicals and reagents to be used on site are described in the Chemicals and Materials Storage and Handling Plan (Pretium 2022a, Appendix 3-1-1-5). At mine closure, any reagents and chemicals no longer needed for the mine will be packaged according to regulatory requirements and returned to the supplier or disposed of at a licensed off site facility following Pretium's Waste Management Plan (Pretium 2022a, Appendix 3-1-1-8). The on-site inventory of hazardous wastes will be actively managed through the later stages of mine operation to result in low quantities on site at the cessation of operations. Items that can be returned to the supplier or sold at cost will be returned/sold.

Spills during mine operations are immediately addressed following Pretium's Spill Response Plan (Pretium 2022a, Appendix 3-1-1-7), with the contaminated materials removed, contained and shipped off site to a licensed facility, or remediated in place and tested as appropriate. Any operational spills within containment areas are prevented or limited from migration outside of the containment area. These measures reduce the potential quantity of contaminated soil to be addressed at closure. Additionally, there is very little soil or overburden present at the Brucejack Mine site, facilities being largely constructed on bedrock and NPAG rockfill.

Areas suspected of potential contamination will assessed in accordance with the CSR (BC Reg. 375/96) as described above in Section 5 Contaminated Site Requirements. If contamination is identified through the Preliminary and Detailed Site Investigations, a Reclamation Plan will be prepared and executed. The Reclamation Plan will ensure that any contaminated soil materials identified at mine closure will be excavated and transported off site for disposal at a licensed facility in accordance with regulatory requirements and the above referenced management plans or, as appropriate, remediated on site.

7 GROUNDWATER WELL DECOMMISSIONING

Groundwater wells at the Brucejack Mine site include groundwater monitoring wells such as those required by PE-107835 and a potable water well that supplies the mine site camp and mine infrastructure.

At mine closure, selected groundwater monitoring wells will be left intact for closure and post-closure monitoring purposes. When groundwater wells are no longer required, they will be sealed in accordance with the requirements of the Groundwater Protection Regulation (BC Reg. 39/2016), *BC Water Sustainability Act* (2014).

8 RECLAMATION AND CLOSURE PRESCRIPTIONS

8.1 SUMMARY

8.1.1 Sequence and Schedule

Brucejack Mine closure activities are planned for implementation in a sequential manner such that infrastructure needed to the end of mine closure remains in place and all other reclamation activities occur in a logical progression. Key infrastructure to remain in place until confirmed to no longer be necessary are the WTP and infrastructure required to support it, including power supply, emergency generators, housing for WTP operators and support personnel and transportation infrastructure.

Final closure is expected to take approximately three years, including approximately two years of closure and reclamation activities within the M-243 disturbance area (primarily the mine site area), and an additional year of closing and reclaiming off-site ancillary infrastructure outside of the M-243 permitted area (Table 8.1-1). The latter includes the southern Statutory ROW portion of the transmission line and closing and reclaiming the BJAR and adjacent camps and infrastructure from km 59 to the intersection of the BJAR and Highway 37.

Reclamation activities within this period are planned and designed to provide for long term stable landforms and site conditions, and acceptable post-closure water quality in the Brucejack Creek aquatic receiving environment downstream of the mine. Underground mine reclamation, including removal of underground mobile equipment and completion of other pre-flooding preparatory measures, and flooding will begin immediately following closure (Table 8.1-2). Removal of surface equipment, buildings and infrastructure not required for water treatment and ongoing reclamation activities will occur during the first summer season of the closure phase. Surface reclamation will then be conducted as described below, including recontouring to prevent barriers or hazards to wildlife, establishment of stable post-closure surface drainage, and decompaction as appropriate.

Mine flooding is estimated to be complete within seven months based on accelerated flooding accomplished by water withdrawal from the WRTSF; the withdrawal rate will be to the current licensed rate during the winter low flow period, and at accelerated rates during the freshet high flow period. Water treatment of the underground mine pool will continue throughout the active flooding period, predicted to be an additional eight months (total 15 months) [(refer also to the Closure Underground Water Quality Adaptive Management Plan (Pretium 2020b, Appendix 4-2-2)]. Watertight plugs will be installed in the West Zone (WZ) and VOK portals, and in the raise planned north of Brucejack Creek, during the first year of the closure phase to allow underground mine flooding to its ultimate flooding elevation. The mine equilibrium flooding elevation is predicted to be approximately 1404 masl (seasonal variation from 1394 to 1412 masl).

The WTP and related facilities will be removed when water treatment is no longer required. Mine openings to surface (portals and raises) will be sealed within the first two summer seasons of the closure phase, when access is no longer required. Remaining surface reclamation will be completed by the end of the second summer, along with removal of remaining surface infrastructure and equipment, including the transmission line. Monitoring and reporting will continue throughout the closure phase and for ten years following completion of site reclamation.

Table 8.1-1. Brucejack Mine Reclamation and Closure Schedule

	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Mine Operations													
Closure Period		SITE RECLAMATION		OFF-SITE COMPLETION									
Post-Closure Period													

Table 8.8-2. Brucejack Mine Site Area Reclamation and Closure Schedule - Detail

	2030				2031				2032				2033				2034				2035				2036				2037				2038				2039				2040				2041			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
UG* Mine Reclamation																																																
UG Flooding & WT**																																																
Buildings & Equipment Removal																																																
Surface Reclamation																																																
Monitoring & Reporting																																																

**UG = underground mine*
**WT = water treatment

The Brucejack Mine site roads and the BJAR will be closed during the closure phase, therefore access for post-closure monitoring will be by helicopter. Post-closure monitoring will be carried out for site stability, surface and groundwater quality, aquatic resources, and reclamation success (including natural encroachment into facility areas by endemic vegetation). Geotechnical inspections will be conducted as required.

8.1.2 Mine Site Surface Reclamation

Mine reclamation at closure will begin with orderly and methodical removal of structures and equipment as described in detail in Section 8.2, except that required to support mine flooding and water treatment.

Most buildings and other infrastructure at the Brucejack Mine site are located on constructed pads (Table 8.1-3; Figure 8.1-1). The pads are stable, constructed with a combination of bedrock cuts (with excavated PAG surface material deposited into the WRTSF) and fill methods using NPAG quarried rock, or through placement of NPAG fill only. Off-pad facilities at the mine site include the upper camp area (including various offices and other, mostly modular, structures) CWP, site roads, contact water management infrastructure, overburden stockpile, WRTSF outlet weir, WRD, and the electrical services building, and other structures located in the low-lying area between the surface heavy shop and the Johnson Creek (East) diversion channel. Infrastructure within the upper camp area and warehouse and vicinity areas is mainly constructed on in-situ overburden, with several of these structures having been placed or constructed during advanced exploration or mine construction.

Table 8.1-3. Mine Site Constructed Pads and Infrastructure Areas.

Surface Infrastructure Pad	Area (ha)
Mill (including STPs) pad*	3.17
Lower camp pad*	2.39
VOK portal pad and storage *	1.01
Old heavy shop pad	0.60
Upper camp area (non-pad)	3.90
Upper camp bunk 6 pad*	1.04
Helipad and storage pads**	0.38
Main warehouse, electrical and waste sorting area	1.83
Diesel power station pad*	0.66
WZ portal pad**	2.31
Incinerator pad**	0.37
CWP	1.43
Truck shop pad	1.08
Total	**20.17**

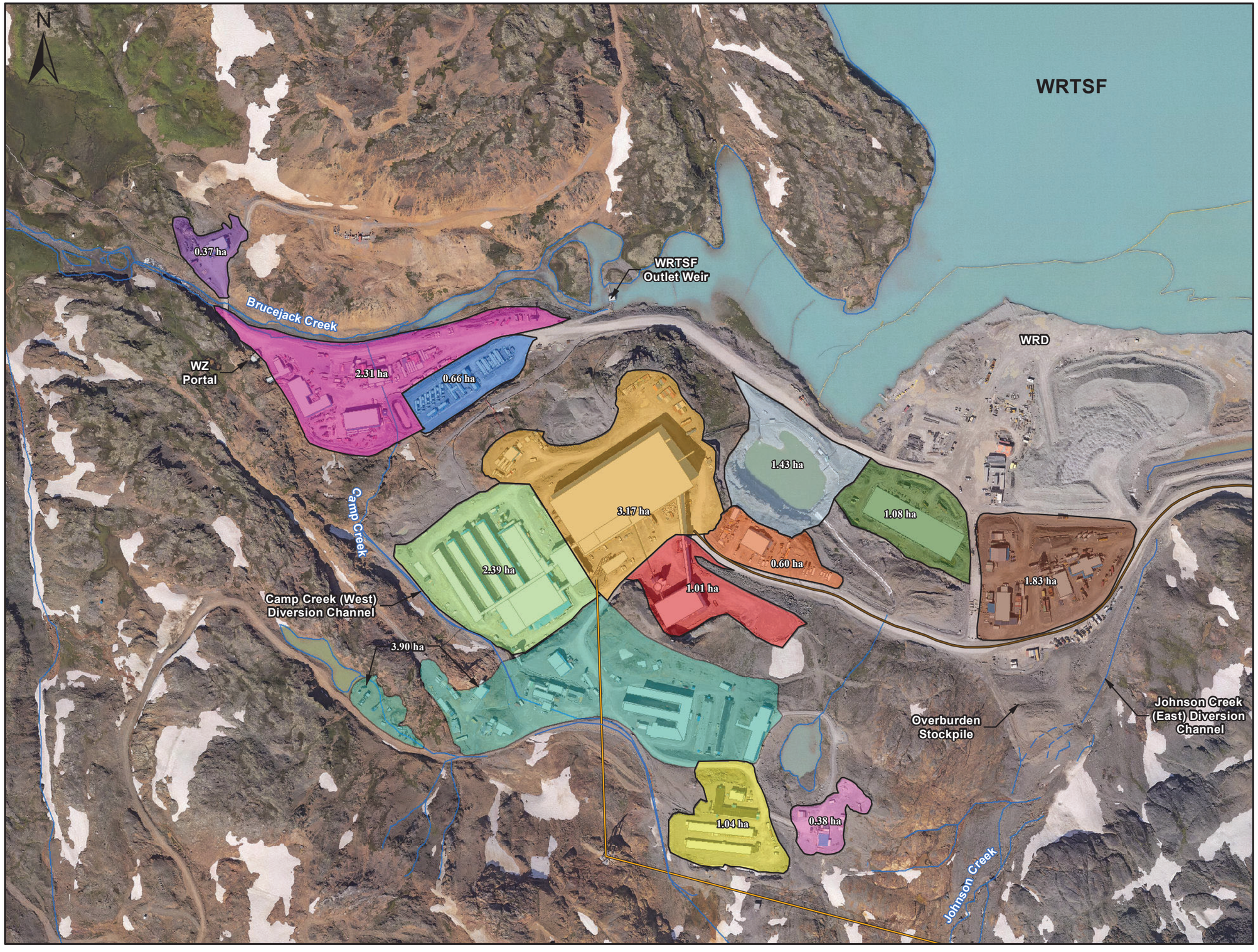
*Combination cut and fill
**Fill only

Facilities pads within the mine site will be left in place at mine closure following removal of structures and equipment, with some recontouring of NPAG rock fill materials to reduce any potential for slumping and erosion and to support achievement of the end land use objective. In preparation for final reclamation, the mine site road surfaces, NPAG crushed rock cover on the pads, and low gradient areas near the Johnson Creek Diversion will be shallow ripped to reduce surface compaction, minimize surface erosion, allow for downward water infiltration, and create the conditions for such passive natural revegetation as may occur. Culverts will be removed from the roads and cross-drains and water bars will be established to create stable drainage. Figure 8.1-2 summarizes mine site area surface reclamation treatments at closure.

Recontouring and decompaction work during closure will be aimed primarily at preventing hazards or barriers to wildlife movement to achieve the end land use objective of wildlife matrix habitat (movement areas) particularly for mountain goat, grizzly bear, and hoary marmot (M-243, Condition E.3). These animals will be able to move across the mine site post-closure to access foraging areas or other habitat that provides life requisites. Reclamation work during closure will be secondarily aimed, to the extent feasible and suitable, at creating conditions for passive revegetation via propagules from local endemic vegetation species in adjacent areas. The Brucejack reclamation liability costing includes seeding much of the mine site using Pretium's high elevation native seed mixture, however a passive reclamation approach is preferred (refer to Section 3.6.3).

Contact water management infrastructure will remain in place until surface water collection and treatment are no longer required, at which time ditches not required for post-closure water management will be backfilled, pipeline and pumping infrastructure will be removed, and manholes will either be removed or rendered inactive. The seepage collection weirs below the lower camp pad will be breached or removed. The CWP, which is constructed in bedrock, will remain in place, and be allowed to spill passively via its spillway. The non-contact diversion channels will remain in place.

Waste rock dump development is planned such that most PAG rock will be placed subaqueously in the WRTSF during mine operations. At mine closure, remaining sections of exposed PAG rock on the dump pad will be placed subaqueously in a retreat manner, such that there are shallow ponded areas over much of the pad and exposed NPAG rock on surface near the shore of the WRTSF.



Legend

Constructed Pads / Infrastructure Areas

- Mill (including WTP) Pad
- Lower Camp Pad
- VOK Portal Pad and Storage Area
- Truck Shop Pad
- Old Heavy Shop Pad
- Upper Camp Area
- Bunk 6 Pad
- Helipad and Storage Pads
- Main Warehouse, Electrical and Waste Sorting Area
- CWP Area
- DPS Pad
- WZ Pad
- Incinerator Pad

Existing Infrastructure

- Transmission Line
- Brucejack Access Road
- **WRTSF** Waste Rock and Tailings Storage Facility
- **WRD** Waste Rock Dump
- **WZ** West Zone

1:4,000

0 100 200

Metres

Coordinate System: NAD 1983 UTM Zone 9N

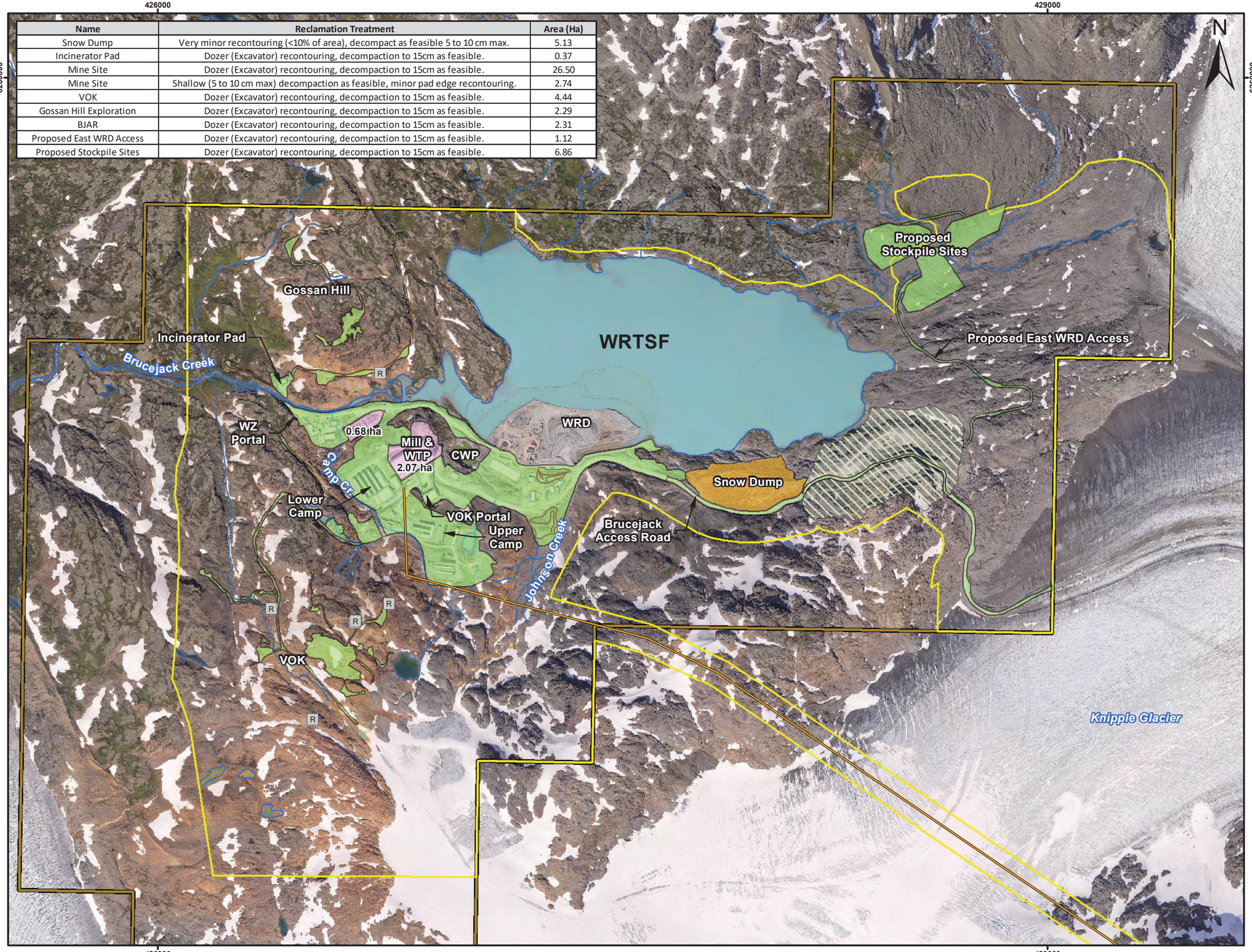
NEWCREST BRUCEJACK

Map ID: BJGA20220930144

Imagery: 2022 Lidar | Date: December 6, 2022

Figure 8.1-1. Constructed Pads and Infrastructure Areas

Name	Reclamation Treatment	Area (Ha)
Snow Dump	Very minor recontouring (<10% of area), decompact as feasible 5 to 10 cm max.	5.13
Incinerator Pad	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	0.37
Mine Site	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	26.50
Mine Site	Shallow (5 to 10 cm max) decompaction as feasible, minor pad edge recontouring.	2.74
VOK	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	4.44
Gossan Hill Exploration	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	2.29
BJAR	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	2.31
Proposed East WRD Access	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	1.12
Proposed Stockpile Sites	Dozer (Excavator) recontouring, decompaction to 15cm as feasible.	6.86



Legend

Reclamation Treatments

- Dozer (Excavator) recontouring, decompaction to 15cm as feasible.
- Shallow (5 to 10 cm max) decompaction as feasible, minor pad edge recontouring.
- Very minor recontouring (<10% of area), decompact as feasible 5 to 10 cm max.

Existing Infrastructure

- Km 72 NPAQ Quarry
- Buildings
- Transmission Line
- Reclamation Stockpile
- R — Air Raise
- WRTSF — Waste Rock and Tailings Storage Facility
- CWP — Contact Water Pond
- WTP — Water Treatment Plant
- WZ — West Zone

Current M-243 PMA Boundaries

- M-243 Permitted Mine Area (2022)

Mineral Tenures

- Mining Lease

1:12,500

0 250 500

Metres

Coordinate System: NAD 1983 UTM Zone 9N

NEWCREST BRUCEJACK

Map ID: BJAUTH20220929140

Imagery: 2022 Lidar | Date: December 12, 2022

Figure 8.1-2. Mine Site Surface Reclamation Treatments

8.1.3 Underground Mine

At closure, all underground tanks and their contents will be removed and their contents shipped off site for re-use or shipment to licensed facilities. Hydrocarbons and hazardous materials from fixed equipment that is not being removed will also removed for off site shipment to licensed facilities. Fixed underground equipment suitable for re-use will be removed and transported off site. All mobile equipment and supplies will be removed from the underground mine and shipped off site for re-use or disposal as appropriate.

Most stopes will be backfilled with waste rock and paste tailings during operations. Flooding and water treatment during mine closure will occur as described in the Closure Underground Water Quality Adaptive Management Plan (Pretium 2020b, Appendix 4-2-2). At closure, the underground mine workings will be flooded over a period of approximately seven months. Water treatment of the underground mine pool is planned to continue for and additional eight months, for a total treatment duration of 15 months.

Both portals and the raise planned north of Brucejack Creek will be sealed with watertight plugs to enable the mine to flood to the predicted elevations. The portals and all raises will be sealed when no longer required for access. Any seepage from the plugs will be allowed to drain to Brucejack Creek / WRTSF.

8.1.4 Transmission Line

The Brucejack transmission line will remain in operation until this power supply is no longer required at the mine site; this is expected to follow the scheduled 15 months of closure phase water treatment. When no longer required, the Brucejack transmission line towers and conductor will be removed using helicopter support as necessary. Substation equipment and components will be removed using ground access. Transmission line and substation components will be transported off site for recycling or disposal as appropriate.

Within the southernmost 6.7 km section of the M-243 portion transmission line that is below treeline, there may be some disturbance of surficial materials in the areas around the tower bases during the dismantling of the towers. Any growth media that are disturbed will be seeded with either the high or low elevation seed mixture, as appropriate, and concrete foundations will be covered contingent on availability of suitable materials. Removal of transmission line structures over most of the M-243 transmission line section is not expected to result in significant ground disturbance nor effects on landforms, as these are anchored in rock. Post- transmission line and tower removal, all portions of the transmission line are expected to meet the wildlife matrix habitat end land use objective.

8.2 STRUCTURES AND EQUIPMENT

8.2.1 Introduction

This section describes the approaches that will be used to close the various mine structures, facilities, and equipment, including a description of decommissioning activities. Figure 8.2-1 shows mine site surface infrastructure within the mining leases at the end of 2022. Figure 8.2-2 provides a detailed view of the current mine site (2022) surface infrastructure.

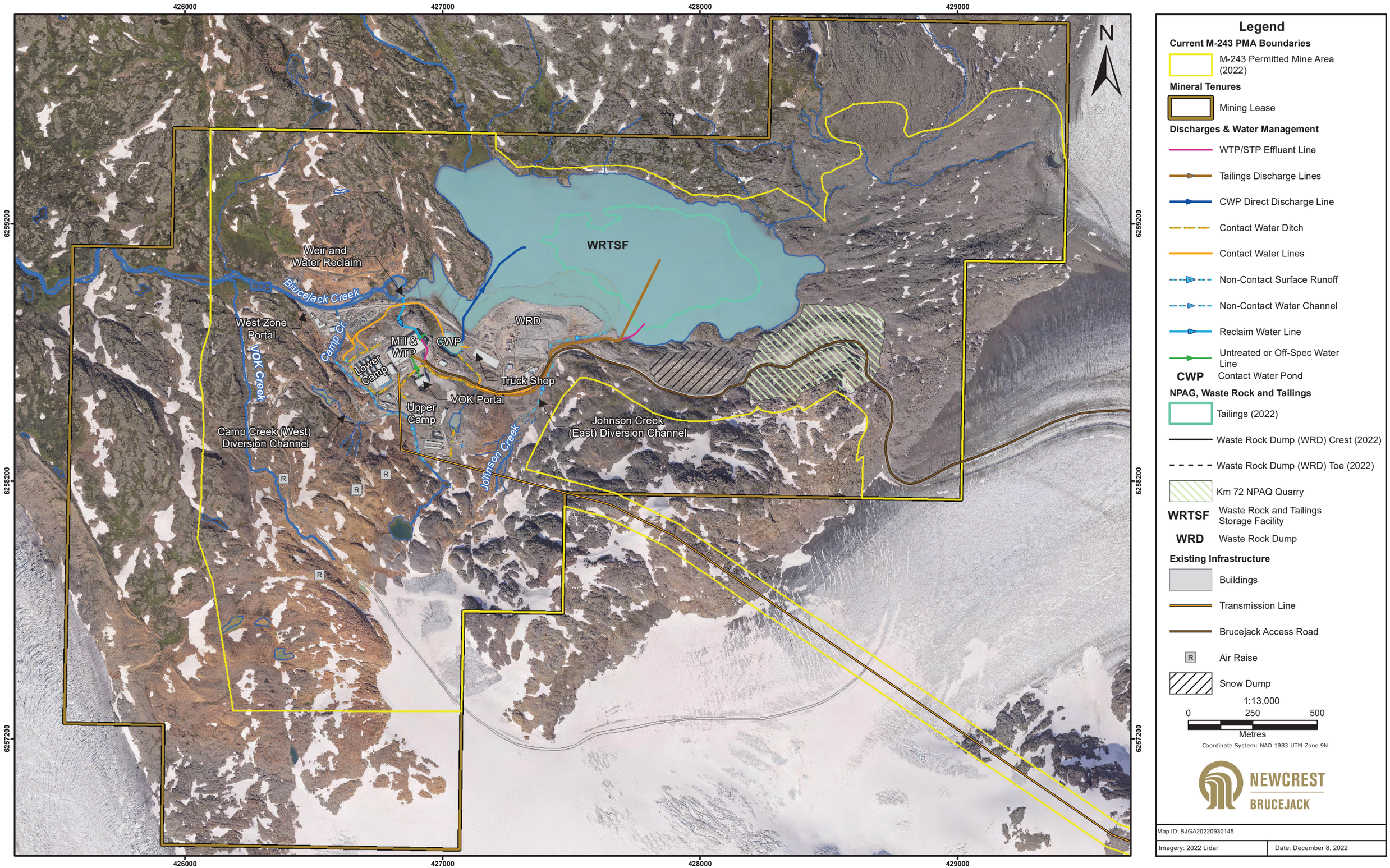


Figure 8.2-1 Mine Site Area Surface Plan End of 2022

Legend

Infrastructure

- Buildings
- Transmission Line
- Vent Raise
- **WRTSF** Waste Rock and Tailings Storage Facility
- **WRD** Waste Rock Dump
- **CWP** Contact Water Pond
- **WTP** Water Treatment Plant
- **WZ** West Zone

Discharges & Water Management

- WTP/STP Effluent Line
- Tailings Discharge Lines
- CWP Direct Discharge Line
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Reclaim Water Line
- Untreated or Off-Spec Water Line
- Potable Water Line

M-243 PMA Boundaries

- M-243 Permitted Mine Area (2022)

Mineral Tenures

- Mining Lease

1:4,500

0 125 250

Metres

Coordinate System: NAD 1983 UTM Zone 9N

NEWCREST BRUCEJACK

Map ID: BJGA20220930146

Imagery: 2022 Lidar | Date: December 1, 2022

Figure 8.2-2. Brucejack Mine Site 2022 - Detailed Infrastructure Plan

8.2.2 Underground Mine

Description

There are two portals: the VOK portal, located east of the mill building at 1408 masl, and the WZ portal, located at the western end of the WZ pad at 1365 masl (Figure 8.2-2). Four vent air raises are currently located within the mine site and one additional vent raise is planned during mine life north of Brucejack Creek, with the possible addition of a fresh air intake raise (Figure 8.2-2). Figure 8.2-3 shows a typical surface structure for a vent raise. The four existing raises are located in high elevation terrain southwest of the mine site and above the VOK zone, and the planned raise is located north of Brucejack Creek, east of the incinerator. The potential fresh air intake is located proximal to vent raise #1 (Figure 8.2-2).

Major underground mine infrastructure includes a grizzly, crusher, conveyor belts, ventilation fans, an electric air heating system (supplemented by propane heaters when required), electrical cables, transformers, pumping stations, water pipelines, paste backfill pipelines, water tanks, electrical substations, explosive magazines, refuge areas, mine communications, and other ancillary installations. Two 20,000 kg tanks store bulk emulsion at the explosives magazine loop, along with a third 20,000 kg mobile tank.

Figure 8.2-3. Surface Structure for Vent Raise.

Closure

At closure, all underground tanks including the fuel and emulsion tanks will be emptied and both the tanks and their contents taken off site for use by others or proper disposal following Pretium's Chemicals and Materials Storage and Handling Plan and Waste Management Plan (Pretium 2022a,

Appendix 3-1-1-5). Hazardous materials, fuels, oils and glycol from fixed equipment that is not being removed will be drained and/or removed, and then transported to surface for off site shipment to licensed facilities for disposal following the above referenced plans. Fixed underground equipment suitable for re-use will be removed and transported off site. All mobile equipment and supplies will be removed from the underground mine and shipped off site for re-use or disposal as appropriate.

Most stopes will be backfilled with waste rock and paste tailings during operations. Flooding and water treatment during mine closure is described in the Closure Underground Water Quality Adaptive Management Plan (Pretium 2020b, Appendix 4-2-2), and in the 4950 tpd Joint M-243/PE-107835 Amendments Application (Pretium 2022b, Appendices 5-2 and 5-3). At closure, the underground mine workings will be flooded over a period of approximately seven months. Flooding will be via natural groundwater recharge and water withdrawal from the WRTSF at the currently licensed rate (70 m^3/h) during the winter low flow months, augmented by accelerated water withdrawal from the WRTSF via pumping or siphoning into the portals during the freshet period. Water treatment of the underground mine pool is planned to continue for 15 months.

Watertight plugs will be installed inside each portal and in the raise planned north of Brucejack Creek to enable the mine to flood to the predicted equilibrium elevation of approximately 1404 masl elevation (varying seasonally between 1394 and 1412 masl) (Pretium 2022b, Appendix 5.1-3, Section 6.1.3). The WZ and VOK portals surface elevations are 1365 and 1408 masl respectively, and the surface elevation of the planned raise north of Brucejack Creek is 1392 masl. Any seepage from the portals and raise plugs will be allowed to drain to Brucejack Creek / WRTSF. All portals and raises will be sealed when no longer required for access.

8.2.3 Surface Structures and Equipment

8.2.3.1 General Closure and Reclamation Methods

This section describes general methods for closure and reclamation of surface buildings and other infrastructure. Current mine site surface buildings and infrastructure are shown on Figure 8.2-1 and Figure 8.2-2 and listed in Appendix 8.2-1; the latter includes key information pertinent to building deconstruction or demolition, and reclamation of building locations.

Surface buildings and infrastructure not required for water treatment and ongoing reclamation activities will be removed during the first summer season of the closure phase. The upper camp will be retained through the closure phase while other camp structures (and other mine site structures and equipment) are removed and the mine site is reclaimed. As the camp population declines, bunk 3 will be removed first, with bunk 6 and its adjacent communications infrastructure retained until water treatment and site reclamation are complete and final demobilization from the mine site is to take place. Temporary modifications will be made to the mill building to enable safe and efficient operation of the internal water treatment facilities while most of the building is removed.

Wastes generated through building deconstruction, demolition and related mine site closure activities will be handled and disposed in accordance with regulatory requirements and Pretium's Waste Management Plan (Pretium 2022a, Appendix 3-1-1-8) and Refuse Incinerator Management Plan (Pretium 2020b, Appendix 4-2-7). Table 8.2-1 summarizes waste types and disposal methods.

Table 8.2-1. Brucejack Mine Waste Types and Disposal Methods

Waste Type	Disposal				
	On site Incineration	Burn Pit	On site Disposal	Off site Facility[a]	Off site Recycling
Aerosol containers[b]				X	
Batteries[b]				X	X
Appliances					X
Clean cardboard (recyclable)					X
Concrete, bentonite and shotcrete[b]			X		
Conveyor belts (rubber/steel)				X	
Copper/brass pipe and fittings					X
Demolition debris (general, non-hazardous)				X	
Electric motors					X
Electronics					X
Fluorescent light ballasts and other lights (halogen, LED)					X
First Aid waste (bandages, etc.)[b]	X			X	
General refuse from camp (i.e., spent toiletries)	X			X	
Glycol[b]				X	
HDPE pipe[c]			X	X	
Hose (air, water, hydraulic)	X			X	
Incinerator ash				X	
Insulation/fibreglass				X	
Waste lead[b]				X	
Mattresses				X	
Metal culverts				X	X
Non-ferrous metals (aluminum cans, tin, etc.)					X
Oily rags (<3% oil by weight)[d]	X			X	
Paint (coatings, adhesive and waste paint)[b]				X	
Paper and cardboard (non-recyclable)	X	X		X	
Plastic containers (beverages)					X
Plastic (tarps, shrink wrap, etc.)				X	
Plastic pipe (PVC, ABS and PEX)[e]				X	
Putrescible food waste, packaging and plastics	X			X	
PVC lake curtain[f]				X	
Scrap metal (rebar, steel balls, vehicles, old parts)				X	X
Sewage sludge	X			X	
Steel structural cladding[g]					X
Storage tanks				X	
Styrofoam	X			X	
Tires					X
Tools (electric/pneumatic/hand)				X	X
Transformers					X
Transmission line conductor				X	X
Transmission line steel					X
Used air filters	X			X	
Used oil/fuel filters[b]					X
Used, empty plastic containers for bulk WTP chemicals[b, h]	X			X	X
Vent bags					X
Waste fuel (gasoline, diesel)[b]				X	
Waste oil[b]	X				
Wiring					X
Wood (pallets, lumber)	X	X		X	X

Notes:
[a] Such as a landfill or other licenced facility appropriate for the waste.
[b] Hazardous waste
[c] HDPE lines in the WRTSF will be removed as feasible and disposed off site. Pipe will remain in place in the WRTSF if it cannot be removed.
[d] Oil contaminated rags containing less than 3% of oil by weight are permitted to be incinerated provided they do not exceed 0.2% of the total waste incinerated per year (EMA Air Permit PA-107025 Condition 1.7.5).
[e] Polyvinylchloride (PVC) plastic pipe will not be incinerated and will be disposed off site. Combustion of plastics will be minimized through waste reduction and recycling programs where feasible.
[f] Curtain material will be removed as feasible and disposed off site.
[g] Insulation foam is removed from the cladding on site and disposed separately off site.
[h] Empty totes will be sent off site for recycling or returned to the supplier. Spent chemical reagent bags will be incinerated or disposed of off site depending on the type of chemical reagent and all other plastic chemical containers will be incinerated.

Skirting, add-on roofs, and framed entrances will be removed and services disconnected from trailers, and then the modules will be transported off site for re-use or disposal as appropriate. Modular buildings (e.g. upper and lower camp complexes, Figure 8.2-4; Appendix 8.2-1) will be disassembled and the modules will be transported off site for possible sale and/or re-use. Modules unsuitable for re-use, along with structural steel, cladding, wood and other additions to trailers and modular structures will be handled as described below for non-modular buildings.

Steel cladding, structural steel and steel framing will be dismantled and processed on site, and subsequently removed and transported off site for recycling, or otherwise included with general non-hazardous demolition debris and transported off site for land-filling (see Table 8.2-1). Clean wood suitable for burning in accordance with the requirements of PA-107025 will be burned in the approved burn pits. Other re-usable and recyclable materials/equipment and will be transported off site (Table 8.2-1).

Figure 8.2-4. Modular Lower Camp Complex During Construction in 2016.

Contaminated site investigations will be conducted as described in Section 5. Hydrocarbon contaminated soil will be transported off site for disposal at a licensed facility or, as appropriate, remediated on site. Hazardous wastes will be transported off site for disposal at a licensed facility.

Buried services will be removed from site for recycling or landfilling as appropriate. Building footprints on fill or overburden will be recontoured as appropriate for stability and achieving the end land use, and decompacted as feasible and appropriate. Concrete foundations and/or pads will remain in place with adjacent pad materials or overburden graded to or near pad level to prevent barriers to wildlife movement, or hazards. Reclamation treatments at closure are summarized on Figure 8.1-2.

The subsections below describe methods specific to the main buildings, and infrastructure with additional reclamation considerations.

8.2.3.2 Building-Specific Methods

8.2.3.2.1 Mill

8.2.3.2.1.1 Description

The mill building (Figure 8.2-2 and Figure 8.2-5) is constructed with metal roof and wall cladding and installed on concrete grade beams and pedestals. It includes the facilities and equipment for ore processing, concentrate storage and load-out, WTP, paste plant, reagents storage, lab, warehouse, offices, and other associated equipment and supplies storage. An exterior conveyor carries crushed ore the VOK portal building to the mill building.

The WTP, housed at the northern end of the mill building, treats groundwater seepage and surface contact water collected in the CWP as per M-243 and PE-107835 requirements, along with process water. The WTP includes processing equipment, a chemical dosing system, storage tanks, agitators, and dosing pumps.

Figure 8.2-5. Mill, Conveyor to VOK Portal and VOK Portal (Photo August 2022).

8.2.3.2.1.2 Closure

All equipment except the WTP and pipelines and other connections required for its function will be removed from the mill building at closure. Reagents will be properly secured and removed off site to appropriate facilities unless required for WTP operations. Lubricants and oils will be drained from equipment and packaged for disposal at a licensed off site facility. Equipment will be transported off site and sent for recycling or reuse. Conveyors will be dismantled, and the metal components removed off site for sale or recycling. Conveyor belts will be disposed in the underground mine or transported off site for disposal at a licensed facility (landfill). Remaining supplies will be used for various closure

activities, as required. Any remaining reagents (i.e., that are not required for the WTP) will be taken off site for resale or disposal. The motors and pumps and other equipment will be removed and taken off site for reuse or recycling. Wiring and electrical equipment not required for WTP operations will be removed off site and taken to appropriate facilities for disposal. Any hazardous materials will be removed for disposal at off site licensed facilities.

Temporary modifications will be made to the mill building to enable safe and efficient operation of the internal water treatment facilities while most of the building is removed. The WTP and remaining mill building will remain in place for the 15 month water treatment period or until it has been confirmed that water treatment is no longer necessary. WTP sludge produced during closure will be transported off site and disposed at a licensed facility.

When water treatment is no longer needed, the water treatment plant equipment and other remaining interior equipment and structures will be removed from site for re-use or disposal. The remaining mill building will be dismantled and the metal siding and roofing will be removed off site for recycling or disposal. In the unlikely event of any spills being present around the building, a site investigation will be completed as described in Section 5 and the contaminated materials will be removed and disposed off site at licensed facilities; hydrocarbons may be treated on site as appropriate. The concrete floor of the mill will be left in place and surrounding pad materials will be graded onto it to prevent any barriers to movement.

8.2.3.2.2 Portal Structures

8.2.3.2.2.1 Description

The VOK portal is located east of the mill building at a surface elevation of 1408 masl (Figure 8.2-2 and Figure 8.2-6). The portal structure building contains an access portal, conveyor portal, mine air heaters, ventilation fans, the conveyor drive motor and mechanism, an electrical substation, and a monorail located in the ceiling of the building for the mine air fan motor and components. The roof and the sides of the building are constructed with metal cladding. The building is located on a concrete pad.

The WZ portal was originally developed in the 1980's by the Granduc-Newcana joint venture (with Newhawk as the operator), and is located near the western end of the WZ pad at a surface elevation of 1365 masl (Figure 8.2-7). It is the primary personnel and equipment access and is the waste rock haulage egress location. Infrastructure includes an access portal, mine air heaters, and ventilation fans.

Figure 8.2-6. VOK Portal Building, Tower and Conveyor Gallery (Photo July 2020).

Figure 8.2-7. West Zone Portal (Photo July 2020).

8.2.3.2.2.2 Closure

At closure, the conveyor connection from the VOK building to the mill will be removed and dis-assembled. If still suitable for use, the conveyor structure will be removed from site for re-use. If there is no re-purposing potential, the conveyor belt will be removed from site and appropriately disposed or may be placed in the underground mine. Re-usable components such as the mine air heaters, ventilation fans, conveyor mechanism and other equipment will be removed and transported off site for re-use; otherwise they will be disposed off site as appropriate. Building and conveyor steel structural components and cladding will be transported off site for re-use or recycling. Demolition debris will be transported off site for disposal as appropriate. The same approach will be used for the WZ portal infrastructure, as appropriate.

Concrete pads will remain in place and be addressed as described in Section 8.2.3.1.

Engineered watertight plugs will be installed in both portals at closure and both portals will be sealed to prevent access. The plugs will be designed to allow flooding to the predicted equilibrium average water level of 1404 masl (seasonal variation between 1394 and 1412 masl).

8.2.3.2.3 Lower Camp Complex

8.2.3.2.3.1 Description

The lower camp complex (Figure 8.2-2) is a multi-storey modular building with metal clad walls and roofs (Figure 8.2-8). The lower camp complex includes accommodations and associated facilities such as kitchen and dining, medical, reception, offices, recreational facilities, laundry, mine dry and mill dry. The lower camp complex buildings are constructed on steel platforms placed on top of pedestals anchored to bedrock or piles. Most of the complex (dorms, kitchen, and

recreation/medical/laundry/offices) is constructed from modules placed on top of the steel platforms. The mill dry and offices building, situated adjacent to the mill, was framed in place.

Figure 8.2-8. Lower Camp Complex (Photo September 2022).

8.2.3.2.3.2 Closure

All contents of the lower camp complex will be removed and shipped off site for re-use, recycling or disposal as appropriate. Exterior steel staircases, and steel roofing and cladding will be removed and transported off site for recycling or disposal as appropriate. Trailer modules will be disassembled and removed from site to be sold or disposed. The structural steel bases of the main lower camp building and steel floor and building frames for the mill dry/offices building will be removed and shipped off site for recycling or disposal. The concrete building pedestals will be cut off at their bases and buried in the rock fill portion of the pad. Electrical and piping service connections will be removed and recycled or disposed off site. Materials that can be recycled will be separated and taken off site for recycling. Materials suitable for landfilling will be taken off site to a licensed facility. Clean unpainted wood will be separate and burned in the burn pits if feasible.

8.2.3.2.4 Heavy Shops

8.2.3.2.4.1 Description

The current surface equipment heavy shop (Figure 8.2-2) is a wood frame and steel clad building constructed during advanced exploration (Figure 8.2-9). A second heavy shop, for underground mine equipment, is located on the WZ pad. The WZ heavy shop (Figure 8.2-2) is a mainly steel frame and clad building on a concrete slab (Figure 8.2-10). A new truck shop is under construction; it is a metal framed structure with metal cladding (Figure 8.2-11). The new truck shop will include 3 workshop bays for underground equipment, 2 workshop bays each for light vehicles and trucks, 2 tire shop bays, 1 wash bay, lube and oil storage, welding shop, office modules, fire protection room, electrical room, and warehouse on the ground floor. The service space lower and upper levels will include mechanical service space and area for offices, meeting room, washroom, lockers, lunchroom, tool crib, and maintenance shop wicket.

Figure 8.2-9. Surface Heavy Shop (Photo July 2020).

Figure 8.2-10. West Zone Heavy Shop (Photo July 2020).

Figure 8.2-11. New Truck Shop (Photo October 2022).

8.2.3.2.4.2 Closure

During closure, when no longer required, contents of the heavy shops, including all tools and equipment, will be removed from the mine site for reuse/resale. Oil, grease, and lubricants will be drained from the equipment and placed with other waste oils for removal from the site and recycling at a designated facility. Wiring and cables will be removed from the buildings and transported off site for disposal at an appropriate facility. Clean wood materials will be burned at the mine burn pit if separation is feasible. The interior metal structures such as shelving will be dismantled and taken off site for resale or metal recycling.

Metal framing, building sheathing and roofing will be removed and sent off site for recycling or disposal. Non-burnable wastes from building demolition will be removed from the site and disposed in a designated landfill. Concrete flooring at ground level will be left in place and adjacent pad fill materials will be graded even with the concrete pad. The floor slabs will be punctured utilizing heavy equipment to allow for long term drainage. Partial or complete pad covering will be completed if there are sufficient pad fill materials to accomplish this without compromising pad stability or causing other issues.

8.2.3.2.5 Waste Handling Facilities

8.2.3.2.5.1 Primary Waste Sorting and Staging Facility

The primary waste sorting and staging facility (Figure 8.2-2 and Figure 8.2-12) is a seacan and wood frame building, with exterior metal cladding and metal roofing, constructed on a concrete pad.

Figure 8.2-12. Primary Waste Sorting and Staging Facility (Photo July 2020).

8.2.3.2.5.2 Incinerator and Burn Pit

The Brucejack incinerator and waste sorting facility, and primary mine burn pit is located north of Brucejack Creek, northwest of the WZ pad (Figure 8.2-2). There is a bridge across Brucejack Creek to access the facility. The incinerator building is wood framed on a concrete pad with steel exterior cladding and roofing (Figure 8.2-13).

Figure 8.2-13. Incinerator and Waste Sorting Facility (Photo July 2020).

8.2.3.2.5.3 Closure

The waste handling facilities will not be removed until the final stages of building and facility removal during closure, as they are required to manage wastes produced during building deconstruction and

other closure activities. As waste collection and handling receptacles and large bins are no longer required, they will be shipped off site for re-use, recycling or disposal as appropriate. The primary waste sorting and staging facility building will be deconstructed or demolished in the same manner as other similarly constructed buildings, with metal cladding removed and transported off site for recycling or disposal, seacans removed and transported off site for re-use, clean burnable wood collected and burned in the burn pit, and insulation and other non-recyclable materials transported off site for landfilling. Adjacent surficial materials will be graded level with the concrete floor.

The incinerator will be removed off site once all demolition and clean-up has been completed and taken to a designated facility for disposal or sold for reuse. Remaining ash from the incinerator will be transported off site for disposal. The incinerator building will be de-constructed or demolished, with metal cladding removed and transported off site for recycling or disposal, insulation and any other non-recyclables transported off site and disposed as appropriate, and clean wood materials burned in the burn pit. The foundation and concrete floor of the incinerator will be left in place and adjacent pad materials will be graded level to it. The burn pit will be backfilled with pad/fill material.

8.2.3.2.6 Hydrocarbon Storage Facilities

8.2.3.2.6.1 Description

Hydrocarbons such as propane, diesel and gasoline are stored at several locations within the mine site area (Figure 8.2-2). Spill prevention, secondary containment and other measures are in place for these storage and dispensing facilities appropriate to the hydrocarbon types and quantities and in accordance with Pretium's Chemicals and Materials Storage and Handling Plan and Spill Response Plan (Pretium 2022a, Appendix 3-1-1-5 and 3-1-1-7).

The main hydrocarbon storage location is the DPS, located at the eastern end of the WZ pad, down-gradient of the mill pad (Figure 8.2-2). Back-up generators and associated fuel storage are located on the DPS pad, along with fuel storage and dispensing for surface equipment and light vehicles (Figure 8.2-14).

Figure 8.2-14. DPS Pad Facilities (Photo July 2020).

The DPS fuel storage is a lined facility where the discharge passes through an oil water separator system before discharge into the DPS sump, which is connected to the contact water management system. Tankage includes diesel to supply the backup diesel power generation system, and diesel

and gasoline dispensing tanks for equipment, light vehicles, small mobile equipment [boats, snowmobiles, all terrain vehicles (ATVs) and rugged terrain vehicles (RTVs)], and miscellaneous gas engine equipment (mobile generators). Another diesel dispensing tank is located near the WZ portal to service underground mine equipment and vehicles; that tank is also connected to the DPS oil water separator system.

Propane tanks are positioned on the lower camp and mill pads, and on the WZ pad to provide heat for surface buildings and the underground mine. An additional propane tank on the WZ pad supplies fuel for the incinerator and to heat the incinerator building.

8.2.3.2.6.2 Closure

At closure, the fuel tanks and any fuel remaining in the tanks will be collected and removed off site for recycling or repurposed. Precautions will be taken to minimize any potential for spills in accordance with Pretium's Chemicals and Materials Storage and Handling Plan and Spill Response Plan (Pretium 2022a, Appendix 3-1-1-5 and 3-1-1-7). Any spilled fuel on liner will be collected with the appropriate spill response materials and removed offsite for disposal at a licensed facility. Any hydrocarbon contaminated liner material will be removed and disposed offsite at a licensed facility. Clean liners will be cut and/or shredded and disposed of in the underground mine or shipped off site for disposal at a licensed facility. A contaminated site investigation of underlying materials will be completed as described in Section 5. If hydrocarbon contamination is found, additional investigation will be completed if required (refer to Section 5) and materials will be removed in accordance with CSR requirements and disposed in accordance with Pretium's Spill Response Plan (Pretium 2022a, Appendix 3-1-1-7), or treated on site as appropriate. Clean crush or surficial materials from the pad location will be regraded over the formerly lined ground surface. The concrete pad for WZ pad diesel dispensing will be left in place, with surrounding concrete barriers removed and pad materials graded to the concrete surface. A contaminated site investigation will be completed for this area as described in Section 5, including that smaller tank areas will be investigated for residual hydrocarbons. If hydrocarbon contamination is found, additional investigation will be completed if required (refer to Section 5) and materials will be removed in accordance with CSR requirements and disposed in accordance with Pretium's Spill Response Plan (Pretium 2022a, Appendix 3-1-1-7), or treated on site as appropriate.

8.2.3.2.7 Pipelines

8.2.3.2.7.1 Description

External (not contained in buildings) surface pipelines at the mine site include High-density polyethylene (HDPE) pipelines for the contact water management system, tailings discharge (twin lines) (Figure 8.2-2), WTP/sewage treatment plant (STP) influent and effluent discharge lines, direct emergency discharge line from the CWP, pipeline connection from the potable water supply well to the potable treatment facilities, and potable water distribution line. The tailings and effluent discharge lines extend into the ponded portion of the WRTSF, where the tailings lines are suspended within the WRTSF by cable systems (Figure 1-1). The tailings lines are partly buried along their surface extents.

8.2.3.2.7.2 Closure

During closure, the tailings and WTP/STP/CWP effluent discharge pipelines will be disconnected from the mill building and the CWP. Effluent pipelines disconnection will not occur until water treatment has concluded, and the potable water pipeline will remain in place until potable water supply via

pipeline is no longer required. Pipelines on land (outside the WRTSF) will be removed, cut up and taken off site for landfill disposal. The tailings pipeline cables will be removed via the winch systems, with the latter then removed from site for re-use or recycling. Pipeline sections within the WRTSF will removed to the extent feasible and disposed as described above; sections that cannot be removed will remain in the WRTSF.

8.3 WRTSF

8.3.1 Waste Rock and Tailings

8.3.1.1 Description

All mine surface and underground waste rock is managed as PAG in accordance with M-243 and Pretium's ML/ARD Management Plan (Pretium 2021, Appendix 3-1-1-6) and is required to be either backfilled in the underground mine below the ultimate flooding elevation or deposited subaqueously in the WRTSF (refer to M-243 Condition D.3.c.iii). WRTSF operations are conducted in accordance with applicable conditions in M-243 and the Waste Rock and Tailings Storage Facility OMS Manual (Pretium 2022a, Appendix 3-1-1-9). Figures 10-1 through 10-3 show the horizontal extents of the waste rock dump crest and toe for the years noted based on the 2022 mine plan presented in the 4950 tpd M-243/PE-107835 Joint Application (Pretium 2022b). Surface waste rock excavation from mine construction is complete and these materials have been placed in the WRTSF; subaqueous deposition of underground mine waste rock will be ongoing through mine life.

Waste rock may be stored subaerially for up to two years. Some is temporarily stored in surface stockpiles at the WRD as part of facility management, and some is used temporarily to surface the WRD, with the latter then replaced with either 'fresh' PAG rock or NPAG rock excavated from the km 72 NPAG quarry within the two year period. There are also provisions to leave exposed rock causeways on the WRD with shallow ponded sections in between; this approach has not been used to date and is more likely to occur late in mine life as the waste rock dump platform nears its maximum extent.

Tailings are NPAG and either piped into the underground mine where they are disposed as paste backfill in mined out stopes or discharged deep within the ponded portion of the WRTSF via the two tailings pipelines. Expected tailings extents throughout mine life, based on the 2022 mine plan, are also depicted on Figures 10-1 through 10-3.

8.3.1.2 Closure

Waste rock dump development is planned such that most PAG rock destined for the WRTSF will be placed subaqueously during mine operations. At mine closure, remaining sections of exposed PAG rock on the dump pad will be placed subaqueously in a retreat manner, such that there will be a shallow ponded area over much of the pad and exposed NPAG rock on surface near the shore of the WRTSF.

Tailings will remain submerged in the WRTSF. HDPE pipelines in the WRTSF and the tailings pipeline support cable system will be addressed as described above in Section 8.2.3.2.7. The WRTSF sediment curtain will be removed and these materials disposed off site at a licensed facility.

Most of the WRTSF will remain ponded at mine closure.

8.3.2 WRTSF Outlet Weir and Reclaim Pump System

8.3.2.1 Description

An instream concrete and steel weir structure is located at the WRTSF outlet with steel walkways and a steel building housing flow measurement equipment and the reclaim pump system (Figure 8.3-1). HDPE pipe and electrical service lines connect the weir to the mill building. The weir structure provides a means to accurately measure discharge rates from the WRTSF and a suitable location for water withdrawal and pumping from the WRTSF. Details of the weir are provided in the Water Management Plan - OMS Manual (Pretium 2021, Appendix 3-1-1-9).

Figure 8.3-1. WRTSF Outlet Weir (Photo July 2020).

8.3.2.2 Closure

The weir structure, building and water reclaim system will remain in place until the underground mine has flooded to its ultimate elevation and supplemental water withdrawal from the WRTSF is no longer required. The reclaim pumps and instrumentation will be removed from site for re-use or disposal at an appropriate facility. The weir building will be disassembled. Piping and unrecyclable building contents and components will be removed from site and disposed at appropriate facilities. The steel building and walkway components will be removed recycled or disposed at appropriate facilities. The concrete lock blocks that form a portion of the structure will be removed from site for re-use if they are still usable, and otherwise disposed within the exposed NPAG portion of the WRD pad. The central reinforced concrete portion of the weir will remain in place, where it is expected that it will be gradually covered by streambed sediments. Deconstruction and removal will be the opposite of construction, using a small temporary coffer dam structure to isolate the demolition activities from the flow in the stream.

8.4 CONTACT WATER POND, SURFACE WATER MANAGEMENT SYSTEM, AND WATERCOURSES

8.4.1 Description

Mine site water management infrastructure and function is described in detail in the Water Management Plan - OMS Manual (Pretium 2021, Appendix 3-1-1-9); a summary is provided in Section 2.5.5. There are approximately 2.5 km total of non-contact diversion channels at the mine site. The Camp Creek (West) and Johnson Creek (East) diversion channels (Figure 8.2-2) intercept surface runoff from outside of the primary mine infrastructure area and direct it to Brucejack Creek and the WRTSF, respectively. Both are engineered channels, partially constructed in bedrock and otherwise lined with geotextile and armored with riprap (Figure 8.4-1).

Figure 8.4-1. Camp Creek Diversion Channel (Photo July 2020).

The surface contact water management system collects surface runoff from areas of surface PAG rock excavation within the primary mine facilities area located between the diversion channels, and directs it to the CWP (refer to Pretium 2021, Appendix 3-1-1-9, for details). Water collection and conveyance infrastructure includes several unlined ditches constructed in bedrock, lined and riprapped ditches in fill or overburden (approximately 1.2 km of collection ditches in total), HDPE pipelines, two small concrete weirs down-gradient of the camp pad, several manholes and lined sumps, various pumps and culverts. The largest contact water management system pumps are located at the CWP. The 50,000 m^3 capacity CWP (Figure 8.4-2) is entirely excavated in bedrock, with no liner and a concrete covered bedrock spillway. Surface contact water is collected in the CWP and then piped to the WTP for treatment.

Figure 8.4-2. Contact Water Pond.

8.4.2 Closure

The non-contact diversion channels will remain in place for closure and post-closure. The surface contact water collection system will be disassembled during the first two summers of the closure phase, after which surface drainage will be passive toward the WRTSF, CWP, Brucejack Creek or Camp Creek. Pumps and HDPE pipes will be removed. The HDPE pipe will be cut up and transported off site for disposal at a licensed facility. Liner in ditches will be removed and disposed in the same way as the HDPE pipe.

Contact water collection ditches will be backfilled during the closure phase when their function is no longer required. The concrete water collection weirs below the camp pad will be breached and the water allowed to drain passively to Camp Creek.

The CWP and its pumping systems to the WTP will remain in place until use of the WTP is no longer required, to allow continued availability of the CWP as emergency storage in case of WTP upset conditions. When no longer required, the pumps will be removed off site and re-purposed or disposed at an appropriate facility. Remaining HDPE pipe will be removed and cut into sections and transported off site for disposal at a licensed facility. The CWP will remain in place, with the spillway remaining intact, and allowed to spill passively via the current emergency spillway, to the WRTSF. Safety berms installed around the mill pad and up-gradient of the CWP will remain in place.

8.5 OVERBURDEN STOCKPILE

Approximately 30,000 m^3 of overburden is stockpiled at the mine site, in one stockpile (Figure 8.2-2). As discussed in Section 3.2.1, this material is not currently recommended for use in final site reclamation. The current plan for this stockpile at closure is to recontour it to a lower profile that is less likely to erode.

8.6 KM 72 NPAG QUARRY

The km 72 NPAG quarry is located near the east end of the WRTSF (Figure 8.1-2); it occupies approximately 14 ha, is excavated in rock, and is benched into a steep, bedrock slope (Figure 3.3-7).

The NPAG quarry will remain in place post- closure. No reclamation measures are feasible.

8.7 SNOW DUMP

The snow dump is located outside of the gossanous area, between the km 72 NPAG quarry and mine site; it covers approximately 5.13 ha (Figure 8.1-2). The snow dump is where snow removed during mine site snow clearing activities is stockpiled due to lack of space for this within the mine site. Most of the material placed at the snow dump is snow and ice, however surficial road and pad materials are unavoidably mixed with the snow when surfaces are ploughed or excavated to the ground surface. This results in some accumulation of these materials at the snow dump site. The snow dump site is graded during the summer months to help accelerate melting.

Snow removal needs will decline significantly during closure, which is expected to allow remaining snow and ice in the snow dump to fully melt. Once snow and ice have melted to ground surface, the area will be decompacted as appropriate and the area will be seeded with Pretium's high elevation seed mix (Table 3.4-2).

8.8 ROAD RECLAMATION

8.8.1 Description

The BJAR, of which the ~km 71 to 73.3 section is located within the M-243 area (Figure 1-1 and Figure 8.2-1), will remain in use during closure until water treatment is no longer required and mine site area reclamation activities are complete. Other mine site area roads will remain in use during closure until access to facilities are no longer required.

8.8.2 Closure

Mine site area roads will be decommissioned and reclaimed when the infrastructure to which they provide access is no longer required. The last site roads to be closed will be those providing mine site access to the underground mine and to the WTP. As roads are decommissioned, culverts will be removed and cross drains installed to restore natural drainage and provide for stable post-mine drainage. Steel culverts will be taken off site for recycling or disposal. The areas where the culverts have been removed will be graded to provide stable slopes at exposed cuts and riprapped as appropriate. Road surfaces will be decompacted up to 15 cm (Figure 8.1-2) as appropriate and feasible, to allow for surface drainage and to reduce the potential of road surface failure with time. Ditches will be backfilled and graded to provide surface stability and reduce erosion potential.

8.9 BRUCEJACK TRANSMISSION LINE

The Brucejack transmission line will be dismantled when its power supply is no longer required. The towers will be de-strung and the tower conductor will be removed. Helicopters will be used to re-spool

and remove the conductors and to dismantle and remove the towers. Conductor and tower materials will be transported off site and recycled or disposed as appropriate. Substation equipment and components will be removed using ground access. Transmission line and substation components will be transported off site for recycling or disposal as appropriate. The substation fence will be removed, and the pad area will be decompacted and seeded with Pretium's low elevation seed mix (Table 3.4-1).

9 LONG-TERM STABILITY

Brucejack Mine infrastructure development areas and excavations in rock, such as the constructed surface infrastructure pads, underground mine workings and surface openings, the WRTSF, and the km 72 NPAG quarry, have been designed and constructed following professional geotechnical and other engineering practices, and in accordance with M-243 and Code requirements. Stable landforms require a stable foundation. Pre-construction geotechnical field investigations were completed to support engineering designs and the regulatory approval application process. Mine facilities and post-closure surface landforms sites are designed to remain stable throughout mine life and beyond through closure and post-closure.

Geotechnical monitoring programs are in place for underground mine ground control and the WRD during mine operations. A Subsidence Monitoring and Management Plan (Pretium 2020b, Appendix 4-2-8) is in place in accordance with M-243 Condition D.13. A post-closure geotechnical monitoring program will be developed as mine closure approaches.

Closure of facilities will be planned and implemented such that final structures and landforms will have long-term stability during post-closure. Surface water will be managed to reduce its effect on the constructed landforms. Diversion channels will remain in place to direct water away from the infrastructure pads and in a manner that will not cause surface erosion in adjacent areas. Water from within the contact water catchment will be allowed to drain passively to the WRTSF, CWP, Brucejack Creek and Camp Creek.

Watertight plugs will be installed at closure in the WZ and VOK portals, and in the raise north of Brucejack Creek. All portals and raises will be sealed to prevent access. Watertight plugs and seals will be engineered and designed to be structurally sound. All designed landforms and structures will be monitored for stability during operations and following closure.

10 FIVE YEAR MINE RECLAMATION PLAN

Design of the Brucejack Mine site has focussed on efficient and essential use of surface disturbances. The total surface disturbance area within the PMA is small (terrestrial infrastructure area of 55 ha) (Section 8.1.2; Figure 8.1-1) and is almost entirely needed for operations. Because of this small, intensively used footprint, revegetation has not been possible to date within the mine's primary infrastructure area and there are no foreseeable opportunities for progressive reclamation in the next five years beyond the small areas being used to support reclamation research (see Section 3.7). Almost all reclamation within the PMA will be completed during the mine closure. Reclamation at mine closure is described in Section 8.

Outside of the primary infrastructure area, progressive reclamation of areas disturbed through surface exploration will continue (e.g., current Gossan Hill exploration areas north of Brucejack Creek, Figure 8.1-2). The surface exploration disturbance is much less intensive than within the primary facilities area, and extents within the PMA are very small as most exploration proximal to the mine is conducted underground.

Surface layouts for end of 2023, 2025 and end of mine (end of 2029) are shown on Figures Figure 10-1, Figure 10-2, and Figure 10-3 respectively. Development of a second WRD at the east end of the WRTSF, with associated access and temporary surface waste rock stockpiles, is planned to begin in 2023 subject to regulatory authorization. This infrastructure, including progressive extents of the WRDs (south and east) is shown on these figures. A 5th ventilation raise is planned north of Brucejack Creek for 2025; this is shown on Figures Figure 10-2 and Figure 10-3. As is the case with the mine's primary infrastructure area, this additional infrastructure will be required for the duration of mine operations.

At closure, following subaqueous deposition of all PAG waste rock, the east WRD access and temporary PAG waste rock stockpile sites will be shallow ripped to reduce surface compaction, minimize surface erosion, allow for downward water infiltration, and create the conditions for such passive natural revegetation as may occur. Culverts will be removed from the access road and cross-drains and water bars will be established to create stable drainage. Figure 8.1-2 summarizes surface reclamation treatments for this area at closure. Although the proposed additional east WRD associated access and stockpile locations are situated outside of the gossanous area, the area is primarily exposed bedrock or rocky terrain with very little vegetation cover. Nonetheless, as is the case with the other mine site surface disturbance areas, reclamation work during closure will be aimed, to the extent feasible and suitable, at creating conditions for passive revegetation via propagules from local endemic vegetation species in adjacent areas (i.e., a passive reclamation approach is preferred; refer to Section 3.6.3.).

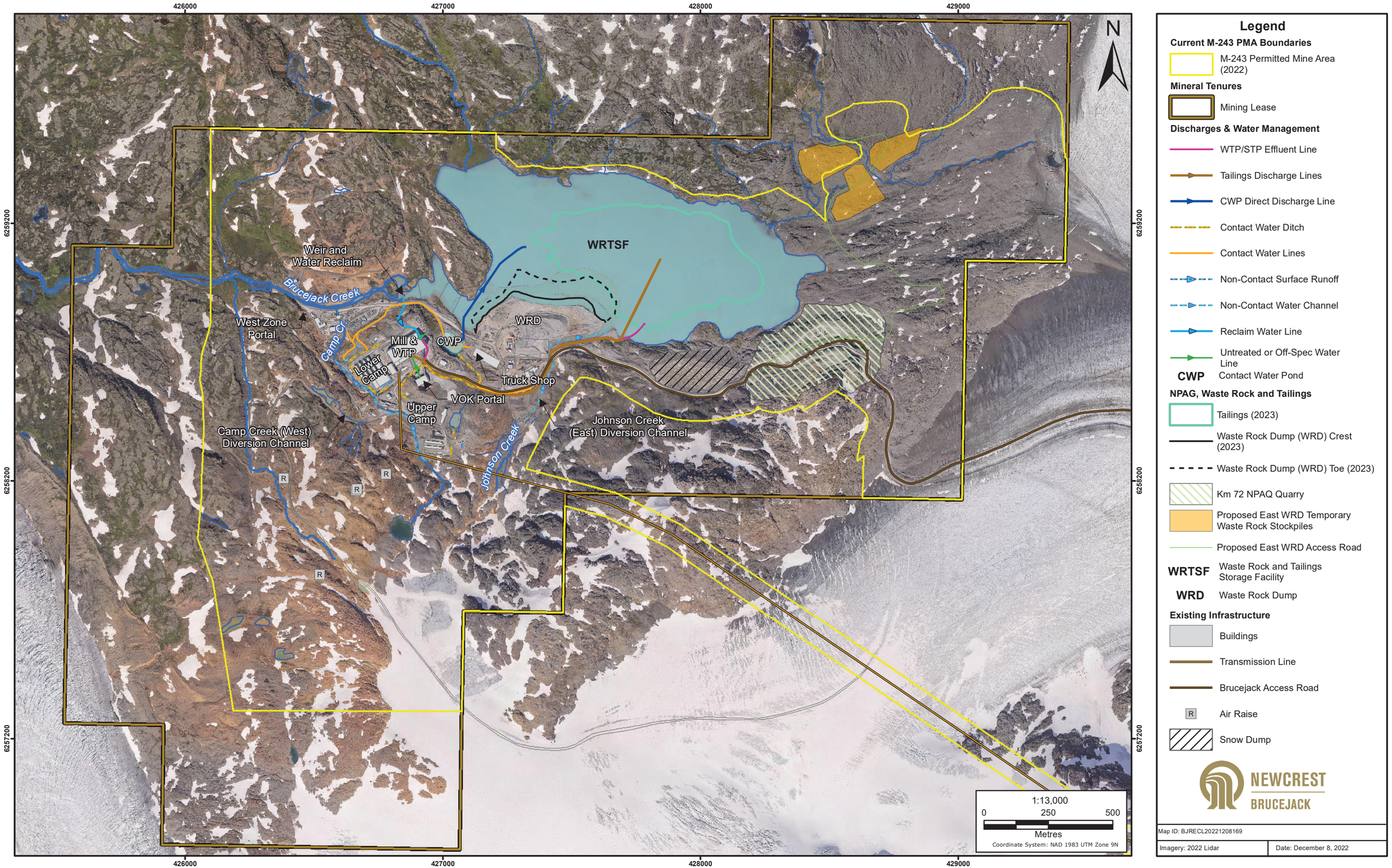


Figure 10-1 Mine Site Area Surface Plan End of 2023

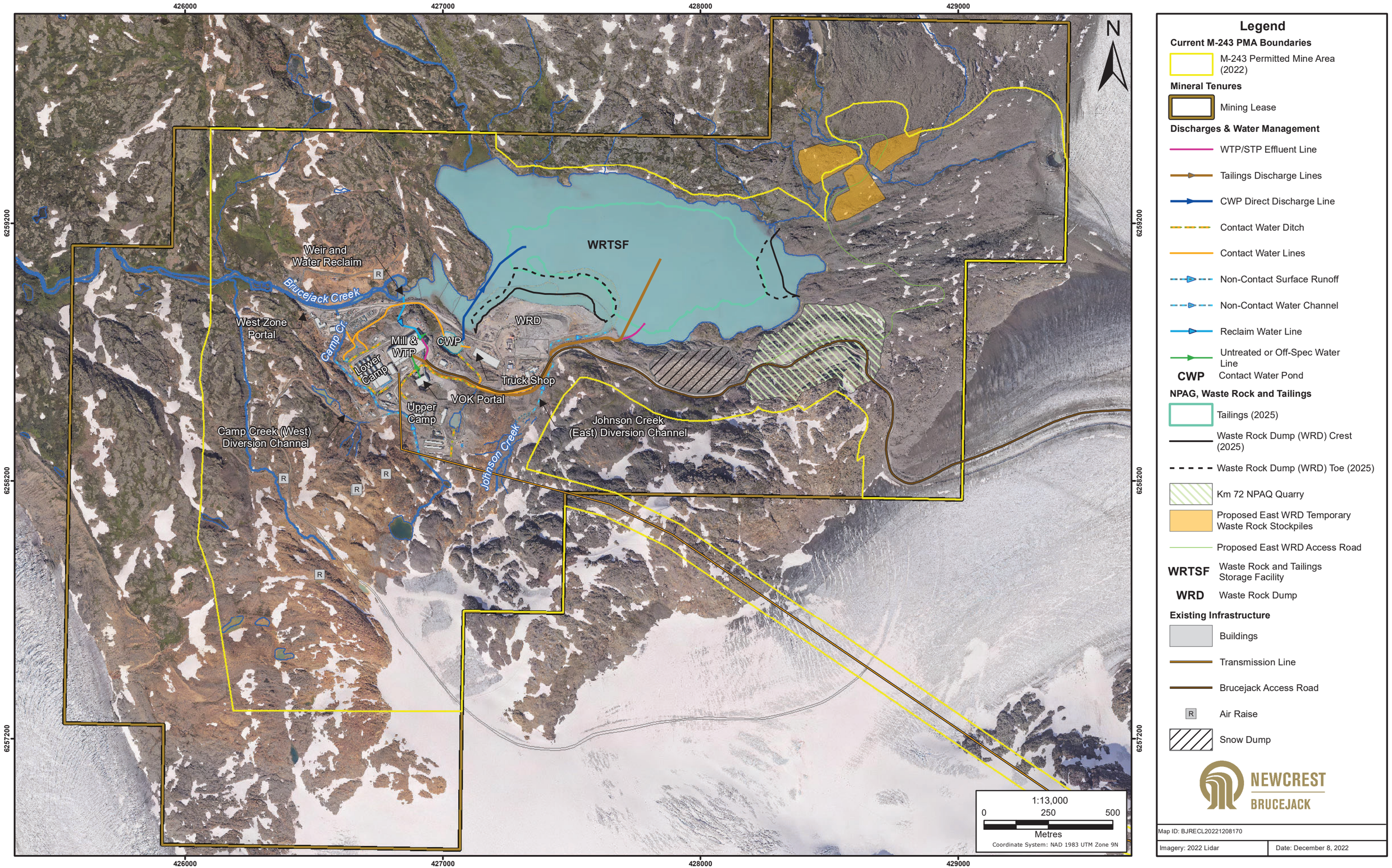


Figure 10-2 Mine Site Area Surface Plan End of 2025

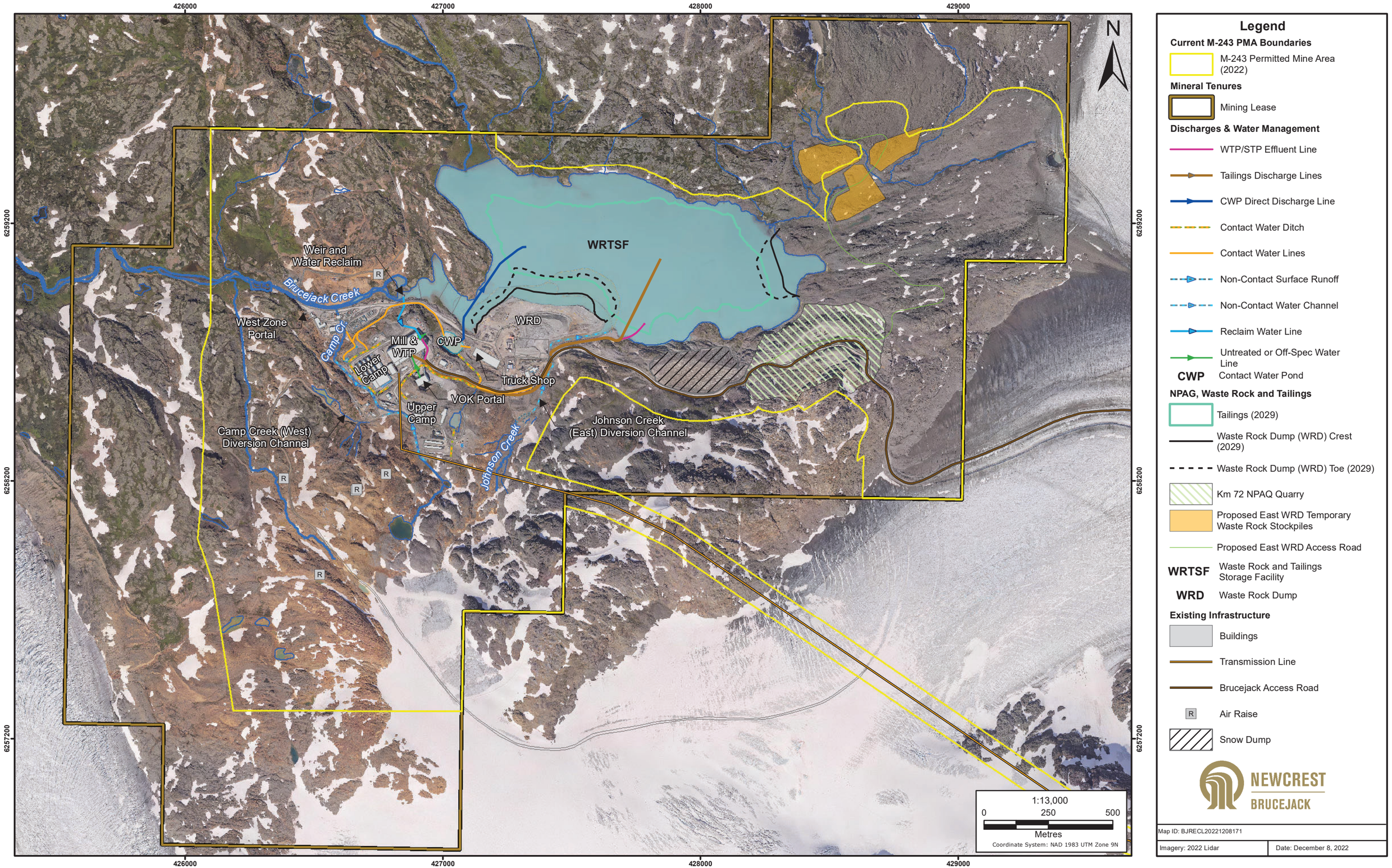


Figure 10-3 Mine Site Area Surface Plan End of 2029

11 TEMPORARY CLOSURE

In the event of a temporary shutdown, irrespective of length, a small contingent of 40 to 50 personnel per rotation (80 to 100 total) will remain on site to implement care and maintenance activities, including ongoing mine dewatering and associated water treatment, and to maintain site access and security. This is necessary for environmental protection purposes and to protect the considerable investment in site infrastructure and equipment. Fuel will be removed from equipment that is not required and removed for off site disposal. The VOK portal building will be secured to prevent portal access, and the WZ portal will be gated and secured. All vent raises have metal screens to prevent access; therefore, no additional measures will be needed for these. Site security systems will remain operational.

Road and transmission line monitoring and maintenance will continue. The gate at the Bell-Irving River crossing near Highway 37 will be kept locked to prevent unauthorized access to the BJAR and the mine and will be monitored for signs of unlawful entry. The gate at Wildfire security will be kept secured.

Table 11-1 lists the minimum contingent of personnel planned to be retained at the Brucejack Mine in case of temporary closure.

Table 11-1. Brucejack Mine Temporary Closure List of Personnel

Position/Title	Base Location	# Personnel (x 2 for cross-shifts)
Mine Manager	Mine Site	1
Environmental Manager	Mine Site	1
Surface Operations Manager	Mine Site	1
H&S Superintendent	Mine Site	1
Mountain Safety	Varies	3
Mine Captain	Mine Site	2
Underground Miners (for dewatering and UG maintenance)	Mine Site	4
Environmental Technicians	Mine Site	2
Environmental Technicians	Knipple Camp	2
Water Treatment Plant Operators	Mine Site	2
Sewage Treatment Plant Operators	Mine Site	1
Maintenance Personnel (including skilled trades)	Mine Site	6
Equipment Operators	Mine Site / Knipple Camp	6
Camp Personnel (Kitchen & Accommodations)	Mine Site	6
Camp Personnel	Knipple Camp	3
Camp Personnel / Caretaker / Security	Wildfire Camp	2
TOTAL		43

If an extended temporary shutdown of the mine occurs that lasts longer than one year, constructed pads and slopes will be checked for stability and erosion and any areas requiring maintenance will be

treated. WRD operations will be continued until all subaerially exposed waste rock has been subaqueously disposed in accordance with M-243 requirements. A long-term care and maintenance plan will be prepared for regulatory approval.

At times of temporary halts to mine operations, ML/ARD management will be continued, including operation of the WTP. As well, the following will be implemented to reduce or mitigate potential ML/ARD risk:

- Subaqueous deposition of subaerially exposed rock will be continued;
- Any remaining tailings will be disposed of in the WRTSF or underground; and
- Any remaining WTP sludge that cannot be co-mingled with tailings for discharge to the WRTSF will be transported off site for disposal at a licensed facility.

In the event of temporary shut-down periods, access to and along the BJAR will continue to be managed to minimize indirect mortality (i.e., hunting) of wildlife. Signs will be posted to indicate access closure warnings. The mine infrastructure will also be managed by removing wildlife attractants and through continued implementation and enforcement of the Environmental Management System component management plans.

12 POST-CLOSURE MONITORING AND MAINTENANCE

12.1 OVERVIEW

Monitoring is required under Section 10.7.21 of the Code to demonstrate that reclamation and environmental protection objectives including land use, productivity, water quality, and stability of structures are being achieved. Mine closure is estimated to be completed within three years, followed by post-closure monitoring over the following ten years. The results of the monitoring program are to be included in the Annual Reclamation Report (per Section 10.4.4 of the Code).

The following is a description of conceptual post-closure monitoring plans planned for the Brucejack Mine. The length of time required for monitoring may be extended if the early results of the program indicate further monitoring is required. All facilities will be dismantled and/or removed from site during closure with site drainage and landforms contoured to a final closed state. As such, regular maintenance is not anticipated. Maintenance needs will be identified on an as-needed basis based on the monitoring and inspection programs described below.

Monitoring programs will be designed to address evolving needs and are anticipated to decrease in scope through the closure and post-closure periods. During the closure period, monitoring programs will focus on monitoring and management of reclamation activities. During the post-closure period, monitoring programs will focus on demonstrating reclamation success. The general scope of monitoring programs will include:

- Surface water quality and quantity, sediments, and aquatic biological resources;
- Groundwater quality and levels, including water chemistry and level in the underground mine as feasible;
- Structural integrity of portals and raise watertight plugs;
- Geotechnical assessment of post-mine landform and watercourse stability, including for the surface above the underground mine (subsidence); and
- Assessments of reclamation program success in meeting the end land use objectives.

Additional details are provided in the subsections below.

12.2 SURFACE WATER QUALITY AND QUANTITY, SEDIMENTS, AND AQUATIC BIOLOGICAL RESOURCES

Surface water quality and quantity, sediments and aquatic biological resources monitoring and sampling will continue to follow the requirements of PE-107835 through the closure period, with the exception of the reference site (L3 outflow) and effluent discharges as these cease (first tailings, then mine water and CWP influents and WTP effluent once water treatment has concluded, and finally treated domestic wastewater once the site has been fully closed). Once there is no longer a presence at the Brucejack site, surface water quality and quantity (flow) monitoring will continue twice per year (spring/fall) and sediments and aquatic biological sampling will be conducted every second year (biennially) until the end of the first ten years of the post-closure period.

12.3 GROUNDWATER

Monitoring of select groundwater installations will occur during the active closure and post-closure periods. Currently, PE-107835 stipulates the completion of four additional groundwater monitoring wells at closure, with an installation plan submitted two years prior to closure.

The number of groundwater quality sampling stations and monitoring frequency during active and post-closure periods will be established in consultation with BC Ministry of Environment and Climate Change Strategy (MECCS) and BC Ministry of Energy, Mines and Petroleum Resources (MEMPR). During active closure, new and existing wells situated immediately downgradient of the mine workings are recommended for more frequent (i.e., quarterly) monitoring events, while wells situated farther from the mine are recommended for biannual monitoring. During the first ten years of the post-closure period, it is recommended that biannual water quality monitoring be implemented across the well network. Biannual monitoring events are recommended in early June and late September, bookending the open water season.

During the groundwater monitoring events, it is recommended that groundwater sampling crews undertake visual inspections of the West Zone and VOK portals to identify and photograph any seeps potentially created by the recovering mine pool. If channelized flow exists, it is recommended that crews measure flows and field parameters (pH, EC) and collected samples comprising the routine groundwater analyte suite.

Water level data will be collected at locations earmarked for groundwater quality sampling and additional monitoring installations as agreed upon with MECCS and MEMPR. All monitoring stations will be equipped with dedicated dataloggers for continuous water level monitoring and will be downloaded during sampling events, safe access permitting.

Monitoring of underground mine pool is outlined in the Closure Underground Water Quality Adaptive Management Plan which is updated every five years and will be finalized two years prior to closure, as stipulated in PE-107835. During the post-closure period, discrete sampling of the mine pool from multiple depths is recommended from one or more vent raises. Sampling frequency is recommended to coincide with groundwater quality sampling events. Continuous monitoring of mine pool elevation and electrical conductivity, as a surrogate for water quality, is recommended from one or more dataloggers.

Water level data collected from monitoring installation and mine pool will be used to validate and/or update the numerical groundwater model, thereby facilitating prediction of the location and volumetric flux of contact water migrating from the underground to Brucejack Creek. Water quality monitoring of the mine pool and downgradient monitoring wells will inform conceptualization of geochemical loadings to Brucejack Creek.

12.4 MINE OPENINGS

The structural integrity of the watertight plugs in the WZ and VOK portals and the raise north of Brucejack Creek will be checked prior to placement of exterior seals at the end of the closure period to ensure these are performing as required and designed. Repairs will be carried out if and as needed.

12.5 GEOTECHNICAL

Geotechnical monitoring, inspection and assessment of post-mine landforms will continue annually during closure and for the first ten years of post-closure. Implementation of the Subsidence Monitoring and Management Plan (Pretium 2020b, Appendix 4-2-8) will continue through closure, and with a modified program appropriate to post-closure, and as approved by MEMPR, implemented during the first ten years of post-closure. The CWP and its spillway, and post-mine watercourses (particularly the two diversion channels) will continue to be inspected annually for structural integrity and performance. Post-mine, pads, decommissioned roads (including drainage crossings), the km 72 NPAG quarry, the WRD pad, and other post-mine landscape features will be inspected for stability and performance. Repairs will be carried out if and as needed.

12.6 RECLAMATION PROGRAM

Monitoring and assessments of the reclamation program success in meeting the end land use objectives will be conducted annually during the first ten years of post-closure. This will include monitoring for erosion, particularly any determined to affect surface water quality downstream of the WRTSF discharge, and remediation as appropriate. The mine site area will be inspected to confirm that closure measures implemented to achieve the end land use objective of matrix habitat remain intact, with remedial measures implemented as appropriate as necessary. Natural locally endemic vegetation species encroachment onto the mine site will be monitored and documented.

12.7 POST-CLOSURE PERSONNEL REQUIREMENTS AND ACCESS

Since regular maintenance is not anticipated post-closure, limited personnel are required. During the first-year post-closure, there will be 1 full time Environmental Manager and 1 full time Project Manager. For subsequent years, both the Environmental Manager and Project Manager time allocation will be reduced to 25%. During the ten years post-closure, additional support will be received from consultants. The Environmental Manager, Project Manager, and consultants will be based offsite and helicopter transportation will be used for post-closure site access.

Post-closure monitoring will require personnel and access to site twice per year for surface water quality monitoring, four times over ten years for sediment and aquatics monitoring, quarterly for groundwater monitoring, and annually for mine openings, geotechnical, and reclamation monitoring.

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Appendix 8.2-1: Mine Site Surface Buildings and Infrastructure, 2022

Building Name	Sub-structures	General Location*	Floor Material: Concrete/Gravel/Wood/Steel	Structure: Steel or Wood	Construction Type: Modular or Stick
Mill & WTP	-	Mill pad	Concrete**	Steel	Stick
Propane filling station and vapourizer	-	Mill pad	Wood/steel	Steel	Modular
VOK portal building	Conveyor and transfer, galley and take-up tower.	VOK portal pad	Concrete**	Steel	Stick
	VOK conveyor hoarding	VOK portal pad	Concrete	Steel	Modular/stick
Phase 2 camp	Kitchen, 3 dorm wings, offices, dry, medical, housekeeping services, recreational facilities and potable water building	Phase 2 camp pad	Wood/steel**	Wood	Modular
Technical Services	-	Phase 2 camp pad	Wood/steel	Wood	Modular
Sewage treatment plant (STP)	C75 A & B, sludge plant and structure	Phase 2 camp pad	Wood/gravel	Steel	Modular
Operations camp propane MCC	-	Phase 2 camp pad	Steel/gravel	Steel	Modular
H&S training building	-	Phase 1 camp area	Wood	Wood	Stick
Bunk 2	-	Phase 1 camp area	Wood	Wood	Stick
Bunk 3	-	Phase 1 camp area	Wood	Wood	Stick
Bunk 4	-	Phase 1 camp area	Wood/steel	Wood	Modular
Bunk 5	-	Phase 1 camp area	Wood/steel	Wood	Modular
Bunk 6	-	Phase 1 camp bunk 6 pad	Wood/steel	Wood	Modular
Firehall	-	Phase 1 camp area	Concrete/wood/steel	Wood/steel	Stick/modular
Offices & storage	Multiple trailers for Maintenance, Environmental, Contracts departments, etc.	Phase 1 camp area	Wood	Steel	Stick/modular
	Phase 1 camp electrical building	Phase 1 camp area	Gravel	Wood	Stick
Carpentry shop	Carpentry shop	Phase 1 camp area	Wood	Wood	Stick
	Carpenters storage building(s)	Phase 1 camp area	Wood/steel	Wood	Stick
IT Services Atco trailer/office	IT Services Atco trailer/office	Phase 1 camp area	Wood/steel	Wood	Modular
	Phase 1 camp satellite building, lift station	Phase 1 camp area	Wood	Wood	Stick
IMC server building (Communications)	-	Phase 1 camp bunk 6 pad	Steel	Steel	Modular
Plumbing storage	-	Helipad and storage pads	Steel/wood/gravel	Wood/steel	Stick
Phase 1 camp potable water building	-	Phase 1 camp area	Wood	Wood	Stick
Surface equipment heavy shop	Surface equipment heavy shop	Surface equipment heavy shop pad	Concrete/steel	Wood	Stick
	Light vehicle heavy shop	Surface equipment heavy shop pad	Concrete/wood	Wood	Stick
	Welding shop	Surface equipment heavy shop pad	Concrete	Wood	Modular
Warehouse	Warehouse	Main warehouse, electrical and waste sorting area	Concrete	Wood,	Modular
	Warehouse offices	Main warehouse, electrical and waste sorting area	Wood/steel	Steel	Modular
	Warehouse and electrical washcart	Main warehouse, electrical and waste sorting area	Wood/steel	Wood	Modular
Electrical storage	-	Main warehouse, electrical and waste sorting area	Gravel/wood/steel	Wood	Modular
Warehouse coverall storage	-	Main warehouse, electrical and waste sorting area	Gravel	Steel	Stick
Primary waste sorting facility	-	Main warehouse, electrical and waste sorting area	Concrete	Wood	Modular
DPS MCC building	-	DPS pad	Wood/steel	Steel	Modular
Generator buildings DPS (6 units)	-	DPS pad	Wood/steel	Steel	Modular
Cold storage	-	WZ pad	Gravel/wood	Wood	Stick
UG equipment heavy shop	-	WZ pad	Concrete	Wood	Stick
WZ warehouse	WZ warehouse	WZ pad	Concrete	Wood	Stick
	WZ air heater electrical building	WZ pad	Concrete	Steel	Stick
WZ offices	WZ offices and WZ washcart	WZ pad	Wood/steel	Wood	Modular
	WZ seacan storage and storage coveralls	WZ pad	Wood/steel	Steel	Modular
CWP MCC building	-	WZ pad	Wood/steel	Steel	Modular
CWP pumphouse building	-	WZ pad	Wood/steel	Steel	Modular
WZ propane MCC	-	WZ pad	Concrete/gravel	Steel	Modular
WRTSF outlet weir and water reclaim	-	WZ pad	Concrete/steel	Steel/precast concrete	Stick
Incinerator	-	Incinerator pad	Concrete	Wood	Stick

*Refer to Figure 3.7-1 Constructed Pads and Infrastructure Areas
** Constructed with concrete piles
DPS = diesel power station
H&S = health and safety
IT = information technology
MCC = motor control center
Stick = structurally framed at site
UG = underground mine

WRTSF = waste rock and tailings storage facility

WTP = water treatment plant
WZ = West Zone

Chapter 5 Appendices

Appendix 5-1: 4950 tpd Groundwater Model Report

Brucejack Mine: 4950 tpd Groundwater Model Report

June 6, 2023

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

LORAX ENVIRONMENTAL

Executive Summary

Introduction

The Brucejack groundwater model has been updated in support of a proposed ore production increase for Brucejack Mine from 3800 tonnes per day (tpd) to 4950 tpd. This document describes updates to the numerical groundwater model performed in support of the Brucejack Mine 4950 tpd Joint *Mines Act* Permit (M-243) and *Environmental Management Act* Effluent Permit (PE-107835) Amendments Application (4950 tpd Joint Application). Results from this modeling work have been used to inform water balance and water quality model updates supporting the application.

The 3800 tpd groundwater model underwent a major update in 2020 in support of the 5 Year Mine Plan and Reclamation Program Update (2020 Update). Methods and findings of this study were presented in a stand-alone groundwater modeling report appended to the submission. The 2020 groundwater model superseded the 2015 permitting model which had informed the 2018 amendment application for an increased ore throughput from 2700 tpd to 3800 tpd.

The 4950 tpd groundwater model differs from the 2020 groundwater model in that it incorporates as-built mine plan and climate information to the end of 2021 and implements the 4950 tpd mine plan for future predictions. The model setup and parameterization otherwise remain identical to the 2020 groundwater model.

Model Calibration

The Brucejack groundwater model has benefitted from a comprehensive environmental monitoring program that includes daily record keeping of underground dewatering rates and dedicated water level logger deployment at all active monitoring wells. The monitoring program has revealed strong seasonality in groundwater levels and underground dewatering rates and long-term data trends consistent with a groundwater system that is being depressurized from depth.

The 2020 groundwater model was calibrated for both baseline and as-built mining operations periods. The baseline model simulated steady state water levels from 20 groundwater installations and baseflow in Brucejack Creek. The 2020 model provided an acceptable calibration to both targets.

The as-built operations model simulated the 2011 to 2018 period, with special focus on matching underground dewatering rates between 2015 and 2018 during which active mining occurred. The model incorporated the as-built mine progression on a monthly time

step. Along with the measured dewatering rates, transient groundwater level data from 21 monitoring wells were used as calibration targets. This dynamic data record capturing groundwater system response to seasonal and long-term hydraulic stress served as a powerful tool for calibrating bedrock hydraulic parameters and recharge rates. Over the calibration period, the 2020 model reasonably simulated both the magnitude and seasonality of underground dewatering rates, as well as seasonal and long-term trends in key monitoring locations near the Valley of the Kings (VOK) and West Zone workings.

Model Validation

Data collected from 2019 through 2021 have been used to validate the 2020 groundwater model. This data set includes underground dewatering rates and continuous water level data collected from 30 monitoring wells. Twelve of these wells comprise 2018-series monitoring wells whose data were not available for the calibration period. In this way, data from the 2018 monitoring wells serve to independently validate model performance. As-built mine progression over the 2019 to 2021 period was approximated in the groundwater model with groundwater recharge rates adjusted to reflect recent climate conditions.

Over the validation period, the model reasonably simulates peak underground dewatering rates but overpredicts annual minima by 450 m^3/d to 900 m^3/d. Over the calibration and validation period (2015 to 2021), the model overpredicted cumulative dewatered volumes by about 13% (3.92 Mm^3 vs. 3.47 Mm^3). Overall, the simulated dewatering rates are considered acceptable and reasonably conservative for estimating treatment requirements. Good performance of the model against observed water level data collected since 2018, particularly at locations where prior water level data did not exist, further enhances model credibility. As such, it was deemed unnecessary to recalibrate the groundwater model.

Future Operations Predictions

The 4950 tpd mine plan follows an average 3800 tpd production rate until January 2024 and then increases throughput to an average of 4950 tpd until the end of operations in December 2029. The 3800 tpd model simulated mining though the end of 2032. The 4950 tpd underground mine extents are similar to the 3800 tpd mine extents with the following differences:

- The VOK extends 30 m deeper and 175 m to the northeast on account of mining extension areas of the Brucejack mineralization;
- New exploration developments extend farther east, west and south than exploration developments included in the 3800 tpd mine plan; and,
- A tunnel is advanced from the West Zone to north of Brucejack Creek to establish a vent raise.

The 4950 tpd model predicts dewatering rates will stabilize over the last three years of mine life (2027 to 2029), ranging annually between 2,600 m^3/d and 4,300 m^3/d (30 L/s to 50 L/s). The 4950 tpd rates are marginally higher (by about 2 L/s) in the low flow period (April) than those predicted for the 3800 tpd mine plan. Cumulatively, the 4950 tpd model simulates 15% less extracted groundwater over the life of mine than the 3800 tpd mine plan due to a shorter mine life. Monitoring well water levels are drawn down on average 15 m more than the 3800 tpd mine at end of operations. Baseflow in Brucejack Creek is predicted to decrease during operations, stabilizing approximately 7 L/s (or 12%) lower than baseline at BJ 3.10 and 20 L/s (or 25%) lower than baseline at BJ 1.74. This baseflow reduction does not account for any increase in flow resulting from deposition of tailings and waste rock in the WRTSF. Predicted baseflow reductions are similar for both 4950 tpd and 3800 tpd models and the 2015 permitting groundwater model.

Closure Predictions

The 4950 tpd groundwater model simulates the passive reflooding of the mine by groundwater only, starting in 2030. Active reflooding of the mine using reclaim water is handled separately in the water balance model. Under passive flooding, the mine pool is predicted to recover to its equilibrium level around 23 months after onset of flooding. This is several months faster than what was predicted for the 3800 tpd mine plan. The equilibrium water level in the 4950 tpd mine is expected to vary seasonally between 1394 masl and 1412 masl, averaging 1401 masl, provided plugs are installed at the VOK and West Zone portals and in the vent raise daylighting north of Brucejack Creek. This is consistent with the equilibrium water level predicted for the 3800 tpd mine plan.

The equilibrium contact water flux issuing from the flooded 4950 tpd mine void varies seasonally between 10.4 L/s and 22.9 L/s, averaging 14.9 L/s annually. This is 4.7 L/s higher than what was predicted by the 3800 tpd model. The increase in contact water flux arises from an overall larger and deeper mine excavation, advancement of the vent raise north of Brucejack Creek and exploration developments. The majority of contact water reports to Brucejack Creek between BJ 2.62 and BJ 3.10, with some contact water reporting below BJ 2.62 and to the WRTSF itself. For the purpose of arriving at conservative water quality model predictions and thus an aggressive treatment strategy, an upper end value of 95% contact water flow reporting above 2.62 is assumed in the water quality model.

Baseflow is predicted to recover within 5% of baseline levels approximately three years after the end of operations, which is in line with predictions from the 3800 tpd model. Therefore, findings of earlier effects assessment on surface water quantity in Brucejack Creek remain valid with respect to predicted changes in baseflow quantity.

Model Sensitivity and Uncertainty

A sensitivity analysis carried out on the 3800 tpd model remains valid for the 4950 tpd model since the calibration has not been updated and the revised mine plan produces similar results as the 3800 tpd model. Having benefitted from several years of high quality calibration data, the analysis found that even modest (two-fold) changes in global hydraulic conductivity are not supported. Changes in fault hydraulic conductivity did not result in material changes in model predictions. Plug hydraulic conductivity will impact contact water fluxes and mine pool elevation only when increased well above a reasonably attainable value. Overall, the sensitivity analysis supports the use of the calibrated model moving forward in predictions and suggests that any future modifications of model properties will likely only need to occur on a localized scale.

Model uncertainty was assessed by examining the forecasted dewatering rates of the 2020 model against observed dewatering data from 2019 to 2021. The uncertainty arises from differences in planned and executed mine plan, average and experienced climate and general model parameterization. When expressed as a percent of observed rates, the model overestimates winter low flow rates on the order of 90% while open water flow rates are overestimated on the order of 30%. When the as-built mine plan and climate are simulated (by the 4950 tpd model), the winter low flow rates remain overestimated by 90% while open water season dewatering rates are essentially replicated. The conservativeness of the groundwater model is considered appropriate for the objectives it is seeking to fulfil.

Continued collection of groundwater level data and daily tracking of mine water management volumes will be instrumental in future groundwater model validation. It is recommended that future updates of the groundwater model include new faults which may impart non-trivial hydrogeological influence on the mine. Focus should also be placed on resolving the disparity between simulated and observed winter dewatering rates.

Authorship

This update to the Brucejack Mine Groundwater Model was prepared by Lorax Environmental Services Ltd. (Lorax) for Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies. The report was written by Laura-Lee Findlater, B.Sc., P.Geo., and Joseph Xu, Ph.D., and reviewed by Alison Shaw, Ph.D., P.Geo. Lorax Environmental Services Ltd. has relied on information available in scientific literature and information supplied by Pretium in preparing this report.

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

asl	above sea level
EMA	*Environmental Management Act*
K	hydraulic conductivity
km	kilometre
L/s	litres per second
m	metre
m bgs	metres below ground surface
m^3/d	metres cubed per day
m/s	metres per second
MA	*Mines Act*
MAP	mean annual precipitation
mm	millimetres
NRMSE	normalized root mean square error
Pretium	Pretium Resources Inc.
PCIC	Pacific Climate Impacts Consortium
Q_{base}	baseflow simulated by the water balance model
tpd	tonnes per day
VOK	Valley of the Kings
VWP	vibrating wire piezometer
WRTSF	Waste Rock and Tailings Storage Facility

1. Introduction

1.1 Background

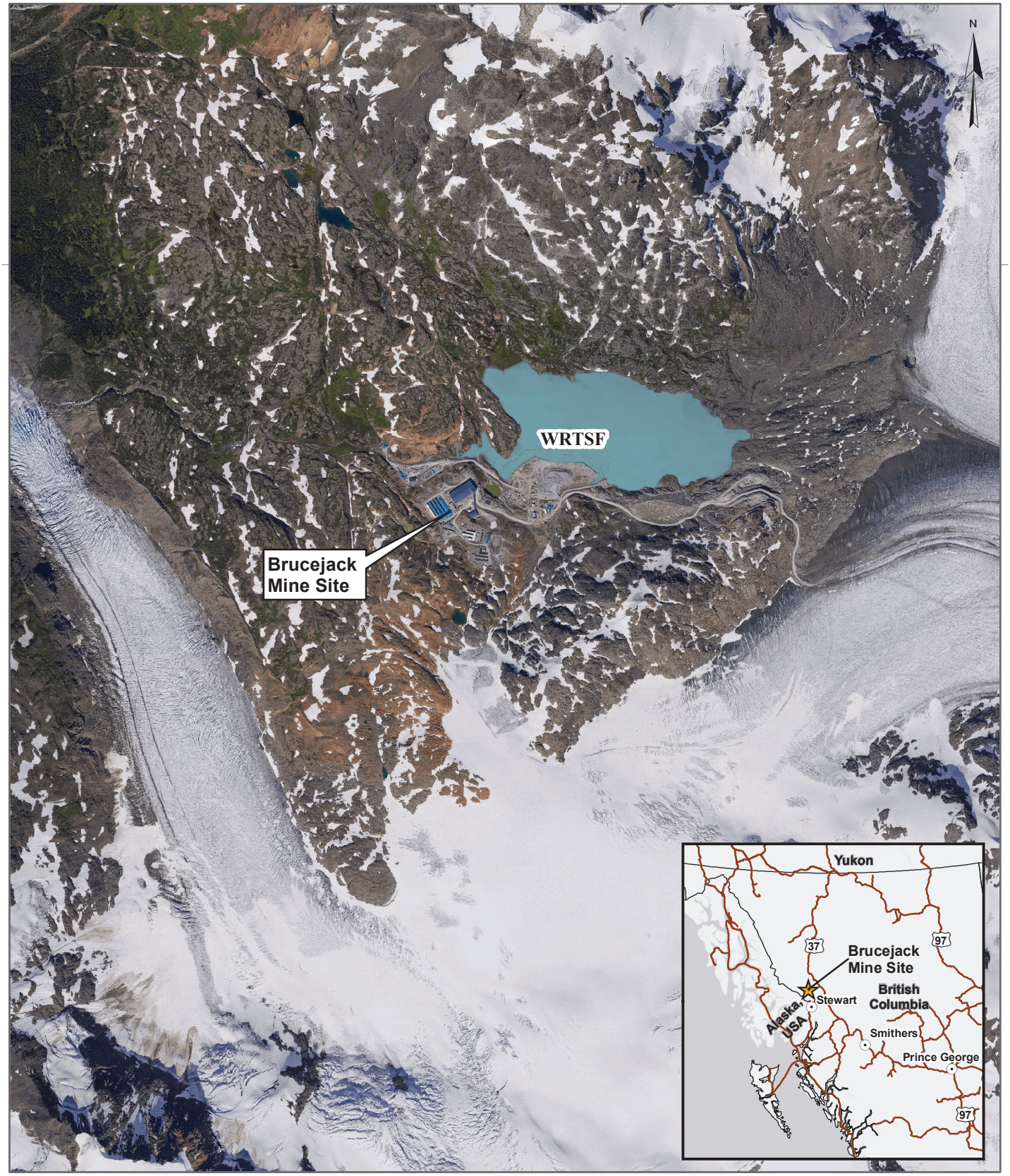
The Brucejack Mine (the mine), located in northwest British Columbia (BC), is a high-grade underground gold and silver mine operated by Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies. The mine is located approximately 60 km north-northwest of Stewart (Figure 1-1).

The mine received its BC Environmental Assessment Certificate (EAC) (#M15-01) in March 2015, and received *Mines Act* Permit (M-243) and *Environmental Management Act* Effluent Permit (PE-107835) in July and August 2015, respectively. Construction was initiated in September 2015 and commercial production was achieved in July 2017. M-243 was amended in December 2018 to increase the average ore production rate from 2700 tpd to 3800 tpd.

Numerical groundwater modeling of the mine was undertaken between 2013 and 2015 to support the EAC and *Mines Act*/*Environmental Management Act* (*MA/EMA*) permits applications (BGC, 2014c, 2015). Mine dewatering rates predicted by the 2015 groundwater model were later adjusted for the production increase presented in the 2018 *Mines Act* Permit Amendment (Pretium, 2018).

Pretium submitted its first 5 Year Mine Plan and Reclamation Program Update in 2020 (2020 Update) (Pretium, 2020). The numerical groundwater model underwent a significant update in support of the 2020 Update where it was migrated into a different modeling platform, refined and recalibrated to data collected up until the end of 2018 (Lorax, 2020b). Future predictions were provided for a mine plan that was primarily based on the 2019 Technical Report on the Brucejack Mine (2019 Technical Report; Jones *et al.*, 2019) with the addition of underground exploration development that was planned over the next five years.

Pretium is seeking amendments to permits M-243 and PE-107835 to increase its ore production rate from 3800 tpd to 4950 tpd (4950 tpd Joint Application). The numerical groundwater model has been updated to inform water balance and water quality modeling studies supporting the amendment application. The numerical model has been validated against data collected up until the end of 2021 and simulates the updated 4950 tpd mine plan. This document describes updates to the numerical groundwater model performed in support of the 4950 tpd Joint Application.



LEGEND

Site Location

DATE SAVED:	Nov 29, 2022
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:30,000

0 250 500 Meters

CLIENT:

NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Update

TITLE:

Brucejack Mine Location Map

PROJECT #: A624-4

FIGURE: 1-1

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022GW Report\Fig 1-1_Projection Location.mxd

1.2 Scope of Work

The purpose of this report is to summarize the methods and findings of the 4950 tpd Joint Application numerical groundwater model. More specifically, this report provides:

- A summary of hydrogeological setting of the mine including hydrogeological data collected through the end of 2021 that has been used to update and validate the 4950 tpd model;
- A summary of model setup and predictions for the baseline period, which are unchanged from those presented in the 2021 model update;
- Updated model results for the current operations period extending to the end of 2021;
- Updated predictions of dewatering rates and groundwater levels during future operations under the increased production rate;
- Updated predictions of mine flooding time, volume and spatial distribution of contact water fluxes to Brucejack Creek and groundwater elevations during closure and post-closure; and,
- Updated predictions of baseflow impacts in Brucejack Creek arising from mine operations and closure.

The results of the 4950 tpd predictive simulations have been compared to corresponding predictions from the 2020 groundwater model to quantify changes in impacts on groundwater arising from the production increase. Updated groundwater model predictions have been used to inform updates to the site-wide water balance and water quality models (Lorax, 2023a,b).

2. Hydrogeological Setting

2.1 Physiography

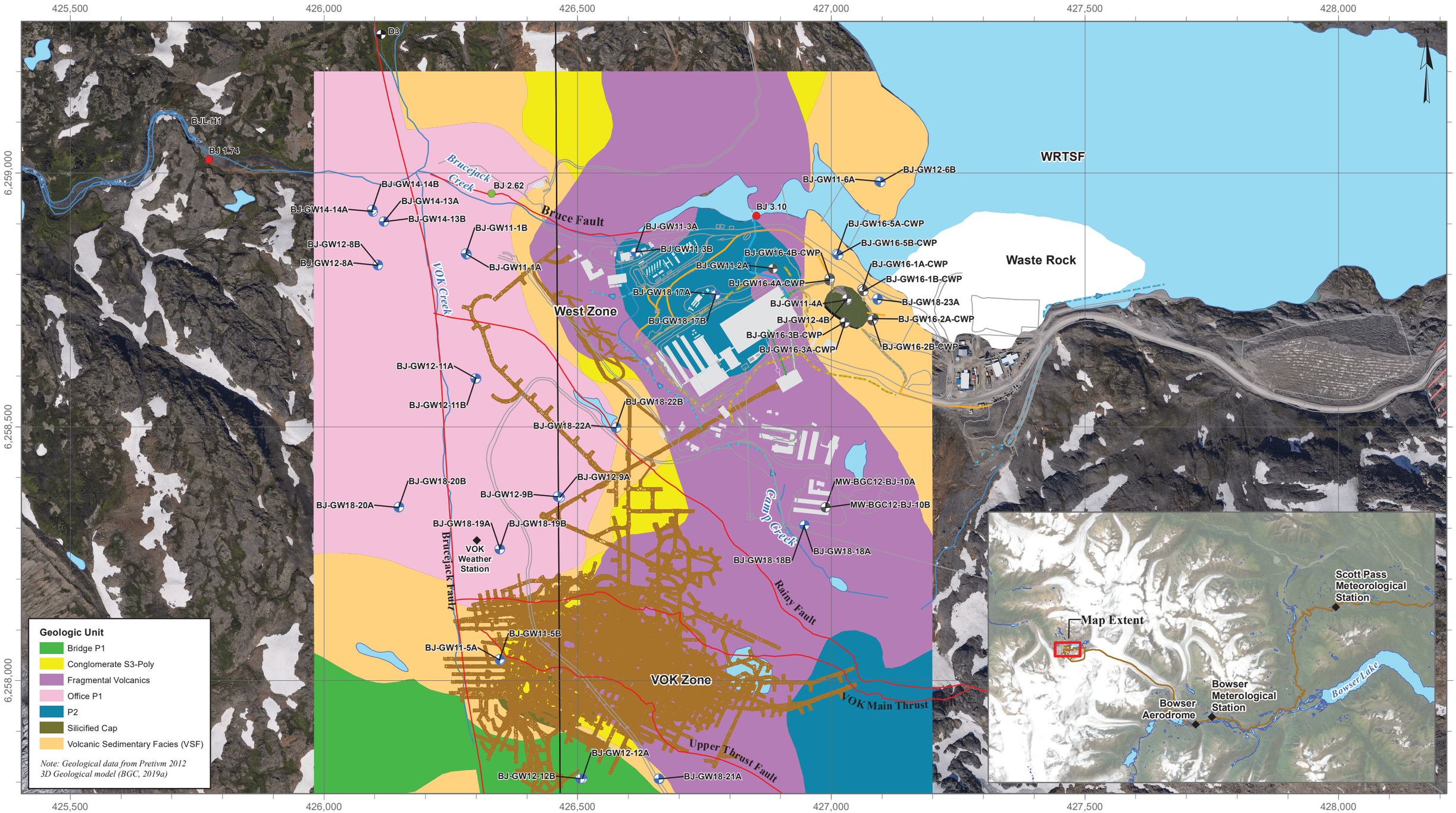
The Brucejack Mine is located in the Boundary Range of the Coast Mountain Physiographic Belt. Mine infrastructure is located at 1360 to 1415 metres above sea level (masl) along Brucejack Creek and immediately southwest of the Brucejack Waste Rock and Tailings Storage Facility (WRTSF; Figure 2-1). The mine site is above treeline and lies in a transition zone between the very wet coastal and drier interior regions of BC. This part of northwestern BC is dominated by weather systems generated from the Pacific Ocean but is also strongly influenced by orographic effects caused by the local mountain topography that produces high spatial variability in snowfall, precipitation, temperatures and snowmelt. In addition, the extensive glacial areas around the mine site can impact snowmelt rates and produce high runoff volumes during the summer months. The humid climate and physical characteristics of the region result in dynamic streams and rivers with high annual runoff rates and high average stream flows.

2.2 Climate

Three sources of climate data were used to inform the Brucejack groundwater model: period of record weather data recorded at climate stations operated by Pretium; monthly synthetic climate data obtained from ClimateBC; and, daily gridded climate data available from the Pacific Climate Impacts Consortium (PCIC). These climate data are fully described in the water balance model reports prepared for the 2020 Update and 4950 tpd permit amendment application (Lorax, 2020a, 2023a). Summaries of mine site and ClimateBC data are presented in the sections below.

2.2.1 VOK Climate Station

The Valley of the Kings (VOK) weather station (1500 masl) and snow course are situated adjacent to the mine site and most relevant to the set-up and execution of the Brucejack groundwater model. Pretium also operates climate stations at two low elevation locations: Bowser Lake and Scott Pass (Figure 2-1). The VOK climate station is instrumented with research grade sensors and programmed hourly to record the following parameters: air temperature, relative humidity, average wind speed and gusts, solar radiation, net radiation, atmospheric pressure, and total precipitation. These data are essentially continuous, and high-quality, for the period of record September 2014 through December 2022. Monthly precipitation measured at the VOK climate station since 2015 is summarized in Table 2-1.



LEGEND

- Monitoring Well (currently monitored)
- Monitoring Well (Decommissioned)
- Potable Supply Well
- Hydrometric Station
- Hydrometric Station (Decommissioned)
- SWQ Station
- Weather Station
- Fault
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Reclaim Water Line
- Untreated or Off-Spec Water Line
- Building Infrastructure
- Cross Section
- 2021 Underground Workings (As-Built)
- Surface Contour (50m)
- Surface Contour (10m)

DATE SAVED:	Feb 27, 2023
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:7,000

0 100 200 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT: **4,950 tpd Groundwater Model Report**

TITLE: Brucejack Mine General Arrangement

PROJECT #: A624-4

FIGURE: 2-1

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Table 2-1:
Precipitation (mm) measured at VOK climate station.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2015	241	96	177	152	19	105	143	213	201	392	190	139	2,069
2016	122	188	75	161	118	48	83	63	230	82	212	144	1,527
2017	161	97	143	44	107	117	64	176	180	231	108	130	1,556
2018	111	92	84	81	71	50	60	100	59	189	163	164	1,224
2019	182	33	76	119	29	81	187	356	152	260	294	121	1,890
2020	130	162	104	89	95	155	127	278	189	190	277	161	1,955
2021	214	169	204	99	95	86	53	156	378	296	308	86	2,143
Average													
2015-2019	163	101	111	111	69	80	107	182	164	231	193	140	1,653
2015-2021	166	120	123	106	76	92	102	192	198	234	222	135	1,766

2.2.2 ClimateBC

The ClimateBC data tool generates synthetic climate data for use in water resources applications and climate change studies in British Columbia. Methodologies related to Climate BC are summarized in Wang *et al.* (2012). To support the 2020 update of the groundwater model (Lorax, 2020b), precipitation and potential evaporation data were extracted for grid points within the Brucejack Creek watershed. Extracted data spanned 100 m elevation bands between 1300 masl to >2000 masl. Consistent with BGC (2017a), raw precipitation outputs from ClimateBC were found to overestimate local precipitation depths within the Brucejack watershed. The raw outputs were adjusted to reflect 'true' conditions at the mine site, using the five years (2015-2019) of reference data at the VOK climate station as a guide.

Representative orographic gradients for the Brucejack Creek watershed were derived from the extracted data according to the UBC Watershed Model Manual (Quick *et al.*, 1995). Winter precipitation gradients were determined to be 3% per 100 m gain in elevation, summer precipitation gradients were computed to be 2% per 100 m gain in elevation, and potential evaporation gradients were determined to be on the order of negative 3% per 100 m elevation gain for applicable months (*i.e.*, May to September). Representative outputs from ClimateBC are summarized for three elevation ranges (or bands) within the Brucejack Creek watershed for precipitation (Table 2-2) and potential evaporation (Table 2-3).

A comparison between ClimateBC outputs (1983-2018) and measured VOK station data (2015-2019) is shown in Figure 2-2. ClimateBC estimates long-term mean annual

precipitation (MAP) for the mine site on the order of 1,950 for VOK station elevation which is higher than the average MAP measured at the VOK since 2015 (Table 2-2). Therefore, the long-term average MAP simulated by ClimateBC is an appropriate and conservative metric to inform groundwater recharge rates in the numerical groundwater model.

Table 2-2:
ClimateBC outputs of precipitation, Brucejack Creek Watershed

Elevation Band (masl)	% Area of WRTSF Basin	Precipitation (mm)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1300 to 1500	40%	255	170	144	91	78	68	85	132	180	253	214	221	1,891
1500 to 1700	35%	271	177	150	98	81	71	88	137	188	266	223	232	1,981
>1700	25%	301	190	160	110	87	77	95	147	201	290	239	253	2,150

Table 2-3:
ClimateBC outputs of potential evaporation, Brucejack Creek Watershed

Elevation Band (masl)	% Area of WRTSF Basin	Evaporation (mm)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1300 to 1500	40%	0	0	0	0	55	70	72	56	29	0	0	0	282
1500 to 1700	35%	0	0	0	0	51	66	68	52	27	0	0	0	264
>1700	25%	0	0	0	0	23	59	61	47	24	0	0	0	216

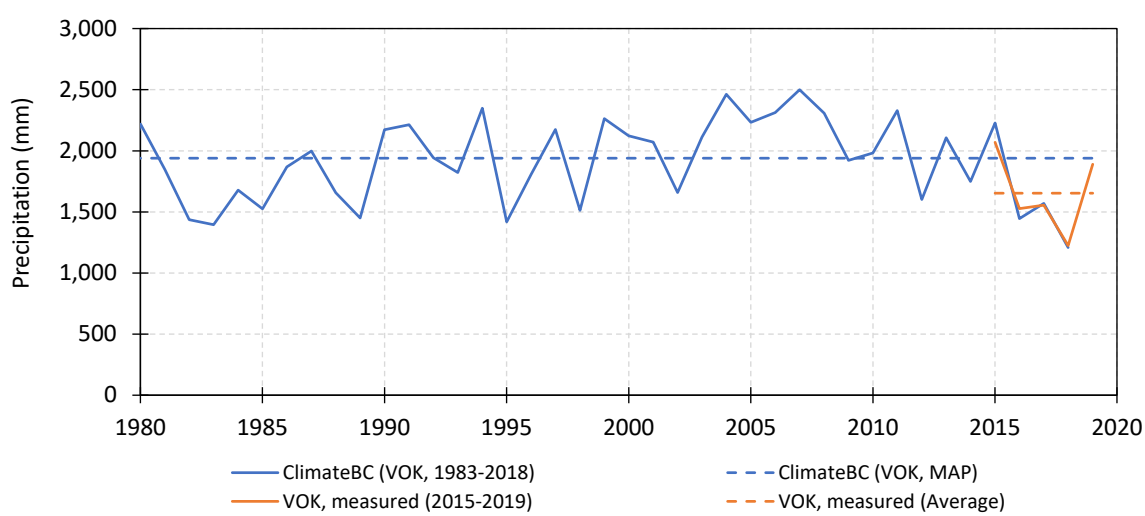


Figure 2-2: Time series comparing ClimateBC outputs and 2015-2019 measured precipitation for VOK climate station.

2.3 Hydrology/Baseflow Regime

Four lines of evidence were used to define baseflow conditions in local tributaries and the 2020 groundwater model: measured and synthetic streamflow data for the BJL-H1 hydrometric station (8.5 km^2) established by Rescan in 2010; 2014 to 2019 measured streamflow data for hydrometric stations established by Pretium at BJ 3.10 (6.5 km^2) and BJ 1.74 (8.5 km^2) (Figure 2-1); modelled outputs from a calibrated surface watershed model for the Brucejack Creek watershed; and, regional streamflow data for Water Survey of Canada gauge 08DD001 (Unuk River near Stewart, 1960-96; 1,480 km^2).

2.3.1 Previous Assessment

A hydrology assessment was undertaken for the Brucejack property in 2010 (Rescan, 2011) and updated in 2013 for an Environmental Assessment supporting the neighboring KSM project (Rescan, 2013). The assessments presented measured and synthetic flow data from the BJL-H1 monitoring station downstream from the WRTSF (Figure 2-1). Ultimately, the average of January and February synthetic low flows, 0.073 m^3/s, was used to evaluate the baseflow simulated by the 2015 groundwater model (BGC, 2015).

2.3.2 Measured Data

Every year since 2016, Pretium has submitted an annual monitoring report for the prior calendar year summarizing monitoring data and current state of understanding with respect to streamflow conditions within the Brucejack Creek watershed (*e.g.*, Pretium, 2022). The locations of relevant streamflow gauges are shown for reference in Figure 2-1, including gauges situated at location BJ 3.10 (record period 2014-present) and further afield at BJ 1.74 (2008-present). Since 2016, flows have been measured at BJ 3.10 by a weir, which includes a heated control house.

Patterns of streamflow at BJ 3.10 and BJ 1.74 are strongly influenced by snow accumulation and snowmelt processes, where roughly 85% of runoff on an annual basis is expected to report to receivers between May and the end of October. By comparison, runoff depths for other months of the year (*i.e.*, November through April) are much lower. Winter streamflow volumes are well characterized at the mine and at BJ 3.10 typically range from 0.050-0.120 m^3/s between December and April (Figure 2-3, Table 2-4).

Table 2-4:
Summary of streamflow measurements at BJ 3.10 (2014-2019).

	Discharge (m^3/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	0.031	0.031	0.033	0.049	0.736	1.146	1.093	0.682	0.707	0.784	0.205	0.079	0.470
2015	0.056	0.056	0.048	0.084	0.790	1.142	0.791	0.575	0.486	0.610	0.197	0.129	0.416
2016	0.130	0.114	0.092	0.222	0.705	1.079	0.863	0.489	0.626	0.190	0.175	0.111	0.401
2017	0.069	0.064	0.056	0.046	0.409	1.143	0.917	0.779	0.533	0.315	0.169	0.098	0.385
2018	0.104	0.083	0.071	0.088	0.627	0.797	0.617	0.458	0.269	0.233	0.168	0.181	0.310
2019	0.095	0.067	0.071	0.099	0.609	1.003	0.725	0.652	0.512	0.320	0.298	0.164	0.386
Mean	0.081	0.069	0.062	0.098	0.646	1.051	0.834	0.606	0.522	0.409	0.202	0.127	0.395

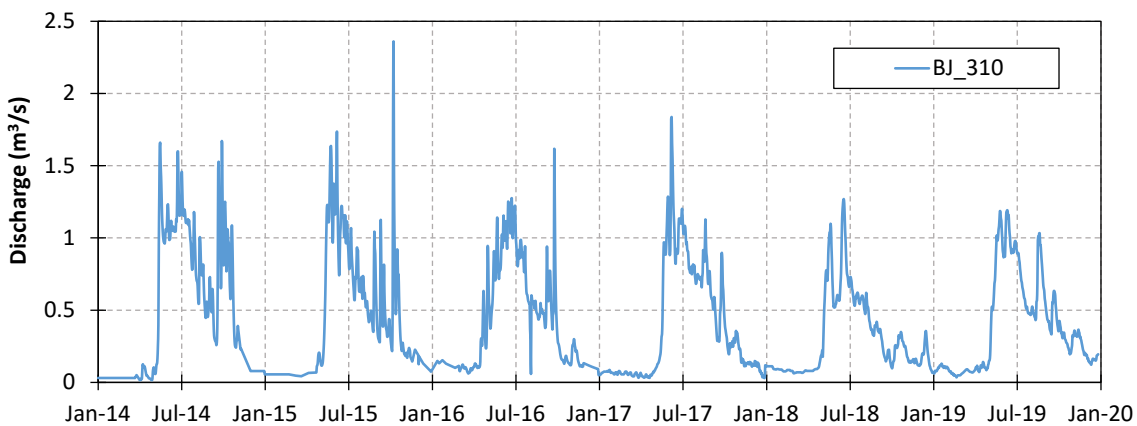


Figure 2-3: Time series showing measured discharge at BJ 3.10 (2014-2019).

2.3.3 Surface Watershed Model Outputs

2.3.3.1 Approach

A modified version of the Birkenes watershed model (Christophersen and Seip, 1982) is used in the site wide water balance model to replicate the streamflow regime at the mine (Figure 2-4, left panel). The Birkenes model represents the watershed using a series of connected reservoirs which aim to replicate a measured hydrograph by separating total discharge into three component flows (Figure 2-4, right panel): quick flow, or event runoff, which may be associated with melting of snowpack or summer storms; interflow, which is flow through shallow overburden material and soils; and baseflow, which in concept is the portion of the hydrograph which is derived from groundwater discharge.

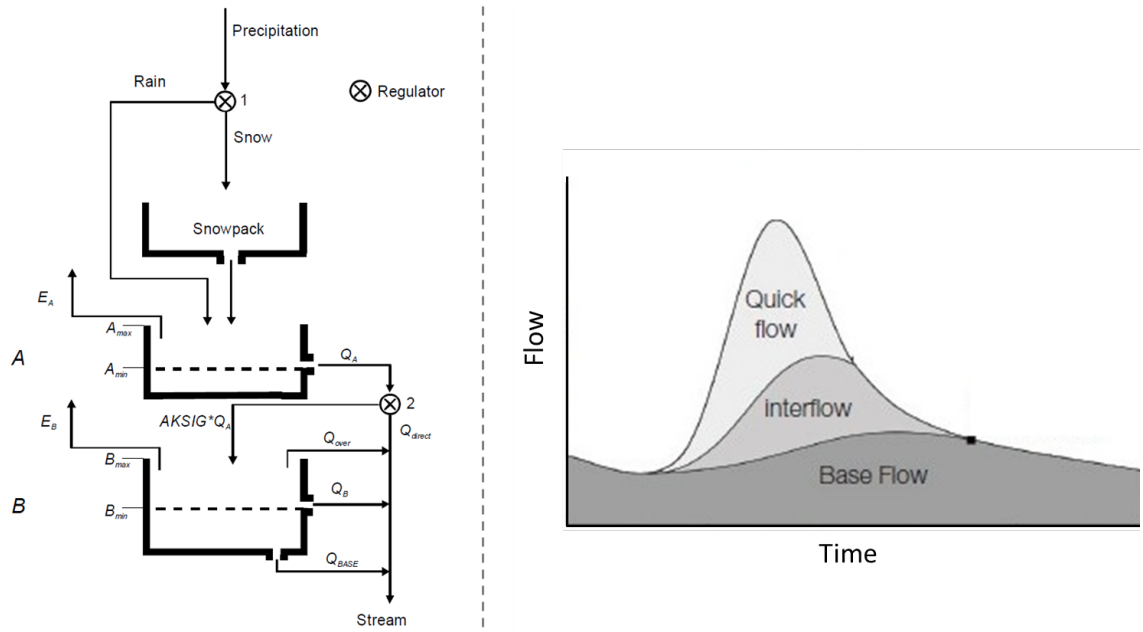


Figure 2-4: Overview schematic of the Birkenes 3-reservoir model (left) and conceptual hydrograph with partitioning of total flow to component parts of quick flow, interflow and baseflow (right).

As outlined in Lorax (2020a, 2023a), the site wide water balance model reads in a long-term daily climate dataset, developed from the PNWNAmet dataset accessible from the Pacific Climate Impacts Consortium (PCIC) data portal. The gridded data span the period 1945 to 2012 and are described by Werner *et al.* (2019).

Conceptually, incoming precipitation is partitioned in the Birkenes model to rain or a snow reservoir based on air temperature thresholds. Rainfall is directed into Fast and Slow Surface reservoirs, which represent areas of fast runoff response, and slower-draining soil areas, respectively. Fast and slow surface recession flow from the surface storage reservoirs can go directly to surface discharge, or to the deep surface water reservoir, depending on the fraction of remaining available storage in the latter. When the deep surface water reservoir contains water, slow recession flow from the reservoir reports as baseflow. Withdrawals from these reservoirs are governed by constant proportional losses applied to the reservoir volume at a given time-step. As the reservoir volume is drawn down (assuming no additional inputs), the rate of withdrawal is reduced, and thus the outflow signature approximates a negative exponential decay function (*i.e.*, the recession curve).

Snow within the snowfall reservoir remains in storage until snowmelt begins, which is controlled in the model using daily temperature-dependent melt functions. When snow within the snowfall reservoir melts, these waters can either report to other model reservoirs if they are depleted or generate quick flow following the mechanisms described for rainfall.

Over the course of a simulation, evaporation is withdrawn from both surface reservoirs (fast and slow), and from the deep surface water reservoir, but at a lower rate. Similar to the handling for snow versus rain, evaporation is computed in the model using temperature-based controls.

2.3.3.2 Outputs

Two outputs from the calibrated watershed model were used in the development of the 2020 groundwater model: annual average estimates of baseflow (Q_{base}) at the BJ 3.10 monitoring location (Figure 2-1); and, average monthly estimates of rainfall plus snowmelt (Table 2-5).

The annual average baseflow estimated from the surface water balance model is considered representative of the long-term groundwater contribution to the catchment water balance making it a suitable calibration target for the average conditions simulated by the baseline groundwater model. For a 67-year simulation spanning the daily climate record from PCIC, average annual baseflow at BJ 3.10 was computed to be 61 L/s, ranging between a minimum of 50 L/s to a maximum of 92 L/s. The 61 L/s annual average baseflow computes to an average yield of 9.3 L/s/km^2, which is similar in magnitude to period of record minimum and lower quartile flows for the Unuk River (~10 L/s/km^2).

The average monthly rainfall plus snowmelt presented in Table 2-5 was used to constrain the calibration of monthly recharge values employed in the groundwater model. Rain plus snowmelt results obtained from the calibrated Brucejack Creek watershed model indicate a majority (65%) of the annual event water signature reports in May (501 mm) and June (775 mm), with essentially all the remaining event water realized in July, August, September, and October (Table 2-5).

Table 2-5:
Monthly average rainfall plus snowmelt signature derived from the calibrated Brucejack Creek watershed model

	Rain plus Snowmelt (mm)											
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Average case	1	1	1	72	501	775	160	132	178	123	10	4
% Distribution	0%	0%	0%	4%	26%	40%	8%	7%	9%	6%	1%	0%

2.4 Hydrostratigraphy

2.4.1 Geology

The geology of the mine area is summarized in BGC (2015) and expanded upon in Shaw *et al.* (2020). The mine area is largely underlain by volcano-sedimentary rocks of the Lower

Jurassic Hazelton Group. These rocks unconformably overlie volcanic arc sedimentary rocks of the Upper Triassic Stuhini Group. Mine site geology is shown in Figure 2-1. A simplified list of the main lithologies encountered within the mine area includes the following:

- P1 [Office or Bridge]: Hornblende, feldspar phyric latite flows.
- P2: Megacrystic, plagioclase, potassium-feldspar, and hornblende phyric flow.
- V12 [Fragmental volcanics]: Hornblende and/or feldspar phyric latite to andesite fragmental volcanic rocks and subordinate flows with minor ash and lapilli tuff.
- S3-Poly [Polymictic conglomerate]: Heterolithic boulder to coarse cobble conglomerate with sandstone.
- Silicified Cap: Silicified rocks; typically, poorly sorted heterolithic conglomerate, lesser sandstone, and local mudstone; commonly includes rhyolite fragments.
- VSF [Volcanic Sedimentary Facies]: Volcanically derived siltstone and sandstone with minor arenite and pebble conglomerate.

The surficial materials within the Brucejack area consist of a sparse veneer of well-graded glacial till overlying bedrock. Grain size varies from sand to gravel, with some silt and clay, and variable quantities of cobbles and boulders. The thickness of unconsolidated deposits varies at the site but is generally less than 5 m and commonly less than 1 m (BGC, 2014b).

2.4.2 Major Structures

The fault model provided at the time of the 2020 model development included four large (*i.e.,* mine-scale) fault zones intersecting the mine area: the Brucejack Fault Zone, the Rainy Fault, the Valley of the Kings Main Thrust Fault, and the Upper Thrust Fault (Figure 2-1). A fifth major fault, the Bruce Fault, which follows the trace of Brucejack Creek, was simulated in the original permit model (BGC, 2015) and carried forward into the 2020 model and 4950 tpd update.

The Brucejack Fault Zone is a long lived northerly striking anastomosing vertical fault zone with predominantly left lateral strike slip movement showing a net displacement varying between 500 and 800 m (ERSi, 2010). It is comprised of a core of highly fractured rock with a zone of less fractured, fault-disturbed rock mass on either side. The width of the fault zone varies with depth and along strike from approximately 5 to 40 m and the fault is considered to be continuous along strike.

The Rainy Fault, Valley of the Kings Main Thrust Fault and Upper Thrust Fault are three gently dipping south-southwest striking faults. The Rainy Fault has an average thickness of 2 m, with the thickness appearing to increase with depth. Often the Rainy Fault zone is comprised of multiple gouge zones separated by more competent zones of very blocky rock mass. Seepage conditions within the zone vary significantly, from dry to dripping, hence the moniker "Rainy".

Pretium staff (Travis Murphy P.Geo, Operations Manager, pers. communication) indicate that the Rainy Fault is the most commonly encountered fault within the mine workings and is typically grouted when encountered in the mine workings for geotechnical purposes. The Rainy Fault intersects a significant amount of mine workings between the 1200 m elevation to the 1350 m elevation, while the VOK Main Thrust intersects workings only on the 1440 m elevation and the 1470 m elevation. The Upper Thrust lies above the current mine workings and is only identified through diamond drill core. Mine workings intersected the Brucejack Fault in August 2022.

The Bruce Fault, a west-trending fault occupying Brucejack Creek, was identified during 1990s era exploration (McPherson *et al.*, 1994) (Figure 2-1). More recent but still limited data for this structure suggests it is subvertical and possibly comprised of two splays. The faults vary from 0.2 m to 1.5 m thick with moderately gouged fault planes and strongly deformed rubble zones.

2.4.3 Hydraulic Conductivity

The site hydraulic conductivity database is comprised of over 150 measurements and draws from several hydrogeological and geotechnical field programs completed between 2010 and 2018 (BGC, 2014b, 2017, 2019). Test data are tabulated in Appendix A with results plotted versus depth in Figure 2-5. Figure 2-5 is split into three panels with the top panel showing all test data (including tests on overburden), the middle panel showing tests from faulted/fractured rock and the bottom panel showing tests from intact rock without faults or fractures. The determination of whether an interval was fractured or faulted was based on notes in borehole logs indicating whether these features were encountered. Borehole logs for monitoring wells for which hydraulic tests were completed are included in Appendix B.

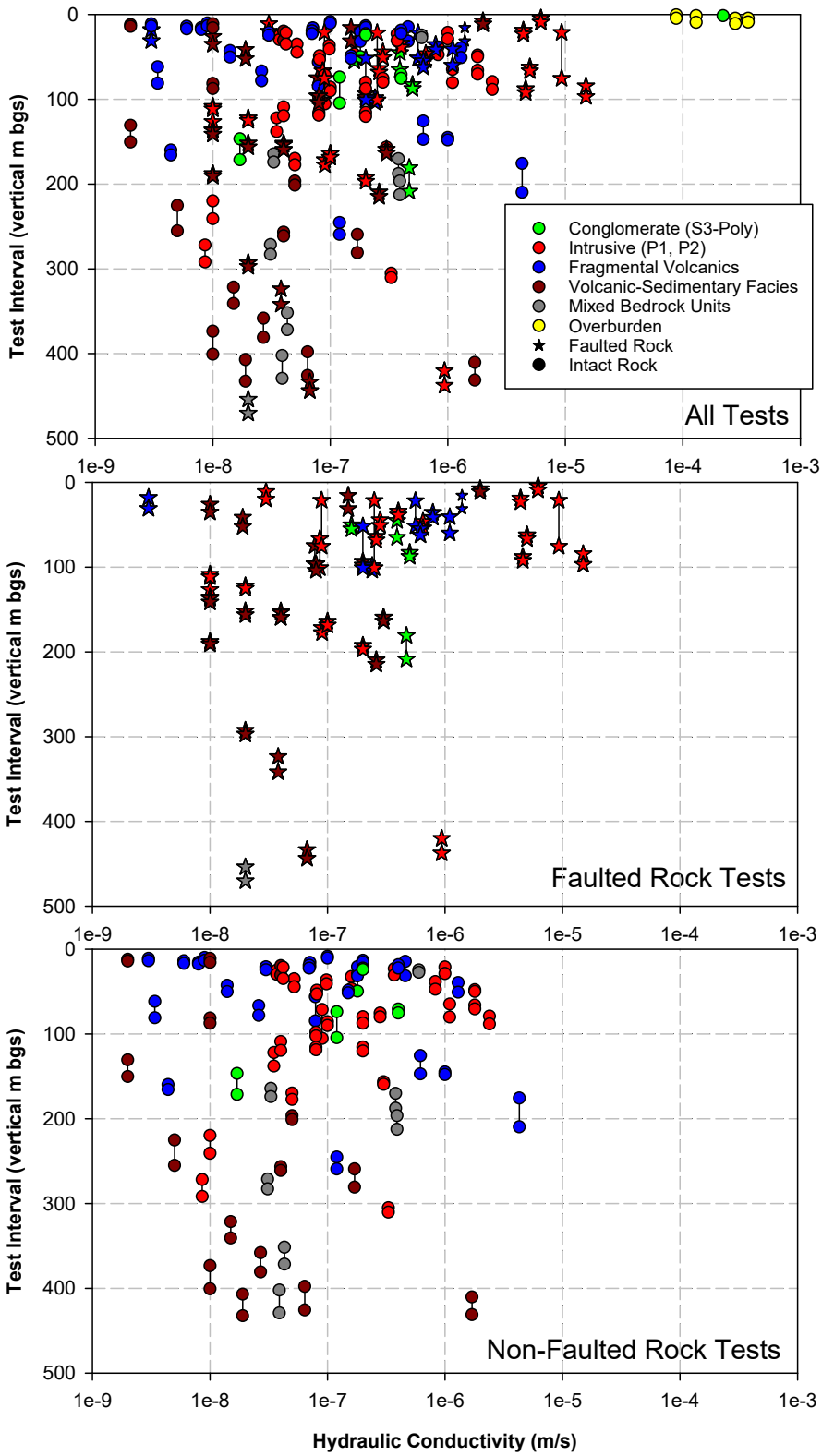


Figure 2-5: Hydraulic conductivity versus depth at Brucejack Mine in faulted (middle panel) and non-faulted (lower panel) rock. Upper panel shows all tests results (including overburden).

Overall, the data suggest bedrock hydraulic conductivity decreases with depth but at any given depth, hydraulic conductivity is highly variable. For example, between 0 m and 100 m depth, hydraulic conductivity ranges from 3E-09 m/s to 1.5E-05 m/s; between 400 m and 500 m, hydraulic conductivity ranges from 2E-08 m/s to 1E-06 m/s.

Figure 2-6 groups the hydraulic testing results by lithology. The most frequently tested unit is the intrusives (49), followed by VSF (31), fragmental volcanics (30) and conglomerate (9). The data do not indicate a strong correlation between hydraulic conductivity and lithology; however, this is partially confounded by the number of tests available for different units for any given depth. The data also indicate that faulted rock intervals are not universally highly conductive.

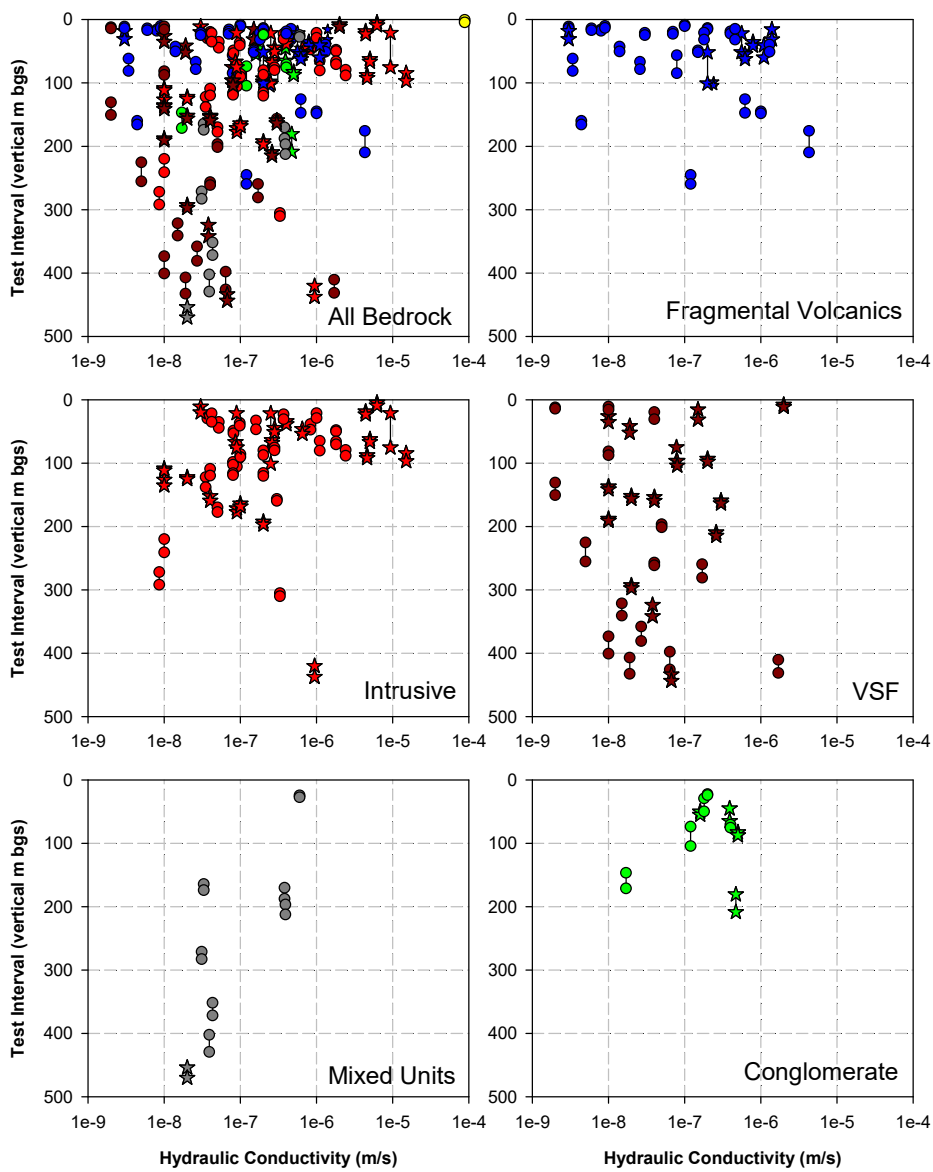


Figure 2-6: Hydraulic conductivity by lithology at Brucejack Mine.

2.5 Groundwater Levels

Numerous monitoring wells have been installed across the Brucejack Mine (Table 2-6) (Appendix B) in several hydrogeological campaigns (BGC, 2014a,b, 2017, 2019). Per PE-107835, high-resolution water level data are collected from the monitoring well network via dedicated loggers and are presented in annual monitoring reports, the most recent of which was submitted in 2022 (Lorax, 2022 in Pretium, 2022). Water level and vertical gradient time series from currently monitored wells are provided in Appendix C. Water level data up to the end of 2018 were used to calibrate the 2020 groundwater model prepared for the 2020 Update (Lorax, 2020b). Water level data collected between 2018 and 2021 have been used to validate the 4950 tpd groundwater model.

June 2021 water levels are contoured in (Figure 2-7). Continuous dewatering of the VOK and West Zone workings has created a marked depression of the groundwater table in the footprint of the workings and farther afield. For wells where 2012 baseline data exist, annual drawdown based on June water levels have been computed (Table 2-6). The largest decline in water levels has been measured at wells upgradient of the VOK, namely BJ-GW11-5A/B and BJ-GW12-12A. These wells are currently dry and actual drawdown at these stations is inferred to be higher than that reported in Table 2-7 (*i.e.*, exceeding 100 m) based on water levels measured at BJ-GW18-19A (~1310 masl).

East of the West Zone, water levels at BJ-GW11-3A and BJ-GW18-17A/B are lower than the elevation of the WRTSF (1364.5 masl) which suggests that the WRTSF is currently recharging groundwater at its outlet.

Several wells where groundwater levels have declined due to mining have recently stabilized or partially recovered in the last three years (BJ-GW11-1A/B, BJ-GW11-3A, BJ-GW11-6B, BJ-GW12-8A/B, BJ-GW12-9B) (Appendix C). This has been attributed to higher precipitation from 2019 to 2021 than in the preceding three years (Table 2-1). Conversely, a few wells experienced notable drops in peak water levels in 2021 including BJ-GW12-11B, BJ-GW18-19B and BJ-GW18-21B, presumably due to expansion and deepening of the VOK workings. West of the Brucejack Fault, water levels at BJ-GW18-20A/B do not appear to be responding to mining which suggests that that the fault is limiting westward depressurization of the groundwater system.

Vertical hydraulic gradients are strongly downward (up to 80%) at most well locations; these downward gradients have either developed or strengthened on account of dewatering of the underground. Several wells demonstrated consistent or seasonally upward gradients, including BJ-GW14-14A/B and BJ-GW12-8A/B, located west of the Brucejack Fault.

Table 2-6:
Summary of new and historic monitoring well installations at the Brucejack Mine.

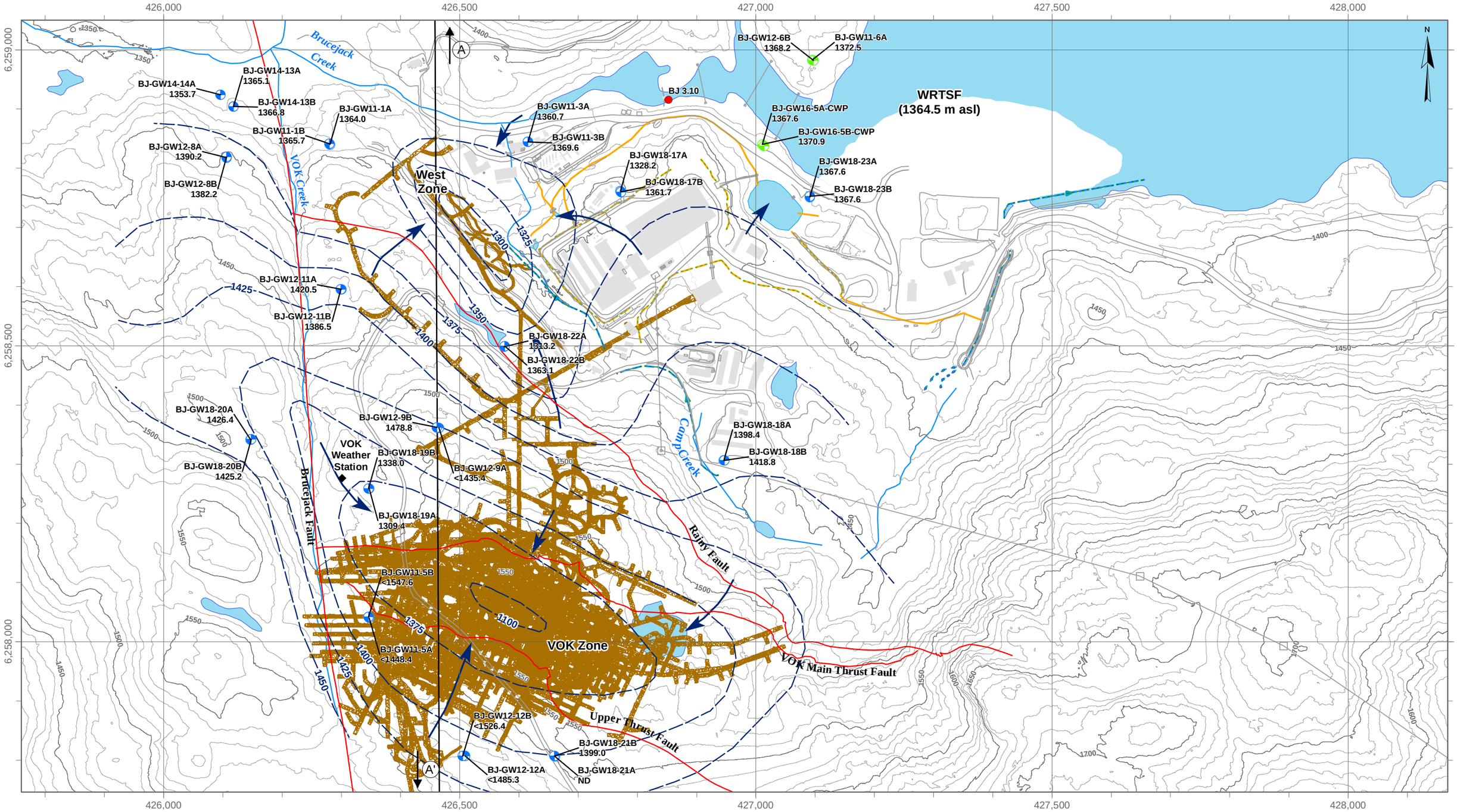
Monitoring Well ID	Reference	Install Date	Easting[1] (m)	Northing[1] (m)	Ground Surface[1] (masl)	Slotted Interval (m bgs)		Slotted Interval (masl)		Baseline Calibration Target[2]	WL Currently Monitored	Notes
						From	To	From	To			
BJ-GW11-1A	BGC, 2014b	Oct-11	426,281	6,258,840	1385.72	78.6	84.8	1307.1	1300.9	Y	Y	
BJ-GW11-1B	BGC, 2014b	Oct-11	426,280	6,258,841	1385.72	35.3	38.4	1350.4	1347.3	Y	Y	
BJ-GW11-2A*	BGC, 2014b	Oct-11	426,885	6,258,812	1423.17	70.7	76.8	1352.5	1346.4	Y		Decommissioned 2016
BJ-GW11-3A	BGC, 2014b	Oct-11	426,615	6,258,844	1367.63	82.3	88.3	1285.3	1279.3	Y	Y	
BJ-GW11-3B	BGC, 2014b	Oct-11	426,615	6,258,844	1367.53	5.8	8.8	1361.7	1358.7	Y	Y	
BJ-GW11-4A*	BGC, 2014b	Oct-11	427,031	6,258,750	1390.46	21.3	30.5	1369.2	1360.0	Y		Decommissioned 2015
BJ-GW12-4B*	BGC, 2014b	Jun-12	427,031	6,258,752	1390.43	94.9	97.9	1295.5	1292.5	Y		Decommissioned 2015
BJ-GW11-5A	BGC, 2014b	Sep-11	426,347	6,258,040	1526.14	68.6	77.7	1457.5	1448.4	Y	Y	Dry as of 2019
BJ-GW11-5B	BGC, 2014b	Sep-11	426,346	6,258,042	1526.16	41	50.2	1485.2	1476.0	Y	Y	Dry as of 2017
BJ-GW11-6A	BGC, 2014b	Oct-11	427,095	6,258,983	1379.81	18.9	28.1	1360.9	1351.7	Y	Y	
BJ-GW12-6B	BGC, 2014b	Jun-12	427,097	6,258,982	1379.56	100.3	103.3	1279.3	1276.3	Y	Y	
BJ-GW12-8A	BGC, 2014b	Jun-12	426,106	6,258,818	1403.38	86.2	92.3	1317.2	1311.1	Y	Y	
BJ-GW12-8B	BGC, 2014b	Jun-12	426,106	6,258,819	1403.30	44.8	50.9	1358.5	1352.4	Y	Y	
BJ-GW12-9A	BGC, 2014b	Aug-12	426,465	6,258,361	1514.40	72.9	79	1441.5	1435.4	Y	Y	Dry as of 2019 (water level in screen)
BJ-GW12-9B	BGC, 2014b	Aug-12	426,461	6,258,362	1514.56	40.6	46.7	1474.0	1467.9	Y	Y	
BJ-GW12-10A*	BGC, 2014b	Jun-12	426,989	6,258,341	1445.59	53.2	59.3	1392.4	1386.3			Decommissioned 2015
BJ-GW12-10B*	BGC, 2014b	Jun-12	426,989	6,258,341	1445.64	38.1	41.1	1407.5	1404.5			Decommissioned 2015
BJ-GW12-11A	BGC, 2014b	Jun-12	426,300	6,258,595	1433.57	26.5	29.5	1407.1	1404.1		Y	
BJ-GW12-11B	BGC, 2014b	Jun-12	426,299	6,258,595	1432.96	50.7	53.8	1382.3	1379.2		Y	
BJ-GW12-12A	BGC, 2014b	Aug-12	426,509	6,257,807	1579.19	87.8	93.9	1491.4	1485.3	Y	Y	Dry as of 2017
BJ-GW12-12B	BGC, 2014b	Aug-12	426,505	6,257,807	1579.16	46.7	52.8	1532.5	1526.4		Y	Dry as of 2015
BJ-GW14-13A	BGC, 2014a	Sep-14	426,118	6,258,904	1362.49	41	99.2	1321.5	1263.3		Y	
BJ-GW14-13B	BGC, 2014a	Sep-14	426,118	6,258,904	1362.76	58.2	73.6	1304.6	1289.2		Y	
BJ-GW14-14A	BGC, 2014a	Sep-14	426,096	6,258,924	1351.10	18.2	30.7	1332.9	1320.4		Y	
BJ-GW14-14B	BGC, 2014a	Sep-14	426,099	6,258,925	1351.99	1.5	4.4	1,350.5	1,347.6		Y	
BJ-GW14-15A	BGC, 2014a	Sep-14	426,618	6,260,069	1451.85	55.4	99.9	1396.5	1352.0			N. shore of WRTSF
BJ-GW14-15B	BGC, 2014a	Sep-14	426,111	6,260,058	1455.25	33.5	79.4	1421.8	1375.9			N. shore of WRTSF
BJ-GW14-16A	BGC, 2014a	Sep-14	427,068	6,259,514	1368.00	5.5	8.6	1362.5	1359.4			N. shore of WRTSF
BJ-GW14-16B	BGC, 2014a	Sep-14	427,068	6,259,514	1368.00	3.5	9.5	1364.5	1358.5			N. shore of WRTSF
BJ-GW16-1A-CWP	BGC, 2017	Jul-16	427,062	6,258,770	1376.95	24.4	27.4	1352.6	1349.5			Decommissioned
BJ-GW16-1B-CWP	BGC, 2017	Jul-16	427,063	6,258,767	1376.99	13.9	15.4	1363.1	1361.6			Decommissioned
BJ-GW16-2A-CWP	BGC, 2017	Jul-16	427,084	6,258,713	1378.36	19.6	22.6	1358.8	1355.8			Decommissioned
BJ-GW16-2B-CWP	BGC, 2017	Jul-16	427,081	6,258,710	1378.55	16.2	17.7	1362.4	1360.9			Decommissioned
BJ-GW16-3A-CWP	BGC, 2017	Jul-16	427,027	6,258,704	1377.60	21.4	24.4	1356.2	1353.2			Decommissioned 2017
BJ-GW16-3B-CWP	BGC, 2017	Jul-16	427,027	6,258,707	1377.51	12.2	13.7	1365.3	1363.8			Decommissioned 2017
BJ-GW16-4A-CWP	BGC, 2017	Jul-16	426,996	6,258,789	1377.51	22.7	24.1	1354.9	1353.4			Decommissioned
BJ-GW16-4B-CWP	BGC, 2017	Jul-16	426,997	6,258,792	1377.42	12.7	14.2	1364.8	1363.3			Decommissioned
BJ-GW16-5A	BGC, 2017	Jul-16	427,011	6,258,840	1372.63	19.3	22.4	1353.3	1350.3		Y	
BJ-GW16-5B	BGC, 2017	Jul-16	427,014	6,258,838	1372.55	9.0	10.5	1363.6	1362.1		Y	
BJ-GW18-17A	BGC, 2019b	Jun-18	426,771	6,258,761	1403.87	144.7	147.7	1259.2	1256.2		Y	
BJ-GW18-17B	BGC, 2019b	Jun-18	426,772	6,258,760	1403.99	72.2	75.3	1331.8	1328.7		Y	
BJ-GW18-18A	BGC, 2019b	Jun-18	426,946	6,258,306	1445.11	98.0	101.0	1347.2	1344.1		Y	
BJ-GW18-18B	BGC, 2019b	Jun-18	426,947	6,258,306	1445.11	61.9	65.0	1383.2	1380.1		Y	
BJ-GW18-19A	BGC, 2019b	Jun-18	426,347	6,258,259	1495.68	193.5	196.6	1302.1	1299.1		Y	
BJ-GW18-19B	BGC, 2019b	Jun-18	426,346	6,258,259	1495.49	155.5	158.5	1340.0	1337.0		Y	
BJ-GW18-20A	BGC, 2019b	Jun-18	426,147	6,258,341	1493.59	161.0	167.1	1332.6	1326.5		Y	
BJ-GW18-20B	BGC, 2019b	Jun-18	426,148	6,258,342	1493.60	114.6	117.7	1379.0	1375.9		Y	
BJ-GW18-21A	BGC, 2019b	Jun-18	426,661	6,257,806	1550.33	195.3	204.5	1355.0	1345.9		Y	
BJ-GW18-21B	BGC, 2019b	Jun-18	426,660	6,257,807	1550.34	153.1	159.2	1397.2	1391.1		Y	
BJ-GW18-22A	BGC, 2019b	Jul-18	426,575	6,258,498	1444.64	372.6	378.7	1072.0	1065.9		Y	Destroyed March 2022. Application in process to replace with VWP in 2023.
BJ-GW18-22B	BGC, 2019b	Jul-18	426,576	6,258,499	1444.64	84.4	87.5	1360.2	1357.2		Y	
BJ-GW18-23A	BGC, 2019b	Jul-18	427,091	6,258,751	1370.84	25.9	29.0	1344.9	1341.9		Y	
BJ-GW18-23B	BGC, 2019b	Jul-18	427,091	6,258,752	1370.81	7.8	10.8	1363.1	1360.0		Y	

Notes:
*Naming convention changed after well decommissioned. Previous naming convention was MW-BGC##-BJ-#A/B.
1. Monitoring well coordinates determined by RTK GPS, horizontal datum UTM Zone 9N NAD 83, Project vertical datum.
2. Baseline calibration target for both original Permitting Model (BGC, 2015) and 2020 update model (Lorax, 2020b)

Table 2-7:
Drawdown in selected monitoring wells since 2012.

Well ID	Ground Surface	Screen Top	Screen Bottom	Jun-12 (Baseline WLE)	Drawdown[2] (m)								
	(masl)	(masl)	(m bgs)	(masl)	Jun-13	Jun-14	Jun-15	Jun-16	Jun-17	Jun-18	Jun-19	Jun-20	Jun-21[3]
BJ-GW11-1A	1385.7	78.6	84.8	1365.1	33.8	25.4	34.5	39.6	1.8	ND	1.8	1.7	1.4
BJ-GW11-1B	1385.7	35.3	38.4	1363.3	0.4	-0.2	-0.8	0.2	-0.3	4.6	0.0	2.5	-2.2
BJ-GW11-3A	1367.6	82.3	88.3	1368.4	8.4	8.7	11.1	15.3	13.1	12.3	8.9	7.4	7.7
BJ-GW11-3B	1367.5	5.8	8.8	1367.3	-2.4	-1.6	-1.6	-0.9	-0.7	-0.8	-2.0	-2.5	-2.3
BJ-GW11-5A	1526.1	68.6	77.7	1514.9	5.4	55.5	29.8	32.5	45.3	59.1*	>65.2*	ND	>65.2
BJ-GW11-5B	1526.2	41	50.2	1513.3	2.7	36.2	28.3	30.3	>35.3	>35.3	>35.3	ND	>35.3
BJ-GW11-6A	1379.8	18.9	28.1	1371.2	0.1	-1.3	-1.3	-1.2	-0.5	-0.2	-1.4	-1.4	-1.3
BJ-GW12-6B	1379.6	100.3	103.3	1368.5*	0.9	0.4	-0.2	0.5	0.4	1.4	0.7	0.3	0.3
BJ-GW12-8A	1403.4	86.2	92.3	1390.1*	0.3	-0.4	1.9	1.6	0.8	1.6	2.1	0.0	0.0
BJ-GW12-8B	1403.3	44.8	50.9	1386.3*	-0.4	-0.7	3.4	4.2	4.0	5.0	4.5	8.4	4.1
BJ-GW12-9B	1514.6	40.6	46.7	1486.2**	13.2	14.6	9.5	7.0	15.4	11.9	5.5	8.0***	7.6
BJ-GW12-11A	1433.6	26.5	29.5	1428.3*	10.6	9.1	7.5	7.5	8.2	8.5	9.4	8.0	7.7
BJ-GW12-11B	1433.0	50.7	53.8	1427.0*	14.1*	20.3	18.0	19.0	31.4	30.0	28.3	29.7	40.6
BJ-GW12-12A	1579.2	87.8	93.9	1528.3**	22.2	42.8	ND	36.1	>43	42.3	>43	ND	>43

Notes:
*Water level from July, ** Water level from August, ***Water level from May
1. WLE = water level elevation, ND = no data
2. Positive values indicate drawdown, water levels preceded by “>” indicate well is dry.
3. Drawdown computed from water levels recorded on June 1 for years 2013 to 2020 (except where noted) and from June 15 for 2021.



LEGEND

- Monitoring Well (currently monitored under PE-107835)
- Monitoring Well (currently monitored, not required by PE-107835)
- Hydrometric Station
- Weather Station
- Fault
- Hydraulic Head Contour (25m)
- Groundwater Flow Direction
- Contact Water Ditch
- Contact Water Lines
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Building Infrastructure
- 2021 Underground Workings (As-Built)
- Surface Contour (50m)
- Surface Contour (10m)

<###: Dry Well
ND: No Data

DATE SAVED:	Nov 29, 2022
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REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:6,000

0 100 200 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

TITLE:

4,950 tpd Groundwater Model Update

PROJECT: June 2021 Hydraulic Head Contours

PROJECT #: A624-2

FIGURE: 2-7

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022GW Report\Fig 2-7_Interpreted Hydraulic Head Contour Map_June2021_20221103.mxd

2.6 Underground Dewatering Rates

Between 1986 and 1991, the Granduc Newcana Joint Venture, with Newhawk as the operator, advanced approximately 5 km of exploratory underground development in the West Zone. In late 2011, under the ownership of Pretium, the historic underground development was dewatered to assess conditions of the workings and determine if the workings could be used as a launching point for a development drive to the Valley of the Kings. Dewatering was halted several months thereafter, then resumed in September 2012 and has been continuous since then.

The mine collects and maintains a database of water managed by the water treatment plant, from which underground dewatering rates are determined. Water pumped from the underground is conveyed from a series of sumps located in VOK and West Zone workings to a single aggregating sump where it is then pumped to the water treatment plant. A portion of the flow is recirculated back to the underground via the underground waterbox. The groundwater component of underground dewatering rates is thus computed by subtracting flows to the underground waterbox from the totalized flows directed to the treatment plant. Monthly average dewatering rates are shown in Figure 2-8 and tabulated in Appendix D.

Potential water losses that are not captured in the dewatering rates which may lead to an underestimation of flows include moisture transported with saturated ore and waste rock to the mill and WRTSF, respectively, and humidity losses via mine ventilation. The first two losses are not constrained but assumed to be negligible whereas ventilation losses have most recently been estimated to be on the order of ~130 m^3/d. During low flow months (March-April), ventilation losses could lead to an underestimation of underground inflow rates on the order of 20%.

The underground dewatering record presented in Figure 2-8 illustrates the seasonality in dewatering rates. Annual minima are generally experienced in March or April and typically range from 500 m^3/d to 750 m^3/d (5.8 L/s to 8.7 L/s). Expansion of the mine void has not increased seasonal minimum inflows to date. Peak monthly mine inflows generally occur in June or July but can also occur later in the summer. Until the end of 2019, peak monthly inflows ranged from 1,800 m^3/d to 2,230 m^3/d (20.8 L/s to 25.8 L/s). In the last two years, these maximum rates have climbed over 2,500 m^3/d. The maximum experienced in June 2021 is attributed to a large rain-on-snow event that occurred late May/early June, which is apparent in a plot comparing daily inflows to climate metrics for 2021 (Figure 2-9).

The daily underground dewatering record for 2021 (Figure 2-9) demonstrates flashiness that is typical of other years. The flashiness is attributed to several factors including precipitation, mining rate, mining elevation, ground conditions and other operational artefacts. Rapid upticks in dewatering rates in response to heavy rainfall events as

experienced in June 2021 have also been noted previously in annual monitoring reports, suggesting a component of fracture driven flow to the underground.

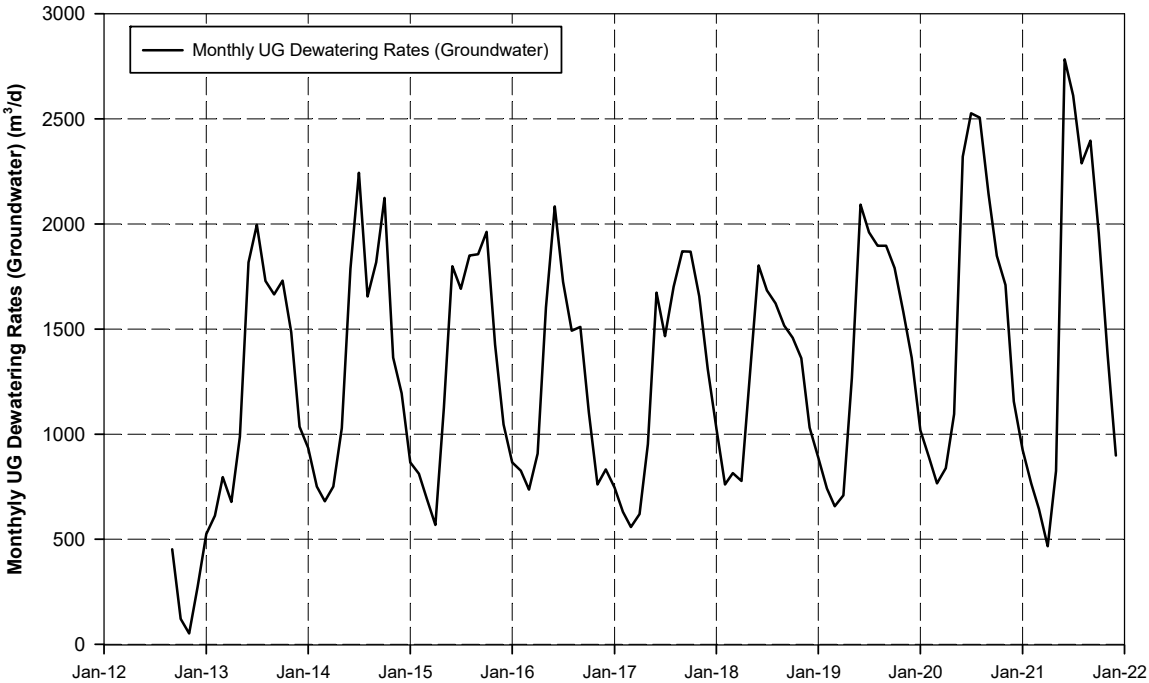


Figure 2-8: Monthly underground dewatering rates for 2012-2021.

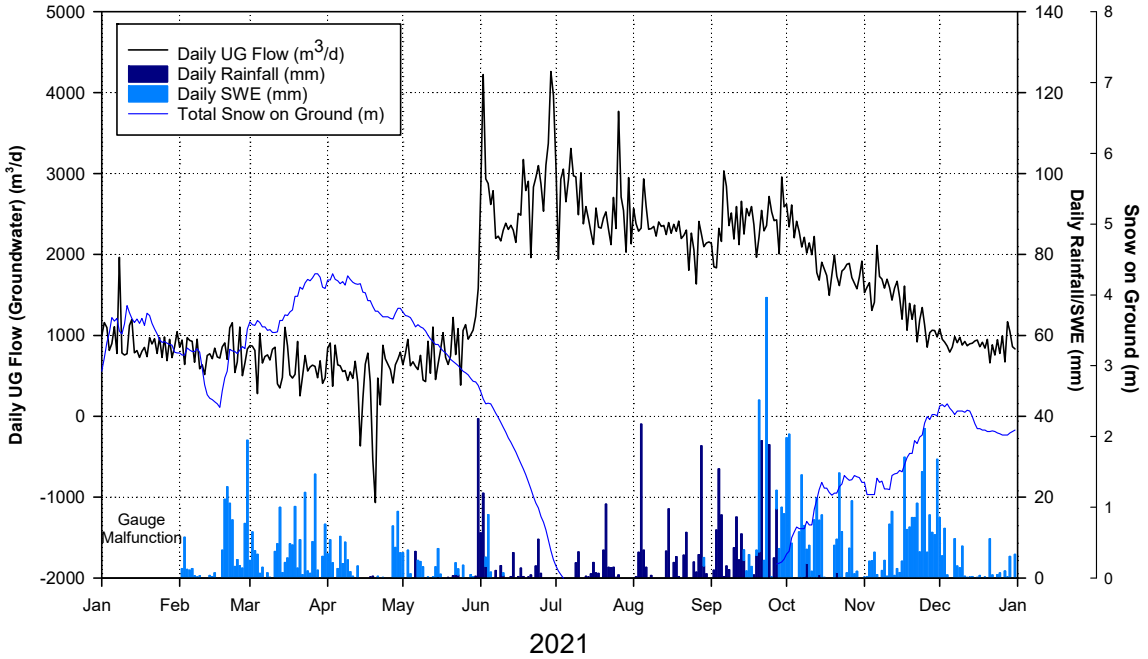


Figure 2-9: 2021 daily underground dewatering rates, daily rainfall and snow water equivalent (SWE).

2.7 Groundwater Quality

Groundwater quality is monitored at the Brucejack Mine per PE-107835 and summarized in annual monitoring reports (Lorax, 2022 in Pretium, 2022). Impacts from mining on current groundwater quality are limited. Dewatering of the underground caused slight shifts in major ion chemistry at historic VOK wells prior to the wells going dry (BJ-GW11-5A/B and BJ-GW12-12A). This manifested as higher proportions of sulphate and/or calcium at these wells.

Elsewhere, selected wells demonstrate impacts from surface operations. BJ-GW11-3A/B show seasonally variable chloride which has been attributed to winter salt application near the wash bay. The only other wells showing clear influence of the mine are BJ-GW18-23A/B which intercept shallower groundwater flowpaths from the CWP.

Overall, groundwater quality data support conclusions from the water level data, *i.e.*, that the mine acts as a groundwater sink with groundwater flowpaths towards the mine.

2.8 Mine Infrastructure

Prior to construction of the Brucejack Mine in 2015, various operators explored the area beginning in 1980. Between 1986 and 1991, the Granduc Newcana Joint Venture, with Newhawk as operator, opened approximately 5,300 m of exploratory development in the West Zone. Drafted extents of the historic West Zone workings were provided by Pretium for incorporation into the groundwater model.

The 2015 to 2018 as-built mine information, which formed the basis of the 2020 groundwater model calibration (Lorax, 2020b), was provided on a monthly timestep. Examination of the plan revealed that individual stopes take on average 17 days to mine and remain open for approximately 10 days before they are backfilled over a few days. The 2019 to 2021 as-built mine plan, used in the validation of the groundwater model, was provided as an annual snapshot. Development extents at the end of 2018 (*i.e.*, the end of calibration period) and 2021 (*i.e.*, the end of validation period) are compared in Figure 2-10 and Table 2-8.

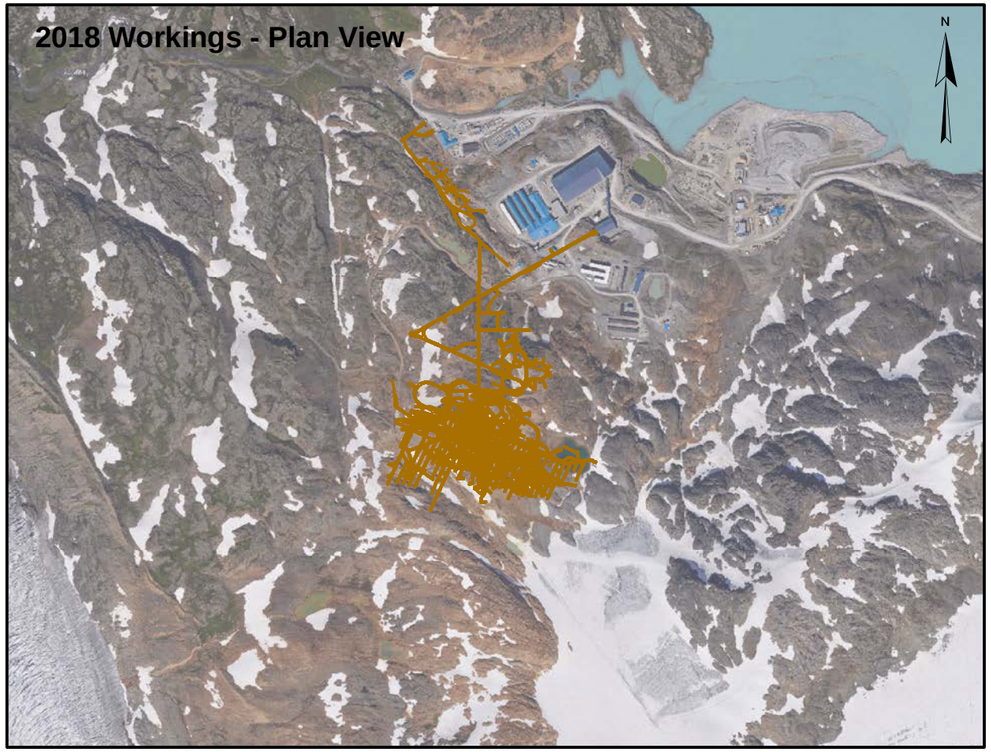
The future progression of the 4950 tpd mine plan was provided on a monthly timestep. The mine plan follows a 3800 tpd milling rate until 2024 and then increases throughput to 4950 tpd until the end of operations in December 2029. Development extents at end of the 4950 tpd mine life (2029) and 3800 tpd mine life (2032) are compared in Figure 2-11 and Table 2-8. Differences between the 3800 tpd and 4950 tpd end of mine extents include the following:

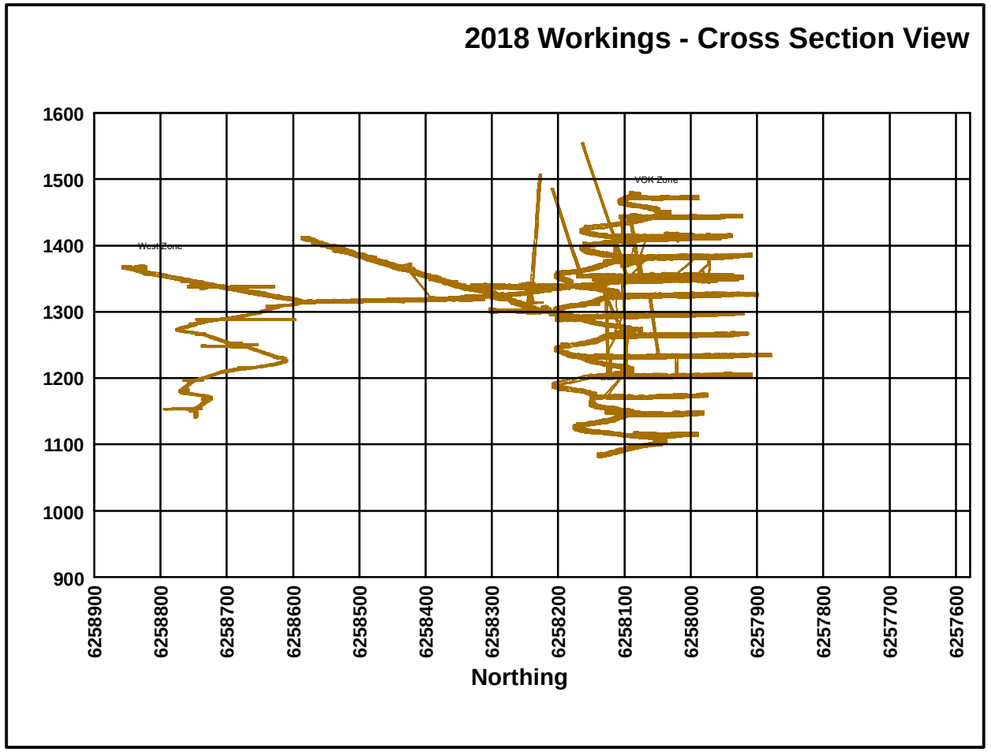
- The VOK extends 30 m deeper and ~175 m to the northeast on account of mining of extension areas of the Brucejack mineralization (circled area in Figure 2-11);
- Exploration developments are new and extend farther east, west and south than previously defined developments; and,
- A tunnel is advanced north of Brucejack Creek to establish a vent raise with surface elevation of 1392 masl.

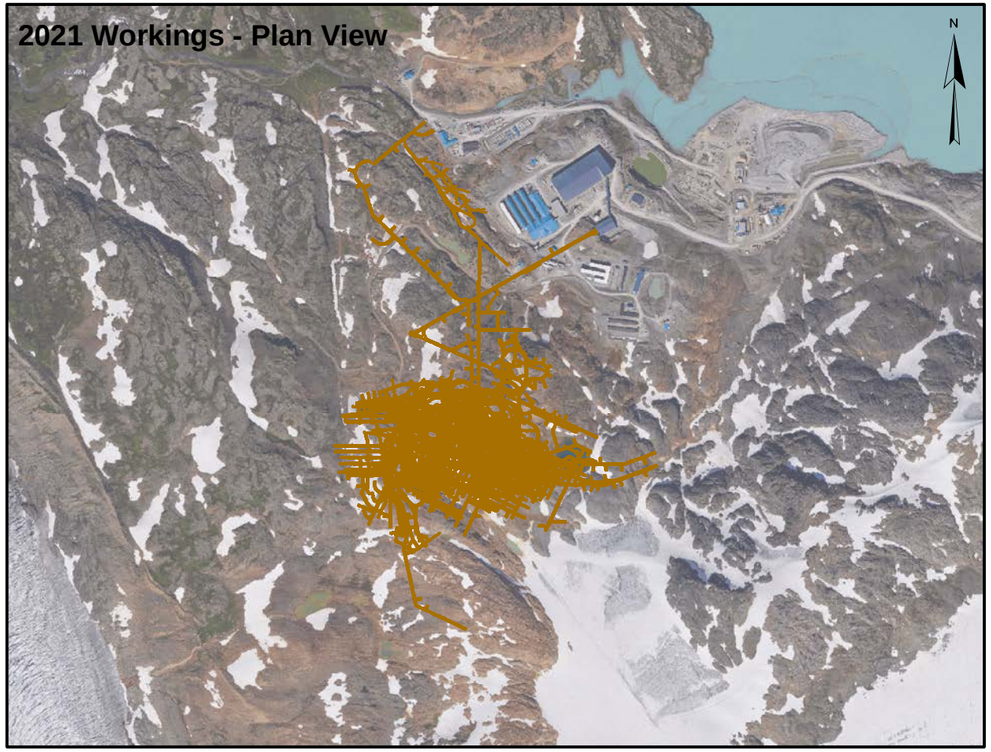
Table 2-8:
Extent of Brucejack mine underground workings.

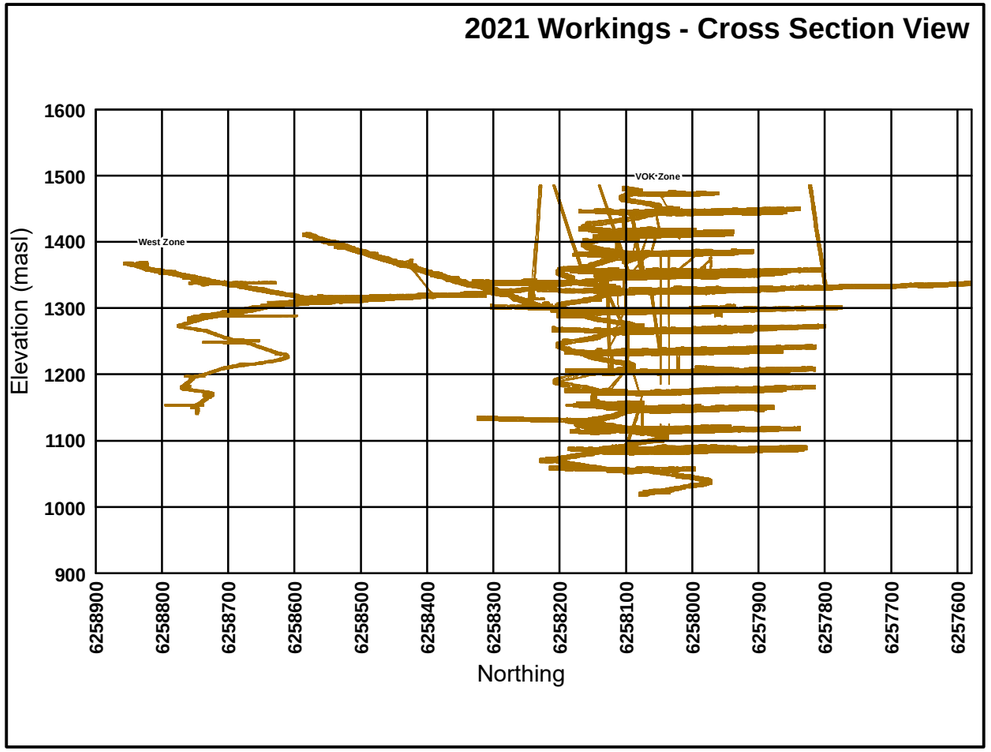
Mine Area	End of 2018	End of 2021	End of Mine[1] (3800 tpd)	End of Mine[2] (4950 tpd)
VOK				
Max Elevation (masl)	1480	1480	1535	1535
Min Elevation (masl)	1087	1015	990	960
West Zone				
Max Elevation (masl)	1369	1369	1385	1385
Min Elevation (masl)	1154	1154	1040	1040

Notes:
1. As simulated in 2020 groundwater model for a 3800 tpd mine plan (Lorax, 2020b).
2. End of current mining extents simulated in 4950 tpd groundwater model.









LEGEND

Workings

Coordinate System: *NAD 1983 UTM Zone 9N*
Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

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0 200 400 Meters

DATE SAVED:	Nov 29, 2022
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REVIEWED:	LF
VERSION:	1

CLIEN

NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Update

TITLE:

Extents of Mine Development – End of 2018 and 2021

PROJECT #: A624-4

FIGURE: 2-10

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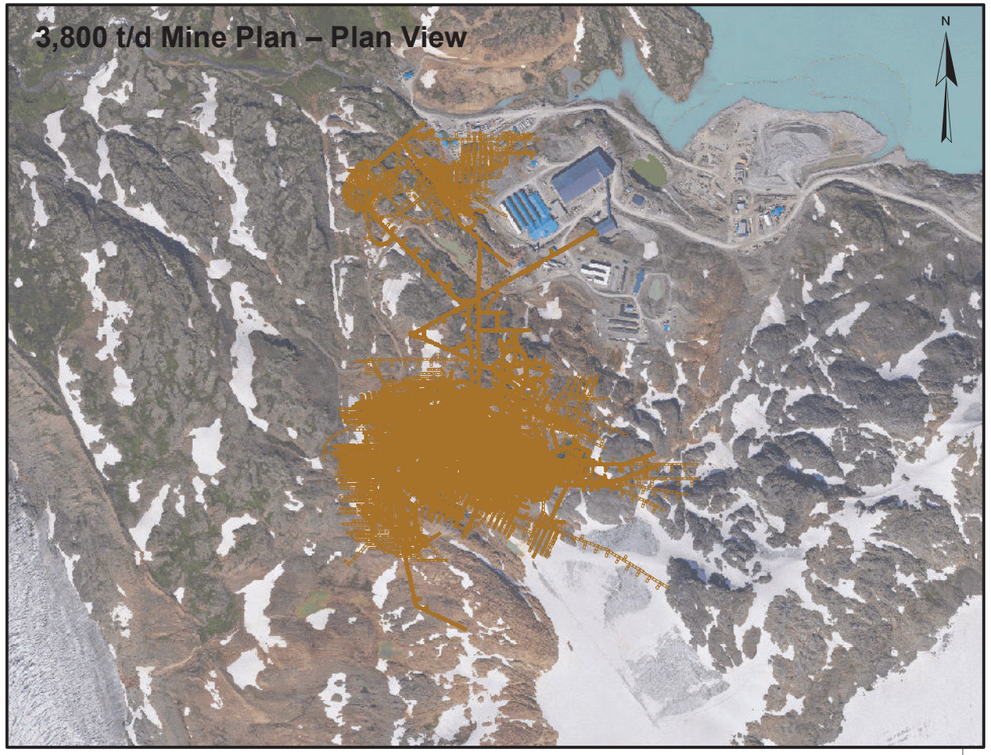

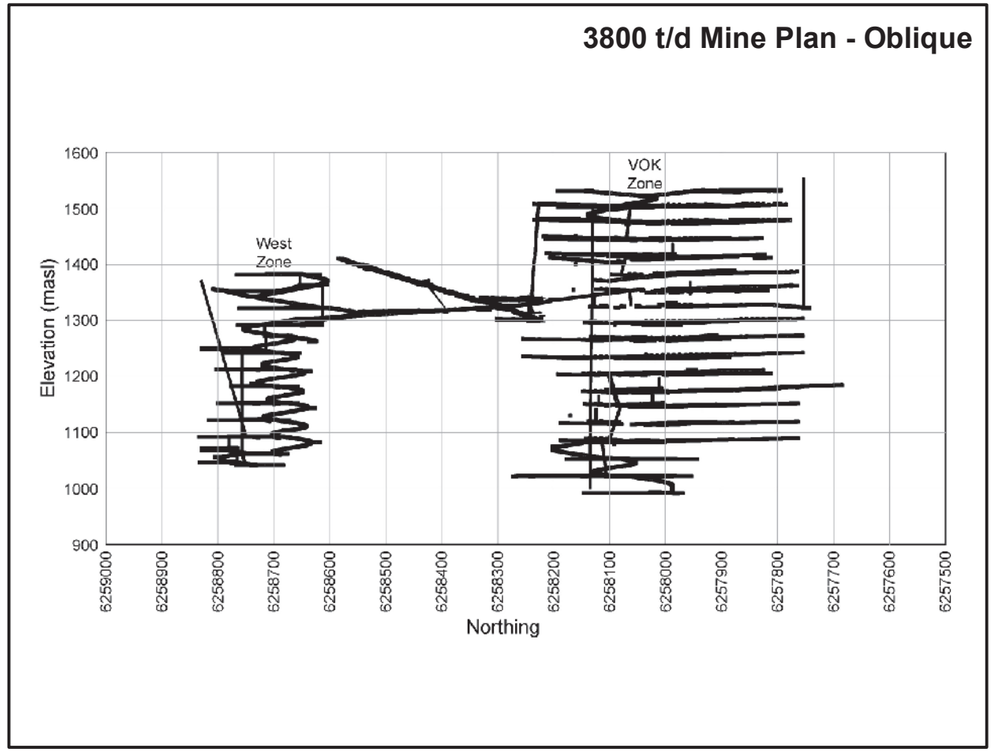

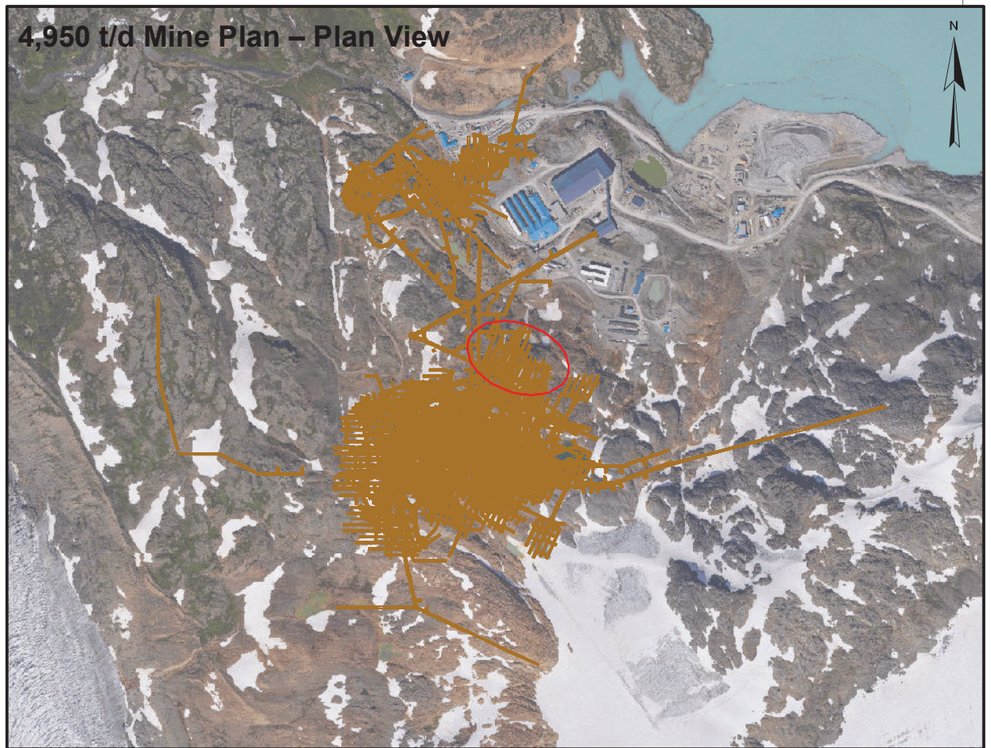

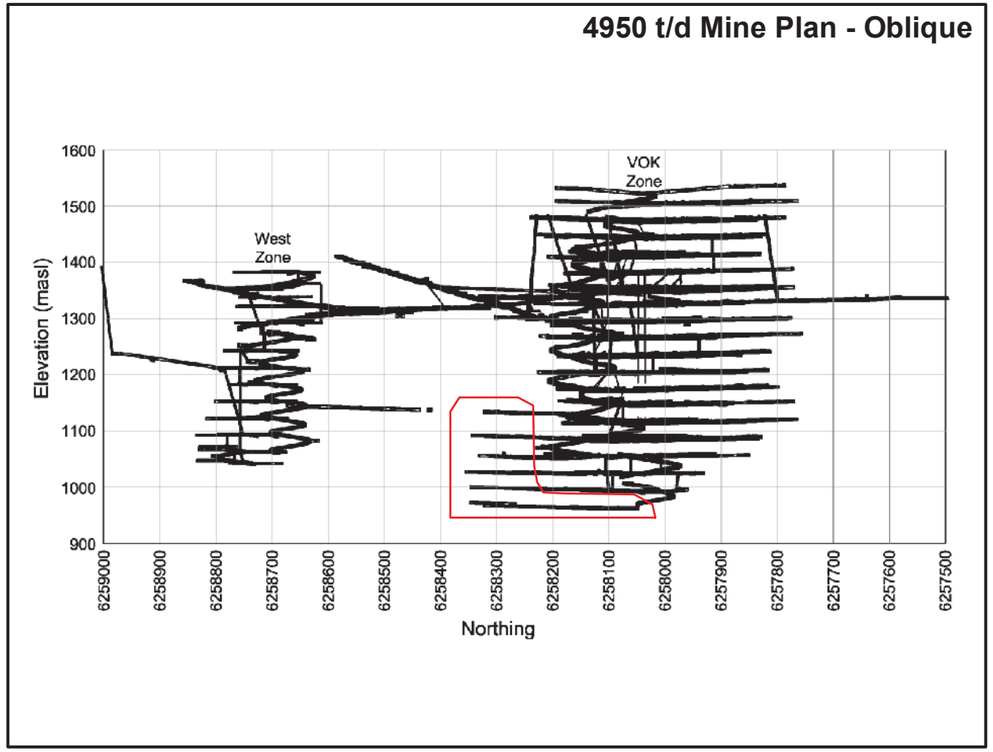

LEGEND

- Workings
- Extension Areas

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Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

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0 200 400 Meters

DATE SAVED:	Jun 01, 2023
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NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Report

TITLE:

Proposed End of Mine Development – 3,800 tpd and 4,950 tpd Mine Plans

PROJECT #:	*FIGURE:*
A624-4	2-11

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2.9 Conceptual Model For Groundwater Flow

2.9.1 Baseline

The Brucejack Mine is located in an area of pronounced topographic relief which experiences abundant precipitation. The topographic relief drives orographic gradients in precipitation, temperature and snowmelt. Nearby mountain peaks north of the WRSTF approach 2380 masl while ground falls precipitously to the west of the mine where Brucejack Creek meets the Sulphurets Glacier (elevation 1050 masl) (Figure 2-12). The WRTSF has an approximate elevation of 1364.5 masl.

Groundwater levels generally follow topography with steep horizontal hydraulic gradients. Groundwater seeps have been observed at site around the mine property. On a regional scale, groundwater flows westward following the trace of Brucejack Creek towards Sulphurets Glacier (Figure 2-12). A conceptual cross-section of groundwater flow diagram during the baseline period is shown Figure 2-14, with the orientation of the cross-section denoted in Figure 2-13.

Recharge to the groundwater system is via infiltration of precipitation, snowmelt and glacial meltwater. Seepage losses from lakes and creeks may also occur. Recharge via glacial meltwater is not well constrained but is inferred to operate all year round, while infiltration of rainfall and snowmelt is inferred to occur primarily between May and October. The seasonal pattern of recharge is evidenced in well hydrographs that fluctuate several to tens of meters throughout the year.

The Brucejack groundwater system resides largely within the bedrock aquifer. Unconsolidated materials (glacial till or colluvium) are thin and discontinuous throughout the site, particularly in the VOK deposit area (Figure 2-13). Overall, site data suggest bedrock hydraulic conductivity decreases with depth and does not appear to be correlated to lithology. The presence of larger scale faults such as the Brucejack Fault, Rainy Fault and Bruce Fault (Figure 2-13, Figure 2-14) are visualized as enhanced permeability structures that may act as preferential pathways for groundwater flow. Completion of the mine's potable water supply well in the Brucejack Fault supports this assertion (Figure 2-13).

Baseline mining features at the mine site (preceding Pretium ownership) included the flooded historic Newhawk exploration developments in the West Zone. The ramp extended about 260 m below ground surface, with the portal near Brucejack Creek, coincident with its current location, at an elevation of ~1365 masl. The historic portal was observed to passively drain towards Brucejack Creek.

Figure 2-12: Brucejack Mine seen from air, looking east. Green arrow denotes where Brucejack Creek meets the Sulphurets Glacier. Blue arrows denote general direction of groundwater flow under baseline conditions.

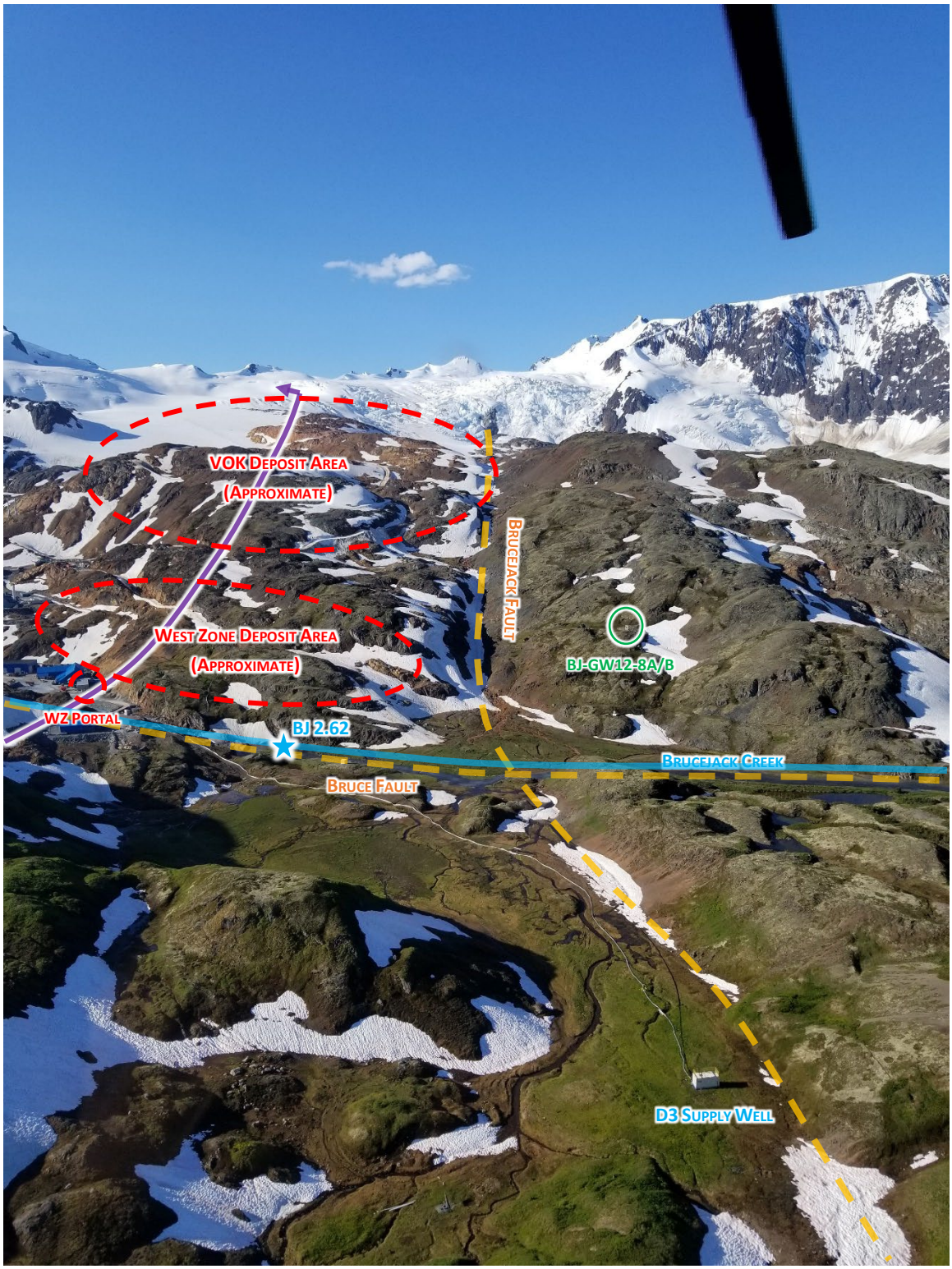


Figure 2-13: Approximate mine deposit areas, Bruce Fault, and Brucejack Fault as seen from air, looking south. Purple line denotes approximate section line location shown in Figure 2-14.

2.9.2 Operations

Pretium's dewatering of the flooded West Zone workings started in late 2011, and after a several months interruption, resumed in September 2012. In 2012, Pretium advanced a ramp from the West Zone towards the Valley of the Kings deposit, from which a 10,000 t bulk sample was extracted in 2013. Dewatering of the underground continued through 2015 to allow for underground fan drilling. Mine construction began in September 2015, with commercial production starting in July 2017. Under the 4950 tpd mine plan, mining will continue through to the end of 2029.

The underground mine is not a progressive geometry in that active mining areas alternate regularly. Stopes may be mined from a deeper level one month and then from a shallower level another month (or at the same time). Stopes themselves remain open for about a month prior to backfilling while developments (tunnels) remain open throughout mining. As a result, developments produce more water, especially those situated on the margins of mine.

A conceptual diagram of groundwater flow during operations is shown Figure 2-14, with the orientation of the cross-section denoted in Figure 2-13. Underground water is collected in a series of sumps and pumped to the water treatment plant. Some of this water is recirculated to the underground to service drills.

Since the inception of continuous mine dewatering in 2012, the dewatering record has followed a seasonal pattern whereby steeper hydraulic gradients result in higher groundwater inflows to the mine as a result of groundwater recharge from snowmelt and rainfall. Rapid upticks in underground dewatering rates occur after significant rainfall events, reflecting the quick flow through fractures (Figure 2-14). As an example, the Rainy Fault received its name for actively dripping into the workings which has been mitigated through grouting. Mine dewatering rates are expected to increase over life of mine as the mine envelope expands laterally and vertically.

Dewatering of the underground results in depressurization of the groundwater system from depth, creating or increasing downward gradients in nearby wells. A large drawdown cone has developed from current operations and will continue to develop through the end of mining in 2029 (Figure 2-14). The dewatering causes groundwater to flow towards the mine from areas that would otherwise discharge to the WRTSF or Brucejack Creek, including groundwater originating north of Brucejack Creek. This results in a modest reduction of baseflow in Brucejack Creek, although this would be offset to some degree by deposition of tailings and waste rock in the WRSTF. Brucejack Creek may itself recharge groundwater in its upper reaches on account of depressed water levels below the creek (Figure 2-14).

2.9.3 Closure Conditions

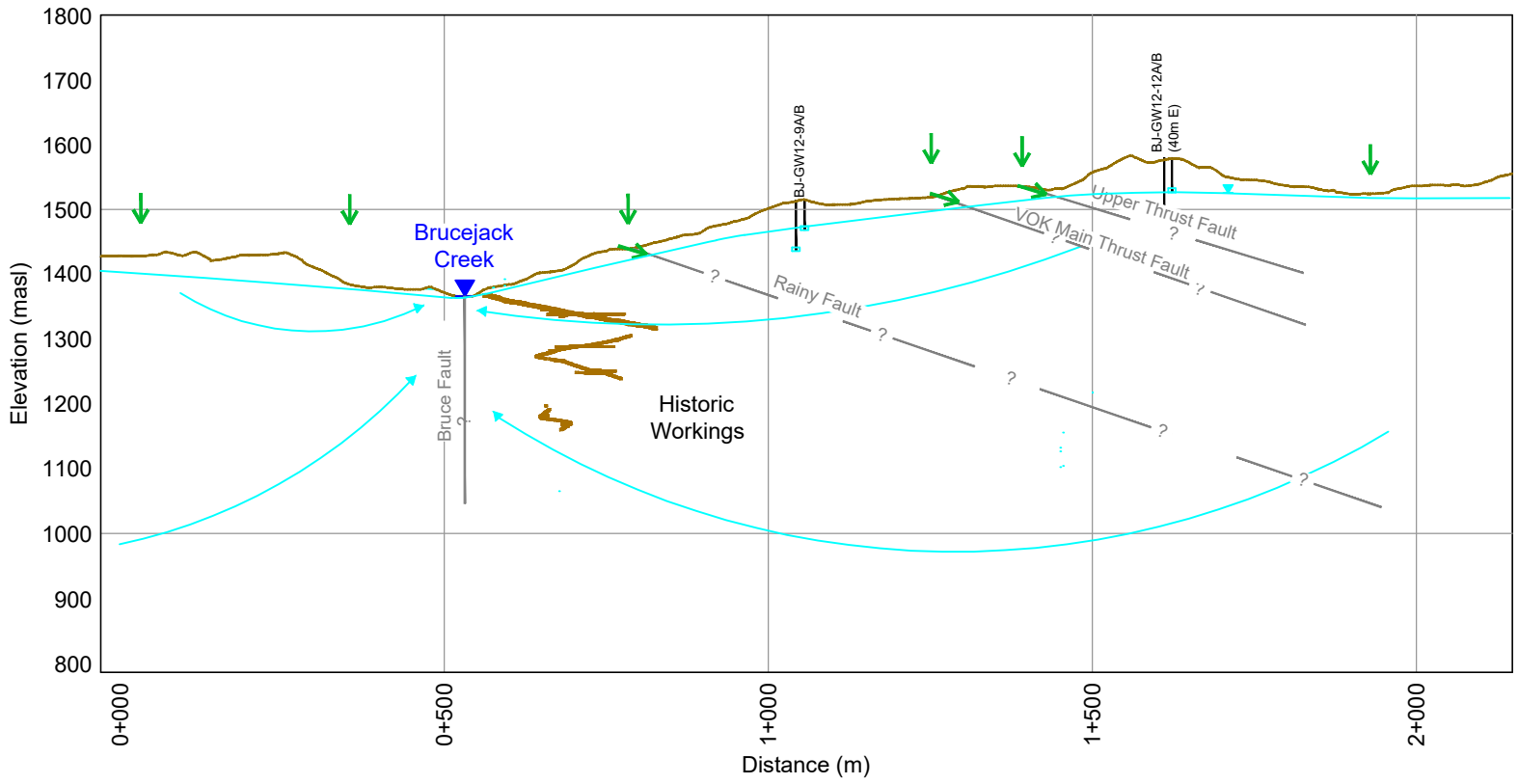
Following operations, the closure phase commences upon cessation of dewatering. The groundwater model simulates passive reflooding of the mine via two mechanisms: (i) groundwater inflows from surrounding areas and (ii) direct recharge over the mine area. A conceptual diagram of groundwater flow in the post-closure period is shown Figure 2-14.

At the beginning of closure, hydraulic gradients towards the mine are steepest, driving large groundwater inflows to the mine. As the water level in the mine recovers, the hydraulic gradients towards the mine decrease and ultimately reverse towards Brucejack Creek. This results in a recovery of baseflow in Brucejack Creek.

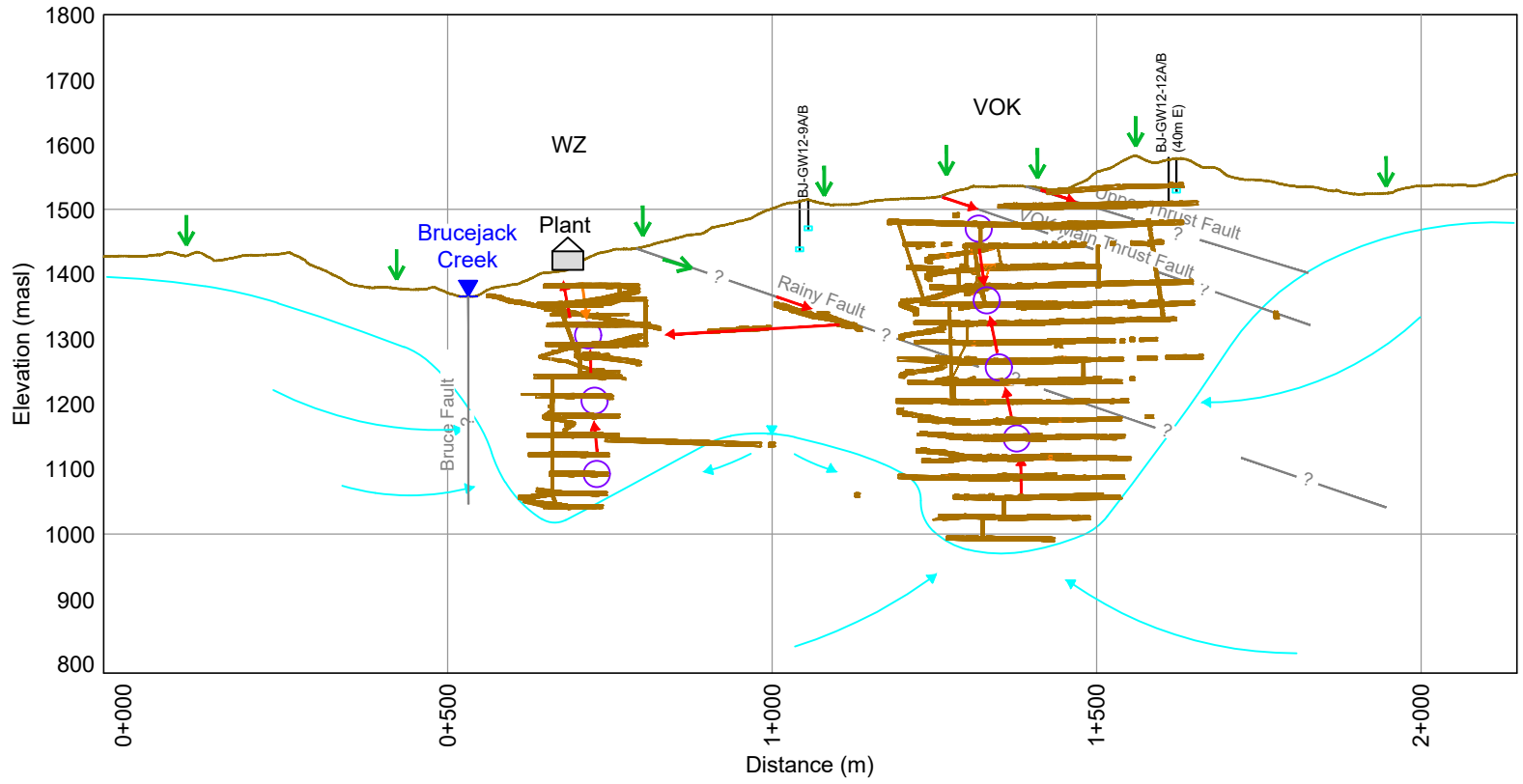
The water level in the mine will build up behind low permeability plugs installed at the portals and vent raise north of Brucejack Creek, ultimately reaching an equilibrium elevation where recharge to the mine will be matched by seepage out of the mine. The post-closure water table will be depressed compared to baseline conditions on account of the high connectivity of the underground developments (Figure 2-14). The open network of underground developments is envisioned as a large-scale sump. Negligible head loss is expected to occur through the developments as no backfilling developments is planned.

Contact water from the flooded mine is assumed to preferentially travel within the open developments towards the downgradient edge of the mine (Figure 2-14). From there, it is expected to travel preferentially in shallower, more permeable strata, towards Brucejack Creek. Surface seepage issuing from the portals may manifest as bypass around the plugs through the rock mass. Provided plugs are situated in competent ground, the bypass seepage is anticipated to be small.

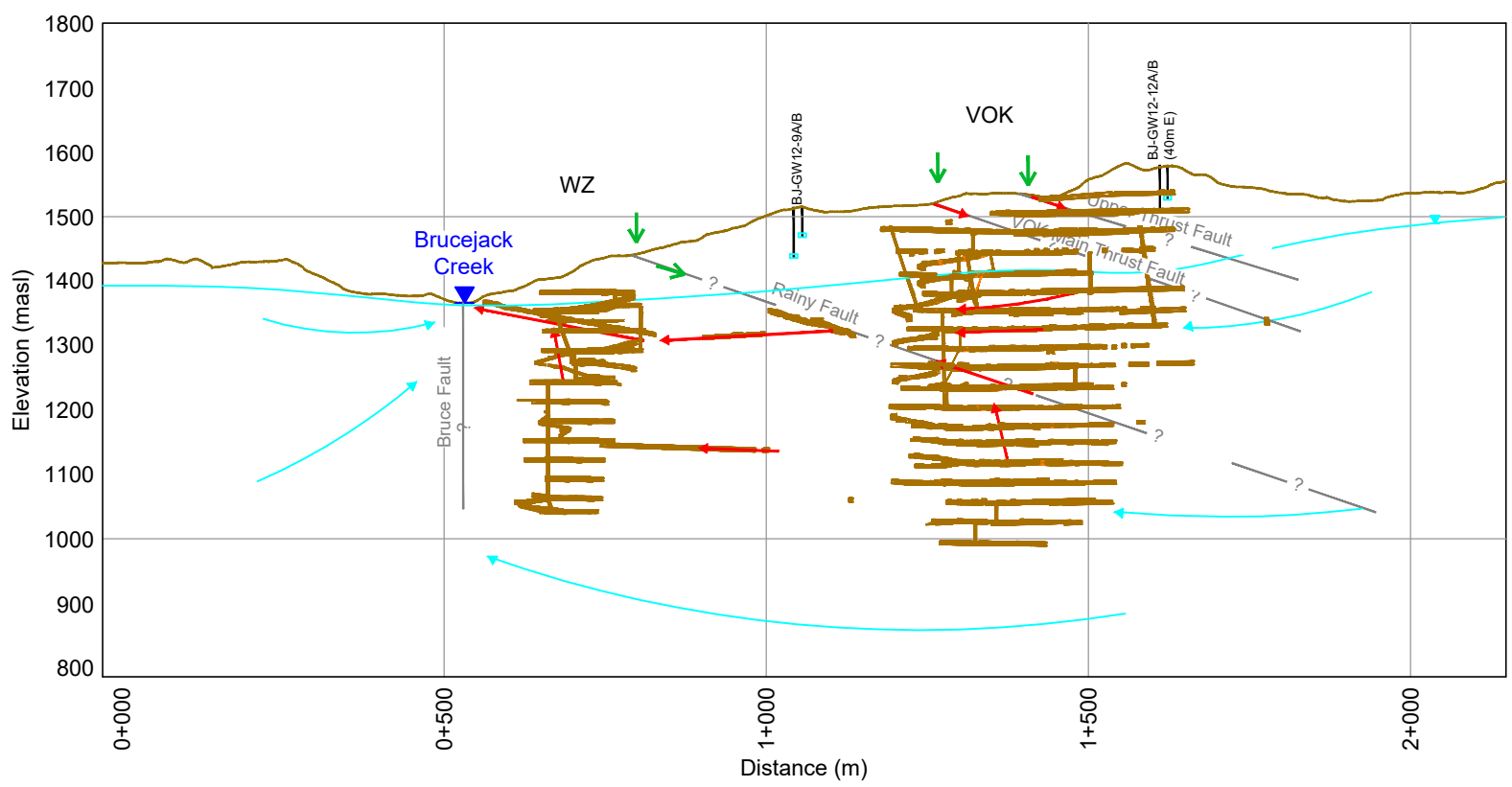
Baseline



Operations



Closure



LEGEND

- Pre-mining Topography
- Water Table
- Groundwater Flow Path
- Contact Groundwater Flow Path
- Recirculation Water
- Recharge
- Fault
- Underground Sump
- Mine Infrastructure
- Workings

DATE SAVED:	Feb 06, 2023
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REVIEWED:	LF
VERSION:	1

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT: **4950 tpd Groundwater Model Report**

TITLE: Conceptual Model of Groundwater Flow

PROJECT #: A624-4

FIGURE: 2-14

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3. Baseline Model

3.1 Overview

An updated simulation of baseline conditions has not been undertaken since the 2020 update (Lorax, 2020b) since bedrock hydraulic parameters and recharge rates have not been recalibrated in the 4950 tpd model. The baseline conceptual model, methods and results from the 2020 model update are described below.

3.2 Model Setup

3.2.1 Software Code

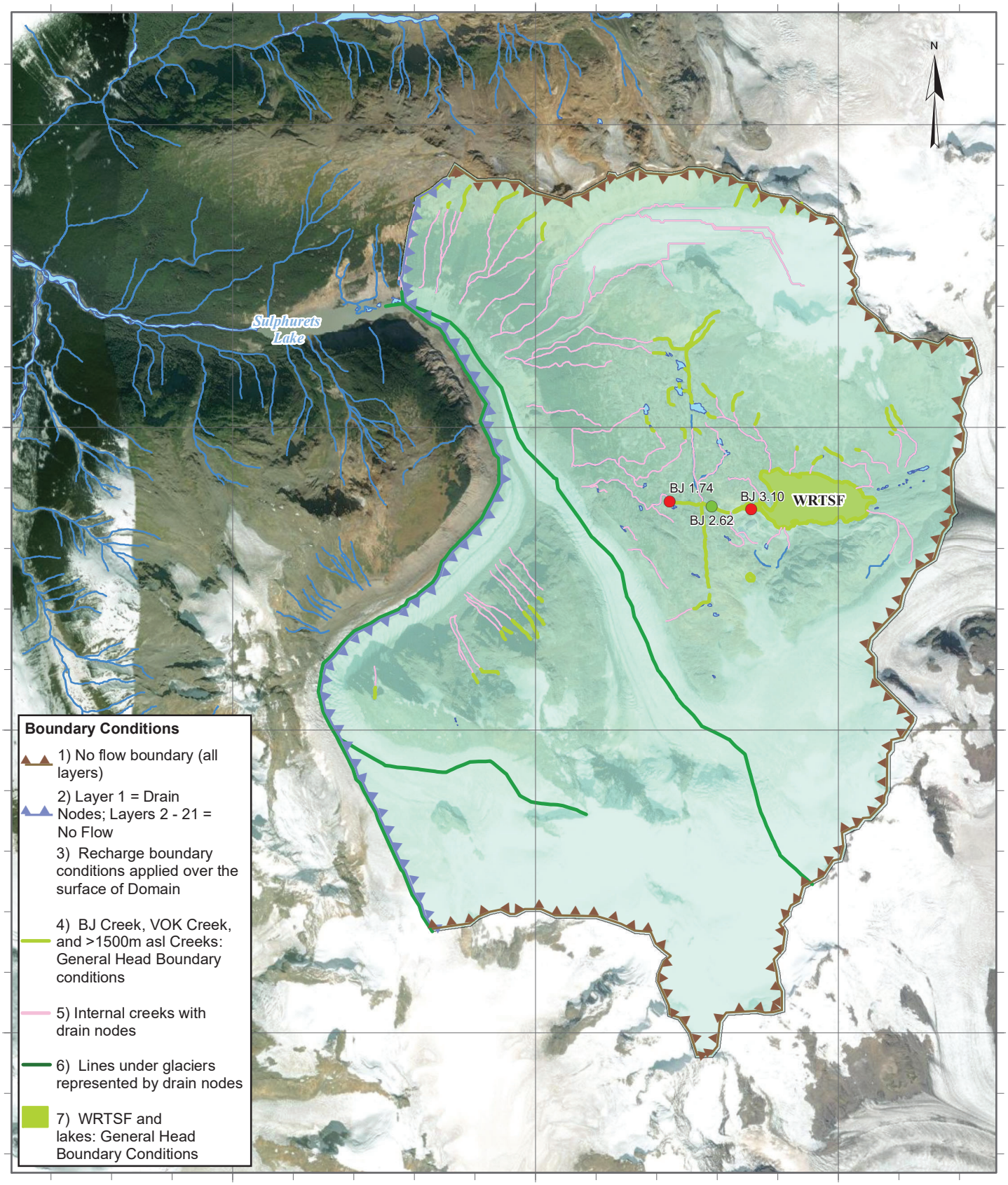
The update to the Brucejack groundwater model was undertaken in FEFLOW 7.2, a part of the MIKE software suite (DHI, 2022). The numerical model treats the hydrogeologic system as an equivalent porous medium. The water table elevation was arrived at while operating the model in 'phreatic' mode. The baseline model was run in steady-state mode reflecting equilibrium conditions.

3.2.2 Model Domain, Discretization

The groundwater model domain covers approximately 65 km^2 (Figure 3-1). The model boundary is constrained on the west margin by the centreline of the west arm of the Sulphurets Glacier. Downstream of the glaciers, Sulphurets Creek forms the model boundary.

The model domain is divided into 21 layers with each layer having uniform thickness over the domain except the bottom layer (Table 3-1). Model layer thickness ranges from 10 m to 30 m for depths including and beyond the extent of the planned workings. The model mesh is comprised of 114,358 elements per layer with node spacing ranging from approximately 15 m to 20 m in the mine area to 30 m to 40 m away from the mine area. In total, the model is comprised of 2,401,518 elements.

The top of Layer 1 corresponds to ground surface and is informed by a digital elevation model at a 25 m grid spacing. The ground surface was modified in areas covered by the Sulphurets Glacier to account for the thickness of ice. A 2016 radar survey of ice thickness along the Knipple Glacier indicated that the ice thickness is approximately 200 m at the portion of the Knipple Glacier closest to the Sulphurets Glacier. From this, a depth profile along the centerline of the Sulphurets glacier was created by assuming zero ice thickness at the bottom and top and 200 m thickness in the estimated accumulation zone. The centerline of the glacier was assumed to be the midpoint between the lateral moraines.



LEGEND

- Hydrometric Station
- SWQ Station
- Glacier Centreline
- Model Domain
- Waterbody
- Watercourse

DATE SAVED:	Dec 06, 2022
DRAWN BY:	GM
REVIEWED:	JX
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:70,000

0 500 1,000 Meters

CLIENT:

NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Report

TITLE:

Model Domain and Boundary Conditions

PROJECT #: A624-4

FIGURE: 3-1

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022GW Report\Fig 3-1_BoundaryConditions_20221206.mxd

Table 3-1:
Groundwater model vertical model discretization and hydraulic conductivity distribution.

Layer	Thickness (m)	Depth to Top of Layer (m)	Hydraulic Conductivity (m/s)			
			Lower-Lying Areas (<1450 masl)	Upland Area (>1450 masl)	Bruce Creek Fault	Rainy and Brucejack Faults
1	10	0	7.5E-07	5.1E-07	1.0E-05	1.0E-06
2	10	10	7.0E-07	4.8E-07	1.0E-05	1.0E-06
3	30	20	8.8E-08	6.0E-08	1.0E-05	1.0E-06
4	30	50	7.0E-08	5.0E-08	1.0E-05	1.0E-06
5	30	80	7.0E-08	5.0E-08	1.0E-05	1.0E-06
6	30	110	7.0E-08	5.0E-08	1.0E-05	1.0E-06
7	30	140	7.0E-08	5.0E-08	1.0E-05	1.0E-06
8	30	170	4.5E-08	3.0E-08	1.0E-05	1.0E-06
9	30	200	4.5E-08	3.0E-08	1.0E-05	1.0E-06
10	30	230	3.5E-08	2.5E-08	1.0E-05	1.0E-06
11	30	260	3.5E-08	2.5E-08	1.0E-05	1.0E-06
12	30	290	3.5E-08	2.5E-08	1.0E-05	1.0E-06
13	30	320	3.0E-08	2.0E-08	(-)	1.0E-06
14	30	350	3.0E-08	2.0E-08	(-)	1.0E-06
15	30	380	3.0E-08	2.0E-08	(-)	1.0E-06
16	30	410	1.5E-08	1.5E-08	(-)	1.0E-06
17	30	440	1.5E-08	1.5E-08	(-)	1.0E-06
18	30	470	1.5E-08	1.5E-08	(-)	1.0E-06
19	30	500	1.2E-08	1.2E-08	(-)	(-)
20	30	530	1.2E-08	1.2E-08	(-)	(-)
21	Varying	560 ~ 2000	1.7E-09	1.7E-09	(-)	(-)

Note:
(-) fault is not explicitly simulated at this depth

3.2.3 Boundary Conditions

As shown in Figure 3-1, the baseline groundwater model was assigned the following boundary conditions:

- A no-flow boundary was assigned to the base of the model domain and along north, east, and south margins of the domain coincinding with the height of land defining the watershed boundary.
- Along the northwestern perimeter segment of the model domain, an unnamed tributary of the Sulphurets Creek was conceptualized as a gaining creek. Drain nodes were assigned to this creek in Layer 1 with reference elevation of 1.5 m below

topographic elevations. At depth, the creek valley functions conceptually as a no-flow symmetry boundary.

- Similarly, drain nodes were assigned in Layer 1 along Sulphurets Creek and the valley centreline of the west arm of Sulphurets Glacier, with the reference elevation 1.5 m below the ground surface. No-flow boundary conditions were assigned to the deep layers.
- A general head boundary or fluid-transfer boundary condition was assigned to Layer 1 beneath the WRTSF, with a reference head equivalent to the average elevation of the lake (1364.5 masl). To mimic the blinding of the lake bottom with sediments, the outflow conductance was assumed to be one order of magnititude higher than the inflow conductance. An outflow conductance of 1E-07 s^{-1} was determined through model calibration.
- To enable interaction between the underground workings and overlying water features, a general head boundary condition was applied to Layer 1 elements containing Upper Camp Creek Lake, Brucejack Creek, VOK Creek, and Camp Creek. The reference elevation for these features was set to 1.5 m less than the digital elevation model ground surface. A general head outflow conductance of 1E-07 s^{-1} was applied to VOK Creek, Camp Creek and Upper Camp Creek Lake. The conductance of Brucejack Creek was set to 1E-06 s^{-1}.
- Other high elevation creeks (*i.e.*, above 1500 masl) in the model domain (including Unnamed Creek) were also simulated with a general head boundary condition with an outflow conductance of 1E-07 s^{-1} and reference elevations equivalent to 1.5 m less than ground surface.
- Lower elevation creeks (*i.e.*, below 1500 masl) in the model domain were simulated as drain nodes with reference heads equivalent to 1.5 m less than ground surface.
- To simulate the presence of numerous groundwater seeps within the area, the zone around the Brucejack Mine approximately below 1500 masl was assigned a seepage face condition once the groundwater level is above the ground surface.

3.2.4 Discrete Features

The historic, flooded underground workings were simulated in FEFLOW using discrete features with flow through the tunnels governed by the Darcy equation with a hydraulic conductivity of 1.0 m/s. Tunnel dimensions of the historic workings are 5 m by 5 m.

3.2.5 Recharge

Recharge was applied as an areal flux to the top layer of the model in all areas except the WRTSF where zero recharge was applied. Outside of glaciated areas, the recharge rate was varied according to topography, reflecting the orographic gradient (Section 2.2). Figure 3-2 shows the distribution of recharge applied in the baseline model; values are expressed as a percentage of mean annual precipitation in Table 3-2. The recharge rates presented in Table 3-2 are the calibrated values that, in combination with the hydraulic conductivity values reported in Table 3-1, produced the best calibration to both groundwater levels and baseflows in the baseline model.

Table 3-2:
Mean annual precipitation and modeled groundwater recharge rates by elevation.

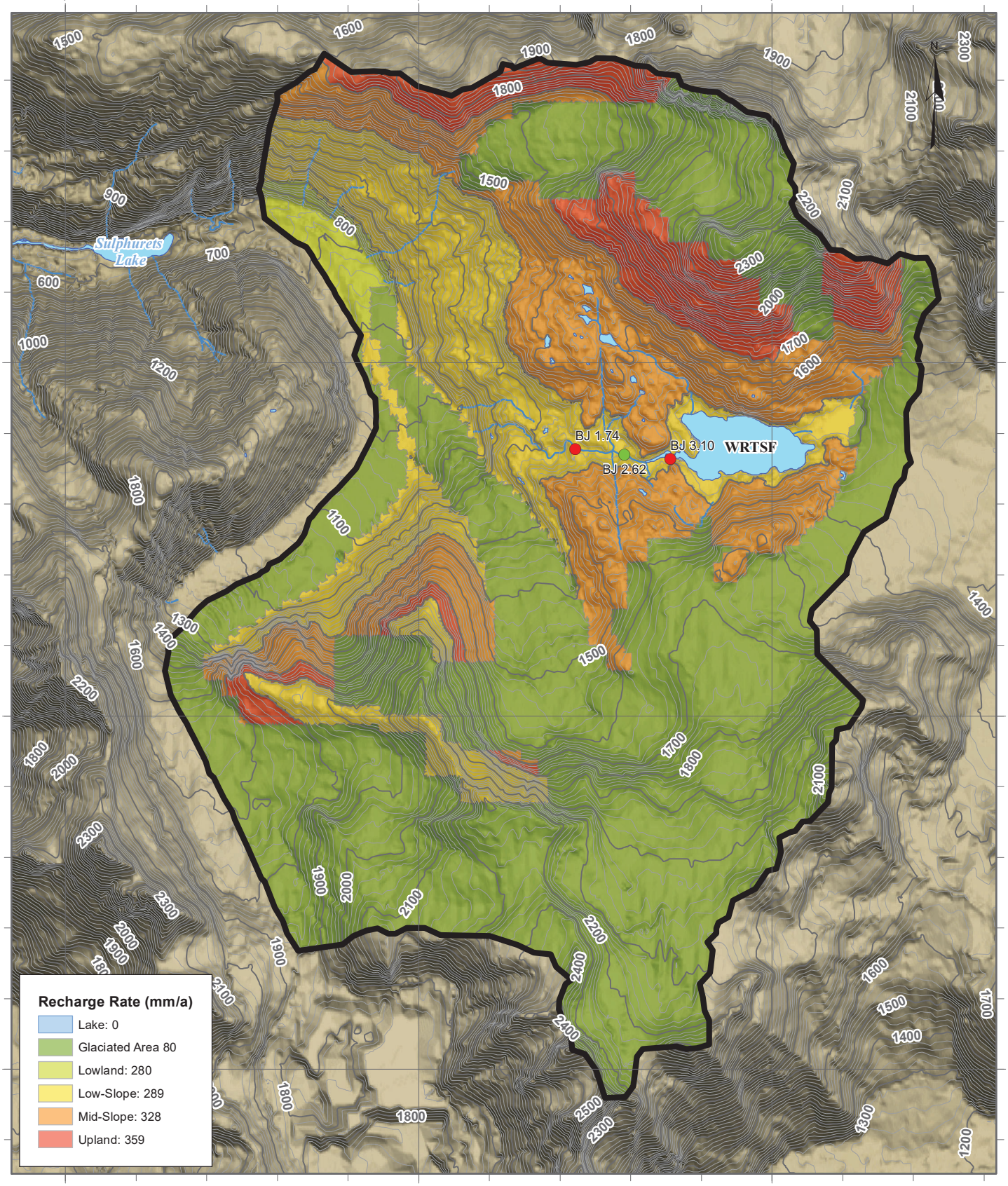
Elevation Band (masl)	MAP[1] (mm/yr)	Simulated	
		Calibrated Recharge (mm/yr)	% of MAP Applied as Recharge[2]
Glaciers (<900 to >1600)	(-)	80	(-)
<900	~1620	280	~17%
900 to 1400	1740	289	17%
1400 to 1700	1981	328	17%
>1700	2150	359	17%

Notes:
1. See discussion in Section 2.3.2.
2. Normalized to mean annual precipitation for the elevation band.

3.2.6 Hydrogeological Units and Parameters

The distribution of hydraulic conductivity values across Layer 1 is shown in Figure 3-3. Calibrated hydraulic conductivity values for bedrock are presented in Table 3-1 and compared to measured hydraulic conductivity values in Figure 3-4. Overburden is not explicitly simulated in the model; all bedrock and faults are simulated as isotropic.

Ultimately, it was found that the optimal calibration metrics could be achieved through a partitioning of the intact bedrock hydraulic conductivity into two zones based on elevation. Bedrock hydraulic conductivity in lower lying areas (<1450 masl) was simulated roughly 50% higher than bedrock hydraulic conductivity in upland areas (>1450 masl) to a depth of 380 m below ground surface. Hydraulic conductivity below 380 m is uniform across the model domain except in faulted areas. The model reflects a hydraulic conductivity trend that decreases with depth (Figure 3-3).



LEGEND

- Model Domain
- Hydrometric Station
- SWQ Station
- Waterbody
- Watercourse
- 100m Contour
- 20m Contour

DATE SAVED:	Dec 06, 2022
DRAWN BY:	GM
REVIEWED:	JX
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

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0 500 1,000 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT: **4,950 tpd Groundwater Model Report**

TITLE: Spatial Distribution of Modeled Recharge Rates

PROJECT #: A624-4

FIGURE: 3-2

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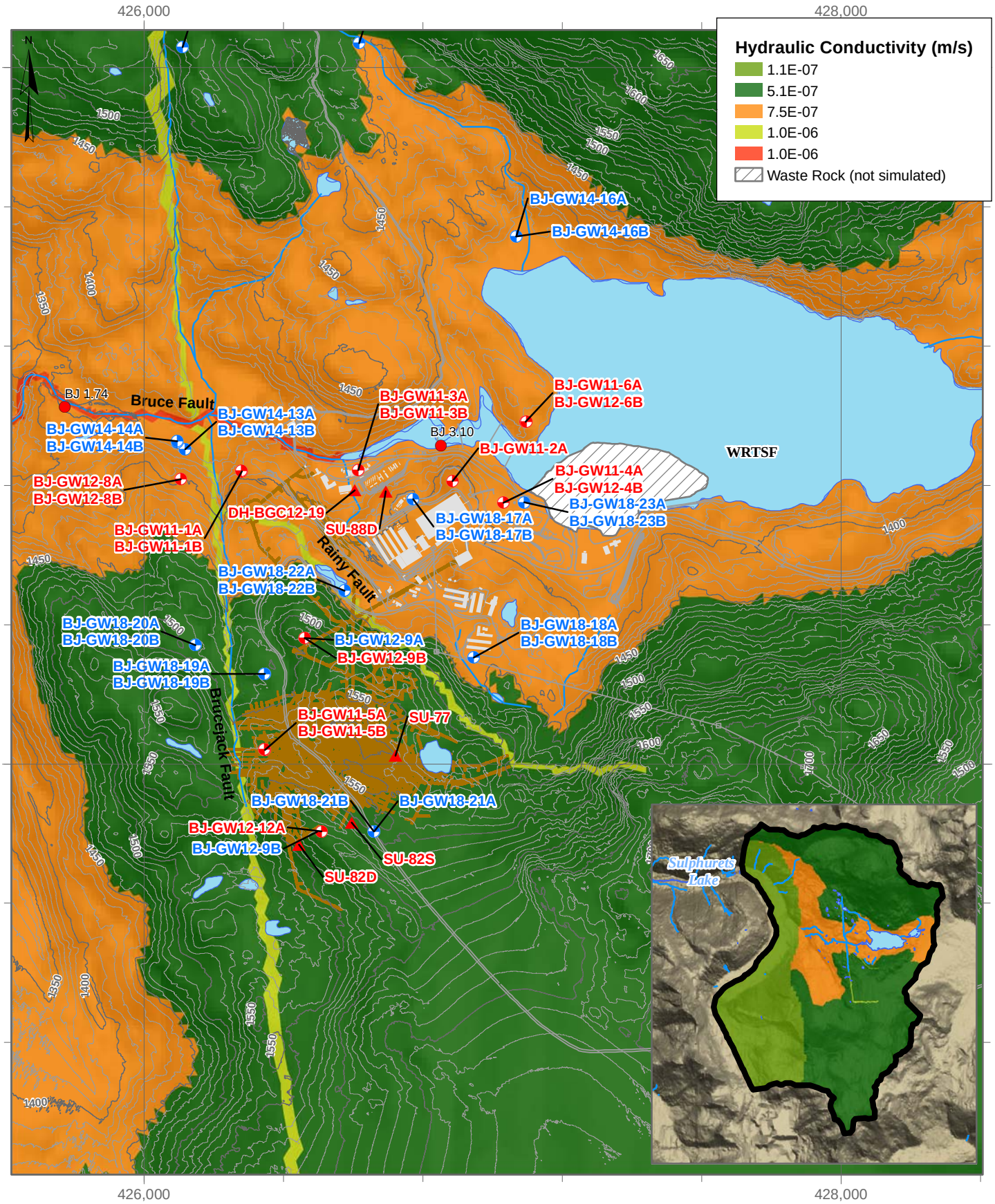


LEGEND

- Baseline Water Level Calibration Target (well)
- Baseline water Level Calibration Target (VWP)
- Other Monitoring Well
- Model Domain
- Hydrometric Station
- 2021 Underground Workings (As-Built)
- Building Infrastructure
- Surface Contour (50m)
- Surface Contour (10m)

DATE SAVED:	Nov 29, 2022
DRAWN BY:	GM
REVIEWED:	JX
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:15,000

0 150 300 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Update

TITLE: Layer 1 Hydraulic Conductivity

PROJECT #: A624-4

FIGURE: 3-3

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022GW Report\Fig 3-5_Hydraulic Conductivity.mxd

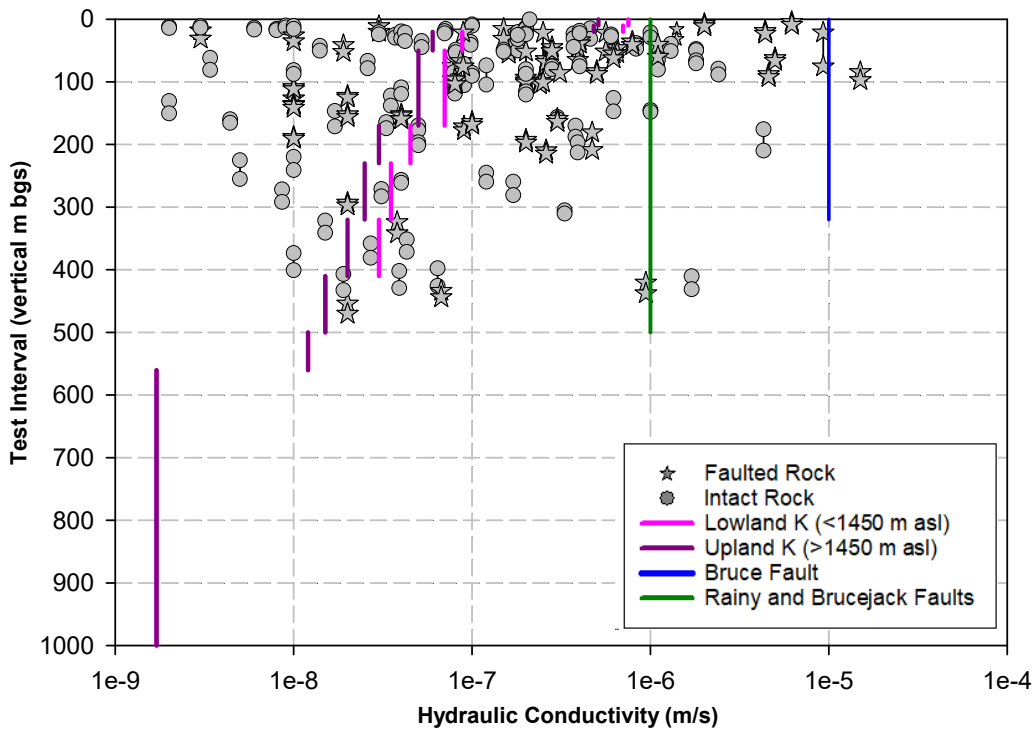


Figure 3-4: Measured and modeled hydraulic conductivity (K) values.

The model simulates a fault along Brucejack Creek (Bruce Fault) as a highly permeable feature (hydraulic conductivity of 1E-05 m/s) extending to 320 m depth. The Brucejack Fault and Rainy Fault are assigned a hydraulic conductivity of 1E-06 m/s to a depth of 500 m. A small fault connecting BJ-GW11-1A/B to the West Zone workings is assigned the same parameters as for the Brucejack Fault and Rainy Fault.

The simulation of Brucejack and Rainy faults as permeable features is supported by multiple lines of evidence. Rapid upticks in dewatering rates after heavy rainfall events suggests that fracture flow does occur (Section 2.6). Seepage has also been specifically observed along the Rainy Fault (Section 2.4.2). The mine's potable drinking water well is completed in the Brucejack Fault north of Brucejack Creek (Figure 2-1), implying higher hydraulic conductivity associated with this feature.

3.3 Baseline Calibration

3.3.1 Overview

Bedrock hydraulic conductivity and recharge were varied in an iterative process to arrive at an improved calibration to baseline groundwater levels and Brucejack Creek baseflow as compared to the 2015 groundwater model (BGC, 2015). In the 2020 model, these parameter combinations were brought forward into the transient operations simulation (simulating years 2011 to 2018) to determine goodness of fit to observed water levels and

dewatering rates. The process was repeated until a reasonable calibration for both baseline and post-disturbance targets was achieved. The calibrated recharge and hydraulic conductivity distributions are presented in Figure 3-2 and Figure 3-3, respectively.

The update of the 2020 model to represent the 4950 tpd mine plan has not resulted in changes to the hydraulic conductivity or recharge distribution determined by the 2020 model. The baseline calibration results presented in the following sections are for the 2020 model and remain valid. The baseline simulation provided an acceptable water balance error (0.01% or 4.8E-06 m^3/s) for the BJ 1.74 catchment area which fully encompasses the mine (Table 3-3).

Table 3-3:
Water balance for BJ 1.74 catchment (2020 model).

Sources	Inflow (m^3/s)	Outflow (m^3/s)	Net Flow (m^3/s)
Dirichlet BC	0	0.058	0.058
General-Head BC	3.08E-05	0.021	0.021
Recharge	0.076	0	-0.076
Storage	0	0	0
Cross Basin Boundary	0.017	0.014	-0.003
Total	0.093	0.093	0

3.3.2 Water Level Elevations

A summary of water level calibration statistics is provided in Table 3-4. The calibrated model yields a normalized root mean squared error (NRMSE) of 7.0% and absolute residual mean of 8.64 m. Both values are an improvement on the original EA and permitting groundwater model metrics (Lorax, 2020b). Water level residuals are biased positive, with the model overpredicting water levels at 14 locations and underpredicting water levels at 6 locations.

Simulated versus observed water levels for individual monitoring wells are tabulated in Table 3-5. Water level residuals (simulated minus observed) are plotted versus elevation in Figure 3-6 with spatial distribution shown in Figure 3-7. The highest residuals (>25 m) are measured at deeper vibrating wire piezometer (VWP) locations SU-77 and DH-BGC12-21 in the VOK. The model, however, reasonably estimates water levels (residuals less than 10 m) at higher elevation datapoints in the VOK (BJ-GW11-5A/B, BJ-GW12-12A, SU-82S/D). The overestimation of water levels at SU-77 and DH-BGC-21 is not considered problematic and could be considered conservative for dewatering predictions.

Table 3-4:
Water level calibration metrics for the 2020 groundwater model.

Calibration Metrics	2020 FEFLOW Model
Number of Targets	20
Range of Observed Water Levels (m)	174
Residual Mean (m)	5.58
Absolute Residual Mean (m)	8.64
NRMSE (%)	7.0%
Correlation	y=1.0038x
Coefficient of Determination (R^2)	0.97

Note:
NRMSE – normalized root mean squared error

Table 3-5:
Simulated and observed baseline water levels and residuals for the 2020 groundwater model.

Instrument ID	Easting[1]	Northing[1]	Ground Surface[1] (masl)	Screen Midpoint Depth[2] (m bgs)	Screen Midpoint Elevation (masl)	Observed Water Level Elevation[3] (masl)	Simulated Water Levels	
							Water Level Elevation (masl)	Residual[4] (m)
BJ-GW11-1A	426,281	6,258,840	1385.7	81.7	1304.0	1365	1379.3	14.3
BJ-GW11-1B	426,280	6,258,841	1385.7	36.85	1348.9	1364	1377.7	13.7
BJ-GW11-2A	426,885	6,258,812	1423.2	73.75	1349.4	1368	1381.6	13.6
BJ-GW11-3A	426,615	6,258,844	1367.6	85.3	1282.3	1368	1370.6	2.6
BJ-GW11-3B	426,615	6,258,844	1367.5	7.3	1360.2	1367	1367.9	0.9
MW-BGC11-BJ-4A	427,031	6,258,750	1390.5	25.9	1364.6	1377	1380.7	3.7
MW-BGC12-BJ-4B	427,031	6,258,752	1390.4	96.4	1294.0	1377	1381.1	4.1
BJ-GW11-5A	426,347	6,258,040	1526.1	73.15	1453.0	1503	1499.1	-3.9
BJ-GW11-5B	426,346	6,258,042	1526.2	45.6	1480.6	1504	1502.4	-1.6
BJ-GW11-6A	427,095	6,258,983	1379.8	23.5	1356.3	1369	1369.4	0.4
BJ-GW12-6B	427,097	6,258,982	1379.6	101.8	1277.8	1366	1370.6	4.6
BJ-GW12-8A	426,106	6,258,818	1403.4	89.25	1314.1	1385	1377.0	-8.0
BJ-GW12-8B	426,106	6,258,819	1403.3	47.85	1355.5	1380	1378.5	-1.5
BJ-GW12-9B	426,461	6,258,362	1514.6	43.65	1470.9	1478	1465.4	-12.6
BJ-GW12-12A	426,509	6,257,807	1579.2	90.85	1488.3	1520	1523.0	3.0
DH-BGC12-19 (VWP)[1]	426,605	6,258,786	1375.0	n/a	1168.0	1357	1384.7	27.7
SU-77 (VWP)[1]	426,721	6,258,133	n/a	n/a	1262.2	1429	1461.3	32.3
SU-82S (VWP)[1]	426,596	6,257,832	n/a	n/a	1476.3	1528	1525.0	-3.0
SU-82D (VWP)[1]	426,446	6,257,768	n/a	n/a	1204.6	1494	1504.9	10.9
SU-88D (VWP)[1]	426,574	6,258,971	n/a	n/a	1182.1	1354	1364.4	10.4

Notes:
n/a – not available, Not Incl. – location is not contained within truncated model domain,
1. Easting, Northing for VWP location is for sensor, not ground surface. VWP = vibrating wire piezometer.
2. Screen midpoint or VWP sensor elevation/depth.
3. Calculated or estimated annual average water level (BGC, 2015).
4. Simulated minus observed.

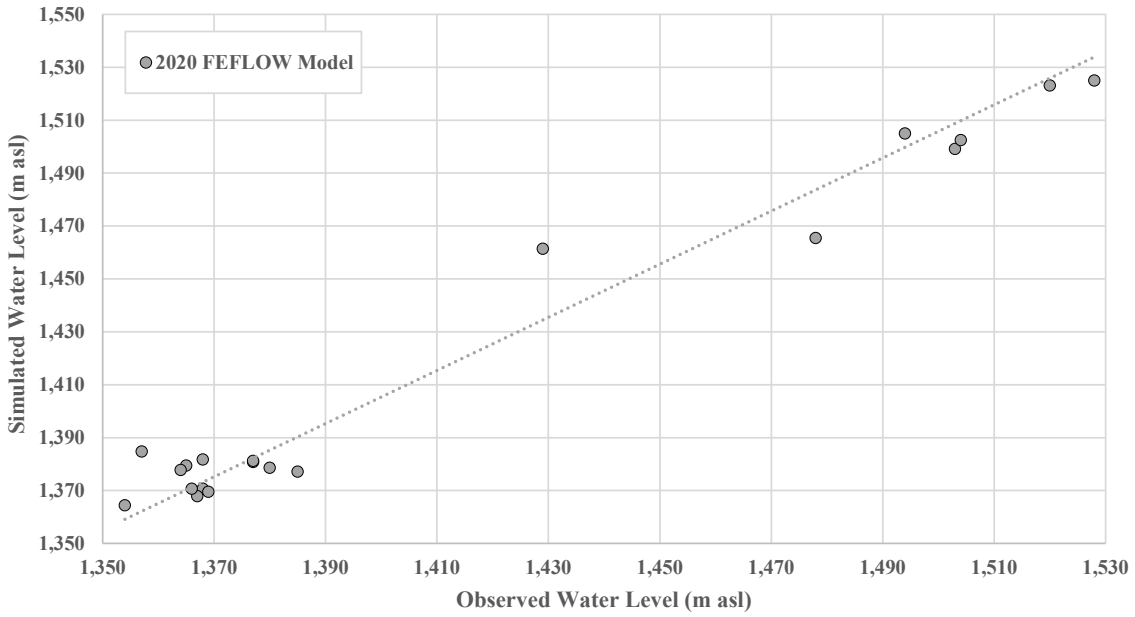


Figure 3-5: Simulated versus observed baseline water levels in the 2020 groundwater model.

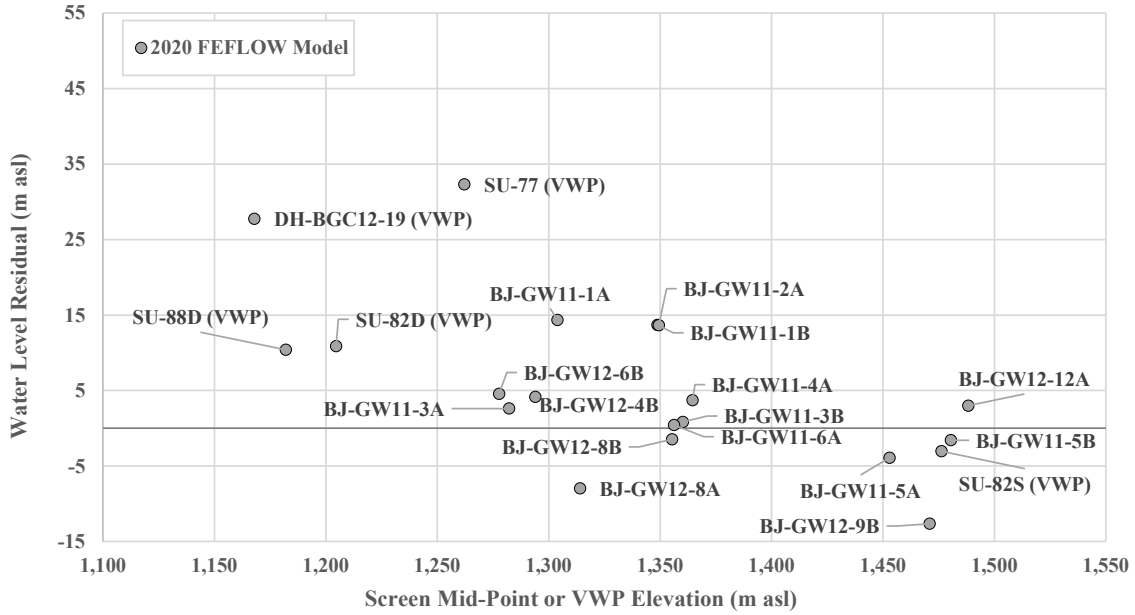
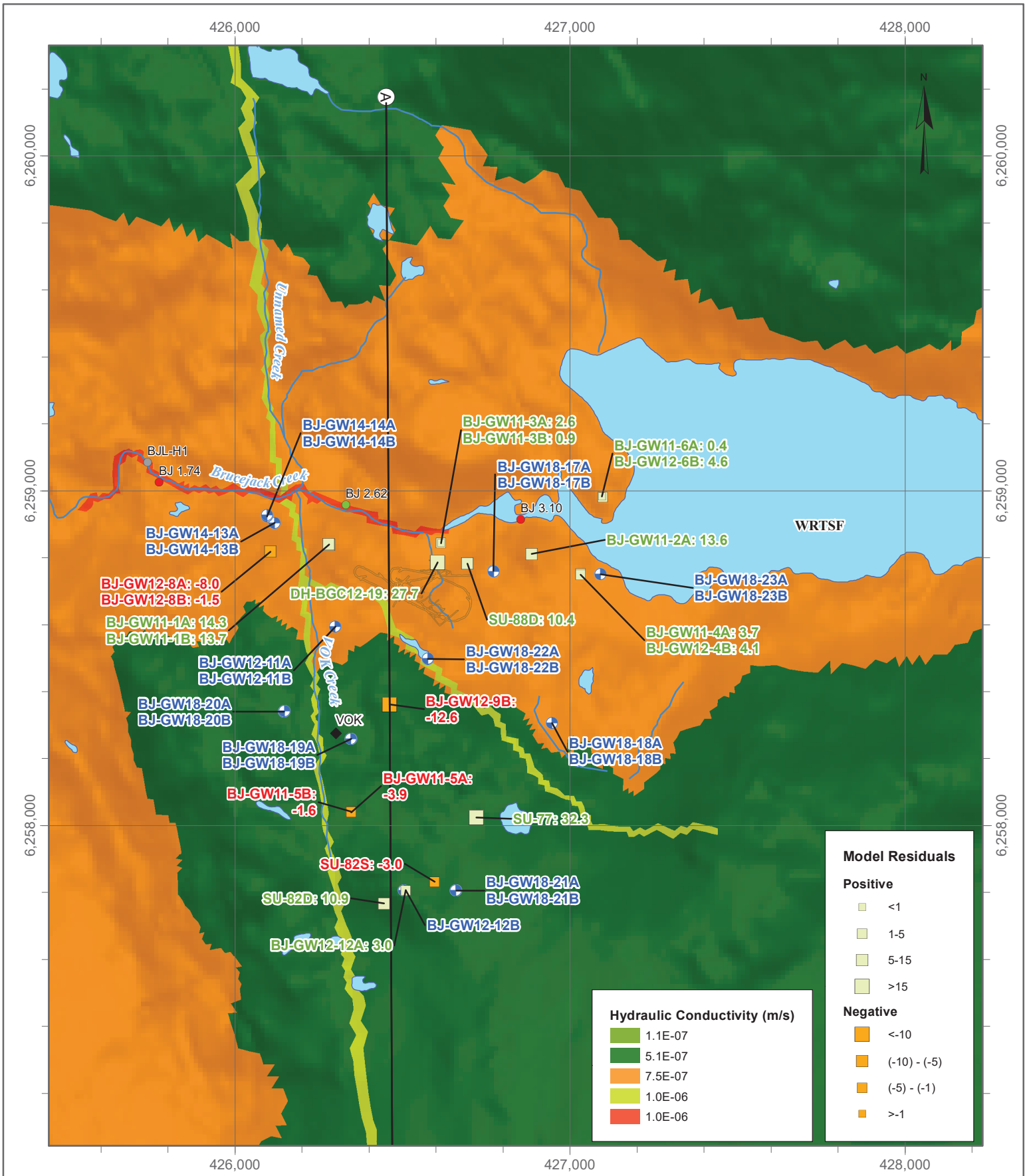


Figure 3-6: Head residual versus screen mid-point elevation in the 2020 baseline groundwater model (truncated domain).



LEGEND

- Other Monitoring Well
- Hydrometric Station
- SWQ Station
- Hydrometric Station (discontinued)
- Weather Station
- Workings (2013)
- Waterbody
- Watercourse
- A—A' Cross Section

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LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Report

TITLE: Spatial Distribution of Head Residuals in the Calibrated 2020 Model

PROJECT #: A624-4

FIGURE: 3-7

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Table 3-6 compares observed and simulated vertical hydraulic gradients at nested well pairs. The 2020 model correctly predicts the direction of hydraulic gradients near the VOK at BJ-GW11-5A/B and at low-lying locations south of the WRTSF and Brucejack Creek. The model does not correctly simulate the direction of hydraulic gradients west of the Brucejack Fault (BJ-GW11-8A/B) and on the northern shore of the WRTSF (BJ-GW11-6A/BJ-GW12-6B). This is not considered problematic as these wells are more distant from mine infrastructure.

Table 3-6:
Observed and simulated baseline vertical gradients in nested monitoring well pairs

Well ID	Ground Surface (masl)	Screen Midpoint (m bgs)	Observed Water Level Elevation[1] (masl)	Observed Vertical Gradient[1] (-)	Simulated	
					Water Level Elevation (masl)	Vertical Gradient[1] (-)
BJ-GW11-1A	1385.7	81.7	1365	0.022	1379.3	0.037
BJ-GW11-1B	1385.7	36.9	1364		1377.7	
BJ-GW11-3A	1367.6	85.3	1368	0.013	1370.6	0.035
BJ-GW11-3B	1367.5	7.3	1367		1367.9	
BJ-GW12-4A	1390.5	25.9	1377	0.000	1380.7	0.006
BJ-GW11-4B	1390.4	96.4	1377		1381.1	
BJ-GW11-5A	1526.1	73.2	1503	-0.036	1499.1	-0.120
BJ-GW11-5B	1526.2	45.6	1504		1502.4	
BJ-GW11-6A	1379.8	23.5	1369	-0.038	1369.4	0.015
BJ-GW12-6B	1379.6	101.8	1366		1370.6	
BJ-GW12-8A	1403.4	89.3	1385	0.121	1377.0	-0.036
BJ-GW12-8B	1403.3	47.9	1380		1378.5	

Notes:
1. Calculated or estimated annual average water level (BGC, 2015).
2. Upwards vertical gradient is positive.

The contoured baseline water table is shown in Figure 3-8 with water levels along cross-section A-A' presented in Figure 3-9. The water levels follow topography with the steepest horizontal gradients (~45%) driven by the topographic high north of the WRTSF (Figure 2-12). Groundwater draining the mine area flows northward towards Brucejack Creek and then deflects along VOK Creek following more subdued horizontal gradients (~6%). The model indicates that the lower portion of VOK Creek is gaining.

Simulated baseline water levels along Section A-A' indicate groundwater divides south of the VOK development and north of Brucejack Creek. Brucejack Creek is the main groundwater discharge zone along section. The deflection of equipotentials near the water table, particularly at BJ-GW12-12A/B indicates strong downward hydraulic gradients near

the future VOK development consistent with an area of groundwater recharge. Equipotentials become more vertical towards Brucejack Creek near the West Zone, then ultimately curve upwards (indicating upward hydraulic gradients) towards the groundwater discharge area defined by Brucejack Creek.

3.3.3 Baseflow

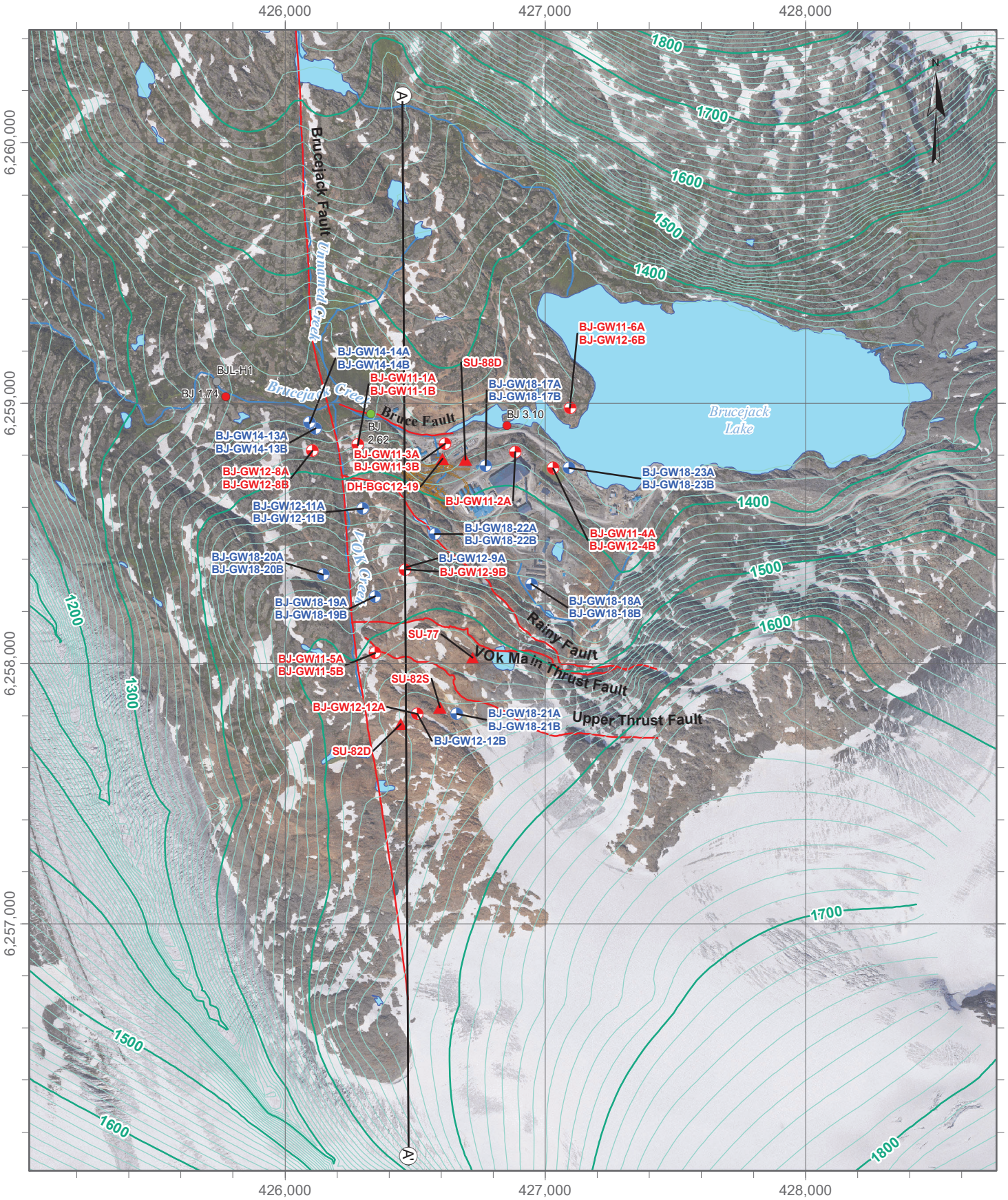
The 2020 groundwater model calibration utilized two baseline baseflow calibration targets: BJ 1.74 and BJ 3.10 (Figure 2-1, Table 3-7). The BJ 1.74 hydrometric station replaced the BJL-H1 station (used to calibrate the 2015 groundwater model) in 2014. The catchment area of BJL-H1 and BJ 1.74 stations is essentially identical which is reflected in a near identical baseflow targets (0.074 m^3/s at BJ 1.74 vs 0.073 m^3/s at BJL-H1).

The baseflow target at BJ 3.10, located at the outlet of the WRTSF, was introduced for the 2020 model update and was derived from the site-wide water balance model (Section 2.3.3). The 2020 model simulated 62 L/s baseflow at BJ 3.10 and 79 L/s baseflow at BJ 1.74 (Lorax, 2020b). These results nearly match targets and offer a significant improvement on baseflow simulated at BJL-H1 by the 2015 permitting model (BGC, 2015) (Table 3-7).

Table 3-7:
Comparison of observed and simulated baseflow at BJL-H1 and BJ 3.10

Baseflow Station	Target Flow (L/s)	2015 Simulated Flow[1] (L/s)	2020 Simulated Flow[2] (L/s)
BJ 1.74 (BJL-H1)	74 (73)	98	79
BJ 3.10	61	n/s	62

Notes:
n/s - not simulated
1. BGC (2015)
2. Lorax (2020b)



LEGEND

- Baseline Water Level Calibration Target (well)
- Baseline water Level Calibration Target (VWP)
- Other Monitoring Well
- Hydrometric Station
- SWQ Station
- Hydrometric Station (discontinued)
- Baseline Head Contour (100m)
- Baseline Head Contour (10m)
- Workings (2013)
- Fault
- Waterbody
- Watercourse
- Cross Section

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LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Report

TITLE:

Simulated Baseline Groundwater Table

PROJECT #: A624-4

FIGURE: 3-8

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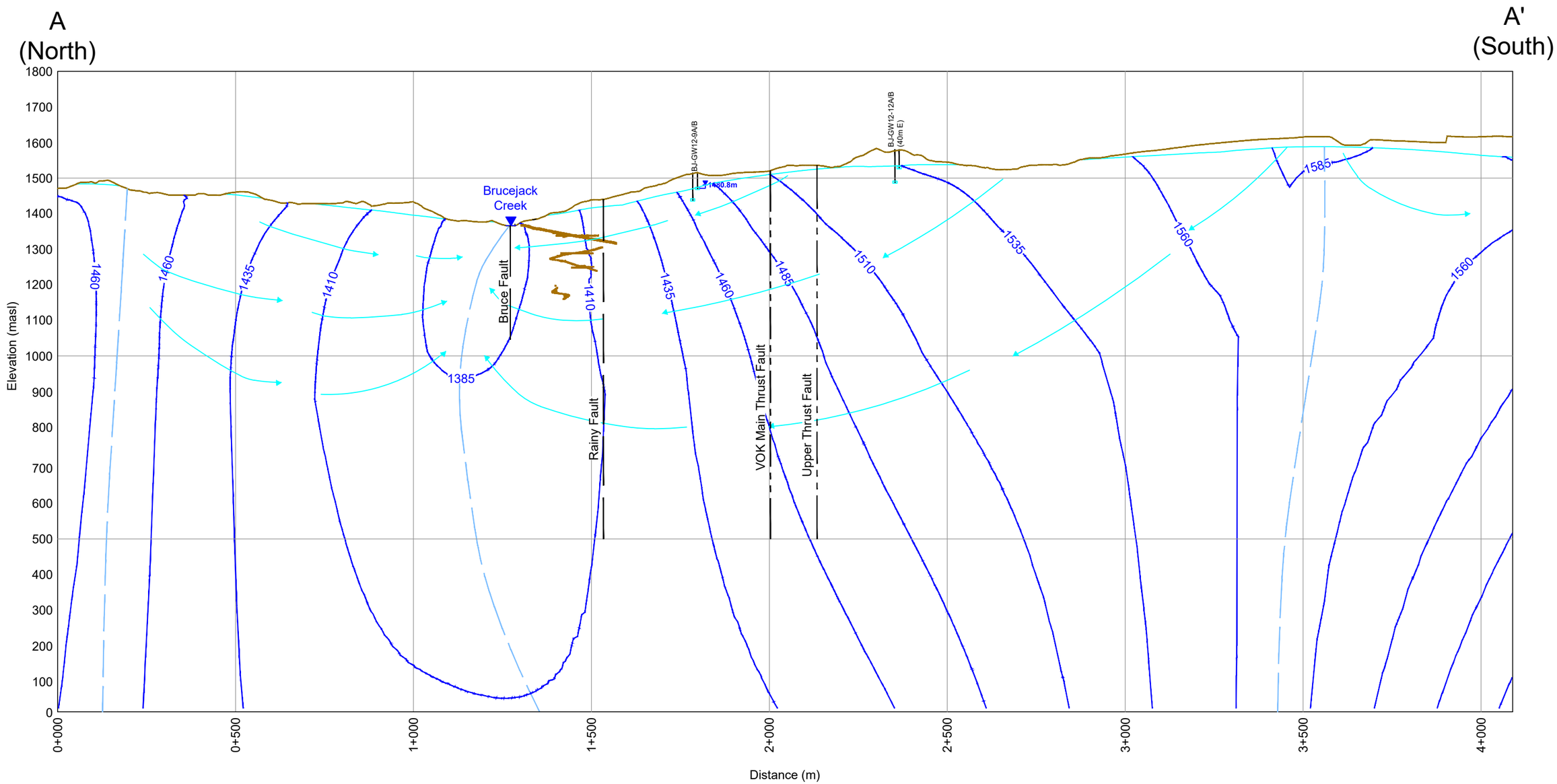

LEGEND

- Pre-mining Topography
- Hydraulic Head Contour
- Water Table (Baseline)
- Groundwater Flow Path
- Groundwater Flow Divide
- Workings (Baseline)
- Fault (Simulated Extents)
- Fault (Simulated Extents, Sensitivity Run 9 only)

Note: Only workings within 100m of the cross section are shown.

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LORAX ENVIRONMENTAL

PROJECT: **4950 tpd Groundwater Model Update**

TITLE: Simulated Baseline Water Table along Cross-Section A-A'

PROJECT #: A624-4

FIGURE: 3-9

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4. Operations Model (2011-2021)

4.1 Overview

The as-built operations groundwater model presented in the 2020 update was developed and calibrated using data collected between 2011 and 2018 (Lorax, 2020b). The 4950 tpd groundwater model builds on the 2020 model by implementing the as-built mine plan until the end of 2021 in a separate simulation. The calibrated parameters determined by the 2020 model remain unchanged, and thus data collected from 2019 through 2021 serve to validate the groundwater model.

4.2 Model Setup

4.2.1 Temporal Discretization

The calibration simulation was run on automatic timestep control from January 2011 to December 2018 for a total of 84 stress periods. The validation simulation run on automatic timestep control from January 2019 to December 2021 for a total of 36 stress periods.

4.2.2 Boundary Conditions

Boundary conditions from the baseline model were modified to simulate transient recharge and mine development over the 2011 to 2021 period.

4.2.2.1 Recharge

Monthly recharge values were applied according to the topographic zoning adopted in the baseline model (Figure 3-2). Recharge values for the 2011 to 2021 period were estimated from precipitation generated from ClimateBC (Wang *et al*, 2016) (Table 4-1) as the site weather station was relocated in 2014. The proportion of precipitation for a given year to the mean annual average (1944 to 2014) was derived and used to adjust the annual recharge rates employed in the baseline model (Table 3-2). Annual recharge values were distributed across the months for all years according to the distribution provided in Table 4-2. The monthly distribution of recharge was determined through the calibration process, but reasonably approximates the rain plus snowmelt distribution computed from the water balance model (Table 2-5).

Table 4-1:
Annual recharge values used in 2011 to 2021 models.

Year	Precipitation[1,2] (mm/yr)	Recharge (mm/yr)				
		Lowland (< 900 masl)	Low-Slope (900-1400 masl)	Mid-Slope (1400-1700 masl)	Upland (>1700 masl)	Glaciated Areas (variable elevation)
Average Year[3]	1950	280	289	328	359	80
2011	1860	267	276	313	342	76
2012	1676	238	246	279	305	68
2013	1696	238	246	279	305	68
2014	1913	280	289	328	359	80
2015	1984	280	289	328	359	80
2016	1770	255	263	298	327	73
2017	1611	232	240	272	298	66
2018	1329	190	197	223	244	54
2019	1890	271	280	318	348	78
2020	1956	281	290	329	360	80
2021	2143	308	318	360	395	88

Note:
1. Generated from ClimateBC (Wang *et al*, 2016) for an elevation of 1500 masl for years 2011-2018.
2. Measured at VOK station (elevation 1500 masl) for years 2019-2021.
3. Average of 1944 to 2014 values generated from ClimateBC with a scaling factor of approximately 0.75 for the elevation 1500 masl.

Table 4-2:
Monthly distribution of annual recharge.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of Annual Recharge	0	0	0	1%	12%	34%	19%	10%	10%	14%	0	0

4.2.2.2 Underground Workings

The underground workings were implemented in the model according to the as-built mine schedule provided by Pretium (Section 2.8). The 2011 to 2018 mine plan was provided in an excel file where a mine progression timeline was provided for stopes and development segments. This facilitated explicit representation of the monthly mine plan in the groundwater model between 2011 and 2018.

Developments (tunnels) and stopes were simulated by applying a drain boundary condition to the element with the elevation corresponding to the elevation of the tunnel or stope. Drain boundary conditions applied to developments remained active throughout the simulation while drains assigned to stopes were deactivated after one month to account for backfilling.

Simulation of the as-built mine plan over the 2019 to 2021 validation period required a different approach as only end of year annual snapshots were available. The as-built annual snapshots were compared to the previous 'future mine plan' that was implemented in the 2020 model for the same years with mine extents manually adjusted on the margins to approximate the as-built end of year snapshots. This was considered a reasonable approach as marginal areas of the mine have greater influence on dewatering rates rather than interior portions of the mine. As such, the mine plan implemented over the validation period represents a hybrid of the as-built mine and the 2020 mine plan. The 2020 3800 tpd mine plan was based on the plan presented in the 2019 Technical Report (Jones *et al.*, 2019).

4.2.3 Hydrogeological Units and Parameters

Calibrated specific yield and specific storage values used in the groundwater model are provided in Table 4-3. Water level hydrographs are particularly sensitive to bedrock storage parameters and the extensive data record (Section 4.2.3) served as useful calibration targets for fine tuning of these parameters. Water levels measured at monitoring wells BJ-GW11-6A/B were particularly useful in this regard since they appeared unimpacted by mining operations and provided a transient baseline calibration target.

The specific yield of backfilled stopes was adjusted to reflect mine waste porosity. The specific yield of stopes backfilled with waste rock was assumed to be 0.15, while the specific yield of paste-filled stopes was set to be equivalent to that of surrounding bedrock.

Table 4-3:
Summary of bedrock storage values used in the calibrated 2020 groundwater model.

Unit	Depth Interval (m bgs)	Specific Yield (-)	Specific Storage (m^{-1})
Faults			
BJ Creek (Layer 1)	0-10	0.1	1E-04
BJ Creek (Layer 2 to Layer 12)	10-320	0.01	1E-05
BJ Fault and Rainy Fault	0-500	0.01	1E-05
Intact Bedrock			
Layer 1 - Layer 3	0-50	0.001	1E-06
Layer 4 - Layer 7	50-170	0.001	5E-07
Layer 8 - Layer 9	170-230	0.001	2E-07
Layer 10 - Layer 14	230-380	0.0005	2E-07
Layer 15 - Layer 21	>380	0.0005	1E-07

The hydraulic conductivity distribution utilized in the as-built model is provided in Table 3-1 with one slight adjustment. In places where developments/stopes cross the Rainy Fault, the hydraulic conductivity of the element(s) containing the fault was decreased to correspond to the hydraulic conductivity of surrounding bedrock. The intent of this adjustment was to simulate grouting of the Rainy Fault during mining. Ultimately the

simulations indicated that once the Rainy Fault had been crossed, subsequent crossings produced nominal amounts of water.

4.3 Model Calibration and Validation

The Brucejack groundwater model calibration/validation benefits from an extensive hydrogeological dataset comprised of ten years of dewatering data and a long-term, high resolution water level record collected from over 30 wells. The wells are broadly situated about the mine site and capture the influence of key hydraulic features (*i.e.*, the Brucejack Fault). The dynamic flow and water level records serve as a robust data set upon which model hydraulic parameters and boundary conditions can be assessed. In an iterative process, parameter combinations were trialed in both the baseline steady state and transient operations model to arrive at a calibration that satisfied all calibration targets. The transient calibration attempted to reproduce some of these key features of the system response, without introducing unnecessary complexity.

4.3.1 Underground Dewatering Rates

Simulated dewatering rates until the end of 2021 are shown in Figure 4-1 and tabulated in Appendix D. While the 2020 groundwater model simulated underground dewatering over the 2011 to 2018 period, the calibration effort primarily focussed on the 2015 to 2018 period during which active mining occurred. The model reasonably simulates observed underground dewatering rates and captures intra-annual variability in flows (Figure 4-1).

Over the 2019 to 2021 validation period, the 4950 tpd model reasonably simulates peak underground dewatering rates but overshoots annual minima by 450 m^3/d to 900 m^3/d. From the discussion presented in Section 2.6, current observed dewatering rates are anticipated to underestimate actual rates by ~130 m^3/d on account of ventilation water losses, therefore the gap between simulated and observed dewatering rates could be decreased by ~130 m^3/d. The overprediction of low-flow period dewatering rates is flagged for further study in future updates of the groundwater model.

Measured and simulated cumulative dewatering volumes from January 2015 through December 2021 are shown in Figure 4-2. Over the calibration period (2015 to 2018), the model overpredicts cumulative dewatered volumes by about 3% (1.89 Mm^3 vs 1.84 Mm^3). Over the calibration and validation period (2015 to 2021), the model overpredicts cumulative dewatered volumes by about 13% (3.92 Mm^3 vs 3.47 Mm^3). Overall, the simulated dewatering rates are considered acceptable and reasonably conservative for estimating treatment requirements.

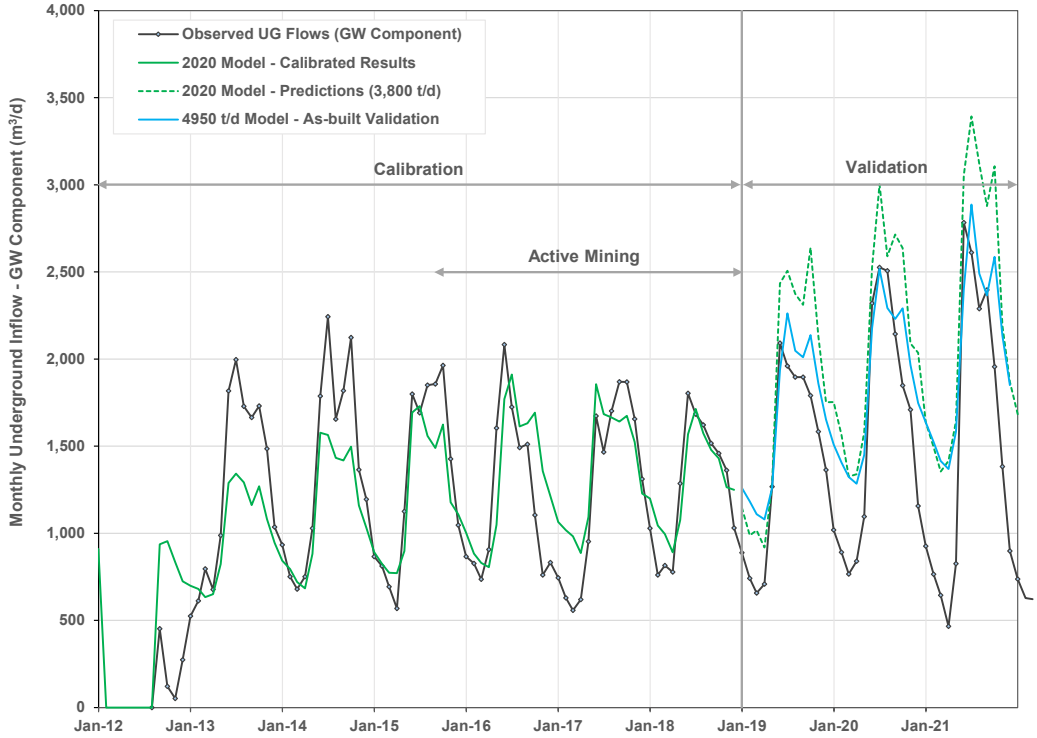


Figure 4-1: Simulated versus observed dewatering rates between 2012 and 2021.

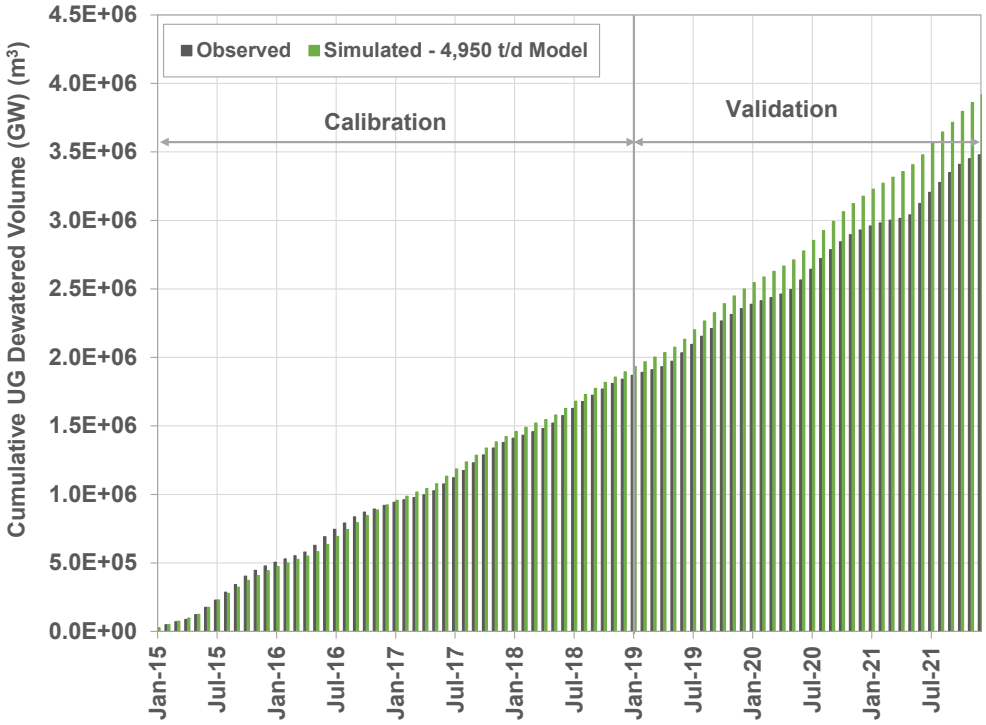


Figure 4-2: Measured and predicted cumulative groundwater volume dewatered from the mine (2015 – 2021).

4.3.2 Water Level Elevations

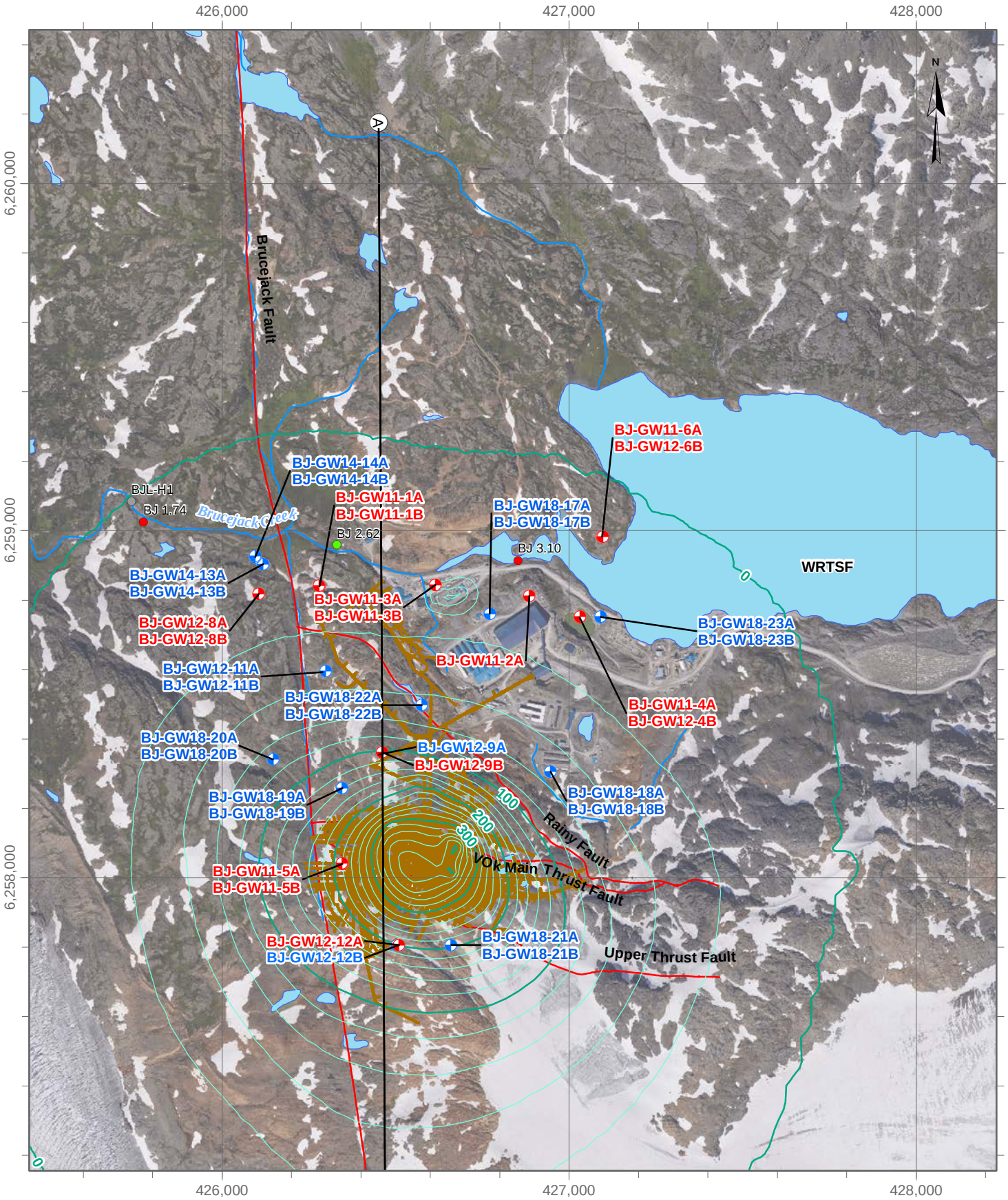
A plan map of simulated drawdown at the end of 2021 is provided in Figure 4-3. The map is a composite of data from two layers in the model. Maximum drawdown from the VOK is simulated in Layer 19 (500 to 530 m bgs) of the model, while maximum drawdown from the West Zone is simulated in Layer 8 (170 to 200 m bgs) of the model. Approximately 70 m of drawdown is simulated in the West Zone, while upwards of 400 m of drawdown is simulated in the VOK.

Simulated end of 2021 water levels along Section A-A' are provided in Figure 4-4. In contrast to Figure 3-9, most groundwater flowpaths are towards the mine and not Brucejack Creek. Monitoring wells BJ-GW12-12A/B and BJ-GW12-9A/B are simulated to be dry with water levels several tens of meters below the bottom of the deeper well screen. This supports the theory that the observed water level in BJ-GW12-9B represents a locally perched water table.

Time series of simulated and observed water levels over the 2012 to 2021 period are shown in Figure 4-5 to Figure 4-7. Underlining of well IDs in the graph panes indicate the well was also calibrated in the baseline model (Chapter 3). Table 4-4 provides simulated and observed June 2021 drawdown while Table 4-5 provides simulated and observed vertical hydraulic gradients at nested well pairs.

The model generally simulates similar water level responses in shallow and deep wells as a result of the necessary simplification of the groundwater system. In well pairs where perched conditions or widely disparate water level behaviour occur, the model tends to reproduce one well's data better than the neighboring. Overall, the model simulates downward gradients at all well pairs, which is largely consistent with observed data (Table 4-5).

Wells situated close to the VOK (BJ-GW11-5A/B and BJ-GW12-12A) show good agreement between simulated and observed water levels over the calibration period (Table 4-4, Figure 4-5). These wells went dry before the validation period but simulated water levels at deeper wells established in 2018 (BJ-GW18-21A/B, -19A/B) are in good agreement with observed water level elevations.



LEGEND

- Baseline Water Level Calibration Target (Well)
- Other Monitoring Well
- SWQ Station
- Hydrometric Station
- Hydrometric Station (discontinued)
- Drawdown Contour - 2021 (100m)
- Drawdown Contour - 2021 (20m)
- Workings (End of 2021)
- Fault
- Ⓐ—Ⓐ Cross Section

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LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Update

TITLE: Simulated Drawdown at the End of 2021

PROJECT #: A624-4

FIGURE: 4-3

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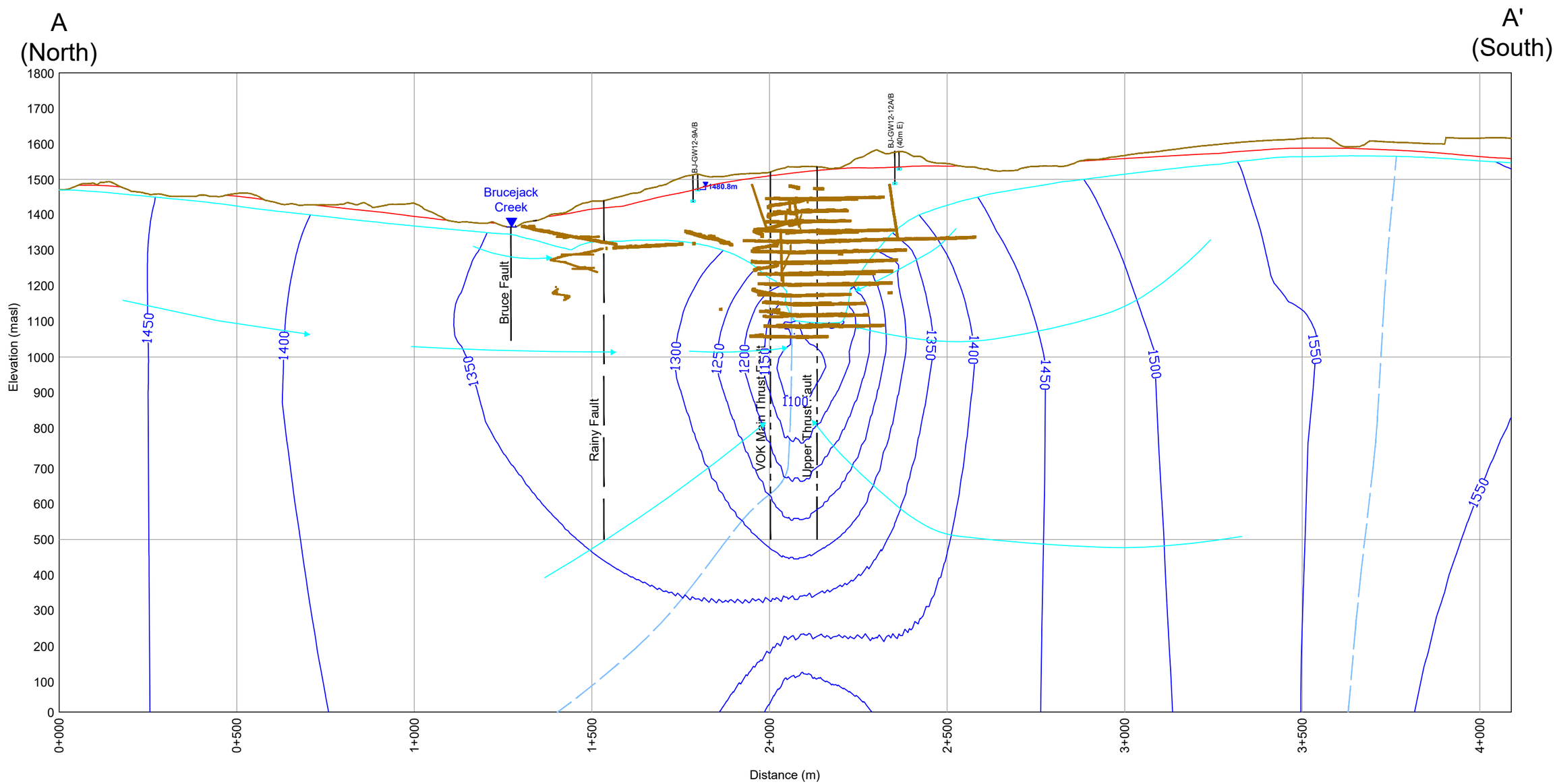

LEGEND

- Pre-mining Topography
- Hydraulic Head Contour
- Water Table (2021)
- Water Table (Baseline)
- Groundwater Flow Path
- Groundwater Flow Divide
- Workings (2021)
- Fault (Simulated Extents)
- Fault (Simulated Extents, Sensitivity Run 9 only)

Note: Only workings within 100m of the cross section are shown.

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PROJECT: **4950 tpd Groundwater Model Update**

TITLE: Simulated End of 2021 Water Table along Cross-Section A-A'

PROJECT #: A624-4

FIGURE: 4-4

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Table 4-4:
Simulated and observed June 2021 drawdown at Brucejack monitoring wells

Well ID	Screen Midpoint El. (masl)	Observed Drawdown[1] (m)	Simulated Drawdown (m)[2]
BJ-GW11-1A	1304.0	1.4	33
BJ-GW11-1B	1348.9	-2.2	24
BJ-GW11-3A	1282.3	7.7	35
BJ-GW11-3B	1360.2	-2.3	9
BJ-GW11-5A	1453.0	>65.2	59
BJ-GW11-5B	1480.6	>35.3	42
BJ-GW11-6A	1356.3	-1.3	0
BJ-GW12-6B	1277.8	0.3	2
BJ-GW12-8A	1314.1	0	15
BJ-GW12-8B	1355.5	4.1	13
BJ-GW12-9B	1470.9	7.6	38
BJ-GW12-11A	1405.6	7.7	39
BJ-GW12-11B	1380.7	40.6	58
BJ-GW12-12A	1488.3	>43	67

Notes:
1. Computed from observed baseline water levels collected between June and August, 2012 (see Table 2-7)
2. Computed from simulated June 2011 water levels.

Table 4-5:
Simulated and observed June 2021 vertical gradients at nested well pairs

Station ID	Screen Midpoint El. (masl)	Observed	Simulated
		Jun-21	Jun-21
BJ-GW11-1A	1304.0	-4%	-19%
BJ-GW11-1B	1348.9		
BJ-GW11-3A	1282.3	-11%	-29%
BJ-GW11-3B	1360.2		
BJ-GW11-6A	1356.3	-5%	-4%
BJ-GW12-6B	1277.8		
BJ-GW12-8A	1314.1	19%	-16%
BJ-GW12-8B	1355.5		
BJ-GW12-9A	1438.5	dry	-84%
BJ-GW12-9B	1470.9		
BJ-GW12-11A	1405.6	-137%	-87%
BJ-GW12-11B	1380.7		
BJ-GW12-12A	1488.3	dry	-76%
BJ-GW12-12B	1529.4		
BJ-GW18-17A	1257.7	-46%	-24%
BJ-GW18-17B	1330.2		
BJ-GW18-18A	1345.7	-56%	-27%
BJ-GW18-18B	1381.7		
BJ-GW18-19A	1300.6	n/a	-47%
BJ-GW18-19B	1338.5		
BJ-GW18-20A	1329.6	3%	-16%
BJ-GW18-20B	1377.5		
BJ-GW18-21A	1350.5	n/a	-46%
BJ-GW18-21B	1394.2		
BJ-GW18-22A	1069.0	-17%	-7%
BJ-GW18-22B	1358.7		

Notes:
1. Negative values indicate downward gradient.

West of the VOK and west of the Brucejack Fault (Figure 4-3), the model simulates lower water levels than observed at BJ-GW18-20A/B, although annual variation appears reasonably matched. Ongoing monitoring at this well pair will elucidate whether the Brucejack Fault is limiting drawdown in this area. Far east of the VOK, simulated water levels are in good agreement with measured water levels at BJ-GW18-18A/B.

Situated between with West Zone and VOK, BJ-GW18-22A is the deepest monitoring well on site (380 m) (Figure 4-6). The model reasonably approximates observed water levels at this well, situated close to underground developments, but underestimates water levels in its nested counterpart (BJ-GW18-22B) screened nearly 300 m shallower.

The model reasonably approximates water level trends and seasonality at selected wells between the West Zone and Brucejack Fault (BJ-GW11-1B and BJ-GW12-11B) (Figure 4-6). The model performs better at these wells versus their associated well pair. West of the Brucejack Fault, the model reasonably approximates long-term trends (or lack thereof) at wells BJ-GW12-8A/B, BJ-GW14-13B and BJ-GW14-14A (Table 4-4).

Several wells east and north of the West Zone were available for calibration of the baseline and operations period model phases (left hand side of Figure 4-7). BJ-GW12-6B and BJ-GW11-6A, north of Brucejack Creek at the outlet of the WRTSF, are background wells which have demonstrated little response to mining (Table 4-4). These wells served as particularly useful targets for calibrating bedrock storage parameters up to 100 m depth. Seasonal fluctuations and absolute water level elevations are faithfully reproduced by the model at this well pair.

Immediately east of the West Zone, the model closely simulated water levels at BJ-GW11-3A until the end of 2019 but diverged significantly thereafter. At the shallow well BJ-GW11-3B, the model overpredicts drawdown and seasonal fluctuations. At nearby well pair BJ-GW18-17A/B, the model reasonably simulates water levels in shallower bedrock (~75 m deep at 17B) but overestimates water levels in deeper bedrock (~148 m deep at 17A). The overestimation of drawdown at one well (BJ-GW11-3A/B) versus the underestimation of drawdown at the other (BJ-GW18-17A) suggests that there may be a structural feature influencing water levels in this area which has not been included in the groundwater model. Pretium geologists have identified a potential fault in this area which may be considered in the next update of the groundwater model pending further characterization work.

4.3.3 Calibration/Validation Summary

In summary, the groundwater model has benefitted from a long-term and dynamic water level and dewatering record which has facilitated calibration of bedrock hydraulic

conductivity, bedrock storage properties and recharge. The model necessarily simplifies the groundwater system but reasonably simulates seasonal water level and underground dewatering rate fluctuations, long-term water level trends and broad spatial trends in water level data. Good performance of the model against observed water level data collected since 2018, particularly at locations where water level data did not exist previously, further enhances model credibility. The model is well positioned to assess monthly average dewatering rates during the open water season but tends to overestimate winter low flows.

Winter low flows and influence of potential structures east of the West Zone are earmarked for further consideration during future model updates. Continued daily monitoring of underground dewatering rates and continuous monitoring of groundwater levels as prescribed by the mine's monitoring programs will be sufficient to inform future model updates. Overall, the groundwater model is well positioned to inform groundwater management at the mine site.

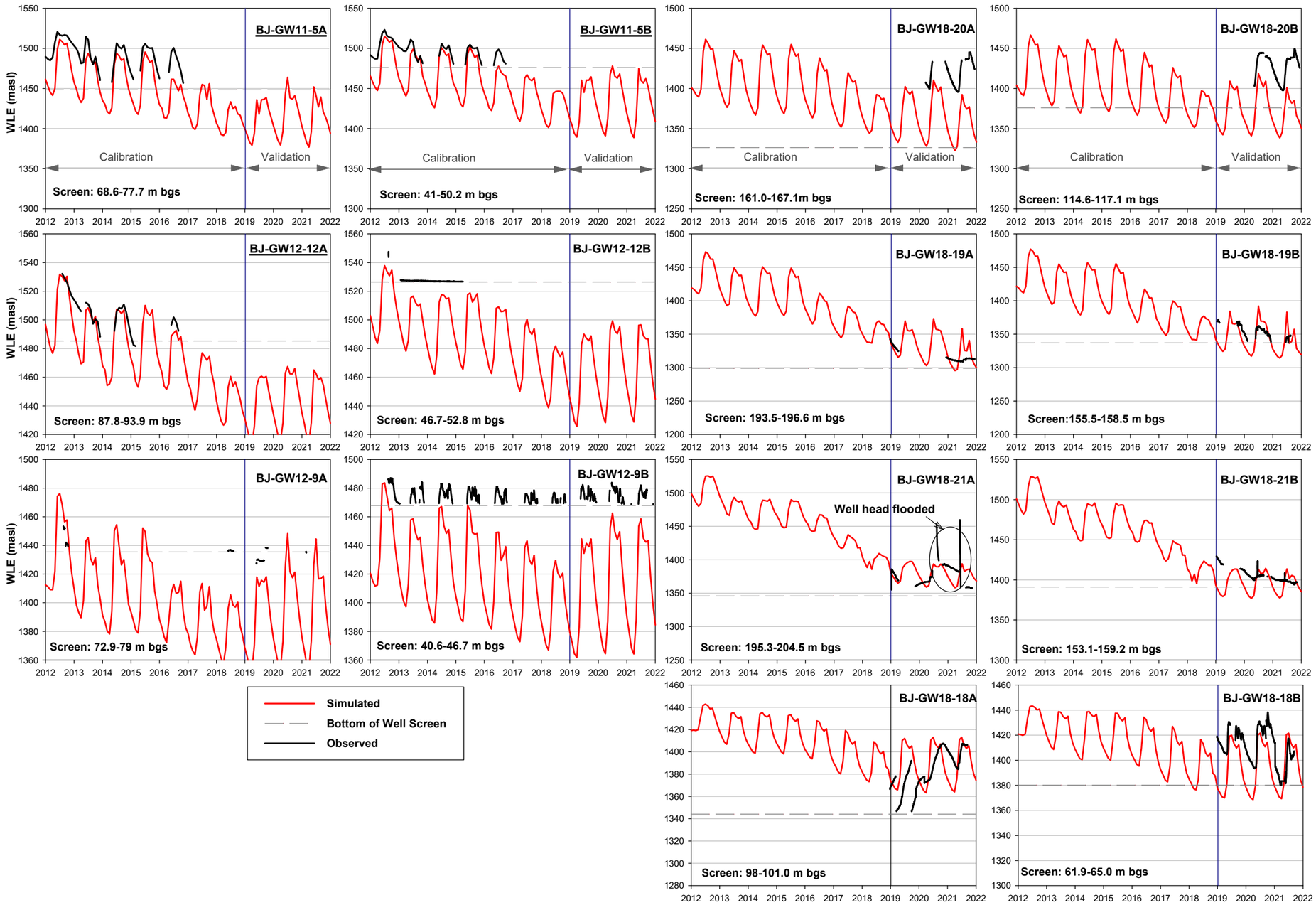


Figure 4-5: Simulated and observed groundwater level hydrographs near the VOK (2012-2021). Underlined well ID indicates location was calibrated in baseline model.

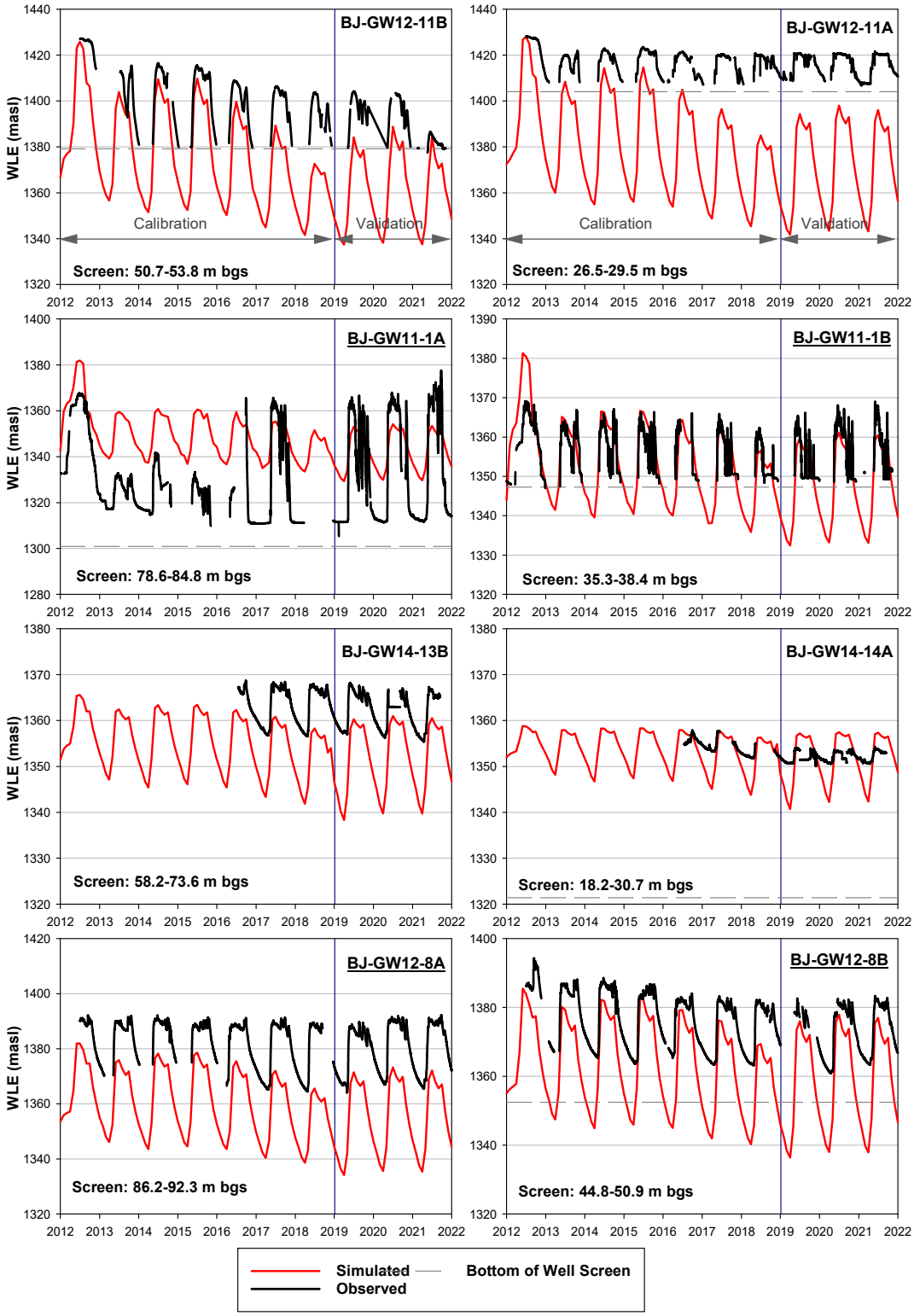


Figure 4-6: Simulated and observed groundwater level hydrographs west of the West Zone (2012-2021). Underlined well ID indicates location was calibrated in baseline model.

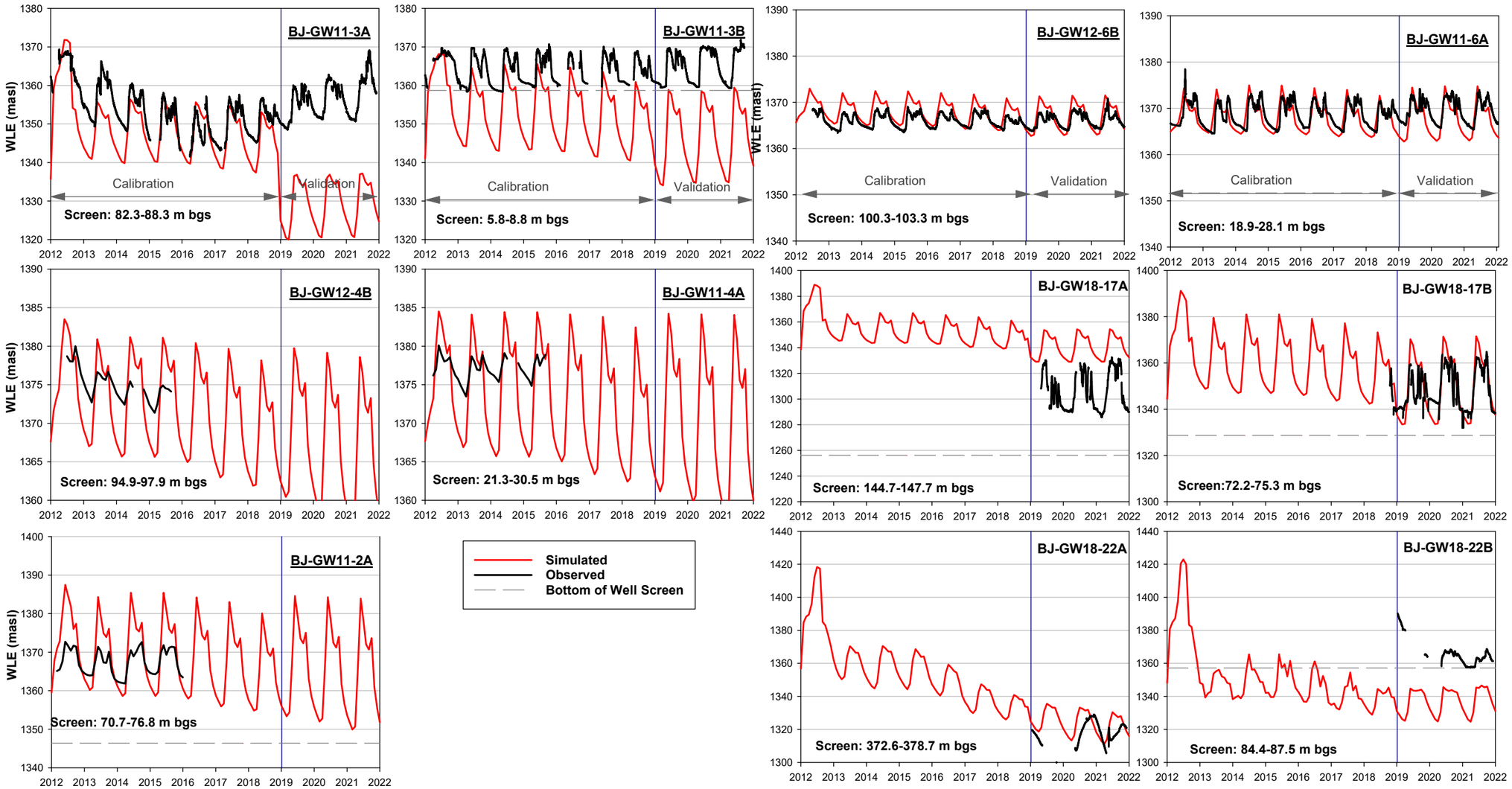


Figure 4-7: Simulated and observed groundwater level hydrographs east, south and north of the West Zone (2012-2021). Underlined well ID indicates location was calibrated in baseline model.

5. Future Operations (2022-2029)

5.1 Overview

The future operations period has been updated in the 4950 tpd model. The mine plan follows a 3800 tpd milling rate until January 2024 and then increases throughput to 4950 tpd until the end of operations in December 2029. Where appropriate, results have been compared to the 2020 model (Lorax, 2020b) for context.

5.2 Model Setup

5.2.1 Temporal Discretization

The future operations model was run on automatic timestep control from January 2022 through the end of December 2029 for a total of 96 stress periods. Mining itself is projected to end in December 2029.

5.2.2 Boundary Conditions

5.2.2.1 Recharge

An 'average climate' recharge time series was implemented in the future operations groundwater model. The recharge values implemented in the groundwater model correspond to the first line, or "Average Year," of Table 4-1 and were distributed across the months according to Table 4-2. This time series was repeated over the eight year duration of future operations.

5.2.2.2 Underground Workings

The underground workings were implemented in the future operations model according to the mine schedule provided by Pretium (Section 2.7). Figure 2-11 shows the full end of mine extents. Developments and stopes were simulated as described in Section 4.2.2. Developments are kept open once explored and simulated as drains for the duration of mining. Drains simulating mining stopes are turned off after one month to account for backfilling.

5.2.3 Hydrogeological Units and Parameters

The hydraulic parameters utilized in the 2011-2021 simulations were applied to the future operations model with no adjustments.

5.3 Model Predictions

5.3.1 Underground Dewatering Rates

Underground dewatering rates predicted by the 4950 tpd model are compared to the 2020 model results in Figure 5-1 with cumulative dewatered volumes from January 2022 to end of mine presented in Figure 5-2 and tabulated in Appendix D. The 2020 groundwater model simulated the 3800 tpd mine dewatering period ending in December 2032 (Lorax, 2020b).

Predicted dewatering rates stabilize over the last three years of mine life (2027 to 2029), ranging annually between 2,600 m^3/d and 4,300 m^3/d (30 L/s to 50 L/s) (Figure 5-1). The 4950 tpd rates are marginally higher (by about 2 L/s) in the low flow period (April) than those predicted for the 3800 tpd mine plan simulated in the 2020 model (Lorax, 2020b). This increase in minimum flows arises from the differences in mine plans discussed in Section 2.8. Simulated peak monthly flow rates during the open water season are similar between the two mine plans.

The cumulative inflow to the 4950 tpd mine is 10% higher than the 3800 tpd model over the period of 2022 to 2029 but, overall, 15% lower than the 3800 tpd mine through 2032 (Figure 5-2). Essentially, the 4950 tpd mining rate results in less groundwater abstraction over the life of mine than the 3800 tpd mine plan due to a shorter mine life.

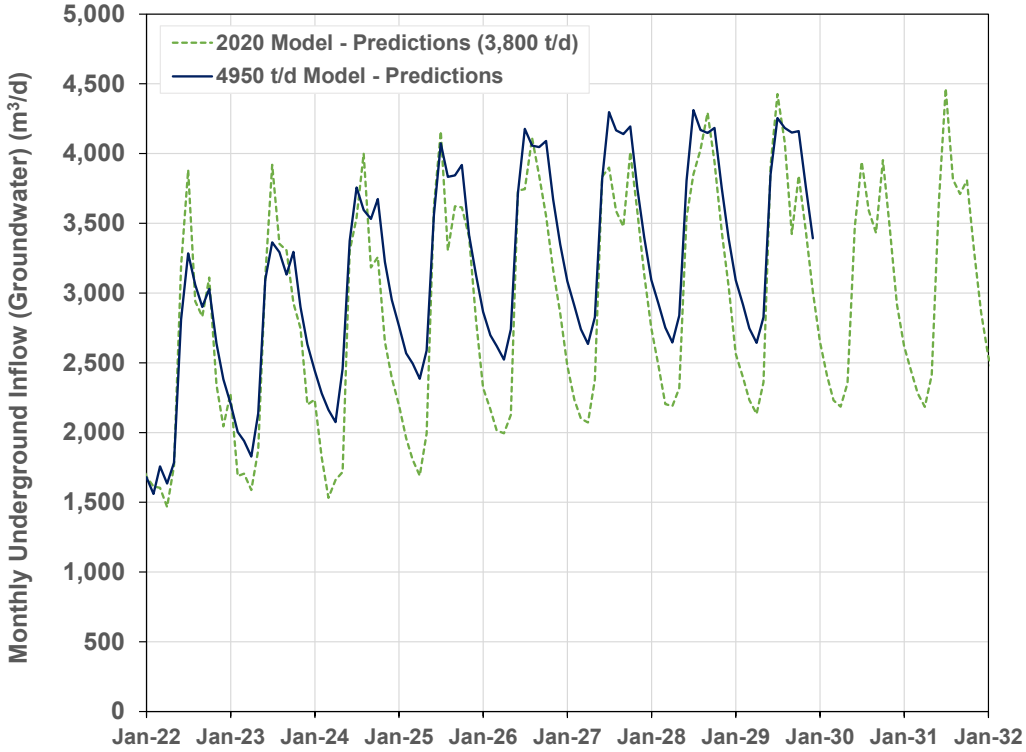


Figure 5-1: Simulated future underground dewatering rates for 3800 tpd and 4950 tpd groundwater models.

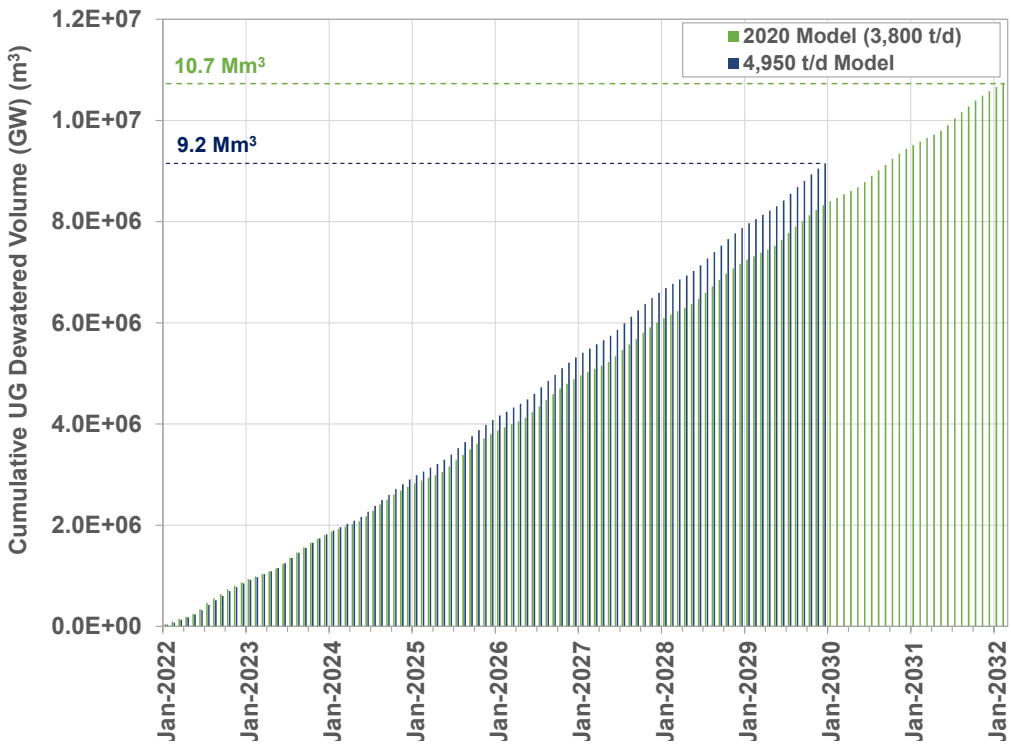


Figure 5-2: Cumulative underground dewatering rates for 3800 tpd and 4950 tpd groundwater models (January 2022 to end of mine).

5.3.2 Water Level Elevations

Figure 5-2 through Figure 5-5 illustrate January 2012 to December 2030 simulated groundwater elevations for the 4950 tpd mine plan. Time series of annual average drawdown, computed from simulated 2011 water levels, are provided in Appendix E with end of mine drawdown summarized in Table 5-1. Overall, predicted drawdown at the end of mine life for the 4950 tpd mine plan (year 2029) exceeds that of the 3800 tpd mine plan (year 2032) at all wells by 15 m on average.

Water levels in wells surrounding the VOK have already experienced significant drawdown from the existing mine (Section 4.3.2, Figure 5-3). Several wells experience a noticeable increase in drawdown around 2025 (BJ-GW18-21A/B, BJ-GW18-19A/B, BJ-GW18-18A) that is attributed to advancement of exploration developments east, south and west of the VOK between 2024 and 2026 (see Figure 2-11). Steadily decreasing water levels are also predicted at BJ-GW18-20A/B.

Most wells flanking the West Zone are simulated to experience marked water level decline starting in 2022 due to expansion and deepening of the West Zone (Figure 5-4 and Figure 5-5). The rapid decline is most noticeable in wells immediately adjacent to the West Zone (BJ-GW11-1A/B, BJ-GW11-3A/B), where water levels decline on the order of 80 m between 2021 and 2029 (Table 5-1). Water levels at BJ-GW18-22A are predicted to drop

over 150 m in the next several years due to expansion of the West Zone and VOK (Table 5-1, Figure 5-5). Mining of the extension areas of the Brucejack mineralization (Figure 2-11), which was not simulated in the 2020 model, produces significantly more drawdown at BJ-GW-18-22A in the 4950 tpd mine plan than in the 3800 tpd mine plan.

Drawdown from West Zone development also extends father afield, materializing in >50 m drawdown in wells west of the Brucejack Fault (BJ-GW12-8A/B, BJGW14-13A, BJ-GW14-14A) (Figure 5-4, Table 5-1) with lesser amount of drawdown (<20 m) experienced north of Brucejack Creek at BJ-GW11-6A/BJ-GW12-6B (Figure 5-5).

Table 5-1:
Simulated drawdown at end of mine for 4950 tpd and 3800 tpd models.

Date	Screen Midpoint El. (masl)	Simulated Drawdown (m)		
		4950 tpd Mine Plan		3800 tpd Mine Plan
		Jun 2021[1]	2029 Avg.[2]	2032 Avg.[2]
BJ-GW11-1A	1304.0	33	126	107
BJ-GW11-1B	1348.9	24	108	94
BJ-GW11-3A	1282.3	35	111	97
BJ-GW11-3B	1360.2	9	90	79
BJ-GW11-5A	1453.0	59	97	97
BJ-GW11-5B	1480.6	42	82	79
BJ-GW11-6A	1356.3	0	10	8
BJ-GW12-6B	1277.8	2	17	13
BJ-GW12-8A	1314.1	15	83	66
BJ-GW12-8B	1355.5	13	68	57
BJ-GW12-9A	1438.5	56	96	92
BJ-GW12-9B	1470.9	38	86	80
BJ-GW12-11A	1405.6	39	104	93
BJ-GW12-11B	1380.7	58	113	100
BJ-GW12-12A	1488.3	67	97	94
BJ-GW12-12B	1529.4	45	82	74
BJ-GW14-13B	1296.9	7	69	47
BJ-GW14-14A	1327.6	2	50	32
BJ-GW18-17A	1257.7	35	121	97
BJ-GW18-17B	1330.2	20	90	70
BJ-GW18-18A	1345.7	32	116	83
BJ-GW18-18B	1381.7	23	90	70
BJ-GW18-19A	1300.6	150	167	159
BJ-GW18-19B	1338.5	137	144	134
BJ-GW18-20A	1329.6	91	128	108
BJ-GW18-20B	1377.5	90	102	89
BJ-GW18-21A	1350.5	139	180	165
BJ-GW18-21B	1394.2	123	148	142
BJ-GW18-22A	1069.0	91	260	193
BJ-GW18-22B	1358.7	80	142	122

Notes:
1. Computed from simulated June 2011 water levels.
2. Computed from annual average water levels simulated for 2011 and end of mine year for 4950 tpd and 3800 tpd models.

A plan map of maximum drawdown at the end of mine is shown in Figure 5-6. The map is a composite of data from two layers in the model. Maximum drawdown from the VOK is simulated in Layer 20 (530 to 560 m bgs) of the model, while maximum drawdown from the West Zone is simulated in Layer 14 (350 to 380 m bgs) of the model. Maximum drawdown at the end of mine life exceeds 425 m in the VOK and 300 m in the West Zone.

Simulated baseline and end of operations water levels along Section A-A' are shown in Figure 5-7. Groundwater draining the area north of Brucejack Creek largely reports to the West Zone while the VOK continues to capture groundwater south of the mine. This is demonstrated in the backward particle tracks shown on Figure 5-6 which trace the origin of water arriving in the underground. Groundwater drawn from farther afield towards the VOK and West Zone tends to flow along the north and south extensions of the Brucejack Fault.

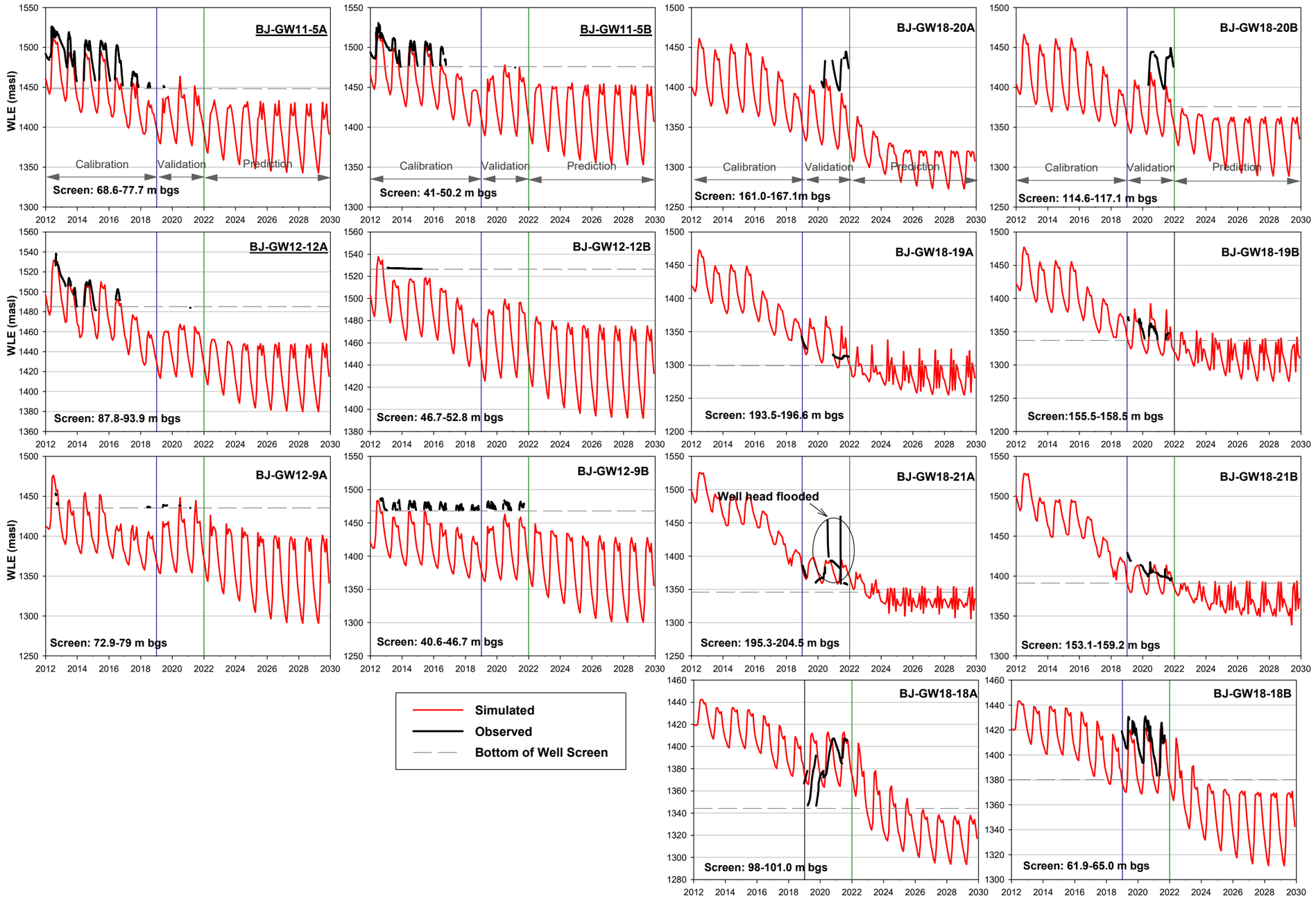


Figure 5-3: Simulated and observed groundwater level hydrographs near the VOK (2012-2029). Underlined well ID indicates location was calibrated in the baseline model.

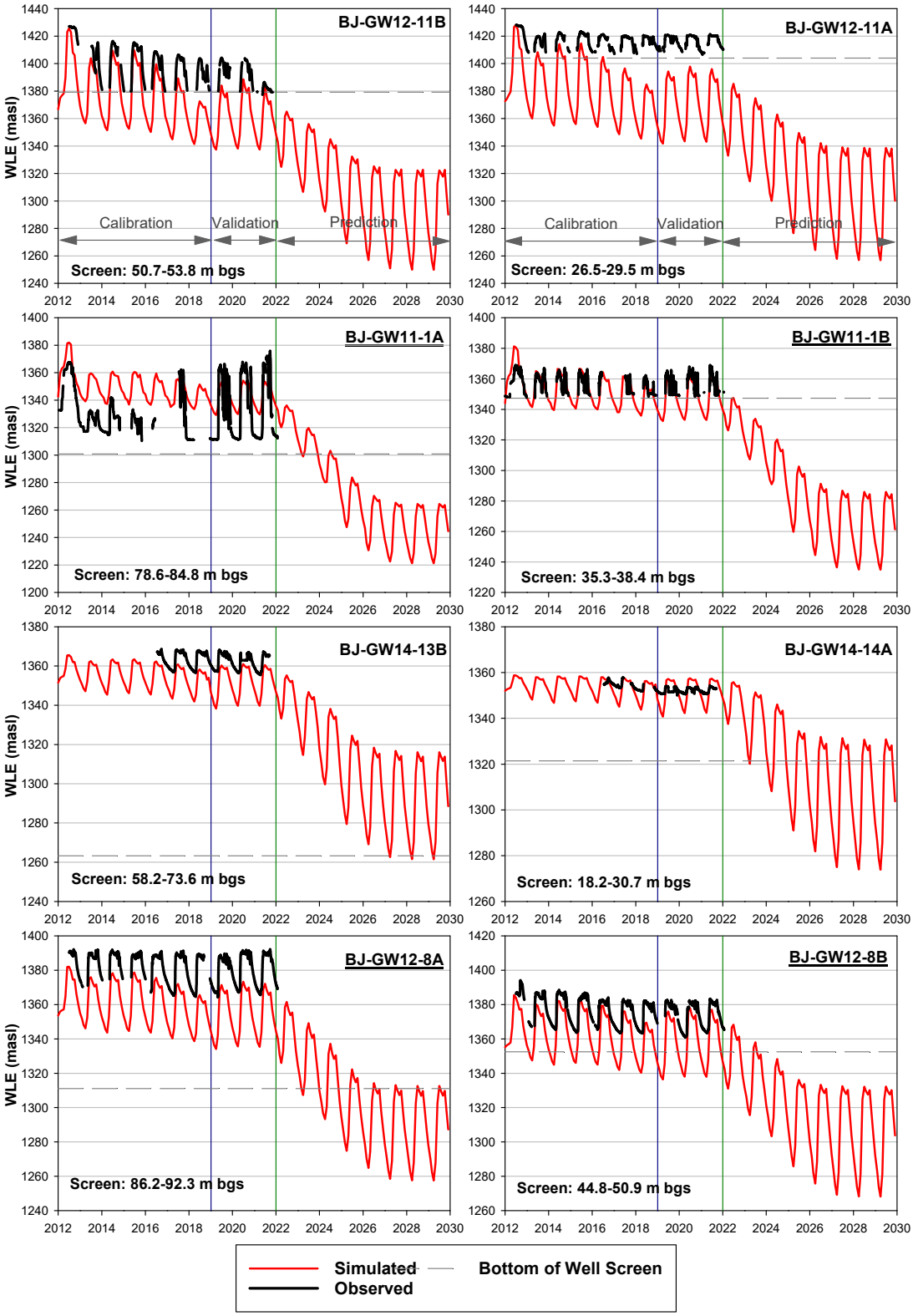


Figure 5-4: Simulated and observed groundwater level hydrographs west of the West Zone (2012-2029). Underlined well ID indicates location was calibrated in baseline model.

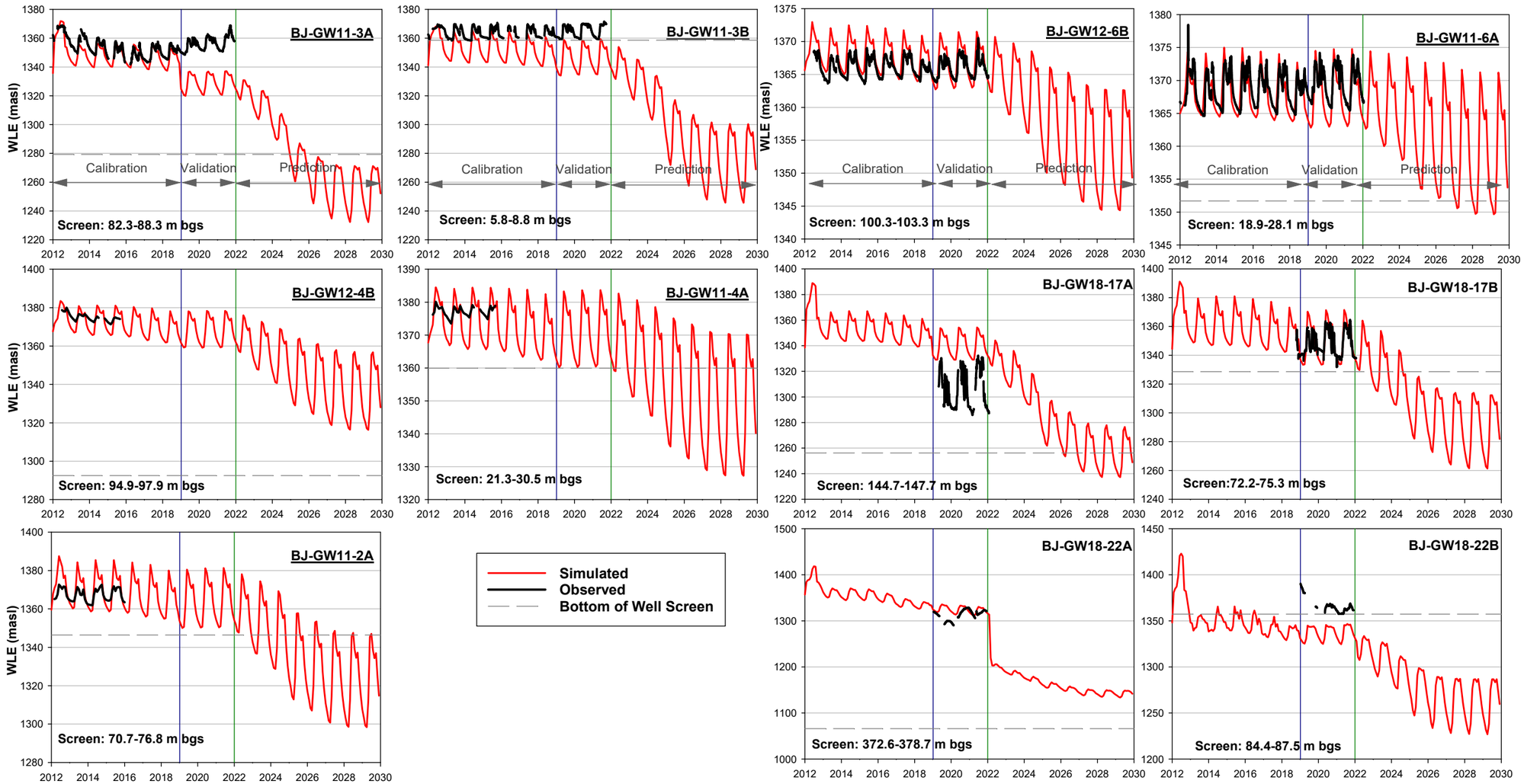
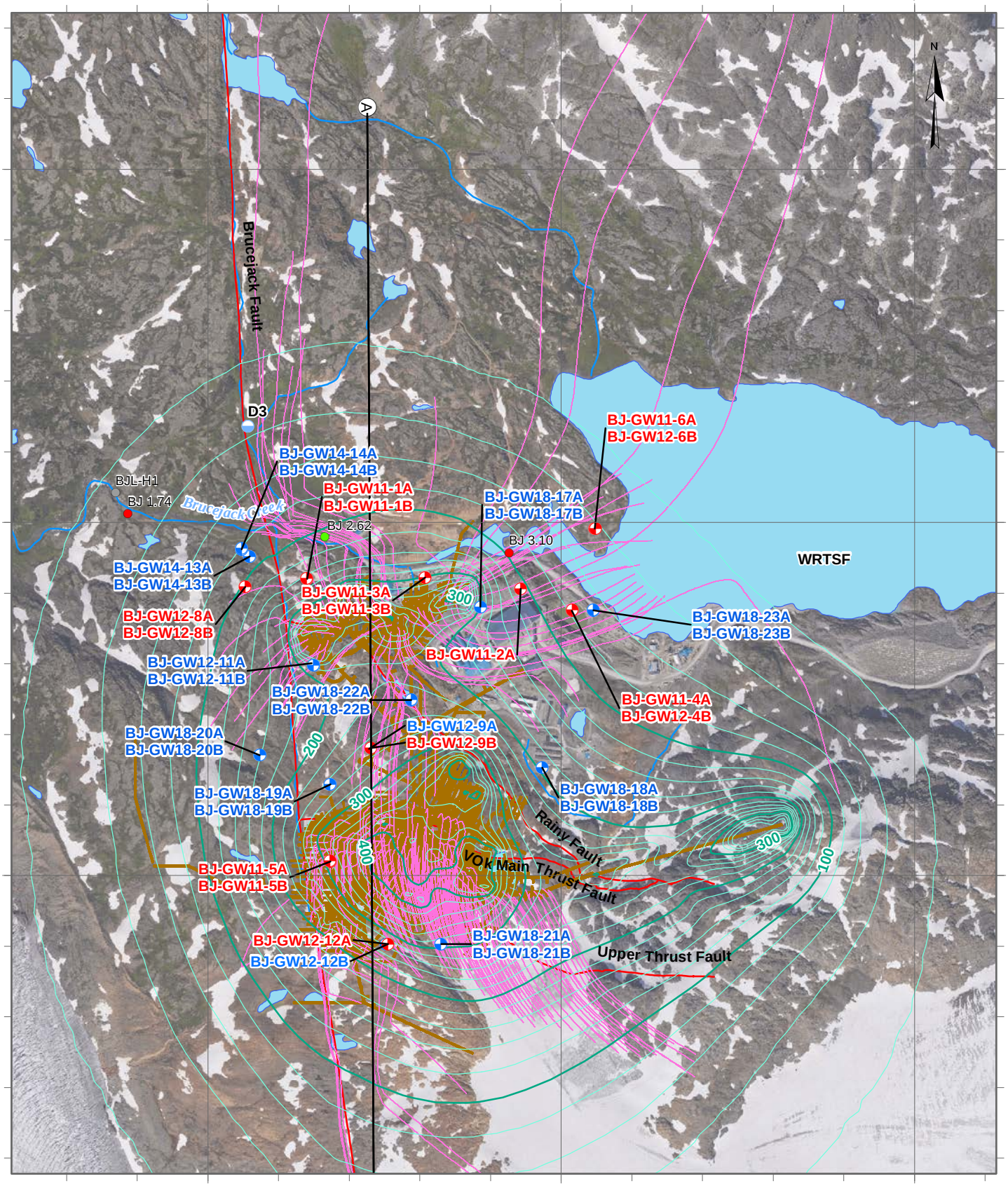


Figure 5-5: Simulated and observed groundwater level hydrographs east and north of the West Zone (2012-2029). Underlined well ID indicates location was calibrated in baseline model.



LEGEND

- Baseline Water Level Calibration Target (Well)
- Other Monitoring Well
- Water Supply Well
- SWQ Station
- Hydrometric Station
- Hydrometric Station (discontinued)
- Drawdown Contour - End of Operations (100m)
- Drawdown Contour - End of Operations (20m)
- Backward Particle Track
- Workings (EOM)
- Fault
- Cross Section

DATE SAVED:	Nov 29, 2022
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:15,000

0 100 200 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Update

TITLE: Simulated Drawdown at the End of Operations

PROJECT #: A624-4

FIGURE: 5-6

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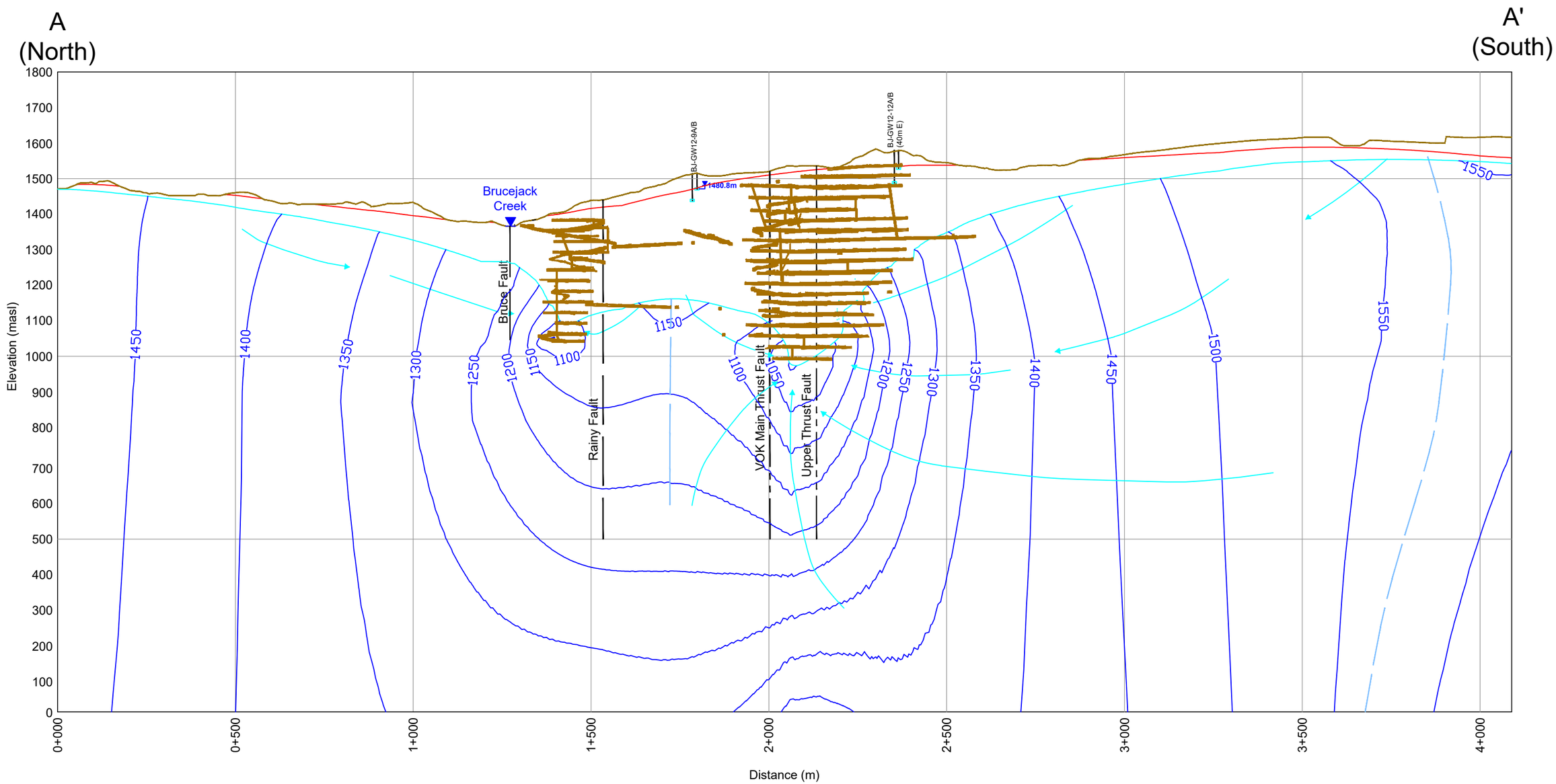

LEGEND

- Pre-mining Topography
- Hydraulic Head Contour
- Water Table (EOM)
- Water Table (Baseline)
- Groundwater Flow Path
- Groundwater Flow Divide
- Workings (EOM)
- Fault (Simulated Extents)
- Fault (Simulated Extents, Sensitivity Run 9 only)

Note: Only workings within 100m of the cross section are shown.

DATE SAVED:	Feb 06, 2023
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT: **4950 tpd Groundwater Model Update**

TITLE: Simulated End of Mine Water Table along Cross-Section A-A'

PROJECT #: A624-4

FIGURE: 5-7

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5.3.3 Baseflow

Mine dewatering diverts groundwater to the underground that would otherwise report to surface drainages and the WRTSF. The result is a modest reduction of baseflow in Brucejack Creek (Figure 5-8, Appendix F). The predicted baseflow reductions at BJ 1.74 and BJ 2.62 do not consider any increase in flow in Brucejack Creek that results from displacement of water in the WRTSF from waste rock and tailings deposition. By the end of operations in 2029, baseflow is predicted to decrease by approximately 7 L/s or 12% at BJ 3.10. At BJ 1.74, baseflow is predicted to decrease by 20 L/s or 25%. Predicted baseflow reductions are similar for both 4950 tpd and 3800 tpd models. The permitting groundwater model predicted comparable end of mine baseflow losses of 21% at BJL-H1, immediately downgradient of BJ 1.74 (BGC, 2015).

At the end of operations, the model simulates average annual seepage from the WRTSF towards the underground on the order of 96 m^3/d (1 L/s) with peak seasonal losses of 212 m^3/d (1.5 L/s) experienced in April (Figure 5-9). For reference, baseflow to the WRTSF under baseline conditions is simulated to be 5,360 m^3/d. At the end of operations, the simulated baseflow to the WRTSF is 4,620 m^3/d. Noting that this seepage loss to the underground working zone will then be dewatered and diverted back to the WRTSF, it is reasonable to conclude that the total water balance of the WRTSF associated with this seepage loss will not be impacted.

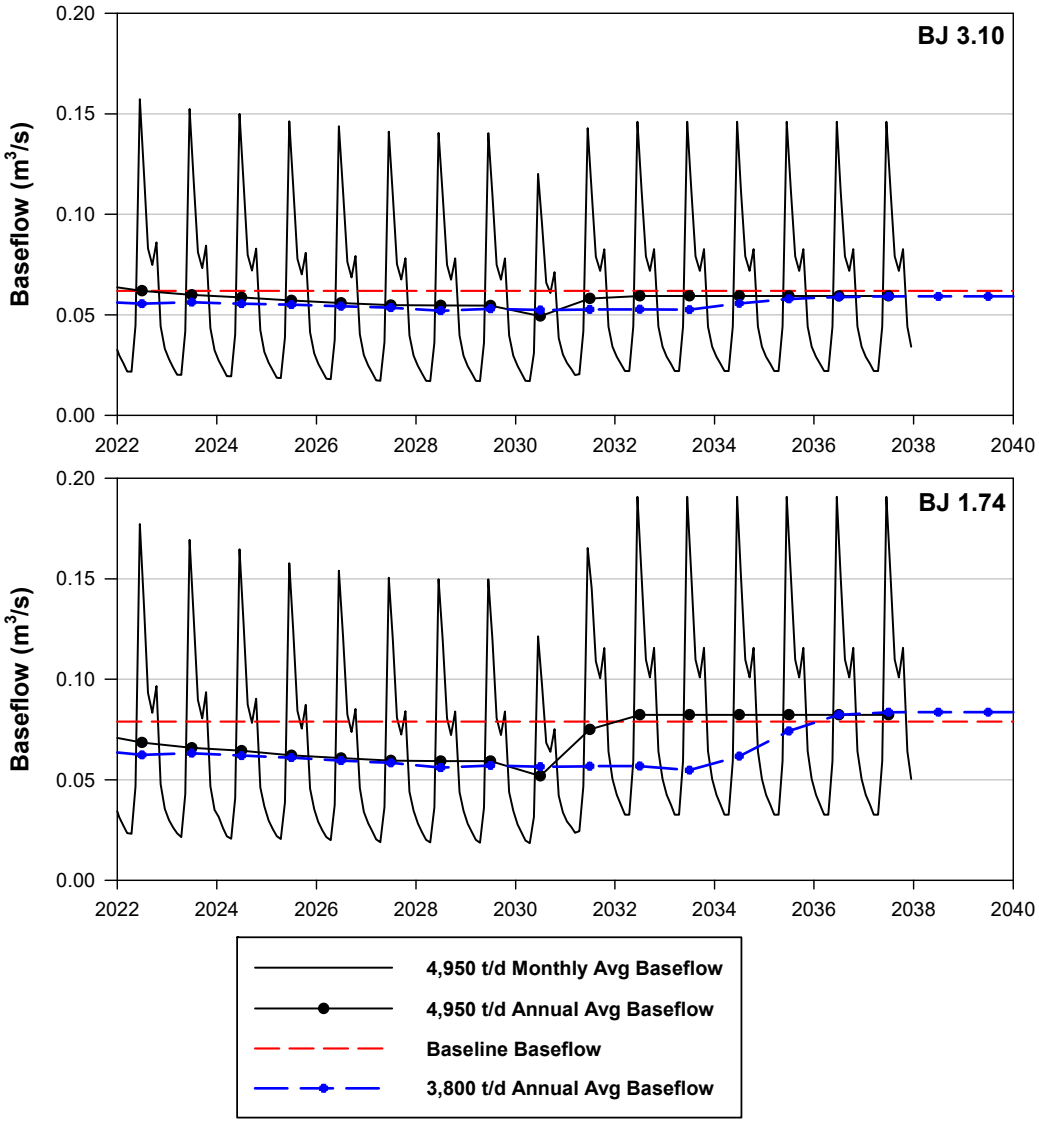


Figure 5-8: Simulated baseflow at BJ 3.10 and BJ 1.74 (2019-2040).

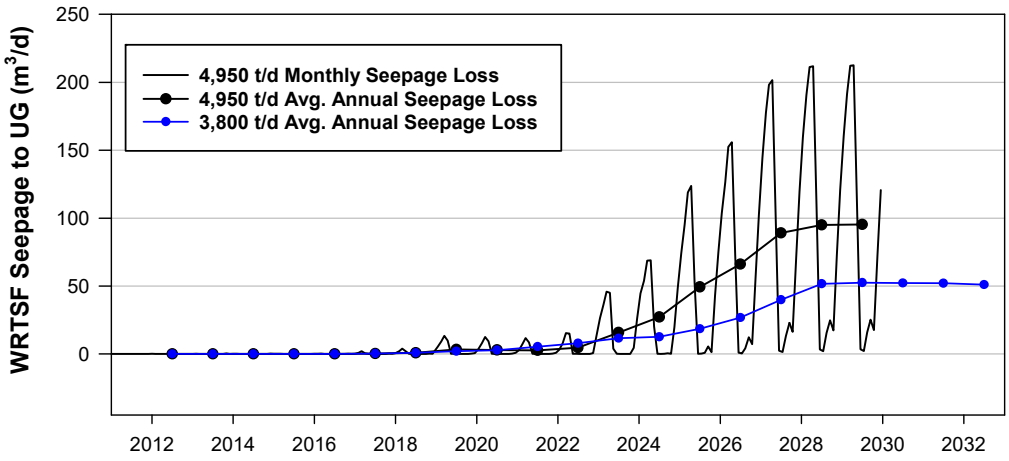


Figure 5-9: Simulated seepage losses from WRTSF to the mine.

6. Closure and Post-Closure

6.1 Overview

The closure period simulations have been updated for the 4950 tpd mine plan with mine reflooding starting in January 2030. Portal plugs will be installed at the West Zone and VOK portals and in a vent raise daylighting north of Brucejack Creek, to allow groundwater to recover above the portal elevations.

The groundwater model simulates flooding of the mine via two mechanisms: (i) groundwater inflows from surrounding areas and (ii) direct recharge over the mine area. Assisted flooding to the mine via BJ 3.10 reclaim is not simulated in the groundwater model, rather it is handled in the water balance and water quality models (Lorax, 2023a,b). Therefore, the results presented below represent natural recovery of the groundwater system and do not necessarily reflect the currently preferred closure option for the underground.

6.2 Model Setup

Mine closure was simulated in two phases: closure and post-closure. The closure phase covers the period of active mine reflooding as the groundwater system recovers to a new equilibrium. The post-closure phase simulates the equilibrium condition where the mine has reflooded to its ultimate elevation and the system responds to seasonal recharge. The objectives of the closure and post-closure simulations were as follows:

- To estimate the underground flooding time under passive conditions;
- To predict changes to the groundwater flow system (*i.e.,* groundwater elevations and flow) during flooding and after equilibration of the groundwater system; and
- To estimate groundwater discharge to surface water receptors in post-closure.

6.2.1 Temporal Discretization

As stated above, closure of Brucejack Mine was simulated in two groundwater modeling phases. In the closure phase, mine reflooding was simulated in a series of steady-state model runs to simulate inflow to the mine at different prescribed mine pool elevations. This produced an inflow rate versus mine pool elevation curve which was used in tandem with the mine volume elevation curve to compute a reflooding time.

The post-closure phase was simulated as a transient run lasting five years. The starting heads for this simulation were imported from the steady-state model where the head in the mine pool was near equilibrium elevation.

6.2.2 Boundary Conditions and Discrete Features

6.2.2.1 Recharge

The steady state models used to estimate mine reflooding time used the average annual recharge values described in Section 3.2.3. The transient mine reflooding simulation simulating post-closure recovery utilized the average annual recharge distribution described in Section 5.2.2.

6.2.2.2 Underground Workings

Drain nodes employed in the underground for operation phases were removed during closure. Groundwater flow within tunnels at closure was simulated using discrete features governed by the Darcy flow equation. To conservatively simulate good connectivity of the mine developments and ensure a flat-water level within the mine zone, the hydraulic conductivity of the discrete features was assumed to be 1 m/s. As most developments (including ramps, declines, and level crosscuts) have cross-section dimensions of 5 m by 5 m, the cross-sectional area of the discrete feature was set to 25 m^2.

6.2.2.3 Hydrogeological Units and Parameters

The groundwater model assumes that mine portals and the vent raise north of Brucejack Creek will be plugged at closure. Plugs were simulated using a hydraulic conductivity of 1E-08 m/s with a thickness of approximately 10 m, equivalent to the top layer thickness of the single element to which they were applied. The elevations of the West Zone and VOK portals are approximately 1365 masl and 1408 masl, respectively. The surface elevation of the currently proposed vent raise north of Brucejack Creek is 1392 masl.

No other changes to hydraulic parameters (hydraulic conductivity, specific storage, specific yield) were applied in the closure models.

6.3 Model Predictions

6.3.1 Natural Reflooding Time and Volumetric Fluxes

Groundwater flows to and from the mine under natural reflooding conditions are compared to the flooded elevation in the mine (VOK) in Figure 6-1. Results for both the 4950 tpd mine plan and 2020 Update (3800 tpd mine plan) are presented. For both mine plans, the initial flooding rates are high on account of the large hydraulic gradient between the mine void and upgradient areas. As the water level recovers in the mine, the hydraulic gradient towards the mine decreases, causing inflow rates to decline.

As the water level in the mine reaches approximately 1355 masl, hydraulic gradients start to reverse in the West Zone area causing mine contact water to flow towards Brucejack Creek. For the 4950 tpd mine plan, this happens about 17 months after the onset of

reflooding. In the 3800 tpd mine plan, gradient reversal occurred around 21 months after the onset of reflooding (Figure 6-1). Groundwater fluxes to and from the mine at closure are tabulated in Appendix G.

The flooded mine reaches an equilibrium where mine inflow equals mine outflow around 24 months after onset of flooding, several months faster than what was predicted for the 3800 tpd mine plan (Lorax, 2020b). The equilibrium contact water flux issuing from the 4950 tpd mine plan varies seasonally between 10.4 L/s and 22.9 L/s, averaging 14.9 L/s annually. This is 4.7 L/s higher than what was predicted by the 3800 tpd model (Lorax, 2020b). The increase in contact water flux arises from an overall larger mine excavation arising from development of extension areas of the Brucejack mineralization and advancement of the vent raise north of Brucejack Creek and exploration developments (Figure 2-11).

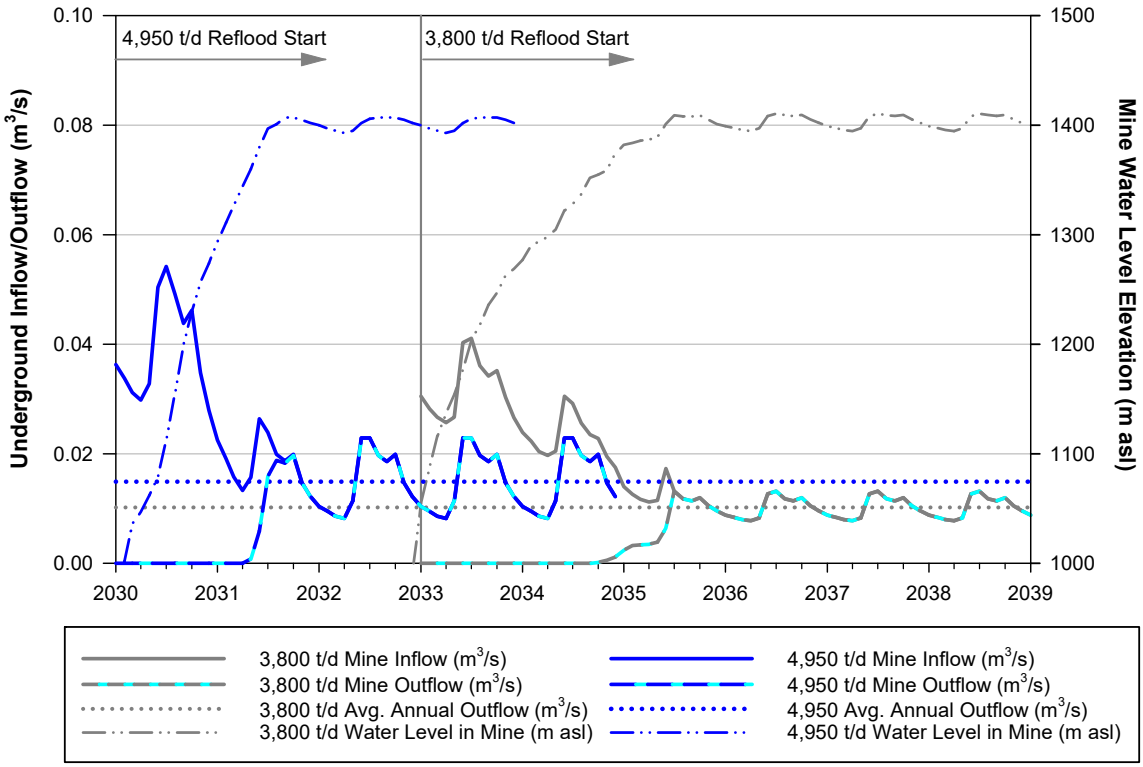


Figure 6-1: Simulated inflow to, outflow from, and water level in the mine during closure for 4950 tpd and 3800 tpd models.

6.3.2 Travel Time

The travel time from West Zone to Brucejack Creek is on the order of two days to one week, as estimated from particle-tracking modeling. Given the high connectivity simulated for the flooded mine zone and the close proximity of the West Zone to Brucejack Creek, it

is reasonable and conservative to assume a "zero" travel time for the mine contact water to Brucejack Creek for the purpose of water quality modeling (Lorax, 2023b).

Forward particle tracking (Figure 6-2) indicates that the majority of contact water from the flooded underground workings reports to a confined stretch along Brucejack Creek between BJ 2.62 and BJ 3.10, with some contact water reporting below BJ 2.62 and to the WRTSF itself. For the purpose of arriving at conservative water quality model predictions and thus an aggressive treatment strategy, an upper end value of 95% contact water flow reporting above 2.62 is assumed in the water quality model.

6.3.3 Groundwater Elevations

The equilibrium water level in the 4950 tpd mine is expected to vary seasonally between 1393 masl and 1407 masl, averaging 1401 masl. This is essentially equivalent to the equilibrium water level predicted for the 3800 tpd mine plan (Figure 6-1).

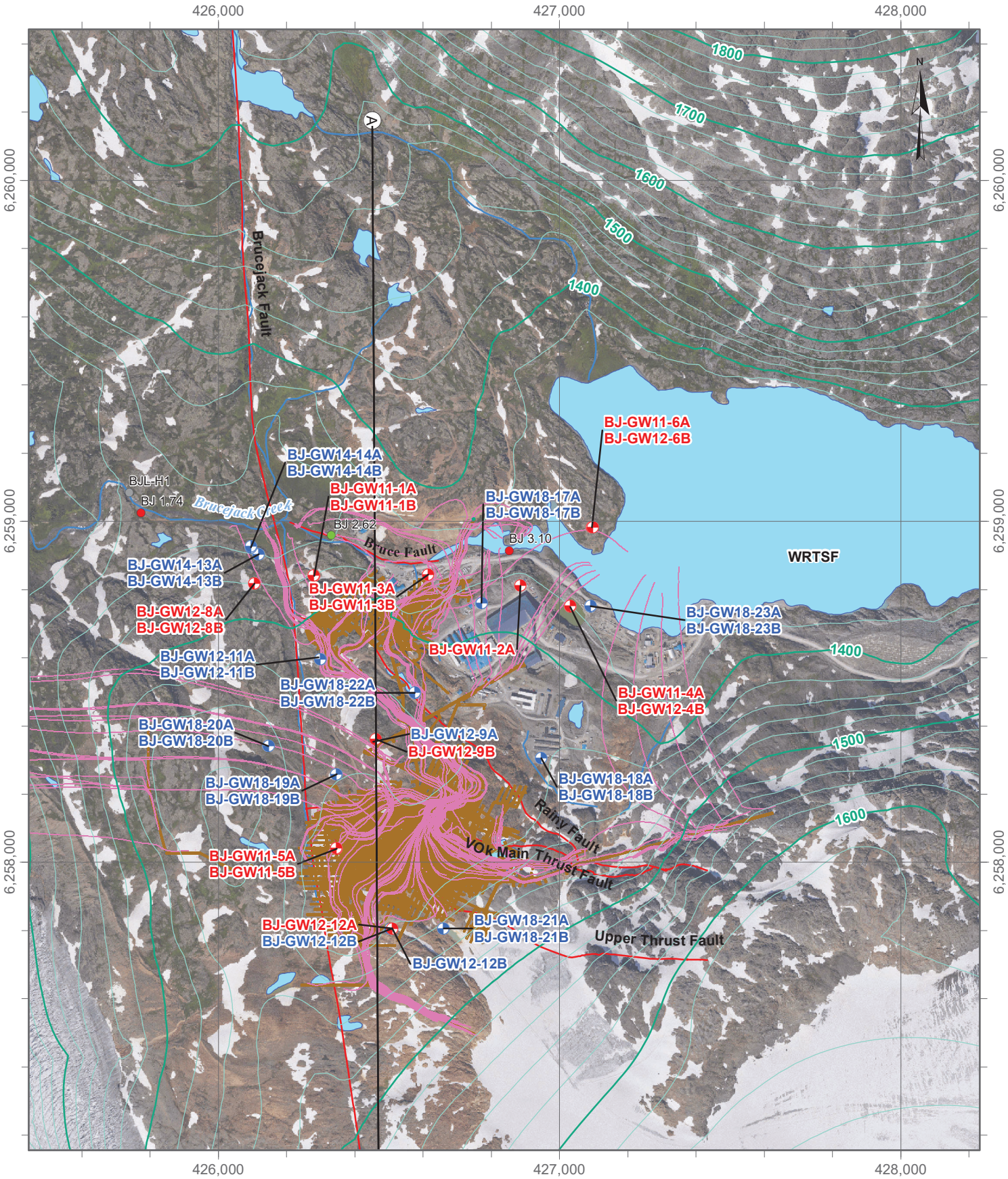
The simulated post-closure water table is shown in plan view in Figure 6-2 along with forward particle tracks from the mine area. The simulated post-closure water table along Section A-A' is shown in Figure 6-3. A map of post-closure drawdown is illustrated in Figure 6-4. The high connectivity of the underground developments at closure creates a flat water table within the mine footprint area. As a result, the horizontal hydraulic gradient through the mine footprint area is low, on the order of ~2.5%. Contact water generated within the VOK workings is simulated to flow primarily within the open underground tunnel network towards the West Zone.

The post-closure water table is over 100 m lower over the VOK footprint as compared to baseline conditions (Figure 6-3, Figure 6-4). Groundwater flowpaths towards Brucejack Creek re-establish in the post-closure period hence the trajectory of contact water forward particles towards Brucejack Creek (Figure 6-2).

The model predicts that the West Zone portal plug will potentially service up to 44 m of head. The model predicts annual average seepage through the plugged portal amounting to 20 m^3/day which varies seasonally between 10 m^3/day to 30 m^3/day.

6.3.4 Baseflow

Simulated baseflow at BJ 3.10 and BJ 1.74 through closure are presented for both 4950 tpd and 3800 tpd models in Figure 5-8 and Appendix F. The results are similar for both mine plan simulations. At both BJ 3.10 and BJ 1.74, baseflow is expected to return to within 5% of baseline levels within three years of the onset of mine reflooding. The original permitting model also predicted minimal (<5%) difference in baseflow at BJL-H1 (immediately below BJ 1.74) between baseline and closure periods. Therefore, findings of earlier effects assessment on surface water quantity in Brucejack Creek remain valid with respect to predicted changes in baseflow quantity.



LEGEND

- Baseline Water Level Calibration Target (Well)
- Other Monitoring Well
- SWQ Station
- Hydrometric Station
- Hydrometric Station (discontinued)
- Head Contour - Post-Closure (20m)
- Forward Particle Track
- Workings (EOM)
- Fault
- Cross Section

DATE SAVED:	Feb 06, 2023
DRAWN BY:	GM
REVIEWED:	LF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

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CLIENT:

NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Report

TITLE:

Simulated Water Table Post-Closure

PROJECT #: A624-4

FIGURE: 6-2

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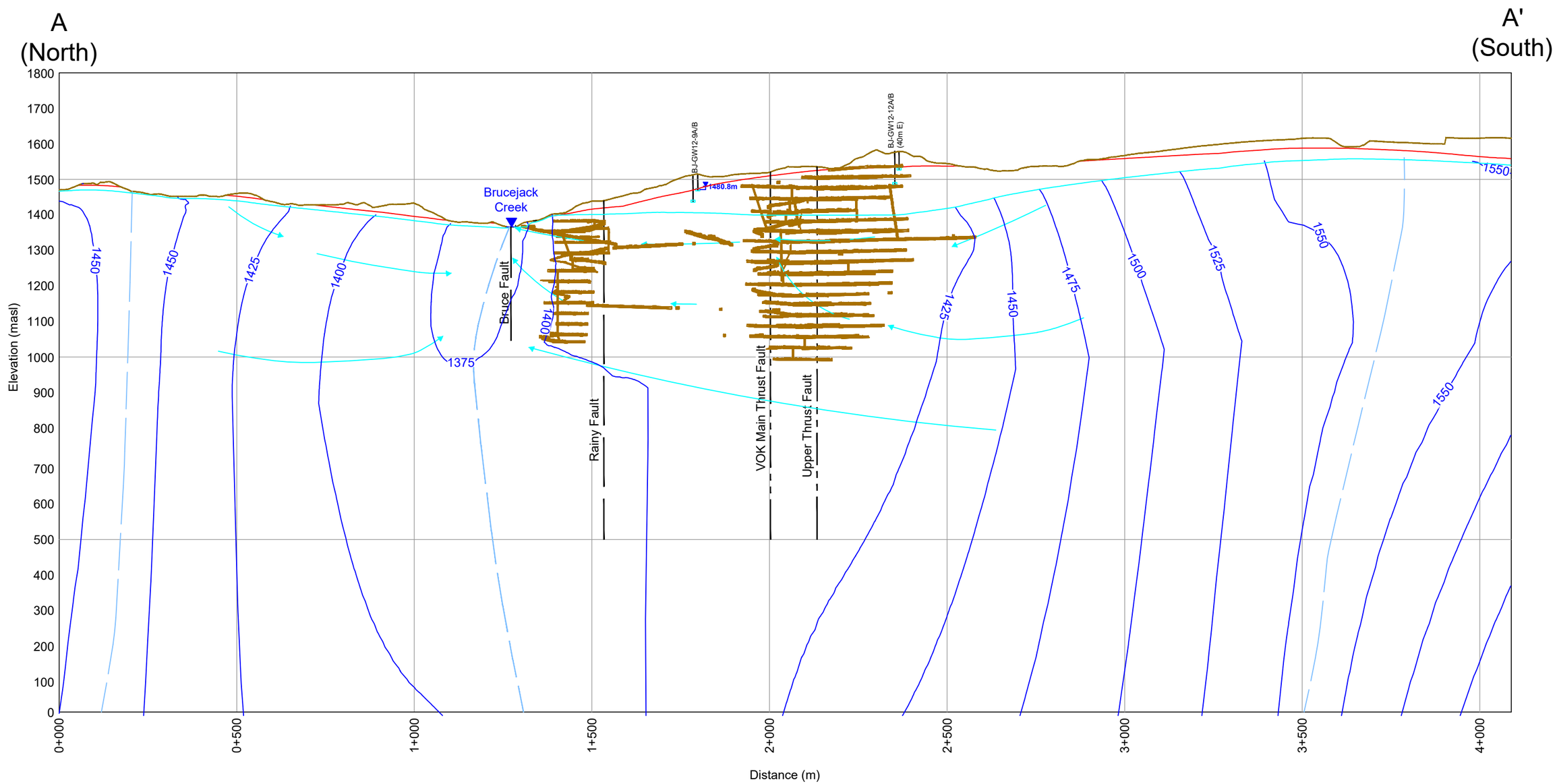

LEGEND

- Pre-mining Topography
- Hydraulic Head Contour
- Water Table (Post-Closure)
- Water Table (Baseline)
- Groundwater Flow Path
- Groundwater Flow Divide
- Workings (EOM)
- Fault (Simulated Extents)
- Fault (Simulated Extents, Sensitivity Run 9 only)

Note: Only workings within 100m of the cross section are shown.

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LORAX ENVIRONMENTAL

PROJECT: **4950 tpd Groundwater Model Update**

TITLE: Simulated Post-Closure Water Table along Cross-Section A-A'

PROJECT #: A624-4

FIGURE: 6-3

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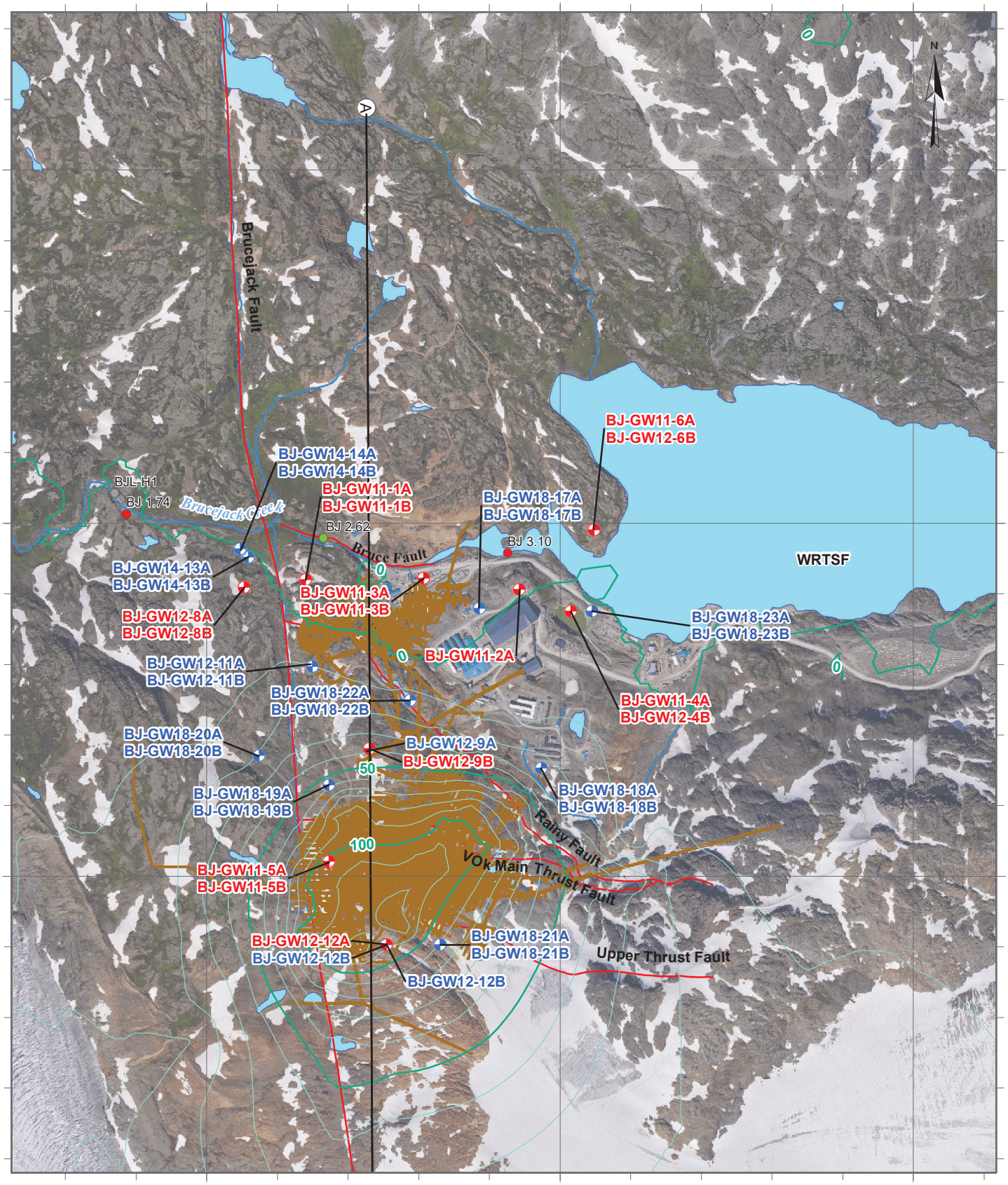

LEGEND

- Baseline Water Level Calibration Target (Well)
- Other Monitoring Well
- SWQ Station
- Hydrometric Station
- Hydrometric Station (discontinued)
- Drawdown Contour - Post-Closure (50m)
- Drawdown Contour - Post-Closure (10m)
- Workings (EOM)
- Fault
- Cross Section

DATE SAVED:	Feb 06, 2023
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REVIEWED:	JX
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

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0 100 200 Meters

CLIENT:

NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

PROJECT:

4,950 tpd Groundwater Model Report

TITLE:

Simulated Drawdown Post-Closure

PROJECT #: A624-4

FIGURE: 6-4

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7. Model Sensitivity and Uncertainty

7.1 Model Sensitivity

7.1.1 Introduction

A sensitivity analysis was performed on the 2020 3800 tpd groundwater model and was informed by an extensive sensitivity analysis performed on the 2015 permitting groundwater model (BGC, 2015; Lorax, 2020b). The 2020 model sensitivity analysis remains valid for the 4950 tpd groundwater model since the calibration has not been updated and the revised mine plan produces similar results as the 2020 model. The 2020 model sensitivity results are summarized here for completeness.

For reference, the 2020 model sensitivity runs are classified into four types (Table 7-1) after Brown (1996) as cited in Wels *et al.* (2012). Type IV parameters are the most problematic as they impact model predictions and are not constrained through model calibration.

Table 7-1:
Model sensitivity types (after Brown, 1996).

Change in Predicted Parameter		Change in Calibration	
	Effect	**Insignificant**	**Significant**
Change in Prediction Results	**Insignificant**	Type I	Type II
	Significant	Type IV	Type III

7.1.2 Methods

The 2020 model sensitivity analysis involved running parameter variations in steady state simulations of baseline and end of operations (2032) periods. Selected sensitivity runs were also carried forward into a steady-state simulation of post-closure conditions. Implications of parameter changes on mine pool elevation, mine flooding time, subsurface contact water fluxes to Brucejack Creek and plug leakage rates were evaluated. A threshold change of 15% relative to the calibrated case was used as the criterion for determining whether a change was considered “sensitive”. For sensitivity runs carried into post-closure, a change in mine pool elevation of 10 m or greater was considered sensitive.

7.1.3 Results

Table 7-2 summarizes the sensitivity analysis undertaken on the 2020 model. The first six runs explored changes in global hydraulic conductivity and recharge and combinations thereof. In general, these values were changed less broadly than in the original permitting

model (BGC, 2015) as a consequence of having a longer and dynamic calibration record to constrain parameter values. Other sensitivity analyses tested hydraulic conductivity of specific features (faults, portal plugs).

Sensitivity runs on global recharge and/or hydraulic conductivity (Runs 1 through 6, Table 7-2) were categorized as Type III, meaning both calibration results and predictions (operations or post-closure) were sensitive to parameter changes. Contact water fluxes and reflooding time were found to be reasonably insensitive to a two-fold increase in global hydraulic conductivity (Run 3) but were sensitive to a two-fold decrease in global hydraulic conductivity (Run 4). While the baseline water level targets do not support a two-fold change in global hydraulic conductivity values, it is useful to know if the model underestimates global hydraulic conductivity, it will not necessarily underestimate contact water fluxes to Brucejack Creek. If the model overpredicts global hydraulic conductivity, mine reflooding times may be longer than simulated, however, contact fluxes to Brucejack Creek would be smaller.

The hydraulic conductivity of faults (Figure 2-6) were tested in Runs 7 through 10 (Table 7-2). Run 7 increased the K of the Rainy and Brucejack faults ten-fold. This resulted in a deterioration of the water level calibration and had a significant impact on predictions (Type III). A ten-fold reduction in fault conductivity values (Run 8) impacted the water level calibration but did not impact predictions (Type II).

Two thrust faults in the mine area (VOK Main Thrust and Upper Thrust, Section 2.4.2) were not explicitly simulated in the 2020 model. Both increasing and decreasing the hydraulic conductivity of these features (Runs 9 and 10) did not impact calibration results nor predictions. These features are only intermittently, if at all, intersected by the mine workings, so the insensitivity of the model to these features is not surprising.

Several post-closure runs were conducted where the properties of the portal plugs were tested. In the absence of plugs (Run 14), average annual discharge from the West Zone portal to Brucejack Creek is simulated to be ~70% higher than the combined contact water flux and plug leakage of the base case model. The elevation of the mine pool in this scenario is limited by the spill point of the West Zone portal (1365 masl).

Table 7-2:
Sensitivity analysis on 2020 FEFLOW model.

Simulation Runs[1]	Description	Calibration Sensitivity for Baseline Model					Predictive Simulation (End of Operation)[3]					Predictive Simulation (Closure)[4]								Sens. Type[2,5]
		Water Level		Baseflow			Underground Flows		Baseflow			Mine Pool Water Level (masl)	Sens.[2]	Contact Water Discharge to Brucjeack Creek (L/s)	Sens.[2]	Mine Flooding Time (Years)	Sens.[2]	Plug Leakage (L/s)	Sens.[2]	
		% NRMSE	Sens.[2]	BJ 3.10 (m^3/s)	BJ 1.74 (m^3/s)	Sens.[2]	UG Inflow (m^3/s)	Sens.[2]	BJ 3.10 (m^3/s)	BJ 1.74 (m^3/s)	Sens.[2]									
Observed	Observed Calibration Data	n/a	n/a	0.061	0.074	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Base Case	**Kb[6] and Rb[7] (K Plugs= 1E-08 m/s)**	**7.0%**	**n/a**	**0.062**	**0.079**	**n/a**	**0.036**	**n/a**	**0.051**	**0.054**	**n/a**	**1404**	**n/a**	**10**	**n/a**	**2.5**	**n/a**	**0.45**	**n/a**	**n/a**
S.A. Run 1	Recharge = 1.2 x Rb[8]	8.3%	SEN	0.075	0.097	SEN	0.040	INS	0.064	0.068	SEN									Type III
S.A. Run 2	Recharge = 0.8 x Rb[9]	8.6%	SEN	0.049	0.062	SEN	0.032	INS	0.039	0.04	SEN									Type III
S.A. Run 3	K = 2 x Kb (for all units)	19.5%	SEN	0.058	0.071	INS	0.049	SEN	0.04	0.04	SEN	1390	SEN	11	INS	2.5	INS	0.49	INS	Type III
S.A. Run 4	K = 0.5 x Kb (for all units)	15.5%	SEN	0.061	0.082	INS	0.027	SEN	0.055	0.061	INS	1420	SEN	7.8	SEN	4	SEN	0.33	SEN	Type III
S.A. Run 5	Case 1 + Case 3	15.0%	SEN	0.071	0.089	INS	0.054	SEN	0.052	0.052	INS									Type III
S.A. Run 6	Case 2 + Case 4	11.8%	SEN	0.05	0.065	SEN	0.024	SEN	0.043	0.047	INS									Type III
S.A. Run 7	K for all faults = 1E-5 m/s	20.1%	SEN	0.053	0.079	INS	0.063	SEN	0.041	0.041	SEN									Type III
S.A. Run 8	K for all Faults= Kb x 0.1	14.8%	SEN	0.061	0.073	INS	0.033	INS	0.053	0.055	INS									Type II
S.A. Run 9	K for Thrust Faults same as Rainy Fault and Brucejack Fault	7.4%	INS	0.062	0.08	INS	0.038	INS	0.05	0.053	INS									Type I
S.A. Run 10	K for Thrust Faults = Kb x 0.1	7.1%	INS	0.062	0.079	INS	0.035	INS	0.051	0.054	INS									Type I
S.A. Run 11	K Plugs = 1E-10 m/s	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1405	INS	10.2	INS	n.c.	n.c.	0.45	INS	Type I
S.A. Run 12	K Plugs = 1E-06 m/s	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1403	INS	9.5	INS	n.c.	n.c.	0.5	INS	Type I
S.A. Run 13	K Plugs = 1E-04 m/s	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1395	SEN	6.7	SEN	n.c.	n.c.	6.8	SEN	Type IV
S.A. Run 14	Plugs Absent	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1365	SEN	0.7	SEN	n.c.	n.c.	17.7	SEN	Type IV

Notes:

n/a = not applicable, n.c. = not computed

1. S.A. = sensitivity analysis
2. Sens. = sensitivity; SEN = sensitive parameter change with respect to calibration or prediction metrics (>15% difference from base case); INS = indicates an insensitive parameter change (<15% difference from base case). For mine pool elevation, a difference of >20 m from base case is considered sensitive.
3. End of operations steady-state model results.
4. Closure steady-state model results.
5. Sensitivity type classified as per Table 7-1.
6. Kb = hydraulic conductivity distribution from baseline model.
7. Rb = recharge rate from the calibrated baseline model.
8. Equivalent to 1 in 10 wet year.
9. Equivalent to 1 in 10 dry year.

Mine pool elevation, contact flux to Brucejack Creek and plug leakage are insensitive to plug hydraulic conductivity values that are less than or equal to 1E-06 m/s. Once the plug hydraulic conductivity increases to 1E-04 m/s, subsurface contact water fluxes decrease markedly, but are offset by large plug leakage rates. It is unlikely that an engineered plug would be constructed with a hydraulic conductivity of 1E-06 m/s or greater. In a review of design guidelines for permanent tunnel plugs, Lang (1999) indicates seepage should never occur through a plug or along the rock/concrete contact but will always occur to some extent through the surrounding rock mass. Lang (1999) indicates that seepage rates of less than 0.5 L/s measured 20 m downstream of a plug can be easily achieved where the hydraulic conductivity of the rock mass is less than 1E-07 m/s. Therefore, while a significant increase in plug K values constitutes a Type IV parameter, it is reasonable to assume that much better plug performance and lower leakage rates through and around the plug can be achieved at closure.

Overall, the 2020 sensitivity analysis supported the use of the parameter values calibrated during model development. The same holds true for the 4950 tpd model since updates to this version of the model essentially amount to an accelerated mine plan of similar spatial extent while employing the same parameters. Any required future re-calibration of the model is expected to require only small adjustments in hydraulic conductivity and/or recharge.

7.2 Model Uncertainty

The dewatering data collected between 2019 and 2021, which form the basis of the groundwater model validation, provide opportunity to assess uncertainty in model predictions going forward. Figure 7-1 focuses on this time period and includes percent differences between simulated and observed dewatering rates.

In examining the 2020 model predictions, which used average climate and the proposed mine plan after Jones *et al.* (2019), the model generally overpredicts flows over the 2019 to 2021 period. More specifically:

- The largest percent differences from observed values occur during the low flow period, typically in March or April. March and April flows are overpredicted by 90% on average.
- During the open water season (May through October) flow rates are overpredicted by 30% on average. During the highest flow months (June, July), the model overpredicts flows on average by 20%.
- The largest overprediction during the open water season (by 100%) occurred in May 2021. This was due do a delayed freshet where overnight temperatures stayed below zero essentially until June.

Note that the percent differences above do not consider ventilation losses that are presumed to occur on the order of 130 m^3/d (Section) and therefore are biased high.

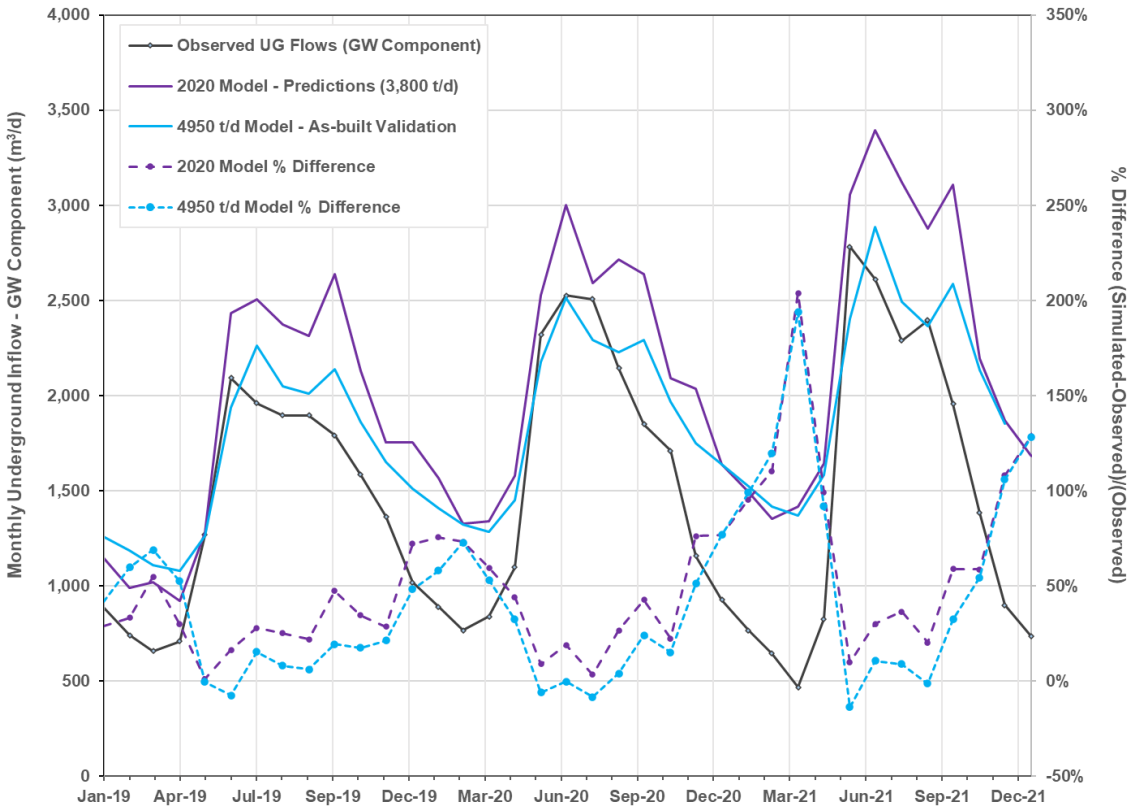

Figure 7-1: Simulated and observed groundwater inflows (2019-2021).

The 4950 tpd model simulates the 2019-2021 period using an approximate as-built annual mine plan and actual climate patterns. Therefore, differences between simulated and observed flow rates are more strongly attributed to model parameterization (hydraulic parameters, recharge distribution) than to the mine plan. The 4950 tpd model still overestimates low flows, but more accurately estimates open water season flows than the 2020 model (Figure 7-1). More specifically:

- Over the May to October open water season, the model overpredicts flows by 10% on average. During the highest flow months the 4950 tpd model underpredicts flows by 10% in June, and overpredicts flows by 10% in July.
- During the lowest flow months (March and April), the 4950 tpd model overpredicts flows by 90%.

The above suggests that if the mine plan were to be closely followed and average climate experienced, measured winter low flow data would still be ~90% less that the simulated values but open water season flows would be well constrained. The overprediction of

winter low flow data is flagged for future study. Initial attempts to reconcile winter low flows by lowering bedrock storage values did not significantly improve predictions, therefore other avenues of investigation are flagged for consideration.

Overall, the assumptions underpinning the groundwater model are conservative, and likely to overpredict future dewatering rates. The combined uncertainty in model predictions for future operations arising from model parameterization and deviations from the proposed mine plan and average climate may lead to an overestimation of open water and low flow season flow dewatering rates of 30% and 90%, respectively. The conservativeness of the groundwater model is considered appropriate for the objectives it is seeking to fulfil (Section 1.2).

8. Conclusions and Recommendations

8.1 Conclusions

The Brucejack groundwater model has been updated in support of a proposed production increase from 3800 tpd to 4950 tpd. Prior to this, the 3800 tpd groundwater model was most recently updated in support of the 2020 Update (Lorax, 2020b in Pretium, 2020). Data collected between 2018 and 2021 were used to validate the 2020 groundwater model which was modified to reflect as-built mine progress and, subsequently, future mine progress proposed under the 4950 tpd mine plan. The main findings of the groundwater model presented herein are as follows:

- Over the calibration and validation periods (2011-2018 and 2019-2021, respectively), the groundwater model reasonably simulates temporal and spatial trends in groundwater levels. The model also reasonably simulates long-term trends and seasonal fluctuations in underground dewatering rates, although winter dewatering rates tend to be overpredicted on the order of 450 m^3/d to 900 m^3/d. The validation period data confirmed that simulated hydraulic parameters and recharge are appropriate and that model recalibration was not warranted.
- Predicted peak monthly average dewatering rates for future operations are expected to stabilize in the last three years of mining at ~4,300 m^3/d. This is similar to peak rates predicted by the 3800 tpd model. Low flow dewatering rates are predicted to stabilize around 2,600 m^3/d which is ~500 m^3/d higher than the 3800 tpd mine plan. However, since the increased production rate is associated with a shorter mine life, the cumulative dewatered volume from the mine is predicted to be 15% lower than that predicted for the 3800 tpd mine plan.
- Monitoring wells across the mine site are predicted to experience on average 15 m more drawdown by the end of mining in 2029 than what was predicted for the 3800 tpd model. This is attributed to differences in the 4950 tpd mine extents which include slightly deeper and broader mine workings in the VOK area; long exploration drifts extended west, south and east of the VOK; and a vent raise advanced north of Brucejack Creek.
- The groundwater model predicts that the 4950 tpd mine will passively reflood to its penultimate elevation in 24 months, in the absence of assisted flooding. This is several months quicker than the 3800 tpd mine plan. The ultimate water level elevation in the mine is simulated to vary between 1393 masl and 1407 masl, averaging 1401 masl on an annual basis, provided that plugs are installed at the

VOK and West Zone portals and in the vent raise daylighting north of Brucejack Creek. This is consistent with predictions for the 3800 tpd mine plan.

- Contact water fluxes generated from the flooded mine are simulated to range seasonally between 10.4 L/s and 22.9 L/s, averaging 14.9 L/s annually. This is 4.7 L/s higher than what was predicted by the 3800 tpd model and is attributed to expansion of the mine extents as listed in the third bullet. The majority of contact water reports to Brucejack Creek between BJ 2.62 and BJ 3.10, with some contact water reporting below BJ 2.62 and to the WRTSF itself. For the purpose of arriving at conservative water quality model predictions and thus an aggressive treatment strategy, an upper end value of 95% contact water flow reporting above BJ 2.62 is assumed in the water quality model.
- The model predicts a 25% reduction in baseflow in Brucejack Creek at station BJ 1.74 by the end of operations in 2029. Baseflow is expected to recover 4% above baseline levels within three years of mine closure. These changes in baseflow are similar to those predicted for the 3800 tpd mine plan and the original 2700 tpd mine plan permitted in 2015, noting that baseflow offsets arising from tailings and waste rock deposition in the WRTSF have not been considered in either the current or previous modelling assessments. Therefore, findings of earlier effects assessment on surface water quantity in Brucejack Creek remain valid with respect to predicted changes in baseflow quantity.
- Sensitivity analyses performed on the 3800 tpd model remain valid for the 4950 tpd model and indicate that most parameters that influence model predictions are constrained in the calibration process. It is anticipated that future updates to the groundwater model will likely be associated with localized parameter adjustments to improve the model accuracy.
- Overall, the assumptions underpinning the groundwater model are conservative, and likely to overpredict future dewatering rates. The combined uncertainty in model predictions for future operations arising from model parameterization and deviations from the proposed mine plan and average climate may lead to an overestimation of open water and low flow season flow dewatering rates of 30% and 90%, respectively.

8.2 Recommendations

The 4950 tpd groundwater model update has benefited from a comprehensive environmental monitoring program that includes daily record keeping of underground pumping and recirculation volumes, dedicated water level dataloggers at all active

monitoring wells, a well-maintained site weather station, and routine streamflow monitoring. Continued implementation of this monitoring program will be instrumental in future groundwater model validation.

It is recommended that future updates of the groundwater model include new faults which may impart non-trivial hydrogeological influence on the mine. For instance, inclusion of a newly identified fault skirting the eastern extents of the mine may improve calibration to observed water levels in wells east of the West Zone. Focus should also be placed on resolving disparity between simulated and observed winter dewatering rates.

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Appendices

Appendix A: Hydraulic Testing Summary

NEWCREST

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Appendix A. Brucejack Hydraulic Testing Summary

Monitoring Well / Borehole ID	Easting[1] (m)	Northing[1] (m)	Elevation[1] (m asl)	Dip	Az.	Reference	Test Type	Test Interval (m AH)			Test Interval (v m mbgs)			Simplified Geology[2]	K (m/s)
								From	To	Length (m)	From	To	Midpoint		
SU-77	426,599	6,258,328	1,507.16	-64	180	BGC (2014b, 2015b)	Packer	67.5	96.6	26.2	74.0	104.5	89.3	Conglomerate	1.2E-07
SU-77	426,599	6,258,328	1,507.16	-63	180	BGC (2014b, 2015b)	Packer	174.2	203.3	26	180.8	208.6	194.7	Conglomerate	4.7E-07
SU-77	426,599	6,258,328	1,507.16	-63	180	BGC (2014b, 2015b)	Packer	308.3	337.4	25.9	321.6	340.9	331.2	Volcanic Sedimentary Facies	1.5E-08
SU-82	426,510	6,258,042	1,541.57	-59	247	BGC (2014b, 2015b)	Packer	97.2	127.1	25.7	74.8	96.2	85.5	Volcanic Sedimentary Facies	7.8E-08
SU-82	426,510	6,258,042	1,541.57	-59	247	BGC (2014b, 2015b)	Packer	219.9	249	25.1	175.8	209.8	192.8	Fragmental Volcanics	4.3E-06
SU-88	426,572	6,258,921	1,389.77	-76	360	BGC (2014b, 2015b)	Packer	55.3	84.4	28.3	56.3	84.7	70.5	Fragmental Volcanics	7.9E-08
DH-BGC12-19	426,567	6,258,826	1,365.04	-75	131	BGC (2014b, 2015b)	Packer	50.9	55.5	4.4	50.1	55.1	52.6	Conglomerate	1.6E-07
DH-BGC12-19	426,567	6,258,826	1,365.04	-75	131	BGC (2014b, 2015b)	Packer	215.5	220.1	4.4	209.4	214.7	212.0	Volcanic Sedimentary Facies	2.6E-07
DH-BGC12-19	426,567	6,258,826	1,365.04	-75	131	BGC (2014b, 2015b)	Packer	313	317.6	4.4	305.2	310.4	307.8	Intrusive	3.3E-07
DH-BGC12-19	426,567	6,258,826	1,365.04	-75	131	BGC (2014b, 2015b)	Packer	401.4	425.8	23.6	402.2	429.2	415.7	Conglomerate	3.9E-08
DH-BGC12-20	426,552	6,258,607	1,419.00	-76	222	BGC (2014b, 2015b)	Packer	33.2	50	16.3	45.1	65.0	55.0	Mixed Units	3.9E-07
DH-BGC12-20	426,552	6,258,607	1,419.00	-76	222	BGC (2014b, 2015b)	Packer	127.7	149.0	20.7	146.7	171.4	159.1	Conglomerate	1.7E-08
DH-BGC12-20	426,552	6,258,607	1,419.00	-76	222	BGC (2014b, 2015b)	Packer	240.5	264.9	23.7	259.5	280.9	270.2	Volcanic Sedimentary Facies	1.7E-07
DH-BGC12-20	426,552	6,258,607	1,419.00	-76	222	BGC (2014b, 2015b)	Packer	380.7	403.6	22.2	398.0	425.8	411.9	Volcanic Sedimentary Facies	6.4E-08
DH-BGC12-21	426,406	6,258,223	1,499.00	-75	-145	BGC (2014b, 2015b)	Packer	36.6	50.6	13.5	32.7	46.7	39.7	Intrusive	1.6E-07
DH-BGC12-21	426,406	6,258,223	1,499.00	-75	-145	BGC (2014b, 2015b)	Packer	131.4	148.1	16.1	122.1	138.1	130.1	Intrusive	3.5E-08
DH-BGC12-21	426,406	6,258,223	1,499.00	-75	-145	BGC (2014b, 2015b)	Packer	228.9	248.6	19	219.9	240.9	230.4	Intrusive	1.0E-08
DH-BGC12-21	426,406	6,258,223	1,499.00	-75	-145	BGC (2014b, 2015b)	Packer	331	349.3	17.7	323.8	341.9	332.9	Volcanic Sedimentary Facies	3.8E-08
DH-BGC12-21	426,406	6,258,223	1,499.00	-75	-145	BGC (2014b, 2015b)	Packer	417.9	437.7	19.1	410.4	431.2	420.8	Volcanic Sedimentary Facies	1.7E-06
DH-BGC12-22	426,481	6,257,936	1,539.76	-75	36	BGC (2014b, 2015b)	Packer	50.9	61.6	10.3	41.3	52.2	46.8	Volcanic Sedimentary Facies	1.9E-08
DH-BGC12-22	426,481	6,257,936	1,539.76	-75	36	BGC (2014b, 2015b)	Packer	258.2	271.9	13.2	245.3	259.5	252.4	Fragmental Volcanics	1.2E-07
DH-BGC12-22	426,481	6,257,936	1,539.76	-75	36	BGC (2014b, 2015b)	Packer	361.8	381.6	19.1	351.8	371.7	361.7	Mixed Units	4.3E-08
DH-BGC12-23	426,503	6,257,856	1,583.69	-70	271	BGC (2014b, 2015b)	Packer	189.6	210	19.2	170.2	187.8	179.0	Mixed Units	3.8E-07
DH-BGC12-23	426,503	6,257,856	1,583.69	-70	271	BGC (2014b, 2015b)	Packer	308.5	331.3	21.5	271.9	292.0	281.9	Intrusive	8.6E-09
DH-BGC12-23	426,503	6,257,856	1,583.69	-70	271	BGC (2014b, 2015b)	Packer	491.3	513	20.3	420.3	437.5	428.9	Intrusive	9.4E-07
DH-BGC12-23	426,503	6,257,856	1,583.69	-70	271	BGC (2014b, 2015b)	Packer	531	550.3	18.2	453.9	470.2	462.1	Mixed Units	2.0E-08
DH-BGC12-24	426,646	6,257,878	1,547.61	-68	2	BGC (2014b, 2015b)	Packer	292.6	306.3	12.7	271.4	283.0	277.2	Mixed Units	3.1E-08
DH-BGC12-24	426,646	6,257,878	1,547.61	-68	2	BGC (2014b, 2015b)	Packer	384.1	406.9	21.2	358.2	380.9	369.5	Volcanic Sedimentary Facies	2.7E-08
DH-BGC12-24	426,646	6,257,878	1,547.61	-68	2	BGC (2014b, 2015b)	Packer	432.8	458.7	24	407.1	432.6	419.9	Volcanic Sedimentary Facies	1.9E-08
DH-BGC12-24	426,646	6,257,878	1,547.61	-68	2	BGC (2014b, 2015b)	Packer	460.3	470.9	9.9	433.6	443.8	438.7	Volcanic Sedimentary Facies	6.7E-08
DH-BGC12-25	426,350	6,258,086	1,527.77	-45	176	BGC (2014b, 2015b)	Packer	198.7	212.5	9.7	164.4	174.1	169.3	Mixed Units	3.3E-08
DH-BGC12-25	426,350	6,258,086	1,527.77	-45	176	BGC (2014b, 2015b)	Packer	238.7	255.4	11.9	196.6	212.6	204.6	Mixed Units	3.9E-07
DH-BGC12-32	426,981	6,258,578	1,410.76	-75	240	BGC (2014b, 2015b)	Packer	30.2	50	19.1	29.4	49.8	39.6	Conglomerate	1.8E-07
DH-BGC12-33	427,073	6,258,623	1,392.65	-75	95	BGC (2014b, 2015b)	Packer	14	30.8	16.2	15.5	31.3	23.4	Fragmental Volcanics	1.4E-06
DH-BGC12-34	427,046	6,258,650	1,395.96	-75	244	BGC (2014b, 2015b)	Packer	14.6	31.4	16.2	14.7	31.6	23.1	Fragmental Volcanics	4.6E-07
DH-BGC12-35	427,021	6,258,692	1,389.40	-75	154	BGC (2014b, 2015b)	Packer	16.2	32.9	16.2	15.4	31.3	23.4	Volcanic Sedimentary Facies	1.5E-07
MW-BGC11-BJ-2A	426,885	6,258,812	1,423.17	-90	0	BGC (2014b, 2015b)	Slug	64.9	80.3	15.4	64.9	80.3	72.6	Intrusive	1.1E-06
MW-BGC11-BJ-3A	426,615	6,258,844	1,367.63	-90	0	BGC (2014b, 2015b)	Slug	79.3	88.4	9.1	79.3	88.4	83.9	Intrusive	2.4E-06
MW-BGC11-BJ-3B	426,615	6,258,844	1,367.53	-90	0	BGC (2014b, 2015b)	Slug	4.5	9.1	4.6	4.5	9.1	6.8	Intrusive	6.2E-06
MW-BGC11-BJ-4A	427,031	6,258,750	1,390.46	-90	0	BGC (2014b, 2015b)	Slug	18.0	31.0	13.0	18.0	31.0	24.5	Fragmental Volcanics	3.0E-09
MW-BGC12-BJ-4B	427,031	6,258,752	1,390.43	-90	0	BGC (2014b, 2015b)	Packer	93.2	97.8	4.6	93.2	97.8	95.5	Volcanic Sedimentary Facies	2.0E-07
MW-BGC11-BJ-5B	426,346	6,258,042	1,526.16	-90	0	BGC (2014b, 2015b)	Slug	39.6	50.9	11.3	39.6	50.9	45.3	Fragmental Volcanics	1.3E-06
MW-BGC11-BJ-6A	427,095	6,258,983	1,379.81	-90	0	BGC (2014b, 2015b)	Slug	20.7	31.8	11.1	20.7	31.8	26.3	Fragmental Volcanics	1.8E-07
MW-BGC12-BJ-6B	427,097	6,258,982	1,379.56	-90	0	BGC (2014b, 2015b)	Slug	98.2	103.8	5.6	98.2	103.8	101	Fragmental Volcanics	2.4E-07

Appendix A. Brucejack Hydraulic Testing Summary

Monitoring Well / Borehole ID	Easting[1] (m)	Northing[1] (m)	Elevation[1] (m asl)	Dip	Az.	Reference	Test Type	Test Interval (m AH)			Test Interval (v m mbgs)			Simplified Geology[2]	K (m/s)
								From	To	Length (m)	From	To	Midpoint		
MW-BGC12-BJ-6B	427,097	6,258,982	1,379.56	-90	0	BGC (2014b, 2015b)	Packer	66.8	78.3	11.5	66.8	78.3	72.6	Fragmental Volcanics	2.6E-08
MW-BGC12-BJ-6B	427,097	6,258,982	1,379.56	-90	0	BGC (2014b, 2015b)	Packer	48.7	51.8	3.1	48.7	51.8	50.2	Fragmental Volcanics	1.5E-07
MW-BGC12-BJ-8A	426,106	6,258,818	1,403.38	-90	0	BGC (2014b, 2015b)	Packer	18.6	23.1	4.6	18.6	23.1	20.8	Intrusive	4.4E-06
MW-BGC12-BJ-8A	426,106	6,258,818	1,403.38	-90	0	BGC (2014b, 2015b)	Packer	48.7	53.1	4.5	48.7	53.1	50.9	Intrusive	8.1E-08
MW-BGC12-BJ-8A	426,106	6,258,818	1,403.38	-90	0	BGC (2014b, 2015b)	Packer	63.7	68.1	4.5	63.7	68.1	65.9	Intrusive	2.6E-07
MW-BGC12-BJ-8A	426,106	6,258,818	1,403.38	-90	0	BGC (2014b, 2015b)	Packer	87.6	92.1	4.6	87.6	92.1	89.8	Intrusive	4.6E-06
MW-BGC12-BJ-8B	426,106	6,258,819	1,403.30	-90	0	BGC (2014b, 2015b)	Slug	44.3	51.0	6.7	44.3	51.0	47.6	Intrusive	2.8E-07
MW-BGC12-BJ-9A	426,465	6,258,361	1,514.40	-90	0	BGC (2014b, 2015b)	Packer	25.1	29.7	4.6	25.1	29.7	27.4	Intrusive	3.7E-08
MW-BGC12-BJ-9A	426,465	6,258,361	1,514.40	-90	0	BGC (2014b, 2015b)	Packer	36.5	41	4.5	36.5	41	38.8	Intrusive	9.8E-08
MW-BGC12-BJ-9A	426,465	6,258,361	1,514.40	-90	0	BGC (2014b, 2015b)	Packer	75.5	80	4.5	75.5	80	77.8	Intrusive	2.8E-07
MW-BGC12-BJ-9B	426,461	6,258,362	1,514.56	-90	0	BGC (2014b, 2015b)	Slug	38.4	47.4	9	38.4	47.4	42.9	Intrusive	8.3E-07
MW-BGC12-BJ-10A	426,989	6,258,341	1,445.59	-90	0	BGC (2014b, 2015b)	Packer	15.7	20.3	4.6	15.7	20.3	18.0	Fragmental Volcanics	7.1E-08
MW-BGC12-BJ-10A	426,989	6,258,341	1,445.59	-90	0	BGC (2014b, 2015b)	Packer	42.7	50.3	7.6	42.7	50.3	46.5	Fragmental Volcanics	1.4E-08
MW-BGC12-BJ-10B	426,989	6,258,341	1,445.64	-90	0	BGC (2014b, 2015b)	Slug	35.6	41.4	5.8	35.6	41.4	38.5	Fragmental Volcanics	7.9E-07
MW-BGC12-BJ-11B	426,299	6,258,595	1,432.96	-90	0	BGC (2014b, 2015b)	Packer	34	38.6	4.6	34	38.6	36.3	Intrusive	4.0E-07
MW-BGC12-BJ-11B	426,299	6,258,595	1,432.96	-90	0	BGC (2014b, 2015b)	Packer	46.2	53.8	7.7	46.2	53.8	50.0	Intrusive	6.5E-07
MW-BGC12-BJ-12A	426,509	6,257,807	1,579.19	-90	0	BGC (2014b, 2015b)	Packer	48	50	2	48	50	49	Intrusive	1.8E-06
MW-BGC12-BJ-12A	426,509	6,257,807	1,579.19	-90	0	BGC (2014b, 2015b)	Packer	66	70.5	4.5	66	70.5	68.3	Intrusive	1.8E-06
MW-BGC12-BJ-12A	426,509	6,257,807	1,579.19	-90	0	BGC (2014b, 2015b)	Slug	84.3	97	12.7	84.3	97	90.7	Intrusive	1.5E-05
DH-BGC14-11 (SU-	427,049	6,258,794	1,371.12	-75	20	BGC (2014b, 2015b)	Packer	20.2	30.9	10.3	19.5	30.6	25.1	Volcanic Sedimentary Facies	4.0E-08
DH-BGC14-12 (SU-	427,138	6,258,739	1,365.35	-75	180	BGC (2014b, 2015b)	Packer	33.9	41.3	7.2	35.1	44.6	39.8	Intrusive	5.2E-08
DH-BGC14-13 (SU-	427,192	6,258,663	1,368.68	-90	0	BGC (2014b, 2015b)	Packer	23	30.8	7.8	23	30.8	26.9	Intrusive	3.7E-07
MW-BGC14-13A	426,118	6,258,904	1,362.49	-90	0	BGC (2015b)	Packer	21.2	28.9	7.7	21.2	28.9	25.1	Intrusive	1.0E-06
MW-BGC14-13A	426,118	6,258,904	1,362.49	-90	0	BGC (2015b)	Packer	66.6	100.9	34.4	66.6	100.9	83.7	Intrusive	8.6E-08
MW-BGC14-13A	426,118	6,258,904	1,362.49	-90	0	BGC (2015b)	Packer	21.6	100.9	79.4	21.6	100.9	61.2	Intrusive	2.5E-07
MW-BGC14-13B	426,118	6,258,904	1,362.76	-90	0	BGC (2014a, 2015b)	Pump	21.2	75.4	54.2	21.2	75.4	48.3	Intrusive	8.9E-08
MW-BGC14-13B	426,118	6,258,904	1,362.76	-90	0	BGC (2014a, 2015b)	Slug	21.2	75.4	54.2	21.2	75.4	48.3	Intrusive	9.3E-06
MW-BGC14-14A	426,096	6,258,924	1,351.10	-90	0	BGC (2015b)	Packer	10.9	19.9	9	10.9	19.9	15.4	Intrusive	3.0E-08
MW-BGC14-14A	426,096	6,258,924	1,351.10	-90	0	BGC (2015b)	Packer	21.6	34.9	13.3	21.6	34.9	28.3	Intrusive	4.2E-08
MW-BGC14-14B	426,095	6,258,927	1,355.00	-90	0	BGC (2014a, 2015b)	Pump	0.45	4.5	4	0.5	4.4	2.4	Overburden	8.8E-05
MW-BGC14-15A	426,618	6,260,069	1,451.85	-90	0	BGC (2015b)	Packer	21.7	51.5	29.9	21.7	51.5	36.6	Fragmental Volcanics	5.6E-07
MW-BGC14-15A	426,618	6,260,069	1,451.85	-90	0	BGC (2015b)	Packer	51.7	101.0	49.4	51.7	101.0	76.3	Fragmental Volcanics	2.0E-07
MW-BGC14-15B	426,611	6,260,058	1,455.25	-90	0	BGC (2015b)	Packer	40.8	60	19.3	40.8	60	50.4	Fragmental Volcanics	1.1E-06
MW-BGC14-15B	426,611	6,260,058	1,455.25	-90	0	BGC (2015b)	Packer	61.8	81.1	19.4	61.8	81.1	71.4	Fragmental Volcanics	3.4E-09
MW-BGC14-16A	427,068	6,259,514	1,368.00	-90	0	BGC (2014a, 2015b)	Slug	4.6	9	6.2	4.6	10.8	7.7	Overburden	2.8E-04
MW-BGC14-16A		6,259,514	1,368.00	-90	0	BGC (2014a, 2015b)	Pump	4.6	9	6.2	4.6	10.8	7.7	Overburden	3.6E-04
MW-BGC14-16B	427,068	6,259,514	1,368.00	-90	0	BGC (2014a, 2015b)	Slug	1.4	9.3	7.9	1.4	9.3	5.4	Overburden	1.3E-04
DH-BGC14-08 (SU-	426,522	6,258,137	1,544.89	-45	55	BGC (2015b)	Packer	182.3	235.7	37.8	125.8	147.3	136.5	Fragmental Volcanics	6.2E-07
DH-BGC14-08 (SU-	426,522	6,258,137	1,544.89	-45	55	BGC (2015b)	Packer	273.8	297.2	16.5	160.0	165.7	162.9	Fragmental Volcanics	4.4E-09
MW-BGC12-BJ-10A	426,989	6,258,341	1,445.59	-90	0	BGC (2015b)	Packer	54.7	62.3	7.6	54.7	62.3	58.5	Fragmental Volcanics	6.2E-07
MW-BGC16-BJ-01A	427,062	6,258,770	1,376.95	-90	0	BGC (2017b)	Packer	24.5	27.42	2.92	24.5	27.42	25.96	Mixed Units	6.0E-07
MW-BGC16-BJ-01B	427,063	6,258,767	1,376.99	-90	0	BGC (2017b)	Slug	13.44	15.39	1.95	13.44	15.39	14.415	Fragmental Volcanics	2.0E-07
MW-BGC16-BJ-02A	427,084	6,258,713	1,378.36	-90	0	BGC (2017b)	Packer	19.29	22.65	3.36	19.29	22.65	20.97	Fragmental Volcanics	7.0E-08
MW-BGC16-BJ-02B	427,081	6,258,710	1,378.55	-90	0	BGC (2017b)	Slug	15.66	17.68	2.02	15.66	17.68	16.67	Fragmental Volcanics	8.0E-09
MW-BGC16-BJ-03A	427,027	6,258,704	1,377.60	-90	0	BGC (2017b)	Packer	13.85	16.85	3	13.85	16.85	15.35	Fragmental Volcanics	6.0E-09
MW-BGC16-BJ-03A	427,027	6,258,704	1,377.60	-90	0	BGC (2017b)	Slug	21.05	24.43	3.38	21.05	24.43	22.74	Fragmental Volcanics	3.0E-08

Appendix A. Brucejack Hydraulic Testing Summary

Monitoring Well / Borehole ID	Easting[1] (m)	Northing[1] (m)	Elevation[1] (m asl)	Dip	Az.	Reference	Test Type	Test Interval (m AH)			Test Interval (v m mbgs)			Simplified Geology[2]	K (m/s)
								From	To	Length (m)	From	To	Midpoint		
MW-BGC16-BJ-03B	427,027	6,258,707	1,377.51	-90	0	BGC (2017b)	Slug	11.15	13.67	2.52	11.15	13.67	12.41	Fragmental Volcanics	3.0E-09
MW-BGC16-BJ-04A	426,996	6,258,789	1,377.51	-90	0	BGC (2017b)	Packer	22.55	24.1	1.55	22.55	24.1	23.325	Conglomerate	2.0E-07
MW-BGC16-BJ-04B	426,997	6,258,792	1,377.42	-90	0	BGC (2017b)	Slug	12.07	14.15	2.08	12.07	14.15	13.11	Volcanic Sedimentary Facies	2.0E-09
MW-BGC16-BJ-05A	427,011	6,258,840	1,372.63	-90	0	BGC (2017b)	Packer	10.05	13.35	3.3	10.05	13.35	11.7	Fragmental Volcanics	9.0E-09
MW-BGC16-BJ-05A	427,011	6,258,840	1,372.63	-90	0	BGC (2017b)	Slug	18.65	22.37	3.72	18.65	22.37	20.51	Fragmental Volcanics	4.0E-07
MW-BGC16-BJ-05B	427,014	6,258,838	1,372.55	-90	0	BGC (2017b)	Slug	8.5	10.5	2	8.5	10.5	9.5	Fragmental Volcanics	1.0E-07
BJ-GW18-17A	426,771	6,258,761	1,403.87	-90	0	BGC (2019b)	Packer	109.12	119.62	10.5	109.12	119.62	114.37	Intrusive	4.0E-08
BJ-GW18-17A	426,771	6,258,761	1,403.87	-90	0	BGC (2019b)	Packer	145.12	148.12	3	145.12	148.12	146.62	Fragmental Volcanics	1.0E-06
BJ-GW18-17B	426,772	6,258,760	1,403.99	-90	0	BGC (2019b)	Packer	71.49	105.49	34	71.49	105.49	88.49	Intrusive	9.0E-08
BJ-GW18-18A	426,946	6,258,306	1,445.11	-90	0	BGC (2019b)	Packer	98.1	102.6	4.5	98.1	102.6	100.35	Intrusive	8.0E-08
BJ-GW18-18B	426,947	6,258,306	1,445.11	-90	0	BGC (2019b)	Packer	62.01	66.51	4.5	62.01	66.51	64.26	Intrusive	5.0E-06
BJ-GW18-19A	426,347	6,258,259	1,495.68	-90	0	BGC (2019b)	Packer	126.39	135.39	9	126.39	135.39	130.89	Intrusive	1.0E-08
BJ-GW18-19A	426,347	6,258,259	1,495.68	-90	0	BGC (2019b)	Packer	171.39	177.39	6	171.39	177.39	174.39	Intrusive	9.0E-08
BJ-GW18-19A	426,347	6,258,259	1,495.68	-90	0	BGC (2019b)	Packer	192.39	196.89	4.5	192.39	196.89	194.64	Intrusive	2.0E-07
BJ-GW18-19B	426,346	6,258,259	1,495.49	-90	0	BGC (2019b)	Packer	108.54	111.54	3	108.54	111.54	110.04	Intrusive	1.0E-08
BJ-GW18-19B	426,346	6,258,259	1,495.49	-90	0	BGC (2019b)	Packer	122.04	125.04	3	122.04	125.04	123.54	Intrusive	2.0E-08
BJ-GW18-19B	426,346	6,258,259	1,495.49	-90	0	BGC (2019b)	Packer	156.54	159.54	3	156.54	159.54	158.04	Intrusive	3.0E-07
BJ-GW18-20A	426,147	6,258,341	1,493.59	-90	0	BGC (2019b)	Packer	79.84	87.34	7.5	79.84	87.34	83.59	Intrusive	2.0E-07
BJ-GW18-20A	426,147	6,258,341	1,493.59	-90	0	BGC (2019b)	Packer	115.84	118.84	3	115.84	118.84	117.34	Intrusive	8.0E-08
BJ-GW18-20A	426,147	6,258,341	1,493.59	-90	0	BGC (2019b)	Packer	151.84	159.34	7.5	151.84	159.34	155.59	Intrusive	4.0E-08
BJ-GW18-20A	426,147	6,258,341	1,493.59	-90	0	BGC (2019b)	Packer	163.84	168.34	4.5	163.84	168.34	166.09	Intrusive	1.0E-07
BJ-GW18-20A	426,147	6,258,341	1,493.59	-90	0	BGC (2019b)	Packer	169.84	177.34	7.5	169.84	177.34	173.59	Intrusive	5.0E-08
BJ-GW18-20B	426,148	6,258,342	1,493.60	-90	0	BGC (2019b)	Packer	85.81	90.31	4.5	85.81	90.31	88.06	Intrusive	1.0E-07
BJ-GW18-20B	426,148	6,258,342	1,493.60	-90	0	BGC (2019b)	Packer	115.54	120.31	4.77	115.54	120.31	117.925	Intrusive	2.0E-07
BJ-GW18-21A	426,661	6,257,806	1,550.33	-90	0	BGC (2019b)	Packer	136.78	141.28	4.5	136.78	141.28	139.03	Volcanic Sedimentary Facies	1.0E-08
BJ-GW18-21A	426,661	6,257,806	1,550.33	-90	0	BGC (2019b)	Packer	151.78	156.28	4.5	151.78	156.28	154.03	Volcanic Sedimentary Facies	2.0E-08
BJ-GW18-21A	426,661	6,257,806	1,550.33	-90	0	BGC (2019b)	Packer	159.08	163.78	4.7	159.08	163.78	161.43	Volcanic Sedimentary Facies	3.0E-07
BJ-GW18-21A	426,661	6,257,806	1,550.33	-90	0	BGC (2019b)	Packer	196.58	201.28	4.7	196.58	201.28	198.93	Volcanic Sedimentary Facies	5.0E-08
BJ-GW18-21A	426,661	6,257,806	1,550.33	-90	0	BGC (2019b)	Packer	225.28	255.28	30	225.28	255.28	240.28	Volcanic Sedimentary Facies	5.0E-09
BJ-GW18-21A	426,661	6,257,806	1,550.33	-90	0	BGC (2019b)	Packer	187.74	190.8	3.06	187.74	190.8	189.27	Volcanic Sedimentary Facies	1.0E-08
BJ-GW18-21B	426,660	6,257,807	1,550.34	-90	0	BGC (2019b)	Packer	81.45	87.45	6	81.45	87.45	84.45	Volcanic Sedimentary Facies	1.0E-08
BJ-GW18-21B	426,660	6,257,807	1,550.34	-90	0	BGC (2019b)	Packer	96.25	103.95	7.7	96.25	103.95	100.1	Volcanic Sedimentary Facies	8.0E-08
BJ-GW18-21B	426,660	6,257,807	1,550.34	-90	0	BGC (2019b)	Packer	130.75	150.45	19.7	130.75	150.45	140.6	Volcanic Sedimentary Facies	2.0E-09
BJ-GW18-21B	426,660	6,257,807	1,550.34	-90	0	BGC (2019b)	Packer	153.45	159.45	6	153.45	159.45	156.45	Volcanic Sedimentary Facies	4.0E-08
BJ-GW18-22A	426,575	6,258,498	1,444.64	-90	0	BGC (2019b)	Packer	256.8	261.3	4.5	256.8	261.3	259.05	Volcanic Sedimentary Facies	4.0E-08
BJ-GW18-22A	426,575	6,258,498	1,444.64	-90	0	BGC (2019b)	Packer	292.8	297.3	4.5	292.8	297.3	295.05	Volcanic Sedimentary Facies	2.0E-08
BJ-GW18-22A	426,575	6,258,498	1,444.64	-90	0	BGC (2019b)	Packer	373.6	400.8	27.2	373.6	400.8	387.2	Volcanic Sedimentary Facies	1.0E-08
BJ-GW18-22B	426,576	6,258,499	1,444.64	-90	0	BGC (2019b)	Packer	70.72	75.42	4.7	70.72	75.42	73.07	Conglomerate	4.0E-07
BJ-GW18-22B	426,576	6,258,499	1,444.64	-90	0	BGC (2019b)	Packer	82.72	87.42	4.7	82.72	87.42	85.07	Conglomerate	5.0E-07
BJ-GW18-23A	427,091	6,258,751	1,370.84	-90	0	BGC (2019b)	Packer	26	35.2	9.2	26	35.2	30.6	Volcanic Sedimentary Facies	1.0E-08
BJ-GW18-23B	427,091	6,258,752	1,370.81	-90	0	BGC (2019b)	Slug	7.6	11.3	3.7	7.6	11.3	9.5	Volcanic Sedimentary Facies	2E-06
BJ-GW18-23B	427,091	6,258,752	1,370.81	-90	0	BGC (2019b)	Packer	11	15.7	4.7	11	15.7	13.35	Volcanic Sedimentary Facies	1.0E-08

Notes:

Az. = azimuth; m ah = metres along hole; v m bgs = vertical meters below ground; K = hydraulic conductivity

1. Drill hole coordinates and elevations for the DH- and MW-series holes provided by Pretium from professional surveys in NAD83 UTM Zone 9N, with the exception of DH-BGC12-20, DH-BGC12-21 and BJ-MW-14B which are from a handheld GPS.
2. Simplified geology based on groupings provided in main report. Logging conducted by BGC and/or Pretivm staff.

Appendix B: Monitoring Well Logs

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

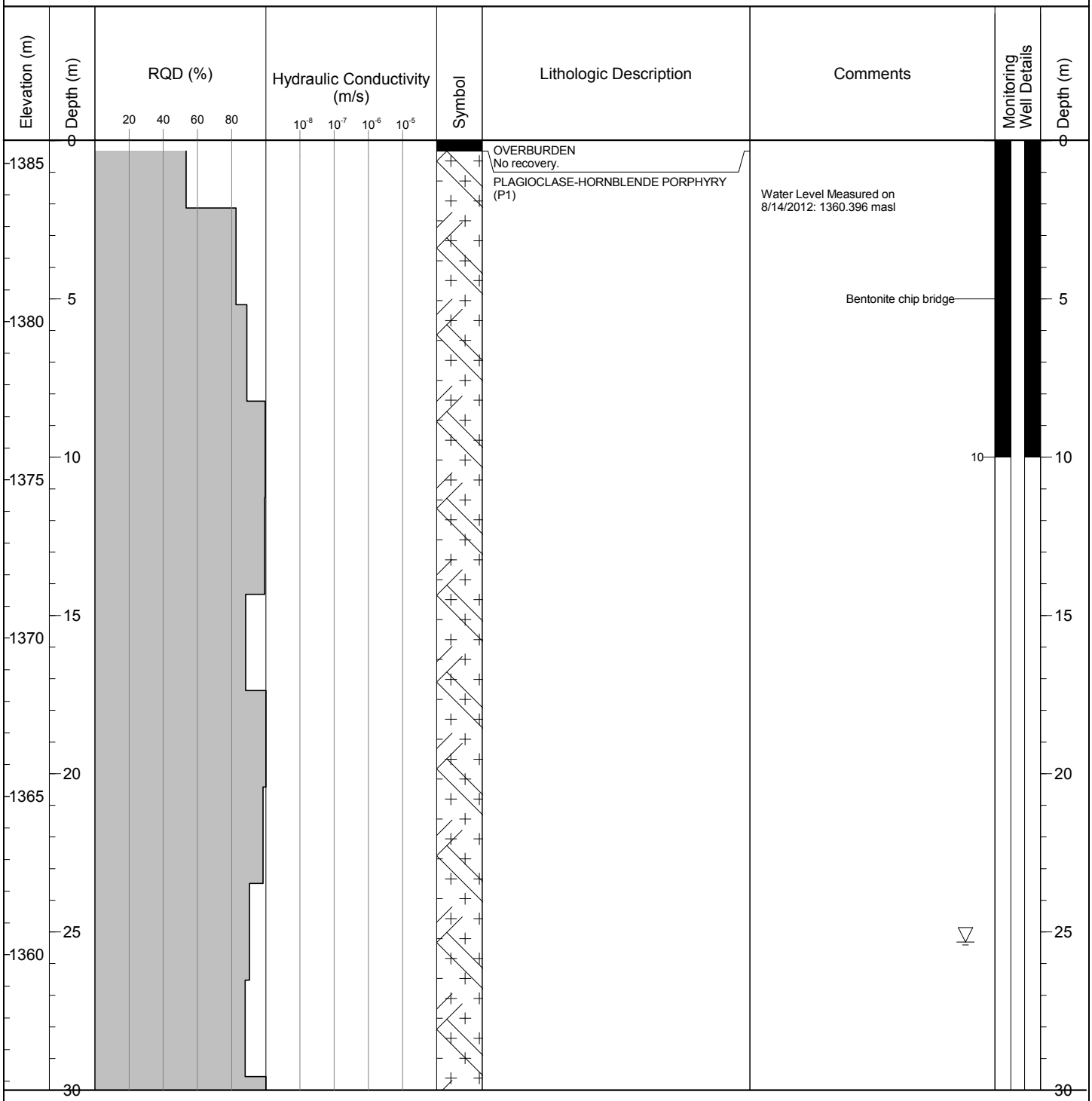
Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

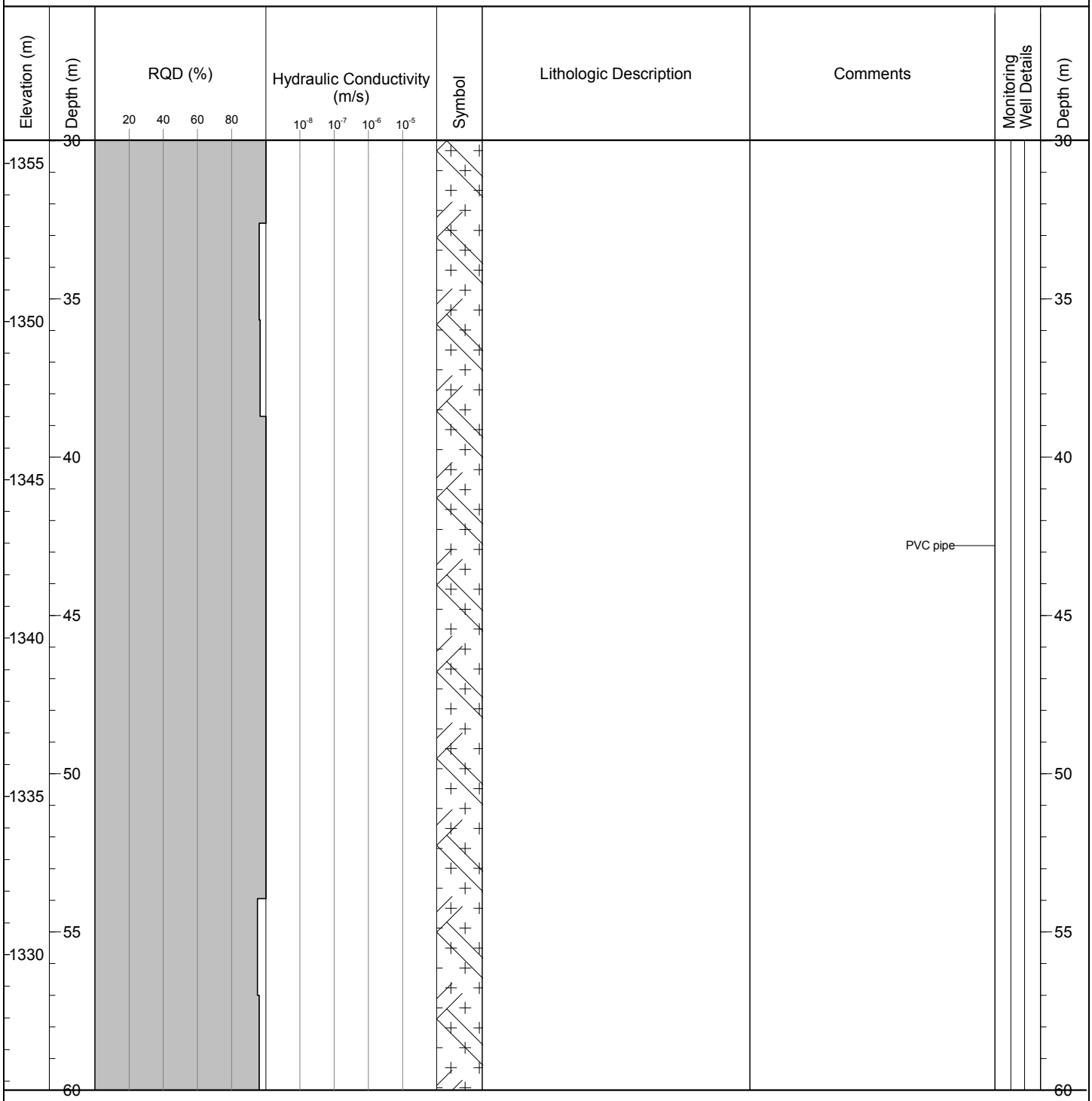
Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

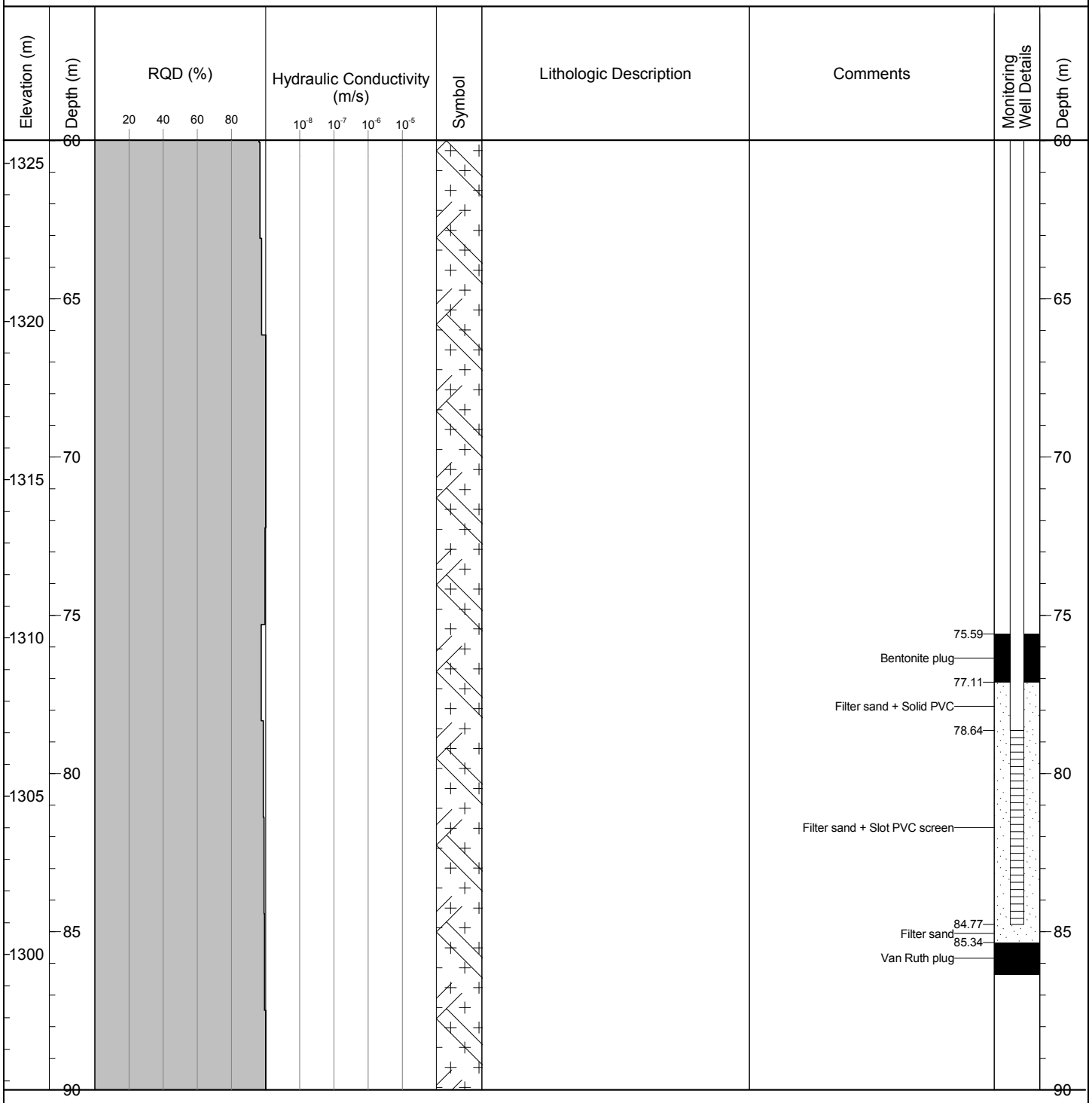
Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1A

Location: West Zone

NEW ID: BJ-GW11-1A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,840N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.57
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.3
Cased To (m): 3

Start date: 30 Sep 11
Finish Date: 02 Oct 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.3
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1295	90							90
1290	95							95
1285	100							100
1280	105				End of Hole: 102.7 m	Bottom of Installation: 85.3 m		105
1275	110							110
1270	115							115
	120							120

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1B

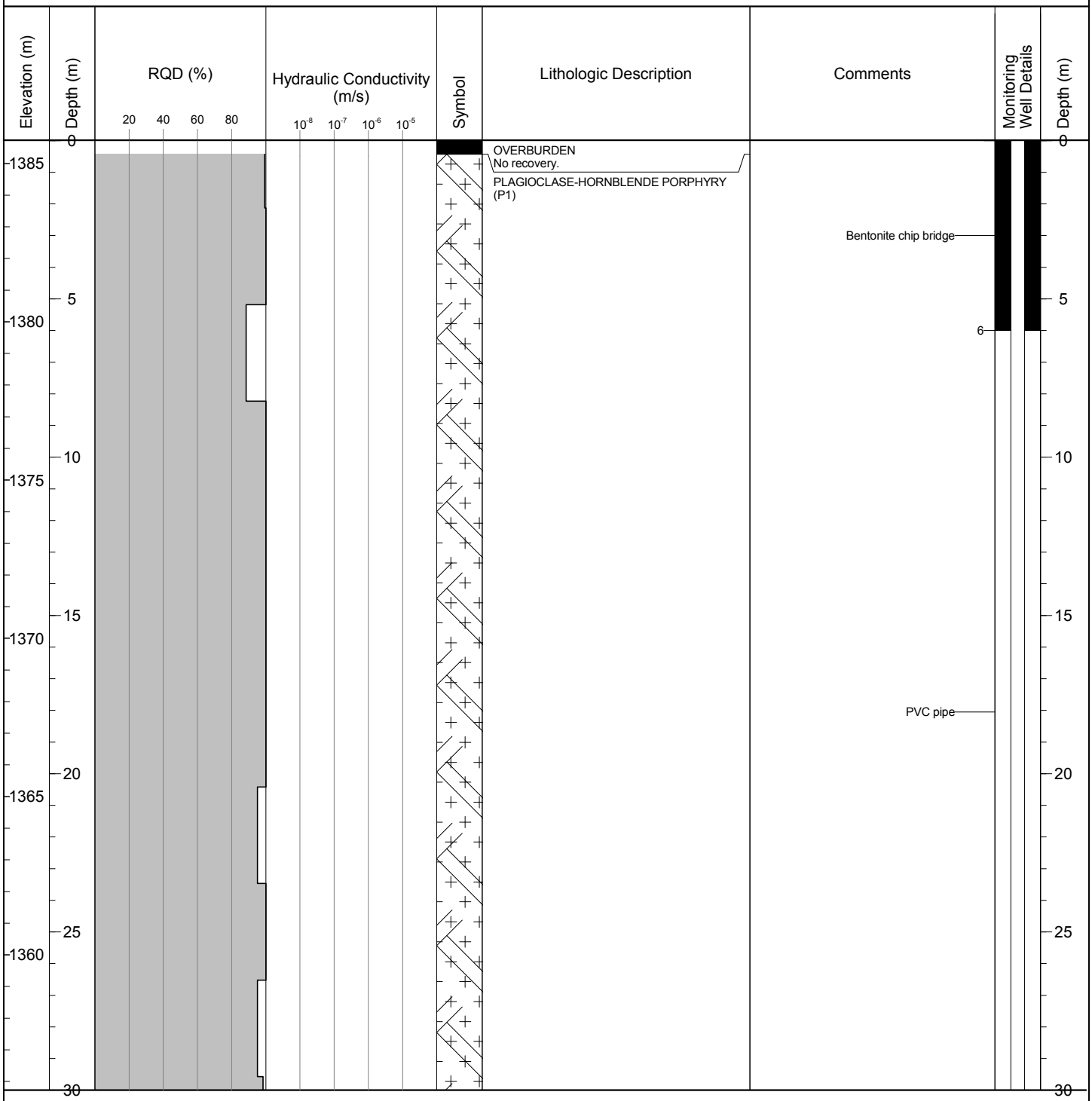
Location: West Zone

NEW ID: BJ-GW11-1B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,841N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.4
Cased To (m): NO CASING INSTALLED

Start date: 02 Oct 11
Finish Date: 02 Oct 11
Final Depth (m): 38.7
Depth To Top Of Rock (m): 0.4
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-1B

Location: West Zone

NEW ID: BJ-GW11-1B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,280E - 6,258,841N
Ground Elevation (m): 1,385.72
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1386.4
Cased To (m): NO CASING INSTALLED

Start date: 02 Oct 11
Finish Date: 02 Oct 11
Final Depth (m): 38.7
Depth To Top Of Rock (m): 0.4
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1355	30							30
						30.1 Bentonite plug		
						31.3		
						Filter sand + Solid PVC		
	35							35
1350						35.3		
						Filter sand + Slot PVC screen		
						Filter sand 38.4		
					End of Hole: 38.7 m	Bottom of Installation: 38.7 m		
1345	40							40
1340	45							45
1335	50							50
1330	55							55
	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

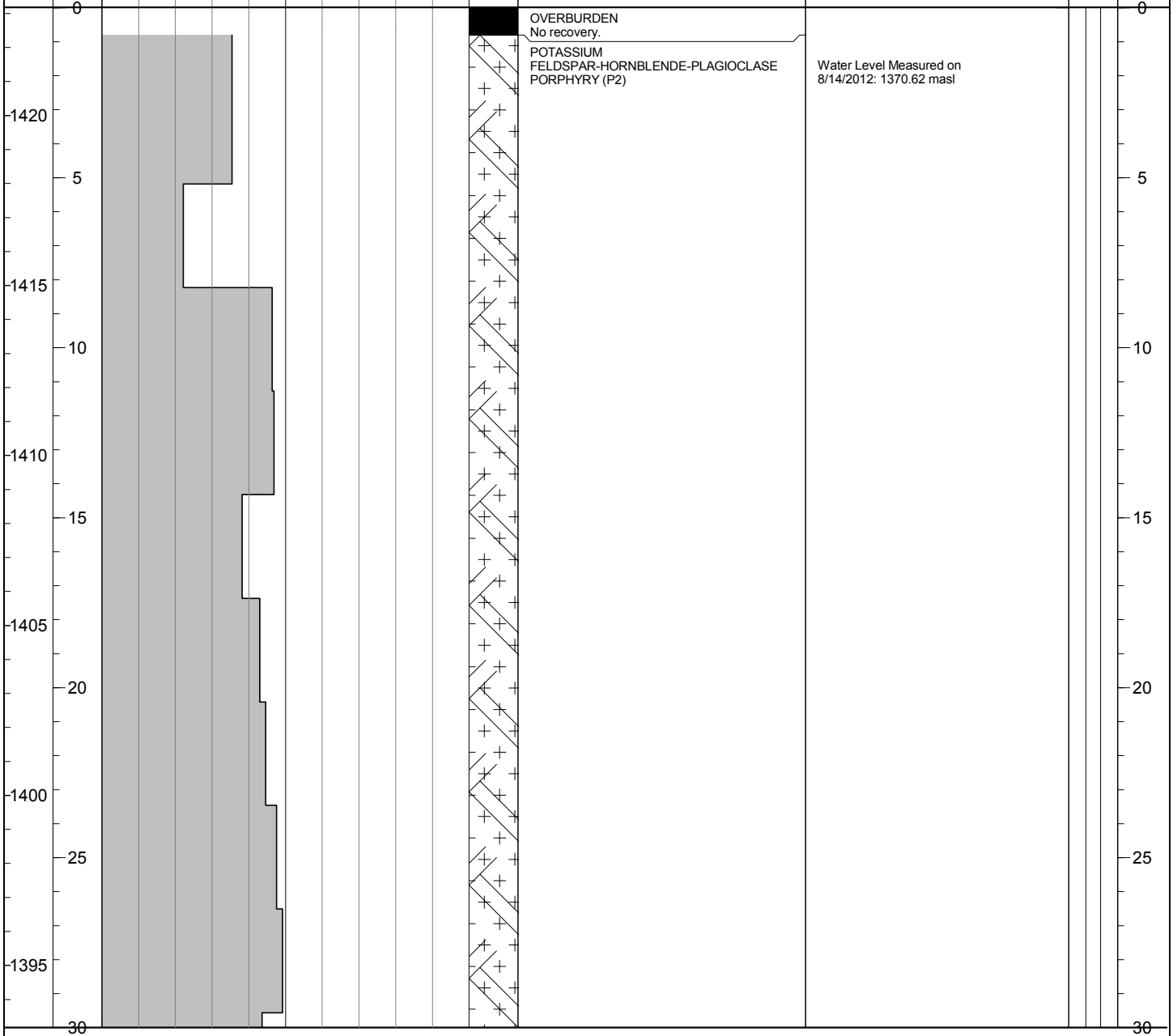
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
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Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
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Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
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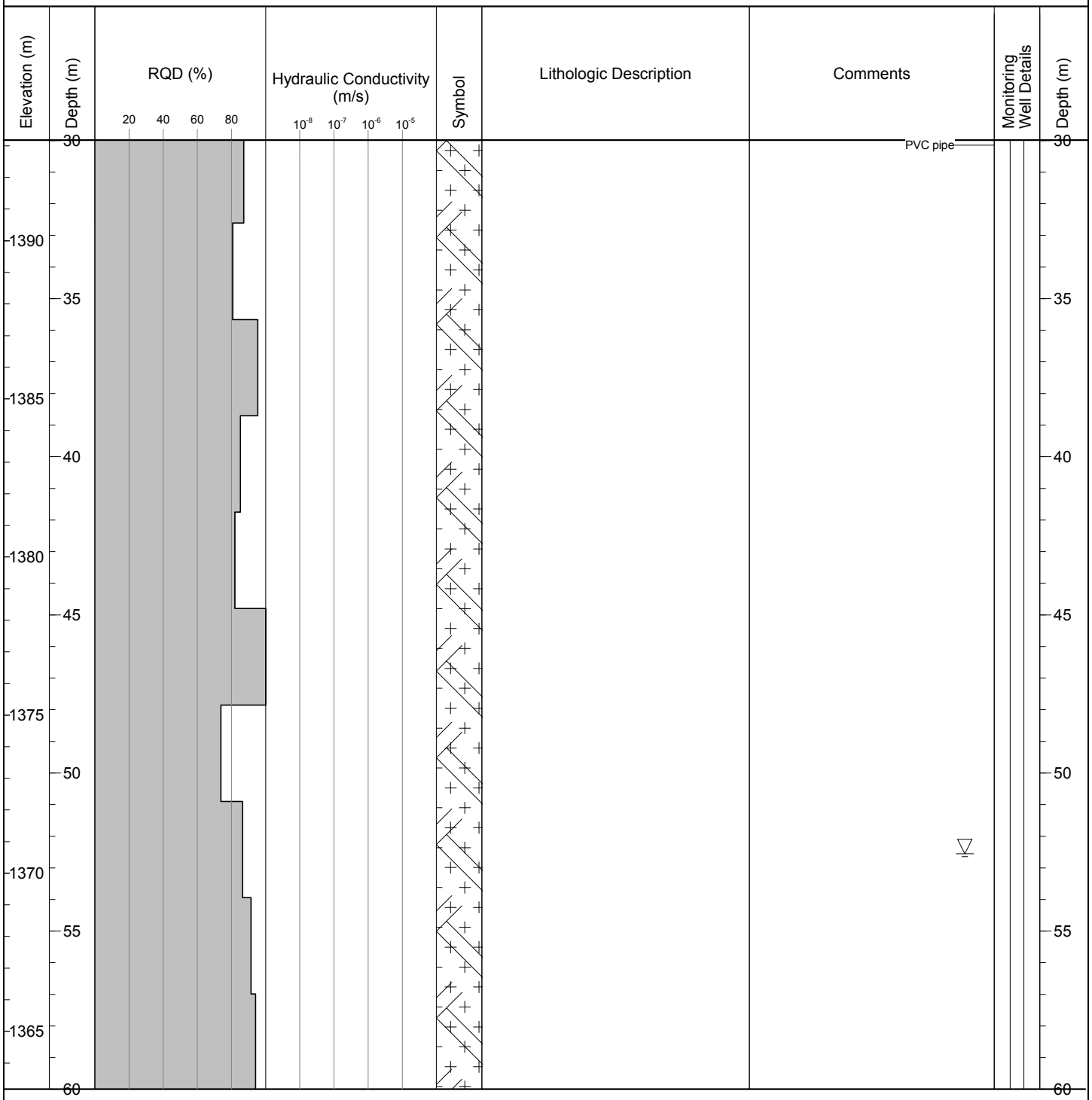

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BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

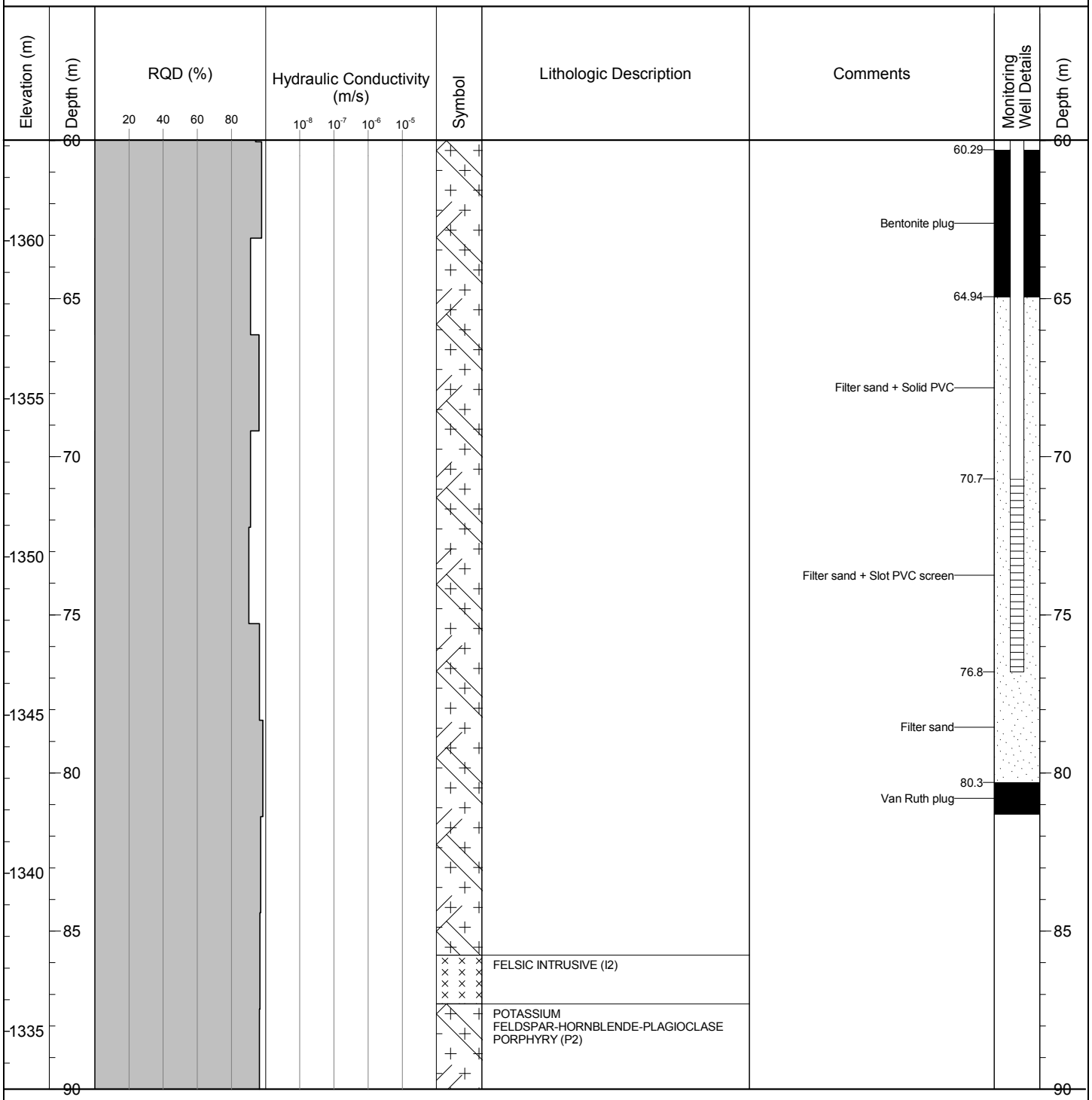
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



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Project: Brucejack
Project No.: 1008-004

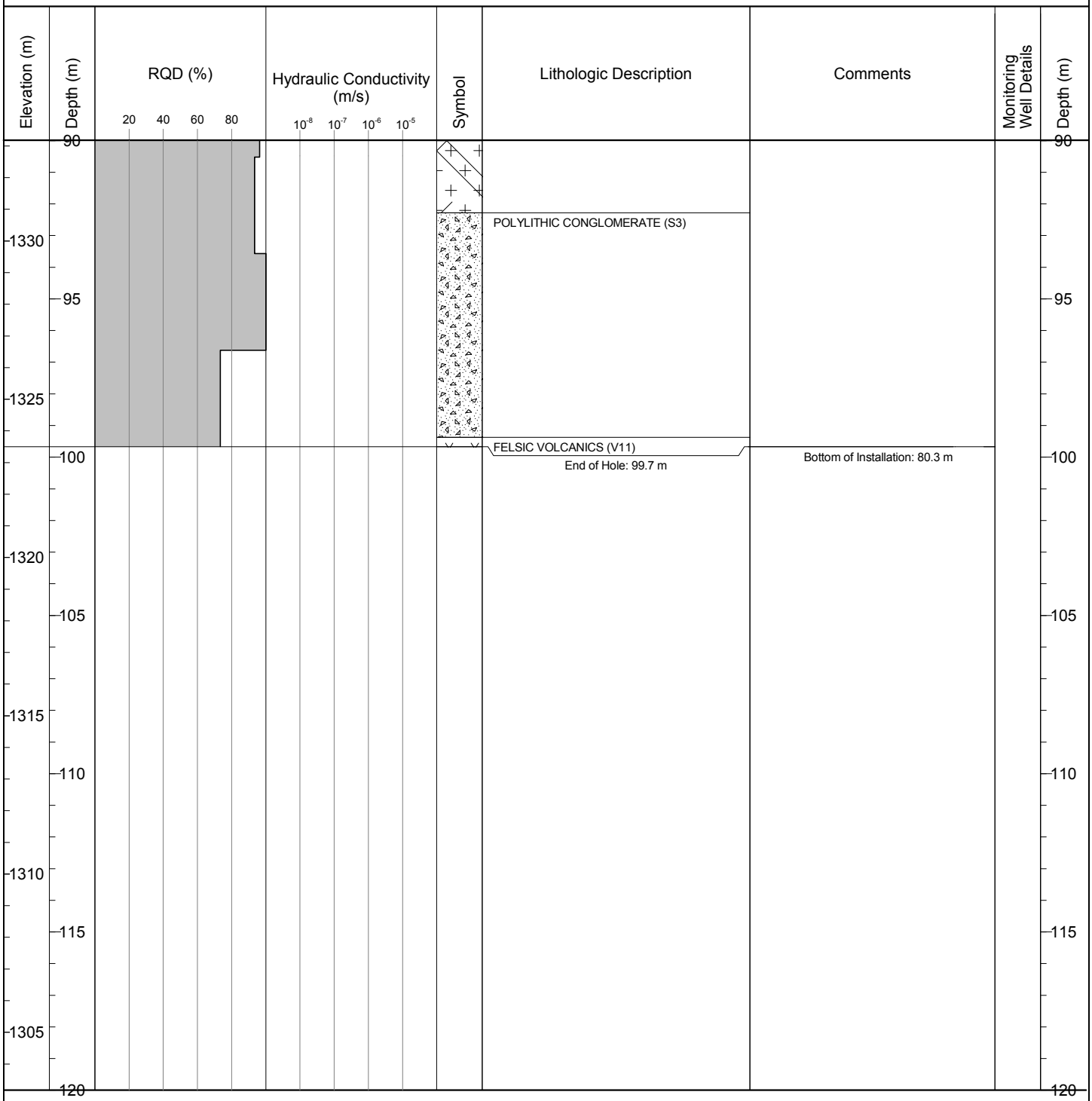
DRILL HOLE # MW-BGC11-BJ-2A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,885E - 6,258,812N
Ground Elevation (m): 1,423.17
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.25
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1423.4
Cased To (m): 3

Start date: 01 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 99.7
Depth To Top Of Rock (m): 0.8
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		OVERBURDEN No recovery.			0
1365					PLAGIOCLASE PORPHYRY (P3)	Water Level Measured on 8/14/2012: 1364.177 masl		
	5							5
1360								
	10							10
1355								
	15							15
1350								
	20							20
1345								
	25							25
1340								
	30							30

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30							30
1335								
	35							35
1330						PVC pipe		
	40							40
1325								
	45							45
1320								
	50							50
1315								
	55							55
1310								
	60							60

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

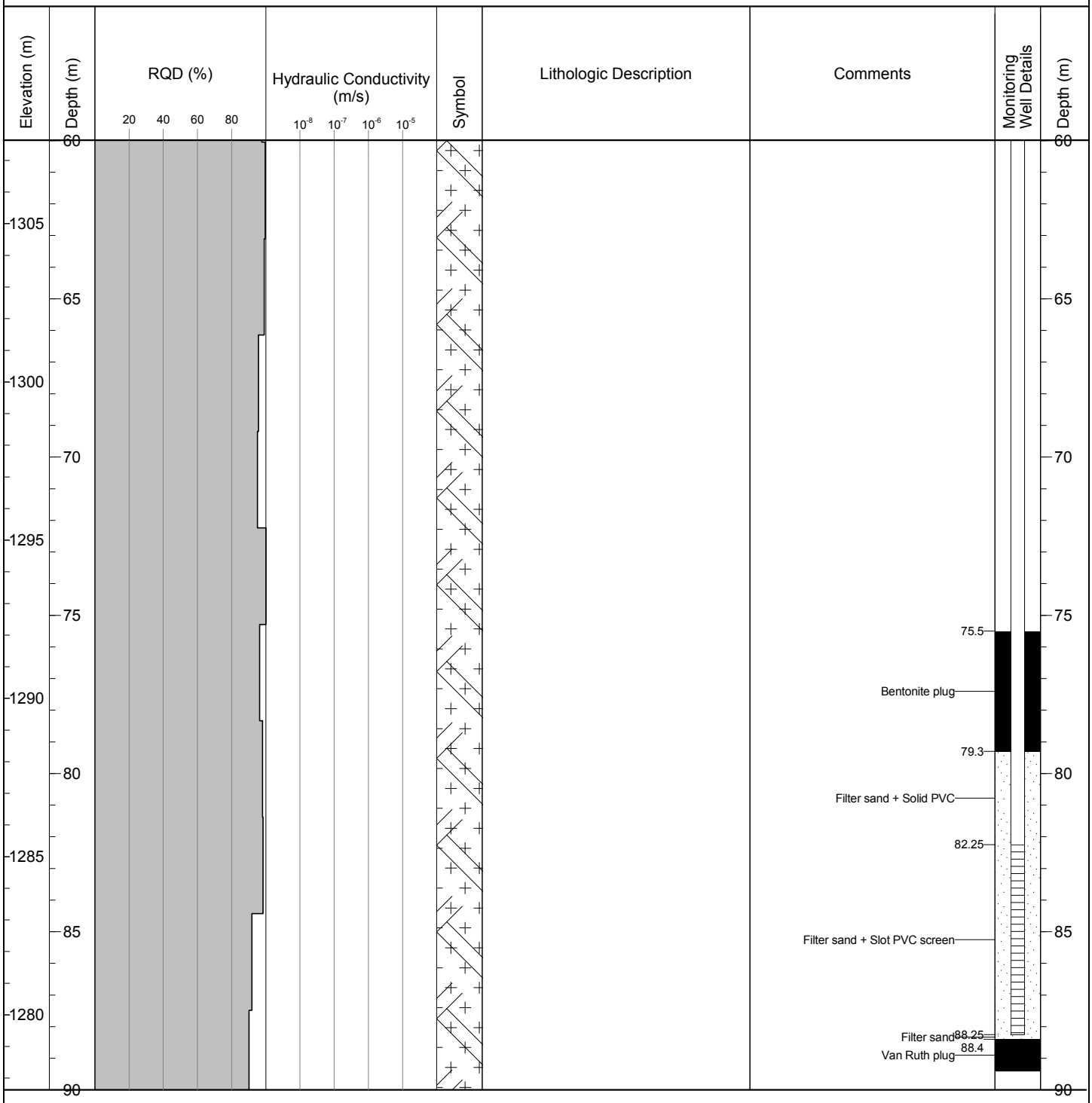
Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3A

Location: West Zone

NEW ID: BJ-GW11-3A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.63
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.11
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.7
Cased To (m): 3

Start date: 02 Oct 11
Finish Date: 03 Oct 11
Final Depth (m): 93.6
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1275	90							90
					End of Hole: 93.6 m	Bottom of Installation: 88.4 m		
1270	95							95
1265	100							100
1260	105							105
1255	110							110
1250	115							115
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-3B

Location: West Zone

NEW ID: BJ-GW11-3B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,615E - 6,258,844N
Ground Elevation (m): 1,367.53
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 2.23
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1369.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 9.4
Depth To Top Of Rock (m): 1.6
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				OVERBURDEN No recovery.			0
1365					PLAGIOCLASE PORPHYRY (P3)	Water Level Measured on 8/14/2012: 1368.632 m	Bentonite plug	
	5						4.5 Filter sand + Solid PVC 5.8	5
1360							Filter sand + Slot PVC screen Filter sand 8.8	
					End of Hole: 9.4 m	Bottom of Installation: 9.1 m		
	10							10
1355								
	15							15
1350								
	20							20
1345								
	25							25
1340								
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

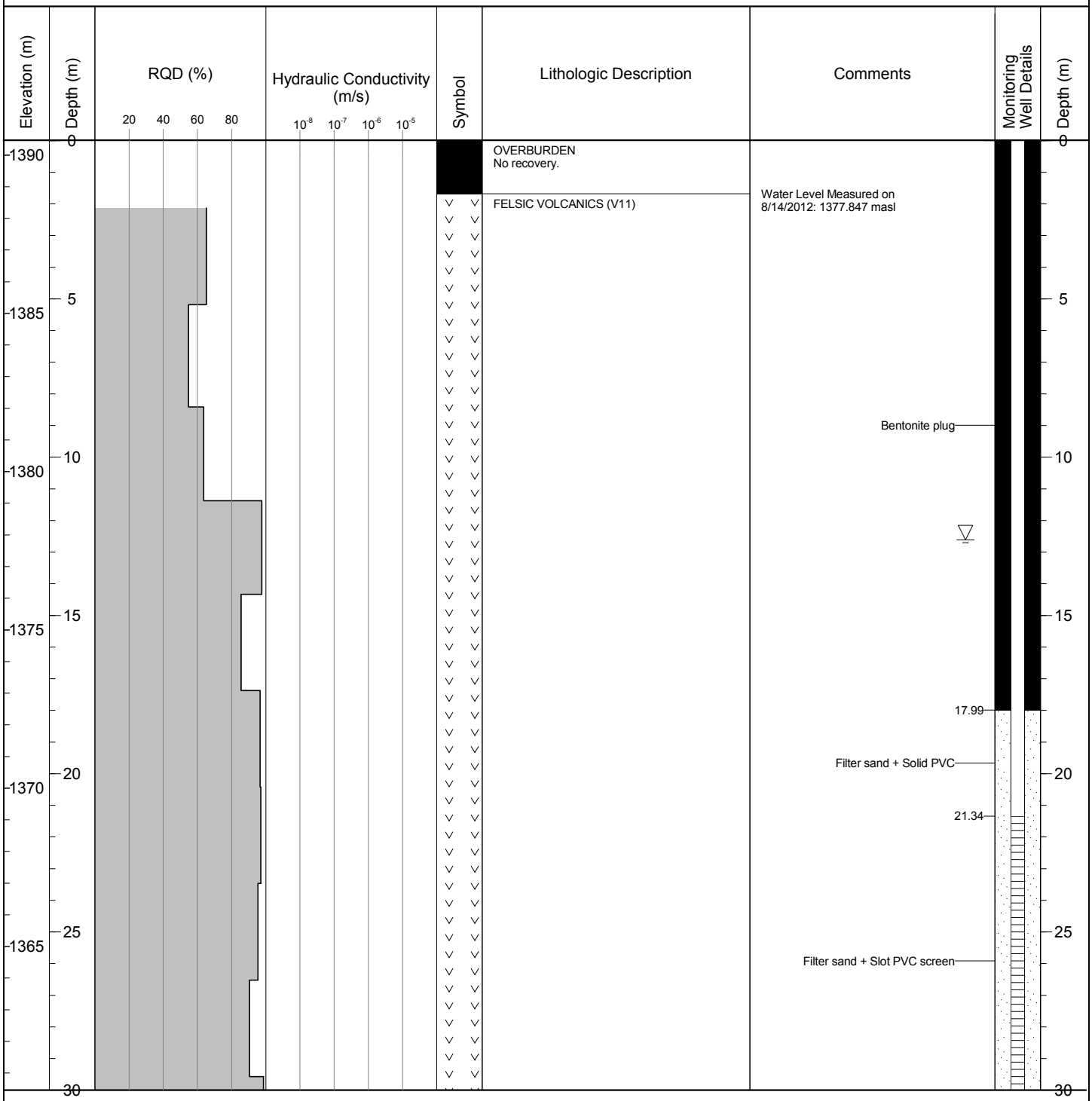
DRILL HOLE # MW-BGC11-BJ-4A

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,750N
Ground Elevation (m): 1,390.46
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.4
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1390.9
Cased To (m): 3

Start date: 04 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 32.6
Depth To Top Of Rock (m): 1.7
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-4A

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,750N
Ground Elevation (m): 1,390.46
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.4
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1390.9
Cased To (m): 3

Start date: 04 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 32.6
Depth To Top Of Rock (m): 1.7
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1360	30					Filter sand 30.49–31; Van Ruth plug		30
					End of Hole: 32.6 m	Bottom of Installation: 31.0 m		
1355	35							35
1350	40							40
1345	45							45
1340	50							50
1335	55							55
	60							60

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details
1390	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PELITE (S5) Interbedded with arenite (S4) with some clasts that are subangular and moderately sorted. No significant mineralization or veining (1-2%). Medium strong (R3-R3.5) from top of bedrock to 5.1 m below ground surface. Strong to very strong (R4-R4.5) below 5.1 m. Slight to moderate weathering (W2-W2.5) on major discontinuities from top of bedrock to 5.1 m below ground surface. Faint alteration (A1-A1.5) below 5.1 m.	Water Level Measured on 8/14/2012: 1377.87 masl	
1385	5						
1380	10						
1375	15				ARENITE (S4) Grey-green, medium grained, interbedded with minor sections of finer grained sands and silts (S5). Quartz-calcite-pyrite concretions and chlorite stringers evident. Locally laminated at approximately 30 degrees TCA. Strong to very strong (R4-R4.5). Faint to no alteration (A1-A1.5).		
1370	20						
1365	25						
	30						

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

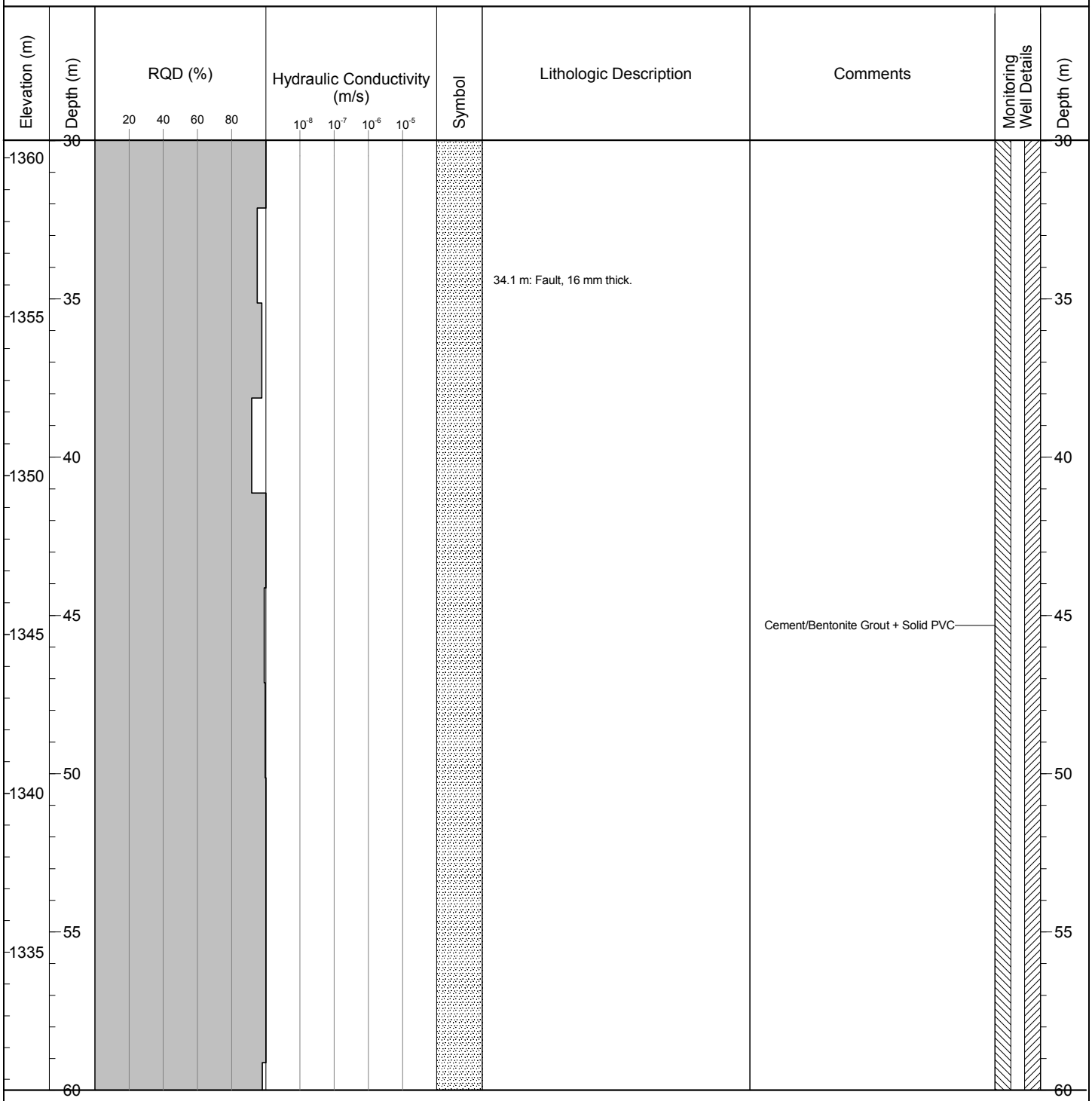
DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1330	60							60
1325	65				65.1 m: Shear, 1 mm thick. 66.5 - 98.13 m: Coarser grained sandstone. Minor sections of larger clasts (on pebble scale). Larger clasts more angular and poorly sorted. Pyrite replacement of clasts, and pyrite abundant in veinlets and blebs. Veining 1-5%.			65
1320	70				72.9 m: Fault, 80 mm thick, broken rock.			70
1315	75							75
1310	80							80
1305	85							85
	90							90

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-4B

Location: Brucejack (Plant Site)

Co-ordinates (m): 427,031E - 6,258,752N
Ground Elevation (m): 1,390.43
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1391.1
Cased To (m): 1.98

Start date: 19 Jun 12
Finish Date: 20 Jun 12
Final Depth (m): 98.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1300	90					90.63 3/8" Coated Bentonite pellets + Solid PVC 91.63		90
1295	95				95.7 m: Fault, 100 mm thick, broken rock.	94.88 10/20 Filter sand + 0.020 Slot PVC screen 97.93		95
					End of Hole: 98.1 m	Bottom of Installation: 98.1 m		
1290	100							100
1285	105							105
1280	110							110
1275	115							115
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

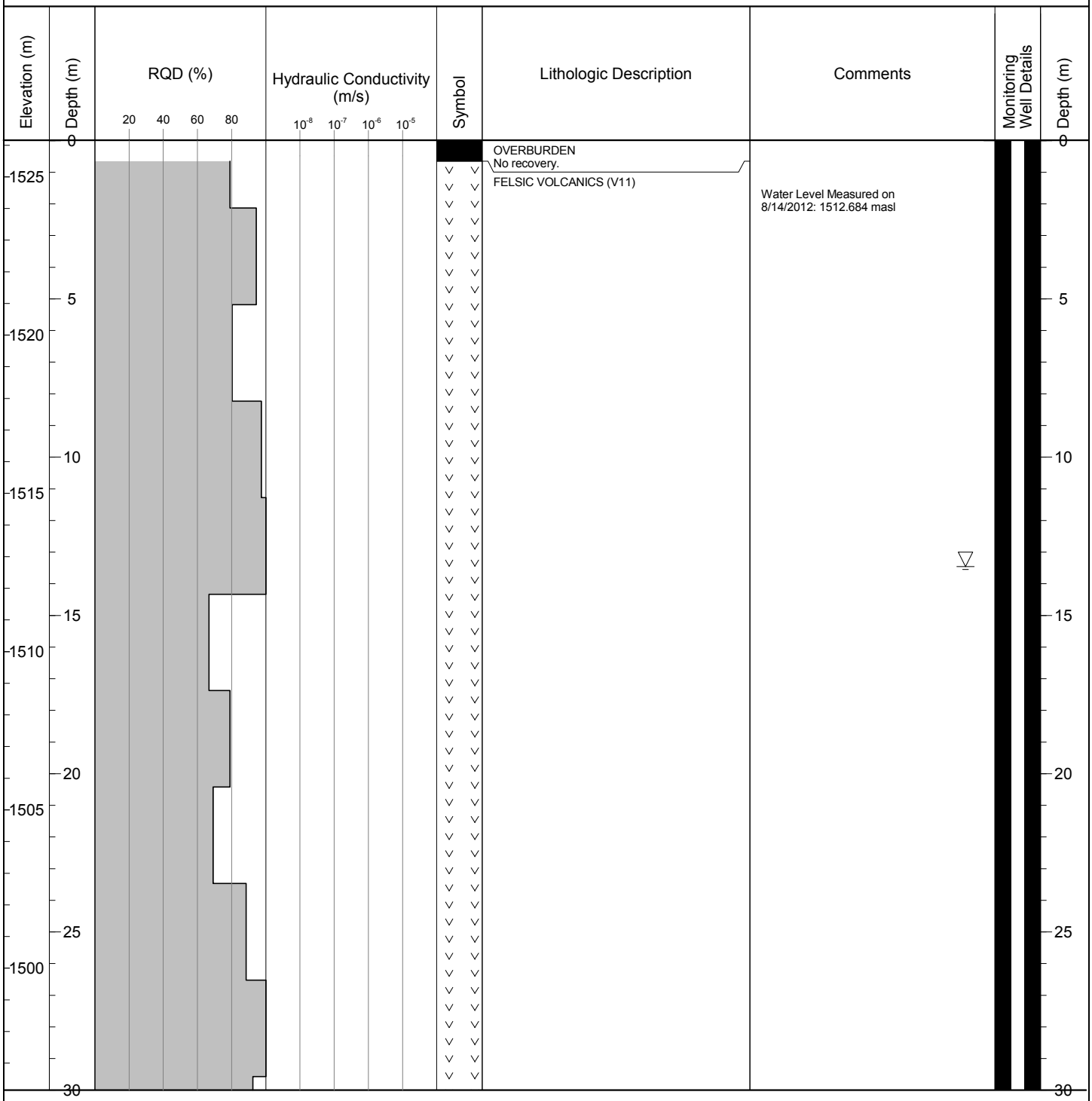
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

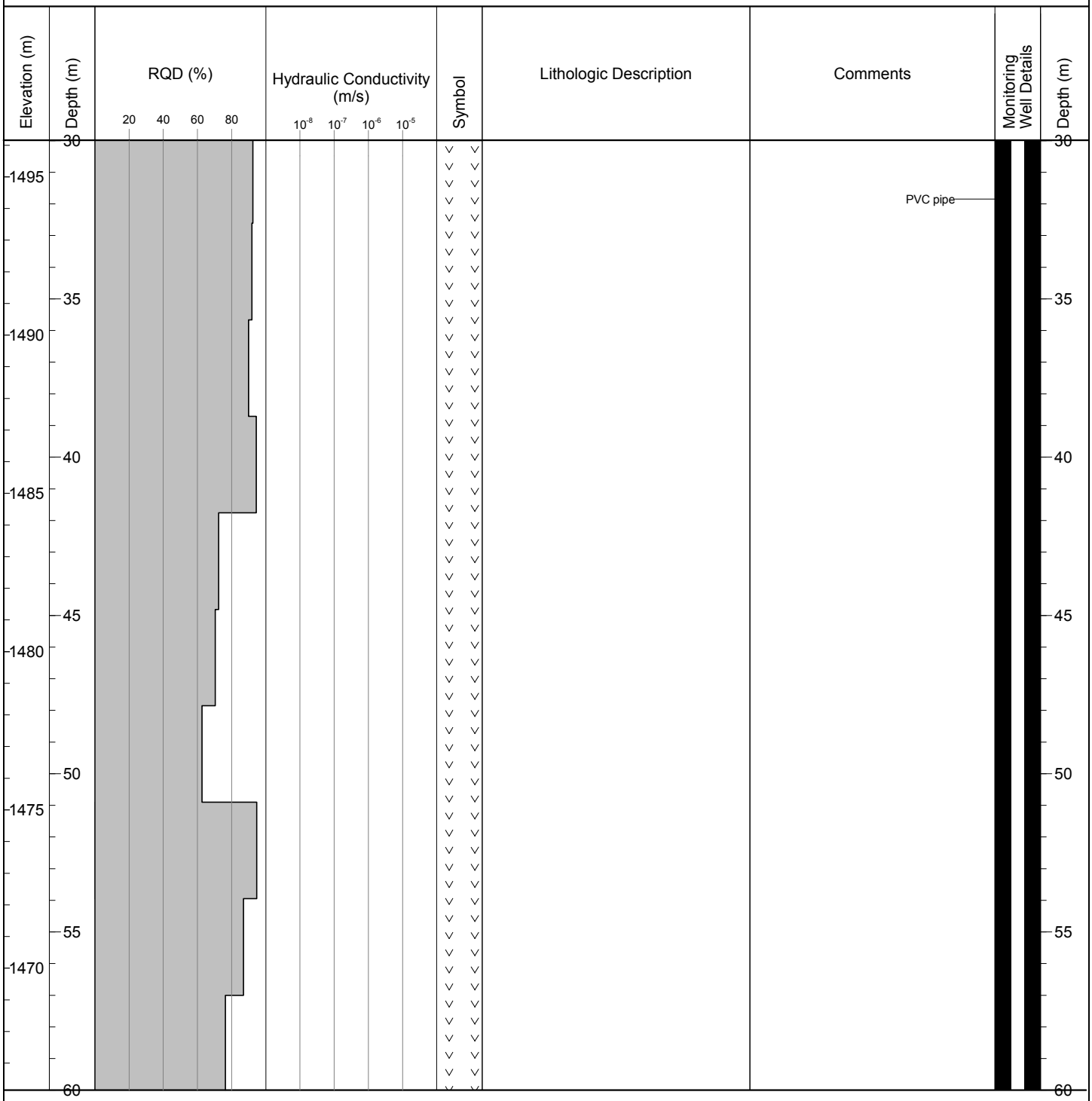
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

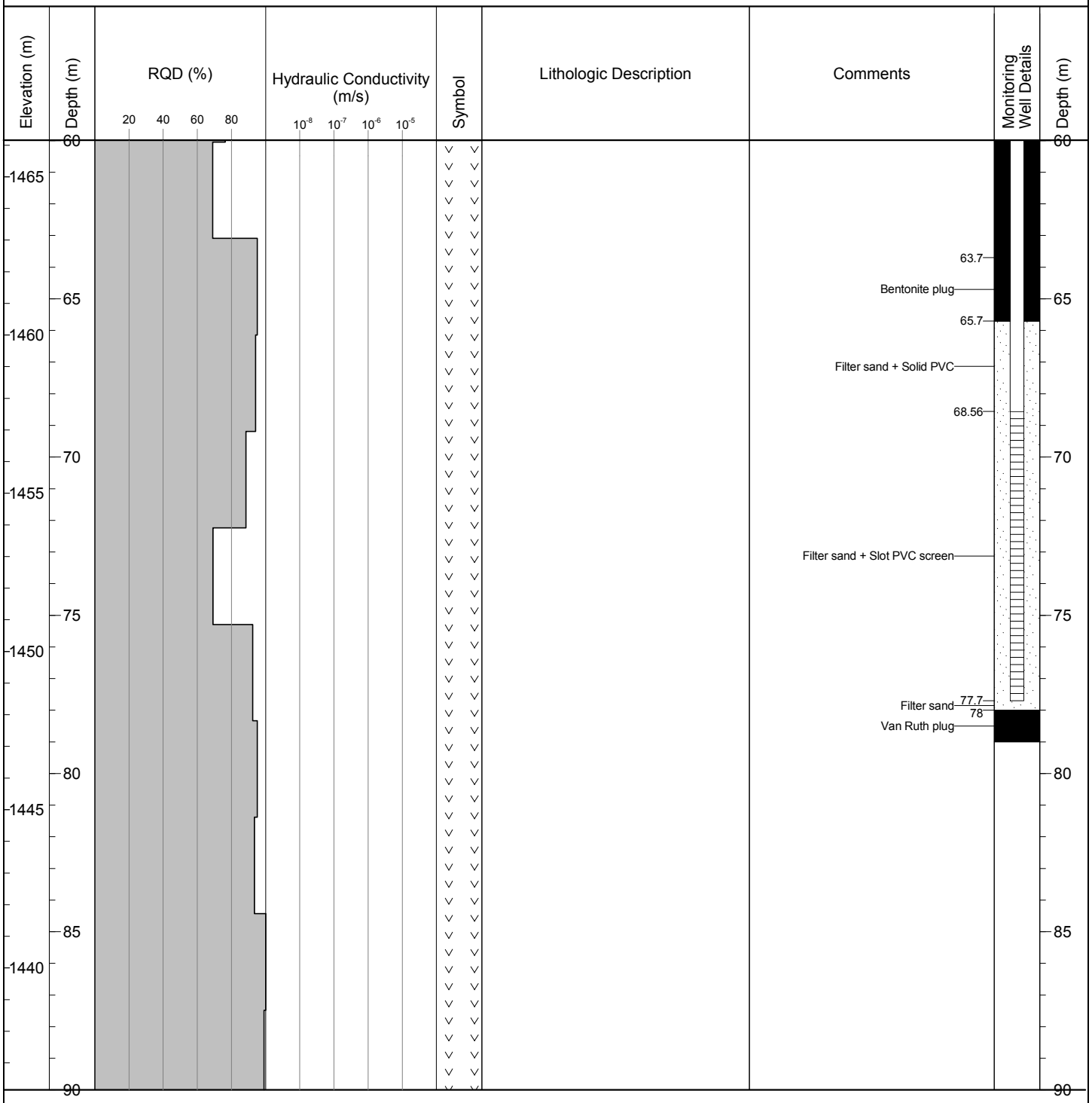
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5A

Location: Valley of Kings Zone

NEW ID: BJ-GW11-5A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,347E - 6,258,040N
Ground Elevation (m): 1,526.14
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.55
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.7
Cased To (m): 3

Start date: 28 Sep 11
Finish Date: 29 Sep 11
Final Depth (m): 102.7
Depth To Top Of Rock (m): 0.7
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1435	90							90
1430	95							95
1425	100							100
1420	105				End of Hole: 102.7 m	Bottom of Installation: 78.0 m		105
1415	110							110
1410	115							115
	120							120

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5B

Location: Valley of Kings Zone

NEW ID: BJ-GW11-5B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,346E - 6,258,042N
Ground Elevation (m): 1,526.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.44
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.6
Cased To (m): NO CASING INSTALLED

Start date: 29 Sep 11
Finish Date: 30 Sep 11
Final Depth (m): 50.9
Depth To Top Of Rock (m): 1.4
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				OVERBURDEN No recovery.			0
1525					FELSIC VOLCANICS (V11)	Water Level Measured on 8/14/2012: 1515.565 masl		
	5							5
1520								
	10							10
1515								
	15							15
1510								
						PVC pipe		
	20							20
1505								
	25							25
1500								
	30							30

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-5B

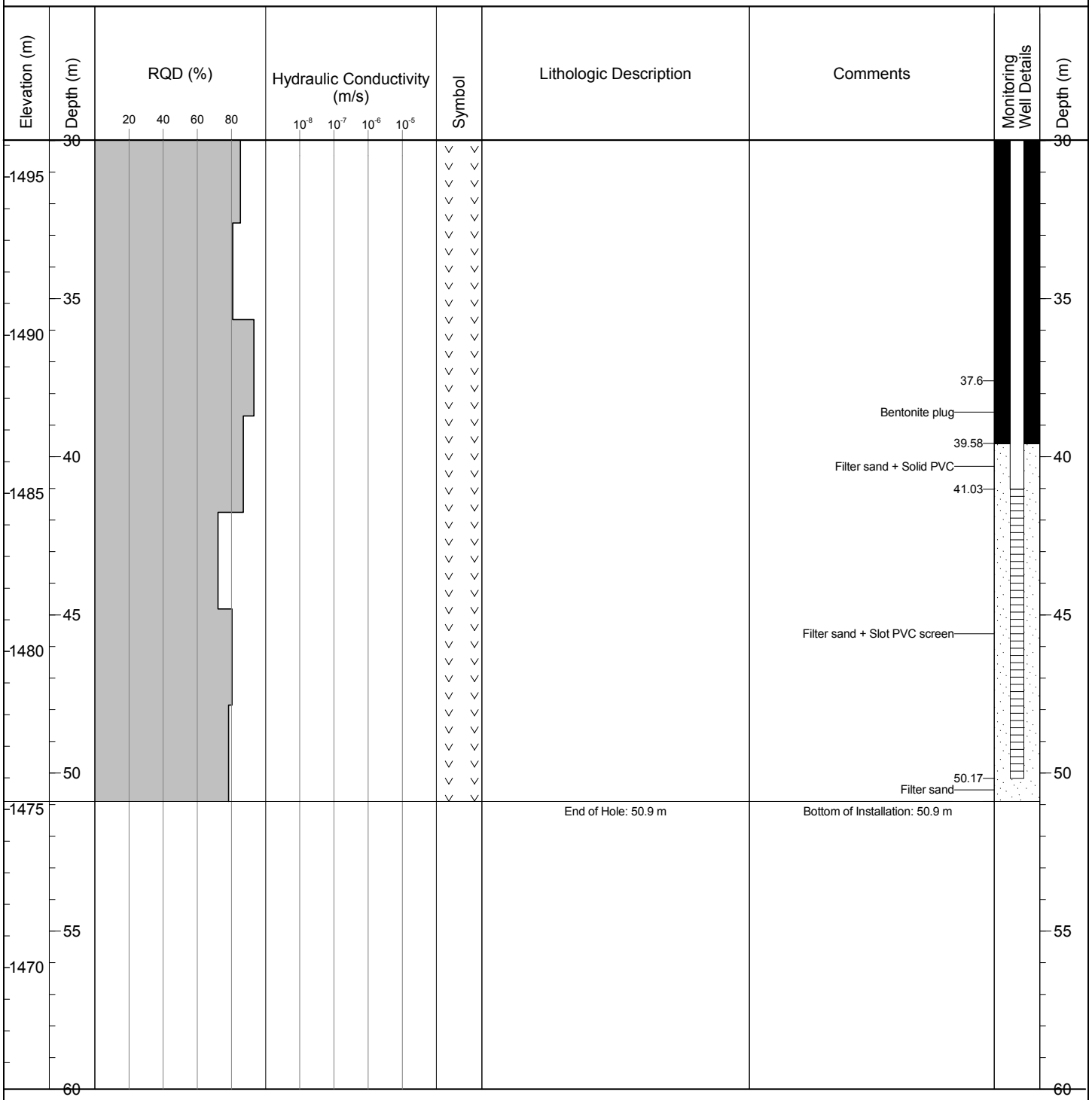
Location: Valley of Kings Zone

NEW ID: BJ-GW11-5B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,346E - 6,258,042N
Ground Elevation (m): 1,526.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.44
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Matrix
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1526.6
Cased To (m): NO CASING INSTALLED

Start date: 29 Sep 11
Finish Date: 30 Sep 11
Final Depth (m): 50.9
Depth To Top Of Rock (m): 1.4
Logged by: Pretium
Reviewed by: BGC



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

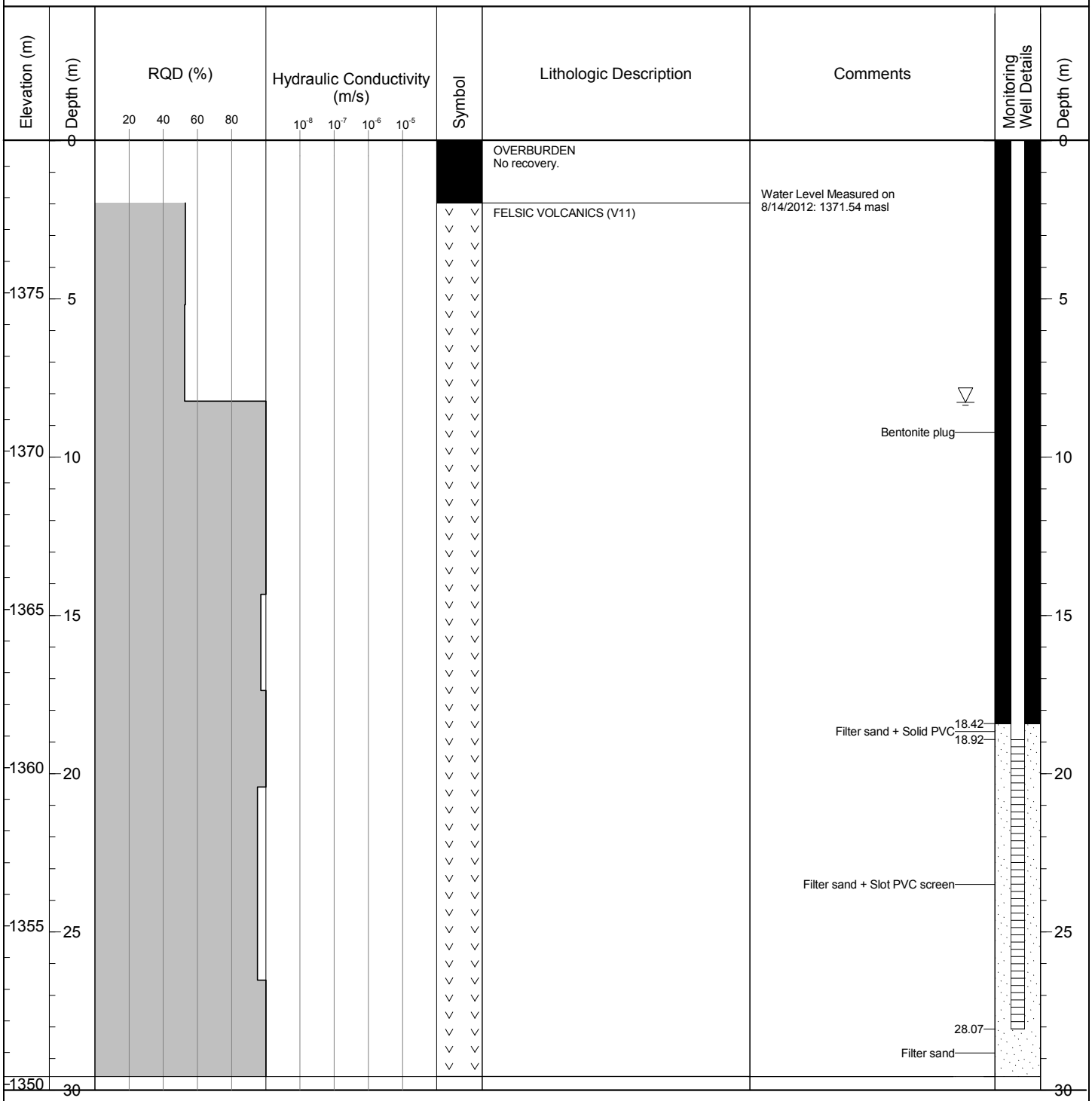
DRILL HOLE # MW-BGC11-BJ-6A

Location: Shore Zone

Co-ordinates (m): 427,095E - 6,258,983N
Ground Elevation (m): 1,379.81
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 1
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1380.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 29.6
Depth To Top Of Rock (m): 2.0
Logged by: Pretium
Reviewed by: BGC



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-004

DRILL HOLE # MW-BGC11-BJ-6A

Location: Shore Zone

Co-ordinates (m): 427,095E - 6,258,983N
Ground Elevation (m): 1,379.81
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 1
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1380.8
Cased To (m): 3

Start date: 03 Oct 11
Finish Date: 04 Oct 11
Final Depth (m): 29.6
Depth To Top Of Rock (m): 2.0
Logged by: Pretium
Reviewed by: BGC

Elevation (m)	Depth (m)	RQD (%) 20 40 60 80	Hydraulic Conductivity (m/s) 10^{-8} 10^{-7} 10^{-6} 10^{-5}	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30				End of Hole: 29.6 m	Bottom of Installation: 31.8 m		30
1345	35							35
1340	40							40
1335	45							45
1330	50							50
1325	55							55
1320	60							60

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				GRAVEL (GW) Coarse, sub-angular, green to brown, odourless, dry, weathered.	Water Level Measured on 8/14/2012: 1367.834 masl		0
1375	5				INTERMEDIATE VOLCANICS (V12) Tuff and crystal tuff with minor zones of brecciation. High degree of disseminated pyrite (up to ~15% in places). Increased base metal sulphides from 35.3 - 37.5 m. Sericite clast replacement with minor fuschite seen throughout unit. Medium strong (R3-R3.5) from top of bedrock to 11.3 m. Strong to very strong (R4-R4.5) below 11.3 m. Slight to moderate alteration (A2.5) on major discontinuities from top of bedrock to 8.3 m. Faint to no alteration (A1-A1.5) below 8.3 m. 3.0 m: Fault, 220 mm thick, weathered rock. 5.5 m: Fault, 130 mm thick. 6.5 m: Fault, 350 mm thick. 7.6 m: Fault, 250 mm thick. 8.1 m: Fault, 220 mm thick.			5
1370	10							10
1365	15							15
1360	20							20
1355	25							25
1350	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

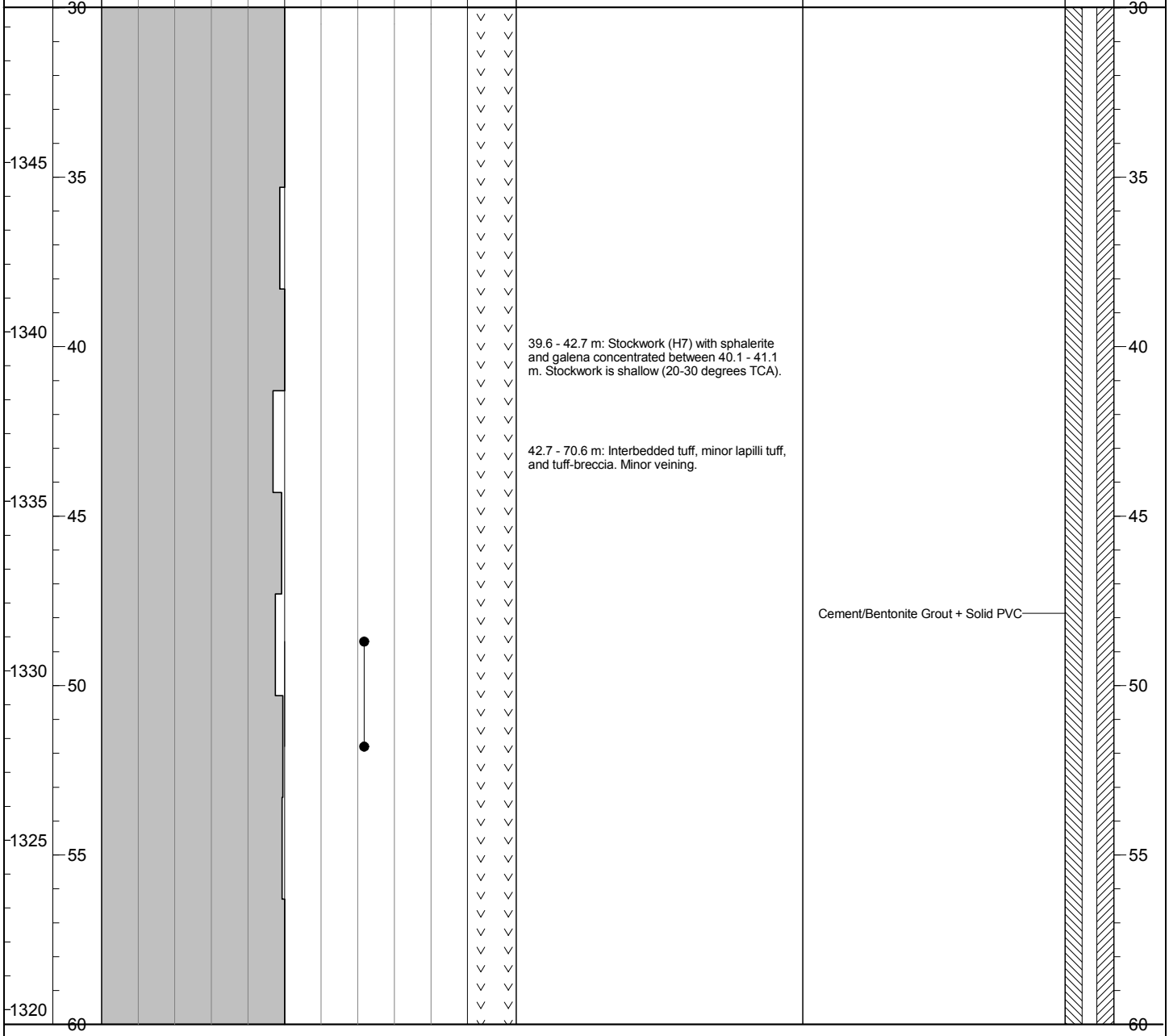
DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	60							60
1315	65							65
1310	70							70
1305	75							75
1300	80							80
1295	85							85
1290	90							90

STOCKWORK (H7)
Quartz-calcite-rhodochrosite with banded chlorite, abundant galena and sphalerite. Strong to very strong (R4-R4.5). Faint to no alteration (A1).
71.9 - 72.5 m: Brecciated section of stockwork.
72.5 - 74.0 m: Stockwork oriented at 10 degrees TCA.

75.4 - 80.0 m: Wall rock, broken rock, sphalerite, galena, pyrite.

87.9 - 90.2 m: Wall rock, broken rock, galena and sphalerite.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-6B

Location: Shore Zone

Co-ordinates (m): 427,097E - 6,258,982N
Ground Elevation (m): 1,379.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1380.2
Cased To (m): 3.84

Start date: 13 Jun 12
Finish Date: 16 Jun 12
Final Depth (m): 103.8
Depth To Top Of Rock (m): 2.5
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90				INTERMEDIATE VOLCANICS (V12) Tuff to crystal tuff with pyrite replacement clasts, significant veining and chlorite stringers. Strong to very strong (R4-R4.5). Faint to slight alteration (A1-A2).			90
1285	95					95.74		95
					96.7 m: Fault, 120 mm thick, crushed rock.	3/8" Coated Bentonite pellets + Solid PVC		
					97.6 m: Fault, 250 mm thick, gouge.	98.2		
1280	100				98.5 m: Fault, 50 mm thick, weathered & broken rock.	100.27		100
					101.4 m: Fault, 30 mm thick, weathered & broken rock.	10/20 Filter sand + 0.020 Slot PVC screen		
						103.32		
					End of Hole: 103.8 m	Bottom of Installation: 103.8 m		
1275	105							105
1270	110							110
1265	115							115
1260	120							120

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

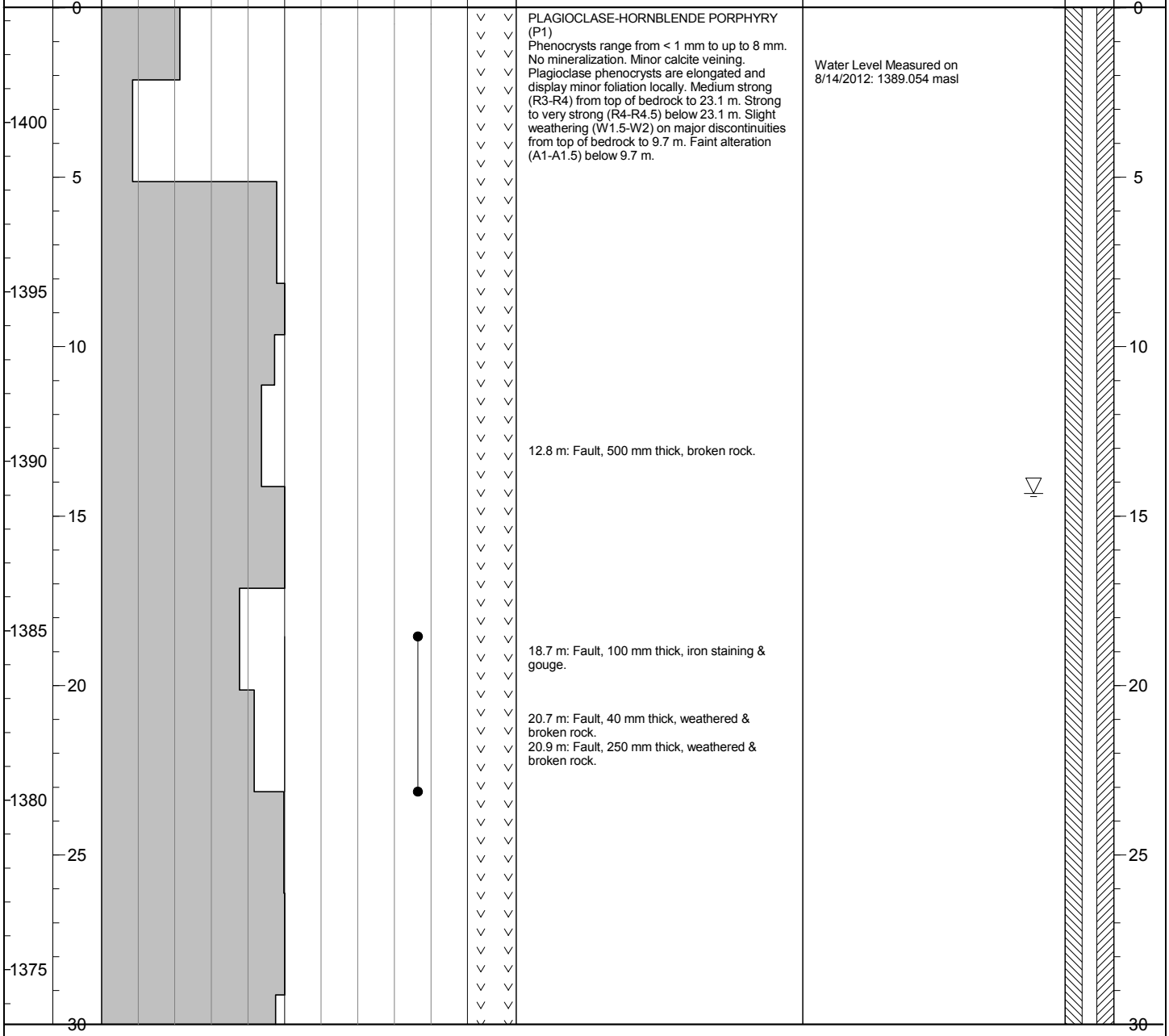
Location: Brucejack

NEW ID: BJ-GW12-8A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description	Comments
PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Phenocrysts range from < 1 mm to up to 8 mm. No mineralization. Minor calcite veining. Plagioclase phenocrysts are elongated and display minor foliation locally. Medium strong (R3-R4) from top of bedrock to 23.1 m. Strong to very strong (R4-R4.5) below 23.1 m. Slight weathering (W1.5-W2) on major discontinuities from top of bedrock to 9.7 m. Faint alteration (A1-A1.5) below 9.7 m.	Water Level Measured on 8/14/2012: 1389.054 masl
12.8 m: Fault, 500 mm thick, broken rock.	
18.7 m: Fault, 100 mm thick, iron staining & gouge.	
20.7 m: Fault, 40 mm thick, weathered & broken rock. 20.9 m: Fault, 250 mm thick, weathered & broken rock.	

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

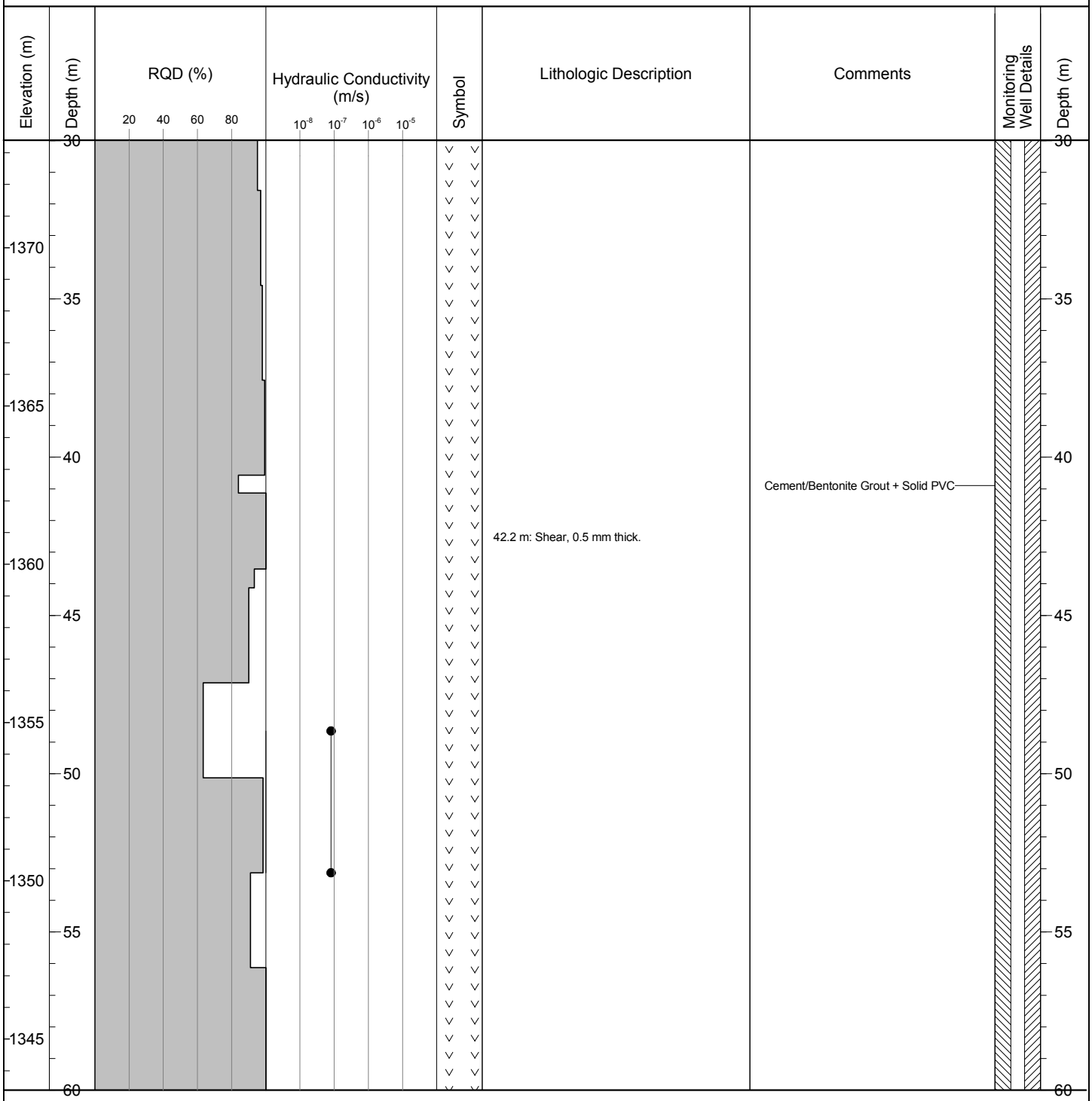
Location: Brucejack

NEW ID: BJ-GW12-8A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

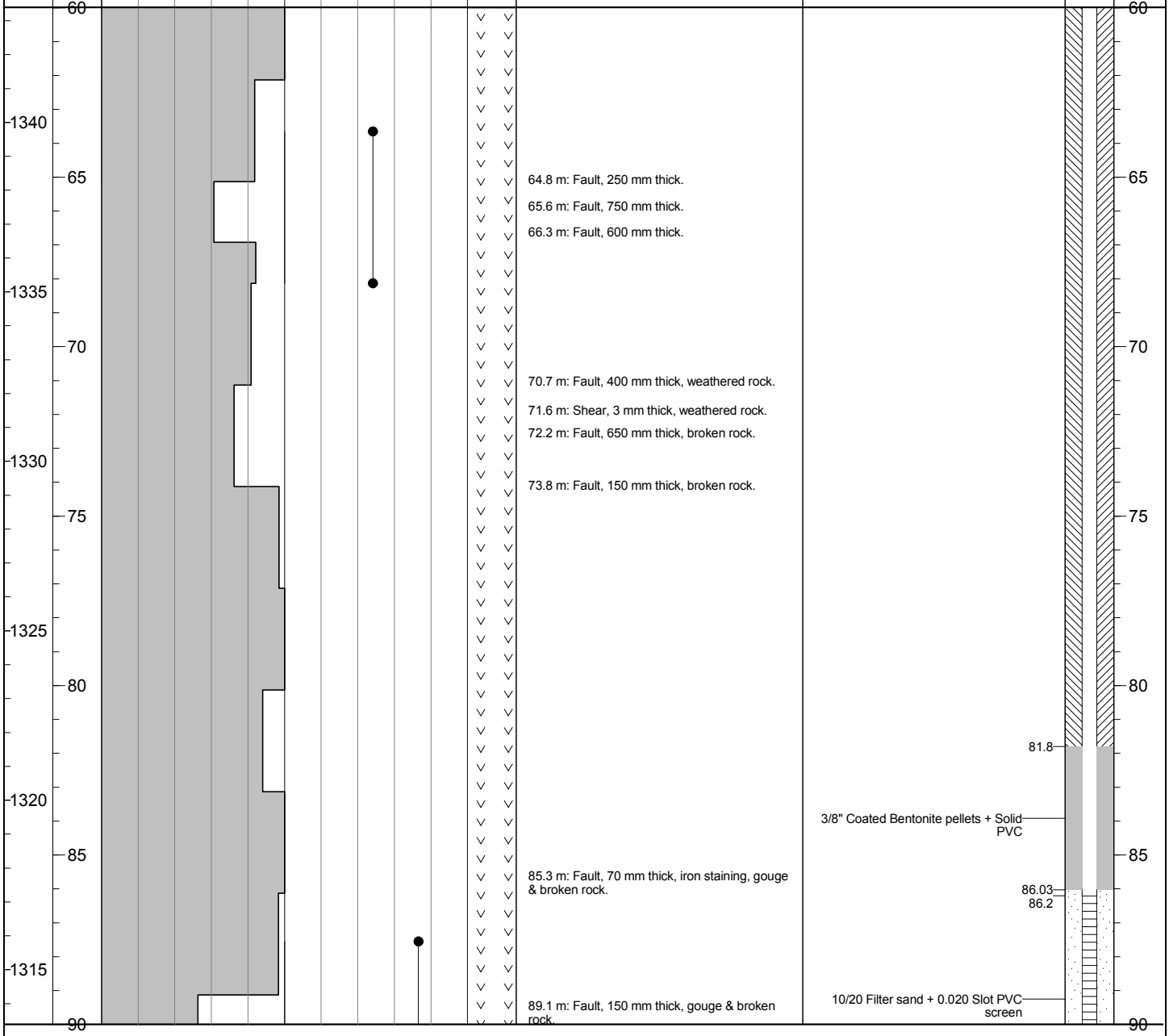
Location: Brucejack

NEW ID: BJ-GW12-8A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8A

Location: Brucejack

NEW ID: BJ-GW12-8A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,818N
Ground Elevation (m): 1,403.38
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.35
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.7
Cased To (m): 1.09

Start date: 16 Jun 12
Finish Date: 18 Jun 12
Final Depth (m): 95.1
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90				90.1 m: Fault, 70 mm thick, broken rock.			90
1310					91.4 m: Fault, 300 mm thick, iron staining & gouge.	92.3		
	95				End of Hole: 95.1 m	Bottom of Installation: 95.1 m		95
1305								
	100							100
1300								
	105							105
1295								
	110							110
1290								
	115							115
1285								
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8B

Location: Brucejack

NEW ID: BJ-GW12-8B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,819N
Ground Elevation (m): 1,403.30
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.33
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.6
Cased To (m): 1.12

Start date: 18 Jun 12
Finish Date: 19 Jun 12
Final Depth (m): 51.0
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1400, 1395, 1390, 1385, 1380, 1375	0, 5, 10, 15, 20, 25, 30				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Phenocrysts range from < 1 mm to up to 8 mm. No mineralization. Minor calcite veining. Plagioclase phenocrysts are elongated and display minor foliation locally. Medium strong (R3-R4) from top of bedrock to 23.1 m. Strong to very strong (R4-R4.5) below 23.1 m. Slight weathering (W1.5-W2) on major discontinuities from top of bedrock to 9.7 m. Faint alteration (A1-A1.5) below 9.7 m.	Water Level Measured on 8/14/2012: 1385.59 masl Cement/Bentonite Grout + Solid PVC		

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-8B

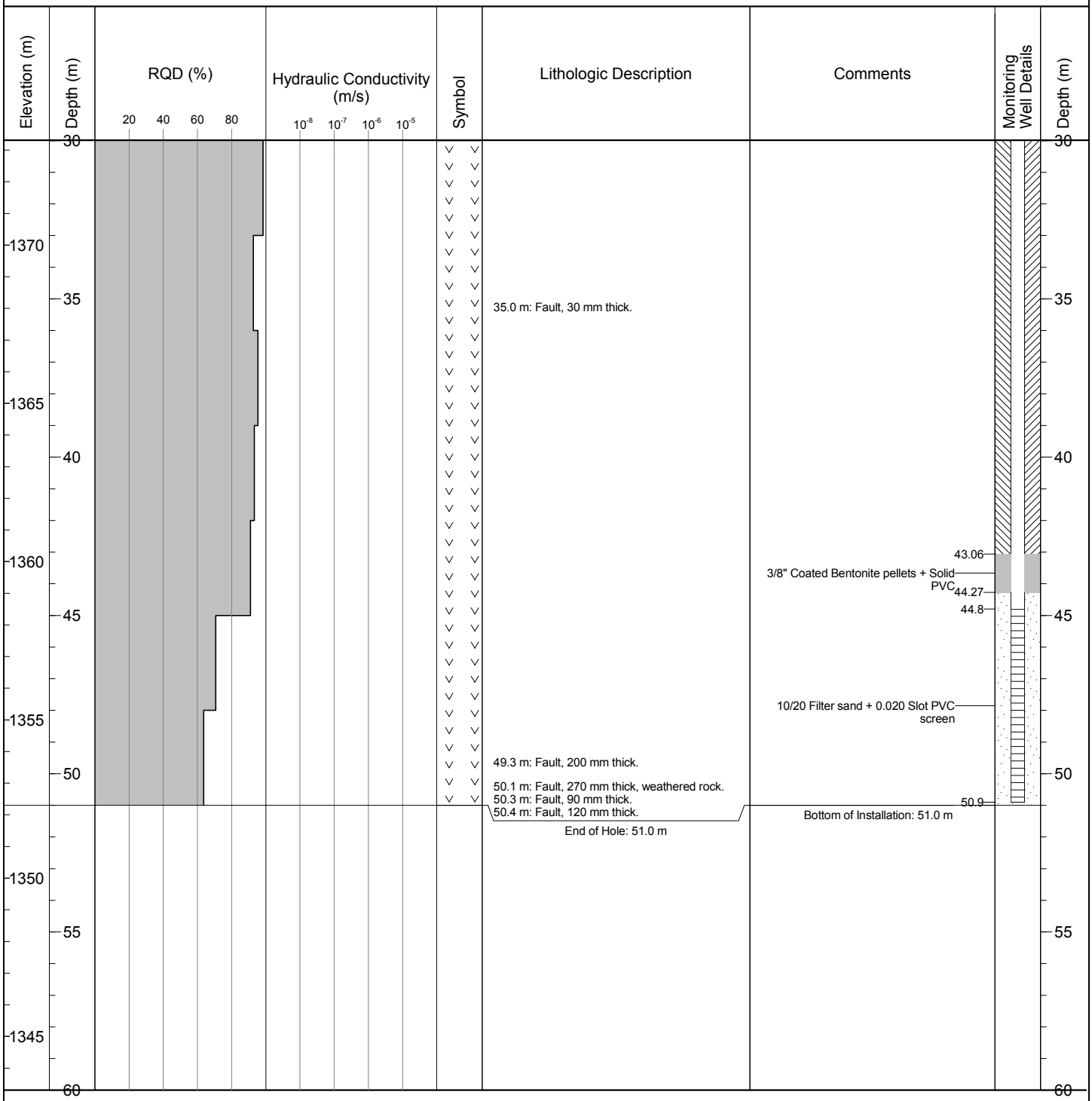
Location: Brucejack

NEW ID: BJ-GW12-8B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,106E - 6,258,819N
Ground Elevation (m): 1,403.30
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.33
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1403.6
Cased To (m): 1.12

Start date: 18 Jun 12
Finish Date: 19 Jun 12
Final Depth (m): 51.0
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9A

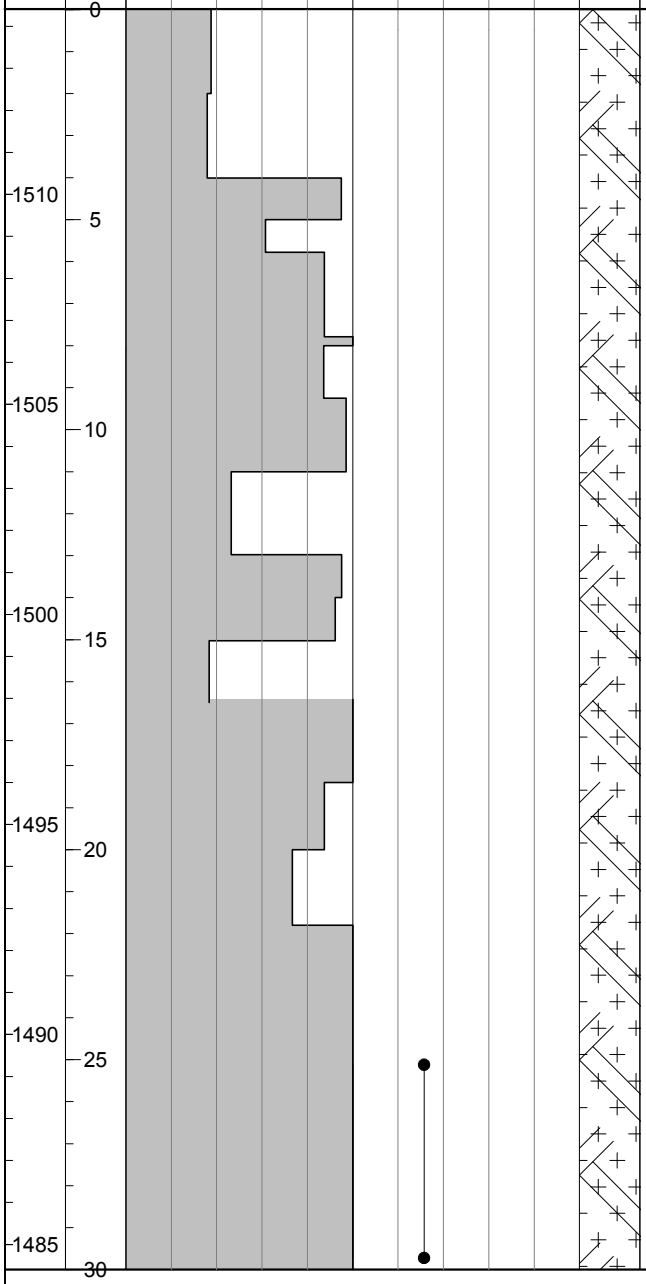
Location: Brucejack

NEW ID: BJ-GW12-9A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



Lithologic Description	Comments
PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Moderately homogeneous porphyry, <2% veining, sericite alteration of matrix and phenocrysts. Strong to very strong (R4-R5). Faint weathering (W1-W1.5)	Water Level Measured on 8/14/2012: 1456.17 masl
7.7 m: Shear, 5 mm thick.	

Monitoring Well Details

Depth (m)

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9A

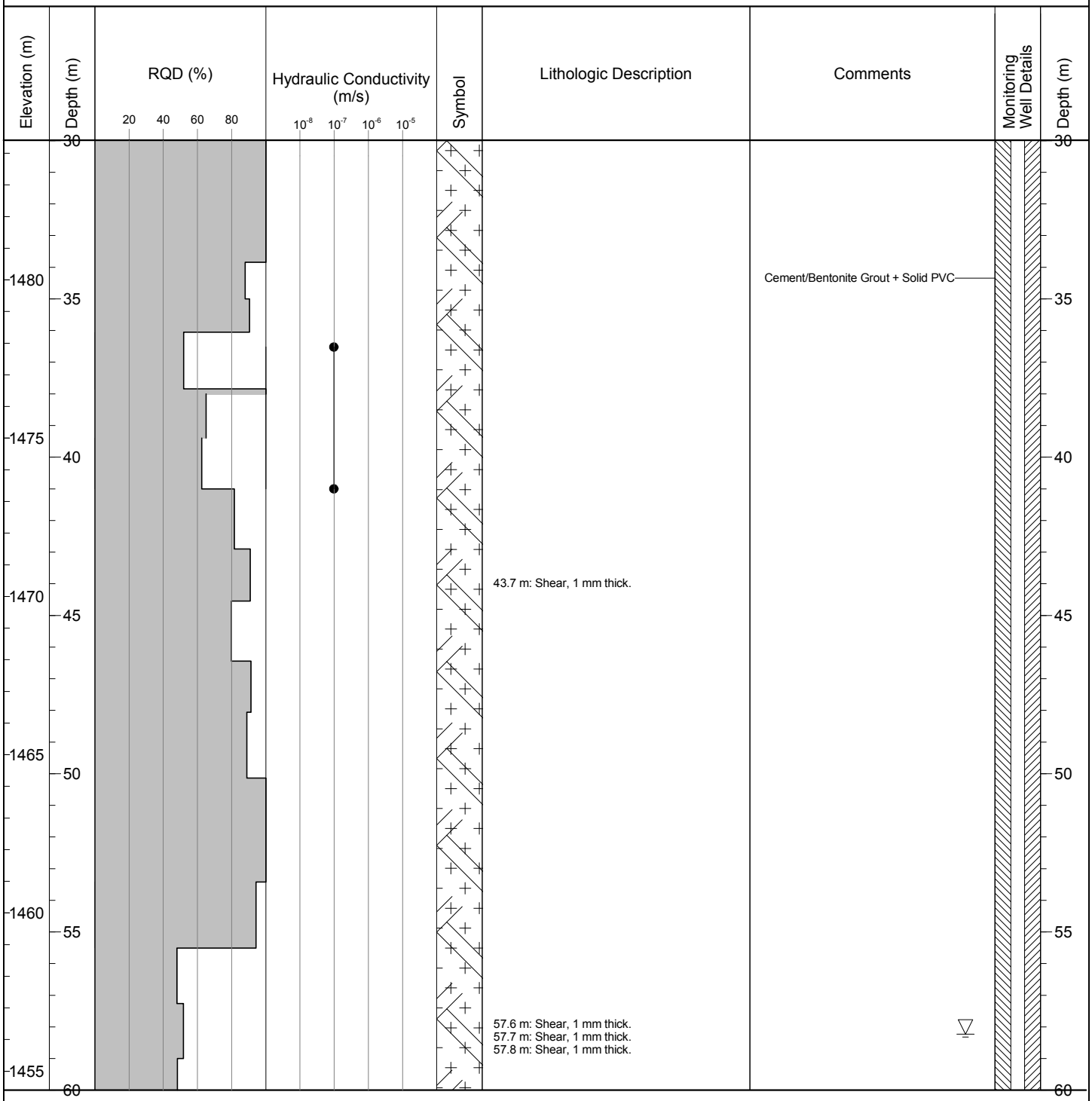
Location: Brucejack

NEW ID: BJ-GW12-9A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9A

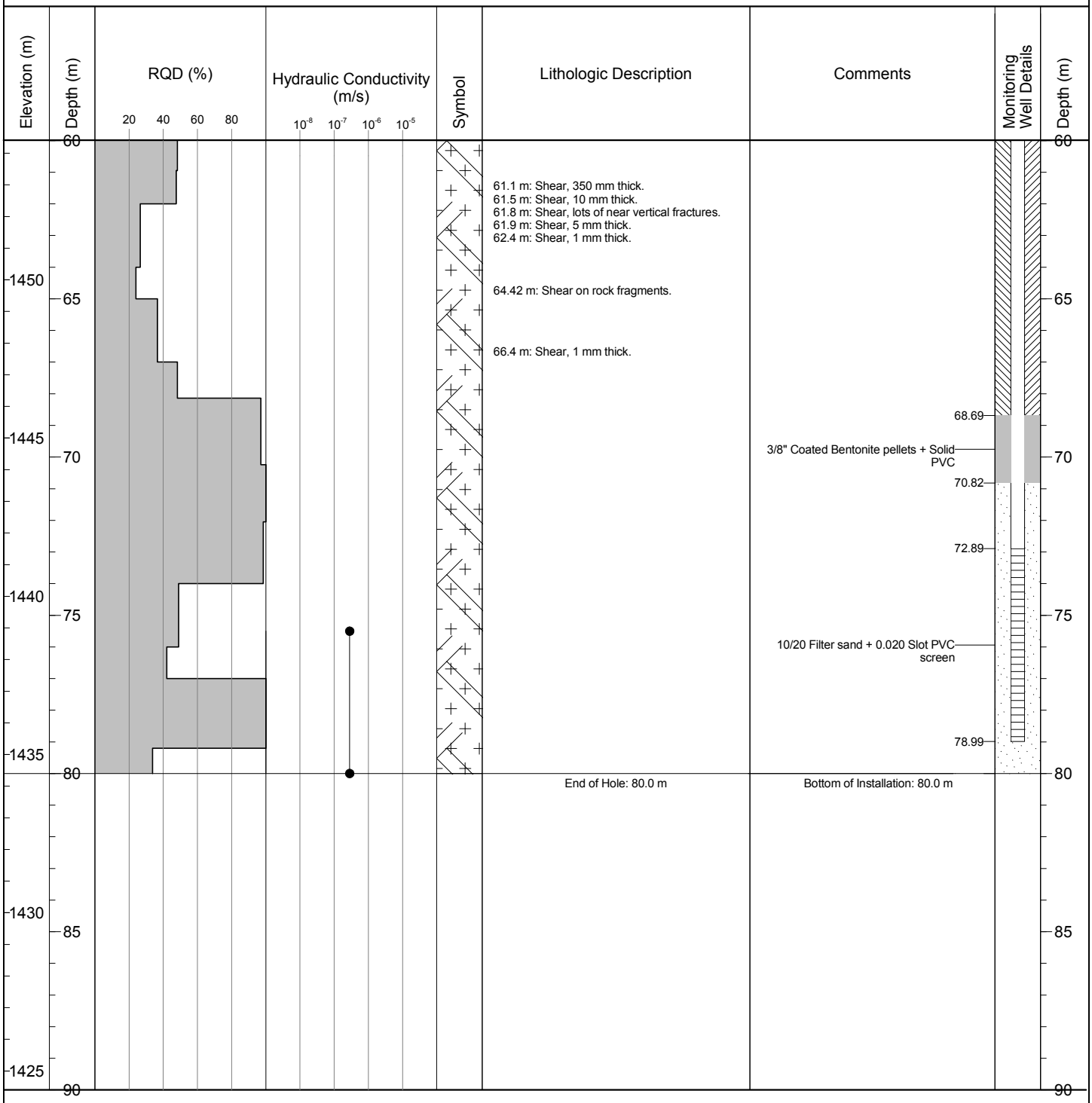
Location: Brucejack

NEW ID: BJ-GW12-9A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,465E - 6,258,361N
Ground Elevation (m): 1,514.40
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.73
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.1
Cased To (m): 1.5

Start date: 01 Aug 12
Finish Date: 04 Aug 12
Final Depth (m): 80.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9B

Location: Brucejack

NEW ID: BJ-GW12-9B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,461E - 6,258,362N
Ground Elevation (m): 1,514.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.2
Cased To (m): 1.09

Start date: 30 Jul 12
Finish Date: 01 Aug 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Moderately homogeneous porphyry, <2% veining, sericite alteration of matrix and phenocrysts. Strong to very strong (R4-R5). Faint alteration (A1.5)	Water Level Measured on 8/14/2012: 1498.128 masl		0
1510	5							5
1505	10							10
1500	15							15
						Cement/Bentonite Grout + Solid PVC		
1495	20				20.4 m: Shear, 1 mm thick.			20
1490	25							25
1485	30							30

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Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-9B

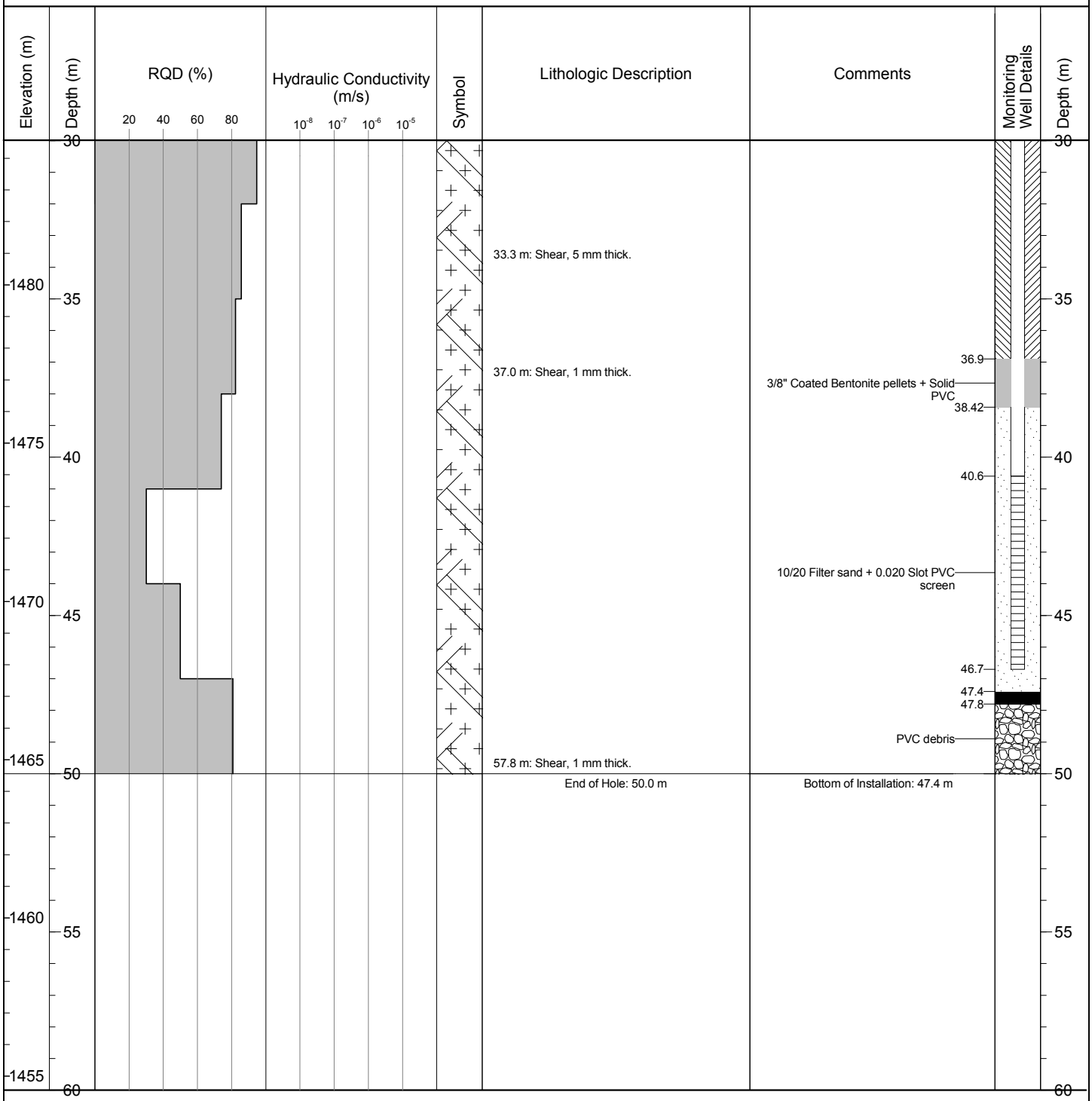
Location: Brucejack

NEW ID: BJ-GW12-9B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,461E - 6,258,362N
Ground Elevation (m): 1,514.56
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.67
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1515.2
Cased To (m): 1.09

Start date: 30 Jul 12
Finish Date: 01 Aug 12
Final Depth (m): 50.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1445	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		INTERMEDIATE VOLCANICS (V12) IInfrequent clasts (< 2% of interval) of plagioclase-horbblende porphyry (P1) (up to 5 cm across, but mostly 2 - 3 cm). Plagioclase phenocrysts tend to be euhedral and are sometimes replaced by pyrite. Moderately to above moderate sericite-chlorite pervasive, phenocryst and clast replacement. Strong to very strong (R4-R4.5). Slight alteration (A2) on major discontinuities from top of bedrock to 5.3 m below ground surface. Faint alteration (A1-A1.5) below 5.3 m.	Water Level Measured on 8/14/2012: 1435.126 masl		0
1440	5							5
1435	10							10
1430	15							15
1425	20							20
1420	25					Cement/Bentonite Grout + Solid PVC		25
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

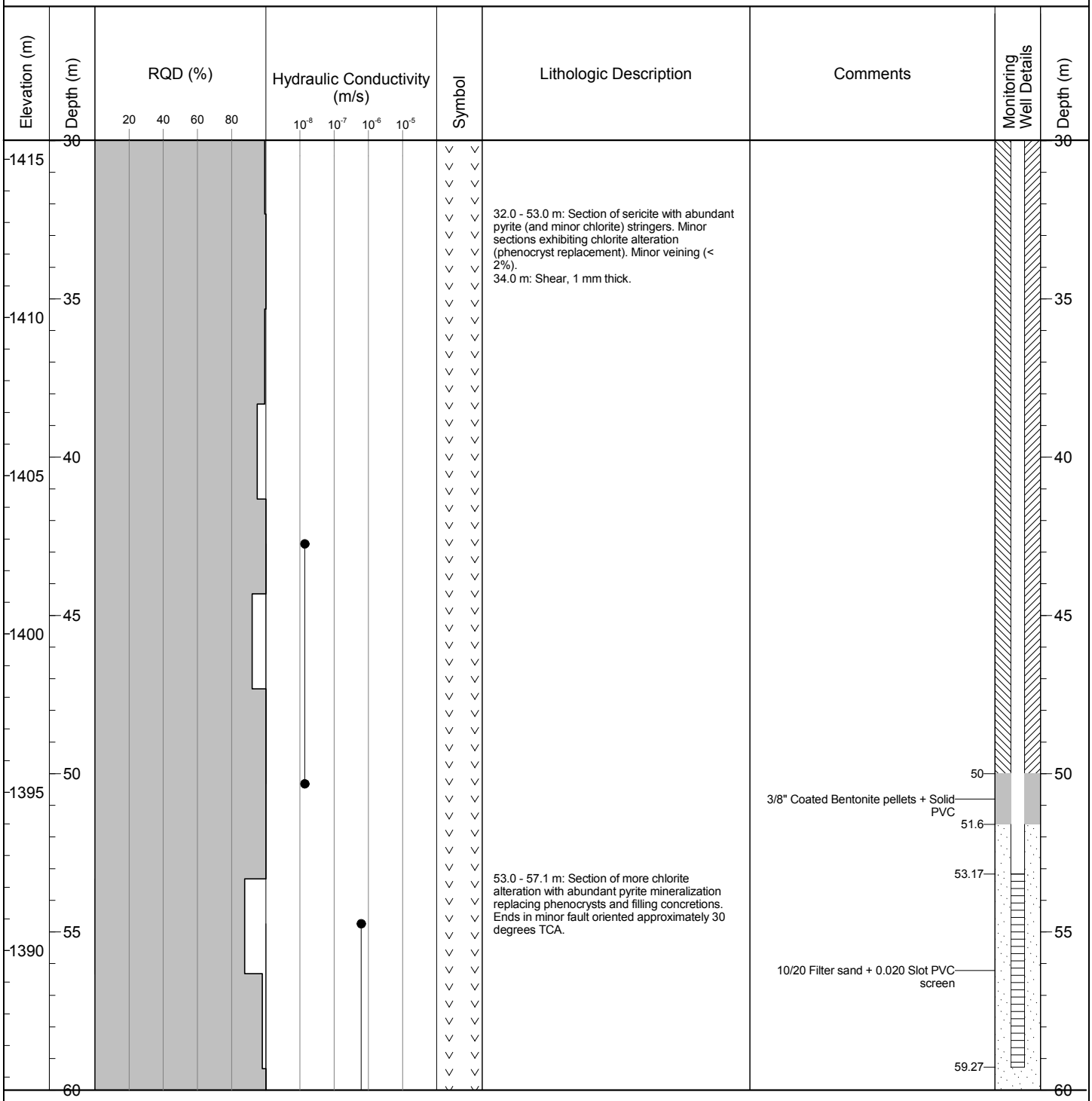
DRILL HOLE # MW-BGC12-BJ-10A

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC12-BJ-10A

Project: Brucejack
Project No.: 1008-007
Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.59
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.38
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.0
Cased To (m): NO CASING INSTALLED

Start date: 20 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 62.3
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1385	60					3/8" Coated Bentonite pellets 60.13–60.48		60
					End of Hole: 62.3 m	Bottom of Installation: 60.1 m		
1380	65							65
1375	70							70
1370	75							75
1365	80							80
1360	85							85
	90							90

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-10B

Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.64
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.72
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.4
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 41.4
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1445	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		INTERMEDIATE VOLCANICS (V12) Infrequent clasts (< 2% of interval) of plagioclase-horbblende porphyry (P1) (up to 5 cm across, but mostly 2 - 3 cm). Plagioclase phenocrysts tend to be euhedral and are sometimes replaced by pyrite. Moderately to above moderate sericite-chlorite pervasive, phenocryst and clast replacement. Strong to very strong (R4-R4.5). Slight alteration (A2) on major discontinuities from top of bedrock to 5.3 m below ground surface. Faint alteration (A1-A1.5) below 5.3 m.	Water Level Measured on 8/14/2012: 1433.149 masl		0
1440	5							5
1435	10							10
1430	15					Cement/Bentonite Grout + Solid PVC		15
1425	20							20
1420	25							25
	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

DRILL HOLE # MW-BGC12-BJ-10B

Project: Brucejack
Project No.: 1008-007
Location: Brucejack (Plant Site)

Co-ordinates (m): 426,989E - 6,258,341N
Ground Elevation (m): 1,445.64
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.72
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1446.4
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 22 Jun 12
Final Depth (m): 41.4
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
1415	30							30
					32.0 - 41.4 m: Section of sericite with abundant pyrite (and minor chlorite) stringers. Minor sections exhibiting chlorite alteration (phenocryst replacement). Minor veining (< 2%).			
1410	35					34.5 3/8" Coated Bentonite pellets + Solid PVC 35.6		35
						38.05		
					39.0 m: Fault, 100 mm thick, fault on vein.	10/20 Filter sand + 0.020 Slot PVC screen		
1405	40					41.1		40
					End of Hole: 41.4 m	Bottom of Installation: 41.4 m		
1400	45							45
1395	50							50
1390	55							55
	60							60

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11A

Location: West Zone

NEW ID: BJ-GW12-11A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,300E - 6,258,595N
Ground Elevation (m): 1,433.57
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1434.2
Cased To (m): NO CASING INSTALLED

Start date: 22 Jun 12
Finish Date: 26 Jun 12
Final Depth (m): 29.5
Depth To Top Of Rock (m): 0.0
Logged by: LM/RH
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Contains pervasive sericite-chlorite alteration with phenocryst replacement. Multiple veinlets. Medium strong to strong (R3-R3.5). Faint to slight alteration (A1.5-A2). 1.5 m: Fault, 300 mm thick, weathered rock. 2.1 m: Fault, 400 mm thick. 2.5 m: Fault, 300 mm thick, weathered & broken rock.	Water Level Measured on 8/14/2012: 1427.261 masl		0
1430	5				4.9 m: Fault, 100 mm thick.			5
1425	10					Cement/Bentonite Grout + Solid PVC		10
1420	15				12.9 - 23.5 m: Stockwork (H7) with minimal mineralization. Steep wall rock veinlets (oriented 50-90 degrees TCA). 15.8 m: Fault, 110 mm thick, broken rock.			15
1415	20							20
1410	25				23.5 - 29.5 m: Some sections of conglomerated porphyry. 27.2 m: Fault, 350 mm thick, weathered & broken rock.	24.9 3/8" Coated Bentonite pellets + Solid PVC 25.8 26.45 10/20 Filter sand + 0.020 Slot PVC screen		25
1405	30				End of Hole: 29.5 m	Bottom of Installation: 29.5 m		30

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

BGC ENGINEERING INC.
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CLIENT: Pretium Resources Inc.

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11B

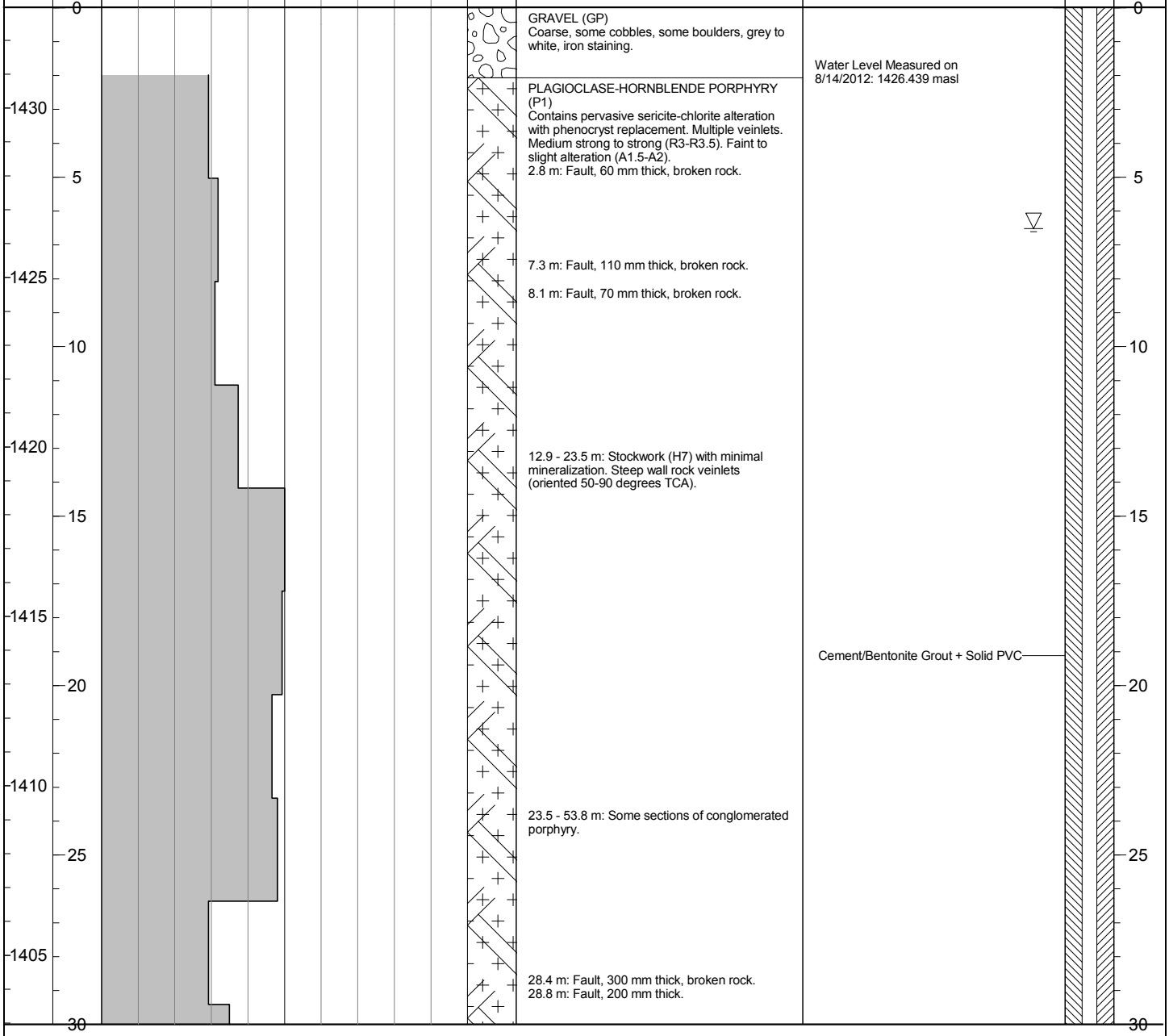
Location: West Zone

NEW ID: BJ-GW12-11B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,299E - 6,258,595N
Ground Elevation (m): 1,432.96
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1433.6
Cased To (m): 1.06

Start date: 26 Jun 12
Finish Date: 28 Jun 12
Final Depth (m): 53.8
Depth To Top Of Rock (m): 2.1
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description

GRAVEL (GP)
Coarse, some cobbles, some boulders, grey to white, iron staining.

PLAGIOCLASE-HORNBLENDE PORPHYRY (P1)
Contains pervasive sericite-chlorite alteration with phenocryst replacement. Multiple veinlets. Medium strong to strong (R3-R3.5). Faint to slight alteration (A1.5-A2).
2.8 m: Fault, 60 mm thick, broken rock.

7.3 m: Fault, 110 mm thick, broken rock.

8.1 m: Fault, 70 mm thick, broken rock.

12.9 - 23.5 m: Stockwork (H7) with minimal mineralization. Steep wall rock veinlets (oriented 50-90 degrees TCA).

23.5 - 53.8 m: Some sections of conglomerated porphyry.

28.4 m: Fault, 300 mm thick, broken rock.
28.8 m: Fault, 200 mm thick.

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-11B

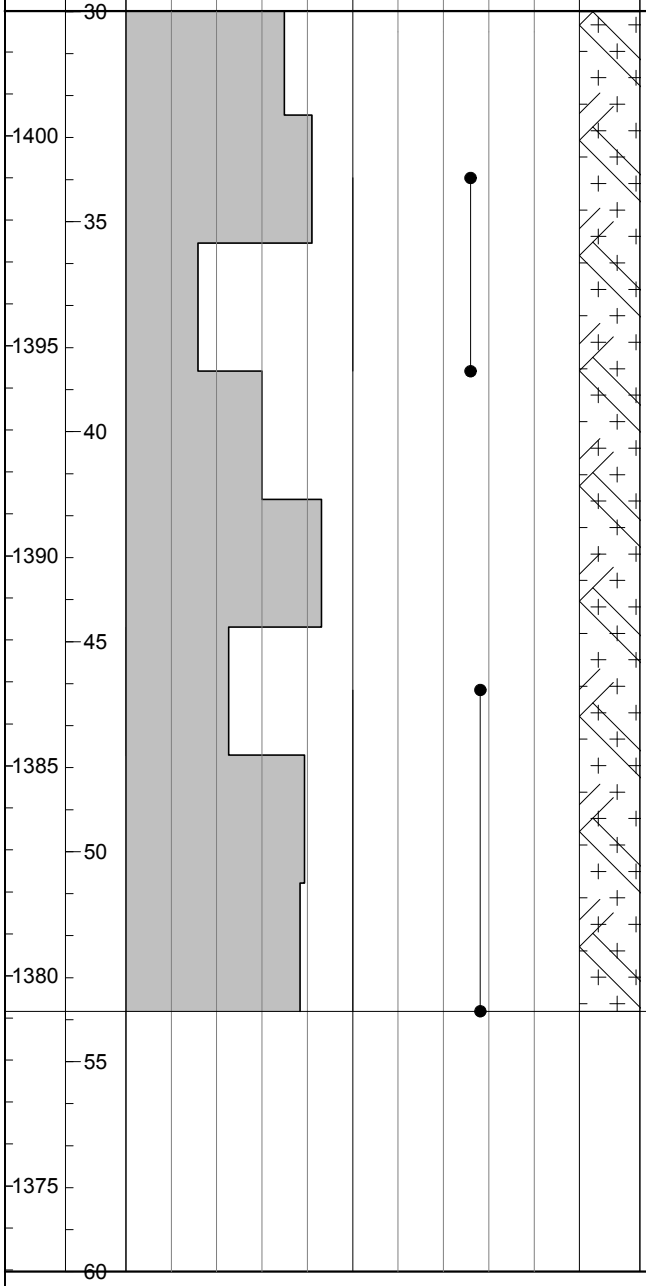
Location: West Zone

NEW ID: BJ-GW12-11B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,299E - 6,258,595N
Ground Elevation (m): 1,432.96
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.61
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: HQ
Top of PVC Elevation (m): 1433.6
Cased To (m): 1.06

Start date: 26 Jun 12
Finish Date: 28 Jun 12
Final Depth (m): 53.8
Depth To Top Of Rock (m): 2.1
Logged by: LM/RH
Reviewed by: KSJ



Lithologic Description

30.2 m: Fault, 50 mm thick.

32.0 m: Fault, 90 mm thick.
32.4 m: Fault, 120 mm thick.

35.3 m: Fault, 50 mm thick.
35.8 m: Fault, 100 mm thick, broken rock.
36.1 m: Fault, 120 mm thick, broken rock.
36.5 m: Fault, 400 mm thick, broken rock.

37.3 m: Fault, 80 mm thick, broken rock.
37.6 m: Fault, 70 mm thick, broken rock.
37.7 m: Fault, 160 mm thick, broken rock.
38.3 m: Fault, 90 mm thick, broken rock.

39.5 m: Fault, 950 mm thick, broken rock.

41.9 m: Fault, 160 mm thick, weathered & broken rock.

44.9 - 45.9 m: Fault zone, 4 faults 60-450 mm thick, iron staining & broken rock.

47.9 m: Fault, 150 mm thick.

48.5 m: Fault, 60 mm thick, fault on calcite vein.
49.0 m: Fault, 130 mm thick, broken rock.

52.4 m: Fault, 80 mm thick, fault on vein.
52.8 m: Fault, 140 mm thick, fault on vein.

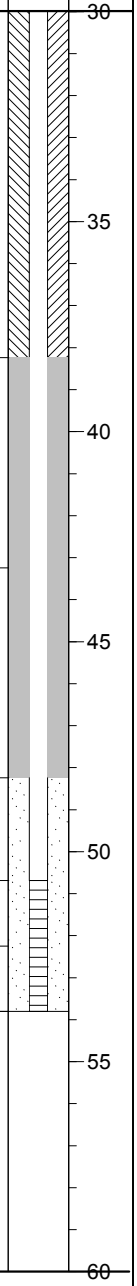
End of Hole: 53.8 m

Comments

3/8" Coated Bentonite pellets + Solid PVC

10/20 Filter sand + 0.020 Slot PVC screen

Bottom of Installation: 53.8 m



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,509E - 6,257,807N
Ground Elevation (m): 1,579.19
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}		PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Heavily sericite altered. Mainly homogenous porphyry textures. Strong to very strong (R4-R5). 7.9 – 10.5 m: strength reduced to medium strong (R3). Slight alteration (A1.5) from top of bedrock to 2.0 m. Faint weathering (1-1.5) below 2.0 m	Water Level Measured on 8/14/2012: 1528.285 masl		0
1575	5							5
1570	10							10
1565	15							15
1560	20				19.8 m: Fault, 5 mm thick, gouge.			20
1555	25							25
1550	30							30

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

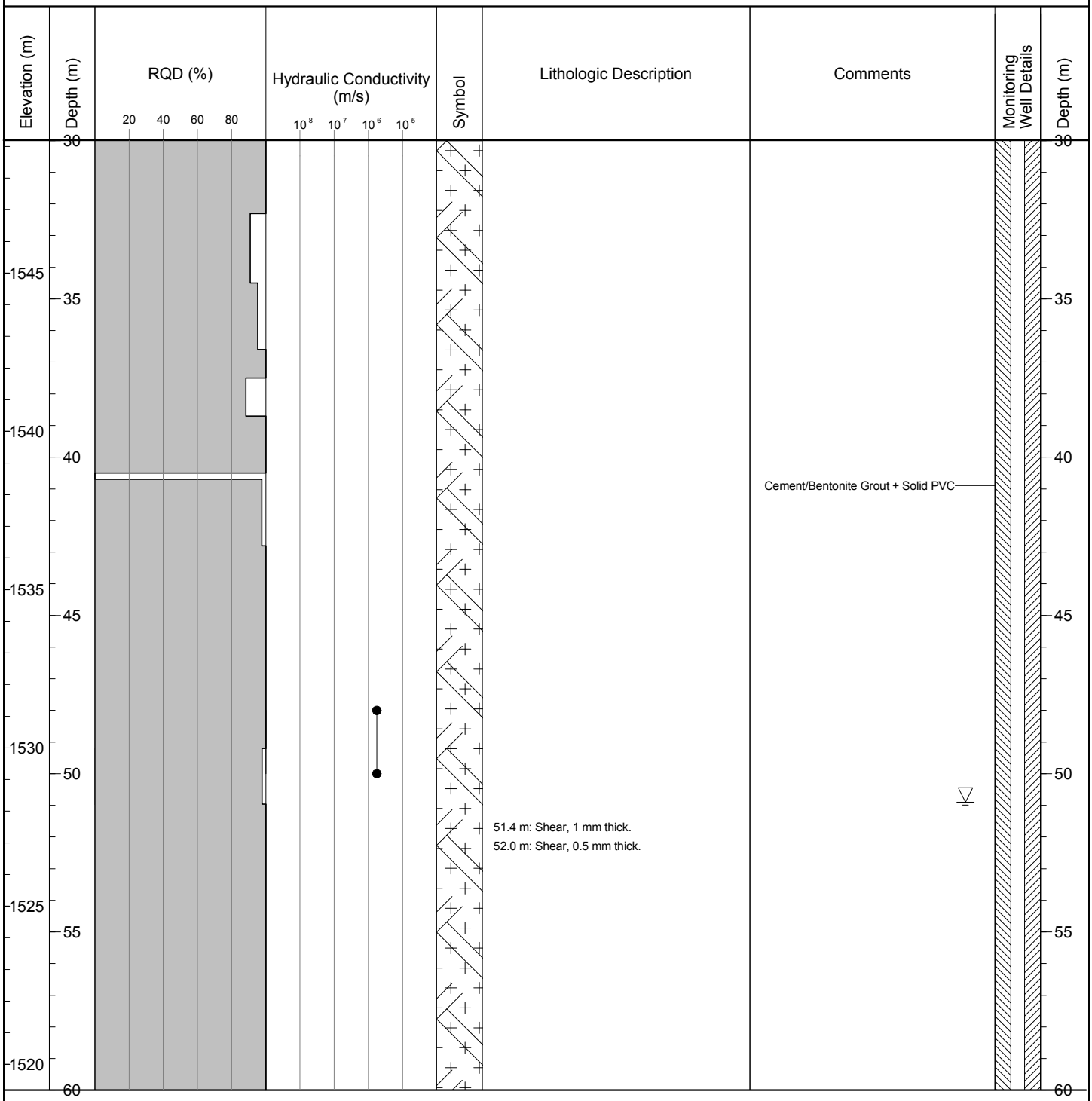
Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,509E - 6,257,807N
Ground Elevation (m): 1,579.19
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

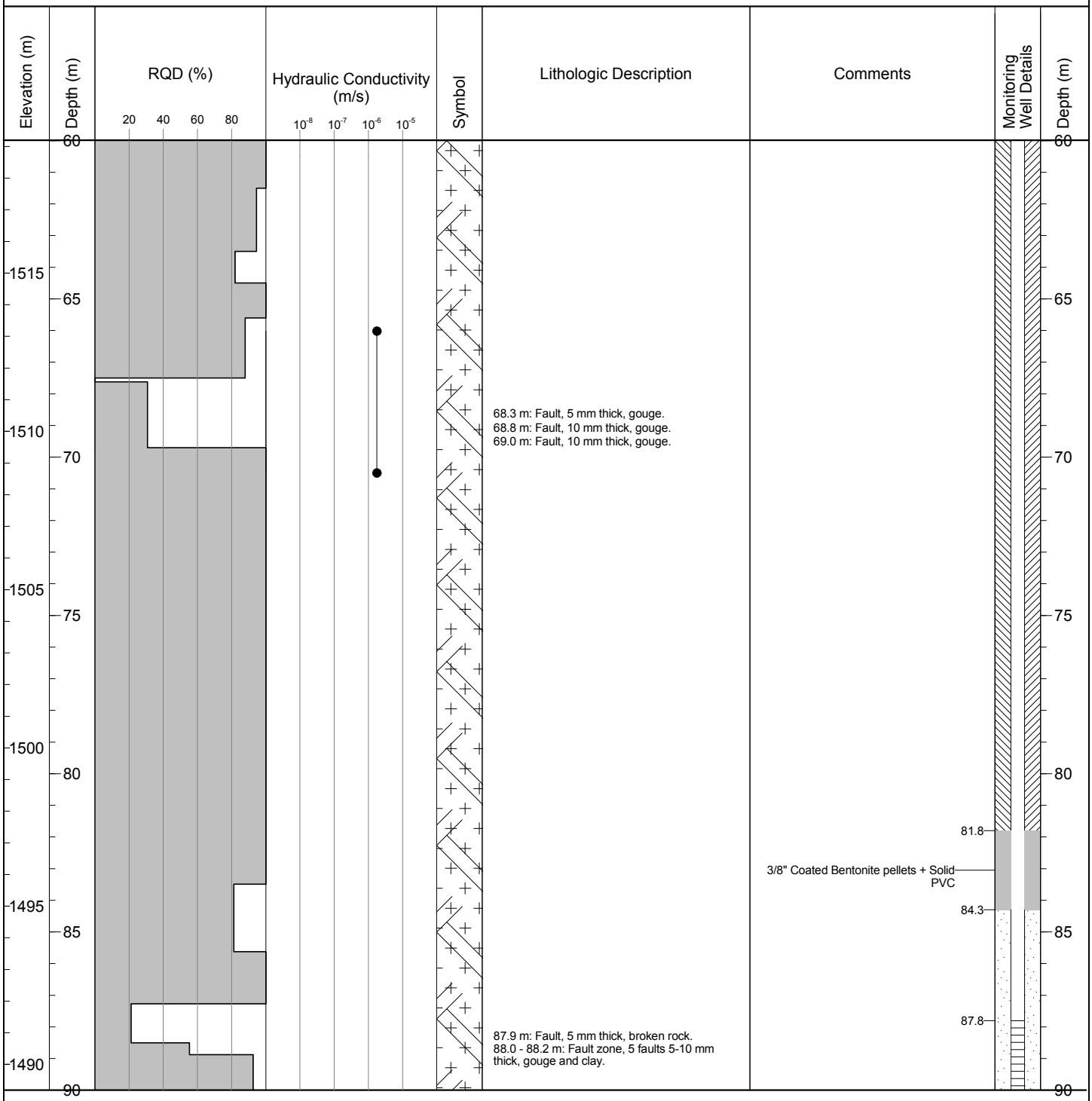
Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,509E - 6,257,807N
Ground Elevation (m): 1,579.19
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ



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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12A

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12A
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,509E - 6,257,807N
Ground Elevation (m): 1,579.19
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1580.0
Cased To (m): 1.2

Start date: 04 Aug 12
Finish Date: 08 Aug 12
Final Depth (m): 100.0
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	90					10/20 Filter sand + 0.020 Slot PVC screen		90
1485						93.9		
	95							95
						97		
1480						3/8" Coated Bentonite pellets + Solid PVC		
	100				End of Hole: 100.0 m	Bottom of Installation: 97.0 m		100
1475								
	105							105
1470								
	110							110
1465								
	115							115
1460								
	120							120

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12B

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,505E - 6,257,807N
Ground Elevation (m): 1,579.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1579.9
Cased To (m): 1

Start date: 09 Aug 12
Finish Date: 10 Aug 12
Final Depth (m): 53.1
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%) (20, 40, 60, 80)	Hydraulic Conductivity (m/s) (10^{-8}, 10^{-7}, 10^{-6}, 10^{-5})	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	0				PLAGIOCLASE-HORNBLENDE PORPHYRY (P1) Heavily sericite altered. Mainly homogenous porphyry textures. Strong to very strong (R4-R5). Slight alteration (A1.5) from top of bedrock to 5.9 m. Faint weathering (1-1.5) below 5.9 m	Water Level Measured on 8/14/2012: 1542.338 masl		0
1575	5							5
1570	10				10.5 m: Fault, 100 mm thick, quartz, iron staining.			10
1565					13.2 m: Shear, 0.5 mm thick.			
	15				14.7 m: Shear, 0.5 mm thick, black staining.			15
1560	20				21.3 - 21.6 m: Fault zone, 2 faults 100 mm thick, gouge.	Cement/Bentonite Grout + Solid PVC		20
1555	25							25
1550	30							30

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CLIENT: Pretium Resources Inc.

BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

Project: Brucejack
Project No.: 1008-007

DRILL HOLE # MW-BGC12-BJ-12B

Location: Valley of Kings Zone

NEW ID: BJ-GW12-12B
ID CHANGE 14 DEC 18

Co-ordinates (m): 426,505E - 6,257,807N
Ground Elevation (m): 1,579.16
Survey Method: Surveyed
Datum: UTM NAD 83 Zone 9
Stick Up (m): 0.78
Surface Completion: PVC Stick-Up

Drill Designation: Heliportable
Drilling Contractor: Radius
Drill Method: Diamond
Core: PQ
Top of PVC Elevation (m): 1579.9
Cased To (m): 1

Start date: 09 Aug 12
Finish Date: 10 Aug 12
Final Depth (m): 53.1
Depth To Top Of Rock (m): 0.0
Logged by: DP/LL
Reviewed by: KSJ

Elevation (m)	Depth (m)	RQD (%)	Hydraulic Conductivity (m/s)	Symbol	Lithologic Description	Comments	Monitoring Well Details	Depth (m)
	30	20 40 60 80	10^{-8} 10^{-7} 10^{-6} 10^{-5}					30
1545	35							35
1540	40							40
1535	45				43.3 m: Fault, 30 mm thick, breccia.	43.16 3/8" Coated Bentonite pellets + Solid PVC 45.22 46.71		45
1530	50					10/20 Filter sand + 0.020 Slot PVC screen 52.8		50
					End of Hole: 53.1 m	Bottom of Installation: 53.1 m		
1525	55							55
1520	60							60

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CLIENT: Pretium Resources Inc.

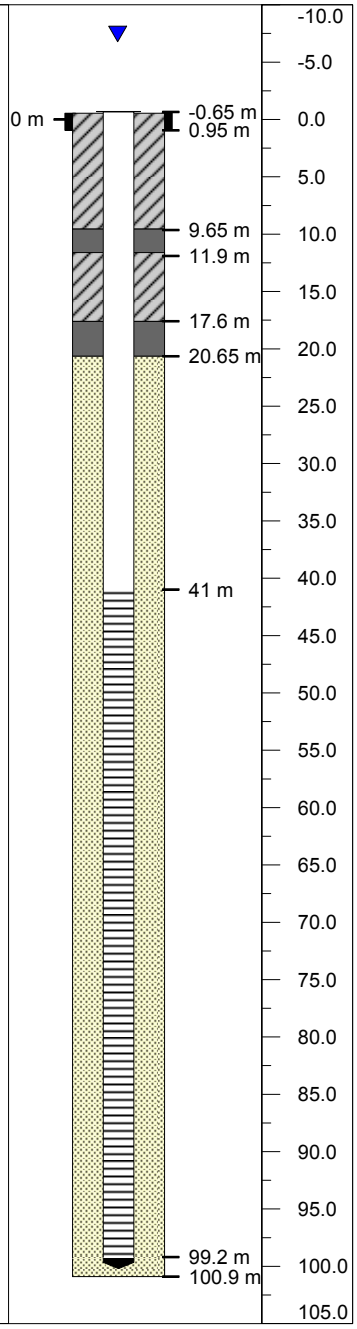
BRUCEJACK (HYDROGEO) BRUCEJACK_HYDROGEO.GDL BGC.GDT 6/4/13

NEW ID: BJ-GW14-13A
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-13A

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 4-8, 2014
				INSTALL DATE:	Sep 9, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Professional Survey	FINAL HOLE DEPTH (m):	100.9
COORDINATES:	426118 E, 6258904 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1362.49				
DATUM:	NAD 83 UTM ZONE 9N	DRILL METHOD:	Diamond-Triple Tube	REVIEWED BY:	DP/TC

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface				
5.0		VOLCANIC ROCK ; fine to medium grained porphyry latite flow with hornblende phenocrysts, sub-mm sericite carbonate replaced plagioclase feldspar and hornblende phenocrysts throughout, generally 5-12 % composition, volcanic flows are weakly phyllic altered, local intensities of altered phenocrysts do occur, commonly distal from weak-moderate phyllic alteration, phenocrysts follow preferential foliation (45 depth to core axis), which also could be a feature of flow characteristic.		Hole initially drilled to HQ diameter, then reamed to PQ diameter.		
10.0			Packer Test 1 9.4 - 13.9 m Invalid Test	At 11.8 m: Fault; infilled with fault gouge, grey, soft, complete loss of drilling fluid circulation. No drill fluid circulation between 11.8 m and 100.9 m (EOH).		
15.0				At 17.6 m: Fault; oxidation staining, many quartz and calcite intrusions.		
20.0			Packer Test 2 21.2 - 28.9 m K=1.0x10-6 m/s	Between 19.6 - 35 m: Highly fractured zone, oxidation staining, surfaces are red-brown.		
25.0						
30.0						
35.0						
40.0						
45.0				Between 48 - 49 m: Fault zone; heavily broken, some sand, average particle size 30 to 50 mm, some fault gouge, annealed fault.		
50.0						
55.0				Between 72 - 75 m: Highly fractured zone; most joints occur parallel to intrusions, 0.5 to 2 mm apperture At 96 m: Fault; clay infilling, grey, wet, soft.		
60.0			Packer Test 4 19.9 - 100.9 m K= 1.8 x 10-7 m/s			
65.0				NOTES: 1) Water was used as drilling fluid. 2) Drilling fluid circulation was lost between 12 m bgs and the EOH (101 m). 3) Water level at the end of drilling (before grouting in well completion) was 4.1 m bgs 4) The stickup for the PVC was measured at 0.6 m after the installation. 5) Flowing artesian conditions (approximately 1 gallon/min) were encountered after completion of the well installation. 6) Well installation completed using 3" (77 mm) dia. schedule 40 PVC; 020 slot schedule 40 PVC well screens. Enviroplug 1/4" pellets were used for the bentonite seal along with cement-bentonite grout. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter. 7) Geological descriptions provided by Pretivm geologists.		
70.0						
75.0						
80.0			Packer Test 3 66.6 - 100.9 m K=8.6x10-8 m/s			
85.0						
90.0						
95.0						
100.0		End of Hole at 100.9 m				
105.0						



LITHOLOGY

- Volcanic Rock
- Static Water Level

WELL CONSTRUCTION MATERIALS

- Well Cap
- Casing
- Solid PVC
- Screened PVC
- End Cap
- Bentonite Seal
- Grout
- Silica Sand

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NEW ID: BJ-GW14-13B
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-13B

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 11-12, 2014
				INSTALL DATE:	Sep 13, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Professional Survey	FINAL HOLE DEPTH (m):	75.4
COORDINATES:	426118 E, 6258904 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1362.76				
DATUM:	NAD 83 UTM ZONE 9N	DRILL METHOD:	Diamond-Triple Tube	REVIEWED BY:	DP/TC

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface OVERBURDEN		Between 0.9 - 6.3 m: Moderately fractured rock with surface staining.	0 m; -1.28 m; 2.2 m	0.0
5.0		VOLCANIC ROCK; Plagioclase-hornblende fine to medium grained porphyritic latite flows with sericite-chlorite pervasive alteration with chlorite preferentially replacing phenocrysts and to a lesser degree groundmass. Pyrite disseminated (~2%) and Rx (2%). Sub-mm ser-chl-carb replaced plagioclase feldspar and hornblende phenocrysts occur throughout, and are generally 4-8% composition. Phenocrysts follow preferential foliation (45dtca), which also could be a feature of flow characteristic(?). Trace joint oxidization runs to 39.5 m.				5.0
10.0				At 13.0 m : Complete loss of circulation, pressure drop while drilling. Between 13.8 - 14.4 m: Quartz vein stockwork, no fractures.		10.0
15.0						15.0
20.0				Between 19.8 - 24.30 m: Moderately fractured; poor circulation, joints include oxidation stains.	21.2 m	20.0
25.0			Packer Test 1 16.95 - 30.3 m Packer Test 2 18.45 - 33.3 m	At 23.1 m: Fault with 60 mm of fault gouge.		25.0
30.0				Between 28.8 - 34.4 m: Fractured rock, oxidation staining on joint surfaces.		30.0
35.0			Packer Test 3 27.45 - 39.3 m			35.0
40.0				Between 39.9 - 43.80 m: Quartz vein stockwork. At 47.39: Fault; 100 mm thick with fault gouge. At 50.66 Fault; 500 mm thick.		40.0
45.0				Between 54.3 - 55.4 m: Foliated rock. Between 57.15 - 57.25 m: Fault At 56.6: Fault with 80 mm of fault gouge At 59.7 m: Moderately fractured massive rock.		45.0
50.0				NOTES: 1) Packer tests terminated due to observation of returns at surface and through adjacent MW-BGC14-13A. 2) The water level was 4.1 m bgs prior to well installation on September 12, 2014. Artesian pressures were recorded as shut-in pressures following well completion on October 8, 2014. The PVC stick-up is 0.8 m at installation. 3) Well installation completed using 2" (52 mm) dia. schedule 40 PVC; 020 slot schedule 40 PVC well screens. Enviroplug 1/4" pellets were used for the bentonite seal. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter. 5) Geological descriptions provided by Pretivm geologists.		50.0
55.0						55.0
60.0					58.2 m	60.0
65.0			Packer Test 4 52.95 - 75.3 m			65.0
70.0						70.0
75.0		End of Hole at 75.4 m			73.6 m; 75.4 m	75.0

LITHOLOGY

- Overburden
- Volcanic Rock
- Static Water Level

WELL CONSTRUCTION MATERIALS

- Well Cap
- Casing
- Solid PVC
- Screened PVC
- End Cap
- Bentonite Seal
- Grout
- Silica Sand

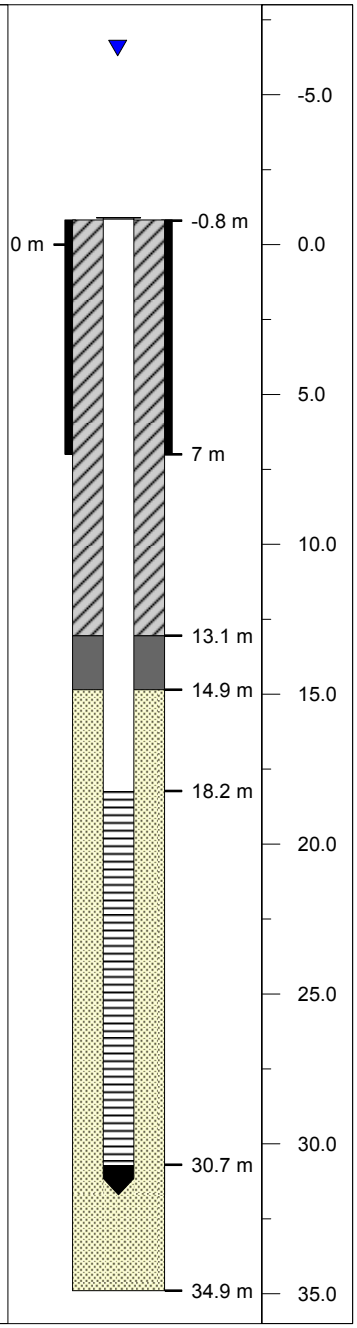
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

NEW ID: BJ-GW14-14A
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-14A

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 9-10, 2014
				INSTALL DATE:	Sep 11, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Professional Survey	FINAL HOLE DEPTH (m):	34.9
COORDINATES:	426096 E, 6258924 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1351.1				
DATUM:	NAD 83 UTM ZONE 9N	DRILL METHOD:	Diamond-Triple Tube	REVIEWED BY:	DP/TC

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface OVERBURDEN; sand, gravel and boulders, inferred based on drillers observations, no sample recovery				
5.0		VOLCANIC ROCK; Plagioclase hornblende fine to medium grained porphyritic latite flow with sericite-chlorite pervasive alteration with chlorite preferentially replacing phenocrysts and to a lesser degree groundmass. Sericite bleached zone from 16.5-20.2m. Local crack and fill chlorite open space crystalization. Pyrite disseminated (~2%) and Rx (2%). Sub-mm sericite-chlorite-carbonate replaced plagioclase feldspar and hornblende phenocrysts occur throughout, and are generally 5-10% composition. Phenocrysts follow preferential foliation (45dtca), which also could be a feature of flow characteristic(?).				
10.0						
15.0			Packer Test 1 10.9 - 19.9 m K= $3x10^{-8}$ m/s	Between 15.5 - 19.5 m: Iron staining on joints, some blocked runs.		
20.0			Packer Test 3 9.55 - 34.9 m K= $4.7x10^{-8}$ m/s	Between 19 - 21.9 m: Fault zone; includes fault gouge infilling, broken rock fragments, sand and gravel, iron staining.		
25.0			Packer Test 2 21.55 - 34.9 m K = 4.2x10-8 m/s	NOTES: 1) Drilling circulation was consistent for the duration of drilling the monitoring well. 2) The water level was 2.37 m bgs prior to well installation on September 10, 2014. Artesian pressures were recorded as shut-in pressures on October 8, 2014. The PVC stickup was 0.8 m at installation. 3) Well installation completed using 2" (52 mm) dia. schedule 40 PVC; 020 slot schedule 40 PVC well screen. Enviroplug 1/4" pellets were used for the bentonite seal along with cement-bentonite grout. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter. 4) Geological descriptions provided by Pretivm geologists.		
30.0						
35.0		End of Hole at 34.9 m				



LITHOLOGY

Overburden
Volcanic Rock
Static Water Level

WELL CONSTRUCTION MATERIALS

Well Cap
Screened PVC
Grout
Casing
End Cap
Silica Sand
Solid PVC
Bentonite Seal

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NEW ID: BJ-GW14-14B
ID CHANGE 14 DEC 18

MONITORING WELL: MW-BGC14-14B

CLIENT:	Pretivm Resources Inc.			PROJECT NUMBER:	1008-014
PROJECT:	Brucejack Project- Potable Groundwater Source Investigation			DRILLING DATES:	Sep 23, 2014
				INSTALL DATE:	Sep 23, 2014
LOCATION:	West of Brucejack Fault	SURVEY METHOD:	Hand Held GPS	FINAL HOLE DEPTH (m):	4.9
COORDINATES:	426095 E, 6258927 N	DRILL CONTRACTOR:	Hy-Tech Drilling	LOGGED BY:	JMC/DP
ELEVATION (m asl):	1355	DRILL METHOD:	Rotary HW Casing Advancer with Tricone	REVIEWED BY:	DP/TC
DATUM:	NAD 83 UTM ZONE 9N				

DEPTH (m)	GRAPHIC LOG	GEOLOGICAL DESCRIPTION	PACKER TEST RESULTS	DRILLING NOTES	WELL CONSTRUCTION DETAILS	DEPTH (m)
0.0		Ground Surface			-0.9 m	
		OVERBURDEN; sand and gravel, boulders inferred based on drilling observations, drilling return fluid ranged from muddy brown to black in colour. No recovery from overburden deposits.			0 m	0.0
					0.45 m	
1.0					1 m	1.0
				At 1.5 m: Drill circulation return water was black with a slight hydrocarbon odour.	1.5 m	
2.0						2.0
			No Packer Tests in Overburden			
3.0						3.0
				NOTES: 1) The water level was 0.07 m below ground surface upon completion of the well installation on September 23, 2014. The PVC stickup was 0.9 m at installation. 2) PW casing was reamed over the HW casing. PW casing is permanently installed. 3) Well installation completed using 3" (77 mm) schedule 40 PVC; 020 slot schedule 40 PVC well screen. Enviroplug 1/4" pellets were used for the bentonite seal. Grade 3 silica sand (1.6 mm to 2.0 mm) was used for the filter.		
4.0					4.42 m	4.0
		End of Hole at 4.9 m			4.9 m	
5.0						5.0

LITHOLOGY

- Overburden
- Static Water Level

WELL CONSTRUCTION MATERIALS

- Well Cap
- Casing
- Solid PVC
- Screened PVC
- End Cap
- Bentonite Seal
- Grout
- Slough
- Silica Sand

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BRITISH COLUMBIA
The Best Place on Earth

Ministry of Environment

☑ Well Construction Report
☐ Well Closure Report
☐ Well Alteration Report

Stamp company name/address/phone/fax/e-mail here, if desired.

Ministry Well ID Plate Number: 47875
Ministry Well Tag Number:
☐ Confirmation/alternative specs. attached
☐ Original well construction report attached

Red lettering indicates minimum mandatory information. See reverse for notes & definitions of abbreviations.

Owner name: PRETIVM RESOURCES
Mailing address: 1600 570 GRANVILLE ST Town VANCOUVER Prov. B.C. Postal Code V6C 3P1
Well Location: Address: Street no. Street name Town
(or) Legal description: Lot Plan D.L. Block Sec. Twp. Rg. Land District
(or) PID: (and) Description of well location (attach sketch, if nec.): Bruce jack mine site

NAD 83: Zone: ✓ (see note 2) (and) UTM Easting: 426112 m UTM Northing: 6259273 m (or) Latitude (see note 3): Longitude:
Method of drilling: ☑ air rotary ☐ cable tool ☐ mud rotary ☐ auger ☐ driving ☐ jetting ☐ excavating ☐ other (specify):
Orientation of well: ☑ vertical ☐ horizontal Ground elevation: 4,481 ft (asl) Method (see note 4): GPS
Class of well (see note 5): Water Supply Sub-class of well: Domestic
Water supply wells: indicate intended water use: ☐ private domestic ☐ water supply system ☐ irrigation ☑ commercial or industrial ☐ other (specify):

Lithologic description (see notes 7-14) or closure description (see notes 15 and 16)

From ft (bgl)	To ft (bgl)	Relative Hardness	Colour	Material Description (Use recommended terms on reverse. List in order of decreasing amount, if applicable)	Water-bearing Estimated Flow (USgpm)	Observations (e.g., fractured, weathered, well sorted, silty wash), closure details
0	36'	SOFT	BROWN	SAND + GRAVEL / SILT	W	
36'	272'	HARD	DRK GREY / BLK.	BEDROCK	W	FRACTURED.
272'	330'	HARD	LT. GREY	BEDROCK	W 60 GPM	HEAVILY FRACTURED.

MINISTRY OF ENVIRONMENT
APR 17 2015
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PLAZA 400

Casing details

From ft (bgl)	To ft (bgl)	Dia in	Casing Material / Open Hole	Wall Thickness in	Drive Shoe
0	38'	6"	STEEL	1/4"	N/A

Screen details

From ft (bgl)	To ft (bgl)	Dia in	Type (see note 18)	Slot Size
270'	150'	5"	PERFORATED	.020
150'	0'	5"	SLOTTED	—

Surface seal: Type: BENTONITE Depth: 15' ft
Method of installation: ☑ Poured ☐ Pumped Thickness: 2 in
Backfill: Type: Depth: ft
Liner: ☑ PVC ☐ Other (specify):
Diameter: 5" in Thickness: 1/4" in
From: 0 ft (bgl) To: 270 ft (bgl) Perforated: From: ft (bgl) To: ft (bgl)

Intake: ☑ Screen ☐ Open bottom ☐ Uncased hole
Screen type: ☐ Telescope ☑ Pipe size
Screen material: ☐ Stainless steel ☑ Plastic ☐ Other (specify):
Screen opening: ☐ Continuous slot ☑ Slotted ☑ Perforated pipe
Screen bottom: ☐ Bail ☑ Plug ☐ Plate ☐ Other (specify):
Filter pack: From: ft To: ft Thickness: in
Type and size of material:

Developed by:

☑ Air lifting ☐ Surging ☐ Jetting ☐ Pumping ☐ Bailing
☐ Other (specify): Total duration: 10 hrs
Notes:

Well yield estimated by:

☐ Pumping ☑ Air lifting ☐ Bailing ☐ Other (specify):
Rate: 60 USgpm Duration: 8 hrs
SWL before test: ft (btoc) Pumping water level: ft (btoc)

Obvious water quality characteristics:

☑ Fresh ☐ Salty ☐ Clear ☑ Cloudy ☐ Sediment ☐ Gas
Colour/odour: Water sample collected: ☐

Final well completion data:

Total depth drilled: 330 ft Finished well depth: 270 ft (bgl)
Final stick up: 24 in Depth to bedrock: 36 ft (bgl)
SWL: 14 ft (btoc) Estimated well yield: 60 USgpm
Artesian flow: USgpm, or Artesian pressure: ft
Type of well cap: Aluminum Well disinfected: ☐ Yes ☑ No
Where well ID plate is attached: Well Casing

Well closure information:

Reason for closure:
Method of closure: ☐ Poured ☐ Pumped
Sealant material: Backfill material:
Details of closure (see note 17):

Well driller (print clearly):

Name (first, last) (see note 19): ANDREW STUEBING
Registration no. (see note 20): WD 0504301
Consultant (if applicable; name and company):

DECLARATION: Well construction, well alteration or well closure, as the case may be, has been done in accordance with the requirements in the *Water Act* and the Ground Water Protection Regulation.

Signature of Driller Responsible

Date of work (YYYY/MM/DD):

Started: 2015/03/05 Completed: 2015/03/21
Comments: Well WW15-03

PLEASE NOTE: The information recorded in this well report describes the works and hydrogeologic conditions at the time of construction, alteration or closure, as the case may be. Well yield, well performance and water quality are not guaranteed as they are influenced by a number of factors, including natural variability, human activities and condition of the works, which may change over time.

white: Customer copy
canary: Driller copy
pink: Ministry copy

Sheet ____ of ____

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.2	INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, grey, minor hydrothermal breccias (H15), moderate to strong phyllic/QSP alteration.
2.14	At 2.14m - Joint, 4mm aperture, with surface staining
2.18	At 2.18m - Joint, 1mm aperture, with surface staining
2.75	At 2.75m - Joint, 1mm aperture, with surface staining
4.52	At 4.52m - Joint, 4mm aperture, with surface staining
5.4	TRANSITIONAL UNIT BETWEEN POLYLITHIC CONGLOMERATE (S3-Poly) and INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine to coarse grained, grey, minor hydrotehermal breccias (H15), moderate to strong phyllic/QSP alteration.
5.51	At 5.51m - Joint, 1mm aperture, with surface staining
5.94	At 5.94m - Joint (curved), 1mm aperture, with surface staining
6.22	At 6.22m - Joint, 1mm aperture, with surface staining
6.38	At 6.38m - Joint, 1mm aperture, with surface staining
7.65	At 7.65m - Joint, 1mm aperture, with surface staining
8	

Columns: Depth (m); Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Geotechnical Description, Major Discontinuities, and Additional Notes; Graphic Log; Weathering Grade (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept Metres 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N	**Drill Designation:** Heliportable	**Start Date:** 02 JUL 16
Ground Elevation (m): 1,376.9	**Drilling Contractor:** HY TECH	**Finish Date:** 03 JUL 16
Survey Method: Surveyed coordinates	**Drill Method:** DIAMOND CORING	**Final Depth (m):** 27.4
Datum: UTM NAD 83 Zone 9	**Core:** PQ	**Depth To Top Of Rock (m):** 1.2
Plunge (°): -90	**Fluid:** Polymer	**Logged By:** JRW, SH
Trend (°): 000	**Cased To (m) :** 1.2	**Reviewed By:** TWC

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES:

At 8.05m - Joint, 1mm aperture, with surface staining

At 9.65m - Joint, 1mm aperture, with orange brown staining

At 9.71 m - Joint, 1mm aperture, with trace light brown clay infill

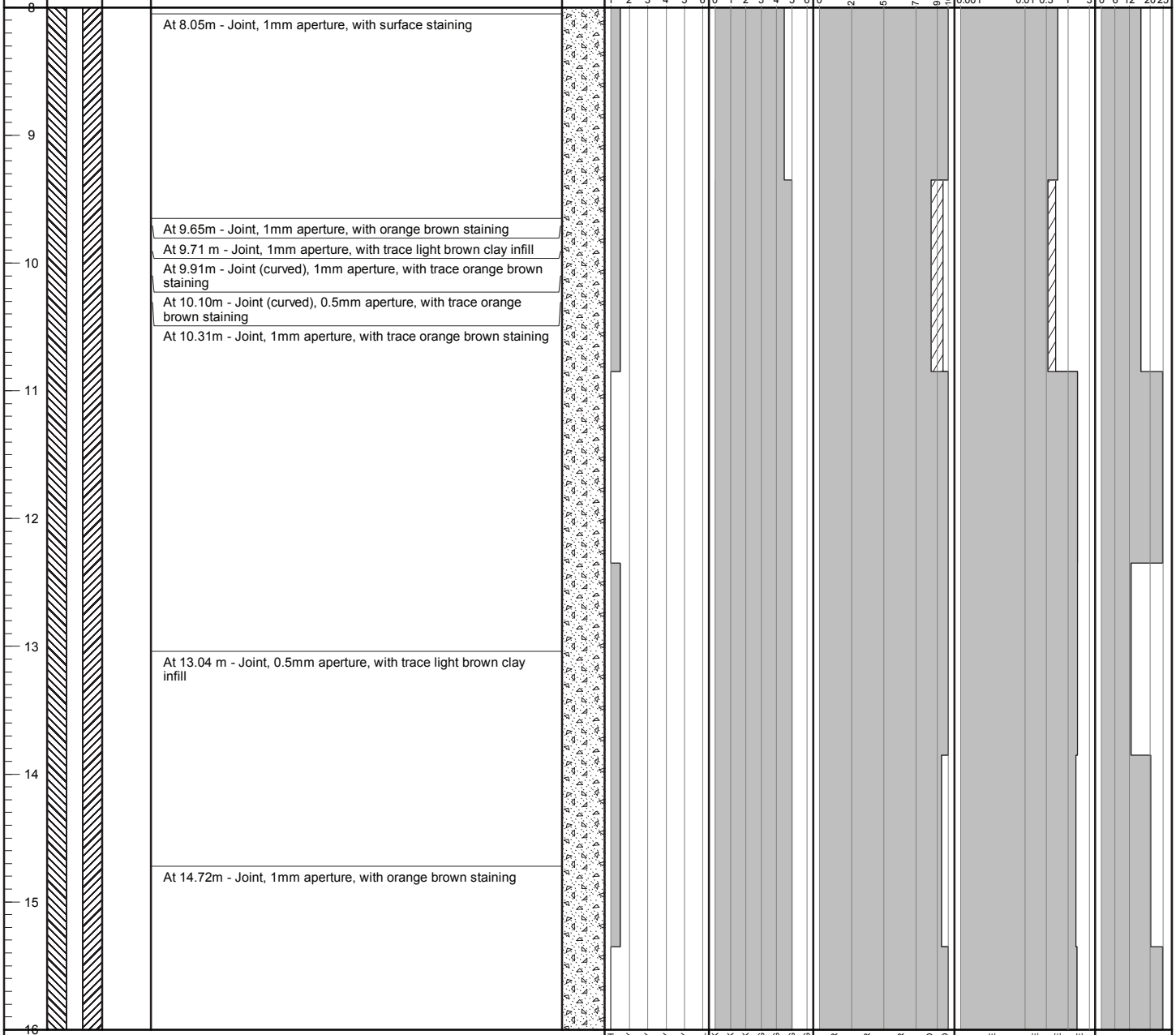
At 9.91m - Joint (curved), 1mm aperture, with trace orange brown staining

At 10.10m - Joint (curved), 0.5mm aperture, with trace orange brown staining

At 10.31m - Joint, 1mm aperture, with trace orange brown staining

At 13.04 m - Joint, 0.5mm aperture, with trace light brown clay infill

At 14.72m - Joint, 1mm aperture, with orange brown staining



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack 2016-2017
Project No.: 1008-022

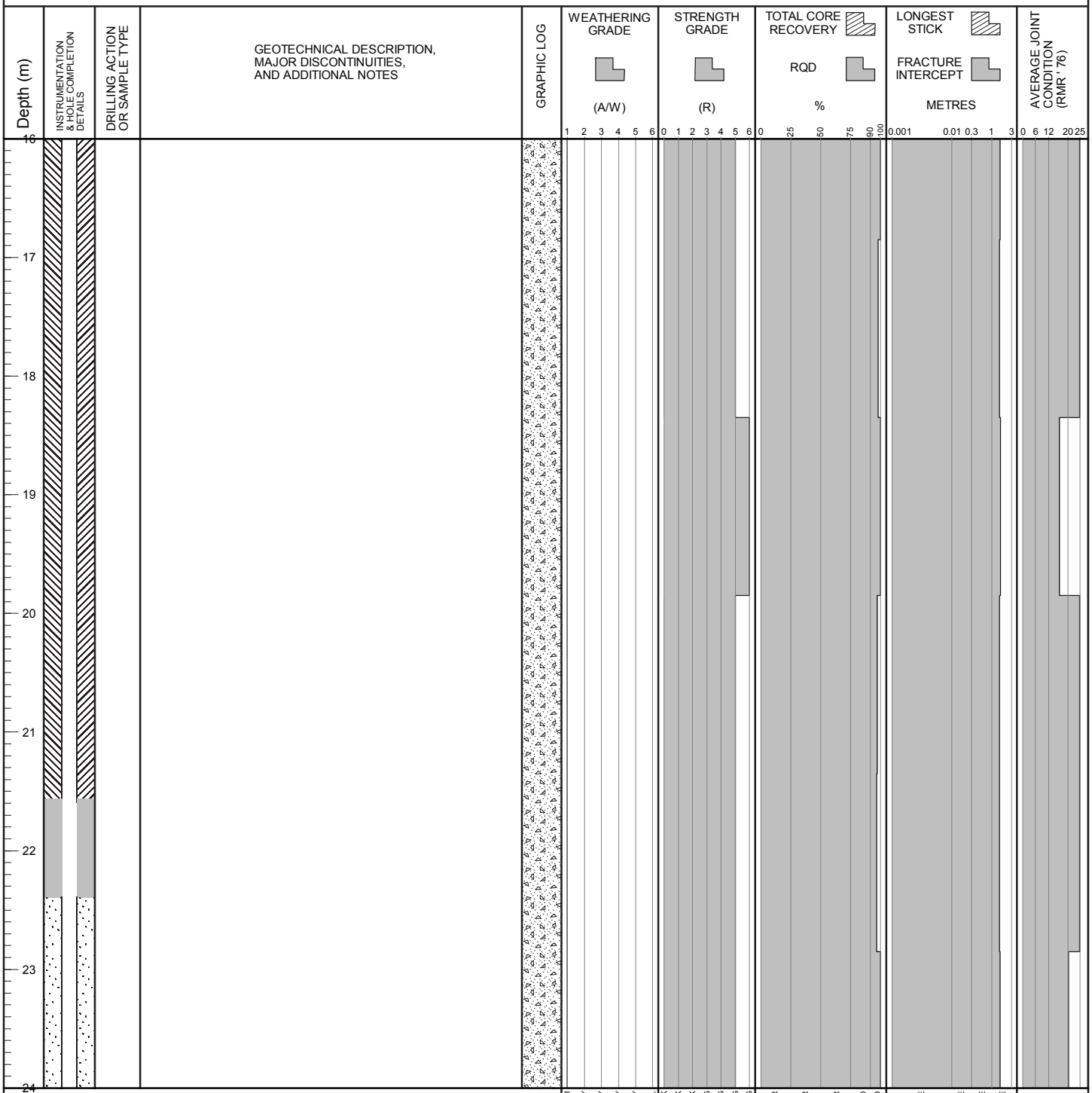
DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

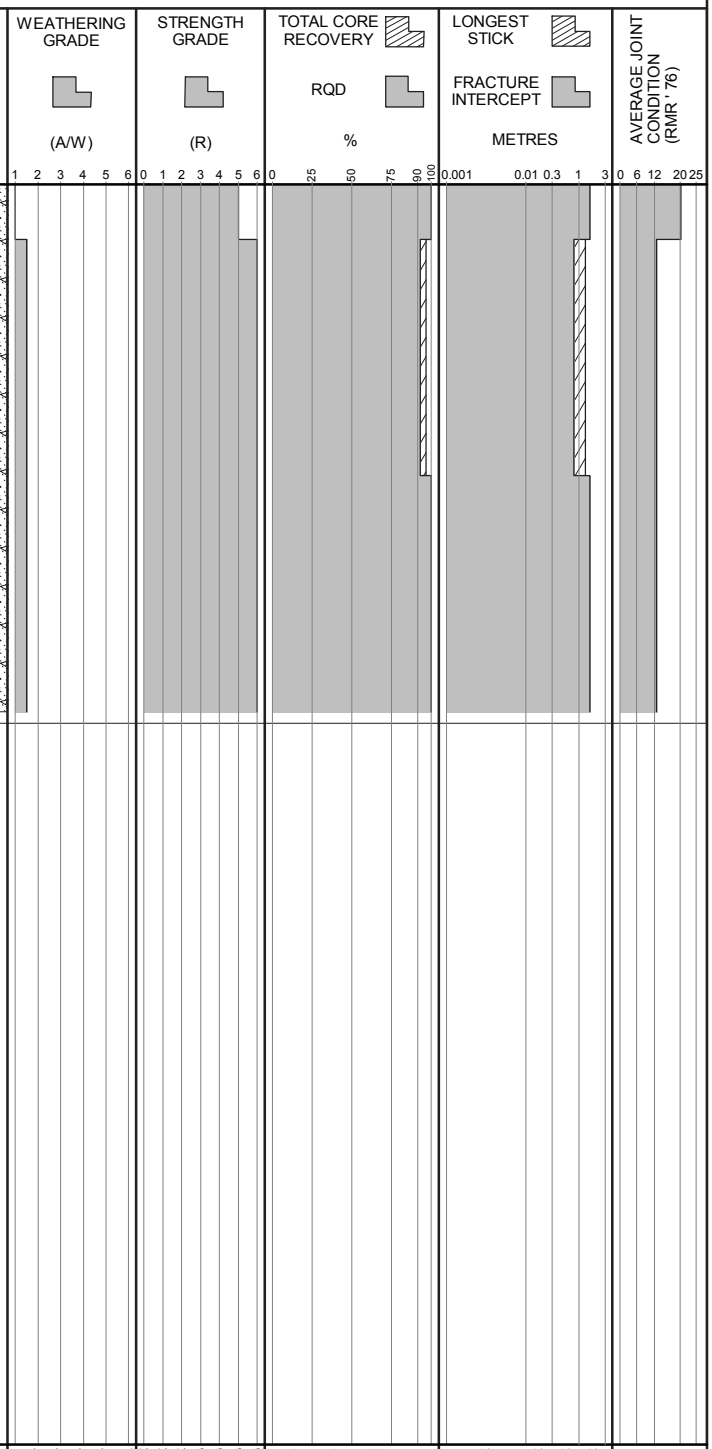
Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
24				
			At 24.53 m - Joint, 1mm aperture, with trace light brown clay infill	
			At 24.57 m - Joint, 1mm aperture, with trace white grey clay infill	
25				
26				
			At 26.70m - Joint (on vein), 1mm aperture, with orange staining	
27				
			END OF HOLE AT: 27.42 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 24.37 to 27.42 m on July 3, 2016. 2) Filter sand placed around screen zone from 22.39 to 27.42 m. 3) Lithology descriptions by Pretium geologists.	
28				
29				
30				
31				
32				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01B

Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.37	INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, light grey, weak to moderate phyllic/QSP alteration.
1.37	At 1.37 m - Joint, 5mm aperture, with coarse sand infill and staining on joint surfaces
1.50	At 1.50m - Joint (stepped), 1mm aperture, with staining on surfaces
2.03	At 2.03m - Joint (undulating smooth), 1mm aperture, with surface staining
3.27	At 3.27m - Joint (rough planar), 1mm aperture, with surface staining
4.00	At 4.00 m - Joint, 3mm aperture, with sand infill and staining on joint surfaces
4.20	At 4.20m - Joint, 1mm aperture, with surface staining
4.53	At 4.53m - Joint (curved), 1mm aperture, with surface staining
4.64	At 4.64 m - Joint, 1mm aperture, with sand infill and staining on joint surfaces
5.70	At 5.70m - Joint, 1mm aperture, with surface staining
5.75	At 5.75 m - Joint, 4mm aperture, with staining on joint surfaces

Columns: Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Graphic Log; Weathering Grade (A/W) — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD (%) — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept (metres) — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76)

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-01B

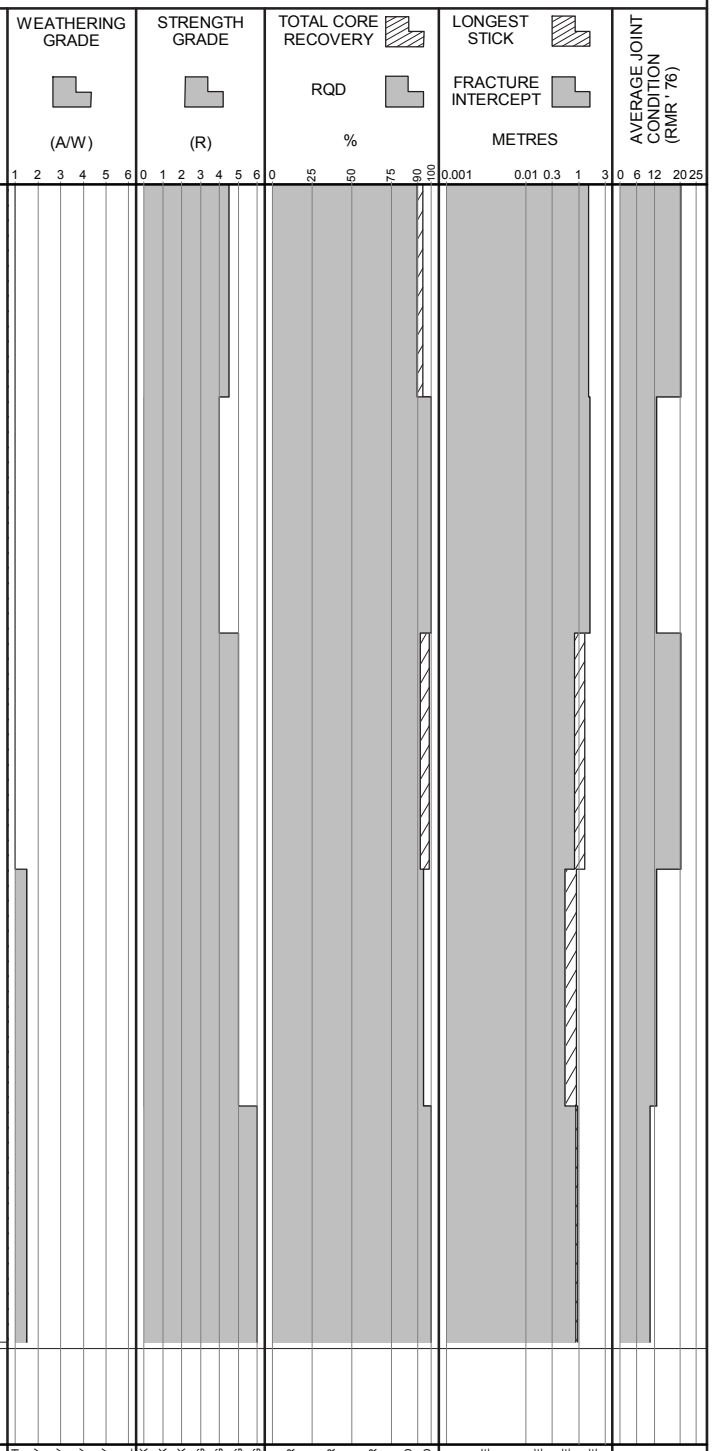
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
			At 10.58 m - Joint (on vein), 0.5mm aperture, with trace grey clay infill
11			
12			
			At 12.41 m - Joint, 1mm aperture, with grey clay infill
13			
14			
			At 14.47 m - Joint, 1mm aperture, with grey clay infill, yellow brown staining, dark brown staining
15			
			At 15.34 m - Joint, aperture unknown (second half of joint not recovered) with grey white clay infill
			END OF HOLE AT: 15.39 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-01B

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR' 76) 0 6 12 20 25
16			slotted screen from 13.87 to 15.37 m on July 7, 2016. 2) Filter sand placed around screen zone from 13.44 to 15.37 m. 3) Lithology descriptions by Pretium geologists.						
17									
18									
19									
20									
21									
22									
23									
24									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02A

Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.2	INTERMEDIATE VOLCANICS (V4) Medium grained, greenish blue, pyroclastic, weak to moderate chlorite-sericite alteration.
	At 1.30m - Joint, 0.5mm aperture, with dark brown stain
	At 1.36m - Joint, 0.5mm aperture, with dark brown stain
	At 1.40m - Joint, 1mm aperture, with dark brown stain
	At 1.52m - Joint, 1mm aperture, with dark brown stain
	At 1.70 - Joint, 1mm aperture, with dark brown stain
	At 2.03 m - Joint, 2mm aperture, with trace orange brown clay infill
	At 2.30m - Joint, 1mm aperture, with dark brown stain
	At 2.37m - Joint, 1.5mm aperture, with dark brown stain
	At 2.49 m - Joint, 0.5mm aperture, with trace orange brown clay infill
	At 2.73 m - Joint, 1mm aperture, with trace orange brown clay infill
	At 3.00 m - Fault, 220mm aperture, with fault gouge and broken rock infill. Circulation lost during drilling.
	At 3.48 m - Joint, 1mm aperture, with trace dark brown clay infill
	At 5.21m - Joint, 1mm aperture, with dark brown stain
	At 7.11 m - Joint, 1mm aperture, with trace light brown clay infill
8	

Columns: Depth (m); Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Geotechnical Description, Major Discontinuities, and Additional Notes; Graphic Log; Weathering Grade (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept Metres 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-02A

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			At 10.08 m - Joint, 1mm aperture, with trace white grey clay infill
11			
12			At 11.89 m - Joint, 1mm aperture, with trace white clay infill
13			At 12.80 m - Joint, 1mm aperture, with trace white clay infill
14			At 14.14 m - Joint, 0.5mm aperture, with trace white grey clay infill
15			At 15.57 m - Joint, 1mm aperture, with trace grey clay infill
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02A

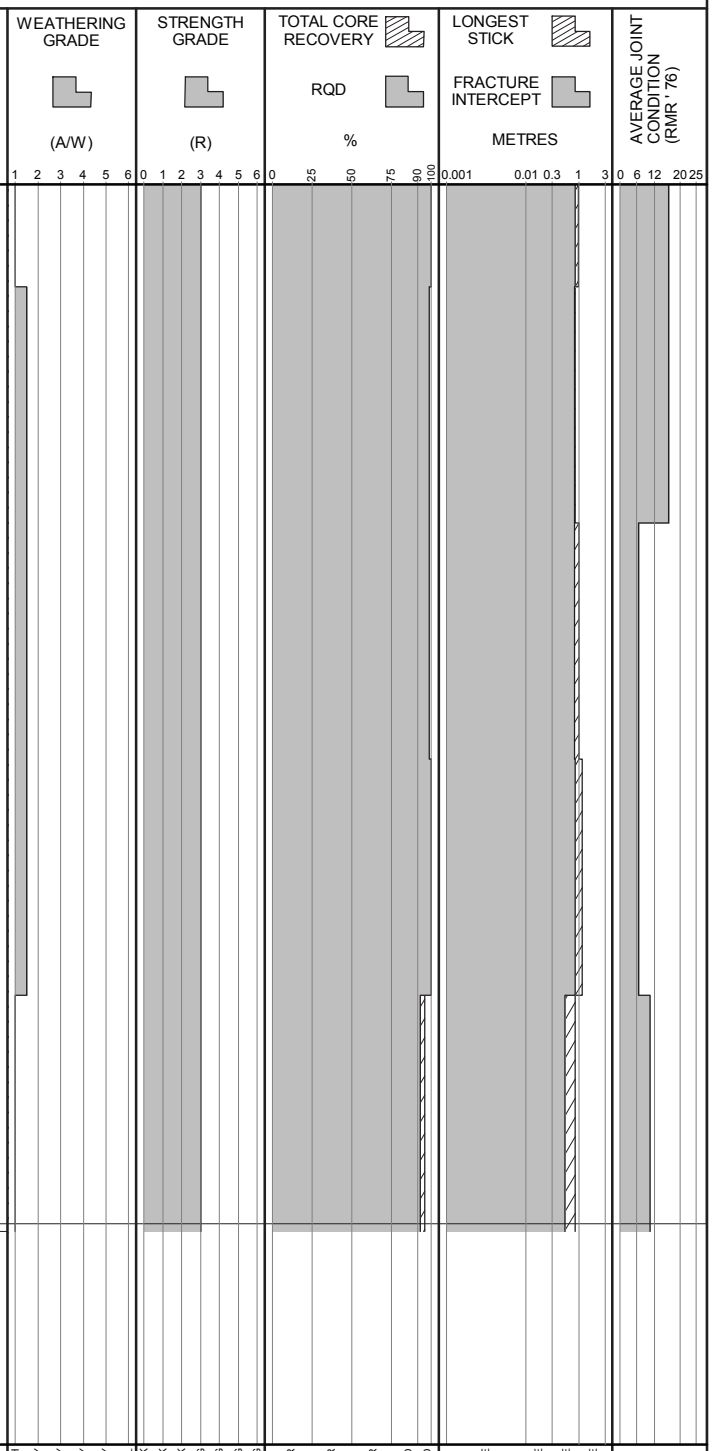
Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
			At 16.77 m - Joint, 1mm aperture, with trace white grey clay infill
17			
			At 17.39 m - Joint, 0.5mm aperture, with trace white grey clay infill
18			
19			
			At 19.36 m - Joint, 1mm aperture, with trace white grey clay infill
20			
21			At 20.94 m - Bedding Joint, 1mm aperture, with trace white grey clay infill
			At 21.24 m - Joint, 1mm aperture, with trace white grey clay infill
22			
23			END OF HOLE AT: 22.60 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 19.55 to 22.60 m on July 5, 2016. 2) Filter sand placed around screen zone from 19.16 to 22.60 m. 3) Lithology descriptions by Pretium geologists.
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02B

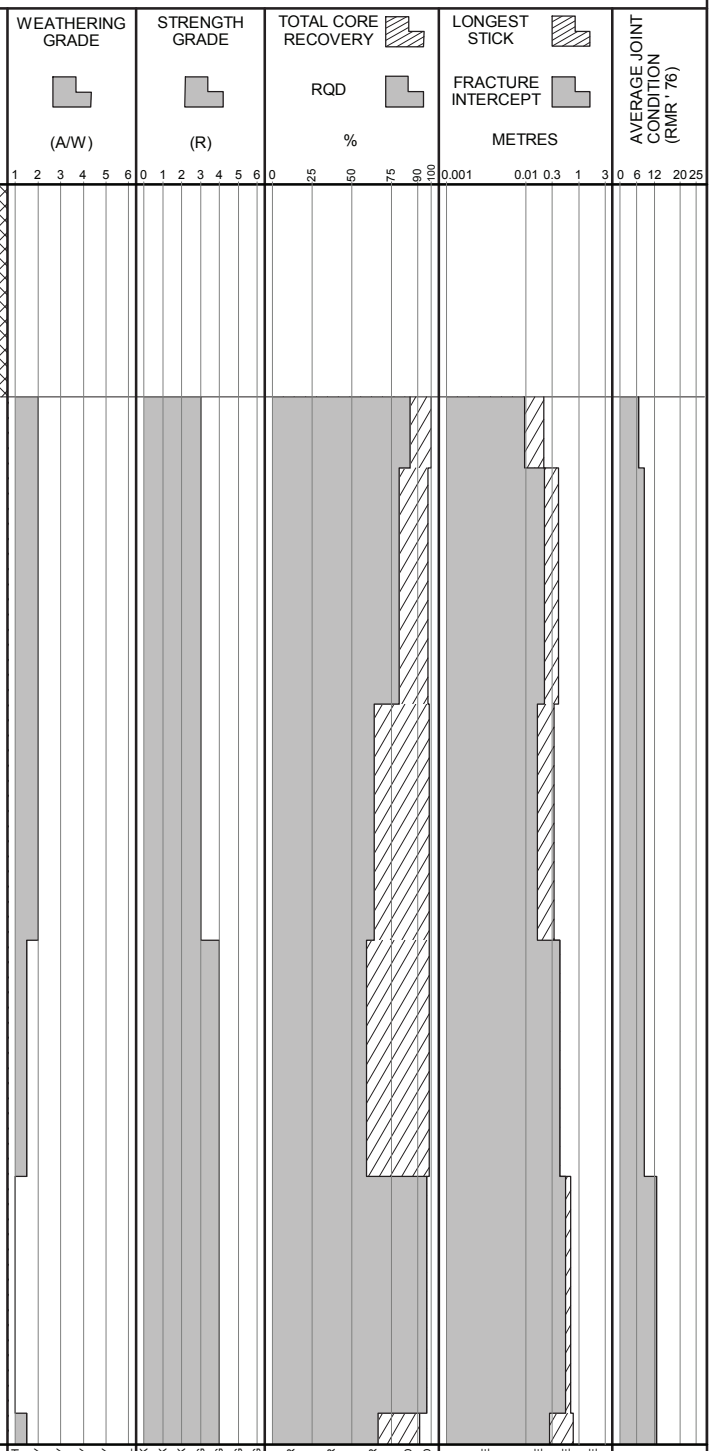
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
1			
2			INTERMEDIATE VOLCANICS (V4) Fine grained, greenish grey, porphyritic, weak to moderate phyllic/QSP alteration.
			At 1.43 m - Joint, 3mm aperture, with trace green grey clay infill and dark brown staining
			At 1.44 m - Joint, aperture size unknown (second half of joint missing), with trace brown clay infill and dark brown staining
			At 1.62m - Joint, 1mm aperture, with dark brown stain
			At 1.80 m - Joint, aperture size unknown (second half of joint missing), with green grey clay infill, trace brown clay infill and dark brown staining
3			At 2.18 m - Joint, 90mm aperture, with broken rock infill and dark brown staining
			At 2.58 m - Joint, 1mm aperture, with green grey clay infill and dark brown staining
			At 2.75m - Joint, 1mm aperture, with dark brown stain
			At 3.29 m - Joint, 2mm aperture, with trace brown clay infill, trace green grey clay infill and dark brown staining
			At 3.30 m - Joint, (aperture size could not be determined), with trace brown clay infill and dark brown staining
4			At 3.34 m - Joint, 1 to 4mm aperture, with brown clay and green grey clay infill and dark brown staining
			At 3.49m - Joint, 0.5mm aperture, with dark brown stain
			At 3.56 m - Joint, aperture size could not be determined (joint too broken), with brown clay infill and green grey clay infill, and dark brown staining
			At 3.87 m - Joint, 1.5mm aperture, with trace dark brown clay infill
5			At 3.88m - Joint, 0.5mm aperture, with dark brown stain
			At 4.01 m - Joint, 1.5mm aperture, with trace dark brown clay infill, dark brown staining
			At 4.15 m - Joint, 1mm aperture, with trace dark brown clay infill, dark brown staining
			At 4.19m - Joint, 1mm aperture, with dark brown stain
			At 4.38 m - Joint, 1mm aperture, with trace dark brown clay infill, dark brown staining
6			At 4.53 m - Joint (on vein), 1mm aperture, with trace dark brown clay infill, dark brown staining, on 8mm white vein
			At 4.64 m - Joint, 1mm aperture, with trace brown clay infill, dark brown staining
			At 4.99m - Joint, 1mm aperture, with dark brown stain
			At 5.18 m - Joint, 1mm aperture, with trace green grey clay infill
7			At 5.71m - Joint, 1mm aperture, with orange brown stain
			At 5.89 m - Joint, 1mm aperture, with grey white clay infill
			At 6.65m - Joint, 0.5mm aperture, with yellow brown stain
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # MW-BGC16-BJ-02B

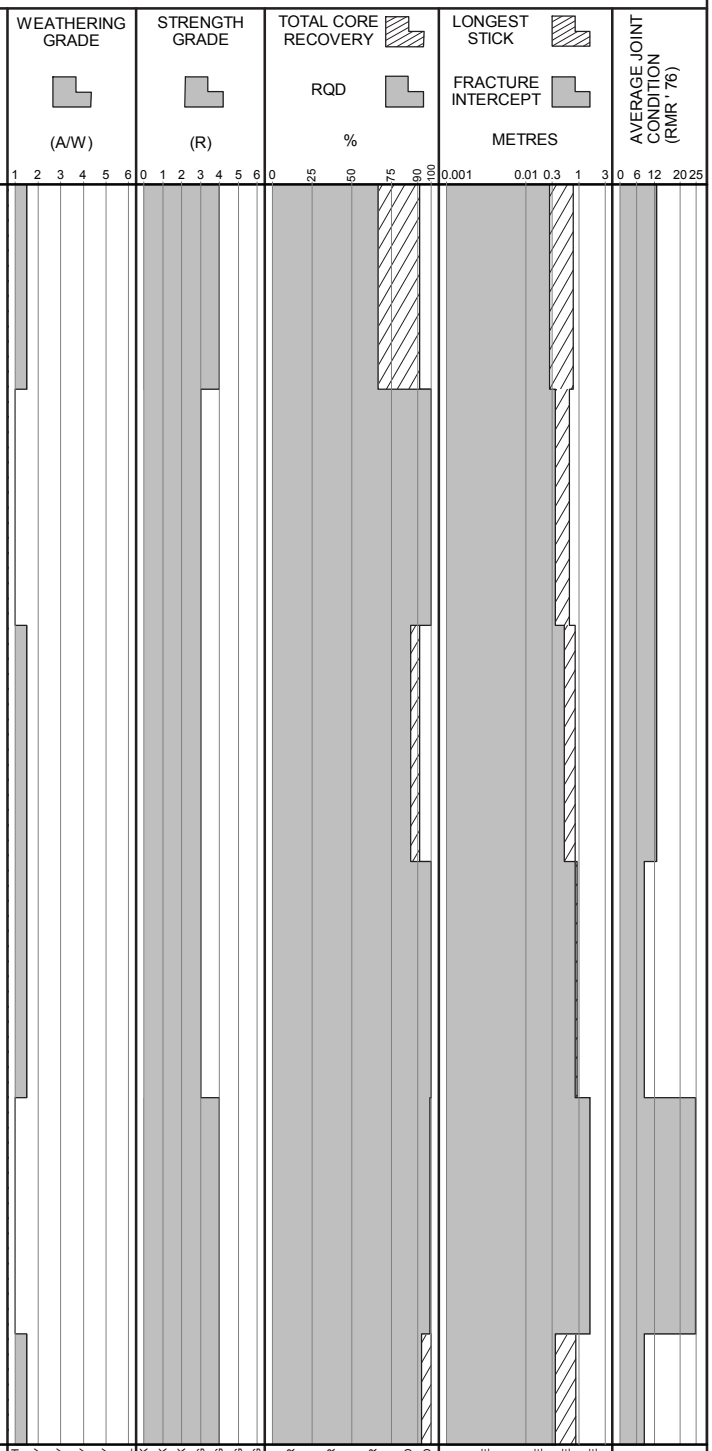
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
			At 8.75 m - Joint, 0.5mm aperture, with trace green grey clay infill
9			At 8.76 m - Joint, 1mm aperture, with green grey clay infill, dark brown staining
			At 9.65m - Joint, 0.5mm aperture, with yellow brown stain
			At 9.84m - Joint, 0.5mm aperture, with yellow brown stain
10			At 9.86m - Joint, 0.5mm aperture, with yellow brown stain
11			
			At 11.29 m - Joint, 1mm aperture, with trace white clay infill
12			
			At 12.63m - Joint, 0.5mm aperture, with trace white clay infill
13			
			At 13.45m - Joint, 1mm aperture, with trace grey clay infill
14			
15			
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02B

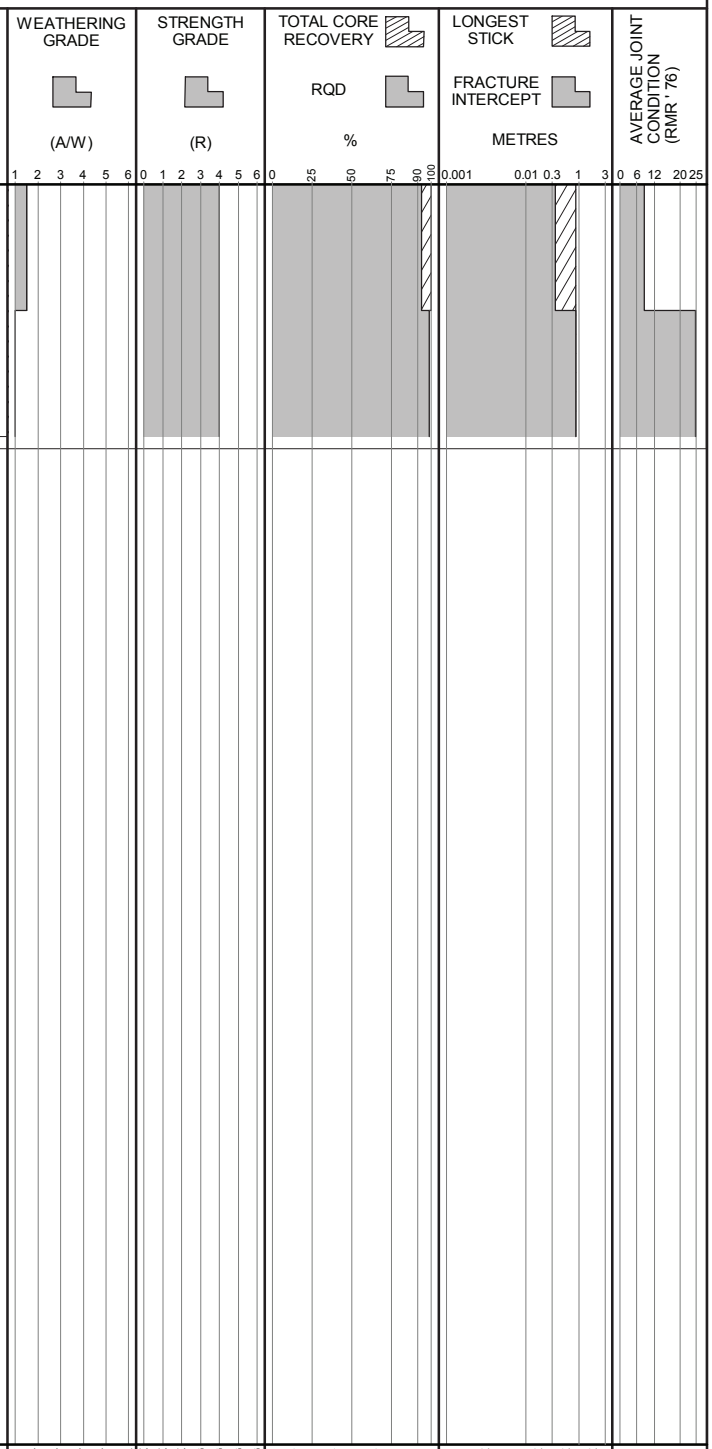
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
16									
17			At 16.69m - Joint, 1mm aperture, with grey clay and decomposed rock infill At 16.70m - Joint, aperture size could not be determined (couldn't fit joint together properly), with trace grey clay and decomposed rock infill At 16.75m - Joint, 1.5mm aperture, with trace grey white clay infill						
18			END OF HOLE AT: 17.68 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 16.16 to 17.68 m on July 7, 2016. 2) Filter sand placed around screen zone from 15.66 to 17.68 m. 3) Lithology descriptions by Pretium geologists.						
19									
20									
21									
22									
23									
24									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

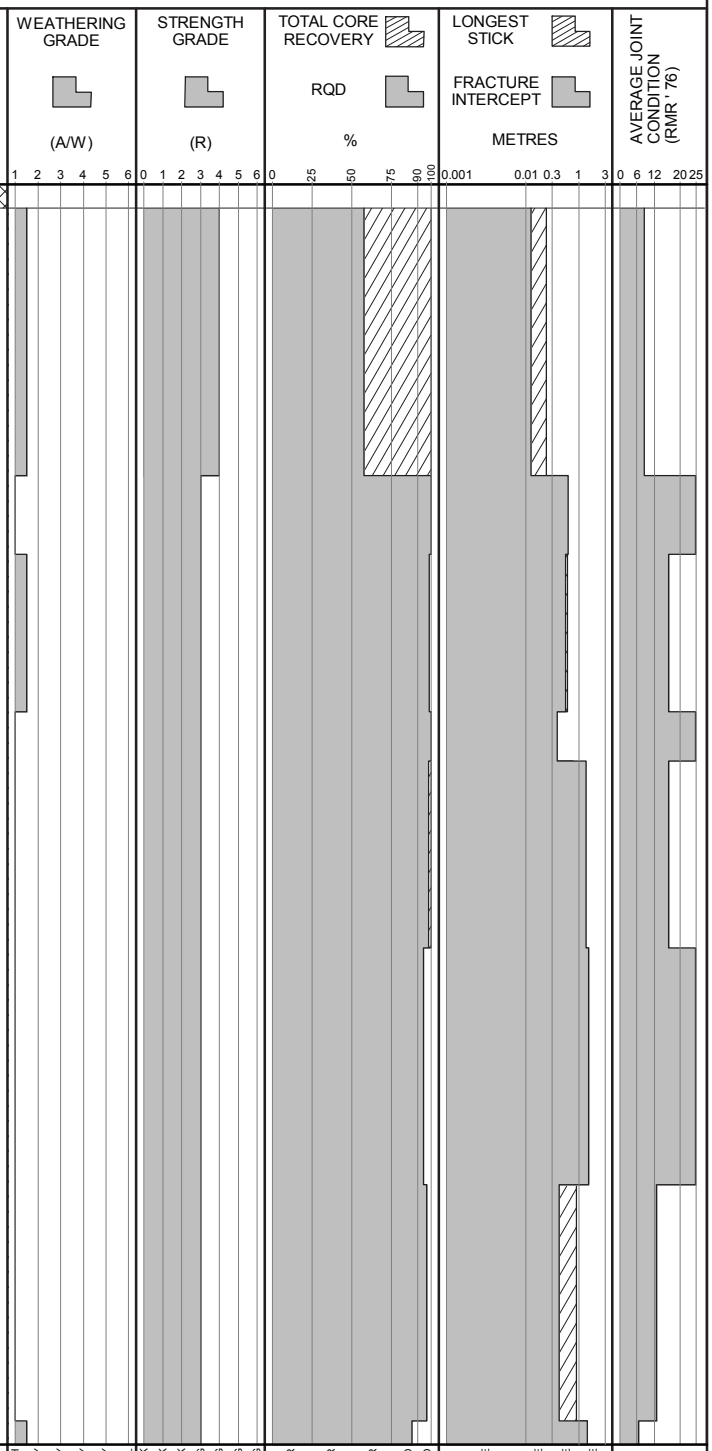
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, greenish grey, minor hydrothermal breccias (H15) from 6.58 to 6.71 m, moderate to strong phyllic/QSP alteration.
			At 0.34 m - Joint, 1mm aperture, with grey clay and crushed rock infill
1			At 0.58 m - Joint, 2mm aperture, with grey clay and crushed rock infill
			At 0.82 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.05 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.37 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.42 m - Joint, 1mm aperture, with trace light brown clay infill
2			At 1.68 m - Joint, aperture size unknown (other joint face too broken up), with trace light brown clay infill
3			At 3.21 m - Joint, 0.5mm aperture, with trace grey clay infill
4			
5			
6			
			At 6.42 m - Joint, 0.5mm aperture, with grey clay infill
7			
			At 7.20 m - Joint, 1mm aperture, with white grey clay infill
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

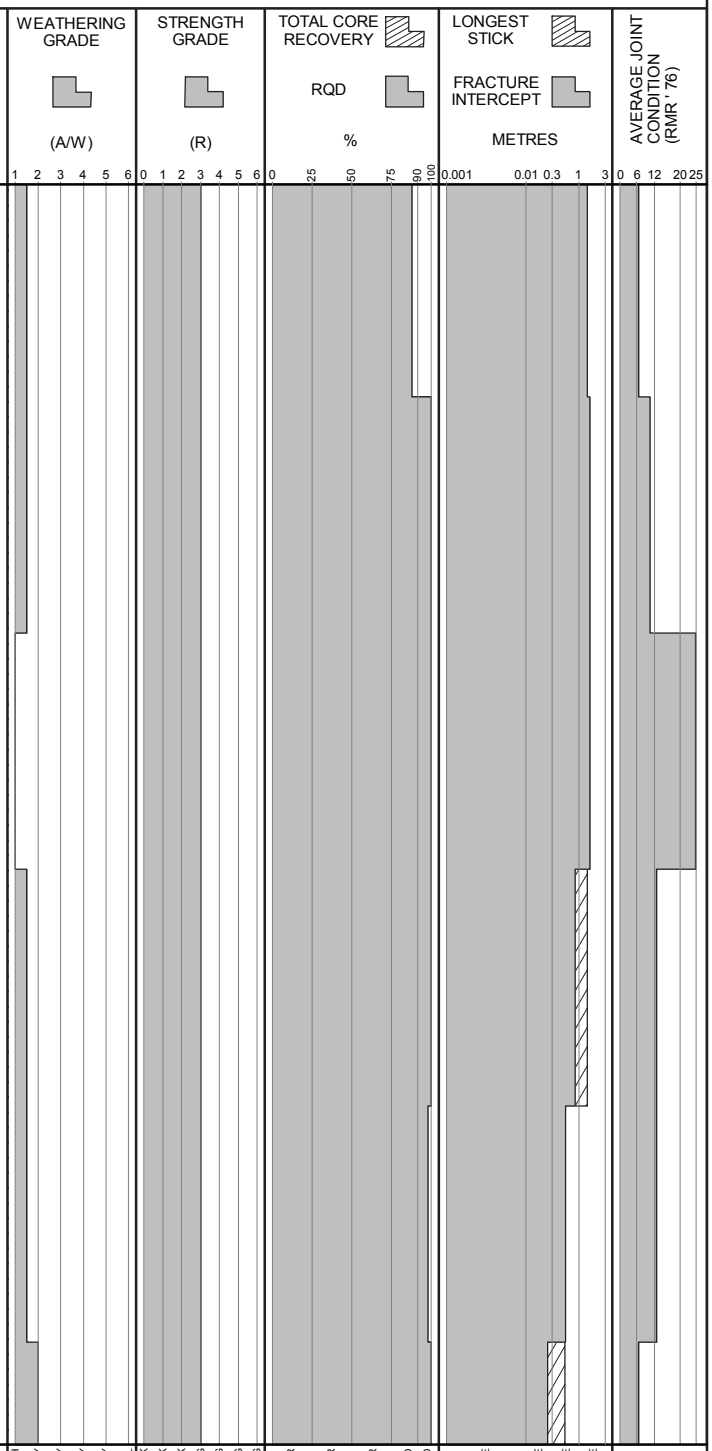
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			At 9.35 m - Joint, 2mm aperture, with grey white clay infill
10			At 10.26 m - Joint, 0.5mm aperture, with grey white clay infill
11			
12			
13			
14			At 13.77 m - Joint, 1mm aperture, with grey white clay infill At 14.33 m - Joint (with vein), 1mm aperture, with grey white clay infill
15			
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-03A

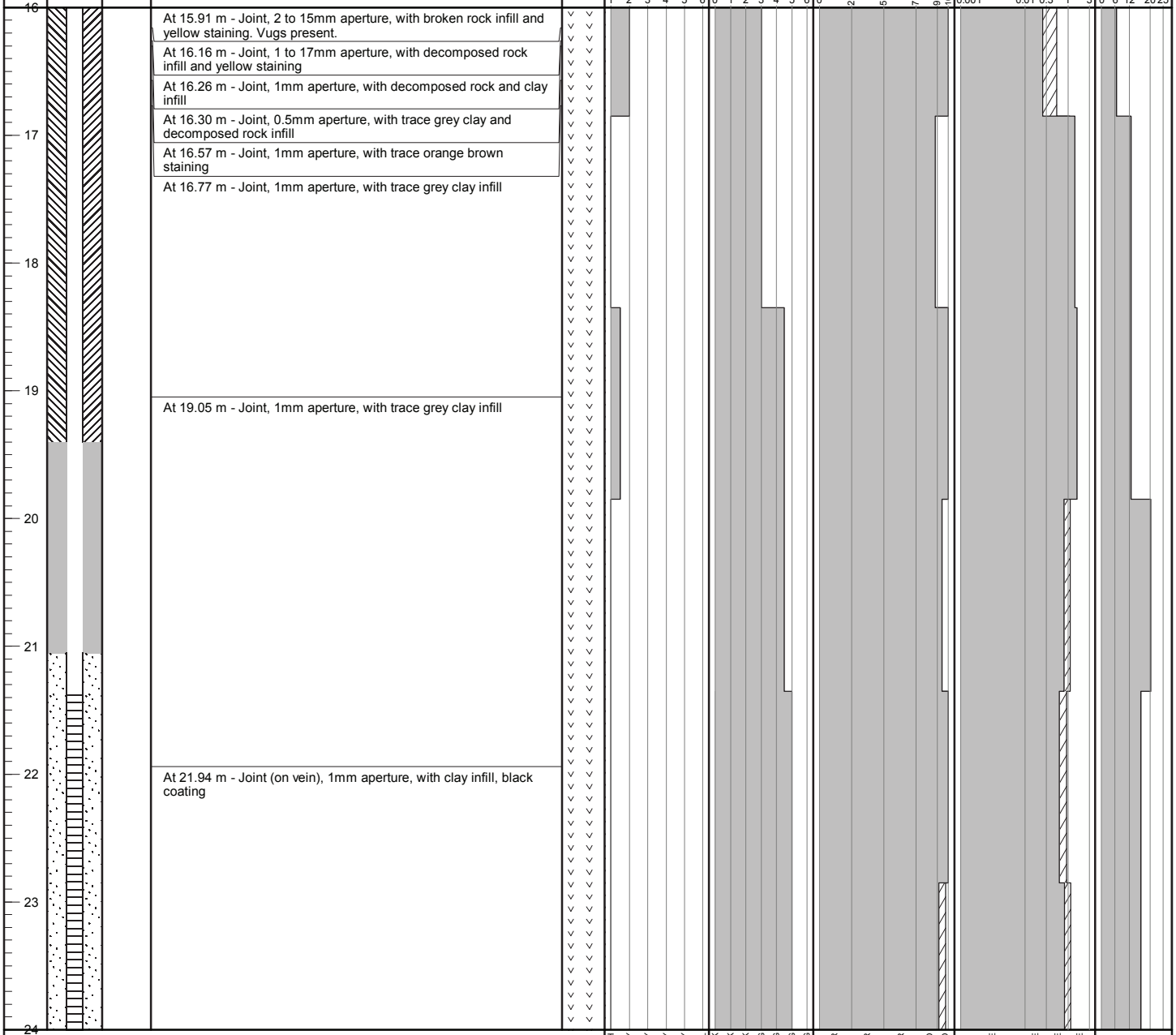
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16	At 15.91 m - Joint, 2 to 15mm aperture, with broken rock infill and yellow staining. Vugs present.
	At 16.16 m - Joint, 1 to 17mm aperture, with decomposed rock infill and yellow staining
	At 16.26 m - Joint, 1mm aperture, with decomposed rock and clay infill
	At 16.30 m - Joint, 0.5mm aperture, with trace grey clay and decomposed rock infill
17	At 16.57 m - Joint, 1mm aperture, with trace orange brown staining
	At 16.77 m - Joint, 1mm aperture, with trace grey clay infill
18	
19	At 19.05 m - Joint, 1mm aperture, with trace grey clay infill
20	
21	
22	At 21.94 m - Joint (on vein), 1mm aperture, with clay infill, black coating
23	
24	



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
24									
25			END OF HOLE AT: 24.43 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 21.38 to 24.43 m on July 6, 2016. 2) Filter sand placed around screen zone from 21.05 to 24.43 m. 3) Lithology descriptions by Pretium geologists.						
26									
27									
28									
29									
30									
31									
32									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03B

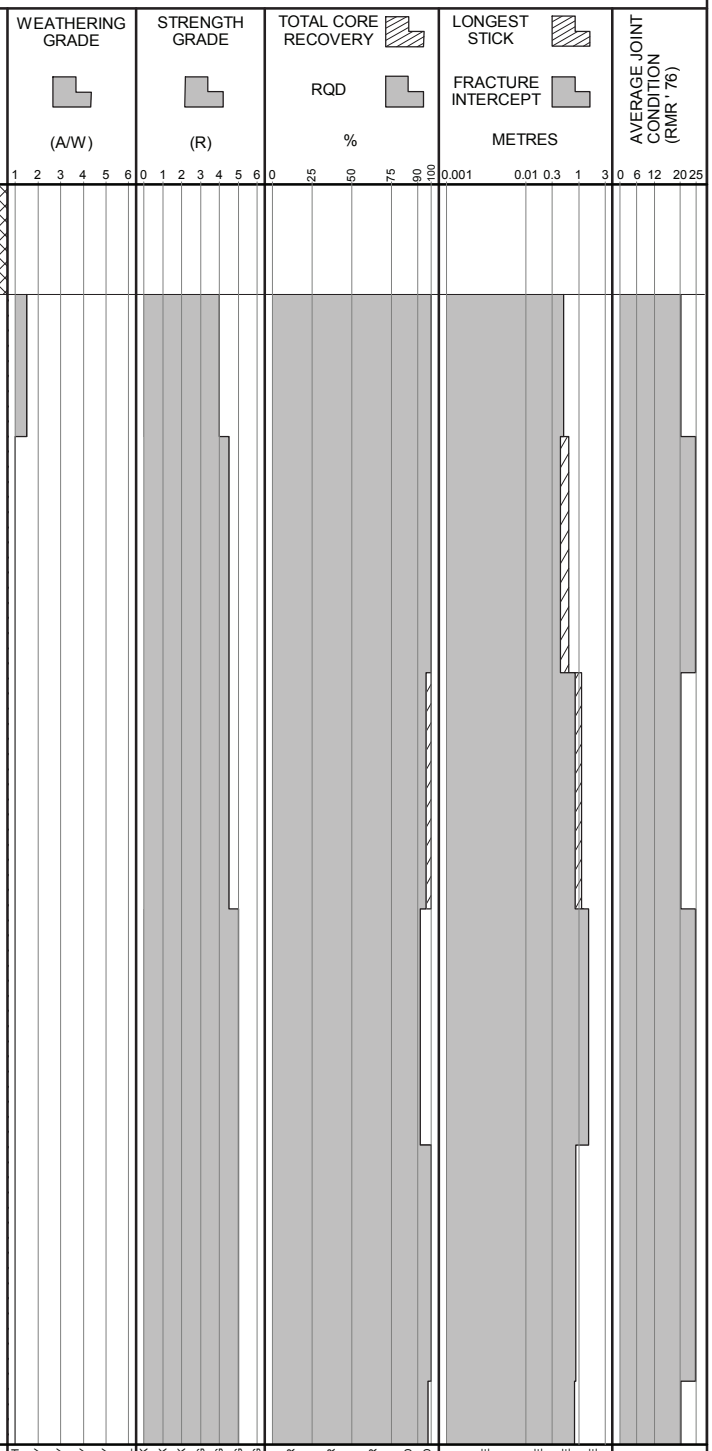
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,707N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 08 JUL 16
Finish Date: 08 JUL 16
Final Depth (m): 13.7
Depth To Top Of Rock (m): 0.7
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
1			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, light grey, laminated, moderate to strong phyllic/QSP alteration. At 1.06 m - Joint, 1mm aperture, with surface staining
2			
3			
4			
5			
6			
7			
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03B

Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,707N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 08 JUL 16
Finish Date: 08 JUL 16
Final Depth (m): 13.7
Depth To Top Of Rock (m): 0.7
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
11			
12			
13			At 13.30 m - Joint (on vein), 8mm aperture, with clay, calcite infill
14			END OF HOLE AT: 13.67 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 12.17 to 13.67 m on July 8, 2016. 2) Filter sand placed around screen zone from 11.15 to 13.67 m. 3) Lithology descriptions by Pretium geologists.
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04A

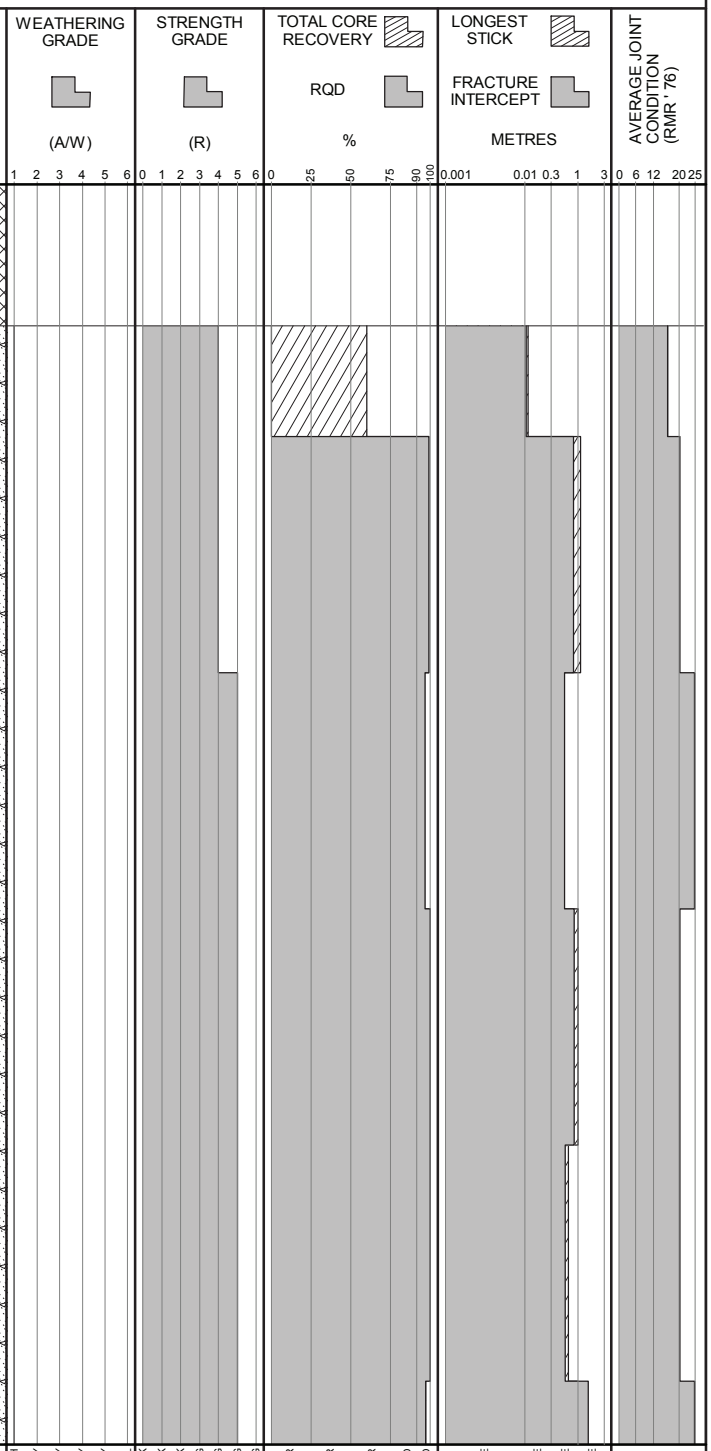
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
0			FILL	
1			CONGLOMERATE (S3-VSF) Coarse grained, dark grey, polymyctic, >90% reworked volcano-sedimentary facies sediments, moderate to strong sericite alteration.	
2				
3				
4				
5				
6				
7				
8				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04A

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
11			At 11.00 m - Joint (on vein), 10mm aperture, with broken rock infill
13			At 13.03 m - Joint, 3mm aperture, with decomposed rock infill

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04A

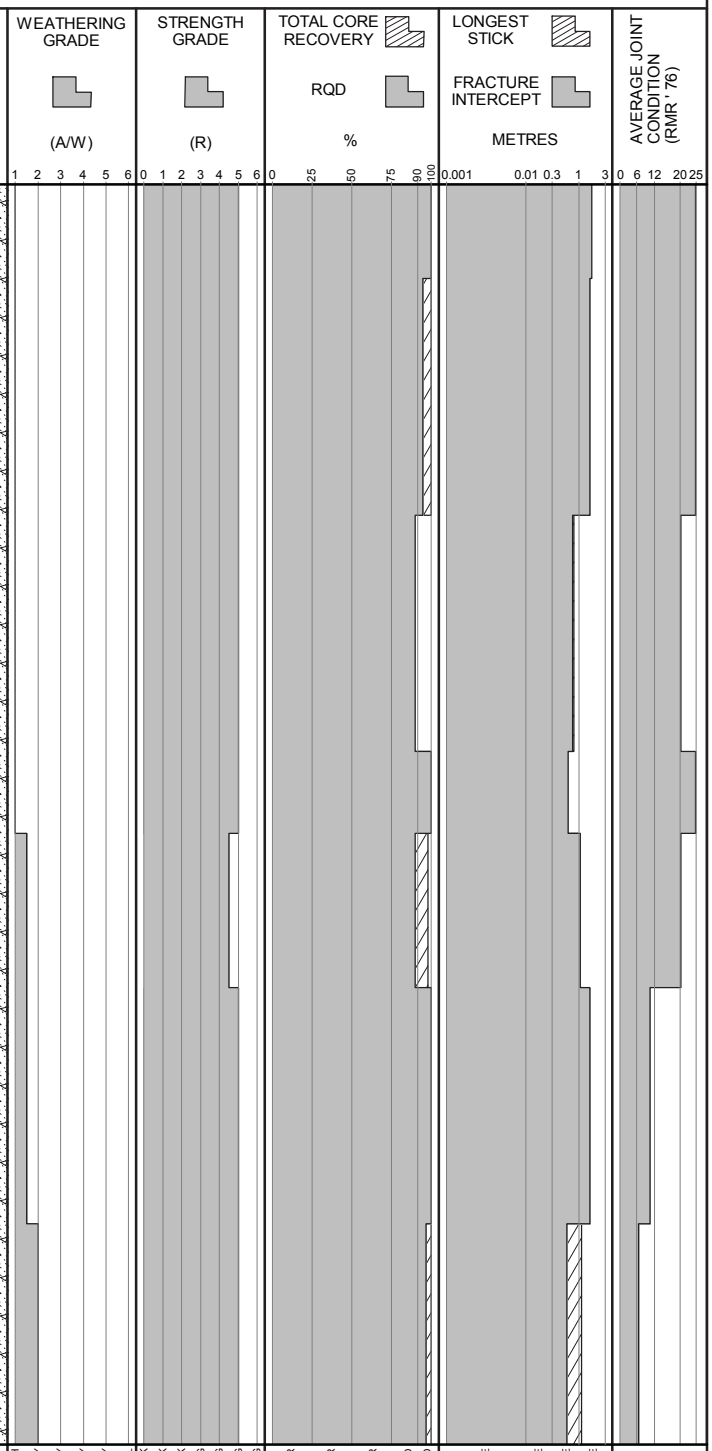
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			
20			
			At 20.22 m - Joint, 1mm aperture, with trace grey clay infill, potential vugs on Joint
21			
22			
			At 22.25 m - Joint (on vein), 1mm aperture, with trace grey clay infill. Curved joint.
23			
			At 23.60 m - Joint, 1mm aperture, with grey clay and decomposed rock infill
24			At 23.80 m - Joint, 90mm aperture, with apparent broken rock infill



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04A

Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
24			(potentially was very weak/fractured, and not broken, in-situ)						
			At 23.89 m - Joint (on vein), 1mm aperture, with trace grey clay and decomposed rock infill						
			END OF HOLE AT: 24.17 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 22.65 to 24.12 m on July 10, 2016. 2) Filter sand placed around screen zone from 22.28 to 24.12 m. 3) Lithology descriptions by Pretium geologists.						
25									
26									
27									
28									
29									
30									
31									
32									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY % / RQD: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04B

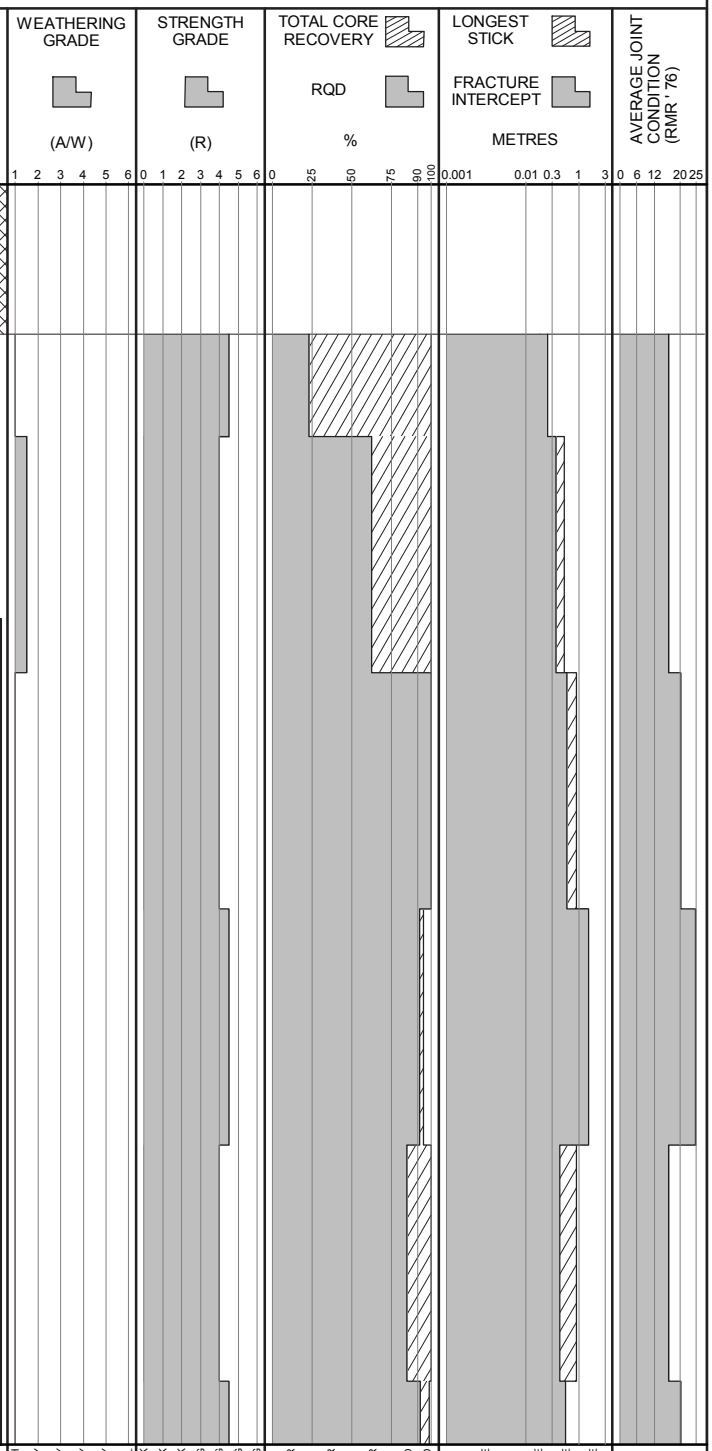
Location: CWP Pad A

Co-ordinates (m): 426,997E - 6,258,792N
Ground Elevation (m): 1,377.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 10 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 14.2
Depth To Top Of Rock (m): 1.0
Logged By: JRW
Reviewed By: TWC

Depth (m)	Instrumentation & Hole Completion Details	Drilling Action or Sample Type	Geotechnical Description, Major Discontinuities, and Additional Notes
0			FILL
1			VOLCANO-SEDIMENTARY FACIES SERIES SANDSTONES (S4-VSF) Fine grained, dark grey, polymyctic, moderate to strong phyllic/QSP alteration.
			At 1.75 m - Joint, 1mm aperture, with oxides/staining
2			At 2.25 m - Joint, 2mm aperture, with decomposed rock infill
3			VOLCANO-SEDIMENTARY FACIES SERIES SILT AND MUDSTONES (S5-VSF) Fine grained, dark grey to black, sheared, moderate to strong phyllic/QSP alteration.
4			
5			
6			
7			At 7.15 m - Joint (on contact), 5mm aperture, with decomposed rock infill
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04B

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,997E - 6,258,792N
Ground Elevation (m): 1,377.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 10 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 14.2
Depth To Top Of Rock (m): 1.0
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
8					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
9									
10									
11									
12									
13									
14									
15			END OF HOLE AT: 14.15 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 12.65 to 14.15 m on July 10, 2016. 2) Filter sand placed around screen zone from 12.07 to 14.15 m. 3) Lithology descriptions by Pretium geologists.						
16									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05A

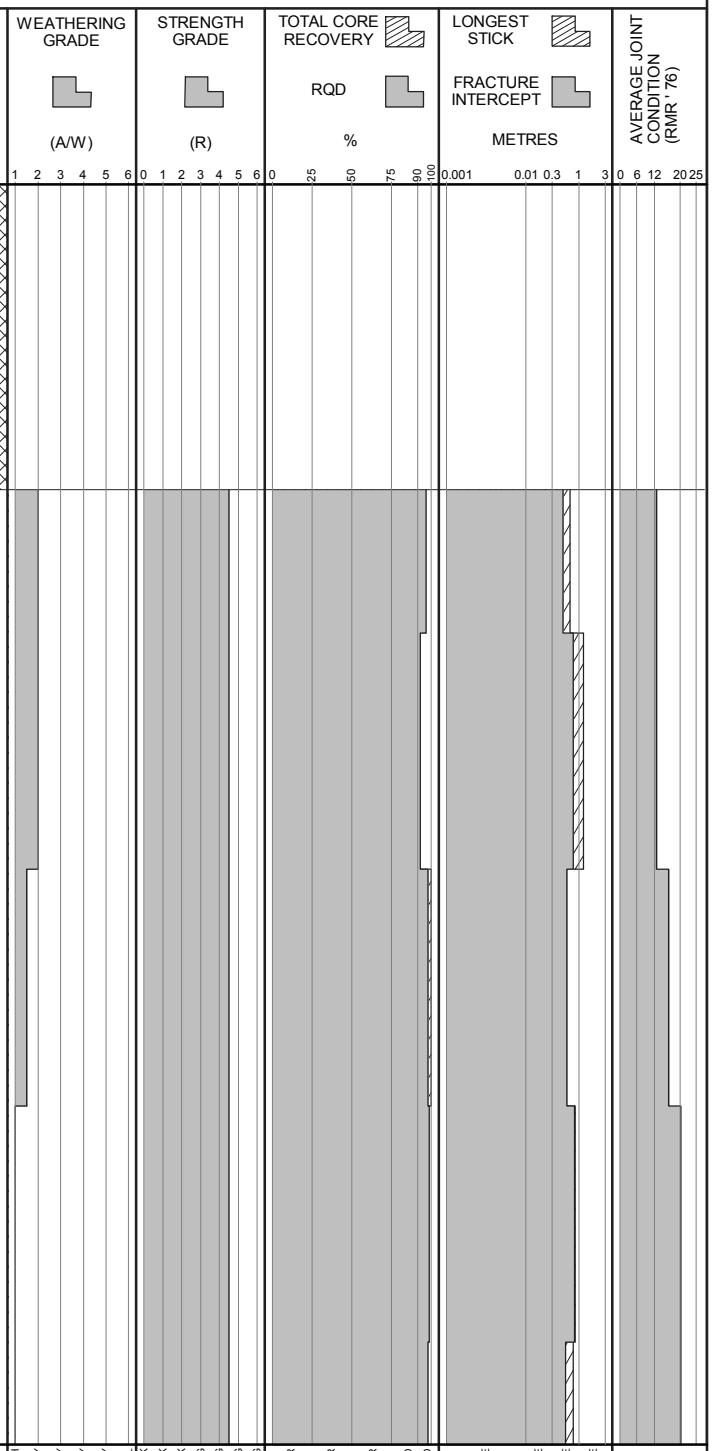
Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
2			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, light greenish grey, minor hydrothermal breccias (H15), moderate to strong sericite-chlorite alteration.
			At 2.55 m - Joint, 1mm aperture, with orange staining
			At 2.76 m - Joint, 1mm aperture, with dark orange brown staining
3			At 2.95 m - Joint, 1mm aperture, with surface staining
4			At 4.16 m - Joint, 1mm aperture, with surface staining
5			
			At 5.54 m - Joint, 1mm aperture, with surface staining
6			
7			
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05A

Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
11			At 11.33 m - Joint, 1mm aperture, with surface staining
12			
13			
14			At 13.55 m - Joint, 2mm aperture, with decomposed rock infill, and oxidizes/surface staining
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-05A

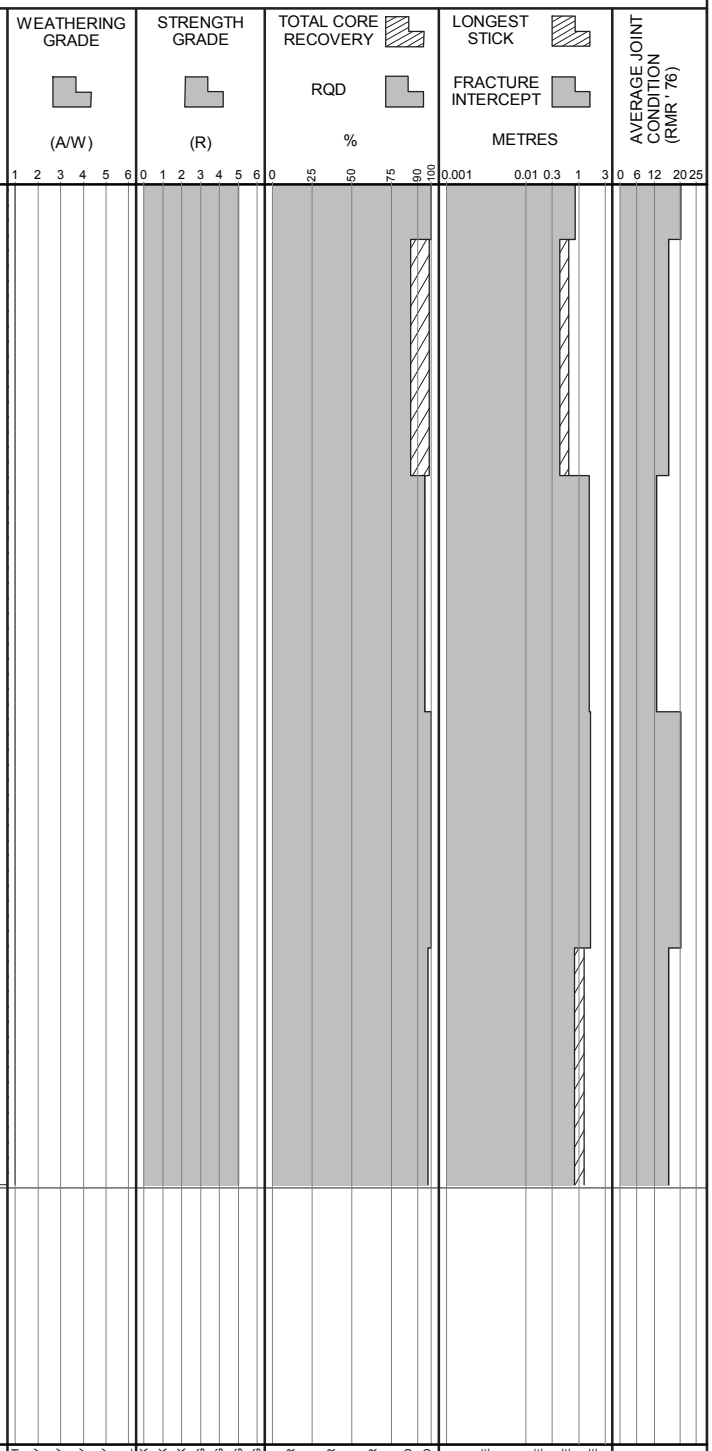
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			At 19.00 m - Joint, 2mm aperture, with decomposed rock infill
20			
21			
22			
23			END OF HOLE AT: 22.37 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 19.32 to 22.37 m on July 11, 2016. 2) Filter sand placed around screen zone from 18.65 to 22.37 m. 3) Lithology descriptions by Pretium geologists.
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05B

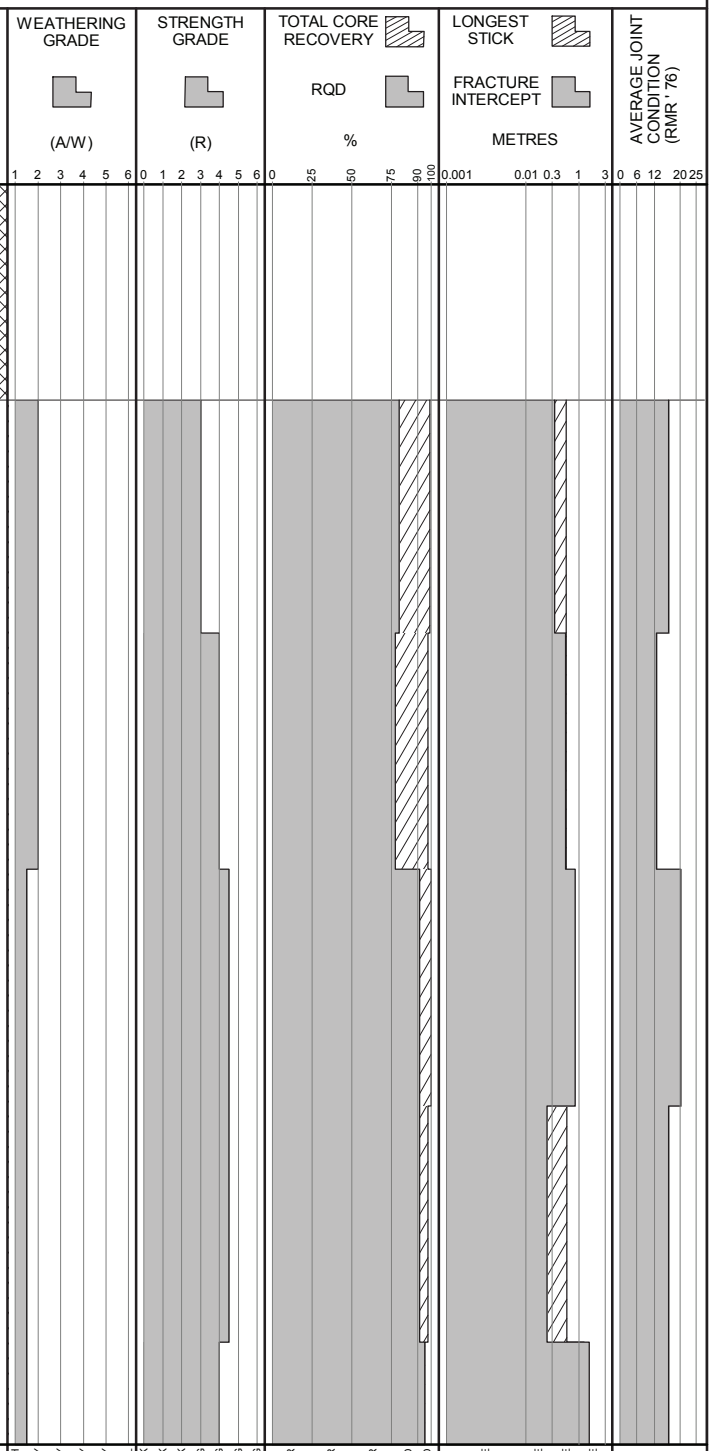
Location: CWP Pad B

Co-ordinates (m): 427,014E - 6,258,838N
Ground Elevation (m): 1,372.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 11 JUL 16
Finish Date: 12 JUL 16
Final Depth (m): 13.3
Depth To Top Of Rock (m): 1.4
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Instrumentation & Hole Completion Details	Drilling Action or Sample Type	Geotechnical Description, Major Discontinuities, and Additional Notes
0			FILL
1			
2			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, pale blue-green, locally weakly silicified. At 1.37 m - Joint, 1mm aperture, with grey clay infill At 1.83 m - Joint, 1.5mm aperture, with grey clay and decomposed rock infill and dark brown staining At 1.91 m - Joint, 1mm aperture, with grey clay infill and dark brown staining At 2.22 m - Joint, 1mm aperture, with orange brown staining At 2.34 m - Joint, 1.5mm aperture, with orange brown staining
3			At 3.17 m - Joint, 1mm aperture, with orange staining At 3.29 m - Joint, 0.5mm aperture, with orange staining. Curved joint.
4			At 3.90 m - Joint, 1mm aperture, with orange staining. Very long, undulating joint.
5			At 5.07 m - Joint, 0.5mm aperture, with orange staining
6			At 6.00 m - Joint, 1mm aperture, with surface staining At 6.10 m - Joint, 1mm aperture, with surface staining At 6.20 m - Joint, 1mm aperture, with surface staining At 6.33 m - Joint, 1mm aperture, with surface staining
7			
8			At 7.64 m - Joint, 1mm aperture, with surface staining



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05B

Location: CWP Pad B

Co-ordinates (m): 427,014E - 6,258,838N
Ground Elevation (m): 1,372.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 11 JUL 16
Finish Date: 12 JUL 16
Final Depth (m): 13.3
Depth To Top Of Rock (m): 1.4
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			At 9.40 m - Joint, 1mm aperture, with surface staining
10			At 10.00 m - Joint, 1mm aperture, with surface staining
			At 10.56 m - Joint (on vein), 1mm aperture, with waxy coating of decomposed rock
11			
			At 11.47 m - Joint, 1mm aperture, with waxy coating of decomposed rock
12			
13			
			END OF HOLE AT: 13.25 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 9.00 to 10.50 m on July 12, 2016. 2) Filter sand placed around screen zone from 8.50 to 10.50 m. 3) Backfilled from end of hole to 10.50m with bentonite chips. 4) Lithology descriptions by Pretium geologists.
14			
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

SYMBOLS AND TERMS

FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation

Project Number: 1008029

SOIL/ROCK SYMBOLS		
Overburden	Fill	Till
Fragmental volcanics [V12]	Porphyry [P1]	Conglomerate [S3-Poly]
Silicified con-glomerate [H8]	Sandstone/ arenite [S4-Vsf]	Mafic dyke [V6]

INSTRUMENT DETAILS SYMBOLS		
Grout	Cuttings / slough	Bentonite chips
Bentonite pellets	Sand	Standpipe screen in sand
Standpipe in bentonite	Standpipe in grout	

NOTES

1. Depths are along hole and relative to ground surface.

LIST OF ACRONYMS	
A	Alteration
K	Hydraulic conductivity
R	Strength grade
W	Weathering
RMR	Rock mass rating
RQD	Rock quality designation

SYMBOLS AND TERMS

FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation Project Number: 1008029

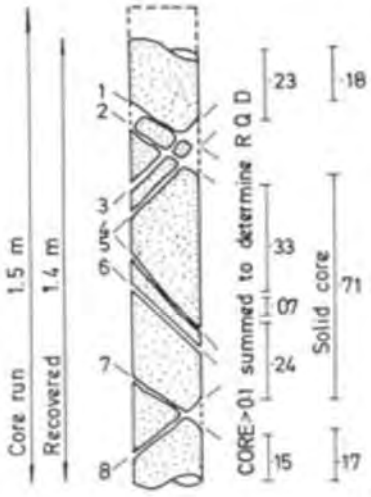
WEATHERING/ALTERATION [1]		
GRADE	**Description**	**Field Identification**
A/W 1	Fresh and Unweathered	No visible sign of rock material weathering
A/W 1.5	Faintly Weathered	Discolouration on major discontinuity surfaces
A/W 2	Slightly Weathered or Altered	Discolouration indicated weathering of rock material and discontinuity surfaces. All rock material may be discoloured by weathering and may be weaker than in its fresh condition.
A/W 3	Moderately Weathered or Altered	Less than 50% of rock material decomposed and/or disintegrated to soil. Fresh/ discoloured rock present as a continuous framework or corestones.
A/W 4	Highly Weathered or Altered	More than 50% rock material is decomposed or disintegrated to soil. Fresh/Discoloured rock present as discontinuous framework or corestones.
A/W 5	Completely Weathered or Altered	All rock material decomposed and/or disintegrated to soil. Original mass structure still largely intact
A/W 6	Residual Soil	All rock material converted to soil; mass structure and material fabric destroyed.

Note: Weathering/alteration half grades can be assigned to indicate a transition zone.

STRENGTH/HARDNESS CLASSIFICATION FOR ROCK [1]		
GRADE	**Description**	**Field Identification**
R6	Extremely Strong	Specimen can only be chipped with flat end of geological hammer
R5	Very Strong	Specimen requires many blows of flat end of geological hammer to fracture
R4	Strong	Specimen requires more than one blow of flat end of geological hammer to fracture
R3	Medium Strong	Cannot be scraped or peeled with pocket knife; can be fractured with single firm blow of flat end of the geologic hammer
R2	Weak	Can be peeled with pocket knife with difficulty; shallow indentation made by firm blow with point of geological hammer
R1	Very Weak	Crumbles under firm blow with point of geological hammer; can be peeled by a pocket knife
R0	Extremely Weak	Indented by thumbnail

Note: Strength/hardness half grades can be assigned to indicate a transition zone.

JOINT CONDITION [2]	
Condition of Joints	**Rating**
Very rough surfaces. Not continuous. No separation. Hard joint wall rock.	25
Slightly rough surfaces. Separation <1mm. Hard joint wall rock.	20
Slightly rough surfaces. Separation <1mm. Soft joint wall rock.	12
Slickensided surfaces or gouge <5mm thick or joints open 1-5mm. Continuous joints.	6
Soft gouge >5mm thick or joints open >5mm. Continuous joints.	0



Core recovery $= \frac{1.40}{1.50} = 93\%$

Solid core recovery $= \frac{1.06}{1.50} = 71\%$

R Q D $= \frac{0.95}{1.50} = 63\%$

Fracture index $= \frac{8}{1.50} = 5.3$ /m run

If strength grade ≤ R1, do not include in RQD.

SYMBOLS AND TERMS

FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation Project Number: 1008029

Texture [3]		
Term	**Particle Size**	**Examples**
Very Coarse	> 60 mm	Porphyritic
Coarse	2 - 60 mm	Breccia, Gneiss (measurable grains)
Medium	0.06 - 2 mm	Sandstone, Gabbro, Granite, Schist (visible grains)
Fine	0.002 - 0.06 mm	Tuff, Siltstone, Claystone, Mudstone, Basalt
Very Fine	< 0.002 mm	

Fabric	
Term	**Description**
Homogeneous/ Uniform	Equigranular or homogeneous grains
Bedded	Deposited in layers, can be sedimentary or volcaniclastic rocks
Foliated	Minerals are aligned due to shearing or metamorphism
Gneissic	Alternating layers of different colour or texture with mineral alignment and typically parts along layers
Porphyritic	Crystalline texture with bimodal grain size distribution, fine to medium grained groundmass with coarse to very coarse phenocrysts
Stockwork	Veins (typically quartz, calcite, or gypsum/anhydrite) make up greater than 10% of the rock mass, they may be aligned with foliation or irregularly oriented
Microfractured	Hairline fractures are the primary fabric of the rock, typically oriented in all directions and intersecting one another
Brecciated	Healed or welded angular clasts with matrix, may be matrix – or clast-supported

SYMBOLS AND TERMS
FOR SOIL/ROCK DESCRIPTIONS ON BOREHOLE LOGS

Project: Brucejack 2018 Groundwater Monitoring Well Installation and Site Investigation Project Number: 1008029

REFERENCES

1) International Society of Rock Mechanics (ISRM). (1977). Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses. *International Journal of Rock Mechanics, Mineral Science, and Geomechanics Abstracts, 15,* 319-368.

2) Bieniawski, Z. T. (1976). Rock mass classifications in rock engineering. In Z. T. Bieniawski (Ed.), *Exploration for Rock Engineering (pp. 97-106). Cape Town, South Africa: Balkema.*

3) International Society for Rock Mechanics (ISRM). (1981). Basic Geotechnical Description of Rock Masses. *International Journal of Rock Mechanics, Mineral Science, and Geomechanics Abstracts, 18,* 85 -110.

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

Project No.: 1008-029

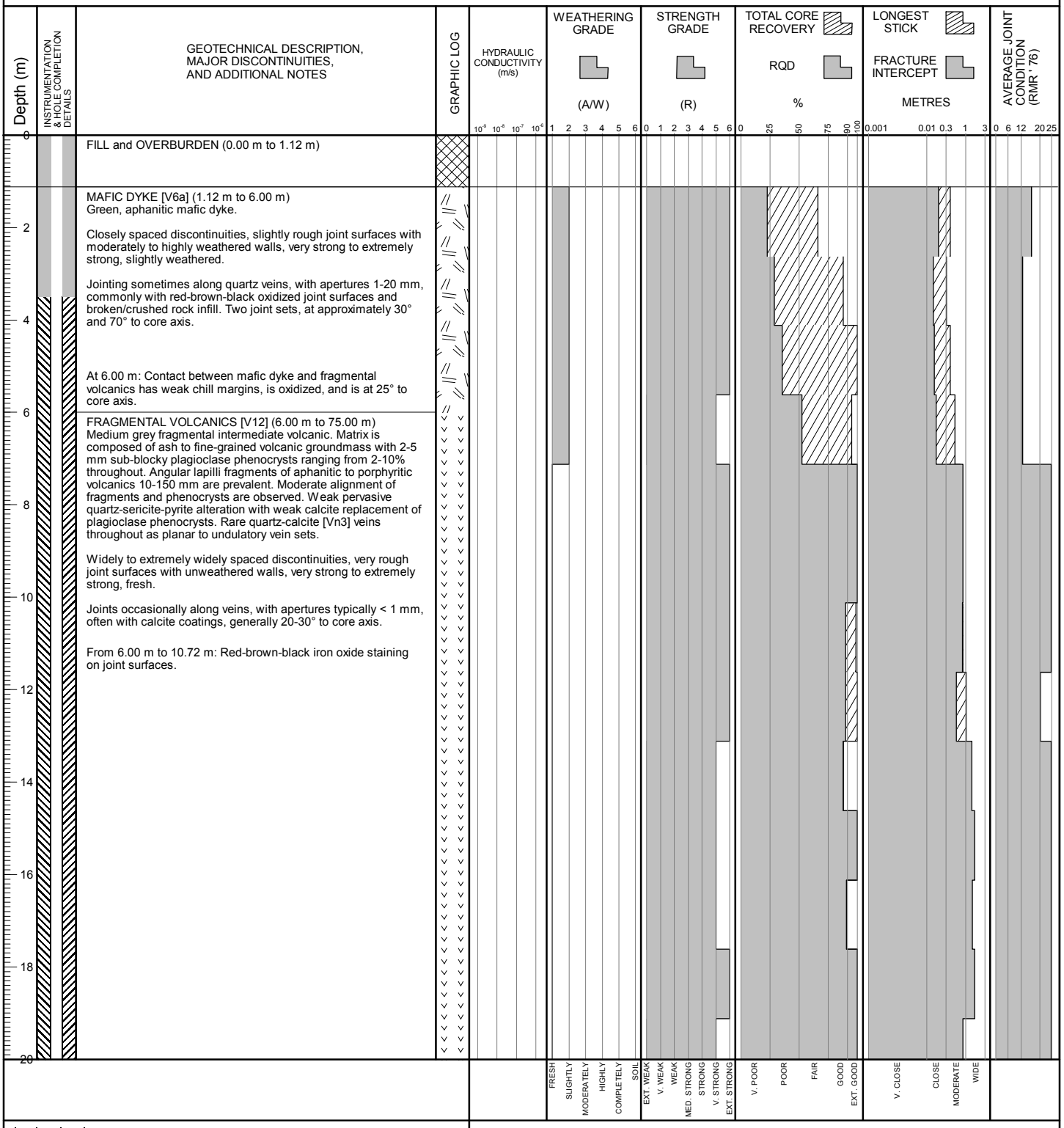
Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0	FILL and OVERBURDEN (0.00 m to 1.12 m)
1.12	MAFIC DYKE [V6a] (1.12 m to 6.00 m) Green, aphanitic mafic dyke. Closely spaced discontinuities, slightly rough joint surfaces with moderately to highly weathered walls, very strong to extremely strong, slightly weathered. Jointing sometimes along quartz veins, with apertures 1-20 mm, commonly with red-brown-black oxidized joint surfaces and broken/crushed rock infill. Two joint sets, at approximately 30° and 70° to core axis. At 6.00 m: Contact between mafic dyke and fragmental volcanics has weak chill margins, is oxidized, and is at 25° to core axis.
6.00	FRAGMENTAL VOLCANICS [V12] (6.00 m to 75.00 m) Medium grey fragmental intermediate volcanic. Matrix is composed of ash to fine-grained volcanic groundmass with 2-5 mm sub-blocky plagioclase phenocrysts ranging from 2-10% throughout. Angular lapilli fragments of aphanitic to porphyritic volcanics 10-150 mm are prevalent. Moderate alignment of fragments and phenocrysts are observed. Weak pervasive quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Rare quartz-calcite [Vn3] veins throughout as planar to undulatory vein sets. Widely to extremely widely spaced discontinuities, very rough joint surfaces with unweathered walls, very strong to extremely strong, fresh. Joints occasionally along veins, with apertures typically < 1 mm, often with calcite coatings, generally 20-30° to core axis. From 6.00 m to 10.72 m: Red-brown-black iron oxide staining on joint surfaces.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

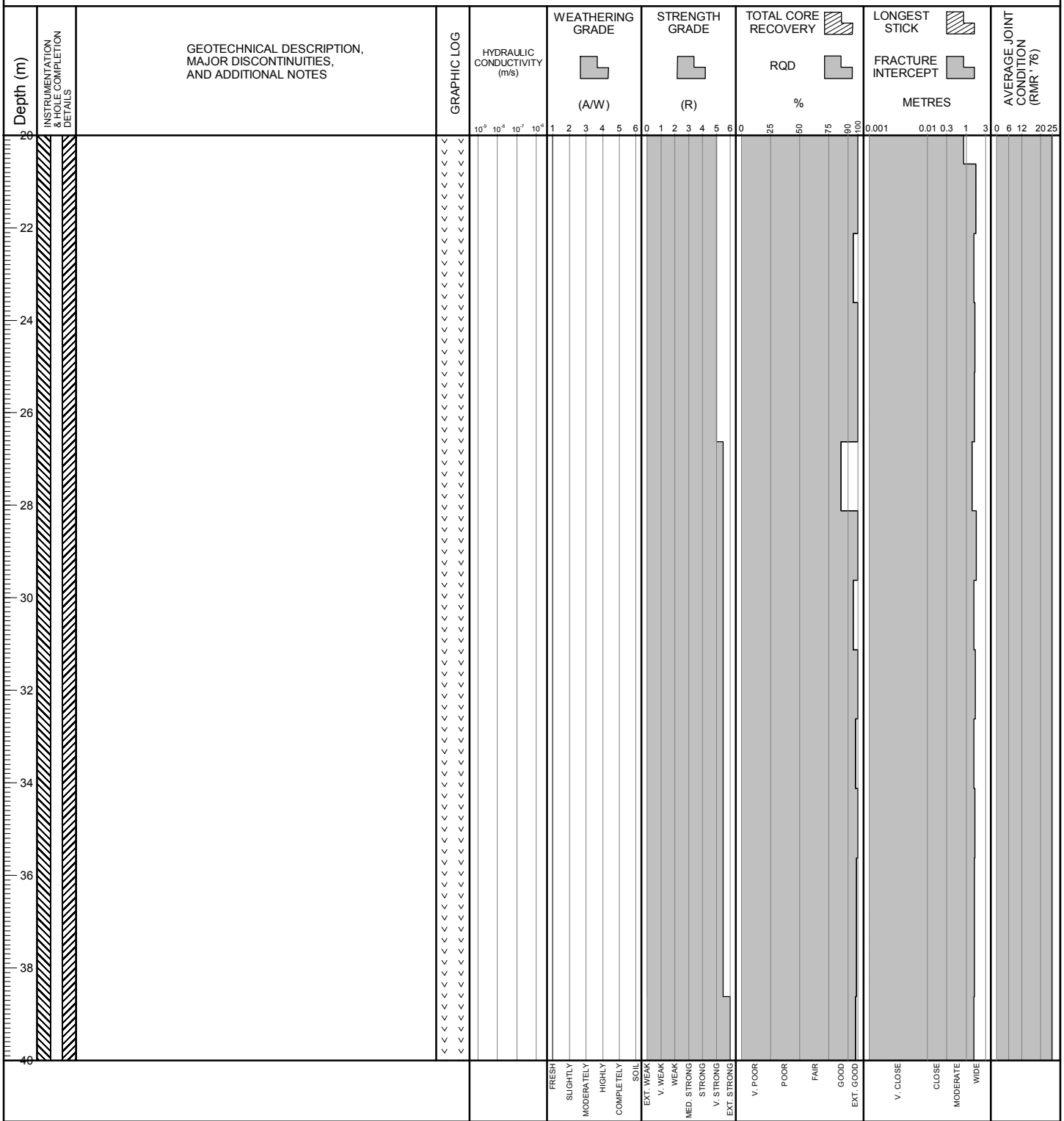
Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

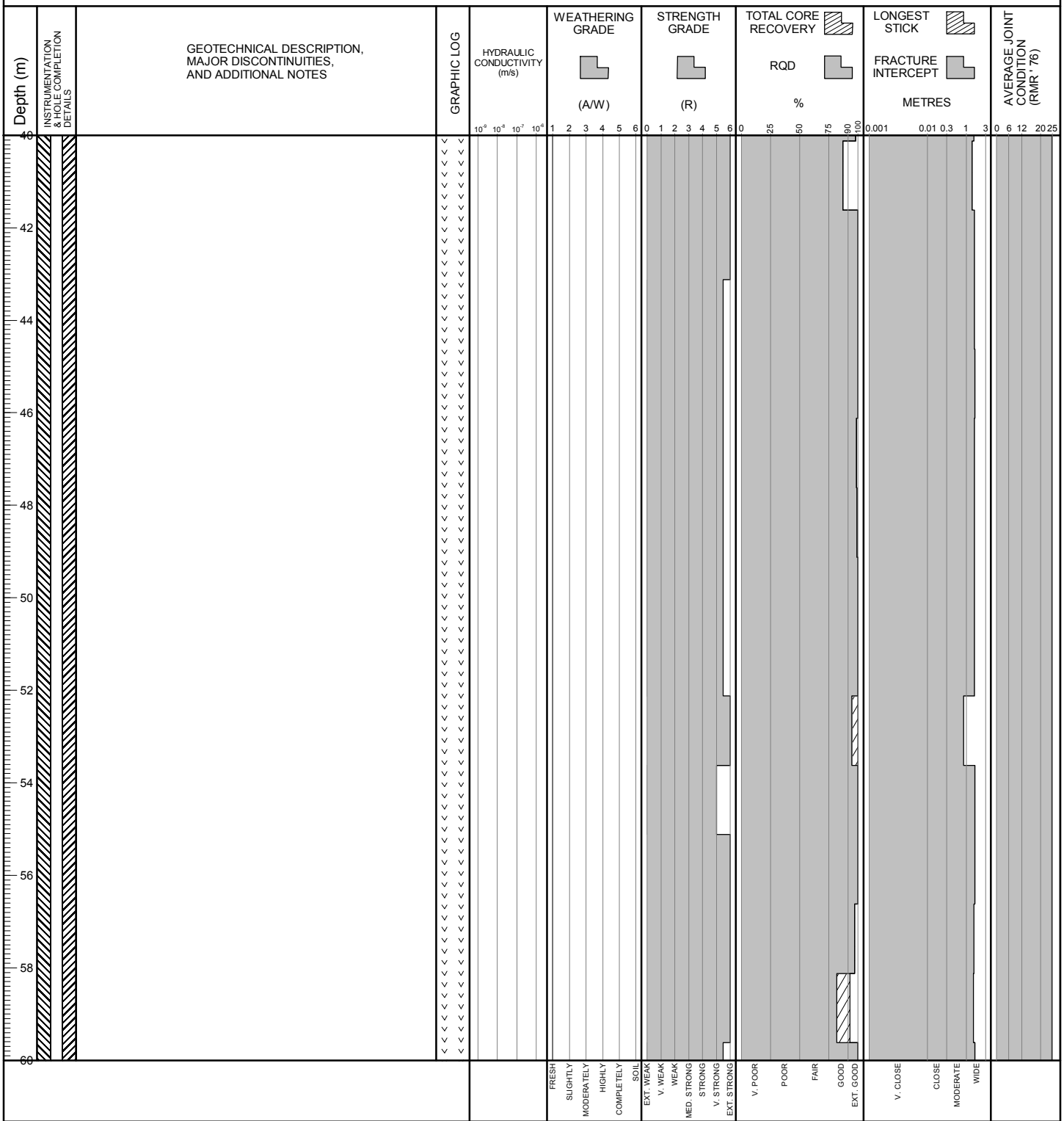
Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
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Drill Designation: Tech 5000
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Start Date: 30 MAY 18
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Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 65.00 m to 76.76 m: Joint apertures 1-5 mm and infilled with silt and/or clay.

At 75.00 m: Contact between fragmental volcanics and porphyry is ambiguous.

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (75.00 m to 142.68 m)
Medium grey porphyritic volcanics/intrusives. Predominantly composed of euhedral, clay-altered mafic (hornblende?) phenocrysts and subhedral, calcite-altered plagioclase phenocrysts ranging from 5-25% throughout a grey, fine-grained matrix. Weak alignment of phenocrysts. Occasional intermediate fragments. Weak, pervasive, quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Rare quartz-calcite [Vn3] veins throughout as planar to undulatory vein sets.

Widely to extremely widely spaced discontinuities, slightly rough to very rough joint surfaces with unweathered walls, very strong to extremely strong, fresh.

Joints with apertures typically < 1 mm, sometimes with calcite or chlorite coatings.

Weathering grade: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
Strength grade: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Fracture intercept: V. CLOSE, CLOSE, MODERATE, WIDE

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

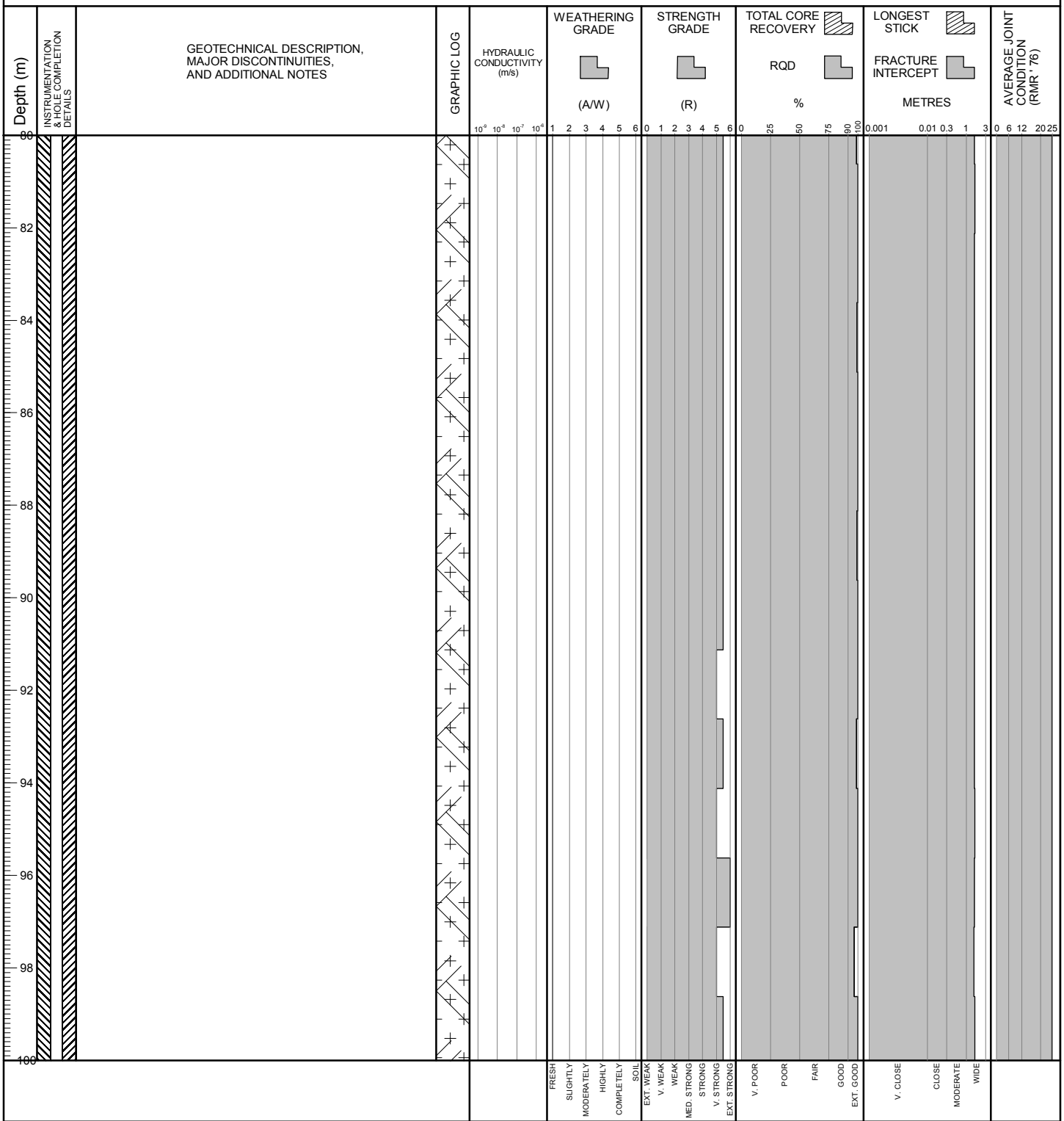
Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
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Datum: UTM NAD 83 Zone 9
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Start Date: 30 MAY 18
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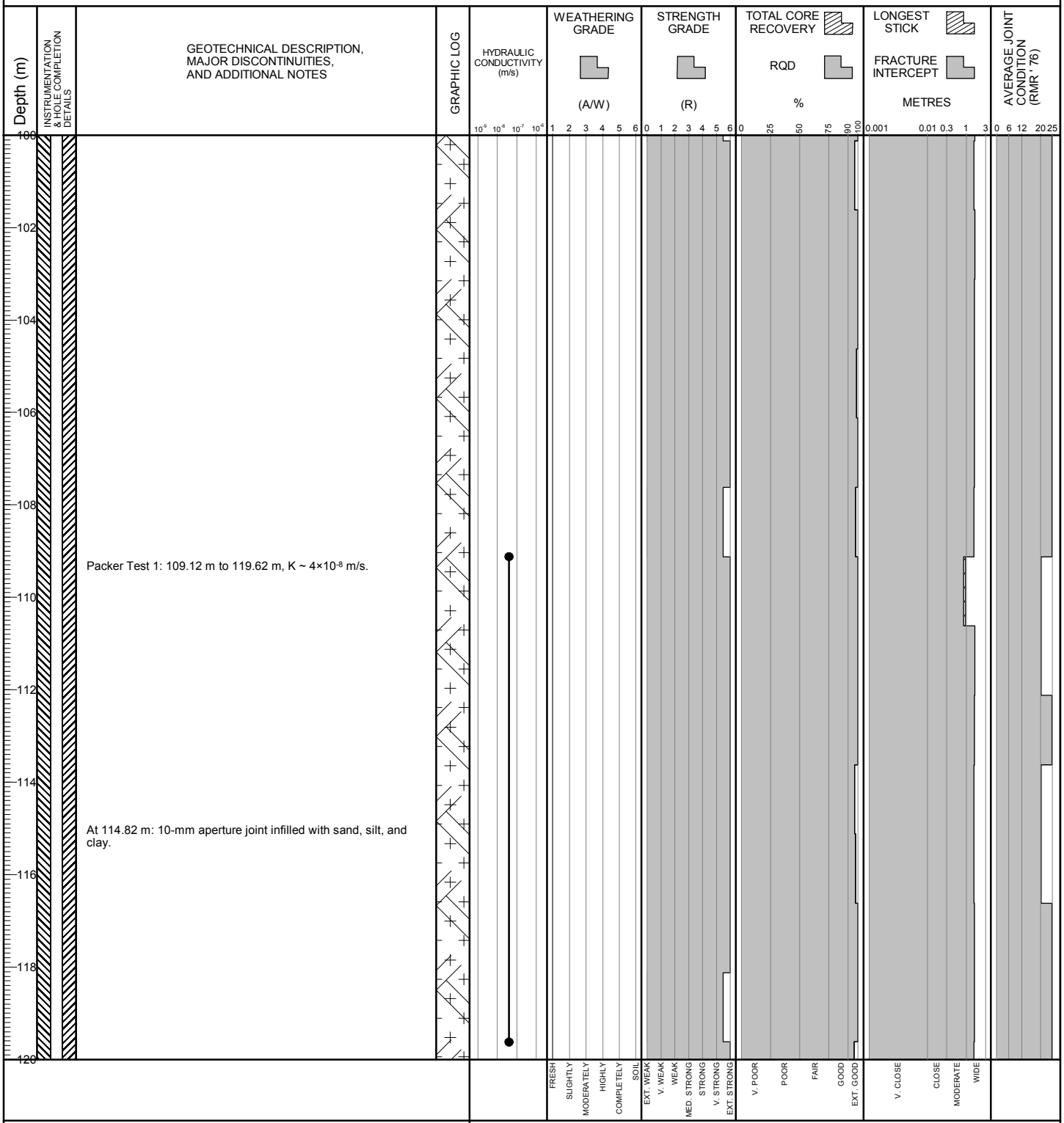


BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

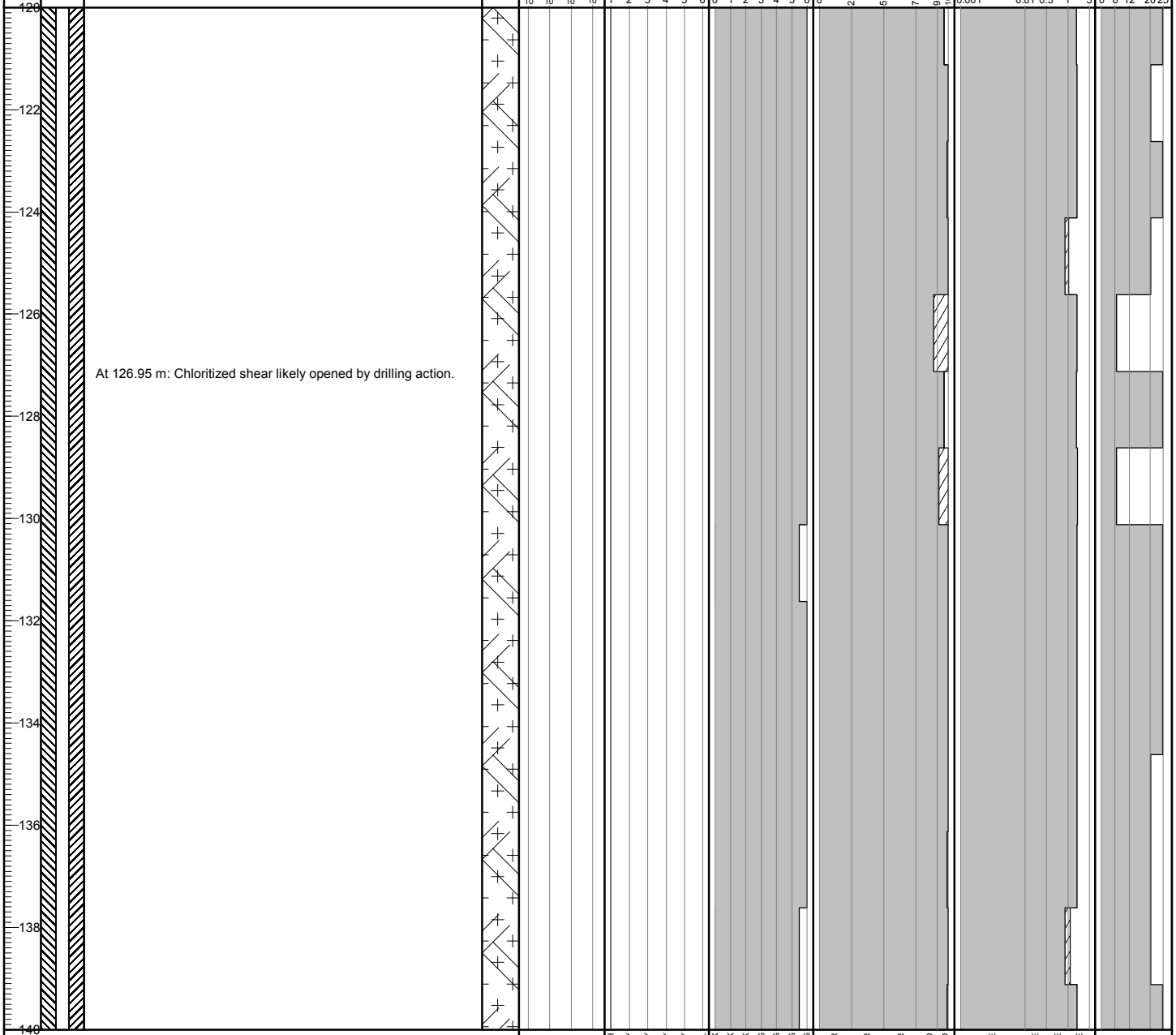
Project No.: 1008-029 **Location:** Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
120–140		At 126.95 m: Chloritized shear likely opened by drilling action.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17A

Project No.: 1008-029

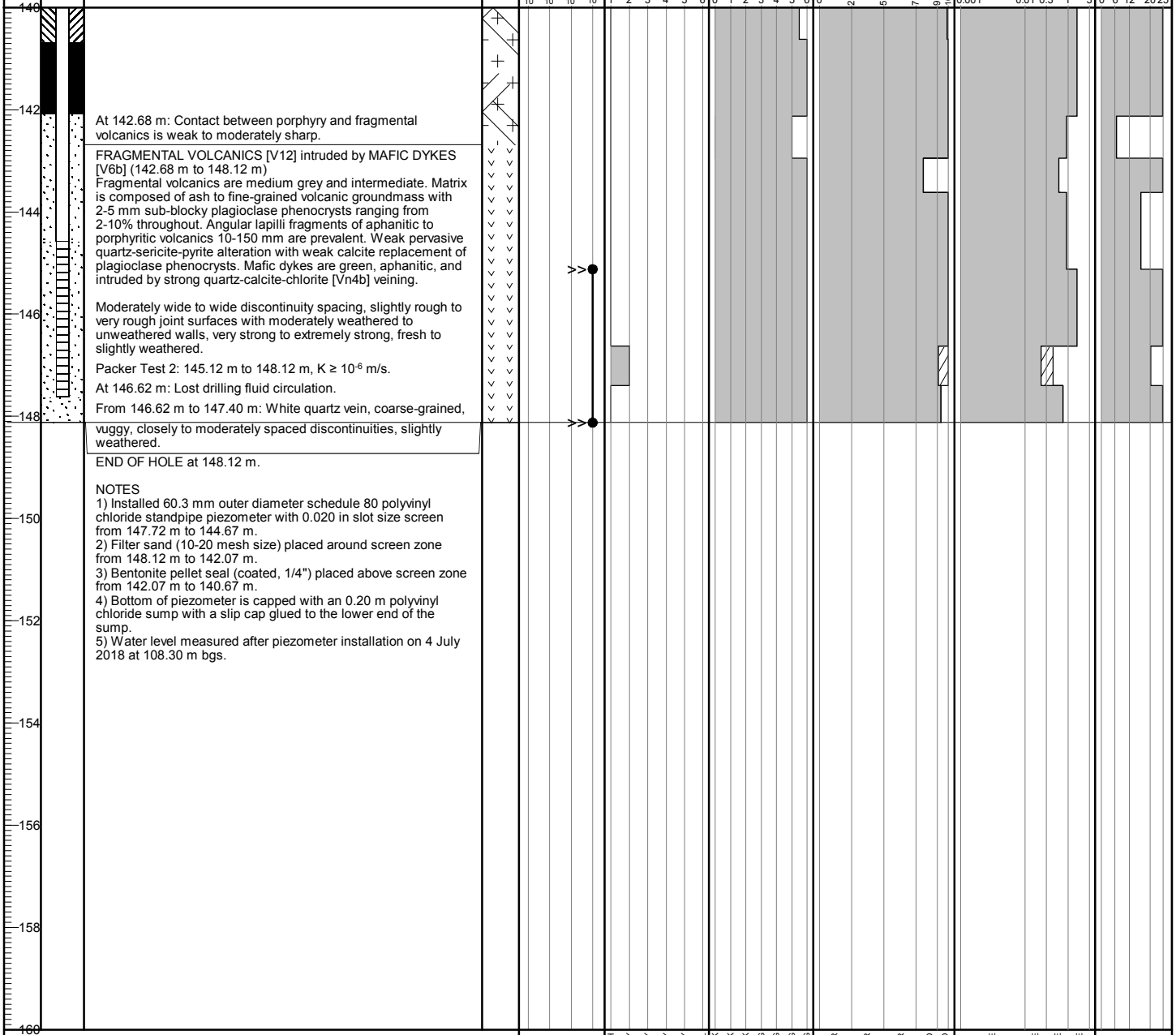
Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,771E - 6,258,761N
Ground Elevation (m): 1,403.87
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 5.75

Start Date: 30 MAY 18
Finish Date: 05 JUN 18
Final Depth (m): 148.12
Depth To Top Of Rock (m): 1.12
Logged By: BDT/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)



At 142.68 m: Contact between porphyry and fragmental volcanics is weak to moderately sharp.

FRAGMENTAL VOLCANICS [V12] intruded by MAFIC DYKES [V6b] (142.68 m to 148.12 m)
Fragmental volcanics are medium grey and intermediate. Matrix is composed of ash to fine-grained volcanic groundmass with 2-5 mm sub-blocky plagioclase phenocrysts ranging from 2-10% throughout. Angular lapilli fragments of aphanitic to porphyritic volcanics 10-150 mm are prevalent. Weak pervasive quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Mafic dykes are green, aphanitic, and intruded by strong quartz-calcite-chlorite [Vn4b] veining.

Moderately wide to wide discontinuity spacing, slightly rough to very rough joint surfaces with moderately weathered to unweathered walls, very strong to extremely strong, fresh to slightly weathered.

Packer Test 2: 145.12 m to 148.12 m, K ≥ 10^{-6} m/s.

At 146.62 m: Lost drilling fluid circulation.

From 146.62 m to 147.40 m: White quartz vein, coarse-grained, vuggy, closely to moderately spaced discontinuities, slightly weathered.

END OF HOLE at 148.12 m.

NOTES
1) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 147.72 m to 144.67 m.
2) Filter sand (10-20 mesh size) placed around screen zone from 148.12 m to 142.07 m.
3) Bentonite pellet seal (coated, 1/4") placed above screen zone from 142.07 m to 140.67 m.
4) Bottom of piezometer is capped with an 0.20 m polyvinyl chloride sump with a slip cap glued to the lower end of the sump.
5) Water level measured after piezometer installation on 4 July 2018 at 108.30 m bgs.

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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
Ground Elevation (m): 1,403.99
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
Depth To Top Of Rock (m): 1.19
Logged By: BDT/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

FILL and OVERBURDEN (0.00 m to 1.19 m)

FRAGMENTAL VOLCANICS [V12] (1.19 m to 69.28 m)
Medium grey fragmental intermediate volcanic. Matrix is comprised of ash to fine-grained volcanic groundmass with 2-5 mm sub-blocky plagioclase phenocrysts ranging from 2-10% throughout. Angular lapilli fragments of aphanitic to porphyritic volcanics 10-150 mm are prevalent. Weak pervasive quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Veining is negligible <1% throughout. Rare quartz-calcite [Vn3] generations are observed throughout as planar to undulatory vein sets.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with slightly weathered to unweathered walls, very strong to extremely strong, fresh.

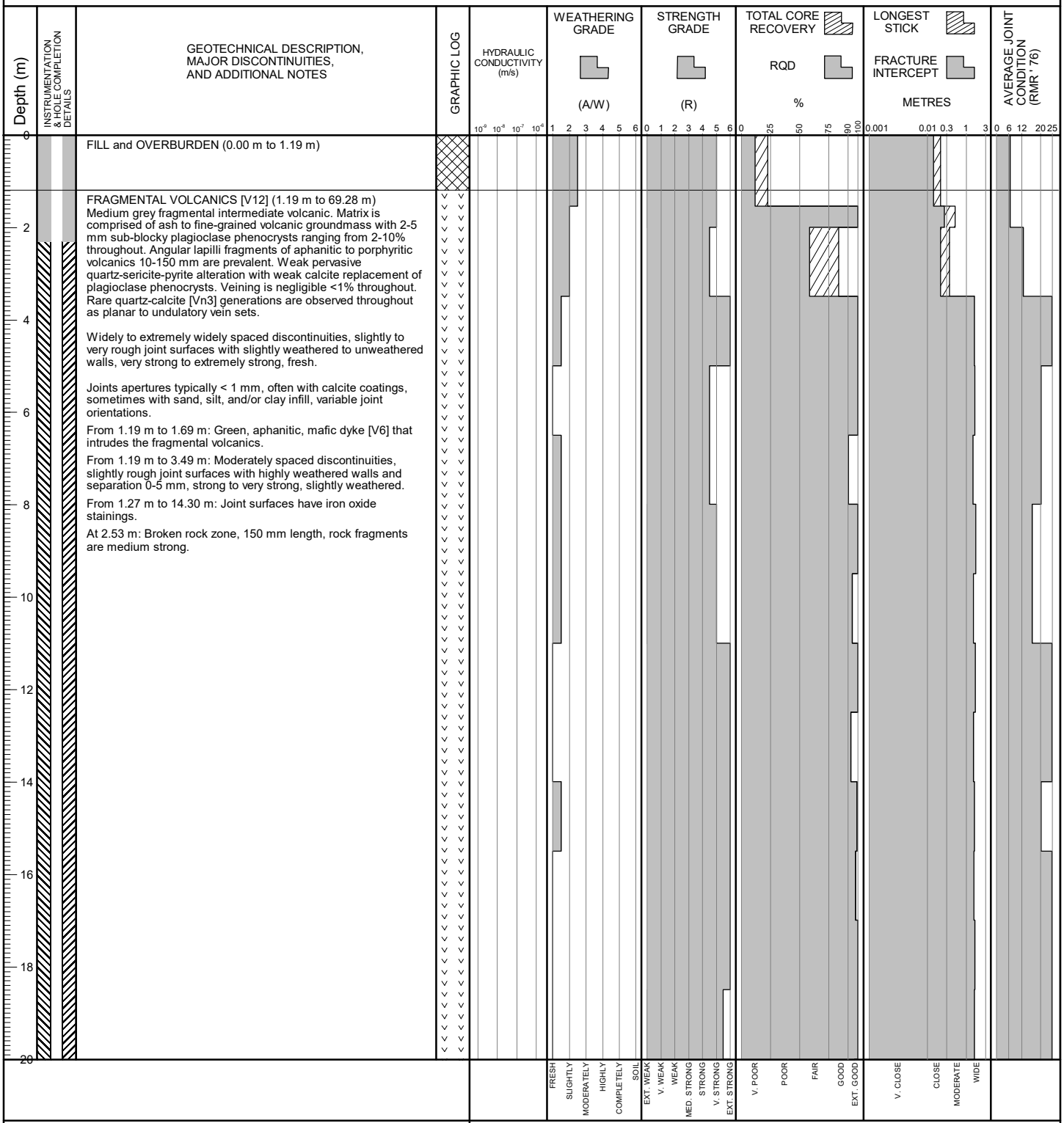
Joints apertures typically < 1 mm, often with calcite coatings, sometimes with sand, silt, and/or clay infill, variable joint orientations.

From 1.19 m to 1.69 m: Green, aphanitic, mafic dyke [V6] that intrudes the fragmental volcanics.

From 1.19 m to 3.49 m: Moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation 0-5 mm, strong to very strong, slightly weathered.

From 1.27 m to 14.30 m: Joint surfaces have iron oxide stainings.

At 2.53 m: Broken rock zone, 150 mm length, rock fragments are medium strong.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

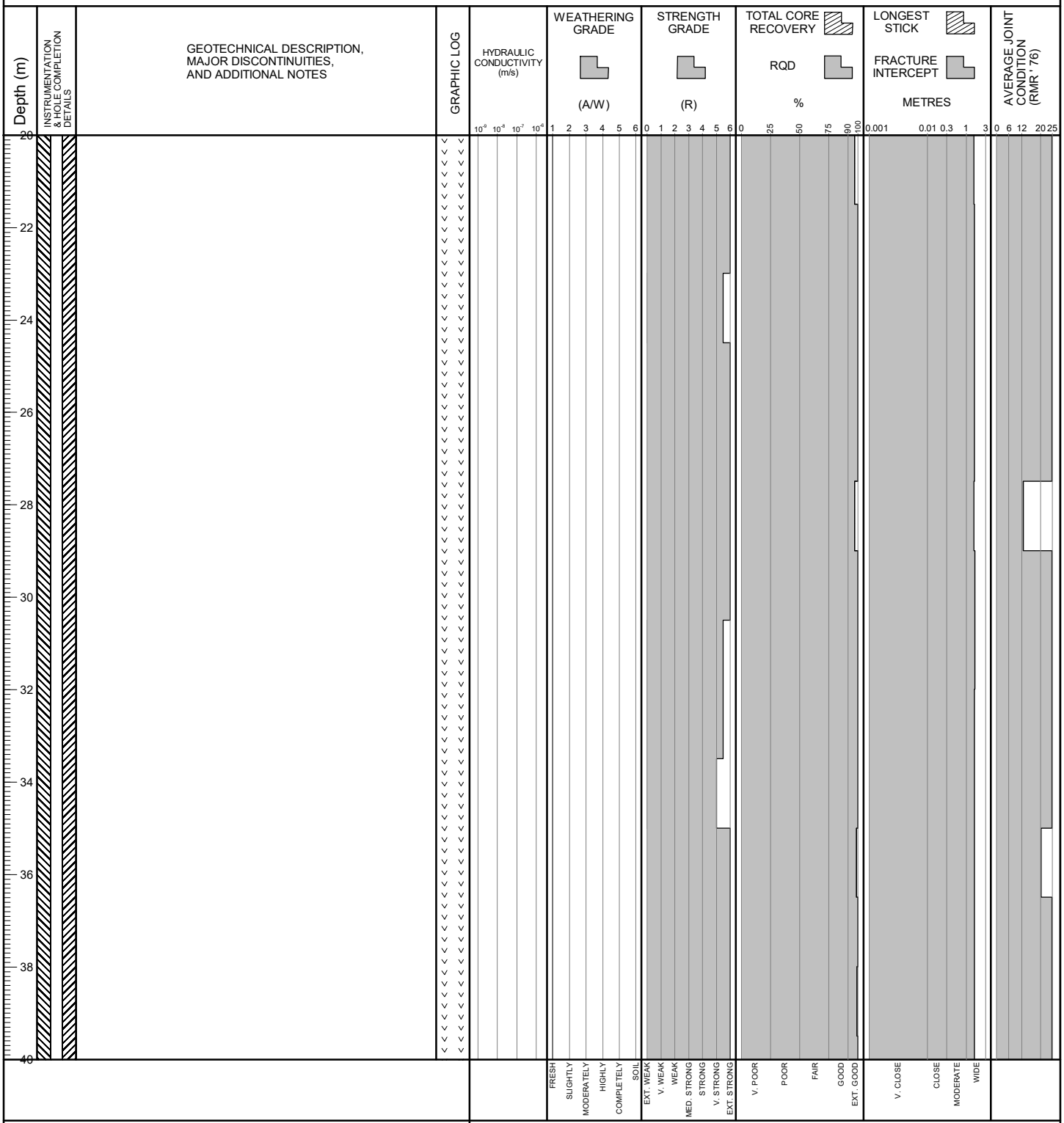
Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
Ground Elevation (m): 1,403.99
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
Depth To Top Of Rock (m): 1.19
Logged By: BDT/BM
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
Ground Elevation (m): 1,403.99
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
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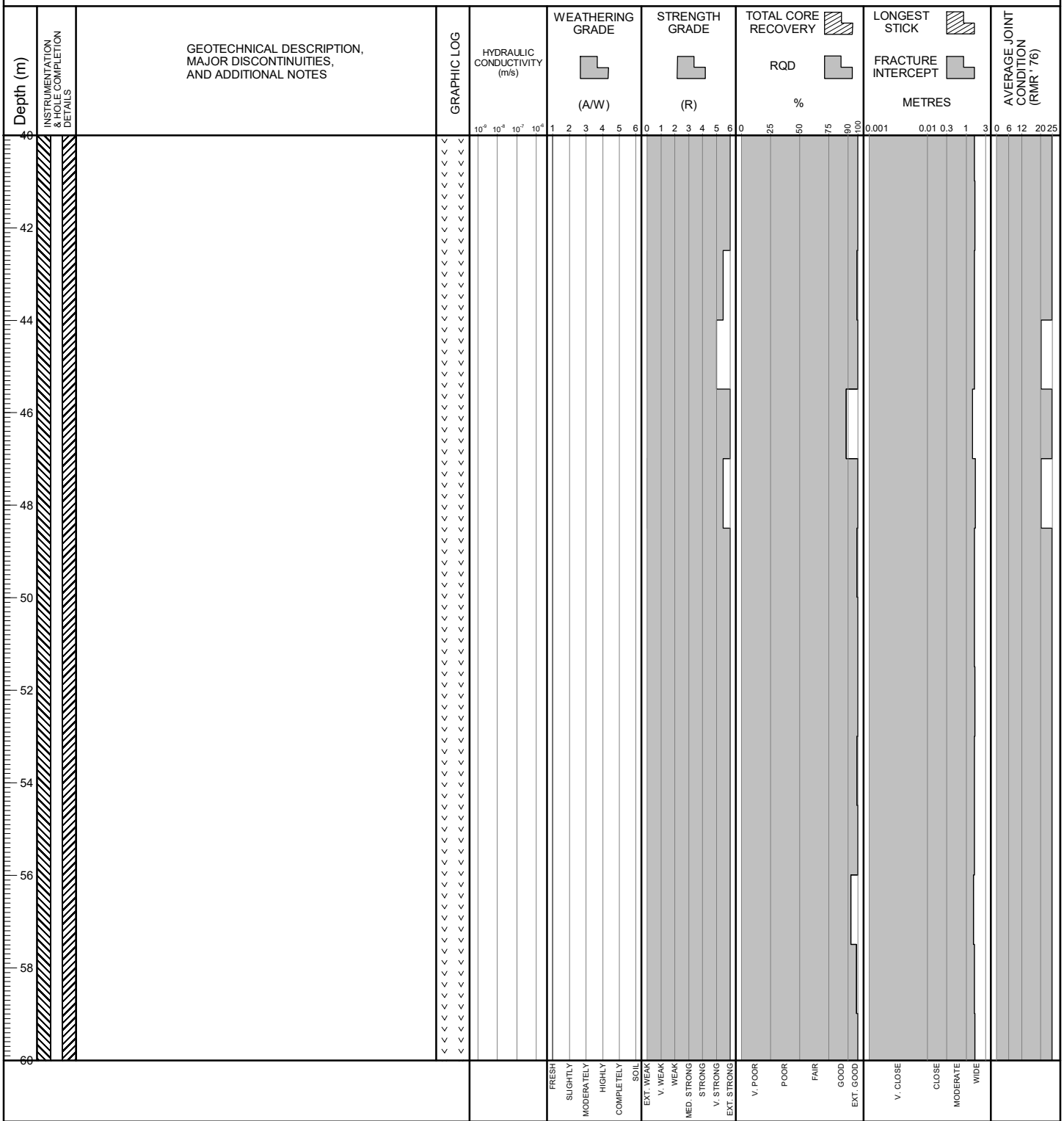

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AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
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Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
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Drill Designation: Tech 5000
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Drill Method: Diamond Coring
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Fluid: Water
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Start Date: 05 JUN 18
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Logged By: BDT/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

At 69.28 m: Contact between [V12] and [P1] is weakly developed.

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (69.28 m to 105.49 m)
Medium grey porphyritic volcanic/intrusives. Predominantly comprised of euhedral, clay-altered mafic (hornblende?) phenocrysts and subhedral, calcite-altered plagioclase phenocrysts ranging from 5-25% throughout a grey, fine-grained matrix. Weak alignment of phenocrysts. Occasional intermediate fragments. Weak, pervasive, quartz-sericite-pyrite alteration with weak calcite replacement of plagioclase phenocrysts. Veining is negligible <1% throughout. Rare quartz-calcite [Vn3] generations are observed throughout as planar to undulatory vein sets.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with slightly weathered to unweathered walls, very strong to extremely strong, fresh.

Joints apertures typically < 1 mm, often with calcite coatings, sometimes with sand, silt, and/or clay infill, generally 20-30° to core axis.

Packer Test 2: 71.49 m to 105.49 m, K ~ 9×10^{-8} m/s.

Packer Test 3: 74.49 m to 105.49 m, K ≤ 10^{-8} m/s.

WEATHERING GRADE (A/W): FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

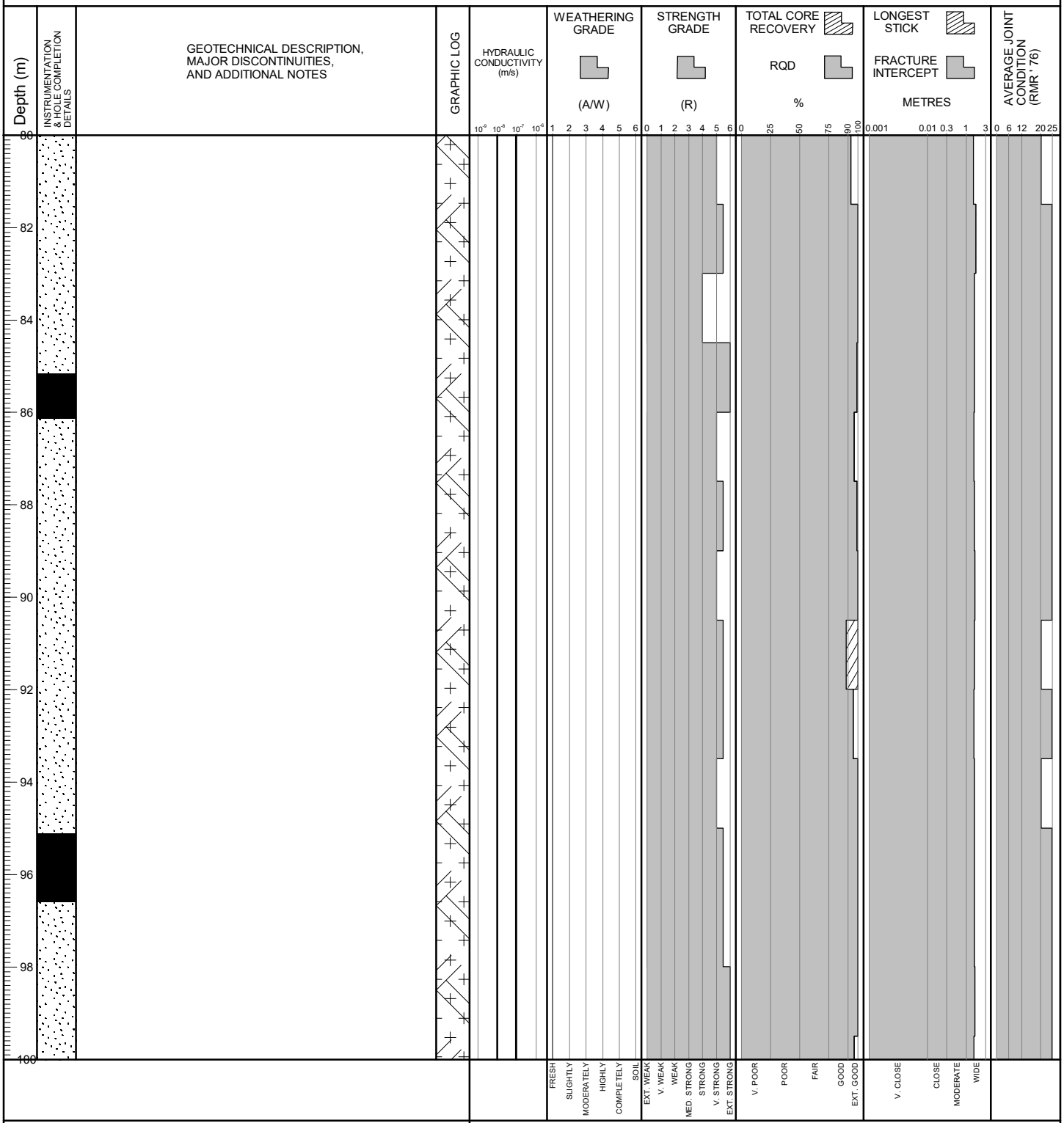
Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
Ground Elevation (m): 1,403.99
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
Depth To Top Of Rock (m): 1.19
Logged By: BDT/BM
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-17B

Project No.: 1008-029

Location: Sewage Treatment Plant Pad

Co-ordinates (m): 426,772E - 6,258,760N
Ground Elevation (m): 1,403.99
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 2.78

Start Date: 05 JUN 18
Finish Date: 08 JUN 18
Final Depth (m): 105.49
Depth To Top Of Rock (m): 1.19
Logged By: BDT/BM
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes	Graphic Log	Hydraulic Conductivity (m/s)	Weathering Grade (A/W)	Strength Grade (R)	Total Core Recovery / RQD (%)	Longest Stick / Fracture Intercept (Metres)	Average Joint Condition (RMR' 76)
100		Packer Test 1: 100.99 m to 105.49 m, K ≤ 10^{-8} m/s.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
102									
104									
106		END OF HOLE at 105.49 m.							
108		NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 75.27 m to 72.22 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 75.76 m to 72.10 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 72.10 m to 69.68 m. 5) Water level measured after piezometer installation on 4 July 2018 at 60.22 m bgs.							
110									
112									
114									
116									
118									
120									

Weathering Grade: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

Strength Grade: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD

Fracture Intercept: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

FILL (0.00 m to 1.12 m)

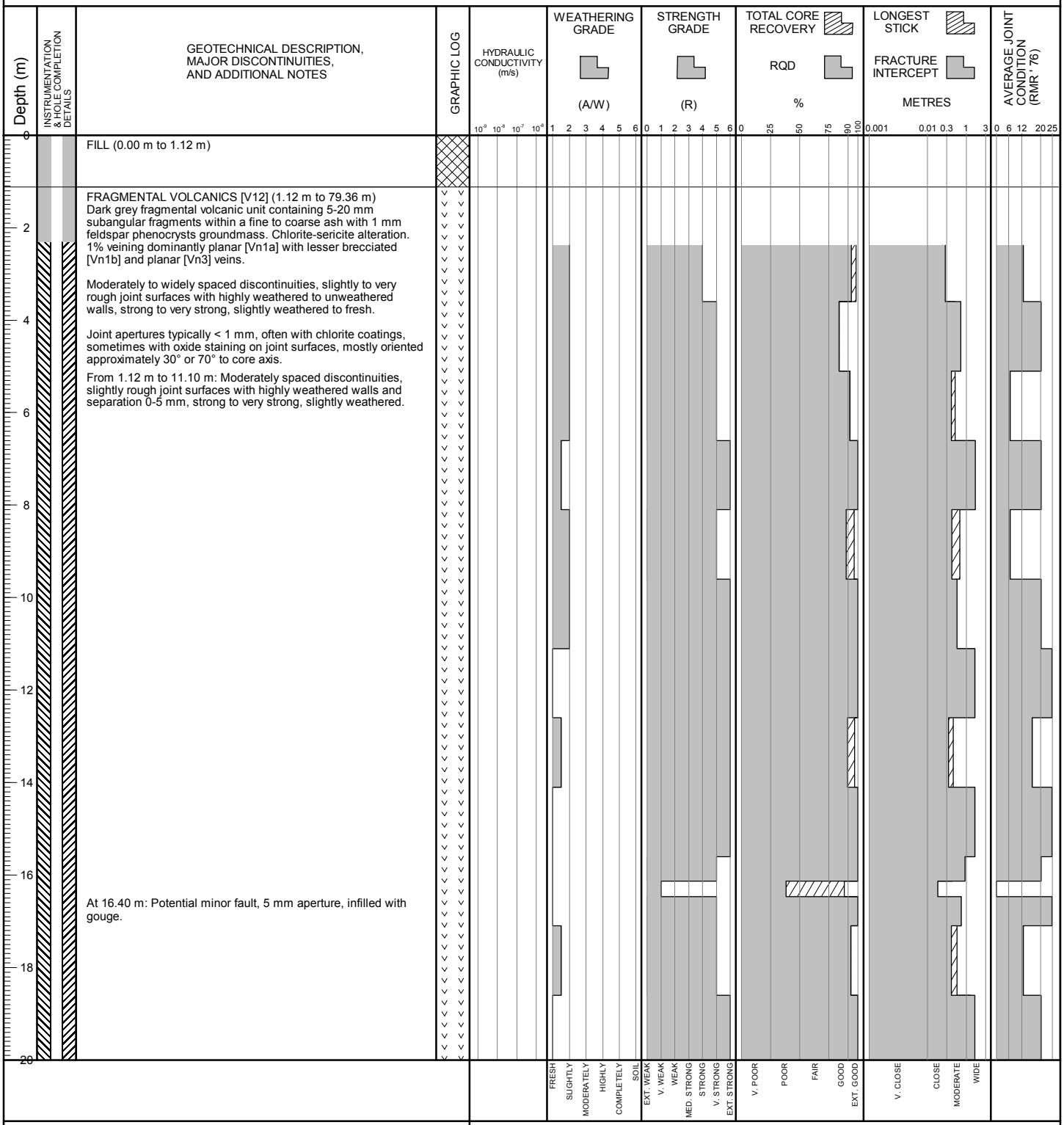
FRAGMENTAL VOLCANICS [V12] (1.12 m to 79.36 m)
Dark grey fragmental volcanic unit containing 5-20 mm subangular fragments within a fine to coarse ash with 1 mm feldspar phenocrysts groundmass. Chlorite-sericite alteration. 1% veining dominantly planar [Vn1a] with lesser brecciated [Vn1b] and planar [Vn3] veins.

Moderately to widely spaced discontinuities, slightly to very rough joint surfaces with highly weathered to unweathered walls, strong to very strong, slightly weathered to fresh.

Joint apertures typically < 1 mm, often with chlorite coatings, sometimes with oxide staining on joint surfaces, mostly oriented approximately 30° or 70° to core axis.

From 1.12 m to 11.10 m: Moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation 0-5 mm, strong to very strong, slightly weathered.

At 16.40 m: Potential minor fault, 5 mm aperture, infilled with gouge.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

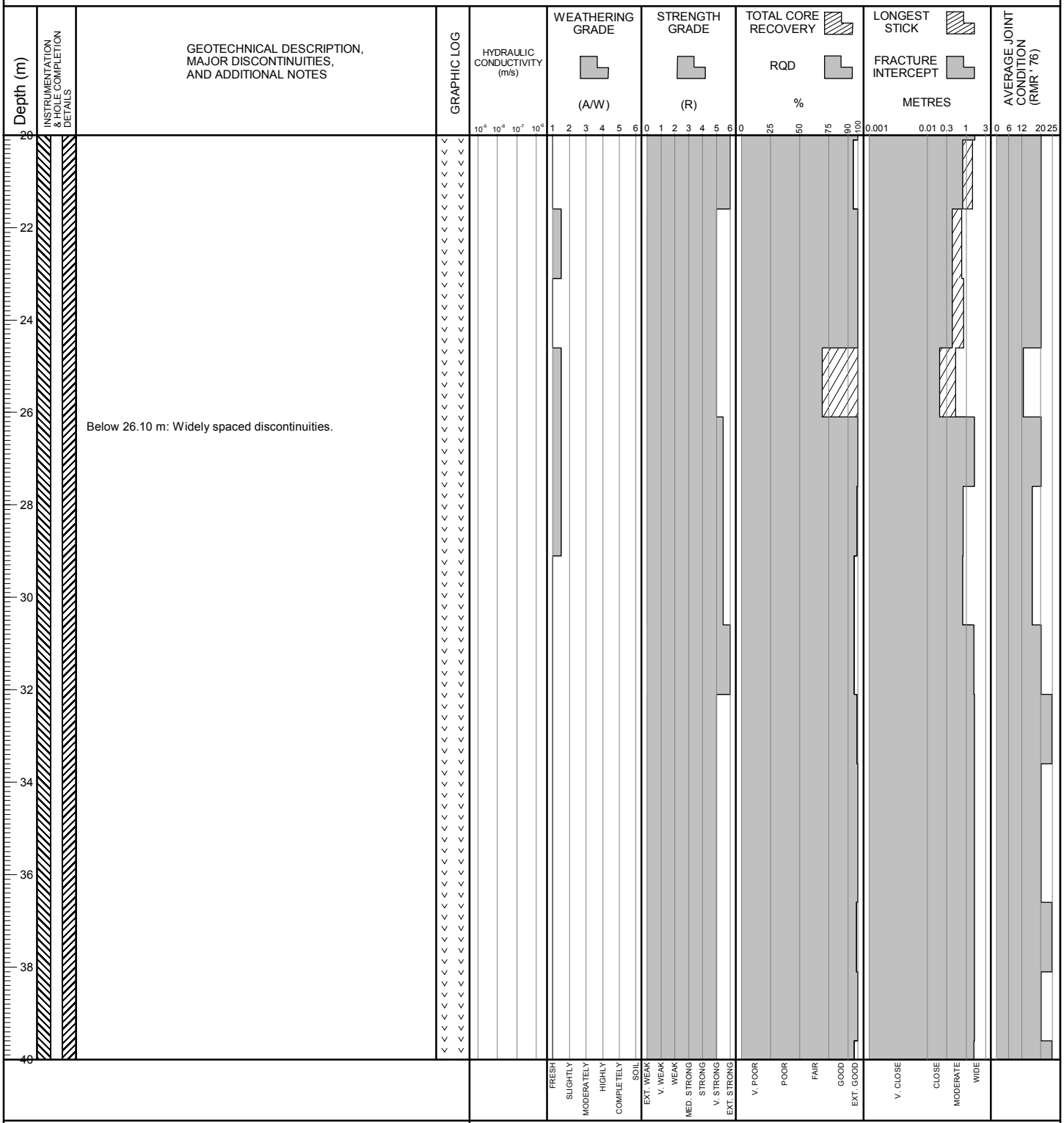
Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

Project No.: 1008-029

Location: Bunkhouse 6

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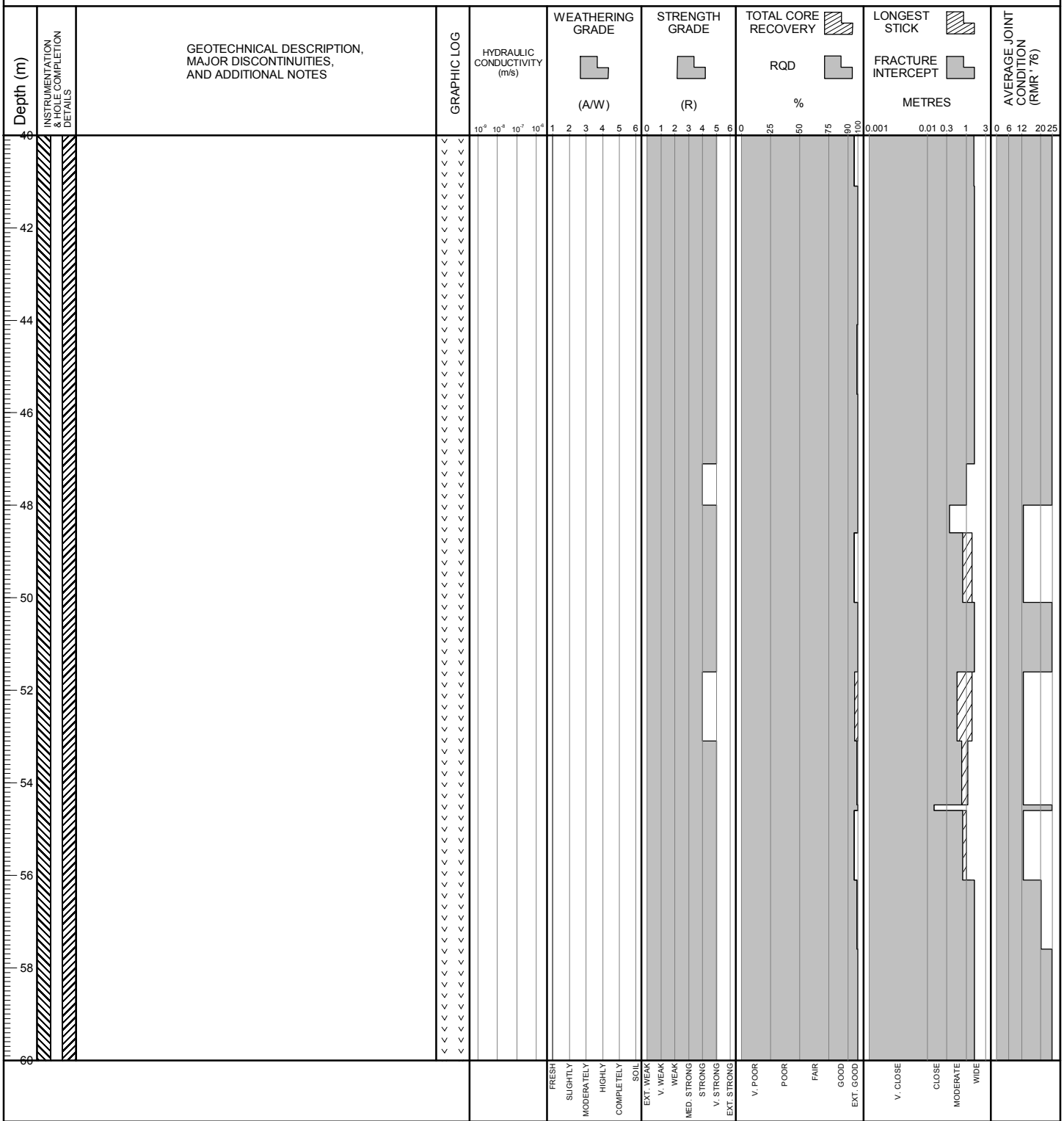
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
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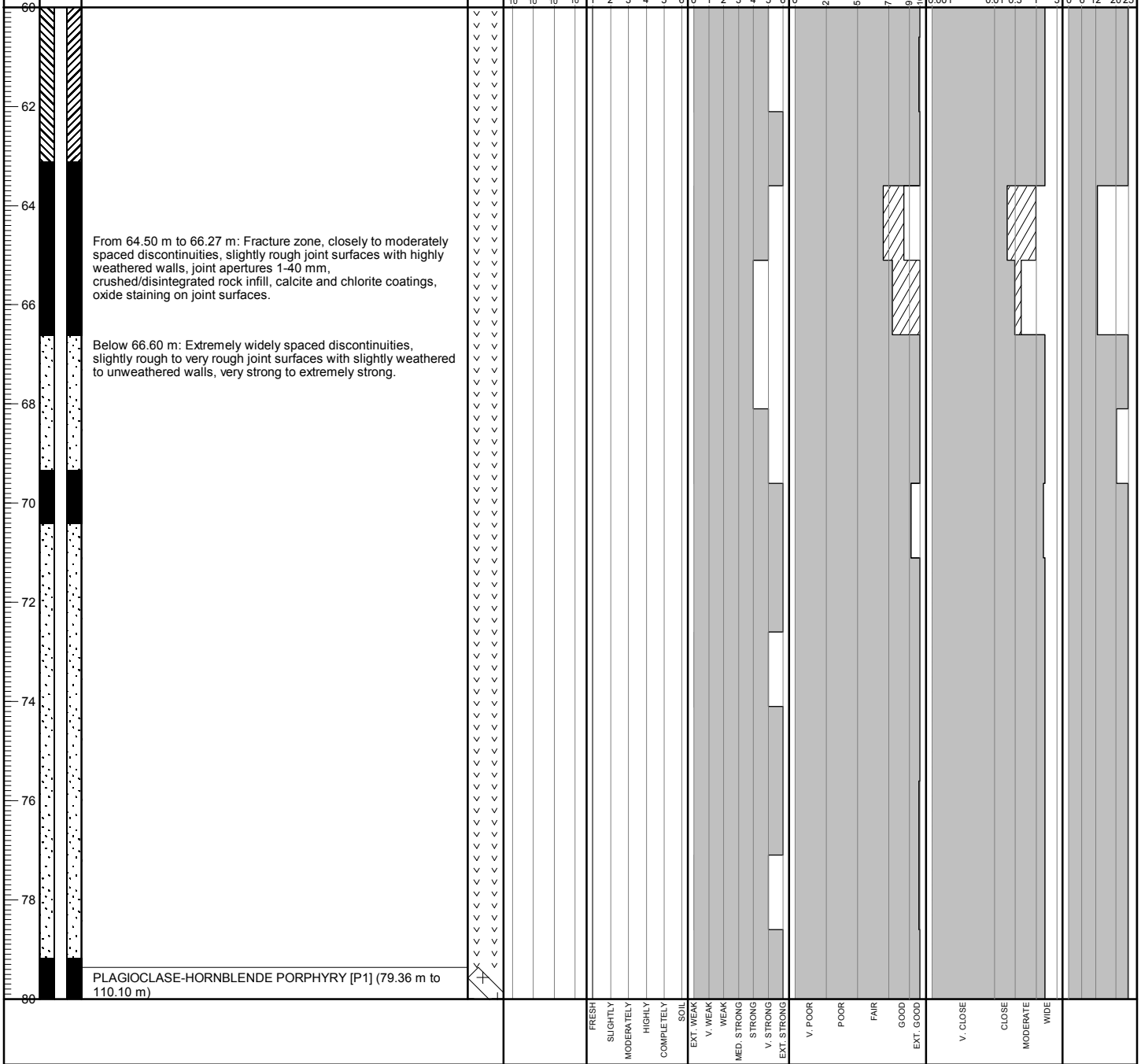
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
Finish Date: 11 JUN 18
Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
Reviewed By: HP

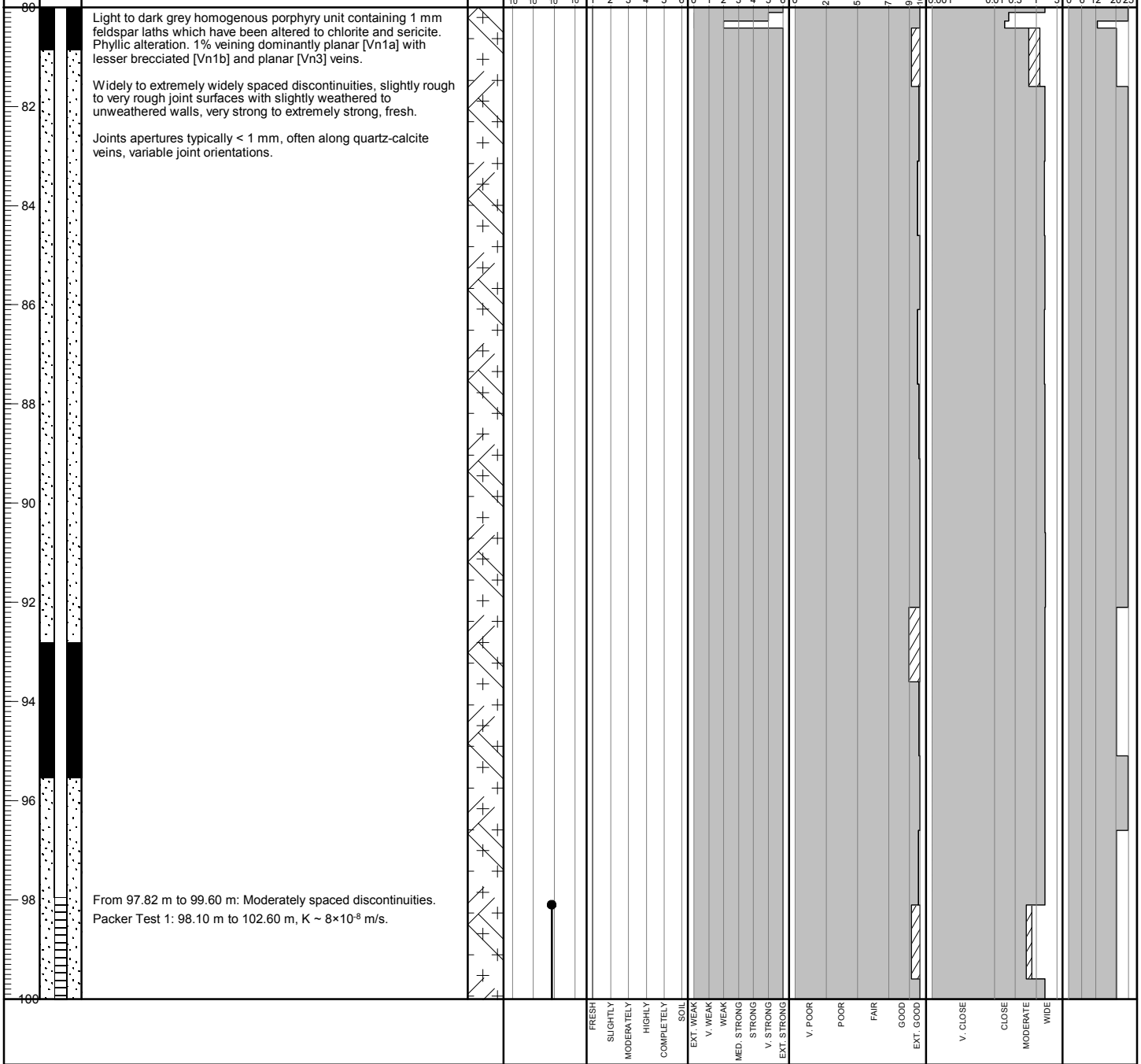
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Light to dark grey homogenous porphyry unit containing 1 mm feldspar laths which have been altered to chlorite and sericite. Phyllic alteration. 1% veining dominantly planar [Vn1a] with lesser brecciated [Vn1b] and planar [Vn3] veins.

Widely to extremely widely spaced discontinuities, slightly rough to very rough joint surfaces with slightly weathered to unweathered walls, very strong to extremely strong, fresh.

Joints apertures typically < 1 mm, often along quartz-calcite veins, variable joint orientations.

From 97.82 m to 99.60 m: Moderately spaced discontinuities.
Packer Test 1: 98.10 m to 102.60 m, K ~ 8×10^{-8} m/s.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18A

Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,946E - 6,258,306N
Ground Elevation (m): 1,445.11
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Datum: UTM NAD 83 Zone 9
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Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
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Fluid: Water
Cased To (m) : 1.28

Start Date: 09 JUN 18
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Final Depth (m): 110.10
Depth To Top Of Rock (m): 1.12
Logged By: DZ/DS
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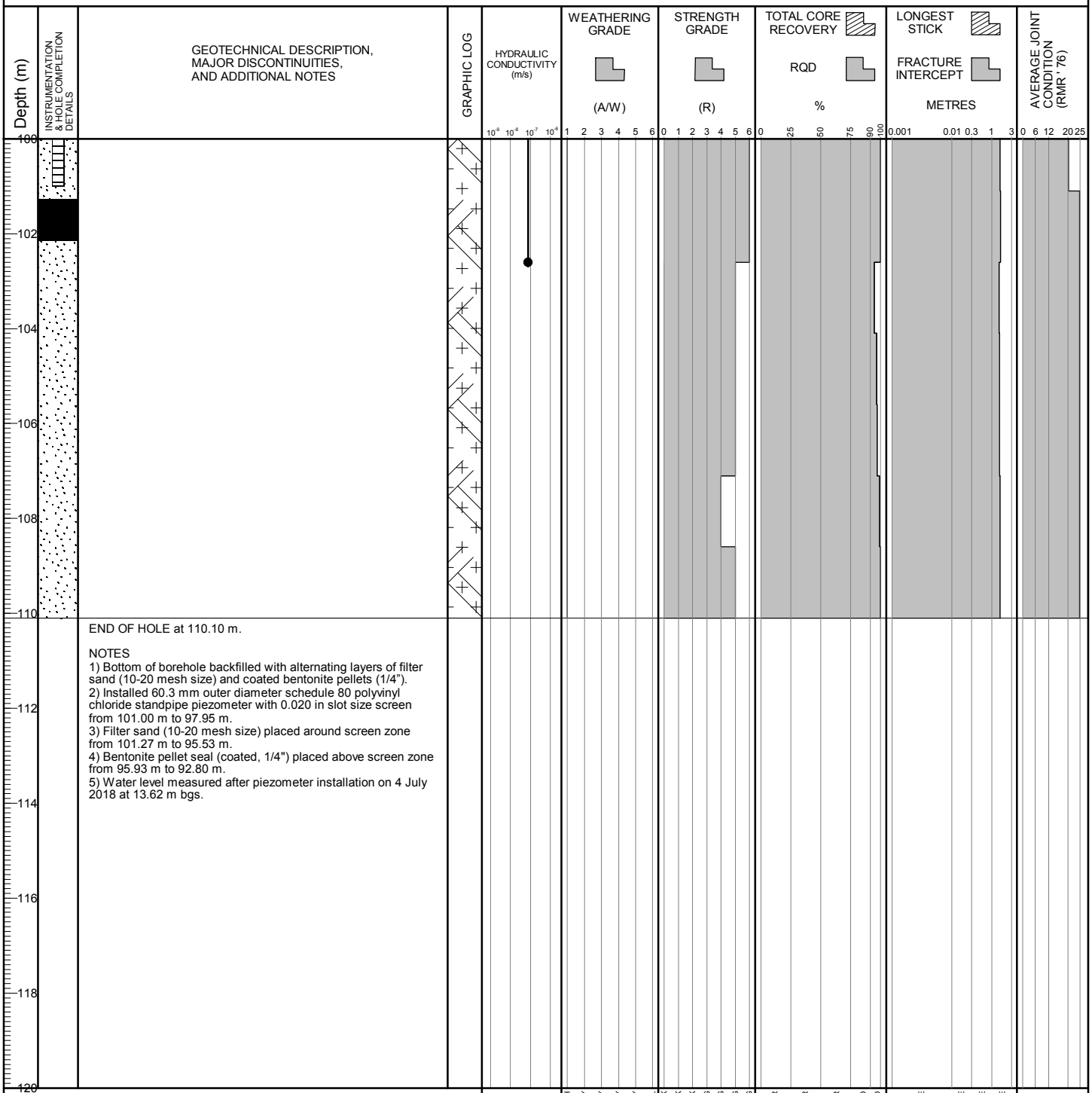

END OF HOLE at 110.10 m.

NOTES
1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4").
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 101.00 m to 97.95 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 101.27 m to 95.53 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 95.93 m to 92.80 m.
5) Water level measured after piezometer installation on 4 July 2018 at 13.62 m bgs.

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

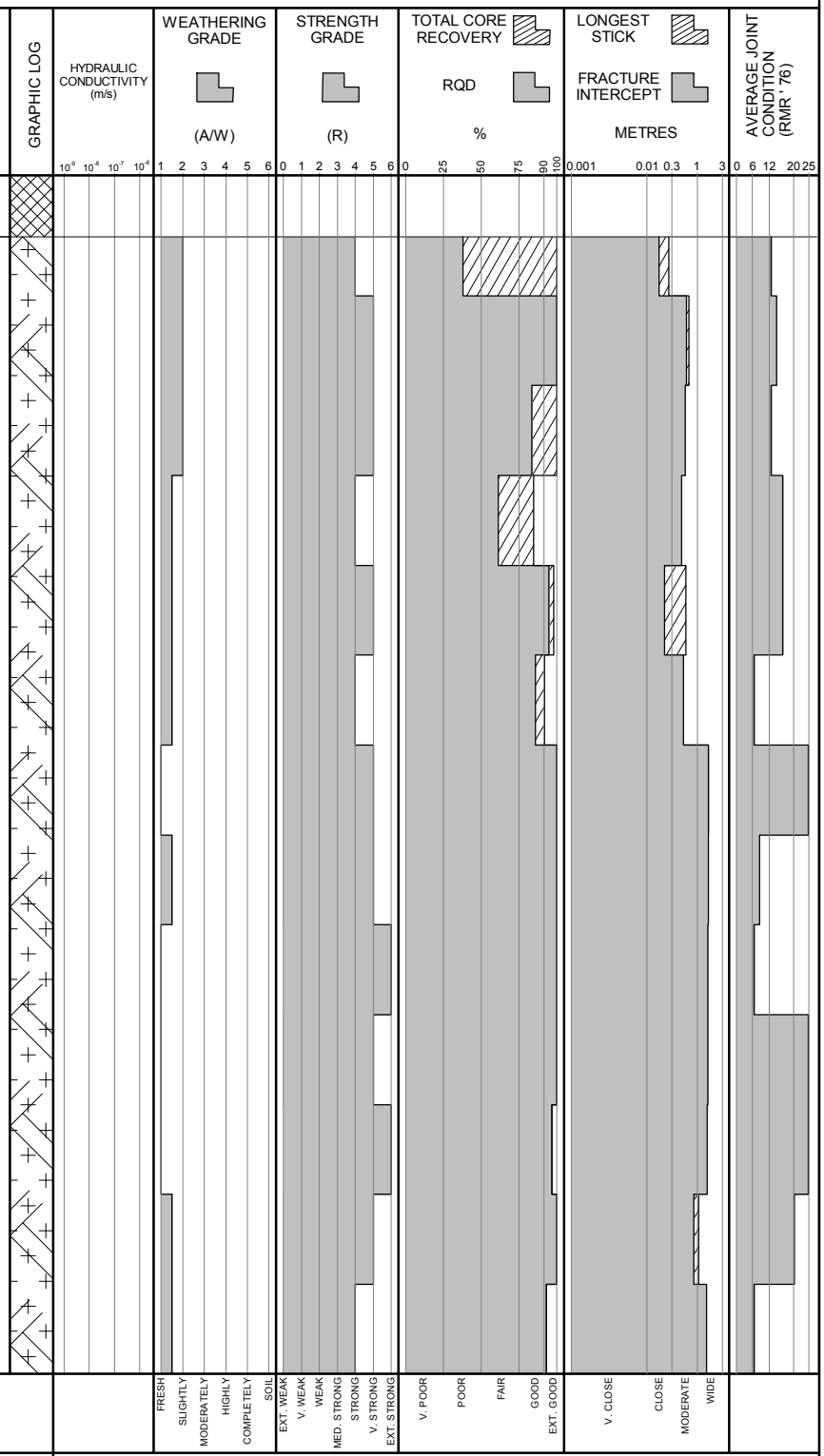
Location: Bunkhouse 6

Co-ordinates (m): 426,947E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.27

Start Date: 06 JUN 18
Finish Date: 09 JUN 18
Final Depth (m): 66.51
Depth To Top Of Rock (m): 1.03
Logged By: DZ/DS
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
0		FILL (0.00 m to 1.03 m)
1.03		PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (1.03 m to 66.51 m) Green porphyritic volcanic/intrusive. Predominantly comprised of subhedral, calcite-altered plagioclase phenocrysts ranging from 5-25%, with minor specks of dark mafic phenocrysts throughout a green, fine-grained matrix. Occasional mafic fragments. Weak to strong pervasive quartz-sericite-pyrite alteration with moderate pervasive chlorite replacement. Interval of minor 2% quartz-calcite veining. Dominantly comprised of cuspate-lobate [Vn1a] and planar to brecciate grey-pink calcite [Vn3] veins. Lesser crosscutting [Vn4b] tension gash style veins and pyrite-rich [Vn0] veins. Moderately to widely spaced discontinuities, variably slightly to very rough joint surfaces with highly weathered to unweathered walls, strong to very strong, slightly weathered to fresh. Joint apertures typically < 1 mm, often with oxide staining on joint surfaces, sometimes with calcite or chlorite coatings, mostly oriented approximately 30° or 70° to core axis. From 1.03 m to 8.22 m: Slightly weathered, moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation 0-5 mm.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

Location: Bunkhouse 6

Co-ordinates (m): 426,947E - 6,258,306N
Ground Elevation (m): 1,445.11
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
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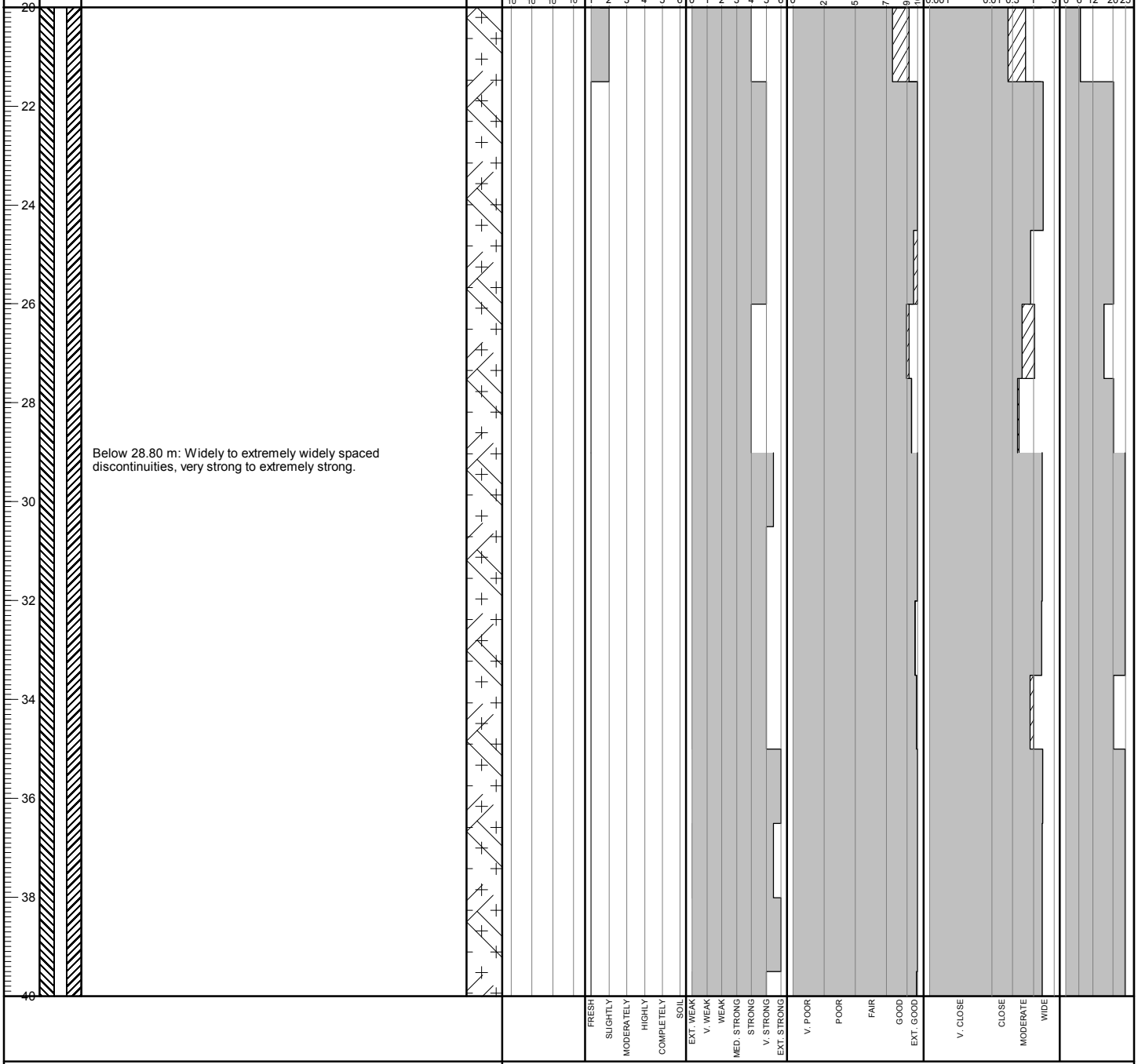
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

Below 28.80 m: Widely to extremely widely spaced discontinuities, very strong to extremely strong.



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Client: Pretium Resources Inc.

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Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-18B

Project No.: 1008-029

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Datum: UTM NAD 83 Zone 9
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Trend (°): 000

Drill Designation: Zinex A5
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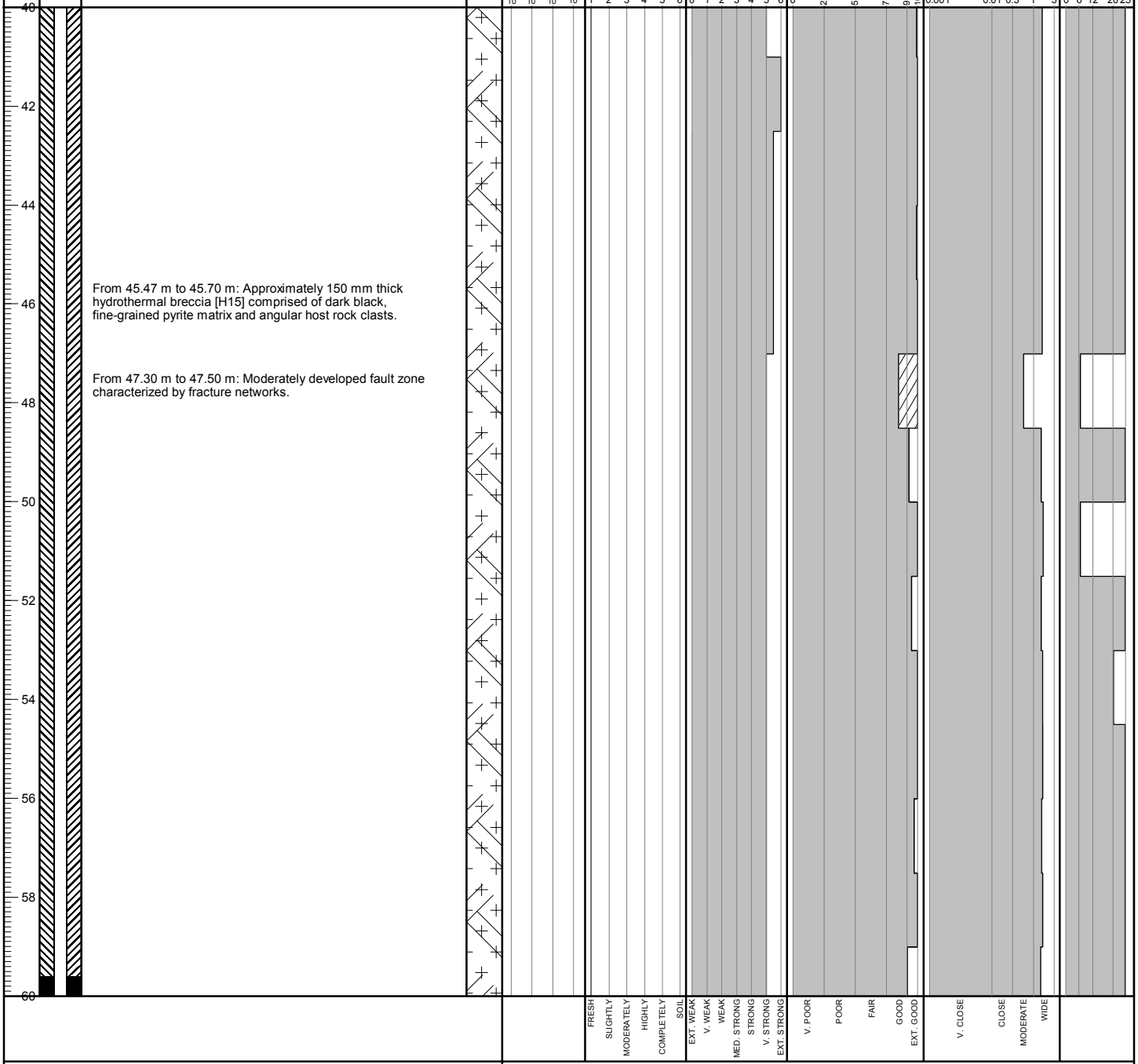
From 45.47 m to 45.70 m: Approximately 150 mm thick hydrothermal breccia [H15] comprised of dark black, fine-grained pyrite matrix and angular host rock clasts.

From 47.30 m to 47.50 m: Moderately developed fault zone characterized by fracture networks.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

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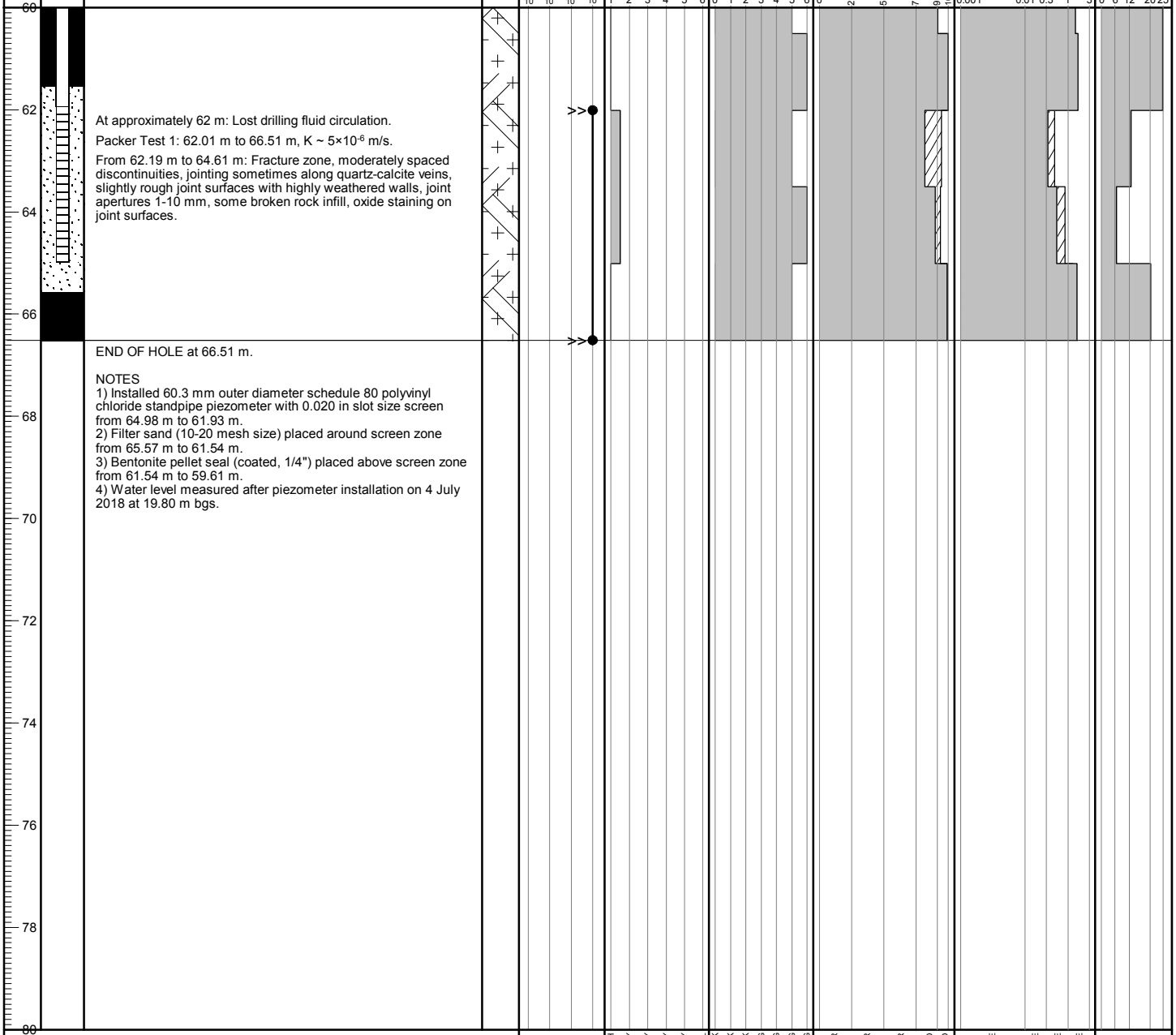

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19A

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (0.00 m to 196.89 m)
Light to dark green porphyritic volcanic/intrusive. Predominantly comprised of subhedral, sericite-altered plagioclase phenocrysts ranging from 5-25%, with minor specks of dark mafic phenocrysts throughout a green, fine-grained matrix. Weak alignment of phenocrysts. Rare mafic fragments. Moderate pervasive chlorite replacement with isolated intervals of strong pervasive quartz-sericite-pyrite alteration. Variable veining structures.

Variable rock mass and discontinuity properties detailed in specific intervals.

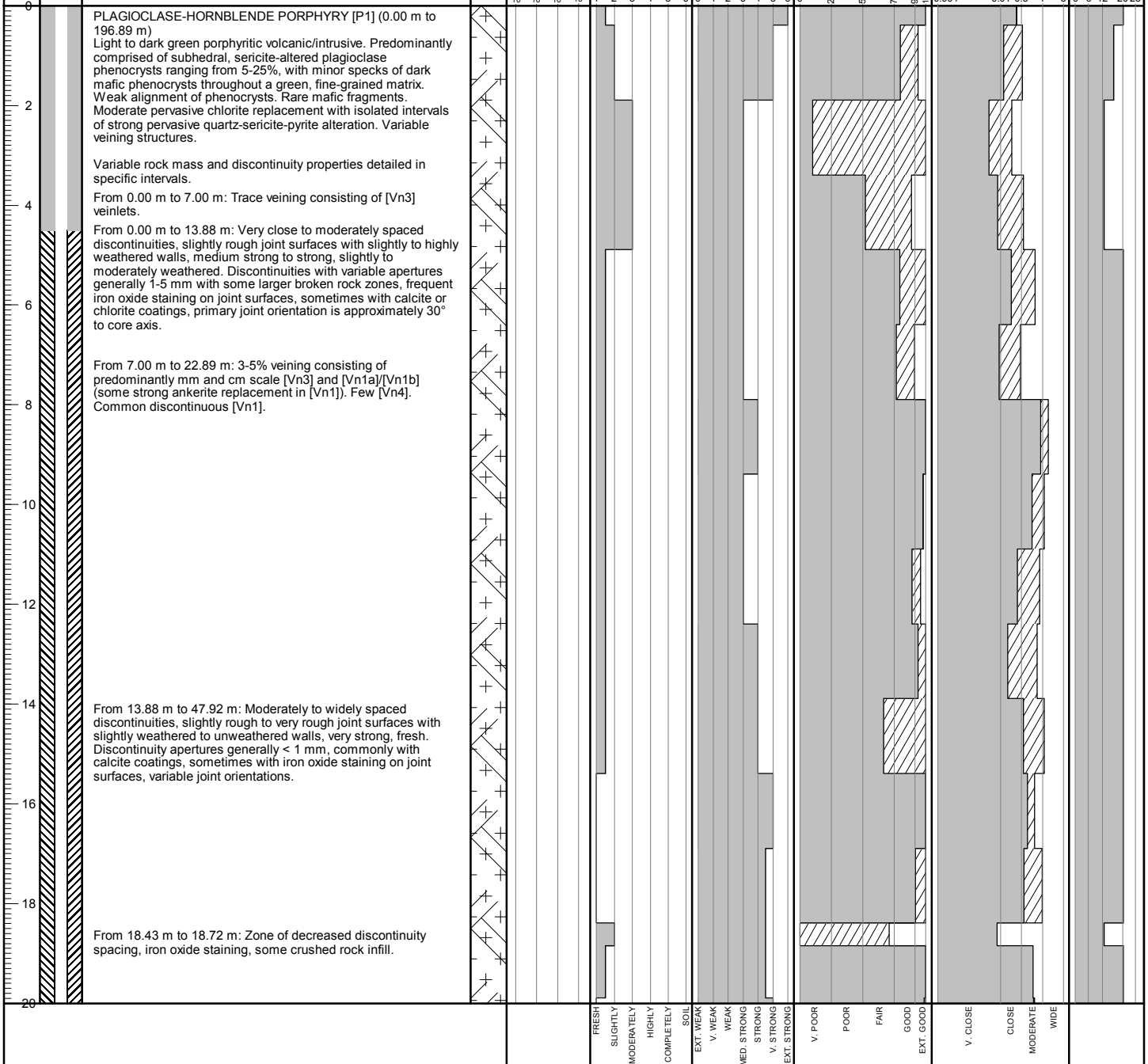
From 0.00 m to 7.00 m: Trace veining consisting of [Vn3] veinlets.

From 0.00 m to 13.88 m: Very close to moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, medium strong to strong, slightly to moderately weathered. Discontinuities with variable apertures generally 1-5 mm with some larger broken rock zones, frequent iron oxide staining on joint surfaces, sometimes with calcite or chlorite coatings, primary joint orientation is approximately 30° to core axis.

From 7.00 m to 22.89 m: 3-5% veining consisting of predominantly mm and cm scale [Vn3] and [Vn1a]/[Vn1b] (some strong ankerite replacement in [Vn1]). Few [Vn4]. Common discontinuous [Vn1].

From 13.88 m to 47.92 m: Moderately to widely spaced discontinuities, slightly rough to very rough joint surfaces with slightly weathered to unweathered walls, very strong, fresh. Discontinuity apertures generally < 1 mm, commonly with calcite coatings, sometimes with iron oxide staining on joint surfaces, variable joint orientations.

From 18.43 m to 18.72 m: Zone of decreased discontinuity spacing, iron oxide staining, some crushed rock infill.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

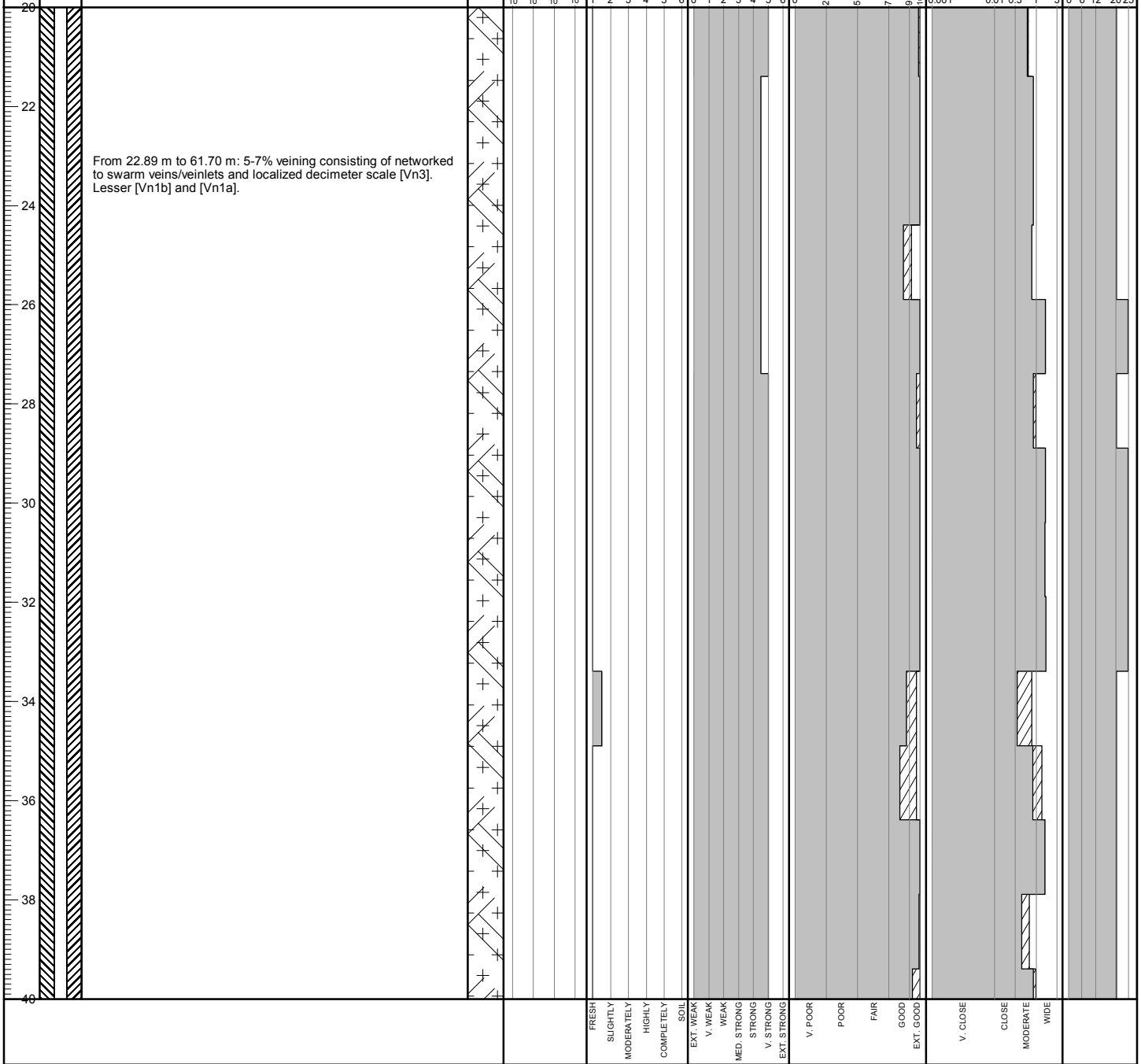
Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
20–40		From 22.89 m to 61.70 m: 5-7% veining consisting of networked to swarm veins/veinlets and localized decimeter scale [Vn3]. Lesser [Vn1b] and [Vn1a].



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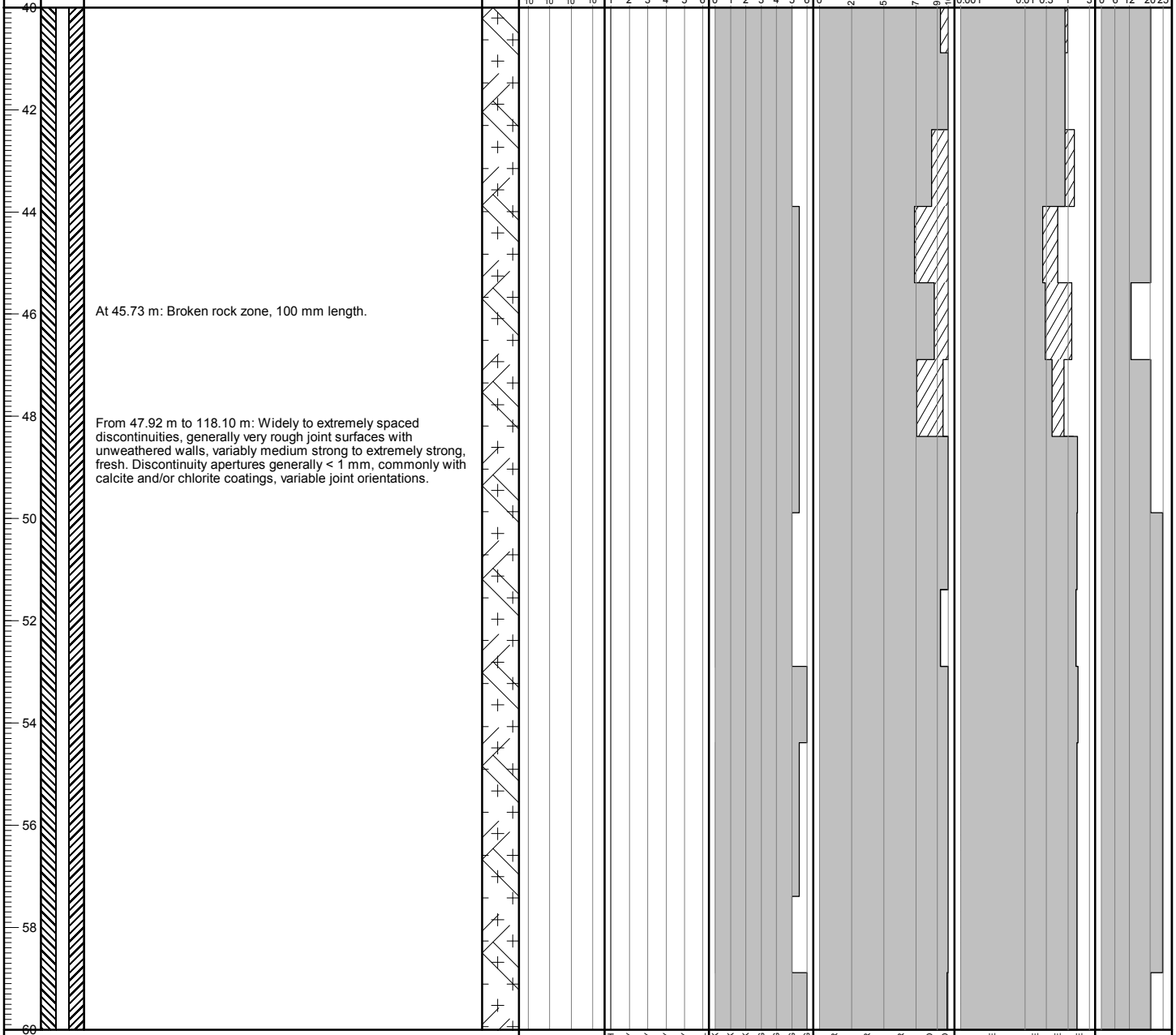
At 45.73 m: Broken rock zone, 100 mm length.

From 47.92 m to 118.10 m: Widely to extremely spaced discontinuities, generally very rough joint surfaces with unweathered walls, variably medium strong to extremely strong, fresh. Discontinuity apertures generally < 1 mm, commonly with calcite and/or chlorite coatings, variable joint orientations.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

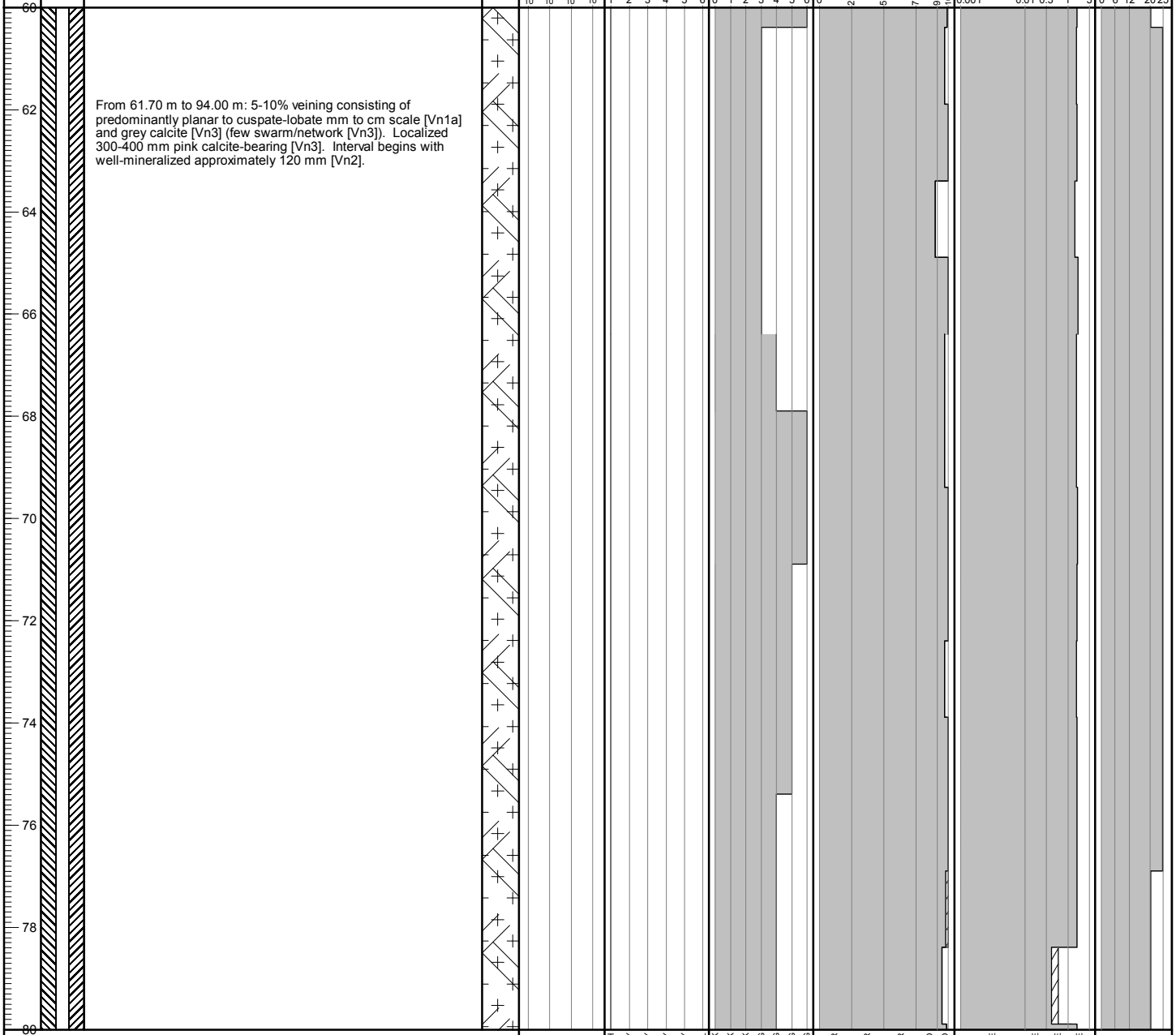
Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

From 61.70 m to 94.00 m: 5-10% veining consisting of predominantly planar to cuspate-lobate mm to cm scale [Vn1a] and grey calcite [Vn3] (few swarm/network [Vn3]). Localized 300-400 mm pink calcite-bearing [Vn3]. Interval begins with well-mineralized approximately 120 mm [Vn2].



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
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Datum: UTM NAD 83 Zone 9
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Drill Designation: Tech 5000
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Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
80–100		From 94.00 m to 104.52 m: 7-10% veining consisting of predominantly swarm/networked cm and mm scale [Vn3] (veins and veinlets). Few sheeted, brecciated, and boudinaged [Vn1a]/[Vn1b].		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25

Depth scale: 80, 82, 84, 86, 88, 90, 92, 94, 96, 98, 100

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD

FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
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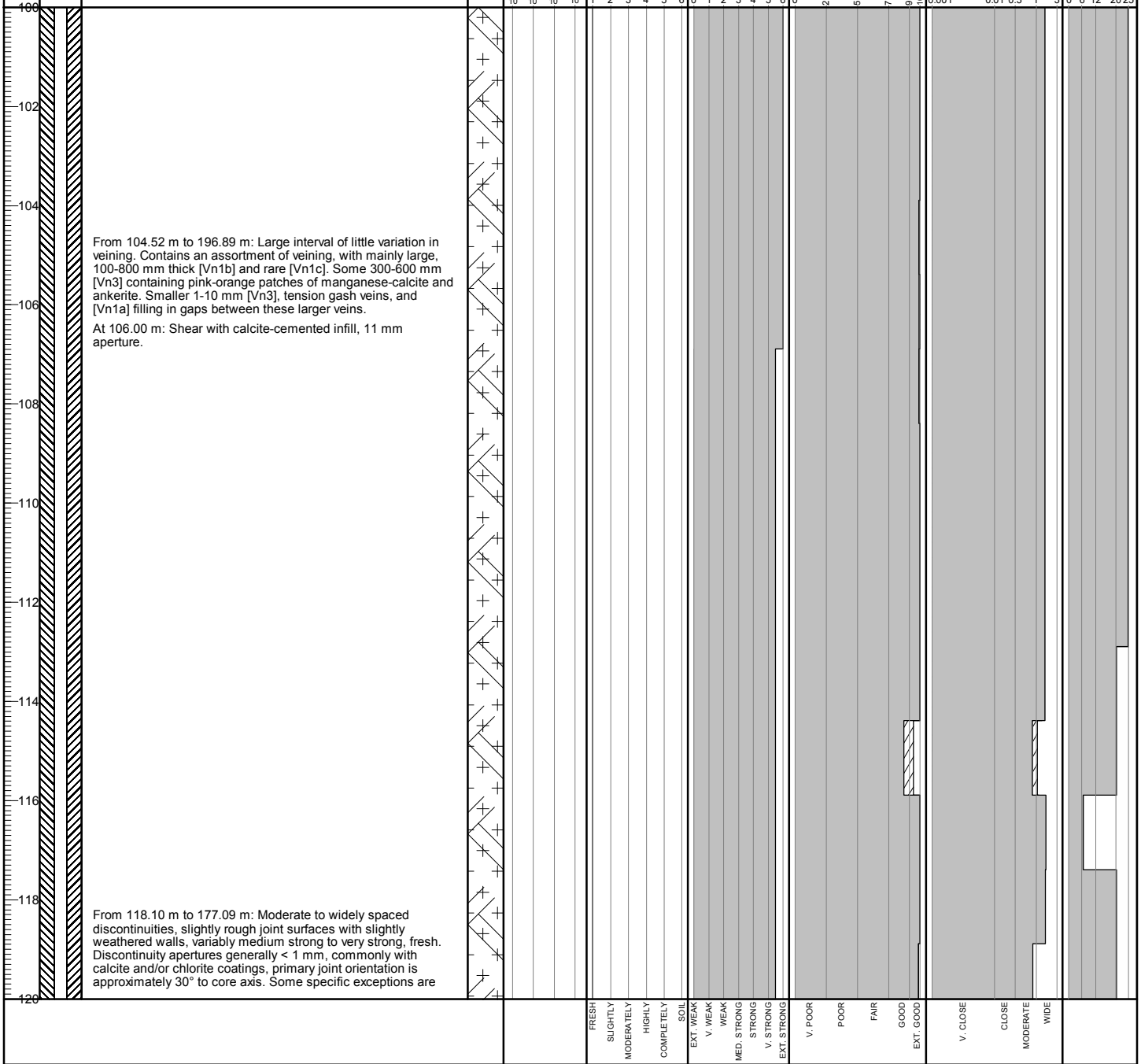

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

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Trend (°): 000

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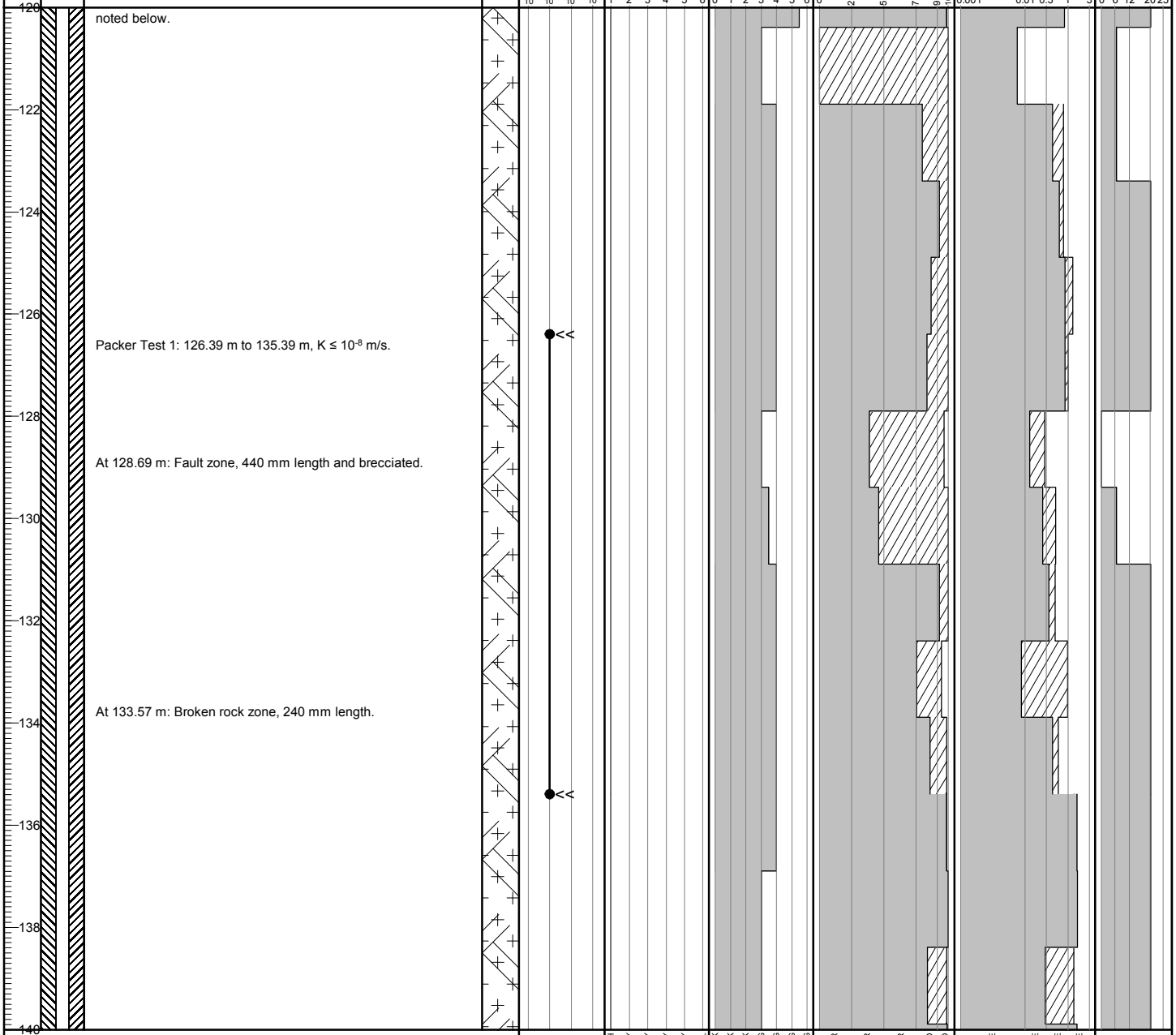
noted below.

Packer Test 1: 126.39 m to 135.39 m, K ≤ 10^{-8} m/s.

At 128.69 m: Fault zone, 440 mm length and brecciated.

At 133.57 m: Broken rock zone, 240 mm length.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

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Ground Elevation (m): 1,495.68
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Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
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Final Depth (m): 196.89
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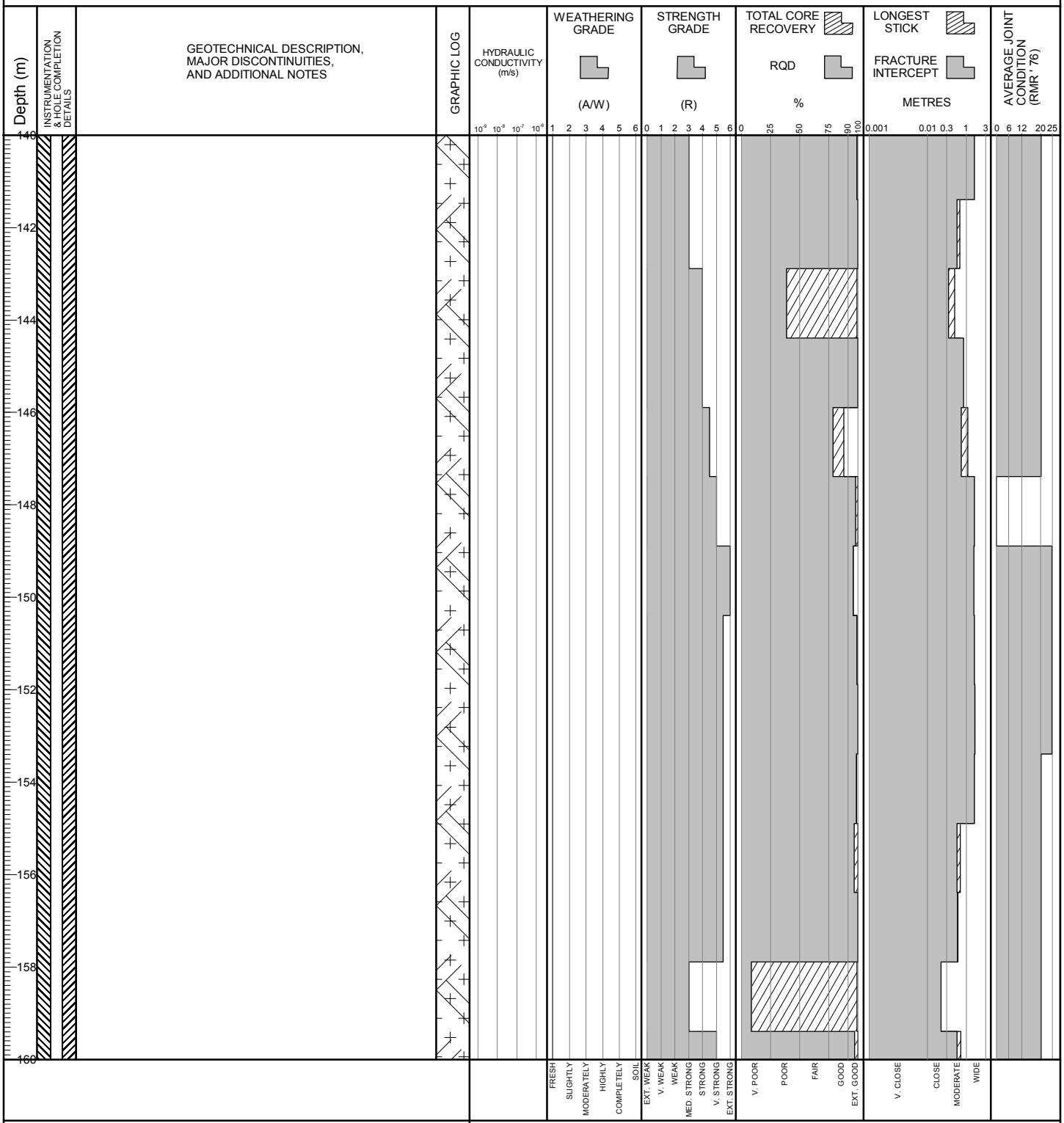

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
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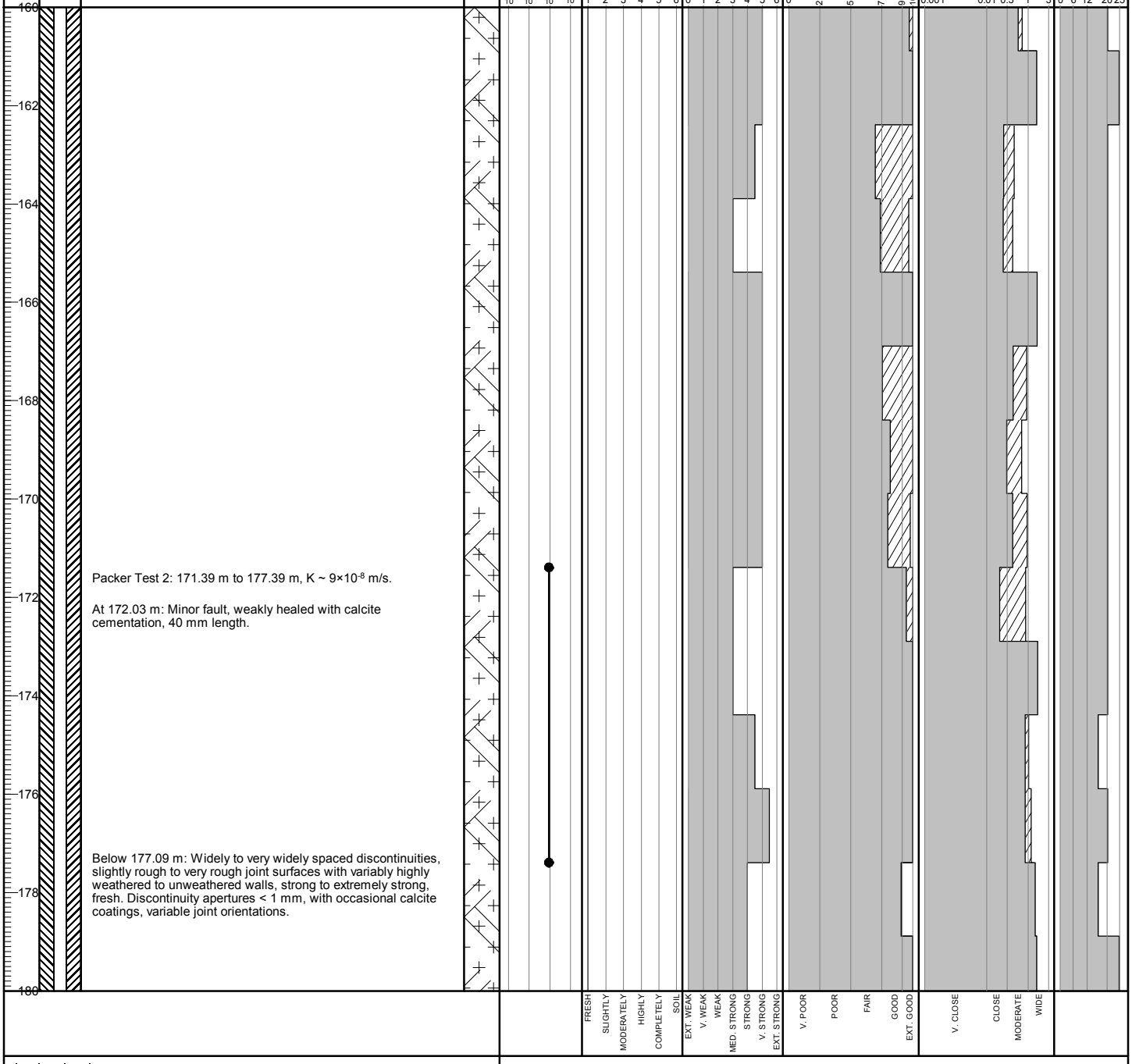
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 2: 171.39 m to 177.39 m, K ~ 9×10^{-8} m/s.

At 172.03 m: Minor fault, weakly healed with calcite cementation, 40 mm length.

Below 177.09 m: Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with variably highly weathered to unweathered walls, strong to extremely strong, fresh. Discontinuity apertures < 1 mm, with occasional calcite coatings, variable joint orientations.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-19A

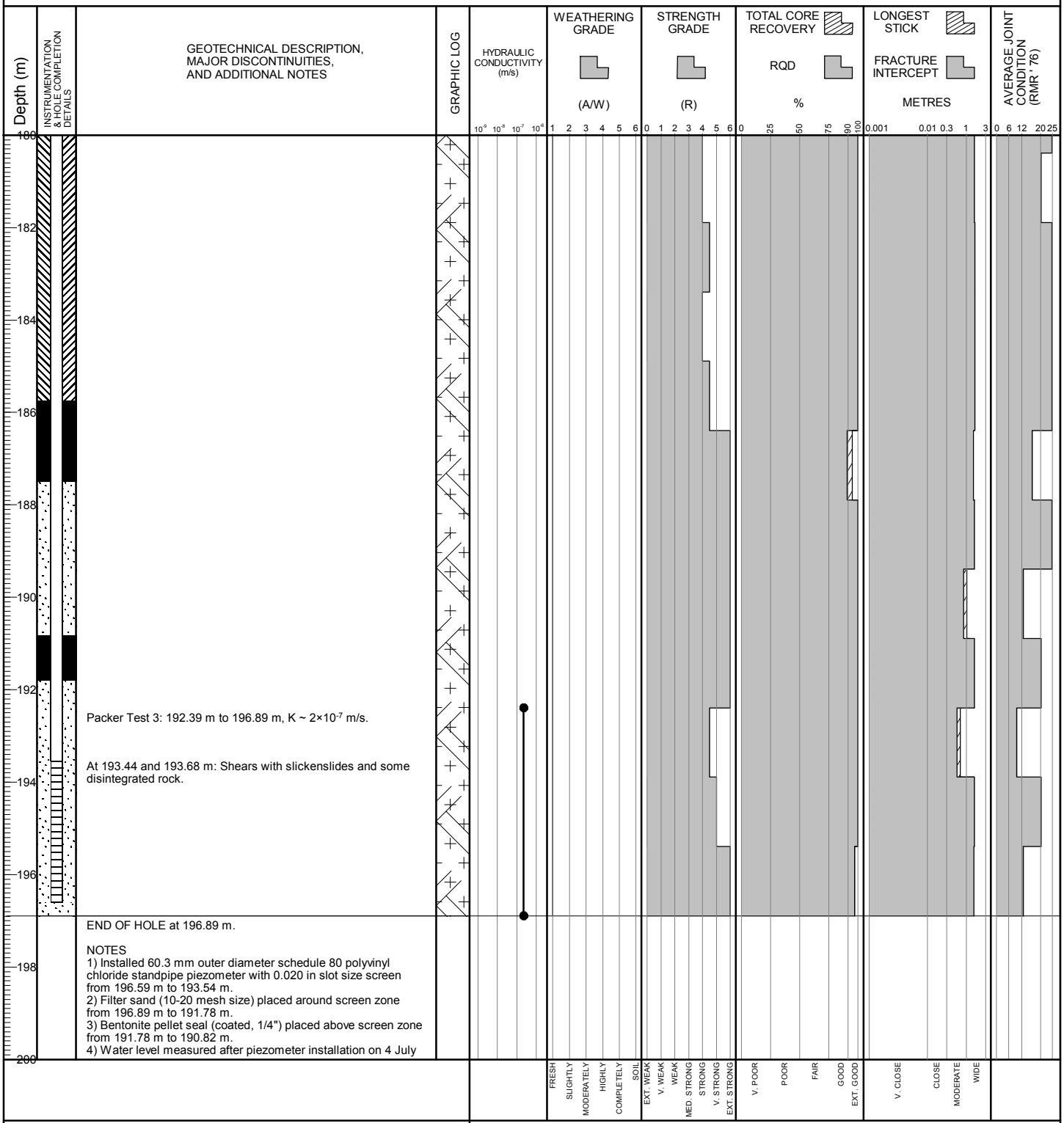
Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19A

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,347E - 6,258,259N
Ground Elevation (m): 1,495.68
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.50

Start Date: 08 JUN 18
Finish Date: 13 JUN 18
Final Depth (m): 196.89
Depth To Top Of Rock (m): 0.00
Logged By: BDT/BM/HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
200		2018 at 124.46 m bgs.							
202									
204									
206									
208									
210									
212									
214									
216									
218									
220									

Scales: HYDRAULIC CONDUCTIVITY 10^{-9} 10^{-8} 10^{-7} 10^{-6}; WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19B

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (0.00 m to 159.54 m)
Grey-green porphyritic unit with 2 mm feldspar laths. Both phenocrysts and groundmass have been altered to sericite. Chlorite and sericite alteration. Variable veining structures.

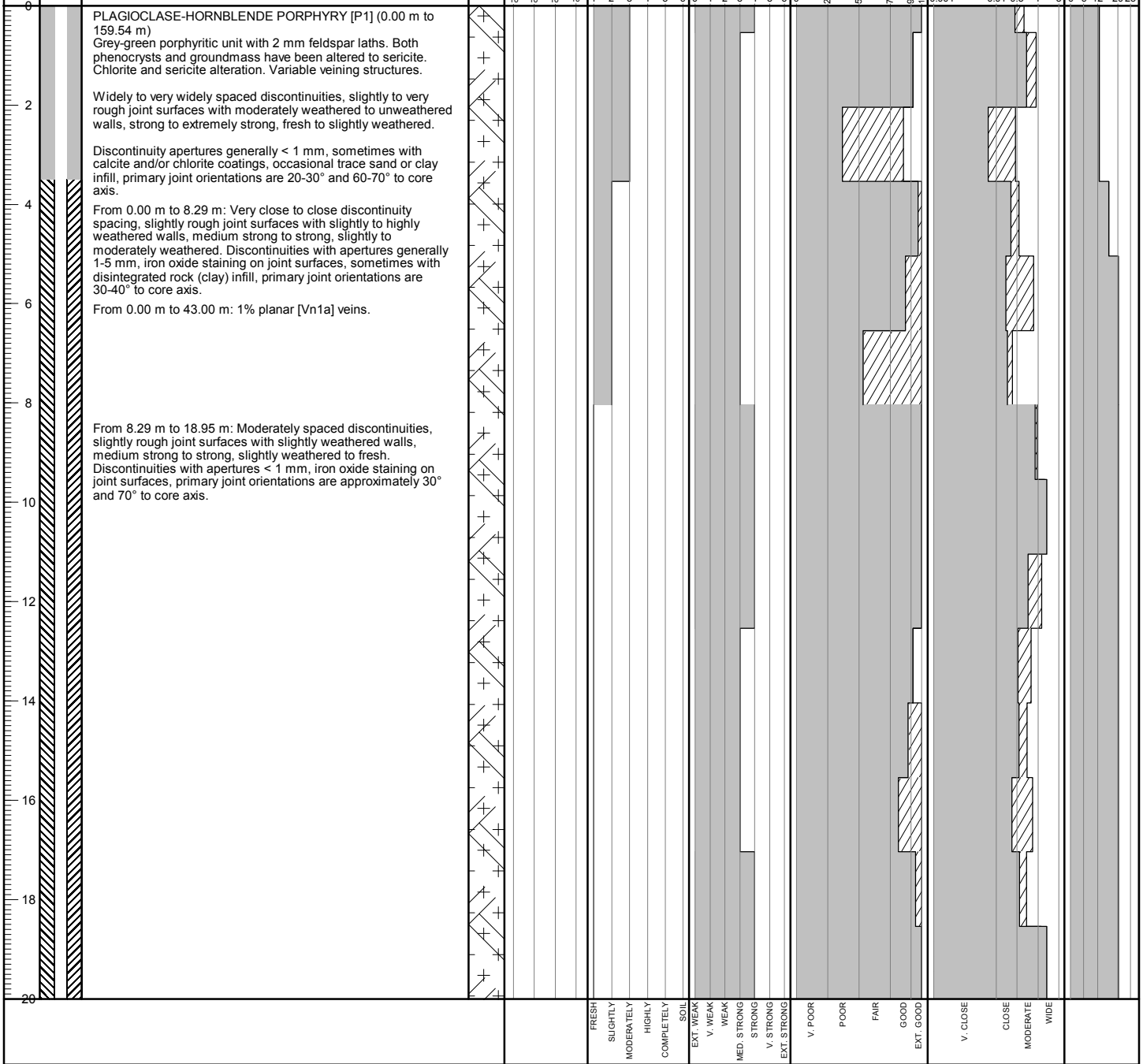
Widely to very widely spaced discontinuities, slightly to very rough joint surfaces with moderately weathered to unweathered walls, strong to extremely strong, fresh to slightly weathered.

Discontinuity apertures generally < 1 mm, sometimes with calcite and/or chlorite coatings, occasional trace sand or clay infill, primary joint orientations are 20-30° and 60-70° to core axis.

From 0.00 m to 8.29 m: Very close to close discontinuity spacing, slightly rough joint surfaces with slightly to highly weathered walls, medium strong to strong, slightly to moderately weathered. Discontinuities with apertures generally 1-5 mm, iron oxide staining on joint surfaces, sometimes with disintegrated rock (clay) infill, primary joint orientations are 30-40° to core axis.

From 0.00 m to 43.00 m: 1% planar [Vn1a] veins.

From 8.29 m to 18.95 m: Moderately spaced discontinuities, slightly rough joint surfaces with slightly weathered walls, medium strong to strong, slightly weathered to fresh. Discontinuities with apertures < 1 mm, iron oxide staining on joint surfaces, primary joint orientations are approximately 30° and 70° to core axis.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19B

Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
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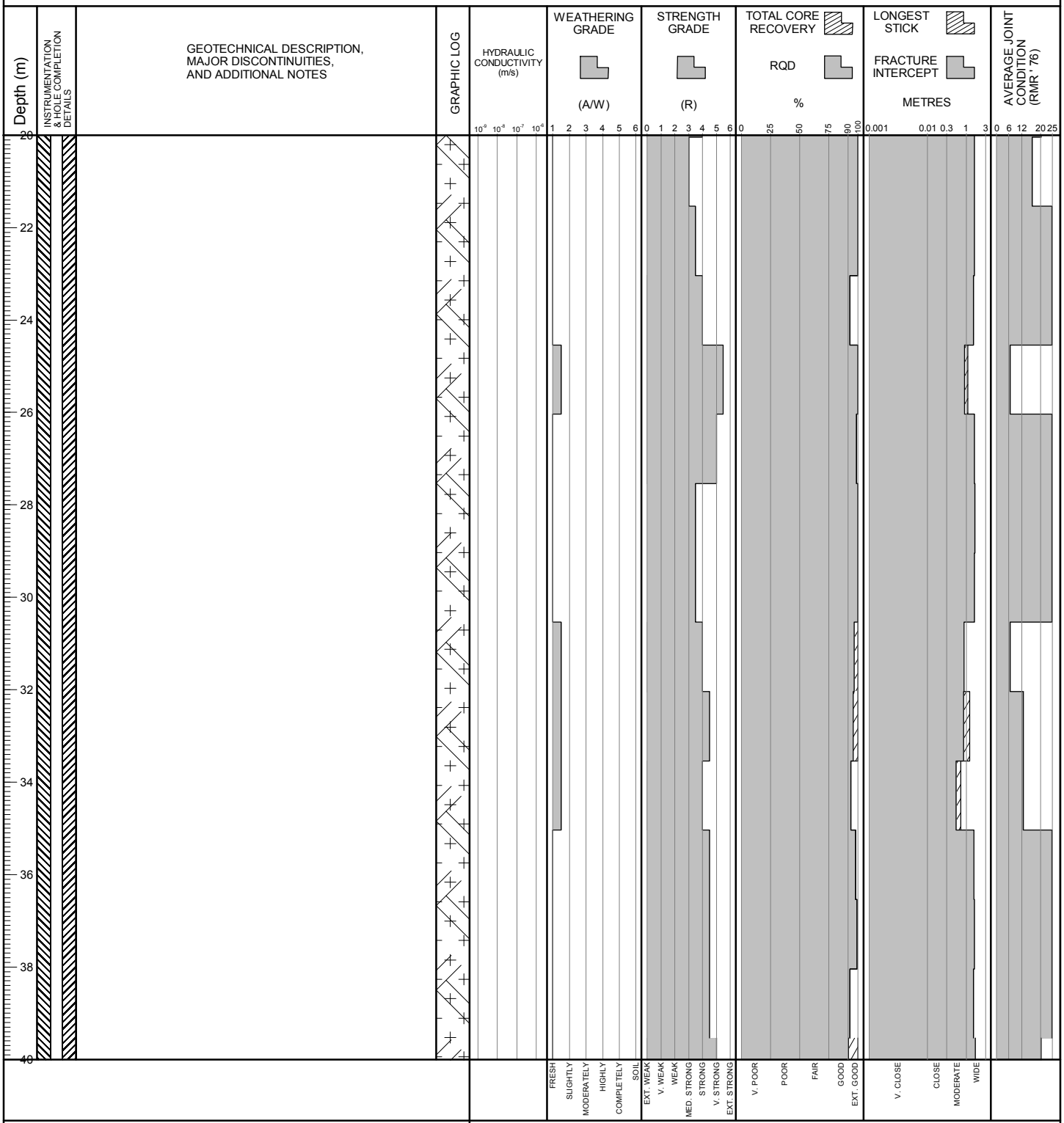

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-19B

Project No.: 1008-029

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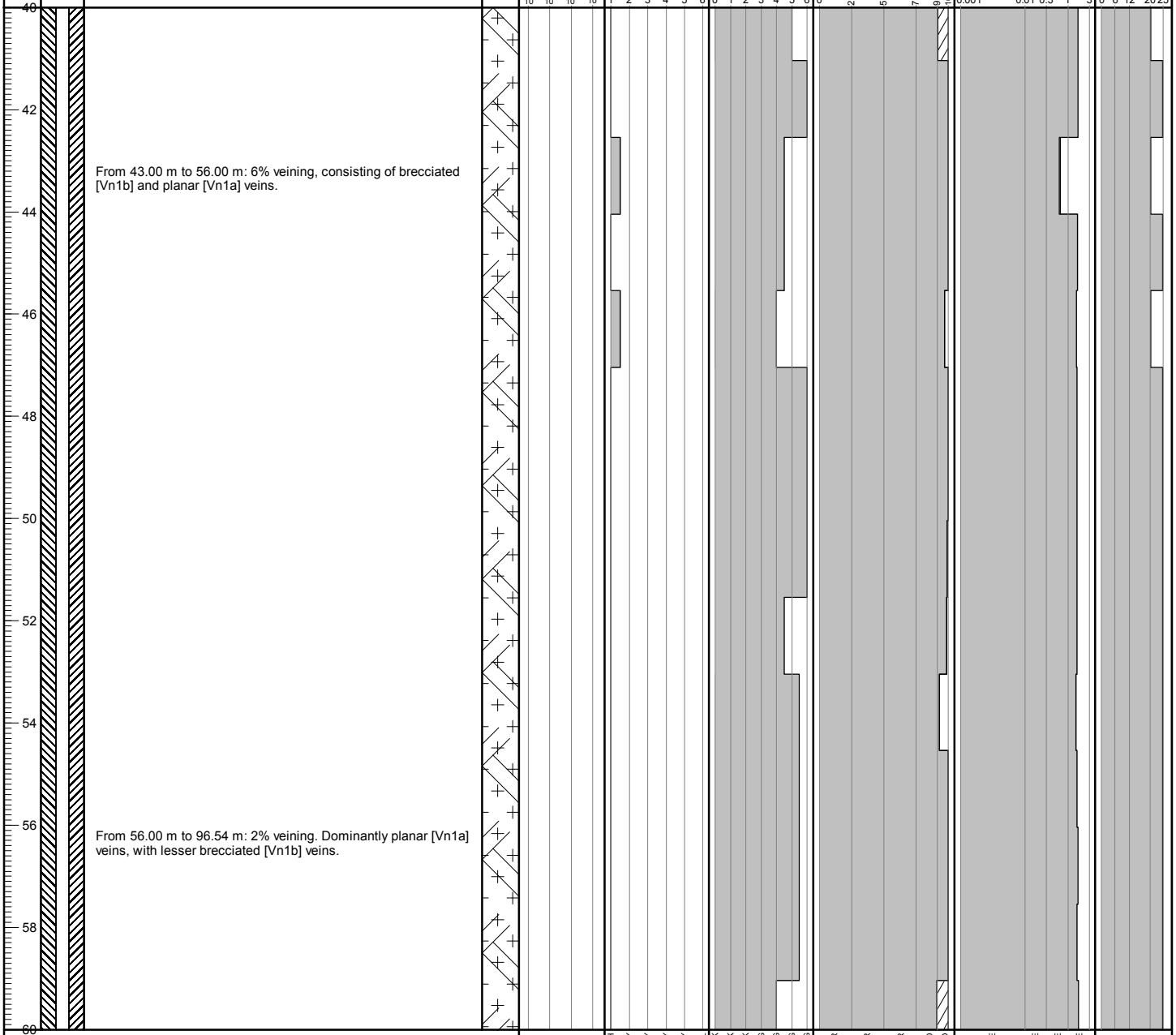
From 43.00 m to 56.00 m: 6% veining, consisting of brecciated [Vn1b] and planar [Vn1a] veins.

From 56.00 m to 96.54 m: 2% veining. Dominantly planar [Vn1a] veins, with lesser brecciated [Vn1b] veins.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

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Drill Method: Diamond Coring
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Fluid: Water
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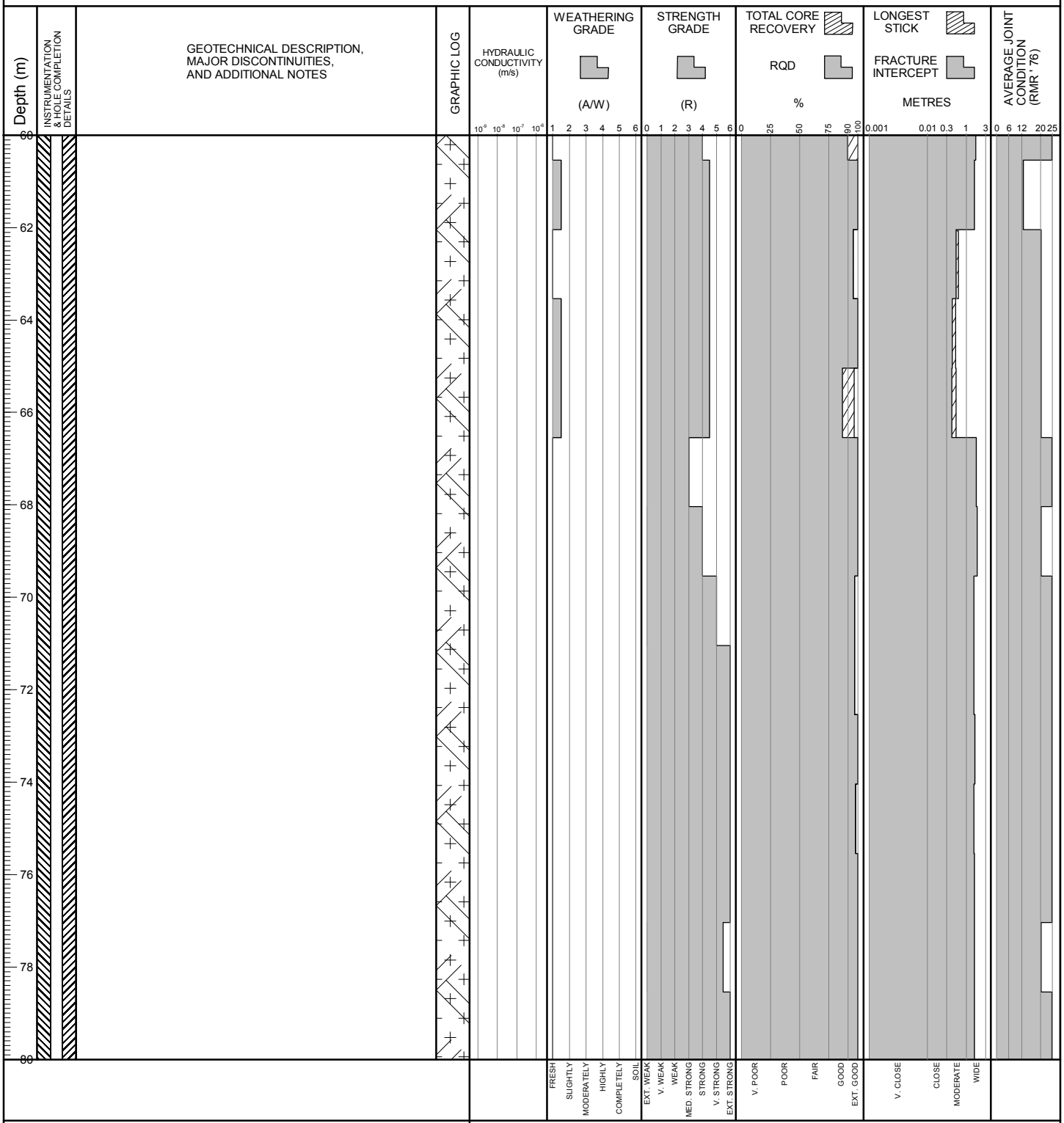

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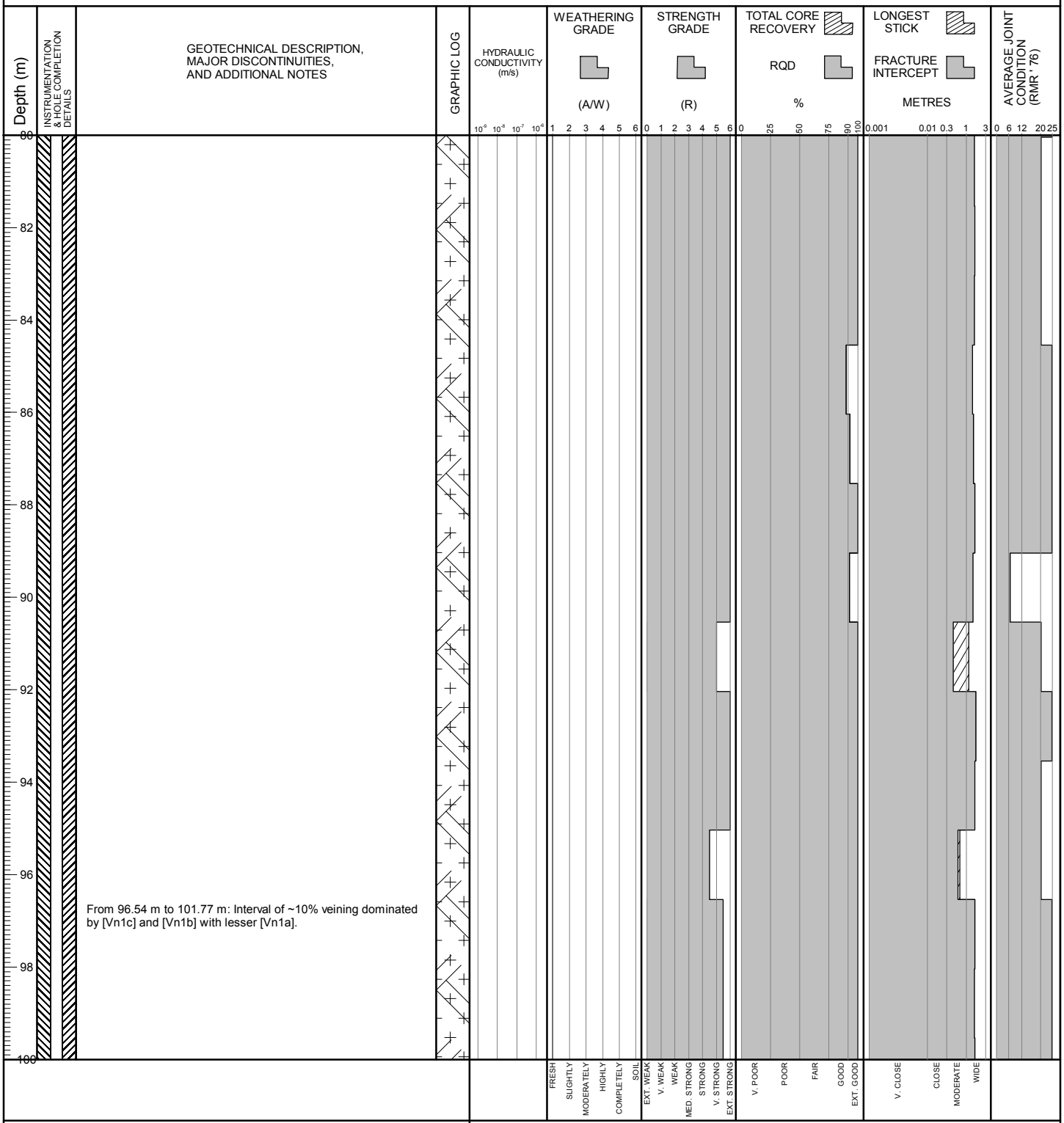

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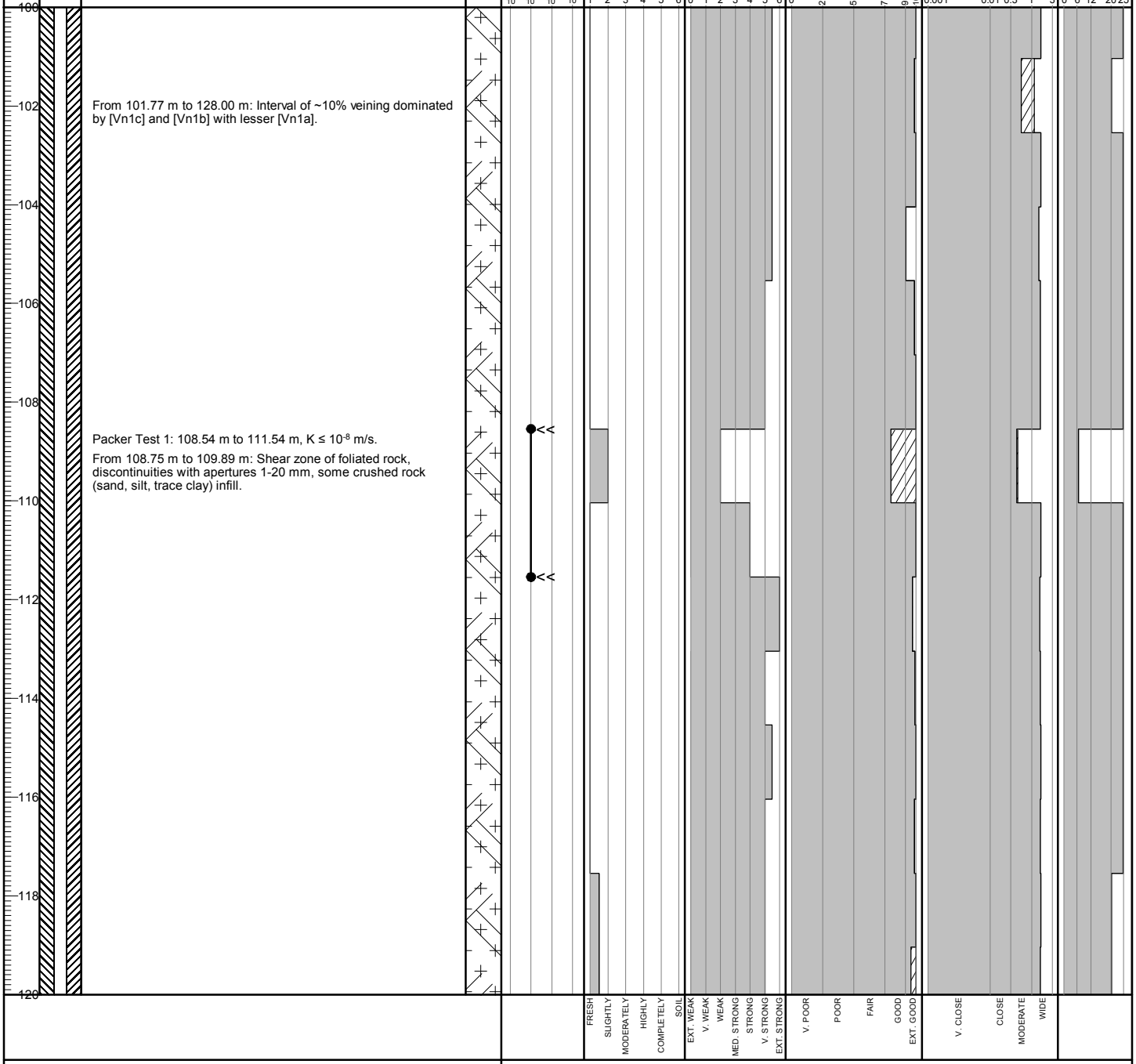
From 101.77 m to 128.00 m: Interval of ~10% veining dominated by [Vn1c] and [Vn1b] with lesser [Vn1a].

Packer Test 1: 108.54 m to 111.54 m, K ≤ 10^{-8} m/s.

From 108.75 m to 109.89 m: Shear zone of foliated rock, discontinuities with apertures 1-20 mm, some crushed rock (sand, silt, trace clay) infill.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

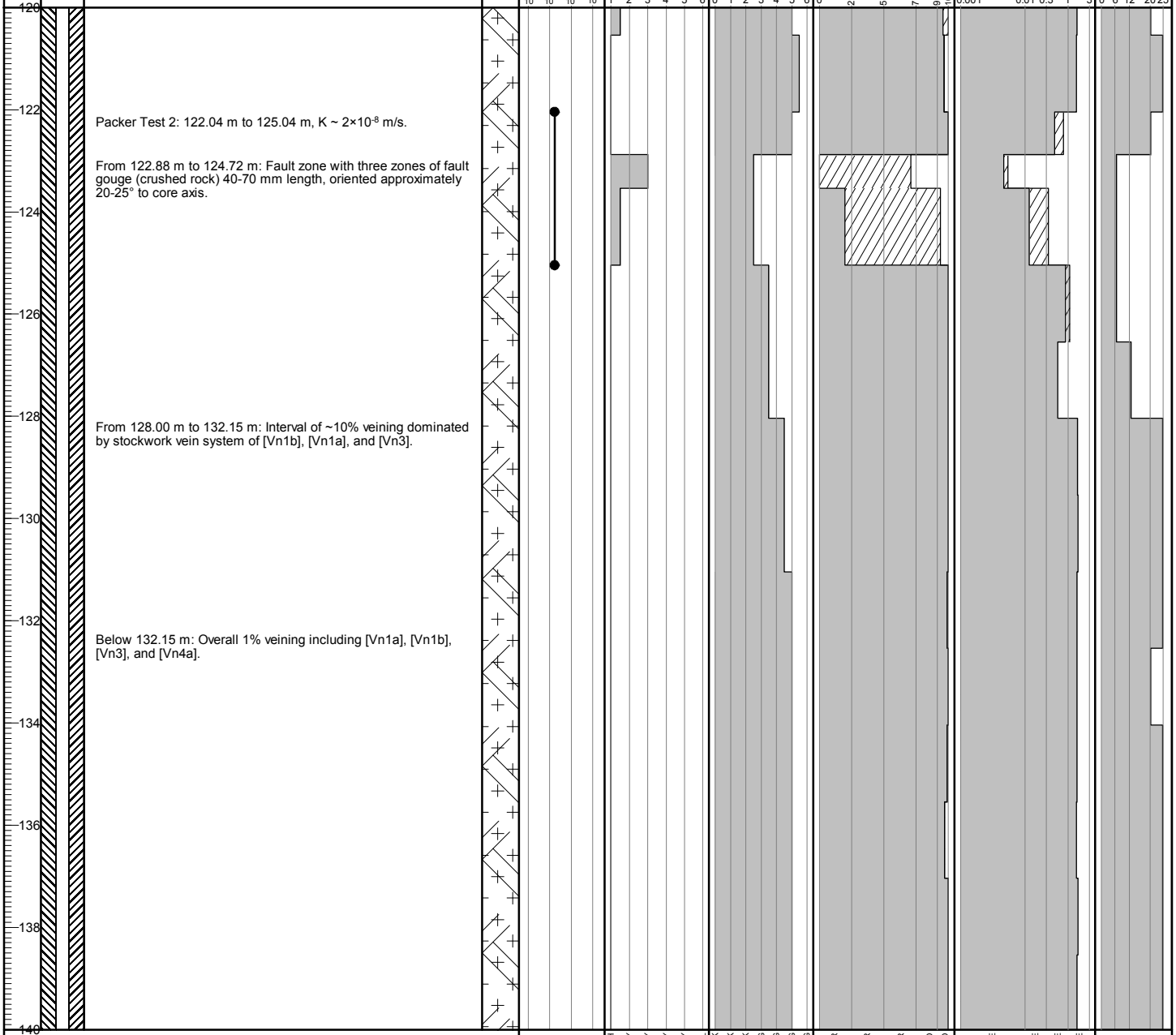
Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
122	Packer Test 2: 122.04 m to 125.04 m, K ~ 2×10^{-8} m/s.
124	From 122.88 m to 124.72 m: Fault zone with three zones of fault gouge (crushed rock) 40-70 mm length, oriented approximately 20-25° to core axis.
128	From 128.00 m to 132.15 m: Interval of ~10% veining dominated by stockwork vein system of [Vn1b], [Vn1a], and [Vn3].
132	Below 132.15 m: Overall 1% veining including [Vn1a], [Vn1b], [Vn3], and [Vn4a].



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-19B

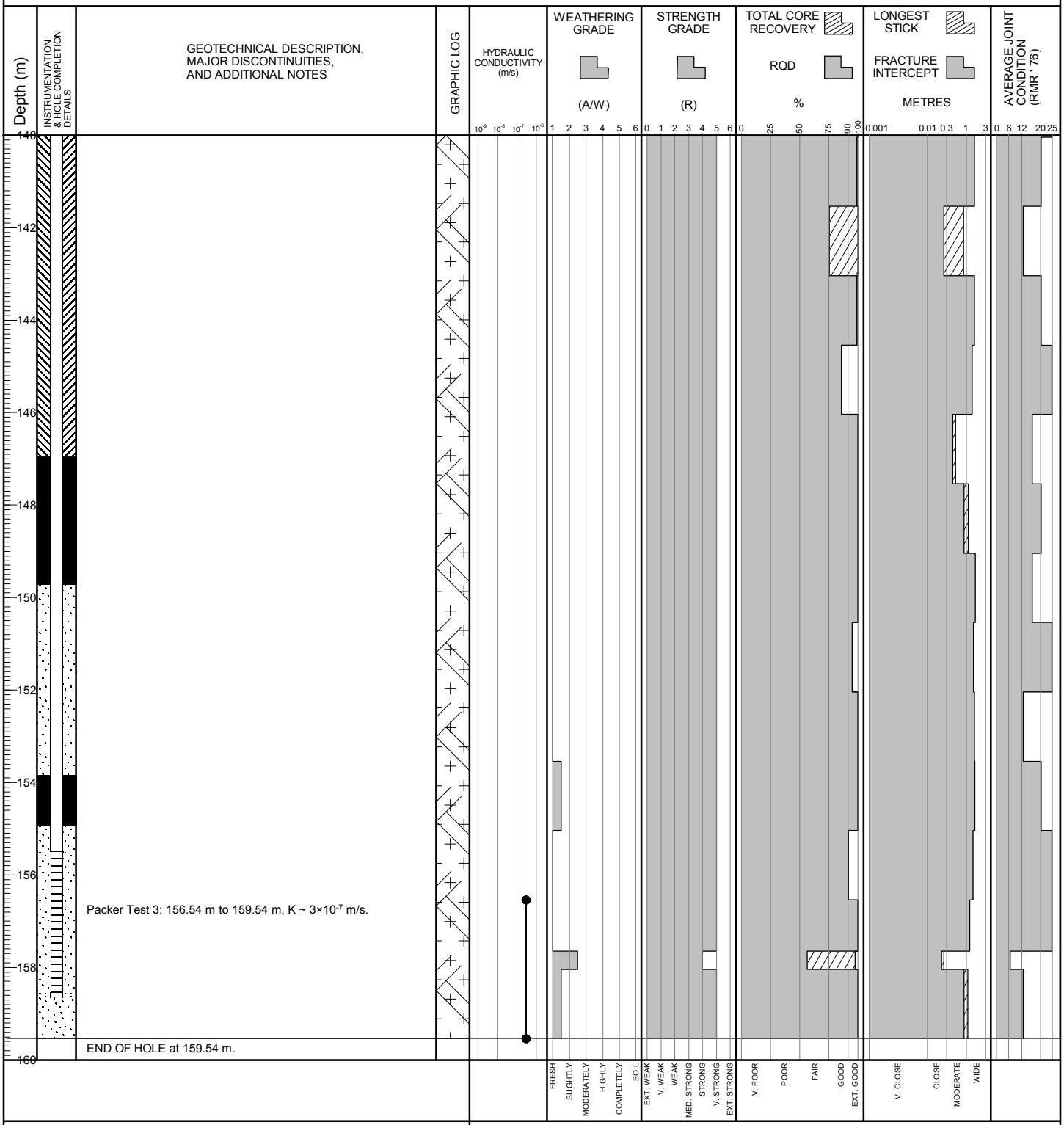
Project No.: 1008-029

Location: North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** North Valley of Kings

Co-ordinates (m): 426,346E - 6,258,259N
Ground Elevation (m): 1,495.49
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.16

Start Date: 14 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 159.54
Depth To Top Of Rock (m): 0.00
Logged By: HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
160		NOTES 1) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 158.54 m to 155.49 m. 2) Filter sand (10-20 mesh size) placed around screen zone from 159.54 m to 154.92 m. 3) Bentonite pellet seal (coated, 1/4") placed above screen zone from 154.92 m to 153.84 m. 4) Water level measured after piezometer installation on 4 July 2018 at 105.10 m bgs.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
162									
164									
166									
168									
170									
172									
174									
176									
178									
180					FRESH SLIGHTLY MODERATELY HIGHLY COMPLETELY SOIL	EXT. WEAK V. WEAK WEAK MED. STRONG STRONG V. STRONG EXT. STRONG	V. POOR POOR FAIR GOOD EXT. GOOD	V. CLOSE CLOSE MODERATE WIDE	

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

OVERBURDEN (0.00 m to 1.16 m)

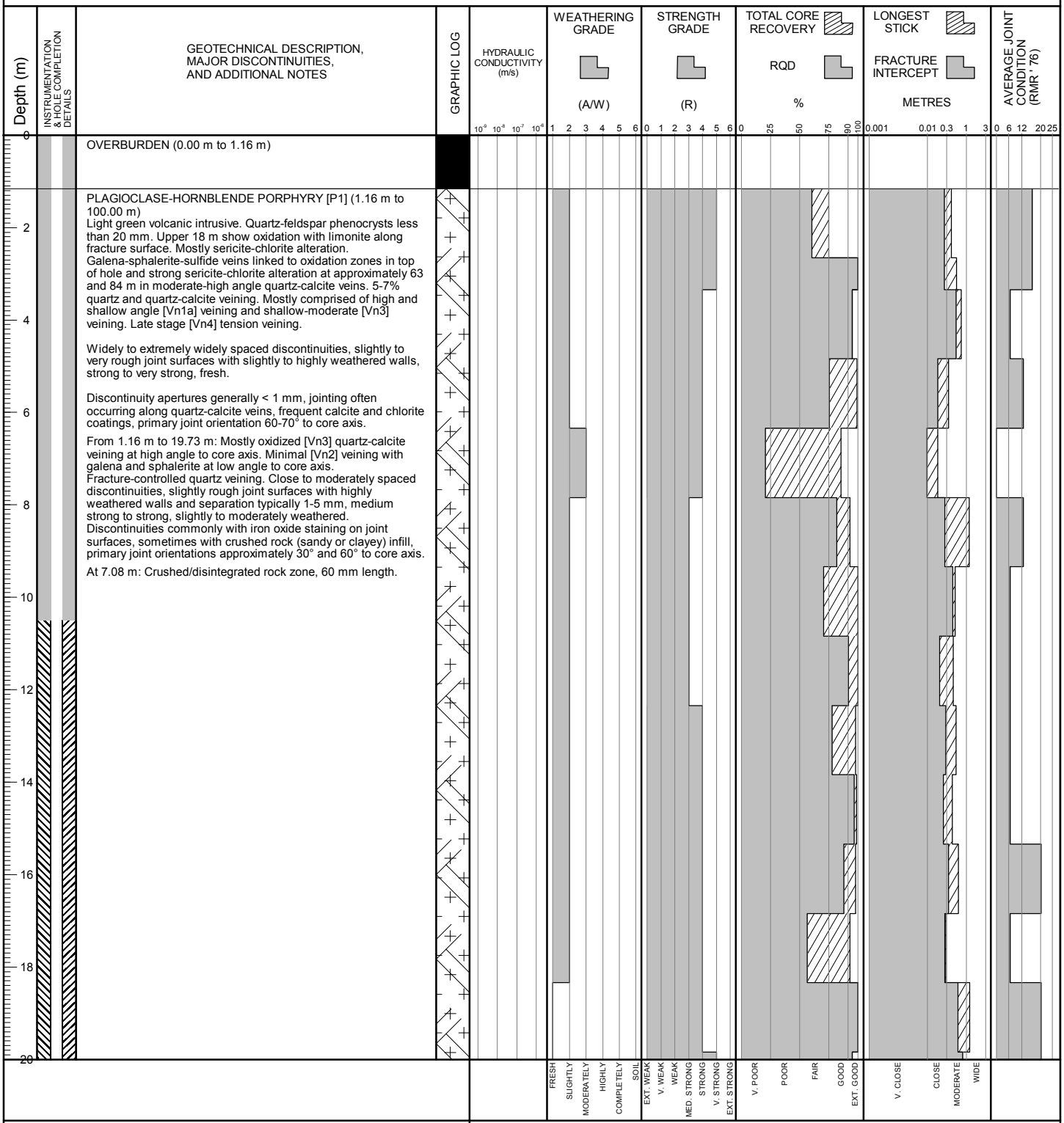
PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (1.16 m to 100.00 m)
Light green volcanic intrusive. Quartz-feldspar phenocrysts less than 20 mm. Upper 18 m show oxidation with limonite along fracture surface. Mostly sericite-chlorite alteration. Galena-sphalerite-sulfide veins linked to oxidation zones in top of hole and strong sericite-chlorite alteration at approximately 63 and 84 m in moderate-high angle quartz-calcite veins. 5-7% quartz and quartz-calcite veining. Mostly comprised of high and shallow angle [Vn1a] veining and shallow-moderate [Vn3] veining. Late stage [Vn4] tension veining.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with slightly to highly weathered walls, strong to very strong, fresh.

Discontinuity apertures generally < 1 mm, jointing often occurring along quartz-calcite veins, frequent calcite and chlorite coatings, primary joint orientation 60-70° to core axis.

From 1.16 m to 19.73 m: Mostly oxidized [Vn3] quartz-calcite veining at high angle to core axis. Minimal [Vn2] veining with galena and sphalerite at low angle to core axis.
Fracture-controlled quartz veining. Close to moderately spaced discontinuities, slightly rough joint surfaces with highly weathered walls and separation typically 1-5 mm, medium strong to strong, slightly to moderately weathered. Discontinuities commonly with iron oxide staining on joint surfaces, sometimes with crushed rock (sandy or clayey) infill, primary joint orientations approximately 30° and 60° to core axis.

At 7.08 m: Crushed/disintegrated rock zone, 60 mm length.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
20	From 19.73 m to 42.46 m: Moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, strong, fresh. Discontinuity apertures generally < 2 mm, with calcite coatings, occasional iron oxide staining on joint surfaces, variable joint orientations.
22	
24	At 24.49 m: 100 mm shear zone.
26	
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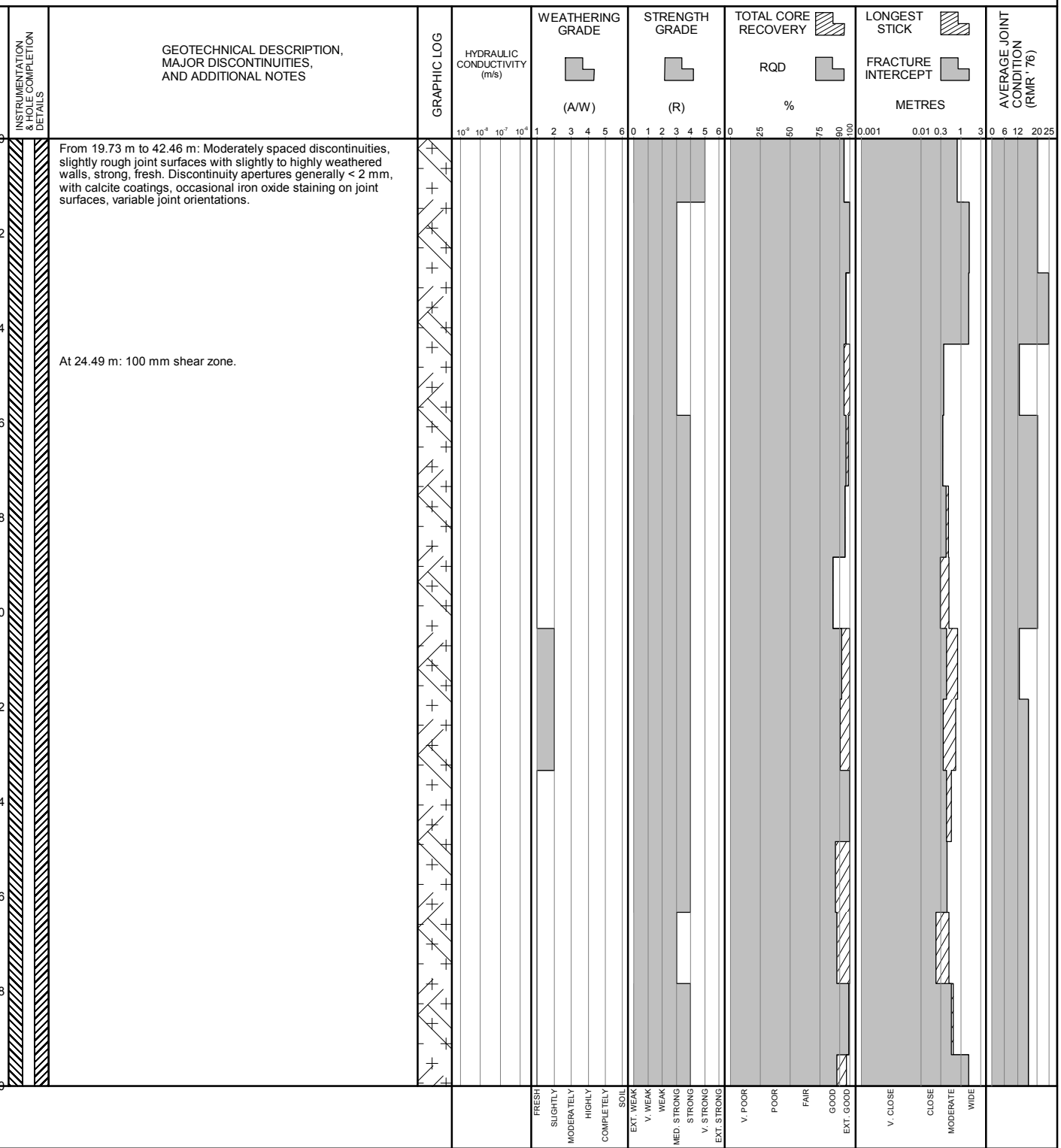
38	
40	



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
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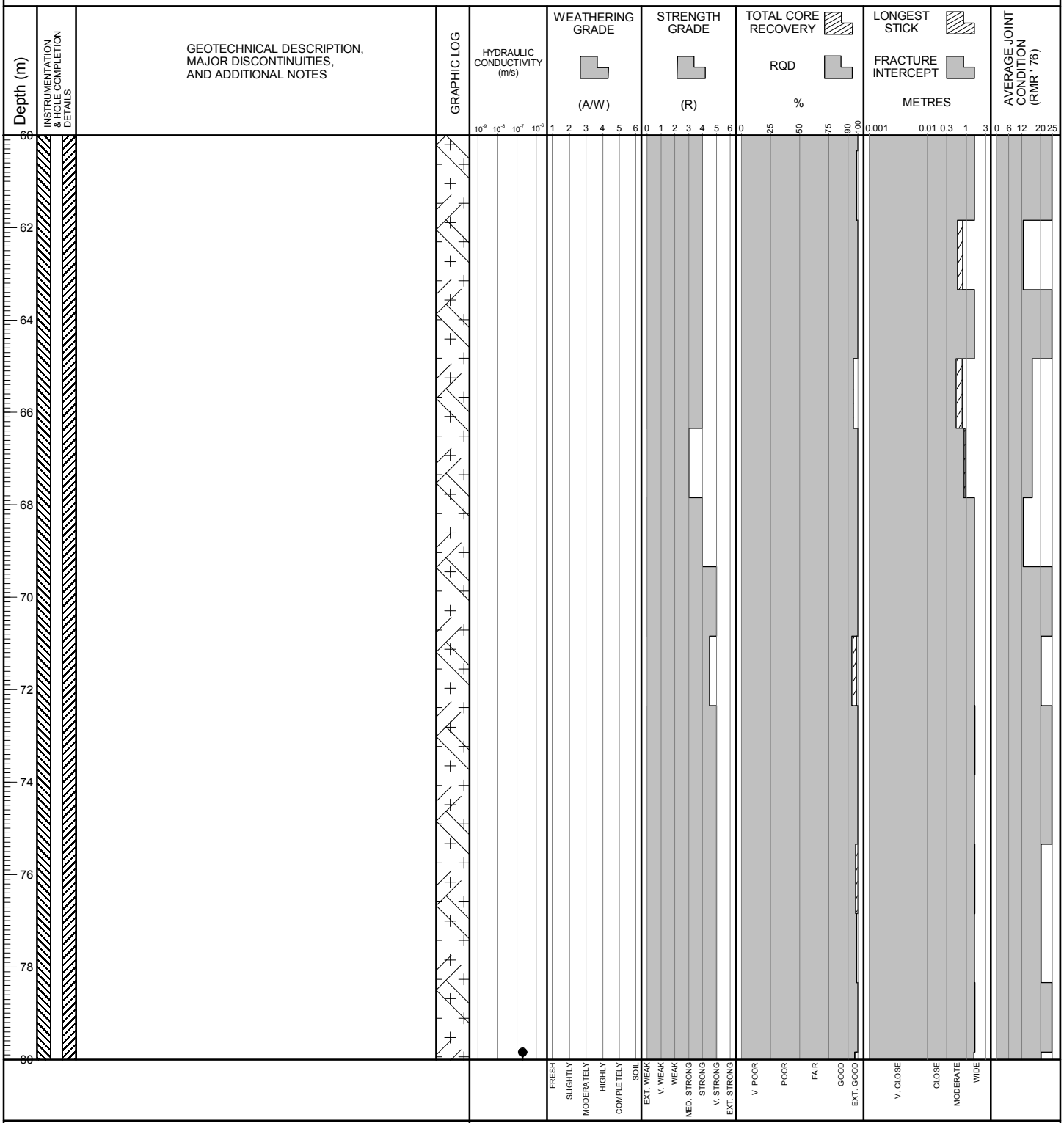

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20A

Project No.: 1008-029

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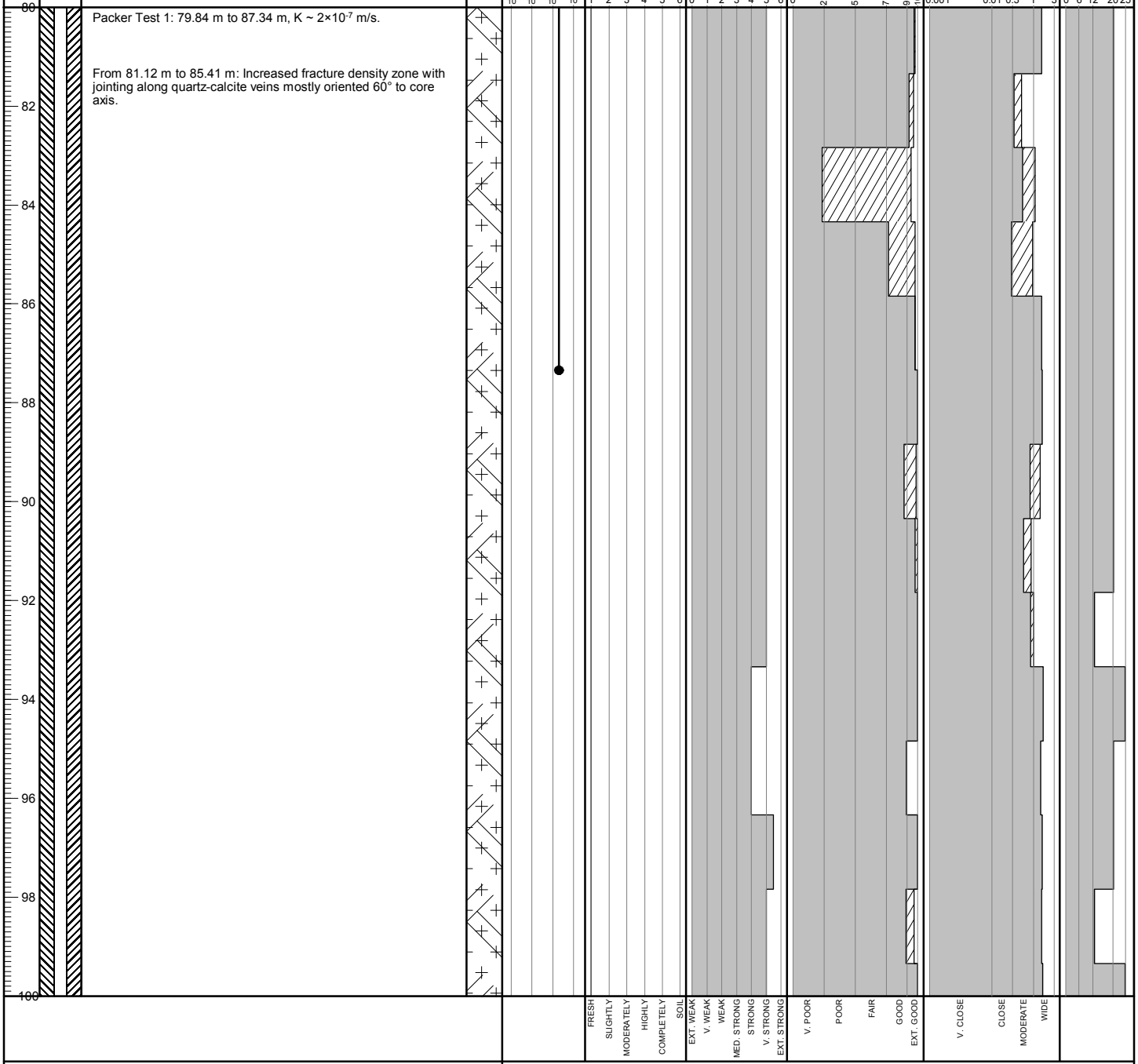
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 1: 79.84 m to 87.34 m, K ~ 2×10^{-7} m/s.

From 81.12 m to 85.41 m: Increased fracture density zone with jointing along quartz-calcite veins mostly oriented 60° to core axis.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
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Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
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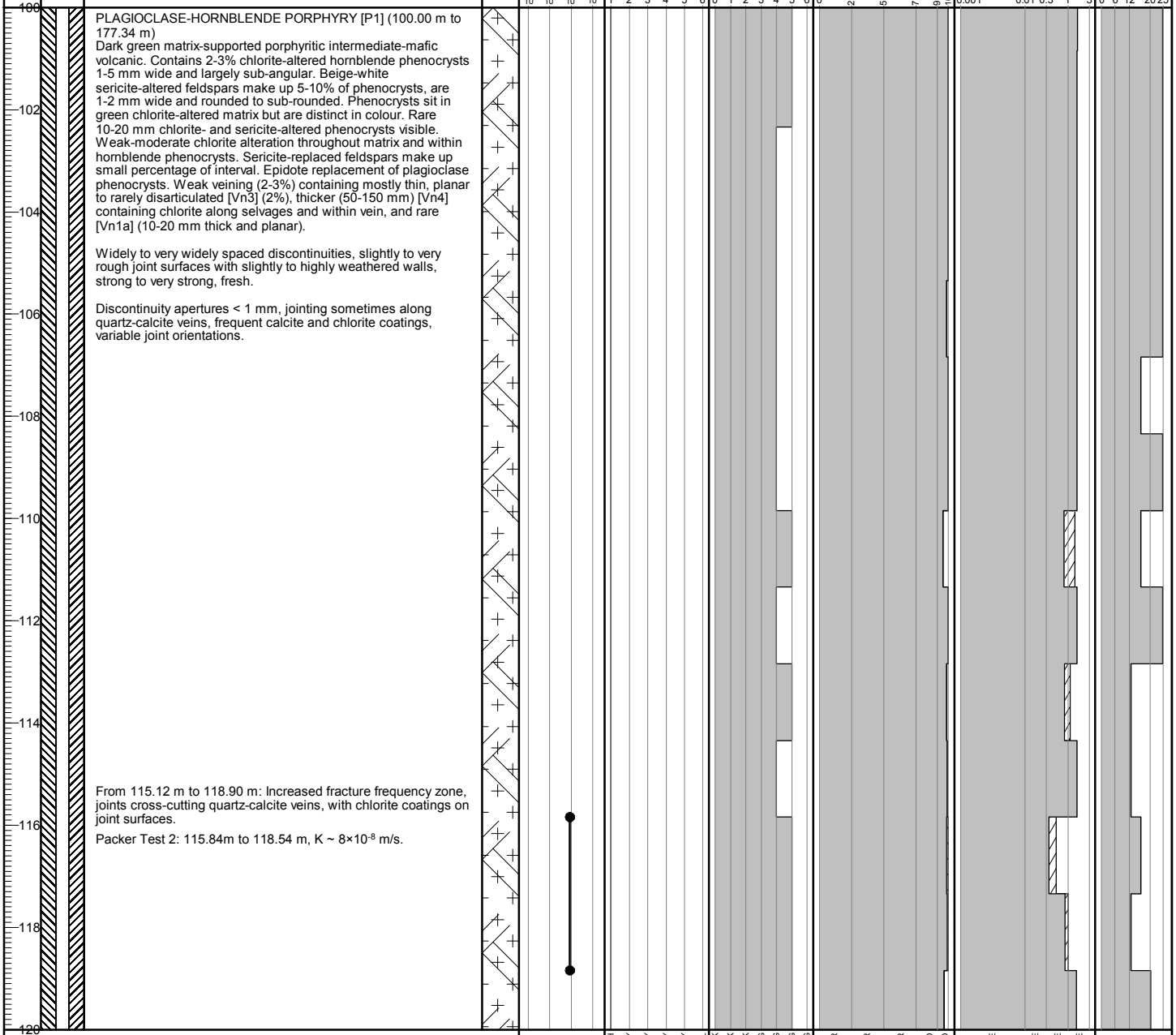
PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (100.00 m to 177.34 m)
Dark green matrix-supported porphyritic intermediate-mafic volcanic. Contains 2-3% chlorite-altered hornblende phenocrysts 1-5 mm wide and largely sub-angular. Beige-white sericite-altered feldspars make up 5-10% of phenocrysts, are 1-2 mm wide and rounded to sub-rounded. Phenocrysts sit in green chlorite-altered matrix but are distinct in colour. Rare 10-20 mm chlorite- and sericite-altered phenocrysts visible. Weak-moderate chlorite alteration throughout matrix and within hornblende phenocrysts. Sericite-replaced feldspars make up small percentage of interval. Epidote replacement of plagioclase phenocrysts. Weak veining (2-3%) containing mostly thin, planar to rarely disarticulated [Vn3] (2%), thicker (50-150 mm) [Vn4] containing chlorite along selvages and within vein, and rare [Vn1a] (10-20 mm thick and planar).

Widely to very widely spaced discontinuities, slightly to very rough joint surfaces with slightly to highly weathered walls, strong to very strong, fresh.

Discontinuity apertures < 1 mm, jointing sometimes along quartz-calcite veins, frequent calcite and chlorite coatings, variable joint orientations.

From 115.12 m to 118.90 m: Increased fracture frequency zone, joints cross-cutting quartz-calcite veins, with chlorite coatings on joint surfaces.

Packer Test 2: 115.84m to 118.54 m, K ~ 8×10^{-8} m/s.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-20A

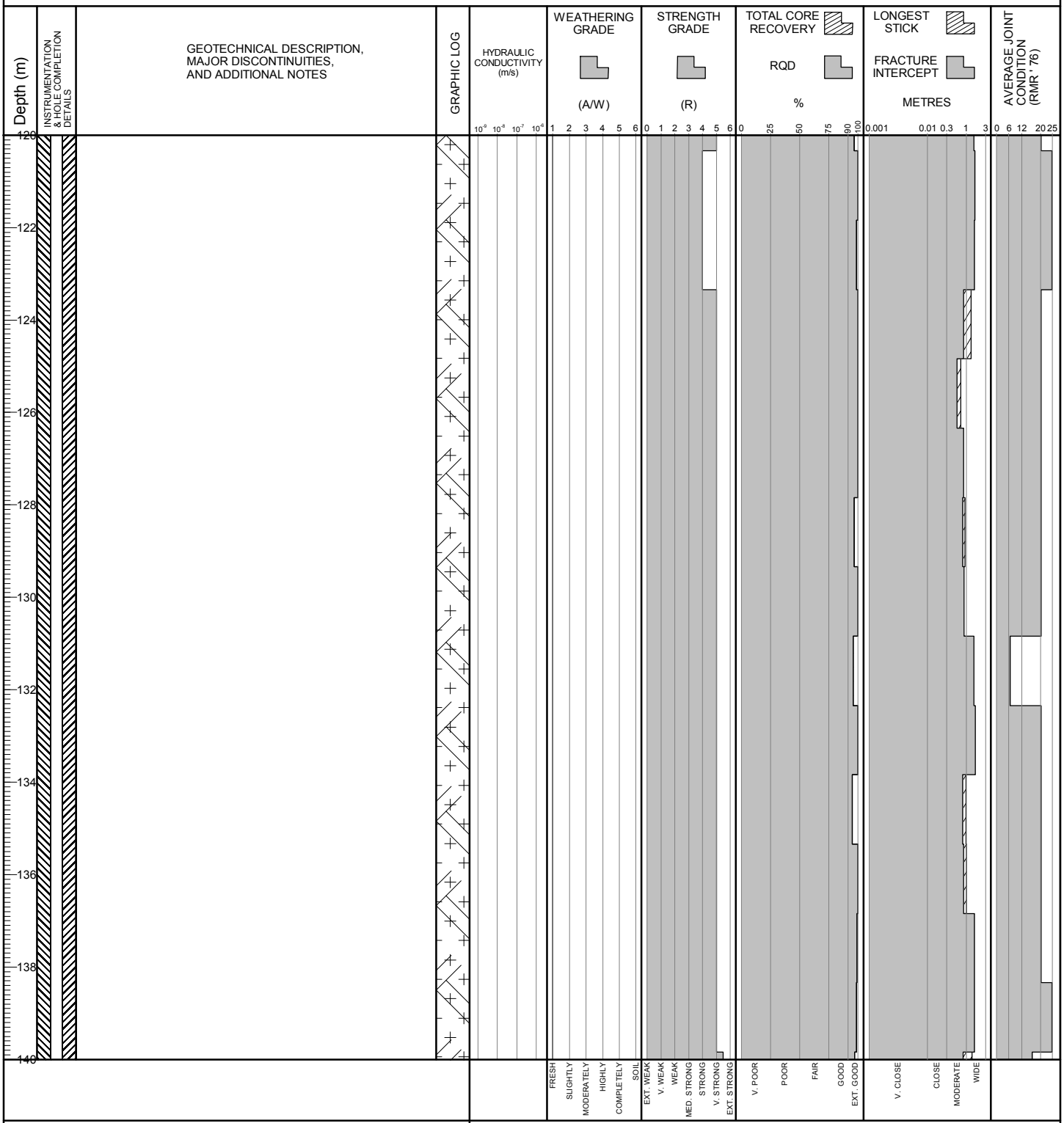
Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

Start Date: 12 JUN 18
Finish Date: 17 JUN 18
Final Depth (m): 177.34
Depth To Top Of Rock (m): 1.16
Logged By: DS/DZ
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,147E - 6,258,341N
Ground Elevation (m): 1,493.59
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
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Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 9.38

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Finish Date: 17 JUN 18
Final Depth (m): 177.34
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Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

140
142
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150
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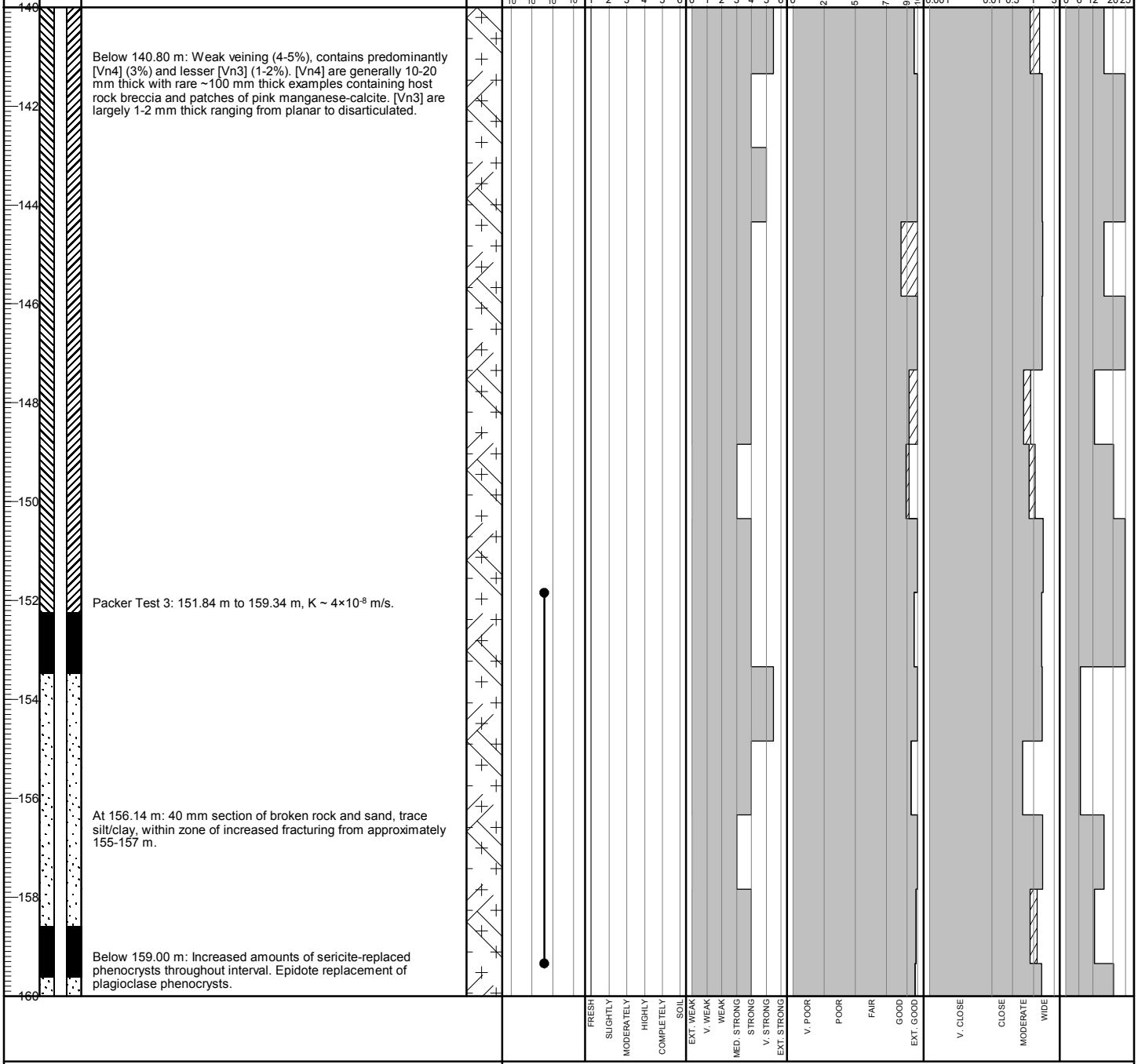
156
158
160

Below 140.80 m: Weak veining (4-5%), contains predominantly [Vn4] (3%) and lesser [Vn3] (1-2%). [Vn4] are generally 10-20 mm thick with rare ~100 mm thick examples containing host rock breccia and patches of pink manganese-calcite. [Vn3] are largely 1-2 mm thick ranging from planar to disarticulated.

Packer Test 3: 151.84 m to 159.34 m, K ~ 4×10^{-8} m/s.

At 156.14 m: 40 mm section of broken rock and sand, trace silt/clay, within zone of increased fracturing from approximately 155-157 m.

Below 159.00 m: Increased amounts of sericite-replaced phenocrysts throughout interval. Epidote replacement of plagioclase phenocrysts.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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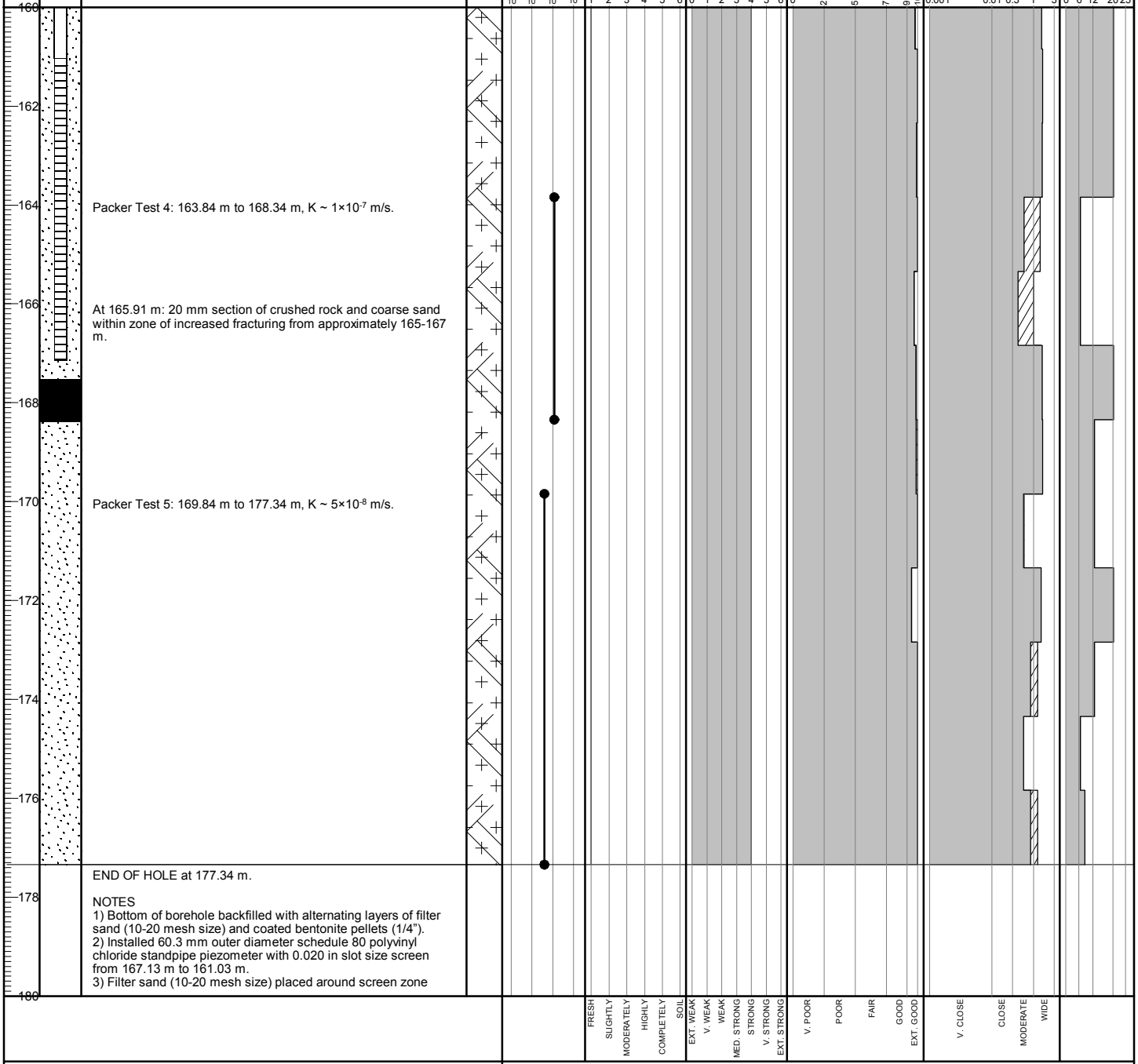

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD %	LONGEST STICK METRES / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
180		from 167.53 m to 159.62 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 159.62 m to 158.59 m. 5) Water level measured after piezometer installation on 4 July 2018 at 57.85 m bgs.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
182									
184									
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190									
192									
194									
196									
198									
200					FRESH SLIGHTLY MODERATELY HIGHLY COMPLETELY SOIL	EXT. WEAK V. WEAK WEAK MED. STRONG STRONG V. STRONG EXT. STRONG	V. POOR POOR FAIR GOOD EXT. GOOD	V. CLOSE CLOSE MODERATE WIDE	

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
0		OVERBURDEN (0.00 m to 0.61 m)
0.61 – 20		PLAGIOCLASE-HORNBLENDE PORPHYRY [P1] (0.61 m to 120.34 m) Green porphyritic volcanic/intrusive. Predominantly comprised of subhedral, sericite-altered plagioclase phenocrysts ranging from 5-25%, with minor specks of dark mafic phenocrysts throughout a green, fine-grained matrix. Weak alignment of phenocrysts. Rare mafic fragments. Moderate pervasive chlorite replacement with isolated intervals of strong pervasive quartz-sericite-pyrite alteration. Moderate pervasive chlorite alteration throughout with strong sericite replacement of phenocrysts. Interval of moderate 4-5% quartz-calcite veining. Dominantly comprised of planar to undulatory [Vn1a] and grey-calcite [Vn3] veins typically oriented at a shallow angle to the core axis. Moderate [Vn4] tension gash style veins crosscut these veins and are oriented at a high angle to the core axis. Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with variably highly weathered to unweathered walls, generally strong to very strong, fresh. Discontinuity apertures typically < 1 mm, frequently with calcite and/or chlorite coatings, primary joint orientation approximately 40° to core axis. From 0.61 m to 17.25 m: Strong fracture-controlled orange oxidation and earthy orange goethite/limonite replacement in veins. Strong pervasive quartz-sericite-pyrite alteration. Interval of strong 10% quartz-base metal sulfide veining in highly fractured and oxidized zone. Dominantly comprised of strongly mineralized and sheeted [Vn2] base metal sulfide veins that are marginal to faults. [Vn1a] and overprinting [Vn3] grey-calcite networks/stockworks that are often fracture controlled. Veins often display vuggy textures that are replaced by orange earthy iron oxides (goethite/limonite). Lesser [Vn4] veins. Close to moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered wall rock, strong, slightly weathered. Discontinuity apertures typically 1-10 mm, common iron oxide staining on joint surfaces, some broken and crushed rock infill in larger aperture discontinuities, some chlorite coatings, variable joint orientations. From 5.09 m to 6.22 m: Strongly developed fault zone characterized by strongly oxidized surfaces, iron oxide replacement and quartz-base metal sulfide veining. Subsidiary fracture networks are common. Sections 10-60 mm length of fault gouge (broken/crushed rock, clayey), oriented approximately 30° to core axis. From 17.25 m to 40.51 m: Moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, strong, fresh. Discontinuity apertures approximately < 2 mm, frequent calcite and occasional chlorite coatings, occasional iron oxide staining on joint surfaces, variable joint orientations.

Graphic log

Hydraulic conductivity (m/s): 10^{-9} 10^{-8} 10^{-7} 10^{-6}

Weathering grade (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL

Strength grade (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG

Total core recovery / RQD (%): 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

Longest stick / Fracture intercept (metres): 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE

Average joint condition (RMR' 76): 0, 6, 12, 20, 25

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AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

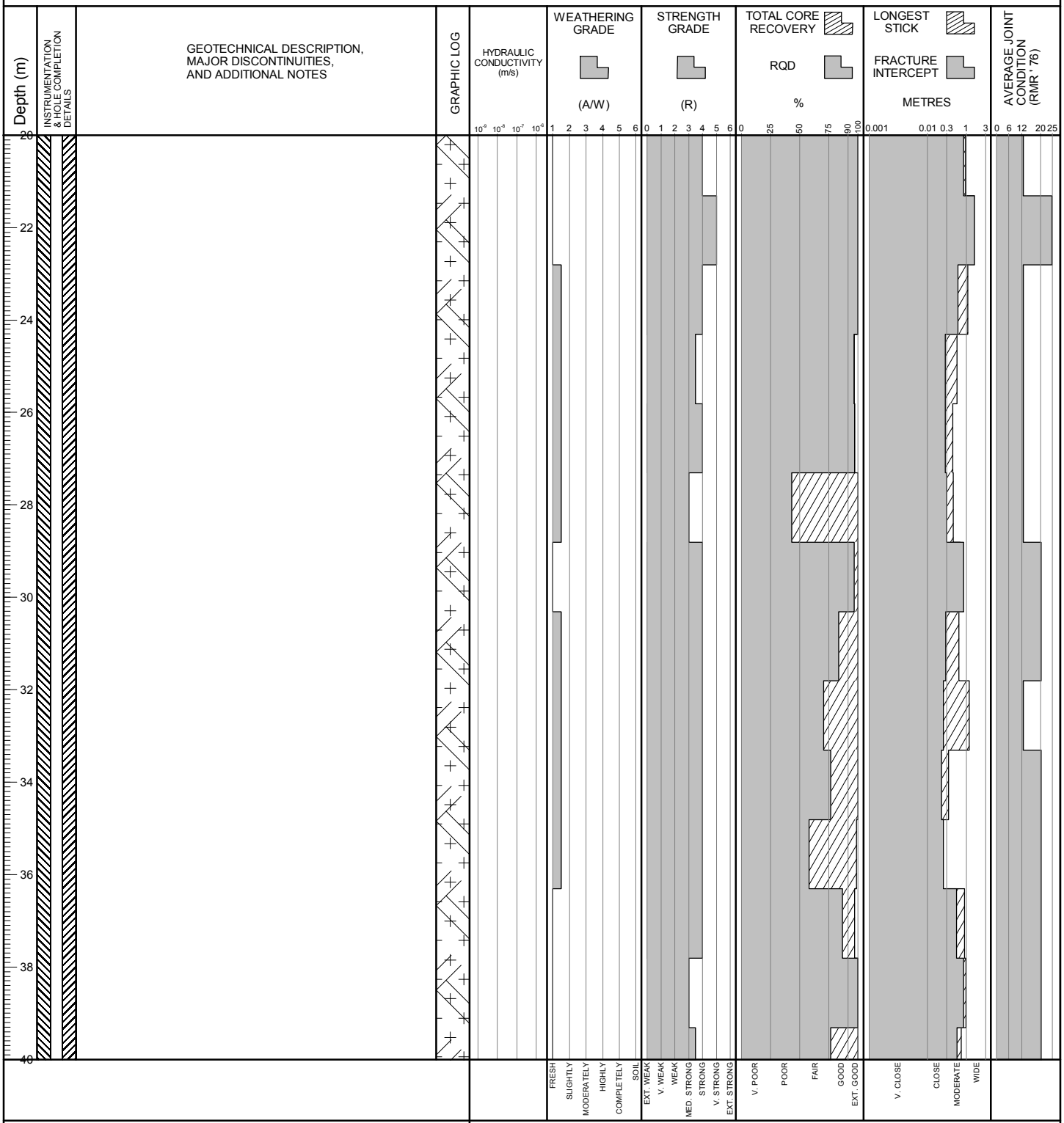
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
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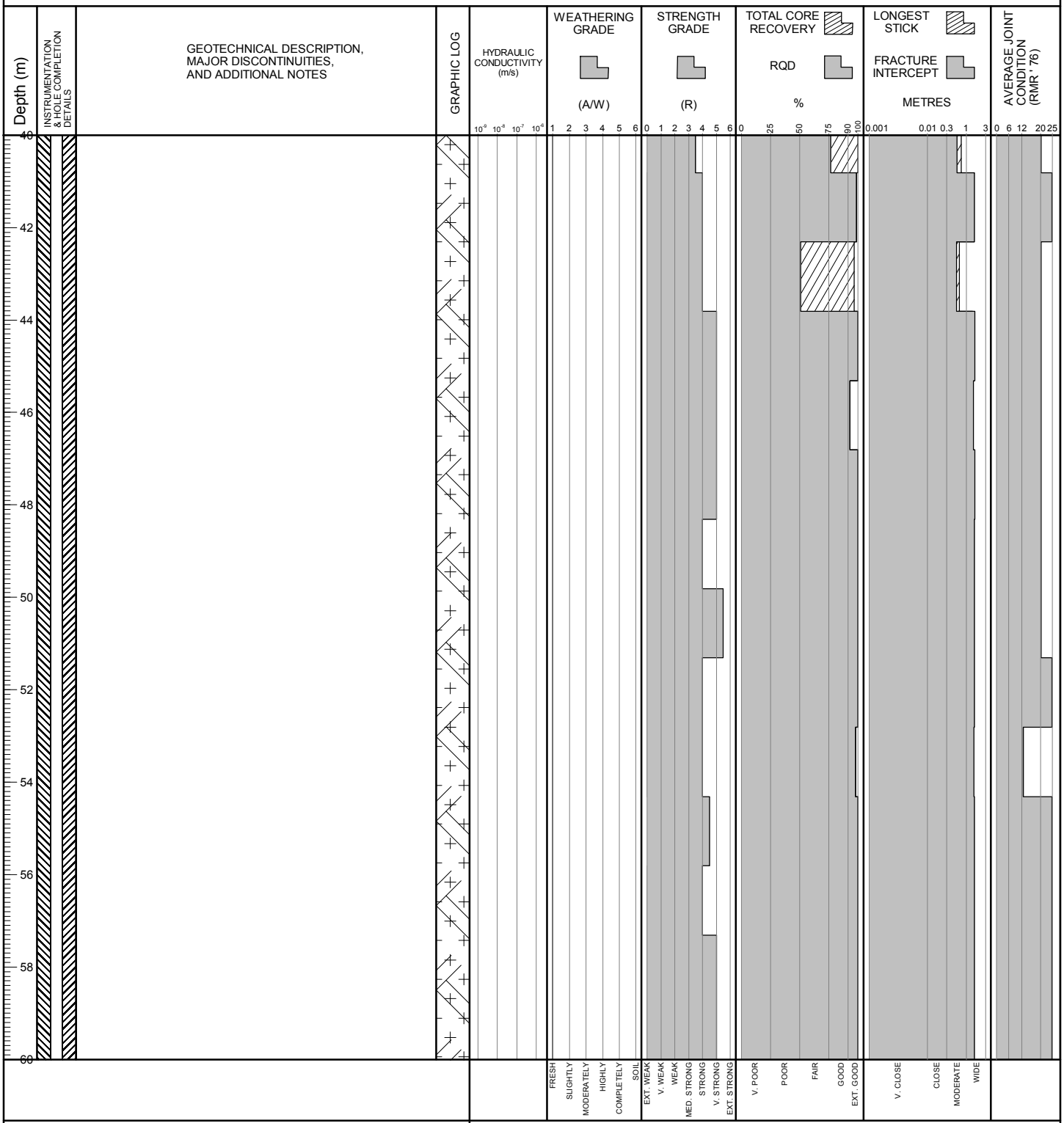
Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
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Drill Designation: Zinex A5
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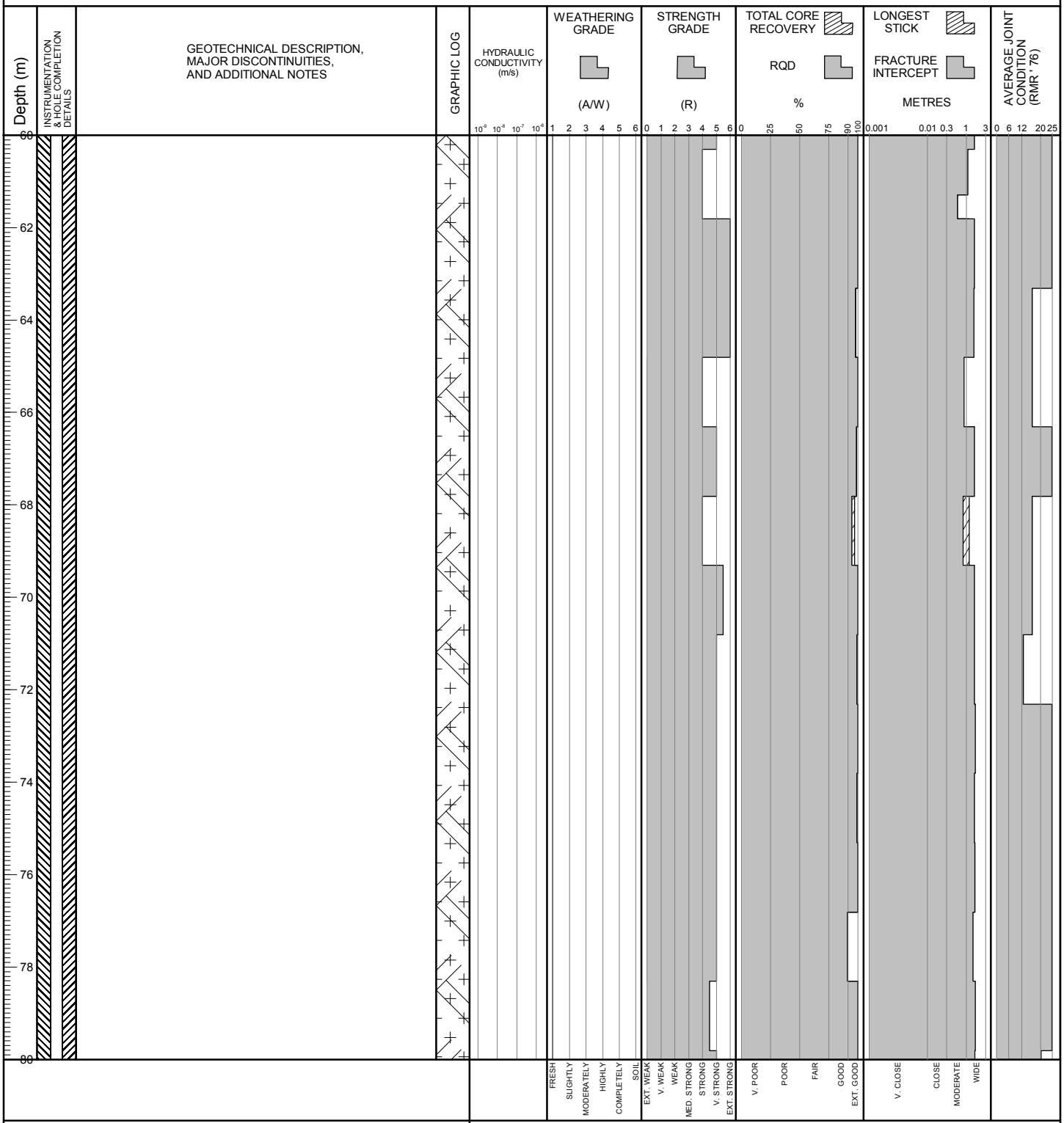
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

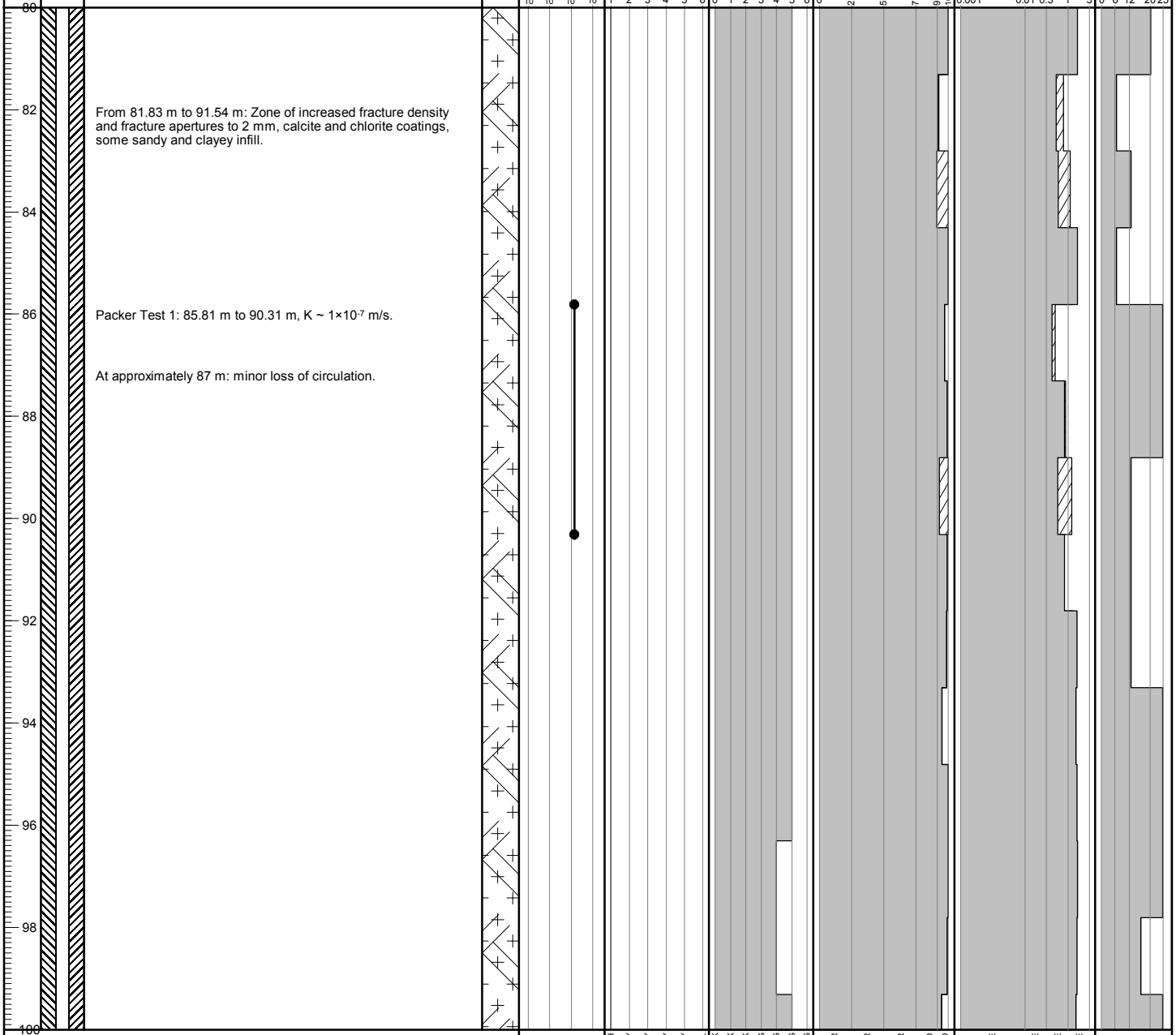
Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 81.83 m to 91.54 m: Zone of increased fracture density and fracture apertures to 2 mm, calcite and chlorite coatings, some sandy and clayey infill.

Packer Test 1: 85.81 m to 90.31 m, K ~ 1×10^{-7} m/s.

At approximately 87 m: minor loss of circulation.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

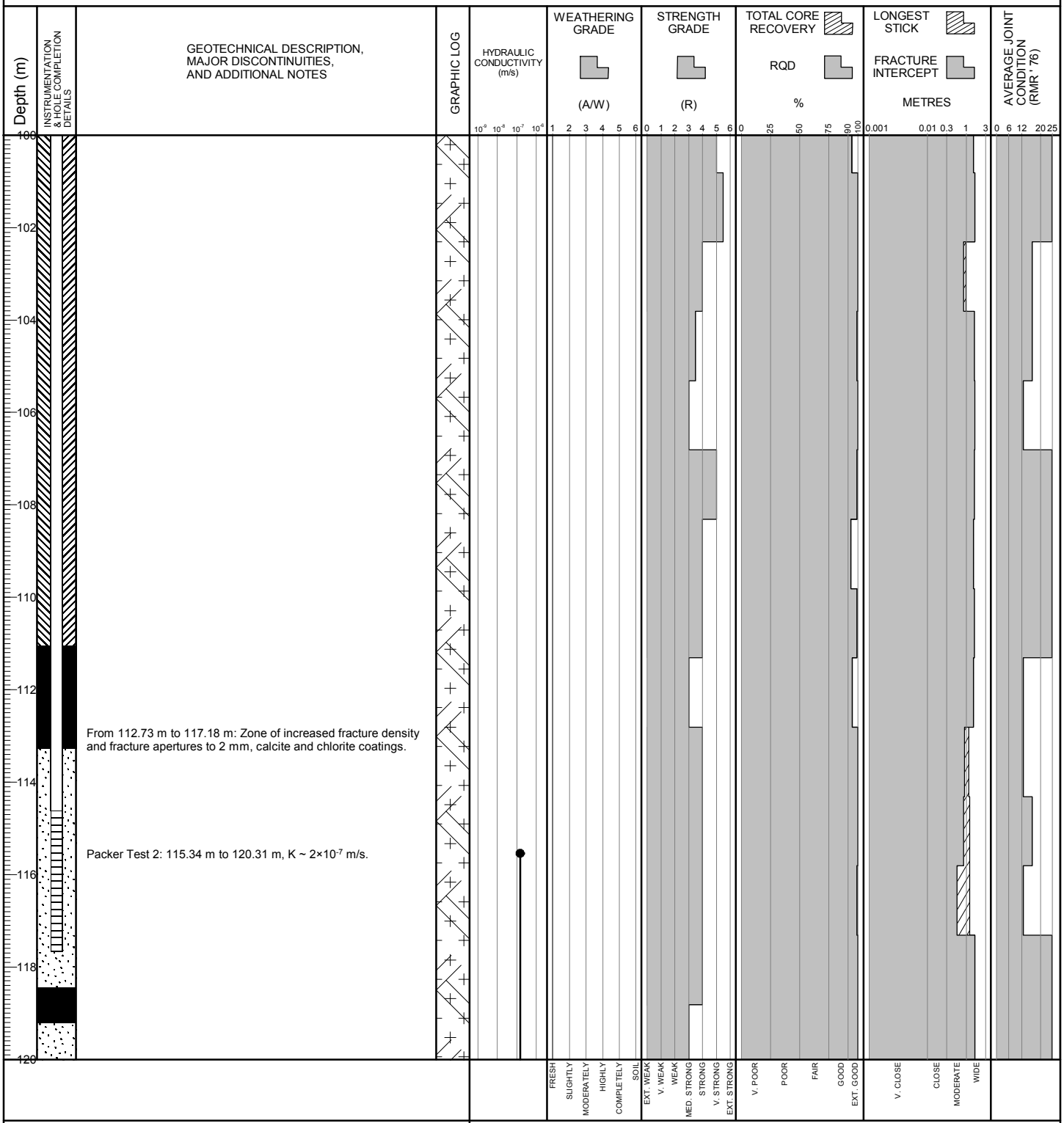
Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-20B

Project No.: 1008-029

Location: West of Brucejack Fault

Co-ordinates (m): 426,148E - 6,258,342N
Ground Elevation (m): 1,493.60
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 1.20

Start Date: 17 JUN 18
Finish Date: 20 JUN 18
Final Depth (m): 120.34
Depth To Top Of Rock (m): 0.61
Logged By: DS/DZ/FP/KB
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR '76)
120		END OF HOLE at 120.34 m.							
122		NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 117.67 m to 114.62 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 118.45 m to 113.27 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 113.27 m to 111.05 m. 5) Water level measured after piezometer installation on 4 July 2018 at 17.70 m bgs.							
124									
126									
128									
130									
132									
134									
136									
138									
140									

Scales: HYDRAULIC CONDUCTIVITY 10^{-9} 10^{-8} 10^{-7} 10^{-6}; WEATHERING GRADE 1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL); STRENGTH GRADE 0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG); TOTAL CORE RECOVERY / RQD 0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD); LONGEST STICK / FRACTURE INTERCEPT 0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE); AVERAGE JOINT CONDITION 0 6 12 20 25

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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21A

Project No.: 1008-029

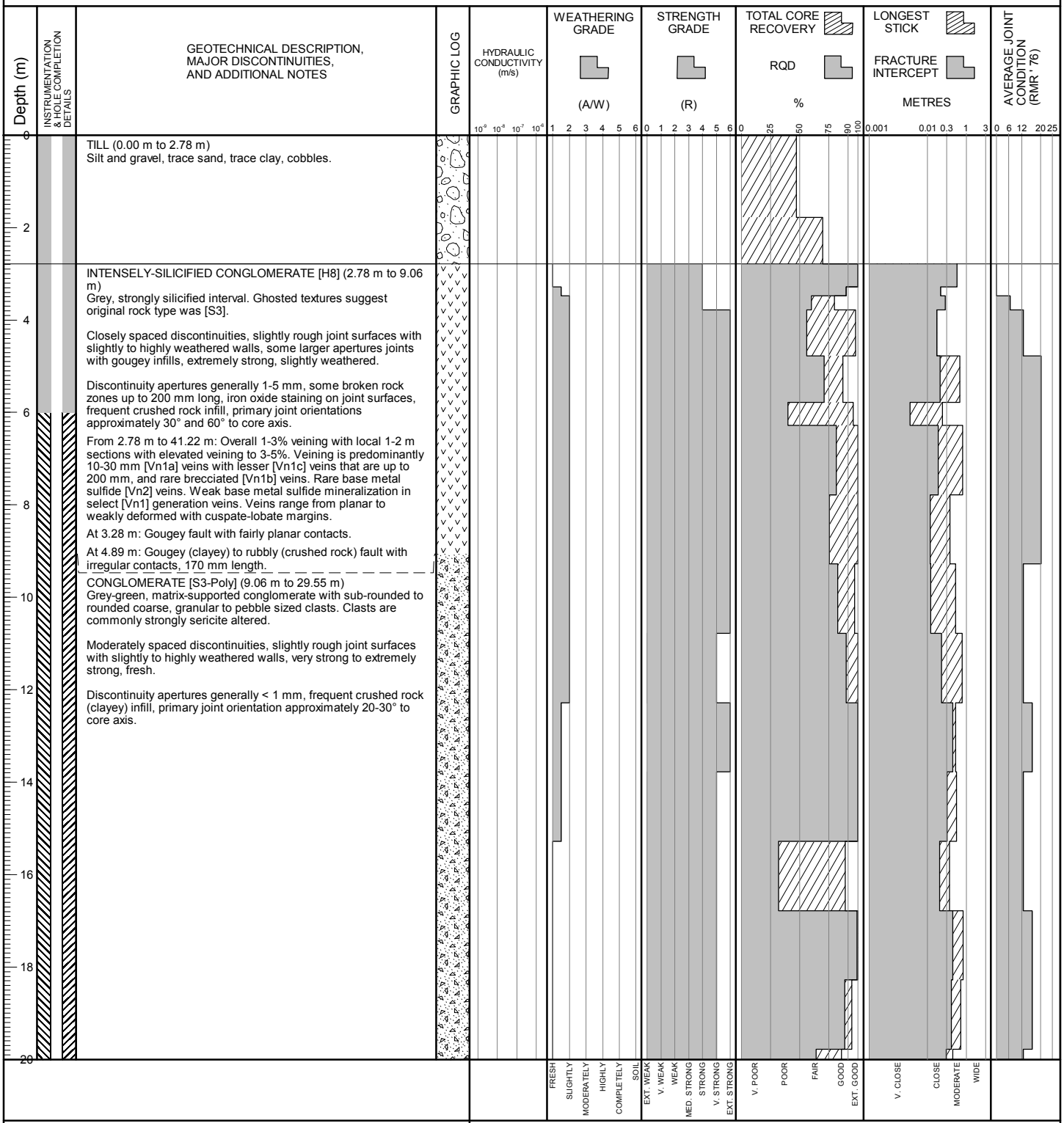
Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0	TILL (0.00 m to 2.78 m) Silt and gravel, trace sand, trace clay, cobbles.
3	INTENSELY-SILICIFIED CONGLOMERATE [H8] (2.78 m to 9.06 m) Grey, strongly silicified interval. Ghosted textures suggest original rock type was [S3]. Closely spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, some larger apertures joints with gougey infills, extremely strong, slightly weathered. Discontinuity apertures generally 1-5 mm, some broken rock zones up to 200 mm long, iron oxide staining on joint surfaces, frequent crushed rock infill, primary joint orientations approximately 30° and 60° to core axis. From 2.78 m to 41.22 m: Overall 1-3% veining with local 1-2 m sections with elevated veining to 3-5%. Veining is predominantly 10-30 mm [Vn1a] veins with lesser [Vn1c] veins that are up to 200 mm, and rare brecciated [Vn1b] veins. Rare base metal sulfide [Vn2] veins. Weak base metal sulfide mineralization in select [Vn1] generation veins. Veins range from planar to weakly deformed with cuspate-lobate margins. At 3.28 m: Gougey fault with fairly planar contacts. At 4.89 m: Gougey (clayey) to rubbly (crushed rock) fault with irregular contacts, 170 mm length.
9.06	CONGLOMERATE [S3-Poly] (9.06 m to 29.55 m) Grey-green, matrix-supported conglomerate with sub-rounded to rounded coarse, granular to pebble sized clasts. Clasts are commonly strongly sericite altered. Moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, very strong to extremely strong, fresh. Discontinuity apertures generally < 1 mm, frequent crushed rock (clayey) infill, primary joint orientation approximately 20-30° to core axis.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

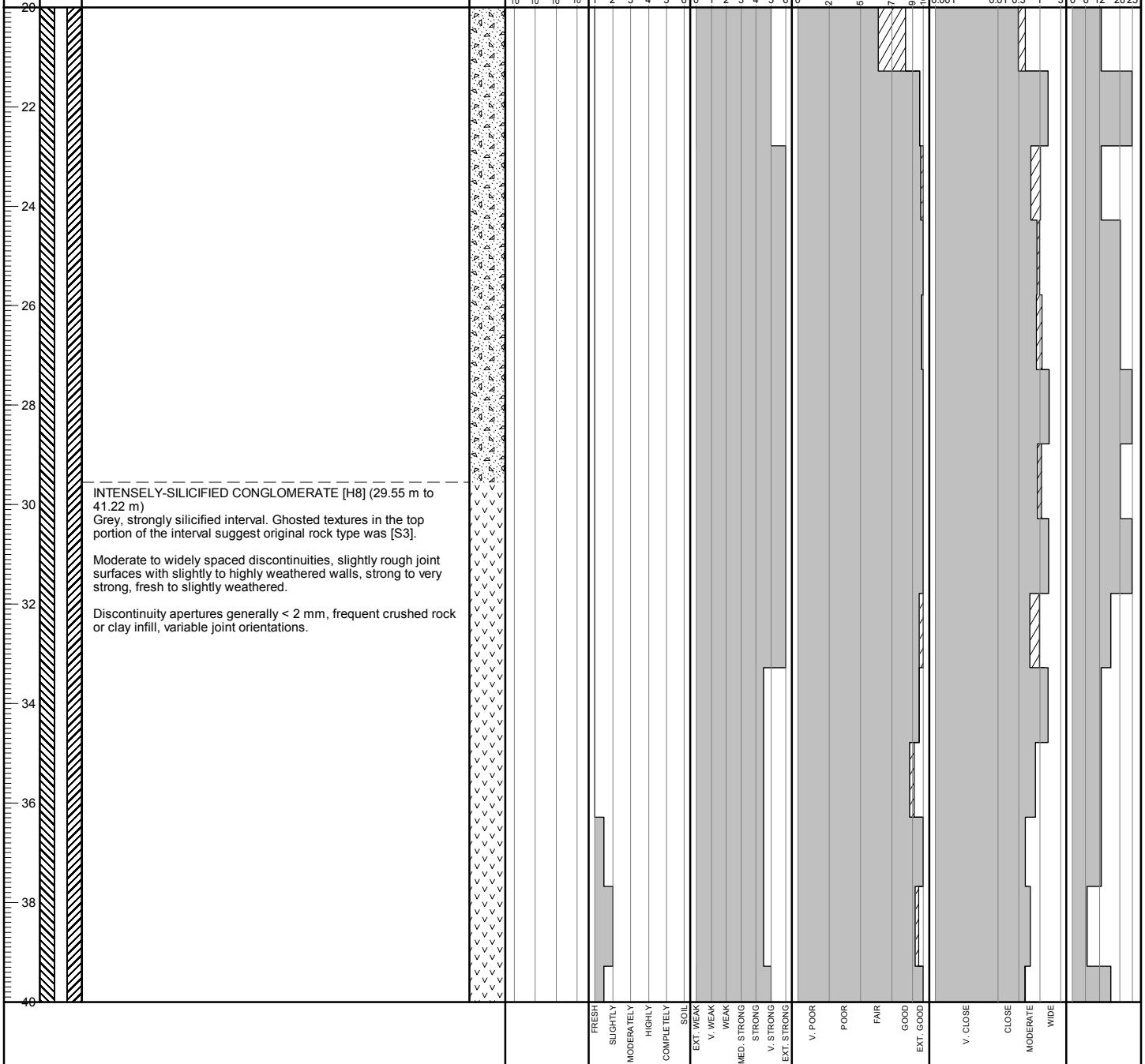
Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

INTENSELY-SILICIFIED CONGLOMERATE [H8] (29.55 m to 41.22 m)
Grey, strongly silicified interval. Ghosted textures in the top portion of the interval suggest original rock type was [S3].

Moderate to widely spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, strong to very strong, fresh to slightly weathered.

Discontinuity apertures generally < 2 mm, frequent crushed rock or clay infill, variable joint orientations.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

SANDSTONE/ARENITE [S4-Vsf] (41.22 m to 255.28 m)
Medium greenish-grey, massive, silty to coarse sand [S4-Vsf]. Rare < 1 m interbeds of [S3] as observed above. Occasional calcite-pyrite concretions. Some patches of high-temperature sericite alteration. Overall 1-3% veining with local 1-2 m sections with elevated veining to 3-5%. Veining is predominantly 10-30 mm [Vn1a] veins with lesser [Vn1c] veins that are up to 200 mm, and rare brecciated [Vn1b] veins. Occasional 20-50 mm grey, calcite-rich [Vn3] veins. Rare base metal sulfide [Vn2] veins. Weak base metal sulfide mineralization in select [Vn1] generation veins. Veins range from planar to weakly deformed with cuspate-lobate margins.

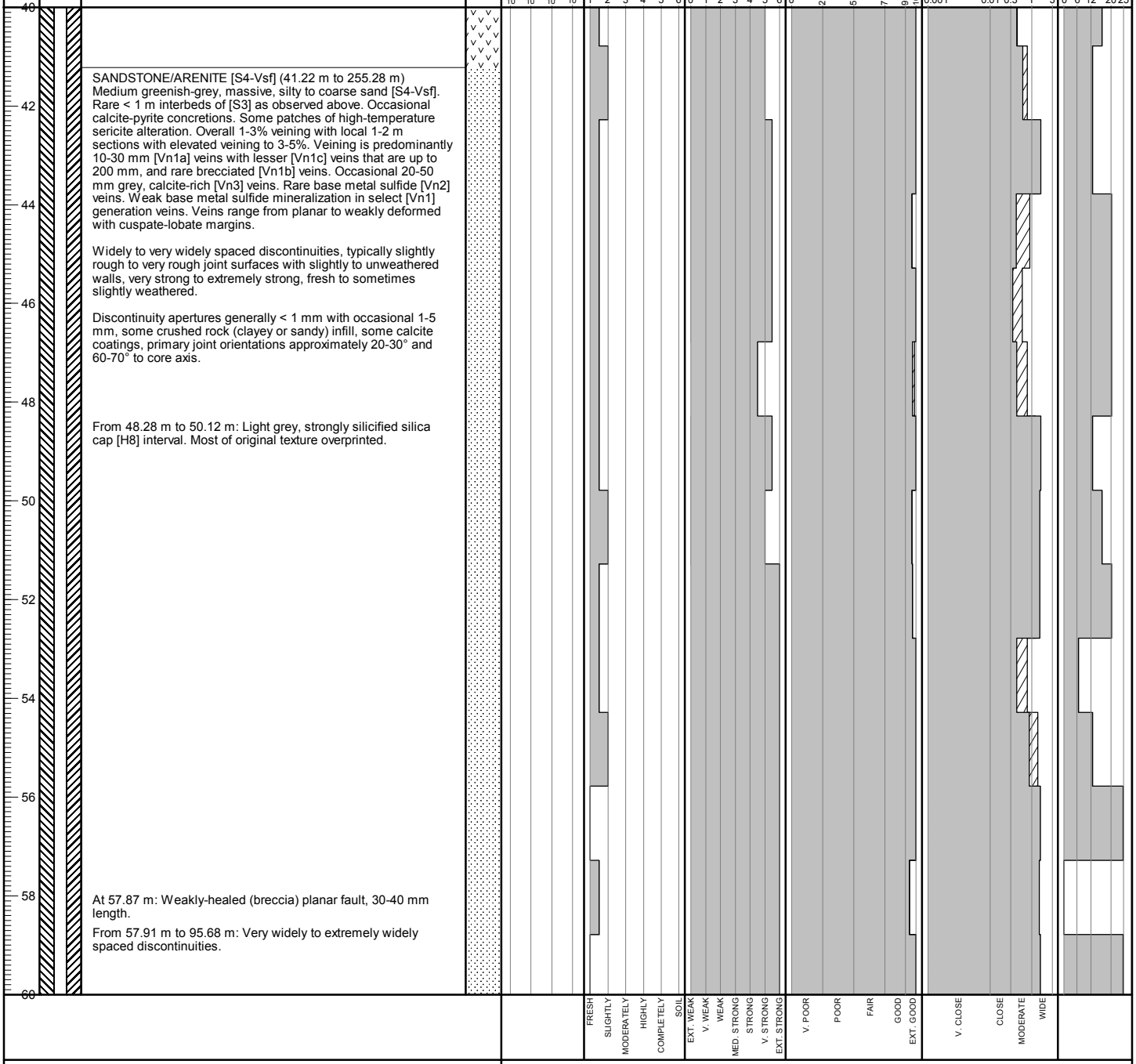
Widely to very widely spaced discontinuities, typically slightly rough to very rough joint surfaces with slightly to unweathered walls, very strong to extremely strong, fresh to sometimes slightly weathered.

Discontinuity apertures generally < 1 mm with occasional 1-5 mm, some crushed rock (clayey or sandy) infill, some calcite coatings, primary joint orientations approximately 20-30° and 60-70° to core axis.

From 48.28 m to 50.12 m: Light grey, strongly silicified silica cap [H8] interval. Most of original texture overprinted.

At 57.87 m: Weakly-healed (breccia) planar fault, 30-40 mm length.

From 57.91 m to 95.68 m: Very widely to extremely widely spaced discontinuities.



BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY RQD %	LONGEST STICK FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
60–80		From 65.05 m to 84.53 m: Zone of strong veining with 5-8% overall but locally stronger due to larger [Vn1c] veins. Veining consists of a network of [Vn1] generations and common strongly mineralized base metal sulfide [Vn2] veins. Veins are moderately deformed and commonly have cuspate-lobate margins.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6 (FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL)	0 1 2 3 4 5 6 (EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG)	0 25 50 75 90 100 (V. POOR, POOR, FAIR, GOOD, EXT. GOOD)	0.001 0.01 0.3 1 3 (V. CLOSE, CLOSE, MODERATE, WIDE)	0 6 12 20 25

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
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Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
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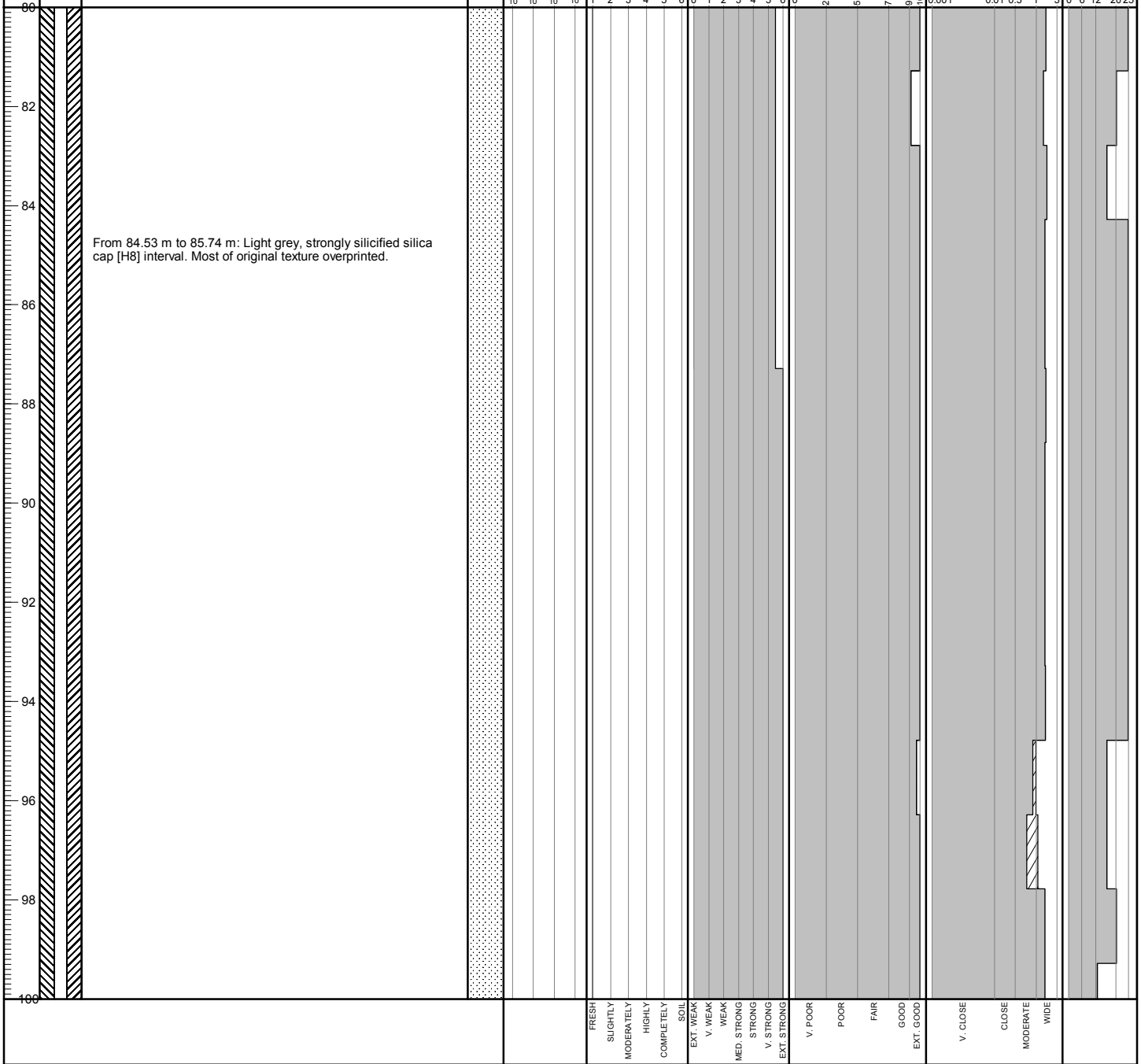
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 84.53 m to 85.74 m: Light grey, strongly silicified silica cap [H8] interval. Most of original texture overprinted.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	***Drill Designation:*** Tech 5000	***Start Date:*** 18 JUN 18
Ground Elevation (m): 1,550.33	***Drilling Contractor:*** Hy-Tech Drilling Ltd.	***Finish Date:*** 24 JUN 18
Survey Method: Mine Survey	***Drill Method:*** Diamond Coring	***Final Depth (m):*** 255.28
Datum: UTM NAD 83 Zone 9	***Core:*** PQ3	***Depth To Top Of Rock (m):*** 2.78
Plunge (°): -90	***Fluid:*** Water	***Logged By:*** HM/LS
Trend (°): 000	***Cased To (m) :*** 3.00	***Reviewed By:*** HP

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-21A

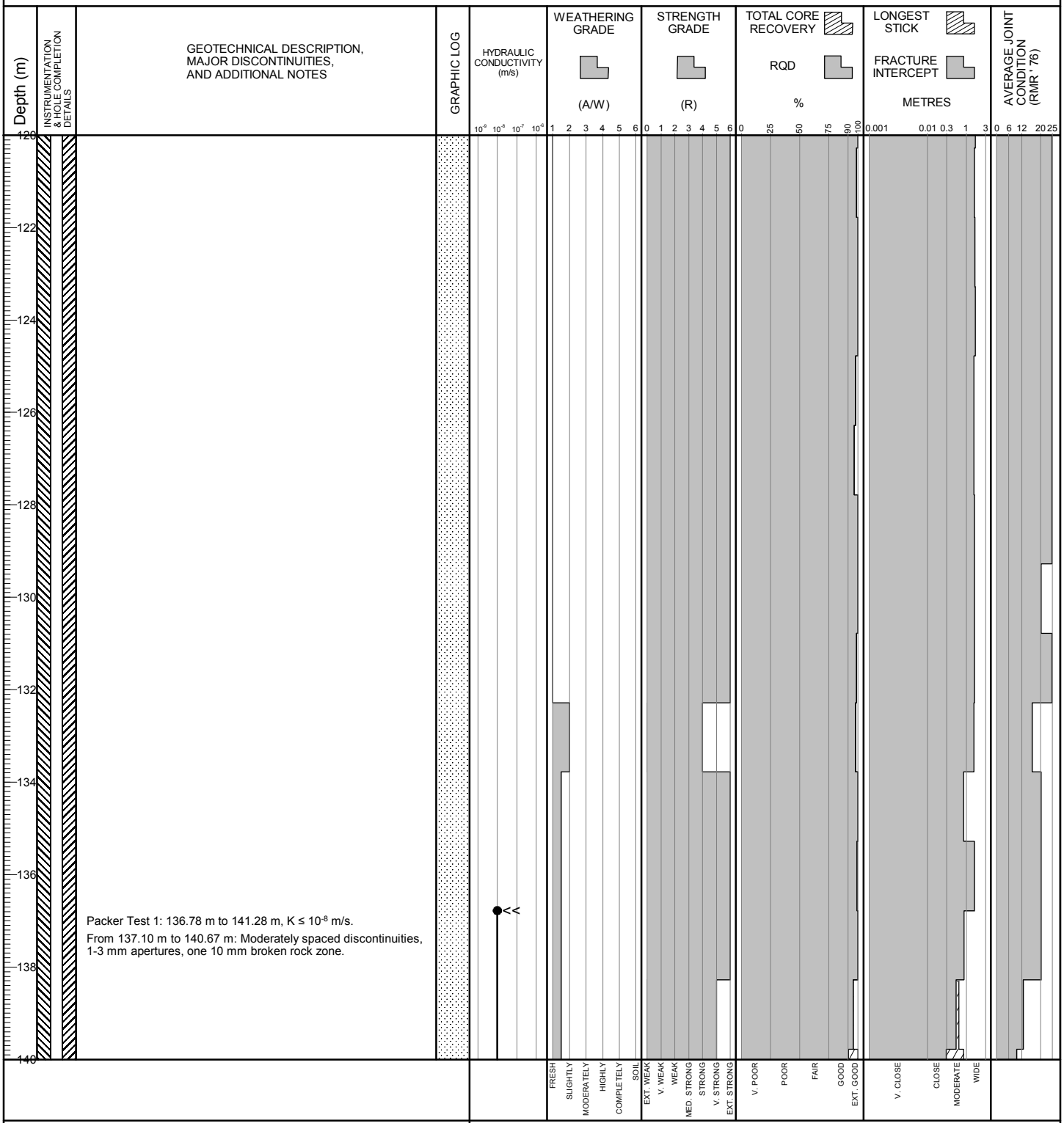
Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	***Drill Designation:*** Tech 5000	***Start Date:*** 18 JUN 18
Ground Elevation (m): 1,550.33	***Drilling Contractor:*** Hy-Tech Drilling Ltd.	***Finish Date:*** 24 JUN 18
Survey Method: Mine Survey	***Drill Method:*** Diamond Coring	***Final Depth (m):*** 255.28
Datum: UTM NAD 83 Zone 9	***Core:*** PQ3	***Depth To Top Of Rock (m):*** 2.78
Plunge (°): -90	***Fluid:*** Water	***Logged By:*** HM/LS
Trend (°): 000	***Cased To (m) :*** 3.00	***Reviewed By:*** HP

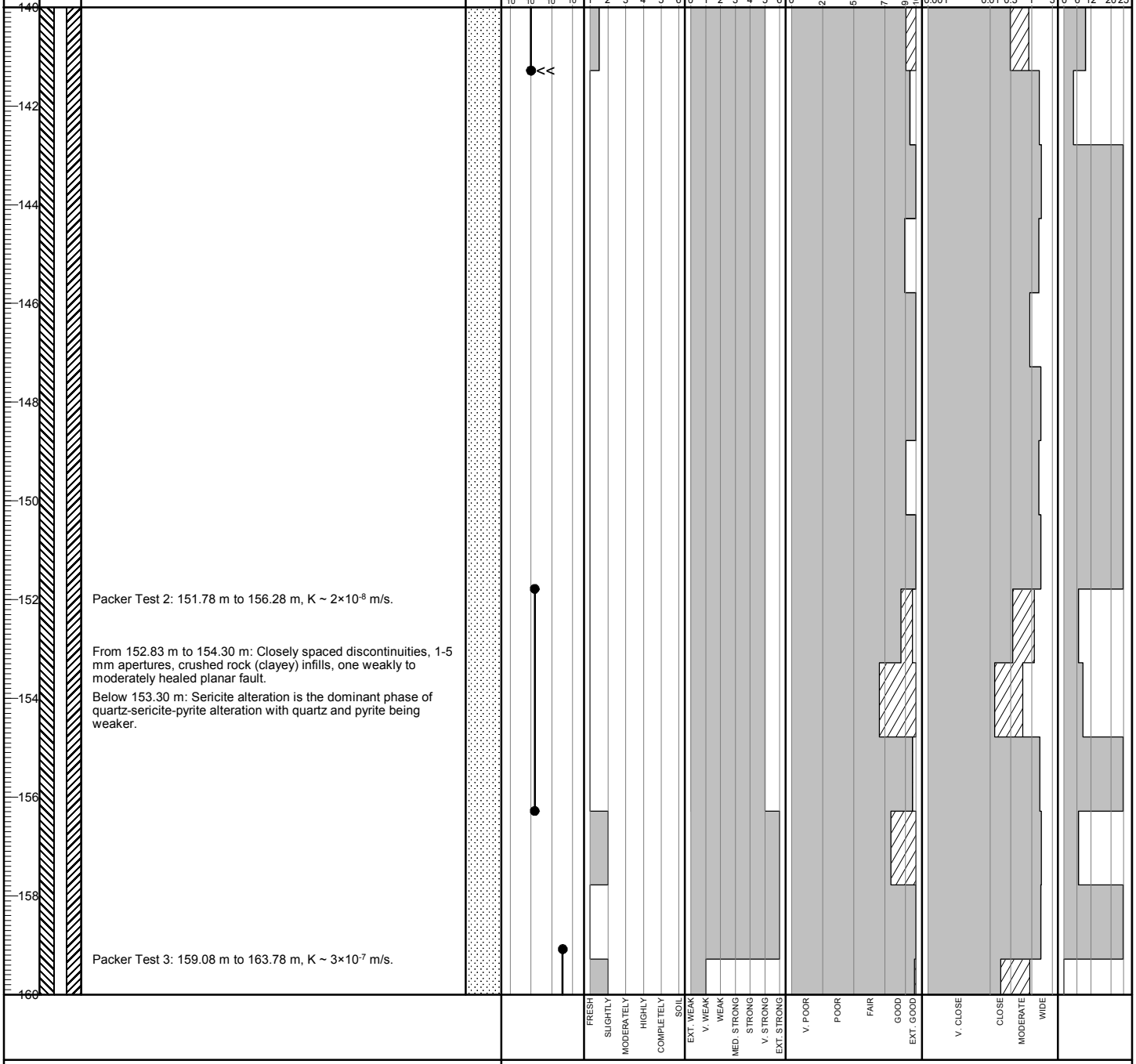
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 2: 151.78 m to 156.28 m, K ~ 2×10^{-8} m/s.

From 152.83 m to 154.30 m: Closely spaced discontinuities, 1-5 mm apertures, crushed rock (clayey) infills, one weakly to moderately healed planar fault.

Below 153.30 m: Sericite alteration is the dominant phase of quartz-sericite-pyrite alteration with quartz and pyrite being weaker.

Packer Test 3: 159.08 m to 163.78 m, K ~ 3×10^{-7} m/s.



BGC ENGINEERING INC.
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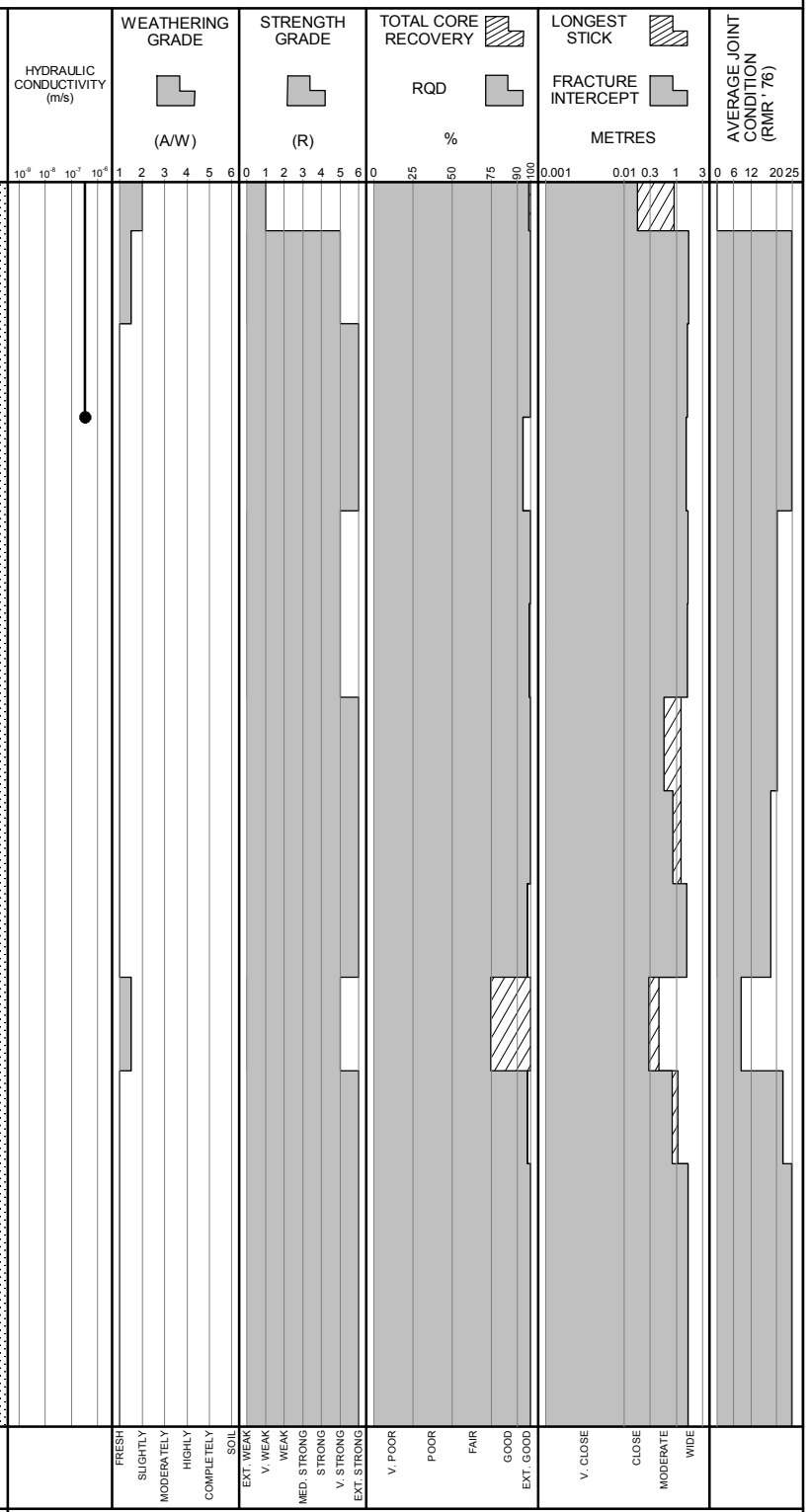
Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N	**Drill Designation:** Tech 5000	**Start Date:** 18 JUN 18
Ground Elevation (m): 1,550.33	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 24 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 255.28
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
160		At approximately 160 m: Minor loss of drilling fluid circulation.	
		At 160.25 m: Healed fault with angular fault fragments that are gouge-supported, sharp planar contacts, 70 mm aperture.	
162			
164			
166			
168			
170			
172			
174			
176			
178			
180			



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.78
Plunge (°): -90	**Fluid:** Water	**Logged By:** HM/LS
Trend (°): 000	**Cased To (m) :** 3.00	**Reviewed By:** HP

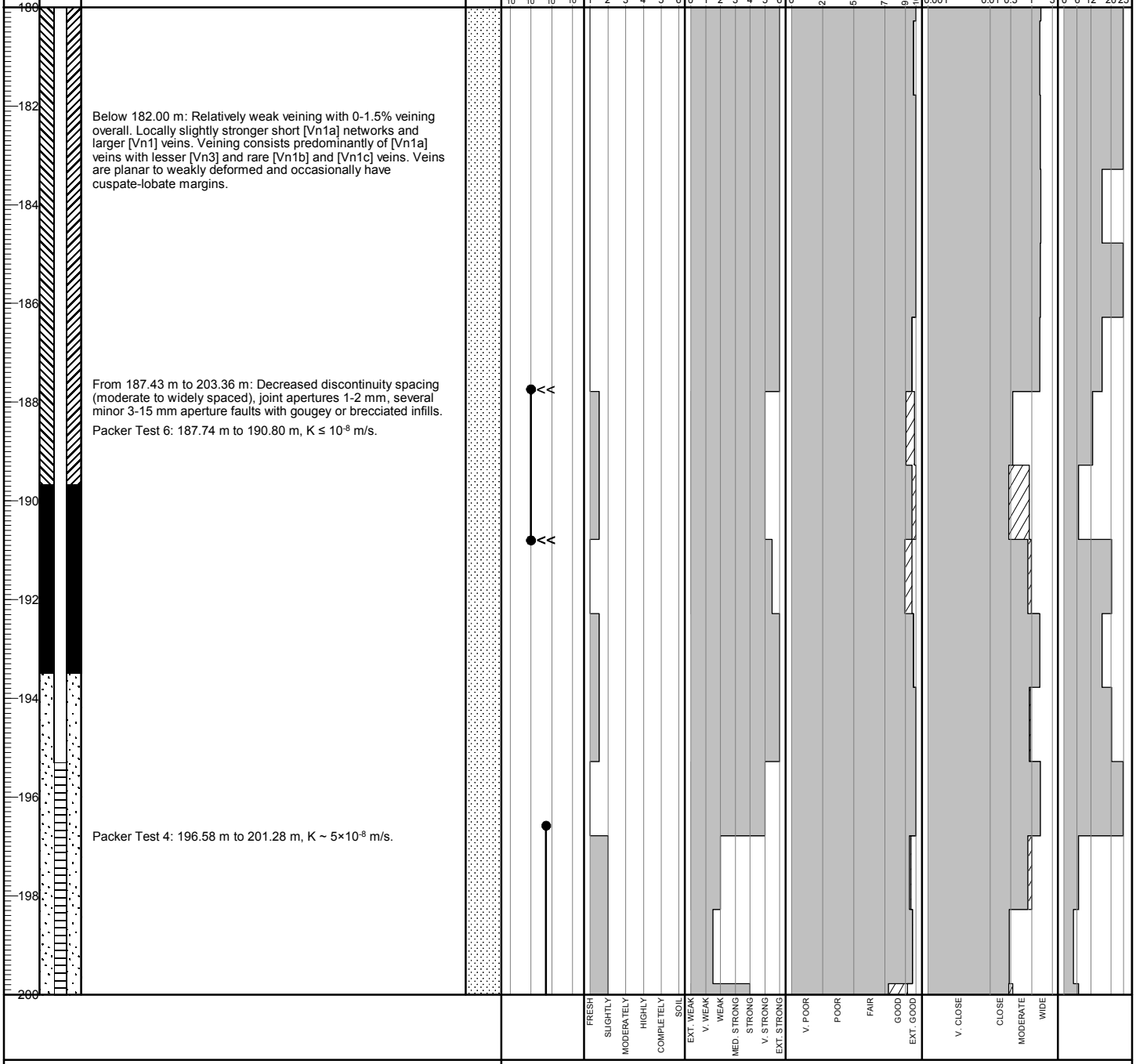
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Below 182.00 m: Relatively weak veining with 0-1.5% veining overall. Locally slightly stronger short [Vn1a] networks and larger [Vn1] veins. Veining consists predominantly of [Vn1a] veins with lesser [Vn3] and rare [Vn1b] and [Vn1c] veins. Veins are planar to weakly deformed and occasionally have cuspate-lobate margins.

From 187.43 m to 203.36 m: Decreased discontinuity spacing (moderate to widely spaced), joint apertures 1-2 mm, several minor 3-15 mm aperture faults with gougey or brecciated infills.

Packer Test 6: 187.74 m to 190.80 m, K ≤ 10^{-8} m/s.

Packer Test 4: 196.58 m to 201.28 m, K ~ 5×10^{-8} m/s.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

DRILL HOLE # BJ-GW18-21A

Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP

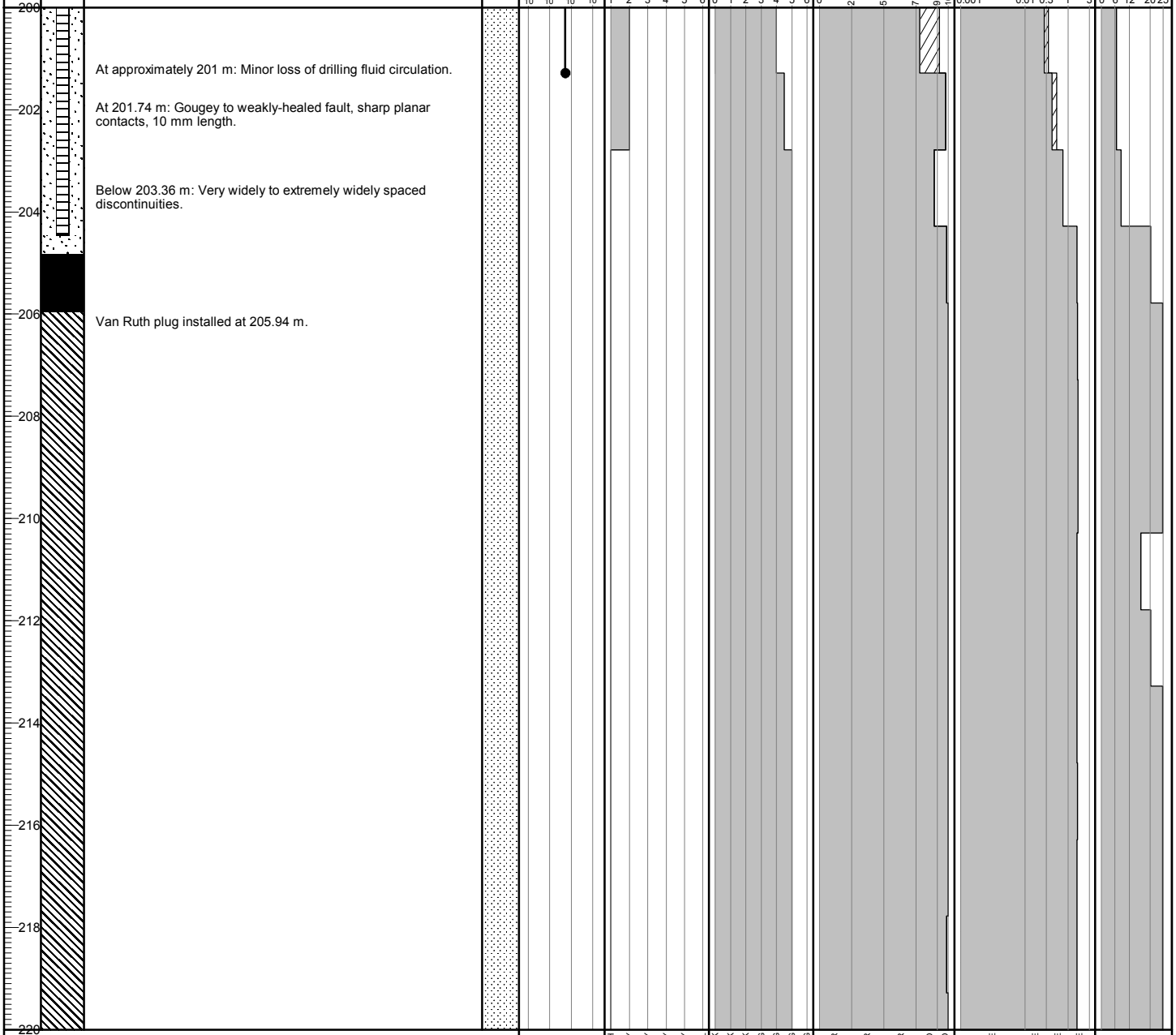
Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

At approximately 201 m: Minor loss of drilling fluid circulation.

At 201.74 m: Gougey to weakly-healed fault, sharp planar contacts, 10 mm length.

Below 203.36 m: Very widely to extremely widely spaced discontinuities.

Van Ruth plug installed at 205.94 m.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
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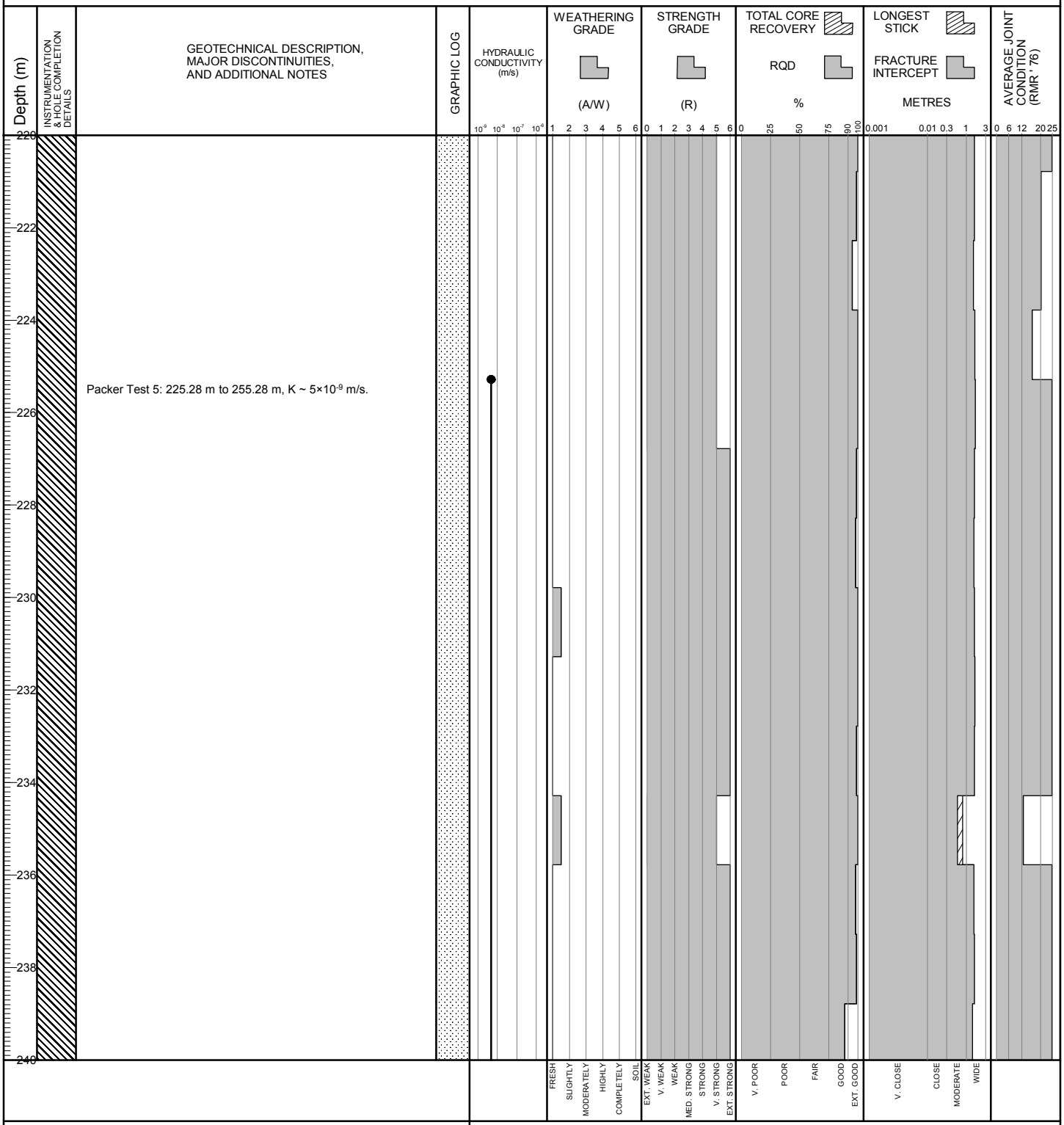

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21A

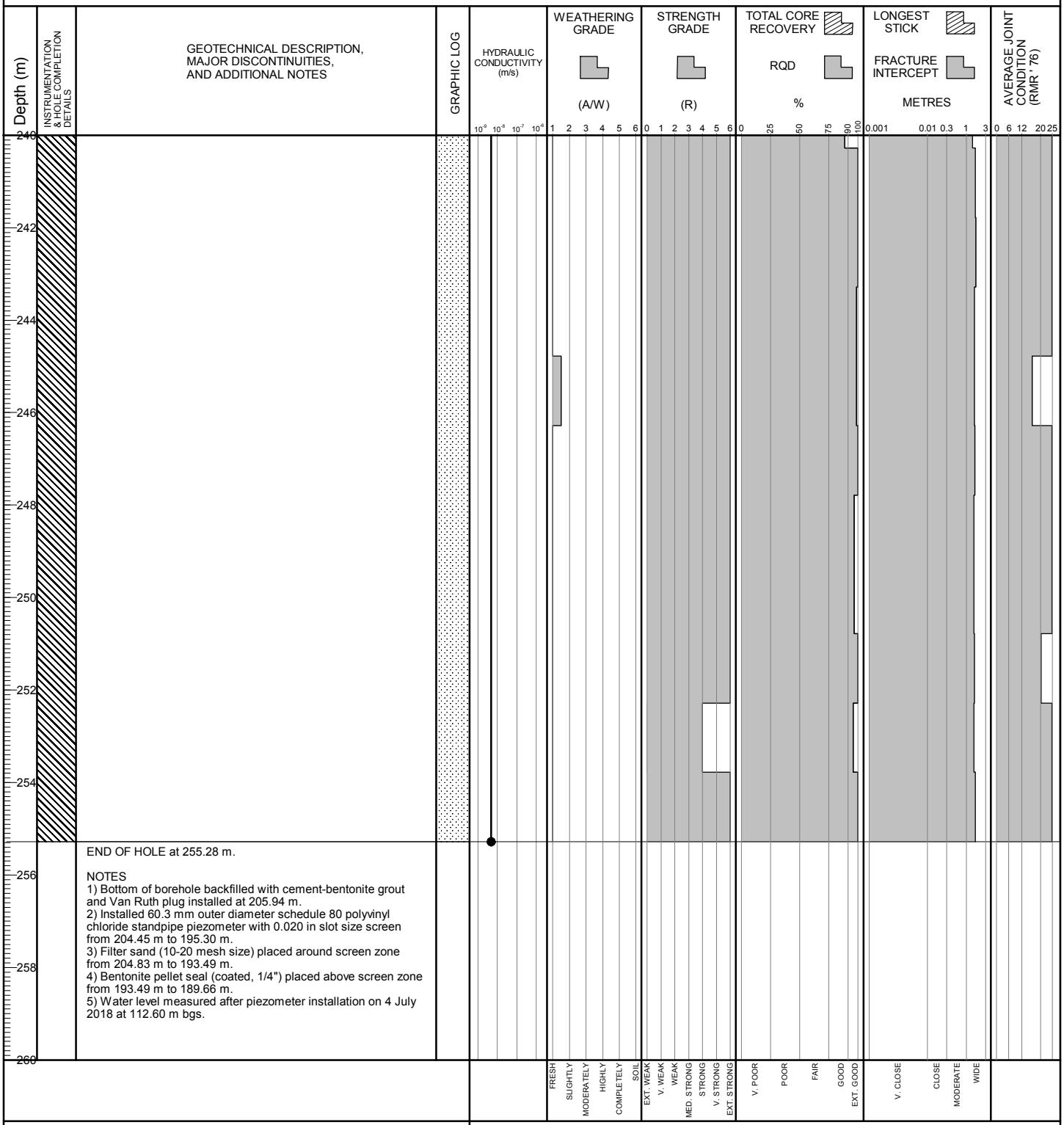
Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,661E - 6,257,806N
Ground Elevation (m): 1,550.33
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 3.00

Start Date: 18 JUN 18
Finish Date: 24 JUN 18
Final Depth (m): 255.28
Depth To Top Of Rock (m): 2.78
Logged By: HM/LS
Reviewed By: HP



END OF HOLE at 255.28 m.

NOTES
1) Bottom of borehole backfilled with cement-bentonite grout and Van Ruth plug installed at 205.94 m.
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 204.45 m to 195.30 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 204.83 m to 193.49 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 193.49 m to 189.66 m.
5) Water level measured after piezometer installation on 4 July 2018 at 112.60 m bgs.

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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21B

Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

OVERBURDEN (0.00 m to 2.77 m)

INTENSELY-SILICIFIED CONGLOMERATE [H8] (2.77 m to 8.20 m)
Grey, strongly silicified interval. Ghosted textures suggest original rock type was [S3]. Approximately 5% quartz veins as disarticulated [Vn1a] veins. Strong silicification of host and most fragments, minor sericite alteration of clasts.

Close to moderately spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, very strong to extremely strong, slightly weathered.

Discontinuity apertures generally < 1 mm, commonly with iron oxide staining on joint surfaces, some sand infill, primary joint orientations approximately 30° and 60° to core axis.

At 3.75 m: Weakly developed fault zone with minor fault gouge, 20 mm length.

At 6.17 m: Moderately developed fault zone with minor fault gouge, 170 mm length.

CONGLOMERATE [S3] (8.20 m to 29.80 m)
Grey-green, matrix-supported conglomerate with sub-rounded to rounded coarse, granular to pebble sized clasts. Clasts range from 2-100 mm and are commonly strongly sericite altered. Quartz veining, mostly disarticulated [Vn1a] veins and disarticulated and deformed [Vn1c]/[Vn1b] vein networks. Moderate vein associated silicification, with sericite alteration of fragments/clasts and chlorite alteration that is patchy throughout host matrix.

Moderately spaced discontinuities, slightly rough joint surfaces with variable but mostly highly weathered walls, very strong to extremely strong, slightly weathered to fresh.

Discontinuity apertures generally 0.5-5 mm, some iron oxide staining on joint surfaces in shallower part of unit, some crushed/disintegrated rock (clayey or sandy) infill, minor calcite coatings, variable joint orientations.

From 11.40 m to 19.14 m: Four minor to moderately developed fault zones with some fault gouge, 15-140 mm length.

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
RQD: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
FRACTURE INTERCEPT: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

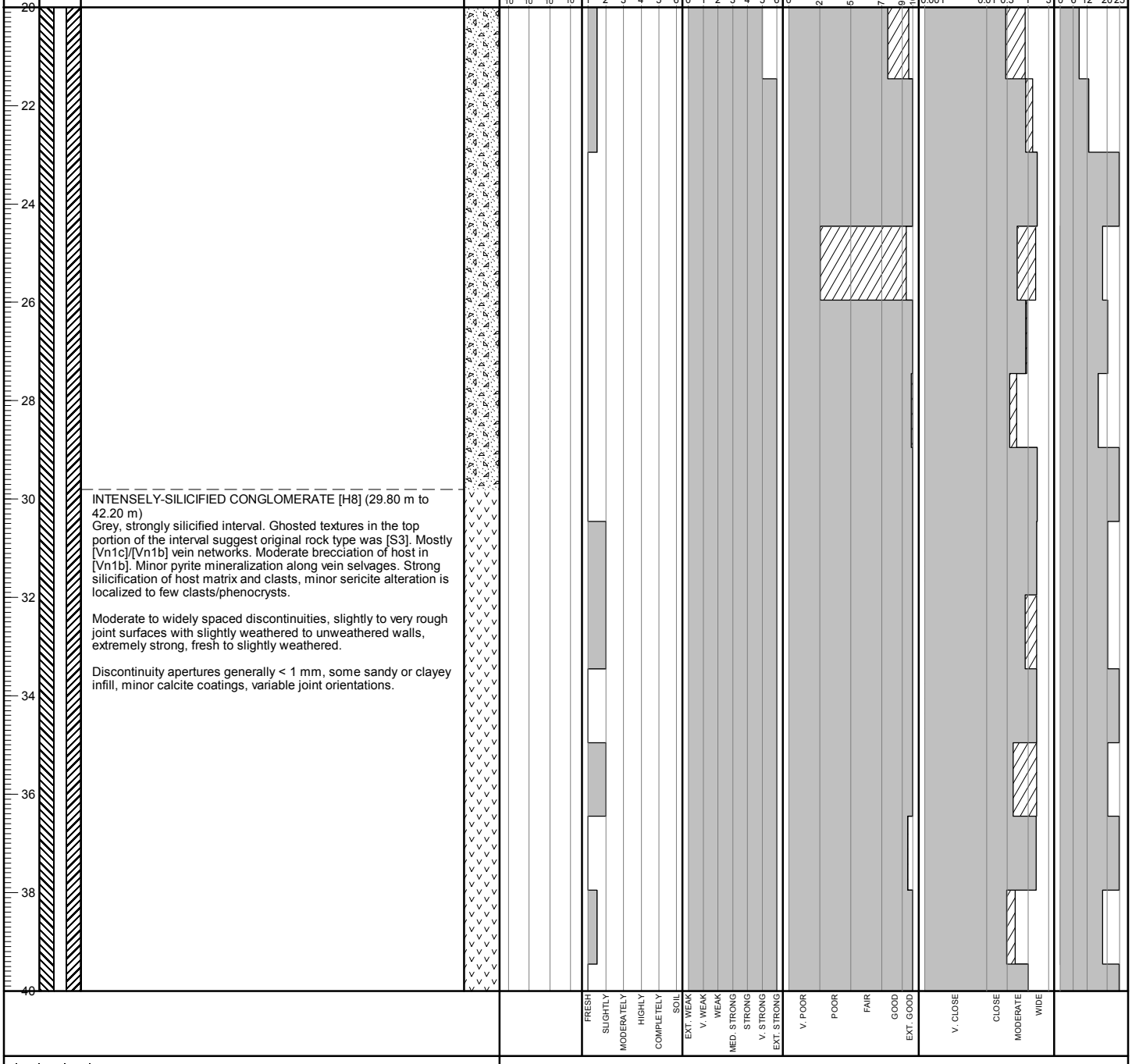
Co-ordinates (m): 426,660E - 6,257,807N	**Drill Designation:** Tech 5000	**Start Date:** 24 JUN 18
Ground Elevation (m): 1,550.34	**Drilling Contractor:** Hy-Tech Drilling Ltd.	**Finish Date:** 29 JUN 18
Survey Method: Mine Survey	**Drill Method:** Diamond Coring	**Final Depth (m):** 159.45
Datum: UTM NAD 83 Zone 9	**Core:** PQ3	**Depth To Top Of Rock (m):** 2.77
Plunge (°): -90	**Fluid:** Water	**Logged By:** LS/HM/BM
Trend (°): 000	**Cased To (m) :** 4.50	**Reviewed By:** HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

INTENSELY-SILICIFIED CONGLOMERATE [H8] (29.80 m to 42.20 m)
Grey, strongly silicified interval. Ghosted textures in the top portion of the interval suggest original rock type was [S3]. Mostly [Vn1c]/[Vn1b] vein networks. Moderate brecciation of host in [Vn1b]. Minor pyrite mineralization along vein selvages. Strong silicification of host matrix and clasts, minor sericite alteration is localized to few clasts/phenocrysts.

Moderate to widely spaced discontinuities, slightly to very rough joint surfaces with slightly weathered to unweathered walls, extremely strong, fresh to slightly weathered.

Discontinuity apertures generally < 1 mm, some sandy or clayey infill, minor calcite coatings, variable joint orientations.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
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Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
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Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

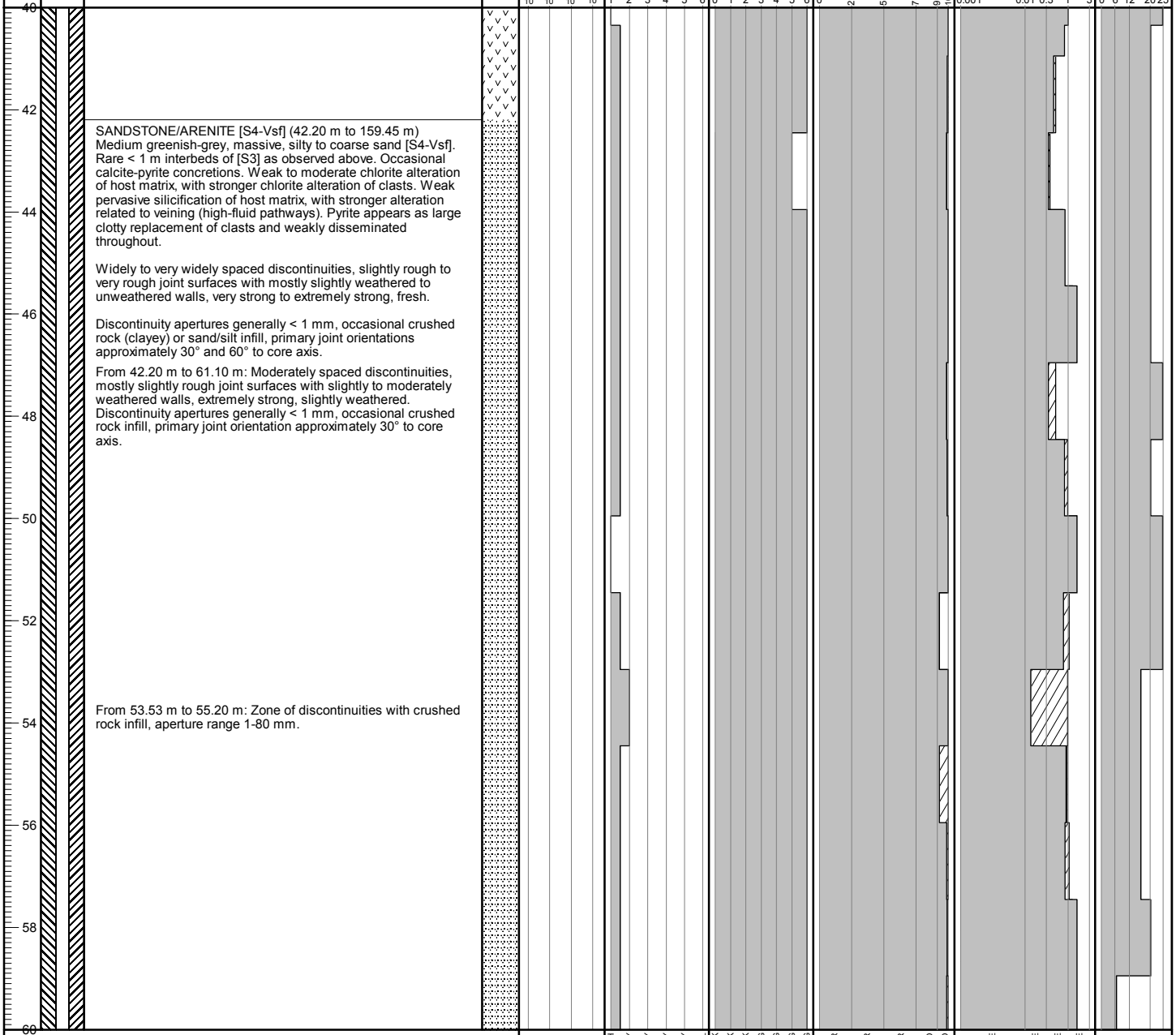
SANDSTONE/ARENITE [S4-Vsf] (42.20 m to 159.45 m)
Medium greenish-grey, massive, silty to coarse sand [S4-Vsf]. Rare < 1 m interbeds of [S3] as observed above. Occasional calcite-pyrite concretions. Weak to moderate chlorite alteration of host matrix, with stronger chlorite alteration of clasts. Weak pervasive silicification of host matrix, with stronger alteration related to veining (high-fluid pathways). Pyrite appears as large clotty replacement of clasts and weakly disseminated throughout.

Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with mostly slightly weathered to unweathered walls, very strong to extremely strong, fresh.

Discontinuity apertures generally < 1 mm, occasional crushed rock (clayey) or sand/silt infill, primary joint orientations approximately 30° and 60° to core axis.

From 42.20 m to 61.10 m: Moderately spaced discontinuities, mostly slightly rough joint surfaces with slightly to moderately weathered walls, extremely strong, slightly weathered. Discontinuity apertures generally < 1 mm, occasional crushed rock infill, primary joint orientation approximately 30° to core axis.

From 53.53 m to 55.20 m: Zone of discontinuities with crushed rock infill, aperture range 1-80 mm.



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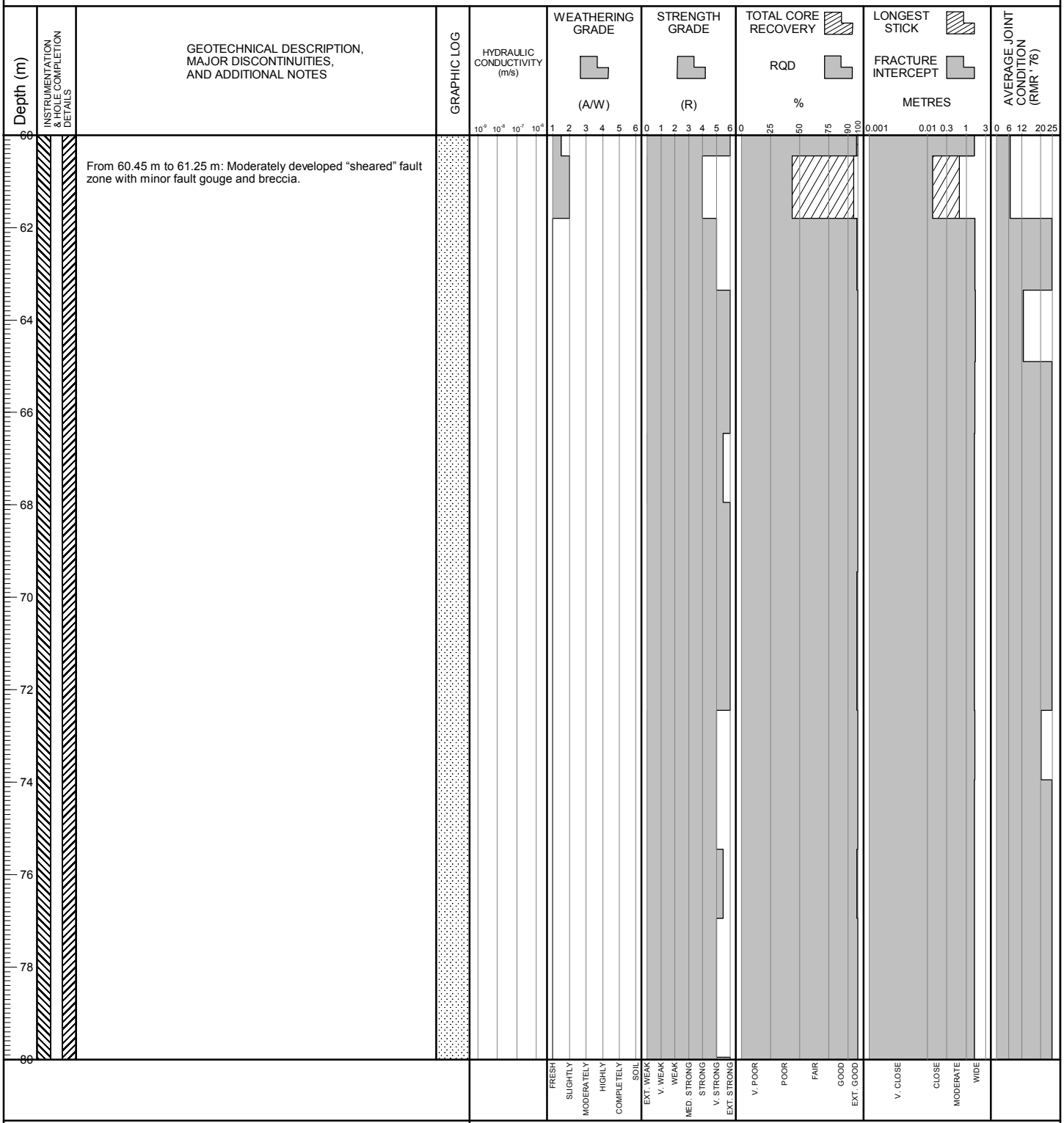
Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
60–80	From 60.45 m to 61.25 m: Moderately developed "sheared" fault zone with minor fault gouge and breccia.



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Drill Method: Diamond Coring
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Fluid: Water
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Start Date: 24 JUN 18
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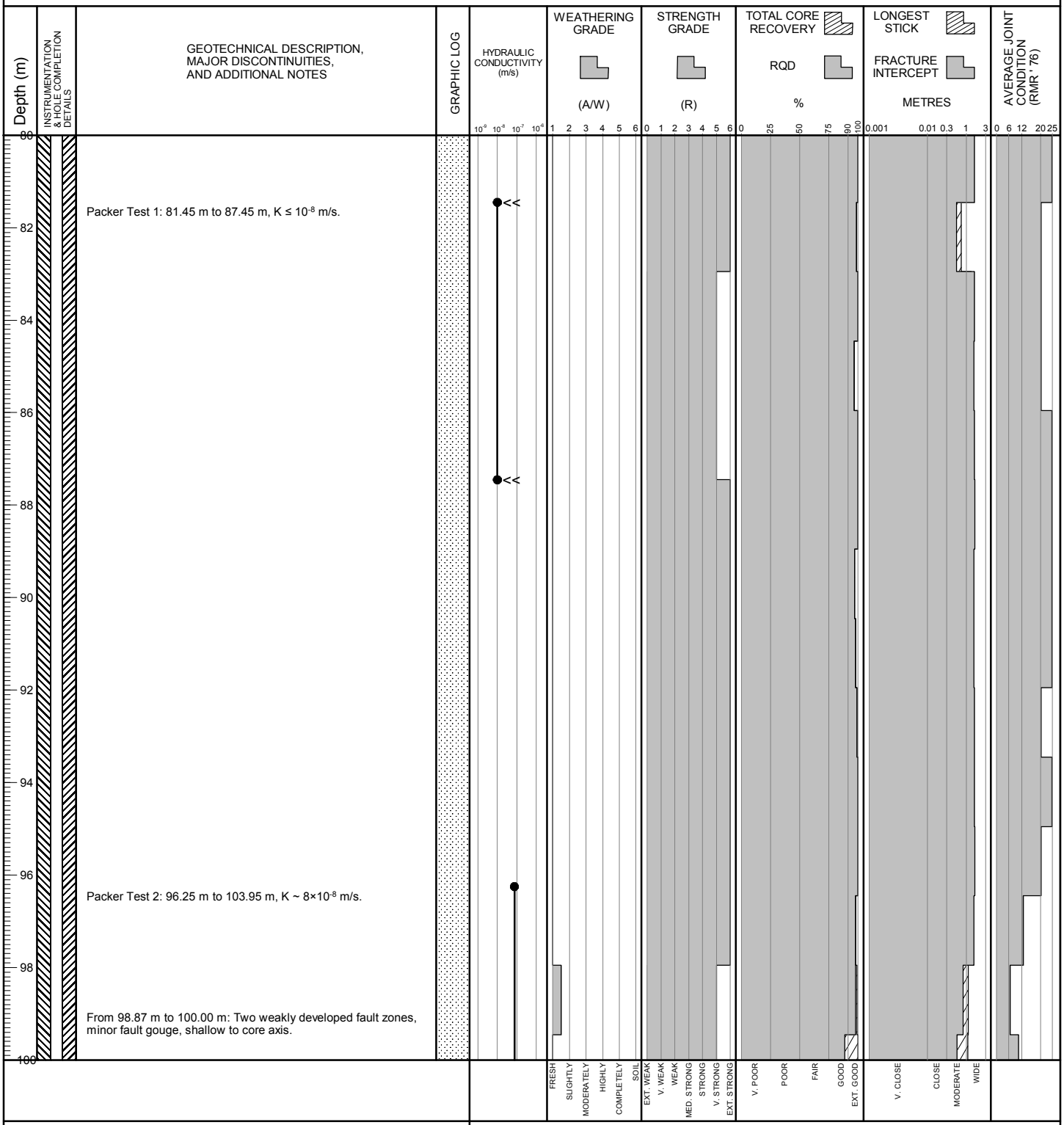

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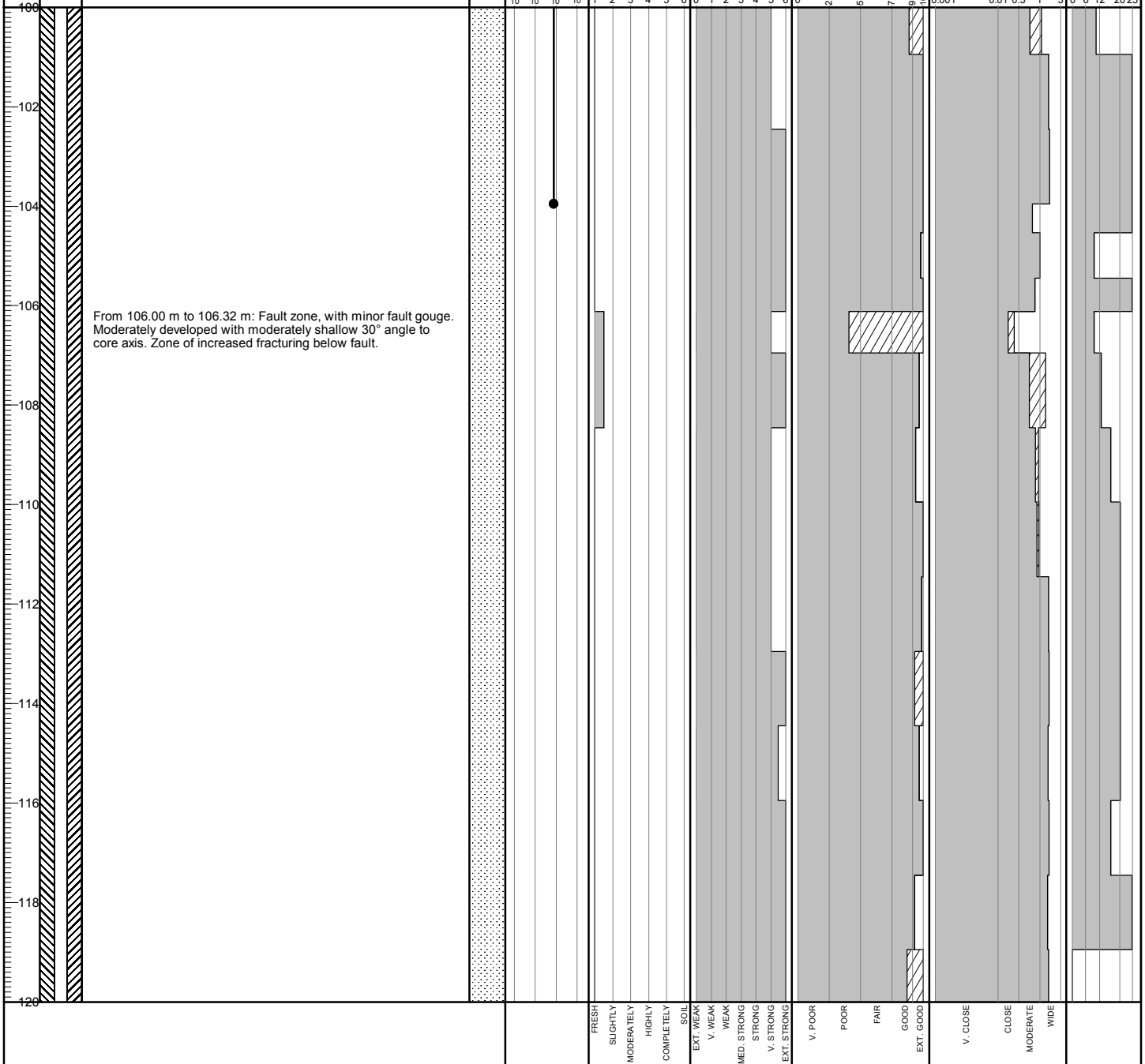
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
100–120		From 106.00 m to 106.32 m: Fault zone, with minor fault gouge. Moderately developed with moderately shallow 30° angle to core axis. Zone of increased fracturing below fault.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
120		From 120.12 m to 120.45 m: Moderately developed fault zone with fault gouge.
122		
124		
126		
128		
130		Packer Test 3: 130.75 m to 150.45 m, K ~ 2×10^{-9} m/s.
132		
134		
136		
138		
140		

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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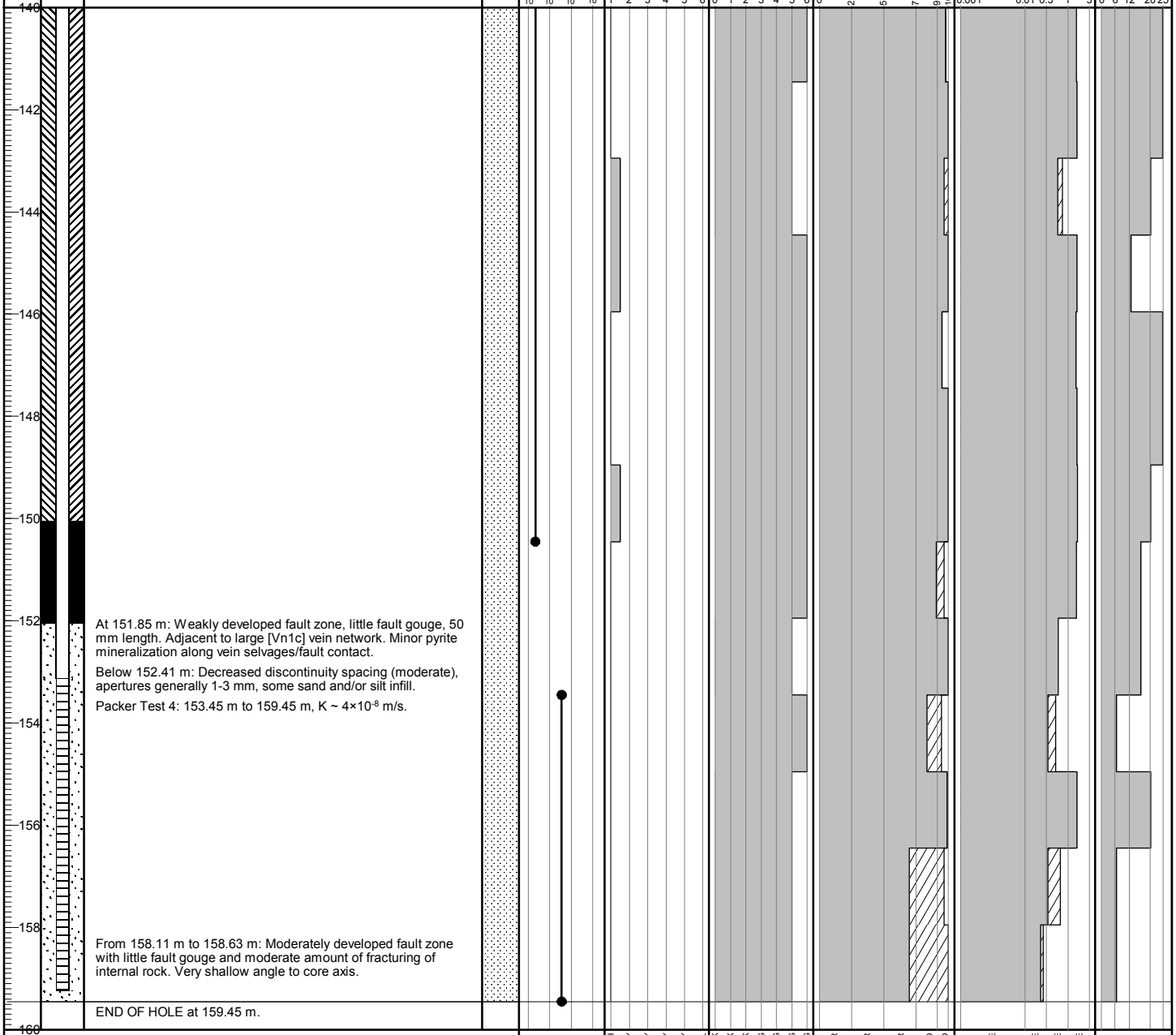
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-21B

Project No.: 1008-029

Location: South Valley of Kings

Co-ordinates (m): 426,660E - 6,257,807N
Ground Elevation (m): 1,550.34
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.50

Start Date: 24 JUN 18
Finish Date: 29 JUN 18
Final Depth (m): 159.45
Depth To Top Of Rock (m): 2.77
Logged By: LS/HM/BM
Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
160		NOTES 1) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 159.23 m to 153.13 m. 2) Filter sand (10-20 mesh size) placed around screen zone from 159.45 m to 152.05 m. 3) Bentonite pellet seal (coated, 1/4") placed above screen zone from 152.05 m to 150.05 m. 4) Water level measured after piezometer installation on 4 July 2018 at 122.70 m bgs.							
162									
164									
166									
168									
170									
172									
174									
176									
178									
180									

Hydraulic conductivity: 10^{-9} 10^{-8} 10^{-7} 10^{-6}
Weathering grade (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
Strength grade (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
Total core recovery / RQD %: 0, 25, 50, 75, 90, 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
Longest stick / fracture intercept metres: 0.001, 0.01, 0.3, 1, 3 — V. CLOSE, CLOSE, MODERATE, WIDE
Average joint condition (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

FILL and OVERBURDEN (0.00 m to 3.10 m)

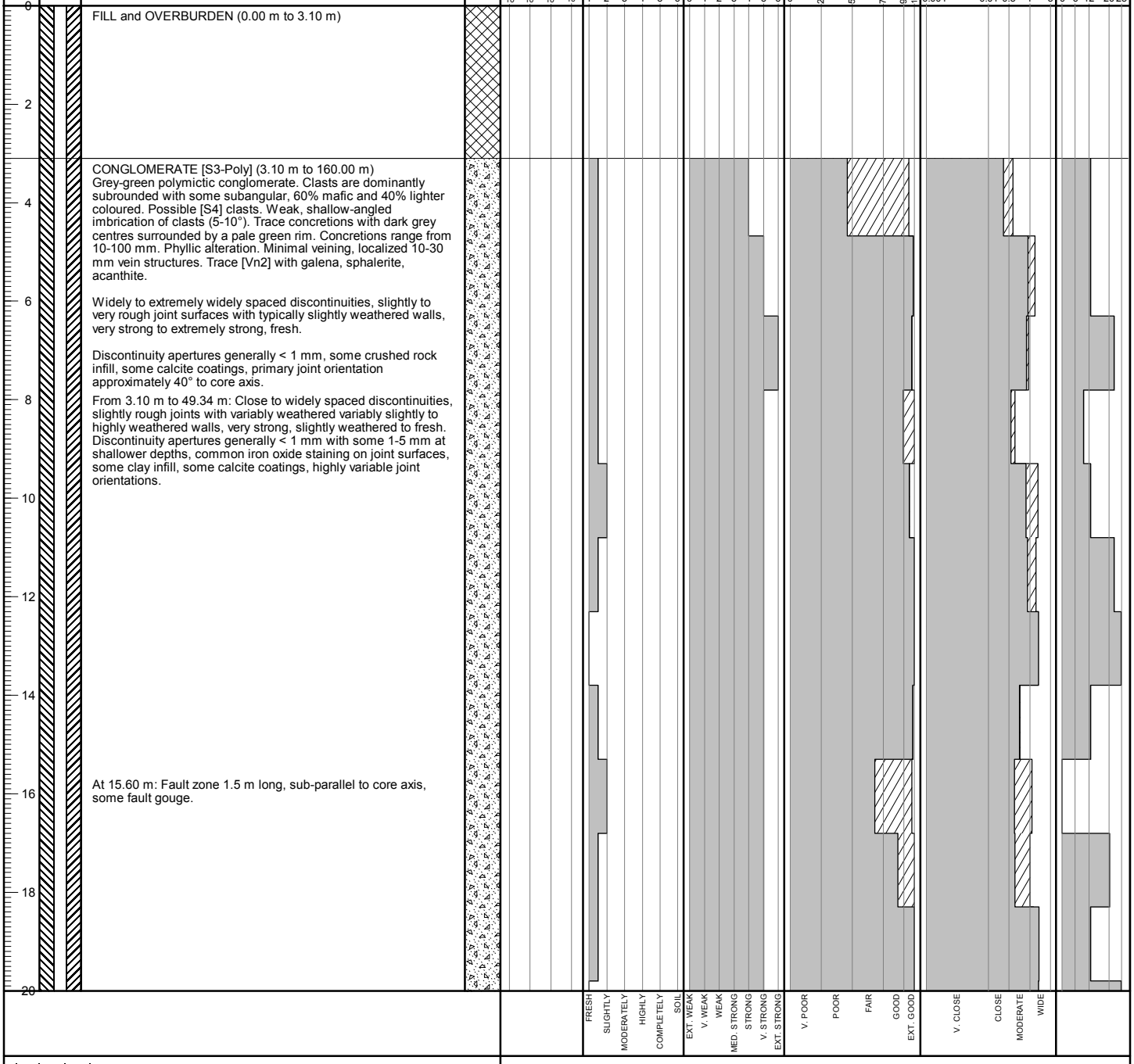
CONGLOMERATE [S3-Poly] (3.10 m to 160.00 m)
Grey-green polymictic conglomerate. Clasts are dominantly subrounded with some subangular, 60% mafic and 40% lighter coloured. Possible [S4] clasts. Weak, shallow-angled imbrication of clasts (5-10°). Trace concretions with dark grey centres surrounded by a pale green rim. Concretions range from 10-100 mm. Phyllic alteration. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite.

Widely to extremely widely spaced discontinuities, slightly to very rough joint surfaces with typically slightly weathered walls, very strong to extremely strong, fresh.

Discontinuity apertures generally < 1 mm, some crushed rock infill, some calcite coatings, primary joint orientation approximately 40° to core axis.

From 3.10 m to 49.34 m: Close to widely spaced discontinuities, slightly rough joints with variably weathered variably slightly to highly weathered walls, very strong, slightly weathered to fresh. Discontinuity apertures generally < 1 mm with some 1-5 mm at shallower depths, common iron oxide staining on joint surfaces, some clay infill, some calcite coatings, highly variable joint orientations.

At 15.60 m: Fault zone 1.5 m long, sub-parallel to core axis, some fault gouge.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

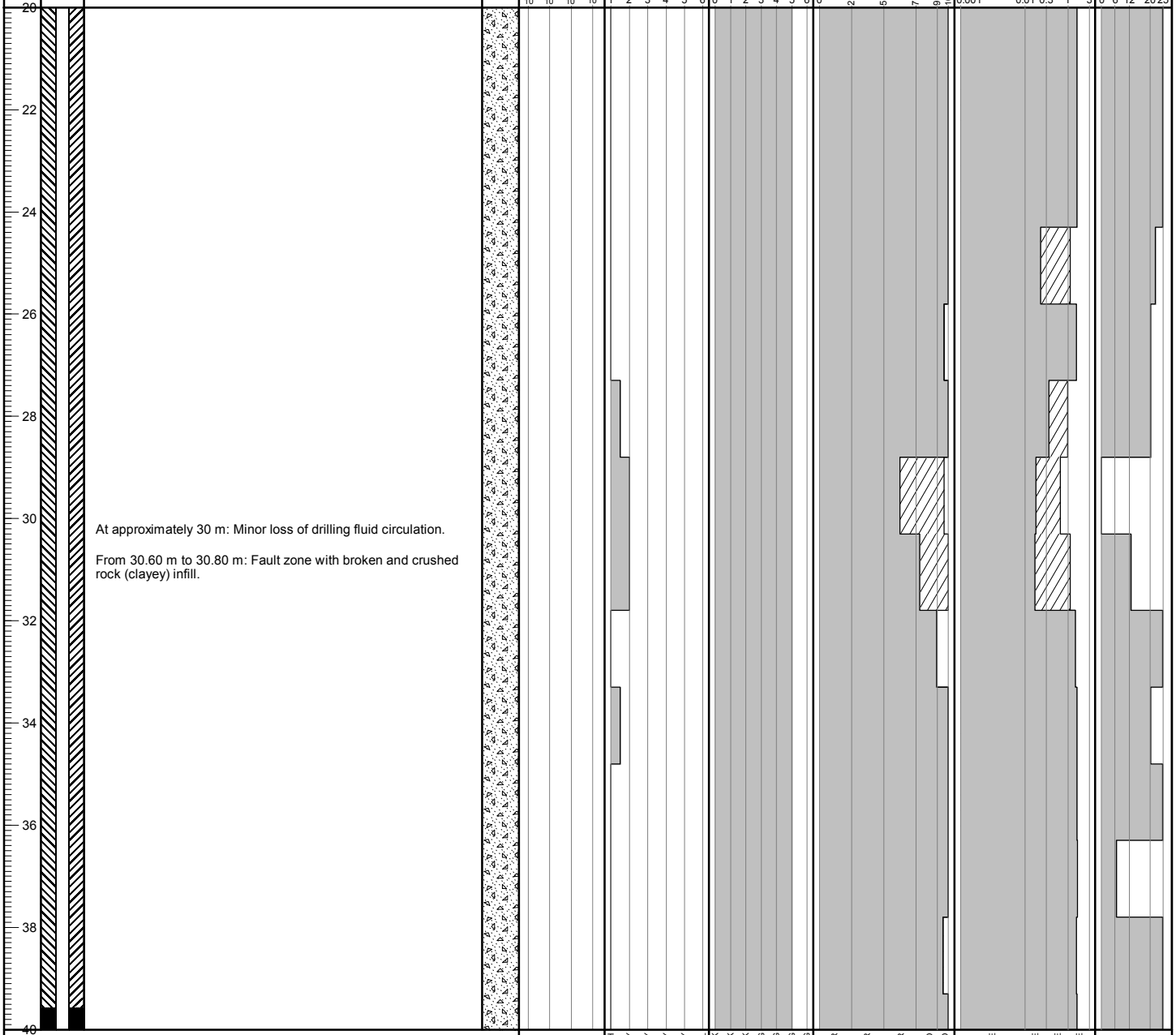
Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

At approximately 30 m: Minor loss of drilling fluid circulation.

From 30.60 m to 30.80 m: Fault zone with broken and crushed rock (clayey) infill.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

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Fluid: Water
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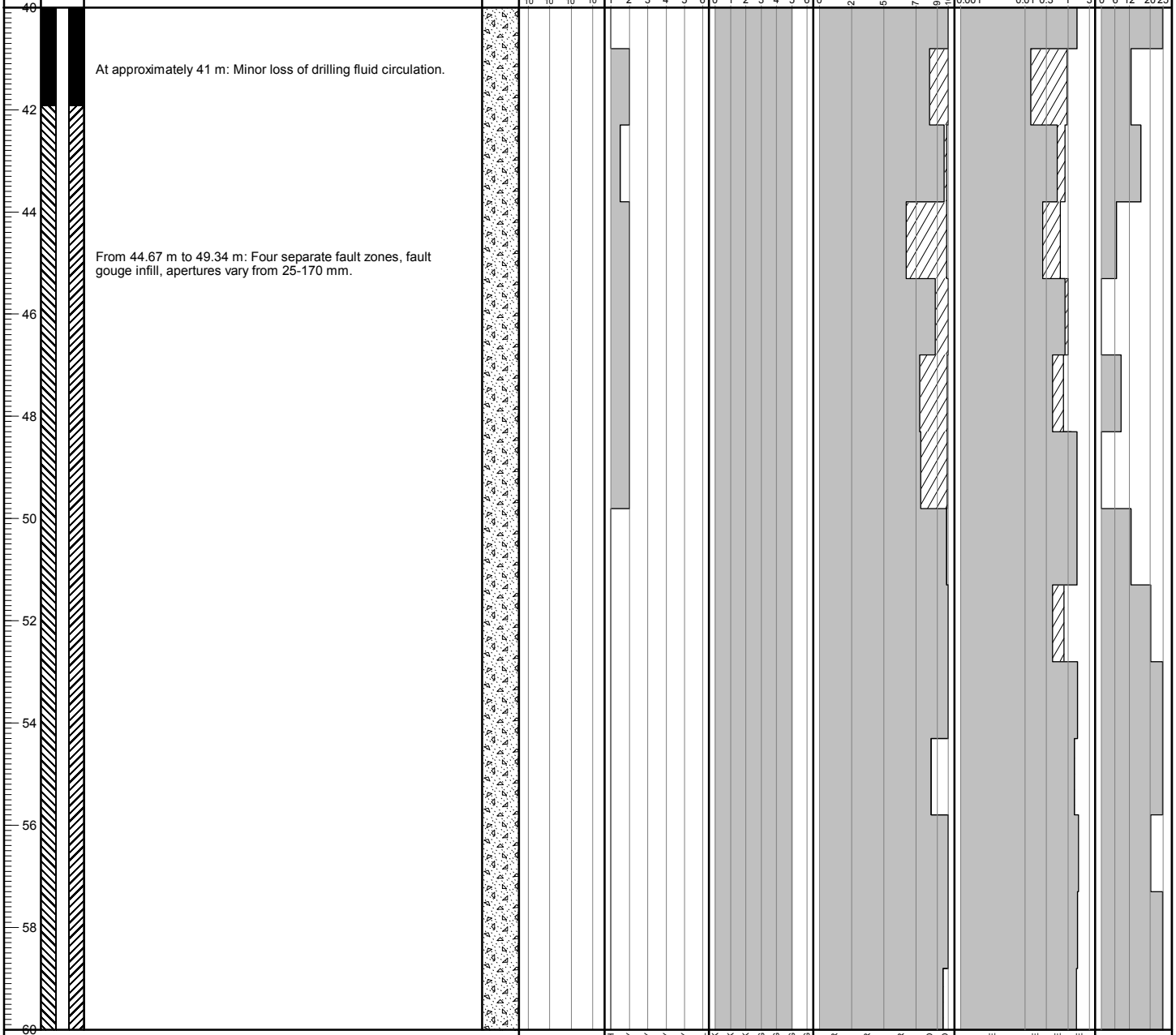
At approximately 41 m: Minor loss of drilling fluid circulation.

From 44.67 m to 49.34 m: Four separate fault zones, fault gouge infill, apertures vary from 25-170 mm.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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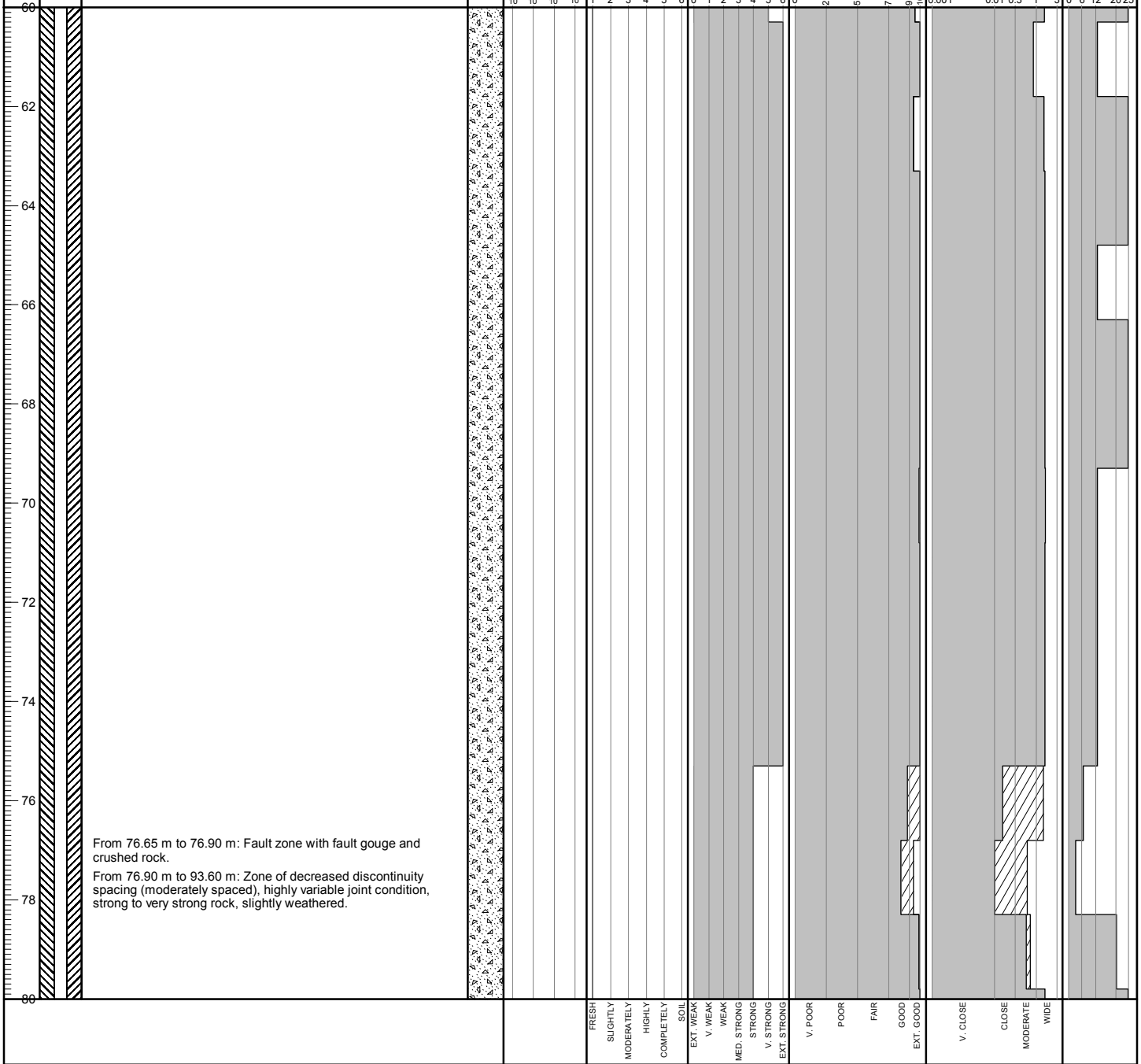

From 76.65 m to 76.90 m: Fault zone with fault gouge and crushed rock.

From 76.90 m to 93.60 m: Zone of decreased discontinuity spacing (moderately spaced), highly variable joint condition, strong to very strong rock, slightly weathered.

Project No.: 1008-029 **Location:** Twin Towers

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Ground Elevation (m): 1,444.64
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Trend (°): 000

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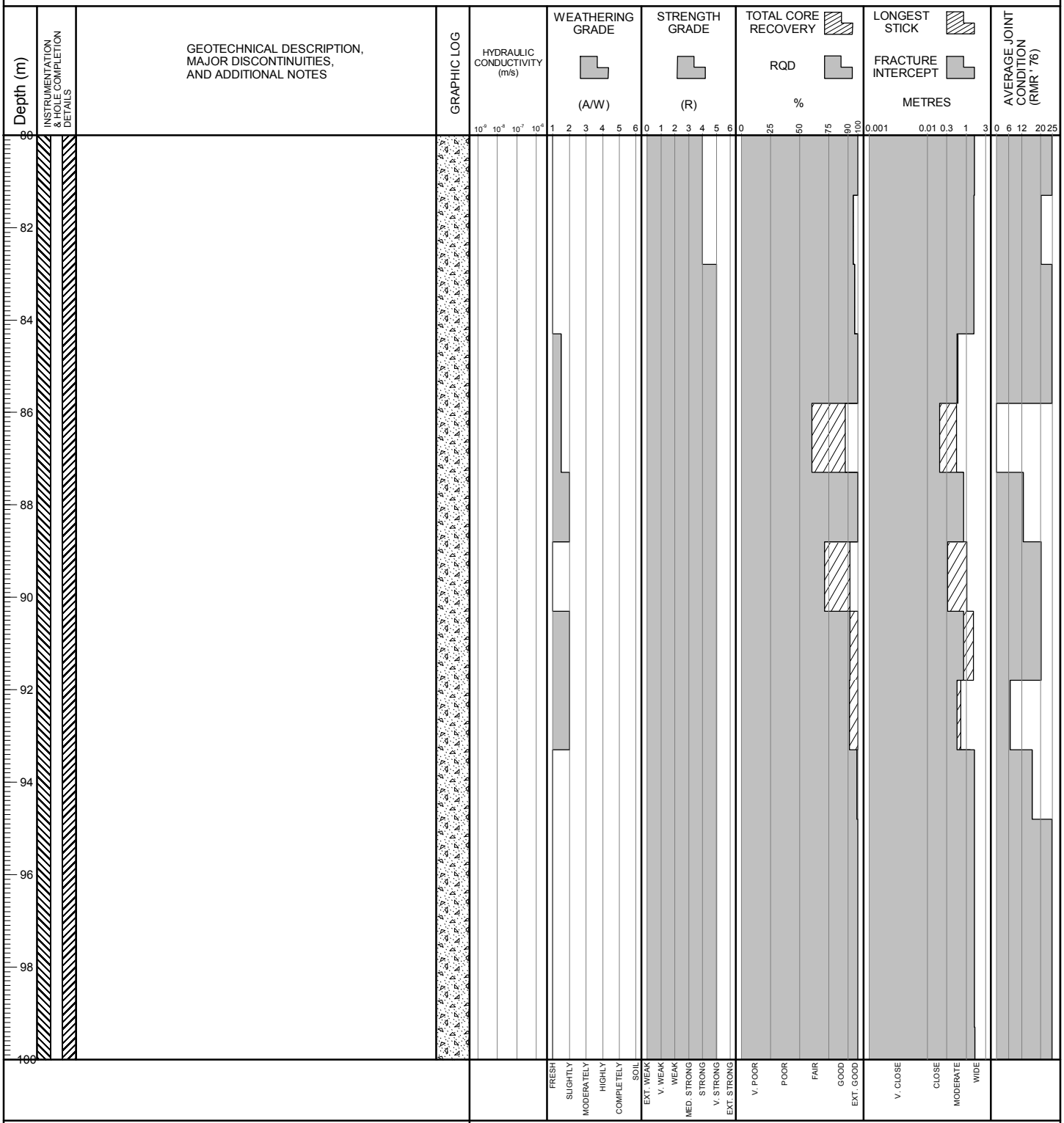

BGC ENGINEERING INC.
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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029

Location: Twin Towers

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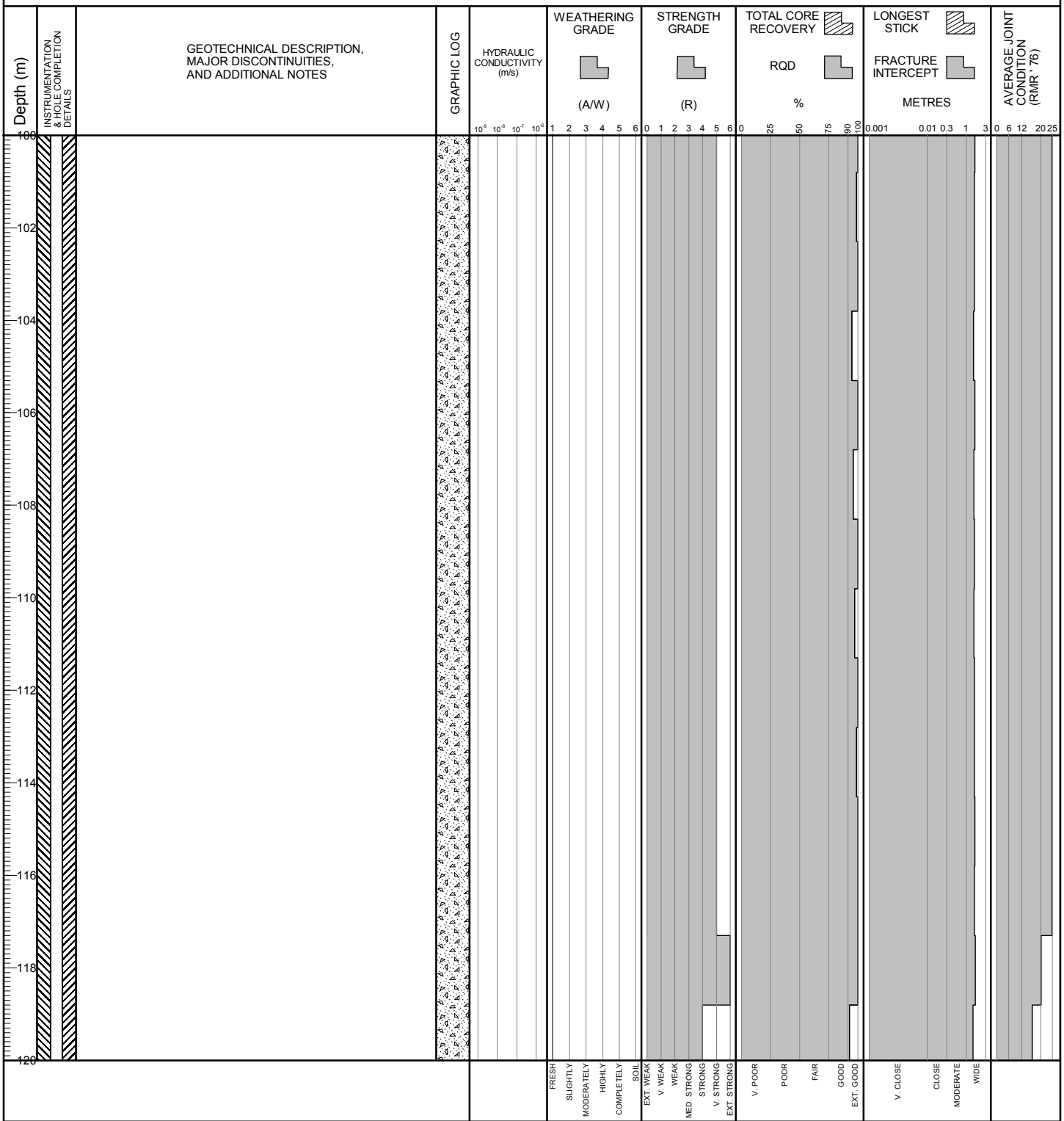

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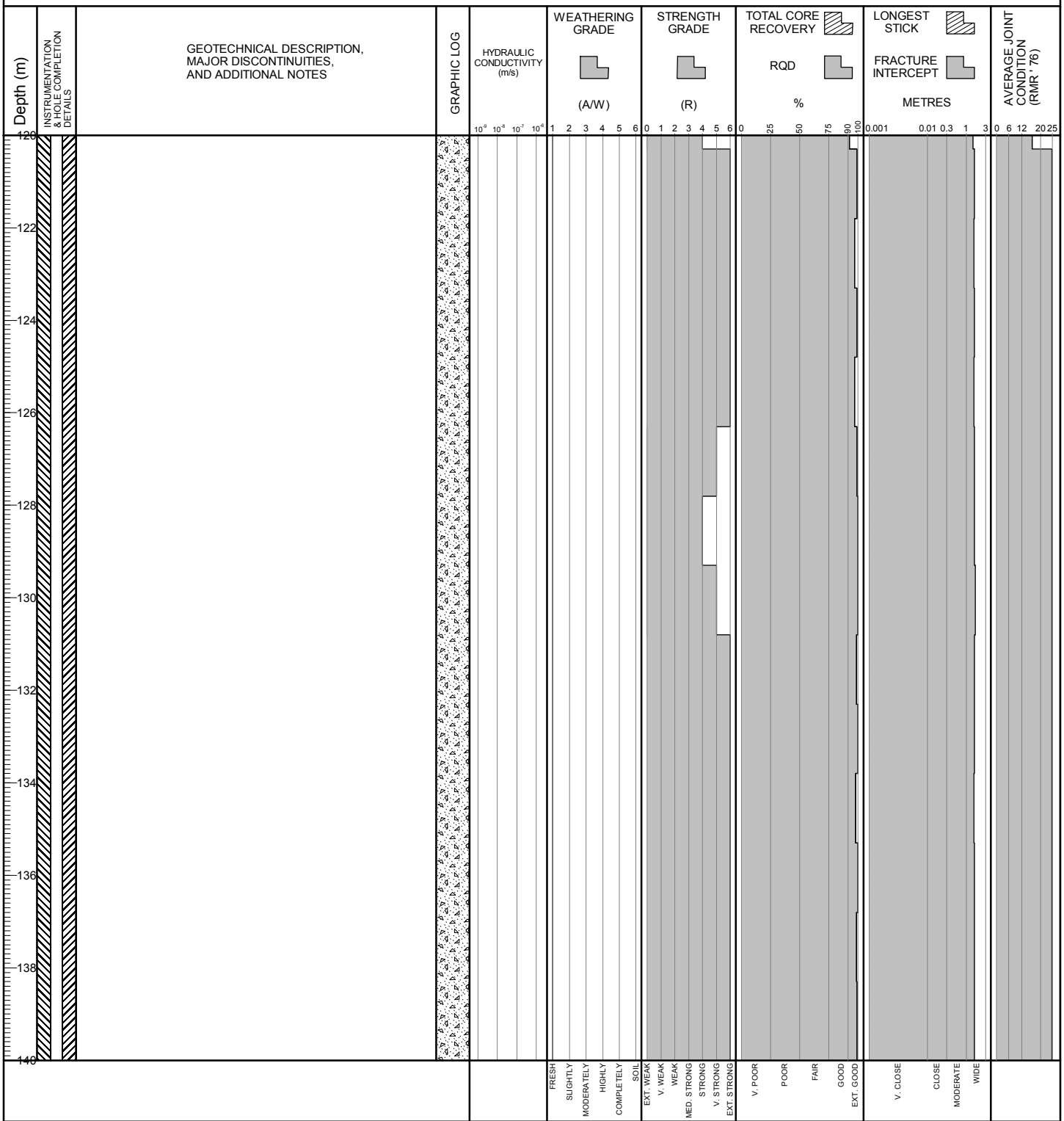

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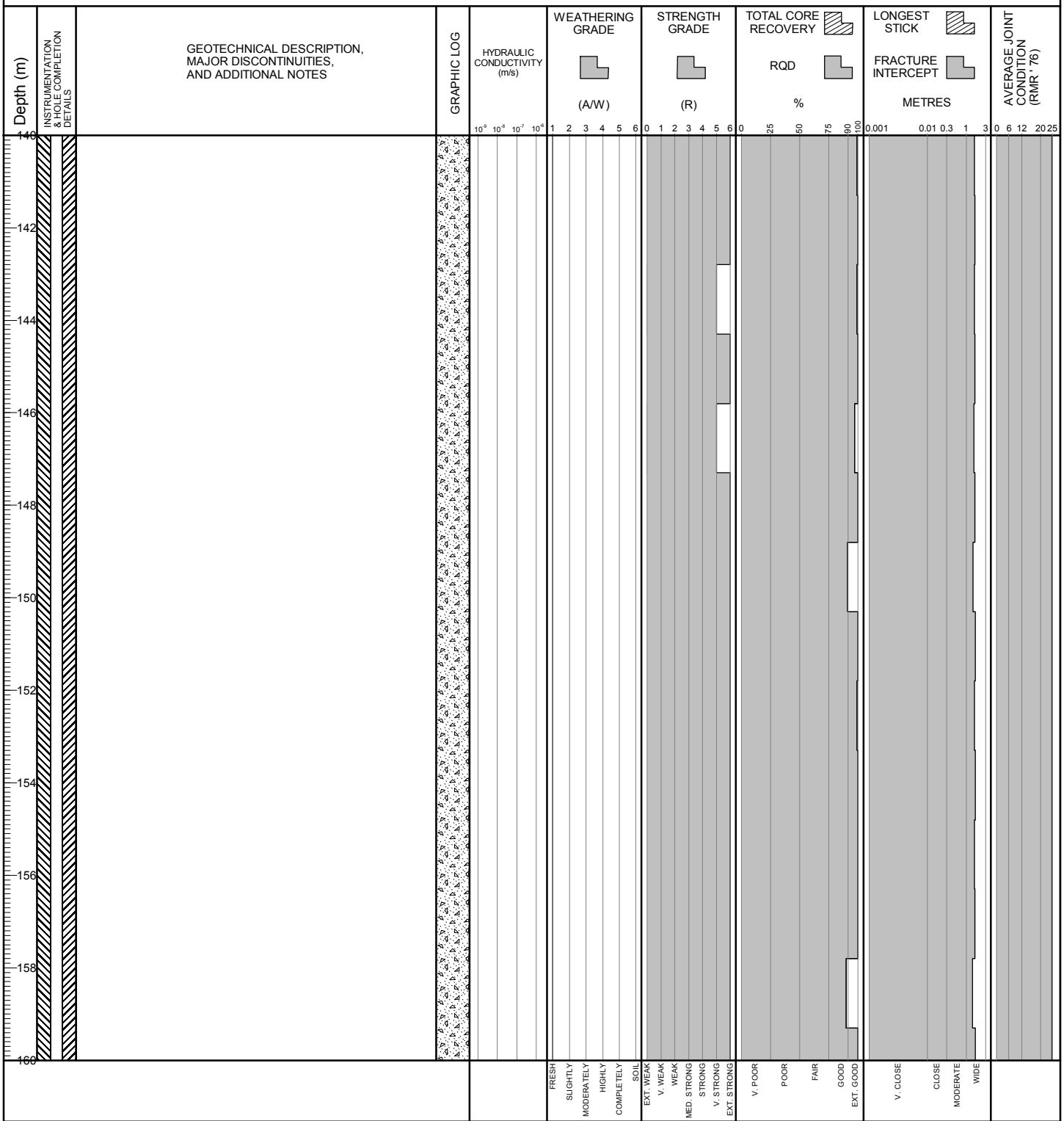

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Logged By: FP/KB
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes	Graphic Log	Hydraulic Conductivity (m/s)	Weathering Grade (A/W)	Strength Grade (R)	Total Core Recovery / RQD (%)	Longest Stick / Fracture Intercept (Metres)	Average Joint Condition (RMR' 76)
160		SANDSTONE/ARENITE [S4-Vsf] (160.00 m to 195.00 m) Light to medium green, fine to medium grained sandstone. Interbedded with intervals of polymictic conglomerate up to 1.5 m. Phyllic alteration. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite. Extremely strong, fresh.		10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
162									
164									
166									
168									
170									
172									
174									
176									
178									
180					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

Project No.: 1008-029 **Location:** Twin Towers

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Datum: UTM NAD 83 Zone 9
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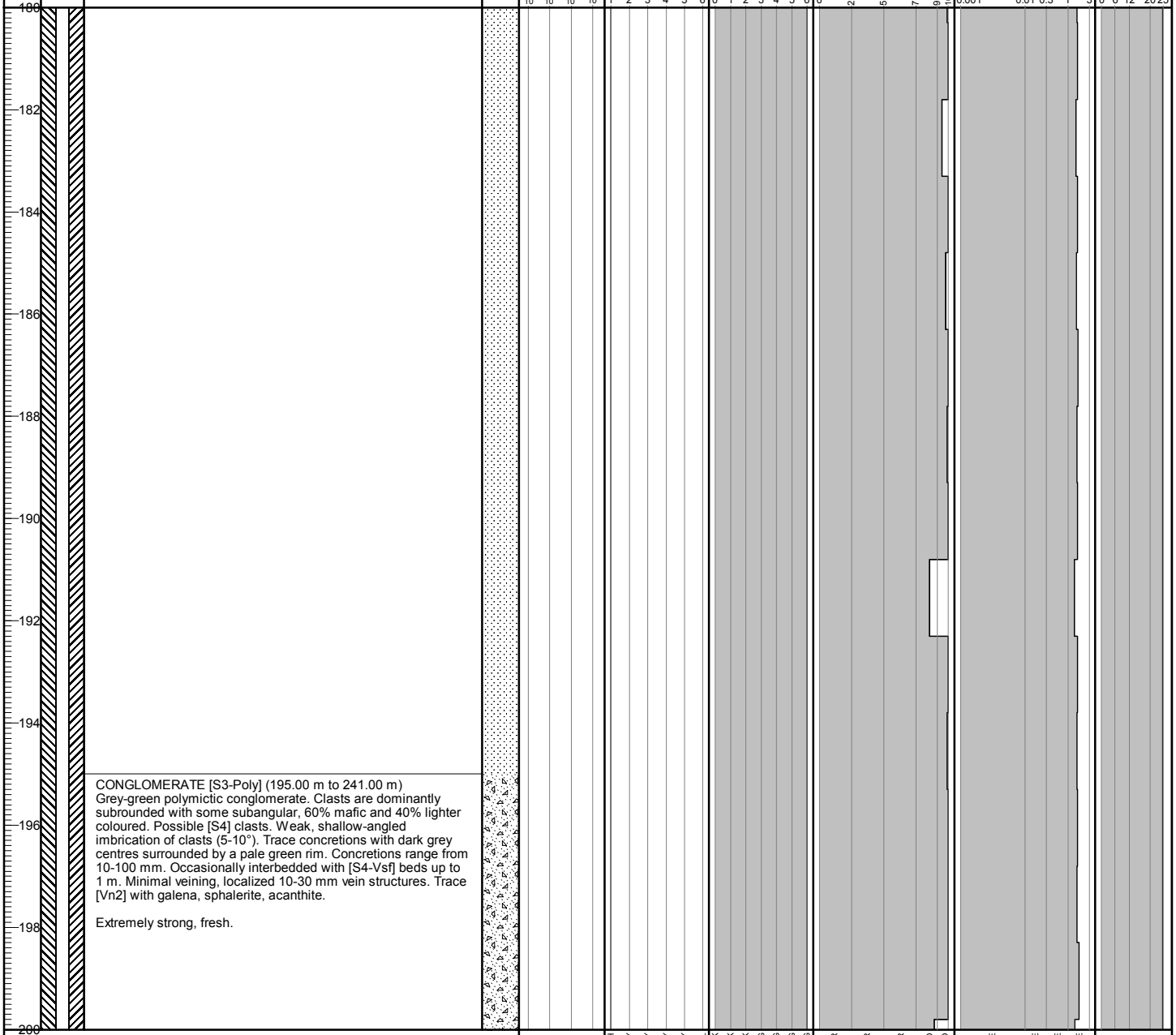

CONGLOMERATE [S3-Poly] (195.00 m to 241.00 m)
Grey-green polymictic conglomerate. Clasts are dominantly subrounded with some subangular, 60% mafic and 40% lighter coloured. Possible [S4] clasts. Weak, shallow-angled imbrication of clasts (5-10°). Trace concretions with dark grey centres surrounded by a pale green rim. Concretions range from 10-100 mm. Occasionally interbedded with [S4-Vsf] beds up to 1 m. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite.

Extremely strong, fresh.

Project No.: 1008-029 **Location:** Twin Towers

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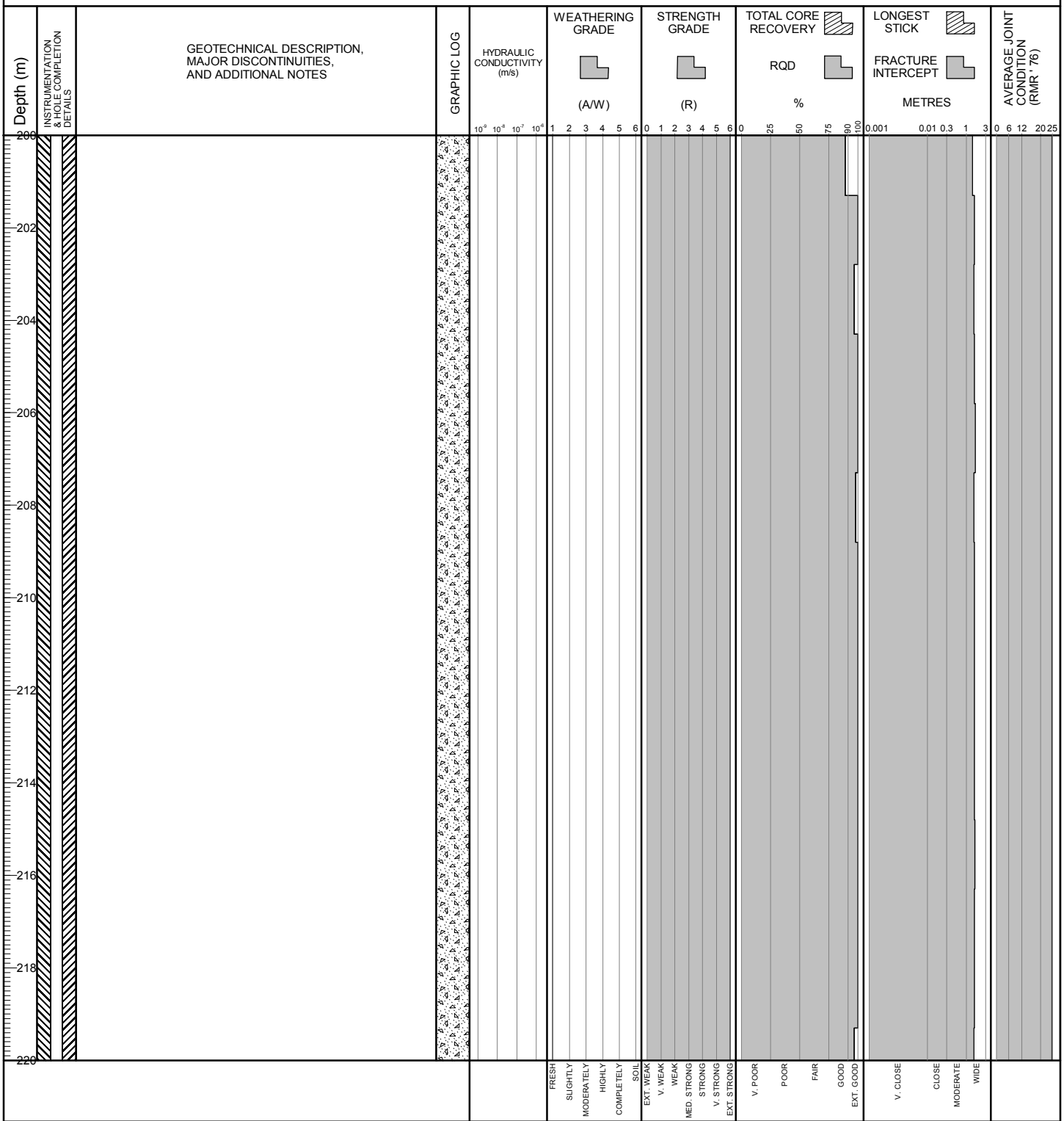

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Client: Pretium Resources Inc.

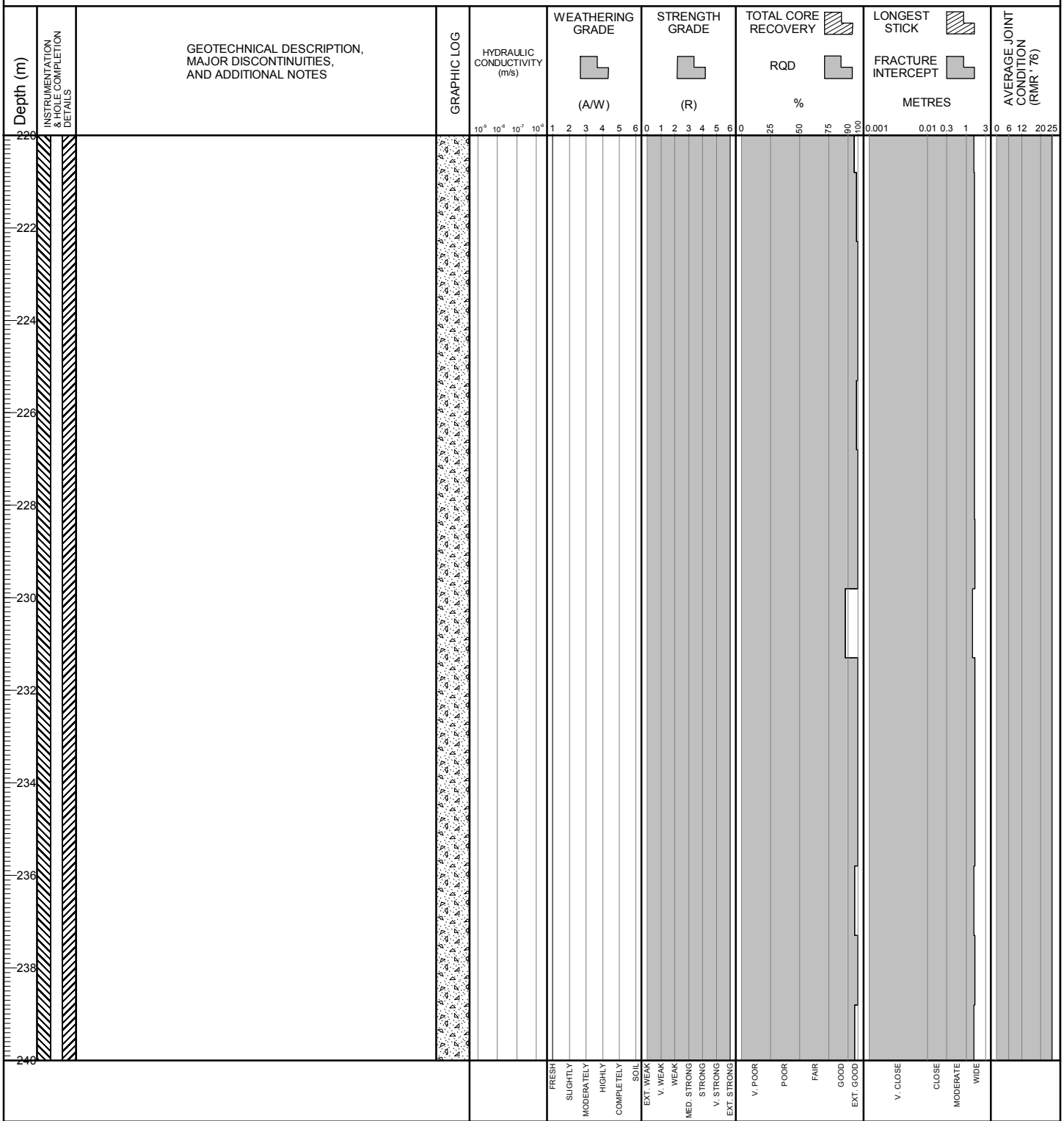
BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY RQD % | LONGEST STICK FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

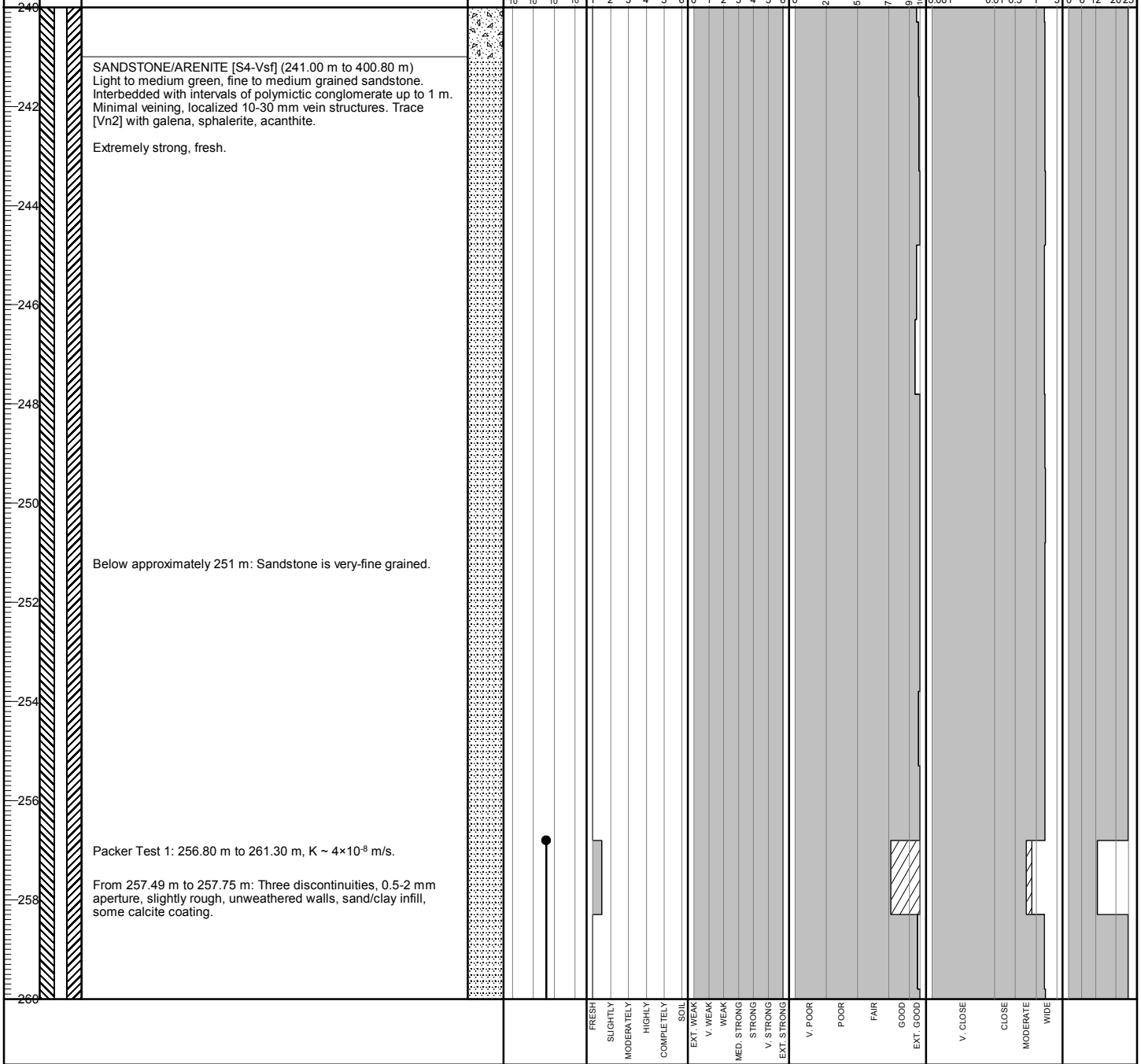
SANDSTONE/ARENITE [S4-Vsf] (241.00 m to 400.80 m)
Light to medium green, fine to medium grained sandstone. Interbedded with intervals of polymictic conglomerate up to 1 m. Minimal veining, localized 10-30 mm vein structures. Trace [Vn2] with galena, sphalerite, acanthite.

Extremely strong, fresh.

Below approximately 251 m: Sandstone is very-fine grained.

Packer Test 1: 256.80 m to 261.30 m, K ~ 4×10^{-8} m/s.

From 257.49 m to 257.75 m: Three discontinuities, 0.5-2 mm aperture, slightly rough, unweathered walls, sand/clay infill, some calcite coating.



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Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

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Datum: UTM NAD 83 Zone 9
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Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
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Fluid: Water
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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
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Plunge (°): -90
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Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

Packer Test 2: 292.80 m to 297.30 m, K ~ 2×10^{-8} m/s.

From 293.59 m to 293.87 m: Two discontinuities, 2 mm aperture, smooth, unweathered walls, clay and sand infill, calcite coatings, some shearing along veins.

Below approximately 295 m: No conglomerate interbeds.

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Drill Method: Diamond Coring
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Fluid: Water
Cased To (m) : 4.10

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300				10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
302									
304									
306									
308									
310									
312									
314									
316									
318		From 317.80 m to 349.60 m: Slightly elevated veining with 0.5-2% veining overall. Veining is predominantly quartz-calcite [Vn3] veins with lesser [Vn1] generations. Sporadic [Vn0] and [Vn4] veins.							
320					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22A

Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,575E - 6,258,498N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
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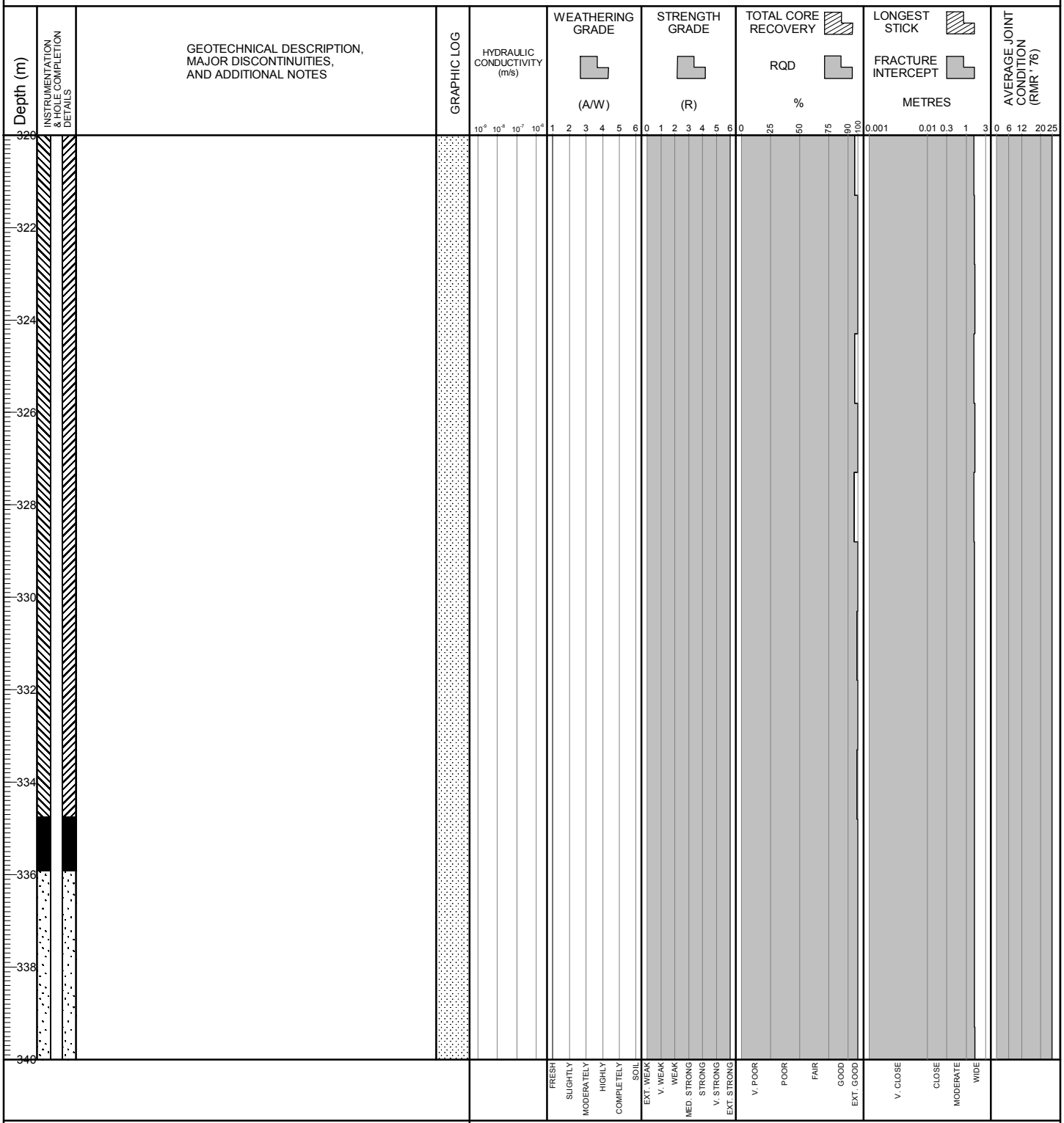

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AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project No.: 1008-029 **Location:** Twin Towers

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Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.10

Start Date: 20 JUN 18
Finish Date: 02 JUL 18
Final Depth (m): 400.80
Depth To Top Of Rock (m): 3.10
Logged By: FP/KB
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
340		
342		
344		
346		
348		
350		From 349.60 m to 383.85 m: Minimal veining 0-1%, localized 10-30 mm vein structures consisting of [Vn1] and [Vn3] veins with [Vn3] veins being slightly more dominant.
352		
354		
356		
358		
360		

Graphic Log

Hydraulic Conductivity (m/s): 10^{-9} 10^{-8} 10^{-7} 10^{-6}

Weathering Grade (A/W): 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL

Strength Grade (R): 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG

Total Core Recovery / RQD (%): 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90, 100 EXT. GOOD

Longest Stick / Fracture Intercept (METRES): 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1, 3 WIDE

Average Joint Condition (RMR' 76): 0, 6, 12, 20, 25

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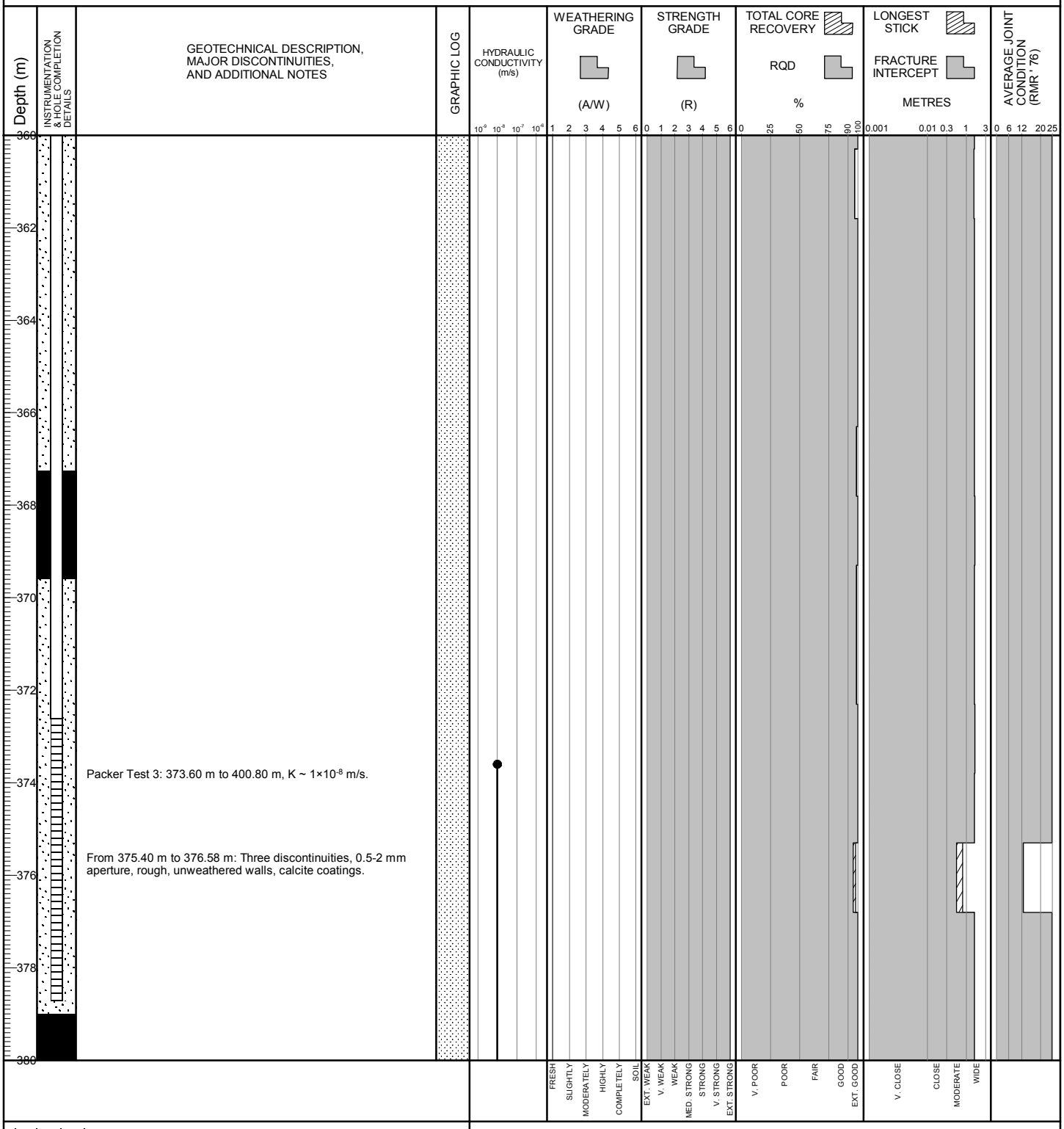

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Reviewed By: HP

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	HYDRAULIC CONDUCTIVITY (m/s)	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
380				10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
382									
384		Below 383.85 m: Zone of elevated veining (2-4%) that is predominantly quartz-calcite [Vn3] and quartz-calcite and chlorite [Vn4b] veins. Veins range from 5-80 mm in width.							
386									
388									
390									
392									
394									
396									
398									
400					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

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400				10^{-9} 10^{-8} 10^{-7} 10^{-6}	1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
402		END OF HOLE at 400.80 m. NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 378.71 m to 372.61 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 379.00 m to 369.58 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 369.58 m to 367.24 m. 5) Unstabilized water level measured after piezometer installation on 2 July 2018 06:35 at 64.20 m bgs.								
404									
406									
408									
410									
412									
414									
416									
418									
420					FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL	EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG	V. POOR, POOR, FAIR, GOOD, EXT. GOOD	V. CLOSE, CLOSE, MODERATE, WIDE	

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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

Location: Twin Towers

Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
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FILL and OVERBURDEN (0.00 m to 3.80 m)

CONGLOMERATE [S3-Poly] (3.80 m to 91.92 m)
Grey-green polymictic conglomerate. Clasts are dominantly subrounded with some subangular, 60% mafic and 40% lighter coloured. Possible [S4] clasts. Weak, shallow-angled imbrication of the clasts (5-10°). Trace concretions with dark grey centres surrounded by a pale green rim. Concretions range from 10-100 mm. Phyllic alteration. Overall hole has weak veining with 0-1% veining consisting of 10-30 mm [Vn1a] and [Vn3] veinlets/veins. Veins are weakly deformed and occasionally have cuspate-lobate margins.

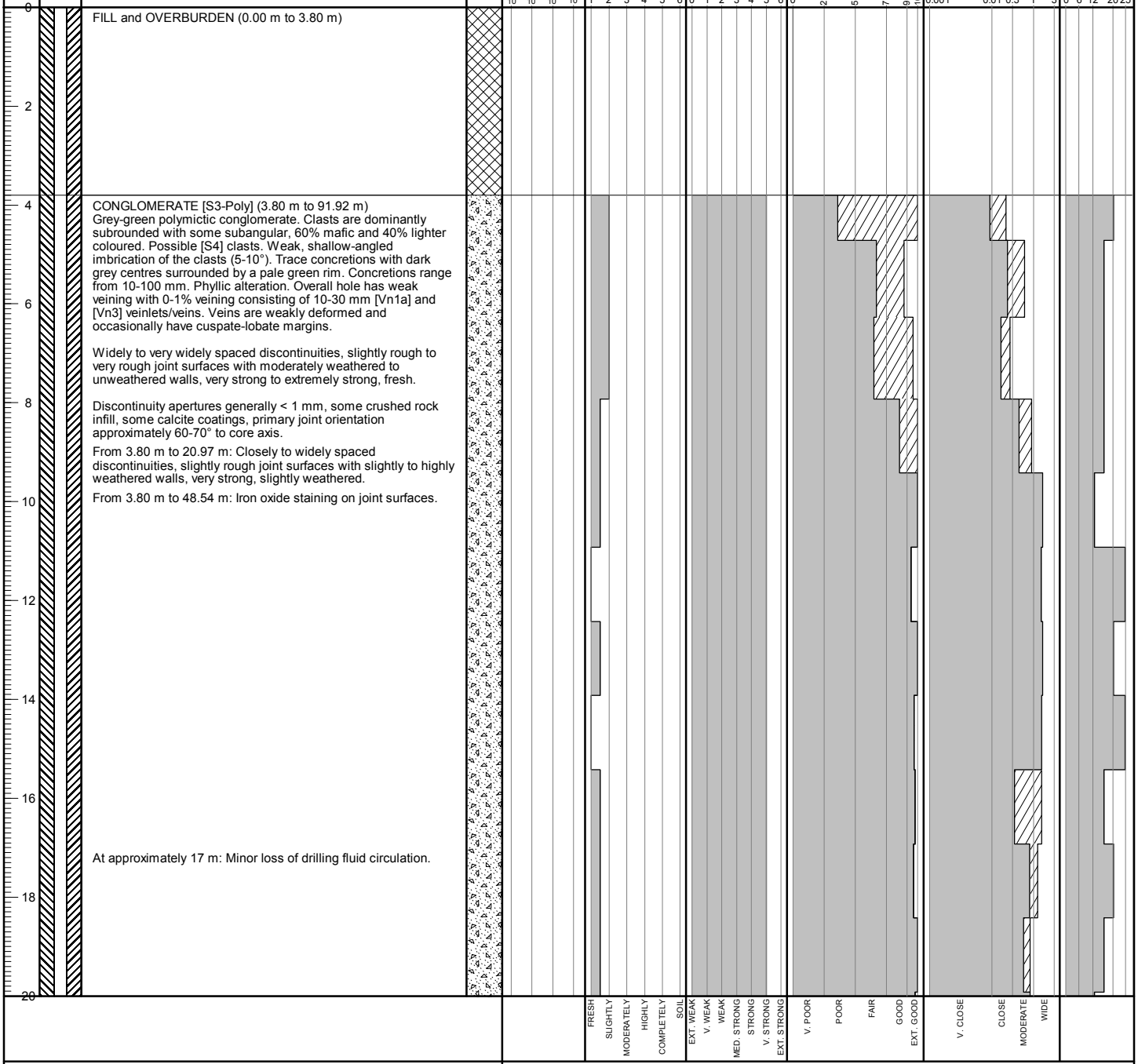
Widely to very widely spaced discontinuities, slightly rough to very rough joint surfaces with moderately weathered to unweathered walls, very strong to extremely strong, fresh.

Discontinuity apertures generally < 1 mm, some crushed rock infill, some calcite coatings, primary joint orientation approximately 60-70° to core axis.

From 3.80 m to 20.97 m: Closely to widely spaced discontinuities, slightly rough joint surfaces with slightly to highly weathered walls, very strong, slightly weathered.

From 3.80 m to 48.54 m: Iron oxide staining on joint surfaces.

At approximately 17 m: Minor loss of drilling fluid circulation.



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

Location: Twin Towers

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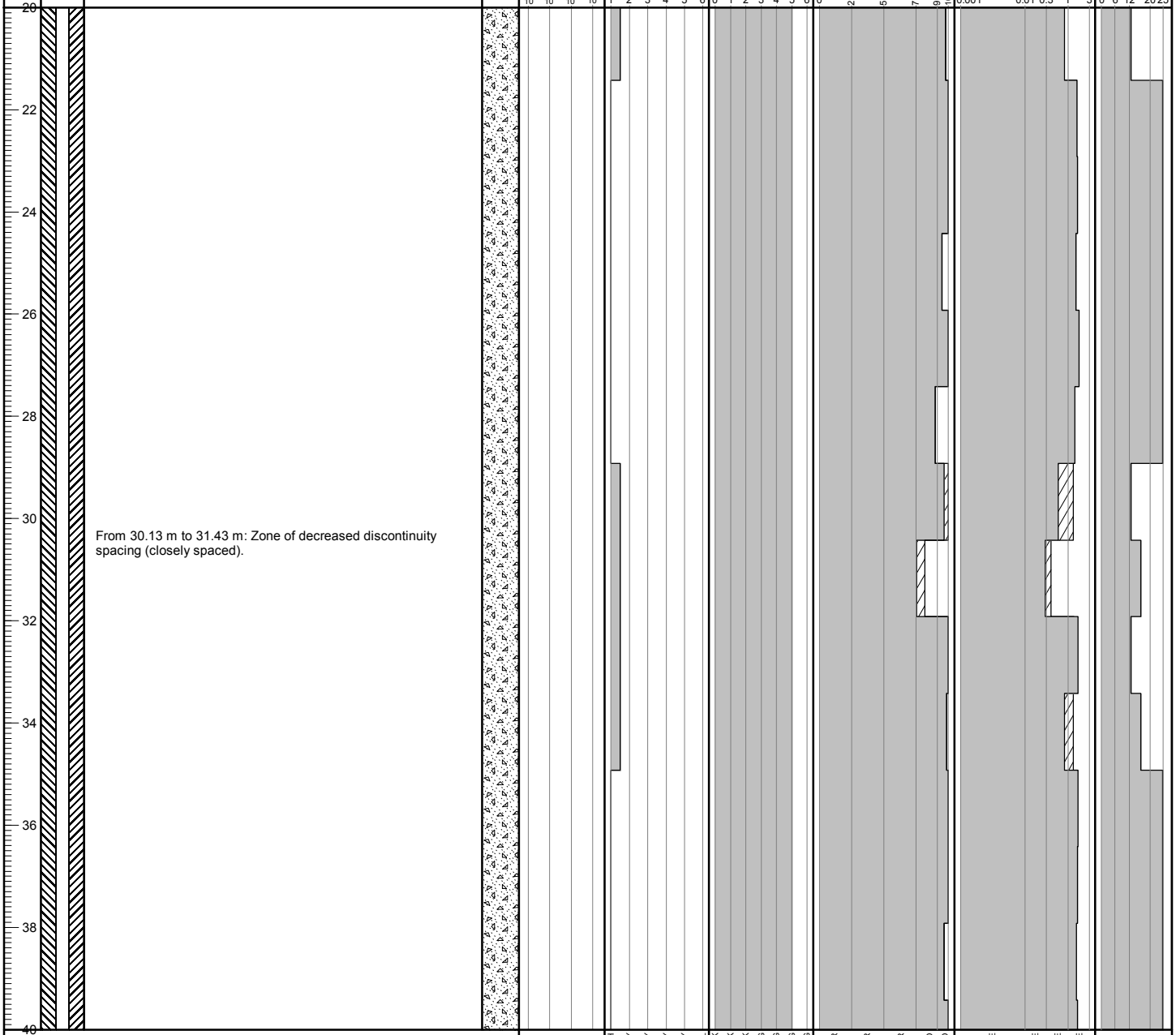
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

From 30.13 m to 31.43 m: Zone of decreased discontinuity spacing (closely spaced).



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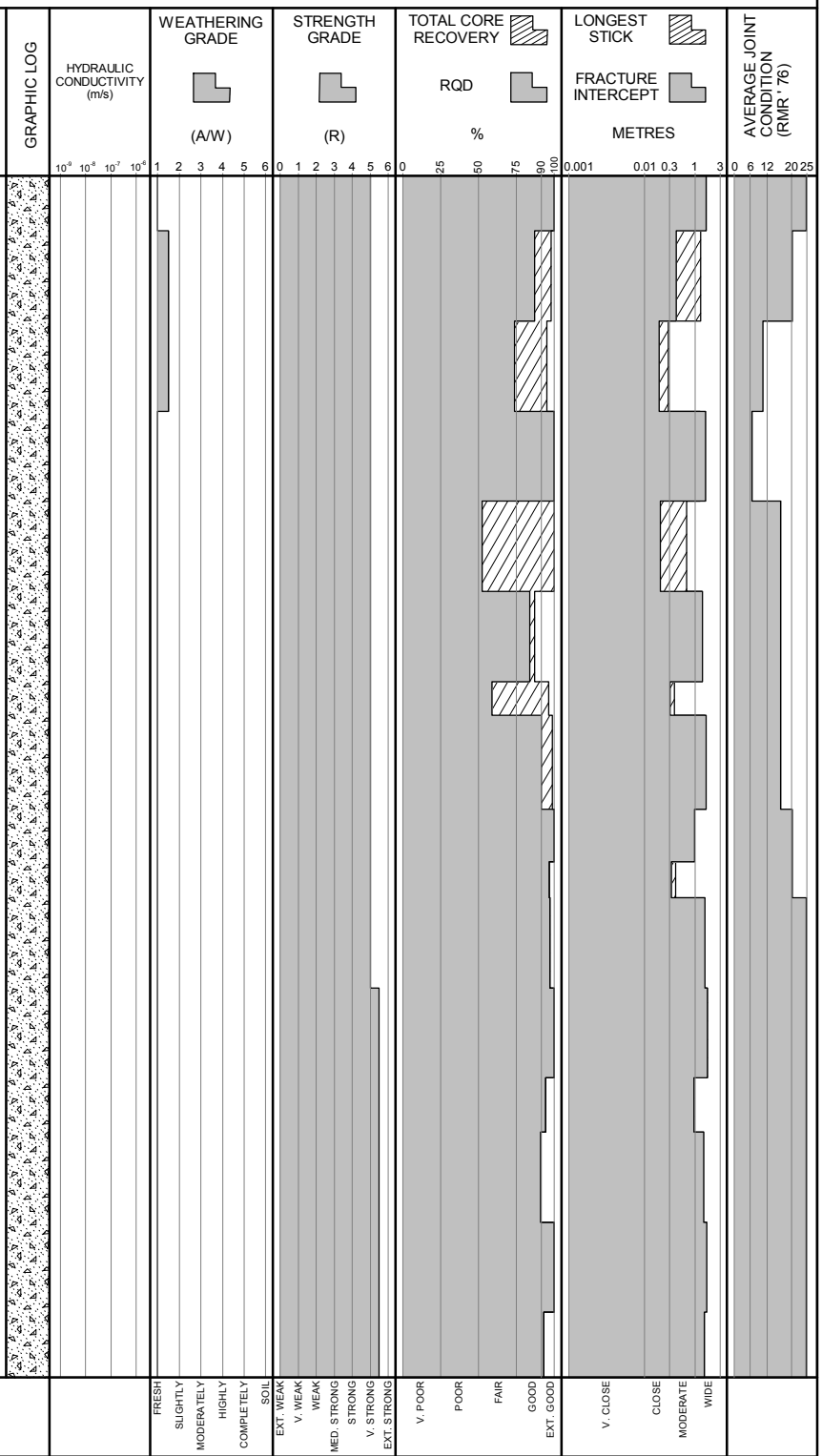
Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
40		
42		
44		From 43.48 m to 43.69 m: Fault, planar, gouge infill, 10 mm aperture. Zone of decreased discontinuity spacing (closely spaced) above and below fault.
46		
48		
50		
52		
54		
56		
58		
60		



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BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

Location: Twin Towers

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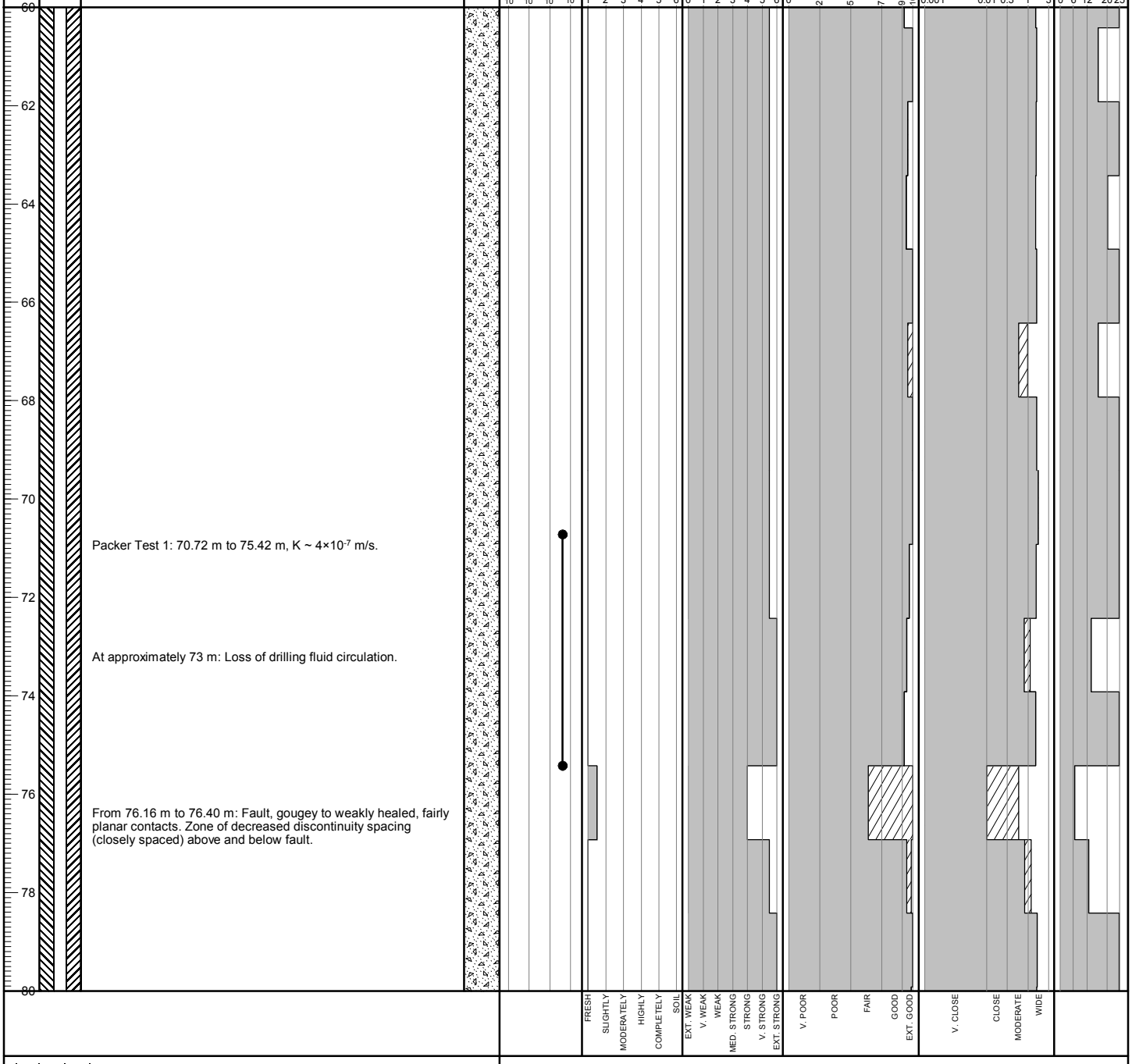
Packer Test 1: 70.72 m to 75.42 m, K ~ 4×10^{-7} m/s.

At approximately 73 m: Loss of drilling fluid circulation.

From 76.16 m to 76.40 m: Fault, gougey to weakly healed, fairly planar contacts. Zone of decreased discontinuity spacing (closely spaced) above and below fault.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-22B

Project No.: 1008-029

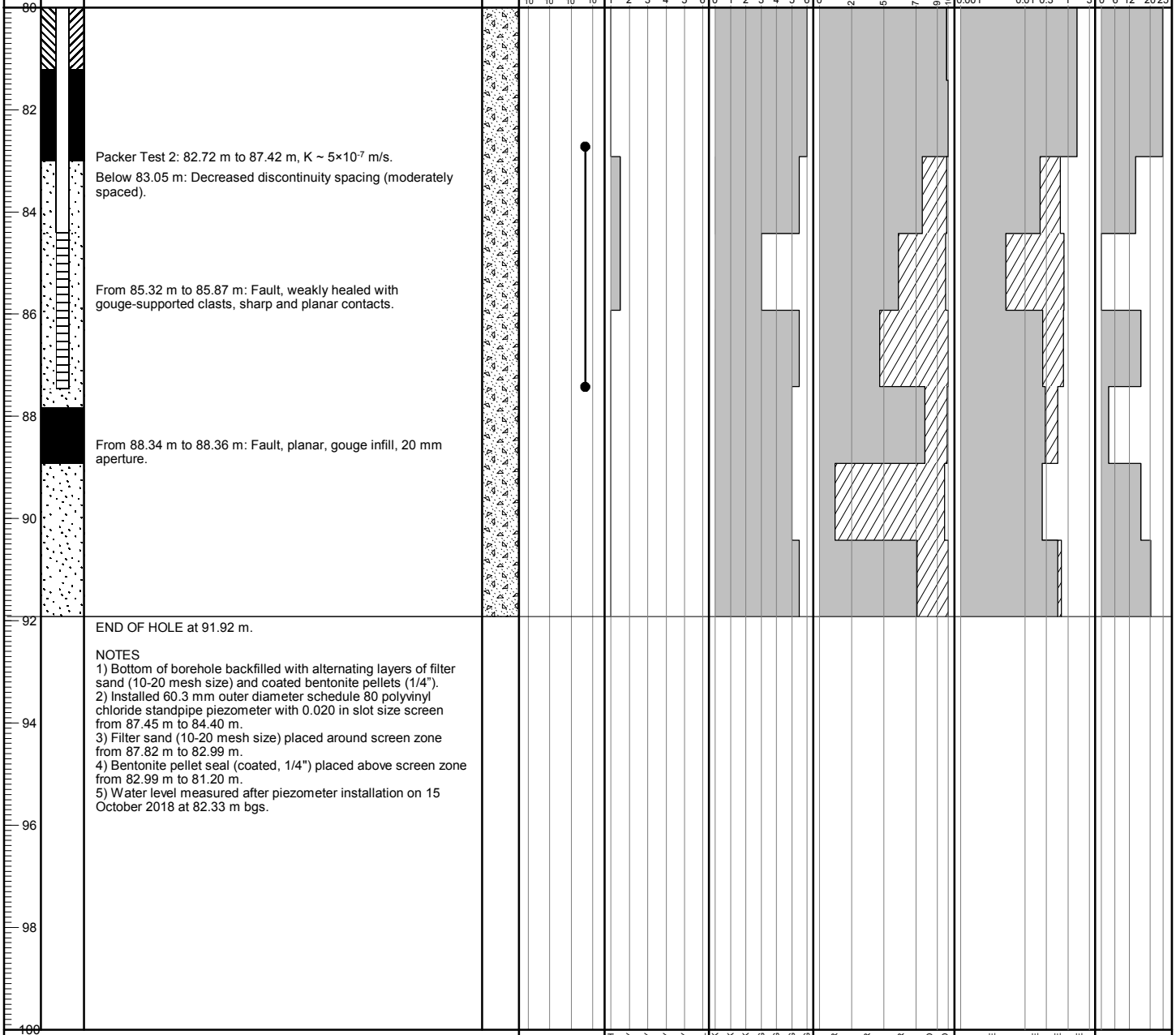
Location: Twin Towers

Co-ordinates (m): 426,576E - 6,258,499N
Ground Elevation (m): 1,444.64
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Zinex A5
Drilling Contractor: Geotech Drilling Services Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.00

Start Date: 02 JUL 18
Finish Date: 06 JUL 18
Final Depth (m): 91.92
Depth To Top Of Rock (m): 3.80
Logged By: FP/BM
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)



END OF HOLE at 91.92 m.

NOTES
1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4").
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 87.45 m to 84.40 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 87.82 m to 82.99 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 82.99 m to 81.20 m.
5) Water level measured after piezometer installation on 15 October 2018 at 82.33 m bgs.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-23A

Project No.: 1008-029

Location: Contact Water Pond

Co-ordinates (m): 427,091E - 6,258,751N
Ground Elevation (m): 1,370.84
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.24

Start Date: 30 JUN 18
Finish Date: 01 JUL 18
Final Depth (m): 35.20
Depth To Top Of Rock (m): 2.96
Logged By: BM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD % | LONGEST STICK METRES / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

OVERBURDEN (0.00 m to 2.96 m)

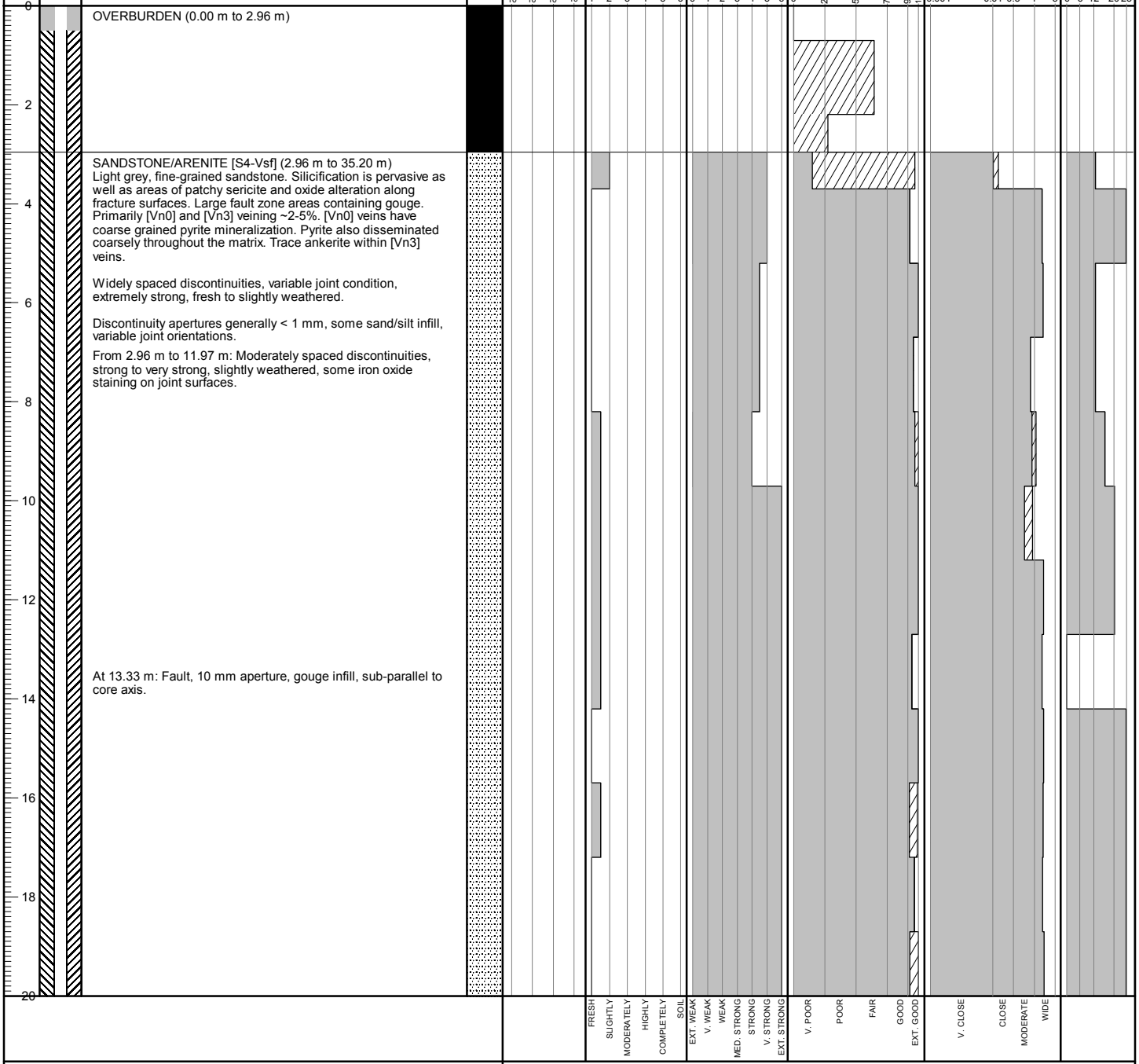
SANDSTONE/ARENITE [S4-Vsf] (2.96 m to 35.20 m)
Light grey, fine-grained sandstone. Silicification is pervasive as well as areas of patchy sericite and oxide alteration along fracture surfaces. Large fault zone areas containing gouge. Primarily [Vn0] and [Vn3] veining ~2-5%. [Vn0] veins have coarse grained pyrite mineralization. Pyrite also disseminated coarsely throughout the matrix. Trace ankerite within [Vn3] veins.

Widely spaced discontinuities, variable joint condition, extremely strong, fresh to slightly weathered.

Discontinuity apertures generally < 1 mm, some sand/silt infill, variable joint orientations.

From 2.96 m to 11.97 m: Moderately spaced discontinuities, strong to very strong, slightly weathered, some iron oxide staining on joint surfaces.

At 13.33 m: Fault, 10 mm aperture, gouge infill, sub-parallel to core axis.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-23A

Project No.: 1008-029

Location: Contact Water Pond

Co-ordinates (m): 427,091E - 6,258,751N
Ground Elevation (m): 1,370.84
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.24

Start Date: 30 JUN 18
Finish Date: 01 JUL 18
Final Depth (m): 35.20
Depth To Top Of Rock (m): 2.96
Logged By: BM/LS
Reviewed By: HP

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | HYDRAULIC CONDUCTIVITY (m/s) | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY % / RQD | LONGEST STICK METRES / FRACTURE INTERCEPT | AVERAGE JOINT CONDITION (RMR' 76)

At 20.75 m: Fault, 80 mm aperture, along vein, sub-parallel to core axis.

Packer Test 2: 26.00 m to 35.20 m, K ~ 1×10^{-8} m/s.

At 27.05 m: Fault, 5 mm aperture, gouge infill.

Packer Test 1: 30.50 m to 35.20 m, K ≤ 10^{-8} m/s.

Below 32.08 m: Zone of decreased discontinuity spacing (moderately spaced), some clay infill.

END OF HOLE at 35.20 m.

NOTES
1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4").
2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 28.96 m to 25.91 m.
3) Filter sand (10-20 mesh size) placed around screen zone from 29.70 m to 25.32 m.
4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 25.32 m to 24.04 m.
5) Water level measured after piezometer installation on 4 July 2018 at 4.07 m bgs.

WEATHERING GRADE: FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE: EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY: V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK: V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: 2018 Groundwater Monitoring Well Installation and Site Investigation

DRILL HOLE # BJ-GW18-23B

Project No.: 1008-029

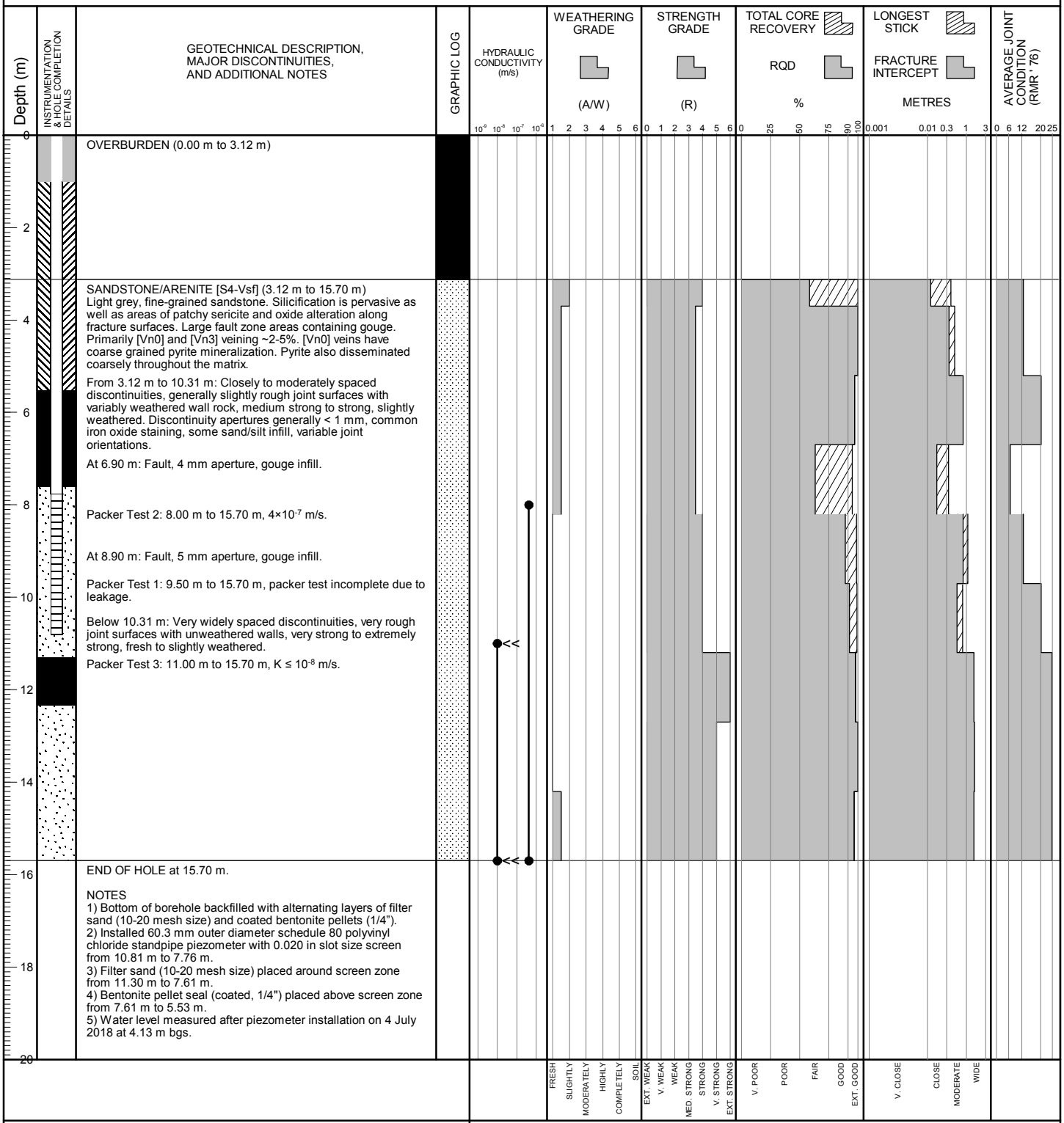
Location: Contact Water Pond

Co-ordinates (m): 427,091E - 6,258,752N
Ground Elevation (m): 1,370.81
Survey Method: Mine Survey
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Tech 5000
Drilling Contractor: Hy-Tech Drilling Ltd.
Drill Method: Diamond Coring
Core: PQ3
Fluid: Water
Cased To (m) : 4.30

Start Date: 01 JUL 18
Finish Date: 01 JUL 18
Final Depth (m): 15.70
Depth To Top Of Rock (m): 3.12
Logged By: BM/LS
Reviewed By: HP

Depth (m)	Instrumentation & Hole Completion Details	Geotechnical Description, Major Discontinuities, and Additional Notes
0		OVERBURDEN (0.00 m to 3.12 m)
3.12		SANDSTONE/ARENITE [S4-Vsf] (3.12 m to 15.70 m) Light grey, fine-grained sandstone. Silicification is pervasive as well as areas of patchy sericite and oxide alteration along fracture surfaces. Large fault zone areas containing gouge. Primarily [Vn0] and [Vn3] veining ~2-5%. [Vn0] veins have coarse grained pyrite mineralization. Pyrite also disseminated coarsely throughout the matrix. From 3.12 m to 10.31 m: Closely to moderately spaced discontinuities, generally slightly rough joint surfaces with variably weathered wall rock, medium strong to strong, slightly weathered. Discontinuity apertures generally < 1 mm, common iron oxide staining, some sand/silt infill, variable joint orientations. At 6.90 m: Fault, 4 mm aperture, gouge infill. Packer Test 2: 8.00 m to 15.70 m, 4×10^{-7} m/s. At 8.90 m: Fault, 5 mm aperture, gouge infill. Packer Test 1: 9.50 m to 15.70 m, packer test incomplete due to leakage. Below 10.31 m: Very widely spaced discontinuities, very rough joint surfaces with unweathered walls, very strong to extremely strong, fresh to slightly weathered. Packer Test 3: 11.00 m to 15.70 m, $K \leq 10^{-8}$ m/s.
15.70		END OF HOLE at 15.70 m. NOTES 1) Bottom of borehole backfilled with alternating layers of filter sand (10-20 mesh size) and coated bentonite pellets (1/4"). 2) Installed 60.3 mm outer diameter schedule 80 polyvinyl chloride standpipe piezometer with 0.020 in slot size screen from 10.81 m to 7.76 m. 3) Filter sand (10-20 mesh size) placed around screen zone from 11.30 m to 7.61 m. 4) Bentonite pellet seal (coated, 1/4") placed above screen zone from 7.61 m to 5.53 m. 5) Water level measured after piezometer installation on 4 July 2018 at 4.13 m bgs.



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 3/5/19

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.2	INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, grey, minor hydrothermal breccias (H15), moderate to strong phyllic/QSP alteration.
2.14	At 2.14m - Joint, 4mm aperture, with surface staining
2.18	At 2.18m - Joint, 1mm aperture, with surface staining
2.75	At 2.75m - Joint, 1mm aperture, with surface staining
4.52	At 4.52m - Joint, 4mm aperture, with surface staining
5.4	TRANSITIONAL UNIT BETWEEN POLYLITHIC CONGLOMERATE (S3-Poly) and INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine to coarse grained, grey, minor hydrotehermal breccias (H15), moderate to strong phyllic/QSP alteration.
5.51	At 5.51m - Joint, 1mm aperture, with surface staining
5.94	At 5.94m - Joint (curved), 1mm aperture, with surface staining
6.22	At 6.22m - Joint, 1mm aperture, with surface staining
6.38	At 6.38m - Joint, 1mm aperture, with surface staining
7.65	At 7.65m - Joint, 1mm aperture, with surface staining
8	

Columns: Depth (m); Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Geotechnical Description, Major Discontinuities, and Additional Notes; Graphic Log; Weathering Grade (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept Metres 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N	**Drill Designation:** Heliportable	**Start Date:** 02 JUL 16
Ground Elevation (m): 1,376.9	**Drilling Contractor:** HY TECH	**Finish Date:** 03 JUL 16
Survey Method: Surveyed coordinates	**Drill Method:** DIAMOND CORING	**Final Depth (m):** 27.4
Datum: UTM NAD 83 Zone 9	**Core:** PQ	**Depth To Top Of Rock (m):** 1.2
Plunge (°): -90	**Fluid:** Polymer	**Logged By:** JRW, SH
Trend (°): 000	**Cased To (m) :** 1.2	**Reviewed By:** TWC

Depth (m) | INSTRUMENTATION & HOLE COMPLETION DETAILS | DRILLING ACTION OR SAMPLE TYPE | GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES | GRAPHIC LOG | WEATHERING GRADE (A/W) | STRENGTH GRADE (R) | TOTAL CORE RECOVERY / RQD % | LONGEST STICK / FRACTURE INTERCEPT METRES | AVERAGE JOINT CONDITION (RMR' 76)

GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES:

At 8.05m - Joint, 1mm aperture, with surface staining

At 9.65m - Joint, 1mm aperture, with orange brown staining

At 9.71 m - Joint, 1mm aperture, with trace light brown clay infill

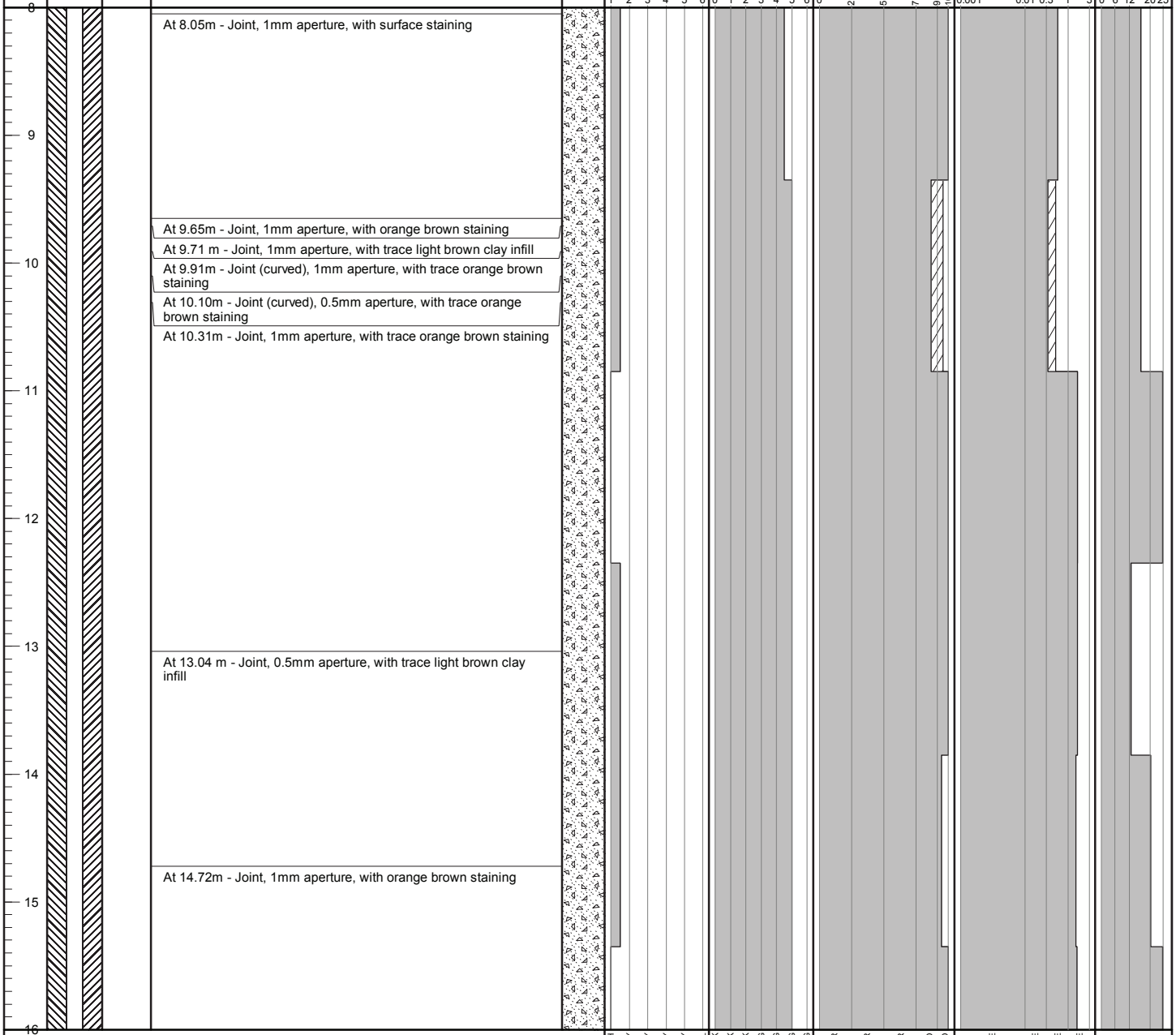
At 9.91m - Joint (curved), 1mm aperture, with trace orange brown staining

At 10.10m - Joint (curved), 0.5mm aperture, with trace orange brown staining

At 10.31m - Joint, 1mm aperture, with trace orange brown staining

At 13.04 m - Joint, 0.5mm aperture, with trace light brown clay infill

At 14.72m - Joint, 1mm aperture, with orange brown staining



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

Project: Brucejack 2016-2017
Project No.: 1008-022

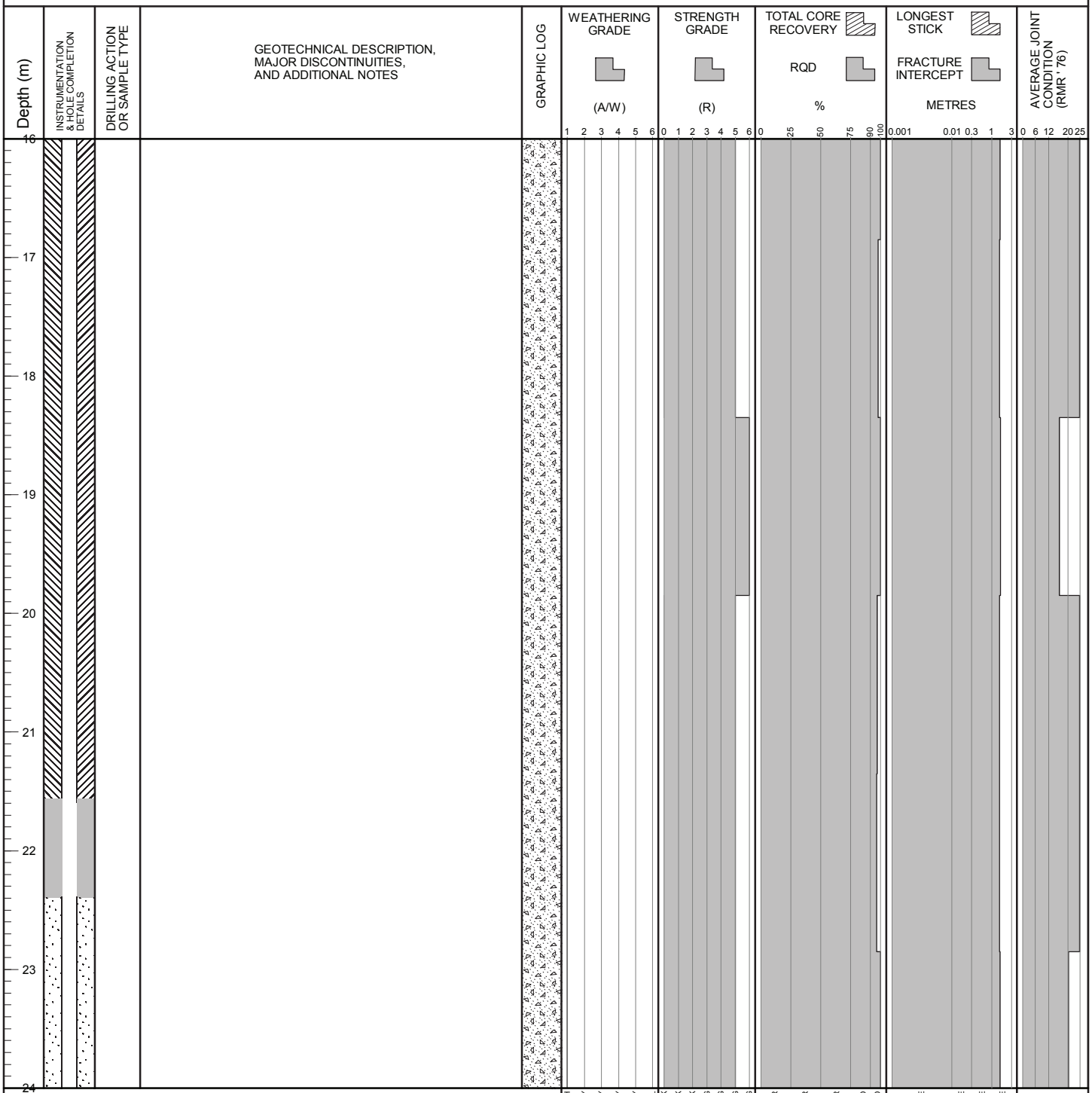
DRILL HOLE # MW-BGC16-BJ-01A

Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01A

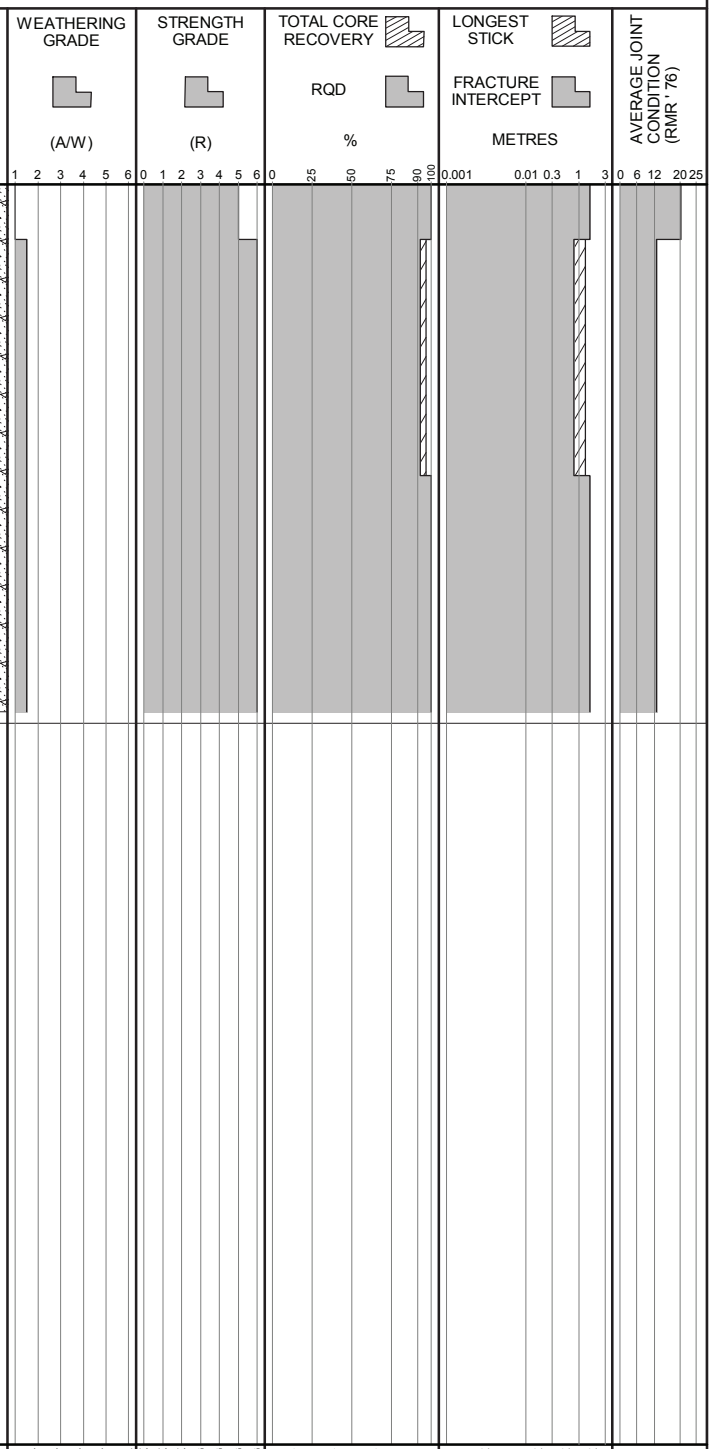
Location: CWP Pad C

Co-ordinates (m): 427,062E - 6,258,770N
Ground Elevation (m): 1,376.9
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 02 JUL 16
Finish Date: 03 JUL 16
Final Depth (m): 27.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
24				
			At 24.53 m - Joint, 1mm aperture, with trace light brown clay infill	
			At 24.57 m - Joint, 1mm aperture, with trace white grey clay infill	
25				
26				
			At 26.70m - Joint (on vein), 1mm aperture, with orange staining	
27				
			END OF HOLE AT: 27.42 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 24.37 to 27.42 m on July 3, 2016. 2) Filter sand placed around screen zone from 22.39 to 27.42 m. 3) Lithology descriptions by Pretium geologists.	
28				
29				
30				
31				
32				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-01B

Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.37	INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, light grey, weak to moderate phyllic/QSP alteration.
1.37	At 1.37 m - Joint, 5mm aperture, with coarse sand infill and staining on joint surfaces
1.50	At 1.50m - Joint (stepped), 1mm aperture, with staining on surfaces
2.03	At 2.03m - Joint (undulating smooth), 1mm aperture, with surface staining
3.27	At 3.27m - Joint (rough planar), 1mm aperture, with surface staining
4.00	At 4.00 m - Joint, 3mm aperture, with sand infill and staining on joint surfaces
4.20	At 4.20m - Joint, 1mm aperture, with surface staining
4.53	At 4.53m - Joint (curved), 1mm aperture, with surface staining
4.64	At 4.64 m - Joint, 1mm aperture, with sand infill and staining on joint surfaces
5.70	At 5.70m - Joint, 1mm aperture, with surface staining
5.75	At 5.75 m - Joint, 4mm aperture, with staining on joint surfaces

Columns: Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Graphic Log; Weathering Grade (A/W) — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD (%) — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept (metres) — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76)

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-01B

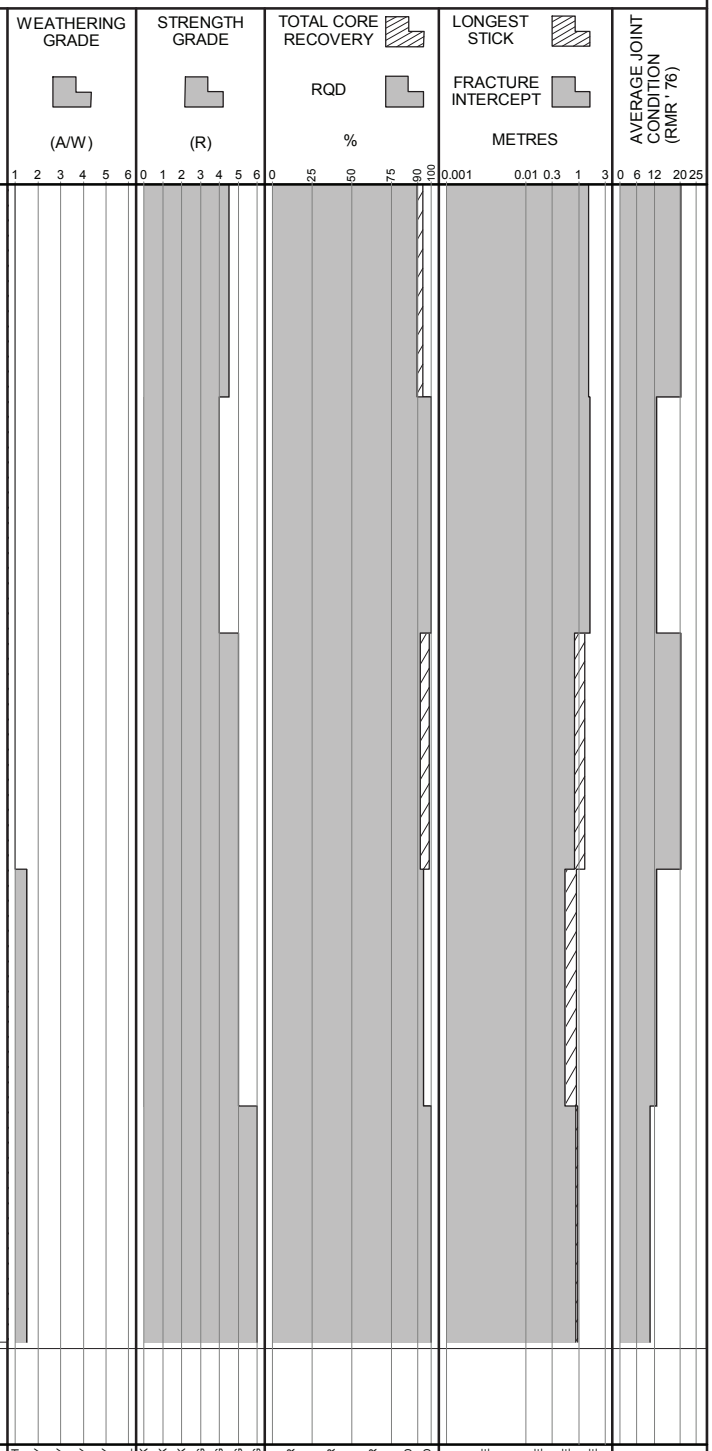
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
			At 10.58 m - Joint (on vein), 0.5mm aperture, with trace grey clay infill
11			
12			
			At 12.41 m - Joint, 1mm aperture, with grey clay infill
13			
14			
			At 14.47 m - Joint, 1mm aperture, with grey clay infill, yellow brown staining, dark brown staining
15			
			At 15.34 m - Joint, aperture unknown (second half of joint not recovered) with grey white clay infill
			END OF HOLE AT: 15.39 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-01B

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad C

Co-ordinates (m): 427,063E - 6,258,767N
Ground Elevation (m): 1,377.0
Survey Method: Surveyed coordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.2

Start Date: 07 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 15.4
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W) 1 2 3 4 5 6	STRENGTH GRADE (R) 0 1 2 3 4 5 6	TOTAL CORE RECOVERY / RQD % 0 25 50 75 90 100	LONGEST STICK / FRACTURE INTERCEPT METRES 0.001 0.01 0.3 1 3	AVERAGE JOINT CONDITION (RMR' 76) 0 6 12 20 25
16			slotted screen from 13.87 to 15.37 m on July 7, 2016. 2) Filter sand placed around screen zone from 13.44 to 15.37 m. 3) Lithology descriptions by Pretium geologists.						
17									
18									
19									
20									
21									
22									
23									
24									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02A

Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Geotechnical description, major discontinuities, and additional notes
0	FILL
1.2	INTERMEDIATE VOLCANICS (V4) Medium grained, greenish blue, pyroclastic, weak to moderate chlorite-sericite alteration.
	At 1.30m - Joint, 0.5mm aperture, with dark brown stain
	At 1.36m - Joint, 0.5mm aperture, with dark brown stain
	At 1.40m - Joint, 1mm aperture, with dark brown stain
	At 1.52m - Joint, 1mm aperture, with dark brown stain
	At 1.70 - Joint, 1mm aperture, with dark brown stain
	At 2.03 m - Joint, 2mm aperture, with trace orange brown clay infill
	At 2.30m - Joint, 1mm aperture, with dark brown stain
	At 2.37m - Joint, 1.5mm aperture, with dark brown stain
	At 2.49 m - Joint, 0.5mm aperture, with trace orange brown clay infill
	At 2.73 m - Joint, 1mm aperture, with trace orange brown clay infill
	At 3.00 m - Fault, 220mm aperture, with fault gouge and broken rock infill. Circulation lost during drilling.
	At 3.48 m - Joint, 1mm aperture, with trace dark brown clay infill
	At 5.21m - Joint, 1mm aperture, with dark brown stain
	At 7.11 m - Joint, 1mm aperture, with trace light brown clay infill
8	

Columns: Depth (m); Instrumentation & Hole Completion Details; Drilling Action or Sample Type; Geotechnical Description, Major Discontinuities, and Additional Notes; Graphic Log; Weathering Grade (A/W) 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL; Strength Grade (R) 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG; Total Core Recovery / RQD % 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD; Longest Stick / Fracture Intercept Metres 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE; Average Joint Condition (RMR' 76) 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-02A

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			At 10.08 m - Joint, 1mm aperture, with trace white grey clay infill
11			
12			At 11.89 m - Joint, 1mm aperture, with trace white clay infill
13			At 12.80 m - Joint, 1mm aperture, with trace white clay infill
14			At 14.14 m - Joint, 0.5mm aperture, with trace white grey clay infill
15			At 15.57 m - Joint, 1mm aperture, with trace grey clay infill
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02A

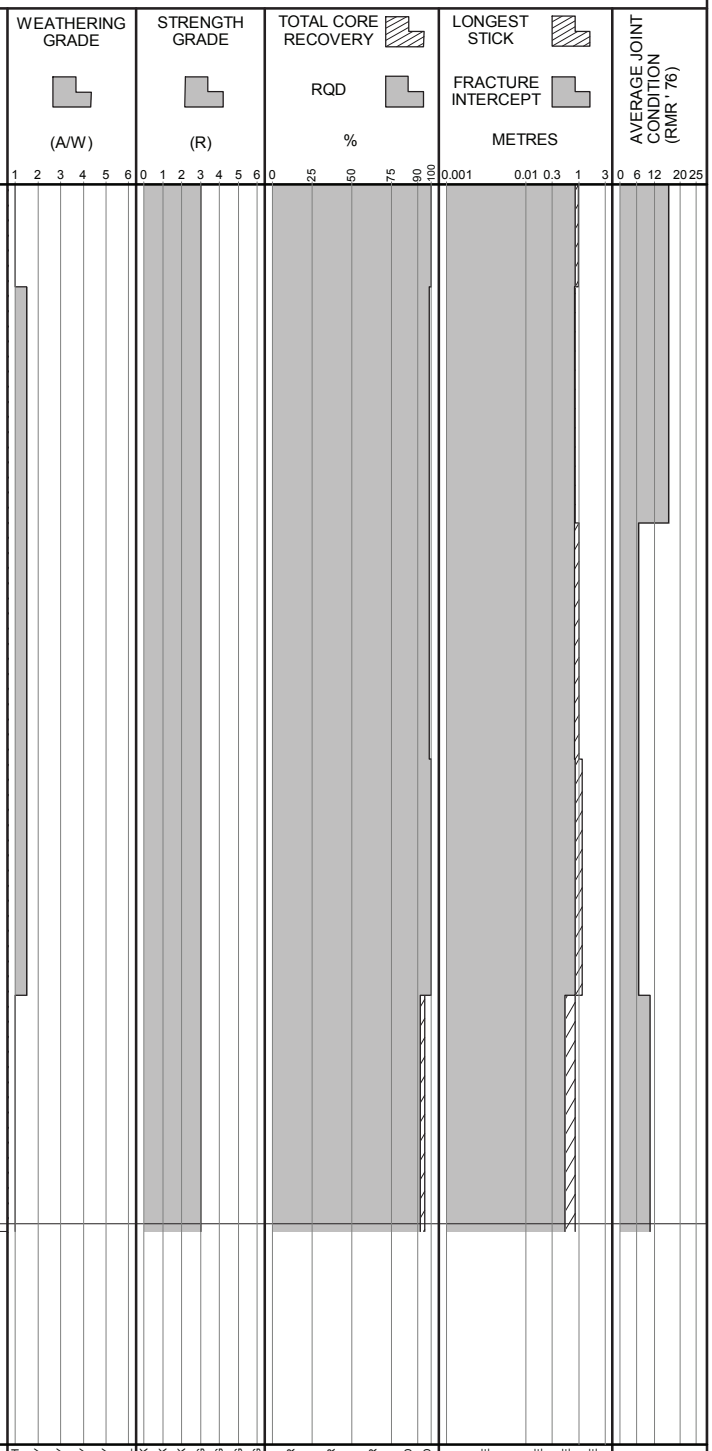
Location: CWP Pad D

Co-ordinates (m): 427,084E - 6,258,713N
Ground Elevation (m): 1,378.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 04 JUL 16
Finish Date: 05 JUL 16
Final Depth (m): 22.6
Depth To Top Of Rock (m): 1.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
			At 16.77 m - Joint, 1mm aperture, with trace white grey clay infill
17			
			At 17.39 m - Joint, 0.5mm aperture, with trace white grey clay infill
18			
19			
			At 19.36 m - Joint, 1mm aperture, with trace white grey clay infill
20			
21			At 20.94 m - Bedding Joint, 1mm aperture, with trace white grey clay infill
			At 21.24 m - Joint, 1mm aperture, with trace white grey clay infill
22			
23			END OF HOLE AT: 22.60 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 19.55 to 22.60 m on July 5, 2016. 2) Filter sand placed around screen zone from 19.16 to 22.60 m. 3) Lithology descriptions by Pretium geologists.
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02B

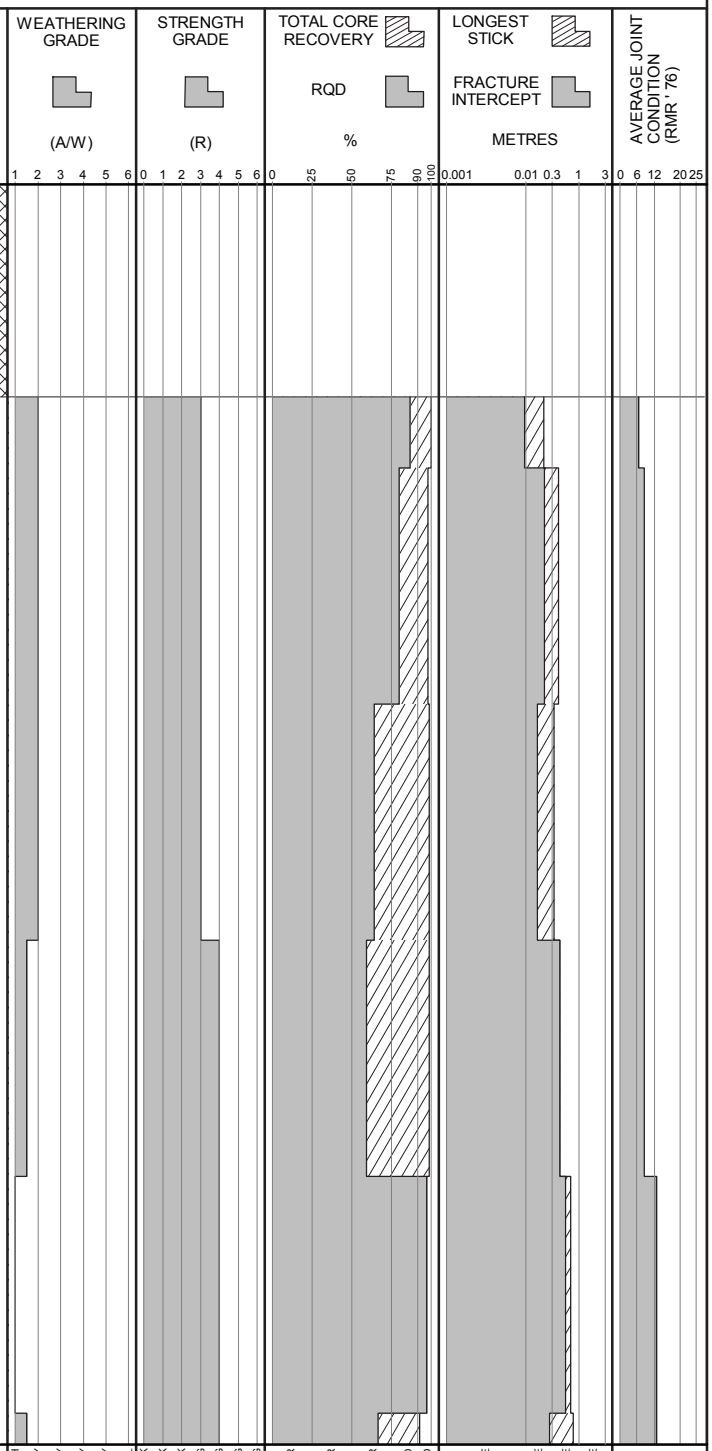
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
1			
2			INTERMEDIATE VOLCANICS (V4) Fine grained, greenish grey, porphyritic, weak to moderate phyllic/QSP alteration.
			At 1.43 m - Joint, 3mm aperture, with trace green grey clay infill and dark brown staining
			At 1.44 m - Joint, aperture size unknown (second half of joint missing), with trace brown clay infill and dark brown staining
			At 1.62m - Joint, 1mm aperture, with dark brown stain
			At 1.80 m - Joint, aperture size unknown (second half of joint missing), with green grey clay infill, trace brown clay infill and dark brown staining
3			At 2.18 m - Joint, 90mm aperture, with broken rock infill and dark brown staining
			At 2.58 m - Joint, 1mm aperture, with green grey clay infill and dark brown staining
			At 2.75m - Joint, 1mm aperture, with dark brown stain
			At 3.29 m - Joint, 2mm aperture, with trace brown clay infill, trace green grey clay infill and dark brown staining
			At 3.30 m - Joint, (aperture size could not be determined), with trace brown clay infill and dark brown staining
4			At 3.34 m - Joint, 1 to 4mm aperture, with brown clay and green grey clay infill and dark brown staining
			At 3.49m - Joint, 0.5mm aperture, with dark brown stain
			At 3.56 m - Joint, aperture size could not be determined (joint too broken), with brown clay infill and green grey clay infill, and dark brown staining
			At 3.87 m - Joint, 1.5mm aperture, with trace dark brown clay infill
5			At 3.88m - Joint, 0.5mm aperture, with dark brown stain
			At 4.01 m - Joint, 1.5mm aperture, with trace dark brown clay infill, dark brown staining
			At 4.15 m - Joint, 1mm aperture, with trace dark brown clay infill, dark brown staining
			At 4.19m - Joint, 1mm aperture, with dark brown stain
			At 4.38 m - Joint, 1mm aperture, with trace dark brown clay infill, dark brown staining
6			At 4.53 m - Joint (on vein), 1mm aperture, with trace dark brown clay infill, dark brown staining, on 8mm white vein
			At 4.64 m - Joint, 1mm aperture, with trace brown clay infill, dark brown staining
			At 4.99m - Joint, 1mm aperture, with dark brown stain
			At 5.18 m - Joint, 1mm aperture, with trace green grey clay infill
7			At 5.71m - Joint, 1mm aperture, with orange brown stain
			At 5.89 m - Joint, 1mm aperture, with grey white clay infill
			At 6.65m - Joint, 0.5mm aperture, with yellow brown stain
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

DRILL HOLE # MW-BGC16-BJ-02B

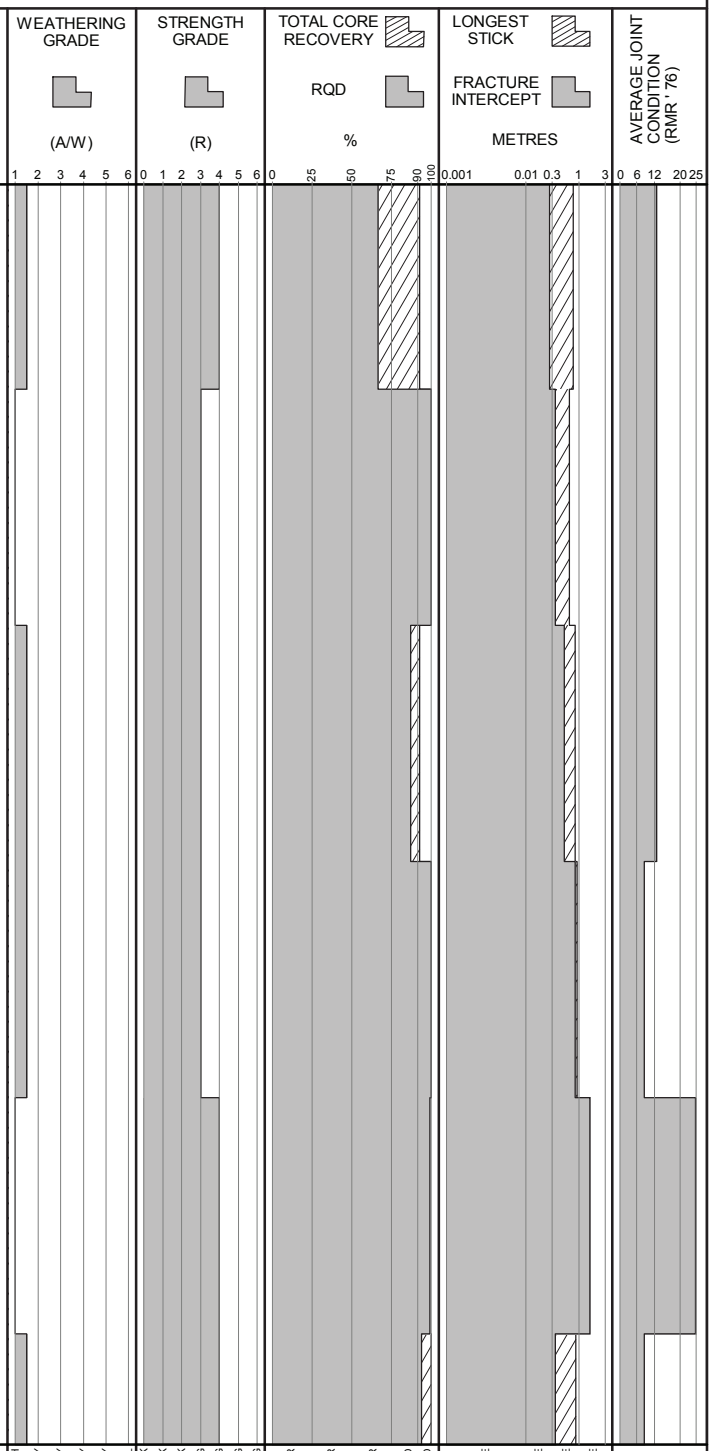
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
			At 8.75 m - Joint, 0.5mm aperture, with trace green grey clay infill
9			At 8.76 m - Joint, 1mm aperture, with green grey clay infill, dark brown staining
			At 9.65m - Joint, 0.5mm aperture, with yellow brown stain
			At 9.84m - Joint, 0.5mm aperture, with yellow brown stain
10			At 9.86m - Joint, 0.5mm aperture, with yellow brown stain
11			
			At 11.29 m - Joint, 1mm aperture, with trace white clay infill
12			
			At 12.63m - Joint, 0.5mm aperture, with trace white clay infill
13			
			At 13.45m - Joint, 1mm aperture, with trace grey clay infill
14			
15			
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-02B

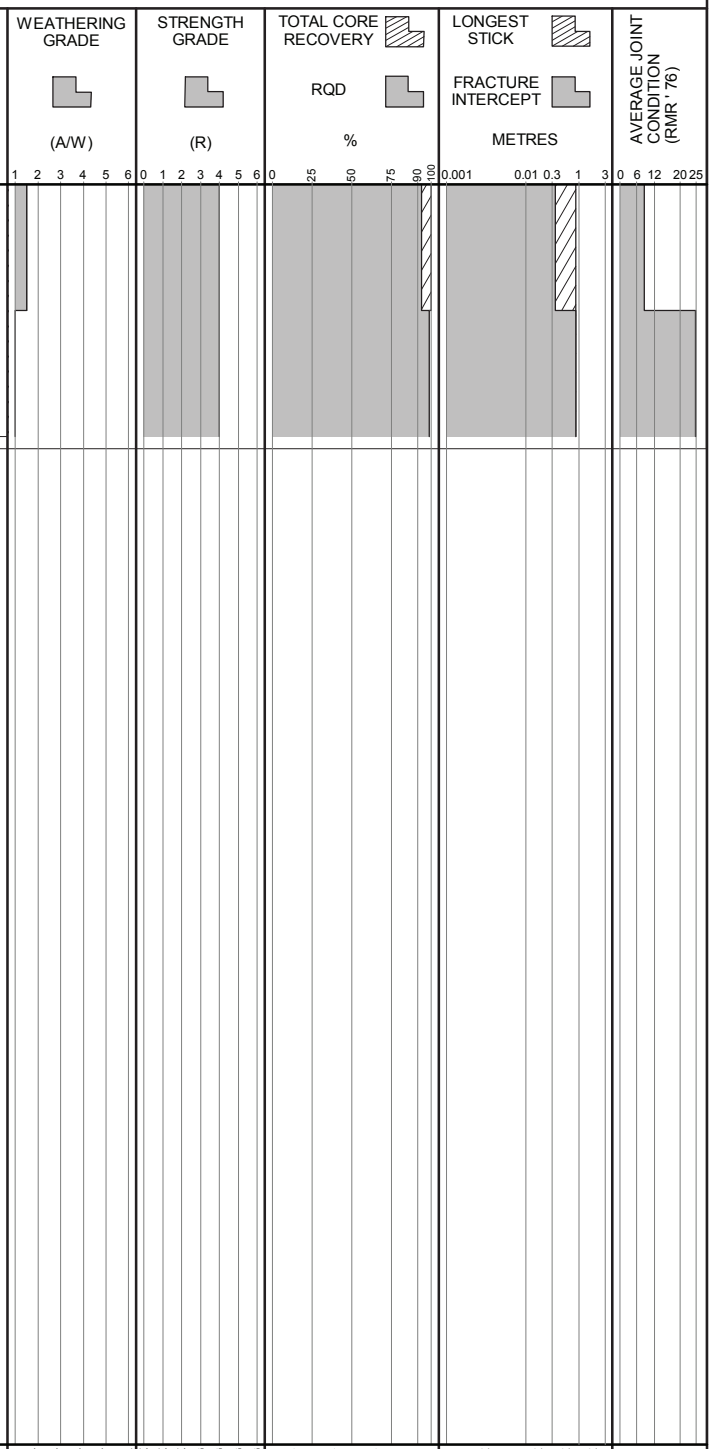
Location: CWP Pad D

Co-ordinates (m): 427,081E - 6,258,710N
Ground Elevation (m): 1,378.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.0

Start Date: 06 JUL 16
Finish Date: 07 JUL 16
Final Depth (m): 17.7
Depth To Top Of Rock (m): 1.4
Logged By: SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
16									
17			At 16.69m - Joint, 1mm aperture, with grey clay and decomposed rock infill At 16.70m - Joint, aperture size could not be determined (couldn't fit joint together properly), with trace grey clay and decomposed rock infill At 16.75m - Joint, 1.5mm aperture, with trace grey white clay infill						
18			END OF HOLE AT: 17.68 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 16.16 to 17.68 m on July 7, 2016. 2) Filter sand placed around screen zone from 15.66 to 17.68 m. 3) Lithology descriptions by Pretium geologists.						
19									
20									
21									
22									
23									
24									



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

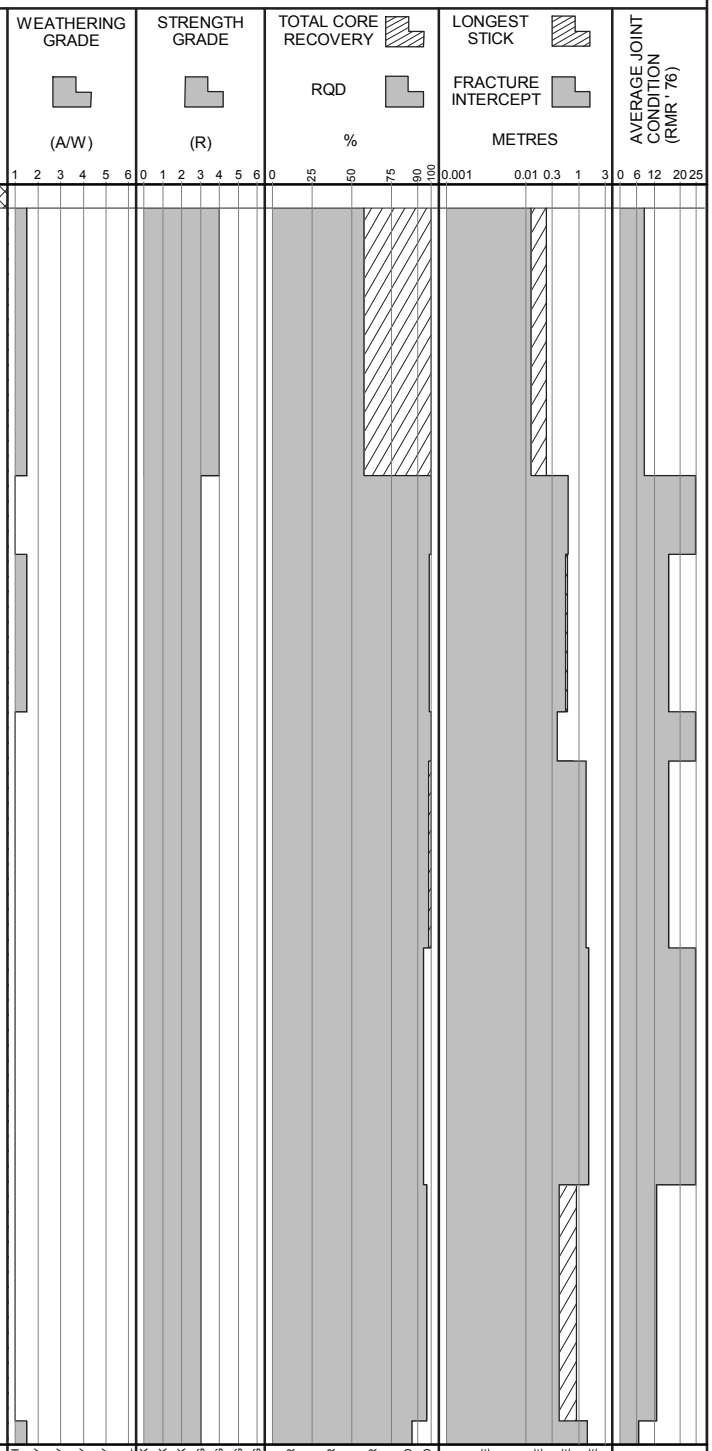
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, greenish grey, minor hydrothermal breccias (H15) from 6.58 to 6.71 m, moderate to strong phyllic/QSP alteration.
			At 0.34 m - Joint, 1mm aperture, with grey clay and crushed rock infill
1			At 0.58 m - Joint, 2mm aperture, with grey clay and crushed rock infill
			At 0.82 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.05 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.37 m - Joint, 1mm aperture, with trace light brown clay infill
			At 1.42 m - Joint, 1mm aperture, with trace light brown clay infill
2			At 1.68 m - Joint, aperture size unknown (other joint face too broken up), with trace light brown clay infill
3			At 3.21 m - Joint, 0.5mm aperture, with trace grey clay infill
4			
5			
6			
			At 6.42 m - Joint, 0.5mm aperture, with grey clay infill
7			
			At 7.20 m - Joint, 1mm aperture, with white grey clay infill
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

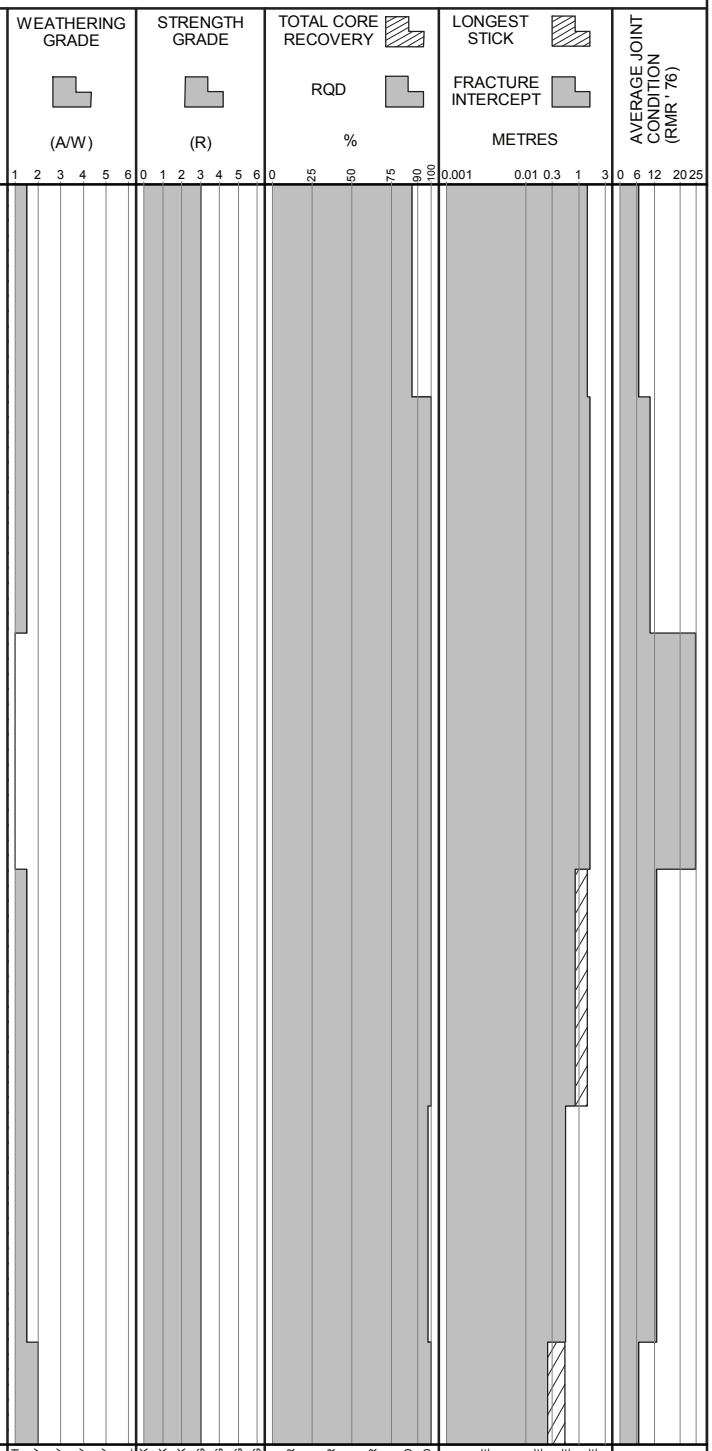
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			At 9.35 m - Joint, 2mm aperture, with grey white clay infill
10			At 10.26 m - Joint, 0.5mm aperture, with grey white clay infill
11			
12			
13			
14			At 13.77 m - Joint, 1mm aperture, with grey white clay infill At 14.33 m - Joint (with vein), 1mm aperture, with grey white clay infill
15			
16			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-03A

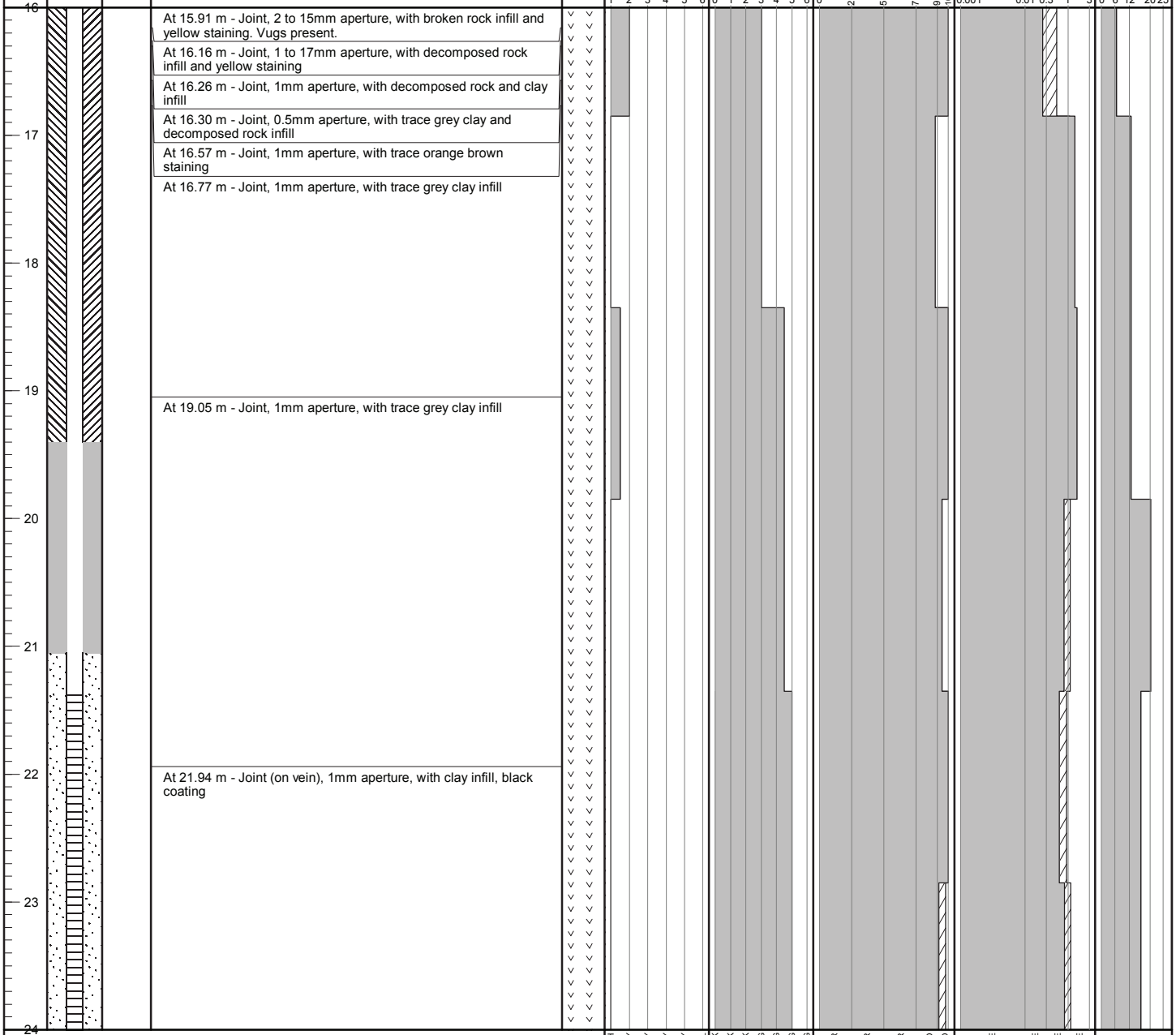
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16	At 15.91 m - Joint, 2 to 15mm aperture, with broken rock infill and yellow staining. Vugs present.
	At 16.16 m - Joint, 1 to 17mm aperture, with decomposed rock infill and yellow staining
	At 16.26 m - Joint, 1mm aperture, with decomposed rock and clay infill
	At 16.30 m - Joint, 0.5mm aperture, with trace grey clay and decomposed rock infill
17	At 16.57 m - Joint, 1mm aperture, with trace orange brown staining
	At 16.77 m - Joint, 1mm aperture, with trace grey clay infill
18	
19	At 19.05 m - Joint, 1mm aperture, with trace grey clay infill
20	
21	
22	At 21.94 m - Joint (on vein), 1mm aperture, with clay infill, black coating
23	
24	



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03A

Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,704N
Ground Elevation (m): 1,377.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 1.1

Start Date: 05 JUL 16
Finish Date: 06 JUL 16
Final Depth (m): 24.4
Depth To Top Of Rock (m): 0.2
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
24									
25			END OF HOLE AT: 24.43 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 21.38 to 24.43 m on July 6, 2016. 2) Filter sand placed around screen zone from 21.05 to 24.43 m. 3) Lithology descriptions by Pretium geologists.						
26									
27									
28									
29									
30									
31									
32									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

WEATHERING GRADE: 1 FRESH, 2 SLIGHTLY, 3 MODERATELY, 4 HIGHLY, 5 COMPLETELY, 6 SOIL
STRENGTH GRADE: 0 EXT. WEAK, 1 V. WEAK, 2 WEAK, 3 MED. STRONG, 4 STRONG, 5 V. STRONG, 6 EXT. STRONG
TOTAL CORE RECOVERY / RQD: 0 V. POOR, 25 POOR, 50 FAIR, 75 GOOD, 90 EXT. GOOD, 100
LONGEST STICK / FRACTURE INTERCEPT: 0.001 V. CLOSE, 0.01 CLOSE, 0.3 MODERATE, 1 WIDE, 3
AVERAGE JOINT CONDITION (RMR' 76): 0, 6, 12, 20, 25

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03B

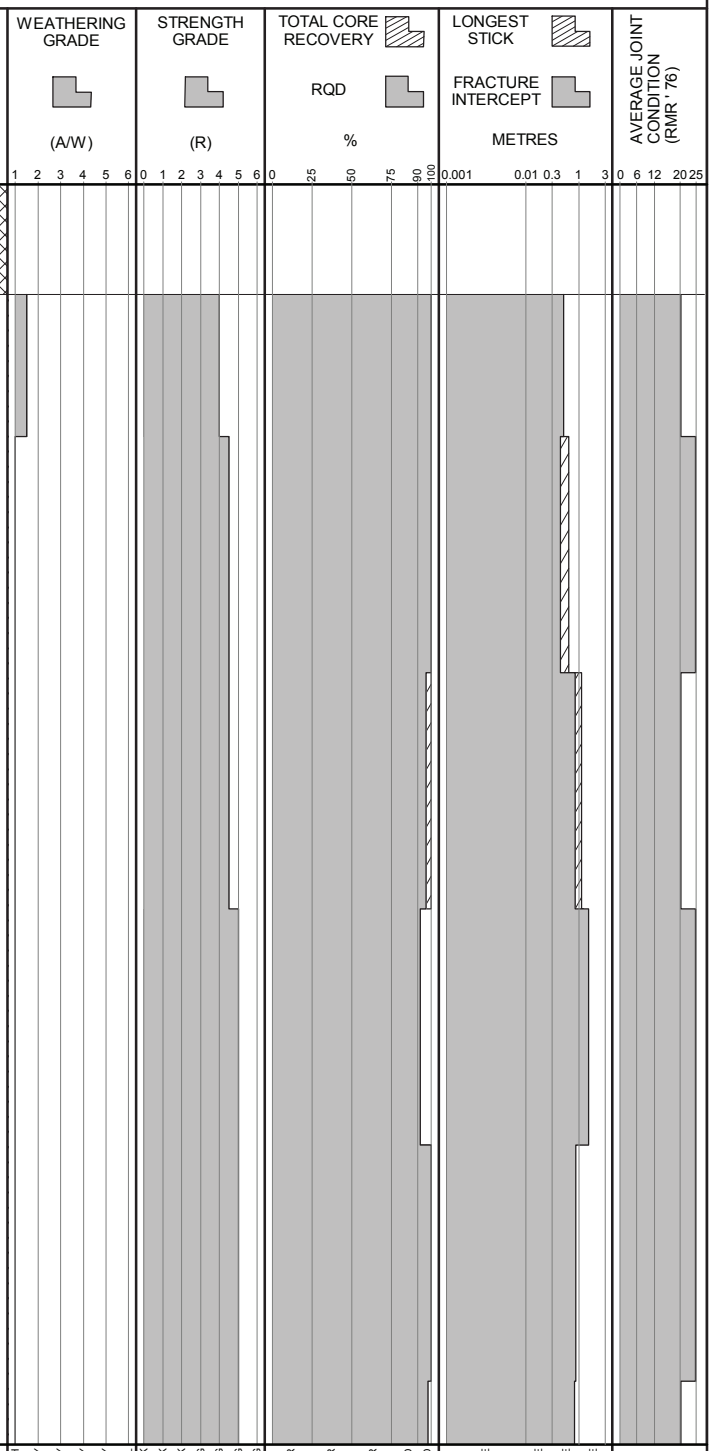
Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,707N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 08 JUL 16
Finish Date: 08 JUL 16
Final Depth (m): 13.7
Depth To Top Of Rock (m): 0.7
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
1			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, light grey, laminated, moderate to strong phyllic/QSP alteration. At 1.06 m - Joint, 1mm aperture, with surface staining
2			
3			
4			
5			
6			
7			
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-03B

Location: CWP Pad E

Co-ordinates (m): 427,027E - 6,258,707N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 08 JUL 16
Finish Date: 08 JUL 16
Final Depth (m): 13.7
Depth To Top Of Rock (m): 0.7
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
11			
12			
13			At 13.30 m - Joint (on vein), 8mm aperture, with clay, calcite infill
14			END OF HOLE AT: 13.67 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 12.17 to 13.67 m on July 8, 2016. 2) Filter sand placed around screen zone from 11.15 to 13.67 m. 3) Lithology descriptions by Pretium geologists.
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD %: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04A

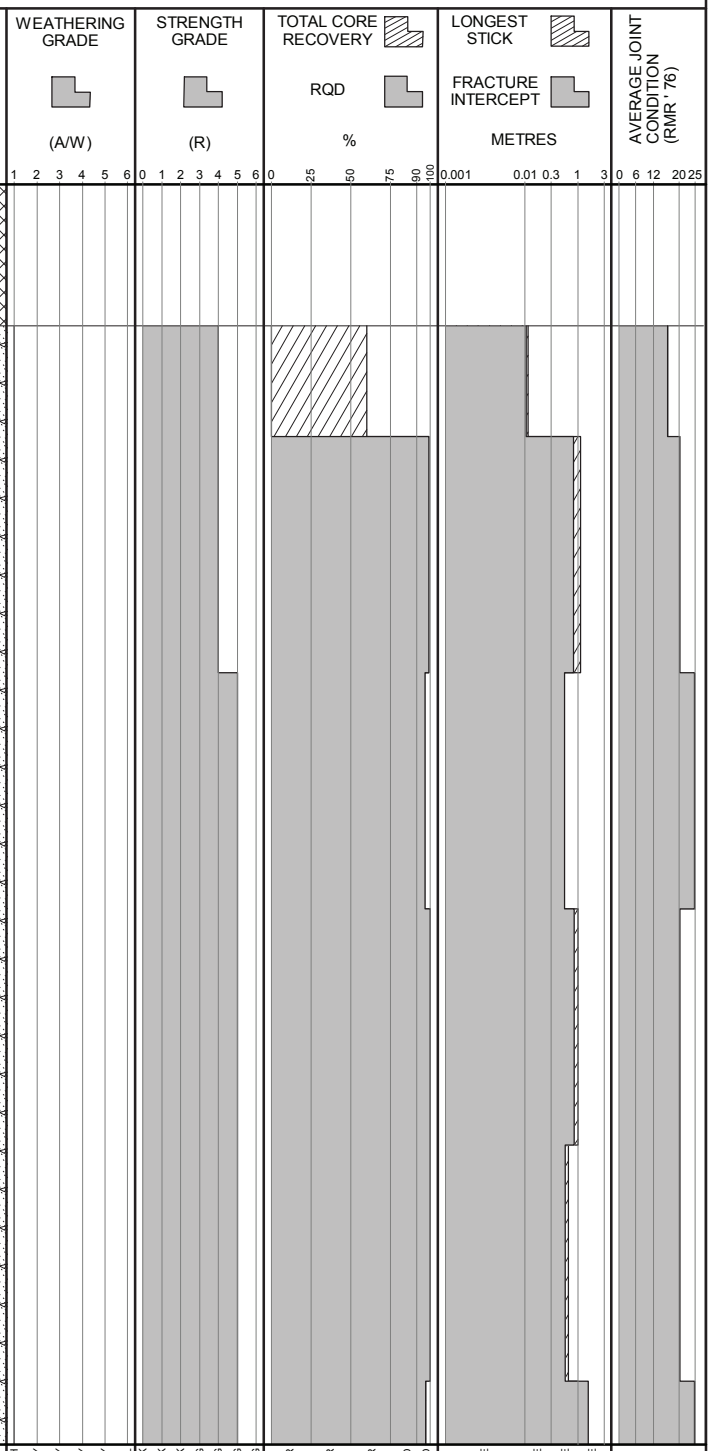
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG
0			FILL	
1			CONGLOMERATE (S3-VSF) Coarse grained, dark grey, polymyctic, >90% reworked volcano-sedimentary facies sediments, moderate to strong sericite alteration.	
2				
3				
4				
5				
6				
7				
8				



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04A

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
11			At 11.00 m - Joint (on vein), 10mm aperture, with broken rock infill
13			At 13.03 m - Joint, 3mm aperture, with decomposed rock infill

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04A

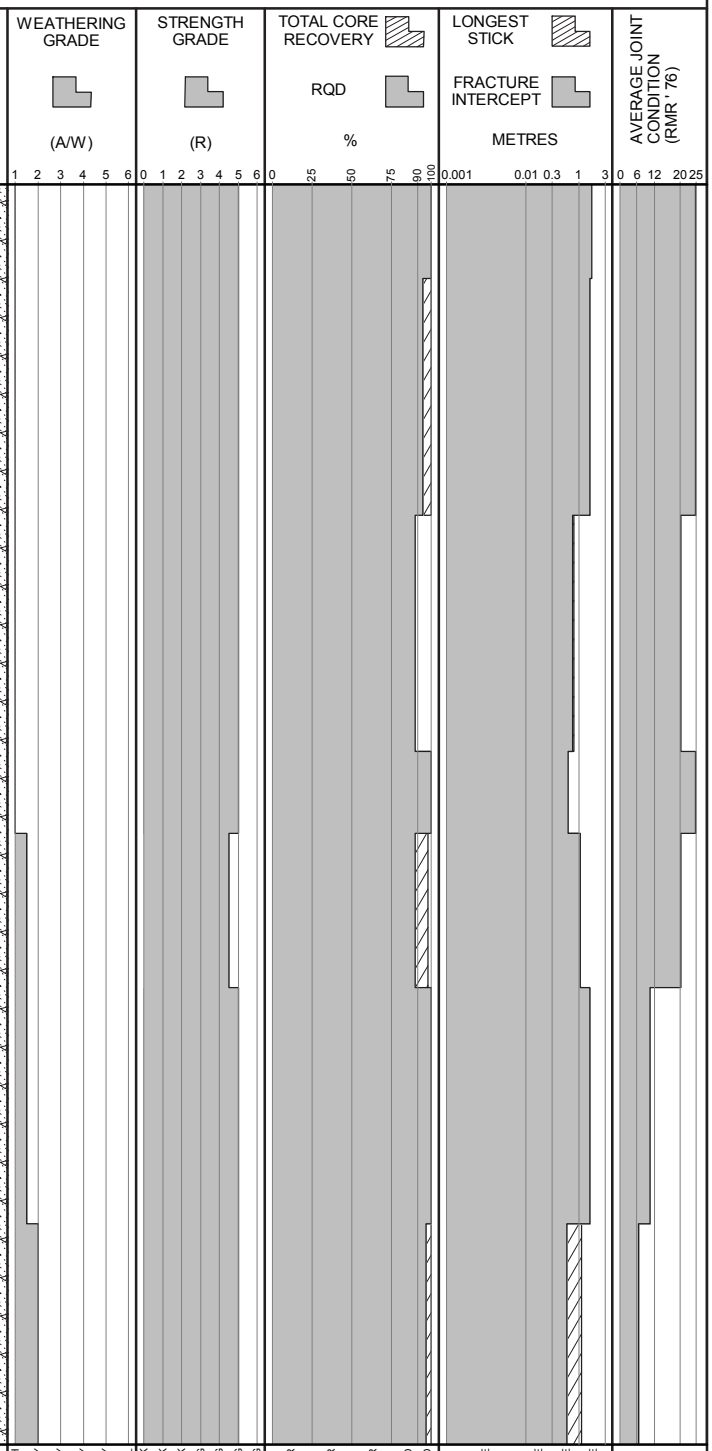
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			
20			
			At 20.22 m - Joint, 1mm aperture, with trace grey clay infill, potential vugs on Joint
21			
22			
			At 22.25 m - Joint (on vein), 1mm aperture, with trace grey clay infill. Curved joint.
23			
			At 23.60 m - Joint, 1mm aperture, with grey clay and decomposed rock infill
24			At 23.80 m - Joint, 90mm aperture, with apparent broken rock infill



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04A

Location: CWP Pad A

Co-ordinates (m): 426,996E - 6,258,789N
Ground Elevation (m): 1,377.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 0.9

Start Date: 09 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 24.2
Depth To Top Of Rock (m): 0.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY % / RQD	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
24			(potentially was very weak/fractured, and not broken, in-situ)						
			At 23.89 m - Joint (on vein), 1mm aperture, with trace grey clay and decomposed rock infill						
			END OF HOLE AT: 24.17 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 22.65 to 24.12 m on July 10, 2016. 2) Filter sand placed around screen zone from 22.28 to 24.12 m. 3) Lithology descriptions by Pretium geologists.						
25									
26									
27									
28									
29									
30									
31									
32									

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
TOTAL CORE RECOVERY % / RQD: 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD
LONGEST STICK / FRACTURE INTERCEPT METRES: 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE
AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-04B

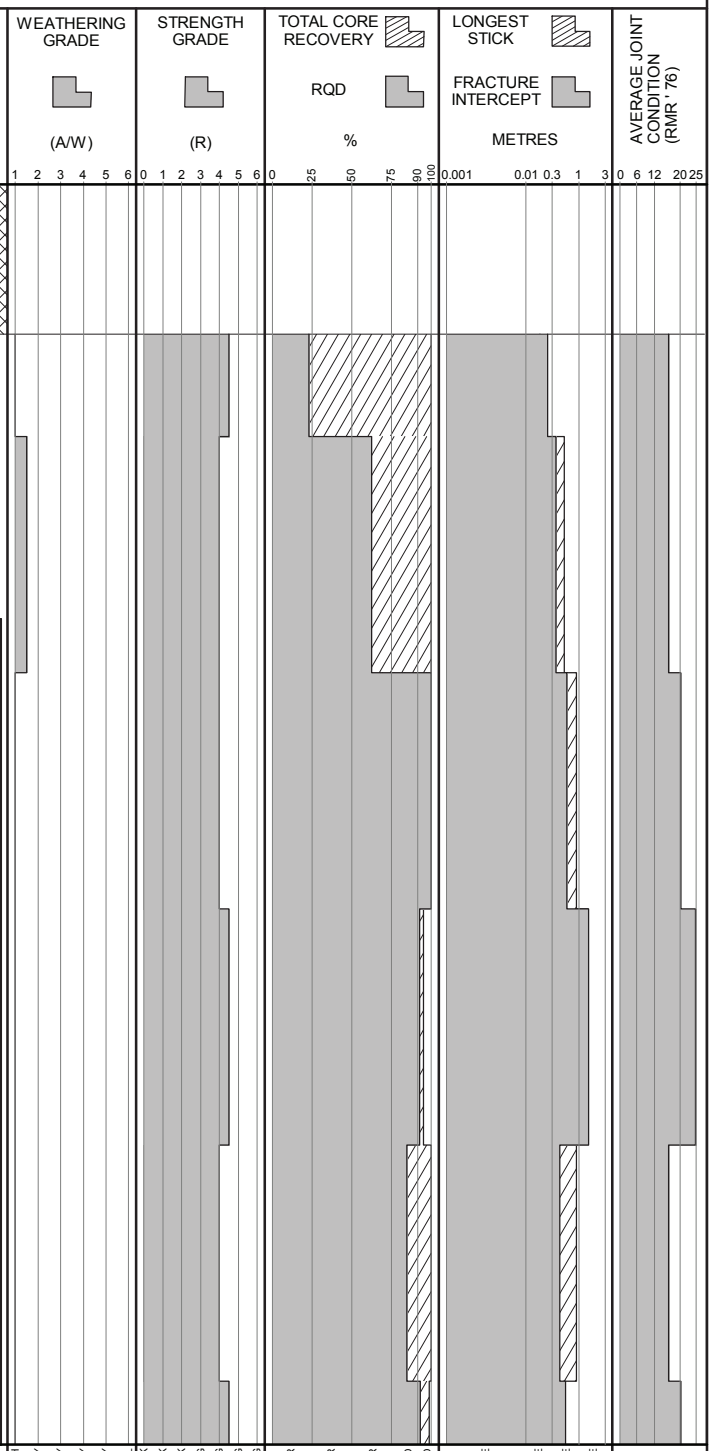
Location: CWP Pad A

Co-ordinates (m): 426,997E - 6,258,792N
Ground Elevation (m): 1,377.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 10 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 14.2
Depth To Top Of Rock (m): 1.0
Logged By: JRW
Reviewed By: TWC

Depth (m)	Instrumentation & Hole Completion Details	Drilling Action or Sample Type	Geotechnical Description, Major Discontinuities, and Additional Notes
0			FILL
1			VOLCANO-SEDIMENTARY FACIES SERIES SANDSTONES (S4-VSF) Fine grained, dark grey, polymyctic, moderate to strong phyllic/QSP alteration.
			At 1.75 m - Joint, 1mm aperture, with oxides/staining
2			At 2.25 m - Joint, 2mm aperture, with decomposed rock infill
3			VOLCANO-SEDIMENTARY FACIES SERIES SILT AND MUDSTONES (S5-VSF) Fine grained, dark grey to black, sheared, moderate to strong phyllic/QSP alteration.
4			
5			
6			
7			At 7.15 m - Joint (on contact), 5mm aperture, with decomposed rock infill
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-04B

Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad A

Co-ordinates (m): 426,997E - 6,258,792N
Ground Elevation (m): 1,377.4
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 10 JUL 16
Finish Date: 10 JUL 16
Final Depth (m): 14.2
Depth To Top Of Rock (m): 1.0
Logged By: JRW
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES	GRAPHIC LOG	WEATHERING GRADE (A/W)	STRENGTH GRADE (R)	TOTAL CORE RECOVERY / RQD %	LONGEST STICK / FRACTURE INTERCEPT METRES	AVERAGE JOINT CONDITION (RMR' 76)
8					1 2 3 4 5 6	0 1 2 3 4 5 6	0 25 50 75 90 100	0.001 0.01 0.3 1 3	0 6 12 20 25
9									
10									
11									
12									
13									
14									
15			END OF HOLE AT: 14.15 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 12.65 to 14.15 m on July 10, 2016. 2) Filter sand placed around screen zone from 12.07 to 14.15 m. 3) Lithology descriptions by Pretium geologists.						
16									

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL
EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG
V. POOR, POOR, FAIR, GOOD, EXT. GOOD
V. CLOSE, CLOSE, MODERATE, WIDE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05A

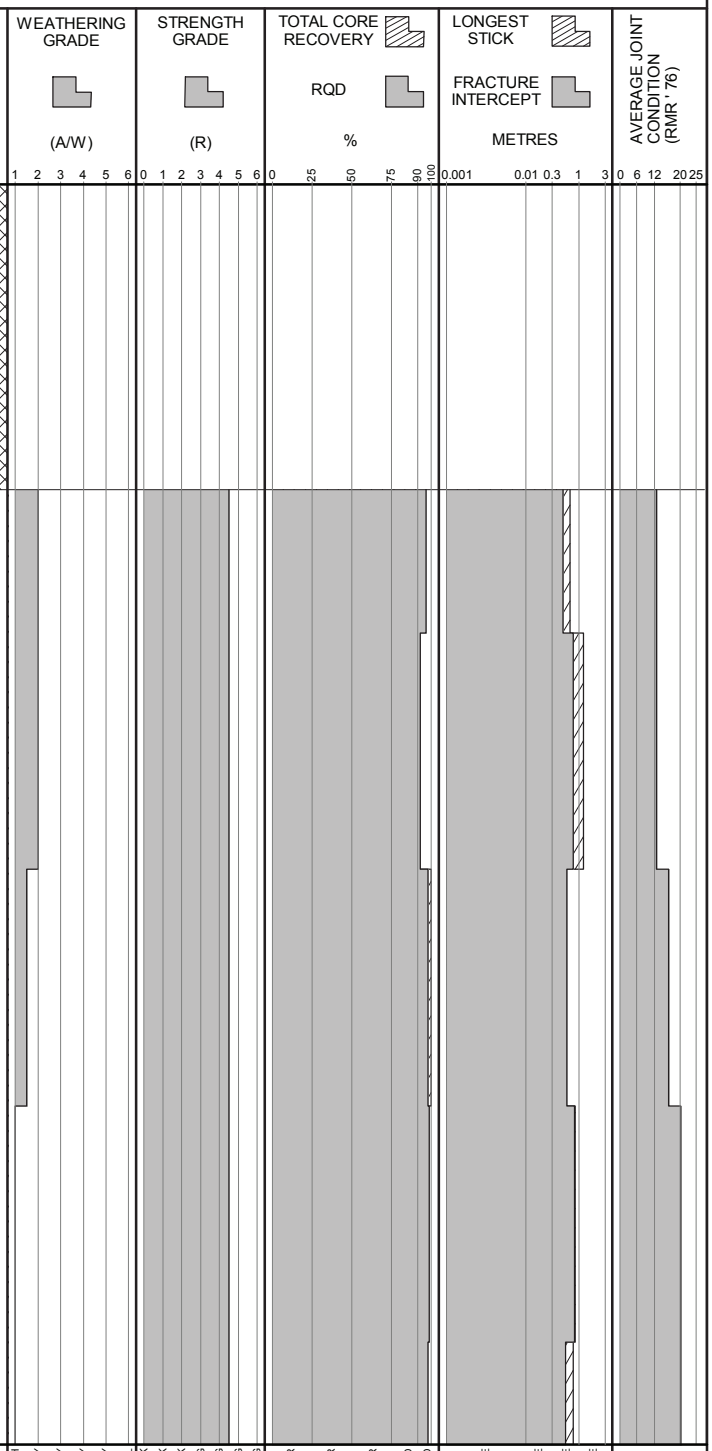
Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
0			FILL
2			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Fine grained, light greenish grey, minor hydrothermal breccias (H15), moderate to strong sericite-chlorite alteration.
			At 2.55 m - Joint, 1mm aperture, with orange staining
			At 2.76 m - Joint, 1mm aperture, with dark orange brown staining
3			At 2.95 m - Joint, 1mm aperture, with surface staining
4			At 4.16 m - Joint, 1mm aperture, with surface staining
5			
			At 5.54 m - Joint, 1mm aperture, with surface staining
6			
7			
8			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05A

Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			
10			
11			At 11.33 m - Joint, 1mm aperture, with surface staining
12			
13			
14			At 13.55 m - Joint, 2mm aperture, with decomposed rock infill, and oxidizes/surface staining
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

DRILL HOLE # MW-BGC16-BJ-05A

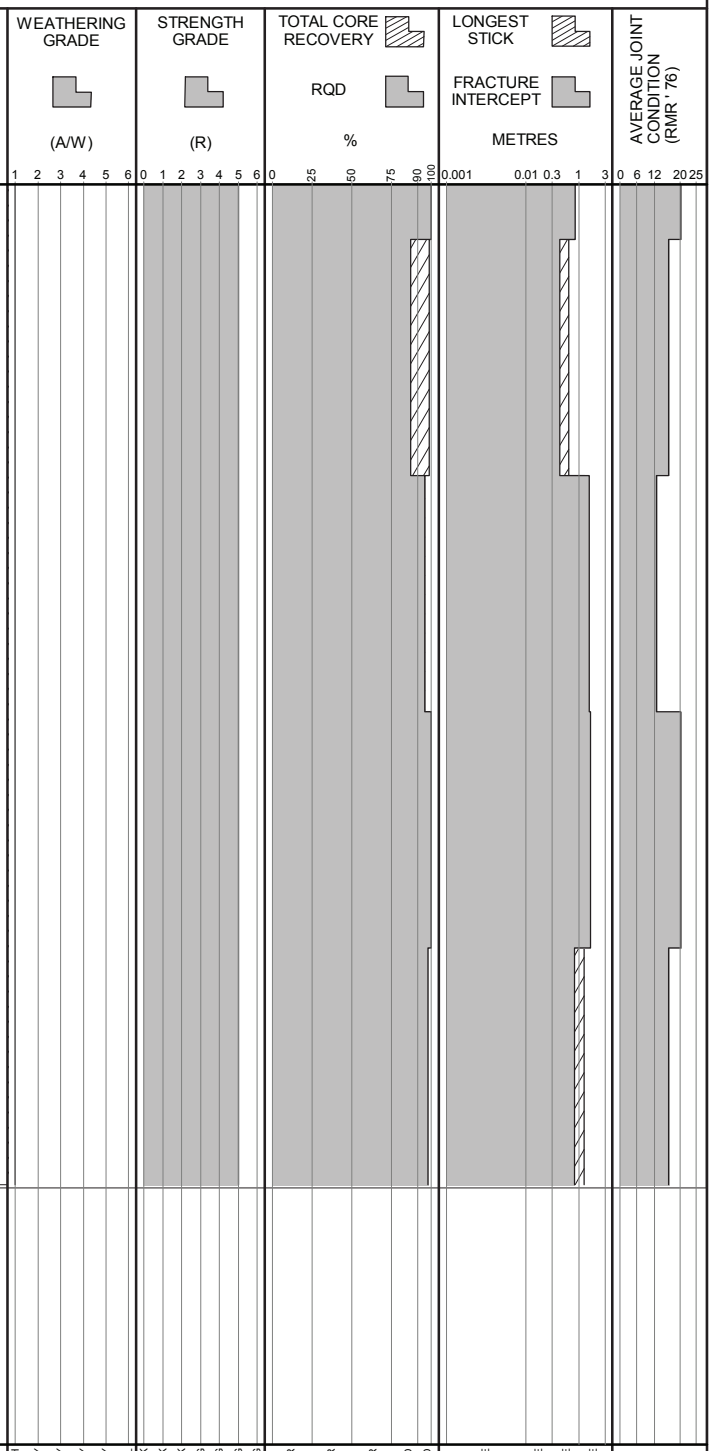
Project: Brucejack 2016-2017
Project No.: 1008-022
Location: CWP Pad B

Co-ordinates (m): 427,011E - 6,258,840N
Ground Elevation (m): 1,372.6
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) : 2.0

Start Date: 10 JUL 16
Finish Date: 11 JUL 16
Final Depth (m): 22.4
Depth To Top Of Rock (m): 1.9
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
16			
17			
18			
19			At 19.00 m - Joint, 2mm aperture, with decomposed rock infill
20			
21			
22			
23			END OF HOLE AT: 22.37 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 19.32 to 22.37 m on July 11, 2016. 2) Filter sand placed around screen zone from 18.65 to 22.37 m. 3) Lithology descriptions by Pretium geologists.
24			



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

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AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05B

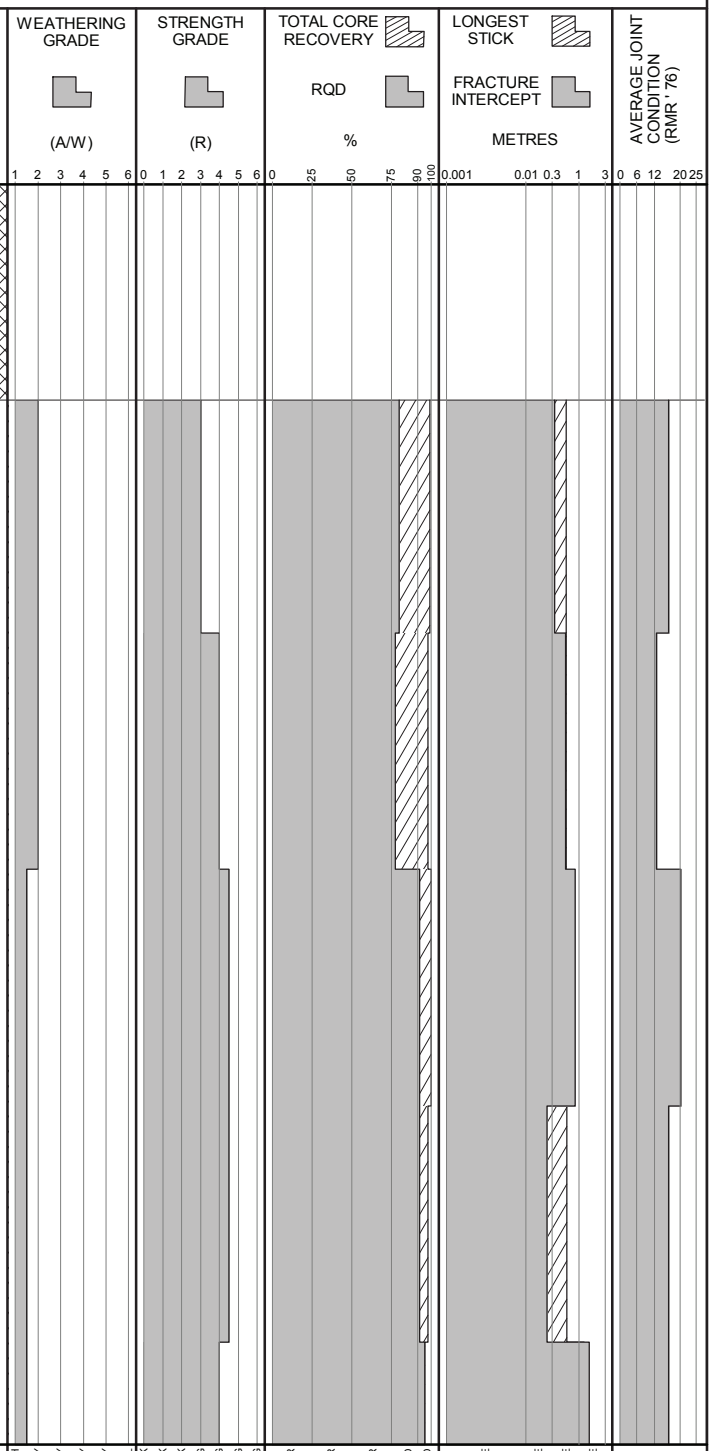
Location: CWP Pad B

Co-ordinates (m): 427,014E - 6,258,838N
Ground Elevation (m): 1,372.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 11 JUL 16
Finish Date: 12 JUL 16
Final Depth (m): 13.3
Depth To Top Of Rock (m): 1.4
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	Instrumentation & Hole Completion Details	Drilling Action or Sample Type	Geotechnical Description, Major Discontinuities, and Additional Notes
0			FILL
1			
2			INTERMEDIATE FRAGMENTAL VOLCANICS (V12) Medium grained, pale blue-green, locally weakly silicified. At 1.37 m - Joint, 1mm aperture, with grey clay infill At 1.83 m - Joint, 1.5mm aperture, with grey clay and decomposed rock infill and dark brown staining At 1.91 m - Joint, 1mm aperture, with grey clay infill and dark brown staining At 2.22 m - Joint, 1mm aperture, with orange brown staining At 2.34 m - Joint, 1.5mm aperture, with orange brown staining
3			At 3.17 m - Joint, 1mm aperture, with orange staining At 3.29 m - Joint, 0.5mm aperture, with orange staining. Curved joint.
4			At 3.90 m - Joint, 1mm aperture, with orange staining. Very long, undulating joint.
5			At 5.07 m - Joint, 0.5mm aperture, with orange staining
6			At 6.00 m - Joint, 1mm aperture, with surface staining At 6.10 m - Joint, 1mm aperture, with surface staining At 6.20 m - Joint, 1mm aperture, with surface staining At 6.33 m - Joint, 1mm aperture, with surface staining
7			
8			At 7.64 m - Joint, 1mm aperture, with surface staining



POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Project: Brucejack 2016-2017
Project No.: 1008-022

DRILL HOLE # MW-BGC16-BJ-05B

Location: CWP Pad B

Co-ordinates (m): 427,014E - 6,258,838N
Ground Elevation (m): 1,372.5
Survey Method: Surveyed co-ordinates
Datum: UTM NAD 83 Zone 9
Plunge (°): -90
Trend (°): 000

Drill Designation: Heliportable
Drilling Contractor: HY TECH
Drill Method: DIAMOND CORING
Core: PQ
Fluid: Polymer
Cased To (m) :

Start Date: 11 JUL 16
Finish Date: 12 JUL 16
Final Depth (m): 13.3
Depth To Top Of Rock (m): 1.4
Logged By: JRW, SH
Reviewed By: TWC

Depth (m)	INSTRUMENTATION & HOLE COMPLETION DETAILS	DRILLING ACTION OR SAMPLE TYPE	GEOTECHNICAL DESCRIPTION, MAJOR DISCONTINUITIES, AND ADDITIONAL NOTES
8			
9			At 9.40 m - Joint, 1mm aperture, with surface staining
10			At 10.00 m - Joint, 1mm aperture, with surface staining
			At 10.56 m - Joint (on vein), 1mm aperture, with waxy coating of decomposed rock
11			
			At 11.47 m - Joint, 1mm aperture, with waxy coating of decomposed rock
12			
13			
			END OF HOLE AT: 13.25 m. NOTES: 1) Installed 5.08cm (2") PVC standpipe piezometer with 10-slot slotted screen from 9.00 to 10.50 m on July 12, 2016. 2) Filter sand placed around screen zone from 8.50 to 10.50 m. 3) Backfilled from end of hole to 10.50m with bentonite chips. 4) Lithology descriptions by Pretium geologists.
14			
15			
16			

GRAPHIC LOG

WEATHERING GRADE (A/W): 1 2 3 4 5 6 — FRESH, SLIGHTLY, MODERATELY, HIGHLY, COMPLETELY, SOIL

STRENGTH GRADE (R): 0 1 2 3 4 5 6 — EXT. WEAK, V. WEAK, WEAK, MED. STRONG, STRONG, V. STRONG, EXT. STRONG

TOTAL CORE RECOVERY / RQD (%): 0 25 50 75 90 100 — V. POOR, POOR, FAIR, GOOD, EXT. GOOD

LONGEST STICK / FRACTURE INTERCEPT (METRES): 0.001 0.01 0.3 1 3 — V. CLOSE, CLOSE, MODERATE, WIDE

AVERAGE JOINT CONDITION (RMR' 76): 0 6 12 20 25

POINT LOAD TESTS
D — TEST TYPE: DIAMETRAL (D); AXIAL (A)
1.5— Is_{50} (MPa)

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Client: Pretium Resources Inc.

LOG SCALE: 1:50

BRUCEJACK (ROCKONLY_ALLDATA) BRUCEJACK_ROCK.GDL BGC.GDT 1/3/17

Appendix C: Observed Groundwater Level Time Series

NEWCREST

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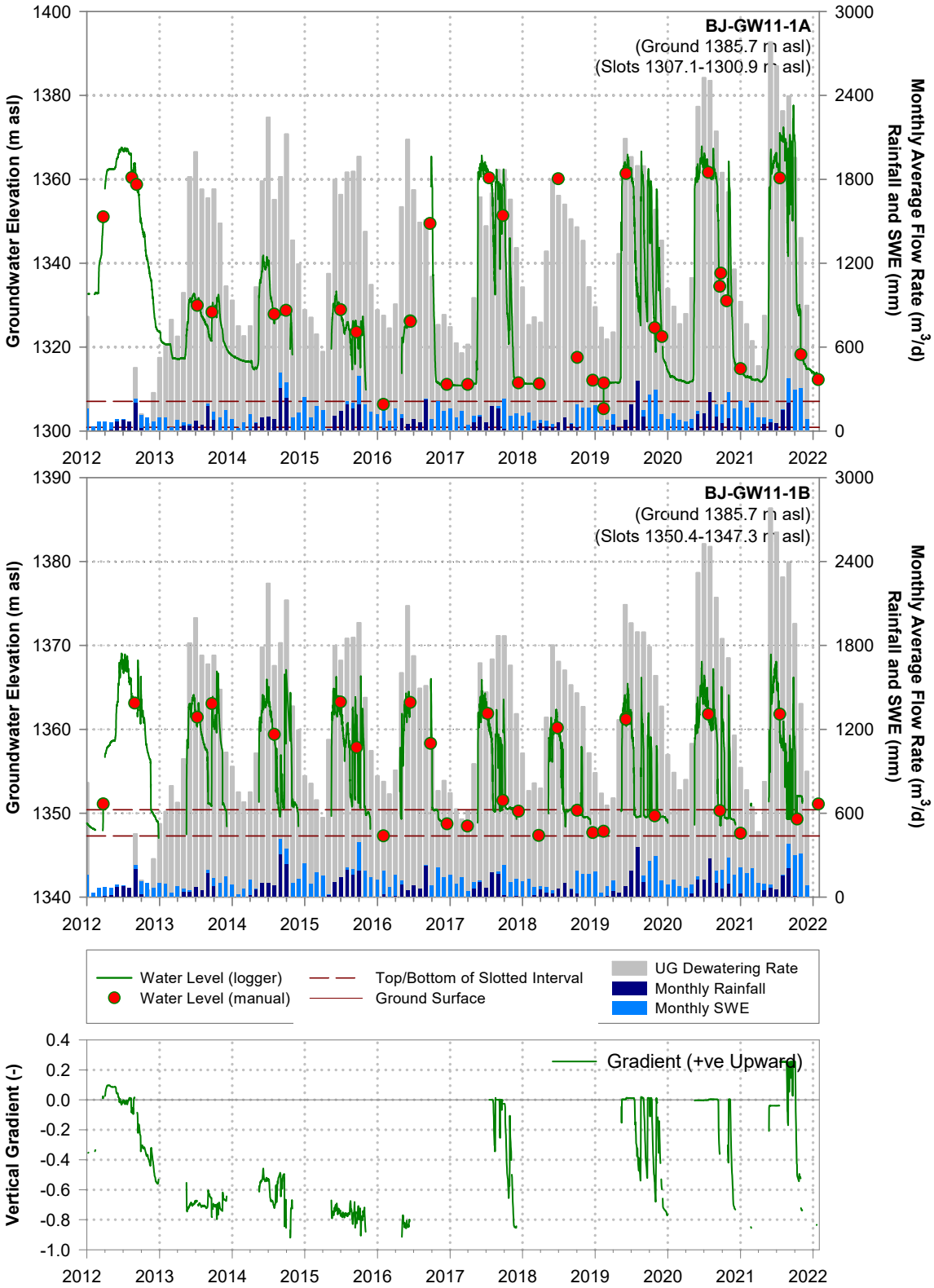

Figure 1: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-1A/B

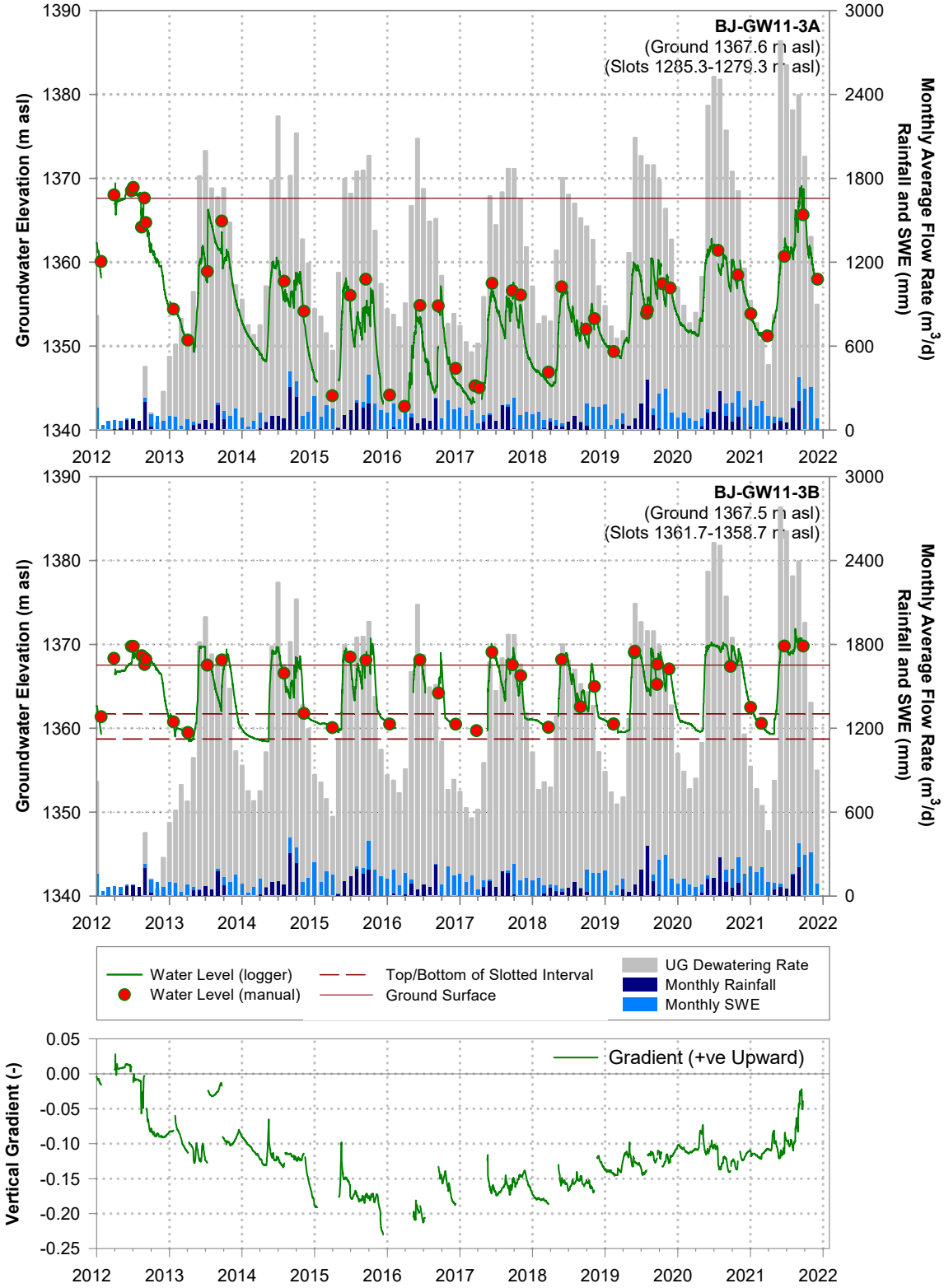

Figure 2: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-3A/B

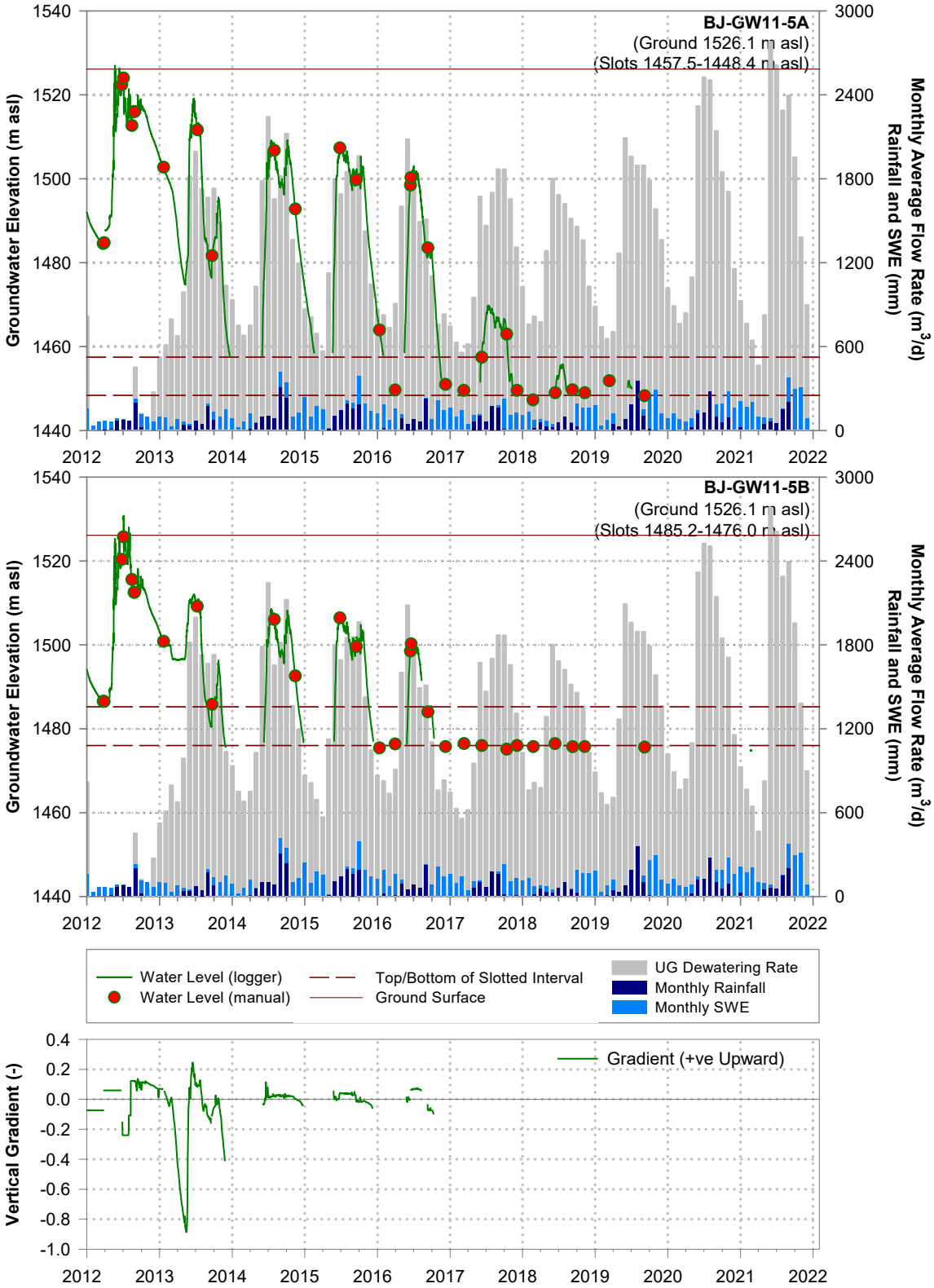

Figure 3: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-5A/B

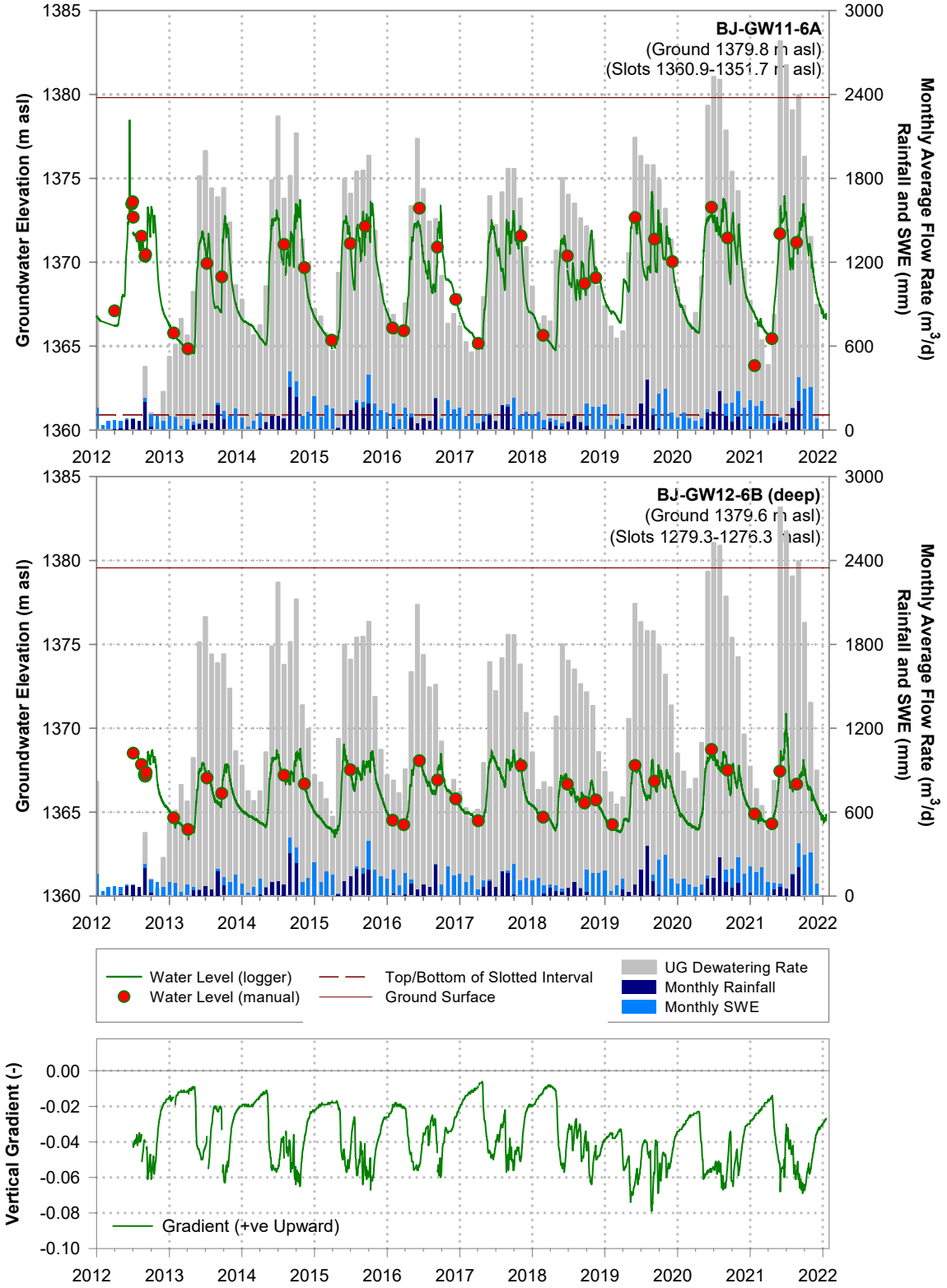

Figure 4: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW11-6A/BJ-GW12-6B

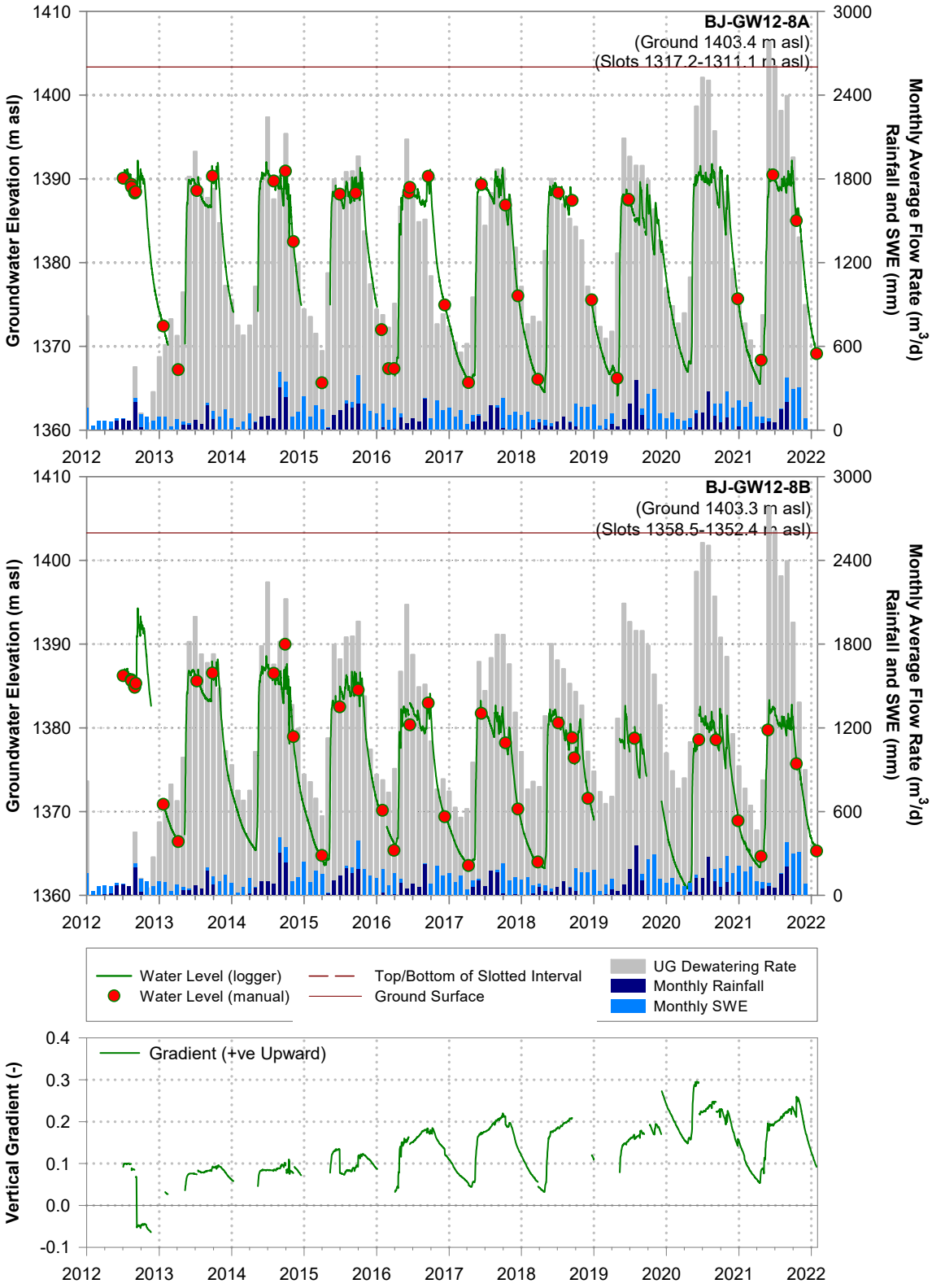

Figure 5: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-8A/B

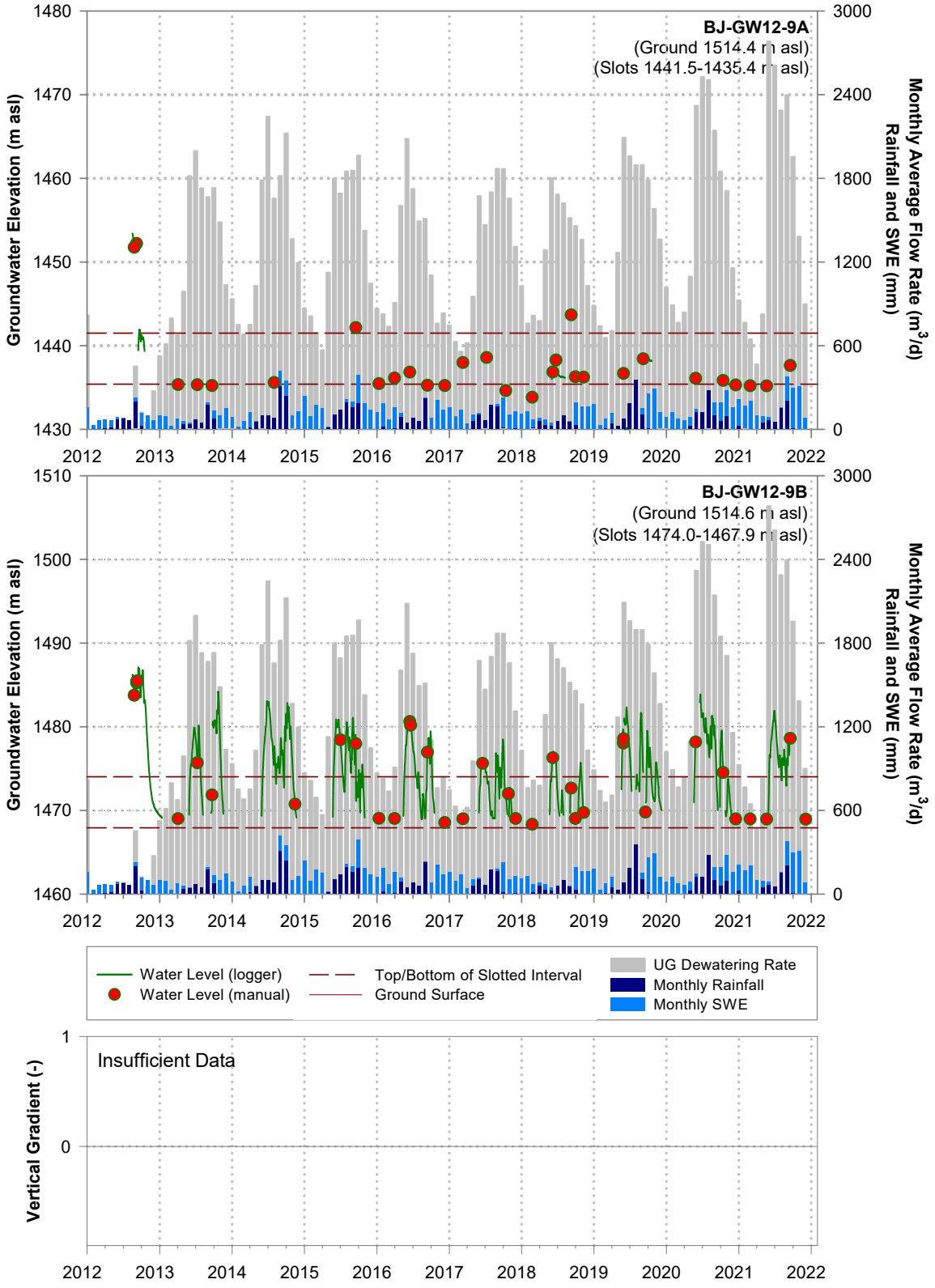

Figure 6: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-9A/B

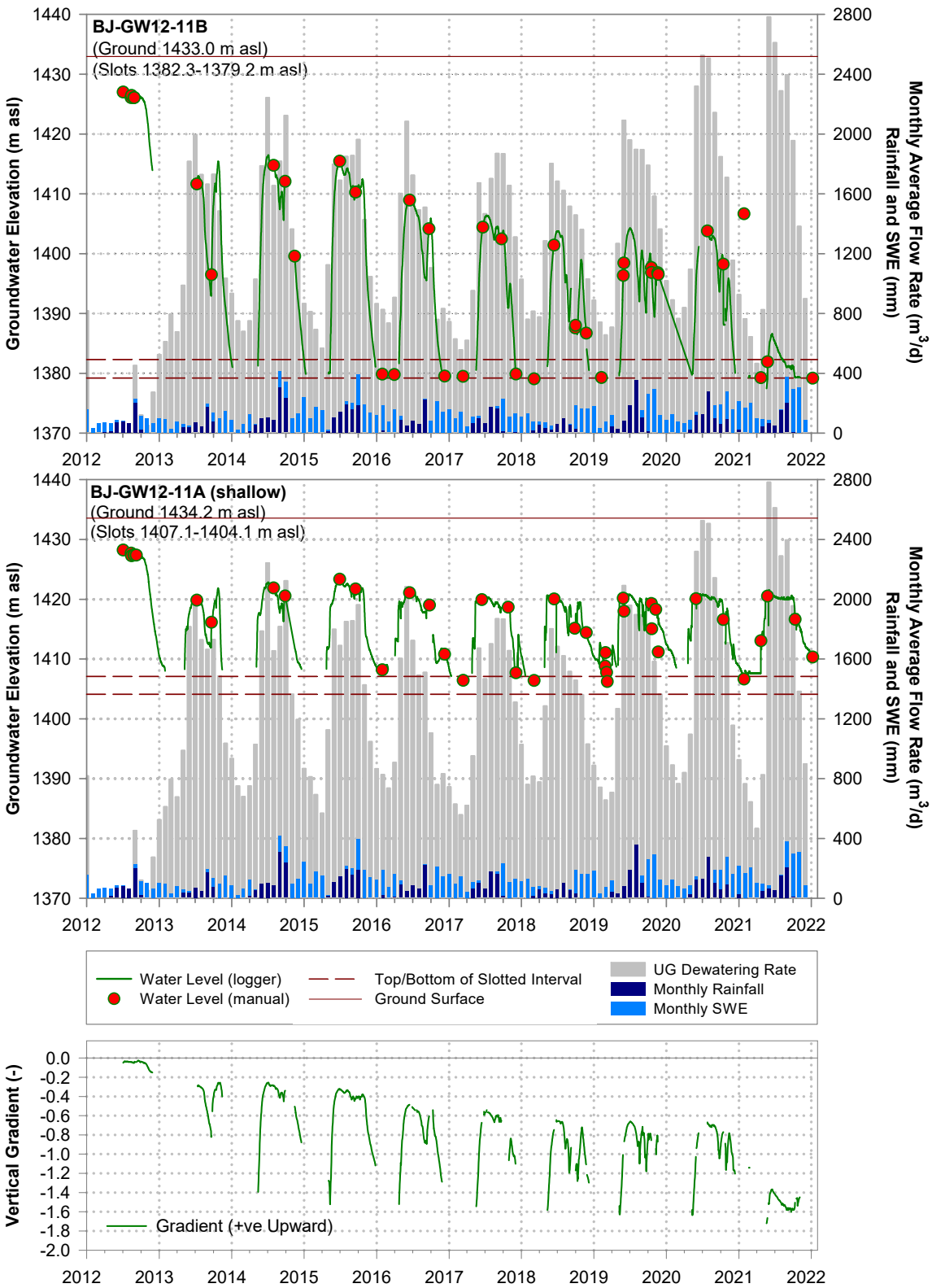

Figure 7: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-11A/B

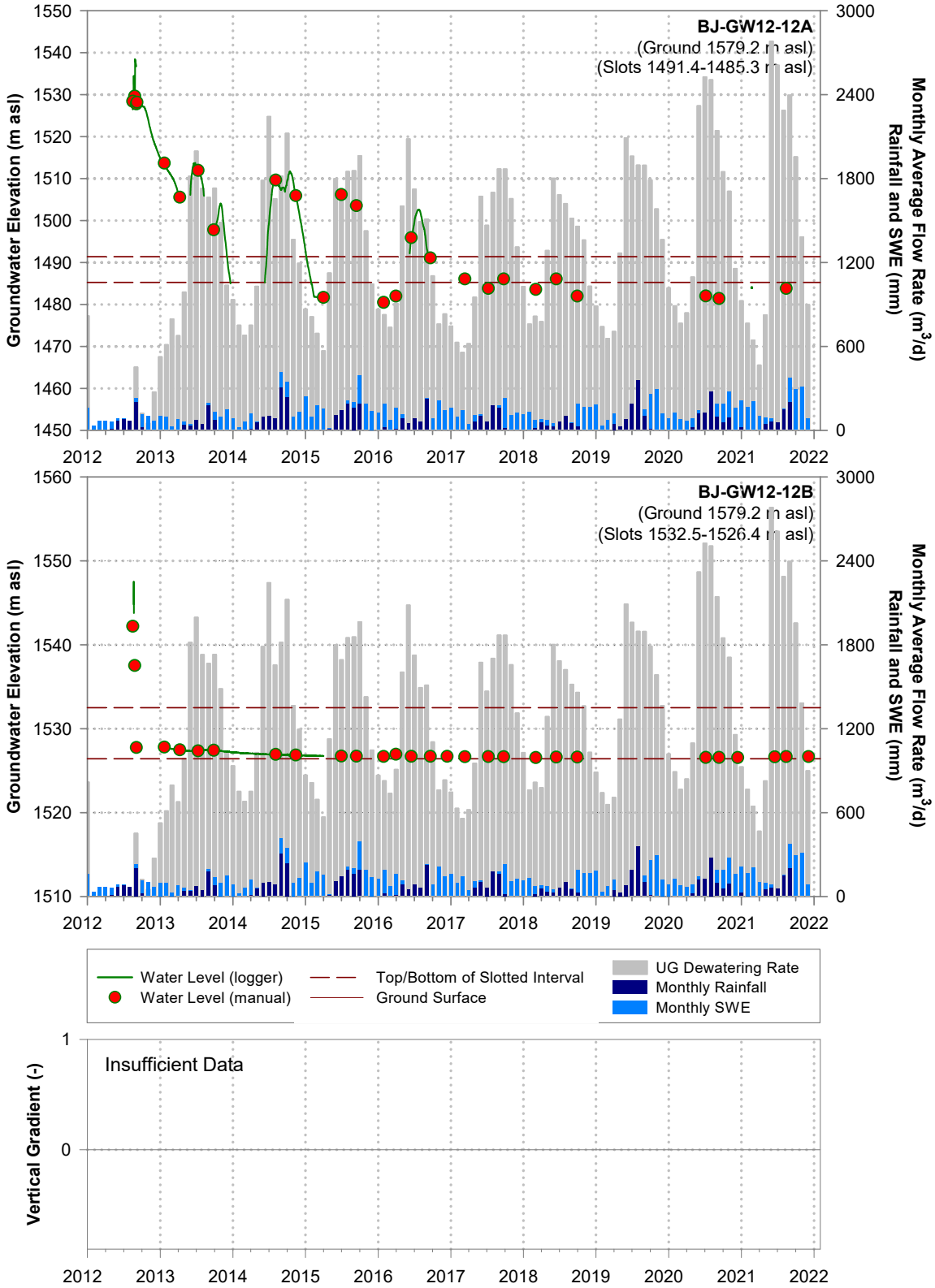

Figure 8: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW12-12A/B

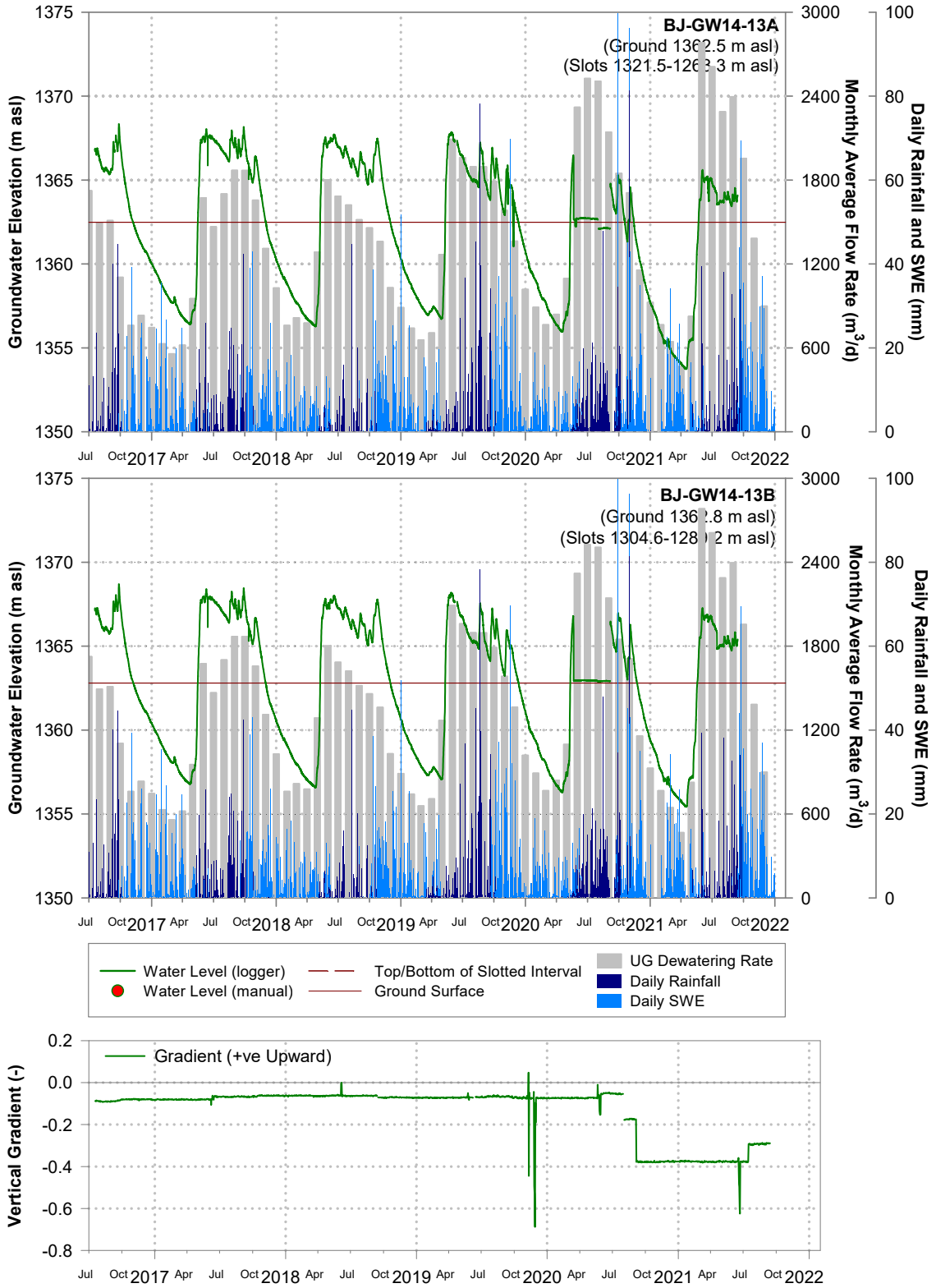

Figure 9: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW14-13A/B

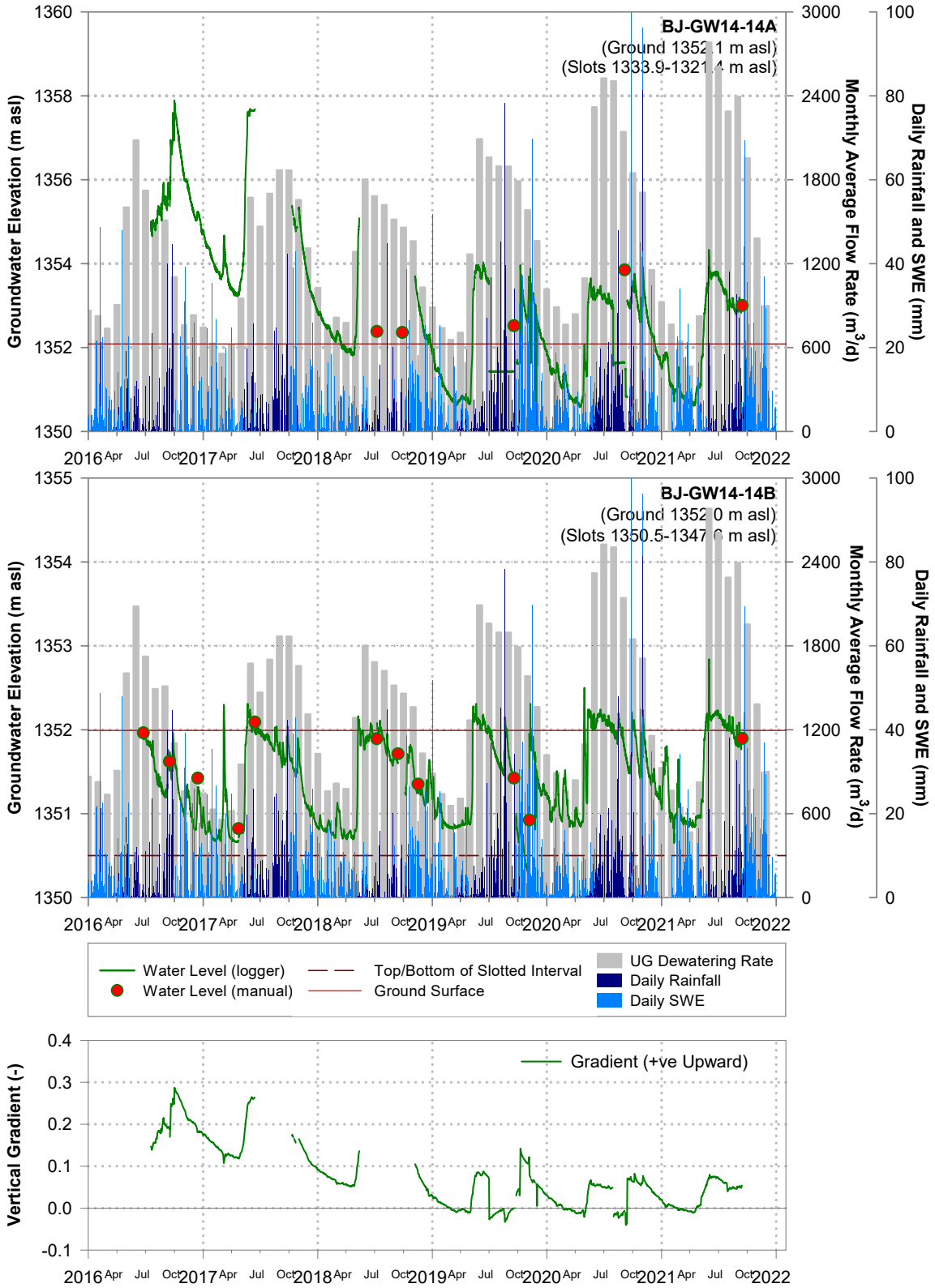

Figure 10: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW14-14A/B

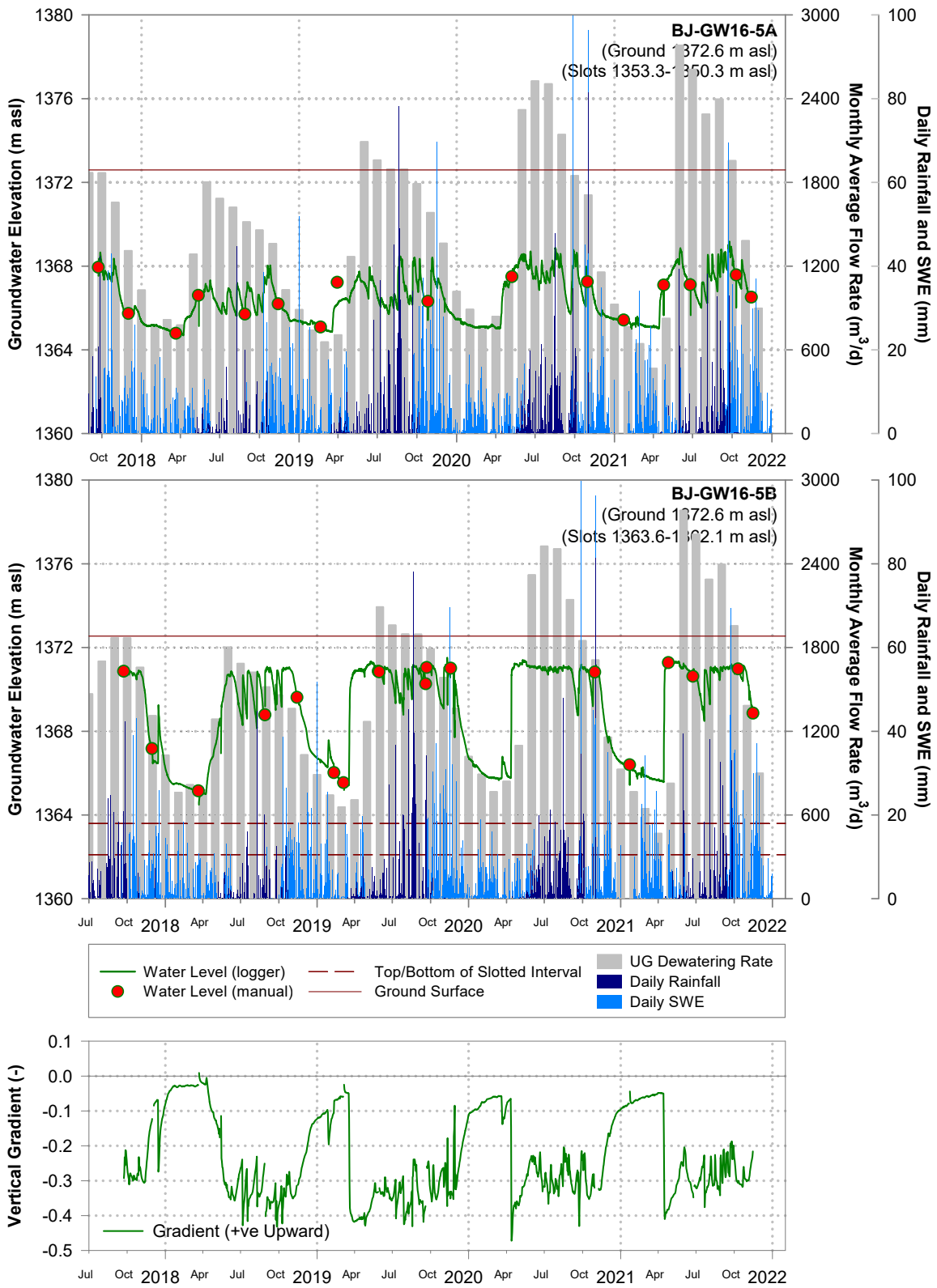

Figure 11: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW16-5A/B

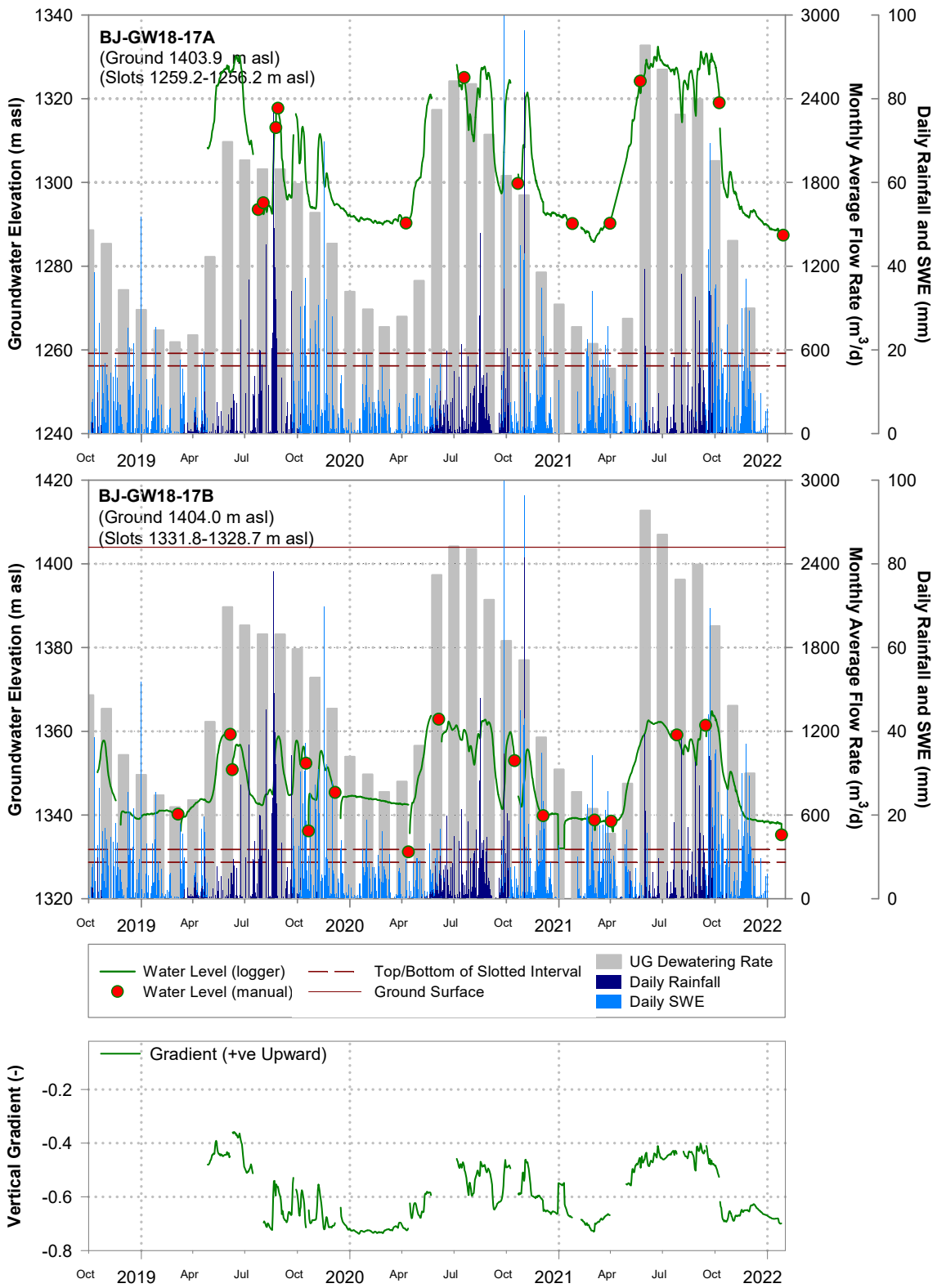

Figure 12: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-17A/B

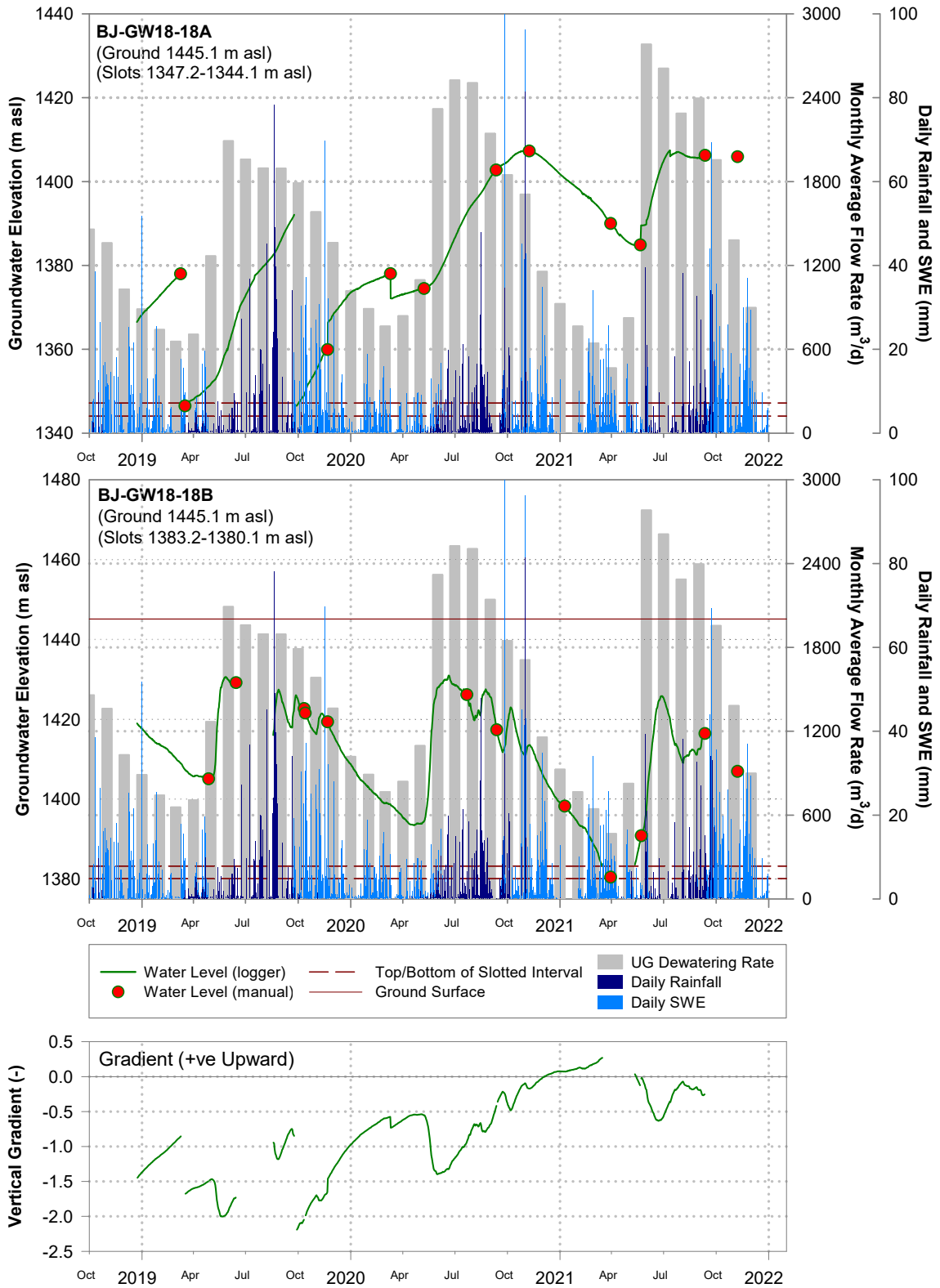

Figure 13: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-18A/B

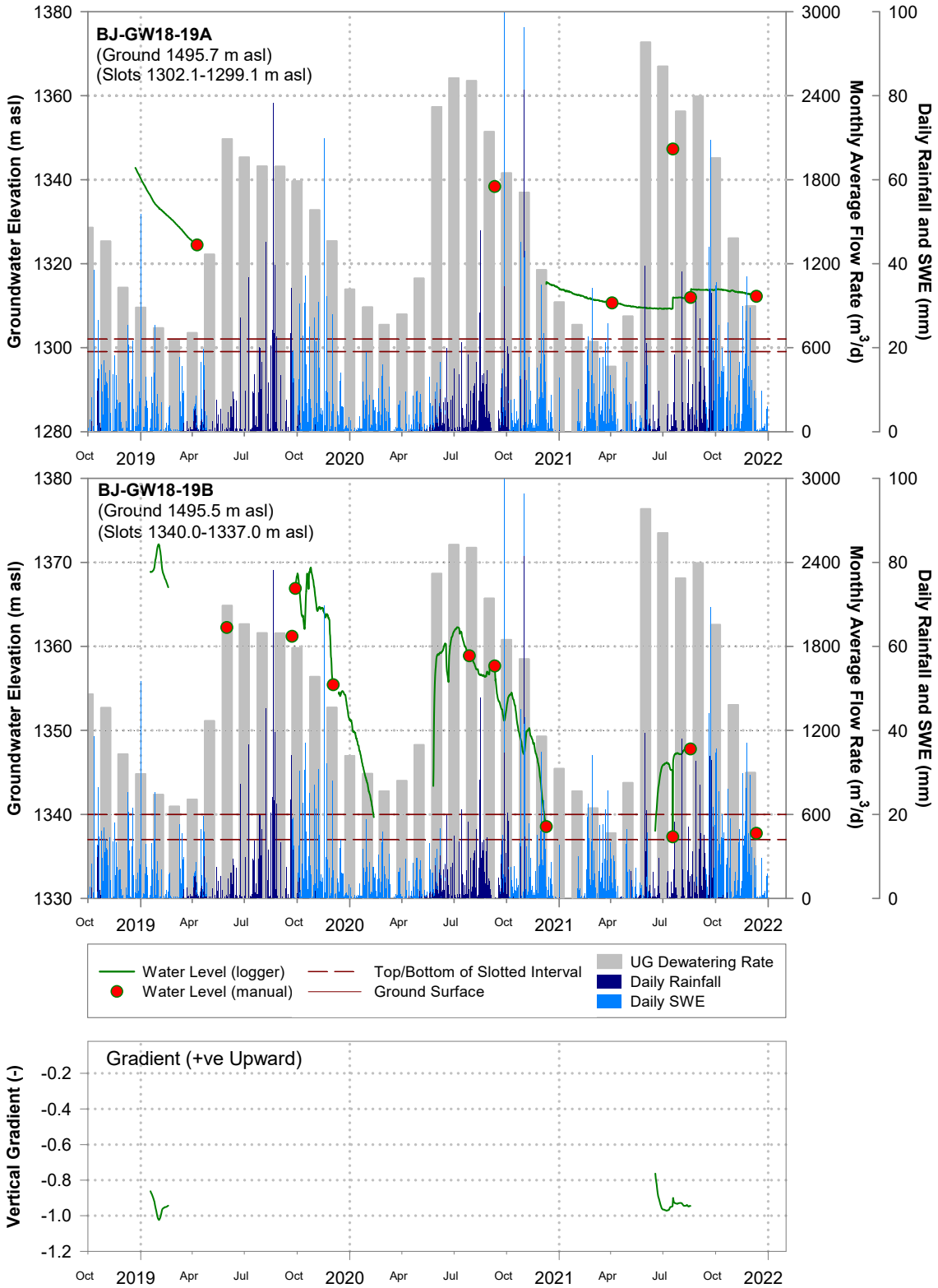

Figure 14: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-19A/B

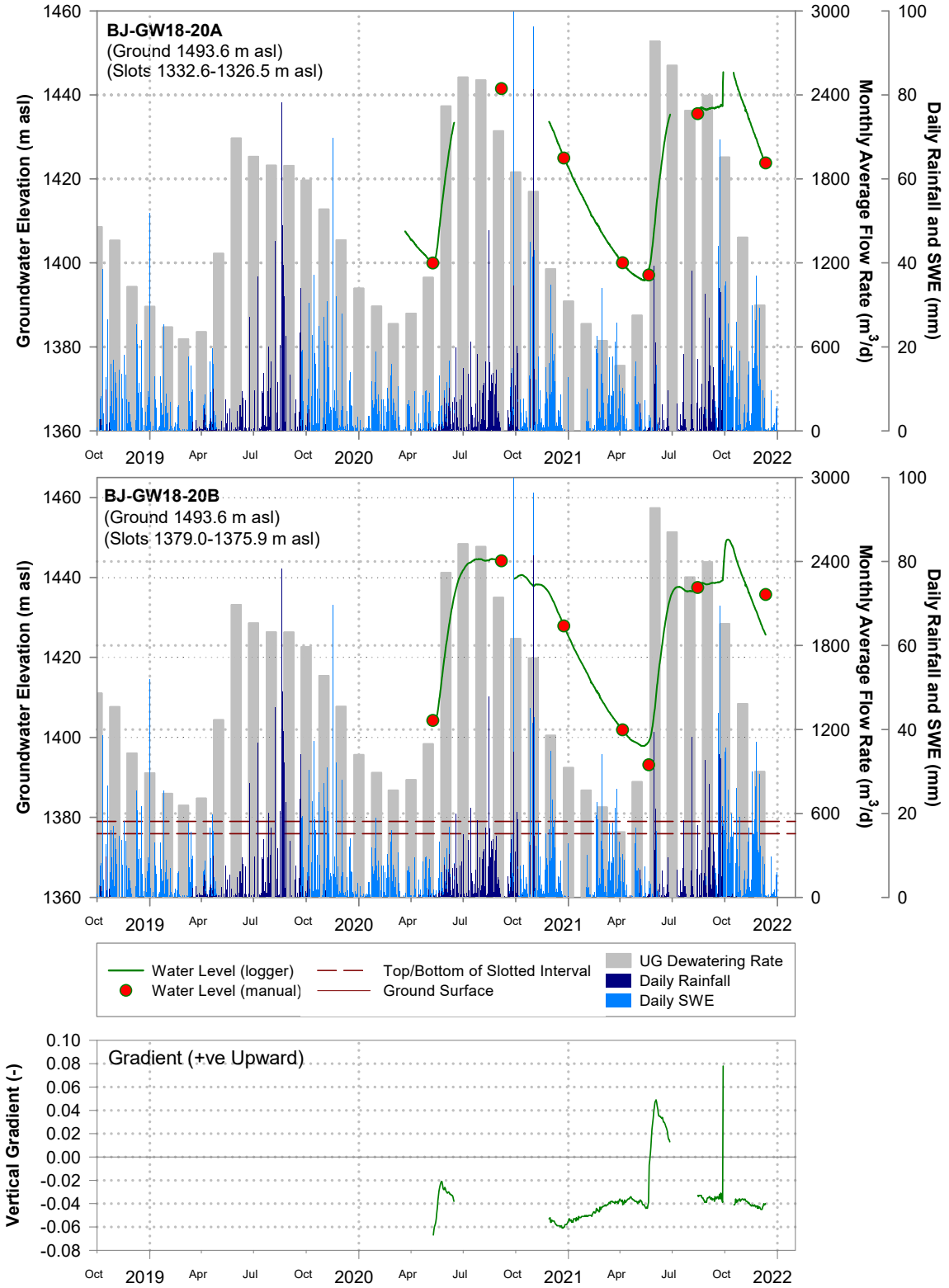

Figure 15: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-20A/B

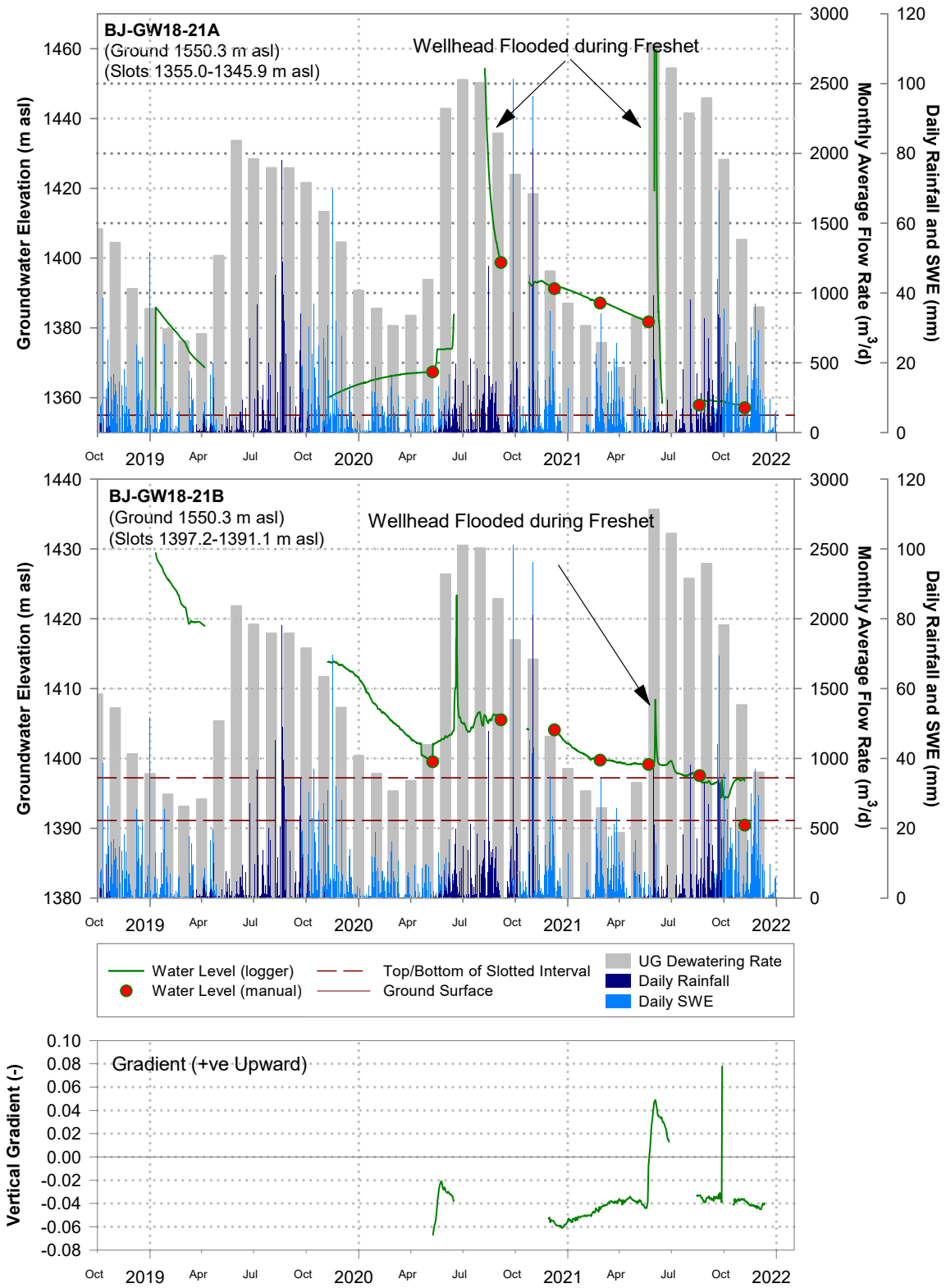

Figure 16: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-21A/B

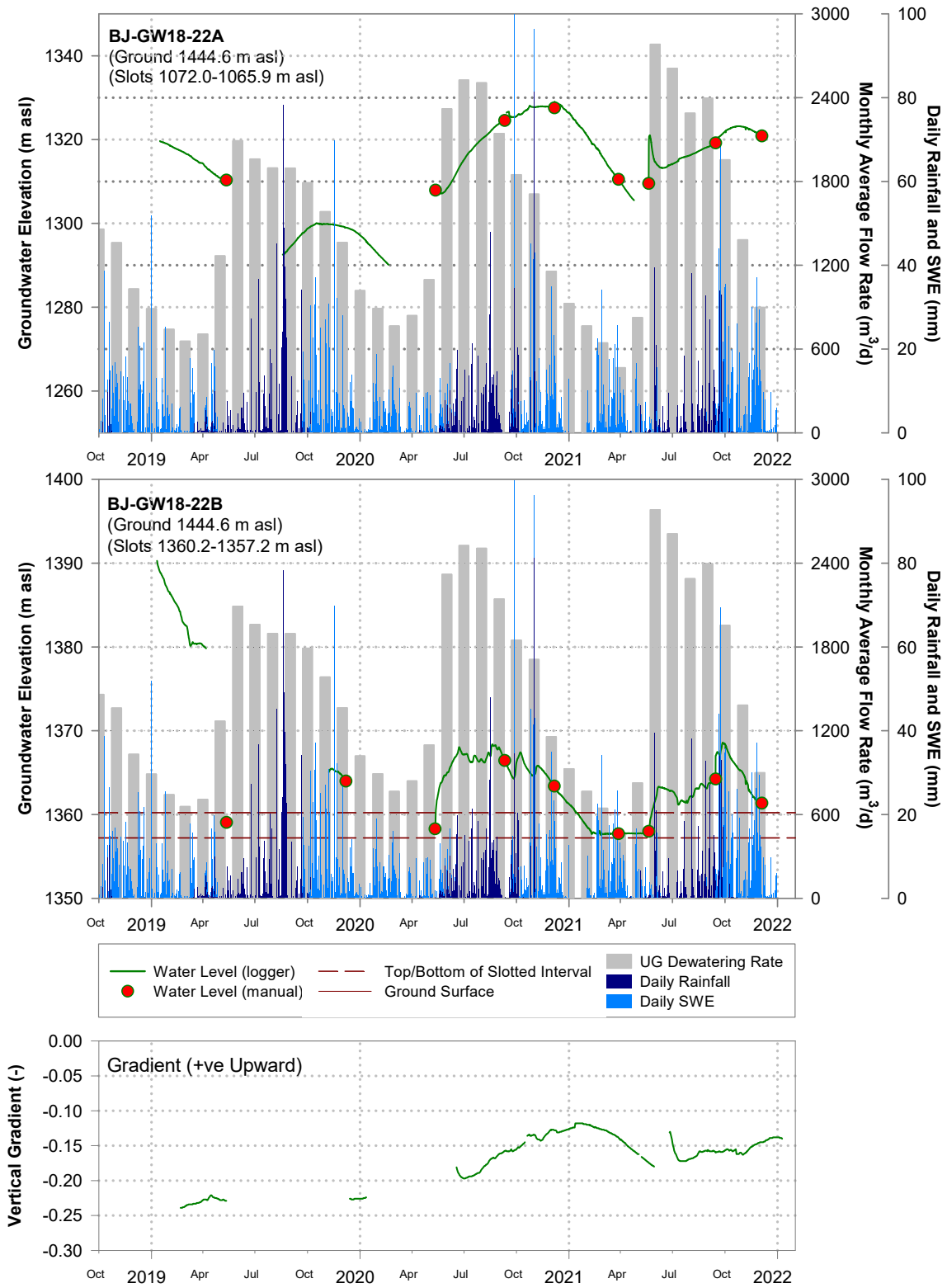

Figure 17: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-22A/B

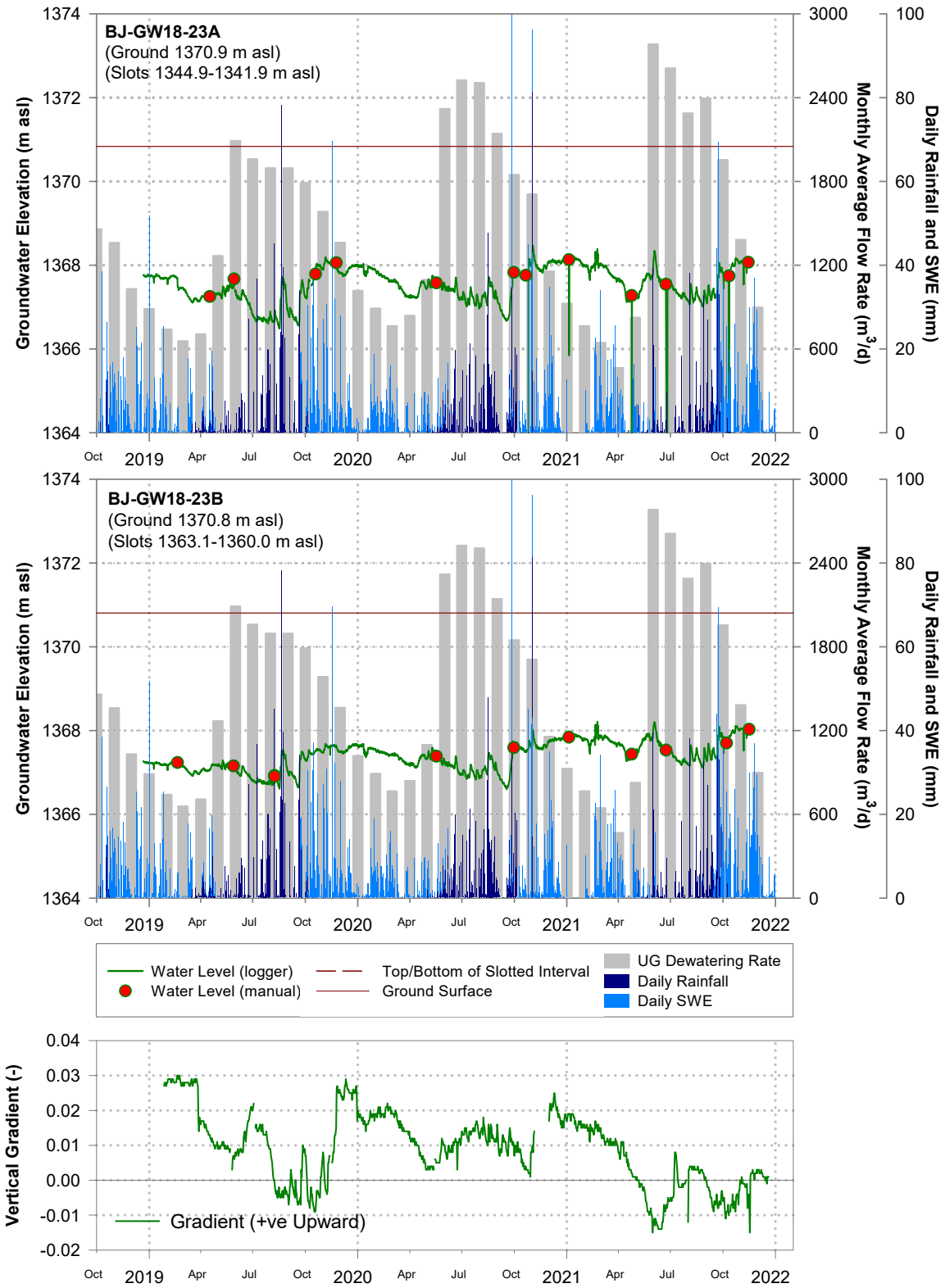

Figure 18: Groundwater hydrographs and vertical hydraulic gradients measured at well nest BJ-GW18-23A/B

Appendix D: Observed and Simulated Monthly Underground Dewatering Rates

NEWCREST

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Appendix D-1: Observed and Simulated Underground Dewatering Rates (2011-2021)

OBSERVED							FEFLOW SIMULATED		
Month/ Year	**UG Monthly Flow In (m^3)**	**Water Supplied to UG Drills (UG Waterbox)[1] (m^3)**	**Underground Monthly Flow - Groundwater Only (m^3)**	**Underground Monthly Flow - Groundwater Only (m^3/d)**	**Underground Monthly Flow - Groundwater Only (m^3/s)**	**Metric for UG Water Measurement[2]**	**Month/ Year**	**Monthly Underground Dewatering (m^3/d)**	**Monthly Underground Dewatering (m^3/s)**
Nov-2011				1,124	0.013		Nov-2011	1,064	0.012
Dec-2011				938	0.011		Dec-2011	930	0.011
Jan-2012				818	0.009		Jan-2012	909	0.011
Feb-2012				-	-		Feb-2012	0	0.000
Mar-2012				-	-		Mar-2012	0	0.000
Apr-2012				-	-		Apr-2012	0	0.000
May-2012				-	-		May-2012	0	0.000
Jun-2012				-	-		Jun-2012	0	0.000
Jul-2012				-	-		Jul-2012	0	0.000
Aug-2012				-	-		Aug-2012	0	0.000
Sep-2012				452	0.005		Sep-2012	937	0.011
Oct-2012				121	0.001		Oct-2012	955	0.011
Nov-2012				52	0.001		Nov-2012	834	0.010
Dec-2012				274	0.003		Dec-2012	724	0.008
Jan-2013				525	0.006		Jan-2013	699	0.008
Feb-2013				612	0.007		Feb-2013	680	0.008
Mar-2013				796	0.009		Mar-2013	634	0.007
Apr-2013				677	0.008		Apr-2013	650	0.008
May-2013				988	0.011		May-2013	823	0.010
Jun-2013				1,817	0.021		Jun-2013	1,289	0.015
Jul-2013				1,996	0.023		Jul-2013	1,342	0.016
Aug-2013				1,729	0.020		Aug-2013	1,292	0.015
Sep-2013				1,665	0.019		Sep-2013	1,161	0.013
Oct-2013				1,731	0.020		Oct-2013	1,269	0.015
Nov-2013				1,485	0.017		Nov-2013	1,082	0.013
Dec-2013				1,036	0.012		Dec-2013	946	0.011
Jan-2014				934	0.011		Jan-2014	843	0.010
Feb-2014				751	0.009		Feb-2014	794	0.009
Mar-2014				680	0.008		Mar-2014	720	0.008
Apr-2014				751	0.009		Apr-2014	684	0.008
May-2014				1,029	0.012		May-2014	882	0.010
Jun-2014				1,787	0.021		Jun-2014	1,577	0.018
Jul-2014				2,243	0.026		Jul-2014	1,564	0.018
Aug-2014				1,655	0.019		Aug-2014	1,433	0.017
Sep-2014				1,818	0.021		Sep-2014	1,418	0.016
Oct-2014	65,838		65,838	2,124	0.025	WTP Flow totalizer	Oct-2014	1,497	0.017
Nov-2014	40,932		40,932	1,364	0.016	WTP effluent to environment totalizer	Nov-2014	1,159	0.013
Dec-2014	37,036		37,036	1,195	0.014	WTP effluent to environment totalizer	Dec-2014	1,032	0.012
Jan-2015	26,851		26,851	866	0.010	WTP effluent to environment totalizer	Jan-2015	892	0.010
Feb-2015	22,741		22,741	812	0.009	WTP effluent to environment totalizer	Feb-2015	824	0.010
Mar-2015	21,493		21,493	693	0.008	WTP effluent to environment totalizer	Mar-2015	773	0.009

Appendix D-1: Observed and Simulated Underground Dewatering Rates (2011-2021)

OBSERVED							FEFLOW SIMULATED		
Month/ Year	**UG Monthly Flow In (m^3)**	**Water Supplied to UG Drills (UG Waterbox)[1] (m^3)**	**Underground Monthly Flow - Groundwater Only (m^3)**	**Underground Monthly Flow - Groundwater Only (m^3/d)**	**Underground Monthly Flow - Groundwater Only (m^3/s)**	**Metric for UG Water Measurement[2]**	**Month/ Year**	**Monthly Underground Dewatering (m^3/d)**	**Monthly Underground Dewatering (m^3/s)**
Apr-2015	17,040		17,040	568	0.007	WTP effluent to environment totalizer	Apr-2015	771	0.009
May-2015	34,893		34,893	1,126	0.013	WTP effluent to environment totalizer	May-2015	898	0.010
Jun-2015	53,970		53,970	1,799	0.021	WTP effluent to environment totalizer	Jun-2015	1,694	0.020
Jul-2015	52,426		52,426	1,691	0.020	WTP effluent to environment totalizer	Jul-2015	1,730	0.020
Aug-2015	57,352		57,352	1,850	0.021	WTP effluent to environment totalizer	Aug-2015	1,558	0.018
Sep-2015	55,688		55,688	1,856	0.021	WTP effluent to environment totalizer	Sep-2015	1,490	0.017
Oct-2015	60,859		60,859	1,963	0.023	WTP effluent to environment totalizer	Oct-2015	1,624	0.019
Nov-2015	42,789		42,789	1,426	0.017	WTP effluent to environment totalizer	Nov-2015	1,178	0.014
Dec-2015	32,450		32,450	1,047	0.012	WTP effluent to environment totalizer	Dec-2015	1,109	0.013
Jan-2016	26,843		26,843	866	0.010	WTP effluent to environment totalizer	Jan-2016	1,003	0.012
Feb-2016	23,973		23,973	827	0.010	WTP effluent to environment totalizer	Feb-2016	884	0.010
Mar-2016	22,818		22,818	736	0.009	WTP effluent to environment totalizer	Mar-2016	830	0.010
Apr-2016	27,217		27,217	907	0.011	WTP effluent to environment totalizer	Apr-2016	805	0.009
May-2016	51,703	*2,000*	49,703	1,603	0.019	CWTP Raw Mine Totalizer (Daily)	May-2016	1,049	0.012
Jun-2016	64,498	*2,000*	62,498	2,083	0.024	CWTP Raw Mine Totalizer (Daily)	Jun-2016	1,770	0.020
Jul-2016	55,446	*2,000*	53,446	1,724	0.020	CWTP Raw Mine Totalizer (Daily)	Jul-2016	1,912	0.022
Aug-2016	48,254	*2,000*	46,254	1,492	0.017	CWTP Raw Mine Totalizer (Daily)	Aug-2016	1,613	0.019
Sep-2016	47,327	*2,000*	45,327	1,511	0.017	CWTP Raw Mine Totalizer (Monthly)	Sep-2016	1,631	0.019
Oct-2016	36,232	*2,000*	34,232	1,104	0.013	CWTP Raw Mine Totalizer (Monthly)	Oct-2016	1,692	0.020
Nov-2016	24,818	*2,000*	22,818	761	0.009	CWTP Raw Mine Totalizer (Monthly)	Nov-2016	1,357	0.016
Dec-2016	27,804	*2,000*	25,804	832	0.010	CWTP Raw Mine Totalizer (Monthly)	Dec-2016	1,214	0.014
Jan-2017	25,046	1,950	23,096	745	0.009	CWTP Raw Mine Totalizer (Monthly)	Jan-2017	1,065	0.012
Feb-2017	25,388	7,122	18,267	630	0.007	CWTP Raw Mine Totalizer (Monthly)	Feb-2017	1,018	0.012
Mar-2017	25,128	7,832	17,296	558	0.006	CWTP Raw Mine Totalizer (Monthly)	Mar-2017	982	0.011
Apr-2017	23,955	5,361	18,594	620	0.007	CWTP Raw Mine Totalizer (Monthly)	Apr-2017	886	0.010
May-2017	38,171	8,652	29,519	952	0.011	CWTP Raw Mine Totalizer (Monthly)	May-2017	1,093	0.013
Jun-2017	59,100	8,902	50,198	1,673	0.019	CWTP Raw Mine Totalizer (Monthly)	Jun-2017	1,855	0.021
Jul-2017	56,824	11,369	45,455	1,466	0.017	CWTP Raw Mine Totalizer (Monthly)	Jul-2017	1,683	0.019
Aug-2017	64,507	11,760	52,747	1,702	0.020	WTP monthly totalizer and shift total OWT	Aug-2017	1,665	0.019
Sep-2017	67,352	11,255	56,097	1,870	0.022	Shift total OWTP (Totalizer A+B)	Sep-2017	1,641	0.019
Oct-2017	71,498	13,573	57,924	1,869	0.022	Shift total OWTP (Totalizer A+B)	Oct-2017	1,674	0.019
Nov-2017	64,170	14,484	49,686	1,656	0.019	Shift total OWTP (Totalizer A+B)	Nov-2017	1,524	0.018
Dec-2017	57,070	16,435	40,635	1,311	0.015	Shift total OWTP (Totalizer A+B)	Dec-2017	1,228	0.014
Jan-2018	48,729	16,844	31,884	1,029	0.012	Shift total OWTP (Totalizer A+B)	Jan-2018	1,200	0.014
Feb-2018	38,720	16,658	22,062	761	0.009	Shift total OWTP (Totalizer A+B)	Feb-2018	1,044	0.012
Mar-2018	45,687	20,412	25,275	815	0.009	Shift total OWTP (Totalizer A+B)	Mar-2018	995	0.012
Apr-2018	43,626	20,309	23,317	777	0.009	Shift total OWTP (Totalizer A+B)	Apr-2018	891	0.010
May-2018	64,519	24,654	39,865	1,286	0.015	Shift total OWTP (Totalizer A+B)	May-2018	1,076	0.012
Jun-2018	75,270	21,186	54,084	1,803	0.021	Shift total OWTP (Totalizer A+B)	Jun-2018	1,568	0.018
Jul-2018	75,283	23,075	52,208	1,684	0.019	Shift total OWTP (Totalizer A+B)	Jul-2018	1,714	0.020
Aug-2018	71,404	21,125	50,278	1,622	0.019	Shift total OWTP (Totalizer A+B)	Aug-2018	1,574	0.018

Appendix D-1: Observed and Simulated Underground Dewatering Rates (2011-2021)

OBSERVED							FEFLOW SIMULATED		
Month/ Year	UG Monthly Flow In (m^3)	Water Supplied to UG Drills (UG Waterbox)[1] (m^3)	Underground Monthly Flow - Groundwater Only (m^3)	Underground Monthly Flow - Groundwater Only (m^3/d)	Underground Monthly Flow - Groundwater Only (m^3/s)	Metric for UG Water Measurement[2]	Month/ Year	Monthly Underground Dewatering (m^3/d)	Monthly Underground Dewatering (m^3/s)
Sep-2018	62,938	17,445	45,493	1,516	0.018	Shift total OWTP (Totalizer A+B)	Sep-2018	1,479	0.017
Oct-2018	66,077	20,857	45,221	1,459	0.017	Shift total OWTP (Totalizer A+B)	Oct-2018	1,429	0.017
Nov-2018	58,844	18,001	40,843	1,361	0.016	Shift total OWTP (Totalizer A+B)	Nov-2018	1,264	0.015
Dec-2018	52,778	20,822	31,955	1,031	0.012	Shift total OWTP (Totalizer A+B)	Dec-2018	1,249	0.014
Jan-2019	51,204	23,652	27,552	889	0.010	Shift total OWTP (Totalizer A+B)	Jan-2019	1,260	0.015
Feb-2019	45,208	23,707	21,501	741	0.009	Shift total OWTP (Totalizer A+B)	Feb-2019	1,184	0.014
Mar-2019	48,464	28,104	20,360	657	0.008	Shift total OWTP (Totalizer A+B)	Mar-2019	1,109	0.013
Apr-2019	46,823	25,584	21,239	708	0.008	Shift total OWTP (Totalizer A+B)	Apr-2019	1,080	0.013
May-2019	65,453	26,148	39,305	1,268	0.015	Shift total OWTP (Totalizer A+B)	May-2019	1,261	0.015
Jun-2019	91,868	29,118	62,750	2,092	0.024	Shift total OWTP (Totalizer A+B)	Jun-2019	1,935	0.022
Jul-2019	93,032	32,254	60,778	1,961	0.023	Shift total OWTP (Totalizer A+B)	Jul-2019	2,262	0.026
Aug-2019	87,994	29,200	58,795	1,897	0.022	Shift total OWTP (Totalizer A+B)	Aug-2019	2,048	0.024
Sep-2019	85,812	28,934	56,878	1,896	0.022	Shift total OWTP (Totalizer A+B)	Sep-2019	2,011	0.023
Oct-2019	87,047	31,543	55,504	1,790	0.021	Shift total OWTP (Totalizer A+B)	Oct-2019	2,138	0.025
Nov-2019	78,500	30,991	47,509	1,584	0.018	Shift total OWTP (Totalizer A+B)	Nov-2019	1,860	0.022
Dec-2019	72,809	30,528	42,282	1,364	0.016	Shift total OWTP (Totalizer A+B)	Dec-2019	1,653	0.019
Jan-2020	62,952	31,367	31,585	1,019	0.012	Shift total OWTP (Totalizer A+B)	Jan-2020	1,509	0.017
Feb-2020	56,749	30,919	25,831	891	0.010	Shift total OWTP (Totalizer A+B)	Feb-2020	1,407	0.016
Mar-2020	58,348	34,618	23,730	765	0.009	Shift total OWTP (Totalizer A+B)	Mar-2020	1,323	0.015
Apr-2020	57,150	31,977	25,173	839	0.010	Shift total OWTP (Totalizer A+B)	Apr-2020	1,285	0.015
May-2020	67,954	33,975	33,979	1,096	0.013	Shift total OWTP (Totalizer A+B)	May-2020	1,450	0.017
Jun-2020	101,337	31,736	69,601	2,320	0.027	Shift total OWTP (Totalizer A+B)	Jun-2020	2,177	0.025
Jul-2020	112,722	34,407	78,315	2,526	0.029	Shift total OWTP (Totalizer A+B)	Jul-2020	2,516	0.029
Aug-2020	111,974	34,280	77,694	2,506	0.029	Shift total OWTP (Totalizer A+B)	Aug-2020	2,293	0.027
Sep-2020	94,773	30,475	64,298	2,143	0.025	Shift total OWTP (Totalizer A+B)	Sep-2020	2,230	0.026
Oct-2020	91,816	34,519	57,297	1,848	0.021	Shift total OWTP (Totalizer A+B)	Oct-2020	2,291	0.027
Nov-2020	87,000	35,718	51,282	1,709	0.020	Shift total OWTP (Totalizer A+B)	Nov-2020	1,966	0.023
Dec-2020	70,658	34,820	35,838	1,156	0.013	Shift total OWTP (Totalizer A+B)	Dec-2020	1,748	0.020
Jan-2021	64,388	35,676	28,712	926	0.011	Shift total OWTP (Totalizer A+B)	Jan-2021	1,637	0.019
Feb-2021	54,903	32,717	22,186	765	0.009	Shift total OWTP (Totalizer A+B)	Feb-2021	1,523	0.018
Mar-2021	60,258	40,293	19,965	644	0.007	Shift total OWTP (Totalizer A+B)	Mar-2021	1,415	0.016
Apr-2021	50,416	36,430	13,986	466	0.005	Shift total OWTP (Totalizer A+B)	Apr-2021	1,369	0.016
May-2021	66,226	40,635	25,591	826	0.010	Shift total OWTP (Totalizer A+B)	May-2021	1,584	0.018
Jun-2021	121,469	37,988	83,481	2,783	0.032	Shift total OWTP (Totalizer A+B)	Jun-2021	2,402	0.028
Jul-2021	115,876	34,939	80,937	2,611	0.030	Shift total OWTP (Totalizer A+B)	Jul-2021	2,887	0.033
Aug-2021	109,505	38,558	70,947	2,289	0.026	Shift total OWTP (Totalizer A+B)	Aug-2021	2,491	0.029
Sep-2021	110,828	38,934	71,893	2,396	0.028	Shift total OWTP (Totalizer A+B)	Sep-2021	2,366	0.027
Oct-2021	102,064	41,443	60,621	1,956	0.023	Shift total OWTP (Totalizer A+B)	Oct-2021	2,587	0.030
Nov-2021	80,078	38,607	41,471	1,382	0.016	Shift total OWTP (Totalizer A+B)	Nov-2021	2,134	0.025
Dec-2021	65,864	38,002	27,862	899	0.010	Shift total OWTP (Totalizer A+B)	Dec-2021	1,851	0.021

Notes:
1. *Italicized* values were not measured and are assumed to be equivalent to January 2017 flow value.
2. WTP = water treatment plant; CWTP = contact water treatment plant; OWTP = operational water treatment plant

Appendix D-2: Simulated Underground Dewatering Rates 2022-2029

Month/ Year	Monthly Underground Dewatering Rate (m^3/d)	Monthly Underground Dewatering Rate (m^3/s)	Month/ Year	Monthly Underground Dewatering Rate (m^3/d)	Monthly Underground Dewatering Rate (m^3/s)
Jan-2022	1,680	0.019	Jan-2026	2,866	0.033
Feb-2022	1,560	0.018	Feb-2026	2,698	0.031
Mar-2022	1,757	0.020	Mar-2026	2,621	0.030
Apr-2022	1,635	0.019	Apr-2026	2,523	0.029
May-2022	1,783	0.021	May-2026	2,740	0.032
Jun-2022	2,810	0.033	Jun-2026	3,717	0.043
Jul-2022	3,285	0.038	Jul-2026	4,177	0.048
Aug-2022	3,059	0.035	Aug-2026	4,057	0.047
Sep-2022	2,900	0.034	Sep-2026	4,047	0.047
Oct-2022	3,030	0.035	Oct-2026	4,090	0.047
Nov-2022	2,640	0.031	Nov-2026	3,672	0.043
Dec-2022	2,381	0.028	Dec-2026	3,349	0.039
Jan-2023	2,210	0.026	Jan-2027	3,085	0.036
Feb-2023	2,004	0.023	Feb-2027	2,909	0.034
Mar-2023	1,941	0.022	Mar-2027	2,740	0.032
Apr-2023	1,828	0.021	Apr-2027	2,635	0.031
May-2023	2,138	0.025	May-2027	2,827	0.033
Jun-2023	3,097	0.036	Jun-2027	3,815	0.044
Jul-2023	3,363	0.039	Jul-2027	4,298	0.050
Aug-2023	3,293	0.038	Aug-2027	4,166	0.048
Sep-2023	3,132	0.036	Sep-2027	4,140	0.048
Oct-2023	3,295	0.038	Oct-2027	4,195	0.049
Nov-2023	2,899	0.034	Nov-2027	3,750	0.043
Dec-2023	2,633	0.030	Dec-2027	3,398	0.039
Jan-2024	2,446	0.028	Jan-2028	3,094	0.036
Feb-2024	2,280	0.026	Feb-2028	2,920	0.034
Mar-2024	2,163	0.025	Mar-2028	2,753	0.032
Apr-2024	2,074	0.024	Apr-2028	2,646	0.031
May-2024	2,458	0.028	May-2028	2,839	0.033
Jun-2024	3,374	0.039	Jun-2028	3,805	0.044
Jul-2024	3,757	0.043	Jul-2028	4,311	0.050
Aug-2024	3,595	0.042	Aug-2028	4,169	0.048
Sep-2024	3,531	0.041	Sep-2028	4,148	0.048
Oct-2024	3,675	0.043	Oct-2028	4,184	0.048
Nov-2024	3,224	0.037	Nov-2028	3,752	0.043
Dec-2024	2,951	0.034	Dec-2028	3,391	0.039
Jan-2025	2,761	0.032	Jan-2029	3,092	0.036
Feb-2025	2,568	0.030	Feb-2029	2,917	0.034
Mar-2025	2,495	0.029	Mar-2029	2,748	0.032
Apr-2025	2,386	0.028	Apr-2029	2,643	0.031
May-2025	2,588	0.030	May-2029	2,827	0.033
Jun-2025	3,559	0.041	Jun-2029	3,851	0.045
Jul-2025	4,073	0.047	Jul-2029	4,254	0.049
Aug-2025	3,834	0.044	Aug-2029	4,183	0.048
Sep-2025	3,844	0.044	Sep-2029	4,151	0.048
Oct-2025	3,918	0.045	Oct-2029	4,161	0.048
Nov-2025	3,415	0.040	Nov-2029	3,764	0.044
Dec-2025	3,129	0.036	Dec-2029	3,392	0.039

Appendix E: Simulated Drawdown (2019-2029)

NEWCREST

PRETIUM RESOURCES INC.

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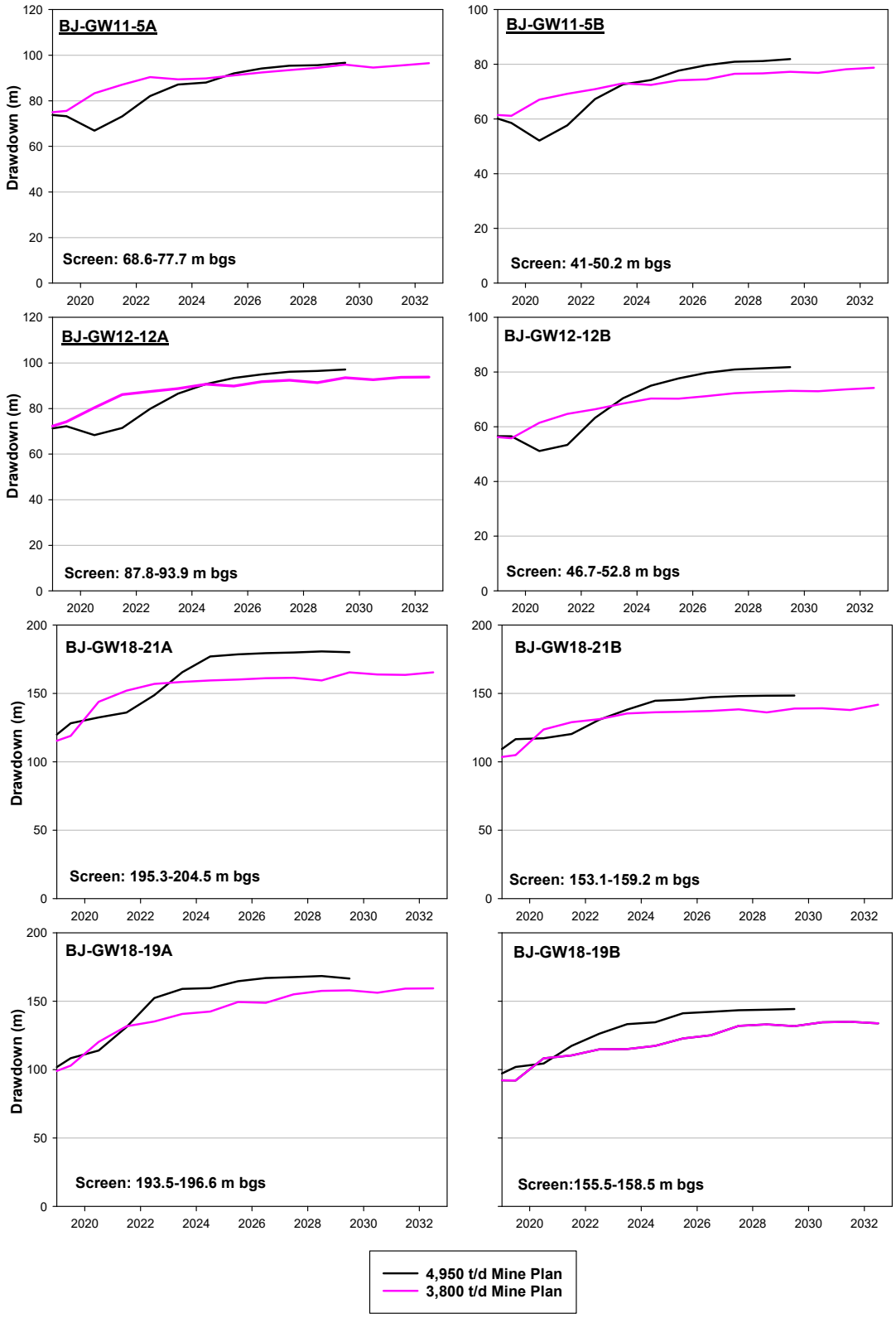

Figure E-1: Simulated average annual drawdown in wells upgradient of the VOK (2019-2029). Underlined well ID indicates location was calibrated in baseline model.

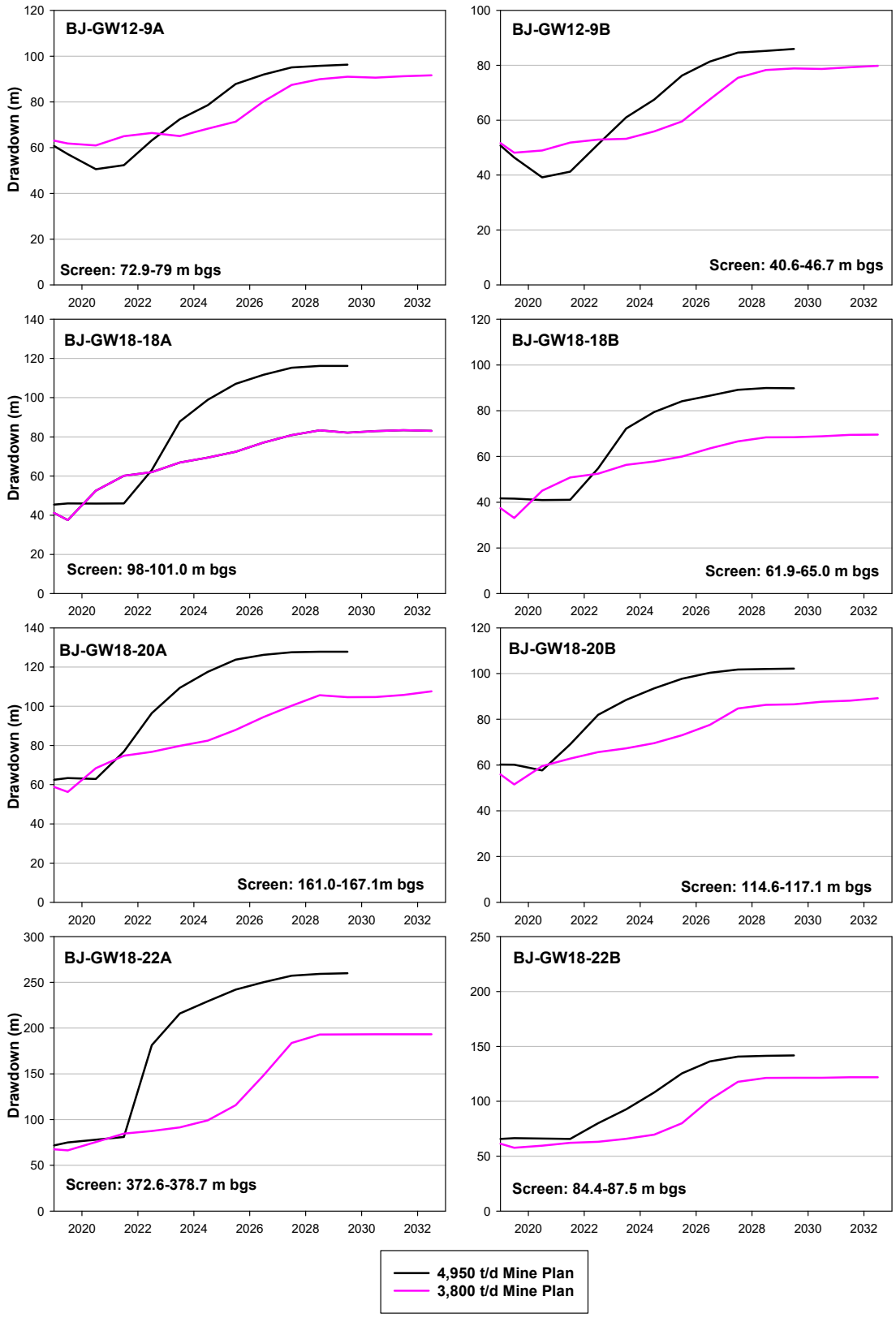

Figure E-2: Simulated average annual drawdown in wells south of the VOK (2019-2029).

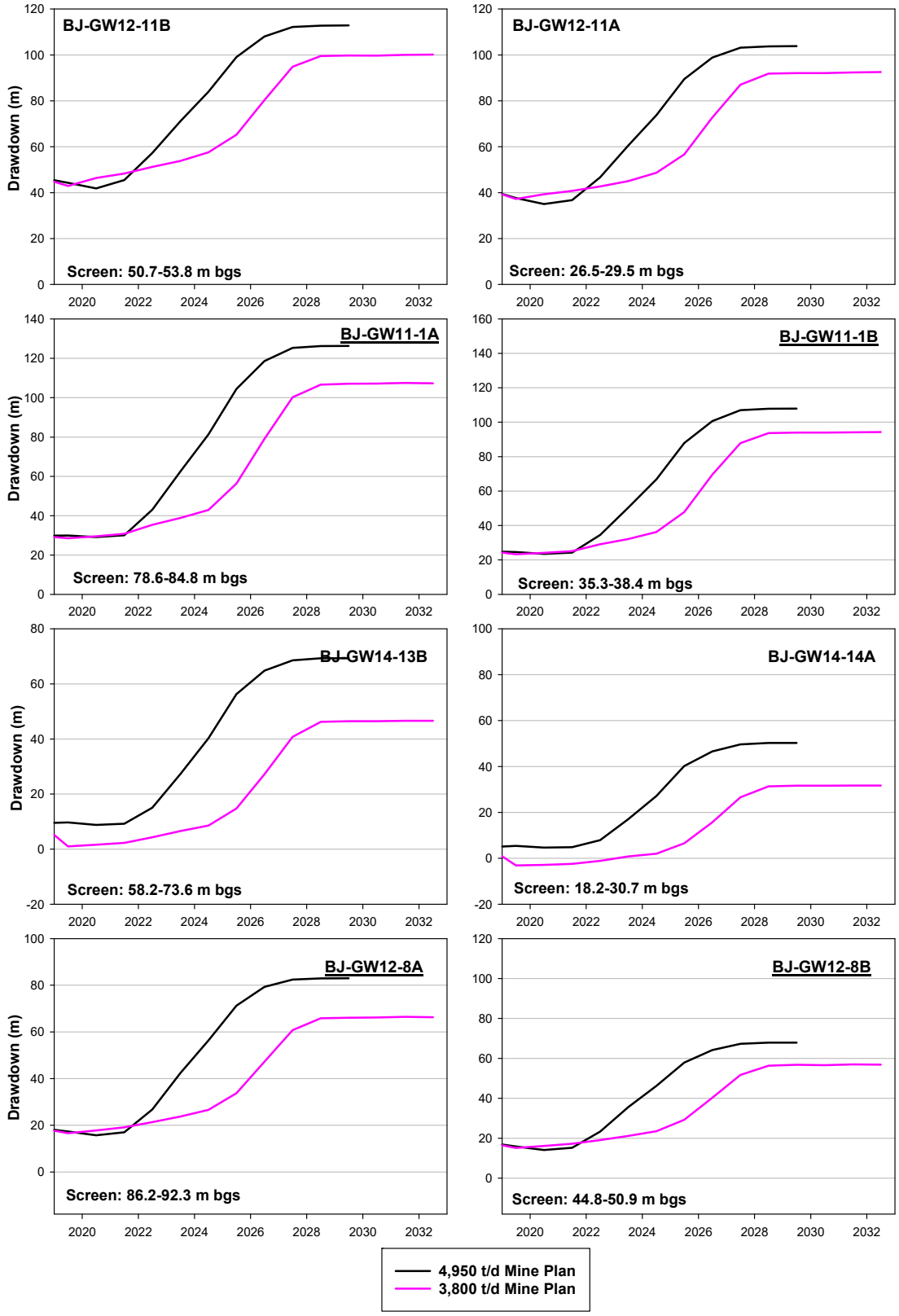

Figure E-3: Simulated average annual drawdown in wells west of West Zone (2019-2032). Underlined well ID indicates location was calibrated in baseline model.

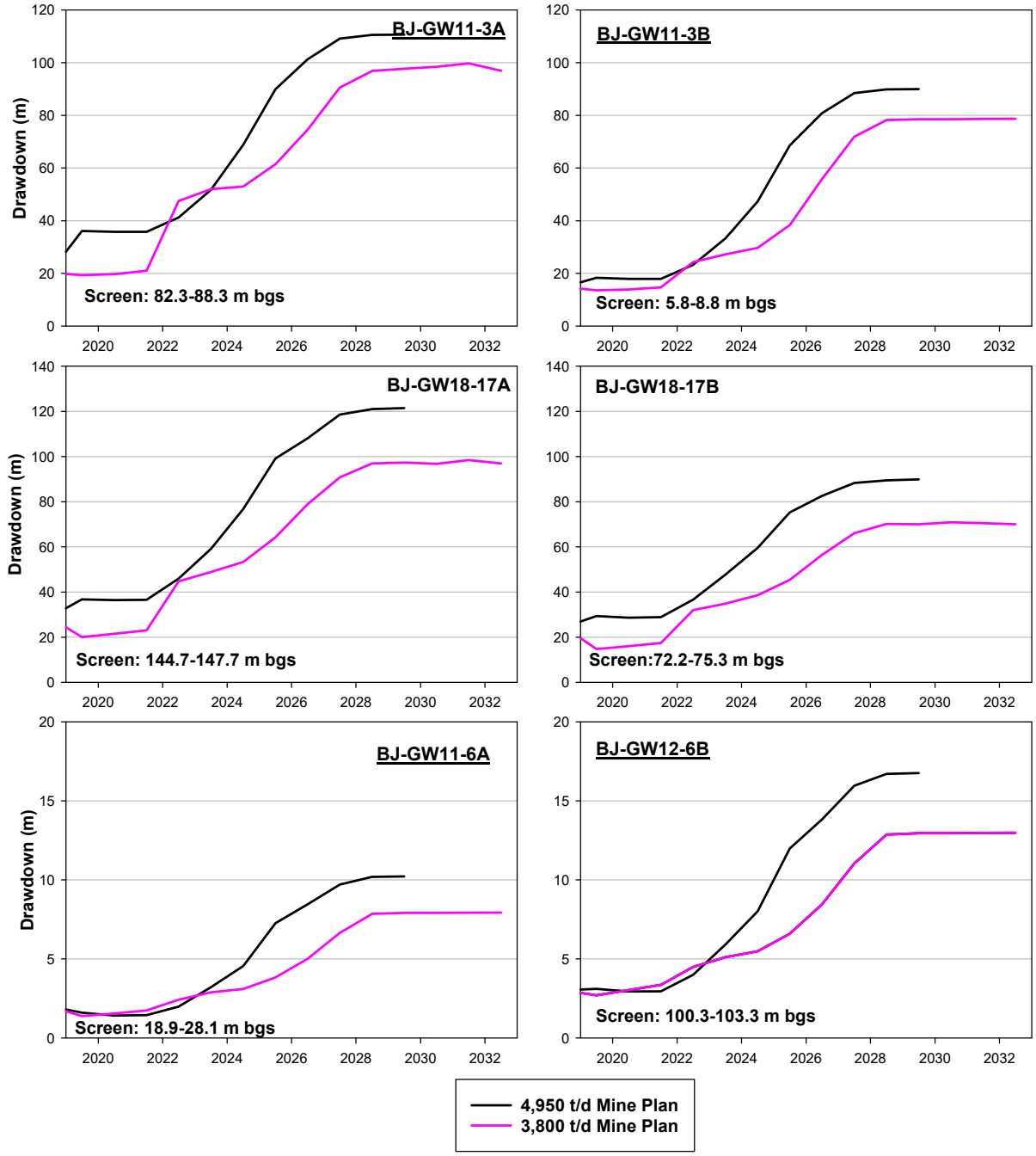

Figure E-4: Simulated average annual drawdown in wells east of West Zone (2019-2029). Underlined well ID indicates location was calibrated in baseline model.

Appendix F: Simulated Baseflow in Brucejack Creek

NEWCREST

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Appendix F-1: Simulated Baseflow in Brucejack Creek (2011-2021)

	Simulated Baseflow (m^3/s)		
	BJ-3.10	**BJ-2.62**	**BJ-1.74**
Jan-2011	0.028	0.029	0.034
Feb-2011	0.025	0.025	0.030
Mar-2011	0.022	0.022	0.026
Apr-2011	0.023	0.023	0.027
May-2011	0.048	0.052	0.060
Jun-2011	0.156	0.172	0.210
Jul-2011	0.114	0.125	0.153
Aug-2011	0.082	0.089	0.107
Sep-2011	0.076	0.083	0.098
Oct-2011	0.089	0.097	0.116
Nov-2011	0.043	0.043	0.048
Dec-2011	0.033	0.033	0.035
Jan-2012	0.026	0.026	0.027
Feb-2012	0.024	0.023	0.024
Mar-2012	0.021	0.021	0.023
Apr-2012	0.022	0.022	0.025
May-2012	0.044	0.046	0.053
Jun-2012	0.132	0.144	0.174
Jul-2012	0.101	0.110	0.133
Aug-2012	0.073	0.079	0.094
Sep-2012	0.067	0.068	0.079
Oct-2012	0.079	0.080	0.093
Nov-2012	0.039	0.040	0.043
Dec-2012	0.030	0.030	0.032
Jan-2013	0.025	0.025	0.026
Feb-2013	0.022	0.022	0.023
Mar-2013	0.020	0.020	0.020
Apr-2013	0.020	0.020	0.020
May-2013	0.040	0.040	0.042
Jun-2013	0.131	0.134	0.159
Jul-2013	0.098	0.100	0.117
Aug-2013	0.070	0.070	0.081
Sep-2013	0.066	0.066	0.075
Oct-2013	0.077	0.078	0.089
Nov-2013	0.038	0.038	0.042
Dec-2013	0.029	0.030	0.032
Jan-2014	0.025	0.025	0.026
Feb-2014	0.021	0.022	0.022
Mar-2014	0.019	0.019	0.020
Apr-2014	0.020	0.020	0.020
May-2014	0.046	0.045	0.049
Jun-2014	0.157	0.162	0.192
Jul-2014	0.115	0.117	0.138
Aug-2014	0.080	0.081	0.094
Sep-2014	0.075	0.076	0.087
Oct-2014	0.090	0.091	0.106
Nov-2014	0.041	0.041	0.045
Dec-2014	0.031	0.031	0.033
Jan-2015	0.025	0.025	0.027
Feb-2015	0.022	0.022	0.023
Mar-2015	0.019	0.019	0.020
Apr-2015	0.020	0.020	0.021
May-2015	0.046	0.046	0.049
Jun-2015	0.164	0.168	0.200
Jul-2015	0.117	0.119	0.140
Aug-2015	0.081	0.082	0.094
Sep-2015	0.075	0.076	0.087
Oct-2015	0.090	0.091	0.105
Nov-2015	0.041	0.042	0.045
Dec-2015	0.031	0.031	0.034
Jan-2016	0.026	0.026	0.027
Feb-2016	0.022	0.022	0.023
Mar-2016	0.019	0.019	0.020
Apr-2016	0.020	0.020	0.021
May-2016	0.041	0.041	0.044
Jun-2016	0.139	0.142	0.168

	Simulated Baseflow (m^3/s)		
	BJ-3.10	**BJ-2.62**	**BJ-1.74**
Jul-2016	0.105	0.106	0.125
Aug-2016	0.074	0.074	0.085
Sep-2016	0.069	0.070	0.079
Oct-2016	0.081	0.082	0.093
Nov-2016	0.039	0.039	0.043
Dec-2016	0.029	0.030	0.032
Jan-2017	0.024	0.024	0.025
Feb-2017	0.021	0.021	0.022
Mar-2017	0.018	0.018	0.019
Apr-2017	0.019	0.019	0.020
May-2017	0.038	0.037	0.039
Jun-2017	0.123	0.125	0.148
Jul-2017	0.094	0.094	0.110
Aug-2017	0.067	0.067	0.077
Sep-2017	0.062	0.063	0.071
Oct-2017	0.073	0.073	0.084
Nov-2017	0.037	0.037	0.040
Dec-2017	0.028	0.028	0.030
Jan-2018	0.022	0.023	0.024
Feb-2018	0.020	0.020	0.021
Mar-2018	0.017	0.018	0.018
Apr-2018	0.018	0.018	0.018
May-2018	0.032	0.032	0.033
Jun-2018	0.093	0.094	0.109
Jul-2018	0.073	0.074	0.085
Aug-2018	0.054	0.054	0.061
Sep-2018	0.051	0.051	0.057
Oct-2018	0.058	0.058	0.066
Nov-2018	0.031	0.032	0.034
Dec-2018	0.024	0.025	0.026
Jan-2019	0.020	0.021	0.022
Feb-2019	0.018	0.018	0.019
Mar-2019	0.016	0.016	0.017
Apr-2019	0.017	0.017	0.017
May-2019	0.037	0.037	0.038
Jun-2019	0.145	0.146	0.165
Jul-2019	0.114	0.115	0.132
Aug-2019	0.080	0.081	0.092
Sep-2019	0.073	0.074	0.083
Oct-2019	0.085	0.086	0.098
Nov-2019	0.044	0.045	0.048
Dec-2019	0.033	0.034	0.035
Jan-2020	0.027	0.027	0.028
Feb-2020	0.023	0.023	0.024
Mar-2020	0.020	0.020	0.021
Apr-2020	0.020	0.020	0.021
May-2020	0.044	0.044	0.046
Jun-2020	0.164	0.166	0.188
Jul-2020	0.127	0.128	0.147
Aug-2020	0.088	0.089	0.101
Sep-2020	0.081	0.081	0.092
Oct-2020	0.094	0.095	0.109
Nov-2020	0.048	0.048	0.052
Dec-2020	0.036	0.036	0.038
Jan-2021	0.030	0.031	0.032
Feb-2021	0.026	0.026	0.027
Mar-2021	0.022	0.022	0.023
Apr-2021	0.022	0.022	0.023
May-2021	0.047	0.047	0.050
Jun-2021	0.169	0.170	0.193
Jul-2021	0.128	0.129	0.148
Aug-2021	0.088	0.089	0.101
Sep-2021	0.079	0.080	0.090
Oct-2021	0.091	0.091	0.104
Nov-2021	0.047	0.048	0.051
Dec-2021	0.036	0.036	0.038

Appendix F-2: Simulated Baseflow in Brucejack Creek for Future Operations (2022-2029)

	Simulated Baseflow (m^3/s)		
	BJ-3.10	**BJ-2.62**	**BJ-1.74**
Jan-2022	0.030	0.030	0.031
Feb-2022	0.026	0.026	0.027
Mar-2022	0.022	0.022	0.023
Apr-2022	0.022	0.022	0.023
May-2022	0.045	0.045	0.047
Jun-2022	0.157	0.159	0.177
Jul-2022	0.120	0.121	0.137
Aug-2022	0.083	0.084	0.093
Sep-2022	0.075	0.075	0.083
Oct-2022	0.086	0.086	0.097
Nov-2022	0.044	0.045	0.048
Dec-2022	0.033	0.034	0.036
Jan-2023	0.028	0.029	0.030
Feb-2023	0.024	0.024	0.026
Mar-2023	0.020	0.021	0.023
Apr-2023	0.020	0.020	0.022
May-2023	0.042	0.042	0.043
Jun-2023	0.152	0.153	0.169
Jul-2023	0.118	0.118	0.132
Aug-2023	0.081	0.082	0.090
Sep-2023	0.073	0.074	0.081
Oct-2023	0.085	0.085	0.094
Nov-2023	0.043	0.044	0.047
Dec-2023	0.033	0.033	0.035
Jan-2024	0.027	0.028	0.032
Feb-2024	0.023	0.024	0.026
Mar-2024	0.020	0.020	0.022
Apr-2024	0.020	0.020	0.021
May-2024	0.040	0.040	0.041
Jun-2024	0.150	0.151	0.165
Jul-2024	0.116	0.116	0.128
Aug-2024	0.080	0.080	0.088
Sep-2024	0.072	0.072	0.078
Oct-2024	0.083	0.083	0.090
Nov-2024	0.042	0.044	0.046
Dec-2024	0.032	0.033	0.037
Jan-2025	0.026	0.027	0.030
Feb-2025	0.022	0.023	0.026
Mar-2025	0.019	0.020	0.022
Apr-2025	0.019	0.019	0.020
May-2025	0.039	0.039	0.039
Jun-2025	0.146	0.146	0.158
Jul-2025	0.114	0.113	0.124
Aug-2025	0.078	0.078	0.084
Sep-2025	0.070	0.070	0.076
Oct-2025	0.081	0.081	0.087
Nov-2025	0.041	0.043	0.046
Dec-2025	0.031	0.032	0.035

	Simulated Baseflow (m^3/s)		
	BJ-3.10	**BJ-2.62**	**BJ-1.74**
Jan-2026	0.026	0.027	0.029
Feb-2026	0.022	0.023	0.025
Mar-2026	0.018	0.019	0.021
Apr-2026	0.018	0.019	0.020
May-2026	0.038	0.038	0.038
Jun-2026	0.144	0.144	0.154
Jul-2026	0.112	0.112	0.121
Aug-2026	0.076	0.077	0.082
Sep-2026	0.069	0.069	0.074
Oct-2026	0.079	0.079	0.085
Nov-2026	0.040	0.042	0.046
Dec-2026	0.030	0.031	0.034
Jan-2027	0.025	0.026	0.028
Feb-2027	0.021	0.022	0.024
Mar-2027	0.018	0.018	0.020
Apr-2027	0.017	0.018	0.019
May-2027	0.037	0.036	0.036
Jun-2027	0.141	0.141	0.151
Jul-2027	0.110	0.110	0.120
Aug-2027	0.075	0.075	0.081
Sep-2027	0.068	0.068	0.073
Oct-2027	0.078	0.078	0.084
Nov-2027	0.040	0.041	0.044
Dec-2027	0.030	0.031	0.035
Jan-2028	0.025	0.026	0.028
Feb-2028	0.021	0.022	0.024
Mar-2028	0.017	0.018	0.020
Apr-2028	0.017	0.018	0.019
May-2028	0.036	0.036	0.036
Jun-2028	0.141	0.141	0.150
Jul-2028	0.109	0.109	0.120
Aug-2028	0.075	0.075	0.081
Sep-2028	0.068	0.068	0.072
Oct-2028	0.078	0.078	0.084
Nov-2028	0.040	0.041	0.044
Dec-2028	0.030	0.031	0.035
Jan-2029	0.025	0.026	0.028
Feb-2029	0.021	0.022	0.024
Mar-2029	0.017	0.018	0.020
Apr-2029	0.017	0.018	0.019
May-2029	0.036	0.036	0.036
Jun-2029	0.140	0.140	0.150
Jul-2029	0.109	0.109	0.119
Aug-2029	0.075	0.075	0.081
Sep-2029	0.068	0.068	0.072
Oct-2029	0.078	0.078	0.084
Nov-2029	0.040	0.041	0.044
Dec-2029	0.030	0.031	0.035

Appendix F-3: Simulated Baseflow in Brucejack Creek at Closure (2030-2037)

	Simulated Baseflow (m^3/s)		
	BJ-3.10	**BJ-2.62**	**BJ-1.74**
Jan-2030	0.025	0.026	0.028
Feb-2030	0.021	0.022	0.024
Mar-2030	0.017	0.018	0.020
Apr-2030	0.017	0.018	0.018
May-2030	0.031	0.032	0.032
Jun-2030	0.120	0.119	0.121
Jul-2030	0.095	0.093	0.097
Aug-2030	0.066	0.066	0.068
Sep-2030	0.061	0.061	0.064
Oct-2030	0.071	0.072	0.075
Nov-2030	0.039	0.040	0.042
Dec-2030	0.030	0.032	0.034
Jan-2031	0.026	0.028	0.029
Feb-2031	0.023	0.024	0.026
Mar-2031	0.020	0.021	0.024
Apr-2031	0.020	0.022	0.024
May-2031	0.042	0.041	0.047
Jun-2031	0.143	0.142	0.165
Jul-2031	0.111	0.123	0.145
Aug-2031	0.079	0.093	0.109
Sep-2031	0.072	0.086	0.101
Oct-2031	0.083	0.099	0.116
Nov-2031	0.044	0.056	0.064
Dec-2031	0.034	0.043	0.050
Jan-2032	0.029	0.037	0.043
Feb-2032	0.026	0.032	0.038
Mar-2032	0.022	0.028	0.033
Apr-2032	0.022	0.028	0.033
May-2032	0.044	0.051	0.059
Jun-2032	0.146	0.164	0.191
Jul-2032	0.112	0.128	0.151
Aug-2032	0.079	0.094	0.110
Sep-2032	0.072	0.086	0.101
Oct-2032	0.083	0.099	0.116
Nov-2032	0.044	0.056	0.064
Dec-2032	0.034	0.043	0.050
Jan-2033	0.029	0.037	0.043
Feb-2033	0.026	0.032	0.038
Mar-2033	0.022	0.028	0.033
Apr-2033	0.022	0.028	0.033
May-2033	0.044	0.051	0.059
Jun-2033	0.146	0.164	0.191
Jul-2033	0.112	0.128	0.151
Aug-2033	0.079	0.094	0.110
Sep-2033	0.072	0.086	0.101
Oct-2033	0.083	0.099	0.116
Nov-2033	0.044	0.056	0.064
Dec-2033	0.034	0.043	0.050

	Simulated Baseflow (m^3/s)		
	BJ-3.10	**BJ-2.62**	**BJ-1.74**
Jan-2034	0.029	0.037	0.043
Feb-2034	0.026	0.032	0.038
Mar-2034	0.022	0.028	0.033
Apr-2034	0.022	0.028	0.033
May-2034	0.044	0.051	0.059
Jun-2034	0.146	0.164	0.191
Jul-2034	0.112	0.128	0.151
Aug-2034	0.079	0.094	0.110
Sep-2034	0.072	0.086	0.101
Oct-2034	0.083	0.099	0.116
Nov-2034	0.044	0.056	0.064
Dec-2034	0.034	0.043	0.050
Jan-2035	0.029	0.037	0.043
Feb-2035	0.026	0.032	0.038
Mar-2035	0.022	0.028	0.033
Apr-2035	0.022	0.028	0.033
May-2035	0.044	0.051	0.059
Jun-2035	0.146	0.164	0.191
Jul-2035	0.112	0.128	0.151
Aug-2035	0.079	0.094	0.110
Sep-2035	0.072	0.086	0.101
Oct-2035	0.083	0.099	0.116
Nov-2035	0.044	0.056	0.064
Dec-2035	0.034	0.043	0.050
Jan-2036	0.029	0.037	0.043
Feb-2036	0.026	0.032	0.038
Mar-2036	0.022	0.028	0.033
Apr-2036	0.022	0.028	0.033
May-2036	0.044	0.051	0.059
Jun-2036	0.146	0.164	0.191
Jul-2036	0.112	0.128	0.151
Aug-2036	0.079	0.094	0.110
Sep-2036	0.072	0.086	0.101
Oct-2036	0.083	0.099	0.116
Nov-2036	0.044	0.056	0.064
Dec-2036	0.034	0.043	0.050
Jan-2037	0.029	0.037	0.043
Feb-2037	0.026	0.032	0.038
Mar-2037	0.022	0.028	0.033
Apr-2037	0.022	0.028	0.033
May-2037	0.044	0.051	0.059
Jun-2037	0.146	0.164	0.191
Jul-2037	0.112	0.128	0.151
Aug-2037	0.079	0.094	0.110
Sep-2037	0.072	0.086	0.101
Oct-2037	0.083	0.099	0.116
Nov-2037	0.044	0.056	0.064
Dec-2037	0.034	0.043	0.050

Appendix G: Simulated Mine Inflow and Outflow During Closure

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Appendix G: Groundwater flow to and from the underground workings at closure (2030-2034)

	Inflow to Mine Void (m^3/s)	Outflow/ Contact Water Flux (m^3/s)
Jan-2030	0.036	0.000
Feb-2030	0.034	0.000
Mar-2030	0.031	0.000
Apr-2030	0.030	0.000
May-2030	0.033	0.000
Jun-2030	0.050	0.000
Jul-2030	0.054	0.000
Aug-2030	0.049	0.000
Sep-2030	0.044	0.000
Oct-2030	0.046	0.000
Nov-2030	0.035	0.000
Dec-2030	0.028	0.000
Jan-2031	0.023	0.000
Feb-2031	0.019	0.000
Mar-2031	0.016	0.000
Apr-2031	0.013	0.000
May-2031	0.016	0.001
Jun-2031	0.026	0.006
Jul-2031	0.024	0.016
Aug-2031	0.020	0.019
Sep-2031	0.019	0.018
Oct-2031	0.020	0.020
Nov-2031	0.015	0.015
Dec-2031	0.012	0.012
Jan-2032	0.010	0.010
Feb-2032	0.010	0.010
Mar-2032	0.009	0.009
Apr-2032	0.008	0.008
May-2032	0.011	0.011
Jun-2032	0.023	0.023
Jul-2032	0.023	0.023
Aug-2032	0.020	0.020
Sep-2032	0.019	0.019
Oct-2032	0.020	0.020
Nov-2032	0.015	0.015
Dec-2032	0.012	0.012
Jan-2033	0.010	0.010
Feb-2033	0.010	0.010
Mar-2033	0.009	0.009
Apr-2033	0.008	0.008
May-2033	0.011	0.011
Jun-2033	0.023	0.023
Jul-2033	0.023	0.023
Aug-2033	0.020	0.020
Sep-2033	0.019	0.019
Oct-2033	0.020	0.020
Nov-2033	0.015	0.015
Dec-2033	0.012	0.012
Jan-2034	0.010	0.010
Feb-2034	0.010	0.010
Mar-2034	0.009	0.009
Apr-2034	0.008	0.008
May-2034	0.011	0.011
Jun-2034	0.023	0.023
Jul-2034	0.023	0.023
Aug-2034	0.020	0.020
Sep-2034	0.019	0.019
Oct-2034	0.020	0.020
Nov-2034	0.015	0.015
Dec-2034	0.012	0.012

Appendix 5-2: 4950 tpd Water Balance Model Report

Brucejack Mine: 4950 tpd Water Balance Model Report

June 6, 2023

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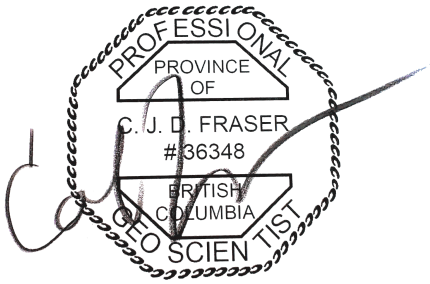
LORAX ENVIRONMENTAL

Authorship

This report was prepared by Lorax Environmental Services Ltd. (Lorax) for Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies. The report was written by Colin Fraser, M.Sc., P.Geo. with support from Joseph Xu, Ph.D., and reviewed by Scott Jackson, M.Sc., P.Geo. and Alison Shaw, Ph.D., P.Geo. Lorax Environmental Services Ltd. has relied on information available in the scientific literature and information supplied by Pretium in preparing this report.

Lorax Environmental Services, Ltd.
per:



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List of Acronyms and Abbreviations

AR5	Fifth Assessment Report
BC	British Columbia
CMIP	Coupled Model Intercomparison Project
CWCS	Contact Water Collection System
CWP	Contact Water Pond
EMA	*Environmental Management Act*
FWT	Freshwater Tank
GW	Groundwater
LOM	Life of Mine
MA	*Mines Act*
MA-EMA	Brucejack Mine Project: Application for *Mines Act* and *Environmental Management Act* Permits
MDMER	Metal and Diamond Mining Effluent Regulations
NPAG	Non-potentially Acid Generating
PAG	Potentially Acid Generating
PCIC	Pacific Climate Impacts Consortium
QA/QC	Quality Assurance Quality Control
RCP	Representative Concentration Pathway
SNAP	Scenario Network for Alaska and Arctic Planning
STP	Sewage Treatment Plant
TSS	Total Suspended Solids
TWT	Treated Water Tank
VEC	Volume Elevation Curve
UBC	University of British Columbia
VOK	Valley of the Kings
WBM	Water Balance Model
WQM	Water Quality Model
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant
WZ	West Zone

1. Introduction

1.1 Project Overview

Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies (Newcrest), owns and operates Brucejack Mine, a gold-silver mine located in the Coast Mountains of northwest British Columbia. The mine site (all mine infrastructure west of the upper Knipple Glacier) is situated within the Brucejack Creek watershed, which is a small headwater sub-basin within the Sulphurets Creek watershed. Sulphurets Creek is a tributary of the Unuk River that flows southwest, eventually discharging to the Pacific Ocean northeast of Ketchikan, Alaska.

Peaks surrounding the mine site reach elevations of approximately 2,400 masl and icefields surround the property to the north, west, south, and east. The property lies in a transition zone between the very wet coastal and drier interior regions of BC. Local climate is dominated by weather systems generated from the Pacific Ocean, and orographic effects caused by the local mountain topography produce high spatial variability in snowfall, rainfall, air temperature and snowmelt. In addition, extensive glaciation within the Brucejack watershed produces high runoff volumes in summer months, when air temperatures reach their annual maxima. Accordingly, the humid climate and physical characteristics of the region result in dynamic streamflow conditions and high annual runoff rates in local catchments.

Infrastructure for the Project was constructed over an approximately 2-year period beginning in September 2015. Critical infrastructure was sited to take advantage of local topography and accommodate environmental considerations, while avoiding avalanche hazards. An as-built general arrangement for the mine site is presented in Figure 1-1 and shows the following:

- The location of mine site infrastructure, including the location of a non-potentially acid generating (NPAG) quarry at km 72 of the Brucejack Access Road, with reference to the Brucejack watershed and the waste rock and tailings storage facility (WRTSF).
- Roads and various pads/laydown areas which provide access to mine site power distribution systems, the Valley of Kings (VOK) and West Zone (WZ) portals, camp accommodation and food services complexes, various maintenance/storage buildings and a sewage treatment plant (STP).
- The mill building, which contains ore processing circuits, a water treatment plant (WTP), a paste backfill plant and a metallurgical laboratory.

- Water management infrastructure, including diversion channels for non-contact water, contact water interceptor ditches, a contact water drainage collection system, plus sumps and collection areas to direct runoff to a contact water pond (CWP) and the WTP, as required.
- A waste rock platform and subaqueous waste rock disposal area in the WRTSF, with turbidity curtains and other measures in place to minimize and contain resulting suspended sediments.
- A subaqueous tailings disposal area in the deepest part of the WRTSF, using thickened tailings discharged at depth to minimize the release of suspended sediments. Pipelines used to transport tailings and waste to the WRTSF are also shown in Figure 1-1.

1.2 Previous Water Balance Model Studies

BGC (BGC, 2015a) prepared a site-wide water balance model (WBM) to support preparation of the 2015 Brucejack Mine Application for *Mines Act* (MA) and *Environmental Management Act* (EMA) Permits (Pretium, 2015); this application considered ore throughput at an average of 2,700 tonnes per day (tpd). BGC also updated the WBM in 2017 to support permitting of the mine at 3,800 tpd for a period of approximately 14 years (BGC, 2017c). Over time, a generally consistent model architecture was used by BGC, noting that new data and information offered opportunities for WBM refinement. The BGC water balance model was encoded at a monthly time step in MS-Excel software, where future mine site water balance conditions were resolved for a base case which considered average monthly climate conditions.

By 2017, much of the technical details of the as-built Brucejack Mine general arrangement and water management system were encoded into the MS-Excel model, with methodology in place to estimate: water volumes produced within the underground mine; the collection and conveyance of contact water from mine footprint areas; the accounting of reclaim water usage; and use of Project infrastructure such as the WTP to meet water use requirements of the mill, with excess treated effluent released to the environment, when mill water requirements are fully met. The most recent version of the WBM (BGC, 2017c) also assessed different scenarios for waste rock placement and tailings deposition.

LEGEND

- Water Quality Monitoring Station
- Potable Water Well
- Contact Water Collection
- WTP/STP Effluent Line
- Reclaim Water Line
- Tailings Discharge Lines
- CWP Direct Discharge Line
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- NPAG
- Contact Water Pond
- Brucejack Creek
- WRTSF
- Contours (50m)

DATE SAVED:	Feb 28, 2023
DRAWN BY:	DM
REVIEWED:	RB
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:7,500

0 125 250 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

TITLE: **4950 tpd Joint Application**

PROJECT: Brucejack Mine, General Arrangment

PROJECT #: A624-4

FIGURE: 1-1

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In 2020, the site-wide water balance and water quality models were updated as required by Brucejack Mine *Environmental Management Act* Permit PE-107835 and *Mines Act* Permit M-243 (2020 Mine Plan and Reclamation Program Update; Pretium, 2020c) (2020 Update). Condition 5.6 (Mine Data and Water Quality Modelling Review) of PE-107835 stipulates the permittee must conduct a review of the environmental monitoring required under the permit and reassess predictive modelling with respect to the environmental impacts. Condition D.4(e) Water Quality Predictions, including the requirement to validate and refine predictions based on site-specific monitoring information and Condition E.14(b) which requires compilation and interpretation of monitoring data as part of the Mine Plan and Reclamation Program Update, are relevant permit conditions under M-243.

Beyond the impetus of the 2020 Update, several other factors motivated the update of the site-wide WBM. First, a considerable amount of site-specific climate and streamflow data has been collected at the mine site since the WBM was last updated. For example, several years of additional climate data have been collected at the Valley of Kings (VOK) climate station (elevation 1,503 masl) and streamflow data from gauges situated below the WRTSF at BJ 3.10 and BJ 1.74. Furthermore, new datasets including those offered by ClimateBC, the Pacific Climate Impacts Consortium (PCIC) and Scenario Network for Alaska and Arctic Planning (SNAP) were incorporated into the revised WBM for the mine.

In addition, more than 2.5 years of mine site water monitoring data (*i.e.*, data associated with diversions, collection basins, tanks, pipelines and ponds) had been collected at the mine site, between July 2017 January 2020. These high frequency (hourly, daily) monitoring data capture important details related to the capture, use, recycling and discharge of contact and freshwaters at the mine site. Finally, monthly WBM outputs in Excel format were traditionally read into the Brucejack Mine Water Quality Model (WQM) which is a management tool configured using GoldSim environmental modelling software (GoldSim Technology Group LLC; www.goldsim.com). By modernizing the WBM into a software platform common to the WQM, there are obvious efficiencies and benefits to be gained by the end-user. GoldSim was specifically designed to facilitate problem solving in the water resource sector, thus a highly suitable software package to complete any proposed WBM and WQM updates for the Brucejack mine site.

1.3 Study Objectives and Report Structure

The objectives of this study are to:

- Using the 2020 WBM as a basis (Lorax, 2020), developed a revised WBM that supports an updated water quality model (WQM) as required for the 4950 tpd Joint M-243/PE-107835 Amendments Application (4950 tpd Joint Application). Note the revised WQM is described in full under separate cover (Lorax, 2023b).
- Review and present the data used to support development of the revised site-wide WBM, including inputs from an updated mine plan, relevant monitoring studies, design/engineering studies, and operational water monitoring datasets. Key information is presented in Section 2 and Section 3 of this report.
- Describe the WBM architecture and outline all relevant inputs and assumptions within the model. Material presented in Section 3, including GoldSim wire diagrams and representative model outputs, address this study objective.
- Discuss the calibration approach and present calibration results for the WBM. This objective is also addressed in Section 3, where outputs are presented to demonstrate model performance at both the watershed-scale (*i.e.*, BJ 3.10, Brucejack Creek below the WRTSF), as well as at the spatial extent of the mine site (*i.e.*, WTP and mill complex).
- Present and synthesize the results from the GoldSim WBM model. Section 4 of the report is dedicated to the presentation of the study results. As part of this exercise, results are presented for operations (2022-2029) and closure/post-closure (2030-2050 time periods.
- Summarize study results, discuss model sensitivities, identify data gaps and outline recommendations for future modelling studies. Section 5 of the report presents this concluding information.

2. Data Sources

This section of the report presents the various data sources utilized in the WBM update, including inputs from an updated mine plan, relevant baseline studies (*i.e.,* climate, hydrology, hydrogeology), design/engineering studies, and operational water monitoring datasets.

2.1 Annual Monitoring Reports and Related Studies

This study is informed by the data collection and water modelling studies (water balance, groundwater and water quality) conducted for Brucejack Mine over the last nine years. Since 2013, annual monitoring reports for the meteorology, hydrology, hydrogeology, surface water quality and aquatic resources disciplines have been prepared by Brucejack staff and their technical consultants. Also, many technical studies have been completed at Brucejack Mine, several of which have advanced the understanding of mine site water balance conditions and the water management systems in place to safeguard the mine and receiving environment.

The following annual monitoring reports and datasets were reviewed to complete this study:

- Pretium Resources Inc. (Pretium) (2016). Brucejack Mine 2015 Annual Report for *Mines Act* Permit No. M-243 and *Environmental Management Act* Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2016.
- Pretium Resources Inc. (Pretium) (2017). Brucejack Mine 2016 Annual Report for *Mines Act* Permit No. M-243 and *Environmental Management Act* Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2017.
- Pretium Resources Inc. (Pretium) (2018a). Brucejack Mine 2017 Annual Report for *Mines Act* Permit No. M-243 and *Environmental Management Act* Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2018.
- Pretium Resources Inc. (Pretium) (2019). Brucejack Mine 2018 Annual Report for *Mines Act* Permit No. M-243 and *Environmental Management Act* Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2019.

- Pretium Resources Inc. (Pretium) (2020a). Brucejack Mine 2019 Annual Report for *Mines Act* Permit No. M-243 and *Environmental Management Act* Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2020.
- Pretium Resources Inc. (Pretium) (2021). Brucejack Mine 2020 Annual Report for Mines Act Permit No. M-243 and Environmental Management Act Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2021.
- Pretium Resources Inc. (Pretium) (2022). Brucejack Mine 2021 Annual Report for *Mines Act* Permit No. M-243 and *Environmental Management Act* Permits 107835 & 107025. Submitted to BC Ministry of Energy and Mines and BC Ministry of Environment. March 2022.
- Period of record daily and monthly streamflow datasets maintained by Newcrest Mining Limited for the BJ 3.10 and BJ 1.74 monitoring stations.
- Period of record daily and monthly climate datasets maintained by Newcrest Mining Limited for the Bowser, Scott Pass and VOK climate stations.
- Operational water monitoring datasets maintained by Newcrest Mining Limited and spanning the period March 2017 to April 2022.

Relevant to this technical study and WBM update, the following reports and guidance documents are notable:

- BGC Engineering Inc. (2013). Brucejack Project Feasibility Study, Water Management Plan. Final Report – Rev 1. Report prepared for Pretium Resources Inc.
- BGC Engineering Inc. (2015a). Brucejack Project – MA/EMA Permitting Phase – Brucejack Mine Water Balance Model, 2700 tpd Permit Application. Report prepared for Pretium Resources Inc.
- BGC Engineering Inc. (2015b). Brucejack Project – MA/EMA Permitting Phase – Numerical Hydrogeologic Model Update Report. Report prepared for Pretium Resources Inc.
- BGC Engineering Inc. (2017a). Contact Water Pond Hydrogeological Assessment. Project No.: 1008-022. Report prepared for Pretium Resources Inc. January 2017.
- BGC Engineering Inc. (2017b). Brucejack Mine, Assessment of Reclaim Water Volumes for 3800 tpd Permit Amendments. Doc. No. BJ-2017-56. Report prepared for Pretium Resources Inc. December 2017.

- BGC Engineering Inc. (2017c). Brucejack Mine Water Balance Model, 3800 tpd Permit Amendment Application. Document No.: BJ-2017-57. Report prepared for Pretium Resources Inc. December 2017.
- Pretium Resources Inc. (Pretium) (2018b). BGC Engineering Inc. and Pretium Resources Inc., 2018. Brucejack Mine – Operation, Maintenance & Surveillance Manual. Water Management Plan. Version 004, December 15, 2018.
- Pretium Resources Inc. (Pretium) (2020b). OMS Manual – Water Management Plan. Brucejack Mine – Version 5. Prepared for Pretium Resources Inc. by SRK Consulting (Canada) Inc., March 2020.
- Lorax Environmental Service Limited (Lorax) (2020). Brucejack Mine: 2020 Water Balance Model Review and Update. Prepared by Lorax Environmental Services Ltd. for Pretium Resources Inc. Submitted July 2020.

2.2 Mine Plan Data and Project Schedule

2.2.1 Mine Plan Data

Mine plan data relevant to the WBM can be found within the 4950 tpd Joint Application (Pretium, 2023). Key tables for the WBM are re-produced in Appendix A, which include the following information:

- The Life of Mine (LOM) Ore Production Schedule.
- The Waste Rock Inventory, which includes accounting for total waste, waste to be used as fill in the underground mine and waste to be placed in the WRTSF.
- The Tailings Schedule, which includes separation of waste tonnages in terms of tailings to be placed in the WRTSF below water cover versus tailings placement in the underground mine as paste backfill.

To provide context for the reader, the processing of ore began at Brucejack Mine in July 2017 (Figure 2-2 and Figure 2-2 upper panel). Following start-up, ore processing ramped up to a rate of 2,700 tpd, remaining relatively constant until January 2019. Over the course of 2019, ore processing increased toward the allowable (as of December 14, 2018) permitted rate of 3,800 tpd. In the calendar years 2020, 2021 and 2022, mill feed was relatively constant and varied on average between 3,600-3,800 tpd.

As stipulated in the mine plan assessed for this application (*i.e.*, 4950 tpd, refer to Appendix A), mill feed from 2022 and 2023 is forecasted to be 3,800 tpd on a calendar year basis, which equates roughly to an ore processing rate of 1,390 kt/yr. Ore processing is forecasted

to increase slightly in 2024 prior to reaching maximum values for years 2025 through 2029 (approximately 1,800 kt/yr). Ore processing is scheduled to cease at the end of Q4 2029.

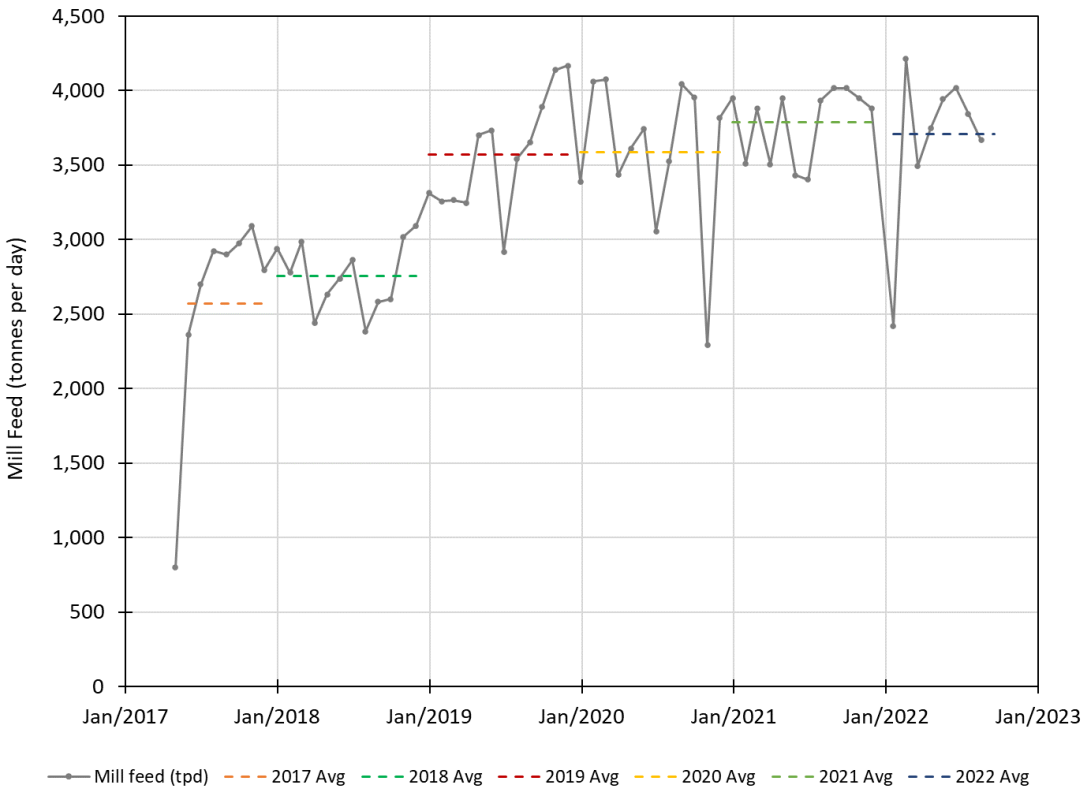


Figure 2-1: Mill feed rate (in dry metric tonnes) at the Brucejack mill for the period July 2017 through September 2022.

Total tailings produced under the 2022-2029 mine plan are shown in Figure 2-2, middle panel. Though proportions differ slightly by year, roughly 40% of produced tailings are scheduled to be placed as cemented backfill in the underground mine, whereas the remaining 60% is to be placed under permanent water cover in the WRTSF (Figure 2-2, middle panel). With respect to waste rock (total), tonnages produced are greatest on an annual basis through 2024, noting values are much lower for subsequent years (Figure 2-2, lower panel).

Figure 2-2: Life of Mine (LOM) Ore, Tailings Production and Waste Rock Tonnages for the Brucejack Mine. Shaded areas on each plot indicate measured values for the period 2017-22.

2.2.2 Mine Phases

2.2.2.1 Construction and Operations

Construction of major works related to ore processing and site-wide water management began in September 2015, with most activities completed by mid-2017. The processing of ore, including production and placement of tailings in either the WRTSF or underground mine, has been ongoing since July 2017.

Milling of ore is planned to continue through December 2029, as indicated in the 2022 LOM schedule (Appendix A).

2.2.2.2 Closure and Post-Closure Water Management Activities

Closure and post-closure activities relevant to the WBM are outlined in Chapter 3, Closure and Reclamation Update of the 2020 Update (Pretium, 2020c) and in the 4950 tpd Joint Application (Pretium, 2023). Briefly, the primary goals of closure and post-closure water management activities will be to minimize the long-term effects on the environment and return the site to as close to its pre-disturbance condition as possible without the need for long-term active water treatment. Therefore, several assumptions are encoded into the WBM with respect to these two Project phases. For example, closure is assumed to involve the removal of all structures and equipment, closure of the portals, flooding of underground mine workings, and site rehabilitation. At final closure, the WBM assumes two surface diversion channels will remain in place and the CWP will flood to the elevation of the current spillway, with overflow reporting to the WRTSF.

2.3 Climate Data

Four sources of climate data are used to setup and run water balance simulations: period of record data from the climate stations operated by Pretium; monthly synthetic climate data obtained from ClimateBC; daily gridded climate data available from the Pacific Climate Impacts Consortium (PCIC); and, monthly climate change scenario data made available by the Scenario Network for Alaska and Arctic Planning (SNAP).

ClimateBC - https://climatebc.ca/

PCIC - https://pacificclimate.org/data/daily-gridded-meteorological-datasets

SNAP - https://uaf-snap.org/climate-tools/download-raw-data/

2.3.1 Meteorological Data from Pretium Climate Stations

Each year, since 2013, Pretium has submitted an annual monitoring report which summarizes calendar year monitoring data and current state of understanding with respect

to climate conditions within the Brucejack Creek watershed (*e.g.*, Pretium, 2016; Pretium, 2017; Pretium, 2018a; Pretium, 2019; Pretium, 2020a; Pretium, 2021a). The locations of automated climate stations and snow courses maintained by Newcrest are shown in Figure 2-3.

Situated adjacent to the mine site, data from the VOK climate station (1,500 m asl) and snow course are most relevant to the set-up and execution of the Brucejack WBM. The VOK climate station is instrumented with research grade sensors and programmed to record the following parameters hourly: air temperature (min, max, mean), relative humidity, average wind speed and gusts, solar radiation, net radiation, atmospheric pressure and total precipitation. Measured data utilized in this assessment were compiled to daily and monthly timestep prior to use. The steps taken to post-process raw measured data to final values, such as the specifics relating to the correction of gauged precipitation data for wind and under-catch, are provided in the annual meteorology monitoring reports.

A sub-set of the measured climate record for the VOK climate station is shown in Figure 2-4. These data are essentially continuous and high-quality for the period of record September 2014 through October 2022. As such, they provide a sound representation of local climate conditions and reliable source of climate data to represent mine site water balance conditions over the past eight+ years.

LEGEND

- VOK Climate Station and Snow Course
- Water Quality Monitoring Station
- Potable Water Well
- WTP/STP Effluent Line
- Reclaim Water Line
- Tailings Discharge Lines
- CWP Direct Discharge Line
- Non-Contact Water Channel
- Contact Water Collection
- NPAG Quarry
- Contact Water Pond
- Brucejack Creek
- WRTSF
- Contours (50m)

DATE SAVED:	Feb 28, 2023
DRAWN BY:	DM
REVIEWED:	RB
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:7,500

0 125 250 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

TITLE:

4950 tpd Joint Application

PROJECT: Brucejack Mine and VOK Climate Station

PROJECT #: A624-4

FIGURE: 2-3

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022 WQ Infrastructure\Mine Site Infrastructure and Sample Locations_F2-3.mxd

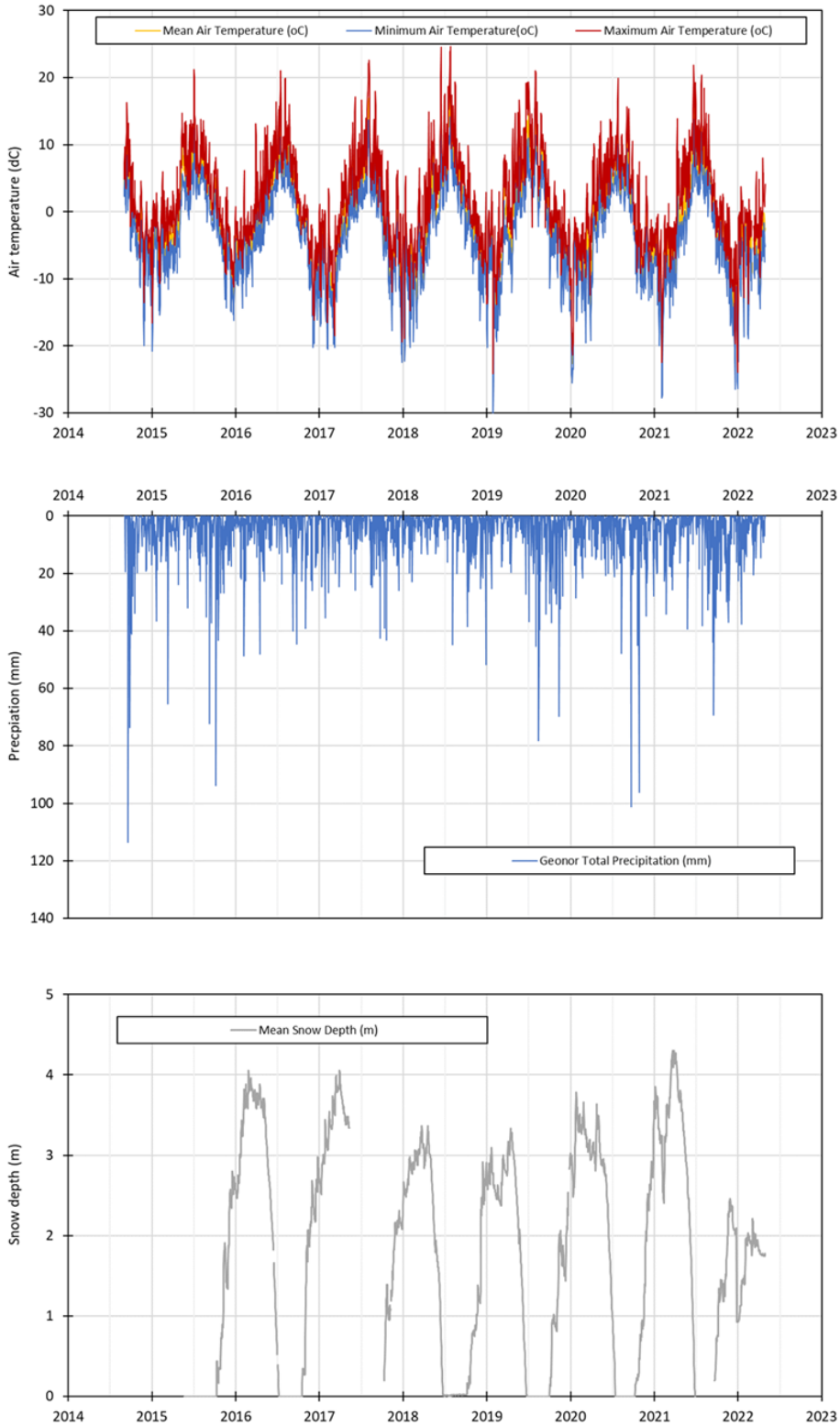


Figure 2-4: Time series plots for VOK climate station (September 2014-April 2022). Plots presented in the figure show patterns and trends in air temperature, precipitation and snow depth, each of which is key to the mine site water balance.

2.3.2 ClimateBC

The ClimateBC data tool generates synthetic climate data for use in water resources applications and climate change studies in British Columbia. For a location of interest, outputs from ClimateBC include 56 seasonal and 168 monthly climate variables that are either directly calculated or derived. Methodologies related to ClimateBC are summarized in Wang *et al*. (2012) and at the host website: http://cfcg.forestry.ubc.ca/projects/climate-data/climatebcwna/.

To support the water balance update and other supporting studies associated with the 2020 5 Year Mine Plan Update (*e.g.*, set up and execution of groundwater modelling runs), air temperature, precipitation and potential evaporation data were extracted for grid points within the Brucejack watershed. Extracted data spanned 100 m elevation bands between 1,300 masl to >2,000 masl. Representative orographic gradients (*e.g.*, % change in precipitation per 100 m elevation gain) for the Brucejack Creek watershed were derived from the extracted data by re-arranging Equation 1 from the UBC Watershed Model Manual (Quick *et al.*, 1995):

$$P_2 = P_1(1+a)^{\Delta elev/100} \qquad (1)$$

where P_1 is precipitation at the lower elevation (mm), P_2 is precipitation at the higher elevation (mm), Δelev = difference in elevation between lower elevation and higher elevation, and α is the percentage change in precipitation per 100 m increase in elevation.

Recall from earlier discussion in Section 1 that the mine site is situated in a locale dominated by weather systems generated from the Pacific Ocean which are highly variable and also strongly influenced by orographic effects caused by the local mountain topography and the presence of glaciers. Similar to findings reported in BGC (2017c), raw precipitation outputs from ClimateBC were found to overestimate local precipitation conditions within the Brucejack watershed. However, the raw outputs from ClimateBC were readily adjusted to reflect 'true' conditions at the mine site, using five years of reference data at VOK climate station as a guide. For illustrative purposes, a comparison of adjusted annual precipitation from ClimateBC (*i.e.*, for grid point 56.453N, -130.189W and elevation 1,503 masl; approximate location of VOK climate station) and measured data from VOK climate station are shown below (Figure 2-5).

Overall, data from ClimateBC provide useful context with respect to long-term average precipitation for the mine site, the expected range and variability in precipitation from year-to-year, as well as the magnitude of annual precipitation measured at the mine site since 2014. For example, mean annual precipitation at the elevation of the VOK climate station is inferred to be on the order of 1,950 mm and annual depths are expected to vary on an annual basis between 1,400-2500 mm.

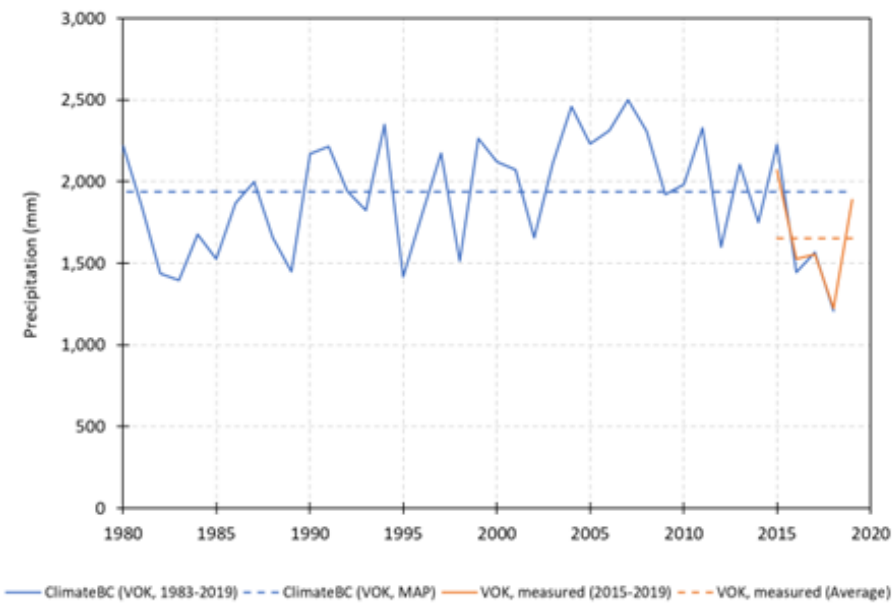


Figure 2-5: Time series comparing ClimateBC and measured precipitation outputs for VOK climate station.

2.3.3 Gridded Climate Datasets

For years prior to 2022, climate data from the VOK climate station are read directly into the WBM. To run the model forward, daily air temperature and precipitation data are required. This requirement could be met by looping, or averaging, the relatively short-measured record for the VOK station, to represent future conditions. However, gridded climate datasets are readily available for Western North America at a daily time step and well-suited for use in WBM studies such as this one.

Following a review of available datasets, data from the PNWNAmet dataset were downloaded from the Pacific Climate Impacts Consortium (PCIC) data portal, for nearest grid points to the mine site (https://www.pacificclimate.org/data/daily-gridded-meteorological-datasets). These gridded data have daily frequency, span the period 1945-2012 period, and are described by Werner *et al*. (2019). Furthermore, downloaded data cover the following parameters: minimum temperature, maximum temperature, average temperature and precipitation. Note that additional specifics describing the use of climate data in the WBM are presented in Section 3.2.

Like data from ClimateBC, gridded precipitation from PNWNAmet were found to overestimate mine site conditions. However, since the base data underpinning both ClimateBC and PNWNAmet are the same, these precipitation data were adjusted prior to use (*i.e.,* based on VOK measured data) following scaling procedures outlined in Lorax (2020).

2.3.4 Climate Change Scenario Data

In the future, conditions at the Brucejack Creek watershed are expected to be warmer and slightly wetter than today. Accordingly, there are merits in exploring WBM sensitivity to these potential changes, with emphasis on years corresponding to proposed operations (2022-2029) and closure (2030-2033) activities.

Climate Change Scenario Data used in this assessment were obtained from the Scenario Network for Alaska and Arctic Planning (SNAP, University of Alaska – Fairbanks). Specifically, Projected Monthly and Derived Air Temperature/Precipitation Products - 2km CMIP5/AR5 files were downloaded, which are gridded climate datasets spanning the period 2006-2100 (SNAP, 2020). SNAP serves out data for three Representative Concentration Pathway (RCP) scenarios (*i.e.*, RCP4.5, RCP6.0 and RCP8.5), five separate climate models, as well as a 5-model composite average for each RCP scenario. Monthly climate change scenario data for the 5-model average RCP6.0 scenario were used to inform the WBM update, although other datasets and scenarios can be incorporated into the WBM in the future.

Figure 2-6 shows future predicted changes for air temperature and precipitation for the mine site separated into four 20-year bands. By the end of the century (*i.e.*, 2100) annual air temperature is projected to increase by 3°C over current conditions. An increase in precipitation is also projected for the Brucejack Creek watershed, though changes over time are relatively minor and amount to a 9% increase in total precipitation by 2100, for the 5-model average under the RCP6.0 scenario. In contrast, predicted changes for the operations and closure phases (*i.e.*, 2022-2033) are minor, showing increases in annual temperature and precipitation of 0.5°C and 3%, respectively (Figure 2-6).

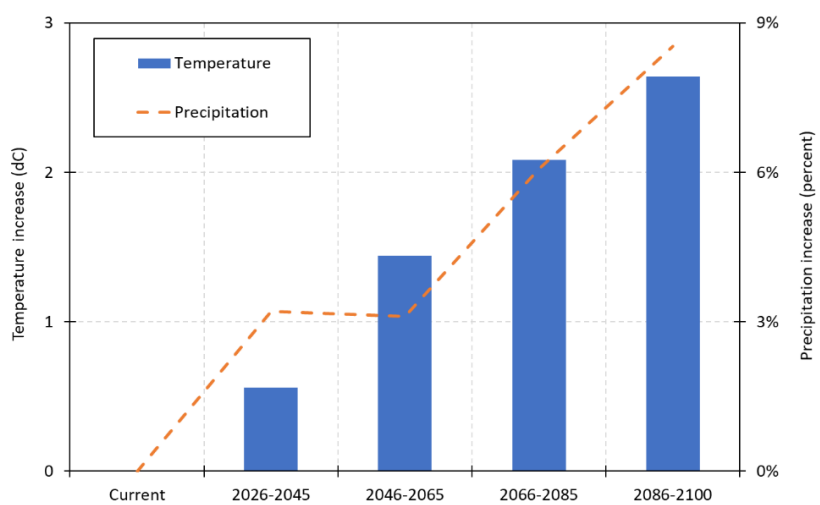
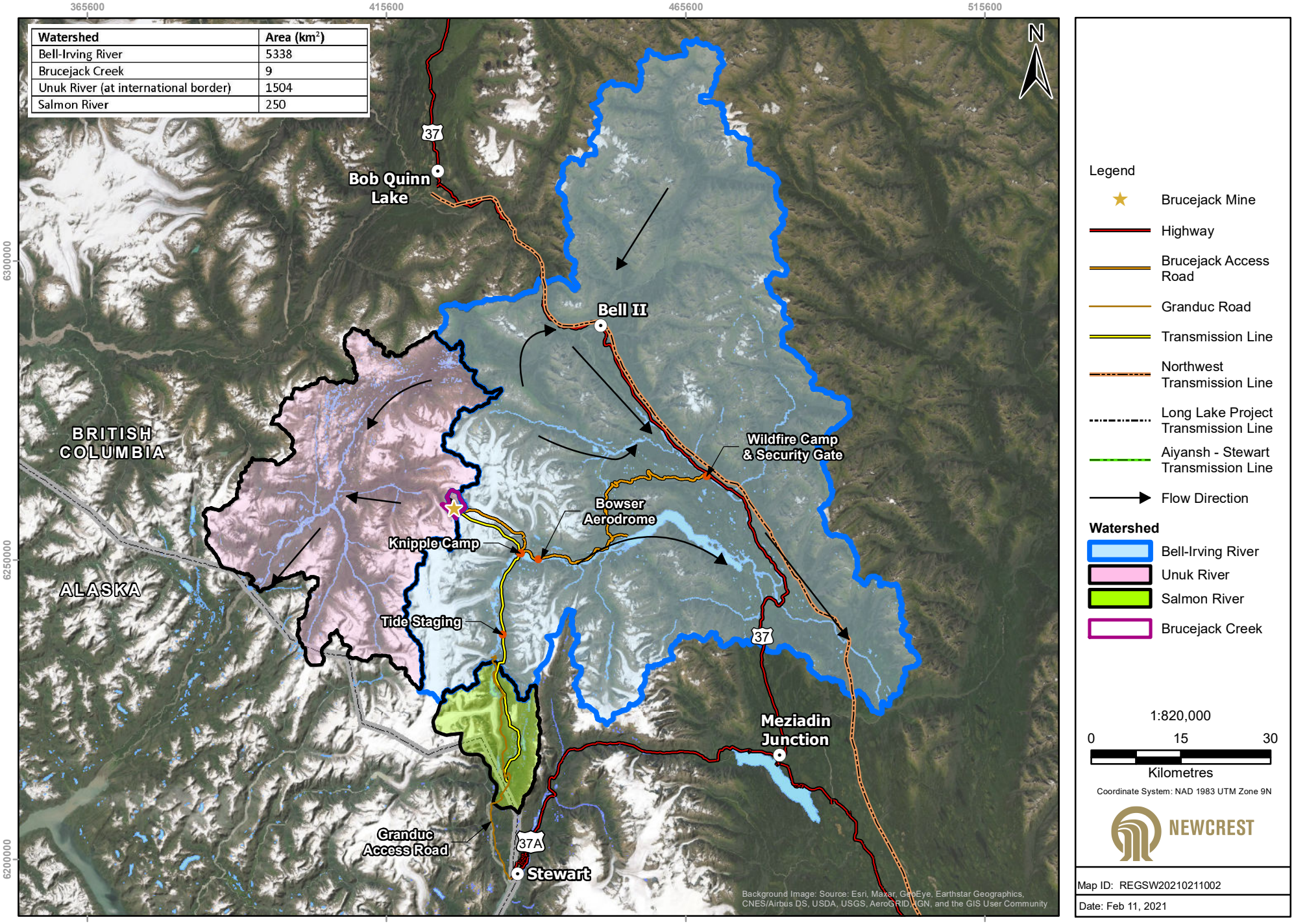


Figure 2-6: Summary of RCP6.0 climate change scenario trends for the Brucejack Mine. Data shown are 5-model average results and show predicted air temperature and precipitation increases for four future time periods (SNAP, 2020).

2.4 Streamflow Data

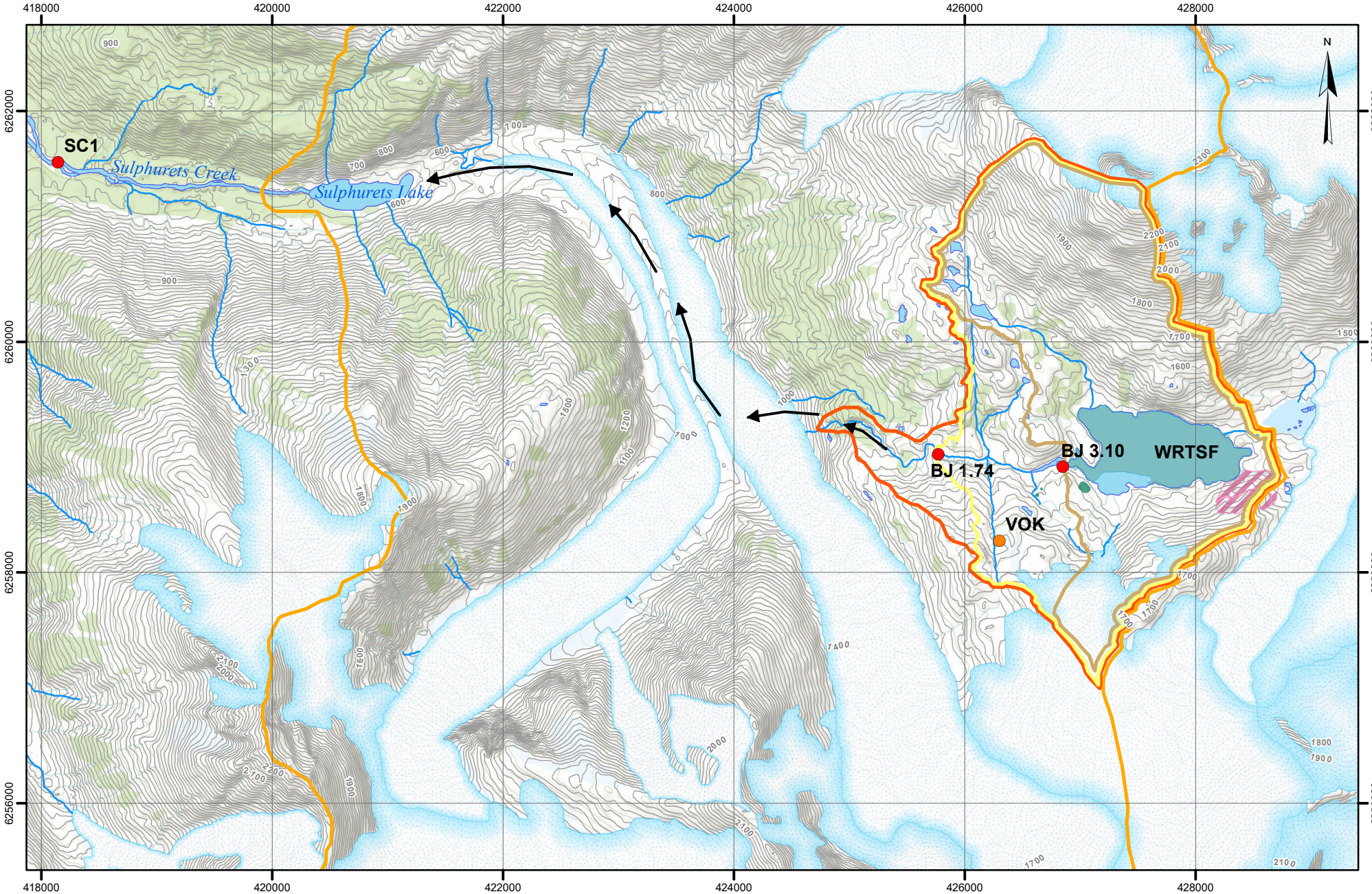
The Brucejack Creek catchment (drainage area 8.5 km^2 at station BJ 1.74) is a small headwater sub-basin within the larger Sulphurets Creek watershed (drainage area 300 km^2 at the confluence with the Unuk River). The catchment is in a glaciated, alpine environment, with its uppermost portion flowing into the WRTSF (drainage area 6.7 km^2 at BJ 3.10). About 17 km downstream of Sulphurets Lake, Sulphurets Creek meets with the larger Unuk River which ultimately flows into the Pacific Ocean, northeast of Ketchikan, Alaska (Figure 2-7).

Brucejack Mine's Hydrometric Monitoring Program aims to collect and analyze hydrometric data in compliance with monitoring provisions of Effluent Permit PE-107835 issued under the provincial Environmental Management Act and the Metal and Diamond Mining Effluent Regulations (MDMER) of the federal Fisheries Act. The active hydrometric monitoring program consists of three streamflow monitoring stations and a level monitoring station (Figure 2-8; Table 2-1): hydrometric gauges at BJ 3.10 and BJ 1.74, located along Brucejack Creek; a hydrometric gauge at SC-1 located along Sulphurets Creek; and the BJ WRTSF level monitoring station. Record periods for the three hydrometric stations are as follows: BJ 1.74 (2008 – present), BJ 3.10 (2014 – present), and SC-1 (2016 – present). The most-downstream node considered in the site-wide WBM coincides with the location of the BJ 1.74 monitoring station.



Watershed	Area (km^2)
Bell-Irving River	5338
Brucejack Creek	9
Unuk River (at international border)	1504
Salmon River	250

Figure 2-7: Regional watershed map.



LEGEND

- VOK Climate Station and Snow Course
- Monitoring Stations
- Glaciers
- Flow Direction
- BJ 3.10
- BJ 1.74
- Brucejack Creek
- SC1
- Contact Water Pond
- NPAG
- WRTSF
- Watercourse
- Contours (20m)

DATE SAVED:	Feb 28, 2023
DRAWN BY:	DM
REVIEWED:	RG
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

0 0.5 1
Kilometers

CLIENT: NEWCREST BRUCEJACK
LORAX ENVIRONMENTAL

TITLE:
4950 tpd Joint Application

PROJECT: Sulphurets Watershed

PROJECT #: A624-4

FIGURE: 2-8

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022 WQ Infrastructure\Sulphurets Watershed_F2-8.mxd

Table 2-1:
Hydrometric Monitoring Network

Monitoring Station	Location	Easting [a]	Northing	Elevation (masl)	Drainage Area (km²)	Glacier Cover (km² [%])	Period of Record	Monitoring Type
BJ 1.74	Brucejack Creek	425,739	6,259,085	1,349	8.5	0.82 [9.6]	2008 to present [b]	Continuous Stream Water Level
BJ WRTSF	Western shore of WRTSF near outflow	427,112	6,258,918	1,375	6.7	0.71 [11]	2013 to present	Continuous Lake Level
BJ 3.10	Brucejack Creek at WRTSF outflow	426,859	6,258,921	1,373			2018 to present	Continuous stream level and discharge [c]
SC-1	Sulphurets Creek downstream of the outlet of Sulphurets Lake	419,911	6,261,307	546	75.7	34.5 [46]	2016 to present	Continuous Stream Water Level

[a] *UTM Zone 9U, NAD 83*
[b] *Originally BJL-H1, relocated to BJ 1.74 in 2014.*
[c] *Discharge measurements conducted on the channel downstream from the weir. No visible tributaries are located between the station and gauging section.*

Hydrometric monitoring standards adopted by Pretium are based on standards published by the British Columbia Ministry of Environment (MECCS, 2018), the United States Geological Survey (Turnipseed and Sauer, 2010), and the International Organization for Standardization (ISO, 2007). Standard discharge measurement techniques (MECCS, 2018) are employed at stations BJ 3.10, BJ 1.74, and SC-1 (*e.g.*, 20-panel waded measurements with a current meter) whereas methods used in the development of stage-discharge rating curves follow as close as possible guidelines by MECCS (2018) and ISO (2010). A stage-discharge rating curve is an empirical relation used to calculate streamflow (discharge) from continuously recorded water level data.

Rating curves for Brucejack monitoring stations are constructed using the Rating Development Toolbox within Aquarius Time-Series (AQTS). In concept, discharges and water levels are manually measured over a range of flow conditions (*i.e.*, low to high) to generate the curve. Typically, a minimum of ten discharge measurements across a range of stage and streamflow conditions are recommended to develop a robust stage discharge relationship (MECCS, 2018), a threshold that is well exceeded for the Brucejack hydrometric stations. Rating curves for monitoring stations are updated annually as new data becomes available and/or stream channel conditions change.

Each year since 2013, Pretium has prepared an annual monitoring report which summarizes calendar year monitoring data and current state of understanding with respect to streamflow conditions within the Brucejack Creek watershed (*e.g.*, Pretium, 2016; Pretium, 2017; Pretium, 2018a; Pretium, 2019; Pretium, 2020; Pretium, 2021 and Pretium, 2022). The flow regimes of BJ 1.74 and BJ 3.10 is highly similar where daily/monthly patterns of streamflow at BJ 3.10 are strongly influenced by snow accumulation and snowmelt processes, where roughly 85% of runoff on an annual basis is expected to report to receiving streams between May and the end of October (Figure 2-9 and Table 2-2). By comparison, discharges and runoff depths for other months of the year (*i.e.*, November through April) are much lower. Winter streamflow rates are well characterized within the Brucejack Creek watershed and range typically between 0.05-0.120 m^3/s between December and April, at BJ 3.10. The transition from annual low flow conditions coincides with warmer air temperatures in the spring and the melting of snowpack. Measured discharges through open-water (ice free) months typically range between 0.5-2.5 m^3/s (Figure 2-9 upper panel, at BJ 3.10).

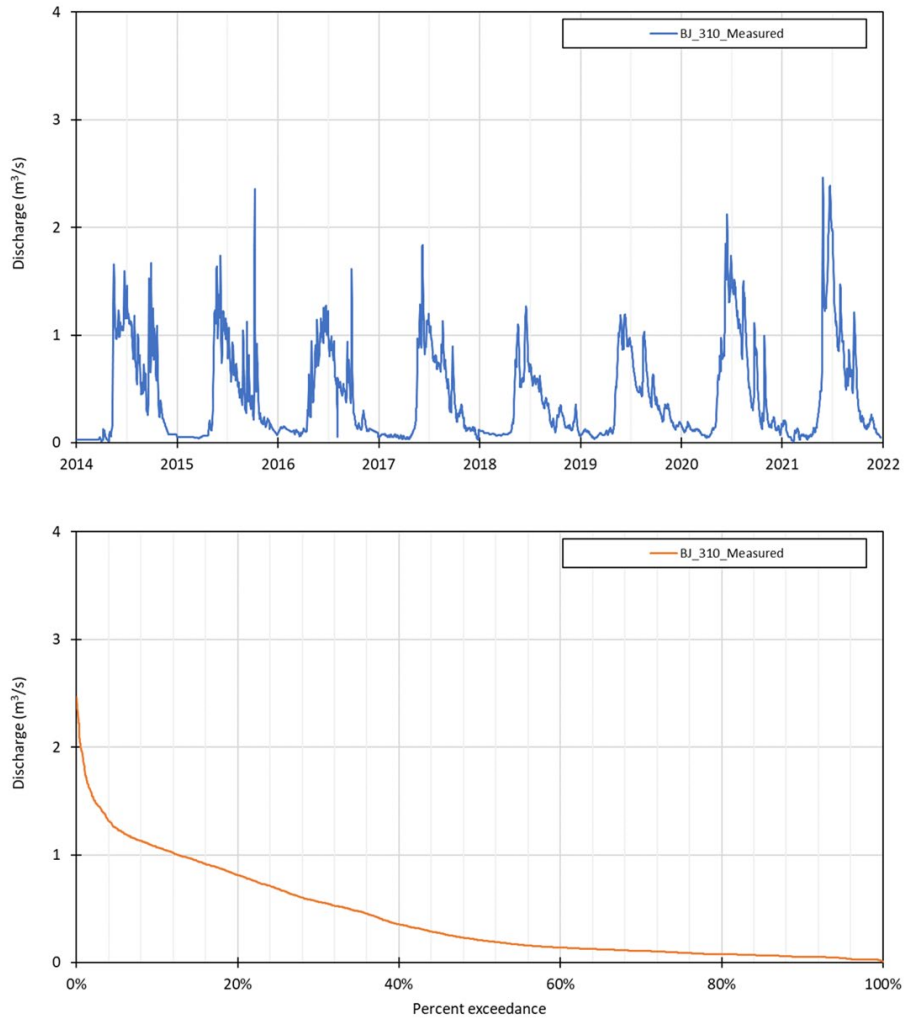


Figure 2-9: Streamflow measurements below the WRTSF outlet (BJ 3.10) for the period 2014-2021. Data for the station is presented in time series (upper panel) and flow duration curve format (lower panel).

Table 2-2:
Flow statistics summary for BJ 3.10 station (2014-2021).

	Discharge (m^3/s)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	0.031	0.031	0.033	0.049	0.736	1.146	1.093	0.682	0.707	0.784	0.205	0.079	0.467
2015	0.056	0.056	0.048	0.084	0.790	1.142	0.791	0.575	0.486	0.610	0.197	0.129	0.416
2016	0.130	0.114	0.092	0.222	0.705	1.079	0.864	0.489	0.626	0.190	0.175	0.111	0.400
2017	0.069	0.064	0.056	0.046	0.409	1.142	0.917	0.779	0.533	0.315	0.169	0.098	0.385
2018	0.104	0.083	0.071	0.088	0.627	0.797	0.617	0.458	0.269	0.233	0.168	0.181	0.310
2019	0.095	0.067	0.071	0.099	0.609	1.003	0.725	0.652	0.512	0.320	0.298	0.164	0.386
2020	0.144	0.128	0.096	0.073	0.450	1.290	1.408	1.110	0.534	0.407	0.332	0.152	0.512
2021	0.140	0.057	0.075	0.066	0.283	1.723	1.413	0.872	0.741	0.331	0.178	0.108	0.500
Period (2014-2021)	0.096	0.075	0.068	0.091	0.576	1.165	0.978	0.702	0.551	0.399	0.215	0.128	0.422

	Yield ($L/s/km^2$)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	4.6	4.6	5.0	7.4	109.8	171.0	163.1	101.8	105.5	117.0	30.6	11.8	69.8
2015	8.4	8.3	7.2	12.6	117.9	170.4	118.0	85.8	72.6	91.1	29.4	19.2	62.1
2016	19.4	17.1	13.8	33.1	105.2	161.0	128.9	73.0	93.4	28.4	26.1	16.6	59.7
2017	10.4	9.5	8.4	6.9	61.1	170.5	136.9	116.3	79.5	47.1	25.2	14.6	57.4
2018	15.5	12.4	10.6	13.2	93.6	119.0	92.2	68.4	40.2	34.8	25.1	27.1	46.2
2019	14.2	10.0	10.6	14.8	91.0	149.6	108.2	97.3	76.5	47.8	44.5	24.5	57.6
2020	21.4	19.1	14.3	10.9	67.2	192.6	210.1	165.7	79.6	60.7	49.6	22.7	76.4
2021	20.9	8.4	11.1	9.9	42.2	257.1	210.9	130.2	110.6	49.3	26.6	16.1	74.7
Period (2014-2021)	14.3	11.2	10.1	13.6	86.0	173.9	146.0	104.8	82.2	59.5	32.1	19.1	63.0

	Runoff depth (mm)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
2014	12	11	13	19	294	443	437	273	273	313	79	32	2,202
2015	22	20	19	33	316	442	316	230	188	244	76	51	1,959
2016	52	42	37	86	282	417	345	196	242	76	68	44	1,884
2017	28	23	22	18	164	442	367	311	206	126	65	39	1,813
2018	41	30	28	34	251	308	247	183	104	93	65	73	1,459
2019	38	24	29	38	244	388	290	260	198	128	115	66	1,819
2020	57	47	38	28	180	499	563	444	206	163	128	61	2,411
2021	56	21	30	26	113	666	565	349	287	132	69	43	2,357
Period (2014-2021)	38	27	27	35	230	451	391	281	213	159	83	51	1,988

2.5 Groundwater Recharge to the Underground Mine

Numerical groundwater modeling studies of the Brucejack mine were undertaken in 2013, 2014, and 2015 to support applications for an Environmental Assessment Certificate and *Mines Act* / *Environmental Management Act* permits. These modeling studies drew upon site investigations characterizing hydrogeological conditions initiated in 2010, based on drilling, hydraulic testing, and monitoring well and vibrating wire piezometer installations. Data available through late 2014 were used in conceptual and numerical groundwater model development, calibration, and benchmarking. It is important to note that the numerical groundwater model was updated in support of the 2020 Mine Plan and Reclamation Program Update. Briefly, the 2020 groundwater model update and work completed since that time builds upon the assumptions underpinning the 2015 groundwater model, incorporating a longer water level and underground dewatering records, and is constructed using FEFLOW 7.2 simulation software (DHI, 2020).

In addition to modelling, routine groundwater quantity and quality monitoring has been ongoing at the Brucejack Mine site since 2011. Hydrogeological field programs comprised of drilling, hydraulic testing, and monitoring well installation were undertaken in 2016 and 2018 (BGC, 2017; BGC, 2019). The 2018 field investigation established 14 new monitoring wells, fulfilling *Environmental Management Act* Permit PE-107835 and *Mines Act* Permit M-243 requirements.

In summary, the groundwater flow system at the Brucejack Mine has been conceptualized to provide estimates of groundwater inflow to the existing and future underground mine workings during operations and closure, and for groundwater seepage flow paths during post-closure (Lorax, 2023a). An example of the measured and modelled GW inflow data records used in the WBM is shown in Figure 2-10 noting GW inflow to the underground mine shows strong seasonality, where fluxes are much higher in the spring, summer, and autumn, than during the winter. Measured data for the pre-2019 period show GW inflow varies between 30-80 m^3/hr on an annual basis. By comparison, modelled rates of GW inflow are predicted to become progressively higher and range from 60-160 m^3/hr on an annual basis, by the end of mining, when the underground mine is at full extent.

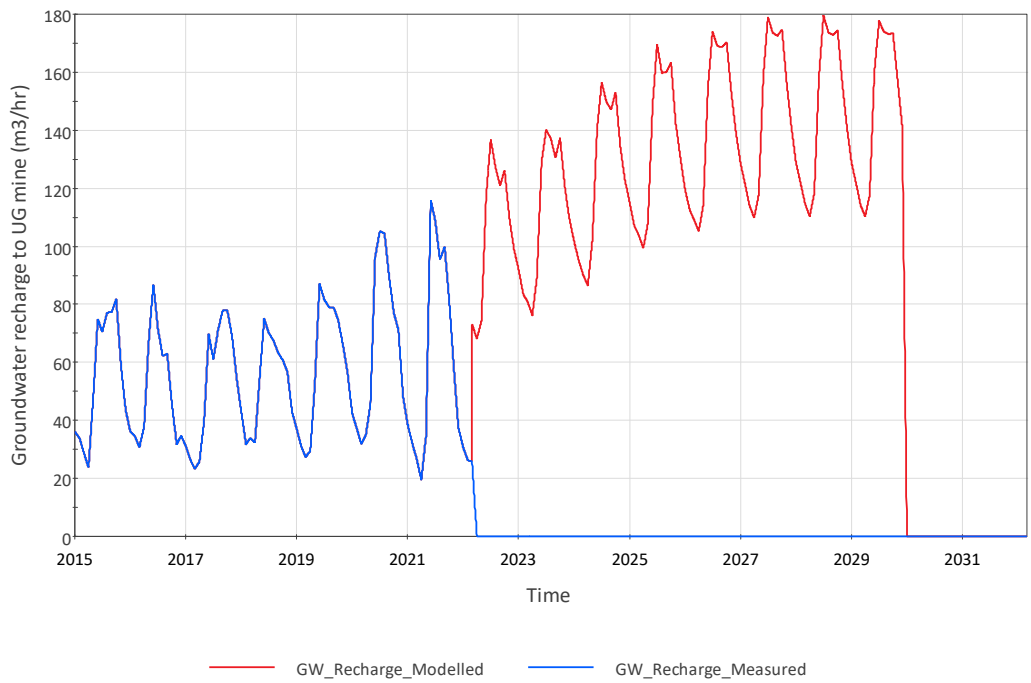


Figure 2-10: Measured (blue) and modelled (red) time series of GW inflow (or recharge) to the underground mines.

2.6 Other Water Monitoring Data

In addition to climate and streamflow monitoring activities, Pretium maintains a water monitoring database (*i.e.,* 12-hour and daily time-step) related to water infrastructure and water management at the mine site. Available data span the period from commencement of ore processing (July 2017) with data collection ongoing.

Set-up and re-configuration of the WBM benefited from water monitoring data that provide representative information on:

- The magnitude of runoff volumes associated with the contact water collection system.
- Pumping strategies (*i.e.*, flow rates, seasonal timing) between the CWP and the WTP, and steps taken to manage CWP stage/volume, over the course of the year.
- Freshwater use within the underground mine for drilling and dust suppression purposes. The underground mine is serviced by flows from the freshwater tank (FWT).
- The magnitude and seasonal patterns of reclaim water diversions associated with Pretium's permitted water allocation from Brucejack Creek below the WRTSF.

- The fate of treated effluent from the WTP, including amounts used in the mill to support ore processing, volumes recycled back to the CWP, and/or released to the Brucejack WRTSF via the treated water tank (TWT) when water supply requirements are fully met.
- The water volumes associated with the production of concentrate, paste backfill and tailings slurry.

Figure 2-11 and Figure 2-12 show representative examples of the available monitoring data for key water infrastructure and water management pathways (2017-2022) and are discussed further in Section 3 and Section 4 of this report.

2.7 Bathymetry Surveys

Pretium completed bathymetric surveys of the WRTSF in 2015 and each year thereafter since 2018. A comparison of the completed surveys confirms shallowing and volume loss over time in the WRTSF on account of waste rock and tailing placement (Figure 2-13).

For example, WRTSF volume was estimated to be 30.3 Mm^3 in 2015 versus 24.7 Mm^3 in 2022, and data from these two dates indicate the reduction in maximum depth of the facility was approximately 25 m between sampling dates. By 2029 and following placement of all waste rock and tailings outlined in the LOM schedule, the final volume in the WRTSF will be on the order of 21 Mm^3.

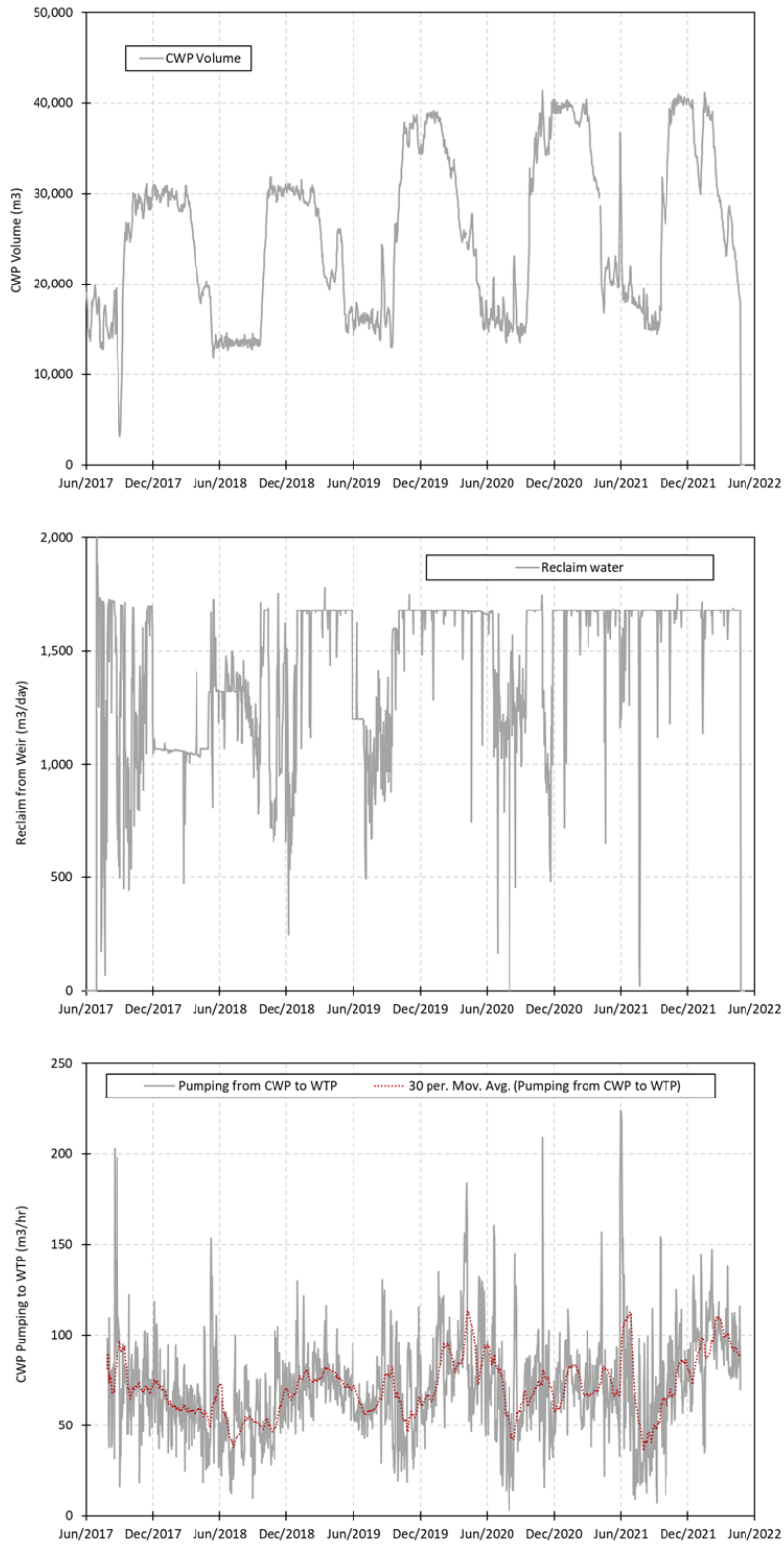


Figure 2-11: Examples of operational monitoring data for Brucejack Mine: CWP volume (upper panel); reclaim from weir (middle); and CWP pumping to WTP (lower).

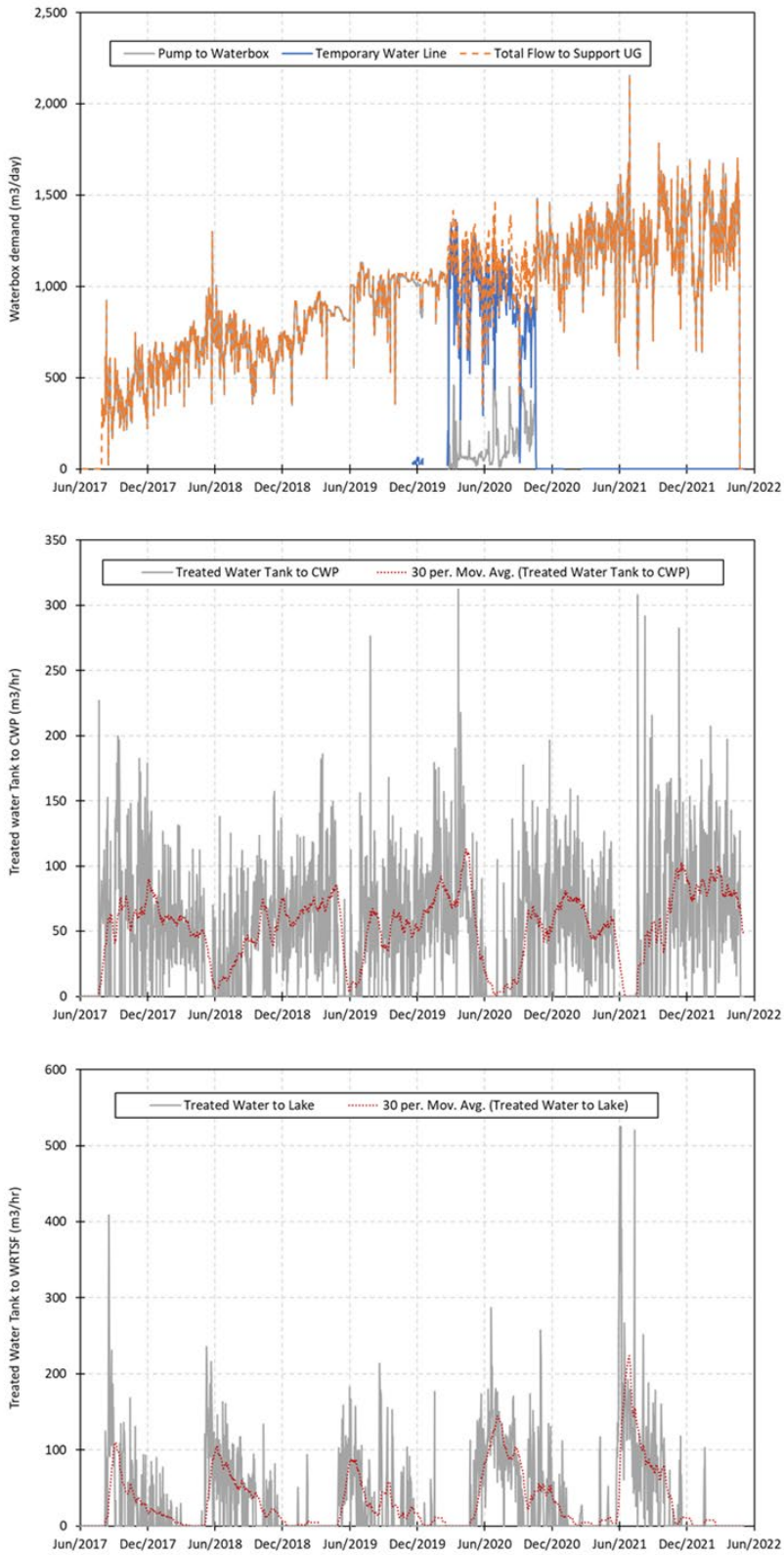
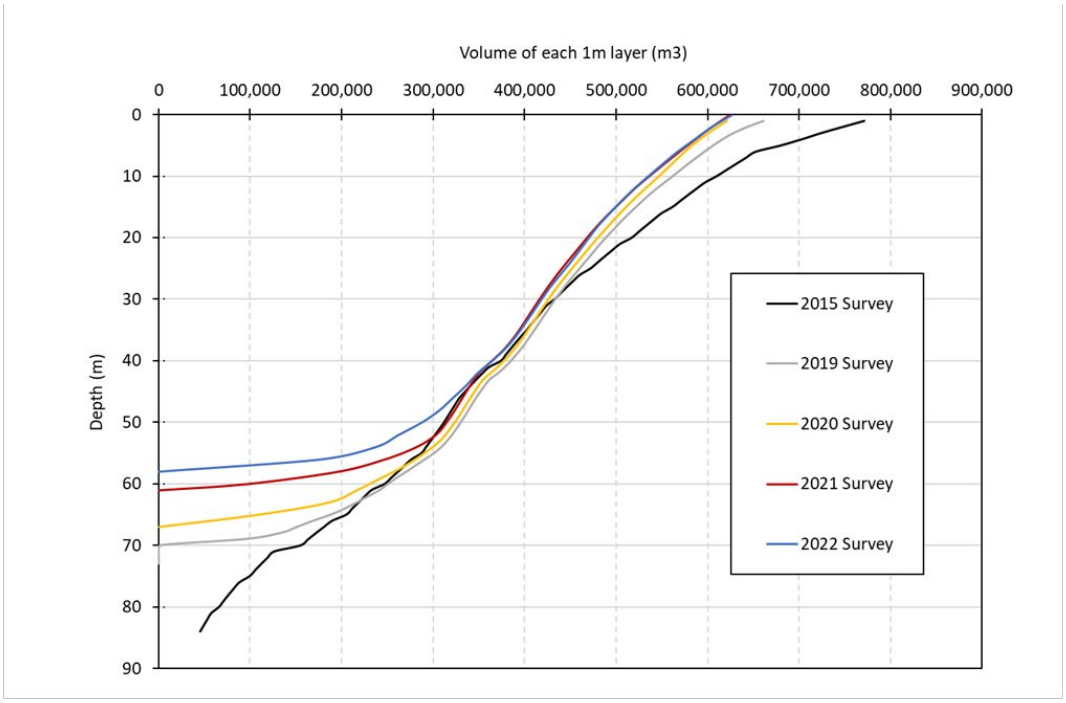


Figure 2-12: Examples of operational monitoring data for Brucejack Mine: FWT to waterbox below ground (upper panel); TWT to CWP (middle); and treated water tank to WRTSF (lower).



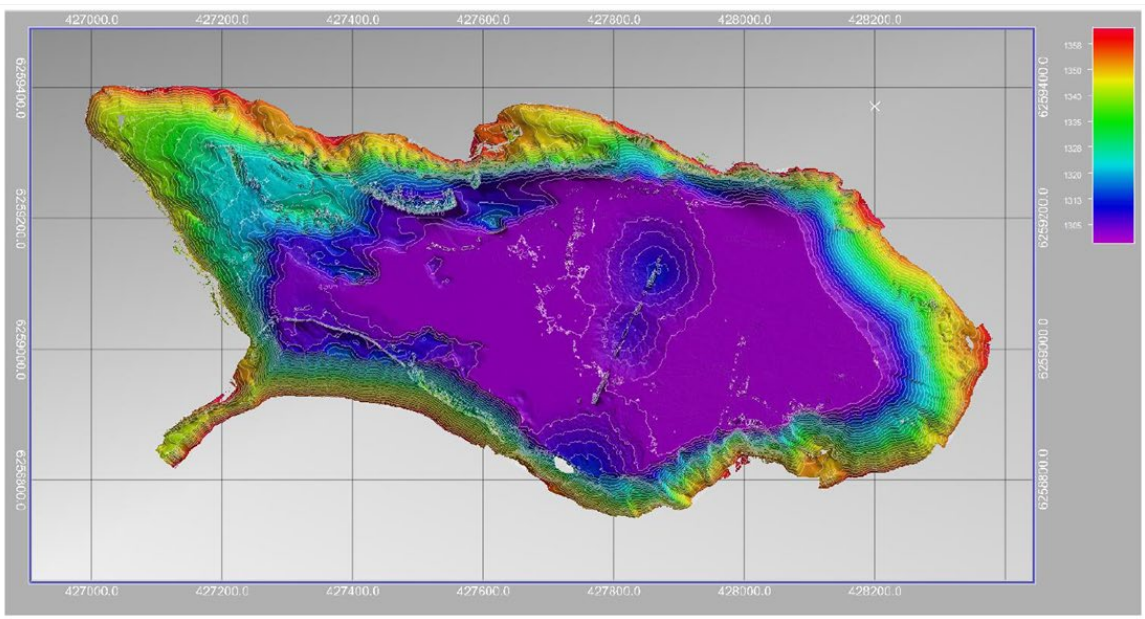


Figure 2-13: Comparison of recent bathymetric survey data for the Brucejack WRTSF (upper panel) and a plot showing a 2021 bathymetric survey map (lower panel).

3. Brucejack Mine Water Balance Model

3.1 Overview of WBM

Overview schematics of the Brucejack Mine WBM are shown in Figure 3-1, Figure 3-2 and Figure 3-3. Figure 3-1 and Figure 3-2 show conceptual layouts of the mine site with reference to the Brucejack watershed and WBM nodes established on Brucejack Creek below the mine site for operations and post-closure respectively. Arrows in Figure 3-1 and Figure 3-2 connect the identified components of the WBM and represent surface conveyances, flowpaths, pipelines and material flows, noting that different line colours are used to distinguish 'flow' associated with non-contact/background, water treatment plant effluent, surface contact and mine contact waters.

Figure 3-3 is a screen capture from the GoldSim model and shows the main containers of the model (boxes) and any inter-connections between containers, depicted by arrows. Within each container shown in the plot, more detailed sub-models and time series inputs are encoded. The sections of text below describe main elements of the WBM, assumptions within each, and introduce the sub-models that are the working parts of the overall WBM. For reference, Figure 3-4 is provided and gives an introduction to the Input, Function and Stock elements that appear in many GoldSim wire diagrams presented later in this section of the report (*e.g.*, Figure 3-10 and Figure 3-17).

3.1.1 Key Model Features for Operations and Closure

The bullets below outline the main water management components represented in the WBM for the operations phase (Figure 3-1):

- The WBM considers a contact water pond (CWP) which is assumed to receive approximately 60% of surface runoff from the mine site contact water collection system (primarily the mill and lower camp pads). Captured contact water is pumped to the WTP for treatment. The remaining 40% is assumed to be collection system leakage that reports directly to the waste rock tailings storage facility (WRTSF) or Brucejack Creek below the WRTSF;
- Sump waters from the underground mine, which includes groundwater inflows, paste backfill bleed water (*i.e.*, the excess water not consumed in the paste backfill cementation reaction) and water from the FWT that is directed to the underground mine to support drilling/dust suppression activities;

  - Like water reporting to the contact water collection system (CWCS), water volumes captured in the mine sumps are pumped to surface and report to the clarifier;

- The WBM accounts for make-up/reclaim water taken from BJ 3.10 and necessary to meet mill demand. Reclaim from BJ 3.10 is directed to the FWT to supplement water requirements below ground and in the mill;
- A water treatment plant (WTP), which treats water from the CWP and the underground mine (via the clarifier). Treated effluent from the WTP is used in the mill process, with any excess not required for process discharged to the WRTSF, or re-cycled back to the CWP;
- Discharge of effluent from a sewage treatment plant (STP) to the WRTSF;
- A mill which discharges a tailings slurry to the WRTSF and/or conveys paste backfill to the underground mine;
- The conveyance of contact flows from the km 72 NPAG quarry and the WR platform to the WRTSF via surface runoff; and
- Deposition of waste rock sub-aqueously in the WRTSF and to the underground mine as backfill.

At closure, the WBM assumes as base case that mine facilities will be decommissioned, and the underground mine workings will be flooded over a seven-month period, starting in January 2030 (Lorax, 2023a). The natural flooding from groundwater inflows will be accelerated by pumping water from the WRTSF into the underground mine at a rate equal to 70 m^3/hr (~ 50,000 m^3/month) between January and April and then at an increased rate equivalent to 20% of the mean monthly flows at BJ 3.10 during May June and July. In closure, underground mine water will be treated by the WTP at a rate of 10,000 m^3/day and recirculated back underground throughout the flooding period, as well as for an additional eight months to ensure that water quality is effectively managed.

The WBM also considers the post-closure phase. The following mine-related components are relevant for this Project phase: flows from the km 72 NPAG quarry; flows from the reclaimed plant site; and drainages from the underground mine which flow to the WRTSF and Brucejack Creek via groundwater pathways. An overview schematic for the post-closure phase is shown in Figure 3-2.

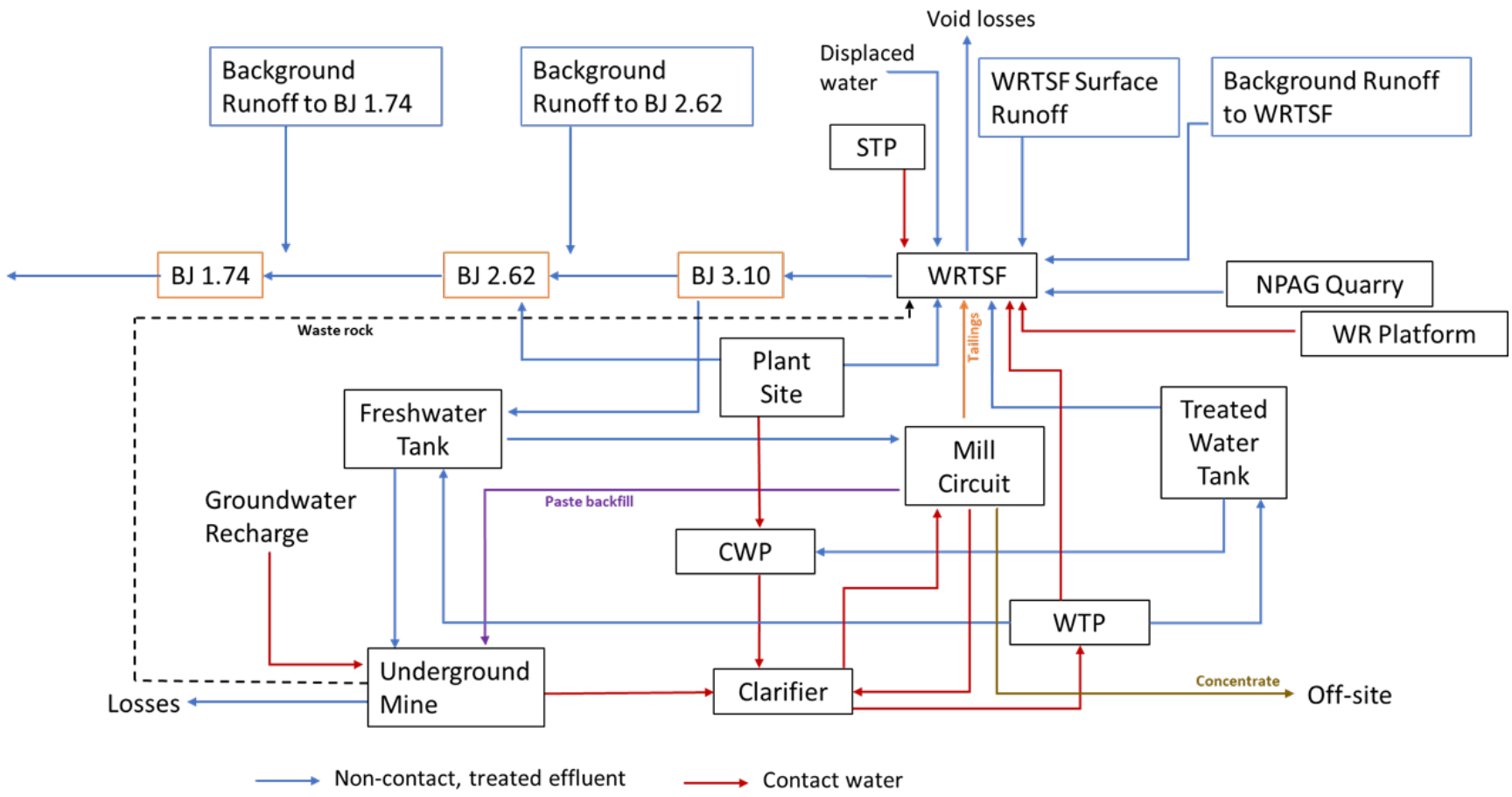


Figure 3-1: Overview Schematic – Conceptual Layout for Life-of-Mine (LOM)

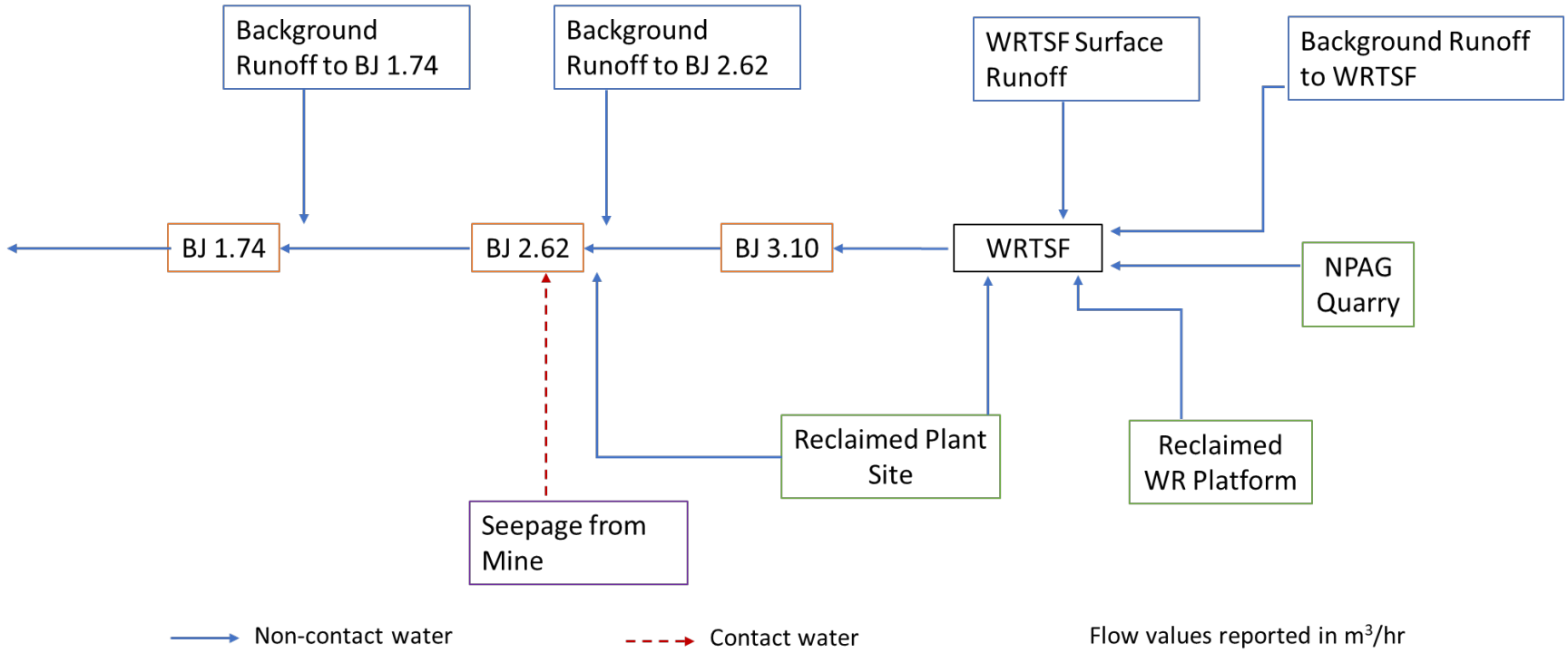


Figure 3-2: Overview Schematic – Conceptual Layout for Post-closure

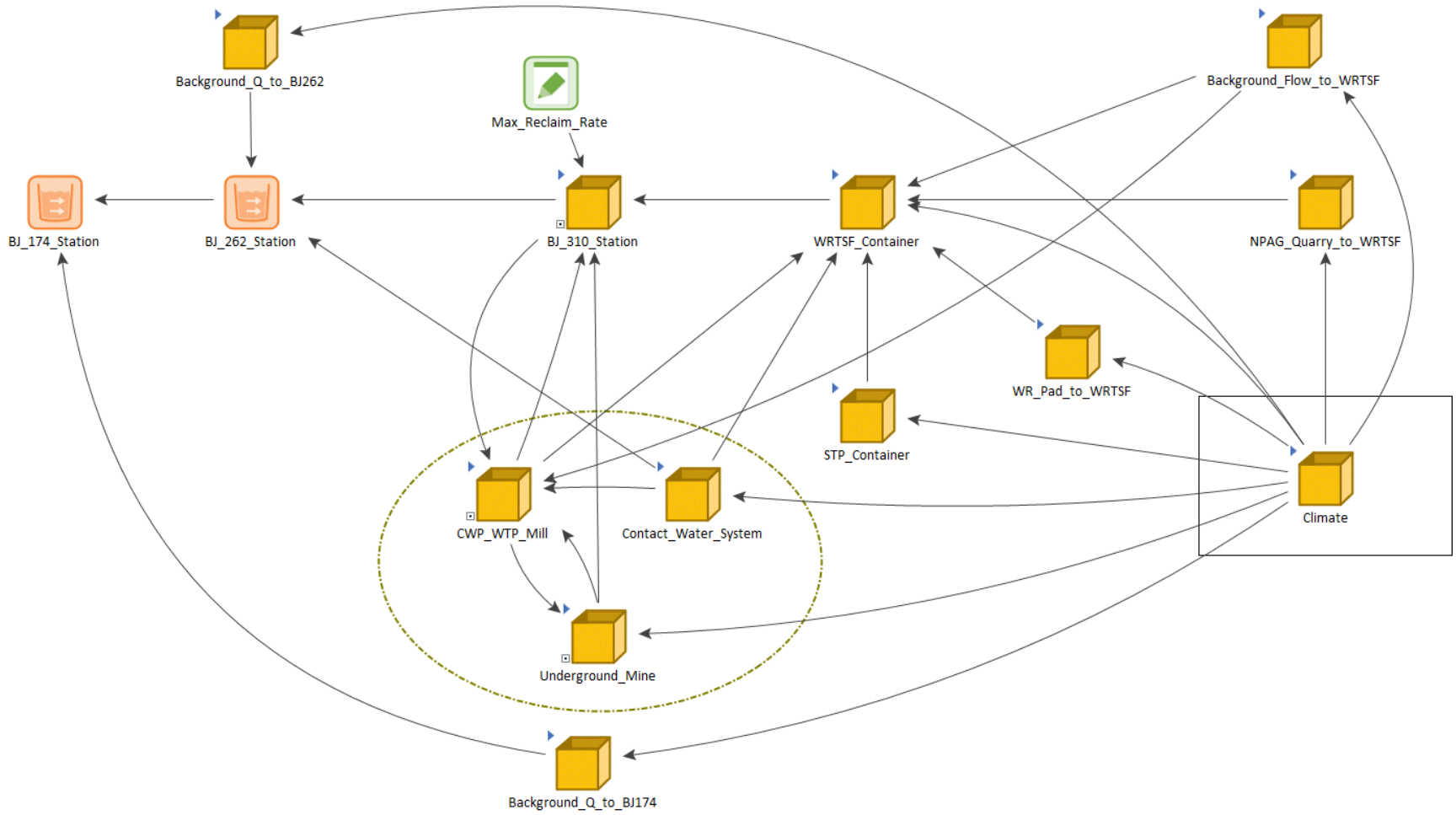


Figure 3-3: WBM Overview Schematic – Brucejack Mine, GoldSim Layout

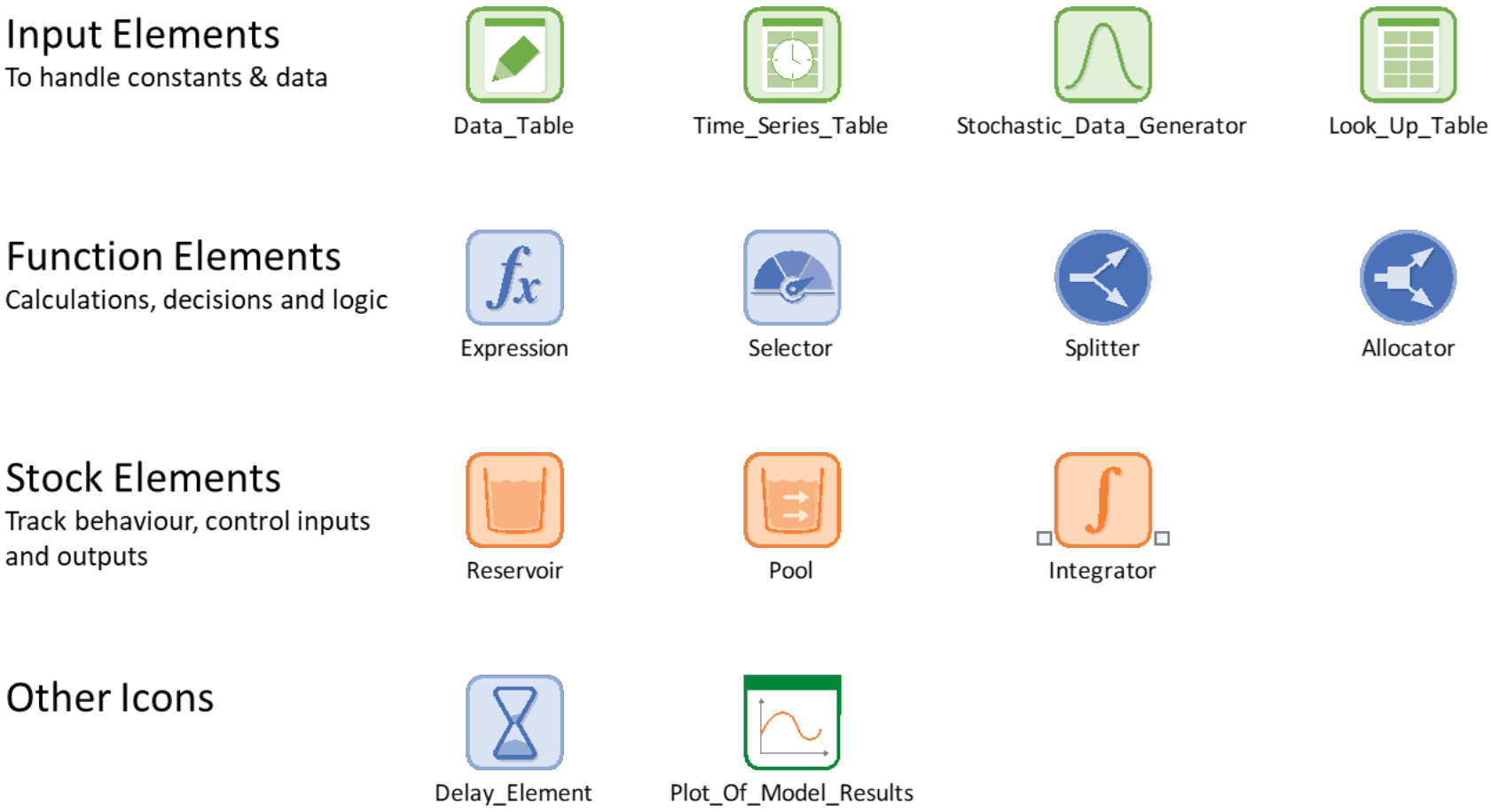


Figure 3-4: Overview of Input, Function and Stock elements in GoldSim simulation software.

3.2 Climate Data

Climate data are used to drive several of the sub-models within the WBM. This is evident in Figure 3-3 by the several 'arrow' connections between the Climate folder and other components of the WBM. Technical detail represented within the Climate container of the model is shown in Figure 3-5. At the right side of schematic (Figure 3-5), period of record data recorded by the VOK climate station are organized into air temperature and precipitation read-in tables (grey shading). On the left side of the Figure 3-5 (white and pink shading), long-term average synthetic climate data from PNWNAmet are similarly organized into air temperature and precipitation read-in tables. Finally, monthly climate change scenario data tables available from the Scenario Network for Alaska and Arctic Planning (SNAP) for RCP6.0, are shown in the centre of Figure 3-5 (blue shading).

Consistent with the 2020 5-Year Plan water balance model, Base Case results presented in Section 4 use climate data inputs in the current version of the WBM (based on the 4950 tpd Joint Application mine plan) as follows: VOK climate station measurements are read into the model for the pre-2022 time period at daily timestep; and for the period 2022-2100, average daily climate readings developed from a 30-yr portion of the PNWNAmet daily- gridded dataset, are continuously looped for the duration of the simulation (Figure 3-6, upper panel). Note that PNWNAmet data spanning the period 1983-2012 (see Section 3.3.3) are used to generate the long-term daily averaged air temperature and precipitation inputs which are continuously looped in the water balance model.

The GoldSim model is also constructed to read in daily variable climate inputs for the period 2022-2100 (Figure 3-6, middle panel) and daily variable climate inputs adjusted for future climate change for the period 2022-2100 (Figure 3-6, lower panel). Briefly, daily-varying climate readings developed from a 30-yr portion of the PNWNAmet daily- gridded dataset, are continuously looped, for the duration of these two climate input options (*i.e.*, variable climate case and variable climate case plus climate change). Upon instruction, GoldSim then 'time-steps' the variable climate inputs to produce 30 unique realizations of results, in essence, allowing a full range of meteoric conditions to be modelled upon each year of the Project timeline. Regarding air temperature and precipitation adjustments for future climate change, annual scalars are read into the WBM based on the RCP6.0 scenario developed from datasets prepared by the Scenario Network for Alaskan and Arctic Planning (SNAP) (refer to Section 3.3.4).

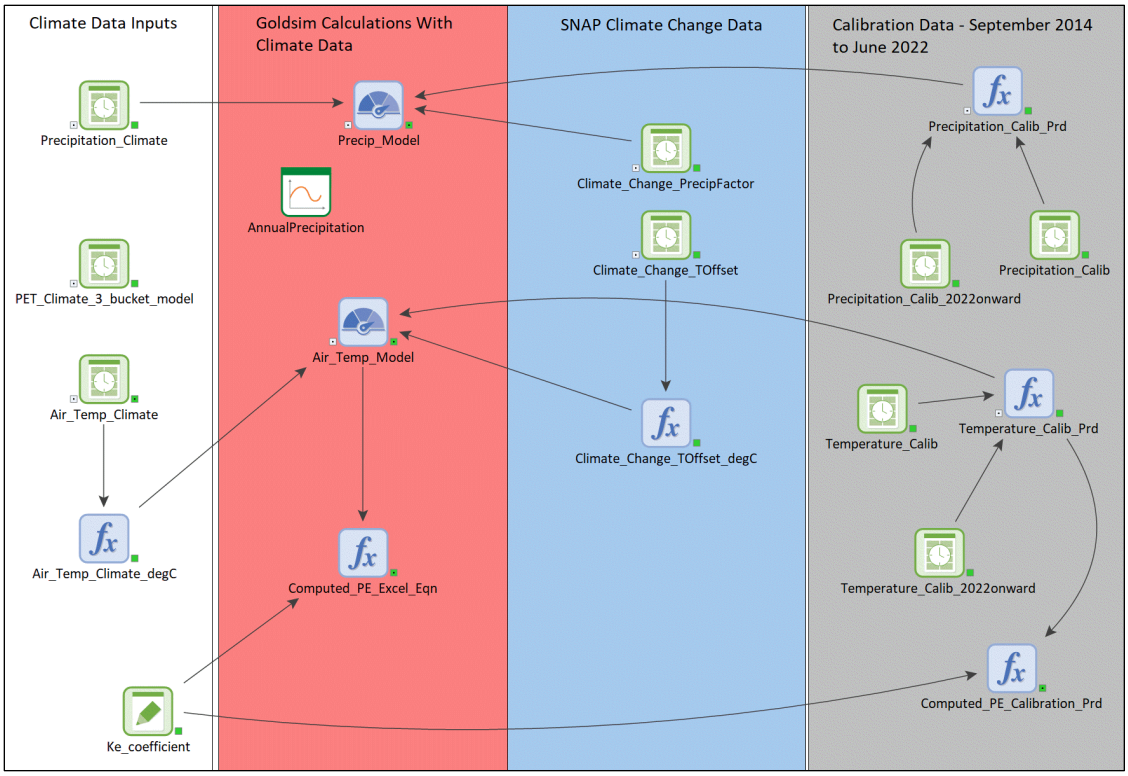


Figure 3-5: Schematic showing the Climate container of the Brucejack Mine WBM.

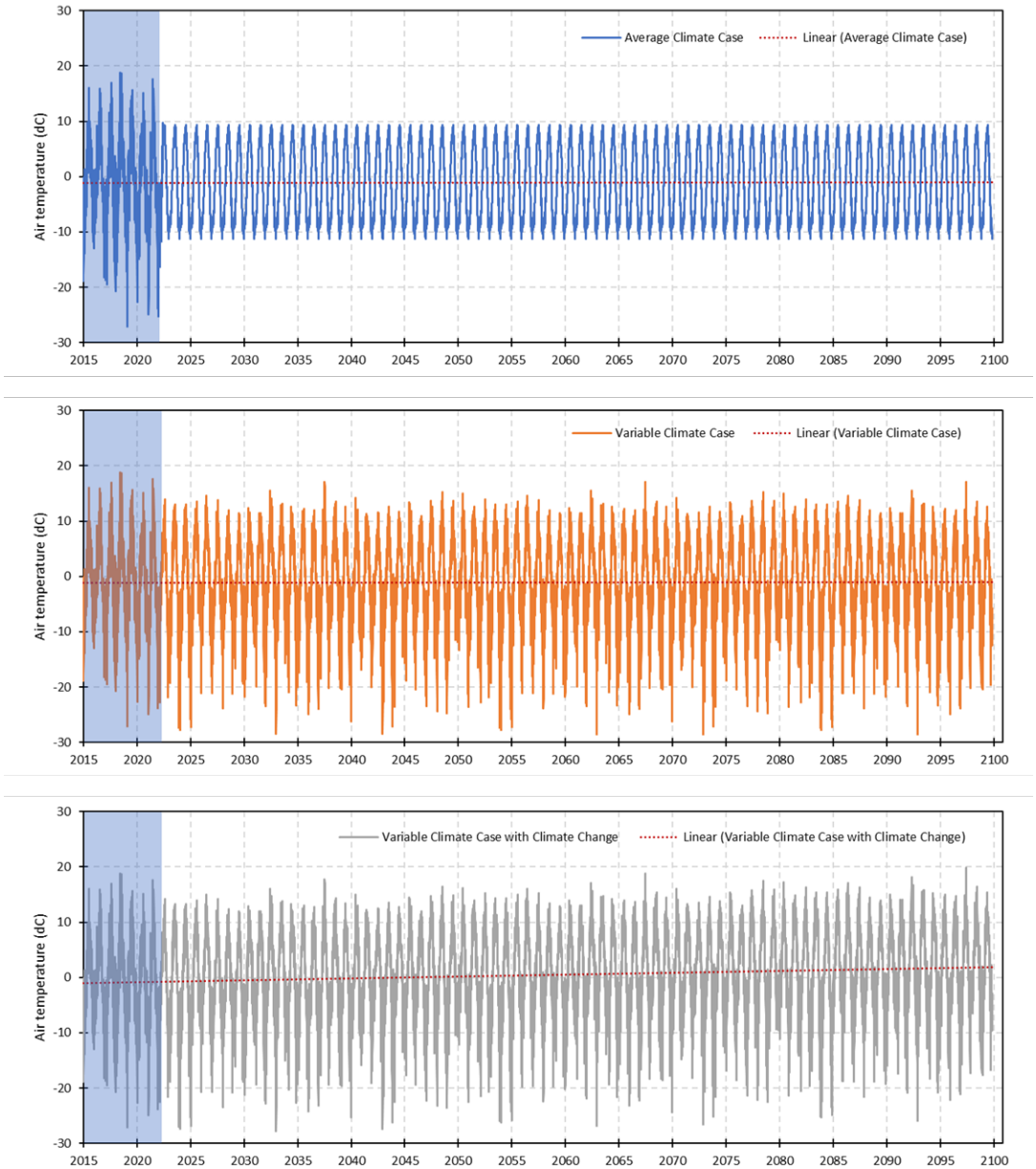


Figure 3-6 (a): Time series plots illustrating options for the input of air temperature (shown) and precipitation data (see Figure 3-6b) into the WBM. For the period 2022-2100, options include: looping of average daily climate data for the period (upper panel); looping of variable climate data for the period (middle panel); and looping of variable climate data adjusted for future climate change (lower panel).

Note: For each climate data input option, measured air temperature and precipitation data for the pre-2022 period are read into the model (blue shading). For the variable climate case and variable climate plus climate change case, only results for realization #1 (of n = 30) are shown in the plots above. Since the variable climate record used in the WBM is 30-years in length, the model can read in thirty realizations of climate input data and produce thirty unique realizations of WBM output for each year of any model simulation.

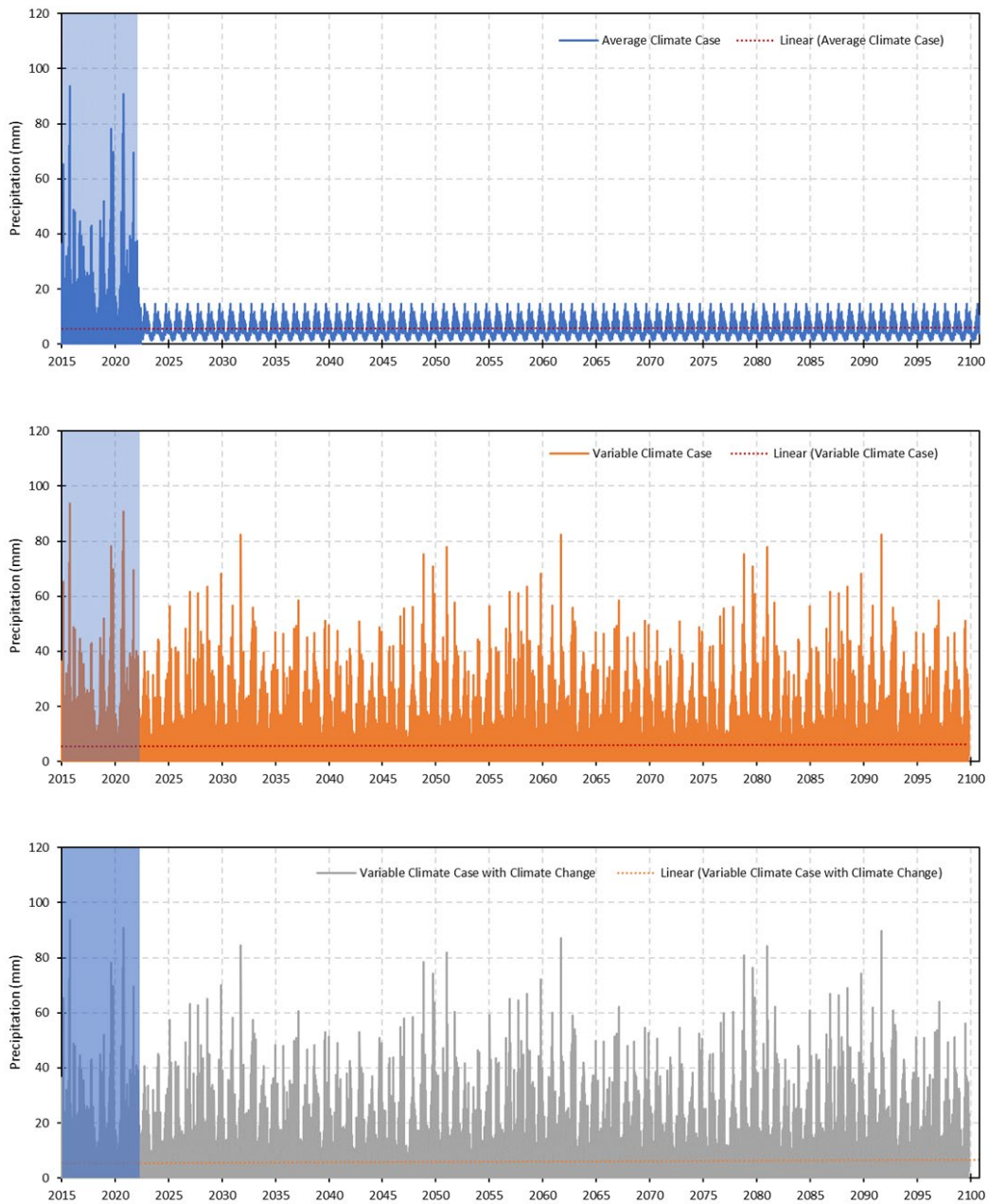


Figure 3-6 (b): Time series plots illustrating options for the input of precipitation data into the WBM. For the period 2022-2100, options include: looping of average daily climate data for the period (upper panel); looping of variable climate data for the period (middle panel); and looping of variable climate data adjusted for future climate change (lower panel).

Note: For each climate data input option, measured air temperature and precipitation data for the pre-2022 period are read into the model (blue shading). For the variable climate case and variable climate plus climate change case, only results for realization #1 (of n = 30) are shown in the plots above. Since the variable climate record used in the WBM is 30-years in length, the model can read in thirty realizations of climate input data and produce thirty unique realizations of WBM output for each year of any model simulation.

3.3 Watershed Scale Runoff Modelling

3.3.1 Model Description

A modified version of the Birkenes watershed model is used to replicate the streamflow regime within the Brucejack Creek watershed. This model is depicted in concept diagram and GoldSim coded format in Figure 3-7. The Birkenes model was developed as part of a research program to understand linkages between stream chemistry and flow in a small (< 1 km^2) catchment in southern Norway (*e.g.*, Christophersen and Seip, 1982; Seip *et al.*, 1985). Previous efforts on the WBM considered a similar approach, so the modelling concept (*i.e.*, simplified, reservoir-based watershed modelling) is not new (BGC, 2017c). However, any runoff modelling completed previously was undertaken at a monthly time step, whereas watershed model calibration and integration into the WBM is now handled at daily time step.

The Birkenes model represents the watershed using a series of connected reservoirs which aim to replicate a measured hydrograph by separating total discharge into three component flows: quick flow, or event runoff, which may be associated with melting of snowpack or summer storms; interflow, which is flow through shallow overburden material and soils; and baseflow, which in concept is the portion of the hydrograph which is derived from groundwater discharge. Conceptually, incoming precipitation is partitioned in the model to rain, or a snow reservoir, based on air temperature thresholds.

Rainfall is directed into Fast and Slow Surface reservoirs, which represent areas of fast runoff response, and slower-draining soil areas, respectively. Fast and slow surface recession flow from the surface storage reservoirs can go directly to surface discharge, or to the Deep Surface Water reservoir, depending on the fraction of remaining available storage in the latter. When the Deep Surface Water reservoir contains water, slow recession flow from the reservoir reports as baseflow. Withdrawals from these reservoirs are governed by constant proportional losses applied to the reservoir volume at a given time-step. As the reservoir volume is drawn down (assuming no additional inputs), the rate of withdrawal is reduced, and thus the outflow signature approximates a negative exponential decay function (*i.e.*, the recession curve).

Snow within the Snowfall reservoir remains in storage until snowmelt begins, which is controlled in the model using daily temperature-dependent melt functions. When snow within the Snow Reservoir melts, these waters can either report to other model reservoirs if they are depleted or generate quick flow following the mechanisms described for Rainfall. Over the course of a simulation, evaporation is withdrawn from both surface reservoirs (Fast and Slow), and from the Deep Surface reservoir, but at a lower rate. Similar to the handling for snow versus rain, evaporation is computed in the model using temperature-based controls.

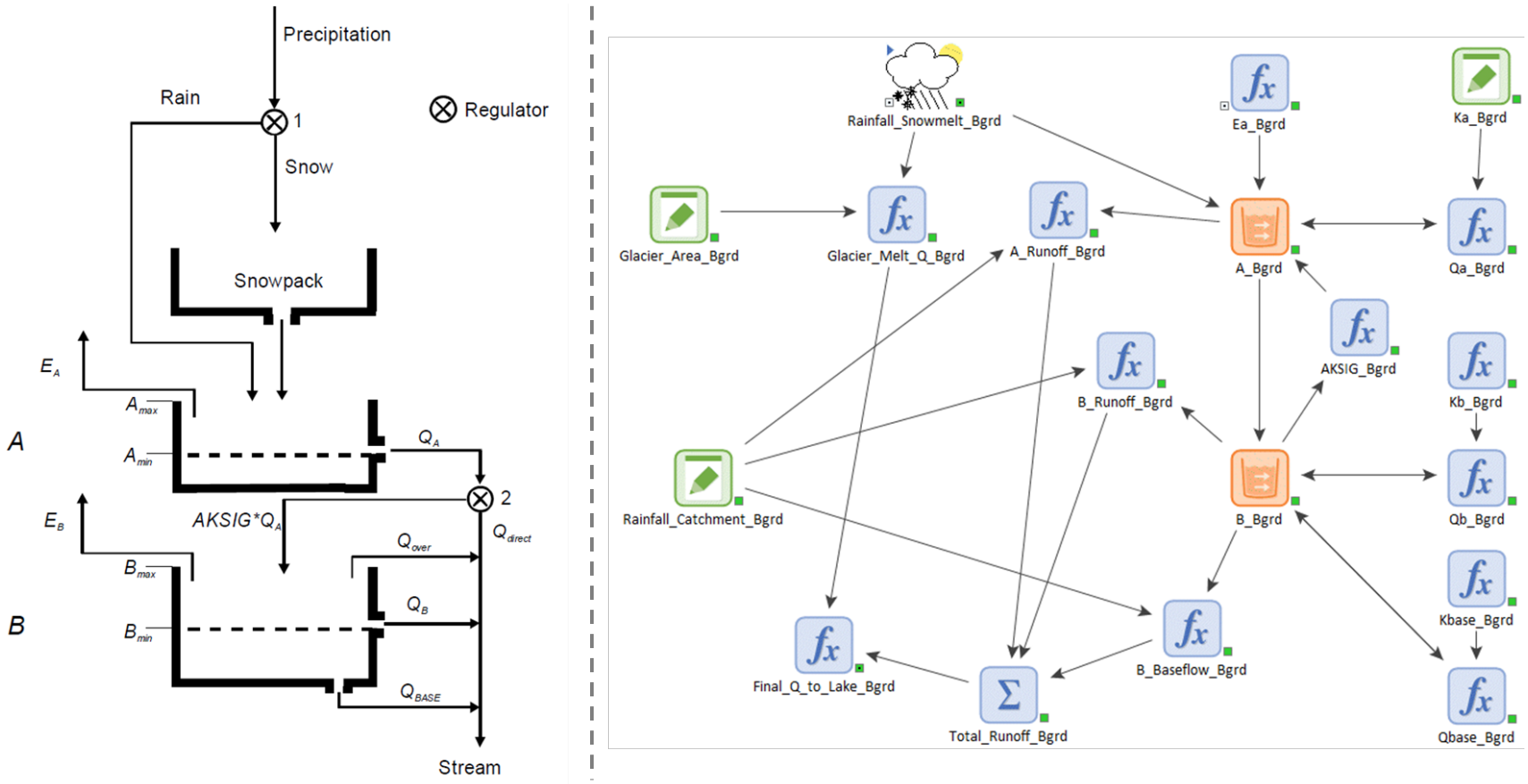


Figure 3-7: Overview schematic of the Birkenes 3-reservoir model (left) and coding of the model in GoldSim (right panel)

3.3.2 Approach to Model Calibration

The watershed model was calibrated for the mine site using measured climate data for the VOK climate station and measured streamflow data for BJ 3.10, spanning the period January 2015 to December 2021. Therefore, the calibration effort was based on a seven-year measured climate and streamflow record. The overall approach to the calibration was to first develop and test a preliminary calibration for the Brucejack watershed (*i.e.*, 6.5 km^2), then build-out the various sub-models that appear in the WBM, by applying a generic set of watershed model parameters developed during the initial calibration process, to these sub-models. With reference to Figure 3-1 and Figure 3-2, runoff/discharge is derived for the following portions of the WBM, using a generic set of watershed model parameters: background runoff that reports to the WRTSF, background runoff that reports below BJ 3.10 but above BJ 2.62, background runoff that reports below BJ 2.62 but above BJ 1.74, as well as runoff from the footprints of the km 72 NPAG quarry and waste rock platform beside the WRTSF.

With all the modelling work completed in GoldSim, measured and modelled results at BJ 3.10 for the full seven-year timeframe were then carefully assessed. To evaluate the efficacy of the calibration and overall model performance, visual comparisons of time series results, statistical analyses using measures like the Nash-Sutcliffe Efficiency coefficient, and flow-duration curve comparisons, between measured and modelled data, were performed.

3.3.3 Summary of Relevant Catchment Areas and Glacier Extents

The sub-watershed models embedded into the GoldSim WBM generate runoff (depth in mm) which is subsequently converted to a flow rate, in m^3/s, based on catchment area. A summary of catchment areas relevant to the WBM setup is provided in Table 3-1.

When air temperatures are at their maximum and snowpack is fully melted, the WBM accounts for glacial melt using a temperature-dependent melt approach following the approach adopted by BGC previously (BGC, 2017c). A summary of glacier extents relevant to the WBM setup is also provided in Table 3-1.

Table 3-1:
Summary of catchment areas and footprints used in the WBM

Catchment	Total area (km^2)	Glacial footprint (km^2)
Background runoff to Brucejack WRTSF	5.41	0.43
Background runoff below BJ 3.10 and above BJ 2.62	0.78	0.27
Background runoff below BJ_2.62 and above BJ_1.74	1.31	0.11
NPAG Quarry	0.15	---
Waste Rock Platform area	0.09	---
Footprint of the Contact Water Collection System	0.20	---
WRTSF	0.70	---
BJ 3.10 at weir	6.55	0.43
BJ 2.62	7.33	0.69
BJ 1.74	8.63	0.81

3.3.4 Summary of Three Reservoir Model Coefficients

A summary of the Birkenes model coefficients necessary to populate and calibrate the runoff models developed in GoldSim is provided in Table 3-2. The temperature-dependent glacier melt coefficients used in the WBM are also reported in this table.

Table 3-2:
Summary of Birkenes Model Coefficients for BJ 3.10 Calibration

Metric	Value
Area (km^2)	6.5
$A_{initial}$ (mm)	100
A_{min} (mm)	300
B_{max} (mm)	1,500
B_{min} (mm)	300
$B_{initial}$ (mm)	250
K_A (mm/mm/d)[1]	0.3
K_B (mm/mm/d)[1]	0.04
K_{BASE} (mm/mm/d)[1]	0.001
K_e (mm/°C/d)	0.2
M_{coeff1} (mm/°C/d)[2]	4
M_{coeff2} (mm/°C/d)[3]	6
M_{coeff3} (mm/°C/d)[4]	5

[1]mm/mm/d indicates mm of runoff per mm of reservoir volume per day
[2]Melt coefficient for T < 5°C; [3]Melt coefficient for T < 15°C; [4]Melt coefficient – glacier

3.3.5 Summary of Model Performance for the Calibration Period (2015-2021)

Measured data and modelled results for the calibration period were assessed using metrics such as comparisons of measured and modelled averages, the Root Mean Square Error (RMSE), the Nash-Sutcliffe efficiency coefficient (NSE) and log-NSE coefficient (Table 3-3). In addition to a visual comparison of modelled and measured values (Figure 3-8; Figure 3-9), these metrics allowed the skill of the model at replicating measured conditions to be objectively quantified. At a high level, measured and modelled streamflow statistics such as mean, median, P5 (5th percentile) and P95 (95th percentile), compare very favourably for the calibration period at BJ 3.10 (Table 3-3). Similarly, the RMSE metric indicates close correspondence between modelled and measured conditions.

The Nash Sutcliffe Efficiency Coefficient (NSE) is commonly used to assess the predictive power of hydrological models. An NSE value of 1.0 means that a perfect match has been made between the modelled output and the measured data, whereas a value of 0 indicates that the predictions are only as accurate as the mean of the measured data (Moriasi *et al.* 2007). Furthermore, NSE values that exceed 0.70 are viewed by Moriasi and coauthors as being a very good calibration. The NSE tends to overemphasize the errors in peak flows more than low flows because it is based on the square root of the deviations between measured and modelled values. To account for this, a logarithmic transformation is run on the modelled and measured values prior to calculating the NSE, which results in more weight being placed on the low flows.

Table 3-3:
Summary of Model Performance for the Calibration Period (2015-2021), BJ 3.10

Performance Measure	BJ 3.10_Measured	BJ 3.10_Weir.GoldSim	Comment
Mean (m^3/s)	0.417	0.403	Values compare within 5%
Median (m^3/s)	0.211	0.234	
P5 (m^3/s)	0.054	0.056	
P95 (m^3/s)	1.243	1.195	
RMSE	0.195		---
NSE	0.79		Very good[1]
log NSE	0.86		Very good[1]
RSR	0.46		Very good[1]

[1]Qualitative descriptions based on the performance classifications presented in Moriasi *et al*. (2007) - Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations.

With respect to the modeling effort undertaken for Brucejack Mine, the calibration period shows NSE and log-NSE values are 0.78 and 0.89, respectively, at BJ 3.10 (Table 3-3). Further afield, NSE (0.75) and log-NSE (0.81) values were slightly lower at BJ 1.74, but still very satisfactory. As a final check on model performance at BJ 3.10, the RMSE-

observations standard deviation ratio (RSR) was also computed. RSR is calculated as the ratio of the RMSE and the standard deviation of measured data. The computed RSR for the calibration period (*i.e.*, 0.46) was also indicative of very strong match between measured data and modelled results. In summary, a watershed model has been developed for application within the Brucejack Creek watershed, and the robust calibration results provide confidence that sub-area runoff models within the larger model domain, are based on a strong foundation of measurement and modelling.

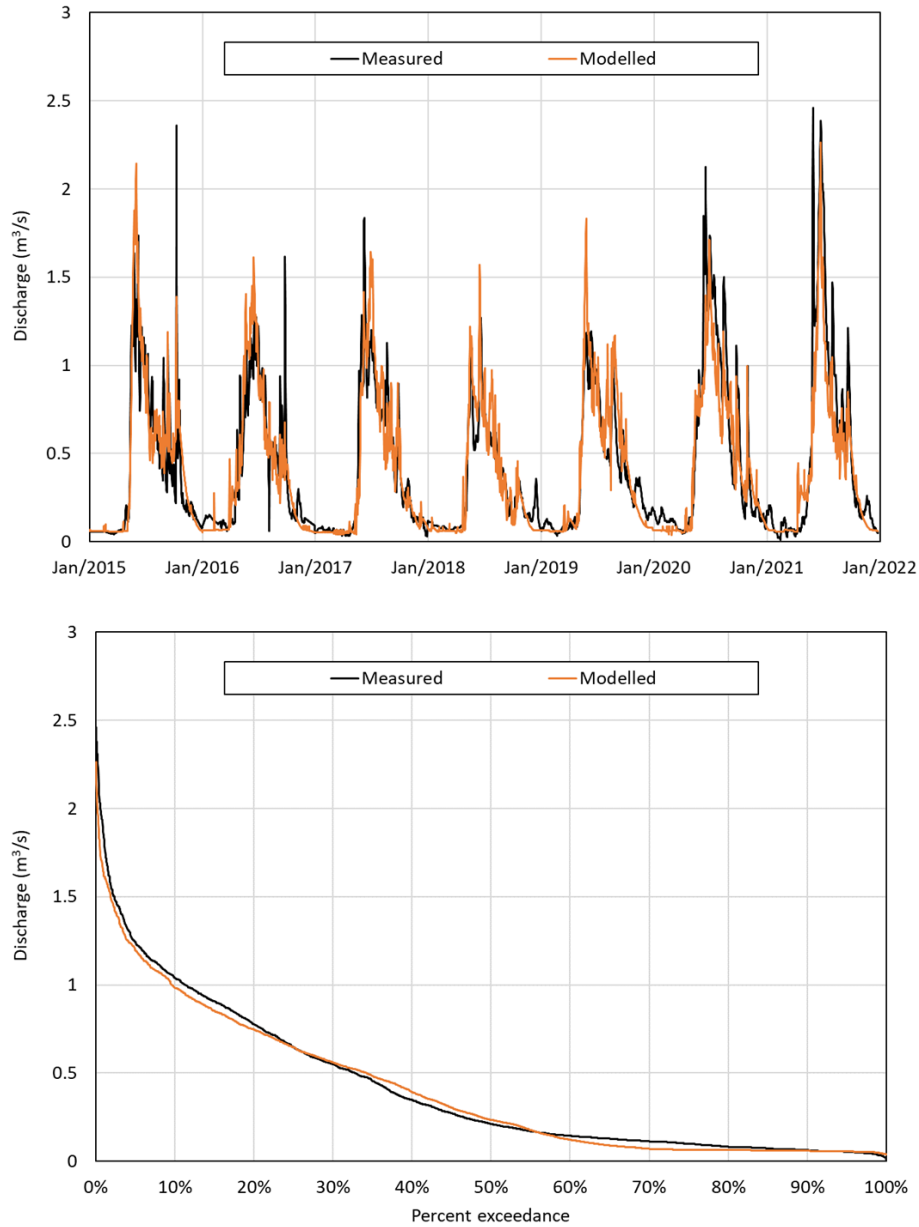


Figure 3-8: Comparison of measured versus modelled streamflow at BJ 3.10 for the calibration period of 2015-2021 as time series (upper panel) and flow duration curve (lower panel) plots.

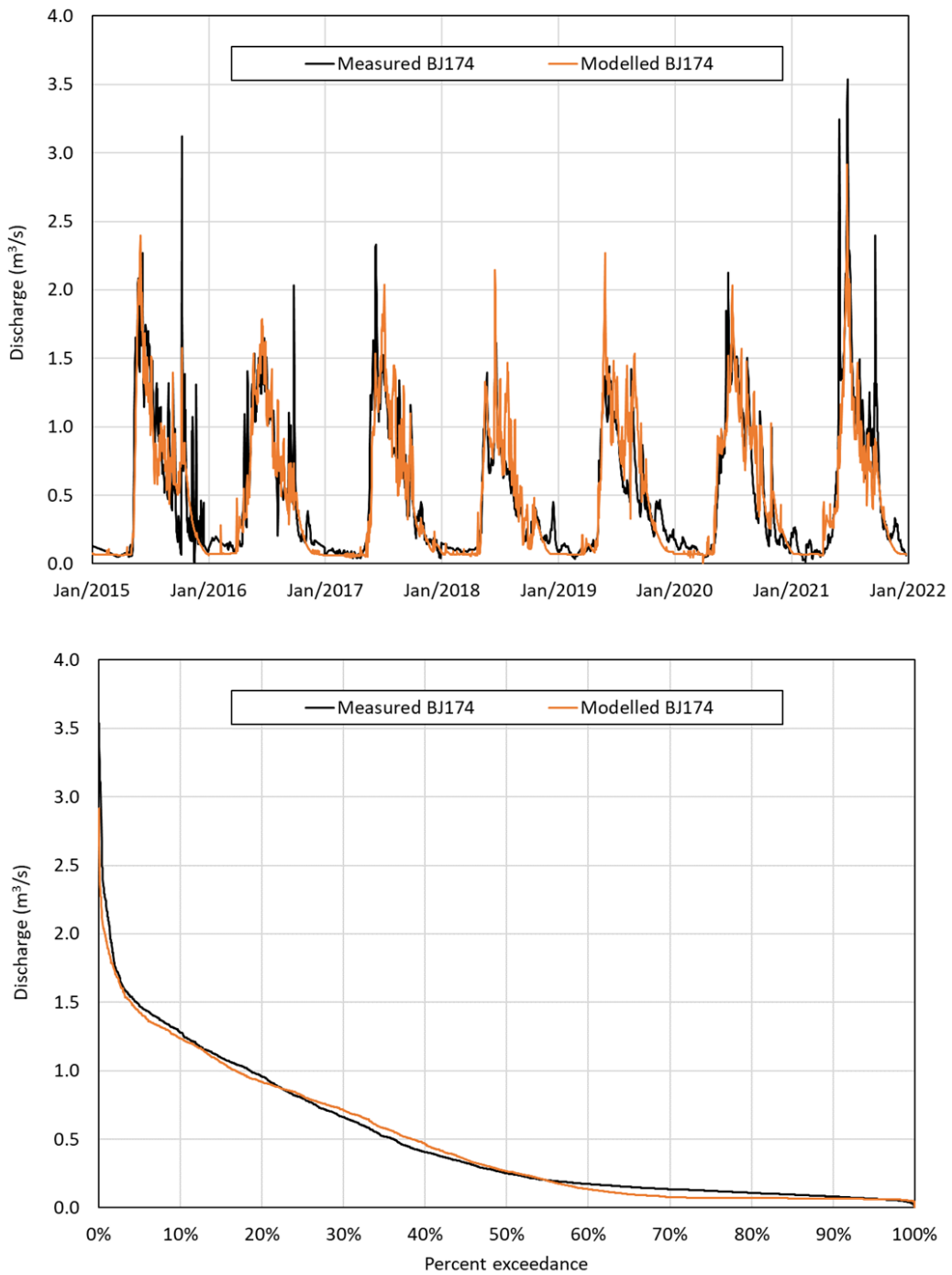


Figure 3-9: Comparison of measured versus modelled streamflow at BJ 1.74 for the calibration period of 2015-2021 as time series (upper panel) and flow duration curve (lower panel) plots.

3.4 Underground Mine Sub-model

3.4.1 Overview

The water balance of the Underground Mine is depicted in Figure 3-10. Main concepts/components shown on the figure include:

- The pumping of freshwater from surface to the 'waterbox', which is situated in the underground mine. The waterbox reservoir is situated in the lower right-hand corner of Figure 3-10. Stored water within the waterbox is used to support drilling and dust suppression activities, as required.
- Pictured immediately above the waterbox reservoir (Figure 3-10) are Input and Function elements that handle calculations related to underground water use and the re-cycling of used water back to the Underground Mine Sump – which is positioned at the bottom left corner of the schematic.
- The accounting of any paste backfill, and any leakage from placed material, is handled by Input and Function elements (shown Figure 3-10, upper-middle of plot).
- In the upper left of Figure 3-10, time series elements and an expression handle the read-in of measured (pre-2022) and modelled GW (2022 and forward) inflows that report through the underground mine to the mine sump. Measured and modelled GW fluxes were shown previously in Section 2 (see Figure 2-10).
- Finally, a Stock element (reservoir) is used to represent the UG_Mine_Sump. Within this element is functionality to control which inputs report to the sump, and how material is exported from the system.

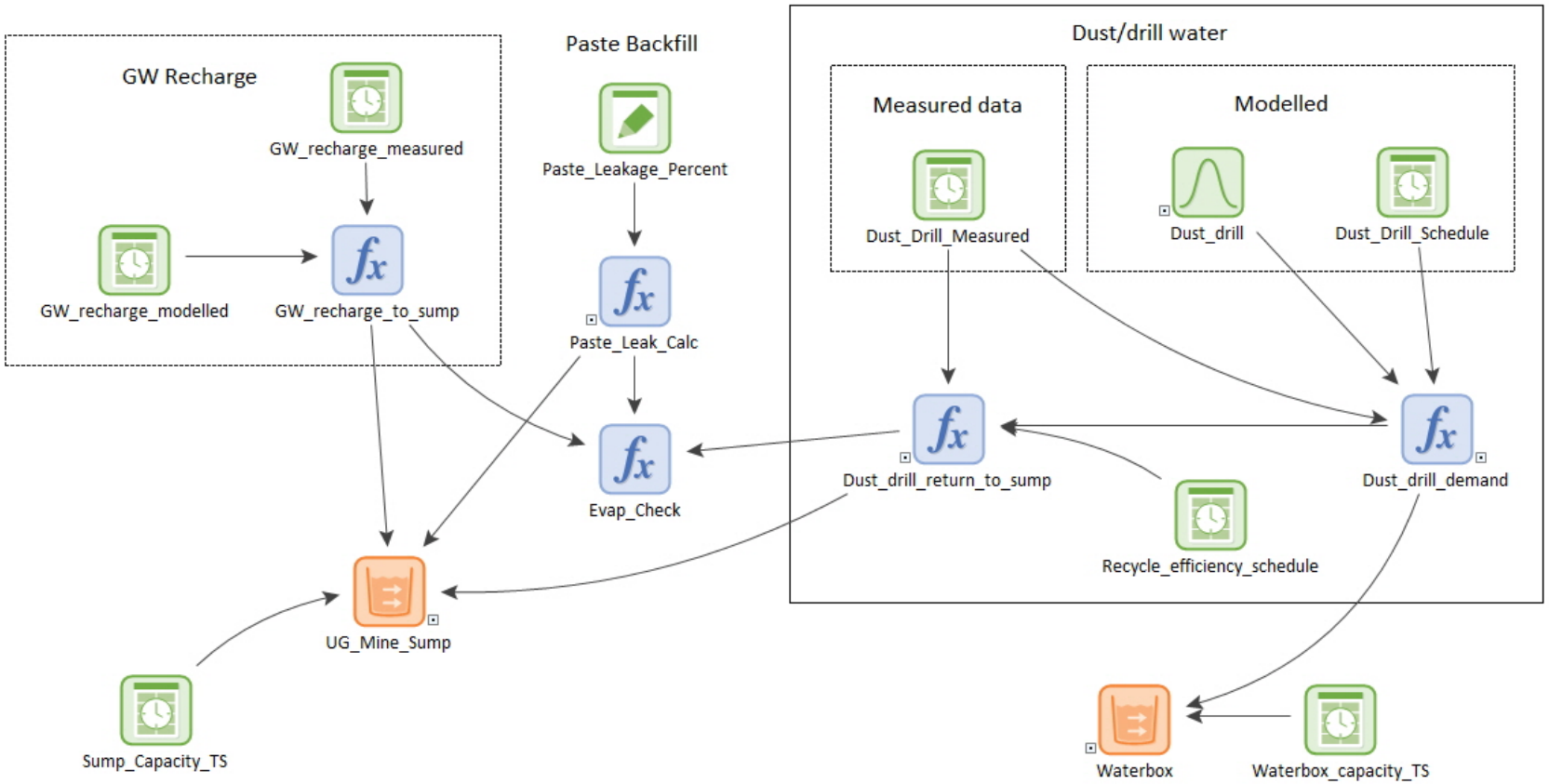


Figure 3-10: GoldSim wire diagram depicting the water balance of the Underground Mine.

3.4.2 Model Inputs and Assumptions, Underground Mine

Below is a list of assumptions relevant to the Underground Mine Sub-model:

- For the pre-2022 time period, measured data that represent flow from the freshwater tank, to the underground waterbox, are read into the WBM model (Figure 3-11).
- Flows to the waterbox are represented in the model using a stochastic Input element, which produces a daily varying flux that closely mimics patterns evident in the measured record.
    - In the 2020 WBM (Lorax, 2020), below ground water used for dust suppression and drilling was assumed to increase linearly to maximum values of approximately 50 m^3/hr and were then held constant for the period of Operations.
    - However, following inspection of measured records for below ground water use (Figure 2-12, upper panel), the 2022 WBM update allows below ground water use to increase linearly to values on the order of 80 m^3/hr by 2025, remaining constant thereafter.
- While the assumed rate of below ground use was increased in the 2022 WBM, it is important to note that most of this water is assumed to recycle back to mine sumps with a 95% efficiency.
- As a Base Case, the WBM assumes paste backfill is 60% solids by mass, with water comprising the residual mass.
- The WBM assumes that 2.5% of the paste backfill water content, seeps or leaks, and reports to the main sump. Note that this same assumption was applied in previous versions of the WBM (BGC, 2017c).
- Measured GW inflow (pre-2022), modelled GW inflow, dust suppression/drill waters and paste leakage are assumed to report to the Main Sump. When the Main Sump is full, and to prevent overflow, all excess water is pumped to surface and directed to the clarifier and WTP.

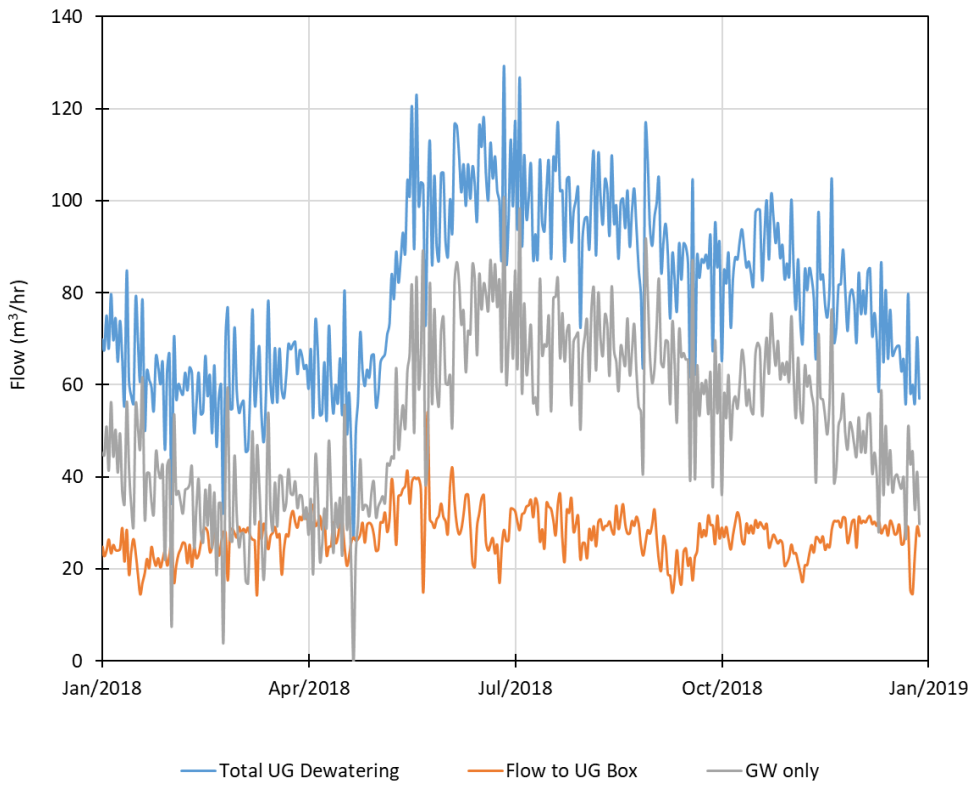


Figure 3-11: Measured data for a representative year showing dominant flows of the Underground Mine water balance, including total flow to sump, groundwater recharge to sump and flows to the 'waterbox' which are used to support drilling and dust suppression activities in the mine.

3.4.2.1 Closure and Post-Closure

Pretium (2023) describes the rehabilitation activities associated with closure of the underground mine, including removal of pumping, electrical and ventilation systems and reclamation activities at portals. As part of the rehabilitation measures, five plugs will be placed in the underground mine – two situated in the WZ and three in the VOK Zone. Further details supporting the rationale and location of plugs is provided in Lorax (2023a).

Closure water balance modelling in this study considers two scenarios: Passive Fill Scenario and Accelerated Fill Scenario. Relevant WBM considerations and assumptions are outlined below for these two scenarios.

Passive Fill Scenario

- Following cessation of ore processing, the mine will be allowed to fill passively.
- For this scenario, the WBM assumes no pumping of water from the FWT to the waterbox, after mining ceases in December 2029. Similarly, the model assumes that pumping of sump waters from depth in the mine, to surface, ceases as well.

- The mine void is estimated to be 1.54 Mm^3 and the Passive Fill scenario ends when the mine pool is fully developed, maximum water elevation is reached, and seepage flowpaths from the underground mine to the receiving environment establish.

Accelerated Fill Scenario

- Following cessation of ore processing, pumping of the mine sump will stop and groundwater recharge will begin to fill the mine void.
- To shorten the fill time, the Accelerated Fill scenario assumes permitted reclaim of 70 m^3/hr is directed to the underground mine. This diversion of reclaim water is consistent with Pretium's existing water use licence and equates to roughly 50,000 m^3/mon of surface water, which in addition to groundwater recharge, shortens the fill duration under this scenario.
- Diversion of reclaim water specific to this scenario is proposed to begin Jan 2030 and occur for four months, until the end of April. Consistent with Operations phase water management, the proposed point of diversion for reclaim allowances is Brucejack Creek at monitoring location BJ 3.10.
- The Accelerated Fill scenario also assumes that up to 20% of the natural flow of Brucejack Creek at BJ 3.10 is diverted to the underground mine over the course of May, June, July and August 2030.
    - The diversion is proposed as a 'percentage of natural flow' in order to minimize any alteration to the flow regime of Brucejack Creek and any effects on aquatic biota.
    - Streamflow monitoring data for BJ 3.10 indicates the proposed diversion equates, on average, to a volume of 1.66 Mm^3.
- Under this scenario, a continued re-circulation of water between the mine pool and WTP, is proposed, with treated effluent from the WTP directed back to the underground mine (Figure 3-12). Maximum rate of treatment at the WTP is 10,000 m^3/day (or 417 m^3/hr), which expressed as a monthly volume is approximately 300,000 m^3. This means that several 'treatments' of the mine pool volume are possible over the course of the Accelerated Fill scenario.

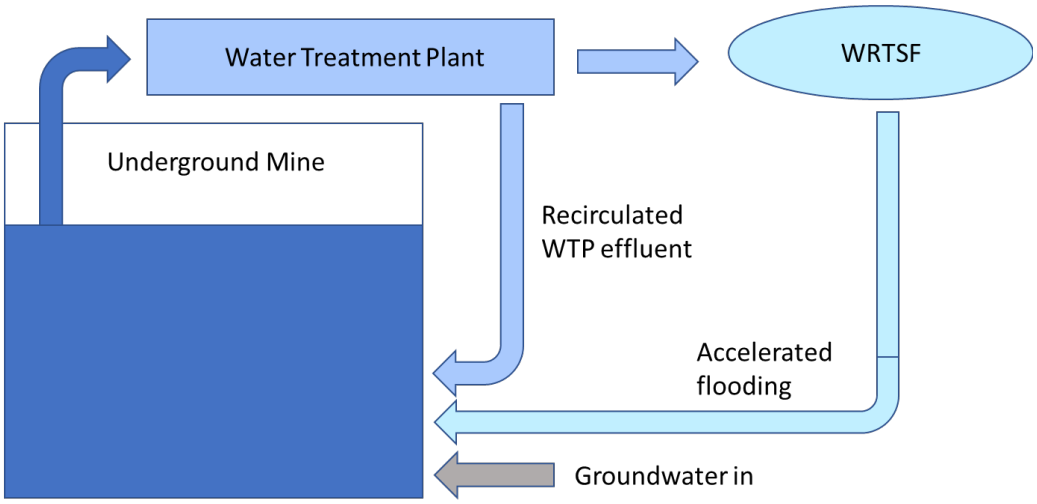


Figure 3-12: Conceptual illustration of an Accelerated Fill scenario with circulation between the underground mine and WTP.

3.5 Surface Water Management System

The surface water management system for the mine site includes two non-contact water diversion channels, a contact water collection system (CWCS) and the contact water pond (CWP). The surface water management system is described further in the sections below, while highlighting relevant WBM model inputs and assumptions related to it.

3.5.1 Non-Contact Water Diversions

Diversion channels at the mine site divert surface runoff around surface infrastructure and temporary waste rock storage areas (Figure 3-13). Diverted water discharges either to the WRTSF via the Johnson Creek (East) Diversion Channel or downstream to Brucejack Creek below the WRTSF via the Camp Creek (West) Diversion Channel.

3.5.2 Contact Water Collection System

Contact water at the mine site is defined as water contacting PAG rock exposed through mining or related rock excavation activities. Three main sources of contact water are relevant at the mine site:

- Contact water resulting from placement of waste rock in the WRTSF.
- Groundwater seepage within the underground mine contacting exposed surfaces then reporting to sumps. These waters are pumped to surface and directed to the WTP.
- Surface waters produced following contact with PAG bedrock exposures at the mine site (*e.g.*, pads associated with the mill and lower camp).

LEGEND

- VOK Climate Station and Snow Course
- Water Quality Monitoring Station
- Potable Water Well
- WTP/STP Effluent Line
- Reclaim Water Line
- Tailings Discharge Lines
- CWP Direct Discharge Line
- Non-Contact Water Channel
- Contact Water Collection
- Untreated/Off-Spec Water
- Contact Water Pond
- Brucejack Creek
- WRTSF
- Contours (50m)

DATE SAVED:	Feb 28, 2023
DRAWN BY:	DM
REVIEWED:	CF
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:4,000

0 75 150 Meters

CLIENT: NEWCREST BRUCEJACK

LORAX ENVIRONMENTAL

TITLE: **4950 tpd Joint Application**

PROJECT: Mine Site General Arrangement

PROJECT #: A624-4

FIGURE: 3-13

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022 WQ Infrastructure\General Mine Arrangement_F3-13.mxd

With respect to surface contact water, a network of interception ditches, pipelines, sumps, collection areas and pumps, are in place at the mine site to manage these flows (Figure 3-13).

3.5.3 Flow Measurements for the CWCS

Using a modified mass balance equation (*i.e.*, CWCS = ΔCWP Storage + CWP Outflow – WTP Inflows), the CWP monitoring dataset was used to back-calculate CWCS flow rates and runoff volumes, at daily frequency. An estimated flow series for the CWCS, spanning the period July 2017 to December 2021, is shown in Figure 3-14. For comparison purposes, the CWCS flow series is expressed as a runoff depth, in units mm, which allows for efficient comparison to measured runoff depths at BJ 3.10. Noting that runoff data for the entirety of 2017-2021 are shown in the plot for BJ 3.10, several observations are apparent from a data comparison of runoff depths at CWCS and BJ 3.10:

- The two flow records show strong similarities in terms of the onset of freshet runoff conditions in May. Runoff response to summer storms and rainfall events is also apparent in both flow records.
- The two flow records share a pattern of low, and generally constant, runoff depth through winter. However, a notable difference in Figure 3-14 is that CWCS runoff depths are lower in magnitude than measured depths at BJ 3.10 through the winter.
- A second major difference is these runoff data indicate total freshet runoff at the CWCS is much lower that at BJ 3.10. This is not surprising as the bulk of the freshet hydrograph is attributed to melting of snow and efforts are made at the mine site each winter to remove snow from roads, pads and roofs of buildings, such that access is efficient and safety requirements are met. Furthermore, the larger WRTSF watershed includes snowmelt contributions over a wider range of elevations that are assumed to sustain higher runoff depths at the outlet during freshet.

These observations are relevant to Section 3.5.2 below which is where inputs and assumptions relevant to the set-up of the CWCS sub-model, are discussed.

A GoldSim container is shown in Figure 3-3 for the CWCS. Within the container, a three-reservoir runoff model is used to compute contact water collection system runoff. Surface runoff captured by the CWCS is directed to the Contact Water Pond (CWP), where volumes of water may be stored for later use or directed to treatment (WTP) for discharge to the WRTSF. Discussed later in Section 3.6, the CWP and WTP elements of the GoldSim WBM are located within the CWP_WTP_mill container (Figure 3-3).

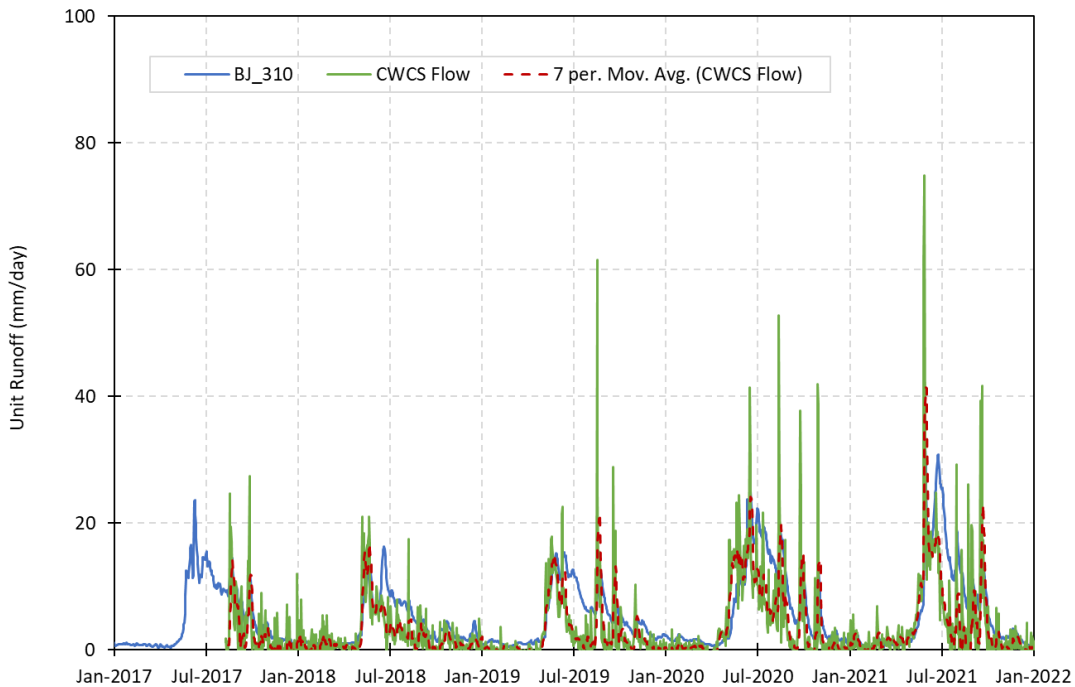


Figure 3-14: Time series data showing CWCS flow to the CWP, August 2017 to December 2021.

3.5.4 Summary of Inputs and Assumptions for the Contact Water Collection System

To achieve a reasonable visual calibration of the CWCS runoff model, the following steps and assumptions are applied in the WBM:

- A three-reservoir model was populated with the calibration coefficients and input values indicated in Table 3-4.
- An area of 20 ha is assigned in the model to convert CWCS runoff depths to an equivalent flow rate (Table 3-4).
- Within the rainfall/snowfall scheme of the CWCS runoff model, a data scalar was added to reduce snowpack within the CWCS to 60% of the expected value. This assumption is much like the value used previously by BGC whereby snowpack was reduced 50% for their CWCS runoff model (BGC, 2017c).
- As per BGC (2017c), only a portion of the total runoff generated by the footprint of the CWCS is assumed to report to the CWP. Previously, BGC assumed 75% of the runoff generated by the CWCS reports to the CWP (*i.e.*, 25% of the runoff reports passively to either the WRTSF or Brucejack Creek below BJ 3.10). However, to achieve a suitable runoff model calibration, it was necessary to refine this assumption and assume 60% of total CWCS runoff reports to the CWP.

- A mapping analysis was completed to apportion the 40% losses from the CWCS footprint to either the WRTSF or Brucejack Creek. A splitter element is used in the GoldSim model to direct the CWCS losses to the WRTSF or Brucejack Creek in proportions 0.6 and 0.4, respectively.
- At closure, the CWCS will be reclaimed and the current plan is for the CWP to remain, fill to the level of the current spillway, then discharge freely to the WRTSF. These activities are scheduled to occur in the summer and autumn of 2030. During the closure and post-closure phase, total runoff from the CWCS footprint is directed to the WRTSF and Brucejack Creek in proportions 0.6 and 0.4, respectively.

Table 3-4:
Summary of Birkenes Model Coefficients for CWCS

Metric	Value
Area (ha)	20
$A_{initial}$ (mm)	100
A_{min} (mm)	100
B_{max} (mm)	700
B_{min} (mm)	500
$B_{initial}$ (mm)	600
K_A (mm/mm/d)	0.09
K_B (mm/mm/d)	0.3
K_{BASE} (mm/mm/d)	0.3
K_e (mm/C/d)	0.2
M_{coeff1} (mm/C/d)[1]	4
M_{coeff2} (mm/C/d)[2]	6

[1]Melt coefficient for T < 5°C; [2]Melt coefficient for T < 15°C

3.5.5 Contact Water Pond

The CWP is situated adjacent the mill complex (Figure 3-13) and has been in service since 2017. Relevant technical details for the facility are summarized in design, construction and engineering reports prepared by BGC Engineering (refer to BGC, 2013; BGC, 2017a).

Maximum storage in the CWP is assumed in the WBM to be 50,000 m^3. Each autumn, additional water (up to 40,000 m^3) resides in the pond to minimize the likelihood of mill process water deficit by late winter (Pretium, 2020b). Stored water in the CWP is directed to the clarifier and WTP when required, where it is treated, then used for ore processing, which diminishes CWP supply, by March. In contrast, the CWP is managed at a low

volume (~15,000 m^3) during freshet and summer, such that adequate storage is available to accommodate flood flows. To maintain a constant volume within the CWP during freshet and summer, excess water in the CWP is directed to the WTP, and treated effluent may be used in the mill, or discharged to the WRTSF should mill requirements be fully met. The patterns of CWP stage/volume described above are clearly illustrated in monitoring data for the facility (Figure 3-15).

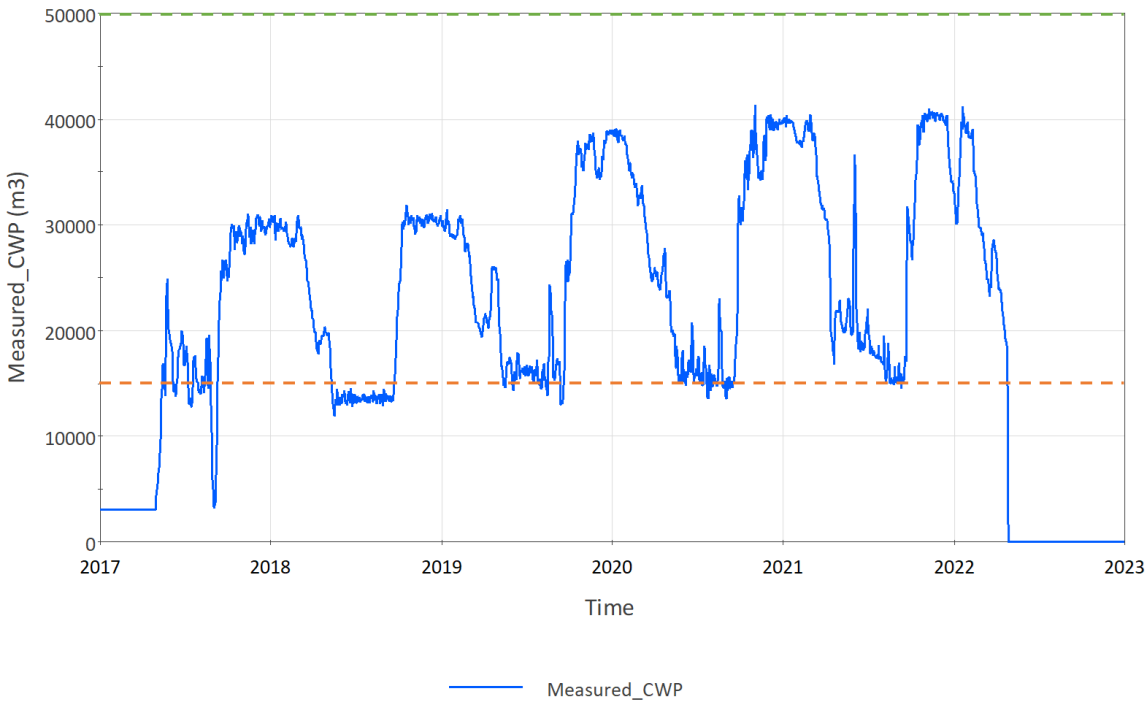


Figure 3-15: Time series showing CWP volume (blue) for the period 2017-2022. The dashed green line indicates the maximum operational storage capacity of the pond, whereas the dashed orange line indicates the volume above which generates leakage from the facility.

3.5.6 Leakage Losses from the CWP to WRTSF

A leakage study was completed by BGC in 2017 to quantify the magnitude of losses from the facility (BGC, 2017a). A principal finding from the study is that stage-dependent (*i.e.*, when CWP storage exceeds ~15,000 m^3) contact water may seep from the CWP toward the WRTSF. The study reports three potential rates of leakage, a low case, a high case and a geometric mean case, each case differing in predicted leakage by approximately an order of magnitude. The WBM is configured to account for leakage losses from the CWP at rates equivalent to geometric mean case predictions (Figure 3-16) which equates to seepage losses on the order of 1 m^3/day.

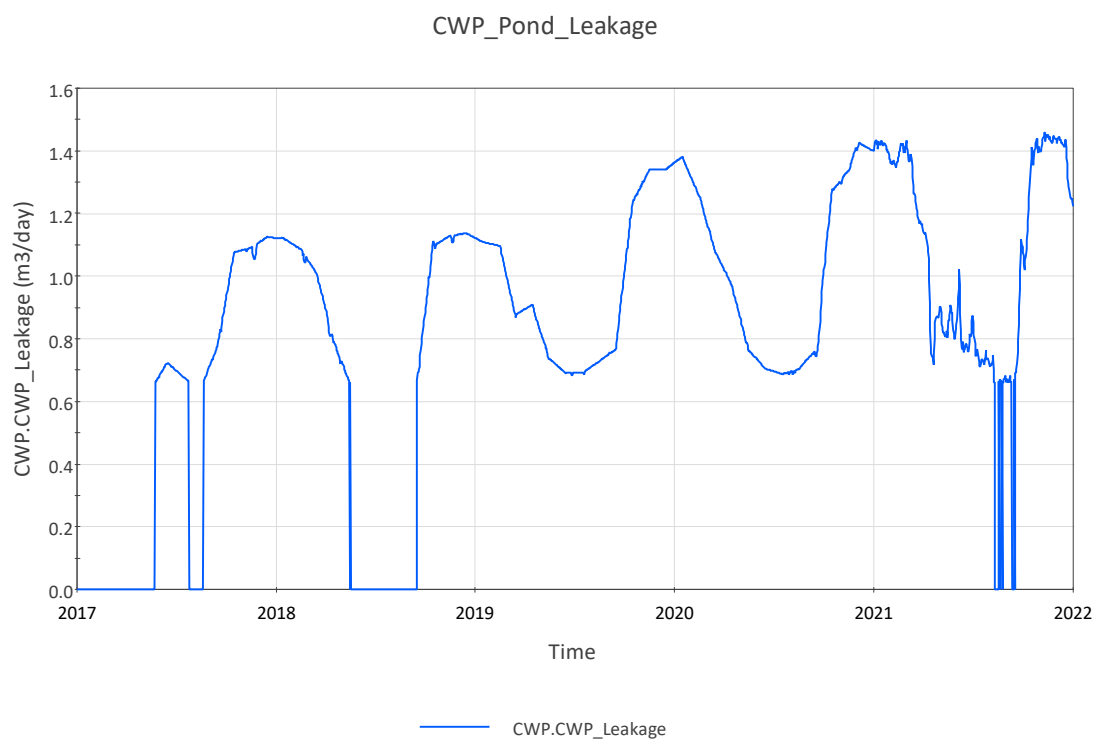


Figure 3-16: Example leakage loss estimates of the CWP for the geometric mean case.

3.6 CWP, WTP and Mill Water Balance

3.6.1 Overview

A GoldSim sub-model illustrating the water balance of the CWP, WTP and mill, is shown in Figure 3-17. The layout of the sub-model is defined by eight interconnected reservoirs. Reservoirs are included to represent the: CWP, clarifier, WTP, TWT, FWT, and the mill, the latter which is described using three pools (*i.e.*, Mill, Process_Return and Process_Water _Tank). A number of Input and Expression elements are used in conjunction with the identified pools to resolve the water balance for this important aspect of the site-wide WBM.

GoldSim functionality shown in the upper-left area of Figure 3-17 handles interactions between the CWP, clarifier, WTP and TWT. To elaborate, three sources of water (CWP, underground dewatering and process water return flow) report to the clarifier, with representative measured data shown in Figure 3-18. The clarifier removes solid particulates or suspended solids from influent. Clarifier outflow reports to the WTP, and from the WTP, treated effluent may be directed in the WBM to one of two places: 1) the FWT, which is a critical point of supply for the underground mine (waterbox) and the mill; or 2) toward the TWT. For treated effluent directed to the TWT, there is logic in the model to direct volumes

back to the CWP if volume is below capacity, or alternatively, to the WRTSF (Figure 3-19), if supply requirements are being fully met. Model logic for the CWP-WTP-TWT circuit is controlled by two 'Selectors' shown in Figure 3-17, as well as a look-up table. Note that Figure 3-17 also shows Input and Expression elements that are connected to the clarifier and WTP. These elements of the WBM handle calculations related to clarifier Underflow and WTP waste from the Actiflo (plus polishing) circuit.

Pictured middle-lower on Figure 3-17 is the mill circuit. Here, the mill 'pulls' water from the FWT to meet water demands for ore processing. Volumes within the FWT are maintained by WTP effluent and any reclaim water volumes which are drawn from the BJ 3.10 weir, noting that Pretium is currently permitted to withdraw water from the BJ 3.10 weir all months of the year at 70 m^3/hr. With respect to mill demand calculations (*i.e.*, for concentrate, tailings and paste backfill), these are computed in the containers shown at the right-hand side of Figure 3-17. The WBM is configured such that water supply entering the mill generally meets or exceeds true demand. In this regard, excess water reports to the process water tank (PWT). The majority of flow from the PWT is directed back to the mill, whereas a smaller flow is directed from the tank back to the clarifier-WTP.

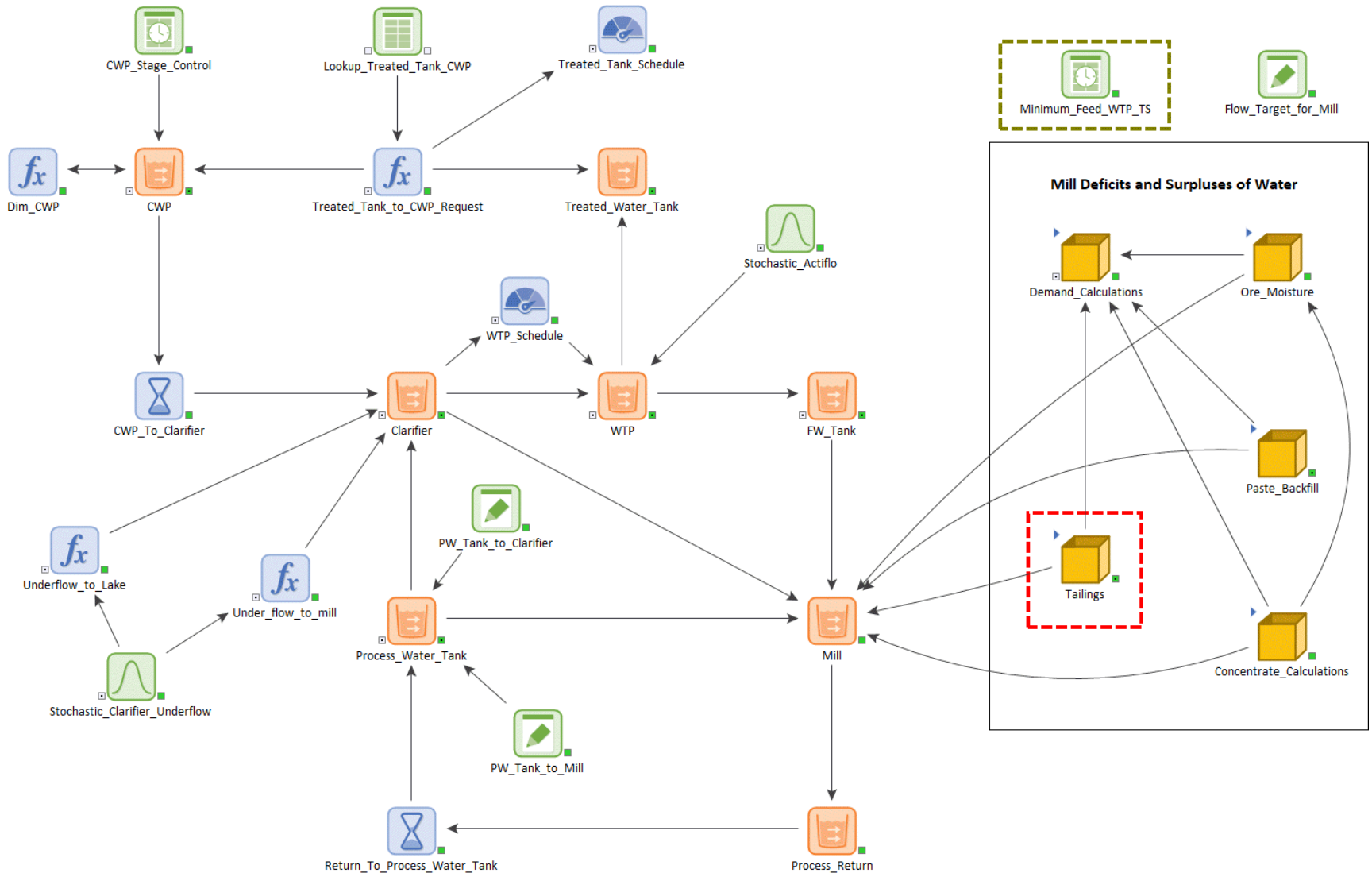


Figure 3-17: Overview schematic of the CWP-WTP-Mill sub-model

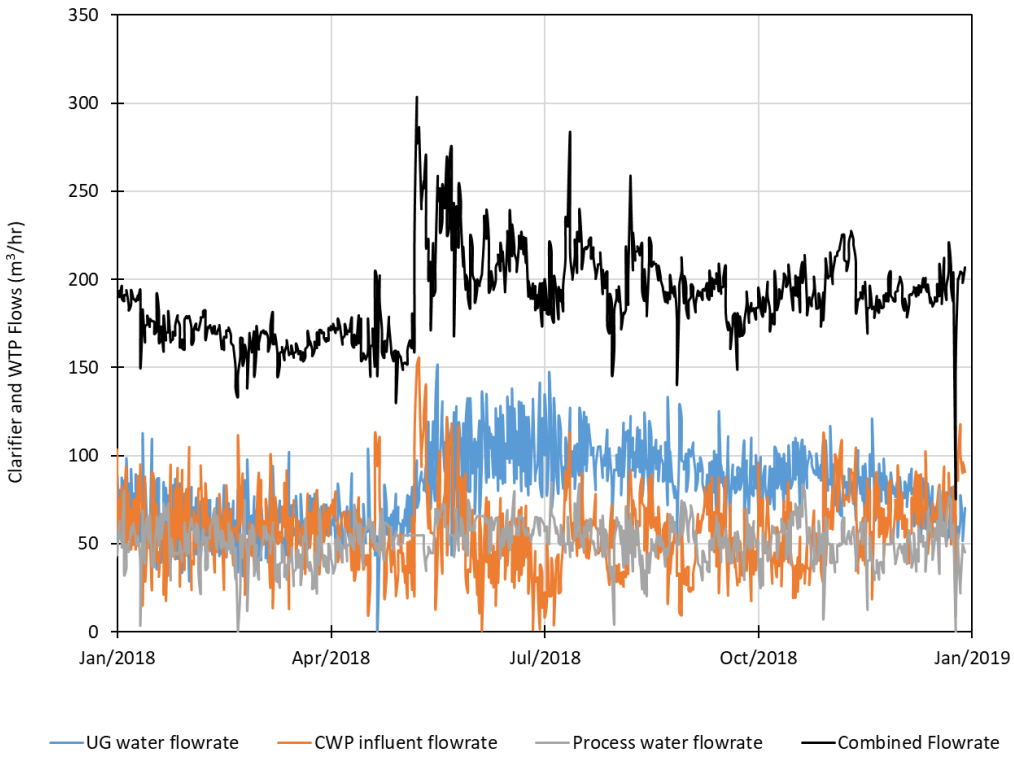


Figure 3-18: Time series showing representative measured data for the clarifier

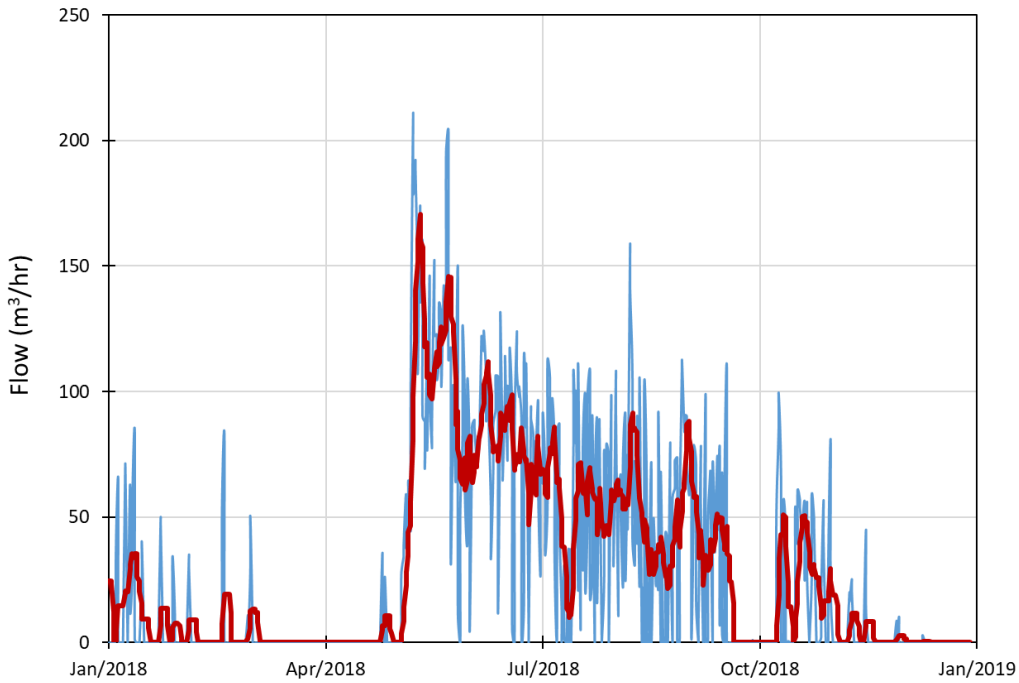


Figure 3-19: Representative time series showing discharge of treated effluent from the TWT to the Brucejack WRTSF. The blue line shows measured data, whereas a 7-day running mean of the measured data is shown in red

3.6.2 Inputs and Assumptions for the CWP-WTP-Mill Sub-model

The bullet points below summarize relevant water balance assumptions for the CWP-WTP-Mill sub-model:

- The CWP is assumed to be 50,000 m^3. For LOM years 2020-2029, the WBM assumes the CWP will be managed at low volume (~15,000 m^3) during spring, summer and autumn, and a much higher volume (up to 40,000 m^3) during the winter (*e.g.*, November through March).
- Any captured runoff from the CWCS is assumed to report to the CWP. Any stage-dependent leakage from the CWP is computed by the WBM for the geometric mean case.
- The clarifier pool is configured to receive daily inputs from three sources: any underground mine dewatering flow; CWP 'overflow', which are in essence pumped flows from the CWP; and PWT overflow.
- A stochastic Input element is used in GoldSim to compute clarifier underflow. Clarifier underflow is directed to the mill and set a mean value of 12 m^3/hr. The purpose of the stochastic Input element calculation is used to create GoldSim output for this term, an approach which aims to match the daily variability about the mean value of the measured record.
- The WBM assumes a target minimum WTP inflow rate of 180 m^3/hr, whereas the maximum allowable flow rate for the WTP is set at 417 m^3/hr.
- Actiflo waste volumes are computed using measured data that define a relationship between waste volumes and WTP inflow rate (Figure 3-20). Using these relationships and modelled WTP inflow rates as a predictor, associated waste volumes are computed in the WBM using a GoldSim Input element.
- The WBM assumes the TWT is 63 m^3. Should surplus water be reporting to the WTP, overflow (or bypass) can be directed toward this tank. From here, model logic is in place to direct WTP overflow to either the CWP, if volume exists in the pond, or the WRTSF.
- The WBM assumes the FWT is 667 m^3. The FWT is the water supply for the mine site fire suppression system; therefore, it is essential this tank is near capacity at all times. The WBM contains code to ensure the tank remains full, as a priority.

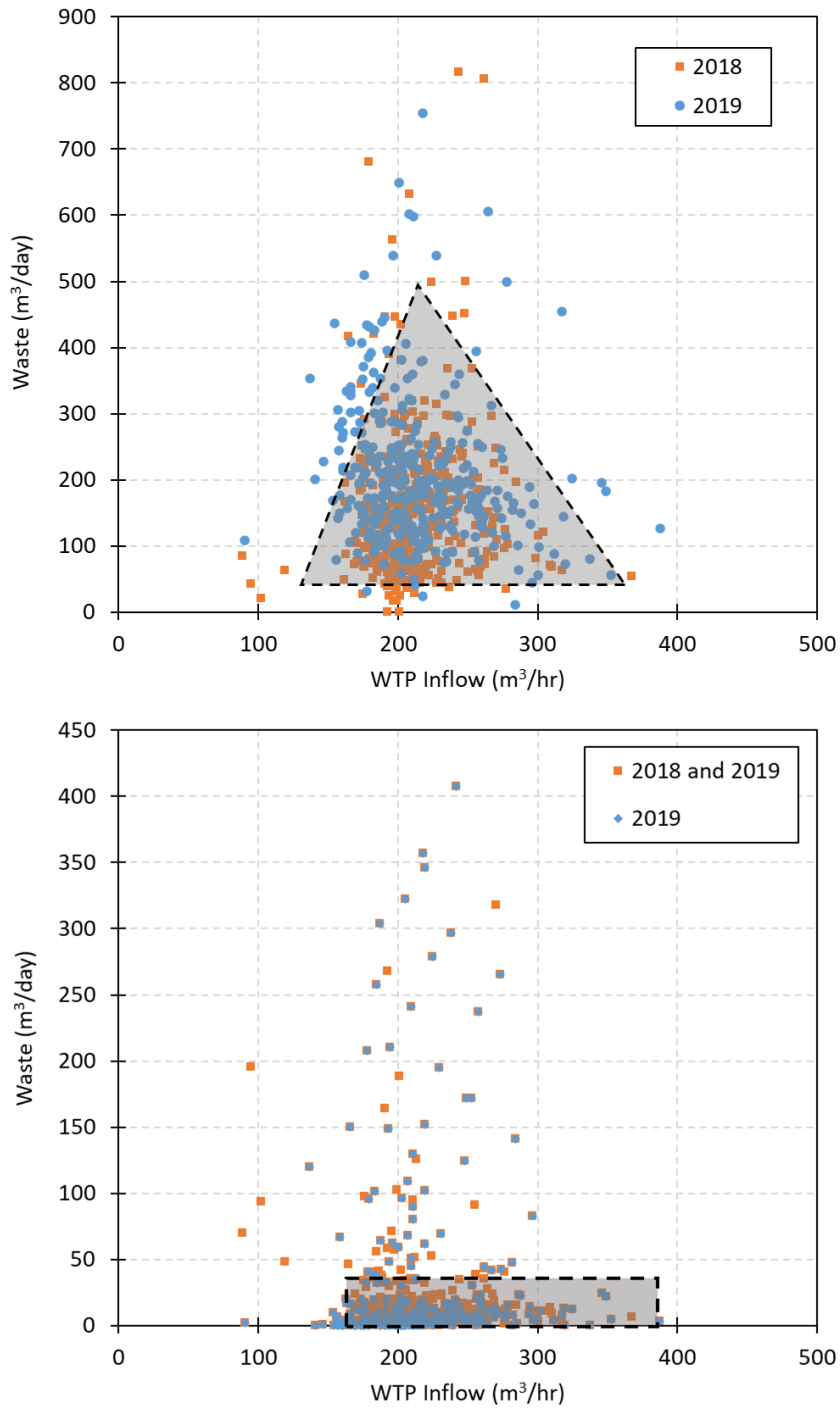


Figure 3-20: Measured waste and WTP inflow data for Brucejack Mine. Data in the upper panel illustrate the relationship between Actiflo waste and WTP inflow, whereas the lower plot shows the linkage between Actiflo polish waste and WTP inflow.

Note: The shaded areas above are intended to identify 'areas' that encompasses the bulk of the measured data. Stochastic input tools in GoldSim, using WTP inflow as a predictor, were used to estimate waste volumes predominantly falling within the boundaries of the shaded areas.

- The FWT receives effluent from the WTP, as well as any reclaim diversion volumes taken from BJ 3.10 weir. Pretium is permitted to divert from BJ 3.10 weir at a flow rate of 70 m^3/hr or a monthly volume of approximately 50,000 m^3. These flow rates are encoded into the WBM.
- As a general target, the WBM seeks to achieve balanced or constant flows on the order of 180-200 m^3/hr for the FWT. This equates to a maximum of 4,300 m^3/day, which experience shows is the upper limit for water demands at the mine site for ore processing at 3,800 tpd.
    - In 2022, the water balance model code was updated to allow additional flow to report to the FWT as demand for water increases for the 4950 tpd case.
- The PWT is assumed to have a volume of 352 m^3. Recycling of PWT volumes back to the mill is configured in the WBM at 330 m^3/hr. Furthermore, PWT pumping to the clarifier is set at 52 m^3/hr.
- Water balance model assumptions relevant to ore processing calculations are aligned with the approach of BGC (2017c) with details summarized in Table 3-5.

Table 3-5:
Ore Processing Assumptions – Brucejack WBM, Base Case

WBM Component	Base Case Assumption
Mill feed	As dictated by the 4950 tpd Joint Application Mine Plan, resolved monthly through 2029
Ore moisture	3% (by weight)
Tailings[1]	60% solids (by weight)
Paste backfill	60% solids (by weight)
Concentrate[2]	5.07% of mill feed at 93% solids (by weight)
U/G mine water supply[3]	Increase linearly with mill feed to a maximum of 80 m^3/hr
Flow target, Freshwater Tank	180-200 m^3/hr
Flow target, Process Water Tank to Mill	330 m^3/hr
Flow target, Process Water Tank to Clarifier	51 m^3/hr
Clarifier Underflow	12 m^3/hr
STP Effluent	90 m^3/day
WTP, Maximum treatment rate	417 m^3/hr or 10,000 m^3/day
Reclaim diversion, maximum rate	70 m^3/hr

1 A value of 55% solids (by weight) was assumed for 2017-2020.
2 An estimate of concentrate equating to 6.5% of mill feed at 93% solids (by weight) assumed for 2017-2021.
3 Informed by measured data for the period July 2017 to December 2021.

3.6.3 CWP-WTP-Mill Sub-model Calibration

Because there is robust operational monitoring data for the mine site, comparisons of measured data and modelled results were made for a 2018-2022 'calibration period'. The purpose of the evaluation was to ensure the model was replicating patterns and magnitudes of flow/volumes at key locations within the CWP-WTP-Mill sub-model. The focus of the calibration effort was on the following measured and modelled terms: CWP volume; any reclaim diversion from BJ 3.10 weir; the WTP pumping signature to the TWT; recycling of water from the TWT to the CWP; and finally, overflow from the TWT to the WRTSF.

Four figures are presented below in an effort to summarize the findings of the sub-model calibration (Figure 3-21, Figure 3-22, Figure 3-23 and Figure 3-24). For the period July 2017 to December 2021, Figure 3-21 illustrates the WBM provides a reliable replication of stored volumes within the CWP. Measured CWP volumes are shown in the figure by the blue line and modelled data are red, and results show model skill in handling CWP volume over several winter and ice-free periods. Measured reclaim (grey) and modelled reclaim (green) are also shown in Figure 3-21 to illustrate WBM handling of these diversions from BJ 3.10 weir to the FWT.

Measured and modelled data comparisons also provide the opportunity to confirm the model is handling WTP overflow correctly, and whether pumping of effluent to the TWT, and pumping from there to either the CWP or the WRTSF, is handled reliably in terms pattern/magnitude of flow rates. Key results are Figure 3-22 (WTP overflow to TWT), Figure 3-23 (TWT to CWP) and Figure 3-24 (TWT to WRTSF). Based on a visual inspection of these results it is concluded that the WBM model reliably represents water management related to the CWP, WTP and mill.

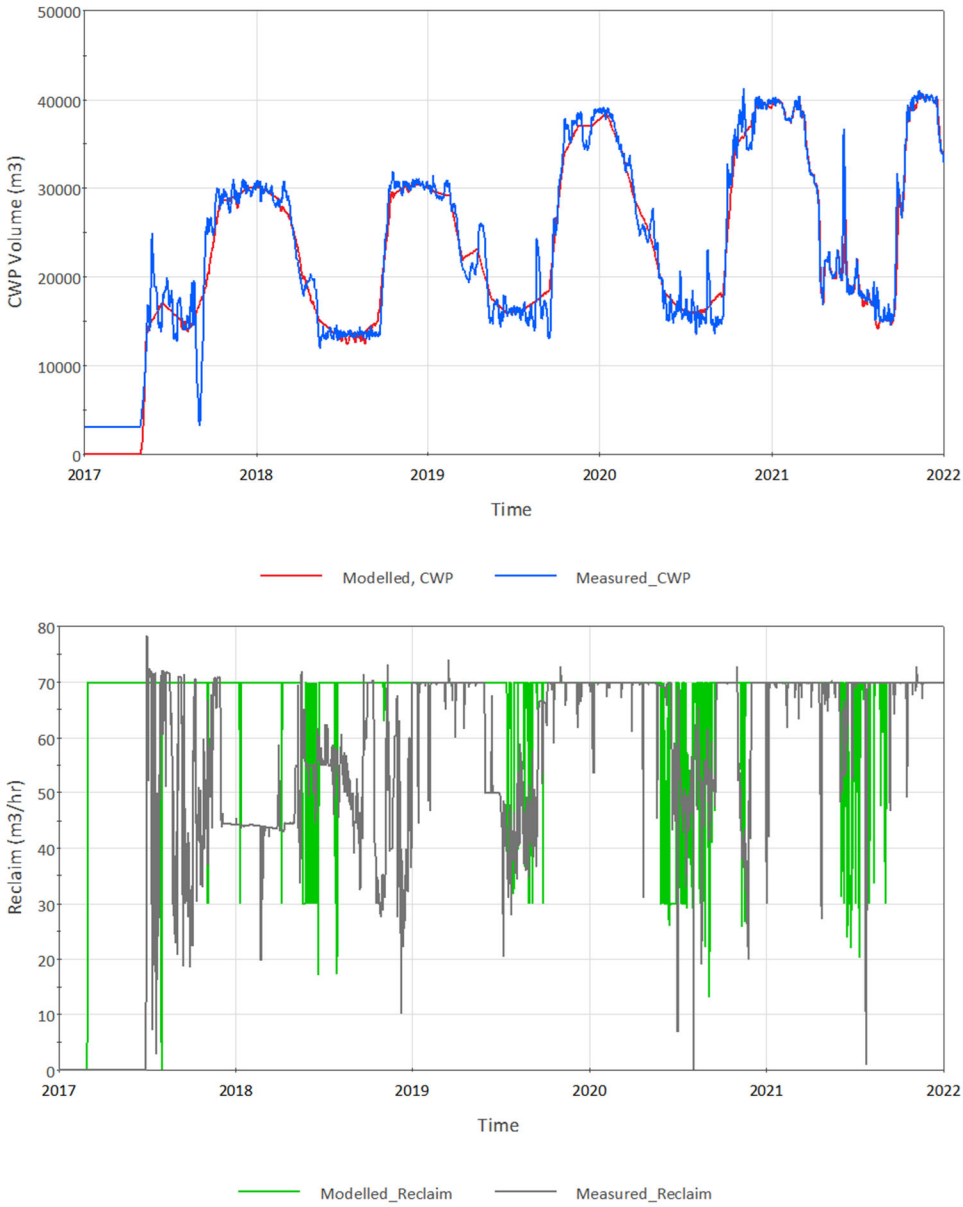


Figure 3-21: Comparison of measured and modelled volumes at CWP (upper panel) and measured and modelled reclaim flow rates (lower panel for the period 2017 through 2021.

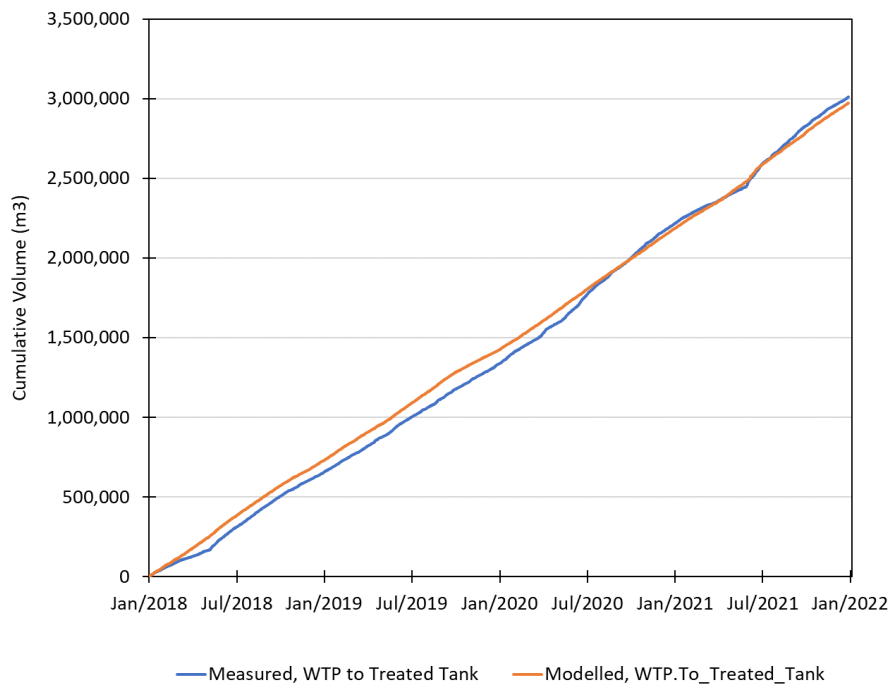


Figure 3-22: Comparison of measured and modelled flow series for WTP overflow directed to the TWT (2018-2021).

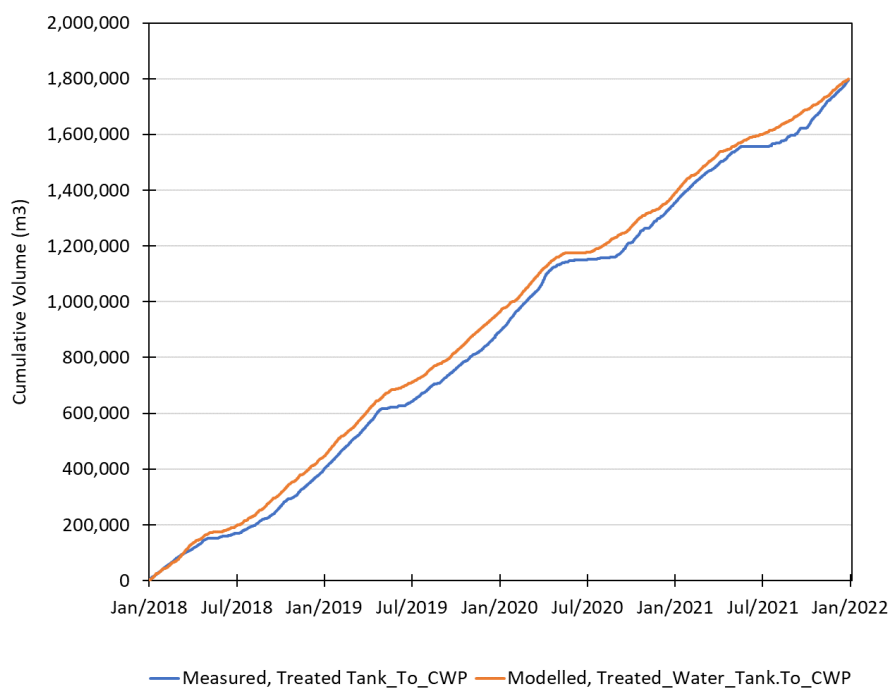


Figure 3-23: Comparison of measured and modelled flow series for TWT pumping to the CWP (2018-2021).

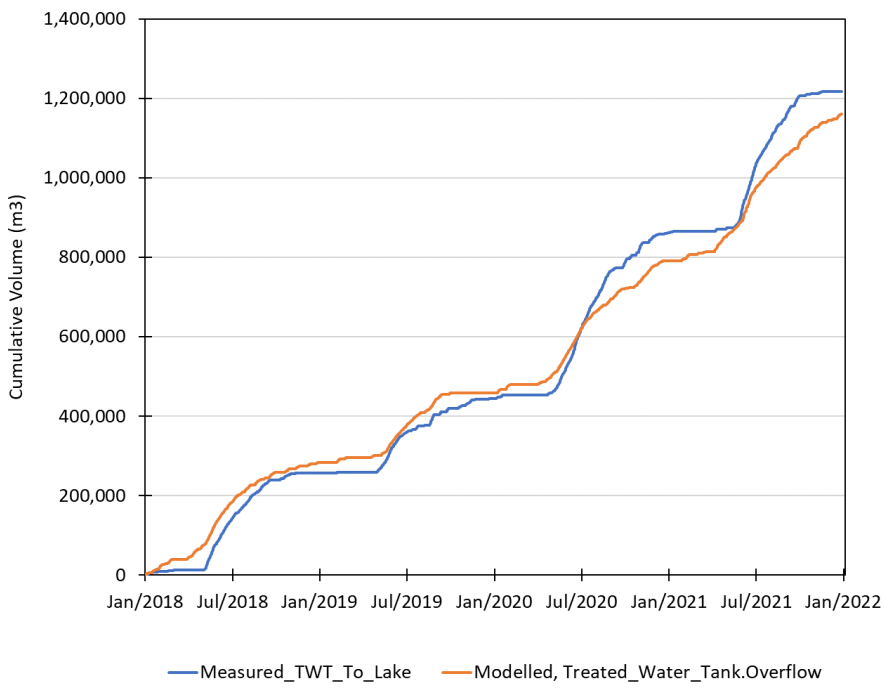


Figure 3-24: Comprison of measured and modelled flow series for TWT overflow to the WRTSF (2018-2021).

3.7 Sewage Treatment Plant

The WBM accounts for the discharge of effluent from the Brucejack Mine sewage treatment plant (STP) to the Brucejack WRTSF (Figure 3-3).

A schematic showing the Input and Function elements used to compute STP flows in the GoldSim WBM is provided (Figure 3-25, upper panel). An STP Schedule is encoded in the model, which serves to turn the STP on or off, based on user adjusted dates. The WBM reads in measured STP data for the pre-2022 simulation period. For the period January 2022 to early closure, the model derives flows that are reflective of recent monitoring data, which equates to an average of 90 m^3/day (Figure 3-25, lower panel). STP discharges are modelled forward using the stochastic Input element in GoldSim, which introduces variability about the mean value of 90 m^3/day and provides modelled output that matches recent observations very well.

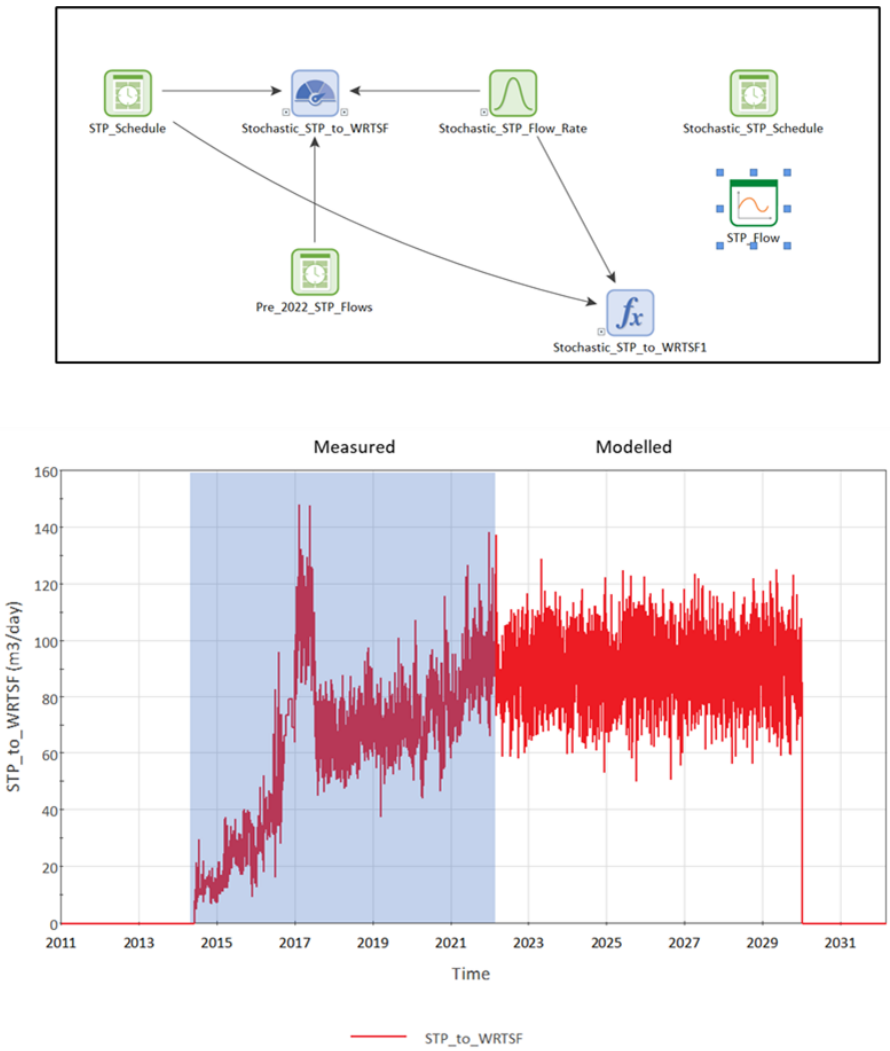


Figure 3-25: Schematic showing GoldSim wire diagram (upper panel) and results from the Sewage Treatment Plant (STP) container (lower panel).

3.8 Brucejack WRTSF

Figure 3-26 provides an overview of the WRTSF container. The WRTSF pool, situated centre-left in the schematic, is a critical model element in the diagram. The WRTSF is a principal point of discharge at the mine site, and accordingly, 11 main inflow terms and three outflow terms are controlled by this WBM element (Table 3-6).

Model inputs and assumptions for the Brucejack WRTSF are described further in the sections below.

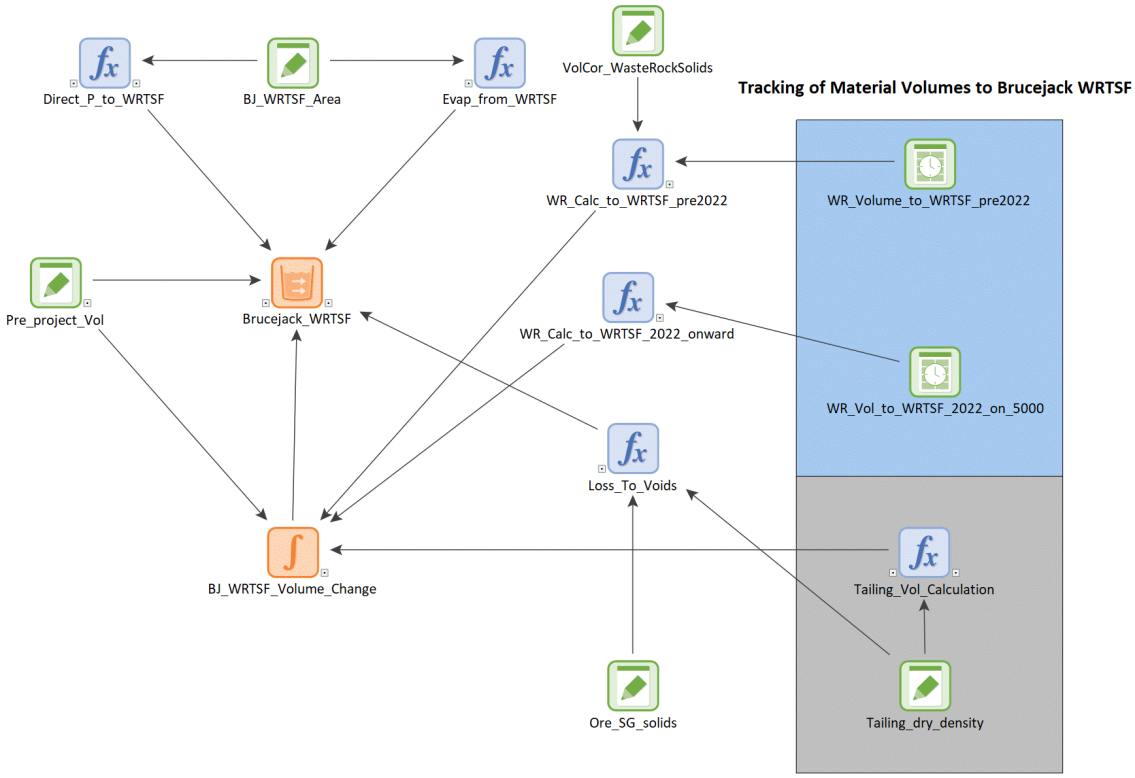


Figure 3-26: GoldSim schematic of the Brucejack WRTSF container.

3.8.1 Precipitation and Evaporation

At a daily time-step, precipitation and evaporation data from the Climate container are used to represent meteoric inputs that report to and from the WRTSF. Precipitation and evaporation depths are converted in the WBM to daily volumes and flow rates based on a scaling procedure using WRTSF area, which is assumed to be 70 ha (Table 3-1).

3.8.2 Placement of Waste Rock and Tailings in WRTSF

Tailings and waste rock placement in the WRTSF displaces water and reduces the volume of the storage facility. Further, pore spaces in the placed material consume WRTSF storage, as material settles to the bottom of the facility. Model code is in place to handle reductions in WRTSF volume owing to the placement of waste rock and tailings solids in the WRTSF. Calculations are handled in the GoldSim model using the assumptions and approach outlined in BGC (2017c).

Table 3-6:
Summary of Inflows and Outflow Terms for the Brucejack WRTSF

	ID	Term	Description
Inflows	1	Direct_P_to_TSF	This WBM term tracks rainfall and snowmelt flux to the WRTSF surface
	2	Final_Q_toTSF_Bgrd	This WBM term accounts for background runoff to the WRTSF
	3	Final_Q_Quarry	This term represents the runoff volumes for the NPAG quarry
	4	Final Q_WR_Pad	This model term tracks runoff volumes from the waste rock platform to the WRTSF
	5	Treated_Water_Tank.Overflow	The discharge of treated effluent from the TWT to the WRTSF are tracked through this term
	6	Tails_Water_to_TSF	This WBM term accounts for tailings slurry water to the WRTSF
	7	Stochastic STP_to_TSF	Any discharges from the STP are accounted for in the WRTSF by this model term.
	8	WTP_Actiflow_to TSF	This term tracks WTP Actiflo wastes that are directed to the WRTSF
	9 a,b	CWCS losses to TSF	CWCS losses to the WRTSF are tracked through two flow terms (*i.e.*, direct runoff, system losses)
	10	CWP.CWP_Leakage	Any stage-dependent leakage from the CWP reports to the WRTSF via this term.
Outflows	1	TSF_Evap	This term represents the evaporative flux from the WRTSF surface
	2	Loss_to_Voids	Loss of WRTSF water to tailings and waste rock voids are accounted for by this model term
	3	Brucejack_TSF.overflow	This WBM term tracks any WRTSF outlet overflow to Brucejack Creek

4. Water Balance Model Results

This section of the report presents an accounting of WBM conditions for the operations, closure, and post-closure phases of the Brucejack Mine. Prior to any technical discussion, Section 4.1 provides a high-level summary and discussion of the site-wide water balance for the mine site.

4.1 Overview

A site-wide water balance model was originally constructed for Brucejack Mine in Excel using a monthly time-step (BGC, 2017a,b). The water balance model was updated in 2020 for the 5 Year Plan (Lorax, 2020), and again in 2022, to support preparation of the 4950 tpd Joint Application. Since 2020, water balance updates for the mine site have been completed using GoldSim modeling software, the same software platform which is used to run the Brucejack Mine water quality model.

4.1.1 Operations (2022-2029)

Generalized flow schematics of the mine site water balance for operations and closure/post-closure are shown for reference in Figure 4-1 and Figure 4-2 respectively. During operations, main sources of water for ore processing at the Brucejack Mine include: 1) water that is recycled from the mill process; 2) water conveyed by contact water ditches and surface sumps and reports to the CWP; 3) water that reports to sumps of the underground mine and is pumped to surface; and 4) permitted water withdrawals that are sourced from Brucejack Creek adjacent the BJ 3.10 weir.

Water recycled from the mill process or withdrawn from CWP storage is first treated prior to being used in the mill. In concept, surplus treated water may be discharged to Brucejack WRTSF when mill water requirements are fully met or it is necessary to manage pond volumes at a certain level. Alternatively, surplus treated water may be managed back to the CWP should there be available storage in the pond. Operational water data collected between 2018 and present indicates that discharges of treated effluent to the WRTSF are necessary between May and October because the majority of annual runoff is realized during these months, and accordingly, water surpluses are encountered at the mine site in general.

Water that reports to the underground mine is captured in sumps and then pumped to surface (Figure 4-1). Like water sourced from the CWP, sump water is treated prior to being used in the mill or discharged to the WRTSF when freshwater supply exceeds mill water demand. A major component of underground sump water is groundwater recharge

that daylights in the mine due to dewatering activities. Groundwater inflows are seasonally variable, with values being lower in winter (*e.g.,* February, March), and notable that recharge rates to the mine are predicted to increase with time as the footprint below ground increases with the progression of mining (refer again to Figure 2-10). In addition to groundwater recharge, water from the FWT in the mill building is also directed below ground to support mining activities, such as drilling and dust suppression. Like groundwater recharge, the majority of this circulated water reports back to underground sumps and is pumped to surface for treatment, use in the mill, or release to the WRTSF.

Mill demands/surpluses and underground mine water requirements for the 2022-2029 period, which includes 4950 tpd throughput between 2025 and 2029, are summarized as follows:

- Concentrate: The model assumes approximately 5% of total production reports to an off-site facility as concentrate for secondary processing in a slurry of 93% solids by weight. The average concentrate demand is estimated by the model to be 0.7 m^3/hr (or 17 m^3/d) for the 2022-2029 period.
- Tailings to Brucejack WRTSF: For 2022–2029, the model assumes 2,656 tpd (approximately 60% of total tailings production), on average, will be deposited at depth in Brucejack WRTSF in a slurry of 60% solids by weight (~71 m^3/hr of slurry water).
- Paste Backfill: The model assumes 1,704 tpd will be deposited in the underground mine in a cemented backfill paste of 60% solids by weight (~47 m^3/hr of slurry water).
- Underground (mine supply) water: based on operational water monitoring data collected between 2017 and present, water demand within the underground mine has increased linearly over time to levels on the order of 50-60 m^3/hr in 2022. The WBM assumes below ground water use is approximately 80 m^3/hr after 4950 tpd production is reached in 2025.

In summary, for operations (2022-2029) the site-wide water balance model provides an accounting of project activities at the spatial scale of the mine site (*i.e.*, the tracking of flows between the FWT, the underground mine, the CWP, the WTP, the mill, and the WRTSF), and also tracks background and surface water flows from the headwaters of the Brucejack WRTSF watershed, downstream to the BJ 1.74 monitoring location, which is well downstream of the Brucejack WRTSF. In addition, the water balance model tracks volumes of water and mine waste that report to Brucejack WRTSF over the period of active mining. For example, the model accounts for the displacement of WRTSF volume resulting

from tailings and waste rock deposition and losses of WRTSF water to tailings voids upon placement in the WRTSF.

4.1.2 Closure Filling Scenarios and Post-closure

Several closure/filling scenarios are contemplated in the water balance model (*e.g.*, passive fill versus active with treatment) with detailed results for a Base Case and sensitivity scenarios presented in Section 4.5. For post-closure, the WBM fully accounts for any background/non-contact runoff generated within the BJ 3.10, BJ 2.62 and BJ 1.74 watersheds (Figure 4-2). The model assumes the mine site, including the mill, access roads and related laydowns/pads, are reclaimed, with any runoff from these footprints assumed to report passively to either Brucejack WRTSF or Brucejack Creek below the BJ 3.10 weir.

Post-closure seepage flow from the underground mine to Brucejack Creek is depicted on Figure 4-2. Contact water fluxes generated from the flooded mine are simulated to range seasonally between 10.4 L/s and 22.9 L/s, averaging 14.9 L/s annually. This is approximately 5 L/s higher than what was predicted by the 3,800 tpd model and is attributed to expansion of the mine extents as listed in the third bullet. Approximately 95% of contact water reports to Brucejack Creek above BJ-2.62, of which approximately 10% reports to the WRTSF. A further 4% of contact water reports to Brucejack Creek between BJ-2.62 and BJ-1.74. About 1% of contact water reports below BJ-1.74.

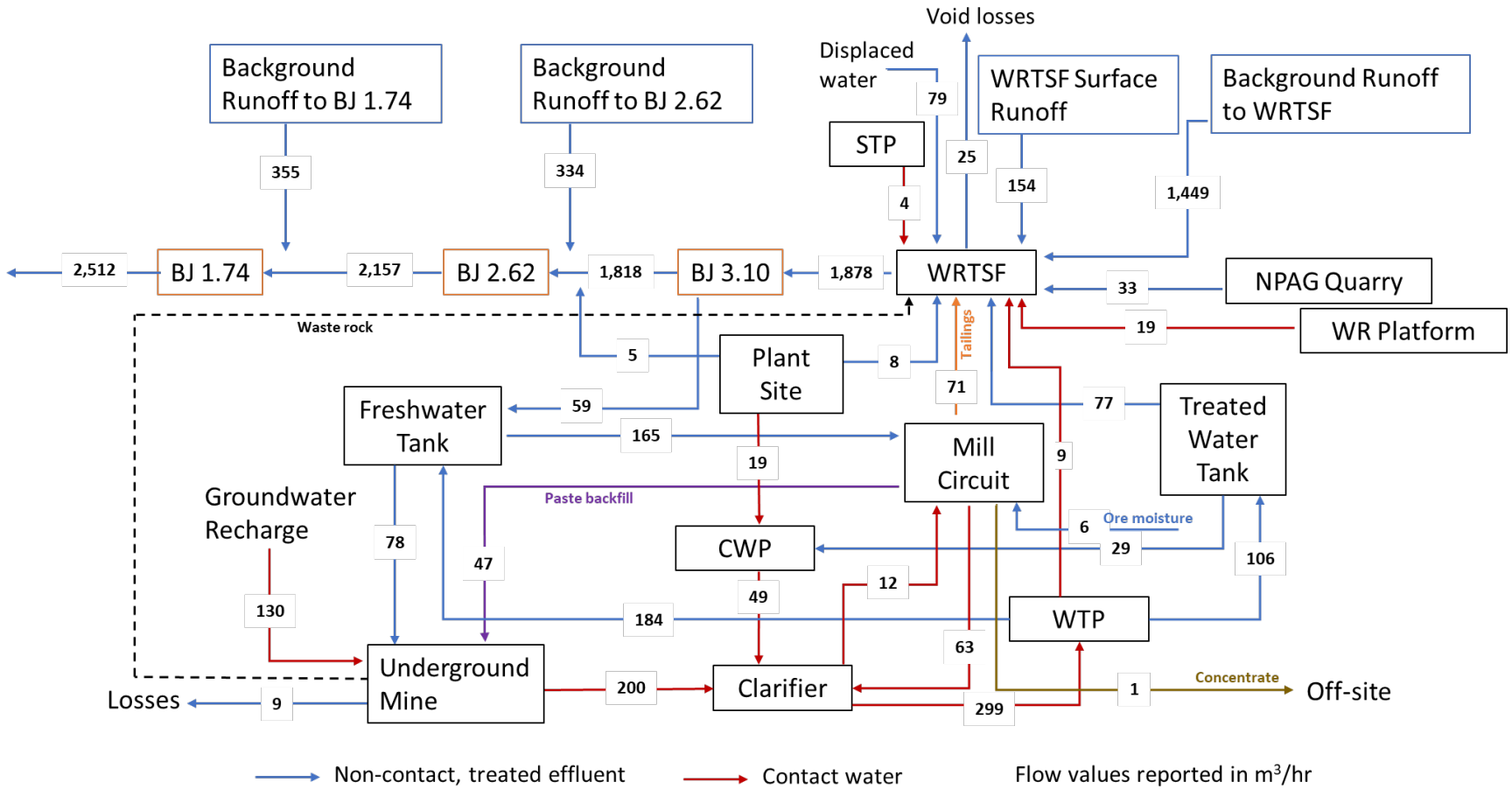


Figure 4-1: Water balance summary for LOM operations (2022-2029) – Base Case (Average Climate Conditions)

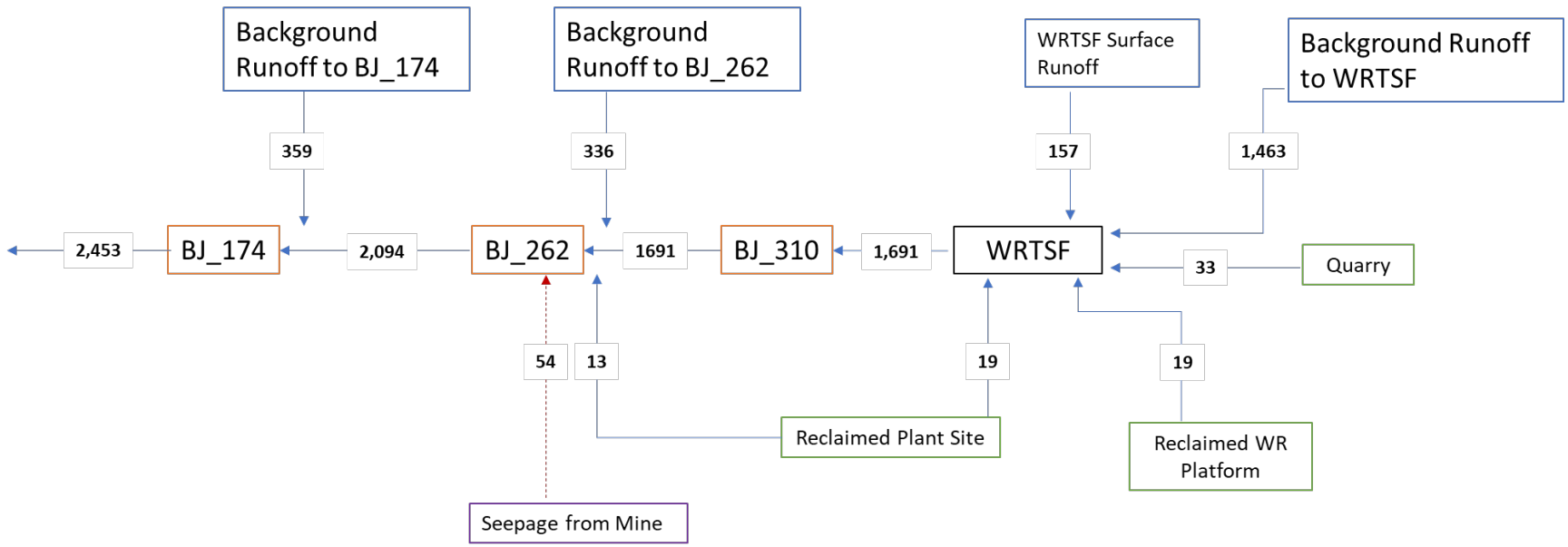


Figure 4-2: Water balance summary for closure and post-closure (2030-2050) – Base Case (Average Climate Conditions)

4.2 Operations (2022-2029)

4.2.1 Underground Mine

Representative output from the Underground Mine sub-model is shown in Figure 4-3. Dominant fluxes in the underground mine water balance are groundwater recharge fluxes and pumping flows (to surface) associated with the mine sump (Figure 4-3). In contrast, paste leakage flows are very minor and water balance flows associated with dust suppression and drilling in the underground are intermediate in magnitude.

It is noteworthy that pumped volumes to surface carry a seasonal signature (*i.e.*, sumps flows are lower in magnitude in winter months that for spring, summer and autumn periods). Operational experience from 2017-2021 indicates mine dewatering flows, along with diversions from reclaim and the CWP, are required to meet water demands at the FWT and mill, through the winter period. Measured data confirms the annual minima for GW inflow to the mine was in the range 20-35 m^3/hr for the 2017-2021 period. However, annual minima are predicted to increase to 80-100 m^3/hr by 2025, coinciding with 4950 tpd ore processing, and predicted to be higher still by end of mining in 2029 (*i.e.*, 110 m^3/hr). Owing to the increase over time, winter water scarcity is anticipated to lessen over LOM, assuming future winter minima show increases that are aligned with reported GW modelling results.

4.2.2 Contact Water Collection

Representative flows associated with the CWCS are shown in Figure 4-4. Recoverable contact runoff (red line) and CWCS losses (blue line) are shown as separate terms in the plot. Like mine dewatering flows, measured and modelled results for CWCS runoff results show strong seasonality. During freshet and following storm events, CWCS inflow rates to the CWP are estimated to range from 20-100 m^3/hr typically, although they may be much higher for short periods of time (*i.e.*, >140 m^3/hr) (Figure 4-4).

The CWP has a capacity of 50,000 m^3 and several days of runoff from the CWCS has the potential to change the volume of the facility quite readily. In contrast, CWCS inflow rates are very low (<1-2 m^3/hr) for extended periods of time in the winter. Thus, there is little, if any, potential for the CWCS to appreciably influence CWP volume under typical winter conditions.

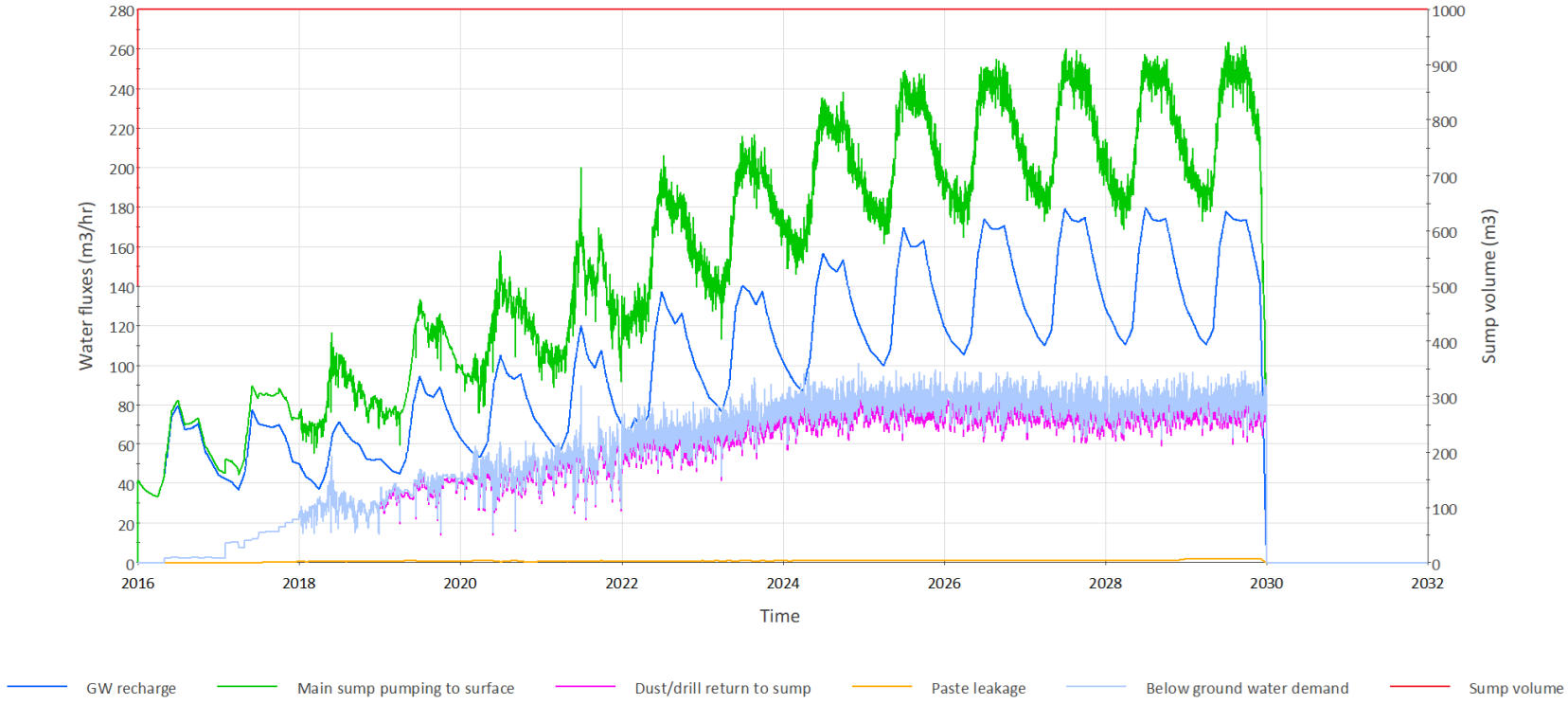


Figure 4-3: Water balance of the Underground Mine for LOM.

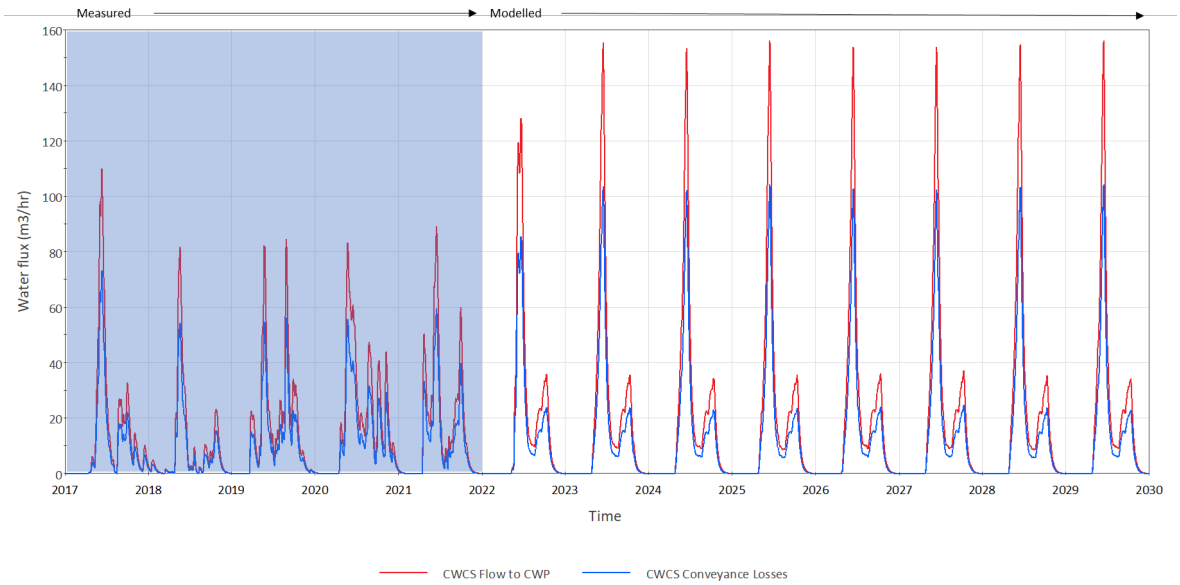


Figure 4-4: Time series showing contact water collection system flow estimates for LOM. Contact water flows that are directed to the CWP are demarcated by the red line, whereas the CWCS loss term is shown by the blue line.

4.2.3 Contact Water Pond

Representative water balance results specific to the CWP are shown in Figure 4-5 (CWP volume, CWP pumping to WTP) and Figure 4-6 (CWP leakage). The results illustrate that modelled volumes within the CWP mimic patterns and trends evident in water monitoring data collected at the facility since July 2017. As a general strategy, CWP volumes are managed to a constant volume/level (~15,000 m^3) over the course of spring, summer and autumn, but higher in the winter (*e.g.*, 38,000-40,000 m^3). Low volumes are maintained during the open water period, since there are requirements to store design flood flows within the pond, when they arise. Excess water is intentionally stored in the pond through autumn, then used over the course of the winter, when additional water volumes may be needed.

To maintain a low (15,000 m^3) and constant volume in the CWP, any excess water at the facility is pumped to the WTP. Since the CWCS produces much of its annual runoff at freshet and following summer rainfall events, higher rates of pumping are necessary to manage inflow from the CWCS during these periods. Any leakage losses from the CWP are relatively minor compared to other terms that comprise the site-wide water balance (Figure 4-6). Rates of leakage are estimated at 0.7 m^3/day during the open water (ice-free) period, when CWP volumes are lowest on an annual basis (*i.e.,* on the order of 15,000 m^3). Rates of leakage from the CWP are roughly double (1.4 m^3/day) when volumes in the facility are at their annual maxima, over the course of the winter.

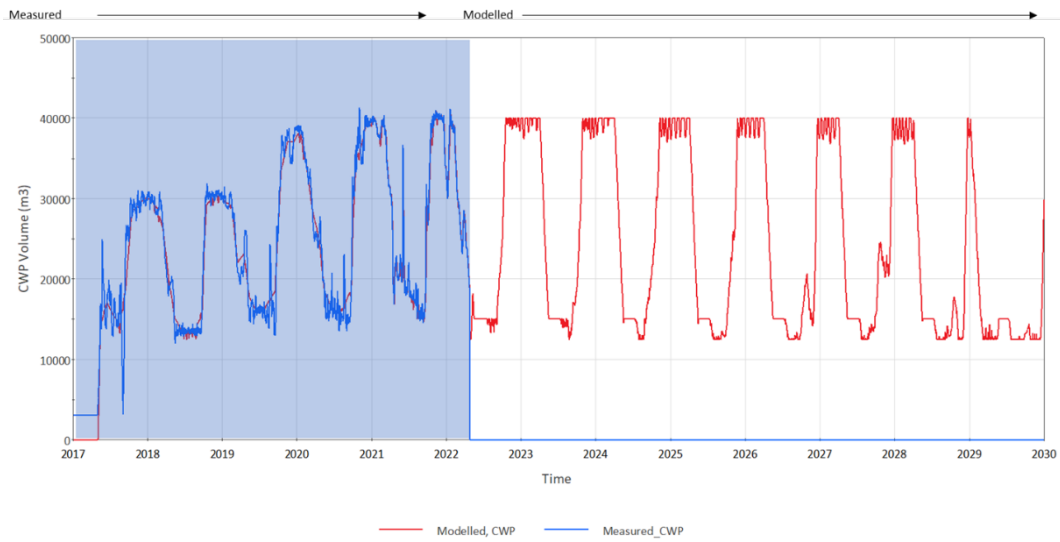


Figure 4-5: Results from the WBM showing CWP volume (measured and modelled) for LOM.

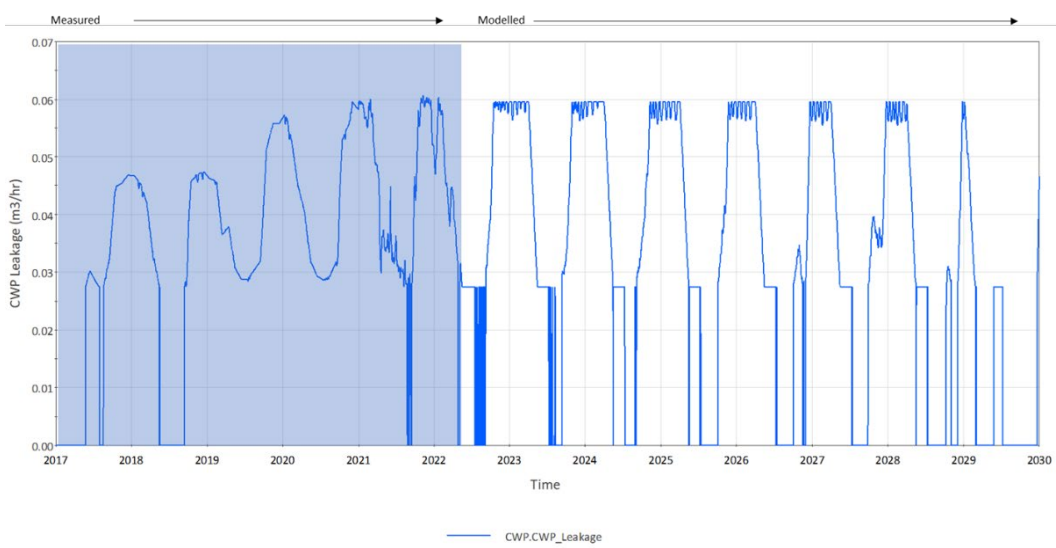


Figure 4-6: WBM estimates of CWP leakage for LOM.

A key finding of the study is that demand for water at the mill, does not result in the CWP being depleted for Base Case. To elaborate, the WBM is set up to 'draw' water into the mill from multiple sources, to meet mill water requirements. Sources of water for the mill include reclaim diversions from BJ 3.10 weir, pumping of below ground mine sump water to surface then directing it to the mill via the WTP, and drawing upon stored volumes in the CWP. WBM results can be audited to determine if instabilities occur at the mill in terms of water supply or whether the CWP was completely drained on account of water demand pressures. In summary, the Base Case model run returned stable and expected conditions

at the CWP – which is an early indicator that water demands at the mill may be met by the available supply and existing water management system for the 4950 tpd scenario.

4.2.4 Clarifier, WTP and Treated Water Tank

Representative model outputs are shown for the clarifier, WTP and TWT in Figure 4-7, Figure 4-8 and Figure 4-9. Data in Figure 4-7 confirm the main inputs to the clarifier, which are underground dewatering flows, pumped flows from the CWP and overflow from the PWT. Furthermore, the results confirm there is a seasonal signature at the clarifier, which is expected, since mine dewatering and CWCS runoff volumes show higher flows/volumes during freshet and open water months, compared to winter periods.

Clarifier overflow (Figure 4-7; red line) is directed to the WTP where effluent is partitioned to either the FWT or TWT (Figure 4-8). In this plot, WTP.Overflow (red line) designates flow directed to the FWT and WTP.Total_Outflow (blue line) represents pumping of treated water to the TWT. Representative inflow and outflow data for the TWT are shown in Figure 4-9 and demonstrate the accounting of water volumes to the tank (blue line), any pumping to the CWP (green line) and pumping of treated effluent to the Brucejack WRTSF (red line).

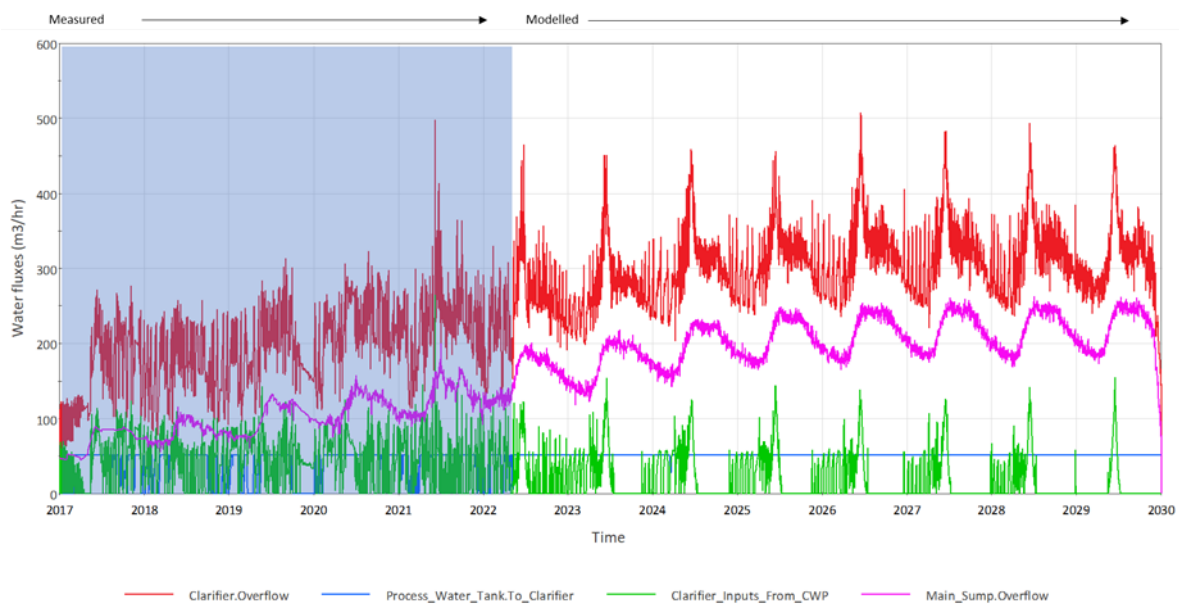


Figure 4-7: Summary of water balance results for the clarifier for LOM.

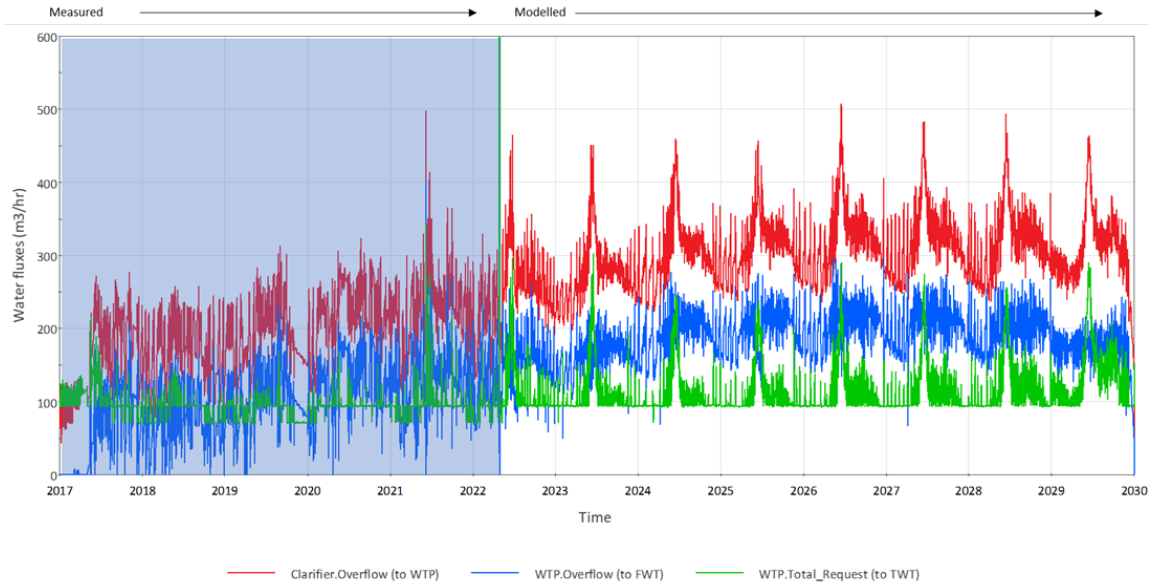


Figure 4-8: Summary of water balance results for the WTP for LOM.

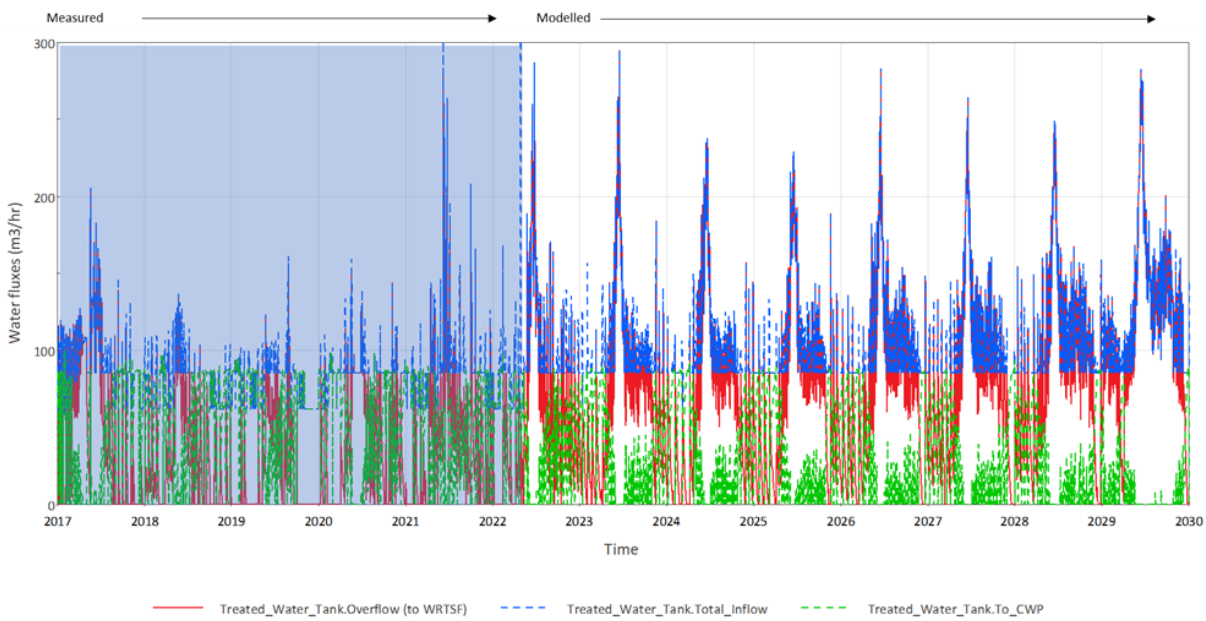


Figure 4-9: Summary of water balance results for the TWT for LOM.

4.2.5 Reclaim Diversion from BJ 3.10 Weir

Relevant results from the WBM are shown to illustrate the magnitude and pattern of reclaim diversion from BJ 3.10 (Figure 4-10). Overall, the time series for the period 2017-2029 confirms the general strategy to divert at a maximum rate in the winter and shoulder periods of autumn and spring, followed by diversion at a lesser rate (*e.g.*, 30-50 m^3/hr) during ice-free months when water surpluses are evident.

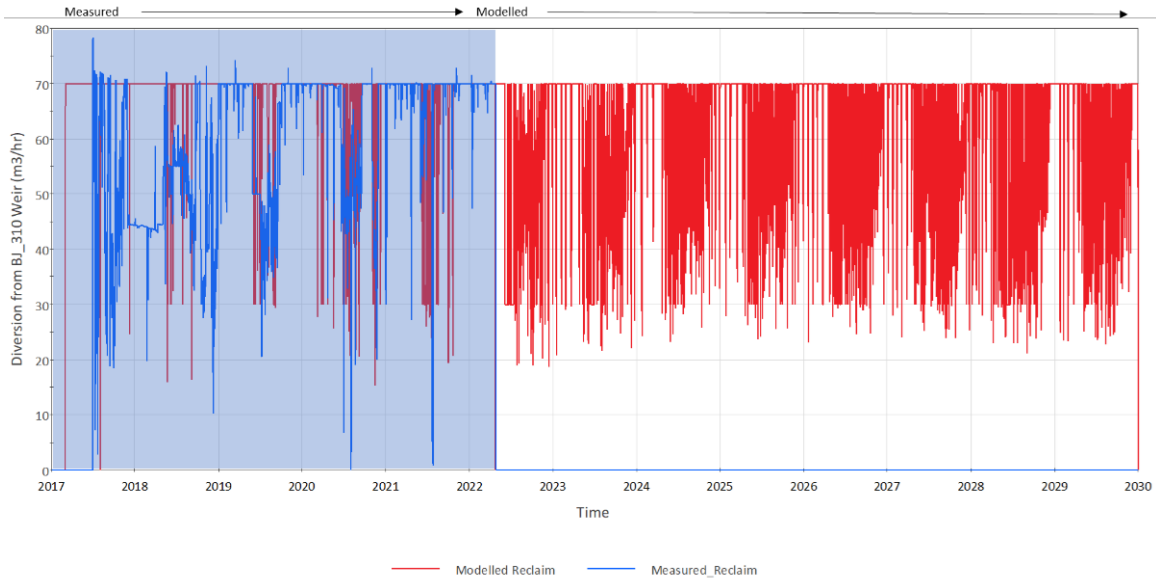


Figure 4-10: Total reclaim request from BJ 3.10 weir over LOM.

4.2.6 Freshwater Tank

This section presents water balance outputs for the FWT, the tank that provides supply to the mine site fire suppression system, the underground mine and the mill. Diversions from the FWT, to the underground mine are scheduled to support drilling and dust suppression activities. A supply of freshwater is required at the mill to process ore.

With respect to the requirement to maintain the tank near capacity (*e.g.*, 85% full or more), WBM results demonstrate this can be readily achieved for LOM under a 4950 tpd scenario (Figure 4-11). Inflow and outflow data are summarized for LOM for the FWT (Figure 4-12). Plotted data show total inflow to the tank (green line), pumping from the tank to the UG Mine (or waterbox, blue line) and tank overflow (pink line), which is the freshwater supply to the mill. Accordingly, a continuous supply of water is maintained at the FWT under Base Case, with mill supply being on the order of 150-220 m^3/hr over LOM.

Similar to discussion for the CWP (refer to Section 4.4.3), a key finding of the study is that demand for water at the mill does not result in depletion, or flow irregularities, at the FWT under Base Case (Table 3-5). In summary, the Base Case model run returned stable and expected conditions at the FWT – which is an indicator that mine site water demands are being met by the available supply and model assumptions which describe the Brucejack Mine water management system.

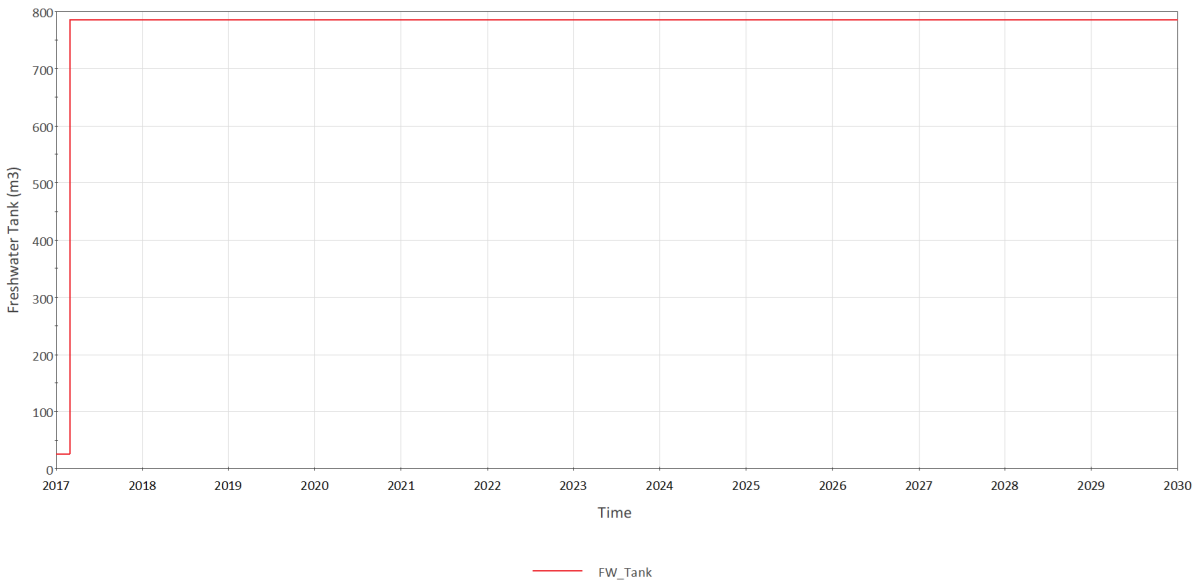


Figure 4-11: Time series showing FW Tank volume over LOM.

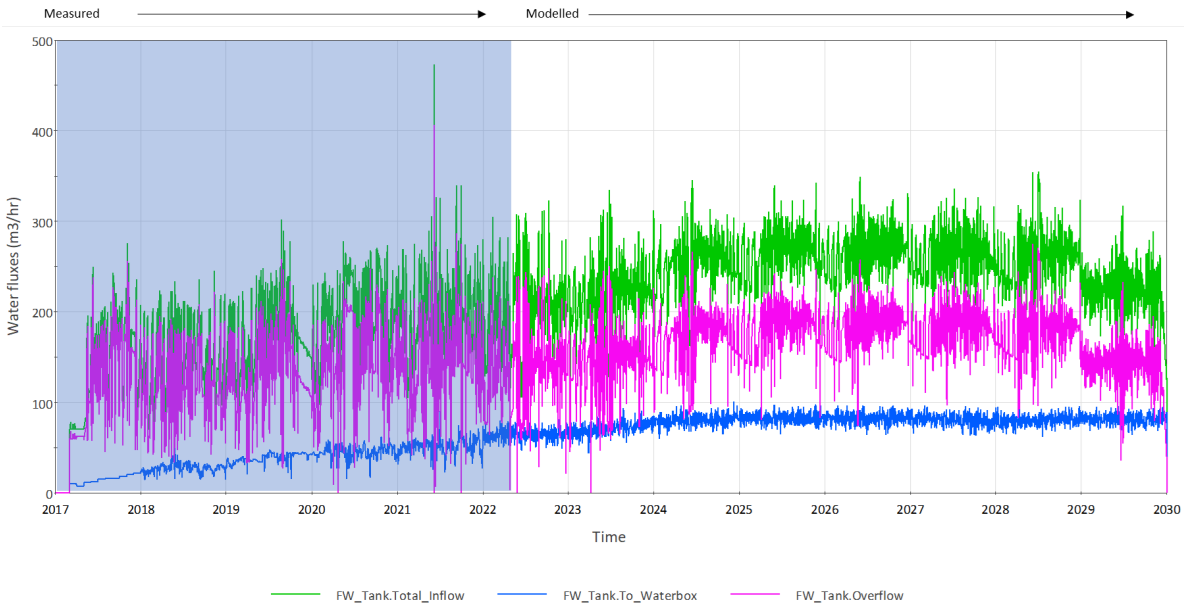


Figure 4-12: Time series showing inflow and outflows from the FWT over LOM.

4.2.7 Water Demand and Ore Processing

Water balance plots are presented in this section for mill surpluses and demands, including ore moisture, water demand for concentrate, tailings and paste backfill (Figure 4-13 and Figure 4-14). The bullet points below provide a summary of model results related to water demand and ore processing:

- Ore moisture is a source of water to the mill. At maximum rate of ore processing (*i.e.,* 2025-2029), ore moisture flow is slightly greater than 6 m^3/hr (Figure 4-13, upper panel).
- Concentrate water demand is shown in Figure 4-13 (lower panel). At maximum rate of ore processing, concentrate water demand is estimated to be on the order of 0.8 m^3/hr.
- Water requirements associated with tailings and paste backfill are shown in Figure 4-14. For the period 2022-2029, maximum demand for water to produce tailings is 90 m^3/hr for Base Case (*i.e*., tailings solids, 60% by weight; Table 3-5), whereas estimated demand for paste backfill is generally lower each year (*i.e.*, 40-55 m3/hr typically) although demand is estimated to be 85 m^3/hr in 2029, the last year of operations for the 4950 tpd scenario.
    - When aggregated, for any month over LOM, combined demand for water to produce tailings and paste is ≤140 m^3/hr under the Base Case.

Within the CWP-WTP-mill water balance, water supplies are managed to the FWT, which is a critical input of freshwater to the mill. At daily timestep, water cycles through the mill circuit, and any surpluses/deficits of water on account of ore moisture, concentrate, tailings and paste backfill activities, are accounted. Similar to discussion for the CWP (Section 4.4.3) and the FWT (Section 4.4.66), a key finding for Base Case is that demand for water at the mill is met by the available supply for the period 2022-2029. This is demonstrated by the time series data presented in Figure 4-15, which provides an accounting of 'water required' and 'water available' for concentrate, tailings and paste production. In Figure 4-15, time series showing water requirement and availability overprint one another, providing confirmation that mill water demands are met for the Base Case scenario.

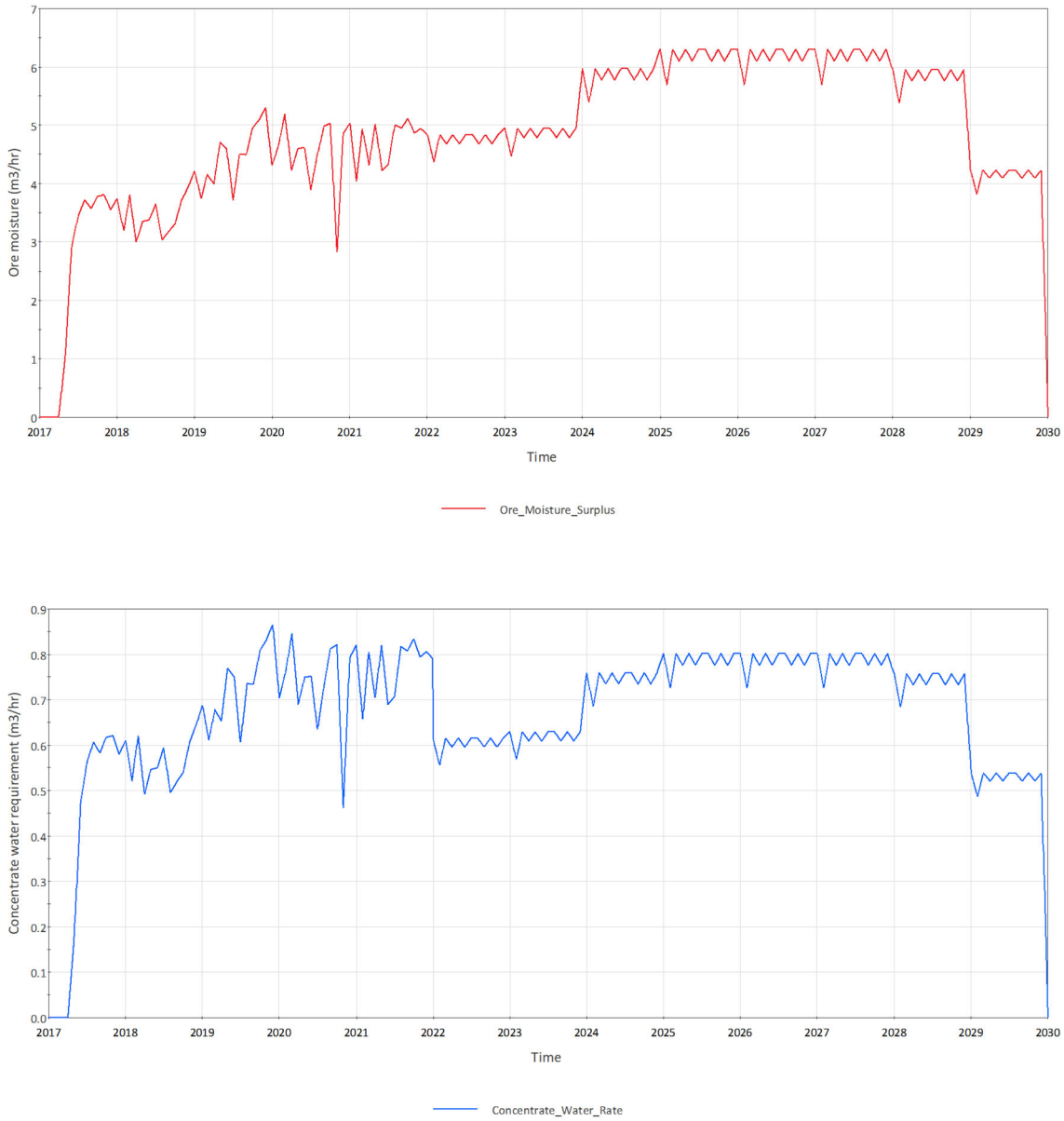
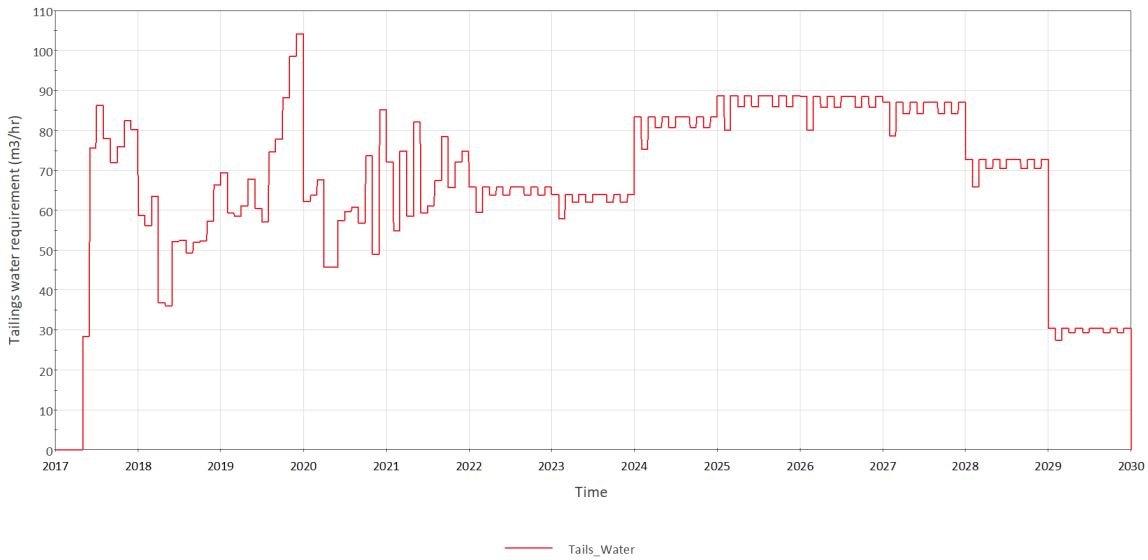


Figure 4-13: Time series illustrating water available as ore moisture and water requirements associated with production of concentrate (2017-2029).



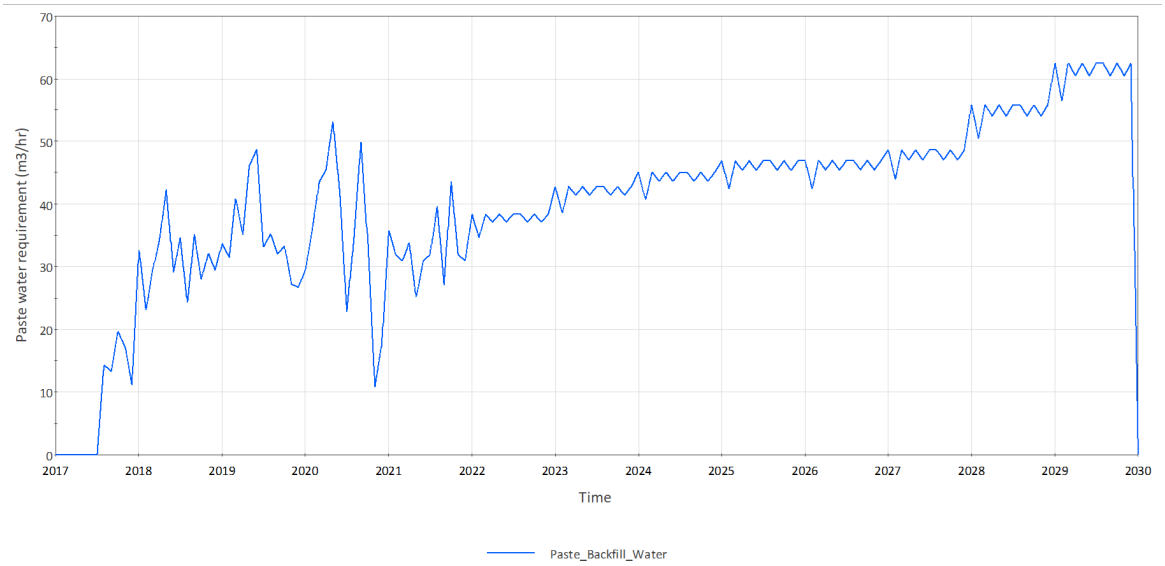


Figure 4-14: Water requirements associated with tailings and paste backfill over LOM (2017-2029).

Figure 4-15: Time series plots summarizing water requirements and availability in the mill for concentrate, tailings and paste production for LOM (2017-2029).

4.2.8 Sewage Treatment Plant

A time series shows measured and modelled discharges from the STP (Figure 4-16). Apparent in the plot are the increasing and variable rates of STP discharge which characterize the exploration and construction stages of site activity. For example, rates of discharge ranged from 10-40 m^3/day from autumn 2014 through to the end of 2015 but were much higher later in 2016 and throughout 2017, at the peak of construction (*i.e.*, 80-140 m^3/day).

Also apparent in Figure 4-16 are the modelled STP flows for the operations phase, which range from 65-85 m^3/day through to end of 2021, but are higher for the 2022-2029 period (*i.e.,* range from 70-100 m^3/day; average 90 m^3/day. For the period of future mining, the average flow rate is the equivalent of 3.75 m^3/hr, and thus, STP effluent discharge is a relatively minor flow in the overall site-wide water balance.

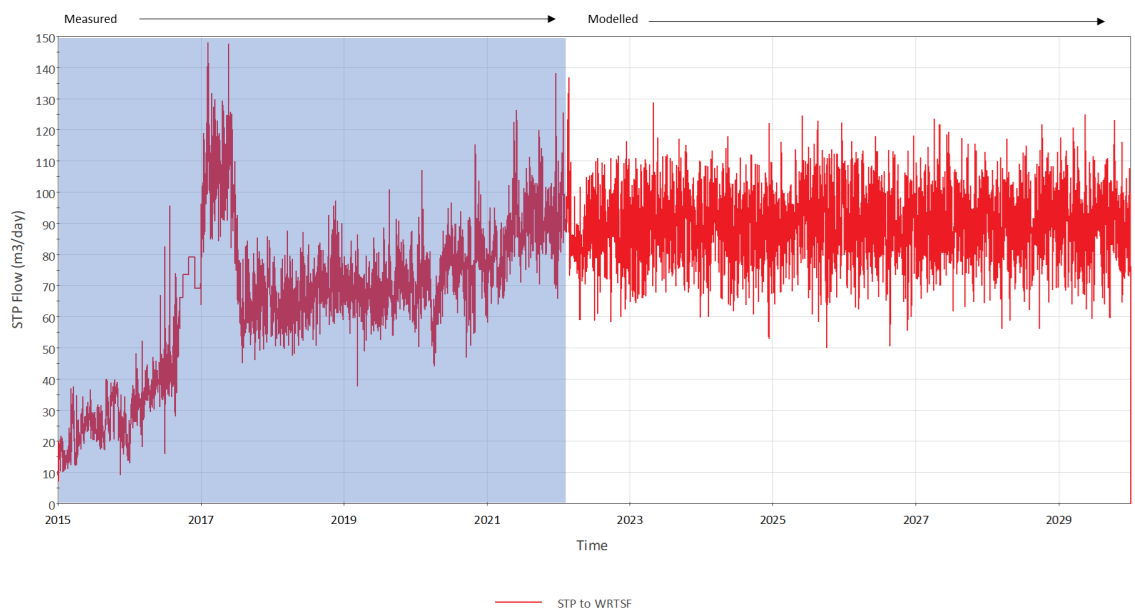


Figure 4-16: Time series showing modelled STP discharges at the Brucejack Mine for LOM.

4.2.9 WRTSF

Owing to placement of waste rock and tailings solids in the WRTSF, the volume of stored water within the facility will decrease over LOM. Measured and modelled changes in WRTSF volume are shown in Figure 4-17. Detailed bathymetric surveys were completed at the WRTSF in 2015, 2019, 2020, 2021 and 2022.

Measured and modelled data for the WRTSF indicate the following: the rate of change in WRTSF volume is generally constant over the construction and operations phases; stored

volumes are predicted to decrease from pre-mine levels of roughly 30 Mm^3 to 20.7 Mm^3; and the estimated change in volume (approximately 9.3 Mm^3) and duration of change (roughly 15 years; from 2015-2029) translate to an average flow rate (or displacement rate) from the WRTSF of 20.2 L/s. Further, a comparison of measured and modelled WRTSF volumes through 2022 provides an initial indication that this component of the model is reasonably well calibrated and producing reliable results.

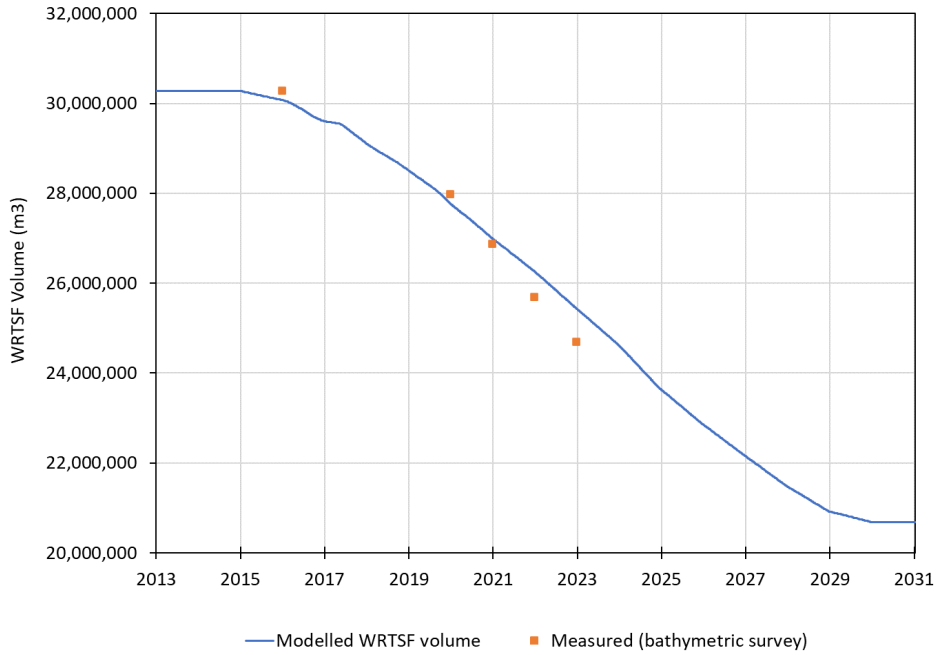


Figure 4-17: Estimated change in WRTSF volume on account of waste rock and tailings placement within the facility.

4.2.10 Receiving Stream Stations

Modelled discharge records (2017-2031) are shown for receiving stream nodes BJ 3.10, BJ 2.62 and BJ 1.74 in Figure 4-18. Noteworthy observations based on assessment of these model results include:

- The data show a progressive increase in flow from BJ 3.10 to BJ 2.62 and BJ 1.74. The drainage area reporting to these three WBM nodes increases progressively, and so the result is expected.
- With respect to winter baseflows, flow rates at BJ 3.10 are on the order of 60-100 L/s. By comparison, flow rates at BJ 2.62 and BJ 1.74 are larger in magnitude on account of increased basin area.

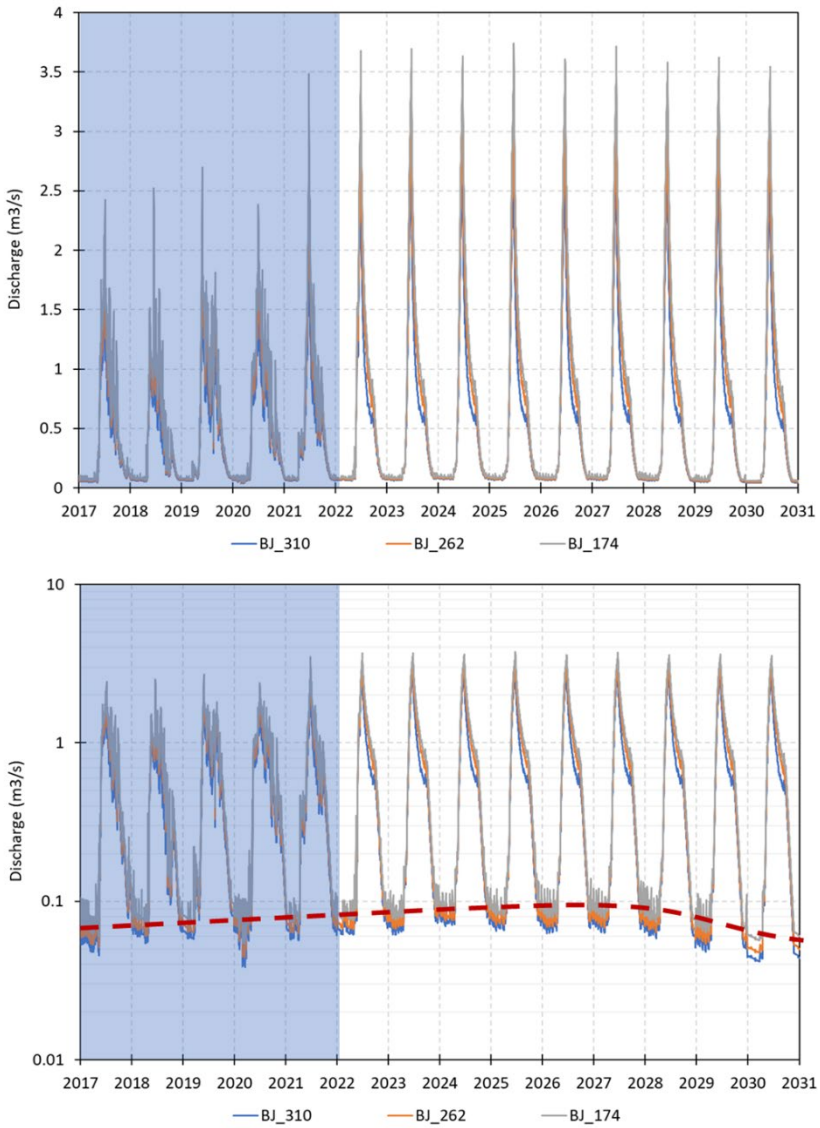


Figure 4-18: Time series showing modelled daily discharges at BJ 3.10, BJ 2.62 and BJ 1.74 for LOM with no y-axis scaling (upper panel) and log y-axis scaling (lower panel). In the lower panel, the progressive increase in winter baseflow resulting from waste rock, tailings and effluent disposal in the WRTSF, is shown by the dashed red line.

- Following freshet and through the open-water period, discharges at the three receiving stream stations are much higher. For example, streamflow conditions at BJ 3.10 typically range from 0.1-1.0 m^3/s between May and November, while noted that higher rates of discharge (on the order of 2.0 m^3/s) may be sustained for short periods of time (days, weeks) during the ice-free period. Further afield at BJ 2.62 and BJ 1.74, discharge patterns and variability are similar, but the magnitude of flows are higher on account of larger catchment areas.

- Data in Figure 4-18 (lower panel) shows an increase in winter baseflow condition owing to mine development. As outlined above in Section 4.2.9, the placement of waste rock and tailings solids in the WRTSF results in water displacement and a reduction in volume of the facility. However, in parallel, diversions of water from BJ 3.10 weir (reclaim) and the ongoing return of treated effluent and contact water to the WRTSF, continue during LOM, which masks the water displacement signal to a degree.
- Receiver stream flow conditions are also summarized in Figure 4-1 and Figure 4-2 (in m^3/hr), with model results expressed as annual average values for operations (2022-2029) and closure/post-closure (2030-2050).

4.2.11 Water Balance Model Sensitivities

This section of the report discusses results for various sensitivities tested with the Brucejack WBM, including a tailings solid sensitivity, variable climate sensitivities, and a groundwater recharge sensitivity.

4.2.11.1 Tailings Solids, Operational Variability

The Base Case configuration of the WBM assumes the solids content of tailings and paste backfill is 60% by weight for the 2020-2029 period. Under this scenario, model results indicate the maximum water demand for tailings and paste backfill is roughly 140 m^3/hr for 4950 tpd milling (Figure 4-14). However, the solids content of tailings, in particular, may be subject to operational variability, therefore, this sensitivity aims to: demonstrate water requirements for tailings produced at varying solids percentages; and, illustrate the benefit of targeting 60% solids content for tailings rather than a lower target which requires input of additional water.

Results from the WBM confirm that as the percent solids of the tailings change (*e.g.*, from 60% solids to 55% or 50% solids), mill water demand increases accordingly (Figure 4-19). For example, the WBM sensitivity illustrates that mill demand can be expected to increase by 20 m^3/hr (*i.e.*, from 90 m^3/hr to 110 m^3/hr) as percent solids of tailings decrease from 60% to 55%. In contrast, mill water demand can be expected to increase by 45 m^3/hr should percent solids of tailings decrease from 60% to 50%.

In the winter when rates of groundwater recharge and surface runoff are at their annual minimums, mill operations are in part sustained by reclaim diversions from the BJ 3.10 weir, which are currently fixed at 70 m^3/hr for the mine site, as well as from stored water volumes in the CWP. Through this lens, the benefits of maintaining a tailings solids target of 60% becomes apparent, which in effect minimizes pressure on available water stores in the CWP storage and reduces mill water losses to the WRTSF as tailings are produced and disposed of during LOM.

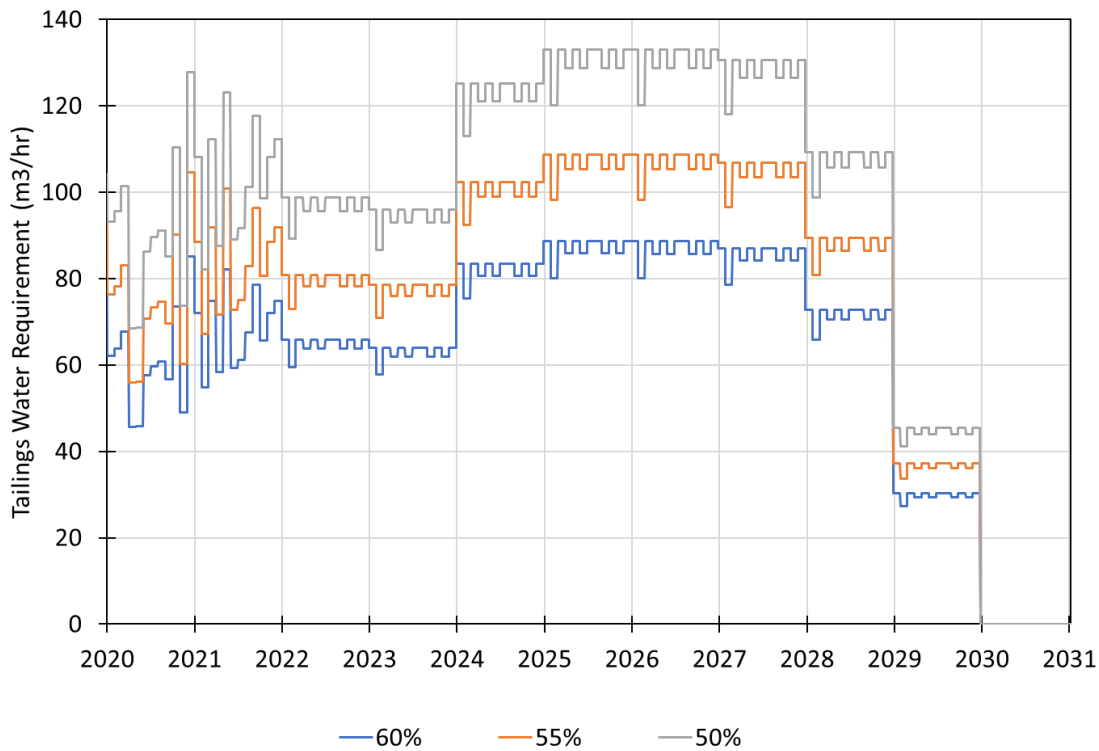


Figure 4-19: Percent solids sensitivity analysis for tailings water requirements, Brucejack WBM – 4950 tpd case.

4.2.11.2 Groundwater Recharge Sensitivity

The Base Case configuration of the WBM incorporates expected case predictions of groundwater inflow to the underground mine. Under this scenario, model results show a progressive increase in recharge to the underground over the Project timeline. Furthermore, rates of inflow are anticipated to vary seasonally, with recharge to the mine being greater during the ice-free period compared to winter months (Figure 4-20 and Figure 2-10). Base Case results from the WBM also confirm demand at the mill may be met for the 4950 tpd scenario using existing water infrastructure and water management strategies.

Given the magnitude (*i.e.*, monthly fluxes on the order of 75-200 m^3/hr for the period 2022-2029) and importance of groundwater recharge as a source of water to the mill, a sensitivity was conducted to assess WBM changes under Lower and Upper groundwater recharge scenarios (Figure 4-20, upper panel). The technical specifics and modelling assumptions underpinning the Lower- and Upper-Case groundwater recharge scenarios are presented in Lorax (2023a). Key findings of this water balance sensitivity are summarized in the bullet points below:

- Total pumping from below ground to surface is not surprisingly greater for the Upper Case groundwater recharge scenario compared to the Lower Case groundwater scenario (Figure 4-20, upper panel).
  - In year 2023 for example, pumping to surface ranges from 70-125 m^3/hr for the Lower Case compared to 85-155 m^3/hr for the Upper Case.
  - By comparison, pumping to surface ranges from 100-160 m^3/hr for the Lower Case compared to 125-200 m^3/hr for the Upper Groundwater Case, by 2028 and 2029.
- Plots illustrating the management of water volumes at the TWT are shown in Figure 4-21 and Figure 4-22. In each of these figures, the upper panel shows raw model results from the WBM at daily timestep, whereas the lower panel shows 30-day average trendlines fitted to the raw model results, for ease of interpretation.
  - Regarding the release of treated effluent, WBM results predict proportionally more discharge to the WRTSF will occur for the Upper Case compared to Lower Case.
    - As a general strategy, treated effluent is 'bled' from the mill water balance when supply exceeds demand and the CWP volume is at capacity.
      - For example, by 2029 the WBM predicts releases of treated effluent to the WRTSF will vary from 25-313 m^3/hr over the course of the year for the Upper Case groundwater scenario, whereas releases to the WRTSF for the Lower Case are 25-287 m^3/hr (Figure 4-21, lower panel).
    - Owing to the long-term expected increase in groundwater recharge to the underground mine over LOM, it is noted that releases of treated effluent to the WRTSF increase with time accordingly, for all scenarios assessed (*i.e.,* Base Case, Lower Case and Upper Case).
  - In contrast, proportionally more water is managed from the TWT to the CWP under the Lower Case versus the Upper Case (Figure 4-22).
    - As outlined in previous discussion, water management infrastructure in the form of tanks, pumps and pipelines are in place at site, which allows for recycling of treated effluent to the CWP when there is available storage in the facility.
    - For the Lower Case, there is less water available to support mill activities than under Upper Case. Accordingly, rates of discharge of treated effluent to the WRTSF are lower (Figure 4-21, lower panel) and rates of recycle to the CWP are higher (*e.g.*, range typically between 25-60 m^3/hr in winter for 2028; Figure 4-22 lower panel) for Lower Case.

    - Note that over LOM the peak and total volumes of water recycled to the CWP decreases for Base Case, Upper Caser and Lower Case. This is because groundwater recharge increases with below ground development (Figure 4-20) and the requirement to recycle water to the CWP, in concept, lessens over this progression.

- Regarding reclaim diversions from the BJ 3.10 weir for the two groundwater cases, diversion rates while similar, are proportionally greater for the Lower Case than for the Upper Case (Figure 4-23 upper and lower panels).
    - In essence, any potential short comings in water supply for the Lower Case are compensated for by enhanced rates of reclaim diversion.
    - Note that modelled reclaim diversions for all cases and all time periods remain below the allowable threshold of 70 m^3/hr.
- Overall, the groundwater sensitivity analysis illustrates water demands at the mill may be met using existing infrastructures (*i.e.,* reclaim weir, the CWP, the WTP and TWT) and already developed water management strategies.
    - A key aspect of mine water management at the site is the ongoing balancing of flows/water volumes at the mill achieved by: reclaim diversions from Brucejack Creek; the release of treated effluent to the WRTSF when necessary; and, the recycling of excess water to the CWP when available storage in the facility exists.

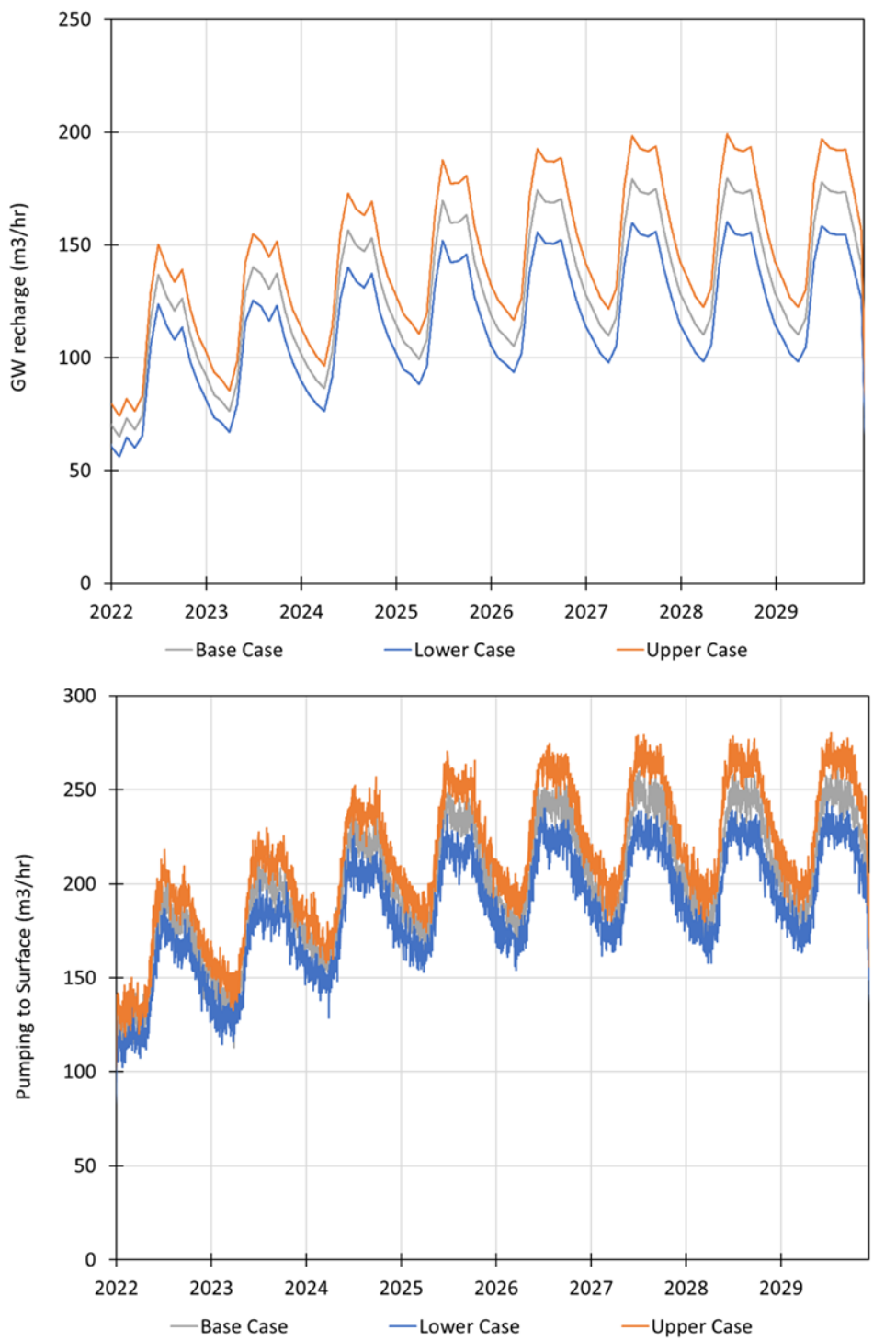


Figure 4-20: Time series plots illustrating Base Case (grey), Lower Case (blue) and Upper Case (orange) model results for groundwater recharge to the UG mine (upper panel) and total pumping from below ground to surface (lower panel)

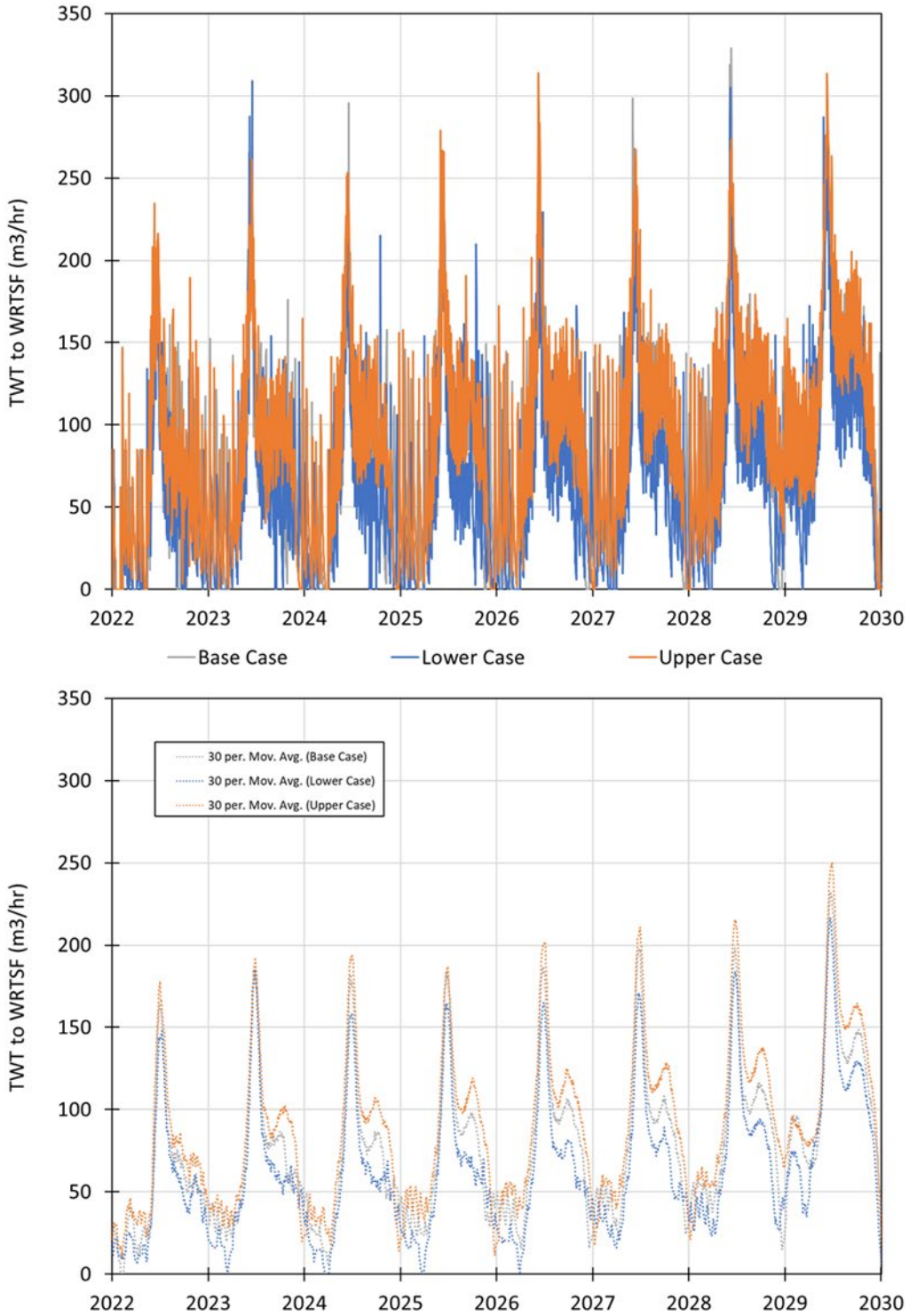


Figure 4-21: Time series plots illustrating Base Case (grey), Lower Case (blue) and Upper Case (orange) model results for release of treated water to the WRTSF. Raw results from the WBM are shown in the upper panel whereas results in the lower panel show a 30-day moving average.

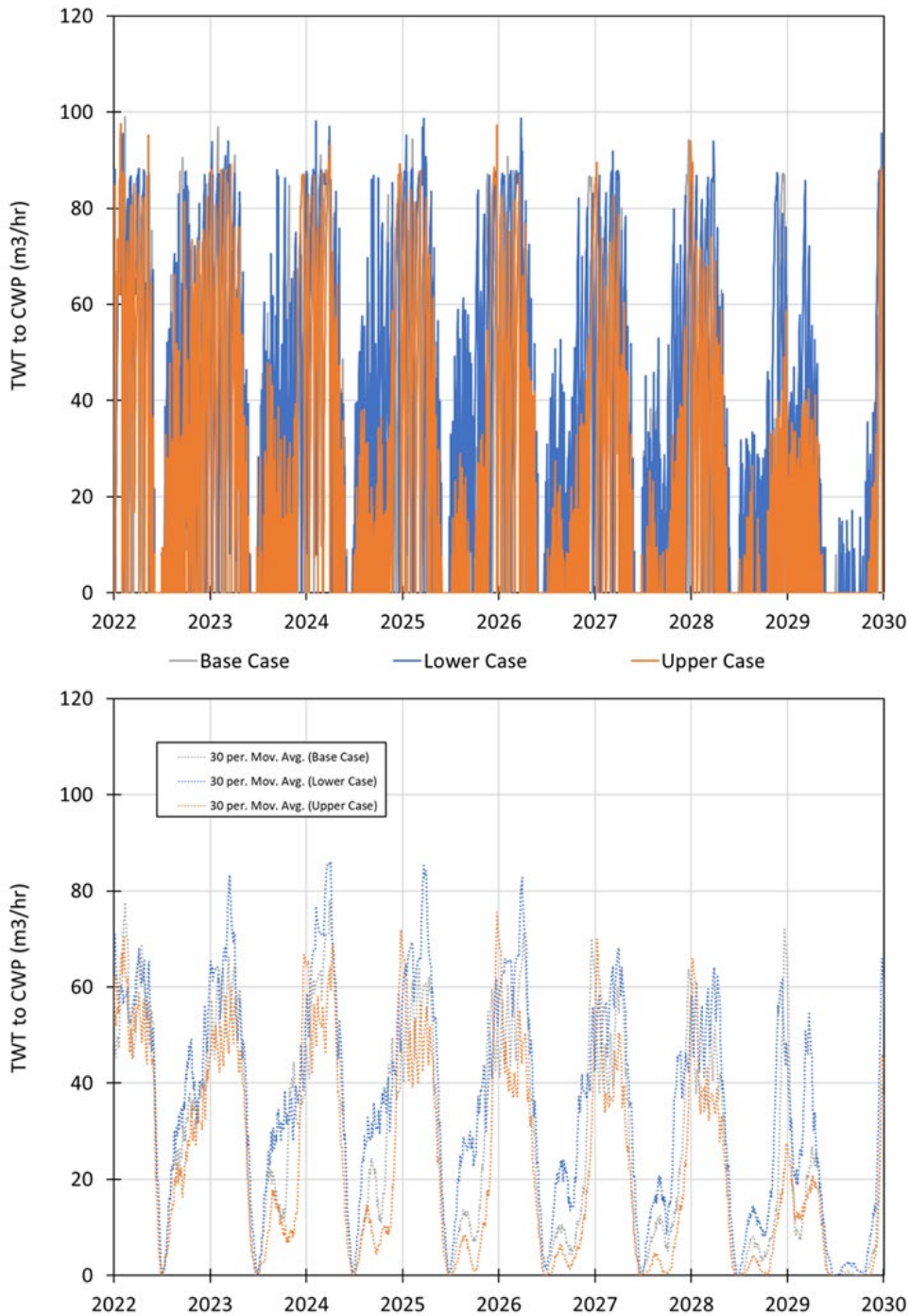


Figure 4-22: Time series plots illustrating Base Case (grey), Lower Case (blue) and Upper Case (orange) model results for the recycling of treated effluent from the TWT to the CWP. Raw results from the WBM are shown in the upper panel whereas results in the lower panel show a 30-day moving average.

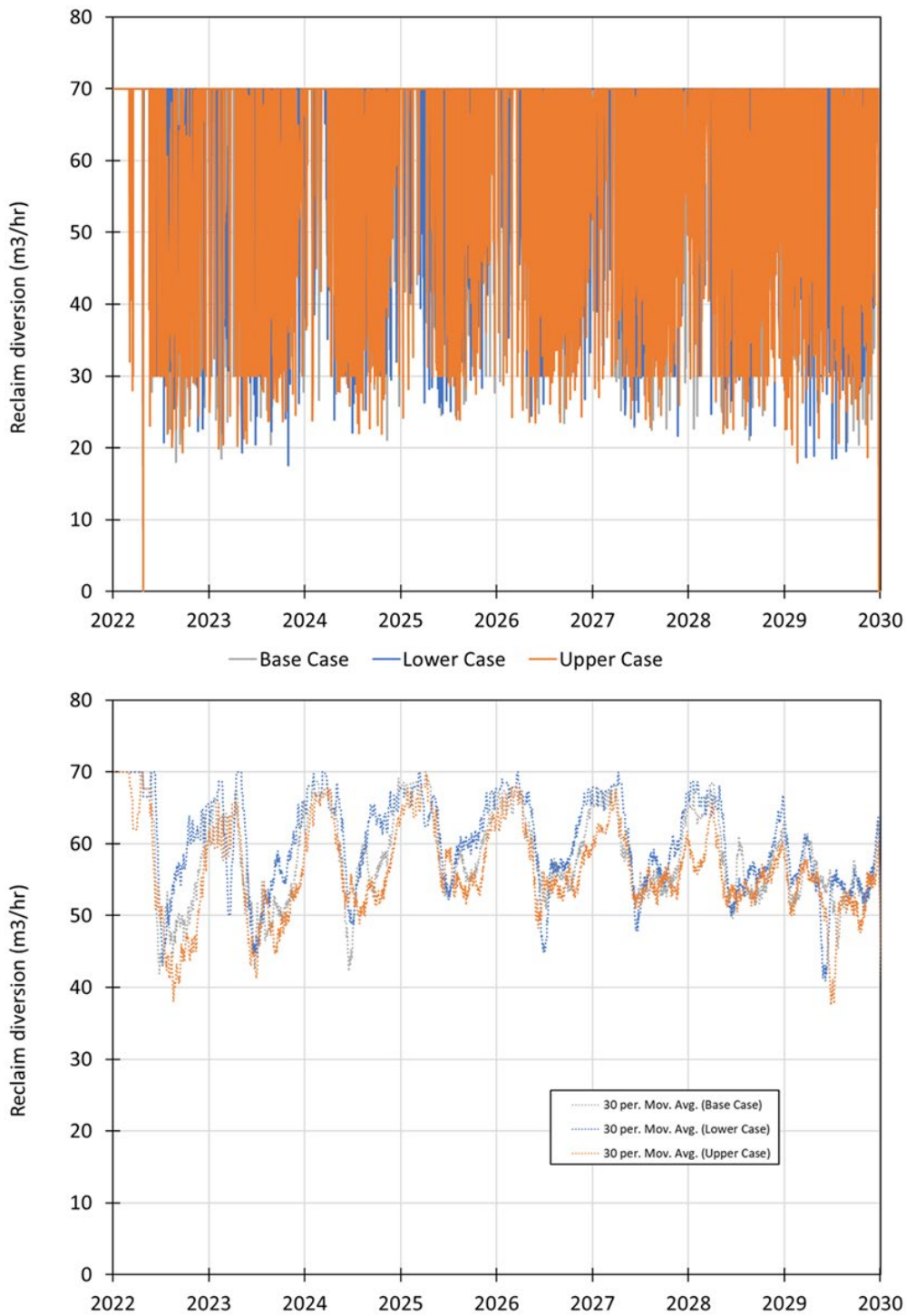


Figure 4-23: Time series plots illustrating Base Case (grey), Lower Case (blue) and Upper Case (orange) model results for the diversion of reclaim water from the BJ 3.10 weir. Raw results from the WBM are shown in the upper panel whereas results in the lower panel show a 30-day moving average.

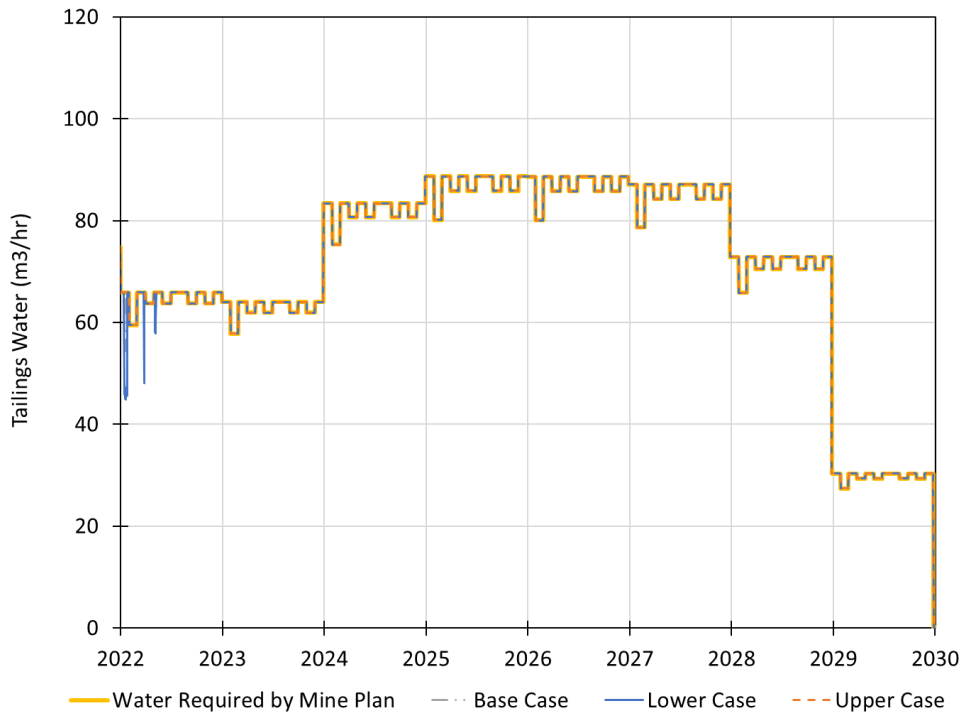


Figure 4-24: Plot illustrating tailings water requirements for the 4950 tpd case (yellow line) compared to available water modelled for Base Case, the Lower Caw and Upper Case groundwater sensitivities.

4.2.11.3 Variable Climate Sensitivity

When the WBM is run in variable climate mode, a range of hydro-climatic output is computed for model nodes at daily timestep (Figure 4-25). Variable climate case (VCC) results are presented in this section to demonstrate the multi- realization capabilities of the WBM, as well, to discuss climate sensitive components of the WBM for the operations period.

WBM elements that are directly influenced by air temperature and precipitation inputs are as follows:

- natural catchment runoff reporting to the WRTSF and BJ 3.10 nodes (Figure 4-25, upper panel),
- the exchange of precipitation and evaporation at the WRTSF surface,
- runoff from the WR platform and km 72 NPAG quarry,
- background runoff reporting to Brucejack Creek at BJ 2.62 and BJ 1.74 nodes, and
- runoff that reports to the CWP via the contact water collection system (CWCS).

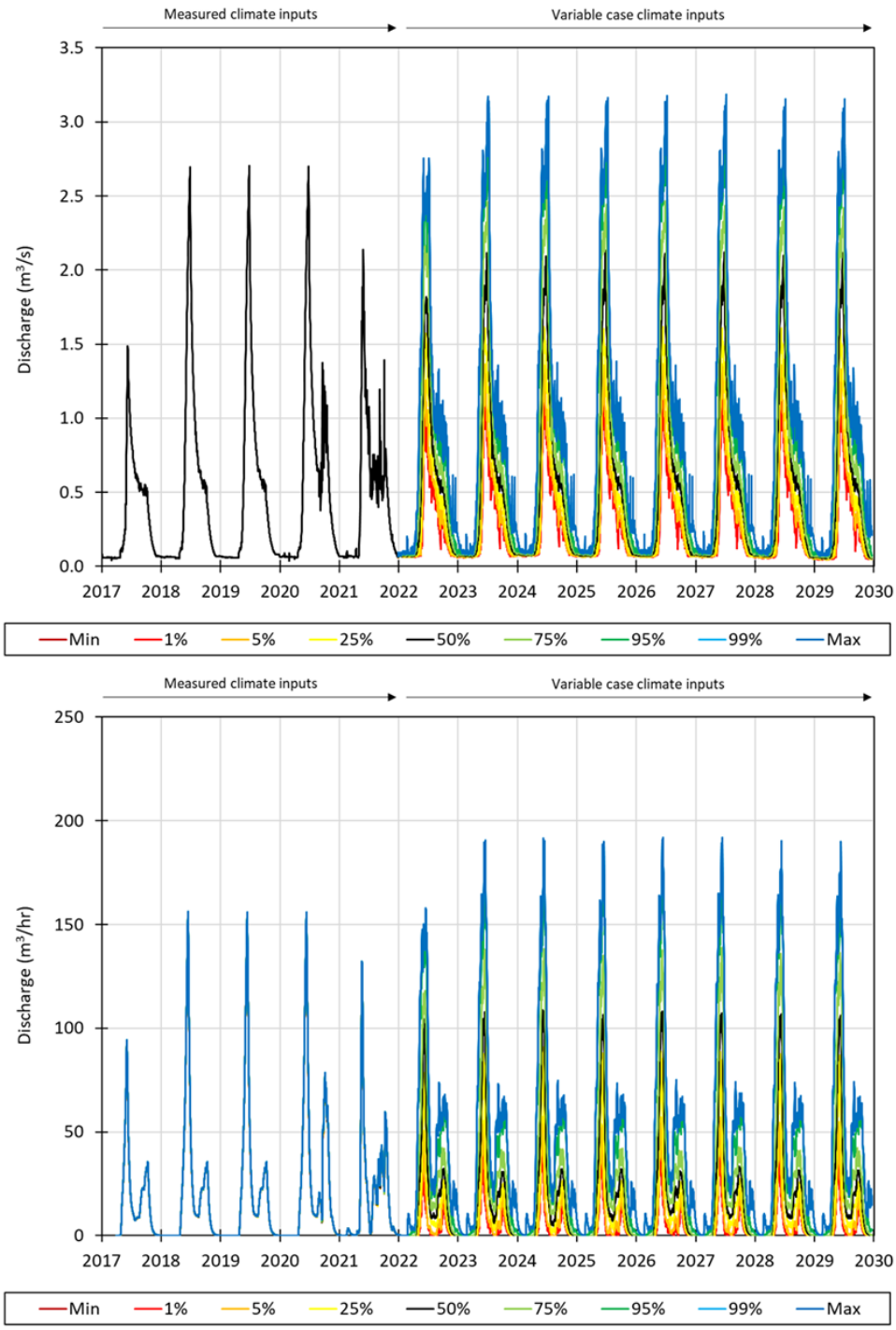


Figure 4-25: Examples of variable climate case output from the WBM for BJ 3.10 (upper panel, in m^3/s) and the CWCS (lower panel, in m^3/hr). Statistical outputs presented in the two charts are computed at daily timestep from 30-realizations of WBM output. For the simulation shown, measured climate inputs are read into the model for the pre-2022 time period versus the read-in of variable climate inputs thereafter.

Of the water fluxes identified above, the WBM term with a direct connection to either the supply/demand of water at the mill/WTP, is runoff from the CWCS (Figure 4-25, lower panel). Runoff from the CWCS is conveyed to the CWP, then directed to the WTP as required, with treated effluent managed in multiple ways: for example, treated effluent may be directed to the FWT to support mill/underground operations; or managed to the TWT whereby effluent may be released to the WRTSF or can be recycled back to the CWP when there is space in the pond.

During freshet, multi-realization output from the model predicts peak daily discharges on the order of 50-80 m^3/hr for dry years at the CWCS, compared to peak daily fluxes ranging from 100-190 m^3/hr for wet years. Inspection of wet vs dry realization results from the variable climate case model confirm that during wetter than normal years/conditions, more treated effluent is discharged to the WRTSF than during dry than normal years (Figure 4-26, upper panel). Further, the model confirms that during dry years/periods, recycling rates of effluent to the CWP are greater, compared to wet periods (Figure 4-26, upper panel). Figure 4-26, lower panel, shows modelled CWP volumes for the variable climate simulation for the 2022-2029 period.

Despite the differences in flow/volume reporting through the CWCS and CWP under variable climate, volumes at the CWP are predicted to remain relatively balanced through the winter (40,000 m^3) and open water periods (~15,000 m^3), a result suggesting mine site infrastructure such as the CWP, WTP and TWT are capable of maintaining a similar supply of water for mine site activities, whether climate conditions are wet, dry or typical.

Regarding required and available water for the production of concentrate, paste and tailings under variable climate, a key result from the variable climate case model is shown in Figure 4-27. This figure shows variable case climate results for paste water requirements (red line) versus paste water availability (blue line). Statistics in the plot (*i.e.*, min, mean and max) are computed at daily timestep from 30-realizations of WBM output for the variable climate case. The overprinting of the lines on the paste water plot is interpreted to mean water demand at the mill is met by the available water supply. Though not shown, the WBM returned similar results for concentrate and tailings water requirements for the variable climate simulation.

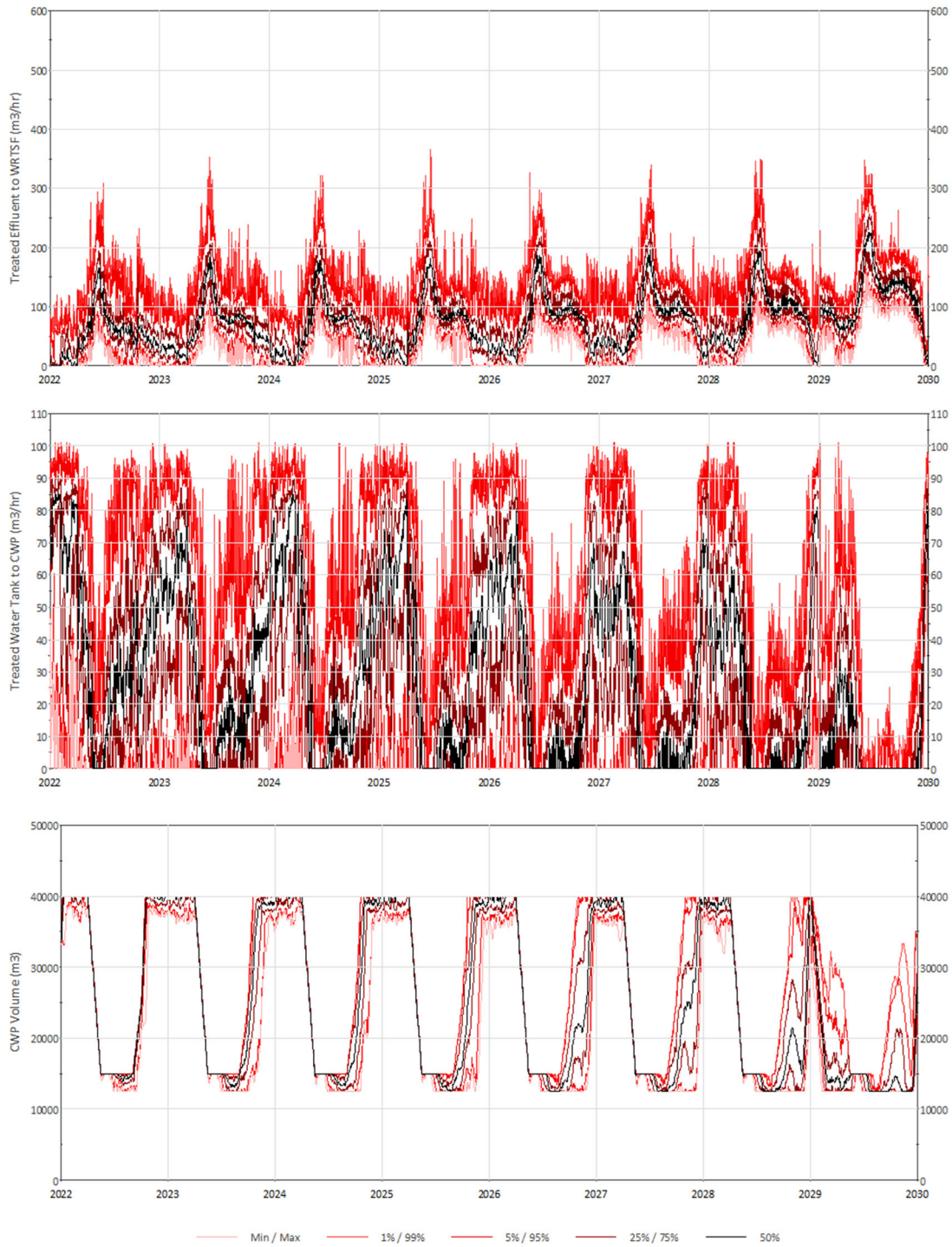


Figure 4-26: Variable case climate results showing release of treated effluent to the WRTSF (upper panel), recycling of water from the TWT to the CWP (middle panel), and CWP volume, for the 2022-2029 period. Statistical outputs presented in the three charts are computed at daily timestep from 30-realizations of WBM output.

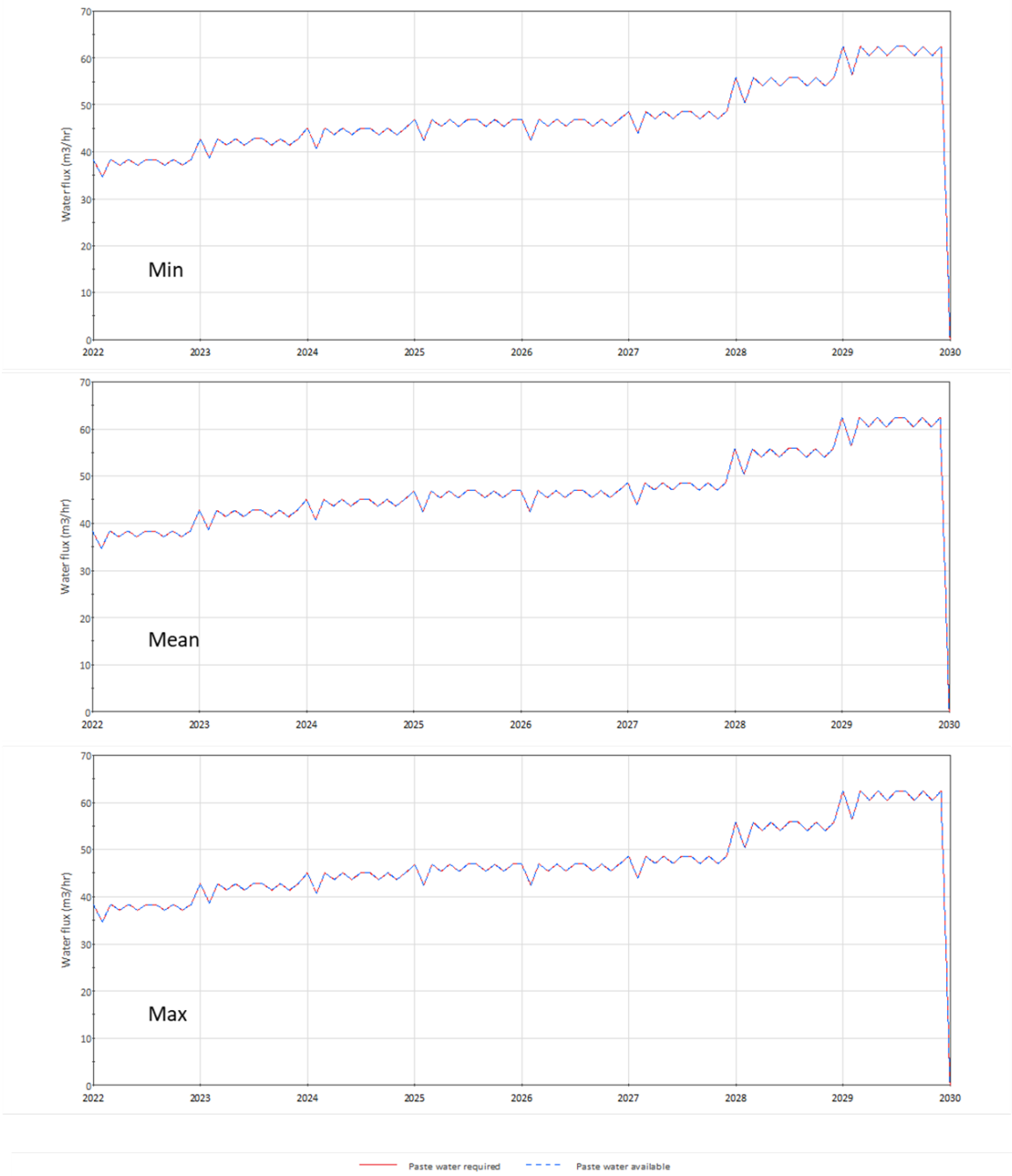


Figure 4-27: Variable case climate results showing statistical outputs (min – upper panel; mean – middle panel; max – lower panel) for paste water requirements (red line) versus paste water availability (blue line). Statistics are computed at daily timestep from 30-realizations of WBM output for the variable climate case. The overprinting of the lines on the plot is interpreted to indicate that water demand at the mill is met by the available supply.

4.2.11.4 Variable Climate plus Climate Change Sensitivity

The variable climate mode of the WBM can also be executed to represent forward looking scenarios that consider climate change (refer to Section 2.3.4). Regarding air temperature and precipitation adjustments extending out to 2100, annual scalars are read into the WBM based on the RCP6.0 scenario developed from datasets prepared by the Scenario Network for Alaskan and Arctic Planning (SNAP). For the operations period sensitivity presented below, the site-wide WBM was initialized consistent with the setup for the variable climate case, with the exception that air temperature and precipitation trends for RCP6.0 were turned on for this sensitivity.

Over the period of operations (2022-2029), any changes in air temperature (0.5°C increase) and precipitation (+3% increase) attributable to climate change are anticipated to be very minor (Figure 2-6). Therefore, comparison of multi-realization output from the VCC versus VCC plus climate change models are expected to be very similar. By means of example, percentile plots comparing CWCS runoff volumes for the VCC versus VCC plus climate change scenarios are shown in Figure 4-28. Similarly, patterns of water management at the TWT (*i.e.,* flows managed to either the CWP or WRTSF) are evidently the same for the VCC versus VCC plus climate change scenarios (Figure 4-29, discharge of treated effluent to WRTSF plot shown).

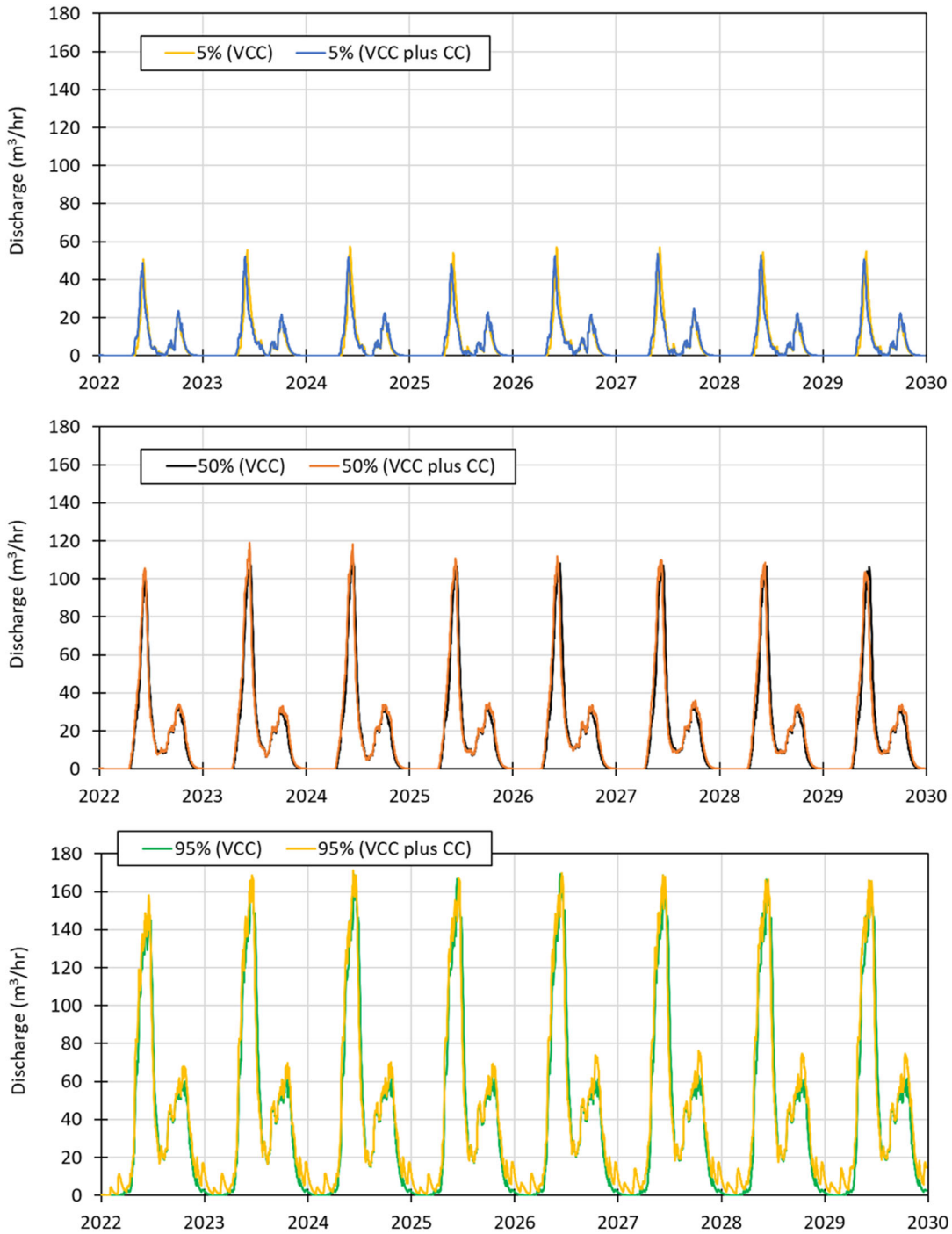


Figure 4-28: Hydrographs for CWCS flow reporting to the CWP. Plots show output statistics (*i.e.*, 5th percentile – upper panel; 50th percentile – middle panel; 95th percentile – lower panel) based on 30 realizations of WBM output for the VCC versus VCC plus CC cases.

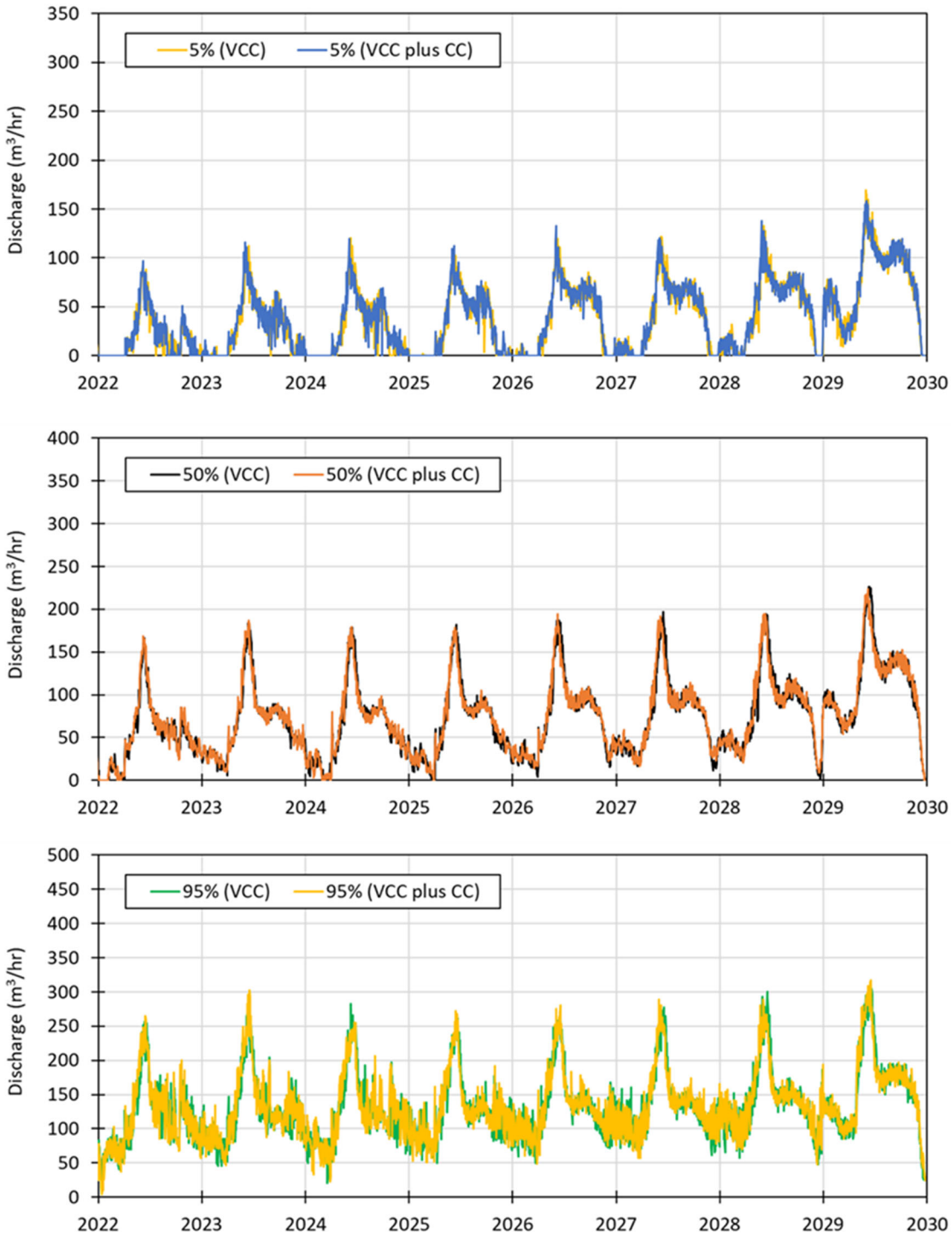


Figure 4-29: Discharge plots showing effluent release from the TWT to the WRTSF (*i.e.*, 5th percentile – upper panel; 50th percentile – middle panel; 95th percentile – lower panel) based on 30 realizations of WBM output. The plots compare model results for the VCC versus VCC plus CC cases.

4.3 Closure and Post-Closure Results

4.3.1 Overview

A water balance summary is provided for Brucejack Mine for the closure and post-closure phase (Figure 4-2). As for Operations, the WBM fully accounts for any background/non-contact runoff generated within the BJ 3.10, BJ 2.62 and BJ 1.74 watersheds. However, the model assumes the mine site, including the mill, access roads and related laydowns/pads, are reclaimed, with any runoff from these footprints assumed to report passively to either the WRTSF or Brucejack Creek below the BJ 3.10 weir. Following Active Closure and during Post-Closure, the STP and WTP are also assumed to be decommissioned, and therefore, are not shown in Figure 4-2.

Seepage flow from the underground mine to Brucejack Creek is depicted on Figure 4-2. Contact water fluxes generated from the flooded mine are simulated to average 14.9 L/s annually (or 54 m^3/hr). This is roughly 5 L/s higher than what was predicted by the 3,800 tpd model and is attributed to expansion of the mine extents as listed in the third bullet. Approximately 95% of contact water reports to Brucjack Creek above BJ-2.62, of which approximately 10% reports to the WRTSF. A further 4% of contact water reports to Brucejack Creek between BJ-2.62 and BJ-1.74. About 1% of contact water reports below BJ-1.74.

4.3.2 Fill Scenarios and Sensitivity, Underground Mine

To support closure costing and water quality predictive studies under the 2020 Mine Plan Update, two fill scenarios were considered for the Underground Mine. These scenarios were updated for the 4950 tpd Joint Application. The scenarios include Passive Fill and Accelerated Fill, noting the Accelerated Fill scenario is carried forward as a Base Case for water quality predictions (Lorax, 2023a).

For each scenario, it was assumed the underground mine would remain ‘open’ through the end of 2029, to support final phases of ore processing and allow any relevant remediation works to be carried out. Accordingly, filling under each scenario is assumed to begin on January 1, 2030. The bullet points below along with Figure 4-30, Figure 4-31, Figure 4-32 and Figure 4-33 summarize key findings of the modelling exercise.

Passive Fill

- Simulation work indicates passive filling of the mine will take place over a period of approximately 20 months (Figure 4-30, upper panel). Assuming flooding begins in January 2030, the underground mine floods and begins to fully discharge to

Brucejack Creek with timing coincident with the transition to autumn 2031 (Figure 4-31).

- Once filled, the mine pool will have an estimated volume of 1.54 Mm^3, with average elevation of the mine pool being 1,401 m asl (ranges seasonally from 1,393-1,407 m asl.
- Following filling, the GW model estimates seepage will discharge from the mine and report to Brucejack Creek upstream of BJ 2.62. Estimated travel times for seepage (*i.e.*, the time between mine pool filling and the 'daylighting' of contact water in the receiving environment) are on the order of days to weeks.
- The expected case estimate of seepage flow from the mine is approximately 15 L/s on average, with rates of seepage predicted to vary between 10-23 L/s over the year (Figure 4-31, lower panel; Figure 4-32, upper panel). For context, streamflow measurements at BJ 2.62 are estimated to be on the order of 55-135 L/s during winter months (Dec-Apr), with flows being much higher during the ice-free period (May-Nov) (Figure 4-32, lower panel).

Accelerated Fill

- The Accelerated Fill scenario explores time to fill following diversion of winter and freshet flows to the underground. Beginning in January 2030, diversion from BJ 3.10 is proposed from the BJ 3.10 weir at a rate of 70 m^3/hr for a 4-month period (Figure 4-30, lower panel).
- In May 2030 and for up to a four-month period, the Accelerated Fill scenario proposes the diversion of 20% MMD (mean monthly discharge) from the BJ 3.10 weir to the underground mine. By end of June or early July 2030, the combined volume from reclaim diversion, freshet diversion and GW inflow to the mine, fills the mine void, after which, no further diversion is proposed under this scenario (Figure 4-30, lower panel; Figure 4-31, upper panel).
    - Streamflow conditions at BJ 3.10 for the Passive Fill and Accelerated Fill scenarios for 2030 are compared in Figure 4-33 to illustrate the magnitude and duration of streamflow regime changes associated with the Accelerated Fill scenario.
- Assuming a maximum rate of treatment of 10,000 m^3/day, re-circulation to the WTP over a 15-month period (Figure 4-30, lower panel) enables treatment of approximately 4.5 Mm^3 of water, which is a volume 2.9-times greater than the mine void.

- Following filling of the mine void, the expected case estimate of seepage flow from the mine is 15 L/s on average, with rates of seepage predicted to vary between 8-22 L/s over the year (Figure 4-31, lower panel; Figure 4-32, lower panel). Owing to faster fill of the underground mine for the Accelerated Fill Scenario, groundwater seepage is expected to report to the receiving environment during summer of 2030 (Figure 4-31, lower panel; Figure 4-32, lower panel).
- The Accelerated Fill Scenario has been encoded in the WBM as Base Case to support robust water quality predictions for closure and post-closure phases.

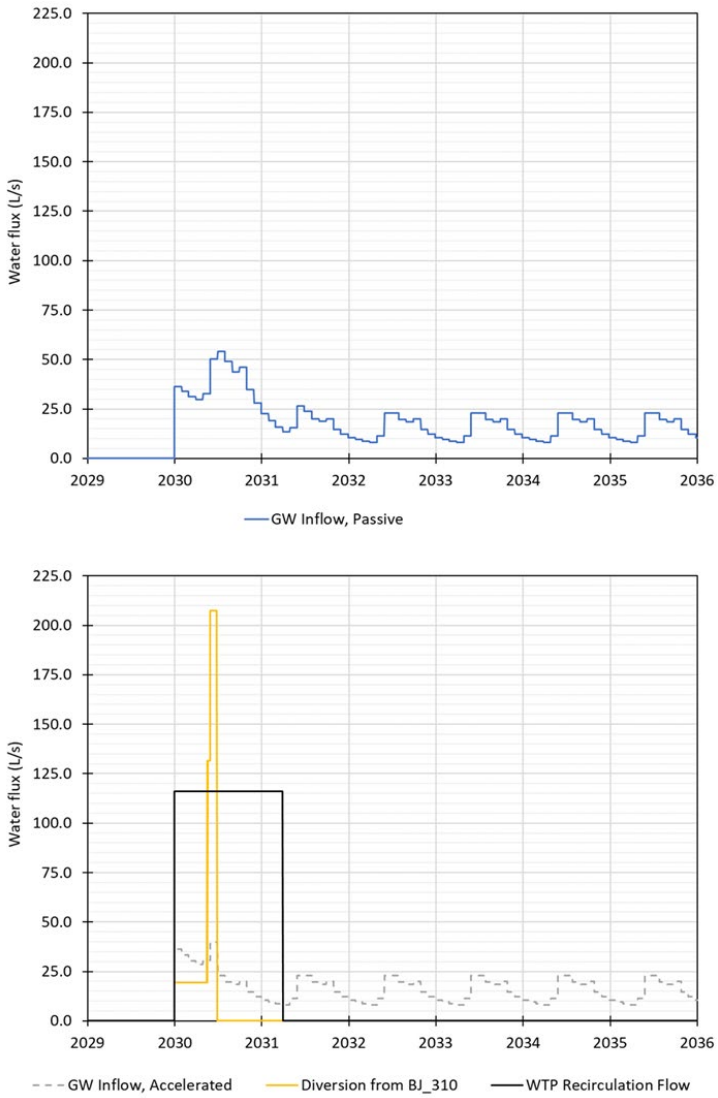


Figure 4-30: Comparison of inflows to the underground mine for Passive Fill (upper) and Accelerated Fill (lower) scenarios. Under the Accelerated Fill scenario, water from the mine pool will be continually recirculated to the WTP for a 15-month period.

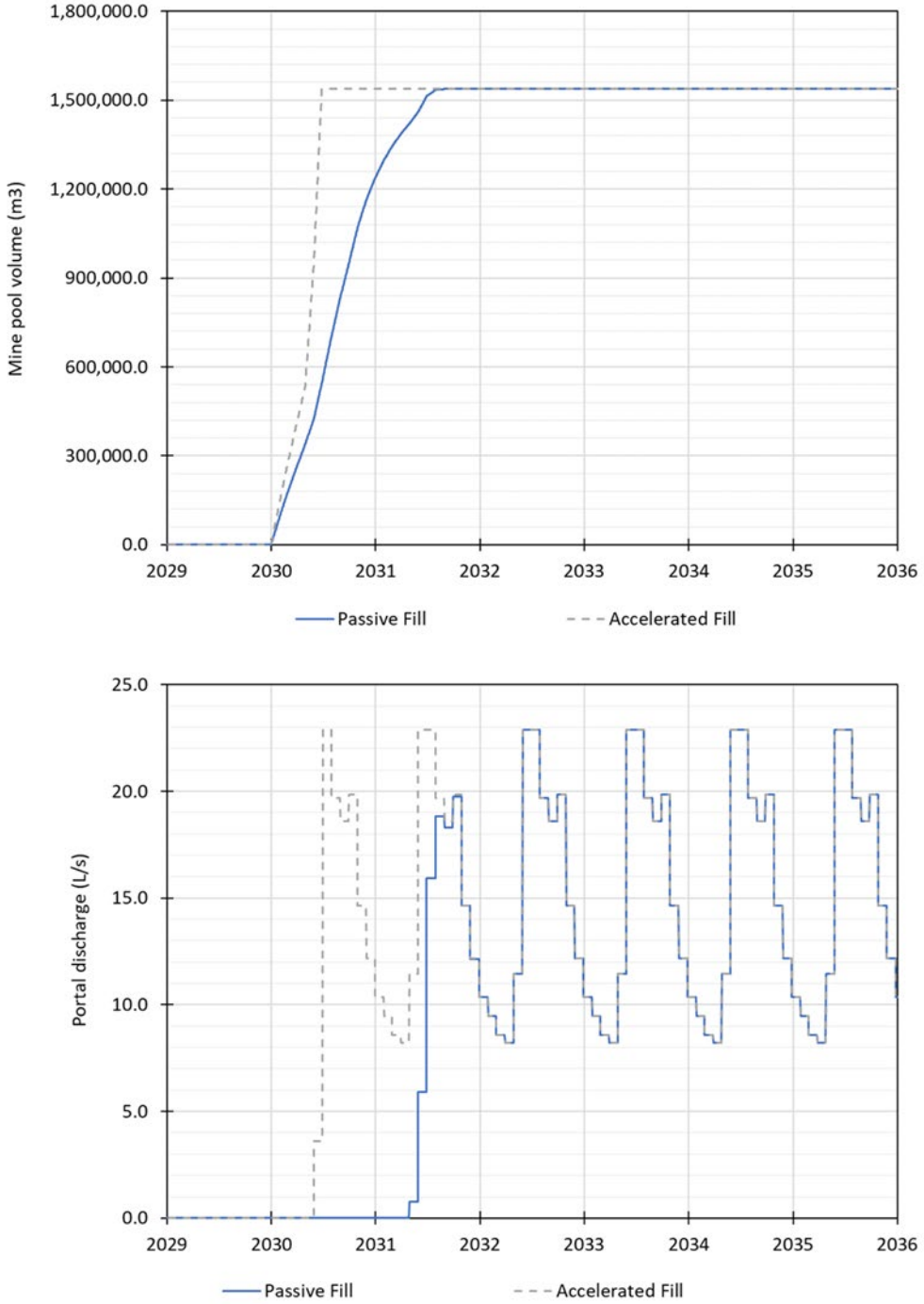


Figure 4-31: Comparison of mine pool volume predictions (upper) and GW seepage rates from the underground mine (lower) for the Passive Fill and Accelerated Fill scenarios.

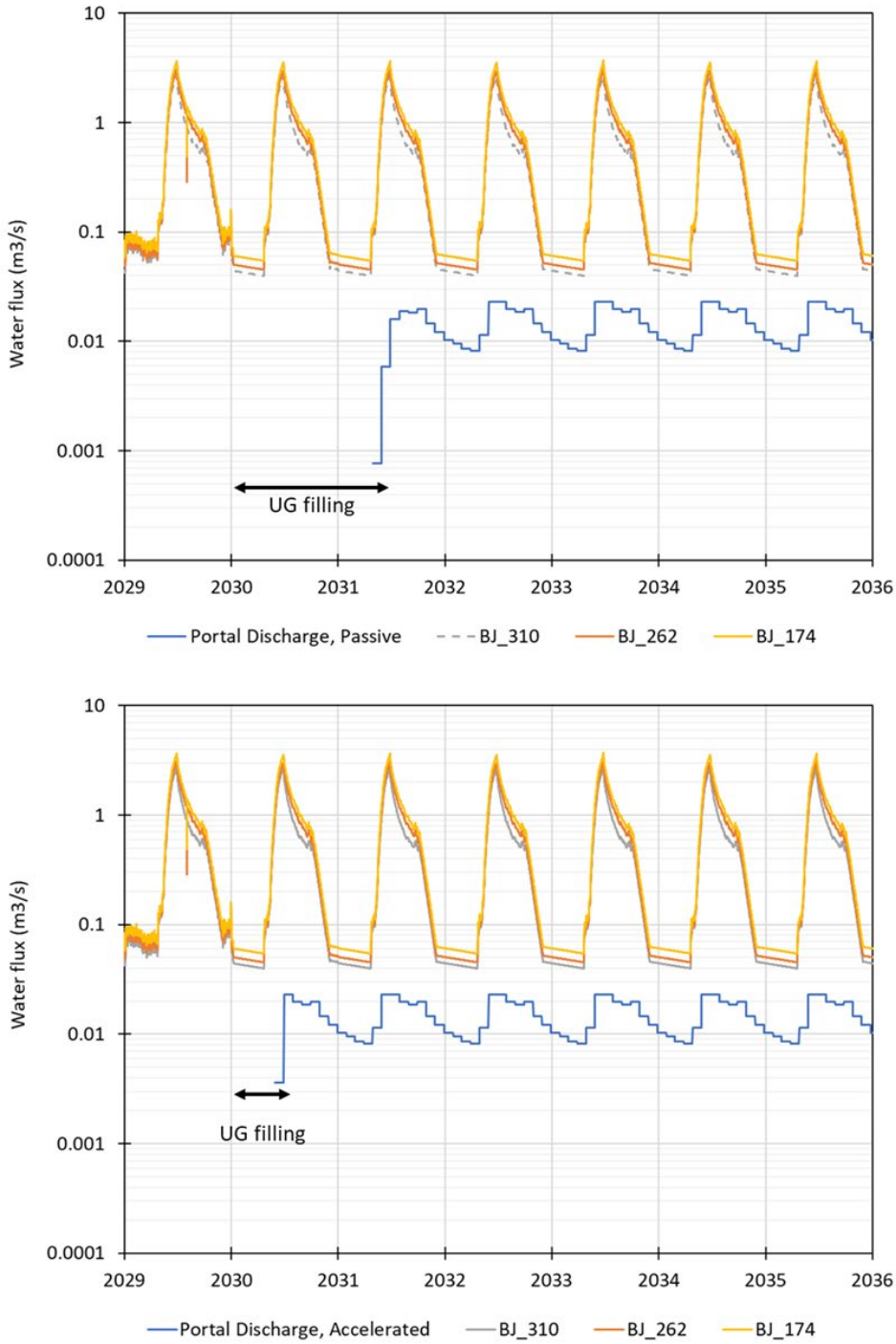


Figure 4-32: Comparison of streamflow conditions at BJ 3.10, BJ 2.62 and BJ 1.74 for the Passive Fill (upper) and Accelerated Fill (lower) scenarios. GW seepage predictions (labelled Portal Discharge in the figures) for the two scenarios are also shown in the plots.

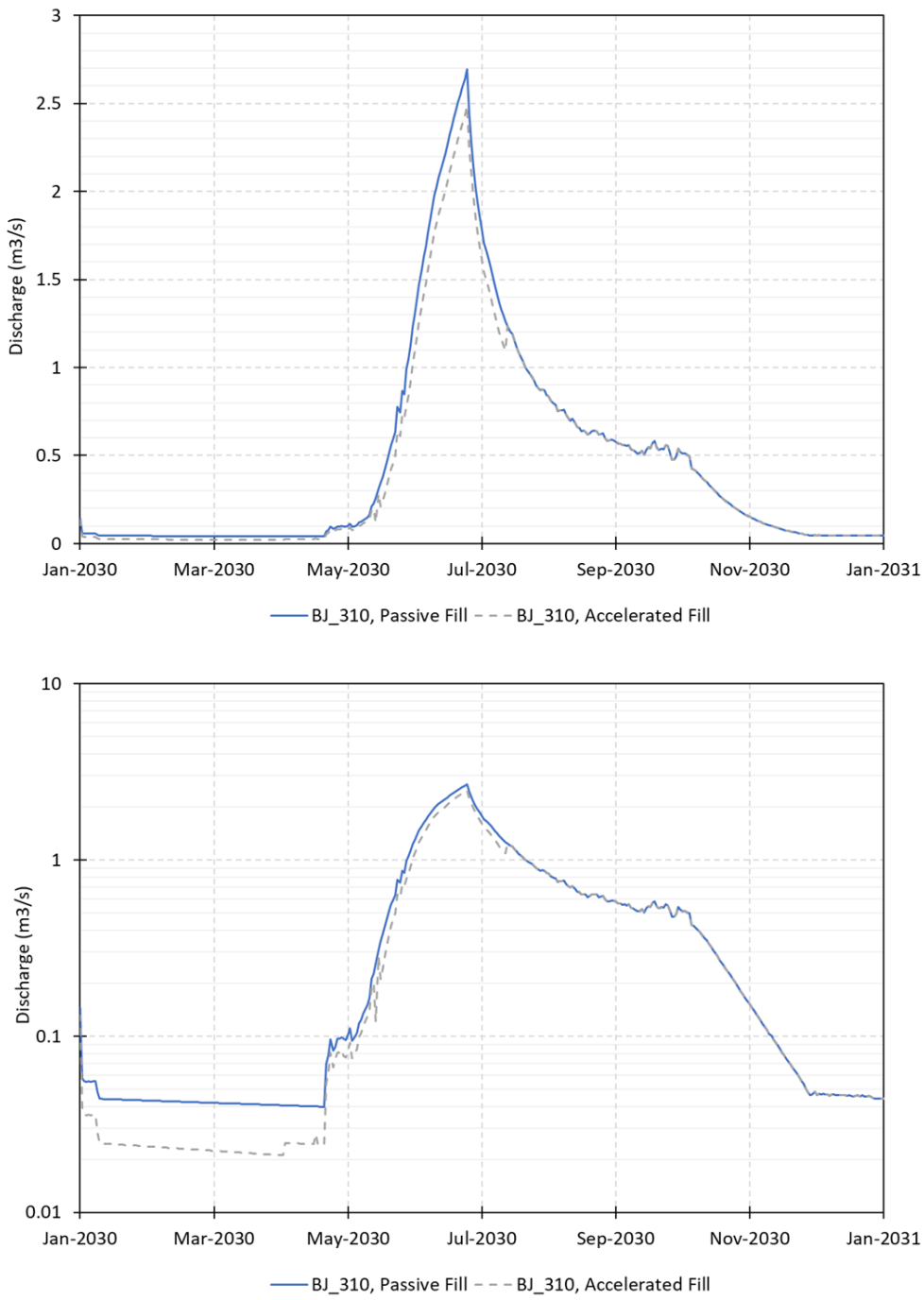


Figure 4-33: Comparison of streamflow conditions at BJ 3.10 for the Passive Fill and Accelerated Fill scenarios for 2030. The upper and lower panel show results without and with log-scaling on the Y-axis.

5. Summary and Conclusions

5.1 Review of Study Objectives

The objectives of the study are outlined in Section 1.3. Using the 2020 WBM as a basis (Lorax, 2020), Objective 1 is to develop a revised WBM that supports an updated water quality model (WQM) as required for the 2023 4950 tpd permit application. Note the revised WQM is described in full under separate cover (Lorax, 2023b). Objective 2 is to review and present the data used to support development of the revised site-wide WBM, including inputs from an updated mine plan, relevant monitoring studies, design/engineering studies, and operational water monitoring datasets. Key information is presented in Section 2 and Section 3 of this report.

Objective 3 of the study is to describe the WBM architecture and outline all relevant inputs and assumptions within the model. Material presented in Section 3, including GoldSim wire diagrams and representative model outputs, address this study objective. Objective 4 aims to discuss the calibration approach and present calibration results for the WBM. This objective is also addressed in Section 3, where outputs are presented to demonstrate model performance at both the watershed-scale (*i.e.*, BJ 3.10, Brucejack Creek below the WRTSF), as well as at the spatial extent of the mine site (*i.e.*, WTP and mill complex).

Objective 5 is to present and synthesize the results from the GoldSim WBM model. Section 4 of the report is dedicated to the presentation of the study results. As part of this exercise, results are presented for operations (2022-2029) and closure/post-closure (2030-2050 time periods. And finally, Objective 6 and the aim of Section 5 of the report is to summarize study results, discuss model sensitivities, identify data gaps and outline recommendations for future modelling studies.

5.2 Summary of Revised Model

A revised WBM has been developed for the Brucejack Mine. The model runs on a daily time step and is constructed using GoldSim software, which is the same platform used by the WQM. The WBM incorporates monthly mine plan data and schedules for ore processing, and accounts for placement of tailings in the underground mine as paste backfill and the placement of tailings and waste rock in the WRTSF.

The WBM is driven by a daily climate record of air temperature and precipitation measurements. Results are presented in Section 4 for a Base Case which uses measured climate data for 2015-2021 and daily average climate conditions thereafter. However, the model can read climate data inputs in other ways, including read-in of daily varying climate data and incorporation of climate change scenario data. The generation of runoff from

background catchments and select mine site footprints is computed within the model using daily climate data and a three-reservoir (*i.e.*, event flow, interflow, baseflow) watershed model, which has been calibrated to the instrumental record for hydrometric stations located within the Brucejack Creek watershed.

The model has been populated with measured data for the pre-2022 time period. This includes for example, climate data from the VOK climate station, streamflow data from baseline monitoring stations, measured data for the underground mine (*e.g.*, water use data, GW inflow data, sump pumping records), WRTSF bathymetry data and measured records of waste rock and tailings (volumes, tonnages) for materials already placed in the WRTSF. This means that for a calibration period of 2015-2021, results from simulations can readily be compared to measured water balance data. To the extent possible, the WBM is calibrated, or results are compared directly to, operational water monitoring datasets and previous studies.

5.3 Key Findings

5.3.1 Operations (2022-2029)

A generalized schematic of the site-wide water balance is presented in Figure 4-1, which summarizes annual average results (in m^3/hr) for a Base Case. Ore processing assumptions for the Base Case are presented in Table 3-5. At daily time step, the Base Case was computed using measured climate data for 2015-2021 and averaged daily climate inputs for 2022 onward. As a complement to Figure 4-1, text and figures presented throughout Section 4.4 provide the reader with a fulsome breakdown of WBM results.

For the Base Case, model results suggest a robust water supply is maintained at the mill with the existing water management system and allowable WRTSF reclaim volumes. The supply is maintained by underground dewatering flows, a combination of runoff from the CWCS and stored volumes within the CWP, recycling of water within the mill and diversion of water from the BJ 3.10 weir up to permitted allowances. Supply provided from reclaim is essentially fixed with the maximum allowable diversion being a cap at 70 m^3/hr, which is approximately 50,000 m^3/month. Supply in the form of contact water, captured by the CWCS, shows strong seasonal variability. Contact water volumes report through the collection system mainly following snowmelt and large rainfall events, noting that supply is not reliable from the CWCS in cold months. Supply provided by pumping from the underground mine is also seasonally variable, with winter again being the period when volumes are at a minimum, on an annual basis.

To meet demand at the mill through the winter, a general strategy adopted since operations began has been to operate the CWP at high stage/volume, which requires a fill period that

is scheduled in late autumn. Stored volumes within the CWP can then be sent to the mill (via the WTP and FWT), which complements the available supply, and prevents water deficit and upset from occurring within the processing circuit. WBM results can be audited for Base Case, or separate sensitivities *(e.g.*, groundwater recharge, variable climate), for indication of water deficit or depletion. For the Base Case, key indicators of the water balance including the CWP, FWT and mill Circuit showed stable and expected conditions which is evidence that water supply exceeded demand for the LOM simulation.

It is important to note that model predictions for GW inflow (to the underground mine) show an increasing trend with time, as the mine is built out to full extent. Annual minima in GW inflow are predicted to increase over LOM, which in concept, reduces water supply 'pressure' as the development timeline progresses. It will be important to periodically review GW inflow measurements and cross-compare these data to outputs from the GW model to ensure inflow rates are increasing over LOM, as predicted. It is also worth noting that the Base Case assumes the solids content of tailings and paste backfill is 60% by weight. The solids content of the tailings and paste backfill is subject to a degree of operational variability and results presented in Section 4 show mill water demands are sensitive to these operational parameters.

The WBM was configured using recent monitoring data. Measured data were relied upon extensively to describe, for example, seasonal staging of the CWP, modelled assumptions for reclaim diversions, pumping instructions from the CWP to the WTP, and the management of water at the TWT to either the CWP or the Brucejack WRTSF, within the WBM.

5.3.2 Closure and Post-Closure

A water balance summary is provided for the Brucejack Mine for the closure and post-closure phase (Figure 4-2, Figure 4-30, Figure 4-31, Figure 4-32, Figure 4-33). The model assumes the mine site, including the mill, access roads and related laydowns/pads, are reclaimed, with any runoff from these footprints assumed to report passively to either the WRTSF or Brucejack Creek below the BJ 3.10 weir. Under the closure and post-closure scenario, the STP and WTP are also assumed to be decommissioned.

With respect to flooding of the mine pool, the study reports on two filling scenarios: Passive Fill and Accelerated Fill. Simulation work indicates passive filling of the mine will take place over a period of approximately 20 months. Once filled, the mine pool will have an estimated volume of 1.54 Mm^3, with maximum elevation of the mine pool estimated to be 1,401 masl. Based on the associated WQM study (Lorax, 2023b), the Accelerated Fill scenario has been incorporated in the current closure plan presented in the Brucejack Mine

4950 tpd MA/EMA permit amendment application (Pretium, 2023) and includes recirculation of the mine pool (to the WTP) for a period of 15-months.

Following filling, contact water fluxes generated from the flooded mine are simulated to range seasonally between 10 L/s and 23 L/s, averaging 14.9 L/s annually (Figure 4-31). This is 5 L/s higher than what was predicted by the 3,800 tpd model and is attributed to expansion of the mine extents. Approximately 95% of contact water reports to Brucjack Creek above BJ-2.62, of which approximately 10% reports to the WRTSF. A further 4% of contact water reports to Brucejack Creek between BJ-2.62 and BJ-1.74. About 1% of contact water reports below BJ-1.74.

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Appendix A: Brucejack Mine Water Balance Model - Development Sequence and Schedules

To represent past and future development sequences and schedules within the Goldsim WBM, the schedules presented in Table A.1-1, Table A.1-2, Table A.1-3, Table A.1-4 and Table A.1-5 are used for the 4950 tpd case. For the pre-2022 period, monthly actuals (*i.e.,* final reported values) are carried forward into the water model. In contrast, for the period 2022-2029, mine plan data presented in Pretium 2022 (*i.e*., 4950 tpd permit amendment) are used in the WBM.

Table A.1:
Life of Mine Ore Production Schedule

	Ore (t/mon)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual (t)**
2017	0	0	0	11,999	47,073	77,022	87,024	88,856	89,510	92,445	89,752	88,775	672,455
2018	84,646	84,907	83,213	77,277	81,876	85,360	81,566	75,611	78,978	85,405	93,140	99,194	1,011,172
2019	97,130	96,037	99,388	105,801	113,420	101,573	99,805	109,664	114,901	122,337	126,566	117,503	1,304,125
2020	109,254	119,821	115,054	107,317	112,122	103,843	101,813	115,131	121,924	96,535	92,723	120,329	1,315,866
2021	110,791	108,906	112,959	113,479	112,963	104,180	113,485	121,289	122,454	121,624	119,411	119,120	1,380,662
2022	112,295	111,907	115,972	115,848	115,972	115,848	117,811	115,972	115,848	115,972	115,848	119,097	1,388,389
2023	114,827	114,431	118,588	118,460	118,588	118,460	120,468	118,588	118,460	118,588	118,460	132,506	1,430,424
2024	138,540	138,071	143,078	142,924	143,078	142,924	145,346	143,078	142,924	143,078	142,924	149,266	1,715,229
2025	146,261	145,757	151,051	150,890	151,051	150,890	153,447	151,051	150,890	151,051	150,890	153,448	1,806,677
2026	146,265	145,760	151,055	150,893	151,055	150,893	153,450	151,055	150,893	151,055	150,893	153,449	1,806,713
2027	146,262	145,758	151,053	150,891	151,053	150,891	153,448	151,053	150,891	151,053	150,891	149,304	1,802,545
2028	138,100	137,632	142,623	142,470	142,623	142,470	144,885	142,623	142,470	142,623	142,470	148,289	1,709,278
2029	144,806	144,306	149,548	149,388	149,548	149,388	151,919	149,548	149,388	149,548	149,388	78,410	1,715,183

Table A.2:
Life of Mine Paste Schedule

	Paste (t/mon)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual (t)**
2017	0	0	0	0	0	0	0	14,798	13,790	20,323	17,752	11,530	78,193
2018	33,667	23,775	30,217	35,556	43,702	30,053	35,852	25,107	36,446	28,926	33,264	30,426	386,991
2019	34,825	32,530	42,190	36,324	47,720	50,318	34,237	36,365	33,114	34,353	28,149	27,605	437,730
2020	30,533	37,209	44,934	47,065	54,957	42,500	23,492	35,997	51,628	34,714	11,150	18,095	432,274
2021	37,000	33,000	32,000	35,000	26,000	32,000	33,000	41,000	28,000	45,000	33,000	32,000	407,000
2022	39,673	35,833	39,673	38,393	39,673	38,393	39,673	39,673	38,393	39,673	38,393	39,673	467,114
2023	44,231	39,950	44,231	42,804	44,231	42,804	44,231	44,231	42,804	44,231	42,804	44,231	520,781
2024	46,603	42,093	46,603	45,099	46,603	45,099	46,603	46,603	45,099	46,603	45,099	46,603	548,708
2025	48,484	43,792	48,484	46,920	48,484	46,920	48,484	48,484	46,920	48,484	46,920	48,484	570,864
2026	48,546	43,848	48,546	46,980	48,546	46,980	48,546	48,546	46,980	48,546	46,980	48,546	571,588
2027	50,256	45,392	50,256	48,634	50,256	48,634	50,256	50,256	48,634	50,256	48,634	50,256	591,719
2028	57,490	51,927	57,490	55,636	57,490	55,636	57,490	57,490	55,636	57,490	55,636	57,490	676,900
2029	88,863	80,263	88,863	85,996	88,863	85,996	88,863	88,863	85,996	88,863	85,996	88,863	1,046,288

Table A.3:
Life of Mine Tailings Schedule

	Tailings (t/mon)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual (t)**
2017	0	0	0	0	25,351	67,541	76,924	69,538	64,246	67,818	73,569	71,597	516,584
2018	52,433	50,084	56,713	32,965	32,263	46,641	46,835	44,042	46,438	46,770	51,158	59,239	565,581
2019	61,959	52,942	52,235	54,534	60,499	53,970	51,043	66,539	69,410	78,772	87,993	93,050	782,946
2020	68,114	69,892	74,165	49,992	50,154	63,065	65,405	66,630	62,212	80,592	53,798	93,384	797,403
2021	79,000	60,000	82,000	64,000	90,000	65,000	67,000	74,000	86,000	72,000	79,000	82,000	900,000
2022	72,163	65,179	72,163	69,835	72,163	69,835	72,163	72,163	69,835	72,163	69,835	72,163	849,658
2023	70,127	63,340	70,127	67,865	70,127	67,865	70,127	70,127	67,865	70,127	67,865	70,127	825,687
2024	91,371	82,529	91,371	88,424	91,371	88,424	91,371	91,371	88,424	91,371	88,424	91,371	1,075,823
2025	97,179	87,775	97,179	94,044	97,179	94,044	97,179	97,179	94,044	97,179	94,044	97,179	1,144,203
2026	97,121	87,722	97,121	93,988	97,121	93,988	97,121	97,121	93,988	97,121	93,988	97,121	1,143,518
2027	95,409	86,176	95,409	92,331	95,409	92,331	95,409	95,409	92,331	95,409	92,331	95,409	1,123,362
2028	80,045	72,299	80,045	77,463	80,045	77,463	80,045	80,045	77,463	80,045	77,463	80,045	942,471
2029	55,351	49,994	55,351	53,565	55,351	53,565	55,351	55,351	53,565	55,351	53,565	55,351	651,712

Table A.4:
Life of Mine Waste Rock to WRTSF (pre-2022)

	Waste rock volume (m3/mon)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual (m3)**
2014	0	0	0	0	0	0	0	0	0	0	0	8,087	8,087
2015	16,713	16,713	16,713	16,713	16,713	16,713	16,713	16,713	16,713	16,713	16,713	19,552	203,395
2016	23,611	28,054	37,179	42,780	43,778	44,853	50,974	53,987	42,036	36,382	40,338	25,422	469,395
2017	11,179	14,672	10,911	8,488	12,785	16,285	18,476	19,185	18,348	18,041	17,901	18,360	184,632
2018	18,509	19,985	23,254	24,293	22,258	19,769	20,684	20,744	21,952	23,545	22,997	22,800	260,791
2019	20,736	21,840	23,254	22,452	21,989	21,199	22,987	23,405	22,836	24,240	26,061	25,052	276,050
2020	22,337	21,223	21,223	25,917	30,065	29,137	28,266	26,816	26,259	25,737	24,832	19,406	301,218
2021	13,125	15,892	17,220	16,172	18,556	17,347	18,579	17,197	14,921	17,117	16,791	8,879	191,796

Table A.5:
Life of Mine Waste Rock to WRTSF (post-2022)

	Waste rock volume (m3/mon)												
Year	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual (m3)**
2022	27,257	24,619	27,257	26,377	27,257	26,377	27,257	27,257	26,377	27,257	26,377	27,257	320,926
2023	26,919	24,314	26,919	26,051	26,919	26,051	26,919	26,919	26,051	26,919	26,051	26,919	316,949
2024	29,725	26,848	29,725	28,766	29,725	28,766	29,725	29,725	28,766	29,725	28,766	29,725	349,984
2025	8,616	7,782	8,616	8,338	8,616	8,338	8,616	8,616	8,338	8,616	8,338	8,616	101,444
2026	1,578	1,425	1,578	1,527	1,578	1,527	1,578	1,578	1,527	1,578	1,527	1,578	18,578
2027	896	809	896	867	896	867	896	896	867	896	867	896	10,551
2028	4	4	4	4	4	4	4	4	4	4	4	4	48
2029	471	425	471	455	471	455	471	471	455	471	455	471	5,540

Appendix 5-3: 4950 tpd Water Quality Model Report

Brucejack Mine: 4950 tpd Water Quality Model Report

June 6, 2023

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Authorship

This update to the Brucejack Gold Mine Water Quality Model was prepared by Lorax Environmental Services Ltd. (Lorax) for Pretium Resources Inc. (Pretium). The report was written by Alison Shaw, Ph.D., P.Geo.; Patrick Mueller, B.Sc., P.Chem.; Robert Goldblatt, B.Sc., RPBio; John Dockrey, M.Sc., P.Geo.; and reviewed by Alison Shaw, Ph.D., P.Geo. Lorax Environmental Services Ltd. has relied on information available in scientific literature and information supplied by Pretium in preparing this report.

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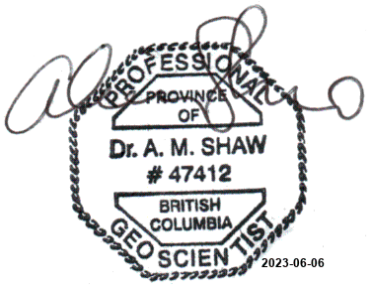

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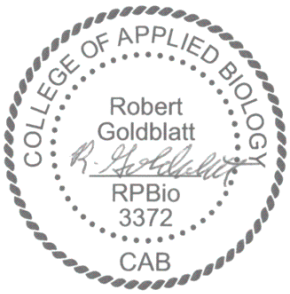

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List of Acronyms and Abbreviations

ABA	Acid Base Accounting
BLM	Biotic Ligand Model
CCME	Canadian Council of Ministers of the Environment
CMP	Chemical Management Plan
CWP	Contact Water Pond
DOC	Dissolved Organic Carbon
EIS	Environmental Impact Statement
EC20	Concentration causing a 20% effect in a chronic toxicity test
EMA	*Environmental Management Act*
FWAL	Freshwater Aquatic Life
LOM	Life of Mine
MA	*Mines Act*
MA & EMA	Brucejack Gold Mine Project: Application for *Mines Act* and *Environmental Management Act* Permits
MDL	Method Detection Limit
ML/ARD	Metal Leaching/Acid Rock Drainage
NMP	Nitrogen Management Plan
NPAG	Non-Potentially Acid Generating
NPR	Neutralization Potential Ratio
PAG	Potentially Acid Generating
PF	Powder Factor
PHREEQC	Computer Program for Geochemical Calculations
POC	Parameter of Concern
POPC	Parameter of Potential Concern
SAG	Semi-Autogenous Grinding
SFE	Shake Flask Extraction
STP	Sewage Treatment Plant
TPD	Tonnes Per Day
TSS	Total Suspended Solids
WQG	Water Quality Guideline
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant

1 Introduction

This report presents water quality predictions for Brucejack Mine under an increased production rate scenario. Brucejack Mine is an underground mine operation which is owned and operated by Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies (Newcrest). The mine is located approximately 60 km NNW of Stewart, B.C and began construction in September 2015 with gold production commencing in July 2017. This report has been prepared on behalf of Pretium in support of an application to amend *Mines Act* (MA) Permit M-243 and *Environmental Management Act* (EMA) Effluent Permit 107835 (PE-107835) to allow for an increase to the mine's production rate from average 3800 tonnes per day (tpd) to 4950 tpd.

Brucejack Mine is an underground mine operation with related surface infrastructure including a mill, a water treatment plant (WTP), a contact water pond (CWP), a waste rock and tailings storage facility (WRTSF), and a sewage treatment plant (STP) (Figure 1-1). Based on the proposed increased production rate, the total mine operating life is estimated to be 12.5 years.

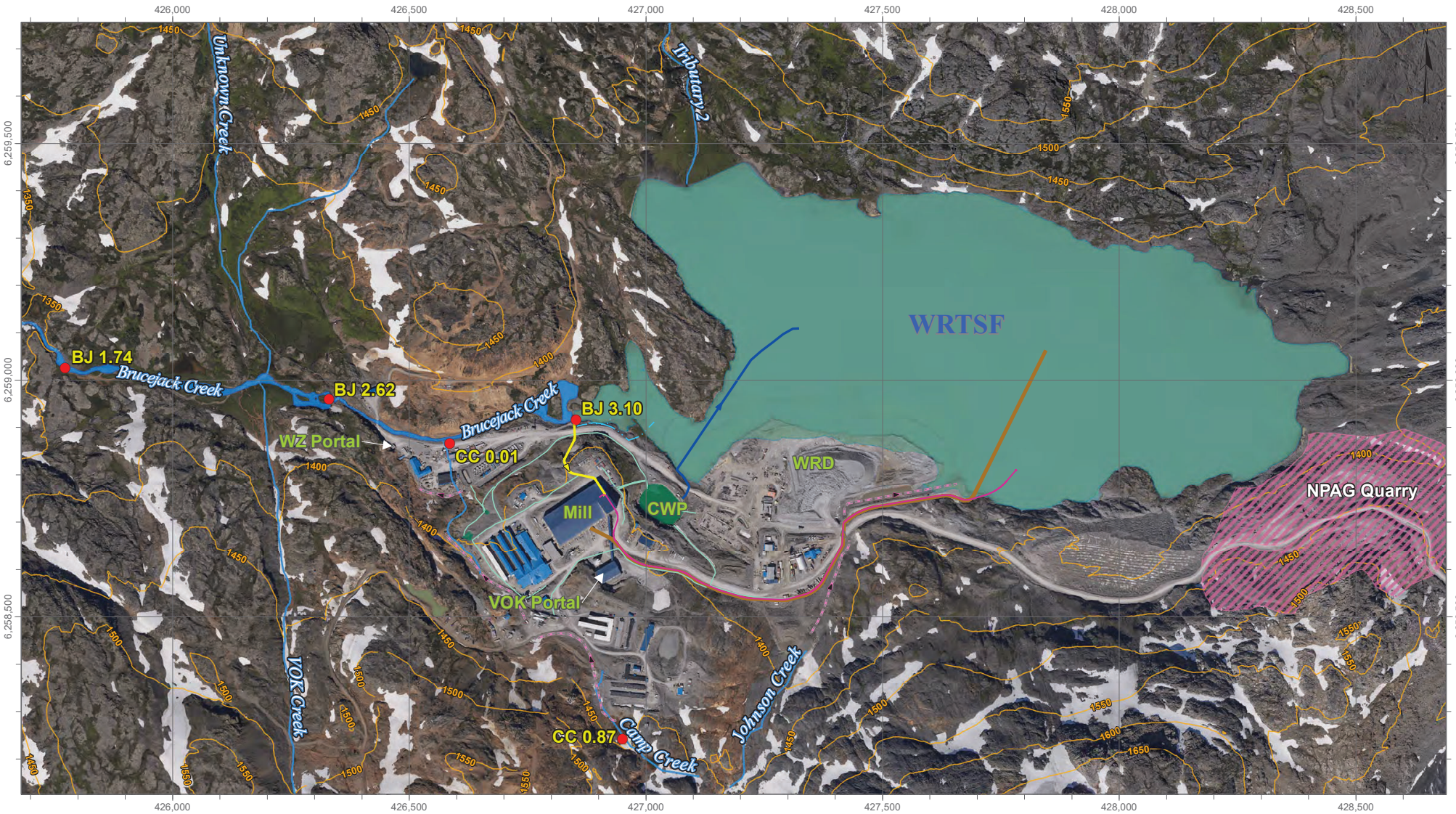
The water quality model predicts how mining activities at Brucejack Mine will influence water quality in the receiving environment through life of mine (LOM) and into the post-closure phase, considering Base Case and Upper Case geochemistry conditions. Water quality predictions are provided for two stations: 1) BJ 3.10, the mine's regulated WRTSF discharge location; and 2) BJ 2.62, a downstream monitoring location in Brucejack Creek which will receive underground mine loads via groundwater pathways once the mine has been flooded following closure (Figure 1-1).

This report describes revisions to Brucejack Mine's water quality model that were made subsequent to the 2015 *MA & EMA* Permits Application (Pretium 2015) and following additional model revisions made in support of subsequent permit amendment applications for increased nitrite and nitrate discharge limits (submitted November 2016), co-deposition of water treatment plant sludge with tailings (submitted January 2017), extension of the PAG waste rock exposure time criterion (submitted January 2017), approval of an updated Cr Management Plan (submitted February 2017), and increased ore production rate of 3800 tpd (submitted April 2018 and referred to as the 2018 model). The water quality model was reviewed and updated in 2020 (Lorax 2020a) as part of the 5 Year Mine Plan and Reclamation Program Update (Pretium, 2020c).

The revised water quality model incorporates changes to the mine plan schedules, updated source terms based on experimental and operational data collected since 2015, an updated groundwater model (Lorax, 2023a) and a revised water balance model (Lorax, 2023b).

The objectives of this report are to:

- Describe the water quality model and outline all relevant inputs and assumptions within the model (Section 2).
- Present the water quality model source terms (*i.e.*, inputs) and any revisions made based on new monitoring or experimental data sets (Section 3).
- Present water quality model results as compared to previous model results, and relevant water quality guidelines and discharge limits (Section 4).
- Present an aquatic effects assessment for model results that are higher than previously assessed (Section 5).
- Summarize the 4950 tpd water quality model results and the results of the associated effects assessment (Section 6).



LEGEND

- Water Quality Monitoring Station
- WTP/STP Effluent Line
- Reclaim Water Line
- Tailings Discharge Lines
- CWP Direct Discharge Line
- Non-Contact Water Channel
- Contact Water Collection
- NPAG Quarry
- Contact Water Pond
- Brucejack Creek
- WRTSF
- Contours (50m)

DATE SAVED:	Dec 01, 2022
DRAWN BY:	DM
REVIEWED:	RB
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:7,500

0 125 250 Meters

CLIENT: NEWCREST BRUCEJACK; LORAX ENVIRONMENTAL

PROJECT:

4950 tpd Amendments Application

TITLE: Brucejack Mine Site Infrastructure and Water Quality Monitoring Stations

PROJECT #: A624-4

FIGURE: 1-1

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2 Modelling Approach and Assumptions

This chapter describes the approach and assumptions for the Brucejack Mine water quality model. A detailed description of the water quality model is presented, followed by a summary of updates to the model as compared to the 2020 model (Lorax, 2020a).

2.1 Water Quality Model

2.1.1 Overview

The Brucejack Mine water quality model employs a mass balance approach that accounts for background water quality and runoff volumes reporting from undisturbed portions of the Brucejack Creek watershed, as well as chemical loads emanating from mine sources (*e.g.*, underground workings, waste rock, tailings discharge) and water management structures (*e.g.*, Contact Water Pond (CWP), the water treatment plant (WTP) and the sewage treatment plant (STP)). Loads associated with solids such as deposited waste rock, explosive-related nitrogen species and tailings, were pre-determined and input directly to the mass balance calculations. Each component of the existing environment and mine site area that may contribute to water quality at the outlet to the WRTSF (BJ 3.10) and at Brucejack Creek monitoring station BJ 2.62 has been included in the water quality model.

Background water quality signatures are derived from pre-construction monitoring (ERM Rescan, 2014), while mine-related water quality signatures are based on geochemical source terms as described in Section 3. The water quality model was constructed following the structure of the mine's water balance model (Lorax, 2023b) which incorporates the results of an updated groundwater model (Lorax, 2023a). The water balance model tracks all background and mine-impacted waters that report to the waste rock and tailings storage facility (WRTSF) and various monitoring sites along Brucejack Creek. An overview of the water balance is provided in Section 2.1.5, with additional information on derivation of the water balance provided in the water balance model update (Lorax, 2023b).

The water quality model assumes the WRTSF is vertically stratified for most of the year, but fully mixed during the month of October when the lake experiences temperature-driven turnover events. This assumption is supported by lake profiling data collected through monitoring programs developed for the WRTSF (described in Section 2.1.8).

As for the water balance model, the water quality model was developed in GoldSim; a flexible, object-oriented software tool that is designed for carrying out dynamic, probabilistic simulations of complex systems. GoldSim can be applied to deterministic simulations in which all inputs are pre-determined by the user. This approach was used to

predict water quality concentrations at mixing locations within the conceptual flow networks defined for each of the specified mine phases.

The model uses monthly time steps throughout the duration of mine life and includes the following:

- Construction phase: 21 months, from September 2015 through May 2017, which corresponds to the two-year construction phase;
- Operations phase: 151 months, from June 2017 to December 2029;
- Closure phase: 36 months, from January 2030 to December 2032, which corresponds to the estimated timing and duration of the closure phase; and
- Post-closure phase: 192 months, from January 2033 to December 2049, which corresponds to the first 16 years of the post-closure period.

Site data acquired through to the end of 2021 have been used to update the water quality model. The water quality model results presented in this report cover the operations, closure and post-closure phases from January 2022 through to the end of December 2049. Loadings associated with construction and mining activities prior to January 2022 have been incorporated into the model since a portion of these loads will impact water quality of the WRTSF (as determined by the residence time in the WRTSF, which is estimated to be approximately 18 months).

The model generally follows a mass balance approach and assumes that no mass is lost through geochemical reactions or natural biogeochemical processes. A notable exception is for underground mine water where secondary reactions are incorporated into the source terms for certain parameters, as described in Section 3.4.3. In the WRTSF, various natural biogeochemical mechanisms are expected to attenuate trace element and nutrient concentrations (*e.g.*, biological uptake of nitrogen and phosphorus, as well as metal scavenging by particles). Attenuation processes are not modelled, but the distribution of nitrogen among inorganic species (*i.e.,* ammonia, nitrite and nitrate) is adjusted to account for nitrification processes that occur naturally in WRTSF.

2.1.2 General Site-Wide Mitigations

Water quality predictions presented in this report assume implementation of several mitigation strategies. For the purpose of water quality modelling, it is assumed that the mitigations will be effective as intended. These mitigations include:

- A Sewage Treatment Plant (STP) which treats grey and blackwater from the mine site facilities to effluent quality discharge requirements throughout life of mine (LOM). Treated water is discharged to the WRTSF;

- Management of contact water, via collection ditches, pipelines and related structures, as per the OMS Manual - Water Management Plan (SRK, 2020);
- A Water Treatment Plant (WTP) which treats underground seepage and surface contact water from the site contact water collection system to effluent quality discharge requirements throughout LOM. Treated water is discharged to the WRSTF or is recycled in the mill and mine water supply;
- Management of potentially acid generating (PAG) waste rock through deposition of waste rock into the WRTSF. It is assumed that suspended sediments associated with the waste rock will continue to largely settle in the lake, which acts as a natural sedimentation pond. It is further assumed that any sediments remaining in suspension will be managed using the sediment control curtains;
- Deposition of thickened tailings solids and effluent to the bottom of the WRTSF via a suspended tailings pipeline; it is assumed that fines associated with tailings will continue to remain at the bottom of the lake, similar to natural fine grained sediment;
- Management of blasting-related nitrogen compounds following source control measures and best management practices as outlined in the Nitrogen Management Plan (NMP; Pretium 2022); and
- Management of hexavalent chromium associated with cement use in the underground mine as described in the Chromium Management Plan (CMP; Pretium 2019b).

2.1.3 Mine Plan

The Brucejack Mine water quality model and the associated groundwater and water balance models have been developed based on the 4950 tpd Joint Application mine plan provided to Lorax in September 2022. There are minimal changes in the mine development extents of the 4950 tpd mine plan (presented in Chapter 3 of the 4950 tpd Joint M-243/PE-107835 Amendments Application; Pretium, 2023) compared to those of the 3800 tpd mine plan presented in the 2020 Mine Plan and Reclamation Program Update (2020 Update) submission (Pretium, 2020c). However, because the ore production rate will be higher, the mine life will decrease (with the end of operations planned for 2029 rather than 2032).

The mine schedules used for development of water quality model source terms are presented within the associated source term sections. The model applies actual mine schedules through 2021 and projected schedules for 2022 through 2029.

2.1.4 Groundwater Model

The 4950 tpd groundwater model update is described in Lorax (2023a). The groundwater model provides the following predictions that are used to inform water balance and water quality models:

- Inflows to the underground mine during operations;
- Flooding rates into the underground mine void at closure;
- Time to flood the underground mine void and the ultimate flooded elevation in the mine at closure;
- The timing, volumetric flux and spatial distribution of contact water draining from the underground towards surface water receptors at closure; and,
- Changes in baseflow at surface water receptors during operations and closure.

The 4950 tpd groundwater model is an extension of the 2020 groundwater model prepared for the 2020 5 Year Mine Plan and Reclamation Program Update (Lorax 2020b). The 2020 groundwater model synthesized data collected in multiple field programs executed through the end of 2018. The 2020 model was calibrated to steady-state baseline and transient operations conditions. Baseline calibration targets included annual average water levels and baseflow in Brucejack Creek. The operations phase calibration targets included high resolution groundwater levels and monthly average underground dewatering rates collected between 2011 and 2018, the latter ~3.5 years corresponding to a period of active mining. The 2020 model achieved an acceptable calibration to both steady state and transient targets, capturing both seasonal fluctuations and long-term trends.

The 2020 groundwater model was updated with approximate as-built mine extents, provided by Pretium in annual snapshots, and recent climate data to simulate water levels and underground dewatering rates on a monthly basis for the 2019 to 2021 validation period. The model continued to reasonably simulate data trends over this period, and importantly, reasonably simulate water levels at 2018-series wells where data were previously unavailable. Acceptable model performance over the validation period precluded the need to recalibrate hydraulic parameters prior to implementing the 4950 tpd mine plan.

The 4950 tpd mine plan was provided by Pretium and included developments planned for the remaining life of mine (2022 through 2029). The 4950 tpd mine plan was implemented on a monthly time step to capture the seasonality of underground dewatering rates for future operations. Per the as-built operations simulations, stopes were simulated as actively dewatered for one month followed by waste rock or paste backfill the following month. All

developments were kept open for the duration of operations. The groundwater model assumed that dewatering would conclude at the end of mining in 2029.

The 4950 tpd groundwater model simulates the closure period in two phases. The closure simulations assume that underground developments will remain open with plugs installed at the West Zone and VOK portals. The developments were reconfigured to accurately represent the volume of mine void and were assigned a high hydraulic conductivity (*i.e.*, a low resistance to flow) to enable the development of a flat water table across the mine void at closure.

The first phase of closure simulations comprised a series of steady-state model runs to develop an inflow rate versus mine pool elevation curve. This was used in tandem with the mine volume elevation curve to compute mine reflooding time. These simulations also revealed the mine pool elevation at which contact water from the mine starts to reach Brucejack Creek and contact water volumetric flux.

The second phase of closure simulations represents long-term closure when the mine pool has reached its equilibrium elevation. This was simulated as a transient run lasting five years, progressed on a monthly time step. This simulation captures seasonality in both the underground flooded elevation and contact water fluxes to Brucejack Creek.

2.1.5 Water Balance Model

The water balance model for the Brucejack Mine has been updated based on a review of site operations and plans and is presented in Lorax 2023b. The water balance is a detailed interpretation of the mine and water management plans, with consideration of baseline and operational climate, hydrometric, and hydrogeological data collected for the mine site area (*i.e.*, the area that comprises all mine infrastructure within the Brucejack mining leases). The section below presents an overview of the water balance developed by Lorax which has been integrated into the water quality model described above.

The water balance for the Brucejack Mine was derived using information from the following sources:

- Site and regional climate data and local streamflow data (*i.e.*, BJ 3.10, BJ 1.74) spanning the baseline, construction, and operations phase;
- Drainage areas, glacier extents and runoff coefficients;
- Mine schedules for waste rock, ore and tailings consistent with annual reporting through to the end of 2021 and the 4950 tpd mine plan (presented in Chapter 3 of the 4950 tpd Joint M-243/PE-107835 Amendments Application; Pretium, 2023);
- Underground mine design and mill feed rates;

- Estimated groundwater inflows and seepage rates for the underground mine as presented by Lorax (2023b); and,
- Operational water monitoring datasets, including data describing the underground mine water use (drilling, dust suppression), process plant water use and freshwater make-up requirements, tailings density and properties.

The water quality model results presented in Section 4 use measured climate data inputs for the pre-2022 time period; whereas, simulated average daily climate values are applied for the subsequent time period. The simulated data were developed from a 30-yr portion of the PNWNAmet daily- gridded dataset, and continuously looped, for the duration of the simulation; PNWNAmet data spanning the period 1983-2012 are used to generate the average daily air temperature and precipitation inputs. Measured and synthetic climate data used in the modelling analysis are discussed further in Section 2.3 and Section 3.2 of (Lorax, 2023b).

The water balance configurations for the operations and post-closure phases used to develop the water quality model are illustrated in Figure 2-1 and Figure 2-2 respectively.

The following are the main water management components represented in the water balance model for the operations phase:

1. A contact water pond (CWP) which is assumed to receive approximately 60% of surface runoff from the mine site contact water collection system (primarily the mill and camp pads). This water is pumped to the WTP for treatment. The remaining 40% is assumed collection system leakage that reports directly to the WRTSF or Brucejack Creek below the WRTSF;
2. Dewatering from the underground mine, which includes groundwater inflows, paste backfill bleed water (*i.e.*, the excess water not consumed in the paste backfill cementation reaction) and water from the Freshwater Tank that is directed to the underground mine to support drilling/dust suppression activities, then captured in mine sumps;
3. The water treatment plant (WTP), which treats water from the CWP and the underground mine. The treated effluent is used in the mill process, with any excess not required for process discharged to the WRTSF, or re-cycled back to the CWP;
4. Discharge of effluent from a sewage treatment plant (STP) to the WRTSF;
5. A mill which discharges a tailings slurry to the WRTSF and pipes paste backfill to the underground mine;

6. The conveyance of contact flows from the NPAG Quarry and the waste rock platform to the WRTSF via surface runoff; and
7. Deposition of waste rock subaqueously in the WRTSF and to the underground mine as backfill.

The operations phase components of the Brucejack Mine are summarized in Figure 2-1, along with other water inflows and losses relevant to the WRTSF and receiving stream nodes (*i.e.*, BJ 3.10, BJ 2.62 and BJ 1.74). Over the course of a year, monthly average discharges from the WRTSF during operations are expected to range from 0.05 to >1.5 m^3/s. Outflow from the WRTSF includes runoff from background/contact sub-catchments reporting to the facility, as well as contributions of water displaced by the deposition of waste rock and tailings solids. Total lake water volume capacity at the start of operations is approximately 28.5 Mm^3 and is reduced to 21.0 Mm^3 at the end of operations.

At closure, mine facilities will be decommissioned, and the underground mine workings will be flooded, starting in January 2030. The natural flooding from groundwater inflows will be accelerated by pumping water from the WRTSF into the underground mine at a rate equal to 70 m^3/hr (~ 50,000 $m^3/month$) between January and April and then at an increased rate equivalent to 20% of the mean monthly flows at BJ 3.10 during May, June, and July. Underground mine water will be treated by the WTP at a rate of 10,000 m^3/day and recirculated back underground throughout the flooding time period as well as for an additional eight months to ensure that water quality is effectively managed.

The reconfiguration of flows and the associated water management plan during closure is reflected in the post-closure water balance illustrated in Figure 2-2. The post-closure water balance includes the following mine-related components:

- Flows from the NPAG Quarry;
- Flows from the reclaimed plant site; and
- Drainages from the underground mine which flow to the WRTSF and Brucejack Creek via groundwater pathways.

In addition to accounting for mine-related loads, the water quality model predictions incorporate contributions from Camp Creek and other non-contact runoff surrounding the mine site.

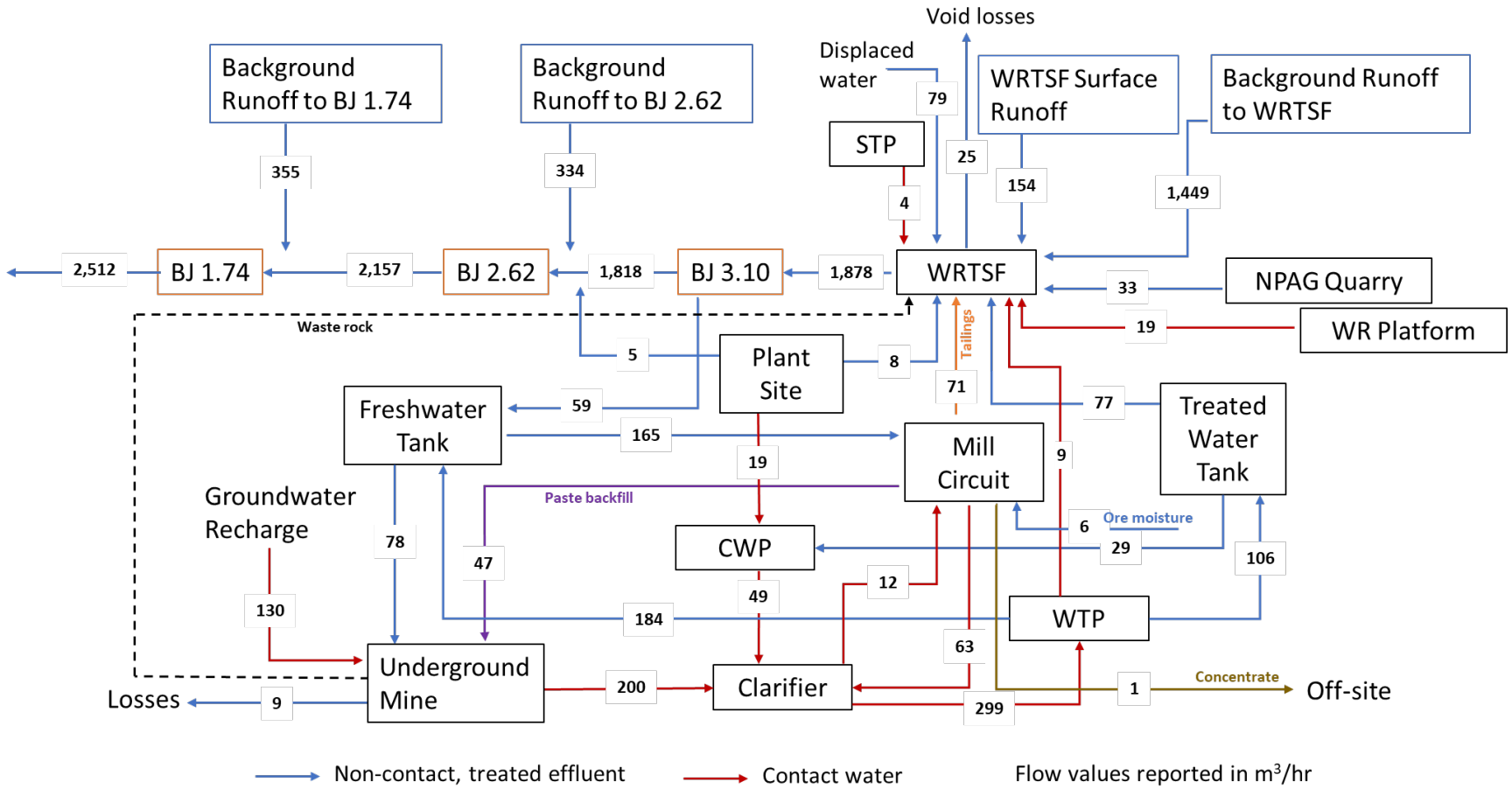


Figure 2-1: Brucejack Mine Water Balance Model schematic for the operations phase, 2022-2029 (from Lorax 2023b).

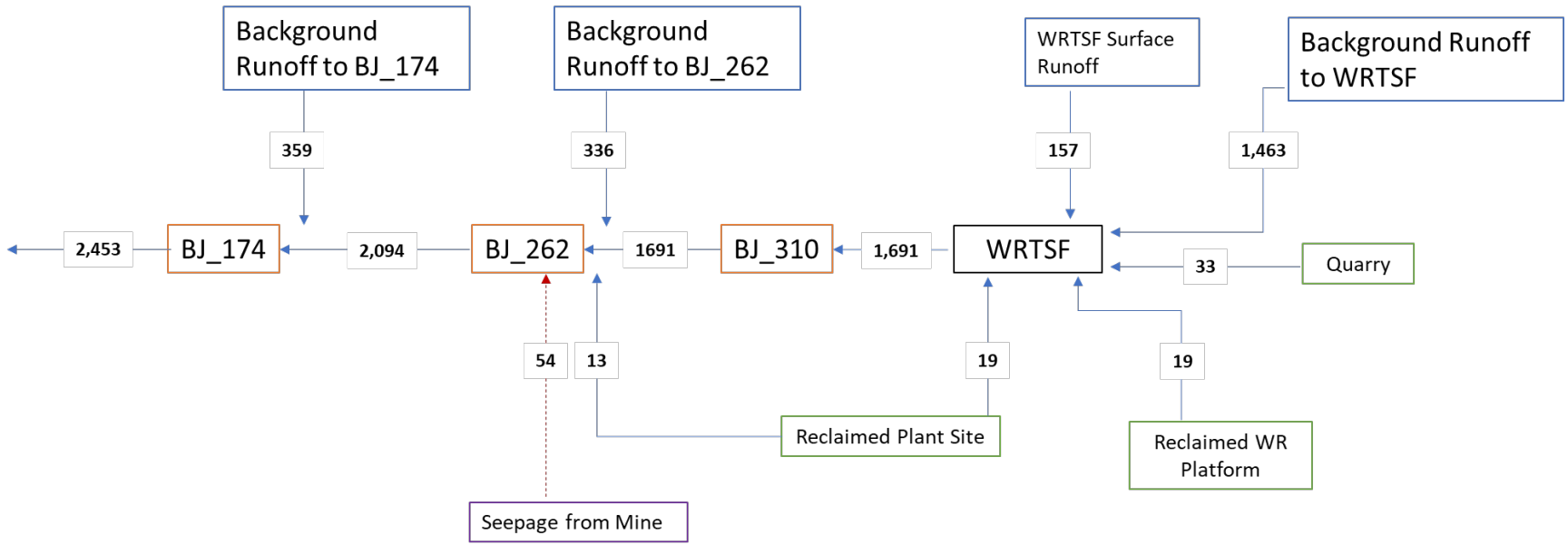


Figure 2-2: Brucejack Mine Water Balance Model schematic for the post-closure phase, 2030-2050 (from Lorax 2023b).

2.1.6 Modelling Locations and Parameters

Water quality predictions are generated for two locations:

- BJ 3.10, located at the outlet of the WRTSF (Figure 1-1); and
- BJ 2.62, a monitoring station in Brucejack Creek, located downstream of the WRTSF.

During the operations phase, mine-affected inputs are directed to the WRTSF. Monitoring station BJ 3.10 at the WRTSF outlet is the mine's final discharge compliance location where WRTSF discharge limits specified in PE-107835 apply.

During the post-closure phase, once the mine is flooded, the majority of groundwater flow paths from the underground mine discharge to the upper reaches of Brucejack Creek between the WRTSF outlet and BJ 2.62. Monitoring station BJ 2.62 is located at the bottom of a cascade downstream of the WRTSF and Camp Creek; the cascade is expected to result in fully-mixed conditions upstream of BJ 2.62. BJ 2.62, therefore, represents a key location for the post-closure water quality predictions.

Water quality predictions were generated for the parameters listed in Table 2-1, including major ions representative of mine-related inputs and all parameters with BC freshwater aquatic life (FWAL) guidelines. Neither pH nor TSS was modelled, as they depend on a wide range of factors that are not fully accounted for in the mass loading approach.

Table 2-1:
Water quality parameters included in the Brucejack Mine Water Quality Model

Parameter	Formula
Major Anions	
Ammonia (as N)	NH_3-N
Nitrate (as N)	NO_3-N
Nitrite (as N)	NO_2-N
Chloride	Cl^-
Fluoride	F^-
Sulfate	SO_4^{2-}
Phosphorus	P
Metals (Total and Dissolved)	
Aluminum	Al
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Bismuth	Bi
Boron	B
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Molybdenum	Mo
Nickel	Ni
Phosphorous	P
Potassium	K
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Strontium	Sr
Thallium	Tl
Tin	Sn
Titanium	Ti
Uranium	U
Vanadium	V
Zinc	Zn

2.1.7 Water Quality Modelling Cases

Water quality predictions through operations, closure and post-closure mine phases were generated for a Base Case and an Upper Case. The Base Case represents an expected condition, whereas the Upper Case applies upper case geochemical source terms to all mine-related inputs to the model. Both cases are based on average flow conditions for all flows. Additional model sensitivities were assessed in previous water quality models, as described below.

The 2015 *MA & EMA* Permits Application water quality model (Pretium, 2015) evaluated the sensitivity of the water quality model to elevated geochemical source terms, elevated background, elevated TSS inputs from Camp Creek, a permanently stratified lake system and elevated hydraulic conductivity in the surrounding bedrock. The water quality model results showed that the model was relatively insensitive to most of these variables, with the exception of the geochemical source terms.

The 2018 water quality model (Lorax, 2018) assessed the influence of upper case geochemical sources terms, in addition to two different waste rock and tailings management strategies. The first strategy evaluated considered a scenario where all waste rock is placed in the WRTSF (Scenario 1), whereas the second scenario maximized the amount of waste rock placed as backfill in the underground mine (Scenario 2). The water quality predictions for the two scenarios showed similar trends with most parameters showing only minor differences.

Based on an assessment of previous water quality model sensitivity results, the main area of model uncertainty identified was geochemistry. For this reason, Base Case and Upper Case geochemistry scenarios were carried forward for subsequent water quality models (the 2020 model (Lorax, 2020a) and the model presented herein).

2.1.8 Modelled Vertical Mixing of the WRTSF

Northern lakes are typically dimictic, meaning that the water column becomes fully mixed in the spring and fall due to seasonal changes in surface water temperature. As surface water warms after ice melt it reaches its maximum density at approximately 4 °C. At that temperature, surface water will be more dense than the rest of the water column and sink which causes the whole water column to become mixed. Warming of the surface layer in summer produces a stratified water column, with a warm surface layer on top of a colder bottom layer. In the fall, as the surface layer cools to 4 °C the water column undergoes another period of mixing before ice forms.

This dimictic behaviour is applied to the WRTSF, as observed from the 2019 timeseries of vertical profiles of temperature (Figure 2-3). The temperature profile in late June, after ice

melt, shows that the whole water column had become warmer as the warmer and denser surface water sank. By late July, the water column had become stratified, with warm water in the upper 8 m and 4-5°C through the rest of the water column. By late September, the water column had warmed to approximately 6°C as the water column mixed again before ice formed.

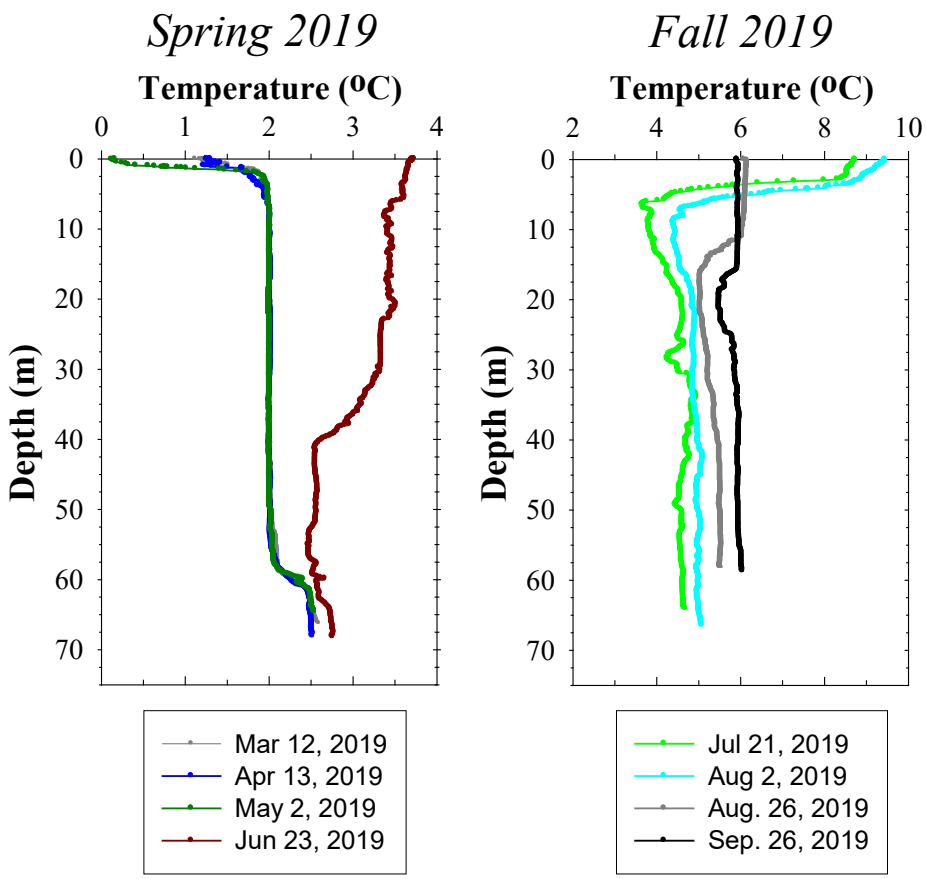


Figure 2-3: Vertical profiles of temperature in the WRTSF during spring and fall of 2019.

Beginning in 2020 the WRTSF no longer underwent a spring turnover. This is likely due to increasing concentrations of total dissolved solids (TDS) in the WRTSF over time, which increases the density of the water. This can be seen by comparing the specific conductance, a measure of TDS, of the deeper portion of the WRTSF in 2019 (~300 µS/cm) to 2020 (~350 µS/cm) (Figure 2-4). In the spring of 2020, when ice on the WRTSF melted and runoff from snowmelt drained to the WRTSF, this created a low-density (low TDS) freshwater lens on top of the higher density (high TDS) water column. While the surface layer density would have increased as it warmed from 0°C to 4°C, the effect of temperature on density was not enough to overcome the density difference between surface and deep water due to TDS; therefore, surface water did not sink to depth in spring. Vertical profiles

of temperature in July of 2019 and 2020 illustrate the differences in vertical mixing between these years (Figure 2-4). In 2019, spring turnover caused the deep water of the WRTSF to increase from 2°C in winter to 4°C in June (Figure 2-3) whereas in 2020, with no spring turnover, the sub-surface layer remained at 2°C in July (Figure 2-4).

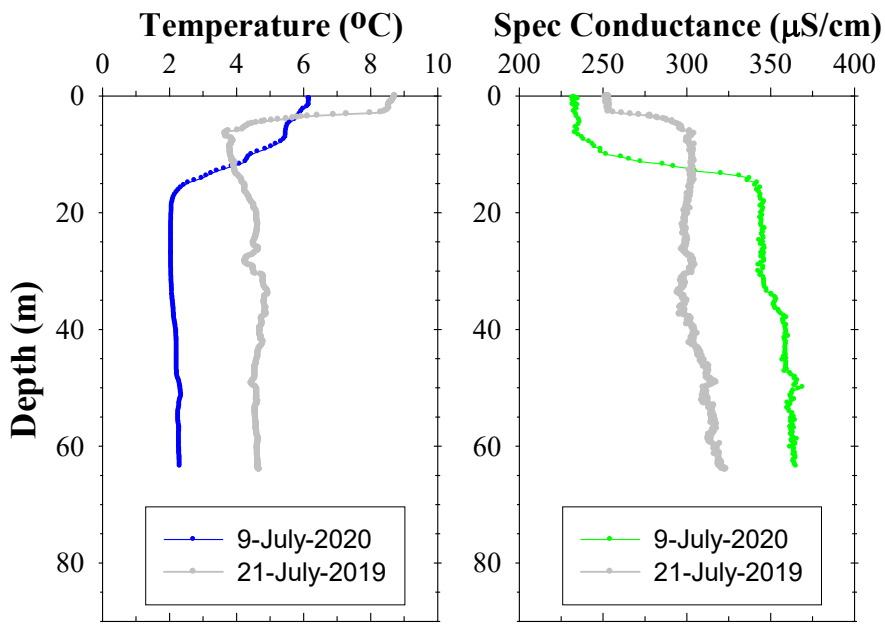


Figure 2-4: Vertical profiles of temperature and specific conductance in the WRTSF during July of 2019 and 2020.

The freshwater lens on the WRTSF in the spring of 2020 mixed with deeper water throughout the summer, which increased the TDS of the surface layer. In the fall, the TDS difference between the surface layer and sub-surface layer was small, which allowed fall turnover to occur when the temperature of the surface layer decreased to 4°C. The same pattern of no turnover in the spring and a turnover occurring in the fall was observed in 2021. Thus, the increase in TDS of the WRTSF over time, caused by placement of waste rock and tailings in the WRTSF, has changed the water body from dimictic to monomictic, with only a fall turnover.

The water quality model, having monthly time steps, previously had the water column fully mixed in July and October and stratified during other months. The base case for the current model is to be fully mixed in October and stratified for all other months. When the water column is stratified the model has two layers. The upper layer is represented by the upper 10 m of the WRTSF and the lower layer extends from a depth of 10 m to the bottom of the WRTSF (~58 m depth). The upper 10 m of the WRTSF contains approximately 24% of the total WRTSF volume. Modelled loadings to the surface layer are from background

runoff, uncaptured mine site runoff, and NPAG Quarry runoff. Modelled loadings to the lower layer are from waste rock deposition, WTP discharge, STP discharge, and tailings disposal.

2.2 Summary of Updates to the Water Quality Model

The water quality model has been revised and updated to reflect current operations and plans for future development. The revisions from the last major modelling exercise (Lorax, 2020a) include updates to various source terms based on new data, the incorporation of new terms based on trends observed in the monitoring data sets, changes to the mine plan schedules, and revisions to water management plans.

The major revisions incorporated into the current water quality model include the following:

- An updated groundwater model which has been calibrated to observed flows (Lorax, 2023a).
- Revision to the site's water balance based on observed flows, changes to the mine plan and updated water management plans (described in Lorax, 2023b).
- Revision to assumptions regarding WRTSF mixing behaviour where a spring turnover event is not included in the model beyond 2019.
- Application of operational monitoring results to the background source term for parameters where recent data show lower concentrations than baseline data sets.
- Revision to the source terms applied for surface runoff at the mine site based on site monitoring data for CWP influent.
- Updates to the underground mine water source terms based on new kinetic tests, site monitoring data, and solubility constraints.
- Revision to the tailings source terms based on operational data collected at the Semi-Autogenous Grinding (SAG) mill.
- Refinement of water treatment plant removal efficiencies based on operational data sets.
- Revision to the STP effluent term using operational water quality data sets for all parameters.

3 Source Terms

The Brucejack Mine water quality model incorporates the combined effects of all major background (non-contact) and mine-related (contact) sources. The water quality predictions presented in Chapter 4 are based on source terms developed for the following components:

- Background sources;
- NPAG Quarry runoff;
- Mine site runoff;
- Waste rock and weathered material from surface excavations deposited in the WRTSF;
- Underground Mine waste rock placed in the WRTSF;
- Underground Mine water;
- Water Treatment Plant effluent and solid phase sludge;
- Tailings deposited in the WRTSF and placed in the underground mine as paste backfill;
- Sewage Treatment Plant effluent; and
- Blasting-related nitrogen compounds.

The derivation of source terms for each of these components is described in the following sections. In each case, the approach used to develop source terms is reviewed, along with the predicted parameter concentrations or loadings as compared to data acquired between 2015 and 2021. Source terms developed for the water quality model are based on static and kinetic geochemical data sets, experimental data, as well as operational data sets acquired through the various site monitoring programs.

3.1 Background Water Quality

3.1.1 Overview

Concentrations of non-contact water used in the water quality model were derived from monitoring datasets for BJ 3.10, at the outlet of the WRTSF. Baseline monitoring that occurred in 2011 through 2013 is the primary dataset used for non-contact water (ERM Rescan, 2014). This dataset reflects the cumulative influence of background precipitation, evaporation, groundwater, and surface runoff to the lake, and also accounts for waste rock

deposited in the WRTSF prior to 2013, and any other activity that may have impacted water quality, up to the completion of baseline monitoring in 2013. The baseline data set includes drainage from the Goldwedge Property that reports to the WRTSF via Catear Creek (also known as Tributary 2 (Figure 1-1)) including lakes along Catear Creek where Goldwedge tailings were placed. Water quality data from monitoring conducted by Newhawk between 1987 and 2001 (n = 56 samples) had high method detection limits and a limited number of parameters that were analyzed; therefore, these data were not used for source term development.

The baseline dataset was compared to BJ 3.10 monitoring results from 2017 through 2021 to identify parameters with concentrations that were overestimated by the baseline monitoring dataset. This could result from improved analytical detection limits, or from the larger number of samples in recent monitoring for certain seasons than was possible to collect during baseline monitoring. If the concentrations for a parameter were lower in recent monitoring than in baseline monitoring, then the recent monitoring results were used to derive non-contact water source terms for that parameter. If the concentrations from recent monitoring were higher than from baseline monitoring, then the baseline monitoring results were used to derive non-contact water source terms. Previous water quality models only used baseline monitoring results for deriving non-contact water source terms.

The flows assigned to the non-contact water source terms are based on the water balance model (Lorax, 2023a; described in Section 2.1.5). The background source terms derived from the BJ 3.10 datasets were used for all non-contact water.

3.1.2 Background Source Terms

The monitoring data were grouped into quarters (three-month long periods) to reflect distinctive seasonal hydrologic phases at the site. At the Brucejack Mine, site conditions are most consistent with three-month periods that are shifted one calendar month forward, relative to normal calendar quarters. The background source term values were therefore calculated by applying a “Shifted Quarters” approach using the following time intervals:

- Shifted Quarter 1: February, March, and April;
- Shifted Quarter 2: May, June, and July;
- Shifted Quarter 3: August, September, and October; and
- Shifted Quarter 4: November, December, and January.

Background water quality source terms were calculated from median values for each Shifted Quarter dataset (Table 3-1) and applied to both the Base Case and Upper Case models.

Table 3-1:
Background (Brucejack Lake and Upper Brucejack Creek) source terms for Base Case scenario

Parameter	Shifted Quarter 1 (Feb/Mar/Apr) (mg/L)		Shifted Quarter 2 (May/Jun/Jul) (mg/L)		Shifted Quarter 3 (Aug/Sep/Oct) (mg/L)		Shifted Quarter 4 (Nov/Dec/Jan) (mg/L)	
Anions								
Ammonia (as N)	0.0025		0.0025		0.0025		0.0025	
Nitrate (as N)	0.0025		0.013		0.0052		0.0025	
Nitrite (as N)	0.0005		0.0005		0.0005		0.0005	
Chloride	0.25		0.25		0.25		0.25	
Fluoride	0.01		0.01		0.01		0.01	
Sulfate	9.8		9.2		9		9.6	
Total Phosphorus	0.001		0.0037		0.0036		0.0017	
Metals	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Al	0.01	0.0015	0.099	0.0098	0.12	0.01	0.018	0.0025
Sb	0.00022	0.00021	0.00027	0.00019	0.0003	0.00029	0.00025	0.00025
As	0.00063	0.00057	0.0011	0.00041	0.00083	0.00057	0.00057	0.00052
Ba	0.037	0.036	0.04	0.032	0.04	0.034	0.034	0.034
Be	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002	0.00002
Bi	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025	0.000025
B	0.005	0.005	0.005	0.005	0.005	0.005	0.05	0.005
Cd	0.000005	0.000005	0.000005	0.000005	0.0000068	0.000005	0.0000085	0.0000085
Ca	9.4	9.5	8.4	8.6	9.3	9.1	8.9	9.1
Cr	0.00005	0.00005	0.00005	0.00005	0.00012	0.00005	0.00012	0.00005
Co	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Cu	0.00025	0.0001	0.00025	0.0001	0.00025	0.0001	0.00025	0.00005
Fe	0.011	0.005	0.037	0.005	0.041	0.005	0.015	0.005
Pb	0.000025	0.000025	0.00026	0.000025	0.00019	0.000025	0.00025	0.000025
Li	0.00025	0.00025	0.00025	0.00025	0.0013	0.00076	0.0025	0.0025
Mg	0.31	0.3	0.34	0.29	0.31	0.3	0.3	0.3
Mn	0.0024	0.0019	0.022	0.0087	0.0084	0.0031	0.0029	0.00089
Hg	0.0000025	0.0000025	0.0000025	0.0000025	0.0000025	0.0000025	0.0000025	0.0000025
Mo	0.00037	0.00035	0.00032	0.0003	0.00038	0.00036	0.0005	0.0005
Ni	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
K	0.082	0.077	0.2	0.089	0.29	0.11	1	1
Se	0.00005	0.00011	0.00005	0.00005	0.00009	0.00005	0.0005	0.00005
Si	0.6	0.59	1	0.54	0.88	0.53	0.56	0.55
Ag	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
Na	1	1	1	1	1	1	1	1
Sr	0.063	0.061	0.054	0.055	0.061	0.058	0.056	0.056
Tl	0.000054	0.000005	0.000045	0.000005	0.000045	0.000005	0.000058	0.00005
Sn	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Ti	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
U	0.000025	0.000023	0.000032	0.000014	0.000043	0.000026	0.0001	0.0001
V	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Zn	0.0015	0.0005	0.0015	0.0005	0.0015	0.0005	0.0015	0.0005

3.2 NPAG Quarry

3.2.1 Overview

Since 2015, approximately 1.1 Mt of rock has been excavated from the NPAG Quarry to provide material for building foundations, roads and other construction activities at the mine site (Table 3-2). It is projected that approximately 50,000 t of NPAG Quarry rock will be excavated on an annual basis through operations. The NPAG Quarry is located near the southeast end of the WRTSF and runoff from the NPAG Quarry flows into the WRTSF. The NPAG Quarry is comprised predominantly of volcanic (plagioclase-hornblende) porphyry, with lesser amounts of conglomerate (S3), and negligible sulfide mineralization. Results from the preliminary ML/ARD characterization (Pretium, 2015) and subsequent confirmatory sampling programs (Pretium, 2016; 2017; 2018a; 2019a; 2020c; 2021; 2022a), as well as the 2020 Environmental Monitoring Review (Lorax, 2020d) confirm that rock excavated from the NPAG Quarry is consistently NPAG with low neutral metal leaching potential. Runoff source terms were developed to capture contributions from drainage in contact with exposures in the NPAG Quarry.

Table 3-2:
Annual NPAG Quarry excavation schedule

Year	NPAG Quarry Rock Blasted and Excavated (t)
2015	417,424
2016	450,026
2017	45,813
2018	84,718
2019	73,000
2020	5,000
2021	38,000

Note: that the projected excavation of NPAG Quarry rock is 50,000 t/year

3.2.2 NPAG Quarry Runoff Source Term Evaluation

Shake flask extraction (SFE) tests carried out on rock samples collected from the NPAG Quarry are used to predict the quality of surface drainages from the NPAG Quarry to the WRTSF. Median and 90th percentile values of the cumulative SFE results for 51 samples are used to represent Base Case and Upper Case source terms, respectively. The concentration values assigned to NPAG Quarry runoff flows, as designated by the site water balance, are presented in Table 3-3, as compared to BC FWAL guidelines which are provided for reference.

Table 3-3:
Source terms for NPAG Quarry runoff

Parameter	Units	BC FWAL		NPAG Quarry source terms based on SFE data (n=51)	
		Long-term	Short-term	*Base Case*	*Upper Case*
Chloride	mg/L	150	600	0.2	1.0
Fluoride	mg/L	NP	0.82	0.06	0.10
Sulfate	mg/L	128	NP	3.0	5.8
Al	mg/L	0.05	0.1	**0.31**	**0.76**
Sb	mg/L	0.009	NP	0.0005	0.0030
As	mg/L	NP	0.005	0.0068	**0.018**
Ba	mg/L	1	NP	0.094	0.28
Be	mg/L	0.00013	NP	0.000007	0.0001
Bi	mg/L	NP	NP	0.000007	0.0001
B	mg/L	1.2	NP	0.0093	0.021
Cd	mg/L	0.00008	0.00016	0.00001	0.000058
Ca	mg/L	NP	NP	8.9	12
Cr	mg/L	0.001	NP	0.0001	0.0005
Co	mg/L	0.004	0.11	0.000071	0.00029
Cu	mg/L	0.0003	0.0018	***0.00064***	***0.0017***
Fe	mg/L	NP	1	0.018	0.037
Pb	mg/L	0.0039	0.016	0.0001	0.0008
Li	mg/L	NP	NP	0.0010	0.0040
Mg	mg/L	NP	NP	0.17	0.47
Mn	mg/L	0.73	0.85	0.0064	0.023
Hg	mg/L	0.00002	NP	0.00001	***0.0005***
Mo	mg/L	7.6	46	0.0008	0.0021
Ni	mg/L	0.25	NP	0.0001	0.0005
P	mg/L	NP	NP	0.027	0.05
K	mg/L	NP	NP	2.7	7.1
Se	mg/L	0.002	NP	0.0001	0.0005
Si	mg/L	NP	NP	2.2	3.0
Ag	mg/L	0.00005	0.0001	0.000016	***0.00008***
Na	mg/L	NP	NP	1.3	2.8
Sr	mg/L	NP	NP	0.065	0.15
Tl	mg/L	0.0008	NP	0.000008	0.00005
Sn	mg/L	NP	NP	0.00002	0.0005
Ti	mg/L	NP	NP	0.00065	0.011
U	mg/L	0.0085	NP	0.00015	0.00024
V	mg/L	NP	NP	0.0015	0.0056
Zn	mg/L	0.0075	0.033	0.001	0.003

Notes: Base Case and Upper Case values are based on median and 90th percentile values for 51 SFE analyses; NP = none proposed; BC FWAL = water quality guidelines for the protection of freshwater aquatic life (ENV 2017, ENV 2019a); values in bold italics are higher than the long-term BC FWAL; values in bold are higher than the short-term BC FWAL.

3.3 Mine Site

3.3.1 Overview

A total of ~1.5 Mt of waste rock and 111 kt of weathered surface material were excavated from the mine site surface area to support the construction of site roads and pads for various facilities including the mill, Phase 2 Camp and CWP. Construction of the mine site was initiated in September 2015 and continued during 2016, with the majority of excavation occurring in Q1 and Q2 of 2016.

Geochemical source terms were developed for 1) mine site run-off associated with exposures from surface excavation; 2) mine site surface waste rock deposited in the WRTSF; and 3) weathered surface material placed in the WRTSF. For waste rock placed in the WRTSF, instantaneous and post-depositional loads were calculated. The instantaneous surface waste rock load represents the mass of available soluble constituents that are instantaneously released into solution. The post-depositional loads represent the longer-term loads released following deposition of the waste rock in the WRTSF. The approach for derivation of each of these water quality model inputs are described in the sections below.

3.3.2 Mine Site Runoff

Contact water associated with runoff from the core infrastructure portion of the mine site is collected by the contact water collection system, which directs water to the CWP (Figure 1-1). Non-contact surface runoff from areas immediately surrounding the mine site are directed to the WRTSF via the East (Johnson Creek) Diversion Channel, and to Camp Creek via the West (Camp Creek) Diversion Channel. The mine site runoff source term includes runoff from all exposed rock units from the core infrastructure portion of the mine site.

A block model was developed by Pretium for the mine site excavation area based on the five geologic units identified through surface mapping and drilling campaigns. These units are: ANDX (intermediate fragmental volcanic rock), VSF (volcanic sedimentary facies), P2 (K-feldspar bearing porphyry), P1 (plagioclase-hornblende bearing porphyry) and S3 (conglomerate) and are described in the *MA & EMA* Permits Application (Pretium, 2015). The surface waste rock units are similar to those found in the underground mine, but have slightly different metal contents and acid base accounting (ABA) characteristics. Consequently, surface materials were characterized independent of the underground block model units. The rock units exposed as a result of these excavations include ANDX, VSF, P2, P1, and S3.

Previous water quality models used SFE results from 92 lithology-specific samples to predict loads received by the WRTSF from mine site surface run-off. The Base Case and Upper Case values were derived using median and 90th percentile values Table 3-4. However, based on a review of surface runoff samples collected from mine site contact water draining into the CWP (n=10), it was noted that concentrations of most parameters were higher than those derived from the SFE data set (Table 3-4). Therefore, the source terms applied to the water quality model for surface runoff have been revised to reflect site monitoring contact water data rather than static test SFE results.

Table 3-4:
Mine site runoff source term evaluation comparing mine site contact water samples to SFE data for mine site surface rock

Parameter	Units	BC FWAL		All Data			
		Long-term	Short-term	Mine Site Contact Water Samples (n=10)		Mine Site SFE data (n=92)	
				Base Case (average)	*Upper Case (max)*	*Median*	*90th Percentile*
Chloride	mg/L	150	600	6	24	1	5
Fluoride	mg/L	NP	0.82	0.17	0.61	0.08	0.214
Sulfate	mg/L	128	NP	*154*	*370*	13	58
Al	mg/L	0.05	0.1	0.042	**0.429**	**0.15**	**0.3**
Sb	mg/L	0.009	NP	0.00074	0.00182	0.0047	***0.025***
As	mg/L	NP	0.005	0.00072	0.00353	**0.011**	**0.075**
Ba	mg/L	1	NP	0.033	0.073	0.044	0.16
Be	mg/L	0.00013	NP	0.000021	*0.00107*	0.000007	0.000018
Bi	mg/L	NP	NP	0.00005	0.00005	0.000007	0.000007
B	mg/L	1.2	NP	0.015	0.04	0.014	0.037
Cd	mg/L	0.00008	0.00016	0.000078	**0.00161**	0.000006	0.000033
Ca	mg/L	NP	NP	92	129	15	34
Cr	mg/L	0.001	NP	0.00017	0.00087	0.00003	0.00013
Co	mg/L	0.004	0.11	0.00096	*0.0117*	0.000028	0.00047
Cu	mg/L	0.0003	0.0018	*0.00059*	**0.0131**	***0.0005***	***0.0016***
Fe	mg/L	NP	1	0.01	**4.7**	0.007	0.018
Pb	mg/L	0.0039	0.016	0.00005	0.000941	0.000045	0.00043
Li	mg/L	NP	NP	0.0037	0.0072	0.0034	0.0092
Mg	mg/L	NP	NP	3.5	6.3	0.8	2.1
Mn	mg/L	0.73	0.85	0.18	**1.34**	0.02	0.18
Hg	mg/L	0.00002	NP	0.000005	0.000005	0.00001	0.00001
Mo	mg/L	7.6	46	0.00061	0.00293	0.002	0.011
Ni	mg/L	0.25	NP	0.0005	0.0035	0.0001	0.00045
P	mg/L	NP	NP	0.05	0.123	0.004	0.027
K	mg/L	NP	NP	2.7	4	3.7	10.6
Se	mg/L	0.002	NP	0.00035	0.00066	0.00016	***0.0042***
Si	mg/L	NP	NP	2.4	3.8	1.63	2.57
Ag	mg/L	0.00005	0.0001	0.00001	0.000062	0.000009	0.000034
Na	mg/L	NP	NP	7	21	1.6	4.3
Sr	mg/L	NP	NP	0.56	1	7.1	27
Tl	mg/L	0.0008	NP	0.000012	0.000049	0.000034	0.00011
Sn	mg/L	NP	NP	0.0001	0.00032	0.00002	0.00007
Ti	mg/L	NP	NP	0.0003	0.0003	0.00013	0.00051
U	mg/L	0.0085	NP	0.00031	0.0008	0.00021	0.0013
V	mg/L	NP	NP	0.0005	0.00075	0.00071	0.003
Zn	mg/L	0.0075	0.033	0.0068	**0.183**	0.001	0.002

Notes: Base Case and Upper Case values are based on average and maximum mine site contact runoff concentrations; NP = none proposed; BC FWAL = water quality guidelines for the protection of freshwater aquatic life (ENV 2017, ENV 2019a); values in bold italics are higher than the long-term BC FWAL; values in bold are higher than the short-term BC FWAL.

3.3.3 Surface Waste Rock

A summary of the lithology-specific surface waste rock excavation work carried out during Construction phase is provided in Table 3-5. Preliminary ML/ARD characterization designated three out of the five geologic model units for surface waste rock as NPAG based on median neutralization potential ratio (NPR) values; however, the NPR values are very close to the PAG threshold value of 2 (2.0, 2.4 and 2.6 for the S3, P2 and ANDX units, respectively). The majority of the VSF and P1 samples are characterized as PAG with NPR values generally <2. Results from confirmatory sampling of these units are consistent with the preliminary characterization. Thus, surface-blasted mine site waste rock was generally classified as PAG and all was managed through sub-aqueous deposition in the WRTSF. A discussion of the preliminary geochemical assessment and confirmatory sampling is summarized in the 2015 and 2016 Annual Reports (Pretium, 2016; 2017).

Table 3-5:
Tracked mine site waste rock tonnages placed in the WRTSF during construction

Date	VSF	S3	ANDX	P2	P1	Total
Sep-15	0	0	33,056	0	0	33,056
Oct-15	8,413	13,208	41,711	0	0	63,332
Nov-15	17,491	0	153,449	0	0	170,940
Dec-15	2,460	17,612	65,745	90,596	0	176,412
Jan-16	107,301	0	65,513	164,889	0	337,703
Feb-16	36,593	0	62,627	142,320	0	241,539
Mar-16	62,070	0	15,231	102,935	0	180,236
Apr-16	2,465	0	2,913	4,928	55,469	65,775
May-16	0	0	52,920	4,145	11,507	68,572
Jun-16	0	0	33,599	2,408	6,915	42,922
Jul-16	0	0	8,791	0	0	8,791
Aug-16	0	0	0	0	0	0
Sep-16	11,850	0	0	0	0	11,850
Oct-16	34,312	0	0	0	0	34,312
Nov-16	64,287	0	0	0	0	64,287
Dec-16	1,601	0	0	0	0	1,601
Total	**348,843**	**30,819**	**535,554**	**512,220**	**73,891**	**1,501,327**
Percent of Total	*5%*	*5%*	*34%*	*28%*	*28%*	

3.3.3.1 Instantaneous Loads

Lithology-specific SFE data sets were used to predict the instantaneous loads from mine site surface waste rock deposited in the WRTSF. Source terms were developed using the waste rock schedule and SFE data from preliminary characterization studies of mine site surface waste rock lithologies. The source terms for instantaneous loads to the WRTSF from submerged mine site waste rock incorporate all the available SFE data and utilize the tracked waste rock tonnages deposited in the WRTSF during the Construction phase.

Monthly loads were scaled to account for the proportion of waste rock considered to be reactive (*i.e.*, soluble) using the fraction of material that is < 6.4 mm, or approximately 20% of the total waste rock. Base Case and Upper Case source terms were calculated from the cumulative dataset using the 75th and 90th percentile lithology-specific SFE values and the scaled monthly waste rock excavation tonnages (Table 3-5). The source terms for Base Case and Upper Case instantaneous mine site surface waste rock loads are unchanged from previous models (*i.e.,* Lorax 2018; 2020) and are summarized in Table 3-6 and Table 3-7, respectively.

3.3.3.2 Post-Depositional Loads

Leachate data from saturated column kinetic tests comprising lithology-specific surface waste rock (VSF, ANDX, P2, S3) were used to assess which parameters have the potential for long term leaching behaviour after deposition in the WRTSF. Based on the assessment, As and Sb were identified as parameters showing longer-term release patterns. Post-depositional loads for these parameters were calculated using stabilized column leachate concentration data combined with the surface waste rock schedule (Table 3-5) and assumptions regarding waste rock reactivity. In reality, the loads contributed to the WRTSF would be controlled by molecular diffusion; however, waste rock sequencing information is not available, therefore the approach used to derive post-depositional As and Sb loads is based on lithology-specific loading rates.

Median and 90th percentile leachate concentration values were used to derive Base Case and Upper Case loading rates. Loading rates (mg/kg/month) for each surface waste rock lithology were multiplied by the respective lithology-specific cumulative waste rock tonnages (Table 3-5) to derive monthly post-depositional loads. Leachate quality from the P2 column was used as a surrogate for the P1 unit when calculating the potential contributions from the P1 waste rock tonnages deposited in the WRTSF. It is assumed that any waste rock deposited in the lake will contribute post-depositional loads for approximately one year following placement. It is expected that most of the waste rock dump subaqueous exposed faces will be covered within one year through ongoing deposition of waste rock, thereby burying the underlying layers and limiting post-depositional leaching.

No revisions to these terms were applied to this model update since most of the waste rock was placed in the WRTSF over 6 years ago, significantly longer than the assumed time period over which diffusional loads would be released to the WRTSF. Furthermore, no surface waste rock characterization data has been collected to warrant further revision to these terms. Base Case and Upper Case As and Sb post-depositional loads are summarized in Table 3-8, along with the total cumulative waste rock tonnages susceptible to leaching.

Table 3-6:
Base Case mine site waste rock deposition source term loads (g)

Parameter	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
Chloride	39,667	71,830	226,116	122,243	400,444	218,480	207,390	77,896	78,929	49,555	10,549	0	28,441	82,348	154,289	3,843
Fluoride	2,182	4,238	12,227	10,161	26,104	16,210	14,012	2,751	4,131	2,597	580	0	1,422	4,117	7,714	192
Sulfate	674,337	1,016,728	3,392,721	3,387,798	6,507,574	4,900,583	3,465,152	502,373	1,231,229	774,776	179,340	0	177,755	514,674	964,305	24,017
Al	4,056	6,639	21,809	20,208	47,445	32,151	25,632	8,531	8,502	5,319	1,079	0	2,019	5,847	10,955	273
Sb	153	375	923	1,546	3,629	2,475	2,087	363	349	217	41	0	145	420	787	20
As	475	799	2,585	2,553	6,062	4,103	3,309	305	857	539	126	0	257	745	1,396	35
Ba	2,211	3,015	10,671	10,419	17,652	14,345	9,188	2,022	4,112	2,586	588	0	274	795	1,489	37
Be	0.14	0.37	0.73	0.88	1.5	1.0	0.79	0.28	0.29	0.18	0.040	0	0.060	0.16	0.31	0.010
Bi	0.14	0.27	0.72	0.74	1.4	1.0	0.76	0.28	0.29	0.18	0.040	0	0.050	0.14	0.27	0.010
B	334	641	1,890	2,070	5,077	3,358	2,814	560	679	425	89	0	230	665	1,246	31
Cd	0.24	0.57	1.3	1.6	3.2	2.2	1.8	0.29	0.46	0.29	0.060	0	0.13	0.37	0.69	0.020
Ca	406,585	625,751	2,103,608	2,016,657	4,254,166	3,054,251	2,279,297	628,938	807,822	506,494	108,132	0	146,470	424,091	794,587	19,790
Cr	0.60	1.5	3.5	3.4	8.7	5.2	4.7	2.2	1.4	0.90	0.20	0	0.50	1.4	2.7	0.10
Co	1.2	6.7	6.6	15	20	14	11	1.1	2.3	1.4	0.30	0	0.70	2.1	3.9	0.10
Cu	16	49	83	122	180	134	98	31	34	21	4.3	0	5.2	15	28	0.70
Fe	218	463	1,139	1,056	1,996	1,360	1,042	327	424	267	58	0	85	247	463	12
Pb	2.7	5.0	15	18	45	30	25	3.6	5.3	3.3	0.70	0	2.0	5.8	11	0.30
Li	83	178	529	492	1609	937	900	141	166	104	22	0	99	286	536	13
Mg	22,908	38,856	126,384	132,775	321,219	217,266	177,108	50,681	49,077	30,661	6,092	0	13,580	39,321	73,673	1,835
Mn	1,009	2,078	5,400	8,642	17,181	12,716	9,741	1,694	2,131	1,330	268	0	486	1,408	2,638	66
Hg	0.20	0.38	1.0	1.1	2.0	1.5	1.1	0.39	0.41	0.26	0.050	0	0.070	0.21	0.39	0.010
Mo	140	199	687	489	887	664	434	132	254	160	37	0	27	78	146	4.0
Ni	2.0	7.2	12	20	43	27	24	4.5	4.4	2.7	0.50	0	2.1	6.2	12	0.30
P	208	578	1,061	1,358	2,031	1,489	1,080	163	380	239	55	0	64	185	347	9
K	183,757	271,012	927,638	667,310	1,344,299	955,116	675,557	129,186	325,333	205,234	48,870	0	50,553	146,373	274,248	6,830
Se	4.0	15	33	120	303	210	182	20	13	8.0	1.0	0	11	32	60	1.0
Si	39,964	66,139	210,601	194,414	426,984	295,558	228,474	67,433	80,177	50,257	10,629	0	16,993	49,203	92,188	2,296
Ag	0.38	0.64	2.0	1.3	2.8	1.8	1.4	0.62	0.73	0.46	0.10	0	0.14	0.39	0.73	0.020
Na	41,650	74,838	237,527	258,118	658,797	434,777	366,513	51,301	81,048	50,817	11,077	0	29,934	86,671	162,389	4,044
Sr	6,733	10,651	35,686	47,614	101,605	74,752	56,956	5,316	12,787	8,020	1,791	0	3,000	8,688	16,277	405
Tl	1.0	1.8	5.3	6.5	15	10	8.2	1.5	2.0	1.2	0.30	0	0.60	1.6	3.1	0.10
Sn	0.80	1.3	4.1	4.2	8.6	6.2	4.6	1.6	1.7	1.0	0.20	0	0.30	0.80	1.5	0.00
Ti	5.5	8.9	29	27	59	41	32	6.8	11	6.6	1.5	0	2.3	6.8	13	0.30
U	22	30	106	70	119	91	56	10	37	24	5.8	0	3.2	9.3	17	0.40
V	27	48	152	128	359	222	196	38	51	32	7.1	0	20	57	106	2.7
Zn	20	54	103	127	203	145	108	73	48	30	5.3	0	7.1	21	39	1.0

Table 3-7:
Upper Case mine site waste rock deposition source term loads (g)

Parameter	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
Chloride	87,267	144,009	472,270	272,097	743,282	442,478	377,376	128,388	165,782	104,289	23,209	0	45,505	131,757	246,862	6,148
Fluoride	4,681	7,866	24,814	17,987	42,055	27,278	21,752	5,854	8,794	5,532	1,245	0	2,090	6,053	11,340	282
Sulfate	1,158,272	1,754,587	5,903,673	5,496,388	11,107,309	8,112,715	5,886,555	682,547	2,064,992	1,301,120	308,044	0	356,931	1,033,465	1,936,324	48,225
Al	4,732	10,047	30,260	27,524	90,882	52,752	50,730	9,723	9,844	6,158	1,259	0	5,618	16,268	30,480	759
Sb	404	714	2,135	4,663	9,164	7,150	5,334	588	882	548	107	0	176	511	957	24
As	1,293	2,246	7,244	7,728	19,211	12,840	10,640	821	2,351	1,479	344	0	842	2,437	4,567	114
Ba	3,261	4,462	15,798	16,152	27,876	22,540	14,684	3,096	6,112	3,841	867	0	449	1,299	2,433	61
Be	0.17	0.43	0.92	0.95	1.7	1.2	0.90	0.28	0.35	0.22	0.050	0	0.070	0.21	0.40	0.010
Bi	0.14	0.27	0.72	0.74	1.5	1.0	0.78	0.46	0.33	0.20	0.040	0	0.050	0.16	0.29	0.010
B	579	1,005	3,142	2,956	6,959	4,662	3,767	930	1,154	723	154	0	307	889	1,666	41
Cd	0.65	1.4	3.8	3.1	8.6	5.1	4.6	0.46	1.2	0.73	0.17	0	0.50	1.5	2.7	0.070
Ca	682,667	997,040	3,432,859	3,323,136	6,459,886	4,856,248	3,428,501	710,799	1,286,223	808,311	181,556	0	178,750	517,556	969,705	24,151
Cr	0.80	1.9	4.8	7.3	18	12	10	3.9	2.2	1.4	0.20	0	0.80	2.2	4.2	0.10
Co	3.8	11	20	39	67	52	38	2.6	7.4	4.6	1.0	0	1.5	4.3	8.1	0.20
Cu	28	68	145	202	352	259	194	40	56	35	7.4	0	11	31	58	1.4
Fe	353	788	2,088	1,630	4,722	2,702	2,547	838	743	465	94	0	304	881	1,651	41
Pb	6.8	12	37	47	108	76	60	5.9	13	8.1	1.8	0	3.9	11	21	0.50
Li	126	553	1,397	860	6,127	2,709	3,499	313	257	161	33	0	551	1,594	2,987	74
Mg	29,790	52,780	169,226	181,968	463,519	306,465	257,537	59,263	62,602	39,132	7,923	0	20,961	60,690	113,711	2,832
Mn	3,233	5,082	16,137	18,193	33,339	25,754	17,985	2,541	5,989	3,765	860	0	765	2,215	4,150	103
Hg	0.20	0.38	1.0	1.1	2.0	1.5	1.1	0.39	0.41	0.26	0.050	0	0.070	0.21	0.39	0.010
Mo	240	360	1,225	841	1,781	1,225	894	162	422	266	64	0	75	218	408	10
Ni	4.0	12	26	29	81	48	46	5.6	7.8	4.9	1.1	0	4.8	14	26	0.70
P	496	1,124	2,778	2,858	6,537	4,208	3,562	289	881	555	132	0	323	935	1,751	44
K	224,911	338,641	1,151,320	887,363	1,869,264	1,311,261	962,150	241,528	417,422	262,689	59,815	0	72,666	210,399	394,208	9,818
Se	27	88	232	362	1,225	726	714	51	61	38	7.3	0	71	206	386	10
Si	55,534	87,642	286,738	234,403	496,966	346,456	258,988	87,982	109,261	68,573	14,769	0	19,610	56,779	106,382	2,650
Ag	0.78	1.3	4.1	2.6	6.1	3.9	3.1	1.4	1.5	0.96	0.21	0	0.33	0.96	1.8	0.040
Na	64,221	216,644	577,901	422,841	2,306,669	1,106,648	1,311,508	113,975	125,871	78,901	17,080	0	189,557	548,848	1,028,335	25,611
Sr	11,511	17,280	59,112	71,713	144,970	109,067	79,967	11,204	22,031	13,821	3,061	0	3,845	11,133	20,860	520
Tl	1.6	2.7	8.4	11	23	17	13	1.8	3.1	1.9	0.40	0	0.70	2.2	4.1	0.10
Sn	1.5	2.2	7.4	7.2	14	11	7.4	2.0	2.9	1.8	0.40	0	0.40	1.1	2.1	0.050
Ti	8.6	14	46	53	118	84	65	10	17	10	2.3	0	4.2	12	23	0.60
U	29	42	145	92	181	127	88	14	49	31	7.7	0	7.3	21	40	1.0
V	50	84	276	230	589	380	317	50	93	58	13	0	29	84	158	3.9
Zn	40	84	205	222	405	290	216	79	82	52	11	0	14	41	77	1.9

Table 3-8:
Source Terms for post-depositional loads of antimony and arsenic from mine site waste rock submerged in the WRTSF

Date	Sb		As		Waste Rock Susceptible to Leaching
	Base Case	Upper Case	Base Case	Upper Case	
	(g)	(g)	(g)	(g)	(t)
Sep-15	1.1	1.2	2.3	2.3	33,056
Oct-15	8.4	8.8	34	35	96,388
Nov-15	14	15	53	54	267,327
Dec-15	27	29	119	123	443,740
Jan-16	36	41	226	234	781,442
Feb-16	43	51	292	302	1,022,981
Mar-16	48	57	355	367	1,203,217
Apr-16	50	60	375	388	1,268,992
May-16	52	63	384	397	1,337,564
Jun-16	54	64	389	402	1,380,486
Jul-16	54	65	389	403	1,389,277
Aug-16	54	65	389	403	1,389,277
Sep-16	53	64	393	406	1,368,071
Oct-16	46	57	378	391	1,339,051
Nov-16	42	52	390	403	1,232,398
Dec-16	29	38	325	335	1,057,587
Jan-17	20	26	217	224	719,885
Feb-17	13	16	151	156	478,346
Mar-17	8.0	10	88	91	298,110
Apr-17	6.0	6.8	68	70	232,335
May-17	3.7	4.2	60	61	163,763
June-17 through Dec 2017 (sum)	9.0	10	244	248	512,630

3.3.4 Weathered Surface Material

Weathered surface material was excavated from the mine site surface in preparation for operations. A summary of the tracked tonnages of weathered surface material placed in the WRTSF by deposition month is provided in Table 3-9.

Table 3-9:
Tracked tonnages of weathered surface material deposited in the WRTSF

Month	Weathered Surface Material to the WRTSF (t)
Nov-15	57,356
Dec-15	14,196
Jan-16	9,688
Feb-16	18,998
Mar-16	6,244
Apr-16	756
Aug-16	37
Sep-16	37
Jan-17	784
Feb-17	474
May-17	419
Jul-17	697
Aug-17	504
Sep-17	442
Oct-17	56
May-18	208
Total	110,896

Soil size weathered parent materials were salvaged, as feasible, during construction and stockpiled as required by MEMPR for potential use in mine reclamation; a total of 30,000 m^3 was stockpiled. A geochemical surficial materials characterization program completed during construction in 2015 indicated however that these materials have a high PAG potential and elevated metal concentrations (*e.g.*, As levels (21-446 ppm) exceeding the CCME guideline of 12 ppm), and have high coarse fragment content, generally low organic matter content and limited soil development. Other weathered surficial materials that were not feasible to salvage due to shallow depth over bedrock, terrain and other constraints, and particularly materials dominantly comprised of broken rock, were deposited in the WRTSF. Details of the 2015 geochemical characterization program and an overview of the baseline studies are provided in the 2015 Annual Report (Pretium, 2016).

SFE data were used to predict the instantaneous loads from mine site weathered surface material deposited in the WRTSF. Given the relatively fine particle size distribution of the surficial material, all the material is considered reactive (*i.e.*, soluble). Base Case and Upper Case source terms were calculated from the cumulative dataset using median and 90th percentile SFE values, respectively, and the monthly excavation schedule (Table 3-9). The source terms for Base Case and Upper Case are summarized in Table 3-10 and Table 3-11, respectively.

Table 3-10:
Base Case weathered surface material source term loads

Parameter	Units	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	Aug-16	Sep-16	Jan-17	Feb-17	May-17	Jul-17	Aug-17	Sep-17	Oct-17	May-18
Chloride	G	172,068	42,588	29,064	56,994	18,732	2,268	111	111	2,352	1,422	1,257	2,091	1,512	1,326	168	624
Fluoride	G	10,324	2,555	1,744	3,420	1,124	136	6.7	6.7	141	85	75	125	91	80	10	37
Sulfate	G	3,871,530	958,230	653,940	1,282,365	421,470	51,030	2,498	2,498	52,920	31,995	28,283	47,048	34,020	29,835	3,780	14,040
Ag	G	0.69	0.17	0.12	0.23	0.075	0.0091	0.00044	0.00044	0.0094	0.0057	0.0050	0.0084	0.0060	0.0053	0.0007	0.0025
Al	G	3,742	926	632	1240	407	49	2.4	2.4	51	31	27	45	33	29	3.7	14
As	G	86	21	15	28	9.4	1.1	0.056	0.056	1.2	0.71	0.63	1.0	0.76	0.66	0.08	0.31
B	G	1,867	462	315	618	203	25	1.2	1.2	26	15	14	23	16	14	1.8	6.8
Ba	G	5,825	1,442	984	1,929	634	77	3.8	3.8	80	48	43	71	51	45	5.7	21
Be	G	1.2	0.30	0.20	0.40	0.13	0.016	0.00078	0.00078	0.016	0.0100	0.0088	0.015	0.011	0.0093	0.0012	0.0044
Bi	G	1.2	0.30	0.20	0.40	0.13	0.016	0.00078	0.00078	0.016	0.0100	0.0088	0.015	0.011	0.0093	0.0012	0.0044
Ca	G	2,942,363	728,255	496,994	974,597	320,317	38,783	1,898	1,898	40,219	24,316	21,495	35,756	25,855	22,675	2,873	10,670
Cd	G	4.2	1.0	0.71	1.4	0.46	0.056	0.0027	0.0027	0.058	0.035	0.031	0.051	0.037	0.032	0.004	0.015
Co	G	18	4.4	3.0	5.9	1.9	0.23	0.011	0.011	0.24	0.15	0.13	0.22	0.16	0.14	0.017	0.064
Cr	G	5.2	1.3	0.87	1.7	0.56	0.068	0.0033	0.0033	0.071	0.043	0.038	0.063	0.045	0.040	0.005	0.019
Cu	G	227	56	38	75	25	3.0	0.15	0.15	3.1	1.9	1.7	2.8	2.0	1.8	0.2	0.8
Fe	G	1,204	298	203	399	131	16	0.78	0.78	16	10.0	8.8	15	11	9.3	1.2	4.4
Hg	G	1.7	0.43	0.29	0.57	0.19	0.023	0.0011	0.0011	0.024	0.014	0.013	0.021	0.015	0.013	0.0017	0.0062
K	G	135,159	33,453	22,830	44,769	14,714	1,782	87	87	1,847	1,117	987	1,642	1,188	1,042	132	490
Li	G	156	39	26	52	17	2.1	0.10	0.10	2.1	1.3	1.1	1.9	1.4	1.2	0	0.6
Mg	G	69,946	17,312	11,815	23,168	7,615	922	45	45	956	578	511	850	615	539	68	254
Mn	G	23,401	5,792	3,953	7,751	2,548	308	15	15	320	193	171	284	206	180	23	85
Mo	G	168	42	28	56	18	2.2	0.11	0.11	2.3	1.4	1.2	2.0	1.5	1.3	0.16	0.61
Na	G	92,056	22,785	15,549	30,492	10,022	1,213	59	59	1,258	761	672	1,119	809	709	90	334
Ni	G	69	17	12	23	7.5	0.91	0.044	0.044	0.94	0.57	0.50	0.84	0.60	0.53	0.067	0.250
P	G	3,097	767	523	1,026	337	41	2.0	2.0	42	26	23	38	27	24	3	11
Pb	G	12	3.0	2.0	4.0	1.3	0.16	0.0078	0.0078	0.16	0.100	0.088	0.15	0.11	0.093	0.01	0.04
Sb	G	69	17.0	11.6	23	7.5	0.91	0.044	0.044	0.94	0.57	0.50	0.84	0.60	0.53	0.07	0.25
Se	G	32	8	5	11	3	0.42	0.021	0.021	0.44	0.26	0.23	0.39	0.28	0.25	0.03	0.12
Si	G	147978	36626	24995	49015	16110	1950	95	95	2023	1223	1081	1798	1300	1140	144	537
Sn	G	5	1.3	0.9	1.7	0.6	0.068	0.003	0.003	0.071	0.043	0.038	0.063	0.045	0.040	0.005	0.019
Sr	G	8921.7	2208.2	1507.0	2955.1	971.25	117.60	5.7554	5.7554	121.95	73.731	65.175	108.42	78.397	68.753	9	32
Ti	G	8.6	2.1	1.5	2.8	0.94	0.113	0.0056	0.0056	0.118	0.071	0.063	0.105	0.076	0.066	0.0084	0.031
Tl	G	6.7	1.66	1.13	2.22	0.73	0.088	0.0043	0.0043	0.092	0.055	0.049	0.082	0.059	0.052	0.0066	0.024
U	G	2.5	0.6	0.4	0.8	0.27	0.03	0.0016	0.0016	0.03	0.021	0.018	0.030	0.022	0.019	0.0024	0.009
V	G	7.74	1.92	1.31	2.56	0.84	0.10	0.005	0.005	0.11	0.06	0.06	0.09	0.07	0.06	0.0076	0.028
Zn	G	172.1	42.6	29.1	57.0	18.73	2.27	0.1110	0.1110	2.35	1.422	1.257	2.091	1.512	1.326	0.17	0.62

Table 3-11:
Upper Case weathered surface material source term loads

Parameter	Units	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	Aug-16	Sep-16	Jan-17	Feb-17	May-17	Jul-17	Aug-17	Sep-17	Oct-17	May-18
Chloride	G	172,068	42,588	29,064	56,994	18,732	2,268	111	111	2,352	1,422	1,257	2,091	1,512	1,326	168	624
Fluoride	G	17,723	4,387	2,994	5,870	1,929	234	11	11	242	146	129	215	156	137	17	64
Sulfate	G	15,434,500	3,820,144	2,607,041	5,112,362	1,680,260	203,440	9,957	9,957	210,974	127,553	112,753	187,563	135,626	118,942	15,070	55,973
Ag	G	3.7	0.92	0.62	1.2	0.40	0.049	0.0024	0.0024	0.051	0.031	0.027	0.045	0.033	0.029	0.00	0.01
Al	G	13,509	3,344	2,282	4,475	1,471	178	8.7	8.7	185	112	99	164	119	104	13	49
As	G	220	55	37	73	24	2.9	0.14	0.14	3.0	1.8	1.6	2.7	1.9	1.7	0.22	0.80
B	G	2,786	689	471	923	303	37	1.8	1.8	38	23	20	34	24	21	3	10
Ba	G	11,775	2,914	1,989	3,900	1,282	155	7.6	7.6	161	97	86	143	103	91	11	43
Be	G	6.4	1.6	1.1	2.1	0.69	0.084	0.0041	0.0041	0.087	0.053	0.047	0.077	0.056	0.049	0.0062	0.0231
Bi	G	1.2	0.30	0.20	0.40	0.13	0.016	0.00078	0.00078	0.016	0.0100	0.0088	0.015	0.011	0.0093	0.0012	0.0044
Ca	G	7,909,966	1,957,770	1,336,072	2,620,014	861,110	104,260	5,103	5,103	108,121	65,369	57,784	96,123	69,507	60,956	7,723	28,685
Cd	G	67	17	11	22	7.3	0.88	0.043	0.043	0.91	0.55	0.49	0.81	0.59	0.52	0.07	0.24
Co	G	410	101	69	136	45	5.4	0.26	0.26	5.6	3.4	3.0	5.0	3.6	3.2	0.40	1.49
Cr	G	14	3.4	2.3	4.6	1.5	0.18	0.0089	0.0089	0.19	0.11	0.10	0.17	0.12	0.11	0.01	0.05
Cu	G	572	142	97	189	62	7.5	0.37	0.37	7.8	4.7	4.2	6.9	5.0	4.4	0.56	2.07
Fe	G	4,026	997	680	1,334	438	53	2.6	2.6	55	33	29	49	35	31	4	15
Hg	G	1.7	0.43	0.29	0.57	0.19	0.023	0.0011	0.0011	0.024	0.014	0.013	0.021	0.015	0.013	0.002	0.006
K	G	300,947	74,486	50,833	99,683	32,762	3,967	194	194	4,114	2,487	2,198	3,657	2,644	2,319	294	1,091
Li	G	392	97	66	130	43	5.2	0.25	0.25	5.4	3.2	2.9	4.8	3.4	3.0	0	1
Mg	G	135,865	33,627	22,949	45,002	14,791	1,791	88	88	1,857	1,123	993	1,651	1,194	1,047	133	493
Mn	G	175,664	43,478	29,671	58,185	19,123	2,315	113	113	2,401	1,452	1,283	2,135	1,544	1,354	172	637
Mo	G	618	153	104	205	67	8.2	0.40	0.40	8.5	5.1	4.5	7.5	5.4	4.8	1	2
Na	G	149,699	37,052	25,286	49,585	16,297	1,973	97	97	2,046	1,237	1,094	1,819	1,315	1,154	146	543
Ni	G	317	78	53	105	34	4.2	0.20	0.20	4.3	2.6	2.3	3.8	2.8	2.4	0.31	1.1
P	G	12,458	3,083	2,104	4,126	1,356	164	8.0	8.0	170	103	91	151	109	96	12	45
Pb	G	258	64	44	86	28	3.4	0.17	0.17	3.5	2.1	1.9	3.1	2.3	2.0	0.3	0.9
Sb	G	5485528	1357705	926560	1816969	597176	72304	3539	3539	74982	45333	40073	66661	48203	42273	5356	19893
Se	G	188	46	32	62	20	2.5	0.121	0.121	2.6	1.55	1.37	2.3	1.65	1.45	0.2	0.7
Si	G	104	26	18	35	11	1.4	0.1	0.1	1.4	0.9	0.8	1.3	0.9	0.8	0.1	0.4
Sn	G	322111	79725	54408	106693	35066	4246	208	208	4403	2662	2353	3914	2830	2482	314	1168
Sr	G	10	3	1.7	3.4	1.1	0.14	0.007	0.007	0.14	0.085	0.075	0.13	0.091	0.080	0.010	0.037
Ti	G	27066	6699	4572	8965	2947	357	17	17	370	224	198	329	238	209	26	98
Tl	G	54	13.3	9.1	17.8	5.9	0.71	0.035	0.035	0.74	0.45	0.39	0.65	0.47	0.42	0.053	0.195
U	G	19	4.8	3.3	6.4	2.1	0.26	0.0125	0.0125	0.27	0.161	0.142	0.24	0.171	0.150	0.019	0.070
V	G	11	2.7	1.8	3.6	1.2	0.14	0.0069	0.0069	0.15	0.09	0.08	0.13	0.09	0.08	0.010	0.039
Zn	G	14	3.4	2.3	4.6	1.5	0.18	0.01	0.01	0.19	0.11	0.10	0.17	0.12	0.11	0.013	0.050

3.4 Underground Mine

3.4.1 Overview

Based on the mine plan represented in this model update, approximately 8.0 Mt of waste rock will be generated over LOM as the underground mine is developed. A portion of this waste rock will be placed as rock backfill in the underground mine, with the rest to be deposited in the WRTSF under permanent water cover, as prescribed by the mine plan.

Materials backfilled into the underground mine – in addition to wall rock exposures, paste bleed water, and infiltrating groundwater – will contribute a geochemical load to underground mine water. This section describes the geochemical source terms for underground mine water and the loads associated with waste rock produced from the underground mine that will ultimately be stored in the WRTSF.

3.4.2 Underground Mine Waste Rock

The total mass of waste rock generated from the underground mine during the LOM is estimated to be 8.0 Mt, with 4.6 Mt of waste rock excavated having already been excavated (as of December 2021). Waste rock generated during operations will be managed through subaqueous deposition in the WRTSF and/or backfilling in the underground mine. A previous water quality model assessed two end-member waste rock deposition scenarios – one with maximized deposition in the WRTSF, and one with maximized backfill placement. The results for the two modelled scenarios were very similar and thus this model presents only the expected deposition scenario, recognizing that this may change.

Source terms were developed for: 1) underground mine waste rock deposited in the WRTSF; and 2) contact water from the underground mine. Underground waste rock terms were derived for both instantaneous and post-depositional loads (as described in Section 3.3.1), along with loads associated with sub-aerial exposure of waste rock while stored on surface before being deposited into the WRTSF.

Preliminary ML/ARD characterization of underground mine waste rock (464 pre-2016 samples) showed that the vast majority of samples are PAG (NPR < 2). The confirmatory sampling program was developed to monitor the geochemistry of rock excavated from the underground mine and assess any potential variation from the initial characterization of the defined geologic model units. Confirmatory sample results to date are generally consistent with prior characterization results, with the majority of samples indicated to be PAG (Pretium, 2020d). Given the PAG designation, all waste rock from underground is scheduled to be deposited in the WRTSF and/or backfilled in mined out stopes of the underground mine below the post-closure water table. *Mine Act* Permit M-243 limits subaerial exposure of waste rock to be deposited in the WRTSF to a maximum of 2 years. Summaries of the geochemical assessment and confirmatory sampling results are provided

in the ML/ARD Review and Update (Pretium, 2020d) and well as the subsequent annual reports (Pretium, 2021; 2022a).

Lithology-specific underground mine waste rock schedules have been developed as per the mine plan. The underground waste rock geologic model units defined for water quality modelling purposes are:

- VSF (volcanically-derived siltstone and sandstone);
- ANDX (latite to andesite fragmental volcanics);
- Conglomerate (cobble to boulder conglomerate with sandstone);
- Office P1 (hornblende, feldspar phyric latite flows);
- Office P2 (plagioclase, K-feldspar, hornblende porphyry); and
- Silicified Cap (silicified heterolithic conglomerate, sandstone and mudstone).

The schedule for underground waste rock placement in the WRTSF is presented in Table 3-12, whereas the underground mine backfill waste rock schedule is presented in Table 3-13. Both schedules are based on the mine plan represented in this model update. Loads were calculated for the instantaneous release, diffusive release, and potential leaching due to exposure on the waste rock deposition pad. Loads associated with backfilled waste rock are presented in Section 3.4.3 along with other mine water components.

Table 3-12:
Lithology-specific waste rock schedule for waste rock to be placed in the WRTSF

Year	Conglomerate	Fragmental	Office P1	Office P2	Silicified Cap	VSF	Total waste rock placed in WRTSF
	(kt)	(kt)	(kt)	(kt)	(kt)	(kt)	(kt)
2015	27	19	0	0	1	50	98
2016	141	266	27	0	37	240	712
2017	54	204	1	0	17	209	484
2018	80	281	0	0	46	293	700
2019	63	155	57	0	15	476	766
2020	53	74	34	0	14	673	849
2021	24	63	180	0	8	518	792
2022	10	79	79	0	2	407	578
2023	19	172	135	0	4	240	571
2024	57	217	102	3	7	245	630
2025	33	35	37	2	1	75	183
2026	5	5	7	0	1	17	33
2027	4	2	3	0	0	9	19
2028	0	1	0	0	0	2	3
2029	0	1	0	0	0	1	2
Total (LOM)	**570**	**1574**	**663**	**5**	**153**	**3455**	**6420**

Note that actual schedules are presented for 2015-2021, whereas projected schedules, as prescribed by the mine plan, are presented for 2020-2029.

Table 3-13:
Lithology-specific waste rock schedule for waste rock to be backfilled in the underground mine

Year	Conglomerate	Fragmental	Office P1	Office P2	Silicified Cap	VSF	Total waste rock placed as backfill
	(kt)	(kt)	(kt)	(kt)	(kt)	(kt)	(kt)
2018	n/a	n/a	n/a	n/a	n/a	n/a	28
2019	n/a	n/a	n/a	n/a	n/a	n/a	22
2020	n/a	n/a	n/a	n/a	n/a	n/a	66
2021	n/a	n/a	n/a	n/a	n/a	n/a	102
2022	4	32	32	0	1	163	231
2023	8	73	57	0	2	101	241
2024	16	60	28	1	2	67	173
2025	41	43	46	2	2	92	225
2026	31	32	43	0	4	109	220
2027	35	19	30	0	2	86	172
2028	0	16	5	0	1	38	59
2029	4	21	3	0	0	28	57
Total (LOM)	**139**	**295**	**243**	**3**	**13**	**685**	**1596**

Note that waste rock backfill is not currently tracked by lithology and thus the backfill placed in the underground mine between 2018 and 2021 is presented as a total. No waste rock was placed as backfill prior to 2018. The backfilled values presented for 2022 through 2029 are based on the mine plan and thus are lithology specific.

3.4.2.1 Instantaneous Loads

Lithology-specific SFE data sets combined with waste rock deposition schedules were used to predict the instantaneous loads from underground waste rock deposited in the WRTSF, as described in Section 3.3.3.1 for surface waste rock. The source terms for instantaneous loads to the WRTSF from submerged underground waste rock incorporate all available SFE data and utilize the tracked waste rock tonnages deposited in the WRTSF (through to the end of 2021), as well as the projected waste rock schedules (Table 3-12).

Monthly loads are scaled to account for the proportion of waste rock considered to be reactive (*i.e.*, soluble) using the fraction of material that is < 6.4 mm, estimated to be approximately 40% of the total underground waste rock. The proportion of reactive fines assumed for the waste rock is based on particle size distributions completed for representative subsamples from field bin and saturated column tests.

Base Case and Upper Case source terms were calculated from the cumulative dataset using the median (or 75th percentile in some cases to be consistent with observed lake quality) and 90th percentile lithology-specific SFE values and the scaled annual waste rock excavation tonnages (Table 3-12), assuming that waste rock is placed in the WRTSF during ice free months only (June-November). Base Case and Upper Case source terms for waste rock submerged in the WRTSF are presented in Table 3-14 and Table 3-15, respectively.

Table 3-14:
Base Case underground waste rock instantaneous loads (g)

Parameter	Units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Chloride	g	705352	5593171	3876866	5454436	5421000	5492783	5271301	4416978	4962908	1331639	235229	131822	23325	19238	4416978
Fluoride	g	30773	228132	162113	228225	241356	262821	234797	179379	201535	54778	9974	5636	1035	815	179379
Sulfate	g	5271211	37102855	24099929	34681996	33461400	35383213	28915978	22749025	28141537	8335700	1439749	868611	130758	113378	22749025
Al	g	52434	399426	288635	405186	440233	479351	448950	341696	373338	100327	18376	10168	1927	1479	341696
Sb	g	3504	22033	15322	22002	26934	32680	27700	17158	19090	5860	1115	653	110	79	17158
As	g	10895	78606	59263	83424	89944	103619	83829	60326	69037	18024	3355	1879	394	298	60326
Ba	g	5725	43063	28195	41035	38304	39412	33804	27713	33338	9477	1655	971	153	132	27713
Be	g	2	14	9	13	13	13	13	11	12	4	1	0	0	0	11
Bi	g	1	7	4	6	7	7	7	5	6	2	0	0	0	0	5
B	g	14522	89677	61308	87212	104234	125199	102874	64663	74331	23125	4322	2586	417	312	64663
Cd	g	1	5	3	5	5	5	5	4	4	1	0	0	0	0	4
Ca	g	1206982	8761913	5322516	7869922	7339758	7384026	6680931	5390578	6584901	2049556	348469	210417	27325	24385	5390578
Cr	g	33	243	149	223	250	267	289	207	221	70	13	7	1	1	207
Co	g	28	189	110	163	150	153	127	100	129	43	7	5	1	0	100
Cu	g	18	142	51	99	89	69	131	98	106	45	7	5	0	0	98
Fe	g	1365	11336	8125	11514	10717	10836	9566	8386	9674	2418	429	236	47	39	8386
Pb	g	18	101	39	64	46	39	24	18	42	23	3	3	0	0	18
Li	g	15134	108497	76924	108417	112638	124434	103472	78156	90808	24800	4507	2598	476	381	78156
Mg	g	103961	749463	483690	698010	750884	800059	783302	583701	651146	196808	35054	20319	3014	2406	583701
Mn	g	1382	8880	4657	7216	7075	7418	6715	4651	6068	2307	380	244	22	20	4651
Hg	g	1	9	6	8	9	10	10	7	8	2	0	0	0	0	7
Mo	g	406	2932	1935	2864	3030	3377	3046	2154	2422	717	133	76	12	9	2154
Ni	g	54	404	276	422	424	494	397	267	309	87	17	10	2	1	267
P	g	926	6841	4605	6530	7022	7449	7262	5556	6166	1783	317	181	29	23	5556
K	g	862711	5816085	3844576	5453515	6222882	6935260	6434140	4535714	5075785	1552123	280396	164562	25050	19584	4535714
Se	g	893	5540	3646	5261	6046	7174	5815	3681	4363	1398	256	156	23	18	3681
Si	g	301569	2187327	1515926	2188461	2399637	2693587	2447971	1745309	1928360	549263	101834	57652	10063	7603	1745309
Ag	g	6	42	29	42	44	50	42	30	34	10	2	1	0	0	30
Na	g	5841835	42793352	29910105	42160208	44689800	48478822	43686050	33288666	37561715	10433506	1883419	1073435	189287	150149	33288666
Sr	g	47476	335853	211887	308318	303130	318011	279278	215856	260480	79729	13771	8267	1166	1000	215856
Tl	g	42	258	156	229	250	288	231	148	185	64	11	7	1	1	148
Sn	g	5	32	24	33	45	55	53	34	34	10	2	1	0	0	34
Ti	g	64	489	355	500	507	546	473	375	427	111	20	11	2	2	375
U	g	248	1887	1140	1666	1417	1297	1192	1108	1380	413	69	42	5	5	1108
V	g	399	3032	2315	3256	3494	3958	3355	2487	2762	698	132	72	16	12	2487
Zn	g	233	1631	1141	1626	1752	1979	1677	1202	1378	390	72	41	7	6	1202

Table 3-15:
Upper Case underground waste rock instantaneous loads (g)

Parameter	Units	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Chloride	g	809324	6459381	4431412	6250821	6486000	6591460	6769999	4881006	5514392	6005457	1648458	293569	163035	27921	22421
Fluoride	g	35342	277998	182969	257193	317243	327243	401662	263237	302469	302781	89961	16286	8922	1359	1006
Sulfate	g	14194358	92639826	57987558	83168305	82163760	88785243	68907197	53194667	51474950	66210417	21015510	3612924	2270307	303545	271255
Al	g	114325	839524	584101	820297	911789	988998	952978	697543	714233	779806	220539	39987	22566	3882	3008
Sb	g	4749	30803	20967	30330	34951	41388	34673	26091	22368	25512	7780	1457	858	141	105
As	g	18411	129761	99205	139552	161093	190352	160381	125791	109400	120731	32212	6121	3394	710	514
Ba	g	9810	69656	47631	68610	72473	80806	69594	52756	50402	57906	16620	3033	1755	298	234
Be	g	3	20	14	20	21	23	21	15	15	17	5	1	1	0	0
Bi	g	1	8	6	8	9	10	9	7	7	8	2	0	0	0	0
B	g	21754	150910	103311	146569	153876	170541	142629	110176	105112	123271	35411	6384	3754	630	508
Cd	g	22	254	120	265	125	120	72	36	52	84	27	6	3	0	0
Ca	g	3133017	20251393	12045331	17512922	17436360	18582840	15307685	11200286	11265124	14410759	4836002	821986	520453	61522	55859
Cr	g	62	514	329	527	494	543	493	351	352	394	113	21	12	2	1
Co	g	190	1296	817	1210	1155	1263	968	748	710	902	278	49	30	4	4
Cu	g	66	670	451	745	665	721	689	489	510	542	138	28	14	3	2
Fe	g	4210	33419	23994	33703	31566	32397	27082	22010	23567	27797	7008	1236	695	138	116
Pb	g	12	20851	512	149	43885	26466	137996	60647	104081	78433	28476	5065	2538	194	90
Li	g	22183	152068	106074	149766	150497	167975	126045	103621	94583	116703	32495	5835	3487	616	511
Mg	g	302276	1963831	1148227	1658842	1621481	1673580	1413012	1020102	1085124	1390758	469060	78895	50279	5624	5312
Mn	g	20643	133944	71583	106311	89066	83794	63771	45185	55244	80772	29348	4681	3160	259	301
Hg	g	1	9	6	8	10	11	12	8	8	9	3	0	0	0	0
Mo	g	664	4946	3438	5031	5239	5863	5106	3863	3694	4157	1152	215	121	22	17
Ni	g	116	900	584	941	866	1001	773	587	514	615	176	34	20	3	3
P	g	1898	13967	9565	13792	14530	15925	14383	10719	10658	11996	3399	620	353	61	47
K	g	1165810	8054630	5495688	7776233	8589373	9567981	8538244	6373536	6148903	6957227	2036533	369463	214925	35344	27731
Se	g	1987	11539	8354	11962	15589	19970	15847	12199	8867	9906	3084	608	359	64	44
Si	g	334089	2463138	1694425	2459348	2614264	2899783	2614469	1944670	1900878	2122490	600391	110776	62776	10920	8371
Ag	g	27	178	132	187	215	259	207	164	134	152	42	8	5	1	1
Na	g	7024325	51999106	35759435	50411103	52386624	55588794	51006099	38294910	39925046	45299435	12669107	2256147	1291160	220223	178354
Sr	g	96663	620892	382165	554701	578191	639744	526086	389270	368512	458534	150884	26249	16347	2120	1811
Tl	g	75	497	311	450	435	467	364	280	276	353	111	19	12	2	1
Sn	g	64	370	289	406	622	810	733	536	409	405	123	25	14	3	2
Ti	g	242	1674	1210	1705	1865	2143	1756	1385	1243	1426	393	73	42	8	6
U	g	451	3556	2232	3240	2719	2484	2238	1679	2146	2654	753	126	75	11	10
V	g	995	8211	5917	8350	8345	8612	8185	6219	6788	7505	1925	347	189	37	30
Zn	g	401	5142	2874	5730	3323	3302	2610	1694	2068	2527	631	139	68	11	8

An additional term was developed to account for unclassified underground mine waste rock, termed 'heavy waste', which was placed in the WRTSF between April 2019 and February 2020 (~94 kt), and which will be placed in the WRTSF by October 2023 (~71 kt). The heavy waste placement schedule applied to the water quality model is presented in Table 3-16. The instantaneous loads associated with deposition of this material were derived from SFE data (n=10), following the same approach as outlined above for waste rock. Base Case and Upper Case source terms for heavy waste in the WRTSF are presented in Table 3-17 and Table 3-18, respectively.

Table 3-16:
Schedule for heavy waste placement in the WRTSF

Month-Year	Heavy Waste Placed in WRTSF (t)
Apr-19	15,759
May-19	32,054
Jun-19	13,184
Sep-19	3,996
Oct-19	7,437
Nov-19	11,577
Feb-20	10,135
Jul-23	23,810
Aug-23	23,810
Sep-23	23,810

Table 3-17:
Base Case heavy waste instantaneous loads

Parameter	Unit	Apr-19	May-19	Jun-19	Sep-19	Oct-19	Nov-19	Feb-20	Jul-23	Aug-23	Sep-23
Chloride	G	94554	192322	79104	23978	44620	69463	60811	142862	142862	142862
Fluoride	G	4728	9616	3955	1199	2231	3473	3041	7143	7143	7143
Sulfate	G	567324	1153930	474624	143870	267718	416779	364867	857172	857172	857172
Al	G	12032	24473	10066	3051	5678	8839	7738	18179	18179	18179
Sb	G	551	1120	461	140	260	405	354	832	832	832
As	G	1860	3784	1556	472	878	1367	1196	2811	2811	2811
Ba	G	3893	7919	3257	987	1837	2860	2504	5882	5882	5882
Be	G	0.38	0.77	0.32	0.096	0.18	0.28	0.24	0.57	0.57	0.57
Bi	G	0.33	0.67	0.28	0.084	0.16	0.24	0.21	0.5	0.5	0.5
B	G	3498	7116	2927	887	1651	2570	2250	5286	5286	5286
Cd	G	0.26	0.53	0.22	0.066	0.12	0.19	0.17	0.39	0.39	0.39
Ca	G	348431	708705	291498	88360	164423	255972	224089	526446	526446	526446
Cr	G	11	23	9.5	2.9	5.4	8.3	7.3	17	17	17
Co	G	3.5	7.1	2.9	0.89	1.7	2.6	2.3	5.3	5.3	5.3
Cu	G	0.017	0.034	0.014	0.0042	0.0078	0.012	0.011	0.025	0.025	0.025
Fe	g	496	1010	415	126	234	365	319	750	750	750
Pb	g	0.019	0.039	0.016	0.0049	0.009	0.014	0.012	0.029	0.029	0.029
Li	g	967	1966	809	245	456	710	622	1461	1461	1461
Mg	g	17209	35003	14397	4364	8121	12642	11068	26001	26001	26001
Mn	g	768	1563	643	195	363	564	494	1161	1161	1161
Hg	g	0.47	0.96	0.4	0.12	0.22	0.35	0.3	0.71	0.71	0.71
Mo	g	62	126	52	16	29	45	40	94	94	94
Ni	g	4.7	9.6	4	1.2	2.2	3.5	3	7.1	7.1	7.1
P	g	213	433	178	54	100	156	137	321	321	321
K	g	315101	640912	263614	79908	148695	231486	202653	476088	476088	476088
Se	g	136	277	114	35	64	100	88	206	206	206
Si	g	101646	206746	85037	25777	47966	74673	65372	153577	153577	153577
Ag	g	2.4	4.8	2	0.6	1.1	1.7	1.5	3.6	3.6	3.6
Na	g	628784	1278939	526042	159456	296720	461930	404394	950032	950032	950032
Sr	g	16807	34185	14061	4262	7931	12347	10809	25394	25394	25394
Tl	g	6.8	14	5.7	1.7	3.2	5	4.3	10	10	10
Sn	g	1.7	3.4	1.4	0.42	0.78	1.2	1.1	2.5	2.5	2.5
Ti	g	14	28	11	3.5	6.5	10	8.8	21	21	21
U	g	23	46	19	5.8	11	17	15	34	34	34
V	g	126	257	106	32	60	93	81	191	191	191
Zn	g	95	192	79	24	45	69	61	143	143	143

Table 3-18:
Upper Case heavy waste instantaneous loads

Parameter	Unit	Apr-19	May-19	Jun-19	Sep-19	Oct-19	Nov-19	Feb-20	Jul-23	Aug-23	Sep-23
Chloride	g	141831	288482	118656	35968	66929	104195	91217	214293	214293	214293
Fluoride	g	7612	15482	6368	1930	3592	5592	4895	11500	11500	11500
Sulfate	g	1059005	2154002	885965	268558	499740	777988	681085	1600054	1600054	1600054
Al	g	17549	35695	14682	4450	8281	12892	11287	26515	26515	26515
Sb	g	789	1605	660	200	372	580	507	1192	1192	1192
As	g	3044	6191	2546	772	1436	2236	1958	4599	4599	4599
Ba	g	6330	12876	5296	1605	2987	4651	4071	9565	9565	9565
Be	g	2.1	4.3	1.8	0.54	1	1.6	1.4	3.2	3.2	3.2
Bi	g	0.48	0.97	0.4	0.12	0.23	0.35	0.31	0.72	0.72	0.72
B	g	5059	10289	4232	1283	2387	3716	3253	7643	7643	7643
Cd	g	1.6	3.2	1.3	0.4	0.74	1.1	1	2.4	2.4	2.4
Ca	g	850986	1730894	711936	215806	401576	625169	547301	1285758	1285758	1285758
Cr	g	16	32	13	4	7.5	12	10	24	24	24
Co	g	13	27	11	3.3	6.2	9.6	8.4	20	20	20
Cu	g	0.033	0.067	0.028	0.0084	0.016	0.024	0.021	0.05	0.05	0.05
Fe	g	1116	2269	933	283	527	820	718	1686	1686	1686
Pb	g	0.037	0.074	0.031	0.0093	0.017	0.027	0.024	0.055	0.055	0.055
Li	g	2013	4095	1684	511	950	1479	1295	3042	3042	3042
Mg	g	35406	72015	29620	8979	16708	26010	22771	53495	53495	53495
Mn	g	1956	3979	1637	496	923	1437	1258	2956	2956	2956
Hg	g	0.95	1.9	0.79	0.24	0.45	0.69	0.61	1.4	1.4	1.4
Mo	g	111	226	93	28	52	81	71	168	168	168
Ni	g	19	39	16	4.9	9.1	14	12	29	29	29
P	g	407	827	340	103	192	299	261	614	614	614
K	g	339449	690435	283983	86082	160184	249373	218312	512875	512875	512875
Se	g	203	413	170	51	96	149	131	307	307	307
Si	g	126088	256461	105485	31975	59500	92629	81092	190506	190506	190506
Ag	g	3.4	6.8	2.8	0.85	1.6	2.5	2.2	5.1	5.1	5.1
Na	g	1011728	2057841	846413	256569	477430	743256	650680	1528623	1528623	1528623
Sr	g	24768	50379	20721	6281	11688	18196	15929	37423	37423	37423
Tl	g	11	21	8.8	2.7	5	7.7	6.8	16	16	16
Sn	g	4.5	9.2	3.8	1.2	2.1	3.3	2.9	6.9	6.9	6.9
Ti	g	29	59	24	7.3	14	21	19	44	44	44
U	g	44	90	37	11	21	32	28	67	67	67
V	g	293	596	245	74	138	215	188	442	442	442
Zn	g	203	413	170	52	96	149	131	307	307	307

3.4.2.2 Post-Depositional Loads

Leachate data from saturated column kinetic tests comprising waste rock from the underground mine (VSF, Fragmental and Conglomerate) were used to assess which parameters have the potential for longer-term leaching behaviour. Based on the assessment, As and Sb were identified as parameters showing longer-term release patterns. These are the only parameters for which a post-depositional load is applied. Post-depositional loads for these parameters are based on stabilized waste rock column leachate concentration data (*i.e.*, last five analyses, up until December 2021) combined with the underground waste rock schedule (Table 3-12) and assumptions regarding waste rock reactivity.

Following the approach applied in previous models, median and 90th percentile leachate concentration values were used to derive Base Case and Upper Case loading rates. Loading rates (mg/kg/month) for each underground waste rock lithology were combined with the lithology-specific tonnages presented in Table 3-12 to derive updated monthly loads released to the WRTSF. Leachate quality from the surface P2 column was used as a surrogate for the underground Office P2 and Office P1 units when calculating the potential contributions from these waste rock tonnages deposited in the WRTSF. Leachate quality from the acid generating S3 column was used as a surrogate for the Silicic Cap. It is assumed that any waste rock deposited in the lake will contribute post-depositional loads for approximately one year following placement. After this time, it is assumed that on-going deposition of waste rock from development of the underground mine will limit post-depositional leaching. Base Case and Upper Case As and Sb predictions for post-deposition loads are summarized in Table 3-19.

The contribution of post-depositional loads is projected to continue throughout the closure and post-closure periods. Ultimately, final tailings production and natural sedimentation in the WRTSF are assumed to cover the final waste rock deposits and inhibit further contaminant release.

Table 3-19:
Underground waste rock post-deposition loads (g)

Year	D-Sb		D-As	
	Base Case	Upper Case	Base Case	Upper Case
	(g)	(g)	(g)	(g)
2015	26.8	31.5	707.8	808.1
2016	678	784	13607	15484
2017	1106	1257	17128	19422
2018	1097	1241	15749	17836
2019	936	1061	15066	17092
2020	639	725	12037	13685
2021	469	534	9182	10434
2022	400	450	5788	6540
2023	541	604	5436	6095
2024	790	889	8662	9740
2025	517	588	7345	8307
2026	110	128	2414	2748
2027	24	28	597	680
2028	10	12	243	278
2029	3	4	33	37
Closure and post-closure	2	2	17	20

3.4.2.3 Surface Exposure Loads

Most of the underground waste rock brought to surface will be deposited in the WRTSF immediately; however, a portion may be stored at surface for up to two years prior to subaqueous deposition as per *Mines Act* Permit M-243 Condition D.3(c)(v). The exposed surface portion of the waste rock pad develops as waste rock is added to the pad and waste rock is deposited into the WRTSF. Subaerially exposed PAG pad materials may be replaced with either NPAG or fresh PAG materials within the two-year time frame, or the surface PAG materials may be excavated and deposited in the main body of the lake, leaving shallow ponded areas within the pad (geotechnical and other conditions apply to these activities).

Accumulated loads associated with exposure of waste rock over a two-year time frame have been incorporated into the Brucejack Mine water quality model. Proportional loads from the four major geological model units (representing 97% of waste rock to be excavated from the underground mine; Table 3-12) were determined based on field bin leachate results (as presented in the 2016 Annual Report; Pretium, 2017) and the estimated maximum volume of waste rock to be subaerially exposed on the waste rock platform at any given time (~180,000 m^3). The total loads accumulated over a two-year time frame,

along with the monthly loads for May-October (*i.e.*, the months when leaching would be anticipated), are presented in Table 3-20. These data, along with the approach applied for derivation of surface exposure loads, have been reviewed and based on this assessment, no updates were made to this term for this model.

Table 3-20:
Subaerially-exposed underground waste rock loads

Parameter	Loads Accumulated over 2 Years (kg)	Monthly Loads (May-October) (kg)
Chloride	465	77
Fluoride	29	4.8
Sulfate	23570	3928
Al	12	2.1
Sb	5.0	0.83
As	8.3	1.4
Ba	8.6	1.4
Be	0.015	0.0025
Bi	0.075	0.013
B	15	2.6
Cd	0.015	0.0024
Ca	4297	716
Cr	0.023	0.0039
Co	0.13	0.021
Cu	2.6	0.43
Fe	4.2	0.70
Pb	0.040	0.0066
Li	26	4.3
Mg	459	77
Mn	21	3.5
Hg	0.0014	0.00023
Mo	2.2	0.36
Ni	0.37	0.061
P	37	6.2
K	915	153
Se	1.7	0.29
Si	196	33
Ag	0.0064	0.0011
Na	11844	1974
Sr	162	27
Tl	0.029	0.0048
Sn	0.015	0.0025
Ti	1.4	0.23
U	3.2	0.53
V	0.21	0.036
Zn	0.69	0.11

3.4.3 Underground Mine Water

The underground mine water source term represents the cumulative geochemical load of wall rock, groundwater, paste backfill and rockfill in the underground mine workings. Loading rates associated with each of these mine components are developed in this section, along with solubility controls for underground mine water. Source terms are developed for three distinct periods of mine life: operations, closure, and post-closure.

During operations, mine workings are actively dewatering and expanding. Source terms for each of the mine components (wall rock, rockfill, paste backfill) are calculated by upscaling kinetic tests. In the case of wall rock, loading rates are scaled by calibration to site monitoring data. The geochemical loadings generated from the underground mine will increase throughout operations as mine workings expand and PAG exposures gradually become acid generating. Loads from paste backfill bleed water and blasting residues in the mine underground are discussed in Sections 3.6.6 and 3.8.5, respectively.

At closure, mine workings will be flooded over an estimated seven month time period and are predicted to reach a final water elevation of approximately 1393 masl to 1407 masl, averaging 1401 masl. For the purpose of source term calculation, an elevation of 1380 masl is conservatively applied (1380 masl would have higher wall rock exposures and associated loadings). Submergence of mine workings will release an initial flush of water-soluble oxidation products stored on mineral surfaces, termed 'flushing loads'. This flushing load along with continued oxidation of unsaturated mine workings will result in elevated loading during mine flooding. Water quality during closure will be mitigated by accelerated flooding and re-circulation of mine water through the WTP as described in the 4950 tpd groundwater model report and water balance model report (Lorax, 2023a and 2023b, respectively). This will reduce metal concentrations in mine water during flooding, for parameters that are treated by the WTP, and accelerate stabilization of the mine pool (*i.e.*, the water present in the underground mine).

The post-closure source terms define the long-term geochemical loadings that will emanate from the underground mine. Loading sources to the mine pool in post-closure will originate from continued oxidation of unsaturated mine workings above the water table, and residual loadings from saturated mine workings.

3.4.3.1 Background Groundwater

The background groundwater source term is applied to groundwater infiltrating into the mine workings during operations. This source term is meant to represent groundwater before it interacts with the underground mine. During closure and post-closure, this source term is re-assigned to the saturated concentration source terms defined in Section 3.4.3.2.3.

This change is made to reflect the potential for groundwater moving through flooded mine workings to pickup a geochemical load through interaction with wall rock, rockfill and paste backfill.

The groundwater source term is based on water quality monitoring of adit drainage from time periods when mine workings were flooded. Nearly all of the mine workings excavated by Newhawk were saturated, making the adit drainage prior to dewatering in October 2011 representative of local groundwater in the mining area. The median concentrations observed in adit drainage from October 2009 to October 2011 were used for the background groundwater source term with some minor modifications (Table 3-21). The concentration of pH-sensitive parameters (*e.g.,* Ca, Mg, Co, Mn, P, Sr and Zn) were observed to decline when pH increased shortly after mine workings were dewatered. For example, D-Zn concentrations ranged from 0.007 mg/L to 0.046 mg/L when mine workings were flooded and have declined to 0.001 mg/L to 0.0068 mg/L (median 0.002 mg/L) when mine workings were dewatered. This poses a challenge for model calibration, which scales wall rock loading rates to reproduce observed underground water quality. Improved method detection limits (MDLs) after October 2011 for Be, Bi, Cd, Cu, Fe and Hg present another challenge. To support a conservative model calibration, the minimum concentration of these parameters once dewatering commenced is applied to background groundwater chemistry in operations. Background groundwater chemistry used in the water quality model is unchanged from previous models and shown in Table 3-21. Note that no distinction is made between Base Case and Upper Case background groundwater water quality for the purpose of the water quality model.

Table 3-21:
Background groundwater source term concentrations

Parameter	Unit	Base Case and Upper Case
Ammonia	mg/L	0.0102
Nitrate	mg/L	0.02995
Nitrite	mg/L	0.001
Chloride	mg/L	0.5
Fluoride	mg/L	0.203
Sulfate	mg/L	116
Ag	mg/L	0.00001
Al	mg/L	0.015
As	mg/L	0.00213
B	mg/L	0.034
Ba	mg/L	0.0187
Be	mg/L	0.0001
Bi	mg/L	0.00005
Ca	mg/L	21.48
Cd	mg/L	0.000005
Co	mg/L	0.0001
Cr	mg/L	0.00016
Cu	mg/L	0.0002
Fe	mg/L	0.01
Hg	mg/L	0.000005
K	mg/L	1.78
Li	mg/L	0.0521
Mg	mg/L	3.044
Mn	mg/L	0.01274
Mo	mg/L	0.00158
Na	mg/L	16.6
Ni	mg/L	0.0005
P	mg/L	0.00595
Pb	mg/L	0.000083
Sb	mg/L	0.00122
Se	mg/L	0.0001
Si	mg/L	3.01
Sn	mg/L	0.0001
Sr	mg/L	0.8421
Tl	mg/L	0.000015
U	mg/L	0.000206
V	mg/L	0.001
Zn	mg/L	0.001

3.4.3.2 Unsaturated Underground Mine Source Terms

The unsaturated underground mine source terms were developed following the approach outlined in previous water quality model reports (Pretium, 2015; Lorax, 2018; Lorax, 2020c). The only updates incorporated into unsaturated mine components are additional kinetic test results and the 4950 tpd waste deposition schedule.

The unsaturated underground mine source terms are applied in all phases of mine life. Loading rates are defined per tonnage of rockfill and paste backfill or surface area of wall rock. The surface area and tonnage of these mine components increase throughout operations as defined by the mine plan. During closure, the total loading from unsaturated mine workings declines as the water table rises and submerges mine workings. The same loading rates (per unit area or tonnage) are applied during the operations and closure phases. However, the post-closure loading rates are modified so that only the final humidity cell cycles (median of final 5 cycles) are used to estimate long term loading rates.

3.4.3.2.1 Wall Rock Loads

The wall rock loading rate represents the geochemical load produced from oxidation of wall rock exposures as a function of time. The wall rock source term is calculated by multiplying lithology-specific humidity cell loading rates (units of mg/kg/wk) by wall rock conversion factors (units of kg/m^2) which produce area-normalized wall rock loading rates (units of $mg/m^2/wk$). This loading rate is then calibrated using site monitoring data by adjusting the wall rock scaling factor. The development of this term follows the same approach as outlined in previous water quality models developed for the site (Pretium, 2015; Lorax, 2018; Lorax, 2020a). Updates in the current model iteration are limited to incorporation of additional humidity cell test results and the updated mine schedule.

The wall rock exposure schedule is shown in Table 3-22. This schedule shows the annualized wall rock exposures as well as the area exposed above an elevation of 1380 masl which is assumed to remain unsaturated during post closure. The humidity cells used to represent different wall rock lithologies are shown in Table 3-23. Source term calculations apply the 75th percentile loading rate for Base Case and the 90th percentile loading rate to the Upper Case. The post-closure source term uses the median loading rate of the final 5 cycles. The HCT loading rates and wall rock exposure areas are multiplied by the wall rock conversion factors developed in Lorax (2020a) shown in Table 3-24, to produce wall rock source terms for operations and closure (Table 3-25 and Table 3-26, respectively).

Loading rates have been updated using data generated through January 17th, 2022 for ongoing kinetic tests (HC20, HC21, HC23, HC25, HC28, HC29, HC31, HC32, HC34, HC36).

Table 3-22:
Cumulative wall rock exposures over mine life

Mine Year	P1	VSF	S3	ANDX	P2	SILCAP	Total
	m²	m²	m²	m²	m²	m²	m²
2014	-	55,087	1,684	13,506	-	158	70,435
2015	-	75,681	19,405	34,270	-	440	129,796
2016	1,531	177,380	34,343	104,914	-	3,977	322,145
2017	2,439	327,068	56,444	236,256	-	8,404	630,611
2018	4,860	570,057	116,257	425,178	-	21,471	1,137,823
2019	19,368	761,338	145,543	532,552	-	29,880	1,488,681
2020	24,938	981,703	174,992	662,246	-	34,918	1,878,798
2021	76,495	1,377,936	210,945	773,706	-	34,918	2,474,000
2022	126,707	1,706,515	227,952	842,138	-	38,419	2,941,731
2023	199,748	2,007,774	238,299	911,396	-	40,203	3,397,420
2024	300,593	2,245,312	280,700	1,041,496	664	46,237	3,915,002
2025	345,389	2,448,019	305,908	1,110,449	1,221	49,867	4,260,853
2026	425,843	2,615,726	319,299	1,172,854	1,221	52,349	4,587,292
2027	513,350	2,737,932	338,069	1,240,474	1,223	53,548	4,884,595
2028	563,769	2,824,469	361,420	1,298,438	1,294	57,237	5,106,627
2029	566,858	2,882,749	379,121	1,377,920	1,294	58,252	5,266,195
>1380 masl*	211,218	287,414	34,354	266,832	0	7261	807,079

*Wall rock exposed above elevation of 1380 masl used in post-closure source term.

Source term calculations apply the 75th percentile loading rate for Base Case and the 90th percentile loading rate to the Upper Case. The post-closure source term uses the median loading rate of the final 5 cycles. The HCT loading rates and wall rock exposure areas are multiplied by the wall rock conversion factors developed in Lorax (2020a) shown in Table 3-24, to produce wall rock source terms for operations and closure (Table 3-25 and Table 3-26, respectively).

Table 3-23:
Humidity cells used to represent rock units under neutral and acidic conditions

Rock Unit	Weathering State	Humidity Cells
P2	Neutral	HC23*, HC34
VSF	Neutral	HC3, HC7, HC10, HC11, HC12, HC13, HC14, HC15, HC17, HC18, HC20, HC29, HC33
P1	Neutral	HC28, HC35, HC27
S3 (Conglomerate)	Neutral	HC19, HC21**
Frag	Neutral	HC5, HC8, HC9, HC16, HC24, HC31***, HC32
Silicified Cap	Neutral	HC36
All Rock Units	Acidic	HC2, HC4, HC26, HC22, HC25, HC23*, HC21**, HC31***

Notes: *HC23-Neutral until cycle 227, acidic starting cycle 228 onward.
**HC21-Neutral until cycle 110, acidic starting cycle 111 onward.
***HC31-Neutral until cycle 125, acidic starting cycle 126 onward.

Table 3-24:
Wall rock conversion factors used to relate humidity cell loading rates (mg/kg/wk) to wall rock loading rates (mg/m^2/wk)

Parameter	Units	Base Case	Upper Case
Sulfate	kg/m^2	61.6	93
Ag	kg/m^2	1.5	2.4
As	kg/m^2	118	160
Ba	kg/m^2	23.7	41.7
Ca	kg/m^2	33.4	73.4
Cd	kg/m^2	0.10	0.30
Co	kg/m^2	0.30	1.0
Cr(VI)	kg/m^2	-	-
Cu	kg/m^2	0.40	0.50
Fe	kg/m^2	0.10	0.30
Hg	kg/m^2	0.80	2.5
K	kg/m^2	218.8	238.1
Mg	kg/m^2	15.2	40.4
Mn	kg/m^2	0.70	2.0
Mo	kg/m^2	120	134
Na	kg/m^2	215	222
Ni	kg/m^2	1.20	1.9
Pb	kg/m^2	6.9	8.6
Sb	kg/m^2	283	417
Se	kg/m^2	40	45
Si	kg/m^2	53.2	101
Sr	kg/m^2	5.3	16
Tl	kg/m^2	87	131
U	kg/m^2	66	105
Zn	kg/m^2	0.10	0.40

Table 3-25:
Operations and closure wall rock source terms

Parameter	Units	Acidic Rock		P1		S3		ANDX		P2		Silicified Cap		VSF	
		Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/m²/wk	3440	6040	182	408	1480	4540	813	1520	2010	3280	653	1170	745	1600
Ag	mg/m²/wk	0.0000975	0.000242	1.56E-05	2.59E-05	7.02E-06	1.66E-05	1.76E-05	0.000035	1.98E-05	3.89E-05	3.35E-05	5.64E-05	1.65E-05	3.84E-05
As	mg/m²/wk	1.53	2.74	0.221	0.41	0.0944	0.199	0.282	0.792	0.309	1.22	0.0675	0.116	1.04	2.76
Ba	mg/m²/wk	0.11	0.281	0.142	0.299	0.101	0.264	0.158	0.33	0.0948	0.194	0.11	0.246	0.107	0.24
Ca	mg/m²/wk	367	1170	65.1	172	107	479	73.1	189	134	324	36.4	108	85.2	269
Cd	mg/m²/wk	0.00115	0.00471	1.31E-06	6.72E-06	4.63E-05	0.000179	2.93E-06	1.31E-05	1.99E-05	7.95E-05	8.38E-05	0.000342	5.04E-06	1.94E-05
Co	mg/m²/wk	0.00327	0.0153	1.22E-05	6.12E-05	0.00148	0.00608	5.34E-05	0.000253	7.71E-05	0.000335	3.27E-05	0.000148	0.000396	0.00189
Cr	mg/m²/wk	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	mg/m²/wk	0.0632	0.125	0.00011	0.000222	0.00608	0.0177	0.000121	0.000217	0.000101	0.000204	0.000182	0.00042	0.000134	0.000251
Fe	mg/m²/wk	0.66	2.41	0.000463	0.00214	0.000224	0.00078	0.00047	0.00567	0.000406	0.00263	0.000344	0.00172	0.000296	0.0023
Hg	mg/m²/wk	0.00000424	1.82E-05	3.7E-06	0.000012	3.86E-06	0.000022	3.87E-06	1.76E-05	3.7E-06	0.000012	3.8E-06	1.25E-05	3.84E-06	1.73E-05
K	mg/m²/wk	132	407	124	248	459	1020	254	379	578	690	157	230	214	386
Mg	mg/m²/wk	17.3	61.8	4.59	13.7	6.57	35.6	4.07	12.6	8.25	24.1	2.25	8.04	5.05	19.4
Mn	mg/m²/wk	0.455	1.77	0.00833	0.0302	0.133	0.468	0.0437	0.147	0.0994	0.32	0.0253	0.093	0.0598	0.202
Mo	mg/m²/wk	0.0167	0.032	0.0461	0.0603	0.132	0.17	0.125	0.177	0.0316	0.0597	0.0292	0.0536	0.331	0.536
Na	mg/m²/wk	22.4	109	243	448	3570	7520	1590	2040	4480	5100	1220	1690	1190	1810
Ni	mg/m²/wk	0.00652	0.0148	5.62E-05	0.00012	0.001	0.00228	0.000164	0.000403	0.000127	0.0003	0.000211	0.000433	0.00301	0.0065
Pb	mg/m²/wk	0.0654	0.133	0.000638	0.00114	0.00911	0.0277	0.0017	0.0035	0.000447	0.000788	0.000391	0.000759	0.000492	0.000989
Sb	mg/m²/wk	0.0789	0.158	0.17	0.374	0.634	1.57	0.648	1.34	0.362	1.21	0.498	1.09	0.829	2.29
Se	mg/m²/wk	0.062	0.11	0.0056	0.00817	0.0508	0.0777	0.0278	0.0593	0.159	0.219	0.0416	0.0741	0.0319	0.0552
Si	mg/m²/wk	32.5	78.8	11.9	29.4	14.8	38.7	16.1	44.4	9.36	24.3	8.94	21.7	16	43.4
Sr	mg/m²/wk	0.726	3.66	0.223	0.93	0.599	3.2	0.515	2.13	0.975	3.39	0.125	0.506	0.684	2.73
Tl	mg/m²/wk	0.00498	0.0165	0.000781	0.00161	0.00652	0.0249	0.00193	0.00491	0.00083	0.00215	0.000753	0.0012	0.0022	0.00613
U	mg/m²/wk	0.279	0.673	0.0142	0.0358	0.075	0.171	0.0159	0.048	0.0073	0.0223	0.00783	0.0166	0.0178	0.0523
Zn	mg/m²/wk	0.0563	0.28	6.12E-05	0.000377	0.00501	0.0282	0.000157	0.000904	0.000217	0.00114	0.00189	0.0114	0.000202	0.000992

Table 3-26:
Post-closure wall rock source terms

Parameter	Units	Acidic Rock		P1		S3		ANDX		P2		Silicified Cap		VSF	
		Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/m²/wk	3370	5090	84.4	127	1400	2120	776	1170	1820	2740	733	1110	601	908
Ag	mg/m²/wk	0.000145	0.000232	1.34E-05	2.15E-05	6.6E-06	1.06E-05	0.000015	0.000024	0.000033	5.28E-05	0.000035	5.59E-05	1.16E-05	1.86E-05
As	mg/m²/wk	0.937	1.27	0.0984	0.134	0.0308	0.0418	0.137	0.186	0.0104	0.0141	0.0385	0.0523	0.548	0.744
Ba	mg/m²/wk	0.0519	0.0913	0.0984	0.173	0.0735	0.129	0.0905	0.159	0.0422	0.0742	0.0422	0.0742	0.0595	0.105
Ca	mg/m²/wk	159	349	53.4	117	95.5	210	68.5	150	128	280	48.8	107	68.8	151
Cd	mg/m²/wk	0.00106	0.00318	1.79E-07	5.37E-07	5.52E-05	0.000166	3.33E-06	9.99E-06	0.000031	0.000093	0.000138	0.000414	6.36E-06	1.91E-05
Co	mg/m²/wk	0.00233	0.00775	1.02E-06	3.4E-06	0.00167	0.00556	7.17E-05	0.000239	9.81E-05	0.000327	5.91E-05	0.000197	0.000225	0.000751
Cr	mg/m²/wk	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	mg/m²/wk	0.0488	0.061	3.45E-05	4.32E-05	0.0134	0.0167	0.000096	0.00012	6.04E-05	7.55E-05	0.000432	0.00054	0.000151	0.000189
Fe	mg/m²/wk	0.824	2.47	0.000272	0.000816	0.000242	0.000726	0.00402	0.0121	0.00129	0.00387	0.000522	0.00157	0.000783	0.00235
Hg	mg/m²/wk	0.00000423	1.32E-05	3.62E-06	1.13E-05	3.52E-06	0.000011	3.63E-06	1.14E-05	3.52E-06	0.000011	3.72E-06	1.16E-05	3.61E-06	1.13E-05
K	mg/m²/wk	39.8	43.3	45.9	50	411	448	219	238	547	595	210	228	133	145
Mg	mg/m²/wk	7.54	20	3.89	10.3	5.9	15.7	4.03	10.7	7.84	20.8	3.01	8	4.03	10.7
Mn	mg/m²/wk	0.193	0.552	0.00129	0.00368	0.118	0.336	0.027	0.0772	0.0587	0.168	0.0309	0.0884	0.0377	0.108
Mo	mg/m²/wk	0.0125	0.0139	0.0315	0.0352	0.0743	0.083	0.044	0.0491	0.00553	0.00619	0.00338	0.00378	0.159	0.178
Na	mg/m²/wk	15.8	16.3	109	113	3210	3300	1630	1680	4260	4390	1630	1680	902	929
Ni	mg/m²/wk	0.00464	0.00735	5.46E-05	8.65E-05	0.00121	0.00192	0.000154	0.000243	7.92E-05	0.000125	0.000338	0.000536	0.00347	0.00549
Pb	mg/m²/wk	0.0151	0.0188	0.000201	0.00025	0.0274	0.0341	0.000759	0.000946	0.000531	0.000662	0.000519	0.000647	0.000269	0.000335
Sb	mg/m²/wk	0.0747	0.11	0.0888	0.131	0.24	0.353	0.275	0.405	0.0812	0.12	0.119	0.175	0.291	0.429
Se	mg/m²/wk	0.025	0.028	0.00277	0.00311	0.0378	0.0425	0.0179	0.0201	0.0592	0.0665	0.0306	0.0343	0.0258	0.0289
Si	mg/m²/wk	27.8	52.9	5.69	10.8	9.79	18.6	8.19	15.6	6.28	12	3.67	6.99	7.39	14.1
Sr	mg/m²/wk	0.196	0.587	0.0954	0.286	0.436	1.31	0.268	0.803	0.254	0.763	0.103	0.31	0.305	0.916
Tl	mg/m²/wk	0.00253	0.00384	0.000342	0.000518	0.00235	0.00357	0.000695	0.00105	0.000228	0.000346	0.000202	0.000306	0.000926	0.0014
U	mg/m²/wk	0.0562	0.0892	0.00438	0.00696	0.0776	0.123	0.00426	0.00677	0.00254	0.00403	0.0038	0.00604	0.00617	0.00979
Zn	mg/m²/wk	0.0476	0.19	6.05E-05	0.000242	0.00581	0.0232	0.000187	0.000748	0.000303	0.00121	0.00391	0.0156	0.000246	0.000984

3.4.3.2.2 Rockfill Loads

Waste rock backfill (rockfill) will contribute a geochemical load to the underground mine. The projected amount of rockfill that will be placed into mine workings over life of mine is shown in Table 3-13. The rockfill source term is based on lithology-specific humidity cell data scaled to reflect field conditions following the approach outlined in the *MA & EMA* Permits Application (Pretium, 2015). The only updates to the current rockfill source term from previous model iterations are incorporation of ongoing kinetic test results through January 17th, 2022, and the rockfill mass based on the 4950 tpd mine schedule.

Humidity cell loading rates are scaled to reflect the differences in field and laboratory conditions using 'scaling factors'. A summary of the scaling factors used to convert laboratory loading rates to field loading rates for underground mine rockfill are presented in Table 3-27. These scaling factors are based on first principles and physicochemical properties that impact mine waste weathering. Note that these are the same scaling factors used in previous versions of the water quality model (Pretium, 2015; Lorax, 2018; Lorax, 2020a)

Table 3-27:
Scaling factors applied to humidity cell loading rates to predict rockfill source term

Scaling Factors	*Base Case*	*Upper Case*
Temperature Correction	0.3	0.3
Contact Water Factor	0.5	1.0
Grain Size Correction Factor	0.2	0.2

Scaling factors used to convert laboratory humidity cell weathering rates to field conditions include a temperature correction, a contact water factor and a grain size correction factor. Sulphide oxidation rates are temperature sensitive; therefore, the temperature difference between laboratory and field conditions is predicted based on an Arrhenius relationship used to derive the 'temperature correction' scaling factor. Humidity cells are designed to achieve complete flushing of mineral surfaces, ensured by the small sample size (1 kg) and high flushing rate (0.5 L/week). This high flushing rate inhibits oxide accumulation on mineral surfaces in humidity cell tests. In unsaturated waste rock, a portion of oxidation products will accumulate on mineral surfaces, particularly in areas of the rock fill which are poorly flushed. To account for this accumulation of weathering products on mineral surfaces associated with insufficient rinsing, a 'contact water' scaling factor is introduced. Drill core samples used for laboratory kinetic testwork are ground to a relatively fine grain size (< ¼"), hence, material used in humidity cells have a greater surface area to mass ratio than is expected for waste rock. The grain size scaling factor reflects differences between

grain size in humidity cell tests and in the field. For an explanation of the selected scaling factor values shown in Table 3-27, see Pretium (2015).

The same humidity cell groupings that were used in calculating the wall rock source term were applied to the waste rock backfill source term. Median and 90th percentile loading rates were used to estimate the Base Case and Upper Case rock fill source terms, respectively. The scaled waste rock backfill loading rates used to calculate the updated underground mine water source term are provided in Table 3-28.

Upon mine closure, backfilled waste rock will be submerged below the final water table to mitigate the long-term potential for ARD development, as per Condition D.3(c)(iii) in *Mines Act* Permit M-243. As such, no unsaturated waste rock backfill term has been developed for post-closure.

Table 3-28:
Source terms for unsaturated rockfill during operations and closure

Parameter	Units	Acidic Rock		P1		S3		ANDX		P2		Silicified Cap		VSF	
		Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/t/wk	1400	3740	62.1	263	564	2930	324	978	882	2120	248	756	306	1030
Ag	mg/t/wk	0.000648	0.00547	0.000099	0.000648	0.000134	0.000416	0.000159	0.000876	0.000132	0.000972	0.000181	0.00141	0.000205	0.00096
As	mg/t/wk	0.206	0.9	0.0333	0.154	0.0122	0.0744	0.0468	0.296	0.0233	0.456	0.0145	0.0433	0.173	1.03
Ba	mg/t/wk	0.093	0.37	0.145	0.43	0.108	0.38	0.169	0.475	0.101	0.28	0.0996	0.354	0.109	0.345
Ca	mg/t/wk	272	978	51.6	140	72	391	55.5	155	106	265	23	88.2	64.2	220
Cd	mg/t/wk	0.247	0.834	8.79E-05	0.00134	0.00762	0.0359	0.000516	0.00261	0.00444	0.0159	0.0181	0.0684	0.00111	0.00389
Co	mg/t/wk	0.214	0.81	0.00048	0.00367	0.0918	0.365	0.00333	0.0152	0.00492	0.0201	0.00223	0.00888	0.0239	0.113
Cr	mg/t/wk	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cu	mg/t/wk	2.33	13.1	0.00663	0.0266	0.131	2.12	0.00753	0.026	0.00576	0.0245	0.00768	0.0504	0.00762	0.0301
Fe	mg/t/wk	114	424	0.0984	0.428	0.0468	0.156	0.0687	1.13	0.0942	0.526	0.0957	0.343	0.0642	0.461
Hg	ug/t/wk	0.000137	0.000417	0.000135	0.000287	0.000137	0.000528	0.000139	0.000421	0.000134	0.000287	0.000138	0.0003	0.000138	0.000414
K	mg/t/wk	7.68	90.6	10.3	62.4	46.8	257	25.8	95.4	69.3	174	15.1	57.8	21.6	97.2
Mg	mg/t/wk	22.4	80.4	8.19	20.4	9.72	52.9	6.9	18.8	14.3	35.8	3.12	11.9	8.49	28.9
Mn	mg/t/wk	12.4	47.9	0.264	0.906	4.8	14	1.44	4.4	3.09	9.6	0.924	2.79	1.76	6.06
Mo	mg/t/wk	0.002	0.013	0.00966	0.027	0.0265	0.0762	0.0233	0.0792	0.00429	0.0268	0.0048	0.024	0.0639	0.24
Na	mg/t/wk	1.73	26.2	24.5	121	372	2030	182	552	546	1380	119	458	139	491
Ni	mg/t/wk	0.101	0.412	0.00136	0.00378	0.0151	0.072	0.00225	0.0127	0.00139	0.00948	0.00285	0.0137	0.0498	0.205
Pb	mg/t/wk	0.0927	0.822	0.000987	0.00792	0.0212	0.193	0.00462	0.0244	0.00122	0.0055	0.00108	0.0053	0.000996	0.0069
Sb	mg/t/wk	0.00627	0.0229	0.0129	0.0539	0.0441	0.227	0.0492	0.193	0.0193	0.174	0.0363	0.157	0.0594	0.329
Se	mg/t/wk	0.0336	0.143	0.00306	0.0109	0.0321	0.104	0.0152	0.0792	0.084	0.292	0.0259	0.099	0.0175	0.0738
Si	mg/t/wk	12.6	41.8	4.83	17.4	6.42	22.9	6.78	26.3	4.53	14.4	3.72	12.8	6.51	25.7
Sr	mg/t/wk	2.46	12.6	0.912	3.51	2.92	12.1	2.16	8.04	4.26	12.8	0.606	1.91	2.79	10.3
Tl	mg/t/wk	0.000807	0.00666	0.000117	0.000738	0.00126	0.0114	0.000387	0.00224	0.000143	0.000984	7.17E-05	0.000547	0.000441	0.0028
U	mg/t/wk	0.0465	0.338	0.00423	0.0206	0.024	0.0984	0.0039	0.0275	0.00167	0.0128	0.00265	0.00954	0.00522	0.03
Zn	mg/t/wk	11.6	36.8	0.0176	0.0565	0.735	4.22	0.0281	0.136	0.039	0.17	0.354	1.71	0.0417	0.149

3.4.3.2.3 Paste Backfill Loads

During operations, paste backfill is placed in underground voids for ground support. The schedule for placement of paste backfill to the underground mine is provided in Table 3-39.

The unsaturated source term for paste backfill is derived by scaling humidity cell loading rates to field conditions, as described in the *MA & EMA* Permits Application (Pretium, 2015). Subsequent model updates incorporated: (1) HCT results on paste tailings collected from site (T18) which superseded older kinetic testing which used metallurgical paste tailings samples (T12), and (2) development of a calibrated hexavalent Cr loading term to more accurately predict behaviour associated with cement addition (Lorax, 2020c). Updates to the current source term iteration include incorporation of ongoing kinetic test results from T18 through January 17th, 2022, and the paste backfill mass based on the 4950 tpd mine schedule.

Median and 90th percentile loading rates were used to estimate the operations Base Case and Upper Case paste backfill loading rates, respectively. The post-closure source term for paste backfill uses the median loading rate of the final 5 cycles. The humidity cell loading rates are scaled using the same scaling factors described in the *MA & EMA* Permits Application (Pretium, 2015) to relate the laboratory kinetic test to field conditions. The scaling factors are shown in Table 3-29, and are meant to reflect differences between laboratory and field conditions, as described in 3.4.3.2.2. Justification for the selected scaling factor values can be found in Pretium (2015). The loading rates applied to paste backfill in the water quality model during operations and closure are shown in Table 3-30.

Table 3-29:
Scaling factors applied to humidity cell loading rates to predict paste backfill source term.

Scaling Factors	*Unit*	*Base Case*	*Upper Case*
Temperature Correction	-	0.3	0.3
Contact Water Factor	-	0.5	1.0
Grain Size Correction Factor	-	0.05	0.1

Table 3-30:
Source terms for unsaturated paste backfill

Parameter	Units	Operations and Closure		Post-closure	
		Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/t/wk	0.15	1.65	0.164	0.657
Ag	mg/t/wk	1.55E-07	6.84E-07	1.75E-07	6.99E-07
As	mg/t/wk	0.000175	0.000834	0.000197	0.000789
Ba	mg/t/wk	0.000101	0.000537	9.68E-05	0.000387
Ca	mg/t/wk	0.127	0.798	0.152	0.606
Cd	mg/t/wk	6.95E-08	5.37E-07	1.05E-07	4.2E-07
Co	mg/t/wk	3.18E-07	4.59E-06	1.56E-07	6.24E-07
Cr(VI) – Short Term	mg/t/wk	0.0564	0.0636	-	-
Cr(VI) – Long Term	mg/t/wk	2.46E-07	1.05E-06	2.43E-07	9.72E-07
Cu	mg/t/wk	1.79E-06	1.68E-05	1.47E-06	5.88E-06
Fe	mg/t/wk	2.25E-05	0.000232	2.45E-05	9.78E-05
Hg	mg/t/wk	3.11E-08	1.39E-07	3.5E-08	1.4E-07
K	mg/t/wk	0.00351	0.0735	0.00235	0.00939
Mg	mg/t/wk	0.00358	0.0435	0.00344	0.0138
Mn	mg/t/wk	3.67E-05	0.000241	2.89E-05	0.000116
Mo	mg/t/wk	1.35E-05	0.000112	1.03E-05	4.11E-05
Na	mg/t/wk	0.000699	0.0178	0.000664	0.00266
Ni	mg/t/wk	3.14E-07	2.66E-06	3.67E-07	1.47E-06
Pb	mg/t/wk	1.97E-07	2.41E-06	3.14E-07	1.26E-06
Sb	mg/t/wk	1.67E-05	0.000133	1.46E-05	5.82E-05
Se	mg/t/wk	1.13E-05	6.42E-05	1.07E-05	4.29E-05
Si	mg/t/wk	0.0173	0.0873	0.0223	0.0891
Sr	mg/t/wk	0.000765	0.00576	0.000716	0.00287
Tl	mg/t/wk	6.61E-08	9.81E-07	3.23E-08	1.29E-07
U	mg/t/wk	3.71E-06	3.54E-05	2.38E-06	9.51E-06
Zn	mg/t/wk	6.29E-06	3.69E-05	9.23E-06	3.69E-05

3.4.3.3 Saturated Underground Mine Source Terms

Active flooding of the mine at closure will submerge approximately 78% of the paste tailings, 85% of the wall rock exposures and 100% of the rock fill assuming a minimum water table elevation of 1380 masl. As these mine components are submerged, an initial 'flushing' load will be released, followed by longer-term saturated loads which will continue to be released in post-closure. The saturated underground mine source term follows the same approach described in Lorax (2020c). Updates to the source term in this model iteration are: (1) limited addition of additional kinetic testing incorporated into the paste backfill and rockfill loading rates described in previous sections, and (2) changes in the volume and elevation of mine waste deposition and wall rock exposures based on the 4950 tpd mine plan.

3.4.3.3.1 Flushing Loads

The flushing loads are calculated by estimating the rate that a geochemical load accumulates on rockfill, paste backfill and wall rock when mine workings are unsaturated during operations. The rate of accumulation is estimated from scaled kinetic testing data, while the duration of exposure is estimated from the mine schedule. These loads are assumed to be instantaneously released as the water table rises and mine workings become flooded at closure.

Paste backfill and rockfill mineral surfaces are only partially rinsed with infiltrating mine water during operations. This is reflected in the 'contact water' scaling factor used to produce unsaturated loading rates for these mine components in section 3.4.3.2. The Base Case unsaturated source terms for rockfill and paste backfill assume that 50% of mineral surfaces are effectively rinsed by infiltrating mine water during operations (Table 3-27 and Table 3-29). To calculate the flushing load, it is assumed that the 50% of mineral surfaces that are not effectively rinsed will accumulate a geochemical load at the same rate as mineral surfaces that are rinsed. That is, the 50% of mineral surfaces that are not effectively rinsed during operations will accumulate and contribute to the flushing load at the same rate that the 50% of mineral surfaces that are well rinsed contribute to the unsaturated load. Hence, the rate that a geochemical load accumulates on paste backfill and rockfill mineral surfaces is equal to the geochemical loading rates shown in Table 3-28 and Table 3-30.

Mineral surfaces which contribute to the wall rock source term include bedrock fractures, muck on the mine floor, and wall rock surface exposures themselves. It is assumed that fractures and muck on the mine floor will be relatively well rinsed with infiltrating mine water during operations compared to actual wall rock exposures which are only periodically rinsed by groundwater seeps or drilling water. The initial flush of wall rock is calculated from loading rates observed at wall washing stations. The median loading rate and 90th percentile loading rate are applied to the Base Case and Upper Case source terms, respectively. These loading rates are monitored in the field, and already normalized for wall rock surface area. Therefore, no scaling factors are applied to the accumulation rate of this geochemical load. The rate that geochemical loads accumulate on wall rock exposures are shown in Table 3-31. Note that wall rock washing stations have not been established for minor lithologies (*e.g.*, P1 and silicified CAP). Therefore, the average Base Case and Upper Case accumulation rates observed at wall rock stations established on major rock types (S3, ANDX and VSF) are applied to these lithologies.

The amount of time that the flushing load accumulates on mineral surfaces prior to submergence is defined by the mine schedule (Table 3-13, Table 3-22 and Table 3-39). That is, rockfill placed in 2023 will accumulate a flushing load for 7 years, while rockfill

placed in 2029 will accumulate a flushing load for 1 year prior to flooding in 2030. The average flushing load per unit mass or area of rockfill, paste backfill and wall rock at the end of mine life are shown in Table 3-32.

The timing and extent of mine workings that will flood at closure is a function of the rate of water table rise and the elevation of underground mine workings. The water table is expected to rise to a final elevation of approximately 1401 masl over a 7 month period in closure. During mine flooding, the amount of paste backfill, rockfill and wall rock which will be submerged is calculated on a monthly time step. Thus, the monthly flushing loads are calculated for mine workings that become flooded each month. The elevation of wall rock, rockfill, and paste backfill in the mine underground is shown in Figure 3-1. Note that a portion of mine workings in the WZ remain above the final water table of 1401 masl and is not expected to flood.

Table 3-31:
Accumulation rates of geochemical load on wall rock that will be released during initial flush

Parameter	Units	P1 and Silicified CAP		S3		ANDX		VSF	
		Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/m²/wk	9830	14400	1830	2060	11600	16800	16100	24300
Ag	mg/m²/wk	5.31E-03	7.07E-03	7.18E-03	8.09E-03	7.24E-03	1.12E-02	1.50E-03	1.90E-03
As	mg/m²/wk	4.44	6.22	2.13	2.8	4.82	5.23	6.36	10.6
Ba	mg/m²/wk	0.81	1.06	0.356	0.439	0.938	1.18	1.14	1.55
Ca	mg/m²/wk	2810	3940	462	469	2850	4100	5130	7240
Cd	mg/m²/wk	0.00101	0.00129	0.000155	0.000157	0.000374	0.000401	0.00249	0.00332
Co	mg/m²/wk	0.0271	0.0357	0.00384	0.00515	0.0337	0.0433	0.0437	0.0587
Cr	mg/m²/wk	0.00971	0.0128	0.00587	0.00721	0.0104	0.0122	0.0129	0.0189
Cu	mg/m²/wk	0.131	0.172	0.0466	0.0651	0.102	0.118	0.244	0.334
Fe	mg/m²/wk	0.228	0.325	0.157	0.227	0.32	0.457	0.207	0.291
Hg	mg/m²/wk	7.02E-04	9.63E-04	1.18E-03	1.71E-03	6.37E-04	8.47E-04	2.88E-04	3.37E-04
K	mg/m²/wk	246	362	132	178	276	407	330	503
Mg	mg/m²/wk	182	247	21.4	26.6	82.3	107	442	608
Mn	mg/m²/wk	0.463	0.532	0.16	0.182	0.259	0.289	0.97	1.13
Mo	mg/m²/wk	0.0954	0.144	0.0487	0.0698	0.0718	0.11	0.166	0.253
Na	mg/m²/wk	1640	2530	658	915	2890	4210	1360	2460
Ni	mg/m²/wk	0.08	0.106	0.00909	0.0111	0.0183	0.0228	0.213	0.284
Pb	mg/m²/wk	0.0023	0.00369	0.00188	0.00321	0.00296	0.00484	0.00207	0.00302
Sb	mg/m²/wk	0.494	0.708	0.171	0.241	0.902	1.29	0.409	0.593
Se	mg/m²/wk	0.253	0.347	0.145	0.179	0.146	0.249	0.469	0.614
Si	mg/m²/wk	15.9	22.9	10.3	13.5	19.9	30.6	17.5	24.5
Sr	mg/m²/wk	71.8	98.6	6.43	7.48	80.5	112	128	176
Tl	mg/m²/wk	8.97E-03	1.27E-02	5.88E-03	7.19E-03	1.10E-02	1.70E-02	1.01E-02	1.38E-02
U	mg/m²/wk	0.0413	0.0538	0.0266	0.0321	0.0582	0.0818	0.039	0.0474
Zn	mg/m²/wk	0.124	0.157	0.0313	0.0391	0.0499	0.0665	0.292	0.366

Table 3-32:
Flushing loads from wall rock, paste backfill, and rockfill that will be released upon flooding at closure

Parameter	Wall Rock		Paste Backfill		Rockfill	
	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
	mg/m²	mg/m²	mg/t	mg/t	mg/t	mg/t
Sulfate	7580	10900	85000	1730000	175000	581000
Ag	0.00229	0.00317	0.0704	0.303	0.101	0.541
As	3.13	4.49	60.9	340	66.7	385
Ba	0.572	0.734	53.1	264	61.7	192
Ca	2250	3070	63600	665000	24600	88800
Cd	0.000899	0.00113	0.0238	0.185	6.9	23.6
Co	0.0209	0.0269	0.272	2.49	15.5	65.7
Cr(VI)	-	-	0.106	0.478	-	-
Cu	0.102	0.131	1.02	10.2	53.1	404
Fe	0.138	0.19	10.1	127	2870	10100
Hg	0.000285	0.000365	0.0141	0.0619	0.0709	0.205
K	168	245	3950	75500	11700	44200
Mg	162	213	2780	34700	2940	10700
Mn	0.377	0.419	17.4	141	1130	3880
Mo	0.0709	0.104	9.25	64.1	23.5	86.6
Na	1030	1610	514	21100	90800	335000
Ni	0.0738	0.0941	0.144	1.69	19.2	79.6
Pb	0.00135	0.00204	0.0446	1.18	4.42	30.1
Sb	0.315	0.441	11.7	80.1	23.6	127
Se	0.19	0.25	6.05	33.6	8.54	35.3
Si	10.1	14.2	7990	38500	3390	12800
Sr	57.8	76.8	452	3430	1250	4720
Tl	0.00573	0.00792	0.051	0.667	0.226	1.52
U	0.0254	0.0321	3.11	19.0	4.02	23.6
Zn	0.107	0.130	2.85	17.0	329	1080

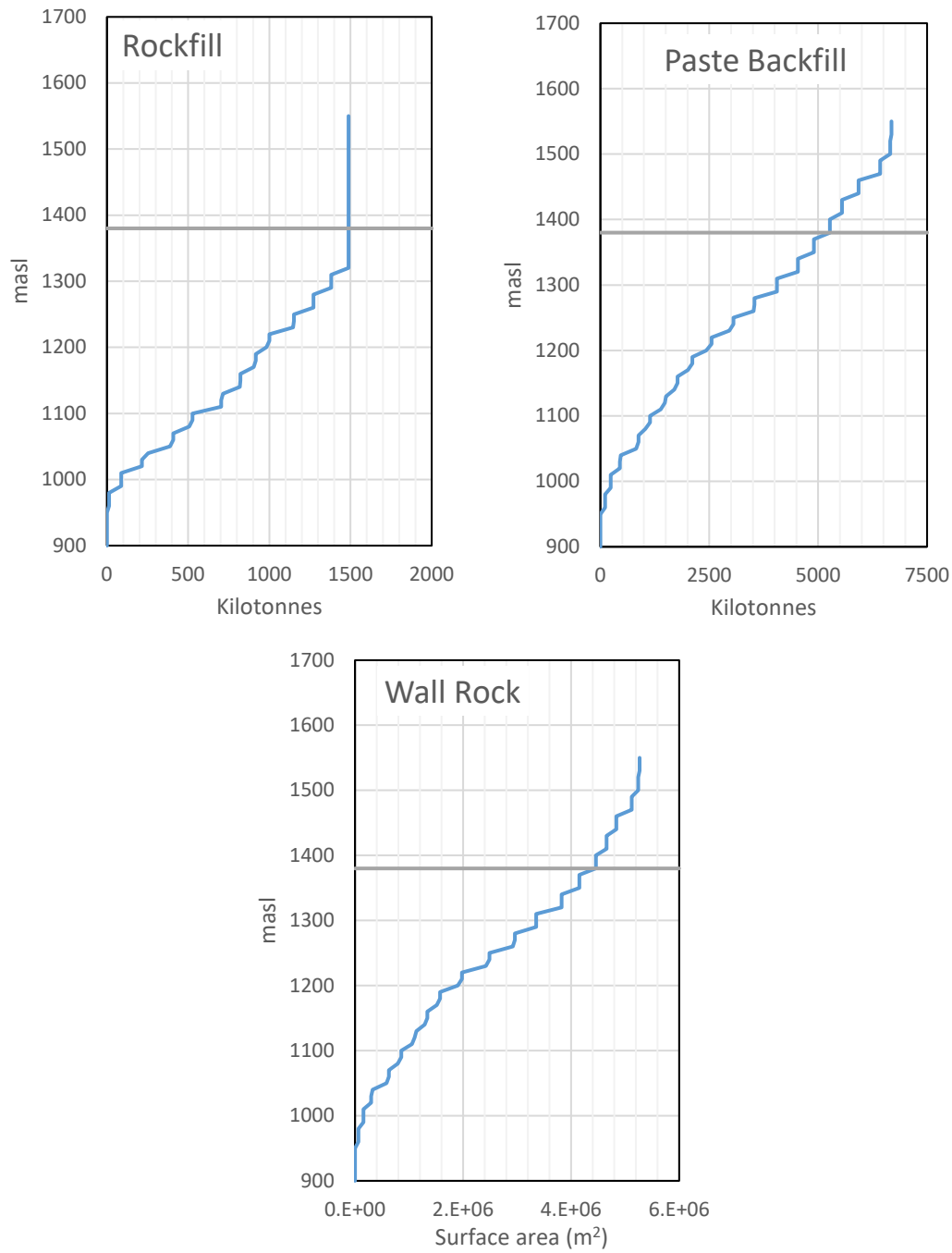


Figure 3-1: Cumulative rockfill tonnage (top left), paste backfill tonnage (top right) and wall rock area (bottom centre) as a function of elevation. Grey line shows minimum water table elevation in post closure of 1380 masl.

3.4.3.3.2 Saturated Concentration Terms

Saturated conditions will inhibit acid generation and metal leaching associated with sulfide mineral oxidation; however, some metal leaching may continue from dissolution of oxide minerals. To reflect this potential for long term metal release from saturated mine

workings, source terms are developed using saturated column data and historic observations of adit drainage from time periods when mine workings were flooded. This source term is developed using the approach applied in previous model iterations with the following updates:

- Incorporation of recent saturated column data
- Updated volume of of rockfill, paste backfill and un-backfilled 'void' space in mine workings as per the 4950 tpd mine schedule.
- Consideration of lower hydraulic conductivity of paste backfill relative to rockfill and void space.

Paste backfill and rockfill are represented using saturated column results completed on waste rock (columns 1 and 2) and tailings (columns 3 and 5). Columns 1 and 2 are ongoing so results through January 2022 are incorporated into source term calculations. The 90th percentile concentrations are applied to the Upper Case and the median concentrations of the final 5 cycles are applied to the Base Case source terms. Mine portal water quality from time periods when mine workings were flooded and passively discharging was used to represent mine workings that are not backfilled (*i.e.*, void space). No updates have been made to this term. The maximum and median concentrations of adit drainage from October 2009 to October 2011 are used to represent Upper Case and Base Case void space in the underground mine.

Chemistries representative of the three saturated mine components (rockfill, paste fill, and void space) are proportioned based on their relative volumes and hydraulic conductivity. The 4950 tpd mine plan indicates a total of 6.4 Mm^3 of rock will be excavated from below the minimum water table elevation of 1380 m. Of this volume 12% will be occupied by rockfill, 71% will be occupied by paste backfill, and 17% will be empty (not-backfilled) void space. The amount of contact water interacting with these different material types will be a function of both their abundance and the relative hydraulic conductivity of these materials. Notably, paste backfill has a hydraulic conductivity of 1.2E-8 to 5.0E-8 m/s, which is <1/10 the hydraulic conductivity of rockfill (1.0E-6 m/s) and void space (1 m/s). Therefore, groundwater will preferentially flow through the more permeable rockfill and void zones. To reflect this in the underground mine source term, the amount of contact water interacting with paste tailings is assumed to be 1/10th of its relative volume. This results in the relative proportions of the three water types being weighted as 39% rockfill, 54% void space, and 7% paste backfill, which is presented in Table 3-33. This source term is applied to groundwater which interacts with saturated mine workings during the closure and post-closure phases.

Table 3-33:
Saturated source term concentrations

Parameter	Units	Base Case	Upper Case
Sulfate	mg/L	81.5	101
Ag	mg/L	2.79E-05	3.36E-05
As	mg/L	0.00917	0.0711
Ba	mg/L	0.0309	0.0492
Ca	mg/L	50.9	58.8
Cd	mg/L	5.25E-05	0.000182
Co	mg/L	0.000171	0.000392
Cr	mg/L	3.15E-06	3.85E-05
Cu	mg/L	0.000435	0.00219
Fe	mg/L	0.0217	0.41
Hg	mg/L	0.000005	0.000005
K	mg/L	2.01	7.89
Mg	mg/L	5.28	6.20
Mn	mg/L	0.217	0.269
Mo	mg/L	0.00551	0.00838
Na	mg/L	7.91	12.7
Ni	mg/L	0.00038	0.000909
Pb	mg/L	8.45E-05	0.00284
Sb	mg/L	0.00113	0.00195
Se	mg/L	0.0001	0.000728
Si	mg/L	3.28	15
Sr	mg/L	0.779	1.16
Tl	mg/L	1.01E-05	0.000107
U	mg/L	0.000375	0.00262
Zn	mg/L	0.0097	0.0239

3.4.3.4 Underground Mine Water Source Term Evaluation

The following sections describe refinements made to the underground mine water source terms. These refinements consider the potential for acid generating from PAG rockfill and wall rock exposures, solubility control. The approach for these model considerations has not been updated from previous model iterations (Pretium, 2015, Lorax 2018 and Lorax 2020c).

3.4.3.4.1 Potential for Acid Generation

During mine operations, gradual acidification of unsaturated PAG rock exposures will occur in the mine underground. The rate at which wall rock and rockfill becomes acidic is described in Appendix 4-B4 of *MA & EMA* Permits Application (Pretium, 2015). Subsequent operational monitoring found the Upper Case acidity assumptions to be overly conservative, and therefore lag time calculations originally developed for the Base Case were applied to the Upper Case scenario. This update is discussed in Lorax (2020c).

During operations and closure, the % of acidic wall rock and rockfill lithologies are calculated as a function of exposure time (S3 and ANDX) (Figure 3-2), or as a constant value (P1, VSF, P2, SILCAP) (Table 3-34) (Pretium, 2015). In the post-closure scenario, it is assumed that the percentage of each wall rock unit which has an NPR<2 becomes acid generating (Table 3-34). All rockfill will be submerged in post-closure, so this assumption only applies to remaining wall rock above the final water table.

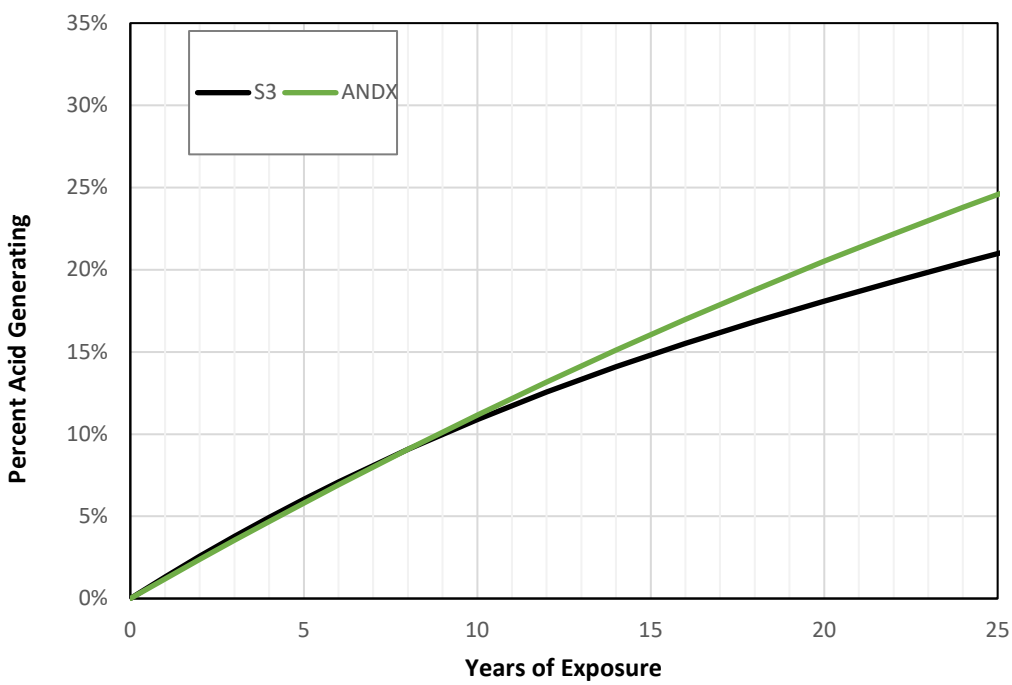


Figure 3-2: Percent of S3 and ANDX wall rock and rockfill exposures predicted to become acid generating as a function of exposure time.

Table 3-34:
Percent of wall rock and rockfill exposures assumed to be acid generating by lithology in operations, closure and post-closure.

Rock Type	Operations and Closure	Post Closure
P1	0%	19%
VSF	5%	84%
S3	Function*	80%
ANDX	Function*	57%
P2	0%	0%
SILCAP	30%	30%

*Acid generation potential calculated as function of exposure time

Monitoring of seep and sump water in the mine underground can provide an early indicator of development of ARD and can support validation of the lag time calculations originally developed in Pretium (2015) shown in Figure 3-2 and Table 3-34. Routine monitoring of seeps and sumps was initiated in 2016 with sampling occurring on a quarterly basis as outlined in the mine's ML/ARD Management Plan (Pretium, 2020a). Out of the 76 distinct seeps that have been sampled, only 4 (Seep 7, Seep 44, Seep 53 and Seep 56) have shown acidic pH values (<6.0 pH) (Figure 3-3; Pretium, 2022a). Three of these seeps (Seep 7, 44, and 56) have shown intermittently acidic seepage. That is, these seeps have rebounded to neutral pH after acidic pH values were initially observed. The only seep that shows persistent acidic seepage is Seep 53. This seep has remained acidic on all nine sampling events that occurred between April 2019 to December 2021, with pH values ranging from 2.7 to 4.4 pH.

Monitoring of underground sumps have shown consistently neutral to alkaline pH (ranging from pH 8.3 to pH 11.6). This shows that bulk underground mine water remains alkaline in and confirms that the acidity load from acidic seeps in the mine underground is not sufficient to cause pH instability in sump water.

The acidic seeps are all hosted in ANDX wall rock exposures. This rock type is relatively abundant in the mine underground (29% of exposures as of December 2021), and has a higher ARD potential than VSF which constitutes a majority of the existing wall rock (Table 3-22). Lag time calculations predict that by the end of 2022, 3.3% of all wall rock exposures, inclusive of the 6.4% of ANDX exposures, would be acid generating.

The observation that all sumps and a majority of seeps (72 of 76) show neutral to alkaline pH data are consistent with the lag time calculations applied in the water quality model. Therefore, no updates to lag time calculations are proposed at this time. The only update incorporated into the acid generation calculations is the 4950 tpd mine plan. The percent

of rockfill and wall rock that are calculated to be acidic at the end of mine life and in post-closure are shown in Table 3-35.

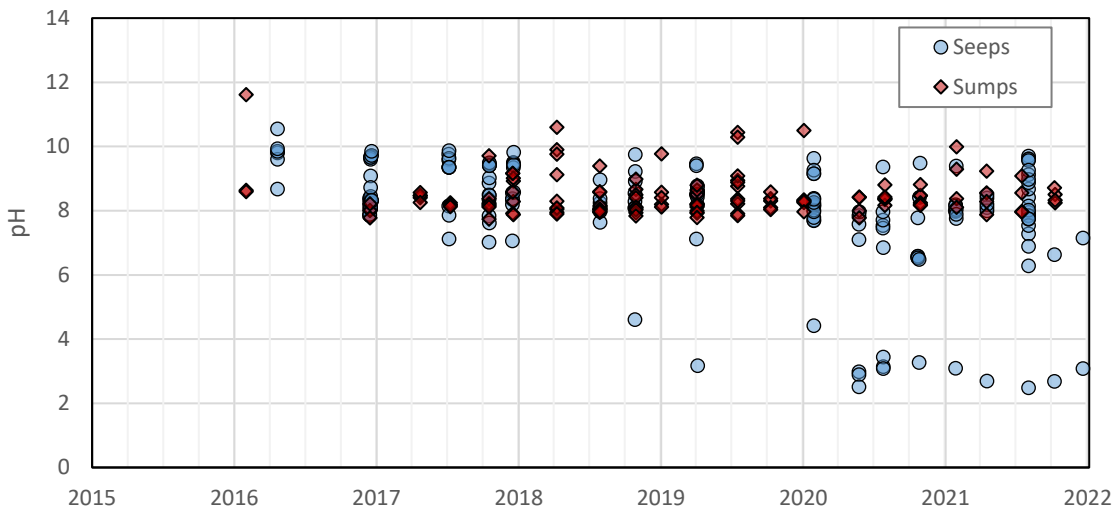


Figure 3-3: Time series of pH monitoring results for seeps and sumps in the underground mine.

Table 3-35:
Percent of subaerial wall rock and rock fill predicted to be acidic at the end of operations and post-closure scenarios.

	End of Operations	Post-closure
Rock Fill[1]	5.3%	-
Wall Rock	6.2%	67%

[1]All rock fill will be submerged at the end of mine life, mitigating the potential for acid generation from rock fill in the post-closure scenario.

3.4.3.4.2 Solubility Controls

Solubility controls were developed for composite underground mine water. Solubility controls are based on surface sorption, secondary mineral formation, and empirical observations of monitoring data. The details of solubility control derivation are presented in the 2020 update water quality model report (Lorax 2020a), with a summary provided in Table 3-36. These solubility controls assume aerobic conditions and are therefore not applied to saturated mine workings during post-closure. The solubility controls are applied to composite drainage during operations, closure and to the portion of mine drainage originating from unsaturated mine workings in post-closure. The solubility controls described herein were originally developed in previous model iterations. No updates are introduced to the solubility controls for the 4950 tpd model iteration.

Table 3-36:
Solubility limits applied to unsaturated mine workings

Parameter	Units	Base Case	Upper Case	Solubility Control
SO_4	mg/L	-	1848	Mineral Precipitation – Gypsum [$CaSO_4 \cdot 2H_2O$]*
Al	mg/L	0.18	12.3	Mineral Precipitation – Gibbsite [$Al(OH)_3$] and Basaluminite [$Al_4(OH)_{10}SO_4$]**
As	mg/L	0.11	0.28	Hydrous Ferric Oxide (HFO) Sorption
Be	mg/L	0.0001	0.0002	Empirical Observation
Bi	mg/L	0.0001	0.0001	Empirical Observation
Cd	mg/L	0.000015	NA	Empirical Observation
Cu	mg/L	0.028	NA	Mineral Precipitation – Tenorite [CuO]
F	mg/L	3.46	3.52	Mineral Precipitation – Fluorite [CaF_2]
Fe	mg/L	0.029	0.39	Mineral Precipitation – Ferrihydrite [$Fe(OH)_3$]
Hg	mg/L	0.000005	0.000005	Empirical Observation
Mn	mg/L	0.22	NA	Mineral Precipitation – Rhodochrosite [$MnCO_3$]
Ni	mg/L	0.00086	NA	Empirical Observation
P	mg/L	0.018	0.184	Mineral Precipitation – Hydroxylapatite [$Ca_5(OH)(PO_4)_3$]
Tl	mg/L	0.00029	0.00037	Empirical Observation
Zn	mg/L	0.0036	NA	Empirical Observation

*Gypsum solubility limit is only reached in Upper Case source term.
**Aluminum concentrations are controlled by gibbsite in Base Case and basaluminite in Upper Case source terms

3.4.3.4.3 Validation of the Underground Mine Water Predictions

The updated underground mine water predictions applying the various revisions described above have been reviewed and compared to water quality monitoring data sets collected between 2015 and 2022. This comparison combines the water balance (Lorax, 2023b) results with geochemical loadings described herein to generate the Upper Case and Base Case mine water concentrations shown in Figure 3-4 and Figure 3-5. The current model predictions for key parameters show good agreement with monitoring data; therefore, no updates to source term calibration are proposed at this time.

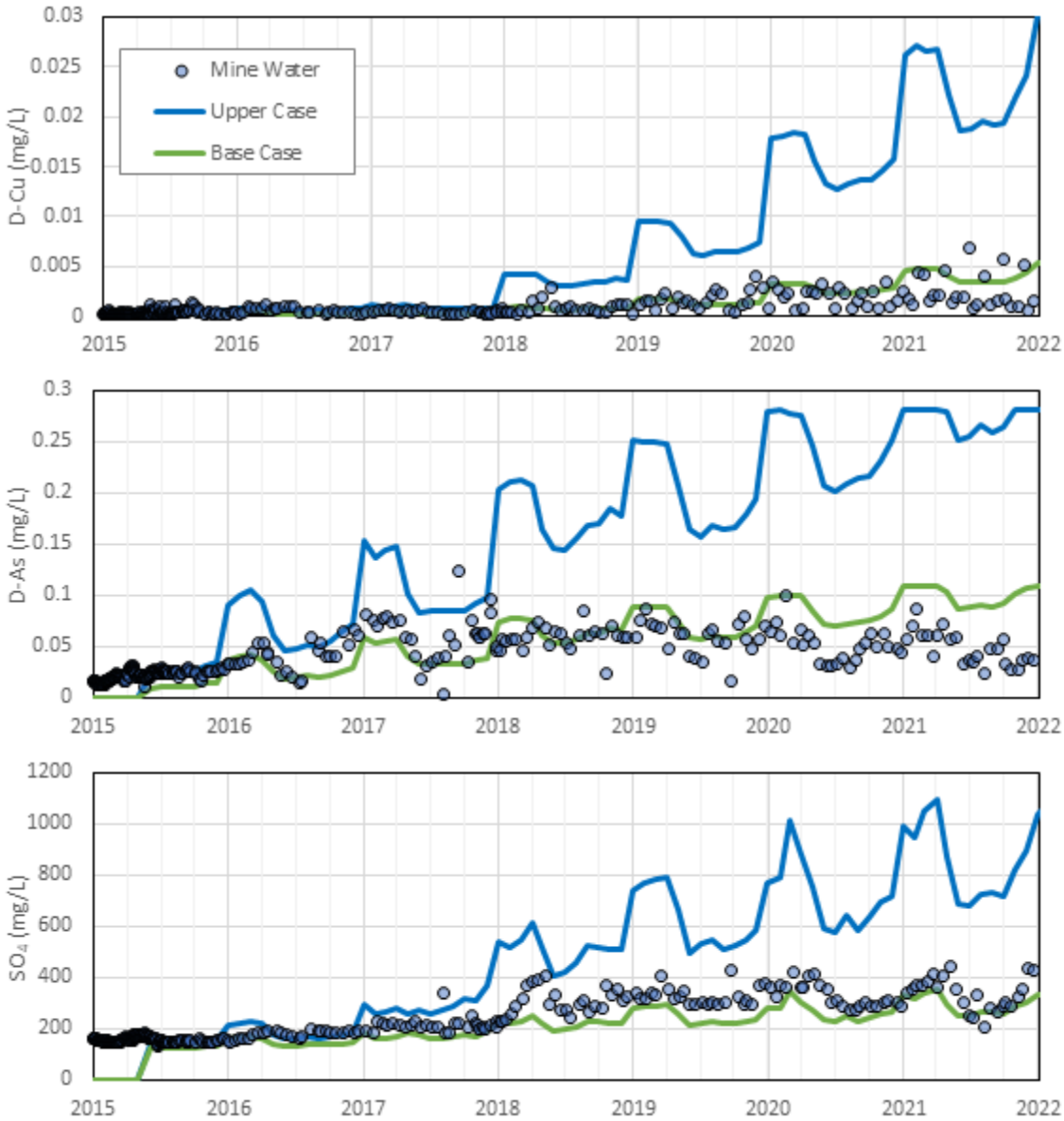


Figure 3-4: Time series plot showing modelled and measured mine water concentrations of D-Cu, D-As and SO_4 from January 2015 to December 2022.

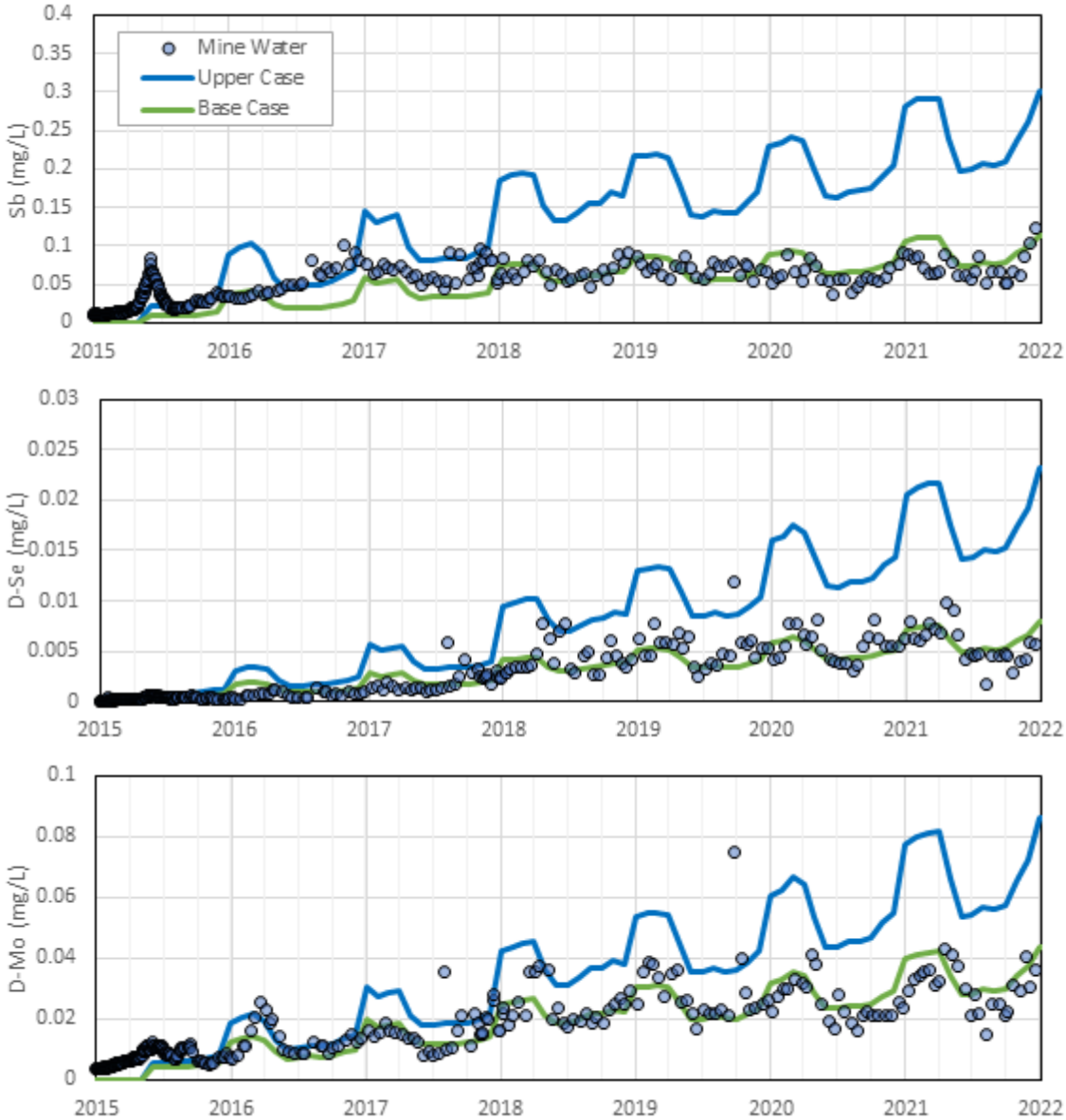


Figure 3-5: Time series plot showing modelled and measured mine water concentrations of D-Sb, D-Se and D-Mo from January 2015 to December 2022.

3.4.3.4.4 Updated Underground Mine Water Source Terms

Final source term predictions for operations, closure and post-closure for the mine underground are summarized in Table 3-37. This table shows the maximum concentrations predicted during operations, closure, and post-closure. The operations source term combines the loadings from rockfill, paste tailings, wall rock, groundwater, paste bleed water, blasting residues and re-circulated drill/dust suppression water from the fresh water

tank. Concentrations during the closure are planned to be mitigated by re-circulation of mine water through the treatment plant, as described in Lorax (2023b). Post-closure concentrations will stabilize as the initial flush is rinsed from the system, and gradually decline owing to the limited amount of mine workings that remain above the final water table elevation.

Table 3-37:
Maximum source term concentrations predicted for underground mine water during operations, closure and post-closure

Parameter	Units	Operations		Closure		Post-closure	
		Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
NH_3	mg-N/L	24.1	37.3	8.1	12.4	0.0303	0.0428
NO_3	mg-N/L	68.4	108	20.6	32.2	0.157	0.274
NO_2	mg-N/L	4.36	6.74	1.23	1.84	0.0023	0.0043
Sulfate	mg/L	421	1240	690	1850	690	775
Ag	mg/L	0.000071	0.000291	0.000266	0.00119	0.000116	0.000365
As	mg/L	0.109	0.281	0.105	0.273	0.0477	0.147
Ba	mg/L	0.0865	0.259	0.2	0.81	0.0759	0.226
Ca	mg/L	81	343	209	1060	128	368
Cd	mg/L	0.00002	0.0039	0.00002	0.0145	6.07E-05	0.000825
Co	mg/L	0.00274	0.0126	0.012	0.054	0.000567	0.00181
Cr(VI)	mg/L	0.00102	0.00221	0.00218	0.00735	0.000124	0.000514
Cu	mg/L	0.00986	0.0597	0.0261	0.179	0.00878	0.0139
Fe	mg/L	0.0293	0.394	0.0293	0.394	0.0255	0.475
Hg	mg/L	0.000005	0.000005	0.000005	0.000005	0.000005	0.000005
K	mg/L	55.3	123	51.1	170	16.3	23.9
Mg	mg/L	5.74	22.6	11.1	65.5	6.28	13.9
Mn	mg/L	0.224	0.929	0.224	3.37	0.21	0.303
Mo	mg/L	0.0541	0.113	0.0447	0.176	0.0141	0.03
Na	mg/L	306	502	264	536	53.1	58.1
Ni	mg/L	0.0009	0.013	0.0009	0.0573	0.000576	0.00248
Pb	mg/L	0.00155	0.00735	0.00202	0.017	0.00269	0.00571
Sb	mg/L	0.13	0.357	0.0676	0.241	0.031	0.062
Se	mg/L	0.0106	0.0336	0.018	0.0861	0.00957	0.0247
Si	mg/L	11.1	37.2	25	117	16.7	57.3
Sr	mg/L	1.28	3.73	2.4	10.8	0.869	2.11
Tl	mg/L	0.0003	0.0004	0.0003	0.0004	0.00012	0.000219
U	mg/L	0.00838	0.0293	0.00675	0.0443	0.0108	0.0207
Zn	mg/L	0.0036	0.199	0.0036	0.70	0.0111	0.0636

3.5 Water Treatment Plant

3.5.1 Overview

The WTP is located within the mill building and receives and treats underground mine water from mine dewatering, CWP water and recycled process water from the mill, and is designed to treat influent flows of 3,120 to 10,000 m^3/day. The overall WTP water balance is shown in Figure 3-6. The water treatment design, metals and solids removal processes, and effluent design criteria are described in the 2015 *MA & EMA* Permits Application (Pretium, 2015); a summary is provided in Section 2.5.3 of the 2020 Mine Plan and Reclamation Program Update (Pretium, 2020c). Key components of the WTP treatment process include a pre-treatment clarifier (for coarse total suspended solids (TSS) removal), primary metal precipitation stage (dissolved metal and TSS removal), secondary metal precipitation stage (for dissolved metal oxy-anion and TSS removal), final metal polishing by filtration (for small particulate TSS removal) and final pH adjustment as shown in Figure 3-7. The WTP is expected to continue operating into the closure phase until active water treatment is no longer required.

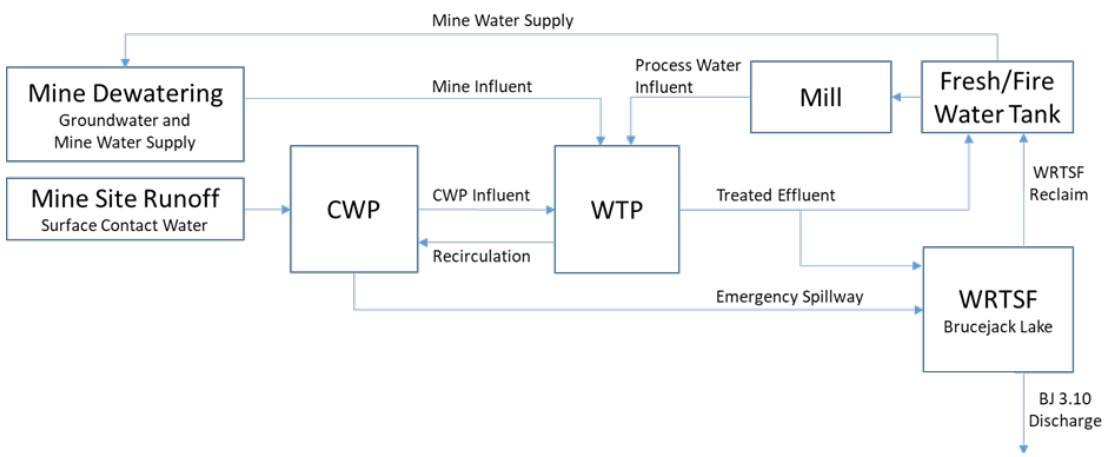


Figure 3-6: Schematic of the WTP water balance

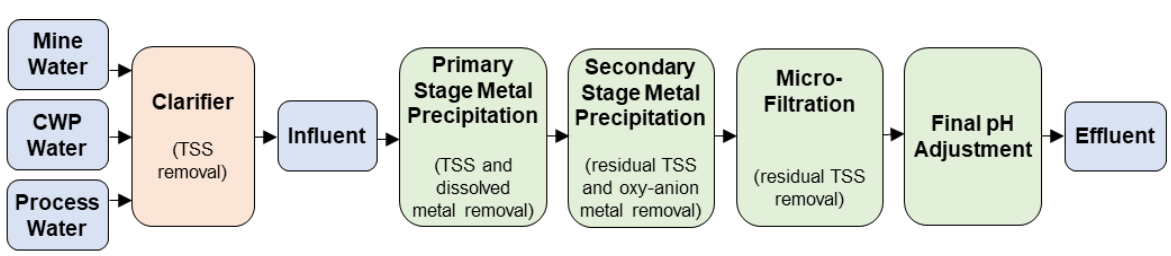


Figure 3-7: Schematic of the Brucejack Mine clarifier and WTP treatment process (green boxes represent the WTP components)

As shown in the WTP flow diagram in Figure 3-7, water requiring treatment is directed to the pre-treatment clarifier to remove TSS by gravity settling, with the clarifier overflow directed to the WTP Influent. The primary metal precipitation stage is designed to use ferric sulfate and sodium sulfide for metal precipitation, whereas the secondary stage is configured for ferric sulfate only. The operations WTP began operating in mid-2017 and ferric sulfate has been successfully used for metal removal in both stages since that time. The combined influent water quality has been monitored in the Clarifier overflow since May 2018. Influent concentrations of most dissolved parameters targeted by treatment are below WTP effluent limits (*i.e.*, Ag, Cd, Co, Cu, Fe, Pb, Mn and Zn), or are effectively treated with ferric sulfate (*i.e.*, Al, As) therefore sodium sulfide treatment has not been activated. The sulfide circuit will be commissioned for use if needed to meet PE-107835 discharge requirements. The treatment efficiency of the sulfide circuit has been evaluated by Pretium for batch treatment at small volumes and was found to be effective at removing dissolved metals targeted for treatment.

The operational treatment flows measured by the Clarifier overflow totalizer for the 2018 through 2021 period range from 825 to 9,372 m^3/day with a median value of 4,948 m^3/day (Figure 3-8) and, overall, are within the design flows of the WTP. On an annual basis, a generally increasing trend is observed in the treatment flows from 2018 to 2021 (4,532 to 5,592 m^3/day, respectively, median values) due to increased mine dewatering flows during this period (Lorax, 2023b). The highest daily WTP flows are typically observed in May through November, reflecting the seasonal influence of increased groundwater infiltration into the mine void and runoff accumulation in the CWP.

The WTP flows are modelled to increase as the mine void expands, and on an annual basis, the flows are modelled to stabilize in 2025 at approximately 7,500 m^3/day (median value) and range from 2,902 to 12,566 m^3/day during operations. The daily influent flows are modelled to peak at levels above the WTP design flow (10,000 m^3/day) for a few days in June of each year. For the modelling of treatment efficacy, it is assumed that influent flows will remain within the WTP design specifications through various water management strategies including temporary storage of water underground or in the CWP (the CWP is drawn down each spring prior to freshet), or reduction of WTP inflows of Mill process water.

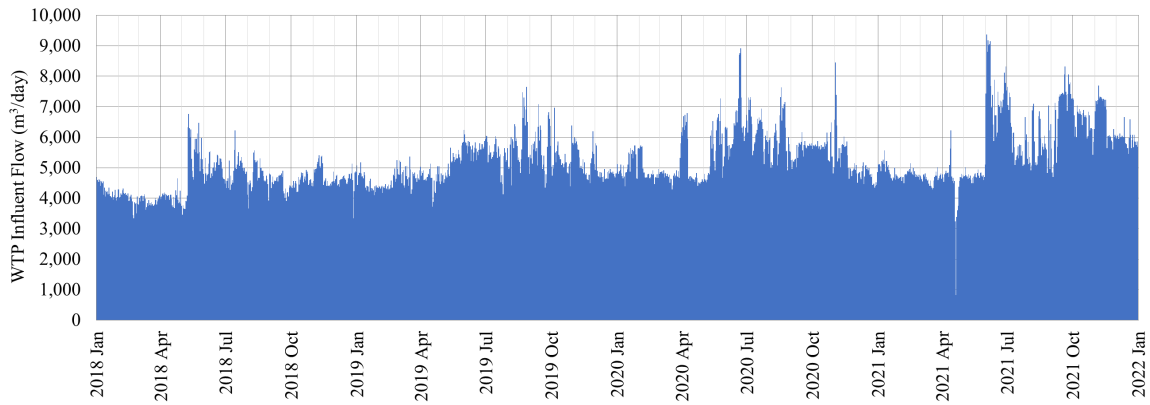


Figure 3-8: Measured Water Treatment Plant (WTP) Influent Flows at the Clarifier Overflow Totalizer from 2018 to 2021.

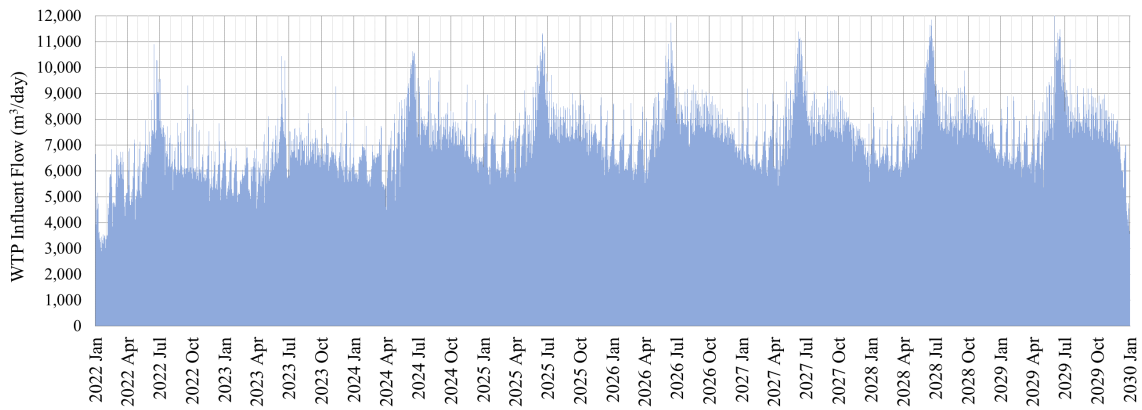


Figure 3-9: Modelled Water Treatment Plant (WTP) Influent Flows During Operations (2022 through 2029).

The WTP generates a solid waste product (sludge) that requires management and disposal. The mass of the sludge produced depends on the TSS content of the influent, the chemical composition of the influent, the flow rate and the nature of the solid particles. The sludge to be produced during the operations phase is predicted to be a cumulative total of 150 kt, with average sludge generation estimated at 7 tpd. The total amount of sludge generated is estimated to represent less than 2% of the total tailings generated on-site. Sludge generated from the WTP is co-deposited with thickened tailings into the WRTSF in accordance with PE-107835 and permit M-243.

3.5.2 WTP Influent, Effluent and Treatment Level

The WTP influent quality was derived from influent flows as prescribed by the Brucejack Mine water balance and source terms developed for the contributing sources: underground mine water (Section 3.4.3), mine site runoff (Section 3.3.2) and process water (Section 3.6.5). Modelled WTP effluent quality is based on predicted influent quality and treatment removal rates that are derived from May 2018 through December 2021 operational data, or proxy data, and these are applied in the water quality model. The measured and modelled removal efficiencies for parameters that are treated in the model are shown in Table 3-38. The modelled removal rates are applied for the Base Case and Upper Case scenarios. The model assumptions are generally set at or below the observed removal efficiencies.

Table 3-38:
WTP influent and effluent water quality as well as observed treatment levels and removal efficiencies (May 2018 through December 2021).

Parameter	Units	Clarifier (WTP Influent)	WTP Effluent	Treatment Level Measured	% Removal Measured	% Removal Modelled
		Median (n=88)	Median (n=89)			
D-Ag	mg/L	0.00001	0.00001	0.00001	0%	0%
D-Al	mg/L	0.1255	0.002	0.002	98%	90%
D-As	mg/L	0.03235	0.00209	0.00209	94%	90%
D-Cd	mg/L	0.00002	0.000015	0.000015	25%	25%
D-Cu	mg/L	0.000885	0.00024	0.00024	73%	95% [1]
D-Mo	mg/L	0.0369	0.0284	0.0284	23%	25%
D-Pb	mg/L	0.000317	0.00005	0.00005	84%	75%
D-P	mg/L	0.0046	0.0011	0.0011	76%	75%
D-Sb	mg/L	0.0564	0.0255	0.0255	55%	50%
D-Se	mg/L	0.00613	0.0044	0.0044	28%	25%
D-U	mg/L	0.002025	0.000826	0.000826	59%	50%
D-V	mg/L	0.00214	0.0005	0.0005	77%	75%
D-Zn	mg/L	0.00265	0.0016	0.0016	40%	25%

[1] The Cu removal rate is derived from Britannia Mine proxy data (Madsen, 2007)

Monitoring of clarifier overflow was initiated in May 2018 and therefore the period from May 2018 through December 2021 was used for comparison of influent and effluent concentrations and derivation of WTP removal estimates. Operational monitoring data indicate the influent concentration of parameters targeted for treatment has been generally low with the exception of Al, As and Sb. The monitoring data from 2018 through 2021 indicate As and Al are effectively treated by the WTP (94% and 98% removal, respectively), whereas a smaller proportion of Sb is removed (55%). The measured removal efficiency for copper (73%) is influenced by low Cu concentrations in the influent,

which will have lower treatment efficiency than when influent D-Cu concentrations are higher. Observations of Cu removal at the Britannia Mine treatment plant, using a precipitation process that is comparable to the one used at Brucejack Mine indicate removal efficiencies of 99.9% for Cu (Madsen, 2007). Therefore, based on operational and proxy data, the removal efficiency for Cu is conservatively modelled at 95%. The measured treatment efficiency of Zn is relatively low (40% removal); however, this is expected for the ferric sulfate precipitation process at the low dissolved Zn concentrations that are observed in the influent (0.00265 mg/L, median concentration).

Sulfate is a component of the reagents that are added during the treatment process (*i.e.,* in ferric sulfate and sulfuric acid) and the median increase in the sulfate concentration from WTP influent to effluent is 67.5 mg/L for the 2018 through 2021 period. Therefore, the WTP is conservatively modelled to add 100 mg/L sulfate to the WTP effluent for the Base Case, and 400 mg/L of sulfate for the Upper Case scenario.

The concentration of parameters targeted for treatment are predicted to increase through operations, as are the WTP influent flows. The modelled treatment removal rates are derived from operational data when the daily treatment flows range from approximately 40% to 70% of the WTP design capacity (10th to 90th percentile of the measured flows, respectively). Therefore, the modelled removal rates are considered representative of treatment performance for flows up to the WTP design flows (10,000 m^3/hr). The treatment source terms reduce the WTP influent concentration by a proportional amount for parameters that are modelled to be treated and this approach accounts for variations in the modelled influent water quality.

3.6 Mill

3.6.1 Overview

The Brucejack Mine mill processes ore using conventional bulk sulfide flotation and gravity concentration to recover gold and silver. The mill produces a gold-silver bearing flotation concentrate which is shipped off-site for further processing. The gravity concentrate is refined on site to produce gold-silver doré ingots.

The mine production schedule used to update the water quality model is presented in Table 3-39. Tailings are managed through subaqueous deposition in the WRTSF and through placement in the underground mine as cemented paste backfill.

The mill components of the GoldSim water quality model were refined in the 2020 Update model based on revisions to mill components of the mine's water balance model and updates to source term data sets for model inputs. The inputs include:

- WTP effluent (described in Section 3.5.2);
- WTP sludge slurry, comprised of approximately 2.5% solids. The WTP sludge slurry is combined with the thickened tailings prior to discharge to the WRTSF;
- Reclaim water from the WRTSF: make-up water supplied to the mill;
- Recycled process water: water from ore processing that is treated by the WTP and circulated back into the mill process as feed water;
- Ore moisture: water that is on the surface of ore processed through the mill; and
- Tailings loads: loads added from processed ore.

The tracked outputs include the tailings slurry discharged to the WRTSF, the process water that is recycled to the mill via the WTP and paste backfill discharged to the underground mine. The following sections describe the source terms developed for the various mill components.

Table 3-39:
Projected ore and tailings schedules

Year	Ore (kt)	Tailings (kt)	Tailings to the WRTSF (kt)	Tailings to Paste Backfill (kt)
2017	684	628	523	105
2018	952	1,006	595	411
2019	1,338	1,303	823	480
2020	1,252	1,307	833	474
2021	1,415	1,383	974	409
2022	1,387	1,317	850	467
2023	1,418	1,346	826	521
2024	1,711	1,625	1,076	549
2025	1,807	1,715	1,144	571
2026	1,807	1,715	1,144	572
2027	1,807	1,715	1,123	592
2028	1,706	1,619	940	679
2029	1,213	1,152	391	760
Total LOM	18,498	17,832	11,242	6,590

3.6.2 WTP Sludge Slurry Water

Authorization for co-deposition of sludge with tailings was issued via amendment of *Mines Act* Permit M-243 and Effluent Permit 107835 in March/April, 2017. The slurry water term is incorporated into the water quality model, where the WTP sludge slurry water is assumed to have the same composition as WTP effluent (described in Section 3.5.2). The solid WTP sludge loads released post-deposition are described below in Section 3.6.5.2.

3.6.3 Reclaim Water

The Mill water supply is supplemented by reclaim water pumped from the weir located at the outlet of the WRTSF (BJ 3.10), as authorized under Conditional Water License C500684. The water quality of reclaim water in the model is set to values predicted for BJ 3.10 by the water quality model.

3.6.4 Ore Moisture

During ore excavation, mine water from the underground workings becomes entrained in the ore muck pile. The water balance model assigns a flow to the water that is associated with ore to be processed through the mill, termed ore moisture. The water quality of ore moisture is assumed in the water quality model to be equivalent to the underground mine water quality (Section 3.4.3).

3.6.5 Tailings and WTP Sludge Loads

The physical grinding and chemical processing of ore results in the release of chemical loads into the mill's process water. These instantaneous loads are added to loads already present in process water from the various contributing sources (*i.e.*, WTP effluent, reclaim water, recirculated process water and ore moisture). The combined mill loads are discharged to the WRTSF with the tailings slurry and to the underground mine with the paste backfill. The tailings discharged to the WRTSF are co-deposited with WTP sludge, and following deposition, loads may be released to the WRTSF through diffusive processes.

The following section describes the approach for deriving: 1) instantaneous tailings loads introduced to the mill; and 2) diffusive loads added to WRTSF from tailings and WTP sludge.

3.6.5.1 Instantaneous Tailings Loads to Mill

As ore is processed through the mill, loads are released to process water. The GoldSim water quality model accounts for recycling of mill process water and tracks the changing chemistry of all flow-related mill inputs. In order to isolate the loadings associated with ore processing, a monitoring program was developed to assess soluble loads added during the grinding process within the SAG mill. Water samples are collected at the inlet and outlet of the SAG mill on a monthly basis (as described in the ML/ARD Management Plan (Pretium 2020a), with data presented in Pretium 2019; 2020b; 2021; 2022a) and have been used to develop the instantaneous tailings loads. For certain parameters, the concentrations measured in the SAG mill influent were consistently higher than the SAG mill effluent (*e.g.*, Ba, Ca, Co, Pb, Mg, Mn, Hg, P, K,Sr, Tl, Ti and U for the Base Case). In these cases,

the instantaneous tailings loadings are set to zero. The Base Case and Upper Case instantaneous tailings loads are based on the median and 90th percentile loadings (per tonne of ore processed) combined with the ore processing schedule. The Base Case and Upper Case instantaneous loading terms are presented in Table 3-40 and Table 3-41, respectively.

Table 3-40:
Base Case instantaneous tailings loads to mill

Parameter	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)
Sulphate	10868	15115	21247	19877	22473	22026	22522	27174	28688	28689	28688	27087	19265
Chloride	2914	4053	5697	5330	6025	5906	6039	7286	7692	7692	7692	7263	5165
Fluoride	375	522	734	687	776	761	778	939	991	991	991	936	666
Al	48	67	94	88	100	98	100	121	127	127	127	120	86
Sb	19	27	38	35	40	39	40	48	51	51	51	48	34
As	26	37	51	48	54	53	54	66	69	69	69	66	47
Ba	0	0	0	0	0	0	0	0	0	0	0	0	0
Be	0.018	0.025	0.035	0.032	0.037	0.036	0.037	0.044	0.047	0.047	0.047	0.044	0.031
Bi	0.0089	0.012	0.017	0.016	0.018	0.018	0.018	0.022	0.023	0.023	0.023	0.022	0.016
B	40	56	79	74	83	81	83	101	106	106	106	100	71
Cd	0.0032	0.0044	0.0062	0.0058	0.0066	0.0065	0.0066	0.008	0.0084	0.0084	0.0084	0.0079	0.0056
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0.019	0.026	0.036	0.034	0.038	0.038	0.038	0.046	0.049	0.049	0.049	0.046	0.033
Co	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu	0.035	0.049	0.069	0.065	0.073	0.072	0.073	0.089	0.094	0.094	0.094	0.088	0.063
Fe	1.9	2.7	3.8	3.5	4	3.9	4	4.8	5.1	5.1	5.1	4.8	3.4
Pb	0	0	0	0	0	0	0	0	0	0	0	0	0
Li	32	45	63	59	67	65	67	80	85	85	85	80	57
Mg	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	12	17	24	22	25	25	25	30	32	32	32	30	22
Ni	0.023	0.033	0.046	0.043	0.049	0.048	0.049	0.059	0.062	0.062	0.062	0.058	0.042
P	0	0	0	0	0	0	0	0	0	0	0	0	0
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Se	0.46	0.64	0.9	0.85	0.96	0.94	0.96	1.2	1.2	1.2	1.2	1.2	0.82
Si	207	288	405	379	429	420	430	519	547	547	547	517	368
Ag	0.0007	0.00098	0.0014	0.0013	0.0015	0.0014	0.0015	0.0018	0.0019	0.0019	0.0019	0.0018	0.0012
Na	36523	50794	71399	66798	75520	74017	75687	91317	96406	96408	96407	91027	64741
Sr	0	0	0	0	0	0	0	0	0	0	0	0	0
Tl	0	0	0	0	0	0	0	0	0	0	0	0	0
Sn	0.018	0.025	0.035	0.032	0.037	0.036	0.037	0.044	0.047	0.047	0.047	0.044	0.031
Ti	0	0	0	0	0	0	0	0	0	0	0	0	0
U	0	0	0	0	0	0	0	0	0	0	0	0	0
V	1.3	1.8	2.6	2.4	2.7	2.7	2.7	3.3	3.5	3.5	3.5	3.3	2.3
Zn	0.18	0.25	0.35	0.32	0.37	0.36	0.37	0.44	0.47	0.47	0.47	0.44	0.31

Table 3-41:
Upper Case instantaneous tailings loads to mill

Parameter	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)	loads (kg)
Sulphate	36039	50120	70453	65913	74518	73036	74683	90106	95128	95130	95129	89820	63883
Chloride	4473	6220	8744	8180	9249	9065	9269	11183	11806	11807	11806	11148	7929
Fluoride	550	766	1076	1007	1138	1116	1141	1376	1453	1453	1453	1372	976
Al	888	1234	1735	1623	1835	1799	1839	2219	2343	2343	2343	2212	1573
Sb	37	52	73	68	77	76	78	94	99	99	99	93	66
As	68	94	132	123	140	137	140	169	178	178	178	168	120
Ba	12	16	23	21	24	24	24	29	31	31	31	29	21
Be	0.025	0.035	0.049	0.046	0.052	0.051	0.052	0.063	0.066	0.066	0.066	0.062	0.044
Bi	0.011	0.016	0.022	0.021	0.023	0.023	0.023	0.028	0.03	0.03	0.03	0.028	0.02
B	128	178	250	234	265	259	265	320	338	338	338	319	227
Cd	0.0066	0.0092	0.013	0.012	0.014	0.013	0.014	0.016	0.017	0.017	0.017	0.016	0.012
Ca	0	0	0	0	0	0	0	0	0	0	0	0	0
Cr	0.21	0.29	0.4	0.38	0.43	0.42	0.43	0.52	0.55	0.55	0.55	0.52	0.37
Co	0.015	0.021	0.03	0.028	0.032	0.031	0.032	0.038	0.041	0.041	0.041	0.038	0.027
Cu	0.058	0.08	0.11	0.11	0.12	0.12	0.12	0.14	0.15	0.15	0.15	0.14	0.1
Fe	63	88	123	115	130	128	131	158	166	166	166	157	112
Pb	0.13	0.18	0.25	0.24	0.27	0.26	0.27	0.33	0.34	0.34	0.34	0.32	0.23
Li	78	108	152	142	161	157	161	194	205	205	205	194	138
Mg	0	0	0	0	0	0	0	0	0	0	0	0	0
Mn	0	0	0	0	0	0	0	0	0	0	0	0	0
Hg	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	17	24	34	32	36	35	36	43	46	46	46	43	31
Ni	0.11	0.16	0.22	0.21	0.23	0.23	0.23	0.28	0.3	0.3	0.3	0.28	0.2
P	67	94	132	123	139	136	139	168	178	178	178	168	119
K	0	0	0	0	0	0	0	0	0	0	0	0	0
Se	2	2.8	3.9	3.6	4.1	4	4.1	5	5.2	5.2	5.2	5	3.5
Si	926	1288	1810	1693	1914	1876	1919	2315	2444	2444	2444	2307	1641
Ag	0.01	0.014	0.02	0.019	0.021	0.021	0.021	0.026	0.027	0.027	0.027	0.026	0.018
Na	53510	74418	104608	97867	110644	108443	110889	133789	141245	141248	141246	133364	94853
Sr	39	55	77	72	81	80	82	98	104	104	104	98	70
Tl	0.015	0.021	0.029	0.027	0.031	0.03	0.031	0.037	0.039	0.039	0.039	0.037	0.026
Sn	0.023	0.032	0.045	0.042	0.048	0.047	0.048	0.058	0.061	0.061	0.061	0.057	0.041
Ti	3.5	4.8	6.8	6.4	7.2	7	7.2	8.7	9.2	9.2	9.2	8.7	6.2
U	0	0	0	0	0	0	0	0	0	0	0	0	0
V	10	14	20	19	22	21	22	26	28	28	28	26	18
Zn	0.3	0.42	0.59	0.55	0.62	0.61	0.62	0.75	0.8	0.8	0.8	0.75	0.53

The instantaneous tailings loadings were calibrated by comparing the GoldSim modelled tailings effluent concentrations to measurements of tailings supernatant and process water. While most parameters show good agreement (Lorax 2020), some parameters (*i.e.*, sulfate, Cl, F, B, Co, Cr, Fe, K, Mo, Na, Se and Sr) required refinements through the application of calibration factors (Table 3-42).

Table 3-42:
Calibration Factors Applied to Modelled Tailings Effluent Concentrations

Parameter	Tailing Discharge Calibration Factor
Sulfate	2.2
Cl	1.9
F	1.7
B	1.5
Co	0.6
Cr	0.2
Fe	0.4
K	6
Mo	4
Na	1.9
Se	4
Sr	3

3.6.5.2 Diffusive Loads from Tailings and WTP Sludge to WRTSF

Diffusion-related loads from co-deposited tailings and WTP sludge to the WRTSF were estimated based on saturated column results and assumptions regarding diffusional transport. The approach for deriving these fluxes has not been updated. A brief overview of how the diffusive flux values were calculated is presented below. Additional discussion related to diffusional transport processes, contaminant behaviour and potential water quality impacts with respect to the co-deposition of sludge with tailings in the WRTSF is provided in a report (*Brucejack Gold Mine: Assessment of Long-Term Sludge Stability for In-Lake and Underground Deposition* (Lorax, 2016a)) that was submitted for the *Mines Act* Permit M-243 and Effluent Permit 107835 amendment applications approved in March/April 2017.

The rate of diffusional transport in sediment porewaters is a function of the concentration gradient, temperature, sediment grain size, porosity and solute size, and can be described by Fick's First Law (Eqn. 1):

$$Jz = \frac{Doj}{F} f \frac{dc}{dz}$$

where J_z is the diffusive flux; D^o_j = *in situ* diffusion coefficient; F = formation factor; ϕ = porosity; and dc/dz = the concentration gradient. Formation factor is a measure of tortuosity, and takes into account the convoluted path ions must follow to circumvent sediment particles (Li and Gregory, 1974). Diffusion coefficients are temperature dependent, with values increasing commensurately with temperature.

To simplify the calculations, a common diffusion coefficient (5×10^{-6} cm^2/s) was assumed for all parameters, as per values presented in Li and Gregory (1974), normalized to 5ºC. Flux calculations also assumed a formation factor of 2 (Ullman and Aller, 1982) and an estimated porosity of 0.7 for silt-sized materials. Leachate data from saturated column test TCol 14 comprising tailings and WTP sludge were used to calculate the concentration gradient (dc/dz).

Calculation of the concentration gradient (dc/dz) included the following assumptions:

- Concentration endmembers in sludge-bearing porewater were set equal to the maximum values measured in saturated column TCol 14;
- Concentration endmembers in the lake bottom water were set equal to median WRTSF concentrations measured throughout 2021 at station BJ 3.10;
- The sediment depth over which diffusion is assumed to apply is 3 cm; and
- Flux calculations do not account for sorption processes within the uppermost oxic sediment layers. This imparts a considerable degree of conservatism since a significant fraction of the upward diffusing Mn and Fe can be expected to re-precipitate as their respective oxide phases in the near-surface sediments and remove trace elements that show strong binding affinities for Fe and Mn oxide surfaces (*e.g.,* As, Cd, Co, Cu, Pb, Ni and Zn).

Derived fluxes (J_z) were used to calculate the annual diffusive load for each parameter to the lake water column by multiplying the diffusive flux ($\mu g/cm^2$/year) for each parameter by the estimated annual tailings surface area (m^2). The annual tailings surface areas are assumed to grow at a steady rate up to the final estimated tailings surface area. The model applied the same final surface area estimate as the previous model (382,250 m^2) since an updated surface area was not available at the time the model was developed. The modelled annual diffusion-related loads contributing to the WRTSF from co-deposited tailings and WTP sludge are presented in Table 3-43.

Table 3-43:
Diffusive loads from tailings and WTP sludge deposited in the WRTSF

Assumed Tailings Area (m²)		*34750*	*69500*	*104250*	*139000*	*173750*	*208500*	*243250*	*278000*	*312750*	*347500*	*382250*	*382250*
Parameter	**Diffusive Flux**	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	**Closure and Post-closure**
	(µg/cm²/y)	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	
Chloride	293	101916	203833	305749	407666	509582	611499	713415	815332	917248	1019165	1121081	1121081
Fluoride	20	6986	13972	20959	27945	34931	41917	48903	55890	62876	69862	76848	76848
Sulfate	50017	17380985	34761969	52142954	69523939	86904924	1.04E+08	1.22E+08	1.39E+08	1.56E+08	173809847	191190832	191190832
Al	0.01	3.5	7	11	14	18	21	25	28	32	35	39	39
Sb	0.098	34	68	102	136	170	204	238	272	306	341	375	375
As	0.51	176	352	528	704	880	1056	1232	1408	1584	1760	1936	1936
Ba	0.034	12	23	35	47	59	70	82	94	106	117	129	129
Be	-0.0034	0	0	0	0	0	0	0	0	0	0	0	0
Bi	-0.0015	0	0	0	0	0	0	0	0	0	0	0	0
B	-2.3	0	0	0	0	0	0	0	0	0	0	0	0
Cd	0.0063	2.2	4.3	6.5	8.7	11	13	15	17	20	22	24	24
Ca	9018	3133814	6267628	9401442	12535256	15669070	18802884	21936698	25070512	28204326	31338140	34471954	34471954
Cr	-0.017	0	0	0	0	0	0	0	0	0	0	0	0
Co	0.015	5.2	10	16	21	26	31	37	42	47	52	57	57
Cu	0.049	17	34	51	68	85	101	118	135	152	169	186	186
Fe	-0.22	0	0	0	0	0	0	0	0	0	0	0	0
Pb	-0.0010	0	0	0	0	0	0	0	0	0	0	0	0
Li	2.3	804	1609	2413	3217	4021	4826	5630	6434	7239	8043	8847	8847
Mg	3941	1369414	2738829	4108243	5477658	6847072	8216487	9585901	10955316	12324730	13694145	15063559	15063559
Mn	509	176874	353749	530623	707498	884372	1061246	1238121	1414995	1591869	1768744	1945618	1945618
Hg	-0.00017	0	0	0	0	0	0	0	0	0	0	0	0
Mo	1.2	429	859	1288	1717	2146	2576	3005	3434	3863	4293	4722	4722
Ni	0.11	39	79	118	158	197	237	276	316	355	395	434	434
K	2855	992159	1984318	2976477	3968637	4960796	5952955	6945114	7937273	8929432	9921592	10913751	10913751
Se	0.071	25	49	74	99	123	148	173	197	222	247	271	271
Si	18	6340	12681	19021	25362	31702	38043	44383	50723	57064	63404	69745	69745
Ag	-0.00015	0	0	0	0	0	0	0	0	0	0	0	0
Na	1213	421521	843042	1264563	1686084	2107604	2529125	2950646	3372167	3793688	4215209	4636730	4636730
Sr	255	88742	177485	266227	354970	443712	532455	621197	709940	798682	887425	976167	976167
Tl	-0.00085	0	0	0	0	0	0	0	0	0	0	0	0
Sn	-0.00098	0	0	0	0	0	0	0	0	0	0	0	0
Ti	-0.34	0	0	0	0	0	0	0	0	0	0	0	0
U	-0.012	0	0	0	0	0	0	0	0	0	0	0	0
V	-0.017	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0.10	33	66	99	132	164	197	230	263	296	329	362	362

3.6.6 Paste Backfill Bleed Water

Porewater contained in paste backfill that is not consumed during the cement curing process will be released as bleed water. The approach for derivation of the paste backfill bleed water term is the same as that presented in previous models, but the data used to develop the term has been updated.

The bleed water quality is assumed to be equivalent to the predicted mill process water composition for all parameters except Cr, which is dominantly introduced from the cement during paste generation. The predicted mill process water composition is calculated in GoldSim considering the flows and concentrations of components introduced to the mill (*i.e.*., WTP effluent, reclaim water, recirculated process water, and ore moisture), along with the loads added from the processed ore (the instantaneous tailings loads). Base Case and Upper Case process water predictions are based on the Base Case and Upper Case terms for the components introduced to the mill.

Chromium concentrations in paste backfill bleed water were calculated following the same approach to that described in the 2020 update model (Lorax 2020a), whereby values are based on the initial flushing results of paste backfill humidity cells. Base Case and Upper Case bleed water Cr concentrations were based on the median (0.00035 mg/L) and the maximum (0.0009 mg/L) concentrations observed in the first 10 cycles of humidity cell T18. The full set of results for humidity cell T18, along with all other humidity cells results, are presented on an annual basis in the Annual Reports (Pretium, 2016; 2017; 2018a; 2019a; 2020a; 2021, 2022a).

3.7 Sewage Treatment Plant

3.7.1 Overview

Domestic wastewater generated at the Brucejack Mine camp is treated and discharged to the WRTSF at depth, as authorized by PE-107835. The mine currently operates three FilterBoxx C75 STPs, each with a rated treatment capacity of 75 m^3/d. The maximum authorized discharge rate by PE-107835 is 175 m^3/d. Monitored discharge rate of treated STP effluent has been approximately 90 m^3/d. Monitored flows are used to estimate STP effluent discharge rates in the Water Balance Model.

PE-107835 requires that STP effluent quality is monitored quarterly, and only for biological oxygen demand (BOD) and TSS. In general, STP effluent has been monitoring monthly for these required parameters, as well as nutrients and anions. Analysis of metals in STP effluent was carried out five times in 2022, but metals are not part of the routine analysis of STP effluent.

3.7.2 STP Effluent

STP source terms for the 4950 tpd model were updated to incorporate combined STP effluent monitoring results collected from January 2019 through September 2022. Base Case source terms were set equal to the 75th percentile of monitoring results, whereas the 90th percentile was used for the Upper Case source terms (Table 3-44). The timeseries of STP effluent concentrations do not have any noticeable seasonality; therefore, all monitoring results were used when calculating percentiles, and the resulting source terms were applied to all months. Monitoring results less than detection limit were set equal to the detection limit for calculating percentiles.

Table 3-44:
Sewage treatment plant discharge source terms

Parameter	Units	Base Case (75th percentile)	Upper Case (90th percentile)
Ammonia	mg-N/L	2.52	9.63
Nitrate	mg-N/L	47.8	59.0
Nitrite	mg-N/L	0.265	0.562
Chloride	mg/L	103	124
Fluoride	mg/L	0.87	1.30
Sulfate	mg/L	256	321
Total Phosphorus	mg/L	0.56	0.73
Al	mg/L	0.42	0.67
Sb	mg/L	0.00223	0.00223
As	mg/L	0.00084	0.00098
Ba	mg/L	0.014	0.018
Be	mg/L	0.000020	0.000020
Bi	mg/L	0.000069	0.000090
B	mg/L	0.11	0.11
Cd	mg/L	0.000037	0.000037
Ca	mg/L	26.3	26.4
Cr	mg/L	0.00019	0.00023
Co	mg/L	0.00010	0.00011
Cu	mg/L	0.0087	0.0172
Fe	mg/L	0.012	0.014
Pb	mg/L	0.0029	0.0031
Li	mg/L	0.058	0.062
Mg	mg/L	4.4	4.5
Mn	mg/L	0.016	0.017
Hg	mg/L	0.0000050	0.0000050
Mo	mg/L	0.0012	0.0012
Ni	mg/L	0.0036	0.0061
K	mg/L	29	31
Se	mg/L	0.00022	0.00024
Si	mg/L	1.99	2.82
Ag	mg/L	0.000011	0.000019
Na	mg/L	255	272
Sr	mg/L	0.39	0.42
Tl	mg/L	0.000010	0.000010
Sn	mg/L	0.00017	0.00021
Ti	mg/L	0.00030	0.00030
U	mg/L	0.000010	0.000010
V	mg/L	0.00050	0.00050
Zn	mg/L	0.051	0.057

3.8 Nitrogen Source Terms

3.8.1 Overview

Blasting residues from the use of explosives represent the dominant source of nitrogen (N) species (ammonia, nitrite and nitrate) at Brucejack Mine. The N containing residues result from non-detonated explosives and explosion gases (*e.g.*, nitrogen oxides) that condense on blasted surfaces (Pommen, 1983). The N residues are finite in contrast to geochemical mineral release to contact water. The export of N species in contact water is proportional to the amount of explosives used and rock blasted, therefore from these data N loading rates based on tonnage blasted are derived as source terms for the water quality model.

The N source terms provided here rely on the implementation of best management practices for explosives handling and blasting as described in the Nitrogen Management Plan (Pretium, 2022b). The input of N from explosives will cease at closure when blasting stops and mine flooding occurs. It is expected that the soluble N species will be released to the mine pool from walls, floors, and backfill to mine water during mine flooding.

Explosives-related nitrogen species are currently introduced to the WRTSF from WTP effluent, waste rock deposition in the WRTSF, tailings slurry discharge, NPAG Quarry rock contact water, mine site surface runoff and sewage treatment plant effluent. Nitrogen source terms arising from background inputs and STP effluent are described in Section 3.1 and Section 3.7, respectively, and are not discussed further in this section.

3.8.2 Data Sources

The source terms for N species (ammonia, nitrite and nitrate) are empirically derived from monitoring records for explosives consumption, ore and waste production, water quality and flows for the January 2015 through August 2022 monitoring period. Records were obtained from the following monitoring programs and used for source term derivation and validation:

- Water quality monitoring data collected at BJ 3.10, profiles within the WRTSF, Process Water, CWP Water, Mine Water, WTP influent and WTP Effluent stations;
- Monitoring of N loads in ore, tailings and paste solids and contact waters;
- Underground water quality monitoring at sumps, paste bleed water and wall wash stations; and,
- Operations records for explosives use, excavation quanities, ore supplied to the mill and waste and effluent discharge quantities to the WRTSF.

3.8.3 Explosives Use

At Brucejack Mine, Titan 7000 bulk emulsion explosive is used for underground blasting. Small amounts of packaged explosives are periodically used when emulsion is not appropriate. These include Dyno AP and Dyno SL and Dynosplit D. All products are ammonium nitrate (AN) based emulsion explosives products that are designed for use in wet conditions. The Titan 7000 is approximately 25% N in the form of ammonia and nitrate. Detonators and boosters are also used for blasting, however these are insignificant sources of N compared to the explosives and therefore usage is not tracked.

Development blasting methods are used to advance drifts and access tunnels for mining operations. The blasts are characterized by short rounds (approximately 4 m depth) with an open square blast face typically 5.5 by 5.5 m in dimension. Small diameter boreholes are drilled for loading explosives and the explosives use rate (powder factor) is high.

Ore is excavated from stopes using production longhole blasting methods, with large diameter boreholes, typically drilled upward or downward from an open drift and loaded with bulk emulsion. The boreholes extend as much as 30 m generally blasting a stope approximately 5 m deep, 30 m high and 15 m wide. Powder factors are low compared to development blasting.

For underground blasting, the overall blasting powder factors (PFs) for mine development (waste) and production (ore) are 1.65 and 0.92 kg/t, respectively, calculated from the period totals for explosives use and blasted rock tonnages. The monthly and overall PFs are plotted in Figure 3-10 for both development and production blasting. The monthly PFs vary significantly through the monitoring period, ranging from 0.77 to 2.93 kg/t for development and 0.70 to 1.30 kg/t for production blasting. The overall PFs for the period of record are considered better indicator of the average explosives usage for mining as the monthly values are influenced by rock conditions and other factors that may alter the PF for any single blast. A general increasing trend in the monthly production PF is observed beginning mid-2021 and is due to the transition from smaller to larger diameter (*i.e.,* 4”) blast holes that was initiated at that time. A new methodology for estimating development explosives usage was implemented January 2021 onwards and yields PF values that are generally higher than those reported from 2015 through 2020.

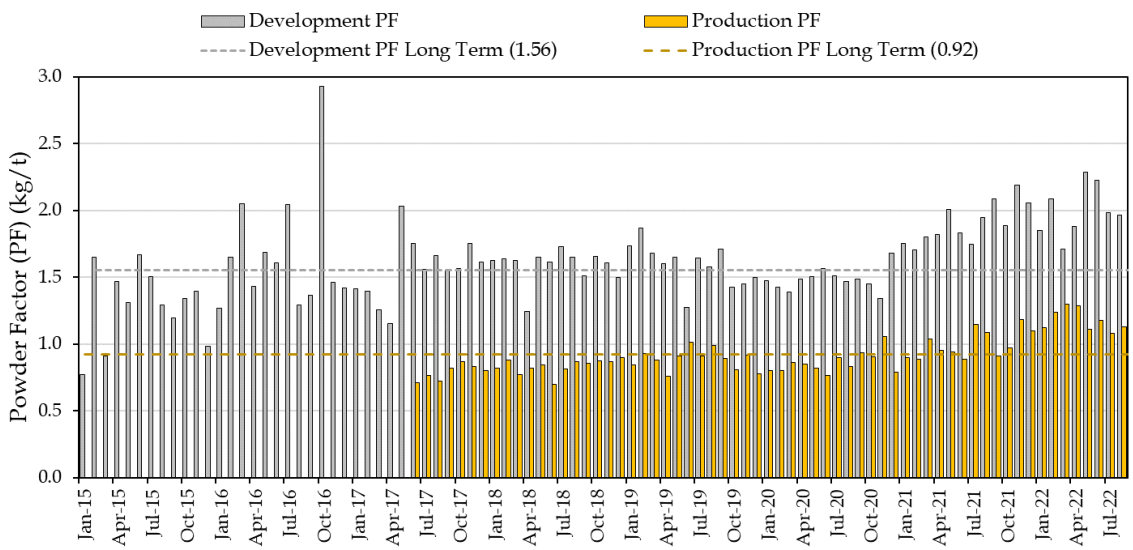


Figure 3-10: Monthly powder factor (PF) for the January 2015 through August 2022 period for development (waste) and production (ore) blasting.

3.8.4 Mine Site and NPAG Quarry

3.8.4.1 Overview

As indicated in Section 3.3.1 and Table 3-5, approximately 1,500 kt of waste rock was blasted and excavated from the mine site surface to develop the site for various facilities including the Mill, Truck Shop, Camp and CWP in preparation for operations. Construction of the mine site was initiated in September 2015 and continued through 2016, with the majority of excavation occurring in Q1 and Q2 of 2016 (Table 3-5). NPAG Quarry rock was used as fill for pad and road construction, as well as road surfacing, and a total of 1,114 kt of quarry rock was excavated from 2015 through 2021 (Table 3-2). A distinction is made for NPAG Quarry rock placed within the mine site which is included in the mine site runoff term, and for the NPAG Quarry rock placed outside the mine site, which is modelled to report directly to the WRTSF.

Source terms for N species are modelled as loading rates to the WRTSF from surface excavation pits, surface fill and from surface waste deposition. The surface waste rock load represents the mass of available soluble N species that is instantaneously released into solution upon contact with surface runoff or subaqueous deposition. The approach for derivation of each of these water quality model inputs are described in the sections below.

3.8.4.2 Mine Site Waste Rock Surfaces

Surface waste deposition is not modelled for the remaining Operations, Closure and Post-Closure periods (*i.e.,* 2021 onwards). However, the historic deposition continues to be incorporated in the water quality model, therefore the source term description is provided below for reference.

The N loading rate is estimated from: 1) the observed changes in the WRTSF total N inventory attributable to waste rock deposition, and 2) the tracked tonnages of waste rock deposited to the WRTSF for the 2016 through 2021 period. Surface excavation and WRTSF deposition was primarily conducted May 2015 through December 2016 during mine construction. There was no significant additional blasted surface waste placed in the WRTSF from 2017 through 2021. Waste rock from surface and underground excavation were deposited concurrently to the WRTSF, but at varying proportions over time; therefore, N load rates were derived for both surface and underground materials to fully account for the incremental change in the WRTSF N inventory between each monitoring event.

The WRTSF water quality data and total surface waste rock deposition are used to derive N loading rates for surface waste rock deposited to the WRTSF (Table 3-45). The total N loading rate of surface waste rock to the WRTSF is calculated to be 0.004 kg-N/t for the January 2016 to January 2017 monitoring period. For modelling, the surface waste rock loading rates were conservatively rounded up to 0.005 kg-N/t for the Base Case and 0.008 kg-N/t for the Upper Case.

Table 3-45:
N loading from surface waste rock to the WRTSF

Loading Term(g-N/t)	Base Case	Upper Case
Surface Waste	5	8

3.8.4.3 Mine Site Runoff

Core mine site surface facilities, including the mill, phase 2 camp, and VOK portal building (and their respective pads constructed by excavating PAG rock and placing NPAG fill), are located within the CWP catchment. Surface runoff from precipitation within the CWP catchment is accumulated in the CWP via the contact water management system (SRK, 2020), which includes ditches, manholes, piping and pumping systems to intercept and redirect runoff. The CWP is also used to store treated WTP effluent and any off-specification WTP effluent. The CWP is pumped to the WTP for treatment and mixes with other influent streams directed to the WTP (*i.e.*, process water and mine water).

The mine site runoff N source terms include N loading from surface blasting and from placement of NPAG Quarry fill used for the construction of pads and roads located within the CWP catchment. The N loading rates to mine site runoff are estimated to be 20% of the loading rates derived for surface waste deposited to the WRTSF, specifically 1 and 2 g-N/t for Base Case and Upper Case, respectively (Table 3-46). Loading rates were not measured during the 2015 through 2021 monitoring period therefore monitoring data are not available for comparison to model assumptions.

Table 3-46:
N loading to mine site runoff within the CWP catchment and to the WRTSF from NPAG quarry operations outside the CWP catchment

Loading Term	Base Case	Upper Case
	g-N/t	
Pit Wall contact water	1	2
Fill contact water	1	2

3.8.4.4 NPAG Quarry Pit and Road Fill Runoff

The NPAG Quarry is located near the southeast end of the WRTSF, with runoff from this area reporting directly to the WRTSF. Approximately 1,114 kt of rock was excavated from the NPAG Quarry from 2015 through 2021 (Table 3-2) to provide material for building foundations, roads, and other construction activities at the mine site. The excavated quarry rock is also crushed and placed in the underground mine as road surfacing. The projected NPAG Quarry rock excavation schedule is 50,000 t/yr for LOM. N species source terms were developed for drainage in contact with exposures in the NPAG Quarry as well as drainage from roads and pads constructed from NPAG Quarry rock.

The NPAG Quarry runoff includes N loading from the quarry pit walls and from the fill used for access roads outside the mine site area (*i.e.,* outside the CWP catchment). The N source terms for NPAG Quarry runoff are the same as the mine site runoff source terms presented above in Table 3-46. The Base Case and Upper Case loading rates are 1 and 2 g-N/t, respectively. The NPAG Quarry N loading rates have not been measured and therefore monitoring data are not available for comparison to model assumptions.

The N loads associated with NPAG Quarry rock placement within the mine site catchment are included with mine site runoff (see Section 3.8.4.3). NPAG Quarry rock is also used for road surfacing in the underground mine and N contributions from this placement are included in the of mine water N source terms (Section 3.8.5.2).

3.8.5 Underground Mine

3.8.5.1 Overview

As described in Section 2.1.3, the 4950 tpd mine plan will result in excavation of waste rock and ore through 2029. The waste deposition schedules are provided in Table 3-12 and Table 3-13; whereas the ore schedule is presented in Table 3-39.

In the underground mine, N is released to mine water from blasted rock, waste rock and paste backfill, and exposed mine surfaces (*i.e.,* walls). The N loading is modelled to be proportional to the quantity of rock blasted and the quantity of blasted rock placed as backfill. The loading of N from waste backfill to Mine Water is estimated to be 20% of the rate for waste to the WRTSF. Blasted ore is directed to the mill and the N loading rate for ore is described in Section 3.8.6.2. The derivation of the N loading rate for paste backfill is described in Section 3.8.6.3.

N source terms were developed for:

1) Underground mine waste rock deposited in the WRTSF; and,
2) Contact water from the underground mine.

3.8.5.2 Blasted Rock and Mine Water

As described in Section 3.4.3, the underground mine workings at the Brucejack Mine occur primarily below the groundwater table, and thus dewatering of the workings is required for all active phases of the mine. The N species arising from explosives used for blasting waste rock and ore are transferred to underground mine water through the dissolution of N species at the blast location, both through contact with groundwater that enters the mine and contact with mine water used for dust suppression. Backfilled waste and cement paste also contribute N to mine water; however, these contributions are accounted for separately in Section 3.8.5.4 (for waste) and Section 3.8.6.3 (for paste). The NPAG Quarry rock used for underground mine road surfacing contributes comparatively small loads to mine water; these loads are assumed to be captured in the derivation of the blasted rock N loading rate to mine water. Water supplied to the underground mine contributes to the mine water N concentrations and these contributions are derived within the water quality model.

Mine water N loading rates from blasted rock are calculated from water quality, flow and blasted rock tonnage records for the January 2015 through July 2017 period. These calculations yield N loading rates of 0.022 and 0.033 kg-N/t as source terms for the Base Case and Upper Case water quality model calculations (Lorax, 2018). The total N is distributed between ammonia, nitrite and nitrate based on the species distributions for N source terms presented in Section 3.8.7.

The observed N loading rates for a monthly time step during the June 2017 to August 2022 monitoring period are plotted in Figure 3-11. The cumulative N loading rate for the period is 29 g-N/t, near the mid-point between the Base and Upper Case assumptions (Table 3-47). The N loading rate for mine water was derived for the January 2015 through July 2017 monitoring period, during which time the dominant source of N to mine water was from blasting. Since July 2017 paste backfill has been placed in mined out stopes and water supplied to the underground mine has increased in both volume and N species concentrations. Waste rock is also backfilled into secondary stopes. These additional contributions are presumed to account for the 29 g-N/t loading rate to mine water that is observed for the 2017 to 2021 monitoring period compared to the Base Case loading rate derived from the 2015 to 2017 data. Therefore, the 2018 water quality model (Lorax, 2018) Base Case N load rate (22 g-N/t) is considered to best represent the N loads to mine water arising from blasting. The N loads from paste backfill bleed water and waste rock backfill are accounted for separately in section 3.8.5.4 and section 3.8.6.3.

Table 3-47:
N loading rates for underground ore, waste rock and paste backfill to Mine Water, the WRTSF and the Mill

Loading Term (g-N/t)	2015 – August 2022 Monitoring Period	Base Case	Upper Case
Blasted rock to Mine Water	29	22	33

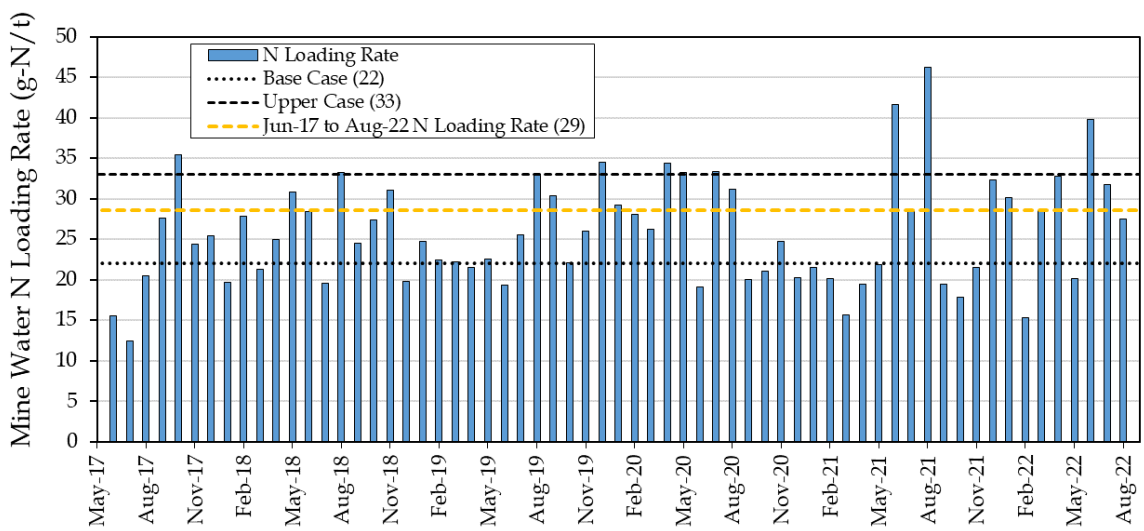


Figure 3-11: Observed N loading from blasted rock to mine water from May 2017 through August 2022.

3.8.5.3 Mine Wall Surfaces

The mine wall source term accounts for N residues on mine walls and floors. Blasting generates N containing gases such as ammonia and nitrogen oxides that condense on exposed surfaces throughout the mine workings. During operations the mine is dewatered and N compounds (ammonia, nitrate and nitrite) accumulate on the exposed surfaces in the underground workings. The N loading rate for mine wall surfaces was derived from the wall wash monitoring program (described in the ML/ARD Management Plan) which measures water soluble residues on the mine walls and floors. The N residues are assumed to be released to contact water when the mine is flooding during closure. The N loading rates for wall and floor surfaces to mine water are 0.383 and 0.567 g-N/m^2, for the Base Case and Upper Case water quality model source terms (Table 3-48). The total N is distributed between ammonia, nitrite and nitrate based on the species distributions for N source terms presented in Section 3.8.7.

Table 3-48:
N loading rates for mine walls to mine water during mine flooding

Loading Term	Base Case	Upper Case
	(g-N/m^2)	(g-N/m^2)
Mine Walls to Mine Water	0.383	0.567

3.8.5.4 Waste Rock Surfaces

Most N residues from blasting remain on blasted waste rock surfaces. The residues can be released to contact water at the waste storage location. Excavated waste rock placed in the WRTSF is assumed to release all N residues to the WRTSF at the time of deposition. Waste placed as backfill in secondary stopes is assumed to release 20% of the N load to contact water from dust suppression or groundwater seepage at the time of deposition. During mine flooding, it is assumed that there will be limited flow through the waste rock pore water due to the confined placement of the rock. Therefore, waste backfill is assumed to release 10% of the N load to mine water during mine flooding.

The estimates of N loading rates to the WRTSF from waste rock are derived by mass balance of the WRTSF for total N accounting for inputs, storage and discharges of N species over a 2 year period. The water residence time the WRTSF is approximately 2 years, based on the WRTSF volume and BJ 3.10 discharge measurements for the 2015 through 2021 period. Therefore, a two-year period is considered appropriate for the derivation of the waste rock N loading rate to the WRTSF using a mass balance approach.

The change in the N inventory of the WRTSF plus the N loads exported from BJ 3.10 are corrected for the N loads added the WRTSF from the WTP effluent and tailings discharge.

The modelled N loading rates for underground waste to the WRTSF is shown in Table 3-49. These are derived from the average and maximum values of the waste rock N loadings for each two-year period from 2015 to 2021, and are 93 and 143 g-N/t for Base Case and Upper Case, respectively (Figure 3-12). The overall loading rate for the monitoring period (2015-2021) is 94 g-N/t.

For waste placed as underground backfill, it is assumed that a small proportion of the N load on the waste rock will be released to mine water and the remainder will remain sequestered in the backfilled stope. As shown in Table 3-49, the N loading rates for backfill at time of placement and during mine flooding are set at 19 and 29 g-N/t, and 14 and 17 g-N/t, Base Case and Upper Case, respectively. The total N loads are distributed between ammonia, nitrite and nitrate based on the distribution for N source terms presented in Table 3-52.

Table 3-49:
N loading rates for underground waste rock to WRTSF and mine water

Loading Term (g-N/t)	2015 – 2021 Monitoring Period	Base Case	Upper Case
Waste Rock to WRTSF	94	93	143
Waste Rock Backfill to Mine Water (at time of placement)	-	19	29
Waste Rock Backfill to Mine Water (during mine flooding)	-	14	17

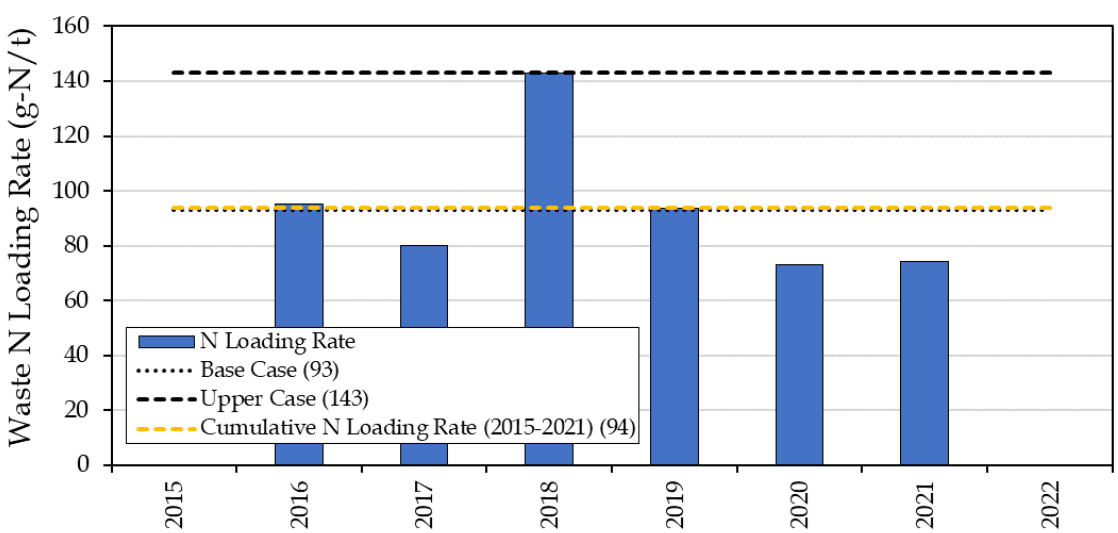


Figure 3-12: Observed annual N loading from waste rock to the WRTSF.

3.8.6 Mill Components

3.8.6.1 Overview

Nitrogen enters the mill through ore, mine water and reclaim water from the WRTSF. The export of N from the mill occurs in backfill tailings paste, as well as discharges of WTP effluent to water supply and the WRTSF, and thickened tailings discharged to the WRTSF. The water quality model uses all the N source terms described in previous sections, as well as for ore (described below) to derive N species concentrations in the mill components of the GoldSim model as described in Section 3.6.1. The following sections describe N source terms developed for ore and the assumptions regarding the release of N loads from tailings and paste backfill.

3.8.6.2 Ore Surfaces

The N loads on ore surfaces are measured using milling records and monitoring data collected from the commencement of ore milling (June 2017). The production (ore) mining method uses the long-hole blasting technique rather than the short rounds used for mine development (waste) blasting, therefore the N loading rate for ore is expected to be lower than for waste.

The N loads on ore are derived from the 75th and 90th percentiles of weekly load measurements over the June 2017 to September 2017 period to yield N source terms of ore loading to the mill of 28 g-N/t and 54 g-N/t, respectively, for Base Case and Upper Case (Table 3-50). The ore N loading rate was measured weekly from June through October 2017, and monthly thereafter. The total N loads are distributed between ammonia, nitrite and nitrate based on the species distribution for N source terms presented in Table 3-52. The weekly N loading rate measurements are compiled as monthly average values for the June through October 2017 period and are used with other monthly measurements to calculate a median monthly N loading rate from ore for June 2017 though August 2022. The median ore N loading rate is 22 g-N/t of ore, well below the Base Case model assumption (28 g-N/t) as shown in Figure 3-13. The N loading rate is sometimes elevated compared to the Base Case with 75th and 95th percentile values of 31 and 45 g-N/t, respectively.

Table 3-50:
N loading rates for ore to the Mill

Loading Term (g-N/t)	2017 – 2022 Monitoring Period	Base Case	Upper Case
Blasted ore to mill	22 (median)	28	54

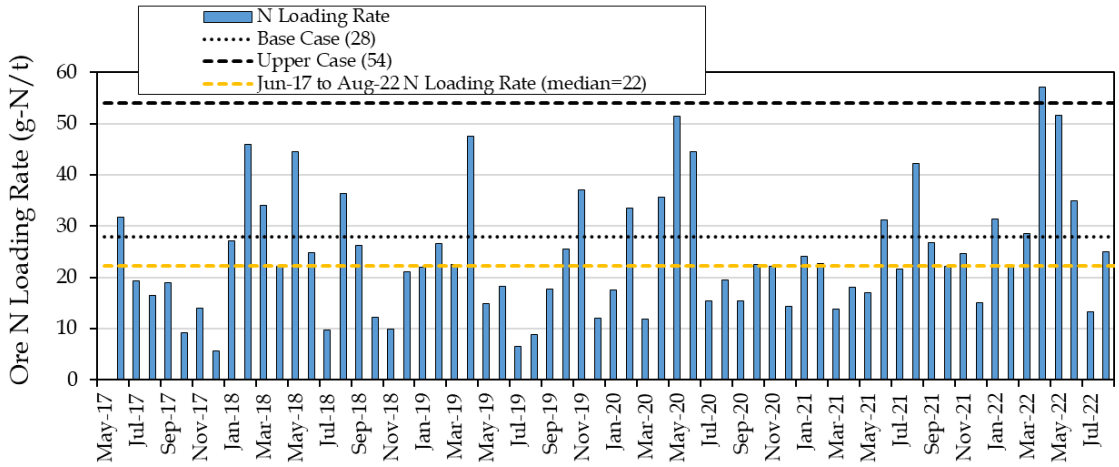


Figure 3-13: Observed N loading rate from ore to mill measured monthly from June 2017 through August 2022.

3.8.6.3 Tailings and Paste Backfill Loads

The water quality of the tailings supernatant discharged to the lake or placed underground as paste backfill are calculated by the GoldSim model based on N loads to the mill from mine water, ore and reclaim water. Base Case and Upper Case process water quality predictions are based on the Base Case and Upper Case terms for the components introduced to the mill.

Tailings discharged to the WRTSF are assumed to instantaneously release 100% of the N loads into the lake. In contrast, tailings placed underground as paste backfill are assumed to sequester more than 90% of the nitrogen compounds within the cured cemented paste. As described previously in Section 3.6.6, porewater contained in paste backfill that is not consumed during the cement curing process will be released as bleed water. Paste backfill bleed water monitoring data were used to estimate N loads transferred from the paste to the bleed water and N species distribution. Loading rates of 0.8 and 3 g-N/t, for Base Case and Upper Case, respectively, are derived from these data to model N release from paste to bleed water at the time of placement and at the time of mine flooding (Table 3-51). The bleed water volume is assumed to equal to approximately 2.5% of the water content in the paste.

Table 3-51:
N loading rates for Paste Backfill to Mine Water

Loading Term (g-N/t)	2017 – 2019 Monitoring Period	Base Case	Upper Case
Paste Backfill to Mine Water (at time of placement)	0.77 (median)	0.8	3
Paste Backfill to Mine Water (during mine flooding)	0.77 (median)	0.8	3

3.8.7 Nitrogen Speciation

Microbially-mediated nitrification processes occur naturally in cold water lakes and control the distribution of nitrogen species in the water column (Sterner, 2007), typically promoting an accumulation of nitrate. Brucejack Lake (now the WRTSF) is a cold water lake, and therefore the observations by Sterner (2007) are relevant to water quality modelling at Brucejack Mine. Nitrification rates in these environments are affected by temperature, nutrient levels, substrate and other environmental factors (Dvir & Neori, 1999; Kaplan *et al.*, 2000; Gerardi, 2002; Ward *et al.*, 2011; Bristow *et al.*, 2015) which may cause variations of the relative proportions of ammonia, nitrite and nitrate in the water column. Temporary decoupling of the rates of oxidation of N species by microbial communities can also occur, leading to temporary accumulation of ammonia or nitrite. The microbially-mediated oxidation of ammonia to nitrite is considered to be the rate-limiting step for overall nitrification (Ginestet *et al.,*1998). Active and inferred inhibited nitrification endpoints are used to model N species distributions in the WRTSF discharge.

The N species distributions in mine water, wall wash stations, the CWP and the WRTSF outlet (BJ 3.10) that were observed 2015 through 2021 were used to develop N speciation terms for modelling. The N loads are assigned the relative distributions indicated in Table 3-52 for the various N load sources. The N speciation for mine water is applied to the N source terms, except for mine wall residues during closure, and at the WRTSF outlet during operations and closure. The N loads at the WRTSF outlet (BJ 3.10) are redistributed as indicated in Table 3-52 to account for several possible nitrification endpoints.

Table 3-52:
Nitrogen (N) species relative distributions used for modelling

Model Term	Relative Distribution of N Species (% as N)		
	Ammonia	Nitrite	Nitrate
Mine water, ore to mill, waste to WRTSF and to backfill, paste backfill	28.8 %	5.2 %	66.0 %
Mine walls	46.5 %	3.2 %	50.3 %
WRTSF outlet (BJ 3.10)	23.2 %	0.84 %	99.9 %

The N species distributions at the WRTSF outlet are set conservatively for all N species. The species distributions are governed by conditions in the WRTSF water column. For the 2015 to 2022 monitoring period, the WRTSF conditions were oxidizing in the surface layer and mid-water column. Overall, the monitoring data at the WRTSF outlet continue to indicate nitrate accumulation and depletion of ammonia and nitrite relative to the inputs to the WRTSF. These changes are attributed to microbially mediated nitrification processes that convert ammonia to nitrite, and nitrite to nitrate (Sterner, 2007).

Data from the June 2017 through August 2022 monitoring period were used to derive N species relative distributions. The maximum ammonia value observed in the CWP water are used to represent a low nitrification endpoint (ammonia equal to 23.2% of N reporting to BJ 3.10), and maximum values from BJ 3.10 are used to model high nitrification endpoint (nitrate equal to 99.9 % of N reporting to BJ 3.10). The WRTSF monitoring data indicate that the proportion of nitrite remains low for both endpoints; therefore, the maximum ratio observed at BJ 3.10 (0.84 % of N reporting to BJ 3.10) was used for nitrite. Although the distributions sum to 124% of the total N predicted to report to BJ 3.10, this approach is considered appropriate as it addresses the uncertainty associated with continuity of the nitrification processes inferred to be active within the WRTSF.

4 Results

4.1 Overview

This section presents updated Brucejack Mine water quality model results for two monitoring sites: 1) BJ 3.10, the mine's regulated final discharge location at the outlet of the WRTSF; and 2) BJ 2.62, a downstream monitoring site in Brucejack Creek that will receive underground mine loads via groundwater pathways after the mine is flooded (Figure 1-1).

Water quality predictions for BJ 3.10 and BJ 2.62 are reviewed as compared to previous model predictions, to applicable discharge limits defined by PE-107835, or to BC FWAL guidelines. Parameters of potential concern (POPC) are identified through this assessment and predictions for these parameters are the focus of the results presented in the subsequent sections.

4.2 Identification of Parameters of Potential Concern

POPCs are identified as parameters predicted to have a base case concentration greater than 80% of a relevant threshold (ENV, 2019b). Parameters identified as POPCs require additional consideration to determine if there are reasons to exclude them from further assessment. Relevant thresholds for Brucejack Creek are discharge limits specified in PE-107835, or BC FWAL guidelines for parameters without discharge limits. There is no dilution zone associated with discharge from the WRTSF, since the discharge is the headwater of Brucejack Creek; therefore, PE-107835 discharge limits are relevant benchmarks for site BJ 2.62 and other locations in Brucejack Creek.

Screening of model results at BJ 3.10 and BJ 2.62 against discharge limits or FWAL guidelines generates the following list of POPCs that require additional review: ammonia, nitrite, nitrate, sulfate, aluminum, arsenic, copper, and selenium (Table 4-1 and Table 4-2). Parameters which are modelled to always have concentrations less than 80% of their discharge limit are not considered POPCs.

Table 4-1: Maximum concentrations from the BJ 3.10 Base Case water quality model, for all mine phases, compared to the maximum from previous model updates, BC water quality guidelines, PE-107835 effluent discharge limits, and POPC benchmarks.

Parameter	Units	Maximum Modelled			POPC benchmark	BC FWAL Guidelines		Effluent Discharge Limit
		2023	2020	2018		Long-term	Short-term	
Ammonia	mg-N/L	**3.53**	3.20	2.8	3.2	NA	NA	4.0
Nitrite	mg-N/L	0.13	**0.23**	**0.2**	0.19	NA	NA	0.24
Nitrate	mg-N/L	**15.2**	9.9	8.7	9.2	NA	NA	11.5
Chloride	mg/L	8.2	6.6	1.4	120	150	600	NP
Fluoride	mg/L	0.29	0.18	0.14	0.66	NP	0.82	NP
Sulfate	mg/L	**114**	71	95	102	128	NP	NP
Aluminum-D	mg/L	**0.062**	**0.047**	0.039	0.040	0.050	0.10	NP
Antimony-T	mg/L	0.020	0.010	0.013	0.022	NA	NP	0.028
Arsenic-T	mg/L	**0.014**	**0.0093**	0.0070	0.008	NP	NA	0.01
Boron-T	mg/L	0.14	0.094	0.069	0.96	1.2	NP	NP
Barium-T	mg/L	0.048	0.061	0.072	0.80	1.0	NP	NP
Beryllium-T	mg/L	0.00003	0.00008	0.00007	0.00010	0.00013	NP	NP
Cadmium-D	mg/L	0.000012	0.000011	0.000012	0.000066	0.000083	0.000159	NP
Chromium-T	mg/L	0.00034	**0.00091**	**0.0013**	0.00080	0.0010	NP	NP
Cobalt-T	mg/L	0.00029	0.00048	0.00050	0.0032	0.0040	0.11	NP
Copper-D	mg/L	**0.00042**	**0.00078**	0.00028	0.00024	0.0003	0.0018	NP
Iron-D	mg/L	0.008	0.018	0.040	0.28	NP	0.35	NP
Iron-T	mg/L	0.040	0.18	0.19	1.36	NP	NA	1.7
Lead-T	mg/L	0.00030	0.00040	0.00050	0.00320	0.0039	0.0160	NP
Mercury-T	mg/L	0.000004	0.000006	0.000005	0.000016	0.000020	NP	NP
Manganese-T	mg/L	0.25	0.18	0.22	0.58	0.73	0.85	NP
Molybdenum-T	mg/L	0.016	0.009	0.009	6.08	7.6	46	NP
Nickel-T	mg/L	0.0005	0.0007	0.0009	0.0200	0.0250	NP	NP
Phosphorus-T	mg/L	0.012	0.012	0.027	NP	NP	NP	NP
Selenium-T	mg/L	**0.0021**	0.0012	0.0010	0.0016	0.0020	NP	NP
Silver-T	mg/L	0.00001	0.00002	0.00004	0.00037	NA	NA	0.00046
Thallium-T	mg/L	0.00009	0.00007	0.00010	0.00064	0.00080	NP	NP
Uranium-T	mg/L	0.0006	0.0004	0.0010	0.0068	0.0085	NP	NP
Zinc-T	mg/L	0.0021	0.0026	0.0029	0.0060	0.0075	0.033	NP

Notes: 2020 water quality model presented in the 2020 Update (Lorax 2020a)
2018 water quality model presented in the 3800 tpd Permit Amendment Application (Lorax, 2018).
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
POPC benchmark is equal to 80% of a discharge limit or 80% of a BC FWAL for parameters without discharge limits.
Bold font indicates parameters and concentrations that are greater than their POPC benchmark.
Concentrations that are higher in the current model than in both previous models are underlined.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Table 4-2: Maximum concentrations from the BJ 2.62 Base Case water quality model, for all mine phases, compared to the maximum from previous model updates, BC water quality guidelines, PE-107835 effluent discharge limits, and POPC benchmarks.

Parameter	Units	Maximum Modelled			POPC benchmark	BC FWAL Guidelines		Effluent Discharge Limit
		2023	2020	2018		Long-term	Short-term	
Ammonia	mg-N/L	**3.21**	2.90	2.8	3.2	NA	NA	4.0
Nitrite	mg-N/L	**0.24**	**0.24**	**0.20**	0.19	NA	NA	0.24
Nitrate	mg-N/L	**13.8**	8.97	8.5	9.2	NA	NA	11.5
Chloride	mg/L	10.3	9.72	2.3	120	150	600	NP
Fluoride	mg/L	0.37	0.40	0.14	0.66	NP	0.82	NP
Sulfate	mg/L	**197**	**133**	94	102	128	NP	NP
Aluminum-D	mg/L	**0.057**	**0.044**	0.039	0.040	0.050	0.10	NP
Antimony-T	mg/L	0.018	0.011	0.014	0.022	NA	NP	0.028
Arsenic-T	mg/L	**0.013**	**0.011**	**0.013**	0.008	NP	NA	0.01
Boron-T	mg/L	0.18	0.15	0.074	0.96	1.2	NP	NP
Barium-T	mg/L	0.077	0.088	0.071	0.80	1.0	NP	NP
Beryllium-T	mg/L	0.00005	**0.00015**	**0.00012**	0.00010	0.00013	NP	NP
Cadmium-D	mg/L	0.000021	0.000022	0.000041	0.000066	0.000083	0.000159	NP
Chromium-T	mg/L	0.0005	**0.0009**	**0.0012**	0.00080	0.0010	NP	NP
Cobalt-T	mg/L	0.0021	**0.0041**	0.0008	0.0032	0.0040	0.11	NP
Copper-D	mg/L	**0.0017**	**0.0027**	**0.0007**	0.00024	0.0003	0.0018	NP
Iron-D	mg/L	0.013	0.022	**3.13**	0.28	NP	0.35	NP
Iron-T	mg/L	0.039	0.194	**3.34**	1.36	NP	NA	1.7
Lead-T	mg/L	0.0004	0.0006	0.0012	0.0032	0.0039	0.016	NP
Mercury-T	mg/L	0.000004	0.000006	0.000008	0.000016	0.000020	NP	NP
Manganese-T	mg/L	0.26	0.16	0.26	0.58	0.73	0.85	NP
Molybdenum-T	mg/L	0.014	0.013	0.009	6.08	7.6	46	NP
Nickel-T	mg/L	0.0005	0.0007	0.0009	0.0200	0.0250	NP	NP
Phosphorus-T	mg/L	0.012	0.012	0.026	NP	NP	NP	NP
Selenium-T	mg/L	**0.0037**	**0.0035**	0.0010	0.0016	0.0020	NP	NP
Silver-T	mg/L	0.00006	0.00007	0.00006	0.00037	NA	NA	0.00046
Thallium-T	mg/L	0.00012	0.00011	0.00010	0.00064	0.00080	NP	NP
Uranium-T	mg/L	0.0011	0.0019	0.0016	0.0068	0.0085	NP	NP
Zinc-T	mg/L	0.0038	0.0032	**0.0086**	0.0060	0.0075	0.033	NP

Notes: 2020 water quality model presented in the 2020 Update (Lorax 2020a)
2018 water quality model presented in the 3800 tpd Permit Amendment Application (Lorax 2018).
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
POPC benchmark is equal to 80% of a discharge limit or 80% of a BC FWAL for parameters without discharge limits.
Bold font indicates parameters and concentrations that are greater than their POPC benchmark.
Concentrations that are higher in the current model than in both previous models are underlined.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

4.3 Water Quality Predictions

This section presents the Base Case and Upper Case water quality predictions for parameters identified as POPCs (Section 4.2). Water quality predictions covering all mine phases are presented for both BJ 3.10 and BJ 2.62 alongside applicable water quality guidelines or discharge limits for reference. The BJ 3.10 predictions illustrate how the WRTSF responds to mine loadings received through LOM, whereas the downstream BJ 2.62 predictions illustrate how Brucejack Creek responds to loads from the WRTSF and the flooded underground mine via groundwater pathways during closure and post-closure.

For each monitoring site, water quality predictions are presented for two cases. The Base Case is considered to represent an expected case; whereas the Upper Case incorporates the combined loadings of upper case geochemical source terms for all inputs. The Upper Case source terms are generally based on 90th percentile values from geochemical or water quality monitoring datasets for all mine-related flows and employs highly conservative assumptions with respect to both contact water chemistry and onset of acidity. Tabulated results for all modelled parameters, for both cases are provided in Appendix A.

The water quality model predictions discussed in the following sections are presented as time series plots covering operations, closure and post-closure mine phases. The discussion of results focuses on observed trends related to the seasonal water balance, the geochemical behaviour of waste rock as a function of time (*e.g.*, the onset of ARD generation) and deposition schedules for the various inputs to the WRTSF (*e.g.*, waste rock, tailings, WTP effluent).

4.3.1 Ammonia

Ammonia originates primarily from blasting residues arising from explosives use. As described in Section 3.8, extensive investigations have been undertaken since 2015 to quantify nitrogen release from waste rock and tailings. The updated predictions for ammonia at both BJ 3.10 and BJ 2.62 are higher than previous model predictions (Table 4-1 and Table 4-2; Figure 4-1 and Figure 4-2); however, ammonia concentrations are not expected to exceed the discharge limit (4.0 mg/L) at any point through LOM.

Base Case ammonia concentrations at BJ 3.10 are predicted to increase through the first few years of operations under the 4950 tpd scenario as blasting activities in the mine increase, reaching a maximum concentration of 3.5 mg/L in 2025 (Figure 4-1). The concentrations of ammonia are predicted to decrease steadily after 2025 as the rate of blasting and explosive quantities decrease. This is reflected in the ammonia loading plot (Figure 4-3) which shows that waste rock loads, the dominant source of ammonia loads, decrease after 2025. Ammonia concentrations at BJ 3.10 continue to decrease at closure

both due to cessation of blasting and the fact that mine-related N loads will follow subsurface pathways to Brucejack Creek downstream of BJ 3.10. Ammonia concentrations are expected to return to background levels early in the post-closure phase.

Upper Case predictions of ammonia at BJ 3.10 follow the same trend as the Base Case predictions, with an increase in predicted concentrations early in operations, followed by a steady decrease for the remainder of operations and a return to background levels during post-closure.

Base Case and Upper Case ammonia predictions at BJ 2.62 show similar trends to predictions at BJ 3.10 during operations, but also have peaks during the closure phase. The closure peaks in ammonia concentrations (2.6 mg/L and 4.4 mg/L for Base Case and Upper Case, respectively) are attributed to flushing loads associated with flooding of the underground mine.

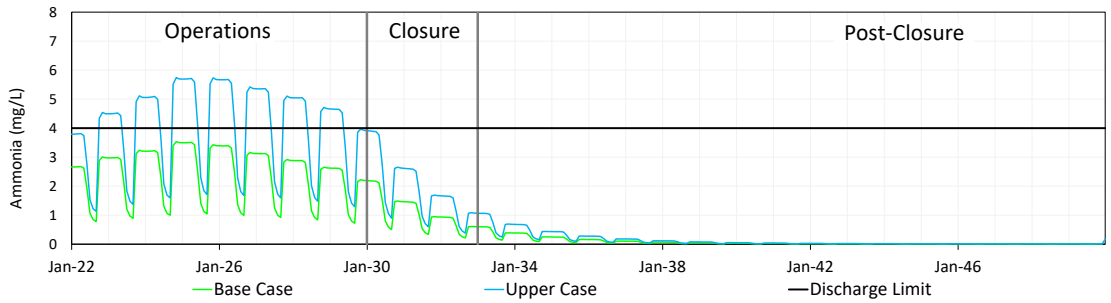


Figure 4-1: Base Case and Upper Case ammonia concentration predictions at BJ 3.10 through operations, closure and post-closure.

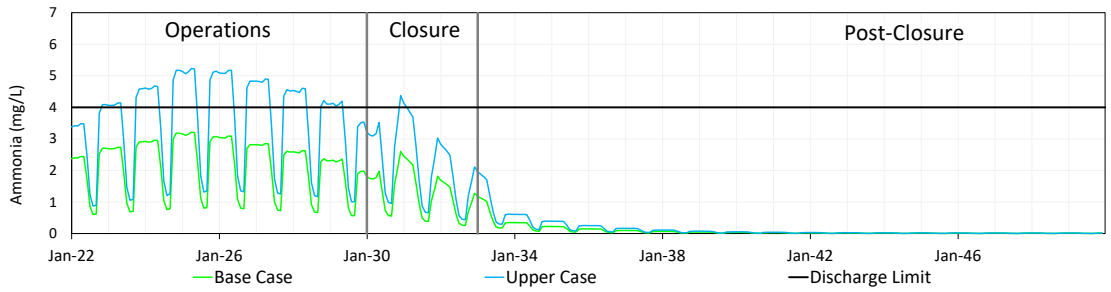


Figure 4-2: Base Case and Upper Case ammonia concentration predictions at BJ 2.62 through operations, closure and post-closure.

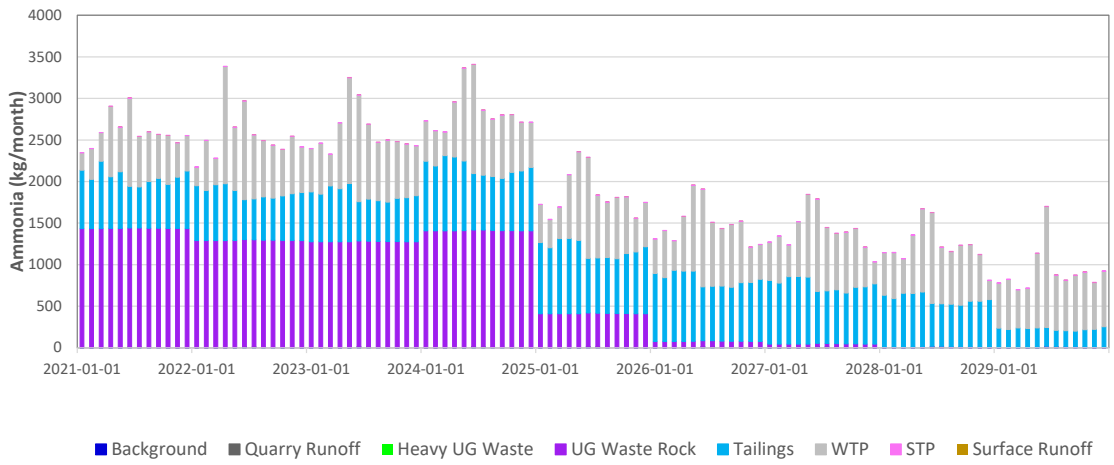


Figure 4-3: Sources of Base Case ammonia loadings to the WRTSF during operations.

4.3.2 Nitrite

As for other nitrogen species, nitrite originates primarily from blasting residues arising from explosives use. The updated predictions for nitrite at BJ 3.10 are lower than previous model predictions and are not expected to exceed the discharge limit (0.24 mg/L) at any point through LOM (Table 4-1 and Table 4-2; Figure 4-4 and Figure 4-5); however, nitrite concentrations at BJ 2.62 are predicted to be equivalent to the discharge limit for one month during closure.

Base Case nitrite concentrations at BJ 3.10 are predicted to increase through the first few years of operations under the 4950 tpd scenario as blasting activities in the mine increase, reaching a maximum concentration of 0.13 mg/L in 2025 (Figure 4-4). The concentrations of nitrite are predicted to decrease steadily through operations as the rate of blasting and explosive quantities decrease. The loading plot (Figure 4-6) illustrates this and shows that waste rock loads, the dominant source of nitrite loads, decrease through operations. Nitrite concentrations at BJ 3.10 continue to decrease at closure as blasting ceases and N loads from the mine are received by Brucejack Creek below BJ 3.10. Nitrite concentrations are expected to return to background levels early in the post-closure phase.

Upper Case predictions of nitrite at BJ 3.10 follow the same trend as the Base Case predictions, with an increase in predicted concentrations early in operations, followed by a steady decrease for the remainder of operations and a return to background levels during post-closure.

Base Case and Upper Case nitrite predictions at BJ 2.62 show similar trends to predictions at BJ 3.10 during operations, but have notable concentration peaks during the closure

phase. The closure peaks in nitrite concentrations (0.24 mg/L and 0.39 mg/L for Base Case and Upper Case, respectively) are attributed to flushing loads associated with flooding of the underground mine.

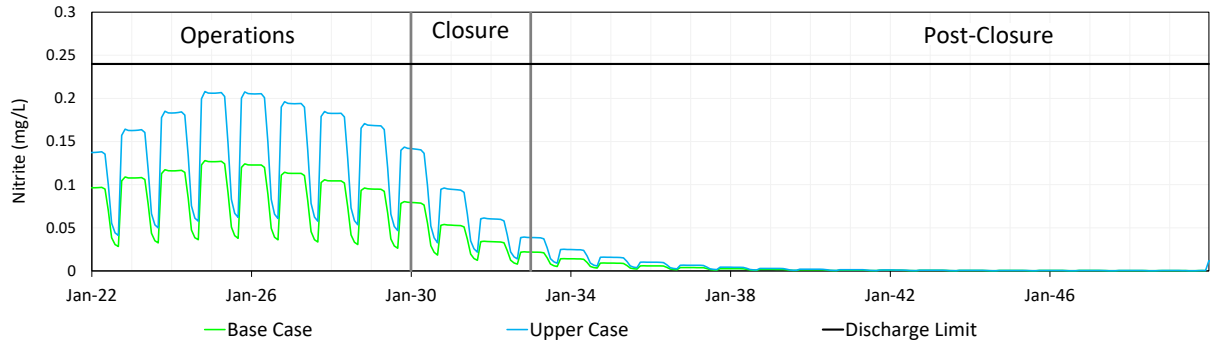


Figure 4-4: Base Case and Upper Case nitrite concentration predictions at BJ 3.10 through operations, closure and post-closure.

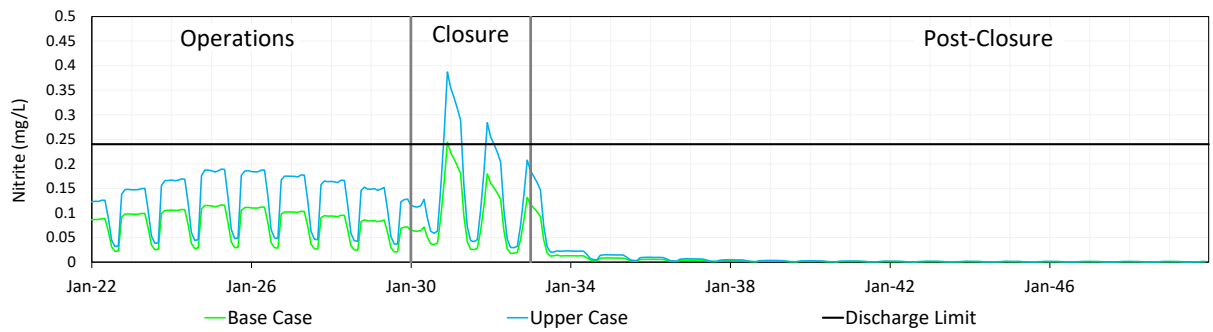


Figure 4-5: Base Case and Upper Case nitrite concentration predictions at BJ 2.62 through operations, closure and post-closure.

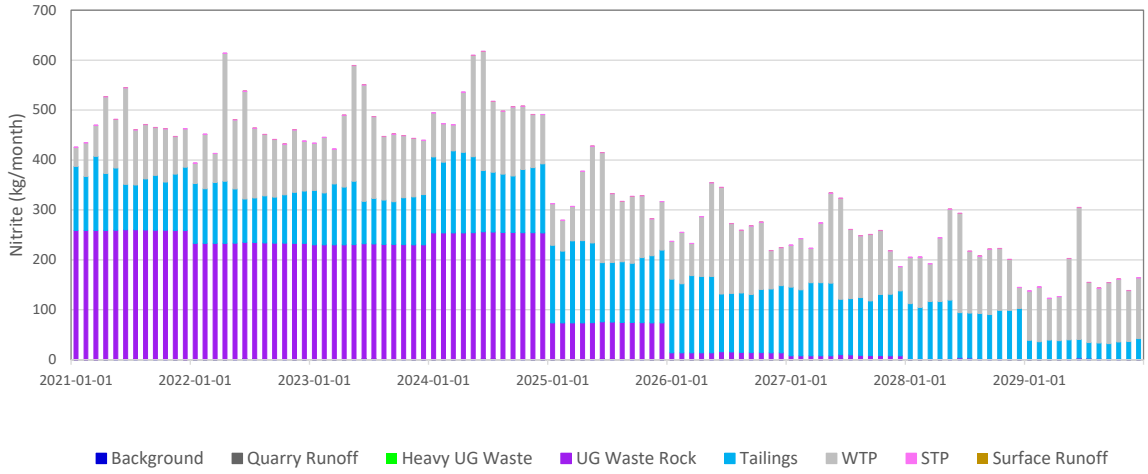


Figure 4-6: Sources of Base Case nitrite loadings to the WRTSF during operations.

4.3.3 Nitrate

Water quality predictions for nitrate at BJ 3.10 and BJ 2.62 are presented in Figure 4-7 and Figure 4-8, respectively. Concentrations of nitrate at BJ 3.10 for both Base Case and Upper Case scenarios are predicted to increase through the first few years of operations, as mining activities progress, reaching maximum concentrations in 2024 (15.2 mg/L and 24.7 mg/L for Base Case and Upper case, respectively). Base Case predictions are predicted to exceed the current discharge limit (11.5 mg/L).

The dominant source of nitrate loadings to the WRTSF are explosive residues associated with deposited waste rock and tailings (Figure 4-9). However, WTP effluent also contributes a significant load throughout operations.

After mining operations cease, nitrate concentrations at BJ 3.10 (both Base Case and Upper Case) decline steadily to background levels within the first few years of post-closure. Nitrate predictions at BJ 2.62 show a similar pattern to predictions at BJ 3.10, but with the marked peaks during closure due to the release of flushing loads as the mine is flooded (as described for ammonia in Section 4.3.1).

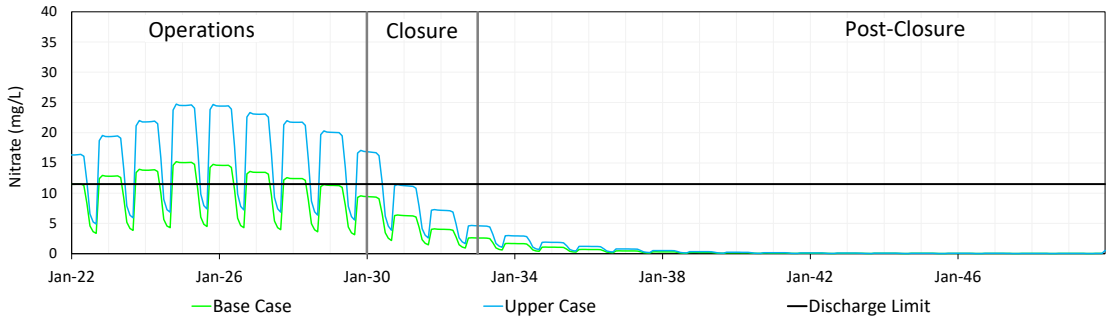


Figure 4-7: Base Case and Upper Case nitrate concentration predictions at BJ 3.10 through operations, closure and post-closure.

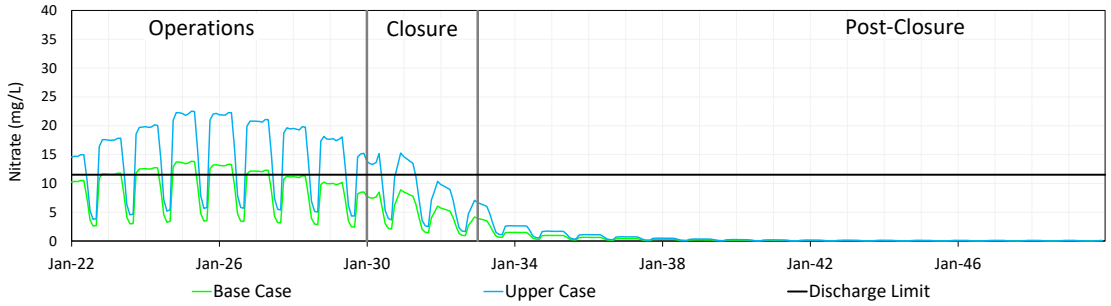


Figure 4-8: Base Case and Upper Case nitrate concentration predictions at BJ 2.62 through operations, closure and post-closure.

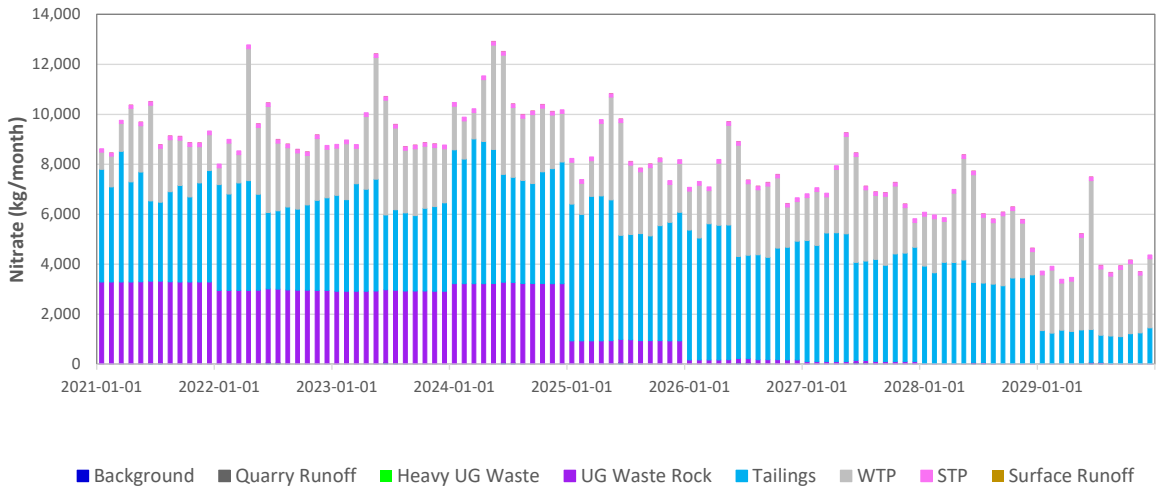


Figure 4-9: Sources of nitrate loadings to the WRTSF during operations.

4.3.4 Sulfate

Water quality predictions for sulfate at BJ 3.10 and BJ 2.62 are presented in Figure 4-10 and Figure 4-11, respectively. Sulfate concentrations within the WRTSF are predicted to gradually increase over operations with maximum concentrations at BJ 3.10 reached at the end of operations (113 mg/L and 297 mg/L, for Base Case and Upper Case, respectively). The observed increase in sulfate over the operations phase is primarily due to the expansion of the underground mine and corresponding increased annual loadings associated with tailings and WTP discharges to the WRTSF (Figure 4-12). Sulfate concentrations are predicted to decrease through closure, as ore processing, and discharge of tailings and WTP effluent cease.

Sulfate predictions for BJ 2.62 show the same pattern as observed at BJ 3.10 for operations, with maximum Base Case sulfate prediction of 104 mg/L. Increased concentrations are predicted for closure (up to 197 mg/L for the Base Case scenario) and are associated with the flushing loads released during flooding of the underground mine. Although the underground mine water will be treated through the flooding period and for 8 additional months, sulfate concentrations will not be mitigated since the WTP does not treat for sulfate. The flushing loads are expected to decrease over time and reach their long-term equilibrium concentration within the first few years of post-closure.

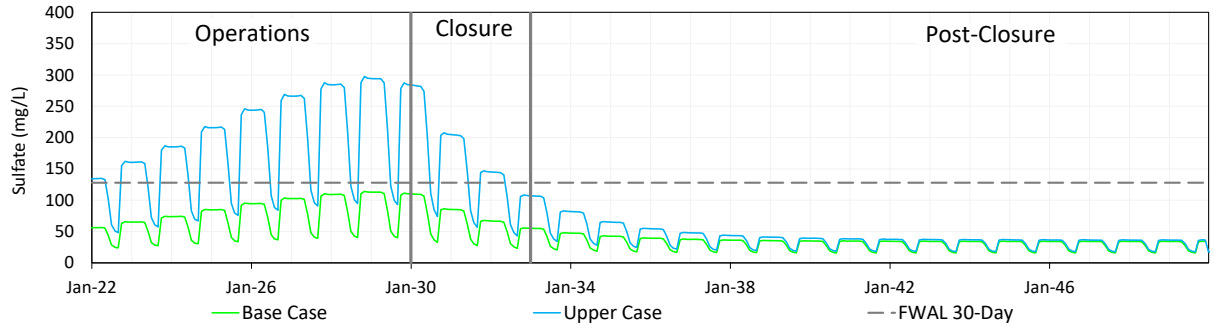


Figure 4-10: Base Case and Upper Case sulfate concentration predictions at BJ 3.10 through operations, closure and post-closure.

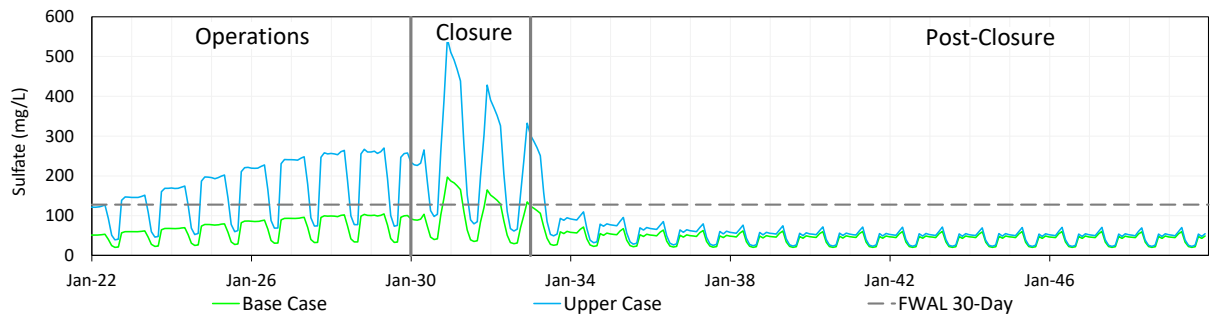


Figure 4-11: Base Case and Upper Case sulfate concentration predictions at BJ 2.62 through operations, closure and post-closure.

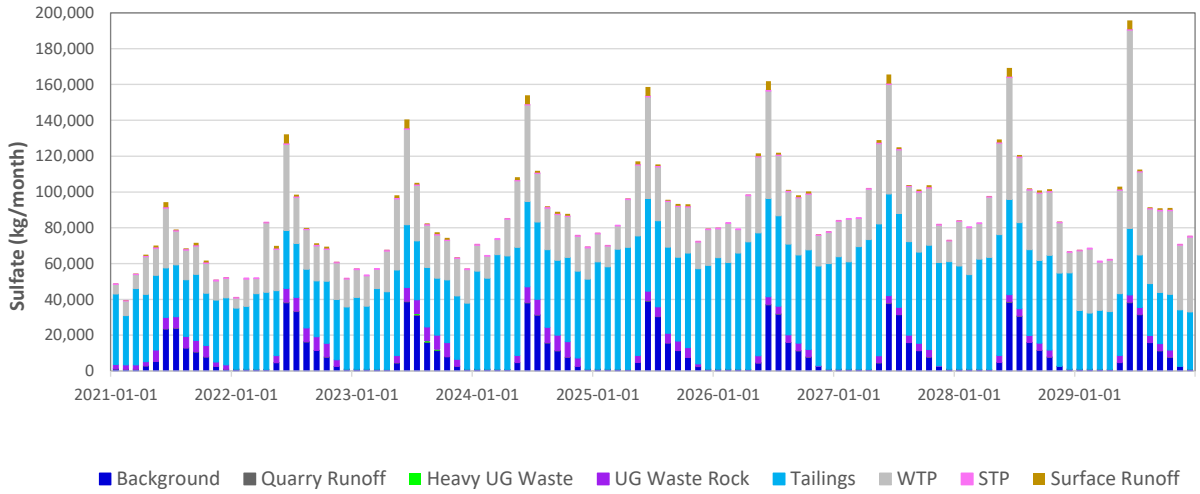


Figure 4-12: Sources of sulfate loadings (kg/month) to the WRTSF during operations.

4.3.5 Aluminum

Predicted concentrations of dissolved aluminum at BJ 3.10 and BJ 2.62 are presented in Figure 4-13 and Figure 4-14, respectively. Base case concentrations are predicted to go above BC FWAL guidelines during operations (maximum Base Case D-Al is 0.062 mg/L). Concentrations for both Base Case and Upper Case are predicted to increase early in operations and then decline towards the end of mine life. The dominant source of aluminum loadings is waste rock; however, the WRTSF also receives significant contributions seasonally from background (May to September) (Figure 4-15). The heavy waste deposited in the WRTSF also contributes a substantial D-Al load in 2023.

The BJ 3.10 predictions for D-Al continue to decline through the closure phase and reach long term post-closure concentrations within the first few years of post-closure. In contrast, D-Al predictions for BJ 2.62 increase during closure as flushing loads from the underground mine are received by Brucejack Creek. The Base Case predictions for BJ 2.62 show a slight increase, whereas the Upper Case predictions are more pronounced.

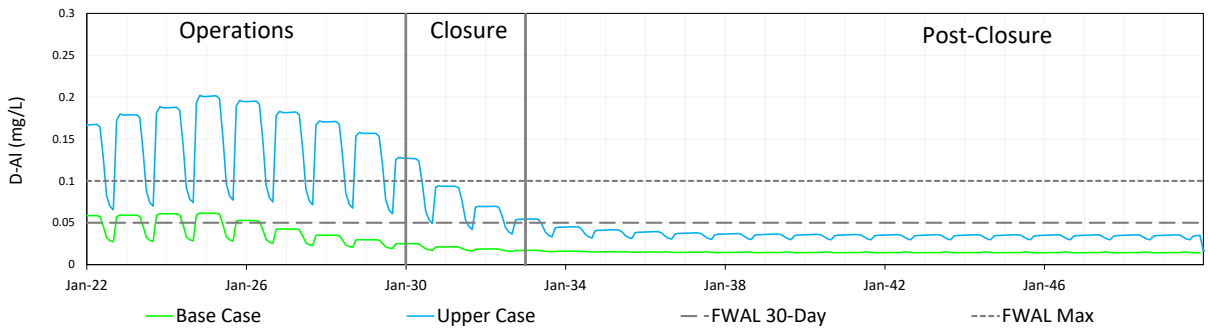


Figure 4-13: Base Case and Upper Case aluminum concentration predictions at BJ 3.10 through operations, closure and post-closure.

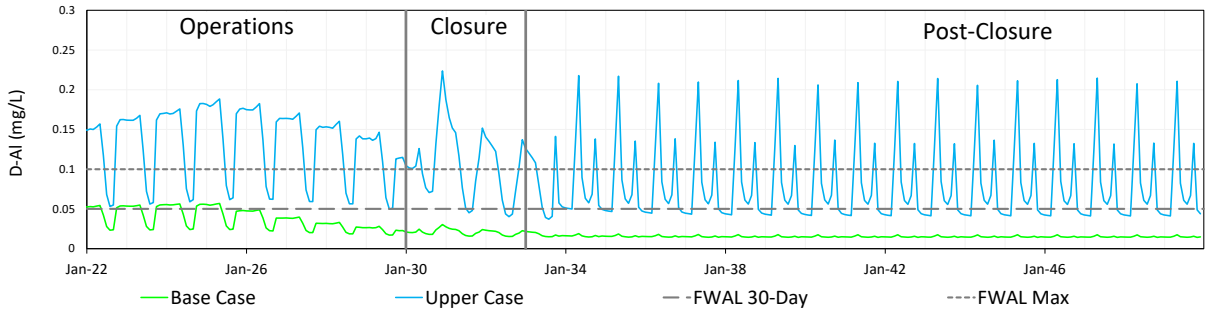


Figure 4-14: Base Case and Upper Case aluminum concentration predictions at BJ 2.62 through operations, closure and post-closure.

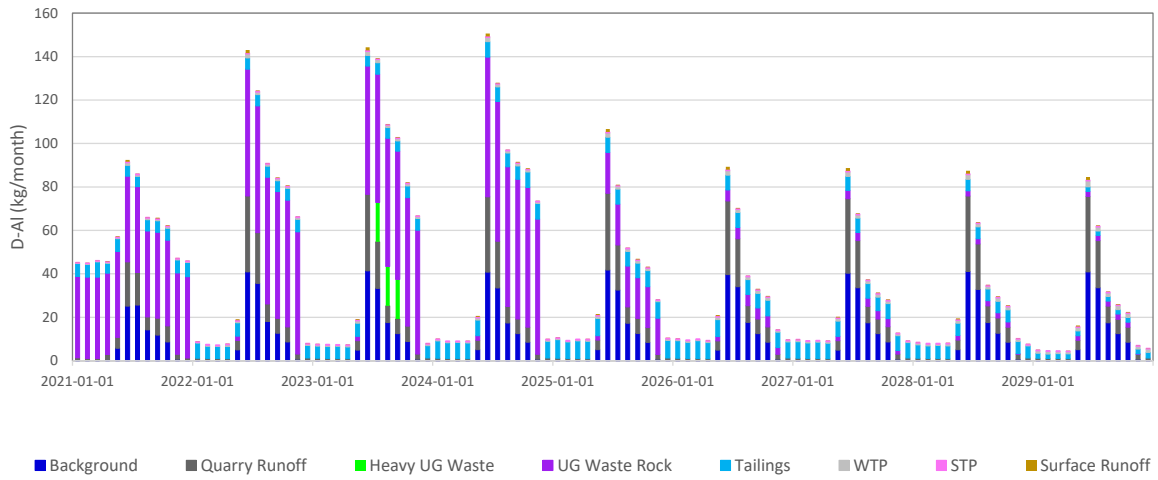


Figure 4-15: Sources of dissolved aluminum loadings (kg/month) to the WRTSF during operations.

4.3.6 Arsenic

Concentrations of total arsenic in the WRTSF are predicted to peak early in operations (Figure 4-16), with maximum Base Case and Upper Case predictions of 0.014 mg/L and 0.026 mg/L, respectively. A steady decline in concentrations of T-As at BJ 3.10 is predicted through the remainder of the operations phase, with concentrations reaching their long term equilibrated values early in post-closure. Predictions at BJ 2.62 (Figure 4-17) follow a similar pattern to concentrations at BJ 3.10 during operations, but increase during closure as mine-related loads are flushed and received by Brucejack Creek. The maximum Base Case T-As concentration predicted for BJ 2.62 is 0.012 mg/L during closure, slightly above the current discharge limit of 0.01 mg/L. Upper Case predictions are significantly higher (up to 0.027 mg/L) reflecting conservative assumptions for all loading terms.

Concentrations of T-As in the WRTSF (BJ 3.10) during operations are primarily influenced by the deposition of underground waste rock and, to a lesser extent, tailings discharges (Figure 4-18). Background levels of T-As are also relatively high and are expected to contribute seasonal loads throughout all mine phases.

The concentrations of T-As predicted for Brucejack Creek at BJ 2.62 during operations mirror predictions at BJ 3.10, but are slightly lower due to the contribution of additional background flows at the downstream station. At closure, loads from the flooded underground mine are received by Brucejack Creek via subsurface groundwater pathways, resulting in an increase in concentrations during closure and into post-closure.

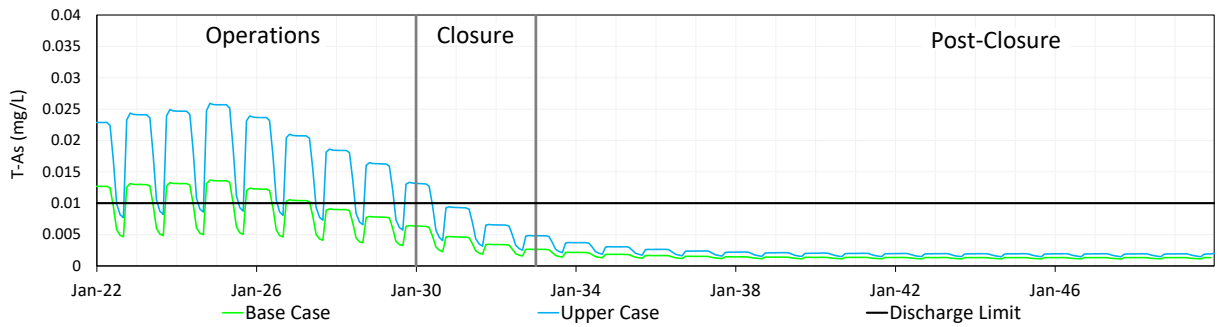


Figure 4-16: Base Case and Upper Case total arsenic concentration predictions at BJ 3.10 through operations, closure and post-closure.

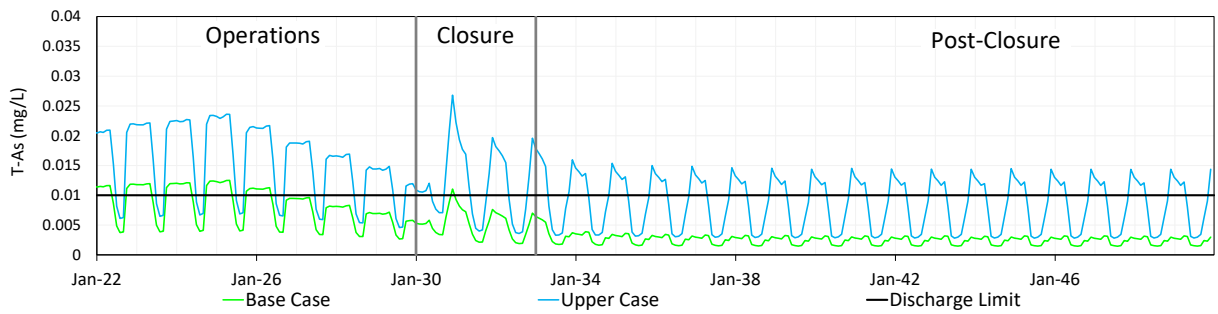


Figure 4-17: Base Case and Upper Case total arsenic concentration predictions at BJ 2.62 through operations, closure and post-closure.

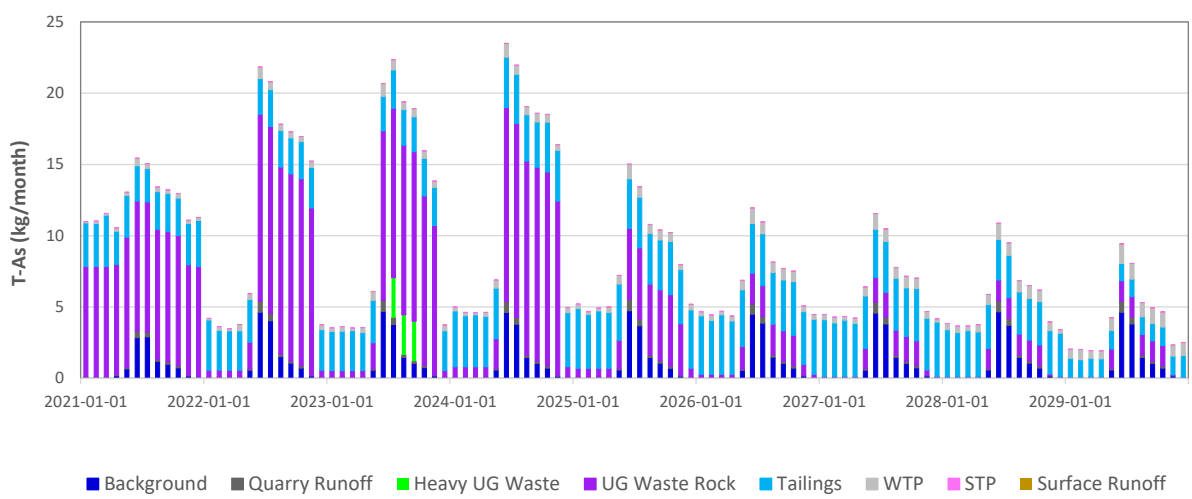


Figure 4-18: Sources of total arsenic loadings to the WRTSF during operations.

4.3.7 Copper

BC updated its copper FWAL guidelines in 2019. The new guideline is applied to the dissolved Cu fraction and is calculated based on site water quality (hardness, pH, temperature, major ions, and dissolved organic carbon) using a biotic ligand model. The Cu guideline prior to August 2019 applied to total Cu and was calculated based on hardness of site water. For Brucejack Creek, which has low levels of hardness and DOC, the long-term (30-d average) FWAL guideline changed from T-Cu=0.002 mg/L to D-Cu= 0.0003 mg/L. The short-term (max) FWAL guideline changed from T-Cu= 0.0046 mg/L to D-Cu=0.0018 mg/L.

Concentrations of D-Cu at both BJ 3.10 (Figure 4-19) and BJ 2.62 (Figure 4-20) are predicted to go above the long-term FWAL guideline early in operations. The main source of Cu loadings to the WRTSF are waste rock and background, with contributions from WTP effluent and tailings increasing as operations progress (Figure 4-21). The annual maximum concentrations at BJ 3.10 peak at the end of operations (0.00042 mg/L and 0.0087 mg/L, for Base Case and Upper Case respectively).

In contrast, the maximum concentrations predicted for BJ 2.62 occur during closure, reaching maximum predicted concentrations of 0.00171 mg/L and 0.011 mg/L, for Base Case and Upper Case. The Base Case BJ 2.62 D-Cu predictions at closure are predicted to remain below the short-term FWAL guideline of 0.0018 mg/L, but seasonally go above the long-term guideline of 0.003 mg/L. The Upper Case D-Cu concentrations are predicted to go above the short-term guideline throughout closure and post-closure on a seasonal basis.

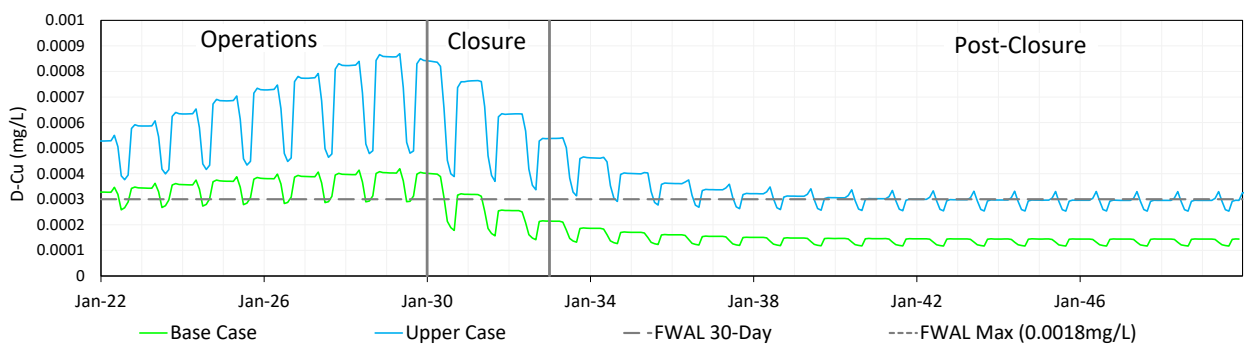


Figure 4-19: Base Case and Upper Case dissolved copper concentration predictions at BJ 3.10 through operations, closure and post-closure.

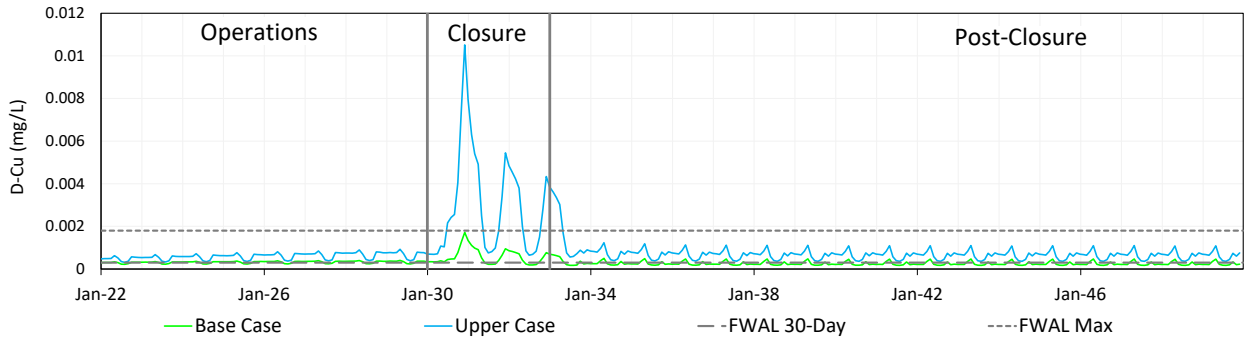


Figure 4-20: Base Case and Upper Case dissolved copper concentration predictions at BJ 2.62 through operations, closure and post-closure.

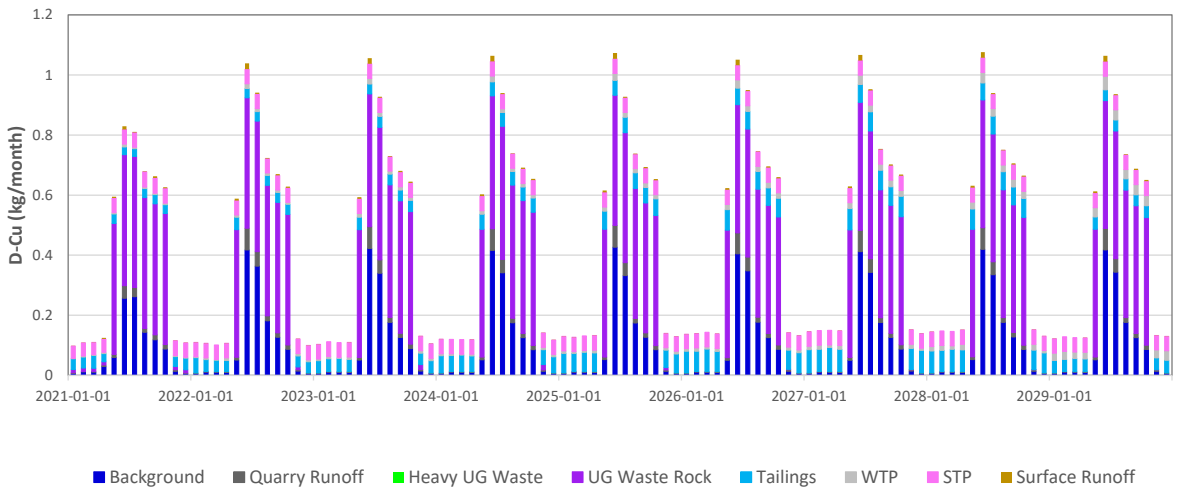


Figure 4-21: Sources of dissolved copper loadings to the WRTSF during operations.

4.3.8 Selenium

Water quality predictions for T-Se at BJ 3.10 (Figure 4-22) show an increasing trend through most of operations, reaching a maximum Base Case concentration of 0.0021 mg/L in 2027. The main source of Se loadings at the beginning of operations is waste rock, but as mining progresses, the contributions from tailings and WTP effluent become more significant (Figure 4-24). A decrease in concentrations is predicted for closure, with T-Se concentrations at BJ 3.10 reaching long term equilibrium levels within approximately 5 years of post-closure. The Base Case T-Se predictions at BJ 3.10 are predicted to go slightly above the BC FWAL guideline of 0.002 mg/L seasonally, starting in 2026. Upper Case predictions follow a similar trend to the Base Case predictions, but are significantly higher with concentrations predicted to go up to 0.0062 mg/L.

T-Se predictions at BJ 2.62 show the same pattern as for BJ 3.10 during operations, but reach maximum concentrations during the closure phase (Figure 4-23). The maximum predicted Base Case concentration of T-Se is 0.0037 mg/L. The elevated T-Se concentrations are predicted to occur on a seasonal basis during low flow months and decrease to long term equilibrium levels within approximately 5 years of post-closure.

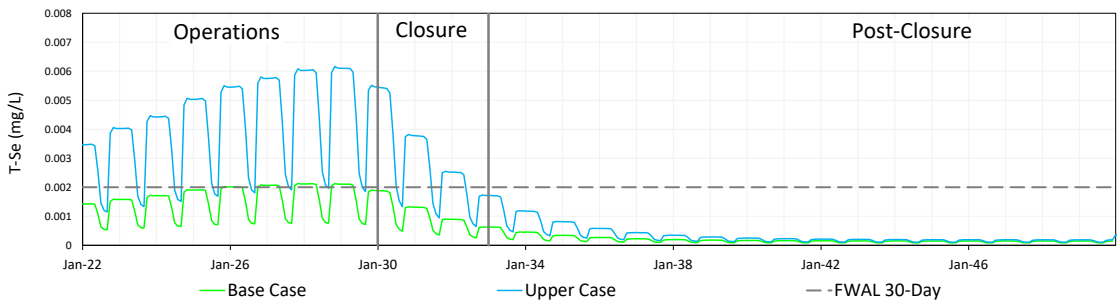


Figure 4-22: Base Case and Upper Case total selenium concentration predictions at BJ 3.10 through operations, closure and post-closure.

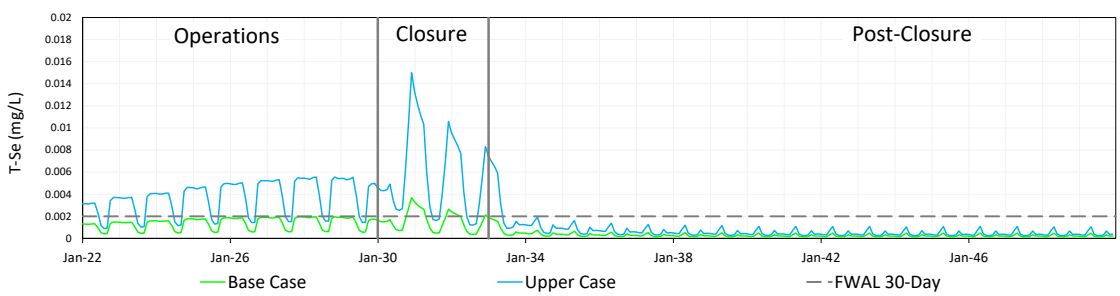


Figure 4-23: Base Case and Upper Case total selenium concentration predictions at BJ 2.62 through operations, closure and post-closure.

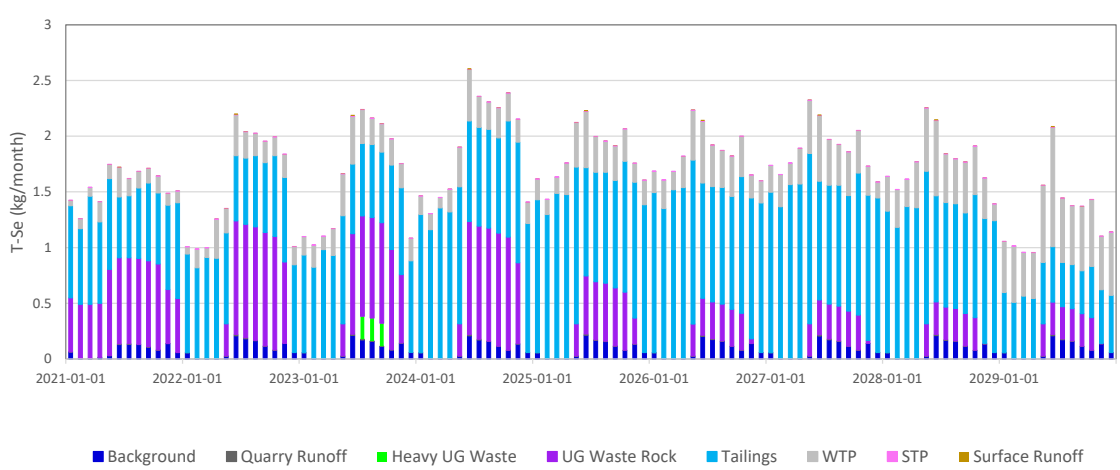


Figure 4-24: Sources of total selenium loadings to the WRTSF during operations.

5 Aquatic Effects Assessment

5.1 Introduction

This section provides an assessment of potential effects from modelled water quality in Brucejack Creek to potential receptors (Figure 5-1). Aquatic life is the most sensitive receptor to changes in water quality. This is indicated by BC water quality guidelines, which are lower for aquatic life than for wildlife. As well, wildlife will infrequently use Brucejack Creek for drinking water, while aquatic life are continually exposed to Brucejack Creek water quality. Therefore, potential effects of water quality to wildlife are not assessed in this section. Potential effects to human health are discussed in Section 5.14.

Parameters of potential concern were identified in Section 4.2 as having a maximum Base Case model result at either BJ 3.10 (WRTSF effluent) or BJ 2.62 (receiving environment during closure and post-closure) that is greater than 80% of relevant benchmarks, either effluent permit discharge limits or BC FWAL guidelines for parameters that do not have discharge limits. POPCs identified are ammonia, nitrate, nitrite, sulfate, D-Al, T-As, D-Cu and T-Se.

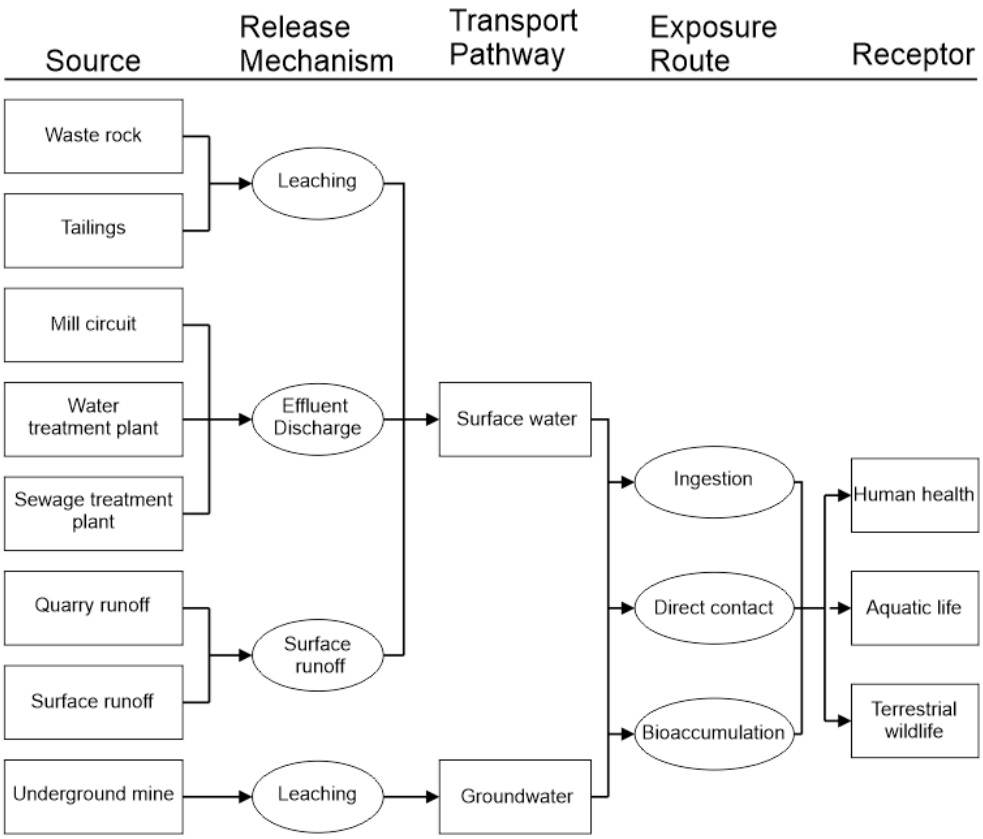


Figure 5-1: Conceptual site model of contaminant transport to receptors.

5.2 Methods For Assessing Risk to Aquatic Life

Potential residual effects of predicted water quality on the aquatic community in Brucejack Creek are assessed using the following criteria:

- **Ecological Context**: the ecological setting in the receiving environment. Ecological context is categorized as **high** for receiving environment that includes sensitive habitats or habitats that have little resilience to changes in water quality or species that are red or blue listed by the B.C. Conservation Data Center; **medium** for habitat that includes fish or fish habitat; and **low** for habitats that do not include fish or fish habitat.
- **Geographic Extent**: the spatial scale over which concentrations of POCs are expected to be greater than environmental benchmarks (discharge limits or BC FWAL guidelines). The extent is categorized as **local** if concentrations of POCs are above benchmarks only in Brucejack Creek and **regional** if effluent discharge elevates concentrations above benchmarks in Sulphurets Creek.
- **Magnitude**: the potential severity for POCs to cause toxicity to aquatic life. The magnitude is categorized as **low** if modelled concentrations are less than half of a toxicity benchmark, **medium** if between 0.5 and 1 times a toxicity benchmark, and **high** if greater than a toxicity benchmark.
- **Duration**: the length of time that a POC is modelled to be greater than an environmental benchmark. Duration is categorized as **short-term** if modelled concentrations are elevated above its benchmark for 1 month of the year, **medium-term** if elevated for several months a year, **long-term** if elevated for more than a year, and **permanent** if post-closure concentrations are above a benchmark. Duration is categorized as **none** if modelled concentrations do not go above its environmental benchmark during the life of mine.
- **Frequency**: how often the effect occurs. Frequency is categorized as **single event**, **occasional** (concentrations are above benchmarks more than once, but irregularly), **regular** (seasonally elevated above benchmarks), or **continuous** (concentrations are above benchmarks throughout the year). Frequency is categorized as **none** if modelled concentrations do not go above its environmental benchmark during the life of mine.
- **Reversibility**: whether the effect to water quality can be reversed after mine operation ends. Effect to water quality is **reversible** if concentrations decrease below an environmental benchmark during post-closure and **irreversible** if concentrations above the benchmark occur more than five years into post-closure.

- **Resiliency**: the capacity of the aquatic community to recover from major changes in structure after mine operation ends. Resiliency is categorized as **high** if the aquatic community is expected to return to its pre-impact state within a few years of post-closure, **medium** if the aquatic community is expected to return to its per-impact state within a decade of post-closure, and **low** if recovery is expected to take more than a decade.
- **Consequence**: consideration of ecological context, geographic extent, magnitude, duration, frequency, reversibility, and resiliency are used to determine consequence of potential residual effects. Consequence is categorized according to the levels in Table 5-1, as described in ENV (2014).

Table 5-1:
Definitions of consequence ratings used in the residual impact assessment.

Consequence	Environmental Impact
Level 1	Limited damage to minimal area of low significance
Level 2	Minor effects on biological or physical environment
Level 3	Moderate short-term effects but affecting ecosystem
Level 4	Serious medium-term environmental effects
Level 5	Very serious long-term environmental effects

- **Likelihood**: the likelihood that adverse impacts will occur. Likelihood is categorized according to the definitions in Table 5-2, as modified from ENV (2014).

Table 5-2:
Definitions of likelihood ratings used in the residual impact assessment.

Description	Frequency of Environmental Impacts
Adverse effects are very likely	More than 1 event per month
Adverse effects are likely	More than 1 event per year
Adverse effects are unlikely	1 event per 1 to 10 years
Adverse effects are very unlikely	1 event per 10 to 100 years

- **Risk**: the risk of the project causing adverse effects is categorized based on the consequence of the effect and the likelihood of the effect, according to the matrix shown in Figure 5-2, as modified from ENV (2014).

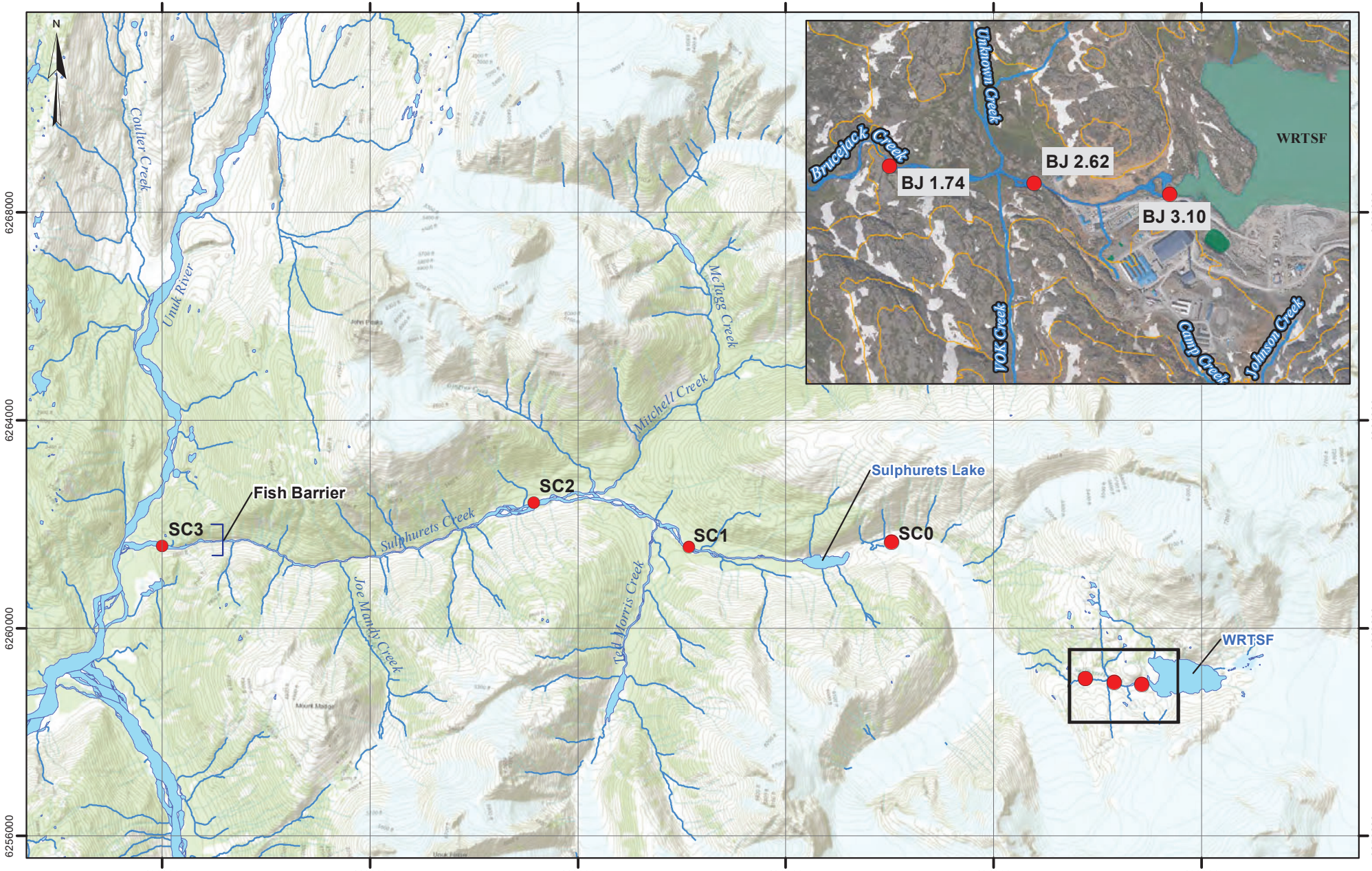
		Consequence Severity				
		Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Likelihood	**Very likely**	Moderate	High	Extreme	Extreme	Extreme
	Likely	Low	Moderate	High	Extreme	Extreme
	Unlikely	Low	Low	Moderate	High	Extreme
	Very unlikely	Low	Low	Low	Moderate	High

Figure 5-2: Categorization matrix for determining risk of adverse effects from modelled water quality to aquatic life in Brucejack Creek.

- **Confidence**: the confidence that the risk assessment is accurate. **Low** confidence is assigned to a risk rating with large data gaps, **moderate** is assigned to a risk assessment with some data gaps, and **high** is assigned to a risk assessement based on strong data to support the asssessment.

5.3 Ecological Context

Brucejack Creek and most of Sulphurets Creek are non-fish-bearing streams (Rescan, 2013a). In Sulphurets Creek, the upper limit of fish distribution is defined by a fish barrier approximately 1.3 km upstream of the Unuk River confluence (Figure 5-3). Therefore, fish-bearing waters are approximately 20 km downstream of Brucejack Creek and 23 km downstream of the outlet of the WRTSF. Invertebrates growing in Brucejack Creek will not be a food supply for fish at the mouth of Sulphurets Creek, given the long distance between Brucejack Creek and fish-bearing waters, as well as the presence of Sulphurets Lake which would trap detritus that drifts into upper Sulphurets Creek. Therefore, Brucejack Creek is non-fish bearing and is not fish habitat. No amphibians have been noted during ecological surveys of these streams (ERM, 2022a). Aquatic life in Brucejack Creek is limited to benthic invertebrates and periphyton.



LEGEND

- Monitoring Stations

DATE SAVED:	Nov 29, 2022
DRAWN BY:	DM
REVIEWED:	RG
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

0 1 2
Kilometers

CLIENT: NEWCREST BRUCEJACK
LORAX ENVIRONMENTAL

PROJECT:
4950 tpd Amendments Application

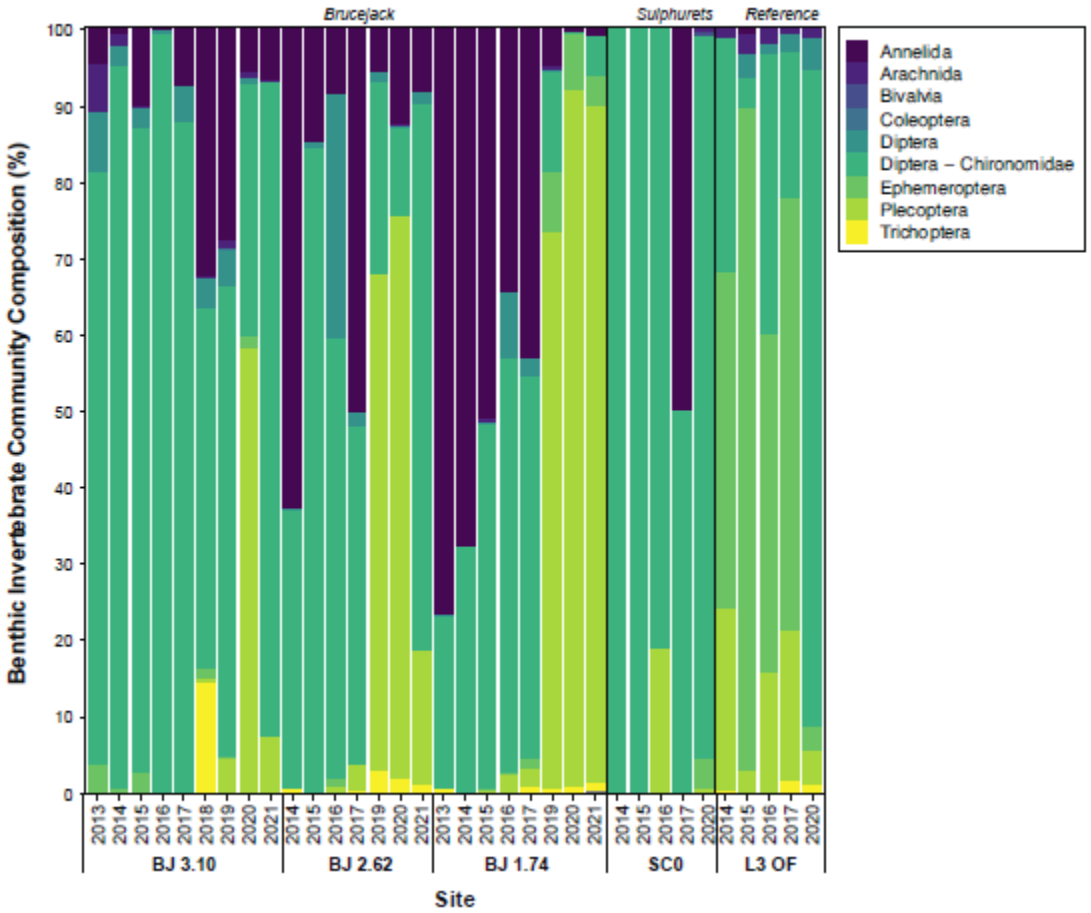
TITLE: Receiving Environment Water Quality Monitoring Sites

PROJECT #: A624-4

FIGURE: 5-3

P:\@Drafting\Brucejack\Drafting Figures\MXD\2022 WQ Infrastructure\Receiving Environment Monitoring Sites_F5-1.mxd

Baseline biological surveys of Brucejack Creek in 2014 and 2015, and annual surveys during construction and operation of the mine, show that the assemblage of benthic invertebrate communities in Brucejack Creek is composed predominantly of chironomids (midges). Annelids (oligochaete worms) and Plecoptera (stoneflies) also comprise a significant proportion of the invertebrate community composition, with an apparent increase in the proportion of stoneflies since baseline (Figure 5-4). Other taxa were uncommon in Brucejack Creek. The community composition in Brucejack Creek has been different than at the reference stream (Lake L3 outfall) which has been predominantly stoneflies and mayflies (Ephemeroptera) with large proportion of chironomids observed only in 2020.

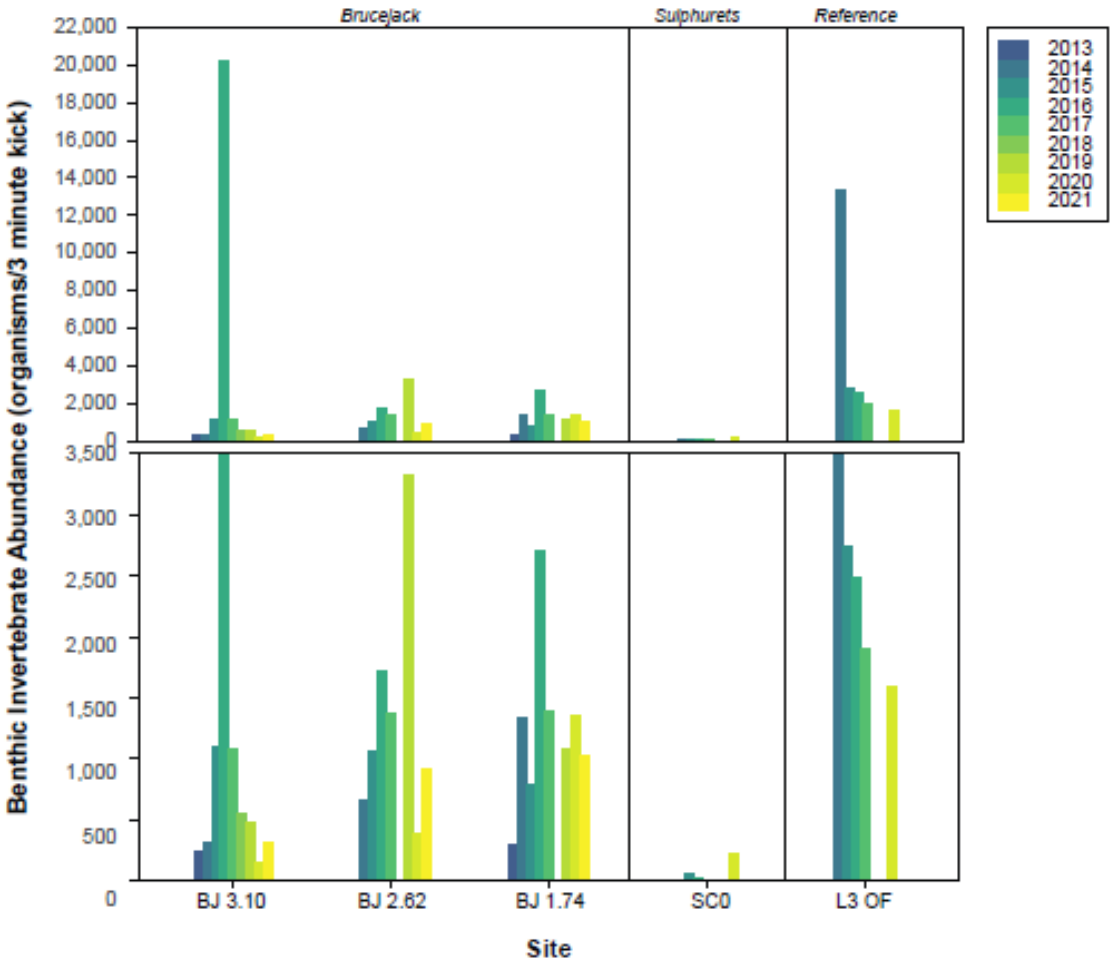


Notes: Ostracoda, Cladocera, Copepoda, Porifera, Nematoda, Platyhelminthes, fish and terrestrial invertebrates were excluded from all calculations. Immature, damaged and unidentified individuals were excluded from all analyses except abundance calculations. Figure is copied from Figure 5.4-2 of the 2021 Aquatic Resources Monitoring Report (ERM, 2022b).

Figure 5-4: Benthic invertebrate community composition by major taxon for Brucejack Creek, upper Sulphurets Creek, & reference lake L3 outfall.

None of the benthic invertebrate taxa collected from Brucejack Creek sites that were listed in the appendices of the annual Aquatic Resources Monitoring Reports and identified to genus level are present on the B.C. Conservation Data Center list of Red (endangered or threatened) or Blue (special concern) listed species.

There have been large interannual differences in total invertebrate abundance at the three sites sampled in Brucejack Creek (Figure 5-5). The total invertebrate abundance at site SC0 in Sulphurets Creek just downstream of Brucejack Creek has been markedly lower than the abundance in Brucejack Creek.



Notes: Ostracoda, Cladocera, Copepoda, Porifera, Nematoda, Platyhelminthes, fish and terrestrial invertebrates were excluded from all calculations. Figure is copied from Figure 5.4-1 of the 2021 Aquatic Resources Monitoring Report (ERM, 2022b).

Figure 5-5: Benthic invertebrate abundance at Brucejack Creek sites, upper Sulphurets Creek, & reference lake L3 outfall. Each bar represents the total number of identifiable individuals captured in a three-minute CABIN kick net (400 µm) survey.

Periphyton surveys in Brucejack Creek have found algal slimes on rocks composed of chlorophytes and diatom species. Macroalgae were not present.

Based on the biological monitoring data for Brucejack Creek and upper Sulphurets Creek that show these streams are non-fish-bearing, are not fish habitat, do not provide habitat for species that are endangered, threatened or of special concern, the ecological context of the receiving environment is considered **low**.

5.4 Resiliency

The aquatic ecosystem of Brucejack Creek is limited to benthic invertebrates and periphyton. If these taxa were adversely affected by discharge of mine effluent, they have the ability to recolonize streams through drift, upstream migration within the water, migration from within the substrate, and aerial sources (Williams and Hynes, 1976). Similarly, the periphyton that inhabit Brucejack Creek would be able to recolonize following a disturbance through resting spores present in sediment and through drift from upstream sources. A disturbance to the Brucejack Creek ecosystem by changes to water quality would not affect source populations for recolonization from nearby tributaries and streams, nor would the physical structure of the stream be altered by changes to water quality. Dispersal of invertebrates from upstream sources to disturbed streams has been shown to occur rapidly (days) (Baumgartner and Robinson, 2017) and seasonally from aerial sources (Westveer *et al.,* 2018). The ability of taxa that are present in Brucejack Creek to rapidly colonize streams after a disturbance indicates that the resiliency of the ecosystem is **high**.

5.5 Geographic Extent

The discharge from the WRTSF is the headwaters of Brucejack Creek. There is little dilution that occurs over the 3 km length of Brucejack Creek. During operations, when all mine loadings are directed to the WRTSF, it is assumed that the concentration modelled for BJ 3.10 is representative of all of Brucejack Creek. During closure and post-closure, mine related loadings from the WRTSF are relatively low since most loadings are derived from the underground mine pool. The water quality model has most of the loadings from the flooded underground mine reporting via subsurface pathways to BJ 2.62; therefore, the concentrations modelled for BJ 2.62 are considered representative of concentrations throughout Brucejack Creek.

Brucejack Creek flows under the Sulphurets Glacier into Sulphurets Lake at the headwaters of Sulphurets Creek (Table 5-3; Figure 5-3). The monthly mixing ratio of flow at the outlet of Sulphurets Lake (site SL-H2) with flow from BJ 3.10 varies seasonally from a minimum of 6:1 in December to a maximum of 21:1 in August (Table 5-3). There are considerably higher monthly mixing ratios that occur farther downstream, just upstream of Mitchell Creek (site SC-MCU).

Table 5-3:
Monthly streamflow ratios at nodes along the Sulphurets Valley

Month	BJ 3.10	SL-H2	SC-MCU
Jan	1	8	25
Feb	1	9	25
Mar	1	9	25
Apr	1	8	25
May	1	8	16
Jun	1	9	17
Jul	1	19	34
Aug	1	21	37
Sep	1	18	32
Oct	1	15	28
Nov	1	9	19
Dec	1	6	17

Notes: Data are reproduced from Table 5 of ERM (2017) which is included as Appendix B of this report.
Node SL-H2 is Sulphurets Creek at Sulphurets Lake Outlet.
Node SC-MCU is Sulphurets Creek just upstream of Mitchell Creek.

The geographic extent of changes to water quality is categorized as local if the modelled concentrations in Brucejack Creek cannot elevate the concentration in upper Sulphurets Creek to a level that is greater than the BC FWAL long-term guideline. If there is the potential that the modelled concentration in Brucejack Creek will elevate the concentration in upper Sulphurets Creek to greater than the BC FWAL guideline, then the geographic extent of changes to water quality is categorized as regional.

The final concentration in upper Sulphurets Creek is conservatively assessed by assuming that the maximum modelled concentration at BJ 3.10 or BJ 2.62 will coincide with the minimum mixing ratio of 6:1 in upper Sulphurets Creek. The concentration at site SC0, in Sulphurets Creek just upstream of Sulphurets Lake is calculated using the following mass balance equation:

$$C_f = \frac{C_1 V_1 + C_2 V_2}{V_1 + V_2}$$

where: C_1 = concentration at BJ 3.10 or BJ 2.62
C_2 = background concentration in upper Sulphurets Creek
C_f = final concentration at SC0
V_1 = flow at BJ 3.10 (set to 1)
V_2 = flow at SC0 (set to 6)

The background concentrations (C_2) used in these calculations are the median concentrations from baseline sampling (2011-2013) at site SC0, during shifted quarter four (sQ4) (Nov.-Jan.) which coincides with the period of minimum mixing ratio. The mass balance equation can be rearranged to solve for C_1 (concentration at BJ 3.10) that would

be required to create a concentration at SC0 that is equal to BC FWAL guidelines when the mixing ratio is 6:1.

5.6 Ammonia

Ammonia was identified as a POPC because the maximum Base Case modelled concentration at BJ 3.10 (3.53 mg-N/L) is greater than 80% of the discharge limit (4 mg-N/L). Measurements of ammonia concentrations at BJ 3.10 show that the Base Case model overestimates the levels of ammonia that are discharged from the WRTSF (Figure 5-6). This is likely due to ammonia being oxidized to nitrate in the WRTSF at a rate that the mass balance model does not account for. Since the Base Case model results are less than the discharge limit, and the Base Case model overestimates measured concentrations at BJ 3.10, ammonia is not considered a POC and no further assessment related to effects on aquatic life in Brucejack Creek has been carried out for ammonia.

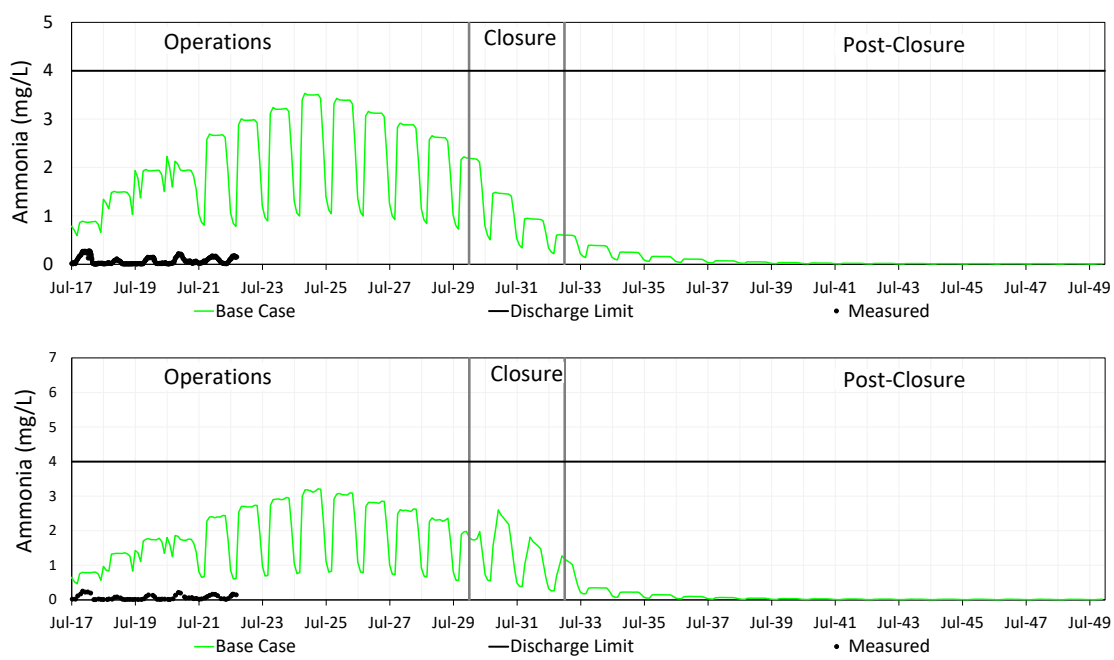


Figure 5-6: Base Case modelled ammonia concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the PE-107835 discharge limit and to measured concentrations.

5.7 Nitrate

5.7.1 Introduction

Nitrate levels in Brucejack Creek have increased since mine operations began in 2017, in agreement with the Base Case model (Figure 5-7). The maximum modelled nitrate

concentration during any of the mine phases is 15.2 mg-N/L for the Base Case model and 24.7 mg-N/L for the Upper Case model. These modelled concentrations are higher than the current discharge limit in PE-107835 of 11.5 mg-N/L. The discharge limit was established in 2016 based on the maximum Upper Case model result at that time, which was based on a mine production rate of 2700 tpd. A higher rate of explosive use for the 4950 tpd mine is the primary reason that modelled nitrate concentrations in Brucejack Creek are higher than the discharge limit set based on modelling done for the 2700 tpd production rate.

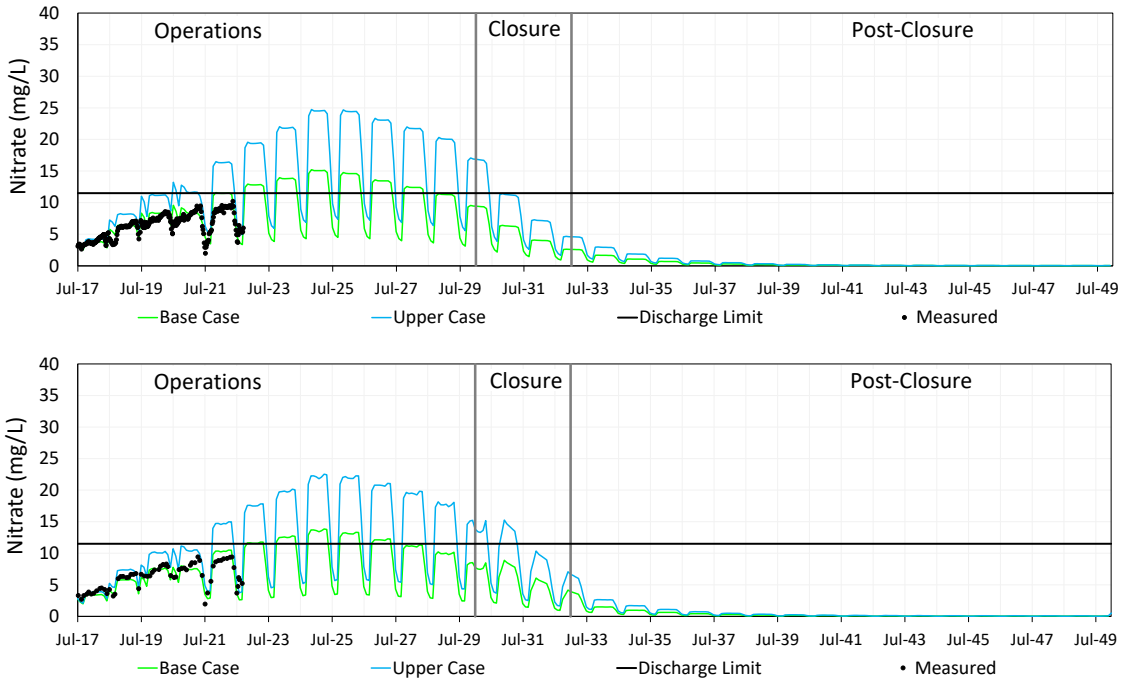


Figure 5-7: Modelled nitrate concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the PE-107835 discharge limit and to measured concentrations.

5.7.2 Geographic Extent

The geographic extent of effects to nitrate concentrations is assessed by estimating if concentrations in upper Sulphurets Creek, at SC0, have the potential to become elevated above the long-term WQG (3 mg-N/L). This is done using a mass balance equation and a minimum mixing ratio of 6:1 (parts SC0 to parts Brucejack Creek water) (see section 5.5).

The background concentration used in the mass balance model is set to the median nitrate concentration for sQ4 (0.03 mg-N/L). More recent monitoring at SC0 indicates that nitrate levels have been influenced by discharge from the WRTSF, but are well below the BC FWAL guideline (Figure 5-8).

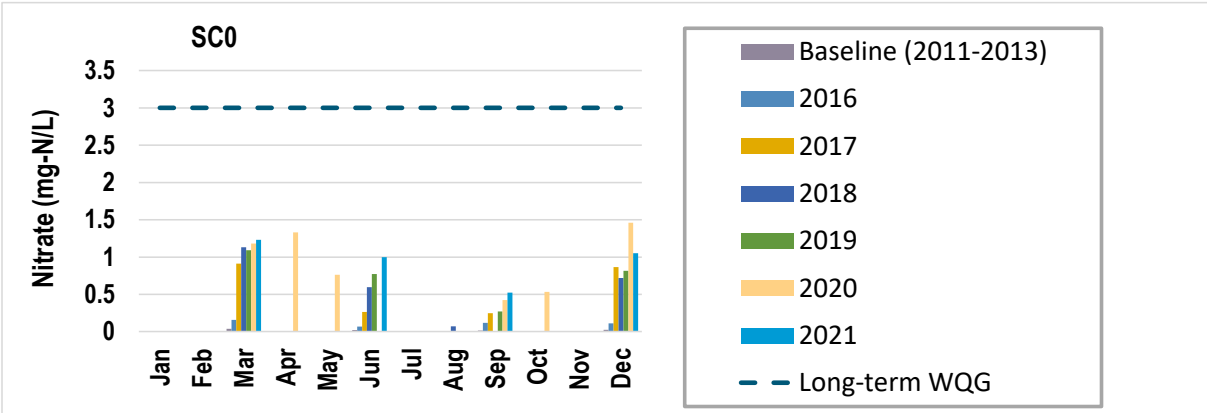


Figure 5-8: Nitrate concentrations in upper Sulphurets Creek measured quarterly since baseline.

During operations, the maximum Base Case modelled concentration is 15.2 mg-N/L, and the maximum Upper Case modelled concentration is 24.7 mg-N/L. The Base Case does not have the potential to cause nitrate levels at SC0 to increase to above the BC long-term FWAL guideline, but the Upper Case does (Table 5-4). Therefore, during operations, the geographic extent of changes to nitrate concentrations is **local** for the Base Case and **regional** for the Upper Case.

Modelled concentrations of nitrate are lower during closure and post-closure because explosives are not used during these mine phases. The lower concentrations of nitrate during closure and post-closure result in the geographic extent of changes to nitrate concentration being **local**, for both the Base Case and Upper Case (Table 5-4).

Table 5-4:
Final nitrate concentration in upper Sulphurets Creek for maximum modelled concentrations in Brucejack Creek during different mine phases.

Mine Phase	Model	C_1 (mg-N/L)	C_2 (mg-N/L)	V_2	V_1	C_f (mg-N/L)
Operations	Base Case	15.2	0.03	6	1	2.2
Operations	Upper Case	24.7	0.03	6	1	**3.6**
Closure	Base Case	8.9	0.03	6	1	1.3
Closure	Upper Case	15.3	0.03	6	1	2.2
Post-closure	Base Case	0.2	0.03	6	1	0.05
Post-closure	Upper Case	0.3	0.03	6	1	0.06
	Maintain SC0 under the FWAL guideline	20.1	0.03	6	1	2.9

Notes: C_1 = source concentration at BJ 3.10 or BJ 2.62
C_2 = background concentration in upper Sulphurets Creek
C_f = final concentration at SC0
V_1 = flow at BJ 3.10 or BJ 2.62 (set to 1)
V_2 = flow at SC0 (set to 6).

Solving the mass balance equation for C_1 when the final concentration at SC0 is set to 2.9 mg-N/L (just below the BC FWAL guideline) shows that a discharge of up to 20 mg-N/L at BJ 3.10 will not cause the concentration at SC0 to increase above the BC FWAL guideline.

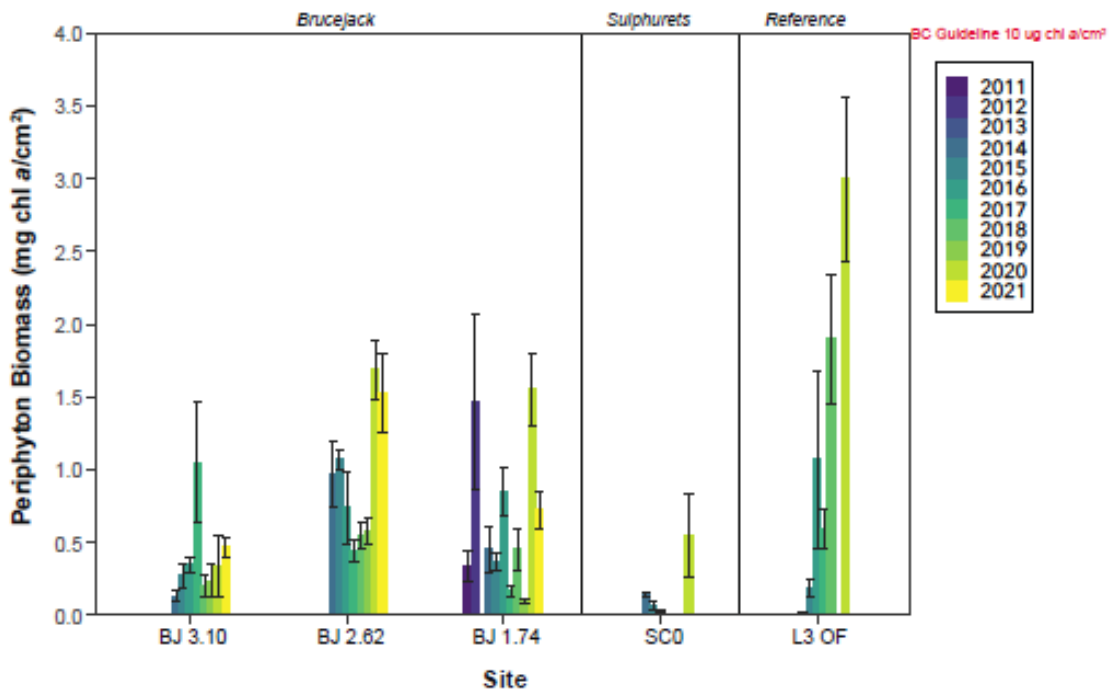
5.7.1 Magnitude

Potential adverse effects of elevated nitrate levels to aquatic life in Brucejack Creek are through eutrophication or toxicity.

5.7.1.1 Eutrophication

Eutrophication is the process by which lakes and streams become biologically more productive due to increased supply of nutrients (phosphorus and/or nitrogen) (MECCS, 2021). In the overwhelming majority of cases, phosphorus is the limiting nutrient (MECCS, 2021). The nitrogen concentration is only rarely of concern since it does not limit algal growth except in very unusual circumstances (MECCS, 2021).

Phosphorous levels modelled for the 4950 tpd mine plan are not higher than were modelled for the 3800 tpd mine plan (Table 4-1). This indicates that phosphorus will continue to be the nutrient that limits periphyton growth in Brucejack Creek, and increasing concentrations of nitrogen compounds (nitrate, nitrite, and ammonia) in Brucejack Creek will not change its trophic status. Annual measurements of periphyton biomass, measured as the concentration of chlorophyll *a* per square meter, at sites in Brucejack Creek have been low compared to the BC FWAL guideline of 100 mg/m^2 (10 $\mu g/m^2$), and have not had a noticeable change over time (Figure 5-9). The lack of change in periphyton biomass over time, even though nitrate levels have increased (Figure 5-7) is expected because there has not been in increase in the supply of biologically available phosphorus, which has been below its detection limit in most samples from BJ 3.10 (Figure 5-10). Because no changes to periphyton biomass are expected to result from changes in water quality in Brucejack Creek associated with the 4950 tpd, the magnitude of potential changes to trophic status of the Brucejack Creek ecosystem is considered **low**.



Notes: Figure is copied from Figure 5.3-1 of the 2021 Aquatic Resources Monitoring Report (ERM, 2022b).

Figure 5-9: Periphyton biomass measured annually at sites in Brucejack Creek, upper Sulphurets Creek, and reference site L3 OF measured annually since baseline.

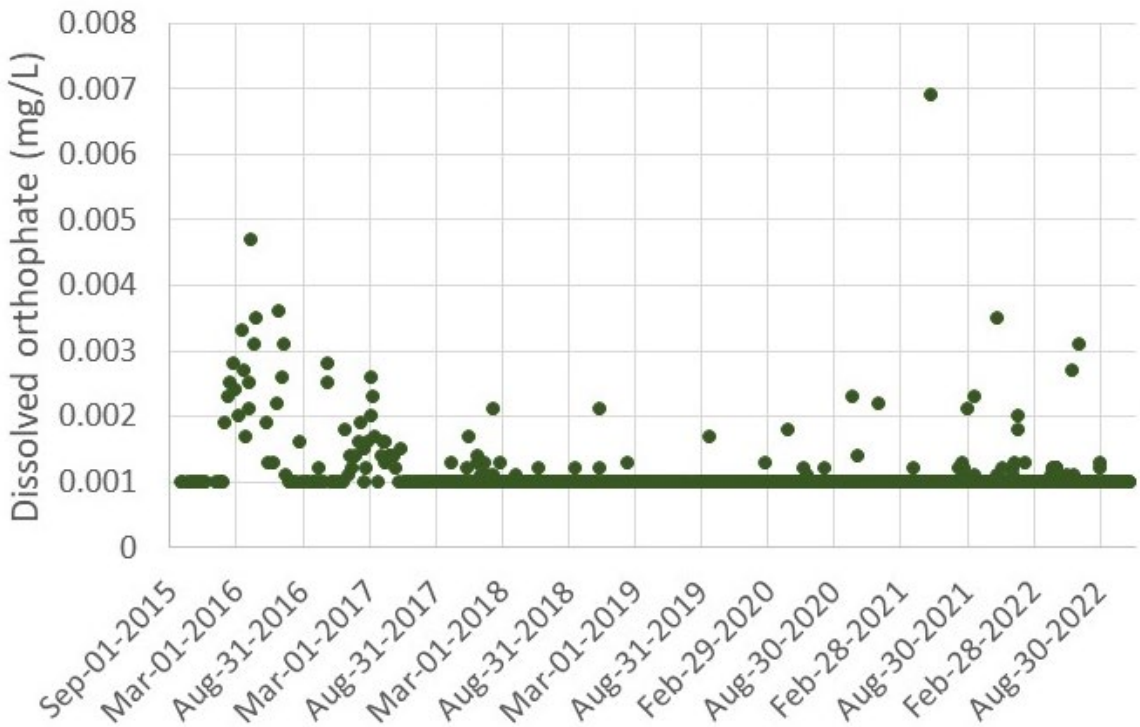


Figure 5-10: Dissolved ortho-phosphate concentration measured weekly at BJ 3.10.

5.7.1.2 Toxicity

The potential for nitrate to be toxic to aquatic life in Brucejack Creek was assessed using site-specific toxicity testing. Nitrate bioassays were conducted by Nautilus Environmental by spiking water collected from BJ 3.10 on December 7, 2021 with various concentrations of nitrate and measuring the effect on species that are representative of aquatic life in Brucejack Creek (Appendix C). Nitrate bioassays were conducted using the waterflea *Ceriodaphnia dubia* and the chironomid *Chironomus dilutus*. *Ceriodaphnia dubia* is an invertebrate that has been shown to be sensitive to chronic toxicity from nitrate (CCME, 2012). *Chironomus dilutus* is representative chironomids, which are the most common invertebrate taxa in Brucejack Creek. Bioassays using algae were not conducted because nitrate is a macronutrient for periphyton, and algae are known to grow well in high concentrations of nitrate.

Chironomus dilutus was more sensitive to acute toxicity than *C. dubia*, but less sensitive to chronic toxicity than *C. dubia* (Table 5-5). The lowest toxicity endpoint in the site-specific bioassays of nitrate was an IC20 of 54.1 mg-N/L. This is the concentration that caused a 20% reduction in growth (measured as dry weight) over the 10-day bioassay.

Table 5-5:
Results of toxicity testing of nitrate in BJ 3.10 water.

Endpoint	Units	*C. dubia*	*C. dilutus*
Survival LC50	mg-N/L	>303	150.7
Growth or Reproduction IC20	mg-N/L	54.1	179.6
Growth or Reproduction IC50	mg-N/L	88.5	>303

The maximum Base Case model result for nitrate in Brucejack Creek, during all mine phases, is 15.2 mg-N/L. This concentration is 3.6 times lower that the lowest chronic endpoint in the site specific bioassays; therefore, the magnitude of potential toxicity effects to aquatic life in Brucejack Creek is considered **low** for all Base Case model results.

The maximum Upper Case model result for nitrate in Brucejack Creek, during all mine phases, is 24.7 mg-N/L. This concentration is 2.2 times lower that the lowest chronic endpoint in the site specific bioassays; therefore, the magnitude of potential toxicity effects to aquatic life in Brucejack Creek is considered **low** for all Upper Case model results.

5.7.2 Duration, Frequency, and Reversibility

Base Case and Upper Case modelled concentrations of nitrate are above the discharge limit for much of the operations phase, then decrease after the use of explosives ceases, at the

end of operations (Figure 5-7); therefore, the duration of elevated nitrate concentrations is **long-term** for both the Base Case and Upper Case.

The Base Case and Upper Case results are above the discharge limit during low flow months, and below the discharge limit during high flow months. Since nitrate is modelled to seasonally exceed its discharge limit, the frequency of elevated nitrate concentrations is **regular**, for both the Base Case and Upper Case.

The Base Case and Upper Case results return to concentrations near baseline levels during post-closure; therefore, the effects of mining on nitrate levels are **reversible**, for both the Base Case and Upper Case.

5.7.3 Consequence

Eutrophication due to Base Case modelled concentrations of nitrate in Brucejack Creek is not expected (**Level 1**). Toxicity to aquatic life in Brucejack Creek from Base Case modelled nitrate levels is not expected, since the maximum modelled concentration is 3.5 times lower than the lowest chronic toxicity endpoint and 10 times lower than the lowest acute toxicity endpoint (Table 5-5). Since the ecological context of Brucejack Creek is low, and no toxicity to aquatic life in Brucejack Creek is expected, the potential consequence of the Base Case modelled nitrate concentrations is low (**Level 1**).

Eutrophication due to Upper Case modelled concentrations of nitrate in Brucejack Creek is not expected (**Level 1**). Toxicity to aquatic life in Brucejack Creek from Upper Case modelled nitrate levels is not expected since the maximum modelled concentration is 2.0 times lower than the lowest chronic toxicity endpoint and 5.5 times lower than the lowest acute toxicity endpoint (Table 5-5). Since the ecological context of Brucejack Creek is low, and no toxicity to aquatic life in Brucejack Creek is expected, the potential consequence of the Base Case modelled nitrate concentrations is low (**Level 1**).

5.7.4 Likelihood

To date, nitrate concentrations at BJ 3.10 have been well represented by the Base Case model and overestimated by the Upper Case model (Figure 5-7). Eutrophication resulting from Base Case and Upper Case modelled concentrations is **very unlikely**, since periphyton growth is limited by phosphorous, and phosphorous concentrations are expected to remain very low.

Base Case modelled concentrations are likely to occur, but toxicity to aquatic life in Brucejack Creek from Base Case concentrations is **very unlikely**. Toxicity from the Upper Case modelled concentrations is unlikely, which, combined with the expectation that Upper Case nitrate concentrations are very unlikely to occur, indicates that adverse effects to aquatic life from Upper Case modelled concentrations is **very unlikely**.

5.7.5 Risk

Both Base Case and Upper Case model results have a Level 1 consequence and are very unlikely to cause eutrophication or toxicity; therefore, the risk of adverse effects from modelled nitrate levels is **low**, for both the Base Case and Upper Case (Figure 5-2).

5.7.6 Confidence

The comparison of modelled nitrate concentrations to five years of monitoring data provides high confidence that the Base Case model well represents expected nitrate concentrations for the 4950 tpd mine plan, and that the Upper Case model overestimates nitrate levels in Brucejack Creek. Monitoring of periphyton biomass from baseline through 2021 has shown that the increase in nitrate concentrations that have occurred since mine construction have not resulted in eutrophication, which provides high confidence that a further increase in nitrate levels due to the 4950 tpd mine plan will not result in eutrophication. The site-specific toxicity testing that was done provides a direct measure of toxicity to species that are representative of aquatic life in Brucejack Creek, which provides a high level of confidence in the assessment of potential toxicity from nitrate. Overall, there is **high** confidence in the assessment of potential risk to aquatic life from the modelled nitrate concentrations.

5.7.7 Summary

The risk of eutrophication from Base Case and Upper Case modelled nitrate concentrations is categorized as low for all mine phases (Table 5-6). The risk of toxicity from Base Case and Upper Case modelled nitrate concentrations is categorized as low for all mine phases (Table 5-7).

Table 5-6:
Summary of effects assessment ratings for eutrophication potential from modelled nitrate concentrations.

	Base Case			Upper Case		
	Operations	**Closure**	**Post-closure**	**Operations**	**Closure**	**Post-closure**
Ecological context	low	low	low	low	low	low
Resiliency	high	high	high	high	high	high
Geographic extent	local	local	local	regional	local	local
Magnitude	low	low	low	low	low	low
Duration	long-term	long-term	long-term	long-term	long-term	long-term
Frequency	regular	regular	regular	regular	regular	regular
Reversibility	reversible	reversible	reversible	reversible	reversible	reversible
Consequence	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1
Likelihood	very unlikely	very unlikely	very unlikely	very unlikely	very unlikely	very unlikely
Risk	low	low	low	low	low	low
Confidence	high	high	high	high	high	high

Table 5-7:
Summary of effects assessment ratings for toxicity potential from modelled nitrate concentrations.

	Base Case			Upper Case		
	Operations	**Closure**	**Post-closure**	**Operations**	**Closure**	**Post-closure**
Ecological context	low	low	low	low	low	low
Resiliency	high	high	high	high	high	high
Geographic extent	local	local	local	regional	local	local
Magnitude	low	low	low	low	low	low
Duration	long-term	long-term	long-term	long-term	long-term	long-term
Frequency	regular	regular	regular	regular	regular	regular
Reversibility	reversible	reversible	reversible	reversible	reversible	reversible
Consequence	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1
Likelihood	very unlikely	very unlikely	very unlikely	very unlikely	very unlikely	very unlikely
Risk	low	low	low	low	low	low
Confidence	high	high	high	high	high	high

5.8 Nitrite

5.8.1 Introduction

Nitrite concentrations in Brucejack Creek are modelled to remain below the PE-107835 discharge limit during operations, for both the Base Case and Upper Case models (Figure 5-11). Comparison of measured and modelled concentrations of nitrite in Brucejack Creek show that the model generally overestimates nitrite levels, although concentrations increased in November and December 2021 to levels that approached Base Case modelled concentrations (Figure 5-11). Modelled nitrite levels at BJ 3.10 decrease toward the end of operations, due to lower rates of explosive use.

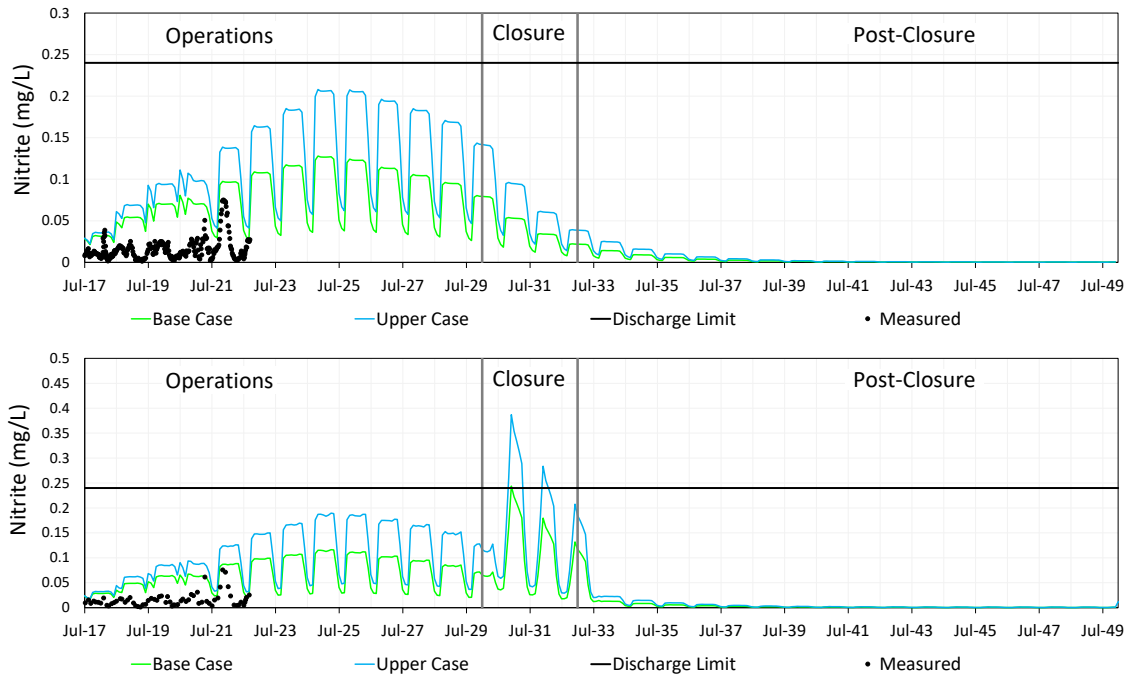


Figure 5-11: Modelled nitrite concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the PE-107835 discharge limit and to measured concentrations.

Base Case modelled nitrite concentrations at BJ 2.62 peak during closure to equal the the discharge limit of 0.24 mg-N/L, and Upper Case peaks are above the discharge limit for two seasons, in response to the flushing water from the flooded underground mine that reports to Brucejack Creek. Modelled concentrations at BJ 2.62 decrease each year during closure and are below the discharge limit during post-closure, for both the Base Case and Upper Case models.

5.8.2 Geographic Extent

The geographic extent of effects to nitrite concentrations is assessed by estimating if concentrations in upper Sulphurets Creek, at SC0, have the potential to become elevated above the long-term WQG (0.02 mg-N/L). This is done using a mass balance equation and a minimum mixing ratio of 6:1 (parts SC0 to parts Brucejack Creek water) (see section 5.5).

The background concentration used in the mass balance model is set to the median baseline concentration for sQ4 (0.0005 mg-N/L). More recent monitoring at SC0 indicates that nitrite levels may have been influenced by discharge from the WRTSF, but are well below the BC FWAL guideline (Figure 5-12).

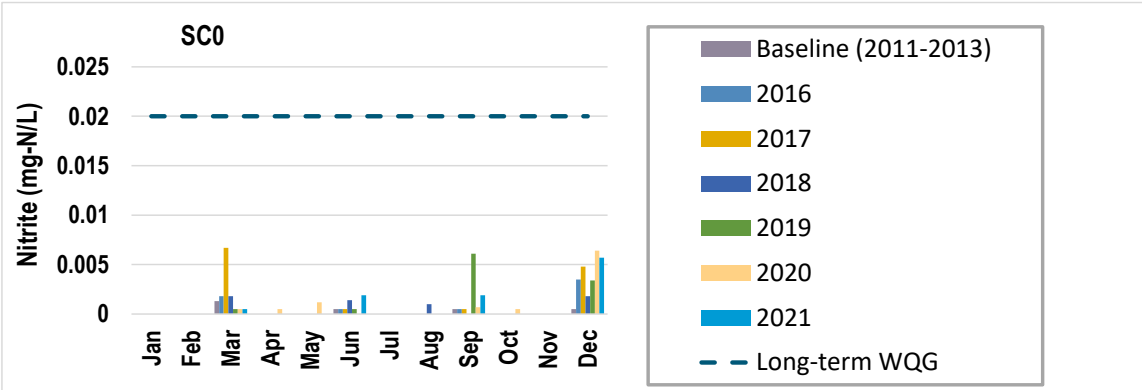


Figure 5-12: Nitrite concentrations in upper Sulphurets Creek measured quarterly since baseline.

The maximum modelled nitrite concentration during operations phase is 0.13 mg-N/L for the Base Case and 0.21 mg-N/L for the Upper Case (Table 5-8). The Base Case nitrite concentrations during operations do not cause concentrations at SC0 to increase above the BC FWAL guideline (Table 5-8); therefore, the geographic extent of potential effects to water quality is **local** during operations for the Base Case. Upper Case predictions during operations, and both Base Case and Upper Case predictions during closure, result in periods when dilution will not bring nitrite concentrations in upper Sulphurets Creek to less than the BC FWAL guideline; therefore, the geographic extent of changes to nitrite concentration is **regional** for these model conditions. During post-closure, nitrite levels in Brucejack Creek are low and the geographic extent of changes to water quality is **local**.

Table 5-8:
Final nitrite conentration in upper Sulphurets Creek for maximum modelled concentrations in Brucejack Creek during different mine phases.

Mine Phase	Model	C_1 (mg-N/L)	C_2 (mg-N/L)	V_2	V_1	C_f (mg-N/L)
Operations	Base Case	0.128	0.0005	6	1	0.019
Operations	Upper Case	0.208	0.0005	6	1	**0.030**
Closure	Base Case	0.244	0.0005	6	1	**0.035**
Closure	Upper Case	0.387	0.0005	6	1	**0.056**
Post-closure	Base Case	0.002	0.0005	6	1	0.001
Post-closure	Upper Case	0.003	0.0005	6	1	0.001
	Maintain SC0 under the FWAL guideline	0.130	0.0005	6	1	0.019

Notes: C_1 = source concentration at BJ 3.10 or BJ 2.62
C_2 = background concentration in upper Sulphurets Creek
C_f = final concentration at SC0
V_1 = flow at BJ 3.10 or BJ 2.62 (set to 1)
V_2 = flow at SC0 (set to 6).

Solving the mass balance equation for C_1 when the final concentration at SC0 is set to 0.019 mg-N/L (just below the BC FWAL guideline) shows that a discharge of up to 0.13 mg-N/L at BJ 3.10 will not cause the concentration at SC0 to increase above the BC FWAL guideline.

5.8.3 Magnitude

The PE-107835 discharge limit of 0.24 mg-N/L was developed to be protective aquatic life in Brucejack Creek from chronic toxicity. Modelled concentrations during operations are between 0.5 and 1 times the discharge limit (Table 5-9); therefore, the magnitude of potential effects to aquatic life during operations is **medium**. The maximum Base Case modelled concentrations during closure is equal to the discharge limit, and the maximum Upper Case concentration is above the discharge limit (Table 5-9); therefore, the magnitude of potential effects to aquatic life during closure is **high**. During post-closure, nitrite is modelled to decrease to baseline levels; therefore, the magnitude during post-closure is **low**.

Table 5-9:
Modelled nitrite concentrations compared to the PE-107835 discharge limit.

Mine Phase	Model	Maximum Modelled (mg-N/L)	Discharge Limit (mg-N/L)	Exceedance Factor
Operations	Base Case	0.128	0.24	0.5 x
Operations	Upper Case	0.208	0.24	0.9 x
Closure	Base Case	0.244	0.24	1.0 x
Closure	Upper Case	0.387	0.24	1.6 x
Post-closure	Base Case	0.002	0.24	0.01 x
Post-closure	Upper Case	0.003	0.24	0.01 x

5.8.4 Duration, Frequency, and Reversibility

Only the Upper Case model results exceed the nitrite discharge limit, and only seasonally during closure (Figure 5-11). The duration of these exceedances of discharge limits is categorized as **medium-term** and the frequency is **regular**. Base Case model results are categorized as **none** for both duration and frequency because they do not exceed the discharge limit during any mine phase.

The Base Case and Upper Case nitrite results return to concentrations near baseline levels during post-closure; therefore, the effects of mining on nitrite levels are **reversible**, for both the Base Case and Upper Case.

5.8.5 Consequence

Adverse effects to aquatic life from modelled nitrite concentrations during operations are not expected, since concentrations do not exceed a discharge limit, for both Base Case and Upper Case; therefore, the consequence of modelled nitrite concentrations during operations is categorized as **Level 1**.

The maximum Base Case modelled concentrations during closure peak at a concentration equal to the discharge limit. Since Base Case modelled concentrations do not go above the level that was developed to be protective of aquatic life in Brucejack Creek no toxicity is expected from the modelled concentration. The closure peak has a regional geographic extent, but the species inhabiting upper Sulphurets Creek are similar to those in Brucejack Creek and modelled nitrite levels are not expected to cause toxicity. Therefore, the consequence for Base Case during closure is categorized as **Level 1.**

The Upper Case peaks at 1.6 times the discharge limit during closure. The closure peaks have a regional geographic extent and a high magnitude. The duration of Upper Case exceedance of discharge limits is medium-term and the frequency is regular. Increases to nitrite concentrations in Brucejack Creek are reversible. The ecological context of the receiving environment is low. Nitrite is a macronutrient for periphyton, and periphyton grow well in nitrite concentrations well above the modelled concentrations. There is no potential for adverse effects to fish, fish habitat, or threatened species. There is potential for the Upper Case peaks during closure to cause chronic toxicity to invertebrates in Brucejack Creek. The resiliency of aquatic life in the receiving environment is high. Considering these factors, the potential consequence of Upper Case modelled concentrations during closure are minor effects, such as reduced growth rate or reduced fecundity, to a portion of the ecosystem (**Level 2**).

Post-closure nitrite concentrations are below the discharge limit for both Base Case and Upper Case models, and no adverse effects to aquatic life in Brucejack Creek are expected (**Level 1**).

5.8.6 Likelihood

Modelled concentrations during operations are likely an overestimate, for both the Base Case and Upper Case models, as seen from the comparison of measured and modelled nitrite from 2017 through 2021 (Figure 5-11). Modelled concentrations during closure may also be an overestimate, although there is higher uncertainty if nitrification processes that occur in the WRTSF will also occur at the same rate in the flooded underground mine. Pretium has developed a Closure Underground Water Quality Management Plan (Pretium, 2018b) to ensure that the underground mine pool water quality is suitable for discharge before reaching its spilling elevation (~1355 masl). The plan also identifies monitoring programs required to manage the potential risk to water quality in Brucejack Creek

associated with flooding at closure. The opportunity to improve mitigation of nitrite in flooded underground mine water makes it unlikely that closure peaks will be as high as currently modelled.

Given that Base Case and Upper Case modelled concentrations during operations are less than the discharge limit, adverse effects to aquatic life during operations are **very unlikely**. During closure, Base Case nitrite concentrations peak at a concentration equal to the discharge limit, and adverse effects from Base Case closure concentrations are **very unlikely.** Upper Case nitrite during closure is up to 1.6 times higher than the discharge limit. It is likely that toxicity to sensitive species would occur at the modelled Upper Case peak concentrations during closure, but it is expected that mitigation measures implemented at closure will result in nitrite levels in Brucejack Creek that are below the discharge limit, for both the Base Case and Upper Case; therefore, adverse effects to aquatic life during closure are **unlikely** for the Upper Case.

Modelled nitrite during post-closure decrease to levels below the discharge limit, and adverse effects from nitrite are **very unlikely** during post-closure, for both the Base Case and Upper Case.

5.8.7 Risk

During operations and post-closure both Base Case and Upper Case model results have a Level 1 consequence and are very unlikely to cause toxicity; therefore, the risk of adverse effects from modelled nitrate levels is **low** (Figure 5-2). During closure, the Base Case consequence is Level 1 and adverse effects are very unlikely; therefore, the risk of adverse effects is **low**. Upper Case during closure has a Level 2 consequence and is unlikely to cause adverse effects; therefore, the risk rating is **low** (Figure 5-2).

5.8.8 Confidence

The comparison of modelled concentrations to five years of monitoring data illustrate that the Base Case typically overestimates nitrite levels at BJ 3.10 and BJ 2.62, and that measured concentrations are consistently well below the Upper Case results. This lengthy monitoring dataset provides high confidence that the Base Case modelled nitrite concentrations represent the expected concentrations in Brucejack Creek, and that the Upper Case model overestimates nitrite levels during operation.

The low ecological context of the receiving environment, and the site-specific discharge limit developed for protection of aquatic life in Brucejack Creek used as a benchmark for potential adverse effects to aquatic life from modelled nitrite levels, provide **high** confidence that the risk ratings for nitrite are accurate.

5.8.9 Summary

The risk of toxicity from Base Case and Upper Case modelled nitrite concentrations is categorized as low for all mine phases (Table 5-10).

Table 5-10:
Summary of effects assessment ratings for toxicity potential from modelled nitrite concentrations.

	Base Case			Upper Case		
	Operations	**Closure**	**Post-closure**	**Operations**	**Closure**	**Post-closure**
Ecological context	low	low	low	low	low	low
Resiliency	high	high	high	high	high	high
Geographic extent	local	regional	local	regional	regional	local
Magnitude	medium	high	low	medium	high	low
Duration	none	none	none	none	medium-term	none
Frequency	none	none	none	none	regular	none
Reversibility	reversible	reversible	reversible	reversible	reversible	reversible
Consequence	Level 1	Level 1	Level 1	Level 1	Level 2	Level 1
Likelihood	very unlikely	very unlikely	very unlikely	very unlikely	unlikely	very unlikely
Risk	low	low	low	low	low	low
Confidence	high	high	high	high	high	high

5.9 Sulfate

Sulfate was identified as POPC based on its modelled concentration being greater than 80% of the BC FWAL guideline (Section 4.2). The identification of POPCs conservatively used baseline hardness for calculating guidelines that are hardness dependent, which includes the sulfate guideline. The release of the SO_4^{2-} anion from mined material is accompanied by release of Ca^{2+} and Mg^{2+} cations. This means that hardness will increase as sulfate concentration increases, as has been observed in water quality monitoring at BJ 3.10.

Comparison of Base Case modelled sulfate concentrations to the long-term FWAL guideline calculated using the Base Case modelled hardness indicates that sulfate levels will remain below the guideline throughout the life of mine (Figure 5-13). Monitoring of sulfate in Brucejack Creek indicates that concentrations have been slightly greater than the Base Case model, but well below the Upper Case model, and that the Base Case model is representative of expected sulfate concentrations in Brucejack Creek. Since sulfate is expected to remain below its FWAL guideline, sulfate is not a POC and no further assessment related to effects on aquatic life in Brucejack Creek has been carried out for sulfate.

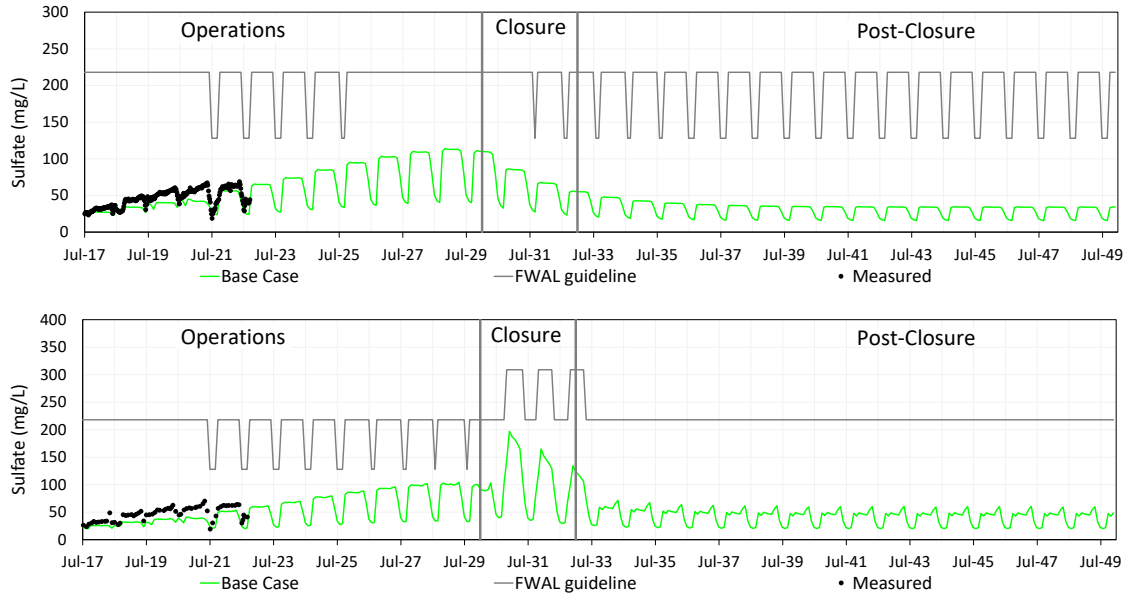


Figure 5-13: Modelled sulfate concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the hardness dependent BC FWAL guideline and to measured concentrations.

5.10 Dissolved Aluminum

Dissolved aluminum was identified as a POPC because the maximum Base Case model predictions at BJ 3.10 (0.062 mg/L) and BJ 2.62 (0.057 mg/L) are above the long-term FWAL guideline of 0.05 mg/L (Figure 5-14). Base Case modelled D-Al concentrations are highest early in operations and decrease below FWAL guidelines later in operations as the amount of waste rock (the dominant source of loadings) placed in the WRTSF decreases.

Although there have been sporadic water quality samples from BJ 3.10 that had D-Al concentrations above the long-term FWAL guideline, most measurements have been below the guideline and below Base Case model predictions. The increase in D-Al concentrations at BJ 3.10 that is seen in the Base Case model during operations has not been observed from the weekly measurements made at BJ. 3.10. The observation of sporadic elevated D-Al concentrations at BJ 3.10 is attributed to relatively high TSS episodes and the associated presence of colloidal Al particles which may pass through the 0.45 µm filter that is operationally used to define the dissolved fraction.

The Base Case and Upper Case models are considered to overpredict D-Al concentrations since the model employs a mass balance approach and does not account for solubility-controlled precipitation reactions which are expected to occur in the WRTSF. For this reason, concentrations above the long-term guideline are not anticipated over life of mine.

D-Al is therefore not considered a POC and no further assessment related to effects to aquatic life in Brucejack Creek has been carried out for D-Al.

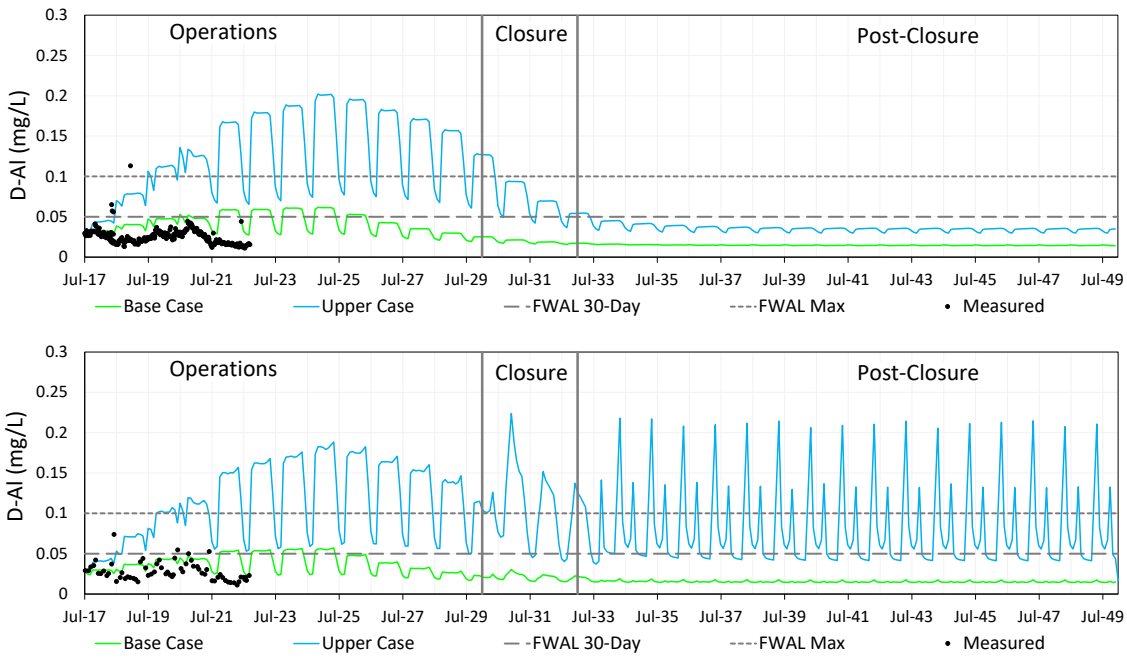


Figure 5-14: Modelled dissolved aluminum concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the BC FWAL guidelines and to measured concentrations.

5.11 Total Arsenic

5.11.1 Introduction

Arsenic levels in Brucejack Creek have increased since mine operations began in 2017, in agreement with the Base Case model (Figure 5-15). The maximum modelled T-As concentration during operations is 0.0137 mg/L (13.7 µg/L) for the Base Case model and 0.0259 mg/L (25.9 µg/L) for the Upper Case model. T-As levels in Brucejack Creek are expected to increase during the first year of closure when water from the flooded underground mine first reports to Brucejack Creek, then decline. The peak concentrations during closure are 0.0111 mg/L for the Base Case and 0.0268 mg/L for the Upper Case. Post-closure T-As is expected to stabilize with annual maxima of 0.0032 mg/L for the Base Case. Post-closure Upper Case T-As levels are higher than the current discharge limit, with annual maxima of 0.0145 mg/L.

The current discharge limit in in PE-107835 is 0.010 mg/L. The discharge limit was established as part of the permit amendment for the 3800 tpd production rate (Pretium, 2018b). It was set at the maximum Upper Case model result during operations, and site-

specific toxicity test results that indicated 0.010 mg/L is unlikely to cause toxicity to aquatic life in Brucejack Creek. Arsenic concentrations in the WRTSF are higher for the 4950 tpd models than they were for the 3800 tpd models, largely due to the higher rates of waste rock and tailings deposition to the WRTSF, as well as to the change in modelled lake turnover from twice a year for the 3800 tpd model to once a year in the 4950 tpd model.

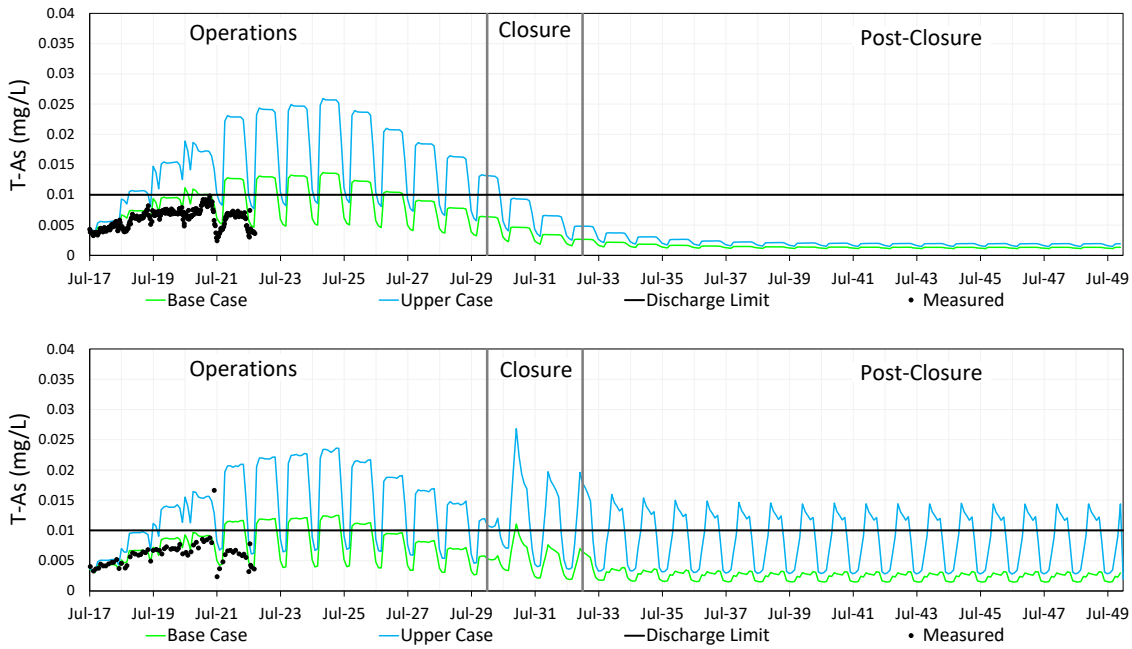


Figure 5-15: Modelled total arsenic concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the PE-107835 discharge limit and to measured concentrations.

5.11.2 Geographic Extent

The geographic extent of effects to T-As concentrations is assessed by estimating if concentrations in upper Sulphurets Creek, at SC0, have the potential to become elevated above the long-term WQG (0.005 mg/L). This is done using a mass balance equation and a minimum mixing ratio of 6:1 (parts SC0 to parts Brucejack Creek water) (see section 5.5).

Total arsenic concentrations measured at SC0, in upper Sulphurets Creek, are strongly affected by seasonality (Figure 5-16). During open water months, glacial melt contributes high levels of TSS to Sulphurets Creek which results in T-As concentrations that are greater than the BC FWAL guideline of 0.005 mg/L. During winter months, T-As at SC0 is markedly lower, ranging from 0.0003-0.0032 mg/L. Although T-As concentrations in Brucejack Creek have increased since mine operations began, a noticeable change to T-As

at SC0 has not been observed. The median baseline concentration during sQ4 was 0.0013 mg/L. The median T-As concentration from the seven samples collected in December from 2013 through 2021 is 0.0005 mg/L. This latter concentration is used in the mass balance equation for determining geographic extent as it better represents background levels than the higher baseline concentration.

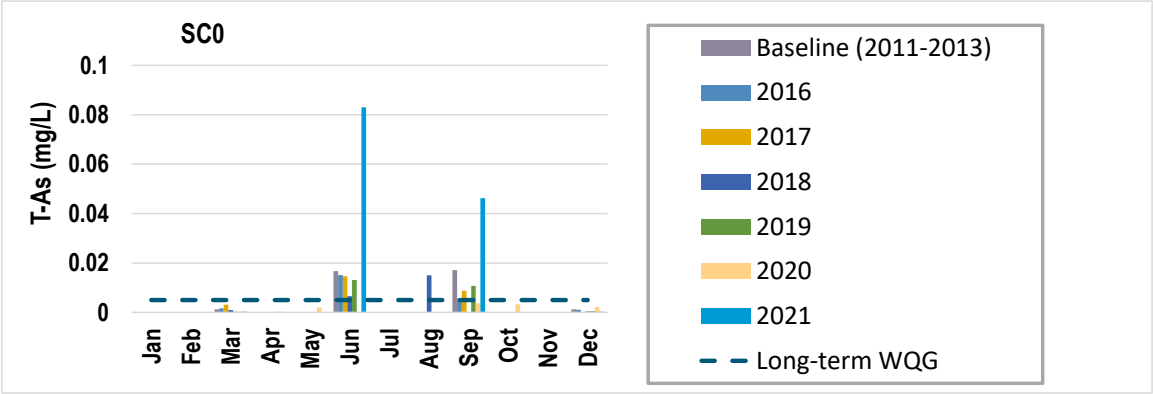


Figure 5-16: Total arsenic concentrations in upper Sulphurets Creek measured quarterly since baseline.

Total arsenic concentrations of ≤0.0313 mg/L in Brucejack Creek will ensure that concentrations at SC0 are less than the BC FWAL guideline when there is minimal dilution available (Table 5-11). The maximum modelled T-As concentration during all mine phases is 0.0268 mg/L (Upper Case model during closure). Since all modelled concentrations are less than 0.0313 mg/L, all model scenarios do not have the potential to elevate T-As at SC0 to concentrations above the FWAL guideline; therefore, the geographic extent of changes to water quality is **local** for both the Base Case and Upper Case.

Table 5-11:
Final total arsenic conentration in upper Sulphurets Creek for maximum modelled concentrations in Brucejack Creek during different mine phases.

Mine Phase	Model	C_1 (mg-N/L)	C_2 (mg-N/L)	V_2	V_1	C_f (mg-N/L)
Operations	Base Case	0.0137	0.0005	6	1	0.0024
Operations	Upper Case	0.0259	0.0005	6	1	0.0041
Closure	Base Case	0.0111	0.0005	6	1	0.0020
Closure	Upper Case	0.0268	0.0005	6	1	0.0043
Post-closure	Base Case	0.0032	0.0005	6	1	0.0009
Post-closure	Upper Case	0.0145	0.0005	6	1	0.0025
	Maintain SC0 under the FWAL guideline	0.0313	0.0005	6	1	0.0049

Notes: C_1 = source concentration at BJ 3.10 or BJ 2.62
C_2 = background concentration in upper Sulphurets Creek
C_f = final concentration at SC0
V_1 = flow at BJ 3.10 or BJ 2.62 (set to 1)
V_2 = flow at SC0 (set to 6).

5.11.3 Magnitude

The PE-107835 discharge limit of 0.01 mg/L was developed based on the Upper Case modelled concentration during operations for the 3800 tpd production rate, and a site-specific toxicity test that demonstrated that 0.01 mg/L T-As is unlikely to cause to toxicity to aquatic life in Brucejack Creek. The bioassay was done using a species of algae (*Pseudokirchneriella subcapitata*), since algae are known to be more sensitive to chronic toxicity from arsenic than are invertebrates, and algal toxicity tests are the basis for the BC FWAL guideline. This test was done in 2017 using water collected from BJ 3.10 and spiked with arsenic. The test produced a low effect chronic toxicity endpoint (IC20 for growth) of 0.0376 mg/L (Table 5-12). The *P. subcapitata* bioassay of arsenic in Brucejack Creek water was repeated in 2018 (IC20 = 0.0931 mg/L) and again in 2021 (IC20 = 0.0980 mg/L) (Table 5-12). All three toxicity tests were conducted by Nautilus Environmental. Test reports are presented in Appendix D.

Table 5-12:
Chronic toxicity endpoints from Pseudokirchneriella subcapitata bioassays of BJ 3.10 water spiked with arsenic.

Collection date	IC20 for growth
October 30, 2017	0.0376 mg/L
June 25, 2018	0.0931 mg/L
June 14, 2021	0.0980 mg/L
Geometric mean	0.0700 mg/L

The BC protocol for the derivation of FWAL guidelines says "If there is more than one comparable record (i.e. same species, same life stage, same endpoint, same exposure duration), then the species effects endpoint is to be represented by the geometric mean of these records." (MECCS, 2019). The three toxicity tests of BJ 3.10 water with added arsenic meet these criteria for being comparable records. The geometric mean of the three tests, 0.070 mg/L, will be used as the environmental benchmark for assessing the magnitude of potential toxicity from modelled T-As concentrations for the 4950 tpd production rate.

The 4950 tpd model results are less than half the chronic toxicity threshold of 0.070 mg/L, for Base Case and Upper Case model results, during all mine phases (Table 5-13). This comparison to the toxicity threshold indicates that the potential for modelled T-As concentrations to cause toxicity to aquatic life in Brucejack Creek has a **low** magnitude.

Table 5-13:
Modelled arsenic concentrations compared to the low-effect chronic toxicity endpoint from site-specific bioassays.

Mine Phase	Model	Maximum Modelled (mg/L)	Toxicity Benchmark (mg/L)	Exceedance Factor
Operations	Base Case	0.0137	0.070	0.20 ×
Operations	Upper Case	0.0259	0.070	0.37 ×
Closure	Base Case	0.0111	0.070	0.16 ×
Closure	Upper Case	0.0268	0.070	0.38 ×
Post-closure	Base Case	0.0032	0.070	0.05 ×
Post-closure	Upper Case	0.0145	0.070	0.21 ×

5.11.4 Duration, Frequency, and Reversibility

Base Case and Upper Case modelled concentrations of T-As are less than half of the environmental benchmark of 0.070 mg/L throughout the life of mine. Thus, the modelled concentrations of T-As in Brucejack Creek for both model cases are categorized as **none** for duration and frequency. Base Case T-As levels decrease to near baseline levels during post-closure; therefore, the Base Case modelled changes to T-As concentrations are **reversible**. Upper Case is modelled to stabilize with annual maxima of 0.0145 mg/L during post-closure. Since this concentration is well above the baseline levels, the Upper Case model results are considered **irreversible**.

5.11.5 Consequence

Toxicity to aquatic life in Brucejack Creek from Base Case modelled T-As levels is not expected, since the maximum modelled concentration is 5 times lower than the chronic

toxicity threshold of 0.070 mg/L developed from bioassays that tested the toxicity of arsenic in Brucejack Creek water (Table 5-13). Since the ecological context of Brucejack Creek is low, and no toxicity to aquatic life in Brucejack Creek is expected, the potential consequence of the Base Case modelled T-As concentrations is low (**Level 1**).

Toxicity to aquatic life in Brucejack Creek from Upper Case modelled T-As levels is not expected, since the maximum modelled concentration is 2.6 times lower than the site-specific toxicity threshold (Table 5-13). Since the ecological context of Brucejack Creek is low, and no toxicity to aquatic life in Brucejack Creek is expected, the potential consequence of the Upper Case modelled T-As concentrations is low (**Level 1**).

5.11.6 Likelihood

To date, T-As concentrations at BJ 3.10 have been well represented by the Base Case model and overestimated by the Upper Case model (Figure 5-15). Base Case modelled T-As concentrations are likely to occur, but toxicity to aquatic life in Brucejack Creek from Base Case concentrations is **very unlikely**.

Monitoring of T-As concentrations at BJ 3.10 and BJ 2.62 indicate that the Upper Case model produces an overestimate of potential T-As levels in Brucejack Creek, which are very unlikely to occur. If Upper Case T-As levels do occur, it is unlikely that toxicity will occur to aquatic life in Brucejack Creek. Considering the likelihood of Upper Case occurring and the likelihood of toxicity, adverse effects to aquatic life from Upper Case modelled concentrations is categorized as **very unlikely**.

5.11.7 Risk

Both Base Case and Upper Case model results have a Level 1 consequence and are very unlikely to cause toxicity; therefore, the risk of adverse effects from modelled T-As levels is **low**, for both the Base Case and Upper Case (Figure 5-2).

5.11.8 Confidence

The comparison of modelled T-As concentrations to five years of monitoring data provides high confidence that the Base Case model well represents expected T-As concentrations for the 4950 tpd production rate, and that the Upper Case model overestimates T-As levels in Brucejack Creek. The site-specific toxicity testing that was done provides a direct measure of toxicity to species that are representative of aquatic life in Brucejack Creek, which provides a high level of confidence in the assessment of potential toxicity from modelled T-As levels. Overall, there is **high** confidence in the assessment of potential risk to aquatic life from the modelled T-As concentrations.

5.11.9 Summary

The risk of toxicity from Base Case and Upper Case modelled arsenic concentrations is categorized as low for all mine phases (Table 5-14).

Table 5-14:
Summary of effects assessment ratings for toxicity potential from modelled total arsenic concentrations.

	Base Case			Upper Case		
	Operations	**Closure**	**Post-closure**	**Operations**	**Closure**	**Post-closure**
Ecological context	low	low	low	low	low	low
Resiliency	high	high	high	high	high	high
Geographic extent	local	local	local	local	local	local
Magnitude	low	low	low	low	low	low
Duration	none	none	none	none	none	none
Frequency	none	none	none	none	none	none
Reversibility	reversible	reversible	reversible	irreversible	irreversible	irreversible
Consequence	Level 1	Level 1	Level 1	Level 1	Level 1	Level 1
Likelihood	very unlikely	very unlikely	very unlikely	very unlikely	very unlikely	very unlikely
Risk	low	low	low	low	low	low
Confidence	high	high	high	high	high	high

5.12 Dissolved Copper

5.12.1 Introduction

Modelled D-Cu concentrations at BJ 3.10 increase throughout operations (Figure 5-17). The Base Case model shows that D-Cu is expected to increase to greater than the BC FWAL guideline during operations. The BC FWAL guideline is calculated using a biotic ligand model (BLM) that uses site water quality as inputs. BJ 3.10 water is moderately soft and has dissolved organic carbon levels that are typically below detection limit. Based on these inputs, the BLM calculates a long-term WQG of 0.0003 mg/L (0.3 µg/L) that is slightly greater than the routine analytical detection limit of 0.0002 mg/L (0.2 µg/L) that is provided by ALS Environmental laboratory. The maximum Base Case result during operations is 0.00042 mg/L (0.42 µg/L) and the maximum Upper Case during operations is 0.00087 mg/L (0.87 µg/L).

The D-Cu concentrations modelled at BJ 2.62 during closure are much higher than during operations, due to loadings from the flooded underground mine that report to Brucejack Creek through groundwater pathways. The maximum BJ 2.62 concentration during closure

is 0.00171 mg/L (1.71 µg/L) for the Base Case and 0.01052 (10.52 µg/L) for the Upper Case.

PE-107835 does not set a discharge limit at BJ 3.10 for D-Cu. D-Cu was not identified as a POPC in the application to increase the production rate to 3800 tpd (Pretium, 2018b) because the BC FWAL guideline was much higher at the time the application was submitted. The BLM-derived guidelines went into effect in 2019.

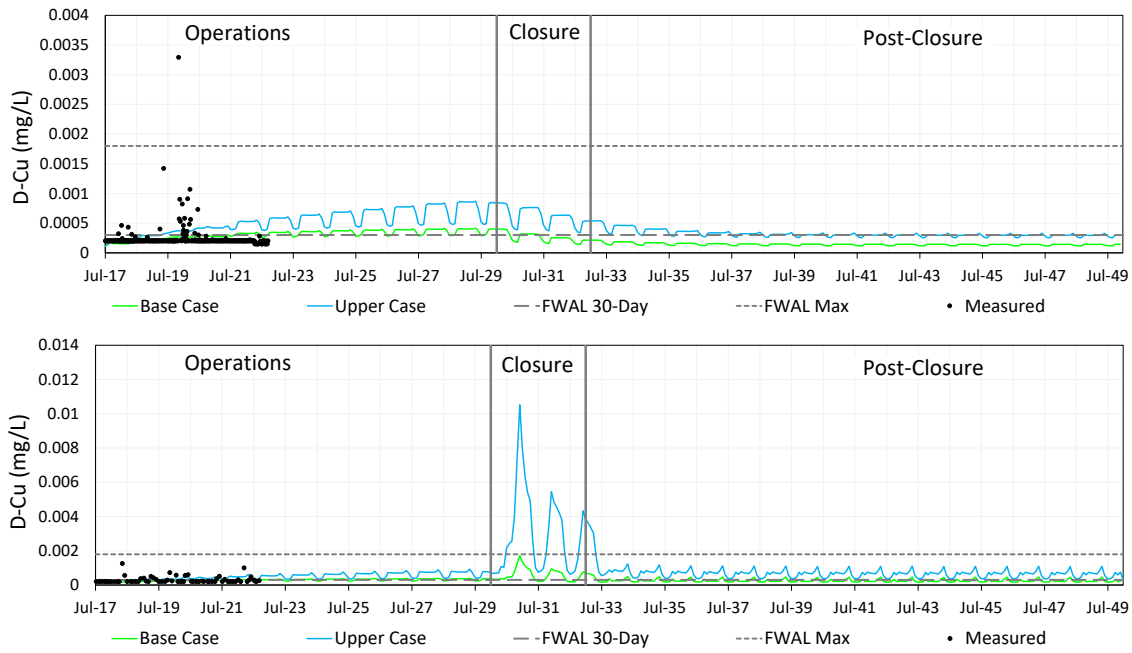


Figure 5-17: Modelled dissolved copper concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the BC FWAL guidelines and to measured concentrations.

5.12.2 Geographic Extent

The geographic extent of changes to water quality is defined as local if the modelled concentrations do not elevate concentrations at SC0 in upper Sulphurets Creek above the FWAL guideline, and regional if the modelled concentrations have the potential to cause SC0 concentrations to increase to greater than the FWAL guideline. Dissolved copper levels measured at SC0 from 2015 through 2021 are typically above the long-term FWAL guideline of 0.0003 mg/L (Table 5-15 and Figure 5-18). The high D-Cu levels that have been measured at SC0 are considered to be naturally occurring, and not induced by loadings from Brucejack Creek, because most BJ 3.10 and BJ 2.62 samples have had D-Cu concentrations below the detection limit of 0.0002 mg/L. Five of the 31 samples from SC0 had D-Cu levels greater than the peak Upper Case modelled concentration at BJ 2.62 (0.011 mg/L). During operations, the maximum Base Case concentration (0.00042 mg/L)

is less than the median D-Cu concentration at SC0, and the maximum Upper Case modelled concentration (0.00087 mg/L) is less than the average concentration at SC0. Because the typical D-Cu concentrations at SC0 are higher than Base Case and Upper Case modelled concentrations of D-Cu in Brucejack Creek, during all mine phases, the geographic extent of the modelled concentrations is categorized as **local**.

Table 5-15:
Summary statistics of dissolved copper concentrations in water quality samples collected at SC0 from 2015 through 2021.

Statistic	Concentration	Units
# samples	31	mg/L
Maximum	0.02150	mg/L
75th percentile	0.00578	mg/L
Median	0.00059	mg/L
Average	0.00417	mg/L
25th percentile	0.00033	mg/L
Minimum	0.00020	mg/L

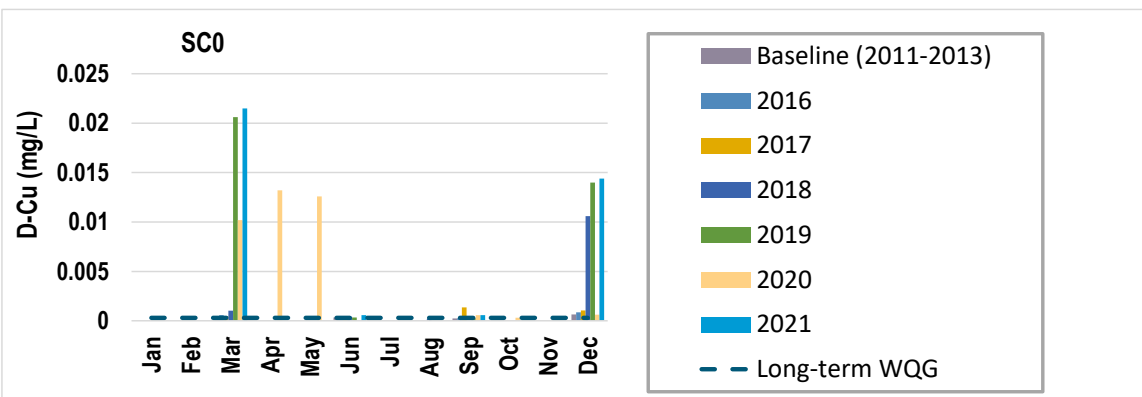


Figure 5-18: Dissolved copper concentrations in upper Sulphurets Creek measured quarterly since baseline.

5.12.3 Magnitude

The potential for D-Cu to cause toxicity to aquatic life in Brucejack Creek was assessed by conducting toxicity tests using water collected from BJ 3.10 and spiked with copper. The BJ 3.10 sample was collected on January 10, 2022 and shipped to Nautilus Environmental for testing. Species tested were the algae *Pseudokirchneriella subcapitata*, the duckweed *Lemna minor*, and the invertebrates *Ceriodaphnia dubia* and *Chironomus dilutus*. *P. subcapitata* and *C. dilutus* represent taxa commonly occurring in Brucejack Creek, and *C.*

dubia and *L. minor* are species of aquatic invertebrate and aquatic plant that the BLM model indicates are sensitive to chronic toxicity from D-Cu.

The Nautilus lab report from the site-specific D-Cu bioassays is provided as Appendix E. Acute toxicity to *C. dubia* occurred at 0.0122 mg/L (LC50 or median lethal endpoint) (Table 5-16). The acute toxicity endpoint for the chironomid *C. dilutus* was higher than any of the concentrations tested, up to 0.0310 mg/L. The plant and algae bioassays only tested growth, so did not have acute toxicity endpoints.

Table 5-16:
Results of toxicity testing of dissolved copper in BJ 3.10 water.

Endpoint	Units	*P. subcaptitata*	*L. minor* (frond count)	*L. minor* (dry wt.)	*C. dubia*	*C. dilutus*
Survival LC50	mg/L				0.0122	>0.0310
Growth or Reproduction IC20	mg/L	0.0023	0.0029	0.0034	0.0052	>0.0310
Growth or Reproduction IC50	mg/L	0.0166	>0.0103	>0.0103	0.0109	>0.0310

The aquatic plants and algae were more sensitive to chronic toxicity from D-Cu than the invertebrates species (Table 5-16). The lowest chronic endpoint was an IC20 of 0.0023 mg/L for the algae *P. subcapitata*. This is the concentration that caused a 20% reduction in growth rate of this algae. Note that the duckweed test measures growth in two ways: as the number of fronds that grow over the 7 day test and as the increase in dry weight over the 7 day test. The IC20 for frond count was slightly higher that the IC20 for growth of *P. subcapitata*. The lowest chronic endpoint from these bioassays (0.0023 mg/L) will be used as the toxicity benchmark for assessing the magnitude of potential toxicity from modelled concentrations of D-Cu in Brucejack Creek.

During operations both the Base Case and Upper Case model results are below the toxicity benchmark (Table 5-17). The peak concentrations that are modelled to occur during closure have the potential to cause chronic toxicity to sensitive species for the Base Case. The Upper Case peak is greater than the LC50 for *C. dubia* (Table 5-17); therefore, has the potential to cause acute toxicity to sensitive species. During post-closure, D-Cu concentrations decrease and stabilize at concentrations similar to operations.

Table 5-17:
Modelled dissolved copper concentrations compared to the low-effect chronic toxicity benchmark from site-specific bioassays.

Mine Phase	Model	Maximum Modelled (mg/L)	Toxicity Benchmark (mg/L)	Exceedance Factor
Operations	Base Case	0.00042	0.0023	0.18 ×
Operations	Upper Case	0.00087	0.0023	0.38 ×
Closure	Base Case	0.00171	0.0023	0.74 ×
Closure	Upper Case	0.01052	0.0023	4.57 ×
Post-closure	Base Case	0.00046	0.0023	0.20 ×
Post-closure	Upper Case	0.00109	0.0023	0.47 ×

The 4950 tpd model results during operations and post-closure are less than half the chronic toxicity threshold for both the Base Case and Upper Case; therefore, the magnitude of potential effects during operations and post-closure is categorized as **low**. During closure, the maximum Base Case model concentration is slightly less than the chronic toxicity benchmark; therefore, the magnitude of potential effect is categorized as **medium**. The maximum Upper Case concentration during closure has the potential to cause acute toxicity; therefore, the magnitude of potential effects is **high**.

5.12.4 Duration, Frequency, and Reversibility

Base Case and Upper Case modelled concentrations of D-Cu are less than half of the environmental benchmark of 0.0023 mg/L during operations and during post-closure. Thus, the modelled concentrations of D-Cu in Brucejack Creek during operations and during post-closure, for both model cases, are categorized as **none** for duration and frequency.

During closure, the Base Case D-Cu concentration is less than half of the environmental benchmark except for 3 months during the first year of closure; therefore, the duration is classified as **medium-term** and the frequency is classified as **regular**. During closure, the Upper Case D-Cu concentrations are seasonally greater than the environmental benchmark for each of the closure years; therefore, the duration is classified as **long-term**, the frequency is classified as **regular**.

Base Case D-Cu levels decrease to near baseline levels during post-closure; therefore, the Base Case modelled changes to D-Cu concentrations are **reversible**. Upper Case is modelled to stabilize with annual maxima of 0.00111 mg/L during post-closure. Since this concentration is well above the baseline levels, the Upper Case model results are considered **irreversible**.

5.12.5 Consequence

During operations and post-closure, toxicity to aquatic life in Brucejack Creek is not expected, for both the Base Case and Upper Case models, since maximum modelled concentrations are less than half the site-specific chronic toxicity benchmark (Table 5-17). Since the ecological context of Brucejack Creek is low, and no toxicity to aquatic life in Brucejack Creek is expected, the potential consequence of the Base Case and Upper Case modelled D-Cu concentrations is low (**Level 1**) during operations and post-closure.

During closure, there is potential for chronic toxicity to sensitive species from the maximum Base Case modelled concentration. This potential for minor effects on the biological ecosystem during closure makes the consequence **Level 2**. The Upper Case during closure has higher potential to cause chronic toxicity, and has the potential to cause acute toxicity to sensitive species. Given the low ecological context, the Upper Case during closure has the potential to cause moderate, short-term effects to the ecosystem which is categorized as **Level 3**.

5.12.6 Likelihood

To date, D-Cu concentrations at BJ 3.10 have typically been less that the Base Case model. The Upper Case model has overestimated D-Cu concentrations at BJ 3.10 and BJ 2.62. Episodes of D-Cu concentrations at BJ 3.10 that are greater than the Base Case and Upper Case model have occurred in association with elevated TSS. These monitoring results indicate that the Base Case model better represents D-Cu concentrations during operations. Toxicity to aquatic life in Brucejack Creek from Base Case concentrations during operations and post-closure is **very unlikely**.

There is uncertainty if Base Case modelled concentrations during closure will continue to be an overestimate of actual concentrations, since the sources of D-Cu change, as does the use of the water treatment plant and the pathway of loadings to Brucejack Creek. The Upper Case concentrations during closure are much higher than Base Case, and are less likely to occur than Base Case. The modelled closure scenario has accelerated flooding of the underground mine and recirculation of water through the water treatment plant for 15 months post-operations. Other mitigation scenarios have not yet been modelled, but will be modelled as part of closure planning for the underground mine. A Closure Underground Water Quality Adaptive Management Plan (Pretium, 2020e) was developed to describe potential mitigation options available to manage the flushing concentration peaks and ensure that underground mine pool water quality is suitable for discharge before reaching its spilling elevation (~1355 masl). The plan also identifies monitoring programs required to manage the potential risk associated with flooding at closure.

The opportunity to improve mitigation of D-Cu in flooded underground mine water makes it unlikely that closure peaks will be as high as currently modelled. Given that there is

potential for chronic toxicity to occur during closure to species that are sensitive to copper toxicity from the Base Case modelled D-Cu levels, but the modelled peaks during closure are unlikely to occur, the likelihood of toxicity to aquatic life in Brucejack Creek during closure is categorized as **unlikely** for the Base Case. Given that it is highly unlikely that Upper Case peaks during closure will occur, the likelihood of toxicity to aquatic life in Brucejack Creek during closure is also categorized as **unlikely** for the Upper Case.

5.12.7 Risk

During operations and post-closure, both Base Case and Upper Case model results have a Level 1 consequence and are very unlikely to cause toxicity; therefore, the risk of adverse effects from modelled D-Cu levels is **low** (Figure 5-2).

During closure, the Base Case has Level 2 consequence and is unlikely to cause toxicity; therefore, the risk of the Base Case causing adverse effects during closure is **low**.

During closure, the Upper Case has Level 3 consequence and is unlikely to cause toxicity; therefore, the risk of the Upper Case causing adverse effects during closure is **moderate**.

5.12.8 Confidence

The comparison of modelled D-Cu concentrations to five years of monitoring data provides high confidence that the Base Case model well represents expected D-Cu concentrations during operations, and that the Upper Case is an overestimate of D-Cu during operations. The site-specific toxicity testing that was done provides a direct measure of toxicity to species that are representative of aquatic life in Brucejack Creek, which provides a high level of confidence in the assessment of potential toxicity from modelled D-Cu levels to aquatic life in the receiving environment. Thus, there is **high** confidence in the assessment of potential risk to aquatic life from the modelled D-Cu concentrations during operations.

There is moderate confidence that observed D-Cu concentrations in Brucejack Creek will continue to be lower than the Base Case model during closure and post-closure. It is likely that closure planning will be able to mitigate the peak D-Cu concentrations that are modelled to occur during closure. The moderate uncertainty in how well the models represent D-Cu during closure provides **moderate** confidence in the assessment of risk to aquatic life in Brucejack Creek during closure.

The site-specific toxicity testing that indicates post-closure modelled concentrations of D-Cu have a low risk to aquatic life and provides **high** confidence in the assessment of risk during post-closure.

5.12.9 Summary

The risk of toxicity from Base Case and Upper Case modelled copper concentrations is categorized as low for all mine phases, except for the Upper Case during closure which has a moderate risk rating (Table 5-18).

Table 5-18:
Summary of effects assessment ratings for toxicity potential from modelled dissolved copper concentrations.

	Base Case			Upper Case		
	Operations	**Closure**	**Post-closure**	**Operations**	**Closure**	**Post-closure**
Ecological context	low	low	low	low	low	low
Resiliency	high	high	high	high	high	high
Geographic extent	local	local	local	local	local	local
Magnitude	low	medium	low	low	high	low
Duration	none	medium-term	none	none	long-term	none
Frequency	none	regular	none	none	regular	none
Reversibility	reversible	reversible	reversible	irreversible	irreversible	irreversible
Consequence	Level 1	Level 2	Level 1	Level 1	Level 3	Level 1
Likelihood	very unlikely	unlikely	very unlikely	very unlikely	unlikely	very unlikely
Risk	low	low	low	low	moderate	low
Confidence	high	moderate	high	high	moderate	high

5.13 Total Selenium

5.13.1 Introduction

Measured concentrations of T-Se at BJ 3.10 and BJ 2.62 have been well represented by the Base Case model (Figure 5-19). Base Case modelled T-Se has a maximum concentration during operations of 0.0021 mg/L, which is slightly greater than the BC FWAL guideline of 0.0020 mg/L. The peak concentration during closure is 0.0037 mg/L. T-Se is modelled to decrease during closure and post-closure to steady state concentrations with an annual range of 0.0002-0.0005 mg/L.

Measured concentrations of T-Se have been below the Upper Case modelled concentrations. The Upper Case has a maximum concentration during operations of 0.0062 mg/L and a peak during closure of 0.0150 mg/L. Upper Case T-Se concentrations decrease during closure and post-closure to steady state concentrations with an annual range of 0.0003-0.0011 mg/L.

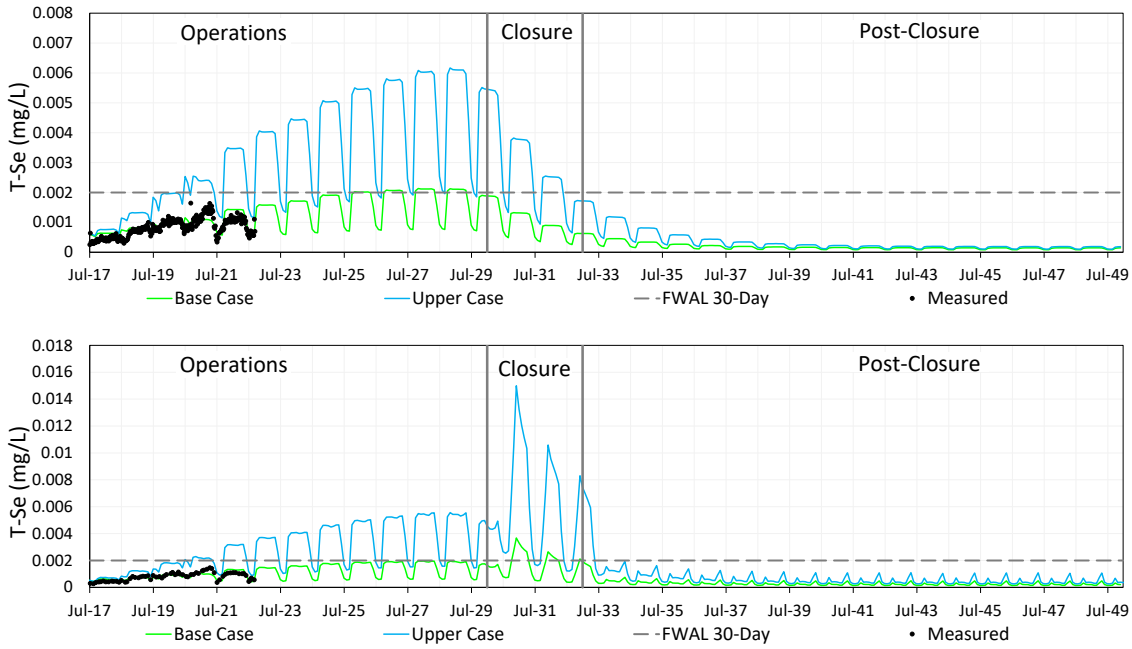


Figure 5-19: Modelled total selenium concentrations at BJ 3.10 (top) and BJ 2.62 (bottom) compared to the BC FWAL guideline and to measured concentrations.

The BC FWAL guidelines for Se were developed based on the taxa shown to be most sensitive to Se exposure, namely fish and aquatic birds (BCMOE 2014). It is generally thought that algae and invertebrates are fairly tolerant to elevated Se concentrations, and the more important role these organisms play is in the transfer of Se into the aquatic food web (Janz *et al.*, 2010). Inorganic Se in water can be taken up by primary producers, such as periphyton, and incorporated into tissues as organic forms of Se. These organic Se forms have the potential to bioaccumulate in higher trophic levels to tissue concentrations that can cause reproductive impairments, such as decreased fertility, reduced egg hatchability, and increased frequency of deformity in embryos.

5.13.2 Ecological Context

Egg laying vertebrates (fish, aquatic birds, and amphibians) are potential receptors for adverse effects from Se in water. Fish are not present in Brucejack Creek or upper Sulphurets Creek (Rescan, 2013a). A fish barrier is present near the mouth of Sulphurets Creek, approximately 1.3 km upstream from the Unuk River. No fish occur upstream of this barrier, meaning the nearest fish-bearing water to the WRTSF is approximately 23 km downstream.

Baseline monitoring of waterbirds found that riverine birds, such as American dippers, were present outside of the local study area but were not observed in the Brucejack Creek area (Rescan 2013b). The baseline survey results indicate the birds that feed primarily on

benthic invertebrates in Brucejack Creek are uncommon or not present. An aquatic bird survey of the Brucejack Creek area was conducted in July 2022 to supplement the baseline survey results (ERM, 2022a; memo included as Appendix F). An aerial survey spotted seven shorebirds in the vicinity of Brucejack Creek, none of which could be identified. A ground survey found one sandpiper, one semipalmated plover, and feathers and scat of Canada goose in the vicinity of Brucejack Creek. None of the identified species are listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or the British Columbia Conservation Data Centre. The memo notes that the sandpiper and plover observed in July could either be breeding residents or fall transients. Residents typically spend roughly three months in the area and rear young, meanwhile transients average closer to a four-day stay (Farmer and Durbian, 2006). While these species are present in the area, they have the potential to feed on aquatic insects in Brucejack Creek. Canada goose have the potential to consume food beside the creek but are not expected to feed on aquatic invertebrates in the creek.

A survey for amphibians along Brucejack Creek was also conducted in July 2022 (ERM, 2022a; Appendix F). No amphibians were observed. The memo concludes that Brucejack Creek is poor habitat for western toad (a provincially blue-listed species), because the elevation of the creek is too high and ponds thaw after the toad breeding season. In addition, the creek does not provide the very low flow and warm water that toads prefer.

Considering that Brucejack Creek does not contain fish or amphibians, and has the potential for a small number of birds to feed on benthic invertebrates in the creek during the short open-water season, the ecological context of Brucejack Creek for aquatic life to potentially experience adverse effects from selenium is considered **low**.

5.13.3 Geographic Extent

The geographic extent of effects to T-Se concentrations is assessed by estimating if concentrations in upper Sulphurets Creek, at SC0, have the potential to become elevated above the long-term WQG (0.002 mg/L). This is done using a mass balance equation and a minimum mixing ratio of 6:1 (parts SC0 to parts Brucejack Creek water) (see section 5.5).

Baseline median T-Se concentration at SC0 during sQ4 is 0.00027 mg/L. The maximum modelled T-Se concentration during the operations phase is 0.0062 mg/L. With minimal mixing ratio of 6:1, the maximum final concentration at SC0 during operations is 0.0011 mg/L, which is less than the BC FWAL guideline of 0.002 mg/L (Table 5-19). Because modelled discharge from the WRTSF does not increase concentration at SC0 to above the FWAL guideline, the geographic extent of effects to water quality during operations is **local**.

During closure, the maximum Base Case model result has the potential to raise T-Se concentration at SC0 to 0.0008 mg/L (Table 5-19); therefore, the geographic extent for Base Case during closure is **local**. The maximum Upper Case model result during closure has the potential to raise T-Se concentration at SC0 to 0.0024 mg/L (Table 5-19), which is above the FWAL guideline of 0.0020 mg/L; therefore, the geographic extent for Upper Case during closure is **regional**. If concentrations in Brucejack Creek reached the Upper Case peak concentration during closure, a mixing ratio of 8:1 would be needed to dilute T-Se to below the guideline, which is expected occur at SC0 except in the low flow months of December and January (Table 5-3).

The geographic extent during post-closure is **local** for both the Base Case and Upper Case.

Solving the mass balance equation for C_1 when the final concentration at SC0 is set to 0.0019 mg/L (just below the BC FWAL guideline) shows that a discharge of up to 0.0117 mg/L at BJ 3.10 will not cause the concentration at SC0 to increase above the BC FWAL guideline.

Table 5-19:
Final total selenium conentration in upper Sulphurets Creek for maximum modelled concentrations in Brucejack Creek during different mine phases.

Mine Phase	Model	C_1 (mg-N/L)	C_2 (mg-N/L)	V_2	V_1	C_f (mg-N/L)
Operations	Base Case	0.0021	0.00027	6	1	0.0005
Operations	Upper Case	0.0062	0.00027	6	1	0.0011
Closure	Base Case	0.0037	0.00027	6	1	0.0008
Closure	Upper Case	0.0150	0.00027	6	1	**0.0024**
Post-closure	Base Case	0.0005	0.00027	6	1	0.0003
Post-closure	Upper Case	0.0011	0.00027	6	1	0.0004
	Maintain SC0 under the FWAL guideline	0.0117	0.00027	6	1	0.0019

5.13.1 Magnitude

Potential adverse effects from elevated selenium levels in Brucejack Creek are toxicity to aquatic birds. The most direct means of determining the potential for toxic effects of Se in birds is through measurement of Se concentrations in eggs (BCMOE, 2014). The BC FWAL guideline for bird eggs is 6 µg/g dry weight. BC also developed a water quality guideline (0.002 mg/L) as an indirect measure of potential risk of toxic effects to fish and aquatic birds, because sampling water is much more commonly done and does not require sacrificing a bird egg. The T-Se water quality guideline provides a benchmark for assessing water quality model results.

The Base Case model during operations has a maximum concentration approximately equal to the guideline for protection of aquatic life (Table 5-20). The Upper Case model during operations has a maximum concentration that is 3.1 times the FWAL guideline. The peak in T-Se that is modelled to occur early in closure results in concentrations that are up to twice the FWAL guideline for the Base Case and 7.5 times the FWAL guideline for the Upper Case.

Table 5-20:
Modelled selenium concentrations compared to the BC FWAL guideline.

Mine Phase	Model	Maximum Modelled (mg/L)	FWAL guideline (mg/L)	Exceedance Factor
Operations	Base Case	0.0021	0.002	1.1 ×
Operations	Upper Case	0.0062	0.002	3.1 ×
Closure	Base Case	0.0037	0.002	1.8 ×
Closure	Upper Case	0.0150	0.002	7.5 ×
Post-closure	Base Case	0.0005	0.002	0.2 ×
Post-closure	Upper Case	0.0011	0.002	0.5 ×

The BC FWAL long-term guidelines are intended to protect the most sensitive species and most sensitive life stage against sub-lethal and lethal effects for indefinite exposures. Thus, model results that are less than or equal to the guideline will have a low potential to cause toxicity. The magnitude of the potential to cause toxicity should increase with increasing concentration of T-Se in water, because higher T-Se levels in water should cause higher tissue Se concentrations in benthic invertebrates which may be a source of food to birds. The magnitude of the potential to cause toxicity will also depend on the proportion of a bird's diet that comes from benthic invertebrates in Brucejack Creek, and the timing of foraging in Brucejack Creek. If tissue selenium concentrations of invertebrates in Brucejack Creek become elevated, then resident birds have a greater chance of accumulating Se in their eggs than do migrant individuals. As well, birds that feed on a Se rich diet while eggs are developing have a greater potential for toxic effects than birds that feed on Se rich diet only after the breeding season.

The aquatic birds that were observed in the vicinity of Brucejack Creek in July 2022 have the potential to be resident during the open water season, and to feed in Brucejack Creek before the breeding season. Therefore, water quality model results that are between 1 and 2 times the BC FWAL guideline will be categorized as having moderate potential to cause toxic effects, and concentrations greater than twice the guideline will be categorized as having a high potential. Thus, Base Case is **low** magnitude during operations, a **medium**

magnitude during closure, and a **low** magnitude during post-closure. Upper Case has a **high** magnitude during operations and closure, and a **low** magnitude during post-closure.

5.13.2 Duration, Frequency, and Reversibility

Base Case modelled concentrations of T-Se are seasonally slightly above the FWAL guideline for the last few years of operations, increase during the first year of closure, then decrease to below the guideline during post-closure (Figure 5-19). Thus, T-Se levels in Brucejack Creek for the Base Case model are categorized as being elevated for a **long-term** duration, occur **regularly**, and are **reversible**.

Upper Case modelled concentrations of T-Se are above the FWAL guideline for most of operations and closure, then decrease to below the guideline during post-closure. Thus, T-Se levels in Brucejack Creek for the Upper Case model are categorized as being elevated for a **long-term** duration, occur **continuously**, and are **reversible**.

5.13.3 Consequence

Elevated levels of T-Se in Brucejack Creek have the potential to bioaccumulate in benthic invertebrates. Brucejack Creek invertebrates are not a source of food to fish but may be food for the small number of aquatic birds that occur in the vicinity of Brucejack Creek. Base Case modelled concentrations of T-Se are not expected to result in toxic effects during operations (**Level 1**). Base Case modelled concentrations have the potential to cause toxic effects for one breeding season during closure (**Level 2**). Base Case results during post-closure are below the BC FWAL guideline (**Level 1**).

The Upper Case T-Se levels during operations and closure have potential to cause toxicity to a small populations of birds, but not to other parts of the Brucejack Creek ecosystem (**Level 3**). Upper Case results during post-closure are below the BC FWAL guideline (**Level 1**).

5.13.4 Likelihood

To date, T-Se concentrations at BJ 3.10 have been well represented by the Base Case model and overestimated by the Upper Case model (Figure 5-19). Base Case modelled T-Se concentrations are likely to occur, but toxicity to aquatic life from Base Case concentrations during operations is **very unlikely**. The Upper Case model has overestimated T-Se concentrations during the last 5 years of monitoring, and it is **very unlikely** that Upper Case concentrations will be observed during operations and result in toxicity to aquatic life.

During closure, the Base Case model is still the expected case and Upper Case modelled T-Se concentrations represent the upper range of potential changes to T-Se levels in Brucejack Creek. The modelled closure scenario includes mitigation measures of

accelerated flooding of the underground mine and recirculation of water through the water treatment plant for 15 months post-operations. Other mitigation scenarios that could reduce the peak T-Se concentrations during closure have not yet been modelled, but will be as part of closure planning. A Closure Underground Water Quality Adaptive Management Plan (Pretium, 2020e) was developed to describe potential mitigation options available to manage the flushing concentration peaks and ensure that the underground mine pool water quality is suitable for discharge before reaching its spilling elevation (~1355 masl). The plan also identifies monitoring programs required to manage the potential risk to water quality in Brucejack Creek associated with flooding at closure.

The opportunity to improve mitigation of T-Se in flooded underground mine water makes it unlikely that closure peaks will be as high as currently modelled. Given that there is potential for toxicity to aquatic birds during closure from the Base Case modelled T-Se levels, but the modelled peaks during closure are unlikely to occur, the likelihood of toxicity to aquatic life in Brucejack Creek during closure is categorized as **unlikely** for the Base Case. Given that it is highly unlikely that Upper Case peaks during closure will occur, the likelihood of toxicity to aquatic birds in the Brucejack Creek vicinity during closure is also categorized as **unlikely** for the Upper Case.

During post-closure, the likelihood of toxicity to aquatic birds in the Brucejack Creek vicinity is categorized as **very unlikely**, for both the Base Case and Upper Case.

5.13.5 Risk

During operations and post-closure, the Base Case model has Level 1 consequence and is very unlikely to cause toxicity; therefore, the risk of adverse effects is **low**. During closure, the Base Case model has Level 2 consequence and is unlikely to cause toxicity; therefore, the risk of adverse effects is **low**.

The Upper Case model has Level 3 consequence during operations and closure. Toxic effects to aquatic birds from Upper Case concentrations occurring during operations is highly unlikely, and is categorized as unlikely during closure. Thus, the risk of adverse effects from Upper Case T-Se levels is **low** during operations and **moderate** during closure. The post-closure, Upper Case consequence is Level 1 and the likelihood is very unlikely; therefore, the risk of adverse effects is **low**.

5.13.6 Confidence

Confidence that T-Se concentrations during operations are represented by the Base Case model is high, and that Base Case modelled T-Se concentrations will not cause toxicity is also **high**, since maximum concentrations are equal to the BC FWAL guideline.

There is uncertainty how T-Se levels that are greater than the BC FWAL guideline will bioaccumulate in the Brucejack Creek aquatic ecosystem. Aquatic birds are the potential

receptor for toxic effects from T-Se in Brucejack Creek. Selenium could cause toxicity to aquatic birds if it accumulates in the tissues of benthic invertebrates, and if the benthic invertebrates are a primary source of food for the birds prior to the breeding season. The assessment assumes that the birds that are present in the Brucejack Creek vicinity receive a high proportion of their diet from benthic invertebrates in the creek, and that they are resident populations that feed in Brucejack Creek prior to breeding and can accumulate selenium in their eggs. Given that these conservative assumptions were made about the potential for toxic effects to aquatic birds, and the uncertainty in the applicability of the bioaccumulation model used to derive the BC FWAL guideline to the Brucejack Creek ecosystem, the confidence in risk assessment ratings for model results that are greater than the BC FWAL guideline (Upper Case model during operations and closure, and the Base Case model during closure) is **moderate**. The confidence in post-closure ratings is **high**.

5.13.7 Summary

The risk of toxicity from Base Case and Upper Case modelled selenium concentrations is categorized as low for all mine phases (Table 5-21).

Table 5-21:
Summary of effects assessment ratings for toxicity potential from modelled dissolved copper concentrations.

	Base Case			Upper Case		
	Operations	**Closure**	**Post-closure**	**Operations**	**Closure**	**Post-closure**
Ecological context	low	low	low	low	low	low
Resiliency	high	high	high	high	high	high
Geographic extent	local	local	local	local	regional	local
Magnitude	low	medium	low	high	high	low
Duration	long-term	long-term	long-term	long-term	long-term	long-term
Frequency	regular	regular	regular	continuous	continuous	continuous
Reversibility	reversible	reversible	reversible	reversible	reversible	reversible
Consequence	Level 1	Level 2	Level 1	Level 3	Level 3	Level 1
Likelihood	very unlikely	unlikely	very unlikely	very unlikely	unlikely	very unlikely
Risk	low	low	low	low	moderate	low
Confidence	high	moderate	high	moderate	moderate	high

5.14 Human Health

Health Canada drinking water guidelines are designed to protect the health of the most vulnerable members of society, such as children and the elderly, from long-term exposure. The Assessment of Potential Health Effects carried out for the Application/EIS (Chapter 21 of Rescan, 2013) concluded that it is unlikely that people drink water from the Brucejack watershed. This conclusion was based on the inaccessibility of the watershed, the cold

weather during winter, absence of country foods such as fish in the area, and general low use of the Brucejack watershed by individuals from First Nations groups or the general public (Appendix 21-A of Chapter 21 of the Application/EIS; Rescan, 2013). There was no indication of Skii km Lax Ha or other First Nations obtaining drinking water from the Mine Site Area.

Since modelled concentrations in Brucejack Creek are above drinking water guidelines for some parameters, untreated Brucejack Creek water should not be used as the drinking water source for the mine camp. Mine camp drinking water is currently taken from a potable water well.

5.15 Summary of Risk Assessment of POCs

Model results were screened using ecological benchmarks, either discharge limits or BC FWAL guidelines for parameters that don't have discharge limits. Eight parameters were identified as parameters of potential concern using this screening method. Ammonia, sulfate, and D-Al were further evaluated and determined to not be parameters of concern. The remaining five parameters (nitrate, nitrite, T-As, D-Cu and T-Se) were assessed for Base Case and Upper Case modelled concentrations to cause adverse effects to aquatic life in Brucejack Creek, during each phase of mine life. The potential for modeled concentrations of POCs to cause toxic effects to aquatic life in Brucejack Creek was assessed. The potential for modeled concentrations of nitrate to cause eutrophication was also assessed. The potential risk of adverse effects was rated as low, for all POCs, for both Base Case and Upper Case, for all mine phases, with the exception of the Upper Case model result for T-Se during closure (Table 5-22). If Upper Case T-Se concentrations during closure are not mitigated, there is moderate risk for toxic effects to aquatic birds breeding in the vicinity of Brucejack Creek.

Table 5-22:
Summary of risk ratings for Base Case and Upper Case modelled concentrations of parameters of concern.

	Base Case			Upper Case		
	Operations	Closure	Post-closure	Operations	Closure	Post-closure
Nitrate (eutrophication)	low	low	low	low	low	low
Nitrate (toxicity)	low	low	low	low	low	low
Nitrite	low	low	low	low	low	low
Total arsenic	low	low	low	low	low	low
Dissolved copper	low	low	low	low	low	low
Total selenium	low	low	low	low	moderate	low

6 Summary

The Brucejack Mine water quality model has been updated in support of an application to increase the mine's production rate to 4950 tpd. The updated model applies the 4950 tpd mine plan and incorporates an updated groundwater model, an updated water balance model, new geochemical data sets, and operational data acquired through the mine's various monitoring programs.

The overall approach for modelling water quality follows what has been presented in previous model reports (*e.g.*, Lorax 2020a), but applies recent monitoring and experimental data sets where applicable. Notable updates for the 2023 water quality model include:

- An updated groundwater model which incorporates the 4950 tpd mine plan and recent flow observations (Lorax, 2023a).
- Revision to the site's water balance based on observed flows, changes to the mine plan and updated water management plans (described in Lorax, 2023b).
- Revision to assumptions regarding WRTSF mixing behaviour where a spring turnover event is not included in the model beyond 2019 (Section 2.1.8).
- Application of operational monitoring results to the background source term for parameters where recent data show lower concentrations than baseline data sets (Section 3.1).
- Refinement of water treatment plant removal efficiencies based on operational data sets (Section 3.5).
- Revision to the STP effluent term using operational water quality data sets for all parameters (Section 3.7).

The water quality model results and the associated effects assessment are summarized as follows:

- Based on predicted water quality for operation, closure and post-closure phases, parameters of potential concern were identifed as having maximum Base Case modelled concentrations above 80% of relevant benchmarks (either discharge limits or FWAL guidelines). POPCs identified were ammonia, nitrite, nitrate, sulfate, aluminum, arsenic, copper, and selenium. These POPCs were assessed for potential to cause toxicity to aquatic life in the receiving environment.
- The maximum Base Case prediction for ammonia at BJ 3.10 (3.53 mg-N/L) occurs during the operations phase, with loads primarily attributed to the deposition of

waste rock in the WRTSF. Maximum Base Case predictions at BJ 2.62 (3.21 mg-N/L) occur during closure when flushing loads are released from the underground mine upon flooding. Ammonia is not predicted to go above the current discharge limit of 4.0 mg-N/L at any point during LOM.

- The maximum Base Case prediction for nitrite at BJ 3.10 (0.13 mg-N/L) is below the current discharge limit of 0.24 mg/L. Base Case predictions at BJ 2.62 go up to the current discharge limit (0.24 mg-N/L) during closure when flushing loads are released from the underground mine upon flooding. This flushing peak is of short duration (one month) and will be managed as per the Underground Water Quality at Closure Adaptive Management Plan (Pretium, 2020e) to ensure that concentrations in the receiving environment remain below the discharge limit.
- The maximum Base Case predictions for nitrate at BJ 3.10 (15.2 mg-N/L) and BJ 2.62 (13.8 mg-N/L) occur during the operations phase, with loads attributed to blasting residues associated with waste rock deposited in the WRTSF. Nitrate levels measured in Brucejack Creek during operations have been well represented by the Base Case model, and the updated model predicts that nitrate will go above the current discharge limit of 11.5 mg-N/L. An effects assessment was carried out on the modelled nitrate concentrations, supported by site-specific toxicity testing. The effect assessment concluded that there is low risk of eutrophication and low risk of toxicity to aquatic life in Brucejack Creek, for both the Base Case and Upper Case models.
- The maximum Base Case prediction for sulfate at BJ 3.10 (114 mg/L) occurs during the operations phase, with loads dominantly attributed to tailings effluent discharged to the WRTSF. Maximum Base Case predictions at BJ 2.62 (197 mg/L) occur during closure when flushing loads are released from the underground mine upon flooding. Base Case modelled sulfate concentrations are below the BC FWAL guideline applicable to the modelled hardness levels; therefore, toxicity to aquatic life in the receiving environment is unlikely.
- The maximum Base Case predictions for D-Al at BJ 3.10 (0.062 mg/L) and BJ 2.62 (0.057 mg/L) occur during the operations phase, with mine-related loads dominantly attributed to the deposition of waste rock in the WRTSF. Base Case D-Al concentrations go above the long-term BC FWAL guideline of 0.05 mg/L, but the model is considered to be overly conservative with respect to D-Al since it does not account for solubility-controlled precipitation reactions. Monitoring of D-Al at BJ 3.10 has shown that measured concentrations have been lower than Base Case predictions, which supports the conclusion that solubility-controlled

precipitation reactions are occuring and concentrations above the BC FWAL guideline are not anticipated.

- The maximum Base Case prediction for T-As at BJ 3.10 (0.014 mg/L) occurs early in the operations phase, with loads dominantly attributed to waste rock placed in the WRTSF. Maximum Base Case predictions at BJ 2.62 (0.012 mg /L) also occur during operations. A concentration peak at BJ 2.62 of 0.011 mg/L is predicted during closure when flushing loads are released from the underground mine upon flooding. T-As concentrations at BJ 3.10 and BJ 2.62 are predicted to exceed the mine's current discharge limit of 0.010 mg/L during operations, as well as at BJ 2.62 during closure. An effects assessment, which included the results of three separate site-specific toxicity tests, concluded that there is low risk of toxicity to aquatic life in the receiving environment, for both the Base Case and Upper case models.
- The maximum Base Case prediction for D-Cu at BJ 3.10 (0.00042 mg/L) occurs at the end of the operations phase, with loads dominantly attributed to background runoff and waste rock deposited in the WRTSF. Maximum Base Case D-Cu predictions at BJ 2.62 (0.0017 mg/L) occur during closure when flushing loads are released from the underground mine upon flooding. Predicted D-Cu concentrations at BJ 3.10 and BJ 2.62 are consistenly greater than the BC FWAL long-term guideline but remain below the BC FWAL short-term guideline. An effects assessment, which included results of site-specific toxicity testing of four species, concluded that there is low risk of toxicity to aquatic life in the receiving environment for both the Base Case and Upper Case models.
- The maximum Base Case prediction for T-Se at BJ 3.10 (0.0021 mg/L) occurs during the operations phase, with loads dominantly attributed to tailings effluent and waste rock placed in the WRTSF. Maximum Base Case T-Se predictions at BJ 2.62 (0.0037 mg/L) occur during closure when flushing loads are released from the underground mine upon flooding. T-Se concentrations at both BJ 3.10 and BJ 2.62 are predicted to go above the BC FWAL long-term guideline of 0.002 mg/L. An effects assessment concluded that there is low risk of toxicity to aquatic life in the receiving environment, including waterbirds, from both the Base Case and Upper Case models.

Water quality monitoring results have shown that water has and is continuing to be managed to meet the requirements of PE-107835, including effluent quality limits. Concentrations of metals and other parameters monitored at the outlet of the WRTSF have been below the current limits in PE-107835 and/or below BC FWAL guidelines. The

4950 tpd Base Case water quality model predicts that certain parameters (nitrite, nitrate, T-As, D-Cu, and T-Se) will be equal to or greater than the mine's current discharge limits or BC FWAL guidelines. However, based on the effects assessment results presented in Section 5, the anticipated concentrations of these parameters are unlikely to cause toxicity to aquatic life in Brucejack Creek.

Efforts to reduce model uncertainty and advance closure planning will be on-going throughout mine operations. Model uncertainties will be addressed through continued assessment of data collected through the environmental monitoring programs and specific analytical programs designed to target key areas of uncertainty. The environmental management plans in effect outline sampling recommendations, management triggers, and corrective actions that are designed to minimize potential adverse effects to water quality. These include monitoring programs developed for surface water, groundwater, WTP influent and effluent, STP discharge, mine site contact water, waste rock, NPAG quarry rock, tailings, paste backfill, and underground mine water. The results will be evaluated to identify potential environmental issues, to improve understanding of site-specific geochemical behaviour, and to verify the site-wide water quality model.

Recommendations to reduce model uncertainty that go beyond work described in environmental management plans are as follows:

- Saturated column tests on WTP sludge if the chemistry of mine water changes significantly or if modifications are made to the water treatment process.
- Kinetic tests on tailings if changes are made to the milling process such that the chemistry of the tailings changes significantly.
- An assessment of water treatment plant removal efficiencies using the sodium sulfide treatment process to refine contigency plans.

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Appendix A-1: BJ 3.10 Results

Appendix A-1-1: Base BJ 3.10 Base Case Water Quality Predictions

Operations

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg
1	Jan	3.50	**15.1**	0.127	8.16	0.284	113	0.0000125	***0.0614***	0.0132	0.132	0.0425	0.0000329	0.0000339	19.3	0.0000115	0.000264	0.000113	***0.000404***	0.00830	0.00000394	17.4	0.123	2.10
2	Feb	3.50	**15.1**	0.127	8.15	0.283	113	0.0000125	***0.0614***	0.0132	0.132	0.0425	0.0000329	0.0000338	19.3	0.0000115	0.000264	0.000113	***0.000403***	0.00830	0.00000394	17.4	0.123	2.10
3	Mar	3.50	**15.1**	0.127	8.15	0.283	113	0.0000125	***0.0614***	0.0132	0.132	0.0425	0.0000329	0.0000338	19.3	0.0000115	0.000264	0.000113	***0.000403***	0.00830	0.00000394	17.4	0.123	2.10
4	Apr	3.51	**15.1**	0.127	8.16	0.283	113	0.0000125	***0.0614***	0.0132	0.132	0.0425	0.0000329	0.0000338	19.4	0.0000115	0.000265	0.000113	***0.000402***	0.00831	0.00000394	17.4	0.123	2.11
5	May	3.43	**14.8**	0.124	7.97	0.277	110	0.0000123	***0.0601***	0.0130	0.129	0.0419	0.0000324	0.0000339	19.0	0.0000115	0.000260	0.000112	***0.000420***	0.00819	0.00000388	16.9	0.120	2.07
6	Jun	2.49	10.7	0.0901	5.89	0.205	83.3	0.0000101	0.0474	0.00962	0.0959	0.0377	0.0000281	0.0000312	16.0	0.00000984	0.000206	0.0000931	***0.000372***	0.00719	0.00000343	12.4	0.0884	1.59
7	Jul	1.40	6.05	0.0508	3.40	0.121	50.7	0.00000795	0.0335	0.00572	0.0558	0.0346	0.0000240	0.0000287	12.6	0.00000790	0.000139	0.0000738	0.000290	0.00625	0.00000301	7.04	0.0499	1.02
8	Aug	1.13	4.85	0.0408	2.79	0.0996	42.6	0.00000749	0.0297	0.00479	0.0456	0.0345	0.0000234	0.0000290	12.0	0.00000757	0.000124	0.0000697	0.000293	0.00611	0.00000294	5.70	0.0402	0.884
9	Sep	1.04	4.50	0.0378	2.61	0.0936	40.5	0.00000737	0.0285	0.00458	0.0430	0.0346	0.0000233	0.0000296	11.8	0.00000757	0.000121	0.0000685	***0.000313***	0.00606	0.00000292	5.32	0.0377	0.850
10	Oct	3.39	**14.6**	0.123	7.97	0.277	110	0.0000122	***0.0593***	0.0127	0.129	0.0408	0.0000326	0.0000337	19.9	0.0000113	0.000285	0.000122	***0.000401***	0.00822	0.00000382	16.9	0.124	2.22
11	Nov	3.53	**15.2**	0.128	8.25	0.287	114	0.0000125	***0.0617***	0.0133	0.134	0.0413	0.0000331	0.0000340	20.3	0.0000116	0.000294	0.000125	***0.000408***	0.00837	0.00000388	17.5	0.128	2.30
12	Dec	3.50	**15.1**	0.127	8.17	0.284	113	0.0000125	***0.0613***	0.0132	0.133	0.0413	0.0000330	0.0000339	20.2	0.0000115	0.000292	0.000124	***0.000405***	0.00834	0.00000387	17.4	0.127	2.28

Closure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg
1	Jan	2.19	9.44	0.0794	7.84	0.263	110	0.0000120	0.0251	0.00601	0.131	0.0388	0.0000325	0.0000337	20.2	0.0000115	0.000291	0.000124	***0.000401***	0.00834	0.00000308	15.4	0.127	2.28
2	Feb	2.19	9.41	0.0791	7.82	0.262	110	0.0000120	0.0251	0.00600	0.130	0.0388	0.0000324	0.0000337	20.2	0.0000115	0.000291	0.000124	***0.000400***	0.00833	0.00000308	15.4	0.127	2.27
3	Mar	2.18	9.38	0.0789	7.79	0.261	109	0.0000120	0.0251	0.00598	0.130	0.0388	0.0000324	0.0000336	20.1	0.0000114	0.000290	0.000124	***0.000399***	0.00833	0.00000308	15.3	0.126	2.27
4	Apr	2.17	9.35	0.0786	7.77	0.261	109	0.0000120	0.0251	0.00597	0.130	0.0388	0.0000323	0.0000336	20.1	0.0000114	0.000289	0.000124	***0.000399***	0.00832	0.00000308	15.3	0.126	2.27
5	May	2.11	9.08	0.0763	7.55	0.253	106	0.0000117	0.0247	0.00580	0.126	0.0381	0.0000316	0.0000329	19.7	0.0000112	0.000282	0.000121	***0.000389***	0.00815	0.00000302	14.8	0.122	2.21
6	Jun	1.53	6.57	0.0553	5.54	0.186	79.2	0.00000959	0.0217	0.00432	0.0922	0.0346	0.0000270	0.0000290	16.3	0.00000937	0.000217	0.0000985	***0.000307***	0.00704	0.00000276	10.8	0.0886	1.68
7	Jul	0.806	3.47	0.0292	3.04	0.104	46.2	0.00000737	0.0188	0.00253	0.0509	0.0326	0.0000228	0.0000260	12.5	0.00000734	0.000140	0.0000745	0.000214	0.00602	0.00000262	5.76	0.0469	1.03
8	Aug	0.594	2.56	0.0215	2.31	0.0793	36.6	0.00000680	0.0178	0.00202	0.0388	0.0328	0.0000219	0.0000255	11.6	0.00000680	0.000118	0.0000684	0.000189	0.00578	0.00000261	4.28	0.0347	0.844
9	Sep	0.505	2.17	0.0183	2.01	0.0692	32.7	0.00000654	0.0171	0.00182	0.0337	0.0328	0.0000213	0.0000251	11.3	0.00000659	0.000110	0.0000656	0.000178	0.00564	0.00000258	3.67	0.0296	0.772
10	Oct	1.46	6.31	0.0530	5.46	0.184	84.5	0.00000990	0.0211	0.00424	0.0907	0.0364	0.0000278	0.0000299	17.9	0.0000102	0.000228	0.000102	***0.000316***	0.00723	0.00000285	10.7	0.0877	2.19
11	Nov	1.49	6.41	0.0539	5.55	0.187	86.3	0.0000100	0.0212	0.00432	0.0922	0.0367	0.0000281	0.0000301	18.2	0.0000104	0.000233	0.000103	***0.000321***	0.00729	0.00000287	10.9	0.0892	2.26
12	Dec	1.47	6.33	0.0532	5.49	0.185	85.5	0.0000100	0.0212	0.00428	0.0912	0.0367	0.0000280	0.0000300	18.1	0.0000104	0.000232	0.000103	***0.000319***	0.00727	0.00000287	10.8	0.0882	2.24

PostClosure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg
1	Jan	0.603	2.60	0.0218	2.51	0.0889	55.2	0.00000750	0.0171	0.00226	0.0405	0.0343	0.0000225	0.0000260	15.6	0.00000931	0.000151	0.0000740	0.000214	0.00594	0.00000265	5.31	0.0375	2.18
2	Feb	0.601	2.59	0.0218	2.50	0.0887	55.1	0.00000750	0.0171	0.00226	0.0404	0.0344	0.0000225	0.0000260	15.6	0.00000931	0.000151	0.0000740	0.000214	0.00595	0.00000266	5.30	0.0374	2.18
3	Mar	0.599	2.58	0.0217	2.49	0.0885	55.0	0.00000751	0.0172	0.00226	0.0403	0.0344	0.0000225	0.0000260	15.6	0.00000930	0.000151	0.0000740	0.000214	0.00595	0.00000266	5.29	0.0373	2.18
4	Apr	0.597	2.57	0.0216	2.49	0.0883	54.9	0.00000751	0.0172	0.00225	0.0402	0.0344	0.0000225	0.0000260	15.6	0.00000929	0.000151	0.0000740	0.000214	0.00595	0.00000266	5.27	0.0371	2.17
5	May	0.580	2.50	0.0210	2.42	0.0861	53.6	0.00000738	0.0170	0.00220	0.0391	0.0339	0.0000221	0.0000256	15.3	0.00000917	0.000149	0.0000727	0.000210	0.00585	0.00000262	5.12	0.0361	2.12
6	Jun	0.419	1.81	0.0152	1.84	0.0656	41.6	0.00000651	0.0163	0.00172	0.0294	0.0317	0.0000202	0.0000239	13.5	0.00000818	0.000124	0.0000644	0.000180	0.00541	0.00000249	3.75	0.0262	1.62
7	Jul	0.223	0.961	0.00808	1.11	0.0403	26.7	0.00000577	0.0161	0.00115	0.0178	0.0312	0.0000193	0.0000235	11.2	0.00000688	0.0000922	0.0000569	0.000147	0.00519	0.00000249	2.07	0.0140	1.00
8	Aug	0.165	0.711	0.00598	0.887	0.0327	22.2	0.00000561	0.0157	0.00100	0.0145	0.0317	0.0000193	0.0000237	10.6	0.00000645	0.0000823	0.0000552	0.000137	0.00517	0.00000252	1.57	0.0105	0.827
9	Sep	0.140	0.605	0.00508	0.797	0.0296	33.5	0.00000550	0.0153	0.000951	0.0130	0.0320	0.0000191	0.0000236	13.4	0.00000856	0.0000785	0.0000542	0.000144	0.00512	0.00000250	1.51	0.00906	2.08
10	Oct	0.389	1.67	0.0141	1.76	0.0646	46.8	0.00000670	0.0159	0.00174	0.0279	0.0334	0.0000211	0.0000250	14.7	0.00000884	0.000124	0.0000656	0.000186	0.00557	0.00000258	3.89	0.0248	2.15
11	Nov	0.394	1.70	0.0143	1.79	0.0657	47.9	0.00000676	0.0159	0.00177	0.0282	0.0336	0.0000212	0.0000251	15.0	0.00000905	0.000126	0.0000660	0.000188	0.00561	0.00000259	3.99	0.0253	2.19
12	Dec	0.389	1.68	0.0141	1.77	0.0651	47.5	0.00000675	0.0160	0.00176	0.0280	0.0336	0.0000212	0.0000251	14.9	0.00000906	0.000125	0.0000659	0.000187	0.00561	0.00000260	3.95	0.0250	2.17

Long-Term BCWQG	NA	NA	NA	150	NP	128	NP	0.05	NP	NP	NP	NP	NP	NP	0.00008	NP	NP	0.0003	NP	NP	NP	NP	NP
Short-Term BCWQG	NA	NA	NA	600	0.82	NP	NP	0.1	NP	NP	NP	NP	NP	NP	0.00016	NP	NP	0.0018	0.35	NP	NP	NP	NP
Discharge Limit	4	11.5	0.24	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shaded green & **bold font**.
Concentrations that greater than short-term guidelines are shaded blue & **bold font**.
Concentrations that exceed an effluent discharge limit are shaded **grey & bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-1: BJ 3.10 Results

Appendix A-1-1: Base BJ 3.10 Base Case Water Quality Predictions

Operations

	Month	D-Mn	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca
1	Jan	0.183	0.0155	51.0	0.000403	0.00769	0.0000590	0.0194	0.00206	1.63	0.0000832	0.400	0.00534	0.0000567	0.000594	0.000832	0.00121	0.0000128	0.173	**0.0136**	0.135	0.0483	0.0000329	0.0000339	19.3
2	Feb	0.183	0.0155	51.0	0.000403	0.00769	0.0000590	0.0194	0.00206	1.63	0.0000832	0.399	0.00534	0.0000568	0.000594	0.000833	0.00121	0.0000128	0.173	**0.0136**	0.135	0.0482	0.0000329	0.0000339	19.3
3	Mar	0.183	0.0155	50.9	0.000403	0.00769	0.0000591	0.0194	0.00207	1.63	0.0000832	0.400	0.00534	0.0000567	0.000593	0.000833	0.00121	0.0000128	0.172	**0.0136**	0.135	0.0482	0.0000329	0.0000338	19.3
4	Apr	0.184	0.0155	51.0	0.000403	0.00769	0.0000591	0.0194	0.00207	1.63	0.0000832	0.400	0.00534	0.0000567	0.000592	0.000834	0.00121	0.0000128	0.172	**0.0136**	0.135	0.0482	0.0000329	0.0000338	19.3
5	May	0.180	0.0152	49.8	0.000399	0.00793	0.0000584	0.0189	0.00204	1.60	0.0000818	0.392	0.00526	0.0000556	0.000610	0.000818	0.00119	0.0000126	0.168	**0.0133**	0.132	0.0475	0.0000324	0.0000339	19.0
6	Jun	0.135	0.0112	36.8	0.000349	0.00682	0.0000490	0.0138	0.00154	1.30	0.0000704	0.302	0.00487	0.0000418	0.000502	0.000657	0.000998	0.0000104	0.145	0.0100	0.0978	0.0435	0.0000281	0.0000312	15.9
7	Jul	0.0801	0.00651	21.3	0.000302	0.00487	0.0000389	0.00785	0.000913	0.968	0.0000598	0.194	0.00474	0.0000259	0.000332	0.000486	0.000790	0.00000807	0.122	0.00623	0.0568	0.0412	0.0000240	0.0000287	12.6
8	Aug	0.0656	0.00532	17.5	0.000297	0.00464	0.0000369	0.00636	0.000768	0.887	0.0000580	0.169	0.00480	0.0000221	0.000318	0.000445	0.000744	0.00000759	0.119	0.00530	0.0464	0.0412	0.0000234	0.0000290	11.9
9	Sep	0.0613	0.00499	16.4	0.000297	0.00486	0.0000365	0.00594	0.000739	0.860	0.0000573	0.163	0.00480	0.0000212	0.000341	0.000432	0.000734	0.00000745	0.119	0.00503	0.0436	0.0410	0.0000233	0.0000296	11.8
10	Oct	0.199	0.0151	49.8	0.000402	0.00756	0.0000593	0.0187	0.00202	1.65	0.0000837	0.391	0.00533	0.0000537	0.000594	0.000808	0.00118	0.0000125	0.160	**0.0131**	0.131	0.0467	0.0000326	0.0000337	19.8
11	Nov	0.206	0.0157	51.6	0.000409	0.00776	0.0000607	0.0196	0.00209	1.69	0.0000852	0.403	0.00537	0.0000566	0.000613	0.000837	0.00121	0.0000129	0.162	**0.0137**	0.136	0.0470	0.0000331	0.0000340	20.3
12	Dec	0.204	0.0155	51.1	0.000407	0.00770	0.0000604	0.0194	0.00207	1.68	0.0000848	0.400	0.00536	0.0000566	0.000607	0.000832	0.00121	0.0000128	0.160	**0.0136**	0.135	0.0469	0.0000330	0.0000339	20.2

Closure

	Month	D-Mn	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca
1	Jan	0.224	0.0133	47.8	0.000407	0.00745	0.0000603	0.00984	0.00184	1.68	0.0000847	0.387	0.00536	0.0000474	0.000606	0.000639	0.00113	0.0000120	0.0964	0.00636	0.133	0.0441	0.0000325	0.0000337	20.2
2	Feb	0.224	0.0133	47.6	0.000406	0.00743	0.0000603	0.00981	0.00183	1.68	0.0000846	0.386	0.00536	0.0000474	0.000604	0.000638	0.00113	0.0000120	0.0961	0.00634	0.133	0.0440	0.0000324	0.0000337	20.1
3	Mar	0.223	0.0132	47.5	0.000406	0.00742	0.0000602	0.00979	0.00183	1.67	0.0000845	0.386	0.00536	0.0000472	0.000603	0.000637	0.00113	0.0000120	0.0959	0.00633	0.133	0.0440	0.0000324	0.0000336	20.1
4	Apr	0.223	0.0132	47.4	0.000405	0.00740	0.0000601	0.00975	0.00182	1.67	0.0000844	0.385	0.00535	0.0000471	0.000601	0.000636	0.00112	0.0000120	0.0957	0.00631	0.132	0.0440	0.0000323	0.0000336	20.1
5	May	0.217	0.0128	46.0	0.000397	0.00723	0.0000587	0.00947	0.00177	1.63	0.0000826	0.375	0.00525	0.0000458	0.000583	0.000622	0.00110	0.0000117	0.0940	0.00614	0.129	0.0432	0.0000316	0.0000329	19.7
6	Jun	0.160	0.00934	33.5	0.000340	0.00561	0.0000483	0.00690	0.00129	1.31	0.0000703	0.285	0.00482	0.0000342	0.000427	0.000510	0.000920	0.00000961	0.0898	0.00471	0.0942	0.0401	0.0000270	0.0000290	16.2
7	Jul	0.0902	0.00506	18.1	0.000286	0.00357	0.0000373	0.00373	0.000706	0.945	0.0000586	0.176	0.00465	0.0000203	0.000233	0.000391	0.000722	0.00000738	0.0920	0.00303	0.0519	0.0391	0.0000228	0.0000260	12.4
8	Aug	0.0696	0.00381	13.6	0.000275	0.00291	0.0000345	0.00281	0.000535	0.846	0.0000562	0.145	0.00469	0.0000163	0.000178	0.000359	0.000669	0.00000681	0.0959	0.00252	0.0396	0.0394	0.0000219	0.0000255	11.5
9	Sep	0.0608	0.00329	11.7	0.000269	0.00266	0.0000331	0.00243	0.000464	0.800	0.0000550	0.133	0.00466	0.0000145	0.000156	0.000343	0.000648	0.00000654	0.0981	0.00227	0.0344	0.0391	0.0000213	0.0000251	11.3
10	Oct	0.225	0.00916	32.8	0.000364	0.00531	0.0000501	0.00672	0.00127	1.34	0.0000737	0.315	0.00507	0.0000334	0.000412	0.000515	0.000942	0.00000992	0.0968	0.00462	0.0922	0.0420	0.0000278	0.0000299	17.9
11	Nov	0.233	0.00932	33.4	0.000368	0.00540	0.0000508	0.00682	0.00129	1.36	0.0000745	0.322	0.00510	0.0000346	0.000420	0.000521	0.000953	0.0000101	0.0959	0.00468	0.0944	0.0422	0.0000281	0.0000301	18.2
12	Dec	0.231	0.00922	33.0	0.000367	0.00536	0.0000506	0.00675	0.00127	1.35	0.0000744	0.319	0.00509	0.0000348	0.000417	0.000519	0.000949	0.0000100	0.0951	0.00464	0.0939	0.0421	0.0000280	0.0000300	18.1

PostClosure

	Month	D-Mn	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca
1	Jan	0.240	0.00428	14.5	0.000319	0.00299	0.0000367	0.00294	0.000585	0.924	0.0000612	0.237	0.00477	0.0000191	0.000192	0.000370	0.000735	0.00000751	0.0945	0.00264	0.0433	0.0399	0.0000225	0.0000260	15.6
2	Feb	0.239	0.00426	14.4	0.000319	0.00299	0.0000367	0.00293	0.000583	0.925	0.0000612	0.237	0.00477	0.0000191	0.000192	0.000371	0.000735	0.00000751	0.0943	0.00264	0.0433	0.0399	0.0000225	0.0000260	15.6
3	Mar	0.239	0.00425	14.4	0.000319	0.00300	0.0000367	0.00292	0.000582	0.925	0.0000612	0.237	0.00477	0.0000191	0.000191	0.000371	0.000734	0.00000752	0.0941	0.00263	0.0432	0.0400	0.0000225	0.0000260	15.6
4	Apr	0.239	0.00424	14.3	0.000319	0.00299	0.0000367	0.00292	0.000581	0.925	0.0000612	0.236	0.00477	0.0000190	0.000191	0.000371	0.000734	0.00000752	0.0939	0.00263	0.0431	0.0400	0.0000225	0.0000260	15.6
5	May	0.233	0.00412	13.9	0.000313	0.00298	0.0000360	0.00283	0.000565	0.909	0.0000602	0.231	0.00469	0.0000186	0.000186	0.000364	0.000726	0.00000738	0.0923	0.00257	0.0419	0.0393	0.0000221	0.0000256	15.3
6	Jun	0.174	0.00305	10.3	0.000281	0.00271	0.0000321	0.00209	0.000422	0.794	0.0000545	0.182	0.00441	0.0000145	0.000140	0.000326	0.000674	0.00000652	0.0917	0.00213	0.0314	0.0374	0.0000202	0.0000239	13.4
7	Jul	0.0972	0.00175	5.93	0.000257	0.00214	0.0000288	0.00120	0.000247	0.680	0.0000506	0.123	0.00448	0.00000993	0.0000829	0.000295	0.000607	0.00000578	0.0956	0.00167	0.0189	0.0378	0.0000193	0.0000235	11.2
8	Aug	0.0740	0.00138	4.64	0.000254	0.00186	0.0000280	0.000947	0.000196	0.648	0.0000501	0.106	0.00454	0.00000862	0.0000670	0.000288	0.000583	0.00000561	0.0978	0.00151	0.0152	0.0384	0.0000193	0.0000237	10.6
9	Sep	0.234	0.00123	4.10	0.000284	0.00176	0.0000299	0.000850	0.000175	0.630	0.0000496	0.175	0.00454	0.00000804	0.0000616	0.000288	0.000620	0.00000550	0.0979	0.00141	0.0137	0.0383	0.0000191	0.0000236	13.4
10	Oct	0.243	0.00304	9.85	0.000305	0.00238	0.0000329	0.00200	0.000409	0.803	0.0000568	0.213	0.00468	0.0000138	0.000134	0.000332	0.000679	0.00000671	0.0962	0.00214	0.0294	0.0392	0.0000211	0.0000250	14.7
11	Nov	0.243	0.00310	9.99	0.000308	0.00242	0.0000333	0.00203	0.000416	0.811	0.0000572	0.218	0.00469	0.0000146	0.000137	0.000335	0.000686	0.00000676	0.0953	0.00216	0.0305	0.0393	0.0000212	0.0000251	14.9
12	Dec	0.240	0.00307	9.89	0.000307	0.00242	0.0000333	0.00201	0.000411	0.809	0.0000571	0.216	0.00469	0.0000150	0.000137	0.000335	0.000686	0.00000675	0.0945	0.00215	0.0307	0.0393	0.0000212	0.0000251	14.9

Long-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	1.2	1	0.00013	NP	NP
Short-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	NP	NP	NP	NP	NP
Discharge Limit	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.46	NP	0.01	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shaded green & **bold font**.
Concentrations that greater than short-term guidelines are shaded blue & **bold font**.
Concentrations that exceed an effluent discharge limit are shaded **grey & bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-1: BJ 3.10 Results

Appendix A-1-1: Base BJ 3.10 Base Case Water Quality Predictions

Operations

	Month	T-Cd	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.0000122	0.000264	0.000341	0.000527	0.0401	0.00000394	17.5	0.123	2.12	0.189	0.0155	51.0	0.000464	0.0119	0.000261	0.0194	***0.00211***	1.93	0.000143	0.400	0.00534	0.0000873	0.000607	0.000864	0.00209
2	Feb	0.0000122	0.000264	0.000340	0.000526	0.0401	0.00000394	17.5	0.123	2.12	0.190	0.0155	50.9	0.000463	0.0119	0.000261	0.0194	***0.00212***	1.93	0.000142	0.400	0.00534	0.0000873	0.000606	0.000864	0.00209
3	Mar	0.0000122	0.000264	0.000339	0.000526	0.0400	0.00000394	17.5	0.123	2.13	0.190	0.0155	50.9	0.000463	0.0119	0.000260	0.0194	***0.00212***	1.93	0.000142	0.400	0.00534	0.0000873	0.000606	0.000864	0.00209
4	Apr	0.0000122	0.000265	0.000338	0.000525	0.0398	0.00000394	17.5	0.123	2.13	0.190	0.0155	50.9	0.000462	0.0119	0.000259	0.0194	***0.00212***	1.93	0.000142	0.400	0.00534	0.0000873	0.000605	0.000865	0.00209
5	May	0.0000121	0.000260	0.000329	0.000540	0.0391	0.00000388	17.1	0.120	2.09	0.187	0.0152	49.8	0.000456	0.0120	0.000255	0.0190	***0.00209***	1.90	0.000139	0.393	0.00526	0.0000858	0.000623	0.000848	0.00206
6	Jun	0.0000103	0.000206	0.000251	0.000490	0.0362	0.00000343	12.5	0.0886	1.62	0.142	0.0113	36.8	0.000391	0.0105	0.000240	0.0138	0.00157	1.61	0.000111	0.302	0.00487	0.0000719	0.000515	0.000678	0.00184
7	Jul	0.00000816	0.000139	0.000156	0.000416	0.0351	0.00000301	7.15	0.0500	1.06	0.0894	0.00653	21.3	0.000322	0.00817	0.000240	0.00790	0.000932	1.33	0.0000812	0.194	0.00474	0.0000588	0.000346	0.000498	0.00164
8	Aug	0.00000795	0.000124	0.000139	0.000424	0.0358	0.00000294	5.82	0.0403	0.917	0.0749	0.00535	17.5	0.000311	0.00791	0.000237	0.00641	0.000787	1.26	0.0000739	0.169	0.00480	0.0000563	0.000333	0.000454	0.00162
9	Sep	0.00000818	0.000121	0.000141	0.000444	0.0362	0.00000292	5.45	0.0379	0.879	0.0697	0.00502	16.4	0.000309	0.00811	0.000227	0.00598	0.000762	1.22	0.0000713	0.164	0.00480	0.0000556	0.000356	0.000440	0.00161
10	Oct	0.0000120	0.000285	0.000272	0.000522	0.0385	0.00000382	17.1	0.124	2.25	0.206	0.0152	49.8	0.000436	0.0119	0.000243	0.0187	***0.00206***	1.96	0.000120	0.392	0.00533	0.0000852	0.000607	0.000840	0.00204
11	Nov	0.0000122	0.000294	0.000278	0.000530	0.0384	0.00000388	17.7	0.129	2.32	0.213	0.0157	51.6	0.000444	0.0121	0.000244	0.0196	***0.00213***	2.00	0.000122	0.404	0.00537	0.0000875	0.000626	0.000868	0.00207
12	Dec	0.0000122	0.000292	0.000277	0.000527	0.0381	0.00000387	17.5	0.127	2.30	0.211	0.0155	51.1	0.000442	0.0120	0.000244	0.0195	***0.00212***	1.99	0.000121	0.401	0.00536	0.0000873	0.000620	0.000864	0.00206

Closure

	Month	T-Cd	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.0000121	0.000291	0.000160	0.000524	0.0332	0.00000308	15.5	0.127	2.30	0.231	0.0133	47.8	0.000410	0.0120	0.000220	0.00988	0.00189	1.98	0.0000871	0.388	0.00536	0.0000779	0.000619	0.000641	0.00193
2	Feb	0.0000121	0.000291	0.000160	0.000523	0.0331	0.00000308	15.5	0.127	2.30	0.231	0.0133	47.6	0.000409	0.0120	0.000220	0.00985	0.00188	1.98	0.0000870	0.387	0.00536	0.0000779	0.000617	0.000641	0.00193
3	Mar	0.0000121	0.000290	0.000159	0.000522	0.0331	0.00000308	15.4	0.126	2.29	0.231	0.0133	47.5	0.000409	0.0119	0.000219	0.00982	0.00187	1.98	0.0000868	0.386	0.00536	0.0000778	0.000615	0.000640	0.00193
4	Apr	0.0000121	0.000289	0.000159	0.000521	0.0330	0.00000308	15.4	0.126	2.29	0.230	0.0132	47.3	0.000408	0.0119	0.000218	0.00979	0.00187	1.97	0.0000867	0.385	0.00535	0.0000777	0.000613	0.000639	0.00193
5	May	0.0000118	0.000282	0.000155	0.000509	0.0324	0.00000302	15.0	0.122	2.23	0.224	0.0128	46.0	0.000400	0.0116	0.000214	0.00951	0.00181	1.93	0.0000848	0.375	0.00525	0.0000759	0.000596	0.000624	0.00189
6	Jun	0.00000982	0.000217	0.000123	0.000424	0.0311	0.00000276	10.9	0.0887	1.70	0.167	0.00936	33.5	0.000342	0.00943	0.000209	0.00694	0.00133	1.62	0.0000719	0.285	0.00482	0.0000642	0.000440	0.000512	0.00170
7	Jul	0.00000758	0.000140	0.0000876	0.000339	0.0322	0.00000262	5.86	0.0470	1.06	0.0997	0.00508	18.1	0.000288	0.00690	0.000222	0.00378	0.000723	1.30	0.0000595	0.176	0.00465	0.0000528	0.000248	0.000392	0.00155
8	Aug	0.00000717	0.000118	0.0000857	0.000319	0.0335	0.00000261	4.40	0.0348	0.878	0.0790	0.00384	13.6	0.000276	0.00616	0.000223	0.00286	0.000552	1.21	0.0000569	0.145	0.00469	0.0000503	0.000193	0.000360	0.00153
9	Sep	0.00000718	0.000110	0.0000915	0.000309	0.0341	0.00000258	3.79	0.0298	0.802	0.0694	0.00332	11.7	0.000270	0.00584	0.000215	0.00247	0.000484	1.16	0.0000555	0.133	0.00466	0.0000489	0.000171	0.000344	0.00152
10	Oct	0.0000109	0.000228	0.000134	0.000442	0.0337	0.00000285	10.9	0.0879	2.21	0.232	0.00918	32.8	0.000366	0.00926	0.000215	0.00675	0.00130	1.66	0.0000751	0.316	0.00507	0.0000659	0.000426	0.000517	0.00177
11	Nov	0.0000111	0.000233	0.000137	0.000448	0.0335	0.00000287	11.1	0.0894	2.28	0.241	0.00934	33.4	0.000370	0.00934	0.000216	0.00686	0.00133	1.67	0.0000760	0.323	0.00510	0.0000667	0.000434	0.000523	0.00179
12	Dec	0.0000111	0.000232	0.000137	0.000447	0.0333	0.00000287	11.0	0.0884	2.26	0.238	0.00924	33.0	0.000368	0.00927	0.000216	0.00678	0.00132	1.66	0.0000759	0.320	0.00509	0.0000665	0.000430	0.000521	0.00178

PostClosure

	Month	T-Cd	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.0000100	0.000151	0.000108	0.000349	0.0332	0.00000265	5.44	0.0377	2.21	0.247	0.00430	14.5	0.000320	0.00615	0.000210	0.00297	0.000629	1.25	0.0000618	0.238	0.00477	0.0000524	0.000206	0.000371	0.00161
2	Feb	0.0000100	0.000151	0.000108	0.000349	0.0332	0.00000266	5.42	0.0376	2.20	0.247	0.00428	14.4	0.000320	0.00614	0.000210	0.00297	0.000628	1.25	0.0000618	0.238	0.00477	0.0000524	0.000206	0.000371	0.00161
3	Mar	0.00001000	0.000151	0.000108	0.000349	0.0331	0.00000266	5.41	0.0375	2.20	0.246	0.00427	14.4	0.000319	0.00613	0.000210	0.00296	0.000627	1.25	0.0000618	0.237	0.00477	0.0000524	0.000205	0.000371	0.00161
4	Apr	0.00000999	0.000151	0.000108	0.000349	0.0330	0.00000266	5.39	0.0374	2.20	0.246	0.00426	14.3	0.000319	0.00612	0.000209	0.00295	0.000625	1.25	0.0000618	0.237	0.00477	0.0000524	0.000205	0.000371	0.00161
5	May	0.00000985	0.000149	0.000105	0.000342	0.0324	0.00000262	5.24	0.0363	2.15	0.240	0.00414	13.9	0.000313	0.00605	0.000205	0.00287	0.000608	1.23	0.0000607	0.232	0.00469	0.0000514	0.000200	0.000365	0.00159
6	Jun	0.00000867	0.000124	0.0000878	0.000306	0.0322	0.00000249	3.86	0.0263	1.65	0.182	0.00307	10.3	0.000281	0.00557	0.000219	0.00214	0.000452	1.12	0.0000549	0.183	0.00441	0.0000464	0.000154	0.000326	0.00150
7	Jul	0.00000714	0.0000922	0.0000693	0.000276	0.0335	0.00000249	2.17	0.0141	1.04	0.107	0.00177	5.93	0.000257	0.00497	0.000221	0.00125	0.000263	1.05	0.0000508	0.123	0.00448	0.0000436	0.0000979	0.000295	0.00146
8	Aug	0.00000683	0.0000823	0.0000734	0.000270	0.0341	0.00000252	1.68	0.0106	0.861	0.0835	0.00140	4.64	0.000254	0.00473	0.000221	0.000999	0.000212	1.02	0.0000503	0.107	0.00454	0.0000435	0.0000825	0.000288	0.00147
9	Sep	0.00000929	0.0000785	0.0000802	0.000281	0.0341	0.00000250	1.63	0.00925	2.11	0.242	0.00125	4.10	0.000284	0.00462	0.000213	0.000895	0.000195	0.994	0.0000498	0.176	0.00454	0.0000431	0.0000771	0.000288	0.00152
10	Oct	0.00000956	0.000124	0.0000974	0.000320	0.0338	0.00000258	4.01	0.0250	2.18	0.251	0.00306	9.85	0.000305	0.00540	0.000209	0.00204	0.000440	1.14	0.0000572	0.214	0.00468	0.0000483	0.000148	0.000332	0.00156
11	Nov	0.00000977	0.000126	0.0000992	0.000323	0.0335	0.00000259	4.11	0.0255	2.21	0.250	0.00312	9.99	0.000309	0.00541	0.000209	0.00207	0.000454	1.14	0.0000575	0.219	0.00469	0.0000487	0.000152	0.000335	0.00157
12	Dec	0.00000977	0.000125	0.0000995	0.000323	0.0333	0.00000260	4.08	0.0252	2.19	0.248	0.00309	9.89	0.000308	0.00539	0.000209	0.00205	0.000455	1.14	0.0000574	0.217	0.00469	0.0000488	0.000151	0.000335	0.00157

Long-Term BCWQG	NP	0.004	0.001	NP	NA	0.00002	NP	NP	NP	0.7282	7.6	NP	0.025	NP	0.004	NA	0.002	NP	NP	NP	NP	0.0008	0.0085	NP	0.0075
Short-Term BCWQG	NP	0.11	NP	NP	NA	NP	NP	NP	NP	0.84856	46	NP	NP	NP	0.016	NA	NP	NP	NP	NP	NP	NP	NP	NP	0.033
Discharge Limit	NP	NP	NP	NP	1.7	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.028	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shaded green & **bold font**.
Concentrations that greater than short-term guidelines are shaded blue & **bold font**.
Concentrations that exceed an effluent discharge limit are shaded **grey & bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-1: BJ 3.10

Appendix A-1-2: Upper Case BJ 3.10 Upper Case Water Quality Predictions

Operations

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg
1	Jan	**5.69**	**24.5**	0.206	17.9	0.510	***294***	0.0000383	***0.201***	0.0253	0.301	0.0586	0.0000621	0.0000423	41.7	***0.000317***	0.00112	0.000213	***0.000858***	0.104	0.0000117	35.8	0.530	3.56
2	Feb	**5.69**	**24.5**	0.206	17.9	0.509	***294***	0.0000383	***0.201***	0.0253	0.301	0.0587	0.0000620	0.0000423	41.7	***0.000317***	0.00111	0.000213	***0.000857***	0.104	0.0000119	35.8	0.529	3.56
3	Mar	**5.70**	**24.5**	0.206	17.9	0.509	***294***	0.0000383	***0.201***	0.0253	0.301	0.0588	0.0000620	0.0000423	41.7	***0.000317***	0.00111	0.000213	***0.000857***	0.104	0.0000120	35.8	0.530	3.56
4	Apr	**5.71**	**24.6**	0.207	17.9	0.509	***294***	0.0000384	***0.202***	0.0253	0.301	0.0589	0.0000619	0.0000423	41.7	***0.000318***	0.00112	0.000213	***0.000857***	0.103	0.0000121	35.8	0.530	3.57
5	May	**5.59**	**24.1**	0.202	17.5	0.498	***287***	0.0000376	***0.198***	0.0248	0.294	0.0579	0.0000611	0.0000423	40.9	***0.000311***	0.00110	0.000209	***0.000870***	0.103	0.0000121	34.9	0.518	3.50
6	Jun	**4.11**	**17.7**	0.149	12.9	0.368	***213***	0.0000290	***0.151***	0.0183	0.217	0.0506	0.0000520	0.0000377	32.1	***0.000233***	0.000845	0.000169	***0.000737***	0.0875	0.0000122	25.6	0.380	2.65
7	Jul	2.29	9.87	0.0830	7.34	0.211	123	0.0000192	***0.0968***	0.0107	0.123	0.0439	0.0000400	0.0000332	21.8	***0.000136***	0.000519	0.000121	***0.000523***	0.0591	0.0000127	14.3	0.213	1.62
8	Aug	1.85	7.95	0.0668	5.90	0.172	101	0.0000167	***0.0819***	0.00879	0.0990	0.0426	0.0000366	0.0000330	19.3	***0.000110***	0.000430	0.000109	***0.000480***	0.0489	0.0000121	11.6	0.170	1.36
9	Sep	1.71	7.38	0.0620	5.53	0.161	94.6	0.0000160	***0.0771***	0.00827	0.0926	0.0422	0.0000358	0.0000333	18.7	***0.000102***	0.000409	0.000106	***0.000490***	0.0470	0.0000116	10.8	0.158	1.30
10	Oct	**5.53**	**23.8**	0.200	17.5	0.498	***287***	0.0000370	***0.193***	0.0244	0.294	0.0586	0.0000619	0.0000418	43.7	***0.000322***	0.00122	0.000231	***0.000844***	0.112	0.0000112	34.9	0.538	3.77
11	Nov	**5.75**	**24.7**	0.208	18.1	0.515	***297***	0.0000385	***0.202***	0.0256	0.305	0.0597	0.0000632	0.0000425	45.1	***0.000333***	0.00126	0.000239	***0.000866***	0.115	0.0000114	36.2	0.558	3.91
12	Dec	**5.69**	**24.5**	0.206	17.9	0.510	***295***	0.0000383	***0.201***	0.0253	0.302	0.0596	0.0000628	0.0000423	44.7	***0.000330***	0.00125	0.000237	***0.000859***	0.114	0.0000116	35.8	0.553	3.87

Closure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg
1	Jan	3.92	**16.9**	0.142	17.4	0.486	***284***	0.0000361	***0.127***	0.0128	0.298	0.0596	0.0000627	0.0000422	44.7	***0.000329***	0.00124	0.000237	***0.000842***	0.114	0.0000111	31.8	0.552	3.87
2	Feb	3.90	**16.8**	0.141	17.3	0.484	***283***	0.0000360	***0.127***	0.0128	0.297	0.0596	0.0000626	0.0000422	44.6	***0.000329***	0.00124	0.000236	***0.000840***	0.113	0.0000113	31.7	0.550	3.86
3	Mar	3.89	**16.8**	0.141	17.3	0.483	***282***	0.0000360	***0.127***	0.0128	0.296	0.0597	0.0000625	0.0000421	44.5	***0.000328***	0.00124	0.000236	***0.000838***	0.113	0.0000114	31.6	0.549	3.85
4	Apr	3.88	**16.7**	0.140	17.2	0.482	***282***	0.0000359	***0.127***	0.0127	0.295	0.0597	0.0000624	0.0000421	44.4	***0.000327***	0.00123	0.000236	***0.000836***	0.113	0.0000116	31.5	0.547	3.84
5	May	3.76	**16.2**	0.136	16.7	0.468	***274***	0.0000350	***0.124***	0.0124	0.287	0.0585	0.0000613	0.0000412	43.3	***0.000318***	0.00120	0.000230	***0.000820***	0.112	0.0000115	30.6	0.532	3.74
6	Jun	2.73	**11.7**	0.0987	12.2	0.343	***201***	0.0000270	***0.0968***	0.00915	0.209	0.0506	0.0000515	0.0000356	33.5	***0.000236***	0.000913	0.000182	***0.000662***	0.0953	0.0000118	22.2	0.385	2.79
7	Jul	1.44	6.19	0.0521	6.63	0.188	111	0.0000174	***0.0642***	0.00521	0.113	0.0432	0.0000394	0.0000304	21.8	***0.000132***	0.000539	0.000125	***0.000470***	0.0731	0.0000124	11.9	0.204	1.63
8	Aug	1.06	4.56	0.0383	4.98	0.142	84.7	0.0000147	***0.0537***	0.00407	0.0846	0.0415	0.0000354	0.0000292	18.6	***0.000102***	0.000429	0.000109	***0.000399***	0.0590	0.0000120	8.80	0.150	1.30
9	Sep	0.899	3.87	0.0326	4.31	0.124	74.0	0.0000135	0.0491	0.00359	0.0728	0.0407	0.0000344	0.0000284	17.4	***0.0000914***	0.000394	0.000102	***0.000389***	0.0564	0.0000115	7.53	0.128	1.17
10	Oct	2.62	11.3	0.0947	12.0	0.339	***204***	0.0000275	***0.0927***	0.00891	0.206	0.0522	0.0000508	0.0000361	35.5	***0.000242***	0.000937	0.000187	***0.000737***	0.0884	0.0000106	21.8	0.381	3.33
11	Nov	2.66	11.4	0.0962	12.2	0.345	***207***	0.0000281	***0.0941***	0.00906	0.209	0.0528	0.0000515	0.0000364	36.3	***0.000247***	0.000960	0.000190	***0.000760***	0.0903	0.0000108	22.2	0.388	3.43
12	Dec	2.63	11.3	0.0951	12.1	0.341	***205***	0.0000280	***0.0936***	0.00899	0.207	0.0528	0.0000513	0.0000364	36.1	***0.000246***	0.000955	0.000190	***0.000760***	0.0897	0.0000110	22.0	0.383	3.40

PostClosure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg
1	Jan	1.07	4.61	0.0387	5.39	0.158	107	0.0000175	***0.0543***	0.00442	0.0902	0.0443	0.0000389	0.0000297	24.7	***0.000130***	0.000578	0.000127	***0.000537***	0.0661	0.0000113	10.1	0.160	2.78
2	Feb	1.07	4.59	0.0386	5.37	0.158	107	0.0000175	***0.0544***	0.00442	0.0900	0.0444	0.0000389	0.0000298	24.7	***0.000130***	0.000578	0.000127	***0.000538***	0.0659	0.0000116	10.1	0.160	2.77
3	Mar	1.06	4.58	0.0385	5.36	0.158	107	0.0000175	***0.0545***	0.00442	0.0898	0.0445	0.0000389	0.0000298	24.7	***0.000129***	0.000578	0.000127	***0.000538***	0.0657	0.0000117	10.0	0.159	2.77
4	Apr	1.06	4.56	0.0383	5.34	0.157	106	0.0000176	***0.0546***	0.00442	0.0896	0.0446	0.0000388	0.0000298	24.7	***0.000129***	0.000577	0.000127	***0.000538***	0.0655	0.0000117	10.0	0.159	2.77
5	May	1.03	4.42	0.0372	5.22	0.154	104	0.0000173	***0.0539***	0.00431	0.0871	0.0439	0.0000392	0.0000293	24.3	***0.000128***	0.000575	0.000125	***0.000540***	0.0691	0.0000119	9.73	0.154	2.70
6	Jun	0.743	3.20	0.0269	3.97	0.117	79.2	0.0000144	0.0480	0.00333	0.0644	0.0403	0.0000394	0.0000271	20.2	***0.000104***	0.000500	0.000109	***0.000502***	0.0793	0.0000125	7.12	0.112	2.06
7	Jul	0.394	1.70	0.0143	2.32	0.0701	47.6	0.0000109	0.0392	0.00214	0.0366	0.0379	0.0000349	0.0000261	15.0	0.0000649	0.000341	0.0000880	***0.000383***	0.0645	0.0000125	3.90	0.0594	1.26
8	Aug	0.291	1.25	0.0105	1.80	0.0553	37.9	0.00000974	0.0350	0.00179	0.0285	0.0376	0.0000320	0.0000260	13.5	0.0000511	0.000277	0.0000807	***0.000328***	0.0527	0.0000120	2.95	0.0441	1.02
9	Sep	0.247	1.06	0.00895	1.60	0.0495	36.0	0.00000924	0.0342	0.00165	0.0251	0.0373	0.0000314	0.0000258	14.3	0.0000466	0.000260	0.0000777	***0.000313***	0.0512	0.0000115	2.55	0.0378	2.13
10	Oct	0.685	2.95	0.0248	3.70	0.112	81.2	0.0000141	0.0440	0.00327	0.0607	0.0413	0.0000357	0.0000279	21.2	***0.0000957***	0.000455	0.000106	***0.000459***	0.0600	0.0000109	7.02	0.105	2.54
11	Nov	0.695	2.99	0.0252	3.76	0.113	82.9	0.0000143	0.0448	0.00333	0.0615	0.0416	0.0000360	0.0000281	21.6	***0.0000972***	0.000461	0.000107	***0.000466***	0.0609	0.0000111	7.17	0.106	2.62
12	Dec	0.687	2.96	0.0249	3.72	0.112	82.1	0.0000143	0.0448	0.00332	0.0609	0.0417	0.0000360	0.0000281	21.4	***0.0000963***	0.000457	0.000107	***0.000463***	0.0607	0.0000111	7.10	0.105	2.59

Long-Term BCWQG	NA	NA	NA	150	NP	128	NP	0.05	NP	NP	NP	NP	NP	NP	0.00008	NP	NP	0.0003	NP	NP	NP	NP	NP
Short-Term BCWQG	NA	NA	NA	600	0.82	NP	NP	0.1	NP	NP	NP	NP	NP	NP	0.00016	NP	NP	0.0018	0.35	NP	NP	NP	NP
Discharge Limit	4	11.5	0.24	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-1: BJ 3.10

Appendix A-1-2: Upper Case BJ 3.10 Upper Case Water Quality Predictions

Operations

	Month	D-Mn	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca
1	Jan	0.261	0.0264	79.5	0.00148	0.0261	0.00831	0.0311	0.00605	3.84	0.000316	0.807	0.00656	0.0000845	0.00141	0.00260	0.0151	0.0000386	0.285	**0.0257**	0.304	0.0639	0.0000621	0.0000423	41.7
2	Feb	0.261	0.0264	79.4	0.00148	0.0261	0.00830	0.0311	0.00605	3.84	0.000316	0.806	0.00656	0.0000845	0.00141	0.00260	0.0151	0.0000386	0.285	**0.0257**	0.304	0.0640	0.0000620	0.0000423	41.7
3	Mar	0.262	0.0264	79.4	0.00148	0.0261	0.00829	0.0311	0.00605	3.85	0.000316	0.806	0.00656	0.0000845	0.00141	0.00261	0.0151	0.0000386	0.285	**0.0257**	0.304	0.0640	0.0000620	0.0000423	41.7
4	Apr	0.262	0.0264	79.4	0.00149	0.0262	0.00828	0.0311	0.00605	3.85	0.000316	0.807	0.00656	0.0000845	0.00141	0.00261	0.0151	0.0000387	0.285	**0.0257**	0.304	0.0641	0.0000619	0.0000423	41.7
5	May	0.257	0.0258	77.6	0.00146	0.0261	0.00805	0.0304	0.00592	3.77	0.000310	0.790	0.00645	0.0000828	0.00141	0.00256	0.0148	0.0000379	0.280	**0.0252**	0.297	0.0631	0.0000611	0.0000423	40.9
6	Jun	0.194	0.0189	57.1	0.00113	0.0203	0.00580	0.0221	0.00436	2.90	0.000241	0.594	0.00580	0.0000617	0.00109	0.00198	0.0114	0.0000292	0.228	**0.0187**	0.219	0.0561	0.0000520	0.0000377	32.1
7	Jul	0.115	0.0108	32.6	0.000751	0.0128	0.00323	0.0126	0.00252	1.88	0.000161	0.358	0.00537	0.0000375	0.000663	0.00126	0.00693	0.0000194	0.176	**0.0112**	0.124	0.0504	0.0000400	0.0000332	21.7
8	Aug	0.0940	0.00882	26.5	0.000656	0.0111	0.00255	0.0102	0.00206	1.62	0.000140	0.298	0.00533	0.0000315	0.000582	0.00108	0.00567	0.0000168	0.164	0.00930	0.0998	0.0492	0.0000366	0.0000330	19.2
9	Sep	0.0879	0.00824	24.9	0.000632	0.0109	0.00232	0.00951	0.00194	1.54	0.000134	0.284	0.00530	0.0000299	0.000586	0.00102	0.00536	0.0000160	0.161	0.00872	0.0933	0.0485	0.0000358	0.0000333	18.7
10	Oct	0.281	0.0258	77.7	0.00153	0.0255	0.00794	0.0299	0.00592	4.00	0.000328	0.788	0.00649	0.0000803	0.00145	0.00253	0.0160	0.0000373	0.280	**0.0248**	0.296	0.0641	0.0000619	0.0000418	43.7
11	Nov	0.291	0.0267	80.4	0.00158	0.0264	0.00839	0.0314	0.00612	4.13	0.000339	0.815	0.00657	0.0000846	0.00150	0.00262	0.0166	0.0000389	0.287	**0.0259**	0.307	0.0650	0.0000632	0.0000425	45.1
12	Dec	0.288	0.0264	79.6	0.00156	0.0261	0.00832	0.0311	0.00606	4.10	0.000336	0.808	0.00656	0.0000844	0.00149	0.00260	0.0164	0.0000386	0.285	**0.0257**	0.304	0.0649	0.0000628	0.0000423	44.7

Closure

	Month	D-Mn	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca
1	Jan	0.288	0.0230	74.9	0.00156	0.0243	0.00126	0.0220	0.00541	4.10	0.000336	0.775	0.00650	0.0000646	0.00149	0.00211	0.0164	0.0000361	0.199	**0.0132**	0.300	0.0649	0.0000627	0.0000422	44.7
2	Feb	0.287	0.0229	74.7	0.00156	0.0243	0.00125	0.0219	0.00539	4.09	0.000335	0.773	0.00649	0.0000645	0.00148	0.00211	0.0163	0.0000360	0.198	**0.0131**	0.300	0.0649	0.0000626	0.0000422	44.6
3	Mar	0.286	0.0229	74.5	0.00155	0.0242	0.00125	0.0219	0.00537	4.08	0.000335	0.771	0.00649	0.0000643	0.00148	0.00211	0.0163	0.0000360	0.198	**0.0131**	0.299	0.0649	0.0000625	0.0000421	44.5
4	Apr	0.286	0.0228	74.2	0.00155	0.0242	0.00124	0.0218	0.00536	4.07	0.000334	0.769	0.00649	0.0000641	0.00147	0.00210	0.0162	0.0000359	0.197	**0.0131**	0.298	0.0649	0.0000624	0.0000421	44.4
5	May	0.279	0.0221	72.1	0.00151	0.0235	0.00121	0.0212	0.00520	3.96	0.000325	0.748	0.00636	0.0000624	0.00143	0.00205	0.0159	0.0000350	0.193	**0.0127**	0.289	0.0636	0.0000613	0.0000412	43.3
6	Jun	0.208	0.0161	52.5	0.00116	0.0177	0.000886	0.0154	0.00378	3.01	0.000250	0.556	0.00568	0.0000466	0.00104	0.00157	0.0120	0.0000270	0.165	0.00954	0.211	0.0560	0.0000515	0.0000356	33.4
7	Jul	0.121	0.00866	28.2	0.000734	0.0104	0.000488	0.00826	0.00203	1.86	0.000160	0.322	0.00521	0.0000273	0.000564	0.000993	0.00710	0.0000174	0.137	0.00571	0.114	0.0496	0.0000394	0.0000304	21.7
8	Aug	0.0933	0.00648	21.1	0.000617	0.00811	0.000371	0.00618	0.00152	1.54	0.000135	0.255	0.00514	0.0000217	0.000428	0.000823	0.00563	0.0000147	0.132	0.00456	0.0853	0.0481	0.0000354	0.0000292	18.6
9	Sep	0.0825	0.00558	18.1	0.000571	0.00722	0.000321	0.00532	0.00131	1.41	0.000124	0.228	0.00507	0.0000193	0.000374	0.000748	0.00518	0.0000135	0.130	0.00404	0.0735	0.0470	0.0000344	0.0000285	17.4
10	Oct	0.272	0.0158	51.4	0.00121	0.0171	0.000820	0.0152	0.00371	3.09	0.000258	0.585	0.00590	0.0000453	0.00105	0.00154	0.0123	0.0000275	0.169	0.00928	0.207	0.0578	0.0000508	0.0000361	35.5
11	Nov	0.282	0.0160	52.3	0.00123	0.0174	0.000832	0.0154	0.00378	3.15	0.000263	0.598	0.00593	0.0000468	0.00107	0.00156	0.0126	0.0000281	0.169	0.00943	0.211	0.0583	0.0000515	0.0000364	36.3
12	Dec	0.279	0.0159	51.7	0.00123	0.0172	0.000824	0.0153	0.00374	3.13	0.000262	0.593	0.00593	0.0000468	0.00106	0.00155	0.0125	0.0000280	0.168	0.00935	0.210	0.0582	0.0000513	0.0000364	36.1

PostClosure

	Month	D-Mn	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca
1	Jan	0.268	0.00715	22.5	0.000783	0.00846	0.000368	0.00660	0.00167	1.85	0.000164	0.367	0.00523	0.0000249	0.000497	0.000853	0.00720	0.0000175	0.132	0.00480	0.0931	0.0499	0.0000389	0.0000297	24.7
2	Feb	0.267	0.00714	22.4	0.000784	0.00845	0.000368	0.00659	0.00167	1.85	0.000165	0.366	0.00524	0.0000249	0.000497	0.000853	0.00719	0.0000175	0.132	0.00480	0.0929	0.0500	0.0000389	0.0000298	24.7
3	Mar	0.267	0.00712	22.4	0.000784	0.00844	0.000367	0.00657	0.00167	1.85	0.000165	0.366	0.00524	0.0000249	0.000496	0.000854	0.00718	0.0000175	0.132	0.00480	0.0927	0.0501	0.0000389	0.0000298	24.7
4	Apr	0.267	0.00710	22.3	0.000783	0.00843	0.000366	0.00656	0.00166	1.85	0.000165	0.365	0.00524	0.0000248	0.000496	0.000854	0.00717	0.0000176	0.131	0.00479	0.0925	0.0501	0.0000388	0.0000298	24.7
5	May	0.261	0.00690	21.7	0.000769	0.00835	0.000357	0.00637	0.00162	1.82	0.000162	0.357	0.00515	0.0000242	0.000483	0.000836	0.00718	0.0000173	0.129	0.00468	0.0899	0.0493	0.0000392	0.0000293	24.3
6	Jun	0.199	0.00508	16.0	0.000633	0.00717	0.000274	0.00468	0.00119	1.47	0.000132	0.277	0.00480	0.0000191	0.000359	0.000693	0.00643	0.0000144	0.121	0.00374	0.0664	0.0460	0.0000394	0.0000271	20.2
7	Jul	0.116	0.00285	9.03	0.000463	0.00504	0.000168	0.00260	0.000660	1.06	0.0000984	0.177	0.00476	0.0000130	0.000203	0.000533	0.00444	0.0000109	0.115	0.00266	0.0377	0.0445	0.0000349	0.0000261	15.0
8	Aug	0.0897	0.00220	6.95	0.000412	0.00415	0.000134	0.00200	0.000505	0.938	0.0000883	0.147	0.00481	0.0000111	0.000158	0.000482	0.00358	0.00000974	0.115	0.00230	0.0293	0.0443	0.0000320	0.0000260	13.5
9	Sep	0.245	0.00194	6.09	0.000392	0.00384	0.000121	0.00176	0.000441	0.886	0.0000839	0.184	0.00479	0.0000103	0.000141	0.000457	0.00336	0.00000925	0.116	0.00211	0.0257	0.0437	0.0000314	0.0000258	14.3
10	Oct	0.257	0.00494	15.1	0.000641	0.00626	0.000255	0.00444	0.00113	1.47	0.000133	0.302	0.00503	0.0000179	0.000346	0.000672	0.00564	0.0000141	0.124	0.00367	0.0622	0.0472	0.0000357	0.0000279	21.2
11	Nov	0.266	0.00503	15.3	0.000649	0.00636	0.000259	0.00450	0.00115	1.49	0.000134	0.309	0.00505	0.0000189	0.000354	0.000682	0.00572	0.0000143	0.124	0.00372	0.0638	0.0474	0.0000360	0.0000281	21.6
12	Dec	0.263	0.00498	15.2	0.000645	0.00633	0.000257	0.00445	0.00114	1.48	0.000134	0.306	0.00506	0.0000193	0.000351	0.000680	0.00568	0.0000143	0.123	0.00371	0.0636	0.0474	0.0000360	0.0000281	21.4

Long-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	1.2	1	0.00013	NP	NP
Short-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	NP	NP	NP	NP	NP
Discharge Limit	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.46	NP	0.01	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-1: BJ 3.10

Appendix A-1-2: Upper Case BJ 3.10 Upper Case Water Quality Predictions

Operations

	Month	T-Cd	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.000318	0.00112	0.000389	0.000981	0.129	0.0000117	35.9	0.530	3.58	0.268	0.0264	79.5	0.00149	0.0474	***0.00849***	**0.0311**	***0.00610***	4.15	0.000319	0.807	0.00656	0.000115	0.00142	0.00262	***0.0159***
2	Feb	0.000318	0.00111	0.000388	0.000980	0.129	0.0000119	35.9	0.530	3.58	0.268	0.0264	79.4	0.00149	0.0473	***0.00848***	**0.0311**	***0.00610***	4.15	0.000319	0.807	0.00656	0.000115	0.00142	0.00262	***0.0159***
3	Mar	0.000318	0.00111	0.000387	0.000980	0.128	0.0000120	35.9	0.530	3.58	0.269	0.0264	79.4	0.00149	0.0473	***0.00847***	**0.0311**	***0.00610***	4.15	0.000320	0.807	0.00656	0.000115	0.00142	0.00263	***0.0159***
4	Apr	0.000318	0.00112	0.000386	0.000980	0.128	0.0000121	35.9	0.530	3.59	0.269	0.0264	79.4	0.00149	0.0473	***0.00845***	**0.0312**	***0.00610***	4.15	0.000320	0.807	0.00656	0.000115	0.00142	0.00263	***0.0159***
5	May	0.000312	0.00110	0.000377	0.000990	0.127	0.0000121	35.1	0.518	3.52	0.264	0.0258	77.6	0.00146	0.0467	***0.00823***	**0.0305**	***0.00597***	4.07	0.000314	0.791	0.00645	0.000113	0.00142	0.00258	***0.0156***
6	Jun	0.000234	0.000845	0.000289	0.000855	0.112	0.0000122	25.7	0.380	2.67	0.202	0.0189	57.1	0.00114	0.0360	***0.00597***	0.0222	***0.00440***	3.21	0.000243	0.594	0.00580	0.0000918	0.00110	0.00200	***0.0122***
7	Jul	0.000136	0.000519	0.000183	0.000649	0.0853	0.0000127	14.4	0.213	1.66	0.125	0.0109	32.5	0.000753	0.0227	0.00342	0.0126	***0.00254***	2.24	0.000162	0.358	0.00537	0.0000704	0.000677	0.00127	***0.00777***
8	Aug	0.000110	0.000430	0.000162	0.000611	0.0766	0.0000121	11.7	0.170	1.40	0.103	0.00884	26.5	0.000658	0.0197	0.00274	0.0102	***0.00208***	1.99	0.000141	0.298	0.00533	0.0000657	0.000597	0.00108	0.00654
9	Sep	0.000103	0.000409	0.000162	0.000621	0.0754	0.0000116	10.9	0.158	1.33	0.0963	0.00827	24.9	0.000633	0.0191	0.00251	0.00955	0.00196	1.90	0.000135	0.284	0.00530	0.0000642	0.000601	0.00102	0.00624
10	Oct	0.000323	0.00122	0.000327	0.000965	0.138	0.0000112	35.0	0.539	3.79	0.288	0.0258	77.6	0.00153	0.0464	***0.00811***	**0.0300**	***0.00595***	4.32	0.000330	0.789	0.00649	0.000112	0.00146	0.00255	***0.0168***
11	Nov	0.000334	0.00126	0.000336	0.000988	0.140	0.0000114	36.3	0.559	3.93	0.298	0.0267	80.4	0.00158	0.0478	***0.00857***	**0.0314**	***0.00616***	4.44	0.000341	0.816	0.00657	0.000116	0.00151	0.00264	***0.0174***
12	Dec	0.000331	0.00125	0.000334	0.000982	0.139	0.0000116	36.0	0.553	3.90	0.295	0.0265	79.6	0.00157	0.0474	***0.00850***	**0.0312**	***0.00611***	4.41	0.000339	0.808	0.00656	0.000115	0.00150	0.00262	***0.0172***

Closure

	Month	T-Cd	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.000330	0.00124	0.000273	0.000964	0.139	0.0000111	31.9	0.552	3.89	0.294	0.0230	74.9	0.00156	0.0465	0.00142	0.0220	***0.00545***	4.40	0.000338	0.776	0.00650	0.0000951	0.00150	0.00212	***0.0172***
2	Feb	0.000329	0.00124	0.000272	0.000962	0.138	0.0000113	31.8	0.551	3.88	0.294	0.0230	74.7	0.00156	0.0463	0.00141	0.0220	***0.00544***	4.39	0.000338	0.774	0.00649	0.0000950	0.00149	0.00211	***0.0172***
3	Mar	0.000328	0.00124	0.000272	0.000961	0.138	0.0000114	31.8	0.549	3.87	0.293	0.0229	74.5	0.00156	0.0462	0.00141	0.0219	***0.00542***	4.38	0.000337	0.772	0.00649	0.0000949	0.00149	0.00211	***0.0171***
4	Apr	0.000327	0.00123	0.000271	0.000959	0.137	0.0000116	31.7	0.548	3.87	0.293	0.0228	74.2	0.00155	0.0461	0.00140	0.0218	***0.00540***	4.37	0.000336	0.770	0.00649	0.0000947	0.00149	0.00210	***0.0171***
5	May	0.000319	0.00120	0.000264	0.000940	0.136	0.0000115	30.7	0.532	3.77	0.286	0.0222	72.1	0.00151	0.0449	0.00136	0.0212	***0.00525***	4.26	0.000328	0.749	0.00636	0.0000925	0.00144	0.00205	***0.0167***
6	Jun	0.000236	0.000913	0.000207	0.000783	0.120	0.0000118	22.4	0.385	2.82	0.215	0.0161	52.5	0.00116	0.0338	0.00105	0.0154	***0.00381***	3.31	0.000251	0.557	0.00568	0.0000765	0.00106	0.00157	***0.0128***
7	Jul	0.000132	0.000539	0.000138	0.000597	0.0996	0.0000124	12.0	0.204	1.66	0.130	0.00868	28.2	0.000735	0.0202	0.000673	0.00831	***0.00205***	2.22	0.000161	0.322	0.00521	0.0000599	0.000578	0.000994	***0.00793***
8	Aug	0.000103	0.000429	0.000126	0.000529	0.0870	0.0000120	8.92	0.150	1.33	0.103	0.00651	21.1	0.000618	0.0161	0.000559	0.00623	0.00154	1.91	0.000135	0.255	0.00514	0.0000558	0.000443	0.000824	0.00650
9	Sep	0.0000920	0.000394	0.000128	0.000519	0.0851	0.0000115	7.65	0.128	1.20	0.0911	0.00560	18.1	0.000572	0.0145	0.000503	0.00536	0.00133	1.76	0.000125	0.228	0.00507	0.0000537	0.000389	0.000749	0.00605
10	Oct	0.000242	0.000937	0.000220	0.000862	0.115	0.0000106	22.0	0.381	3.36	0.280	0.0158	51.4	0.00121	0.0332	0.000985	0.0152	***0.00375***	3.41	0.000260	0.586	0.00590	0.0000778	0.00106	0.00154	***0.0131***
11	Nov	0.000248	0.000960	0.000225	0.000886	0.116	0.0000108	22.4	0.388	3.46	0.289	0.0161	52.3	0.00123	0.0336	0.000997	0.0155	***0.00382***	3.46	0.000265	0.598	0.00593	0.0000788	0.00109	0.00157	***0.0134***
12	Dec	0.000246	0.000955	0.000224	0.000887	0.116	0.0000110	22.1	0.383	3.43	0.286	0.0159	51.7	0.00123	0.0333	0.000990	0.0153	***0.00379***	3.44	0.000264	0.593	0.00593	0.0000786	0.00108	0.00155	***0.0134***

PostClosure

	Month	T-Cd	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.000130	0.000578	0.000161	0.000672	0.0934	0.0000113	10.2	0.160	2.80	0.275	0.00717	22.5	0.000784	0.0167	0.000542	0.00664	0.00172	2.18	0.000165	0.368	0.00523	0.0000582	0.000511	0.000853	***0.00808***
2	Feb	0.000130	0.000578	0.000161	0.000672	0.0931	0.0000116	10.2	0.160	2.80	0.275	0.00716	22.4	0.000784	0.0167	0.000541	0.00662	0.00171	2.18	0.000165	0.367	0.00524	0.0000582	0.000511	0.000854	***0.00807***
3	Mar	0.000130	0.000578	0.000161	0.000673	0.0928	0.0000117	10.2	0.160	2.80	0.274	0.00714	22.4	0.000784	0.0166	0.000540	0.00661	0.00171	2.18	0.000165	0.367	0.00524	0.0000582	0.000510	0.000854	***0.00807***
4	Apr	0.000130	0.000577	0.000161	0.000673	0.0925	0.0000117	10.1	0.159	2.79	0.274	0.00712	22.3	0.000784	0.0166	0.000538	0.00659	0.00171	2.18	0.000166	0.366	0.00524	0.0000582	0.000510	0.000854	***0.00805***
5	May	0.000128	0.000575	0.000158	0.000672	0.0954	0.0000119	9.85	0.155	2.73	0.268	0.00692	21.7	0.000770	0.0163	0.000527	0.00641	0.00166	2.13	0.000162	0.358	0.00515	0.0000571	0.000497	0.000837	***0.00805***
6	Jun	0.000104	0.000500	0.000133	0.000627	0.105	0.0000125	7.23	0.112	2.09	0.207	0.00510	16.0	0.000634	0.0136	0.000445	0.00472	0.00122	1.79	0.000133	0.277	0.00480	0.0000510	0.000373	0.000693	0.00726
7	Jul	0.0000651	0.000341	0.000100	0.000513	0.0916	0.0000125	4.01	0.0595	1.29	0.126	0.00287	9.02	0.000463	0.00975	0.000358	0.00265	0.000676	1.42	0.0000986	0.176	0.00476	0.0000466	0.000218	0.000534	0.00530
8	Aug	0.0000515	0.000277	0.0000974	0.000461	0.0811	0.0000120	3.06	0.0442	1.05	0.0992	0.00223	6.95	0.000413	0.00842	0.000327	0.00205	0.000522	1.31	0.0000885	0.147	0.00481	0.0000460	0.000174	0.000482	0.00447
9	Sep	0.0000472	0.000260	0.000103	0.000447	0.0802	0.0000115	2.67	0.0379	2.16	0.253	0.00196	6.09	0.000393	0.00788	0.000306	0.00181	0.000461	1.25	0.0000840	0.185	0.00479	0.0000453	0.000157	0.000457	0.00424
10	Oct	0.0000964	0.000455	0.000138	0.000593	0.0882	0.0000109	7.15	0.105	2.57	0.265	0.00496	15.1	0.000642	0.0126	0.000430	0.00447	0.00116	1.81	0.000133	0.303	0.00503	0.0000524	0.000361	0.000673	0.00652
11	Nov	0.0000979	0.000461	0.000141	0.000601	0.0888	0.0000111	7.29	0.106	2.64	0.274	0.00505	15.3	0.000650	0.0127	0.000434	0.00454	0.00119	1.82	0.000135	0.310	0.00505	0.0000529	0.000368	0.000682	0.00661
12	Dec	0.0000970	0.000457	0.000141	0.000599	0.0884	0.0000111	7.22	0.105	2.62	0.271	0.00499	15.2	0.000646	0.0126	0.000433	0.00449	0.00118	1.81	0.000134	0.307	0.00506	0.0000530	0.000365	0.000681	0.00656

Long-Term BCWQG	NP	0.004	0.001	NP	NA	0.00002	NP	NP	NP	0.7282	7.6	NP	0.025	NP	0.004	NA	0.002	NP	NP	NP	NP	0.0008	0.0085	NP	0.0075
Short-Term BCWQG	NP	0.11	NP	NP	NA	NP	NP	NP	NP	0.8486	46	NP	NP	NP	0.016	NA	NP	NP	NP	NP	NP	NP	NP	NP	0.033
Discharge Limit	NP	NP	NP	NP	1.7	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.028	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-2: BJ 2.62 Results

Appendix A-2-1: Base Case BJ 2.62 Base Case Water Quality Predictions

Operations

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
1	Jan	3.16	**13.6**	0.114	7.21	0.252	100	0.0000117	***0.0556***	0.0120	0.117	0.0416	0.0000316	0.0000330	18.1	0.0000112	0.000238	0.000106	***0.000362***	0.00798	0.00000379	15.4	0.108	1.88	0.161
2	Feb	3.11	**13.4**	0.113	7.26	0.252	101	0.0000116	***0.0550***	0.0118	0.118	0.0419	0.0000316	0.0000329	18.2	0.0000108	0.000240	0.000106	***0.000369***	0.00793	0.00000380	15.4	0.109	1.90	0.162
3	Mar	3.15	**13.6**	0.114	7.11	0.249	99.2	0.0000117	***0.0553***	0.0119	0.115	0.0419	0.0000315	0.0000328	18.0	0.0000107	0.000236	0.000105	***0.000363***	0.00797	0.00000379	15.1	0.107	1.87	0.159
4	Apr	3.21	**13.8**	0.116	7.28	0.257	101	0.0000118	***0.0563***	0.0121	0.117	0.0420	0.0000318	0.0000330	18.2	0.0000108	0.000239	0.000106	***0.000370***	0.00803	0.00000382	15.5	0.108	1.90	0.162
5	May	3.20	**13.8**	0.116	7.45	0.259	104	0.0000118	***0.0570***	0.0121	0.120	0.0412	0.0000316	0.0000335	19.0	0.0000116	0.000253	0.000108	***0.000400***	0.00802	0.00000381	15.7	0.111	1.97	0.169
6	Jun	2.22	9.58	0.0806	5.32	0.185	76.1	0.00000961	0.0435	0.00864	0.0864	0.0371	0.0000272	0.0000306	15.5	0.00000962	0.000193	0.0000890	***0.000345***	0.00699	0.00000334	11.1	0.0792	1.47	0.122
7	Jul	1.12	4.81	0.0406	2.76	0.0984	42.3	0.00000735	0.0287	0.00463	0.0455	0.0340	0.0000232	0.0000279	11.9	0.00000738	0.000122	0.0000690	0.000252	0.00600	0.00000291	5.62	0.0398	0.876	0.0657
8	Aug	0.806	3.47	0.0293	2.14	0.0768	34.1	0.00000680	0.0241	0.00358	0.0352	0.0345	0.0000225	0.0000280	11.2	0.00000698	0.000103	0.0000641	0.000244	0.00581	0.00000282	4.27	0.0295	0.718	0.0476
9	Sep	0.824	3.55	0.0299	2.13	0.0764	34.3	0.00000688	0.0247	0.00373	0.0350	0.0345	0.0000226	0.0000287	11.4	0.00000721	0.000108	0.0000648	0.000270	0.00585	0.00000284	4.23	0.0297	0.740	0.0492
10	Oct	2.99	**12.9**	0.108	7.07	0.246	98.7	0.0000113	***0.0535***	0.0113	0.114	0.0400	0.0000311	0.0000327	18.9	0.0000108	0.000260	0.000113	***0.000366***	0.00785	0.00000367	14.9	0.109	2.00	0.175
11	Nov	3.18	**13.7**	0.115	7.40	0.257	103	0.0000118	***0.0558***	0.0120	0.120	0.0406	0.0000317	0.0000331	19.1	0.0000113	0.000267	0.000116	***0.000371***	0.00799	0.00000374	15.8	0.114	2.08	0.183
12	Dec	3.18	**13.7**	0.115	7.21	0.251	100	0.0000118	***0.0560***	0.0121	0.118	0.0406	0.0000316	0.0000329	19.1	0.0000112	0.000268	0.000117	***0.000367***	0.00801	0.00000375	15.4	0.115	2.09	0.184

Closure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
1	Jan	2.45	8.50	0.222	9.68	0.346	***187***	0.0000504	0.0275	0.00898	0.164	0.0676	0.0000445	0.0000382	50.2	0.0000137	0.00186	0.000404	***0.00134***	0.0120	0.00000372	15.6	0.163	3.79	0.234
2	Feb	2.36	8.26	0.209	9.31	0.333	***182***	0.0000475	0.0255	0.00787	0.157	0.0657	0.0000435	0.0000377	48.0	0.0000130	0.00174	0.000382	***0.00111***	0.0117	0.00000367	15.0	0.156	3.67	0.232
3	Mar	2.27	8.02	0.196	8.94	0.319	***175***	0.0000445	0.0245	0.00725	0.151	0.0635	0.0000423	0.0000371	45.6	0.0000128	0.00161	0.000359	***0.000977***	0.0114	0.00000361	14.5	0.150	3.55	0.229
4	Apr	2.17	7.79	0.180	8.56	0.304	***165***	0.0000408	0.0242	0.00692	0.145	0.0607	0.0000409	0.0000364	42.8	0.0000126	0.00146	0.000331	***0.000907***	0.0110	0.00000354	14.1	0.143	3.41	0.228
5	May	1.97	8.49	0.0945	7.22	0.241	111	0.0000208	0.0245	0.00546	0.118	0.0445	0.0000318	0.0000330	28.0	0.0000125	0.000680	0.000183	***0.000524***	0.00849	0.00000311	13.9	0.114	2.59	0.213
6	Jun	1.35	5.80	0.0507	5.01	0.169	73.3	0.0000100	0.0209	0.00403	0.0826	0.0348	0.0000264	0.0000289	17.0	0.00000969	0.000258	0.0000976	***0.000332***	0.00689	0.00000277	9.57	0.0788	1.63	0.146
7	Jul	0.734	3.00	0.0372	2.83	0.0982	45.9	0.0000101	0.0189	0.00321	0.0474	0.0348	0.0000234	0.0000264	14.4	0.00000726	0.000253	0.0000942	***0.000445***	0.00616	0.00000266	5.04	0.0433	1.01	0.0761
8	Aug	0.569	2.22	0.0356	2.29	0.0809	40.0	0.0000108	0.0180	0.00299	0.0385	0.0366	0.0000231	0.0000263	14.7	0.00000684	0.000287	0.0000984	***0.000466***	0.00609	0.00000267	3.82	0.0345	0.894	0.0560
9	Sep	0.556	2.10	0.0389	2.30	0.0817	41.7	0.0000119	0.0181	0.00297	0.0383	0.0374	0.0000233	0.0000264	15.8	0.00000715	0.000333	0.000106	***0.000475***	0.00617	0.00000269	3.69	0.0344	0.924	0.0538
10	Oct	1.57	6.24	0.0917	6.05	0.209	102	0.0000199	0.0236	0.00597	0.100	0.0441	0.0000311	0.0000316	26.0	0.0000111	0.000641	0.000176	***0.000765***	0.00822	0.00000305	10.9	0.0975	2.42	0.206
11	Nov	2.06	7.54	0.161	8.03	0.284	***145***	0.0000359	0.0267	0.00852	0.135	0.0564	0.0000380	0.0000350	38.6	0.0000126	0.00128	0.000297	***0.00127***	0.0102	0.00000339	13.6	0.133	3.17	0.229
12	Dec	2.60	8.89	**0.244**	10.3	0.368	***197***	0.0000553	0.0303	0.0107	0.174	0.0712	0.0000463	0.0000391	54.1	0.0000141	0.00205	0.000442	***0.00171***	0.0125	0.00000381	16.3	0.174	4.00	0.244

PostClosure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
1	Jan	1.18	3.92	0.117	6.07	0.212	124	0.0000327	0.0217	0.00609	0.108	0.0548	0.0000398	0.0000345	38.1	0.0000199	0.00105	0.000241	***0.000695***	0.0104	0.00000353	9.28	0.110	3.36	0.248
2	Feb	1.13	3.79	0.110	5.78	0.203	118	0.0000309	0.0212	0.00582	0.102	0.0536	0.0000387	0.0000340	36.5	0.0000188	0.000985	0.000228	***0.000665***	0.0102	0.00000348	8.83	0.104	3.27	0.246
3	Mar	1.08	3.66	0.102	5.49	0.193	113	0.0000290	0.0207	0.00553	0.0969	0.0522	0.0000376	0.0000334	34.9	0.0000181	0.000917	0.000216	***0.000628***	0.00988	0.00000342	8.49	0.0979	3.17	0.243
4	Apr	1.02	3.51	0.0925	5.14	0.181	106	0.0000265	0.0203	0.00514	0.0905	0.0501	0.0000359	0.0000326	32.7	0.0000169	0.000824	0.000198	***0.000579***	0.00944	0.00000334	8.10	0.0911	3.05	0.241
5	May	0.701	2.71	0.0451	3.46	0.119	72.8	0.0000141	0.0190	0.00340	0.0560	0.0392	0.0000268	0.0000285	22.9	0.0000128	0.000402	0.000118	***0.000498***	0.00717	0.00000292	5.97	0.0541	2.42	0.227
6	Jun	0.405	1.69	0.0184	1.92	0.0679	43.2	0.00000769	0.0162	0.00179	0.0306	0.0327	0.0000211	0.0000248	14.9	0.00000890	0.000170	0.0000724	0.000246	0.00566	0.00000257	3.61	0.0274	1.58	0.159
7	Jul	0.216	0.862	0.0123	1.19	0.0429	28.0	0.00000718	0.0153	0.00128	0.0199	0.0328	0.0000206	0.0000244	12.3	0.00000723	0.000140	0.0000658	0.000190	0.00547	0.00000258	1.95	0.0162	0.954	0.0818
8	Aug	0.177	0.662	0.0128	1.09	0.0394	25.6	0.00000769	0.0149	0.00130	0.0188	0.0342	0.0000212	0.0000249	12.5	0.00000765	0.000152	0.0000683	0.000193	0.00558	0.00000261	1.61	0.0153	0.826	0.0592
9	Sep	0.178	0.643	0.0144	1.60	0.0590	48.3	0.00000824	0.0157	0.00207	0.0201	0.0347	0.0000235	0.0000261	17.6	0.0000113	0.000174	0.0000718	***0.000337***	0.00616	0.00000275	1.74	0.0229	2.14	0.214
10	Oct	0.339	1.46	0.0124	2.64	0.0929	59.2	0.00000946	0.0172	0.00275	0.0341	0.0360	0.0000309	0.0000296	19.6	0.0000161	0.000140	0.0000673	***0.000366***	0.00780	0.00000310	3.79	0.0406	2.56	0.239
11	Nov	0.349	1.51	0.0128	1.77	0.0845	54.7	0.0000103	0.0157	0.00268	0.0303	0.0384	0.0000392	0.0000337	23.5	0.0000210	0.000142	0.0000650	0.000240	0.00972	0.00000352	3.88	0.0277	2.98	0.254
12	Dec	0.349	1.51	0.0129	1.67	0.0986	60.4	0.0000116	0.0164	0.00336	0.0325	0.0396	0.0000411	0.0000351	24.6	0.0000212	0.000155	0.0000647	0.000261	0.0102	0.00000359	4.00	0.0283	3.00	0.253

	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
Long-Term BCWQG	NA	NA	NA	150	NP	128	NP	0.05	NP	NP	NP	NP	NP	NP	0.00008	NP	NP	0.0003	NP	NP	NP	NP	NP	NP
Short-Term BCWQG	NA	NA	NA	600	0.82	NP	NP	0.1	NP	NP	NP	NP	NP	NP	0.00016	NP	NP	0.0018	0.35	NP	NP	NP	NP	NP
Discharge Limit	4	11.5	0.24	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO^3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO^4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-2: BJ 2.62 Results

Appendix A-2-1: Base Case BJ 2.62 Base Case Water Quality Predictions

Operations

	Month	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca	T-Cd
1	Jan	0.0139	45.2	0.000385	0.00698	0.0000549	0.0175	0.00186	1.50	0.0000792	0.358	0.00530	0.0000561	0.000538	0.000776	0.00114	0.0000120	0.156	**0.0123**	0.125	0.0467	0.0000316	0.0000330	18.1	0.0000118
2	Feb	0.0139	45.3	0.000386	0.00694	0.0000552	0.0173	0.00186	1.51	0.0000794	0.361	0.00530	0.0000510	0.000529	0.000768	0.00113	0.0000119	0.157	**0.0121**	0.120	0.0471	0.0000316	0.0000329	18.2	0.0000114
3	Mar	0.0138	44.6	0.000383	0.00695	0.0000546	0.0174	0.00184	1.49	0.0000788	0.355	0.00530	0.0000515	0.000527	0.000774	0.00113	0.0000120	0.156	**0.0123**	0.118	0.0470	0.0000315	0.0000328	18.0	0.0000112
4	Apr	0.0142	46.0	0.000387	0.00708	0.0000551	0.0178	0.00190	1.51	0.0000793	0.360	0.00530	0.0000524	0.000536	0.000785	0.00115	0.0000121	0.158	**0.0125**	0.120	0.0472	0.0000318	0.0000330	18.2	0.0000114
5	May	0.0142	46.3	0.000390	0.00781	0.0000561	0.0177	0.00191	1.54	0.0000799	0.372	0.00520	0.0000523	0.000569	0.000782	0.00119	0.0000121	0.163	**0.0125**	0.123	0.0469	0.0000316	0.0000335	19.0	0.0000122
6	Jun	0.0101	33.1	0.000340	0.00637	0.0000466	0.0123	0.00138	1.23	0.0000685	0.278	0.00487	0.0000379	0.000453	0.000615	0.000971	0.00000981	0.140	0.00907	0.0881	0.0431	0.0000272	0.0000306	15.5	0.0000100
7	Jul	0.00524	17.1	0.000291	0.00403	0.0000361	0.00629	0.000737	0.882	0.0000579	0.166	0.00479	0.0000216	0.000268	0.000438	0.000736	0.00000745	0.117	0.00518	0.0463	0.0410	0.0000232	0.0000279	11.8	0.00000757
8	Aug	0.00405	13.3	0.000285	0.00362	0.0000337	0.00462	0.000585	0.791	0.0000558	0.141	0.00485	0.0000174	0.000243	0.000389	0.000682	0.00000685	0.118	0.00402	0.0358	0.0409	0.0000225	0.0000280	11.2	0.00000771
9	Sep	0.00402	13.2	0.000288	0.00407	0.0000341	0.00475	0.000595	0.793	0.0000558	0.142	0.00483	0.0000178	0.000275	0.000394	0.000701	0.00000695	0.118	0.00414	0.0355	0.0408	0.0000226	0.0000287	11.5	0.00000806
10	Oct	0.0134	44.0	0.000385	0.00690	0.0000552	0.0165	0.00178	1.52	0.0000797	0.353	0.00527	0.0000480	0.000525	0.000743	0.00113	0.0000116	0.154	**0.0116**	0.116	0.0458	0.0000311	0.0000327	18.9	0.0000116
11	Nov	0.0141	46.2	0.000391	0.00706	0.0000566	0.0177	0.00187	1.56	0.0000812	0.367	0.00532	0.0000559	0.000554	0.000778	0.00115	0.0000121	0.147	**0.0124**	0.127	0.0457	0.0000317	0.0000331	19.1	0.0000119
12	Dec	0.0139	45.0	0.000392	0.00703	0.0000569	0.0177	0.00185	1.57	0.0000814	0.358	0.00533	0.0000560	0.000557	0.000779	0.00114	0.0000121	0.147	**0.0124**	0.125	0.0457	0.0000316	0.0000330	19.1	0.0000118

Closure

	Month	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca	T-Cd
1	Jan	0.0132	56.7	0.000498	0.00619	0.000160	0.0109	0.00320	5.17	0.000338	0.667	0.00615	0.0000804	0.000964	0.00101	0.00153	0.0000504	0.0942	0.00930	0.172	0.0729	0.0000445	0.0000382	50.2	0.0000143
2	Feb	0.0126	54.6	0.000488	0.00603	0.000138	0.0101	0.00296	4.90	0.000319	0.641	0.00608	0.0000718	0.000862	0.000906	0.00148	0.0000475	0.0912	0.00819	0.160	0.0709	0.0000435	0.0000377	48.0	0.0000136
3	Mar	0.0121	52.5	0.000478	0.00599	0.000125	0.00955	0.00277	4.61	0.000299	0.614	0.00601	0.0000685	0.000801	0.000847	0.00145	0.0000445	0.0900	0.00757	0.154	0.0686	0.0000423	0.0000371	45.6	0.0000134
4	Apr	0.0118	50.3	0.000466	0.00617	0.000118	0.00929	0.00261	4.26	0.000275	0.583	0.00592	0.0000647	0.000764	0.000819	0.00141	0.0000408	0.0900	0.00724	0.147	0.0659	0.0000409	0.0000364	42.7	0.0000132
5	May	0.0120	43.2	0.000395	0.00795	0.0000738	0.00889	0.00167	2.37	0.000145	0.405	0.00520	0.0000434	0.000554	0.000615	0.00121	0.0000208	0.0939	0.00581	0.121	0.0500	0.0000318	0.0000330	28.0	0.0000131
6	Jun	0.00831	29.9	0.000333	0.00557	0.0000492	0.00618	0.00117	1.28	0.0000762	0.266	0.00480	0.0000312	0.000391	0.000494	0.000945	0.0000101	0.0906	0.00444	0.0844	0.0406	0.0000264	0.0000289	17.0	0.0000101
7	Jul	0.00458	16.7	0.000290	0.00324	0.0000552	0.00359	0.000785	1.16	0.0000777	0.180	0.00478	0.0000205	0.000265	0.000450	0.000734	0.0000101	0.0951	0.00375	0.0482	0.0417	0.0000234	0.0000264	14.3	0.00000746
8	Aug	0.00358	13.2	0.000284	0.00263	0.0000572	0.00293	0.000698	1.19	0.0000842	0.164	0.00487	0.0000181	0.000237	0.000440	0.000702	0.0000109	0.103	0.00342	0.0391	0.0430	0.0000231	0.0000263	14.7	0.00000756
9	Sep	0.00346	13.1	0.000286	0.00276	0.0000590	0.00288	0.000721	1.29	0.0000911	0.171	0.00484	0.0000185	0.000243	0.000445	0.000736	0.0000119	0.104	0.00337	0.0388	0.0436	0.0000233	0.0000264	15.8	0.00000799
10	Oct	0.00946	35.7	0.000388	0.00563	0.0000912	0.00747	0.00172	2.25	0.000140	0.382	0.00528	0.0000410	0.000559	0.000680	0.00110	0.0000199	0.102	0.00633	0.102	0.0498	0.0000311	0.0000316	26.0	0.0000119
11	Nov	0.0118	47.2	0.000447	0.00593	0.000144	0.00981	0.00261	3.78	0.000244	0.534	0.00574	0.0000647	0.000835	0.000929	0.00132	0.0000359	0.0942	0.00885	0.142	0.0616	0.0000380	0.0000350	38.6	0.0000132
12	Dec	0.0141	60.2	0.000514	0.00630	0.000194	0.0121	0.00357	5.63	0.000370	0.711	0.00625	0.0000856	0.00110	0.00116	0.00160	0.0000553	0.0974	**0.0111**	0.182	0.0766	0.0000463	0.0000391	54.1	0.0000147

PostClosure

	Month	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca	T-Cd
1	Jan	0.00792	34.7	0.000426	0.00394	0.000119	0.00833	0.00183	3.47	0.000221	0.490	0.00578	0.0000508	0.000693	0.000913	0.00264	0.0000327	0.0917	0.00643	0.116	0.0600	0.0000398	0.0000345	38.1	0.0000205
2	Feb	0.00760	33.0	0.000419	0.00386	0.000113	0.00790	0.00174	3.29	0.000210	0.472	0.00572	0.0000434	0.000646	0.000873	0.00252	0.0000309	0.0901	0.00616	0.105	0.0589	0.0000387	0.0000340	36.5	0.0000194
3	Mar	0.00730	31.4	0.000411	0.00379	0.000107	0.00746	0.00164	3.10	0.000198	0.453	0.00566	0.0000413	0.000608	0.000833	0.00240	0.0000290	0.0895	0.00587	0.0995	0.0574	0.0000376	0.0000334	34.9	0.0000187
4	Apr	0.00694	29.4	0.000400	0.00373	0.000123	0.00699	0.00151	2.85	0.000181	0.428	0.00556	0.0000385	0.000563	0.000880	0.00216	0.0000265	0.0940	0.00548	0.0931	0.0553	0.0000359	0.0000326	32.7	0.0000175
5	May	0.00493	18.9	0.000344	0.00419	0.000128	0.00423	0.000880	1.62	0.000103	0.302	0.00489	0.0000250	0.000508	0.000925	0.00127	0.0000141	0.0942	0.00379	0.0586	0.0449	0.0000268	0.0000285	22.9	0.0000134
6	Jun	0.00296	10.5	0.000286	0.00303	0.0000561	0.00221	0.000450	0.917	0.0000626	0.187	0.00454	0.0000150	0.000202	0.000466	0.000771	0.00000769	0.0935	0.00223	0.0324	0.0387	0.0000211	0.0000248	14.9	0.00000934
7	Jul	0.00172	6.34	0.000264	0.00200	0.0000453	0.00139	0.000289	0.815	0.0000603	0.128	0.00469	0.0000107	0.000126	0.000391	0.000733	0.00000718	0.101	0.00183	0.0207	0.0396	0.0000206	0.0000244	12.2	0.00000786
8	Aug	0.00150	5.75	0.000264	0.00173	0.0000490	0.00137	0.000276	0.851	0.0000642	0.120	0.00474	0.0000102	0.000123	0.000408	0.000810	0.00000769	0.102	0.00175	0.0194	0.0407	0.0000212	0.0000249	12.5	0.00000850
9	Sep	0.00154	6.08	0.000304	0.00222	0.0000876	0.00150	0.000301	1.03	0.0000676	0.203	0.00477	0.0000106	0.000281	0.000653	0.00111	0.00000824	0.102	0.00246	0.0207	0.0409	0.0000235	0.0000261	17.6	0.0000121
10	Oct	0.00310	10.0	0.000331	0.00306	0.0000881	0.00243	0.000559	1.20	0.0000725	0.265	0.00524	0.0000153	0.000347	0.000677	0.00194	0.00000947	0.0997	0.00313	0.0355	0.0415	0.0000309	0.0000296	19.6	0.0000168
11	Nov	0.00340	10.0	0.000363	0.00318	0.0000472	0.00200	0.000402	1.26	0.0000787	0.332	0.00571	0.0000203	0.000195	0.000422	0.00285	0.0000103	0.0873	0.00303	0.0377	0.0435	0.0000392	0.0000337	23.5	0.0000217
12	Dec	0.00383	10.7	0.000381	0.00369	0.0000493	0.00203	0.000389	1.44	0.0000863	0.364	0.00582	0.0000214	0.000205	0.000438	0.00288	0.0000116	0.0874	0.00371	0.0403	0.0446	0.0000411	0.0000351	24.6	0.0000218

Long-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	1.2	1	0.00013	NP	NP	NP
Short-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	NP	NP	NP	NP	NP	NP
Discharge Limit	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.46	NP	0.01	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-2: BJ 2.62 Results

Appendix A-2-1: Base Case BJ 2.62 Base Case Water Quality Predictions

Operations

	Month	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.000238	0.000317	0.000493	0.0374	0.00000379	15.5	0.108	1.90	0.167	0.0139	45.2	0.000441	0.0109	0.000260	0.0176	0.00195	1.77	0.000133	0.359	0.00530	0.0000844	0.000550	0.000804	0.00203
2	Feb	0.000240	0.000311	0.000495	0.0372	0.00000380	15.5	0.109	1.92	0.168	0.0139	45.3	0.000442	0.0108	0.000238	0.0173	0.00190	1.78	0.000133	0.362	0.00530	0.0000836	0.000541	0.000796	0.00203
3	Mar	0.000236	0.000309	0.000489	0.0369	0.00000379	15.2	0.107	1.89	0.165	0.0138	44.6	0.000441	0.0107	0.000236	0.0175	0.00188	1.76	0.000132	0.356	0.00530	0.0000839	0.000539	0.000802	0.00203
4	Apr	0.000239	0.000313	0.000496	0.0373	0.00000382	15.6	0.109	1.92	0.168	0.0142	46.0	0.000444	0.0109	0.000239	0.0178	0.00194	1.78	0.000134	0.361	0.00530	0.0000845	0.000548	0.000813	0.00204
5	May	0.000253	0.000311	0.000522	0.0387	0.00000381	15.9	0.112	1.99	0.176	0.0142	46.3	0.000444	0.0118	0.000254	0.0177	0.00196	1.84	0.000133	0.373	0.00520	0.0000828	0.000582	0.000810	0.00206
6	Jun	0.000193	0.000230	0.000466	0.0362	0.00000334	11.2	0.0793	1.50	0.130	0.0101	33.1	0.000377	0.00994	0.000242	0.0124	0.00141	1.55	0.000105	0.278	0.00487	0.0000689	0.000466	0.000634	0.00182
7	Jul	0.000122	0.000135	0.000382	0.0354	0.00000291	5.73	0.0399	0.913	0.0758	0.00527	17.1	0.000308	0.00730	0.000244	0.00634	0.000752	1.26	0.0000750	0.166	0.00479	0.0000559	0.000283	0.000447	0.00162
8	Aug	0.000103	0.000134	0.000379	0.0371	0.00000282	4.41	0.0297	0.746	0.0558	0.00407	13.3	0.000294	0.00685	0.000225	0.00466	0.000609	1.16	0.0000672	0.141	0.00485	0.0000530	0.000259	0.000396	0.00159
9	Sep	0.000108	0.000137	0.000404	0.0370	0.00000284	4.37	0.0300	0.766	0.0569	0.00404	13.2	0.000297	0.00727	0.000220	0.00478	0.000621	1.15	0.0000669	0.143	0.00483	0.0000532	0.000291	0.000401	0.00160
10	Oct	0.000260	0.000254	0.000490	0.0387	0.00000367	15.1	0.109	2.02	0.182	0.0134	44.0	0.000415	0.0110	0.000237	0.0165	0.00182	1.84	0.000112	0.354	0.00527	0.0000803	0.000538	0.000770	0.00199
11	Nov	0.000267	0.000262	0.000501	0.0360	0.00000374	15.9	0.114	2.10	0.189	0.0141	46.2	0.000425	0.0110	0.000245	0.0177	0.00196	1.84	0.000115	0.368	0.00532	0.0000845	0.000566	0.000807	0.00202
12	Dec	0.000268	0.000262	0.000497	0.0360	0.00000375	15.5	0.115	2.11	0.190	0.0139	45.0	0.000425	0.0110	0.000245	0.0177	0.00194	1.85	0.000115	0.359	0.00533	0.0000846	0.000569	0.000808	0.00201

Closure

	Month	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.00186	0.000446	0.00148	0.0360	0.00000372	15.7	0.163	3.82	0.241	0.0132	56.7	0.000499	0.0113	0.000337	0.0109	***0.00330***	5.47	0.000340	0.668	0.00615	0.000110	0.000976	0.00101	0.00238
2	Feb	0.00174	0.000415	0.00124	0.0351	0.00000367	15.1	0.157	3.70	0.238	0.0126	54.6	0.000490	0.0110	0.000287	0.0101	***0.00300***	5.20	0.000321	0.642	0.00608	0.000106	0.000875	0.000908	0.00234
3	Mar	0.00161	0.000392	0.00111	0.0347	0.00000361	14.6	0.150	3.57	0.236	0.0121	52.5	0.000479	0.0108	0.000273	0.00958	***0.00281***	4.91	0.000301	0.615	0.00601	0.000103	0.000813	0.000848	0.00230
4	Apr	0.00146	0.000364	0.00104	0.0344	0.00000354	14.2	0.143	3.43	0.235	0.0118	50.3	0.000467	0.0106	0.000267	0.00932	***0.00264***	4.56	0.000277	0.584	0.00592	0.0000986	0.000776	0.000821	0.00226
5	May	0.000680	0.000214	0.000649	0.0336	0.00000311	14.1	0.115	2.61	0.221	0.0120	43.2	0.000397	0.0122	0.000238	0.00892	0.00171	2.69	0.000147	0.405	0.00520	0.0000747	0.000566	0.000617	0.00203
6	Jun	0.000258	0.000119	0.000452	0.0317	0.00000277	9.68	0.0789	1.66	0.154	0.00833	29.9	0.000335	0.00927	0.000217	0.00622	0.00120	1.60	0.0000771	0.266	0.00480	0.0000619	0.000404	0.000496	0.00174
7	Jul	0.000253	0.000105	0.000575	0.0335	0.00000266	5.15	0.0434	1.05	0.0863	0.00460	16.7	0.000291	0.00655	0.000251	0.00365	0.000799	1.54	0.0000784	0.180	0.00478	0.0000546	0.000280	0.000451	0.00160
8	Aug	0.000287	0.000130	0.000601	0.0358	0.00000267	3.95	0.0347	0.923	0.0644	0.00360	13.2	0.000285	0.00590	0.000241	0.00297	0.000721	1.56	0.0000846	0.165	0.00487	0.0000537	0.000253	0.000441	0.00160
9	Sep	0.000333	0.000142	0.000609	0.0360	0.00000269	3.83	0.0347	0.950	0.0616	0.00348	13.1	0.000286	0.00603	0.000238	0.00291	0.000746	1.65	0.0000915	0.172	0.00484	0.0000539	0.000259	0.000445	0.00163
10	Oct	0.000641	0.000214	0.000893	0.0355	0.00000305	11.0	0.0978	2.44	0.213	0.00948	35.7	0.000390	0.00974	0.000257	0.00750	0.00176	2.58	0.000141	0.383	0.00528	0.0000742	0.000574	0.000682	0.00195
11	Nov	0.00128	0.000337	0.00140	0.0343	0.00000339	13.7	0.134	3.19	0.236	0.0118	47.2	0.000449	0.0105	0.000319	0.00984	***0.00270***	4.08	0.000245	0.535	0.00574	0.0000940	0.000847	0.000931	0.00217
12	Dec	0.00205	0.000484	0.00185	0.0366	0.00000381	16.5	0.174	4.02	0.251	0.0141	60.2	0.000516	0.0117	0.000372	0.0121	***0.00367***	5.94	0.000371	0.712	0.00625	0.000115	0.00112	0.00117	0.00246

PostClosure

	Month	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.00105	0.000281	0.000837	0.0356	0.00000353	9.40	0.110	3.38	0.255	0.00794	34.7	0.000427	0.00796	0.000300	0.00836	0.00192	3.77	0.000222	0.490	0.00578	0.0000813	0.000705	0.000913	0.00354
2	Feb	0.000985	0.000260	0.000801	0.0348	0.00000348	8.95	0.104	3.29	0.253	0.00762	33.0	0.000419	0.00772	0.000267	0.00793	0.00177	3.59	0.000210	0.473	0.00572	0.0000787	0.000659	0.000874	0.00342
3	Mar	0.000917	0.000247	0.000765	0.0344	0.00000342	8.60	0.0981	3.19	0.250	0.00732	31.4	0.000411	0.00755	0.000260	0.00750	0.00167	3.40	0.000198	0.454	0.00566	0.0000766	0.000621	0.000834	0.00330
4	Apr	0.000824	0.000229	0.000715	0.0342	0.00000334	8.21	0.0913	3.08	0.248	0.00696	29.4	0.000401	0.00739	0.000298	0.00702	0.00155	3.15	0.000182	0.429	0.00556	0.0000737	0.000576	0.000880	0.00306
5	May	0.000402	0.000148	0.000630	0.0335	0.00000292	6.09	0.0543	2.45	0.234	0.00495	18.9	0.000345	0.00749	0.000302	0.00426	0.000919	1.94	0.000104	0.302	0.00489	0.0000576	0.000522	0.000925	0.00213
6	Jun	0.000170	0.0000933	0.000374	0.0335	0.00000257	3.71	0.0275	1.61	0.168	0.00298	10.5	0.000286	0.00594	0.000246	0.00225	0.000478	1.25	0.0000630	0.188	0.00454	0.0000474	0.000216	0.000467	0.00161
7	Jul	0.000140	0.0000803	0.000324	0.0357	0.00000258	2.06	0.0163	0.992	0.0920	0.00174	6.34	0.000264	0.00496	0.000246	0.00145	0.000302	1.20	0.0000605	0.127	0.00469	0.0000456	0.000142	0.000391	0.00165
8	Aug	0.000152	0.0000991	0.000330	0.0359	0.00000261	1.74	0.0155	0.855	0.0676	0.00153	5.75	0.000264	0.00476	0.000231	0.00141	0.000298	1.22	0.0000643	0.121	0.00474	0.0000464	0.000138	0.000408	0.00172
9	Sep	0.000174	0.000107	0.000474	0.0359	0.00000275	1.87	0.0231	2.16	0.221	0.00156	6.08	0.000304	0.00497	0.000263	0.00154	0.000333	1.37	0.0000677	0.204	0.00477	0.0000465	0.000296	0.000653	0.00202
10	Oct	0.000140	0.000104	0.000501	0.0354	0.00000310	3.92	0.0409	2.59	0.245	0.00312	10.0	0.000331	0.00605	0.000263	0.00246	0.000591	1.54	0.0000728	0.266	0.00524	0.0000502	0.000362	0.000677	0.00285
11	Nov	0.000142	0.000103	0.000383	0.0358	0.00000352	3.99	0.0279	3.00	0.261	0.00342	10.0	0.000363	0.00595	0.000231	0.00204	0.000490	1.55	0.0000787	0.332	0.00571	0.0000512	0.000208	0.000422	0.00376
12	Dec	0.000155	0.000103	0.000405	0.0358	0.00000359	4.11	0.0285	3.02	0.260	0.00385	10.7	0.000381	0.00645	0.000231	0.00206	0.000481	1.73	0.0000866	0.364	0.00582	0.0000521	0.000217	0.000438	0.00378

Long-Term BCWQG	0.004	0.001	NP	NA	0.00002	NP	NP	NP	0.7282	7.6	NP	0.025	NP	0.004	NA	0.002	NP	NP	NP	NP	0.0008	0.0085	NP	0.0075
Short-Term BCWQG	0.11	NP	NP	NA	NP	NP	NP	NP	0.8486	46	NP	NP	NP	0.016	NA	NP	NP	NP	NP	NP	NP	NP	NP	0.033
Discharge Limit	NP	NP	NP	1.7	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.028	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-2: BJ 2.62 Results

Appendix A-2-2: Upper Case BJ 2.62 Base Case Water Quality Predictions

Operations

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
1	Jan	**5.14**	**22.1**	0.186	15.8	0.450	***260***	0.0000350	***0.182***	0.0229	0.266	0.0557	0.0000574	0.0000404	37.8	***0.000280***	0.000988	0.000193	***0.000761***	0.0921	0.0000109	31.6	0.466	3.16	0.230
2	Feb	**5.08**	**21.9**	0.184	15.9	0.453	***262***	0.0000346	***0.179***	0.0226	0.268	0.0562	0.0000573	0.0000403	38.0	***0.000282***	0.000994	0.000194	***0.000772***	0.0926	0.0000109	31.7	0.470	3.19	0.232
3	Mar	**5.12**	**22.1**	0.186	15.6	0.443	***256***	0.0000350	***0.181***	0.0228	0.262	0.0558	0.0000568	0.0000402	37.5	***0.000276***	0.000974	0.000191	***0.000757***	0.0905	0.0000111	31.1	0.460	3.13	0.227
4	Apr	**5.23**	**22.5**	0.189	15.8	0.452	***261***	0.0000356	***0.185***	0.0233	0.266	0.0562	0.0000582	0.0000406	38.0	***0.000281***	0.000993	0.000194	***0.000771***	0.0930	0.0000113	31.6	0.467	3.18	0.232
5	May	**5.21**	**22.4**	0.189	16.4	0.467	***270***	0.0000359	***0.188***	0.0232	0.274	0.0564	0.0000673	0.0000412	39.6	***0.000303***	0.00112	0.000205	***0.000926***	0.136	0.0000114	32.4	0.480	3.31	0.251
6	Jun	3.69	**15.9**	0.134	11.7	0.333	***193***	0.0000266	***0.138***	0.0164	0.195	0.0488	0.0000528	0.0000365	30.1	***0.000215***	0.000808	0.000159	***0.000721***	0.0974	0.0000111	22.9	0.340	2.42	0.180
7	Jul	1.83	7.89	0.0664	5.91	0.171	100	0.0000164	***0.0794***	0.00859	0.0993	0.0415	0.0000368	0.0000316	19.2	***0.000111***	0.000434	0.000108	***0.000448***	0.0522	0.0000106	11.4	0.170	1.36	0.0948
8	Aug	1.35	5.83	0.0491	4.48	0.131	77.5	0.0000135	***0.0623***	0.00644	0.0748	0.0405	0.0000333	0.0000309	16.5	0.0000807	0.000331	0.0000928	***0.000394***	0.0414	0.00000962	8.66	0.123	1.06	0.0688
9	Sep	1.35	5.82	0.0491	4.48	0.131	77.5	0.0000138	***0.0640***	0.00666	0.0742	0.0406	0.0000351	0.0000316	16.9	***0.0000854***	0.000360	0.0000957	***0.000441***	0.0496	0.00000970	8.58	0.124	1.10	0.0729
10	Oct	**4.87**	**21.0**	0.176	15.5	0.441	***255***	0.0000334	***0.173***	0.0216	0.259	0.0558	0.0000610	0.0000399	39.9	***0.000289***	0.00112	0.000212	***0.000805***	0.118	0.0000102	30.7	0.472	3.37	0.252
11	Nov	**5.17**	**22.3**	0.187	16.2	0.462	***267***	0.0000353	***0.183***	0.0230	0.273	0.0568	0.0000595	0.0000406	41.1	***0.000298***	0.00113	0.000218	***0.000793***	0.108	0.0000105	32.4	0.495	3.50	0.259
12	Dec	**5.17**	**22.3**	0.187	15.8	0.450	***260***	0.0000353	***0.183***	0.0231	0.269	0.0571	0.0000587	0.0000405	41.2	***0.000299***	0.00113	0.000219	***0.000767***	0.104	0.0000108	31.6	0.498	3.52	0.260

Closure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
1	Jan	**4.13**	**14.6**	**0.354**	25.7	**0.831**	***511***	0.000206	***0.188***	0.0219	0.502	0.175	0.0000830	0.0000527	196	***0.00168***	0.00838	0.00122	***0.00794***	0.150	0.0000110	45.6	0.768	13.2	0.719
2	Feb	3.99	**14.2**	**0.334**	24.6	0.792	***491***	0.000193	***0.165***	0.0190	0.479	0.167	0.0000809	0.0000517	184	***0.00151***	0.00783	0.00115	***0.00630***	0.145	0.0000111	43.5	0.736	12.4	0.685
3	Mar	3.85	**13.9**	**0.313**	23.4	0.752	***468***	0.000180	***0.152***	0.0174	0.454	0.158	0.0000786	0.0000506	172	***0.00138***	0.00727	0.00107	***0.00540***	0.141	0.0000111	41.5	0.702	11.7	0.650
4	Apr	3.69	**13.6**	**0.289**	22.2	0.706	***439***	0.000163	***0.146***	0.0166	0.428	0.147	0.0000763	0.0000492	158	***0.00125***	0.00659	0.000974	***0.00491***	0.137	0.0000113	39.3	0.669	10.8	0.610
5	May	3.52	**15.2**	0.157	16.2	0.460	***282***	0.0000763	***0.126***	0.0117	0.272	0.0856	0.0000832	0.0000408	80.4	***0.000625***	0.00317	0.000479	***0.00250***	0.214	0.0000110	28.7	0.497	5.97	0.408
6	Jun	2.41	10.4	0.0898	11.2	0.315	***185***	0.0000295	***0.0945***	0.00858	0.188	0.0514	0.0000599	0.0000347	35.4	***0.000251***	0.00118	0.000203	***0.00104***	0.136	0.0000108	19.9	0.343	2.83	0.222
7	Jul	1.29	5.30	0.0629	6.50	0.194	113	0.0000291	***0.0768***	0.00713	0.114	0.0505	0.0000401	0.0000305	32.0	***0.000264***	0.00106	0.000194	***0.00217***	0.0743	0.0000104	11.4	0.193	2.15	0.136
8	Aug	0.987	3.89	0.0587	5.40	0.167	98.0	0.0000323	***0.0705***	0.00666	0.0978	0.0534	0.0000371	0.0000299	34.3	***0.000289***	0.00120	0.000213	***0.00242***	0.0616	0.00000955	9.37	0.156	2.16	0.124
9	Sep	0.956	3.67	0.0633	5.59	0.175	103	0.0000372	***0.0722***	0.00668	0.101	0.0568	0.0000423	0.0000301	38.9	***0.000331***	0.00145	0.000243	***0.00256***	0.0835	0.00000960	9.48	0.157	2.41	0.138
10	Oct	2.74	11.0	0.152	14.5	0.438	***262***	0.0000719	***0.131***	0.0137	0.261	0.0824	0.0000663	0.0000392	75.3	***0.000664***	0.00290	0.000450	***0.00405***	0.143	0.00000980	25.7	0.439	5.60	0.373
11	Nov	3.52	**13.1**	**0.260**	20.6	0.649	***390***	0.000143	***0.180***	0.0205	0.391	0.131	0.0000732	0.0000462	139	***0.00126***	0.00577	0.000857	***0.00746***	0.139	0.0000104	36.5	0.618	9.61	0.558
12	Dec	**4.37**	**15.3**	**0.387**	27.6	**0.896**	***545***	0.000228	***0.224***	0.0265	0.542	0.190	0.0000872	0.0000546	216	***0.00194***	0.00930	0.00135	***0.0105***	0.159	0.0000110	48.8	0.822	14.4	0.777

PostClosure

	Month	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
1	Jan	1.96	6.67	0.185	15.9	0.481	***302***	0.000123	***0.126***	0.0175	0.317	0.120	0.0000721	0.0000468	124	***0.000875***	0.00469	0.000702	***0.00384***	0.139	0.0000111	26.3	0.510	8.90	0.515
2	Feb	1.88	6.46	0.174	15.0	0.456	***287***	0.000115	***0.120***	0.0167	0.299	0.115	0.0000700	0.0000458	117	***0.000819***	0.00438	0.000659	***0.00360***	0.134	0.0000113	24.9	0.482	8.44	0.495
3	Mar	1.80	6.25	0.162	14.2	0.430	***271***	0.000107	***0.124***	0.0158	0.281	0.109	0.0000677	0.0000447	109	***0.000762***	0.00407	0.000615	***0.00336***	0.128	0.0000114	23.6	0.454	7.97	0.474
4	Apr	1.70	6.01	0.147	13.2	0.397	***251***	0.0000963	***0.207***	0.0145	0.259	0.102	0.0000651	0.0000430	99.4	***0.000685***	0.00365	0.000556	***0.00303***	0.176	0.0000114	22.0	0.421	7.35	0.449
5	May	1.21	4.74	0.0739	8.32	0.245	***158***	0.0000458	***0.218***	0.00918	0.145	0.0644	0.0000702	0.0000344	52.7	***0.000353***	0.00189	0.000291	***0.00168***	0.185	0.0000112	13.7	0.243	4.35	0.343
6	Jun	0.711	2.97	0.0314	4.37	0.129	85.5	0.0000193	***0.0897***	0.00382	0.0704	0.0436	0.0000497	0.0000281	25.2	***0.000146***	0.000773	0.000140	***0.000756***	0.122	0.0000109	7.26	0.119	2.25	0.205
7	Jul	0.374	1.50	0.0204	2.66	0.0802	53.1	0.0000162	***0.0634***	0.00278	0.0453	0.0414	0.0000365	0.0000271	20.2	***0.000101***	0.000555	0.000117	***0.000558***	0.0675	0.0000105	4.21	0.0714	1.46	0.114
8	Aug	0.300	1.14	0.0206	2.47	0.0750	49.1	0.0000178	***0.0670***	0.00304	0.0443	0.0435	0.0000387	0.0000275	21.5	***0.000106***	0.000593	0.000124	***0.000588***	0.0789	0.00000964	3.76	0.0680	1.41	0.0938
9	Sep	0.300	1.10	0.0230	2.76	0.0829	54.8	0.0000202	***0.137***	0.00600	0.0488	0.0454	0.0000490	0.0000299	24.1	***0.000128***	0.000726	0.000138	***0.000748***	0.114	0.00000989	4.00	0.0751	2.39	0.240
10	Oct	0.596	2.57	0.0218	5.18	0.140	93.4	0.0000216	***0.141***	0.00906	0.0672	0.0464	0.0000564	0.0000372	29.7	***0.000122***	0.000569	0.000119	***0.000881***	0.122	0.0000105	6.80	0.113	2.74	0.258
11	Nov	0.615	2.66	0.0226	3.64	0.131	88.2	0.0000176	***0.0576***	0.0141	0.0650	0.0465	0.0000703	0.0000455	27.8	***0.000116***	0.000500	0.000108	***0.000755***	0.144	0.0000111	7.28	0.101	3.21	0.275
12	Dec	0.612	2.65	0.0228	3.44	0.146	94.5	0.0000196	***0.0526***	0.0156	0.0708	0.0503	0.0000746	0.0000478	32.0	***0.000129***	0.000502	0.000108	***0.000898***	0.152	0.0000111	7.84	0.102	3.55	0.285

	N-NH_3	N-NO_3	N-NO_2	Chloride	Fluoride	Sulfate	D-Ag	D-Al	D-As	D-B	D-Ba	D-Be	D-Bi	D-Ca	D-Cd	D-Co	D-Cr	D-Cu	D-Fe	D-Hg	D-K	D-Li	D-Mg	D-Mn
Long-Term BCWQG	NA	NA	NA	150	NP	128	NP	0.05	NP	NP	NP	NP	NP	NP	0.00008	NP	NP	0.0003	NP	NP	NP	NP	NP	NP
Short-Term BCWQG	NA	NA	NA	600	0.82	NP	NP	0.1	NP	NP	NP	NP	NP	NP	0.00016	NP	NP	0.0018	0.35	NP	NP	NP	NP	NP
Discharge Limit	4	11.5	0.24	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO^3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO^4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-2: BJ 2.62 Results

Appendix A-2-2: Upper Case BJ 2.62 Base Case Water Quality Predictions

Operations

	Month	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca	T-Cd
1	Jan	0.0234	70.0	0.00134	0.0235	0.00751	0.0281	0.00537	3.45	0.000284	0.716	0.00637	0.0000811	0.00125	0.00236	0.0133	0.0000353	0.259	**0.0232**	0.274	0.0603	0.0000574	0.0000404	37.7	0.000281
2	Feb	0.0234	70.6	0.00134	0.0234	0.00739	0.0277	0.00538	3.47	0.000286	0.722	0.00638	0.0000757	0.00125	0.00236	0.0134	0.0000349	0.255	**0.0229**	0.270	0.0609	0.0000573	0.0000403	38.0	0.000282
3	Mar	0.0231	69.1	0.00132	0.0232	0.00746	0.0280	0.00532	3.42	0.000281	0.708	0.00635	0.0000765	0.00123	0.00236	0.0131	0.0000353	0.257	**0.0232**	0.265	0.0604	0.0000568	0.0000402	37.4	0.000277
4	Apr	0.0238	71.1	0.00134	0.0240	0.00759	0.0285	0.00548	3.47	0.000285	0.719	0.00639	0.0000778	0.00125	0.00240	0.0134	0.0000359	0.262	**0.0236**	0.269	0.0609	0.0000582	0.0000406	37.9	0.000282
5	May	0.0239	72.2	0.00140	0.0253	0.00752	0.0284	0.00550	3.56	0.000293	0.744	0.00631	0.0000779	0.00132	0.00241	0.0153	0.0000362	0.270	**0.0236**	0.276	0.0617	0.0000673	0.0000412	39.6	0.000303
6	Jun	0.0169	51.3	0.00105	0.0187	0.00519	0.0198	0.00391	2.66	0.000222	0.541	0.00570	0.0000558	0.000979	0.00181	0.0110	0.0000268	0.216	**0.0168**	0.196	0.0546	0.0000528	0.0000365	30.1	0.000216
7	Jul	0.00870	26.1	0.000652	0.0104	0.00258	0.0101	0.00201	1.61	0.000138	0.297	0.00529	0.0000309	0.000531	0.00106	0.00578	0.0000165	0.160	0.00914	0.100	0.0483	0.0000368	0.0000316	19.1	0.000111
8	Aug	0.00665	20.0	0.000542	0.00851	0.00183	0.00735	0.00154	1.30	0.000114	0.237	0.00524	0.0000240	0.000431	0.000865	0.00434	0.0000136	0.150	0.00687	0.0754	0.0468	0.0000333	0.0000310	16.5	0.0000815
9	Sep	0.00659	19.9	0.000558	0.00901	0.00184	0.00757	0.00154	1.33	0.000116	0.239	0.00522	0.0000248	0.000467	0.000857	0.00477	0.0000139	0.152	0.00707	0.0748	0.0468	0.0000351	0.0000316	16.9	0.0000863
10	Oct	0.0227	68.5	0.00138	0.0230	0.00700	0.0264	0.00521	3.58	0.000295	0.704	0.00629	0.0000716	0.00128	0.00226	0.0148	0.0000337	0.262	**0.0219**	0.261	0.0613	0.0000610	0.0000399	39.9	0.000290
11	Nov	0.0239	72.0	0.00143	0.0237	0.00755	0.0283	0.00548	3.73	0.000306	0.735	0.00640	0.0000812	0.00134	0.00237	0.0149	0.0000356	0.261	**0.0234**	0.279	0.0615	0.0000595	0.0000406	41.1	0.000298
12	Dec	0.0233	70.1	0.00143	0.0234	0.00756	0.0283	0.00535	3.75	0.000308	0.717	0.00637	0.0000813	0.00135	0.00238	0.0149	0.0000356	0.261	**0.0234**	0.276	0.0618	0.0000587	0.0000405	41.2	0.000299

Closure

	Month	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca	T-Cd
1	Jan	0.0345	108	0.00904	0.0234	0.00170	0.0344	0.0131	21.1	0.00212	2.20	0.00831	0.000111	0.00482	0.00359	0.0820	0.000206	0.256	**0.0223**	0.511	0.181	0.0000830	0.0000527	196	0.00168
2	Feb	0.0321	103	0.00846	0.0218	0.00151	0.0311	0.0120	19.8	0.00198	2.08	0.00814	0.000101	0.00420	0.00316	0.0738	0.000193	0.231	**0.0193**	0.481	0.172	0.0000809	0.0000517	184	0.00151
3	Mar	0.0302	98.2	0.00787	0.0208	0.00141	0.0289	0.0111	18.5	0.00184	1.96	0.00796	0.0000962	0.00380	0.00290	0.0675	0.000180	0.218	**0.0177**	0.457	0.163	0.0000786	0.0000506	172	0.00138
4	Apr	0.0286	93.1	0.00715	0.0204	0.00135	0.0276	0.0103	16.8	0.00167	1.81	0.00775	0.0000909	0.00353	0.00278	0.0616	0.000163	0.213	**0.0169**	0.431	0.152	0.0000763	0.0000492	158	0.00125
5	May	0.0208	68.0	0.00335	0.0249	0.00115	0.0199	0.00584	7.95	0.000761	1.01	0.00634	0.0000605	0.00190	0.00194	0.0333	0.0000763	0.195	**0.0120**	0.275	0.0911	0.0000832	0.0000408	80.4	0.000625
6	Jun	0.0145	47.2	0.00129	0.0172	0.000820	0.0140	0.00347	3.12	0.000282	0.524	0.00557	0.0000427	0.00100	0.00147	0.0142	0.0000295	0.164	0.00900	0.190	0.0572	0.0000599	0.0000347	35.4	0.000251
7	Jul	0.00904	27.3	0.00127	0.0101	0.000569	0.00929	0.00265	2.99	0.000284	0.398	0.00534	0.0000275	0.000974	0.00122	0.0136	0.0000291	0.153	0.00767	0.115	0.0574	0.0000401	0.0000305	31.9	0.000265
8	Aug	0.00772	22.5	0.00141	0.00817	0.000497	0.00816	0.00252	3.27	0.000321	0.388	0.00536	0.0000241	0.00100	0.00115	0.0148	0.0000323	0.156	0.00709	0.0984	0.0598	0.0000371	0.0000299	34.3	0.000290
9	Sep	0.00785	22.9	0.00163	0.00846	0.000496	0.00829	0.00269	3.74	0.000370	0.426	0.00536	0.0000249	0.00108	0.00116	0.0173	0.0000372	0.158	0.00708	0.102	0.0630	0.0000423	0.0000301	38.9	0.000332
10	Oct	0.0198	60.8	0.00317	0.0193	0.00110	0.0202	0.00616	7.46	0.000718	0.955	0.00636	0.0000565	0.00223	0.00222	0.0338	0.0000719	0.211	**0.0140**	0.262	0.0881	0.0000663	0.0000392	75.3	0.000665
11	Nov	0.0287	86.2	0.00626	0.0226	0.00156	0.0299	0.0103	14.6	0.00145	1.61	0.00739	0.0000877	0.00396	0.00327	0.0621	0.000143	0.249	**0.0208**	0.398	0.136	0.0000732	0.0000462	139	0.00126
12	Dec	0.0382	115	0.01000	0.0258	0.00198	0.0395	0.0149	23.2	0.00234	2.40	0.00859	0.000118	0.00573	0.00426	0.0947	0.000228	0.293	**0.0268**	0.550	0.196	0.0000872	0.0000546	216	0.00194

PostClosure

	Month	D-Mo	D-Na	D-Ni	D-P	D-Pb	D-Sb	D-Se	D-Si	D-Sn	D-Sr	D-Ti	D-Tl	D-U	D-V	D-Zn	T-Ag	T-Al	T-As	T-B	T-Ba	T-Be	T-Bi	T-Ca	T-Cd
1	Jan	0.0199	64.4	0.00514	0.0148	0.00106	0.0251	0.00734	13.6	0.00129	1.38	0.00707	0.0000755	0.00320	0.00276	0.0446	0.000123	0.197	**0.0178**	0.325	0.125	0.0000721	0.0000468	124	0.000875
2	Feb	0.0189	61.1	0.00481	0.0143	0.00102	0.0237	0.00691	12.8	0.00121	1.31	0.00695	0.0000669	0.00299	0.00262	0.0418	0.000115	0.190	**0.0170**	0.302	0.120	0.0000700	0.0000458	117	0.000819
3	Mar	0.0179	57.8	0.00448	0.0138	0.000968	0.0222	0.00647	11.9	0.00112	1.23	0.00683	0.0000635	0.00279	0.00247	0.0390	0.000107	0.196	**0.0161**	0.284	0.114	0.0000677	0.0000447	109	0.000762
4	Apr	0.0166	53.6	0.00403	0.0133	0.000902	0.0205	0.00590	10.7	0.00101	1.13	0.00664	0.0000590	0.00254	0.00230	0.0352	0.0000963	0.284	**0.0148**	0.262	0.107	0.0000651	0.0000430	99.3	0.000686
5	May	0.0101	32.4	0.00196	0.0124	0.000554	0.0112	0.00307	4.98	0.000463	0.634	0.00554	0.0000365	0.00122	0.00198	0.0207	0.0000459	0.293	0.00957	0.148	0.0700	0.0000702	0.0000344	52.7	0.000354
6	Jun	0.00528	16.9	0.000842	0.00804	0.000295	0.00524	0.00137	2.00	0.000183	0.315	0.00488	0.0000205	0.000474	0.000920	0.00950	0.0000193	0.164	0.00426	0.0722	0.0496	0.0000497	0.0000281	25.2	0.000147
7	Jul	0.00319	10.2	0.000688	0.00488	0.000189	0.00342	0.000897	1.69	0.000158	0.218	0.00492	0.0000145	0.000345	0.000681	0.00632	0.0000162	0.143	0.00334	0.0461	0.0484	0.0000365	0.0000271	20.1	0.000101
8	Aug	0.00296	9.51	0.000749	0.00420	0.000179	0.00348	0.000905	1.89	0.000178	0.218	0.00502	0.0000140	0.000386	0.000653	0.00641	0.0000178	0.154	0.00345	0.0448	0.0500	0.0000387	0.0000275	21.5	0.000107
9	Sep	0.00318	10.3	0.000847	0.00608	0.000270	0.00395	0.00102	2.28	0.000203	0.250	0.00502	0.0000158	0.000567	0.00120	0.00797	0.0000202	0.220	0.00639	0.0493	0.0516	0.0000490	0.0000299	24.1	0.000129
10	Oct	0.00515	14.9	0.000695	0.00911	0.000463	0.00519	0.00151	2.87	0.000190	0.350	0.00542	0.0000286	0.000781	0.00140	0.00878	0.0000216	0.224	0.00942	0.0686	0.0522	0.0000564	0.0000372	29.7	0.000123
11	Nov	0.00543	15.3	0.000719	0.00906	0.000731	0.00432	0.00115	3.62	0.000203	0.415	0.00590	0.0000389	0.000620	0.000794	0.00881	0.0000176	0.129	**0.0145**	0.0725	0.0516	0.0000703	0.0000455	27.8	0.000117
12	Dec	0.00604	16.2	0.000786	0.0109	0.000893	0.00433	0.00116	4.25	0.000257	0.511	0.00617	0.0000473	0.000779	0.000786	0.0106	0.0000196	0.124	**0.0159**	0.0786	0.0553	0.0000746	0.0000478	32.0	0.000129

Long-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	1.2	1	0.00013	NP	NP	NP
Short-Term BCWQG	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NA	NP	NA	NP	NP	NP	NP	NP	NP
Discharge Limit	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.46	NP	0.01	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Appendix A-2: BJ 2.62 Results

Appendix A-2-2: Upper Case BJ 2.62 Base Case Water Quality Predictions

Operations

	Month	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	0.000988	0.000360	0.000893	0.115	0.0000109	31.7	0.466	3.18	0.236	0.0234	70.0	0.00134	0.0419	***0.00769***	**0.0281**	***0.00546***	3.72	0.000287	0.717	0.00637	0.000109	0.00127	0.00238	***0.0142***
2	Feb	0.000994	0.000354	0.000898	0.115	0.0000109	31.9	0.470	3.21	0.238	0.0235	70.6	0.00135	0.0421	***0.00755***	0.0277	***0.00542***	3.75	0.000289	0.723	0.00638	0.000108	0.00127	0.00238	***0.0143***
3	Mar	0.000974	0.000352	0.000884	0.113	0.0000111	31.2	0.460	3.15	0.233	0.0231	69.1	0.00133	0.0413	***0.00762***	0.0280	***0.00536***	3.68	0.000284	0.709	0.00635	0.000109	0.00124	0.00238	***0.0140***
4	Apr	0.000993	0.000357	0.000897	0.116	0.0000113	31.8	0.468	3.20	0.238	0.0239	71.1	0.00135	0.0426	***0.00775***	**0.0286**	***0.00552***	3.73	0.000288	0.720	0.00639	0.000110	0.00126	0.00242	***0.0142***
5	May	0.00112	0.000361	0.00105	0.161	0.0000114	32.6	0.480	3.34	0.258	0.0239	72.2	0.00140	0.0445	***0.00770***	**0.0284**	***0.00554***	3.87	0.000297	0.745	0.00631	0.000108	0.00133	0.00243	***0.0162***
6	Jun	0.000808	0.000268	0.000842	0.122	0.0000111	23.0	0.340	2.45	0.188	0.0170	51.3	0.00106	0.0331	***0.00537***	0.0199	***0.00394***	2.99	0.000224	0.541	0.00570	0.0000869	0.000992	0.00182	***0.0118***
7	Jul	0.000434	0.000157	0.000579	0.0796	0.0000106	11.5	0.170	1.39	0.105	0.00872	26.1	0.000653	0.0189	0.00278	0.0101	***0.00203***	1.99	0.000139	0.297	0.00529	0.0000652	0.000546	0.00107	0.00665
8	Aug	0.000331	0.000151	0.000529	0.0711	0.00000962	8.80	0.123	1.09	0.0770	0.00667	20.0	0.000543	0.0157	0.00201	0.00739	0.00157	1.67	0.000115	0.238	0.00524	0.0000598	0.000446	0.000870	0.00525
9	Sep	0.000360	0.000155	0.000575	0.0794	0.00000970	8.72	0.125	1.12	0.0807	0.00661	19.9	0.000559	0.0161	0.00202	0.00761	0.00157	1.69	0.000117	0.240	0.00522	0.0000602	0.000483	0.000861	0.00566
10	Oct	0.00112	0.000305	0.000929	0.145	0.0000102	30.9	0.473	3.39	0.259	0.0228	68.5	0.00139	0.0417	***0.00717***	0.0264	***0.00525***	3.91	0.000297	0.705	0.00629	0.000104	0.00129	0.00228	***0.0157***
11	Nov	0.00113	0.000315	0.000923	0.131	0.0000105	32.6	0.495	3.52	0.265	0.0239	71.9	0.00143	0.0431	***0.00773***	**0.0283**	***0.00556***	4.00	0.000308	0.736	0.00640	0.000110	0.00135	0.00239	***0.0158***
12	Dec	0.00113	0.000315	0.000897	0.128	0.0000108	31.7	0.499	3.54	0.266	0.0233	70.1	0.00144	0.0421	***0.00774***	**0.0283**	***0.00544***	4.03	0.000310	0.717	0.00637	0.000110	0.00136	0.00240	***0.0157***

Closure

	Month	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	***0.00838***	***0.00127***	0.00807	0.174	0.0000110	45.7	0.768	13.2	0.727	0.0345	108	0.00904	0.0566	0.00188	**0.0345**	***0.0132***	21.4	0.00212	2.20	0.00831	0.000139	0.00483	0.00359	***0.0829***
2	Feb	***0.00783***	***0.00118***	0.00643	0.169	0.0000111	43.6	0.736	12.5	0.692	0.0321	103	0.00846	0.0546	0.00166	**0.0311**	***0.0120***	20.1	0.00198	2.08	0.00814	0.000135	0.00422	0.00316	***0.0747***
3	Mar	***0.00727***	***0.00110***	0.00554	0.164	0.0000111	41.6	0.702	11.7	0.657	0.0302	98.2	0.00787	0.0525	0.00155	**0.0289**	***0.0111***	18.8	0.00184	1.96	0.00796	0.000130	0.00382	0.00291	***0.0684***
4	Apr	***0.00659***	***0.00101***	0.00505	0.161	0.0000113	39.5	0.669	10.8	0.616	0.0287	93.1	0.00715	0.0503	0.00149	0.0276	***0.0103***	17.1	0.00168	1.81	0.00775	0.000125	0.00354	0.00278	***0.0625***
5	May	0.00317	0.000510	0.00262	0.239	0.0000110	28.9	0.498	6.00	0.415	0.0208	68.0	0.00335	0.0450	0.00131	0.0199	***0.00588***	8.27	0.000763	1.01	0.00634	0.0000917	0.00191	0.00195	***0.0341***
6	Jun	0.00118	0.000224	0.00116	0.161	0.0000108	20.0	0.343	2.86	0.231	0.0145	47.2	0.00130	0.0318	0.000988	0.0140	***0.00350***	3.45	0.000283	0.524	0.00557	0.0000734	0.00101	0.00147	***0.0150***
7	Jul	0.00106	0.000205	0.00230	0.102	0.0000104	11.5	0.193	2.18	0.146	0.00906	27.3	0.00127	0.0191	0.000765	0.00935	***0.00266***	3.37	0.000284	0.398	0.00534	0.0000615	0.000990	0.00123	***0.0145***
8	Aug	0.00120	0.000244	0.00255	0.0915	0.00000955	9.50	0.156	2.19	0.132	0.00774	22.5	0.00142	0.0161	0.000681	0.00820	***0.00254***	3.64	0.000321	0.389	0.00536	0.0000597	0.00102	0.00115	***0.0157***
9	Sep	0.00145	0.000279	0.00269	0.113	0.00000960	9.62	0.157	2.44	0.146	0.00787	22.9	0.00163	0.0165	0.000675	0.00833	***0.00271***	4.10	0.000370	0.427	0.00536	0.0000603	0.00109	0.00116	***0.0182***
10	Oct	0.00290	0.000488	0.00418	0.170	0.00000980	25.8	0.439	5.63	0.380	0.0198	60.8	0.00317	0.0375	0.00127	0.0202	***0.00620***	7.80	0.000720	0.956	0.00636	0.0000896	0.00225	0.00222	***0.0347***
11	Nov	***0.00577***	0.000898	0.00759	0.163	0.0000104	36.7	0.618	9.64	0.565	0.0287	86.2	0.00626	0.0477	0.00173	**0.0299**	***0.0104***	14.9	0.00146	1.61	0.00739	0.000117	0.00398	0.00328	***0.0630***
12	Dec	***0.00930***	***0.00139***	0.0107	0.183	0.0000110	48.9	0.822	14.4	***0.785***	0.0382	115	0.01000	0.0600	0.00216	**0.0395**	***0.0150***	23.6	0.00234	2.40	0.00859	0.000147	0.00575	0.00426	***0.0956***

PostClosure

	Month	T-Co	T-Cr	T-Cu	T-Fe	T-Hg	T-K	T-Li	T-Mg	T-Mn	T-Mo	T-Na	T-Ni	T-P	T-Pb	T-Sb	T-Se	T-Si	T-Sn	T-Sr	T-Ti	T-Tl	T-U	T-V	T-Zn
1	Jan	***0.00469***	0.000742	0.00398	0.164	0.0000111	26.5	0.510	8.92	0.522	0.0199	64.4	0.00514	0.0334	0.00124	0.0251	***0.00743***	13.9	0.00129	1.38	0.00707	0.000106	0.00321	0.00276	***0.0455***
2	Feb	***0.00438***	0.000690	0.00374	0.159	0.0000113	25.1	0.482	8.46	0.502	0.0189	61.1	0.00481	0.0320	0.00117	0.0237	***0.00694***	13.1	0.00121	1.31	0.00695	0.000102	0.00301	0.00262	***0.0427***
3	Mar	***0.00407***	0.000646	0.00349	0.153	0.0000114	23.7	0.454	7.99	0.481	0.0179	57.8	0.00448	0.0306	0.00112	0.0222	***0.00650***	12.2	0.00113	1.23	0.00683	0.0000988	0.00280	0.00247	***0.0399***
4	Apr	0.00365	0.000587	0.00316	0.203	0.0000114	22.1	0.421	7.37	0.456	0.0166	53.6	0.00403	0.0290	0.00106	0.0206	***0.00593***	11.0	0.00101	1.13	0.00664	0.0000940	0.00255	0.00230	***0.0361***
5	May	0.00189	0.000321	0.00181	0.211	0.0000112	13.8	0.243	4.38	0.350	0.0101	32.4	0.00197	0.0228	0.000725	0.0113	***0.00311***	5.31	0.000463	0.635	0.00554	0.0000690	0.00123	0.00198	***0.0216***
6	Jun	0.000773	0.000161	0.000883	0.148	0.0000109	7.37	0.119	2.28	0.214	0.00530	16.9	0.000843	0.0146	0.000471	0.00529	0.00139	2.34	0.000184	0.315	0.00488	0.0000529	0.000488	0.000920	***0.0103***
7	Jul	0.000555	0.000127	0.000692	0.0955	0.0000105	4.31	0.0715	1.50	0.124	0.00321	10.2	0.000689	0.00992	0.000389	0.00348	0.000910	2.08	0.000158	0.218	0.00492	0.0000494	0.000361	0.000681	0.00721
8	Aug	0.000593	0.000154	0.000725	0.109	0.00000964	3.89	0.0683	1.44	0.102	0.00298	9.51	0.000749	0.00908	0.000365	0.00352	0.000928	2.26	0.000178	0.219	0.00502	0.0000502	0.000402	0.000653	0.00733
9	Sep	0.000726	0.000173	0.000885	0.143	0.00000989	4.14	0.0754	2.41	0.247	0.00320	10.3	0.000847	0.00982	0.000446	0.00399	0.00104	2.62	0.000203	0.251	0.00502	0.0000512	0.000582	0.00120	***0.00887***
10	Oct	0.000569	0.000155	0.00102	0.151	0.0000105	6.93	0.114	2.76	0.265	0.00517	14.9	0.000695	0.0150	0.000647	0.00522	0.00154	3.21	0.000191	0.351	0.00542	0.0000601	0.000795	0.00140	***0.00967***
11	Nov	0.000500	0.000146	0.000901	0.170	0.0000111	7.39	0.101	3.23	0.282	0.00545	15.3	0.000719	0.0147	0.000916	0.00435	0.00124	3.91	0.000204	0.416	0.00590	0.0000701	0.000632	0.000794	***0.00971***
12	Dec	0.000502	0.000146	0.00104	0.177	0.0000111	7.94	0.102	3.58	0.291	0.00606	16.2	0.000786	0.0165	0.00107	0.00436	0.00126	4.54	0.000257	0.512	0.00617	0.0000780	0.000791	0.000786	***0.0115***

Long-Term BCWQG	0.004	0.001	NP	NA	0.00002	NP	NP	NP	0.7282	7.6	NP	0.025	NP	0.004	NA	0.002	NP	NP	NP	NP	0.0008	0.0085	NP	0.0075
Short-Term BCWQG	0.11	NP	NP	NA	NP	NP	NP	NP	0.8486	46	NP	NP	NP	0.016	NA	NP	NP	NP	NP	NP	NP	NP	NP	0.033
Discharge Limit	NP	NP	NP	1.7	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.028	NP	NP	NP	NP	NP	NP	NP	NP	NP

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that greater than long-term guidelines are shown in ***bold italic*** font.
Concentrations that greater than short-term guidelines are shown in **bold** font.
Concentrations that exceed an effluent discharge limit are shaded in **grey bold font**.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO^3$.
Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO^4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used.
Chromium guideline is for Cr(VI).
NP=none proposed.
NA=not applicable because the WQG is superseded by the discharge limit.

Memorandum

Date: January 18, 2017

To: Robert Goldblatt, Lorax Environmental Services Ltd., and Sylvia Van Zalingen, Environmental Manager, Pretium Resources Inc.

CC: Greg Norton, ERM Partner

From: ERM Consultants Canada Ltd.

Subject: **Streamflow Ratios Supporting Dilution Analyses in Brucejack Creek and Sulphurets Creek**

1. INTRODUCTION

The geographic extent of potential effects from elevated nitrate and nitrite are defined as waters (i.e. receiving environment) with predicted concentrations greater than the British Columbia Water Quality Guidelines (BCWQGs) for the protection of aquatic life. Brucejack Creek at BJ 3.10 is predicted to have concentrations of nitrate and nitrite greater than their respective BCWQGs. Brucejack Creek flows into Sulphurets Creek at SC0, where nitrate and nitrite concentrations are below the BCWQGs (Table 1).

Table 1. Dilution required to equal BC Water Quality Guidelines in Sulphurets Creek

Parameter	Model case	BJ 3.10 (mg-N/L)	SC0 (mg-N/L)	BCWQG (mg-N/L)	Required Dilution
Nitrate	Expected Case	5.1	0.05	3.0	1:1
	Upper Case	11.5	0.05	3.0	3:1
Nitrite	Expected Case	0.11	0.001	0.02	5:1
	Upper Case	0.24	0.001	0.02	12:1

The maximum required dilution is 12:1 Brucejack Creek at BJ 3.10 to Sulphurets Creek at SC0 (to produce NO_2 <0.02 mg-N/L). This memorandum provides an update to the assessment of streamflow ratios along Sulphurets Creek, and includes the results of previous studies, as well as a description of the methodology used to assess ratios used in this update.

2. BACKGROUND

ERM (2014) provided streamflow ratio estimates that support a dilution analysis of flows from Brucejack Creek into Sulphurets Creek. Three approaches were used to estimate streamflow ratio:

a) *use of drainage area as a surrogate for streamflow ratio;*

b) *analysis of data collected during the baseline monitoring program (open water season only); and*

c) *regional hydrologic analysis.*

The ratio of streamflow at Sulphurets Lake Outflow (at hydrometric station SL-H1) to streamflow at Brucejack Creek (at hydrometric station BJ 1.74, also known as BJL-H1a), using *Methods a*, *b*, and *c*, were 8.8, 14.6, and 9.7, respectively (ERM 2014). Based on these results, ERM (2014) concluded that the drainage area approach (i.e., *Method a*) provides the most conservative estimates for streamflow ratios, with 8:1 being the ratio selected for the Sulphurets Lake Inflow compared to Brucejack Creek at BJ 1.74. This conclusion assumes that drainage area ratios (*Method a*) may be used as a surrogate for streamflow ratios, which may further be used as a surrogate for dilution ratios.

ERM (2016) was completed and superseded ERM (2014) following collection of additional 366 concurrent daily streamflow records (June to September 2013-2015). It was found that additional data did not change ERM (2014) recommendations (ERM 2016). Catchment area ratios consistently provided the most conservative streamflow ratio and so was recommended.

Streamflow ratios, determined from the ratio of measured discharge, is the preferred method (*Method b*), but these results were not chosen in the previous study (*Method a*) due to the limited extent of site record available, and use of open water season data only.

3. 2017 STREAMFLOW RATIOS

ERM has recently completed a detailed hydrologic analysis of the major tributaries of the Sulphurets Valley, which resulted in the development of a series of long-term transposed streamflow records for select hydrometric monitoring stations (Table 2). These records (each 66 years in length) were derived by integrating project hydrometric records, with long-term regional Water Survey of Canada records, using the empirical frequency pairing method described in Butt (2013).

The monthly distribution of average streamflow in Brucejack Creek is different from Sulphurets Creek (Plate 1), and these differences impact streamflow ratios at different times of the year. The highest monthly flows in Brucejack Creek occur during the prominent freshet peak, while for Sulphurets Creek, the highest flows occur during the summer months, in response to melting of large, lower elevation glaciers. Thus, major differences in runoff between Brucejack Creek and Sulphurets Creek result from the presence, size, orientation and elevation of glaciers, and that the catchment area ratio (*Method a*) did not reflect these differences accurately.

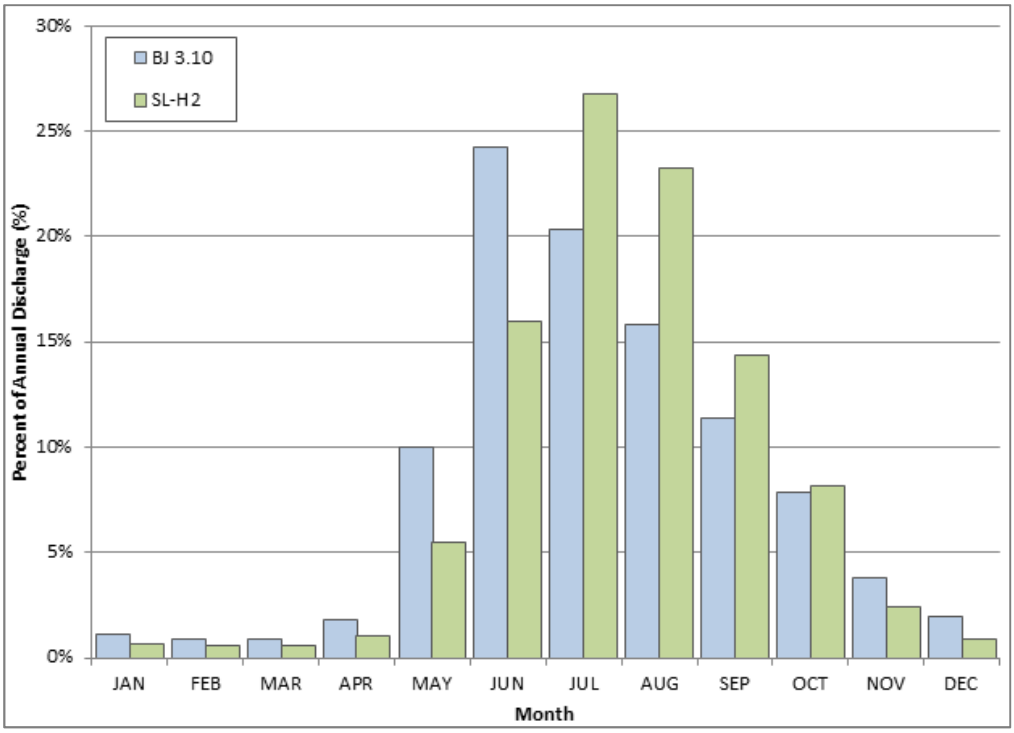

Plate 1. Monthly Distribution of Streamflow

The long-term transposed streamflow records were used to more accurately determine the ratios of streamflow at Brucejack Creek (at BJ 3.10), to various nodes along Sulphurets Creek using average monthly flows (Table 3). The process was straight forward, though some nodes were not located at specific monitoring stations, and thus minor spatial extrapolation of runoff was necessary. Extrapolation was achieved by assuming that flows downstream of monitoring stations were a function of non-glaciated runoff conditions, which was calculated for each node as proportional runoff, based on a mass balance of flows in the Sulphurets Valley.

Table 2. Hydrometric Stations with Long-Term Transposed Streamflow Records

#	Node	Description	Easting	Northing	Catchment (km^2)
1	BJ 1.74	Brucejack Creek, 1.74 km upstream of Confluence	425737	6259076	8.5
2	SL-H2	Sulphurets Creek, downstream of Sulphurets Lake	419769	6261350	75.6
3	TMC-H1	Ted Morris Creek	416883	6259497	56.6
4	MC-H2	Mitchell Creek, immediately upstream of Confluence	416740	6262837	87.9
5	GC-H1	Gingras Creek, immediately upstream of Confluence	416277	6262834	9.8
6	SC-H1	Sulphurets Creek, at the Mouth	408256	6261490	289.4

Table 3. Sulphurets Valley Dilution Ratio Node Details

Node	Alias	Easting	Northing	Catchment (km^2)	Catchment Ratio[1]
Brucejack Lk (BJ 3.10)	BJ 3.10	427030	6258895	6.7	1
Sulphurets Creek d/s Sulphurets Lk	SL-H2	419769	6261350	75.6	11
Sulphurets Creek, u/s Ted Morris Crk	SC-TMU	417520	6261990	86.8	13
Sulphurets Creek, d/s Ted Morris Crk	SC-TMD	417285	6262111	149.8	22
Sulphurets Creek, u/s Mitchell Crk	SC-MCU	416354	6262487	151.5	23

Notes:

1. *Catchment Ratio provided as a reference, using the methodology described in ERM (2014), Method "a"*

Previous studies were based on discharge data from BJ 1.74. Therefore, streamflow for BJ 1.74 was transposed to BJ 3.10 by catchment area proration. Long-term streamflow were then determined at other nodes by using the long-term streamflow records from nearby monitoring stations, and integrating where necessary to provide reasonable estimates of discharge at the specific node.

- SL-H2 used the long-term transposed records of the monitoring station SL-H2,
- SC-TMU used SL-H2, with the addition of runoff from the non-glaciated catchment area downstream of the monitoring station SL-H2,
- SC-TMD used SC-TMU, with the addition of runoff from the monitoring station TMC-H1, and the addition of runoff from the non-glaciated Ted Morris Valley catchment downstream of TMC-H1,
- SC-MCU used SC-TMD, with the addition of runoff from the non-glaciated catchment Sulphurets Valley catchment area downstream of SC-TMD.

Monthly streamflow is included in Table 4, and monthly ratios are included in Table 5 and Plate 2 (the dashed line represents the 12:1 discharge ratio).

Table 4. Average Monthly Streamflow (m^3/s) at nodes along Sulphurets Valley

Node	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
BJ 3.10	0.06	0.05	0.05	0.10	0.55	1.32	1.1	0.86	0.62	0.43	0.20	0.10
SL-H2	0.51	0.45	0.45	0.81	4.31	12.5	21.0	18.2	11.2	6.41	1.88	0.68
SC-TMU	10.9	11.8	11.9	11.0	9.30	10.7	19.0	21.8	18.6	16.7	9.97	7.99
SC-TMD	24.5	24.5	24.8	24.3	15.8	17.7	33.6	37.4	32.4	27.7	19.3	16.8
SC-MCU	24.8	24.9	25.1	24.6	15.9	17.3	33.6	37.4	32.5	27.9	19.4	17.0

Table 5. Monthly Streamflow ratios at nodes along Sulphurets Valley

Node	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
BJ 3.10	1	1	1	1	1	1	1	1	1	1	1	1
SL-H2	8	9	9	8	8	9	19	21	18	15	9	6
SC-TMU	11	12	12	11	9	11	19	22	19	17	10	8
SC-TMD	24	25	25	24	16	17	34	37	32	28	19	17
SC-MCU	25	25	25	25	16	17	34	37	32	28	19	17

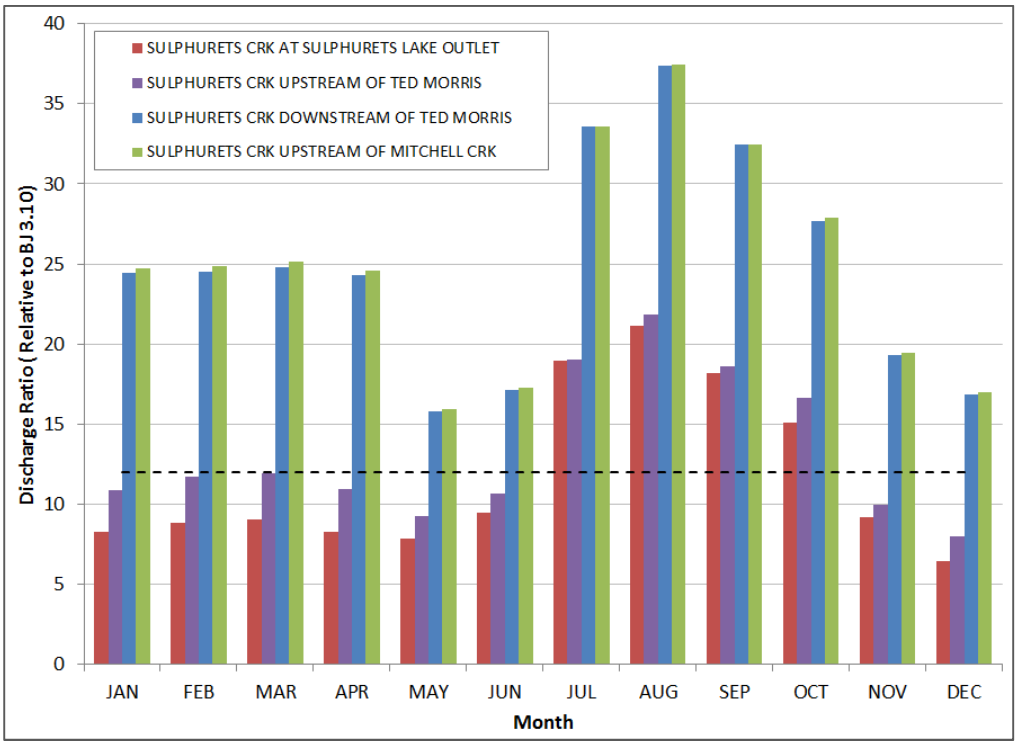

Plate 1. Streamflow Ratios at Nodes Along Sulphurets Valley

4. CLOSING

ERM used long-term streamflow estimates to derive estimates of streamflow ratios at nodes along the Sulphurets Valley. It was found that the required 12:1 streamflow ratio (compared to streamflow in Brucejack Creek at BJ 3.10) will be comfortably achieved in all months, immediately below the Ted Morris confluence, at SC-TMD.

Should you have any questions or concerns, please do not hesitate to contact ERM.

ERM Consultants Canada Ltd.

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ERM Project Manager

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Evaluation of the toxicity of nitrate to *Chironomus dilutus* and *Ceriodaphnia dubia*

Final Report

April 19, 2022

Submitted to: **Pretivm Resources Inc.**
Vancouver, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

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SIGNATURE PAGE

Report By: Karen Lee, R.P.Bio. Project Biologist	Reviewed By: James Elphick, R.P.Bio. Senior Environmental Toxicologist

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

Sample Information and Test Type

Sample ID	Nitrate in laboratory water Nitrate in site water (BJ-3.10)
Sample collection date	December 7, 2021
Sample receipt date	December 9, 2021
Sample receipt temperature	4.1 – 8.6°C
Test types	10-d *Chironomus dilutus* survival and growth *Ceriodaphnia dubia* survival and reproduction

Summary of Results

Endpoint	**mg/L NO_3-N (95% CL)**	
	Laboratory Water	Site Water (BJ-3.10)
Chironomus dilutus		
Survival LC50	>280	150.7 (130.7 – 173.9)
Dry weight IC20	24.2 (9.0 – 55.0)	179.6 (2.9 – N/A)
Dry weight IC50	>280	>303
Ceriodaphnia dubia		
Survival LC50	>286.5	>303
Reproduction IC20	120.0 (82.5 – 150.4)	54.1 (46.0 – 61.1)
Reproduction IC50	187.5 (176.9 – 197.3)	88.5 (77.8 – 98.8)

LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits, N/A = Not Available

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted toxicity tests using *Chironomus dilutus* and *Ceriodaphnia dubia* on behalf of Pretivm Resources Inc. to evaluate the effects nitrate on survival and growth or reproduction. Tests were conducted concurrently at the Nautilus Environmental laboratory in Burnaby, BC, using site water identified as BJ-3.10 and the laboratory control waters with a hardness of 100 mg/L. The purpose of the tests was to determine whether nitrate exhibited a different degree of toxicity in site water compared to laboratory water.

The results of the toxicity tests are presented in this report. Copies of laboratory data sheets and statistical analyses for the tests are provided in Appendices A and B. The results of analytical chemistry are provided in Appendix C. The chain-of-custody form is provided in Appendix D.

2.0 METHODS

The site water was collected by Pretivm Resources Inc. staff on December 7, 2021 in five 20-L carboys and delivered to the Nautilus Environmental laboratory in Burnaby, BC on December 9, 2021. The sample was received at a temperature ranging between 4.1 and 8.6°C. Methods for the toxicity tests are summarized in Tables 1 and 2. Testing was conducted according to procedures described by Environment Canada (1997 and 2007). A stock solution of 25 g/L NO_3-N was used for preparation of test solutions. In the case of the chironomid test, the method was modified to perform the exposure with a minimal amount of control sand in the test containers to provide substrate for the test organisms.

Subsamples of nitrate were collected in plastic HDPE bottles for each concentration at test initiation from freshly prepared solutions and at termination from the test vessels. Laboratory control water and site water were also analyzed for hardness, total dissolved and suspended solids, major anions, nutrients and total and dissolved metals. Subsamples were analyzed by ALS Environmental (Burnaby, BC); results are provided in Appendix C.

Statistical analyses for the tests were performed using CETIS (Tidepool Scientific Software, 2013) and were conducted using averaged measured concentrations of nitrate from test initiation and termination.

Table 1. Summary of test conditions: 10-d *Chironomus dilutus* water-only survival and growth test.

Test species	*Chironomus dilutus*
Organism source	Aquatic BioSystems, Fort Collins, CO
Organism age	Third instar
Test type	Static-renewal
Test duration	10 days
Test vessel	375-mL glass container
Test volume	275 mL of test solution and ~2 mm of control sand
Test concentrations	Seven concentrations, plus laboratory/site control
Test replicates	5 per sample
Number of organisms	10 per replicate
Control/dilution water	Moderately hard synthetic water prepared using dechlorinated municipal tapwater
Test solution renewal	Three times a week on non-consecutive days
Test temperature	23 ± 1°C
Feeding	6 mg of Tetramin per replicate daily
Light intensity	500 to 1000 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	None, until day 4 of test
Test measurements	Temperature, dissolved oxygen, pH and conductivity of overlying water measured daily; hardness, alkalinity and total ammonia of overlying water measured at test initiation and termination
Test protocol	Environment Canada (1997), EPS 1/RM/32 (modified)
Statistical software	CETIS Version 1.9.4
Test endpoints	Survival and dry weight
Test acceptability criteria for controls	≥70% survival; ≥0.6 mg/worm dry weight
Reference toxicant	Potassium chloride (KCl)

Table 2. Summary of test conditions: *Ceriodaphnia dubia* survival and reproduction test.

Test species	*Ceriodaphnia dubia*
Organism source	In-house culture
Organism age	<24 hour old neonates, produced within a 12 hour window
Test type	Static-renewal
Test duration	7 ± 1 day
Test vessel	20-mL glass test tube
Test volume	15 mL
Test solution depth	10 cm
Test concentrations	Seven concentrations, plus laboratory/site control
Test replicates	10 per treatment
Number of organisms	1 per replicate
Control/dilution water	20% Perrier water and 80% deionized water + 5 µg/L Se and 2 µg/L vitamin B12
Test solution renewal	Daily (100% renewal)
Test temperature	25 ± 1°C
Feeding	Daily with *Pseudokirchneriella subcapitata* and TCC[1] (3:1 ratio)
Light intensity	100 to 600 lux at water surface
Photoperiod	16 hours light / 8 hours dark
Aeration	None
Test measurements	Temperature, dissolved oxygen, pH and conductivity measured daily; hardness and alkalinity of undiluted sample measured at test initiation; survival and reproduction checked daily
Test protocol	Environment Canada (2007), EPS 1/RM/21
Statistical software	CETIS Version 1.9.4
Test endpoints	Survival and reproduction
Test acceptability criteria for controls	≥80% survival; ≥15 young per surviving control producing three broods; ≥60% of controls producing three or more broods; no ephippia present
Reference toxicant	Sodium chloride (NaCl)

[1] TCC = Trout chow and Cerophyl

3.0 RESULTS

Measured concentrations of nitrate were in good agreement with the targeted values (Tables 3 to 6) and were generally within 10% of nominal values (after accounting for the background level of nitrate in sample BJ-3.10). The measured values after 24-48 hours of exposure were also generally within 10% of the values measured at test initiation, indicating that the test solutions were stable in between solution renewals.

Results of the *C. dilutus* survival and growth tests are summarized in Tables 3 and 4. The LC50 was >280 mg/L NO_3-N in the laboratory water test and was 150.7 mg/L NO_3-N in site water. Adverse effects were observed on the growth of *C. dilutus*, with IC20 values of 24.2 and 179.6 mg/L NO_3-N in laboratory and site water, respectively.

Results of the *C. dubia* survival and reproduction tests are summarized in Tables 5 and 6. No effects were observed on survival in either the laboratory or site waters, resulting in LC50 values that were greater than the highest test concentrations. The IC20 for reproduction was 120.0 and 54.1 mg/L NO_3 in laboratory and site water, respectively. Nitrate exhibited a higher degree of toxicity in site water compared to the laboratory water.

Table 3. Results of the *Chironomus dilutus* survival and growth test conducted in laboratory water.

mg/L NO_3-N		Survival (%) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
Nominal	**Average measured**		
Laboratory Control	Laboratory Control (0.08)	96.0 ± 5.5	1.99 ± 0.16
4.7	4.5	98.0 ± 4.5	1.83 ± 0.18
9.4	9.0	94.0 ± 5.5	1.66 ± 0.24
18.8	17.5	98.0 ± 4.5	1.61 ± 0.16
37.5	37.1	92.0 ± 4.5	1.77 ± 0.26
75	70.2	94.0 ± 5.5	1.46 ± 0.13
150	145	90.0 ± 0.0	1.34 ± 0.11
300	280	58.0 ± 19.2	1.30 ± 0.49
Test Endpoint (mg/L NO_3-N)			
LC50		>280	--
IC20 (95% CL)		--	24.2 (9.0 – 55.0)
IC50 (95% CL)		--	>280

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits, N/A = Not Available

Table 4. Results of the *Chironomus dilutus* survival and growth test conducted in site water.

mg/L NO_3-N		Survival (%) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
Nominal	**Average measured**		
Site Water Control	Site Water Control (8.9)	92.0 ± 11.0	1.60 ± 0.42
4.7	13.8	96.0 ± 5.5	1.69 ± 0.24
9.4	18.2	98.0 ± 4.5	1.43 ± 0.20
18.8	27.0	90.0 ± 10.0	1.67 ± 0.23
37.5	45.8	98.0 ± 4.5	1.66 ± 0.17
75	78.6	92.0 ± 4.5	1.53 ± 0.17
150	163.0	38.0 ± 19.2	1.37 ± 0.24
300	303.0	14.0 ± 16.7	1.03 ± 0.81
Test Endpoint (mg/L NO_3-N)			
LC50 (95% CL)		150.7 (130.7 – 173.9)	--
IC20 (95% CL)		--	179.6 (2.9 – N/A)
IC50 (95% CL)		--	>303

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits, N/A = Not Available

Table 5. Results of the *Ceriodaphnia dubia* survival and reproduction test conducted in laboratory water.

mg/L NO_3-N		Survival (%)	Reproduction (Mean ± SD)
Nominal	**Average measured**		
Laboratory Control	Laboratory Control (0.61)	100	23.1 ± 2.8
4.7	5.1	100	20.9 ± 3.9
9.4	9.6	100	21.3 ± 2.7
18.8	17.8	100	21.3 ± 3.8
37.5	35.0	100	20.6 ± 2.0
75	70.8	100	21.7 ± 3.9
150	145.5	100	17.5 ± 2.8
300	286.5	90	1.6 ± 2.3
Test Endpoint (mg/L NO_3-N)			
LC50		>286.5	--
IC20 (95% CL)		--	120.0 (82.5 – 150.4)
IC50 (95% CL)		--	187.5 (176.9 – 197.3)

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

Table 6. Results of the *Ceriodaphnia dubia* survival and reproduction test conducted in site water.

mg/L NO_3-N		Survival (%)	Reproduction (Mean ± SD)
Nominal	**Average measured**		
Site Water Control	8.9	100	22.2 ± 3.2
4.7	13.0	100	20.9 ± 4.7
9.4	17.2	100	21.1 ± 2.8
18.8	26.2	100	20.4 ± 1.8
37.5	45.8	100	19.9 ± 3.0
75	80.7	100	12.6 ± 3.8
150	164.5	90	1.0 ± 1.4
300	303.0	70	0.0 ± 0.0
Test Endpoint (mg/L NO_3-N)			
LC50		>303	--
IC20 (95% CL)		--	54.1 (46.0 – 61.1)
IC50 (95% CL)		--	88.5 (77.8 – 98.8)

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

4.0 QA/QC

The health histories of the test organisms used in the exposures were acceptable and met the requirements of the Environment Canada protocols. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests, with the exception of the freshly prepared dilutions in the *C. dubia* test in site water on Day 3; temperature was recorded at 23°C, which is marginally outside of the required range of 25±1°C. This deviation would not be expected to have affected the results of the test. There were no other deviations from the test methodologies. Uncertainty associated with these tests is best described by the standard deviations around the means or the confidence limits surrounding the point estimates.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 7. Results for the tests fell within the acceptable range for organism performance of mean and two standard deviations, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in the tests was appropriate.

Table 7. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
C. dilutus	Survival (LC50): 4.3 g/L KCl	5.4 (3.9 – 7.4) g/L KCl	16	December 10, 2021
C. dubia	Survival (LC50): 2.1 g/L NaCl	2.0 (1.8 – 2.2) g/L NaCl	5	December 21, 2021
	Reproduction (IC50): 1.7 (1.5-1.8) g/L NaCl	1.7 (1.4 – 2.2) g/L NaCl	11	

SD = Standard Deviation, CV = Coefficient of Variation, LC = Lethal Concentration, IC = Inhibition Concentration

5.0 REFERENCES

Environment Canada. 1997. Biological test method: test for survival and growth in sediment using the larvae of freshwater midges (*Chironomus tentans* and *Chrironomus riparius*). Environmental Protection Series EPS 1/RM/32. December 1997. Environment Canada, Method Development and Application Section, Environmental Technology Centre, Ottawa, ON. 131 pp.

Environment Canada. 2007. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. Environmental Protection Series. Report EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 74 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.9.4 Tidepool Scientific Software, McKinleyville, CA. 275 pp.

APPENDIX A – *Chironomus dilutus* Toxicity Test Data

Chironomus dilutus Water-only Test Summary Sheet

Client: Lorax/Pretivm
Work Order No.: 212487

Start Date: Dec 10/21
Set up by: KJL/GJU/MDO

Sample Information:

Sample ID: NO_3 in MHW
Sample Date: Dec 7/21
Date Received: Dec 9/21
Sample Volume: 5x 20L (4x20L + 1x20L)

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: Dec 10/21
Age or size (Day 0): 3rd in-star

KCI Reference Toxicant Results:

Reference Toxicant ID: CT104
Stock Solution ID: n/a
Date Initiated: Dec 10/21

96-h LC50 (95% CL): 4.3 (0.8 - 6.5)

96-h LC50 Reference Toxicant Mean and Range: 5.4 (3.9 - 7.4) CV (%): 16%

Test Results:
(measured values)

mg/L NO_3-N	Survival	Dry Weight
LC25 (%v/v) (95% CL)	206.8 (172.1 - N/A)	—
LC50(%v/v) (95% CL)	>280	—
IC25(%v/v) (95% CL)	—	54.4 (25.8 - 104.9)
IC50(%v/v) (95% CL)	—	>280
~~NOEC~~ MDO	—	—
~~LOEC~~ MDO	—	—

Reviewed by: [signature]

Date reviewed: Feb. 15 2022

Water-only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Water Quality

water-only

Client: Larax/Pretivm

W.O #: 212487

blue

Start Date: Dec 10/21

Termination Date: Dec 20/21

CER #: 12

Test Organism: *Chironomus dilutus*

Lab Water Nitrate

Temperature (°C)

Sample ID (mg/L NO_3-N)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Control	22.0	22.0	22.0	22.0	~~22.0~~	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
4.7	22.0	22.0	↓	↓	① ~~24.0~~ EC	↓	22.0	22.0	↓	↓	↓	↓	↓	↓
9.4	22.0	22.0	↓	↓	24.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓
18.8	22.0	22.0	↓	↓	24.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓
37.5	22.0	22.0	↓	↓	24.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓
75	22.0	22.0	↓	↓	24.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓
150	22.0	22.0	↓	↓	24.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓
300	22.0	22.0	↓	↓	24.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓
Technician Initials	GM	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

① 24.0

Thermometer: CER #12

Conductivity (µS)

② 332, 370

Sample ID (mg/L NO_3-N)	Day 0	1	2	3 Old	3 New (EC ①)	4	5 Old	5 New	6	7 Old	7 New (② EC)	8	9	10
① 331 Lab Control	328	338	364	379	~~369~~	357	383	327	362	373	~~378~~	358	370	386
369 4.7	363	380	398	410	~~404~~	392	408	366	389	402	~~403~~	392	403	415
404 9.4	398	414	432	442	~~476~~	428	438	402	420	431	~~403~~	419	430	439
476 18.8	472	483	499	509	~~621~~	500	513	472	500	514	474	494	507	518
37.5	616	618	631	642	621	634	642	613	636	651	612	640	654	667
75	903	902	907	921	910	920	937	908	928	946	908	934	949	962
150	1471	1423	1415	1427	1474	1465	1480	1447	1485	1499	1462	1479	1488	1486
300	2570	2470	2460	2480	2540	2530	2560	2500	2550	2600	2560	2600	2620	2610
Technician Initials	GM	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

Conductivity meter/probe: 6 / 6

Comments:

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

Water only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ MDO 10-d Water Quality

Water only

Client: Lorax/Pretivm
W.O #: 212487
Sample ID: NO3 in MHW blue

Start Date: Dec 10/21
Termination Date: Dec 20/21
CER #: 12
Test Organism: *Chironomus dilutus*

Lab water Nitrate

Dissolved Oxygen (mg/L)

Sample ID (mg/L NO3-N)	Day 0	1	2	3 Old	3 New	① 4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Control	8.6	6.2	4.3	4.0	7.6	4.2	7.6	7.9	7.9	8.0	8.6	8.0	8.0	7.7
4.7	8.6	6.2	4.4	3.9	7.6	4.1	7.9	8.5	8.0	8.1	8.5	8.1	8.1	7.8
9.4	8.7	6.1	4.7	3.9	7.6	3.8	8.0	8.6	8.2	8.0	8.4	8.0	8.3	7.8
18.8	8.7	6.2	4.7	4.3	7.7	3.9	8.0	8.6	8.3	8.2	8.6	8.3	8.3	8.0
37.5	8.7	6.2	4.7	4.5	7.6	4.2	7.8	8.6	8.4	7.9	8.6	8.4	8.6	8.1
75	8.7	6.4	4.7	4.3	7.7	5.0	8.0	8.6	8.3	8.1	8.7	8.4	8.5	8.1
150	8.7	6.4	4.6	4.1	7.7	3.9	8.0	8.6	8.3	8.0	8.4	8.0	8.5	8.1
300	8.7	6.2	~~4.6~~	3.9	7.6	~~3.7~~ 3.4 ② MDO	8.2	8.7	8.2	8.1	8.5	8.1	8.5	8.0
Technician Initials	GM	GM	PYL	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

DO meter/probe: 6 / 6

pH

Sample ID (mg/L NO3-N)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Control	7.5	7.0	6.7	6.9	7.6	6.7	7.4	7.5	7.5	7.5	7.5	7.5	7.3	7.3
4.7	7.5	7.0	6.7	7.0	7.4	6.8	7.6	7.4	7.4	7.5	7.4	7.5	7.3	7.4
9.4	7.5	7.1	6.7	7.0	7.5	6.9	7.6	7.4	7.5	7.5	7.5	7.5	7.3	7.4
18.8	7.5	7.1	6.8	7.0	7.5	6.9	7.7	7.5	7.6	7.6	7.5	7.6	7.4	7.5
37.5	7.5	7.1	6.8	7.1	7.6	7.0	7.6	7.5	7.7	7.6	7.6	7.6	7.5	7.6
75	7.6	7.2	6.8	7.1	7.6	7.1	7.7	7.6	7.8	7.7	7.7	7.7	7.6	7.7
150	7.6	7.3	6.8	7.2	7.7	7.1	7.8	7.6	7.8	7.8	7.7	7.8	7.7	7.7
300	7.7	7.3	7.1	7.2	7.8	7.1	7.9	7.7	7.9	7.9	7.8	7.8	7.8	7.8
Technician Initials	GM	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

pH meter/probe: 6 / 6

Light meter: lit-1
Light intensity (Lux): 500-940

Comments:
① Aeration initiated.
② 3.7

Reviewed by: [signature]
Date Reviewed: Feb. 15, 2022

10-d Chironomid ~~Sediment~~ Water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ WPO 10-d Survival and Weight

Water only

Client: Lorax/Pretivm
W.O. #: 212487
Sample ID: NO3 in MHW

Start Date: Dec 10/21
Termination Date: Dec 20/21
Test Organism: *Chironomus dilutus*
Balance: 1

Lab Control Nitrate

Sample ID (mg/L NO3-N)	La Pan No. blue	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
Control ~~Sediment~~ WPO	1	A	10	0	0	KJL	1042.89	1063.05	10	EC/EC
Lab Ctrl	2	B	10	0	0	KJL	1051.58	1068.68	10	
	3	C	9	0	1	KJL	1046.82	1065.62	9	
	4	D	9	0	1	KJL	1060.34	1079.23	9	
	5	E	10	0	0	KJL	1035.09	1055.55	10	
4.7	6	A	10	0	0	EC	1037.83	1057.67	10	
	7	B	10	0	0	EC	1052.07	1070.43	10	
	8	C	10 ①	0	0	EC	1046.59	1060.34	9	
	9	D	9	0	1	EC	1047.87	1065.33	9	
	10	E	10	0	0	EC	1037.39	1056.05	10	
9.4	11	A	9	0	1	SXH	1052.94	1068.93	9	
	12	B	10 ①	0	0	SXH	1053.86	1067.00	9	
	13	C	9	0	1	SXH	1044.59	1059.20	9	
	14	D	10	0	0	SXH	1050.30	1064.60	10	
	15	E	9	0	1	SXH	1032.44	1050.68	9	
18.8	16	A	10	0	0	KYL	1044.10	1060.12	10	
	17	B	10	0	0	KYL	1038.53	1053.17	10	
	18	C	10	0	0	KYL	1040.45	1058.98	10	
	19	D	9	0	1	KYL	1045.44	1060.58	9	
	20	E	10	0	0	KYL	1041.47	1056.15	10	

Date/time pan placed in oven: Dec 13/21 @ 1100h
Date/time pan removed from oven: Dec 14/21 @ 1000h

Date/time pan + organisms placed in oven: Dec 20/21 @ 1130h
Date/time pan + organisms removed from oven: Dec 21/21 @ 0900h

Comments: ① 1 pupae
reweigh: 5: 1055.98 13: 1059.41

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

10-d Chironomid ~~Sediment~~ Water-only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water-only 10-d Survival and Weight

Client: Lorax/Pretium
W.O. #: 212487
Sample ID: NO3 in MHW
Lab Control Nitrate

Start Date: Dec 10/21
Termination Date: Dec 20/21
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID (mg/L NO3-N)	Pan No.	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	21	A	9	0	1	MDO	1050.28	1064.57	9	EC/EC
37.5	22	B	9	0	1		1047.32	1064.91	9	
	23	C	11	0	0		1044.14	1060.41	11	
	24	D	9	0	1		1044.04	1063.03	9	
	25	E	9	0	1		1049.15	1064.76	9	
75	26	A	9	0	1	KJL	1036.75	1051.06	9	
	27	B	9 ①	0	1	KJL	1044.00	1056.71	8	
	28	C	9	0	1	KJL	1040.87	1053.75	9	
	29	D	10	0	0	KJL	1038.85	1052.52	10	
	30	E	10	0	0	SXH	1037.04	1050.17	10	
150	31	A	9	0	1	EC	1041.40	1054.20	9	
	32	B	9	0			1041.64	1053.83	9	
	33	C	9	0			1037.10	1049.33	9	
	34	D	9 ①	0			1031.83	1041.10	8	
	35	E	9	0			1036.67	1049.36	9	
300	36	A	5 ②	0	5	SXH	1038.30	1046.78	5	
	37	B	4 ②	0	6	KYL	1038.46	1045.35	4	
	38	C	~~10~~ 9	1	0	KJL	1038.26	1042.90	9	
	39	D	5 ②	0	5	KYL	1031.27	1037.60	5	
	40	E	6	0	4	KJL	1033.33	1041.10	6	

Date/time pan placed in oven: Dec 13/21 @ 1100h
Date/time pan removed from oven: Dec 14/21 @ 1000h

Date/time pan + organisms placed in oven: Dec 20/21 @ 1130h
Date/time pan + organisms removed from oven: Dec 21/21 @ 0900h

Comments: ① 1 pupae
② Checked by KJL
reweigh 23: 1060.74 31: 1054.42

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

CETIS Analytical Report

Report Date: 02 Feb-22 09:27 (p 1 of 2)
Test Code/ID: 212487a / 01-9409-7847

Chironomus 10-d Survival and Growth ~~Sediment~~ Water Only Test

Nautilus Environmental

Analysis ID:	15-3230-1634	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:26	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Batch ID:	05-9003-5703	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee
Start Date:	10 Dec-21	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Mod-Hard Synthetic Water
Ending Date:	20 Dec-21	**Species:**	Chironomus dilutus	**Brine:**	
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO **Age:** 3rd

Sample ID:	19-2321-2544	**Code:**	BJ-3.10	**Project:**	
Sample Date:	06 Dec-21 ~~12:20~~	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 ~~08:50~~	**CAS (PC):**		**Station:**	~~BJ-3.10~~ Lab Water w NO3
Sample Age:	84h (4.1 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	559688	200	Yes	Two-Point Interpolation

Point Estimates

Level	~~%~~ mg/L NO3-N	95% LCL	95% UCL	TU	95% LCL	95% UCL
EC5	87.37	n/a	165.4	1.145	0.6047	n/a
EC10	153.3	140.9	175.6	0.6523	0.5694	0.71
EC15	169.4	151.8	217	0.5904	0.4608	0.6587
EC20	187.2	162.9	281.7	0.5343	0.355	0.614
EC25	206.8	172.1	n/a	0.4836	n/a	0.5811
EC40	278.9	200.5	n/a	0.3586	n/a	0.4987
EC50	>280	n/a	n/a	<0.3571	n/a	n/a

10d Survival Rate Summary

			Calculated Variate(A/B)							Isotonic Variate	
Conc-~~%~~ mg/L NO3-N	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	A/B	Mean	%Effect
0.082	N	5	0.9600	0.9000	1.0000	0.0548	5.71%	0.0%	48/50	0.97	0.0%
4.525		5	0.9800	0.9000	1.0000	0.0447	4.56%	-2.08%	49/50	0.97	0.0%
9.03		5	0.9400	0.9000	1.0000	0.0548	5.83%	2.08%	47/50	0.96	1.03%
17.5		5	0.9800	0.9000	1.0000	0.0447	4.56%	-2.08%	49/50	0.96	1.03%
37.1		5	0.9200	0.9000	1.0000	0.0447	4.86%	4.17%	47/51	0.93	4.12%
70.15		5	0.9400	0.9000	1.0000	0.0548	5.83%	2.08%	47/50	0.93	4.12%
145		5	0.9000	0.9000	0.9000	0.0000	0.00%	6.25%	45/50	0.9	7.22%
280		5	0.5800	0.4000	0.9000	0.1924	33.16%	39.58%	29/50	0.58	40.21%

10d Survival Rate Detail

Conc-~~%~~ mg/L NO3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.082	N	1.0000	1.0000	0.9000	0.9000	1.0000
4.525		1.0000	1.0000	1.0000	0.9000	1.0000
9.03		0.9000	1.0000	0.9000	1.0000	0.9000
17.5		1.0000	1.0000	1.0000	0.9000	1.0000
37.1		0.9000	0.9000	1.0000	0.9000	0.9000
70.15		0.9000	0.9000	0.9000	1.0000	1.0000
145		0.9000	0.9000	0.9000	0.9000	0.9000
280		0.5000	0.4000	0.9000	0.5000	0.6000

10d Survival Rate Binomials

Conc-~~%~~ mg/L NO3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.082	N	10/10	10/10	9/10	9/10	10/10
4.525		10/10	10/10	10/10	9/10	10/10
9.03		9/10	10/10	9/10	10/10	9/10
17.5		10/10	10/10	10/10	9/10	10/10
37.1		9/10	9/10	11/11	9/10	9/10
70.15		9/10	9/10	9/10	10/10	10/10
145		9/10	9/10	9/10	9/10	9/10
280		5/10	4/10	9/10	5/10	6/10

Analyst: MDO QA: Feb-15/22

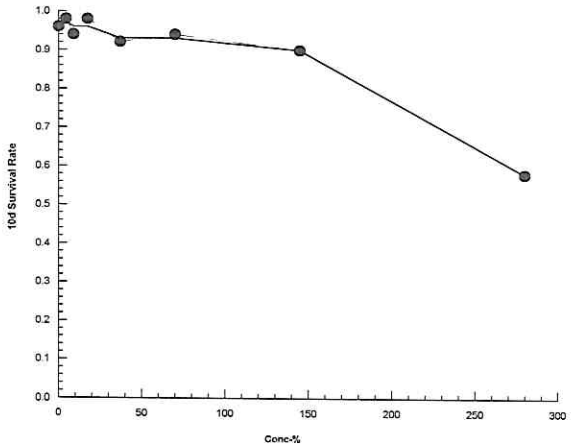
Water only

Chironomus 10-d Survival and Growth Sediment Test MDO

Nautilus Environmental

Analysis ID:	15-3230-1634	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:26	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



CETIS Analytical Report

Report Date: 02 Feb-22 09:26 (p 1 of 2)
Test Code/ID: 212487a / 01-9409-7847

Chironomus 10-d Survival and Growth ~~Sediment~~ Water only Test MDO

Nautilus Environmental

Analysis ID:	14-7279-1229	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:25	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

Batch ID:	05-9003-5703	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee		
Start Date:	10 Dec-21	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Mod-Hard Synthetic Water		
Ending Date:	20 Dec-21	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	19-2321-2544	**Code:**	BJ-3.10	**Project:**	
Sample Date:	08 Dec-21 ~~12:20~~ MDO	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	MDO 09 Dec-21 ~~08:59~~ MDO	**CAS (PC):**		**Station:**	~~BJ-3.10~~ MDO Lab Water w NO3
Sample Age:	84h (4.1 °C)	**Client:**	Pretivm Resources Inc.		

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Normal [ω=1]	Off [μ*=μ]	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
6	57.87	-109.1	-104.7	0.4290	Yes	0.8487	2.512	0.5258	Non-Significant Lack of Fit

Point Estimates

Level	~~mg/L~~ MDO mg/L NO3-N	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	0.3042	n/a	5.83	328.7	17.15	n/a
IC10	2.483	0.1981	10.55	40.28	9.481	504.9
IC15	9.109	2.171	26.09	10.98	3.833	46.07
IC20	24.24	8.971	54.96	4.126	1.819	11.15
IC25	54.4	25.84	104.9	1.838	0.953	3.871
IC40	381.4	109.8	1196	0.2622	0.08363	0.9109
IC50	1192	161.2	8812	0.08391	0.01135	0.6205

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	2.05	0.1872	1.671	2.429	10.95	<1.0E-37	Significant Parameter
γ	0.3559	0.1633	0.02502	0.6868	2.179	0.0357	Significant Parameter
δ	1192	906.9	-645.9	3029	1.314	0.1969	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	107	35.66	3	610.9	<1.0E-37	Significant
Lack of Fit	0.2529	0.05058	5	0.8487	0.5258	Non-Significant
Pure Error	1.907	0.0596	32			
Residual	2.16	0.05838	37			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variances	Bartlett Equality of Variance Test	13.62	14.07	0.0583	Equal Variances
	Mod Levene Equality of Variance	2.093	2.423	0.0840	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9524	0.9447	0.0915	Normal Distribution
	Anderson-Darling A2 Normality Te	0.6114	2.492	0.1128	Normal Distribution

Analyst: MDO QA: Feb 15/22

Chironomus 10-d Survival and Growth ~~Sediment~~ water-only Test MDO

Nautilus Environmental

Analysis ID:	14-7279-1229	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:25	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

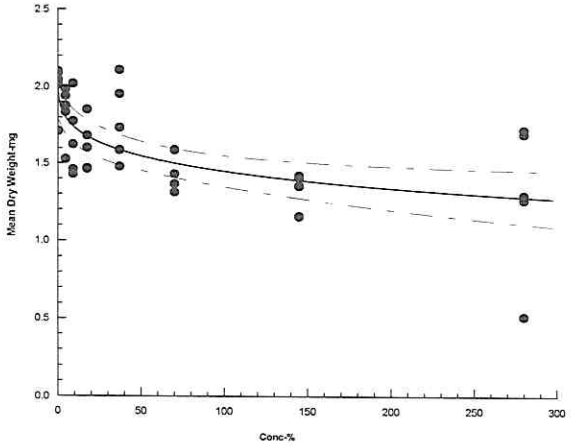
Mean Dry Weight-mg Summary

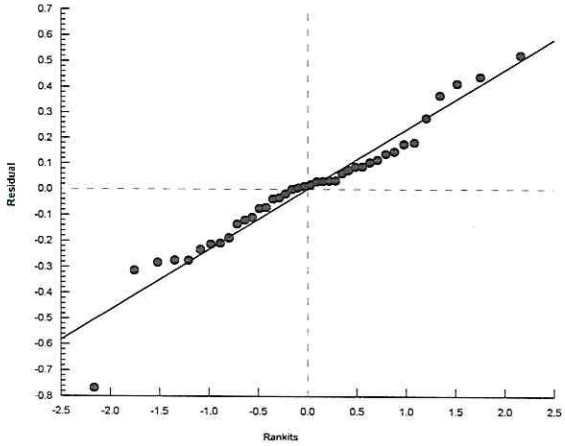
Conc-% mg/L NO_3-N	Code	Count	Calculated Variate Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0.082	N	5	1.992	1.71	2.099	0.07205	0.1611	8.09%	0.0%
4.525		5	1.833	1.528	1.984	0.08039	0.1798	9.81%	8.0%
9.03		5	1.662	1.43	2.021	0.1091	0.2441	14.68%	16.55%
17.5		5	1.614	1.464	1.853	0.07271	0.1626	10.07%	18.98%
37.1		5	1.773	1.479	2.11	0.1159	0.2592	14.62%	10.98%
70.15		5	1.458	1.313	1.59	0.05681	0.127	8.71%	26.81%
145		5	1.341	1.159	1.422	0.04747	0.1061	7.92%	32.69%
280		5	1.299	0.5156	1.723	0.2182	0.4878	37.55%	34.79%

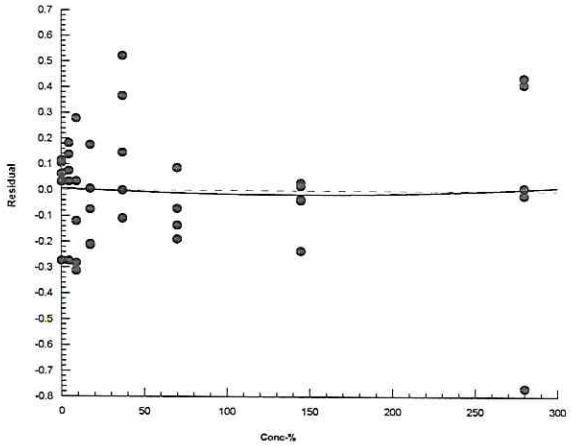
Mean Dry Weight-mg Detail

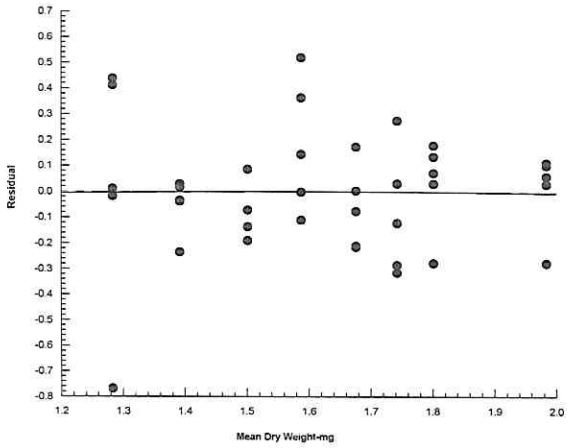
Conc-% mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.082	N	2.016	1.71	2.089	2.099	2.046
4.525		1.984	1.835	1.528	1.94	1.876
9.03		1.777	1.46	1.623	1.43	2.021
17.5		1.602	1.464	1.853	1.682	1.468
37.1		1.588	1.954	1.479	2.11	1.734
70.15		1.59	1.589	1.431	1.367	1.313
145		1.422	1.354	1.359	1.159	1.41
280		1.696	1.723	0.5156	1.266	1.295

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Normal [ω=1]









Chironomus dilutus Water-only Test Summary Sheet

Client: Lorax/Pretivm
Work Order No.: 212487

Start Date: Dec 10/21
Set up by: KJL/GJW/MDO

Sample Information:

Sample ID: NO_3 in BJ-3.10
Sample Date: Dec 7/21
Date Received: Dec 9/21
Sample Volume: 5 x 20L (4x20L + 1x20L)

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: Dec 10/21
Age or size (Day 0): 3rd in-star

KCl Reference Toxicant Results:

Reference Toxicant ID: CT104
Stock Solution ID: n/a
Date Initiated: Dec 10/21

96-h LC50 (95% CL): 4.3 (0.8-6.5)

96-h LC50 Reference Toxicant Mean and Range: 5.4(3.9-7.4) CV (%): 16%

Test Results:
(measured values)

mg/L NO_3-N	Survival	Dry Weight
LC25 (%v/v) (95% CL)	N/A	—
LC50(%v/v) (95% CL)	150.7 (130.7-173.9)	—
IC25(%v/v) (95% CL)	—	208.5 (52.1 - N/A)
IC50(%v/v) (95% CL)	—	>303
MDO ~~NOEC~~ MDO	—	—
~~LOEC~~ MDO	—	—

Reviewed by: [signature]

Date reviewed: Feb. 15, 2022

Water only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ MPD 10-d Water Quality

Water only

Client: Lorax / Pretivm

W.O #: 212487

black

Start Date: Dec 10/21

Termination Date: Dec 20/21

CER #: 12

Test Organism: *Chironomus dilutus*

Site Control
Nitrate

Temperature (°C)

Sample ID (mg/L NO_3-N)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.5	22.0	22.0	22.0
4.7	22.0	22.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓	↓	↓	↓
9.4	22.0	22.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓	↓	↓	↓
18.8	22.0	22.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓	↓	↓	↓
37.5	22.0	22.0	↓	↓	22.0	↓	↓	↓	↓	↓	↓	↓	↓	↓
75	22.0	22.0	↓	↓	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓
150	22.0	22.0	↓	↓	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓
300	22.0	22.0	↓	↓	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓
Technician Initials	GM	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

Thermometer: CER #12

Conductivity (µS)

Sample ID (mg/L NO_3-N)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Control	326	344	357	368	326	355	374	328	348	356	328	349	357	~~360~~ ① 376
4.7	362	373	387	398	373	389	404	360	379	390	364	386	401	410
9.4	397	404	416	426	407	422	438	399	417	428	400	415	425	439
18.8	470	477	485	495	484	499	507	466	487	503	471	489	500	508
37.5	613	608	615	623	637	643	658	607	637	655	613	630	646	657
75	899	862	871	880	922	928	943	892	927	947	908	932	945	952
150	1446	1434	1410	1421	1479	1476	1494	1438	1466	1488	1467	1486	1510	1526
300	2510	2400	2360	2380	2620	2610	2640	2600	2580	2620	2560	2630	2650	2680
Technician Initials	GM	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

Conductivity meter/probe: 6 / 6

Comments:

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

Water Only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Water Quality

Water only

Client: Lorax/Pretivm
W.O #: 212487
Sample ID: NO3 in BJ-3.10 black

Start Date: Dec 10/21
Termination Date: Dec 20/21
CER #: 12
Test Organism: *Chironomus dilutus*

Site Control Nitrate

Dissolved Oxygen (mg/L)

Sample ID (mg/L NO_3-N)	Day 0	1	2	3 Old	3 New	① 4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	8.3	6.1	4.5	4.0	8.5	3.9	7.7	8.7	8.4	8.1	7.9	8.0	8.4	7.9
4.7	8.3	6.1	4.5	4.1	8.0	3.8	8.0	8.3	8.5	8.1	7.9	7.8	8.3	8.0
9.4	8.3	6.2	4.7	4.4	8.1	4.0	8.0	8.4	8.5	8.1	8.0	7.7	8.4	8.0
18.8	8.3	6.2	4.7	4.2	8.1	4.1	8.1	8.5	8.4	8.1	8.0	7.9	8.4	8.0
37.5	8.3	6.2	4.5	4.1	7.9	3.7	8.0	8.6	8.1	8.1	8.0	8.0	8.3	8.0
75	8.4	6.2	4.8	3.8	8.0	4.0	8.2	8.6	8.3	8.1	8.0	7.5	8.4	7.8
150	8.4	6.3	4.6	4.3	8.0	4.3	8.2	8.6	8.2	7.9	8.1	7.5	8.2	7.6
300	8.5	6.4	4.7	4.6	8.1	5.1	8.2	8.7	8.3	7.9	8.1	7.5	8.2	7.8
Technician Initials	GM	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

DO meter/probe: 6 / 6

pH

Sample ID (mg/L NO_3-N)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	7.2	6.7	6.6	6.7	7.4	6.7	7.5	7.4	7.3	7.3	7.5	7.5	7.3	~~7.3~~ 7.2
4.7	7.2	6.8	6.6	6.8	7.4	6.7	7.5	7.3	7.5	7.3	7.3	7.5	7.3	7.4
9.4	7.3	6.8	6.6	6.9	7.5	6.8	7.6	7.4	7.5	7.5	7.4	7.5	7.4	7.4
18.8	7.3	6.8	6.6	6.9	7.6	6.8	7.5	7.4	7.5	7.5	7.4	7.5	7.4	7.3
37.5	7.4	6.9	6.6	6.9	7.6	6.8	7.6	7.5	7.6	7.5	7.5	7.6	7.4	7.5
75	7.4	7.0	6.7	6.9	7.7	6.9	7.7	7.5	7.6	7.6	7.5	7.7	7.5	~~7.7~~ 7.5
150	7.5	7.1	6.8	7.1	7.7	7.0	7.8	7.6	7.7	7.6	7.6	7.8	7.7	7.7
300	7.6	7.1	7.0	7.2	7.8	7.2	7.8	7.7	7.8	7.8	7.7	7.9	7.8	7.8
Technician Initials	MDO	GM	PM	EC	EC	EC	EC	EC	EC	EC	EC	GM	PM	EC

pH meter/probe: 6 / 6

Light meter: lit-1
Light intensity (Lux): 500-940

Comments: ① Aeration initiated.

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

10-d Chironomid ~~Sediment~~ Water-only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water-only 10-d Survival and Weight

Client: Lorax/Pretivm
W.O. #: 212487
Sample ID: NO_3 in BJ-3.10

Start Date: Dec 10/21
Termination Date: Dec 20/21
Test Organism: *Chironomus dilutus*
Balance: 1

Site Control nitrate

Sample ID (mg/L NO_3-N)	Pan No. black	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	1	A	8	0	2	MDO	1044.42	1062.48	8	EC/EC
Site Ctrl	2	B	11	0	0		1035.77	1050.47	11	
	3	C	10	0	0		1039.11	1054.56	10	
	4	D	10②	0	0		1043.44	1055.17	10	
	5	E	8①	0	2		1039.33	1051.13	7	
4.7	6	A	9①	0	1	SXH	1040.83	1054.95	8	
	7	B	10	0	0	SXH	1033.94	1047.79	10	
	8	C	10	0	0	SXH	1048.14	1064.49	10	
	9	D	10	0	0	SXH	1053.02	1069.39	10	
	10	E	9	0	1	SXH	1053.66	1072.02	9	
9.4	11	A	9	0	1	KYL	1050.21	1065.83	9	
	12	B	11	0	0	KYL	1032.38	1046.09	11	
	13	C	10	0	0	KYL	1049.65	1063.73	10	
	14	D	10	0	0	KYL	1031.16	1045.90	10	
	15	E	10	0	0	KYL	1054.72	1067.36	10	
18.8	16	A	8	0	2	KJV	1047.76	1063.67	8	
	17	B	10	0	0	KJV	1039.84	1055.02	10	
	18	C	8	0	2	KJL	1033.65	1048.22	8	
	19	D	9	0	1	KJL	1047.79	1062.20	9	
	20	E	10	0	0	KJL	1043.73	1058.15	10	

Date/time pan placed in oven: Dec 13/21 @1100h
Date/time pan removed from oven: Dec 14/21 @1000h

Date/time pan + organisms placed in oven: Dec 20/21 @1130h
Date/time pan + organisms removed from oven: Dec. 21/21 @0900h

Comments: ① Pupae x1
② Two significantly smaller

Remeigh: 11: 1066.10 17: 1055.28

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

10-d Chironomid ~~Sediment~~ Water-only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ MDO Water-only 10-d Survival and Weight

Client: Lorax/Pretivm
W.O. #: 212487
Sample ID: NO3 in B1-3.10

Start Date: Dec 10/21
Termination Date: Dec 20/21
Test Organism: *Chironomus dilutus*
Balance: \

Site control nitrate

Sample ID (mg/L NO3-N)	Pan No. (mg/L)	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~ MDO	21	A	10	0	0	EC	1048.45	~~1065.46~~ 1065.46	10	EC / EC
37.5	22	B	10				1047.69	1063.55	10	
	23	C	10				1054.84	1069.00	10	
	24	D	10				1044.24	1061.28	10	
	25	E	9		1		1035.84	1052.80	9	
75	26	A	9	0	1	MDO	1043.30	1054.96	9	
	27	B	10		0		1038.61	1053.41	10	
	28	C	9 ②		1		1050.36	1065.73	9	
	29	D	9		1		1056.51	1071.70	9	
	30	E	9		1		1048.90	1062.32	9	
150	31	A	4	0	6	KJL	1046.58	1052.07	4	
	32	B	3	0	7	KJL	1043.99	1048.77	3	
	33	C	3 ①	0	7	SXH	1048.10	1052.20	3	
	34	D	7 ①	0	3	SXH	1043.95	1050.80	7	
	35	E	2	0	8	KJL	1033.48	1036.56	2	
300	36	A	4 ①	KYL ~~0~~ 4	~~6~~ 2 KYL	KYL	1037.20	1040.25	4	
	37	B	0	7	3	KYL	1040.15	—	—	
	38	C	1	3	6	KJL	1040.56	1042.50	1	
	39	D	2 ①	2	6	SXH	1041.89	1042.65	2	
	40	E	0	3	7	KJL	1037.62	—	—	

Date/time pan placed in oven: Dec 13/21 @ 1100h
Date/time pan removed from oven: Dec 14/21 @ 1000h

Date/time pan + organisms placed in oven: Dec 20/21 @ 1130h
Date/time pan + organisms removed from oven: Dec 21/21 @ 0900h

Comments: ① checked by KJL reweigh 21: 1065.91 32: 1048.90
② One significantly smaller

Reviewed by: [signature]

Date Reviewed: Feb. 15, 2022

CETIS Analytical Report

Water only

Report Date:	02 Feb-22 09:31 (p 1 of 2)
Test Code/ID:	212487b / 19-7876-7153

Chironomus 10-d Survival and Growth ~~Sediment~~ Test MDO — **Nautilus Environmental**

Analysis ID:	08-3438-5130	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:31	**Analysis:**	Trimmed Spearman-Kärber	**Status Level:**	1

Batch ID:	03-4944-4752	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee		
Start Date:	10 Dec-21	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Site water BJ 3.10		
Ending Date:	20 Dec-21	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	19-2321-2544	**Code:**	BJ-3.10	**Project:**	
Sample Date:	09 Dec-21 ~~12:20~~ 1345 MDO	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	84h (4.1 °C)	**Client:**	Pretivm Resources Inc.		NO_3

Trimmed Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0.07843	14.68%	2.178	0.03104	150.7	130.7	173.9

10d Survival Rate Summary

Conc-% mg/L NO_3-N MDO	Code	Count	Calculated Variate(A/B) Mean	Min	Max	Std Dev	CV%	%Effect	A/B	Isotonic Variate Mean	%Effect
8.885	N	5	0.9200	0.8000	1.0000	0.1095	11.91%	0.0%	47/51	0.9533	0.0%
13.8		5	0.9600	0.9000	1.0000	0.0548	5.71%	-4.35%	48/50	0.9533	0.0%
18.15		5	0.9800	0.9000	1.0000	0.0447	4.56%	-6.52%	50/51	0.9533	0.0%
27.05		5	0.9000	0.8000	1.0000	0.1000	11.11%	2.17%	45/50	0.94	1.4%
45.85		5	0.9800	0.9000	1.0000	0.0447	4.56%	-6.52%	49/50	0.94	1.4%
78.65		5	0.9200	0.9000	1.0000	0.0447	4.86%	0.0%	46/50	0.92	3.5%
163		5	0.3800	0.2000	0.7000	0.1924	50.62%	58.7%	19/50	0.38	60.14%
303		5	0.1400	0.0000	0.4000	0.1673	119.50%	84.78%	7/50	0.14	85.31%

10d Survival Rate Detail

Conc-% mg/L NO_3-N MDO	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
8.885	N	0.8000	1.0000	1.0000	1.0000	0.8000
13.8		0.9000	1.0000	1.0000	1.0000	0.9000
18.15		0.9000	1.0000	1.0000	1.0000	1.0000
27.05		0.8000	1.0000	0.8000	0.9000	1.0000
45.85		1.0000	1.0000	1.0000	1.0000	0.9000
78.65		0.9000	1.0000	0.9000	0.9000	0.9000
163		0.4000	0.3000	0.3000	0.7000	0.2000
303		0.4000	0.0000	0.1000	0.2000	0.0000

10d Survival Rate Binomials

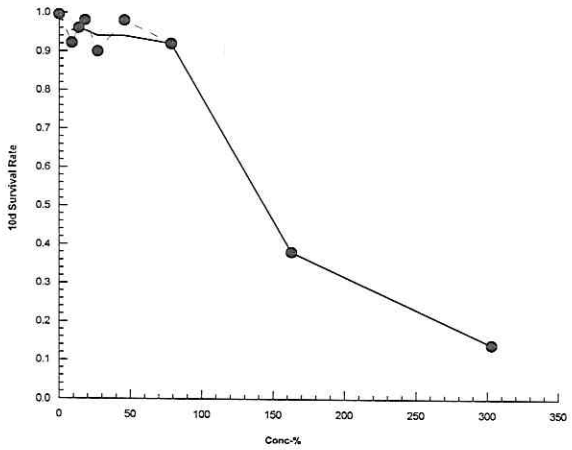
Conc-% mg/L NO_3-N MDO	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
8.885	N	8/10	11/11	10/10	10/10	8/10
13.8		9/10	10/10	10/10	10/10	9/10
18.15		9/10	11/11	10/10	10/10	10/10
27.05		8/10	10/10	8/10	9/10	10/10
45.85		10/10	10/10	10/10	10/10	9/10
78.65		9/10	10/10	9/10	9/10	9/10
163		4/10	3/10	3/10	7/10	2/10
303		4/10	0/10	1/10	2/10	0/10

Water only

Chironomus 10-d Survival and Growth Sediment Test MDO **Nautilus Environmental**

Analysis ID:	08-3438-5130	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:31	**Analysis:**	Trimmed Spearman-Kärber	**Status Level:**	1

Graphics



CETIS Analytical Report

Report Date: 02 Feb-22 09:31 (p 1 of 2)
Test Code/ID: 212487b / 19-7876-7153

Chironomus 10-d Survival and Growth ~~Sediment~~ Water only Test

Nautilus Environmental

Analysis ID:	00-0936-0682	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:31	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Batch ID:	03-4944-4752	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Karen Lee		
Start Date:	10 Dec-21	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Site water BJ 3.10		
Ending Date:	20 Dec-21	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	19-2321-2544	**Code:**	BJ-3.10	**Project:**	
Sample Date:	mo ~~06~~ Dec-21 mo ~~12:20~~ 1345	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	84h (4.1 °C)	**Client:**	Pretivm Resources Inc.		w NO_3

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	686321	200	Yes	Two-Point Interpolation

Point Estimates

Level	mo % mg/L NO_3-N	95% LCL	95% UCL	TU	95% LCL	95% UCL
IC5	57.7	n/a	175.1	1.733	0.5712	n/a
IC10	99.07	n/a	n/a	1.009	n/a	n/a
IC15	143.3	n/a	n/a	0.6976	n/a	n/a
IC20	179.6	2.877	n/a	0.5567	n/a	34.76
IC25	208.5	52.09	n/a	0.4797	n/a	1.92
IC40	>303	n/a	n/a	<0.33	n/a	n/a
IC50	>303	n/a	n/a	<0.33	n/a	n/a

Mean Dry Weight-mg Summary

			Calculated Variate						Isotonic Variate	
Conc-% mg/L NO_3-N mo	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	Mean	%Effect
8.885	N	5	1.6	1.173	2.257	0.4167	26.05%	0.0%	1.646	0.0%
13.8		5	1.692	1.385	2.04	0.2383	14.08%	-5.78%	1.646	0.0%
18.15		5	1.427	1.246	1.741	0.2003	14.04%	10.8%	1.586	3.61%
27.05		5	1.674	1.442	1.989	0.226	13.50%	-4.67%	1.586	3.61%
45.85		5	1.658	1.416	1.884	0.1725	10.40%	-3.68%	1.586	3.61%
78.65		5	1.532	1.296	1.708	0.1699	11.09%	4.19%	1.532	6.89%
163		5	1.37	0.9786	1.593	0.2408	17.58%	14.34%	1.37	16.74%
303		3	1.027	0.38	1.94	0.813	79.13%	35.76%	1.027	37.57%

Mean Dry Weight-mg Detail

Conc-% mg/L NO_3-N mo	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
8.885	N	2.257	1.336	1.545	1.173	1.686
13.8		1.765	1.385	1.633	1.637	2.04
18.15		1.741	1.246	1.408	1.474	1.264
27.05		1.989	1.518	1.821	1.601	1.442
45.85		1.701	1.586	1.416	1.704	1.884
78.65		1.296	1.48	1.708	1.688	1.491
163		1.372	1.593	1.367	0.9786	1.54
303		0.7625	1.94	0.38		

Analyst: MDO QA: Feb 15/22

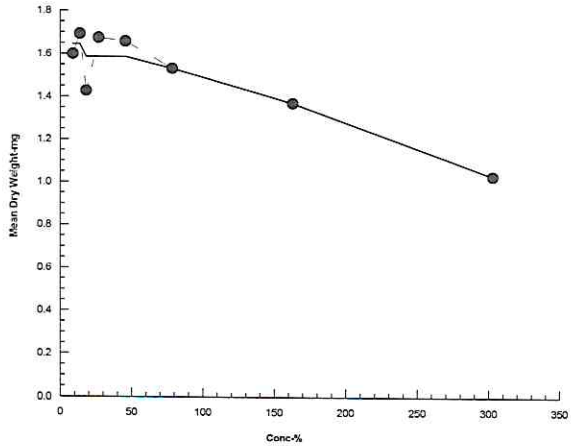
Water only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test

Nautilus Environmental

Analysis ID:	00-0936-0682	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.9.4
Analyzed:	02 Feb-22 9:31	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



APPENDIX B – *Ceriodaphnia dubia* Toxicity Test Data

Ceriodaphnia dubia Summary Sheet

Client: Lorax / Pretivm
Work Order No.: 212488

Start Date/Time: Dec 10/21 @ 1230L
Set up by: JZL

Sample Information:

Sample ID: NO3 Lab Water
Sample Date: Dec 7/21
Date Received: Dec 9/21
Sample Volume: 5 x 20L
(4 x 20L + 1 x 20L)

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6.0 to 8.5

Test Organism Information:

Broodstock No.: BB113021 + BB120221B + BB120321
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 22
Mortality (%) in previous 7 d: 3
Individual female # used ≥8 young on test day: #1,2,4 + #21-23,30,35,36,39,40 + #1,3,4,6-8,10-14,16-20.

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd 296
Stock Solution ID: 21Na03
Date Initiated: Dec 21/21

7-d LC50 (95% CL): 2.1 (1.5-3.0) g/L NaCL
7-d IC50 (95% CL): 1.7 (1.5-1.8) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0 (1.8-2.2) g/L NaCL CV (%): 5%
7-d IC50 Reference Toxicant Mean and Historical Range: 1.7 (1.4-2.2) g/L NaCL CV (%): 11%

Test Results:
(measured values)

mg/L NO_3-N	Survival	Reproduction
LC50 % (v/v) (95% CL)	>286.25	—
IC25 % (v/v) (95% CL)	—	146.6 (110 - 157.4)
IC50 % (v/v) (95% CL)	—	187.5 (176.9 - 197.3)

Reviewed by: [signature]

Date reviewed: Feb. 14, 2022

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax / Pretium
Sample ID: NO_3 Lab Water
Work Order #: 212488

Start Date & Time: Dec. 10/21 @ 1230h
Stop Date & Time: Dec. 16/21 @ 1400h
CER #: 4
Test Species: *Ceriodaphnia dubia*

mg/L NO_3-N

Concentration: Lab Control	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	24.0	24.5		
DO (mg/L)	8.1	6.5	8.1	7.2	8.0	6.9	8.0	6.8	8.1	7.0	8.2	6.9		
pH	7.9	7.6	7.9	7.7	7.9	7.6	7.9	7.5	8.0	7.5	7.9	7.6		
Cond. (µS/cm)	210	214		208		208		214		213		219		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration: 4.7	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.5	24.0	25.0	24.0	24.0	24.0	24.5	24.0	24.0	25.0		
DO (mg/L)	7.7	6.6	7.6	6.7	7.3	7.2	7.4	7.0	7.6	7.0	7.5	6.7		
pH	7.8	7.5	7.8	7.5	7.9	7.6	7.9	7.5	8.0	7.6	~~8.0~~ 7.9	7.6		
Cond. (µS/cm)	249	245		245		247		246		245		245		
Initials	JZL	JZL		RZS		KYL		JZL		BAM		JZL		

Concentration: 37.5	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.5	24.5	25.0	24.0	24.0	24.0	24.5	24.0	24.0	25.0		
DO (mg/L)	7.9	6.5	7.7	6.7	7.4	7.2	7.7	7.0	7.7	7.1	7.7	6.8		
pH	7.8	7.5	7.8	7.5	7.9	7.6	8.0	7.6	8.1	7.6	7.8	7.6		
Cond. (µS/cm)	509	504		508		501		500		484		481		
Initials	JZL	JZL		RZS		~~SAK~~ KYL BAM		JZL		BAM		JZL		

Concentration: 300	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.5	24.5	25.0	24.0	24.0	24.0	24.0	24.5	24.0	25.0		
DO (mg/L)	7.9	6.6	7.7	6.7	7.6	7.2	7.8	7.0	8.0	7.1	7.8	6.8		
pH	7.8	7.4	7.8	7.5	7.8	7.5	7.9	7.7	8.2	7.7	8.0	7.6		
Cond. (µS/cm)	~~1370~~ ① 2490	2590		2470		2450		2480		2490		2400		
Initials	JZL	JZL		RZS		KYL		JZL		JZL		JZL		

Thermometer: CER #4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control			
Hardness*	100			
Alkalinity*	~~99~~ 87 MDO			

* mg/L as CaCO3

Analysts: SAK, JZL, RZS, ~~GJO~~ JW, KYL, BAM
Reviewed by: [signature]
Date reviewed: Feb. 14, 2022

Sample Description: clear, colorless, odorless, no particulates

Comments: Broodboard Used: ~~BB120321~~ BB120321 MDO #1, 3, 4, 6-8, 10-14, 16-20
BB120221B #21-23, 30, 35, 36, 39, 40
~~BB120321~~ BB130321 MDO #1, 2, 4.

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Lorax / Pretium
Sample ID: NO3 Lab Water
Work Order: 212488

Start Date & Time: Dec. 10/21 @ 1230h
Stop Date & Time: Dec 16/21 @ 1400h
Set up by: JZL

mg/L NO_3-N

Days	Concentration: Lab Control										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	4	4	3	/	~~3~~ 4	3	4	3	/	4	SAH
4	/	/	/	4	/	/	/	/	4	/	JZL
5	9	4	6	7	9	9	9	8	11	9	JZL
6	11	12	12	10	12	9	11	10	14	12	JZL
7											
8											
Total	24	20	21	21	25	21	24	21	29	25	SXH

Days	Concentration: 4.7										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	3	/	3	3	/	3	3	/	/	3	SAH
4	/	5	/	/	3	/	4	4	/	/	JZL
5	9	9	7	8	10	6	8	8	7	11	JZL
6	10	~~9~~ 8	8	7	13	10	13	11	11	13	JZL
7											
8											
Total	22	23	~~18~~ 18	18	26	19	15	23	18	27	SXH

Days	Concentration: 9.4										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	5	/	/	3	4	5	2	/	4	5	SAH
4	/	3	2	/	/	/	/	/	/	/	JZL
5	8	9	7	7	10	8	8	7	7	9	JZL
6	10	10	8	8	10	11	11	11	11	10	JZL
7											
8											
Total	23	22	17	18	24	24	21	18	22	24	SXH

Days	Concentration: 18.8										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	4	4	4	/	/	4	/	/	4	3	SAH
4	/	/	/	3	5	/	/	3	/	/	JZL
5	7	8	8	10	/	7	7	10	8	8	JZL
6	12	12	11	10	10	9	7	12	12	11	JZL
7											
8											
Total	23	24	23	23	15	20	14	25	24	22	SXH

Days	Concentration: 37.5										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	2	3	2	4	/	/	3	~~4~~ 5	2	SAH
4	/	/	/	/	/	/	/	/	/	/	JZL
5	8	9	8	7	9	8	8	9	7	9	JZL
6	11	8	11	12	8	10	10	10	10	13	JZL
7											
8											
Total	19	19	22	21	21	18	18	22	22	24	SXH

Days	Concentration: 75										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	/	/	/	/	2	/	3	/	4	SAH
4	4	2	4	4	4	/	2	/	3	/	JZL
5	9	/	8	8	8	9	7	7	7	9	JZL
6	13	10	10	10	11	12	12	11	11	13	JZL
7											
8											
Total	26	12	22	22	23	23	21	21	21	26	SXH

Days	Concentration: 150										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	3	/	3	2	/	3	2	3	/	3	SAH
4	/	2	/	/	/	/	/	7	/	/	JZL
5	6	6	8	4	8	6	4	/	6	7	JZL
6	11	12	8	8	7	9	7	10	10	10	JZL
7											
8											
Total	20	20	19	14	15	18	13	20	16	20	SXH

Days	Concentration: 300										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	/	2	/	/	/	/	/	/	/	SAH
4	X	/	/	/	/	/	/	/	/	/	JZL
5		/	2	/	/	/	2	/	/	2	JZL
6		2	/	/	/	/	4	/	/	2	JZL
7											
8											
Total	0x	2	4	0	0	0	6	0	0	4	SXH

Days	Concentration:										
	A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Notes: X = mortality.

Comments: 1. Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

2. Ephippia present in Controls (Y) (N)?

Reviewed by: [signature]

Date reviewed: Feb. 14, 2022

Version 2.2 Issued Sep. 11, 2018

Nautilus Environmental Company Inc.

CETIS Analytical Report

Report Date: 04 Feb-22 15:00 (p 1 of 4)
Test Code/ID: 212488a / 04-7466-1609

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-4478-0823	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:59	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Batch ID:	16-0247-1370	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mikayla Oldach		
Start Date:	10 Dec-21 12:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water		
Ending Date:	16 Dec-21 14:00	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	12-2471-6419	**Code:**	48FFB083	**Project:**	
Sample Date:	07 Dec-21 13:45	**Material:**	Nitrate	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	71h (4.1 °C)	**Client:**	Pretivm Resources Inc.		NO_3

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1287207	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L NO_3-N	95% LCL	95% UCL
EC5	204.2	162.9	n/a
EC10	286.5	182.4	n/a
EC15	>286.5	n/a	n/a
EC20	>286.5	n/a	n/a
EC25	>286.5	n/a	n/a
EC40	>286.5	n/a	n/a
EC50	>286.5	n/a	n/a

6d Survival Rate Summary

			Calculated Variate(A/B)							Isotonic Variate	
Conc-mg/L NO_3-N	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	A/B	Mean	%Effect
0.6125	N	10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
5.105		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
9.59		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
17.85		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
35		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
70.8		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
145.5		10	1.0000	1.0000	1.0000	0.0000	0.00%	0.0%	10/10	1	0.0%
286.5		10	0.9000	0.0000	1.0000	0.3162	35.14%	10.0%	9/10	0.9	10.0%

6d Survival Rate Detail

Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.6125	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
5.105		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.59		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17.85		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
35		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
70.8		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
145.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
286.5		0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

6d Survival Rate Binomials

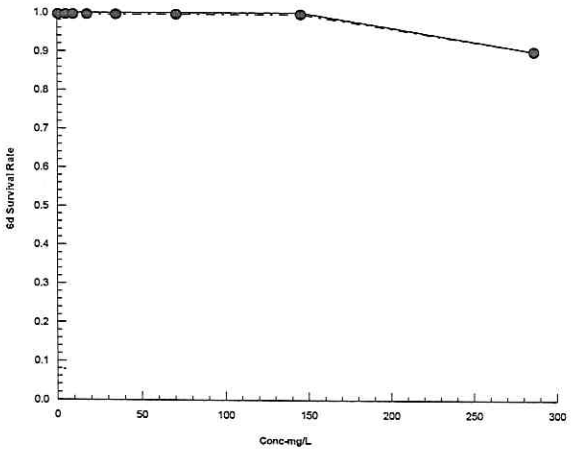
Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.6125	N	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
5.105		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.59		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
17.85		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
35		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
70.8		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
145.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
286.5		0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Analyst: MDO QA: Feb·14/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-4478-0823	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:59	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	02-5331-1555	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:59	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Batch ID:	16-0247-1370	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mikayla Oldach		
Start Date:	10 Dec-21 12:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water		
Ending Date:	16 Dec-21 14:00	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	12-2471-6419	**Code:**	48FFB083	**Project:**	
Sample Date:	07 Dec-21 13:45	**Material:**	Nitrate	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	71h (4.1 °C)	**Client:**	Pretivm Resources Inc.		~ NO_3

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	579249	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L NO_3-N	95% LCL	95% UCL
IC5	2.572	1.548	78.3
IC10	76.03	3.025	97.71
IC15	95.53	9.4	128.8
IC20	120	82.47	150.4
IC25	146.6	110	157.4
IC40	169.9	159.5	179
IC50	187.5	176.9	197.3

Reproduction Summary

			Calculated Variate						Isotonic Variate	
Conc-mg/L NO_3-N	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	Mean	%Effect
0.6125	N	10	23.1	20	29	2.807	12.15%	0.0%	23.1	0.0%
5.105		10	20.9	15	27	3.9	18.66%	9.52%	21.17	8.37%
9.59		10	21.3	17	24	2.71	12.72%	7.79%	21.17	8.37%
17.85		10	21.3	14	25	3.831	17.99%	7.79%	21.17	8.37%
35		10	20.6	18	24	2.011	9.76%	10.82%	21.15	8.44%
70.8		10	21.7	12	26	3.889	17.92%	6.06%	21.15	8.44%
145.5		10	17.5	13	20	2.759	15.76%	24.24%	17.5	24.24%
286.5		10	1.6	0	6	2.271	141.90%	93.07%	1.6	93.07%

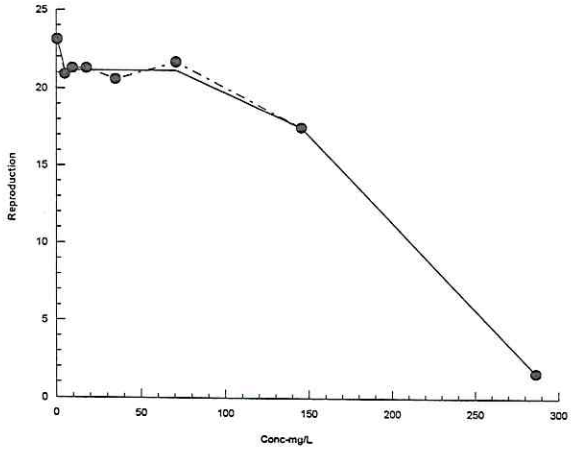
Reproduction Detail

Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.6125	N	24	20	21	21	25	21	24	21	29	25
5.105		22	23	18	18	26	19	15	23	18	27
9.59		23	22	17	18	24	24	21	18	22	24
17.85		23	24	23	23	15	20	14	25	24	22
35		19	19	22	21	21	18	18	22	22	24
70.8		26	12	22	22	23	23	21	21	21	26
145.5		20	20	19	14	15	18	13	20	16	20
286.5		0	2	4	0	0	0	6	0	0	4

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	02-5331-1555	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:59	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



Ceriodaphnia dubia Summary Sheet

Client: Lorax/Pretivm
Work Order No.: 212488

Start Date/Time: Dec 10/21 @ 1200L
Set up by: JZL

Sample Information:

Sample ID: NO3 Site water
Sample Date: Dec 7/21
Date Received: Dec 9/21
Sample Volume: 5x 20L
(4x20L + 1x20L)

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6.0 to 8.5

Test Organism Information:

Broodstock No.: BB113021 + BB120221B + BB120321
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 22
Mortality (%) in previous 7 d: 3
Individual female # used ≥8 young on test day: #1,2,4 + #21-23,30,35,36,39,40 + #1,3,4,6-8,10-14,16-20.

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd296
Stock Solution ID: 21NaCl3
Date Initiated: Dec 21/21

7-d LC50 (95% CL): 2.1(1.5-3.0) g/L NaCL
7-d IC50 (95% CL): 1.7(1.5-1.8) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0(1.8-2.2) g/L NaCL CV (%): 5%
7-d IC50 Reference Toxicant Mean and Historical Range: 1.7(1.4-2.2) g/L NaCL CV (%): 11%

Test Results:
(measured values)

mg/L NO3-N	Survival	Reproduction
LC50 % (v/v) (95% CL)	>303	—
IC25 % (v/v) (95% CL)	—	59.0(50.9-67.8)
IC50 % (v/v) (95% CL)	—	88.5(77.8-98.8)

MDO

Reviewed by: [signature]

Date reviewed: Feb. 14, 2022

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax / Pretium
Sample ID: NO3 site water
Work Order #: 212488

Start Date & Time: Dec 10/21 @ 1200h
Stop Date & Time: Dec 16/21 @ 1430h
CER #: 4
Test Species: *Ceriodaphnia dubia*

mg/L NO3-N

Concentration site control	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.0	24.0	24.5	24.0	24.0	24.0	24.0	24.0	24.0	25.0		
DO (mg/L)	7.8	6.6	7.8	6.3	7.9	7.4	7.9	6.8	7.9	7.4	7.8	6.8		
pH	7.3	7.2	7.4	7.3	7.5	7.1	7.4	7.4	7.7	7.4	7.4	7.4		
Cond. (µS/cm)	331	327		330		328		333		327		323		
Initials	GM	JZ		RB		BAM		JZ		BAM		JZ		

Concentration 4.7	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.5	24.0	24.5	24.0	23.0	24.0	24.5	24.0	24.0	25.0		
DO (mg/L)	8.0	6.6	7.9	6.6	7.9	7.2	8.0	7.0	8.1	7.4	8.3	7.0		
pH	7.4	7.2	7.4	7.3	7.5	7.4	7.6	7.3	7.7	7.3	7.5	7.4		
Cond. (µS/cm)	368	366		369		376		371		367		363		
Initials	GM	JZ		RB		BAM		JZ		BAM		JZ		

Concentration 37.5	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.5	24.5	25.0	24.5	23.0	24.0	25.0	24.0	24.0	25.0		
DO (mg/L)	7.8	6.7	7.9	6.6	7.9	7.2	8.1	7.1	8.1	7.4	7.6	7.0		
pH	7.4	7.1	7.5	7.2	7.5	7.3	7.6	7.3	7.7	7.4	7.5	7.3		
Cond. (µS/cm)	628	616		622		643		630		649		631		
Initials	GM	JZ		RB		BAM		JZ		BAM		JZ		

Concentration 300	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.0	24.5	25.0	25.0	23.0	24.0	24.5	24.0	24.0	25.0		
DO (mg/L)	7.8	6.6	8.0	6.6	8.1	7.2	8.1	7.1	8.1	7.4	7.8	7.1		
pH	7.4	7.1	7.4	7.2	7.4	7.2	7.5	7.4	7.7	7.4	7.5	7.3		
Cond. (µS/cm)	2560	2620		2590		2650		2560		2690		2610		
Initials	GM	JZ		RB		BAM		JZ		BAM		JZ		

Thermometer: CER #4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Site Control			
Hardness*	70			
Alkalinity*	~~35~~ 60			

* mg/L as CaCO3

Analysts: GM, ~~BM~~ MDO, RZS, JZ, BAM
Reviewed by:
Date reviewed: Feb. 14, 2022

Sample Description: Clear, colorless, odorless, no particulates

Comments: Broodboard Used: BB113021 #1,2,4.
BB120221B # 21-23,30,35,36,39,40.
BB120321 # 1,3,4,6-8,10-14,16-20.

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax / Pretium
Sample ID: NO3 Site Water
Work Order #: 212488

Start Date & Time: Dec. 10/21 @ 1200h
Stop Date & Time: Dec 16/21 @ 1430h
CER #: 4
Test Species: *Ceriodaphnia dubia*

Concentration Lab Control	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	25.0	24.0	24.0	24.5		
DO (mg/L)	8.1	6.6	8.1	6.3	8.0	6.9	8.0	6.9	8.1	7.3	8.2	6.9		
pH	7.9	7.6	7.9	7.6	7.9	7.6	7.9	7.7	8.0	7.8	7.9	7.6		
Cond. (µS/cm)	210	214		208		208		~~208~~ 214		213		223		
Initials	GM	JZL		RZS		RZS		JZL		JZL		JZL		

Concentration	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Thermometer: CER #4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control				
Hardness*	MDD ~~72~~ 100				
Alkalinity*	~~84~~ ~~94~~ 87				

* mg/L as CaCO3

Analysts: GM, MDD ~~DYK~~, RZS, JZL
Reviewed by: [illegible]
Date reviewed: Feb. 14, 2022

Sample Description: clear, colorless, odorless, no particulates

Comments: Broodboard Used: BB113021 # 1, 2, 4
BB120221B # 21-23, 30, 35, 36, 39, 40
BB120321 # 1, 3, 4, 6-8, 10-14, 16-20.

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Lorax / Pretivm
Sample ID: NO3 Site water
Work Order: 212488

mg/L NO_3-N

Start Date & Time: Dec. 10/21 @ 1200h
Stop Date & Time: Dec. 16/21 @ 1430h
Set up by: JZL

Days	Concentration: lab control										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	4	3	/	3	/	/	/	/	3	PM
4	4	/	/	4	/	2	/	4	4	/	JZL
5	4	10	9	8	9	7	5	8	8	9	JZL
6	9	11	10	10	10	11	11	10	12	12	JZL
7											
8											
Total	17	25	22	22	22	20	16	22	24	24	SXH

Days	Concentration: site control										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	3	/	4	3	4	4	/	3	/	PM
4	3	/	4	/	/	/	6	3	/	/	JZL
5	8	8	9	8	9	7	/	6	9	8	JZL
6	13	12	14	4	10	14	11	12	12	11	JZL
7											
8											
Total	24	23	27	16	22	25	21	21	24	19	SXH

Days	Concentration: 4.7										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	3	3	3	/	/	/	2	3	/	2	PM
4	/	/	/	/	/	2	/	/	/	/	JZL
5	10	5	8	2	6	10	8	10	7	8	JZL
6	15	10	10	12	8	12	14	12	12	17	JZL
7											
8											
Total	28	18	21	14	14	24	24	25	19	22	SXH

Days	Concentration: 9.4										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	3	/	/	/	3	3	4	/	/	/	PM
4	/	2	2	3	/	/	/	2	2	3	JZL
5	9	8	6	10	9	7	6	5	9	10	JZL
6	4	12	12	12	9	11	12	10	13	10	JZL
7											
8											
Total	16	22	20	25	21	21	22	17	24	23	SXH

Days	Concentration: 18.8										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	3	/	4	/	/	/	/	/	/	PM
4	2	/	3	/	3	/	/	2	/	/	JZL
5	9	7	8	8	11	9	9	8	10	10	JZL
6	9	12	10	4	8	11	11	11	12	10	JZL
7											
8											
Total	20	22	21	16	22	20	20	21	22	20	SXH

Days	Concentration: 37.5										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	/	/	2	/	/	/	/	2	/	PM
4	2	3	3	/	/	/	2	/	/	/	JZL
5	5	9	8	8	8	7	9	7	7	10	JZL
6	9	11	10	7	15	12	12	8	13	10	JZL
7											
8											
Total	16	23	21	17	23	19	23	15	22	20	SXH

Days	Concentration: 75										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	/	/	/	/	/	/	/	/	/	RBS
4	3	/	2	2	2	/	2	/	/	3	JZL
5	6	/	6	7	5	4	4	2	4	7	JZL
6	6	7	8	7	5	7	10	4	7	6	JZL
7											
8											
Total	15	7	16	16	12	11	16	6	11	16	SXH

Days	Concentration: 150										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	/	/	/	/	/	/	/	/	/	RBS
4	/	/	/	/	/	/	/	/	X	/	JZL
5	/	/	/	/	/	/	2	/		/	JZL
6	/	/	/	2	2	/	2	/		2	JZL
7											
8											
Total	0	0	0	2	2	0	4	0	0x	2	SXH

Days	Concentration: 300										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	GM
2	/	/	/	/	/	/	/	/	/	/	PM
3	/	/	/	/	X	X	/	/	/	/	RBS
4	/	/	/	/			/	X	/	/	JZL
5	/	/	/	/			/		/	/	JZL
6	/	/	/	/			/		/	/	JZL
7											
8											
Total	0	0	0	0	~~X~~ 0x SXH	0x	0	0x	0	0	SXH

Notes: X = mortality.

Comments: 1. Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

2. Ephippia present in Controls (Y), (N)?

Reviewed by: [signature]

Date reviewed: Feb. 14, 2022

CETIS Analytical Report

Report Date:	04 Feb-22 14:53 (p 1 of 1)
Test Code/ID:	212488b / 10-2994-3377

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	19-8837-7138	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:50	**Analysis:**	Single 2x2 Contingency Table	**Status Level:**	1

Batch ID:	12-1189-6404	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mikayla Oldach		
Start Date:	10 Dec-21 12:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	BJ 3.10		
Ending Date:	16 Dec-21 14:30	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	12-2471-6419	**Code:**	48FFB083	**Project:**	
Sample Date:	07 Dec-21 13:45	**Material:**	Nitrate	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	BJ-3.10 @ NO_3
Sample Age:	70h (4.1 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result
Untransformed	C > T	Lab Water passed 6d survival rate

Fisher Exact Test

Control	vs	Control	Test Stat	P-Type	P-Value	Decision(α:5%)
Dilution Water		Lab Water	1.0000	Exact	1.0000	Non-Significant Effect

Data Summary

Conc-mg/L NO_3-N	Code	NR	R	NR + R	Prop NR	Prop R	%Effect
0.6125	L	10	0	10	1	0	0.0%
8.915	D	10	0	10	1	0	0.0%

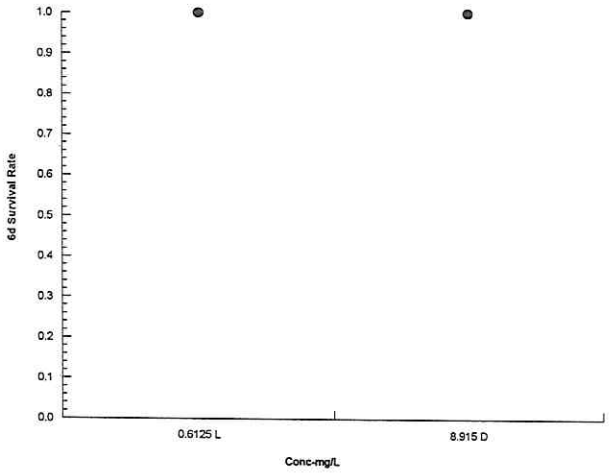
6d Survival Rate Detail

Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.6125	L	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
8.915	D	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

6d Survival Rate Binomials

Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.6125	L	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
8.915	D	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



L = lab water
D = dilution (site) water

Analyst: MDO QA: Feb 14/22

CETIS Analytical Report

Report Date: 04 Feb-22 14:52 (p 1 of 1)
Test Code/ID: 212488b / 10-2994-3377

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	10-6601-2739	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:50	**Analysis:**	Parametric-Two Sample	**Status Level:**	1

Batch ID:	12-1189-6404	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mikayla Oldach		
Start Date:	10 Dec-21 12:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	BJ 3.10		
Ending Date:	16 Dec-21 14:30	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	12-2471-6419	**Code:**	48FFB083	**Project:**	
Sample Date:	07 Dec-21 13:45	**Material:**	Nitrate	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	BJ-3.10 w NO_3
Sample Age:	70h (4.1 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Lab Water passed reproduction	10.67%

Equal Variance t Two-Sample Test

Control	vs	Control II	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Dilution Water		Lab Water	0.5855	1.734	2.369	18	CDF	0.2827	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	3.2	3.2	1	0.3429	0.5655	Non-Significant Effect
Error	168	9.33333	18			
Total	171.2		19			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F Test	1.143	6.541	0.8456	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9454	0.866	0.3026	Normal Distribution

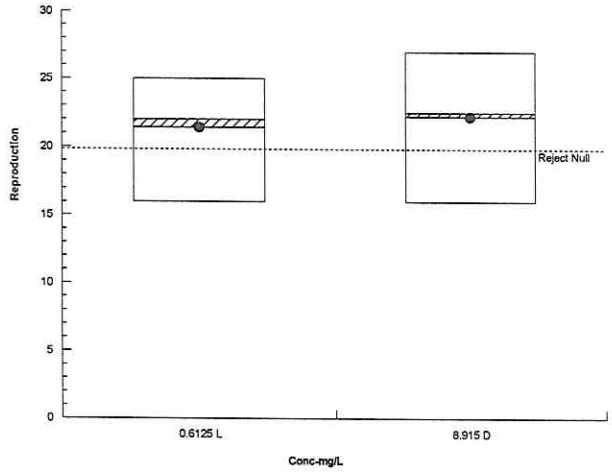
Reproduction Summary

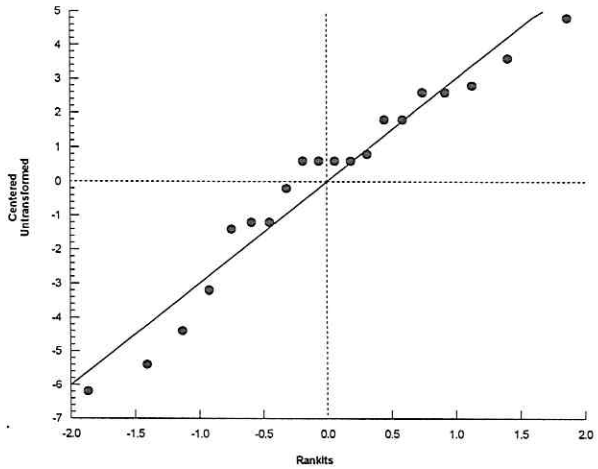
Conc-mg/L NO_3-N	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.6125	L	10	21.4	19.29	23.51	22	16	25	0.9333	13.79%	0.00%
8.915	D	10	22.2	19.94	24.46	22.5	16	27	0.9978	14.21%	-3.74%

Reproduction Detail

Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.6125	L	17	25	22	22	22	20	16	22	24	24
8.915	D	24	23	27	16	22	25	21	21	24	19

Graphics





CETIS Analytical Report

Report Date:	04 Feb-22 14:52 (p 1 of 2)
Test Code/ID:	212488b / 10-2994-3377

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	15-2607-2327	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:52	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

Batch ID:	12-1189-6404	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mikayla Oldach		
Start Date:	10 Dec-21 12:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	BJ 3.10		
Ending Date:	16 Dec-21 14:30	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	12-2471-6419	**Code:**	48FFB083	**Project:**	
Sample Date:	07 Dec-21 13:45	**Material:**	Nitrate	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	70h (4.1 °C)	**Client:**	Pretivm Resources Inc.		$\bar{\omega}NO_3$

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Binomial [ω=n/[p·q]]	Off [μ*=μ]	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
6	-2.449	16.9	11.14	1.0000	Yes				Lack of Fit Not Tested

Point Estimates

Level	mg/L NO_3-N	95% LCL	95% UCL
EC5	143.8	106.1	169.8
EC10	185.8	154.9	211
EC15	217.8	189	243
EC20	245.4	215.8	272.6
EC25	270.9	237.9	302.1
EC40	~~343.6~~ >303	291.9	398.8
EC50	~~394.9~~ >303	~~326.6~~ >303	~~477.5~~ >303

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	1	0.0002353	0.9994	1.001	4251	<1.0E-37	Significant Parameter
γ	2.914	0.3589	1.991	3.837	8.118	4.6E-04	Significant Parameter
δ	394.9	28.45	321.8	468.1	13.88	3.5E-05	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	941300	313800	3	6327000	<1.0E-37	Significant
Residual	0.248	0.04959	5			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Goodness-of-Fit	Pearson Chi-Sq GOF Test	0.2478	11.07	0.9985	Non-Significant Heterogeneity
	Likelihood Ratio GOF Test	0.3574	11.07	0.9964	Non-Significant Heterogeneity
Distribution	Shapiro-Wilk W Normality Test	0.8694	0.6805	0.1488	Normal Distribution
	Anderson-Darling A2 Normality Te	0.6656	2.492	0.0825	Normal Distribution

6d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-mg/L NO_3-N	Code	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
8.915	D	10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.0%	10	10
12.95		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.0%	10	10
17.15		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.0%	10	10
26.2		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.0%	10	10
45.8		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.0%	10	10
80.7		10	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.0%	10	10
164.5		10	0.9000	0.0000	1.0000	0.1000	0.3162	35.14%	10.0%	9	10
303		10	0.7000	0.0000	1.0000	0.1528	0.4830	69.01%	30.0%	7	10

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	15-2607-2327	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:52	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

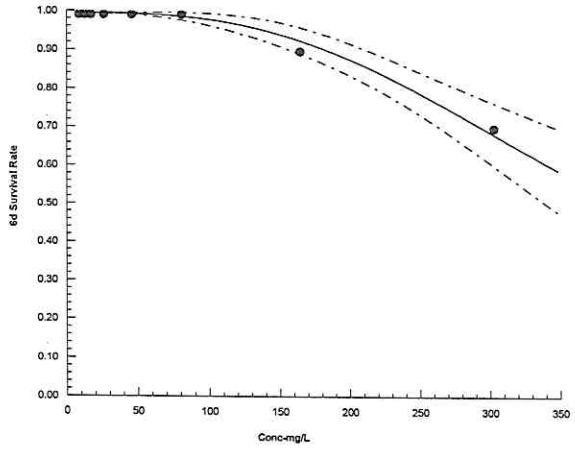
6d Survival Rate Detail

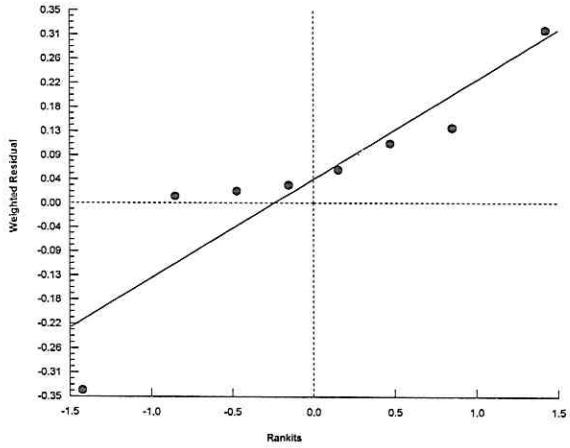
Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
8.915	D	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12.95		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
17.15		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
26.2		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
45.8		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
80.7		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
164.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000
303		1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	1.0000	0.0000	1.0000	1.0000

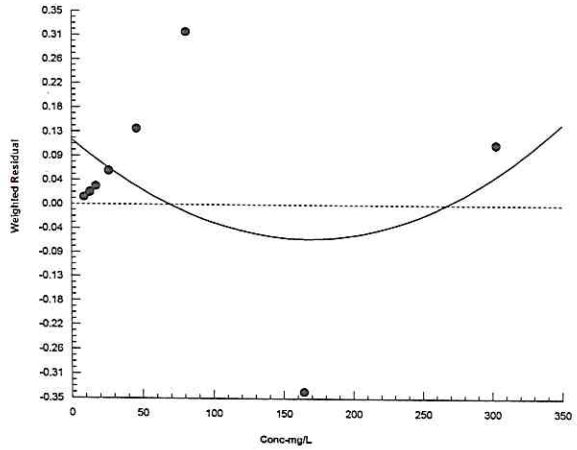
6d Survival Rate Binomials

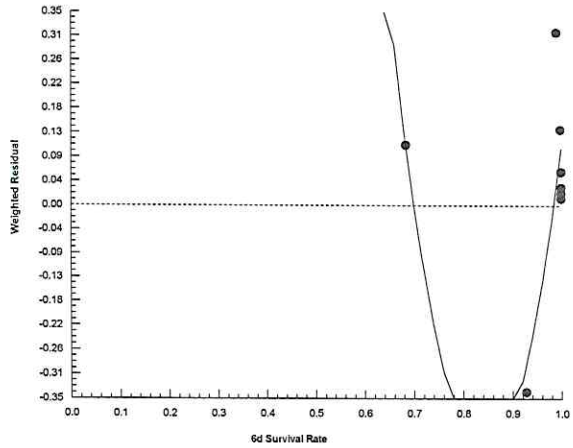
Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
8.915	D	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
12.95		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
17.15		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
26.2		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
45.8		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
80.7		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
164.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	0/1	1/1
303		1/1	1/1	1/1	1/1	0/1	0/1	1/1	0/1	1/1	1/1

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Binomial [ω=n/[p·q]]









CETIS Analytical Report

Report Date:	04 Feb-22 14:53 (p 1 of 2)
Test Code/ID:	212488b / 10-2994-3377

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	06-8768-7576	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:51	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Batch ID:	12-1189-6404	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Mikayla Oldach		
Start Date:	10 Dec-21 12:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	BJ 3.10		
Ending Date:	16 Dec-21 14:30	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	12-2471-6419	**Code:**	48FFB083	**Project:**	
Sample Date:	07 Dec-21 13:45	**Material:**	Nitrate	**Source:**	Pretivm Resources Inc.
Receipt Date:	09 Dec-21 08:59	**CAS (PC):**		**Station:**	BJ-3.10 w NO_3
Sample Age:	70h (4.1 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	346020	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L NO_3-N	95% LCL	95% UCL
IC5	12.6	10.2	47.85
IC10	41.91	11.65	51.64
IC15	49.63	23.56	56.1
IC20	54.1	45.96	61.08
IC25	58.98	50.9	67.79
IC40	76.33	66.79	87.84
IC50	88.51	77.84	98.85

Reproduction Summary

			Calculated Variate						Isotonic Variate	
Conc-mg/L NO_3-N	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	Mean	%Effect
8.915	D	10	22.2	16	27	3.155	14.21%	0.0%	22.2	0.0%
12.95		10	20.9	14	28	4.654	22.27%	5.86%	21	5.41%
17.15		10	21.1	16	25	2.846	13.49%	4.96%	21	5.41%
26.2		10	20.4	16	22	1.776	8.71%	8.11%	20.4	8.11%
45.8		10	19.9	15	23	3.035	15.25%	10.36%	19.9	10.36%
80.7		10	12.6	6	16	3.836	30.44%	43.24%	12.6	43.24%
164.5		10	1	0	4	1.414	141.40%	95.5%	1	95.5%
303		10	0	0	0	0		100.0%	0	100.0%

Reproduction Detail

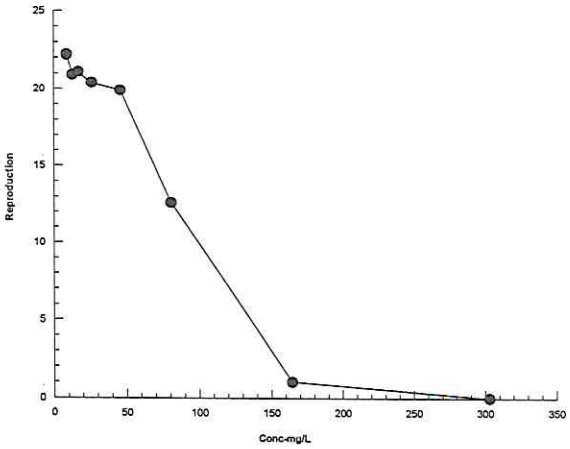
Conc-mg/L NO_3-N	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
8.915	D	24	23	27	16	22	25	21	21	24	19
12.95		28	18	21	14	14	24	24	25	19	22
17.15		16	22	20	25	21	21	22	17	24	23
26.2		20	22	21	16	22	20	20	21	22	20
45.8		16	23	21	17	23	19	23	15	22	20
80.7		15	7	16	16	12	11	16	6	11	16
164.5		0	0	0	2	2	0	4	0	0	2
303		0	0	0	0	0	0	0	0	0	0

D = dilution (site) water

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	06-8768-7576	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.9.4
Analyzed:	04 Feb-22 14:51	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



Client: Lorax / Pretium

W.O.#: 212487-488

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
China Lab Ctrl	Dec 10/21	Dec. ~~10~~ 10/21	10①	1.0	1.2	80	50①	5.2	104	EC
MHW										
Site Ctrl	Dec 10/21	Dec ~~10~~ 10/21	10①	0.7	0.8	60	10①	0.7	70	EC
BJ 3.10										
Cento 20% Perrier	Dec10/21	Dec10/21	100	9.3	9.9	87	50	~~7~~ 5.0	100	EC
Lab control										

Notes: ① Diluted to 100mL with DI water

Reviewed by: [signature] Date Reviewed: Feb. 14, 2022

APPENDIX C – Analytical Chemistry

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21C8572**	Page	: 1 of 10
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Mikayla Oldach	Account Manager	: Emmanuel Mariano
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 21-Dec-2021 16:20
PO	: 2022-0187	Date Analysis Commenced	: 23-Dec-2021
C-O-C number	: ----	Issue Date	: 10-Jan-2022 09:46
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439		
No. of samples received	: 62		
No. of samples analysed	: 62		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Caleb Deroche	Lab Analyst	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
RRV	*Reported result verified by repeat analysis.*

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water Control Day 0 Cerio	Lab Water 4.7 mg/L Day 0 Cerio	Lab Water 9.4 mg/L Day 0 Cerio	Lab Water 18.8 mg/L Day 0 Cerio	Lab Water 37.5 mg/L Day 0 Cerio
				Client sampling date / time	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-001	VA21C8572-002	VA21C8572-003	VA21C8572-004	VA21C8572-005
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.488	5.04	9.70	18.2	36.0

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water 75 mg/L Day 0 Cerio	Lab Water 150 mg/L Day 0 Cerio	Lab Water 300 mg/L Day 0 Cerio	Site Water Control Day 0 Cerio/chiron	Site Water 4.7 mg/L Day 0 Cerio/chiron
				Client sampling date / time	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-006	VA21C8572-007	VA21C8572-008	VA21C8572-009	VA21C8572-010
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	75.8	151	295	8.79	13.0

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 9.4 mg/L Day 0 Cerio/chiron	Site Water 18.8 mg/L Day 0 Cerio/chiron	Site Water 37.5 mg/L Day 0 Cerio/chiron	Site Water 75 mg/L Day 0 Cerio/chiron	Site Water 150 mg/L Day 0 Cerio/chiron
				Client sampling date / time	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-011	VA21C8572-012	VA21C8572-013	VA21C8572-014	VA21C8572-015
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	17.0	24.6	45.4	77.5	168

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 300 mg/L Day 0 Cerio/chiron	Lab Water Control Day 6 Cerio	Lab Water 4.7 mg/L Day 6 Cerio	Lab Water 9.4 mg/L Day 6 Cerio	Lab Water 18.8 mg/L Day 6 Cerio
				Client sampling date / time	10-Dec-2021	16-Dec-2021	16-Dec-2021	16-Dec-2021	16-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-016	VA21C8572-017	VA21C8572-018	VA21C8572-019	VA21C8572-020
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	319	0.737	5.17	9.48	17.5

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water 37.5 mg/L Day 6 Cerio	Lab Water 75 mg/L Day 6 Cerio	Lab Water 150 mg/L Day 6 Cerio	Lab Water 300 mg/L Day 6 Cerio	Site Water Control Day 6 Cerio
				Client sampling date / time	16-Dec-2021	16-Dec-2021	16-Dec-2021	16-Dec-2021	16-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-021	VA21C8572-022	VA21C8572-023	VA21C8572-024	VA21C8572-025
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	34.0	65.8	140	278	9.04

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 4.7 mg/L Day 6 Cerio	Site Water 9.4 mg/L Day 6 Cerio	Site Water 18.8 mg/L Day 6 Cerio	Site Water 37.5 mg/L Day 6 Cerio	Site Water 75 mg/L Day 6 Cerio
				Client sampling date / time	16-Dec-2021	16-Dec-2021	16-Dec-2021	16-Dec-2021	16-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-026	VA21C8572-027	VA21C8572-028	VA21C8572-029	VA21C8572-030
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	12.9	17.3	27.8	46.2	83.9

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 150 mg/L Day 6 Cerio	Site Water 300 mg/L Day 6 Cerio	Lab Water Control Day 0 Chiron	Lab Water 4.7 mg/L Day 0 Chiron	Lab Water 9.4 mg/L Day 0 Chiron
				Client sampling date / time	16-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-032	VA21C8572-033	VA21C8572-034	VA21C8572-035	VA21C8572-036
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	161	287	0.0529	4.62	9.07

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water 18.8 mg/L Day 0 Chiron	Lab Water 37.5 mg/L Day 0 Chiron	Lab Water 75 mg/L Day 0 Chiron	Lab Water 150 mg/L Day 0 Chiron	Lab Water 300 mg/L Day 0 Chiron
				Client sampling date / time	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021	10-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-037	VA21C8572-038	VA21C8572-039	VA21C8572-040	VA21C8572-041
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	17.6	37.4	69.9	143	279

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water Control Day 10 Chiron	Lab Water 4.7 mg/L Day 10 Chiron	Lab Water 9.4 mg/L Day 10 Chiron	Lab Water 18.8 mg/L Day 10 Chiron	Lab Water 37.5 mg/L Day 10 Chiron
				Client sampling date / time	20-Dec-2021	20-Dec-2021	20-Dec-2021	20-Dec-2021	20-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-042	VA21C8572-043	VA21C8572-044	VA21C8572-045	VA21C8572-046
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.112	4.43	8.99	17.4	36.8

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water 75 mg/L Day 10 Chiron	Lab Water 150 mg/L Day 10 Chiron	Lab Water 300 mg/L Day 10 Chiron	Site Water Control Day 10 Chiron	Site Water 4.7 mg/L Day 10 Chiron
				Client sampling date / time	20-Dec-2021	20-Dec-2021	20-Dec-2021	20-Dec-2021	20-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-047	VA21C8572-048	VA21C8572-049	VA21C8572-050	VA21C8572-051
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	70.4	147	281	8.98	14.6 RRV

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 9.4 mg/L Day 10 Chiron	Site Water 18.8 mg/L Day 10 Chiron	Site Water 37.5 mg/L Day 10 Chiron	Site Water 75 mg/L Day 10 Chiron	Site Water 150 mg/L Day 10 Chiron
				Client sampling date / time	20-Dec-2021	20-Dec-2021	20-Dec-2021	20-Dec-2021	20-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-052	VA21C8572-053	VA21C8572-054	VA21C8572-055	VA21C8572-056
					Result	Result	Result	Result	Result
Anions and Nutrients									
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	19.3 RRV	29.5 RRV	46.3	79.8	158

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 300 mg/L Day 10 Chiron	21NO3-N01 Stock 25 mg/L NO3-N	Lab Ctrl Day 0 OAM	Site Ctrl Day 0 OAM	Lab Ctrl Day 10 OAM
				Client sampling date / time	20-Dec-2021	07-Dec-2021	10-Dec-2021	10-Dec-2021	20-Dec-2021
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-057	VA21C8572-058	VA21C8572-059	VA21C8572-060	VA21C8572-061
					Result	Result	Result	Result	Result
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	----	----	0.0257	0.170	1.83
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	287	24800	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Ctrl Day 10 OAM	Site Water Day 0	----	----	----
				Client sampling date / time	20-Dec-2021	10-Dec-2021	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-062	VA21C8572-063	--------	--------	--------
					Result	Result	----	----	----
Physical Tests									
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	----	54.7	----	----	----
conductivity	----	E100	2.0	µS/cm	----	318	----	----	----
pH	----	E108	0.10	pH units	----	7.80	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	----	176	----	----	----
solids, total suspended [TSS]	----	E160-H	3.0	mg/L	----	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	----	4.80	----	----	----
hardness (as CaCO3), dissolved	----	EC100	0.60	mg/L	----	64.8	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	1.88	0.184 RRV	----	----	----
bromide	24959-67-9	E235.Br-L	0.050	mg/L	----	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	----	2.65	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	----	0.168	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	----	8.99	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	----	0.0470	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	----	8.92	----	----	----
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	----	<0.0010	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	----	0.0034	----	----	----
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	----	61.8	----	----	----
Organic / Inorganic Carbon									
carbon, dissolved organic [DOC]	----	E358-L	0.50	mg/L	----	0.71	----	----	----
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	----	0.52	----	----	----
Total Metals									
aluminum, total	7429-90-5	E468	0.0030	mg/L	----	0.112	----	----	----
antimony, total	7440-36-0	E468	0.000030	mg/L	----	0.00915	----	----	----
arsenic, total	7440-38-2	E468	0.000050	mg/L	----	0.00660	----	----	----
barium, total	7440-39-3	E468	0.00010	mg/L	----	0.0461	----	----	----
beryllium, total	7440-41-7	E468	0.0000050	mg/L	----	0.0000064	----	----	----
bismuth, total	7440-69-9	E468	0.000050	mg/L	----	<0.000050	----	----	----
boron, total	7440-42-8	E468	0.010	mg/L	----	0.100	----	----	----
cadmium, total	7440-43-9	E468	0.0000050	mg/L	----	0.0000140	----	----	----
calcium, total	7440-70-2	E468	0.020	mg/L	----	24.2	----	----	----
cesium, total	7440-46-2	E468	0.0000050	mg/L	----	0.00143	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Ctrl Day 10 OAM	Site Water Day 0	----	----	----
				Client sampling date / time	20-Dec-2021	10-Dec-2021	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-062	VA21C8572-063	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
chromium, total	7440-47-3	E468	0.00050	mg/L	----	<0.00050	----	----	----
cobalt, total	7440-48-4	E468	0.000050	mg/L	----	0.000079	----	----	----
copper, total	7440-50-8	E468	0.00050	mg/L	----	<0.00050	----	----	----
gallium, total	7440-55-3	E468	0.000050	mg/L	----	0.000102	----	----	----
iron, total	7439-89-6	E468	0.010	mg/L	----	0.044	----	----	----
lanthanum, total	7439-91-0	E468	0.000050	mg/L	----	<0.000050	----	----	----
lead, total	7439-92-1	E468	0.000050	mg/L	----	0.000577	----	----	----
lithium, total	7439-93-2	E468	0.00050	mg/L	----	0.0593	----	----	----
magnesium, total	7439-95-4	E468	0.010	mg/L	----	1.49	----	----	----
manganese, total	7439-96-5	E468	0.00020	mg/L	----	0.0494	----	----	----
mercury, total	7439-97-6	E508	0.0000050	mg/L	----	<0.0000050	----	----	----
molybdenum, total	7439-98-7	E468	0.000050	mg/L	----	0.00696	----	----	----
nickel, total	7440-02-0	E468	0.00020	mg/L	----	0.00052	----	----	----
niobium, total	7440-03-1	E468	0.00010	mg/L	----	<0.00010	----	----	----
phosphorus, total	7723-14-0	E468	0.050	mg/L	----	<0.050	----	----	----
potassium, total	7440-09-7	E468	0.030	mg/L	----	10.8	----	----	----
rhenium, total	7440-15-5	E468	0.0000050	mg/L	----	0.0000076	----	----	----
rubidium, total	7440-17-7	E468	0.000020	mg/L	----	0.0129	----	----	----
selenium, total	7782-49-2	E468	0.00020	mg/L	----	0.00096	----	----	----
silicon, total	7440-21-3	E468	0.10	mg/L	----	1.55	----	----	----
silver, total	7440-22-4	E468	0.0000050	mg/L	----	0.0000117	----	----	----
sodium, total	7440-23-5	E468	0.020	mg/L	----	28.8	----	----	----
strontium, total	7440-24-6	E468	0.00020	mg/L	----	0.502	----	----	----
sulfur, total	7704-34-9	E468	0.50	mg/L	----	18.0	----	----	----
tantalum, total	7440-25-7	E468	0.00010	mg/L	----	<0.00010	----	----	----
tellurium, total	13494-80-9	E468	0.000050	mg/L	----	<0.000050	----	----	----
thallium, total	7440-28-0	E468	0.0000050	mg/L	----	0.0000517	----	----	----
thorium, total	7440-29-1	E468	0.0000050	mg/L	----	0.0000072	----	----	----
tin, total	7440-31-5	E468	0.00020	mg/L	----	<0.00020	----	----	----
titanium, total	7440-32-6	E468	0.00020	mg/L	----	0.00071	----	----	----
tungsten, total	7440-33-7	E468	0.000010	mg/L	----	0.00129	----	----	----
uranium, total	7440-61-1	E468	0.0000020	mg/L	----	0.000452	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Ctrl Day 10 OAM	Site Water Day 0	----	----	----
				Client sampling date / time	20-Dec-2021	10-Dec-2021	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-062	VA21C8572-063	--------	--------	--------
					Result	Result	----	----	----
Total Metals									
vanadium, total	7440-62-2	E468	0.00020	mg/L	----	0.00033	----	----	----
yttrium, total	7440-65-5	E468	0.0000050	mg/L	----	0.0000411	----	----	----
zinc, total	7440-66-6	E468	0.0030	mg/L	----	<0.0030	----	----	----
zirconium, total	7440-67-7	E468	0.000050	mg/L	----	<0.000050	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E469	0.0010	mg/L	----	0.0195	----	----	----
antimony, dissolved	7440-36-0	E469	0.000030	mg/L	----	0.00908	----	----	----
arsenic, dissolved	7440-38-2	E469	0.000050	mg/L	----	0.00600	----	----	----
barium, dissolved	7440-39-3	E469	0.00010	mg/L	----	0.0428	----	----	----
beryllium, dissolved	7440-41-7	E469	0.0000050	mg/L	----	<0.0000050	----	----	----
bismuth, dissolved	7440-69-9	E469	0.000050	mg/L	----	<0.000050	----	----	----
boron, dissolved	7440-42-8	E469	0.0050	mg/L	----	0.0933	----	----	----
cadmium, dissolved	7440-43-9	E469	0.0000050	mg/L	----	0.0000127	----	----	----
calcium, dissolved	7440-70-2	E469	0.020	mg/L	----	23.6	----	----	----
cesium, dissolved	7440-46-2	E469	0.0000050	mg/L	----	0.00136	----	----	----
chromium, dissolved	7440-47-3	E469	0.00050	mg/L	----	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E469	0.000050	mg/L	----	0.000060	----	----	----
copper, dissolved	7440-50-8	E469	0.00020	mg/L	----	<0.00020	----	----	----
gallium, dissolved	7440-55-3	E469	0.000050	mg/L	----	0.000099	----	----	----
iron, dissolved	7439-89-6	E469	0.010	mg/L	----	<0.010	----	----	----
lanthanum, dissolved	7439-91-0	E469	0.000050	mg/L	----	<0.000050	----	----	----
lead, dissolved	7439-92-1	E469	0.000050	mg/L	----	0.000092	----	----	----
lithium, dissolved	7439-93-2	E469	0.00050	mg/L	----	0.0561	----	----	----
magnesium, dissolved	7439-95-4	E469	0.010	mg/L	----	1.43	----	----	----
manganese, dissolved	7439-96-5	E469	0.00020	mg/L	----	0.0451	----	----	----
mercury, dissolved	7439-97-6	E509	0.0000050	mg/L	----	<0.0000050	----	----	----
molybdenum, dissolved	7439-98-7	E469	0.000050	mg/L	----	0.00682	----	----	----
nickel, dissolved	7440-02-0	E469	0.00020	mg/L	----	0.00028	----	----	----
niobium, dissolved	7440-03-1	E469	0.00010	mg/L	----	<0.00010	----	----	----
phosphorus, dissolved	7723-14-0	E469	0.050	mg/L	----	<0.050	----	----	----
potassium, dissolved	7440-09-7	E469	0.030	mg/L	----	10.6	----	----	----
rhenium, dissolved	7440-15-5	E469	0.0000050	mg/L	----	0.0000078	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Ctrl Day 10 OAM	Site Water Day 0	----	----	----
				Client sampling date / time	20-Dec-2021	10-Dec-2021	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21C8572-062	VA21C8572-063	--------	--------	--------
					Result	Result	----	----	----
Dissolved Metals									
rubidium, dissolved	7440-17-7	E469	0.000020	mg/L	----	0.0124	----	----	----
selenium, dissolved	7782-49-2	E469	0.00020	mg/L	----	0.00091	----	----	----
silicon, dissolved	7440-21-3	E469	0.050	mg/L	----	1.42	----	----	----
silver, dissolved	7440-22-4	E469	0.0000050	mg/L	----	<0.0000050	----	----	----
sodium, dissolved	7440-23-5	E469	0.020	mg/L	----	28.0	----	----	----
strontium, dissolved	7440-24-6	E469	0.00010	mg/L	----	0.489	----	----	----
sulfur, dissolved	7704-34-9	E469	0.50	mg/L	----	18.4	----	----	----
tantalum, dissolved	7440-25-7	E469	0.00010	mg/L	----	<0.00010	----	----	----
tellurium, dissolved	13494-80-9	E469	0.000050	mg/L	----	<0.000050	----	----	----
thallium, dissolved	7440-28-0	E469	0.0000050	mg/L	----	0.0000480	----	----	----
thorium, dissolved	7440-29-1	E469	0.0000050	mg/L	----	<0.0000050	----	----	----
tin, dissolved	7440-31-5	E469	0.00020	mg/L	----	<0.00020	----	----	----
titanium, dissolved	7440-32-6	E469	0.00020	mg/L	----	<0.00020	----	----	----
tungsten, dissolved	7440-33-7	E469	0.000010	mg/L	----	0.00126	----	----	----
uranium, dissolved	7440-61-1	E469	0.0000020	mg/L	----	0.000440	----	----	----
vanadium, dissolved	7440-62-2	E469	0.000050	mg/L	----	0.000143	----	----	----
yttrium, dissolved	7440-65-5	E469	0.0000050	mg/L	----	0.0000163	----	----	----
zinc, dissolved	7440-66-6	E469	0.0010	mg/L	----	<0.0010	----	----	----
zirconium, dissolved	7440-67-7	E469	0.000050	mg/L	----	<0.000050	----	----	----
dissolved mercury filtration location	----	EP509	-	-	----	Field	----	----	----
dissolved metals filtration location	----	EP421	-	-	----	Field	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA21C8572**	Page	: 1 of 19
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Mikayla Oldach	Account Manager	: Emmanuel Mariano
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 21-Dec-2021 16:20
PO	: 2022-0187	Issue Date	: 10-Jan-2022 09:46
C-O-C number	: ----		
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439		
No. of samples received	: 62		
No. of samples analysed	: 62		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Anions and Nutrients	QC-377104-001	----	nitrate (as N)	14797-55-8	E235.NO3-L	0.0052 mg/L B	0.005 mg/L	Blank result exceeds permitted value
Anions and Nutrients	QC-377286-001	----	nitrate (as N)	14797-55-8	E235.NO3-L	0.0144 mg/L B	0.005 mg/L	Blank result exceeds permitted value
Total Metals	QC-378469-001	----	arsenic, total	7440-38-2	E468	0.000058 mg/L B	0.00005 mg/L	Blank result exceeds permitted value
Total Metals	QC-378469-001	----	zinc, total	7440-66-6	E468	0.0194 mg/L B	0.003 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	*Description*
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Laboratory Control Sample (LCS) Recoveries								
Dissolved Metals	QC-378611-002	----	sulfur, dissolved	7704-34-9	E469	79.4 % MES	80.0-120%	Recovery less than lower control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Lab Ctrl Day 10 OAM	E298	20-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Site Ctrl Day 10 OAM	E298	20-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Lab Ctrl Day 0 OAM	E298	10-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	22 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Site Ctrl Day 0 OAM	E298	10-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	22 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Site Water Day 0	E298	10-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	22 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Site Water Day 0	E235.Br-L	10-Dec-2021	----	----	----		29-Dec-2021	28 days	20 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Site Water Day 0	E235.Cl	10-Dec-2021	----	----	----		29-Dec-2021	28 days	20 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Site Water Day 0	E378-U	10-Dec-2021	----	----	----		29-Dec-2021	3 days	20 days	× EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Site Water Day 0	E235.F	10-Dec-2021	----	----	----		29-Dec-2021	28 days	20 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 150 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 18.8 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 300 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 37.5 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 4.7 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 75 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 9.4 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water Control Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 150 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 18.8 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 37.5 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 4.7 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 75 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 9.4 mg/L Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water Control Day 6 Cerio	E235.NO3-L	16-Dec-2021	----	----	----		28-Dec-2021	3 days	13 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 150 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 150 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 18.8 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 18.8 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 300 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 300 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 37.5 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 4.7 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 4.7 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 75 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 75 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 9.4 mg/L Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 9.4 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water Control Day 0 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water Control Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 150 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 18.8 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 300 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 300 mg/L Day 6 Cerio	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 37.5 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 4.7 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 75 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 9.4 mg/L Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water Control Day 0 Cerio/chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water Day 0	E235.NO3-L	10-Dec-2021	----	----	----		29-Dec-2021	3 days	20 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 37.5 mg/L Day 0 Chiron	E235.NO3-L	10-Dec-2021	----	----	----		28-Dec-2021	3 days	21 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
21NO3-N01 - Stock 25 mg/L NO3-N	E235.NO3-L	07-Dec-2021	----	----	----		28-Dec-2021	3 days	22 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 150 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 18.8 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 300 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 37.5 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 4.7 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 75 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 9.4 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water Control Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 150 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 18.8 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 300 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 37.5 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 4.7 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 75 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 9.4 mg/L Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water Control Day 10 Chiron	E235.NO3-L	20-Dec-2021	----	----	----		28-Dec-2021	3 days	9 days	× EHT
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Site Water Day 0	E235.NO2-L	10-Dec-2021	----	----	----		29-Dec-2021	3 days	20 days	× EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Site Water Day 0	E235.SO4	10-Dec-2021	----	----	----		29-Dec-2021	28 days	20 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Site Water Day 0	E366	10-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	22 days	✓

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Site Water Day 0	E372-U	10-Dec-2021	30-Dec-2021	----	----		31-Dec-2021	28 days	22 days	✓
Dissolved Metals : Dissolved Mercury in Water by CVAAS										
Glass vial dissolved (hydrochloric acid)										
Site Water Day 0	E509	10-Dec-2021	07-Jan-2022	----	----		07-Jan-2022	28 days	29 days	✗ EHT
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS (Trace Level)										
HDPE dissolved (nitric acid)										
Site Water Day 0	E469	10-Dec-2021	30-Dec-2021	----	----		04-Jan-2022	180 days	26 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Site Water Day 0	E358-L	10-Dec-2021	30-Dec-2021	----	----		30-Dec-2021	28 days	21 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
Site Water Day 0	E355-L	10-Dec-2021	30-Dec-2021	----	----		30-Dec-2021	28 days	21 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Site Water Day 0	E290	10-Dec-2021	----	----	----		29-Dec-2021	14 days	19 days	✗ EHT
Physical Tests : Conductivity in Water										
HDPE										
Site Water Day 0	E100	10-Dec-2021	----	----	----		29-Dec-2021	28 days	19 days	✓
Physical Tests : pH by Meter										
HDPE										
Site Water Day 0	E108	10-Dec-2021	----	----	----		29-Dec-2021	0.25 hrs	466 hrs	✗ EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE										
Site Water Day 0	E162	10-Dec-2021	----	----	----		23-Dec-2021	7 days	14 days	✗ EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TSS by Gravimetry										
HDPE										
Site Water Day 0	E160-H	10-Dec-2021	----	----	----		23-Dec-2021	7 days	14 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
Site Water Day 0	E121	10-Dec-2021	----	----	----		24-Dec-2021	3 days	15 days	× EHTR
Total Metals : Total Mercury in Water by CVAAS										
Glass vial total (hydrochloric acid)										
Site Water Day 0	E508	10-Dec-2021	----	----	----		07-Jan-2022	28 days	29 days	✓
Total Metals : Total Metals in Water by CRC ICPMS (Trace Level)										
HDPE total (nitric acid)										
Site Water Day 0	E468	10-Dec-2021	----	----	----		04-Jan-2022	180 days	26 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

EHT: Exceeded ALS recommended hold time prior to analysis.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	377708	0	1	0.0	5.0	✗
Ammonia by Fluorescence	E298	378801	1	5	20.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	377935	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	377934	1	10	10.0	5.0	✓
Conductivity in Water	E100	377709	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	382793	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS (Trace Level)	E469	378611	1	2	50.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	378802	1	1	100.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	377945	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	377933	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	377073	4	62	6.4	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	377937	1	5	20.0	5.0	✓
pH by Meter	E108	377707	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	377938	1	8	12.5	5.0	✓
TDS by Gravimetry	E162	376095	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	382696	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS (Trace Level)	E468	378469	1	2	50.0	5.0	✓
Total Nitrogen by Colourimetry	E366	378800	1	2	50.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	378804	1	1	100.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	378803	1	1	100.0	5.0	✓
TSS by Gravimetry	E160-H	376105	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	376595	1	17	5.8	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	377708	1	1	100.0	5.0	✓
Ammonia by Fluorescence	E298	378801	1	5	20.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	377935	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	377934	1	10	10.0	5.0	✓
Conductivity in Water	E100	377709	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	382793	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS (Trace Level)	E469	378611	1	2	50.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	378802	1	1	100.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	377945	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	377933	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	377073	4	62	6.4	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	377937	1	5	20.0	5.0	✓
pH by Meter	E108	377707	1	18	5.5	5.0	✓
Sulfate in Water by IC	E235.SO4	377938	1	8	12.5	5.0	✓

Matrix: **Water**

Evaluation: ✗ = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
TDS by Gravimetry	E162	376095	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	382696	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS (Trace Level)	E468	378469	1	2	50.0	5.0	✓
Total Nitrogen by Colourimetry	E366	378800	1	2	50.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	378804	1	1	100.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	378803	1	1	100.0	5.0	✓
TSS by Gravimetry	E160-H	376105	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	376595	1	17	5.8	5.0	✓
Method Blanks (MB)							
Alkalinity Species by Titration	E290	377708	1	1	100.0	5.0	✓
Ammonia by Fluorescence	E298	378801	1	5	20.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	377935	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	377934	1	10	10.0	5.0	✓
Conductivity in Water	E100	377709	1	4	25.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	382793	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS (Trace Level)	E469	378611	1	2	50.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	378802	1	1	100.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	377945	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	377933	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	377073	4	62	6.4	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	377937	1	5	20.0	5.0	✓
Sulfate in Water by IC	E235.SO4	377938	1	8	12.5	5.0	✓
TDS by Gravimetry	E162	376095	1	20	5.0	5.0	✓
Total Mercury in Water by CVAAS	E508	382696	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS (Trace Level)	E468	378469	1	2	50.0	5.0	✓
Total Nitrogen by Colourimetry	E366	378800	1	2	50.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	378804	1	1	100.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	378803	1	1	100.0	5.0	✓
TSS by Gravimetry	E160-H	376105	1	17	5.8	5.0	✓
Turbidity by Nephelometry	E121	376595	1	17	5.8	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	378801	1	5	20.0	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	377935	1	8	12.5	5.0	✓
Chloride in Water by IC	E235.Cl	377934	1	10	10.0	5.0	✓
Dissolved Mercury in Water by CVAAS	E509	382793	1	20	5.0	5.0	✓
Dissolved Metals in Water by CRC ICPMS (Trace Level)	E469	378611	1	2	50.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	378802	0	1	0.0	5.0	✗
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	377945	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	377933	1	9	11.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	377073	4	62	6.4	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Matrix Spikes (MS) - Continued							
Nitrite in Water by IC (Low Level)	E235.NO2-L	377937	1	5	20.0	5.0	✓
Sulfate in Water by IC	E235.SO4	377938	1	8	12.5	5.0	✓
Total Mercury in Water by CVAAS	E508	382696	1	20	5.0	5.0	✓
Total Metals in Water by CRC ICPMS (Trace Level)	E468	378469	1	2	50.0	5.0	✓
Total Nitrogen by Colourimetry	E366	378800	1	2	50.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	378804	0	1	0.0	5.0	×
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	378803	0	1	0.0	5.0	×

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160-H Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Dissolved Organic Carbon by Combustion (Low Level)	E358-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Dissolved Organic Carbon (Non-Purgeable), also known as NPOC (dissolved), is a direct measurement of DOC after a filtered (0.45 micron) sample has been acidified and purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of DC (dissolved carbon) is comprised of IC (which is common), this method is more accurate and more reliable than the DOC by subtraction method (i.e. DC minus DIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Metals in Water by CRC ICPMS (Trace Level)	E468 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS (Trace Level)	E469 Vancouver - Environmental	Water	APHA 3030B/6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collisiion/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Total Mercury in Water by CVAAS	E508 Vancouver - Environmental	Water	EPA 1631E (mod)	Water samples undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS
Dissolved Mercury in Water by CVAAS	E509 Vancouver - Environmental	Water	APHA 3030B/EPA 1631E (mod)	Water samples are filtered (0.45 um), preserved with HCl, then undergo a cold-oxidation using bromine monochloride prior to reduction with stannous chloride, and analyzed by CVAAS.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion
Preparation for Dissolved Organic Carbon for Combustion	EP358 Vancouver - Environmental	Water	APHA 5310 B (mod)	Preparation for Dissolved Organic Carbon
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Mercury Water Filtration	EP509 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HCl.

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
T2Z 3V9
Phone 403.253.7121

Point Edward ( )
704 Mara Street, Suite 122
Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Dec 20/21 Page 1 of 7

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0187

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

Environmental Division
Vancouver
Work Order Reference
VA21C8572
Telephone : +1 604 253 4188

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total nitrate (NO3-N)	Receipt Temperature (°C)
1	Lab Water Control Day 0 Cerio	10/12/21			1x125 mL		✓	7.8
2	Lab Water 4.7 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
3	Lab Water 9.4 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
4	Lab Water 18.8 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
5	Lab Water 37.5 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
6	Lab Water 75 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
7	Lab Water 150 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
8	Lab Water 300 mg/L Day 0 Cerio	10/12/21			1x125 mL		✓	
9	Site Water Control Day 0 Cerio/chiron	10/12/21			1x125 mL		✓	
10	Site Water 4.7 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

samples are not preserved

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)
Nautilus Env. (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

RJ (Printed Name) | Dec-21 | 16:20 (Signature)
(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
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Phone 403.253.7121

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Point Edward, Ontario, Canada
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Phone 519.339.8787

Chain of Custody

Date Dec 20/21 Page 2 of 7

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0187

Sample Collection By:

Sample Type: Grab ( ) OR Composite (●)

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total nitrate (NO3-N)											Receipt Temperature (°C)
11	Site Water 9.4 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓											
12	Site Water 18.8 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓											
13	Site Water 37.5 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓											
14	Site Water 75 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓											
15	Site Water 150 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓											
16	Site Water 300 mg/L Day 0 Cerio/chiron	10/12/21			1x125 mL		✓											
17	Lab Water ~~Lab~~ Control Day 6 Cerio	16/12/21			1x125 mL		✓											
18	Lab Water 4.7 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
19	Lab Water 9.4 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
20	Lab Water 18.8 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

samples are not preserved

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Phone 604.420.8773

Calgary ( )
10823 27 Street SE
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Chain of Custody

Date Dec 20/21 Page 3 of 7

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0187

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total nitrate (NO3-N)											Receipt Temperature (°C)
21	Lab Water 37.5 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
22	Lab Water 75 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
23	Lab Water 150 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
24	Lab Water 300 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
25	Site Water Control Day 6 Cerio	16/12/21			1x125 mL		✓											
26	Site Water 4.7 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
27	Site Water 9.4 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
28	Site Water 18.8 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
29	Site Water 37.5 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
30 20	Site Water 75 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

samples are not preserved

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Chain of Custody

Date Dec 20/21 Page 4 of 7

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0187

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total nitrate (NO3-N)											Receipt Temperature (°C)
31	Site Water 75 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
32	Site Water 150 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
33	Site Water 300 mg/L Day 6 Cerio	16/12/21			1x125 mL		✓											
34	Lab Water ~~Lab~~ Control Day 0 Chiron	10/12/21			1x125 mL		✓											
35	Lab Water 4.7 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓											
36	Lab Water 9.4 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓											
37	Lab Water 18.8 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓											
38	Lab Water 37.5 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓											
39	Lab Water 75 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓											
40	Lab Water 150 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓											

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

samples are not preserved

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

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Phone 519.339.8787

Chain of Custody

Date Dec 20/21 Page 5 of 7

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0187

Sample Collection By: **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total nitrate (NO3-N)	Receipt Temperature (°C)
41	Lab Water 300 mg/L Day 0 Chiron	10/12/21			1x125 mL		✓	
42	Lab Water ~~Lab~~ Control Day 10 Chiron	20/12/21			1x125 mL		✓	
43	Lab Water 4.7 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
44	Lab Water 9.4 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
45	Lab Water 18.8 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
46	Lab Water 37.5 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
47	Lab Water 75 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
48	Lab Water 150 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
49	Lab Water 300 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓	
50 ~~10~~	Site Water ~~Lab~~ Control Day 10 Chiron	20/12/21			1x125 mL		✓	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

samples are not preserved

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Dec 20/21 Page 6 of 7

Report to:		**Invoice To:**	
Company	Nautilus Environmental Company Inc	**Company**	(same as previous)
Address	8664 Commerce Court	**Address**	
City/Prov/PC	Burnaby, BC, V5A 4N7	**City/Prov/PC**	
Contact	Mikayla Oldach	**Contact**	Nair Yamamoto
Phone	604-420-8773	**Phone**	604-420-8773
Email	mikayla@nautilusenvironmental.ca	**Email**	nair@nautilusenvironmental.ca
		PO No.	2022-0187

Sample Collection By: **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total nitrate (NO3-N)	Overlying ammonia										Receipt Temperature (°C)
51	Site Water 4.7 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
52	Site Water 9.4 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
53	Site Water 18.8 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
54	Site Water 37.5 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
55	Site Water 75 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
56	Site Water 150 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
57	Site Water 300 mg/L Day 10 Chiron	20/12/21			1x125 mL		✓											
58	21NO3-N01	7/12/21			1x125 mL	stock 25 mg/L NO_3-N	✓											
59	Lab Ctrl Day 0 OAM	10/12/21			1x125 mL			✓										
60	Site Ctrl Day 0 OAM	10/12/21			1x125 mL			✓										

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-samples for N analysis are not preserved
-samples for overlying ammonia analysis are preserved with sulfuric acid

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
T2Z 3V9
Phone 403.253.7121

Point Edward ( )
704 Mara Street, Suite 122
Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Dec 20/21 Page 7 of 7

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0187

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Overlying ammonia	Physical parameters	Major anions	Nutrients (DOC, TOC)	Total metals + mercury package	Dissolved metals + mercury package	(see "full suite" list attached)					Receipt Temperature (°C)
6 1	Lab Ctrl Day 10 OAM	20/12/21			1x125 mL		✓											
6 2	Site Ctrl Day 10 OAM	20/12/21			1x125 mL		✓											
6 3	Site Water Day 0	10/12/21			1 x 500 mL			✓	✓									
6 4	Site Water Day 0	10/12/21			2 x 100 mL amber glass	total and dissolved nutrients; preserved				✓								
6 5	Site Water Day 0	10/12/21			1 x 60 mL hdpe, 1 x 40mL glass	preserved with nitric acid and HCl, respectively					✓							
6 6	Site Water Day 0	10/12/21			1 x 60 mL hdpe, 1 x 40mL glass	preserved with nitric acid and HCl, respectively						✓						
7																		
8																		
9																		
10																		

Same sample.

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-samples for overlying ammonia analysis are preserved with sulfuric acid
-please see attached for further details on analyses for physical parameters, major anions, nutrients, total and dissolved metals + mercury package

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

VA21C8572

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus (Company) 20/12/21 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

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Form 020; Revised by TP 2021/11/17

"Full suite" parameter list

VA21C8572

Parameter	Detection Limit
Physical Parameters	
pH	0.01
Specific Conductivity	2 µS/cm
Hardness as $CaCO_3$ (Dissolved)	1 mg/L
Total Dissolved Solids	10 mg/L
Total Suspended Solids	2 mg/L
Turbidity	0.1 NTU
Major Anions	
Alkalinity – Total	1 mg/L
Chloride	0.5 mg/L
Fluoride	0.02 mg/L
Bromide	0.05 mg/L
Sulphate	0.5 mg/L
Nutrients	
Nitrate Nitrogen	0.005 mg/L
Nitrite Nitrogen	0.005 mg/L
Nitrogen – Total	0.05 mg/L
Ammonia Nitrogen	0.02 mg/L
Ortho phosphorus - dissolved	0.005 mg/L
Phosphorous – Total	0.005 mg/L
Dissolved Organic Carbon	0.5 mg/L
Total and Dissolved Metals	
Aluminum	0.001 mg/L
Antimony	0.0001 mg/L
Arsenic	0.0002 mg/L
Barium	0.0001 mg/L
Beryllium	0.0001 mg/L
Bismuth	0.0005 mg/L
Boron	0.01 mg/L
Cadmium	0.0001 mg/L
Calcium	0.05 mg/L
Chromium	0.0005 mg/L
Cobalt	0.0001 mg/L
Copper	0.0002 mg/L
Iron	0.01 mg/L
Lead	0.0001 mg/L
Lithium	0.001 mg/L
Magnesium	0.1 mg/L
Manganese	0.0002 mg/L
Mercury	0.00001 mg/L
Molybdenum	0.0001 mg/L
Nickel	0.0005 mg/L
Potassium	0.1 mg/L
Selenium	0.0003 mg/L
Silicon	0.05 mg/L
Silver	0.00001 mg/L
Sodium	0.1 mg/L
Strontium	0.0002 mg/L
Thallium	0.00001 mg/L
Tin	0.0002 mg/L
Titanium	0.01 mg/L
Uranium	0.00001 mg/L
Vanadium	0.001 mg/L
Zinc	0.001 mg/L

APPENDIX D – Chain-of-Custody Form

Nautilus Environmental

Chain of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

Sample Collection By:	NG/NG	
	Report to: Robin McCall	**Invoice to:**
Company	Pretivm Resources Inc.	Same
Address	Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.	
City/Prov/Postal Code	Vancouver, BC V7X 1L4 Box 49334	
Contact	Robin McCall	
Phone	(604) 558-1784	
Email	RMcCall@pretivm.com Environmental@pretivm.com	invoices@pretivm.com

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	# OF CONTAINERS	COMMENTS	ANALYSES REQUIRED: Ceriodaphnia 3-brood test (100% only) (Chronic -	Daphnia Magna 48 hrs (100% only) (Acute -EPS1/RM/14)	Chironomus dilutus (water only) (test method	Ceriodaphnia 3-brood test (with dilutions) (Chronic - EPS1/RM/21)	Daphnia Magna 48 hrs (with dilutions) (Acute -EPS1/RM/14)	*Chironomus* survival and growth in water spiked with	*Ceriodaphnia* survival and reproduction in water spiked with Nitrate	Chironomus survival and growth in water spiked with Copper	*Ceriodaphnia* survival and reproduction in water spiked with Copper	*Lemna minor* growth in water spiked with Copper	*Pseudokirchneriella subcapitata* growth in water spiked with Copper		Receipt Temperature (°C)
1	BJ-3.10	7-Dec-21	13:45	Water	20L	4	Grab						X	X					4.1	-8.6
2	BJ-3.10	7-Dec-21	13:45	Water	20L	1	Grab								X	X	X	X		↓
3																				
4																				
5													87	88	89	90	91	92		
6													87	88	89	90	91	92		
7													124	124	124	124	124	124		
8													12	12	12	12	12	12		
9													1	1	1	1	1	1		
10													2	2	2	2	2	2		

PROJECT INFORMATION	SAMPLE RECEIPT		RELIQUINSHED BY (CLIENT)	RELIQUINSHED BY (COURIER)
Client:	**Total # Containers:**	5	**Signature:**	**Signature:**
P.O. No.: 1024767	**Good Condition?**	Y	**Print: Nathan Glas**	**Print:**
Shipped Via:	**Matches Schedule?**	Y	**Company: Pretivm**	**Company:**
			Time/Date: December 7, 2021, 18:00	**Time/Date:**
				RECEIVED BY (LABORATORY)
			Signature:	**Signature:** TM
			Print:	**Print:** Tyrone
			Company:	**Company: Nautilus Environmental**
			Time/Date:	**Time/Date:** Dec. 9/21 @ 8:39

SPECIAL INSTRUCTIONS/COMMENTS: **If there are any mortalities, please email envionmental@pretivm.com ASAP. In the event of a failure, please re-peat the test with in the 5 day holding time with the original sample.**

Clear, colourless, odourless, no particulates

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

END OF REPORT

Toxicity testing on sample Weir at 3.10 and laboratory water amended with arsenic and antimony

Sample collected October 30, 2017

Final Report

December 15, 2017

Submitted to: **Pretium Exploration**
Vancouver, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

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SIGNATURE PAGE

Report By: Mimi Tran, Dipl. T. Laboratory Biologist	Reviewed By: Edmund Canaria, R.P.Bio Environmental Biologist- Senior Analyst

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

Sample Information and Test Type

Sample IDs and Treatment	Weir at 3.10 and laboratory water amended with arsenic (As) and antimony (Sb)
Collection date	October 30, 2017 (Weir at 3.10)
Receipt date	November 1, 2017 (Weir at 3.10)
Sample test treatment preparation/amendment date	November 1, 2017 for Weir at 3.10 and laboratory water
Receipt temperature	8.8°C (Weir at 3.10)
Test types	72-h *Pseudokirchneriella subcapitata* growth inhibition

Summary of Results (amended laboratory water test)

Endpoint	µg/L As	µg/L Sb
P. subcapitata		
Growth IC25 (95% CL)	10.9 (3.8 – 90.6)	17.0 (9.3 – 121.9)
Growth IC50 (95% CL)	122.6 (92.8 – 143.6)	162.6 (121.2 – 193.4)
NOEC	3.5	8.5
LOEC	7.1	12.8

IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

Summary of Results (amended Weir at 3.10 test)

Endpoint	µg/L As	µg/L Sb
P. subcapitata		
Growth IC25 (95% CL)	42.7 (33.3 – 48.0)	54.3 (42.6 – 60.7)
Growth IC50 (95% CL)	74.1 (67.5 – 81.7)	95.2 (85.6 – 101.5)
NOEC	11.4	14.1
LOEC	18.7	23.2

IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted 72-h *Pseudokirchneriella subcapitata* growth inhibition tests for Pretium Exploration. Sample Weir at 3.10 was collected on October 30, 2017 and delivered to the Nautilus Environmental laboratory in Burnaby, BC on November 1, 2017. The sample was transported in one 20-L plastic container and was received at a temperature of 8.8°C. The sample was stored in the dark at 4 ± 2°C prior to testing.

Sample Weir at 3.10 was amended with a range of arsenic (As) and antimony (Sb) concentrations, according to instructions provided by Lorax Environmental prior to testing. A concurrent test, using *P. subcapitata* laboratory control water, amended to the same arsenic and antimony concentrations as the sample, was also performed. Testing was initiated on November 1, 2017.

This report describes the results of the toxicity tests. Copies of raw laboratory data sheets and statistical analyses are provided in Appendix A. Copies of analytical chemistry analyses supplied by Lorax Environmental are provided in Appendix B. The chain-of-custody form is provided in Appendix C.

2.0 METHODS

Methods for the toxicity tests are summarized in Table 1. Testing using *P. subcapitata* was conducted according to procedure described by Environment Canada (2007).

The amended Weir at 3.10 and laboratory water test solutions were prepared at the Nautilus Environmental laboratory using an in-house concentrated arsenic stock solution, and a concentrated antimony stock solution supplied by Lorax Environmental. Aliquots of each prepared test solution were sent to ALS Environmental, Burnaby, BC for measurement of total and dissolved arsenic and antimony. Analytical results were reported directly to Lorax Environmental, and subsequently supplied to Nautilus Environmental for inclusion in the final report. Table 1 provides a summary of the nominal and total measured arsenic and antimony concentrations.

Statistical analyses for the tests were performed using CETIS (Tidepool Scientific Software, 2013). The test endpoints were calculated using total measured arsenic and antimony values, as instructed by Lorax Environmental.

Table 1. Nominal and total measured As and Sb concentrations in laboratory water and sample Weir at 3.10.

Test Treatment	µg/L As		µg/L Sb	
	Nominal	Total Measured	Nominal	Total Measured
Laboratory Water				
Laboratory Control	0	0	0	0
Concentration 1	3.5	3.5	4.4	8.47
Concentration 2	7	7.09	8.8	12.8
Concentration 3	14	13.9	18	20
Concentration 4	28	28.4	35	37.3
Concentration 5	56	56.2	70	76.6
Concentration 6	112	110	141	146
Concentration 7	224	220	282	291
Concentration 8	448	441	563	593
Weir at 3.10				
Laboratory Control	0	0	0	0
Un-amended Weir at 3.10	3.33	4.55	4.55	6.17
Concentration 1	7	11.4	8.8	14.1
Concentration 2	14	18.7	18	23.2
Concentration 3	28	31.6	35	39.4
Concentration 4	56	60.4	70	78.6
Concentration 5	112	115	141	144
Concentration 6	224	224	282	289
Concentration 7	448	461	563	573

Table 2. Summary of test conditions: 72-h *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain UTCC# 37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	Full strength sample diluted to 95.2% (v/v) with nutrients (site control), full strength sample diluted to 95.2% (v/v) with nutrients and amended with a range of seven As and Sb concentrations, plus laboratory control. Laboratory control/dilution water amended with a range of eight As and Sb concentrations, plus laboratory control.
Test replicates	4 per treatment; 8 for laboratory control and site control
Number of organisms	10,000 cells/mL
Laboratory control water	Deionized water supplemented with nutrients
Site control dilution water	Full strength sample (Weir at 3.10) diluted to 95.2% (v/v) with nutrients
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature and pH measured at test initiation; pH of two control wells measured at test termination
Test protocol	Environment Canada (2007b), EPS 1/RM/25
Statistical software	CETIS Version 1.8.7
Test endpoint	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnCl_2$)

3.0 RESULTS

Results of the toxicity test with *P. subcapitata* are summarized in Table 3. An inhibitory effect on cell yield was observed in the laboratory water spiked with both As and Sb. Analyzing the test data for individual measured total metal, the IC25 and IC50 for arsenic were 10.9 and 122.6 µg/L As, respectively; and with respect to antimony, the IC25 value was 17.0 µg/L Sb and the IC50 value was 162.6 µg/L Sb. The arsenic NOEC for cell yield was 3.5 µg/L As and the LOEC was 7.1 µg/L As. The NOEC and LOEC values for antimony were 8.5 and 12.8 µg/L Sb, respectively.

Results of the toxicity test with *P. subcapitata* on the arsenic and antimony amended Weir at 3.19 sample are summarized in Table 4. Adverse effects on cell yield were also observed in the sample spiked with As and Sb. Note that these results were based on the combined effects of As and Sb. If analyzed for each measured total metal, the resulting IC25 and IC50 values for arsenic were 42.7 and 74.1 µg/L As, respectively; and the IC25 and IC50 values for antimony were 54.3 and 95.2 µg/L, respectively. The NOEC for arsenic was 11.4 µg/L As and the LOEC was 18.7 µg/L As. With respect to antimony, the NOEC was 14.1 µg/L Sb and the LOEC was 23.2 µg/L Sb.

Table 3. Results: 72-h *Pseudokirchneriella subcapitata* growth inhibition test (laboratory control water amended with As and Sb).

Test Treatment	Total Measured As (µg/L)	Total Measured Sb (µg/L)	Cell Yield ($x10^4$ cells/mL) (Mean ±SD)
Laboratory Control	0	0	27.6 ± 1.7
Concentration 1	3.5	8.47	27.2 ± 2.2
Concentration 2	7.09	12.8	21.2 ± 2.2
Concentration 3	13.9	20	20.2 ± 1.7
Concentration 4	28.4	37.3	20.0 ± 2.2
Concentration 5	56.2	76.6	21.0 ± 2.2
Concentration 6	110	146	14.8 ± 1.5
Concentration 7	220	291	8.8 ± 1.5
Concentration 8	441	593	2.8 ± 1.0
Test Endpoint (µg/L As or Sb)			
IC25 (95% CL)	10.9 (3.8 – 90.6)	17.0 (9.3 – 121.9)	--
IC50 (95% CL)	122.6 (92.8 – 143.6)	162.6 (121.2 – 193.4)	--
NOEC	3.5	8.5	--
LOEC	7.1	12.8	--

SD = Standard Deviation, IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

Table 4. Results: 72-h *Pseudokirchneriella subcapitata* growth inhibition test (Weir at 3.10 amended with As and Sb).

Test Treatment	Total Measured As (µg/L)	Total Measured Sb (µg/L)	Cell Yield ($x10^4$ cells/mL) (Mean ±SD)
Laboratory Control	0	0	27.6 ± 2.4
Un-amended Weir at 3.10	4.55	6.17	152.8 ± 10.2
Concentration 1	11.4	14.1	152.5 ± 9.1
Concentration 2	18.7	23.2	132.8 ± 4.8
Concentration 3	31.6	39.4	132.8 ± 8.2
Concentration 4	60.4	78.6	93.5 ± 6.5
Concentration 5	115	144	39.2 ± 4.2
Concentration 6	224	289	19.0 ± 2.2
Concentration 7	461	573	4.0 ± 0.8
Test Endpoint (µg/L As or Sb)			
IC25 (95% CL)	42.7 (33.3 – 48.0)	54.3 (42.6 – 60.7)	--
IC50 (95% CL)	74.1 (67.5 – 81.7)	95.2 (85.6 – 101.5)	--
NOEC	11.4	14.1	--
LOEC	18.7	23.2	--

SD = Standard Deviation, IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

4.0 QA/QC

The health history of the test organism used in the exposures was acceptable and met the requirements of the test protocol. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. Uncertainty associated with the tests is best described by the standard deviation around the mean and/or the confidence intervals around the point estimates.

Results of the reference toxicant test conducted during the testing program are summarized in Table 7. Results for this test fell within the acceptable range for organism performance of mean and two standard deviation range, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organism used in these tests were appropriate. The reference toxicant test was performed under the same conditions as those used for the samples.

Table 5. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
P. subcapitata	Growth (IC50): 28.6 µg/L Zn	32.8 (26.5 – 40.6)	11	October 25, 2017

SD = Standard Deviation, CV = Coefficient of Variation, IC = Inhibition Concentration

5.0 REFERENCES

Environment Canada. 2007. Biological test method: growth inhibition test using the freshwater alga. Environmental Protection Series, Report EPS 1/RM/25. Second Edition, March 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 53 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.7.16 Tidepool Scientific Software, McKinleyville, CA. 222 pp.

APPENDIX A – *Pseudokirchneriella subcapitata* Toxicity Test Data

Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax/Pretium Exploration
Work Order No.: 171295

Start Date: Nov 2/17
Set up by: MG

Sample Information:

Sample ID: lab control spiked with Sb and As.
Sample Date: Nov 2/17
Date Received: Nov 2/17
Sample Volume: n/a

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8 - 34.9) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5 - 40.6) µg/L Zn CV (%): 11

Test Results:

µg/L Sb	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	17.0 (9.3 - 121.9)
IC50 ~~%(v/v)~~ mg (95% CL)	162.6 (121.2 - 193.4)
µg/L Sb NOEC	8.5
LOEC	12.8

Reviewed by: JCh

Date reviewed: Dec. 8/17

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax / Pretium Setup by: MG

Sample ID: Lab ~~Control~~ water MG Spiked with Sb and As. Test Date/Time: Nov 2/17 @ 1900h.

Work Order No.: 171295 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: 04 17/17 Age of Culture: 6d Culture Health: Good

Culture Count: 1 500 2 530 Average: 515 Culture Cell Density (c1): 515 x 10^4 cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 515 x 10^4 cells/ml = 4.27 mL

Time Zero Counts: 1 20 2 22 Average: 21

No. of Cells/mL: 21 x 10^4 Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9545 cells/mL.

Concentration ~~%(v/v)~~ mg ~~mg/L~~ Sb and As.	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control 7.3	~~6.9~~ MG	23.0	24.0	24.0	24.0	24.0	✓	✓	✓	✓
Concentration 1	7.3	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Concentration 2	7.3	23.0					✓	✓	✓	✓
Concentration 3	7.3	23.0					✓	✓	✓	✓
Concentration 4	7.3	23.0					✓	✓	✓	✓
Concentration 5	7.2	23.0					✓	✓	✓	✓
Concentration 6	7.2	23.0					✓	✓	✓	✓
Concentration 7	7.2	23.0					✓	✓	✓	✓
Concentration 8	7.1	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	A	A	MG	MG	A	A

Initial control pH: Well 1: 7.3 Well 2: 7.3

Final control pH: Well 1: 7.0 Well 2: 7.0

Light intensity (lux): 4030 Date measured: Nov 2/17

Thermometer: 4 Light meter: 1 pH meter/probe: 1/1

Sample Description: clear, colourless, odourless, no particulates.

Comments:

Reviewed: JGL Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax/Pretium
Start Date/Time: Nov 2/17 @ 1900h
Work Order #: 171295
Termination Date: Nov 5/17 @ 1900h
Sample ID: Lab water spiked with ~~%(v/v)~~ mg/L Sb and As.
Test set up by: MLT Sb and As.

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	31					MLT
	B	27					
	C	30					
	D	28					
	E	30					
	F	26					
	G	28					
	H	29					
Concentration 1	A	26					
	B	29					
	C	27					
	D	31					
Concentration 2	A	20					
	B	25					
	C	23					
	D	21					
Concentration 3	A	19					
	B	21					
	C	23					
	D	22					
Concentration 4	A	24					
	B	21					
	C	20					
	D	19					
Concentration 5	A	25					
	B	21					
	C	22					
	D	20					
Concentration 6	A	15					
	B	17					
	C	17					
	D	14					
Concentration 7	A	8					
	B	11					
	C	9					
	D	11					

Comments:

Reviewed by: JGL
Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax/Pretium Start Date/Time: Nov 2/17 @ 1900h
Work Order #: 171295 Termination Date: Nov 5/17 @ 1900h
Sample ID: Lab water spiked with sband As. Test set up by: MLJ

~~%(v/v)~~ mg/L sband As. Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
Concentration mg/L ~~7~~ 8	A	4					MLJ
	B	3					↓
	C	5					↓
	D	3					↓
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JGb Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1900h
WO#:	171295	Termination Date/Tim	5-Nov-17 @ 1900h
Sample ID:	Lab Control		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	31				31	30.0	mean	27.7
	B	27				27	26.0	SD	1.685018
	C	30				30	29.0	CV	6.089593
	D	28				28	27.0		
	E	30				30	29.0		
	F	26				26	25.0		
	G	28				28	27.0		
	H	29				29	28.0		
Concentration 1	A	26				26	25.0		
	B	29				29	28.0		
	C	27				27	26.0		
	D	31				31	30.0		
Concentration 2	A	20				20	19.0		
	B	25				25	24.0		
	C	23				23	22.0		
	D	21				21	20.0		
Concentration 3	A	19				19	18.0		
	B	21				21	20.0		
	C	23				23	22.0		
	D	22				22	21.0		
Concentration 4	A	24				24	23.0		
	B	21				21	20.0		
	C	20				20	19.0		
	D	19				19	18.0		
Concentration 5	A	25				25	24.0		
	B	21				21	20.0		
	C	22				22	21.0		
	D	20				20	19.0		
Concentration 6	A	15				15	14.0		
	B	17				17	16.0		
	C	17				17	16.0		
	D	14				14	13.0		
Concentration 7	A	8				8	7.0		
	B	11				11	10.0		
	C	9				9	8.0		
	D	11				11	10.0		

Reviewed by: JGh

Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1900h
WO#:	171295	Termination Date/Time	5-Nov-17 @ 1900h
Sample ID:	Lab Control		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	31				31	30.0	mean	27.7
	B	27				27	26.0	SD	1.685018
	C	30				30	29.0	CV	6.089593
	D	28				28	27.0		
	E	30				30	29.0		
	F	26				26	25.0		
	G	28				28	27.0		
	H	29				29	28.0		
Concentration 8	A	4				4	3.0		
	B	3				3	2.0		
	C	5				5	4.0		
	D	3				3	2.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JM

Date reviewed: Dec. 8/17

CETIS Summary Report

Report Date: 29 Nov-17 16:02 (p 1 of 1)
Test Code: 171295b Sb | 20-9906-2629

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	04-7911-7254	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
17-2527-4361	Cell Yield	IC5	9.087	N/A	9.814		Linear Interpolation (ICPIN)
		IC10	10	7.976	11.24		
		IC15	11	9.162	13.49		
		IC20	12.08	10.43	18.77		
		IC25	17.04	9.279	121.9		
		IC40	118.7	94.1	140.2		
		IC50	162.6	121.2	193.4		

Cell Yield Summary

(1) C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	25	30	0.5957	1.685	6.1%	0.0%
8.47		4	27.25	23.72	30.78	25	30	1.109	2.217	8.14%	1.36%
12.8		4	21.25	17.72	24.78	19	24	1.109	2.217	10.43%	23.08%
20		4	20.25	17.53	22.97	18	22	0.8539	1.708	8.43%	26.7%
37.3		4	20	16.56	23.44	18	23	1.08	2.16	10.8%	27.6%
76.6		4	21	17.56	24.44	19	24	1.08	2.16	10.29%	23.98%
146		4	14.75	12.36	17.14	13	16	0.75	1.5	10.17%	46.61%
291		4	8.75	6.363	11.14	7	10	0.75	1.5	17.14%	68.33%
593		4	2.75	1.227	4.273	2	4	0.4787	0.9574	34.82%	90.05%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
8.47		25	28	26	30				
12.8		19	24	22	20				
20		18	20	22	21				
37.3		23	20	19	18				
76.6		24	20	21	19				
146		14	16	16	13				
291		7	10	8	10				
593		3	2	4	2				

(1) sample analyzed for Sb ~~using Sb concentrations~~ in the mixture. MT

CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	17-2527-4361	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:52	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	04-7911-7254	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1964978	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	9.087	N/A	9.814
IC10	10	7.976	11.24
IC15	11	9.162	13.49
IC20	12.08	10.43	18.77
IC25	17.04	9.279	121.9
IC40	118.7	94.1	140.2
IC50	162.6	121.2	193.4

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25	30	0.5957	1.685	6.1%	0.0%
8.47		4	27.25	25	30	1.109	2.217	8.14%	1.36%
12.8		4	21.25	19	24	1.109	2.217	10.43%	23.08%
20		4	20.25	18	22	0.8539	1.708	8.43%	26.7%
37.3		4	20	18	23	1.08	2.16	10.8%	27.6%
76.6		4	21	19	24	1.08	2.16	10.29%	23.98%
146		4	14.75	13	16	0.75	1.5	10.17%	46.61%
291		4	8.75	7	10	0.75	1.5	17.14%	68.33%
593		4	2.75	2	4	0.4787	0.9574	34.82%	90.05%

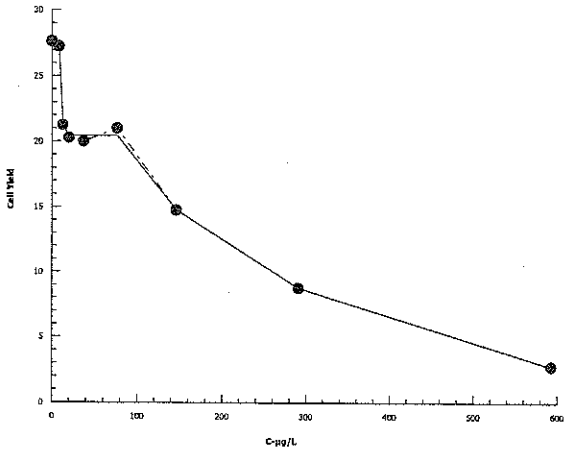
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
8.47		25	28	26	30				
12.8		19	24	22	20				
20		18	20	22	21				
37.3		23	20	19	18				
76.6		24	20	21	19				
146		14	16	16	13				
291		7	10	8	10				
593		3	2	4	2				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	17-2527-4361	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:52	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-0828-4955	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:51	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	04-7911-7254	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	10.3%	8.47	12.8	10.41	

Dunnett Multiple Comparison Test

Control vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	8.47	0.337	2.563	2.852	10	0.8622	CDF	Non-Significant Effect
	12.8*	5.729	2.563	2.852	10	<0.0001	CDF	Significant Effect
	20*	6.627	2.563	2.852	10	<0.0001	CDF	Significant Effect
	37.3*	6.852	2.563	2.852	10	<0.0001	CDF	Significant Effect
	76.6*	5.953	2.563	2.852	10	<0.0001	CDF	Significant Effect
	146*	11.57	2.563	2.852	10	<0.0001	CDF	Significant Effect
	291*	16.96	2.563	2.852	10	<0.0001	CDF	Significant Effect
	593*	22.35	2.563	2.852	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2462	307.75	8	93.19	<0.0001	Significant Effect
Error	102.375	3.302419	31			
Total	2564.375		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	2.792	20.09	0.9467	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.952	0.9236	0.0892	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	27.5	25	30	0.5957	6.1%	0.0%
8.47		4	27.25	23.72	30.78	27	25	30	1.109	8.14%	1.36%
12.8		4	21.25	17.72	24.78	21	19	24	1.109	10.43%	23.08%
20		4	20.25	17.53	22.97	20.5	18	22	0.8539	8.43%	26.7%
37.3		4	20	16.56	23.44	19.5	18	23	1.08	10.8%	27.6%
76.6		4	21	17.56	24.44	20.5	19	24	1.08	10.29%	23.98%
146		4	14.75	12.36	17.14	15	13	16	0.75	10.17%	46.61%
291		4	8.75	6.363	11.14	9	7	10	0.75	17.14%	68.33%
593		4	2.75	1.227	4.273	2.5	2	4	0.4787	34.82%	90.05%

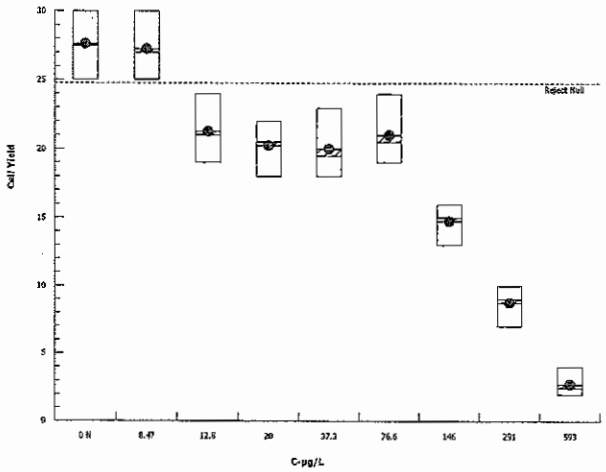
EC Alga Growth Inhibition Test — **Nautilus Environmental**

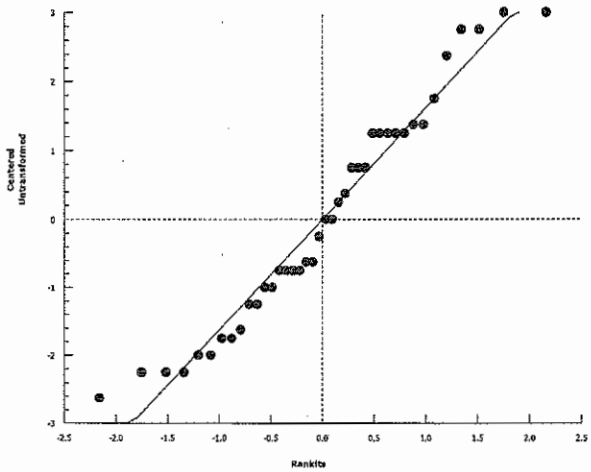
Analysis ID:	07-0828-4955	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:51	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
8.47		25	28	26	30				
12.8		19	24	22	20				
20		18	20	22	21				
37.3		23	20	19	18				
76.6		24	20	21	19				
146		14	16	16	13				
291		7	10	8	10				
593		3	2	4	2				

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax / Pretium Exploration
Start Date: Nov 2/17
Work Order No.: 171295
Set up by: MG.

Sample Information:

Sample ID: Lab control spiked with Sb and As.
Sample Date: Nov 2/17
Date Received: Nov 2/17
Sample Volume: n/a

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8 - 34.9) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5 - 40.6) ug/L Zn CV (%): 11

Test Results:

ug/L As	Algal Growth
IC25 ~~%(v/v)~~ mg/L (95% CL)	10.9 (3.8 - 90.6)
IC50 ~~%(v/v)~~ ug/L As mg/L (95% CL)	122.6 (92.8 - 143.6)
NOEC	3.5
LOEC	7.1

Reviewed by: JGu
Date reviewed: Dec. 13/17

CETIS Summary Report

Report Date: 11 Dec-17 11:37 (p 1 of 1)
Test Code: 171295b As | 13-2504-1330

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	09-7866-4338	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
03-2867-9649	Cell Yield	3.5	7.09	4.981	10.3%		Dunnett Multiple Comparison Test

Cell Yield Summary

①

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	25	30	0.5957	1.685	6.1%	0.0%
3.5		4	27.25	23.72	30.78	25	30	1.109	2.217	8.14%	1.36%
7.09		4	21.25	17.72	24.78	19	24	1.109	2.217	10.43%	23.08%
13.9		4	20.25	17.53	22.97	18	22	0.8539	1.708	8.43%	26.7%
28.4		4	20	16.56	23.44	18	23	1.08	2.16	10.8%	27.6%
56.2		4	21	17.56	24.44	19	24	1.08	2.16	10.29%	23.98%
110		4	14.75	12.36	17.14	13	16	0.75	1.5	10.17%	46.61%
220		4	8.75	6.363	11.14	7	10	0.75	1.5	17.14%	68.33%
441		4	2.75	1.227	4.273	2	4	0.4787	0.9574	34.82%	90.05%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
3.5		25	28	26	30				
7.09		19	24	22	20				
13.9		18	20	22	21				
28.4		23	20	19	18				
56.2		24	20	21	19				
110		14	16	16	13				
220		7	10	8	10				
441		3	2	4	2				

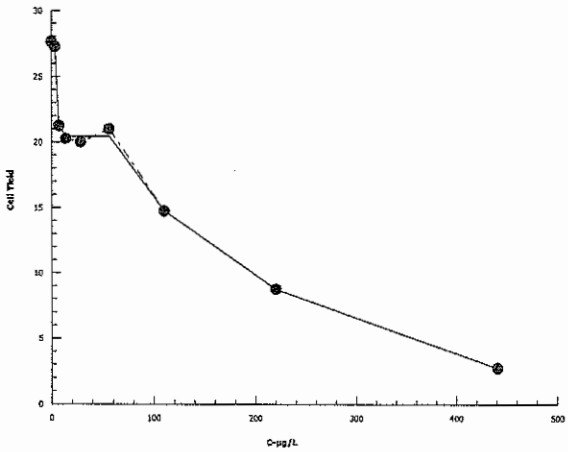
① analyzed ~~As~~ Mo for As in the mixture.

Analyst: MT QA: JGH Dec-13/17

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-9813-6067	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:35	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 11 Dec-17 11:37 (p 1 of 2)
Test Code: 171295b As | 13-2504-1330

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-9813-6067	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:35	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	09-7866-4338	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	934656	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	3.965	0.2366	4.634
IC10	4.683	3.31	6.029
IC15	5.505	4.195	7.667
IC20	6.445	5.003	13.21
IC25	10.94	3.83	90.58
IC40	88.66	70.73	105.5
IC50	122.6	92.77	143.6

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25	30	0.5957	1.685	6.1%	0.0%
3.5		4	27.25	25	30	1.109	2.217	8.14%	1.36%
7.09		4	21.25	19	24	1.109	2.217	10.43%	23.08%
13.9		4	20.25	18	22	0.8539	1.708	8.43%	26.7%
28.4		4	20	18	23	1.08	2.16	10.8%	27.6%
56.2		4	21	19	24	1.08	2.16	10.29%	23.98%
110		4	14.75	13	16	0.75	1.5	10.17%	46.61%
220		4	8.75	7	10	0.75	1.5	17.14%	68.33%
441		4	2.75	2	4	0.4787	0.9574	34.82%	90.05%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
3.5		25	28	26	30				
7.09		19	24	22	20				
13.9		18	20	22	21				
28.4		23	20	19	18				
56.2		24	20	21	19				
110		14	16	16	13				
220		7	10	8	10				
441		3	2	4	2				

Analyst: MT QA: JGu Dec. 13/17

CETIS Analytical Report

Report Date: 11 Dec-17 11:37 (p 1 of 2)
Test Code: 171295b As | 13-2504-1330

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	03-2867-9649	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:37	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	09-7866-4338	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	10.3%	3.5	7.09	4.981	

Dunnett Multiple Comparison Test

Control vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	3.5	0.337	2.563	2.852	10	0.8622	CDF	Non-Significant Effect
	7.09*	5.729	2.563	2.852	10	<0.0001	CDF	Significant Effect
	13.9*	6.627	2.563	2.852	10	<0.0001	CDF	Significant Effect
	28.4*	6.852	2.563	2.852	10	<0.0001	CDF	Significant Effect
	56.2*	5.953	2.563	2.852	10	<0.0001	CDF	Significant Effect
	110*	11.57	2.563	2.852	10	<0.0001	CDF	Significant Effect
	220*	16.96	2.563	2.852	10	<0.0001	CDF	Significant Effect
	441*	22.35	2.563	2.852	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2462	307.75	8	93.19	<0.0001	Significant Effect
Error	102.375	3.302419	31			
Total	2564.375		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	2.792	20.09	0.9467	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.952	0.9236	0.0892	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	27.5	25	30	0.5957	6.1%	0.0%
3.5		4	27.25	23.72	30.78	27	25	30	1.109	8.14%	1.36%
7.09		4	21.25	17.72	24.78	21	19	24	1.109	10.43%	23.08%
13.9		4	20.25	17.53	22.97	20.5	18	22	0.8539	8.43%	26.7%
28.4		4	20	16.56	23.44	19.5	18	23	1.08	10.8%	27.6%
56.2		4	21	17.56	24.44	20.5	19	24	1.08	10.29%	23.98%
110		4	14.75	12.36	17.14	15	13	16	0.75	10.17%	46.61%
220		4	8.75	6.363	11.14	9	7	10	0.75	17.14%	68.33%
441		4	2.75	1.227	4.273	2.5	2	4	0.4787	34.82%	90.05%

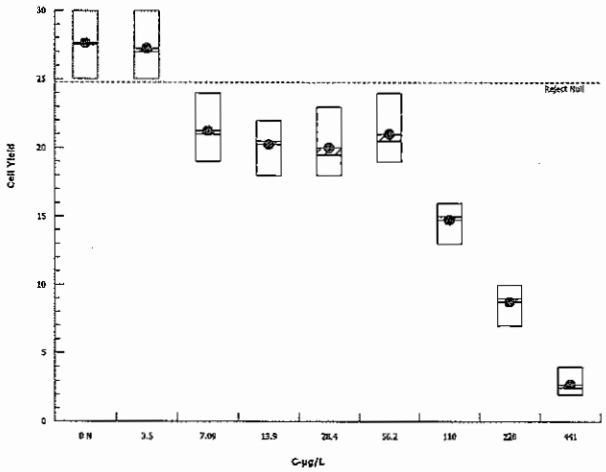
EC Alga Growth Inhibition Test — **Nautilus Environmental**

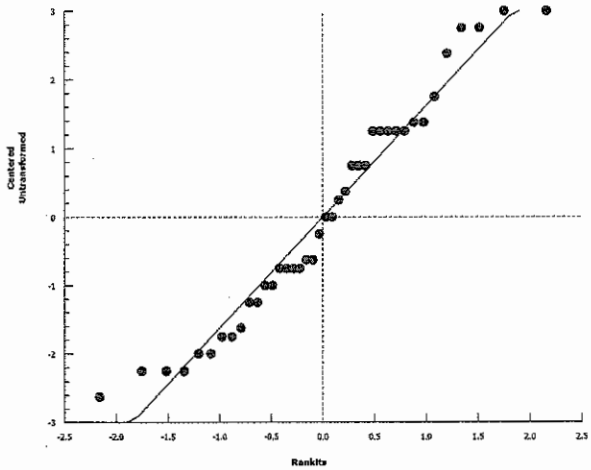
Analysis ID:	03-2867-9649	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:37	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
3.5		25	28	26	30				
7.09		19	24	22	20				
13.9		18	20	22	21				
28.4		23	20	19	18				
56.2		24	20	21	19				
110		14	16	16	13				
220		7	10	8	10				
441		3	2	4	2				

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax/Pretium Exploration
Start Date: Nov 2/17
Work Order No.: 171295
Set up by: MG

Sample Information:

Sample ID: Weir at 3.10 spiked with Sb and As.
Sample Date: Oct 30/17
Date Received: Nov 1/17
Sample Volume: 1x20L

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8-34.9) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5-40.6) ug/L Zn CV (%): 11

Test Results:

ug/L Sb	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	54.3 (42.6-60.7)
IC50 ~~%(v/v)~~ mg (95% CL)	95.2 (85.6-101.5)
ug/L Sb NOEC	14.1
LOEC	23.2

Reviewed by: JGu
Date reviewed: Dec. 8/17

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax / Pretium Setup by: MG

Sample ID: Weir at 3.10 spiked with Sb and As Test Date/Time: Nov 2/17 @ 1910h

Work Order No.: 171295 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: Oct 27/17 Age of Culture: 6d Culture Health: Good

Culture Count: 1 560 2 530 Average: 515 Culture Cell Density (c1): 515 x 10^4 cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 515 x 10^4 cells/ml = 4.27 mL

Time Zero Counts: 1 20 2 22 Average: 21

No. of Cells/mL: 21 x 10^4 Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9545 cells/mL

Concentration ~~%(v/v)~~ mg ~~mg/L~~ Sb and As.	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	7.3	23.0	24.0	24.0	24.0	24.0	✓	✓	✓	✓
(site control) ~~GHLF mg~~ (Weir at 3.10)	7.8	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Concentration 1	7.9	23.0					✓	✓	✓	✓
Concentration 2	7.9	23.0					✓	✓	✓	✓
Concentration 3	8.0	23.0					✓	✓	✓	✓
Concentration 4	8.0	23.0					✓	✓	✓	✓
Concentration 5	7.9	23.0					✓	✓	✓	✓
Concentration 6	7.9	23.0					✓	✓	✓	✓
Concentration 7	7.9	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	[illegible]	[illegible]	MG	MG	[illegible]	[illegible]

Initial control pH: Well 1: 7.3 Well 2: 7.3

Final control pH: Well 1: 7.0 Well 2: 7.0

Light intensity (lux): 4160 Date measured: Nov 2/17

Thermometer: 4 Light meter: 1 pH meter/probe: 1/1

Sample Description: clear, colourless, odourless, no particulates

Comments:

Reviewed: [illegible] Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Loxax/Pretium
Start Date/Time: Nov 2/17 @ 1910h
Work Order #: 171295
Termination Date: Nov 5/17 @ 1910h
Sample ID: weir at ~~BJ~~ MLT 3,10 spiked with Sb and As
Test set up by: MLT

mg/L Sb and ~~As%(v/v)~~ mg

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	28					MLT
	B	30					
	C	27					
	D	33					
	E	26					
	F	27					
	G	31					
	H	27					
weir at ~~BJ~~ MLT 3,10 (site control)	A	~~144~~ ~~164~~ MLT 141					
	B	170					
	C	161					
	D	150					
(95.2%v/v)	~~E~~ A MLT	145					
	~~F~~ B	153					
	~~G~~ C	146					
	~~H~~ D	MLT ~~141~~					
Concentration 1	A	163					
	B	142					
	C	151					
	D	158					
Concentration 2	A	136					
	B	139					
	C	128					
	D	132					
Concentration 3	A	141					
	B	140					
	C	130					
	D	124					
Concentration 4	A	90					
	B	101					
	C	99					
	D	88					
Concentration 5	A	40					
	B	36					
	C	39					
	D	46					

Comments:

Reviewed by: JGu
Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax/Pretium
Start Date/Time: Nov 2/17 @ 1910h
Work Order #: 171295
Termination Date: Nov 5/17 @ 1910h
Sample ID: ~~B7~~ 3.10 spiked with Sb and As
Test set up by: MG

ug/L ~~%(v/v)~~ weirat

Sb and As Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
Concentration 6	A	17					MG
	B	21					
	C	20					
	D	22					
Concentration 7	A	5					
	B	4					
	C	5					
	D	6					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JGh
Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1910h
WO#:	171295	Termination Date/Tim	5-Nov-17 @ 1910h
Sample ID:	Weir at 3.10		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	28				28	27.0	mean	27.7
	B	30				30	29.0	SD	2.445842
	C	27				27	26.0	CV	8.839182
	D	33				33	32.0		
	E	26				26	25.0		
	F	27				27	26.0		
	G	31				31	30.0		
	H	27				27	26.0		
Weir at 3.10 (Site Control)	A	141				141	140.0		
	B	170				170	169.0		
	C	161				161	160.0		
	D	150				150	149.0		
	E	145				145	144.0		
	F	153				153	152.0		
	G	146				146	145.0		
	H	164				164	163.0		
Concentration 1	A	163				163	162.0		
	B	142				142	141.0		
	C	151				151	150.0		
	D	158				158	157.0		
Concentration 2	A	136				136	135.0		
	B	139				139	138.0		
	C	128				128	127.0		
	D	132				132	131.0		
Concentration 3	A	141				141	140.0		
	B	140				140	139.0		
	C	130				130	129.0		
	D	124				124	123.0		
Concentration 4	A	90				90	89.0		
	B	101				101	100.0		
	C	99				99	98.0		
	D	88				88	87.0		
Concentration 5	A	40				40	39.0		
	B	36				36	35.0		
	C	39				39	38.0		
	D	46				46	45.0		

Reviewed by: JGh

Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1910h
WO#:	171295	Termination Date/Tim	5-Nov-17 @ 1910h
Sample ID:	Weir at 3.10		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	28				28	27.0	mean	27.7
	B	30				30	29.0	SD	2.445842
	C	27				27	26.0	CV	8.839182
	D	33				33	32.0		
	E	26				26	25.0		
	F	27				27	26.0		
	G	31				31	30.0		
	H	27				27	26.0		
Concentration 6	A	17				17	16.0		
	B	21				21	20.0		
	C	20				20	19.0		
	D	22				22	21.0		
Concentration 7	A	5				5	4.0		
	B	4				4	3.0		
	C	5				5	4.0		
	D	6				6	5.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JGu

Date reviewed: Dec. 8/17

CETIS Summary Report

Report Date: 17 Nov-17 16:41 (p 1 of 1)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
09-4967-9773	Cell Yield	14.1	23.2	18.09	7.28%		Dunnett Multiple Comparison Test

Cell Yield Summary

① C-µg/L Sb	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	25	32	0.8647	2.446	8.85%	0.0%
6.17	Dilution Water	8	152.8	144.2	161.3	140	169	3.624	10.25	6.71%	-452.9%
14.1		4	152.5	138	167	141	162	4.555	9.11	5.97%	-452.0%
23.2		4	132.8	125.1	140.4	127	138	2.394	4.787	3.61%	-380.5%
39.4		4	132.8	119.7	145.8	123	140	4.09	8.18	6.16%	-380.5%
78.6		4	93.5	83.23	103.8	87	100	3.227	6.455	6.9%	-238.5%
144		4	39.25	32.58	45.92	35	45	2.097	4.193	10.68%	-42.08%
289		4	19	15.56	22.44	16	21	1.08	2.16	11.37%	31.22%
573		4	4	2.701	5.299	3	5	0.4082	0.8165	20.41%	85.52%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
6.17	Dilution Water	140	169	160	149	144	152	145	163
14.1		162	141	150	157				
23.2		135	138	127	131				
39.4		140	139	129	123				
78.6		89	100	98	87				
144		39	35	38	45				
289		16	20	19	21				
573		4	3	4	5				

① analyzed for Sb in the mixture.

Analyst: MLT QA: JGM Dec. 8/17

CETIS Analytical Report

Report Date: 17 Nov-17 16:41 (p 1 of 2)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	13-9524-6339	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	266003	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	17.01	9.582	19.06
IC10	20.62	15.27	45.73
IC15	41.49	9.493	46.5
IC20	47.48	34.8	53.1
IC25	54.32	42.56	60.69
IC40	80.24	68.05	87.12
IC50	95.19	85.56	101.5

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
6.17	Dilution Water	8	152.8	140	169	3.624	10.25	6.71%	0.0%
14.1		4	152.5	141	162	4.555	9.11	5.97%	0.16%
23.2		4	132.8	127	138	2.394	4.787	3.61%	13.09%
39.4		4	132.8	123	140	4.09	8.18	6.16%	13.09%
78.6		4	93.5	87	100	3.227	6.455	6.9%	38.79%
144		4	39.25	35	45	2.097	4.193	10.68%	74.3%
289		4	19	16	21	1.08	2.16	11.37%	87.56%
573		4	4	3	5	0.4082	0.8165	20.41%	97.38%

Cell Yield Detail

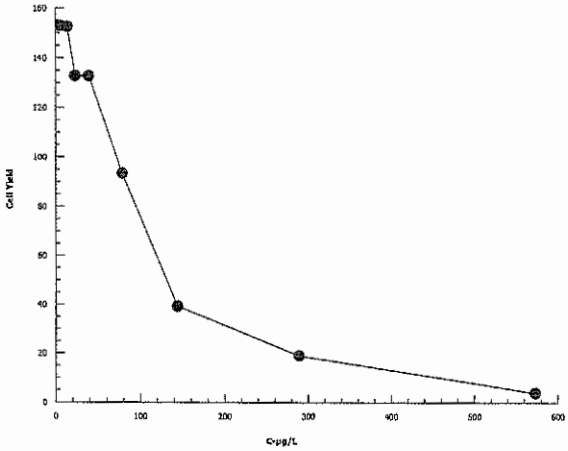
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
6.17	Dilution Water	140	169	160	149	144	152	145	163
14.1		162	141	150	157				
23.2		135	138	127	131				
39.4		140	139	129	123				
78.6		89	100	98	87				
144		39	35	38	45				
289		16	20	19	21				
573		4	3	4	5				

Analyst: MLT QA: JOH Dec-8/17

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	13-9524-6339	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 17 Nov-17 16:41 (p 1 of 2)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-4967-9773	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	7.28%	14.1	23.2	18.09	

Dunnett Multiple Comparison Test

Control	vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
6.17		14.1	0.05677	2.526	11.12	10	0.9157	CDF	Non-Significant Effect
6.17		23.2*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
6.17		39.4*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
6.17		78.6*	13.46	2.526	11.12	10	<0.0001	CDF	Significant Effect
6.17		144*	25.78	2.526	11.12	10	<0.0001	CDF	Significant Effect
6.17		289*	30.37	2.526	11.12	10	<0.0001	CDF	Significant Effect
6.17		573*	33.78	2.526	11.12	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	119713.9	17101.98	7	330.8	<0.0001	Significant Effect
Error	1447.75	51.70536	28			
Total	121161.6		35			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	17.41	18.48	0.0149	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.989	0.9166	0.9717	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
6.17	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	0.0%
14.1		4	152.5	138	167	153.5	141	162	4.555	5.97%	0.16%
23.2		4	132.8	125.1	140.4	133	127	138	2.394	3.61%	13.09%
39.4		4	132.8	119.7	145.8	134	123	140	4.09	6.16%	13.09%
78.6		4	93.5	83.23	103.8	93.5	87	100	3.227	6.9%	38.79%
144		4	39.25	32.58	45.92	38.5	35	45	2.097	10.68%	74.3%
289		4	19	15.56	22.44	19.5	16	21	1.08	11.37%	87.56%
573		4	4	2.701	5.299	4	3	5	0.4082	20.41%	97.38%

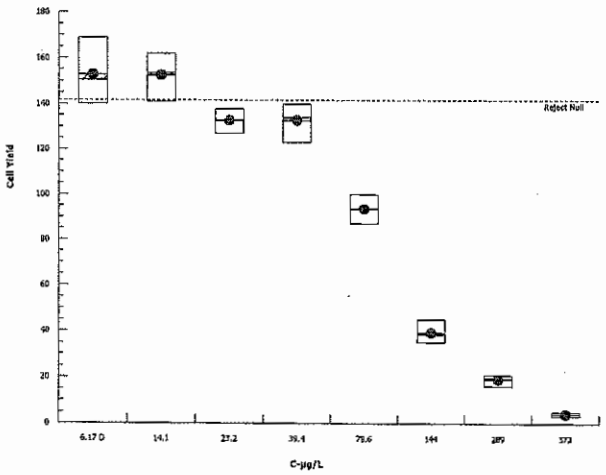
EC Alga Growth Inhibition Test — **Nautilus Environmental**

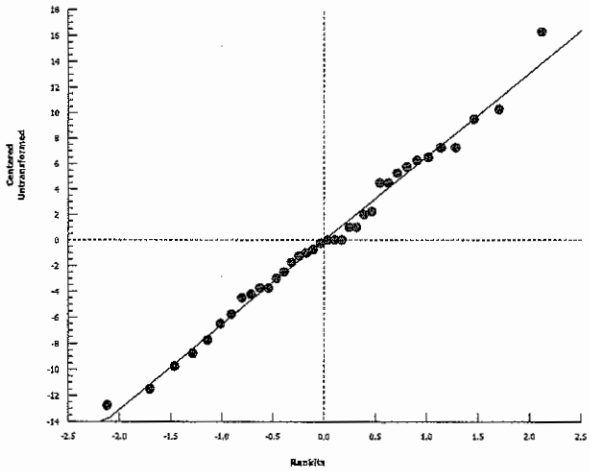
Analysis ID:	09-4967-9773	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
6.17	Dilution Water	140	169	160	149	144	152	145	163
14.1		162	141	150	157				
23.2		135	138	127	131				
39.4		140	139	129	123				
78.6		89	100	98	87				
144		39	35	38	45				
289		16	20	19	21				
573		4	3	4	5				

Graphics





CETIS Analytical Report

Report Date: 17 Nov-17 16:41 (p 1 of 2)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-2910-9010	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	25.6%	Fails cell yield

Unequal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		6.17*	33.58	1.895	7.059	7	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.5634	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	62625.06	62625.06	1	1128	<0.0001	Significant Effect
Error	777.375	55.52679	14			
Total	63402.44		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	17.56	8.885	0.0012	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.9637	0.8408	0.7300	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	26.5	25	32	0.8647	8.85%	0.0%
6.17	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	-452.9%

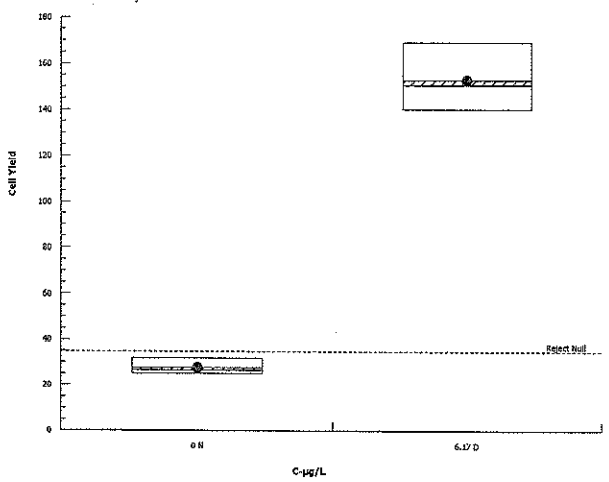
Cell Yield Detail

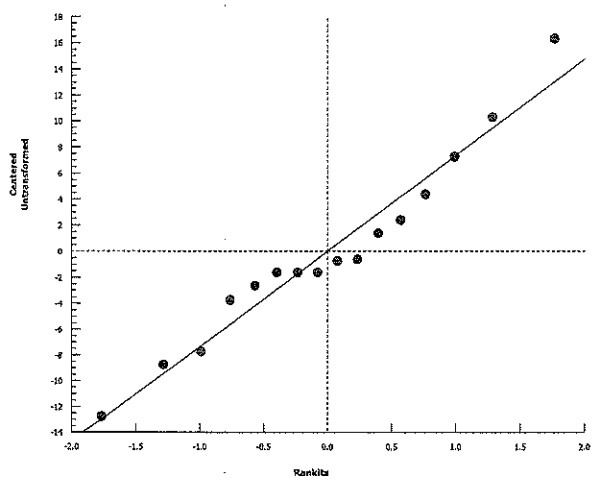
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
6.17	Dilution Water	140	169	160	149	144	152	145	163

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-2910-9010	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: LorGx / Pretium Exploration
Start Date: Nov 2/17
Work Order No.: 171295
Set up by: MG

Sample Information:

Sample ID: Weir at 3.10 spiked with Sb and As.
Sample Date: Oct 30/17
Date Received: Nov 1/17
Sample Volume: 1x20L

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8 - 34.9) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5 - 40.6) µg/L Zn CV (%): 11

Test Results:

µg/L As	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	42.7 (33.3 - 48.0)
IC50 ~~%(v/v)~~ mg (95% CL)	74.1 (67.5 - 81.7)
µg/L As. NOEC	11.4
LOEC	18.7

Reviewed by: JOL
Date reviewed: Dec. 8/17

CETIS Summary Report

Report Date: 17 Nov-17 16:47 (p 1 of 1)
Test Code: 171295a As | 08-8019-8931

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
09-2717-2239	Cell Yield	<4.55	4.55	NA	25.6%		Unequal Variance t Two-Sample Test
12-5267-1525	Cell Yield	11.4	18.7	14.6	7.28%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
16-8163-3805	Cell Yield	IC5	13.74	8.588	15.82		Linear Interpolation (ICPIN)
		IC10	16.63	12.69	41.53		
		IC15	33.17	7.979	37.36		
		IC20	37.65	28.76	42.19		
		IC25	42.71	33.3	48.01		
		IC40	61.75	52.98	69.43		
		IC50	74.06	67.49	81.69		

Cell Yield Summary

① C-µg/L As	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	25	32	0.8647	2.446	8.85%	0.0%
4.55	Dilution Water	8	152.8	144.2	161.3	140	169	3.624	10.25	6.71%	-452.9%
11.4		4	152.5	138	167	141	162	4.555	9.11	5.97%	-452.0%
18.7		4	132.8	125.1	140.4	127	138	2.394	4.787	3.61%	-380.5%
31.6		4	132.8	119.7	145.8	123	140	4.09	8.18	6.16%	-380.5%
60.4		4	93.5	83.23	103.8	87	100	3.227	6.455	6.9%	-238.5%
115		4	39.25	32.58	45.92	35	45	2.097	4.193	10.68%	-42.08%
224		4	19	15.56	22.44	16	21	1.08	2.16	11.37%	31.22%
461		4	4	2.701	5.299	3	5	0.4082	0.8165	20.41%	85.52%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
4.55	Dilution Water	140	169	160	149	144	152	145	163
11.4		162	141	150	157				
18.7		135	138	127	131				
31.6		140	139	129	123				
60.4		89	100	98	87				
115		39	35	38	45				
224		16	20	19	21				
461		4	3	4	5				

① analyzed for As in the mixture

CETIS Analytical Report

Test Code: 171295a As | 08-8019-8931

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-8163-3805	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:47	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	696220	200	Yes	Two-Point Interpolation

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	13.74	8.588	15.82
IC10	16.63	12.69	41.53
IC15	33.17	7.979	37.36
IC20	37.65	28.76	42.19
IC25	42.71	33.3	48.01
IC40	61.75	52.98	69.43
IC50	74.06	67.49	81.69

Cell Yield Summary

			Calculated Variate						
C-µg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
4.55	Dilution Water	8	152.8	140	169	3.624	10.25	6.71%	0.0%
11.4		4	152.5	141	162	4.555	9.11	5.97%	0.16%
18.7		4	132.8	127	138	2.394	4.787	3.61%	13.09%
31.6		4	132.8	123	140	4.09	8.18	6.16%	13.09%
60.4		4	93.5	87	100	3.227	6.455	6.9%	38.79%
115		4	39.25	35	45	2.097	4.193	10.68%	74.3%
224		4	19	16	21	1.08	2.16	11.37%	87.56%
461		4	4	3	5	0.4082	0.8165	20.41%	97.38%

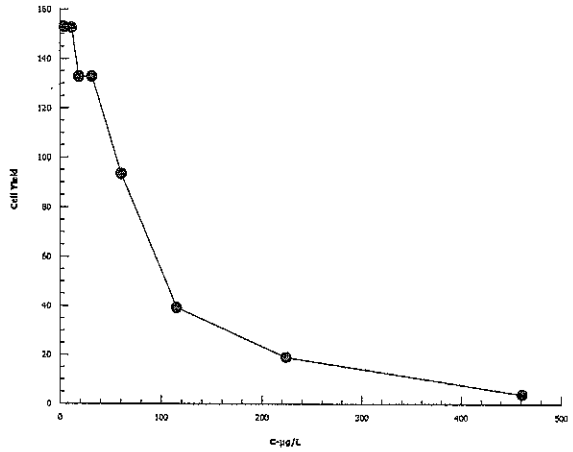
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.55	Dilution Water	140	169	160	149	144	152	145	163
11.4		162	141	150	157				
18.7		135	138	127	131				
31.6		140	139	129	123				
60.4		89	100	98	87				
115		39	35	38	45				
224		16	20	19	21				
461		4	3	4	5				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-8163-3805	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:47	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 17 Nov-17 16:47 (p 1 of 4)
Test Code: 171295a As | 08-8019-8931

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-5267-1525	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	7.28%	11.4	18.7	14.6	

Dunnett Multiple Comparison Test

Control	vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
4.55		11.4	0.05677	2.526	11.12	10	0.9157	CDF	Non-Significant Effect
4.55		18.7*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
4.55		31.6*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
4.55		60.4*	13.46	2.526	11.12	10	<0.0001	CDF	Significant Effect
4.55		115*	25.78	2.526	11.12	10	<0.0001	CDF	Significant Effect
4.55		224*	30.37	2.526	11.12	10	<0.0001	CDF	Significant Effect
4.55		461*	33.78	2.526	11.12	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	119713.9	17101.98	7	330.8	<0.0001	Significant Effect
Error	1447.75	51.70536	28			
Total	121161.6		35			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	17.41	18.48	0.0149	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.989	0.9166	0.9717	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
4.55	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	0.0%
11.4		4	152.5	138	167	153.5	141	162	4.555	5.97%	0.16%
18.7		4	132.8	125.1	140.4	133	127	138	2.394	3.61%	13.09%
31.6		4	132.8	119.7	145.8	134	123	140	4.09	6.16%	13.09%
60.4		4	93.5	83.23	103.8	93.5	87	100	3.227	6.9%	38.79%
115		4	39.25	32.58	45.92	38.5	35	45	2.097	10.68%	74.3%
224		4	19	15.56	22.44	19.5	16	21	1.08	11.37%	87.56%
461		4	4	2.701	5.299	4	3	5	0.4082	20.41%	97.38%

Analyst: MLT QA: JCle Dec. 8/17

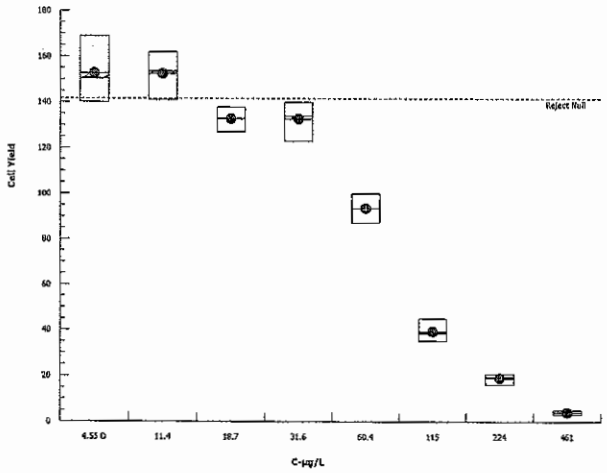
EC Alga Growth Inhibition Test — **Nautilus Environmental**

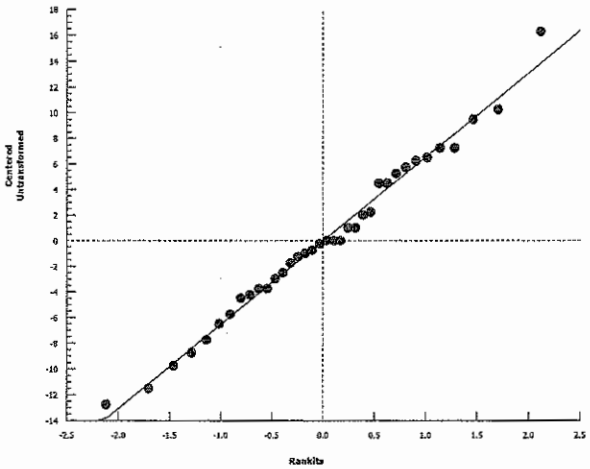
Analysis ID:	12-5267-1525	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.55	Dilution Water	140	169	160	149	144	152	145	163
11.4		162	141	150	157				
18.7		135	138	127	131				
31.6		140	139	129	123				
60.4		89	100	98	87				
115		39	35	38	45				
224		16	20	19	21				
461		4	3	4	5				

Graphics





EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-2717-2239	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	25.6%	Fails cell yield

Unequal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		4.55*	33.58	1.895	7.059	7	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.5634	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	62625.06	62625.06	1	1128	<0.0001	Significant Effect
Error	777.375	55.52679	14			
Total	63402.44		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	17.56	8.885	0.0012	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.9637	0.8408	0.7300	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	26.5	25	32	0.8647	8.85%	0.0%
4.55	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	-452.9%

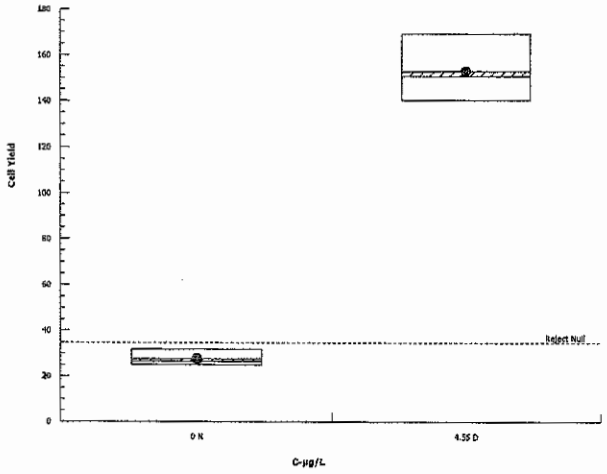
Cell Yield Detail

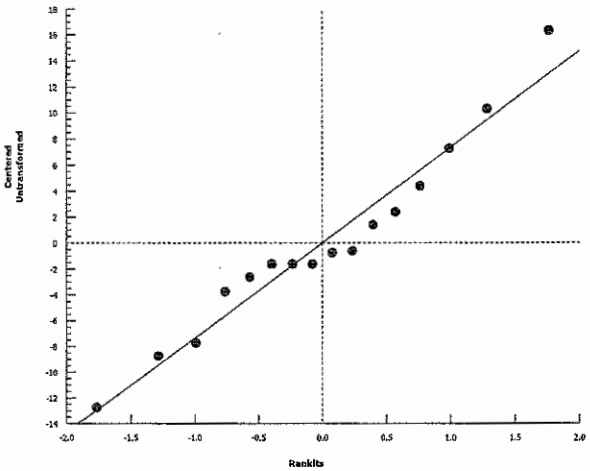
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
4.55	Dilution Water	140	169	160	149	144	152	145	163

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-2717-2239	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





APPENDIX B – Analytical Chemistry

LORAX ENVIRONMENTAL SERVICES
ATTN: Robert Goldblatt
2289 Burrard Street
Vancouver BC V6J 3H9

Date Received: 03-NOV-17
Report Date: 21-NOV-17 14:38 (MT)
Version: FINAL

Client Phone: 604-688-7173

Certificate of Analysis

Lab Work Order #: L2018129
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Shane Stack
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-1	L2018129-2	L2018129-3	L2018129-4	L2018129-5
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONTROL	P. SUB LAB WATER CONCENTRATION 1	P. SUB LAB WATER CONCENTRATION 2	P. SUB LAB WATER CONCENTRATION 3	P. SUB LAB WATER CONCENTRATION 4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	53.0				
	Hardness (as CaCO3) (mg/L)	8.91	8.85	9.20	9.28	8.99
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	5.8				
	Ammonia, Total (as N) (mg/L)	<0.0050				
	Chloride (Cl) (mg/L)	3.54				
	Nitrate (as N) (mg/L)	2.66				
	Nitrite (as N) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	0.106				
	Sulfate (SO4) (mg/L)	3.44				
Total Metals	Aluminum (Al)-Total (mg/L)	0.0031	<0.0030	<0.0030	0.0030	<0.0030
	Antimony (Sb)-Total (mg/L)	<0.00010	0.00847	0.0128	0.0200	0.0373
	Arsenic (As)-Total (mg/L)	<0.00010	0.00350	0.00709	0.0139	0.0284
	Barium (Ba)-Total (mg/L)	0.00295	0.00273	0.00264	0.00268	0.00264
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.030	0.028	0.029	0.029	0.030
	Cadmium (Cd)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000058
	Calcium (Ca)-Total (mg/L)	0.852	0.800	0.814	0.795	0.803
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00022	0.00022	0.00021	0.00022	0.00022
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000056
	Lithium (Li)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Magnesium (Mg)-Total (mg/L)	1.62	1.56	1.66	1.74	1.77
	Manganese (Mn)-Total (mg/L)	0.0685	0.0650	0.0674	0.0675	0.0701
	Molybdenum (Mo)-Total (mg/L)	0.00175	0.00185	0.00190	0.00185	0.00180
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Total (mg/L)	0.31	0.31	0.32	0.31	0.32
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	6.5	6.2	6.5	6.4	6.6
	Strontium (Sr)-Total (mg/L)	0.00066	0.00039	0.00034	0.00040	0.00036
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-6	L2018129-7	L2018129-8	L2018129-9	L2018129-10
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONCENTRATION 5	P. SUB LAB WATER CONCENTRATION 6	P. SUB LAB WATER CONCENTRATION 7	P. SUB LAB WATER CONCENTRATION 8	P. SUB BJ3.10 SITE WATER CONTROL
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)					236
	Hardness (as CaCO3) (mg/L)	8.81	8.98	9.18	8.85	69.1
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					51.8
	Ammonia, Total (as N) (mg/L)					0.251
	Chloride (Cl) (mg/L)					4.32
	Nitrate (as N) (mg/L)					6.38
	Nitrite (as N) (mg/L)					0.0111
	Phosphorus (P)-Total (mg/L)					0.118
	Sulfate (SO4) (mg/L)					34.9
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030	0.0075	<0.0030	<0.0030	0.0277
	Antimony (Sb)-Total (mg/L)	0.0766	0.146	0.291	0.593	0.00617
	Arsenic (As)-Total (mg/L)	0.0562	0.110	0.220	0.441	0.00455
	Barium (Ba)-Total (mg/L)	0.00279	0.00324	0.00339	0.00452	0.0552
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.030	0.032	0.031	0.028	0.068
	Cadmium (Cd)-Total (mg/L)	0.0000091	0.0000144	<0.0000050	<0.0000050	0.0000110
	Calcium (Ca)-Total (mg/L)	0.815	0.889	0.804	0.806	24.4
	Chromium (Cr)-Total (mg/L)	<0.00010	0.00012	<0.00010	<0.00010	0.00010
	Cobalt (Co)-Total (mg/L)	0.00023	0.00021	0.00022	0.00022	0.00025
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	<0.030	0.038	<0.030	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	0.000094	0.000194	<0.000050	<0.000050	0.000055
	Lithium (Li)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0151
	Magnesium (Mg)-Total (mg/L)	1.77	1.59	1.64	1.66	2.57
	Manganese (Mn)-Total (mg/L)	0.0683	0.0689	0.0688	0.0691	0.0883
	Molybdenum (Mo)-Total (mg/L)	0.00183	0.00183	0.00183	0.00177	0.00287
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	3.8
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000454
	Silicon (Si)-Total (mg/L)	0.32	0.32	0.31	0.31	1.26
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	6.7	6.5	6.5	6.6	16.2
	Strontium (Sr)-Total (mg/L)	0.00035	0.00036	0.00035	0.00032	0.349
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-11	L2018129-12	L2018129-13	L2018129-14	L2018129-15
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 1	P. SUB BJ3.10 CONCENTRATION 2	P. SUB BJ3.10 CONCENTRATION 3	P. SUB BJ3.10 CONCENTRATION 4	P. SUB BJ3.10 CONCENTRATION 5
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)					
	Hardness (as CaCO3) (mg/L)	67.4	65.9	65.8	69.1	68.9
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					
	Ammonia, Total (as N) (mg/L)					
	Chloride (Cl) (mg/L)					
	Nitrate (as N) (mg/L)					
	Nitrite (as N) (mg/L)					
	Phosphorus (P)-Total (mg/L)					
	Sulfate (SO4) (mg/L)					
Total Metals	Aluminum (Al)-Total (mg/L)	0.0359	0.0308	0.0248	0.0284	0.0247
	Antimony (Sb)-Total (mg/L)	0.0141	0.0232	0.0394	0.0786	0.144
	Arsenic (As)-Total (mg/L)	0.0114	0.0187	0.0316	0.0604	0.115
	Barium (Ba)-Total (mg/L)	0.0567	0.0562	0.0546	0.0555	0.0567
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.067	0.066	0.068	0.068	0.067
	Cadmium (Cd)-Total (mg/L)	0.0000071	<0.0000050	0.0000097	0.0000097	0.0000107
	Calcium (Ca)-Total (mg/L)	23.6	22.8	23.0	23.6	23.3
	Chromium (Cr)-Total (mg/L)	0.00011	0.00010	<0.00010	<0.00010	0.00010
	Cobalt (Co)-Total (mg/L)	0.00026	0.00027	0.00025	0.00026	0.00025
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	0.000064	0.000064	0.000055	0.000057	0.000061
	Lithium (Li)-Total (mg/L)	0.0149	0.0147	0.0147	0.0161	0.0157
	Magnesium (Mg)-Total (mg/L)	2.66	2.69	2.58	2.73	2.51
	Manganese (Mn)-Total (mg/L)	0.0885	0.0910	0.0859	0.0870	0.0874
	Molybdenum (Mo)-Total (mg/L)	0.00292	0.00303	0.00294	0.00285	0.00290
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	3.9	3.8	3.7	3.8	3.8
	Selenium (Se)-Total (mg/L)	0.000438	0.000478	0.000401	0.000409	0.000424
	Silicon (Si)-Total (mg/L)	1.28	1.27	1.29	1.25	1.28
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	16.7	16.9	16.0	16.8	16.4
	Strontium (Sr)-Total (mg/L)	0.334	0.348	0.341	0.348	0.352
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-16	L2018129-17			
	Description					
	Sampled Date	02-NOV-17	02-NOV-17			
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 6	P. SUB BJ3.10 CONCENTRATION 7			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)					
	Hardness (as CaCO3) (mg/L)	68.8	69.9			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					
	Ammonia, Total (as N) (mg/L)					
	Chloride (Cl) (mg/L)					
	Nitrate (as N) (mg/L)					
	Nitrite (as N) (mg/L)					
	Phosphorus (P)-Total (mg/L)					
	Sulfate (SO4) (mg/L)					
Total Metals	Aluminum (Al)-Total (mg/L)	0.0271	0.0310			
	Antimony (Sb)-Total (mg/L)	0.289	0.573			
	Arsenic (As)-Total (mg/L)	0.224	0.461			
	Barium (Ba)-Total (mg/L)	0.0559	0.0599			
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050			
	Boron (B)-Total (mg/L)	0.068	0.067			
	Cadmium (Cd)-Total (mg/L)	0.0000121	0.0000086			
	Calcium (Ca)-Total (mg/L)	23.5	23.9			
	Chromium (Cr)-Total (mg/L)	0.00012	0.00011			
	Cobalt (Co)-Total (mg/L)	0.00026	0.00026			
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Lead (Pb)-Total (mg/L)	0.000063	0.000055			
	Lithium (Li)-Total (mg/L)	0.0150	0.0150			
	Magnesium (Mg)-Total (mg/L)	2.60	2.74			
	Manganese (Mn)-Total (mg/L)	0.0868	0.0895			
	Molybdenum (Mo)-Total (mg/L)	0.00292	0.00279			
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30			
	Potassium (K)-Total (mg/L)	3.9	4.1			
	Selenium (Se)-Total (mg/L)	0.000457	0.000454			
	Silicon (Si)-Total (mg/L)	1.28	1.28			
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Total (mg/L)	16.7	17.1			
	Strontium (Sr)-Total (mg/L)	0.348	0.341			
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010			
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-1	L2018129-2	L2018129-3	L2018129-4	L2018129-5
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONTROL	P. SUB LAB WATER CONCENTRATION 1	P. SUB LAB WATER CONCENTRATION 2	P. SUB LAB WATER CONCENTRATION 3	P. SUB LAB WATER CONCENTRATION 4
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	0.00618	0.00966	0.0167	0.0334
	Arsenic (As)-Dissolved (mg/L)	<0.00010	0.00392	0.00756	0.0149	0.0302
	Barium (Ba)-Dissolved (mg/L)	0.00310	0.00251	0.00264	0.00289	0.00310
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.024	0.024	0.025	0.025	0.025
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	0.764	0.759	0.776	0.787	0.768
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00022	0.00021	0.00021	0.00022	0.00022
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	1.70	1.69	1.76	1.78	1.72
	Manganese (Mn)-Dissolved (mg/L)	0.0721	0.0732	0.0728	0.0736	0.0742
	Molybdenum (Mo)-Dissolved (mg/L)	0.00156	0.00159	0.00159	0.00168	0.00169
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Dissolved (mg/L)	0.270	0.267	0.267	0.265	0.278
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	7.4	7.9	7.7	7.8	7.4
	Strontium (Sr)-Dissolved (mg/L)	0.00032	0.00039	0.00034	0.00041	0.00038
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0010	0.0012	0.0013	0.0013	0.0012

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-6	L2018129-7	L2018129-8	L2018129-9	L2018129-10
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONCENTRATION 5	P. SUB LAB WATER CONCENTRATION 6	P. SUB LAB WATER CONCENTRATION 7	P. SUB LAB WATER CONCENTRATION 8	P. SUB BJ3.10 SITE WATER CONTROL
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000480
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0038	0.0035	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	<0.0010	<0.0010	0.0012	0.0014	0.0291
	Antimony (Sb)-Dissolved (mg/L)	0.0637	0.125	0.239	0.483	0.00739
	Arsenic (As)-Dissolved (mg/L)	0.0572	0.116	0.224	0.445	0.00429
	Barium (Ba)-Dissolved (mg/L)	0.00284	0.00314	0.00342	0.00430	0.0570
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.027	0.028	0.027	0.027	0.062
	Cadmium (Cd)-Dissolved (mg/L)	0.0000116	0.0000188	<0.0000050	<0.0000050	0.0000127
	Calcium (Ca)-Dissolved (mg/L)	0.794	0.790	0.767	0.789	23.1
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00021	0.00022	0.00021	0.00021	0.00026
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	0.00022	0.00021	<0.00020
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	0.000083	0.000173	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0162
	Magnesium (Mg)-Dissolved (mg/L)	1.66	1.70	1.76	1.67	2.79
	Manganese (Mn)-Dissolved (mg/L)	0.0718	0.0724	0.0723	0.0717	0.0958
	Molybdenum (Mo)-Dissolved (mg/L)	0.00169	0.00171	0.00168	0.00166	0.00230
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	4.2
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000473
	Silicon (Si)-Dissolved (mg/L)	0.271	0.276	0.268	0.271	1.27
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	7.5	7.6	7.7	7.5	19.6
	Strontium (Sr)-Dissolved (mg/L)	0.00038	0.00035	0.00035	0.00036	0.379
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000044
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000374
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0014	0.0013	0.0014	0.0028	0.0015

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-11	L2018129-12	L2018129-13	L2018129-14	L2018129-15
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 1	P. SUB BJ3.10 CONCENTRATION 2	P. SUB BJ3.10 CONCENTRATION 3	P. SUB BJ3.10 CONCENTRATION 4	P. SUB BJ3.10 CONCENTRATION 5
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	0.000495	0.000475	0.000499	0.000472	0.000490
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0263	0.0262	0.0229	0.0276	0.0247
	Antimony (Sb)-Dissolved (mg/L)	0.0133	0.0196	0.0342	0.0630	0.113
	Arsenic (As)-Dissolved (mg/L)	0.0111	0.0179	0.0320	0.0598	0.115
	Barium (Ba)-Dissolved (mg/L)	0.0581	0.0565	0.0566	0.0560	0.0563
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.059	0.058	0.059	0.059	0.061
	Cadmium (Cd)-Dissolved (mg/L)	0.0000107	0.0000127	0.0000103	0.0000113	0.0000098
	Calcium (Ca)-Dissolved (mg/L)	22.6	22.1	22.0	23.3	23.2
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00024	0.00024	0.00025	0.00024	0.00024
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0172	0.0152	0.0157	0.0158	0.0165
	Magnesium (Mg)-Dissolved (mg/L)	2.65	2.57	2.64	2.65	2.63
	Manganese (Mn)-Dissolved (mg/L)	0.0919	0.0892	0.0915	0.0905	0.0909
	Molybdenum (Mo)-Dissolved (mg/L)	0.00222	0.00225	0.00226	0.00225	0.00221
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	4.1	3.9	4.0	4.0	4.2
	Selenium (Se)-Dissolved (mg/L)	0.000419	0.000427	0.000455	0.000416	0.000464
	Silicon (Si)-Dissolved (mg/L)	1.20	1.24	1.22	1.19	1.22
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	19.2	18.0	18.5	18.5	18.8
	Strontium (Sr)-Dissolved (mg/L)	0.363	0.361	0.367	0.366	0.355
	Thallium (Tl)-Dissolved (mg/L)	0.000043	0.000041	0.000042	0.000045	0.000043
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000373	0.000380	0.000378	0.000369	0.000387
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0017	0.0014	0.0013	0.0023	0.0018

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-16	L2018129-17			
	Description					
	Sampled Date	02-NOV-17	02-NOV-17			
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 6	P. SUB BJ3.10 CONCENTRATION 7			
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010			
	Uranium (U)-Total (mg/L)	0.000486	0.000474			
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050			
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030			
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD			
	Aluminum (Al)-Dissolved (mg/L)	0.0261	0.0293			
	Antimony (Sb)-Dissolved (mg/L)	0.238	0.466			
	Arsenic (As)-Dissolved (mg/L)	0.226	0.448			
	Barium (Ba)-Dissolved (mg/L)	0.0571	0.0568			
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050			
	Boron (B)-Dissolved (mg/L)	0.060	0.062			
	Cadmium (Cd)-Dissolved (mg/L)	0.0000122	0.0000119			
	Calcium (Ca)-Dissolved (mg/L)	23.3	23.6			
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010			
	Cobalt (Co)-Dissolved (mg/L)	0.00024	0.00025			
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020			
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030			
	Lead (Pb)-Dissolved (mg/L)	0.000056	0.000051			
	Lithium (Li)-Dissolved (mg/L)	0.0161	0.0160			
	Magnesium (Mg)-Dissolved (mg/L)	2.56	2.65			
	Manganese (Mn)-Dissolved (mg/L)	0.0901	0.0899			
	Molybdenum (Mo)-Dissolved (mg/L)	0.00234	0.00238			
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30			
	Potassium (K)-Dissolved (mg/L)	4.1	4.3			
	Selenium (Se)-Dissolved (mg/L)	0.000439	0.000427			
	Silicon (Si)-Dissolved (mg/L)	1.19	1.18			
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Dissolved (mg/L)	18.1	18.2			
	Strontium (Sr)-Dissolved (mg/L)	0.375	0.367			
	Thallium (Tl)-Dissolved (mg/L)	0.000043	0.000045			
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010			
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010			
	Uranium (U)-Dissolved (mg/L)	0.000385	0.000411			
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050			
	Zinc (Zn)-Dissolved (mg/L)	0.0021	0.0015			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Total	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Total	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Reference Information

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmer

L2018129-COFC

of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Lorax Environmental	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robert Goldblatt	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2289 Burrard Street	Email 1:	Robert.Goldblatt@lorax.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6J 3H9	Email 2:		○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-688-7173 Fax:	Email 3:		**Analysis Request**
Invoice To	Same as Report ? ☐ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☐ Yes ☐ No	Job #:		
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Tot. low level metals ICP+MS (P)	Diss. low level metals ICP+MS (F/P)	Conductivity	Hardness	Total Alkalinity	Chloride	Ammonia	Nitrite	Nitrate	Total Phosphorus	Sulphate		Number of Containers
	P. sub lab water control	02-Nov-17			X	X	X	X	X	X	X	X	X	X	X		3
	P. sub lab water concentration 1	02-Nov-17			X	X											2
	P. sub lab water concentration 2	02-Nov-17			X	X											2
	P. sub lab water concentration 3	02-Nov-17			X	X											2
	P. sub lab water concentration 4	02-Nov-17			X	X											2
	P. sub lab water concentration 5	02-Nov-17			X	X											2
	P. sub lab water concentration 6	02-Nov-17			X	X											2
	P. sub lab water concentration 7	02-Nov-17			X	X											2
	P. sub lab water concentration 8	02-Nov-17			X	X											2

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Mimi Tran	02-Nov-17		TP	NOV 3	20:35	12.8 °C				

ALS Environmental

Chain of Custody / Analytical Request Form

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COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Lorax Environmental	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robert Goldblatt	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2289 Burrard Street	Email 1: Robert. Goldblatt@lorax.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6J 3H9	Email 2:	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-688-7173 Fax:	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☐ Yes ☐ No	Job #:	
Company:		PO / AFE:	
Contact:		LSD:	
Address:			
Phone:	Fax:	Quote #:	
[redacted] Lab Work Order # [redacted] (lab use only)	[redacted]	ALS Contact:	Sampler:

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Tot. low level metals ICP+MS (P)	Diss. low level metals ICP+MS (F/P)	Conductivity	Hardness	Total Alkalinity	Chloride	Ammonia	Nitrite	Nitrate	Total Phosphorus	Sulphate		Number of Containers
[redacted]	P. sub BJ3.10 site water control	02-Nov-17			X	X	X	X	X	X	X	X	X	X	X		3
[redacted]	P. sub BJ3.10 concentration 1	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 2	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 3	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 4	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 5	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 6	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 7	02-Nov-17			X	X											2
[redacted]																	
[redacted]																	
[redacted]																	
[redacted]																	

L2018129-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwa... ...ommercial/AB Tier 1 - Natural, etc) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

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Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Mini Tran	02-Nov-17		TP	Nov 3	20:35	12.8 °C				

APPENDIX C – Chain-of-Custody Forms

Nautilus Environmental

Chain of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

WO# 171295

Sample Collection By:	DB/BDT	
	Report to:	**Invoice to:**
Company	Pretivm Resources Inc.	Same
Address	Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.	
City/Prov/Postal Code	Vancouver, BC V7X 1L4 Box 49334	
Contact	Max Holtby	
Phone	(604) 558-1784	
Email	mholtby@pretivm.com svanzalingen@pretivm.com	invoices@pretivm.com

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	# OF CONTAINERS	COMMENTS	Ceriodaphnia 3-brood test (100% only) (Chronic -	Daphnia Magna 48 hrs (100% only) (Acute -EPS1/RM/14)		Ceriodaphnia 3-brood test (with dilutions) (Chronic - EPS1/RM/21)	Daphnia Magna 48 hrs (with dilutions) (Acute -EPS1/RM/14)		Rainbow Trout 96 hrs (100% only) (Acute-EPS1/RM/13)	Algal Growth Inhibition Test (100% Only) (ESP 1/RM/25)	724 P Subcontracted Spiked BJ 3.10 testing			Receipt Temperature (°C)
1	① Weir at 3.10	30-Oct-17	15:09	Water	20L	1	Grab									X			8.8
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

PROJECT INFORMATION	SAMPLE RECEIPT		RELIQUINSHED BY (CLIENT)	RELIQUINSHED BY (COURIER)
Client:	**Total # Containers:**	1	**Signature:**	**Signature:**
P.O. No.: 20329B	**Good Condition?**	Y	**Print:** Darcie Blackall	**Print:**
Shipped Via:	**Matches Schedule?**	Y	**Company:** Pretivm	**Company:**
			Time/Date: October 30, 2017; 18:00	**Time/Date:**
				RECEIVED BY (LABORATORY)
			Signature:	**Signature:** NY
			Print:	**Print:** Nair Yamamoto
			Company:	**Company:** Nautilus Environmental
			Time/Date:	**Time/Date:** NOV 01/17 @ 14:50

SPECIAL INSTRUCTIONS/COMMENTS: Please cc report to environmental@pretivm.com, svanzalingen@pretivm.com, rmccall@pretivm.com, robert.goldblatt@lorax.ca. Attn: Mimi Tran & Krysta Pearcy. Please refer to the instructions provided by Robert Goldblatt.

Sample description: clear, colourless, odourless, no particulates

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

① client requested a ~~lab~~ MQ concurrent lab water test. Please see attached.

END OF REPORT

Toxicity testing on sample BJ 3.10 and laboratory water amended with antimony, arsenic and ammonia

Sample collected June 25, 2018

Final Report

July 20, 2018 (Revised July 24, 2018)

Submitted to: **Pretivm Resources Inc.**
Vancouver, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

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SIGNATURE PAGE

Report By:
Eric Cheung, B.Sc.
Laboratory Biologist

Reviewed By:
Armando Tang, R.P.Bio.
Senior Reviewer

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

Sample Information and Test Type

Sample ID and Treatment	BJ 3.10 (site water) and laboratory water amended with antimony (Sb), arsenic (As), or ammonia (NH_3-N)
Sample collection date	June 25, 2018 (BJ 3.10)
Sample receipt date	June 27, 2018 (BJ 3.10)
Sample and laboratory water Treatment amendment date	July 3, 2018 for *Pseudokirchneriella subcapitata* test and *Ceriodaphnia dubia* test
	July 4, 2018 for *Chironomus dilutus* test
Sample receipt temperature	13.6°C
Test types	72-h *Pseudokirchneriella subcapitata* growth inhibition
	10-d *Chironomus dilutus* survival and growth
	Ceriodaphnia dubia survival and reproduction

Summary of Results

Endpoints	µg/L (95% CL)			
	Site Water (BJ 3.10)		Laboratory Water	
	Sb	As	Sb	As
P. subcapitata				
Growth IC25	>1220	110.0 (99.3 – 119.8)	675.5 (627.7 – 713.6)	49.9 (6.4 – 59.3)
Growth IC50	>1220	200.5 (184.3 – 214.2)	854.6 (811.8 – 893.5)	94.0 (82.8 – 104.0)
NOEC	599	54.7	81.5	13.3
LOEC	1220	103	159	25.5

IC = Inhibition Concentration, CL = Confidence Limits,
NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

Endpoints	mg/L (95% CL)	
	Site Water (BJ 3.10) NH_3-N	Laboratory Water NH_3-N
C. dilutus		
Survival LC50	73.5 (65.4 – 82.7)	81.5 (62.4 – 106.4)
Growth IC25	>93.1	>97.0
Growth IC50	>93.1	>97.0
NOEC (survival, dry weight)	48.1, 48.1	50, 50
LOEC (survival, dry weight)	93.1, >48.1	97, >50

LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits,
NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

Endpoints	mg/L (95% CL)	
	Site Water (BJ 3.10) NH_3-N	Laboratory Water NH_3-N
C. dubia		
Survival LC50	33.9 (28.1 – 41.0)	34.7 (24.3 – 49.6)
Reproduction IC25	24.0 (18.3 - 25.9)	14.2 (11.3 - 15.6)
Reproduction IC50	30.4 (28.1 - 31.9)	18.8 (16.5 - 20.2)
NOEC (survival, reproduction)	23.9, 23.9	24.3, 12.3
LOEC (survival, reproduction)	48.4, >23.9	>24.3, 24.3

LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits
NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted toxicity tests for Pretivm Resources Inc. evaluating toxicity effects of antimony (Sb) and arsenic (As) on *Pseudokirchneriella subcapitata* and ammonia (NH_3-N) on *Chironomus dilutus* and *Ceriodaphnia dubia*. Site water BJ 3.10 was amended with a series of Sb, As, and NH_3-N concentrations, according to instructions provided by Pretivm Resources Inc. prior to testing. Concurrent tests using laboratory control water, amended to the same Sb, As and NH_4 concentrations as the site water, were also performed.

BJ 3.10 was collected on June 25, 2018 and delivered to the Nautilus Environmental laboratory in Burnaby, BC on June 27, 2018. The sample was transported in two 20-L plastic containers which were received at 13.6°C. The sample was stored in the dark at 4 ± 2°C prior to testing. The laboratory water was prepared in-house and was the same water used to culture the test species and/or used for testing at Nautilus Environmental. The following toxicity tests were performed:

- 72-h *Pseudokirchneriella subcapitata* growth inhibition
- 10-d *Chironomus dilutus* survival and growth
- *Ceriodaphnia dubia* survival and reproduction

Testing for *P. subcapitata* and *C. dubia* was initiated on July 3, 2018, and testing for *C. dilutus* was initiated on July 4, 2018. This report describes the results of these toxicity tests. Copies of raw laboratory data sheets and statistical analyses for each test species are provided in Appendices A to C. The analytical chemistry and chain-of-custody form are provided in Appendix D and E respectively.

2.0 METHODS

Methods for the toxicity tests are summarized in Tables 4 to 6. Testing for *P. subcapitata* and *C. dubia* was conducted according to procedures described by Environment Canada (2007a and 2007b). For the *C. dubia* test, BJ 3.10 was hardness-adjusted to match the hardness of the laboratory control water and was used as site-control and dilution water. Testing for *C. dilutus* was conducted according to procedures described by Environmental Canada (1997) with the following modifications: i) 200 mL of test solution was used in each replicate; ii) four replicates were used in each concentration; iii) total ammonia of overlying water was only measured at test initiation; iv) a pinch of clean sand was added into each test jar as substrate.

The Sb-, As- and NH_3-N-amended BJ 3.10 and laboratory water test solutions were prepared at the Nautilus Environmental laboratory. Analytical results were reported to Nautilus Environmental for inclusion in the final report. Tables 1 to 3 provide a summary of the nominal and total measured arsenic, antimony and ammonia concentrations. The total measured concentrations of Sb, As and NH_3-N were used to estimate LC50, IC25, IC50, NOEC and LOEC values. Statistical analyses for all the tests were performed using CETIS (Tidepool Scientific Software, 2013). Tests performed in site water used site water as the control value and tests performed in laboratory water used lab water as the control value for statistical analysis.

Table 1 Nominal and total measured Sb and As concentrations in laboratory water and site water BJ 3.10 for the 72-h *Pseudokirchneriella subcapitata* growth inhibition test.

Test Treatment	µg/L Sb		µg/L As	
	Nominal	Total Measured	Nominal	Total Measured
Laboratory Water				
Laboratory Control	0	<0.10	0	<0.10
Concentration 1	9	10.9	3	3.4
Concentration 2	18	21.1	6	6.7
Concentration 3	36	41.9	12	13.3
Concentration 4	72	81.5	24	25.5
Concentration 5	144	159	48	49.6
Concentration 6	288	321	96	99.3
Concentration 7	576	631	192	196
Concentration 8	1152	1230	384	386
BJ 3.10				
BJ 3.10	0	8.37	0	4.36
Concentration 1	9	16.2	3	7.78
Concentration 2	18	26.0	6	10.9
Concentration 3	36	44.4	12	17.5
Concentration 4	72	81.5	24	29.9
Concentration 5	144	158	48	54.7
Concentration 6	288	307	96	103
Concentration 7	576	599	192	199
Concentration 8	1152	1220	384	395

Table 2 Nominal and total measured NH_3-N concentrations in laboratory water and site water BJ 3.10 for the 10-d *Chironomus dilutus* survival and growth test.

Test Treatment	mg/L NH_3-N	
	Nominal	Total Measured
Laboratory Water		
Laboratory Control	0	0.0053
Concentration 1	2	1.48
Concentration 2	4	3.08
Concentration 3	8	6.7
Concentration 4	16	13.3
Concentration 5	32	25.3
Concentration 6	64	50.0
Concentration 7	128	97.0
BJ 3.10		
BJ 3.10	0	0.0099
Concentration 1	2	1.25
Concentration 2	4	2.52
Concentration 3	8	5.15
Concentration 4	16	10.2
Concentration 5	32	20.9
Concentration 6	64	48.1
Concentration 7	128	93.1

Table 3 Nominal and total measured NH_3-N concentrations in laboratory water and site water BJ 3.10 for the *Ceriodaphnia dubia* survival and reproduction test.

Test Treatment	mg/L NH_3-N	
	Nominal	Total Measured
Laboratory Water		
Laboratory Control	0	NT
Concentration 1	2	1.58
Concentration 2	4	3.11
Concentration 3	8	6.06
Concentration 4	16	12.3
Concentration 5	32	24.3
Concentration 6	64	49.6
Concentration 7	128	98.7
BJ 3.10		
BJ 3.10	0	0.01
Concentration 1	2	1.97
Concentration 2	4	2.99
Concentration 3	8	5.81
Concentration 4	16	11.8
Concentration 5	32	23.9
Concentration 6	64	48.4
Concentration 7	128	93.6

NT= Not Tested

Table 4. Summary of test conditions: *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain CPCC# 37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	Eight concentrations, plus laboratory control/site control (BJ 3.10)
Test replicates	4 per treatment; 8 for laboratory control
Number of organisms	10,000 cells/mL
Control/dilution water	Deionized water supplemented with nutrients/site control (BJ 3.10)
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature and pH measured at test initiation; pH of two control wells measured at test termination
Test protocol	Environment Canada (2007a), EPS 1/RM/25
Statistical software	CETIS Version 1.8.7
Test endpoints	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnSO_4$)

Table 5. Summary of test conditions: *Chironomus dilutus* survival and growth test.

Test species	*Chironomus dilutus*
Organism source	Aquatic BioSystems, Fort Collins, CO
Organism age	Third instar
Test type	Static
Test duration	10 days
Test vessel	375-mL glass container
Test volume	200 mL overlying water
Test replicates	4 replicates per concentration
Number of organisms	10 per replicate
Control/dilution water	Reconstituted moderately-hard water/site control (BJ 3.10)
Test solution renewal	None
Test temperature	23 ± 1°C
Feeding	6 mg of Tetramin per replicate daily
Light intensity	500 to 1000 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	Continuous gentle aeration
Test measurements	Temperature, dissolved oxygen, pH and conductivity of overlying water measured daily; hardness and alkalinity at test initiation and termination; total ammonia of overlying water measured at test initiation
Test protocol	Environment Canada (1997), EPS 1/RM/32
Statistical software	CETIS Version 1.8.7
Test endpoints	Survival and dry weight
Test acceptability criteria for controls	≥70% survival and ≥0.6 mg/worm dry weight
Reference toxicant	Potassium chloride (KCl)

Table 6. Summary of test conditions: *Ceriodaphnia dubia* survival and reproduction test.

Test species	*Ceriodaphnia dubia*
Organism source	In-house culture
Organism age	<24 hour old neonates, produced within a 12 hour window
Test type	Static-renewal
Test duration	7 ± 1 day
Test vessel	20-mL glass test tube
Test volume	15 mL
Test solution depth	10 cm
Test concentrations	Seven concentrations, plus laboratory control/site control (BJ 3.10)
Test replicates	10 per treatment
Number of organisms	1 per replicate
Control/dilution water	Laboratory water: 20% Perrier water and 80% deionized water + 5 µg/L Se and 2 µg/L vitamin B1 Site water (BJ 3.10): hardness adjusted to match the hardness of the laboratory water
Test solution renewal	Daily (100% renewal)
Test temperature	25 ± 1°C
Feeding	Daily with *Pseudokirchneriella subcapitata* and YCT (3:1 ratio)
Light intensity	100 to 600 lux at water surface
Photoperiod	16 hours light / 8 hours dark
Aeration	None
Test measurements	Temperature, dissolved oxygen, pH and conductivity measured daily; hardness and alkalinity of undiluted sample measured at test initiation; survival and reproduction checked daily
Test protocol	Environment Canada (2007b), EPS 1/RM/21
Statistical software	CETIS Version 1.8.7
Test endpoints	Survival and reproduction
Test acceptability criteria for controls	≥80% survival; ≥15 young per surviving control producing three broods; ≥60% of controls producing three or more broods; no ephippia present
Reference toxicant	Sodium chloride (NaCl)

3.0 RESULTS

Results of the toxicity tests are summarized in Tables 7 to 10.

In the *P. subcapitata* growth inhibition test with Sb (Table 7), inhibitory effects on cell yield were observed in the site water. The NOEC and LOEC were 599 and 1220 µg/L Sb, respectively; the IC25 and IC50 were >1220 µg/L Sb. Inhibitory effects were observed on cell yield in laboratory water. The IC25 and IC50 for cell yield were 675.5 and 854.6 µg/L Sb, respectively. The NOEC and LOEC on cell yield were 81.5 and 159.0 µg/L Sb in laboratory water, respectively.

In the *P. subcapitata* growth inhibition test with As (Table 8), inhibitory effects on cell yield were observed in site water. The IC25 and IC50 for cell yield were 110.0 and 200.5 µg/L As, respectively. The NOEC and LOEC on cell yield were 54.7 and 103.0 µg/L As. In the laboratory water, inhibitory effects on cell yield were also observed. The IC25 and IC50 for cell yield were 49.9 and 94.0 µg/L As, respectively. The NOEC and LOEC on cell yield were 13.3 and 25.5 µg/L As, respectively.

In the *C. dilutus* survival and growth test with NH_3-N (Table 9), adverse effects were observed on survival in both the site water and laboratory water, which resulted in an LC50 of 73.5 and 81.5 mg/L NH_3-N, respectively. The NOEC and LOEC for survival were 48.1 and 93.1 mg/L NH_3-N in site water and 50 and 97 mg/L NH_3-N in laboratory water, respectively. There were no adverse effects observed on dry weight in neither the laboratory water nor the site water. The NOEC and LOEC for dry weight were 48.1 and >48.1 mg/L NH_3-N in site water and 50.0 and >50.0 mg/L NH_3-N in laboratory water, respectively.

In the *C. dubia* survival and growth test with NH_3-N (Table 10), adverse effects were observed on survival and reproduction in both the laboratory water and the site water. In the site water, the LC50 was estimated to be 33.9 mg/L NH_3-N, and the IC25 and IC50 were estimated to be 24.0 and 30.4 mg/L NH_3-N, respectively. The NOEC and LOEC on survival were 23.9 and 48.4 mg/L NH_3-N, and on reproduction were 23.9 and >23.9 mg/L NH_3-N, respectively. In the laboratory water, the LC50 was estimated to be 34.7 mg/L NH_3-N, and the IC25 and IC50 were estimated to be 14.2 and 18.8 mg/L NH_3-N, respectively. The NOEC and LOEC on survival were 24.3 and >24.3 mg/L NH_3-N, and on reproduction were 12.3 and 24.3 mg/L NH_3-N, respectively.

Table 7 Results: *Pseudokirchneriella subcapitata* growth inhibition test with Sb.

Total measured Sb (µg/L)	Site Water (BJ 3.10) Cell Yield (x 10^4 cells/mL) (Mean ± SD)	Total measured Sb (µg/L)	Laboratory water Cell Yield (x 10^4 cells/mL) (Mean ± SD)
<0.10 (Lab control)	29.1 ± 2.0	0	28.9 ± 2.0
8.37 (un-amended BJ 3.10)	147.8 ± 8.3	10.9	27.2 ± 1.3
16.2	146.0 ± 5.7	21.1	28.8 ± 2.8
26.0	151.8 ± 6.9	41.9	27.5 ± 1.3
44.4	153.3 ± 4.3	81.5	27.8 ± 1.7
81.5	155.8 ± 7.0	159	25.5 ± 1.7
158	155.5 ± 13.2	321	25.0 ± 1.4
307	136.3 ± 2.2	631	23.8 ± 1.3
599	138.3 ± 8.6	1230	3.2 ± 1.0
1220	119.8 ± 6.8	--	--
Test endpoint (µg/L)		**Test endpoint (µg/L)**	
IC25	>1220	IC25 (95% CL)	675.5 (627.7 – 713.6)
IC50	>1220	IC50 (95% CL)	854.6 (811.8 – 893.5)
NOEC	599	NOEC	81.5
LOEC	1220	LOEC	159

SD = Standard Deviation, IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

Table 8 Results: *Pseudokirchneriella subcapitata* growth inhibition test with As.

Total measured As (µg/L)	Site Water (BJ 3.10) Cell Yield (x 10^4 cells/mL) (Mean ± SD)	Total measured As (µg/L)	Laboratory water Cell Yield (x 10^4 cells/mL) (Mean ± SD)
<0.10 (Lab control)	28.0 ± 1.3	<0.10	28.8 ± 1.4
4.36 (unamended BJ 3.10)	141.4 ± 4.1	3.4	28.8 ± 1.7
7.78	145.3 ± 4.8	6.7	27.8 ± 2.4
10.9	150.5 ± 5.4	13.3	29.0 ± 2.4
17.5	141.3 ± 4.6	25.5	21.0 ± 2.2
29.9	132.3 ± 8.5	49.6	22.2 ± 2.5
54.7	135.8 ± 5.0	99.3	13.8 ± 1.0
103	113.3 ± 4.3	196	9.5 ± 1.3
199	73.2 ± 2.9	386	6.8 ± 1.3
395	37.5 ± 5.4	--	--
Test endpoint (µg/L)		**Test endpoint (µg/L)**	
IC25 (95% CL)	110.0 (99.3 – 119.8)	IC25 (95% CL)	49.9 (6.4 – 59.3)
IC50 (95% CL)	200.5 (184.3 – 214.2)	IC50 (95% CL)	94.0 (82.8 – 104.0)
NOEC	54.7	NOEC	13.3
LOEC	103	LOEC	25.5

SD = Standard Deviation, IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

Table 9. Results: *Chironomus dilutus* survival and growth test with NH_3-N.

Total measured NH_3-N (mg/L)	Site Water (BJ 3.10)		Total measured NH_3-N (mg/L)	Laboratory water	
	Survival (%) (Mean ± SD)	Dry weight (mg) (Mean ± SD)		Survival (%) (Mean ± SD)	Dry weight (mg) (Mean ± SD)
<0.01	92.5 ± 9.6	1.56 ± 0.28	<0.01	77.5 ± 5.0	2.08 ± 0.19
1.25	87.5 ± 12.6	1.90 ± 0.12	1.48	82.5 ± 9.6	2.24 ± 0.23
2.52	80.0 ± 14.1	2.28 ± 0.53	3.08	87.5 ± 9.6	2.31 ± 0.55
5.15	90.0 ± 11.6	2.17 ± 0.33	6.7	85.0 ± 5.8	2.52 ± 0.43
10.2	77.5 ± 5.0	2.04 ± 0.15	13.3	77.5 ± 5.0	2.67 ± 0.47
20.9	90.0 ± 8.2	2.15 ± 0.25	25.3	65.0 ± 12.9	2.37 ± 0.19
48.1	80.0 ± 14.1	2.19 ± 0.56	50.0	60.0 ± 8.2	2.76 ± 0.60
93.1	27.5 ± 22.2	2.99 ± 0.83	97.0	35.0 ± 31.1	2.49 ± 0.47
Test endpoint (mg/L NH_3-N)			**Test endpoint (mg/L NH_3-N)**		
LC50 (95% CL)	73.5 (65.4 – 82.7)	--	LC50 (95% CL)	81.5 (62.4 – 106.4)	--
IC25	--	>93.1	IC25 (95% CL)	--	>97
IC50	--	>93.1	IC50 (95% CL)	--	>97
NOEC	48.1	48.1	NOEC	50	50
LOEC	93.1	>48.1	LOEC	97	>50

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

Table 10. Results: *Ceriodaphnia dubia* survival and reproduction test with NH_3-N.

Total measured NH_3-N (mg/L)	Site Water (BJ 3.10)		Total measured NH_3-N (mg/L)	Laboratory water	
	Survival (%)	Reproduction (Mean ± SD)		Survival (%)	Reproduction (Mean ± SD)
NT (Lab control)	90.0	17.4 ± 2.6	NT	90.0	17.4 ± 2.6
0.01(Un-amended BJ 3.10)	100	18.3 ± 3.7	1.58	90.0	17.0 ± 3.8
1.97	100	20.3 ± 3.4	3.11	90.0	17.9 ± 6.4
2.99	100	20.3 ± 5.1	6.06	100	19.7 ± 1.9
5.81	100	19.6 ± 4.4	12.3	90.0	15.8 ± 4.3
11.8	90.0	19.6 ± 4.1	24.3	100	4.8 ± 2.5
23.9	100	14.8 ± 3.6	49.6	0.0	0.0 ± 0.0
48.4	10.0	0.0 ± 0.0	98.7	0.0	0.0 ± 0.0
93.6	0.0	0.0 ± 0.0	--	--	--
Test endpoint (mg/L NH_3-N)			**Test endpoint (mg/L NH_3-N)**		
LC50 (95% CL)	33.9 (28.1 – 41.0)	--	LC50 (95% CL)	34.7 (24.3 – 49.6)	--
IC25 (95% CL)	--	24.0 (18.3 – 25.9)	IC25 (95% CL)	--	14.2 (11.3 – 15.6)
IC50 (95% CL)	--	30.4 (28.1 – 31.9)	IC50 (95% CL)	--	18.8 (16.5 – 20.2)
NOEC	23.9	23.9	NOEC	24.3	12.3
LOEC	48.4	>23.9	LOEC	>24.3	24.3

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, N/T= Not Tested

4.0 QA/QC

The health history of the test organisms used in the exposure was acceptable and met the requirements of the Environment Canada protocols. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. There were no deviations from the test methodology except that the testing with all species was initiated outside of the three day holding time. In addition, the *C. dilutus* test was conducted in water only, instead of sediment, following the procedures described in the Methods section.

Uncertainty associated with the tests are best described by the standard deviation around the mean and/or the confidence intervals around the point estimates. Results of the reference toxicant tests conducted during the testing program are summarized in Table 11. Results for these tests fell within the range for organism performance of the mean and two standard deviations, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in these tests was appropriate. The reference toxicant tests were performed under the same conditions as those used for the sample.

Table 11. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
P. subcapitata	Growth (IC50): 34.1 µg/L Zn	31.4 (26.1 – 37.8)	10	June 29, 2018
C. dilutus	Survival (LC50): 6.6 g/L KCl	5.1 (2.8 – 9.1)	34	July 4, 2018
C. dubia	Survival (LC50): 2.1 g/L NaCl	2.0 (1.8 – 2.3)	6	July 4, 2018
	Reproduction (IC50): 1.4 g/L NaCl	1.3 (0.8 – 1.9)	24	

SD = Standard Deviation, CV = Coefficient of Variation, LC = Lethal Concentration, IC = Inhibition Concentration

5.0 REFERENCES

Environment Canada. 1997. Biological test method: test for survival and growth in sediment using the larvae of freshwater midges (*Chironomus tentans* and *Chrironomus riparius*). Environmental Protection Series EPS 1/RM/32. December 1997. Environment Canada, Method Development and Application Section, Environmental Technology Centre, Ottawa, ON. 131 pp.

Environment Canada. 2007a. Biological test method: growth inhibition test using the freshwater alga. Environmental Protection Series, Report EPS 1/RM/25, Second Edition, March 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 53 pp.

Environment Canada. 2007b. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. Environmental Protection Series, Report EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 74 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.4.29 Tidepool Scientific Software, McKinleyville, CA. 222 pp.

APPENDIX A – *Pseudokirchneriella subcapitata* Toxicity Test Data

Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax (Pretium)
Work Order No.: 181047

Start Date: July 03/18
Set up by: MLT

Sample Information:

Sample ID: BJ 3.10 amended with Sb
Sample Date: June 25/18
Date Received: June 27/18
Sample Volume: 1x20L.

Test Organism Information:

Culture Date: June 29/18
Age of culture (Day 0): 4d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC171
Stock Solution ID: 18Zn01
Date Initiated: June 29/18

72-h IC50 (95% CL): 34.1 (29.4-37.0) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 31.4 (26.1-37.8) µg/L Zn CV (%): 10

Test Results:

µg/L Sb	Algal Growth
IC25 ~~%(v/v)~~ mg/L (95% CL)	>1220
IC50 ~~%(v/v)~~ mg/L (95% CL)	>1220
NOEC	599
LOEC	1220

Reviewed by: JGu

Date reviewed: July 17/18

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax (Pretium) Setup by: MG

Sample ID: BJ 3.10 amended with Sb Test Date/Time: July 3/18 @ 1700h

Work Order No.: 181047 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: June 29/18 Age of Culture: 4d Culture Health: Good

Culture Count: 1 250 2 225 Average: 237.5 Culture Cell Density (c1): 237.5 x10⁴ cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 237.5x10⁴ cells/ml = 9.26mL

Time Zero Counts: 1 21 2 22 Average: 21.5

No. of Cells/mL: 21.5x10⁴ Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9773 cells/mL

Concentration ~~%(v/v) MG~~ ug/L Sb	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	7.0	24.0	25.0	25.0	25.0	25.0	✓	✓	✓	✓
BJ 3.10 (site control)	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
9	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
18	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
36	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
72	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
144	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
288	7.7	24.0	↓	↓	↓	↓	✓	✓	✓	✓
576	7.6	24.0	↓	↓	↓	↓	✓	✓	✓	✓
1152	7.0	24.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG

Initial control pH: Well 1: 7.0 Well 2: 7.0

Final control pH: Well 1: 7.8 Well 2: 7.8

Light intensity (lux): 4150 Date measured: July 3/18

Thermometer: 4 Light meter: 1 pH meter/probe: 1 / 1

Sample Description: clear, colourless, odourless, no particulates

Comments:

Reviewed: [illegible] Date reviewed: July 17/18

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Borax (Pretium) Start Date/Time: July 3/18 @ 1700h
Work Order #: 181049 Termination Date: July 6/18 @ 1700h
Sample ID: BJ 3,10 Test set up by: MG
µg/L Sb ~~%(v/v)~~ amended with Sb

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	31					MG
	B	32					
	C	27					
	D	30					
	E	31					
	F	28					
	G	29					
	H	33					
BJ 3,10 (site)	A	160					
	B	~~150~~ MG 150					
	C	154					
	D	142					
	~~E A~~	~~159~~ MG 159					
	~~F B~~	144					
	~~G C~~	138					
	~~H D~~	143					
9	A	145					
	B	150					
	C	153					
	D	140					
18	A	151					
	B	160					
	C	156					
	D	144					
36	A	156					
	B	148					
	C	155					
	D	158					
72	A	151					
	B	154					
	C	155					
	D	167					
144	A	140					
	B	155					
	C	159					
	D	172					

Comments:

Reviewed by: JGh Date Reviewed: July 17/18

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Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax (Pretium) Start Date/Time: July 3/18 @ 1700h
Work Order #: 181047 Termination Date: July 6/18 @ 1700h
Sample ID: BJ 3.10 Test set up by: MG
mg/L Sb ~~%(v/v)~~ amended with Sb

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
288	A	136					MG
	B	135					
	C	140					
	D	138					
576	A	138					
	B	129					
	C	150					
	D	140					
1152	A	116					
	B	114					
	C	125					
	D	128					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JGh Date Reviewed: July 17/18

CETIS Summary Report

Report Date:	16 Jul-18 16:58 (p 1 of 1)
Test Code:	181047c | 12-8067-6653

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	08-0214-5895	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 17:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
21-3321-6323	Cell Yield	<8.37	8.37	NA	19.6%		Unequal Variance t Two-Sample Test
02-5217-1502	Cell Yield	599	1220	854.9	8.14%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
14-7822-0266	Cell Yield	IC5	224.1	147.7	262		Linear Interpolation (ICPIN)
		IC10	617.6	68.62	758.4		
		IC15	840.6	577	1087		
		IC20	1144	804.1	N/A		
		IC25	>1220	N/A	N/A		
		IC40	>1220	N/A	N/A		
		IC50	>1220	N/A	N/A		

Cell Yield Summary

C-µg/L Sb	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	29.13	27.43	30.82	26	32	0.7181	2.031	6.97%	0.0%
8.37	Site Control	8	147.8	140.8	154.7	137	159	2.92	8.259	5.59%	-407.3%
16.2		4	146	136.9	155.1	139	152	2.858	5.715	3.92%	-401.3%
26		4	151.8	140.8	162.7	143	159	3.449	6.898	4.55%	-421.0%
44.4		4	153.3	146.3	160.2	147	157	2.175	4.349	2.84%	-426.2%
81.5		4	155.8	144.5	167	150	166	3.521	7.042	4.52%	-434.8%
158		4	155.5	134.5	176.5	139	171	6.589	13.18	8.48%	-433.9%
307		4	136.3	132.7	139.8	134	139	1.109	2.217	1.63%	-367.8%
599		4	138.3	124.5	152	128	149	4.308	8.617	6.23%	-374.7%
1220		4	119.8	108.9	130.6	113	127	3.4	6.801	5.68%	-311.2%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	31	26	29	30	27	28	32
8.37	Site Control	159	149	153	141	158	143	137	142
16.2		144	149	152	139				
26		150	159	155	143				
44.4		155	147	154	157				
81.5		150	153	154	166				
158		139	154	158	171				
307		135	134	139	137				
599		137	128	149	139				
1220		115	113	124	127				

① site water BJ 3.10 amended with Sb.
Negative control = Lab water
site control = BJ 3.10

Pseudokirchneriella subcapitata Algal Counts

Client: Lorax (Pretium)
WO#: 181047
Sample ID: BJ 3.10 amended with Sb

Start Date/Time: 3-Jul-18 @ 1700h
Termination Date/Time: 6-Jul-18 @ 1700h

Initial Cell Density: 9773 cell/mL

215000
0.22
0.01
9772.727

Concentration ug/L Sb	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	31				31	30.0	mean	29.1
	B	32				32	31.0	SD	2.03101
	C	27				27	26.0	CV	6.967986
	D	30				30	29.0		
	E	31				31	30.0		
	F	28				28	27.0		
	G	29				29	28.0		
	H	33				33	32.0		
8.37 ✓	A	160				160	159.0		
(BJ 3.10)	B	150				150	149.0		
(Site Control)	C	154				154	153.0		
	D	142				142	141.0		
	E	159				159	158.0		
	F	144				144	143.0		
	G	138				138	137.0		
	H	143				143	142.0		
16.2 ✓	A	145				145	144.0		
	B	150				150	149.0		
	C	153				153	152.0		
	D	140				140	139.0		
26 ✓	A	151				151	150.0		
	B	160				160	159.0		
	C	156				156	155.0		
	D	144				144	143.0		
44.4 ✓	A	156				156	155.0		
	B	148				148	147.0		
	C	155				155	154.0		
	D	158				158	157.0		
81.5 ✓	A	151				151	150.0		
	B	154				154	153.0		
	C	155				155	154.0		
	D	167				167	166.0		
158 ✓	A	140				140	139.0		
	B	155				155	154.0		
	C	159				159	158.0		
	D	172				172	171.0		

Reviewed by: JGh

Date reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client: Lorax (Pretium)
WO#: 181047
Sample ID: BJ 3.10 amended with Sb

Start Date/Time: 3-Jul-18 @ 1700h
Termination Date/Time: 6-Jul-18 @ 1700h

Initial Cell Density: 9773 cell/mL

215000
0.22
0.01
9772.727

Concentration ug/L Sb	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A					#DIV/0!	#DIV/0!	mean	#DIV/0!
	B					#DIV/0!	#DIV/0!	SD	#DIV/0!
	C					#DIV/0!	#DIV/0!	CV	#DIV/0!
	D					#DIV/0!	#DIV/0!		
	E					#DIV/0!	#DIV/0!		
	F					#DIV/0!	#DIV/0!		
	G					#DIV/0!	#DIV/0!		
	H					#DIV/0!	#DIV/0!		
307 ✓	A	136				136	135.0		
	B	135				135	134.0		
	C	140				140	139.0		
	D	138				138	137.0		
599 ✓	A	138				138	137.0		
	B	129				129	128.0		
	C	150				150	149.0		
	D	140				140	139.0		
1220 ✓	A	116				116	115.0		
	B	114				114	113.0		
	C	125				125	124.0		
	D	128				128	127.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: [illegible]

Date reviewed: July 17/18

CETIS Analytical Report

Report Date:	16 Jul-18 16:58 (p 1 of 2)
Test Code:	181047c | 12-8067-6653

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	14-7822-0266	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:57	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	08-0214-5895	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 17:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1062551	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.1087	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	224.1	147.7	262
IC10	617.6	68.62	758.4
IC15	840.6	577	1087
IC20	1144	804.1	N/A
IC25	>1220	N/A	N/A
IC40	>1220	N/A	N/A
IC50	>1220	N/A	N/A

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
8.37	Site Control	8	147.8	137	159	2.92	8.259	5.59%	0.0%
16.2		4	146	139	152	2.858	5.715	3.92%	1.18%
26		4	151.8	143	159	3.449	6.898	4.55%	-2.71%
44.4		4	153.3	147	157	2.175	4.349	2.84%	-3.72%
81.5		4	155.8	150	166	3.521	7.042	4.52%	-5.42%
158		4	155.5	139	171	6.589	13.18	8.48%	-5.25%
307		4	136.3	134	139	1.109	2.217	1.63%	7.78%
599		4	138.3	128	149	4.308	8.617	6.23%	6.43%
1220		4	119.8	113	127	3.4	6.801	5.68%	18.95%

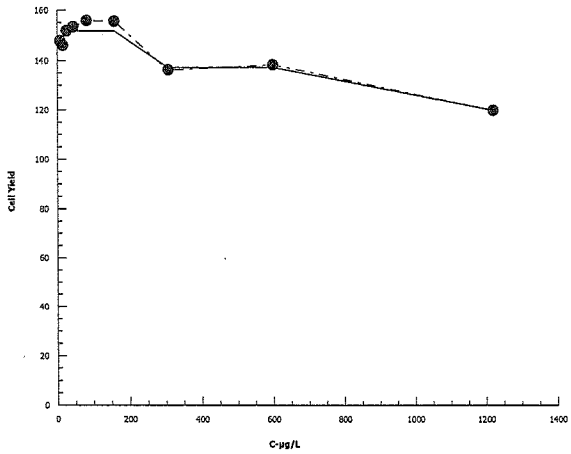
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
8.37	Site Control	159	149	153	141	158	143	137	142
16.2		144	149	152	139				
26		150	159	155	143				
44.4		155	147	154	157				
81.5		150	153	154	166				
158		139	154	158	171				
307		135	134	139	137				
599		137	128	149	139				
1220		115	113	124	127				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	14-7822-0266	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:57	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	02-5217-1502	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:58	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	08-0214-5895	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 17:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	8.14%	599	1220	854.9	

Dunnett Multiple Comparison Test

Control	vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
8.37		16.2	0.3729	2.563	12.03	10	0.8512	CDF	Non-Significant Effect
8.37		26	-0.8523	2.563	12.03	10	0.9965	CDF	Non-Significant Effect
8.37		44.4	-1.172	2.563	12.03	10	0.9991	CDF	Non-Significant Effect
8.37		81.5	-1.705	2.563	12.03	10	0.9999	CDF	Non-Significant Effect
8.37		158	-1.651	2.563	12.03	10	0.9999	CDF	Non-Significant Effect
8.37		307	2.45	2.563	12.03	10	0.0636	CDF	Non-Significant Effect
8.37		599	2.024	2.563	12.03	10	0.1463	CDF	Non-Significant Effect
8.37		1220*	5.966	2.563	12.03	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.1087	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	4459.4	557.425	8	9.489	<0.0001	Significant Effect
Error	1821	58.74194	31			
Total	6280.4		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	8.477	20.09	0.3883	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9906	0.9236	0.9812	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
8.37	Site Control	8	147.8	140.8	154.7	146	137	159	2.92	5.59%	0.0%
16.2		4	146	136.9	155.1	146.5	139	152	2.858	3.92%	1.18%
26		4	151.8	140.8	162.7	152.5	143	159	3.449	4.55%	-2.71%
44.4		4	153.3	146.3	160.2	154.5	147	157	2.175	2.84%	-3.72%
81.5		4	155.8	144.5	167	153.5	150	166	3.521	4.52%	-5.42%
158		4	155.5	134.5	176.5	156	139	171	6.589	8.48%	-5.25%
307		4	136.3	132.7	139.8	136	134	139	1.109	1.63%	7.78%
599		4	138.3	124.5	152	138	128	149	4.308	6.23%	6.43%
1220		4	119.8	108.9	130.6	119.5	113	127	3.4	5.68%	18.95%

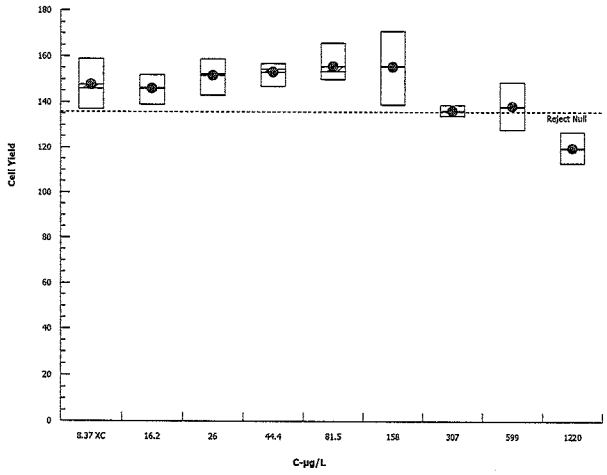
EC Alga Growth Inhibition Test — **Nautilus Environmental**

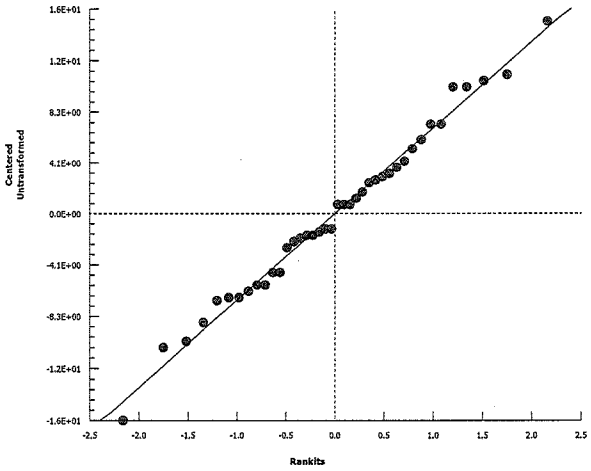
Analysis ID:	02-5217-1502	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:58	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
8.37	Site Control	159	149	153	141	158	143	137	142
16.2		144	149	152	139				
26		150	159	155	143				
44.4		155	147	154	157				
81.5		150	153	154	166				
158		139	154	158	171				
307		135	134	139	137				
599		137	128	149	139				
1220		115	113	124	127				

Graphics





EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	21-3321-6323	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:58	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	08-0214-5895	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 17:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	19.6%	Fails cell yield

Unequal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		8.37*	39.45	1.895	5.697	7	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			1.0000	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	56287.56	56287.56	1	1556	<0.0001	Significant Effect
Error	506.375	36.16964	14			
Total	56793.94		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	16.54	8.885	0.0015	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.9707	0.8408	0.8493	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	29.13	27.43	30.82	29.5	26	32	0.7181	6.97%	0.0%
8.37	Site Control	8	147.8	140.8	154.7	146	137	159	2.92	5.59%	-407.3%

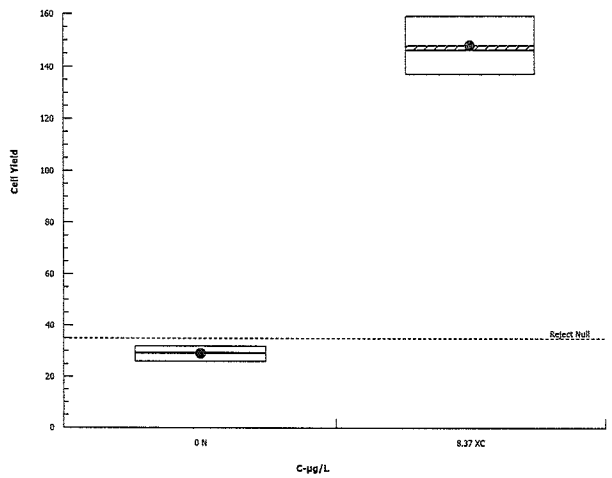
Cell Yield Detail

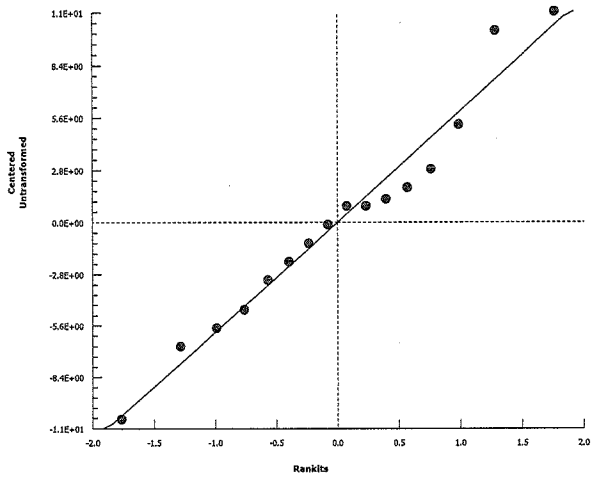
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	31	26	29	30	27	28	32
8.37	Site Control	159	149	153	141	158	143	137	142

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	21-3321-6323	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:58	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax (Pretium)
Work Order No.: 181047

Start Date: July 03/18
Set up by: MG

Sample Information:

Sample ID: Lab water amended with Sb
Sample Date: July 3/18
Date Received: July 3/18
Sample Volume: n/a

Test Organism Information:

Culture Date: June 29/18
Age of culture (Day 0): 4d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC171
Stock Solution ID: 18Zn 01
Date Initiated: June 29/18

72-h IC50 (95% CL): 34.1 (29.4 - 37.0) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 31.4 (26.1-37.8) ug/L Zn CV (%): 10

Test Results:

ug/L Sb	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	675.5 (627.7 - 713.6)
IC50 ~~%(v/v)~~ ug/L Sb mg (95% CL)	854.6 (811.8 - 893.5)
NOEC	81.5
LOEC	159

Reviewed by: JGh

Date reviewed: July 17/18

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax (Pretium) Setup by: MG

Sample ID: Lab water amended with Sb Test Date/Time: July 3/18 @ 1640h

Work Order No.: 181047 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: June 29/18 Age of Culture: 4d Culture Health: Good

Culture Count: 1 250 2 225 Average: 237.5 Culture Cell Density (c1): 237.5x10⁴ cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 237.5x10⁴ cells/ml = 9.26 mL

Time Zero Counts: 1 21 2 22 Average: 21.5

No. of Cells/mL: 21.5x10⁴ Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9773 cells/mL

Concentration ~~%(v/v)~~ mg µg/L Sb	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	7.0	24.0	25.0	25.0	25.0	25.0	✓	✓	✓	✓
9	6.9	24.0	↓	↓	↓	↓	✓	✓	✓	✓
18	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
36	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
72	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
144	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
288	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
576	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
1152	4.3	24.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG

Initial control pH: Well 1: 7.0 Well 2: 7.0

Final control pH: Well 1: 7.2 Well 2: 7.2

Light intensity (lux): 4100 Date measured: July 3/18

Thermometer: 4 Light meter: 1 pH meter/probe: 1 / 1

Sample Description: clear, colourless, ~~no~~ MG odourless, no particulates

Comments:

Reviewed: JBh Date reviewed: July 17/18

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax (Pretium) Start Date/Time: July 3/18 @ 1640h
Work Order #: 181047 Termination Date: July 6/18 @ 1640h
Sample ID: Lab water Test set up by: MLG
mg/L Sb ~~%(v/v)~~ amended with Sb

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	29					MLG
	B	30					
	C	27					
	D	32					
	E	31					
	F	28					
	G	33					
	H	29					
9	A	30					
	B	28					
	C	27					
	D	28					
18	A	28					
	B	27					
	C	33					
	D	31					
36	A	28					
	B	29					
	C	27					
	D	30					
72	A	27					
	B	29					
	C	31					
	D	28					
144	A	29					
	B	26					
	C	25					
	D	26					
288	A	27					
	B	24					
	C	26					
	D	27					
576	A	25					
	B	26					
	C	25					
	D	23					

Comments:

Reviewed by: JOh Date Reviewed: July 17/18

2/2

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax (Pretium) Start Date/Time: July 3/18 @ 1640h
Work Order #: 181047 Termination Date: July 6/18 @ 1640h
Sample ID: Lab Test set up by: MG
µg/L Sb ~~%(v/v)~~ amended with Sb

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
1152	A	3					MG
	B	5					↓
	C	4					↓
	D	5					↓
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JOh Date Reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client: Lorax (Pretium)
WO#: 181047
Sample ID: Lab Water amended with Sb

Start Date/Time: 3-Jul-18 @ 1640h
Termination Date/Time 6-Jul-18 @ 1640h

Initial Cell Density: 9773 cell/mL

	215000
	0.22
	0.01
	9772.727

Concentration ug/L Sb	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	29				29	28.0	mean	28.9
	B	30				30	29.0	SD	2.03101
	C	27				27	26.0	CV	7.028268
	D	32				32	31.0		
	E	31				31	30.0		
	F	28				28	27.0		
	G	33				33	32.0		
	H	29				29	28.0		
10.9 ✓	A	30				30	29.0		
	B	28				28	27.0		
	C	27				27	26.0		
	D	28				28	27.0		
21.1 ✓	A	28				28	27.0		
	B	27				27	26.0		
	C	33				33	32.0		
	D	31				31	30.0		
41.9 ✓	A	28				28	27.0		
	B	29				29	28.0		
	C	27				27	26.0		
	D	30				30	29.0		
81.5 ✓	A	27				27	26.0		
	B	29				29	28.0		
	C	31				31	30.0		
	D	28				28	27.0		
159 ✓	A	29				29	28.0		
	B	26				26	25.0		
	C	25				25	24.0		
	D	26				26	25.0		
321 ✓	A	27				27	26.0		
	B	24				24	23.0		
	C	26				26	25.0		
	D	27				27	26.0		
631 ✓	A	25				25	24.0		
	B	26				26	25.0		
	C	25				25	24.0		
	D	23				23	22.0		

Reviewed by: JCh

Date reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client: Lorax (Pretium)
WO#: 181047
Sample ID: Lab Water amended with Sb

Start Date/Time: 3-Jul-18 @ 1640h
Termination Date/Time 6-Jul-18 @ 1640h

Initial Cell Density: 9773 cell/mL

									215000
									0.22
									0.01
Concentration ug/L Sb	Rep	Count 1 ($x 10^4$)	Count 2 ($x 10^4$)	Count 3 ($x 10^4$)	Count 4 ($x 10^4$)	Mean ($x 10^4$)	Cell Yield ($x 10^4$) cell/mL		9772.727
Control	A					#DIV/0!	#DIV/0!	mean	#DIV/0!
	B					#DIV/0!	#DIV/0!	SD	#DIV/0!
	C					#DIV/0!	#DIV/0!	CV	#DIV/0!
	D					#DIV/0!	#DIV/0!		
	E					#DIV/0!	#DIV/0!		
	F					#DIV/0!	#DIV/0!		
	G					#DIV/0!	#DIV/0!		
	H					#DIV/0!	#DIV/0!		
1230 ✓	A	3				3	2.0		
	B	5				5	4.0		
	C	4				4	3.0		
	D	5				5	4.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: TGU

Date reviewed: July 17/18

CETIS Summary Report

Report Date:	16 Jul-18 16:40 (p 1 of 1)
Test Code:	181047a | 13-4744-3490

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	03-8455-8610	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:40	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	06 Jul-18 16:40	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-2273-3234	**Code:**	Lab Control	**Client:**	Pretium Exploration
Sample Date:	03 Jul-18	**Material:**	Water Sample	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Exploration		
Sample Age:	17h	**Station:**	Lab Control		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
00-3618-6148	Cell Yield	81.5	159	113.8	9.39%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
04-6970-7128	Cell Yield	IC5	86.64	N/A	179.7		Linear Interpolation (ICPIN)
		IC10	136.4	49.63	460.7		
		IC15	410.9	N/A	774.8		
		IC20	644.5	286.4	682.8		
		IC25	675.5	627.7	713.6		
		IC40	777.9	735.4	814.4		
		IC50	854.6	811.8	893.5		

Cell Yield Summary

(i) C-µg/L Sb	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	28.88	27.18	30.57	26	32	0.7181	2.031	7.03%	0.0%
10.9		4	27.25	25.25	29.25	26	29	0.6292	1.258	4.62%	5.63%
21.1		4	28.75	24.37	33.13	26	32	1.377	2.754	9.58%	0.43%
41.9		4	27.5	25.45	29.55	26	29	0.6455	1.291	4.7%	4.76%
81.5		4	27.75	25.03	30.47	26	30	0.8539	1.708	6.15%	3.9%
159		4	25.5	22.74	28.26	24	28	0.866	1.732	6.79%	11.69%
321		4	25	22.75	27.25	23	26	0.7071	1.414	5.66%	13.42%
631		4	23.75	21.75	25.75	22	25	0.6292	1.258	5.3%	17.75%
1230		4	3.25	1.727	4.773	2	4	0.4787	0.9574	29.46%	88.74%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	28	29	26	31	30	27	32	28
10.9		29	27	26	27				
21.1		27	26	32	30				
41.9		27	28	26	29				
81.5		26	28	30	27				
159		28	25	24	25				
321		26	23	25	26				
631		24	25	24	22				
1230		2	4	3	4				

(i) Lab water amended with Sb.

CETIS Analytical Report

Report Date: 16 Jul-18 16:40 (p 1 of 2)
Test Code: 181047a | 13-4744-3490

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	04-6970-7128	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:35	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	03-8455-8610	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:40	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	06 Jul-18 16:40	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-2273-3234	**Code:**	Lab Control	**Client:**	Pretium Exploration
Sample Date:	03 Jul-18	**Material:**	Water Sample	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Exploration		
Sample Age:	17h	**Station:**	Lab Control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1377376	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.7195	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	86.64	N/A	179.7
IC10	136.4	49.63	460.7
IC15	410.9	N/A	774.8
IC20	644.5	286.4	682.8
IC25	675.5	627.7	713.6
IC40	777.9	735.4	814.4
IC50	854.6	811.8	893.5

Cell Yield Summary

			Calculated Variate						
C-µg/L Sb	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	28.88	26	32	0.7181	2.031	7.03%	0.0%
10.9		4	27.25	26	29	0.6292	1.258	4.62%	5.63%
21.1		4	28.75	26	32	1.377	2.754	9.58%	0.43%
41.9		4	27.5	26	29	0.6455	1.291	4.7%	4.76%
81.5		4	27.75	26	30	0.8539	1.708	6.15%	3.9%
159		4	25.5	24	28	0.866	1.732	6.79%	11.69%
321		4	25	23	26	0.7071	1.414	5.66%	13.42%
631		4	23.75	22	25	0.6292	1.258	5.3%	17.75%
1230		4	3.25	2	4	0.4787	0.9574	29.46%	88.74%

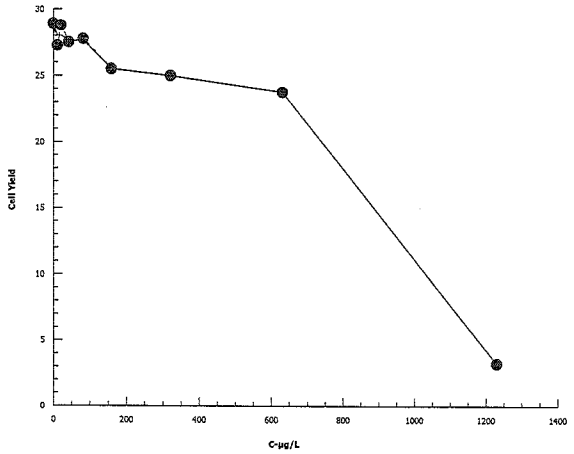
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	28	29	26	31	30	27	32	28
10.9		29	27	26	27				
21.1		27	26	32	30				
41.9		27	28	26	29				
81.5		26	28	30	27				
159		28	25	24	25				
321		26	23	25	26				
631		24	25	24	22				
1230		2	4	3	4				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	04-6970-7128	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:35	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	16 Jul-18 16:40 (p 1 of 2)
Test Code:	181047a | 13-4744-3490

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	00-3618-6148	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:35	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	03-8455-8610	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:40	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	06 Jul-18 16:40	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-2273-3234	**Code:**	Lab Control	**Client:**	Pretium Exploration
Sample Date:	03 Jul-18	**Material:**	Water Sample	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Exploration		
Sample Age:	17h	**Station:**	Lab Control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	9.39%	81.5	159	113.8	

Dunnett Multiple Comparison Test

Control vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	10.9	1.535	2.563	2.713	10	0.3185	CDF	Non-Significant Effect
	21.1	0.1181	2.563	2.713	10	0.9175	CDF	Non-Significant Effect
	41.9	1.299	2.563	2.713	10	0.4294	CDF	Non-Significant Effect
	81.5	1.063	2.563	2.713	10	0.5494	CDF	Non-Significant Effect
	159*	3.188	2.563	2.713	10	0.0116	CDF	Significant Effect
	321*	3.661	2.563	2.713	10	0.0034	CDF	Significant Effect
	631*	4.842	2.563	2.713	10	0.0001	CDF	Significant Effect
	1230*	24.21	2.563	2.713	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.7195	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2146.475	268.3094	8	89.8	<0.0001	Significant Effect
Error	92.625	2.987903	31			
Total	2239.1		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	4.767	20.09	0.7821	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9815	0.9236	0.7460	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	28.88	27.18	30.57	28.5	26	32	0.7181	7.03%	0.0%
10.9		4	27.25	25.25	29.25	27	26	29	0.6292	4.62%	5.63%
21.1		4	28.75	24.37	33.13	28.5	26	32	1.377	9.58%	0.43%
41.9		4	27.5	25.45	29.55	27.5	26	29	0.6455	4.7%	4.76%
81.5		4	27.75	25.03	30.47	27.5	26	30	0.8539	6.15%	3.9%
159		4	25.5	22.74	28.26	25	24	28	0.866	6.79%	11.69%
321		4	25	22.75	27.25	25.5	23	26	0.7071	5.66%	13.42%
631		4	23.75	21.75	25.75	24	22	25	0.6292	5.3%	17.75%
1230		4	3.25	1.727	4.773	3.5	2	4	0.4787	29.46%	88.74%

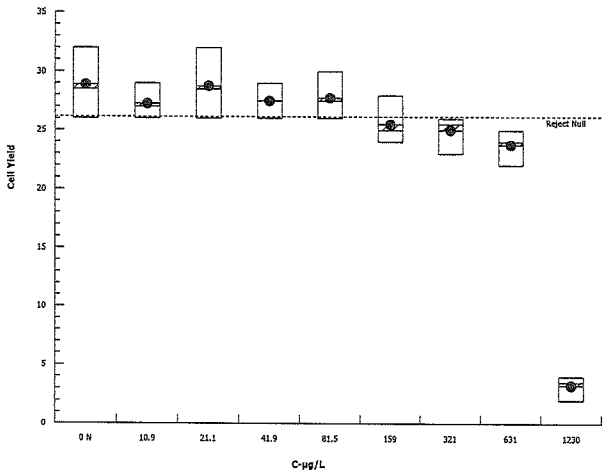
EC Alga Growth Inhibition Test — **Nautilus Environmental**

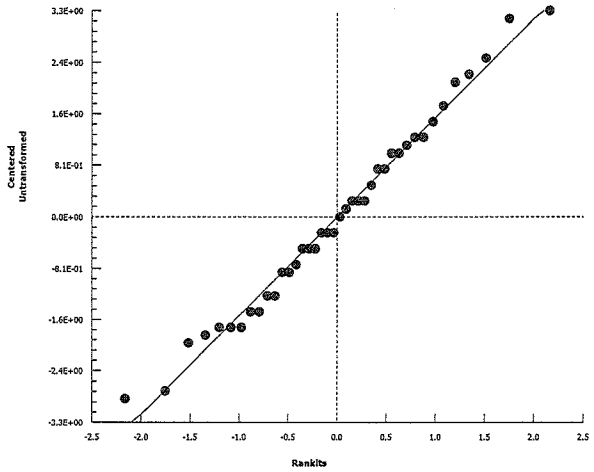
Analysis ID:	00-3618-6148	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:35	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	28	29	26	31	30	27	32	28
10.9		29	27	26	27				
21.1		27	26	32	30				
41.9		27	28	26	29				
81.5		26	28	30	27				
159		28	25	24	25				
321		26	23	25	26				
631		24	25	24	22				
1230		2	4	3	4				

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax (Pretium)
Work Order No.: 181047

Start Date: July 03/18
Set up by: MET

Sample Information:

Sample ID: BJ 3.10 amended with As
Sample Date: June 25/18
Date Received: June 27/18
Sample Volume: 1x20L.

Test Organism Information:

Culture Date: June 29/18
Age of culture (Day 0): 4d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC171
Stock Solution ID: 18Zn 01
Date Initiated: June 29/18

72-h IC50 (95% CL): 34.1 (29.4-37.0) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 31.4 (26.1-37.8) ug/L Zn CV (%): 10

Test Results:

ug/L As	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	110 (99.3 - 119.8)
IC50 ~~%(v/v)~~ ug/L As (95% CL)	200.5 (184.3 - 214.2)
mg	54.7
NOEC	103
LOEC.	

Reviewed by: JGL

Date reviewed: July 17/18

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client : Lornex (Pretium) Setup by: MG

Sample ID: BJ 3,10 amended with As. Test Date/Time: July 3/18 @ 1645h

Work Order No.: 181047 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: June 29/18 Age of Culture: 4d Culture Health: Good

Culture Count: 1 250 2 225 Average: 4d Culture Cell Density (c1): 237.5 x10⁴ cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 237.5x10⁴ cells/ml = 9.26mL

Time Zero Counts: 1 21 2 22 Average: 21.5

No. of Cells/mL: 21.5x10⁴ Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9773 cells/mL

Concentration ~~%(v/v)~~ ~~MG~~ µg/L As.	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	7.0	24.0	25.0	25.0	25.0	25.0	✓	✓	✓	✓
BJ 3,10 (site control)	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
3	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
6	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
12	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
24	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
48	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
96	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
192	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
384	7.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG

Initial control pH: Well 1: 7.0 Well 2: 7.0

Final control pH: Well 1: 7.0 Well 2: 7.0

Light intensity (lux): 3910 Date measured: July 3/18

Thermometer: 4 Light meter: 1 pH meter/probe: 1.1

Sample Description: clear colourless, odourless, no particulates

Comments:

Reviewed: [illegible] Date reviewed: July 17/18

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Loraxo (Pretium) Start Date/Time: July 3/18 @ ~~1430h~~ 1645h MG
Work Order #: 181047 Termination Date: July 6/18 @ 1645h
Sample ID: BJ 3.10 Test set up by: ML
mg/L As. ~~%(v/v)~~ amended with As

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	28					MG
	B	29					
	C	31					
	D	29					
	E	30					
	F	27					
	G	30					
	H	28					
BJ 3.10 (Site)	A	140					
	B	142					
	C	151					
	D	145					
	~~E~~A	138					
	~~F~~B	139					
	~~G~~C	141					
	~~H~~D	143					
3	A	144					
	B	146					
	C	142					
	D	153					
6	A	151					
	B	155					
	C	156					
	D	144					
12	A	141					
	B	148					
	C	143					
	D	137					
24	A	144					
	B	135					
	C	130					
	D	124					
48	A	140					
	B	141					
	C	136					
	D	130					

Comments:

Reviewed by: JGH Date Reviewed: July 17/18

2/2

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax (Pretium) Start Date/Time: July 3/18 @ 1645h
Work Order #: 181047 Termination Date: July 6/18 @ 1645h
Sample ID: BJ 3,40 Test set up by: MG
µg/L AS ~~%(v/v)~~ amended with AS.

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						"
	B						
	C						
	D						
	E						
	F						
	G						
	H						
96	A	110					MG
	B	112					
	C	120					
	D	115					
192	A	76					
	B	75					
	C	76					
	D	70					
384	A	32					
	B	40					
	C	45					
	D	37					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JCa Date Reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client: Lorax (Pretium)
WO#: 181047
Sample ID: BJ 3.10 amended with As

Start Date/Time: 3-Jul-18 @ 1645h
Termination Date/Time: 6-Jul-18 @ 1645h

Initial Cell Density: 9773 cell/mL

	215000
	0.22
	0.01
	9772.727

Concentration ug/L As	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	28				28	27.0	mean	28.0
	B	29				29	28.0	SD	1.309307
	C	31				31	30.0	CV	4.672305
	D	29				29	28.0		
	E	30				30	29.0		
	F	27				27	26.0		
	G	30				30	29.0		
	H	28				28	27.0		
4.36 ✓	A	140				140	139.0		
(BJ 3.10)	B	142				142	141.0		
(Site Control)	C	151				151	150.0		
	D	145				145	144.0		
	E	138				138	137.0		
	F	139				139	138.0		
	G	141				141	140.0		
	H	143				143	142.0		
7.78 ✓	A	144				144	143.0		
	B	146				146	145.0		
	C	142				142	141.0		
	D	153				153	152.0		
10.9 ✓	A	151				151	150.0		
	B	155				155	154.0		
	C	156				156	155.0		
	D	144				144	143.0		
17.5 ✓	A	141				141	140.0		
	B	148				148	147.0		
	C	143				143	142.0		
	D	137				137	136.0		
29.9 ✓	A	144				144	143.0		
	B	135				135	134.0		
	C	130				130	129.0		
	D	124				124	123.0		
54.7 ✓	A	140				140	139.0		
	B	141				141	140.0		
	C	136				136	135.0		
	D	130				130	129.0		

Reviewed by: JOH

Date reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client: Lorax (Pretium)
WO#: 181047
Sample ID: BJ 3.10 amended with As

Start Date/Time: 3-Jul-18 @ 1645h
Termination Date/Time: 6-Jul-18 @ 1645h

Initial Cell Density: 9773 cell/mL

215000
0.22
0.01
9772.727

Concentration ug/L As	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A					#DIV/0!	#DIV/0!	mean	#DIV/0!
	B					#DIV/0!	#DIV/0!	SD	#DIV/0!
	C					#DIV/0!	#DIV/0!	CV	#DIV/0!
	D					#DIV/0!	#DIV/0!		
	E					#DIV/0!	#DIV/0!		
	F					#DIV/0!	#DIV/0!		
	G					#DIV/0!	#DIV/0!		
	H					#DIV/0!	#DIV/0!		
103 ✓	A	110				110	109.0		
	B	112				112	111.0		
	C	120				120	119.0		
	D	115				115	114.0		
199 ✓	A	76				76	75.0		
	B	75				75	74.0		
	C	76				76	75.0		
	D	70				70	69.0		
395 ✓	A	32				32	31.0		
	B	40				40	39.0		
	C	45				45	44.0		
	D	37				37	36.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JGU

Date reviewed: July 17/18

CETIS Summary Report

Report Date: 16 Jul-18 17:04 (p 1 of 1)
Test Code: 181047d | 16-4127-8209

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	00-7443-0938	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:45	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 16:45	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
06-3081-4152	Cell Yield	<4.36	4.36	NA	10.2%		Unequal Variance t Two-Sample Test
04-9297-9493	Cell Yield	54.7	103	75.06	5.64%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
01-9387-5079	Cell Yield	IC5	21.6	12.8	38.33		Linear Interpolation (ICPIN)
		IC10	59.71	8.608	69.76		
		IC15	74.59	62.84	86.12		
		IC20	93.12	79.95	109.8		
		IC25	110	99.29	119.8		
		IC40	157.6	147.3	168.1		
		IC50	200.5	184.3	214.2		

Cell Yield Summary

① C-µg/L As	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	28	26.91	29.09	26	30	0.4629	1.309	4.68%	0.0%
4.36	Site Control	8	141.4	137.9	144.8	137	150	1.463	4.138	2.93%	-404.9%
7.78		4	145.3	137.6	152.9	141	152	2.394	4.787	3.3%	-418.7%
10.9		4	150.5	141.8	159.2	143	155	2.723	5.447	3.62%	-437.5%
17.5		4	141.3	134	148.5	136	147	2.287	4.573	3.24%	-404.5%
29.9		4	132.3	118.8	145.7	123	143	4.23	8.461	6.4%	-372.3%
54.7		4	135.8	127.8	143.7	129	140	2.496	4.992	3.68%	-384.8%
103		4	113.3	106.3	120.2	109	119	2.175	4.349	3.84%	-304.5%
199		4	73.25	68.68	77.82	69	75	1.436	2.872	3.92%	-161.6%
395		4	37.5	28.83	46.17	31	44	2.723	5.447	14.52%	-33.93%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	28	30	28	29	26	29	27
4.36	Site Control	139	141	150	144	137	138	140	142
7.78		143	145	141	152				
10.9		150	154	155	143				
17.5		140	147	142	136				
29.9		143	134	129	123				
54.7		139	140	135	129				
103		109	111	119	114				
199		75	74	75	69				
395		31	39	44	36				

① site water BJ 3.10 amended with As.
negative control = Lab water
site control = BJ 3.10.

Analyst: MLT QA: JGA July 17/18

CETIS Analytical Report

Report Date:	16 Jul-18 17:04 (p 1 of 2)
Test Code:	181047d | 16-4127-8209

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	01-9387-5079	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 17:03	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	00-7443-0938	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:45	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 16:45	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	789714	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			1.0000	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	21.6	12.8	38.33
IC10	59.71	8.608	69.76
IC15	74.59	62.84	86.12
IC20	93.12	79.95	109.8
IC25	110	99.29	119.8
IC40	157.6	147.3	168.1
IC50	200.5	184.3	214.2

Cell Yield Summary

			Calculated Variate						
C-µg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
4.36	Site Control	8	141.4	137	150	1.463	4.138	2.93%	0.0%
7.78		4	145.3	141	152	2.394	4.787	3.3%	-2.74%
10.9		4	150.5	143	155	2.723	5.447	3.62%	-6.45%
17.5		4	141.3	136	147	2.287	4.573	3.24%	0.09%
29.9		4	132.3	123	143	4.23	8.461	6.4%	6.45%
54.7		4	135.8	129	140	2.496	4.992	3.68%	3.98%
103		4	113.3	109	119	2.175	4.349	3.84%	19.89%
199		4	73.25	69	75	1.436	2.872	3.92%	48.19%
395		4	37.5	31	44	2.723	5.447	14.52%	73.47%

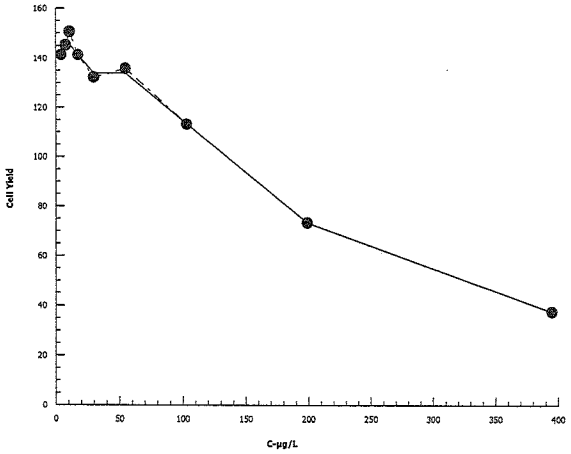
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.36	Site Control	139	141	150	144	137	138	140	142
7.78		143	145	141	152				
10.9		150	154	155	143				
17.5		140	147	142	136				
29.9		143	134	129	123				
54.7		139	140	135	129				
103		109	111	119	114				
199		75	74	75	69				
395		31	39	44	36				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	01-9387-5079	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 17:03	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	04-9297-9493	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 17:03	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	00-7443-0938	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:45	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 16:45	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	5.64%	54.7	103	75.06	

Dunnett Multiple Comparison Test

Control	vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
4.36		7.78	-1.245	2.563	7.974	10	0.9993	CDF	Non-Significant Effect
4.36		10.9	-2.933	2.563	7.974	10	1.0000	CDF	Non-Significant Effect
4.36		17.5	0.04017	2.563	7.974	10	0.9325	CDF	Non-Significant Effect
4.36		29.9*	2.933	2.563	7.974	10	0.0215	CDF	Significant Effect
4.36		54.7	1.808	2.563	7.974	10	0.2117	CDF	Non-Significant Effect
4.36		103*	9.039	2.563	7.974	10	<0.0001	CDF	Significant Effect
4.36		199*	21.89	2.563	7.974	10	<0.0001	CDF	Significant Effect
4.36		395*	33.38	2.563	7.974	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			1.0000	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	49419.4	6177.425	8	239.3	<0.0001	Significant Effect
Error	800.375	25.81855	31			
Total	50219.77		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	3.973	20.09	0.8596	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9913	0.9236	0.9880	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
4.36	Site Control	8	141.4	137.9	144.8	140.5	137	150	1.463	2.93%	0.0%
7.78		4	145.3	137.6	152.9	144	141	152	2.394	3.3%	-2.74%
10.9		4	150.5	141.8	159.2	152	143	155	2.723	3.62%	-6.45%
17.5		4	141.3	134	148.5	141	136	147	2.287	3.24%	0.09%
29.9		4	132.3	118.8	145.7	131.5	123	143	4.23	6.4%	6.45%
54.7		4	135.8	127.8	143.7	137	129	140	2.496	3.68%	3.98%
103		4	113.3	106.3	120.2	112.5	109	119	2.175	3.84%	19.89%
199		4	73.25	68.68	77.82	74.5	69	75	1.436	3.92%	48.19%
395		4	37.5	28.83	46.17	37.5	31	44	2.723	14.52%	73.47%

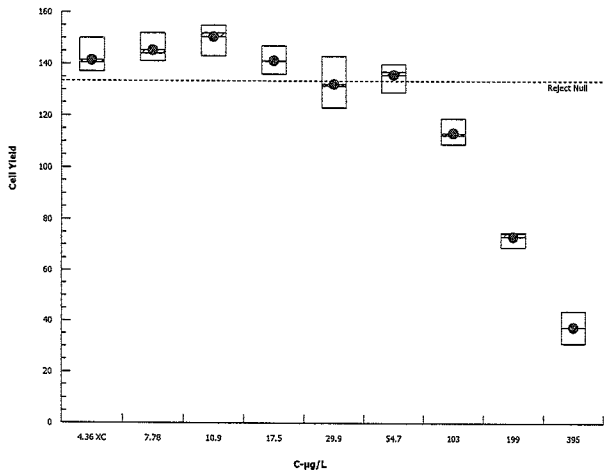
EC Alga Growth Inhibition Test — **Nautilus Environmental**

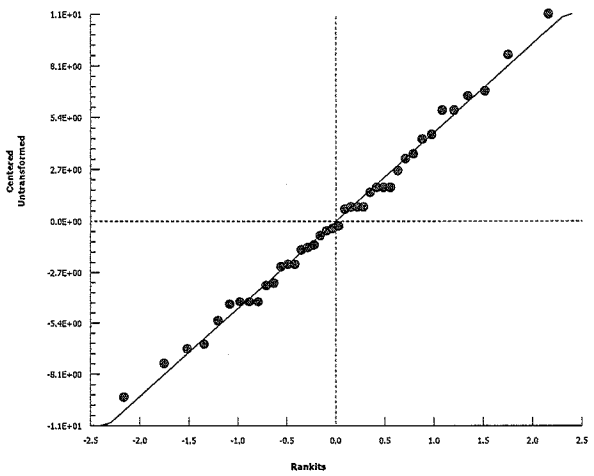
Analysis ID:	04-9297-9493	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 17:03	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.36	Site Control	139	141	150	144	137	138	140	142
7.78		143	145	141	152				
10.9		150	154	155	143				
17.5		140	147	142	136				
29.9		143	134	129	123				
54.7		139	140	135	129				
103		109	111	119	114				
199		75	74	75	69				
395		31	39	44	36				

Graphics





CETIS Analytical Report

Test Code: 181047d | 16-4127-8209

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	06-3081-4152	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 17:03	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	00-7443-0938	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:45	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	BJ 3.10
Ending Date:	06 Jul-18 16:45	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-4111-6106	**Code:**	2636A7CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Water Sample	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Exploration		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	10.2%	Fails cell yield

Unequal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		4.36*	73.88	1.86	2.854	8	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.7305	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	51415.56	51415.56	1	5458	<0.0001	Significant Effect
Error	131.875	9.419642	14			
Total	51547.44		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	9.99	8.885	0.0071	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.8854	0.8408	0.0471	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	28	26.91	29.09	28	26	30	0.4629	4.68%	0.0%
4.36	Site Control	8	141.4	137.9	144.8	140.5	137	150	1.463	2.93%	-404.9%

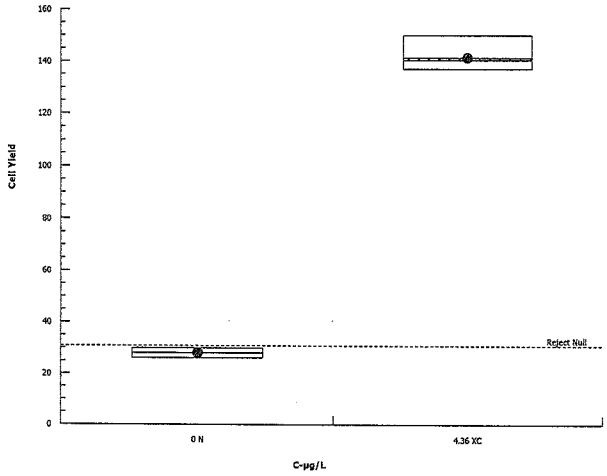
Cell Yield Detail

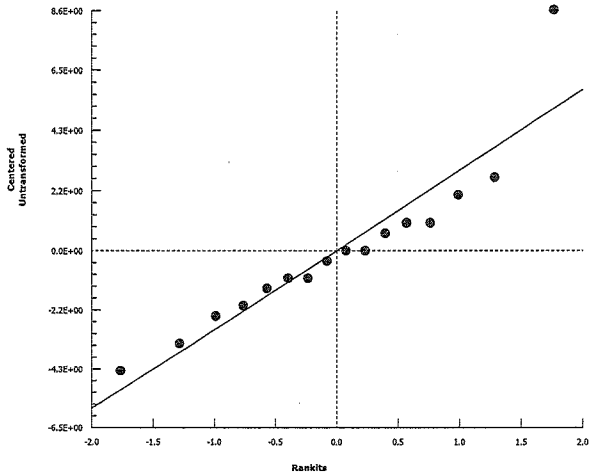
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	28	30	28	29	26	29	27
4.36	Site Control	139	141	150	144	137	138	140	142

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	06-3081-4152	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 17:03	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax (Pretium)
Work Order No.: ~~181067~~ 181047 MG

Start Date: July 03/18
Set up by: MG

Sample Information:

Sample ID: Lab water amended with As
Sample Date: July 3/18
Date Received: July 3/18
Sample Volume: n/a

Test Organism Information:

Culture Date: June 29/18
Age of culture (Day 0): 4d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC171
Stock Solution ID: 18Zn01
Date Initiated: June 29/18

72-h IC50 (95% CL): 34.1 (29.4-37.0) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 31.4 (26.1-37.8) ug/L Zn CV (%): 10

Test Results:

	Algal Growth
IC25 MG ~~%(v/v)~~ ug/L As (95% CL)	49.9 (6.4-59.3)
IC50 ~~%(v/v)~~ ug/L As (95% CL)	94.0 (82.8-104)
MG NOEC	13.3
LOEC	25.5

Reviewed by: JGu

Date reviewed: July 17/18

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax (Pretium) Setup by: MG

Sample ID: Lab water amended with As Test Date/Time: July 3/18 @ 1630h.

Work Order No.: 181047 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: June 29/18 Age of Culture: 4d Culture Health: Good

Culture Count: 1 250 2 225 Average: 237.5 Culture Cell Density (c1): 237.5 x10⁴ cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 237.5 x10⁴ cells/ml = 9.26mL

Time Zero Counts: 1 21 2 22 Average: 21.5

No. of Cells/mL: 21.5 x10⁴ Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9773 cells/mL

Concentration ~~%(v/v)~~ mg µg/L As	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	7.0	24.0	25.0	25.0	25.0	25.0	✓	✓	✓	✓
3	6.9	24.0	↓	↓	↓	↓	✓	✓	✓	✓
6	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
12	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
24	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
48	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
96	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
192	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
384	6.8	24.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	MG	MG	MG	MG	MG	MG

Initial control pH: Well 1: 7.0 Well 2: 7.0

Final control pH: Well 1: 7.2 Well 2: 7.2

Light intensity (lux): 3800 Date measured: July 3/18

Thermometer: 4 Light meter: 1 pH meter/probe: 1/1

Sample Description: clear, colourless, odourless, no particulates.

Comments:

Reviewed: JGL Date reviewed: July 17/18

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax (Pretium) Start Date/Time: July 3/18 @ 1630h
Work Order #: 181047 Termination Date: July 6/18 @ 1630h
Sample ID: Lab water amended with As. Test set up by: MG
mg/L As. ~~%(v/v)~~

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	30					MG
	B	29					
	C	32					
	D	30					
	E	28					
	F	30					
	G	28					
	H	31					
3	A	32					
	B	30					
	C	28					
	D	29					
6	A	27					
	B	32					
	C	29					
	D	27					
12	A	32					
	B	27					
	C	32					
	D	29					
24	A	20					
	B	21					
	C	25					
	D	22					
48	A	23					
	B	20					
	C	24					
	D	26					
96	A	14					
	B	15					
	C	14					
	D	16					
192	A	9					
	B	11					
	C	10					
	D	12					

Comments:

Reviewed by: JCh Date Reviewed: July 17/18

8/2

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Loax (Pretium) Start Date/Time: July 3/18 @ 1630h
Work Order #: 181047 Termination Date: July 6/18 @ 1630h.
Sample ID: Lab Test set up by: MG
mg/L ~~AS %(v/v)~~ MG amended with AS.

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
384	A	9					MG
	B	8					
	C	6					
	D	8					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JCK Date Reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client:	Lorax (Pretium)	Start Date/Time:	3-Jul-18 @ 1630h
WO#:	181047	Termination Date/Time	6-Jul-18 @ 1630h
Sample ID:	Lab Water amended with As		
		Initial Cell Density:	9773 cell/mL

	215000
	0.22
	0.01
	9772.727

Concentration ug/L As	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	30				30	29.0	mean	28.8
	B	29				29	28.0	SD	1.38873
	C	32				32	31.0	CV	4.82655
	D	30				30	29.0		
	E	28				28	27.0		
	F	30				30	29.0		
	G	28				28	27.0		
	H	31				31	30.0		
3.4 ✓	A	32				32	31.0		
	B	30				30	29.0		
	C	28				28	27.0		
	D	29				29	28.0		
6.7 ✓	A	27				27	26.0		
	B	32				32	31.0		
	C	29				29	28.0		
	D	27				27	26.0		
13.3 ✓	A	32				32	31.0		
	B	27				27	26.0		
	C	32				32	31.0		
	D	29				29	28.0		
25.5 ✓	A	20				20	19.0		
	B	21				21	20.0		
	C	25				25	24.0		
	D	22				22	21.0		
49.6 ✓	A	23				23	22.0		
	B	20				20	19.0		
	C	24				24	23.0		
	D	26				26	25.0		
99.3 ✓	A	14				14	13.0		
	B	15				15	14.0		
	C	14				14	13.0		
	D	16				16	15.0		
196 ✓	A	9				9	8.0		
	B	11				11	10.0		
	C	10				10	9.0		
	D	12				12	11.0		

Reviewed by: JGh

Date reviewed: July 17/18

Pseudokirchneriella subcapitata Algal Counts

Client:	Lorax (Pretium)	Start Date/Time:	3-Jul-18 @ 1630h
WO#:	181047	Termination Date/Time	6-Jul-18 @ 1630h
Sample ID:	Lab Water amended with As		
		Initial Cell Density:	9773 cell/mL

									215000
									0.22
									0.01
Concentration ug/L As	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		9772.727
Control	A					#DIV/0!	#DIV/0!	mean	#DIV/0!
	B					#DIV/0!	#DIV/0!	SD	#DIV/0!
	C					#DIV/0!	#DIV/0!	CV	#DIV/0!
	D					#DIV/0!	#DIV/0!		
	E					#DIV/0!	#DIV/0!		
	F					#DIV/0!	#DIV/0!		
	G					#DIV/0!	#DIV/0!		
	H					#DIV/0!	#DIV/0!		
386 ✓	A	9				9	8.0		
	B	8				8	7.0		
	C	6				6	5.0		
	D	8				8	7.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JGH

Date reviewed: July 17/18

CETIS Summary Report

Report Date:	16 Jul-18 16:44 (p 1 of 1)
Test Code:	181047b | 19-6848-4540

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	18-3001-9439	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	06 Jul-18 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-0043-3412	**Code:**	Lab Control	**Client:**	Pretium Exploration
Sample Date:	03 Jul-18	**Material:**	Water Sample	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Exploration		
Sample Age:	16h	**Station:**	Lab Control		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
15-7989-7192	Cell Yield	13.3	25.5	18.42	9.91%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
17-0501-9398	Cell Yield	IC5	14.76	N/A	16.12		Linear Interpolation (ICPIN)
		IC10	16.97	12.52	19.08		
		IC15	19.49	15.51	23.42		
		IC20	22.37	18.24	66.4		
		IC25	49.88	6.376	59.27		
		IC40	73	61.61	79.47		
		IC50	94	82.76	104		

Cell Yield Summary

C-µg/L As	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	28.75	27.59	29.91	27	31	0.491	1.389	4.83%	0.0%
3.4		4	28.75	26.03	31.47	27	31	0.8539	1.708	5.94%	0.0%
6.7		4	27.75	23.99	31.51	26	31	1.181	2.363	8.52%	3.48%
13.3		4	29	25.1	32.9	26	31	1.225	2.449	8.45%	-0.87%
25.5		4	21	17.56	24.44	19	24	1.08	2.16	10.29%	26.96%
49.6		4	22.25	18.27	26.23	19	25	1.25	2.5	11.24%	22.61%
99.3		4	13.75	12.23	15.27	13	15	0.4787	0.9574	6.96%	52.17%
196		4	9.5	7.446	11.55	8	11	0.6455	1.291	13.59%	66.96%
386		4	6.75	4.748	8.752	5	8	0.6292	1.258	18.64%	76.52%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	29	28	31	29	27	29	27	30
3.4		31	29	27	28				
6.7		26	31	28	26				
13.3		31	26	31	28				
25.5		19	20	24	21				
49.6		22	19	23	25				
99.3		13	14	13	15				
196		8	10	9	11				
386		8	7	5	7				

① Lab water amended with As.

CETIS Analytical Report

Report Date:	16 Jul-18 16:44 (p 1 of 2)
Test Code:	181047b | 19-6848-4540

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	17-0501-9398	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:43	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	18-3001-9439	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	06 Jul-18 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-0043-3412	**Code:**	Lab Control	**Client:**	Pretium Exploration
Sample Date:	03 Jul-18	**Material:**	Water Sample	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Exploration		
Sample Age:	16h	**Station:**	Lab Control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1301082	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.5800	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	14.76	N/A	16.12
IC10	16.97	12.52	19.08
IC15	19.49	15.51	23.42
IC20	22.37	18.24	66.4
IC25	49.88	6.376	59.27
IC40	73	61.61	79.47
IC50	94	82.76	104

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	28.75	27	31	0.491	1.389	4.83%	0.0%
3.4		4	28.75	27	31	0.8539	1.708	5.94%	0.0%
6.7		4	27.75	26	31	1.181	2.363	8.52%	3.48%
13.3		4	29	26	31	1.225	2.449	8.45%	-0.87%
25.5		4	21	19	24	1.08	2.16	10.29%	26.96%
49.6		4	22.25	19	25	1.25	2.5	11.24%	22.61%
99.3		4	13.75	13	15	0.4787	0.9574	6.96%	52.17%
196		4	9.5	8	11	0.6455	1.291	13.59%	66.96%
386		4	6.75	5	8	0.6292	1.258	18.64%	76.52%

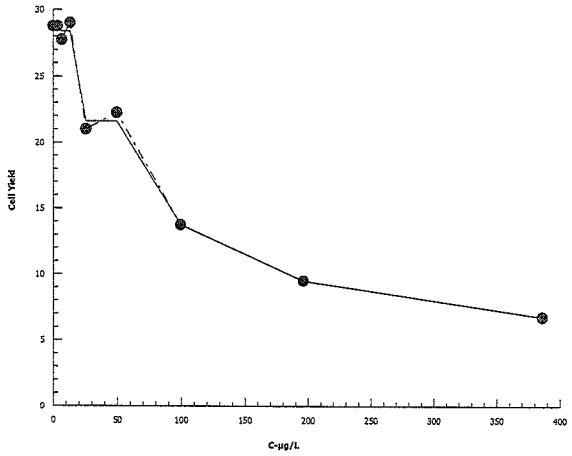
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	29	28	31	29	27	29	27	30
3.4		31	29	27	28				
6.7		26	31	28	26				
13.3		31	26	31	28				
25.5		19	20	24	21				
49.6		22	19	23	25				
99.3		13	14	13	15				
196		8	10	9	11				
386		8	7	5	7				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	17-0501-9398	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:43	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	16 Jul-18 16:43 (p 1 of 2)
Test Code:	181047b | 19-6848-4540

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-7989-7192	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:43	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	18-3001-9439	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	03 Jul-18 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	06 Jul-18 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	4d

Sample ID:	06-0043-3412	**Code:**	Lab Control	**Client:**	Pretium Exploration
Sample Date:	03 Jul-18	**Material:**	Water Sample	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Exploration		
Sample Age:	16h	**Station:**	Lab Control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	9.91%	13.3	25.5	18.42	

Dunnett Multiple Comparison Test

Control vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	3.4	0	2.563	2.85	10	0.9394	CDF	Non-Significant Effect
	6.7	0.8992	2.563	2.85	10	0.6321	CDF	Non-Significant Effect
	13.3	-0.2248	2.563	2.85	10	0.9683	CDF	Non-Significant Effect
	25.5*	6.968	2.563	2.85	10	<0.0001	CDF	Significant Effect
	49.6*	5.844	2.563	2.85	10	<0.0001	CDF	Significant Effect
	99.3*	13.49	2.563	2.85	10	<0.0001	CDF	Significant Effect
	196*	17.31	2.563	2.85	10	<0.0001	CDF	Significant Effect
	386*	19.78	2.563	2.85	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.5800	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2701.125	337.6406	8	102.4	<0.0001	Significant Effect
Error	102.25	3.298387	31			
Total	2803.375		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	5.274	20.09	0.7280	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9719	0.9236	0.4133	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	28.75	27.59	29.91	29	27	31	0.491	4.83%	0.0%
3.4		4	28.75	26.03	31.47	28.5	27	31	0.8539	5.94%	0.0%
6.7		4	27.75	23.99	31.51	27	26	31	1.181	8.52%	3.48%
13.3		4	29	25.1	32.9	29.5	26	31	1.225	8.45%	-0.87%
25.5		4	21	17.56	24.44	20.5	19	24	1.08	10.29%	26.96%
49.6		4	22.25	18.27	26.23	22.5	19	25	1.25	11.24%	22.61%
99.3		4	13.75	12.23	15.27	13.5	13	15	0.4787	6.96%	52.17%
196		4	9.5	7.446	11.55	9.5	8	11	0.6455	13.59%	66.96%
386		4	6.75	4.748	8.752	7	5	8	0.6292	18.64%	76.52%

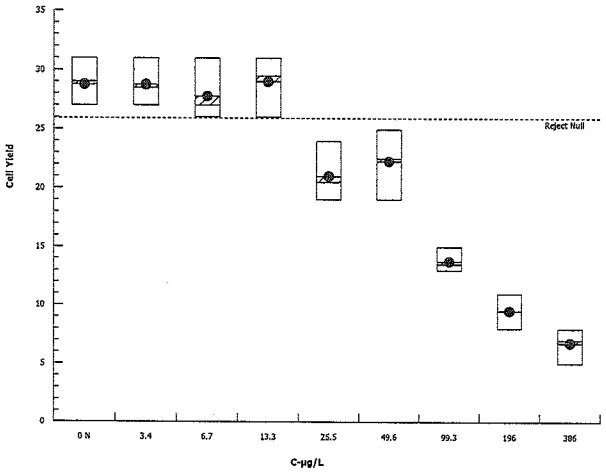
EC Alga Growth Inhibition Test — **Nautilus Environmental**

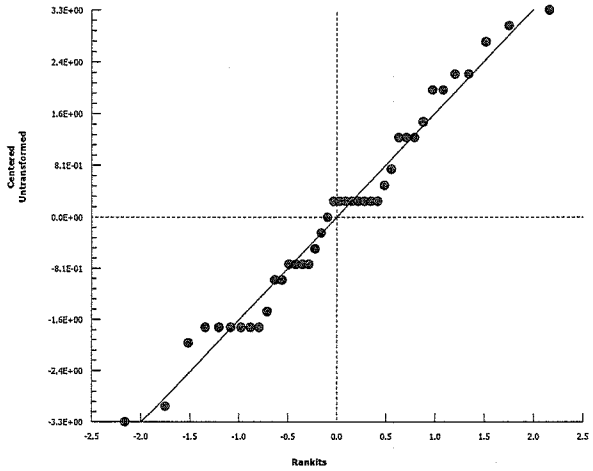
Analysis ID:	15-7989-7192	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	16 Jul-18 16:43	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	29	28	31	29	27	29	27	30
3.4		31	29	27	28				
6.7		26	31	28	26				
13.3		31	26	31	28				
25.5		19	20	24	21				
49.6		22	19	23	25				
99.3		13	14	13	15				
196		8	10	9	11				
386		8	7	5	7				

Graphics





APPENDIX B – *Chironomus dilutus* Toxicity Test Data

Chironomus dilutus Water-only Test Summary Sheet

Client: Pretium
Work Order No.: 181048

Start Date: Jul 4/18
Set up by: EC

Sample Information:

Sample ID: BJ 3.10 (amended w/ ammonia)
Sample Date: June 25/18
Date Received: June 27/18
Sample Volume: 2X20L

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: Jul 4/18
Age or size (Day 0): 3rd in-star

KCl Reference Toxicant Results:

Reference Toxicant ID: CT66
Stock Solution ID: n/a
Date Initiated: Jul 4/18

96-h LC50 (95% CL): 6.6 (5.8-7.5) g/L KCl

96-h LC50 Reference Toxicant Mean and Range: 5.1 (2.8-9.1) g/L KCl CV (%): 34

Test Results:

① 73.5 (65.4 - 82.7)

mg/L NH4	Survival	Dry Weight
LC25 (%v/v) (95% CL)	—	—
LC50(%v/v) (95% CL)	~~Ec 58.0 (45.9 - 73.4) ①~~	—
IC25(%v/v) (95% CL)	—	>93.1 (N/A-N/A)
IC50(%v/v) (95% CL)	—	>93.1 (N/A-N/A)
Ec NOEC	Ec ~~24.8~~ 48.1	Ec ~~93.1 24.8~~ 48.1
LOEC	93.1	~~>93.1 24.8~~ Ec 48.1

N/A = Not available

Reviewed by: JOh

Date reviewed: July ~~18~~ 23 /18

EC water-only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Water Quality

Client: Pretium
W.O #: 181048
Sample ID: BJ 3.10

Start Date: ~~Jun 29/18~~ Jul 3/18
Termination Date: ~~Jul 9/18~~ Jul 13/18
CER #: 11 14
Test Organism: *Chironomus dilutus*

Temperature (°C)

~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Site Control	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc1 (2)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 2 (4)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc3 (8)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 4 (16)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc5 (32)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc6 (64)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc7 (128)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

Thermometer: CER 11

Conductivity (µS)

~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Site Control	217	236	243	246	257	260	275	280	278	281	282
Conc1 (2)	219	223	229	232	245	250	265	277	279	285	286
Conc 2 (4)	241	243	254	259	279	281	290	304	315	324	331
Conc3 (8)	268	274	281	278	305	307	334	341	348	354	364
Conc4 (16)	320	321	328	338	352	360	376	372	395	394	395
Conc5 (32)	429	425	428	430	443	448	467	472	473	488	458
Conc6 (64)	666	665	672	664	679	681	700	685	696	696	702
Conc7 (128)	1129	1123	1130	1112	1137	1113	1121	1148	1155	1136	1143
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

Conductivity meter/probe: C-3 / Cp-3

Comments: ① The spiking concentration is denoted in brackets.

Reviewed by: JGh

Date Reviewed: July 16/18

EC water-only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Water Quality

Client: Pretium

W.O. #: 181048

Sample ID: BJ 3.10

Start Date: ~~Jun 29/18~~ Jul 14/18

Termination Date: ~~Jun 1 8/18~~ Jul 14/18

CER #: 11

Test Organism: *Chironomus dilutus*

Dissolved oxygen (mg/L)

~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Site Control	8.5	7.9	7.4	7.9	8.0	8.0	8.2	8.0	8.0	8.1	8.0
Conc 1 (2)	8.5	8.0	7.3	7.8	7.9	8.0	8.2	7.8	8.1	8.1	8.1
Conc 2 (4)	8.5	8.0	7.3	7.8	7.9	8.0	8.1	7.9	8.1	8.0	8.0
Conc 3 (8)	8.5	8.0	7.5	7.8	7.8	8.0	8.1	7.9	8.0	7.9	8.0
Conc 4 (16)	8.5	7.9	7.8	7.9	7.8	8.0	8.2	8.0	8.0	8.0	8.0
Conc 5 (32)	8.5	8.0	7.7	7.9	7.9	7.9	8.2	8.0	8.0	8.0	8.1
Conc 6 (64)	8.5	8.0	7.7	7.9	7.9	8.0	8.3	8.1	8.0	8.1	8.0
Conc 7 (128)	8.5	7.7	7.8	7.9	7.8	8.0	8.2	8.2	8.0	8.1	8.0
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

DO meter/probe: DO-3 / D-3

pH

~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Site Control	7.5	7.7	7.5	7.6	7.5	7.6	7.6	7.6	7.7	7.6	7.7
Conc 1 (2)	7.5	7.8	7.5	7.6	7.6	7.6	7.7	7.6	7.7	7.7	7.7
Conc 2 (4)	7.5	7.8	7.8	7.6	7.6	7.6	7.6	7.6	7.7	7.4	7.6
Conc 3 (8)	7.5	7.7	7.8	7.6	7.6	7.6	7.6	7.6	7.6	7.7	7.7
Conc 4 (16)	7.5	7.6	7.7	7.5	7.6	7.5	7.5	7.7	7.6	7.6	7.7
Conc 5 (32)	7.4	7.7	7.8	7.5	7.6	7.4	7.4	7.5	7.5	7.4	7.5
Conc 6 (64)	7.3	7.7	7.7	7.5	7.5	7.4	7.4	7.6	7.5	7.3	7.4
Conc 7 (128)	7.3	7.6	7.6	7.4	7.5	7.4	7.4	7.2	7.2	7.0	7.1
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

pH meter/probe: pH-3 / p-3

Light meter: Lit 1

Light intensity (Lux): 500-1000

Comments: ① The spiking concentration is denoted in brackets.

Reviewed by: [illegible]

Date Reviewed: July 16/18

water only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sedimen~~ water t 10-d Water Quality

Client: Pretium

W.O #: 181048

Sample ID: see below

Start Date: Jul 4/18

Termination Date: Jul 14/18

CER #: 11

Test Organism: *Chironomus dilutus*

Temperature (°C)

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Lab water	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Technician Initials	EC	EC	EC	EC	JB	MLT	EC	EC	EC	EC	EC

Thermometer: CER 11

Conductivity (µS)

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Lab water	432	430	436	423	450	455	468	481	487	487	483
Technician Initials	EC	EC	EC	EC	JB	MLT	EC	EC	EC	EC	EC

Conductivity meter/probe: C-3 / Cp-3

Dissolved oxygen (mg/L)

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Lab water	8.5	7.9	7.9	7.9	7.7	7.9	8.2	8.0	8.1	7.9	8.0
Technician Initials	EC	EC	EC	EC	JB	MLT	EC	EC	EC	EC	EC

DO meter/probe: DO-3 / D-3

pH

Sample ID	Day										
	0	1	2	3	4	5	6	7	8	9	10
Lab water	7.8	8.0	8.0	7.8	7.7	7.7	7.7	7.8	7.8	7.8	7.9
Technician Initials	EC	EC	EC	EC	JB	MLT	EC	EC	EC	EC	EC

pH meter/probe: pH-3 / p-3

Light meter: Lit1

Light intensity (Lux): 500 - 1000

Comments:

Reviewed by: [illegible]

Date Reviewed: July 16/18

10-d Chironomid ~~Sediment~~ water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Survival and Weight

Client: Pretium
W.O. #: 181048
Sample ID: ~~Site water spiked w/ ammonia~~ BJ 3.10

Start Date: ~~Jun 29~~ Jul 4/18
Termination Date: Jul 14/18
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID	Pan No.	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	1	A	8 ①	0	2		1011.28	1020.28	7	
Site Control	2	B	10	0	0		1028.43	1044.72	10	
(BJ 3.10)	3	C	10	0	0		1039.22	1053.17	10	
	4	D	9	0	1		1053.67	1070.89	9	
		~~E~~								
Conc 1	5	A	9	0	1		1011.02	1028.75	9	
	6	B	7	0	3		1010.25	1024.50	7	
	7	C	10	0	0		995.35	1013.20	10	
	8	D	9	0	1		1020.88	1037.10	9	
		~~E~~								
Conc 2	9	A	8 ①	0	2		1042.09	1061.26	7	
	10	B	9 ①	0	1		1037.66	1050.07	8	
	11	C	6 ①	0	4		1036.23	1049.87	5	
	12	D	9	0	1		1022.51	1042.78	9	
		~~E~~								
Conc 3	13	A	8 ①	0	2		991.26	1005.36	7	
	14	B	10	0	0		976.58	994.59	10	
	15	C	10	0	0		1040.18	1063.35	10	
	16	D	8	0	2		1037.75	1058.07	8	
		~~E~~								

Comments: ① 1 pupae Reweighed: Pan 3: 1052.70 mg, Pan 15: 1062.68 mg

Reviewed by: JCL

Date Reviewed: July 16/18

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Survival and Weight

Client: Pretium
W.O. #: 181048
Sample ID: ~~Site water spiked w/ ammonia~~ BJ 3.10

Start Date: ~~Jun 29/18~~ Jul 3/18
Termination Date: ~~Jul 9/18~~ Jul 14/18
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID	BJ Pan No.	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	17	A	8	0	2		1037.28	1053.80	8	
Conc 4	18	B	8	0	2		1023.19	1040.77	8	
	19	C	7 ①	0	3		1025.67	1036.62	6	
	20	D	8	0	2		1021.42	1037.83	8	
		~~E~~								
Conc 5	21	A	8	0	2		1088.15	1104.83	8	
	22	B	9	0	1		1033.63	1054.55	9	
	23	C	9	0	1		998.00	1014.50	9	
	24	D	10	0	0		1027.48	1051.19	10	
		~~E~~								
Con 6	25	A	6 ①	0	4		1015.86	1026.35	5	
	26	B	9	0	1		1035.18	1060.11	9	
	27	C	9	0	1		1033.17	1055.07	9	
	28	D	8 ①	0	2		1076.39	1086.59	7	
		~~E~~								
Conc 7	29	A	4	0	6		1002.37	1010.51	4	
	30	B	2	0	8		1028.76	1035.86	2	
	31	C	5	0	5		1018.48	1035.41	5	
	32	D	0	8	2		988.97	—	0	
		~~E~~								

Comments: ① 1 pupa Reweighed: Pan 24: 1050.56 mg, Pan 25: 1025.77 mg

Reviewed by: [illegible] Date Reviewed: July 16/18

10-d Chironomid ~~Sediment~~ water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ EL 10-d Survival and Weight

Client: Pretium

W.O. #: 181048

Sample ID: see below

Start Date: Jul 4 /18

Termination Date: Jul 14/18

Test Organism: *Chironomus dilutus*

Balance: 1

Sample ID	LW Pan No.	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
Control ~~Sediment~~ EL	1	A	8	0	2	EL	1017.41	1032.64	8	EL
(Lab water)	2	B	8	0	2	↓	1050.94	1068.39	8	↓
	3	C	8	0	2	↓	1023.84	1042.25	8	↓
	4	D	7 ①	0	3	↓	1029.49	1041.15	6	↓
		E								
		A								
		B								
		C								
		D								
		E								
		A								
		B								
		C								
		D								
		E								
		A								
		B								
		C								
		D								
		E								

Comments: ① 1 pupa Reweighed on Pan 1: 1032.08mg.

Reviewed by: JCu

Date Reviewed: July 16/18

CETIS Summary Report

Report Date:	23 Jul-18 12:27 (p 1 of 2)
Test Code:	181048a | 19-9646-6415

Chironomus 10-d Survival and Growth ~~Sediment~~ Test (EC) — **Nautilus Environmental**

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
03-3331-4337	10d Survival Rate	0.01	>0.01	NA	NA		Fisher Exact Test
02-9757-1517	10d Survival Rate	48.1	93.1	66.92	NA		Fisher Exact/Bonferroni-Holm Test
20-7862-0143	Mean Dry Weight-mg	<0.01	0.01	NA	15.7%		Equal Variance t Two-Sample Test
07-7713-4363	Mean Dry Weight-mg	48.1	>48.1	NA	39.3%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	mg/L	95% LCL	95% UCL	TU	Method
12-3393-9560	10d Survival Rate	EC50	73.54	65.41	82.67		Trimmed Spearman-Kärber
17-1178-3127	Mean Dry Weight-mg	IC5	>93.1	N/A	N/A		Linear Interpolation (ICPIN)
		IC10	>93.1	N/A	N/A		
		IC15	>93.1	N/A	N/A		
		IC20	>93.1	N/A	N/A		
		IC25	>93.1	N/A	N/A		
		IC40	>93.1	N/A	N/A		
		IC50	>93.1	N/A	N/A		

10d Survival Rate Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0.01	Lab Water	4	0.775	0.6954	0.8546	0.7	0.8	0.025	0.05	6.45%	0.0%
0.01	Negative Control	4	0.925	0.7727	1	0.8	1	0.04787	0.09574	10.35%	-19.35%
1.25		4	0.875	0.6748	1	0.7	1	0.06292	0.1258	14.38%	-12.9%
2.52		4	0.8	0.575	1	0.6	0.9	0.07071	0.1414	17.68%	-3.23%
5.15		4	0.9	0.7163	1	0.8	1	0.05774	0.1155	12.83%	-16.13%
10.2		4	0.775	0.6954	0.8546	0.7	0.8	0.025	0.05	6.45%	0.0%
20.9		4	0.9	0.7701	1	0.8	1	0.04082	0.08165	9.07%	-16.13%
48.1		4	0.8	0.575	1	0.6	0.9	0.07071	0.1414	17.68%	-3.23%
93.1		4	0.275	0	0.6278	0	0.5	0.1109	0.2217	80.63%	64.52%

Mean Dry Weight-mg Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0.01	Lab Water	4	2.082	1.779	2.386	1.904	2.301	0.09527	0.1905	9.15%	0.0%
0.01 ✓	Negative Control	4	1.556	1.113	1.998	1.286	1.913	0.139	0.2781	17.87%	25.29%
1.25 ✓		4	1.898	1.701	2.095	1.785	2.036	0.06198	0.124	6.53%	8.84%
2.52 ✓		4	2.282	1.444	3.12	1.551	2.728	0.2633	0.5267	23.08%	-9.58%
5.15 ✓		4	2.168	1.649	2.687	1.801	2.54	0.163	0.326	15.04%	-4.11%
10.2 ✓		4	2.035	1.789	2.281	1.825	2.198	0.07728	0.1546	7.6%	2.29%
20.9 ✓		4	2.153	1.76	2.547	1.833	2.371	0.1237	0.2475	11.49%	-3.41%
48.1 ✓		4	2.19	1.298	3.081	1.457	2.77	0.2801	0.5601	25.58%	-5.15%
93.1 ✓		3	2.99	0.925	5.056	2.035	3.55	0.48	0.8314	27.8%	-43.6%

Negative Control: BJ 3.10 (sitewater)

Ec

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	0.8	0.8	0.8	0.7
0.01	Negative Control	0.8	1	1	0.9
1.25		0.9	0.7	1	0.9
2.52		0.8	0.9	0.6	0.9
5.15		0.8	1	1	0.8
10.2		0.8	0.8	0.7	0.8
20.9		0.8	0.9	0.9	1
48.1		0.6	0.9	0.9	0.8
93.1		0.4	0.2	0.5	0

Mean Dry Weight-mg Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	1.904	2.181	2.301	1.943
0.01	Negative Control	1.286	1.629	1.395	1.913
1.25		1.97	2.036	1.785	1.802
2.52		2.596	1.551	2.728	2.252
5.15		2.014	1.801	2.317	2.54
10.2		2.065	2.198	1.825	2.051
20.9		2.085	2.324	1.833	2.371
48.1		2.098	2.77	2.433	1.457
93.1		2.035	3.55	3.386	

10d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	8/10	8/10	8/10	7/10
0.01	Negative Control	8/10	10/10	10/10	9/10
1.25		9/10	7/10	10/10	9/10
2.52		8/10	9/10	6/10	9/10
5.15		8/10	10/10	10/10	8/10
10.2		8/10	8/10	7/10	8/10
20.9		8/10	9/10	9/10	10/10
48.1		6/10	9/10	9/10	8/10
93.1		4/10	2/10	5/10	0/10

Negative Control : BJ 3.10 (site water)

CETIS Analytical Report

Report Date:	23 Jul-18 12:19 (p 1 of 2)
Test Code:	181048a | 19-9646-6415

Chironomus 10-d Survival and Growth ~~Sediment~~ Ec Test — **Nautilus Environmental**

Analysis ID:	12-3393-9560	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:15	**Analysis:**	Trimmed Spearman-Kärber	**Official Results:**	Yes

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ Ec dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Trimmed Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0.075	29.73%	1.867	0.02542	73.54	65.41	82.67

10d Survival Rate Summary

			Calculated Variate(A/B)								
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0.01	Negative Control	4	0.925	0.8	1	0.04787	0.09574	10.35%	0.0%	37	40
1.25		4	0.875	0.7	1	0.06292	0.1258	14.38%	5.41%	35	40
2.52		4	0.8	0.6	0.9	0.07071	0.1414	17.68%	13.51%	32	40
5.15		4	0.9	0.8	1	0.05774	0.1155	12.83%	2.7%	36	40
10.2		4	0.775	0.7	0.8	0.025	0.05	6.45%	16.22%	31	40
20.9		4	0.9	0.8	1	0.04082	0.08165	9.07%	2.7%	36	40
48.1		4	0.8	0.6	0.9	0.07071	0.1414	17.68%	13.51%	32	40
93.1		4	0.275	0	0.5	0.1109	0.2217	80.63%	70.27%	11	40

10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	0.8	1	1	0.9
1.25		0.9	0.7	1	0.9
2.52		0.8	0.9	0.6	0.9
5.15		0.8	1	1	0.8
10.2		0.8	0.8	0.7	0.8
20.9		0.8	0.9	0.9	1
48.1		0.6	0.9	0.9	0.8
93.1		0.4	0.2	0.5	0

10d Survival Rate Binomials

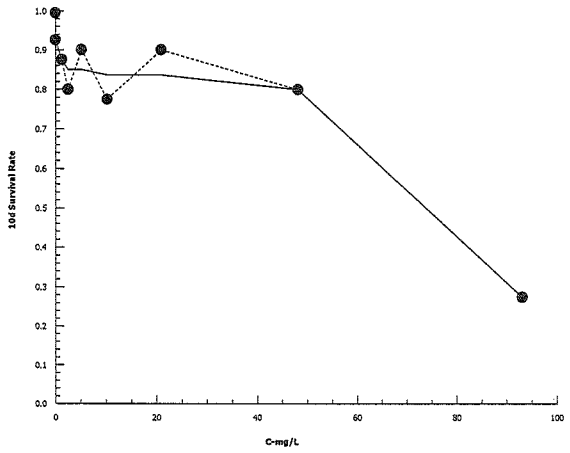
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	8/10	8/10	8/10	7/10
0.01	Negative Control	8/10	10/10	10/10	9/10
1.25		9/10	7/10	10/10	9/10
2.52		8/10	9/10	6/10	9/10
5.15		8/10	10/10	10/10	8/10
10.2		8/10	8/10	7/10	8/10
20.9		8/10	9/10	9/10	10/10
48.1		6/10	9/10	9/10	8/10
93.1		4/10	2/10	5/10	0/10

Negative Control : BJ 3.10 (site water)

Chironomus 10-d Survival and Growth ~~Sediment~~ EC Test — **Nautilus Environmental**

Analysis ID:	12-3393-9560	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:15	**Analysis:**	Trimmed Spearman-Kärber	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	23 Jul-18 12:19 (p 1 of 3)
Test Code:	181048a | 19-9646-6415

Chironomus 10-d Survival and Growth ~~Sediment~~ EC Test — **Nautilus Environmental**

Analysis ID:	02-9757-1517	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:16	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ EC dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	NOEL	LOEL	TOEL	TU
Untransformed		C > T	NA	NA	48.1	93.1	66.92	

Fisher Exact/Bonferroni-Holm Test

Sample	vs	Sample	Test Stat	P-Value	P-Type	Decision(α:5%)
0.01		1.25	0.3559	1.0000	Exact	Non-Significant Effect
0.01		2.52	0.09633	0.4817	Exact	Non-Significant Effect
0.01		5.15	0.5	1.0000	Exact	Non-Significant Effect
0.01		10.2	0.05744	0.3447	Exact	Non-Significant Effect
0.01		20.9	0.5	1.0000	Exact	Non-Significant Effect
0.01		48.1	0.09633	0.4817	Exact	Non-Significant Effect
0.01		93.1	0	<0.0001	Exact	Significant Effect

Data Summary

C-mg/L	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0.01	Negative Contr	37	3	40	0.925	0.075	0.0%
1.25		35	5	40	0.875	0.125	5.41%
2.52		32	8	40	0.8	0.2	13.51%
5.15		36	4	40	0.9	0.1	2.7%
10.2		31	9	40	0.775	0.225	16.22%
20.9		36	4	40	0.9	0.1	2.7%
48.1		32	8	40	0.8	0.2	13.51%
93.1		11	29	40	0.275	0.725	70.27%

10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	0.8	1	1	0.9
1.25		0.9	0.7	1	0.9
2.52		0.8	0.9	0.6	0.9
5.15		0.8	1	1	0.8
10.2		0.8	0.8	0.7	0.8
20.9		0.8	0.9	0.9	1
48.1		0.6	0.9	0.9	0.8
93.1		0.4	0.2	0.5	0

10d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	8/10	8/10	8/10	7/10
0.01	Negative Control	8/10	10/10	10/10	9/10
1.25		9/10	7/10	10/10	9/10
2.52		8/10	9/10	6/10	9/10
5.15		8/10	10/10	10/10	8/10
10.2		8/10	8/10	7/10	8/10
20.9		8/10	9/10	9/10	10/10
48.1		6/10	9/10	9/10	8/10
93.1		4/10	2/10	5/10	0/10

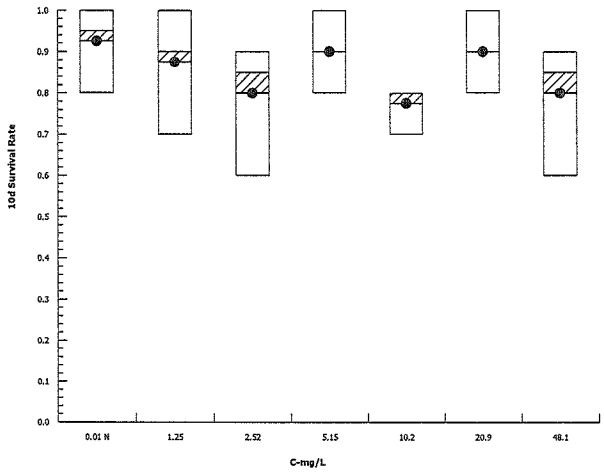
Negative (control) = BJ 3.10 (site water)

Analyst: EC QA: July 23/18

Chironomus 10-d Survival and Growth ~~Sediment~~ EC Test — **Nautilus Environmental**

Analysis ID:	02-9757-1517	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:16	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Graphics



Chironomus 10-d Survival and Growth ~~Sediment~~ EC Test — **Nautilus Environmental**

Analysis ID:	03-3331-4337	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:18	**Analysis:**	Single 2x2 Contingency Table	**Official Results:**	Yes

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ EC dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	Test Result
Untransformed		C > T	NA	NA	Passes 10d survival rate

Fisher Exact Test

Sample	vs	Sample	Test Stat	P-Value	P-Type	Decision(α:5%)
0.01		0.01	1	1.0000	Exact	Non-Significant Effect

Data Summary

C-mg/L	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0.01	Lab Water	31	9	40	0.775	0.225	0.0%
0.01	Negative Contr	37	3	40	0.925	0.075	-19.35%

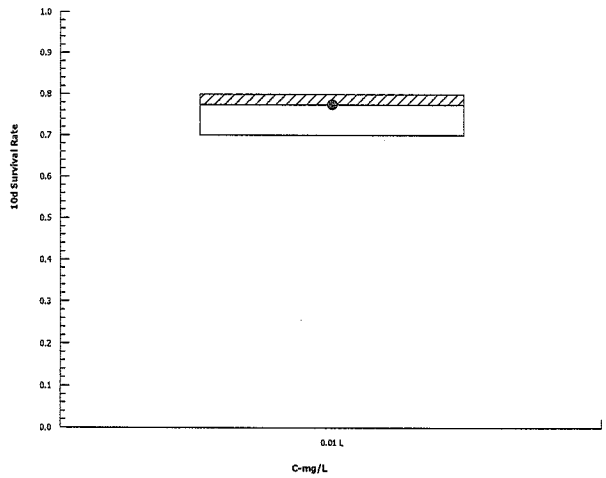
10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	0.8	0.8	0.8	0.7
0.01	Negative Control	0.8	1	1	0.9

10d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	8/10	8/10	8/10	7/10
0.01	Negative Control	8/10	10/10	10/10	9/10

Graphics



Negative Control = BJ.3.10 (site water)

CETIS Analytical Report

Report Date:	23 Jul-18 12:19 (p 1 of 2)
Test Code:	181048a | 19-9646-6415

Chironomus 10-d Survival and Growth ~~Sediment~~ Ec Test — **Nautilus Environmental**

Analysis ID:	17-1178-3127	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:16	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	140800	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L	95% LCL	95% UCL
IC5	>93.1	N/A	N/A
IC10	>93.1	N/A	N/A
IC15	>93.1	N/A	N/A
IC20	>93.1	N/A	N/A
IC25	>93.1	N/A	N/A
IC40	>93.1	N/A	N/A
IC50	>93.1	N/A	N/A

Mean Dry Weight-mg Summary

			Calculated Variate						
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.01	Negative Control	4	1.556	1.286	1.913	0.139	0.2781	17.87%	0.0%
1.25		4	1.898	1.785	2.036	0.06197	0.1239	6.53%	-22.01%
2.52		4	2.282	1.551	2.728	0.2633	0.5267	23.08%	-46.67%
5.15		4	2.168	1.801	2.54	0.163	0.326	15.04%	-39.36%
10.2		4	2.035	1.825	2.198	0.07728	0.1546	7.6%	-30.78%
20.9		4	2.153	1.833	2.371	0.1237	0.2475	11.49%	-38.42%
48.1		4	2.19	1.457	2.77	0.2801	0.5601	25.58%	-40.74%
93.1		3	2.99	2.035	3.55	0.48	0.8314	27.8%	-92.21%

Mean Dry Weight-mg Detail

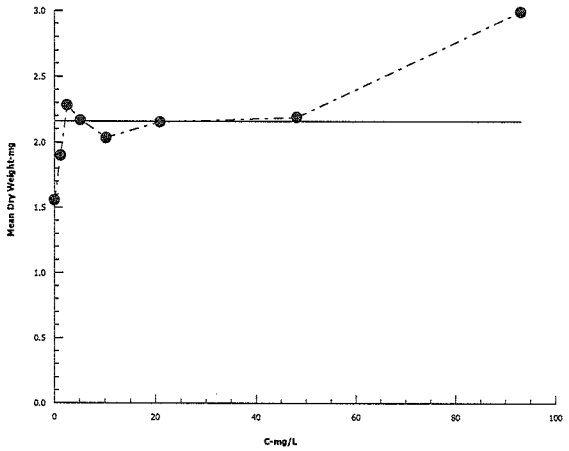
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	1.286	1.629	1.395	1.913
1.25		1.97	2.036	1.785	1.802
2.52		2.596	1.551	2.728	2.252
5.15		2.014	1.801	2.317	2.54
10.2		2.065	2.198	1.825	2.051
20.9		2.085	2.324	1.833	2.371
48.1		2.098	2.77	2.433	1.457
93.1		2.035	3.55	3.386	

Negative Control = BJ 3.10 (site water)

Chironomus 10-d Survival and Growth ~~Sediment~~ Ec Test — **Nautilus Environmental**

Analysis ID:	17-1178-3127	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:16	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	23 Jul-18 12:27 (p 1 of 2)
Test Code:	181048a | 19-9646-6415

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Analysis ID:	07-7713-4363	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:27	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	39.3%	48.1	>48.1	NA	

Dunnett Multiple Comparison Test

Control	vs	C-mg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
0.01		1.25	-1.37	2.448	0.612	6	0.9958	CDF	Non-Significant Effect
0.01		2.52	-2.904	2.448	0.612	6	1.0000	CDF	Non-Significant Effect
0.01		5.15	-2.449	2.448	0.612	6	0.9999	CDF	Non-Significant Effect
0.01		10.2	-1.915	2.448	0.612	6	0.9993	CDF	Non-Significant Effect
0.01		20.9	-2.39	2.448	0.612	6	0.9999	CDF	Non-Significant Effect
0.01		48.1	-2.535	2.448	0.612	6	0.9999	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1.458932	0.2431553	6	1.945	0.1203	Non-Significant Effect
Error	2.625762	0.1250363	21			
Total	4.084693		27			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	9.028	16.81	0.1720	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9647	0.8975	0.4474	Normal Distribution

Mean Dry Weight-mg Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.01	Negative Control	4	1.556	1.113	1.998	1.512	1.286	1.913	0.139	17.87%	0.0%
1.25		4	1.898	1.701	2.095	1.886	1.785	2.036	0.06197	6.53%	-22.01%
2.52		4	2.282	1.444	3.12	2.424	1.551	2.728	0.2633	23.08%	-46.67%
5.15		4	2.168	1.649	2.687	2.166	1.801	2.54	0.163	15.04%	-39.36%
10.2		4	2.035	1.789	2.281	2.058	1.825	2.198	0.07728	7.6%	-30.78%
20.9		4	2.153	1.76	2.547	2.205	1.833	2.371	0.1237	11.49%	-38.42%
48.1		4	2.19	1.298	3.081	2.266	1.457	2.77	0.2801	25.58%	-40.74%

Mean Dry Weight-mg Detail

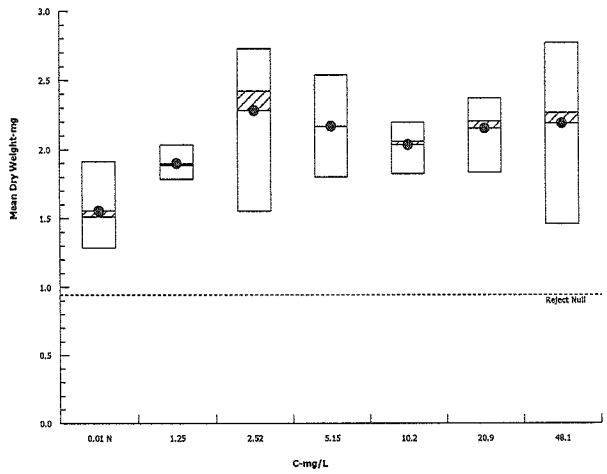
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	1.286	1.629	1.395	1.913
1.25		1.97	2.036	1.785	1.802
2.52		2.596	1.551	2.728	2.252
5.15		2.014	1.801	2.317	2.54
10.2		2.065	2.198	1.825	2.051
20.9		2.085	2.324	1.833	2.371
48.1		2.098	2.77	2.433	1.457

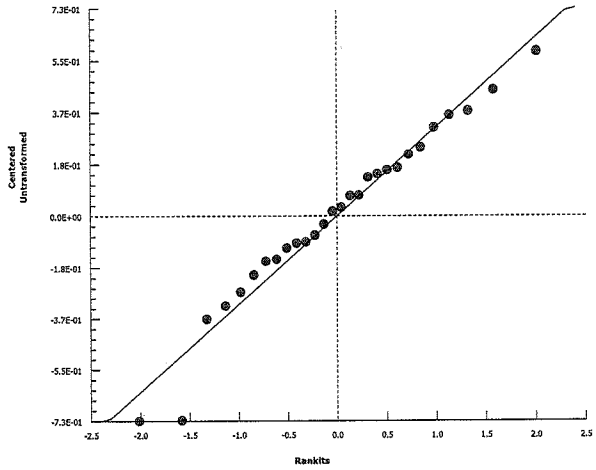
Negative Control : BJ 3.10 (site water)

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Analysis ID:	07-7713-4363	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:27	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Report Date:	23 Jul-18 12:19 (p 3 of 3)
Test Code:	181048a | 19-9646-6415

Chironomus 10-d Survival and Growth ~~Sediment~~ Ex Test — **Nautilus Environmental**

Analysis ID:	20-7862-0143	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	23 Jul-18 12:18	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	20-3421-5690	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus ~~tentans~~ Ex dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 8h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C > T	NA	NA	15.7%	Fails mean dry weight-mg

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
0.01		0.01*	3.125	1.943	0.328	6	0.0102	CDF	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.5546976	0.5546976	1	9.763	0.0205	Significant Effect
Error	0.3409043	0.05681738	6			
Total	0.8956019		7			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	2.13	47.47	0.5505	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9295	0.6451	0.5119	Normal Distribution

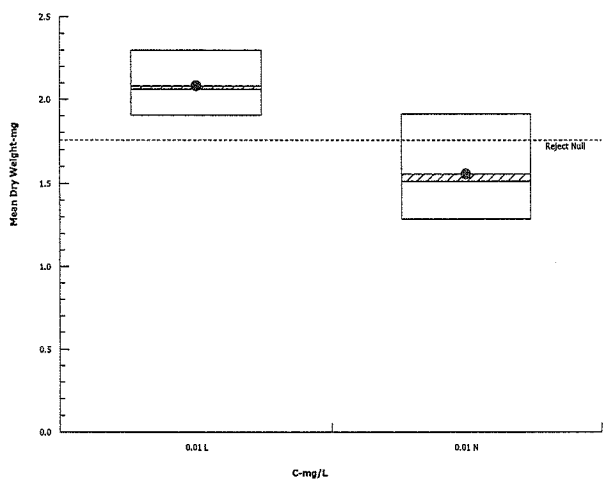
Mean Dry Weight-mg Summary

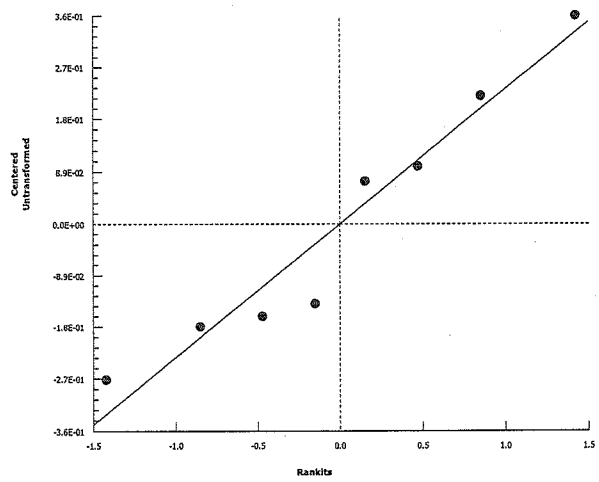
C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.01	Lab Water	4	2.082	1.779	2.386	2.062	1.904	2.301	0.09527	9.15%	0.0%
0.01	Negative Control	4	1.556	1.113	1.998	1.512	1.286	1.913	0.139	17.87%	25.29%

Mean Dry Weight-mg Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Lab Water	1.904	2.181	2.301	1.943
0.01	Negative Control	1.286	1.629	1.395	1.913

Graphics





Negative Control = BJ-3.10 (site water)

Chironomus dilutus Water-only Test Summary Sheet

Client: Pretium
Work Order No.: 181048

Start Date: Jul 4/18
Set up by: EC

Sample Information:

Sample ID: Lab water (amended w/ ammonia)
Sample Date: /
Date Received: /
Sample Volume: /

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: Jul 4/18
Age or size (Day 0): 3rd in-star

KCl Reference Toxicant Results:

Reference Toxicant ID: CT66
Stock Solution ID: n/a
Date Initiated: Jul 4/18

96-h LC50 (95% CL): 6.6 (5.8-7.5) g/L KCl

96-h LC50 Reference Toxicant Mean and Range: 5.1 (2.8-9.1) g/L KCl CV (%): 34

Test Results:

mg/L NH4	Survival	Dry Weight
LC25 (~~%v/v~~) (95% CL)	/	/
LC50(~~%v/v~~) (95% CL)	81.5 (62.4-106.4)	/
IC25(~~%v/v~~) (95% CL)	/	>97 (N/A-N/A)
IC50(~~%v/v~~) (95% CL)	/	>97 (N/A-N/A)
~~EC~~ NOEC	50	~~EC~~ ~~97~~ 50
LOEC	97	~~EC~~ ~~>97~~ >50

N/A : not available.

Reviewed by: JCh

Date reviewed: July 18/18

P1/2

EC water only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Water Quality

Client: Pretium

W.O #: 181048

Sample ID: Lab water

Start Date: ~~Jun 29~~ Jul 14 /18

Termination Date: ~~Jul 13/18~~ Jul 14/18

CER #: 11

Test Organism: *Chironomus dilutus*

Temperature (°C)

EC ~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Lab control	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 1 (2)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 2 (4)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 3 (8)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 4 (16)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 5 (32)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 6 (64)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Conc 7 (128)	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

Thermometer: CER 11

② 489

Conductivity (µS)

EC ~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Lab Control	432	430	436	423	450	455	466	481	487	487	493
Conc 1 (2)	441	445	451	459	468	465	496	508	511	511	517
Conc 2 (4)	455	460	469	461	492	491	500	505	510	536	543
Conc 3 (8) EC	~~489~~	493	496	500	513	519	533	541	556	577	565
Conc 4 (16) EC	~~341~~ ~~504~~	555	564	~~567~~	585	579	555	609	615	615	621
Conc 5 (32) EC	~~532~~ ~~692~~	672	684	652	707	686	698	716	721	727	714
Conc 6 (64)	~~918~~	919	929	948	939	926	931	932	942	935	942
Conc 7 (128)	~~881~~ EC	980	976	977	987	991	1013	1014	1035	1014	1017
EC ~~Lab~~	1440										
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

Conductivity meter/probe: C-3, Cp-3

Comments: ① The spiking concentration is denoted in brackets.
③ Checked w/ another meter

Reviewed by: [illegible]

Date Reviewed: July 16/18

EC water only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater EC ~~Sedim~~ent 10-d Water Quality

Client: Pretium
W.O. #: 181048
Sample ID: BJ 3.10

Start Date: EC ~~Jun 29~~ Jul 8 /18
Termination Date: ~~Jul EC 9/13/18~~ EC Jul 14/18
CER #: 11
Test Organism: *Chironomus dilutus*

Dissolved oxygen (mg/L)

EC ~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Lab Control	8.5	7.9	7.9	7.9	7.7	7.9	8.2	8.0	8.1	7.9	8.0
Conc 1 (2)	8.5	8.0	7.9	7.9	7.8	7.9	8.1	8.0	8.0	8.0	8.2
Conc 2 (4)	8.5	8.0	7.8	7.9	7.8	7.9	8.2	8.1	7.9	8.2	8.1
Conc 3 (8)	8.5	8.1	7.9	7.8	7.8	7.9	8.2	7.9	8.1	8.1	8.1
Conc 4 (16)	8.5	8.1	7.8	7.9	7.9	7.9	8.2	8.0	8.1	8.1	8.1
Conc 5 (32)	8.5	8.0	7.7	7.9	8.0	8.0	8.1	8.1	8.0	8.0	8.0
Conc 6 (64)	8.5	8.1	7.8	7.9	8.0	8.1	8.1	8.1	8.0	8.1	8.0
Conc 7 (128)	8.5	8.0	7.8	7.9	8.0	8.1	8.1	8.1	8.0	8.1	8.0
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

DO meter/probe: DO-3 / D-3

pH

EC ~~Sample ID~~ mg-N/L NH4 ①	Day 0	1	2	3	4	5	6	7	8	9	10
Lab Control	7.8	8.0	8.0	7.8	7.7	7.7	7.7	7.8	7.8	7.8	7.9
Conc 1 (2)	7.8	7.9	8.0	7.8	7.7	7.7	7.7	7.8	7.7	7.7	7.8
Conc 2 (4)	7.8	8.0	8.0	7.8	7.8	7.7	7.7	7.8	7.7	7.9	7.9
Conc 3 (8)	7.8	8.0	8.0	7.8	7.8	7.7	7.7	7.8	7.8	7.8	7.8
Conc 4 (16)	7.~~87~~ EC	8.0	7.7	7.8	7.8	7.7	7.7	7.8	7.8	7.8	7.8
Conc 5 (32)	7.~~47~~ EC	8.0	7.8	7.8	7.8	7.7	7.7	7.8	7.8	7.5	7.6
Conc 6 (64)	7.~~86~~ EC	7.9	7.7	7.6	7.7	7.6	7.6	7.8	7.8	7.8	7.8
Conc 7 (128)	7.~~85~~ EC	7.9	7.8	7.6	7.7	7.5	7.6	7.7	7.8	7.1	7.0
~~EC~~											
Technician Initials	EC	EC	EC	EC	JB	MG	EC	EC	EC	EC	EC

pH meter/probe: pH-3 / p-3

Light meter: Lit 1

Light intensity (Lux): 500 - 1000

Comments: ① The spiking concentration is denoted ~~at~~ in brackets.

Reviewed by: JOH

Date Reviewed: EC July 16/18

P 1/2

EL water only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater EL ~~Sediment~~ 10-d Survival and Weight

Jul ~~8~~ 4

Client: Pretium

W.O. #: 181048

Sample ID: EL ~~See~~ Lab water

Start Date: EL ~~Jun 29/18~~

Termination Date: Jul ~~14~~ 15 EL/18

Test Organism: *Chironomus dilutus*

Balance: 1

Sample ID	LW Pan No.	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
EL ~~Control Sediment~~	1	A	8	0	2	EL	1017.41	1032.64	8	EL
Lab water	2	B	8	0	2	↓	105~~8~~0.94	1068.39	8	↓
Control	3	C	8	0	2	↓	1023.84	1042.25	8	↓
	4	D	7 ①	0	3	↓	1029.49	1041.15	6	↓
		~~E~~								
Conc 1	5	A	7	0	3	EL	1010.40	1028.17	7	EL
	6	B	8 ①	0	2	↓	1017.24	1033.18	EL ~~8~~ 7	↓
	7	C	9	0	1	↓	1026.60	1045.56	9	↓
	8	D	9 ①	0	1	↓	1009.56	1025.72	8	↓
		~~E~~								
Conc 2	9	A	8	0	2	EL	990.59	1007.11	8	EL
	10	B	8	0	2	↓	1010.51	1035.57	8	↓
	11	C	9	0	1	↓	997.37	1015.47	9	↓
	12	D	~~9~~ ① 10 ①	0	0	↓	1048.52	1066.75	9	↓
		~~E~~								
Conc 3	13	A	8	0	2	EL	1042.65	1065.69	8	EL
	14	B	9	0	1	↓	1027.51	1050.72	9	↓
	15	C	8 ②	0	2	↓	1012.99	1024.38	6	↓
	16	D	9	0	1	↓	1017.29	1041.92	9	↓
		~~E~~								

Comments: ① 1 pupa ② 2 pupae Reweighed: Pan 1: 1032.08 mg, Pan 7: 1045.02 mg

Reviewed by: JGL

Date Reviewed: July 16/18

10-d Chironomid ~~Sediment~~ water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Survival and Weight

Client: Pretium
W.O. #: 181048
Sample ID: Lab water

Start Date: Jul 4/18
Termination Date: Jul 18/18
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID	Pan No.	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	17	A	8	0	2	EC	1003.09	~~1032.64~~ (4)	8	
Conc 4	18	B	8 (1)	0	2		1018.55	~~1068.39~~ (5)	7	
	19	C	8	0	2		1012.36	~~1042.25~~ (6)	8	
	20	D	7	0	3		1040.47	1062.88	7	
		E								
Conc 5	21	A	7	0	3		1013.10	1030.505	7	
	22	B	~~5~~ 6 (1)	1	~~4~~ 3		1008.70	1024.00	5	
	23	C	5 (2)	1	4		1016.68	1023.95	3	
	24	D	8	0	2		1018.34	1035.06	8	
		E								
Conc 6	25	A	5 (3)	0	5		991.84	1004.66	5	
	26	B	6	1	3		1051.19	1063.83	6	
	27	C	6	0	4		987.53	1005.19	5	
	28	D	7	0	3		1039.79	1059.59	7	
		E								
Conc 7	29	A	8 (2)	0	2		1030.13	1043.71	6	
	30	B	2	1	7		989.34	994.04	2	
	31	C	3 (2)	0	7		1011.39	1013.55	1	
	32	D	1	0	9		984.83	988.02	1	
		E								

(4) 1023.77
(5) 1038.29
(6) 1029.03

Comments: (1) 1 pupa (2) 2 pupae (3) jars marked as seeded w/ 10 organisms.
Reweighed: Pan 20: 1062.35 mg Pan 27: 1004.78 mg

Reviewed by: JCh

Date Reviewed: July 16/18

CETIS Summary Report

Report Date:	18 Jul-18 17:35 (p 1 of 2)
Test Code:	181048b | 15-3814-7999

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Batch ID:	15-3423-2355	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	08-6457-3678	**Code:**	Lab control	**Client:**	Pretivm Resources Inc.
Sample Date:	04 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	04 Jul-18	**Source:**	Pretivm Resources Inc.		
Sample Age:	NA	**Station:**	Lab control		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
18-4124-5311	10d Survival Rate	50	97	69.64	NA		Fisher Exact/Bonferroni-Holm Test
14-8073-1007	Mean Dry Weight-mg	50	>50	NA	34.2%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	mg/L	95% LCL	95% UCL	TU	Method
14-6325-4124	10d Survival Rate	EC50	81.51	62.44	106.4		Trimmed Spearman-Kärber
09-9642-6071	Mean Dry Weight-mg	IC5	>97	N/A	N/A		Linear Interpolation (ICPIN)
		IC10	>97	N/A	N/A		
		IC15	>97	N/A	N/A		
		IC20	>97	N/A	N/A		
		IC25	>97	N/A	N/A		
		IC40	>97	N/A	N/A		
		IC50	>97	N/A	N/A		

10d Survival Rate Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0.01	Negative Control	4	0.775	0.6954	0.8546	0.7	0.8	0.025	0.05	6.45%	0.0%
1.48		4	0.825	0.6727	0.9773	0.7	0.9	0.04787	0.09574	11.61%	-6.45%
3.08		4	0.875	0.7227	1	0.8	1	0.04787	0.09574	10.94%	-12.9%
6.7		4	0.85	0.7581	0.9419	0.8	0.9	0.02887	0.05774	6.79%	-9.68%
13.3		4	0.775	0.6954	0.8546	0.7	0.8	0.025	0.05	6.45%	0.0%
25.3		4	0.65	0.4446	0.8554	0.5	0.8	0.06455	0.1291	19.86%	16.13%
50		4	0.6	0.4701	0.7299	0.5	0.7	0.04082	0.08165	13.61%	22.58%
97		4	0.35	0	0.8447	0.1	0.8	0.1555	0.3109	88.83%	54.84%

Mean Dry Weight-mg Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0.01	Negative Control	4	2.082	1.779	2.386	1.904	2.301	0.09527	0.1905	9.15%	0.0%
1.48		4	2.236	1.872	2.599	2.02	2.539	0.1142	0.2285	10.22%	-7.36%
3.08		4	2.309	1.434	3.183	2.011	3.132	0.2749	0.5498	23.81%	-10.86%
6.7		4	2.523	1.832	3.215	1.898	2.88	0.2173	0.4345	17.22%	-21.18%
13.3		4	2.673	1.929	3.417	2.084	3.201	0.2338	0.4675	17.49%	-28.34%
25.3		4	2.367	2.07	2.663	2.09	2.493	0.09327	0.1865	7.88%	-13.65%
50		4	2.758	1.809	3.706	2.107	3.532	0.298	0.5961	21.61%	-32.43%
97		4	2.491	1.739	3.243	2.16	3.19	0.2363	0.4725	18.97%	-19.61%

Negative Control = Lab control

Analyst: EC QA: JGH July 18/18

Chironomus 10-d Survival and Growth ~~Sediment~~ EL Test — **Nautilus Environmental**

10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	0.8	0.8	0.8	0.7
1.48		0.7	0.8	0.9	0.9
3.08		0.8	0.8	0.9	1
6.7		0.8	0.9	0.8	0.9
13.3		0.8	0.8	0.8	0.7
25.3		0.7	0.6	0.5	0.8
50		0.5	0.6	0.6	0.7
97		0.8	0.2	0.3	0.1

Mean Dry Weight-mg Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	1.904	2.181	2.301	1.943
1.48		2.539	2.277	2.107	2.02
3.08		2.065	3.132	2.011	2.026
6.7		2.88	2.579	1.898	2.737
13.3		2.585	2.82	2.084	3.201
25.3		2.493	2.46	2.423	2.09
50		2.564	2.107	3.532	2.829
97		2.263	2.35	2.16	3.19

10d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	8/10	8/10	8/10	7/10
1.48		7/10	8/10	9/10	9/10
3.08		8/10	8/10	9/10	10/10
6.7		8/10	9/10	8/10	9/10
13.3		8/10	8/10	8/10	7/10
25.3		7/10	6/10	5/10	8/10
50		5/10	6/10	6/10	7/10
97		8/10	2/10	3/10	1/10

Negative Control = Lab water

CETIS Analytical Report

Report Date: 17 Jul-18 10:27 (p 1 of 2)
Test Code: 181048b | 15-3814-7999

Chironomus 10-d Survival and Growth ~~Sediment~~ EC Test — **Nautilus Environmental**

Analysis ID:	14-6325-4124	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Jul-18 10:24	**Analysis:**	Trimmed Spearman-Kärber	**Official Results:**	Yes

Batch ID:	15-3423-2355	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	08-6457-3678	**Code:**	Lab control	**Client:**	Pretivm Resources Inc.
Sample Date:	04 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	04 Jul-18	**Source:**	Pretivm Resources Inc.		
Sample Age:	NA	**Station:**	Lab control		

Trimmed Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0.225	42.11%	1.911	0.0579	81.51	62.44	106.4

10d Survival Rate Summary

			Calculated Variate(A/B)								
C-mg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect	A	B
0.01	Negative Control	4	0.775	0.7	0.8	0.025	0.05	6.45%	0.0%	31	40
1.48		4	0.825	0.7	0.9	0.04787	0.09574	11.61%	-6.45%	33	40
3.08		4	0.875	0.8	1	0.04787	0.09574	10.94%	-12.9%	35	40
6.7		4	0.85	0.8	0.9	0.02887	0.05774	6.79%	-9.68%	34	40
13.3		4	0.775	0.7	0.8	0.025	0.05	6.45%	0.0%	31	40
25.3		4	0.65	0.5	0.8	0.06455	0.1291	19.86%	16.13%	26	40
50		4	0.6	0.5	0.7	0.04082	0.08165	13.61%	22.58%	24	40
97		4	0.35	0.1	0.8	0.1555	0.3109	88.83%	54.84%	14	40

10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	0.8	0.8	0.8	0.7
1.48		0.7	0.8	0.9	0.9
3.08		0.8	0.8	0.9	1
6.7		0.8	0.9	0.8	0.9
13.3		0.8	0.8	0.8	0.7
25.3		0.7	0.6	0.5	0.8
50		0.5	0.6	0.6	0.7
97		0.8	0.2	0.3	0.1

10d Survival Rate Binomials

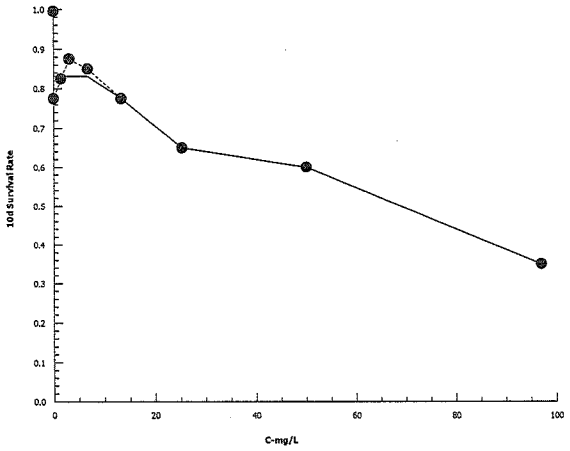
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	8/10	8/10	8/10	7/10
1.48		7/10	8/10	9/10	9/10
3.08		8/10	8/10	9/10	10/10
6.7		8/10	9/10	8/10	9/10
13.3		8/10	8/10	8/10	7/10
25.3		7/10	6/10	5/10	8/10
50		5/10	6/10	6/10	7/10
97		8/10	2/10	3/10	1/10

Negative Control = Lab control water

Chironomus 10-d Survival and Growth ~~Sediment~~ EL Test — **Nautilus Environmental**

Analysis ID:	14-6325-4124	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Jul-18 10:24	**Analysis:**	Trimmed Spearman-Kärber	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	17 Jul-18 10:27 (p 1 of 2)
Test Code:	181048b | 15-3814-7999

Chironomus 10-d Survival and Growth ~~Sediment~~ Test EL — **Nautilus Environmental**

Analysis ID:	18-4124-5311	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Jul-18 10:24	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Batch ID:	15-3423-2355	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	08-6457-3678	**Code:**	Lab control	**Client:**	Pretivm Resources Inc.
Sample Date:	04 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	04 Jul-18	**Source:**	Pretivm Resources Inc.		
Sample Age:	NA	**Station:**	Lab control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	NOEL	LOEL	TOEL	TU
Untransformed		C > T	NA	NA	50	97	69.64	

Fisher Exact/Bonferroni-Holm Test

Sample	vs	Sample	Test Stat	P-Value	P-Type	Decision(α:5%)
0.01		1.48	1	1.0000	Exact	Non-Significant Effect
0.01		3.08	1	1.0000	Exact	Non-Significant Effect
0.01		6.7	1	1.0000	Exact	Non-Significant Effect
0.01		13.3	0.6052	1.0000	Exact	Non-Significant Effect
0.01		25.3	0.1616	0.8080	Exact	Non-Significant Effect
0.01		50	0.07356	0.4413	Exact	Non-Significant Effect
0.01		97	0.0001275	0.0009	Exact	Significant Effect

Data Summary

C-mg/L	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0.01	Negative Contr	31	9	40	0.775	0.225	0.0%
1.48		33	7	40	0.825	0.175	-6.45%
3.08		35	5	40	0.875	0.125	-12.9%
6.7		34	6	40	0.85	0.15	-9.68%
13.3		31	9	40	0.775	0.225	0.0%
25.3		26	14	40	0.65	0.35	16.13%
50		24	16	40	0.6	0.4	22.58%
97		14	26	40	0.35	0.65	54.84%

10d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	0.8	0.8	0.8	0.7
1.48		0.7	0.8	0.9	0.9
3.08		0.8	0.8	0.9	1
6.7		0.8	0.9	0.8	0.9
13.3		0.8	0.8	0.8	0.7
25.3		0.7	0.6	0.5	0.8
50		0.5	0.6	0.6	0.7
97		0.8	0.2	0.3	0.1

10d Survival Rate Binomials

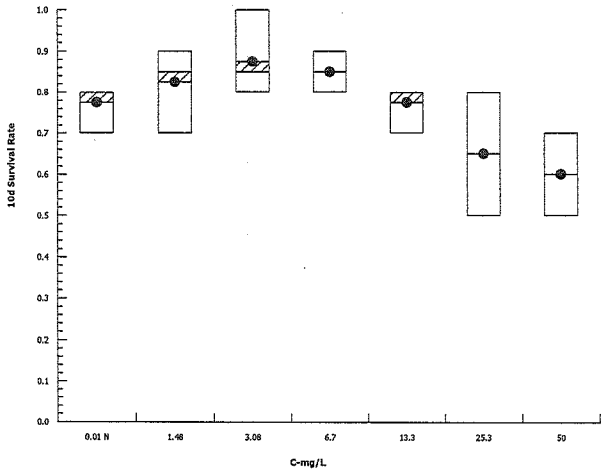
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	8/10	8/10	8/10	7/10
1.48		7/10	8/10	9/10	9/10
3.08		8/10	8/10	9/10	10/10
6.7		8/10	9/10	8/10	9/10
13.3		8/10	8/10	8/10	7/10
25.3		7/10	6/10	5/10	8/10
50		5/10	6/10	6/10	7/10
97		8/10	2/10	3/10	1/10

Lab control water = Negative Control water

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Analysis ID:	18-4124-5311	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Jul-18 10:24	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	17 Jul-18 10:27 (p 1 of 2)
Test Code:	181048b | 15-3814-7999

Chironomus 10-d Survival and Growth ~~Sediment~~ EC Test — **Nautilus Environmental**

Analysis ID:	09-9642-6071	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Jul-18 10:26	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	15-3423-2355	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32 (modified)	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	08-6457-3678	**Code:**	Lab control	**Client:**	Pretivm Resources Inc.
Sample Date:	04 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	04 Jul-18	**Source:**	Pretivm Resources Inc.		
Sample Age:	NA	**Station:**	Lab control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1644536	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L	95% LCL	95% UCL
IC5	>97	N/A	N/A
IC10	>97	N/A	N/A
IC15	>97	N/A	N/A
IC20	>97	N/A	N/A
IC25	>97	N/A	N/A
IC40	>97	N/A	N/A
IC50	>97	N/A	N/A

Mean Dry Weight-mg Summary

			Calculated Variate						
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.01	Negative Control	4	2.082	1.904	2.301	0.09527	0.1905	9.15%	0.0%
1.48		4	2.236	2.02	2.539	0.1142	0.2285	10.22%	-7.36%
3.08		4	2.309	2.011	3.132	0.2749	0.5498	23.81%	-10.86%
6.7		4	2.523	1.898	2.88	0.2173	0.4345	17.22%	-21.18%
13.3		4	2.673	2.084	3.201	0.2338	0.4675	17.49%	-28.34%
25.3		4	2.367	2.09	2.493	0.09327	0.1865	7.88%	-13.65%
50		4	2.758	2.107	3.532	0.298	0.5961	21.61%	-32.43%
97		4	2.491	2.16	3.19	0.2363	0.4725	18.97%	-19.61%

Mean Dry Weight-mg Detail

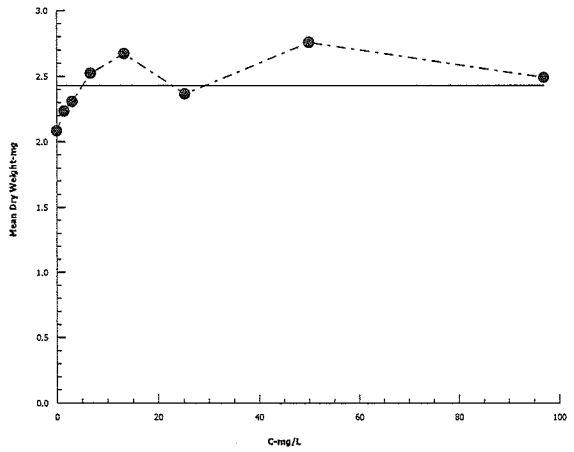
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	1.904	2.181	2.301	1.943
1.48		2.539	2.277	2.107	2.02
3.08		2.065	3.132	2.011	2.026
6.7		2.88	2.579	1.898	2.737
13.3		2.585	2.82	2.084	3.201
25.3		2.493	2.46	2.423	2.09
50		2.564	2.107	3.532	2.829
97		2.263	2.35	2.16	3.19

Negative Control = Lab control water

Chironomus 10-d Survival and Growth S~~ediment~~ Test — **Nautilus Environmental**

Analysis ID:	09-9642-6071	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Jul-18 10:26	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 18 Jul-18 17:35 (p 1 of 2)
Test Code: 181048b | 15-3814-7999

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Analysis ID:	14-8073-1007	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:35	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	15-3423-2355	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Eric Cheung
Start Date:	04 Jul-18	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Reconstituted Water
Ending Date:	14 Jul-18	**Species:**	Chironomus dilutus	**Brine:**	
Duration:	10d 0h	**Source:**	Aquatic Biosystems, CO	**Age:**	3rd instar

Sample ID:	08-6457-3678	**Code:**	Lab control	**Client:**	Pretivm Resources Inc.
Sample Date:	04 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	04 Jul-18	**Source:**	Pretivm Resources Inc.		
Sample Age:	NA	**Station:**	Lab control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	34.2%	50	>50	NA	

Dunnett Multiple Comparison Test

Control	vs	C-mg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
0.01		1.48	-0.5259	2.448	0.713	6	0.9546	CDF	Non-Significant Effect
0.01		3.08	-0.7762	2.448	0.713	6	0.9762	CDF	Non-Significant Effect
0.01		6.7	-1.514	2.448	0.713	6	0.9974	CDF	Non-Significant Effect
0.01		13.3	-2.026	2.448	0.713	6	0.9995	CDF	Non-Significant Effect
0.01		25.3	-0.9753	2.448	0.713	6	0.9863	CDF	Non-Significant Effect
0.01		50	-2.318	2.448	0.713	6	0.9998	CDF	Non-Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.7391	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1.407398	0.2345663	6	1.382	0.2676	Non-Significant Effect
Error	3.564844	0.1697545	21			
Total	4.972242		27			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	7.005	16.81	0.3204	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.962	0.8975	0.3892	Normal Distribution

Mean Dry Weight-mg Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.01	Negative Control	4	2.082	1.779	2.386	2.062	1.904	2.301	0.09527	9.15%	0.0%
1.48		4	2.236	1.872	2.599	2.192	2.02	2.539	0.1142	10.22%	-7.36%
3.08		4	2.309	1.434	3.183	2.045	2.011	3.132	0.2749	23.81%	-10.86%
6.7		4	2.523	1.832	3.215	2.658	1.898	2.88	0.2173	17.22%	-21.18%
13.3		4	2.673	1.929	3.417	2.703	2.084	3.201	0.2338	17.49%	-28.34%
25.3		4	2.367	2.07	2.663	2.442	2.09	2.493	0.09327	7.88%	-13.65%
50		4	2.758	1.809	3.706	2.696	2.107	3.532	0.298	21.61%	-32.43%

Mean Dry Weight-mg Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4
0.01	Negative Control	1.904	2.181	2.301	1.943
1.48		2.539	2.277	2.107	2.02
3.08		2.065	3.132	2.011	2.026
6.7		2.88	2.579	1.898	2.737
13.3		2.585	2.82	2.084	3.201
25.3		2.493	2.46	2.423	2.09
50		2.564	2.107	3.532	2.829

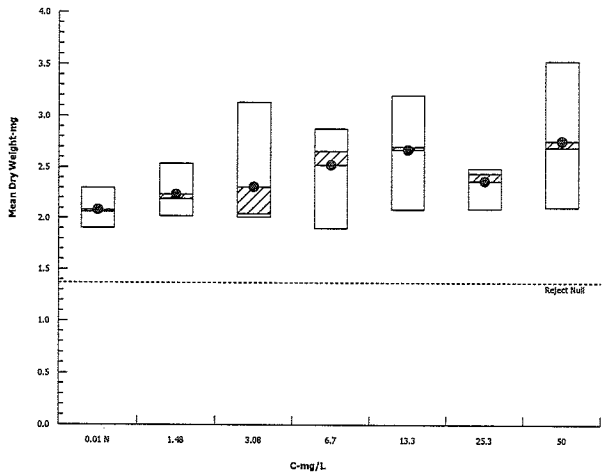
Negative Control = Lab water

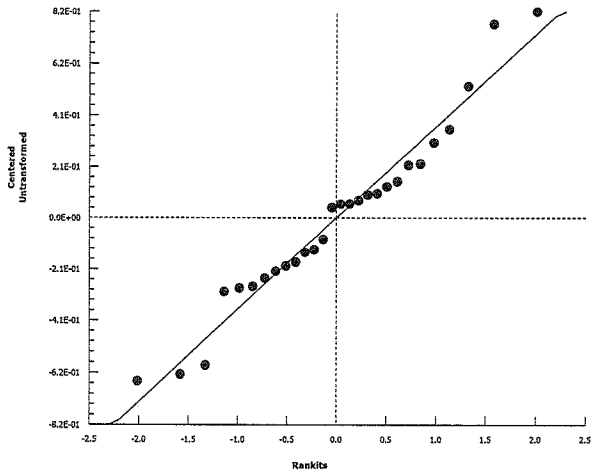
Analyst: EC QA: JGK July 18/18

Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Analysis ID:	14-8073-1007	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:35	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Graphics





Client: Pretium

W.O.#: 181048

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
Site	Jul ~~13~~ 14									
Fr ~~Lab~~ Ctl	~~Jun 29/18~~	Jul 5/18	50	1.7	1.8	32	50	2.9	58	EC
Conc 1				1.8	1.9	34		2.9	58	
Conc 2				1.9	2.0	36		3.0	60	
Conc 3				1.8	1.9	34		2.8	56	
Conc 4				1.9	2.0	36		2.9	58	
Conc 5				1.7	1.8	32		2.8	56	
Conc 6				1.9	2.0	36		2.8	56	
Conc 7				1.8	1.9	34		2.8	56	
Day 0										
EC	Jul ~~13~~ 14	(2)								
Site ~~Lab~~ Ctl	~~Jul 9/18~~	50	50	2.7	2.8	52	50	3.2	64	
Conc 1		50	50	3.0	3.1	58		3.2	64	
Conc 2		50	50	3.1	3.2	60		3.5	70	
Conc 3		10 (1)	10 (1)	Fr ~~3.0~~ 0.5	Fr ~~3.1~~ 0.6	40		3.5	70	
Conc 4		50	50	2.3	2.4	44		3.9	78	
Conc 5		10 (1)	10 (1)	0.5	0.6	40		3.6	72	
Conc 6		10 (1)	10 (1)	0.1	0.2	0		4.0	Fr ~~80~~ 80	
Conc 7		~~50~~ 10 (1) Fr	10 (1)	0.1	0.2	0		4.0	80	
Day 10										

Notes: (1) Diluted to 100 mL w/ D.I. water.

(2) Date measured: Jul 14/18 for all samples.

Reviewed by: JOL

Date Reviewed: July 17/18

Client: Pretium

W.O.#: 181048

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Ec ~~Day 0~~ Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
	Jul 14									
Day 0 Lab Ctl	~~Jun 29~~/18	Jul 5/18	50	2.9	3.0	56	10 ①	1.5	150	EC
Conc 1	↓	↓	↓	2.8	2.9	54	↓	1.6	160	↓
Conc 2				2.9	3.0	56		1.6	160	
Conc 3				2.9	3.0	56		1.1	110	
Conc 4				2.8 x Ec	2.9	54		1.2	120	
Conc 5				2.7	2.8	52		1.5	150	
Conc 6				2.9	3.0	56		1.6	160	
Conc 7	✓	✓	✓	2.9	3.0	56	✓	1.7	170	
	~~Jul 14~~									
Day 10 Lab Ctl	Jul 9/18 Ec	Jul 14/18	10 ①	0.9	1.0	80	50	6.5	130	
Conc 1	↓	↓	10 ①	0.8	0.9	70	10 ①	1.7	170	
Conc 2			10 ①	0.9	1.0	80	10 ①	1.5	150	
Conc 3			10 ①	0.7	0.8	60	10 ①	1.7	170	
Conc 4			10 ①	0.8	0.9	70	10 ①	1.7	170	
Conc 5			10 ①	0.7	0.8	60	10 ①	1.6	160	
Conc 6			10 ①	0.5	0.6	40	10 ①	1.6	160	
Conc 7	✓	✓	10 ①	0.2	0.3	10	10 ①	1.5	150	✓

Notes: ① Diluted to 100 mL w/ D.I. water

Reviewed by: JGh

Date Reviewed: July 17/18

Client: Pretium

W.O.#: 181048

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
MHW 062818	Jul 4/18	Jul 4/18	50	2.9	3.0	56	50	6.8	136	EV

Notes:

Reviewed by: Jay

Date Reviewed: July 17/18

Nautilus Environmental
Water Quality Data For Ammonia

Client : Pretium

Species : Chironomus dilutus

Work Order No: 181048

Sample Type: Overlying ammonia

Sample ID : EC ~~Lab water~~ BJ 3.10

Date Measured: See below

	Date	Sample ID	Temperature (°C)	pH	Total Ammonia as N (mg/L) ①	Unionized Ammonia (mg/L)	Tech. Init.
Day 0 Site water	Jul 4/18 EC	~~Lab~~ Site Control	23.0	7.75 EC	0.010	0.000	EC
		Conc 1	23.0	7.85 EC	1.25	0.019	
		Conc 2	23.0	7.5	2.52	0.039	
		Conc 3	23.0	7.5	5.15	0.079	
		Conc 4	23.0	7.5	10.2	0.157	
		Conc 5	23.0	7.4	20.9	0.256	
		Conc 6	23.0	7.3	24.8	0.242	
		Conc 7	23.0	7.3	93.1	0.907	
Day 10 EC Lab water	Jul EC 4/17	Lab Control	23.0	7.8	0.005	0.000	
		Conc 1	23.0	7.8	1.48	0.045	
		Conc 2	23.0	7.8	3.08	0.093	
		Conc 3	23.0	7.8	6.70	0.202	
		Conc 4	23.0	7.7	13.3	0.321	
		Conc 5	23.0	7.7	25.3	0.610	
		Conc 6	23.0	7.6	50.0	0.963	
		Conc 7	23.0	7.5	97.0	1.490	✓

Ammonia Salicylate Lot #: —

Ammonia Cyanurate Lot #: —

Comments: ① Subsamples were sent to analytical chemistry Lab for ~~tot~~ EC total ammonia analyses.

Reviewed by: JOh

Date Reviewed: July 17/18

APPENDIX C – *Ceriodaphnia dubia* Toxicity Test Data

Ceriodaphnia dubia Summary Sheet

Client: Lotrax (Pratum)
Work Order No.: 181138

Start Date/Time: July 3/18 @ 1700h
Set up by: [illegible]

Sample Information:

Sample ID: BJ 3-10
Sample Date: June 25/18
Date Received: June 27/18
Sample Volume: 2 x 20L

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 4.0 to 8.4 ; pH = 6.0 to 9.0

Test Organism Information:

Broodstock No.: BB062018 A & B
Age of young (Day 0): <24-h (within 8-h)
Avg No. young in first 3 broods of previous 7 d: 32
Mortality (%) in previous 7 d: 5
Individual female # used ≥8 young on test day: 3-10, 32, 35-40

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd187
Stock Solution ID: 18NaCl2 (100g/L NaCl)
Date Initiated: July 4/18

7-d LC50 (95% CL): 2.1 (1.5 – 3.0) g/L NaCL
7-d IC50 (95% CL): 1.4 (1.3 – 1.6) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0 (1.8 – 2.3) g/L NaCL CV (%): 6
7-d IC50 Reference Toxicant Mean and Historical Range: 1.3 (0.8 – 1.9) g/L NaCL CV (%): ~~23~~ 24

Test Results:

~~mg/L~~ mg/L NH4

	Survival	Reproduction
LC50 %v/v (95% CL)	~~31.7 (27.6 – 36.4)~~	
IC25 %v/v (95% CL)	~~8~~	24.0 (18.3 – 25.9)
IC50 %v/v (95% CL)		30.4 (~~27.5~~ 28.1 – ~~31~~ 31.9)
NOEC %v/v	23.9	23.9
LOEC %v/v	48.4	~~48.4~~ > 23.9

~~033~~ 33.9 (28.1 – 41.0)

Reviewed by: JCh

Date reviewed: July 18/18

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lotrax (Prefilm)
Sample ID: Control
Work Order #: 181138

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9/18 @ 1800h
CER #: 4
Test Species: *Ceriodaphnia dubia*

Control Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0		
DO (mg/L)	8.2	7.3	7.9	7.0	7.9	7.5	8.2	7.2	8.2	7.5	8.2	7.4		
pH	8.3	7.9	8.2	8.0	8.0	8.0	8.2	7.8	7.9	7.8	8.1	7.8		
Cond. (µS/cm)	209	209		209		210		211		210		205		
Initials	KL	KL		KL		KL		KL		MR/KL		KL		

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Thermometer: 4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control			
Hardness*	100			
Alkalinity*	90			

* mg/L as CaCO3

Analysts: KL, MLT

Reviewed by: JOH

Date reviewed: July 18/18

Sample Description: ~~spiked 55~~

Comments: Broodboard Used: RB062018A&B (3-10, 32, 35-40)

pg 2/3 BM
1/2

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax (Pretium)
Sample ID: ammonia in site water
Work Order #: 181138
NH4 (mg-N/L)

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9/18 @ 1800h
CER #: 4
Test Species: *Ceriodaphnia dubia*

Site Ctrl Concentration BJ 3.10	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.0	7.9	7.0	8.2	7.2	8.2	7.4		
pH	7.9	7.8	8.0	8.0	7.9	7.9	8.1	7.8	7.7	7.7	7.8	7.7		
Cond. (µS/cm)	368	370		370		372		367		368		352		
Initials	KL	KL		KL		KL		KL		MLT		KL		

Concentration 2.0	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.2	7.9	7.0	8.2	7.2	8.2	7.4		
pH	7.8	7.8	8.0	8.0	7.9	7.9	8.1	7.8	7.7	7.7	7.8	7.7		
Cond. (µS/cm)	384	387		385 ~~369~~ KL		389		384		386		372		
Initials	KL	KL		KL		KL		KL		MLT		KL		

Concentration 4.0	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.2	7.9	7.0	8.2	7.3	8.2	7.4		
pH	7.8	7.8	8.0	8.0	7.9	7.9	8.0	7.8	7.7	7.7	7.8	~~7.7~~		
Cond. (µS/cm)	400	403		400		401 ~~400~~ KL		398		400		387		
Initials	KL	KL		KL		KL		KL		MLT		KL		

Concentration 8.0	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.2	7.9	7.0	8.2	7.4	8.2	7.4		
pH	7.8	7.8	8.0	8.0	7.9	7.9	8.0	7.8	7.7	7.8	7.8	7.7		
Cond. (µS/cm)	429	432		429		429		427		432		413		
Initials	KL	KL		KL		KL		KL		MLT		KL		

Thermometer: 4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control	BJ 3.10 (unamended)		~~BJ~~ BJ 3.10 (amended) KL
Hardness*	100	60		110
Alkalinity*	90	38		71

* mg/L as CaCO3

Analysts: KL, MLT
Reviewed by: [illegible]
Date reviewed: July 18/18

Sample Description: Clear, colourless, odourless, no particulates; spiked 35.8 mL of 10 g/L NH4 into 281 g hardness amended site water to make 128 mg/L NH4

Comments: Broodboard Used: BB0620(8A&B(3-10, 32, 35-40)

pg 2/3 on 2/2

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax (Pretium)
Sample ID: ammonia in site water
Work Order #: 181138

Start Date & Time: July 3 /18 @ 1700h
Stop Date & Time: July 9 /18 @ 1800h
CER #: 4
Test Species: *Ceriodaphnia dubia*

NH4 (mg-N-L)

Concentration 16	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.2	7.9	7.0	8.2	7.4	8.2	7.4		
pH	7.7	7.8	8.0	8.0	7.9	7.9	8.0	7.7	7.6	7.8	7.8	7.7		
Cond. (µS/cm)	488	490		487		488		491		490		467		
Initials	KL	KL		KL		KL		KL		MLT		KL		

Concentration 32	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.2	7.9	7.0	8.2	7.4	8.2	7.4		
pH	7.7	7.8	7.9	7.9	7.8	7.9	~~8~~ 7.9	7.7	7.6	7.8	7.8	7.8		
Cond. (µS/cm)	608	604		606		603		607		615		574		
Initials	KL	KL		KL		KL		KL		MLT		KL		

Concentration 64	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.2	7.4	7.9	7.2	8.1	7.2	7.9	7.0	8.2	7.5	8.2	7.4		
pH	7.6	7.8	7.8	7.9	7.7	7.9	7.9	7.7	7.6	7.8	7.7	7.7		
Cond. (µS/cm)	845	841		839		~~7.9~~ 836		850		850		790		
Initials	KL	KL		KL		KL	KL	KL		MLT		KL		

Concentration 128	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.0									
DO (mg/L)	8.2	7.4	7.9	7.2	8.1									
pH	7.4	7.6	7.8	7.6	7.6									
Cond. (µS/cm)	~~1335~~	1315		1322										
Initials	KL	KL		KL	KL									

Thermometer: 4 DO meter/probe: 1 / 1 (3-10) pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control	BJ (unamended)		BJ 3-10 (amended)
Hardness*	100	~ 60		110
Alkalinity*	90	38		71

* mg/L as CaCO3

Analysts: KL, MLT

Reviewed by: JOL

Date reviewed: July 18/18

Sample Description: Clear, colourless, odourless, no particulates ; spiked 35 Sal of 10g/L NH_4 into 2.8L of amended site water to make ~ 28mg/L NH_4 hardness

Comments: Broodboard Used: BB06201 8A & B (3-10, 32, 35-40)

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Lorax (Pretflum)
Sample ID: ammonia in amended site water
Work Order: 181138

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9/18 @ 1800h
Set up by: KL

MG-N/L NH4

Days	Concentration: site control (hardness amended)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
4	5	3	3	3	3	✓	2	✓	4	✓	KL
5	5	6	7	8	5	6	5	6	7	4	MG
6	10	10	11	11	7	11	9	8	14	10	KL
7											
8											
Total	20	19	21	22	~~0~~ KL 15	17	16	14	25	14	KL

Days	Concentration: 2 (20)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
4	2	2	3	2	4	2	2	4	✓	2	KL
5	5	6	5	6	7	7	7	8	6	5	MG
6	9	11	9	13	12	15	13	14	11	11	KL
7											
8											
Total	16	19	17	21	23	24	22	26	17	18	KL

Days	Concentration: 4 (30)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
4	4	2	3	3	5	4	✓	2	2	2	KL
5	5	8	7	7	6	7	✓	6	7	6	MG
6	11	13	11	13	12	11	6	13	13	14	KL
7											
8											
Total	20	23	21	23	23	22	6	21	22	22	KL

Days	Concentration: 8 (5.8)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
4	2	4	3	3	5	2	4	2	4	4	KL
5	6	6	7	5	8	5	7	6	6	7	~~KL~~ MG
6	7	12	10	12	10	12	12	11	✓	14	KL
7											
8											
Total	15	22	20	20	23	19	23	19	10	25	KL

Days	Concentration: 16 (11.8)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
4	4	2	4	3	4	3	4	3	3	4	KL
5	6	5	7	8	7	7	8	6	8	7	MG
6	9	8	12	11	12	7	11	12	11	X	KL
7											
8											
Total	19	15	23	22	23	17	23	21	22	11X	KL

Days	Concentration: 32 (23.9)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
4	4	3	4	4	2	2	4	3	3	2	KL
5	4	✓	4	5	6	6	5	4	6	5	MG
6	9	5	6	✓	9	8	7	9	10	9	KL
7											
8											
Total	17	8	14	9	17	16	16	16	19	16	KL

Days	Concentration: 64 (48.4)										
	A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	KL
3	✓	X	✓	✓	✓	X	✓	X	X	X	KL
4	X	|	✓	✓	✓	|	✓	|	|	|	KL
5	|	|	✓	X	✓	|	✓	|	|	|	MG
6	|	|	X	|	X	|	✓	|	|	|	KL
7	|	|	|	|	|	|	|	|	|	|	
8	|	|	|	|	|	|	|	|	|	|	
Total	0X →					→	0	0X	→		~~KL~~ KL

Days	Concentration: 128 (93.6)										
	A	B	C	D	E	F	G	H	I	J	Init
1	X	✓	X	X	X	X	X	X	X	X	KL
2	|	X	|	|	|	|	|	|	|	|	
3	|	|	|	|	|	|	|	|	|	|	
4	|	|	|	|	|	|	|	|	|	|	
5	|	|	|	|	|	|	|	|	|	|	
6	|	|	|	|	|	|	|	|	|	|	
7	|	|	|	|	|	|	|	|	|	|	
8	|	|	|	|	|	|	|	|	|	|	
Total	0X →										KL

Days	Concentration:										
	A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Notes: X = mortality.

Sample Description: See WQ Sheet.
Comments: Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

Reviewed by: JOh
Date reviewed: July 18/18

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Lotax (Pretflum)
Sample ID: ~~Dup~~ Control
Work Order: 8113 8

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9/18 @ 1800h
Set up by: VL

Days	Concentration: lab control A	B	C	D	E	F	G	H	I	J	Init
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	VL
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	VL
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	VL
4	4	4	2	2	2	4	4	3	3	3	VL
5	5	7x	6	7	6	7	5	6	7	5	~~VL~~ MG
6	9	|	9	9	9	9	9	8	11	9	VL
7		|									
8		|									
Total	18	11x	17	18	17	20	18	17	21	17	VL

Days	Concentration: A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Days	Concentration: A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Days	Concentration: A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Days	Concentration: A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Days	Concentration: A	B	C	D	E	F	G	H	I	J	Init
1											
2											
3											
4											
5											
6											
7											
8											
Total											

Notes: X = mortality.

Sample Description: ~~Seee~~ VL see WQ Sheet

Comments: Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

Reviewed by: [illegible]

Date reviewed: July 18/18

CETIS Summary Report

Report Date:	18 Jul-18 17:45 (p 1 of 2)
Test Code:	181138b | 17-4341-0777

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10 (amended to hardness ~100 mg/L $CaCO_3$)
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
17-5419-6368	6d Survival Rate	0.0123	>0.0123	NA	NA		Fisher Exact Test
18-0856-4383	6d Survival Rate	23.9	48.4	34.01	NA		Fisher Exact/Bonferroni-Holm Test
05-9282-6040	Reproduction	0.0123	>0.0123	NA	14.3%		Equal Variance t Two-Sample Test
19-2741-1568	Reproduction	23.9	>23.9	NA	22.8%		Steel Many-One Rank Sum Test

Point Estimate Summary

Analysis ID	Endpoint	Level	mg/L	95% LCL	95% UCL	TU	Method
11-7142-4162	6d Survival Rate	EC50	33.93	28.09	40.99		Spearman-Kärber
18-7357-0590	Reproduction	IC5	13.6	2.58	14.47		Linear Interpolation (ICPIN)
		IC10	15.73	5.705	17.69		
		IC15	18.17	12.22	22.84		
		IC20	20.96	15.61	24.79		
		IC25	23.99	18.32	25.86		
		IC40	27.64	25.19	29.34		
		IC50	30.36	28.11	31.91		

6d Survival Rate Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	1 Negative Control	10	0.9	0.6738	1	0	1	0.1	0.3162	35.14%	0.0%
0.0123	2 Dilution Water	10	1	1	1	1	1	0	0	0.0%	-11.11%
1.97		10	1	1	1	1	1	0	0	0.0%	-11.11%
2.99		10	1	1	1	1	1	0	0	0.0%	-11.11%
5.81		10	1	1	1	1	1	0	0	0.0%	-11.11%
11.8		10	0.9	0.6738	1	0	1	0.1	0.3162	35.14%	0.0%
23.9		10	1	1	1	1	1	0	0	0.0%	-11.11%
48.4		10	0.1	0	0.3262	0	1	0.1	0.3162	316.2%	88.89%
93.6		10	0	0	0	0	0	0	0		100.0%

Reproduction Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	1 Negative Control	10	17.4	15.52	19.28	11	21	0.8327	2.633	15.13%	0.0%
0.0123 ✓	2 Dilution Water	10	18.3	15.64	20.96	14	25	1.174	3.713	20.29%	-5.17%
1.97 ✓		10	20.3	17.87	22.73	16	26	1.075	3.401	16.75%	-16.67%
2.99 ✓		10	20.3	16.64	23.96	6	23	1.62	5.122	25.23%	-16.67%
5.81 ✓		10	19.6	16.47	22.73	10	25	1.384	4.377	22.33%	-12.64%
11.8 ✓		10	19.6	16.68	22.52	11	23	1.293	4.088	20.86%	-12.64%
23.9 ✓		10	14.8	12.26	17.34	8	19	1.123	3.553	24.01%	14.94%
48.4 ✓		10	0	0	0	0	0	0	0		100.0%
93.6 ✓		10	0	0	0	0	0	0	0		100.0%

① negative control = laboratory water; 20% perm
② Dilution water = site water amended 4x to hardness ~100 mg/L $CaCO_3$.

Analyst: KL QA: JGM July 18/18

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1	0	1	1	1	1	1	1	1	1
0.0123	Dilution Water	1	1	1	1	1	1	1	1	1	1
1.97		1	1	1	1	1	1	1	1	1	1
2.99		1	1	1	1	1	1	1	1	1	1
5.81		1	1	1	1	1	1	1	1	1	1
11.8		1	1	1	1	1	1	1	1	1	0
23.9		1	1	1	1	1	1	1	1	1	1
48.4		0	0	0	0	0	0	1	0	0	0
93.6		0	0	0	0	0	0	0	0	0	0

Reproduction Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	18	11	17	18	17	20	18	17	21	17
0.0123	Dilution Water	20	19	21	22	15	17	16	14	25	14
1.97		16	19	17	21	23	24	22	26	17	18
2.99		20	23	21	23	23	22	6	21	22	22
5.81		15	22	20	20	23	19	23	19	10	25
11.8		19	15	23	22	23	17	23	21	22	11
23.9		17	8	14	9	17	16	16	16	19	16
48.4		0	0	0	0	0	0	0	0	0	0
93.6		0	0	0	0	0	0	0	0	0	0

6d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.0123	Dilution Water	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.97		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.99		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
5.81		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
11.8		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	0/1
23.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
48.4		0/1	0/1	0/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1
93.6		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

CETIS Analytical Report

Report Date:	18 Jul-18 17:10 (p 1 of 2)
Test Code:	181138b | 17-4341-0777

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	11-7142-4162	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:08	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10 (hardness amended to ~110 mg/L $CaCO_3$)
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0	0.00%	1.531	0.04105	33.93	28.09	40.99

6d Survival Rate Summary

			Calculated Variate(A/B)								
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0.0123	Dilution Water	10	1	1	1	0	0	0.0%	0.0%	10	10
1.97		10	1	1	1	0	0	0.0%	0.0%	10	10
2.99		10	1	1	1	0	0	0.0%	0.0%	10	10
5.81		10	1	1	1	0	0	0.0%	0.0%	10	10
11.8		10	0.9	0	1	0.1	0.3162	35.14%	10.0%	9	10
23.9		10	1	1	1	0	0	0.0%	0.0%	10	10
48.4		10	0.1	0	1	0.1	0.3162	316.2%	90.0%	1	10
93.6		10	0	0	0	0	0		100.0%	0	10

6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.0123	① Dilution Water	1	1	1	1	1	1	1	1	1	1
1.97		1	1	1	1	1	1	1	1	1	1
2.99		1	1	1	1	1	1	1	1	1	1
5.81		1	1	1	1	1	1	1	1	1	1
11.8		1	1	1	1	1	1	1	1	1	0
23.9		1	1	1	1	1	1	1	1	1	1
48.4		0	0	0	0	0	0	1	0	0	0
93.6		0	0	0	0	0	0	0	0	0	0

6d Survival Rate Binomials

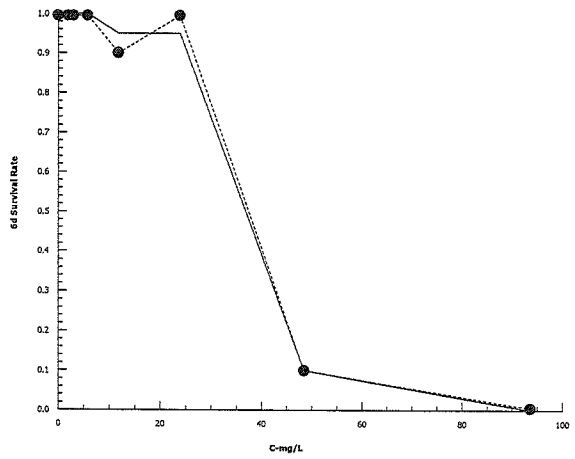
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.0123	① Dilution Water	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.97		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.99		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
5.81		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
11.8		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	0/1
23.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
48.4		0/1	0/1	0/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1
93.6		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

① Dilution water = laboratory water; 20% permeate

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	11-7142-4162	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:08	**Analysis:**	Untrimmed Spearman-Kärber	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 18 Jul-18 17:24 (p 1 of 2)
Test Code: 181138b | 17-4341-0777

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	18-0856-4383	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:24	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10 (hardness ~~adj~~ to ~100 mg/L $CaCO_3$) amended
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	NOEL	LOEL	TOEL	TU
Untransformed		C > T	NA	NA	23.9	48.4	34.01	

Fisher Exact/Bonferroni-Holm Test

Sample	vs	Sample	Test Stat	P-Value	P-Type	Decision(α:5%)
0.0123		1.97	1	1.0000	Exact	Non-Significant Effect
0.0123		2.99	1	1.0000	Exact	Non-Significant Effect
0.0123		5.81	1	1.0000	Exact	Non-Significant Effect
0.0123		11.8	0.5	1.0000	Exact	Non-Significant Effect
0.0123		23.9	1	1.0000	Exact	Non-Significant Effect
0.0123		48.4	5.954E-05	0.0004	Exact	Significant Effect

Data Summary

C-mg/L	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0.0123	① Dilution Water	10	0	10	1	0	0.0%
1.97		10	0	10	1	0	0.0%
2.99		10	0	10	1	0	0.0%
5.81		10	0	10	1	0	0.0%
11.8		9	1	10	0.9	0.1	10.0%
23.9		10	0	10	1	0	0.0%
48.4		1	9	10	0.1	0.9	90.0%

6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.0123	① Dilution Water	1	1	1	1	1	1	1	1	1	1
1.97		1	1	1	1	1	1	1	1	1	1
2.99		1	1	1	1	1	1	1	1	1	1
5.81		1	1	1	1	1	1	1	1	1	1
11.8		1	1	1	1	1	1	1	1	1	0
23.9		1	1	1	1	1	1	1	1	1	1
48.4		0	0	0	0	0	0	1	0	0	0

6d Survival Rate Binomials

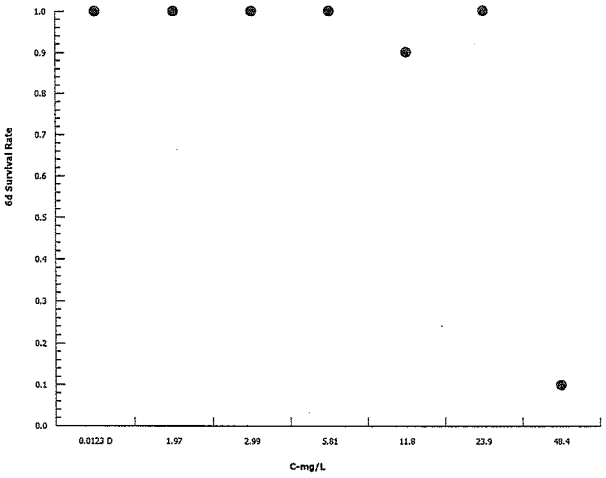
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.0123	① Dilution Water	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.97		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.99		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
5.81		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
11.8		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	0/1
23.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
48.4		0/1	0/1	0/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1

① Dilution water = laboratory control ; 20% perifer

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	18-0856-4383	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:24	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Graphics



Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	17-5419-6368	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 15:54	**Analysis:**	Single 2x2 Contingency Table	**Official Results:**	Yes

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	Test Result
Untransformed		C > T	NA	NA	Passes 6d survival rate

Fisher Exact Test

Control	vs	C-mg/L	Test Stat	P-Value	P-Type	Decision(α:5%)
Negative Control		0.0123	1	1.0000	Exact	Non-Significant Effect

Data Summary

C-mg/L	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0	(1) Negative Contr	9	1	10	0.9	0.1	0.0%
0.0123	(2) Dilution Water	10	0	10	1	0	-11.11%

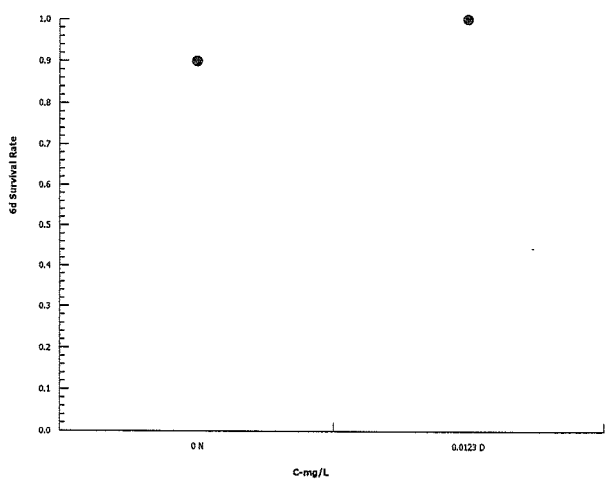
6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1	0	1	1	1	1	1	1	1	1
0.0123	Dilution Water	1	1	1	1	1	1	1	1	1	1

6d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.0123	Dilution Water	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



(1) Negative control = laboratory water; 20% permeate

(2) Dilution water = site water amended to hardness ~110 mg/L $CaCO_3$.

CETIS Analytical Report

Report Date:	18 Jul-18 15:57 (p 1 of 2)
Test Code:	181138b | 17-4341-0777

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	18-7357-0590	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 15:53	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10 (amended to hardness ~110 mg/L $CaCO_3$)
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	320896	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L	95% LCL	95% UCL
IC5	13.6	2.58	14.47
IC10	15.73	5.705	17.69
IC15	18.17	12.22	22.84
IC20	20.96	15.61	24.79
IC25	23.99	18.32	25.86
IC40	27.64	25.19	29.34
IC50	30.36	28.11	31.91

Reproduction Summary

			Calculated Variate						
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.0123	① Dilution Water	10	18.3	14	25	1.174	3.713	20.29%	0.0%
1.97		10	20.3	16	26	1.075	3.401	16.75%	-10.93%
2.99		10	20.3	6	23	1.62	5.122	25.23%	-10.93%
5.81		10	19.6	10	25	1.384	4.377	22.33%	-7.1%
11.8		10	19.6	11	23	1.293	4.088	20.86%	-7.1%
23.9		10	14.8	8	19	1.123	3.553	24.01%	19.13%
48.4		10	0	0	0	0	0		100.0%
93.6		10	0	0	0	0	0		100.0%

Reproduction Detail

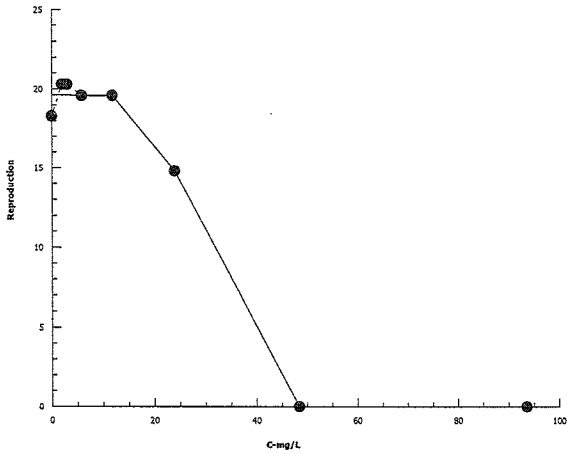
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.0123	① Dilution Water	20	19	21	22	15	17	16	14	25	14
1.97		16	19	17	21	23	24	22	26	17	18
2.99		20	23	21	23	23	22	6	21	22	22
5.81		15	22	20	20	23	19	23	19	10	25
11.8		19	15	23	22	23	17	23	21	22	11
23.9		17	8	14	9	17	16	16	16	19	16
48.4		0	0	0	0	0	0	0	0	0	0
93.6		0	0	0	0	0	0	0	0	0	0

① Dilution water = site water amended to hardness ~ 110 mg/L $CaCO_3$.

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	18-7357-0590	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 15:53	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	18 Jul-18 17:43 (p 1 of 2)
Test Code:	181138b | 17-4341-0777

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	19-2741-1568	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:42	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10 (amended to hardness ~110 mg/L CaCO3)
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	22.8%	23.9	>23.9	NA	

Steel Many-One Rank Sum Test

Control	vs	C-mg/L	Test Stat	Critical	Ties	DF	P-Value	P-Type	Decision(α:5%)
0.0123		1.97	122	75	5	18	0.9941	Asymp	Non-Significant Effect
0.0123		2.99	129	75	3	18	0.9992	Asymp	Non-Significant Effect
0.0123		5.81	117.5	75	5	18	0.9824	Asymp	Non-Significant Effect
0.0123		11.8	119	75	5	18	0.9875	Asymp	Non-Significant Effect
0.0123		23.9	84.5	75	4	18	0.1953	Asymp	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	220.2833	44.05667	5	2.641	0.0330	Significant Effect
Error	900.7	16.67963	54			
Total	1120.983		59			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	2.088	15.09	0.8369	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9105	0.9459	0.0003	Non-normal Distribution

Reproduction Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.0123	① Dilution Water	10	18.3	15.64	20.96	18	14	25	1.174	20.29%	0.0%
1.97		10	20.3	17.87	22.73	20	16	26	1.075	16.75%	-10.93%
2.99		10	20.3	16.64	23.96	22	6	23	1.62	25.23%	-10.93%
5.81		10	19.6	16.47	22.73	20	10	25	1.384	22.33%	-7.1%
11.8		10	19.6	16.68	22.52	21.5	11	23	1.293	20.86%	-7.1%
23.9		10	14.8	12.26	17.34	16	8	19	1.123	24.01%	19.13%

Reproduction Detail

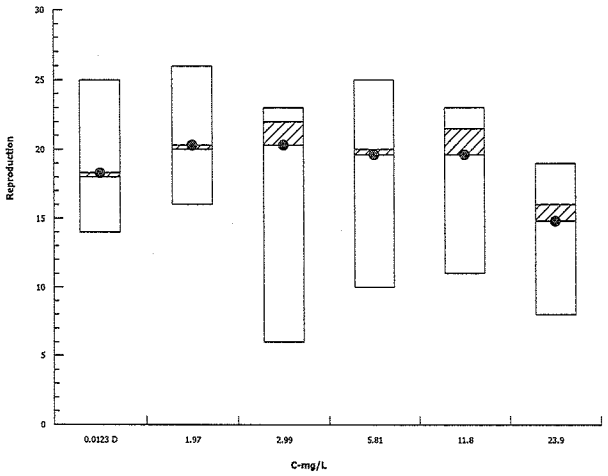
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.0123	① Dilution Water	20	19	21	22	15	17	16	14	25	14
1.97		16	19	17	21	23	24	22	26	17	18
2.99		20	23	21	23	23	22	6	21	22	22
5.81		15	22	20	20	23	19	23	19	10	25
11.8		19	15	23	22	23	17	23	21	22	11
23.9		17	8	14	9	17	16	16	16	19	16

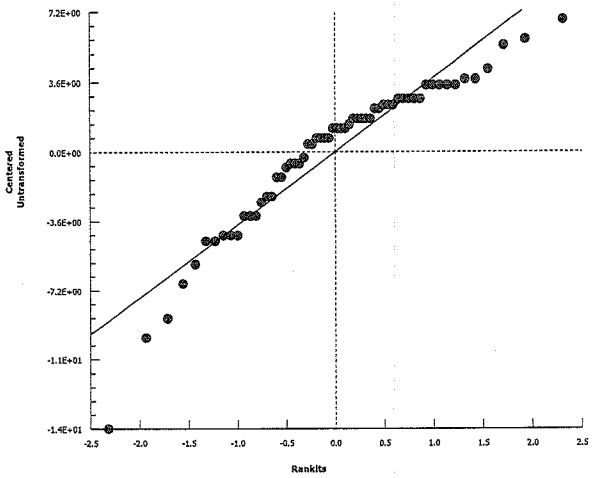
① Dilution water = laboratory water 3 20L pernier

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	19-2741-1568	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:42	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes

Graphics





CETIS Analytical Report

Report Date:	18 Jul-18 15:57 (p 3 of 3)
Test Code:	181138b | 17-4341-0777

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	05-9282-6040	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 15:54	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	16-3815-1981	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	Site water BJ 3.10 (amended to hardness ~110 mg/L CaCO3)
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	04-0870-3946	**Code:**	185C53CA	**Client:**	Pretium Exploration
Sample Date:	25 Jun-18 16:03	**Material:**	Ammonia	**Project:**	
Receive Date:	27 Jun-18 16:50	**Source:**	Pretium Resources Inc.		
Sample Age:	8d 1h (13.6 °C)	**Station:**	BJ 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C > T	NA	NA	14.3%	Passes reproduction

Equal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		0.0123	-0.6252	1.734	2.496	18	0.7302	CDF	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	4.05	4.05	1	0.3909	0.5397	Non-Significant Effect
Error	186.5	10.36111	18			
Total	190.55		19			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	1.989	6.541	0.3203	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.9788	0.866	0.9177	Normal Distribution

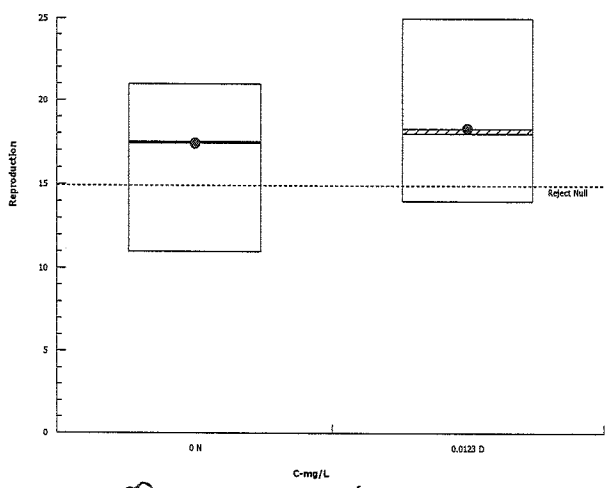
Reproduction Summary

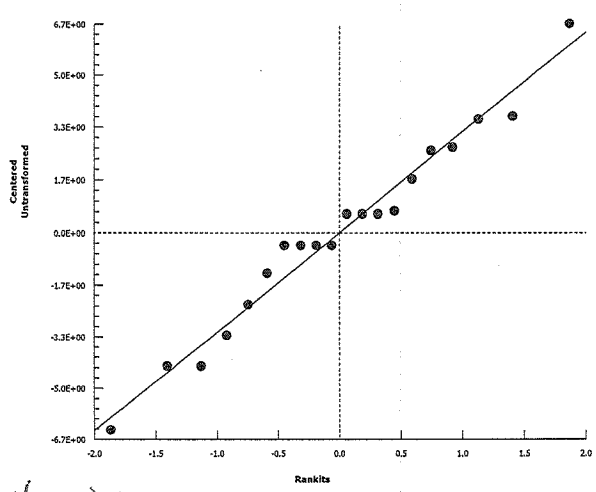
C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	① Negative Control	10	17.4	15.52	19.28	17.5	11	21	0.8327	15.13%	0.0%
0.0123	② Dilution Water	10	18.3	15.64	20.96	18	14	25	1.174	20.29%	-5.17%

Reproduction Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	18	11	17	18	17	20	18	17	21	17
0.0123	Dilution Water	20	19	21	22	15	17	16	14	25	14

Graphics





① Negative control = laboratory water > 20% gamer
② Dilution water = site water amended to hardness ~110 mg/L CaCO3.

JGh

Ceriodaphnia dubia Summary Sheet

Client: Borax (Prefilm)
Work Order No.: 181138

Start Date/Time: July 3/18 @ 1700h
Set up by: VL

Sample Information:

Sample ID: ~~BJ 3-10~~ VL Lab water w/ammonia
Sample Date: June 25/18
Date Received: June 27/18
Sample Volume: 2x 20L

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 4.0 to 8.4 ; pH = 6.0 to 9.0

Test Organism Information:

Broodstock No.: BB062018 A & B
Age of young (Day 0): <24-h (within 8-h)
Avg No. young in first 3 broods of previous 7 d: 32
Mortality (%) in previous 7 d: 5
Individual female # used ≥8 young on test day: 3-10, 32, 35-40

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd187
Stock Solution ID: 18NaO2 (100g/L NaCl)
Date Initiated: July 4/18

7-d LC50 (95% CL): 2.1 (1.5 – 3.0) g/L NaCL
7-d IC50 (95% CL): 1.4 (1.3 – 1.6) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0 (1.8 – 2.3) g/L NaCL CV (%): 6
7-d IC50 Reference Toxicant Mean and Historical Range: 1.3 (0.8 – 1.9) g/L NaCL CV (%): ~~23~~ 24

Test Results:

mg-N/L NH4 VL

	Survival	Reproduction
LC50 %v/v (95% CL)	34.7 (24.3 – 49.6)	
IC25 %v/v (95% CL)		14.2 (11.3 – 15.6)
IC50 %v/v (95% CL)		18.8 (16.5 – 20.2)
NOEC %v/v	24.3	12.3
LOEC %v/v	~~49.6~~ VL >24.3	24.3

Reviewed by: JBL

Date reviewed: July 18/18

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax (Pretium)
Sample ID: ammonia in labwater
Work Order #: ~~184473~~ 181138

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9/18 @ 1800h
CER #: 4
Test Species: *Ceriodaphnia dubia*

NH4 (mg-N/L)

Concentration 20% pentex	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0		
DO (mg/L)	8.2	7.3	7.9	~~8.0~~ 7.0	7.9	7.5	8.2	7.2	8.2	7.5	8.2	7.4		
pH	8.~~83~~	7.9	8.2	8.0	8.0	8.0	8.2	7.8	7.9	7.9	8.1	7.8		
Cond. (µS/cm)	209	209		209		210		211		210		205		
Initials	KL	KL		KL		KL		KL		MLT / KL		KL		

Concentration 2.0	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.5	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.3	7.9	7.0	7.9	7.5	8.0	7.3	8.0	7.4	8.2	7.4		
pH	8.0	7.9	8.1	8.0	8.0	8.0	8.1	7.8	7.7	7.8	7.9	7.8		
Cond. (µS/cm)	225	230		219		227		224		219		217		
Initials	KL	KL		KL		KL		KL		MLT / KL		KL		

Concentration 4.0	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.5	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.3	7.9	7.0	7.9	7.5	8.0	7.4	8.0	7.4	8.2	7.4		
pH	8.0	7.9	8.1	8.0	8.0	8.0	8.1	7.8	7.7	7.8	7.9	7.8		
Cond. (µS/cm)	241	243	~~234~~ KL	242		242		238		238	~~237~~ KL	233		
Initials	KL	KL		KL		KL		KL		MLT / KL		KL		

Concentration 8.0	Days 0 init.	1 old	1 new	2 old	2 new	3 old	3 new	4 old	4 new	5 old	5 new	6 old	6 new	7 final
Temperature (°C)	24.0	25.0	24.0	25.0	24.5	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.3	7.9	7.0	7.9	7.5	8.0	7.4	8.0	7.4	8.2	7.4		
pH	7.9	7.9	8.1	8.0	8.0	8.0	8.1	7.8	7.7	7.9	7.9	7.8		
Cond. (µS/cm)	272	273		272		272		271		273		261		
Initials	KL	KL		KL		KL		KL		MLT / KL		KL		

Thermometer: 4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control			
Hardness*	100			
Alkalinity*	90			

* mg/L as CaCO3

Analysts: KL, MLT

Reviewed by: JGA

Date reviewed: July 17/18

Sample Description: spiked 35.8ml of ~~10g NH~~ KL 10g/L NH4 in 2.8L lab control to make 128 mg/L ~~and dilut~~ KL

Comments: Broodboard Used: BB0620C8A4B (3-10, 32, 35-40)

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Lorax (Pretium)
Sample ID: ammonia in labwater
Work Order #: B1138

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9/18 @ 1800h
CER #: 4
Test Species: *Ceriodaphnia dubia*

NH4 (mg-N/L) Concentration 160

	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.5	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.3	7.9	7.0	7.9	7.5	8.0	7.3	8.0	7.4	8.2	7.4		
pH	7.9	7.9	8.0	8.0	8.0	8.0	8.1	7.8	7.7	7.9	7.9	7.8		
Cond. (µS/cm)	333	333		333		330		~~332~~ 331		334		315		
Initials	KL	KL		KL		KL		KL		KL/MLT		KL		

Concentration 320

	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.5	25.0	24.5	25.0	25.0	25.0	24.0	25.0		
DO (mg/L)	8.0	7.3	7.9	7.0	7.9	7.5	8.0	7.5	8.0	7.4	8.2	7.4		
pH	7.8	7.9	8.0	8.0	7.9	8.0	8.1	7.8	7.7	7.9	7.9	8.0		
Cond. (µS/cm)	455	453		452		450		454		458		429		
Initials	KL	KL		KL		KL		KL		KL/MLT		KL		

Concentration 64.0

	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0	25.0	24.5	25.0	24.5							
DO (mg/L)	8.0	7.3	7.9	7.0	7.9	7.5	8.0							
pH	7.6	7.8	7.8	8.0	7.8	8.0	8.0							
Cond. (µS/cm)	699	703		693		688								
Initials	KL	KL		KL		KL		~~KL~~ KL						

KL

Concentration 128

	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	24.0	25.0	24.0											
DO (mg/L)	8.0	7.3	7.9											
pH	7.5	7.7	7.8											
Cond. (µS/cm)	1179	1163												
Initials	KL	KL												

KL

Thermometer: 4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control			
Hardness*	100			
Alkalinity*	90			

KL

* mg/L as CaCO3

Analysts: KL, MLT

Reviewed by: JCL

Date reviewed: July 17/18

Sample Description: see previous page

Comments: Broodboard Used: B0B062018 A&B (3-10, 32, 35-40)

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Lorax (Pretium)
Sample ID: ammonia in labwater
Work Order: 181138

Start Date & Time: July 3/18 @ 1700h
Stop Date & Time: July 9 /18 @ ~~1800h~~ 1800h
Set up by: KL

mg-N/L
KL ~~mg/L~~ NH_4 (1.6)

Days	Concentration: 0 (control)											Concentration: 2 (3.1) KL											Concentration: 4 ~~(6.1)~~ (3.1) KL										
	A	B	C	D	E	F	G	H	I	J	Init	A	B	C	D	E	F	G	H	I	J	Init	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL
2	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL
3	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL	4	/	/	/	/	/	/	/	/	/	KL
4	4	4	2	2	2	4	4	3	3	3	KL	2	4	4	3	2	2	3	/	3	2	KL	/	4	2	/	4	2	4	4	5	3	KL
5	5	7X	6	7	6	7	5	6	7	5	MG	4	6	6	7	7X	5	6	4	5	6	MG	6	5	5	1X	5	5	6	7	6	6	MG
6	9	|	9	9	9	9	9	8	11	9	KL	8	9	9	12	|	9	10	10	11	11	KL	9	11	9	|	13	9	10	12	9	13	KL
7																																	
8																																	
Total	18	11X	17	18	17	20	18	17	21	17	KL	14	19	19	22	9X	16	19	14	19	19	KL	19	20	16	1X	22	16	20	23	20	22	KL

Days	Concentration: 8 (6.1)											Concentration: 16 (12.3)											Concentration: 32 (24.3)										
	A	B	C	D	E	F	G	H	I	J	Init	A	B	C	D	E	F	G	H	I	J	Init	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL
2	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL
3	4	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL	/	/	/	/	/	/	/	/	/	/	KL
4	/	3	2	3	4	3	5	3	3	3	KL	4	4	4	3	4'	4	2	/	3	3	KL	/	2	/	/	/	/	/	/	/	/	KL
5	4	7	7	6	8	7	6	6	6	8	MG	6	5	7	5	6X	5	5	2	5	6	MG	3	4	3	4	2	3	3	V	3	3	MG
6	8	8	11	12	10	11	9	10	9	11	KL	8	3	10	10	|	10	12	6	8	8	KL	/	4	/	/	/	/	4	4	4	2	KL
7																																	
8								KL								1a	19a																
Total	16	18	20	21	22	21	20	~~20~~ 19	18	22	HM	18	12	21	18	~~10X~~ 10X	~~18~~ 19	19	8	16	17	HM	3	10	3	4	2	3	7	4	7	5	HM

Days	Concentration: 64 (49.6)											Concentration: 128 (98.7)											Concentration:										
	A	B	C	D	E	F	G	H	I	J	Init	A	B	C	D	E	F	G	H	I	J	Init	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	KL	X	X	X	X	X	X	X	X	X	X	KL											
2	X	X	X	X	/	X	X	X	X	/	KL	|	|	|	|	|	|	|	|	|	|											
3	|	|	|	|	X	|	|	|	|	X	KL																					
4	|	|	|	|	|	|	|	|	|	|	KL																					
5	|	|	|	|	|	|	|	|	|	|																							
6	|	|	|	|	|	|	|	|	|	|																							
7	|	|	|	|	|	|	|	|	|	|																							
8	|	|	|	|	|	|	|	|	|	|																							
Total	0X	→									KL	0X	→									KL											

Notes: X = mortality.

Sample Description: See WQ sheet
Comments: Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

Reviewed by: JOh
Date reviewed: July 17/18

Version 2.1 Issued July 29, 2009

Nautilus Environmental

CETIS Summary Report

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Batch ID:	17-5133-3415	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	02-8811-9099	**Code:**	112C593B	**Client:**	Pretivm Resources Inc.
Sample Date:	03 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Resources Inc.		
Sample Age:	17h	**Station:**	20% perrier Lab control		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
00-0068-0995	6d Survival Rate	24.3	>24.3	NA	NA		Fisher Exact/Bonferroni-Holm Test
16-5787-3869	Reproduction	12.3	24.3	17.29	22.9%		Steel Many-One Rank Sum Test

Point Estimate Summary

Analysis ID	Endpoint	Level	mg/L	95% LCL	95% UCL	TU	Method
13-5760-5717	6d Survival Rate	EC50	34.72	24.3	49.6		Binomial/Graphical
09-6133-3549	Reproduction	IC5	8.148	1.358	12.86		Linear Interpolation (ICPIN)
		IC10	10.85	7.421	13.46		
		IC15	12.69	8.738	14.15		
		IC20	13.43	9.9	14.86		
		IC25	14.21	11.32	15.57		
		IC40	16.82	14.44	18.05		
		IC50	18.79	16.47	20.15		

6d Survival Rate Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	① Negative Control	10	0.9	0.6738	1	0	1	0.1	0.3162	35.14%	0.0%
1.58		10	0.9	0.6738	1	0	1	0.1	0.3162	35.14%	0.0%
3.11		10	0.9	0.6738	1	0	1	0.1	0.3162	35.14%	0.0%
6.06		10	1	1	1	1	1	0	0	0.0%	-11.11%
12.3		10	0.9	0.6738	1	0	1	0.1	0.3162	35.14%	0.0%
24.3		10	1	1	1	1	1	0	0	0.0%	-11.11%
49.6		10	0	0	0	0	0	0	0		100.0%
98.7		10	0	0	0	0	0	0	0		100.0%

Reproduction Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	① Negative Control	10	17.4	15.52	19.28	11	21	0.8327	2.633	15.13%	0.0%
1.58		10	17	14.3	19.7	9	22	1.193	3.771	22.18%	2.3%
3.11		10	17.9	13.33	22.47	1	23	2.019	6.385	35.67%	-2.87%
6.06		10	19.7	18.31	21.09	16	22	0.6155	1.947	9.88%	-13.22%
12.3		10	15.8	12.71	18.89	8	21	1.365	4.315	27.31%	9.2%
24.3		10	4.8	3.022	6.578	2	10	0.786	2.486	51.78%	72.41%
49.6		10	0	0	0	0	0	0	0		100.0%
98.7		10	0	0	0	0	0	0	0		100.0%

① Negative control = laboratory water ; 20% ~~filter~~ perrier

6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1	0	1	1	1	1	1	1	1	1
1.58		1	1	1	1	0	1	1	1	1	1
3.11		1	1	1	0	1	1	1	1	1	1
6.06		1	1	1	1	1	1	1	1	1	1
12.3		1	1	1	1	0	1	1	1	1	1
24.3		1	1	1	1	1	1	1	1	1	1
49.6		0	0	0	0	0	0	0	0	0	0
98.7		0	0	0	0	0	0	0	0	0	0

Reproduction Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	18	11	17	18	17	20	18	17	21	17
1.58		14	19	19	22	9	16	19	14	19	19
3.11		19	20	16	1	22	16	20	23	20	22
6.06		16	18	20	21	22	21	20	19	18	22
12.3		18	12	21	18	10	19	19	8	16	17
24.3		3	10	3	4	2	3	7	4	7	5
49.6		0	0	0	0	0	0	0	0	0	0
98.7		0	0	0	0	0	0	0	0	0	0

6d Survival Rate Binomials

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	Negative Control	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.58		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
3.11		1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1
6.06		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
12.3		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
24.3		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
49.6		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
98.7		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

CETIS Analytical Report

Report Date:	13 Jul-18 19:23 (p 1 of 2)
Test Code:	181138a | 18-3683-4013

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-5760-5717	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	13 Jul-18 19:23	**Analysis:**	Binomial Method	**Official Results:**	Yes

Batch ID:	17-5133-3415	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	02-8811-9099	**Code:**	112C593B	**Client:**	Pretivm Resources Inc.
Sample Date:	03 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Resources Inc.		
Sample Age:	17h	**Station:**	20% perrier Lab control		

Binomial/Graphical Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0.1	0.00%	1.541	0	34.72	24.3	49.6

6d Survival Rate Summary

			Calculated Variate(A/B)								
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**	**A**	**B**
0	Negative Control	10	0.9	0	1	0.1	0.3162	35.14%	0.0%	9	10
1.58		10	0.9	0	1	0.1	0.3162	35.14%	0.0%	9	10
3.11		10	0.9	0	1	0.1	0.3162	35.14%	0.0%	9	10
6.06		10	1	1	1	0	0	0.0%	-11.11%	10	10
12.3		10	0.9	0	1	0.1	0.3162	35.14%	0.0%	9	10
24.3		10	1	1	1	0	0	0.0%	-11.11%	10	10
49.6		10	0	0	0	0	0		100.0%	0	10
98.7		10	0	0	0	0	0		100.0%	0	10

6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	① Negative Control	1	0	1	1	1	1	1	1	1	1
1.58		1	1	1	1	0	1	1	1	1	1
3.11		1	1	1	0	1	1	1	1	1	1
6.06		1	1	1	1	1	1	1	1	1	1
12.3		1	1	1	1	0	1	1	1	1	1
24.3		1	1	1	1	1	1	1	1	1	1
49.6		0	0	0	0	0	0	0	0	0	0
98.7		0	0	0	0	0	0	0	0	0	0

6d Survival Rate Binomials

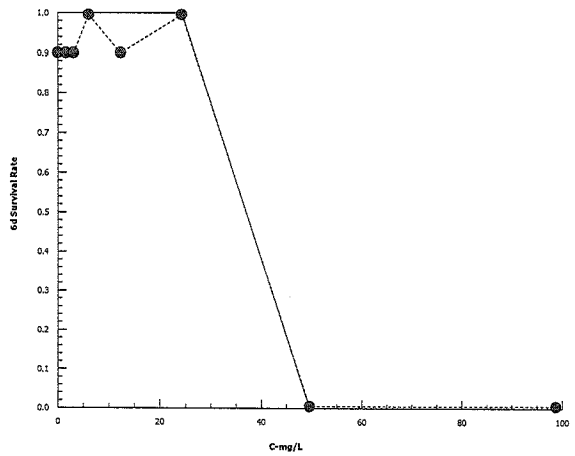
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	① Negative Control	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.58		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
3.11		1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1
6.06		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
12.3		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
24.3		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
49.6		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1
98.7		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

① Negative control = laboratory water; 20% Perrier

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-5760-5717	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	13 Jul-18 19:23	**Analysis:**	Binomial Method	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	18 Jul-18 17:16 (p 1 of 2)
Test Code:	181138a | 18-3683-4013

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	00-0068-0995	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:16	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Batch ID:	17-5133-3415	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	02-8811-9099	**Code:**	112C593B	**Client:**	Pretivm Resources Inc.
Sample Date:	03 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Resources Inc.		
Sample Age:	17h	**Station:**	20% perrier Lab control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	NOEL	LOEL	TOEL	TU
Untransformed		C > T	NA	NA	24.3	>24.3	NA	

Fisher Exact/Bonferroni-Holm Test

Control	vs	C-mg/L	Test Stat	P-Value	P-Type	Decision(α:5%)
Negative Control		1.58	0.7632	1.0000	Exact	Non-Significant Effect
		3.11	0.7632	1.0000	Exact	Non-Significant Effect
		6.06	1	1.0000	Exact	Non-Significant Effect
		12.3	0.7632	1.0000	Exact	Non-Significant Effect
		24.3	1	1.0000	Exact	Non-Significant Effect

Data Summary

C-mg/L	Control Type	NR	R	NR + R	Prop NR	Prop R	%Effect
0	1 Negative Contr	9	1	10	0.9	0.1	0.0%
1.58		9	1	10	0.9	0.1	0.0%
3.11		9	1	10	0.9	0.1	0.0%
6.06		10	0	10	1	0	-11.11%
12.3		9	1	10	0.9	0.1	0.0%
24.3		10	0	10	1	0	-11.11%

6d Survival Rate Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	1 Negative Control	1	0	1	1	1	1	1	1	1	1
1.58		1	1	1	1	0	1	1	1	1	1
3.11		1	1	1	0	1	1	1	1	1	1
6.06		1	1	1	1	1	1	1	1	1	1
12.3		1	1	1	1	0	1	1	1	1	1
24.3		1	1	1	1	1	1	1	1	1	1

6d Survival Rate Binomials

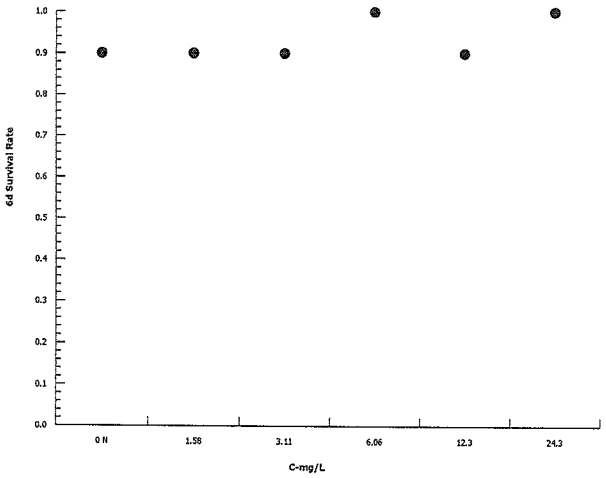
C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	1 Negative Control	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.58		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
3.11		1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1
6.06		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
12.3		1/1	1/1	1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1
24.3		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Negative control = laboratory water; 20% perrier

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	00-0068-0995	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:16	**Analysis:**	STP 2x2 Contingency Tables	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	10 Jul-18 19:18 (p 1 of 2)
Test Code:	181138a | 18-3683-4013

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	02-9159-5316	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	10 Jul-18 19:18	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	17-5133-3415	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	02-8811-9099	**Code:**	112C593B	**Client:**	Pretivm Resources Inc.
Sample Date:	03 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Resources Inc.		
Sample Age:	17h	**Station:**	20% perrier Lab control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	71385	200	Yes	Two-Point Interpolation

Point Estimates

Level	mg/L	95% LCL	95% UCL
IC5	8.148	1.273	12.88
IC10	10.85	7.165	13.49
IC15	12.69	8.848	14.13
IC20	13.43	10.07	14.87
IC25	14.21	11.42	15.58
IC40	16.82	14.86	18.28
IC50	18.79	17.08	20.65

Reproduction Summary

			Calculated Variate						
C-mg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	① Negative Control	10	17.4	11	21	0.8327	2.633	15.13%	0.0%
1.58		10	17	9	22	1.193	3.771	22.18%	2.3%
3.11		10	17.9	1	23	2.019	6.385	35.67%	-2.87%
6.06		10	19.7	16	22	0.6155	1.947	9.88%	-13.22%
12.3		10	15.8	8	21	1.365	4.315	27.31%	9.2%
24.3		10	4.8	2	10	0.786	2.486	51.78%	72.41%
49.6		10	0	0	0	0	0		100.0%
98.7		10	0	0	0	0	0		100.0%

Reproduction Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	① Negative Control	18	11	17	18	17	20	18	17	21	17
1.58		14	19	19	22	9	16	19	14	19	19
3.11		19	20	16	1	22	16	20	23	20	22
6.06		16	18	20	21	22	21	20	19	18	22
12.3		18	12	21	18	10	19	19	8	16	17
24.3		3	10	3	4	2	3	7	4	7	5
49.6		0	0	0	0	0	0	0	0	0	0
98.7		0	0	0	0	0	0	0	0	0	0

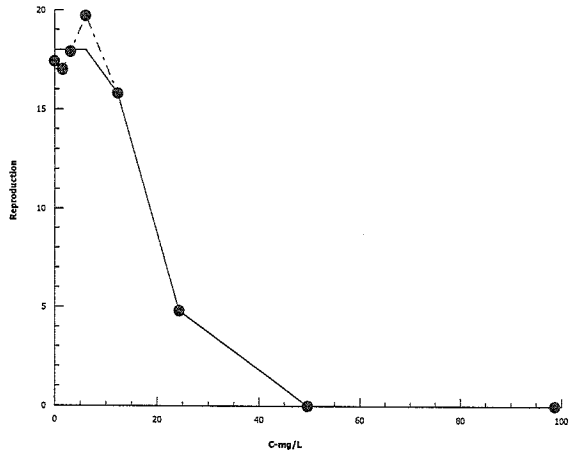
① negative control = laboratory water ; 20% perrier

Analyst: KL QA: JGM July 17/18

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	02-9159-5316	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	10 Jul-18 19:18	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date:	18 Jul-18 17:16 (p 1 of 2)
Test Code:	181138a | 18-3683-4013

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	16-5787-3869	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:16	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	17-5133-3415	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Kania Lywe
Start Date:	03 Jul-18 17:00	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	20% Perrier Water
Ending Date:	09 Jul-18 18:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Duration:	6d 1h	**Source:**	In-House Culture	**Age:**	<24h

Sample ID:	02-8811-9099	**Code:**	112C593B	**Client:**	Pretivm Resources Inc.
Sample Date:	03 Jul-18	**Material:**	Ammonia	**Project:**	
Receive Date:	03 Jul-18	**Source:**	Pretium Resources Inc.		
Sample Age:	17h	**Station:**	20% perrier Lab control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	22.9%	12.3	24.3	17.29	

Steel Many-One Rank Sum Test

Control vs	C-mg/L	Test Stat	Critical	Ties	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	1.58	108	75	0	18	0.8923	Asymp	Non-Significant Effect
	3.11	120.5	75	1	18	0.9913	Asymp	Non-Significant Effect
	6.06	133	75	3	18	0.9998	Asymp	Non-Significant Effect
	12.3	98.5	75	3	18	0.6489	Asymp	Non-Significant Effect
	24.3*	55	75	0	18	0.0004	Asymp	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	1438.133	287.6267	5	19.07	<0.0001	Significant Effect
Error	814.6	15.08519	54			
Total	2252.733		59			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	16.44	15.09	0.0057	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.8603	0.9459	<0.0001	Non-normal Distribution

Reproduction Summary

C-mg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	① Negative Control	10	17.4	15.52	19.28	17.5	11	21	0.8327	15.13%	0.0%
1.58		10	17	14.3	19.7	19	9	22	1.193	22.18%	2.3%
3.11		10	17.9	13.33	22.47	20	1	23	2.019	35.67%	-2.87%
6.06		10	19.7	18.31	21.09	20	16	22	0.6155	9.88%	-13.22%
12.3		10	15.8	12.71	18.89	17.5	8	21	1.365	27.31%	9.2%
24.3		10	4.8	3.022	6.578	4	2	10	0.786	51.78%	72.41%

Reproduction Detail

C-mg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	① Negative Control	18	11	17	18	17	20	18	17	21	17
1.58		14	19	19	22	9	16	19	14	19	19
3.11		19	20	16	1	22	16	20	23	20	22
6.06		16	18	20	21	22	21	20	19	18	22
12.3		18	12	21	18	10	19	19	8	16	17
24.3		3	10	3	4	2	3	7	4	7	5

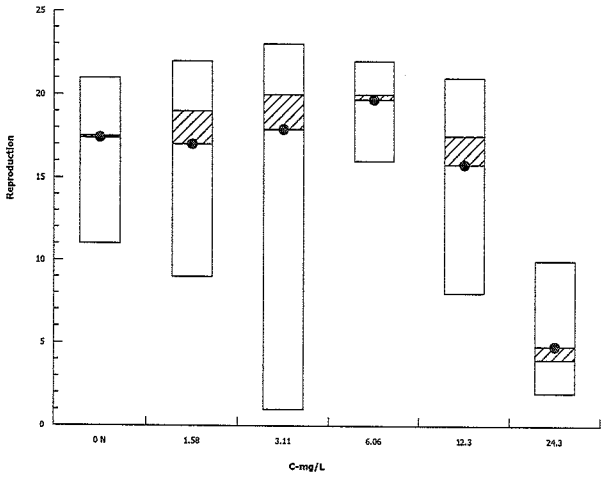
① Negative control = laboratory water, 20% perrier

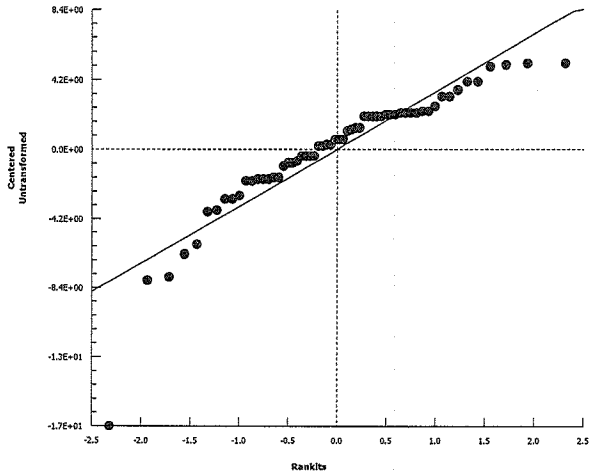
Analyst: KL QA: JGL July 18/18

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	16-5787-3869	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv1.8.7
Analyzed:	18 Jul-18 17:16	**Analysis:**	Nonparametric-Control vs Treatments	**Official Results:**	Yes

Graphics





Client: (Borax Premium)

W.O.#: 18438

Hardness and Alkalinity Datasheet

	Alkalinity						Hardness			
Sample ID	Subsample Date	Date Measured	Sample Volume (mL)	(mL) 0.02N HCL/H_2SO_4 used to pH 4.5	(mL) of 0.02N HCL/H_2SO_4 used to pH 4.2	Total Alkalinity (mg/L$CaCO_3$)	Sample Volume (mL)	Volume of 0.01M EDTA Used (mL)	Total Hardness (mg/L $CaCO_3$)	Technician
BJ 3.10 (unamended)	July 3/18	July 3/18	50	2.0	2.1	38	50	3.0	60	VL
BJ 3.10 (Amended)	↓	↓	100	7.3	7.5	71	50	5.5	110	↓
20% permeate	↓	↓	100	9.2	9.4	90	50	5.0	100	↓

Notes:

Reviewed by: JOL

Date Reviewed: July 17/18

APPENDIX D – Analytical Chemistry

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 13:41 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122747

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122747-1	L2122747-2	L2122747-3	L2122747-4	L2122747-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	SITE WATER	CONC 1 (SITE WATER)	CONC 2 (SITE WATER)	CONC 3 (SITE WATER)	CONC 4 (SITE WATER)
Grouping	**Analyte**					
WATER						
Total Metals	Antimony (Sb)-Total (mg/L)	0.00837	0.0162	0.0260	0.0444	0.0815

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122747-6	L2122747-7	L2122747-8	L2122747-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5 (SITE WATER)	CONC 6 (SITE WATER)	CONC 7 (SITE WATER)	CONC 8 (SITE WATER)	
Grouping	**Analyte**					
WATER						
Total Metals	Antimony (Sb)-Total (mg/L)	0.158	0.307	0.599	1.22	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122747-COFC

JS TAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total antimony (Sb)										Receipt Temperature (°C)
1	Site Water ~~Lab Control~~	03/07/18	1730h	water	1x125mL	preserved	✓										
2	Conc 1 (site water)						✓										
3	Conc 2 (site water)						✓										
4	Conc 3 (site water)						✓										
5	Conc 4 (site water)						✓										
6	Conc 5 (site water)						✓										
7	Conc 6 (site water)						✓										
8	Conc 7 (site water)						✓										
9	Conc 8 (site water)	✓	✓	✓	✓	✓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

CW July 3 (Printed Name) (Signature)

V2°C 18:25 (Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 13:38 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122746

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122746-1	L2122746-2	L2122746-3	L2122746-4	L2122746-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	LAB CONTROL	CONC 1(LAB WATER)	CONC 2(LAB WATER)	CONC 3(LAB WATER)	CONC 4(LAB WATER)
Grouping	**Analyte**					
WATER						
Total Metals	Antimony (Sb)-Total (mg/L)	<0.00010	0.0109	0.0211	0.0419	0.0815

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122746-6	L2122746-7	L2122746-8	L2122746-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5(LAB WATER)	CONC 6(LAB WATER)	CONC 7(LAB WATER)	CONC 8(LAB WATER)	
Grouping	**Analyte**					
WATER						
Total Metals	Antimony (Sb)-Total (mg/L)	0.159	0.321	0.631	1.23	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122746-COFC

JS TAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nalr@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total antimony (Sb)										Receipt Temperature (°C)
1	Lab Control	03/07/18	1730h	water	1x125mL	preserved	✓										
2	Conc 1 (lab water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (lab water)						✓										
4	Conc 3 (lab water)						✓										
5	Conc 4 (lab water)						✓										
6	Conc 5 (lab water)						✓										
7	Conc 6 (lab water)						✓										
8	Conc 7 (lab water)						✓										
9	Conc 8 (lab water)						✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) CW 17°C (Signature)

(Company) July 3 18:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 12:27 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122751

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122751-1	L2122751-2	L2122751-3	L2122751-4	L2122751-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	SITE WATER	CONC 1 (SITE WATER)	CONC 2 (SITE WATER)	CONC 3 (SITE WATER)	CONC 4 (SITE WATER)
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Antimony (Sb)-Dissolved (mg/L)	0.00529	0.0143	0.0234	0.0409	0.0743

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122751-6	L2122751-7	L2122751-8	L2122751-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5 (SITE WATER)	CONC 6 (SITE WATER)	CONC 7 (SITE WATER)	CONC 8 (SITE WATER)	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Antimony (Sb)-Dissolved (mg/L)	0.147	0.281	0.554	1.12	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122751-COFC

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Dissolved antimony (Sb)										Receipt Temperature (°C)
1	Site Water ~~Lab Control~~	03/07/18	1730h	water	1x125mL	preserved and filtered	✓										
2	Conc 1 (site water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (site water)	↓	↓	↓	↓	↓	✓										
4	Conc 3 (site water)	↓	↓	↓	↓	↓	✓										
5	Conc 4 (site water)	↓	↓	↓	↓	↓	✓										
6	Conc 5 (site water)	↓	↓	↓	↓	↓	✓										
7	Conc 6 (site water)	↓	↓	↓	↓	↓	✓										
8	Conc 7 (site water)	↓	↓	↓	↓	↓	✓										
9	Conc 8 (site water)	✓	✓	✓	✓	✓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) 17°C (Signature)

(Company) July 3 18:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage: Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 13:54 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122750

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122750-1	L2122750-2	L2122750-3	L2122750-4	L2122750-5
	Description					
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:03	17:03	17:03	17:03
	Client ID	LAB CONTROL	CONC 1 (LAB WATER)	CONC 2 (LAB WATER)	CONC 3 (LAB WATER)	CONC 4 (LAB WATER)
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	0.00933	0.0187	0.0380	0.0729

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122750-6	L2122750-7	L2122750-8	L2122750-9	
	Description					
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:03	17:03	17:03	17:03	
	Client ID	CONC 5 (LAB WATER)	CONC 6 (LAB WATER)	CONC 7 (LAB WATER)	CONC 8 (LAB WATER)	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Antimony (Sb)-Dissolved (mg/L)	0.141	0.281	0.551	1.12	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Antimony (Sb)-Dissolved	B	L2122750-6, -7
Method Blank	Antimony (Sb)-Dissolved	MB-LOR	L2122750-8, -9
Matrix Spike	Antimony (Sb)-Dissolved	MS-B	L2122750-8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122750-COFC

S
A L

TESTING LOCATION (Please Circle)

Burnaby ◉
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ◯
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ◯ OR Composite ◯

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	dissolved antimony (Sb)										Receipt Temperature (°C)
1	Lab Control	03/07/18	1730h	water	1x125mL	preserved and filtered	✓										
2	Conc 1 (lab water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (lab water)	↓	↓	↓	↓	↓	✓										
4	Conc 3 (lab water)	↓	↓	↓	↓	↓	✓										
5	Conc 4 (lab water)	↓	↓	↓	↓	↓	✓										
6	Conc 5 (lab water)	↓	↓	↓	↓	↓	✓										
7	Conc 6 (lab water)	↓	↓	↓	↓	↓	✓										
8	Conc 7 (lab water)	↓	↓	↓	↓	↓	✓										
9	Conc 8 (lab water)	↓	↓	↓	↓	↓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) CW July 3 (Signature)

(Company) 17°C 18:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 13:52 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122749

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122749-1	L2122749-2	L2122749-3	L2122749-4	L2122749-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	SITE CONTROL	CONC 1 (SITE WATER)	CONC 2 (SITE WATER)	CONC 3 (SITE WATER)	CONC 4 (SITE WATER)
Grouping	**Analyte**					
WATER						
Total Metals	Arsenic (As)-Total (mg/L)	0.00436	0.00778	0.0109	0.0175	0.0299

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122749-6	L2122749-7	L2122749-8	L2122749-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5 (SITE WATER)	CONC 6 (SITE WATER)	CONC 7 (SITE WATER)	CONC 8 (SITE WATER)	
Grouping	**Analyte**					
WATER						
Total Metals	Arsenic (As)-Total (mg/L)	0.0547	0.103	0.199	0.395	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122749-COFC

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total arsenic (As)										Receipt Temperature (°C)
1	~~Lab~~ Site Control	03/07/18	1730h	water	1x125mL	preserved	✓										
2	Conc 1 (site water)						✓										
3	Conc 2 (site water)						✓										
4	Conc 3 (site water)						✓										
5	Conc 4 (site water)						✓										
6	Conc 5 (site water)						✓										
7	Conc 6 (site water)						✓										
8	Conc 7 (site water)						✓										
9	Conc 8 (site water)	✓	✓	✓	✓	✓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) Jul 3/18 @ 1300h (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature) July 3

(Company) 17°C (Date DD/MM/YY and Time) 18:25

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 13:47 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122748

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122748-1	L2122748-2	L2122748-3	L2122748-4	L2122748-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	LAB CONTROL	CONC 1 (LAB WATER)	CONC 2 (LAB WATER)	CONC 3 (LAB WATER)	CONC 4 (LAB WATER)
Grouping	**Analyte**					
WATER						
Total Metals	Arsenic (As)-Total (mg/L)	<0.00010	0.00343	0.00670	0.0133	0.0255

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122748-6	L2122748-7	L2122748-8	L2122748-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5 (LAB WATER)	CONC 6 (LAB WATER)	CONC 7 (LAB WATER)	CONC 8 (LAB WATER)	
Grouping	**Analyte**					
WATER						
Total Metals	Arsenic (As)-Total (mg/L)	0.0496	0.0993	0.196	0.386	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122748-COFC

JS
AL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total arsenic (As)										Receipt Temperature (°C)
1	Lab Control	03/07/18	1730h	water	1x125mL	preserved	✓										
2	Conc 1 (lab water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (lab water)						✓										
4	Conc 3 (lab water)						✓										
5	Conc 4 (lab water)						✓										
6	Conc 5 (lab water)						✓										
7	Conc 6 (lab water)						✓										
8	Conc 7 (lab water)						✓										
9	Conc 8 (lab water)	✓	✓	✓	✓	✓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

CW 17°C (Printed Name) (Signature)

July 3 18:25 (Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 14:22 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122753

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122753-1	L2122753-2	L2122753-3	L2122753-4	L2122753-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	SITE CONTROL	CONC 1 (SITE WATER)	CONC 2 (SITE WATER)	CONC 3 (SITE WATER)	CONC 4 (SITE WATER)
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Arsenic (As)-Dissolved (mg/L)	0.00442	0.00754	0.0108	0.0176	0.0298

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122753-6	L2122753-7	L2122753-8	L2122753-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5 (SITE WATER)	CONC 6 (SITE WATER)	CONC 7 (SITE WATER)	CONC 8 (SITE WATER)	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Arsenic (As)-Dissolved (mg/L)	0.0543	0.103	0.198	0.393	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122753-COFC

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Dissolved arsenic (As)										Receipt Temperature (°C)
1	Site ~~Lab~~ Control	03/07/18	1730h	water	1x125mL	preserved and filtered	✓										
2	Conc 1 (site water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (site water)						✓										
4	Conc 3 (site water)						✓										
5	Conc 4 (site water)						✓										
6	Conc 5 (site water)						✓										
7	Conc 6 (site water)						✓										
8	Conc 7 (site water)						✓										
9	Conc 8 (site water)	✓	✓	✓	✓	✓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) Jul 3/18 @ 1900h (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

CW (Printed Name) 17°C (Signature)

(Company) July 3 18:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 14:20 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122752

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122752-1	L2122752-2	L2122752-3	L2122752-4	L2122752-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	LAB CONTROL	CONC 1 (LAB WATER)	CONC 2 (LAB WATER)	CONC 3 (LAB WATER)	CONC 4 (LAB WATER)
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Arsenic (As)-Dissolved (mg/L)	<0.00010	0.00329	0.00654	0.0128	0.0255

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122752-6	L2122752-7	L2122752-8	L2122752-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time	17:30	17:30	17:30	17:30	
	Client ID	CONC 5 (LAB WATER)	CONC 6 (LAB WATER)	CONC 7 (LAB WATER)	CONC 8 (LAB WATER)	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	
	Arsenic (As)-Dissolved (mg/L)	0.0503	0.0999	0.197	0.380	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122752-COFC

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date July 3.2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung, Mimi T.
Phone	604-420-8773
Email	mimi@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	dissolved arsenic (As)										Receipt Temperature (°C)
1	Lab Control	03/07/18	1730h	water	1x125mL	preserved and filtered	✓										
2	Conc 1 (lab water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (lab water)	↓	↓	↓	↓	↓	✓										
4	Conc 3 (lab water)	↓	↓	↓	↓	↓	✓										
5	Conc 4 (lab water)	↓	↓	↓	↓	↓	✓										
6	Conc 5 (lab water)	↓	↓	↓	↓	↓	✓										
7	Conc 6 (lab water)	↓	↓	↓	↓	↓	✓										
8	Conc 7 (lab water)	↓	↓	↓	↓	↓	✓										
9	Conc 8 (lab water)	✓	✓	✓	✓	✓	✓										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) CW 17°C (Signature)

(Company) July 3 19:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 04-JUL-18
Report Date: 23-JUL-18 12:49 (MT)
Version: FINAL REV. 2

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2123767

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Comments:

23-JUL-2018 Ammonia data has been revised for L2123767-7.

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2123767-1	L2123767-2	L2123767-3	L2123767-4	L2123767-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	04-JUL-18	04-JUL-18	04-JUL-18	04-JUL-18	04-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	SITE CONTROL	CONC 1 (SITE WATER)	CONC 2 (SITE WATER)	CONC 3 (SITE WATER)	CONC 4 (SITE WATER)
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0099	1.25	2.52	5.15	10.2

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2123767-6	L2123767-7	L2123767-8		
	Description	Water	Water	Water		
	Sampled Date	04-JUL-18	04-JUL-18	04-JUL-18		
	Sampled Time	17:30	17:30	17:30		
	Client ID	CONC 5 (SITE WATER)	CONC 6 (SITE WATER)	CONC 7 (SITE WATER)		
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	20.9	48.1	93.1		

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2123767-COFC

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date Jume 29 2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung
Phone	604-420-8773
Email	eric@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	~~Dissolved~~ Total ammonia										Receipt Temperature (°C)
1	Site ~~Lab~~ Control	04 07 ~~29/06~~/18	1730	water	1x125mL	preserved with 1 mL 1:1 Sulfuric Acid	✓										27
2	Conc 1 (site water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (site water)						✓										
4	Conc 3 (site water)						✓										
5	Conc 4 (site water)						✓										
6	Conc 5 (site water)						✓										
7	Conc 6 (site water)						✓										
8	Conc 7 (site water)	↓	↓	↓	↓	↓	✓										
9																	
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) Jul 4/18 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

HA (Printed Name) (Signature)

(Company) 7/4 - 5:13P (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Eric Cheung
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 04-JUL-18
Report Date: 05-JUL-18 14:44 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2123766

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2123766-1	L2123766-2	L2123766-3	L2123766-4	L2123766-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	04-JUL-18	04-JUL-18	04-JUL-18	04-JUL-18	04-JUL-18
	Sampled Time	17:30	17:30	17:30	17:30	17:30
	Client ID	LAB CONTROL	CONC 1 (LAB WATER)	CONC 2 (LAB WATER)	CONC 3 (LAB WATER)	CONC 4 (LAB WATER)
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0053	1.48	3.08	6.70	13.3

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2123766-6	L2123766-7	L2123766-8		
	Description	Water	Water	Water		
	Sampled Date	04-JUL-18	04-JUL-18	04-JUL-18		
	Sampled Time	17:30	17:30	17:30		
	Client ID	CONC 5 (LAB WATER)	CONC 6 (LAB WATER)	CONC 7 (LAB WATER)		
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	25.3	50.0	97.0		

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2123766-COFC

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date June 29 2018 Page 1 of 1

Report to:

Company	Nautilus Environmental
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC
Contact	Eric Cheung
Phone	604-420-8773
Email	eric@nautilusenvironmental.ca

Invoice To:

Company	(same)
Address	
City/Prov/PC	
Contact	
Phone	
Email	(same) + nair@nautilusenvironmental.ca
PO No.	

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	~~Dissolved~~ Total ammonia										Receipt Temperature (°C)
1	Lab Control	~~29/06~~ 04/07/18	1730	water	1x125mL	preserved with 1 mL 1:1 Sulfuric Acid	✓										27
2	Conc 1 (lab water)	↓	↓	↓	↓	↓	✓										
3	Conc 2 (lab water)						✓										
4	Conc 3 (lab water)						✓										
5	Conc 4 (lab water)						✓										
6	Conc 5 (lab water)						✓										
7	Conc 6 (lab water)						✓										
8	Conc 7 (lab water)	✓	✓	✓	✓	✓	✓										
9																	
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

RUSH

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Eric Cheung (Printed Name) (Signature)

Nautilus Env. (Company) Jul 4/18 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

HA (Printed Name) (Signature)

(Company) 7/4 - 8:31P (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Kania Lywe
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 17:48 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122745

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122745-1	L2122745-2	L2122745-3	L2122745-4	L2122745-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time					
	Client ID	BJ 3.10(UNAMENDED)	BJ 3.10(AMENDED)	BJ 3.10(2.0)	BJ 3.10(4.0)	BJ 3.10(8.0)
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	0.0142	0.0123	1.97	2.99	5.81

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122745-6	L2122745-7	L2122745-8	L2122745-9	
	Description	Water	Water	Water	Water	
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	
	Sampled Time					
	Client ID	BJ 3.10(16.0)	BJ 3.10(32.0)	BJ 3.10(64.0)	BJ 3.10(128.0)	
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	11.8	23.9	48.4	93.6	

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122745-COFC

JS TAL

TESTING LOCATION (Please Circle)

Burnaby
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date_____Page___of___

Report to:

Company: 1
Address:
City/Prov/PC:
Contact: Kania L.
Phone:
Email: kania@nautilusenvironmental.ca

Invoice To:

Company:
Address:
City/Prov/PC:
Contact:
Phone:
Email:
PO No.:

Sample Collection By:

Sample Type: Grab ○ OR Composite ○

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	ANALYSES REQUIRED: Total Ammonia										Receipt Temperature (°C)
1	BJ 3.10 (unamended)	03/07/18		water	1 x 125 mL	mg-N/L	X										
2	BJ 3.10 (amended)				1 x 125 mL		X										
3	BJ 3.10 (2.0)				1 x 125 mL		X										
4	BJ 3.10 (4.0)				1 x 125 mL		X										
5	BJ 3.10 (8.0)				1 x 125 mL		X										
6	BJ 3.10 (16.0)				1 x 125 mL		X										
7	BJ 3.10 (32.0)				1 x 125 mL		X										
8	BJ 3.10 (64.0)				1 x 125 mL		X										
9	BJ 3.10 (128.0)				1 x 125 mL		X										
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

Rush Analysis

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Jaymee Buenaog (Printed Name) JB (Signature)
Nautilus Environmental (Company) 03/07/18@17:25 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) CW 17°C (Signature)
(Company) July 3 18:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

NAUTILUS ENVIRONMENTAL
ATTN: Kania Lywe
8664 Commerce Court
Imperial Square Lake City
Burnaby BC V5A 4N7

Date Received: 03-JUL-18
Report Date: 04-JUL-18 16:05 (MT)
Version: FINAL

Client Phone: 604-420-8773

Certificate of Analysis

Lab Work Order #: L2122744

Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Heather McKenzie
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122744-1	L2122744-2	L2122744-3	L2122744-4	L2122744-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18	03-JUL-18
	Sampled Time					
	Client ID	LAB (2.0)	LAB (4.0)	LAB (8.0)	LAB (16.0)	LAB (32.0)
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	1.58	3.11	6.06	12.3	24.3

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2122744-6	L2122744-7			
	Description	Water	Water			
	Sampled Date	03-JUL-18	03-JUL-18			
	Sampled Time					
	Client ID	LAB (64.0)	LAB (128.0)			
Grouping	**Analyte**					
WATER						
Anions and Nutrients	Ammonia, Total (as N) (mg/L)	49.6	98.7			

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

L2122744-COFC

.US
NTAL

(1)

TESTING LOCATION (Please Circle)

Burnaby
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary
#4, 6125 12 Street SE
Calgary, Alberta, Canada
T2H 2K1
Phone 403.253.7121

Chain of Custody

Date_____Page___of___

Report to:

Company	(1)
Address	
City/Prov/PC	
Contact	Kania L.
Phone	
Email	kania@nautilusenvironmental.ca

Invoice To:

Company	
Address	
City/Prov/PC	
Contact	
Phone	
Email	
PO No.	

Sample Collection By:

Sample Type: Grab ○ OR Composite ○

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total Ammonia										Receipt Temperature (°C)
1	Lab (2.0)	03/07/18		water	1 x 125 mL	mg-N/L	X										
2	Lab (4.0)				1x 125 mL		X										
3	Lab (8.0)				1x 125 mL		X										
4	Lab (16.0)				1x 125 mL		X										
5	Lab (32.0)				1x 125 mL		X										
6	Lab (64.0)				1x 125 mL		X										
7	Lab (128.0)				1x 125 mL	✓	X										
8																	
9																	
10																	

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

Rush analysis

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Jaymee Bucaneg (Printed Name) JB (Signature)

Nautilus Environmental (Company) 03/07/18@17:25 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) CW 17°C (Signature)

(Company) July 3 18:25 (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Version 1.2; Revised by CC 2016/10/06

APPENDIX E – Chain-of-Custody Form

Nautilus Environmental

Chain of Custody (electronic)

[X] Alberta: #4 - 6125 12 Street SE, Calgary, AB, T2H 2K1

2x20L

Sample Collection By:	Xavier Pinto; Nathan Venos	
	Report to:	**Invoice to:**
Company	Pretivm Resources Inc.	Same
Address	Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.	
City/Prov/Postal Code	Vancouver, BC V7X 1L4 Box 49334	
Contact	Max Holtby	
Phone	(604) 558-1784	
Email	mholtby@pretivm.com svanzalingen@pretivm.com	invoices@pretivm.com

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	# OF CONTAINERS	COMMENTS	Ceriodaphnia 3-brood test (100% only) (Chronic -EPS1/RM/21)	Daphnia Magna 48 hrs (100% only) (Acute -EPS1/RM/14)	Rainbow Trout 96 hrs (100% only) (Acute-EPS1/RM/13)		Ceriodaphnia 3-brood test (with dilutions) (Chronic -EPS1/RM/21)	Daphnia Magna 48 hrs (with dilutions) (Acute -EPS1/RM/14)	Algal Growth Inhibition Test with dilutions (ESP 1/RM/25)		*Pseudokirchneriella* spiked with antimony (WO# 181147)	*Pseudokirchneriella* spiked with arsenic (181148)	*Chironomus* spiked with ammonia	*C. dubia* spiked with quenching (181138)		Receipt Temperature (°C)
1	BJ 3.10	25-Jun-18	16:03	Water	20L carboy	1	Grab									X	X	X	X		13.6
2	BJ 3.10	25-Jun-18	16:05	Water	20L carboy	1	Grab									X	X	X	X		13.6
3																					
4																					
5																					
6																					
7																					
8																					
9																					
10																					

PROJECT INFORMATION	SAMPLE RECEIPT		RELIQUINSHED BY (CLIENT)	RELIQUINSHED BY (COURIER)
Client: Brucejack Mine	**Total # Containers:**	2	**Signature:** Xavier Pinto	**Signature:**
P.O. No.: 1024767	**Good Condition?**	✓	**Print: Xavier Pinto**	**Print:**
Shipped Via:	**Matches Schedule?**	✓	**Company: Pretivm**	**Company:**
			Time/Date: June 25, 2018 - 17:30	**Time/Date:**
				RECEIVED BY (LABORATORY)
			Signature:	**Signature:**
			Print:	**Print:** Eric Cheung
			Company:	**Company: Nautilus Environmental**
			Time/Date:	**Time/Date:** Jun 27/18 @ 1650h

SPECIAL INSTRUCTIONS/COMMENTS: please cc report to environmental@pretivm.com, svanzalingen@pretivm.com, rmccall@pretivm.com. **If there are any mortalities, please email envionmental@pretivm.com ASAP. In the event of a failure, please re-peat the test with in the 5 day holding time with the original sample.**

Clear, Colorless, No part'in'atti, odourless

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

END OF REPORT

Toxicity Testing on sample BJ-3.10 with As and Lab Water with As

Sample collected June 14, 2021

Final Report

August 5, 2021
(Revised November 12, 2021)

Submitted to: **Pretivm Resources Inc**
Vancouver, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

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SIGNATURE PAGE

Report By:
Sierra Klueppel, B.Sc.
Laboratory Biologist

Reviewed By:
Edmund Canaria, R.P.Bio.
Senior Analyst

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

Sample Information and Test Type

Sample ID	BJ-3.10 with As, Lab Water with As
Sample collection date	June 14, 2021
Sample receipt date	June 16, 2021
Sample receipt temperature	8.5 to 8.9°C
Test types	72-h *Pseudokirchneriella subcapitata* growth inhibition

Summary of Results

Cell Yield	µg/L total As (95% CL) (measured values)	
	Lab Water with As	**BJ-3.10 with As**
Growth IC25	51.6 (33.1 – 75.0)	124.1 (56.1 – 223.1)
Growth IC50	233.1 (165.5 – 321.7)	329.4 (268.6 – 363.5)
NOEC, LOEC	2.8, 5.6	10.1, 15.5

IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted 72-h *Pseudokirchneriella subcapitata* growth inhibition toxicity tests for Pretivm Resources in lab water and site water (BJ-3.10) spiked with arsenic (As). Sample BJ-3.10 was collected on June 14, 2021 and delivered to the Nautilus Environmental laboratory in Burnaby, BC on June 16, 2021. The sample was transported in three 20-L plastic containers and was received at a temperature range of 8.5 to 8.9°C. The sample was stored in the dark at 4 ± 2°C prior to testing.

Testing with *P. subcapitata*, was initiated on June 16, 2021. This report describes the results of these toxicity tests. Copies of raw laboratory data sheets and statistical analyses for each test species are provided in Appendices A. The chain-of-custody form is provided in Appendix B.

2.0 METHODS

Methods for the toxicity tests are summarized in Table 1. Testing was conducted according to procedures described by Environment Canada (2007). Statistical analyses for all the tests were performed using CETIS (Tidepool Scientific Software, 2013). Subsamples of each test concentration in lab and site waters were collected and sent to ALS Environmental, Burnaby to confirm that solutions were prepared correctly. Test endpoints were calculated based on measured total As.

Table 1. Summary of test conditions: *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain CPCC# 37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	Eight concentrations, plus laboratory control and site control
Test replicates	4 per treatment; 8 for laboratory control and site control
Number of organisms	10,000 cells/mL
Control/dilution water	Deionized water supplemented with nutrients, site water supplemented with nutrients
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature and pH measured at test initiation; pH of two control wells measured at test termination
Test protocol	Environment Canada (2007), EPS 1/RM/25
Statistical software	CETIS Version 1.9.4
Test endpoints	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnSO_4$)

3.0 RESULTS

Results of the toxicity tests are summarized in Tables 2 and 3. For the Lab Water with As the IC25 and IC50 values were 51.6 and 233.1 µg/L total As (measured values), respectively. For the sample BJ-3.10 with As the IC25 and IC50 values were 124.1 and 329.4 µg/L total As (measured values), respectively.

Table 1. Results: *Pseudokirchneriella subcapitata* growth inhibition test.

Lab Water with As	
Concentration µg/L total As (measured values)	**Cell Yield (x 10^4 cells/mL) (Mean ± SD)**
Laboratory Control	21.8 ± 2.5
2.8	19.8 ± 1.5
5.6	17.5 ± 1.3
11.4	18.8 ± 1.7
22.4	19.8 ± 3.1
44.8	16.8 ± 1.3
88.6	13.2 ± 1.7
178	12.8 ± 2.6
348	8.2 ± 1.5
Test Endpoint (µg/L total As) (measured values)	
IC25 (95% CL)	51.6 (33.1– 75.0)
IC50 (95% CL)	233.1 (165.5 – 321.7)
NOEC	2.8
LOEC	5.6

SD = Standard Deviation, IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

Table 3. Results: *Pseudokirchneriella subcapitata* growth inhibition test.

BJ-3.10 with As	
Concentration µg/L total As (measured values)	**Cell Yield (x 10^4 cells/mL) (Mean ± SD)**
Site Control (BJ-3.10)	58.4 ± 4.1
7.4	53.2 ± 2.6
10.1	62.2 ± 7.8
15.5	49.2 ± 5.7
26.3	49.5 ± 7.0
48.4	48.8 ± 5.0
93.7	47.2 ± 5.2
179.0	39.2 ± 6.1
354.0	28.0 ± 0.8
Test Endpoint (µg/L total As) (measured values)	
IC25 (95% CL)	124.1 (56.1 – 223.1)
IC50 (95% CL)	329.4 (268.6 – 363.5)
NOEC	10.1
LOEC	15.5

SD = Standard Deviation, IC = Inhibition Concentration, CL = Confidence Limits, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration

4.0 QA/QC

The health history of the test organisms used in the exposure was acceptable and met the requirements of the Environment Canada protocol. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocol throughout the tests. There were no deviations from the test method. Uncertainty associated with these tests are best described by the standard deviation around the mean and/or the confidence intervals around the point estimates.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 4. Results for these tests fell within the range for organism performance of the mean and two standard deviations, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organisms used in these tests was appropriate the reference toxicant tests were performed under the same conditions as those used for the sample.

Table 4. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
P. subcapitata	Growth (IC50): 35.0 µg/L Zn	32.1 (26.8 – 38.5)	9	June 10, 2021

SD = Standard Deviation, CV = Coefficient of Variation, IC = Inhibition Concentration

5.0 REFERENCES

Environment Canada. 2007. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. Environmental Protection Series, Report EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 74 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.9.4.11 Tidepool Scientific Software, McKinleyville, CA. 222 pp.

APPENDIX A – *Pseudokirchneriella subcapitata* Toxicity Test Data

Pseudokirchneriella subcapitata Summary Sheet

Client: Pretium
Work Order No.: 211173

Start Date: June 16/21
Set up by: SAM

Sample Information:

Sample ID: Lab Water w/ As
Sample Date: June 16/21 ~~June 14/21~~ SM
Date Received: June 16/21
Sample Volume: ~~6 x 1L~~ SM 2L x 1

Test Organism Information:

Culture Date: June 11/21
Age of culture (Day 0): 5d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC216
Stock Solution ID: 21ZnO1
Date Initiated: June 10/21

72-h IC50 (95% CL): 35.0 (31.2-39.0) mg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.1 (26.8-38.5) mg/L Zn CV (%): 9

Test Results:

mg/L As Total	Algal Growth
IC25 ~~%(v/v)~~ SM (95% CL)	51.6 (33.1-75.0) (measured values)
IC50 ~~%(v/v)~~ SM (95% CL) mg/L As Total	233.1 (165.5-321.7) (measured values)

Reviewed by: [signature]

Date reviewed: July 13, 2021

NOEC: 2.8 mg/L As Total

LOEC: 5.6 mg/L As Total

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client : Pretium **Setup by:** SAL

Sample ID: Lab water w/ As **Test Date/Time:** June 16/21 @ 1500h

Work Order No.: 211173 **CER #:** 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: June 11/21 **Age of Culture:** 5d **Culture Health:** Good

Culture Count: 1 115 2 105 **Average:** 110 **Culture Cell Density (c1):** 110×10^4 cells/mL

v1 = 220,000 cells/ml x 60 ml / (c1) 110×10^4 cells/ml = 12mL

Time Zero Counts: 1 22 2 24 **Average:** 23

No. of Cells/mL: 23×10^4 cells/mL **Initial Density:** # cells/mL ÷ 220 µL x 10 µL = 10455 cells/mL

Concentration (nominal) ~~%(v/v)~~ µg/L As	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	6.8	23.0	25.0	25.0	25.0	26.0	✓	✓	✓	✓
3	6.8	↓	↓	↓	↓	↓	↓	↓	↓	↓
6	6.7	↓	↓	↓	↓	↓	↓	↓	↓	↓
12	6.7	↓	↓	↓	↓	↓	↓	↓	↓	↓
24	6.7	↓	↓	↓	↓	↓	↓	↓	↓	↓
48	6.7	↓	↓	↓	↓	↓	↓	↓	↓	↓
96	6.7	22.0	↓	↓	↓	↓	↓	↓	↓	↓
192	6.7	↓	↓	↓	↓	↓	↓	↓	↓	↓
384	6.7	↓	↓	↓	↓	↓	↓	↓	↓	↓
Initials	SAL	SAL	SAL	SAL	SAL	JOL	SAL	SAL	SAL	JOL

Initial control pH: Well 1: 6.8 Well 2: 6.9

Final control pH: Well 1: 6.9 Well 2: 7.0

Light intensity (lux): 3900 **Date measured:** June 16/21

Thermometer: 1 **Light meter:** 1 **pH meter/probe:** 1 / 1

Sample Description: spiked with 21As01

Comments:

Reviewed: **Date reviewed:** July 13, 2021

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pretium
Start Date/Time: June 16/21 @1500h
Work Order #: 211173
Termination Date: June 19/21 @1500h
Sample ID: Lab Water w/ As
Test set up by: SAK

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	21					SAK
mg/L As (nominal)	B	26					
	C	23					
	D	24					
	E	19					
	F	20					
	G	25					
	H	24					
3	A	19					
	B	22					
	C	22					
	D	20					
6	A	19					
	B	17					
	C	20					
	D	18					
12	A	18					
	B	20					
	C	19					
	D	22					
24	A	21					
	B	18					
	C	19					
	D	25					
48	A	16					
	B	18					
	C	18					
	D	19					
96	A	14					
	B	12					
	C	15					
	D	16					
192	A	11					
	B	12					
	C	16					
	D	16					

Comments:

Reviewed by: [signature]
Date Reviewed: July 13, 2021

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pretium
Start Date/Time: June 16/21 @ 1500h
Work Order #: 211173
Termination Date: June 19/21 @ 1500h
Sample ID: Lab Water w/ As
Test set up by: SAH

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
(nominal)	G						
mg/L As	H						
	A	8					SAH
384	B	11					↓
	C	8					
	D	10					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: [signature]
Date Reviewed: July 13, 2021

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: ~~211172~~ 211173
Sample ID: Lab Water w/As

Start Date/Time: June 16/21@1500h
Termination Date/Time June 19/21@1500h

pg.1/2

Initial Cell Density: 10455 cell/mL

230000
0.22
0.01
10454.55

Concentration mg/L As (nominal)	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	21				21	20.0	mean	21.7
	B	26				26	25.0	SD	2.492847
	C	23				23	22.0	CV	11.48537
	D	24				24	23.0		
	E	19				19	18.0		
	F	20				20	19.0		
	G	25				25	24.0		
	H	24				24	23.0		
3	A	19				19	18.0		
	B	22				22	21.0		
	C	22				22	21.0		
	D	20				20	19.0		
6	A	19				19	18.0		
	B	17				17	16.0		
	C	20				20	19.0		
	D	18				18	17.0		
12	A	18				18	17.0		
	B	20				20	19.0		
	C	19				19	18.0		
	D	22				22	21.0		
24	A	21				21	20.0		
	B	18				18	17.0		
	C	19				19	18.0		
	D	25				25	24.0		
48	A	16				16	15.0		
	B	18				18	17.0		
	C	18				18	17.0		
	D	19				19	18.0		
96	A	14				14	13.0		
	B	12				12	11.0		
	C	15				15	14.0		
	D	16				16	15.0		
192	A	11				11	10.0		
	B	12				12	11.0		
	C	16				16	15.0		
	D	16				16	15.0		

Reviewed by: _____

Date reviewed: July 13, 2021

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: ~~211172~~ 211173
Sample ID: Lab Water w/As

Start Date/Time: June 16/21@1500h
Termination Date/Time June 19/21@1500h

Initial Cell Density: 10455 cell/mL

230000
0.22
0.01
10454.55

Concentration mg/L As (nominal)	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A					#DIV/0!	#DIV/0!	mean	#DIV/0!
	B					#DIV/0!	#DIV/0!	SD	#DIV/0!
	C					#DIV/0!	#DIV/0!	CV	#DIV/0!
	D					#DIV/0!	#DIV/0!		
	E					#DIV/0!	#DIV/0!		
	F					#DIV/0!	#DIV/0!		
	G					#DIV/0!	#DIV/0!		
	H					#DIV/0!	#DIV/0!		
384	A	8				8	7.0		
	B	11				11	10.0		
	C	8				8	7.0		
	D	10				10	9.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: _____

Date reviewed: July 13, 2021

CETIS Analytical Report

Report Date: 10 Nov-21 16:26 (p 1 of 2)
Test Code/ID: 211173b / 06-1996-0149

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	10-9047-1179	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	10 Nov-21 16:25	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1

Batch ID:	05-2236-4308	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	16 Jun-21 15:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients		
Ending Date:	19 Jun-21 15:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	5d

Sample ID:	06-0524-6678	**Code:**	Lab Water w/ As	**Project:**	
Sample Date:	16 Jun-21 09:00	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	16 Jun-21 09:00	**CAS (PC):**		**Station:**	Lab Water w/ As
Sample Age:	6h (8.5 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	2.8	5.6	3.96		14.99%

Dunnett Multiple Comparison Test

Control vs	Conc-µg/L	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Negative Control	2.8	1.572	2.563	3.26	10	CDF	0.3024	Non-Significant Effect
	5.6*	3.341	2.563	3.26	10	CDF	0.0079	Significant Effect
	11.4	2.359	2.563	3.26	10	CDF	0.0769	Non-Significant Effect
	22.4	1.572	2.563	3.26	10	CDF	0.3024	Non-Significant Effect
	44.8*	3.931	2.563	3.26	10	CDF	0.0017	Significant Effect
	88.6*	6.682	2.563	3.26	10	CDF	8.8E-07	Significant Effect
	178*	7.076	2.563	3.26	10	CDF	4.1E-07	Significant Effect
	348*	10.61	2.563	3.26	10	CDF	1.7E-07	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.295	3.036	0.7216	No Outliers Detected
Control Trend	Mann-Kendall Trend Test	2.295		1.0000	Non-Significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	689.225	86.1531	8	19.97	<1.0E-37	Significant Effect
Error	133.75	4.31452	31			
Total	822.975		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	5.156	20.09	0.7408	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9751	0.9236	0.5128	Normal Distribution

Cell Yield Summary

Conc-µg/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	21.75	19.67	23.83	22.5	18	25	0.8814	11.46%	0.00%
2.8		4	19.75	17.36	22.14	20	18	21	0.75	7.59%	9.20%
5.6		4	17.5	15.45	19.55	17.5	16	19	0.6455	7.38%	19.54%
11.4		4	18.75	16.03	21.47	18.5	17	21	0.8539	9.11%	13.79%
22.4		4	19.75	14.82	24.68	19	17	24	1.548	15.67%	9.20%
44.8		4	16.75	14.75	18.75	17	15	18	0.6292	7.51%	22.99%
88.6		4	13.25	10.53	15.97	13.5	11	15	0.8539	12.89%	39.08%
178		4	12.75	8.565	16.93	13	10	15	1.315	20.63%	41.38%
348		4	8.25	5.863	10.64	8	7	10	0.75	18.18%	62.07%

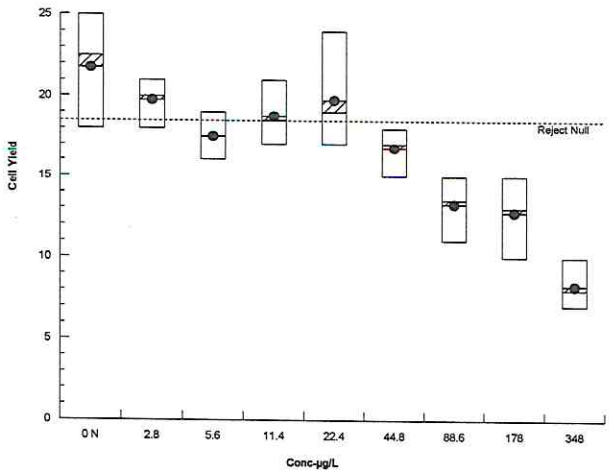
EC Alga Growth Inhibition Test — **Nautilus Environmental**

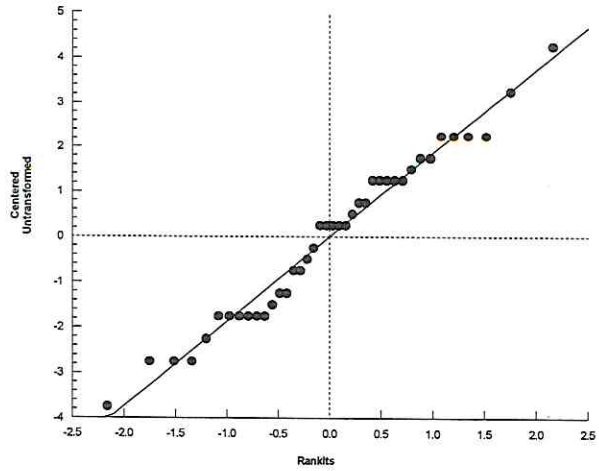
Analysis ID:	10-9047-1179	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	10 Nov-21 16:25	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1

Cell Yield Detail

Conc-µg/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	20	25	22	23	18	19	24	23
2.8		18	21	21	19				
5.6		18	16	19	17				
11.4		17	19	18	21				
22.4		20	17	18	24				
44.8		15	17	17	18				
88.6		13	11	14	15				
178		10	11	15	15				
348		7	10	7	9				

Graphics





CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	02-9561-1721	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	06 Jul-21 16:57	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

Batch ID:	05-2236-4308	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	16 Jun-21 15:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients		
Ending Date:	19 Jun-21 15:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	5d

Sample ID:	06-0524-6678	**Code:**	Lab Water w/ As	**Project:**	
Sample Date:	16 Jun-21 09:00	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	16 Jun-21 09:00	**CAS (PC):**		**Station:**	Lab Water w/ As
Sample Age:	6h (8.5 °C)	**Client:**	Pretivm Resources Inc.		

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Gompertz: μ=α·exp[log[0.5]·[x/δ]^γ]	Normal [ω=1]	Off [μ*=μ]	None	None

Regression Summary

Iters	Log LL	AICc	BIC	Adj R2	Optimize	F Stat	Critical	P-Value	Decision(α:5%)
9	-30.67	68.01	72.41	0.7685	Yes	1.816	2.409	0.1284	Non-Significant Lack of Fit

Point Estimates

Level	μg/L	95% LCL	95% UCL
IC5	2.679	0.08169	8.129
IC10	9.209	3.19	18.14
IC15	19.37	9.412	32.97
IC20	33.36	19.18	51.9
IC25	51.58	33.1	74.99
IC40	138.1	101.5	183.2
IC50	233.1	165.5	321.7

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	21.26	0.7123	19.82	22.71	29.85	<1.0E-37	Significant Parameter
γ	0.583	0.1061	0.368	0.798	5.495	3.0E-06	Significant Parameter
δ	233.1	42.02	147.9	318.2	5.547	2.6E-06	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	12240	4079	3	834.9	<1.0E-37	Significant
Lack of Fit	47.02	7.836	6	1.816	0.1284	Non-Significant
Pure Error	133.8	4.315	31			
Residual	180.8	4.886	37			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.873	3.036	0.0979	No Outliers Detected
Variances	Bartlett Equality of Variance Test	5.156	15.51	0.7408	Equal Variances
	Mod Levene Equality of Variance	1.087	2.255	0.3982	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9699	0.9447	0.3577	Normal Distribution
	Anderson-Darling A2 Normality Te	0.3551	2.492	0.4643	Normal Distribution
Control Trend	Mann-Kendall Trend Test	2		0.9049	Non-Significant Trend in Controls

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	02-9561-1721	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	06 Jul-21 16:57	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

Cell Yield Summary

			Calculated Variate						
Conc-µg/L	**Code**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0	N	8	21.75	18	25	0.8814	2.493	11.46%	0.0%
2.8		4	19.75	18	21	0.75	1.5	7.60%	9.2%
5.6		4	17.5	16	19	0.6455	1.291	7.38%	19.54%
11.4		4	18.75	17	21	0.8539	1.708	9.11%	13.79%
22.4		4	19.75	17	24	1.548	3.096	15.67%	9.2%
44.8		4	16.75	15	18	0.6292	1.258	7.51%	22.99%
88.6		4	13.25	11	15	0.8539	1.708	12.89%	39.08%
178		4	12.75	10	15	1.315	2.63	20.63%	41.38%
348		4	8.25	7	10	0.75	1.5	18.18%	62.07%

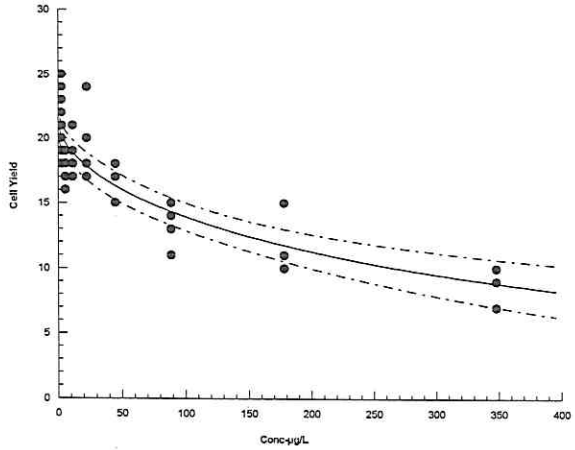
Cell Yield Detail

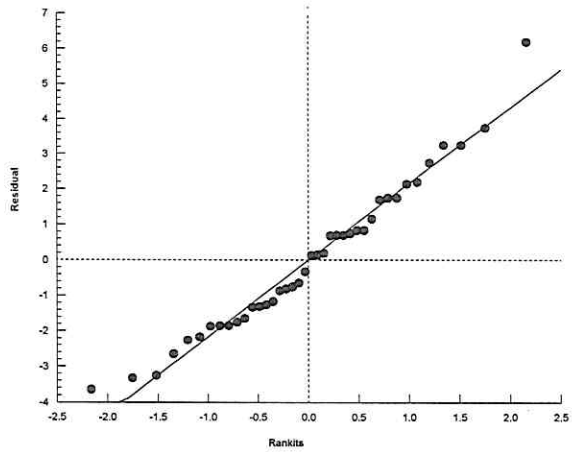
Conc-µg/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Rep 7**	**Rep 8**
0	N	20	25	22	23	18	19	24	23
2.8		18	21	21	19				
5.6		18	16	19	17				
11.4		17	19	18	21				
22.4		20	17	18	24				
44.8		15	17	17	18				
88.6		13	11	14	15				
178		10	11	15	15				
348		7	10	7	9				

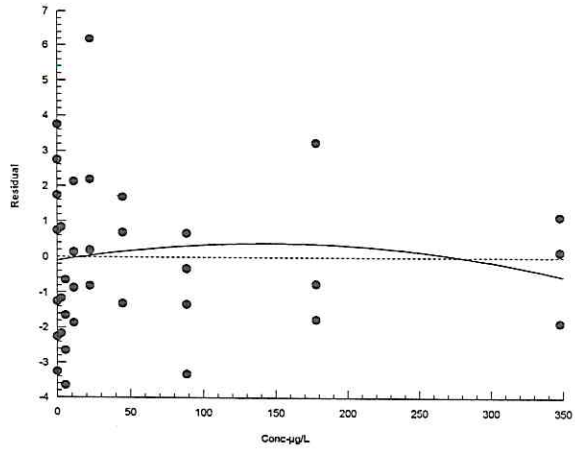
EC Alga Growth Inhibition Test — **Nautilus Environmental**

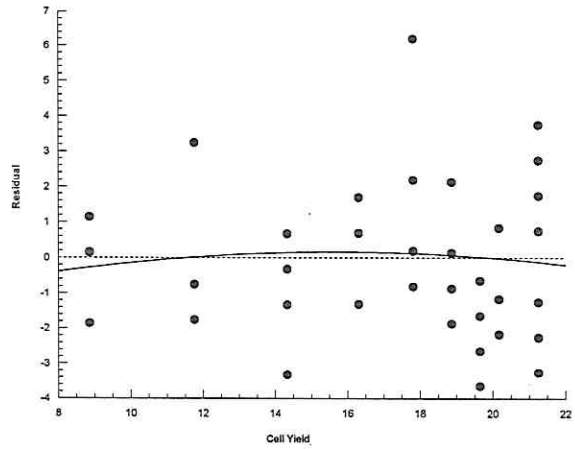
Analysis ID:	02-9561-1721	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	06 Jul-21 16:57	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1

Graphics Model: 3P Log-Gompertz: μ=α·exp[log[0.5]·[x/δ]^γ] Distribution: Normal [ω=1]









Pseudokirchneriella subcapitata Summary Sheet

Client: Pretium
Work Order No.: 211173

Start Date: June 16/21
Set up by: SAL

Sample Information:

Sample ID: BJ-3.10 w/ As
Sample Date: June 14/21
Date Received: June 16/21
Sample Volume: 6 × ~~6L~~ 1L

Test Organism Information:

Culture Date: June 11/21
Age of culture (Day 0): 5d

Zinc Reference Toxicant Results:

Reference Toxicant ID: ~~Z~~ SC216
Stock Solution ID: 21Zn01
Date Initiated: June 10/21

72-h IC50 (95% CL): 35.0 (31.2 - 39.0) mg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.1 (26.8 - 38.5) mg/L Zn CV (%): 9

Test Results:

mg/L ~~Zn~~ As total	Algal Growth
IC25 ~~%(v/v)~~ (95% CL)	124.1 ~~(41.5 - 216.2)~~ (56.1 - 223.1). (measured values)
IC50 ~~%(v/v)~~ (95% CL)	329.4 ~~(258.8 - 360.0)~~ (268.6 - 363.5) (measured values)
mg/L ~~Zn~~ As total	

Reviewed by: [signature]

Date reviewed: July 13, 2021

NOEC: 10.1 mg/L As total
~~NO~~ LOEC: 15.5 mg/L As total

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client : Pretium

Setup by: SAU

Sample ID: BJ-3.10 w/As

Test Date/Time: June 16/21 @ 1500h

Work Order No.: 211173

CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: June 11/21

Age of Culture: 5d

Culture Health: Good

Culture Count: 1 115 2 105

Average: 110

Culture Cell Density (c1): 110×10^4 cells/mL

v1 = 220,000 cells/ml x 60 ml / (c1) 110×10^4 cells/ml = 12 mL

Time Zero Counts: 1 22 2 24

Average: 23

No. of Cells/mL: 23×10^4 cells/mL

Initial Density: # cells/mL ÷ 220 µL x 10 µL = 10455 cells/mL

Concentration (nominal) ~~%(v/v)~~ mg/L As	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	6.8	23.0	25.0	25.0	25.0	26.0	✓	✓	✓	✓
3	7.5	22.0	↓	↓	↓	↓	↓	↓	↓	↓
6	7.6	↓	↓	↓	↓	↓	↓	↓	↓	↓
12	7.6	↓	↓	↓	↓	↓	↓	↓	↓	↓
24	7.5	↓	↓	↓	↓	↓	↓	↓	↓	↓
48	7.6	↓	↓	↓	↓	↓	↓	↓	↓	↓
96	7.6	↓	↓	↓	↓	↓	↓	↓	↓	↓
192	7.6	↓	↓	↓	↓	↓	↓	↓	↓	↓
384	7.6	↓	↓	↓	↓	↓	↓	↓	↓	↓
BJ-3.10 site water control	7.5	24.0	↓	↓	↓	↓	↓	↓	↓	↓
Initials	SAU	SAU	SAU	SAU	SAU	JZ	SAU	SAU	SAU	JZ

Initial control pH: Well 1: 6.8 Well 2: 6.9

Final control pH: Well 1: 6.9 Well 2: 7.0

Light intensity (lux): 3400 Date measured: June 16/21

Thermometer: 1 Light meter: 1 pH meter/probe: 1/1

Sample Description: Clear colourless, odourless, w/ no particulates spiked w/ 21ASOI

Comments: ~~Ctrl~~ Control & Dilution Water = site water (BJ-3.10)

Reviewed: Date reviewed: July 13, 2021

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pretium
Start Date/Time: June 16/21 @ 1500h
Work Order #: 211173
Termination Date: June 19/21 @ 1500h
Sample ID: BJ.310 ~~Site Water~~ w/ As
Test set up by: SAM
~~%(v/v)~~

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control (lab control) mg/L As (nominal)	A	20					SAM
	B	24					
	C	23					
	D	25					
	E	25					
	F	19					
	G	~~20~~ 23					
	H	21					
3	A	56					
	B	57					
	C	52					
	D	52					
6	A	52					
	B	65					
	C	66					
	D	70					
12	A	42					
	B	55					
	C	52					
	D	52					
24	A	42					
	B	48					
	C	58					
	D	54					
48	A	43					
	B	49					
	C	54					
	D	53					
96	A	42					
	B	52					
	C	53					
	D	46					
192	A	24					
	B	37					
	C	42					
	D	46					

Comments:

Reviewed by: [signature]
Date Reviewed: July 13, 2021

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pretium

Start Date/Time: June 16/21 @ 1500h

Work Order #: 211173

Termination Date: June 19/21 @ 1500h

Sample ID: BJ-3.10 ~~Site Water~~ W/ As

Test set up by: SAH

~~%(v/v)~~ mg/L As (nominal)

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
~~Control~~ Site control (BJ-3.10)	A	56					SAH
	B	58					
	C	61					
	D	54					
	E	~~31~~ 66					
	F	56					
	G	63					
	H	61					
384	A	29					
	B	29					
	C	30					
	D	28					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: [signature]

Date Reviewed: July 13, 2021

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: ~~211172~~ 211173
Sample ID: BJ-3.10 w/As

Start Date/Time: June 16/21@1500h
Termination Date/Time June 19/21@1500h

Initial Cell Density: 10455 cell/mL

	230000
	0.22
	0.01
	10454.55

Concentration µg/L As (nominal)	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	20				20	19.0	mean	21.5
	B	24				24	23.0	SD	2.267787
	C	23				23	22.0	CV	10.57019
	D	25				25	24.0		
	E	25				25	24.0		
	F	19				19	18.0		
	G	23				23	22.0		
	H	21				21	20.0		
3	A	56				56	55.0		
	B	57				57	56.0		
	C	52				52	51.0		
	D	52				52	51.0		
6	A	52				52	51.0		
	B	65				65	64.0		
	C	66				66	65.0		
	D	70				70	69.0		
12	A	42				42	41.0		
	B	55				55	54.0		
	C	52				52	51.0		
	D	52				52	51.0		
24	A	42				42	41.0		
	B	48				48	47.0		
	C	58				58	57.0		
	D	54				54	53.0		
48	A	43				43	42.0		
	B	49				49	48.0		
	C	54				54	53.0		
	D	53				53	52.0		
96	A	42				42	41.0		
	B	52				52	51.0		
	C	53				53	52.0		
	D	46				46	45.0		
192	A	34				34	33.0		
	B	37				37	36.0		
	C	42				42	41.0		
	D	48				48	47.0		

Reviewed by: _____

Date reviewed: July 13, 2021

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: ~~211172~~ 211173
Sample ID: BJ-3.10 w/As

Start Date/Time: June 16/21@1500h
Termination Date/Time June 19/21@1500h

Initial Cell Density: 10455 cell/mL

230000
0.22
0.01
10454.55

Concentration mg/L As (nominal)	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Site Control	A	56				56	55.0	mean	58.3
	B	58				58	57.0	SD	4.068608
	C	61				61	60.0	CV	6.97521
	D	54				54	53.0		
	E	66				66	65.0		
	F	56				56	55.0		
	G	63				63	62.0		
	H	61				61	60.0		
384	A	29				29	28.0		
	B	29				29	28.0		
	C	30				30	29.0		
	D	28				28	27.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: _____

Date reviewed: July 13, 2021

CETIS Analytical Report

Report Date:	10 Nov-21 16:29 (p 1 of 2)
Test Code/ID:	211173a / 03-6834-7608

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	02-6567-6741	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	10 Nov-21 16:28	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1

Batch ID:	05-2236-4308	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	16 Jun-21 15:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients		
Ending Date:	19 Jun-21 15:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	5d

Sample ID:	11-6802-2868	**Code:**	BJ-3.10 w/ As	**Project:**	
Sample Date:	14 Jun-21 13:30	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	16 Jun-21 09:01	**CAS (PC):**		**Station:**	BJ-3.10 w/ As
Sample Age:	50h (8.5 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	NOEL	LOEL	TOEL	TU	PMSD
Untransformed	C > T	10.1	15.5	12.51		13.94%

Dunnett Multiple Comparison Test

Control vs	Conc-µg/L	Test Stat	Critical	MSD	DF	P-Type	P-Value	Decision(α:5%)
Site Control	7.4	1.614	2.563	8.137	10	CDF	0.2849	Non-Significant Effect
	10.1	-1.22	2.563	8.137	10	CDF	0.9992	Non-Significant Effect
	15.5*	2.874	2.563	8.137	10	CDF	0.0247	Significant Effect
	26.3*	2.795	2.563	8.137	10	CDF	0.0297	Significant Effect
	48.4*	3.031	2.563	8.137	10	CDF	0.0170	Significant Effect
	93.7*	3.504	2.563	8.137	10	CDF	0.0052	Significant Effect
	179*	6.023	2.563	8.137	10	CDF	4.7E-06	Significant Effect
	354*	9.567	2.563	8.137	10	CDF	1.7E-07	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.434	3.036	0.4692	No Outliers Detected
Control Trend	Mann-Kendall Trend Test	2.434		0.5540	Non-Significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	3628.4	453.55	8	16.87	<1.0E-37	Significant Effect
Error	833.375	26.8831	31			
Total	4461.77		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance Test	11.63	20.09	0.1685	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9692	0.9236	0.3389	Normal Distribution

Cell Yield Summary

Conc-µg/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
4.2	XC	8	58.38	54.97	61.78	58.5	53	65	1.438	6.97%	0.00%
7.4		4	53.25	49.07	57.43	53	51	56	1.315	4.94%	8.78%
10.1		4	62.25	49.83	74.67	64.5	51	69	3.902	12.54%	-6.64%
15.5		4	49.25	40.21	58.29	51	41	54	2.839	11.53%	15.63%
26.3		4	49.5	38.36	60.64	50	41	57	3.5	14.14%	15.20%
48.4		4	48.75	40.81	56.69	50	42	53	2.496	10.24%	16.49%
93.7		4	47.25	38.99	55.51	48	41	52	2.594	10.98%	19.06%
179		4	39.25	29.49	49.01	38.5	33	47	3.065	15.62%	32.76%
354		4	28	26.7	29.3	28	27	29	0.4082	2.92%	52.03%

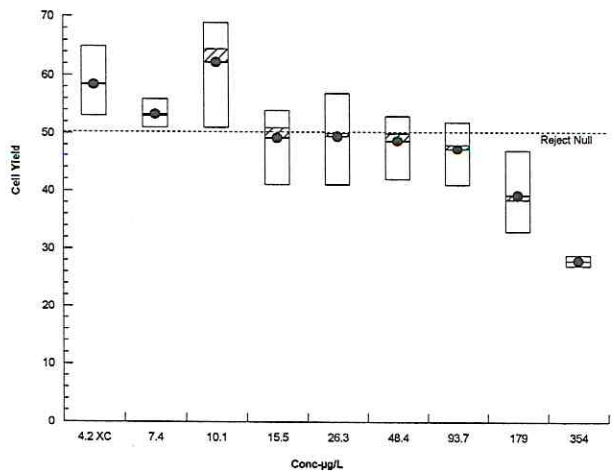
EC Alga Growth Inhibition Test — **Nautilus Environmental**

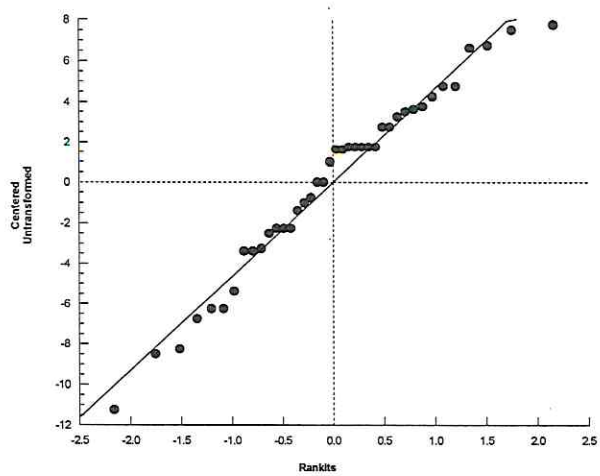
Analysis ID:	02-6567-6741	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	10 Nov-21 16:28	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1

Cell Yield Detail

Conc-µg/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.2	XC	55	57	60	53	65	55	62	60
7.4		55	56	51	51				
10.1		51	64	65	69				
15.5		41	54	51	51				
26.3		41	47	57	53				
48.4		42	48	53	52				
93.7		41	51	52	45				
179		33	36	41	47				
354		28	28	29	27				

Graphics





CETIS Analytical Report

Report Date:	21 Jul-21 15:06 (p 1 of 2)
Test Code/ID:	211173a / 03-6834-7608

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-0925-1766	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	21 Jul-21 15:06	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Batch ID:	05-2236-4308	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	16 Jun-21 15:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients		
Ending Date:	19 Jun-21 15:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	5d

Sample ID:	11-6802-2868	**Code:**	BJ-3.10 w/ As	**Project:**	
Sample Date:	14 Jun-21 13:30	**Material:**	Water Sample	**Source:**	Pretivm Resources Inc.
Receipt Date:	16 Jun-21 09:01	**CAS (PC):**		**Station:**	BJ-3.10 w/ As
Sample Age:	50h (8.5 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1111932	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Extreme Value	Grubbs Extreme Value Test	2.434	3.036	0.4692	No Outliers Detected
Control Trend	Mann-Kendall Trend Test	2.434		0.5540	Non-Significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	11.37	2.993	13.96
IC10	13.21	9.932	37.75
IC15	15.31	12.37	147.1
IC20	97.98	n/a	137.3
IC25	124.1	56.06	223.1
IC40	231.3	130	294.2
IC50	329.4	268.6	363.5

Cell Yield Summary

			Calculated Variate						Isotonic Variate	
Conc-µg/L	Code	Count	Mean	Min	Max	Std Dev	CV%	%Effect	Mean	%Effect
4.2	XC	8	58.38	53	65	4.069	6.97%	0.0%	58.38	0.0%
7.4		4	53.25	51	56	2.63	4.94%	8.78%	57.75	1.07%
10.1		4	62.25	51	69	7.805	12.54%	-6.64%	57.75	1.07%
15.5		4	49.25	41	54	5.679	11.53%	15.63%	49.38	15.42%
26.3		4	49.5	41	57	7	14.14%	15.2%	49.38	15.42%
48.4		4	48.75	42	53	4.992	10.24%	16.49%	48.75	16.49%
93.7		4	47.25	41	52	5.188	10.98%	19.06%	47.25	19.06%
179		4	39.25	33	47	6.131	15.62%	32.76%	39.25	32.76%
354		4	28	27	29	0.8165	2.92%	52.03%	28	52.03%

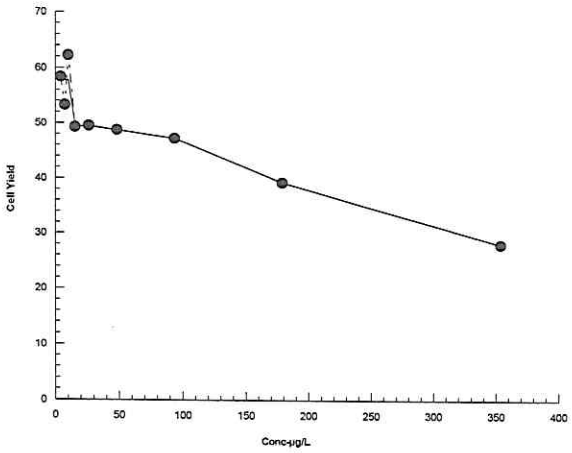
Cell Yield Detail

Conc-µg/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.2	XC	55	57	60	53	65	55	62	60
7.4		55	56	51	51				
10.1		51	64	65	69				
15.5		41	54	51	51				
26.3		41	47	57	53				
48.4		42	48	53	52				
93.7		41	51	52	45				
179		33	36	41	47				
354		28	28	29	27				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-0925-1766	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.9.4
Analyzed:	21 Jul-21 15:06	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1

Graphics



ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B3125**	Page	: 1 of 3
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Jeslin Wijaya	Account Manager	: Hilary Woods
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 28-Jun-2021 17:05
PO	: ----	Date Analysis Commenced	: 29-Jun-2021
C-O-C number	: 10-380592	Issue Date	: 06-Jul-2021 14:45
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439		
No. of samples received	: 8		
No. of samples analysed	: 8		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
mg/L	milligrams per litre

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	3 mgl As mg/L	6 mgl As mg/L	12mgl As mg/L	24 mgl As mg/L	48 mgl As mg/L
				Client sampling date / time	16-Jun-2021	16-Jun-2021	16-Jun-2021	16-Jun-2021	16-Jun-2021
Analyte	CAS Number	Method	LOR	Unit	VA21B3125-001	VA21B3125-002	VA21B3125-003	VA21B3125-004	VA21B3125-005
					Result	Result	Result	Result	Result
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00282	0.00563	0.0114	0.0224	0.0448
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00264	0.00540	0.0107	0.0219	0.0442
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	96 mgl As mg/L	192 mgl As mg/L	384 mgl As mg/L	----	----
				Client sampling date / time	16-Jun-2021	16-Jun-2021	16-Jun-2021	----	----
Analyte	CAS Number	Method	LOR	Unit	VA21B3125-006	VA21B3125-007	VA21B3125-008	--------	--------
					Result	Result	Result	----	----
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0886	0.178	0.348	----	----
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0874	0.172	0.340	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

10- 380592

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of ____

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)	
Company:	Nautilus Environmental Company Inc	Standard: ✓	Other (specify):	✓	Regular (Standard Turnaround Times - Business Days)
Contact:	Jeslin Wijaya ; Sierra Kloeppel	Select: PDF	Excel Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	8664 Commerce Court	Email 1:	Jeslin @nautilus environmental.ca		Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	Sierra @nautilusenvironmental.ca		Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604-420-8773 Fax:				
Invoice To	Same as Report ? (circle) (Yes) or No (if No, provide details)	Client / Project Information		Analysis Request	
	Copy of Invoice with Report? (circle) (Yes) or No	Job #:		(Indicate Filtered or Preserved, F/P)	
Company:		PO / AFE:			
Contact:		LSD:			
Address:					
Phone:	Fax:	Quote #:			
Lab Work Order # (lab use only)	3125	ALS Contact:	Sampler:		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total As (P)	Dissolved As (F/P)	Number of Containers
	3 µg/L As (in Lab Water)	June 16/21			✓	✓	2
	6				✓	✓	2
	12				✓	✓	2
	24				✓	✓	2
	48				✓	✓	2
	96				✓	✓	2
	192				✓	✓	2
	384				✓	✓	2

Environmental Division
Vancouver
Work Order Reference
VA21B3125
Telephone : +1 604 253 4188

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

* Warny Arsenic present in samples

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
				JUN 28 2021	505	7 °C				

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

GENF 18.01 Front

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA21B3127**	Page	: 1 of 3
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Jeslin Wijaya	Account Manager	: Hilary Woods
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 28-Jun-2021 17:05
PO	: ----	Date Analysis Commenced	: 29-Jun-2021
C-O-C number	: 10-380593	Issue Date	: 07-Jul-2021 11:57
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439		
No. of samples received	: 10		
No. of samples analysed	: 10		

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- Analytical Results

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Annabelle Prasad	Analyst	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Saron Kim	Analyst	Metals, Burnaby, British Columbia

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Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab control	Site control(BJ 3.10	3mgl As	6mgl As	12mgl As
							mg/L	mg/L	mg/L
				Client sampling date / time	16-Jun-2021	16-Jun-2021	16-Jun-2021	16-Jun-2021	16-Jun-2021
Analyte	CAS Number	Method	LOR	Unit	VA21B3127-001	VA21B3127-002	VA21B3127-003	VA21B3127-004	VA21B3127-005
					Result	Result	Result	Result	Result
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	<0.00010	0.00417	0.00744	0.0101	0.0155
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	<0.00010	0.00404	0.00732	0.00980	0.0150
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	24mgl As	48mgl As	96mgl As	192mgl As	384mgl As
					mg/L	mg/L	mg/L	mg/L	mg/L
				Client sampling date / time	16-Jun-2021	16-Jun-2021	16-Jun-2021	16-Jun-2021	16-Jun-2021
Analyte	CAS Number	Method	LOR	Unit	VA21B3127-006	VA21B3127-007	VA21B3127-008	VA21B3127-009	VA21B3127-010
					Result	Result	Result	Result	Result
Total Metals									
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.0263	0.0484	0.0937	0.179	0.354
Dissolved Metals									
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.0260	0.0479	0.0922	0.180	0.358
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

10- 380593

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

Page ____ of

Report To		Report Format / Distribution		Service Request:(Rush subject to availability - Contact ALS to confirm TAT)
Company:	Nautilus Environmental Company Inc.	Standard: ✓	Other (specify):	✓ Regular (Standard Turnaround Times - Business Days)
Contact:	Jestin Wijaya, Sierra Klueppel	Select: PDF Excel Digital Fax		Priority(2-4 Business Days)-50% surcharge - Contact ALS to confirm TAT
Address:	8664 commerce court	Email 1:	jestin@nautilusenvironmental.ca	Emergency (1-2 Business Days)-100% Surcharge - Contact ALS to confirm TAT
		Email 2:	sierra@nautilusenvironmental.ca	Same Day or Weekend Emergency - Contact ALS to confirm TAT
Phone:	604 - 420 8773 Fax:			
Invoice To	Same as Report ? (circle) (Yes) or No (if No, provide details)	Client / Project Information		Analysis Request
	Copy of Invoice with Report? (circle) (Yes) or No	Job #:		(Indicate Filtered or Preserved, F/P)
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only):	3127	ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Total As (P/F)	Dissolved As (F/P)
	Lab control	June16/21			✓	✓
	Site control (BJ 3.10)				✓	✓
	3 ug/L As (in ~~Lab~~ Site Water)				✓	✓
	6				✓	✓
	12				✓	✓
	24				✓	✓
	48				✓	✓
	96				✓	✓
	192				✓	✓
	384				✓	✓

Environmental Division
Vancouver
Work Order Reference
VA21B3127
Telephone : + 1 604 253 4188

Special Instructions / Regulation with water or land use (CCME- Freshwater Aquatic Life/BC CSR-Commercial/AB Tier 1-Natural/ETC) / Hazardous Details

*Warning Arsenic present in samples

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date:	Time:	Received by: TL	Date: JUN 28 2021	Time: 1651	Temperature: 7 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

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APPENDIX B – Chain-of-Custody Forms

Nautilus Environmental

Chain of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

Sample Collection By:	RS/NG	
	Report to: Robin McCall	**Invoice to:**
Company	Pretivm Resources Inc.	Same
Address	Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.	
City/Prov/Postal Code	Vancouver, BC V7X 1L4 Box 49334	
Contact	Robin McCall	
Phone	(604) 558-1784	
Email	RMcCall@pretivm.com Environmental@pretivm.com	invoices@pretivm.com

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	# OF CONTAINERS	COMMENTS	Ceriodaphnia 3-brood test (100% only) (Chronic -	Daphnia Magna 48 hrs (100% only) (Acute -EPS1/RM/14)	Chironomus dilutus (water only) (test method	Ceriodaphnia 3-brood test (with dilutions) (Chronic - EPS1/RM/21)	Daphnia Magna 48 hrs (with dilutions) (Acute -EPS1/RM/14)		Rainbow Trout 96 hrs (100% only) (Acute-EPS1/RM/13)	Algal Growth Inhibition Test (100% Only) (ESP 1/RM/25)	*P.subcapitata* with Arsenic in Lab and Site water				Receipt Temperature (°C)
1	BJ-3.10	14-Jun-21	13:30	Water	20L	3	Grab		x	x	x			x	x					3.5 - 8.4
2	Bj-3.10	14-Jun-21	13:30	Water	6L	6	Grab									X				
3																				
4																				
5																				
6																				
7																				
8									68	69	70			71	72	73				
9									"	"	"			"	"	"				
10									21	21	21			21	21	21				

PROJECT INFORMATION	SAMPLE RECEIPT		RELIQUINSHED BY (CLIENT)	RELIQUINSHED BY (COURIER)
Client:	**Total # Containers:**	9	**Signature:**	**Signature:**
P.O. No.: 1024767	**Good Condition?**	Y	**Print:** Richelle Sussbauer	**Print:**
Shipped Via:	**Matches Schedule?**	Y	**Company:** Pretivm	**Company:**
			Time/Date: June 14, 2021, 2021 18:00	**Time/Date:**
				RECEIVED BY (LABORATORY)
			Signature:	**Signature:** TH
			Print:	**Print:** Tyrone
			Company:	**Company:** Nautilus Environmental
			Time/Date:	**Time/Date:** June 16/21 @ 9:01

SPECIAL INSTRUCTIONS/COMMENTS: Please cc report to environmental@pretivm.com, svanzalingen@pretivm.com, rmccall@pretivm.com. **If there are any mortalities, please email envionmental@pretivm.com ASAP. In the event of a failure, please re-peat the test with in the 5 day holding time with the original sample.**

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

END OF REPORT

Evaluation of the toxicity of copper to *C. dubia*, *P. subcapitata*, *L. minor* and *C. dilutus*

Final Report

April 21, 2022

Submitted to: **Pretivm Resources Inc.**
Vancouver, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

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SIGNATURE PAGE

Report by: Mikayla Oldach, M.Sc. Environmental Toxicologist	Reviewed by: James Elphick, R.P.Bio. Senior Environmental Toxicologist

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

Sample Information and Test Type

Sample ID	Cu in Laboratory Water Cu in Site Water (BJ-3.10)
Sample collection date	January 10, 2022
Sample receipt and test initiation date	January 13, 2022
Sample receipt temperature	10.6 – 11.3°C
Test types	7-d *Ceriodaphnia dubia* survival and reproduction 72-h *Pseudokirchneriella subcapitata* growth inhibition 7-d *Lemna minor* growth inhibition 10-d *Chironomus dilutus* water-only survival and growth

Summary of Results

Endpoint	µg/L Cu (95% CL)	
	Laboratory Water *	Site Water (BJ-3.10)
Ceriodaphnia dubia		
Survival LC50	22.5 (18.2 – 27.8)	12.2 (8.6 – 17.4)
Reproduction IC20	12.5 (2.2 – 21.1)	5.2 (3.4 – 9.9)
Reproduction IC50	23.3 (16.6 – 27.0)	10.9 (7.3 – 13.3)
Pseudokirchneriella subcapitata		
Growth IC20	7.4 (4.9 – 10.1)	2.3 (1.9 – 2.8)
Growth IC50	25.6 (20.2 – 32.5)	16.6 (14.7 – 18.0)
Lemna minor		
Frond count IC20	3.0 (2.1 – 4.0)	2.9 (0.8 – 3.4)
Frond count IC50	>9.7	>10.3
Dry weight IC20	2.2 (1.4 – 3.1)	3.4 (2.1 – 5.0)
Dry weight IC50	>9.7	>10.3
Chironomus dilutus		
Survival LC50	>32.8	>31.0
Reproduction IC20	>32.8	>31.0
Reproduction IC50	>32.8	>31.0

LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits
*Hardness-adjusted to approximately 70 mg/L $CaCO_3$

1.0 INTRODUCTION

Nautilus Environmental Company Inc. (Nautilus) conducted toxicity tests on behalf of Pretivm Resources Inc. (Pretivm) to evaluate the toxicity of copper (Cu) in site water and laboratory water. Tests were performed using *Ceriodaphnia dubia*, *Pseudokirchneriella subcapitata*, *Lemna minor* and *Chironomus dilutus* at the Nautilus laboratory in Burnaby, BC. For each species, a test was conducted in both site water identified as BJ-3.10, and in laboratory water with a hardness of approximately 70 mg/L $CaCO_3$, to compare the toxicity of copper.

The results of the toxicity tests are presented in this report. Copies of laboratory data sheets and statistical analyses for the tests are provided in Appendices A through D. The results of analytical chemistry are provided in Appendix E. The chain-of-custody form is provided in Appendix F.

2.0 METHODS

The site water was collected by Pretivm staff on January 10, 2022 in five 20-L carboys and delivered to the Nautilus laboratory on January 13, 2022. The sample was received at a temperature ranging from 10.6 to 11.3°C. Methods for the toxicity tests are summarized in Tables 1 through 4. Testing was conducted according to procedures described by Environment Canada (1997 and 2007a, b, c). A stock solution of 106 mg/L Cu added as copper chloride ($CuCl_2$) was used for preparation of the highest concentration for each test and more dilute test solutions were prepared using half-series dilutions.

Subsamples were collected in plastic HDPE bottles for each concentration at test initiation at test termination for measurement of total and dissolved copper. Laboratory control water and site water BJ-3.10 were also analyzed for hardness, total dissolved and suspended solids, major anions, nutrients and total and dissolved metals. Subsamples were analyzed by ALS Environmental (Burnaby, BC); results are provided in Appendix E.

Statistical analyses for the tests were performed using CETIS (Tidepool Scientific Software, 2013). As per client specification (Robert Goldblatt, pers comm.), average measured dissolved copper concentrations from test initiation and termination were used for statistical analyses, with the exception of the algal test in which measurements were only taken at test initiation; analytical values that were below detection limits were interpreted as half the detection limit value.

Table 1. Summary of test conditions: *Ceriodaphnia dubia* survival and reproduction test.

Test species	*Ceriodaphnia dubia*
Organism source	In-house culture
Organism age	<24 hour old neonates, produced within a 12 hour window
Test type	Static-renewal
Test duration	7 ± 1 day
Test vessel	20-mL glass test tube
Test volume	15 mL
Test solution depth	10 cm
Test concentrations	Seven concentrations, plus laboratory control
Test replicates	10 per treatment
Number of organisms	1 per replicate
Control water	20% Perrier diluted with deionized water to hardness of ~70 mg/L
Test solution renewal	Daily (100% renewal)
Test temperature	25 ± 1°C
Feeding	Daily with *Pseudokirchneriella subcapitata* and TCC[1] (3:1 ratio)
Light intensity	100 to 600 lux at water surface
Photoperiod	16 hours light / 8 hours dark
Aeration	None
Test measurements	Temperature, dissolved oxygen, pH and conductivity measured daily; hardness and alkalinity of undiluted sample measured at test initiation; survival and reproduction checked daily
Test protocol	Environment Canada (2007a), EPS 1/RM/21
Statistical software	CETIS Version 2.1.1
Test endpoints	Survival and reproduction
Test acceptability criteria for controls	≥80% survival; ≥15 young per surviving control producing three broods; ≥60% of controls producing three or more broods; no ephippia present
Reference toxicant	Sodium chloride (NaCl)

[1] TCC = Trout chow and Cerophyl

Table 2. Summary of test conditions: 72-h *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain CPCC #37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	Seven concentrations, plus laboratory control
Test replicates	4 per treatment; 8 for laboratory control
Number of organisms	10,000 cells/mL
Control water	20% Perrier diluted with deionized water to hardness of ~70 mg/L and supplemented with nutrients
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature and pH measured at test initiation; pH of two control wells measured at test termination
Test protocol	Environment Canada (2007b), EPS 1/RM/25
Statistical software	CETIS Version 2.1.1
Test endpoint	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnSO_4$)

Table 3. Summary of test conditions: 7-d *Lemna minor* growth inhibition test.

Test species	*Lemna minor*, strain CPCC# 490
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Centre, and originally isolated from Wainfleet, Stinking Barn, Niagara Peninsula, Ontario, Canada
Organism age	7- to 10-day old culture
Test type	Static
Test duration	7 days
Test vessel	250-mL glass container
Test volume	100 mL
Test solution depth	4 cm
Test concentrations	Seven concentrations, plus laboratory control
Test replicates	4 per treatment
Number of organisms	Two 3-frond plants per replicate
Control/dilution water	Modified APHA media (deionized water plus 1% of each APHA stock solution A, B and C); 20% Perrier water diluted with deionized water to hardness of ~70 mg/L
Test solution renewal	None
Test temperature	25 ± 2°C
Feeding	None
Light intensity	4000 to 5600 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature, pH and conductivity measured in all concentrations at test initiation; dissolved oxygen of highest concentration measured at test initiation; temperature and pH measured at test termination
Test protocol	Environment Canada (2007c), EPS 1/RM/37
Statistical software	CETIS Version 2.1.1
Test endpoints	Number of fronds and dry weight
Test acceptability criterion for controls	≥ 8-fold increase in number of fronds
Reference toxicant	Potassium chloride (KCl)

Table 4. Summary of test conditions: 10-d *Chironomus dilutus* water-only survival and growth test.

Test species	*Chironomus dilutus*
Organism source	Aquatic BioSystems, Fort Collins, CO
Organism age	Third instar
Test type	Static-renewal
Test duration	10 days
Test vessel	375-mL glass container
Test volume	275 mL
Test concentrations	Seven concentrations, plus laboratory/site control
Test replicates	5 per sample
Number of organisms	10 per replicate
Control water	20% Perrier water diluted with deionized water to hardness of ~70 mg/L
Test solution renewal	Three times a week on non-consecutive days
Test temperature	23 ± 1°C
Feeding	6 mg of Tetramin per replicate daily
Light intensity	500 to 1000 lux at water surface
Photoperiod	16 hours light/8 hours dark
Aeration	None, unless dissolved oxygen falls below 40% saturation
Test measurements	Temperature, dissolved oxygen, pH and conductivity of overlying water measured daily; hardness, alkalinity and total ammonia of overlying water measured at test initiation and termination
Test protocol	Environment Canada (1997), EPS 1/RM/32 (modified)
Statistical software	CETIS Version 2.1.1
Test endpoints	Survival and dry weight
Test acceptability criteria for controls	≥70% survival; ≥0.6 mg/worm dry weight
Reference toxicant	Potassium chloride (KCl)

3.0 RESULTS

Measured concentrations of total copper were close to target nominal concentrations (within 10%) at test initiation for all tests, indicating that the test solutions had been dosed correctly. Dissolved copper at test initiation was similar to total copper with the exception of the *L. minor* growth inhibition test, which had dissolved copper concentrations at approximately 58% of the target concentrations, likely reflecting the interaction of constituents of the media used for this species on solubility of copper. Dissolved copper concentrations measured at test termination were similar to those present at test initiation for the *C. dubia* test, but concentrations declined during exposure in the *L. minor* and *C. dilutus* tests, both of which were static tests with no solution renewals. Copper was not measured at test termination for the *P. subcapitata* test.

Results of the *C. dubia* survival and reproduction tests are summarized in Tables 5 and 6. Adverse effects were observed on survival and reproduction in both laboratory water and site water. The LC50 for survival was 22.5 µg/L Cu in laboratory water and 12.2 µg/L Cu in site water. The IC20 for reproduction was 12.5 µg/L Cu in laboratory water and 5.2 µg/L Cu in site water.

Results of the *P. subcapitata* growth inhibition tests are summarized in Tables 7 and 8. Adverse effects were observed on growth of *P. subcapitata* with IC20 values of 7.4 µg/L Cu in laboratory water and 2.3 µg/L Cu in site water.

Results of the *L. minor* growth inhibition tests are summarized in Tables 9 and 10. Adverse effects were observed on the frond growth and dry weight of *L. minor* with IC20 values of 3.0 and 2.2 µg/L Cu, respectively, in laboratory water, and 2.9 and 3.4 µg/L Cu, respectively, in site water. As noted above, the concentration of dissolved copper measured in solution was lower than total copper measurements, and declined during exposure, resulting in a calculated average dissolved copper concentration that was less than one-quarter of the total copper that was present at test initiation. Thus, the point estimates reported here are lower than they would be if presented on the basis of total copper, or on the basis of the concentration present at test initiation.

Results of the *C. dilutus* survival and growth tests are summarized in Tables 11 and 12. No significant adverse effects were observed on survival or growth in either laboratory water or site water, with LC50 and IC20 values of >32.8 µg/L Cu for laboratory water and >31.0 µg/L Cu for site water.

Table 5. Results of the *Ceriodaphnia dubia* survival and reproduction test conducted in Laboratory Water.

Nominal (µg/L Cu)	Measured Average (µg/L Cu)		Survival (%)	Reproduction (Mean ± SD)
	Total	Dissolved		
Lab Control *	0.8	0.3	100	20.7 ± 3.5
0.75	1.1	1.1	100	18.2 ± 3.8
1.5	1.7	1.6	100	18.3 ± 4.6
3	2.9	2.7	100	16.3 ± 2.9
6	5.2	4.9	100	19.7 ± 3.0
12	10.1	9.3	100	19.8 ± 2.4
24	22.7	19.6	70	13.6 ± 9.0
48	44.0	40.2	0	0.0 ± 0.0
	Test Endpoint (µg/L Cu)			
	LC50 (95% CL)		22.5 (18.2 – 27.8)	--
	IC20 (95% CL)		--	12.5 (2.2 – 21.1)
	IC50 (95% CL)		--	23.3 (16.6 – 27.0)

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

* Lab Control is the hardness adjusted control

Table 6. Results of the *Ceriodaphnia dubia* survival and reproduction test conducted in Site Water.

Nominal (µg/L Cu)	Measured Average (µg/L Cu)		Survival (%)	Reproduction (Mean ± SD)
	Total	Dissolved		
Site Control	0.4	0.3	100	20.5 ± 4.6
0.75	1.2	0.9	100	22.5 ± 4.6
1.5	1.9	1.5	100	21.9 ± 5.8
3	3.0	2.4	100	21.7 ± 4.3
6	8.1	4.4	90	18.4 ± 6.9
12	11.0	9.0	70	13.7 ± 10.9
24	24.3	19.8	30	1.5 ± 2.6
48	42.8	37.0	0	--
	Test Endpoint (µg/L Cu)			
	LC50 (95% CL)		12.2 (8.6 – 17.4)	--
	IC20 (95% CL)		--	5.2 (3.4 – 9.9)
	IC50 (95% CL)		--	10.9 (7.3 – 13.3)

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

Table 7. Results of the *Pseudokirchneriella subcapitata* growth inhibition test conducted in Laboratory Water.

Nominal (µg/L Cu)	Measured (Day 0) (µg/L Cu)		Cell Yield (x 10^4 cells/mL) (Mean ± SD)
	Total	Dissolved	
Lab Control *	0.2	0.4	17.2 ± 0.7
0.75	1.2	1.0	15.8 ± 2.2
1.5	1.7	1.6	16.0 ± 2.2
3	3.0	2.8	14.5 ± 1.9
6	5.9	5.3	15.0 ± 1.6
12	11.8	10.4	12.0 ± 1.4
24	23.0	20.9	10.2 ± 0.5
48	46.4	42.3	5.5 ± 2.5
	Test Endpoint (µg/L Cu)		
	IC20 (95% CL)		7.4 (4.9 – 10.1)
	IC50 (95% CL)		25.6 (20.2 – 32.5)

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

* Lab Control is the hardness adjusted control

Table 8. Results of the *Pseudokirchneriella subcapitata* growth inhibition test conducted in Site Water.

Nominal (µg/L Cu)	Measured (Day 0) (µg/L Cu)		Cell Yield (x 10^4 cells/mL) (Mean ± SD)
	Total	Dissolved	
Site Control	0.2	0.2	16.9 ± 1.0
0.75	1.0	1.0	17.0 ± 0.8
1.5	1.8	1.7	15.0 ± 0.8
3	3.2	2.9	12.2 ± 1.0
6	6.2	6.7	10.8 ± 1.5
12	12.1	11.4	11.0 ± 0.8
24	24.4	22.4	6.5 ± 0.6
48	48.8	46.3	4.0 ± 1.2
	Test Endpoint (µg/L Cu)		
	IC20 (95% CL)		2.3 (1.9 – 2.8)
	IC50 (95% CL)		16.6 (14.7 – 18.0)

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

Table 9. Results of the *Lemna minor* growth inhibition test conducted in Laboratory Water.

Nominal (µg/L Cu)	Measured Average (µg/L Cu)		Frond Growth (No. of fronds) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
	Total	Dissolved		
Lab Control *	0.2	0.1	59.8 ± 3.5	8.0 ± 0.2
0.75	0.9	0.4	59.0 ± 1.8	7.6 ± 0.4
1.5	1.1	0.5	61.2 ± 6.2	7.6 ± 0.8
3	2.2	0.7	58.5 ± 8.2	7.4 ± 1.2
6	3.4	1.1	61.8 ± 5.9	7.7 ± 0.2
12	7.1	2.0	56.0 ± 3.7	6.6 ± 0.8
24	14.0	3.9	40.5 ± 2.6	5.5 ± 0.3
48	27.0	9.7	33.5 ± 3.0	5.1 ± 0.4
	Test Endpoint (µg/L Cu)			
	IC20 (95% CL)		3.0 (2.1 – 4.0)	2.2 (1.4 – 3.1)
	IC50		>9.7	>9.7

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

* Lab Control is the hardness adjusted control

Table 10. Results of the *Lemna minor* growth inhibition test conducted in Site Water.

Nominal (µg/L Cu)	Measured Average (µg/L Cu)		Frond Growth (No. of fronds) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
	Total	Dissolved		
Site Control	0.2	0.1	65.5 ± 3.7	7.2 ± 0.5
0.75	1.2	0.5	58.8 ± 1.7	7.6 ± 1.5
1.5	1.3	0.7	55.8 ± 5.9	6.9 ± 0.2
3	2.2	1.0	58.5 ± 5.3	6.8 ± 0.8
6	4.0	1.5	56.0 ± 3.6	6.9 ± 0.4
12	7.5	2.6	55.0 ± 2.9	6.4 ± 0.3
24	13.2	4.7	38.2 ± 5.3	5.3 ± 0.5
48	25.4	10.3	34.8 ± 1.7	5.0 ± 0.1
	Test Endpoint (µg/L Cu)			
	IC20 (95% CL)		2.9 (0.8 – 3.4)	3.4 (2.1 – 5.0)
	IC50		>10.3	>10.3

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

Table 11. Results of the *Chironomus dilutus* survival and growth test conducted in Laboratory Water.

Nominal (µg/L Cu)	Measured Average (µg/L Cu)		Survival (%) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
	Total	Dissolved		
Lab Control *	0.6	0.3	92.0 ± 8.4	1.89 ± 0.13
0.75	1.5	1.1	94.0 ± 13.4	1.76 ± 0.25
1.5	1.9	1.7	94.0 ± 8.9	1.98 ± 0.18
3	2.8	2.7	94.0 ± 8.9	1.86 ± 0.22
6	5.1	4.8	92.0 ± 8.4	1.84 ± 0.26
12	9.4	8.9	86.0 ± 15.2	1.86 ± 0.20
24	18.2	17.4	92.0 ± 13.0	1.76 ± 0.19
48	33.5	32.8	94.0 ± 5.5	1.74 ± 0.19
	Test Endpoint (µg/L Cu)			
	LC50		>32.8	--
	IC20		--	>32.8
	IC50		--	>32.8

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration

* Lab Control is the hardness adjusted control

Table 12. Results of the *Chironomus dilutus* survival and growth test conducted in Site Water.

Nominal (µg/L Cu)	Measured Average (µg/L Cu)		Survival (%) (Mean ± SD)	Dry Weight (mg) (Mean ± SD)
	Total	Dissolved		
Site Control	0.5	0.4	92.0 ± 8.4	1.83 ± 0.26
0.75	1.2	1.0	96.0 ± 5.5	1.90 ± 0.20
1.5	1.8	1.5	86.0 ± 5.5	1.70 ± 0.13
3	2.7	2.5	92.0 ± 13.0	1.87 ± 0.19
6	5.0	4.5	100 ± 0.0	1.66 ± 0.07
12	9.0	8.4	98.0 ± 4.5	1.52 ± 0.09
24	17.4	16.3	92.0 ± 8.4	1.71 ± 0.18
48	33.0	31.0	98.0 ± 4.5	1.60 ± 0.14
	Test Endpoint (µg/L Cu)			
	LC50		>31.0	--
	IC20		--	>31.0
	IC50		--	>31.0

SD = Standard Deviation, LC = Lethal Concentration, IC = Inhibition Concentration, CL = Confidence Limits

4.0 QA/QC

The health history of the test organisms used in the exposure was acceptable and met the requirements of the Environment Canada protocol. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocol throughout the test.

Due to a shipping delay associated with delivery of the test organisms, the *C. dilutus* test was initiated one week later than the *C. dubia*, *P. subcapitata* and *L. minor* tests. Although the site water was held at the laboratory during this time period, this holding time is unlikely to have influenced the test results, since the site waters was being used as a dilution water in the test, rather than as a sample, and copper was introduced into the sample immediately prior to testing. Otherwise, there were no deviations from the test methodology other than the planned modifications described in Section 2.0. Uncertainty associated with the test is best described by the standard deviation around the mean and/or the confidence intervals around the point estimates.

Results of the reference toxicant tests conducted during the testing program are summarized in Table 13. Results for these tests fell within the range for organism performance of the mean and two standard deviations, based on historical results obtained by the laboratory with this test, with the exception of the *P. subcapitata* test, which had a result that was marginally lower than the two standard deviation range. There was nothing unusual about this test and it is expected that test results fall outside of the two standard deviation range in 5% of cases based on chance alone. Based on the narrow two standard deviation range for this test method and the minor deviation from the range, this was considered to be an acceptable deviation. Thus, the sensitivity of the organisms used in this test was considered to be appropriate. The reference toxicant tests were performed under the same conditions as those used for the sample.

Table 13. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
C. dubia	Survival (LC50): 2.1 g/L NaCl	2.0 (1.8–2.2) g/L NaCl	5	January 18, 2022
	Reproduction (IC50): 1.8 g/L NaCl	1.7 (1.4–2.2) g/L NaCl	11	
P. subcapitata	Growth (IC50): 25.6 µg/L Zn	32.3 (26.8–38.9) µg/L Zn	9	January 20, 2022
L. minor	Frond count (IC50): 2.9 g/L KCl	3.3 (2.8–3.9) g/L KCl	8	January 12, 2022
C. dilutus	Survival (LC50): 4.5 g/L KCl	5.4 (3.8–7.6) g/L KCl	17	January 21, 2022

SD = Standard Deviation, CV = Coefficient of Variation, LC = Lethal Concentration, IC = Inhibition Concentration

5.0 REFERENCES

Environment Canada. 1997. Biological test method: test for survival and growth in sediment using the larvae of freshwater midges (*Chironomus tentans* and *Chrironomus riparius*). Environmental Protection Series EPS 1/RM/32. December 1997. Environment Canada, Method Development and Application Section, Environmental Technology Centre, Ottawa, ON. 131 pp.

Environment Canada. 2007a. Biological test method: test of reproduction and survival using the cladoceran *Ceriodaphnia dubia*. Environmental Protection Series. Report EPS 1/RM/21, Second Edition, February 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 74 pp.

Environment Canada. 2007b. Biological test method: growth inhibition test using the freshwater alga. Environmental Protection Series, Report EPS 1/RM/25. Second Edition, March 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 53 pp.

Environment Canada. 2007c. Biological test method: tests for measuring the inhibition of growth using the freshwater macrophyte, *Lemna minor*. Environmental Protection Series, Report EPS 1/RM/37. Second Edition. January 2007. Environment Canada, Method Development and Application Section, Environmental Technology Centre, Ottawa, ON. 112 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.7.16 Tidepool Scientific Software, McKinleyville, CA. 275 pp.

APPENDIX A – *Ceriodaphnia dubia* Toxicity Test Data

Ceriodaphnia dubia Summary Sheet

Client: Lorax/Petrum Resources Inc. Start Date/Time: Jan 14/22 @ 1130h
Work Order No.: 212490 Set up by: JZL

Sample Information:

Sample ID: Cu w lab water
Sample Date: Jan 13/22
Date Received: Jan 13/22
Sample Volume: N/A

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6.0 to 8.5

Test Organism Information:

Broodstock No.: BB010522B
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 22
Mortality (%) in previous 7 d: 0
Individual female # used ≥8 young on test day #21-40

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd298
Stock Solution ID: 21Na03
Date Initiated: Jan 18/22

7-d LC50 (95% CL): 2.1 (1.5-3.0) g/L NaCL
7-d IC50 (95% CL): 1.8 (1.5-2.0) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0 (1.8-2.2) g/L NaCL CV (%): 5
7-d IC50 Reference Toxicant Mean and Historical Range: 1.7 (1.4-2.2) g/L NaCL CV (%): 11

Test Results:
(measured values)

ug/L Cu	Survival	Reproduction
LC50 % (v/v) (95% CL)	22.5 (18.2-27.8)	
IC25 % (v/v) (95% CL)		14.6 (10.6-22.0)
IC50 % (v/v) (95% CL)		23.3 (16.6-27.0)

MDO

Reviewed by: JGr Date reviewed: Mar. 28/22

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Pretium Resources Inc. / Lorax
Sample ID: MDO BS-3.10 Cu w/ Lab Water
Work Order #: 212490

Start Date & Time: Jan. 14/22 @ 1130h
Stop Date & Time: Jan. 20/22 @ 1300h
CER #: 4
Test Species: *Ceriodaphnia dubia*

µg/L Cu (nominal)

Lab Water Concentration Control (Hardness adj.)	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	24.5	24.5	25.0	25.0	24.0	24.0	24.0	24.0	24.5	25.0		
DO (mg/L)	7.5	7.1	7.8	7.2	7.7	7.3	8.2	7.3	8.3	6.9	7.7	6.4		
pH	7.7	7.5	7.7	7.7	7.8	7.8	7.9	7.6	7.8	7.5	7.7	7.6		
Cond. (µS/cm)	159	156		157		155		156		156		~~157~~ 160		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration 0.75	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	24.5	24.5	25.0	25.0	24.0	24.0	24.0	24.0	24.5	25.5		
DO (mg/L)	7.8	7.2	7.9	7.2	7.8	7.3	8.3	7.3	8.2	7.0	7.7	6.7		
pH	7.7	7.5	7.7	7.7	7.8	7.7	7.9	7.6	7.8	7.5	7.8	7.5		
Cond. (µS/cm)	155	159		160		156		157		157		~~156~~ 158		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration 6	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	24.5	25.0	25.0	25.0	24.0	24.0	24.0	24.0	24.5	25.0		
DO (mg/L)	7.8	7.2	7.9	7.2	7.9	7.4	8.4	7.4	8.2	7.0	7.7	6.7		
pH	7.7	7.5	7.6	7.6	7.8	7.7	7.9	7.5	7.8	7.4	7.7	7.5		
Cond. (µS/cm)	153	157		160		156		157		156		159		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration 48	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.5	25.0	25.0	25.0	25.0	24.0	24.5	24.0	24.5	25.0			
DO (mg/L)	7.9	7.1	8.0	7.2	7.8	7.6	8.4	7.3	8.2	7.0	7.8			
pH	7.7	7.5	7.6	7.6	7.8	7.6	7.9	7.6	7.8	7.4	7.7			
Cond. (µS/cm)	154	155		156		156		155		155				
Initials	JZL	JZL		RZS		SAK		JZL		JZL				

Thermometer: CER #4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Control	Hardness adjusted control		
Hardness*	98 MDO	74		
Alkalinity*	92	66		

* mg/L as CaCO3

Analysts: SAK, JZL, RZS
Reviewed by: JGL
Date reviewed: Mar. 23/22

Sample Description: Clear, colourless, odourless, no particulates

Comments: Broodboard Used: BB010522B #21-40

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Pretium Resources Inc. / Larax
Sample ID: ~~BJ 3.10~~ w/ lab water
Work Order #: 212490

Start Date & Time: Jan. 14/22 @ 1130h
Stop Date & Time: Jan. 20/22 @ 1300h
CER #: 4
Test Species: *Ceriodaphnia dubia*

Lab (negative) Control	Days													
Concentration	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0	24.0	25.0	25.0		
DO (mg/L)	8.1	7.0	8.1	7.1	8.1	7.2	8.2	7.3	8.1	6.8	8.1	6.5		
pH	7.9	7.7	8.0	7.8	8.0	7.8	~~7.9~~ 8.0	7.7	7.9	7.5	8.0	7.6		
Cond. (µS/cm)	210	210		210		212		211		211		212		
Initials	JZL	JZL		RZS		SAM		JZL		JZL		JZL		

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Thermometer: CER #4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Lab Control			
Hardness*	98			
Alkalinity*	92			

* mg/L as CaCO3

Analysts: JZL, RZS, SAM
Reviewed by: JOh
Date reviewed: Mar. 23/22

Sample Description: Clear, colorless, odorless, no particulates

Comments: Broodboard Used: BB010522B #21-40

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Pretium / Lorax (Resources Inc.)
Sample ID: ~~BJ-3.104~~ w/ Lab water
Work Order: 212490

Start Date & Time: Jan. 14/22 @ 1130h
Stop Date & Time: Jan. 20/22 @ 1300h
Set up by: JZL/SAK

ug/L Cu

Days	Concentration: Lab Control										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	4	2	6	6	5	4	/	3	4	4	SAK
4	/	8	/	/	/	/	6	/	/	/	JZL
5	8	/	9	8	6	8	11	8	8	8	JZL
6	13	14	11	12	12	11	12	12	10	12	JZL
7											
8											
Total	25	24	26	26	23	23	29	23	22	24	SAK

Days	Concentration: Lab water Control (Hardness adj)										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	4	/	4	4	4	4	3	/	8	/	SAK
4	/	6	/	/	6	/	/	4	/	5	JZL
5	9	8	8	6	10	6	5	8	8	10	JZL
6	7	10	10	6	11	9	7	9	9	10	JZL
7											
8											
Total	20	24	22	16	20	19	15	21	25	25	SAK

Days	Concentration: 0.75										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	6	4	/	4	5	3	/	5	5	SAK
4	/	/	/	8	/	/	/	4	/	/	JZL
5	8	7	6	10	8	8	7	7	2	8	JZL
6	3	9	5	5	3	6	8	11	10	7	JZL
7											
8											
Total	11	22	15	23	15	19	18	22	17	20	SAK

Days	Concentration: 1.5										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	5	4	5	5	5	8	4	/	3	SAK
4	3	/	/	/	/	/	/	/	4	/	JZL
5	/	8	8	6	7	6	9	8	6	5	JZL
6	6	10	6	10	5	10	8	6	4	9	JZL
7											
8											
Total	9	23	18	21	17	21	25	18	14	17	SAK

Days	Concentration: 3										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	3	4	5	4	/	4	4	5	/	SAK
4	4	/	/	/	/	4	/	/	/	/	JZL
5	7	7	5	4	7	7	8	3	8	5	JZL
6	8	9	5	8	5	5	4	9	7	5	JZL
7											
8											
Total	19	19	14	17	16	16	16	16	20	10	SAK

Days	Concentration: 6										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	4	3	3	4	/	4	5	/	4	/	SAK
4	/	/	/	/	6	/	/	3	/	3	JZL
5	8	8	8	5	9	9	9	3	7	9	JZL
6	12	10	7	9	10	6	4	10	6	9	JZL
7											
8											
Total	24	21	18	18	25	19	18	16	17	21	SAK

Days	Concentration: 12										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	4	/	/	5	/	4	5	4	2	5	SAK
4	/	5	3	/	4	/	/	/	7	/	JZL
5	8	8	5	5	8	5	8	7	11	8	JZL
6	5	7	8	10	10	10	10	7	10	10	JZL
7											
8											
Total	17	20	16	20	22	19	23	18	20	23	SAK

Days	Concentration: 24										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	X	X	/	/	/	RZS
3	4	3	/	/	3			5	3	4	SAK
4	/	/	/	4	X			/	/	/	JZL
5	7	8	7	10				7	7	7	JZL
6	10	7	8	7				10	6	9	JZL
7											
8											
Total	21	18	15	21	~~0X~~ 3X	0X	0X	22	16	20	SAK

Days	Concentration: 48										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	X	/	X	X	/	/	/	JZL
2	X	X	X	/	X	/	/	X	/	/	RZS
3									/	/	SAK
4									/	X	JZL
5									X		JZL
6											
7											
8											
Total	0X										SAK

Notes: X = mortality.

Comments: 1. Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

2. Ephippia present in Controls (Y), (N)?

Reviewed by: JGL

Date reviewed: Mar. 23/22

Version 2.2 Issued Sep. 11, 2018

Nautilus Environmental Company Inc.

CETIS Summary Report

Report Date:	09 Mar-22 14:39 (p 1 of 2)
Test Code/ID:	212490a / 09-3392-9632

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel MMO
Start Date:	14 Jan-22 11:30 ✓	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water (dilution water)~~ Hardness adjusted lab control
Ending Date:	20 Jan-22 13:00 ✓	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	35h	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
06-9099-8477	6d Survival Rate	Fisher Exact Test	1.0000	Method Control passed 6d survival rate	1
09-2200-7374	Reproduction	Equal Variance t Two-Sample Test	0.0040	Method Control failed reproduction	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
00-8695-6599	6d Survival Rate	Spearman-Kärber	✓	EC50	22.51	18.19	27.84	1
01-8362-5241	Reproduction	Linear Interpolation (ICPIN)		IC10	1.008	0.6651	18.05	1
			✓	IC15	10.62	0.8772	20.3	
			✓	IC20	12.47	2.182	21.14	
			✓	IC25	14.61	10.57	22.02	
			✓	IC40	20.83	13.9	24.87	
				IC50	23.27	16.58	26.96	

6d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	LC	10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
0.31	MC	10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
1.08		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
1.58		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
2.73		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
4.86		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
9.27		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
19.55		10	0.7000	0.3544	1.0460	0.0000	1.0000	0.1528	0.4830	69.01%	30.00%
40.25		10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	---	100.00%

Reproduction Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	LC	10	24.5	23.02	25.98	22	29	0.654	2.068	8.44%	0.00%
0.31 ✓	MC	10	20.7	18.22	23.18	15	25	1.096	3.466	16.74%	15.51%
1.08 ✓		10	18.2	15.49	20.91	11	23	1.2	3.795	20.85%	25.71%
1.58 ✓		10	18.3	15.01	21.59	9	25	1.453	4.596	25.11%	25.31%
2.73 ✓		10	16.3	14.25	18.35	10	20	0.9074	2.869	17.60%	33.47%
4.86 ✓		10	19.7	17.57	21.83	16	25	0.9434	2.983	15.14%	19.59%
9.27 ✓		10	19.8	18.09	21.51	16	23	0.7572	2.394	12.09%	19.18%
19.55 ✓		10	13.6	7.156	20.04	0	22	2.849	9.009	66.24%	44.49%
40.25 ✓		10	0	0	0	0	0	0	0	---	100.00%

LC = lab (negative) control

MC = method control (hardness adjusted lab control)

Analyst: MDO QA: JGU Mar 23/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

6d Survival Rate Detail — MD5: DDB2D1BE5DE25ED0F283ECD13F5D808E

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	LC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.31	MC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.08		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.58		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2.73		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4.86		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.27		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19.55		1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
40.25		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Reproduction Detail — MD5: 5CBF0E6D1A3C08542EA392DC5D69FB79

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	LC	25	24	26	26	23	23	29	23	22	24
0.31	MC	20	24	22	16	20	19	15	21	25	25
1.08		11	22	15	23	15	19	18	22	17	20
1.58		9	23	18	21	17	21	25	18	14	17
2.73		19	19	14	17	16	16	16	16	20	10
4.86		24	21	18	18	25	19	18	16	17	21
9.27		17	20	16	20	22	19	23	18	20	23
19.55		21	18	15	21	3	0	0	22	16	20
40.25		0	0	0	0	0	0	0	0	0	0

6d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	LC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.31	MC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.08		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.58		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.73		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
4.86		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.27		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
19.55		1/1	1/1	1/1	1/1	0/1	0/1	0/1	1/1	1/1	1/1
40.25		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

CETIS Analytical Report

Report Date:	09 Mar-22 13:26 (p 1 of 1)
Test Code/ID:	212490a / 09-3392-9632

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	06-9099-8477	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:24	**Analysis:**	Single 2x2 Contingency Table	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	3DE6AB8F5D66A6609557DEB01175DBB4	**Editor ID:**	004-311-246-8

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water (dilution water)~~ moo Hardness adjusted lab control
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13/Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13/Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	35h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result
Untransformed	C > T	Method Control passed 6d survival rate endpoint

Fisher Exact Test

Control I	vs	Control II	Test Stat	P-Type	P-Value	Decision(α:5%)
Lab Control		Method Control	1.0000	Exact	1.0000	Non-Significant Effect

6d Survival Rate Frequencies

Conc-ug/L	Code	NR	R	NR + R	Prop NR	Prop R	%Effect
0	LC	10	0	10	1.0000	0.0000	0.00%
0.31	MC	10	0	10	1.0000	0.0000	0.00%

6d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	LC	10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	0.00%
0.31	MC	10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	0.00%

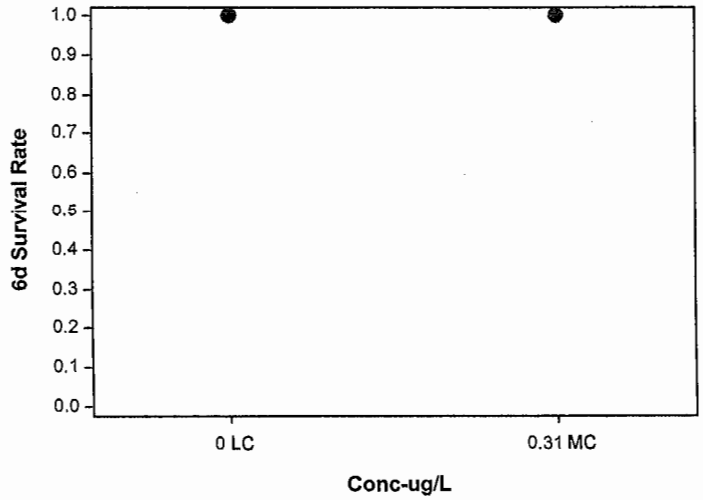
6d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	LC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.31	MC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

6d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	LC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.31	MC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



Analyst: MDO QA: JCW Mar. 23/22

CETIS Analytical Report

Report Date:	09 Mar-22 13:26 (p 1 of 2)
Test Code/ID:	212490a / 09-3392-9632

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	00-8695-6599	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:24	**Analysis:**	Untrimmed Spearman-Kärber	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	9A41956334B6172C3E753FCA3C4A2140	**Editor ID:**	004-311-246-8

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water (dilution water)~~ MDO
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	Hardness adjusted lab control
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 MDO Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	14 MDO Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	35h	**Client:**	Pretivm Resources Inc.		

Spearman-Kärber Estimates

Threshold Option	Threshold	Trim	Mu	Sigma	EC50	95% LCL	95% UCL
Control Threshold	0	0.00%	1.352	0.0462	22.51	18.19	27.84

6d Survival Rate Summary

			Calculated Variate(A/B)							Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**A/B**	**Mean**	**%Effect**
0.31	MC	10	1.0000	1.0000	1.0000	1.0000	0.00%	0.00%	10/10	1.0000	0.00%
1.08		10	1.0000	1.0000	1.0000	1.0000	0.00%	0.00%	10/10	1.0000	0.00%
1.58		10	1.0000	1.0000	1.0000	1.0000	0.00%	0.00%	10/10	1.0000	0.00%
2.73		10	1.0000	1.0000	1.0000	1.0000	0.00%	0.00%	10/10	1.0000	0.00%
4.86		10	1.0000	1.0000	1.0000	1.0000	0.00%	0.00%	10/10	1.0000	0.00%
9.27		10	1.0000	1.0000	1.0000	1.0000	0.00%	0.00%	10/10	1.0000	0.00%
19.55		10	0.7000	1.0000	0.0000	1.0000	69.01%	30.00%	7/10	0.7000	30.00%
40.25		10	0.0000	0.0000	0.0000	0.0000	---	100.00%	0/10	0	100.00%

6d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.31	MC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.08		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.58		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2.73		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4.86		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.27		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
19.55		1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.0000	1.0000	1.0000	1.0000
40.25		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6d Survival Rate Binomials

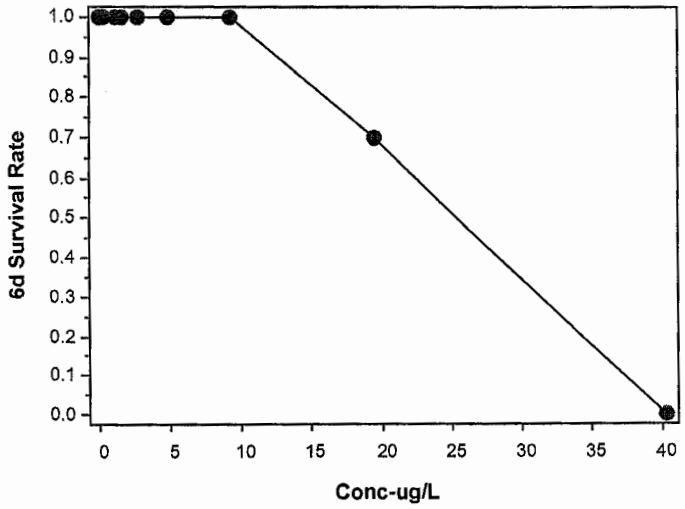
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.31	MC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.08		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.58		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.73		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
4.86		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.27		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
19.55		1/1	1/1	1/1	1/1	0/1	0/1	0/1	1/1	1/1	1/1
40.25		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

Analyst: MDO QA: JCL Mar. 23 /22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	00-8695-6599	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:24	**Analysis:**	Untrimmed Spearman-Kärber	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	9A41956334B6172C3E753FCA3C4A2140	**Editor ID:**	004-311-246-8

Graphics



CETIS Analytical Report

Report Date:	09 Mar-22 13:26 (p 1 of 2)
Test Code/ID:	212490a / 09-3392-9632

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	09-2200-7374	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:24	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	CFBD54645D5516DD8E7534451679A0F3	**Editor ID:**	004-311-246-8

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water (diluted with Lab Water)~~ MDO Hardness adjusted lab control
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 MDO Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 MDO Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	35h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Method Control failed reproduction endpoint	9.03%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Lab Control		Method Control*	18	2.977	1.734	2.213	CDF	0.0040	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	72.2	72.2	1	8.865	0.0081	Significant Effect
Error	146.6	8.14444	18			
Total	218.8		19			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	2.808	6.541	0.1401	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9535	0.866	0.4226	Normal Distribution

Reproduction Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	LC	10	24.5	23.02	25.98	24	22	29	0.654	8.44%	0.00%
0.31	MC	10	20.7	18.22	23.18	20.33	15	25	1.096	16.74%	15.51%

Reproduction Detail

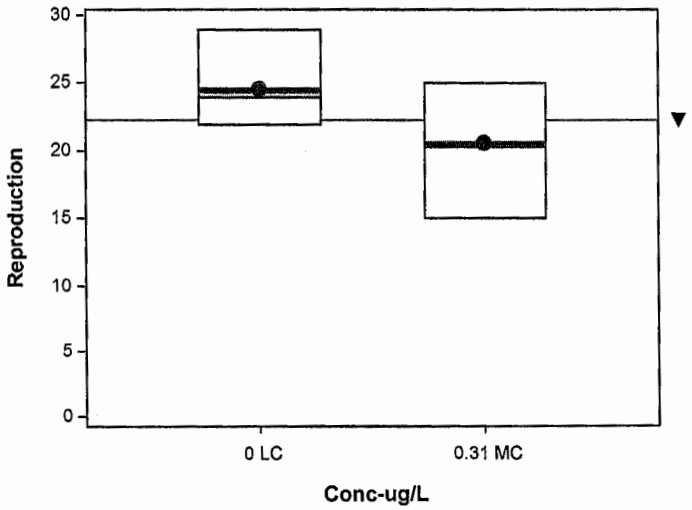
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	LC	25	24	26	26	23	23	29	23	22	24
0.31	MC	20	24	22	16	20	19	15	21	25	25

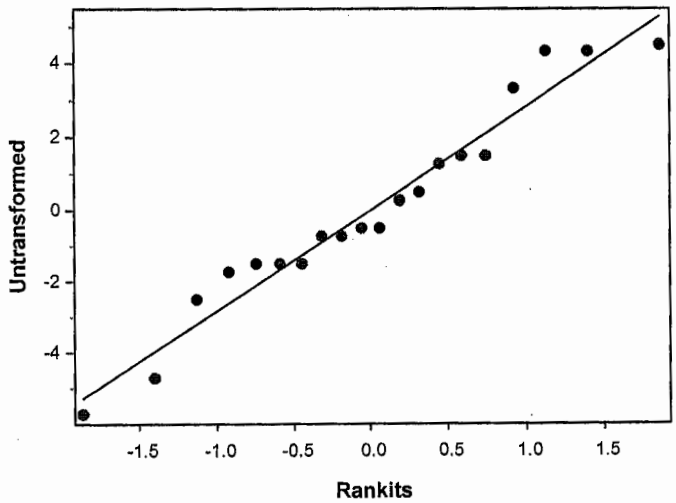
Analyst: MDO QA: JGL Mar. 23/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	09-2200-7374	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:24	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	CFBD54645D5516DD8E7534451679A0F3	**Editor ID:**	004-311-246-8

Graphics





CETIS Analytical Report

Report Date: 09 Mar-22 13:26 (p 1 of 2)
Test Code/ID: 212490a / 09-3392-9632

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	01-8362-5241	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:25	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	B0B5D69FD8A9227234952A0FB48FE29A	**Editor ID:**	004-311-246-8

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water (dilution water)~~ MDO
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	Hardness adjusted lab control
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	35h	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	874555	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	1.008	0.6651	18.05
IC15	10.62	0.8772	20.3
IC20	12.47	2.182	21.14
IC25	14.61	10.57	22.02
IC40	20.83	13.9	24.87
IC50	23.27	16.58	26.96

Reproduction Summary

			Calculated Variate						Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**Mean**	**%Effect**
0.31	MC	10	20.7	20.33	15	25	16.74%	0.00%	20.7	0.00%
1.08		10	18.2	18.5	11	23	20.85%	12.08%	18.46	10.82%
1.58		10	18.3	18	9	25	25.11%	11.59%	18.46	10.82%
2.73		10	16.3	16	10	20	17.60%	21.26%	18.46	10.82%
4.86		10	19.7	18.25	16	25	15.14%	4.83%	18.46	10.82%
9.27		10	19.8	20	16	23	12.09%	4.35%	18.46	10.82%
19.55		10	13.6	17	0	22	66.24%	34.30%	13.6	34.30%
40.25		10	0	0	0	0	---	100.00%	0	100.00%

Reproduction Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.31	MC	20	24	22	16	20	19	15	21	25	25
1.08		11	22	15	23	15	19	18	22	17	20
1.58		9	23	18	21	17	21	25	18	14	17
2.73		19	19	14	17	16	16	16	16	20	10
4.86		24	21	18	18	25	19	18	16	17	21
9.27		17	20	16	20	22	19	23	18	20	23
19.55		21	18	15	21	3	0	0	22	16	20
40.25		0	0	0	0	0	0	0	0	0	0

Analyst: MDO QA: JGW Mar. 23/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	01-8362-5241	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:25	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	09 Mar-22 13:21	**MD5 Hash:**	B0B5D69FD8A9227234952A0FB48FE29A	**Editor ID:**	004-311-246-8

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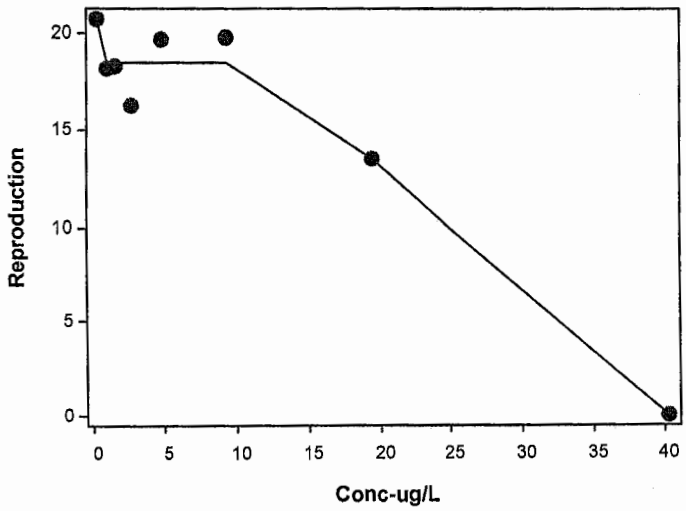


Ceriodaphnia dubia Summary Sheet

Client: Lorax/Pretivm Resources Inc. Start Date/Time: Jan 14/22 @ 1130L
Work Order No.: 212490 Set up by: JZL

Sample Information:

Sample ID: Cu w site water (B)-3.10
Sample Date: Jan 10 22
Date Received: Jan 13 22
Sample Volume: 5x2 OL

Test Validity Criteria:

1) Mean survival of first generation controls is ≥80 %
2) At least 60% of controls have produced three broods within 8 days
3) An average of ≥15 live young produced per surviving female in the control solutions during the first three broods.
4) Invalid if ephippia observed in any control solution at any time.

WQ Ranges:

T (°C) = 25 ± 1; DO (mg/L) = 3.3 to 8.4 ; pH = 6.0 to 8.5

Test Organism Information:

Broodstock No.: BB010522B
Age of young (Day 0): <24-h (within 12-h)
Avg No. young in first 3 broods of previous 7 d: 22
Mortality (%) in previous 7 d: 0
Individual female # used ≥8 young on test day #21-40

NaCl Reference Toxicant Results:

Reference Toxicant ID: Cd298
Stock Solution ID: 21Na03
Date Initiated: Jan 18/22

7-d LC50 (95% CL): 2.1 (1.5-3.0) g/L NaCL
7-d IC50 (95% CL): 1.8 (1.5-2.0) g/L NaCL

7-d LC50 Reference Toxicant Mean and Historical Range: 2.0 (1.8-2.2) g/L NaCL CV (%): 5
7-d IC50 Reference Toxicant Mean and Historical Range: 1.7 (1.4-2.2) g/L NaCL CV (%): 11

Test Results:
(measured values)

ug/L Cu	Survival	Reproduction
LC50 % (v/v) (95% CL)	12.2 (8.6-17.4)	
IC25 % (v/v) (95% CL)		6.2 (3.7-10.4)
IC50 % (v/v) (95% CL)		10.9 (7.3-13.3)

MDO

Reviewed by: JGu Date reviewed: Mar. 29/22

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Pretivum Resources Inc. / Loraxx
Sample ID: ~~B5-3.10~~ (4 w/ site water (B5-3.10))
Work Order #: MDO 212490

Start Date & Time: Jan. 14/22 @ 1130h
Stop Date & Time: Jan. 20/22 @ 1300h
CER #: 4
Test Species: *Ceriodaphnia dubia*

µg/L Cu (nominal)

Concentration: Site Control	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	24.0	24.0	25.0	24.5		
DO (mg/L)	8.1	7.0	7.8	7.1	7.7	7.0	8.2	7.1	8.3	6.9	8.1	6.7		
pH	7.5	7.4	7.6	7.5	7.6	7.8	7.6	7.4	7.5	7.2	7.5	7.4		
Cond. (µS/cm)	305	315		320		325		313		314		310		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

7.4

Concentration: 0.75	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	24.5	24.0	25.0	25.0		
DO (mg/L)	7.8	7.1	7.8	7.2	7.7	7.0	8.2	7.1	8.4	6.9	8.2	6.3		
pH	7.4	7.3	7.6	7.5	7.6	7.4	7.6	7.4	7.5	7.3	7.4	7.3		
Cond. (µS/cm)	297	317		320		323		316		317		317		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration: 6	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	24.5	24.0	25.0	25.0		
DO (mg/L)	8.1	7.1	7.8	7.3	7.7	7.0	8.1	7.1	8.3	6.9	8.2	6.4		
pH	7.4	7.3	7.6	7.4	7.6	7.4	7.7	7.4	7.5	7.2	7.4	7.3		
Cond. (µS/cm)	301	316		RZS ~~320~~ 319		322		315		317		317		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration: 48	Days 0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	26.0	24.0	25.0	25.0	25.0	25.0	25.0		24.5					
DO (mg/L)	8.1	7.1	7.9	7.3	7.8	7.1	8.2		8.3					
pH	7.5	7.3	7.6	7.4	7.6	7.4	7.7		7.5					
Cond. (µS/cm)	302	309		312		323		314						
Initials	JZL	JZL		RZS		SAK		JZL						

Thermometer: CER #4 DO meter/probe: 1 / 1 pH meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

	Site Water ~~Control~~ MDO			
Hardness*	72			
Alkalinity*	54			

* mg/L as CaCO3

Analysts: SAK, JZL, RZS
Reviewed by: JW
Date reviewed: Mar. 29/22

Sample Description: Clear, colorless, odourless, no particulates

Comments: Broodboard Used: BB010522B #21-40

Chronic Freshwater Toxicity Test
Initial and Final Water Quality Measurements

Client: Pretium Resources Inc. / Lorax
Sample ID: ~~BJ-3.10~~ 4wl Site Water (8)-3.10
Work Order #: 212490

Start Date & Time: Jan. 14/22 @ 1130h
Stop Date & Time: Jan. 20/22 @ 1300h
CER #: 4
Test Species: *Ceriodaphnia dubia*

Lab Concentration Control	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)	25.0	24.0	25.0	24.5	25.0	25.0	25.0	24.0	25.0	24.0	25.0	25.0		
DO (mg/L)	8.1	7.0	8.1	7.0	8.1	7.0	8.2	7.0	8.1	6.9	8.1	6.1		
pH	7.9	7.7	8.0	7.8	8.0	7.8	8.0	7.7	7.9	7.5	8.0	7.6		
Cond. (µS/cm)	210	210		210		212		211		211		212		
Initials	JZL	JZL		RZS		SAK		JZL		JZL		JZL		

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Concentration	Days													
	0	1		2		3		4		5		6		7
	init.	old	new	old	new	old	new	old	new	old	new	old	new	final
Temperature (°C)														
DO (mg/L)														
pH														
Cond. (µS/cm)														
Initials														

Thermometer: CER #4 **DO meter/probe:** 1 / 1 **pH meter/probe:** 1 / 1 **Conductivity meter/probe:** 1 / 1

	~~Control~~ Site Water	Lab Control		
Hardness*	72	98		
Alkalinity*	54	92		

* mg/L as CaCO3

Analysts: JZL, RZS, SAK
Reviewed by: [illegible]
Date reviewed: Mar. 24/22

Sample Description: clear, colourless, odourless, no precipitates

Comments: **Broodboard Used:** BB010522B #21-40

Chronic Freshwater Toxicity Test
C. dubia Reproduction Data

Client: Pretium Resources Inc. / Lorax
Sample ID: ~~BJ-3.10~~ Cu w/ Site water (BJ-3.10)
Work Order: 212490

µg/L Cu

Start Date & Time: Jan. 14/22 @ 1130h
Stop Date & Time: Jan. 20/22 @ 1300h
Set up by: JZL/SAK

Days	Concentration: Lab Control										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	4	4	4	3	5	5	3	6	4	SAK
4	/	/	/	/	/	/	/	/	/	/	JZL
5	4	9	9	9	6	8	7	9	4	8	JZL
6	7	12	12	12	12	13	8	11	13	11	JZL
7											
8											
Total	11	25	25	25	21	26	20	23	23	23	SAK

Days	Concentration: Site Control										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	5	/	4	/	/	5	/	2	/	5	SAK
4	/	/	/	/	/	/	/	/	3	/	JZL
5	8	5	10	6	6	8	2	8	9	7	JZL
6	11	12	12	11	12	11	9	12	12	10	JZL
7											
8											
Total	24	17	26	17	18	24	11	22	24	22	SAK

Days	Concentration: 0.75										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	4	/	5	4	/	4	2	3	4	SAK
4	/	/	5	/	/	/	/	/	/	/	JZL
5	7	9	12	7	10	4	7	6	8	6	JZL
6	13	12	12	12	13	8	13	13	10	12	JZL
7											
8											
Total	20	25	29	24	27	12	24	21	21	22	SAK

Days	Concentration: 1.5										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	5	8	5	/	4	3	3	2	/	/	SAK
4	/	/	/	/	/	/	/	/	4	3	JZL
5	/	9	11	8	7	6	8	7	9	11	JZL
6	3	12	10	12	8	13	12	12	12	12	JZL
7											
8											
Total	8	29	26	20	19	22	23	21	25	26	SAK

Days	Concentration: 3										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	4	6	2	2	4	3	4	/	4	SAK
4	2	/	/	/	/	/	/	/	4	/	JZL
5	12	10	9	8	3	4	6	5	12	4	JZL
6	13	8	13	9	10	12	12	11	11	10	JZL
7											
8											
Total	27	22	28	19	15	20	21	20	27	18	SAK

Days	Concentration: 6										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	/	/	/	/	RZS
3	/	/	X	4	/	/	2	4	3	5	SAK
4	/	/		/	/	/	/	/	/	/	JZL
5	7	6		8	9	7	6	8	6	5	JZL
6	11	10		12	12	11	12	10	14	12	JZL
7											
8											
Total	18	16	0X	24	21	18	20	22	23	22	SAK

Days	Concentration: 12										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	/	/	/	/	/	/	X	/	/	X	RZS
3	/	6	/	/	2	4	/	5	8		SAK
4	4	/	/	4	2	/		/	/		JZL
5	/	7	X	8	6	4		8	6		JZL
6	7	11		10	10	12		10	13		
7											
8											
Total	11	24	0X	22	10	20	0X	23	27	0X	SAK

Days	Concentration: 24										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	/	/	/	/	/	/	/	/	/	JZL
2	X	/	X	X	X	/	/	/	/	/	RZS
3		/				/	X	X	/	/	SAK
4		/				/			X	/	JZL
5		4				/				2	JZL
6		3				3				3	JZL
7											
8											
Total	0X	7	0X	0X	0X	3	0X	0X	0X	5	SAK

Days	Concentration: 48										
	A	B	C	D	E	F	G	H	I	J	Init
1	/	X	/	X	/	X	/	/	/	/	JZL
2	X	/	X	/	X	/	X	X	X	/	RZS
3										X	SAK
4											JZL
5											JZL
6											
7											
8											
Total	0X										SAK

Notes: X = mortality.

Comments: 1. Total # Young only based on the first 3 Broods. Fourth and subsequent broods not included in total count.

2. Ephippia present in Controls (Y) (N)?

Reviewed by: [signature]

Date reviewed: Mar. 24/22

CETIS Summary Report

Report Date:	09 Mar-22 14:39 (p 1 of 2)
Test Code/ID:	212490b / 06-4841-6597

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water~~ mso BJ-3.10
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	92h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
19-4631-8650	6d Survival Rate	Fisher Exact Test	1.0000	Site Control passed 6d survival rate	1
19-0103-7390	Reproduction	Wilcoxon Rank Sum Two-Sample Test	0.8393	Negative Control passed reproduction	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
13-5709-5327	6d Survival Rate	GLM: Log-Normal (Probit)		EC10	5.302	2.523	7.658	1
				EC15	6.214	3.27	8.747	
				EC20	7.051	3.997	9.773	
				EC25	7.857	4.725	10.8	
				EC40	10.32	6.992	14.32	
				EC50	12.17	8.622	17.42	
13-5859-1730	Reproduction	Linear Interpolation (ICPIN)	✓	IC10	3.642	1.986	6.884	1
			✓	IC15	4.408	2.761	9.383	
			✓	IC20	5.232	3.36	9.866	
			✓	IC25	6.18	3.724	10.36	
			✓	IC40	9.445	6.048	12.01	
			✓	IC50	10.89	7.305	13.28	

6d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
0.28	XC	10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
0.9		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
1.5		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
2.42		10	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%
4.41		10	0.9000	0.6738	1.1260	0.0000	1.0000	0.1000	0.3162	35.14%	10.00%
9.01		10	0.7000	0.3544	1.0460	0.0000	1.0000	0.1528	0.4830	69.01%	30.00%
19.8		10	0.3000	-0.0456	0.6456	0.0000	1.0000	0.1528	0.4830	161.02%	70.00%
37.05		10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	---	100.00%

Reproduction Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	10	22.2	19.08	25.32	11	26	1.381	4.367	19.67%	0.00%
0.28 ✓	XC	10	20.5	17.19	23.81	11	26	1.462	4.625	22.56%	7.66%
0.9 ✓		10	22.5	19.17	25.83	12	29	1.47	4.649	20.66%	-1.35%
1.5 ✓		10	21.9	17.76	26.04	8	29	1.828	5.782	26.40%	1.35%
2.42 ✓		10	21.7	18.61	24.79	15	28	1.367	4.322	19.92%	2.25%
4.41 ✓		10	18.4	13.44	23.36	0	24	2.192	6.931	37.67%	17.12%
9.01 ✓		10	13.7	5.929	21.47	0	27	3.435	10.86	79.29%	38.29%
19.8 ✓		10	1.5	-0.3547	3.355	0	7	0.8199	2.593	172.85%	93.24%
37.05 ✓		10	0	0	0	0	0	0	0	---	100.00%

N = negative (lab) control

XC = Site control

Analyst: MDO QA: JGu Mar. 24/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

6d Survival Rate Detail — MD5: 4C36519215E936A76D7FBB9B5BC09D53

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.28	XC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2.42		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4.41		1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.01		1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000
19.8		0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000
37.05		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Reproduction Detail — MD5: E08070FF613D0446C5ED67A409E0D19D

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	11	25	25	25	21	26	20	23	23	23
0.28	XC	24	17	26	17	18	24	11	22	24	22
0.9		20	25	29	24	27	12	24	21	21	22
1.5		8	29	26	20	19	22	23	21	25	26
2.42		27	22	28	19	15	20	21	20	27	18
4.41		18	16	0	24	21	18	20	22	23	22
9.01		11	24	0	22	10	20	0	23	27	0
19.8		0	7	0	0	0	3	0	0	0	5
37.05		0	0	0	0	0	0	0	0	0	0

6d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.28	XC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.42		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
4.41		1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.01		1/1	1/1	0/1	1/1	1/1	1/1	0/1	1/1	1/1	0/1
19.8		0/1	1/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1	1/1
37.05		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

CETIS Analytical Report

Report Date:	09 Mar-22 13:33 (p 1 of 1)
Test Code/ID:	212490b / 06-4841-6597

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	19-4631-8650	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:31	**Analysis:**	Single 2x2 Contingency Table	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	264BD78EE8D9B6F468F22CC3871C9041	**Editor ID:**	003-659-051-0

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel		
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water~~ BJ-3.10 MDO		
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	92h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result
Untransformed	C > T	Site Control passed 6d survival rate endpoint

Fisher Exact Test

Control I	vs	Control II	Test Stat	P-Type	P-Value	Decision(α:5%)
Negative Control		Site Control	1.0000	Exact	1.0000	Non-Significant Effect

6d Survival Rate Frequencies

Conc-ug/L	Code	NR	R	NR + R	Prop NR	Prop R	%Effect
0	N	10	0	10	1.0000	0.0000	0.00%
0.28	XC	10	0	10	1.0000	0.0000	0.00%

6d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	0.00%
0.28	XC	10	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.00%	0.00%

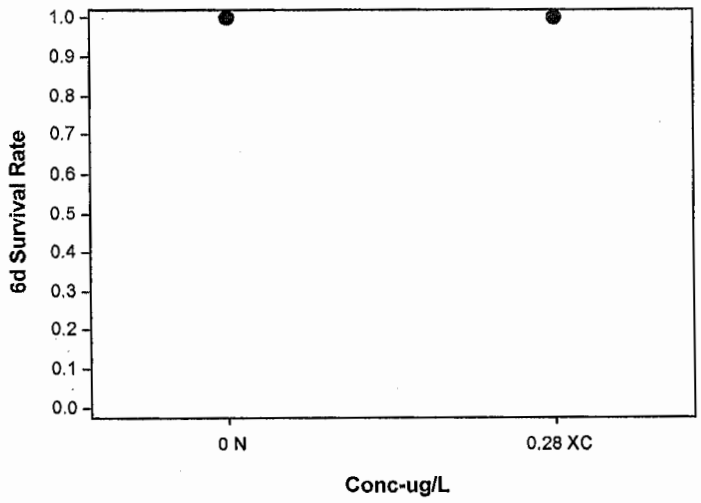
6d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.28	XC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

6d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.28	XC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1

Graphics



Analyst: MDO QA: Mar. 24/22

CETIS Analytical Report

Report Date: 09 Mar-22 13:33 (p 1 of 3)
Test Code/ID: 212490b / 06-4841-6597

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-5709-5327	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:33	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	E925EF5B03E1F0F9B7677764B943AA85	**Editor ID:**	003-659-051-0

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water~~ MDO BJ-3.10
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**	
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture **Age:** <24

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	92h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Regression Options

Model Name	Link Function	Threshold Option	Thresh	PMSD	Optimize	Pooled	Het Corr	Weighted
Log-Normal (Probit)	η=inv Φ[π]	Control Threshold	0		No	Yes	No	Yes

Regression Summary

Iters	LL	AICc	BIC	Mu	Sigma	Cov	R2	F Stat	P-Value	Decision(α:5%)
6	-4.384	15.17	12.93	1.085114	0.2814565	-0.668566	0.896			Indeterminate

Point Estimates

Level	ug/L	95% LCL	95% UCL
EC10	5.302	2.523	7.658
EC15	6.214	3.27	8.747
EC20	7.051	3.997	9.773
EC25	7.857	4.725	10.8
EC40	10.32	6.992	14.32
EC50	12.17	8.622	17.42

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	Test Stat	P-Value	Decision(α:5%)
Slope	3.553	0.7899	2.005	5.101	4.498	<1.0E-05	Significant Parameter
Intercept	-3.855	0.8822	-5.584	-2.126	-4.37	1.2E-05	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	783	783	1	4051	<1.0E-05	Significant Effect
Residual	1.16	0.1933	6			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Model Fit	Likelihood Ratio GOF Test	1.587	12.59	0.9535	Non-Significant Heterogeneity
	Pearson Chi-Sq GOF Test	1.16	12.59	0.9788	Non-Significant Heterogeneity
Distribution	Anderson-Darling A2 Test	0.4724	2.492	0.2479	Normal Distribution
	Shapiro-Wilk W Normality Test	0.9127	0.6805	0.3738	Normal Distribution

6d Survival Rate Summary

			Calculated Variate(A/B)								
Conc-ug/L	Code	Count	Mean	Median	Min	Max	Std Err	Std Dev	CV%	%Effect	A/B
0.28	XC	10	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%	10/10
0.9		10	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%	10/10
1.5		10	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%	10/10
2.42		10	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	0.00%	10/10
4.41		10	0.9000	1.0000	0.0000	1.0000	0.1000	0.3162	35.14%	10.00%	9/10
9.01		10	0.7000	1.0000	0.0000	1.0000	0.1528	0.4830	69.01%	30.00%	7/10
19.8		10	0.3000	0.0000	0.0000	1.0000	0.1528	0.4830	161.02%	70.00%	3/10
37.05		10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	---	100.00%	0/10

Analyst: MDO QA: Mar. 24/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-5709-5327	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:33	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	E925EF5B03E1F0F9B7677764B943AA85	**Editor ID:**	003-659-051-0

6d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.28	XC	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.9		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.5		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
2.42		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
4.41		1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
9.01		1.0000	1.0000	0.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000
19.8		0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000
37.05		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

6d Survival Rate Binomials

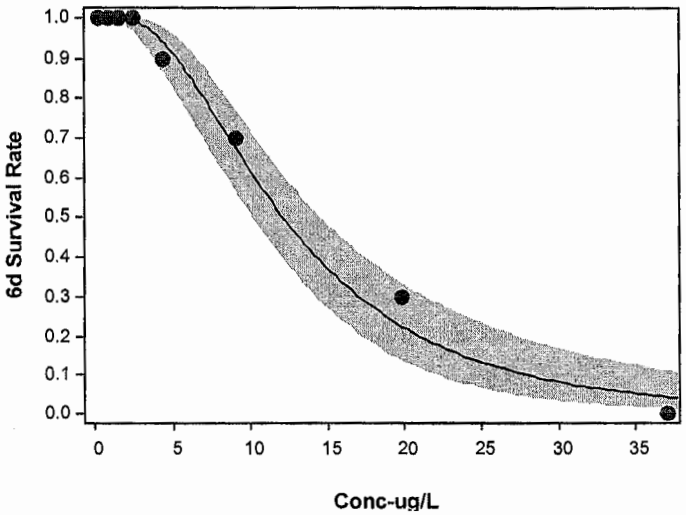
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.28	XC	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
0.9		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
1.5		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
2.42		1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
4.41		1/1	1/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1
9.01		1/1	1/1	0/1	1/1	1/1	1/1	0/1	1/1	1/1	0/1
19.8		0/1	1/1	0/1	0/1	0/1	1/1	0/1	0/1	0/1	1/1
37.05		0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1	0/1

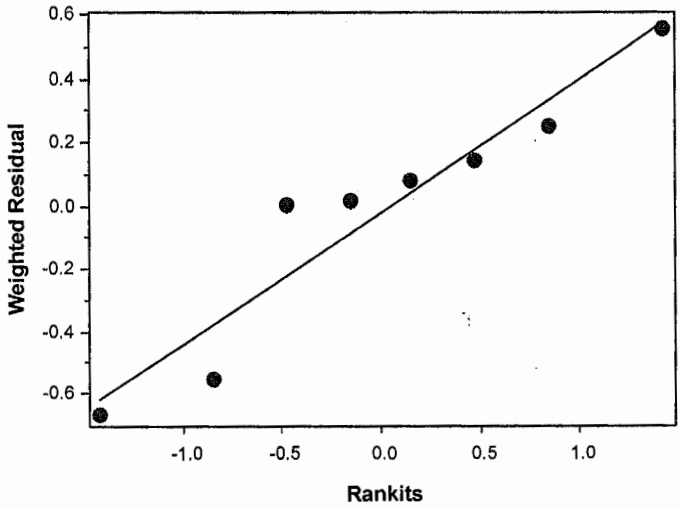
Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

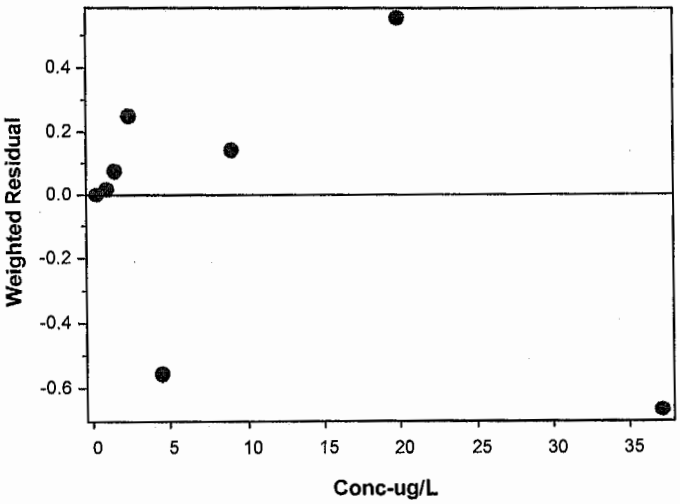
Analysis ID:	13-5709-5327	**Endpoint:**	6d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:33	**Analysis:**	Linear Regression (GLM)	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	E925EF5B03E1F0F9B7677764B943AA85	**Editor ID:**	003-659-051-0

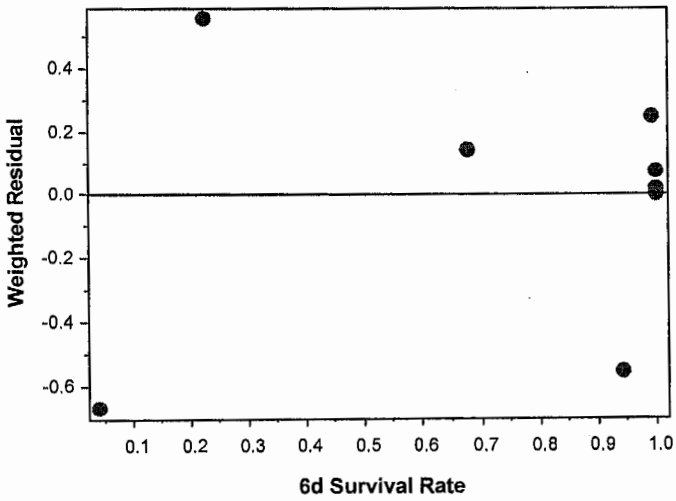
Graphics

Log-Normal: inv Φ[π]=α+β·log[x]









CETIS Analytical Report

Report Date:	09 Mar-22 13:33 (p 1 of 2)
Test Code/ID:	212490b / 06-4841-6597

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	19-0103-7390	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:31	**Analysis:**	Nonparametric-Two Sample	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	9858FDB01C757ED2D85BC7DC0C1C4D9	**Editor ID:**	003-659-051-0

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel		
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water~~ MDO BJ-3.10		
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**			
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:**	<24

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	92h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Negative Control passed reproduction endpoint	17.01%

Wilcoxon Rank Sum Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	Ties	P-Type	P-Value	Decision(α:5%)
Site Control		Negative Control	18	118	---	2	Exact	0.8393	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	14.45	14.45	1	0.7144	0.4091	Non-Significant Effect
Error	364.1	20.2278	18			
Total	378.55		19			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1.122	6.541	0.8669	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8604	0.866	0.0080	Non-Normal Distribution

Reproduction Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	10	22.2	19.08	25.32	23	11	26	1.381	19.67%	-8.29%
0.28	XC	10	20.5	17.19	23.81	22	11	26	1.462	22.56%	0.00%

Reproduction Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0	N	11	25	25	25	21	26	20	23	23	23
0.28	XC	24	17	26	17	18	24	11	22	24	22

Analyst: MDO QA: Mar 24/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	19-0103-7390	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:31	**Analysis:**	Nonparametric-Two Sample	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	9858FDB01C757ED2D85BC7DC0C1C4D9	**Editor ID:**	003-659-051-0

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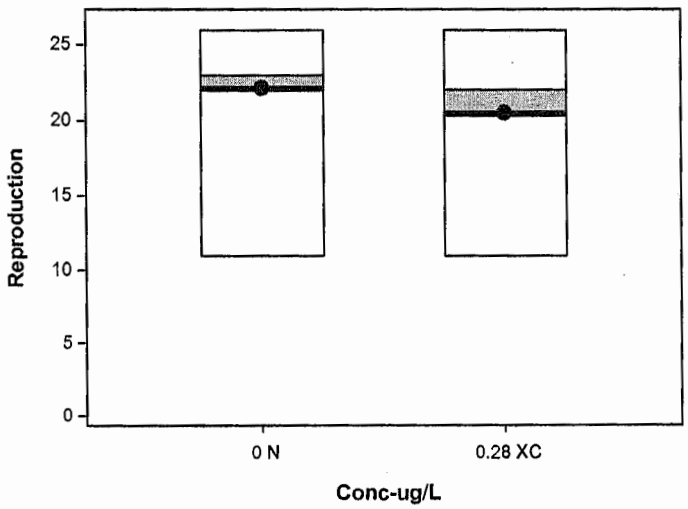
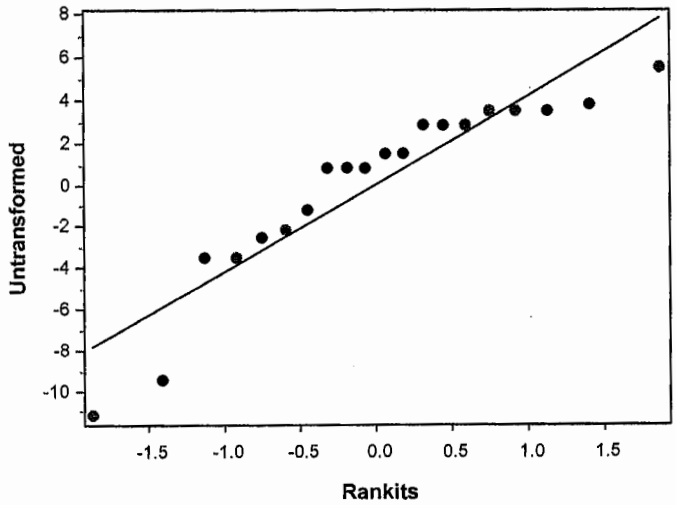




CETIS Analytical Report

Report Date:	09 Mar-22 13:33 (p 1 of 2)
Test Code/ID:	212490b / 06-4841-6597

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-5859-1730	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:32	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	68F0DB913625FEE30361419168C2AEB1	**Editor ID:**	003-659-051-0

Batch ID:	18-9519-1062	**Test Type:**	Reproduction-Survival (7d)	**Analyst:**	Sierra Klueppel	
Start Date:	14 Jan-22 11:30	**Protocol:**	EC/EPS 1/RM/21	**Diluent:**	~~20% Perrier Water~~ BJ-3.10	
Ending Date:	20 Jan-22 13:00	**Species:**	Ceriodaphnia dubia	**Brine:**		
Test Length:	6d 2h	**Taxon:**	Branchiopoda	**Source:**	In-House Culture	**Age:** <24

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	92h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1244678	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	3.642	1.986	6.884
IC15	4.408	2.761	9.383
IC20	5.232	3.36	9.866
IC25	6.18	3.724	10.36
IC40	9.445	6.048	12.01
IC50	10.89	7.305	13.28

Reproduction Summary

			Calculated Variate						Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**Mean**	**%Effect**
0.28	XC	10	20.5	22	11	26	22.56%	0.00%	21.65	0.00%
0.9		10	22.5	23.33	12	29	20.66%	-9.76%	21.65	0.00%
1.5		10	21.9	22.5	8	29	26.40%	-6.83%	21.65	0.00%
2.42		10	21.7	20.33	15	28	19.92%	-5.85%	21.65	0.00%
4.41		10	18.4	20.5	0	24	37.67%	10.24%	18.4	15.01%
9.01		10	13.7	15.5	0	27	79.29%	33.17%	13.7	36.72%
19.8		10	1.5	0	0	7	172.85%	92.68%	1.5	93.07%
37.05		10	0	0	0	0	---	100.00%	0	100.00%

Reproduction Detail

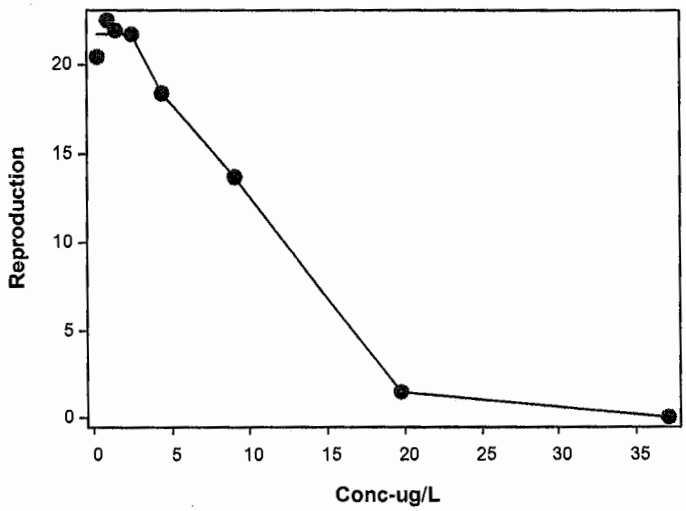
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8	Rep 9	Rep 10
0.28	XC	24	17	26	17	18	24	11	22	24	22
0.9		20	25	29	24	27	12	24	21	21	22
1.5		8	29	26	20	19	22	23	21	25	26
2.42		27	22	28	19	15	20	21	20	27	18
4.41		18	16	0	24	21	18	20	22	23	22
9.01		11	24	0	22	10	20	0	23	27	0
19.8		0	7	0	0	0	3	0	0	0	5
37.05		0	0	0	0	0	0	0	0	0	0

Analyst: MDO QA: JGL Mar. 24/22

Ceriodaphnia 7-d Survival and Reproduction Test — **Nautilus Environmental**

Analysis ID:	13-5859-1730	**Endpoint:**	Reproduction	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:32	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	20 Jan-22 13:00	**MD5 Hash:**	68F0DB913625FEE30361419168C2AEB1	**Editor ID:**	003-659-051-0

Graphics



APPENDIX B – *Pseudokirchneriella subcapitata* Toxicity Test Data

Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax / Pretium Resources Inc.
Work Order No.: 212492

Start Date: Jan 13/22 @ 1630h
Set up by: SAK

Sample Information:

Sample ID: Cu in site water (BJ-3.10)
Sample Date: Jan 10/22
Date Received: Jan 13/22
Sample Volume: 5 x 20L

Test Organism Information:

Culture Date: Jan 7/22
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC224
Stock Solution ID: 21Zn01
Date Initiated: Jan 20/22

72-h IC50 (95% CL): 25.6 (22.8 - 28.7) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.3 (26.8 - 38.9) µg/L Zn CV (%): 9

Test Results: (measured values)

µg/L Cu	Algal Growth
IC25 %(v/v) (95% CL)	2.7 (2.2 - 4.0)
IC50 %(v/v) (95% CL)	16.6 (14.7 - 18.0)

MDO

Reviewed by: JOH

Date reviewed: Mar 28/22

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client : Pretium / Lorax **Setup by:** SAH

Sample ID: BJ-3.10 (in site water) w/cu **Test Date/Time:** Jan. 13/22 @ 1630 h

Work Order No.: 212492 **CER #:** 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: Jan. 7/22 **Age of Culture:** 6d **Culture Health:** Good

Culture Count: 1 ~~27~~ 27 m 2 ~~22~~ 22 m **Average:** ~~21.5~~ 21.5 m **Culture Cell Density (c1):** 250 ~~21.5~~ 21.5 m $\times 10^4$ cells/mL

260 240 250

v1 = 220,000 cells/ml x 40 ml / (c1) 250 x 10^4 cells/ml = 3.5 mL

Time Zero Counts: 1 21 2 22 **Average:** 21.5

No. of Cells/mL: 21.5 x 10^4 cells/mL **Initial Density:** # cells/mL ÷ 220 µL x 10 µL = 9773 cells/mL

Concentration ~~%(v/v)~~ mg/L Cu	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control Negative C.	6.8	23.0	24.0	24.0	25.0	25.0	✓	✓	✓	✓
(BJ-3.10) Site Control	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
0.75	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
1.5	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
3	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
6	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
12	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
24	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
48	7.6	24.0	↓	↓	↓	↓	↓	↓	↓	↓
Initials	SXH	SXH	SAH	SAH	JBL	RD	SAH	SAH	JBL	RD

Initial control pH: Well 1: 6.8 Well 2: 6.8

Final control pH: Well 1: 6.9 Well 2: 6.9

Light intensity (lux): 4260 **Date measured:** Jan. 13/~~22~~ 22 m

Thermometer: 1 **Light meter:** 1 **pH meter/probe:** 1/1

Sample Description: ~~Sample BJ-3.10~~ m Clear, colorless, odorless, no precipitates

Comments:

Reviewed: JBL **Date reviewed:** March 24/22

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pretium / Lorax Start Date/Time: Jan. 13/22 @ 1630h
Work Order #: 212492 Termination Date: Jan. 16/22 @ 1630h
Sample ID: BJ-3.10 w/ Cu (Cu Site Water) ~~%(v/v)~~ Test set up by: SAK

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control mg/L Cu	A	18					SAK
	B	18					
	C	17					
Negative (lab) control	D	19					
	E	19					
	F	19					
	G	17					
	H	17					
0.75	A	~~19~~ 18					
	B	19					
	C	17					
	D	18					
1.5	A	16					
	B	17					
	C	15					
	D	16					
3	A	14					
	B	12					
	C	14					
	D	13					
6	A	13					
	B	13					
	C	10					
	D	11					
12	A	13					
	B	11					
	C	12					
	D	12					
24	A	8					
	B	7					
	C	7					
	D	8					
48	A	6					
	B	4					
	C	6					
	D	4					

Comments:

Reviewed by: JGL Date Reviewed: Mar. 24/22

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Prestium / Lorax
Start Date/Time: Jan. 13/22 @ 1630h
Work Order #: 212492
Termination Date: Jan. 16/22 @ 1630h
Sample ID: BJ-310 w/w (Cu in Site Water)
Test set up by: SAU

%(v/v) Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	19					SAU
	B	19					
Site Control	C	17					
	D	17					
	E	17					
	F	18					
	G	17					
	H	19					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: [illegible]
Date Reviewed: Mar. 24/22

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: 212492
Sample ID: BJ-3.10 (Cu site water)

Start Date/Time: 13-January-22 @1630h
Termination Date/Time 16-January-22 @1630h

Initial Cell Density: 9773 cell/mL

	215000
	0.22
	0.01
	9772.727

Concentration	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Negative (lab) Control	A	18				18	17.0	mean	17.0
	B	18				18	17.0	SD	0.92582
	C	17				17	16.0	CV	5.43873
	D	19				19	18.0		
	E	19				19	18.0		
	F	19				19	18.0		
	G	17				17	16.0		
	H	17				17	16.0		
0.75	A	18				18	17.0		
	B	19				19	18.0		
	C	17				17	16.0		
	D	18				18	17.0		
1.5	A	16				16	15.0		
	B	17				17	16.0		
	C	15				15	14.0		
	D	16				16	15.0		
3	A	14				14	13.0		
	B	12				12	11.0		
	C	14				14	13.0		
	D	13				13	12.0		
6	A	13				13	12.0		
	B	13				13	12.0		
	C	10				10	9.0		
	D	11				11	10.0		
12	A	13				13	12.0		
	B	11				11	10.0		
	C	12				12	11.0		
	D	12				12	11.0		
24	A	8				8	7.0		
	B	7				7	6.0		
	C	7				7	6.0		
	D	8				8	7.0		
48	A	6				6	5.0		
	B	4				4	3.0		
	C	6				6	5.0		
	D	4				4	3.0		

Reviewed by: JGh

Date reviewed: Mar. 24/22

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: 212492
Sample ID: BJ-3.10 (Cu site water)

Start Date/Time: 13-January-22 @1630h
Termination Date/Time 16-January-22 @1630h

Initial Cell Density: 9773 cell/mL

215000
0.22
0.01
9772.727

Concentration	Rep	Count 1 ($x 10^4$)	Count 2 ($x 10^4$)	Count 3 ($x 10^4$)	Count 4 ($x 10^4$)	Mean ($x 10^4$)	Cell Yield ($x 10^4$) cell/mL		
Site Water Control	A	19				19	18.0	mean	16.9
	B	19				19	18.0	SD	0.991031
	C	17				17	16.0	CV	5.864879
	D	17				17	16.0		
	E	17				17	16.0		
	F	18				18	17.0		
	G	17				17	16.0		
	H	19				19	18.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
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	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JGu

Date reviewed: Mar. 24/22

CETIS Summary Report

Report Date:	09 Mar-22 14:34 (p 1 of 1)
Test Code/ID:	212492a / 12-3904-6226

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water		
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	73h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
05-0543-5584	Cell Yield	Wilcoxon Rank Sum Two-Sample Test	0.4592	Site Control passed cell yield	1

Multiple Comparison Summary

Analysis ID	Endpoint	Comparison Method	✓	NOEL	LOEL	TOEL	PMSD	S
09-3057-0884	Cell Yield	Wilcoxon/Bonferroni Adj Test		1.7	2.92	2.228	9.37%	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
14-5271-9214	Cell Yield	Linear Interpolation (ICPIN)		IC10	1.6	1.243	2.058	1
				IC15	1.93	1.51	2.355	
				IC20	2.287	1.859	2.81	
			✓	IC25	2.686	2.203	4.003	
			✓	IC40	12.75	10.59	14.25	
			✓	IC50	16.58	14.68	18.03	

Cell Yield Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	8	17	16.23	17.77	16	18	0.3273	0.9258	5.45%	0.00%
0.2	XC	8	16.88	16.05	17.7	16	18	0.3504	0.991	5.87%	0.74%
1		4	17	15.7	18.3	16	18	0.4082	0.8165	4.80%	0.00%
1.7		4	15	13.7	16.3	14	16	0.4082	0.8165	5.44%	11.76%
2.92		4	12.25	10.73	13.77	11	13	0.4787	0.9574	7.82%	27.94%
6.74		4	10.75	8.363	13.14	9	12	0.75	1.5	13.95%	36.76%
11.4		4	11	9.701	12.3	10	12	0.4082	0.8165	7.42%	35.29%
22.4		4	6.5	5.581	7.419	6	7	0.2887	0.5774	8.88%	61.76%
46.3		4	4	2.163	5.837	3	5	0.5774	1.155	28.87%	76.47%

Cell Yield Detail — MD5: 9DC30820B3CDC8290BC4C243538ED825

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	17	17	16	18	18	18	16	16
0.2 ✓	XC	18	18	16	16	16	17	16	18
1 ✓		17	18	16	17				
1.7 ✓		15	16	14	15				
2.92 ✓		13	11	13	12				
6.74 ✓		12	12	9	10				
11.4 ✓		12	10	11	11				
22.4 ✓		7	6	6	7				
46.3 ✓		5	3	5	3				

N = negative (lab) control
XC = Site control

Analyst: MDO QA: JGL Mar. 24/22

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	05-0543-5584	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:31	**Analysis:**	Nonparametric-Two Sample	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	1B95C63999AD192F540B4AEF8B93AC9A	**Editor ID:**	003-659-051-0

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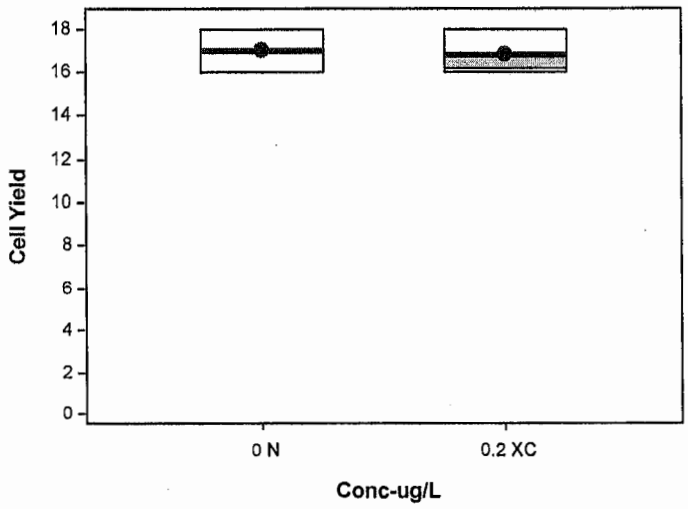
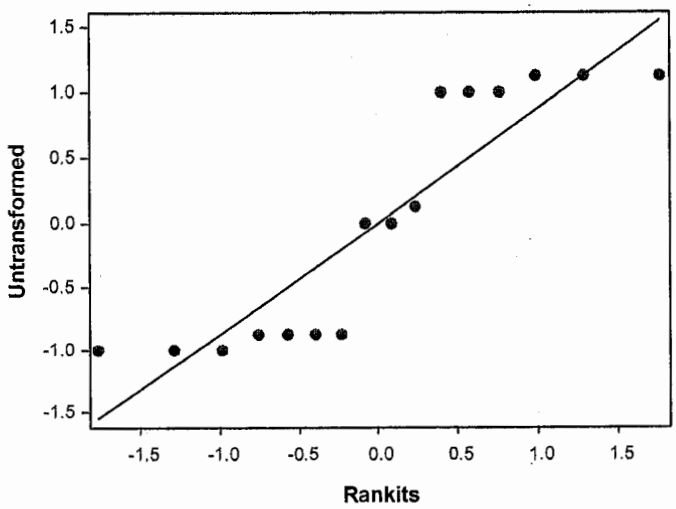




CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	05-0543-5584	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:31	**Analysis:**	Nonparametric-Two Sample	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	1B95C63999AD192F540B4AEF8B93AC9A	**Editor ID:**	003-659-051-0

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water		
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	73h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Site Control passed cell yield endpoint	4.97%

Wilcoxon Rank Sum Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	Ties	P-Type	P-Value	Decision(α:5%)
Negative Control		Site Control	14	65.5	---	3	Exact	0.4592	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0625	0.0625	1	0.06796	0.7981	Non-Significant Effect
Error	12.875	0.919643	14			
Total	12.9375		15			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1.146	8.885	0.8621	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.7914	0.8408	0.0021	Non-Normal Distribution

Cell Yield Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	17	16.23	17.77	17	16	18	0.3273	5.45%	0.00%
0.2	XC	8	16.88	16.05	17.7	16.2	16	18	0.3504	5.87%	0.74%

Cell Yield Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	17	17	16	18	18	18	16	16
0.2	XC	18	18	16	16	16	17	16	18

Analyst: MDO QA: JCh Mar-24/22

CETIS Analytical Report

Report Date:	09 Mar-22 14:34 (p 1 of 2)
Test Code/ID:	212492a / 12-3904-6226

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	14-5271-9214	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:32	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	1E4392388340FD1D089703D653731D28	**Editor ID:**	003-659-051-0

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel	
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water	
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**		
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:** 6d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	73h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1997661	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	1.6	1.243	2.058
IC15	1.93	1.51	2.355
IC20	2.287	1.859	2.81
IC25	2.686	2.203	4.003
IC40	12.75	10.59	14.25
IC50	16.58	14.68	18.03

Cell Yield Summary

			Calculated Variate						Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**Mean**	**%Effect**
0.2	XC	8	16.88	16.2	16	18	5.87%	0.00%	16.94	0.00%
1		4	17	17	16	18	4.80%	-0.74%	16.94	0.00%
1.7		4	15	15	14	16	5.44%	11.11%	15	11.44%
2.92		4	12.25	12.67	11	13	7.82%	27.41%	12.25	27.68%
6.74		4	10.75	11.33	9	12	13.95%	36.30%	10.88	35.79%
11.4		4	11	11	10	12	7.42%	34.81%	10.88	35.79%
22.4		4	6.5	6.5	6	7	8.88%	61.48%	6.5	61.62%
46.3		4	4	4	3	5	28.87%	76.30%	4	76.38%

Cell Yield Detail

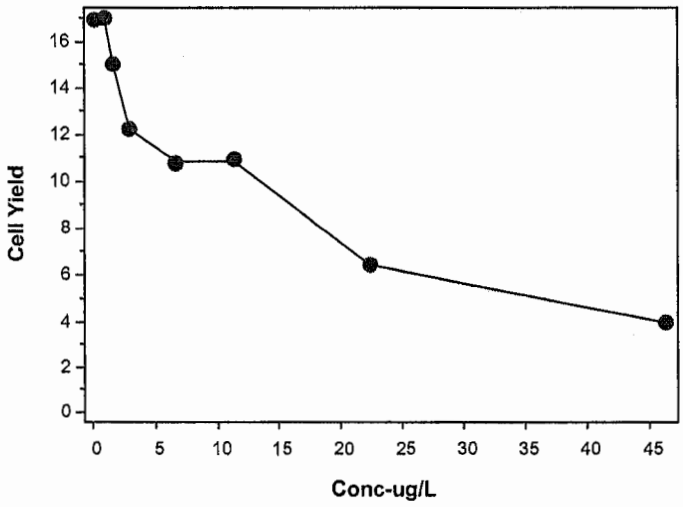
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0.2	XC	18	18	16	16	16	17	16	18
1		17	18	16	17				
1.7		15	16	14	15				
2.92		13	11	13	12				
6.74		12	12	9	10				
11.4		12	10	11	11				
22.4		7	6	6	7				
46.3		5	3	5	3				

Analyst: MDO QA: JGC Mar. 24/22

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	14-5271-9214	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:32	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	1E4392388340FD1D089703D653731D28	**Editor ID:**	003-659-051-0

Graphics



EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-3057-0884	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:34	**Analysis:**	Nonparametric-Multiple Comparison	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	1E4392388340FD1D089703D653731D28	**Editor ID:**	003-659-051-0

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel	
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water	
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**		
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:** 6d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	73h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	NOEL	LOEL	TOEL	TU	MSDu	PMSD
Untransformed	C > T	1.7	2.92	2.228	---	1.582	9.37%

Wilcoxon/Bonferroni Adj Test

Control	vs	Conc-ug/L	df	Test Stat	Critical	Ties	P-Type	P-Value	Decision(α:5%)
Site Control		1	10	27.5	---	3	Exact	1.0000	Non-Significant Effect
		1.7	10	12	---	1	Exact	0.0707	Non-Significant Effect
		2.92*	10	10	---	0	Exact	0.0141	Significant Effect
		6.74*	10	10	---	0	Exact	0.0141	Significant Effect
		11.4*	10	10	---	0	Exact	0.0141	Significant Effect
		22.4*	10	10	---	0	Exact	0.0141	Significant Effect
		46.3*	10	10	---	0	Exact	0.0141	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	711.375	101.625	7	103.9	<1.0E-05	Significant Effect
Error	27.375	0.977679	28			
Total	738.75		35			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Bartlett Equality of Variance Test	3.05	18.48	0.8804	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9134	0.9166	0.0081	Non-Normal Distribution

Cell Yield Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.2	XC	8	16.88	16.05	17.7	16.2	16	18	0.3504	5.87%	0.00%
1		4	17	15.7	18.3	17	16	18	0.4082	4.80%	-0.74%
1.7		4	15	13.7	16.3	15	14	16	0.4082	5.44%	11.11%
2.92		4	12.25	10.73	13.77	12.67	11	13	0.4787	7.82%	27.41%
6.74		4	10.75	8.363	13.14	11.33	9	12	0.75	13.95%	36.30%
11.4		4	11	9.701	12.3	11	10	12	0.4082	7.42%	34.81%
22.4		4	6.5	5.581	7.419	6.5	6	7	0.2887	8.88%	61.48%
46.3		4	4	2.163	5.837	4	3	5	0.5774	28.87%	76.30%

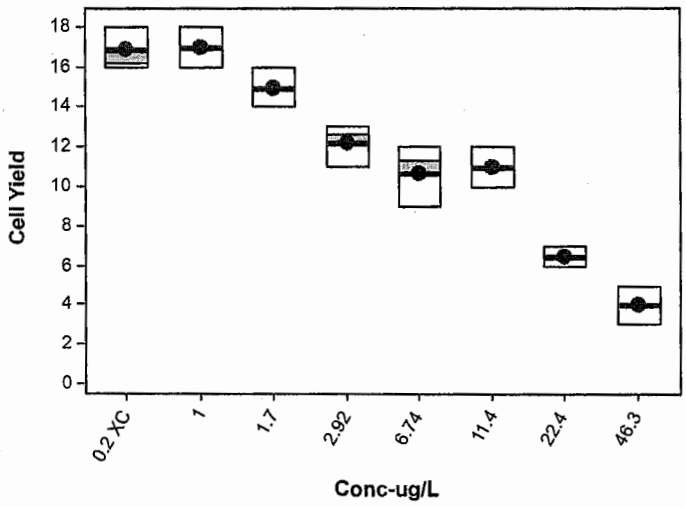
Cell Yield Detail

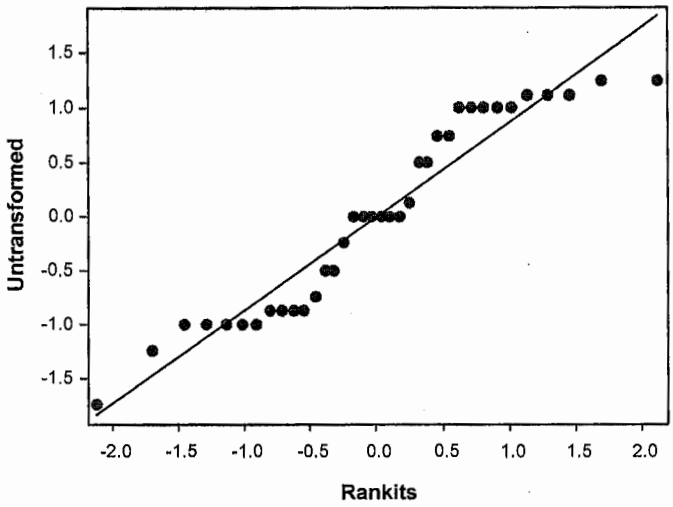
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0.2	XC	18	18	16	16	16	17	16	18
1		17	18	16	17				
1.7		15	16	14	15				
2.92		13	11	13	12				
6.74		12	12	9	10				
11.4		12	10	11	11				
22.4		7	6	6	7				
46.3		5	3	5	3				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-3057-0884	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:34	**Analysis:**	Nonparametric-Multiple Comparison	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	1E4392388340FD1D089703D653731D28	**Editor ID:**	003-659-051-0

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax/Pretivm Resources Inc.
Work Order No.: 212492

Start Date: Jan 13/22 @ 1630h
Set up by: SAK

Sample Information:

Sample ID: Cu in lab water
Sample Date: Jan 13/22
Date Received: Jan 13/22
Sample Volume: N/A

Test Organism Information:

Culture Date: Jan 7/22
Age of culture (Day 0): 6 d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC 224
Stock Solution ID: 21Zn01
Date Initiated: Jan 20/22

72-h IC50 (95% CL): 25.6 (22.8 - 28.7) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.3 (26.8-38.9) µg/L Zn CV (%): 9

Test Results: (measured values)

µg/L Cu	Algal Growth
IC25 %(v/v) (95% CL)	9.5 (6.8 - 12.6)
IC50 %(v/v) (95% CL)	25.6 (20.2 - 32.5)

N/A

Reviewed by: JGL

Date reviewed: Mar. 28/22

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Pretium/Lorax **Setup by:** SAM

Sample ID: Lab Water (BJ-3, +0) (Cu 5th Lab water) w/Cu **Test Date/Time:** Jan. 13/22 @ 1630 h

Work Order No.: 212492 **CER #:** 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: Jan. 7/22 **Age of Culture:** 6d **Culture Health:** Good

Culture Count: 1 260 2 240 **Average:** 250 **Culture Cell Density (c1):** 250×10^4 cells/mL

$$v1 = \frac{220{,}000 \text{ cells/ml} \times 40 \text{ ml}}{(c1) \quad 250 \times 10^4 \text{ cells/ml}} = 3.5 \text{ mL}$$

Time Zero Counts: 1 21 2 22 **Average:** 21.5

No. of Cells/mL: 21.5×10^4 cells/mL **Initial Density:** # cells/mL ÷ 220 µL x 10 µL = 9773 cells/mL

Concentration ~~%(v/v)~~ mg/L Cu	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control (Negative Control)	6.8	23.0	24.0	24.0	25.0	25.0	✓	✓	✓	✓
Lab Water (Lab control)	7.~~7~~8 SKH	24.0								
0.75	① 7.~~6~~8 SKH	24.5								
1.5	7.8	24.0								
3	7.8	24.0								
6	7.8	24.0								
12	7.8	24.0								
24	7.8	24.0								
48	7.8	24.0	✓	✓	✓	✓	✓	✓	✓	✓
Initials	SKH	SKH	SAM	SAM	JRL	RD	SAM	SAM	JRL	RD

Hardness adj 20% Perrier (µ Control)

Initial control pH: Well 1: 6.8 Well 2: 6.8

Final control pH: Well 1: 6.9 Well 2: 6.9

Light intensity (lux): 4260 **Date measured:** Jan. 13/22

Thermometer: 1 **Light meter:** 1 **pH meter/probe:** 1 / 1

Sample Description: 70% Hardness water (Perrier + DI) spiked with Cu ~~2~~ mg/L
mg/L as $CaCO_3$

Comments: ① Remeasured

Reviewed: JRL **Date reviewed:** Mar. 24/22

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pictum / Lorax Start Date/Time: Jan. 13/22 @ 1630h

Work Order #: 212492 Termination Date: Jan. 16/22 @ 1630h

Sample ID: ~~53 3.10~~ (Cu lab Water) w/Cu Test set up by: SAH

%(v/v) MDO

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	18					SAH
µg/L Cu	B	17					
	C	18					
	D	19					
Negative	E	20					
Control	F	18					
	G	17					
	H	18					
0.75	A	16					
	B	20					
	C	16					
	D	15					
1.5	A	18					
	B	17					
	C	19					
	D	14					
3	A	18					
	B	14					
	C	16					
	D	14					
6	A	16					
	B	18					
	C	14					
	D	16					
12	A	13					
	B	14					
	C	11					
	D	14					
24	A	11					
	B	11					
	C	12					
	D	11					
48	A	4	4				
	B	6					
	C	6					
	D	9	10				

Comments:

Reviewed by: JOh Date Reviewed: Mar. 24/22

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Pretium / Lorax Start Date/Time: Jan. 13/22 @ 1630h

Work Order #: 212492 Termination Date: Jan. 16/22 @ 1630h

Sample ID: ~~1B3-3.10~~ Cu lab water w/ EDTA Test set up by: SAK

%(v/v) 100%

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control ~~Site~~ ~~w/ EDT. Below~~ control (lab water) Hardness adjusted lab control	A	18					SAK
	B	19					
	C	18					
	D	18					
	E	18					
	F	19					
	G	19					
	H	17					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JGh Date Reviewed: Mar. 24/22

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: 212492
Sample ID: BJ-3.10 (Cu lab water)

Start Date/Time: 13-January-22 @1630h
Termination Date/Time 16-January-22 @1630h

Initial Cell Density: 9773 cell/mL

	215000
	0.22
	0.01
	9772.727

Concentration	Rep	Count 1 ($x 10^4$)	Count 2 ($x 10^4$)	Count 3 ($x 10^4$)	Count 4 ($x 10^4$)	Mean ($x 10^4$)	Cell Yield ($x 10^4$) cell/mL		
Negative Control	A	18				18	17.0	mean	17.1
	B	17				17	16.0	SD	0.991031
	C	18				18	17.0	CV	5.779374
	D	19				19	18.0		
	E	20				20	19.0		
	F	18				18	17.0		
	G	17				17	16.0		
	H	18				18	17.0		
0.75	A	16				16	15.0		
	B	20				20	19.0		
	C	16				16	15.0		
	D	15				15	14.0		
1.5	A	18				18	17.0		
	B	17				17	16.0		
	C	19				19	18.0		
	D	14				14	13.0		
3	A	18				18	17.0		
	B	14				14	13.0		
	C	16				16	15.0		
	D	14				14	13.0		
6	A	16				16	15.0		
	B	18				18	17.0		
	C	14				14	13.0		
	D	16				16	15.0		
12	A	13				13	12.0		
	B	14				14	13.0		
	C	11				11	10.0		
	D	14				14	13.0		
24	A	11				11	10.0		
	B	11				11	10.0		
	C	12				12	11.0		
	D	11				11	10.0		
48	A	4	4			4	3.0		
	B	6				6	5.0		
	C	6				6	5.0		
	D	9	10			9.5	8.5		

Reviewed by: JGu

Date reviewed: Mar. 24/22

Pseudokirchneriella subcapitata Algal Counts

Client: Pretivm
WO#: 212492
Sample ID: BJ-3.10 (Cu lab water)

Start Date/Time: 13-January-22 @1630h
Termination Date/Time: 16-January-22 @1630h

Initial Cell Density: 9773 cell/mL

215000
0.22
0.01
9772.727

Concentration	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Lab Water Control (hardness adjusted)	A	18				18	17.0	mean	17.3
	B	19				19	18.0	SD	0.707107
	C	18				18	17.0	CV	4.093776
	D	18				18	17.0		
	E	18				18	17.0		
	F	19				19	18.0		
	G	19				19	18.0		
	H	17				17	16.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
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	D					#DIV/0!	#DIV/0!		

Reviewed by: JOh

Date reviewed: Mar. 24/22

CETIS Summary Report

Report Date:	09 Mar-22 14:28 (p 1 of 1)
Test Code/ID:	212492b / 19-4838-4697

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water		
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	16h	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
07-7511-1573	Cell Yield	Equal Variance t Two-Sample Test	0.6121	Lab Control passed cell yield	1

Multiple Comparison Summary

Analysis ID	Endpoint	Comparison Method	✓	NOEL	LOEL	TOEL	PMSD	S
19-9812-9350	Cell Yield	Dunnett Multiple Comparison Test	✓	1.6	2.82	2.124	14.9%	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
13-6739-7652	Cell Yield	NLR: 3P Log-Logistic	✓	IC10	3.547	1.862	5.321	1
			✓	IC15	5.377	3.285	7.664	
			✓	IC20	7.356	4.919	10.09	
			✓	IC25	9.528	6.81	12.64	
			✓	IC40	17.78	14.1	22.16	
			✓	IC50	25.6	20.17	32.5	

Cell Yield Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	8	17.13	16.3	17.95	16	19	0.3504	0.991	5.79%	0.00%
0.41 ✓	LC	8	17.25	16.66	17.84	16	18	0.25	0.7071	4.10%	-0.73%
1.05 ✓		4	15.75	12.22	19.28	14	19	1.109	2.217	14.08%	8.03%
1.6 ✓		4	16	12.56	19.44	13	18	1.08	2.16	13.50%	6.57%
2.82 ✓		4	14.5	11.45	17.55	13	17	0.9574	1.915	13.21%	15.33%
5.32 ✓		4	15	12.4	17.6	13	17	0.8165	1.633	10.89%	12.41%
10.4 ✓		4	12	9.75	14.25	10	13	0.7071	1.414	11.79%	29.93%
20.9 ✓		4	10.25	9.454	11.05	10	11	0.25	0.5	4.88%	40.15%
42.3 ✓		4	5.5	1.496	9.504	3	9	1.258	2.517	45.76%	67.88%

Cell Yield Detail — MD5: 972056BFCC0408CF80658FEA88CCBF9B

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	17	16	17	18	19	17	16	17
0.41	LC	17	18	17	17	17	18	18	16
1.05		15	19	15	14				
1.6		17	16	18	13				
2.82		17	13	15	13				
5.32		15	17	13	15				
10.4		12	13	10	13				
20.9		10	10	11	10				
42.3		3	5	5	9				

N = negative control

LC = laboratory control (hardness adjusted)

JGk
Mar-24/2

CETIS Analytical Report

Report Date: 09 Mar-22 14:28 (p 1 of 4)
Test Code/ID: 212492b / 19-4838-4697

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-7511-1573	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:05	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	65EE4EF0C6C6949CD9F474318732DD4C	**Editor ID:**	003-659-051-0

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel	
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water	
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**		
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:** 6d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	16h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Lab Control passed cell yield endpoint	4.43%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Negative Control		Lab Control	14	-0.2904	1.761	0.7581	CDF	0.6121	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0625	0.0625	1	0.08434	0.7758	Non-Significant Effect
Error	10.375	0.741071	14			
Total	10.4375		15			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1.964	8.885	0.3930	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9079	0.8408	0.1075	Normal Distribution

Cell Yield Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	8	17.13	16.3	17.95	17	16	19	0.3504	5.79%	0.00%
0.41	LC	8	17.25	16.66	17.84	17	16	18	0.25	4.10%	-0.73%

Cell Yield Detail

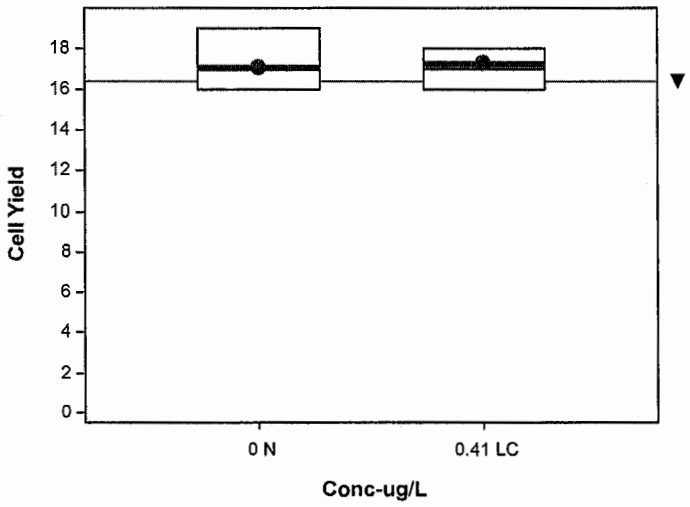
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	N	17	16	17	18	19	17	16	17
0.41	LC	17	18	17	17	17	18	18	16

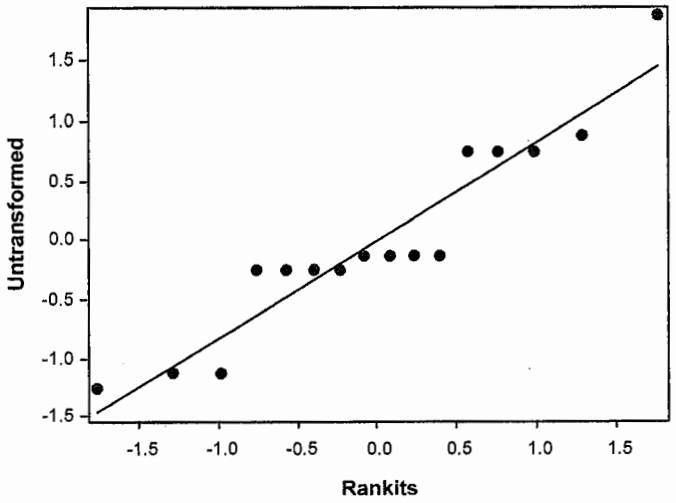
Analyst: MDO QA: JCL Mar. 24/22

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-7511-1573	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:05	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	65EE4EF0C6C6949CD9F474318732DD4C	**Editor ID:**	003-659-051-0

Graphics





CETIS Analytical Report

Report Date:	28 Mar-22 12:08 (p 1 of 3)
Test Code/ID:	212492b / 19-4838-4697

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-8394-1366	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 12:07	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	21313925643948F44AC9DA02734AB75F	**Editor ID:**	003-659-051-0

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel	
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water	
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**		
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:** 6d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	16h	**Client:**	Pretivm Resources Inc.		

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Normal [ω=1]	Off [μ*=μ]	None	None

Regression Summary

Iters	LL	AICc	BIC	Adj R2	PMSD	Thresh	Optimize	F Stat	P-Value	Decision(α:5%)
8	-17.42	41.6	45.6	0.8234	6.91%	16.86	Yes	1.101	0.3819	Non-Significant Lack-of-Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	3.547	1.862	5.321
IC15	5.377	3.285	7.664
IC20	7.356	4.919	10.09
IC25	9.528	6.81	12.64
IC40	17.78	14.1	22.16
IC50	25.6	20.17	32.5

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	16.86	0.5723	15.69	18.02	29.46	<1.0E-05	Significant Parameter
γ	1.112	0.2057	0.6931	1.53	5.404	<1.0E-05	Significant Parameter
δ	25.6	3.363	18.76	32.44	7.613	<1.0E-05	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	7240	2413	3	864.3	<1.0E-05	Significant Effect
Lack of Fit	15.14	3.028	5	1.101	0.3819	Non-Significant Lack-of-Fit
Pure Error	77	2.75	28			
Residual	92.14	2.792	33			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Outlier	Grubbs Extreme Value Test	1.933	2.991	1.0000	No Outliers Detected
Variance	Bartlett Equality of Variance Test	12.08	14.07	0.0981	Equal Variances
	Mod Levene Equality of Variance	0.7407	2.359	0.6398	Equal Variances
Distribution	Anderson-Darling A2 Test	0.6431	2.492	0.0939	Normal Distribution
	Shapiro-Wilk W Normality Test	0.9561	0.9398	0.1625	Normal Distribution
Control Trend	Mann-Kendall Trend Test	1	0.05	1.0000	Non-Significant Control Trend

Analyst: MDO QA: SOU Mar. 28/22

EC Alga Growth Inhibition Test — Nautilus Environmental

Analysis ID:	12-8394-1366	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 12:07	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	21313925643948F44AC9DA02734AB75F	**Editor ID:**	003-659-051-0

Cell Yield Summary

			Calculated Variate							
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.41	LC	8	17.25	17	16	18	0.25	0.7071	4.10%	0.00%
1.05		4	15.75	15	14	19	1.109	2.217	14.08%	8.70%
1.6		4	16	16.5	13	18	1.08	2.16	13.50%	7.25%
2.82		4	14.5	13.67	13	17	0.9574	1.915	13.21%	15.94%
5.32		4	15	15	13	17	0.8165	1.633	10.89%	13.04%
10.4		4	12	12.67	10	13	0.7071	1.414	11.79%	30.43%
20.9		4	10.25	10	10	11	0.25	0.5	4.88%	40.58%
42.3		4	5.5	5	3	9	1.258	2.517	45.76%	68.12%

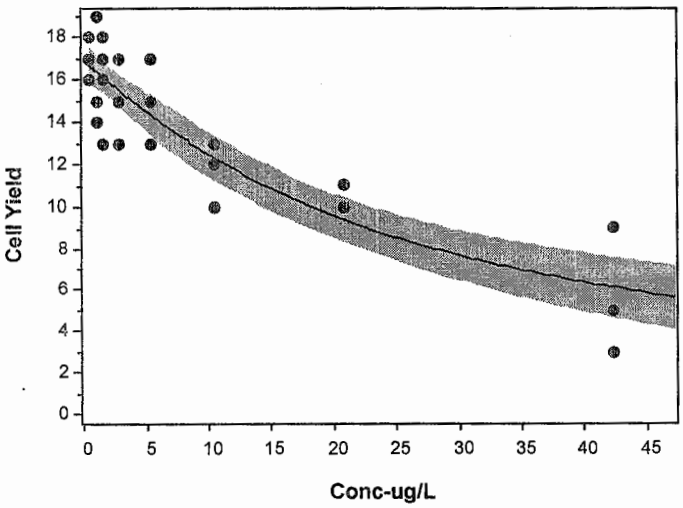
Cell Yield Detail

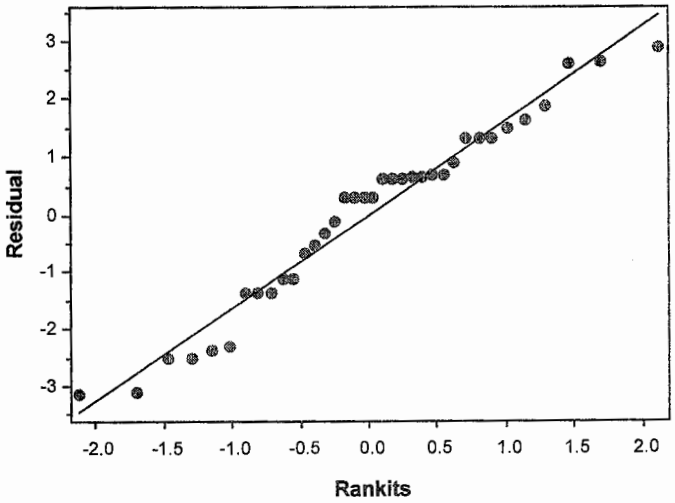
Conc-ug/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**	**Rep 5**	**Rep 6**	**Rep 7**	**Rep 8**
0.41	LC	17	18	17	17	17	18	18	16
1.05		15	19	15	14				
1.6		17	16	18	13				
2.82		17	13	15	13				
5.32		15	17	13	15				
10.4		12	13	10	13				
20.9		10	10	11	10				
42.3		3	5	5	9				

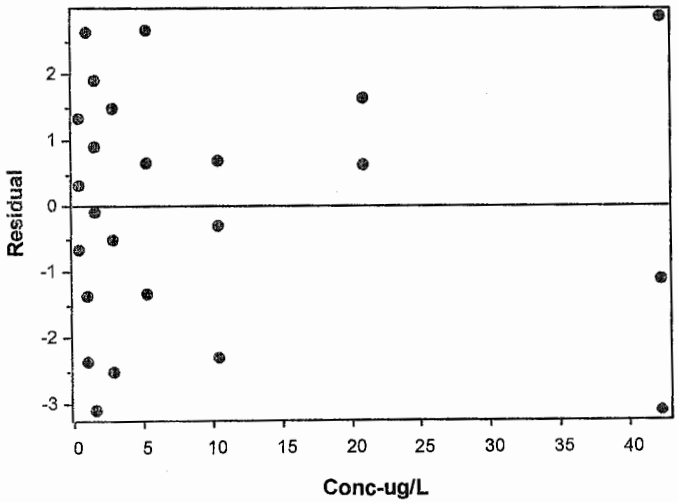
EC Alga Growth Inhibition Test — **Nautilus Environmental**

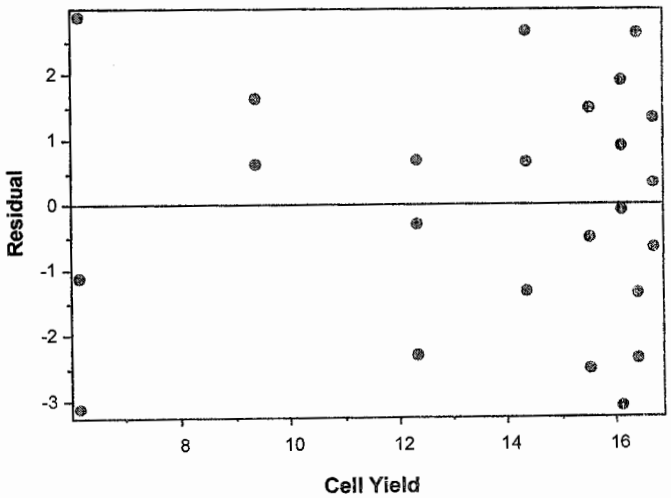
Analysis ID:	12-8394-1366	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 12:07	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	21313925643948F44AC9DA02734AB75F	**Editor ID:**	003-659-051-0

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Normal [ω=1]









EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	19-9812-9350	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:28	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	21313925643948F44AC9DA02734AB75F	**Editor ID:**	003-659-051-0

Batch ID:	18-7776-5714	**Test Type:**	Cell Growth	**Analyst:**	Sierra Klueppel		
Start Date:	13 Jan-22 16:30	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	70 Hardness Water		
Ending Date:	16 Jan-22 16:30	**Species:**	Pseudokirchneriella subcapitata	**Brine:**			
Test Length:	72h	**Taxon:**	Chlorophyta	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	16h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	NOEL	LOEL	TOEL	TU	MSDu	PMSD
Untransformed	C > T	1.6	2.82	2.124	---	2.565	14.87%

Dunnett Multiple Comparison Test

Control	vs	Conc-ug/L	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Lab Control		1.05	10	1.477	2.526	2.565	CDF	0.3205	Non-Significant Effect
		1.6	10	1.231	2.526	2.565	CDF	0.4352	Non-Significant Effect
		2.82*	10	2.708	2.526	2.565	CDF	0.0336	Significant Effect
		5.32	10	2.216	2.526	2.565	CDF	0.0941	Non-Significant Effect
		10.4*	10	5.17	2.526	2.565	CDF	5.8E-05	Significant Effect
		20.9*	10	6.893	2.526	2.565	CDF	<1.0E-05	Significant Effect
		42.3*	10	11.57	2.526	2.565	CDF	<1.0E-05	Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	476.222	68.0318	7	24.74	<1.0E-05	Significant Effect
Error	77	2.75	28			
Total	553.222		35			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Bartlett Equality of Variance Test	12.08	18.48	0.0981	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9674	0.9166	0.3578	Normal Distribution

Cell Yield Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0.41	LC	8	17.25	16.66	17.84	17	16	18	0.25	4.10%	0.00%
1.05		4	15.75	12.22	19.28	15	14	19	1.109	14.08%	8.70%
1.6		4	16	12.56	19.44	16.5	13	18	1.08	13.50%	7.25%
2.82		4	14.5	11.45	17.55	13.67	13	17	0.9574	13.21%	15.94%
5.32		4	15	12.4	17.6	15	13	17	0.8165	10.89%	13.04%
10.4		4	12	9.75	14.25	12.67	10	13	0.7071	11.79%	30.43%
20.9		4	10.25	9.454	11.05	10	10	11	0.25	4.88%	40.58%
42.3		4	5.5	1.496	9.504	5	3	9	1.258	45.76%	68.12%

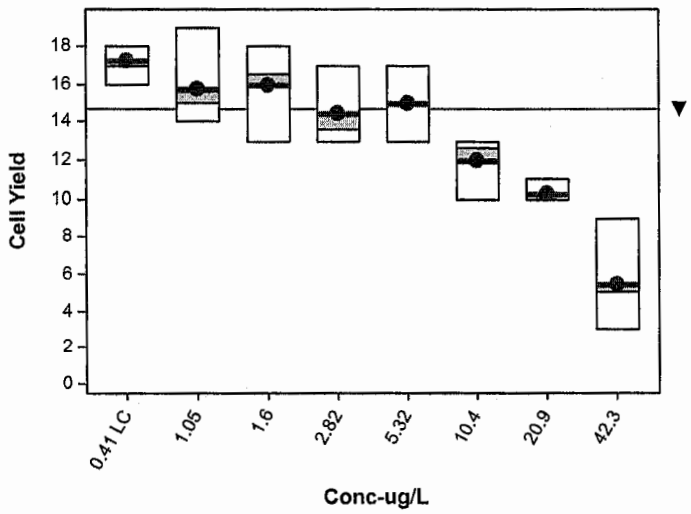
Cell Yield Detail

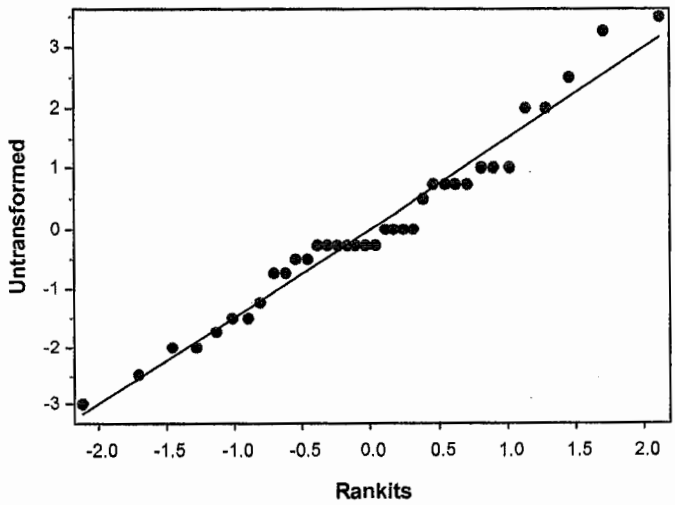
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0.41	LC	17	18	17	17	17	18	18	16
1.05		15	19	15	14				
1.6		17	16	18	13				
2.82		17	13	15	13				
5.32		15	17	13	15				
10.4		12	13	10	13				
20.9		10	10	11	10				
42.3		3	5	5	9				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	19-9812-9350	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:28	**Analysis:**	Parametric-Control vs Treatments	**Status Level:**	1
Edit Date:	16 Jan-22 16:30	**MD5 Hash:**	21313925643948F44AC9DA02734AB75F	**Editor ID:**	003-659-051-0

Graphics





APPENDIX C – *Lemna minor* Toxicity Test Data

Lemna minor Summary Sheet

Client: Lorax/Pretivm Resources Inc. Start Date: Jan 14/22
Work Order No.: 212491 Set up by: GJU

Sample Information:

Sample ID: Cu in lab control (20% Perrier)
Sample Date: Jan 13/22
Date Received: Jan 13/22
Sample Volume: N/A

Test Organism Information:

Culture Date: Jan 5/22
Age of culture (Day 0): 9 days
>8X growth in APHA?: yes (63 fronds)

KCl Reference Toxicant Results:

Reference Toxicant ID: LM215
Date Initiated: Jan 12/22

7-d No. of Fronds IC50 (95% CL): 2.9(2.7-3.1) g/L KCl

7-d No. Fronds IC50 Reference Toxicant Mean (2 SD Range): 3.3(2.8-3.9) g/L KCl CV (%): 8

Test Results: (measured values)

µg/L Cu	Number of Fronds	Dry Weight
IC25 ~~%(v/v)~~ (95% CL)	3.8(2.8-4.9)	3.3(2.3-4.5)
IC50 ~~%(v/v)~~ mod (95% CL)	>9.69	>9.69

Reviewed by: JGu Date reviewed: Mar. 25/22

Plant Growth Inhibition Toxicity Test
Water Quality Measurements

Client :	Premium Resources Inc. / Lorax	**Setup by:**	GM
Sample ID:	Cu in lab control (20% perrier)	**Test Date:**	Jan. 14/22
Work Order No.:	212491	**CER #:**	9
Culture Source:	CPCC #490	**Test Species:**	*Lemna minor*
Test Culture Age:	9 days	**> 8X Growth? (Y/N):**	y (63 fronds)
Light Intensity Range:	4520 - 5350 lux	**Date Measured:**	Jan-12/22

Day	0	1	2	3	4	5	6	7
Shelf Temp (°C)	24.5	25.0	25.0	25.0	24.5	24.5	25.0	25.0
Initials	GM	JZL	RZS	RZS	RZS	RZS	RZS	A

Sample Characteristics:	Initial Water Quality			Adjusted Water Quality
Temperature (°C)	25.0	Aeration?:	20 min	24.5
DO (mg/L)	8.8	Nutrients added?[1]:	y →	8.5
pH	7.7			7.6
Conductivity (µS)	156			944

[1] 10 mL of each APHA stock (A,B and C) added to 970 mL sample.

Concentration (µg/L Cu)	Temperature (°C)		pH		Conductivity (µS)
	Day 0	Day 7	Day 0	Day 7	0 h
Lab Control (20% perrier)	24.5	25.0	7.7	9.1	921
0.75	25.0	25.0	7.8	9.2	945
1.5	25.0	25.0	7.9	9.4	946
3	25.0	25.0	7.9	9.5	946
6	25.5	25.0	7.9	9.2	945
12	25.5	25.0	7.9	9.1	944
24	25.5	25.0	7.9	8.7	945
48	25.5	25.0	7.9	8.6	946
Initials	JZL	A	JZL	A	JZL

Thermometer: CER # 9 Light meter: 1 pH meter/probe: 1 / 1 DO meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

Sample Description: 0.45 mL of 21 CuO3 (106 mg/L) was added to 1L of 20% perrier water + nutrient solution to reach 48 µg/L Cu

Comments: DO for 20% perrier + nutrient + Cu stock (day 0) = 8.4

Reviewed: JM **Date Reviewed:** Mar. 25/22

Plant Growth Inhibition Toxicity Test
Water Quality Measurements

Client :	Resources Inc. Premium / Lorax	**Setup by:**	GM
Sample ID:	Lab control (Modified APHA)	**Test Date:**	Jan. 14/22
Work Order No.:	212491	**CER #:**	9
Culture Source:	CPCC #490	**Test Species:**	*Lemna minor*
Test Culture Age:	9 days	**> 8X Growth? (Y/N):**	y (63 fronds)
Light Intensity Range:	4520 - 5350 lux	**Date Measured:**	Jan. 12/22

Day	0	1	2	3	4	5	6	7
Shelf Temp (°C)	24.5	25.0	25.0	25.0	24.5	24.5	25.0	25.0
Initials	GM	JZ	RZ	RZS	RZS	RZS	RZ	A

Sample Characteristics:	Initial Water Quality (GM)		Adjusted Water Quality (GM)
Temperature (°C)		Aeration?: min	
DO (mg/L)		Nutrients added?[1]:	
pH			
Conductivity (µS)			

[1] 10 mL of each APHA stock (A,B and C) added to 970 mL sample.

Concentration	Temperature (°C)		pH		Conductivity (µS)
	Day 0	Day 7	Day 0	Day 7	0 h
Lab Control (Negative control)	24.0	25.0	8.3	8.6	942
Initials	GM	[illegible]	GM	A	GM

Thermometer: CER# 9 Light meter: 1 pH meter/probe: 1 / 1 DO meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

Sample Description:

Comments:

Reviewed: JGM **Date Reviewed:** Mar. 25/22

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: Premium / Logax
Sample ID: Cu in lab control (20% Perrier)
Work Order #: 212491

Start Date: Jan. 14/22
Termination Date: Jan 21/22
Test set up by: GM

Concentration (mg/L Cu)	Rep	No. of fronds Day 0	No. of fronds Day 7	Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
20% Perrier (lab control)	A	6	64									Algae present on beaker bottom	AS
	B		70										
	C		67										
	D		62										
0.75	A		64										
	B		66										
	C		67										
	D		63										
1.5	A		74										
	B		69										
	C		59										
	D		67										
3	A		74										
	B		65										
	C		54										
	D		65										
6	A		61										
	B		66										
	C		69										
	D		75										
12	A		57										
	B		62										
	C		66										
	D		63										

Comments:

Reviewed by: JBr

Date Reviewed: Mar. 25/22

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: Premium Borax
Sample ID: Cu in lab control (20% Reviva)
Work Order #: 212491

Start Date: Jan. 14/22
Termination Date: Jan. 21/22
Test set up by: GM

Concentration (µg/L Cu)	Rep	No. of fronds Day 0	No. of fronds Day 7	Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
24	A	6	50			X						no algae present on beaker bottom	A
	B		45			X							
	C		47			X							
	D		44			X							
48	A		38			X							
	B		42			X							
	C		36			X							
	D		42			X							
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												

Comments:

Reviewed by: JGr

Date Reviewed: Mar. 25/22

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: Premium / Lorax
Sample ID: Lab control (Modified APHA)
Work Order #: 21241

Start Date: Jan. 14/22
Termination Date: Jan 21/22
Test set up by: GM

Concentration	Rep	No. of fronds		Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
		Day 0	Day 7										
MPO Lab Negative Control	A	6	68										
	B	↓	73										↓
	C		65										
	D		71										
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												

Comments:

Reviewed by: JCh

Date Reviewed: Mar. 25/22

7-d *Lemna minor* Weight Data Sheet

Client: Pretium / Lorax
Sample ID: Cu in Lab control (20% perrier)
WO #: 212491
(µg/L Cu) BB red

Start Date: Jan. 14/22
Termination Date: Jan. 21/22
Balance ID: Bal - 1

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
20% perrier	A	1	1037.61	1045.42	GM / GM
	B	2	1045.69	1053.70	
	C	3	1045.07	1053.37	
	D	4	1051.39	1059.17	
0.75	A	5	1044.21	1051.54	
	B	6	1054.54	1062.29	
	C	7	1064.74	1072.72	
	D	8	1059.08	1066.16	
1.5	A	9	1049.71	1057.68	
	B	10	1060.73	1068.97	
	C	11	1049.73	1056.16	
	D	12	1046.79	1054.39	
3	A	13	1050.00	1058.07	
	B	14	1022.47	1030.59	
	C	15	1039.67	1045.36	
	D	16	1043.20	1050.89	
6	A	17	1050.00	1057.46	
	B	18	GM ~~1053.54~~ 1043.54	1051.27	
	C	19	1037.11	1044.92	
	D	20	1048.73	1056.61	
12	A	21	~~1045.28~~ GM 1045.28	1051.29	
	B	22	1043.92	1050.22	
	C	23	1046.53	1054.29	
	D	24	1039.82	1046.32	
24	A	25	1037.85	1043.52	
	B	26	1062.91	1068.24	
	C	27	1032.88	1038.74	
	D	28	1045.59	1050.78	↓

Date/time pan placed in oven: Jan 11/22 @ 1000h GM

Date/time pan + organisms placed in oven: (A) Jan 21/22 @ 1205h

Date/time pan removed from oven: Jan. 13/22 @ 1000h

Date/time pan + organisms removed from oven: Jan. 24/22 @ 1205h

Comments: 10% reweigh pan #6 = 1062.18 pan #28 = 1050.66 GM
pan #16 = 1050.71

Reviewed by: JCL

Date Reviewed: Mar. 25/22

7-d *Lemna minor* Weight Data Sheet

Client: Pretium / Lorax

Sample ID: Cu in lab control (20% perlite)

WO #: 22441

(mg/L Cu) BB red

Start Date: Jan. 14/22

Termination Date: Jan. 21/22

Balance ID: Bal - 1

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
48	A	29	1049.20	1054.83	GM/GM
	B	30	1055.61	1060.70	↓
	C	31	1041.61	1046.18	↓
	D	32	1049.42	1054.41	↓
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Date/time pan placed in oven: Jan 11/22 @ 1000h

Date/time pan + organisms placed in oven: (A)

Date/time pan removed from oven: Jan 13/22 @ 1000h

Date/time pan + organisms removed from oven: Jan. 24/22 @ 1205h

Comments:

Reviewed by: JOh

Date Reviewed: Mar. 25/22

7-d *Lemna minor* Weight Data Sheet

Client: Premium / Lorax

Sample ID: Negative Lab control (Modified APHA)

WO #: GDM ~~220039~~ 212491

Start Date: Jan. 14/22

Termination Date: Jan. 21/22

Balance ID: Bal - 1

% (v/v) DD black

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
Lab control	A	1	1046.43	1053.96	GDM / GDM
	B	2	1031.02	1039.06	↓
	C	3	1040.56	1047.63	↓
	D	4	1027.67	1034.71	↓
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Date/time pan placed in oven: Jan 12/22 @ 1000h

Date/time pan + organisms placed in oven: Jan 21/22 @ 1205h

Date/time pan removed from oven: Jan. 13/22 @ 1000h

Date/time pan + organisms removed from oven: Jan. 24/22 @ 1205h

Comments: 10% reweigh pan #3 = 1047.60 GDM

Reviewed by: JCu

Date Reviewed: Mar. 25/22

CETIS Summary Report

Report Date:	22 Mar-22 16:15 (p 1 of 2)
Test Code/ID:	212491a / 05-9844-4680

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo
Start Date:	14 Jan-22 ✓	**Protocol:**	EC/EPS 1/RM/37 ✓	**Diluent:**	~~Modified APHA~~ MDO Hardness-adjusted lab control + APHA
Ending Date:	21 Jan-22 ✓	**Species:**	Lemna minor	**Brine:**	
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490 **Age:** 9d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 MDO Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	14 MDO Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water ✓
Sample Age:	24h	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
15-7438-7074	Frond Count	Equal Variance t Two-Sample Test	0.1035	Lab Water passed frond count	1
10-5830-7268	Total Dry Weight-mg	Equal Variance t Two-Sample Test	0.9600	Lab Water passed total dry weight-mg	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
13-1000-6508	Frond Count	NLR: 3P Log-Logistic		IC10	1.473	0.8191	2.149	1
				IC15	2.201	1.398	3.064	
				IC20	2.978	2.068	3.982	
				IC25	3.823	2.831	4.938	
			✓	IC40	6.978	5.456	8.807	
			✓	IC50	~~9.922~~	~~7.314~~	~~13.46~~ MDO	>9.69
12-0067-8792	Total Dry Weight-mg	NLR: 3P Log-Logistic	✓	IC10	0.6599	0.3398	1.072	1
			✓	IC15	1.295	0.7666	1.967	
			✓	IC20	2.151	1.39	3.113	
			✓	IC25	3.271	2.27	4.524	
				IC40	8.98	5.817	13.53	
				IC50	~~16.21~~	~~8.42~~	~~31.22~~ MDO	>9.69

Frond Count Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0.1	L	4	59.75	54.18	65.32	56	64	1.75	3.5	5.86%	0.00%
0	N	4	63.25	57.68	68.82	59	67	1.75	3.5	5.53%	-5.86%
0.41		4	59	56.09	61.91	57	61	0.9129	1.826	3.09%	1.26%
0.46		4	61.25	51.32	71.18	53	68	3.119	6.238	10.19%	-2.51%
0.7		4	58.5	45.48	71.52	48	68	4.093	8.185	13.99%	2.09%
1.11		4	61.75	52.44	71.06	55	69	2.926	5.852	9.48%	-3.35%
2.04		4	56	50.05	61.95	51	60	1.871	3.742	6.68%	6.28%
3.91		4	40.5	36.29	44.71	38	44	1.323	2.646	6.53%	32.22%
9.69		4	33.5	28.73	38.27	30	36	1.5	3	8.96%	43.93%

Total Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0.1 ✓	L	4	7.975	7.594	8.356	7.78	8.3	0.1198	0.2395	3.00%	0.00%
0	N	4	7.42	6.672	8.168	7.04	8.04	0.2351	0.4703	6.34%	6.96%
0.41 ✓		4	7.535	6.89	8.18	7.08	7.98	0.2027	0.4055	5.38%	5.52%
0.46 ✓		4	7.56	6.291	8.829	6.43	8.24	0.3988	0.7977	10.55%	5.20%
0.7 ✓		4	7.392	5.561	9.224	5.69	8.12	0.5756	1.151	15.57%	7.30%
1.11 ✓		4	7.72	7.427	8.013	7.46	7.88	0.09194	0.1839	2.38%	3.20%
2.04 ✓		4	6.642	5.415	7.87	6.01	7.76	0.3858	0.7717	11.62%	16.71%
3.91 ✓		4	5.513	5.024	6.001	5.19	5.86	0.1535	0.3071	5.57%	30.88%
9.69 ✓		4	5.07	4.376	5.764	4.57	5.63	0.218	0.436	8.60%	36.43%

N = negative control
L = lab control (hardness-adjusted)

Analyst: MDO QA: Mar. 25/22

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Frond Count Detail — MD5: FFE985748E94A4C53716D0D3AAE9CB62

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0.1	L	58	64	61	56
0	N	62	67	59	65
0.41		58	60	61	57
0.46		68	63	53	61
0.7		68	59	48	59
1.11		55	60	63	69
2.04		51	56	60	57
3.91		44	39	41	38
9.69		32	36	30	36

Total Dry Weight-mg Detail — MD5: 48644D2D6EEFF293AEB0C9149F25B664

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0.1	L	7.81	8.01	8.3	7.78
0	N	7.53	8.04	7.07	7.04
0.41		7.33	7.75	7.98	7.08
0.46		7.97	8.24	6.43	7.6
0.7		8.07	8.12	5.69	7.69
1.11		7.46	7.73	7.81	7.88
2.04		6.01	6.3	7.76	6.5
3.91		5.67	5.33	5.86	5.19
9.69		5.63	5.09	4.57	4.99

CETIS Analytical Report

Report Date:	22 Mar-22 16:15 (p 1 of 4)
Test Code/ID:	212491a / 05-9844-4680

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-7438-7074	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:13	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	340F1E162E595A1830DF59F93CF67E40	**Editor ID:**	002-888-235-1

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo		
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ Hardness-adjusted lab control + APHA		
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**			
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:**	9d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	14 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	24h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Lab Water passed frond count endpoint	7.60%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Negative Control		Lab Water	6	1.414	1.943	4.809	CDF	0.1035	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	24.5	24.5	1	2	0.2070	Non-Significant Effect
Error	73.5	12.25	6			
Total	98		7			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1	47.47	1.0000	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9304	0.6451	0.5195	Normal Distribution

Frond Count Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	63.25	57.68	68.82	63.5	59	67	1.75	5.53%	0.00%
0.1	L	4	59.75	54.18	65.32	59.5	56	64	1.75	5.86%	5.53%

Frond Count Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	62	67	59	65
0.1	L	58	64	61	56

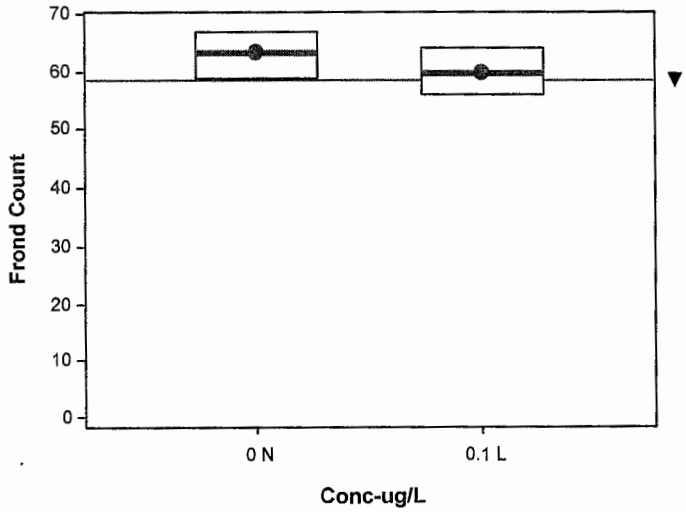
N = negative control
L = lab control (hardness-adjusted)

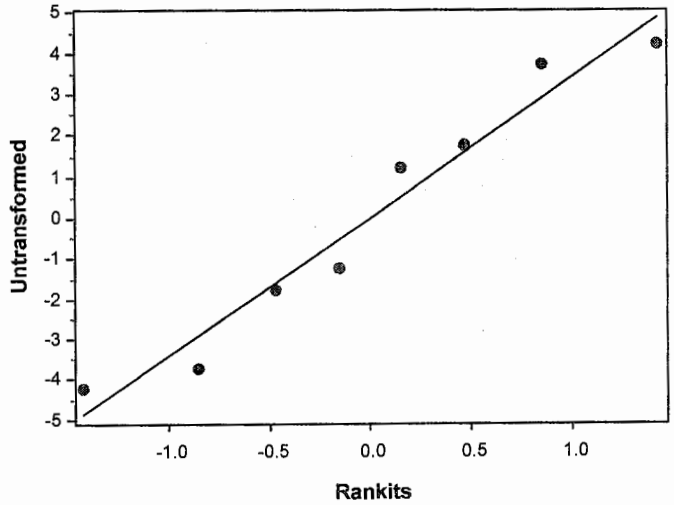
Analyst: MDO QA: JGa Mar. 25/22

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-7438-7074	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:13	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	340F1E162E595A1830DF59F93CF67E40	**Editor ID:**	002-888-235-1

Graphics





EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	10-5830-7268	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:13	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	44BE988FA259392E14A163120AE72E07	**Editor ID:**	002-888-235-1

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo		
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ MDO Hardness-adjusted lab control + APHA		
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**			
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:**	9d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	12 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	24h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Lab Water passed total dry weight-mg endpoint	6.91%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Negative Control		Lab Water	6	-2.103	1.943	0.5128	CDF	0.9600	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.616237	0.616237	1	4.425	0.0801	Non-Significant Effect
Error	0.83563	0.139272	6			
Total	1.45187		7			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	3.855	47.47	0.2970	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9338	0.6451	0.5511	Normal Distribution

Total Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	7.42	6.672	8.168	7.3	7.04	8.04	0.2351	6.34%	0.00%
0.1	L	4	7.975	7.594	8.356	7.91	7.78	8.3	0.1198	3.00%	-7.48%

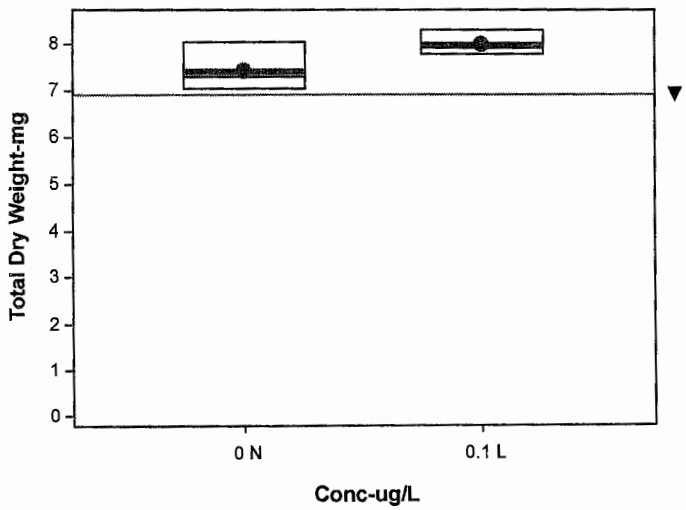
Total Dry Weight-mg Detail

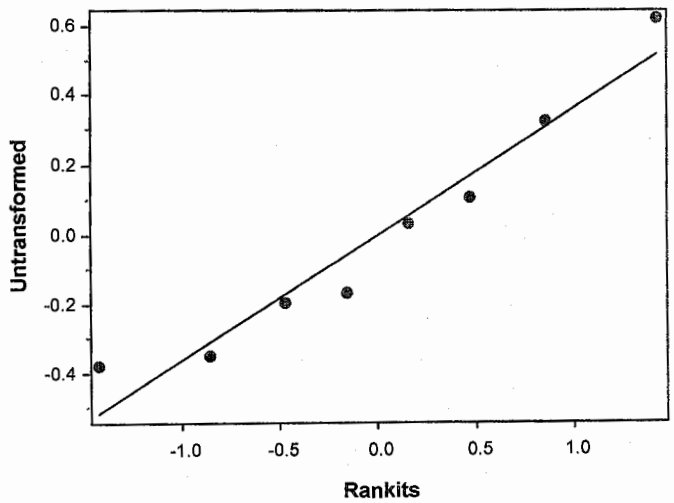
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	7.53	8.04	7.07	7.04
0.1	L	7.81	8.01	8.3	7.78

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	10-5830-7268	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:13	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	44BE988FA259392E14A163120AE72E07	**Editor ID:**	002-888-235-1

Graphics





Analyst: MDO QA: JGW Mar. 25/22

CETIS Analytical Report

Report Date:	22 Mar-22 16:15 (p 1 of 6)
Test Code/ID:	212491a / 05-9844-4680

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	13-1000-6508	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:14	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	D0DA1FCC476D07166A7EE33D33DB803	**Editor ID:**	002-888-235-1

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	Modified APHA + hardness adjusted lab control
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**	
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490 **Age:** 9d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	14 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	14 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	24h	**Client:**	Pretivm Resources Inc.		

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Normal [ω=1]	Off [μ*=μ]	None	None

Regression Summary

Iters	LL	AICc	BIC	Adj R2	PMSD	Thresh	Optimize	F Stat	P-Value	Decision(α:5%)
16	-52.74	112.3	115.9	0.7610	6.91%	62.01	Yes	2.413	0.0659	Non-Significant Lack-of-Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	1.473	0.8191	2.149
IC15	2.201	1.398	3.064
IC20	2.978	2.068	3.982
IC25	3.823	2.831	4.938
IC40	6.978	5.456	8.807
IC50	9.922	7.314	13.46

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	62.01	2.094	57.72	66.29	29.62	<1.0E-05	Significant Parameter
γ	1.152	0.2567	0.627	1.677	4.488	0.0001	Significant Parameter
δ	9.922	1.43	6.996	12.85	6.936	<1.0E-05	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	95470	31820	3	1102	<1.0E-05	Significant Effect
Lack of Fit	280.2	56.03	5	2.413	0.0659	Non-Significant Lack-of-Fit
Pure Error	557.3	23.22	24			
Residual	837.4	28.88	29			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variance	Bartlett Equality of Variance Test	8.715	14.07	0.2738	Equal Variances
	Mod Levene Equality of Variance	0.6956	2.423	0.6752	Equal Variances
Distribution	Anderson-Darling A2 Test	0.1222	2.492	1.0000	Normal Distribution
	Shapiro-Wilk W Normality Test	0.9942	0.9338	0.9997	Normal Distribution

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	13-1000-6508	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:14	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	D0DA1FCC476D07166A7EE33D33DB803	**Editor ID:**	002-888-235-1

Frond Count Summary

			Calculated Variate							
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.1	L	4	59.75	59.5	56	64	1.75	3.5	5.86%	0.00%
0.41		4	59	59	57	61	0.9129	1.826	3.09%	1.26%
0.46		4	61.25	62	53	68	3.119	6.238	10.19%	-2.51%
0.7		4	58.5	59	48	68	4.093	8.185	13.99%	2.09%
1.11		4	61.75	61.5	55	69	2.926	5.852	9.48%	-3.35%
2.04		4	56	56.5	51	60	1.871	3.742	6.68%	6.28%
3.91		4	40.5	40	38	44	1.323	2.646	6.53%	32.22%
9.69		4	33.5	34.67	30	36	1.5	3	8.96%	43.93%

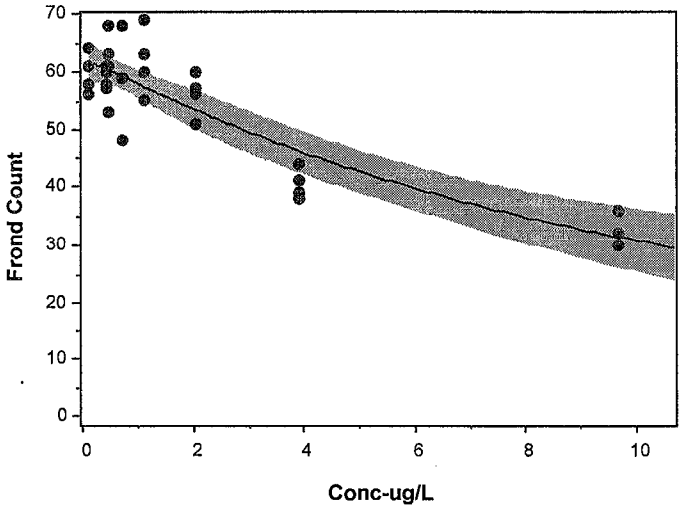
Frond Count Detail

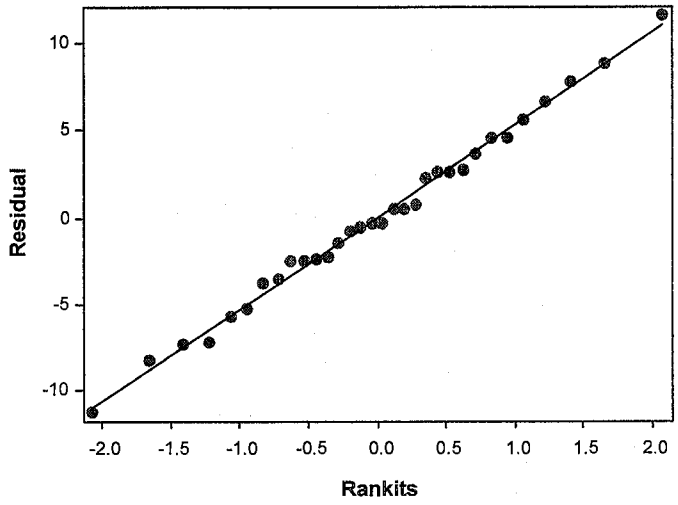
Conc-ug/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
0.1	L	58	64	61	56
0.41		58	60	61	57
0.46		68	63	53	61
0.7		68	59	48	59
1.11		55	60	63	69
2.04		51	56	60	57
3.91		44	39	41	38
9.69		32	36	30	36

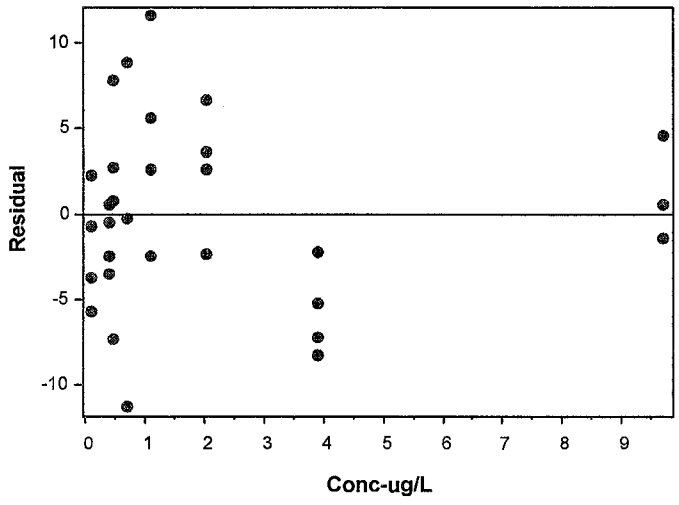
EC Lemna Growth Inhibition Test — **Nautilus Environmental**

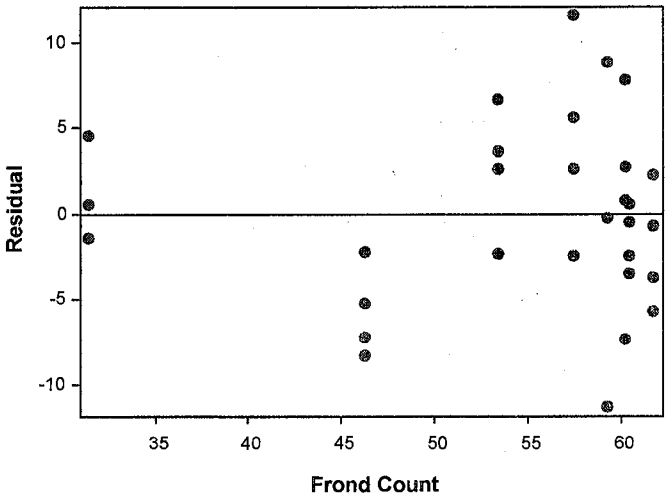
Analysis ID:	13-1000-6508	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:14	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	D0DA1FCC476D07166A7EE33D33DB803	**Editor ID:**	002-888-235-1

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Normal [ω=1]









EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-0067-8792	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:14	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	02CD75FFA5DCF4A138ED467242BA54BC	**Editor ID:**	002-888-235-1

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo		
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	Modified APHA + hardness adjusted lab control		
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**			
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:**	9d

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	13 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	24h	**Client:**	Pretivm Resources Inc.		

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Normal [ω=1]	Off [μ*=μ]	None	None

Regression Summary

Iters	LL	AICc	BIC	Adj R2	PMSD	Thresh	Optimize	F Stat	P-Value	Decision(α:5%)
9	15.33	-23.81	-20.27	0.6993	12.25%	8.275	Yes	1.343	0.2804	Non-Significant Lack-of-Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	0.6599	0.3398	1.072
IC15	1.295	0.7666	1.967
IC20	2.151	1.39	3.113
IC25	3.271	2.27	4.524
IC40	8.98	5.817	13.53
IC50	16.21	8.42	31.22

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	8.275	0.4955	7.261	9.288	16.7	<1.0E-05	Significant Parameter
γ	0.6863	0.2118	0.2531	1.12	3.24	0.0030	Significant Parameter
δ	16.21	4.201	7.62	24.81	3.859	0.0006	Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	1565	521.8	3	1273	<1.0E-05	Significant Effect
Lack of Fit	2.599	0.5199	5	1.343	0.2804	Non-Significant Lack-of-Fit
Pure Error	9.291	0.3871	24			
Residual	11.89	0.41	29			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variance	Bartlett Equality of Variance Test	13.78	14.07	0.0552	Equal Variances
	Mod Levene Equality of Variance	0.6951	2.423	0.6756	Equal Variances
Distribution	Anderson-Darling A2 Test	0.3562	2.492	0.4617	Normal Distribution
	Shapiro-Wilk W Normality Test	0.9643	0.9338	0.3595	Normal Distribution

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-0067-8792	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:14	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	02CD75FFA5DCF4A138ED467242BA54BC	**Editor ID:**	002-888-235-1

Total Dry Weight-mg Summary

			Calculated Variate							
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.1	L	4	7.975	7.91	7.78	8.3	0.1198	0.2395	3.00%	0.00%
0.41		4	7.535	7.54	7.08	7.98	0.2027	0.4055	5.38%	5.52%
0.46		4	7.56	7.785	6.43	8.24	0.3988	0.7977	10.55%	5.20%
0.7		4	7.392	7.88	5.69	8.12	0.5756	1.151	15.57%	7.30%
1.11		4	7.72	7.77	7.46	7.88	0.09194	0.1839	2.38%	3.20%
2.04		4	6.642	6.4	6.01	7.76	0.3858	0.7717	11.62%	16.71%
3.91		4	5.513	5.5	5.19	5.86	0.1535	0.3071	5.57%	30.88%
9.69		4	5.07	5.04	4.57	5.63	0.218	0.436	8.60%	36.43%

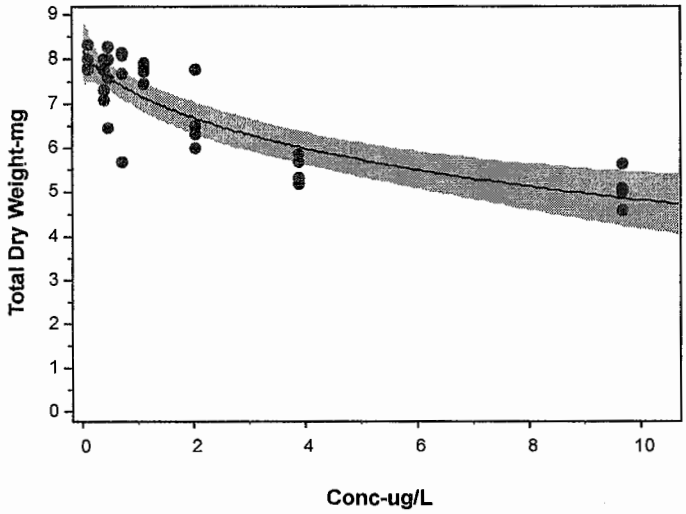
Total Dry Weight-mg Detail

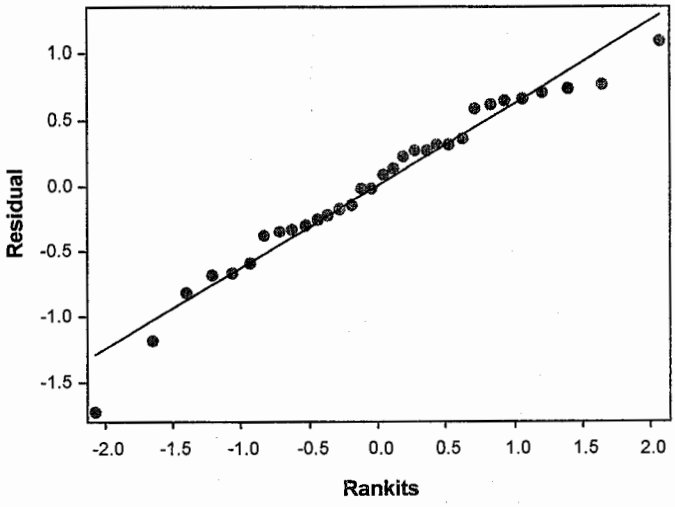
Conc-ug/L	**Code**	**Rep 1**	**Rep 2**	**Rep 3**	**Rep 4**
0.1	L	7.81	8.01	8.3	7.78
0.41		7.33	7.75	7.98	7.08
0.46		7.97	8.24	6.43	7.6
0.7		8.07	8.12	5.69	7.69
1.11		7.46	7.73	7.81	7.88
2.04		6.01	6.3	7.76	6.5
3.91		5.67	5.33	5.86	5.19
9.69		5.63	5.09	4.57	4.99

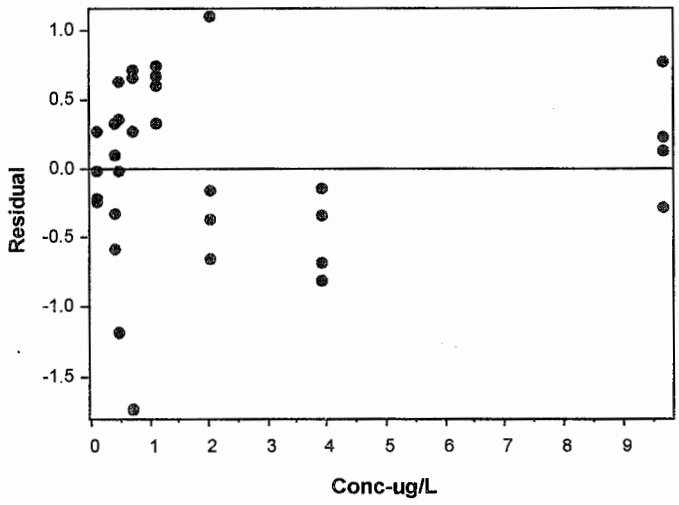
EC Lemna Growth Inhibition Test — **Nautilus Environmental**

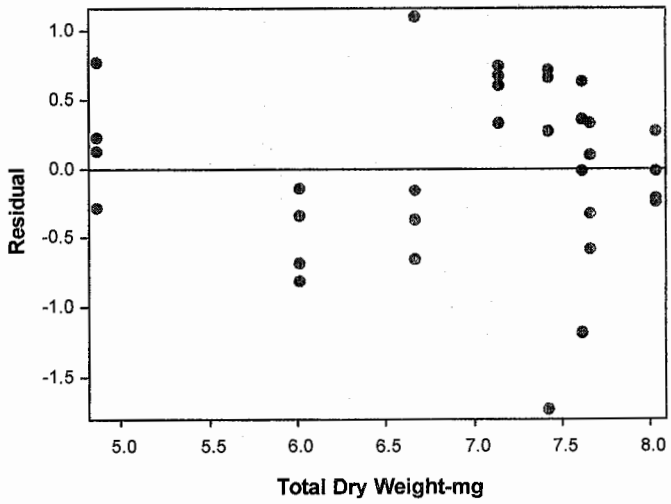
Analysis ID:	12-0067-8792	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	22 Mar-22 16:14	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	22 Mar-22 16:11	**MD5 Hash:**	02CD75FFA5DCF4A138ED467242BA54BC	**Editor ID:**	002-888-235-1

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Normal [ω=1]









Lemna minor Summary Sheet

Client: Pretium / Lorax
Work Order No.: 212491

Start Date: Jan. 14/22
Set up by: GM

Sample Information:

Sample ID: Cu in site control (BJ 3.10)
Sample Date: Jan. 10/22
Date Received: Jan. 13/22
Sample Volume: 5 x 20L

Test Organism Information:

Culture Date: Jan. 5/22
Age of culture (Day 0): 9 days
>8X growth in APHA?: Y (63 fronds)

KCl Reference Toxicant Results:

Reference Toxicant ID: Lm215
Date Initiated: Jan. 12/22

7-d No. of Fronds IC50 (95% CL): 2.9 (2.7-3.1) g/L KCl

7-d No. Fronds IC50 Reference Toxicant Mean (2 SD Range): 3.3 (2.8-3.9) g/L KCl CV (%): 8

Test Results: (measured values)

µg/L Cu	Number of Fronds	Dry Weight
IC25 ~~%(v/v)~~ (95% CL)	3.2 (2.6-3.8)	4.2 (2.7-7.6)
IC50 ~~%(v/v)~~ µg/L (95% CL)	>10.34	>10.34

Reviewed by: JGh

Date reviewed: Mar. 25/22

Plant Growth Inhibition Toxicity Test
Water Quality Measurements

Client :	Pretium / Lorax	**Setup by:**	GM
Sample ID:	Cu in site control (BJ 3.10)	**Test Date:**	Jan. 14/22
Work Order No.:	212491	**CER #:**	9
Culture Source:	CPCC #490	**Test Species:**	*Lemna minor*
Test Culture Age:	9 days	**> 8X Growth? (Y/N):**	y (63 fronds)
Light Intensity Range:	4520 - 5350 lux	**Date Measured:**	Jan. 12/22

Day	0	1	2	3	4	5	6	7
Shelf Temp (°C)	24.5	25.0	25.0	25.0	24.5	24.5	25.0	25.0
Initials	GM	JZL	RZS	RZS	RZS	RZS	RZS	A

Sample Characteristics:	Initial Water Quality			Adjusted Water Quality
Temperature (°C)	25.5	Aeration?: 20 min		25.0
DO (mg/L)	8.9	Nutrients added?[1]: y	→	8.8
pH	7.4			7.6
Conductivity (µS)	316			1085

[1] 10 mL of each APHA stock (A,B and C) added to 970 mL sample.

Concentration (mg/L Cu)	Temperature (°C)		pH		Conductivity (µS)
	Day 0	Day 7	Day 0	Day 7	0 h
Site Control	24.5	25.0	7.7	9.1	1079
0.75	25.0	25.0	7.7	9.4	1073
1.5	25.0	25.0	7.8	9.5	1089
3	25.0	25.0	7.8	9.6	1088
6	25.0	25.0	7.8	9.7	1087
12	25.0	25.0	7.8	9.6	1088
24	25.0	25.0	7.8	8.8	1087
48	25.0	25.0	7.8	8.6	1086
Initials	JZL	A	JZL	A	JZL

Thermometer: CER# 9 Light meter: 1 pH meter/probe: 1 / 1 DO meter/probe: 1 / 1 Conductivity meter/probe: 1 / 1

Sample Description: 0.45 mL of 21 CuO3 (106 mg/L) was added into 1L site control + nutrient solution to reach 48 µg/L Cu. ; clear, colorless, odorless, no particulates.

Comments: DO for site control + nutrient + Cu stock (day 0) = 8.6

Reviewed: JGL **Date Reviewed:** Mar. 25/22

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: Premium / Lorax
Sample ID: Cu in Site Control (BJ 3.10)
Work Order #: 212491

Start Date: Jan. 14/22
Termination Date: Jan 21/22
Test set up by: GM

Concentration (µg/L Cu)	Rep	No. of fronds Day 0	No. of fronds Day 7	Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
Site Control	A	6	67									Algae present on bottom	A
	B		76										
	C		71										
	D		72										
0.75	A		67										
	B		675										
	C		63										
	D		64										
1.5	A		69										
	B		64										
	C		58										
	D		56										
3	A		65										
	B		71										
	C		64										
	D		58										
6	A		60										
	B		59										
	C		67										
	D		62										
12	A		61										
	B		64										
	C		62										
	D		57										

Comments:

Reviewed by: JCh

Date Reviewed: Mar. 25/22

Lemna minor Toxicity Test Data Sheet - 7-d Frond Counts

Client: Premium / Borax
Sample ID: Cu in Site Control (BJ 3.10)
Work Order #: 212491

Start Date: Jan. 14/22
Termination Date: Jan 21/22
Test set up by: [illegible]

Concentration (µg/L Cu)	Rep	No. of fronds Day 0	No. of fronds Day 7	Chlorosis	Necrosis	Yellow	Abnormal size	Gibbosity	Single fronds	Root destruction	Loss of buoyancy	Comments	Initials
24	A	6	40			x						no algae present on beaker bottom	AS
	B		43			x							
	C		42			x							
	D		52			x							
48	A		41			x	x						
	B		43			x	x						
	C		39			x	x						
	D		40			x	x						
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												
	A												
	B												
	C												
	D												

Comments:

Reviewed by: [illegible]

Date Reviewed: Mar. 25/22

7-d *Lemna minor* Weight Data Sheet

Client: Premium Horax

Sample ID: Cu in site control (BJ 3.10)

WO #: 212491

(µg/L Cu) CC green

Start Date: Jan. 14/22

Termination Date: Jan. 21/22

Balance ID: Bal - 1

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
Site control	A	1	1032.17	1038.95	GM/GM
	B	2	1032.95	1040.80	
	C	3	1044.98	1051.81	
	D	4	1052.15	1059.52	
0.75	A	5	1042.57	1052.36	
	B	6	1039.05	1046.17	
	C	7	1040.67	1047.49	
	D	8	1052.97	1059.73	
1.5	A	9	1040.76	1047.97	
	B	10	1048.24	1055.02	
	C	11	1042.60	1049.26	
	D	12	1048.29	1055.11	
3	A	13	1047.66	1054.06	
	B	14	1034.51	1042.52	
	C	15	1042.92	1049.74	
	D	16	1044.36	1050.50	
6	A	17	1033.62	1040.25	
	B	18	1027.99	1034.63	
	C	19	1043.54	1050.99	
	D	20	1046.89	1053.83	
12	A	21	1037.73	1043.90	
	B	22	1056.18	1063.00	
	C	23	1052.45	1058.70	
	D	24	1063.41	1069.94	
24	A	25	1051.87	1056.84	
	B	26	~~1053.08~~ GM 1053.08	1058.10	
	C	27	1037.51	1042.75	
	D	28	1032.25	1038.31	↓

Date/time pan placed in oven: Jan 11/22 @1000h

Date/time pan + organisms placed in (A) oven: Jan 21/22 @ 1205h

Date/time pan removed from oven: Jan. 13/22 @1000h

Date/time pan + organisms removed from oven: Jan. 24/22 @ 1205h

Comments: 10% rewash pan #4 = 1059.45 pan #31 = 1055.01 GM
pan #12 = 1054.99

Reviewed by: JGr

Date Reviewed: Mar. 25/22

7-d *Lemna minor* Weight Data Sheet

Client: Pretium / Lorax

Sample ID: Cu In Site control (B53.10)

WO #: 212491

(mg/L Cu) CCgreen

Start Date: Jan. 14/22

Termination Date: Jan. 21/22

Balance ID: Bal - 1

Concentration	Rep	Pan No.	Pan weight (mg)	Pan + plant (mg)	Initials
48	A	29	1030.47	1035.49	GM / GM
	B	30	1053.67	1058.66	↓
	C	31	1050.15	1055.14	↓
	D	32	1044.12	1048.92	↓
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				
	A				
	B				
	C				
	D				

Date/time pan placed in oven: Jan 11/22 @ 1000h

Date/time pan + organisms placed in oven: (A)

Date/time pan removed from oven: Jan. 13/22 @ 1000h

Date/time pan + organisms removed from oven: Jan. 24/22 @ 1005 h

Comments:

Reviewed by: JCh

Date Reviewed: Mar. 25/22

CETIS Summary Report

Report Date:	09 Mar-22 14:37 (p 1 of 2)
Test Code/ID:	212491b / 14-6262-5326

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo		
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ MOO BJ-3.10		
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**			
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:**	9d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15 ✓	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35 ✓	**CAS (PC):**		**Station:**	BJ-3.10 ✓
Sample Age:	81h (10.6 °C) ✓	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
18-3556-5367	Frond Count	Equal Variance t Two-Sample Test	0.7946	Site Control passed frond count	1
06-2494-7077	Total Dry Weight-mg	Equal Variance t Two-Sample Test	0.2803	Site Control passed total dry weight-mg	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
08-8967-7453	Frond Count	Linear Interpolation (ICPIN)	✓	IC10	0.4863	0.2645	2.376	1
			✓	IC15	1.837	---	3.356	
			✓	IC20	2.865	0.8252	3.352	
			✓	IC25	3.227	2.601	3.835	
			✓	IC40	4.529	3.72	8.811	
			✓	IC50	>10.34	---	---	
16-5069-1625	Total Dry Weight-mg	Linear Interpolation (ICPIN)		IC10	1.982	---	3.452	1
				IC15	2.812	0.1289	3.809	
				IC20	3.435	2.104	5.013	
				IC25	4.161	2.715	7.571	
				IC40	>10.34	---	---	
			✓	IC50	>10.34	---	---	

Frond Count Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	4	63.25	57.68	68.82	59	67	1.75	3.5	5.53%	0.00%
0.1	XC	4	65.5	59.62	71.38	61	70	1.848	3.697	5.64%	-3.56%
0.5		4	58.75	56.03	61.47	57	61	0.8539	1.708	2.91%	7.11%
0.7		4	55.75	46.35	65.15	50	63	2.955	5.909	10.60%	11.86%
1.05		4	58.5	50.03	66.97	52	65	2.661	5.323	9.10%	7.51%
1.53		4	56	50.34	61.66	53	61	1.78	3.559	6.36%	11.46%
2.6		4	55	50.32	59.68	51	58	1.472	2.944	5.35%	13.04%
4.69		4	38.25	29.79	46.71	34	46	2.658	5.315	13.90%	39.53%
10.34		4	34.75	32.03	37.47	33	37	0.8539	1.708	4.91%	45.06%

Total Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	4	7.42	6.672	8.168	7.04	8.04	0.2351	0.4703	6.34%	0.00%
0.1 ✓	XC	4	7.208	6.404	8.011	6.78	7.85	0.2524	0.5048	7.00%	2.86%
0.5 ✓		4	7.622	5.31	9.935	6.76	9.79	0.7268	1.454	19.07%	-2.73%
0.7 ✓		4	6.867	6.488	7.247	6.66	7.21	0.1191	0.2382	3.47%	7.45%
1.05 ✓		4	6.842	5.526	8.159	6.14	8.01	0.4136	0.8272	12.09%	7.78%
1.53 ✓		4	6.915	6.303	7.527	6.63	7.45	0.1923	0.3845	5.56%	6.81%
2.6 ✓		4	6.442	5.973	6.912	6.17	6.82	0.1476	0.2952	4.58%	13.17%
4.69 ✓		4	5.323	4.518	6.127	4.97	6.06	0.2527	0.5055	9.50%	28.27%
10.34 ✓		4	4.95	4.789	5.111	4.8	5.02	0.05049	0.101	2.04%	33.29%

N = negative (lab) control
XC = site control

Analyst: MDO QA: Mar-25/22

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Frond Count Detail — MD5: 33362B954348642D549A5E8ED2FF06C2

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	62	67	59	65
0.1	XC	61	70	65	66
0.5		61	59	57	58
0.7		63	58	52	50
1.05		59	65	58	52
1.53		54	53	61	56
2.6		55	58	56	51
4.69		34	37	36	46
10.34		35	37	33	34

Total Dry Weight-mg Detail — MD5: 36E5B7EBB024484D79CB1D90534995D6

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	7.53	8.04	7.07	7.04
0.1	XC	6.78	7.85	6.83	7.37
0.5		9.79	7.12	6.82	6.76
0.7		7.21	6.78	6.66	6.82
1.05		6.4	8.01	6.82	6.14
1.53		6.63	6.64	7.45	6.94
2.6		6.17	6.82	6.25	6.53
4.69		4.97	5.02	5.24	6.06
10.34		5.02	4.99	4.99	4.8

CETIS Analytical Report

Report Date:	09 Mar-22 13:54 (p 1 of 4)
Test Code/ID:	212491b / 14-6262-5326

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	18-3556-5367	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:53	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	8D6FD7794CD5BB17591B0FF86EE728E5	**Editor ID:**	003-659-051-0

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo		
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ BJ-3.10 MDO		
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**			
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:**	9d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	81h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Site Control passed frond count endpoint	7.82%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Negative Control		Site Control	6	-0.8839	1.943	4.946	CDF	0.7946	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	10.125	10.125	1	0.7814	0.4107	Non-Significant Effect
Error	77.75	12.9583	6			
Total	87.875		7			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1.116	47.47	0.9304	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9419	0.6451	0.6302	Normal Distribution

Frond Count Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	63.25	57.68	68.82	63.5	59	67	1.75	5.53%	0.00%
0.1	XC	4	65.5	59.62	71.38	65.5	61	70	1.848	5.64%	-3.56%

Frond Count Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	62	67	59	65
0.1	XC	61	70	65	66

Analyst: MDO QA: JGW Mar-25/22

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	18-3556-5367	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:53	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	8D6FD7794CD5BB17591B0FF86EE728E5	**Editor ID:**	003-659-051-0

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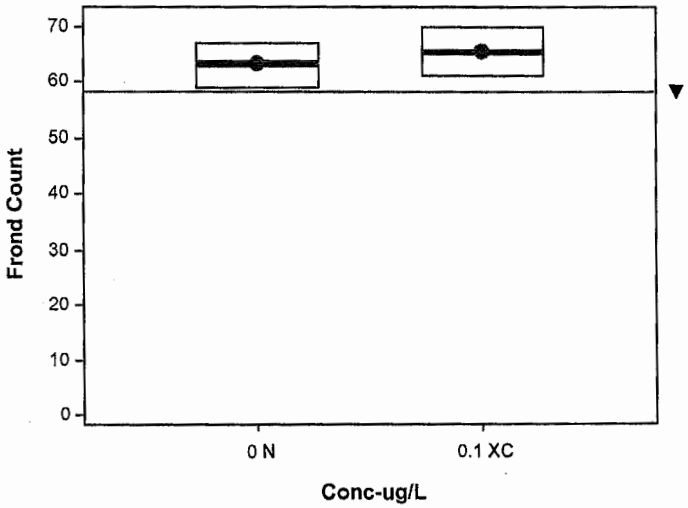
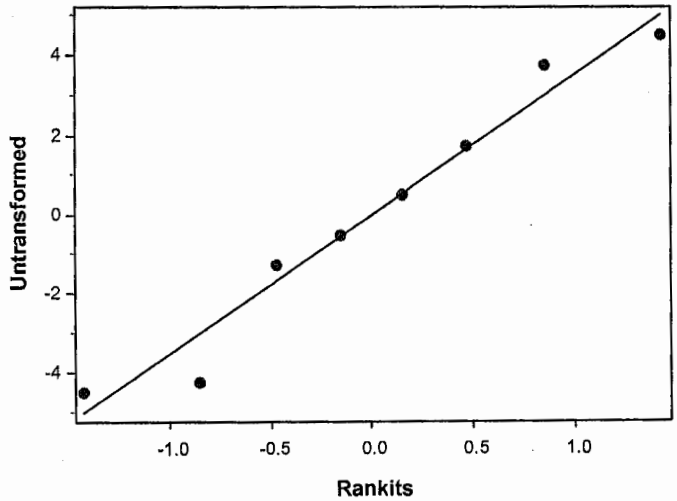




CETIS Analytical Report

Report Date:	09 Mar-22 13:54 (p 1 of 4)
Test Code/ID:	212491b / 14-6262-5326

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	08-8967-7453	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:54	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	8391822CA6A99B5EE5FCC7AEFC2BC873	**Editor ID:**	003-659-051-0

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo	
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ BJ-3.10	
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**		
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:** 9d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	81h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	858626	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	0.4863	0.2645	2.376
IC15	1.837	---	3.356
IC20	2.865	0.8252	3.352
IC25	3.227	2.601	3.835
IC40	4.529	3.72	8.811
IC50	>10.34	---	---

Frond Count Summary

			Calculated Variate						Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**Mean**	**%Effect**
0.1	XC	4	65.5	65.5	61	70	5.64%	0.00%	65.5	0.00%
0.5		4	58.75	58.5	57	61	2.91%	10.31%	58.75	10.31%
0.7		4	55.75	55	50	63	10.60%	14.89%	57.13	12.79%
1.05		4	58.5	58.5	52	65	9.10%	10.69%	57.13	12.79%
1.53		4	56	55	53	61	6.36%	14.50%	56	14.50%
2.6		4	55	55.5	51	58	5.35%	16.03%	55	16.03%
4.69		4	38.25	36.5	34	46	13.90%	41.60%	38.25	41.60%
10.34		4	34.75	34.5	33	37	4.91%	46.95%	34.75	46.95%

Frond Count Detail

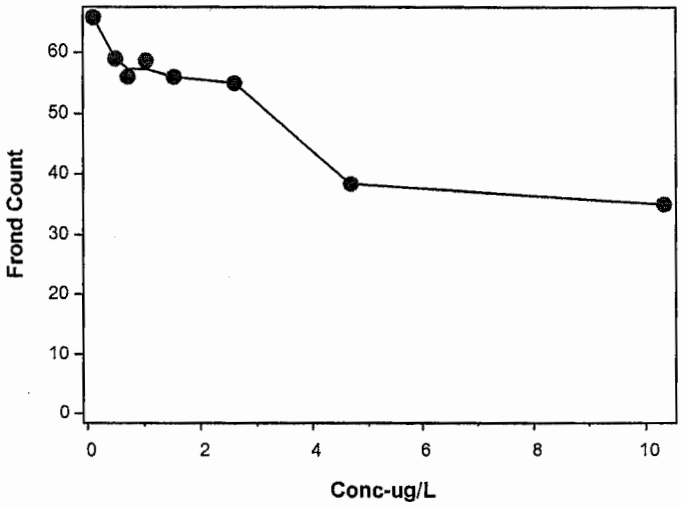
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0.1	XC	61	70	65	66
0.5		61	59	57	58
0.7		63	58	52	50
1.05		59	65	58	52
1.53		54	53	61	56
2.6		55	58	56	51
4.69		34	37	36	46
10.34		35	37	33	34

Analyst: MDO QA: Mar-25/22

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	08-8967-7453	**Endpoint:**	Frond Count	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:54	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	8391822CA6A99B5EE5FCC7AEFC2BC873	**Editor ID:**	003-659-051-0

Graphics



Analyst: MDO QA: Mar. 25/22

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	06-2494-7077	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:53	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	85DC57B7A6AF3A8B779E429FC4457AB8	**Editor ID:**	003-659-051-0

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo	
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ BJ-3.10 MDO	
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**		
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:** 9d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	81h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Site Control passed total dry weight-mg endpoint	9.03%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Negative Control		Site Control	6	0.6158	1.943	0.6704	CDF	0.2803	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0902554	0.0902554	1	0.3792	0.5607	Non-Significant Effect
Error	1.42815	0.238025	6			
Total	1.5184		7			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1.152	47.47	0.9099	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.8234	0.6451	0.0506	Normal Distribution

Total Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	4	7.42	6.672	8.168	7.3	7.04	8.04	0.2351	6.34%	0.00%
0.1	XC	4	7.208	6.404	8.011	7.1	6.78	7.85	0.2524	7.00%	2.86%

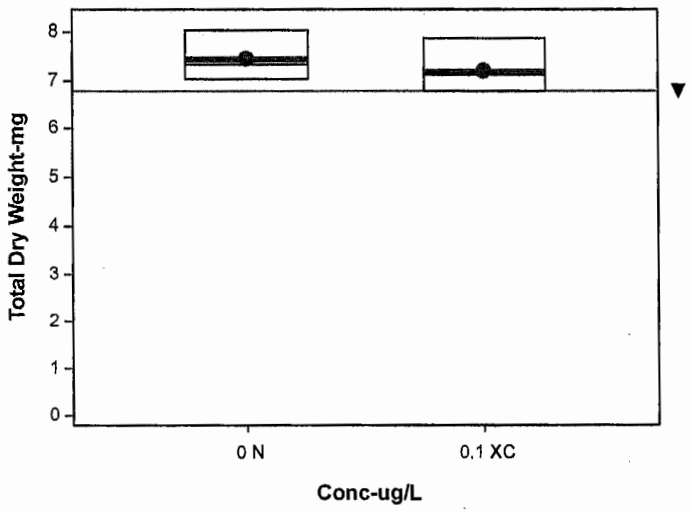
Total Dry Weight-mg Detail

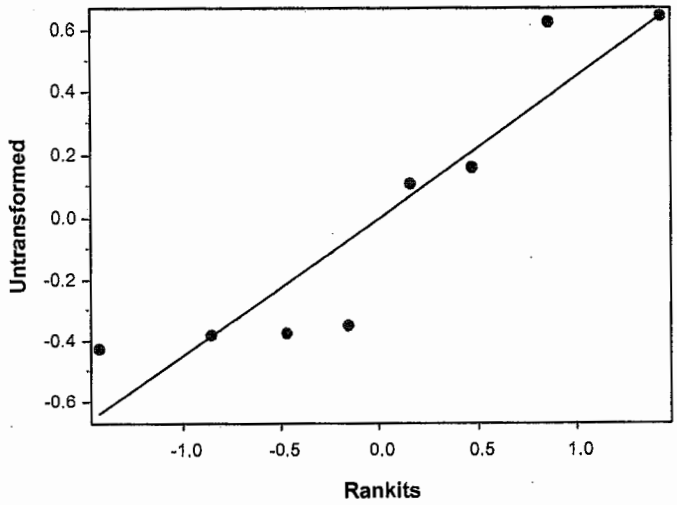
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0	N	7.53	8.04	7.07	7.04
0.1	XC	6.78	7.85	6.83	7.37

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	06-2494-7077	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:53	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	85DC57B7A6AF3A8B779E429FC4457AB8	**Editor ID:**	003-659-051-0

Graphics





EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-5069-1625	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:54	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	68D15E5C41DC54FDE91FEDF9C1911A99	**Editor ID:**	003-659-051-0

Batch ID:	01-8792-2739	**Test Type:**	Lemna Growth	**Analyst:**	Gabriella Utomo		
Start Date:	14 Jan-22	**Protocol:**	EC/EPS 1/RM/37	**Diluent:**	~~Modified APHA~~ BJ-3.10 MDO		
Ending Date:	21 Jan-22	**Species:**	Lemna minor	**Brine:**			
Test Length:	7d 0h	**Taxon:**	Tracheophyta	**Source:**	CPCC#490	**Age:**	9d

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	81h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1163819	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	1.982	---	3.452
IC15	2.812	0.1289	3.809
IC20	3.435	2.104	5.013
IC25	4.161	2.715	7.571
IC40	>10.34	---	---
IC50	>10.34	---	---

Total Dry Weight-mg Summary

			Calculated Variate						Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**Mean**	**%Effect**
0.1	XC	4	7.208	7.1	6.78	7.85	7.00%	0.00%	7.415	0.00%
0.5		4	7.622	6.97	6.76	9.79	19.07%	-5.76%	7.415	0.00%
0.7		4	6.867	6.8	6.66	7.21	3.47%	4.72%	6.875	7.28%
1.05		4	6.842	6.61	6.14	8.01	12.09%	5.06%	6.875	7.28%
1.53		4	6.915	6.79	6.63	7.45	5.56%	4.06%	6.875	7.28%
2.6		4	6.442	6.39	6.17	6.82	4.58%	10.61%	6.442	13.12%
4.69		4	5.323	5.13	4.97	6.06	9.50%	26.15%	5.323	28.22%
10.34		4	4.95	4.99	4.8	5.02	2.04%	31.32%	4.95	33.24%

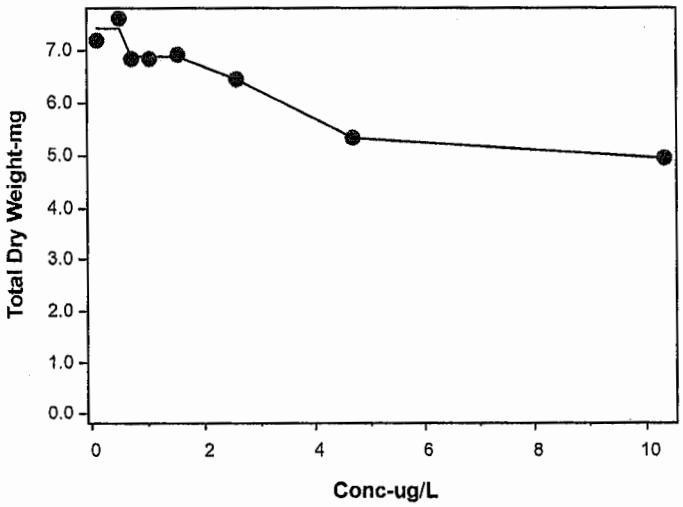
Total Dry Weight-mg Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4
0.1	XC	6.78	7.85	6.83	7.37
0.5		9.79	7.12	6.82	6.76
0.7		7.21	6.78	6.66	6.82
1.05		6.4	8.01	6.82	6.14
1.53		6.63	6.64	7.45	6.94
2.6		6.17	6.82	6.25	6.53
4.69		4.97	5.02	5.24	6.06
10.34		5.02	4.99	4.99	4.8

EC Lemna Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-5069-1625	**Endpoint:**	Total Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 13:54	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	21 Jan-22 0:00	**MD5 Hash:**	68D15E5C41DC54FDE91FEDF9C1911A99	**Editor ID:**	003-659-051-0

Graphics



APPENDIX D – *Chironomus dilutus* Toxicity Test Data

Chironomus dilutus Water-only Test Summary Sheet

Client: Lorax/Pretium Resources Inc.
Work Order No.: 212489

Start Date: Jan 21/22
Set up by: JZL/KJL/DK

Sample Information:

Sample ID: Cu in Lab Water
Sample Date: Jan 20/22
Date Received: Jan 20/22
Sample Volume: N/A

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: Jan 19/22
Age or size (Day 0): 3rd in-star

KCl Reference Toxicant Results:

Reference Toxicant ID: CT106
Stock Solution ID: n/a
Date Initiated: Jan 21/22

96-h LC50 (95% CL): 4.5 (3.3-6.3) g/L KCl

96-h LC50 Reference Toxicant Mean and Range: 5.4 (3.8-7.6) g/L KCl CV (%): 17

Test Results:
(measured values)
ug/L Cu

	Survival	Dry Weight
LC25 (%v/v) (95% CL)	>32.75	—
LC50(%v/v) (95% CL)	>32.75	—
IC25(%v/v) (95% CL)	—	>32.75
IC50(%v/v) (95% CL)	—	>32.75
MDO ~~NOEC~~ MDO	—	—
~~LOEC~~ MDO	—	—

Reviewed by: JOL

Date reviewed: Mar. 28/22

Water Only

10-d Chironomid ~~Sediment~~ Water Only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water Only 10-d Water Quality

Client: Lorax / Pretium Resources Inc.
W.O #: 212489
Cu in Lab water (green)

Start Date: Jan 24/22
Termination Date: ~~Jan. 24/22~~ Jan. 31/22
CER #: 12
Test Organism: *Chironomus dilutus*

Temperature (°C)

Sample ID (µg/L Cu)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Ctrl	22.0	22.5	22.0	22.5	22.0	22.5	22.0	22.0	22.0	22.0	22.0	22.0	22.5	22.5
Perrier Ctrl	22.0	22.5	↓	22.0	22.0	22.0	↓	22.0	↓	↓	22.0	↓	↓	22.0
0.75	22.0	22.5	↓	↓	↓	22.5	↓	↓	↓	↓	↓	↓	↓	↓
1.5	22.0	22.5	↓	↓	↓	22.0	↓	↓	↓	↓	↓	↓	↓	↓
3	22.0	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
6	22.0	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
12	22.0	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
24	22.0	22.5	↓	↓	↓	22.5	↓	↓	↓	↓	↓	↓	↓	↓
48	22.0	22.5	↓	↓	↓	22.5	↓	↓	↓	↓	↓	↓	↓	↓
Technician Initials	JGL	JGL	PYN	RZS	RZS	RZS	RZS	RZS	RZS	GM	GM	GM	PYN	RZS

Thermometer: CER #12

Conductivity (µS)

Sample ID (µg/L Cu)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Ctrl	424	454	443	468	429	425	420	426	442	458	420	450	473	484
Perrier Ctrl	158	201	212	224	160	186	200	158	183	196	158	186	200	209
0.75	158	192	188	198	158	183	194	158	176	187	159	180	190	201
1.5	158	191	186	193	158	171	182	158	175	187	159	179	189	200
3	158	200	188	197	158	178	189	158	175	185	158	185	197	206
6	158	190	188	197	158	176	187	158	172	181	159	173	180	186
12	158	190	193	201	158	184	196	158	177	188	158	175	180	186
24	157	190	185	194	158	179	191	158	185	198	159	180	189	194
48	158	193	188	199	157	177	189	158	179	190	158	178	187	192
Technician Initials	JGL	JGL	PYN	RZS	RZS	RZS	RZS	RZS	RZS	GM	GM	GM	PYN	RZS

Conductivity meter/probe: 3 / 3

Comments:

Reviewed by: JGL

Date Reviewed: Mar. 25/22

10-d Chironomid ~~Sediment~~ Water Only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water Only 10-d Water Quality

Client: Lorax/Pretium Resources Inc.
W.O #: 212489
Sample ID: Cu in lab water green

Start Date: Jan 21/22
Termination Date: ~~Jan. 24/22~~ Jan 31/22
CER #: 12
Test Organism: *Chironomus dilutus*

Dissolved Oxygen (mg/L)

Sample ID (µg/L Cu)	Day 0	1	2	3 Old①	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Ctrl	7.7	6.1	4.9	3.9	8.1	8.0	8.6	8.6	7.8	8.3	8.0	8.0	7.8	7.8
Perrier Ctrl	7.8	6.3	4.9	4.2	8.0	8.0	7.5	8.1	7.7	8.3	8.5	8.1	7.9	8.0
0.75	7.8	6.0	4.8	4.4	8.0	8.0	7.5	8.0	7.8	8.3	8.6	8.1	8.0	8.0
1.5	7.8	5.8	4.8	4.5	8.1	8.0	7.7	7.9	7.8	8.3	8.6	8.1	8.0	7.9
3	7.8	5.9	4.5	4.3	8.1	8.0	7.8	7.9	7.4	8.3	8.6	8.1	8.0	8.0
6	8.0	5.9	4.7	4.1	8.1	8.1	7.8	8.0	7.6	8.3	8.5	8.2	8.0	8.0
12	8.0	5.9	4.9	4.5	8.1	8.1	7.8	8.0	7.8	8.3	8.5	8.2	8.0	8.0
24	8.0	5.8	5.0	4.5	8.2	8.1	7.8	8.0	7.8	8.2	8.5	8.2	8.0	8.1
48	8.0	5.7	4.9	4.1	8.2	8.1	7.9	8.1	7.8	8.1	8.5	8.2	8.0	8.1
Technician Initials	JZ	JM	PYK	RZS	RZS	RZS	RZS	RZS	RZS	GM	GM	GM	PYK	RZS

DO meter/probe: 3 / 3

pH

Sample ID (µg/L Cu)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Lab Ctrl	7.8	7.2	6.9	6.8	7.8	7.6	7.8	7.8	7.7	7.7	7.6	7.8	7.5	7.6
Perrier Ctrl	7.7	7.2	6.9	6.8	7.6	7.6	7.7	7.5	7.7	7.6	7.5	7.7	7.5	7.6
0.75	7.7	7.1	6.8	6.8	7.6	7.5	7.6	7.5	7.7	7.6	7.5	7.7	7.4	7.4
1.5	7.7	7.1	6.8	6.8	7.6	7.6	7.7	7.5	7.7	7.6	7.5	7.8	7.4	7.5
3	7.7	7.2	6.7	6.8	7.6	7.6	7.7	7.5	7.6	7.5	7.5	7.8	7.5	7.6
6	7.7	7.2	6.7	6.8	7.6	7.6	7.7	7.5	7.6	7.6	7.5	7.7	7.5	7.5
12	7.7	7.2	6.7	6.9	7.6	7.7	7.7	7.5	7.7	7.6	7.5	7.7	7.5	7.6
24	7.7	7.2	6.7	6.9	7.6	7.7	7.7	7.5	7.7	7.6	7.6	7.7	7.5	7.6
48	7.7	7.2	6.7	6.8	7.6	7.7	7.7	7.5	7.7	7.6	7.6	7.7	7.5	7.6
Technician Initials	JZ	JM	PYK	RZS	RZ	RZS	RZS	RZS	RZS	GM	GM	GM	PYK	RZ

pH meter/probe: 3 / 3

Light meter: Lit-1
Light intensity (Lux): 450-890
Comments: ① Iniated aeration

Reviewed by: JM
Date Reviewed: Mar. 25/22

10-d Chironomid ~~Sediment~~ Water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water only 10-d Survival and Weight

Client: Lorax | Pretivm Resources Inc.
W.O. #: 212489
Sample ID: Cu in Perrier Control

Start Date: Jan. 21/22
Termination Date: Jan. 31/22
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID (mg/L Cu)	Pan No. (Cu black)	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	1	A	9 ①	0	1	BAM/MDO	1006.13	1023.58	9	EC/JZZ
Perrier Control	2	B	9 ①	0	1	BAM/	1012.83	1028.58	9	
	3	C	8 ①	0	2	BAM/	1022.32	1036.54	8	
	4	D	10	0	0	BAM/	1026.98	1046.40	10	
	5	E	10	0	0	BAM/	1015.75	1036.32	10	
0.75	6	A	7 ①	0	3	KAL/	1008.92	1024.00	7	
	7	B	10	0	0	KAL/	1022.35	1039.17	10	
	8	C	10	0	0	KAL/	EC ~~1026.18~~ 1026.12	1043.83	10	
	9	D	10	0	0	KAL/	1069.31	1086.58	10	
	10	E	10	0	0	KAL/	1019.60	1034.15	10	
1.5	11	A	9	0	1	BAM/	1069.94	1087.52	9	
	12	B	10	0	0	BAM/	1012.56	1030.25	10	
	13	C	8	0	2	BAM/	1017.71	1033.14	8	
	14	D	10	0	0	BAM/	995.00	1013.50	10	
	15	E	10	0	0	BAM/	1032.50	1054.08	10	
3	16	A	10	0	0	MDO	1050.65	1067.91	10	
	17	B	8	0	2	MDO	1048.32	1065.08	8	
	18	C	10	0	0	RZS	1050.48	1066.99	10	
	19	D	10	0	0		1064.90	1082.18	10	
	20	E	9	0	1		1062.11	1080.91	9	

Date/time pan placed in oven: Dec. 21/~~22~~ 21 @ 0900
Date/time pan removed from oven: Dec. 22/21 @ 0900

Date/time pan + organisms placed in oven: Jan. 31/22 @ 1430h
Date/time pan + organisms removed from oven: Feb. 1/22 @ 1430h

Comments: ① Checked by MDO
Reweigh pans: 16 - 1034.06 mg, 19 - 1082.04 mg

Reviewed by: JGL

Date Reviewed: Mar. 25/22

10-d Chironomid ~~Sediment~~ Water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water only 10-d Survival and Weight

Client: Locax / Pretivm Resources Inc.
W.O. #: 212489
Sample ID: Cu in Permeer Control

Start Date: Jan. 21/22
Termination Date: Jan. 31/22
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID (Lyphia)	Cu Pan No. black	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
Control Sediment	21	A	9	0	1	RZS	1055.09	1068.78	9	EC/TM
6	22	B	8	0	2		1059.78	1077.61	8	
	23	C	10	0	0		1060.23	1077.61	10	
	24	D	10	0	0		1060.86	1078.89	10	
	25	E	9	0	1		1061.84	1078.79	9	
12	26	A	9	0	1	KWI	1058.38	1073.05	9	
	27	B	7①	0	3	KWI	1048.67	1062.87	7	
	28	C	10	0	0	KWI	1050.01	1067.30	10	
	29	D	10	0	0	BAM	1083.07	1104.02	10	
	30	E	7①	0	3	KWI	1060.07	1072.67	7	
24	31	A	10	0	0	RZS	1052.79	1067.84	10	
	32	B	9	0	1		1041.03	1056.63	9	
	33	C	10	0	0		1019.14	1035.74	10	
	34	D	10	0	0		1025.49	1045.35	10	
	35	E	7	0	3		1011.28	1024.63	7	
48	36	A	9	1	0	BAM	1048.69	1061.59	9	
	37	B	11	0	0	BAM	1029.87	1050.12	11	
	38	C	9	0	1	BAM	1021.34	1038.12	9	
	39	D	9	0	1	BAM	1007.60	1024.62	~~8~~ 9	
	40	E	10②	0	0	BAM	1006.33	1021.22	9	

Date/time pan placed in oven: Dec. 21/21 @ 0900
Date/time pan removed from oven: Dec. 22/21 @ 0900

Date/time pan + organisms placed in oven: Jan. 31/22 @ 1430h
Date/time pan + organisms removed from oven: Feb. 1/22 @ 1430h

Comments: ① checked by RZS ② Pupae x 1
Reweigh pans: 26 - 1073.01 mg, 36 - 1061.52 mg

Reviewed by: JM

Date Reviewed: Mar. 25/22

10-d Chironomid ~~Sediment~~ Water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water only 10-d Survival and Weight

Client: Lorax / Pretium Resources Inc.
W.O. #: 212489
Sample ID: Cu in lab control

Start Date: Jan. 21/22
Termination Date: Jan. 31/22
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID (mg/L Cu)	Cu Pan No. Blue	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
lab Control ~~Sediment~~ (2)	1	A	10	0	0	MDO	1056.88	1071.94	10	RJS / JGL
	2	B	10	0	0	↓	1045.47	1064.56	10	↓ ↓
	3	C	9	0	1	↓	1048.42	1063.88	9	↓ ↓
	4	D	MDO 9/10	0	0	↓	1038.32	1056.14	10	↓ ↓
	5	E	10①	0	0	↓	1046.96	1063.60	9	↓ ↓
		A								
		B								
		C								
		D								
		E								
		A								
		B								
		C								
		D								
		E								
		A								
		B								
		C								
		D								
		E								

Date/time pan placed in oven: Jan. 24/22 @ 1230h
Date/time pan removed from oven: Jan. 25/22 @ 1230h

Date/time pan + organisms placed in oven: Jan. 31/22 @ 1430h
Date/time pan + organisms removed from oven: Feb. 1/22 @ 1430h

Comments: ① Pupae x 1
Reweigh pan: 1 - 1071.96mg

Reviewed by: JGL

Date Reviewed: Mar. 25/22

CETIS Summary Report

Report Date: 28 Mar-22 11:54 (p 1 of 2)
Test Code/ID: 212489a / 21-3435-0075

Chironomus 10-d Survival and Growth ~~Sediment~~ Water Only Test

Nautilus Environmental

Batch ID:	19-4474-0302	Test Type:	Growth-Survival (10d)	Analyst:	Mikayla Oldach
Start Date:	21 Jan-22	Protocol:	EC/EPS 1/RM/32	Diluent:	Laboratory Water
Ending Date:	31 Jan-22	Species:	Chironomus dilutus	Brine:	
Test Length:	10d 0h	Taxon:		Source:	Aquatic Biosystems, CO Age: 3rd

Sample ID:	05-2581-7971	Code:	Lab Water	Project:	
Sample Date:	13 Jan-22	Material:	Copper	Source:	Pretivm Resources Inc.
Receipt Date:	14 Jan-22 06:00	CAS (PC):		Station:	Lab Water
Sample Age:	8d 0h	Client:	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
15-8842-0919	10d Survival Rate	Fisher Exact Test	0.1811	Method Control passed 10d survival rate	1
06-5066-2648	Mean Dry Weight-mg	Equal Variance t Two-Sample Test	0.9213	Method Control passed mean dry weight-m	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
10-9534-2054	10d Survival Rate	Linear Interpolation (ICPIN)	✓	EC10	>32.75	---	---	1
			✓	EC15	>32.75	---	---	
			✓	EC20	>32.75	---	---	
			✓	EC25	>32.75	---	---	
			✓	EC40	>32.75	---	---	
			✓	EC50	>32.75	---	---	
04-1079-2680	Mean Dry Weight-mg	NLR: 3P Log-Logistic		IC10	42.27	---	147.5	1
				IC15	70.96	---	568.3	
				IC20	104.8	---	3594	
				IC25 >32.75	144.7	---	---	
				IC40	314.3	---	---	
				IC50	495 MDO	---	---	

10d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	LC	5	0.9800	0.9245	1.0360	0.9000	1.0000	0.0200	0.0447	4.56%	0.00%
0.53	MC	5	0.9200	0.8161	1.0240	0.8000	1.0000	0.0374	0.0837	9.09%	6.12%
1.11		5	0.9400	0.7734	1.1070	0.7000	1.0000	0.0600	0.1342	14.27%	4.08%
1.67		5	0.9400	0.8289	1.0510	0.8000	1.0000	0.0400	0.0894	9.52%	4.08%
2.74		5	0.9400	0.8289	1.0510	0.8000	1.0000	0.0400	0.0894	9.52%	4.08%
4.81		5	0.9200	0.8161	1.0240	0.8000	1.0000	0.0374	0.0837	9.09%	6.12%
8.88		5	0.8600	0.6717	1.0480	0.7000	1.0000	0.0678	0.1517	17.63%	12.24%
17.45		5	0.9200	0.7581	1.0820	0.7000	1.0000	0.0583	0.1304	14.17%	6.12%
32.75		5	0.9400	0.8720	1.0080	0.9000	1.0000	0.0245	0.0548	5.83%	4.08%

Mean Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	LC	5	1.753	1.56	1.946	1.506	1.909	0.06951	0.1554	8.87%	0.00%
0.53	MC	5	1.893	1.735	2.052	1.75	2.057	0.05709	0.1277	6.74%	-8.01%
1.11		5	1.758	1.444	2.072	1.455	2.154	0.1131	0.2529	14.38%	-0.29%
1.67		5	1.976	1.749	2.203	1.769	2.176	0.08182	0.183	9.26%	-12.75%
2.74		5	1.858	1.59	2.126	1.651	2.095	0.09661	0.216	11.63%	-5.99%
4.81		5	1.835	1.514	2.155	1.521	2.229	0.1154	0.258	14.06%	-4.68%
8.88		5	1.857	1.61	2.103	1.63	2.095	0.08867	0.1983	10.68%	-5.92%
17.45		5	1.758	1.519	1.997	1.505	1.986	0.08615	0.1926	10.96%	-0.32%
32.75		5	1.737	1.497	1.977	1.433	1.891	0.08655	0.1935	11.14%	0.91%

LC = lab (negative) control
MC = method control (hardness-adjusted lab control)

Analyst: MDO QA: JGU Mar. 28/22

Chironomus 10-d Survival and Growth ~~Sediment~~ Water Only Test for

Nautilus Environmental

10d Survival Rate Detail MD5: 060E01E83D6A076ABF7399E259A87AE6

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	LC	1.0000	1.0000	0.9000	1.0000	1.0000
0.53	MC	0.9000	0.9000	0.8000	1.0000	1.0000
1.11		0.7000	1.0000	1.0000	1.0000	1.0000
1.67		0.9000	1.0000	0.8000	1.0000	1.0000
2.74		1.0000	0.8000	1.0000	1.0000	0.9000
4.81		0.9000	0.8000	1.0000	1.0000	0.9000
8.88		0.9000	0.7000	1.0000	1.0000	0.7000
17.45		1.0000	0.9000	1.0000	1.0000	0.7000
32.75		0.9000	1.0000	0.9000	0.9000	1.0000

Mean Dry Weight-mg Detail MD5: DEF539704C12D73D3F1E09BE26EBC29A

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	LC	1.506	1.909	1.718	1.782	1.849
0.53	MC	1.939	1.75	1.778	1.942	2.057
1.11		2.154	1.682	1.771	1.727	1.455
1.67		2.176	1.769	1.929	1.85	2.158
2.74		1.726	2.095	1.651	1.728	2.089
4.81		1.521	2.229	1.738	1.803	1.883
8.88		1.63	2.029	1.729	2.095	1.8
17.45		1.505	1.733	1.66	1.986	1.907
32.75		1.433	1.841	1.864	1.891	1.654

10d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	LC	10/10	10/10	9/10	10/10	10/10
0.53	MC	9/10	9/10	8/10	10/10	10/10
1.11		7/10	10/10	10/10	10/10	10/10
1.67		9/10	10/10	8/10	10/10	10/10
2.74		10/10	8/10	10/10	10/10	9/10
4.81		9/10	8/10	10/10	10/10	9/10
8.88		9/10	7/10	10/10	10/10	7/10
17.45		10/10	9/10	10/10	10/10	7/10
32.75		9/10	11/11	9/10	9/10	10/10

Analyst: MDO QA: JCH Mar-28/22

CETIS Analytical Report

Report Date: 28 Mar-22 11:54 (p 1 of 1)
Test Code/ID: 212489a / 21-3435-0075

Water Only

Chironomus 10-d Survival and Growth Sediment Test

Nautilus Environmental

Analysis ID:	15-8842-0919	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:52	**Analysis:**	Single 2x2 Contingency Table	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	1E642B29F1B55BFB483E0E90577012B2	**Editor ID:**	002-888-235-1

Batch ID:	19-4474-0302	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Laboratory Water
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**	
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO **Age:** 3rd

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	124 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	MDO 124 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	8d 0h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result
Untransformed	C > T	Method Control passed 10d survival rate endpoint

Fisher Exact Test

Control I	vs	Control II	Test Stat	P-Type	P-Value	Decision(α:5%)
Lab Control		Method Control	0.1811	Exact	0.1811	Non-Significant Effect

10d Survival Rate Frequencies

Conc-ug/L	Code	NR	R	NR + R	Prop NR	Prop R	%Effect
0	LC	49	1	50	0.9800	0.0200	0.00%
0.53	MC	46	4	50	0.9200	0.0800	6.12%

10d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	LC	5	0.9800	0.9245	1.0000	1.0000	0.9000	1.0000	0.0200	4.56%	0.00%
0.53	MC	5	0.9200	0.8161	1.0000	0.9000	0.8000	1.0000	0.0374	9.09%	6.12%

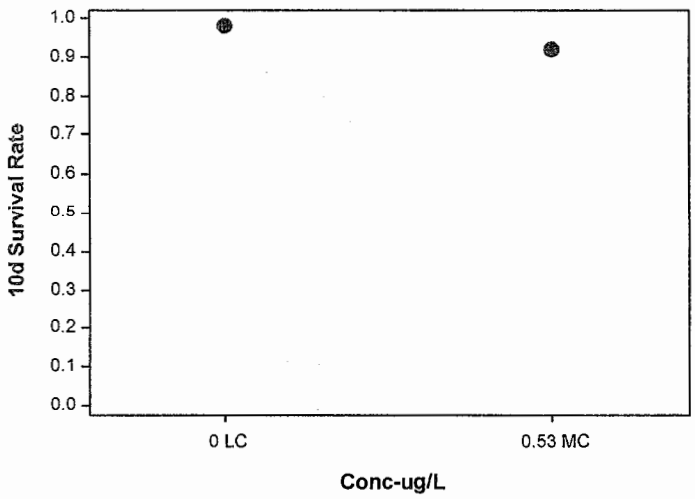
10d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	LC	1.0000	1.0000	0.9000	1.0000	1.0000
0.53	MC	0.9000	0.9000	0.8000	1.0000	1.0000

10d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	LC	10/10	10/10	9/10	10/10	10/10
0.53	MC	9/10	9/10	8/10	10/10	10/10

Graphics



Analyst: MDO QA: JOW Mar. 28 /22

CETIS Analytical Report

Report Date: 28 Mar-22 11:54 (p 1 of 2)
Test Code/ID: 212489a / 21-3435-0075

Chironomus 10-d Survival and Growth ~~Sediment~~ Water Only Test Jow

Nautilus Environmental

Analysis ID:	10-9534-2054	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	B5EFC344FB1B850563219052CC50ED35	**Editor ID:**	002-888-235-1

Batch ID:	19-4474-0302	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach		
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Laboratory Water		
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	1~~8~~ 21 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	1~~3~~ 24 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	8d 0h	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1091537	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
EC10	>32.75	---	---
EC15	>32.75	---	---
EC20	>32.75	---	---
EC25	>32.75	---	---
EC40	>32.75	---	---
EC50	>32.75	---	---

10d Survival Rate Summary

			Calculated Variate(A/B)							Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**A/B**	**Mean**	**%Effect**
0.53	MC	5	0.9200	0.9000	0.8000	1.0000	9.09%	0.00%	46/50	0.9350	0.00%
1.11		5	0.9400	1.0000	0.7000	1.0000	14.27%	-2.17%	47/50	0.9350	0.00%
1.67		5	0.9400	1.0000	0.8000	1.0000	9.52%	-2.17%	47/50	0.9350	0.00%
2.74		5	0.9400	1.0000	0.8000	1.0000	9.52%	-2.17%	47/50	0.9350	0.00%
4.81		5	0.9200	0.9000	0.8000	1.0000	9.09%	0.00%	46/50	0.9200	1.60%
8.88		5	0.8600	0.9000	0.7000	1.0000	17.63%	6.52%	43/50	0.9067	3.03%
17.45		5	0.9200	1.0000	0.7000	1.0000	14.17%	0.00%	46/50	0.9067	3.03%
32.75		5	0.9400	0.9000	0.9000	1.0000	5.83%	-2.17%	48/51	0.9067	3.03%

10d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.53	MC	0.9000	0.9000	0.8000	1.0000	1.0000
1.11		0.7000	1.0000	1.0000	1.0000	1.0000
1.67		0.9000	1.0000	0.8000	1.0000	1.0000
2.74		1.0000	0.8000	1.0000	1.0000	0.9000
4.81		0.9000	0.8000	1.0000	1.0000	0.9000
8.88		0.9000	0.7000	1.0000	1.0000	0.7000
17.45		1.0000	0.9000	1.0000	1.0000	0.7000
32.75		0.9000	1.0000	0.9000	0.9000	1.0000

Analyst: MDO QA: Mar. 28/22

Water Only

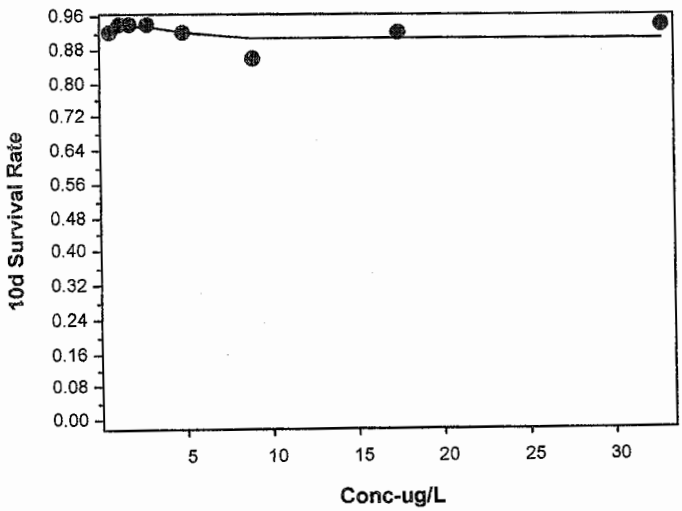
Chironomus 10-d Survival and Growth ~~Sediment~~ Test — **Nautilus Environmental**

Analysis ID:	10-9534-2054	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	B5EFC344FB1B850563219052CC50ED35	**Editor ID:**	002-888-235-1

10d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.53	MC	9/10	9/10	8/10	10/10	10/10
1.11		7/10	10/10	10/10	10/10	10/10
1.67		9/10	10/10	8/10	10/10	10/10
2.74		10/10	8/10	10/10	10/10	9/10
4.81		9/10	8/10	10/10	10/10	9/10
8.88		9/10	7/10	10/10	10/10	7/10
17.45		10/10	9/10	10/10	10/10	7/10
32.75		9/10	11/11	9/10	9/10	10/10

Graphics



Analyst: MDO QA: Mar-28/2

CETIS Analytical Report

Report Date: 28 Mar-22 11:54 (p 1 of 2)
Test Code/ID: 212489a / 21-3435-0075

Water Only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test JOH

Nautilus Environmental

Analysis ID:	06-5066-2648	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	22F34F7DA2C43DA2C756F1D5BBAE0034	**Editor ID:**	002-888-235-1

Batch ID:	19-4474-0302	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach		
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Laboratory Water		
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	1~~3~~4 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	1~~3~~4 Jan-22 06:00 MDO	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	8d 0h	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Method Control passed mean dry weight-mg endpoint	9.54%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Lab Control		Method Control	8	-1.56	1.86	0.1673	CDF	0.9213	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0492402	0.0492402	1	2.434	0.1573	Non-Significant Effect
Error	0.16182	0.0202275	8			
Total	0.21106		9			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	1.482	23.15	0.7123	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.942	0.7411	0.5755	Normal Distribution

Mean Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	LC	5	1.753	1.56	1.946	1.782	1.506	1.909	0.06951	8.87%	0.00%
0.53	MC	5	1.893	1.735	2.052	1.939	1.75	2.057	0.05709	6.74%	-8.01%

Mean Dry Weight-mg Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	LC	1.506	1.909	1.718	1.782	1.849
0.53	MC	1.939	1.75	1.778	1.942	2.057

JOH

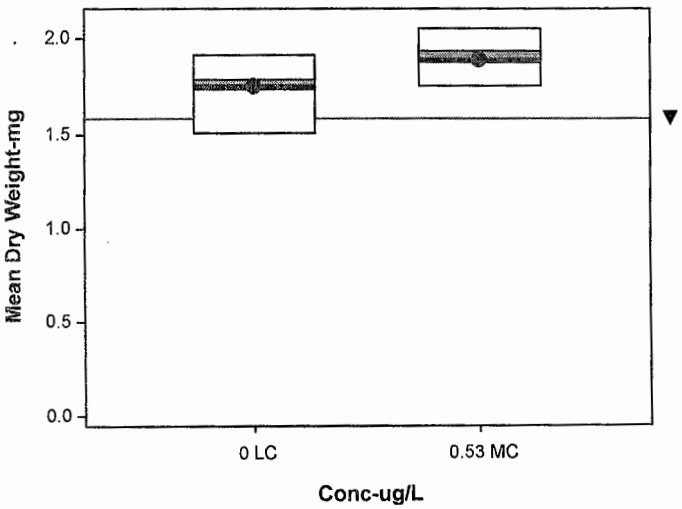
Analyst: MDO QA: Mar. 28/22

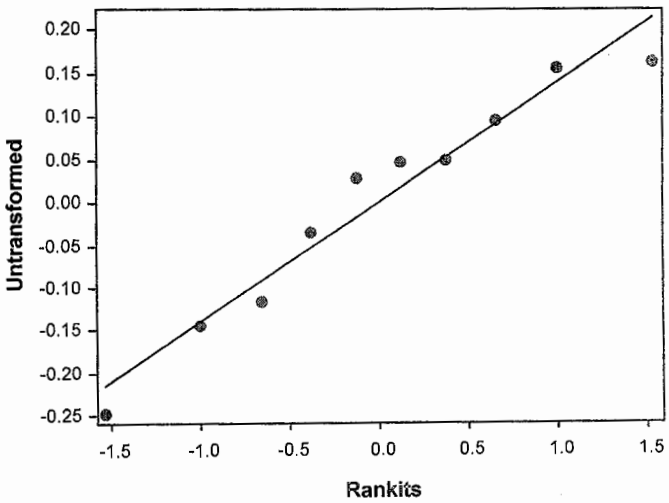
Water Only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test **Nautilus Environmental**

Analysis ID:	06-5066-2648	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	22F34F7DA2C43DA2C756F1D5BBAE0034	**Editor ID:**	002-888-235-1

Graphics





Analyst: MDO QA: JCW Mar. 28/22

CETIS Analytical Report

Report Date: 28 Mar-22 11:54 (p 1 of 3)
Test Code/ID: 212489a / 21-3435-0075

Water Only

Chironomus 10-d Survival and Growth Sediment Test

Nautilus Environmental

Analysis ID:	04-1079-2680	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	6096E4808CB212E1DB0D3E5ADD2FE091	**Editor ID:**	002-888-235-1

Batch ID:	19-4474-0302	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	Laboratory Water
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**	
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO **Age:** 3rd

Sample ID:	05-2581-7971	**Code:**	Lab Water	**Project:**	
Sample Date:	12 Jan-22	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	18 Jan-22 06:00	**CAS (PC):**		**Station:**	Lab Water
Sample Age:	8d 0h	**Client:**	Pretivm Resources Inc.		

Non-Linear Regression Options

Model Name and Function	Weighting Function	PTBS Function	X Trans	Y Trans
3P Log-Logistic: μ=α/[1+[x/δ]^γ]	Normal [ω=1]	Off [μ*=μ]	None	None

Regression Summary

Iters	LL	AICc	BIC	Adj R2	PMSD	Thresh	Optimize	F Stat	P-Value	Decision(α:5%)
21	65.18	-123.7	-119.3	0.0080	8.84%	1.88	Yes	0.6341	0.6751	Non-Significant Lack-of-Fit

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	42.27	---	147.5
IC15	70.96	---	568.3
IC20	104.8	---	3594
IC25	144.7	---	---
IC40	314.3	---	---
IC50	495	---	---

MDO

32.75

Regression Parameters

Parameter	Estimate	Std Error	95% LCL	95% UCL	t Stat	P-Value	Decision(α:5%)
α	1.88	0.08204	1.713	2.046	22.91	<1.0E-05	Significant Parameter
γ	0.893	1.631	-2.411	4.197	0.5477	0.5872	Non-Significant Parameter
δ	495	2397	-4362	5351	0.2065	0.8375	Non-Significant Parameter

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Model	134.6	44.88	3	1108	<1.0E-05	Significant Effect
Lack of Fit	0.1351	0.02702	5	0.6341	0.6751	Non-Significant Lack-of-Fit
Pure Error	1.363	0.0426	32			
Residual	1.498	0.0405	37			

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Variance	Bartlett Equality of Variance Test	2.216	14.07	0.9469	Equal Variances
	Mod Levene Equality of Variance	0.1723	2.423	0.9886	Equal Variances
Distribution	Anderson-Darling A2 Test	0.483	2.492	0.2338	Normal Distribution
	Shapiro-Wilk W Normality Test	0.9733	0.9447	0.4560	Normal Distribution

JOU
Mar. 28/22

Chironomus 10-d Survival and Growth ~~Sediment~~ Water Only Test — **Nautilus Environmental**

Analysis ID:	04-1079-2680	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	6096E4808CB212E1DB0D3E5ADD2FE091	**Editor ID:**	002-888-235-1

Mean Dry Weight-mg Summary

			Calculated Variate							
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
0.53	MC	5	1.893	1.939	1.75	2.057	0.05709	0.1277	6.74%	0.00%
1.11		5	1.758	1.727	1.455	2.154	0.1131	0.2529	14.38%	7.14%
1.67		5	1.976	1.929	1.769	2.176	0.08182	0.183	9.26%	-4.39%
2.74		5	1.858	1.728	1.651	2.095	0.09661	0.216	11.63%	1.86%
4.81		5	1.835	1.803	1.521	2.229	0.1154	0.258	14.06%	3.08%
8.88		5	1.857	1.8	1.63	2.095	0.08867	0.1983	10.68%	1.93%
17.45		5	1.758	1.733	1.505	1.986	0.08615	0.1926	10.96%	7.12%
32.75		5	1.737	1.841	1.433	1.891	0.08655	0.1935	11.14%	8.25%

Mean Dry Weight-mg Detail

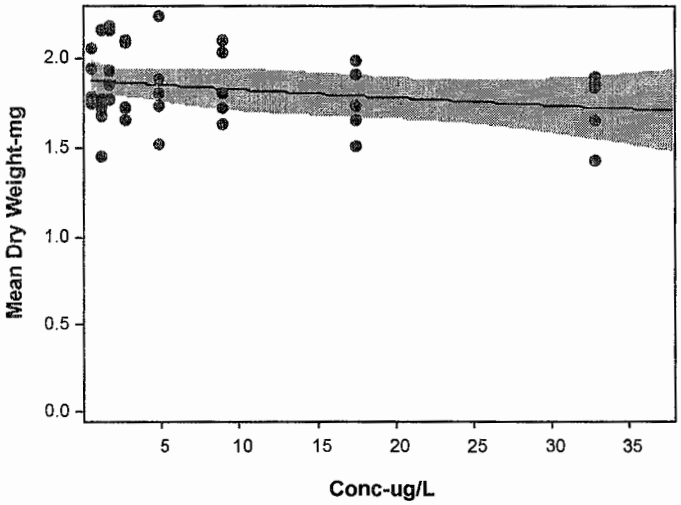
Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.53	MC	1.939	1.75	1.778	1.942	2.057
1.11		2.154	1.682	1.771	1.727	1.455
1.67		2.176	1.769	1.929	1.85	2.158
2.74		1.726	2.095	1.651	1.728	2.089
4.81		1.521	2.229	1.738	1.803	1.883
8.88		1.63	2.029	1.729	2.095	1.8
17.45		1.505	1.733	1.66	1.986	1.907
32.75		1.433	1.841	1.864	1.891	1.654

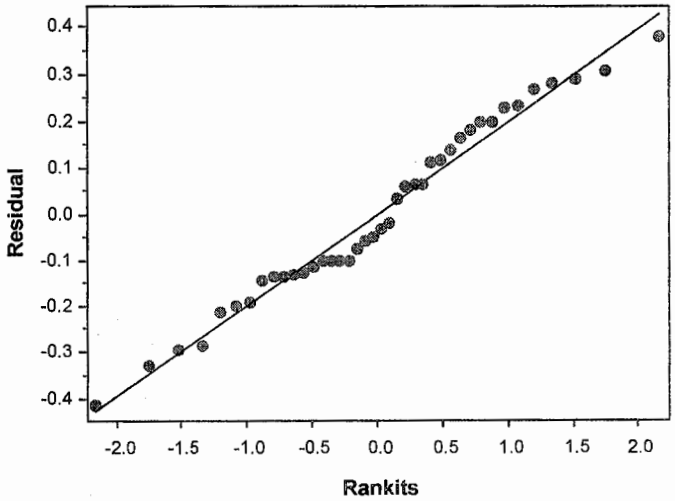
Water Only

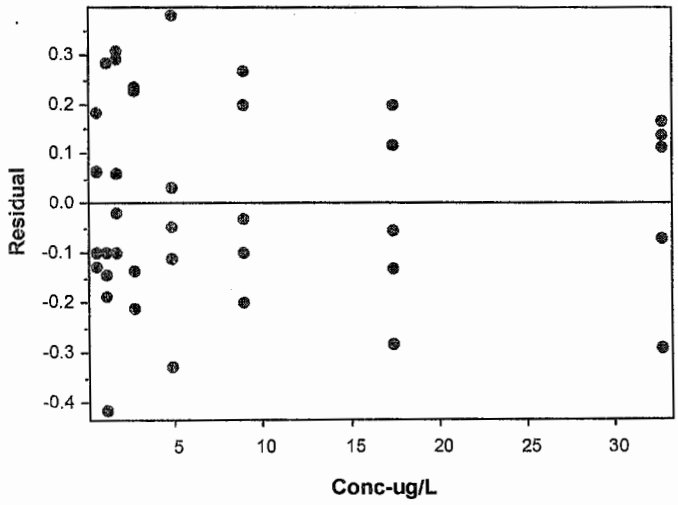
Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

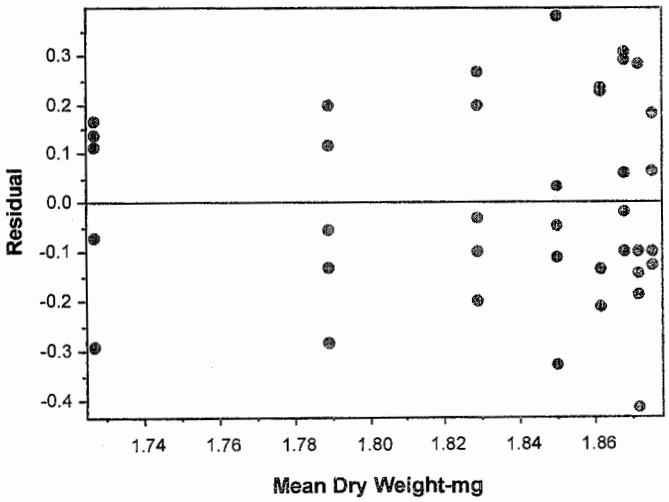
Analysis ID:	04-1079-2680	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	28 Mar-22 11:53	**Analysis:**	Nonlinear Regression (NLR)	**Status Level:**	1
Edit Date:	21 Mar-22 9:48	**MD5 Hash:**	6096E4808CB212E1DB0D3E5ADD2FE091	**Editor ID:**	002-888-235-1

Graphics Model: 3P Log-Logistic: μ=α/[1+[x/δ]^γ] Distribution: Normal [ω=1]









Chironomus dilutus Water-only Test Summary Sheet

Client: Lorax/Pretium Resources Inc.
Work Order No.: 212489

Start Date: Jan 21/22
Set up by: JZL/KJL/DK

Sample Information:

Sample ID: BJ-3.10
Sample Date: Jan 10/22
Date Received: Jan 13/22
Sample Volume: 5x20L

Test Organism Information:

Species: *C. dilutus*
Supplier: Aquatic Biosystems, CO
Date received: Jan 19/22
Age or size (Day 0): 3rd in-star

KCl Reference Toxicant Results:

Reference Toxicant ID: CT106
Stock Solution ID: n/a
Date Initiated: Jan 21/22

96-h LC50 (95% CL): 4.5(3.3-6.3) g/L KCl

96-h LC50 Reference Toxicant Mean and Range: 5.4(3.8-7.6) g/L KCl CV (%): 17

Test Results:
(measured values)
ug/L Cu

	Survival	Dry Weight
LC25 (%v/v) (95% CL)	>31	—
LC50(%v/v) (95% CL)	>31	—
IC25(%v/v) (95% CL)	—	>31
IC50(%v/v) (95% CL)	—	>31
MDO ~~NOEC~~ MDO	—	—
~~LOEC~~ MDO	—	—

Reviewed by: JGU

Date reviewed: Mar. 25/22

10-d Chironomid ~~Sediment~~ Water Only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water Only 10-d Water Quality

Client: Lorax / Pretium Resources Inc.
W.O #: 212489
Cu in site BJ-3.10 (blue)

Start Date: Jan. 21/22 RZS
Termination Date: ~~Jan. 24/22~~ RZS Jan. 31/22
CER #: 12
Test Organism: *Chironomus dilutus*

Temperature (°C)

Sample ID (µg/L Cu)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	23.0	22.0	22.0	22.5	23.5	22.0	22.0	22.5	22.0	22.0	22.0	22.0	22.0	22.0
0.75	23.0	22.5	↓	22.0	↓	↓	↓	22.0	↓	↓	↓	↓	↓	↓
1.5	23.0	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
3	23.0	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
6	23.0	22.5	↓	↓	23.0	↓	↓	↓	↓	↓	↓	↓	↓	↓
12	23.0	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
24	23.5	22.5	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
48	23.5	22.5	↓	↓	23.0	↓	↓	↓	↓	↓	↓	↓	↓	↓
Technician Initials	JZ	JZ	PM	RZS	RZS	RZS	RZS	RZS	RZS	GM	GM	GM	PM	RZS

Thermometer: CER #12

Conductivity (µS)

Sample ID (µg/L Cu)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	318	373	352	374	322	349	368	315	349	369	317	349	371	380
0.75	317	352	336	346	318	341	359	316	348	367	321	351	368	379
1.5	316	351	339	350	319	338	352	316	342	358	318	346	360	368
3	316	354	337	347	318	338	353	316	339	354	318	343	359	368
6	316	354	341	354	318	333	346	316	340	354	318	343	353	357
12	316	355	340	349	318	334	346	317	334	347	319	336	347	352
24	316	353	336	345	319	339	351	315	341	358	318	344	359	365
48	321	358	341	351	318	331	345	315	339	357	320	352	361	370
Technician Initials	JZ	JZ	PM	RZS	RZS	RZS	RZS	RZS	RZS	GM	GM	GM	PM	RZS

Conductivity meter/probe: RZ 631 3

Comments:

Reviewed by: JBL

Date Reviewed: Mar. 25/22

Water Only

10-d Chironomid ~~Sediment~~ Toxicity Test Data Sheet

Freshwater ~~Sediment~~ 10-d Water Quality

Water Only

Client: Lorax ~~Pretium~~ / Pretium Resources Inc.

W.O #: 212489

Sample ID: Cu in site BI 3.10 (blue)

Start Date: Jan 21/22

Termination Date: ~~Jan 24/22~~ Jan 31/22

CER #: 12

Test Organism: *Chironomus dilutus*

Dissolved Oxygen (mg/L)

Sample ID (µg/L Cu)	Day 0	1	2	3 Old①	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	8.0	5.7	4.38	3.9	7.6	8.0	7.4	7.8	7.7	8.3	8.3	8.1	7.8	7.9
0.75	8.0	5.9	4.3	3.9	7.6	8.0	7.7	7.7	7.8	8.3	8.3	8.3	8.0	8.0
1.5	8.0	5.9	4.6	4.1	7.6	8.1	7.7	7.7	7.8	8.3	8.3	8.3	8.0	8.0
3	7.9	6.0	4.7	4.1	7.7	8.1	7.7	7.8	7.8	8.3	8.3	8.3	8.0	8.0
6	7.9	6.0	4.6	4.2	7.7	8.1	7.8	7.8	7.8	8.2	8.3	8.4	8.0	8.1
12	7.9	5.9	4.6	5.0	7.7	8.2	7.8	7.8	7.9	8.2	8.3	8.4	8.1	8.1
24	7.9	5.9	4.8	4.0	7.7	8.1	7.8	7.9	7.9	8.2	8.2	8.4	8.0	8.1
48	7.9	~~6.7~~ 5.7	4.4	4.1	7.7	8.1	7.8	7.9	7.9	8.2	8.2	8.4	8.1	8.1
Technician Initials	JZ	JZ	PM	RZ	RZS	RZS	RZ	RZ	RZS	GM	GM	GM	PM	RZ

DO meter/probe: 3 13

pH

Sample ID (µg/L Cu)	Day 0	1	2	3 Old	3 New	4	5 Old	5 New	6	7 Old	7 New	8	9	10
Site Ctrl	7.2	7.0	6.9	6.8	7.5	7.2	7.4	7.4	7.4	7.6	7.4	7.7	7.5	7.5
0.75	7.3	7.0	6.8	6.6	7.4	7.3	7.5	7.4	7.4	7.6	7.4	7.7	7.5	7.5
1.5	7.3	7.1	6.7	6.6	7.4	7.3	7.5	7.4	7.4	7.6	7.4	7.7	7.5	7.5
3	7.3	7.0	6.7	6.6	7.4	7.2	7.4	7.4	7.4	7.5	7.4	7.7	7.5	7.5
6	7.3	7.1	6.7	6.6	7.4	7.3	7.5	7.4	7.4	7.5	7.4	7.6	7.5	7.3
12	7.3	7.1	6.7	6.7	7.4	7.3	7.5	7.4	7.4	7.5	7.4	7.6	7.5	7.3
24	7.3	7.0	6.6	6.7	7.4	7.4	7.5	7.4	7.4	7.6	7.4	7.6	7.5	7.3
48	7.4	7.0	6.6	6.7	7.5	7.4	7.5	7.4	7.4	7.5	7.4	7.6	7.5	7.4
Technician Initials	JZ	JZ	PM	RZS	RZS	RZS	RZ	RZ	RZS	GM	GM	GM	PM	RZ

pH meter/probe: 3 13

Light meter: Lit-1

Light intensity (Lux): 450-890

Comments: ① Initiated aeration

Reviewed by: JG

Date Reviewed: Mar 25/22

10-d Chironomid ~~Sediment~~ Water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water only 10-d Survival and Weight

Client: Lorax / Pretium Resources Inc.
W.O. #: 212489
Sample ID: Cu in BJ-3.10

Start Date: Jan. 21/22
Termination Date: Jan. 31/22
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID (µg/L Cu)	Cu Pan No. Red	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	1	A	11	0	0	BAM/MDO	1015.90	1033.21	11	EC/JGL
Site Control	2	B	9	0	1	BAM/	1005.46	1021.84	9	
	3	C	8	0	2	BAM/	1028.89	1043.50	8	
	4	D	10	0	0	BAM/	1014.80	1031.69	10	
	5	E	9	0	1	BAM/	1013.74	1034.08	9	
0.75	6	A	10	0	0	KJL/	1073.11	1088.91	10	
	7	B	10	0	0	KJL/	1045.31	1064.38	10	
	8	C	9	0	1	KJL/	1041.88	1060.12	9	
	9	D	9	0	1	KJL/	1048.85	1067.77	9	
	10	E	10	0	0	KJL/	1056.14	1074.74	10	
1.5	11	A	9	0	1	MDO	1012.31	1027.68	9	
	12	B	8	0	2		1024.08	1039.05	8	
	13	C	9	0	1		1032.39	1046.37	9	
	14	D	9	0	1		1054.90	1069.20	9	
	15	E	8	0	2		1053.18	1067.47	8	
3	16	A	10	0	0	RJS	1082.08	1098.39	10	
	17	B	9	0	1		1066.86	1083.56	9	
	18	C	10 ~~7 ①~~	0	~~2~~ 0		1043.63	1062.09	10	
	19	D	7 ①	1	2		1019.45	1034.65	7	
	20	E	10	0	0		1018.88	1037.34	10	

Date/time pan placed in oven: Dec. 21/21 @ 0900
Date/time pan removed from oven: Dec. 23/21 @ 0900

Date/time pan + organisms placed in oven: Jan. 31/22 @ 1555h
Date/time pan + organisms removed from oven: Feb. 1/22 @ 1555h

Comments: (1) checked by KJL
Reweigh pans: 5 - 1034.01mg, 18 - 1062.00mg

Reviewed by: JGL
Date Reviewed: Mar. 25/22

10-d Chironomid ~~Sediment~~ Water only Toxicity Test Data Sheet

Freshwater ~~Sediment~~ Water only 10-d Survival and Weight

Client: Lorax / Pretium Resources Inc.
W.O. #: 213489
Sample ID: Cu in BJ-3.10

Start Date: Jan. 21/22
Termination Date: Jan. 31/22
Test Organism: *Chironomus dilutus*
Balance: 1

Sample ID (Lab Cont Prep)	Cul Pan No. red	Rep	No. alive	No. dead	No. missing	Initials	Pan weight (mg)	Pan + organism (mg)	No. weighed	Initials
~~Control Sediment~~	21	A	10	0	0	BAM/	1058.42	1075.17	10	EC / JBL
6	22	B	10	0	0	BAM/	1080.62	1097.85	10	
	23	C	10	0	0	BAM/	1039.04	1054.68	10	
	24	D	10	0	0	BAM/	1049.88	1067.22	10	
	25	E	10	0	0	BAM/	1036.95	1053.08	10	
12	26	A	10	0	0	SXH/	1022.46	1037.81	10	
	27	B	10	0	0	SXH/	1036.12	1051.81	10	
	28	C	10	0	0	SXH/	1031.21	1046.05	10	
	29	D	11	0	0	SXH/	1043.22	1058.34	11	
	30	E	9	0	1	SXH/	1023.67	1038.26	9	
24	31	A	9	0	1	MDO	1018.51	1034.55	9	
	32	B	10	0	0	MDO	1022.38	1036.27	10	
	33	C	9	0	1	MDO	1026.80	1042.90	9	
	34	D	8	0	2	MDO	1004.32	1019.15	8	
	35	E	10	0	0	KMV/	1012.78	1029.97	10	
48	36	A	10	0	0	BAM/	1034.97	1049.74	10	
	37	B	10	0	0	BAM/	1045.87	1064.62 ~~1049.74~~ ~	10	
	38	C	BAM ~~10~~ 9	1 ①	0	BAM/	1008.29	1022.35 ~~1064.04~~ ~	9	
	39	D	10	0	0	BAM/	1022.84	1037.66	10	
	40	E	10	0	0	SXH/	1050.09	1066.51	10	

Date/time pan placed in oven: Dec. 21/21 @ 0900
Date/time pan removed from oven: Dec. 23/21 @ 0900

Date/time pan + organisms placed in oven: Jan. 31/22 @ 1555h
Date/time pan + organisms removed from oven: Feb. 1/22 @ 1555h

Comments: ① Dupac x1
Reweigh pans: 30 - 1038.17 mg, 35 - 1029.93 mg

Reviewed by: JCh

Date Reviewed: Mar. 25/22

CETIS Summary Report

Report Date: 09 Mar-22 14:51 (p 1 of 2)
Test Code/ID: 212489b / 15-2722-8118

Chironomus 10-d Survival and Growth ~~Sediment~~ Water only Test MDO — **Nautilus Environmental**

Batch ID:	07-9185-3525	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach		
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	BJ 3.10		
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	10d 9h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Single Comparison Summary

Analysis ID	Endpoint	Comparison Method	P-Value	Comparison Result	S
19-3986-1792	10d Survival Rate	Fisher Exact Test	0.1874	Site Control passed 10d survival rate	1
12-1528-1720	Mean Dry Weight-mg	Equal Variance t Two-Sample Test	0.7168	Site Control passed mean dry weight-mg	1

Point Estimate Summary

Analysis ID	Endpoint	Point Estimate Method	✓	Level	ug/L	95% LCL	95% UCL	S
11-6228-5722	10d Survival Rate	Linear Interpolation (ICPIN)		EC10	>31	---	---	1
			✓	EC15	>31	---	---	
			✓	EC20	>31	---	---	
			✓	EC25	>31	---	---	
			✓	EC40	>31	---	---	
			✓	EC50	>31	---	---	
01-8771-4274	Mean Dry Weight-mg	Linear Interpolation (ICPIN)	✓	IC10	4.168	---	---	1
			✓	IC15	>31	---	---	
			✓	IC20	>31	---	---	
			✓	IC25	>31	---	---	
			✓	IC40	>31	---	---	
			✓	IC50	>31	---	---	

10d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	5	0.9800	0.9245	1.0360	0.9000	1.0000	0.0200	0.0447	4.56%	0.00%
0.37	XC	5	0.9200	0.8161	1.0240	0.8000	1.0000	0.0374	0.0837	9.09%	6.12%
1.04		5	0.9600	0.8920	1.0280	0.9000	1.0000	0.0245	0.0548	5.71%	2.04%
1.46		5	0.8600	0.7920	0.9280	0.8000	0.9000	0.0245	0.0548	6.37%	12.24%
2.46		5	0.9200	0.7581	1.0820	0.7000	1.0000	0.0583	0.1304	14.17%	6.12%
4.49		5	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000	0.00%	-2.04%
8.45		5	0.9800	0.9245	1.0360	0.9000	1.0000	0.0200	0.0447	4.56%	0.00%
16.3		5	0.9200	0.8161	1.0240	0.8000	1.0000	0.0374	0.0837	9.09%	6.12%
31		5	0.9800	0.9245	1.0360	0.9000	1.0000	0.0200	0.0447	4.56%	0.00%

Mean Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	N	5	1.753	1.56	1.946	1.506	1.909	0.06951	0.1554	8.87%	0.00%
0.37 ✓	XC	5	1.834	1.511	2.157	1.574	2.26	0.1163	0.2601	14.18%	-4.62%
1.04 ✓		5	1.895	1.646	2.144	1.58	2.102	0.08969	0.2005	10.58%	-8.13%
1.46 ✓		5	1.701	1.536	1.867	1.553	1.871	0.05945	0.1329	7.81%	2.92%
2.46 ✓		5	1.87	1.63	2.11	1.631	2.171	0.08641	0.1932	10.33%	-6.69%
4.49 ✓		5	1.662	1.572	1.752	1.564	1.734	0.03246	0.07259	4.37%	5.19%
8.45 ✓		5	1.517	1.4	1.633	1.375	1.621	0.04198	0.09387	6.19%	13.46%
16.3 ✓		5	1.707	1.478	1.935	1.389	1.855	0.08232	0.1841	10.78%	2.62%
31 ✓		5	1.596	1.421	1.771	1.477	1.817	0.06295	0.1408	8.82%	8.94%

N=negative (lab) control
XC = site control

Analyst: MDO QA: Mar-25/22

Water only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test MDO **Nautilus Environmental**

10d Survival Rate Detail MD5: 3E494F20E48FB13F3CB0050EC2EF353A

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	N	1.0000	1.0000	0.9000	1.0000	1.0000
0.37	XC	1.0000	0.9000	0.8000	1.0000	0.9000
1.04		1.0000	1.0000	0.9000	0.9000	1.0000
1.46		0.9000	0.8000	0.9000	0.9000	0.8000
2.46		1.0000	0.9000	1.0000	0.7000	1.0000
4.49		1.0000	1.0000	1.0000	1.0000	1.0000
8.45		1.0000	1.0000	1.0000	1.0000	0.9000
16.3		0.9000	1.0000	0.9000	0.8000	1.0000
31		1.0000	1.0000	0.9000	1.0000	1.0000

Mean Dry Weight-mg Detail MD5: 4E590947AED0BECFDD190C500CC0AC43

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	N	1.506	1.909	1.718	1.782	1.849
0.37	XC	1.574	1.82	1.826	1.689	2.26
1.04		1.58	1.907	2.027	2.102	1.86
1.46		1.708	1.871	1.553	1.589	1.786
2.46		1.631	1.856	1.846	2.171	1.846
4.49		1.675	1.723	1.564	1.734	1.613
8.45		1.535	1.569	1.484	1.375	1.621
16.3		1.782	1.389	1.789	1.855	1.719
31		1.477	1.817	1.562	1.482	1.642

10d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	N	10/10	10/10	9/10	10/10	10/10
0.37	XC	11/11	9/10	8/10	10/10	9/10
1.04		10/10	10/10	9/10	9/10	10/10
1.46		9/10	8/10	9/10	9/10	8/10
2.46		10/10	9/10	10/10	7/10	10/10
4.49		10/10	10/10	10/10	10/10	10/10
8.45		10/10	10/10	10/10	11/11	9/10
16.3		9/10	10/10	9/10	8/10	10/10
31		10/10	10/10	9/10	10/10	10/10

CETIS Analytical Report

Report Date: 09 Mar-22 14:51 (p 1 of 2)
Test Code/ID: 212489b / 15-2722-8118

Water-only

Chironomus 10-d Survival and Growth Sediment Test MDO

Nautilus Environmental

Analysis ID:	12-1528-1720	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:49	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	D716E786F092A187B7FEFB4335961CA8	**Editor ID:**	004-311-246-8

Batch ID:	07-9185-3525	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach		
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	BJ 3.10		
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	10d 9h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result	PMSD
Untransformed	C > T	Site Control passed mean dry weight-mg endpoint	14.38%

Equal Variance t Two-Sample Test

Control I	vs	Control II	df	Test Stat	Critical	MSD	P-Type	P-Value	Decision(α:5%)
Negative Control		Site Control	8	-0.5981	1.86	0.252	CDF	0.7168	Non-Significant Effect

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	0.0164185	0.0164185	1	0.3577	0.5663	Non-Significant Effect
Error	0.367175	0.0458969	8			
Total	0.383593		9			

ANOVA Assumptions Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variance	Variance Ratio F Test	2.8	23.15	0.3426	Equal Variances
Distribution	Shapiro-Wilk W Normality Test	0.9357	0.7411	0.5061	Normal Distribution

Mean Dry Weight-mg Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	5	1.753	1.56	1.946	1.782	1.506	1.909	0.06951	8.87%	0.00%
0.37	XC	5	1.834	1.511	2.157	1.82	1.574	2.26	0.1163	14.18%	-4.62%

Mean Dry Weight-mg Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	N	1.506	1.909	1.718	1.782	1.849
0.37	XC	1.574	1.82	1.826	1.689	2.26

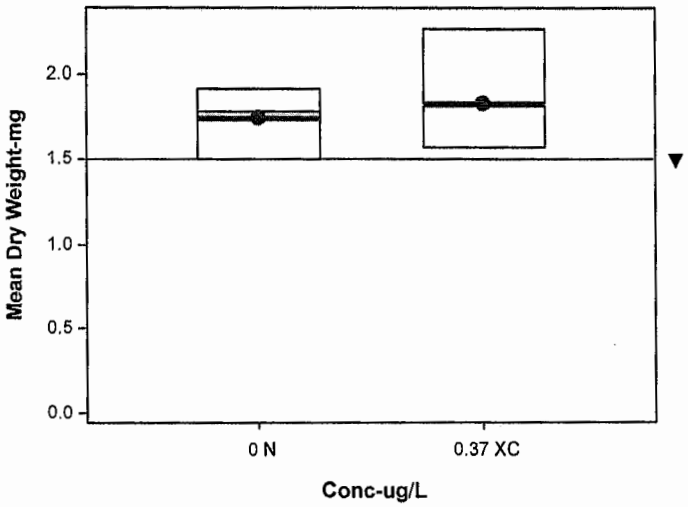
Analyst: MDO QA: JGh Mar. 25/22

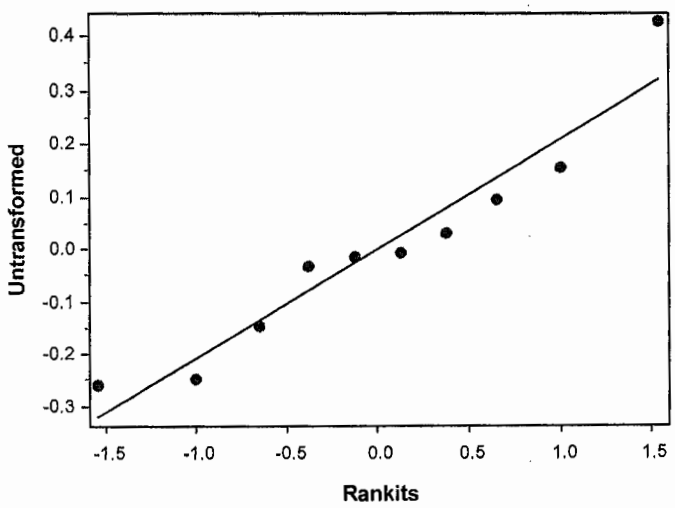
Water only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test MDO **Nautilus Environmental**

Analysis ID:	12-1528-1720	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:49	**Analysis:**	Parametric-Two Sample	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	D716E786F092A187B7FEFB4335961CA8	**Editor ID:**	004-311-246-8

Graphics





CETIS Analytical Report

Report Date: 09 Mar-22 14:51 (p 1 of 4)
Test Code/ID: 212489b / 15-2722-8118

Water-only

Chironomus 10-d Survival and Growth Sediment Test — **Nautilus Environmental**

Analysis ID:	11-6228-5722	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:50	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	899BA8D2B14EE97B19E2005ED1F9CC69	**Editor ID:**	004-311-246-8

Batch ID:	07-9185-3525	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	BJ 3.10
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**	
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO **Age:** 3rd

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	10d 9h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1202753	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
EC10	>31	---	---
EC15	>31	---	---
EC20	>31	---	---
EC25	>31	---	---
EC40	>31	---	---
EC50	>31	---	---

10d Survival Rate Summary

			Calculated Variate(A/B)							Isotonic Variate	
Conc-ug/L	**Code**	**Count**	**Mean**	**Median**	**Min**	**Max**	**CV%**	**%Effect**	**A/B**	**Mean**	**%Effect**
0.37	XC	5	0.9200	0.9000	0.8000	1.0000	9.09%	0.00%	47/51	0.9425	0.00%
1.04		5	0.9600	1.0000	0.9000	1.0000	5.71%	-4.35%	48/50	0.9425	0.00%
1.46		5	0.8600	0.9000	0.8000	0.9000	6.37%	6.52%	43/50	0.9425	0.00%
2.46		5	0.9200	1.0000	0.7000	1.0000	14.17%	0.00%	46/50	0.9425	0.00%
4.49		5	1.0000	1.0000	1.0000	1.0000	0.00%	-8.70%	50/50	0.9425	0.00%
8.45		5	0.9800	1.0000	0.9000	1.0000	4.56%	-6.52%	50/51	0.9425	0.00%
16.3		5	0.9200	0.9000	0.8000	1.0000	9.09%	0.00%	46/50	0.9425	0.00%
31		5	0.9800	1.0000	0.9000	1.0000	4.56%	-6.52%	49/50	0.9425	0.00%

10d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.37	XC	1.0000	0.9000	0.8000	1.0000	0.9000
1.04		1.0000	1.0000	0.9000	0.9000	1.0000
1.46		0.9000	0.8000	0.9000	0.9000	0.8000
2.46		1.0000	0.9000	1.0000	0.7000	1.0000
4.49		1.0000	1.0000	1.0000	1.0000	1.0000
8.45		1.0000	1.0000	1.0000	1.0000	0.9000
16.3		0.9000	1.0000	0.9000	0.8000	1.0000
31		1.0000	1.0000	0.9000	1.0000	1.0000

Analyst: MDO QA: JCW Mar. 25/22

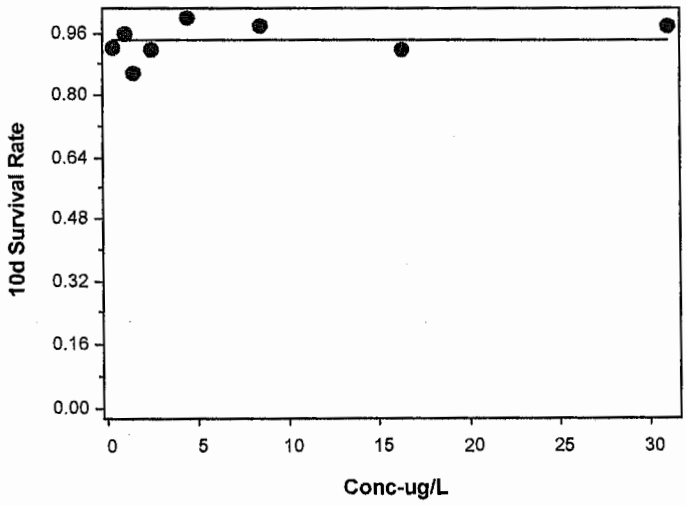
Chironomus 10-d Survival and Growth ~~Sediment~~ water-only Test MDD — **Nautilus Environmental**

Analysis ID:	11-6228-5722	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:50	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	899BA8D2B14EE97B19E2005ED1F9CC69	**Editor ID:**	004-311-246-8

10d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.37	XC	11/11	9/10	8/10	10/10	9/10
1.04		10/10	10/10	9/10	9/10	10/10
1.46		9/10	8/10	9/10	9/10	8/10
2.46		10/10	9/10	10/10	7/10	10/10
4.49		10/10	10/10	10/10	10/10	10/10
8.45		10/10	10/10	10/10	11/11	9/10
16.3		9/10	10/10	9/10	8/10	10/10
31		10/10	10/10	9/10	10/10	10/10

Graphics



CETIS Analytical Report

Report Date: 09 Mar-22 14:51 (p 1 of 1)
Test Code/ID: 212489b / 15-2722-8118

Water only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test MDO — **Nautilus Environmental**

Analysis ID:	19-3986-1792	**Endpoint:**	10d Survival Rate	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:49	**Analysis:**	Single 2x2 Contingency Table	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	894D1F9AF9465E3958D4ACDF23AB5E97	**Editor ID:**	004-311-246-8

Batch ID:	07-9185-3525	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach		
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	BJ 3.10		
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	10d 9h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Data Transform	Alt Hyp	Comparison Result
Untransformed	C > T	Site Control passed 10d survival rate endpoint

Fisher Exact Test

Control I	vs	Control II	Test Stat	P-Type	P-Value	Decision(α:5%)
Negative Control		Site Control	0.1874	Exact	0.1874	Non-Significant Effect

10d Survival Rate Frequencies

Conc-ug/L	Code	NR	R	NR + R	Prop NR	Prop R	%Effect
0	N	49	1	50	0.9800	0.0200	0.00%
0.37	XC	47	4	51	0.9216	0.0784	5.96%

10d Survival Rate Summary

Conc-ug/L	Code	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	N	5	0.9800	0.9245	1.0000	1.0000	0.9000	1.0000	0.0200	4.56%	0.00%
0.37	XC	5	0.9200	0.8161	1.0000	0.9000	0.8000	1.0000	0.0374	9.09%	6.12%

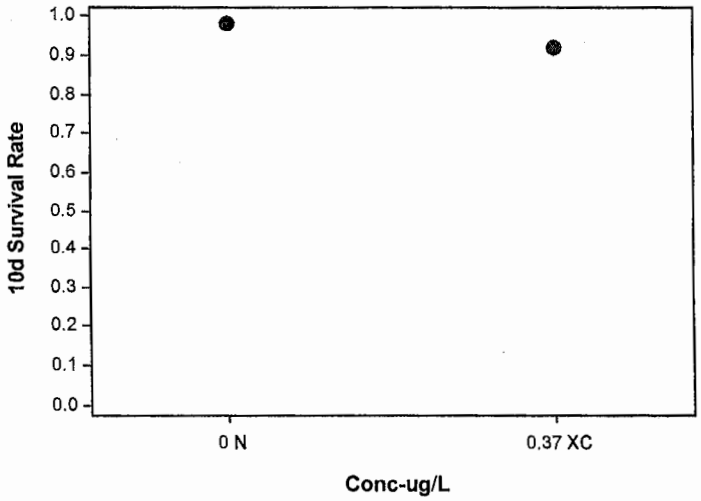
10d Survival Rate Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	N	1.0000	1.0000	0.9000	1.0000	1.0000
0.37	XC	1.0000	0.9000	0.8000	1.0000	0.9000

10d Survival Rate Binomials

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0	N	10/10	10/10	9/10	10/10	10/10
0.37	XC	11/11	9/10	8/10	10/10	9/10

Graphics



Analyst: MDO QA: JGC Mar. 25/22

Chironomus 10-d Survival and Growth ~~Sediment~~ water-only Test MDO

Nautilus Environmental

Analysis ID:	01-8771-4274	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:49	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	371026E49469E69E9513CF24E6B727D2	**Editor ID:**	004-311-246-8

Batch ID:	07-9185-3525	**Test Type:**	Growth-Survival (10d)	**Analyst:**	Mikayla Oldach		
Start Date:	21 Jan-22	**Protocol:**	EC/EPS 1/RM/32	**Diluent:**	BJ 3.10		
Ending Date:	31 Jan-22	**Species:**	Chironomus dilutus	**Brine:**			
Test Length:	10d 0h	**Taxon:**		**Source:**	Aquatic Biosystems, CO	**Age:**	3rd

Sample ID:	03-8477-6048	**Code:**	BJ-3.10	**Project:**	
Sample Date:	10 Jan-22 15:15	**Material:**	Copper	**Source:**	Pretivm Resources Inc.
Receipt Date:	13 Jan-22 11:35	**CAS (PC):**		**Station:**	BJ-3.10
Sample Age:	10d 9h (10.6 °C)	**Client:**	Pretivm Resources Inc.		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	709851	200	Yes	Two-Point Interpolation

Point Estimates

Level	ug/L	95% LCL	95% UCL
IC10	4.168	---	---
IC15	>31	---	---
IC20	>31	---	---
IC25	>31	---	---
IC40	>31	---	---
IC50	>31	---	---

Mean Dry Weight-mg Summary

			Calculated Variate						Isotonic Variate	
Conc-ug/L	Code	Count	Mean	Median	Min	Max	CV%	%Effect	Mean	%Effect
0.37	XC	5	1.834	1.82	1.574	2.26	14.18%	0.00%	1.864	0.00%
1.04		5	1.895	1.907	1.58	2.102	10.58%	-3.35%	1.864	0.00%
1.46		5	1.701	1.708	1.553	1.871	7.81%	7.21%	1.786	4.22%
2.46		5	1.87	1.846	1.631	2.171	10.33%	-1.98%	1.786	4.22%
4.49		5	1.662	1.675	1.564	1.734	4.37%	9.38%	1.662	10.87%
8.45		5	1.517	1.535	1.375	1.621	6.19%	17.29%	1.612	13.55%
16.3		5	1.707	1.782	1.389	1.855	10.78%	6.92%	1.612	13.55%
31		5	1.596	1.562	1.477	1.817	8.82%	12.96%	1.596	14.40%

Mean Dry Weight-mg Detail

Conc-ug/L	Code	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
0.37	XC	1.574	1.82	1.826	1.689	2.26
1.04		1.58	1.907	2.027	2.102	1.86
1.46		1.708	1.871	1.553	1.589	1.786
2.46		1.631	1.856	1.846	2.171	1.846
4.49		1.675	1.723	1.564	1.734	1.613
8.45		1.535	1.569	1.484	1.375	1.621
16.3		1.782	1.389	1.789	1.855	1.719
31		1.477	1.817	1.562	1.482	1.642

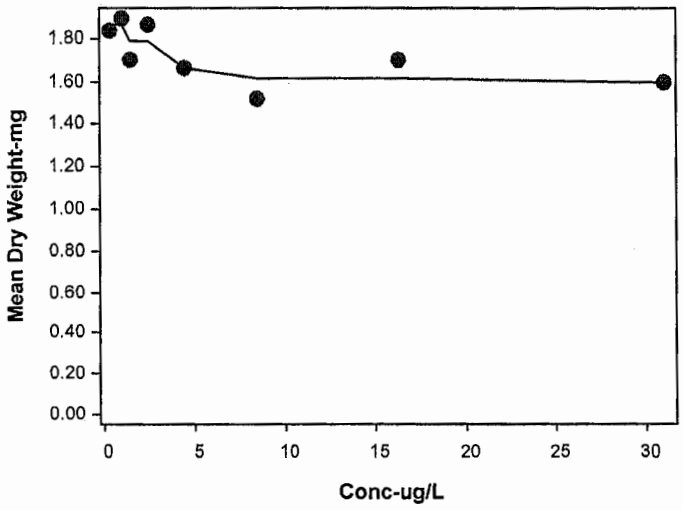
Water-only

Chironomus 10-d Survival and Growth ~~Sediment~~ Test MDO

Nautilus Environmental

Analysis ID:	01-8771-4274	**Endpoint:**	Mean Dry Weight-mg	**CETIS Version:**	CETISv2.1.1
Analyzed:	09 Mar-22 14:49	**Analysis:**	Linear Interpolation (ICPIN)	**Status Level:**	1
Edit Date:	09 Mar-22 14:45	**MD5 Hash:**	371026E49469E69E9513CF24E6B727D2	**Editor ID:**	004-311-246-8

Graphics



Analyst: MDO QA: JGK Mar. 25/22

APPENDIX E – Analytical Chemistry

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA22A1330**	Page	: 1 of 20
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Mikayla Oldach	Account Manager	: Emmanuel Mariano
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 24-Jan-2022 17:30
PO	: 2022-0220	Date Analysis Commenced	: 25-Jan-2022
C-O-C number	: ----	Issue Date	: 03-Feb-2022 14:31
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439 (Vancouver Blanket Quote)		
No. of samples received	: 86		
No. of samples analysed	: 86		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Ilnaz Badbezanchi	Team Leader - Metals preparation	Metals, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Robin Weeks	Team Leader - Metals	Metals, Burnaby, British Columbia
Ruby Pham	Lab Assistant	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water Control Day 0 P.sub	Lab Water 0.75 ug/L Day 0 P.sub	Lab Water 1.5 ug/L Day 0 P.sub	Lab Water 3 ug/L Day 0 P.sub	Lab Water 6 ug/L Day 0 P.sub
				Client sampling date / time	13-Jan-2022	13-Jan-2022	13-Jan-2022	13-Jan-2022	13-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-001	VA22A1330-002	VA22A1330-003	VA22A1330-004	VA22A1330-005
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00120	0.00173	0.00297	0.00592
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00041	0.00105	0.00160	0.00282	0.00532
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 12 ug/L Day 0 P.sub	Lab Water 24 ug/L Day 0 P.sub	Lab Water 48 ug/L Day 0 P.sub	Site Water Control Day 0 P.sub	Site Water 0.75 ug/L Day 0 P.sub
				Client sampling date / time	13-Jan-2022	13-Jan-2022	13-Jan-2022	13-Jan-2022	13-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-006	VA22A1330-007	VA22A1330-008	VA22A1330-009	VA22A1330-010
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.0118	0.0230	0.0464	<0.00050	0.00104
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0104	0.0209	0.0423	0.00020	0.00100
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Site Water 1.5 ug/L Day 0 P.sub	Site Water 3 ug/L Day 0 P.sub	Site Water 6 ug/L Day 0 P.sub	Site Water 12 ug/L Day 0 P.sub	Site Water 24 ug/L Day 0 P.sub
Client sample ID					Site Water 1.5 ug/L Day 0 P.sub	Site Water 3 ug/L Day 0 P.sub	Site Water 6 ug/L Day 0 P.sub	Site Water 12 ug/L Day 0 P.sub	Site Water 24 ug/L Day 0 P.sub
Client sampling date / time					13-Jan-2022	13-Jan-2022	13-Jan-2022	13-Jan-2022	13-Jan-2022
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	VA22A1330-011	VA22A1330-012	VA22A1330-013	VA22A1330-014	VA22A1330-015
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00180	0.00316	0.00623	0.0121	0.0244
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00170	0.00292	0.00674	0.0114	0.0224
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Site Water 48 ug/L Day 0 P.sub	Lab Water Control Day 0 Cerio	Lab Water 0.75 ug/L Day 0 Cerio	Lab Water 1.5 ug/L Day 0 Cerio	Lab Water 3 ug/L Day 0 Cerio
Client sample ID					Site Water 48 ug/L Day 0 P.sub	Lab Water Control Day 0 Cerio	Lab Water 0.75 ug/L Day 0 Cerio	Lab Water 1.5 ug/L Day 0 Cerio	Lab Water 3 ug/L Day 0 Cerio
Client sampling date / time					13-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	*CAS Number*	*Method*	*LOR*	*Unit*	VA22A1330-016	VA22A1330-017	VA22A1330-018	VA22A1330-019	VA22A1330-020
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.0488	<0.00050	0.00094	0.00159	0.00284
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0463	0.00021	0.00086	0.00152	0.00275
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 6 ug/L Day 0 Cerio	Lab Water 12 ug/L Day 0 Cerio	Lab Water 24 ug/L Day 0 Cerio	Lab Water 48 ug/L Day 0 Cerio All metals	Site Water Control Day 0 Cerio
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-021	VA22A1330-022	VA22A1330-023	VA22A1330-024	VA22A1330-025
					Result	Result	Result	Result	Result
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	----	----	----	<0.0030	----
antimony, total	7440-36-0	E420	0.00010	mg/L	----	----	----	0.00024	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	----	----	----	<0.00010	----
barium, total	7440-39-3	E420	0.00010	mg/L	----	----	----	0.00423	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	----	----	----	<0.000020	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	----	----	----	<0.000050	----
boron, total	7440-42-8	E420	0.010	mg/L	----	----	----	<0.010	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	----	----	----	<0.0000050	----
calcium, total	7440-70-2	E420	0.050	mg/L	----	----	----	30.4	----
cesium, total	7440-46-2	E420	0.000010	mg/L	----	----	----	<0.000010	----
chromium, total	7440-47-3	E420	0.00050	mg/L	----	----	----	<0.00050	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	----	----	----	<0.00010	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.00549	0.0104	0.0236	0.0469	<0.00050
iron, total	7439-89-6	E420	0.010	mg/L	----	----	----	<0.010	----
lead, total	7439-92-1	E420	0.000050	mg/L	----	----	----	<0.000050	----
lithium, total	7439-93-2	E420	0.0010	mg/L	----	----	----	<0.0010	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	----	----	----	0.800	----
manganese, total	7439-96-5	E420	0.00010	mg/L	----	----	----	0.00022	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	----	----	----	0.000110	----
nickel, total	7440-02-0	E420	0.00050	mg/L	----	----	----	<0.00050	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	----	----	----	<0.050	----
potassium, total	7440-09-7	E420	0.050	mg/L	----	----	----	0.123	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	----	----	----	<0.00020	----
selenium, total	7782-49-2	E420	0.000050	mg/L	----	----	----	0.000098	----
silicon, total	7440-21-3	E420	0.10	mg/L	----	----	----	1.15	----
silver, total	7440-22-4	E420	0.000010	mg/L	----	----	----	<0.000010	----
sodium, total	7440-23-5	E420	0.050	mg/L	----	----	----	2.19	----
strontium, total	7440-24-6	E420	0.00020	mg/L	----	----	----	0.120	----
sulfur, total	7704-34-9	E420	0.50	mg/L	----	----	----	1.44	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	----	----	----	<0.00020	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 6 ug/L Day 0 Cerio	Lab Water 12 ug/L Day 0 Cerio	Lab Water 24 ug/L Day 0 Cerio	Lab Water 48 ug/L Day 0 Cerio All metals	Site Water Control Day 0 Cerio
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-021	VA22A1330-022	VA22A1330-023	VA22A1330-024	VA22A1330-025
					Result	Result	Result	Result	Result
Total Metals									
thallium, total	7440-28-0	E420	0.000010	mg/L	----	----	----	<0.000010	----
thorium, total	7440-29-1	E420	0.00010	mg/L	----	----	----	<0.00010	----
tin, total	7440-31-5	E420	0.00010	mg/L	----	----	----	<0.00010	----
titanium, total	7440-32-6	E420	0.00030	mg/L	----	----	----	<0.00030	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	----	----	----	<0.00010	----
uranium, total	7440-61-1	E420	0.000010	mg/L	----	----	----	0.000301	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	----	----	----	<0.00050	----
zinc, total	7440-66-6	E420	0.0030	mg/L	----	----	----	<0.0030	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	----	----	----	<0.00020	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	----	----	----	0.0024	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	----	----	----	0.00022	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	----	----	----	<0.00010	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	----	----	----	0.00389	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	----	----	----	<0.000020	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	----	----	----	<0.000050	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	----	----	----	<0.010	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	----	----	----	<0.0000050	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	----	----	----	28.9	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	----	----	----	<0.000010	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	----	----	----	<0.00050	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	----	----	----	<0.00010	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00547	0.0106	0.0218	0.0426	<0.00020
iron, dissolved	7439-89-6	E421	0.010	mg/L	----	----	----	<0.010	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	----	----	----	<0.000050	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	----	----	----	<0.0010	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	----	----	----	0.756	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	----	----	----	0.00016	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	----	----	----	0.000097	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	----	----	----	<0.00050	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 6 ug/L Day 0 Cerio	Lab Water 12 ug/L Day 0 Cerio	Lab Water 24 ug/L Day 0 Cerio	Lab Water 48 ug/L Day 0 Cerio All metals	Site Water Control Day 0 Cerio
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-021	VA22A1330-022	VA22A1330-023	VA22A1330-024	VA22A1330-025
					Result	Result	Result	Result	Result
Dissolved Metals									
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	----	----	----	<0.050	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	----	----	----	0.118	----
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	----	----	----	<0.00020	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	----	----	----	0.000117	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	----	----	----	1.08	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	----	----	----	<0.000010	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	----	----	----	2.26	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	----	----	----	0.117	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	----	----	----	1.49	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	----	----	----	<0.00020	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	----	----	----	<0.000010	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	----	----	----	<0.00010	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	----	----	----	<0.00010	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	----	----	----	<0.00030	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	----	----	----	<0.00010	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	----	----	----	0.000330	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	----	----	----	<0.00050	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	----	----	----	<0.0010	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	----	----	----	<0.00030	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 0.75 ug/L Day 0 Cerio	Site Water 1.5 ug/L Day 0 Cerio	Site Water 3 ug/L Day 0 Cerio	Site Water 6 ug/L Day 0 Cerio	Site Water 12 ug/L Day 0 Cerio
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-026	VA22A1330-027	VA22A1330-028	VA22A1330-029	VA22A1330-030
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00100	0.00177	0.00335	0.00595	0.0116
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00079	0.00142	0.00247	0.00507	0.00988
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 24 ug/L Day 0 Cerio	Site Water 48 ug/L Day 0 Cerio All metals	Lab Water Control Day 0 Lemna	Lab Water 0.75 ug/L Day 0 Lemna	Lab Water 1.5 ug/L Day 0 Lemna
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-031	VA22A1330-032	VA22A1330-033	VA22A1330-034	VA22A1330-035
					Result	Result	Result	Result	Result
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	----	0.0606	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	----	0.00987	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	----	0.00738	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	----	0.0501	----	----	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	----	<0.000020	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	----	<0.000050	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	----	0.093	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	----	0.0000110	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	----	26.0	----	----	----
cesium, total	7440-46-2	E420	0.000010	mg/L	----	0.00144	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	----	<0.00050	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	----	<0.00010	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0243	0.0456	<0.00050	0.00148	0.00198
iron, total	7439-89-6	E420	0.010	mg/L	----	0.020	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	----	0.000404	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	----	0.0609	----	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	----	1.61	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	----	0.0522	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	----	0.00788	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	----	<0.00050	----	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	----	<0.050	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	----	12.0	----	----	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	----	0.0139	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	----	0.00107	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	----	1.80	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	----	<0.000010	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	----	32.3	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	----	0.544	----	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	----	21.4	----	----	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	----	<0.00020	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Site Water 24 ug/L Day 0 Cerio	Site Water 48 ug/L Day 0 Cerio All metals	Lab Water Control Day 0 Lemna	Lab Water 0.75 ug/L Day 0 Lemna	Lab Water 1.5 ug/L Day 0 Lemna
				Client sample ID	Site Water 24 ug/L Day 0 Cerio	Site Water 48 ug/L Day 0 Cerio All metals	Lab Water Control Day 0 Lemna	Lab Water 0.75 ug/L Day 0 Lemna	Lab Water 1.5 ug/L Day 0 Lemna
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
					VA22A1330-031	VA22A1330-032	VA22A1330-033	VA22A1330-034	VA22A1330-035
					Result	Result	Result	Result	Result
Total Metals									
thallium, total	7440-28-0	E420	0.000010	mg/L	----	0.000050	----	----	----
thorium, total	7440-29-1	E420	0.00010	mg/L	----	<0.00010	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	----	<0.00010	----	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	----	0.00035	----	----	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	----	0.00122	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	----	0.000410	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	----	<0.00050	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	----	<0.0030	----	----	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	----	<0.00020	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	----	0.0181	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	----	0.00936	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	----	0.00642	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	----	0.0454	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	----	<0.000020	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	----	<0.000050	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	----	0.094	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	----	0.0000091	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	----	24.0	----	----	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	----	0.00142	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	----	<0.00050	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	----	<0.00010	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0198	0.0378	<0.00020	0.00047	0.00055
iron, dissolved	7439-89-6	E421	0.010	mg/L	----	<0.010	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	----	0.000113	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	----	0.0563	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	----	1.54	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	----	0.0478	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	----	0.00688	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	----	<0.00050	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 24 ug/L Day 0 Cerio	Site Water 48 ug/L Day 0 Cerio All metals	Lab Water Control Day 0 Lemna	Lab Water 0.75 ug/L Day 0 Lemna	Lab Water 1.5 ug/L Day 0 Lemna
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-031	VA22A1330-032	VA22A1330-033	VA22A1330-034	VA22A1330-035
					Result	Result	Result	Result	Result
Dissolved Metals									
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	----	<0.050	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	----	11.1	----	----	----
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	----	0.0137	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	----	0.00100	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	----	1.57	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	----	<0.000010	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	----	30.6	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	----	0.517	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	----	19.5	----	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	----	<0.00020	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	----	0.000048	----	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	----	<0.00010	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	----	<0.00010	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	----	<0.00030	----	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	----	0.00112	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	----	0.000444	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	----	<0.00050	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	----	0.0012	----	----	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	----	<0.00030	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Lab Water 3 ug/L Day 0 Lemna	Lab Water 6 ug/L Day 0 Lemna	Lab Water 12 ug/L Day 0 Lemna	Lab Water 24 ug/L Day 0 Lemna	Lab Water 48 ug/L Day 0 Lemna
Client sample ID					Lab Water 3 ug/L Day 0 Lemna	Lab Water 6 ug/L Day 0 Lemna	Lab Water 12 ug/L Day 0 Lemna	Lab Water 24 ug/L Day 0 Lemna	Lab Water 48 ug/L Day 0 Lemna
Client sampling date / time					14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
					VA22A1330-036	VA22A1330-037	VA22A1330-038	VA22A1330-039	VA22A1330-040
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00352	0.00554	0.0111	0.0212	0.0440
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00088	0.00144	0.00286	0.00618	0.0150
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Site Water Control Day 0 Lemna	Site Water 0.75 ug/L Day 0 Lemna	Site Water 1.5 ug/L Day 0 Lemna	Site Water 3 ug/L Day 0 Lemna	Site Water 6 ug/L Day 0 Lemna
Client sample ID					Site Water Control Day 0 Lemna	Site Water 0.75 ug/L Day 0 Lemna	Site Water 1.5 ug/L Day 0 Lemna	Site Water 3 ug/L Day 0 Lemna	Site Water 6 ug/L Day 0 Lemna
Client sampling date / time					14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
					VA22A1330-041	VA22A1330-042	VA22A1330-043	VA22A1330-044	VA22A1330-045
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00171	0.00184	0.00340	0.00617
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00057	0.00079	0.00131	0.00188
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Site Water 12 ug/L Day 0 Lemna	Site Water 24 ug/L Day 0 Lemna	Site Water 48 ug/L Day 0 Lemna	Lab Water Control Day 6 Cerio	Lab Water 0.75 ug/L Day 6 Cerio
				Client sample ID					
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	20-Jan-2022	20-Jan-2022
					VA22A1330-046	VA22A1330-047	VA22A1330-048	VA22A1330-049	VA22A1330-050
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.0118	0.0222	0.0439	0.00126	0.00119
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00349	0.00669	0.0150	0.00040	0.00129
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Lab Water 1.5 ug/L Day 6 Cerio	Lab Water 3 ug/L Day 6 Cerio	Lab Water 6 ug/L Day 6 Cerio	Lab Water 12 ug/L Day 6 Cerio	Lab Water 24 ug/L Day 6 Cerio
				Client sample ID					
				Client sampling date / time	20-Jan-2022	20-Jan-2022	20-Jan-2022	20-Jan-2022	20-Jan-2022
					VA22A1330-051	VA22A1330-052	VA22A1330-053	VA22A1330-054	VA22A1330-055
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00184	0.00294	0.00500	0.00978	0.0218
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00164	0.00270	0.00424	0.00794	0.0173
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Lab Water 48 ug/L Day 3 Cerio	Site Water 48 ug/L Day 3 Cerio	Site Water Control Day 6 Cerio	Site Water 0.75 ug/L Day 6 Cerio	Site Water 1.5 ug/L Day 6 Cerio
				Client sampling date / time	17-Jan-2022	17-Jan-2022	20-Jan-2022	20-Jan-2022	20-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-056	VA22A1330-057	VA22A1330-058	VA22A1330-059	VA22A1330-060
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.0411	0.0399	0.00052	0.00135	0.00194
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0379	0.0363	0.00046	0.00100	0.00158
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	Site Water 3 ug/L Day 6 Cerio	Site Water 6 ug/L Day 6 Cerio	Site Water 12 ug/L Day 6 Cerio	Lab Water Control Day 7 Lemna	Lab Water 0.75 ug/L Day 7 Lemna
				Client sampling date / time	20-Jan-2022	20-Jan-2022	20-Jan-2022	21-Jan-2022	21-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-061	VA22A1330-062	VA22A1330-063	VA22A1330-064	VA22A1330-065
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00272	0.0102	0.0104	<0.00050	<0.00050
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00237	0.00374	0.00814	<0.00020	0.00035
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 1.5 ug/L Day 7 Lemna	Lab Water 3 ug/L Day 7 Lemna	Lab Water 6 ug/L Day 7 Lemna	Lab Water 12 ug/L Day 7 Lemna	Lab Water 24 ug/L Day 7 Lemna
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-066	VA22A1330-067	VA22A1330-068	VA22A1330-069	VA22A1330-070
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00081	0.00125	0.00301	0.00684
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00036	0.00052	0.00078	0.00122	0.00163
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 48 ug/L Day 7 Lemna	Site Water Control Day 7 Lemna	Site Water 0.75 ug/L Day 7 Lemna	Site Water 1.5 ug/L Day 7 Lemna	Site Water 3 ug/L Day 7 Lemna
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-071	VA22A1330-072	VA22A1330-073	VA22A1330-074	VA22A1330-075
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00994	<0.00050	0.00059	0.00072	0.00102
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00438	<0.00020	0.00042	0.00060	0.00078
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 6 ug/L Day 7 Lemna	Site Water 12 ug/L Day 7 Lemna	Site Water 24 ug/L Day 7 Lemna	Site Water 48 ug/L Day 7 Lemna	BJ 3.10 Day 0 general
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-076	VA22A1330-077	VA22A1330-078	VA22A1330-079	VA22A1330-080
					Result	Result	Result	Result	Result
Physical Tests									
conductivity	----	E100	2.0	µS/cm	----	----	----	----	318
pH	----	E108	0.10	pH units	----	----	----	----	7.83
solids, total dissolved [TDS]	----	E162	10	mg/L	----	----	----	----	205
solids, total suspended [TSS]	----	E160	3.0	mg/L	----	----	----	----	<3.0
turbidity	----	E121	0.10	NTU	----	----	----	----	3.44
Anions and Nutrients									
bromide	24959-67-9	E235.Br-L	0.050	mg/L	----	----	----	----	<0.050
chloride	16887-00-6	E235.Cl	0.50	mg/L	----	----	----	----	2.53
fluoride	16984-48-8	E235.F	0.020	mg/L	----	----	----	----	0.175
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	----	----	----	----	9.20
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	----	----	----	----	0.0250
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	----	----	----	----	<0.0010
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	----	----	----	----	62.5
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00173	0.00311	0.00418	0.00695	----
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00117	0.00170	0.00268	0.00568	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 48 ug/L Day 0 Cerio general	Site Water 48 ug/L Day 0 Cerio general	BJ 3.10 Day 0 total and dissolved nutrients; preserved	Lab Water 48 ug/L Day 0 Cerio total and dissolved nutrients; preserved	Site Water 48 ug/L Day 0 Cerio total and dissolved nutrients; preserved
				Client sampling date / time	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022	14-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-081	VA22A1330-082	VA22A1330-083	VA22A1330-084	VA22A1330-085
					Result	Result	Result	Result	Result
Physical Tests									
conductivity	----	E100	2.0	µS/cm	160	321	----	----	----
pH	----	E108	0.10	pH units	8.03	7.86	----	----	----
solids, total dissolved [TDS]	----	E162	10	mg/L	90	206	----	----	----
solids, total suspended [TSS]	----	E160	3.0	mg/L	<3.0	<3.0	----	----	----
turbidity	----	E121	0.10	NTU	<0.10	3.72	----	----	----
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	----	----	0.168	<0.0050	0.178
bromide	24959-67-9	E235.Br-L	0.050	mg/L	<0.050	<0.050	----	----	----
chloride	16887-00-6	E235.Cl	0.50	mg/L	4.29	2.60	----	----	----
fluoride	16984-48-8	E235.F	0.020	mg/L	0.020	0.175	----	----	----
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	0.397	9.21	----	----	----
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	<0.0010	0.0407	----	----	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	----	----	8.88	0.431	8.92
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	0.0018	0.0036	----	----	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	----	----	0.0054	0.0025	0.0026
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	4.44	62.6	----	----	----
Organic / Inorganic Carbon									
carbon, dissolved organic [DOC]	----	E358-L	0.50	mg/L	----	----	1.07	1.07	1.21
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	----	----	0.66	0.65	1.10

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ 3.10 Day 0 preserved with nitric acid	----	----	----	----
				Client sampling date / time	14-Jan-2022	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-086	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0287	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.0103	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00712	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0477	----	----	----	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.095	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	0.0000119	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	25.2	----	----	----	----
cesium, total	7440-46-2	E420	0.000010	mg/L	0.00149	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	0.012	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	0.000340	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0553	----	----	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	1.57	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.0527	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00778	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	<0.050	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	11.3	----	----	----	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	0.0141	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.00120	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	1.79	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	----	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	30.6	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.524	----	----	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	22.1	----	----	----	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	<0.00020	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000048	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ 3.10 Day 0 preserved with nitric acid	----	----	----	----
				Client sampling date / time	14-Jan-2022	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-086	--------	--------	--------	--------
					Result	----	----	----	----
Total Metals									
thorium, total	7440-29-1	E420	0.00010	mg/L	<0.00010	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	0.00120	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000416	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	<0.00050	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	----	----	----	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	<0.00020	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0169	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00955	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00655	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0452	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.096	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	0.0000120	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	24.2	----	----	----	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	0.00145	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	0.000096	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0566	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	1.46	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.0481	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00699	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	<0.050	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	11.1	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)				Client sample ID	BJ 3.10 Day 0 preserved with nitric acid	----	----	----	----
				Client sampling date / time	14-Jan-2022	----	----	----	----
Analyte	CAS Number	Method	LOR	Unit	VA22A1330-086	--------	--------	--------	--------
					Result	----	----	----	----
Dissolved Metals									
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	0.0131	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000990	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.65	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	28.4	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.515	----	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	20.2	----	----	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	<0.00020	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000051	----	----	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	<0.00010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	0.00116	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000440	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	<0.00050	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	----	----	----	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	<0.00030	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA22A1330**	Page	: 1 of 31
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Mikayla Oldach	Account Manager	: Emmanuel Mariano
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 24-Jan-2022 17:30
PO	: 2022-0220	Issue Date	: 03-Feb-2022 14:31
C-O-C number	: ----		
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439 (Vancouver Blanket Quote)		
No. of samples received	: 86		
No. of samples analysed	: 86		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Summary of Outliers

Outliers : Quality Control Samples

- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Method Blank value outliers occur - please see following pages for full details.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- Quality Control Sample Frequency Outliers occur - please see following pages for full details.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Method Blank (MB) Values								
Total Metals	QC-398702-001	----	arsenic, total	7440-38-2	E420	0.00133 mg/L B	0.0001 mg/L	Blank result exceeds permitted value

Result Qualifiers

Qualifier	Description
B	*Method Blank exceeds ALS DQO. Associated sample results which are < Limit of Reporting or > 5 times blank level are considered reliable.*

Laboratory Control Sample (LCS) Recoveries								
Total Metals	QC-398664-002	----	thorium, total	7440-29-1	E420	79.0 % MES	80.0-120%	Recovery less than lower control limit

Result Qualifiers

Qualifier	Description
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
BJ 3.10 Day 0 - total and dissolved nutrients; preserved	E298	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E298	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid)										
Site Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E298	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
BJ 3.10 Day 0 - general	E235.Br-L	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 0 Cerio - general	E235.Br-L	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E235.Br-L	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
BJ 3.10 Day 0 - general	E235.Cl	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Lab Water 48 ug/L Day 0 Cerio - general	E235.Cl	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E235.Cl	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
BJ 3.10 Day 0 - general	E378-U	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Lab Water 48 ug/L Day 0 Cerio - general	E378-U	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E378-U	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
BJ 3.10 Day 0 - general	E235.F	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Lab Water 48 ug/L Day 0 Cerio - general	E235.F	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E235.F	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
BJ 3.10 Day 0 - general	E235.NO3-L	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Lab Water 48 ug/L Day 0 Cerio - general	E235.NO3-L	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE Site Water 48 ug/L Day 0 Cerio - general	E235.NO3-L	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE BJ 3.10 Day 0 - general	E235.NO2-L	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE Lab Water 48 ug/L Day 0 Cerio - general	E235.NO2-L	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE Site Water 48 ug/L Day 0 Cerio - general	E235.NO2-L	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE BJ 3.10 Day 0 - general	E235.SO4	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE Lab Water 48 ug/L Day 0 Cerio - general	E235.SO4	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE Site Water 48 ug/L Day 0 Cerio - general	E235.SO4	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) BJ 3.10 Day 0 - total and dissolved nutrients; preserved	E366	14-Jan-2022	26-Jan-2022	----	----		27-Jan-2022	28 days	13 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) Lab Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E366	14-Jan-2022	26-Jan-2022	----	----		27-Jan-2022	28 days	13 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid) Site Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E366	14-Jan-2022	26-Jan-2022	----	----		27-Jan-2022	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) BJ 3.10 Day 0 - total and dissolved nutrients; preserved	E372-U	14-Jan-2022	26-Jan-2022	----	----		27-Jan-2022	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) Lab Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E372-U	14-Jan-2022	26-Jan-2022	----	----		27-Jan-2022	28 days	13 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) Site Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E372-U	14-Jan-2022	26-Jan-2022	----	----		27-Jan-2022	28 days	13 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 24 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 3 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 48 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 6 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water Control Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 0.75 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 1.5 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 12 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 24 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 3 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 48 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 6 ug/L Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water Control Day 7 Lemna	E421	21-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	11 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 24 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 3 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 6 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Lab Water Control Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 0.75 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 1.5 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 12 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 3 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 6 ug/L Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water Control Day 6 Cerio	E421	20-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Lab Water 48 ug/L Day 3 Cerio	E421	17-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	15 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 48 ug/L Day 3 Cerio	E421	17-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	15 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) BJ 3.10 Day 0 - preserved with nitric acid	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 24 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 24 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓

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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 3 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 3 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 48 ug/L Day 0 Cerio - All metals	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 48 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 6 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 6 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water Control Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water Control Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 0.75 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓

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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
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HDPE dissolved (nitric acid) Site Water 0.75 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 1.5 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 1.5 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
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HDPE dissolved (nitric acid) Site Water 12 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 48 ug/L Day 0 Cerio - All metals	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 48 ug/L Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 6 ug/L Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
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Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water Control Day 0 Cerio	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water Control Day 0 Lemna	E421	14-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	18 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓

Matrix: **Water**

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Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
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HDPE dissolved (nitric acid) Lab Water 3 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 48 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
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HDPE dissolved (nitric acid) Lab Water Control Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 0.75 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 1.5 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 12 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 24 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓

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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 3 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 48 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 6 ug/L Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water Control Day 0 P.sub	E421	13-Jan-2022	01-Feb-2022	----	----		01-Feb-2022	180 days	19 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
BJ 3.10 Day 0 - total and dissolved nutrients; preserved	E358-L	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Lab Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E358-L	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Site Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E358-L	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
BJ 3.10 Day 0 - total and dissolved nutrients; preserved	E355-L	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E355-L	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓

Matrix: **Water**

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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid) Site Water 48 ug/L Day 0 Cerio - total and dissolved nutrients; preserved	E355-L	14-Jan-2022	26-Jan-2022	----	----		26-Jan-2022	28 days	12 days	✓
Physical Tests : Conductivity in Water										
HDPE BJ 3.10 Day 0 - general	E100	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Physical Tests : Conductivity in Water										
HDPE Lab Water 48 ug/L Day 0 Cerio - general	E100	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Physical Tests : Conductivity in Water										
HDPE Site Water 48 ug/L Day 0 Cerio - general	E100	14-Jan-2022	----	----	----		25-Jan-2022	28 days	12 days	✓
Physical Tests : pH by Meter										
HDPE BJ 3.10 Day 0 - general	E108	14-Jan-2022	----	----	----		25-Jan-2022	0.25 hrs	282 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE Lab Water 48 ug/L Day 0 Cerio - general	E108	14-Jan-2022	----	----	----		25-Jan-2022	0.25 hrs	282 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE Site Water 48 ug/L Day 0 Cerio - general	E108	14-Jan-2022	----	----	----		25-Jan-2022	0.25 hrs	282 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE BJ 3.10 Day 0 - general	E162	14-Jan-2022	----	----	----		25-Jan-2022	7 days	12 days	× EHTR
Physical Tests : TDS by Gravimetry										
HDPE Lab Water 48 ug/L Day 0 Cerio - general	E162	14-Jan-2022	----	----	----		25-Jan-2022	7 days	12 days	× EHTR

Matrix: **Water**

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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E162	14-Jan-2022	----	----	----		25-Jan-2022	7 days	12 days	× EHTR
Physical Tests : TSS by Gravimetry										
HDPE										
BJ 3.10 Day 0 - general	E160	14-Jan-2022	----	----	----		25-Jan-2022	7 days	12 days	× EHTR
Physical Tests : TSS by Gravimetry										
HDPE										
Lab Water 48 ug/L Day 0 Cerio - general	E160	14-Jan-2022	----	----	----		25-Jan-2022	7 days	12 days	× EHTR
Physical Tests : TSS by Gravimetry										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E160	14-Jan-2022	----	----	----		25-Jan-2022	7 days	12 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
BJ 3.10 Day 0 - general	E121	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
Lab Water 48 ug/L Day 0 Cerio - general	E121	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE										
Site Water 48 ug/L Day 0 Cerio - general	E121	14-Jan-2022	----	----	----		25-Jan-2022	3 days	12 days	× EHTR
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 0.75 ug/L Day 7 Lemna	E420	21-Jan-2022	----	----	----		31-Jan-2022	180 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 1.5 ug/L Day 7 Lemna	E420	21-Jan-2022	----	----	----		31-Jan-2022	180 days	11 days	✓

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Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 12 ug/L Day 7 Lemna	E420	21-Jan-2022	----	----	----		31-Jan-2022	180 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 24 ug/L Day 7 Lemna	E420	21-Jan-2022	----	----	----		31-Jan-2022	180 days	11 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 3 ug/L Day 7 Lemna	E420	21-Jan-2022	----	----	----		31-Jan-2022	180 days	11 days	✓
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Total Metals : Total Metals in Water by CRC ICPMS										
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HDPE total (nitric acid)										
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Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water Control Day 6 Cerio	E420	20-Jan-2022	----	----	----		31-Jan-2022	180 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 48 ug/L Day 3 Cerio	E420	17-Jan-2022	----	----	----		31-Jan-2022	180 days	15 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 48 ug/L Day 3 Cerio	E420	17-Jan-2022	----	----	----		31-Jan-2022	180 days	15 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BJ 3.10 Day 0 - preserved with nitric acid	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 0.75 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 0.75 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 1.5 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 1.5 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 12 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 12 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 24 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 24 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 3 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 3 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 48 ug/L Day 0 Cerio - All metals	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 48 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 6 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 6 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water Control Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water Control Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 0.75 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 0.75 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 1.5 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 1.5 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 12 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 12 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 24 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 24 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 3 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 3 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 48 ug/L Day 0 Cerio - All metals	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 48 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 6 ug/L Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 6 ug/L Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water Control Day 0 Cerio	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water Control Day 0 Lemna	E420	14-Jan-2022	----	----	----		31-Jan-2022	180 days	18 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 0.75 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 1.5 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 12 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 24 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 3 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 48 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 6 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water Control Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 0.75 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 1.5 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 12 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 24 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 3 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 48 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 6 ug/L Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water Control Day 0 P.sub	E420	13-Jan-2022	----	----	----		31-Jan-2022	180 days	19 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: ✗ = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Ammonia by Fluorescence	E298	394739	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	394550	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	394549	1	14	7.1	5.0	✓
Conductivity in Water	E100	394543	0	14	0.0	5.0	✗
Dissolved Metals in Water by CRC ICPMS	E421	399094	4	80	5.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	394740	1	16	6.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	394659	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	394548	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	394551	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	394552	1	14	7.1	5.0	✓
pH by Meter	E108	394544	0	20	0.0	5.0	✗
Sulfate in Water by IC	E235.SO4	394547	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	394503	1	15	6.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	398663	4	80	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	394737	1	19	5.2	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	394744	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	394738	1	18	5.5	5.0	✓
TSS by Gravimetry	E160	394502	1	10	10.0	5.0	✓
Turbidity by Nephelometry	E121	394518	1	8	12.5	5.0	✓
Laboratory Control Samples (LCS)							
Ammonia by Fluorescence	E298	394739	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	394550	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	394549	1	14	7.1	5.0	✓
Conductivity in Water	E100	394543	1	14	7.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	399094	4	80	5.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	394740	1	16	6.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	394659	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	394548	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	394551	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	394552	1	14	7.1	5.0	✓
pH by Meter	E108	394544	1	20	5.0	5.0	✓
Sulfate in Water by IC	E235.SO4	394547	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	394503	1	15	6.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	398663	4	80	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	394737	1	19	5.2	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	394744	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	394738	1	18	5.5	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
TSS by Gravimetry	E160	394502	1	10	10.0	5.0	✓
Turbidity by Nephelometry	E121	394518	1	8	12.5	5.0	✓
Method Blanks (MB)							
Ammonia by Fluorescence	E298	394739	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	394550	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	394549	1	14	7.1	5.0	✓
Conductivity in Water	E100	394543	1	14	7.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	399094	4	80	5.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	394740	1	16	6.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	394659	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	394548	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	394551	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	394552	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	394547	1	14	7.1	5.0	✓
TDS by Gravimetry	E162	394503	1	15	6.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	398663	4	80	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	394737	1	19	5.2	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	394744	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	394738	1	18	5.5	5.0	✓
TSS by Gravimetry	E160	394502	1	10	10.0	5.0	✓
Turbidity by Nephelometry	E121	394518	1	8	12.5	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	394739	1	19	5.2	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	394550	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	394549	1	14	7.1	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	399094	4	80	5.0	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	394740	1	16	6.2	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	394659	1	5	20.0	5.0	✓
Fluoride in Water by IC	E235.F	394548	1	14	7.1	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	394551	1	13	7.6	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	394552	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	394547	1	14	7.1	5.0	✓
Total Metals in Water by CRC ICPMS	E420	398663	4	80	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	394737	1	19	5.2	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	394744	1	5	20.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	394738	1	18	5.5	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160 Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Dissolved Organic Carbon by Combustion (Low Level)	E358-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Dissolved Organic Carbon (Non-Purgeable), also known as NPOC (dissolved), is a direct measurement of DOC after a filtered (0.45 micron) sample has been acidified and purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of DC (dissolved carbon) is comprised of IC (which is common), this method is more accurate and more reliable than the DOC by subtraction method (i.e. DC minus DIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion
Preparation for Dissolved Organic Carbon for Combustion	EP358 Vancouver - Environmental	Water	APHA 5310 B (mod)	Preparation for Dissolved Organic Carbon
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
T2Z 3V9
Phone 403.253.7121

Point Edward ( )
704 Mara Street, Suite 122
Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Jan 24/21 Page 1 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
1	Lab Water Control Day 0 P.sub	13/01/22			1x125 mL		✓	✓										3.6
2	Lab Water 0.75 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
3	Lab Water 1.5 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
4	Lab Water 3 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
5	Lab Water 6 µg/LDay 0 P.sub	13/01/22			1x125 mL		✓	✓										
6	Lab Water 12 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
7	Lab Water 24 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
8	Lab Water 48 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)
Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)
RJ (Company) JAN-24 (Date DD/MM/YY and Time) 17:50

Environmental Division
Vancouver
Work Order Reference
VA22A1330
Telephone : +1 604 253 4188

Our liability is limit... only relate to the sample ... for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Chain of Custody

Date Jan 24/22 Page ~~5~~ 2 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite (●)

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
9 1	Site Water Control Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
10 2	Site Water 0.75 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
11 3	Site Water 1.5 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
12 4	Site Water 3 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
13 5	Site Water 6 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
14 6	Site Water 12 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
15 7	Site Water 24 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
16 8	Site Water 48 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

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8664 Commerce Court
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Chain of Custody

Date Jan 24/22 Page 3 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: _____ **Sample Type:** Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals								Receipt Temperature (°C)
17 1	Lab Water Control Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
18 2	Lab Water 0.75 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
19 3	Lab Water 1.5 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
20 4	Lab Water 3 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
21 5	Lab Water 6 µg/LDay 0 Cerio	14/01/22			1x125 mL		✓	✓										
22 6	Lab Water 12 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
23 7	Lab Water 24 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
24 8	Lab Water 48 µg/L Day 0 Cerio	14/01/22			1x125 mL	All metals			✓	✓								
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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TESTING LOCATION (Please Circle)

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8664 Commerce Court
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Chain of Custody

Date Jan 24/22 Page 4 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals								Receipt Temperature (°C)
25 1	Site Water Control Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
26 2	Site Water 0.75 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
27 3	Site Water 1.5 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
28 4	Site Water 3 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
29 5	Site Water 6 µg/LDay 0 Cerio	14/01/22			1x125 mL		✓	✓										
30 6	Site Water 12 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
31 7	Site Water 24 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
32 8	Site Water 48 µg/L Day 0 Cerio	14/01/22			1x125 mL	All metals			✓	✓								
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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Burnaby, British Columbia, Canada
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Chain of Custody

Date Jan 24/22 Page 5 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
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Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
33 1	Lab Water Control Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
34 2	Lab Water 0.75 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
35 3	Lab Water 1.5 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
36 4	Lab Water 3 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
37 5	Lab Water 6 µg/LDay 0 Lemna	14/01/22			1x125 mL		✓	✓										
38 6	Lab Water 12 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
39 7	Lab Water 24 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
40 8	Lab Water 48 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Chain of Custody

Date Jan 24/21 Page 7 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
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Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
49 1	Lab Water Control Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
50 2	Lab Water 0.75 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
51 3	Lab Water 1.5 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
52 4	Lab Water 3 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
53 5	Lab Water 6 µg/LDay 6 Cerio	20/01/22			1x125 mL		✓	✓										
54 6	Lab Water 12 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
55 7	Lab Water 24 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
8																		
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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Chain of Custody

Date Jan 24/21 Page 8 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
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Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite (●)

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
56 1	Lab Water 48 µg/L Day 3 Cerio	17/01/22			1x125 mL		✓	✓										
57 2	Site Water 48 µg/L Day 3 Cerio	17/01/22			1x125 mL		✓	✓										
58 3	Site Water Control Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
59 4	Site Water 0.75 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
60 5	Site Water 1.5 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
61 6	Site Water 3 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
62 7	Site Water 6 µg/LDay 6 Cerio	20/01/22			1x125 mL		✓	✓										
63 8	Site Water 12 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Calgary ( )
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Calgary, Alberta, Canada
T2Z 3V9
Phone 403.253.7121

Point Edward ( )
704 Mara Street, Suite 122
Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Jan 24/21 Page 9 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
64 1	Lab Water Control Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
65 2	Lab Water 0.75 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
66 3	Lab Water 1.5 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
67 4	Lab Water 3 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
68 5	Lab Water 6 µg/LDay 7 Lemna	21/01/22			1x125 mL		✓	✓										
69 6	Lab Water 12 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
70 7	Lab Water 24 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
71 8	Lab Water 48 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
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Phone 519.339.8787

Chain of Custody

Date Jan 24/22 Page 10 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: —

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
72 1	Site Water Control Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
73 2	Site Water 0.75 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
74 3	Site Water 1.5 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
75 4	Site Water 3 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
76 5	Site Water 6 µg/LDay 7 Lemna	21/01/22			1x125 mL		✓	✓										
77 6	Site Water 12 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
78 7	Site Water 24 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
79 8	Site Water 48 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

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Form 020; Revised by TP 2021/11/17

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TESTING LOCATION (Please Circle)

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8664 Commerce Court
Burnaby, British Columbia, Canada
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Phone 519.339.8787

Chain of Custody

Date Jan 24/22 Page 11 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-~~0187~~ 0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Physical parameters	Major anions	Nutrients (DOC,TOC)	Total metals	Dissolved metals							Receipt Temperature (°C)
80 1	BJ 3.10 Day 0	14/01/22			1 x 500 mL	general	✓	✓										
81 2	Lab Water 48 µg/L Day 0 Cerio	14/01/22			1 x 500 mL	general	✓	✓										
82 3	Site Water 48 µg/L Day 0 Cerio	14/01/22			1 x 500 mL	general	✓	✓										
83 4	BJ 3.10 Day 0	14/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
84 5	Lab Water 48 µg/L Day 0 Cerio	14/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
85 6	Site Water 48 µg/L Day 0 Cerio	14/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
86 7	BJ 3.10 Day 0	14/01/22			1 x 60mL	preserved with nitric acid				✓	✓							
8																		
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-samples for DOC are filtered
-samples for dissolved metals are filtered
-samples for total and dissolved metals preserved with nitric acid
~~-see list of "full suite" testing attached~~

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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8664 Commerce Court
Burnaby, British Columbia, Canada
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N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Jan 24/21 Page 1 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: ____ **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
1	Lab Water Control Day 0 P.sub	13/01/22			1x125 mL		✓	✓										3.4
2	Lab Water 0.75 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
3	Lab Water 1.5 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
4	Lab Water 3 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
5	Lab Water 6 µg/LDay 0 P.sub	13/01/22			1x125 mL		✓	✓										
6	Lab Water 12 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
7	Lab Water 24 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
8	Lab Water 48 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE D ... **RY)**

Environmental Division
Vancouver
Work Order Reference
VA22A1330

Telephone : +1 604 253 4188

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

RJ (Company) JAN-24 (Date DD/MM/YY and Time) 17:50

Our liability is limit... only relate to the sample ... ...med for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

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Chain of Custody

Date Jan 24/21 Page 2 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: _____ **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
9 1	Site Water Control Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
10 2	Site Water 0.75 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
11 3	Site Water 1.5 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
12 4	Site Water 3 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
13 5	Site Water 6 µg/LDay 0 P.sub	13/01/22			1x125 mL		✓	✓										
14 6	Site Water 12 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
15 7	Site Water 24 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
16 8	Site Water 48 µg/L Day 0 P.sub	13/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

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Chain of Custody

Date Jan 24/22 Page 3 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
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Email	mikayla@nautilusenvironmental.ca

Invoice To:

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Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: _____ **Sample Type:** Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals								Receipt Temperature (°C)
17 1	Lab Water Control Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
18 2	Lab Water 0.75 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
19 3	Lab Water 1.5 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
20 4	Lab Water 3 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
21 5	Lab Water 6 µg/LDay 0 Cerio	14/01/22			1x125 mL		✓	✓										
22 6	Lab Water 12 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
23 7	Lab Water 24 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
24 8	Lab Water 48 µg/L Day 0 Cerio	14/01/22			1x125 mL	All metals			✓	✓								
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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Date Jan 24/21 Page 4 of 11

Report to:

Company	Nautilus Environmental Company Inc
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Contact	Mikayla Oldach
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Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals								Receipt Temperature (°C)
25 1	Site Water Control Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
26 2	Site Water 0.75 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
27 3	Site Water 1.5 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
28 4	Site Water 3 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
29 5	Site Water 6 µg/LDay 0 Cerio	14/01/22			1x125 mL		✓	✓										
30 6	Site Water 12 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
31 7	Site Water 24 µg/L Day 0 Cerio	14/01/22			1x125 mL		✓	✓										
32 8	Site Water 48 µg/L Day 0 Cerio	14/01/22			1x125 mL	All metals			✓	✓								
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Chain of Custody

Date Jan 24/22 Page 5 of 11

Report to:

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Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
33 1	Lab Water Control Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
34 2	Lab Water 0.75 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
35 3	Lab Water 1.5 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
36 4	Lab Water 3 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
37 5	Lab Water 6 µg/LDay 0 Lemna	14/01/22			1x125 mL		✓	✓										
38 6	Lab Water 12 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
39 7	Lab Water 24 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
40 8	Lab Water 48 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
T2Z 3V9
Phone 403.253.7121

Point Edward ( )
704 Mara Street, Suite 122
Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Date Jan 24/22 Page 6 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: ..... **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
41 1	Site Water Control Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
42 2	Site Water 0.75 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
43 3	Site Water 1.5 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
44 4	Site Water 3 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
45 5	Site Water 6 µg/LDay 0 Lemna	14/01/22			1x125 mL		✓	✓										
46 6	Site Water 12 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
47 7	Site Water 24 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
48 8	Site Water 48 µg/L Day 0 Lemna	14/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

Our liability is limited to the cost of the test requested. The test results only relate to the sample as received. No liability in whole or in part is assumed for the collection, handling, or transport of the sample, application or interpretation of the test data or results in part or in whole.

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
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Phone 519.339.8787

Chain of Custody

Date Jan 24/21 Page 7 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: ____ **Sample Type:** Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
49 1	Lab Water Control Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
50 2	Lab Water 0.75 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
51 3	Lab Water 1.5 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
52 4	Lab Water 3 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
53 5	Lab Water 6 µg/LDay 6 Cerio	20/01/22			1x125 mL		✓	✓										
54 6	Lab Water 12 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
55 7	Lab Water 24 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
8																		
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present In Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Phone 604.420.8773

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Chain of Custody

Date Jan 24/21 Page 8 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
56 1	Lab Water 48 µg/L Day 3 Cerio	17/01/22			1x125 mL		✓	✓										
57 2	Site Water 48 µg/L Day 3 Cerio	17/01/22			1x125 mL		✓	✓										
58 3	Site Water Control Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
59 4	Site Water 0.75 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
60 5	Site Water 1.5 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
61 6	Site Water 3 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
62 7	Site Water 6 µg/LDay 6 Cerio	20/01/22			1x125 mL		✓	✓										
63 8	Site Water 12 µg/L Day 6 Cerio	20/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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8664 Commerce Court
Burnaby, British Columbia, Canada
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Chain of Custody

Date Jan 24/21 Page 9 of 11

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
64 1	Lab Water Control Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
65 2	Lab Water 0.75 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
66 3	Lab Water 1.5 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
67 4	Lab Water 3 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
68 5	Lab Water 6 µg/LDay 7 Lemna	21/01/22			1x125 mL		✓	✓										
69 6	Lab Water 12 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
70 7	Lab Water 24 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
71 8	Lab Water 48 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

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Burnaby (●)
8664 Commerce Court
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Chain of Custody

Date Jan 24/22 Page 10 of 11

Report to:

Company	Nautilus Environmental Company Inc
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Email	mikayla@nautilusenvironmental.ca

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Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By: --

Sample Type: Grab ( ) OR Composite ( )

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)										Receipt Temperature (°C)
72 1	Site Water Control Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
73 2	Site Water 0.75 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
74 3	Site Water 1.5 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
75 4	Site Water 3 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
76 5	Site Water 6 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
77 6	Site Water 12 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
78 7	Site Water 24 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
79 8	Site Water 48 µg/L Day 7 Lemna	21/01/22			1x125 mL		✓	✓										
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

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Chain of Custody

Date Jan 24/22 Page 11 of 11

Report to:

Company	Nautilus Environmental Company Inc
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Contact	Mikayla Oldach
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Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-~~0187~~ 0220 mas

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Physical parameters	Major anions	Nutrients (DOC,TOC)	Total metals	Dissolved metals							Receipt Temperature (°C)
80 1	BJ 3.10 Day 0	14/01/22			1 x 500 mL	general	✓	✓										
81 2	Lab Water 48 µg/L Day 0 Cerio	14/01/22			1 x 500 mL	general	✓	✓										
82 3	Site Water 48 µg/L Day 0 Cerio	14/01/22			1 x 500 mL	general	✓	✓										
83 4	BJ 3.10 Day 0	14/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
84 5	Lab Water 48 µg/L Day 0 Cerio	14/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
85 6	Site Water 48 µg/L Day 0 Cerio	14/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
86 7	BJ 3.10 Day 0	14/01/22			1 x 60mL	preserved with nitric acid				✓	✓							
8																		
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-samples for DOC are filtered
-samples for dissolved metals are filtered
-samples for total and dissolved metals preserved with nitric acid
-see list of "full suite" testing attached

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 24/01/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **VA22A2340**	Page	: 1 of 18
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Mikayla Oldach	Account Manager	: Emmanuel Mariano
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby BC Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 04-Feb-2022 15:30
PO	: 2022-0220	Date Analysis Commenced	: 05-Feb-2022
C-O-C number	: ----	Issue Date	: 15-Feb-2022 17:11
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439 (Vancouver Blanket Quote)		
No. of samples received	: 45		
No. of samples analysed	: 45		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Angela Ren	Team Leader - Metals	Metals, Burnaby, British Columbia
Angelo Salandanan	Lab Assistant	Metals, Burnaby, British Columbia
Christopher Li	Lab Assistant	Metals, Burnaby, British Columbia
Kim Jensen	Department Manager - Metals	Metals, Burnaby, British Columbia
Lindsay Gung	Supervisor - Water Chemistry	Inorganics, Burnaby, British Columbia
Miles Gropen	Department Manager - Inorganics	Inorganics, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances
LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	No Unit
µS/cm	Microsiemens per centimetre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLM	*Detection Limit Adjusted due to sample matrix effects (e.g. chemical interference, colour, turbidity).*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Lab Water Control Day 0 Chiron	Lab Water 0.75 ug/L Day 0 Chiron	Lab Water 1.5 ug/L Day 0 Chiron	Lab Water 3 ug/L Day 0 Chiron	Lab Water 6 ug/L Day 0 Chiron
Client sample ID					Lab Water Control Day 0 Chiron	Lab Water 0.75 ug/L Day 0 Chiron	Lab Water 1.5 ug/L Day 0 Chiron	Lab Water 3 ug/L Day 0 Chiron	Lab Water 6 ug/L Day 0 Chiron
Client sampling date / time					21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
					VA22A2340-001	VA22A2340-002	VA22A2340-003	VA22A2340-004	VA22A2340-005
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00174	0.00205	0.00318	0.00630
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00025	0.00107	0.00171	0.00304	0.00586
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Lab Water 12 ug/L Day 0 Chiron	Lab Water 24 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 0 Chiron	Lab Water Day 0 OAM	Site Water (100%) Day 0 OAM
Client sample ID					Lab Water 12 ug/L Day 0 Chiron	Lab Water 24 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 0 Chiron	Lab Water Day 0 OAM	Site Water (100%) Day 0 OAM
Client sampling date / time					21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
					VA22A2340-006	VA22A2340-007	VA22A2340-008	VA22A2340-009	VA22A2340-010
					Result	Result	Result	Result	Result
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	----	----	----	<0.0050	0.154
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	----	----	0.0043	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	----	----	0.00022	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	----	----	<0.00010	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	----	----	0.00357	----	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	----	----	<0.000020	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	----	----	<0.000050	----	----
boron, total	7440-42-8	E420	0.010	mg/L	----	----	<0.010	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	----	----	<0.0000050	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	----	----	30.2	----	----
cesium, total	7440-46-2	E420	0.000010	mg/L	----	----	<0.000010	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	----	----	<0.00050	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	----	----	<0.00010	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0120	0.0240	0.0462	----	----
iron, total	7439-89-6	E420	0.010	mg/L	----	----	<0.010	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 12 ug/L Day 0 Chiron	Lab Water 24 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 0 Chiron	Lab Water Day 0 OAM	Site Water (100%) Day 0 OAM
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-006	VA22A2340-007	VA22A2340-008	VA22A2340-009	VA22A2340-010
					Result	Result	Result	Result	Result
Total Metals									
lead, total	7439-92-1	E420	0.000050	mg/L	----	----	<0.000050	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	----	----	<0.0010	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	----	----	0.718	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	----	----	0.00012	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	----	----	0.000100	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	----	----	<0.00050	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	----	----	<0.050	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	----	----	0.104	----	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	----	----	<0.00020	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	----	----	0.000108	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	----	----	1.12	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	----	----	<0.000010	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	----	----	2.16	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	----	----	0.118	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	----	----	1.47	----	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	----	----	<0.00020	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	----	----	<0.000010	----	----
thorium, total	7440-29-1	E420	0.00010	mg/L	----	----	<0.00010	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	----	----	<0.00010	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	----	----	<0.00030	----	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	----	----	<0.00010	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	----	----	0.000270	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	----	----	<0.00050	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	----	----	<0.0030	----	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	----	----	<0.00020	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	----	----	0.0029	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	----	----	0.00023	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	----	----	<0.00010	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	----	----	0.00397	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	----	----	<0.000020	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Lab Water 12 ug/L Day 0 Chiron	Lab Water 24 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 0 Chiron	Lab Water Day 0 OAM	Site Water (100%) Day 0 OAM
				Client sample ID					
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
					VA22A2340-006	VA22A2340-007	VA22A2340-008	VA22A2340-009	VA22A2340-010
					Result	Result	Result	Result	Result
Dissolved Metals									
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	----	----	<0.000050	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	----	----	<0.010	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	----	----	<0.0000050	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	----	----	28.4	----	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	----	----	<0.000010	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	----	----	<0.00050	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	----	----	<0.00010	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0113	0.0232	0.0457	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	----	----	<0.010	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	----	----	<0.000050	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	----	----	<0.0010	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	----	----	0.756	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	----	----	<0.00010	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	----	----	0.000101	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	----	----	<0.00050	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	----	----	<0.050	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	----	----	0.131	----	----
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	----	----	<0.00020	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	----	----	0.000106	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	----	----	1.20	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	----	----	<0.000010	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	----	----	2.18	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	----	----	0.116	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	----	----	1.70	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	----	----	<0.00020	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	----	----	<0.000010	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	----	----	<0.00010	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	----	----	<0.00010	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	----	----	<0.00030	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	----	----	<0.00010	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	----	----	0.000313	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 12 ug/L Day 0 Chiron	Lab Water 24 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 0 Chiron	Lab Water Day 0 OAM	Site Water (100%) Day 0 OAM
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-006	VA22A2340-007	VA22A2340-008	VA22A2340-009	VA22A2340-010
					Result	Result	Result	Result	Result
Dissolved Metals									
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	----	----	<0.00050	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	----	----	<0.0010	----	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	----	----	<0.00030	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	----	----

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water Control Day 0 Chiron	Site Water 0.75 ug/L Day 0 Chiron	Site Water 1.5 ug/L Day 0 Chiron	Site Water 3 ug/L Day 0 Chiron	Site Water 6 ug/L Day 0 Chiron
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-011	VA22A2340-012	VA22A2340-013	VA22A2340-014	VA22A2340-015
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	<0.00050	0.00112	0.00194	0.00330	0.00614
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	<0.00020	0.00086	0.00142	0.00267	0.00529
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 12 ug/L Day 0 Chiron	Site Water 24 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water Control Day 10 Chiron	Lab Water 0.75 ug/L Day 10 Chiron
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-016	VA22A2340-017	VA22A2340-018	VA22A2340-019	VA22A2340-020
					Result	Result	Result	Result	Result
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	----	----	0.0296	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	----	----	0.00966	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	----	----	0.00652	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	----	----	0.0452	----	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	----	----	<0.000020	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	----	----	<0.000050	----	----
boron, total	7440-42-8	E420	0.010	mg/L	----	----	0.093	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	----	----	0.0000138	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	----	----	23.8	----	----
cesium, total	7440-46-2	E420	0.000010	mg/L	----	----	0.00150	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	----	----	<0.00050	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	----	----	<0.00010	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0114	0.0233	0.0454	0.00087	0.00118
iron, total	7439-89-6	E420	0.010	mg/L	----	----	0.014	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	----	----	0.000327	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	----	----	0.0576	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	----	----	1.43	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	----	----	0.0479	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	----	----	0.00744	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	----	----	<0.00050	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	----	----	<0.050	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	----	----	10.8	----	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	----	----	0.0130	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	----	----	0.00106	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	----	----	1.76	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	----	----	<0.000010	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	----	----	28.3	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	----	----	0.543	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	----	----	22.0	----	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	----	----	<0.00020	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	----	----	0.000050	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 12 ug/L Day 0 Chiron	Site Water 24 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water Control Day 10 Chiron	Lab Water 0.75 ug/L Day 10 Chiron
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-016	VA22A2340-017	VA22A2340-018	VA22A2340-019	VA22A2340-020
					Result	Result	Result	Result	Result
Total Metals									
thorium, total	7440-29-1	E420	0.00010	mg/L	----	----	<0.00010	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	----	----	<0.00010	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	----	----	<0.00030	----	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	----	----	0.00128	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	----	----	0.000447	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	----	----	<0.00050	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	----	----	<0.0030	----	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	----	----	<0.00020	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	----	----	0.0157	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	----	----	0.0102	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	----	----	0.00668	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	----	----	0.0455	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	----	----	<0.000020	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	----	----	<0.000050	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	----	----	0.095	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	----	----	<0.0000150 DLM	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	----	----	24.6	----	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	----	----	0.00150	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	----	----	<0.00050	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	----	----	<0.00010	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0106	0.0217	0.0422	0.00080	0.00114
iron, dissolved	7439-89-6	E421	0.010	mg/L	----	----	<0.010	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	----	----	0.000100	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	----	----	0.0587	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	----	----	1.48	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	----	----	0.0455	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	----	----	0.00806	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	----	----	<0.00050	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	----	----	<0.050	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	----	----	10.9	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 12 ug/L Day 0 Chiron	Site Water 24 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water Control Day 10 Chiron	Lab Water 0.75 ug/L Day 10 Chiron
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-016	VA22A2340-017	VA22A2340-018	VA22A2340-019	VA22A2340-020
					Result	Result	Result	Result	Result
Dissolved Metals									
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	----	----	0.0128	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	----	----	0.00110	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	----	----	1.72	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	----	----	<0.000010	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	----	----	30.0	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	----	----	0.532	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	----	----	21.3	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	----	----	<0.00020	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	----	----	0.000051	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	----	----	<0.00010	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	----	----	<0.00010	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	----	----	<0.00030	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	----	----	0.00126	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	----	----	0.000457	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	----	----	<0.00050	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	----	----	<0.0010	----	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	----	----	<0.00030	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 1.5 ug/L Day 10 Chiron	Lab Water 3ug/L Day 10 Chiron	Lab Water 6ug/L Day 10 Chiron	Lab Water 12ug/L Day 10 Chiron	Lab Water 24ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-021	VA22A2340-022	VA22A2340-023	VA22A2340-024	VA22A2340-025
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00182	0.00250	0.00387	0.00677	0.0124
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00163	0.00244	0.00376	0.00646	0.0117
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 48ug/L Day 10 Chiron	Lab Water Day 10 OAM	Site Water (100%) Day 10 OAM	Site Water Control Day 10 Chiron	Site Water 0.75 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-026	VA22A2340-027	VA22A2340-028	VA22A2340-029	VA22A2340-030
					Result	Result	Result	Result	Result
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	----	1.03	2.10	----	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0156	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.00025	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00078	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.00056	----	----	----	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	<0.010	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	31.9	----	----	----	----
cesium, total	7440-46-2	E420	0.000010	mg/L	0.000011	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0208	----	----	0.00070	0.00128
iron, total	7439-89-6	E420	0.010	mg/L	<0.010	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	----	----	----	----
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0011	----	----	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	1.14	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00074	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.000165	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	0.223	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	0.618	----	----	----	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	0.00061	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000154	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	1.24	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	----	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	3.39	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.136	----	----	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	2.26	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 48ug/L Day 10 Chiron	Lab Water Day 10 OAM	Site Water (100%) Day 10 OAM	Site Water Control Day 10 Chiron	Site Water 0.75 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-026	VA22A2340-027	VA22A2340-028	VA22A2340-029	VA22A2340-030
					Result	Result	Result	Result	Result
Total Metals									
tellurium, total	13494-80-9	E420	0.00020	mg/L	<0.00020	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	<0.000010	----	----	----	----
thorium, total	7440-29-1	E420	0.00010	mg/L	<0.00010	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	<0.00010	----	----	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	<0.00010	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000150	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00074	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	----	----	----	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	<0.00020	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0122	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.00024	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00068	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.00053	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----
boron, dissolved	7440-42-8	E421	0.010	mg/L	<0.010	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	31.2	----	----	----	----
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	<0.000010	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0198	----	----	0.00063	0.00122
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0010	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	1.14	----	----	----	----
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00057	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.000156	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 48ug/L Day 10 Chiron	Lab Water Day 10 OAM	Site Water (100%) Day 10 OAM	Site Water Control Day 10 Chiron	Site Water 0.75 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-026	VA22A2340-027	VA22A2340-028	VA22A2340-029	VA22A2340-030
					Result	Result	Result	Result	Result
Dissolved Metals									
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	0.206	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	0.606	----	----	----	----
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	0.00054	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000125	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.26	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	3.49	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.124	----	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	2.24	----	----	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	<0.00020	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	<0.000010	----	----	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	<0.00010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	<0.00010	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	<0.00010	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000147	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00072	----	----	----	----
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	----	----	----	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	<0.00030	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	----	----	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 1.5 ug/L Day 10 Chiron	Site Water 3 ug/L Day 10 Chiron	Site Water 6 ug/L Day 10 Chiron	Site Water 12ug/L Day 10 Chiron	Site Water 24 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-031	VA22A2340-032	VA22A2340-033	VA22A2340-034	VA22A2340-035
					Result	Result	Result	Result	Result
Total Metals									
copper, total	7440-50-8	E420	0.00050	mg/L	0.00163	0.00214	0.00396	0.00659	0.0116
Dissolved Metals									
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.00150	0.00224	0.00368	0.00630	0.0109
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Field	Field

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 48 ug/L Day 10 Chiron	Lab Water 48 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 10 Chiron	Site Water 48 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-036	VA22A2340-037	VA22A2340-038	VA22A2340-039	VA22A2340-040
					Result	Result	Result	Result	Result
Physical Tests									
alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	----	69.4	50.7	67.1	44.2
conductivity	----	E100	2.0	µS/cm	----	162	329	195	367
hardness (as CaCO3), dissolved	----	EC100	0.60	mg/L	----	76.3	68.8	76.5	79.8
pH	----	E108	0.10	pH units	----	8.04	7.86	7.85	7.56
solids, total dissolved [TDS]	----	E162	10	mg/L	----	103	209	116	231
solids, total suspended [TSS]	----	E160	3.0	mg/L	----	<3.0	<3.0	<3.0	<3.0
turbidity	----	E121	0.10	NTU	----	<0.10	0.63	0.73	0.66
Anions and Nutrients									
bromide	24959-67-9	E235.Br-L	0.050	mg/L	----	<0.050	<0.050	<0.050	<0.050
chloride	16887-00-6	E235.Cl	0.50	mg/L	----	4.57	2.75	7.62	5.89
fluoride	16984-48-8	E235.F	0.020	mg/L	----	<0.020	0.184	0.022	0.170
nitrate (as N)	14797-55-8	E235.NO3-L	0.0050	mg/L	----	0.428	9.50	0.330	9.62
nitrite (as N)	14797-65-0	E235.NO2-L	0.0010	mg/L	----	0.0049	0.0421	2.77	3.97
phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	----	0.0010	<0.0010	0.153	0.138
sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	----	4.40	64.7	6.12	68.0
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	0.0178	----	----	----	----
antimony, total	7440-36-0	E420	0.00010	mg/L	0.0101	----	----	----	----
arsenic, total	7440-38-2	E420	0.00010	mg/L	0.00700	----	----	----	----
barium, total	7440-39-3	E420	0.00010	mg/L	0.0226	----	----	----	----
beryllium, total	7440-41-7	E420	0.000020	mg/L	<0.000020	----	----	----	----
bismuth, total	7440-69-9	E420	0.000050	mg/L	<0.000050	----	----	----	----
boron, total	7440-42-8	E420	0.010	mg/L	0.114	----	----	----	----
cadmium, total	7440-43-9	E420	0.0000050	mg/L	<0.0000050	----	----	----	----
calcium, total	7440-70-2	E420	0.050	mg/L	29.6	----	----	----	----
cesium, total	7440-46-2	E420	0.000010	mg/L	0.000407	----	----	----	----
chromium, total	7440-47-3	E420	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, total	7440-48-4	E420	0.00010	mg/L	<0.00010	----	----	----	----
copper, total	7440-50-8	E420	0.00050	mg/L	0.0205	----	----	----	----
iron, total	7439-89-6	E420	0.010	mg/L	<0.010	----	----	----	----
lead, total	7439-92-1	E420	0.000050	mg/L	<0.000050	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Site Water 48 ug/L Day 10 Chiron	Lab Water 48 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 10 Chiron	Site Water 48 ug/L Day 10 Chiron
Client sample ID					Site Water 48 ug/L Day 10 Chiron	Lab Water 48 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 10 Chiron	Site Water 48 ug/L Day 10 Chiron
Client sampling date / time					31-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
					VA22A2340-036	VA22A2340-037	VA22A2340-038	VA22A2340-039	VA22A2340-040
					Result	Result	Result	Result	Result
Total Metals									
lithium, total	7439-93-2	E420	0.0010	mg/L	0.0639	----	----	----	----
magnesium, total	7439-95-4	E420	0.0050	mg/L	1.88	----	----	----	----
manganese, total	7439-96-5	E420	0.00010	mg/L	0.00098	----	----	----	----
molybdenum, total	7439-98-7	E420	0.000050	mg/L	0.00798	----	----	----	----
nickel, total	7440-02-0	E420	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, total	7723-14-0	E420	0.050	mg/L	0.228	----	----	----	----
potassium, total	7440-09-7	E420	0.050	mg/L	12.5	----	----	----	----
rubidium, total	7440-17-7	E420	0.00020	mg/L	0.0120	----	----	----	----
selenium, total	7782-49-2	E420	0.000050	mg/L	0.000772	----	----	----	----
silicon, total	7440-21-3	E420	0.10	mg/L	1.71	----	----	----	----
silver, total	7440-22-4	E420	0.000010	mg/L	<0.000010	----	----	----	----
sodium, total	7440-23-5	E420	0.050	mg/L	33.0	----	----	----	----
strontium, total	7440-24-6	E420	0.00020	mg/L	0.571	----	----	----	----
sulfur, total	7704-34-9	E420	0.50	mg/L	22.0	----	----	----	----
tellurium, total	13494-80-9	E420	0.00020	mg/L	<0.00020	----	----	----	----
thallium, total	7440-28-0	E420	0.000010	mg/L	0.000021	----	----	----	----
thorium, total	7440-29-1	E420	0.00010	mg/L	<0.00010	----	----	----	----
tin, total	7440-31-5	E420	0.00010	mg/L	0.00014	----	----	----	----
titanium, total	7440-32-6	E420	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, total	7440-33-7	E420	0.00010	mg/L	0.00118	----	----	----	----
uranium, total	7440-61-1	E420	0.000010	mg/L	0.000092	----	----	----	----
vanadium, total	7440-62-2	E420	0.00050	mg/L	0.00064	----	----	----	----
zinc, total	7440-66-6	E420	0.0030	mg/L	<0.0030	----	----	----	----
zirconium, total	7440-67-7	E420	0.00020	mg/L	<0.00020	----	----	----	----
Dissolved Metals									
aluminum, dissolved	7429-90-5	E421	0.0010	mg/L	0.0102	----	----	----	----
antimony, dissolved	7440-36-0	E421	0.00010	mg/L	0.0104	----	----	----	----
arsenic, dissolved	7440-38-2	E421	0.00010	mg/L	0.00703	----	----	----	----
barium, dissolved	7440-39-3	E421	0.00010	mg/L	0.0233	----	----	----	----
beryllium, dissolved	7440-41-7	E421	0.000020	mg/L	<0.000020	----	----	----	----
bismuth, dissolved	7440-69-9	E421	0.000050	mg/L	<0.000050	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method	LOR	Unit	Client sample ID: Site Water 48 ug/L Day 10 Chiron	Lab Water 48 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 10 Chiron	Site Water 48 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
					VA22A2340-036	VA22A2340-037	VA22A2340-038	VA22A2340-039	VA22A2340-040
					Result	Result	Result	Result	Result
Dissolved Metals									
boron, dissolved	7440-42-8	E421	0.010	mg/L	0.096	----	----	----	----
cadmium, dissolved	7440-43-9	E421	0.0000050	mg/L	<0.0000100 DLM	----	----	----	----
calcium, dissolved	7440-70-2	E421	0.050	mg/L	27.8	29.3	25.1	27.5	30.1
cesium, dissolved	7440-46-2	E421	0.000010	mg/L	0.000441	----	----	----	----
chromium, dissolved	7440-47-3	E421	0.00050	mg/L	<0.00050	----	----	----	----
cobalt, dissolved	7440-48-4	E421	0.00010	mg/L	<0.00010	----	----	----	----
copper, dissolved	7440-50-8	E421	0.00020	mg/L	0.0198	----	----	----	----
iron, dissolved	7439-89-6	E421	0.010	mg/L	<0.010	----	----	----	----
lead, dissolved	7439-92-1	E421	0.000050	mg/L	<0.000050	----	----	----	----
lithium, dissolved	7439-93-2	E421	0.0010	mg/L	0.0604	----	----	----	----
magnesium, dissolved	7439-95-4	E421	0.0050	mg/L	1.91	0.770	1.50	1.90	1.14
manganese, dissolved	7439-96-5	E421	0.00010	mg/L	0.00072	----	----	----	----
molybdenum, dissolved	7439-98-7	E421	0.000050	mg/L	0.00806	----	----	----	----
nickel, dissolved	7440-02-0	E421	0.00050	mg/L	<0.00050	----	----	----	----
phosphorus, dissolved	7723-14-0	E421	0.050	mg/L	0.172	----	----	----	----
potassium, dissolved	7440-09-7	E421	0.050	mg/L	12.1	----	----	----	----
rubidium, dissolved	7440-17-7	E421	0.00020	mg/L	0.0122	----	----	----	----
selenium, dissolved	7782-49-2	E421	0.000050	mg/L	0.000781	----	----	----	----
silicon, dissolved	7440-21-3	E421	0.050	mg/L	1.62	----	----	----	----
silver, dissolved	7440-22-4	E421	0.000010	mg/L	<0.000010	----	----	----	----
sodium, dissolved	7440-23-5	E421	0.050	mg/L	33.1	----	----	----	----
strontium, dissolved	7440-24-6	E421	0.00020	mg/L	0.553	----	----	----	----
sulfur, dissolved	7704-34-9	E421	0.50	mg/L	22.6	----	----	----	----
tellurium, dissolved	13494-80-9	E421	0.00020	mg/L	<0.00020	----	----	----	----
thallium, dissolved	7440-28-0	E421	0.000010	mg/L	0.000020	----	----	----	----
thorium, dissolved	7440-29-1	E421	0.00010	mg/L	<0.00010	----	----	----	----
tin, dissolved	7440-31-5	E421	0.00010	mg/L	0.00012	----	----	----	----
titanium, dissolved	7440-32-6	E421	0.00030	mg/L	<0.00030	----	----	----	----
tungsten, dissolved	7440-33-7	E421	0.00010	mg/L	0.00107	----	----	----	----
uranium, dissolved	7440-61-1	E421	0.000010	mg/L	0.000100	----	----	----	----
vanadium, dissolved	7440-62-2	E421	0.00050	mg/L	0.00067	----	----	----	----

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Site Water 48 ug/L Day 10 Chiron	Lab Water 48 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 10 Chiron	Site Water 48 ug/L Day 10 Chiron
				Client sampling date / time	31-Jan-2022	21-Jan-2022	21-Jan-2022	31-Jan-2022	31-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-036	VA22A2340-037	VA22A2340-038	VA22A2340-039	VA22A2340-040
					Result	Result	Result	Result	Result
Dissolved Metals									
zinc, dissolved	7440-66-6	E421	0.0010	mg/L	<0.0010	----	----	----	----
zirconium, dissolved	7440-67-7	E421	0.00030	mg/L	<0.00030	----	----	----	----
dissolved metals filtration location	----	EP421	-	-	Field	Field	Field	Laboratory	Laboratory

Please refer to the General Comments section for an explanation of any qualifiers detected.

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

				Client sample ID	Lab Water 48 ug/L Day 0 Chiron	Site Water 48 ug/L Day 0 Chiron	Lab Water 48 ug/L Day 10 Chiron	Site Water 48 ug/L Day 10 Chiron	22AI01
				Client sampling date / time	21-Jan-2022	21-Jan-2022	21-Jan-2022	21-Jan-2022	26-Jan-2022
Analyte	CAS Number	Method	LOR	Unit	VA22A2340-041	VA22A2340-042	VA22A2340-043	VA22A2340-044	VA22A2340-045
					Result	Result	Result	Result	Result
Anions and Nutrients									
ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0242	0.154	0.832	0.466	----
nitrogen, total	7727-37-9	E366	0.030	mg/L	0.462	9.40	3.90	11.5	----
phosphorus, total	7723-14-0	E372-U	0.0020	mg/L	<0.0020	<0.0020	0.205	0.186	----
Organic / Inorganic Carbon									
carbon, dissolved organic [DOC]	----	E358-L	0.50	mg/L	1.41	1.23	3.06	3.33	----
carbon, total organic [TOC]	----	E355-L	0.50	mg/L	0.58	0.74	2.69	2.66	----
Total Metals									
aluminum, total	7429-90-5	E420	0.0030	mg/L	----	----	----	----	544

Please refer to the General Comments section for an explanation of any qualifiers detected.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **VA22A2340**	Page	: 1 of 25
Client	: **Nautilus Environmental Company Inc.**	Laboratory	: Vancouver - Environmental
Contact	: Mikayla Oldach	Account Manager	: Emmanuel Mariano
Address	: 8664 Commerce Court Imperial Square Lake City Burnaby BC Canada V5A 4N7	Address	: 8081 Lougheed Highway Burnaby, British Columbia Canada V5A 1W9
Telephone	: ----	Telephone	: +1 604 253 4188
Project	: ----	Date Samples Received	: 04-Feb-2022 15:30
PO	: 2022-0220	Issue Date	: 15-Feb-2022 17:11
C-O-C number	: ----		
Sampler	: ----		
Site	: Tissue, Water and Sediment Testing		
Quote number	: Q69439 (Vancouver Blanket Quote)		
No. of samples received	: 45		
No. of samples analysed	: 45		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Matrix Spike outliers occur.
- Laboratory Control Sample (LCS) outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- Analysis Holding Time Outliers exist - please see following pages for full details.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Laboratory Control Sample (LCS) Recoveries								
Total Metals	QC-407846-002	----	phosphorus, total	7723-14-0	E420	121 % MES	80.0-120%	Recovery greater than upper control limit

Result Qualifiers

Qualifier	*Description*
MES	*Data Quality Objective was marginally exceeded (by < 10% absolute) for < 10% of analytes in a Multi-Element Scan / Multi-Parameter Scan (considered acceptable as per OMOE & CCME).*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: ✗ = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) Lab Water 48 ug/L Day 0 Chiron	E298	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) Lab Water 48 ug/L Day 10 Chiron	E298	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) Site Water 48 ug/L Day 0 Chiron	E298	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) Site Water 48 ug/L Day 10 Chiron	E298	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (lab preserved) Lab Water Day 10 OAM	E298	31-Jan-2022	10-Feb-2022	3 days	10 days	✗ EHTR	10-Feb-2022	28 days	0 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (lab preserved) Site Water (100%) Day 10 OAM	E298	31-Jan-2022	10-Feb-2022	3 days	10 days	✗ EHTR	10-Feb-2022	28 days	0 days	✓
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (lab preserved) Lab Water Day 0 OAM	E298	21-Jan-2022	10-Feb-2022	3 days	20 days	✗ EHTR	10-Feb-2022	28 days	0 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (lab preserved)										
Site Water (100%) Day 0 OAM	E298	21-Jan-2022	10-Feb-2022	3 days	20 days	× EHTR	10-Feb-2022	28 days	0 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E235.Br-L	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E235.Br-L	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E235.Br-L	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Bromide in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E235.Br-L	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E235.Cl	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E235.Cl	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E235.Cl	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E235.Cl	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E378-U	21-Jan-2022	----	----	----		08-Feb-2022	3 days	19 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E378-U	21-Jan-2022	----	----	----		08-Feb-2022	3 days	19 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E378-U	31-Jan-2022	----	----	----		08-Feb-2022	3 days	9 days	× EHTR
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E378-U	31-Jan-2022	----	----	----		08-Feb-2022	3 days	9 days	× EHTR
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E235.F	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E235.F	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E235.F	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E235.F	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E235.NO3-L	21-Jan-2022	----	----	----		09-Feb-2022	3 days	19 days	× EHTR

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E235.NO3-L	21-Jan-2022	----	----	----		09-Feb-2022	3 days	19 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E235.NO3-L	31-Jan-2022	----	----	----		09-Feb-2022	3 days	9 days	× EHTR
Anions and Nutrients : Nitrate in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E235.NO3-L	31-Jan-2022	----	----	----		09-Feb-2022	3 days	9 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E235.NO2-L	21-Jan-2022	----	----	----		09-Feb-2022	3 days	19 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E235.NO2-L	21-Jan-2022	----	----	----		09-Feb-2022	3 days	19 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E235.NO2-L	31-Jan-2022	----	----	----		09-Feb-2022	3 days	9 days	× EHTR
Anions and Nutrients : Nitrite in Water by IC (Low Level)										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E235.NO2-L	31-Jan-2022	----	----	----		09-Feb-2022	3 days	9 days	× EHTR
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E235.SO4	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E235.SO4	21-Jan-2022	----	----	----		09-Feb-2022	28 days	19 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Lab Water 48 ug/L Day 10 Chiron	E235.SO4	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE										
Site Water 48 ug/L Day 10 Chiron	E235.SO4	31-Jan-2022	----	----	----		09-Feb-2022	28 days	9 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 0 Chiron	E366	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	21 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 10 Chiron	E366	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	21 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Site Water 48 ug/L Day 0 Chiron	E366	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	21 days	✓
Anions and Nutrients : Total Nitrogen by Colourimetry										
Amber glass total (sulfuric acid)										
Site Water 48 ug/L Day 10 Chiron	E366	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	21 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 0 Chiron	E372-U	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	22 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 10 Chiron	E372-U	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	22 days	✓
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid)										
Site Water 48 ug/L Day 0 Chiron	E372-U	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	22 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Total Phosphorus by Colourimetry (Ultra Trace)										
Amber glass total (sulfuric acid) Site Water 48 ug/L Day 10 Chiron	E372-U	21-Jan-2022	10-Feb-2022	----	----		11-Feb-2022	28 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 24ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 3ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 48ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 6ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water Control Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 0.75 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 1.5 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 12ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 24 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 3 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 48 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water 6 ug/L Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Site Water Control Day 10 Chiron	E421	31-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	12 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE - dissolved (lab preserved) Lab Water 48 ug/L Day 10 Chiron	E421	31-Jan-2022	12-Feb-2022	----	----		13-Feb-2022	180 days	13 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE - dissolved (lab preserved) Site Water 48 ug/L Day 10 Chiron	E421	31-Jan-2022	12-Feb-2022	----	----		13-Feb-2022	180 days	13 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 0.75 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 1.5 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 12 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 24 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 3 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE - dissolved (lab preserved) Lab Water 48 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
HDPE dissolved (nitric acid) Lab Water 48 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water 6 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid) Lab Water Control Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 0.75 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 1.5 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 12 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 24 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 3 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE - dissolved (lab preserved)										
Site Water 48 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
HDPE dissolved (nitric acid)										
Site Water 48 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water 6 ug/L Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Dissolved Metals : Dissolved Metals in Water by CRC ICPMS										
HDPE dissolved (nitric acid)										
Site Water Control Day 0 Chiron	E421	21-Jan-2022	11-Feb-2022	----	----		11-Feb-2022	180 days	22 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Lab Water 48 ug/L Day 0 Chiron	E358-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	21 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Lab Water 48 ug/L Day 10 Chiron	E358-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	21 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Site Water 48 ug/L Day 0 Chiron	E358-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	21 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid)										
Site Water 48 ug/L Day 10 Chiron	E358-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	21 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 0 Chiron	E355-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
Lab Water 48 ug/L Day 10 Chiron	E355-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
Site Water 48 ug/L Day 0 Chiron	E355-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Organic / Inorganic Carbon : Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)										
Amber glass total (sulfuric acid)										
Site Water 48 ug/L Day 10 Chiron	E355-L	21-Jan-2022	10-Feb-2022	----	----		10-Feb-2022	28 days	20 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE										
Lab Water 48 ug/L Day 0 Chiron	E290	21-Jan-2022	----	----	----		08-Feb-2022	14 days	19 days	× EHTL
Physical Tests : Alkalinity Species by Titration										
HDPE										
Site Water 48 ug/L Day 0 Chiron	E290	21-Jan-2022	----	----	----		08-Feb-2022	14 days	19 days	× EHTL

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : Alkalinity Species by Titration										
HDPE Lab Water 48 ug/L Day 10 Chiron	E290	31-Jan-2022	----	----	----		08-Feb-2022	14 days	9 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE Site Water 48 ug/L Day 10 Chiron	E290	31-Jan-2022	----	----	----		08-Feb-2022	14 days	9 days	✓
Physical Tests : Conductivity in Water										
HDPE Lab Water 48 ug/L Day 0 Chiron	E100	21-Jan-2022	----	----	----		08-Feb-2022	28 days	19 days	✓
Physical Tests : Conductivity in Water										
HDPE Site Water 48 ug/L Day 0 Chiron	E100	21-Jan-2022	----	----	----		08-Feb-2022	28 days	19 days	✓
Physical Tests : Conductivity in Water										
HDPE Lab Water 48 ug/L Day 10 Chiron	E100	31-Jan-2022	----	----	----		08-Feb-2022	28 days	9 days	✓
Physical Tests : Conductivity in Water										
HDPE Site Water 48 ug/L Day 10 Chiron	E100	31-Jan-2022	----	----	----		08-Feb-2022	28 days	9 days	✓
Physical Tests : pH by Meter										
HDPE Lab Water 48 ug/L Day 10 Chiron	E108	31-Jan-2022	----	----	----		08-Feb-2022	0.25 hrs	214 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE Site Water 48 ug/L Day 10 Chiron	E108	31-Jan-2022	----	----	----		08-Feb-2022	0.25 hrs	214 hrs	× EHTR-FM
Physical Tests : pH by Meter										
HDPE Lab Water 48 ug/L Day 0 Chiron	E108	21-Jan-2022	----	----	----		08-Feb-2022	0.25 hrs	454 hrs	× EHTR-FM

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : pH by Meter										
HDPE Site Water 48 ug/L Day 0 Chiron	E108	21-Jan-2022	----	----	----		08-Feb-2022	0.25 hrs	454 hrs	× EHTR-FM
Physical Tests : TDS by Gravimetry										
HDPE Lab Water 48 ug/L Day 0 Chiron	E162	21-Jan-2022	----	----	----		05-Feb-2022	7 days	16 days	× EHTR
Physical Tests : TDS by Gravimetry										
HDPE Site Water 48 ug/L Day 0 Chiron	E162	21-Jan-2022	----	----	----		05-Feb-2022	7 days	16 days	× EHTR
Physical Tests : TDS by Gravimetry										
HDPE Lab Water 48 ug/L Day 10 Chiron	E162	31-Jan-2022	----	----	----		05-Feb-2022	7 days	6 days	✓
Physical Tests : TDS by Gravimetry										
HDPE Site Water 48 ug/L Day 10 Chiron	E162	31-Jan-2022	----	----	----		05-Feb-2022	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE Lab Water 48 ug/L Day 0 Chiron	E160	21-Jan-2022	----	----	----		05-Feb-2022	7 days	16 days	× EHTR
Physical Tests : TSS by Gravimetry										
HDPE Site Water 48 ug/L Day 0 Chiron	E160	21-Jan-2022	----	----	----		05-Feb-2022	7 days	16 days	× EHTR
Physical Tests : TSS by Gravimetry										
HDPE Lab Water 48 ug/L Day 10 Chiron	E160	31-Jan-2022	----	----	----		05-Feb-2022	7 days	6 days	✓
Physical Tests : TSS by Gravimetry										
HDPE Site Water 48 ug/L Day 10 Chiron	E160	31-Jan-2022	----	----	----		05-Feb-2022	7 days	6 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Physical Tests : Turbidity by Nephelometry										
HDPE Lab Water 48 ug/L Day 0 Chiron	E121	21-Jan-2022	----	----	----		06-Feb-2022	3 days	16 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE Site Water 48 ug/L Day 0 Chiron	E121	21-Jan-2022	----	----	----		06-Feb-2022	3 days	16 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE Lab Water 48 ug/L Day 10 Chiron	E121	31-Jan-2022	----	----	----		06-Feb-2022	3 days	6 days	× EHTR
Physical Tests : Turbidity by Nephelometry										
HDPE Site Water 48 ug/L Day 10 Chiron	E121	31-Jan-2022	----	----	----		06-Feb-2022	3 days	6 days	× EHTR
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 24 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		11-Feb-2022	180 days	12 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 48 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		11-Feb-2022	180 days	12 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 0.75 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 1.5 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 12ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 24ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 3ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 48ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 6ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water Control Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 0.75 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 1.5 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 12ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 3 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis: Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water 6 ug/L Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Site Water Control Day 10 Chiron	E420	31-Jan-2022	----	----	----		12-Feb-2022	180 days	13 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE - total (lab preserved) 22AI01	E420	26-Jan-2022	----	----	----		11-Feb-2022	180 days	17 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 0.75 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 1.5 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 12 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 24 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 3 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid) Lab Water 48 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation: Preparation Date	Holding Times: Rec	Holding Times: Actual	Eval	Analysis: Analysis Date	Holding Times: Rec	Holding Times: Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water 6 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Lab Water Control Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 0.75 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water Control Day 0 Chiron	E420	21-Jan-2022	----	----	----		11-Feb-2022	180 days	22 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 1.5 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		12-Feb-2022	180 days	23 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 12 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		12-Feb-2022	180 days	23 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 24 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		12-Feb-2022	180 days	23 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 3 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		12-Feb-2022	180 days	23 days	✓
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 48 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		12-Feb-2022	180 days	23 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
Site Water 6 ug/L Day 0 Chiron	E420	21-Jan-2022	----	----	----		12-Feb-2022	180 days	23 days	✓

Legend & Qualifier Definitions

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended

EHTR: Exceeded ALS recommended hold time prior to sample receipt.

EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	405439	1	19	5.2	5.0	✓
Ammonia by Fluorescence	E298	407083	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	405445	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	405444	1	7	14.2	5.0	✓
Conductivity in Water	E100	405441	1	7	14.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	408190	3	38	7.8	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	407082	1	6	16.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	405449	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	405443	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	405447	1	4	25.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	405446	1	7	14.2	5.0	✓
pH by Meter	E108	405440	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	405442	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	403581	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	407845	3	59	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	407085	1	4	25.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	407084	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	407081	1	10	10.0	5.0	✓
TSS by Gravimetry	E160	403578	1	12	8.3	5.0	✓
Turbidity by Nephelometry	E121	403703	2	29	6.9	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	405439	1	19	5.2	5.0	✓
Ammonia by Fluorescence	E298	407083	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	405445	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	405444	1	7	14.2	5.0	✓
Conductivity in Water	E100	405441	1	7	14.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	408190	3	38	7.8	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	407082	1	6	16.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	405449	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	405443	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	405447	1	4	25.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	405446	1	7	14.2	5.0	✓
pH by Meter	E108	405440	1	10	10.0	5.0	✓
Sulfate in Water by IC	E235.SO4	405442	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	403581	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	407845	3	59	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	407085	1	4	25.0	5.0	✓

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Control Samples (LCS) - Continued							
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	407084	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	407081	1	10	10.0	5.0	✓
TSS by Gravimetry	E160	403578	1	12	8.3	5.0	✓
Turbidity by Nephelometry	E121	403703	2	29	6.9	5.0	✓
Method Blanks (MB)							
Alkalinity Species by Titration	E290	405439	1	19	5.2	5.0	✓
Ammonia by Fluorescence	E298	407083	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	405445	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	405444	1	7	14.2	5.0	✓
Conductivity in Water	E100	405441	1	7	14.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	408190	3	38	7.8	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	407082	1	6	16.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	405449	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	405443	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	405447	1	4	25.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	405446	1	7	14.2	5.0	✓
Sulfate in Water by IC	E235.SO4	405442	1	10	10.0	5.0	✓
TDS by Gravimetry	E162	403581	1	6	16.6	5.0	✓
Total Metals in Water by CRC ICPMS	E420	407845	3	59	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	407085	1	4	25.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	407084	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	407081	1	10	10.0	5.0	✓
TSS by Gravimetry	E160	403578	1	12	8.3	5.0	✓
Turbidity by Nephelometry	E121	403703	2	29	6.9	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	407083	1	12	8.3	5.0	✓
Bromide in Water by IC (Low Level)	E235.Br-L	405445	1	7	14.2	5.0	✓
Chloride in Water by IC	E235.Cl	405444	1	7	14.2	5.0	✓
Dissolved Metals in Water by CRC ICPMS	E421	408190	3	38	7.8	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	407082	1	6	16.6	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U	405449	1	4	25.0	5.0	✓
Fluoride in Water by IC	E235.F	405443	1	7	14.2	5.0	✓
Nitrate in Water by IC (Low Level)	E235.NO3-L	405447	1	4	25.0	5.0	✓
Nitrite in Water by IC (Low Level)	E235.NO2-L	405446	1	7	14.2	5.0	✓
Sulfate in Water by IC	E235.SO4	405442	1	10	10.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	407845	3	59	5.0	5.0	✓
Total Nitrogen by Colourimetry	E366	407085	1	4	25.0	5.0	✓
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L	407084	1	4	25.0	5.0	✓
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U	407081	1	10	10.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 Vancouver - Environmental	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 Vancouver - Environmental	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 Vancouver - Environmental	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TSS by Gravimetry	E160 Vancouver - Environmental	Water	APHA 2540 D (mod)	Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, following by drying of the filter at 104 ± 1°C, with gravimetric measurement of the filtered solids. Samples containing very high dissolved solid content (i.e. seawaters, brackish waters) may produce a positive bias by this method. Alternate analysis methods are available for these types of samples.
TDS by Gravimetry	E162 Vancouver - Environmental	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC (Low Level)	E235.Br-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC (Low Level)	E235.NO2-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC (Low Level)	E235.NO3-L Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sulfate in Water by IC	E235.SO4 Vancouver - Environmental	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Alkalinity Species by Titration	E290 Vancouver - Environmental	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 Vancouver - Environmental	Water	J. Environ. Monit., 2005, 7, 37-42 (mod)	Ammonia in water is analyzed by flow-injection analysis with fluorescence detection after reaction with orthophthaldialdehyde (OPA).
Total Organic Carbon (Non-Purgeable) by Combustion (Low Level)	E355-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Total Organic Carbon (Non-Purgeable), also known as NPOC (total), is a direct measurement of TOC after an acidified sample has been purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of total carbon (TC) is comprised of IC (which is common), this method is more accurate and more reliable than the TOC by subtraction method (i.e. TC minus TIC).
Dissolved Organic Carbon by Combustion (Low Level)	E358-L Vancouver - Environmental	Water	APHA 5310 B (mod)	Dissolved Organic Carbon (Non-Purgeable), also known as NPOC (dissolved), is a direct measurement of DOC after a filtered (0.45 micron) sample has been acidified and purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of DC (dissolved carbon) is comprised of IC (which is common), this method is more accurate and more reliable than the DOC by subtraction method (i.e. DC minus DIC).
Total Nitrogen by Colourimetry	E366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Total Nitrogen is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Total Phosphorus by Colourimetry (Ultra Trace)	E372-U Vancouver - Environmental	Water	APHA 4500-P E (mod).	Total Phosphorus is determined colourimetrically using a discrete analyzer after heated persulfate digestion of the sample.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level)	E378-U Vancouver - Environmental	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a flow analyzer on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Metals in Water by CRC ICPMS	E420 Vancouver - Environmental	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Dissolved Metals in Water by CRC ICPMS	E421 Vancouver - Environmental	Water	APHA 3030B/EPA 6020B (mod)	Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Dissolved Hardness (Calculated)	EC100 Vancouver - Environmental	Water	APHA 2340B	"Hardness (as CaCO3), dissolved" is calculated from the sum of dissolved Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations.

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 Vancouver - Environmental	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Total Organic Carbon by Combustion	EP355 Vancouver - Environmental	Water		Preparation for Total Organic Carbon by Combustion
Preparation for Dissolved Organic Carbon for Combustion	EP358 Vancouver - Environmental	Water	APHA 5310 B (mod)	Preparation for Dissolved Organic Carbon
Digestion for Total Nitrogen in water	EP366 Vancouver - Environmental	Water	APHA 4500-P J (mod)	Samples are heated with a persulfate digestion reagent.
Digestion for Total Phosphorus in water	EP372 Vancouver - Environmental	Water	APHA 4500-P E (mod).	Samples are heated with a persulfate digestion reagent.
Dissolved Metals Water Filtration	EP421 Vancouver - Environmental	Water	APHA 3030B	Water samples are filtered (0.45 um), and preserved with HNO3.

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
V5A 4N7
Phone 604.420.8773

Calgary ( )
10823 27 Street SE
Calgary, Alberta, Canada
T2Z 3V9
Phone 403.253.7121

Point Edward ( )
704 Mara Street, Suite 122
Point Edward, Ontario, Canada
N7V 1X4
Phone 519.339.8787

Chain of Custody

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals	OVeryling ammonia							Receipt Temperature (°C)
1	Lab Water Control Day 0 Chiron	21/01/22			1x125 mL		✓	✓										4
2	Lab Water 0.75 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
3	Lab Water 1.5 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
4	Lab Water 3 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
5	Lab Water 6 µg/LDay 0 Chiron	21/01/22			1x125 mL		✓	✓										
6	Lab Water 12 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
7	Lab Water 24 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
8	Lab Water 48 µg/L Day 0 Chiron	21/01/22			1x125 mL	all metals			✓	✓								
9	Lab Water Day 0 OAM	21/01/22			1x125 mL						✓							
10	Site Water (100%) Day 0 OAM	21/01/22			1x125 mL						✓							

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu/metals are filtered
-overlying ammonia samples preserved with sulfuric acid

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)
Nautilus Env. (Company) 04/02/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

HA (Printed Name) (Signature)
(Company) 2/4 3:30p (Date DD/MM/YY and Time)

Our liability is limited to the c
relate to the sample as receiv
the collection, handling, or tra
interpretation of the test data

Environmental Division
Vancouver
Work Order Reference
VA22A2340

Telephone : +1 604 253 4188

Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

NAUTILUS ENVIRONMENTAL

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Burnaby, British Columbia, Canada
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Chain of Custody

Date Feb 4/22 Page 2 of 6

Report to:

Company	Nautilus Environmental Company Inc
Address	8664 Commerce Court
City/Prov/PC	Burnaby, BC, V5A 4N7
Contact	Mikayla Oldach
Phone	604-420-8773
Email	mikayla@nautilusenvironmental.ca

Invoice To:

Company	(same as previous)
Address	
City/Prov/PC	
Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals								Receipt Temperature (°C)
1	Site Water Control Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
2	Site Water 0.75 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
3	Site Water 1.5 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
4	Site Water 3 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
5	Site Water 6 µg/LDay 0 Chiron	21/01/22			1x125 mL		✓	✓										
6	Site Water 12 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
7	Site Water 24 µg/L Day 0 Chiron	21/01/22			1x125 mL		✓	✓										
8	Site Water 48 µg/L Day 0 Chiron	21/01/22			1x125 mL	all metals			✓	✓								
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu/metals are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 04/02/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Additional costs may be required for sample disposal or storage. Payment net 30 unless otherwise contracted.

Form 020; Revised by TP 2021/11/17

NAUTILUS ENVIRONMENTAL

TESTING LOCATION (Please Circle)

Burnaby (●)
8664 Commerce Court
Burnaby, British Columbia, Canada
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Date Feb 4/22 Page 3 of 5

Report to:

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Address	
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Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals	Overlying ammonia							Receipt Temperature (°C)
1	Lab Water Control Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
2	Lab Water 0.75 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
3	Lab Water 1.5 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
4	Lab Water 3 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
5	Lab Water 6 µg/LDay 10 Chiron	31/01/22			1x125 mL		✓	✓										
6	Lab Water 12 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
7	Lab Water 24 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
8	Lab Water 48 µg/L Day 10 Chiron	31/01/22			1x125 mL	all metals			✓	✓								
9	Lab Water Day 10 OAM	31/01/22			1x125 mL						✓							
10	Site Water (100%) Day 10 OAM	31/01/22			1x125 mL						✓							

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu/metals are filtered
-overlying ammonia samples preserved with sulfuric acid

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

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(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Total copper (Cu)	Dissolved copper (Cu)	Total metals	Dissolved metals								Receipt Temperature (°C)
1	Site Water Control Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
2	Site Water 0.75 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
3	Site Water 1.5 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
4	Site Water 3 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
5	Site Water 6 µg/LDay 10 Chiron	31/01/22			1x125 mL		✓	✓										
6	Site Water 12 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
7	Site Water 24 µg/L Day 10 Chiron	31/01/22			1x125 mL		✓	✓										
8	Site Water 48 µg/L Day 10 Chiron	31/01/22			1x125 mL	all metals			✓	✓								
9																		
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-preserved with nitric acid
-samples for dissolved Cu/metals are filtered

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

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Nautilus Env. (Company) 04/02/22 (Date DD/MM/YY and Time)

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Date Feb 4/22 Page 5 of 6

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Contact	Nair Yamamoto
Phone	604-420-8773
Email	nair@nautilusenvironmental.ca
PO No.	2022-0220

Sample Collection By:

Sample Type: Grab ( ) OR Composite ( )

ANALYSES REQUIRED

	SAMPLE ID	DATE (DD/MM/YY)	TIME	MATRIX	# OF CONTAINERS AND VOLUME (e.g. 1 x 20 L)	COMMENTS	Physical parameters	Major anions	Nutrients (DOC,TOC)	Total aluminum (Al)								Receipt Temperature (°C)
1	Lab Water 48 µg/L Day 0 Chiron	21/01/22			1 x 500 mL	general	✓	✓										
2	Site Water 48 µg/L Day 0 Chiron	21/01/22			1 x 500 mL	general	✓	✓										
3	Lab Water 48 µg/L Day 10 Chiron	31/01/22			1 x 500 mL	general	✓	✓										
4	Site Water 48 µg/L Day 10 Chiron	31/01/22			1 x 500 mL	general	✓	✓										
5	Lab Water 48 µg/L Day 0 Chiron	21/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
6	Site Water 48 µg/L Day 0 Chiron	21/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
7	Lab Water 48 µg/L Day 10 Chiron	31/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
8	Site Water 48 µg/L Day 10 Chiron	31/01/22			2 x 100mL amber glass	total and dissolved nutrients; preserved			✓									
9	22AI01	26/01/22			1x125mL	not preserved				✓								
10																		

SPECIAL INSTRUCTIONS/COMMENTS (CLIENT)

-samples for DOC are filtered
-see list of "full suite" testing attached

SAMPLE RECEIPT DETAILS (LABORATORY)

1. Total No. of Containers		4. Ice Present in Cooler?	Y / N
2. Courier		5. Seal Present?	Y / N
3. Good Condition?	Y / N	6. Initials Present on Seal?	Y / N

SAMPLE DESCRIPTION AND COMMENTS (LABORATORY)

RELINQUISHED BY (CLIENT)

Mikayla Oldach (Printed Name) (Signature)

Nautilus Env. (Company) 04/02/22 (Date DD/MM/YY and Time)

RECEIVED BY (LABORATORY)

(Printed Name) (Signature)

(Company) (Date DD/MM/YY and Time)

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Form 020; Revised by TP 2021/11/17

Feb 4/22

"Full suite" parameter list

Parameter	Detection Limit
Physical Parameters	
pH	0.01
Specific Conductivity	2 µS/cm
Hardness as $CaCO_3$ (Dissolved)	1 mg/L
Total Dissolved Solids	10 mg/L
Total Suspended Solids	2 mg/L
Turbidity	0.1 NTU
Major Anions	
Alkalinity – Total	1 mg/L
Chloride	0.5 mg/L
Fluoride	0.02 mg/L
Bromide	0.05 mg/L
Sulphate	0.5 mg/L
Nutrients	
Nitrate Nitrogen	0.005 mg/L
Nitrite Nitrogen	0.005 mg/L
Nitrogen – Total	0.05 mg/L
Ammonia Nitrogen	0.02 mg/L
Ortho phosphorus - dissolved	0.005 mg/L
Phosphorous – Total	0.005 mg/L
Dissolved Organic Carbon	0.5 mg/L
Total and Dissolved Metals	
Aluminum	0.001 mg/L
Antimony	0.0001 mg/L
Arsenic	0.0002 mg/L
Barium	0.0001 mg/L
Beryllium	0.0001 mg/L
Bismuth	0.0005 mg/L
Boron	0.01 mg/L
Cadmium	0.0001 mg/L
Calcium	0.05 mg/L
Chromium	0.0005 mg/L
Cobalt	0.0001 mg/L
Copper	0.0002 mg/L
Iron	0.01 mg/L
Lead	0.0001 mg/L
Lithium	0.001 mg/L
Magnesium	0.1 mg/L
Manganese	0.0002 mg/L
Mercury	0.00001 mg/L
Molybdenum	0.0001 mg/L
Nickel	0.0005 mg/L
Potassium	0.1 mg/L
Selenium	0.0003 mg/L
Silicon	0.05 mg/L
Silver	0.00001 mg/L
Sodium	0.1 mg/L
Strontium	0.0002 mg/L
Thallium	0.00001 mg/L
Tin	0.0002 mg/L
Titanium	0.01 mg/L
Uranium	0.00001 mg/L
Vanadium	0.001 mg/L
Zinc	0.001 mg/L

APPENDIX F – Chain-of-Custody Form

Nautilus Environmental

Chain of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

Sample Collection By:	RS/NG/BM/TS	
	Report to: Robin McCall	**Invoice to:**
Company	Pretivm Resources Inc.	Same
Address	Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.	
City/Prov/Postal Code	Vancouver, BC V7X 1L4 Box 49334	
Contact	Robin McCall	
Phone	(604) 558-1784	
Email	RMcCall@pretivm.com Environmental@pretivm.com	invoices@pretivm.com

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	# OF CONTAINERS	COMMENTS	Ceriodaphnia 3-brood test (100% only) (Chronic -	Daphnia Magna 48 hrs (100% only) (Acute -EPS1/RM/14)	Chironomus dilutus (water only) (test method	Ceriodaphnia 3-brood test (with dilutions) (Chronic - EPS1/RM/21)	Daphnia Magna 48 hrs (with dilutions) (Acute -EPS1/RM/14)	Lemna minor	Rainbow Trout 96 hrs (100% only) (Acute-EPS1/RM/13)	Algal Growth Inhibition Test (100% Only) (ESP 1/RM/25)	*P.subcapitata* with Arsenic in Lab and Site water	Copper Tests			Receipt Temperature (°C)
1	BJ-3.10	10-Jan-22	15:15	Water	20L	5	Grab			X	X		X			X	X		10.6	-11.3
2																				
3																				
4																				
5										9	0		1			2				
6										8	9		9			9				
7										4	4		4			4				
8										2	2		2			2				
9										1	1		1			1				
10										2	2		2			2				

PROJECT INFORMATION	SAMPLE RECEIPT		RELIQUINSHED BY (CLIENT)	RELIQUINSHED BY (COURIER)
Client:	**Total # Containers:**	5	**Signature:**	**Signature:**
P.O. No.: 1024767	**Good Condition?**	Y	**Print: Laura Fredrickson**	**Print:**
Shipped Via:	**Matches Schedule?**	Y	**Company: Pretivm**	**Company:**
			Time/Date: Jan 10, 2022 18:00	**Time/Date:**
				RECEIVED BY (LABORATORY)
			Signature:	**Signature:** TM
			Print:	**Print:** Tyrone
			Company:	**Company: Nautilus Environmental**
			Time/Date:	**Time/Date:** Jan. 13/22 @ 11:35

SPECIAL INSTRUCTIONS/COMMENTS: **If there are any mortalities, please email envionmental@pretivm.com ASAP. In the event of a failure, please re-peat the test with in the 5 day holding time with the original sample.**

Clear, colourless, odorless, no particulates

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

END OF REPORT

ERM

#1000 - 1100 Melville Street
Vancouver, BC
Canada V6E 4A6

Telephone: +1 604 689 9460
Fax: +1 604 687 4277

www.erm.com

Memo

To	Sylvia Van Zalingen, Newcrest Mining Ltd.
From	Greg Sharam, Brent McMillin, ERM
Date	November 9, 2022
Reference	0642602-003
Subject	Goldwedge Area Lakes Surveys for Waterbirds and Western Toad, July 2022

Dear Ms. Van Zalingen

Newcrest Mining Ltd., Brucejack Mine Division (Brucejack), contracted ERM Consultants Canada Ltd. (ERM) to conduct a field assessment of the Goldwedge area lakes to determine potential effects of water-drawdown on waterbirds and amphibians.

The Goldwedge area lakes are northwest of the Waste Rock and Tailings Storage Facility (WRTSF) in a matrix of exposed rock and recently de-glaciated till, with several small lakes. The area varies between 1,300 m and 1,400 m above sea level and is frequently snow-covered until late in the summer, at the end of July and August. Photo 1 shows the aerial views of the Goldwedge area lakes included in the surveys.

Methods

On July 27 through July 29, 2022, an ERM biologist with experience surveying waterbirds conducted aerial surveys of the Goldwedge area lakes for waterbirds. Aerial surveys followed standard methods developed by the British Columbia (BC) Resource Standards Information Committee (RISC) *Inventory Methods for Waterfowl and Allied Species* (Version 2.0; RIC 1999). The ERM biologist was accompanied by two aerial observers/biologists provided by Brucejack. On July 28, 2022, the ERM biologist conducted a ground survey of the Goldwedge area lakes.

On July 28, 2022, the ERM biologist conducted time-limited ground surveys for amphibians, specifically western toad, using a 15-minute survey period following the protocol described in *Inventory Methods for Pond-breeding Amphibians and Painted Turtle* (Version 2.0; RIC 1998).

Waterbird Results

During the aerial surveys on July 27 through 29, 2022, one unidentified shorebird and eight Canada goose individuals were recorded in the Goldwedge lakes area. The eight Canada geese were present near the same lake each day and are presumed to be the same individuals each day; likely molting and unable to fly. During the ground survey, on July 28, 2022, two waterbird species were recorded: one unidentified sandpiper and three semipalmated plovers. Additionally, a non-waterbird species was recorded: two unidentified ptarmigan fledglings.

Table 1 provides a summary of waterbirds observed during each day of the surveys. Figures 1 to 3 illustrate the survey routes and location of waterbird observations each day.

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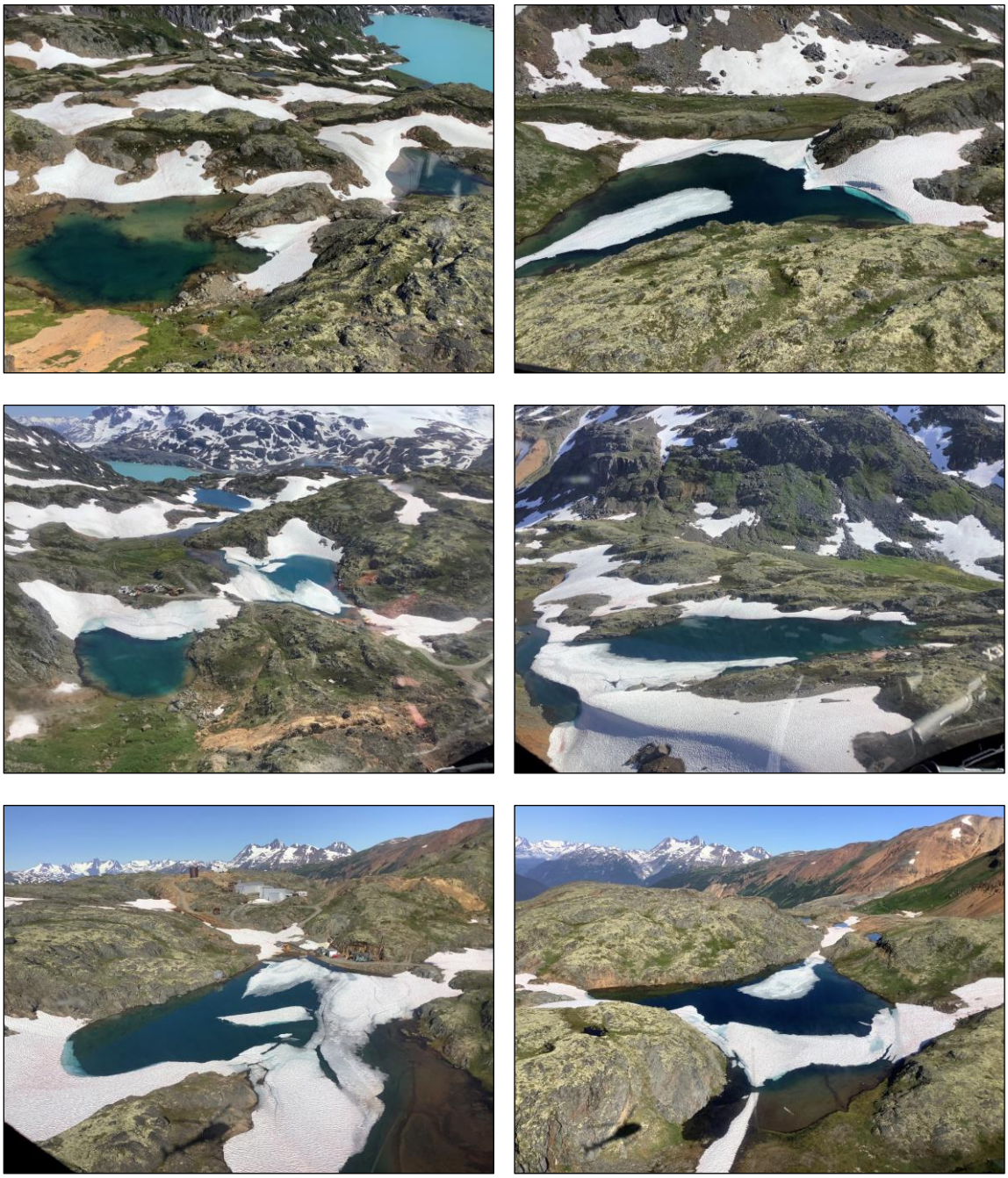

Photo 1: Aerial Views of Goldwedge Area Lakes.

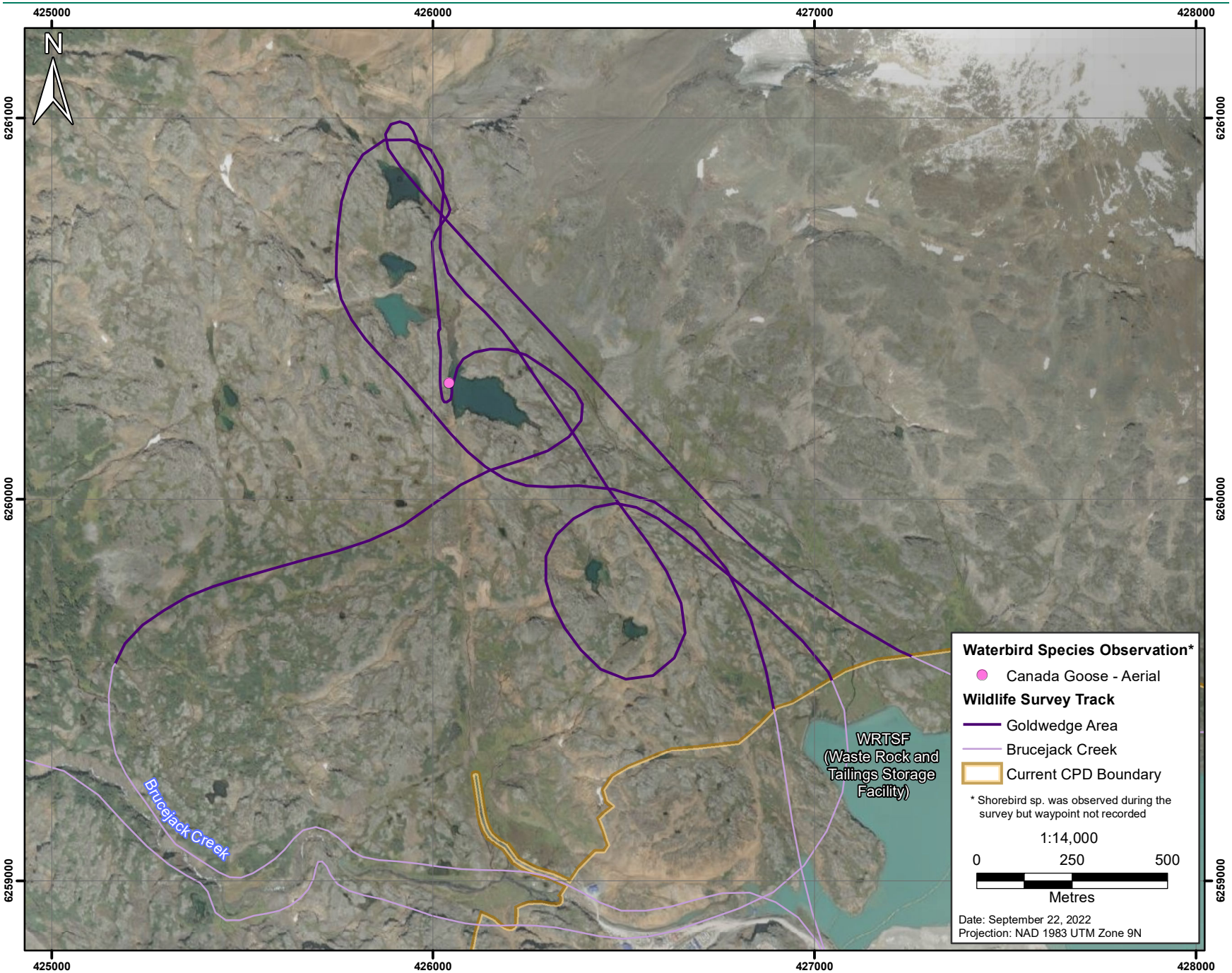

Figure 1: Survey Route and Waterbird Observations July 27, 2022

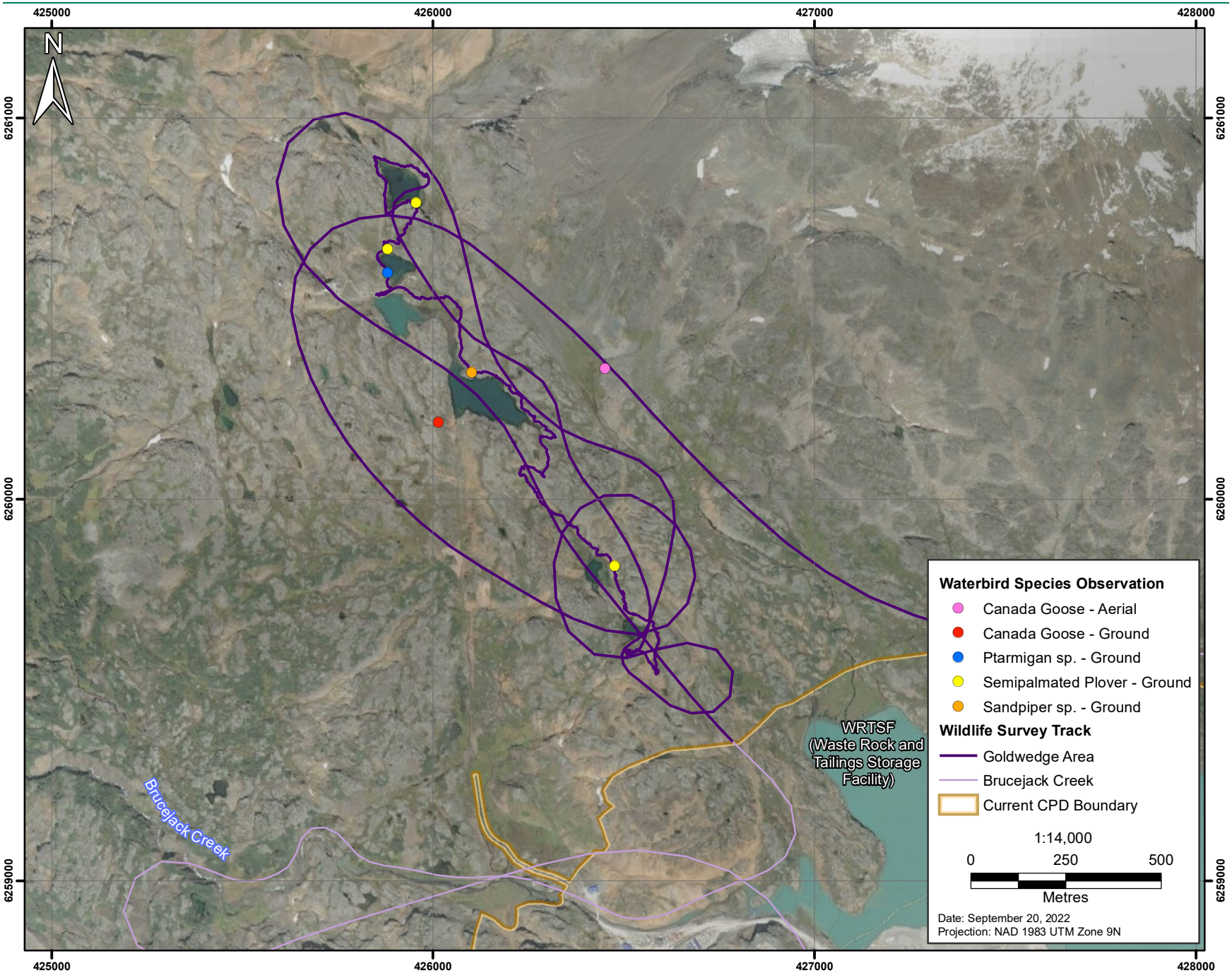

Figure 2: Survey Route and Waterbird Observations July 28, 2022

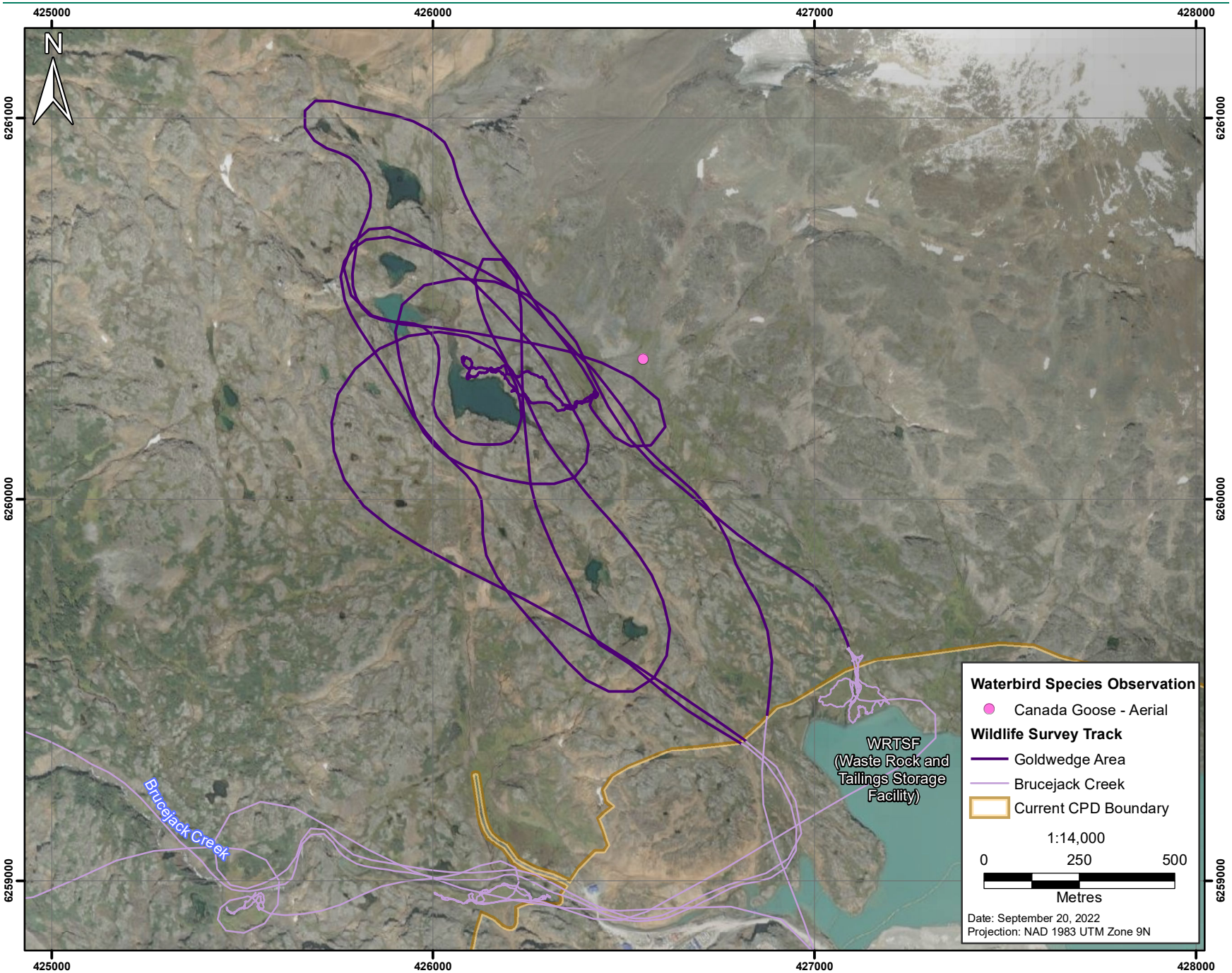

Figure 3: Survey Route and Waterbird Observations July 29, 2022

Table 1: Waterbirds Observed in Goldwedge Area

Date	Survey Type	Species Observed	Count
July 27	Aerial	Canada goose[1]	8
July 27	Aerial	Shorebird sp.[2]	1
July 28	Aerial	Canada goose[1]	8
July 28	Ground	Canada goose[1]	8
July 28	Ground	Sandpiper sp.	1
July 28	Ground	Semipalmated plover	1
July 28	Ground	Semipalmated plover	1
July 28	Ground	Semipalmated plover	1
July 29	Aerial	Canada goose[1]	8

[1] Eight Canada geese were observed on the same lake each day and presumed to be the same individuals each day; likely molting and unable to fly.

[2] Waypoint not recorded; not displayed on Figure 1.

All species observed are considered common in the area. None of the identified species are listed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or the British Columbia Conservation Data Centre.

Bird Presence in the Goldwedge Ponds

The Goldwedge area lakes have low foraging value for geese, dabbling ducks, and diving ducks in summer and fall. Ice and snow were still present on lakes in late July, and food sources like benthic invertebrates and emergent shoreline vegetation were not conspicuous. Fish are entirely absent, making Goldwedge lakes particularly low in foraging quality for divers. Given the persistent snowpack and poor-quality forage, it is unlikely that geese and ducks are summer residents and are likely only fall transients through the site.

In terms of exposure, the creek appears to support a small number of summer resident Canada geese, who could be on site for 2-2.5 months, consuming food from beside Brucejack Creek. A small number (less than a dozen) dabbling ducks and shorebirds may be summer residents on the creek. Geese, ducks and shorebirds may also stop at the creek during fall migration (the creek is frozen in spring migration), where they may spend between 1-3 days on site.

Shorebirds (resident and transient): Both plovers and sandpipers rely primarily on insects. In the breeding season, sandpipers specialize in insect larvae (Winkler et al. 2020a); plovers consume worms in addition to insects (Winkler et al. 2020b). Both shorebird groups occasionally eat some seeds and/or berries, although during breeding [May–August] and fall migration [June-September] seasons, invertebrates are the most important food items (Davis and Smith 1998). Shorebirds also need invertebrates to fuel their spring migration [April-May]. No shorebirds inhabit interior northern B.C. in the winter [October-April].

Late July could feature two scenarios for shorebirds: breeding residents and fall transients. Residents typically spend roughly three months in the area and rear offspring, meanwhile transients average closer to a four-day stay (Farmer and Durbian 2006).

From a nutritional perspective, the Goldwedge area lakes have poor value for shorebirds. The lakes featured persistent ice and snow at the end of July and did not support visible food sources such as benthic invertebrates that birds from spring, summer, and fall scenarios would require. Given that the lakes still contained ice and snow at the end of July, they were likely frozen at the beginning of June when breeding birds would arrive. Therefore, it is unlikely that shorebirds are using this site as a breeding site and more likely that they are only late fall transients at this location.

Waterfowl (resident and transient): Geese and dabbling ducks are herbivorous, eating both terrestrial and aquatic plants. In the breeding season [May-August], dabblers also consume insects and aquatic invertebrates. Diving ducks are primarily carnivorous; mergansers hunt fish, mollusks, and aquatic invertebrates, however these lakes are not fish bearing and do would not support diving ducks. Submerged vegetation form part of the diet for divers like scaup and others in Genus *Aythya* (Winkler et al. 2020c). Time spent foraging is highest during fall migration [August-October] (Paulus 1988).

Late July would mostly consist of local breeding waterfowl, although early fall migrants are also possible at this time. Nesting birds spend around three months in the vicinity, whereas spring [March-May] and fall transients are represented by shorter stays averaging 28 days (O'Neil et al. 2012). Waterfowl are absent from interior northern B.C. in the winter [October-March].

Amphibian Results

During the ground surveys, on July 28, 2022, no adult amphibians, eggs, or tadpoles of any species were observed.

Overall, the Goldwedge area lakes are poor habitat for western toad, as they are situated between 1,300 m and 1,350 m elevation. Surveys for toad breeding ponds were conducted extensively in the Brucejack Regional Study Area in 2011 and 2012 (Chapter 18 and Appendix 18-A of the Environmental Assessment Certificate Application), and no breeding ponds were located above 900 m elevation. Being above 900 m, the lakes are still frozen in May and early June, during the toad breeding period. The Goldwedge area lakes are routinely frozen until the end of June or early July (Robin McCall, Environmental Manager with Newcrest Mining Ltd., personal communication).

Yours,

Greg Sharam, PhD

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Appendix 5-4: WRTSF Best Achievable Technology Assessment

Brucejack Mine: WRTSF Best Achievable Technology Assessment

June 6, 2023

NEWCREST

LORAX ENVIRONMENTAL

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

Executive Summary

This report presents a best achievable technology (BAT) assessment for Brucejack Mine. A BAT assessment is a site-specific evaluation of waste control technologies that have been proven in commercial application and whose risks are known, that accounts for any specific operational, environmental, or geographic conditions and economic viability.

This BAT assessment report has been prepared on behalf of Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies, in support of its application to amend *Mines Act* (MA) Permit M-243 and *Environmental Management Act* (EMA) Effluent Permit 107835 (PE-107835) to allow for an increase to the mine's production rate from 3800 tonnes per day (tpd) to 4950 tpd (4950 tpd Joint Amendments Application). As a result of the increased production rate, concentrations of nitrate, T-Se, D-Cu and T-As at monitoring station BJ 3.10, the mine's regulated discharge compliance location, are predicted to go above BC freshwater aquatic life (FWAL) water quality guidelines or current discharge limits. BJ 3.10 is located at the outlet of the mine's Waste Rock and Tailings Storage Facility (WRTSF), which receives all mine-related discharges. The purpose of this report is to evaluate options for water treatment at the outlet of the WRTSF to meet current discharge limits and applicable water quality guidelines for the proposed increased production scenario.

This BAT assessment has been conducted in accordance with the step-by-step process described in the Ministry of Environment and Climate Change Strategy (ENV) guidance document titled *Best Achievable Technology Assessment to Inform Waste Discharge Standards Handout*, published in October 2021. Treatment technologies for parameters of concern (POCs; *i.e.,* nitrate, T-Se, D-Cu and T-As) during operations were identified and evaluated for feasibility, reliability, control-effectiveness, and cost-effectiveness. Seven technologies were identified for treatment of nitrate, with four deemed feasible and carried forward for further assessment. Six technologies were identified for treatment of T-Se, T-As, and D-Cu, with 2 being deemed feasible for T-Se and D-Cu, and 4 deemed feasible for T-As. The reliability and control-effectiveness evaluations concluded that reverse osmosis (RO) is the most reliable and control-effective technology for all POCs. The most cost-effective technologies in terms of capital and operating cost, respectively, are ion exchange and MBBR for nitrate treatment, RO and nanofiltration (NF) for T-Se and D-Cu treatment, and hydroxide precipitation/co-precipitation and NF for T-As treatment.

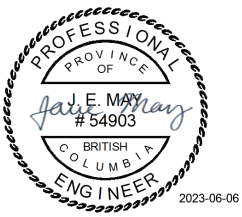
Based on the evaluations of feasibility, reliability, and control-effectiveness described in this BAT assessment, it is concluded that the stringent treatment objectives for T-Se and

D-Cu would require the use of RO technology. Although there are alternative treatment options for nitrate (*e.g.*, ion exchange) and T-As (*e.g.*, hydroxide precipitation/co-precipitation with coagulants), RO offers a robust treatment solution for these parameters as well. Therefore, RO is considered best achievable technology to meet the treatment objectives for all POCs, based on the flows and water quality predicted for WRTSF discharge during operations under the proposed increased production rate scenario.

Authorship

This best achievable technology (BAT) assessment was prepared by Lorax Environmental Services Ltd. (Lorax) for Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies. The report was written by Jane May, B.A.Sc., P.Eng. and Cheng Kuang, M.Sc., RBTech., and reviewed by Alison Shaw, Ph.D., P.Geo. and Patrick Mueller, B.Sc., P.Chem. Lorax Environmental Services Ltd. has relied on information available in scientific literature and information supplied by Pretium and Veolia Water Technologies Canada (Veolia) in preparing this report.

Lorax Environmental Services Ltd.
per:



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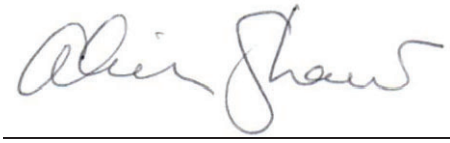

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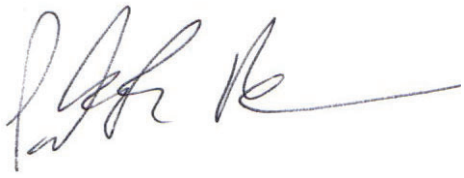

Patrick Mueller, B.Sc., P.Chem.
Environmental Chemist

Lorax Environmental Services EGBC Permit to Practice Number: 1001840

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Acronyms and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BAT	Best Achievable Technology
BC	British Columbia
CWP	Contact Water Pond
EBR	Electro-Biochemical Reactor
EMA	B.C. *Environmental Management Act*
ENV	B.C. Ministry of Environment & Climate Change Strategy
FBR	Fluidized Bed Reactor
FWAL	Freshwater Aquatic Life
GAC	Granular Activated Carbon
LOM	Life of Mine
MA	B.C. *Mines Act*
MBBR	Moving Bed Biofilm Reactor
ML/ARD	Metal Leaching / Acid Rock Drainage
NF	Nanofiltration
OMS	Operation, Maintenance and Surveillance
PAG	Potentially Acid Generating
POC	Parameter of Concern
POPC	Parameter of Potential Concern
RO	Reverse Osmosis
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TPD	Tonnes Per Day
TRP	Trigger Response Plan
TSS	Total Suspended Solids
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant
WQG	Water Quality Guideline
ZVI	Zero Valent Iron

Chemical elements are generally referred to using their one or two letter atomic symbol. Cu denotes copper, for example. A T- or D- preceding the symbol denotes the total or dissolved fraction, respectively (D-Cu, for example). Molecules, functional groups, or polyatomic ions may be referred to either by name (*e.g.*, nitrate) or chemical formula (*e.g.*, NO_3).

1. Introduction

This report presents a best achievable technology (BAT) assessment for treating WRTSF discharge at Brucejack Mine. Brucejack Mine (the mine) is an underground mine operation which is owned and operated by Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies (Newcrest). The mine is located approximately 60 km NNW of Stewart, British Columbia (BC) and began construction in September 2015, with gold production commencing in July 2017.

A BAT assessment is a site-specific evaluation of waste control technologies that have been proven in commercial application and whose risks are known, that accounts for any specific operational, environmental, or geographic conditions and economic viability. This BAT assessment report has been prepared on behalf of Pretium in support of its application to amend *Mines Act* (MA) Permit M-243 and *Environmental Management Act* (EMA) Effluent Permit 107835 (PE-107835) to allow for an increase to the mine's average daily ore production rate from 3800 tonnes per day (tpd) to 4950 tpd (4950 tpd Joint Amendments Application). Water quality modelling based on the mine plan for the proposed increased production rate predicts that concentrations of certain parameters will go above current water quality discharge limits or BC Freshwater Aquatic Life (FWAL) guidelines at monitoring station BJ 3.10, the mine's regulated discharge location at the outlet to the WRTSF (Lorax, 2023b). Therefore, the purpose of this report is to evaluate options for water treatment at the outlet of the WRTSF to meet current discharge limits and applicable water quality guidelines at BJ 3.10 during operations, under the increased production rate scenario.

1.1 Background

Brucejack Mine is an underground mine operation with related surface infrastructure including a mill, a water treatment plant (WTP), a contact water pond (CWP), a waste rock and tailings storage facility (WRTSF), and a sewage treatment plant (STP). Based on the proposed increased production rate, the total mine operating life is estimated to be 13 years. During the operations phase, mine-related inputs are directed to the WRTSF, including STP effluent, WTP effluent, deposition of potentially acid generating (PAG) waste rock, and deposition of thickened tailings solids and effluent to the bottom of the WRTSF. Monitoring station BJ 3.10 at the WRTSF outlet is the mine's final discharge compliance location where WRTSF discharge limits specified in PE-107835 apply.

Source control is the primary method used to maintain acceptable effluent quality at the WRTSF outlet. Source control strategies are implemented through specific management

plans and associated triggers. For example, the Chromium Management Plan and the Nitrogen Management Plan employ trigger response plans (TRPs) to assess and adjust the management of these parameters. There is also a TRP for the CWP. Similarly, the existing WTP implements process control procedures that are used to adjust treatment based on monitoring results, and relevant discharge management information is described in the Operation, Maintenance and Surveillance (OMS) Manuals for the WRTSF (SRK, 2020a) and Water Management Plan (SRK, 2020b). Monitoring of the various sources of contaminant loadings to the WRTSF, and monitoring of WRTSF effluent at BJ 3.10, show that the source control measures implemented have been effective in maintaining acceptable discharge quality to date.

Site-specific water balance and water quality models have been developed for Brucejack Mine. The water quality model predicts how mining activities at Brucejack Mine will influence water quality in the receiving environment through life of mine (LOM), closure, and into the post-closure phase, considering base case and upper case geochemistry conditions. Water quality predictions are provided for two stations: 1) BJ 3.10, the mine's regulated WRTSF discharge location; and 2) BJ 2.62, a downstream monitoring location in Brucejack Creek which will receive underground mine loads via groundwater pathways once the mine has been flooded following closure.

1.2 Scope

The scope of the BAT assessment is limited to surface treatment at the outlet of the WRTSF (as represented by the BJ 3.10 monitoring station). Treatment within the WRTSF, at surface or at depth, was not evaluated. In addition, the scope of the BAT assessment is limited to active treatment technologies; passive and semi-passive treatment strategies were not considered. Lastly, the BAT assessment identified treatment options for predicted water quality during the operations phase; closure and post-closure water quality conditions were not evaluated.

1.3 Objectives

This report has been prepared in accordance with the guidance document titled *Best Achievable Technology Assessment to Inform Waste Discharge Standards Handout*, published in October 2021 by the Ministry of Environment and Climate Change Strategy (ENV). Therefore, the objectives of this report are to:

1. Identify information to be gathered for the BAT assessment (Section 2.1);
2. Identify all potential technologies or options (Section 2.2);
3. Screen potential technologies for feasible options (Section 2.3);

4. Describe and compare the reliability of each option (Section 2.4);
5. Describe and compare the control-effectiveness of each option (Section 2.5);
6. Describe and compare the cost-effectiveness of each option (Section 2.6); and
7. Select the best achievable technology (Section 2.7).

Conclusions from the BAT assessment are summarized in Section 3.

2. Best Achievable Technology Assessment

This section describes the work conducted to carry out the BAT assessment in accordance with the step-by-step process described in the ENV guidance document titled *Best Achievable Technology Assessment to Inform Waste Discharge Standards Handout*, published in October 2021.

2.1 Identification of Assessment Information

The first step of the BAT assessment process is to identify the information required to conduct the assessment. Design basis information must be defined to identify potential treatment options. Design basis includes modelled flow rates and water quality from the WRTSF (Section 2.1.1 and 2.1.2, respectively), discharge criteria for the treated effluent (Section 2.1.3), and the list of target parameters requiring treatment (Section 2.1.4).

2.1.1 Flow Capacity

A water balance model (WBM) has been developed for Brucejack Mine, which can be used to inform the flow capacity requirements for the treatment of WRTSF waters. The WBM is a detailed interpretation of the mine and water management plans, with consideration of baseline and operational climate, hydrometric, and hydrogeological data collected for the mine site area (*i.e.*, the area that comprises all mine infrastructure within the Brucejack mining leases). Detailed information on the water balance model is presented in Lorax, 2023a.

Based on the WBM, the range of flows expected to report to BJ 3.10 from the WRTSF during the operations phase is approximately 190 to 11,500 m^3/hr, with an average flow rate of 1,878 m^3/hr (Lorax, 2023a). For the purposes of this BAT assessment, the design flow rate for the conceptual WRTSF treatment system is 5,760 m^3/hr, which exceeds the predicted average flow rate at BJ 3.10 by a factor of 3 to accommodate treatment during higher-flow periods.

If the design flow rate for the treatment system is less than the predicted peak flow rate (as it is for the purposes of this BAT assessment), there will be periods in which WRTSF waters bypass the treatment system. Based on feedback obtained through treatment vendor engagement, it is understood that treating 100% of the WRTSF outlet year-round would be impractical and uneconomical, due to the wide range of flows and the significant peak flow rates predicted by the WBM. Additionally, WQM predictions indicate that POC concentrations in the effluent are reduced during freshet when flow is highest (Lorax

2023b). If detailed design for the conceptual BAT treatment system is advanced, a modelling analysis of the predicted flow rates at the WRTSF outlet should be conducted to confirm the optimal design flow rate for the treatment system, recognizing that it may not be necessary to treat 100% of the flow from the WRTSF to achieve compliance at BJ 3.10, depending on flow conditions throughout the year.

2.1.2 Influent Water Quality

As noted above, a water quality model has been developed to generate water quality predictions for Brucejack Mine (Lorax, 2023b). The Brucejack Mine water quality model employs a mass balance approach that accounts for background water quality and runoff volumes reporting from undisturbed portions of the Brucejack Creek watershed, as well as chemical loads emanating from mine sources and water management structures, the WTP, and the STP. Each component of the existing environment and mine site area that may contribute to water quality at the outlet to the WRTSF (BJ 3.10) has been included in the water quality model.

For each monitoring site, water quality predictions are presented for two cases. The Base Case is considered to represent a conservative expected case; whereas the Upper Case incorporates the combined effects of upper case geochemical source terms for all inputs. The Upper Case source terms are generally based on 90th percentile values from geochemical or water quality monitoring datasets for all mine-related flows and employs highly conservative assumptions with respect to both contact water chemistry and onset of acidity. Detailed information on the water quality model is presented in Lorax, 2023b.

Monitoring station BJ 3.10 is located at the WRTSF outlet, with immediate change from effluent to aquatic receiving environment occurring at/within the BJ 3.10 weir structure (*i.e.*, there is no dilution zone for WRTSF effluent). Therefore, water quality predictions at BJ 3.10 represent the anticipated influent concentrations to the selected BAT system. Water quality predictions indicate that treatment at the WRTSF outlet will not be required for the closure and post-closure phases, so only operations phase predictions are considered in this assessment. Maximum modelled values for the operations phase are presented in Table 2-1 below. Measured and modelled concentrations at BJ 3.10 decrease during spring freshet; therefore, treatment to meet discharge limits is less likely to be required during spring.

Table 2-1:
Predicted water quality at BJ 3.10 for 4950 tpd production rate

Parameter	Units	Maximum Modelled – Operations Phase	
		Base Case	Upper Case
Ammonia (as N)	mg-N/L	3.5	5.7
Nitrite (as N)	mg-N/L	0.13	0.21
Nitrate (as N)	mg-N/L	15.2	24.7
Chloride	mg/L	8.2	18.1
Fluoride	mg/L	0.29	0.52
Sulfate	mg/L	114	298
D-Al	mg/L	0.062	0.202
T-Sb	mg/L	0.020	0.031
T-As	mg/L	0.014	0.026
T-B	mg/L	0.14	0.31
T-Ba	mg/L	0.048	0.065
T-Be	mg/L	0.00003	0.00006
D-Cd	mg/L	0.000012	0.00033
T-Cr	mg/L	0.00040	0.00040
T-Co	mg/L	0.00030	0.00130
D-Cu	mg/L	0.00040	0.00090
D-Fe	mg/L	0.008	0.115
T-Fe	mg/L	0.041	0.140
T-Pb	mg/L	0.0003	0.0086
T-Hg	mg/L	0.000004	0.000013
T-Mn	mg/L	0.24	0.30
T-Mo	mg/L	0.016	0.027
T-Ni	mg/L	0.00047	0.0016
T-Se	mg/L	0.0021	0.0062
T-Ag	mg/L	0.000013	0.000039
T-Tl	mg/L	0.00009	0.00012
T-U	mg/L	0.0006	0.0015
T-Zn	mg/L	0.0021	0.017

2.1.3 Treatment Objectives

Treated effluent criteria are defined for each parameter with a discharge limit and/or a BC FWAL water quality guideline (WQG). For each parameter, the applicable discharge limit or BC WQG is applied as the treatment objective for the selected BAT system. For parameters with both a short-term and long-term BC WQG, the long-term guideline is applied for conservatism. In summary, the treatment objective for each parameter is equivalent to:

- The discharge limit stipulated by PE-107835; or
- For parameters without an established discharge limit, the long-term BC FWAL WQG is applied; or
- For parameters without an established discharge limit or long-term BC FWAL WQG, the short-term BC FWAL WQG is applied.

A summary of treatment objectives is presented in Table 2-2 below.

Table 2-2:
Treatment objectives

Parameter	Units	Treatment Objective
pH	-	6.5-9.0
TSS	mg/L	**30**
Ammonia (as N)	mg-N/L	**4**
Nitrite (as N)	mg-N/L	**0.24**
Nitrate (as N)	mg-N/L	**11.5**
Chloride	mg/L	***150***
Fluoride	mg/L	**0.82**
Sulfate	mg/L	***128***
D-Al	mg/L	***0.050***
T-Sb	mg/L	**0.028**
T-As	mg/L	**0.01**
T-B	mg/L	***1.2***
T-Ba	mg/L	***1.0***
T-Be	mg/L	***0.00013***
D-Cd	mg/L	***0.000083***
T-Cr	mg/L	***0.0010***
T-Co	mg/L	***0.0040***
D-Cu	mg/L	***0.0003***
D-Fe	mg/L	**0.35**
T-Fe	mg/L	**1.7**
T-Pb	mg/L	***0.0039***
T-Hg	mg/L	***0.000020***
T-Mn	mg/L	***0.73***
T-Mo	mg/L	***7.6***
T-Ni	mg/L	***0.025***
T-Se	mg/L	***0.0020***
T-Ag	mg/L	**0.00046**
T-Tl	mg/L	***0.00080***
T-U	mg/L	***0.0085***
T-Zn	mg/L	***0.0075***

Notes:
Hardness-dependent BC WQGs were calculated using the baseline median harness of 28 mg/L as $CaCO_3$ (Lorax, 2023b).
Long-term BC WQGs are shown in ***bold italic*** font.
Short-term BC WQGs are shown in **bold** font.
Effluent discharge limits (per PE-107835) are **shaded in bold grey font**.

2.1.4 Target Parameters

Water quality model results (Lorax, 2023b) were screened to identify parameters of potential concern (POPCs) to aquatic life in the receiving environment. POPCs were identified as parameters that had a Base Case model result that was greater than 80% of a water quality benchmark (either a discharge limit or a BC FWAL guideline for parameters that do not have discharge limits) during any mine phase. Concentrations that are below these benchmarks are considered protective of aquatic life in the receiving environment because discharge limits were developed to be protective of aquatic life without dilution in the receiving environment. The screening of BJ 3.10 water quality model results for the operations phase identified seven POPCs: ammonia (NH_3), nitrate (NO_3), sulfate (SO_4), total arsenic (T-As), dissolved aluminum (D-Al), dissolved copper (D-Cu), and total selenium (T-Se). These POPCs were then evaluated to determine if there are reasons to exclude them from further assessment. Ammonia was excluded from further assessment because it was determined that denitrification in the WRTSF will convert ammonia to nitrate, resulting in ammonia levels well below its discharge limit (denitrification is a biochemical process that was not included in the mass balance water quality model). Dissolved aluminum was excluded from further assessment because it was determined that solubility constraints result in the precipitation of D-Al in the WRTSF, which reduces the concentration of D-Al at the WRTSF outlet to below its POPC benchmark. Sulfate was excluded from further assessment because the Base Case model results are less than the long-term BC FWAL guideline during all mine phases, when the sulfate guideline is calculated using the modelled hardness, instead of the baseline hardness of 28 mg/L used for calculating the POPC screening benchmark for sulfate. Therefore, only nitrate, T-As, D-Cu and T-Se are carried forward as parameters of concern (POCs; *i.e.*, target parameters for the selected BAT system).

2.2 Identification of All Potential Technologies

The second step of the BAT assessment process is to identify all potential treatment options. This section provides an overview of treatment technologies that are commercially available and have the potential to treat one or multiple POCs in mine effluent. Passive treatment systems that rely on natural degradation of contaminants (*e.g.,* cyanide, ammonia) are not practical for Brucejack Mine due to site-specific limitations (*e.g.,* available footprint, cold climate) and have not been considered. Hence, the assessment presented herein specifically evaluates active biological (Section 2.2.1), chemical (Section 2.2.2) and physical (Section 2.2.3) treatment technologies for removal of nitrate, T-Se, D-Cu, and/or T-As. Typical achievable concentrations or removal efficiencies for POCs

are provided where available. Target POCs, treatment requirements, and by-products/wastes generated by each treatment technology are summarized in Table 2-3.

2.2.1 Biological Technologies

Biological treatment technologies rely on naturally-occurring or cultivated microorganisms to degrade, oxidize, or reduce contaminants in wastewater. Biological treatment can be accomplished via suspended growth and attached growth processes. In suspended growth processes, microorganisms are kept in suspension by mixing the wastewater being treated. In attached growth processes, microorganisms are attached as biofilms to inert packing media through which the wastewater flows. Attached growth processes are preferable for the treatment of mine wastewater because biofilms are less susceptible to variations in contaminant loading (due to variation in flow or quality) and temperature. Biofilms are also more compact and generate less sludge than suspended growth processes. Biological technologies that are applicable for the treatment of POCs in mine wastewater are described below.

2.2.1.1 Moving Bed Biofilm Reactor

A moving bed biofilm reactor (MBBR) utilizes an attached growth process to facilitate biological oxidation or reduction of target parameters. The MBBR technology was developed in Norway for nitrogen removal from wastewater (Dale *et al.,* 2015). Since its first introduction in the 1990s, over 750 installations have been completed worldwide. The large surface area afforded by polyethylene carriers in MBBRs is favorable for biofilm development. Reactors can be used to facilitate both aerobic and anoxic processes. In aerobic systems, biofilm carriers are kept in suspension via aeration, whereas mechanical mixers are used in anoxic systems (Figure 2-1; Buecker, 2017).

Anoxic MBBRs have been shown to remove nitrate and T-Se from mine wastewater via reductive processes (Dale *et al.,* 2015). In the absence of oxygen, nitrate is used as a preferable electron acceptor by denitrifying bacteria to support organic carbon oxidation and cellular growth. During this process, nitrate is reduced to inert nitrogen gas, with nitrite generated as an intermediate product. Some denitrifying bacteria can also use Se oxyanions (selenate and selenite) as electron acceptors in the absence of oxygen and nitrate (CH2M Hill, 2010).

The biological reduction of nitrate and Se requires a source of organic carbon (*e.g.,* methanol) to serve as the electron donor, and nutrients (*e.g.,* phosphorus, micronutrients) to support biological function (MEND, 2014). In wastewater with high levels of nitrate, a sufficient amount of organic carbon is required for complete nitrate reduction before Se

reduction can occur (CH2M Hill, 2010). The excess carbon source added to reactors will generate additional biomass that requires downstream solid/liquid separation and disposal.

Figure 2-1: Anoxic moving bed biofilm reactor schematic (Buecker, 2017).

2.2.1.2 Fluidized Bed Reactor

A fluidized bed reactor (FBR) is another configuration of an attached growth biological treatment system. The media that supports biofilm growth needs to be maintained in suspension, similar to the MBBR, except that the flow of water is used to maintain the media in suspension rather than mixing or aeration. In an FBR, solid granular media (typically sand or activated carbon) is forced into suspension and continuous mixing (*i.e.*, fluidized) by the high-velocity influent stream flowing upwards from the bottom of the reactor tank (Figure 2-2). The fluidization process allows complete mixing of the media, which increases the active surface area for attached growth and biomass development. Given the fluidized nature of FBRs, little to no pre-treatment for total suspended solids (TSS) is required (CH2M Hill, 2010). In addition, reactors can run continuously without backwashing.

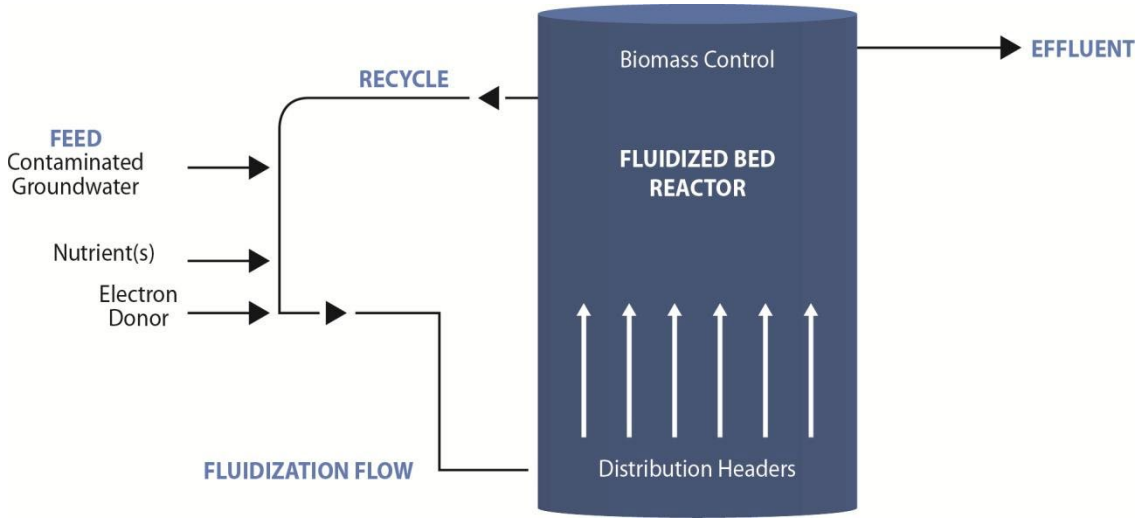

Figure 2-2: Fluidized bed reactor schematic (Envirogen, 2011).

FBRs are seeded with heterotrophic bacteria that are capable of reducing nitrate and Se under anaerobic conditions (CH2M Hill, 2010). Organic carbon and nutrients are pumped into the reactor to serve as the food source/electron donor and to facilitate microbial growth. Excess biomass that sloughs off the media requires downstream solid/liquid separation and disposal. The biomass is typically non-hazardous but should be stored in anoxic/reducing conditions to ensure that the sequestered Se (as elemental Se or adsorbed selenite) is not remobilized.

The FBR technology is commercially proven for removing nitrate from groundwater (CH2M Hill, 2010). It has also been demonstrated at full scale on mining effluent, but few installations have been in operation for long enough to determine long-term feasibility. The typical achievable concentrations of FBR-based systems reported by mining operations are <0.1 mg-N/L for nitrate, and between 5 and 20 µg/L for T-Se (MEND, 2014).

2.2.1.3 ABMet® System

The Advanced Biological Metals Removal Process (ABMet®) technology (patented by GE Water & Process Technology) is an attached growth process which involves running wastewater through a biologically active filter. The biofilter is loaded with granular activated carbon (GAC) and selected strains of microorganisms that target Se removal (Ali and Shrivastava, 2021). Similar to other attached growth processes, ABMet® treatment systems require a carbon source, nutrient additions, and downstream solid/liquid separation for sludge disposal.

There has been pilot-scale and full-scale applications of the ABMet® technology to remove T-Se to low levels (<5 µg/L; CH2M Hill, 2010). A full-scale installation at a gold mine site in South Dakota was reported to consistently meet discharge criteria for nitrate and Se at an average flow rate of 23 m^3/hr (Maniatis and Adams, 2003). The typical achievable concentrations of ABMet® treatment systems reported by mining operations are <0.1 mg-N/L for nitrate, and <5 µg/L for T-Se (MEND, 2014). The range of design flow rates for full-scale ABMet® installations is 6 to 318 m^3/hr. Given its low hydraulic loading rate and long hydraulic retention time requirements, a large footprint is required for the ABMet® system (CH2M Hill, 2010).

2.2.1.4 Electro-Biochemical Reactor

An electro-biochemical reactor (EBR) is an alternative to conventional bioreactors that use organic carbon and excess nutrients to provide the electrons needed for contaminant removal. The EBR technology (patented by INOTEC Inc.) provides a consistent supply of electrons to microorganisms in the reactor at a low voltage potential (1 to 3 V). The electron supply system is controllable, economical, and robust (Opara *et al.,* 2014). Supplying electrons directly to the reactor also generates significantly less sludge and waste products compared to conventional biological treatment technologies. The EBR technology has been demonstrated at bench-scale and pilot-scale only. An average effluent concentration of 2 mg-N/L for nitrate, and 0.5 µg/L for T-Se was achieved for a EBR system piloted at a coal mine operation in British Columbia (Opara *et al.,* 2014).

2.2.2 Chemical Technologies

Chemical treatment technologies generally utilize precipitation/co-precipitation, adsorption, or ion exchange processes for contaminant removal from wastewater. Precipitation/co-precipitation typically involves pH adjustment and the addition of a coagulant to destabilize and aggregate colloidal particles for enhanced settling ability (USEPA, 2002). Chemical adsorption refers to the immobilization of target ions on the surface of a solid phase. Ion exchange is a process where the target ions are preferentially exchanged for ions of similar charge and size from engineered resins. Applications of specific treatment technologies are described below.

2.2.2.1 Hydroxide Precipitation/Co-Precipitation

Hydroxide precipitation/co-precipitation is a common technology used to neutralize acidity and remove metals from mine wastewater. The precipitation of dissolved metals (*e.g.,* Cu) to form metal hydroxides can be summarized based on the following generic reaction:

$$Me^{x+} + X(OH)^{-} \rightarrow Me(OH)_{x\ (s)}$$

The precipitation process occurs at alkaline pH, and the target pH for optimal removal efficiency is metal-specific. To achieve the desired removal efficiencies for various dissolved metals, reactions can be conducted in series to allow for selective precipitation of metal hydroxides at optimal pH conditions. The precipitated solids are then removed using solid/liquid separation techniques (*e.g.*, gravity sedimentation, clarification). The use of a polymeric flocculant enhances the performance of the subsequent separation process and may be necessary to remove smaller flocs (*i.e.*, a mass formed through the aggregation of fine suspended particles) (USEPA, 2014). The resulting sludge residual typically requires treatment (*e.g.*, dewatering) prior to disposal. A general schematic for a chemical precipitation treatment system is illustrated in Figure 2-3.

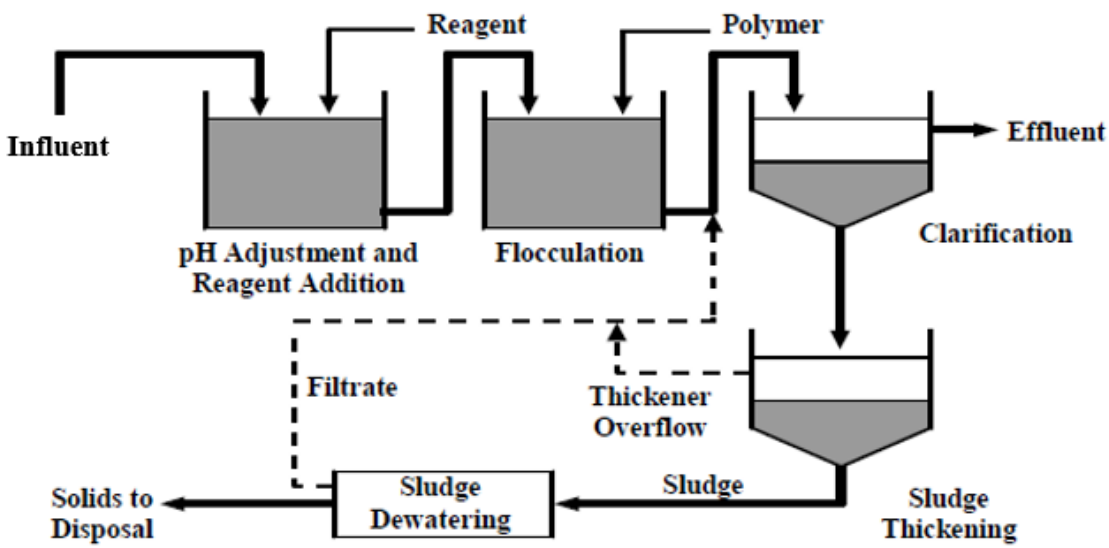

Figure 2-3: Model schematic of a chemical precipitation system (adapted from USEPA, 2002).

Quick lime and hydrated lime are commonly used as neutralization agents due to their ability to reach high target pH at relatively low costs, and their coagulating properties (MEND, 2014). In chemical precipitation tanks, iron (Fe) and aluminum (Al) salts are often added as coagulants to agglomerate colloidal particles together and facilitate the formation of surface complexes between metals and precipitates, resulting in further metal removal (*i.e.*, co-precipitation). For example, a coagulant is required for treatment of T-As, which can be removed via adsorption onto the precipitated Fe or Al hydroxides, and possibly via precipitation as ferric or Al arsenate (Robins, 2001; Violante *et al.*, 2007; Lakshmanan *et al.*, 2009). Iron-based coagulants (*e.g.,* ferric sulfate and ferric chloride) are more effective at removing As (as arsenate [As^{5+}]) than their Al-based counterparts (USEPA, 2003). Various factors can affect the removal efficiency of As via precipitative processes,

including reagent dosage, mixing intensity, and pH. Under optimal conditions, hydroxide precipitation/co-precipitation using coagulants is capable of achieving <5 µg/L of As^{5+} in effluent (USEPA, 2003).

Selenium removal can also be achieved via co-precipitation of selenite with ferrihydrite (USEPA, 2014). The optimal pH for Se (as selenite) co-precipitation is between 4 to 6, with removal efficiencies reported to be in the range of 85 to 95% (USEPA, 2014). While selenate may also be co-precipitated with Fe salts, treatment efficiency is reduced by the presence of sulfate. A pilot-scale test using co-precipitation technology showed effective Se removal; however, the study concluded that larger-scale treatment would not be economically feasible (MEND, 2014).

2.2.2.2 Sulfide Precipitation

Sulfide precipitation can be used to treat dissolved metals to low concentrations according to the following generic reactions, where Me^{2+} represents a divalent metal ion (*e.g.,* Cu^{2+}):

$$Me^{2+} + S^{2-} \rightarrow MeS_{(s)}$$

$$Me^{2+} + HS^{-} \rightarrow MeS_{(s)} + H^{+}$$

Sulfide precipitation can also precipitate As^{3+}, but it is not effective for treating As^{5+}. Hence, As^{5+} must first be reduced to As^{3+}, which may be accomplished in biological systems that can support both As^{5+} reduction and sulfide generation. Sulfide precipitation may be used to precipitate As^{3+} according to the following reaction (Littlejohn *et al.*, 2015):

$$3H_2S + 2H_3AsO_3 \rightarrow As_2S_3 + 6H_2O$$

Similarly, the reduction of Se^{6+} to Se^{4+}, and subsequent precipitation of Se^{4+} with sulfide can be used to remove Se from solution according to the following reaction (Geoffroy and Demopoulos 2011; Hageman *et al.,* 2016):

$$2H_2S + SeO_2 \rightarrow SeS_2 + 2H_2O$$

The typical achievable concentrations from sulfide precipitation are reported to be <50 µg/L for As^{3+}, <30 µg/L for T-Cu, and <50 µg/L for T-Se (MEND, 2014). To achieve the desired removal efficiencies for various dissolved metals, reactions can be conducted in series to allow for selective precipitation of metal sulfides at optimal pH conditions. The main advantage of sulfide precipitation over hydroxide precipitation/co-precipitation is the lower quantity of sludge generated from the process, as well as the lower solubility of metal sulfides compared to metals bound to ferric oxyhydroxides. In addition, metal sulfide sludges are generally denser than metal hydroxide sludges and contain less bound water; therefore, it is easier to thicken and dewater than hydroxide sludge (ITRC, 2010; MEND,

2014). However, sulfide precipitation has the potential for generation of excess hydrogen sulfide (H_2S), which may be a safety concern and requires process control and monitoring. Residual sulfide in effluent may also pose a risk of downstream toxicity, sulphate and acidity generation, and oxygen depletion. Therefore, residual sulfide oxidation may be required prior to discharge (*e.g.*, via aeration or hydrogen peroxide) (MEND, 2014).

2.2.2.3 Ion Exchange

Ion exchange is a reversible chemical reaction in which ions held electrostatically on the surface of a solid resin are exchanged (via sorption processes) for target ions of similar charge in a solution. Resins are generated through a polymerization process, with functional groups grafted onto the polymers to selectively uptake ions. Ion exchange is often preceded by other treatment processes to remove suspended solids, organics, and other contaminants that can foul the resins and reduce their effectiveness. As influent passes through the ion exchange column, the target ions are immobilized onto resins, and the functional group associated ions are displaced and released into the effluent.

Ion exchange resins must be periodically regenerated to remove the sorbed contaminants and replenish the exchanged ions, potentially adding significant capital and operating costs. The exchange capacity of a resin degrades over time due to fouling and scale formation; hence, periodic resin replacement is required to achieve consistently low effluent concentrations. The resin and regenerant solutions must be periodically replaced, with spent materials requiring management and disposal. The regenerate solutions contain the target ions at pH and concentrations which are not suitable for discharge, and thus require further treatment via chemical precipitation, evaporation and crystallization, or ZVI adsorption for Se treatment systems (MEND, 2014).

Ion exchange can achieve high removal efficiencies (>90%) for target ions, depending on the selected resin and influent chemistry. Ion exchange resins are reported to achieve effluent concentrations of <5 µg/L for T-As, <30 µg/L for T-Cu, and <10 µg/L for T-Se (MEND, 2014). However, treatment performance is affected by solution pH and abundance of other ions, notably sulfate, which compete for sites on the exchange resin. In mine effluent with high concentrations of sulfate, it can be difficult and costly to achieve high removal efficiencies for the target POCs.

Unlike many other chemical technologies that depend on the reactivity of selenite for Se treatment, anion exchange resins are more effective at removing selenate than selenite (Golder, 2020). Hence, Se removal efficiency via ion exchange can be improved by ferric hydroxide co-precipitation of selenite as a pre-treatment step. BQE Water's Selen-IX™ system combines ion exchange with an electrochemical step to selectively remove selenate while fixing Se into inorganic solid residue (Mohammadi *et al.,* 2016). Pilot-scale

demonstrations of the Selen-IX™ system were shown to remove Se from mine-impacted water to as low as 1 µg/L. The first full-scale Selen-IX™ plant was commissioned at the Kemess Mine in 2019-2020 to meet the Se treatment objective of 2 µg/L under a design flow rate of 270 m^3/hr (BQE Water, 2021). Given the recent implementation of this technology, its long-term feasibility and treatment performance at higher flow capacities is uncertain.

2.2.2.4 Chemical Adsorption

Chemical adsorption is the formation of a thin film of ions or molecules on the surface of a solid phase. Similar to co-precipitation, metal ions form chemical bonds with the reactive surface of solid material. Adsorption technologies use a fixed bed of media (typically packed into a tank) through which wastewater flows. Typical media used include zero valent iron (ZVI), activated carbon, or activated alumina. Contaminants concentrate at the surface of a sorbent, thereby reducing their concentration in the bulk liquid phase. As contaminated water is passed through the media, contaminants are adsorbed from solution onto exposed adsorbent media surfaces. Multiple tanks in series can be used to increase treatment performance (USEPA, 2002; Reinsel, 2015).

Zero valent iron can be used to remove contaminants from solution via chemical reduction and/or surface complexation (Junyapoon, 2005). Treatment systems using ZVI typically consist of media in covered tanks or filter vessels that hold elemental iron. As elemental iron is oxidized to ferrous and ferric iron, nitrate and selenate are reduced to nitrogen gas and insoluble elemental Se, respectively. The produced ferric iron precipitates can subsequently remove Se (as selenite), As, and Cu from solution via chemical adsorption.

The reactive surface area of ZVI media is rapidly depleted and requires frequent replacement. Downstream solid/liquid separation is also required to separate the spent ZVI media from treated effluent. This technology is commonly applied to permeable reactive barriers designed for *in situ* remediation of groundwater with flow rates orders of magnitude lower than surface water systems (MEND, 2014). Hence, the applicability of this technology to treating mine effluents may be limited, depending on flow requirements.

2.2.3 Physical Technologies

2.2.3.1 Reverse Osmosis

Reverse osmosis (RO) is the high-pressure application of influent to selectively permeable membranes that exclude dissolved ions by charge and particle size, generating a concentrated reject stream (on the feed side of the membrane) and a treated effluent stream. Reverse osmosis requires no chemical additions and may be run in either batch or

continuous mode. A main advantage of RO is its ability to achieve high removal efficiencies for parameters with stringent regulatory discharge limits. For example, RO technology has been demonstrated at full-scale to remove Se (selenate or selenite) to <5 µg/L (CH2M Hill, 2010). The RO process is capable of removing over 95% of total dissolved solids (TDS) from the feed influent solution, but the precise removal efficiency is parameter-specific and dependent on feed influent quality (MEND, 2014). The RO permeate is typically lower in pH compared to the influent and is very low TDS and alkalinity. Hence, pH adjustment and potentially re-mineralization (*e.g.,* alkalinity addition) prior to discharge to comply with effluent pH and toxicity requirements (MEND, 2014).

Due to the high operating pressure required to pump solution through the RO membrane, increased chemical loadings require increased pressure to maintain the rate of water flow through the membrane (*i.e.,* flux). Further, adjustment of the operating pressure may be required due to changes in water viscosity associated with temperature variations. Factors affecting membrane filtration performance include pH, temperature, and the presence of certain constituents (*e.g.,* calcium, sulfate), which may cause membrane fouling (USEPA, 2002). Although membrane cleaning can restore treatment performance, the cleaning process can be difficult and costly. To prevent membrane damage/fouling, some form of pre-treatment (*e.g.,* TSS removal at a minimum) is required to prolong the life spans of RO systems. Typically, the RO membranes need to be replaced every 3 to 5 years (MEND, 2014). Pre-filtration can minimize the loading of salt precipitates and suspended solids on the membrane surface, thereby extending run length, improving system hydraulics, and reducing operations and maintenance requirements (USEPA, 2003).

The most significant residual generated from RO is the reject stream, which is high in TDS. Reject management and disposal strategies must be considered in the design of RO systems, which may include evaporation and subsequent disposal of residual salts, or collection and disposal of the reject water (MEND, 2014).

2.2.3.2 Nanofiltration

Nanofiltration (NF) is the pressurized application of influent to a charged, selectively permeable membrane that rejects (by charge and size) multivalent ions but allows the passage of water and monovalent ions. This process generates a low TDS permeate stream and a concentrated, high TDS reject stream. Nanofiltration is a good substitute for RO when the rejection of multivalent ions (*e.g.,* Cu^{2+}) is more important than rejection of monovalent ions (*e.g.,* nitrate), and where lower removal efficiencies are acceptable. Treatment systems based on NF operate at a lower pressure compared to RO. However, ions near the molecular weight cut-off for NF (*e.g.,* selenate, selenite) may pass through a

NF membrane under certain conditions (CH2M Hill, 2010). Therefore, treatment performance for NF may not be as effective as RO.

Nanofiltration can be employed following chemical and physical bulk removal processes as a polishing step to achieve low effluent concentrations, or as a pre-treatment step to generate a lower volume and higher concentration stream to reduce capital cost and removal efficiency of treatment by other means. The NF permeate is low in TDS and alkalinity, and re-mineralization of the permeate stream may be required prior to discharge (MEND, 2014). The reject stream requires further handling for appropriate disposal. This may include evaporation and subsequent disposal of residual salts, or collection and disposal of the reject water.

2.2.4 Summary

Biological technologies available for the treatment of nitrate and T-Se are MBBR, FBR, ABMet®, and EBR systems. Available chemical technologies for treatment of T-Se, D-Cu, T-As and/or nitrate are hydroxide precipitation/co-precipitation, sulfide precipitation, ion exchange, and chemical adsorption. Lastly, physical technologies available for treatment of T-Se, D-Cu, T-As and/or nitrate are RO and NF. Target POCs, treatment requirements, and by-products/waste generation for all identified treatment technologies are summarized in Table 2-3 below.

Table 2-3:
Summary of all potential treatment technologies for target parameters

Treatment Technology	Target POCs	Treatment Requirements	By-Products/Waste Generation
Biological Technologies			
Moving Bed Biofilm Reactor (MBBR)	Nitrate and T-Se	• Pre-treatment (pH adjustment, TSS removal) is required • Mechanical mixers required to keep biofilm carries in suspension • Reagent additions of carbon and nutrients are needed for microbial growth	Excess biomass that sloughs off from the biofilm carriers requires downstream solid/liquid separation and disposal.
Fluidized Bed Reactor (FBR)	Nitrate and T-Se	• Pre-treatment (pH adjustment, TSS removal) is required • Pumps required for fluidization/recirculation (*i.e.*, suspension and mixing) of granular media • Reagent additions of carbon and nutrients are needed for microbial growth	Excess biomass from the granular media requires downstream solid/liquid separation and disposal.
ABMet® System	Nitrate and T-Se	• Pre-treatment (pH adjustment, TSS removal) is required • Reagent additions of carbon and nutrients are needed for microbial growth	Backwater is required to periodically slough off excess biomass, which requires downstream solid/liquid separation and disposal.
Electro-Biochemical Reactor (EBR)	Nitrate and T-Se	• Requires a consistent supply of electrons and nutrient additions to support microbial growth	Biological sludge requires disposal.
Chemical Technologies			
Hydroxide Precipitation/Co-Precipitation	T-Se, D-Cu, and T-As	• Requires additions of iron or aluminum salts as coagulants • pH adjustment may be required to achieve desired removal efficiency • Oxidation of arsenite to arsenate is required for As treatment • Reduction of selenate to selenite is required for Se treatment	Sludge generated by co-precipitation and coagulation requires disposal.
Sulfide Precipitation	T-Se, D-Cu, and T-As	• pH adjustment may be required to achieve desired removal efficiency • Sulfide can be supplied via reagent additions or produced by biological reduction	Metal sulfide sludge requires management and disposal. Potential generation of excess hydrogen sulfide (H_2S) may be a safety concern and requires process control and monitoring. Residual sulfide in treated effluent may cause downstream toxicity, sulphate and acidity generation, and oxygen depletion.
Ion Exchange	Nitrate, T-Se, D-Cu, and T-As	• Requires specialized resins for selective removal of target ions • Pre-treatment (*e.g.*, TSS removal) may be required to prevent fouling and damage of resins	Spent resin needs to be disposed of as solid waste, and the concentrated regenerant stream requires treatment prior to disposal.
Chemical Adsorption	Nitrate, T-Se, D-Cu, and T-As	• Pre-treatment for TSS required to prevent media clogging and fouling • Media required (*e.g.*, ZVI, activated carbon, activated alumina) • Treatment efficiency is temperature and pH dependent	Spent media and hydroxide sludge (for ZVI treatment) require disposal.
Physical Technologies			
Reverse Osmosis (RO)	Nitrate, T-Se, D-Cu, and T-As	• Requires high pressure application of influent to selectively permeable membranes that exclude dissolved solids. • Pre-treatment (*e.g.*, TSS removal) may be required to prevent fouling and damage of membranes	High TDS reject stream requires management and disposal. Permeate may require pH adjustment and re-mineralization prior to discharge.
Nanofiltration (NF)	T-Se, D-Cu, and T-As	• Requires high pressure application of influent to selectively permeable membranes that reject multivalent ions only • Pre-treatment (*e.g.*, TSS removal) may be required to prevent fouling and damage of membranes	High TDS reject stream requires management and disposal. Permeate may require re-mineralization prior to discharge.

2.3 Screening for Feasible Options

The third step of the BAT assessment is to screen potential technologies to eliminate options that are not feasible. This section provides a feasibility screening of all treatment technologies identified in Section 2.2 for each applicable POC. Each treatment technology was screened against the following criteria:

- The ability of the technology to achieve the applicable discharge limit / FWAL guideline;
- Whether the technology is considered "proven" for treatment of mine wastewater at full-scale; and
- Whether the technology has been demonstrated under representative climate conditions.

Consideration was also given to the range of flow rates expected from the WRTSF during the operations phase. Capital and operational costs were not considered for the screening.

The results of the feasibility screening for each POC are presented in Table 2-4 through Table 2-7. Technologies that meet all of the above criteria for at least one of the POCs were carried forward as feasible options. Information sources used in support of screening include grey literature (*e.g.,* technical reports, government documents), secondary (*e.g.,* review papers) and primary (*e.g.,* original research) publications, as well as professional opinions solicited from Veolia Water Technologies Canada, a vendor for industrial water treatment technologies.

2.3.1 Nitrate

Technologies that were carried forward or excluded as feasible options for treating nitrate in mine wastewater discharged from the WRTSF are summarized in Table 2-4 below. Of the seven commercially available technologies for nitrate treatment, four were carried forward as feasible options warranting further evaluation for BAT selection. Specifically, MBBR, FBR, ion exchange, and RO met the feasibility screening criteria, including the ability to achieve the current nitrate discharge limit specified in PE-107835. The remaining technologies were excluded due to inability to accommodate the range of flows expected from the WRTSF during the Operations phase (ABMet®), or lack of full-scale mine water installations (EBR, chemical adsorption).

Table 2-4:
Feasibility screening of potential treatment technologies for nitrate

Treatment Technology	Capable of Achieving Current Discharge Limit for Nitrate (11.5 mg/L)?	Proven for Mining Applications at Full-Scale?	Demonstrated Under Representative Climate Conditions?	Carry Forward as Feasible Option?
Biological Technologies				
Moving Bed Biofilm Reactor (MBBR)	Yes[1]	Yes	Yes, but pre-heating of influent to ≥10°C is required for cold climates for optimal treatment performance	Yes
Fluidized Bed Reactor	Yes[2]	Yes, but limited full-scale applications for mine wastewater treatment	Yes, but pre-heating of influent to ≥10°C is required for cold climates for optimal treatment performance	Yes
ABMet® System	Yes[2]	Yes. Full-scale installations are capable of treating flow rates between 6 and 318 m^3/hr	Yes. GE's process guarantee indicates a lower temperature limit of 5 °C. In cold climates, nutrient dosing may be increased to maintain bacterial activity instead of pre-heating water	No, the range of flow rates afforded by ABMet® cannot accommodate the range of flows expected from the WRTSF during the Operations phase
Electro-Biochemical Reactor (EBR)	Yes[3]	No, bench-scale and pilot-scale demonstrations only	Yes	No, due to lack of full-scale installations
Chemical Technologies				
Ion Exchange	Yes, but treatment performance is highly dependent on the resin selected	Yes	Yes	Yes
Chemical Adsorption	Yes[1]	Yes, but most full-scale installations are designed to treat contaminated groundwater, rather than mine wastewater	Yes	No, due to lack of full-scale installations for mine wastewater
Physical Technologies				
Reverse Osmosis (RO)	Yes, RO is generally able to remove >95% of TDS[2]	Yes, but limited full-scale applications for mine wastewater treatment	Yes	Yes

Notes:
[1] J. Dallaire (Veolia Water Technologies Canada), personal communication, November 29, 2022.
[2] MEND (2014).
[3] Opara *et al.,* 2014.

2.3.2 Total Selenium

Technologies that were carried forward or excluded as feasible options for treating T-Se in mine effluent discharged from the WRTSF are summarized in Table 2-5. For the purposes of screening treatment options, Se is assumed to be present as selenate at the WRTSF outlet since selenate is the prevalent form of Se in oxygenated surface water (Janz *et al*., 2014).

Of the ten commercially available technologies for Se treatment, two were carried forward as feasible options warranting further evaluation for BAT selection. Specifically, RO and NF met the feasibility screening criteria, including the ability to achieve the long-term BC WQG for T-Se. The remaining technologies were excluded due to inability to reliably achieve the target effluent criteria (*e.g.,* MBBR), or lack of full-scale mine water installations (*e.g.,* EBR).

Table 2-5: Feasibility screening of potential treatment technologies for T-Se

Treatment Technology	Capable of Achieving BC WQG for Total Se (2 µg/L)?	Proven for Mining Applications at Full-Scale?	Demonstrated Under Representative Climate Conditions?	Carry Forward as Feasible Option?
Biological Technologies				
Moving Bed Biofilm Reactor (MBBR)	No[1]	Yes	Yes, but pre-heating of influent to ≥10°C is required for cold climates for optimal treatment performance	No, due to inability to achieve BC WQG of 2 µg/L
Fluidized Bed Reactor	No, achievable Se concentration is reported to range from 5 to 20 µg/L[2]	Yes, but limited full-scale applications for mine wastewater treatment	Yes, but pre-heating of influent to ≥10°C is required for cold climates for optimal treatment performance	No, due to inability to achieve BC WQG of 2 µg/L
ABMet® System	Uncertain, achievable Se concentration is reported to be <5 µg/L[2]	Yes. Full-scale installations are capable of treating flow rates between 6 and 318 m^3/hr.	Yes. GE's process guarantee indicates a lower temperature limit of 5 °C. In cold climates, nutrient dosing may be increased to maintain bacterial activity instead of pre-heating water	No, the range of flow rates afforded by ABMet® cannot accommodate the range of flows expected from the WRTSF during the operations phase
Electro-Biochemical Reactor (EBR)	Yes[3]	No, bench-scale and pilot-scale demonstrations only	Yes	No, due to lack of full-scale installations
Chemical Technologies				
Hydroxide Precipitation/Co-Precipitation	No[1]	Yes	Yes	No, due to inability to achieve BC WQG of 2 µg/L
Sulfide Precipitation	No[1]	Yes	Yes	No, due to inability to achieve BC WQG of 2 µg/L
Ion Exchange (IX)	Traditional IX: No, the abundance of competing ions (*e.g.*, sulfate) in mine effluent has a major impact on Se treatment performance[2] Selen-IX™: Yes[4]	Traditional IX: Yes Selen-IX™: Yes, but very limited full-scale installations. A full-scale plant commissioned in Kemess, BC[4] is capable of removing Se at a design flow rate of 270 m^3/hr	Traditional IX: Yes Selen-IX™: Yes	Traditional IX: No, due to inability to achieve BC WQG of 2 µg/L Selen-IX™: No, due to limited full-scale implementation, particularly at the higher flow rates anticipated at Brucejack Mine
Chemical Adsorption	Unlikely[1]	Yes for ZVI, but most full-scale installations are designed to treat contaminated groundwater, rather than mine wastewater	Yes	No, due to lack of full-scale installations for mine wastewater and uncertain ability to achieve BC WQG of 2 µg/L
Physical Technologies				
Reverse Osmosis (RO)	Yes, RO can achieve 91-99% Se removal[2]	Yes, but limited full-scale applications for mine wastewater treatment	Yes	Yes
Nanofiltration (NF)	Yes, NF can achieve >90% Se removal[2]	Yes, for treating multivalent ions. Limited full-scale applications for mine wastewater treatment	Yes	Yes

Notes:
[1] J. Dallaire (Veolia Water Technologies Canada), personal communication, November 29, 2022.
[2] MEND,2014.
[3] Opara *et al.,* 2014.
[4] BQE Water, 2021.

2.3.3 Dissolved Copper

Technologies that were carried forward or excluded as feasible options for treating D-Cu in mine effluent discharged from the WRTSF are summarized in Table 2-6. Of the six commercially available technologies for Cu treatment, two were carried forward as feasible options warranting further evaluation for BAT selection. Specifically, RO and NF met the feasibility screening criteria, including the ability to achieve the long-term BC WQG for D-Cu. The remaining technologies were excluded due to inability to reliably achieve the BC WQG for D-Cu.

Table 2-6:
Feasibility screening of potential treatment technologies for D-Cu

Treatment Technology	Capable of Achieving BC WQG for Dissolved Cu (0.3 µg/L)?	Proven for Mining Applications at Full Scale?	Demonstrated Under Representative Climate Conditions?	Carry Forward as Feasible Option?
Chemical Technologies				
Hydroxide Precipitation/Co-Precipitation	No[1]	Yes	Yes	No, due to inability to achieve BC WQG of 0.3 µg/L
Sulfide Precipitation	No[1]	Yes	Yes	No, due to inability to achieve BC WQG of 0.3 µg/L
Ion Exchange	No	Yes	Yes	No, due to inability to achieve BC WQG of 0.3 µg/L
Chemical Adsorption	No[1]	Yes, but most full-scale installations are designed to treat contaminated groundwater, rather than mine wastewater	Yes	No, due to inability to achieve BC WQG of 0.3 µg/L
Physical Technologies				
Reverse Osmosis (RO)	Yes, RO can achieve >95% Cu removal[2]	Yes, but limited full-scale applications for mine wastewater treatment	Yes	Yes
Nanofiltration (NF)	Yes, NF can achieve >90% Cu removal[2]	Yes, for treating multivalent ions, but limited full-scale applications for mine wastewater treatment	Yes	Yes

Notes:
[1] J. Dallaire (Veolia Water Technologies Canada), personal communication, November 29, 2022.
[2] MEND (2014).

2.3.4 Total Arsenic

Technologies that were carried forward or excluded as feasible options for treating T-As in mine effluent discharged from the WRTSF are summarized in Table 2-7. Of the six commercially available technologies for As treatment, four were carried forward as feasible options warranting further evaluation for BAT selection. Specifically, hydroxide precipitation/co-precipitation using Fe/Al coagulants, ion exchange, RO, and NF met the feasibility screening criteria, including the ability to achieve the current T-As discharge limit specified in PE-107835. Sulfide precipitation and chemical adsorption were ruled out due to uncertainty regarding their ability to reliably achieve the T-As discharge limit (as per PE-107835) at BJ 3.10.

Table 2-7:
Feasibility screening of potential treatment technologies for T-As

Treatment Technology	Capable of Achieving Current Discharge Limit for Total As (10 µg/L)?	Proven for Mining Applications at Full Scale?	Demonstrated Under Representative Climate Conditions?	Carry Forward as Feasible Option?
Chemical Technologies				
Hydroxide Precipitation/Co-Precipitation with Coagulants	Yes[1]	Yes	Yes	Yes
Sulfide Precipitation	No[2]	Yes	Yes	No, due to inability to achieve discharge limit of 10 µg/L
Ion Exchange	Yes[3]	Yes	Yes	Yes
Chemical Adsorption	Insufficient information	Yes for ZVI, but most full-scale installations are designed to treat contaminated groundwater, rather than mine wastewater	Yes	No
Physical Technologies				
Reverse Osmosis (RO)	Yes, RO can achieve 91-99% of As^{5+} removal, and 20-55% of As^{3+} removal[3]	Yes, but limited full-scale applications for mine wastewater treatment	Yes	Yes
Nanofiltration (NF)	Yes, NF can achieve >90% of As^{5+} removal, and 20-90% of As^{3+} removal[3]	Yes, for treating multivalent ions. Limited full-scale applications for mine wastewater treatment	Yes	Yes

Notes:
[1] USEPA (2003).
[2] J. Dallaire (Veolia Water Technologies Canada), personal communication, November 29, 2022.
[3] MEND (2014).

2.4 Comparison of Reliability

The fourth step of the BAT assessment process is to describe and compare feasible technologies for reliability. Reliability refers to the probability that a technology will operate according to its specifications to perform consistently. Considerations include the ability to maintain treatment performance under variable conditions (*e.g.*, influent water quality, flow rate, temperature) and the intensity of maintenance requirements (*e.g.*, management of scaling, resin replacement). The relative reliability of treatment options carried forward as feasible options for the POCs are discussed and compared in the following subsections. A summary of the relative reliability rankings for each POC is presented in Table 2-8 below, with 1 representing the highest reliability.

Table 2-8:
Reliability rankings for feasible treatment options

Treatment Technology	Relative Reliability Ranking		
	Nitrate	T-Se & D-Cu	T-As
MBBR	3	-	-
FBR	4	-	-
Hydroxide Precipitation/Co-Precipitation with Coagulants	-	-	2
Ion Exchange	2	-	3
RO	1	1	1
NF	-	2	1

2.4.1 Nitrate

The four technologies identified as feasible treatment options for nitrate are MBBR, FBR, ion exchange, and RO. In general, biological treatment systems may suffer from instability due to toxic or inhibitory contaminants (*e.g.,* heavy metals, organics) in influent, making them generally less reliable compared to chemical and physical technologies. Diligent operator attention is required to maintain biological growth and achieve consistent effluent quality from reactors. In contrast, ion exchange and RO systems can achieve consistent treatment performance under a wide range of influent quality and flow conditions; however, resin regeneration (ion exchange) and frequent cleaning (RO) are required (MEND, 2014).

Of the four feasible treatment options identified for nitrate, ion exchange and RO are considered more reliable than biological treatment technologies (MMBR and FBR), primarily because they are less susceptible to variable influent quality, flows, and temperature. FBRs are ranked lower than MBBRs because of the limited number of full-scale installations for mine effluent; whereas, MBBRs are an established technology with

demonstrated long-term feasibility. Ion exchange is ranked lower than RO because it is more sensitive to variations in influent quality and resin selection.

2.4.2 Total Selenium and Dissolved Copper

Two pressure-driven membrane processes (RO and NF) are identified as feasible options for treating T-Se and D-Cu. The main differences between RO and NF are the membranes and operating pressure used for treatment. Given the smaller pore size of RO membranes, RO is considered more reliable than NF for consistent achievement of the stringent treatment objectives, particularly for target ions near the molecular weight cut-off for NF membranes (*e.g.,* selenate, selenite; CH2M Hill, 2010).

2.4.3 Total Arsenic

The four technologies identified as feasible options for treating T-As are hydroxide precipitation/co-precipitation with coagulants, ion exchange, RO, and NF. The treatment requirements discussed for ion exchange systems (Section 2.4.1) and RO and NF processes (Section 2.4.2) are also applicable for As. The RO and NF technologies are considered more reliable than hydroxide precipitation/co-precipitation, as the treatment performance for As via hydroxide precipitation/co-precipitation is dependent on the type and dosage of coagulants used, mixing intensity, and pH (USEPA, 2003). However, these operating parameters can be well-controlled. In contrast, the treatment performance of ion exchange depends on the influent quality (*i.e.*, the presence of competing ions), which is more difficult to maintain via process control. Therefore, ion exchange is considered the least reliable treatment technology for T-As, whereas RO and NF are considered the most reliable.

2.5 Comparison of Control-Effectiveness

The fifth step of the BAT assessment is to describe and compare feasible technologies for control-effectiveness. Control-effectiveness describes how well a control (*e.g.,* treatment technology) is at reducing or managing the risk it is meant to modify (*i.e.*, treatment effectiveness to avoid environmental contamination). The relative control effectiveness of feasible treatment options identified for POCs are discussed and compared based on their ability to achieve successful control of POC concentrations in treated effluent. Secondary consideration is also given to energy requirements and generation of waste products that may pose unintended risks to the downstream environment if not properly managed.

A summary of the relative control-effectiveness rankings for each POC is presented in Table 2-9 below, with 1 representing the highest control-effectiveness.

Table 2-9:
Control-effectiveness rankings for feasible treatment options

Treatment Technology	Relative Control-Effectiveness Ranking		
	Nitrate	T-Se & D-Cu	T-As
MBBR	3	-	-
FBR	3	-	-
Hydroxide Precipitation/Co-Precipitation with Coagulants	-	-	3
Ion Exchange	2	-	4
RO	1	1	1
NF	-	2	2

2.5.1 Nitrate

Treatment systems based on MBBR, FBR, ion exchange, and RO technologies are expected to remove nitrate from mine effluent according to their design specifications. However, the establishment of biological systems (*e.g.,* MBBR, FBR) can take months and cannot be accomplished with influent temperature lower than 10 °C (MEND, 2014). Hence, reactors can only be commissioned during warm seasons, or a water heating system is required to preheat the influent prior to pumping to the reactors. Once microbes are properly seeded and matured, systems can operate under lower temperatures. However, as noted previously, biological processes are generally sensitive to changes in influent water quality, flow, and temperature, which makes system performance more challenging to control. Sludge generated from excess biomass requires solid/liquid separation and disposal. Additionally, any excess nutrients released from the reactors may require further treatment to prevent the risk of eutrophication in the receiving environment.

Unlike biological systems, ion exchange and RO can be operated to achieve consistent effluent quality in a timely and well-controlled manner. Both ion exchange and RO generate a concentrated waste stream that requires management (*i.e.*, treatment and/or disposal). The spent regenerant solutions from ion exchange systems contain target ions (*e.g.,* nitrate) at pH and concentrations that will pose a risk to downstream water quality if not properly managed. Similarly, the high TDS reject stream from RO systems must be managed appropriately. The permeate stream after RO treatment may also require pH adjustment and re-mineralization to meet effluent pH and toxicity requirements (MEND, 2014).

Despite high energy demand and the generation of waste concentrate, RO is considered the most control-effective technology for achieving high removal efficiencies of nitrate. Ion exchange technology also produces a concentrated waste stream, but its control-

effectiveness is subject to variations in influent quality; therefore, it is considered the most control-effective technology after RO. MBBR and FBR systems are considered less control-effective due to their sensitivity to variations in influent quality, flow rate and temperature, and both processes generate biological sludge. Therefore, MBBR and FBR are considered the least control-effective for treatment of nitrate.

2.5.2 Total Selenium and Dissolved Copper

Treatment systems based on RO and NF are expected to achieve consistent effluent quality via pressure-controlled membrane filtration processes. Both RO and NF systems can be automated, with operation performed in a timely and controlled manner. The reject and permeate streams require management, treatment and/or disposal. As discussed in Section 2.4.2, RO is capable of achieving higher removal efficiencies than NF, which may be required to meet the stringent discharge criteria for T-Se and D-Cu. Therefore, RO is ranked higher for control effectiveness compared to NF for the treatment of T-Se and D-Cu.

2.5.3 Total Arsenic

The four technologies identified as feasible options for treating T-As are hydroxide precipitation/co-precipitation with coagulants, ion exchange, RO, and NF. The control effectiveness considerations discussed for ion exchange (Section 2.5.1) and RO and NF (Section 2.5.2) processes are also applicable for As. Treatment systems based on hydroxide precipitation/co-precipitation can be operated in a controlled and timely manner to achieve the target removal efficiency for T-As. The sludge generated from chemical precipitation processes requires disposal, which can typically be accommodated by on-site tailings storage facilities, engineered ponds, open pits, *etc*. (MEND, 2014).

Despite high energy demand and the generation of waste concentrate, RO is considered the most control-effective technology for achieving high removal efficiencies of arsenic. NF is associated with lower energy demand, but also produces a concentrate waste and typically achieves slightly lower removal efficiencies than RO. Hydroxide precipitation/co-precipitation produces sludge (which is easier to manage than the concentrate stream produced by RO and NF), but the removal efficiency of As via hydroxide precipitation/co-precipitation is dependent on the type and dosage of coagulants used, mixing intensity, and pH (USEPA, 2003), so hydroxide precipitation/co-precipitation is considered less control-effective than RO and NF. Ion exchange produces a concentrated waste and its treatment performance depends on the influent quality (*i.e*., the presence of competing ions), which is more difficult to maintain via process control than the operating

parameters for hydroxide precipitation/co-precipitation. Therefore, ion exchange is considered the least control-effective treatment technology for T-As.

2.6 Comparison of Cost-Effectiveness

The sixth step of the BAT assessment process is to describe and compare feasible technologies for cost-effectiveness. This section presents capital and operating cost estimates, as well as an overview of assumptions, limitations, and considerations for comparing cost-effectiveness of the feasible treatment options identified in Section 2.3.

2.6.1 Assumptions and Limitations

Capital and operating cost estimates for each treatment option warranting further evaluation for BAT selection (Section 2.3) are presented in Table 2-10 below. Costs presented in this section are order-of-magnitude (±50%) estimates available in literature (MEND, 2014; *i.e.*, not site-specific for Brucejack Mine), un-adjusted for inflation. Available cost estimates were developed based on a design flow rate of 3000 m^3/hr and a nominal flow rate of 1000 m^3/hr, with the exception of the MBBR technology. Due to limited availability of cost information, the MBBR cost estimates are based on lower design and nominal flow rates (600 m^3/hr and 180 m^3/hr, respectively). However, the MBBR cost estimates have been subsequently scaled up by factors of 5.0 (capital cost) and 5.5 (operating cost) to allow for comparison with the cost estimates for the other technologies. Cost estimates specific to the conceptual WRTSF system at Brucejack Mine are discussed in Section 3.

For most treatment technologies, total installed costs were estimated by applying typical factors to equipment costs to incorporate additional direct and indirect costs. Direct cost factors account for shipping and transportation, installation, site preparation and civil works, piping, HVAC, electrical and controls and plant services and utilities costs. Indirect cost factors account for wrap-around engineering, procurement, construction management, temporary construction services, insurance, spares, and cold commissioning (MEND, 2014).

Actual site costs could vary significantly from the presented estimates, depending on numerous site-specific factors including process factors (*e.g.*, effluent parameters of concern and concentrations, pH, temperature, volume/flow rate) and site factors (*e.g.*, site location, shipping costs, electricity costs, existing effluent management and treatment facilities, existing residuals storage/disposal facilities, site layout, available outdoor footprint, available footprint in process buildings, available utilities, available skilled labour, discharge criteria, *etc.*). Site-specific factors that could have a substantial impact

on total installed cost and operating cost include but are not limited to, the following (MEND, 2014):

- Effluent characteristics, including parameters of concern, concentration, pH, temperature, and ionic strength. These characteristics of the effluent can affect the amounts of reagents required and the amount of sludge or waste products generated which require management and storage.
- Volume or flow rate of the effluent and the seasonal variability of the flow. This can also be influenced by the amount of seasonal attenuation capacity existing on site or that must be added.
- Site location, which can affect materials and equipment transportation costs, reagent shipping costs, and labour costs. Site location may also affect the scheduling of construction and can significantly increase construction costs if construction windows are small or if construction labour needs to be brought to site at a premium, as examples.
- Climatic conditions, which can affect the volumes of effluent to be treated, the available treatment and/or discharge window, the effluent pre-treatment required (*i.e.*, preheating), and the design of residuals storage/disposal facilities.
- Source of electricity supply (grid based, generators) and the resultant electricity costs. It should be noted that the addition of treatment equipment at some sites may require the addition of supplementary power generation equipment, adding significant capital and operating cost to the site.
- Existing effluent management and treatment facilities, their age, effectiveness and capacity.
- Existing residuals storage/disposal facilities. Cost of residual disposal may be significantly increased if new storage/disposal cells or facilities are needed, storage capacity must be augmented to handle new volumes of waste, and/or regulatory approvals must be sought for these new facilities.
- Existing site layout. Distances to transport residuals to storage/disposal facilities, either by pipeline or by trucking can affect operating as well as initial capital costs. Site layout may also affect the cost of supplying utilities to the effluent treatment plant.
- Footprint availability. The availability of land on site, or space within existing process buildings, can impact costs in a variety of ways. Additional buildings may need to be constructed or demolition activities may need to occur.

- Soil qualities and geotechnical characteristics in the area of the mine operations directly impact the cost of construction of any new buildings or structures required for the treatment plant.
- Available service utilities, such as potable water or other special quality water, natural gas, steam, *etc*.
- Available skilled labour, especially labour familiar with the operation of specialty effluent treatment equipment (*e.g*., MBBR, RO, *etc*.). The regional cost differences in labour rates can also affect operating costs and construction costs significantly.
- Test work requirements that can include both bench and pilot testing. These test programs must be conducted before many of the technologies can be implemented at full scale, adding additional costs to the estimate and potentially delaying schedule for implementation.
- Local permitting requirements and stakeholder consultation requirements, which can significantly affect schedule, as well as cost.

Specific assumptions and cost considerations for each technology are described below.

2.6.1.1 Cost Considerations for Feasible Technologies

Capital and operating cost estimates for each of the feasible technology options are summarized in Table 2-10 and discussed below.

Table 2-10:
Capital and operating cost estimates for feasible treatment options

Treatment Technology	Applicable Target Parameters				Equipment Cost ($CAD)	Total Installed Cost ($CAD)	Annual Operating Cost ($CAD/yr)	Operating Cost per Volume ($CAD/m^3)
	NO_3	Se	As	Cu				
MBBR	✓	-	-	-	37,000,000	$98,000,000	$5,225,000	0.60
FBR	✓	-	-	-	n/a	$164,000,000	$14,000,000	0.85 to 1.59
Hydroxide Precipitation/ Co-Precipitation	-	-	✓	-	n/a	$58,600,000 to $72,700,000	$24,300,000 to $30,900,000	2.78 to 3.53
Ion Exchange	✓	-	✓	-	$29,600,000	$76,400,000	$7,400,000	0.85
RO	✓	✓	✓	✓	$49,500,000	$177,300,000	$8,400,000	0.96
NF	-	✓	✓	✓	$49,500,000	$177,300,000	$6,900,000	0.79

Notes:
Cost estimates are adapted from MEND, 2014.
Cost estimates are based on a design flow rate of 3000 m^3/hr and a nominal flow rate of 1000 m^3/hr, with the exception of MBBR. Cost estimates for MBBR were not available at these flow rates, so available capital and operating cost estimates for MBBR technology have been scaled up by factors of 5.0 (based on a design flow rate of 600 m^3/hr) and 5.5 (based on a nominal flow rate of 180 m^3/h), respectively, to allow for comparison with the other technologies presented. Scaling calculations assume the capital cost estimates are based on the design flow rate, and the operating cost estimates are based on the nominal flow rate.
n/a = not available.

Capital investment for MBBR technology is low compared to most other attached growth and suspended growth biological processes. The cost estimates account for pre-heating and heat recovery, assuming a temperature rise of 5°C is required year-round. Capital cost estimates assume that existing chemical make-up, storage, and distribution systems can be utilized for pH adjustment. Operating cost will vary based on reagent consumption (*e.g.*, pH adjustment chemicals, coagulants), which is proportional to contaminant loading, feed pH, and treated effluent limits. Residual biomass typically requires thickening and dewatering prior to disposal; residuals management and storage of biomass residuals has not been considered (MEND, 2014).

FBR technology requires equipment associated with reagent storage and dosing, an influent heat exchange system, the biological reactors, aerobic polishing, and solid/liquid separation and/or sludge handling, thickening and disposal. Due to the relatively recent adoption of this technology, little is known about the long-term stability of residual biomass and the potential for contaminant remobilization under various disposal conditions. If residuals are not stable, significant costs associated with biomass stabilization technology or re-treatment of residual leachate could be incurred (MEND, 2014).

Hydroxide precipitation/co-precipitation technology requires equipment for reagent make-up/storage and feed systems, agitated reaction tank(s), pH adjustment tanks, clarifier/thickener(s) and/or media filter(s), and residuals management. If residuals are not kept stable through prudent disposal techniques, significant costs associated with residuals stabilization technology or re-treatment of residual leachate could be incurred. Operating cost will vary based on reagent consumption (*e.g.*, pH adjustment chemicals, coagulants), which is proportional to contaminant loading, feed pH, and treated effluent limits (MEND, 2014).

Ion exchange requires pre-treatment clarification and media filtration steps for solids removal; therefore, cost estimates account for equipment associated with these systems. Depending on effluent chemistry, additional pre-treatment could add additional operating cost. The cost estimates assume that backwash from media filtration is directed to a settling pond. Regenerant management must be carefully considered based on site-specific factors and could add significant operating and capital costs. Spent resin disposal costs are not accounted for; off-site disposal would add to operating costs. Furthermore, operating costs for ion exchange systems are extremely sensitive to metal loading in the feed stream (MEND, 2014).

Cost estimates for the RO treatment option include clarification and media filtration for solids removal, which is also required pre-treatment for the reverse osmosis system.

Depending on effluent chemistry, additional pre-treatment, post-treatment, and membrane cleaning requirements could add additional capital and operating cost. The available cost estimates do not include management, treatment and/or disposal of the RO concentrate stream, which will likely add significant capital and operating cost. The operating cost for the RO system is highly dependent on the site-specific energy cost and on the required frequency of cleaning cycles, which is dependent the RO feed quality. Further, RO permeate is very low in TDS and alkalinity, so re-mineralization or pH adjustment of the permeate stream prior to discharge to the environment may be required to comply with treatment objectives (MEND, 2014).

Due to the similarities between NF and RO (with the exception of operating pressure and membranes), the capital costs for NF are assumed to be the same as estimated for reverse osmosis. NF operates at lower pressures compared to reverse osmosis; therefore, energy consumption for nanofiltration is assumed to be 2/3 of the energy requirements of RO. Similar to RO, additional pre-treatment, post-treatment, membrane cleaning requirements, and concentrate management could add additional capital and operating cost. The operating cost for the NF system is highly dependent on the site-specific energy cost and on the NF feed quality (MEND, 2014).

2.6.2 Cost-Effectiveness Comparison

2.6.2.1 Nitrate

Technologies deemed feasible for nitrate treatment include MBBR, FBR, ion exchange, and RO. Each technology has been assigned relative cost-effectiveness rankings from 1 to 4, based on capital and operating cost estimates. Cost-effectiveness rankings for nitrate treatment options are presented in Table 2-11 below, with 1 representing the most cost-effective technology and 4 representing the least cost-effective technology.

Table 2-11:
Cost-effectiveness rankings for nitrate treatment options

Treatment Technology	Relative Cost-Effectiveness Ranking – Capital Cost	Relative Cost-Effectiveness Ranking – Operating Cost
Ion Exchange	1	2
MBBR	2	1
FBR	3	4
RO	4	3

On a capital cost basis, ion exchange is the most cost-effective and RO is the least cost-effective, based on estimated equipment and total installed costs. On an annual operating cost (per m^3) basis, MBBR is the most cost-effective and FBR is the least cost-effective.

Further, high feed nitrate concentration increases operating and capital costs and residuals production for FBR systems (MEND, 2014). FRB technology is not considered economically viable for high flow rates (J. Dallaire, personal communication, November 29, 2022).

2.6.2.2 Total Selenium and Dissolved Copper

Technologies deemed feasible for T-Se and D-Cu treatment include RO and NF. Each technology has been assigned relative cost-effectiveness rankings from 1 to 2, based on capital and operating cost estimates. Cost-effectiveness rankings for T-Se and D-Cu treatment options are presented in Table 2-12 below, with 1 representing the most cost-effective technology and 2 representing the least cost-effective technology.

Table 2-12:
Cost-effectiveness rankings for T-Se and D-Cu treatment options

Treatment Technology	Relative Cost-Effectiveness Ranking – Capital Cost	Relative Cost-Effectiveness Ranking – Operating Cost
NF	1	1
RO	1	2

Due to their similarities, RO and NF are equally cost-effective for the treatment of T-Se and D-Cu in terms of equipment and total installed cost; however, NF is more cost-effective than RO from an operating cost standpoint, due to lower energy demands.

2.6.2.3 Total Arsenic

Technologies deemed feasible for T-As are hydroxide precipitation/co-precipitation with coagulants, ion exchange, RO, and NF. Each technology has been assigned relative cost-effectiveness rankings from 1 to 4, based on capital and operating cost estimates. Cost-effectiveness rankings for T-As treatment options are presented in Table 2-13 below, with 1 representing the most cost-effective technology and 4 representing the least cost-effective technology.

Table 2-13:
Cost-effectiveness rankings for T-As treatment options

Treatment Technology	Relative Cost-Effectiveness Ranking – Capital Cost	Relative Cost-Effectiveness Ranking – Operating Cost
Hydroxide Precipitation/Co-Precipitation with Coagulants	1	4
Ion Exchange	2	2
NF	3	1
RO	3	3

On a capital cost basis, hydroxide precipitation/co-precipitation with coagulants is the most cost-effective, and RO and NF are the least cost-effective based on estimated equipment and total installed costs. On an annual operating cost (per m^3) basis, NF is the most cost-effective and hydroxide precipitation/co-precipitation with coagulants is the least cost-effective.

2.7 Selection of Best Achievable Technology

The final step of the BAT assessment is to select the best achievable technology. A best achievable technology is a technology that has been evaluated for feasibility, reliability, control-effectiveness, and cost-effectiveness, and is demonstrated to be best-suited to meet waste discharge standards for the protection of the environment and human health.

Seven treatment technologies were carried forward as candidates for BAT given their ability to achieve applicable discharge limits (nitrate and T-As) or BC WQGs (T-Se and D-Cu) at the final discharge location of Brucejack Mine. The reliability and control-effectiveness evaluations concluded that RO is the most reliable and control-effective technology for all POCs. Alternative technologies that can treat T-As in a reliable and controlled manner include ion exchange, hydroxide precipitation/co-precipitation, and NF. Ion exchange is also deemed reliable and control-effective for nitrate treatment. Of the seven treatment technologies deemed feasible by this BAT assessment, RO is the only option that can reliably meet the target concentrations for T-Se and D-Cu. Therefore, RO is selected as the BAT for effective removal of all POCs in water discharged from the WRTSF during the operations phase.

3. Conclusions

Treatment options for POCs during operations (nitrate, T-Se, D-Cu and T-As) in Brucejack Mine's WRTSF discharge under an increased production scenario were identified and evaluated for feasibility, reliability, control-effectiveness, and cost-effectiveness. Seven technologies were identified for treatment of nitrate, with four deemed feasible and carried forward for further assessment. Six technologies were identified for treatment of T-Se, T-As, and D-Cu, with 2 being deemed feasible for T-Se and D-Cu, and 4 deemed feasible for T-As. The reliability and control-effectiveness evaluations concluded that RO is the most reliable and control-effective technology for all POCs, along with ion exchange (nitrate, T-As), hydroxide precipitation/co-precipitation with coagulants (T-As), and NF (T-As). The most cost-effective technologies in terms of capital and operating cost, respectively, are ion exchange and MBBR for nitrate treatment, RO and NF for T-Se and D-Cu treatment, and hydroxide precipitation/co-precipitation with coagulants and NF for T-As treatment.

Based on the evaluations of feasibility, reliability, and control-effectiveness described in this BAT assessment, the stringent treatment objectives for T-Se and D-Cu require the use of RO technology. The only alternative technology deemed feasible for treatment of these two POCs to the treatment objectives is NF; however, it is less suitable due to its larger pore size and lower removal efficiency. Although alternative treatment options are also well-suited for nitrate (*e.g.*, ion exchange) and T-As (*e.g.*, hydroxide precipitation/co-precipitation with coagulants), RO offers a robust treatment solution for these parameters as well. Therefore, RO is considered best achievable technology to meet the treatment objectives for all POCs, based on the flows and water quality predicted for WRTSF discharge during operations under the increased production scenario.

An RO-based system will require upstream removal of TSS via metal precipitation, clarification, and filtration processes. An RO process will also require management/treatment of the concentrated waste stream, which will add significant operational complexity. Based on the outcome of this BAT assessment, engagement has been initiated with treatment vendors to obtain site-specific proposals and cost estimates for an RO-based system to treat the outflow of the WRTSF at Brucejack Mine. Based on this vendor feedback, the capital cost for a prefabricated RO-based system is expected to be approximately $73,000,000 CAD, assuming a design flow rate of 5,760 m^3/hr. This design flow rate exceeds the average flow predicted to report to BJ 3.10 during operations (1,878 m^3/hr; Lorax, 2023a) by a factor of 3 to accommodate treatment during high-flow periods. The annual operating cost for the system is expected to be approximately

$27,500,000 CAD per year. This system is expected to produce approximately 320 m^3/hr of sludge (with 0.5-1% dryness) and 1,650 m^3/hr of RO concentrate with a conductivity of 2,930 µS/cm. The aforementioned cost estimates of the RO-based system do not include costs associated with downstream treatment or handling of these residual waste products.

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Appendix 5-5: Derivation of Current Discharge Limits in Effluent Permit PE-107835

Appendix 5-5-1: Derivation of Discharge Limits for Iron and Silver

1 SCIENCE BASED ENVIRONMENTAL BENCHMARKS

1.1 SUMMARY OF APPROACH

BC water quality guidelines for the protection of freshwater aquatic life (BC FWAL) are derived to be protective of the most sensitive species and life stages of aquatic life present in British Columbia. These are generic guidelines that may not account for local conditions that could make BC FWAL guidelines over- or under-protective for a particular waterbody. The most common conditions for which generic guidelines are over-protective are for 1) waterbodies in which sensitive species are absent and do not have the potential to occur there, 2) waterbodies with site-specific chemistry that reduces the toxicity of a contaminant, and 3) waterbodies with naturally elevated levels of a contaminant. Under these circumstances, it is warranted to derive science based environmental benchmarks (SBEBs) which are protective of the local aquatic life.

SBEBs developed for the Brucejack Creek receiving environment station BJ 2.62 are presented below for parameters that are predicted to exceed generic BC FWAL guidelines. Separate SBEBs are developed for high flow and low flow months for parameters that have background concentrations that seasonally exceed BC FWAL guidelines when higher flows in Brucejack Creek carry higher suspended sediment loads. Overall, the SBEBs are derived to define a contaminant level below which no significant effect will occur to aquatic life in Brucejack Creek.

1.2 PROPOSED SCIENCE BASED ENVIRONMENTAL BENCHMARKS

SBEBs have been derived for four parameters (nitrite, iron, silver, and zinc) in support of the MA/EMA permit application (Table 1.2-1). SBEBs for Fe and Ag (Section 1.2.1) are based on background concentrations of these parameters, which vary seasonally, therefore different SBEBs are proposed for low flow (October to April) and high flow (May to September) months.

Table 1.2-1. Proposed Science Based Environmental Benchmarks for Station BJ 2.62 in Brucejack Creek

			Proposed SBEB	
Parameter	Units	BC FWAL[1]	Low flow	High flow
Nitrite[2]	mg-N/L	0.02	0.18	0.18
Iron-total	mg/L	1.0	1.0	1.70
Silver-total	mg/L	0.000050	0.000120	0.000460
Zinc-total[3]	mg/L	0.0075	0.055	0.055

Notes:
[1]BC long-term water quality guideline for the protection of freshwater aquatic life.
[2] ZiNitrite guideline assumes that chloride is <2 mg/L.
[3]Zinc guideline and SBEB are hardness dependent. The guideline shown is for background hardness of 28 mg/L as $CaCO_3$. For other hardness levels the formula SBEB (mg/L)=EXP(0.72(LN(hardness))-2.8) applies.*

The proposed SBEBs for nitrite (Section 1.2.2) and zinc (Section 1.2.3) were derived using the recalculation procedure described in BC MOE (2013a). Nitrite and zinc BC FWAL guidelines were derived to be protective of fish, which are the most sensitive taxon to these parameters. Brucejack Creek is not fish bearing, and the closest fish bearing stream is approximately 20 km downstream of Brucejack Creek, therefore the recalculation procedure was used to derive a benchmark that is protective of aquatic life in Brucejack Creek.

1.2.1 Rationale for Iron and Silver SBEBs

The background concentration procedure (BC MOE 2013a) is applicable to waterbodies with natural background levels of a parameter that are higher than the generic BC FWAL guideline. This approach is relevant to Brucejack Creek, which has elevated levels of some metals during high flows, presumably due to metals associated with suspended sediments.

SBEBs were derived by determining the 95th percentiles of BJ 2.62 baseline water quality concentrations for both low flow months (October-March) and high flow months (May-September). If calculated values exceeded the corresponding generic BC FWAL guidelines, the baseline 95th percentile was adopted as the SBEB. Only 2009 to 2013 data from the ERM Rescan-curated baseline water quality dataset were used in the calculation of SBEBs (ERM Rescan, 2014c). As such, samples identified by ERM Rescan as potentially mine-impacted were not included in the derivation of 95th percentile SBEBs. Samples collected during earlier monitoring programs (1987-2001) were also excluded from the calculation of 95th percentiles, as these samples were not analyzed for silver or analyses used high analytical method detection limits. The 2009 to 2013 monitoring period includes data from samples analyzed for an analytical suite of 33 total and dissolved analytes (with anions and nutrients), and low method detection limits.

Baseline concentrations of silver are greater than BC FWAL guideline during both low flow and high flow months (Table 1.2-2). Based on the background concentration procedure, SBEBs are proposed for total silver (0.00012 mg/L during low flow months, 0.00046 during high flow months).

Table 1.2-2. Comparison of Maximum Modeled Concentrations during Construction and Operations Phases to Baseline 95th Percentiles for Total Iron and Silver.

			Low Flow Months (Oct – Apr)[2]		High Flow Months (May – Sep)[3]	
Parameter	Units	BC FWAL[1]	Maximum modeled BJ 2.62	BJ 2.62 Baseline 95th Percentile	Maximum modeled BJ 2.62	BJ 2.62 Baseline 95th Percentile
Iron-T	mg/L	1.0	0.588	0.324	0.924	**1.70**
Silver-T	mg/L	0.000050	**0.000057**	**0.000120**	**0.000110**	**0.000460**

Notes:
[1]BC water quality guideline for the protection of freshwater aquatic life (FWAL). Guidelines shown are for 30-day concentration Hardness-dependent guidelines based on median baseline hardness at BJ 2.62 (28 mg/L as $CaCO_3$).
[2]Data range June 2011 to August 2013; n = 16 sample events
[3]Data range October 2011 to April 2013; n = 11 sample events
Concentrations that exceed guidelines are shown in bold font; values shaded grey are proposed SBEBs.

Baseline concentrations of iron are greater than BC FWAL guideline during high flow months but not low flow months, therefore an SBEB for total iron is proposed only for high flow months (1.7 mg/L).

1.2.2 Rationale for Nitrite SBEB

The current BC 30-day FWAL guideline is based on three studies (Russo and Thurson 1977; BC Research 1981; Sigma 1983) that indicated that fish are the most sensitive taxon to nitrite toxicity. The BC FWAL long-term guideline of 0.02 mg-N/L was based on the conclusion that 0.02 mg/L NO_2-N is the maximum level acceptable for salmonids for continuous exposure in fish rearing tanks (Nordin and Pommen 1986). Toxicity testing indicated that nitrite toxicity is reduced by chloride, therefore BC FWAL guidelines for nitrite are chloride-dependent.

Within the context of the aquatic species assemblage in Brucejack Creek, invertebrates represent the most sensitive taxon present. Fish are absent from Brucejack Creek. Additionally, there are few toxicity data on nitrite effects to algae and macrophytes, although potential environmental effects more likely relate to issues associated with eutrophication from nitrite as a nutrient source (Nordin and Pommen 1986). Therefore, an SBEB is proposed based on the sensitivity of invertebrates to nitrite toxicity.

The BC WQG for nitrite (Nordin and Pommen 1986) describes only two invertebrate studies available at the time of guideline derivation: 1) Wickens (1976), in which a 3-4 week nitrite LC_{50} of 15.4 mg-N/L was reported for *Macrobrachium rosenbergii* (a tropical freshwater prawn); and 2) Beitinger and Huey (1981), in which a 96-hour LC_{50} of 1.9 mg-N/L for *Procambrus simulans* (a crayfish) is reported. Based on the limited dataset, consideration of more recent toxicity studies is warranted for the development of an SBEB for Brucejack Creek.

US EPA (2010) recently led a series of tests that add considerably to the invertebrate nitrite toxicity dataset (Table 1.2-3). The only chronic toxicity test conducted was a 7-day reproduction test using the waterflea *Ceriodaphnia dubia.* The Lowest Observable Effects Concentration from that test was 1.8 mg/L. This formed the basis for an SBEB derived in the Brucejack Exploration Phase Technical Assessment Report. The SBEB was 0.18 mg/L, derived by multiplying the LOEC by an uncertainty factor of 0.1. This same concentration is proposed as an SBEB for Construction, Operation, and Closure phases.

Included in Table 1.2-3 are data from site-specific toxicity tests recently conducted using water collected from the underground drill water sump tested with *Daphnia magna* and water collected from site BJ 2.62 tested with *Chironomus dilutus* (Table 1.2-4). These tests were conducted by spiking site water with nitrite, nitrate, and ammonia at proportions recently measured in effluent from the Exploration water treatment plant, in order to simulate effluent. *Chironomus dilutus* is a midge, and is representative of invertebrates that occur in Brucejack Creek. No toxicity to *C. dilutus* occurred at any of the concentrations tested, up to 2 mg/L. These data support the SBEB of 0.18 as being protective of aquatic life in Brucejack Creek.

The lowest endpoint in the invertebrate nitrite toxicity dataset (Table 1.2-3) is 1.0 mg/L for the stonefly *Amphinemura delosa*. The proposed SBEB of 0.18 mg/L is equivalent to an uncertainty factor of 0.18 applied to the *A. delosa* endpoint. Given that 13 endpoints from 9 invertebrate species were reviewed, the application of an uncertainty factor of 0.18 provides confidence that aquatic life in Brucejack Creek will be protected at the SBEB. Further confidence that the proposed SBEB is protective of aquatic life in Brucejack Creek is provided by the site specific data (Table 1.2-4).

Table 1.2-3. Estimates of Nitrite Toxicity to Freshwater Invertebrates

Test Species	Endpoint [2]	Concentration (mg NO_2-N/L)	Source
Forestfly, Amphinemura delosa	96-hour LC_{50}	1.0	US EPA 2010
Water flea, Daphnia magna	48-hour LC_{50}	1.45	Pretivm[1] (see Table 1.2-3)
Amphipod crustacean, Hyalella azteca	96-hour LC_{50}	1.5	US EPA 2010
Water flea, Ceriodaphnia dubia	7-day LOEC reproduction	1.8	US EPA 2010
Crayfish, Procambarus simulans	96-hour LC_{50}	1.9	Beitinger and Huey (1981), in Nordin and Pommen (1986)
Water flea, Ceriodaphnia dubia	48-hour LC_{50}	4.6	US EPA 2010
Water flea, Ceriodaphnia dubia	7-day LC_{50}	4.7	US EPA 2010
Water flea, Ceriodaphnia dubia	48-hour LC_{50}	5.1	US EPA 2010
Freshwater prawn, Macrobrachium rosenbergii	3-4 week LC_{50}	15.4	Wickens (1976), in Nordin and Pommen (1986)
Midge, Chironomus dilutus	48-hour LC_{50}	15.6	US EPA 2010
Fingernail clam, Sphaerium simile	96-hour LC_{50}	55.7	US EPA 2010
Fatmucket clam, Lampsilis siliquoidea	96-hour LC_{50}	177	US EPA 2010
Midge, Chironomus dilutus	96-hour LC_{50}	>2	Pretivm[1] (see Table 1.2-3)

Notes:
[1] Toxicity testing recently commissioned by Pretivm, conducted at Maxxam Analytics (Burnaby, BC). Tests used site water spiked with nitrogen species (NO_3, NO_2, and NH_4,) at proportions recently measured in effluent from the MWTP (19% NH_4, 77% NO_3, and 4% NO_2).
[2] LC_{50}: Concentration required to cause mortality to 50% of test organisms. ; EC_{50}: Concentration required to cause effect in 50% of test organisms; LOEC: Lowest Observed Effect Concentration.

Table 1.2-4. Results of Site-specific Toxicity Testing of Nitrogen

Nitrogen Concentration Added			Percent Survival		Cell Yield
Nitrite-N (mg/L)	Nitrate-N (mg/L)	Ammonia-N (mg/L)	*Daphnia magna* (waterflea)	*Chironomus dilutus* (midge)	*Pseudokirchneriella subcapitata* (alga)
<0.0050	<0.020	0.0434	100%	100%	122 cells
0.147	2.68	0.722	100%	100%	136 cells
0.265	5.32	1.36	100%	100%	154 cells
0.510	10.8	2.38	100%	100%	147 cells
1.03	21.5	5.35	90%	100%	139 cells
2.05	44.3	11.1	15%	100%	129 cells
LC/EC_{50} for nitrite			**1.45 mg/L**	**>2 mg/L**	**>2 mg/L**

1.2.3 Rationale for Zinc SBEB

A zinc SBEB was developed by ERM Rescan under separate cover (Appendix 1).

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Appendix 5-5-2: Derivation of Discharge Limits for Nitrate and Nitrite

PRETIVM

November 14, 2016

BC Ministry of Environment
Environmental Protection Division
Business Services Branch
Victoria Permit Administration

Via email: PermitAdministration.VictoriaEPD@gov.bc.ca
Mark.Love@gov.bc.ca
Rusto.Markinka@gov.bc.ca

Attention: Mr. Mark Love, Authorizations Section Head – Mining Team Mr. Rusto Martinka, Sr. Environmental Protection Officer

Dear Mr. Love and Mr. Martinka;

Re: PE-107835 Brucejack Gold Mine – Effluent Permit Amendment Application #4

This letter is an application to amend several conditions of Effluent Permit 107835 (PE-107835), issued to Pretium Resources Inc. (Pretivm) for the Brucejack Gold Mine. Pretivm is requesting changes to discharge limits for nitrogen species; several water quality monitoring requirements; permitted discharge locations for effluents discharged to Brucejack Lake; and removal or rewording of the permit condition pertaining to Mine Water Treatment Plant (WTP) sludge disposal.

Water quality monitoring of Brucejack Lake has lead to an improved understanding of nitrogen loading to the lake and secondary processes that affect the concentration of ammonia, nitrite and nitrate in Brucejack Lake. The water quality model has been updated for ammonia, nitrite and nitrate, and an effects assessment has been completed for revised model predictions. Amendments are requested for compliance requirements relating to nitrogen compounds in the WTP effluent and at BJ 3.10.

The amendment requests are listed in the order they appear in PE-107835.

1. **Condition 1.1.1 – Cumulative Compliance Requirements**

Condition 1.1.1 includes the following condition regarding nitrite and nitrate:

The characteristics of the Brucejack Lake Outlet (BJ 3.10) must be equivalent to or better than:

Parameter	Maximum	Units
Nitrite	75	µg/L as N
Nitrate	3	mg/L as N

Amendment request: Amend the maximum limits for nitrate and nitrite specified in Condition 1.1.1 to those listed below:

The characteristics of the Brucejack Lake Outlet (BJ3.10) must be equivalent to or better than:

Parameter	Maximum	Units
Nitrite	0.24	mg/L as N
Nitrate	11.5	mg/L as N

Rationale: Updated water quality modeling indicates that nitrate and nitrite are predicted to exceed the current discharge limits and may reach concentrations of 11.5 mg/L NO_3-N and 0.24 mg/L NO_2-N. An ecological effects assessment has concluded that the potential for adverse effects to aquatic communities in the receiving environment due to the updated modeled concentrations of nitrate and nitrite is not significant. Therefore, these concentrations are recommended as maximum limits for the BJ 3.10 monitoring station. Supporting information is provided in Attachment A.

2. Condition 1.2.2 – Water Treatment Plant Effluent

Condition 1.2.2 includes the following condition regarding nitrite:

The characteristics of the Water Treatment Plants (WTP) discharge should not exceed the following concentrations after treatment. If these levels are exceeded, notification is required following the procedures as per Sections 5.4 and 5.5.

Parameter	Construction WTP Maximum	Operation WTP Maximum	Units
Nitrite	1.9 (max) 0.65 annual average	1.9 (max) 0.65 annual average	mg/L as N

Amendment request: It is requested that nitrite be removed from Condition 1.2.2.

Rationale: Nitrite concentration in the WTP effluent does not influence the nitrite concentration at the Brucejack Lake outlet (BJ 3.10). Nitrite concentration at the lake outlet is controlled by processes occurring in the lake. The most important process is nitrification, which converts a large proportion of ammonia and nitrite loadings to the lake to nitrate. Supporting information is provided in Attachment A.

3. **Condition 1.2.4: Location of WTP effluent pipeline**

Condition 1.2.4 states:

> *1.2.4 The location of the treatment plant and the deep lake outfall are as shown on Site Plan B and D. The sources of WTP influent are mine water and the contact water pond(s).*

Amendment request: Please replace the reference to Site Plans B and D to Site Plans A and B. Please update both Site Plans to show the correct position of the Operations WTP effluent pipeline, as well as the locations of the direct discharge lines from the Contact Water Pond to Brucejack Lake.

Rationale: The Operations WTP pipeline will be routed adjacent to the tailings pipeline for most of its length (i.e. similar to the originally permitted routing and outfall), but will discharge below 30 m depth, nearer to shore than the tailings outfall. The positioning and outfall are designed to prevent scouring of tailings deposited on the lake bottom. An updated Operations site plan is included in Attachment B.

4. **Condition 1.5.3 – Treated Domestic Wastewater**

Condition 1.5.3 states:

> *The Permittee must provide the various plans required under the Municipal Wastewater Regulation as well as the formal as built plans for the sewage treatment plant, all of which shall be signed off by a Qualified Professional prior to commencing the discharge of treated domestic effluent.*

Amendment request: It is requested this condition be removed from the Permit.

Rationale*:* Pretivm considers that this condition has been satisfied and should therefore be removed from the Permit. The sewage treatment plant system is comprised of 3 separate pre-packaged units that use the same treatment process: two Filterboxx C-75 units and one C-25 unit. The STP is not constructed on site and thus the as-built design clause is not applicable to the Brucejack STP system, since the units are delivered to site as 'ready to go' units. The design plans for the first C-75 unit were included in the Mines Act/Environmental Management Act Permit Application. The first C-75 unit was registered under the Municipal Wastewater Regulation in June of 2014 when the first system came online. The second C-75 unit is identical to the first and the additional C-25 unit employs the same treatment process, but treats a lower volume of waste. The application for the C-25 unit, submitted to BC MOE October 15, 2015, contains additional information specific to that treatment unit.

5. **Condition 3.2 – Source Control of Nitrite and Nitrogen**

Condition 3.2 states:

> *The Permittee must implement the Nitrogen Source Control Program (NSCP) as documented in Appendix 6-T of the May 2015 application for a permit. The NSCP indicates that the rate of the explosive usage within the mine will be managed using nitrite, nitrate and or ammonia monitoring at the Water Treatment Plant(s) and supplemental "in Mine" monitoring as necessary to ensure the cumulative Nitrite Limit in Section 1.1 is met.*
>
> *The Permittee must maintain graphical records of the Nitrite Management and monitoring similar to figure 5.1-1 of Appendix 6-T for inspection at the request of Environmental Protection Staff and submission with the annual reports.*

Amendment request: It is requested that Condition 3.2 be amended to the following:

> *The Permittee must implement the current version of the Nitrogen Management Plan (NMP). The NMP describes source control measures, monitoring, auditing and reporting activities that are undertaken to ensure nitrogen sources are controlled and minimized and that the cumulative Ammonia, Nitrite and Nitrate Limits in Section 1.1 are met.*
>
> *The Permittee must maintain records of the activities described in the NMP available for inspection at the request of Environmental Protection Staff.*

Rationale: NMP monitoring and mitigation procedures have been updated and are described in the NMP document. These procedures will continue to evolve as the Project progresses. It is requested that the Permit condition make a generic reference to the current version of the NMP. Specific monitoring, recordkeeping and reporting requirements are described in the NMP. A copy of the updated NMP is included as Appendix A of Attachment A.

6. **Condition 3.7 – Mine Water Treatment Plant Sludge**

Condition 3.7 states:

> *The Sludge(s) from the Construction and/or Operation Mine Water Treatment plants must be characterized using appropriate methods within 90 days of commissioning each plant and remain in storage on site until it is determined that:*
>
> *It is not Hazardous Waste under the Hazardous Waste Regulation, and, the proposed disposal option is approved by the Director.*
>
> *Storage of Water Treatment Plant sludge onsite must not exceed twelve (12) months, unless approved by the Director. Sludge storage must be done in a manner acceptable*

to the Director.

Amendment request: It is requested that Condition 3.7 be amended to the following:

Disposal of sludge from the Operations Mine Water Treatment plant does not require MOE approval if it is disposed off-site at a licensed facility.

On-site co-disposal of WTP sludge with waste rock or tailings to Brucejack Lake is permitted following prior approval by the Director and provided the long-term stability and influence on water quality is assessed and meets the requirements of the ML/ARD management plan.

Storage of Water Treatment Plant sludge onsite must not exceed twelve (12) months, unless approved by the Director. Sludge storage must be done in a manner acceptable to the Director.

Rationale: Off-site sludge disposal at a facility licensed to receive this type of waste has been on-going since the initial characterization of Construction WTP sludge was completed. BC MOE already regulates the licensed haulers/disposers of Brucejack Mine WTP sludge and BC and Alberta (applicable jurisdiction dependent on which facility the sludge is disposed at) regulate the facilities themselves. With respect to co-disposal of sludge with tailings and/or waste rock, long-term stability studies for WTP sludge are ongoing and a lake disposal option is being evaluated in accordance with the ML/ARD management plan.

7. Appendix B – Surface Water Quality Monitoring Requirements at BJ3.10 and BJ2.62

Appendix B states:

Appendix B – Surface Water Quality Monitoring Requirements

Sample Site Name	Metals & General	5 in 30 days
Weir at BJ 3.10	Weekly	Freshet & Fall
BJ 2.62	Monthly	Freshet & Fall

Amendment request: It is requested that 5 in 30 day water quality sampling be removed from Appendix B for sites BJ 3.10 and BJ 2.62.
Rationale: Water quality is monitored weekly year-round at BJ 3.10, therefore specifying 5 in 30 monitoring at BJ 3.10 is not necessary. Site BJ 2.62 is a legacy monitoring location from when WTP and STP effluents were discharged to Brucejack

Creek. Now that all discharges are to Brucejack Lake, the high frequency sampling done at the lake outlet (BJ3.10) is adequate to characterize any mine-related changes to water quality. The high frequency, 5 in 30 sampling at BJ2.62 does not provide any additional meaningful information.

8. **Appendix B – Surface Water Quality and Flow Monitoring Requirements at BJ2.62**

For monitoring station BJ 2.62 Appendix B states:

Appendix B – Surface Water Quality Monitoring Requirements

Sample Site Name	Flow Rate / Staff Gauge	5 in 30 days
BJ 2.62	Continuous flow with manual checks 2x/winter 4x/Summer @ low flow and no recent precipitation.	Freshet & Fall

Amendment request: It is requested flow monitoring requirements at BJ2.62 be removed from Appendix B.

Rationale: BJ 2.62 is a legacy compliance station for the time period when the WTP and STP were discharging to Brucejack Creek. Field observations over the past few years indicate the streambed at BJ 2.62 is not suitable for accurate continuous flow measurements. Flow measurements requirements in Appendix B at stations BJ3.10 and BJL-H1a are sufficient to characterize flows in Brucejack Creek.

9. **Appendix B – Surface Water Quality and Flow Monitoring – CWP**

Appendix B states:

Appendix B – Surface Water Quality Monitoring Requirements

Sample Site Name	Metals and General
CWP influent at WTP	2x/month
CWP direct discharge to lake	1x for each direct discharge otherwise 1x/month during sQtr 2 & 3

Amendment request: It is requested that Appendix B be amended as follows:

Appendix B – Surface Water Quality Monitoring Requirements

Sample Site Name	Metals and General
CWP influent at WTP	2x/month (when discharging to WTP)
CWP direct discharge to lake	1x for each direct discharge

Rationale: Under normal circumstances the CWP collects surface runoff during the snow-free months and discharge from the CWP is directed to the WTP. The CWP water quality is measured as "CWP influent at WTP" twice a month. Water quality monitoring at the CWP is redundant when the monitoring is also conducted at the WTP influent location. As well, water quality sampling at the CWP is often unsafe during sQtr 2 (April through June) due to snow and ice on the pond surface and embankments.

Please contact me by email or at (250) 877-9011 to discuss this Permit amendment request or if you require any additional information.

Sincerely,

Sylvia Van Zalingen

Sylvia Van Zalingen, M.S., P.Ag.
Environmental Manager, Brucejack Mine
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cc: M. Holtby, K. Torpy, W. Osborne, S. Smith, G. Friesen, L. Morgenthaler, R. McCall, T. Sandhals, Pretivm
D. Howe, J. McConnachie, D. Smyth, J. Stuart, MEM

Attachment A

Update to the Brucejack Gold Mine Water Quality Model and Effects Assessment for Nitrogen Compounds

PRETIVM

Update to the Brucejack Gold Mine Water Quality Model and Effects Assessment for Nitrogen Compounds

Prepared for:

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Prepared by:

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Project No. A406-2

14 November 2016

LORAX ENVIRONMENTAL

Executive Summary

PRETIVM

Executive Summary

This report provides updated nitrogen species (ammonia, nitrite and nitrate) predictions and assessment for the Brucejack Gold Mine effluent discharge from Brucejack Lake at site BJ 3.10 using additional water quality data collected and compiled subsequent to the initial Effluent Permit PE-107835 application. This report has been specifically compiled in support of an application by Pretium Resources Inc. (Pretivm) to amend Brucejack Gold Mine Effluent Permit PE-107835 to:

1) increase discharge limits at the lake outlet (site BJ 3.10) for nitrate (from 3.0 mg-N/L to 11.5 mg-N/L) and nitrite (from 0.075 mg-N/L to 0.24 mg-N/L); and
2) remove the Mine Water Treatment Plant (WTP) effluent discharge limit for nitrite.

In support of these proposed amendments, the monitoring data collected during the Project's Exploration and Construction phases have been used to: 1) refine mine-related nitrogen source terms; 2) quantify the extent to which nitrification processes are occurring within Brucejack Lake; 3) generate revised water quality predictions for receiving environments downstream of Brucejack Lake (Brucejack Creek and Sulphurets Creek); and 4) evaluate the potential for adverse effects to aquatic life downstream of Brucejack Lake.

The primary source of nitrogen compounds to Brucejack Lake is residue from explosives use; contributions from treated domestic wastewater and background inflows are negligible. Explosives-related nitrogen compounds are currently introduced to Brucejack Lake from WTP effluent and blasted waste rock deposition. Once the mill is operational, the tailings slurry discharge will also be a source of nitrogen loadings to Brucejack Lake. The Nitrogen Management Plan (NMP) outlines source control measures that have been implemented to limit nitrogen loading to Brucejack Lake.

Current PE-107835 discharge limits for nitrogen compounds were developed based on previous water quality predictions from Environmental Assessment and initial permitting that assumed conservative behaviour of nitrogen compounds in Brucejack Lake (*i.e.* no secondary reactions). The assumption that there is no attenuation of nitrite in the lake necessitated that a nitrite discharge limit be set for effluent from the WTP.

Pretivm has implemented nitrite treatment of WTP effluent in order to meet discharge limits. Monitoring data from the Construction phase of the Project demonstrate that nitrogen in the lake has been behaving non-conservatively, with ammonia and nitrite being converted to nitrate, likely by microbial nitrification processes. Based on the observation that nitrite conversion to nitrate is occurring naturally in the lake, and noting that the

dominant source of nitrogen is from waste rock deposition (a source that cannot be treated), it is recommended that the requirement for a WTP effluent discharge limit for nitrite be removed from the Effluent permit.

Water quality predictions for nitrogen compounds have been updated considering the updated source terms and nitrification processes occurring within Brucejack Lake. Revised predictions for BJ 3.10 indicate the potential for concentrations of nitrate (up to 11.5 mg-N/L) and nitrite (up to 0.24 mg-N/L) that are above the current discharge limit at BJ 3.10. The maximum predicted ammonia concentration of 0.49 mg-N/L is below the current discharge limit.

Based on the results presented here, it is recommended that Effluent Permit PE-107835 be amended to reflect the current understanding of nitrogen species in the lake. Specifically, the magnitude of nitrite attenuation in Brucejack Lake demonstrates that treatment measures implemented to control nitrite concentrations in the WTP discharge are not necessary, and therefore it is recommended that the WTP effluent discharge limit for nitrite be removed. Although the updated water quality model predicts higher concentrations of nitrate and nitrite at the lake outlet, an updated effects assessment carried out for the receiving environment concludes that potential effects to aquatic life in the receiving environment will be not significant at the predicted concentrations of nitrate and nitrite. Based on the updated effects assessment, it is recommended that the BJ 3.10 discharge limits for nitrate and nitrite be amended to 11.5 mg/L-N/L and 0.24 mg-N/L, respectively.

Acknowledgements

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Acknowledgements

This update to the Brucejack Gold Mine Water Quality Model was prepared by Lorax Environmental Services Ltd. (Lorax) for Pretium Resources Inc. (Pretivm). The report was written by Patrick Mueller B.Sc., PChem, Meghan Goertzen, M.Sc., RPBio, and Robert Goldblatt B.Sc., and reviewed by Alison Shaw, Ph.D. and Alan Martin, M.Sc., RPBio. Lorax Environmental Services Ltd. has relied on information available in scientific literature and information supplied by Pretivm in preparing this report.

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List of Acronyms and Abbreviations

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List of Acronyms and Abbreviations

BCWQG	British Columbia water quality guideline for protection of freshwater aquatic life.
CWP	Contact Water Pond
MA/EMA	*Mines Act/Environmental Management Act*
ML/ARD	Metal leaching/acid rock drainage
MOE	British Columbia Ministry of Environment
N	Nitrogen
NMP	Nitrogen management plan
NPAG	Non-potentially acid generating
PAG	Potentially acid generating
pF	Powder Factor
STP	Sewage treatment plant
TSS	Total suspended solids
UG	Underground
WTP	Mine water treatment plant

1. Introduction

1. Introduction

1.1 Overview and Objectives

This report provides updated nitrogen species (ammonia, nitrite and nitrate) predictions and assessment for the Brucejack Gold Mine effluent discharge from Brucejack Lake at site BJ 3.10 using additional water quality data collected and compiled subsequent to the initial Effluent Permit PE-107835 application. This report has been specifically compiled in support of an application by Pretium Resources Inc. (Pretivm) to amend Brucejack Gold Mine Effluent Permit PE-107835 to:

1) increase discharge limits at the lake outlet (site BJ 3.10) for nitrate (from 3.0 mg-N/L to 11.5 mg-N/L) and nitrite (from 0.075 mg-N/L to 0.24 mg-N/L); and
2) remove the Mine Water Treatment Plant (WTP) effluent discharge limit for nitrite.

Specific objectives of this report in support of the proposed discharge limits changes include the following:

- Quantify inorganic nitrogen loadings to Brucejack Lake;
- Describe nitrification processes (ammonia and nitrite oxidation) occuring in the lake based on empirical evidence from water quality monitoring;
- Generate revised water quality predictions for inorganic nitrogen species at the lake outlet;
- Evaluate the potential for adverse effects to aquatic life in the receiving environment; and
- Provide recommendations with respect to nitrogen discharge limits at the WTP and lake outlet.

1.2 Background to Nitrogen Species Loads to Brucejack Lake

The Brucejack Gold Mine is currently in the advanced stages of Construction, with Operations planned to begin in 2017. Relevant to nitrogen species loadings to Brucejack Lake, waste rock (source of nitrogen species from explosives residues) was first deposited subaqueously in Brucejack Lake in 1999 in response to BC Ministry of Energy and Mines direction to a previous site owner – Newhawk Resources – to prevent ML/ARD from waste rock excavated by Newhawk during advanced underground exploration conducted in the 1980's. Advanced underground exploration was re-initiated by Pretivm in early 2013, with subaqueous waste rock deposition occurring intermittently (dependent on development) thereafter until September 2015, when mine Construction was initiated. Large-scale

surface excavation of waste rock occurred during late 2015 and through much of 2016 for surface infrastructure development. There has also been a gradual ramp-up of underground mine development within this period.

Treatment of underground mine water prior to discharge was initiated in early 2013. Treated effluent discharge was to Brucejack Creek until December 2015, at which time it was redirected to Brucejack Lake. Nitrogen species were not treated until late 2014, at which time treatment to oxidize nitrite to nitrate was introduced. Nitrite treatment has occurred to the present time.

Other potential sources of nitrogen species loads to Brucejack Lake include a non-PAG (NPAG) quarry located at the east end of Brucejack Lake (quarry produces aggregate for construction and road surfacing), and treated domestic wastewater effluent. The domestic wastewater effluent discharge was initially to Brucejack Creek, but was redirected to Brucejack Lake in March 2016.

A Nitrogen Management Plan (NMP) describing source control measures for nitrogen compounds was implemented in December 2014, along with enhanced monitoring for nitrogen compounds at upstream and discharge locations. The NMP is an adaptive management plan that is updated, as necessary, to achieve source control objectives to minimize nitrogen losses from explosives use and was last updated November 2016.

A total of 123,000 m^3 of rock from underground workings and 511,000 m^3 of surface excavation were deposited in Brucejack Lake from December 2014 through August 2016. An additional ~25,000 m^3 of waste rock was excavated during autumn 2016 to expand the Contact Water Pond (CWP) to its design limit. The WTP discharged 743,000 m^3 of effluent during the December through August, 2016 period. The rate of underground excavation increased from approximately 1,400 m^3/week in January 2015 to approximately 9,700 m^3/week in August 2016. Underground excavation will increase to approximately 12,000 m^3/week during the remaining Construction Phase (May 2017), and drop to approximately 8,000 m^3/week during the mine Operations Phase.

1.3 Monitoring Data

Water quality monitoring of Brucejack Lake has been ongoing through the Exploration and Construction phases, and includes lake water column profiling at multiple depths and sampling at the lake outlet (site BJ 3.10). The data indicate nitrogen loads to Brucejack Lake have increased, commensurate with increases in underground and surface rock excavation. The concentrations of nitrate, ammonia and nitrite at the lake outlet have remained below permitted limits. The current discharge limits for the lake outlet are 3.0, 0.075 and 1.0 mg-N/L for nitrate, nitrite and ammonia, respectively.

This report uses monitoring data (2014-2016) for discharges to the lake, the lake water column, and the lake outlet to update the water quality model with respect to nitrogen loadings and the behaviour of nitrogen compounds. The results have relevance to water quality predictions and treatment requirements.

1.4 Report Organization

The following chapters provide a description of the NMP (Chapter 2), updates to the water quality model and predictions for nitrogen species (Chapter 3), and an effects assessment based on the updated nitrogen predictions (Chapter 4). Conclusions and recommendations relevant to nitrogen management are provided in Chapter 5.

2. Nitrogen Management Plan

PRETIVM

2. Nitrogen Management Plan

Both the *Mines Act* (MA) Permit M-243 (amended August 4, 2016) and the *Environmental Management Act* (EMA) Permit PE-107835 (amended July 12, 2016) require implementation of a Nitrogen Management Plan (NMP), with specific reference to the NMP included in Appendix 6-T of the MA/EMA Permits Application. An adaptive management approach has been developed that includes regular monitoring and data review, as well as periodic updates of the NMP to respond to changing conditions or requirements. The current Brucejack Gold Mine NMP, dated November 2016, is included as Appendix A and describes source control as the primary mitigation tool for nitrogen species. Further mitigation is achieved through treatment of mine water to remove nitrite prior to discharge to Brucejack Lake. The influence of natural attenuation processes for ammonia and nitrite has not been previously considered in the decision matrix for nitrogen management.

Nitrogen source control is achieved by implementing Best Practices for explosives use at underground mines. By limiting the loss of explosives at the blast face, inputs of inorganic nitrogen compounds to mine water and lake water are minimized. Monitoring is conducted daily and includes blasting records, as well as WTP flow and water quality records to confirm explosives use and nitrogen losses are in the expected range. Treatment is used, as necessary, to remove nitrite from the WTP effluent. Treatment was conducted with a sodium hypochlorite process from April 2015 through April 2016. A new ozone process was commissioned in August 2016 and is operated as needed to meet nitrite WTP effluent criteria (1.9 mg-N/L max; 0.65 mg-N/L annual average).

The NMP is further supported with regular inspections and blasting practices reviews. Re-blasts are investigated and steps are taken to prevent recurrence. Weekly underground inspections of the water management system and explosives handling practices are planned for implementation in the near future. The overall program is reviewed annually by senior management and action items arising are addressed by follow-up. The NMP is updated as needed based on inputs gained from the adaptive management process.

3. Brucejack Lake Water Quality

PRETIVM

3. Brucejack Lake Water Quality

3.1 Monitoring Program Description

The effects of mine-related discharges on Brucejack Lake water quality have been assessed based on results from a monitoring program first initiated in 2014. The program builds upon baseline data sets and includes lake water column profiling at multiple depths and regular sampling at the lake outlet (station BJ 3.10). Nitrogen loadings to Brucejack Lake have increased due to project development, although concentrations of the various N species have thus far remained well below permitted limits (3.0, 0.075 and 1.0 mg-N/L for nitrate, nitrite and ammonia, respectively).

The following sections describe the major sources of nitrogen to Brucejack Lake, summarize the results of the monitoring programs, quantify the loadings received by the lake, identify nitrification processes occurring in the lake and present the updated water quality predictions for the various nitrogen species. Monitoring data are summarized in Appendix B.

3.2 Nitrogen Sources

3.2.1 Explosives Use and Waste Discharge

Nitrogen losses associated with explosives use represent the major source of nitrogen in Brucejack Lake. The explosives-related nitrogen loadings are carried in mine water and surface contact water discharged via the WTP, as well as residues on blasted rock placed in Brucejack Lake. In contrast, Sewage Treatment Plant (STP) effluent represents a minor source of loadings received by the lake. Background contributions of nitrogen are negligible.

Blasting at Brucejack Gold Mine is conducted using a water resistant ANFO emulsion product (Dyno Nobel TITAN 7000). Underground excavation recommenced in December 2014 with approximately 2,200 kg/week of explosives consumption (corresponding to 800 m^3/week excavation). As the project entered the Construction Phase, mine excavation and explosive consumption increased and currently explosives are consumed at a rate of 35,000 kg/week (corresponding to 9,700 m^3/week excavation). The increase in explosives use is mirrored by an increase in the total nitrogen load in mine water (Figure 3-1). The underground excavation of waste rock and ore will increase to approximately 12,000 m^3/week during the remaining Construction Phase, and drop to approximately 8,000 m^3/week during the mine Operations Phase.

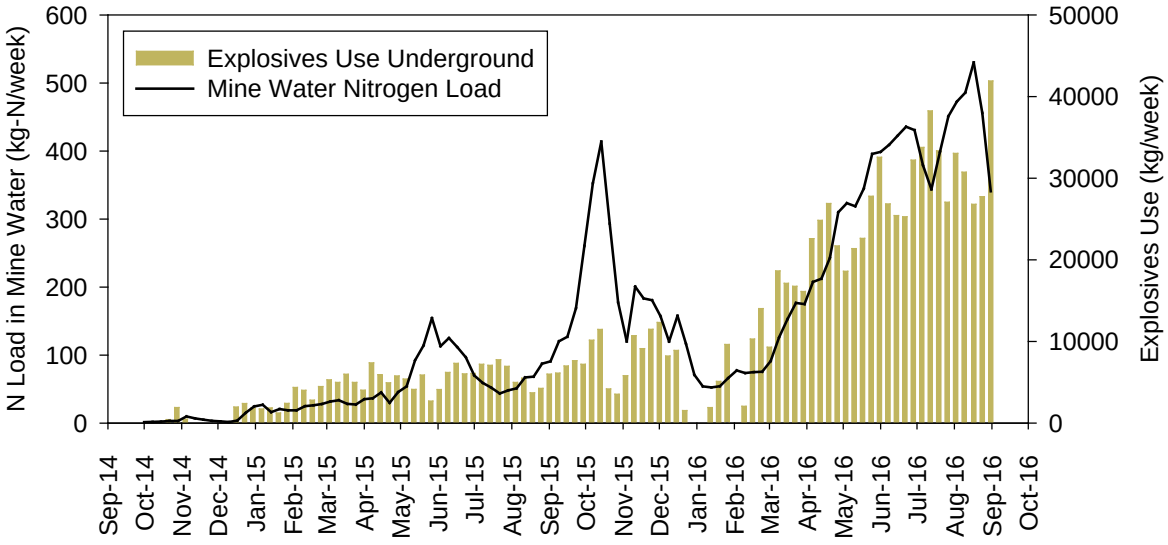


Figure 3-1: Underground explosives use and nitrogen load exported by mine dewatering over the period October 2014 through August 2016.

The underground mine water nitrogen load was compared to the corresponding explosives use to evaluate the nitrogen loading rate to mine water. The 2015 average nitrogen loading rate to mine water was equal to 5.9% of the explosives used (as N). This has improved in 2016 (to the end of August) with the mine water loading rate equal to 4.3% of the explosive used (as N). The higher nitrogen loading rate observed in 2015 reflects the influence of water bearing structures on blast efficiency. Flowing water can prevent efficient explosive consumption leading to non-detonated explosives in the muck pile and mine water, and consequently, increased nitrogen loads in mine water. Significant water bearing structures were encountered in May and September of 2015 leading to difficult blasting conditions. Nitrogen loads in the mine water briefly peaked during both periods (Figure 3-1), dropping after blasting conditions improved and updated blasting practices were implemented.

Underground mine water and Mine Site surface runoff collected in the contact water pond (CWP) are directed to the WTP for treatment prior to discharge, whereas blasted rock is placed directly in Brucejack Lake for subaqueous storage. During placement of waste rock in the lake, soluble nitrogen residues on the rock surfaces (as ammonia, nitrite and nitrate) are released to the lake water column. Quantification of loadings in mine water and lake water indicate that approximately 25% of the explosive residue is derived from mine water, with the balance (approximately 75%) entrained with blasted rock.

WTP and STP effluents are currently discharged continuously to the lake through separate pipelines to depths of 70 m and 30 m, respectively. Total waste loadings (waste rock and

effluents) to Brucejack Lake from various sources between December 2014 and August 2016 are summarized in Table 3-1.

Table 3-1:
Qunatities of waste rock and effluent placed in Brucejack Lake from December 2014 through August 2016

Source	Total Waste Discharged
Underground waste rock to lake	123,000 m^3
Surface waste rock to lake	511,000 m^3
Water treatment plant effluent to lake	743,000 m^3
Sewage treatment plant effluent to lake	5,400 m^3

Explosives use, as well as the excavation and storage of blasted material, are tracked for both surface and underground operations. Surface blasting does not generate a contact water discharge, and therefore explosives losses are not monitored for surface excavation.

For blasting the powder factor (pF) is monitored and represents the amount of explosive required to blast a volume of rock. For underground blasting a pF of 4.0 kg/m^3 was observed in 2015. From January through August 2016 the pF has increased slightly to 4.5 kg/m^3. The surface blasting pF is considerably lower, a full data evaluation was not conducted, however review of individual blast reports indicates the pF was generally in the range of 0.6 to 0.8 kg/m^3.

The waste sources presented in Table 3-1 are described in the following sections in order to quantify the loadings of nitrogen to Brucejack Lake (Section 3.3).

3.2.2 Water Treatment Plant (WTP) Effluent

The WTP is designed to receive and treat underground mine water from mine dewatering and surface contact water collected in the CWP. The WTP removes total suspended sediments (TSS), dissolved metals, and nitrite from influent water. Nitrite treatment is activated only when necessary to meet WTP effluent discharge limits. During active nitrite treatment with sodium hypochlorite from April 2015 through April 2016, nitrite was oxidized to nitrate and ammonia was removed by conversion to nitrogen gas, leaving nitrate as the dominant nitrogen species in the WTP effluent. The ozone process was commissioned in August 2016 to facilitate nitrite oxidization to nitrate, while ammonia is unaffected. Flow and quality of the WTP influents (CWP and underground mine mine) and WTP effluent are described in the sections below.

3.2.2.1 Contact Water Pond (CWP) Flow and Quality

Surface runoff from the core contact water (infrastructure and bedrock excavation) portion of the mine site is directed to the CWP, while the CWP discharge is directed to the WTP. Flow from the CWP commenced in May 2016.

Weekly flows and bi-monthly water quality for the CWP are shown in Figure 3-2. CWP discharges ranged from approximately 800 m^3/week (5 m^3/hr) to 5000 m^3/week (30 m^3/hr) from May through mid-August, originating primarily from surface runoff within the CWP catchment. Total nitrogen concentration ranged between 1 mg-N/L to 5 mg-N/L. CWP water quality and flows during this period were influenced by freshet runoff in June.

Subsequently, between mid-August and late October 2016, dependent on construction needs, WTP effluent and weir dewatering were also periodically directed to the CWP. Construction of the weir at BJ 3.10 commenced mid-August 2016, and construction dewatering was directed to the CWP. The additional flows contributed by WTP effluent water and weir dewatering led to an increase in the CWP flows in the latter half of August, with peak flows of approximately 14,000 m^3/week. The additional inputs to the CWP from the WTP and weir were temporary and flows from the CWP declined when the temporary inputs ceased (data not shown).

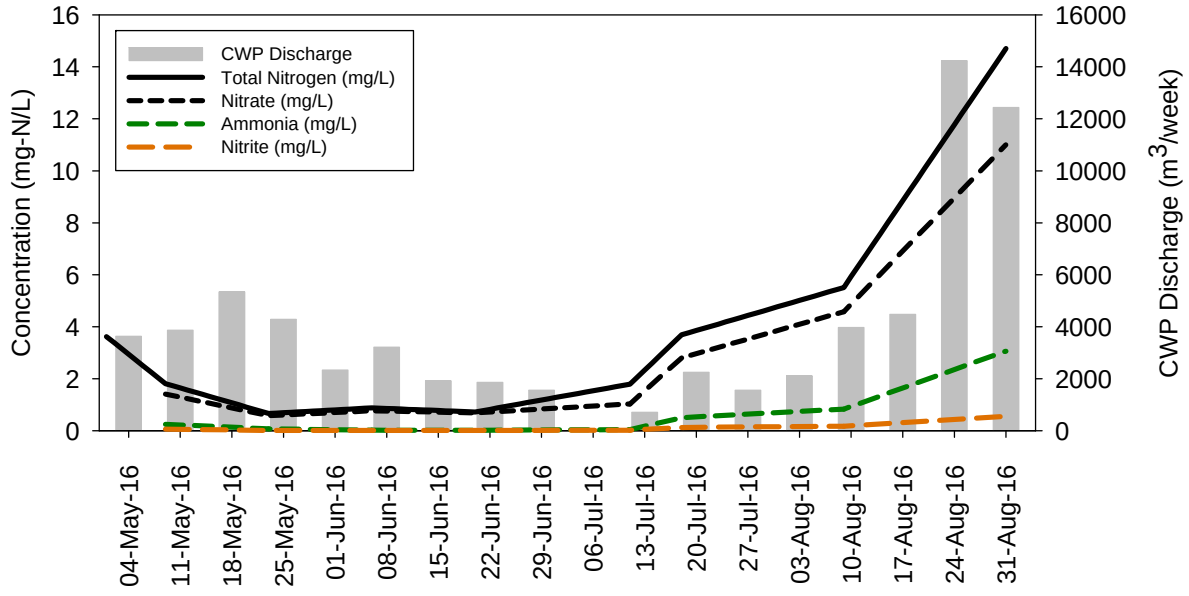


Figure 3-2: Contact Water Pond (CWP) discharge and water quality from May 2016 through August 2016; the CWP began operations May 2016.

3.2.2.2 Underground Mine Water Flow and Quality

Mine water quality and dewatering flow are monitored at the influent to the WTP (Figure 3-3). Nitrogen is introduced to mine water through the dissolution of blasting residues at the blast location, through contact with groundwater that enters the mine. In May 2015 and October 2015, excessive losses of non-detonated explosives led to corresponding peaks in nitrogen compounds. Over the period October 2014 through August 2016, the median distributions of inorganic nitrogen compounds (ammonia, nitrate and nitrite) in mine water at the WTP influent were 26.3% ammonia, 66.7% nitrate and 5.3% nitrite, with the balance of 1.7% attributable to measurement uncertainty.

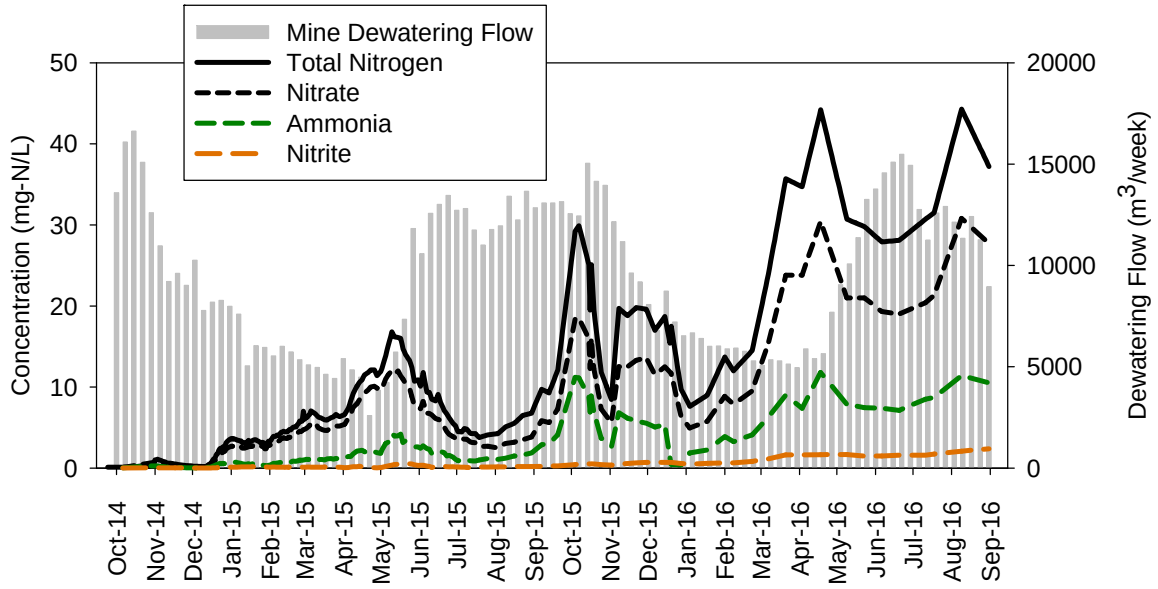


Figure 3-3: Mine dewatering flows and water quality over the period October 2014 through August 2016.

3.2.2.3 Water Treatment Plant Effluent Flow and Quality

WTP effluent water quality and flows are shown in Figure 3-4. Low nitrite and ammonia concentrations were observed during periods of sodium hypochlorite addition (nitrite treatment). When nitrite treatment was inactive, the WTP effluent median distribution of nitrogen species relative to total nitrogen was 26.8% ammonia, 67.6% nitrate and 5.2% nitrite (the balance of 0.4% is attributable to measurement uncertainty), similar to the distribution observed in underground mine water. During periods of active treatment with sodium hypochlorite, the median distribution shifted to 98.9% nitrate, 0.2% ammonia and 0.2% nitrite (with the balance of 0.7% attributable to measurement uncertainty).

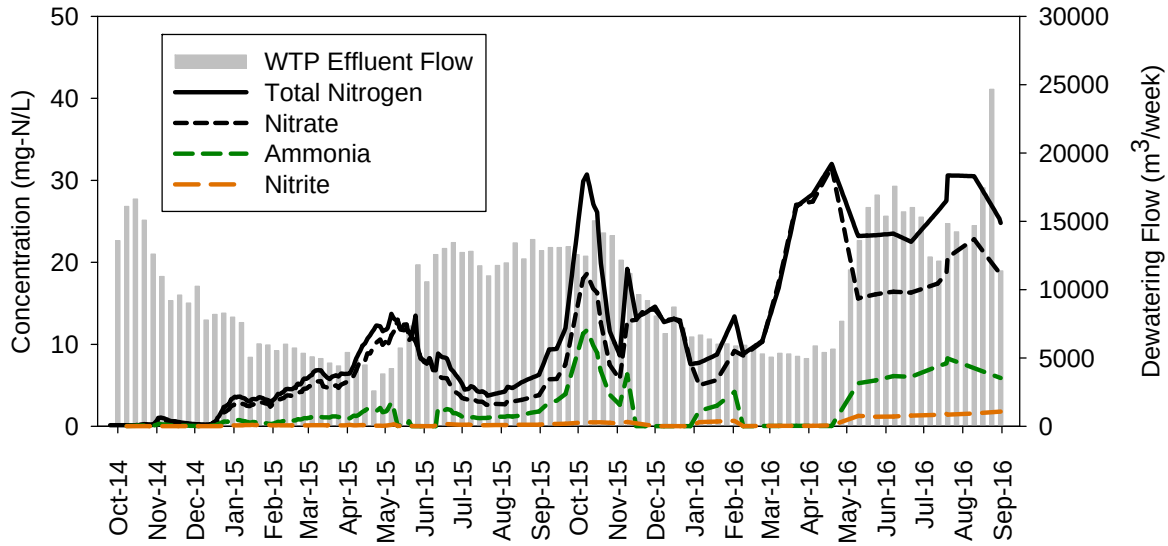


Figure 3-4: Water quality and discharge flows for Water Treatment Plant (WTP) effluent over the period October 2014 through July 2016.

3.2.3 Waste Rock

A portion of the blasting residues generated in the underground is stored on rock surfaces and released upon waste rock submergence in Brucejack Lake. Between December 2014 and August 2016, approximately 511,000 m^3 of surface waste rock and 123,000 m^3 of underground waste rock were deposited in Brucejack Lake, thereby releasing soluble nitrogen compounds directly to lake waters.

Surface excavation associated with the earth works program is mostly complete and the bulk of waste rock currently being deposited in Brucejack Lake is from underground mine operations. During the Operations phase, the deposition of underground waste rock will continue at an approximate rate of 115,000 m^3/year in the first year of mining, declining to approximately 20,000 m^3/year in the eleventh year and almost no deposition by year 18. The lake will also receive tailings generated from the process plant at an average rate of 315,000 m^3/year for the duration of mining operations.

Explosives loss rates associated with waste rock deposition were calculated from comparison of water quality data to rock deposition records (Table 3-2). Underground explosives use was calculated from daily records, while surface explosives use was estimated from excavation volumes and assuming a powder factor (pF) of 0.8%. Based on data for 2015, as well as data for January through April 2016, between 12% and 18% of explosives are released to Brucejack Lake through waste rock submergence, while between 3% to 6% of explosives are lost to mine water. Nitrogen loadings from surface waste rock

deposition in the lake were estimated to be 6% of explosives based on a pF of 0.8 and the actual rock volume excavated.

Table 3-2:
Proportional explosive loss rates for 2015 and 2016 (January to April).

Source	2015	2016 (January to April)
Underground explosives loss to mine water	6%	3%
Underground explosives loss to waste	18%	12%
Surface explosives loss to waste	6%	6%

Notes:
The N content in emulsion was assumed to be 29.7% (by mass)
Explosive loss was calculated from explosive use, and the measured N load in the WTP influent and in Brucejack Lake.
Surface blasting explosive quantities calculated assuming a powder factor of 0.8.

3.2.4 Sewage Treatment Plant (STP) Effluent

Treated domestic wastewater from the STP effluent has been discharging to Brucejack Lake since late March 2016 and represents a minor contribution to the overall nitrogen budget of Brucejack Lake. The STP effluent is currently discharged to the lake via a pipeline at 30 m depth. The current rate of discharge is expected to decrease slightly once the Construction phase of the Project is complete and the camp population is reduced to operational levels.

The STP system has three separate treatment units (C25, C75A and C75B) with a combined capacity of 175 m^3/day. Water quality and flow are measured at the discharge of each unit. The monthly loadings for each nitrogen species at each unit were summed to derive monthly estimates (Figure 3-5). The total STP discharge reached approximately 50 m^3/day (1500 m^3/month) in August 2016, well below the permit limit of 175 m^3/day. The combined water quality data show total nitrogen concentrations ranging from 10 to 80 mg/L over the period November 2014 to August 2016, with ammonia and nitrate being the predominant forms of nitrogen.

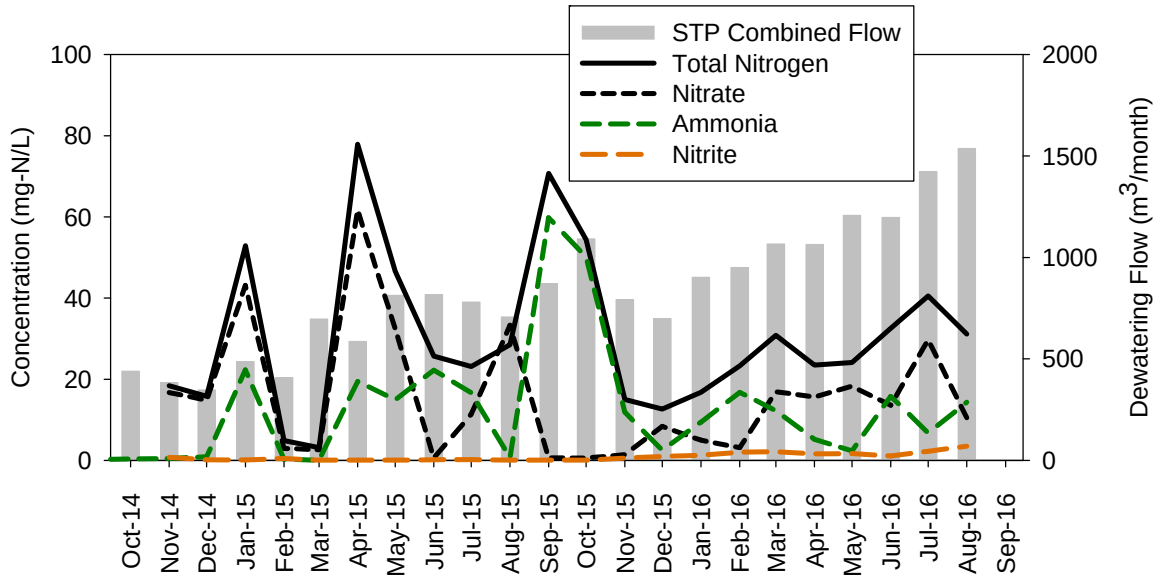


Figure 3-5: Water quality and discharge flows for Sewage Treatment Plant (STP) effluent for period November 2014 through August 2016; the STP effluent was directed to the lake in April 2016.

3.3 Nitrogen Loadings to Brucejack Lake

Nitrogen loadings to Brucejack Lake occur dominantly through waste rock deposition and to a lesser extent through WTP effluent discharge. The STP-treated domestic effluent relative to other sources is a negligible contribution of nitrogen to the lake. Likewise, baseline water quality monitoring indicates there is no significant contribution of nitrogen from natural inflows.

The largest nitrogen loadings have been associated with underground waste rock (peaking at 5,700 kg-N/month in July 2016) and WTP effluent (peaking at 2,100 kg-N/month in August 2016) (Figure 3-6). Surface blasting nitrogen contributions peaked in January 2016 at 1,800 kg-N/month and declined to 250 kg-N/month in August 2016. The STP discharge contributed a peak nitrogen load of 60 kg-N/month in July 2016.

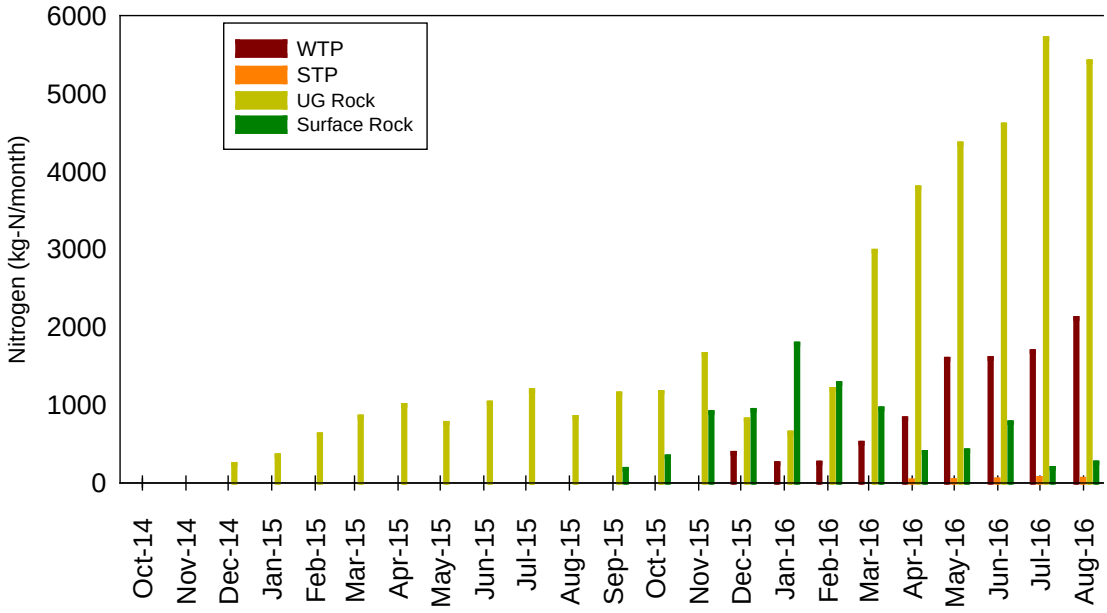


Figure 3-6: Monthly nitrogen loadings for the period November 2014 through August 2016 for Water Treatment Plant (WTP), Sewage Treatment Plant (STP), underground (UG) rock and surface rock.

Unit quantities for nitrogen residues on waste rock and in WTP effluent were calculated for 2015 and 2016 (January to April) (Table 3-3). For 2015, the underground waste rock residue was estimated to be 0.069 kg-N/t with a lower residual of 0.054 kg-N/t observed in 2016 (January through April). In 2015, there were several incidents of underground blasting through water bearing structures with significant flowing water (May and September) that lead to an increased loss of nitrogen compounds from explosives and ultimately contributed to a higher average nitrogen residual in that year. The lower nitrogen residuals observed to date in 2016 are more representative of current blasting practices. The surface waste rock residual was estimated to be constant at 0.005 kg-N/t during both years. The loading of nitrogen in WTP effluent rose from 0.011 kg-N/m^3 in 2015 to 0.020 kg-N/m^3 in 2016 (January through April). This increase reflects the higher excavation rate and explosives use in 2016 compared to 2015.

Table 3-3:
Nitrogen loading rates for 2015 and 2016 (January to April).

Source	2015	2016 (January to April)
Underground waste loading rate (kg-N/t)	0.069	0.054
Surface waste loading rate (kg-N/t)	0.005	0.005
Water treatment plant effluent loading rate (kg-N/m^3)	0.011	0.020

3.4 Brucejack Lake Water Quality Monitoring Data

All mine-related nitrogen loadings report to Brucejack Lake and water quality monitoring programs have been developed to quantify the loadings received by the lake. The lake has a single outlet and nitrogen export is measured at this location (BJ 3.10). Flows and turbidity are continuously monitored with sensors and water quality samples collected on a weekly basis (as outlined Section 3.4.1). Lake chemistry has also been monitored since 2014 at multiple depths in the water column at a station positioned over the deep (80 m) portion of the lake (station BJ 35). Monitoring at BJ 35 was developed to evaluate nitrogen species conversions, as well as the mixing of nitrogen compounds throughout the water column.

3.4.1 BJ 3.10 Lake Outlet Data

Water quality and flow monitoring data for BJ 3.10 over the period September 2014 to August 2016 were compared to model predictions. Over this period, discharge flows followed seasonal trends with low flows from December through April ranging from approximately 100,000 m^3/month to 200,000 m^3/month (Figure 3-7). From May through October, flows were significantly higher, ranging from 1,500,000 m^3/month to 3,000,000 m^3/month. The observed flows at BJ 3.10 are in agreement with seasonal trends and flows predicted by the MA/EMA water balance model, with flows in 2015 and 2016 (January through August) representing approximately 80% and 75% of the model predictions, respectively.

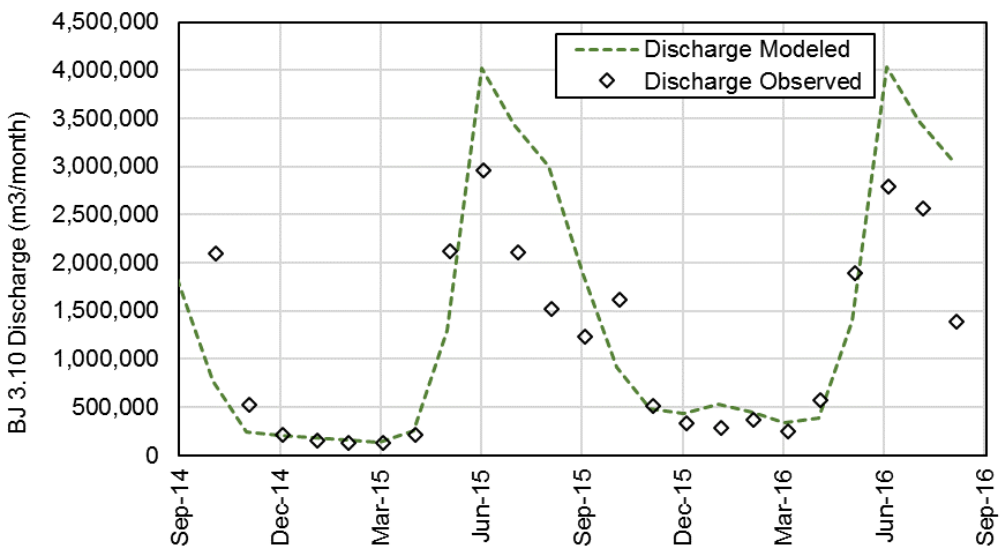


Figure 3-7: Observed monthly discharge at BJ 3.10 from September 2014 through August 2016. Data are compared to the hydrological model used for the Mines Act and Environmental Management Act (MA/EMA) submissions.

All nitrate, nitrite and ammonia concentrations measured to date have remained below their respective discharge limits. Observed ammonia and nitrite concentrations are below MA/EMA predicted concentrations, with median values of 0.010 mg-N/L and 0.0030 mg-N/L, respectively (Figure 3-8). In contrast, observed nitrate concentrations are consistently higher than MA/EMA predicted levels, reaching a peak concentration of 1.22 mg-N/L in 2016. The reason for this is attributed to both nitrification processes occurring in the lake (described in Section 3.5) and model assumptions regarding loading rates.

With regards to nitrogen behaviour, the MA/EMA model assumed conservative behavior of nitrogen species in the lake with ammonia, nitrite and nitrate distributed as 14.8%, 4.2% and 81% of the nitrogen inventory in the lake, respectively. These assumptions are not consistent with observations, which show nitrate accounting for 95.2% (median) of the nitrogen load. This discrepancy between MA/EMA predictions and water measurements can be attributed to the occurrence of nitrification processes in the lake.

With regards to nitrogen loadings, analysis of the lake monitoring data indicates the overall nitrogen loading to Brucejack Lake is higher than the MA/EMA predictions, with the nitrogen inventory in the lake approximately 2-fold higher than predicted. The MA/EMA assumptions were derived from data sets available at the time which included published literature data sets for surface-blasted rock and Brucejack ML/ARD monitoring data collected prior to 2015. Revised predictions were developed based on recent monitoring data that are specific to the underground blasting conditions at the Brucejack Gold Mine. These revised loading estimates indicate that the original loading predictions underestimated total nitrogen losses from the mine.

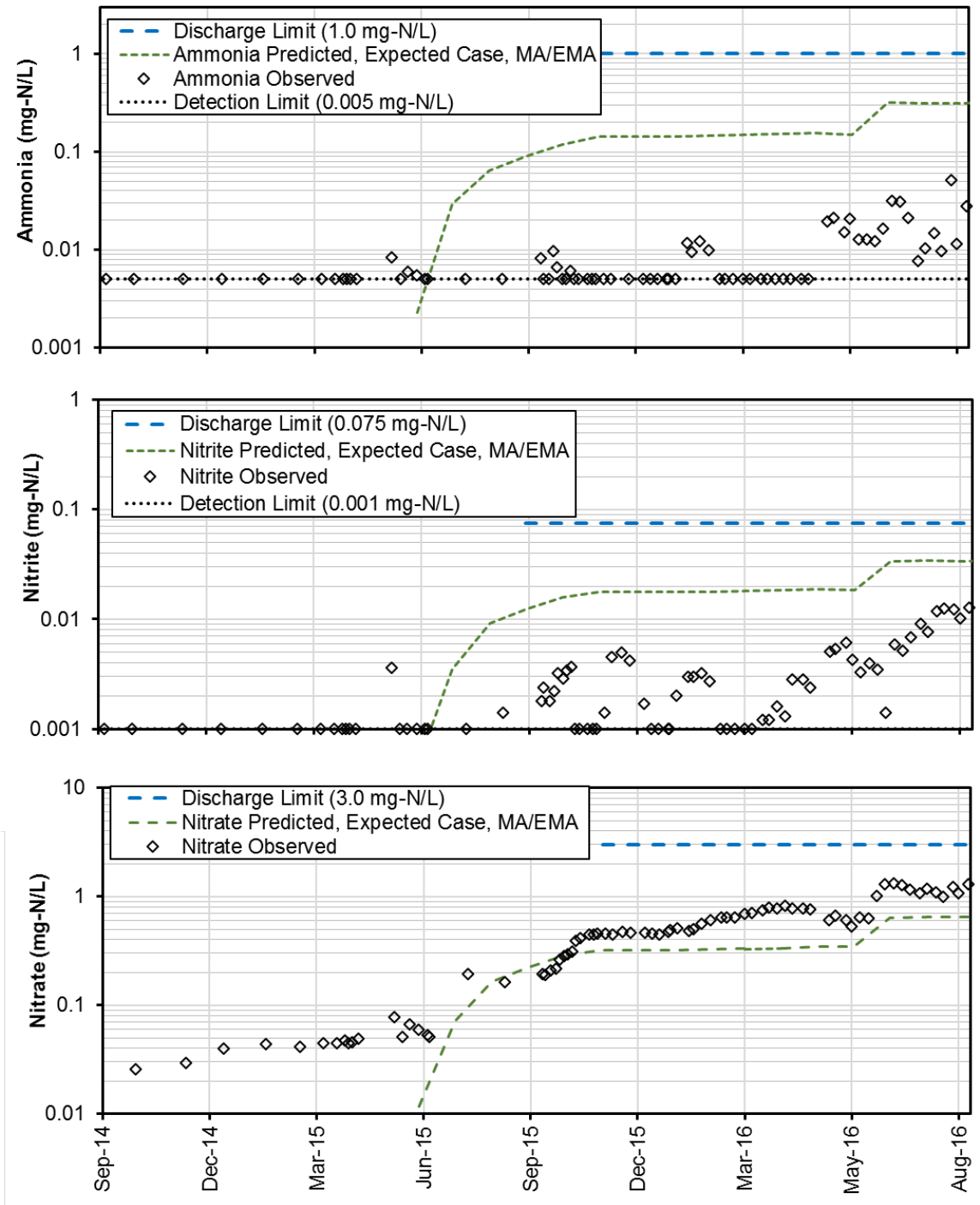


Figure 3-8: Observed concentrations of nitrogen species at BJ 3.10 from September 2014 through August 2016. Data are compared to the Expected Case predicted values presented as part of the Mines Act and Environmental Management Act (MA/EMA) submissions.

3.4.2 Lake Water Column Data

Nitrogen species (nitrate, nitrite and ammonia) have been monitored in the Brucejack Lake water column since 2014 at station BJ 35, the deepest location in Brucejack Lake (80 m deep). The water column is sampled at seven depths (2, 7, 15, 38, 60, 70, and 80m). Water column monitoring data are shown for 2016 in Figure 3-9. Nitrate (NO_3^-) is the predominant form of nitrogen throughout the lake water column for all sampling events. From January through August 2016, the concentrations of nitrogen species at BJ 35 (over all depths) were generally non-detectable for ammonia ($NH_3 + NH_4^+$) and nitrite (NO_2^-). Peak concentrations for ammonia, nitrite and nitrate were 0.10 mg-N/L, 0.059 mg-N/L and 2.0 mg-N/L, respectively (70 m and 80 m depths), observed on August 25th 2016. These elevated signatures for ammonia and nitrite were confined to the lower depths of the lake, with trace or non-detectable levels measured near the lake surface.

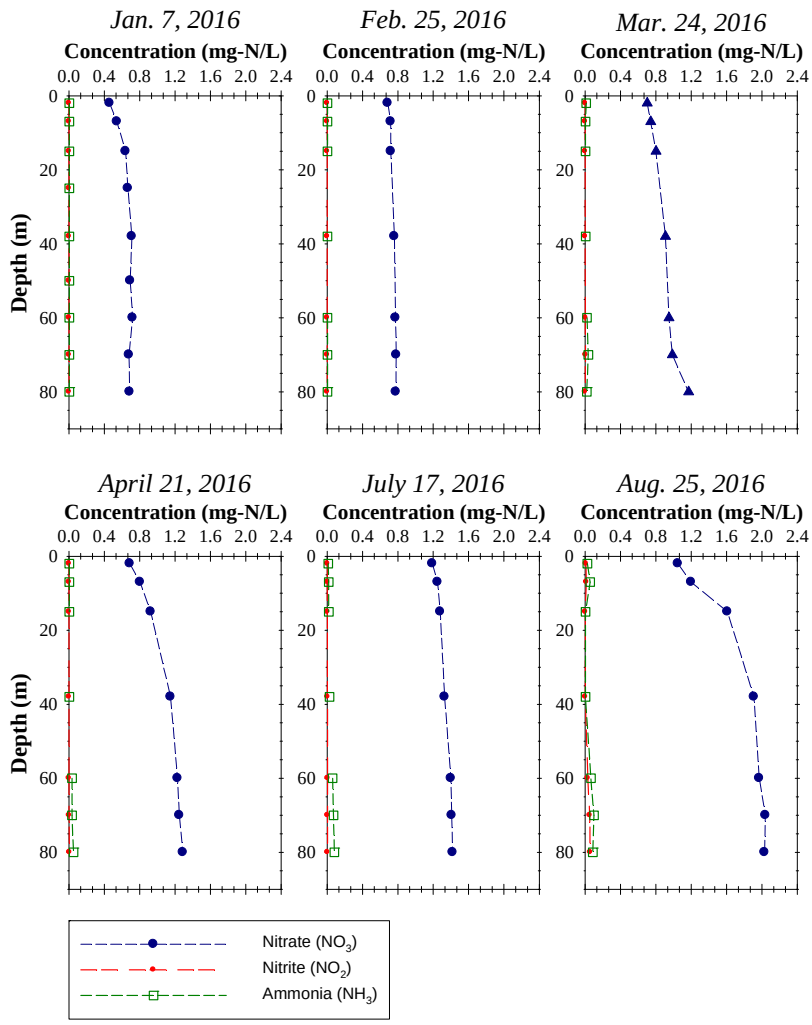


Figure 3-9: Nitrate, ammonia and nitrite concentration profiles in the Brucejack Lake water column (Station BJ 35) from January through August, 2016.

3.5 Nitrification Processes occurring in Brucejack Lake

Empirical observations of lake water quality indicate that nitrification processes are active in Brucejack Lake. At the lake outlet, ammonia is depleted and nitrate is enriched relative to mine water. This shift favouring nitrate is consistent with the influence of nitrification processes on water quality. Nitrification reactions are mediated by bacteria (*e.g., Nitrosomonas* and *Nitrobacter*) that facilitate the oxidation of ammonia to nitrite, and the oxidation of nitrite to nitrate (Figure 3-10).

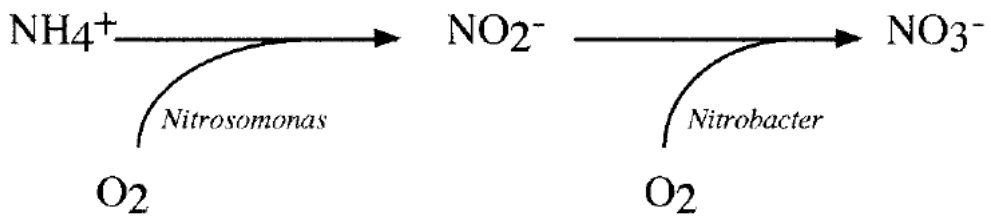


Figure 3-10: Oxidation of ammonia and nitrite by Nitrosomonas and Nitrobacter, respectively (Gerardi, 2002)

Nitrification reactions occur in mine water and in lake water and are mediated by microbial populations that oxidize ammonia and nitrite according to the processes outlined above. Sufficient residence time is required for nitrification processes to run to completion. Residence time in the underground workings is estimated to be approximately 12 hours, which appears to be insufficient time for nitrification processes to run to completion, as is reflected in the elevated proportion of ammonia (30%) in mine water relative to total nitrogen. The estimated residence time of effluent in Brucejack Lake is between 12 to 18 months. Lake water column monitoring provides empirical evidence that nitrification proceeds to near-completion, with ammonia representing only 2.3% (median) of the total nitrogen load at the lake outlet.

To support the conceptual model for nitrification processes, samples of underground mine water, mine slimes and lake water were collected and tested for nitrification bacteria. The test results presented in Table 3-4 indicate the presence of nitrifying bacteria at all locations.

Table 3-4:
Nitrifying bacterial test results for water and mine slime samples.

			#Bacterial Colony Forming Units (CFU)			
Sample	**Location**	**Bacterial Units**	**11 Dec 2014**	**06 Jan 2015**	**08 Mar 2015**	**07 May 2015**
Mine Slime	Underground Mine (1300 Ramp)	CFU/g	620	4100	5600	7700
Mine Water	Underground Mine (1300 Ramp)	CFU/100mL	0	79	280	10
Mine Water	Underground Mine at 1350 Sump	CFU/100mL	55	305	230	120
Lake Water	Lake Outlet at BJ 3.10	CFU/100mL	71	103	0	36
Creek Water	Creek at BJ 2.62	CFU/100mL	3	88	0	29
Control Sample (STP process water)	STP	CFU/100mL	542	2200	3200	2600
Control Sample (deionized water)	Field Blank	CFU/100mL	0	0	0	0

The updated water quality predictions presented below in Section 3.6 incorporate the conversion of nitrogen species due to nitrifying bacteria.

3.6 Updated Water Quality Predictions for Ammonia, Nitrite and Nitrate

Explosive use, mine and surface excavation volumes, as well as water quality data collected since September 2014, were analyzed to re-evaluate the nitrogen terms used in the MA/EMA water quality model. Based on this exercise, it was determined that nitrogen loadings from blasted rock surfaces to the lake were under-estimated. Further, the assumed nitrogen species distribution at the lake outlet did not account for nitrification processes that convert ammonia and nitrite to nitrate within the lake. Based on these considerations, the water quality predictions were revised to reflect:

1) Higher loading rates with respect to nitrogen compounds, based on monitoring data collected between September 2014 and April 2016; and
2) Non-conservative behaviour associated with secondary nitrification processes that convert nitrogen species in the lake, as inferred from the nitrogen species distribution at BJ 3.10.

Selected model terms were updated as shown in Table 3-5 for revised nitrogen species predictions. The Expected Case model scenario was calibrated to the January through April 2016 monitoring data, while the Upper Case was calibrated to the 2015 monitoring data.

Table 3-5:
Updated model terms for the revised water quality nitrogen (N) predictions. Updated terms are compared to the Expected Case and Upper Case terms presented as part of the Mines Act and Environmental Management ACT (MA/EMA) submissions.

		Expected Case		Upper Case	
Model Term	**Units**	**MA/EMA Model**	**Updated Model**	**MA/EMA Model**	**Updated Model**
Powder Factor (pF)	kg explosive / m^3 blasted rock	Construction: 3.24 Operations: 1.97	Construction: 4.15 Operations: 1.97	Construction: 3.24 Operations: 1.97	Construction: 4.15 Operations: 4.15
Excavation Schedule	m^3 blasted rock	Construction: MA/EMA plan Operations: MA/EMA plan	Construction: Nov. 2015 plan Operations: MA/EMA plan	Construction: MA/EMA plan Operations: MA/EMA plan	Construction: Nov. 2015 plan Operations: MA/EMA plan
Mine Water N Load	% of explosives used as N	4%	4%	8%	6%
Mine Water N species distribution	% of total nitrogen as N	Ammonia: 14.8% Nitrite: 4.2% Nitrate: 81%	Ammonia: 28.8% Nitrite: 5.2% Nitrate: 66%	Ammonia: 14.8% Nitrite: 4.2% Nitrate: 81%	Ammonia: 28.8% Nitrite: 5.2% Nitrate: 66%
Underground Waste Rock N Load	% of explosives used as N	5%	13%	10%	18%
Underground Ore N Load	% of explosives used as N	- [A]	13%	- [A]	18%
Lake Water N species distribution	% of total nitrogen as N	Ammonia: 14.8% Nitrite: 4.2% Nitrate: 81%	Ammonia: 4% Nitrite: 2% Nitrate: 94%	Ammonia: 14.8% Nitrite: 4.2% Nitrate: 81%	Ammonia: 4% Nitrite: 2% Nitrate: 94%

[A] In the MA/EMA water quality model, the ore source term was captured in the tailings term and expressed as kg/t of tailings, and is therefore not directly comparable to the revised term.

The Construction Phase excavation schedule was revised in November 2015 by Pretium to address delays with mine construction that resulted in a more compressed excavation schedule than originally planned. The total volume of waste that will be excavated during mine construction remains unchanged; however, the monthly waste volumes for the remainder of mine construction will be slightly higher than originally planned. The actual volumes excavated from September 2015 through August 2016, as well as the revised Construction Phase excavation schedule from September 2016 through May 2017, were included in the model.

The Construction Phase theoretical pF was increased by Pretivm in the November 2015 Construction Phase excavation schedule from 3.24 kg/m^3 to 4.15 kg/m^3. Actual rock

strength will vary from assumptions and will influence the amount of explosive required to fracture the blasted rock. It is typical for the pF to be adjusted based on *in-situ* ground conditions to achieve rock fragmentation objectives. As noted in Section 3.2.1, the pF achieved in 2015 was 4.0 m kg/m^3 increasing slightly to 4.5 kg/m^3 in 2016 (January through August), indicating the revised Construction Phase theoretical pF is appropriate from which to estimate explosive use for construction blasting. The mining of ore during the Operations Phase will be conducted using a different blasting technique (long hole blasting), which requires less explosives than used for mine construction. A theoretical pF of 1.97 kg/m^3 was used for the mine Operations Phase and represents the Expected Case condition. The actual pF will be adjusted based on ground conditions once mining begins, and may increase slightly. Accordingly, an Upper Case pF of 4.15 kg/m^3 (used for mine construction) was conservatively applied to the upper case scenario for the Operations Phase of the mine.

The mine water N load term has been carefully monitored and the Expected Case remains at 4 % of the explosives used (as N), in line with the 4.3% of explosives use observed from January through August 2016 (Section 3.2.1). However, the Upper Case N loss was reduced from 8 % of the explosives used to 6 % of explosives use. This corresponds to the 5.9% N loss that was observed in 2015, a time period that captured challenging blasting conditions and higher rates of N loss from explosives use.

The mine water species distribution previously used in the model was based on mine water monitoring data collected during mine exploration. The mine excavation rate increased significantly from January 2015 through August 2016, reaching the excavation rate expected during the Operations Phase. Therefore, the monitoring data from this time represents a more suitable proxy for modeling the nitrogen species distribution during the Operation Phase. The nitrogen species distribution median values from 2015 and 2016 (for mine water) were used to update the model.

The underground waste rock and ore N loading rates were increased from the previous model assumptions. The N loading rate associated with underground waste rock was previously determined from literature values for surface mining (Ferguson and Leask, 1988; Cameron, 2007; Baily, 2013) and ML/ARD field bin test results. Literature values for N loading to blasted rock in underground mines were not available, and therefore the model assumptions were based on the N loadings observed at surface mines. The N load for ore was originally predicted using supernatant data from metallurgical process bench tests conducted for the Brucejack Gold Mine Project. The actual N loads for waste rock were calculated using monitoring, blasting and excavation data for the January 2015 through April 2016 period, and equates to a loading rate of 18% of explosives used for 2015 and 12% of explosives used from January to April 2016. The observed N loading

rate more accurately represents the waste rock and ore N loading rates for underground blasting conditions at the Brucejack Gold Mine. Based on these site-specific observations, revised rates of 13% of explosives use (Expected Case) and 18% of explosives use (Upper Case) were included in the water quality model.

Previously, the mine water N species distribution was assumed for the lake outlet. However, monitoring data indicate nitrification processes are active in the lake converting ammonia and nitrite to nitrate. Based on observations at the lake outlet (BJ 3.10), the N species distributions were revised to 4%, 2% and 94% for ammonia, nitrite and nitrate, respectively, approximating the median values from 2015 and 2016.

Overall, the revised modeled nitrogen load to Brucejack Lake is approximately 5-fold higher than that presented as part of MA/EMA submission for both the Expected Case and Upper Case model scenarios. This increase in the modeled nitrogen loads are due to:

- An increase in the powder factor for Construction Phase excavation; and
- An increase in the N load on blasted rock surfaces (waste and ore).

Updated water quality predictions to 2035, and water quality observed to 2016, for the lake outlet (BJ 3.10), are shown in Figure 3-11. The Expected Case maximum values for ammonia, nitrite and nitrate are 0.22, 0.11 and 5.1 mg-N/L, respectively, while the Upper Case maximum values for ammonia, nitrite and nitrate are 0.49, 0.24 and 11.5 mg-N/L, respectively (Figure 3-11). The updated predictions for ammonia at BJ 3.10 are in a similar range as the Expected Case predictions presented as part of the MA/EMA (Figure 3-11). The MA/EMA model assumed conservative behaviour for ammonia, and therefore assigned a significant proportion of the nitrogen load to ammonia. Although the overall predicted nitrogen load has increased, ammonia represents a much smaller proportion of the nitrogen load in the updated predictions owing to the inclusion of non-conservative processes. Consequently, the revised ammonia predictions remain low.

The revised predictions for nitrate and nitrite show higher values in comparison to MA/EMA submission. This relates to both: 1) higher N loading rates associated with waste rock and ore; and 2) conversion of ammonia to nitrate through nitrification processes in Brucejack Lake.

The current discharge limits for ammonia, nitrite and nitrate are 1.0, 0.075 and 3.0 mg-N/L, respectively. Under the Expected Case scenario, nitrate is expected to exceed 3.0 mg/L in the summer of 2018, while nitrite is projected to exceed 0.075 mg-N/L in 2019. Ammonia is expected to remain well below the discharge limit of 1.0 mg-N/L for the duration of the project.

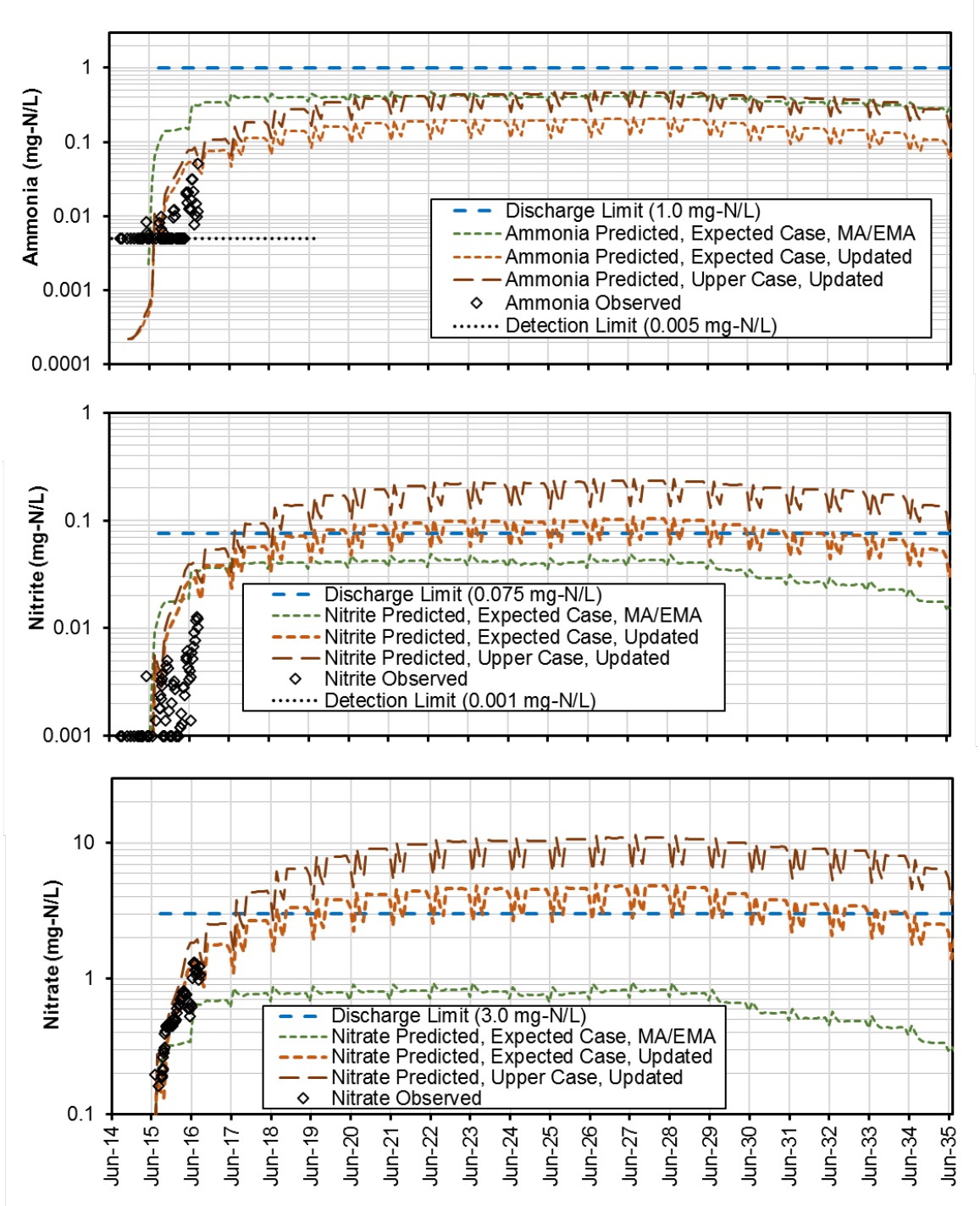


Figure 3-11: Water quality predictions for ammonia, nitrite and nitrate at BJ 3.10 from 2014 through 2035, and observed water quality from September 2014 through August 2016. The updated predictions replace previous predictions included with the Mines Act and Environmental Management Act (MA/EMA) Permits application.

4. Effects Assessment

4. Effects Assessment

4.1 Introduction

The updated predictions for nitrate and nitrite concentrations at the Brucejack Lake outlet (BJ 3.10) exceed the current discharge limits in Effluent Permit PE-107835 (Table 4-1). The current NO_3 discharge limit is equal to the generic long-term BC water quality guideline for the protection of freshwater aquatic life (BCWQG). The current NO_2 discharge limit represents an intermediate value between the short-term BCWQG (0.06 mg-N/L) and the Science Based Environmental Benchmark (0.18 mg-N/L) that was derived for Brucejack Creek in Appendix 7-Z of the MA/EMA Permits Application (Pretivm, 2014).

Table 4-1:
Maximum monthly average predicted concentrations of nitrate and nitrite compared to discharge limits at site BJ 3.10.

	Nitrate (mg-N/L)		Nitrite (mg-N/L)	
Model Case	**Maximum predicted**	**PE-107835 limit**	**Maximum predicted**	**PE-107835 limit**
Expected Case	5.1	3	0.11	0.075
Upper Case	11.5	3	0.24	0.075

The following sections provide a residual effects assessment of the updated predicted concentrations of nitrate and nitrite. The effects assessment method is the same as that used for the MA/EMA Permit Application, which assessed the geographic extent, ecological context, magnitude, duration, frequency, reversibility, and resiliency of potential ecological effects. These criteria were then used to determine the significance of potential effects and confidence in the significance rating.

4.2 Effects Assessment

4.2.1 Geographic Extent

The geographic extent of potential effects from elevated nitrate and nitrite are defined as waters with predicted concentrations greater than BCWQGs. Since BCWQGs are derived to be protective of all species and life stages to continuous exposure, concentrations that are less than the guideline are not predicted to cause toxic effects to aquatic life. Brucejack Creek is predicted to have concentrations of nitrate and nitrite greater than their respective BCWQGs.

Brucejack Creek flows into Sulphurets Creek (Figure 4-1). At site SC0 on Sulphurets Creek, immediately downstream of the confluence with Brucejack Creek, there is a minimum dilution of 8:1 (that is, a minimum of 8 parts Sulphurets water for every part of Brucejack water that flows into Sulphurets Creek) (ERM Rescan, 2014). This level of dilution will produce concentrations that are below BCWQGs for Expected Case and Upper Case predictions of NO_3, and for Expected Case NO_2 (Table 4-2). Upper Case NO_2 prediction would be diluted to 0.028 mg-N/L at 8:1 dilution, which is slightly above the BCWQG. A dilution of 12:1 would be required to produce NO_2 <0.020 mg-N/L in Sulphurets Creek. This level of dilution should be available most of the year at SC0, and would be achieved shortly downstream of SC0 during times of the year with minimum dilution.

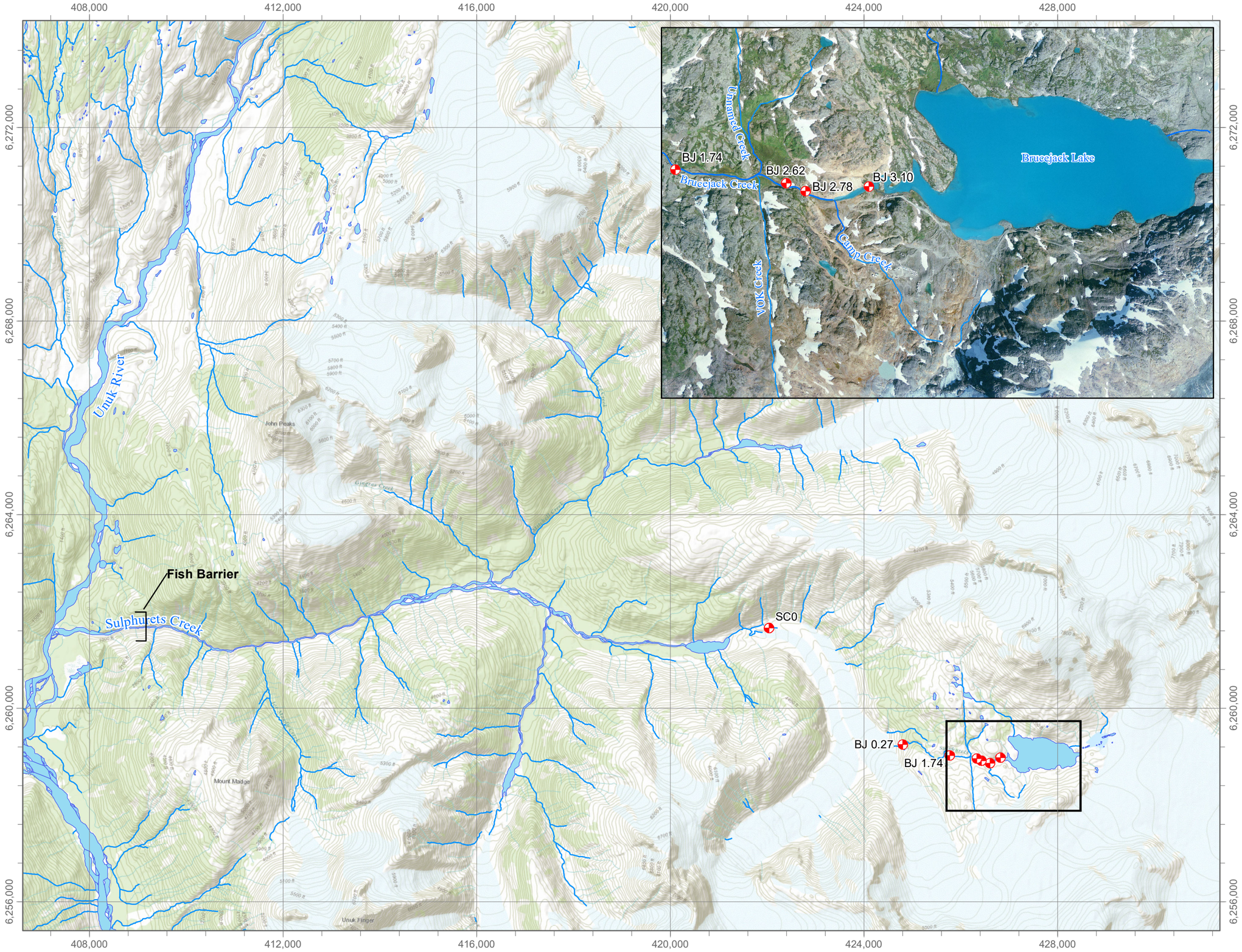
Table 4-2:
Dilution required to equal BC Water Quality Guidelines in Sulphurets Creek

Parameter	Model case	BJ 3.10 (mg-N/L)	SC0 (mg-N/L)	BCWQG (mg-N/L)	Required Dilution
Nitrate	Expected Case	5.1	0.05	3.0	1:1
	Upper Case	11.5	0.05	3.0	3:1
Nitrite	Expected Case	0.11	0.001	0.02	5:1
	Upper Case	0.24	0.001	0.02	12:1

Based on the assessment that BCWQGs will be met in the headwaters of Sulphurets Creek, the geographic extent of the effects of assessment is therefore limited to Brucejack Creek for NO_3, and to site SC0 in Sulphurets Creek for NO_2.

4.2.2 Ecological Context

Brucejack Creek and most of Sulphurets Creek are non-fish-bearing streams. In Sulphurets Creek, the upper limit of fish distribution is defined by a fish barrier approximately 1.3 km upstream of the Unuk River confluence. Overall, the distance between the outlet of Brucejack Lake and fish habitat is approximately 20 km. No amphibians have been noted during ecological surveys of these streams. Aquatic life in these non-fish-bearing water courses is therefore limited to benthic invertebrates and periphyton.



LEGEND

Monitoring Location

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:75,000

0 1 2 Km

DATE SAVED:	Nov 09, 2016
DRAWN BY:	AL
REVIEWED:	MG
VERSION:	1

CLIENT:

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LORAX ENVIRONMENTAL

PROJECT:

Receiving Environment Monitoring Sites

TITLE:

Monitoring Locations

PROJECT #: A384

FIGURE: 4-1

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Surveys in 2014 and 2015 of benthic invertebrate communities in Brucejack Creek show that the assemblage is composed predominantly of chironomids (midges) and oligochaetes (worms) (Figure 4-2). Other taxa were rarely captured. The highest relative percentage of other taxa was 9% Ephemeroptera (mayflies) at BJ0.27 in 2015, although it should be noted that total abundance of invertebrates at that station was low compared to other stations surveyed that year. Only chironomids were found at SC0, in both the 2014 and 2015 surveys. Periphyton surveys in Brucejack Creek have found algal slimes on rocks composed of chlorophytes and diatom species. Macroalgae were not present.

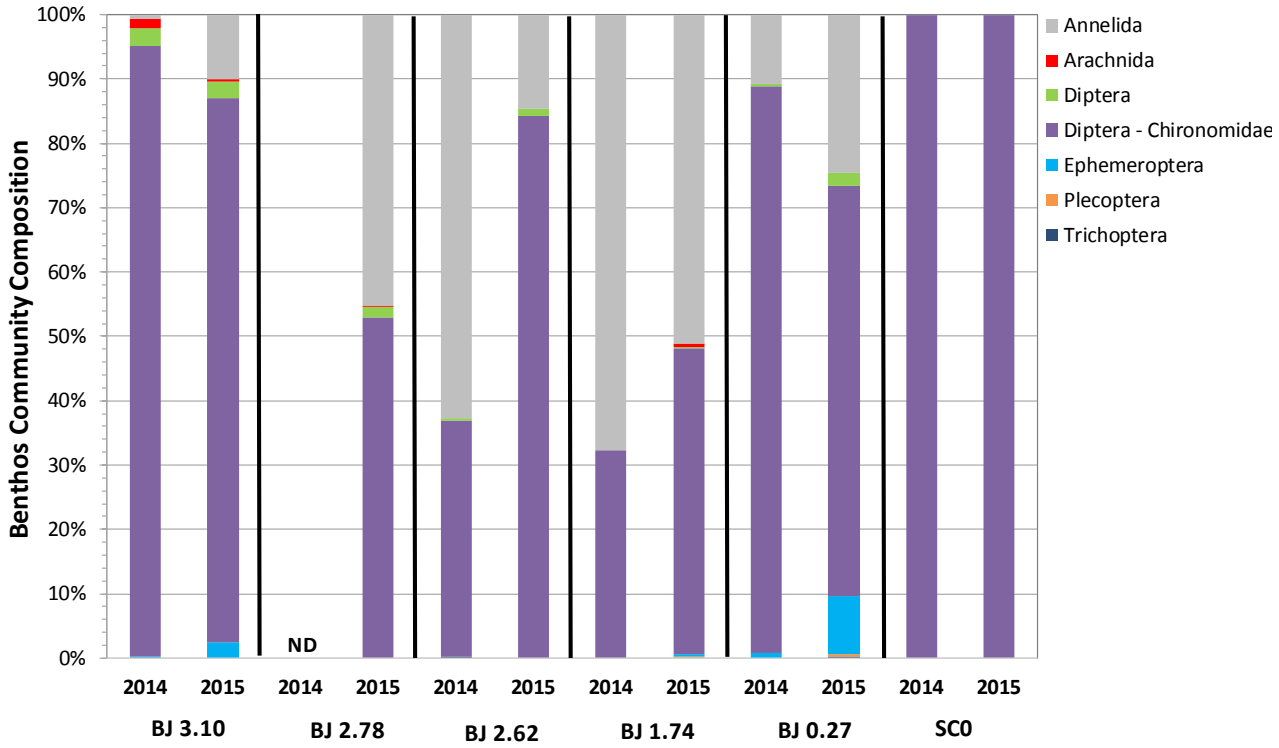

Figure 4-2: Benthic invertebrate community composition by major taxon as measured for 2014 and 2015 biological monitoring programs for Brucejack Creek and upper Sulphurets Creek. ND = no data.

4.2.2.1 Nitrate Toxicity

The long-term BCWQG for NO_3 of 3 mg-N/L was derived from a chronic toxicity endpoint of 30.1 mg-N/L for the pacific tree frog (*Pseudacris regilla*) and a safety factor of 0.1 (Schuyterma and Nebeker 1999). This guideline was supported by a study that measured a statistically significant developmental delay and reduced biomass in early life stage lake trout in water with 6.25 mg/L NO_3-N, and an uncertainty factor of 0.5 (McGurk *et al*. 2006). The fact that the BCWQG for NO_3 is derived from toxicity data for fish and

amphibians, which are not present in the streams being assessed, indicates that the NO_3 BCWQG may be overprotective of aquatic life.

Nitrate chronic toxicity data for invertebrates is summarized in Table 4-3. These data show that invertebrate species that are sensitive to NO_3 toxicity may be negatively affected at concentrations of 11 to 13 mg/L NO_3-N. These data may be representative of species of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) or Trichoptera (caddisflies) which are collectively known as EPT taxa and are considered to be sensitive to most contaminants. EPT taxa are uncommon in Brucejack Creek (Figure 4-2). The chronic toxicity endpoint for *Chironomus dilutus* (49 mg/L NO_3-N) is more applicable to Brucejack Creek benthic invertebrates communities, which are comprised of >90% chironomids and oligochaetes. NO_3 toxicity data for oligochaetes are not available.

Table 4-3:
Chronic nitrate toxicity endpoints for invertebrates

Species	Common name	Life Stage	Endpoint	Nitrate Effect Concentration (mg NO_3-N/L)	Reference
Ceriodaphnia dubia	Water flea	Neonates	7-d IC25 reproduction	11.3	Elphick 2011
Ceriodaphnia dubia	Water flea	Neonates	7-d LOEC* reproduction	43	Scott and Crunkilton 2000
Daphnia magna	Water flea	Neonates	7-d LOEC** reproduction	717	Scott and Crunkilton 2000
Hyalella azteca	Amphipod	Juvenile	14-d IC25 growth	12.9	Elphick 2011
Chironomus dilutus	Midge	3rd Instar	10-d IC25 growth	49.0	Elphick 2011

* Average of five replicate tests
** Average of two replicate tests
IC25 = Concentration that results in 25% inhibition of reproduction or growth
LOEC = Lowest Observed Effect Concentration

Toxicity to periphyton from NO_3 is unlikely, since NO_3 is a macronutrient required for algal growth. Indeed, growth media for culturing the types of algae that occur in Brucejack Creek (chlorophytes and diatoms) typically contain NO_3 levels >100 mg-N/L. Because NO_3 is a nutrient for periphyton, there is the potential that NO_3 from effluent discharge could stimulate the growth of algae in Brucejack Creek and cause a change to trophic status. This could occur only if other macronutrients required for growth, phosphorous in particular, are present. Dissolved orthophosphate concentration at BJ 3.10 has consistently been below its analytical detection limit (<0.001 mg/L) and is not expected to increase during mine operations. Accordingly, phosphorous limitation is expected to prevent enhanced growth of periphyton associated with predictions of NO_3 enrichment.

In summary, NO_3 toxicity data indicate that the Expected Case predicted NO_3 concentrations are one-half the concentration shown to produce chronic toxicity effects to sensitive invertebrates, therefore, no toxic effects from Expected Case predictions are expected. In contrast, the Upper Case NO_3 predictions are approximately equal to the level that has produced chronic toxicity to sensitive invertebrate species. However, species that may be sensitive to NO_3 toxicity (*e.g.*, EPT taxa) make up a small proportion (<10%) of the benthic invertebrate community in Brucejack Creek. Accordingly, the potential for chronic effects, such as reduced growth or reproduction, to the benthic invertebrate community is considered low. As well, benthic invertebrates in Brucejack Creek do not represent potential food for fish, which are not present for 20 km downstream of Brucejack Creek. Therefore, any minor impacts to sensitive taxa in Brucejack Creek would not be predicted to impact fish health.

4.2.2.2 Nitrite Toxicity

The BCWQGs (long- and short-term) for NO_2 were derived to be protective of salmonids. Rainbow trout are the most sensitive species in NO_2 toxicity tests (Nordin and Pommen, 1986). Nitrite toxicity data for invertebrates, which are the taxa representative of aquatic life in Brucejack Creek, are much less common than toxicity data for fish.

The U.S. Environmental Protection Agency contracted NO_2 toxicity testwork to fill in the gaps in toxicity data for invertebrates (USEPA, 2010) (Table 4-4). All tests were acute in nature, except for one test with *Ceriodaphnia dubia*, which produced acute (LC50=4.7 mg/L NO_2-N) and chronic (EC25=1.9 mg/L NO_2-N) toxicity endpoints (acute to chronic ratio (ACR) of 2.5). The lowest toxicity endpoint in this series of tests was an LC50 of 1.0 mg/L NO_2-N for the mayfly species *Amphinemura delosa*. Applying the ACR from the *C. dubia* tests, this translates to a chronic toxicity endpoint of 0.4 mg/L NO_2-N.

Table 4-4:
Chronic nitrite toxicity endpoints for invertebrates

Species	Common name	Endpoint	Nitrite Effect Concentration (mg-N/L)	Reference
Amphinemura delosa	Mayfly	96-h LC50 survival	1.0	USEPA, 2010
Hyalella azteca	Amphipod	96-h LC50 survival	1.5	USEPA, 2010
Ceriodaphnia dubia	Water flea	6-d LC50 survival	4.7	USEPA, 2010
Ceriodaphnia dubia	Water flea	6-d EC25 reproduction	1.9	USEPA, 2010
Chironomus dilutus	Midge	48-h LC50 survival	15.6	USEPA, 2010
Sphaerium simile	Fingernail clam	96-h LC50 survival	55.7	USEPA, 2010
Lampsilis siliquoidea	Fatmucket clam	14-d IC25 growth	177	USEPA, 2010

LC50 = concentration lethal to half the test population
EC25 = Concentration that results in 25% inhibition of reproduction or growth

In summary, the most sensitive invertebrate to NO_2 toxicity is a species of mayfly, which showed an acute toxicity endpoint of 1.0 mg-N/L, and a calculated chronic toxicity endpoint of 0.4 mg-N/L. The Expected Case prediction for NO_2 (0.11 mg-N/L) is four times lower than the most sensitive chronic toxicity endpoint, and the Upper Case prediction (0.24 mg-N/L) is one-half the most sensitive endpoint. The chironomid species tested was much less sensitive to NO_2 toxicity (LC50=15.6 mg/L NO_2-N). Overall, the data indicate that chronic toxicity is not expected to chironomids which make up the majority of benthic invertebrates in Brucejack Creek, nor to mayflies, which are uncommon in Brucejack Creek. Therefore, the ecological context of potential chronic effects to aquatic life in Brucejack Creek is considered low. As well, the ecological context at site SC0 in upper Sulphurets Creek from Upper Case predicted NO_2 concentration is low.

4.2.3 Magnitude, Duration, Frequency, Reversibility, and Resiliency

The magnitude of potential effects to aquatic life is low for both NO_3 and NO_2, since only the uncommon species of benthic invertebrates in Brucejack Creek have the potential for chronic toxicity from exposure to Upper Case predictions.

The duration of potential effects to aquatic life is long-term for both NO_3 and NO_2, since concentrations at the Brucejack Lake outlet are predicted to be elevated for years, until the end of the Operations Phase. The frequency of potential effects to aquatic life is constant, since NO_3 and NO_2 are predicted to be elevated throughout the year. The concentrations of NO_3 and NO_2 are predicted to return to baseline levels after use of explosives ends, during the Closure Phase, and therefore the potential effects are reversible.

The only aquatic life that may be affected by the predicted levels of NO_3 and NO_2 are benthic invertebrate communities in Brucejack Creek. The taxa that have been sampled during benthic invertebrate surveys are common in streams throughout British Columbia. Only the most sensitive taxa, such as mayflies and stoneflies, have the potential to show chronic toxicity associated with NO_3 or NO_2. Acute toxicity effects are not predicted to occur. EPT taxa should be highly resilient to potential chronic toxicity.

4.2.4 Significance of Potential Effects

The potential effects to aquatic life in Brucejack Creek and Upper Sulphurets Creek are considered Not Significant (Table 4-5). The low ecological context of potential effects to aquatic life in these streams is important in making this rating. Chronic toxicity data indicate that potential effects could occur only if the Upper Case NO_3 predictions are realized, and then only for the most sensitive benthic invertebrates, which make up a low proportion of the benthic assemblage. There is no potential for adverse effects to fish or

fish habitat. Also contributing to the Not Significant rating, is the small geographic extent of elevated NO_3 and NO_2 predictions, the low magnitude of potential effects, and the highly resilient nature of benthic invertebrate communities.

Table 4-5:
Residual effects criteria ratings for nitrate and nitrite predictions

Criterion	NO_3 Rating	NO_2 Rating	Comment
Geographic extent	Local	Local	Restricted to Brucejack Creek, and upper Sulphurets Ck. only for Upper Case NO_2 prediction.
Ecological context	Low	Low	No effects predicted to fish, fish habitat, or uncommon species.
Magnitude	Low	Low	Upper Case predictions are equal to (NO_3) or less than (NO_2) levels that could cause chronic toxicity to the most sensitive invertebrates.
Duration	Long-term	Long-term	NO_3 and NO_2 will be elevated throughout the Operations phase of mining.
Frequency	Constant	Constant	Predicted concentrations are relatively constant throughout the year.
Reversibility	Reversible	Reversible	NO_3 and NO_2 levels will return to baseline levels when use of explosives ceases.
Resiliency	High	High	The benthic invertebrates in Brucejack Lake are common throughout British Columbia
Likelihood	Medium	Low	Chronic toxicity from NO_3 is only likely for the Upper Case predictions, and only to the most sensitive benthic invertebrates. Chronic toxicity from predicted NO_2 levels is unlikely.
Significance	Not significant	Not significant	The low ecological context, combined with the other criteria ratings, make the potential for effects to aquatic life not significant.
Confidence	High	High	There is high confidence in the updated nitrogen predictions, and sufficient toxicity data in the literature to rate the ecological effects criteria with high confidence.

5. Conclusions and Recommendations

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5. Conclusions and Recommendations

5.1 Conclusions

Conclusions from this assessment are as follows:

- Residues from explosives used in underground mining were the primary source of nitrogen loading to Brucejack Lake and are primarily associated with underground waste rock and to a lesser degree mine water. Surface waste rock deposition has been a minor contribution and the STP effluent load has been negligible.
- The empirical data acquired between January and April 2016 indicate that the nitrogen loading rate for underground blasted rock to Brucejack Lake is 12% of explosives use as N. This is significantly higher than the literature-based value previously assumed in the MA/EMA Permits Aplication (i.e., 5% of explosives as N). Data presented in the NMP indicates best practices were implemented throughout the monitoring period and therefore this magnitude of nitrogen loss from explosives is expected under normal blasting conditions at Brucejack Gold Mine.
- Empirical evidence indicates nitrification processes are active in Brucejack Lake, depleting ammonia and reducing nitrite levels, and increasing nitrate concentration. The occurrence of nitrification processes is supported by monitoring data that have identified nitrifying bacteria in site matrices (water and sediment) and bench experiments showing nitrification can be induced in ammonia-amended lake waters.
- Nitrification processes in the lake water column are expected to continue through the life of mine and beyond, with nitrate expected to account for more than 95% of the total nitrogen inventory at the lake outlet (BJ 3.10).
- Revised water quality predictions for the Construction and Operations phases incorporate the updated nitrogen loading and speciation information obtained from monitoring data, and show maximum nitrate concentrations of 5.1 mg-N/L (Expected Case) and 11.5 mg-N/L (Upper Case). The maximum values for nitrite are 0.11 mg-N/L (Expected Case) and 0.24 mg-N/L (Upper Case). The current discharge limits for ammonia, nitrite and nitrate are 1.0, 0.075 and 3.0 mg-N/L, respectively. Nitrate is expected to exceed 3.0 mg/L in the summer of 2018 and nitrite is projected to exceed 0.075 mg-N/L in 2019. Ammonia is expected to remain below the discharge limit of 1.0 mg-N/L for the duration of the project.
- Predicted nitrate values at BJ 3.10 are not predicted to cause chronic toxicity to aquatic life in Brucejack Creek or upper Sulphurets Creek. Upper Case nitrate

predictions may cause chronic toxicity to a small proportion of the benthic invertebrate community in Brucejack Creek. Upper Case nitrate predictions will have no adverse effects to fish, fish habitat, or uncommon species. The potential for residual effects from predicted nitrate concentration is considered not significant.

- Predicted nitrite concentrations at BJ 3.10, for both the Expected and Upper Cases, are not predicted to results in chronic toxicity to aquatic life in Brucejack Creek or upper Sulphurets Creek. The potential for adverse effects from predicted nitrite levels is considered not significant.

5.2 Recommendations

Overall, the results provided herein have important implications with regards to nitrite management. The following recommendations are proposed:

- The nitrogen species distribution is controlled by processes occuring in Brucejack Lake. Treatment of nitrite in the WTP effluent is unlikely to influence the concentration of nitrite at the lake outlet. Nitrogen loading is controlled through implementation of the NMP which sets out source control practices and monitoring. It is recommended the discharge limit for nitrite in WTP effluent be removed.
- Nitrate and nitrite are predicted to exceed the current discharge limits and may reach levels of 11.5 mg-N/L and 0.24 mg-N/L, respectively. The biological effects assessment determined that potential adverse effects to aquatic life in Brucejack Creek and Sulphurets Creek from the maximum predicted concentrations are not significant. Therefore, these levels are considered protective of the aquatic life and are recommended as discharge limits at the BJ 3.10 monitoring station.

6. Closure

6. Closure

We trust that this report meets your expectations at this time. Please contact the undersigned with any questions or comments.

Sincerely,

LORAX ENVIRONMENTAL SERVICES LTD.

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References

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Appendix A: Nitrogen Management Plan

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BRUCEJACK GOLD MINE PROJECT

Nitrogen Management Plan

Date: November 10, 2016

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VERSION CONTROL

Revision #	Date Released	Author	Approval	Amendment
0	Nov 16, 2015	Patrick Mueller, Lorax	-	Replacement for the Nitrite Management Plan
1 - Draft	July 29, 2016	Patrick Mueller, Lorax	Lyle Morgentaler, Pretivm	Document reorganization
1 - Final	November 10, 2016	Patrick Mueller, Lorax	Lyle Morgentaler, Pretivm	Update N loading rate and mine water plot

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BRUCEJACK GOLD MINE PROJECT
Nitrogen Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

ANFO	Ammonium Nitrate Fuel Oil
BCM	Bench Cubic Metre
CWP	Contact Water Pond
EMS	Environmental Management System
NMP	Nitrogen Management Plan
NPAG	Not Potentially Acid Generating
O&M	Operation and Maintenance
PAG	Potentially Acid Generating
pF	Powder factor (kg explosive / BCM)
STP	Sewage Treatment Plant
N	Nitrogen
WTP	Water Treatment Plant

1 PURPOSE

The purpose of this Nitrogen Management Plan (NMP) is to provide guidance for Pretium Resources Inc. (Pretivm) on how to avoid, minimize and otherwise mitigate the release of waterborne nitrogen compounds (*i.e.*, ammonia, nitrite, and nitrate) to the receiving environment. These compounds are primarily generated from explosives used during mining operations and to a lesser degree from the discharge of treated domestic wastewater. The procedures used for explosives handling, blasting, contact water management, blasted rock handling, and the treatment of domestic wastewater throughout life of mine are identified or described in the NMP.

2 SCOPE

Source control is generally recognised as an effective strategy for nitrogen mitigation and this is implemented at Brucejack Gold Mine through administrative controls and the implementation of best practices for explosive handling and blasting, as well as domestic wastewater management. Secondary mitigation includes the evaluation and implementation of water treatment as necessary and practicable. The monitoring data collected through the NMP are used to evaluate and update the water quality prediction model source terms for ammonia, nitrite and nitrate.

Specifically, this NMP addresses the following activities:

- Use of best practices for explosives use and domestic wastewater management;
- Establishment of performance targets for the monitoring and management of nitrogen compounds;
- Training programs;
- Monitoring, recordkeeping and corrective action programs;
- Program reviews, evaluation of effectiveness, and implementation of improvements;
- Evaluation of secondary mitigation strategies, as necessary; and,
- Verification of the nitrogen prediction water quality model, as required.

The NMP applies to all individuals working for or on behalf of Pretivm, including employees and contractors who have a role and/or accountability for the development, implementation and maintenance of this NMP.

3 LEGISLATION AND REGULATION

This NMP has been developed in accordance with applicable legislation, regulations and guidelines. Planning for environmental protection is a requirement of both the B.C. *Mines Act* (1996) and the Health, Safety and Reclamation Code for Mines in British Columbia (MEM, 2008). The movement, storage, use and disposal of explosives at mines in B.C. are regulated pursuant to Part 8 of the Code.

Development of a formal NMP is required by Section D.1 of the Brucejack Mine Permit M-243 issued by the Ministry of Energy and Mines under the BC *Mines Act* (1996). The Permit requires that a NMP be prepared as part of an overall EMS and implemented. Section D.5 of the Permit requires that

updates to the water quality prediction model be prepared by July 31, 2020 and every five years thereafter. Discharge of waste from a mine requires authorization pursuant to section 120 (3) of the BC *Environmental Management Act* (2003) and is administered at Brucejack Gold Mine by the BC Ministry of Environment (MOE) under Effluent Permit 107835. An NMP is required under Section 3.2 of the Permit. Treated domestic wastewater is regulated under the BC *Municipal Wastewater Regulation* (Reg. 87/2012).

The *Federal Explosives Act* (R.S.C., 1985, c. E-17) and *Explosives Regulations* (SOR/2013-211) regulate the manufacture, movement, storage, use and disposal of explosives Canada-wide. The BC *Spill Reporting Regulation (*BC Reg. 263/90), issued pursuant to the *Environmental Management Act* (2003), establishes reporting requirements for spills of substances, both as defined in the *Schedule – Reportable Levels for Certain Substances* included in the Regulation. The *Federal Fisheries Act* (R.S.C., 1985, c. F-14, as amended) indicates the release of ammonia, nitrate and nitrite products into fish-bearing waters may constitute deposition of a deleterious substance, as defined in Section 36(3) of the Act. Federally, the discharge of mine effluent is regulated by the *Metal Mining Effluent Regulations* (MMER; SOR/2000-222), issued pursuant to sections 34(2), 36(5), and 38(9) of the Act.

Field sampling must be undertaken in accordance with the *British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment and Biological Samples* (BC MWLAP 2003), and laboratory analyses must be completed in accordance with the *British Columbia Laboratory Manual* (2013 Approval holder Edition; BC MOE 2013).

4 NITROGEN SOURCES AND CONTROLS

4.1 Overview

Residual explosive is a recognized source of ammonia, nitrate and nitrite in adit discharge, surface runoff, and blasted rock surfaces. Nitrogen constitutes approximately 30% of the explosive mixture, apportioned almost equally between ammonia (NH_3 and NH_4^+) and nitrate (NO_3^-) as N, while nitrite (NO_2^-) is an intermediate oxidation product of ammonia. Treated domestic wastewater is also a source of ammonia and nitrate, however this represents a small proportion of the nitrogen load discharged to Brucejack Lake. Water soluble nitrogen compounds are transported to the aquatic environment downstream of Brucejack Mine through discharge from Brucejack Lake at station BJ 3.10.

The Project will generate approximately 1.7 Mm^3 of waste rock from the Mine Site, 1.7 Mm^3 of waste rock from the underground mine and 6.2 Mm3 of ore. Blasting residuals associated with rock excavation can mobilize during the following situations:

- Underground blasting;
- Surface blasting;
- NPAG fill deposition;
- Waste rock storage/deposition; and,
- Ore storage/processing.

Nitrogen residues are exported from blasted rock on the blasted rock surfaces and in the contact water. The mine water is routed through a water treatment plant prior to discharge to Brucejack Lake, whereas waste rock is deposited directly to the lake. Surface contact water from the mill and plant site is diverted to a contact water pond; CWP water is directed to the WTP for treatment prior to discharge to the lake (during mine operations it will be directed to mill process as needed). Contact water may also be discharged directly to Brucejack Lake if the water quality meets WTP discharge limits. Quarry fill is used for road and mill site construction.

4.2 Nitrogen Sources

4.2.1 Explosive Handling and Blasting

The explosive used for underground blasting is an ANFO-emulsion product, TITAN® 7000 Sensitized Bulk Emulsion from Dyno Nobel. Packaged ANFO-Emulsion products are used for surface blasting including DynoNobel BlastGel 1000/1070 or Blastex. Limited amounts of Unimax, a packaged nitroglycerin based explosive, is used for small scale surface blasts.

Handling of explosives is restricted to trained and authorized personnel only. All explosive movements are communicated and traffic control measures are implemented as necessary to minimize accident risk during transport. Explosives are loaded into blast holes with the boosters and detonators; however, detonator tie in is conducted just prior to a blast. Protocols for best blasting practices are listed in Appendix A and Appendix B.

4.2.2 *Explosives Storage Area*

Explosives are stored in restricted areas that are secure and locked, and access is limited to authorized personnel only. Storage conditions are maintained clean and dry. Permanent explosives magazines are located at multiple locations on the mine site and in the underground. Access to the areas is controlled by lock. The four surface magazines are located along the access road at 53 km (2), 71.4 km (1) and 73.2 km (1) and detonators for surface blasting are stored in two magazines at 71.6 km and 73 km. In the underground mine the packaged emulsion products are stored in the WZ 1350 level and bulk emulsion and spoiled explosives are stored in a secured VOK drift. Inventory is used on a first-in, first-out basis to ensure quality control and prevent degradation due to storage. Spoiled explosives are disposed by detonation during the firing of a round during regular blasting operations.

4.2.3 *Rock and Ore Handling*

Waste rock is removed from the underground for disposal in Brucejack Lake. As the mine develops some waste rock will be returned to the underground mine as backfill. Ore is moved to a temporary stockpile for processing in the Mill. Supernatant water from the mill process is discharged to the lake. Surface blasting occurs at the NPAG Quarry and during the Construction Phase at the PAG Mill Site. Quarry rock is used for fill and Mine Site rock is disposed subaqueously in the lake.

Visible non-detonated explosive in the muck pile or in the blasted rock is removed and disposed according to safe disposal practices.

4.2.4 *Explosive Loss Predictions*

A loss of nitrogen from explosive use is normal and expected during blasting operations. For underground operations the overall nitrogen loss rates is on the order of 15% of the explosives used for blasting. Approximately one third of the nitrogen is exported in mine water, and the remaining two thirds remain on the blasted surfaces. The estimates for explosives loss to mine water and the muck pile are summarised in Table 4-1 below. Loss rates were derived using data from underground and surface mining operations (Brucejack Gold Mine monitoring data from January , 2015 through April, 2016 for underground blasting; and, Ferguson and Leask (1988) for surface blasting).

Table 4-1: Explosive losses reporting to Brucejack Lake

		Explosive Loss Rate [1,2]	Destination
Underground Blasting			
	Mine water	4%	Lake
	Underground waste rock storage	13%	Lake
	Underground waste rock backfill	13%	Mine
Surface Blasting			
	NPAG quarry surface runoff	2%	Lake
	NPAG deposition surface runoff	1%	Lake
	Mine Site surface runoff	1%	Lake
	Mine Site waste deposition	2%	Lake

[1] Estimated percentage loss of total explosives used for blasting.
[2] The nitrogen content in the ANFO emulsion products is estimated at 29.7% N assuming an explosive composition of ammonium nitrate (76%), sodium nitrate (12%), mineral oil (7%), and glass oxide (5%).

4.2.5 Treated Domestic Wastewater

Domestic wastewater is treated by the packaged Filterboxx waste water treatment plants using a process that includes a membrane bio-reactor, activated aerobic sludge, membrane clarification and UV disinfection prior to discharge. Two of the plants have a rated treatment capacity of 75 m^3 per day, and the third has a rated capacity of 25 m^3 per day, for a total of 175 m^3 per day maximum discharge of treated domestic wastewater to Brucejack Lake. The plants are operated in accordance with Effluent Permit PE-107835. Maximum predicted discharge levels of nitrate, nitrite and ammonia are presented in Table 4-2. The nitrogen added to the lake from treated domestic wastewater is a small proportion of the total amount when blasting is accounted for, therefore the STPs are not considered for further source control measures.

Table 4-2: Wastewater (Sewage) Treatment Plant Environmental Impact Assessment predicted effluent concentration

	STP effluent
Ammonia (mg N/L)	55
Nitrite (mg N/L)	1
Nitrate (mg N/L)	2

4.3 Source Control

Source control measures are implemented to reduce nitrogen loss from explosives use and to establish mitigation strategies. Source control measures for explosives use and blasting are outlined in Table 4-3 below. Domestic wastewater is treated prior to discharge as described in Section 4.2.5.

Table 4-3: Explosives handling and blasting nitrogen control measures

Activity	Nitrogen Control Measures
Explosive Selection	• Select water resistant explosives appropriate for site conditions
Blast pattern design	• Design patterns to achieve desired fragmentation with minimum explosives use
Blast hole loading	• Dewater blast holes • Used package explosive for flowing holes • Minimize "sleep" time after explosives have been loaded
Water management	• Divert water away from and/or blast holes and contact surfaces

4.4 WTP Effluent and Nitrite Treatment

Mine water and CWP water are routed though the WTP for the removal of solids and dissolved metals prior to discharge. The WTP capacity during the Construction Phase is 6,000 m^3 and this capacity will increase to 10,000 m^3 during the Operations Phase.

Nitrite treatment is a contingency measure and is generally inactive unless certain trigger conditions are met. Trigger conditions are adjusted throughout the year in accordance with WTP effluent quality and to achieve discharge limits in Effluent Permit 107835.

The monitoring of explosives loss to mine water is summarized in Appendix C.

4.5 Secondary Nitrification Processes

WTP discharge is to Brucejack Lake. Natural nitrification processes appear to be active in the lake, converting almost all nitrogen to the nitrate form. Nitrification reactions are controlled by bacteria and can both create and remove nitrite through the oxidation of ammonia to nitrite, and the oxidation of nitrite to nitrate. These reactions can occur in mine water and in the receiving environment and are mediated by distinct the microbial communities *Nitrosomonas* and *Nitrobacter* as indicated in Figure 6-1 below.

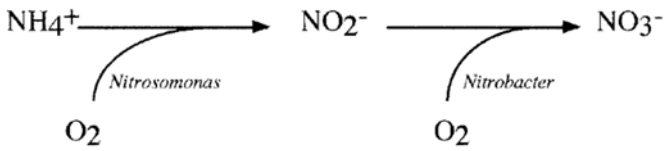

Figure 4-1: Oxidation of ammonia and nitrite by *Nitrosomonas* and *Nitrobacter*, respectively (Gerardi, 2002)

Nitrogen compounds are released at the blast face into contact water. Microbial populations in the underground and surface systems oxidize ammonia and nitrite according to the processes outlined above. Sufficient residence time is required for nitrification processes to run to completion. The anticipated residence time of effluent in the lake is estimated at 12 to 18 months, and lake water

column monitoring provides empirical evidence that nitrification proceeds to completion in the lake water column.

Water based drill fluid can contain biocides that may affect the populations of nitrification bacterial populations in mine water and/or the treatment plant. All drilling additives are reviewed for the presence of bactericides that may inhibit or alter nitrification processes prior to approving their use.

5 NMP IMPLEMENTATION

5.1 Overview

The NMP is implemented with staff training, performance monitoring and management oversight. The monitoring data are regularly reviewed to detect trends and initiate corrective actions as necessary. Personnel are trained regarding the environmental impacts of explosive use and industry best practices for source control. The NMP is regularly reviewed and updated in response to monitoring data and changes in requirements.

5.2 Training, Awareness and Competence

Personnel and contractors involved with explosives handling and use are trained to understand the scope and mechanism of environmental impacts of explosive use. Performance evaluation and follow-up training is provided to relevant personnel to help achieve implementation of best practices.

Work procedures are documented, reviewed and updated to address the following:

- Work practices described in the Health, Safety and Reclamation Code for Mines in British Columbia, Part 8 (2008);
    - Observe the work practices of subordinates on an ongoing basis; and,
    - Take action to correct practices that deviate from best practices.
- Documentation of blasting practices are kept on site with Pretivm and blasting contractors, and describe:
    - Handling, transportation and storage of explosives;
    - Preparation and loading of blast holes;
    - Blast safety protocols;
    - Procedures after blasting; and,
    - Best practices for nitrogen management.

5.3 Performance Monitoring and Reporting

Nitrogen loss performance monitoring is conducted using explosives use and water quality data and is outlined in Table 5-1 below. An internal explosives loss target has been established to detect excessive loss of explosives. The Water Treatment Plant (WTP) effluent performance objectives are specified in Effluent Permit 107835. The monitoring of mine water, CWP water and WTP effluent for nitrogen species is conducted through in-line sensors, on-site field tests and external accredited laboratory analyses. Ammonia and nitrite concentrations are monitored daily to ensure discharge objectives are consistently met. The nitrogen contribution from treated domestic wastewater is compared to the predicted values (refer to Section 4.2.5).

Table 5-1: Performance objectives for nitrogen management

	WTP effluent	BJ 3.10
Explosive loss to mine water (%)	4 [A]	-
Ammonia (mg N/L)	-	1.0
Nitrite maximum / annual mean (mg N/L)	1.9 / 0.65	0.075 / -
Nitrate (mg N/L)	-	3

[A] This is an internal objective only; refer to Appendix C for a summary of WTP monitoring data.

The monitoring data are summarized in daily, weekly and monthly reports that are distributed for review to the Senior Mine Engineer, Environmental Manager and other key individuals (Table 5-2). External reporting of external laboratory results is required via annual reporting. Site monitoring is not required to be submitted, however, records must be maintained and provided for regulatory review if requested by an applicable regulatory agency.

Table 5-2: Summary performance monitoring reports

Report	What is tracked
Blast Report (Daily)	Drilling/blasting records for a given pattern • Hole depth, explosives use, blasted volume/advance • Other activities (*i.e.*, shotcrete, water management, spills, etc.)
Rock Movement Report (Daily)	Waste rock placement records • Surface rock volumes • Underground rock volumes
UG Summary Report (Monthly)	Year to date summary of UG blasting metrics • explosive use, volume blasted, slimes/cuttings moved, shotcrete use
WTP Report (Daily)	Daily performance and effluent quality • report on key performance metrics for WTP operation • metrics include ammonia and nitrite monitoring
WTP Meeting Notes (Weekly)	Water management and WTP Operation • Mine engineer, environmental staff, WTP technician and other expertise as required • WTP performance, mine water quality, CWP water quality, and issues influencing water quality in the water management system

5.4 Inspections

Routine inspections are conducted of the water management systems underground and on surface. The checklists provided in Appendix A and Appendix B are used for evaluation of blasting practices.

Other checklists are developed as needed to target specific control measures. Inspection reports are maintained; corrective actions are identified for implementation.

5.5 Investigation and Corrective Action

Incidents pertinent to nitrogen management are investigated, documented and analyzed to identify root cause. Incident reports are prepared by Pretivm environmental staff and submitted to the Environmental Manager. The reports will include:

- Description of the incident;
- Investigation and assessment of root cause; and,
- Corrective actions.

Corrective actions are implemented in accordance with this plan and reviewed for effectiveness. If further improvements are necessary, these are tracked with the original incident report. The Environmental Manager is responsible to ensure that the corrective actions are tracked until an incident is considered to be addressed. Relevant records are summarized for annual reporting.

5.6 Emergency Procedures and Response

Emergency response procedures related to explosives use are prepared by the blasting contractor. Emergencies are immediately communicated to the Pretivm emergency response coordinator, and response plans and activities are coordinated with Pretivm.

5.7 Management Review

The NMP monitoring activities and results are summarized in reports for regular review by the Senior Mine Engineer and the Environmental Manager. Where improvements are needed agreed upon actions will be implemented.

The overall implementation and effectiveness of the NMP is formally reviewed at least annually with all relevant parties. The Senior Mine Engineer leads the review and includes the Mine Superintendent, The Environmental Superintendent, and all contractors who conduct blasting. Reviews include observation of work practices, review of SOPs, monitoring records, training records, monitoring reports and an overall evaluation of the implementation of the NMP. Review reports are provided to the Senior Mine Engineer and include:

- Review of explosives use, and summary of environmental and audit reports;
- Summary of interviews of the mine, environmental, engineering and blast crews;
- Summary of observed explosives handling and blasting practices; and,
- Action items arising from the review process.

Action items arising from the review process are assigned to the appropriate individuals and tracked for future evaluation.

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APPENDIX A – SURFACE BLASTING PROTOCOLS

There are numerous considerations for surface blasting that may either enhance or reduce explosive consumption efficiency. Outlined below are typical situations that can reduce explosive consumption efficiency and increase the amount of residual nitrogen compounds available for waterborne export from the mine site.

Consideration	Description
Pattern design.	The blast pattern should be designed to meet rock fragmentation objectives considering specific pattern geometry and geo-mechanical rock properties. The pF target is based on the minimum amount of explosive required to meet the fragmentation objectives.
Wet site conditions.	The presence of water in the blast pattern creates challenging site conditions that that affect the amount of nitrogen released to the environment. Explosives appropriate for wet conditions must be used (*i.e.,* ANFO-emulsion). Water must be managed to direct surface flows away from blast holes and to dewater groundwater from the pattern.
Explosive quality.	Poor explosive quality (*i.e.,* out of specification composition) may cause inefficient consumption, and in extreme cases failure to detonate, leading to poor blast performance and increased residue of nitrogen compounds.
Powder column contamination.	This occurs when water or sediment (i.e., drill hole cuttings) are mixed into the powder column. Sediment and water can cause bridging when one part of the powder column is separated from the remaining powder column thereby preventing propagation of the explosion reaction through the column.
Fractures and voids.	Loading explosives into boreholes with fractured rock or voids will result in explosives loading of empty spaces adjacent to the blast hole. Explosives connected to the powder column but confined to small spaces will deflagrate leading to the formation of yellow/orange smoke (nitrous oxides).
Detonation Failure.	The powder column will not detonate if the detonator and booster are outside of the explosive or if the detonator is cut prior to detonation.
Spills.	Spills can collect between blast holes due to leakage from the transfer hosing/connections, or by dripping out of the hose as the hose is moved away from the loaded blast hole. All spills must be removed prior to blasting.
Improper stemming.	Stemming material should be angular coarse crush with a size approximately 1/10th of the blast hole diameter (Floyd, 2011) in order to effectively contain the blast energy. Insufficient stemming or use of improper material for stemming (i.e., borehole cuttings) will fail to contain the blast energy within the blast hole.
Improper decking.	Decking aids with the propagation of the blast energy through the blast pattern and can also be used to isolate the powder column from void spaces and fractured rock. Poorly formed seals will allow the leakage of explosive into empty spaces below the seal, with the seal forming a bridge in the powder column and preventing detonation of the leaked explosive below the seal.

APPENDIX B - UNDERGROUND BLASTING PROTOCOLS

There are numerous considerations for underground blasting that may either enhance or reduce explosive consumption efficiency. Outlined below are typical considerations for improving explosive consumption efficiency and reducing the amount of residual nitrogen compounds available for waterborne export from the mine site.

Consideration	Description
Pattern design	The blast pattern should be designed to meet rock fragmentation objectives considering specific pattern geometry and geo-mechanical rock properties. The pF target is based on the minimum amount of explosive required to meet the fragmentation objectives.
Wet site conditions	The presence of water in the blast face creates challenging blast conditions that that affect the amount of nitrogen released to the environment. Explosives appropriate for wet conditions must be used (*i.e.,* ANFO-emulsion).
Explosive quality	Poor explosive quality (*i.e.,* out of specification composition) may cause inefficient consumption, and in extreme cases failure to detonate, leading to poor blast performance and increased residue of nitrogen compounds.
Powder column contamination	This occurs when water or sediment (*i.e.,* drill hole cuttings) are mixed into the powder column during blast hole loading. Sediment and water can cause bridging when one part of the powder column is separated from the remaining powder column thereby preventing propagation of the explosion reaction through the column.
Fractures and voids	Loading explosives into boreholes with fractured rock or voids will result in explosives loading of empty spaces adjacent to the blast hole. Explosives connected to the powder column but confined to small spaces will deflagrate leading to the formation of yellow/orange smoke (nitrous oxides).
Detonation Failure	The powder column will not detonate if the detonator and booster are outside of the explosive or if the detonator chord is cut prior to detonation.
Spills	Spills can occur at the blast face due to leakage from the blast hole or by dripping out of the hose as the hose is moved between blast holes. All spills must be removed prior to blasting. Waste explosive must be collected before and after detonation to minimize N loss to the adit water and muck pile.

APPENDIX C – EXPLOSIVES LOSS TO ADIT WATER

The loading of nitrogen to mine water from explosives use from January 2015 through August 2016 was compared to expected values (Figure A.3-1 below). During this period the mine excavation rate increased from approximately 1,400 m^3/week in January 2015 to approximately 9,700 m^3/week in August 2016, corresponding to 2,200 kg/week and 35,000 kg/week of explosives consumption, respectively. The nitrogen load from explosives to mine water is expected to be 4% of the explosives use (as N), this is the rate observed during the Exploration Phase of Brucejack Gold Mine.Mine. Mine dewatering flows ranged from approximately 3,000 m^3 to 15,000 m^3 per week during this period and the measured N load exported in the mine water over this monitoring period increased from approximately 30 kg-N/week to 400 kg-N/week.

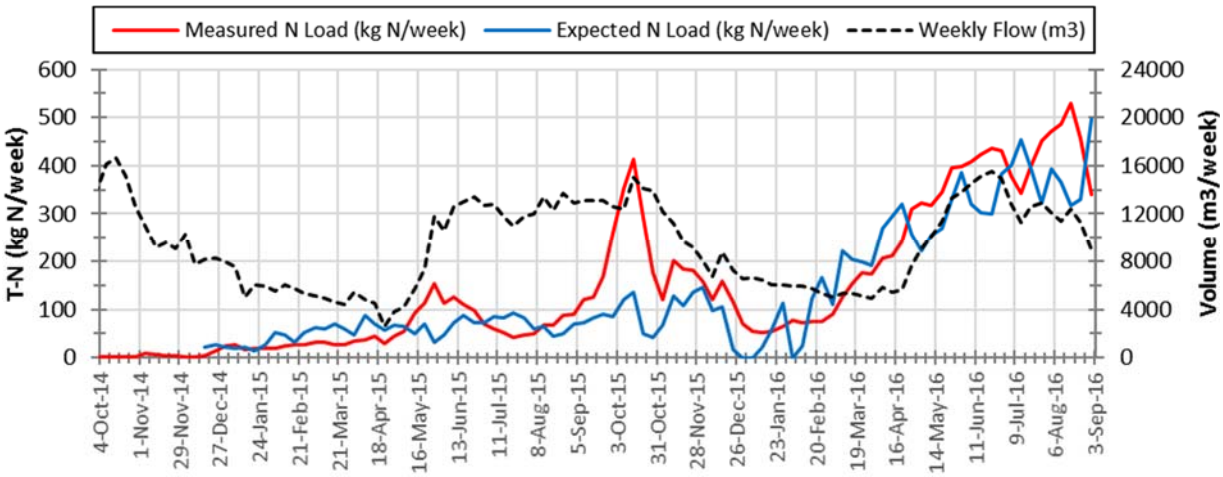


Figure A.3-1: Weekly flows and nitrogen loads predicted from explosive use, and nitrogen loads measured in the WTP effluent (January 2015 through April 2016)

Overall the measured N loads were in the range of expected N loads, except during May 2015 and September/October 2015 when anomalous peak nitrogen loads of 150 kg N/week and 420 kg N/week, respectively, were observed. The short duration increases in the mine water N load were attributable to increased nitrogen losses due to blasting through water bearing structures with significant flows at the blast face; these are challenging blasting conditions that are known to increase the N loading rate from the explosives.

The average loading of N to the mine water in 2015 was 5.9% of the explosives used (as N), and this includes periods of higher than expected N loading to mine water. From January through August 2016 the average N loading rate to mine water was 4.3% of the explosives used (as N), and the comparison of measured and expected loads indicates explosives losses were well controlled through this period.

Appendix B: Nitrogen Monitoring Program Data

PRETIVM

Appendix B.1: Mine Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
10/6/2014	0.109	0.039	0.067	0.003
11/1/2014	1.018	0.277	0.715	0.026
11/2/2014	1.045	0.269	0.748	0.028
11/3/2014	1.102	0.280	0.793	0.029
11/4/2014	1.013	0.210	0.763	0.040
11/5/2014	0.972	0.202	0.741	0.029
11/6/2014	0.932	0.200	0.701	0.031
11/7/2014	0.853	0.164	0.661	0.028
11/8/2014	0.809	0.151	0.622	0.036
11/9/2014	0.756	0.131	0.593	0.032
11/10/2014	0.666	0.100	0.538	0.028
11/11/2014	0.630	0.099	0.508	0.023
11/12/2014	0.603	0.085	0.493	0.025
11/13/2014	0.606	0.091	0.490	0.025
11/14/2014	0.586	0.085	0.483	0.018
11/17/2014	0.502	0.066	0.418	0.018
11/25/2014	0.321	0.043	0.274	0.004
11/26/2014	0.297	0.037	0.255	0.004
11/27/2014	0.287	0.035	0.249	0.004
11/28/2014	0.280	0.034	0.244	0.002
11/29/2014	0.270	0.037	0.230	0.004
11/30/2014	0.265	0.037	0.225	0.003
12/1/2014	0.240	0.033	0.205	0.002
12/2/2014	0.231	0.032	0.197	0.002
12/3/2014	0.232	0.033	0.196	0.003
12/4/2014	0.230	0.034	0.193	0.003
12/5/2014	0.224	0.034	0.186	0.004
12/6/2014	0.215	0.034	0.179	0.002
12/7/2014	0.212	0.034	0.176	0.002
12/11/2014	0.198	0.031	0.163	0.004
12/13/2014	0.315	0.069	0.240	0.006
12/14/2014	0.458	0.112	0.339	0.007
12/15/2014	0.515	0.119	0.386	0.010
12/16/2014	0.600	0.120	0.468	0.012
12/17/2014	0.902	0.221	0.663	0.018
12/18/2014	1.138	0.276	0.834	0.028
12/19/2014	1.213	0.278	0.906	0.029
12/20/2014	1.644	0.413	1.190	0.041
12/21/2014	1.759	0.431	1.280	0.048
12/22/2014	2.186	0.539	1.590	0.057
12/23/2014	2.406	0.575	1.760	0.071
12/24/2014	2.392	0.538	1.780	0.074
12/25/2014	2.576	0.578	1.920	0.078
12/26/2014	2.636	0.540	2.010	0.086
12/27/2014	2.714	0.551	2.070	0.093
12/28/2014	3.134	0.680	2.350	0.104
12/29/2014	3.312	0.742	2.470	0.100
12/30/2014	3.449	0.767	2.580	0.102
12/31/2014	3.562	0.845	2.610	0.107
1/1/2015	3.649	0.837	2.700	0.112
1/2/2015	3.571	0.791	2.670	0.110
1/3/2015	3.637	0.748	2.770	0.119
1/4/2015	3.570	0.727	2.720	0.123
1/5/2015	3.525	0.703	2.700	0.122
1/6/2015	3.440	0.645	2.670	0.125
1/7/2015	3.430	0.622	2.670	0.138

Appendix B.1: Mine Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
1/8/2015	3.358	0.583	2.640	0.135
1/9/2015	3.341	0.565	2.630	0.146
1/10/2015	3.116	0.516	2.460	0.140
1/11/2015	3.093	0.488	2.460	0.145
1/12/2015	3.004	0.437	2.430	0.137
1/13/2015	3.197	0.491	2.550	0.156
1/14/2015	3.181	0.454	2.570	0.157
1/15/2015	3.443	0.546	2.740	0.157
1/16/2015	3.285	0.467	2.660	0.158
1/17/2015	3.266	0.461	2.650	0.155
1/18/2015	3.381	0.506	2.710	0.165
1/19/2015	3.475	0.466	2.860	0.149
1/20/2015	3.517	0.471	2.890	0.156
1/21/2015	3.482	0.437	2.890	0.155
1/22/2015	3.367	0.403	2.810	0.154
1/23/2015	3.313	0.366	2.810	0.137
1/24/2015	3.180	0.358	2.680	0.142
1/25/2015	3.050	0.189	2.710	0.151
1/26/2015	3.199	0.351	2.700	0.148
1/27/2015	3.127	0.330	2.660	0.137
1/28/2015	2.754	0.252	2.370	0.132
1/29/2015	2.788	0.308	2.350	0.130
1/30/2015	3.140	0.305	2.710	0.125
1/31/2015	3.322	0.356	2.870	0.096
2/1/2015	3.279	0.345	2.810	0.124
2/2/2015	3.449	0.424	2.900	0.125
2/3/2015	3.712	0.493	3.090	0.129
2/4/2015	3.912	0.578	3.200	0.134
2/5/2015	3.915	0.565	3.230	0.120
2/6/2015	3.925	0.517	3.290	0.118
2/7/2015	4.090	0.641	3.340	0.109
2/8/2015	4.023	0.608	3.310	0.105
2/9/2015	4.213	0.676	3.430	0.107
2/10/2015	4.416	0.697	3.610	0.109
2/11/2015	4.446	0.657	3.680	0.109
2/12/2015	4.549	0.697	3.760	0.092
2/13/2015	4.465	0.714	3.660	0.091
2/14/2015	4.451	0.705	3.650	0.096
2/15/2015	4.447	0.704	3.650	0.093
2/16/2015	4.642	0.735	3.810	0.097
2/17/2015	4.770	0.780	3.780	0.088
2/18/2015	4.700	0.728	3.860	0.093
2/19/2015	4.940	0.840	3.980	0.086
2/20/2015	5.050	0.859	4.060	0.078
2/21/2015	5.060	0.837	4.090	0.092
2/22/2015	5.057	0.827	4.140	0.090
2/23/2015	5.320	0.876	4.200	0.108
2/24/2015	5.490	0.870	4.400	0.108
2/25/2015	5.820	0.988	4.550	0.112
2/26/2015	5.800	0.956	4.480	0.111
2/27/2015	5.790	0.956	4.590	0.098
2/28/2015	7.020	1.010	4.750	0.115
3/1/2015	6.030	1.030	4.790	0.121
3/2/2015	6.250	1.080	4.860	0.124
3/3/2015	6.280	1.050	5.000	0.135
3/4/2015	6.500	1.060	5.120	0.125

Appendix B.1: Mine Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
3/5/2015	6.610	1.190	5.260	0.129
3/6/2015	7.050	1.210	5.580	0.100
3/8/2015	6.870	1.240	5.500	0.118
3/10/2015	6.630	1.150	5.400	0.116
3/12/2015	6.290	1.060	4.980	0.118
3/15/2015	6.120	1.060	4.740	0.124
3/17/2015	5.950	0.996	4.660	0.127
3/19/2015	5.920	1.130	4.640	0.111
3/22/2015	6.210	1.190	4.930	0.110
3/24/2015	6.310	1.100	4.980	0.113
3/26/2015	6.630	1.190	5.170	0.104
3/29/2015	6.350	1.150	5.190	0.081
4/2/2015	6.600	1.180	5.410	0.043
4/5/2015	7.390	1.440	6.150	0.072
4/7/2015	8.320	1.420	6.710	0.130
4/9/2015	9.230	1.760	7.480	0.173
4/12/2015	10.100	2.110	7.940	0.166
4/14/2015	10.600	2.130	8.430	0.229
4/16/2015	10.900	2.200	8.710	0.147
4/18/2015	11.500	2.010	9.280	0.135
4/21/2015	11.800	1.970	9.650	0.111
4/23/2015	12.100	1.910	10.000	0.059
4/26/2015	12.100	2.000	10.100	0.063
4/28/2015	11.400	1.920	9.860	0.027
5/1/2015	11.900	1.800	9.700	0.064
5/2/2015	12.300	2.240	9.820	0.090
5/5/2015	13.900	3.020	11.000	0.207
5/7/2015	15.100	3.180	11.500	0.278
5/10/2015	16.800	4.280	12.000	0.368
5/12/2015	16.200	3.950	11.500	0.421
5/15/2015	16.100	3.980	12.000	0.477
5/17/2015	16.000	4.200	11.400	0.511
5/19/2015	14.700	3.170	11.000	0.379
5/21/2015	14.000	3.380	10.400	0.491
5/24/2015	13.300	3.040	9.920	0.508
5/26/2015	12.400	2.850	8.870	0.490
5/28/2015	10.700	2.620	7.790	0.396
5/31/2015	10.900	2.590	7.550	0.314
6/2/2015	10.100	2.420	7.290	0.363
6/4/2015	11.800	2.760	8.210	0.364
6/7/2015	9.380	2.390	6.760	0.235
6/9/2015	9.350	2.310	6.730	0.206
6/11/2015	8.500	1.820	6.550	0.078
6/14/2015	8.280	1.750	6.100	0.206
6/16/2015	9.080	1.720	5.990	0.184
6/18/2015	8.110	2.060	5.860	0.215
6/21/2015	7.100	1.900	5.090	0.187
6/23/2015	6.690	1.500	4.510	0.147
6/25/2015	6.170	1.580	4.170	0.149
6/28/2015	5.510	1.340	3.870	0.163
6/30/2015	5.210	1.050	3.700	0.119
7/2/2015	4.500	0.912	3.450	0.133
7/5/2015	4.460	0.944	3.640	0.101
7/9/2015	4.810	0.996	3.560	0.072
7/12/2015	4.270	0.884	3.200	0.066
7/14/2015	4.260	0.885	3.130	0.064

Appendix B.1: Mine Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
7/16/2015	4.260	0.883	3.130	0.047
7/19/2015	3.760	1.010	2.620	0.126
7/26/2015	4.110	1.160	2.700	0.128
8/3/2015	4.240	1.060	2.490	0.143
8/9/2015	5.070	1.220	3.030	0.148
8/16/2015	5.510	1.480	3.180	0.176
8/23/2015	6.500	1.610	3.480	0.176
8/30/2015	6.770	1.870	3.830	0.185
9/7/2015	9.720	2.880	5.850	0.219
9/13/2015	9.280	2.960	5.600	0.269
9/20/2015	12.100	4.110	7.280	0.281
10/4/2015	29.200	11.200	18.400	0.442
10/7/2015	29.900	11.100	18.500	0.469
10/15/2015	25.100	8.890	16.000	0.520
10/16/2015	19.500	6.910	12.300	0.478
10/17/2015	25.100	8.890	16.000	0.520
10/19/2015	19.500	6.910	12.300	0.478
10/25/2015	11.800	3.680	7.300	0.409
11/2/2015	8.450	2.570	5.610	0.351
11/8/2015	19.700	6.830	12.500	0.505
11/15/2015	18.800	6.130	12.500	0.559
11/22/2015	19.800	5.830	13.300	0.640
11/30/2015	19.600	5.520	13.600	0.710
12/7/2015	17.000	5.040	11.500	0.673
12/15/2015	18.700	5.350	12.500	0.705
12/20/2015	17.500	0.423	11.700	0.708
12/28/2015	9.710	0.395	6.410	0.541
1/4/2016	7.610	1.860	4.950	0.498
1/18/2016	8.990	2.210	5.770	0.577
2/1/2016	13.700	3.900	8.850	0.633
2/8/2016	12.000	3.250	7.850	0.650
2/23/2016	14.500	4.100	9.520	0.818
3/7/2016	23.900	6.280	15.400	1.140
3/21/2016	35.700	9.030	23.800	1.630
4/3/2016	34.700	7.360	23.800	1.610
4/18/2016	44.200	11.800	30.400	1.660
5/9/2016	30.700	7.860	21.000	1.670
5/23/2016	29.800	7.430	21.000	1.490
6/6/2016	27.900	7.390	19.300	1.480
6/20/2016	28.100	7.120	19.000	1.600
7/11/2016	30.700	8.500	20.400	1.590
7/18/2016	31.500	8.700	21.300	1.740
8/9/2016	44.300	11.400	30.800	2.090
8/31/2016	37.200	10.500	27.700	2.380

Appendix B.2 Mine Flows

Date	Dewatering Flow	Date	Dewatering Flow	Date	Dewatering Flow
	m3/week		m3/week		m3/week
10/1/2014	13589	1/7/2015	7596	1/6/2016	6677
10/8/2014	16095	1/14/2015	5050	1/13/2016	6400
10/15/2014	16631	1/21/2015	6044	1/20/2016	6015
10/22/2014	15095	1/28/2015	5956	1/27/2016	6031
10/29/2014	12604	2/4/2015	5537	2/3/2016	5891
11/5/2014	10970	2/11/2015	6010	2/10/2016	5930
11/12/2014	9209	2/18/2015	5736	2/17/2016	5771
11/19/2014	9612	2/25/2015	5347	2/24/2016	5300
11/26/2014	9022	3/4/2015	5095	3/2/2016	5064
12/3/2014	10255	3/11/2015	4970	3/9/2016	5351
12/10/2014	7782	3/18/2015	4629	3/16/2016	5300
12/17/2014	8191	3/25/2015	4428	3/23/2016	5132
12/24/2014	8283	4/1/2015	5408	3/30/2016	4963
12/31/2014	7993	4/8/2015	4857	4/6/2016	5887
		4/15/2015	4492	4/13/2016	5404
		4/22/2015	2591	4/20/2016	5648
		4/29/2015	3844	4/27/2016	7691
		5/6/2015	4221	5/4/2016	9053
		5/13/2015	5731	5/11/2016	10082
		5/20/2015	7351	5/18/2016	11372
		5/27/2015	11824	5/25/2016	13263
		6/3/2015	10589	6/1/2016	13777
		6/10/2015	12576	6/8/2016	14568
		6/17/2015	13019	6/15/2016	15101
		6/24/2015	13456	6/22/2016	15486
		7/1/2015	12719	6/29/2016	14944
		7/8/2015	12809	7/6/2016	12766
		7/15/2015	11748	7/13/2016	11253
		7/22/2015	11010	7/20/2016	12591
		7/29/2015	11775	7/27/2016	12911
		8/5/2015	11961	8/3/2016	12135
		8/12/2015	13421	8/10/2016	11341
		8/19/2015	12250	8/17/2016	12415
		8/26/2015	13668	8/24/2016	11272
		9/2/2015	12857	8/31/2016	8963
		9/9/2015	13086		
		9/16/2015	13086		
		9/23/2015	13152		
		9/30/2015	12555		
		10/7/2015	12450		
		10/14/2015	15046		
		10/21/2015	14158		
		10/28/2015	13951		
		11/4/2015	12163		
		11/11/2015	11175		
		11/18/2015	9631		
		11/25/2015	9195		
		12/2/2015	8072		
		12/9/2015	6786		
		12/16/2015	8733		
		12/23/2015	7207		
		12/30/2015	6535		

Appendix B.3: Underground Explosives Use

Date	Explosives Use	Measured N Load
	kg/week	kg-N/week
01/10/2014	0	1.5
08/10/2014	0	1.8
15/10/2014	125	2.2
22/10/2014	425	3.2
29/10/2014	1900	3.1
05/11/2014	475	9.9
12/11/2014	0	6.9
19/11/2014	0	5.1
26/11/2014	0	3.3
03/12/2014	0	2.6
10/12/2014	0	1.7
17/12/2014	1963	3.7
24/12/2014	2388	15.2
31/12/2014	1835	24.4
07/01/2015	1725	27.0
14/01/2015	1850	16.1
21/01/2015	1225	20.6
28/01/2015	2400	18.7
04/02/2015	4350	18.8
11/02/2015	4013	24.8
18/02/2015	2800	26.2
25/02/2015	4475	28.0
04/03/2015	5300	31.8
11/03/2015	4975	33.6
18/03/2015	5975	28.2
25/03/2015	4975	27.4
01/04/2015	4025	35.1
08/04/2015	7375	36.5
15/04/2015	5925	45.1
22/04/2015	4925	29.8
29/04/2015	5765	45.6
06/05/2015	5388	53.9
13/05/2015	4118	92.3
20/05/2015	5875	114.0
27/05/2015	2688	154.4
03/06/2015	4100	113.1
10/06/2015	6200	125.0
17/06/2015	7313	111.4
24/06/2015	6025	96.7
01/07/2015	6075	69.9
08/07/2015	7199	59.1
15/07/2015	7070	52.2
22/07/2015	7750	43.5
29/07/2015	6950	48.1
05/08/2015	4980	51.1
12/08/2015	5500	67.1
19/08/2015	3700	68.3
26/08/2015	4250	87.3
02/09/2015	6000	90.8

Appendix B.3: Underground Explosives Use

Date	Explosives Use	Measured N Load
	kg/week	kg-N/week
09/09/2015	6125	120.2
16/09/2015	7000	126.9
23/09/2015	7650	168.9
30/09/2015	7200	260.6
07/10/2015	10150	352.5
14/10/2015	11475	413.8
21/10/2015	4175	293.2
28/10/2015	3525	177.0
04/11/2015	5800	120.0
11/11/2015	10700	200.6
18/11/2015	9125	183.3
25/11/2015	11481	180.7
02/12/2015	12331	157.3
09/12/2015	8213	119.9
16/12/2015	8900	157.8
23/12/2015	1531	116.7
30/12/2015	0	70.9
06/01/2016	0	54.0
13/01/2016	1900	52.5
20/01/2016	5100	54.3
27/01/2016	9620	66.3
03/02/2016	0	77.5
10/02/2016	2050	73.7
17/02/2016	10300	75.0
24/02/2016	14020	75.6
02/03/2016	9300	91.1
09/03/2016	18646	126.0
16/03/2016	17113	152.8
23/03/2016	16760	176.7
30/03/2016	16120	174.9
06/04/2016	22598	207.5
13/04/2016	24828	212.2
20/04/2016	26896	242.8
27/04/2016	21704	310.1
04/05/2016	18602	323.4
11/05/2016	21372	318.8
18/05/2016	22629	344.7
25/05/2016	27792	395.7
01/06/2016	32568	398.8
08/06/2016	26856	409.2
15/06/2016	25422	422.6
22/06/2016	25280	435.6
29/06/2016	32214	430.8
06/07/2016	33776	379.2
13/07/2016	38242	343.8
20/07/2016	33362	398.8
27/07/2016	27056	451.1
03/08/2016	33036	472.7
10/08/2016	30740	485.9

Appendix B.3: Underground Explosives Use

Date	Explosives Use	Measured N Load
	kg/week	kg-N/week
17/08/2016	26808	530.1
24/08/2016	27737	455.8
31/08/2016	41907	340.8

Appendix B.4: Water Treatment Plant Effluent Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
10/8/2014	0.129	0.040	0.088	0.002
10/13/2014	0.122	0.050	0.072	0.005
10/14/2014	0.124	0.054	0.070	0.005
10/15/2014	0.120	0.050	0.070	0.005
10/16/2014	0.166	0.098	0.068	0.005
10/17/2014	0.143	0.074	0.066	0.002
10/18/2014	0.147	0.064	0.083	0.005
10/19/2014	0.207	0.085	0.122	0.005
10/20/2014	0.229	0.076	0.148	0.005
10/21/2014	0.241	0.071	0.165	0.005
10/22/2014	0.262	0.086	0.169	0.006
10/23/2014	0.253	0.080	0.168	0.006
10/24/2014	0.247	0.084	0.158	0.005
10/25/2014	0.227	0.072	0.151	0.005
10/26/2014	0.226	0.071	0.150	0.005
10/27/2014	0.221	0.071	0.143	0.006
10/28/2014	0.229	0.068	0.153	0.007
10/29/2014	0.253	0.075	0.172	0.006
10/30/2014	0.350	0.103	0.234	0.013
10/31/2014	0.537	0.148	0.373	0.016
11/1/2014	0.687	0.186	0.478	0.023
11/2/2014	1.031	0.292	0.711	0.028
11/3/2014	1.045	0.278	0.737	0.030
11/4/2014	1.074	0.260	0.788	0.026
11/5/2014	1.021	0.220	0.773	0.028
11/6/2014	0.993	0.224	0.740	0.029
11/7/2014	0.945	0.210	0.707	0.028
11/8/2014	0.872	0.191	0.655	0.026
11/9/2014	0.834	0.166	0.637	0.031
11/10/2014	0.762	0.149	0.584	0.029
11/11/2014	0.710	0.131	0.552	0.027
11/12/2014	0.636	0.110	0.504	0.022
11/13/2014	0.625	0.103	0.496	0.026
11/14/2014	0.613	0.102	0.485	0.026
11/15/2014	0.633	0.095	0.517	0.021
11/18/2014	0.516	0.081	0.421	0.014
11/26/2014	0.337	0.054	0.278	0.005
11/27/2014	0.310	0.052	0.254	0.005
11/28/2014	0.307	0.051	0.256	0.005
11/29/2014	0.247	-	0.240	0.007
11/30/2014	0.286	0.045	0.233	0.008
12/1/2014	0.270	0.046	0.224	0.005
12/2/2014	0.252	0.043	0.206	0.003
12/3/2014	0.243	0.042	0.199	0.002
12/4/2014	0.247	0.045	0.199	0.003
12/5/2014	0.245	0.046	0.196	0.003
12/6/2014	0.232	0.046	0.186	0.005
12/7/2014	0.228	0.044	0.182	0.003
12/8/2014	0.231	0.044	0.185	0.003
12/10/2014	0.213	0.043	0.168	0.002
12/12/2014	0.212	0.043	0.169	0.005
12/13/2014	0.204	0.043	0.161	0.010 *
12/14/2014	0.310	0.077	0.226	0.007
12/15/2014	0.298	-	0.290	0.008
12/16/2014	0.506	0.125	0.372	0.009
12/17/2014	0.565	0.126	0.429	0.010
12/18/2014	0.676	0.150	0.513	0.013
12/19/2014	1.044	0.251	0.768	0.025
12/20/2014	1.179	0.280	0.871	0.028

Appendix B.4: Water Treatment Plant Effluent Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
12/21/2014	1.446	0.357	1.050	0.039
12/22/2014	1.753	0.437	1.270	0.046
12/23/2014	1.978	0.475	1.450	0.053
12/24/2014	2.364	0.576	1.720	0.068
12/25/2014	2.384	0.556	1.750	0.078
12/26/2014	2.482	0.565	1.840	0.077
12/27/2014	2.612	0.557	1.970	0.085
12/28/2014	2.679	0.549	2.040	0.090
12/29/2014	2.978	0.642	2.240	0.096
12/30/2014	3.309	0.723	2.480	0.106
12/31/2014	3.394	0.758	2.530	0.106
1/1/2015	3.533	0.814	2.610	0.109
1/2/2015	3.604	0.813	2.680	0.111
1/3/2015	3.498	0.717	2.670	0.111
1/4/2015	3.610	0.752	2.740	0.118
1/5/2015	3.618	0.758	2.740	0.120
1/6/2015	3.625	0.720	2.780	0.125
1/7/2015	3.510	0.658	2.730	0.122
1/8/2015	3.464	0.638	2.700	0.126
1/9/2015	3.417	0.610	2.670	0.137
1/10/2015	3.377	0.588	2.640	0.149
1/11/2015	3.141	0.511	2.490	0.140
1/12/2015	3.134	0.507	2.480	0.147
1/13/2015	3.023	0.448	2.440	0.135
1/14/2015	3.088	0.470	2.470	0.148
1/15/2015	3.284	0.464	2.660	0.160
1/16/2015	3.310	0.509	2.650	0.151
1/17/2015	3.331	0.503	2.670	0.158
1/18/2015	3.292	0.466	2.670	0.156
1/19/2015	3.291	0.476	2.660	0.155
1/20/2015	3.438	0.481	2.810	0.147
1/21/2015	3.554	0.436	2.960	0.158
1/22/2015	3.527	0.445	2.930	0.152
1/23/2015	3.464	0.421	2.890	0.153
1/24/2015	3.418	0.387	2.880	0.151
1/25/2015	3.324	0.349	2.830	0.145
1/26/2015	3.261	0.349	2.770	0.142
1/27/2015	3.260	0.359	2.750	0.151
1/28/2015	3.134	0.301	2.690	0.143
1/29/2015	3.137	0.315	2.670	0.152
1/30/2015	2.774	0.285	2.370	0.119
1/31/2015	2.950	0.289	2.540	0.121
2/1/2015	3.220	0.324	2.780	0.116
2/2/2015	3.288	0.331	2.840	0.117
2/3/2015	3.471	0.418	2.930	0.123
2/4/2015	3.711	0.467	3.120	0.124
2/5/2015	3.967	0.566	3.270	0.131
2/6/2015	3.899	0.503	3.270	0.126
2/7/2015	3.966	0.544	3.300	0.122
2/8/2015	4.105	0.587	3.400	0.118
2/9/2015	4.128	0.618	3.400	0.110
2/10/2015	4.296	0.697	3.490	0.109
2/11/2015	4.493	0.721	3.660	0.112
2/12/2015	4.549	0.671	3.770	0.108
2/13/2015	4.558	0.695	3.760	0.103
2/14/2015	4.509	0.687	3.740	0.082
2/15/2015	4.509	0.696	3.710	0.103
2/16/2015	4.519	0.707	3.720	0.092
2/17/2015	4.589	0.695	3.800	0.094

Appendix B.4: Water Treatment Plant Effluent Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
2/18/2015	4.740	0.722	3.810	0.088
2/19/2015	4.660	0.719	3.910	0.089
2/20/2015	5.080	0.818	4.060	0.087
2/21/2015	5.200	0.868	4.080	0.084
2/22/2015	5.090	0.815	4.140	0.088
2/23/2015	5.142	0.828	4.220	0.094
2/24/2015	5.360	0.875	4.160	0.103
2/25/2015	5.730	0.963	4.500	0.106
2/26/2015	5.830	0.990	4.600	0.106
2/27/2015	5.770	0.989	4.560	0.116
2/28/2015	5.840	0.953	4.620	0.098
3/1/2015	5.950	1.020	4.800	0.117
3/2/2015	6.090	1.030	4.860	0.121
3/3/2015	6.200	1.080	4.970	0.127
3/4/2015	6.250	1.090	5.060	0.141
3/5/2015	6.600	1.050	5.230	0.122
3/6/2015	6.710	1.180	5.380	0.133
3/7/2015	6.820	1.210	5.530	0.127
3/9/2015	6.850	1.230	5.460	0.124
3/11/2015	6.810	1.150	5.510	0.127
3/13/2015	6.400	1.070	4.880	0.124
3/16/2015	5.930	1.080	4.710	0.123
3/18/2015	5.760	1.060	4.650	0.127
3/20/2015	6.050	1.200	4.840	0.131
3/23/2015	6.230	1.220	4.990	0.110
3/25/2015	6.070	1.110	4.670	0.100
3/27/2015	6.440	1.200	5.070	0.102
3/30/2015	6.370	1.050	5.270	0.084
4/3/2015	6.440	0.963	5.570	0.174
4/6/2015	7.400	1.290	6.160	0.087
4/8/2015	8.270	1.230	6.790	0.123
4/10/2015	8.850	1.390	7.550	0.140
4/13/2015	9.820	1.750	8.130	0.145
4/15/2015	10.100	1.930	7.990	0.122
4/17/2015	10.700	2.130	8.890	0.179
4/19/2015	11.100	1.950	8.880	0.136
4/22/2015	11.800	1.910	9.670	0.074
4/24/2015	12.300	1.850	10.200	0.061
4/27/2015	12.200	2.230	10.600	0.068
4/29/2015	11.600	1.710	9.940	0.045
5/2/2015	11.800	1.830	10.400	0.086
5/3/2015	12.000	2.040	9.810	0.111
5/6/2015	13.700	2.910	11.100	0.172
5/8/2015	13.100	1.990	11.600	0.241
5/11/2015	12.800	0.036	13.000	0.042
5/13/2015	11.800	0.123	11.600	0.033
5/16/2015	11.700	0.013	12.400	0.021
5/18/2015	11.900	0.006	12.400	0.005
5/20/2015	11.500	0.621	10.500	0.066
5/22/2015	10.900	0.030	10.900	0.018
5/25/2015	13.500	0.009	10.400	0.007
5/27/2015	9.510	0.013	9.500	0.010
5/29/2015	8.240	0.011	8.430	0.007
6/1/2015	8.030	0.021	7.850	0.014
6/3/2015	7.650	0.019	7.680	0.007
6/5/2015	8.310	0.025	8.540	0.007
6/8/2015	6.850	0.025	7.080	0.007
6/10/2015	6.840	0.029	6.920	0.064
6/12/2015	8.870	2.240	6.300	0.243
6/15/2015	8.430	1.950	5.860	0.267

Appendix B.4: Water Treatment Plant Effluent Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
6/17/2015	8.390	1.950	5.890	0.250
6/19/2015	8.280	2.100	5.820	0.264
6/22/2015	7.010	1.980	4.980	0.238
6/24/2015	6.690	1.590	4.530	0.214
6/26/2015	6.250	1.590	4.150	0.201
6/29/2015	5.680	1.380	3.810	0.202
7/1/2015	5.160	1.170	3.460	0.182
7/3/2015	4.470	1.040	3.340	0.182
7/6/2015	4.560	1.130	3.250	0.167
7/8/2015	4.890	1.060	3.300	0.168
7/10/2015	4.780	1.100	3.350	0.160
7/13/2015	4.280	0.986	3.010	0.134
7/15/2015	4.190	0.980	2.990	0.144
7/17/2015	4.280	1.010	2.970	0.140
7/20/2015	3.990	1.000	2.650	0.137
7/21/2015	3.720	1.020	2.600	0.128
7/27/2015	3.960	1.160	2.720	0.144
8/4/2015	4.240	1.170	2.670	0.157
8/6/2015	4.810	1.250	3.030	0.148
8/10/2015	4.660	1.160	3.000	0.159
8/17/2015	5.350	1.330	3.210	0.197
8/24/2015	5.840	1.620	3.470	0.187
8/31/2015	6.280	1.800	3.800	0.196
9/8/2015	9.370	2.910	5.730	0.266
9/14/2015	9.430	3.120	5.770	0.294
9/21/2015	12.000	3.930	7.550	0.307
10/5/2015	29.900	11.300	18.000	0.446
10/8/2015	30.700	11.700	18.600	0.477
10/13/2015	27.100	9.870	16.800	0.466
10/16/2015	26.100	8.950	16.300	0.485
10/19/2015	19.900	6.740	12.600	0.482
10/26/2015	11.600	3.810	7.510	0.409
11/3/2015	8.650	2.610	5.730	0.356
11/9/2015	19.200	6.310	12.800	0.530
11/16/2015	13.300	0.015	13.000	0.005
11/23/2015	13.800	0.012	14.300	0.005
12/1/2015	14.600	0.014	14.200	0.013
12/8/2015	12.700	0.024	12.900	0.011
12/16/2015	13.100	0.015	13.100	0.008
12/21/2015	12.700	0.015	12.900	0.011
12/29/2015	7.580	0.012	7.900	0.014
1/5/2016	7.740	1.870	5.010	0.493
1/19/2016	8.740	2.510	5.650	0.574
2/2/2016	13.400	4.190	9.190	0.654
2/9/2016	8.830	0.018	8.610	0.013
2/24/2016	10.400	0.032	10.300	0.053
3/8/2016	16.900	0.037	17.500	0.040
3/22/2016	26.800	0.055	27.000	0.050
4/4/2016	28.300	0.043	27.400	0.044
4/19/2016	32.000	0.043	31.600	0.087
5/10/2016	23.200	5.240	15.600	1.260
5/24/2016	23.300	5.600	16.100	1.150
6/7/2016	23.500	6.120	16.400	1.180
6/21/2016	22.500	6.030	16.300	1.300
7/12/2016	26.200	7.270	17.400	1.370
7/19/2016	27.500	7.660	18.600	1.510
7/20/2016	30.600	8.260	20.600	1.400
8/10/2016	30.500	-	22.800	1.550
8/31/2016	24.800	5.880	18.500	1.790

Appendix B.5: Water Treatment Plant Effluent Flow

Date	Flow	Date	Flow	Date	Flow
	m3/week		m3/week		m3/week
10/1/2014	13589	1/7/2015	7596	1/6/2016	6677
10/8/2014	16095	1/14/2015	5050	1/13/2016	6400
10/15/2014	16631	1/21/2015	6044	1/20/2016	6015
10/22/2014	15095	1/28/2015	5956	1/27/2016	6031
10/29/2014	12604	2/4/2015	5537	2/3/2016	5891
11/5/2014	10970	2/11/2015	6010	2/10/2016	5930
11/12/2014	9209	2/18/2015	5736	2/17/2016	5771
11/19/2014	9612	2/25/2015	5347	2/24/2016	5300
11/26/2014	9022	3/4/2015	5095	3/2/2016	5064
12/3/2014	10255	3/11/2015	4970	3/9/2016	5351
12/10/2014	7782	3/18/2015	4629	3/16/2016	5300
12/17/2014	8191	3/25/2015	4428	3/23/2016	5132
12/24/2014	8283	4/1/2015	5408	3/30/2016	4963
12/31/2014	7993	4/8/2015	4857	4/6/2016	5887
		4/15/2015	4492	4/13/2016	5404
		4/22/2015	2591	4/20/2016	5648
		4/29/2015	3844	4/27/2016	7691
		5/6/2015	4221	5/4/2016	11456
		5/13/2015	5731	5/11/2016	13584
		5/20/2015	7351	5/18/2016	16013
		5/27/2015	11824	5/25/2016	16933
		6/3/2015	10589	6/1/2016	15374
		6/10/2015	12576	6/8/2016	17576
		6/17/2015	13019	6/15/2016	15697
		6/24/2015	13456	6/22/2016	16019
		7/1/2015	12719	6/29/2016	15310
		7/8/2015	12809	7/6/2016	12400
		7/15/2015	11748	7/13/2016	12093
		7/22/2015	11010	7/20/2016	14833
		7/29/2015	11775	7/27/2016	14234
		8/5/2015	11961	8/3/2016	13251
		8/12/2015	13421	8/10/2016	14691
		8/19/2015	12250	8/17/2016	17451
		8/26/2015	13668	8/24/2016	24660
		9/2/2015	12857	8/31/2016	11372
		9/9/2015	13086		
		9/16/2015	13086		
		9/23/2015	13152		
		9/30/2015	12555		
		10/7/2015	12450		
		10/14/2015	15046		
		10/21/2015	14158		
		10/28/2015	13951		
		11/4/2015	12163		
		11/11/2015	11175		
		11/18/2015	9631		
		11/25/2015	9195		
		12/2/2015	8072		
		12/9/2015	6786		
		12/16/2015	8733		
		12/23/2015	7207		
		12/30/2015	6535		

Appendix B.6: Contact Water Pond (CWP) Water Quality

Date	Total Nitrogen	Ammonia	Nitrate	Nitrite
	mg-N/L	mg-N/L	mg-N/L	mg-N/L
20/06/2016	0.72	0.014	0.68	0.007
06/06/2016	0.88	0.018	0.76	0.015
11/07/2016	1.79	0.045	1.03	0.015
23/05/2016	0.66	0.069	0.57	0.009
09/05/2016	1.81	0.248	1.41	0.060
18/07/2016	3.69	0.498	2.80	0.126
09/08/2016	5.51	0.833	4.58	0.168
30/08/2016	14.70	3.060	11.00	0.550

Appendix B.7: Contact Water Pond (CWP) Flows

Date	CWP Flow
	m3/week
04/05/2016	3639
11/05/2016	3874
18/05/2016	5339
25/05/2016	4288
01/06/2016	2341
08/06/2016	3217
15/06/2016	1919
22/06/2016	1867
29/06/2016	1560
06/07/2016	0
13/07/2016	714
20/07/2016	2251
27/07/2016	1564
03/08/2016	2112
10/08/2016	3974
17/08/2016	4482
24/08/2016	14242
31/08/2016	12442

Appendix B.8: Sewage Treatment Plant (STP) Flows and Water Quality

Date	Monthly Flow	Total Nitrogen	Ammonia	Nitrate	Nitrite
	m3/month	mg-N/L	mg-N/L	mg-N/L	mg-N/L
01/09/2014 0:00	420		0.2		
01/10/2014 0:00	440				
01/11/2014 0:00	384	18.4	0.5	16.7	0.729
01/12/2014 0:00	348	15.8	0.9	14.8	0.126
01/01/2015 0:00	486	52.9	22.3	43.1	0.064
01/02/2015 0:00	408	4.9	0.3	2.9	0.455
01/03/2015 0:00	697	3.1	0.0	2.6	0.010
01/04/2015 0:00	586	77.9	19.4	61.7	0.043
01/05/2015 0:00	813	46.6	14.9	32.5	0.028
01/06/2015 0:00	817	25.7	22.2	0.6	0.141
01/07/2015 0:00	780	23.1	16.7	11.3	0.169
01/08/2015 0:00	707	28.5	0.7	33.3	0.032
01/09/2015 0:00	871	70.7	59.8	0.6	0.047
01/10/2015 0:00	1092	54.4	50.1	0.6	0.013
01/11/2015 0:00	792	15.0	11.9	1.4	0.530
01/12/2015 0:00	698	12.6	2.5	8.4	0.960
01/01/2016 0:00	903	16.8	9.4	4.9	1.234
01/02/2016 0:00	951	23.3	16.8	3.1	1.992
01/03/2016 0:00	1066	30.8	12.2	16.9	2.126
01/04/2016 0:00	1064	23.5	5.2	15.6	1.587
01/05/2016 0:00	1208	24.1	2.3	18.2	1.673
01/06/2016 0:00	1197	32.5	15.8	13.5	1.056
01/07/2016 0:00	1424	40.5	6.7	29.7	2.230
01/08/2016 0:00	1537	31.1	14.3	10.5	3.484

Appendix B.9: Nitrogen Loads

Date	Surface Volume Excavated	Underground Volume Excavated	N from WTP	N from STP	N from UG Rock	N from Surface Rock	BJ 3.10 N Exported
	m3	m3	kg-N	kg-N	kg-N	kg-N	kg-N
11/30/2014							
12/31/2014					239		
1/31/2015		6270			348		2.8
2/28/2015		3470			618		2.8
3/31/2015		8260			847		2.4
4/30/2015		6280			996		9.7
5/31/2015		4340			765		174
6/30/2015		5810			1026		129
7/31/2015		7130			1186		89
8/31/2015		6140			841		64
9/30/2015	12243	7816			1142	175	112
10/31/2015	23456	8007			1161	334	411
11/30/2015	63311	11498			1650	903	258
12/31/2015	65338	7587	381		809	931	155
1/31/2016	125075	2610	248		642	1783	171
2/29/2016	89459	7590	255		1201	1275	263
3/31/2016	66755	17250	510		2975	952	181
4/30/2016	24360	24461	824	25	3787	392	480
5/31/2016	25397	23838	1587	29	4352	412	555
6/30/2016	15898	26492	1597	39	4596	772	2711
7/31/2016	3909	25802	1685	58	5704	188	3300 *
8/31/2016	5341	38738	2110	48	5406	256	3300 *

* estimated

Appendix B.10: BJ35 Water Quality

Date	Depth	Ammonia	Nitrite	Nitrate
	m	mg-N/L	mg-N/L	mg-N/L
1/7/2016	2	<0.005	<0.001	0.461
1/7/2016	7	<0.005	<0.001	0.544
1/7/2016	15	<0.005	<0.001	0.643
1/7/2016	25	<0.005	<0.001	0.668
1/8/2016	38	<0.005	<0.001	0.713
1/8/2016	50	<0.005	<0.001	0.695
1/8/2016	60	<0.005	<0.001	0.722
1/8/2016	70	<0.005	<0.001	0.68
1/8/2016	80	<0.005	<0.001	0.688
1/10/2016	2	0.0052	<0.001	2.01
1/10/2016	7	<0.005	<0.001	2.01
1/10/2016	15	<0.005	<0.001	2.01
1/10/2016	25	<0.005	<0.001	2.11
1/10/2016	38	<0.005	<0.001	2.27
1/10/2016	60	0.0240	0.0038	2.31
1/10/2016	70	0.0327	0.0071	2.33
1/10/2016	80	0.0337	0.0082	2.31
1/15/2016	7	<0.005	<0.001	0.621
1/15/2016	15	<0.005	<0.001	0.683
1/15/2016	25	<0.005	<0.001	0.69
1/15/2016	38	<0.005	<0.001	0.685
1/15/2016	60	<0.005	<0.001	0.69
1/15/2016	70	0.0084	<0.001	0.685
1/15/2016	80	0.0413	0.0035	0.687
1/25/2016	2	<0.005	<0.001	0.463
1/25/2016	7	<0.005	<0.001	0.687
1/25/2016	15	<0.005	<0.001	0.687
1/25/2016	25	<0.005	<0.001	0.698
1/25/2016	38	0.0066	<0.001	0.716
1/25/2016	50	0.0089	0.0011	0.717
1/25/2016	60	0.0078	<0.001	0.71
1/25/2016	70	0.0066	<0.001	0.737
1/25/2016	80	0.0116	<0.001	0.734
1/31/2016	2	0.005	<0.001	0.617
1/31/2016	7	<0.005	<0.001	0.701
1/31/2016	15	<0.005	<0.001	0.706
1/31/2016	38	<0.005	<0.001	0.719
1/31/2016	60	0.0069	<0.001	0.722
1/31/2016	70	<0.005	<0.001	0.747
1/31/2016	80	0.0082	<0.001	0.764
2/15/2016	2	<0.005	<0.001	0.504

Appendix B.10: BJ35 Water Quality

Date	Depth	Ammonia	Nitrite	Nitrate
	m	mg-N/L	mg-N/L	mg-N/L
2/15/2016	7	<0.005	<0.001	0.69
2/15/2016	15	<0.005	<0.001	0.703
2/15/2016	38	<0.005	<0.001	0.737
2/15/2016	60	0.0127	0.0021	0.738
2/15/2016	70	<0.005	<0.001	0.738
2/15/2016	80	<0.005	<0.001	0.762
2/25/2016	2	<0.005	<0.001	0.687
2/25/2016	7	<0.005	<0.001	0.72
2/25/2016	15	<0.005	<0.001	0.722
2/25/2016	38	<0.005	<0.001	0.762
2/25/2016	60	<0.005	<0.001	0.775
2/25/2016	70	<0.005	<0.001	0.783
2/25/2016	80	<0.005	<0.001	0.779
3/10/2016	2	<0.005	<0.001	0.639
3/10/2016	7	<0.005	<0.001	0.725
3/10/2016	15	<0.005	<0.001	0.766
3/10/2016	38	0.0065	0.002	0.84
3/10/2016	60	0.0132	0.003	0.856
3/10/2016	70	0.0148	0.0035	0.885
3/10/2016	80	0.0263	0.0042	0.869
3/24/2016	2	0.0122	<0.001	0.703
3/24/2016	7	<0.005	<0.001	0.743
3/24/2016	15	<0.005	<0.001	0.802
3/24/2016	38	0.0073	<0.001	0.91
3/24/2016	60	0.0217	0.0032	0.948
3/24/2016	70	0.0364	0.0063	0.988
3/24/2016	80	0.0189	<0.001	1.17
4/7/2016	2	<0.005	<0.001	0.713
4/7/2016	7	<0.005	<0.001	0.789
4/7/2016	15	<0.005	<0.001	0.889
4/7/2016	38	0.0125	<0.001	1.04
4/7/2016	60	0.0246	0.0063	1.16
4/7/2016	70	0.0254	0.0061	1.07
4/7/2016	80	0.0406	0.009	1.23
4/21/2016	2	<0.005	<0.001	0.689
4/21/2016	7	<0.005	<0.001	0.805
4/21/2016	15	<0.005	<0.001	0.926
4/21/2016	38	<0.005	<0.001	1.15
4/21/2016	60	0.0361	<0.001	1.23
4/21/2016	70	0.0349	0.0021	1.25
4/21/2016	80	0.0529	0.0057	1.29

Appendix B.10: BJ35 Water Quality

Date	Depth	Ammonia	Nitrite	Nitrate
	m	mg-N/L	mg-N/L	mg-N/L
7/15/2016	2	<0.005	<0.001	0.464
7/17/2016	2	0.0126	0.0038	1.19
7/17/2016	7	0.0178	0.0025	1.25
7/17/2016	15	0.0192	0.0038	1.28
7/17/2016	38	0.028	0.0047	1.33
7/17/2016	60	0.0619	0.0059	1.4
7/17/2016	70	0.073	0.0047	1.41
7/17/2016	80	0.0823	0.0051	1.42
7/27/2016	2	0.005	0.0064	1.04
7/27/2016	7	0.0106	0.0069	1.26
7/27/2016	15	0.0139	0.0061	1.29
7/27/2016	38	0.0634	0.0047	1.41
7/27/2016	60	0.11	0.0072	1.47
7/27/2016	70	0.113	0.0067	1.47
7/27/2016	80	0.162	0.0106	1.61
8/25/2016	2	0.0261	0.0106	1.05
8/25/2016	7	0.0584	0.0138	1.2
8/25/2016	15	<0.005	0.0018	1.61
8/25/2016	38	<0.005	0.0024	1.91
8/25/2016	60	0.0668	0.0310	1.97
8/25/2016	70	0.101	0.0523	2.04
8/25/2016	80	0.0882	0.0587	2.03

Appendix B.11: BJ 3.10 Water Quality

		Ammonia	Nitrite	Nitrate	N-TN
Station Name	**Date**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Discharge Limit		**1**	**3**	**0.075**	**-**
BJ-3.10	June-20-12	<0.0050	<0.0010	0.0154	<0.050
BJ-3.10	August-21-12	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	August-21-12	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	November-27-12	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	November-27-12	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	December-13-12	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	December-13-12	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	January-29-13	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	January-29-13	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	February-20-13	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	February-20-13	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	March-14-13	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	April-25-13	0.0064	<0.0010	0.0170	<0.050
BJ-3.10	May-19-13	<0.0050	<0.0010	0.0128	0.119
BJ-3.10	May-28-13	<0.0050	<0.0010	0.0128	<0.050
BJ-3.10	June-06-13	<0.0050	<0.0010	0.0092	<0.050
BJ-3.10	June-06-13	<0.0050	<0.0010	0.0099	<0.050
BJ-3.10	June-13-13	<0.0050	<0.0010	0.0078	<0.050
BJ-3.10	June-23-13	<0.0050	<0.0010	<0.0050	<0.050
BJ-3.10	July-16-13	<0.0050	<0.0010	0.0334	<0.050
BJ-3.10	August-13-13	<0.0050	<0.0010	0.0078	<0.050
BJ-3.10	September-21-13	<0.0050	<0.0010	0.0113	<0.050
BJ-3.10	October-22-13	0.0066	<0.0010	0.0456	0.068
BJ-3.10	November-20-13	0.0083	<0.0010	0.0484	0.060
BJ-3.10	November-20-13	0.0096	<0.0010	0.0492	0.052
BJ-3.10	January-06-14	<0.0050	<0.0010	0.0484	0.059
BJ-3.10	February-13-14	0.0057	<0.0010	0.0495	0.063
BJ-3.10	February-22-14	0.0055	<0.0010	0.0522	0.055
BJ-3.10	February-27-14	0.0056	<0.0010	0.0494	0.055
BJ-3.10	March-05-14	0.0066	<0.0010	0.0521	0.051
BJ-3.10	March-29-14	<0.0050	<0.0010	0.0508	0.059
BJ-3.10	September-13-14	<0.0050	<0.0010	<0.0050	0.057
BJ-3.10	October-06-14	<0.0050	<0.0010	0.0255	<0.050
BJ-3.10	November-17-14	<0.0050	<0.0010	0.0294	<0.050
BJ-3.10	December-19-14	<0.0050	<0.0010	0.0396	0.050
BJ-3.10	January-23-15	<0.0050	<0.0010	0.0435	-
BJ-3.10	February-21-15	<0.0050	<0.0010	0.0410	-
BJ-3.10	March-13-15	<0.0050	<0.0010	0.0450	-
BJ-3.10	March-24-15	<0.0050	<0.0010	0.0446	-
BJ-3.10	March-31-15	<0.0050	<0.0010	0.0474	0.057
BJ-3.10	April-03-15	<0.0050	<0.0010	0.0448	0.050
BJ-3.10	April-06-15	<0.0050	<0.0010	0.0458	0.056
BJ-3.10	April-11-15	<0.0050	<0.0010	0.0488	-
BJ-3.10	May-11-15	0.0083	0.0036	0.0779	0.098

Appendix B.11: BJ 3.10 Water Quality

		Ammonia	Nitrite	Nitrate	N-TN
Station Name	**Date**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Discharge Limit		**1**	**3**	**0.075**	**-**
BJ-3.10	May-18-15	<0.0050	<0.0010	0.0507	0.071
BJ-3.10	May-24-15	0.0060	<0.0010	0.0660	0.077
BJ-3.10	June-01-15	0.0055	<0.0010	0.0596	0.071
BJ-3.10	June-08-15	<0.0050	<0.0010	0.0535	-
BJ-3.10	June-10-15	<0.0050	<0.0010	0.0507	0.056
BJ-3.10	July-12-15	<0.0050	<0.0010	0.195	-
BJ-3.10	August-12-15	<0.0050	0.0014	0.162	-
BJ-3.10	September-13-15	0.0082	0.0018	0.192	0.206
BJ-3.10	September-15-15	<0.0050	0.0024	0.188	-
BJ-3.10	September-20-15	<0.0050	0.0018	0.210	-
BJ-3.10	September-24-15	0.0097	0.0022	0.217	0.234
BJ-3.10	September-27-15	0.0067	0.0032	0.262	-
BJ-3.10	October-01-15	<0.0050	0.0029	0.283	0.299
BJ-3.10	October-04-15	<0.0050	0.0034	0.295	-
BJ-3.10	October-08-15	0.0061	0.0037	0.310	0.374
BJ-3.10	October-11-15	<0.0050	0.0010	0.390	-
BJ-3.10	October-15-15	<0.0050	<0.0010	0.413	-
BJ-3.10	October-22-15	<0.0050	<0.0010	0.443	0.452
BJ-3.10	October-26-15	<0.0050	<0.0010	0.449	0.473
BJ-3.10	October-29-15	<0.0050	<0.0010	0.451	0.443
BJ-3.10	November-05-15	<0.0050	0.0014	0.458	0.527
BJ-3.10	November-11-15	<0.0050	0.0045	0.445	0.497
BJ-3.10	November-19-15	-	<0.0050	0.472	0.490
BJ-3.10	November-26-15	<0.0050	0.0042	0.466	0.456
BJ-3.10	December-08-15	<0.0050	0.0017	0.463	0.473
BJ-3.10	December-14-15	<0.0050	<0.0010	0.454	0.447
BJ-3.10	December-20-15	<0.0050	<0.0010	0.450	0.433
BJ-3.10	December-28-15	<0.0050	<0.0010	0.470	0.470
BJ-3.10	December-29-15	-	<0.0010	0.495	-
BJ-3.10	December-29-15	<0.0050	-	-	0.510
BJ-3.10	January-04-16	<0.0050	0.0020	0.510	0.541
BJ-3.10	January-14-16	0.0118	0.0030	0.483	0.501
BJ-3.10	January-18-16	0.0095	0.0030	0.500	0.513
BJ-3.10	January-25-16	0.0122	0.0032	0.556	0.549
BJ-3.10	February-01-16	0.01	0.0027	0.602	0.607
BJ-3.10	February-10-16	<0.0050	<0.0010	0.641	0.624
BJ-3.10	February-15-16	<0.0050	<0.0010	0.637	0.630
BJ-3.10	February-22-16	<0.0050	<0.0010	0.645	0.652
BJ-3.10	March-01-16	<0.0050	<0.0010	0.695	0.682
BJ-3.10	March-07-16	<0.0050	<0.0010	0.708	0.665
BJ-3.10	March-16-16	<0.0050	0.0012	0.744	3.71
BJ-3.10	March-21-16	<0.0050	0.0012	0.796	0.806
BJ-3.10	March-28-16	<0.0050	0.0016	0.781	0.782
BJ-3.10	April-04-16	<0.0050	0.0013	0.814	0.843

Appendix B.11: BJ 3.10 Water Quality

		Ammonia	Nitrite	Nitrate	N-TN
Station Name	**Date**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Discharge Limit		**1**	**3**	**0.075**	**-**
BJ-3.10	April-10-16	<0.0050	0.0028	0.779	0.813
BJ-3.10	April-19-16	<0.0050	0.0028	0.777	0.781
BJ-3.10	April-25-16	<0.0050	0.0024	0.765	0.771
BJ-3.10	May-11-16	0.0197	0.0051	0.606	-
BJ-3.10	May-16-16	0.021	0.0054	0.664	-
BJ-3.10	May-25-16	0.0152	0.0061	0.604	0.63
BJ-3.10	May-30-16	0.0207	0.0043	0.529	0.545
BJ-3.10	June-06-16	0.0127	0.0033	0.644	0.674
BJ-3.10	June-13-16	0.0128	0.004	0.625	0.63
BJ-3.10	June-20-16	0.0123	0.0035	1.01	1.1
BJ-3.10	June-27-16	0.0166	0.0014	1.29	1.35
BJ-3.10	July-04-16	0.0315	0.0059	1.31	1.37
BJ-3.10	July-11-16	0.031	0.0052	1.28	1.38
BJ-3.10	July-18-16	0.0213	0.0068	1.16	1.2
BJ-3.10	July-26-16	0.0077	0.0091	1.07	1.14
BJ-3.10	August-01-16	0.0104	0.0077	1.17	1.21
BJ-3.10	August-09-16	0.0149	0.0118	1.09	1.2
BJ-3.10	August-15-16	0.0097	0.0126	0.986	1.13
BJ-3.10	August-23-16	0.0512	0.0122	1.22	1.33
BJ-3.10	August-28-16	0.0114	0.0102	1.07	1.13
BJ-3.10 June 12, 2012 - August 28, 2016 Statistical Summary	n	108	108	108	108
	median	0.010	0.003	0.402	0.499
	mean	0.004	0.002	0.350	0.357
	10th Ptile	0.006	0.001	0.021	0.056
	90th Ptile	0.024	0.010	1.040	1.201
BJ-3.10 May 25, 2016 - August 28, 2016 Statistical Summary	n	15	15	15	15
	median	0.015	0.006	1.070	1.140
	mean	0.019	0.007	1.004	1.068
	10th Ptile	0.009	0.003	0.574	0.596
	90th Ptile	0.039	0.012	1.298	1.374
	max	0.051	0.013	1.310	1.380

Appendix B.12: BJ 3.10 Flows

Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows
	m3/s		m3/s		m3/s		m3/s		m3/s
23/Sep/2014	1.30	01/Oct/2014	1.14	01/Nov/2014	0.29	01/Dec/2014	0.079	01/Jan/2015	0.056
24/Sep/2014	1.08	02/Oct/2014	1.00	02/Nov/2014	0.34	02/Dec/2014	0.079	02/Jan/2015	0.056
25/Sep/2014	0.99	03/Oct/2014	0.81	03/Nov/2014	0.39	03/Dec/2014	0.079	03/Jan/2015	0.056
26/Sep/2014	0.85	04/Oct/2014	0.99	04/Nov/2014	0.36	04/Dec/2014	0.079	04/Jan/2015	0.056
27/Sep/2014	0.65	05/Oct/2014	1.20	05/Nov/2014	0.34	05/Dec/2014	0.079	05/Jan/2015	0.056
28/Sep/2014	0.78	06/Oct/2014	1.25	06/Nov/2014	0.31	06/Dec/2014	0.079	06/Jan/2015	0.056
29/Sep/2014	1.67	07/Oct/2014	1.16	07/Nov/2014	0.28	07/Dec/2014	0.079	07/Jan/2015	0.056
30/Sep/2014	1.44	08/Oct/2014	0.99	08/Nov/2014	0.26	08/Dec/2014	0.079	08/Jan/2015	0.056
		09/Oct/2014	0.77	09/Nov/2014	0.23	09/Dec/2014	0.079	09/Jan/2015	0.056
		10/Oct/2014	0.84	10/Nov/2014	0.23	10/Dec/2014	0.079	10/Jan/2015	0.056
		11/Oct/2014	1.06	11/Nov/2014	0.23	11/Dec/2014	0.079	11/Jan/2015	0.056
		12/Oct/2014	1.04	12/Nov/2014	0.22	12/Dec/2014	0.079	12/Jan/2015	0.056
		13/Oct/2014	0.98	13/Nov/2014	0.22	13/Dec/2014	0.079	13/Jan/2015	0.056
		14/Oct/2014	0.96	14/Nov/2014	0.21	14/Dec/2014	0.079	14/Jan/2015	0.056
		15/Oct/2014	0.88	15/Nov/2014	0.20	15/Dec/2014	0.079	15/Jan/2015	0.056
		16/Oct/2014	0.71	16/Nov/2014	0.19	16/Dec/2014	0.079	16/Jan/2015	0.056
		17/Oct/2014	0.62	17/Nov/2014	0.18	17/Dec/2014	0.079	17/Jan/2015	0.056
		18/Oct/2014	0.57	18/Nov/2014	0.17	18/Dec/2014	0.079	18/Jan/2015	0.056
		19/Oct/2014	0.72	19/Nov/2014	0.17	19/Dec/2014	0.079	19/Jan/2015	0.056
		20/Oct/2014	0.99	20/Nov/2014	0.16	20/Dec/2014	0.079	20/Jan/2015	0.056
		21/Oct/2014	1.08	21/Nov/2014	0.15	21/Dec/2014	0.079	21/Jan/2015	0.056
		22/Oct/2014	0.98	22/Nov/2014	0.14	22/Dec/2014	0.079	22/Jan/2015	0.056
		23/Oct/2014	0.80	23/Nov/2014	0.13	23/Dec/2014	0.079	23/Jan/2015	0.056
		24/Oct/2014	0.59	24/Nov/2014	0.13	24/Dec/2014	0.079	24/Jan/2015	0.056
		25/Oct/2014	0.45	25/Nov/2014	0.12	25/Dec/2014	0.079	25/Jan/2015	0.056
		26/Oct/2014	0.35	26/Nov/2014	0.11	26/Dec/2014	0.079	26/Jan/2015	0.056
		27/Oct/2014	0.28	27/Nov/2014	0.10	27/Dec/2014	0.079	27/Jan/2015	0.056
		28/Oct/2014	0.25	28/Nov/2014	0.10	28/Dec/2014	0.079	28/Jan/2015	0.056
		29/Oct/2014	0.24	29/Nov/2014	0.090	29/Dec/2014	0.079	29/Jan/2015	0.056
		30/Oct/2014	0.24	30/Nov/2014	0.090	30/Dec/2014	0.079	30/Jan/2015	0.056
		31/Oct/2014	0.28			31/Dec/2014	0.079	31/Jan/2015	0.056

Appendix B.12: BJ 3.10 Flows

Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows
	m3/s		m3/s		m3/s		m3/s		m3/s
01/Feb/2015	0.056	01/Mar/2015	0.052	01/Apr/2015	0.057	01/May/2015	0.19	01/Jun/2015	1.37
02/Feb/2015	0.056	02/Mar/2015	0.052	02/Apr/2015	0.059	02/May/2015	0.16	02/Jun/2015	1.33
03/Feb/2015	0.056	03/Mar/2015	0.051	03/Apr/2015	0.060	03/May/2015	0.15	03/Jun/2015	1.25
04/Feb/2015	0.056	04/Mar/2015	0.051	04/Apr/2015	0.062	04/May/2015	0.12	04/Jun/2015	1.16
05/Feb/2015	0.056	05/Mar/2015	0.050	05/Apr/2015	0.063	05/May/2015	0.12	05/Jun/2015	1.20
06/Feb/2015	0.056	06/Mar/2015	0.049	06/Apr/2015	0.065	06/May/2015	0.12	06/Jun/2015	1.25
07/Feb/2015	0.056	07/Mar/2015	0.049	07/Apr/2015	0.066	07/May/2015	0.12	07/Jun/2015	1.47
08/Feb/2015	0.056	08/Mar/2015	0.048	08/Apr/2015	0.066	08/May/2015	0.13	08/Jun/2015	1.73
09/Feb/2015	0.056	09/Mar/2015	0.048	09/Apr/2015	0.066	09/May/2015	0.17	09/Jun/2015	1.37
10/Feb/2015	0.056	10/Mar/2015	0.044	10/Apr/2015	0.060	10/May/2015	0.23	10/Jun/2015	1.12
11/Feb/2015	0.056	11/Mar/2015	0.044	11/Apr/2015	0.060	11/May/2015	0.36	11/Jun/2015	0.95
12/Feb/2015	0.056	12/Mar/2015	0.044	12/Apr/2015	0.060	12/May/2015	0.49	12/Jun/2015	0.81
13/Feb/2015	0.056	13/Mar/2015	0.044	13/Apr/2015	0.060	13/May/2015	0.52	13/Jun/2015	0.74
14/Feb/2015	0.056	14/Mar/2015	0.044	14/Apr/2015	0.060	14/May/2015	0.68	14/Jun/2015	0.82
15/Feb/2015	0.056	15/Mar/2015	0.044	15/Apr/2015	0.060	15/May/2015	0.89	15/Jun/2015	1.07
16/Feb/2015	0.056	16/Mar/2015	0.044	16/Apr/2015	0.060	16/May/2015	1.06	16/Jun/2015	1.07
17/Feb/2015	0.056	17/Mar/2015	0.044	17/Apr/2015	0.060	17/May/2015	1.20	17/Jun/2015	1.19
18/Feb/2015	0.056	18/Mar/2015	0.044	18/Apr/2015	0.060	18/May/2015	1.22	18/Jun/2015	1.22
19/Feb/2015	0.056	19/Mar/2015	0.044	19/Apr/2015	0.060	19/May/2015	1.16	19/Jun/2015	1.21
20/Feb/2015	0.056	20/Mar/2015	0.044	20/Apr/2015	0.060	20/May/2015	1.14	20/Jun/2015	1.15
21/Feb/2015	0.056	21/Mar/2015	0.044	21/Apr/2015	0.060	21/May/2015	1.10	21/Jun/2015	1.14
22/Feb/2015	0.056	22/Mar/2015	0.044	22/Apr/2015	0.060	22/May/2015	1.14	22/Jun/2015	1.15
23/Feb/2015	0.056	23/Mar/2015	0.044	23/Apr/2015	0.060	23/May/2015	1.30	23/Jun/2015	1.08
24/Feb/2015	0.055	24/Mar/2015	0.044	24/Apr/2015	0.060	24/May/2015	1.49	24/Jun/2015	1.00
25/Feb/2015	0.055	25/Mar/2015	0.044	25/Apr/2015	0.11	25/May/2015	1.61	25/Jun/2015	1.04
26/Feb/2015	0.054	26/Mar/2015	0.044	26/Apr/2015	0.11	26/May/2015	1.63	26/Jun/2015	1.15
27/Feb/2015	0.054	27/Mar/2015	0.050	27/Apr/2015	0.13	27/May/2015	1.54	27/Jun/2015	1.03
28/Feb/2015	0.053	28/Mar/2015	0.050	28/Apr/2015	0.18	28/May/2015	1.33	28/Jun/2015	0.96
		29/Mar/2015	0.053	29/Apr/2015	0.20	29/May/2015	1.07	29/Jun/2015	1.06
		30/Mar/2015	0.055	30/Apr/2015	0.21	30/May/2015	0.97	30/Jun/2015	1.12
		31/Mar/2015	0.056			31/May/2015	1.11		

Appendix B.12: BJ 3.10 Flows

Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows
	m3/s		m3/s		m3/s		m3/s		m3/s
01/Jul/2015	1.05	01/Aug/2015	0.73	01/Sep/2015	0.58	01/Oct/2015	0.37	01/Nov/2015	0.25
02/Jul/2015	0.96	02/Aug/2015	0.65	02/Sep/2015	0.48	02/Oct/2015	0.32	02/Nov/2015	0.19
03/Jul/2015	0.91	03/Aug/2015	0.58	03/Sep/2015	0.40	03/Oct/2015	0.28	03/Nov/2015	0.19
04/Jul/2015	0.83	04/Aug/2015	0.73	04/Sep/2015	0.35	04/Oct/2015	0.25	04/Nov/2015	0.18
05/Jul/2015	0.78	05/Aug/2015	0.72	05/Sep/2015	0.32	05/Oct/2015	0.23	05/Nov/2015	0.20
06/Jul/2015	0.80	06/Aug/2015	0.65	06/Sep/2015	0.30	06/Oct/2015	0.21	06/Nov/2015	0.19
07/Jul/2015	0.86	07/Aug/2015	0.59	07/Sep/2015	0.29	07/Oct/2015	0.47	07/Nov/2015	0.18
08/Jul/2015	1.01	08/Aug/2015	0.61	08/Sep/2015	0.28	08/Oct/2015	1.85	08/Nov/2015	0.17
09/Jul/2015	1.06	09/Aug/2015	0.56	09/Sep/2015	0.27	09/Oct/2015	2.36	09/Nov/2015	0.21
10/Jul/2015	0.92	10/Aug/2015	0.52	10/Sep/2015	0.73	10/Oct/2015	1.45	10/Nov/2015	0.20
11/Jul/2015	0.84	11/Aug/2015	0.51	11/Sep/2015	1.12	11/Oct/2015	1.03	11/Nov/2015	0.22
12/Jul/2015	0.79	12/Aug/2015	0.55	12/Sep/2015	0.86	12/Oct/2015	0.78	12/Nov/2015	0.24
13/Jul/2015	0.73	13/Aug/2015	0.56	13/Sep/2015	0.66	13/Oct/2015	0.58	13/Nov/2015	0.23
14/Jul/2015	0.67	14/Aug/2015	0.52	14/Sep/2015	0.51	14/Oct/2015	0.47	14/Nov/2015	0.22
15/Jul/2015	0.62	15/Aug/2015	0.47	15/Sep/2015	0.42	15/Oct/2015	0.52	15/Nov/2015	0.18
16/Jul/2015	0.57	16/Aug/2015	0.44	16/Sep/2015	0.38	16/Oct/2015	0.77	16/Nov/2015	0.17
17/Jul/2015	0.56	17/Aug/2015	0.41	17/Sep/2015	0.55	17/Oct/2015	0.92	17/Nov/2015	0.16
18/Jul/2015	0.67	18/Aug/2015	0.42	18/Sep/2015	0.81	18/Oct/2015	0.84	18/Nov/2015	0.15
19/Jul/2015	0.73	19/Aug/2015	0.44	19/Sep/2015	0.63	19/Oct/2015	0.70	19/Nov/2015	0.14
20/Jul/2015	0.72	20/Aug/2015	0.45	20/Sep/2015	0.51	20/Oct/2015	0.75	20/Nov/2015	0.16
21/Jul/2015	0.84	21/Aug/2015	0.48	21/Sep/2015	0.44	21/Oct/2015	0.61	21/Nov/2015	0.17
22/Jul/2015	0.93	22/Aug/2015	0.49	22/Sep/2015	0.39	22/Oct/2015	0.48	22/Nov/2015	0.19
23/Jul/2015	0.87	23/Aug/2015	0.49	23/Sep/2015	0.37	23/Oct/2015	0.39	23/Nov/2015	0.20
24/Jul/2015	0.91	24/Aug/2015	0.43	24/Sep/2015	0.35	24/Oct/2015	0.31	24/Nov/2015	0.21
25/Jul/2015	0.75	25/Aug/2015	0.38	25/Sep/2015	0.31	25/Oct/2015	0.27	25/Nov/2015	0.22
26/Jul/2015	0.66	26/Aug/2015	0.35	26/Sep/2015	0.32	26/Oct/2015	0.24	26/Nov/2015	0.22
27/Jul/2015	0.62	27/Aug/2015	0.35	27/Sep/2015	0.35	27/Oct/2015	0.21	27/Nov/2015	0.21
28/Jul/2015	0.71	28/Aug/2015	0.77	28/Sep/2015	0.38	28/Oct/2015	0.23	28/Nov/2015	0.21
29/Jul/2015	0.69	29/Aug/2015	1.04	29/Sep/2015	0.44	29/Oct/2015	0.28	29/Nov/2015	0.21
30/Jul/2015	0.63	30/Aug/2015	0.93	30/Sep/2015	0.44	30/Oct/2015	0.25	30/Nov/2015	0.20
31/Jul/2015	0.70	31/Aug/2015	0.72			31/Oct/2015	0.23		

Appendix B.12: BJ 3.10 Flows

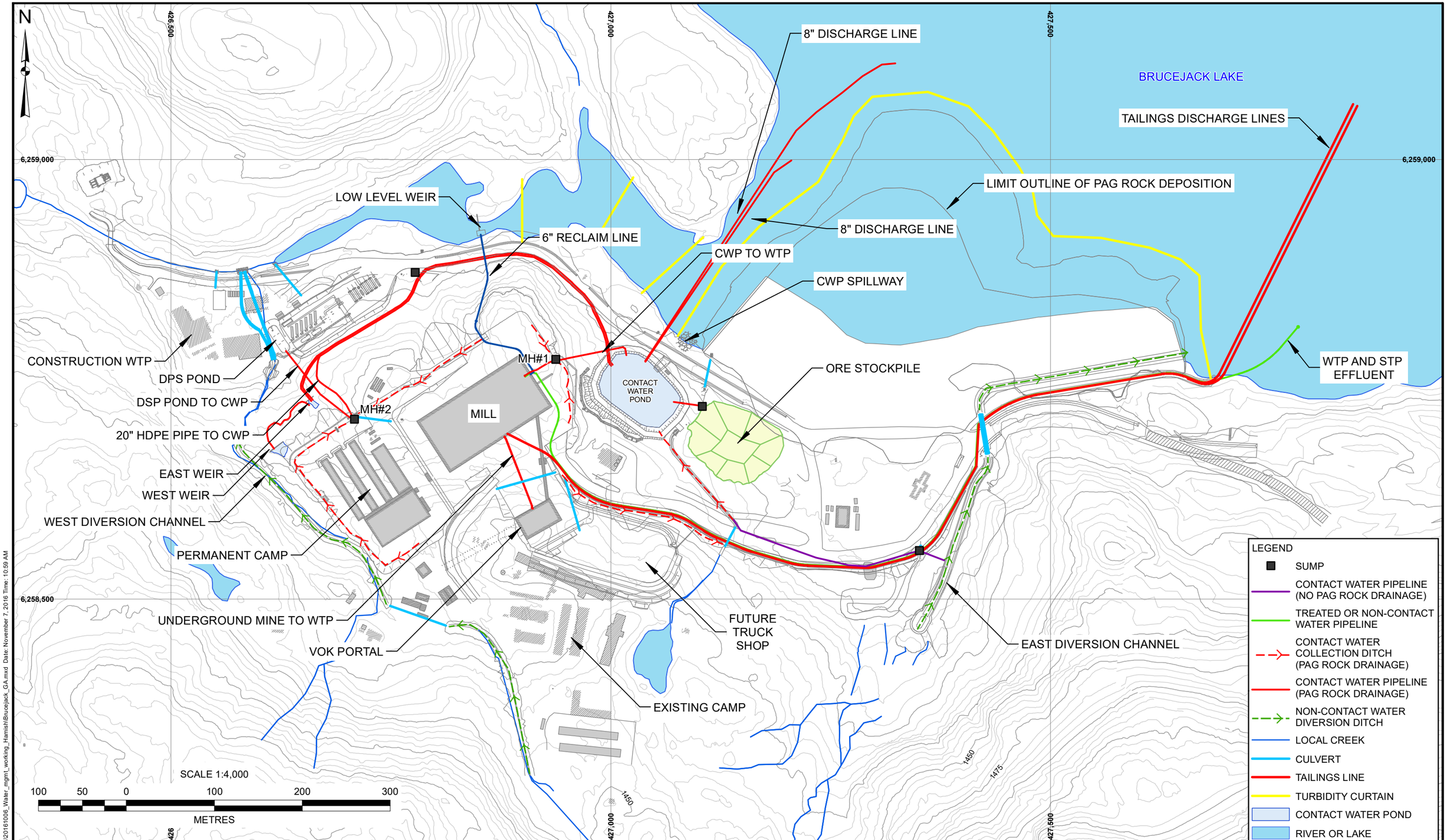
Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows
	m3/s		m3/s		m3/s		m3/s		m3/s
01/Dec/2015	0.19	01/Jan/2016		01/Feb/2016		01/Mar/2016	0.11	01/Apr/2016	0.10
02/Dec/2015	0.19	02/Jan/2016		02/Feb/2016	0.13	02/Mar/2016	0.087	02/Apr/2016	0.11
03/Dec/2015	0.12	03/Jan/2016		03/Feb/2016		03/Mar/2016	0.078	03/Apr/2016	0.11
04/Dec/2015	0.18	04/Jan/2016	0.049	04/Feb/2016		04/Mar/2016	0.084	04/Apr/2016	0.11
05/Dec/2015	0.17	05/Jan/2016		05/Feb/2016		05/Mar/2016	0.10	05/Apr/2016	0.13
06/Dec/2015	0.16	06/Jan/2016		06/Feb/2016		06/Mar/2016	0.10	06/Apr/2016	0.13
07/Dec/2015	0.16	07/Jan/2016		07/Feb/2016		07/Mar/2016	0.10	07/Apr/2016	0.13
08/Dec/2015	0.16	08/Jan/2016		08/Feb/2016		08/Mar/2016	0.12	08/Apr/2016	0.12
09/Dec/2015	0.15	09/Jan/2016		09/Feb/2016		09/Mar/2016	0.12	09/Apr/2016	0.12
10/Dec/2015	0.14	10/Jan/2016		10/Feb/2016	0.22	10/Mar/2016	0.12	10/Apr/2016	0.11
11/Dec/2015	0.14	11/Jan/2016		11/Feb/2016		11/Mar/2016	0.11	11/Apr/2016	0.10
12/Dec/2015	0.13	12/Jan/2016		12/Feb/2016		12/Mar/2016	0.10	12/Apr/2016	0.11
13/Dec/2015	0.13	13/Jan/2016		13/Feb/2016		13/Mar/2016	0.10	13/Apr/2016	0.11
14/Dec/2015	0.12	14/Jan/2016	0.15	14/Feb/2016		14/Mar/2016	0.10	14/Apr/2016	0.10
15/Dec/2015	0.13	15/Jan/2016		15/Feb/2016	0.17	15/Mar/2016	0.11	15/Apr/2016	0.11
16/Dec/2015	0.12	16/Jan/2016		16/Feb/2016		16/Mar/2016	0.10	16/Apr/2016	0.11
17/Dec/2015	0.11	17/Jan/2016		17/Feb/2016		17/Mar/2016	0.10	17/Apr/2016	0.14
18/Dec/2015	0.11	18/Jan/2016	0.13	18/Feb/2016		18/Mar/2016	0.090	18/Apr/2016	0.28
19/Dec/2015	0.11	19/Jan/2016		19/Feb/2016		19/Mar/2016	0.079	19/Apr/2016	0.31
20/Dec/2015	0.11	20/Jan/2016		20/Feb/2016		20/Mar/2016	0.071	20/Apr/2016	0.28
21/Dec/2015	0.10	21/Jan/2016		21/Feb/2016		21/Mar/2016	0.066	21/Apr/2016	0.25
22/Dec/2015	0.10	22/Jan/2016		22/Feb/2016	0.10	22/Mar/2016	0.062	22/Apr/2016	0.36
23/Dec/2015	0.10	23/Jan/2016		23/Feb/2016		23/Mar/2016	0.067	23/Apr/2016	0.52
24/Dec/2015	0.090	24/Jan/2016		24/Feb/2016		24/Mar/2016	0.073	24/Apr/2016	0.63
25/Dec/2015	0.090	25/Jan/2016	0.15	25/Feb/2016		25/Mar/2016	0.069	25/Apr/2016	0.55
26/Dec/2015	0.089	26/Jan/2016		26/Feb/2016		26/Mar/2016	0.084	26/Apr/2016	0.44
27/Dec/2015	0.080	27/Jan/2016		27/Feb/2016		27/Mar/2016	0.098	27/Apr/2016	0.35
28/Dec/2015	0.082	28/Jan/2016		28/Feb/2016		28/Mar/2016	0.092	28/Apr/2016	0.28
29/Dec/2015	0.079	29/Jan/2016		29/Feb/2016		29/Mar/2016	0.086	29/Apr/2016	0.24
30/Dec/2015	0.075	30/Jan/2016				30/Mar/2016	0.085	30/Apr/2016	0.24
31/Dec/2015		31/Jan/2016				31/Mar/2016	0.091		

Appendix B.12: BJ 3.10 Flows

Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows	Date	BJ 3.10 Discharge Flows
	m3/s		m3/s		m3/s		m3/s		m3/s
01/May/2016	0.32	01/Jun/2016	0.81	01/Jul/2016	1.19	01/Aug/2016			
02/May/2016	0.58	02/Jun/2016	0.92	02/Jul/2016	1.22	02/Aug/2016			
03/May/2016	0.94	03/Jun/2016	1.02	03/Jul/2016	1.12	03/Aug/2016			
04/May/2016	0.93	04/Jun/2016	1.02	04/Jul/2016	0.99	04/Aug/2016			
05/May/2016	0.69	05/Jun/2016	0.93	05/Jul/2016	0.95	05/Aug/2016			
06/May/2016	0.55	06/Jun/2016	1.05	06/Jul/2016	0.88	06/Aug/2016			
07/May/2016	0.53	07/Jun/2016	1.15	07/Jul/2016	0.83	07/Aug/2016			
08/May/2016	0.44	08/Jun/2016	1.03	08/Jul/2016	0.80	08/Aug/2016			
09/May/2016	0.37	09/Jun/2016	1.04	09/Jul/2016	0.84	09/Aug/2016			
10/May/2016	0.39	10/Jun/2016	0.98	10/Jul/2016	0.91	10/Aug/2016			
11/May/2016	0.45	11/Jun/2016	1.06	11/Jul/2016	0.92	11/Aug/2016			
12/May/2016	0.49	12/Jun/2016	1.12	12/Jul/2016	0.86	12/Aug/2016			
13/May/2016	0.52	13/Jun/2016	1.07	13/Jul/2016	0.94	13/Aug/2016			
14/May/2016	0.57	14/Jun/2016	0.94	14/Jul/2016	0.98	14/Aug/2016			
15/May/2016	0.67	15/Jun/2016	0.93	15/Jul/2016	0.99	15/Aug/2016			
16/May/2016	0.83	16/Jun/2016	1.09	16/Jul/2016	0.95	16/Aug/2016			
17/May/2016	0.91	17/Jun/2016	1.25	17/Jul/2016	0.91	17/Aug/2016			
18/May/2016	0.84	18/Jun/2016	1.23	18/Jul/2016		18/Aug/2016			
19/May/2016	0.72	19/Jun/2016	1.21	19/Jul/2016		19/Aug/2016			
20/May/2016	0.71	20/Jun/2016	1.23	20/Jul/2016		20/Aug/2016			
21/May/2016	0.75	21/Jun/2016	1.21	21/Jul/2016		21/Aug/2016			
22/May/2016	0.83	22/Jun/2016	1.03	22/Jul/2016		22/Aug/2016			
23/May/2016	1.03	23/Jun/2016	1.08	23/Jul/2016		23/Aug/2016			
24/May/2016	1.14	24/Jun/2016	1.27	24/Jul/2016		24/Aug/2016			
25/May/2016	1.01	25/Jun/2016	1.27	25/Jul/2016		25/Aug/2016			
26/May/2016	0.85	26/Jun/2016	1.07	26/Jul/2016		26/Aug/2016			
27/May/2016	0.76	27/Jun/2016	1.00	27/Jul/2016		27/Aug/2016			
28/May/2016	0.72	28/Jun/2016	1.06	28/Jul/2016		28/Aug/2016			
29/May/2016	0.77	29/Jun/2016	1.14	29/Jul/2016		29/Aug/2016			
30/May/2016	0.78	30/Jun/2016	1.15	30/Jul/2016		30/Aug/2016			
31/May/2016	0.78			31/Jul/2016					

Attachment B

Brucejack Gold Mine Project Site General Arrangement



BRUCEJACK MINE SITE GENERAL ARRANGEMENT - WATER MANAGEMENT PLAN

NOT FOR CONSTRUCTION. For preliminary conceptual purposes only.

PRETIVM

X:\Projects\1008\022\GIS\Analysis\20161006_Water_mgmt_working_HamishBrucejack_GA.mxd Date: November 7, 2016 Time: 10:59 AM

Appendix 5-5-3: Derivation of Discharge Limits for Ammonia, Antimony, and Arsenic

PRETIVM

Brucejack Gold Mine: 2018 Water Quality Model Report in Support of Amendment Applications for Ore Production Increase to 3800 tpd

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LORAX ENVIRONMENTAL

Executive Summary

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Executive Summary

This report provides updated water quality predictions in support of an application by Pretium Resources Inc. (Pretivm) to increase the allowable Brucejack Gold Mine ore production rate from an annual average 0.99 Mt to 1.387 Mt (*i.e.,* average 2700 tpd to average 3800 tpd). Specifically, Pretivm is applying to amend Brucejack Gold Mine *Mines Act* Permit M-243 and *Environmental Management Act* Effluent Permit 107835 as required to authorize the production increase. The updated water quality predictions also reflect a slight increase in the mine ore reserves, from 16.5 Mt for the 2015 MA-EMA Permits Application, to 18.5 Mt. The increase in the ore production rate will reduce the mine life from 18 years as predicted in 2015 to approximately 14 years, with the ore reserve increase slightly offsetting the mine life reduction.

Revisions to the Brucejack Gold Mine water quality model for the production increase application include the incorporation of revised flows from the updated 3800 tpd water balance model, changes to the mine waste schedules, and updates to geochemical source terms based on new data and trends observed in the monitoring data sets. In general, source terms have been developed based on geochemical data sets following a similar approach to that outlined in the 2015 MA-EMA Permits Application. Where possible, operational monitoring data sets have been used for source term development in lieu of static test data sets. Notable updates to the water quality model include:

- Addition of a term to account for stored loads associated with waste rock placed on the waste rock pad for up to two years;
- Revision to the approach for developing blasting-related N loads and the assumed N species distribution in Brucejack Lake;
- Development of a post-depositional diffusional term asssociated with the co-deposition of sludge with tailings in Brucejack Lake; and
- Incorporation of post-depositional As and Sb loads associated with the placement of waste rock in Brucejack Lake.

As part of the production increase application, Pretivm is also seeking authorization for the flexibility to direct waste rock to either Brucejack Lake or as backfill in the underground mine, depending upon operational needs. Two model scenarios for waste deposition were developed to reflect the extremes for waste rock deposition, based on an approach that if the modelled results for the extremes are acceptable, any ‘in-between’ waste deposition would also be acceptable. In the first scenario (Scenario 1), all of the waste rock (5.3 Mt) and 50% of the tailings (8.7 Mt) generated through the operational mine phase would be

placed in Brucejack Lake and the remaining tailings (8.7 Mt) would be backfilled in the underground mine. In the second scenario (Scenario 2), two thirds of the waste rock (3.4 Mt) would be backfilled in the underground mine, with the remainder (1.9 Mt) placed in Brucejack Lake. Consequently, significantly less tailings would be backfilled as paste in the underground mine (5.5 Mt; 32% of total generated). Model updates were completed for both of these mine waste management scenarios.

This report presents Base Case and Upper Case water quality predictions for both scenarios at station BJ 3.10, the mine's regulated discharge point located at the outlet of Brucejack Lake, and station BJ 2.62, a downstream monitoring location in Brucejack Creek. The Base Case is considered to represent a conservative expected case; whereas the Upper Case incorporates the combined effects of upper case geochemical source terms for all inputs.

Water quality model results at BJ 3.10 and BJ 2.62 for the proposed production increase are generally similar to those presented in the 2015 MA-EMA Permits Application; however, concentrations of a few parameters are predicted to increase above the previous maximum predicted concentrations. For Base Case BJ 3.10 water quality predictions, these are: ammonia, nitrite, nitrate, dissolved aluminum (D-Al), total antimony (T-Sb), total arsenic (T-As), dissolved iron (D-Fe), total lithium (T-Li) and total selenium (T-Se); whereas, for Base Case BJ 2.62 water quality predictions, these are ammonia, nitrite, nitrate, chloride (Cl), fluoride (F), D-Al, T-Sb, T-As, D-Fe, total iron (T-Fe), T-Li, T-Se, total uranium (T-U) and total zinc (T-Zn). Despite these increases, the only parameters predicted to exceed PE-107835 discharge limits or applicable BC FWAL guidelines are ammonia, T-Sb, T-As, T-Fe, D-Fe and T-Zn.

The water quality predictions presented for the two waste rock and tailings management scenarios (*i.e.,* Scenario 1 and Scenario 2) show similar trends with most parameters showing only minor differences. It is noted that the maximum Base Case predictions for some parameters are lower in Scenario 1 (*e.g.,* sulfate, silver, zinc), whereas for others they are lower in Scenario 2 (*e.g.,* ammonia, nitrite, nitrate, arsenic). Overall, the results indicate that whichever waste management strategy is implemented will have minimal influence on water quality in the receiving environment.

Parameters of potential concern were identified from both production increase application modelling scenarios and include all those with predictions that are (1) higher than in the 2015 MA-EMA Permits Application, and (2) higher than a PE-107835 discharge limit during Operations (arsenic) <u>or</u> BC FWAL guideline during Closure or Post-Closure (ammonia, antimony, arsenic, iron, and zinc).

Base Case ammonia concentrations at BJ 3.10 are predicted to increase above the PE-107835 discharge limit (1.0 mg/L) early in Operations and remain elevated until the

Closure phase when blasting and waste rock deposition have ceased. Base Case ammonia concentrations at both BJ 3.10 and BJ 2.62 are predicted to decrease to background levels by the end of the Closure phase.

Base Case As predictions for the production increase modelling are similar to the 2015 MA-EMA Permits Application, but the timing of the maximum Operations predictions is earlier in the mine life with the updated mine schedule. The updated model has As exceeding its discharge limit of 5 µg/L in year 2 of Operations, whereas the 2015 MA-EMA Permits Application predicted an exceedance in Year 6. Updated Closure and Post-Closure predictions for As are slightly lower than in the 2015 MA-EMA Permits Application.

The updated Base Case Sb model predicts Sb concentration will be above the BC FWAL working guideline during much of the Operations phase. Antimony is predicted to decrease during Closure phase, and be lower than the guideline during Post-Closure. The pattern is the same presented in the 2015 MA-EMA Permits Application, with maximum prediction Base Case prediction being 13 µg/L in the updated model and 9 µg/L in the 2015 application, which is equal to the BC FWAL guideline.

Iron and Zn concentrations are predicted to exceed respective water quality guidelines at BJ 2.62 during the Closure and Post-Closure phases when the underground mine is flooded and groundwater flows to Brucejack Creek. The predicted elevated Fe concentrations are expected to decrease below BC FWAL guideline limits when solubility constraints are considered. Zinc is predicted to have a maximum concentration of 8.6 µg/L, a slight increase from the maximum of 8.5 µg/L in the 2015 MA-EMA Permits Application, and slightly above the BC FWAL guideline of 7.5 µg/L.

Residual effects from the maximum predicted concentrations of ammonia, As, Sb, Fe, and Zn were assessed. No adverse effects from ammonia, As, Sb, or Zn were predicted, and the assessment gave a low significance rating to potential effects from Fe. The effects ratings were based on toxicity literature that showed that no toxicity is expected to aquatic life in the receiving environment. As well, site specific toxicity testing of As and Sb found that the predicted concentrations are below the No Observable Effects Level to an algal species that is known to be sensitive to arsenic toxicity.

Iron in groundwater entering Brucejack Creek during Post-Closure is predicted to be insoluble in the creek and to precipitate out. Since water is expected to have Fe concentrations below the BC FWAL guidelines, no significant effect to aquatic life from dissolved Fe is expected. Sediment Fe concentrations may increase and may have a localized effect on benthic organisms. The overall significance of iron precipitation is considered low.

Discharge limits based on Operations phase Upper Case BJ 3.10 predictions have been proposed for ammonia (4 mg-N/L), T-Sb (28 µg/L) and T-As (10 µg/L). The Base Case model results represent monthly average concentrations, whereas the Upper Case predictions are expected to capture the variability arising from samples that are greater than the monthly average. The effects assessment indicates that the proposed ammonia, T-Sb and T-As discharge limits will not cause significant adverse effects to aquatic life in the receiving environment.

Potential cumulative effects in lower Sulphurets Creek from the proposed ammonia, Sb and As discharge limits and water quality predictions for the KSM mine are considered not significant. The maximum loading of ammonia, T-Sb or T-As from Brucejack Mine effluent would not cause the cumulative concentration to go above the BC FWAL water quality guidelines, or to change the background concentration when the background levels are above the guideline.

Acknowledgements

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List of Acronyms and Abbreviations

PRETIVM

List of Acronyms and Abbreviations

ABA	Acid Base Accounting
ACR	Acute-to-Chronic Ratio
AF	Assessment Factor, also called the Safety Factor
BC	British Columbia
CCME	Canadian Council of Ministers of the Environment
CMP	Chemical Management Plan
CWP	Contact Water Pond
EC50	Median Effective Concentration, at which 50% of the organisms are affected
EIS	Environmental Impact Statement
EMA	*Environmental Management Act*
FWAL	Freshwater Aquatic Life
LC_{50}	Lethal Concentration, causing mortality in 50% of test organisms
LOEC	Lowest Observed Effect Concentration
LOM	Life of Mine
MA	*Mines Act*
MA-EMA	Brucejack Gold Mine Project: Application for *Mines Act* and *Environmental Management Act* Permits
ML/ARD	Metal Leaching/Acid Rock Drainage
NMP	Nitrogen Management Plan
NOEC	No Observable Effect Concentration
NPAG	Non-Potentially Acid Generating
NPR	Neutralization Potential Ratio
PAG	Potentially Acid Generating
PHREEQC	Computer Program for Geochemical Calculations
POPC	Parameters of Potential Concern
SAG	Semi-Autogenous Grinding
SFE	Shake Flask Extraction

SMAV	Species Mean Acute Value
SMCV	Species Mean Chronic Value
STP	Sewage Treatment Plant
TPD	Tonnes Per Day
TSS	Total Suspended Solids
US EPA	United States Environmental Protection Agency
WQG	Water Quality Guideline
WTP	Water Treatment Plant

1. Introduction

1. Introduction

This report has been prepared in support of an application by Pretium Resources Inc. (Pretivm) to amend Brucejack Gold Mine *Mines Act* Permit M-243 and *Environmental Management Act* Effluent Permit 107835 to allow an increase in ore production rate from the currently permitted average annual 990,000 t on a calendar basis to average annual 1.387 Mt. This equates to an increase from an average ore production rate of 2700 tpd to 3800 tpd. The Brucejack Gold Mine is located approximately 65 km NNW of Stewart, B.C. (Figure 1-1) and began producing gold in June 2017.

The proposed 3800 tpd mine operating life is approximately 14 years, with a total ore reserve of 18.5 Mt. Pretivm is seeking the flexibility, based on operational needs, to direct future waste rock to either Brucejack Lake for subaqueous deposition, or to the underground mine for backfilling of secondary stopes. The 3800 tpd applications include assessments of the two extremes (scenarios) for waste rock deposition (*i.e.*, maximum deposition according to either method), with tailings discharge and paste backfill balanced accordingly. The intent of this approach is that if both extremes are acceptable for a given type of assessment, any 'in between' deposition ratio would logically also be acceptable.

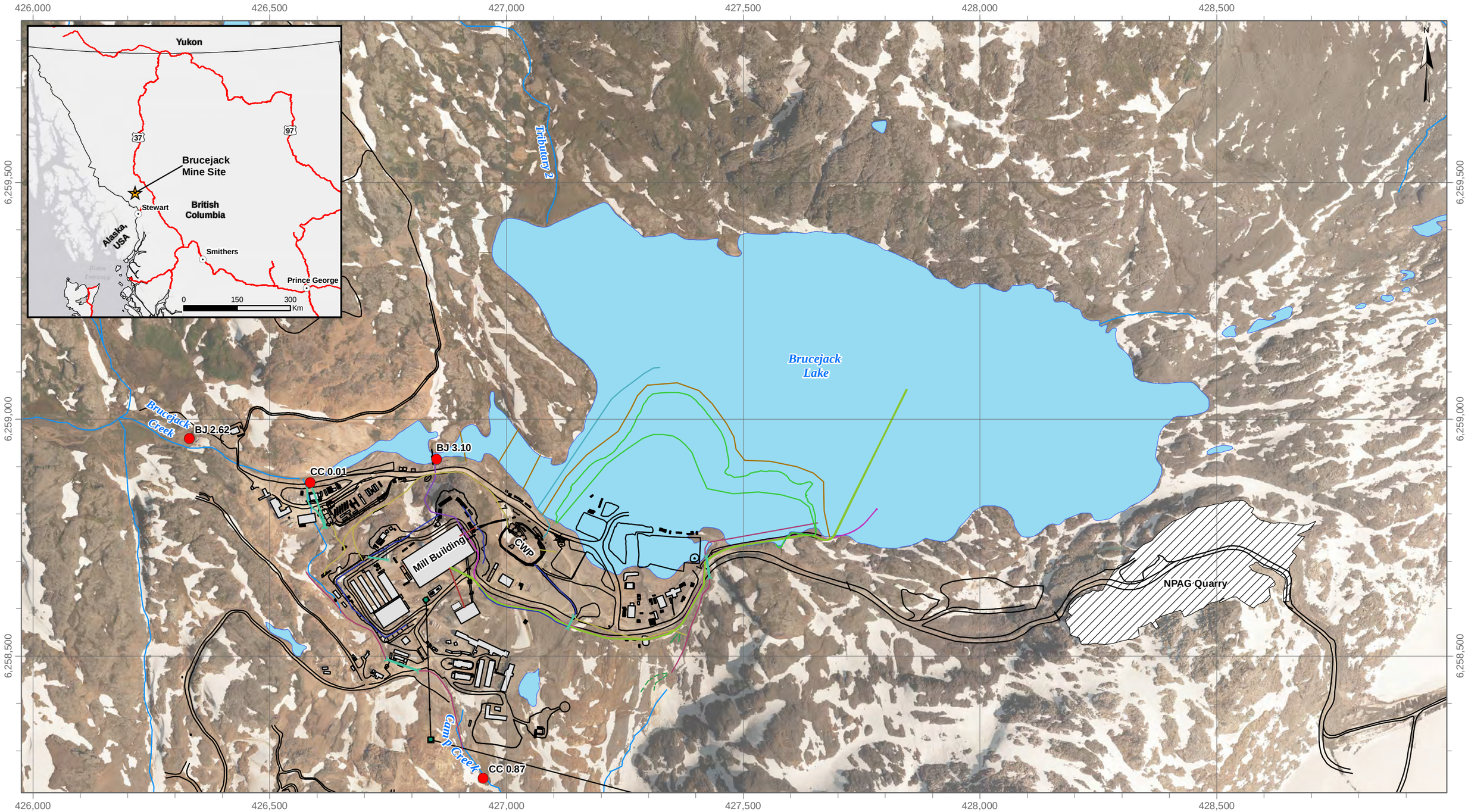
Specifically, in Scenario 1, all future waste rock (5.3 Mt) would be deposited in Brucejack Lake along with approximately 50% of the tailings. The remaining 50% of tailings would be deposited in the underground mine as paste backfill. In Scenario 2, approximately two-thirds of the waste rock (3.4 Mt) would be deposited underground, with an associated increase in the percentage of tailings deposition in the lake (68%).

The purpose of this report is to predict how the proposed change in ore production rate (*i.e.*, the mill processing rate) will impact water quality in the receiving environment through life of mine (LOM) and into the Post-closure phase, considering both scenarios. Water quality modelling results are presented for two stations: 1) BJ 3.10, the mine's regulated discharge location; and 2) BJ 2.62, a downstream monitoring location in Brucejack Creek which will receive underground mine loads via groundwater pathways once the mine has been flooded following closure (Figure 1-1). Results for BJ 3.10 were generated for the Operations, Closure and Post-closure mine phases; whereas water quality results at BJ 2.62 were only produced for the Closure and Post-closure phases.

This report also describes revisions to the water quality model that were presented in the 2015 MA-EMA permits application and subsequently updated in amendment applications for increased nitrite and nitrate discharge limits (submitted November 2016), co-deposition of water treatment plant sludge with tailings (submitted January 2017), extension of the

PAG waste rock exposure time criterion (submitted January 2017) and approval of an updated Cr Management Plan (submitted February 2017). These revisions include updates to various source terms based on new data, the incorporation of new terms based on trends observed in the monitoring data sets, changes to the mine plan schedules, and revisions to water management plans. In general, source terms have been developed based on geochemical data sets following a similar approach to that outlined in the 2015 MA-EMA Permits Application. However, where possible, operational monitoring data sets have been used for source term development in lieu of static test data sets.

Following this introduction, Chapter 2 describes the modelling approach and assumptions used in the generation of the water quality predictions. Chapter 3 describes the water quality model source terms for the various background and mine-related inputs. The model results for Base Case and Upper Case predictions are presented in Chapter 4, with an environmental effects assessment of the water quality predictions provided in Chapter 5. The report concludes with a summary of the results (Chapter 6).



LEGEND

- Water Quality Monitoring Station
- Structure
- NPAG Quarry
- CWP Direct Discharge Line
- Contact Water Ditch
- Contact Water Lines
- Culvert
- Non-Contact Surface Runoff
- Non-Contact Water Channel
- Reclaim Water Line
- Turbitity Curtains
- Subaqueous Waste Rock
- Tailings Discharge Line
- Untreated or Off-Spec Water Line
- WTP/STP Effluent Line

DATE SAVED:	Dec 13, 2017
DRAWN BY:	GM
REVIEWED:	AS
VERSION:	1

Coordinate System: NAD 1983 UTM Zone 9N
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter

1:7,500

0 150 300 Meters

CLIENT: PRETIVM

LORAX ENVIRONMENTAL

TITLE: **Mine Site Infrastructure and Water Quality Monitoring Stations**

PROJECT: Brucejack MA/EMA Permits Application

PROJECT #: A406-5

FIGURE: 1-1

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2. Modelling Approach and Assumptions

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2. Modelling Approach and Assumptions

This chapter describes the modelling approach and assumptions associated with updating water quality predictions for the Brucejack Gold Mine for an increase in ore processing rate (from 2700 tpd to average daily 3800 tpd). Mitigation strategies are outlined, followed by a detailed description of the water quality modelling approach.

2.1 General Site-Wide Mitigations

Water quality predictions presented in this report include consideration of several mitigation strategies. For the purpose of water quality modelling, it is assumed that the proposed mitigations will be effective as designed. These mitigations include:

- A Sewage Treatment Plant (STP) which will meet effluent quality discharge requirements throughout life of mine (LOM). Treated water is discharged to Brucejack Lake;
- Management of contact water, via collection ditches, pipelines and related structures, as per the Water Management Plan;
- An Operations Water Treatment Plant (WTP) which will treat contact water from the site and meet effluent quality discharge requirements throughout LOM. Treated water is discharged to Brucejack Lake;
- Management of potentially acid generating (PAG) waste rock through deposition of waste rock into Brucejack Lake. It is assumed that suspended sediments associated with the waste rock will continue to largely settle in the lake, which acts as a natural sedimentation pond. It is further assumed that any sediments remaining in suspension will be managed using the sediment control curtains;
- Disposal of thickened tailings solids and effluent to the bottom of Brucejack Lake via a suspended tailings pipeline; it is assumed that fines associated with tailings will continue to remain at the bottom of the lake, similar to natural fine grained sediment;
- Management of blasting-related nitrogen compunds following source control measures and best management practices as outlined in the Nitrogen Management Plan (NMP); and
- Management of hexavalent chromium associated with cement use in the underground mine as described in the Chromium Management Plan (CMP).

2.2 Water Quality Model

2.2.1 Overview

The Brucejack Gold Mine water quality model employs a mass balance approach that accounts for background water quality and runoff volumes reporting from undisturbed portions of the Brucejack Creek watershed, as well as chemical loads emanating from mine sources (*e.g.*, underground workings, waste rock, tailings discharge) and water management structures (*e.g.*, Contact Water Pond (CWP), the WTP and the STPs). Loads associated with solids such as deposited waste rock, explosive-related nitrogen species and tailings, were pre-determined and input directly to the mass balance calculations. Each component of the existing environment and Mine Site Area that may contribute to water quality at the outlet to Brucejack Lake (BJ 3.10; model node 1) and at Brucejack Creek monitoring station BJ 2.62 (model node 2) has been included in the water quality model.

Background water quality signatures are derived from pre-Construction monitoring (ERM Rescan, 2014), while mine-related water quality signatures are based on geochemical source terms. The water quality model was constructed in accordance with the structure of the water balance for the Brucejack Gold Mine (BGC, 2018). The water balance model tracks all background and mine-impacted waters that report to Brucejack Lake and various monitoring sites (model nodes) along Brucejack Creek. An overview of the water balance is provided in Section 2.2.2, with additional information on derivation of the water balance provided in the water balance update (BGC, 2018).

The water quality model assumes the lake is vertically stratified for most of the year, but fully mixed during months when the lake experiences temperature-driven turnover events (July and October). This assumption is supported by lake profiling data collected through monitoring programs developed for Brucejack Lake (described in Section 2.2.5).

The water quality model was developed in GoldSim; a flexible, object-oriented software tool that is designed for carrying out dynamic, probabilistic simulations of complex systems. GoldSim can be applied to deterministic simulations in which all inputs are pre-determined by the user. This approach was used to predict water quality concentrations at mixing locations within the conceptual flow networks defined for each of the specified mine phases.

The model uses monthly time steps throughout the duration of mine life and includes a total of 372 consecutive months, consisting of:

- Exploration phase: 32 months, from January 2013 through August 2015, which corresponds to the last 2 ½ years of the exploration period. Calibration predictions

were assessed between February 2013 and March 2014 using observed measurements from that period;

- Construction phase: 21 months, from September 2015 through May 2017, which corresponds to the two-year Construction phase (*i.e.*, Y-2 (September 2015 through May 2016) and Y-1 (June 2016 through May 2017));
- Operations phase: 163 months, from June 2017 to December 2030, which corresponds to the expected timing and duration of the 14-year Operations phase (Note that Y1 is defined as June 2017 to December 2017, whereas all years thereafter are based on a calendar year);
- Closure phase: 36 months, from January 2031 to December 2033, which corresponds to the estimated timing and duration of the Closure phase; and
- Post-closure phase: 120 months, from January 2034 to December 2043, which corresponds to the first 10 years of the Post-closure period.

The predicted monthly flows in the water balance model vary through the year, reflecting site hydrology and hydrogeology. Site data acquired during the Exploration and Construction phases were used to calibrate and validate the water quality model. The water quality model results presented here reflect predictions for the Operations, Closure and Post-closure phases; however, chemical loads associated with Construction phase activities have been incorporated into the model since a portion of these loads will impact Brucejack Lake water quality during the first few years of Operations (as determined by the residence time in the lake, which is estimated to be approximately 18 months).

An underpinning assumption of the modelling approach is that parameters behave in a conservative manner and that no mass is lost through geochemical reactions or natural biogeochemical processes. In this regard, water quality predictions result solely from the mixing of the various water types. This results in significant conservatism in the model, since some degree of removal is expected from secondary reactions. In the underground environment, for example, some degree of attenuation can be expected through adsorption and mineral solubility constraints. In Brucejack Lake, various natural biogeochemical mechanisms are also expected to attenuate trace element and nutrient concentrations (*e.g.*, biological uptake of nitrogen and phosphorus and metal scavenging by particles and removal to lake sediments). Attenuation processes are not modelled, but the distribution of nitrogen among inorganic species (*i.e.*, ammonia, nitrite and nitrate) is adjusted to account for nitrification processes that occur naturally in Brucejack Lake.

2.2.2 Water Balance

The water balance and water management plans for the Brucejack Gold Mine were developed by BGC Engineering (BGC, 2018). The water balance is a detailed interpretation of the mine and water management plans, with consideration of baseline climate, hydrometric, and hydrogeological data collected for the Mine Site Area (*i.e.*, the area that comprises all mine infrastructure to the west of Knipple Glacier). The present section presents an overview of the water balance provided by BGC (BGC, 2018) which has been integrated into the water quality model described above.

The water balance for the Brucejack Gold Mine was derived using information from the following sources:

- Mine schedules for waste rock, ore and tailings;
- Underground mine design and mill feed rates;
- Site-specific and long-term climate dataset for the proposed mine area, including precipitation, potential evaporation and temperature;
- Drainage areas and runoff coefficients;
- Estimated groundwater inflows and seepage rates;
- Process plant water balance model (including freshwater make-up requirements); and
- Tailings density and properties.

The water balance configurations for the Operations and Post-Closure phases used to develop the water quality model are illustrated in Figure 2-1 and Figure 2-2 respectively.

The following are the main water management components of the water balance for the Operations phase:

1. A CWP which receives approximately 70% of surface runoff from the Mine Site contact water management area (primarily the mill and camp pads). This water is pumped to the WTP for treatment. The remaining 30% is assumed diversion ditch leakage that reports directly to the lake;
2. Dewatering from the underground mine, which includes groundwater inflows, and paste backfill bleed water (*i.e.*, the excess water not consumed in the paste backfill cementation reaction);
3. The WTP, which treats water from the CWP and the underground mine. The treated effluent is used in the mill process, with any excess not required for process discharged to Brucejack Lake in an effluent discharge line line along with STP effluent. WTP

effluent used in process is also discharged via the tailings line as part of the tailings slurry;

4. Two STP units which discharge to Brucejack Lake via the WTP/STP effluent line;
5. A mill which discharges a tailings slurry to Brucejack Lake and pipes paste backfill to the underground mine;
6. The conveyance of contact flows from the NPAG Quarry to Brucejack Lake via surface runoff; and
7. Deposition of waste rock subaqueously in Brucejack Lake, and to the underground mine as backfill.

The operational components of the Brucejack Gold Mine are summarized in Figure 2-1, along with other water inflows and losses relevant to the Operations phase water balance. Monthly average lake discharges during operations are expected to range from 0.046 to 1.5 m^3/s. These discharge flows include the contribution of water displaced by the deposition of waste rock and tailings solids. Total lake water volume capacity at the start of operations is 29.5 Mm^3 and is reduced to 22.2 Mm^3 at the end of operations.

At Closure, mine facilities will be decommissioned (*e.g.*, STP, WTP, and mill) and the underground mine workings will be flooded. The reconfiguration of flows and the associated water management plan is reflected in the water balance illustrated in Figure 2-2.

The Post-closure water balance includes the following mine-related components:

- Flows from the NPAG Quarry;
- Flows from the reclaimed plant site; and
- Drainages from the underground mine which flow to Brucejack Lake and Brucejack Creek via groundwater pathways.

In addition to accounting for mine-related loads, the water quality model predictions incorporate contributions from Camp Creek and the Mine Site surrounding background.

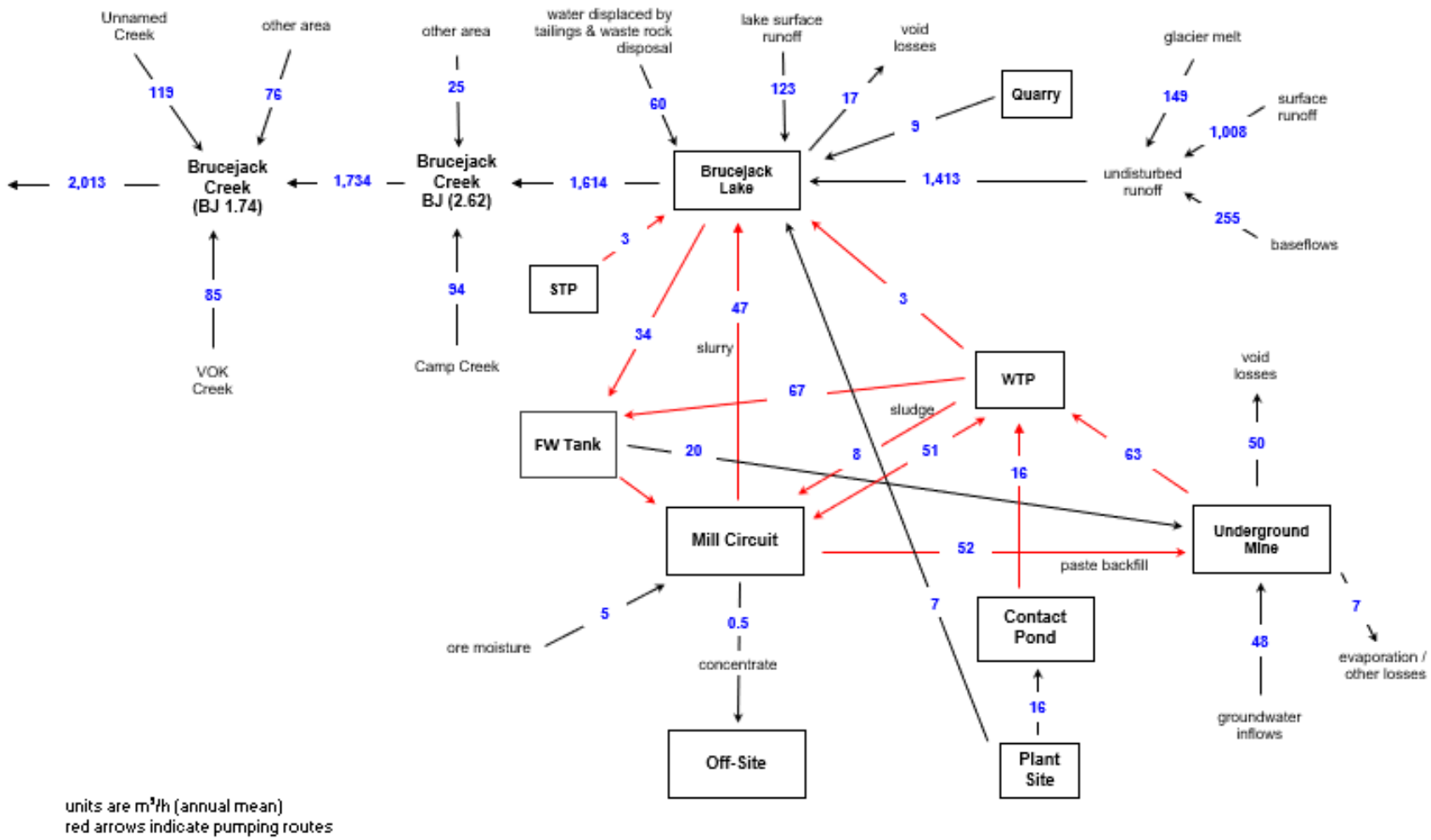


Figure 2-1: Brucejack Lake Water Balance Model Schematic for the Operations Phase.

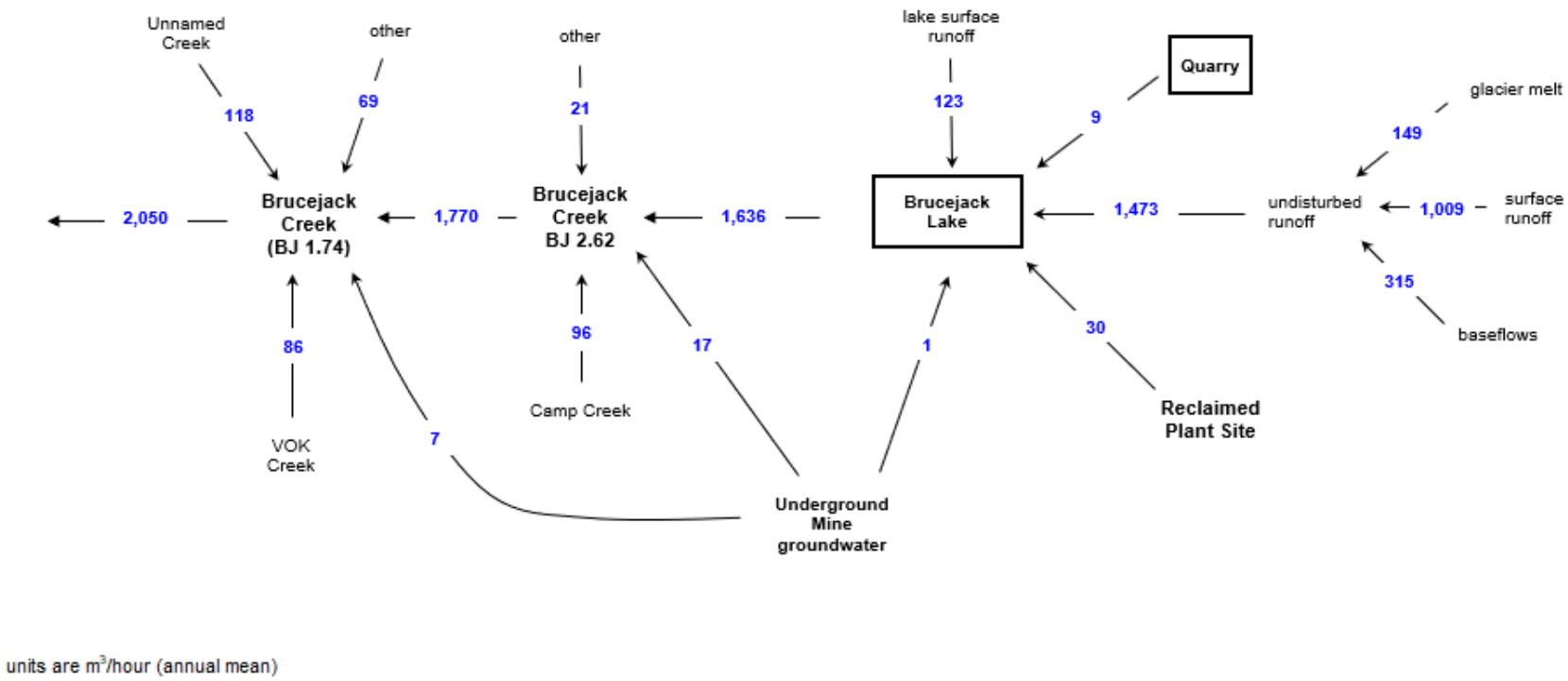


Figure 2-2: Brucejack Lake Water Balance Model Schematic for the Post-closure Phase.

2.2.3 Modelling Locations and Parameters

Water quality predictions are generated for two locations, also termed model nodes (Figure 1-1):

- BJ 3.10, located at the outlet to Brucejack Lake; and
- BJ 2.62, a monitoring station in Brucejack Creek, located downsteam of Brucejack Lake.

During the Operations phase, Brucejack Lake receives all mine-affected inputs, and thus monitoring station BJ 3.10 at the outlet to the lake was selected as the mine's regulated discharge point for Operations, and is the point at which discharge limits in Effluent Permit 107835 apply.

During the Post-closure phase, once the mine is flooded, the majority of groundwater flow paths from the underground mine discharge to the upper reaches of Brucejack Creek between the lake outlet and BJ 2.62. Monitoring station BJ 2.62 is located downstream of Brucejack Lake and Camp Creek at the bottom of a cascade, which is expected to result in fully mixed conditions upstream of BJ 2.62. BJ 2.62, therefore, represents a key location for the Post-closure water quality predictions.

Water quality predictions were generated for the parameters listed in Table 2-1, including major ions representative of mine-related inputs and all parameters with BC freshwater aquatic life (FWAL) guidelines. Neither pH nor TSS was modelled, as they depend on a wide range of factors that are not fully accounted for in the mass loading approach.

Table 2-1:
Water Quality Parameters Included in the Brucejack Gold Mine Water Quality Model

Parameter	Formula
Major Anions	
Ammonia (as N)	NH_3-N
Nitrate (as N)	NO_3-N
Nitrite (as N)	NO_2-N
Chloride	Cl^-
Fluoride	F^-
Sulfate	SO_4^{2-}
Phosphorus	P
Metals (Total and Dissolved)	
Aluminum	Al
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Bismuth	Bi
Boron	B
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Lithium	Li
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Molybdenum	Mo
Nickel	Ni
Phosphorous	P
Potassium	K
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Strontium	Sr
Thallium	Tl
Tin	Sn
Titanium	Ti
Uranium	U
Vanadium	V
Zinc	Zn

2.2.4 Water Quality Modelling Cases

Water quality predictions through Operations, Closure and Post-closure mine phases were generated for a Base Case and an Upper Case. The Base Case represents a conservative expected condition, whereas the Upper Case applies upper case geochemical source terms to all mine-related inputs to the model. Both cases are based on average flow conditions for all flows with the exception of groundwater flows during the Operations phase. The water quality model applies the low hydraulic conductivity (K) groundwater flows as presented in the site water balance, since these flows are more consistent with the groundwater flows observed to date.

Both Base Case and Upper Case conditions were modelled for the two proposed mine scenarios:

- **Scenario 1:** All waste rock generated from the underground mine is placed in Brucejack Lake. This scenario maximizes the amount of tailings that are placed as paste backfill in the underground mine.
- **Scenario 2:** The amount of waste rock placed as backfill in the underground mine is maximized to the extent possible with the remaining portion placed in Brucejack Lake. This scenario results in a higher proportion of tailings being placed in Brucejack Lake.

Mine schedules were developed for both scenarios and are presented in the relevant source term sections below.

2.2.5 Mixing Assumptions for Brucejack Lake

Northern lakes are typically dimictic, meaning that they mix from the surface to the bottom twice per year due to convective overturn in the spring and fall. This behaviour applies to Brucejack Lake, which becomes stratified during the summer and winter months (lower density surface layer on top of a higher density lower layer). The water quality model assumes that Brucejack Lake is dimictic, being fully mixed in July and October and stratified during other months.

The model assumes that the surface layer is represented by the upper 10 m of the lake and that the lower layer extends from a depth of 10 m to the lake bottom. The upper 10 m of Brucejack Lake contains approximately 25% of the total lake volume. Modelled loadings to the surface layer are from background runoff, uncaptured Mine Site runoff, and NPAG Quarry runoff. Modelled loadings to the lower layer are from waste rock deposition, WTP discharge, STP discharge, and tailings disposal.

The model assumptions regarding lake mixing behaviour are supported by 2016-2017 temperature and density monitoring data sets collected throughout the water column (Figure 2-3). Strong stratification is observed through winter and late summer months, whereas the lake is fully mixed in July and October.

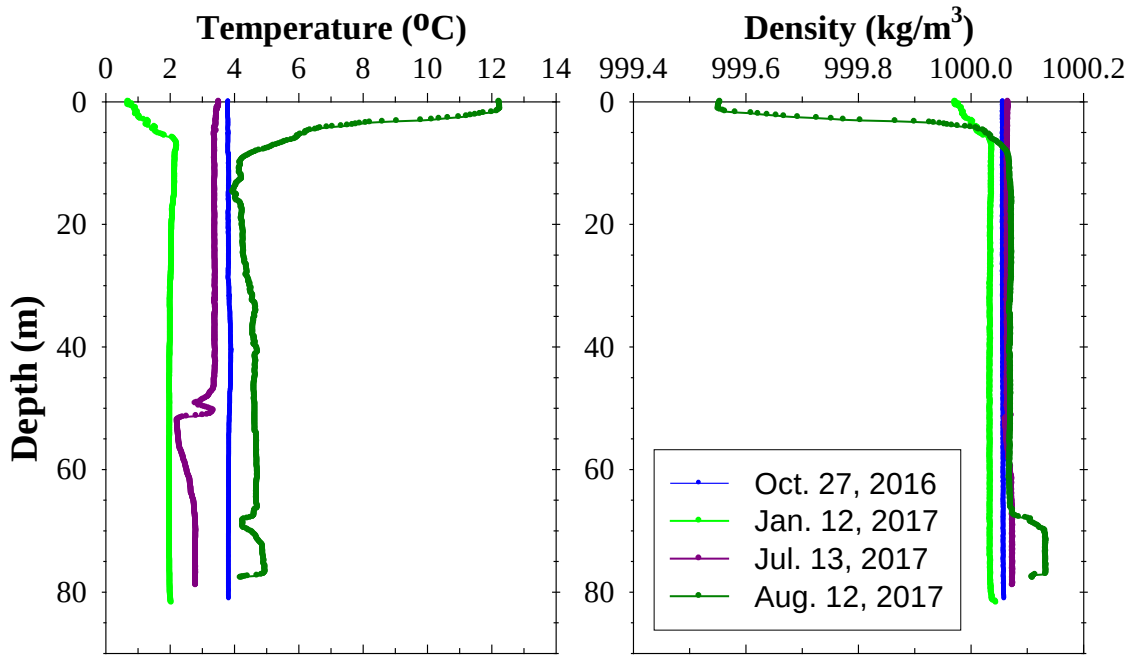


Figure 2-3: Vertical profiles of temperature and density in Brucejack Lake during different seasons of 2016-2017.

2.3 Summary of Updates to the Water Quality Model

The water quality model has been revised since it was presented in the MA-EMA Permits Application (Pretivm, 2015). These revisions include updates to various source terms based on new data, the incorporation of new terms based on trends observed in the monitoring data sets, changes to the mine plan schedules, and revisions to water management plans. The major revisions incorporated into the current water quality model include the following:

- Revision to the site's water balance based on observed flows and changes to the mine plan (described in BGC, 2018); a more detailed understanding of flows and recycling processes within the mill has resulted in changes to the configuration of the GoldSim model with respect to calculation of tailings and bleed water source terms;

- The addition of a term to account for stored loads associated with waste rock placed on the waste rock pad for up to two years;
- The development of a post-depositional diffusional term asssociated with the co-deposition of sludge with tailings in Brucejack Lake;
- Revision to Cr loads associated with paste backfill and bleed water based on new kinetic tests results;
- The incorporation of post-depositional As and Sb loads associated with the placement of waste rock in Brucejack Lake;
- Revisions to the approach for developing blasting-related N loads and the assumed N species distribution in Brucejack Lake;
- Refinement of assumptions related to water quality during the flooding period of the underground workings at Closure; and
- Re-calibration of lake water quality based on water quality monitoring data sets collected in July 2017 when the lake is assumed to have been fully mixed.

3. Source Terms

3. Source Terms

The Brucejack Gold Mine water quality model incorporates the combined effects of all background (non-contact) and mine-related (contact) sources. The water quality predictions presented in Chapter 4 are based on source terms developed for the following components:

- Background sources;
- NPAG Quarry runoff;
- Mine Site runoff;
- Waste rock and weathered material from surface excavations deposited in Brucejack Lake;
- Underground Mine waste rock placed in Brucejack Lake;
- Underground Mine water;
- Water Treatment Plant effluent and solid phase sludge;
- Tailings deposited in Brucejack Lake and placed in the underground mine as paste backfill;
- Sewage Treatment Plant effluent; and
- Blasting-related nitrogen compounds.

The derivation of source terms for each of these components is described in the following sections. In most cases, source terms are based on static and kinetic geochemical data sets following the same approach as described in the MA-EMA Permits Application. However, where possible, source term updates have incorporated recent operational data sets acquired through the various site monitoring programs. The observed Brucejack Lake water quality has been used to validate the model inputs, but has not been used for direct calibration except in the case of N species.

All source terms are updated on an annual basis and comparisons to previous values are presented in the Annual Reports. Water quality model source terms will be refined as additional operational data sets are acquired and these revisions will be incorporated into the 5 year Mine Plan and Reclamation Plan (due June 2020).

3.1 Background Water Quality

3.1.1 Overview

Background (non-contact) water quality terms for the Brucejack Gold Mine are based on monitoring datasets for Brucejack Lake and Camp Creek, as measured at stations BJ 3.10 and CC 0.01, respectively (ERM Rescan, 2014). The BJ 3.10 dataset reflects the cumulative influence of background precipitation, evaporation, groundwater, and surface runoff to the lake, and also accounts for waste rock deposited in Brucejack Lake, and any other activity that may have impacted water quality, up to the completion of baseline monitoring in 2013. The Camp Creek data set was used to calculate a background source term for BJ 2.62. The flows assigned to the background source terms are based on the water balance provided by BGC (described in Section 2.2.2).

Brucejack Lake is situated within the Brucejack Creek watershed and receives water from an area of approximately 6.6 km^2. Beyond the lake, a relatively small volume of undisturbed surface flow and groundwater report to Brucejack Creek between the outlet to Brucejack Lake and downstream monitoring station BJ 2.62. Background water quality specific to this small catchment is not available. Consequently, this flow was assigned chemistry values equal to the background terms used for Brucejack Lake, as a conservative proxy recognizing that these values include the influence of waste rock dumping and other mine inputs to Brucejack Lake.

3.1.2 Background Source Term Values

The source term for Brucejack Lake was developed using baseline monitoring data collected between 2009 and 2013, when Pretivm was conducting advanced mineral exploration in the Brucejack Valley. While periods of exploration during the 2009 to 2013 monitoring period may have affected BJ 3.10 water quality (*e.g.*, waste rock dumping required from underground exploration; ERM Rescan, 2014), the relative effect of including such events in source-term calculations is small and ultimately yields a more conservative source term for modelling purposes. Monitoring data collected by Newhawk between 1987 and 2001 (n = 56 samples) had several limitations (*e.g.*, high method detection limits, limited number of parameters analyzed), making it unsuitable for use in source term development.

The monitoring data were grouped into quarters (three-month long periods) to reflect distinctive seasonal hydrologic phases at the site. At the Brucejack Gold Mine, site conditions are most consistent with three-month periods that are shifted one calendar month forward, relative to normal calendar quarters. The background source term values

were therefore calculated by applying a "Smart Quarters" approach using the following time intervals:

- Smart Quarter 1: February, March, and April;
- Smart Quarter 2: May, June, and July;
- Smart Quarter 3: August, September, and October; and
- Smart Quarter 4: November, December, and January.

Background water quality source terms were calculated from median values for each Smart Quarter dataset (Table 3-1) and applied to both the Base Case and Upper Case models.

Background water quality for BJ 2.62 incorporates the added contributions from Camp Creek based on the data sets available for time periods when Camp Creek was considered to be uninfluenced by exploration and/or mine-related activities (*e.g.*, October 2009-June 2012 and January 2016-present). The Camp Creek data used for calculation of the BJ 2.62 background values are presented in Table 3-2, and represent median values for each of the Smart Quarter intervals described above. The calculated BJ 2.62 background values used in the water quality model are provided in Table 3-3.

Table 3-1: Background (Brucejack Lake and Upper Brucejack Creek) Source Terms for Base Case Scenario

Parameter	Smart Quarter 1 (Feb/Mar/Apr)		Smart Quarter 2 (May/Jun/Jul)		Smart Quarter 3 (Aug/Sep/Oct)		Smart Quarter 4 (Nov/Dec/Jan)	
	(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Anions								
Ammonia (as N)	0.0025		0.0025		0.0025		0.0025	
Nitrate (as N)	0.0025		0.013		0.0052		0.0025	
Nitrite (as N)	0.00050		0.00050		0.00050		0.00050	
Chloride	0.25		0.25		0.25		0.25	
Fluoride	0.010		0.010		0.010		0.010	
Sulfate	9.8		9.2		9.0		9.6	
Total Phosphorus	0.0010		0.011		0.0040		0.0020	
Metals	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Al	0.010	0.0015	0.28	0.0098	0.15	0.010	0.018	0.0025
Sb	0.00022	0.00021	0.00027	0.00019	0.00030	0.00029	0.00025	0.00025
As	0.00060	0.00060	0.0011	0.00040	0.00080	0.00060	0.00060	0.00050
Ba	0.037	0.036	0.040	0.032	0.040	0.034	0.034	0.034
Be	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.00050	0.00025
Bi	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.10	0.00025
B	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.050	0.0050
Cd	0.0000050	0.0000050	0.0000050	0.0000050	0.0000070	0.0000050	0.0000085	0.0000090
Ca	9.4	9.5	8.4	8.6	9.3	9.1	8.9	9.1
Cr	0.000050	0.000050	0.00012	0.000050	0.00027	0.000050	0.00050	0.00025
Co	0.000050	0.000050	0.00012	0.000050	0.000090	0.000050	0.0015	0.000050
Cu	0.00025	0.00025	0.00067	0.00025	0.00038	0.00025	0.00050	0.000050
Fe	0.015	0.015	0.25	0.015	0.069	0.015	0.015	0.015
Pb	0.000025	0.000025	0.00026	0.000025	0.00020	0.000025	0.00025	0.000025
Li	0.00025	0.00025	0.00025	0.00025	0.0013	0.00076	0.0025	0.0025
Mg	0.31	0.30	0.34	0.29	0.31	0.30	0.30	0.30
Mn	0.0024	0.0019	0.022	0.0087	0.0084	0.0031	0.0029	0.00089
Hg	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050	0.0000050
Mo	0.00037	0.00035	0.00032	0.00030	0.00038	0.00036	0.00050	0.00050
Ni	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025	0.00050	0.00025
K	0.082	0.077	0.20	0.089	0.29	0.11	1.0	1.0
Se	0.000050	0.00011	0.000050	0.000050	0.000090	0.000050	0.00050	0.000050
Si	0.60	0.59	1.0	0.54	0.88	0.53	0.56	0.55
Ag	0.0000050	0.0000050	0.000021	0.0000050	0.0000075	0.0000050	0.000010	0.0000050
Na	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Sr	0.063	0.061	0.054	0.055	0.061	0.058	0.056	0.056
Tl	0.000050	0.0000050	0.000050	0.0000050	0.000050	0.0000050	0.000050	0.000050
Sn	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.00025	0.000050
Ti	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
U	0.000025	0.000023	0.000032	0.000014	0.000043	0.000026	0.00010	0.00010
V	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050	0.00050
Zn	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0025	0.00050

Table 3-2:
Camp Creek Source Terms for Calculation of BJ 2.62 Background Water Quality

Parameter	Smart Quarter 1 (Feb/Mar/Apr)		Smart Quarter 2 (May/Jun/Jul)		Smart Quarter 3 (Aug/Sep/Oct)		Smart Quarter 4 (Nov/Dec/Jan)	
	(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Anions								
Ammonia (as N)	0.25		0.016		0.015		0.045	
Nitrate (as N)	2.8		0.18		0.15		0.63	
Nitrite (as N)	0.059		0.0017		0.0010		0.0010	
Chloride	29		3.0		2.0		6.0	
Fluoride	0.19		0.064		0.080		0.095	
Sulfate	155		39		62		127	
Total Phosphorus	0.0010		0.011		0.0040		0.0020	
Metals	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Al	5.0	0.019	1.1	0.019	0.88	0.039	0.11	0.024
Sb	0.0057	0.0043	0.00049	0.00010	0.00050	0.00050	0.00010	0.00010
As	0.040	0.0011	0.0072	0.00010	0.0025	0.00050	0.00013	0.00010
Ba	0.25	0.050	0.049	0.035	0.055	0.035	0.022	0.022
Be	0.0013	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
Bi	0.000050	0.000050	0.000050	0.000050	0.000050	0.000050	0.00050	0.00050
B	0.049	0.046	0.010	0.010	0.10	0.10	0.012	0.011
Cd	0.0012	0.00075	0.00030	0.00029	0.00055	0.00043	0.00048	0.00047
Ca	70	69	15	15	25	23	49	47
Cr	0.0014	0.00010	0.00027	0.00010	0.0010	0.0010	0.00010	0.00011
Co	0.0077	0.0037	0.0017	0.0011	0.0037	0.0024	0.0013	0.0013
Cu	0.028	0.00070	0.0039	0.00068	0.0047	0.0013	0.0012	0.00077
Fe	8.6	0.010	1.5	0.010	1.1	0.030	0.036	0.030
Pb	0.0090	0.000050	0.0022	0.000050	0.00097	0.00050	0.000050	0.000050
Li	0.0068	0.0021	0.0017	0.0012	0.0050	0.0050	0.0020	0.0016
Mg	4.5	3.2	0.79	0.68	1.3	1.2	2.3	2.2
Mn	1.2	0.93	0.24	0.19	0.55	0.47	0.38	0.37
Hg	0.000010	0.000010	0.000052	0.0000050	0.000010	0.000010	0.000010	0.000010
Mo	0.0021	0.0015	0.00012	0.000050	0.0010	0.0010	0.000050	0.000050
Ni	0.0031	0.0013	0.0013	0.0011	0.0021	0.0016	0.0018	0.0018
K	4.4	3.2	0.64	0.41	2.0	2.0	0.40	0.39
Se	0.0013	0.0013	0.00012	0.000095	0.00019	0.00014	0.00010	0.00010
Si	11	1.9	2.1	1.2	2.6	1.3	1.9	1.7
Ag	0.00065	0.000010	0.00012	0.000010	0.00013	0.000020	0.000015	0.000010
Na	18	18	2.2	2.2	2.0	2.0	2.8	2.7
Sr	0.70	0.66	0.070	0.071	0.11	0.097	0.19	0.18
Tl	0.00014	0.000058	0.000063	0.000023	0.00020	0.00020	0.000010	0.000010
Sn	0.00012	0.00010	0.00010	0.00010	0.00050	0.00050	0.00010	0.00010
Ti	0.12	0.010	0.013	0.010	0.010	0.010	0.010	0.010
U	0.0014	0.00035	0.000082	0.000017	0.00020	0.00020	0.000028	0.000017
V	0.0065	0.00050	0.0011	0.00050	0.0010	0.0010	0.0010	0.0010
Zn	0.11	0.020	0.086	0.054	0.074	0.042	0.068	0.067

Table 3-3:
Calculated BJ 2.62 Background Water Quality Values

Parameter	Smart Quarter 1 (Feb/Mar/Apr)		Smart Quarter 2 (May/Jun/Jul)		Smart Quarter 3 (Aug/Sep/Oct)		Smart Quarter 4 (Nov/Dec/Jan)	
	(mg/L)		(mg/L)		(mg/L)		(mg/L)	
Anions								
Ammonia (as N)	0.35		0.013		0.011		0.21	
Nitrate (as N)	0.12		0.046		0.057		0.11	
Nitrite (as N)	0.024		0.0038		0.0038		0.015	
Chloride	1.4		0.50		0.54		1.0	
Fluoride	0.070		0.025		0.031		0.062	
Sulfate	28		13		14		27	
Total Phosphorus	0.35		0.29		0.29		0.32	
Metals	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Al	0.049	0.0089	0.33	0.0088	0.42	0.011	0.14	0.010
Sb	0.0012	0.0012	0.00053	0.00045	0.00075	0.00065	0.0011	0.0010
As	0.0026	0.0023	0.0017	0.00053	0.0026	0.00071	0.0023	0.0018
Ba	0.044	0.042	0.046	0.038	0.052	0.040	0.048	0.043
Be	0.00011	0.00011	0.00010	0.000096	0.00011	0.00010	0.00014	0.00012
Bi	0.00053	0.00053	0.00048	0.00048	0.00049	0.00049	0.0076	0.00052
B	0.025	0.025	0.010	0.010	0.012	0.012	0.031	0.027
Cd	0.000020	0.000010	0.000036	0.000033	0.000030	0.000010	0.000020	0.000010
Ca	14	14	10	9.8	11	11	14	14
Cr	0.00013	0.00012	0.00014	0.000096	0.00023	0.00010	0.00017	0.00014
Co	0.00014	0.00013	0.00036	0.00023	0.00031	0.00012	0.00027	0.00015
Cu	0.0012	0.00059	0.0012	0.00048	0.0014	0.00050	0.0010	0.00053
Fe	0.053	0.034	0.38	0.029	0.37	0.030	0.087	0.031
Pb	0.00027	0.000060	0.00057	0.000048	0.00069	0.000050	0.00038	0.000060
Li	0.029	0.028	0.0030	0.0028	0.0070	0.0067	0.023	0.023
Mg	0.80	0.78	0.42	0.37	0.52	0.43	0.76	0.74
Mn	0.027	0.022	0.042	0.031	0.041	0.018	0.034	0.030
Hg	0.000010	0.000010	0.000012	0.000010	0.000010	0.000010	0.000010	0.000010
Mo	0.00079	0.00077	0.00040	0.00036	0.00059	0.00052	0.00078	0.00077
Ni	0.00061	0.00059	0.00057	0.00055	0.00060	0.00050	0.00062	0.00058
K	0.65	0.63	0.28	0.18	0.43	0.27	0.65	0.60
Se	0.00012	0.00012	0.00012	0.000098	0.00014	0.00010	0.00017	0.00012
Si	1.0	0.92	1.2	0.61	1.4	0.62	1.1	0.88
Ag	0.000020	0.000010	0.000076	0.000010	0.00011	0.000010	0.000040	0.000010
Na	11	11	2.5	2.5	3.7	3.7	9.5	9.3
Sr	0.19	0.19	0.079	0.075	0.099	0.095	0.18	0.18
Tl	0.000020	0.000020	0.000016	0.000011	0.000020	0.000010	0.000020	0.000020
Sn	0.00012	0.00011	0.00010	0.000096	0.00010	0.00010	0.00013	0.00010
Ti	0.011	0.011	0.013	0.0096	0.012	0.0099	0.011	0.010
U	0.00010	0.000090	0.000054	0.000034	0.000070	0.000040	0.00011	0.00010
V	0.0011	0.0011	0.0013	0.00097	0.0013	0.00099	0.0011	0.0010
Zn	0.0053	0.0039	0.0057	0.0038	0.0054	0.0030	0.0055	0.0042

3.2 NPAG Quarry

3.2.1 Overview

Approximately 730 kt of rock has been excavated from the NPAG Quarry to provide material for building foundations, roads and other construction activities at the Mine Site. The NPAG Quarry is located near the southeast end of Brucejack Lake and runoff from the NPAG Quarry flows into Brucejack Lake. The NPAG Quarry is comprised predominantly of volcanic (plagioclase-hornblende) porphyry, with lesser amounts of conglomerate (S3), and negligible sulfide mineralization. Results from the preliminary ML/ARD characterization (Pretivm, 2015) and subsequent confirmatory sampling programs (Pretivm, 2016a; 2017) confirm that rock excavated from the NPAG Quarry is consistently NPAG with low neutral metal leaching potential. Runoff source terms were developed to capture contributions from drainage in contact with exposures in the NPAG Quarry.

3.2.2 NPAG Quarry Runoff

Shake flask extraction (SFE) tests carried out on rock samples collected from the NPAG Quarry were used to predict the quality of surface drainages from the NPAG Quarry. Median and 90th percentile values of the cumulative SFE results for 52 samples were used to represent Base Case and Upper Case source terms, respectively. A comparison of the SFE data with leachate quality from a conservative representative field kinetic test and runoff water quality samples demonstrate that the SFE data provide the most conservative approximation of neutral metal drainage from the NPAG Quarry exposures. The concentration values assigned to NPAG Quarry runoff flows as designated by the site water balance are presented in Table 3-4.

Table 3-4:
Source Terms For NPAG Quarry Runoff

Parameter	Units	Base Case	Upper Case
Chloride	mg/L	0.20	1.0
Fluoride	mg/L	0.060	0.14
Sulfate	mg/L	3.0	6.0
Al	mg/L	0.31	0.77
Sb	mg/L	0.00050	0.0039
As	mg/L	0.0078	0.029
Ba	mg/L	0.094	0.28
Be	mg/L	0.0000070	0.00010
Bi	mg/L	0.0000070	0.00010
B	mg/L	0.0093	0.021
Cd	mg/L	0.000010	0.000058
Ca	mg/L	8.8	12
Cr	mg/L	0.00011	0.00050
Co	mg/L	0.000075	0.00029
Cu	mg/L	0.00065	0.0017
Fe	mg/L	0.018	0.052
Pb	mg/L	0.00013	0.00079
Li	mg/L	0.0011	0.0040
Mg	mg/L	0.17	0.50
Mn	mg/L	0.0073	0.025
Hg	mg/L	0.00001	0.00005
Mo	mg/L	0.00080	0.0021
Ni	mg/L	0.00010	0.00050
P	mg/L	0.028	0.050
K	mg/L	2.8	7.9
Se	mg/L	0.00011	0.00050
Si	mg/L	2.2	3.1
Ag	mg/L	0.000016	0.000080
Na	mg/L	1.3	2.8
Sr	mg/L	0.064	0.15
Tl	mg/L	0.0000090	0.000050
Sn	mg/L	0.000020	0.00050
Ti	mg/L	0.00065	0.011
U	mg/L	0.00015	0.00026
V	mg/L	0.0016	0.0058
Zn	mg/L	0.0010	0.0030

Note: Base Case and Upper Case values are based on median and 90th percentile values for 52 SFE analyses.

3.3 Mine Site

3.3.1 Overview

A total of ~1,500 kt of waste rock and 165 kt of weathered surface material were excavated from the Mine Site surface area to support the construction of site roads and pads for various facilities including the mill, Phase 2 Camp and CWP. Construction of the Mine Site was initiated in September 2015 and continued during 2016, with the majority of excavation occurring in Q1 and Q2 of 2016.

Geochemical source terms were developed for 1) Mine Site run-off associated with exposures from surface excavation; 2) Mine Site surface waste rock deposited in Brucejack Lake; and 3) weathered surface material placed in Brucejack Lake. For waste rock placed in Brucejack Lake, instantaneous and post-depositional loads have been calculated. The instantaneous surface waste rock load represents the mass of available soluble constituents that are instantaneously released into solution. The post-depositional loads represent the longer-term loads released following deposition of the waste rock in Brucejack Lake. The approach for derivation of each of these water quality model inputs are described in the sections below.

3.3.2 Mine Site Runoff

Contact water associated with runoff from the Mine Site will be collected by the contact water collection system, which directs water to the CWP. Non-contact surface runoff from areas immediately surrounding the Mine Site will be directed to Brucejack Lake via the East (Johnson Creek) Diversion Channel, and to Camp Creek via the West (Camp Creek) Diversion Channel. The Mine Site runoff source term includes runoff from all exposed rock units at the Mine Site.

A block model was developed by Pretivm for the Mine Site excavation area based on the five geologic units identified through surface mapping and drilling campaigns. These units are: ANDX (intermediate fragmental volcanic rock), VSF (volcanic sedimentary facies), P2 (K-feldspar bearing porphyry), P1 (plagioclase-hornblende bearing porphyry) and S3 (conglomerate). The surface waste rock units are similar to those found in the underground mine, but have slightly different metal contents and acid base accounting (ABA) characteristics. Consequently, surface materials were characterized independent of the underground block model units. The rock units exposed as a result of these excavations include ANDX, VSF, P2, P1 and S3.

SFE results from 92 lithology-specific samples were used to predict loads to Brucejack Lake from surface run-off at the Mine Site. The Base Case and Upper Case values were

derived using median and 90th percentile values for the complete dataset as presented in Table 3-5.

Table 3-5:
Source Terms for Runoff Associated with Surface Excavations

Parameter	Units	Base Case	Upper Case
Chloride	mg/L	1.0	5.0
Fluoride	mg/L	0.080	0.21
Sulfate	mg/L	13	58
Al	mg/L	0.15	0.30
Sb	mg/L	0.0047	0.025
As	mg/L	0.011	0.075
Ba	mg/L	0.044	0.16
Be	mg/L	0.0000070	0.000018
Bi	mg/L	0.0000070	0.0000070
B	mg/L	0.014	0.037
Cd	mg/L	0.0000060	0.000033
Ca	mg/L	15	34
Cr	mg/L	0.000030	0.00013
Co	mg/L	0.000028	0.00047
Cu	mg/L	0.00050	0.0016
Fe	mg/L	0.0070	0.018
Pb	mg/L	0.000045	0.00043
Li	mg/L	0.0034	0.0092
Mg	mg/L	0.80	2.1
Mn	mg/L	0.020	0.18
Hg	mg/L	0.000005	0.00001
Mo	mg/L	0.0020	0.011
Ni	mg/L	0.00010	0.00045
P	mg/L	0.0040	0.027
K	mg/L	3.7	11
Se	mg/L	0.00016	0.0042
Si	mg/L	1.6	2.6
Ag	mg/L	0.0000090	0.000034
Na	mg/L	1.6	4.3
Sr	mg/L	7.1	27
Tl	mg/L	0.000034	0.00011
Sn	mg/L	0.000020	0.000070
Ti	mg/L	0.00013	0.00051
U	mg/L	0.00021	0.0013
V	mg/L	0.00071	0.0030
Zn	mg/L	0.0010	0.0020

3.3.3 Surface Waste Rock

A summary of the lithology-specific surface waste rock excavation work carried out during Construction is provided in Table 3-6. Preliminary ML/ARD characterization designated three out of the five geologic model units for surface waste rock as NPAG based on median NPR values; however, the NPR values are very close to the PAG threshold value of 2 (2.0, 2.4 and 2.6 for the S3, P2 and ANDX units, respectively). The majority of the VSF and P1 samples are characterized as PAG with NPR values generally <2. Results from confirmatory sampling of these units are consistent with the preliminary characterization. Thus, surface-blasted Mine Site waste rock was generally classified as PAG and all was managed through sub-aqueous deposition in Brucejack Lake. A discussion of the preliminary geochemical assessment and confirmatory sampling is summarized in the Annual Reports (Pretivm, 2016a; 2017).

Table 3-6:
Tracked Mine Site Waste Rock Tonnages Placed in Brucejack Lake During Construction

Year	Month	VSF	S3	ANDX	P2	P1	Total
Y-2	Sep-15	0	0	33,056	0	0	33,056
	Oct-15	8,413	13,208	41,711	0	0	63,332
	Nov-15	17,491	0	153,449	0	0	170,940
	Dec-15	2,460	17,612	65,745	90,596	0	176,412
	Jan-16	107,301	0	65,513	164,889	0	337,703
	Feb-16	36,593	0	62,627	142,320	0	241,539
	Mar-16	62,070	0	15,231	102,935	0	180,236
	Apr-16	2,465	0	2,913	4,928	55,469	65,775
	May-16	0	0	52,920	4,145	11,507	68,572
Y-1	Jun-16	0	0	33,599	2,408	6,915	42,922
	Jul-16	0	0	8,791	0	0	8,791
	Aug-16	0	0	0	0	0	0
	Sep-16	11,850	0	0	0	0	11,850
	Oct-16	34,312	0	0	0	0	34,312
	Nov-16	64,287	0	0	0	0	64,287
	Dec-16	1,601	0	0	0	0	1,601
	Jan-17	0	0	0	0	0	0
	Feb-17	0	0	0	0	0	0
	Mar-17	0	0	0	0	0	0
	Apr-17	0	0	0	0	0	0
	May-17	0	0	0	0	0	0
Total		**348,843**	**30,819**	**535,554**	**512,220**	**73,891**	**1,501,327**
Percent of Total		*5%*	*5%*	*34%*	*28%*	*28%*	

3.3.3.1 Instantaneous Loads

Lithology-specific SFE data sets were used to predict the instantaneous loads from Mine Site surface waste rock deposited in Brucejack Lake. Source terms presented in the MA-EMA Permits Application (Pretivm, 2015) were developed using the projected waste rock schedule and SFE data from the preliminary characterization of the Mine Site surface waste rock lithologies. Since that time, additional confirmatory SFE samples have been collected. The revised source terms for instantaneous loads to Brucejack Lake from submerged Mine Site waste rock incorporate all the available SFE data and utilize the tracked waste rock tonnages deposited in Brucejack Lake during the Construction phase.

Monthly loads were scaled to account for the proportion of waste rock considered to be reactive (*i.e.*, soluble) using the fraction of material that is < 6.4 mm, or approximately 20% of the total waste rock. Revised Base Case and Upper Case source terms were calculated from the cumulative dataset using the 75th and 90th percentile lithology-specific SFE values and the scaled monthly waste rock excavation tonnages (Table 3-6). The revised source terms for Base Case and Upper Case are summarized in Table 3-7 and Table 3-8, respectively.

3.3.3.2 Post-Depositional Loads

Leachate data from saturated column kinetic tests comprising lithology-specific surface waste rock (VSF, ANDX, P2, S3) were used to assess which parameters have the potential for long term leaching behaviour after deposition in Brucejack Lake. Based on the assessment, As and Sb were identified as parameters showing longer-term release patterns. Post-depositional loads for these parameters were calculated using stabilized column leachate concentration data (*i.e.*., last five analyses, up until August 17, 2017) combined with the surface waste rock schedule (Table 3-6) and assumptions regarding waste rock reactivity. In reality, the loads contributed to Brucejack Lake would be controlled by molecular diffusion; however, waste rock sequencing information is not currently available, therefore the approach used to derive post-depositional As and Sb loads is based on lithology-specific loading rates.

Median and 90th percentile leachate concentration values were used to derive Base Case and Upper Case loading rates. Loading rates (mg/kg/month) for each surface waste rock lithology were multiplied by the respective lithology-specific cumulative waste rock tonnages (Table 3-6) to derive monthly post-depositional loads. Leachate quality from the P2 column was used as a surrogate for the P1 unit when calculating the potential contributions from the P1 waste rock tonnages deposited in Brucejack Lake. It is assumed that any waste rock deposited in the lake will contribute post-depositional loads for approximately one year following placement. It is expected that most of the waste rock dump subaqueous exposed faces will be covered within one year through ongoing deposition of waste rock, thereby burying the underlying layers and limiting post-depositional leaching.

Table 3-7:
Base Case Mine Site Waste Rock Deposition Source Term Loads (g)

Parameter	Y-2									Y-1						
	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
Chloride	39,667	71,830	226,116	122,243	400,444	218,480	207,390	77,896	78,929	49,555	10,549	0	28,441	82,348	154,289	3,843
Fluoride	2,182	4,238	12,227	10,161	26,104	16,210	14,012	2,751	4,131	2,597	580	0	1,422	4,117	7,714	192
Sulfate	674,337	1,016,728	3,392,721	3,387,798	6,507,574	4,900,583	3,465,152	502,373	1,231,229	774,776	179,340	0	177,755	514,674	964,305	24,017
Al	4,056	6,639	21,809	20,208	47,445	32,151	25,632	8,531	8,502	5,319	1,079	0	2,019	5,847	10,955	273
Sb	153	375	923	1,546	3,629	2,475	2,087	363	349	217	41	0	145	420	787	20
As	475	799	2,585	2,553	6,062	4,103	3,309	305	857	539	126	0	257	745	1,396	35
Ba	2,211	3,015	10,671	10,419	17,652	14,345	9,188	2,022	4,112	2,586	588	0	274	795	1,489	37
Be	0.14	0.37	0.73	0.88	1.5	1.0	0.79	0.28	0.29	0.18	0.040	0	0.060	0.16	0.31	0.010
Bi	0.14	0.27	0.72	0.74	1.4	1.0	0.76	0.28	0.29	0.18	0.040	0	0.050	0.14	0.27	0.010
B	334	641	1,890	2,070	5,077	3,358	2,814	560	679	425	89	0	230	665	1,246	31
Cd	0.24	0.57	1.3	1.6	3.2	2.2	1.8	0.29	0.46	0.29	0.060	0	0.13	0.37	0.69	0.020
Ca	406,585	625,751	2,103,608	2,016,657	4,254,166	3,054,251	2,279,297	628,938	807,822	506,494	108,132	0	146,470	424,091	794,587	19,790
Cr	0.60	1.5	3.5	3.4	8.7	5.2	4.7	2.2	1.4	0.90	0.20	0	0.50	1.4	2.7	0.10
Co	1.2	6.7	6.6	15	20	14	11	1.1	2.3	1.4	0.30	0	0.70	2.1	3.9	0.10
Cu	16	49	83	122	180	134	98	31	34	21	4.3	0	5.2	15	28	0.70
Fe	218	463	1,139	1,056	1,996	1,360	1,042	327	424	267	58	0	85	247	463	12
Pb	2.7	5.0	15	18	45	30	25	3.6	5.3	3.3	0.70	0	2.0	5.8	11	0.30
Li	83	178	529	492	1609	937	900	141	166	104	22	0	99	286	536	13
Mg	22,908	38,856	126,384	132,775	321,219	217,266	177,108	50,681	49,077	30,661	6,092	0	13,580	39,321	73,673	1,835
Mn	1,009	2,078	5,400	8,642	17,181	12,716	9,741	1,694	2,131	1,330	268	0	486	1,408	2,638	66
Hg	0.20	0.38	1.0	1.1	2.0	1.5	1.1	0.39	0.41	0.26	0.050	0	0.070	0.21	0.39	0.010
Mo	140	199	687	489	887	664	434	132	254	160	37	0	27	78	146	4.0
Ni	2.0	7.2	12	20	43	27	24	4.5	4.4	2.7	0.50	0	2.1	6.2	12	0.30
P	208	578	1,061	1,358	2,031	1,489	1,080	163	380	239	55	0	64	185	347	9
K	183,757	271,012	927,638	667,310	1,344,299	955,116	675,557	129,186	325,333	205,234	48,870	0	50,553	146,373	274,248	6,830
Se	4.0	15	33	120	303	210	182	20	13	8.0	1.0	0	11	32	60	1.0
Si	39,964	66,139	210,601	194,414	426,984	295,558	228,474	67,433	80,177	50,257	10,629	0	16,993	49,203	92,188	2,296
Ag	0.38	0.64	2.0	1.3	2.8	1.8	1.4	0.62	0.73	0.46	0.10	0	0.14	0.39	0.73	0.020
Na	41,650	74,838	237,527	258,118	658,797	434,777	366,513	51,301	81,048	50,817	11,077	0	29,934	86,671	162,389	4,044
Sr	6,733	10,651	35,686	47,614	101,605	74,752	56,956	5,316	12,787	8,020	1,791	0	3,000	8,688	16,277	405
Tl	1.0	1.8	5.3	6.5	15	10	8.2	1.5	2.0	1.2	0.30	0	0.60	1.6	3.1	0.10
Sn	0.80	1.3	4.1	4.2	8.6	6.2	4.6	1.6	1.7	1.0	0.20	0	0.30	0.80	1.5	0.00
Ti	5.5	8.9	29	27	59	41	32	6.8	11	6.6	1.5	0	2.3	6.8	13	0.30
U	22	30	106	70	119	91	56	10	37	24	5.8	0	3.2	9.3	17	0.40
V	27	48	152	128	359	222	196	38	51	32	7.1	0	20	57	106	2.7
Zn	20	54	103	127	203	145	108	73	48	30	5.3	0	7.1	21	39	1.0

Table 3-8:
Upper Case Mine Site Waste Rock Deposition Source Term Loads (g)

Parameter	Y-2									Y-1						
	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
Chloride	87,267	144,009	472,270	272,097	743,282	442,478	377,376	128,388	165,782	104,289	23,209	0	45,505	131,757	246,862	6,148
Fluoride	4,681	7,866	24,814	17,987	42,055	27,278	21,752	5,854	8,794	5,532	1,245	0	2,090	6,053	11,340	282
Sulfate	1,158,272	1,754,587	5,903,673	5,496,388	11,107,309	8,112,715	5,886,555	682,547	2,064,992	1,301,120	308,044	0	356,931	1,033,465	1,936,324	48,225
Al	4,732	10,047	30,260	27,524	90,882	52,752	50,730	9,723	9,844	6,158	1,259	0	5,618	16,268	30,480	759
Sb	404	714	2,135	4,663	9,164	7,150	5,334	588	882	548	107	0	176	511	957	24
As	1,293	2,246	7,244	7,728	19,211	12,840	10,640	821	2,351	1,479	344	0	842	2,437	4,567	114
Ba	3,261	4,462	15,798	16,152	27,876	22,540	14,684	3,096	6,112	3,841	867	0	449	1,299	2,433	61
Be	0.17	0.43	0.92	0.95	1.7	1.2	0.90	0.28	0.35	0.22	0.050	0	0.070	0.21	0.40	0.010
Bi	0.14	0.27	0.72	0.74	1.5	1.0	0.78	0.46	0.33	0.20	0.040	0	0.050	0.16	0.29	0.010
B	579	1,005	3,142	2,956	6,959	4,662	3,767	930	1,154	723	154	0	307	889	1,666	41
Cd	0.65	1.4	3.8	3.1	8.6	5.1	4.6	0.46	1.2	0.73	0.17	0	0.50	1.5	2.7	0.070
Ca	682,667	997,040	3,432,859	3,323,136	6,459,886	4,856,248	3,428,501	710,799	1,286,223	808,311	181,556	0	178,750	517,556	969,705	24,151
Cr	0.80	1.9	4.8	7.3	18	12	10	3.9	2.2	1.4	0.20	0	0.80	2.2	4.2	0.10
Co	3.8	11	20	39	67	52	38	2.6	7.4	4.6	1.0	0	1.5	4.3	8.1	0.20
Cu	28	68	145	202	352	259	194	40	56	35	7.4	0	11	31	58	1.4
Fe	353	788	2,088	1,630	4,722	2,702	2,547	838	743	465	94	0	304	881	1,651	41
Pb	6.8	12	37	47	108	76	60	5.9	13	8.1	1.8	0	3.9	11	21	0.50
Li	126	553	1,397	860	6,127	2,709	3,499	313	257	161	33	0	551	1,594	2,987	74
Mg	29,790	52,780	169,226	181,968	463,519	306,465	257,537	59,263	62,602	39,132	7,923	0	20,961	60,690	113,711	2,832
Mn	3,233	5,082	16,137	18,193	33,339	25,754	17,985	2,541	5,989	3,765	860	0	765	2,215	4,150	103
Hg	0.20	0.38	1.0	1.1	2.0	1.5	1.1	0.39	0.41	0.26	0.050	0	0.070	0.21	0.39	0.010
Mo	240	360	1,225	841	1,781	1,225	894	162	422	266	64	0	75	218	408	10
Ni	4.0	12	26	29	81	48	46	5.6	7.8	4.9	1.1	0	4.8	14	26	0.70
P	496	1,124	2,778	2,858	6,537	4,208	3,562	289	881	555	132	0	323	935	1,751	44
K	224,911	338,641	1,151,320	887,363	1,869,264	1,311,261	962,150	241,528	417,422	262,689	59,815	0	72,666	210,399	394,208	9,818
Se	27	88	232	362	1,225	726	714	51	61	38	7.3	0	71	206	386	10
Si	55,534	87,642	286,738	234,403	496,966	346,456	258,988	87,982	109,261	68,573	14,769	0	19,610	56,779	106,382	2,650
Ag	0.78	1.3	4.1	2.6	6.1	3.9	3.1	1.4	1.5	0.96	0.21	0	0.33	0.96	1.8	0.040
Na	64,221	216,644	577,901	422,841	2,306,669	1,106,648	1,311,508	113,975	125,871	78,901	17,080	0	189,557	548,848	1,028,335	25,611
Sr	11,511	17,280	59,112	71,713	144,970	109,067	79,967	11,204	22,031	13,821	3,061	0	3,845	11,133	20,860	520
Tl	1.6	2.7	8.4	11	23	17	13	1.8	3.1	1.9	0.40	0	0.70	2.2	4.1	0.10
Sn	1.5	2.2	7.4	7.2	14	11	7.4	2.0	2.9	1.8	0.40	0	0.40	1.1	2.1	0.050
Ti	8.6	14	46	53	118	84	65	10	17	10	2.3	0	4.2	12	23	0.60
U	29	42	145	92	181	127	88	14	49	31	7.7	0	7.3	21	40	1.0
V	50	84	276	230	589	380	317	50	93	58	13	0	29	84	158	3.9
Zn	40	84	205	222	405	290	216	79	82	52	11	0	14	41	77	1.9

Base Case and Upper Case As and Sb post-depositional loads are summarized in Table 3-9, along with the total cumulative waste rock tonnages susceptible to leaching.

Table 3-9:
Source Terms for Post-Depositional Loads of Antimony and Arsenic from Mine Site Waste Rock Submerged in Brucejack Lake

Phase	Year	Parameter	Sb		As		Waste Rock Susceptible to Leaching
		Case	Base Case	Upper Case	Base Case	Upper Case	
		Units	g	g	g	g	t
Construction	Y-2	Sep-15	1.1	1.2	2.3	2.3	33,056
		Oct-15	8.4	8.8	34	35	96,388
		Nov-15	14	15	53	54	267,327
		Dec-15	27	29	119	123	443,740
		Jan-16	36	41	226	234	781,442
		Feb-16	43	51	292	302	1,022,981
		Mar-16	48	57	355	367	1,203,217
		Apr-16	50	60	375	388	1,268,992
		May-16	52	63	384	397	1,337,564
	Y-1	Jun-16	54	64	389	402	1,380,486
		Jul-16	54	65	389	403	1,389,277
		Aug-16	54	65	389	403	1,389,277
		Sep-16	53	64	393	406	1,368,071
		Oct-16	46	57	378	391	1,339,051
		Nov-16	42	52	390	403	1,232,398
		Dec-16	29	38	325	335	1,057,587
		Jan-17	20	26	217	224	719,885
		Feb-17	13	16	151	156	478,346
		Mar-17	8.0	10	88	91	298,110
		Apr-17	6.0	6.8	68	70	232,335
		May-17	3.7	4.2	60	61	163,763
Y01*		Year 1 (sum)	9.0	10	244	248	512,630

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.3.4 Weathered Surface Material

Weathered surface material was excavated from the Mine Site surface in preparation for operations, with the bulk of the excavation occurring in Y-1. A summary of the tracked tonnages of weathered surface material placed in Brucejack Lake is provided in Table 3-10.

Table 3-10:
Tracked Tonnages of Weathered Surface Material Deposited in Brucejack Lake

Phase	Year	Month	Weathered Surface Material to Brucejack Lake (t)
Construction	Y-2	Sep-15	0
		Oct-15	0
		Nov-15	57,356
		Dec-15	14,196
		Jan-16	9,688
		Feb-16	18,998
		Mar-16	6,244
		Apr-16	756
		May-16	0
	Y-1	Jun-16	0
		Jul-16	0
		Aug-16	37
		Sep-16	37
		Oct-16	0
		Nov-16	0
		Dec-16	0
		Jan-17	784
		Feb-17	474
		Mar-17	0
		Apr-17	0
		May-17	419
Operations	Y01	Jun-17	0
		Jul-17	697
		Aug-17	504
		Sep-17	442

A geochemical characterization program completed in 2015 indicated there is limited potential for surface materials at the Mine Site to support vegetation, due in part to slow organic matter buildup at this elevation and climate. In addition, the surface material generally has a high PAG potential and elevated metal concentrations (*e.g.*, As levels (21-446 ppm) exceed the CCME guideline of 12 ppm). Overall, the results of the characterization program indicate that the weathered surface material is not suitable for use

in reclamation. As a result, the majority (~111 kt) of the excavated weathered surface material generated to date (particularly the portion with higher rock content) has been deposited in Brucejack Lake. Weathered surface material dominated by soil size fraction particles (<2 mm diameter) (~54 kt) has been stockpiled at the Mine Site for potential reclamation purposes per existing conditions of Permit M-243. Details of the 2015 geochemical characterization program and an overview of the baseline studies are provided in the 2015 Annual Report (Pretivm, 2016a).

SFE data were used to predict the instantaneous loads from Mine Site weathered surface material deposited in Brucejack Lake. Given the relatively fine particle size distribution of the surficial material, all the material is considered reactive (*i.e.*, soluble). Base Case and Upper Case source terms were calculated from the cumulative dataset using median and 90th percentile SFE values, respectively, and the monthly excavation schedule (Table 3-10). The source terms for Base Case and Upper Case are summarized in Table 3-11 and Table 3-12, respectively.

Table 3-11:
Base Case Weathered Surface Material Source Term Loads

Parameter	Units	Y-2									Y-1												Y01			
		Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Chloride	g	0	0	172,068	42,588	29,064	56,994	18,732	2,268	0	0	0	111	111	0	0	0	2,352	1,422	0	0	1,257	0	2,091	1,512	1,326
Fluoride	g	0	0	10,324	2,555	1,744	3,420	1,124	136	0	0	0	6.7	6.7	0	0	0	141	85	0	0	75	0	125	91	80
Sulfate	g	0	0	3,871,530	958,230	653,940	1,282,365	421,470	51,030	0	0	0	2,498	2,498	0	0	0	52,920	31,995	0	0	28,283	0	47,048	34,020	29,835
Ag	g	0	0	0.69	0.17	0.12	0.23	0.075	0.0091	0	0	0	0.00044	0.00044	0	0	0	0.0094	0.0057	0	0	0.0050	0	0.0084	0.0060	0.0053
Al	g	0	0	3,742	926	632	1240	407	49	0	0	0	2.4	2.4	0	0	0	51	31	0	0	27	0	45	33	29
As	g	0	0	86	21	15	28	9.4	1.1	0	0	0	0.056	0.056	0	0	0	1.2	0.71	0	0	0.63	0	1.0	0.76	0.66
B	g	0	0	1,867	462	315	618	203	25	0	0	0	1.2	1.2	0	0	0	26	15	0	0	14	0	23	16	14
Ba	g	0	0	5,825	1,442	984	1,929	634	77	0	0	0	3.8	3.8	0	0	0	80	48	0	0	43	0	71	51	45
Be	g	0	0	1.2	0.30	0.20	0.40	0.13	0.016	0	0	0	0.00078	0.00078	0	0	0	0.016	0.0100	0	0	0.0088	0	0.015	0.011	0.0093
Bi	g	0	0	1.2	0.30	0.20	0.40	0.13	0.016	0	0	0	0.00078	0.00078	0	0	0	0.016	0.0100	0	0	0.0088	0	0.015	0.011	0.0093
Ca	g	0	0	2,942,363	728,255	496,994	974,597	320,317	38,783	0	0	0	1,898	1,898	0	0	0	40,219	24,316	0	0	21,495	0	35,756	25,855	22,675
Cd	g	0	0	4.2	1.0	0.71	1.4	0.46	0.056	0	0	0	0.0027	0.0027	0	0	0	0.058	0.035	0	0	0.031	0	0.051	0.037	0.032
Co	g	0	0	18	4.4	3.0	5.9	1.9	0.23	0	0	0	0.011	0.011	0	0	0	0.24	0.15	0	0	0.13	0	0.22	0.16	0.14
Cr	g	0	0	5.2	1.3	0.87	1.7	0.56	0.068	0	0	0	0.0033	0.0033	0	0	0	0.071	0.043	0	0	0.038	0	0.063	0.045	0.040
Cu	g	0	0	227	56	38	75	25	3.0	0	0	0	0.15	0.15	0	0	0	3.1	1.9	0	0	1.7	0	2.8	2.0	1.8
Fe	g	0	0	1,204	298	203	399	131	16	0	0	0	0.78	0.78	0	0	0	16	10.0	0	0	8.8	0	15	11	9.3
Hg	g	0	0	1.7	0.43	0.29	0.57	0.19	0.023	0	0	0	0.0011	0.0011	0	0	0	0.024	0.014	0	0	0.013	0	0.021	0.015	0.013
K	g	0	0	135,159	33,453	22,830	44,769	14,714	1,782	0	0	0	87	87	0	0	0	1,847	1,117	0	0	987	0	1,642	1,188	1,042
Li	g	0	0	156	39	26	52	17	2.1	0	0	0	0.10	0.10	0	0	0	2.1	1.3	0	0	1.1	0	1.9	1.4	1.2
Mg	g	0	0	69,946	17,312	11,815	23,168	7,615	922	0	0	0	45	45	0	0	0	956	578	0	0	511	0	850	615	539
Mn	g	0	0	23,401	5,792	3,953	7,751	2,548	308	0	0	0	15	15	0	0	0	320	193	0	0	171	0	284	206	180
Mo	g	0	0	168	42	28	56	18	2.2	0	0	0	0.11	0.11	0	0	0	2.3	1.4	0	0	1.2	0	2.0	1.5	1.3
Na	g	0	0	92,056	22,785	15,549	30,492	10,022	1,213	0	0	0	59	59	0	0	0	1,258	761	0	0	672	0	1,119	809	709
Ni	g	0	0	69	17	12	23	7.5	0.91	0	0	0	0.044	0.044	0	0	0	0.94	0.57	0	0	0.50	0	0.84	0.60	0.53
P	g	0	0	3,097	767	523	1,026	337	41	0	0	0	2.0	2.0	0	0	0	42	26	0	0	23	0	38	27	24
Pb	g	0	0	12	3.0	2.0	4.0	1.3	0.16	0	0	0	0.0078	0.0078	0	0	0	0.16	0.100	0	0	0.088	0	0.15	0.11	0.093
Sb	g	0	0	69	17	12	23	7.5	0.91	0	0	0	0.044	0.044	0	0	0	0.94	0.57	0	0	0.50	0	0.84	0.60	0.53
Se	g	0	0	32	7.9	5.4	11	3.5	0.42	0	0	0	0.021	0.021	0	0	0	0.44	0.26	0	0	0.23	0	0.39	0.28	0.25
Si	g	0	0	147,978	36,626	24,995	49,015	16,110	1,950	0	0	0	95	95	0	0	0	2,023	1,223	0	0	1,081	0	1,798	1,300	1,140
Sn	g	0	0	5.2	1.3	0.87	1.7	0.56	0.068	0	0	0	0.0033	0.0033	0	0	0	0.071	0.043	0	0	0.038	0	0.063	0.045	0.040
Sr	g	0	0	8,922	2,208	1,507	2,955	971	118	0	0	0	5.8	5.8	0	0	0	122	74	0	0	65	0	108	78	69
Ti	g	0	0	8.6	2.1	1.5	2.8	0.94	0.11	0	0	0	0.0056	0.0056	0	0	0	0.12	0.071	0	0	0.063	0	0.10	0.076	0.066
Tl	g	0	0	6.7	1.7	1.1	2.2	0.73	0.088	0	0	0	0.0043	0.0043	0	0	0	0.092	0.055	0	0	0.049	0	0.082	0.059	0.052
U	g	0	0	2.5	0.62	0.42	0.83	0.27	0.033	0	0	0	0.0016	0.0016	0	0	0	0.034	0.021	0	0	0.018	0	0.030	0.022	0.019
V	g	0	0	7.7	1.9	1.3	2.6	0.84	0.10	0	0	0	0.0050	0.0050	0	0	0	0.11	0.064	0	0	0.057	0	0.094	0.068	0.060
Zn	g	0	0	172	43	29	57	19	2.3	0	0	0	0.11	0.11	0	0	0	2.4	1.4	0	0	1.3	0	2.1	1.5	1.3

Table 3-12:
Upper Case Weathered Surface Material Source Term Loads

Parameter	Units	Y-2									Y-1												Y01			
		Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17
Chloride	g	0	0	172,068	42,588	29,064	56,994	18,732	2,268	0	0	0	111	111	0	0	0	2,352	1,422	0	0	1,257	0	2,091	1,512	1,326
Fluoride	g	0	0	17,723	4,387	2,994	5,870	1,929	234	0	0	0	11	11	0	0	0	242	146	0	0	129	0	215	156	137
Sulfate	g	0	0	15,434,500	3,820,144	2,607,041	5,112,362	1,680,260	203,440	0	0	0	9,957	9,957	0	0	0	210,974	127,553	0	0	112,753	0	187,563	135,626	118,942
Ag	g	0	0	3.7	0.92	0.62	1.2	0.40	0.049	0	0	0	0.0024	0.0024	0	0	0	0.051	0.031	0	0	0.027	0	0.045	0.033	0.029
Al	g	0	0	13,509	3,344	2,282	4,475	1,471	178	0	0	0	8.7	8.7	0	0	0	185	112	0	0	99	0	164	119	104
As	g	0	0	220	55	37	73	24	2.9	0	0	0	0.14	0.14	0	0	0	3.0	1.8	0	0	1.6	0	2.7	1.9	1.7
B	g	0	0	2,786	689	471	923	303	37	0	0	0	1.8	1.8	0	0	0	38	23	0	0	20	0	34	24	21
Ba	g	0	0	11,775	2,914	1,989	3,900	1,282	155	0	0	0	7.6	7.6	0	0	0	161	97	0	0	86	0	143	103	91
Be	g	0	0	6.4	1.6	1.1	2.1	0.69	0.084	0	0	0	0.0041	0.0041	0	0	0	0.087	0.053	0	0	0.047	0	0.077	0.056	0.049
Bi	g	0	0	1.2	0.30	0.20	0.40	0.13	0.016	0	0	0	0.00078	0.00078	0	0	0	0.016	0.0100	0	0	0.0088	0	0.015	0.011	0.0093
Ca	g	0	0	7,909,966	1,957,770	1,336,072	2,620,014	861,110	104,260	0	0	0	5,103	5,103	0	0	0	108,121	65,369	0	0	57,784	0	96,123	69,507	60,956
Cd	g	0	0	67	17	11	22	7.3	0.88	0	0	0	0.043	0.043	0	0	0	0.91	0.55	0	0	0.49	0	0.81	0.59	0.52
Co	g	0	0	410	101	69	136	45	5.4	0	0	0	0.26	0.26	0	0	0	5.6	3.4	0	0	3.0	0	5.0	3.6	3.2
Cr	g	0	0	14	3.4	2.3	4.6	1.5	0.18	0	0	0	0.0089	0.0089	0	0	0	0.19	0.11	0	0	0.10	0	0.17	0.12	0.11
Cu	g	0	0	572	142	97	189	62	7.5	0	0	0	0.37	0.37	0	0	0	7.8	4.7	0	0	4.2	0	6.9	5.0	4.4
Fe	g	0	0	4,026	997	680	1,334	438	53	0	0	0	2.6	2.6	0	0	0	55	33	0	0	29	0	49	35	31
Hg	g	0	0	1.7	0.43	0.29	0.57	0.19	0.023	0	0	0	0.0011	0.0011	0	0	0	0.024	0.014	0	0	0.013	0	0.021	0.015	0.013
K	g	0	0	300,947	74,486	50,833	99,683	32,762	3,967	0	0	0	194	194	0	0	0	4,114	2,487	0	0	2,198	0	3,657	2,644	2,319
Li	g	0	0	392	97	66	130	43	5.2	0	0	0	0.25	0.25	0	0	0	5.4	3.2	0	0	2.9	0	4.8	3.4	3.0
Mg	g	0	0	135,865	33,627	22,949	45,002	14,791	1,791	0	0	0	88	88	0	0	0	1,857	1,123	0	0	993	0	1,651	1,194	1,047
Mn	g	0	0	175,664	43,478	29,671	58,185	19,123	2,315	0	0	0	113	113	0	0	0	2,401	1,452	0	0	1,283	0	2,135	1,544	1,354
Mo	g	0	0	618	153	104	205	67	8.2	0	0	0	0.40	0.40	0	0	0	8.5	5.1	0	0	4.5	0	7.5	5.4	4.8
Na	g	0	0	149,699	37,052	25,286	49,585	16,297	1,973	0	0	0	97	97	0	0	0	2,046	1,237	0	0	1,094	0	1,819	1,315	1,154
Ni	g	0	0	317	78	53	105	34	4.2	0	0	0	0.20	0.20	0	0	0	4.3	2.6	0	0	2.3	0	3.8	2.8	2.4
P	g	0	0	12,458	3,083	2,104	4,126	1,356	164	0	0	0	8.0	8.0	0	0	0	170	103	0	0	91	0	151	109	96
Pb	g	0	0	258	64	44	86	28	3.4	0	0	0	0.17	0.17	0	0	0	3.5	2.1	0	0	1.9	0	3.1	2.3	2.0
Sb	g	0	0	188	46	32	62	20	2.5	0	0	0	0.12	0.12	0	0	0	2.6	1.5	0	0	1.4	0	2.3	1.6	1.4
Se	g	0	0	104	26	18	35	11	1.4	0	0	0	0.067	0.067	0	0	0	1.4	0.86	0	0	0.76	0	1.3	0.92	0.80
Si	g	0	0	322,111	79,725	54,408	106,693	35,066	4,246	0	0	0	208	208	0	0	0	4,403	2,662	0	0	2,353	0	3,914	2,830	2,482
Sn	g	0	0	10	2.6	1.7	3.4	1.1	0.14	0	0	0	0.0067	0.0067	0	0	0	0.14	0.085	0	0	0.075	0	0.13	0.091	0.080
Sr	g	0	0	27,066	6,699	4,572	8,965	2,947	357	0	0	0	17	17	0	0	0	370	224	0	0	198	0	329	238	209
Ti	g	0	0	54	13	9.1	18	5.9	0.71	0	0	0	0.035	0.035	0	0	0	0.74	0.45	0	0	0.39	0	0.65	0.47	0.42
Tl	g	0	0	19	4.8	3.3	6.4	2.1	0.26	0	0	0	0.013	0.013	0	0	0	0.27	0.16	0	0	0.14	0	0.24	0.17	0.15
U	g	0	0	11	2.7	1.8	3.6	1.2	0.14	0	0	0	0.0069	0.0069	0	0	0	0.15	0.089	0	0	0.078	0	0.13	0.094	0.083
V	g	0	0	14	3.4	2.3	4.6	1.5	0.18	0	0	0	0.0089	0.0089	0	0	0	0.19	0.11	0	0	0.10	0	0.17	0.12	0.11
Zn	g	0	0	2,770	686	468	918	302	37	0	0	0	1.8	1.8	0	0	0	38	23	0	0	20	0	34	24	21

3.4 Underground Mine

3.4.1 Overview

Approximately 6.26 Mt of waste rock will be generated through LOM as the underground mine is developed, including waste rock excavated during Construction (September 2015 through May 2017). As described in Sections 1 and 2.2.4, Pretivm is applying for the flexibility to either deposit waste rock sub-aqueously in Brucejack Lake or to place it as backfill in the underground mine, dependent on operational needs. Water quality modelling was completed for two scenarios that represent the extremes for these approaches: Scenario 1, where all waste rock generated in future (5.3 Mt) would be deposited in Brucejack Lake; and Scenario 2, where a maximum amount of waste rock (3.4 Mt) would be backfilled in the underground mine. Tailings discharge to the lake and paste backfill to the underground mine would be balanced according to the waste rock deposition for these scenarios.

Materials backfilled into the underground mine – in addition to wall rock exposures, paste bleed water, and infiltrating groundwater – will contribute a geochemical load to underground mine water. This section describes the geochemical source term for underground mine water and the loads associated with waste rock produced from the underground mine that will be ultimately stored in Brucejack Lake under both modelled scenarios.

3.4.2 Underground Mine Waste Rock

The total mass of waste rock generated from the underground mine during the LOM is estimated to be 6.26 Mt, with 0.96 Mt of waste rock excavated during the Construction phase having been deposited in Brucejack Lake. Waste rock during the Operations phase will be managed through subaqueous deposition in Brucejack Lake and/or backfilling in the underground mine. As described above, Scenario 1 is an endmember scenario whereby all waste rock would be deposited in Brucejack Lake, whereas Scenario 2 maximizes waste rock backfilling into secondary stopes within the underground mine.

Source terms were developed for: 1) underground mine waste rock deposited in Brucejack Lake; and 2) contact water from the underground mine. Underground waste rock terms were derived for both instantaneous and post-depositional loads (as described in Section 3.3.1), along with loads associated with sub-aerial exposure of waste rock while stored on surface before being deposited into Brucejack Lake.

Preliminary ML/ARD characterization of underground mine waste rock (464 pre-2016 samples) showed that the vast majority of samples are PAG (NPR < 2). The confirmatory

sampling program was developed to monitor the geochemistry of rock excavated from the underground mine and assess any potential variation from the initial characterization of the defined geologic model units. Confirmatory sample results to date are generally consistent with prior characterization results, with the majority of samples indicated to be PAG. Given the PAG designation, all waste rock from underground is scheduled to be deposited in Brucejack Lake and/or backfilled in mined out stopes of the underground mine below the post-closure water table. Mine Act Permit M-243 limits subaerial exposure of waste rock to be deposited in Brucejack Lake to a maximum of 2 years. Summaries of the preliminary geochemical assessment and confirmatory sampling results are provided in the Annual Reports (Pretivm, 2016a; 2017).

Lithology-specific underground mine waste rock schedules have been developed for Scenarios 1 and 2. The underground waste rock geologic model units defined for water quality modelling purposes are:

- VSF (volcanically-derived siltstone and sandstone);
- ANDX (latite to andesite fragmental volcanics);
- S3 (cobble to boulder conglomerate with sandstone);
- Office P1 (hornblende, feldspar phyric latite flows);
- Office P2 (plagioclase, K-feldspar, hornblende porphyry); and
- Silicified Cap (silicified heterolithic conglomerate, sandstone and mudstone).

The schedules for underground waste rock placement in Brucejack Lake are presented in Table 3-13 and Table 3-14, for Scenarios 1 and 2 respectively. The underground mine backfill waste rock schedule is presented in Table 3-15 and only applies to Scenario 2. For each scenario, loads were calculated for the instantaneous release, diffusive release and potential leaching due to exposure on the waste rock deposition pad. Loads associated with backfilled waste rock are presented in Section 3.4.3 along with other mine water components.

Table 3-13: Scenario 1 Underground Mine Waste Rock Tonnages Deposition in Brucejack Lake Schedule

Phase	Year		S3	ANDX	P1	P2	SILCAP	VSF	TOTAL
Construction	Y-2	Sep-15	5,839	6,770	0	0	208	9,066	21,884
		Oct-15	7,484	2,160	0	0	798	11,979	22,421
		Nov-15	6,812	4,705	0	0	385	20,293	32,195
		Dec-15	7,249	5,565	0	0	68	8,361	21,243
		Jan-16	2,988	3,064	0	0	0	7,055	13,107
		Feb-16	5,890	2,947	2,362	0	0	7,661	18,860
		Mar-16	10,930	10,042	8,077	0	415	8,090	37,555
		Apr-16	13,908	18,850	11,303	0	960	23,471	68,491
		May-16	7,089	24,587	2,240	0	1,510	31,320	66,746
	Y-1	Jun-16	14,397	35,065	2,081	0	2,517	20,117	74,177
		Jul-16	20,920	23,357	413	0	4,321	23,234	72,246
		Aug-16	31,487	45,241	0	0	4,223	27,516	108,466
		Sep-16	10,580	46,029	0	0	7,468	22,567	86,644
		Oct-16	8,672	12,784	499	0	6,076	15,154	43,186
		Nov-16	6,240	14,413	0	0	9,916	27,468	58,037
		Dec-16	7,751	29,899	0	0	0	26,624	64,275
		Jan-17	8,351	13,499	0	0	0	0	21,850
		Feb-17	7,354	13,758	0	0	1,408	15,617	38,137
		Mar-17	7,036	23,550	0	0	396	9,042	40,025
		Apr-17	1,900	9,132	0	0	178	6,067	17,277
		May-17	3,101	18,386	0	0	346	6,412	28,245
Operations	Y01*	Year 1	107,077	215,106	12,208	0	26,964	205,534	566,889
	Y02	Year 2	102,703	204,615	4,849	0	19,088	156,846	488,101
	Y03	Year 3	24,753	71,338	41,799	0	16,451	244,916	399,257
	Y04	Year 4	7,739	58,562	59,449	0	4,176	288,002	417,927
	Y05	Year 5	10,762	22,264	50,320	0	421	324,532	408,300
	Y06	Year 6	0	34,239	88,063	0	482	293,956	416,739
	Y07	Year 7	16,296	53,555	108,026	0	0	226,347	404,224
	Y08	Year 8	4,180	119,973	73,361	0	640	176,642	374,795
	Y09	Year 9	7,297	36,388	177,257	0	0	96,757	317,698
	Y10	Year 10	7,827	761	85,882	0	427	198,007	292,904
	Y11	Year 11	9,707	41,993	117,234	0	3,700	127,533	300,167
	Y12	Year 12	5,785	108,591	27,514	12,052	2,396	142,487	298,825
	Y13	Year 13	8,645	143,177	36,844	17,102	213	84,697	290,677
	Y14	Year 14	70,658	75,564	50,451	0	4,548	123,264	324,486
Total (LOM)			**579,407**	**1,549,932**	**960,232**	**29,154**	**120,699**	**3,016,634**	**6,256,056**

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-14: Scenario 2 Underground Mine Waste Rock Tonnages Deposition in Brucejack Lake Schedule

Phase	Year		S3	ANDX	P1	P2	SILCAP	VSF	TOTAL
Construction	Y-2	Sep-15	5,839	6,770	0	0	208	9,066	21,884
		Oct-15	7,484	2,160	0	0	798	11,979	22,421
		Nov-15	6,812	4,705	0	0	385	20,293	32,195
		Dec-15	7,249	5,565	0	0	68	8,361	21,243
		Jan-16	2,988	3,064	0	0	0	7,055	13,107
		Feb-16	5,890	2,947	2,362	0	0	7,661	18,860
		Mar-16	10,930	10,042	8,077	0	415	8,090	37,555
		Apr-16	13,908	18,850	11,303	0	960	23,471	68,491
		May-16	7,089	24,587	2,240	0	1,510	31,320	66,746
	Y-1	Jun-16	14,397	35,065	2,081	0	2,517	20,117	74,177
		Jul-16	20,920	23,357	413	0	4,321	23,234	72,246
		Aug-16	31,487	45,241	0	0	4,223	27,516	108,466
		Sep-16	10,580	46,029	0	0	7,468	22,567	86,644
		Oct-16	8,672	12,784	499	0	6,076	15,154	43,186
		Nov-16	6,240	14,413	0	0	9,916	27,468	58,037
		Dec-16	7,751	29,899	0	0	0	26,624	64,275
		Jan-17	8,351	13,499	0	0	0	0	21,850
		Feb-17	7,354	13,758	0	0	1,408	15,617	38,137
		Mar-17	7,036	23,550	0	0	396	9,042	40,025
		Apr-17	1,900	9,132	0	0	178	6,067	17,277
		May-17	3,101	18,386	0	0	346	6,412	28,245
Operations	Y01*	Year 1	107,077	215,106	12,208	0	26,964	205,534	566,889
	Y02	Year 2	74,215	147,857	3,504	0	13,794	113,339	352,708
	Y03	Year 3	0	0	0	0	0	0	0
	Y04	Year 4	6,247	47,274	47,989	0	3,371	232,486	337,367
	Y05	Year 5	3,704	7,662	17,317	0	145	111,684	140,512
	Y06	Year 6	0	13,443	34,576	0	189	115,417	163,626
	Y07	Year 7	6,441	21,167	42,695	0	-	89,459	159,762
	Y08	Year 8	408	11,704	7,157	0	62	17,232	36,563
	Y09	Year 9	0	0	0	0	0	0	0
	Y10	Year 10	0	0	0	0	0	0	0
	Y11	Year 11	1,177	5,092	14,216	0	449	15,465	36,399
	Y12	Year 12	0	0	0	0	0	0	0
	Y13	Year 13	0	0	0	0	0	0	0
	Y14	Year 14	19,730	21,100	14,088	0	1,270	34,420	90,607
Total (LOM)			**414,997**	**854,208**	**220,725**	**0**	**87,437**	**1,262,150**	**2,839,500**

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-15:
Scenario 2 Underground Waste Rock Tonnages For Backfill

Phase	Year		S3	ANDX	P1	P2	SILCAP	VSF	TOTAL
Operations	**Y01***	Year 1	0	0	0	0	0	0	0
	Y02	Year 2	28,488	56,758	1,345	0	5,294	43,507	135,393
	Y03	Year 3	24,753	71,338	41,799	0	16,451	244,916	399,257
	Y04	Year 4	1,492	11,288	11,460	0	805	55,516	80,560
	Y05	Year 5	7,058	14,602	33,003	0	276	212,848	267,788
	Y06	Year 6	0	20,796	53,487	0	293	178,539	253,113
	Y07	Year 7	9,855	32,388	65,331	0	0	136,888	244,462
	Y08	Year 8	3,772	108,269	66,204	0	578	159,410	338,232
	Y09	Year 9	7,297	36,388	177,257	0	0	96,757	317,698
	Y10	Year 10	7,827	761	85,882	0	427	198,007	292,904
	Y11	Year 11	8,530	36,901	103,018	0	3,251	112,068	263,768
	Y12	Year 12	5,785	108,591	27,514	12,052	2,396	142,487	298,825
	Y13	Year 13	8,645	143,177	36,844	17,102	213	84,697	290,677
	Y14	Year 14	50,928	54,464	36,363	0	3,278	88,844	233,879
Total (LOM)			**164,430**	**695,721**	**739,507**	**29,154**	**33,262**	**1,754,484**	**3,416,556**

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.4.2.1 Instantaneous Loads

Lithology-specific SFE data sets combined with waste rock deposition schedules were used to predict the instantaneous loads from underground waste rock deposited in Brucejack Lake, as described in Section 3.3.3.1 for surface waste rock. The revised source terms for instantaneous loads to Brucejack Lake from submerged underground waste rock incorporate all available SFE data and utilize the tracked waste rock tonnages deposited in Brucejack Lake during the Construction phase and year 1 of Operations, as well as the projected waste rock schedules (Scenario 1 (Table 3-13) and Scenario 2 (Table 3-14)) for the increased mine production rate.

Monthly loads are scaled to account for the proportion of waste rock considered to be reactive (*i.e.*., soluble) using the fraction of material that is < 6.4 mm, estimated to be approximately 40% of the total underground waste rock. The proportion of reactive fines assumed for the waste rock is based on particle size distributions completed for representative subsamples from field bin and saturated column tests.

Base Case and Upper Case source terms were calculated from the cumulative dataset using the median (or 75th percentile in some cases to be consistent with observed lake quality)

and 90th percentile lithology-specific SFE values and the scaled monthly waste rock excavation tonnages (Table 3-13 and Table 3-14). Base Case and Upper Case source terms for waste rock submerged in Brucejack Lake using the recorded tonnages for the Construction phase are presented in Table 3-16 and Table 3-17, respectively. The revised source terms for Base Case and Upper Case under the Scenario 1 waste rock schedule are summarized in Table 3-18 and Table 3-19, and the terms predicted for the Scenario 2 waste rock schedule are presented in Table 3-20 and Table 3-21. An additional calibration factor was applied to Sb concentrations to better align with observed Sb concentrations in Brucejack Lake.

Table 3-16:
Base Case Underground Waste Rock Instantaneous Loads (g) for Construction Phase

Parameter	Y-2									Y-1											
	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17
Chloride	35,328	33,979	47,125	35,273	20,255	26,867	50,738	91,302	96,728	117,491	113,857	180,574	132,150	59,410	72,010	102,045	41,835	58,949	68,016	27,708	47,301
Fluoride	2,929	2,544	3,912	2,761	1,697	2,040	3,965	7,714	9,014	10,494	9,267	15,035	12,489	5,067	6,535	9,566	3,444	5,172	6,270	2,639	4,577
Sulfate	478,240	511,323	658,738	485,939	272,612	391,712	752,560	1,308,453	1,279,908	1,575,491	1,668,002	2,503,510	1,850,335	985,230	1,259,707	1,263,496	537,273	808,922	846,137	342,829	571,662
Al	4,095	3,617	5,495	3,846	2,366	3,257	6,973	12,821	13,095	15,180	13,343	21,260	18,034	7,685	10,007	13,319	4,769	7,326	8,746	3,688	6,392
Sb	203	235	323	207	127	179	308	566	557	589	649	934	640	367	493	525	173	332	303	134	200
As	530	452	729	481	311	361	722	1,467	1,764	1,985	1,709	2,735	2,486	1,026	1,411	1,826	592	981	1,174	507	877
Ba	466	444	619	453	264	371	770	1,376	1,384	1,676	1,591	2,478	2,007	939	1,208	1,398	553	821	942	387	669
Be	0.26	0.27	0.39	0.25	0.16	0.23	0.45	0.82	0.80	0.89	0.87	1.3	1.0	0.52	0.70	0.77	0.26	0.46	0.48	0.21	0.34
Bi	0.13	0.13	0.19	0.13	0.079	0.11	0.23	0.41	0.40	0.45	0.43	0.65	0.52	0.26	0.35	0.39	0.13	0.23	0.24	0.10	0.17
B	607	684	1,016	592	392	501	818	1,655	1,825	1,790	1,875	2,683	2,049	1,111	1,599	1,720	448	1,034	939	440	650
Cd	0.092	0.10	0.13	0.095	0.054	0.089	0.18	0.30	0.25	0.30	0.31	0.46	0.32	0.18	0.22	0.24	0.096	0.15	0.15	0.063	0.10
Ca	57,113	72,147	78,377	61,676	31,084	59,083	126,075	194,650	138,839	187,774	229,949	319,947	223,914	153,060	196,161	116,526	64,378	95,683	84,586	31,770	51,310
Cr	6.4	6.7	9.6	6.3	3.9	5.6	11	20	20	22	21	32	25	13	17	19	6.3	11	12	5.0	8.1
Co	4.4	4.9	6.7	4.5	2.7	3.8	6.6	12	12	13	14	21	14	7.5	9.6	11	4.1	7.0	6.8	2.9	4.4
Cu	4.6	6.1	8.3	4.7	3.0	4.8	8.3	15	13	12	15	19	13	9.5	14	10	2.5	7.4	5.0	2.5	3.0
Fe	159	128	199	147	89	114	246	462	509	611	515	850	738	290	369	540	202	287	366	152	271
Pb	0.18	0.24	0.33	0.18	0.12	0.32	0.81	1.3	0.68	0.65	0.67	0.82	0.66	0.50	0.71	0.44	0.10	0.32	0.22	0.11	0.14
Li	967	802	1,256	895	552	661	1,355	2,637	3,084	3,633	3,119	5,100	4,436	1,767	2,304	3,274	1,181	1,752	2,180	915	1,613
Mg	4,459	5,492	6,004	4,952	2,450	5,242	11,614	17,293	10,418	14,106	16,717	23,857	14,218	9,711	11,204	8,829	5,228	6,915	6,390	2,328	3,729
Mn	270	350	395	298	154	275	530	829	611	784	1,007	1,396	853	614	769	526	276	426	353	135	201
Hg	0.13	0.13	0.19	0.13	0.079	0.11	0.23	0.41	0.40	0.45	0.43	0.65	0.52	0.26	0.35	0.39	0.13	0.23	0.24	0.10	0.17
Mo	29	31	46	29	18	25	46	88	89	92	92	136	105	53	74	85	25	50	49	22	35
Ni	3.2	3.9	5.3	3.2	2.0	2.8	4.6	8.9	9.0	9.3	11	15	11	7.1	10	8.0	2.3	5.4	4.4	2.0	2.9
P	118	121	174	115	71	102	203	370	360	401	390	586	468	233	313	347	118	206	216	93	153
K	70,838	80,192	107,562	73,057	43,002	66,280	124,226	215,260	190,420	211,883	228,932	335,147	222,255	125,294	159,265	179,985	67,050	114,140	109,044	46,358	71,323
Se	37	39	55	35	22	29	55	107	116	128	128	187	165	86	123	110	35	67	68	30	49
Si	23,655	22,863	34,156	22,499	14,125	19,039	37,726	71,059	74,104	82,342	76,696	117,912	97,680	45,233	61,013	73,420	24,430	41,829	46,069	19,921	33,193
Ag	0.53	0.60	0.86	0.52	0.33	0.44	0.73	1.4	1.5	1.5	1.6	2.3	1.7	0.93	1.3	1.4	0.41	0.87	0.79	0.36	0.53
Na	494,232	447,893	687,021	465,592	291,369	361,659	701,510	1,362,696	1,542,789	1,747,695	1,571,211	2,493,827	2,084,557	888,957	1,178,518	1,593,291	545,378	875,743	1,020,136	436,196	743,183
Sr	2,581	2,999	3,485	2,742	1,428	2,464	5,083	8,079	6,384	8,393	9,590	13,949	9,563	5,819	7,209	5,899	2,996	4,245	4,156	1,597	2,638
Tl	3.3	4.0	5.0	3.6	2.0	3.1	5.5	9.1	7.7	9.2	11	16	9.1	5.7	6.8	7.4	3.3	5.1	4.6	1.9	2.8
Sn	0.24	0.28	0.44	0.23	0.16	0.22	0.37	0.76	0.79	0.71	0.73	0.99	0.81	0.46	0.71	0.71	0.13	0.42	0.35	0.18	0.25
Ti	5.1	5.1	7.5	4.9	3.1	4.2	8.2	15	15	17	16	25	20	9.3	13	15	5.0	8.8	9.3	4.1	6.6
U	18	20	23	19	9.8	16	30	48	41	56	62	94	60	34	39	41	22	28	29	11	19
V	27	20	34	24	15	18	41	79	91	107	87	145	134	51	68	96	34	50	65	27	49
Zn	17	18	23	17	9.7	15	29	49	44	53	56	84	58	31	39	43	18	27	28	12	19

Table 3-17:
Upper Case Underground Waste Rock Instantaneous Loads (g) for Construction Phase

Parameter	Y-2									Y-1											
	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17
Chloride	74,242	60,799	92,103	70,059	41,479	50,451	103,982	195,933	226,050	277,026	239,492	397,479	331,198	128,954	159,705	245,615	96,443	131,575	168,171	68,868	123,033
Fluoride	3,665	3,347	5,154	3,469	2,179	2,619	4,859	9,621	11,263	12,644	11,444	18,199	14,924	6,305	8,337	11,737	3,973	6,423	7,437	3,192	5,399
Sulfate	1,816,683	1,989,630	2,592,899	1,874,931	1,062,531	1,576,241	2,958,228	5,093,057	4,741,905	5,647,946	6,062,775	9,067,613	6,192,985	3,351,865	4,177,461	4,653,545	1,932,533	2,960,629	3,004,928	1,229,980	1,985,569
Al	9,747	7,978	12,741	8,903	5,589	7,071	15,256	29,181	32,292	37,525	31,547	51,416	45,878	18,305	24,147	33,631	11,766	17,883	22,272	9,416	16,596
Sb	445	492	647	460	263	392	727	1,257	1,163	1,358	1,464	2,179	1,464	799	998	1,134	458	720	718	297	472
As	1,892	1,624	2,582	1,684	1,095	1,237	2,533	5,233	6,472	7,375	6,437	10,133	9,727	4,209	5,957	6,594	2,127	3,633	4,299	1,858	3,240
Ba	1,109	1,144	1,608	1,090	658	943	1,853	3,349	3,275	3,715	3,680	5,542	4,312	2,165	2,862	3,185	1,140	1,911	2,012	856	1,405
Be	0.80	0.95	1.0	0.91	0.44	0.76	1.4	2.1	1.6	2.3	2.8	4.2	2.1	1.4	1.4	1.6	0.99	1.2	1.1	0.40	0.65
Bi	0.13	0.13	0.19	0.13	0.079	0.11	0.23	0.41	0.40	0.45	0.43	0.65	0.52	0.26	0.35	0.39	0.13	0.23	0.24	0.10	0.17
B	1,602	1,818	2,615	1,603	1,019	1,358	2,240	4,329	4,547	4,608	4,940	7,135	5,027	2,765	3,806	4,332	1,275	2,642	2,418	1,100	1,629
Cd	3.0	3.7	4.1	3.4	1.7	2.8	5.1	7.7	5.9	8.2	10	15	7.5	4.9	5.1	5.9	3.6	4.4	4.2	1.5	2.3
Ca	386,374	447,895	550,643	405,929	222,408	367,016	728,267	1,196,749	988,407	1,212,966	1,366,708	1,983,557	1,345,592	806,349	1,013,487	916,336	411,397	631,143	605,438	242,652	387,655
Cr	6.7	7.0	9.9	6.6	4.0	5.8	12	21	20	23	22	34	26	13	18	20	6.8	12	12	5.2	8.6
Co	34	48	49	32	17	51	148	231	138	175	199	244	272	193	285	80	33	80	61	25	43
Cu	10	10	15	9.7	6.3	8.7	18	34	34	37	34	52	45	21	30	33	10	19	21	9.1	15
Fe	432	334	514	401	236	294	648	1,205	1,360	1,693	1,419	2,380	2,059	784	971	1,478	588	782	1,031	420	763
Pb	11	12	13	12	5.7	1,727	5,893	8,246	1,648	1,545	339	59	29	380	16	21	15	16	17	5.7	10
Li	2,102	2,093	2,996	2,067	1,246	1,599	2,891	5,456	6,002	6,863	6,723	10,401	7,892	3,697	4,788	6,145	2,234	3,568	3,898	1,650	2,731
Mg	46,809	51,926	58,682	51,733	25,401	42,594	83,283	126,409	98,625	141,071	161,260	247,894	139,663	78,681	80,879	102,312	60,842	70,242	75,471	27,213	46,136
Mn	3,068	3,844	4,071	3,301	1,628	3,411	7,810	11,843	7,767	10,731	12,800	17,799	12,919	8,771	11,210	6,294	3,632	5,243	4,750	1,755	2,921
Hg	0.15	0.19	0.22	0.13	0.079	0.20	0.57	0.92	0.60	0.71	0.77	0.97	1.1	0.73	1.1	0.39	0.13	0.33	0.27	0.12	0.20
Mo	71	86	122	68	45	73	152	278	245	246	262	348	317	197	294	200	49	134	112	53	79
Ni	16	23	24	14	7.7	26	76	120	70	87	99	117	142	103	154	37	14	40	29	12	21
P	223	234	369	209	144	180	313	648	727	708	681	995	837	414	608	692	168	394	383	180	277
K	131,408	136,200	192,432	130,388	78,769	114,161	221,098	397,042	381,019	426,984	423,355	640,354	475,827	236,741	306,700	372,492	133,011	221,247	231,942	98,948	160,460
Se	107	116	153	109	63	92	176	307	290	344	362	541	387	206	262	284	114	179	183	76	123
Si	31,808	31,328	45,748	30,454	18,863	25,931	51,760	96,204	98,541	110,808	105,196	160,369	132,343	63,191	85,177	96,799	33,067	56,280	61,233	26,313	43,841
Ag	2.4	2.8	4.3	2.3	1.6	2.0	3.1	6.5	7.3	6.7	7.2	10	7.5	4.3	6.4	6.7	1.5	4.1	3.4	1.7	2.3
Na	727,504	718,387	1,042,172	707,795	432,373	582,345	1,115,538	2,073,399	2,160,877	2,442,205	2,341,991	3,608,162	2,821,845	1,323,021	1,734,501	2,168,373	764,768	1,252,051	1,369,948	584,152	968,917
Sr	13,347	15,587	19,107	14,276	7,748	12,159	22,461	36,976	31,812	39,231	45,492	66,667	41,326	24,862	30,091	30,586	14,174	20,974	20,002	7,940	12,460
Tl	10	11	13	11	5.7	8.9	18	31	27	35	36	56	40	21	25	28	13	17	19	7.6	13
Sn	6.3	8.1	13	5.8	4.6	6.0	9.3	21	22	17	18	22	19	13	21	18	1.0	11	7.3	4.4	5.2
Ti	24	22	34	22	14	18	34	67	77	84	74	117	101	42	58	79	25	43	49	22	36
U	57	65	75	58	30	60	142	225	164	215	232	332	268	162	212	140	68	102	102	40	68
V	95	73	120	85	54	63	136	268	318	375	307	510	469	178	235	340	120	177	228	96	172
Zn	33	32	45	33	19	27	54	96	97	116	109	172	133	60	76	99	39	57	66	27	46

Table 3-18:
Scenario 1 Base Case Underground Waste Rock Instantaneous Loads (g) for Operations Phase

Parameter	Y01*	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Chloride	2,447,586	2,193,354	1,393,167	1,392,510	1,343,432	1,243,129	1,187,156	1,305,078	582,033	756,852	735,387	1,128,845	1,122,151	1,212,156
Fluoride	173,567	153,936	106,978	110,400	107,047	100,392	92,259	101,872	45,022	60,380	56,928	87,567	85,366	83,816
Sulfate	47,297,179	41,456,036	29,282,051	28,842,370	29,204,408	26,852,110	25,403,281	23,776,141	14,170,174	18,133,876	16,481,674	20,678,792	19,216,216	25,515,455
Al	436,588	387,077	267,559	276,451	250,193	261,519	261,022	288,126	195,610	166,443	191,692	234,470	247,800	219,314
Sb	13,254	11,385	9,421	9,796	10,163	9,634	8,942	7,694	5,792	6,800	6,055	6,289	5,518	7,759
As	54,319	47,997	31,456	30,434	26,810	26,713	25,661	31,746	14,691	15,139	17,527	29,532	31,648	23,418
Ba	35,359	31,510	19,583	18,628	17,447	17,008	17,526	18,041	11,931	11,349	12,466	15,341	15,891	18,526
Be	14	12	9.6	10	9.8	10	9.7	9.0	7.6	7.0	7.2	7.2	7.0	7.8
Bi	6.8	5.9	4.8	5.0	4.9	5.0	4.9	4.5	3.8	3.5	3.6	3.6	3.5	3.9
B	48,923	42,062	35,138	36,889	38,945	35,677	31,831	27,826	17,060	24,353	19,930	23,239	19,488	27,701
Cd	4.6	3.9	3.2	3.3	3.2	3.4	3.5	2.9	3.1	2.6	2.7	2.2	2.2	2.9
Ca	12,345,355	10,954,661	6,624,977	5,916,348	5,874,255	5,333,176	5,555,336	4,995,983	3,461,848	3,835,099	3,832,108	4,426,980	4,327,964	6,830,903
Cr	332	285	237	249	244	249	241	221	189	176	179	175	169	192
Co	202	176	137	141	147	136	126	111	74	94	82	91	80	116
Cu	215	173	199	216	232	230	211	153	169	175	155	118	93	150
Fe	8,595	7,694	4,955	5,033	4,506	4,632	4,664	5,358	3,265	2,852	3,336	4,451	4,762	4,203
Pb	11	8.1	14	16	15	20	21	15	28	17	20	9.0	9.4	12
Li	74,399	65,748	46,349	47,742	45,446	44,755	43,025	45,555	27,633	28,562	29,440	37,458	37,404	37,926
Mg	698,830	604,292	478,639	495,070	488,106	495,785	489,948	437,652	394,271	358,033	366,982	341,097	328,760	415,256
Mn	12,837	11,004	8,113	7,471	7,609	7,514	7,895	5,809	6,890	6,106	6,249	4,949	4,730	8,191
Hg	6.8	5.9	4.8	5.0	4.9	5.0	4.9	4.5	3.8	3.5	3.6	3.6	3.5	3.9
Mo	2,428	2,042	1,833	1,893	1,900	1,868	1,714	1,551	1,188	1,292	1,215	1,228	1,084	1,328
Ni	504	416	330	275	263	243	219	208	117	162	157	188	159	222
P	6,122	5,271	4,312	4,514	4,410	4,501	4,366	4,048	3,431	3,163	3,242	3,227	3,139	3,504
K	5,029,401	4,364,503	3,492,856	3,695,919	3,669,394	3,725,168	3,666,164	3,272,263	2,937,363	2,683,576	2,719,492	2,499,926	2,392,689	3,047,506
Se	3,231	2,774	2,239	2,291	2,219	2,260	2,190	2,056	1,698	1,577	1,631	1,696	1,667	1,790
Si	1,451,732	1,263,339	982,695	1,030,217	994,579	1,009,564	978,298	953,488	733,338	687,557	711,165	764,535	754,972	799,317
Ag	25	21	19	20	21	20	17	15	9.3	13	11	12	10	14
Na	33,568,759	29,383,237	22,245,332	23,319,027	22,776,572	22,399,487	21,253,585	21,193,245	14,116,928	14,800,512	14,637,165	17,322,502	16,819,999	17,937,880
Sr	315,419	276,363	190,320	183,174	178,881	172,248	171,208	161,310	116,891	119,721	121,526	139,928	138,279	171,670
Tl	231	201	149	148	158	142	135	110	79	103	88	90	75	138
Sn	12	9.8	11	13	13	13	12	9.6	8.3	9.3	8.1	7.4	6.1	7.5
Ti	258	223	181	192	189	189	180	171	131	130	129	136	130	144
U	1,590	1,421	862	815	747	774	855	829	730	561	669	645	689	902
V	1,508	1,344	887	904	799	830	825	974	574	499	592	822	884	709
Zn	809	709	509	511	503	500	505	455	390	361	372	366	359	474

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-19:
Scenario 1 Upper Case Underground Waste Rock Instantaneous Loads (g) for Operations Phase

Parameter	Y01*	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Chloride	3,888,958	3,523,129	2,056,270	2,023,967	1,819,967	1,745,489	1,729,607	2,145,959	886,965	979,035	1,105,128	1,872,245	1,991,446	1,791,483
Fluoride	186,384	165,028	116,145	120,225	117,102	109,680	100,327	109,906	48,800	66,227	61,767	94,371	91,381	90,324
Sulfate	86,800,763	76,213,301	53,780,284	53,419,601	53,591,578	51,009,791	50,043,414	45,489,551	33,437,574	35,841,299	34,662,907	37,422,809	35,397,662	49,252,585
Al	535,059	473,913	330,065	341,556	311,145	321,813	317,502	351,779	229,463	202,926	229,508	289,289	303,622	266,061
Sb	21,010	18,386	13,469	13,626	13,816	13,189	12,821	11,403	8,692	9,344	8,881	9,318	8,696	12,194
As	108,555	94,812	67,567	66,771	61,477	59,999	55,485	64,629	30,313	35,228	36,923	59,047	60,405	47,932
Ba	56,648	49,096	38,254	39,411	38,559	38,673	37,553	35,203	28,100	26,920	27,337	28,058	27,076	31,823
Be	34	31	16	14	14	12	15	12	10	10	10	9.6	9.6	21
Bi	6.8	5.9	4.8	5.0	4.9	5.0	4.9	4.5	3.8	3.5	3.6	3.6	3.5	3.9
B	74,945	63,931	56,771	60,852	64,387	59,528	52,425	45,739	28,677	40,541	32,947	37,594	31,026	42,711
Cd	126	115	61	53	57	47	52	40	28	37	33	34	31	77
Ca	18,945,967	16,407,960	12,124,618	11,818,822	11,664,868	11,806,806	12,181,707	10,216,790	10,364,319	8,984,986	9,452,790	7,965,700	7,713,264	11,567,599
Cr	347	299	241	251	246	250	244	225	191	176	181	180	175	199
Co	2,904	2,227	2,517	2,362	1,974	2,789	3,211	2,434	4,496	2,487	3,338	1,342	1,440	2,123
Cu	565	484	411	436	421	436	419	401	333	301	313	320	314	315
Fe	23,434	21,236	12,275	12,038	10,387	10,533	10,868	13,553	6,913	6,042	7,558	11,562	12,708	10,870
Pb	18,211	7,480	60,947	86,569	73,288	128,152	157,230	106,804	257,860	124,967	170,579	40,118	53,703	73,638
Li	103,326	91,295	63,550	64,312	63,996	58,680	54,052	55,905	25,862	36,783	33,115	48,057	45,223	52,116
Mg	2,076,322	1,898,494	950,903	829,296	805,384	737,897	874,225	786,396	630,871	561,886	627,865	654,666	696,915	1,225,235
Mn	168,820	142,970	107,664	96,776	87,107	104,220	121,975	93,891	145,224	90,681	114,644	60,594	64,015	112,754
Hg	12	9.1	10	10	8.8	12	13	10	17	10	13	6.1	6.3	8.4
Mo	4,128	3,314	3,669	3,878	3,832	4,141	3,994	3,247	3,793	3,149	3,268	2,250	1,986	2,657
Ni	1,473	1,103	1,358	1,287	1,074	1,539	1,760	1,324	2,499	1,375	1,845	723	774	1,103
P	11,330	9,544	9,154	10,024	10,285	9,948	8,782	8,070	5,482	6,679	5,845	6,545	5,706	6,250
K	6,507,109	5,653,192	4,470,472	4,705,538	4,663,465	4,669,714	4,528,892	4,160,439	3,413,550	3,281,809	3,276,774	3,248,025	3,097,729	3,787,859
Se	5,267	4,608	3,311	3,294	3,266	3,156	3,096	2,858	2,139	2,207	2,183	2,393	2,312	2,952
Si	1,672,411	1,449,614	1,131,256	1,169,573	1,129,340	1,139,182	1,097,792	1,069,414	807,451	773,893	795,699	861,216	841,887	905,777
Ag	114	95	97	107	115	106	90	76	48	72	56	62	47	65
Na	36,714,651	32,145,861	23,971,628	24,815,411	24,325,605	23,718,241	22,560,304	22,295,817	14,746,182	15,747,012	15,469,350	18,399,154	17,804,747	19,647,208
Sr	614,216	539,699	369,075	355,656	364,590	339,763	340,039	286,949	229,381	249,430	236,540	242,068	225,894	362,690
Tl	522	464	290	274	255	258	276	269	219	183	209	214	223	289
Sn	314	241	357	413	444	437	372	290	265	314	258	212	151	209
Ti	1,250	1,093	841	893	866	847	782	821	475	535	520	679	658	630
U	3,294	2,793	2,168	2,034	1,796	2,169	2,467	2,065	2,864	1,789	2,283	1,364	1,456	2,107
V	5,277	4,717	3,055	3,098	2,760	2,788	2,722	3,294	1,685	1,619	1,865	2,806	2,980	2,415
Zn	1,693	1,502	1,021	1,034	982	977	974	994	686	650	692	817	831	904

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-20:
Scenario 2 Base Case Underground Waste Rock Instantaneous Loads (g) for Operations Phase

Parameter	Y01*	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Chloride	2,447,586	1,584,942	0	1,124,088	462,326	488,094	469,200	127,316	0	0	89,175	0	0	338,474
Fluoride	173,567	111,236	0	89,119	36,839	39,417	36,463	9,938	0	0	6,903	0	0	23,404
Sulfate	47,297,179	29,956,605	0	23,282,668	10,050,349	10,543,042	10,040,149	2,319,474	0	0	1,998,619	0	0	7,124,762
Al	436,588	279,706	0	223,162	86,101	102,681	103,164	28,108	0	0	23,245	0	0	61,240
Sb	13,254	8,227	0	7,908	3,498	3,783	3,534	751	0	0	734	0	0	2,166
As	54,319	34,683	0	24,567	9,226	10,488	10,142	3,097	0	0	2,125	0	0	6,539
Ba	35,359	22,769	0	15,037	6,004	6,678	6,927	1,760	0	0	1,512	0	0	5,173
Be	14	8.5	0	8.1	3.4	3.9	3.8	0.88	0	0	0.87	0	0	2.2
Bi	6.8	4.2	0	4.0	1.7	2.0	1.9	0.44	0	0	0.44	0	0	1.1
B	48,923	30,395	0	29,778	13,403	14,008	12,581	2,715	0	0	2,417	0	0	7,735
Cd	4.6	2.8	0	2.6	1.1	1.3	1.4	0.29	0	0	0.33	0	0	0.81
Ca	12,345,355	7,915,963	0	4,775,904	2,021,555	2,093,984	2,195,638	487,382	0	0	464,693	0	0	1,907,415
Cr	332	206	0	201	84	98	95	22	0	0	22	0	0	54
Co	202	127	0	114	51	54	50	11	0	0	9.9	0	0	32
Cu	215	125	0	175	80	90	83	15	0	0	19	0	0	42
Fe	8,595	5,560	0	4,063	1,551	1,819	1,843	523	0	0	405	0	0	1,174
Pb	11	5.9	0	13	5.3	7.8	8.5	1.5	0	0	2.5	0	0	3.4
Li	74,399	47,510	0	38,539	15,640	17,572	17,005	4,444	0	0	3,570	0	0	10,590
Mg	698,830	436,668	0	399,640	167,976	194,662	193,642	42,695	0	0	44,501	0	0	115,953
Mn	12,837	7,952	0	6,031	2,619	2,950	3,121	567	0	0	758	0	0	2,287
Hg	6.8	4.2	0	4.0	1.7	2.0	1.9	0.44	0	0	0.44	0	0	1.1
Mo	2,428	1,476	0	1,528	654	734	677	151	0	0	147	0	0	371
Ni	504	301	0	222	91	96	87	20	0	0	19	0	0	62
P	6,122	3,809	0	3,644	1,518	1,767	1,725	395	0	0	393	0	0	979
K	5,029,401	3,153,840	0	2,983,488	1,262,778	1,462,626	1,448,980	319,225	0	0	329,774	0	0	850,965
Se	3,231	2,004	0	1,850	764	887	865	201	0	0	198	0	0	500
Si	1,451,732	912,903	0	831,631	342,272	396,389	386,653	93,017	0	0	86,238	0	0	223,196
Ag	25	15	0	16	7.3	7.7	6.8	1.5	0	0	1.3	0	0	3.9
Na	33,568,759	21,232,662	0	18,824,013	7,838,286	8,794,792	8,400,063	2,067,500	0	0	1,774,949	0	0	5,008,851
Sr	315,419	199,703	0	147,865	61,560	67,631	67,667	15,737	0	0	14,737	0	0	47,936
Tl	231	146	0	120	54	56	53	11	0	0	11	0	0	38
Sn	12	7.1	0	10	4.6	5.1	4.6	0.94	0	0	0.98	0	0	2.1
Ti	258	161	0	155	65	74	71	17	0	0	16	0	0	40
U	1,590	1,027	0	658	257	304	338	81	0	0	81	0	0	252
V	1,508	971	0	730	275	326	326	95	0	0	72	0	0	198
Zn	809	512	0	412	173	196	199	44	0	0	45	0	0	132

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-21:
Scenario 2 Upper Case Underground Waste Rock Instantaneous Loads (g) for Operations Phase

Parameter	Y01*	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14
Chloride	3,888,958	2,545,853	0	1,633,824	626,320	685,338	683,593	209,348	0	0	134,011	0	0	500,242
Fluoride	186,384	119,251	0	97,051	40,299	43,064	39,652	10,722	0	0	7,490	0	0	25,222
Sulfate	86,800,763	55,072,601	0	43,122,352	18,442,903	20,028,161	19,778,678	4,437,718	0	0	4,203,333	0	0	13,752,956
Al	535,059	342,455	0	275,717	107,077	126,355	125,486	34,318	0	0	27,831	0	0	74,293
Sb	21,010	13,286	0	10,999	4,755	5,178	5,067	1,112	0	0	1,077	0	0	3,405
As	108,555	68,512	0	53,900	21,157	23,558	21,929	6,305	0	0	4,477	0	0	13,384
Ba	56,648	35,477	0	31,814	13,270	15,184	14,842	3,434	0	0	3,315	0	0	8,886
Be	34	22	0	11	4.8	4.9	5.8	1.1	0	0	1.3	0	0	5.9
Bi	6.8	4.2	0	4.0	1.7	2.0	1.9	0.44	0	0	0.44	0	0	1.1
B	74,945	46,197	0	49,122	22,158	23,373	20,720	4,462	0	0	3,995	0	0	11,926
Cd	126	83	0	43	20	19	21	3.9	0	0	4.0	0	0	21
Ca	18,945,967	11,856,579	0	9,540,607	4,014,325	4,635,750	4,814,581	996,696	0	0	1,146,275	0	0	3,230,057
Cr	347	216	0	203	85	98	96	22	0	0	22	0	0	56
Co	2,904	1,610	0	1,906	679	1,095	1,269	237	0	0	405	0	0	593
Cu	565	350	0	352	145	171	166	39	0	0	38	0	0	88
Fe	23,434	15,346	0	9,718	3,575	4,136	4,295	1,322	0	0	916	0	0	3,035
Pb	18,211	5,405	0	69,882	25,221	50,317	62,142	10,419	0	0	20,685	0	0	20,562
Li	103,326	65,971	0	51,915	22,023	23,040	21,363	5,454	0	0	4,016	0	0	14,553
Mg	2,076,322	1,371,874	0	669,439	277,163	289,723	345,520	76,717	0	0	76,137	0	0	342,126
Mn	168,820	103,312	0	78,121	29,977	40,920	48,208	9,160	0	0	13,902	0	0	31,485
Hg	12	6.6	0	8.2	3.0	4.6	5.2	1.00	0	0	1.6	0	0	2.4
Mo	4,128	2,395	0	3,131	1,319	1,626	1,579	317	0	0	396	0	0	742
Ni	1,473	797	0	1,039	370	604	696	129	0	0	224	0	0	308
P	11,330	6,897	0	8,091	3,540	3,906	3,471	787	0	0	709	0	0	1,745
K	6,507,109	4,085,061	0	3,798,491	1,604,876	1,833,487	1,789,956	405,870	0	0	397,352	0	0	1,057,696
Se	5,267	3,330	0	2,659	1,124	1,239	1,224	279	0	0	265	0	0	824
Si	1,672,411	1,047,508	0	944,124	388,649	447,281	433,881	104,326	0	0	96,489	0	0	252,923
Ag	114	68	0	86	40	42	36	7.5	0	0	6.8	0	0	18
Na	36,714,651	23,228,966	0	20,031,952	8,371,367	9,312,580	8,916,518	2,175,061	0	0	1,875,862	0	0	5,486,153
Sr	614,216	389,993	0	287,099	125,469	133,402	134,394	27,993	0	0	28,684	0	0	101,275
Tl	522	336	0	221	88	101	109	26	0	0	25	0	0	81
Sn	314	174	0	333	153	172	147	28	0	0	31	0	0	58
Ti	1,250	790	0	721	298	332	309	80	0	0	63	0	0	176
U	3,294	2,018	0	1,642	618	851	975	201	0	0	277	0	0	588
V	5,277	3,408	0	2,501	950	1,095	1,076	321	0	0	226	0	0	674
Zn	1,693	1,085	0	835	338	384	385	97	0	0	84	0	0	252

Notes: Year 1 of operations consists of only seven months (June through December of 2017).

3.4.2.2 Post-Depositional Loads

Leachate data from saturated column kinetic tests comprising waste rock from the underground mine (VSF, Fragmental and Conglomerate (S3)) were used to assess which parameters have the potential for longer-term leaching behaviour. Based on the assessment, As and Sb were identified as parameters showing longer-term release patterns. These are the only parameters for which a post-depositional load is applied. Post-depositional loads for these parameters are based on stabilized waste rock column leachate concentration data (*i.e.*, last five analyses, up until August 17, 2017) combined with the underground waste rock schedule (Table 3-13 and Table 3-14) and assumptions regarding waste rock reactivity.

Median and 90th percentile leachate concentration values were used to derive Base Case and Upper Case loading rates. Loading rates (mg/kg/month) for each underground waste rock lithology were multiplied by cumulative waste rock tonnages calculated from lithology-specific tonnages presented in Table 3-13 and Table 3-14. Leachate quality from the surface P2 column was used as a surrogate for the underground Office P2 and Office P1 units when calculating the potential contributions from these waste rock tonnages deposited in Brucejack Lake. Leachate quality from the acid generating S3 column was used as a surrogate for the Silicic Cap. It is assumed that any waste rock deposited in the lake will contribute post-depositional loads for approximately one year following placement. After this time, it is assumed that on-going deposition of waste rock from development of the underground mine limit post-depositional leaching.

Base Case and Upper Case As and Sb predictions for post-deposition loads for Scenario 1 and Scenario 2 are summarized in Table 3-22 and Table 3-23, respectively.

The contribution of post-depositional loads is projected to continue throughout the Closure and Post-closure periods. Ultimately, final tailings production and natural sedimentation in Brucejack Lake are assumed to bury the final waste deposits and inhibit further contaminant release.

Table 3-22:
Scenario 1 Underground Waste Rock Post-Deposition Loads (g)

Phase	Year	Parameter	Sb		As	
		Case	Base Case	Upper Case	Base Case	Upper Case
		Units	g	g	g	g
Construction	Y-2	Sep-15	3.0	3.4	63	71
		Oct-15	5.1	6.0	141	161
		Nov-15	8.0	9.3	216	247
		Dec-15	11	13	288	329
		Jan-16	12	14	320	365
		Feb-16	14	17	377	430
		Mar-16	19	22	489	558
		Apr-16	27	32	648	739
		May-16	36	41	762	868
	Y-1	Jun-16	48	55	952	1,084
		Jul-16	59	68	1,203	1,369
		Aug-16	77	89	1,567	1,783
		Sep-16	90	103	1,717	1,953
		Oct-16	94	108	1,785	2,030
		Nov-16	98	113	1,875	2,132
		Dec-16	105	120	1,913	2,174
		Jan-17	108	124	1,966	2,235
		Feb-17	112	128	2,005	2,279
		Mar-17	115	131	1,986	2,256
		Apr-17	109	125	1,857	2,109
		May-17	106	122	1,795	2,038
Operations	Y01*		729	831	12,036	13,661
	Y02		1,218	1,393	20,908	23,746
	Y03		626	715	10,824	12,292
	Y04		326	368	4,960	5,617
	Y05		228	255	3,443	3,896
	Y06		187	208	2,719	3,071
	Y07		238	269	3,075	3,462
	Y08		367	410	3,425	3,829
	Y09		304	344	2,552	2,835
	Y10		129	151	2,075	2,337
	Y11		152	176	2,480	2,801
	Y12		314	352	2,956	3,306
	Y13		455	505	3,198	3,548
	Y14		461	524	6,606	7,474
Closure and Post-closure **			461	524	6,606	7,474

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).
** Source terms presented for Closure and Post-Closure represent annual and are assumed to continue throughout theses phases (~13 years).

Table 3-23:
Scenario 2 Underground Waste Rock Post-Deposition Loads (g)

Phase	Year	Parameter	D-Sb		D-As	
		Case	Base Case	Upper Case	Base Case	Upper Case
		Units	g	g	g	g
Construction	Y-2	Sep-15	3.0	3.0	63	71
		Oct-15	5.0	6.0	141	161
		Nov-15	8.0	9.0	216	247
		Dec-15	11	13	288	329
		Jan-16	12	14	320	365
		Feb-16	14	17	377	430
		Mar-16	19	22	489	558
		Apr-16	27	32	648	739
		May-16	36	41	762	868
	Y-1	Jun-16	48	55	952	1,084
		Jul-16	59	68	1,203	1,369
		Aug-16	77	89	1,567	1,783
		Sep-16	90	103	1,717	1,953
		Oct-16	94	108	1,785	2,030
		Nov-16	98	113	1,875	2,132
		Dec-16	105	120	1,913	2,174
		Jan-17	108	124	1,966	2,235
		Feb-17	112	128	2,005	2,279
		Mar-17	115	131	1,986	2,256
		Apr-17	109	125	1,857	2,109
		May-17	106	122	1,795	2,038
Operations	Y01*		729	831	12,036	13,661
	Y02		1,079	1,234	18,518	21,031
	Y03		670	766	11,495	13,055
	Y04		433	491	6,859	7,778
	Y05		139	156	1,957	2,212
	Y06		69	77	995	1,123
	Y07		94	106	1,213	1,365
	Y08		73	83	849	955
	Y09		43	48	305	338
	Y10		43	48	305	338
	Y11		34	38	325	363
	Y12		26	30	341	384
	Y13		26	30	341	384
	Y14		76	89	1,578	1,795
Closure and Post-closure **			76	89	1,578	1,795

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).
** Source terms presented for Closure and Post-Closure represent annual loadings and are assumed to continue throughout theses phases (~13 years).

3.4.2.3 Surface Exposure Loads

Most of the underground waste rock brought to surface will be deposited in Brucejack Lake immediately; however, a portion may be stored at surface for up to two years prior to subaqueous deposition as per *Mines Act* Permit M-243 Condition D.3(c)(v). The exposed surface portion of the waste rock dump (the pad) develops as waste rock is added to the dump and waste rock is pushed into the lake. Subaerially exposed PAG pad materials may be replaced with either NPAG or fresh PAG materials within the two-year time frame, or the surface PAG materials may be excavated and deposited in the main body of the lake, leaving shallow ponded areas within the pad (geotechnical and other conditions apply to these activities).

Accumulated loads associated with exposure of waste rock over a two-year time frame have been incorporated into the updated Brucejack Gold Mine water quality model. Proportional loads from the four major geological model units (representing 96% of waste rock to be excavated from the underground mine; Table 3-13) were determined based on field bins leachate results (as presented in the 2016 Annual Report; Pretivm, 2017) and the estimated maximum volume of waste rock to be subaerially exposed on the waste rock platform at any given time (~180,000 m^3). The total loads accumulated over a two-year time frame, along with the monthly loads for May-October (*i.e.*, the months when leaching would be anticipated), are presented in Table 3-24.

Table 3-24:
Subaerially-exposed Underground Waste Rock Loads

Parameter	Loads Accumulated over 2 Years (kg)	Monthly Loads (May-October) (kg)
Chloride	465	77
Fluoride	29	4.8
Sulfate	23,570	3,928
Al	0.0064	0.0011
Sb	12	2.1
As	8.3	1.4
Ba	15	2.6
Be	8.6	1.4
Bi	0.015	0.0025
B	0.075	0.013
Cd	4297	716
Ca	0.015	0.0024
Cr	0.13	0.021
Co	0.02	0.0039
Cu	2.55	0.43
Fe	4.22	0.70
Pb	0.0014	0.00023
Li	915	153
Mg	26	4.3
Mn	459	77
Hg	21	3.50
Mo	2.2	0.36
Ni	11,844	1,974
P	0.37	0.061
K	37	6.2
Se	0.040	0.0066
Si	5.0	0.83
Ag	1.7	0.29
Na	196	33
Sr	0.015	0.0025
Tl	162	27
Sn	1.4	0.23
Ti	0.029	0.0048
U	3.2	0.53
V	0.21	0.036
Zn	0.69	0.11

3.4.3 Underground Mine Water

The underground workings of the Brucejack Gold Mine are primarily below the groundwater table and thus dewatering is required for all active phases of mine development. Water in the underground mine is collected and conveyed by a system of sumps and pumps located throughout the working levels, with all water ultimately reporting to a main sump that is pumped to a clarifier before being directed to the WTP.

Individual components of the underground mine workings source term include: blasting residues, groundwater inflow, exposed wall rock, waste rock fill (Scenario 2 only), paste backfill (cemented thickened tailings) and bleed water from paste backfill. Loadings associated with blasting residues are summarized separately in Section 3.8. The following sections describe the development of geochemical source terms for the mine underground during Operations and Post-closure. Loads from paste backfill bleed water contributing to the underground mine water source terms are discussed under Mill Components (Section 3.6).

3.4.3.1 Background Groundwater

The groundwater source term component of the model is based on adit drainage water quality observed during saturated time periods (*i.e.*, when the mine was flooded). Adit drainage represents water from a relatively large drainage area, and thus is considered to provide a more representative estimate of typical background groundwater than any individual groundwater well. Therefore, water quality sample data from the Brucejack adit during time periods when the mine workings were saturated were used to estimate the geochemical load carried in background groundwater. Median and maximum concentrations observed in adit drainage from 2009 to October 2011 (*i.e.*, when the mine workings were saturated) were used for the Base Case and Upper Case source terms, respectively (Table 3-25). This term is unchanged from the original MA-EMA Permits Application (Pretivm, 2015).

Table 3-25:
Background Groundwater Source Term Concentrations

Parameter	Units	Base Case	Upper Case
Sulfate	mg/L	116	118
Al	mg/L	0.015	0.092
Sb	mg/L	0.0012	0.0016
As	mg/L	0.0021	0.0077
Ba	mg/L	0.019	0.033
Cd	mg/L	0.00011	0.00037
Ca	mg/L	54	61
Cr	mg/L	0.00016	0.0010
Co	mg/L	0.00032	0.00070
Cu	mg/L	0.00050	0.0034
Fe	mg/L	0.030	0.84
Pb	mg/L	0.000083	0.0060
Mg	mg/L	4.9	5.3
Mn	mg/L	0.16	0.20
Hg	mg/L	0.000010	0.000010
Mo	mg/L	0.0016	0.0017
Ni	mg/L	0.00050	0.0010
K	mg/L	1.8	2.0
Se	mg/L	0.00010	0.0010
Si	mg/L	3.0	3.1
Ag	mg/L	0.000010	0.000020
Na	mg/L	17	19
Sr	mg/L	1.1	1.1
Tl	mg/L	0.000015	0.00020
U	mg/L	0.00021	0.00022
Zn	mg/L	0.019	0.046

3.4.3.2 Wall Rock

The exposed wall rock areas will increase as the mine develops and contribute increasing geochemical loads to the underground system. The wall rock exposure schedule is presented in Table 3-26.

Source terms for exposed underground wall rock are based on the lithology-specific humidity cell data (based on units described in Section 3.4.2) and wall rock conversion factors calibrated from site monitoring data. The wall rock source term is calculated by multiplying humidity cell loading rates (units of mg/kg/wk) by wall rock conversion factors (units of kg/m^2) which produce area normalized wall rock loading rates (units of $mg/m^2/wk$). Details of the approach are outlined in the MA-EMA Permits Application

(Pretivm, 2015). Updates to source term inputs used since the 2016 Annual Report (Pretivm, 2017) and MA-EMA Permits Application include:

- Classification of humidity cell weathering state (neutral/acidic);
- Additional humidity cell test results;
- Wall rock conversion factors updated with recent monitoring data and wall rock exposure estimates; and
- Humidity cell statistics used in wall rock conversion factor calibration.

The classification of humidity cell weathering state has been updated to reflect the evolving pH conditions in humidity cell tests. Humidity cells HC21 (S3) and HC31 (VSF) became persistently acidic (pH < 6) after 110 and 125 cycles, respectively. Data collected from earlier dates is still incorporated into the 'neutral' pH loading rates for the respective lithologies, while data collected after the cells became persistently acidic is incorporated into the 'acidic' loading rate. The updated humidity cell classification used to represent different rock units and acidic waste rock is shown in Table 3-27.

The humidity cell tests shown in Table 3-27 are ongoing, and additional results have been incorporated into statistics on loading rates used to calculate source terms. This source term update incorporates data available up until August 22, 2017. The 75th percentile loading rates were used to derive Base Case loads, while the 90th percentile values were used to derive the Upper Case loads (Table 3-28). The 75th percentile was used as opposed to the median loading rates to be consistent with wall rock conversion factor calibration, which used 75th percentile values, as described below. The final humidity cell loading rates calculated as the median of the last 5 cycles were used to calculate the Post-closure loading rate. This loading rate is applied in both Base Case and Upper Case scenarios (Table 3-28).

Table 3-26: Cumulative Wall Rock Exposures Over Mine Life

Mine Year	P1	VSF	S3	ANDX	P2	SILCAP
	m^2	m^2	m^2	m^2	m^2	m^2
Historic	2,291	75,188	0	31,790	216	0
Y-02	8,411	102,525	19,132	53,578	216	0
Y-01	9,174	144,797	64,403	130,349	216	4,715
Y01	13,081	211,921	99,688	201,359	216	13,484
Y02	14,515	258,290	130,418	262,576	216	19,161
Y03	29,253	340,290	142,026	291,874	216	24,798
Y04	53,288	431,211	148,032	330,822	216	26,995
Y05	68,806	530,694	152,944	340,579	216	27,200
Y06	94,585	616,712	152,944	350,712	216	27,381
Y07	127,943	686,535	158,032	367,430	216	27,381
Y08	150,524	740,038	159,310	404,326	216	27,576
Y09	200,722	767,331	161,393	416,679	216	27,576
Y10	227,440	828,869	163,855	416,918	216	27,710
Y11	263,174	867,606	166,883	429,828	216	28,843
Y12	271,676	910,144	168,715	464,103	3,805	29,580
Y13	280,866	934,396	171,281	507,784	9,027	29,632
Y14	296,757	968,730	191,000	529,965	9,027	30,883
Post-Closure *	49,495	32,249	10,456	70,929	0	2,678

Notes: * Surface area above final water table.

Table 3-27: Humidity Cells Used to Represent Various Rock Units under Neutral and Acidic Conditions

Rock Unit	Weathering State	Humidity Cells
P2	Neutral	HC23, HC34
VSF	Neutral	HC3, HC7, HC10, HC11, HC12, HC13, HC14, HC15, HC17, HC18, HC20, HC29, HC33
P1	Neutral	HC28, HC35, HC27
S3	Neutral	HC19, HC21*
VSF	Neutral	HC5, HC8, HC9, HC16, HC24, HC31**, HC32
Silicified Cap	Neutral	HC36
All Rock Units	Acidic	HC2, HC4, HC26, HC22, HC25 HC21*, HC31**

Notes: *HC31-Neutral until cycle 125, acidic starting cycle 126 onward.
**HC21-Neutral until cycle 110, acidic starting cycle 111 onward.

Table 3-28:
Humidity Cell Loading Rates (mg/kg/wk) Grouped by Lithology and Weathering State

model_unit		Acidic Rock				P1				CGLM				ANDX				P2				Silicified Cap				VSF			
statistic		**Final**	**Median**	**P75**	**90th**	**Final**	**Median**	**P75**	**90th**	**Final**	**Median**	**P75**	**90th**	**Final**	**Median**	**P75**	**90th**	**Final**	**Median**	**P75**	**90th**	**Final**	**Median**	**P75**	**90th**	**Final**	**Median**	**P75**	**90th**
Sulphate	mg/kg/wk	50.9	44	50.4	57.3	1.67	2.25	3.28	5.29	22.8	18.8	24	48.8	11.1	10	12.2	15.3	32.3	29.9	32.9	35.3	6.75	5.64	7.12	8.53	9.62	10.2	12.1	17.3
Ag	mg/kg/wk	0.0000345	0.0000126	0.0000247	0.0000345	0.00000918	0.00000271	0.00000457	0.0000049	0.0000044	0.00000448	0.00000468	0.00000693	0.00000981	0.00000494	6.67E-06	1.01E-05	2.27E-05	2.86E-06	0.0000045	7.98E-06	2.23E-05	4.60E-06	0.00000771	1.88E-05	7.70E-06	6.50E-06	0.00000837	1.49E-05
As	mg/kg/wk	0.00693	0.00775	0.0125	0.0162	0.000835	0.00112	0.00188	0.00259	0.000261	0.000406	0.0008	0.00124	0.00116	0.00161	0.0025	0.005	0.000114	0.00127	0.00361	0.00868	0.00049	0.00049	0.000585	0.000789	0.00457	0.00579	0.00885	0.0174
Ba	mg/kg/wk	0.00263	0.00348	0.00473	0.00682	0.00421	0.0049	0.00607	0.00721	0.0031	0.0036	0.00425	0.00633	0.00391	0.00571	0.0067	0.00795	0.00222	0.00361	0.00422	0.00476	0.00198	0.00384	0.00504	0.00615	0.00261	0.00371	0.00458	0.0058
Ca	mg/kg/wk	6.54	8.03	10.4	15.4	2.43	2.67	2.95	3.42	9.12	8.65	10.2	20.1	5.27	5.11	5.83	6.44	15.4	12.4	14.2	15.4	3.26	3.07	3.45	3.86	4.47	5.04	5.63	7.01
Cd	mg/kg/wk	0.0109	0.00916	0.0113	0.0155	0.00000213	0.00000337	0.0000135	0.0000233	0.000552	0.000254	0.000463	0.000598	0.0000286	0.0000164	2.74E-05	4.52E-05	0.000312	0.000145	0.000194	0.000267	0.000647	0.000501	0.000661	0.000781	6.21E-05	3.66E-05	0.0000499	6.39E-05
Co	mg/kg/wk	0.0109	0.00673	0.00968	0.014	0.00000359	0.0000168	0.0000424	0.0000625	0.00556	0.00306	0.00494	0.00608	0.000185	0.000107	0.000165	0.000225	0.000387	0.000141	0.000236	0.000322	8.68E-05	6.79E-05	0.0000834	0.000103	0.000748	0.000795	0.00132	0.00189
Cr	mg/kg/wk	0.00082	0.00069	0.000887	0.00115	0.0000219	0.0000141	0.000224	0.000235	0.000118	0.000222	0.00023	0.000239	0.000136	0.00014	0.000235	0.000242	3.17E-05	1.43E-05	0.000222	0.000226	0.000022	1.47E-05	0.000223	0.00023	0.000179	0.000181	0.000236	0.000244
Cu	mg/kg/wk	0.114	0.0578	0.0868	0.121	0.00011	0.000223	0.000284	0.00045	0.0334	0.00435	0.0152	0.0353	0.000245	0.000255	0.000299	0.000424	0.000167	0.000202	0.000252	0.0004	0.0004	0.000228	0.000275	0.000365	0.000388	0.000255	0.000335	0.000504
Fe	mg/kg/wk	6.12	4.18	5.34	6.09	0.00269	0.00328	0.00453	0.00677	0.00242	0.00156	0.00224	0.0026	0.0107	0.00228	0.00392	0.00795	0.0108	0.00312	0.00431	0.00823	0.00572	0.00315	0.00329	0.0035	0.00761	0.00213	0.00294	0.00762
Hg	mg/kg/wk	0.00000522	0.00000459	0.00000528	0.00000726	0.00000458	0.00000452	0.00000465	0.0000048	0.0000044	0.00000455	0.00000483	0.0000088	0.0000045	0.00000464	4.84E-06	7.02E-06	4.52E-06	4.50E-06	0.00000463	4.74E-06	4.45E-06	4.60E-06	0.00000475	4.90E-06	4.50E-06	4.61E-06	0.0000048	6.90E-06
K	mg/kg/wk	0.231	0.306	0.618	1.75	0.181	0.331	0.625	1.21	0.282	0.453	0.892	2.82	0.184	0.323	0.655	1.22	0.0798	0.186	0.305	0.613	0.055	0.0785	0.117	0.217	0.255	0.453	0.987	1.76
Mg	mg/kg/wk	0.532	0.874	1.15	1.53	0.414	0.417	0.457	0.5	0.0447	0.0815	0.142	0.425	0.262	0.251	0.307	0.36	0.0836	0.16	0.226	0.33	0.309	0.271	0.328	0.377	0.289	0.324	0.39	0.506
Mn	mg/kg/wk	0.374	0.442	0.605	0.831	0.00323	0.00957	0.0126	0.0155	0.168	0.16	0.19	0.234	0.0412	0.0514	0.0643	0.074	0.14	0.118	0.147	0.161	0.0212	0.0299	0.0347	0.0462	0.054	0.0591	0.0856	0.101
Mo	mg/kg/wk	0.000104	0.000111	0.000177	0.000262	0.000259	0.000327	0.000389	0.000459	0.00062	0.000882	0.0011	0.00127	0.000374	0.000783	0.00104	0.00133	4.34E-05	0.000148	0.000272	0.000451	5.28E-05	0.0002	0.000266	0.000417	0.00134	0.00214	0.00277	0.00401
Na	mg/kg/wk	0.0478	0.0587	0.091	0.482	0.034	0.0559	0.0862	0.422	0.0351	0.0503	0.0828	0.388	0.028	0.0668	0.242	1.78	0.0229	0.0463	0.0772	0.277	0.0176	0.0229	0.0312	0.0492	0.033	0.0644	0.237	3.87
Ni	mg/kg/wk	0.00421	0.00318	0.00468	0.00737	0.0000458	0.0000455	0.000047	0.0000631	0.00101	0.000502	0.000834	0.0012	0.0000938	0.0000755	0.000141	0.000211	0.000067	4.65E-05	0.000109	0.000158	0.000134	0.000092	0.0001	0.000144	0.00288	0.00166	0.00251	0.00342
Pb	mg/kg/wk	0.0141	0.00355	0.00913	0.0165	0.000017	0.0000333	0.0000957	0.000134	0.00397	0.000706	0.00132	0.00322	0.000101	0.000155	0.000249	0.000407	5.94E-05	4.32E-05	0.0000649	9.02E-05	0.000044	3.15E-05	0.0000446	6.76E-05	3.45E-05	3.57E-05	0.0000736	0.000116
Sb	mg/kg/wk	0.000123	0.000168	0.000223	0.00034	0.000226	0.000425	0.000621	0.000929	0.000847	0.00147	0.00224	0.00378	0.00093	0.00167	0.00235	0.00326	0.000181	0.00072	0.00151	0.00327	0.000572	0.00145	0.00201	0.00298	0.00102	0.002	0.00294	0.00552
Se	mg/kg/wk	0.000869	0.0011	0.00158	0.00247	0.0000697	0.000105	0.000143	0.000184	0.000946	0.00107	0.00127	0.00173	0.000444	0.000525	0.000734	0.00134	0.00151	0.00282	0.00399	0.00498	0.000612	0.000933	0.00117	0.00176	0.000643	0.000584	0.000798	0.00123
Si	mg/kg/wk	0.525	0.456	0.597	0.753	0.123	0.168	0.232	0.295	0.184	0.214	0.279	0.382	0.155	0.229	0.304	0.442	0.125	0.154	0.188	0.248	0.0819	0.142	0.182	0.22	0.144	0.22	0.304	0.431
Sr	mg/kg/wk	0.056	0.087	0.135	0.226	0.0201	0.0319	0.044	0.0612	0.0822	0.0972	0.113	0.201	0.0495	0.074	0.0998	0.135	0.0633	0.161	0.188	0.218	0.0172	0.0202	0.0236	0.0364	0.0602	0.0948	0.131	0.172
Tl	mg/kg/wk	0.0000287	0.00003	0.0000564	0.000125	0.00000397	0.00000395	0.0000091	0.0000124	0.0000272	0.0000421	0.0000754	0.00019	0.00000803	0.0000136	0.000023	0.000038	2.68E-06	5.12E-06	0.00000933	1.84E-05	2.23E-06	2.46E-06	0.0000089	9.41E-06	1.07E-05	0.000015	0.0000257	4.68E-05
U	mg/kg/wk	0.00158	0.00177	0.004	0.0063	0.0000842	0.00015	0.000243	0.00036	0.00118	0.000799	0.00114	0.00164	0.0000689	0.000135	0.00025	0.000463	5.04E-05	6.36E-05	0.000121	0.000215	0.000071	9.76E-05	0.000138	0.000177	9.83E-05	0.000179	0.000274	0.000513
Zn	mg/kg/wk	0.513	0.419	0.532	0.652	0.000615	0.000457	0.000608	15	0.0581	0.0245	0.0501	0.0704	0.00179	0.000875	0.00156	0.00231	0.00286	0.00131	0.00199	0.00285	0.0146	0.00855	0.0133	0.0163	0.00238	0.00138	0.00196	0.00245

The calibration of wall rock conversion factors has been updated with recent mine dewatering and water quality data. The wall rock conversion factor is a calibrated scaling factor, which relates wall rock normalized loading rates from the mine underground to humidity cell loading rates. The time period used in the original MA-EMA Permits Application was January 2013 to December 2013. This time period was selected to account for seasonal variations in flow and loading rates over a full calendar year, and because active mining was taking place during this time period. The calibration time period used in the updated model is based on data collected from January 2015 to December 2016. This time period incorporates active mining and seasonal variations over a two-year time period, and has the advantage of increased water quality monitoring frequency. Data after December 2016 are not incorporated, as significant re-circulation of surface water to the underground mine began in 2017 (10 to 11759 m^3/month from January 2017 to August 2017). Figures comparing measured and modelled concentrations for sulfate, D-As and D-Sb are shown in Figure 3-1, Figure 3-2 and Figure 3-3, respectively.

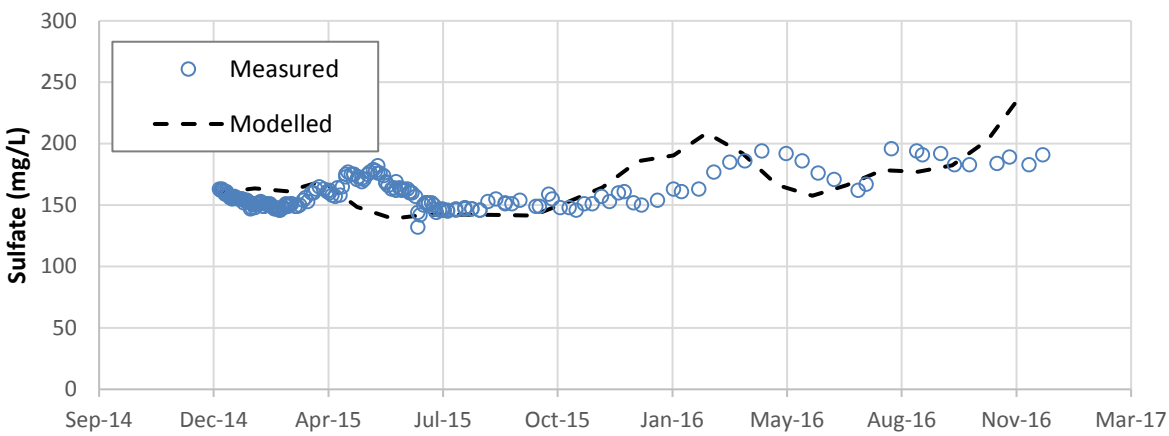


Figure 3-1: Time series plot showing modelled and measured sulfate concentrations over the calibration time period (January 2015 to December 2016).

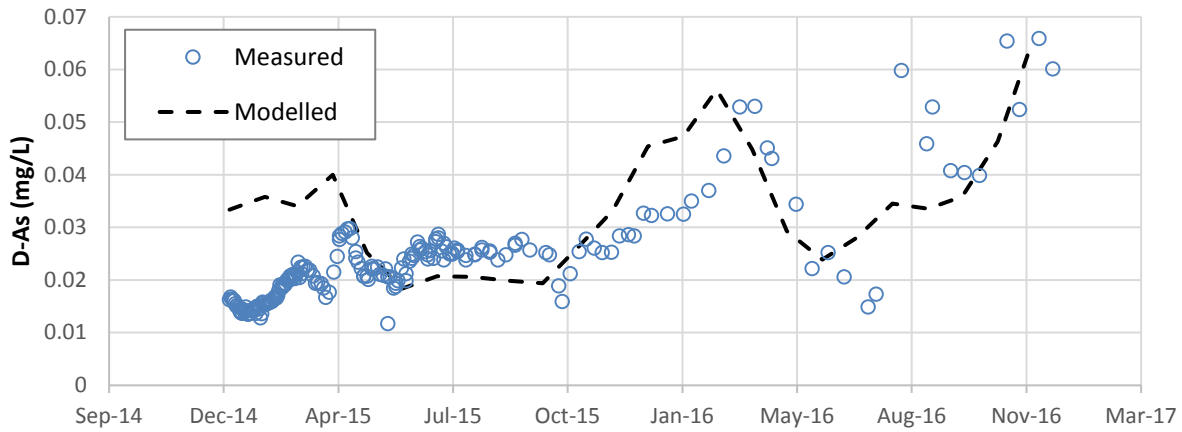


Figure 3-2: Time series plot showing modelled and measured D-As concentrations over the calibration time period (January 2015 to December 2016).

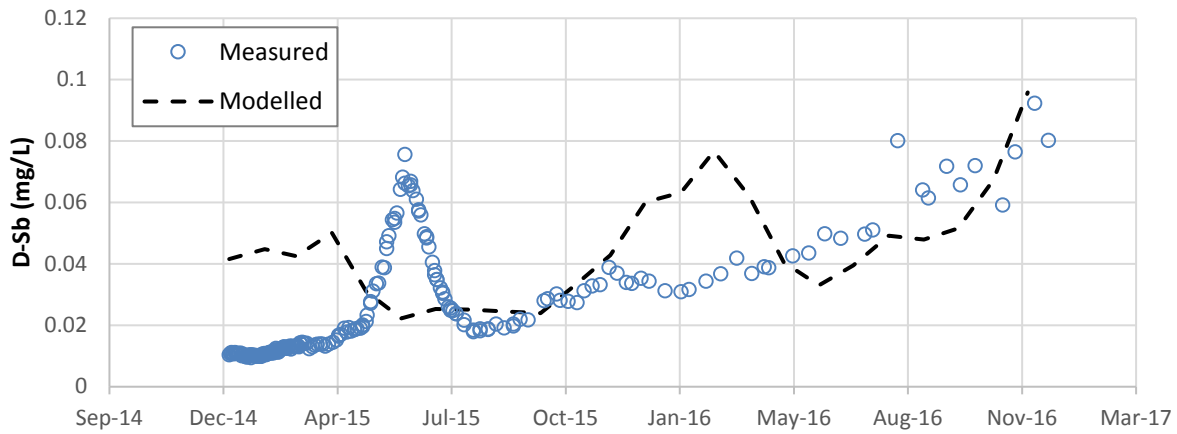


Figure 3-3: Time series plot showing modelled and measured D-Sb concentrations over the calibration time period (January 2015 to December 2016).

In the original MA-EMA Permits Application, the first 5 cycles of humidity cells were used to calculate wall rock conversion factors. Since this time, the geochemistry of underground mine water has evolved, and the 75th percentile loading rates are considered to better represent loading rates.

The updated wall rock conversion factors calculated over the calibration time period are provided in Table 3-29. The revised wall rock source terms are presented in Table 3-30 and Table 3-31.

Table 3-29:
Wall Rock Conversion Factors Used to Relate Humidity Cell Loading Rates (mg/kg/wk) to Wall Rock Loading Rates (mg/m2/wk)

Parameter	Units	Base Case	Upper Case
Sulfate	kg/m^2	150	202
Ag	kg/m^2	111	111
As	kg/m^2	227	242
Ba	kg/m^2	166	217
Ca	kg/m^2	150	202
Cd	kg/m^2	11.1	11.1
Co	kg/m^2	7.32	7.32
Cr	kg/m^2	272	272
Cu	kg/m^2	11.0	11.0
Fe	kg/m^2	367	367
Hg	kg/m^2	14.8	14.8
K	kg/m^2	150	202
Mg	kg/m^2	150	202
Mn	kg/m^2	38.1	38.1
Mo	kg/m^2	184	190
Na	kg/m^2	150	202
Ni	kg/m^2	23.7	23.7
Pb	kg/m^2	60.5	65.3
Sb	kg/m^2	629	634
Se	kg/m^2	26.1	26.1
Si	kg/m^2	150	202
Sr	kg/m^2	150	202
Tl	kg/m^2	207	251
U	kg/m^2	190	190
Zn	kg/m^2	15.4	15.4

Table 3-30:
Base Case Wall Rock Source Terms

Parameter	Units	Acidic Rock		P1		S3		ANDX		P2		Silicified Cap		VSF	
		Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure
Sulfate	mg/m²/wk	6,420	7,430	329	244	2,740	3,330	1,460	1,620	4,370	4,720	823	986	1,490	1,400
Ag	mg/m²/wk	0.0018	0.0049	0.00039	0.0013	0.00064	0.00063	0.00071	0.0014	0.00041	0.0033	0.00066	0.0032	0.00093	0.0011
As	mg/m²/wk	2.7	2.4	0.39	0.29	0.14	0.091	0.56	0.41	0.44	0.040	0.17	0.17	2.0	1.6
Ba	mg/m²/wk	0.71	0.54	1.0	0.86	0.74	0.64	1.2	0.80	0.74	0.46	0.79	0.41	0.76	0.54
Ca	mg/m²/wk	1,170	955	390	355	1,260	1,330	746	769	1,810	2,250	448	476	736	653
Cd	mg/m²/wk	0.053	0.063	0.000020	0.000012	0.0015	0.0032	0.000095	0.00017	0.00084	0.0018	0.0029	0.0038	0.00021	0.00036
Co	mg/m²/wk	0.032	0.051	0.000079	0.000017	0.014	0.026	0.00050	0.00087	0.00066	0.0018	0.00032	0.00041	0.0037	0.0035
Cr	mg/m²/wk	0.22	0.26	0.0045	0.0070	0.071	0.038	0.045	0.044	0.0046	0.010	0.0047	0.0071	0.058	0.058
Cu	mg/m²/wk	0.26	0.51	0.0010	0.00050	0.020	0.15	0.0012	0.0011	0.00091	0.00075	0.0010	0.0018	0.0012	0.0018
Fe	mg/m²/wk	1,950	2,850	1.5	1.3	0.73	1.1	1.1	5.0	1.5	5.0	1.5	2.7	0.99	3.6
Hg	mg/m²/wk	0.000078	0.000089	0.000077	0.000078	0.000077	0.000075	0.000079	0.000077	0.000077	0.000077	0.000078	0.000076	0.000078	0.000077
K	mg/m²/wk	45	34	48	26	66	41	47	27	27	12	12	8.0	66	37
Mg	mg/m²/wk	128	78	61	60	12	6.5	37	38	23	12	40	45	47	42
Mn	mg/m²/wk	15	13	0.33	0.11	5.4	5.7	1.8	1.4	4.0	4.8	1.0	0.72	2.0	1.8
Mo	mg/m²/wk	0.027	0.026	0.080	0.064	0.22	0.15	0.19	0.092	0.036	0.011	0.049	0.013	0.52	0.33
Na	mg/m²/wk	8.6	7.0	8.2	5.0	7.3	5.1	9.8	4.1	6.8	3.3	3.3	2.6	9.4	4.8
Ni	mg/m²/wk	0.10	0.14	0.0015	0.0015	0.016	0.032	0.0024	0.0030	0.0015	0.0021	0.0029	0.0043	0.053	0.092
Pb	mg/m²/wk	0.13	0.51	0.0012	0.00061	0.025	0.14	0.0056	0.0036	0.0016	0.0021	0.0011	0.0016	0.0013	0.0012
Sb	mg/m²/wk	0.13	0.094	0.33	0.17	1.1	0.65	1.3	0.71	0.55	0.14	1.1	0.44	1.5	0.78
Se	mg/m²/wk	0.030	0.024	0.0028	0.0019	0.029	0.026	0.014	0.012	0.076	0.041	0.025	0.017	0.016	0.017
Si	mg/m²/wk	67	77	25	18	31	27	33	23	23	18	21	12	32	21
Sr	mg/m²/wk	13	8.2	4.7	2.9	14	12	11	7.2	24	9.2	3.0	2.5	14	8.8
Tl	mg/m²/wk	0.0062	0.0059	0.00082	0.00082	0.0087	0.0056	0.0028	0.0017	0.0011	0.00056	0.00051	0.00046	0.0031	0.0022
U	mg/m²/wk	0.25	0.23	0.022	0.012	0.11	0.17	0.019	0.0099	0.0091	0.0072	0.014	0.010	0.026	0.014
Zn	mg/m²/wk	2.9	3.5	0.0031	0.0042	0.17	0.40	0.0060	0.012	0.0089	0.019	0.058	0.099	0.0094	0.016

Table 3-31:
Upper Case Wall Rock Source Terms

Parameter	Units	Acidic Rock		P1		S3		ANDX		P2		Silicified Cap		VSF	
		Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure
Sulfate	mg/m²/wk	10,500	9,370	973	307	8,980	4,200	2,820	2,040	6,500	5,940	1,570	1,240	3,180	1,770
Ag	mg/m²/wk	0.0049	0.0049	0.00070	0.0013	0.00099	0.00063	0.0014	0.0014	0.0011	0.0033	0.0027	0.0032	0.0021	0.0011
As	mg/m²/wk	6.0	2.6	0.96	0.31	0.46	0.097	1.9	0.43	3.2	0.042	0.29	0.18	6.5	1.7
Ba	mg/m²/wk	1.8	0.71	1.9	1.1	1.7	0.83	2.1	1.1	1.3	0.60	1.7	0.53	1.6	0.70
Ca	mg/m²/wk	2,830	1,200	629	447	3,700	1,680	1,180	970	2,830	2,830	710	600	1,290	822
Cd	mg/m²/wk	2.9	2.0	0.0043	0.00039	0.11	0.10	0.0083	0.0053	0.049	0.057	0.14	0.12	0.012	0.011
Co	mg/m²/wk	2.6	2.0	0.012	0.00066	1.1	1.0	0.041	0.034	0.059	0.071	0.019	0.016	0.35	0.14
Cr	mg/m²/wk	0.37	0.26	0.075	0.0070	0.077	0.038	0.078	0.044	0.073	0.010	0.074	0.0071	0.078	0.058
Cu	mg/m²/wk	22	21	0.083	0.020	6.5	6.2	0.078	0.045	0.074	0.031	0.067	0.074	0.093	0.071
Fe	mg/m²/wk	2840	2850	3.2	1.3	1.2	1.1	3.7	5.0	3.8	5.0	1.6	2.7	3.6	3.6
Hg	mg/m²/wk	0.00012	0.000089	0.000082	0.000078	0.00015	0.000075	0.00012	0.000077	0.000081	0.000077	0.000083	0.000076	0.00012	0.000077
K	mg/m²/wk	322	43	223	33	519	52	224	34	113	15	40	10	324	47
Mg	mg/m²/wk	282	98	92	76	78	8.2	66	48	61	15	69	57	93	53
Mn	mg/m²/wk	28	13	0.53	0.11	8.0	5.7	2.5	1.4	5.5	4.8	1.6	0.72	3.4	1.8
Mo	mg/m²/wk	0.066	0.026	0.12	0.066	0.32	0.16	0.34	0.095	0.11	0.011	0.11	0.013	1.0	0.34
Na	mg/m²/wk	89	8.8	78	6.3	71	6.5	328	5.2	51	4.2	9.1	3.2	712	6.1
Ni	mg/m²/wk	0.24	0.14	0.0020	0.0015	0.038	0.032	0.0068	0.0030	0.0051	0.0021	0.0046	0.0043	0.11	0.092
Pb	mg/m²/wk	3.0	2.6	0.025	0.0031	0.59	0.73	0.075	0.019	0.017	0.011	0.012	0.0081	0.021	0.0064
Sb	mg/m²/wk	0.26	0.095	0.72	0.17	2.9	0.65	2.5	0.72	2.5	0.14	2.3	0.44	4.3	0.79
Se	mg/m²/wk	0.067	0.024	0.0050	0.0019	0.047	0.026	0.036	0.012	0.13	0.041	0.048	0.017	0.033	0.017
Si	mg/m²/wk	139	97	54	23	70	34	81	29	46	23	41	15	79	27
Sr	mg/m²/wk	42	10	11	3.7	37	15	25	9.1	40	12	6.7	3.2	32	11
Tl	mg/m²/wk	0.026	0.0061	0.0026	0.00084	0.040	0.0057	0.0080	0.0017	0.0039	0.00057	0.0020	0.00047	0.0099	0.0023
U	mg/m²/wk	0.90	0.23	0.052	0.012	0.24	0.17	0.066	0.0099	0.031	0.0072	0.025	0.010	0.073	0.014
Zn	mg/m²/wk	120	94	0.19	0.11	13	11	0.43	0.33	0.52	0.53	3.0	2.7	0.45	0.44

3.4.3.3 Waste Rock Backfill

Waste rock backfill will be placed in the mine underground in Scenario 2. Scenario 1 assumes that all waste rock will be placed in Brucejack Lake. The Scenario 2 waste rock backfill schedule is presented in Table 3-15.

Waste rock fill source terms are based on lithology-specific humidity cell data scaled to reflect field conditions following the approach outlined in the MA-EMA Permits Application (Pretivm, 2015). The updates to the paste backfill source term since the 2016 Annual Report include:

- Re-classification of humidity cell weathering state (neutral/acidic); and
- Additional humidity cell test results.

The same humidity cell groupings that were used in calculating the wall rock source term were applied to the waste rock backfill source term (Table 3-27). Median and 90th percentile loading rates were used to estimate the Base Case and Upper Case rock fill source terms, respectively (Table 3-28). The scaled waste rock backfill loading rates used to calculate the updated underground mine water source term are provided in Table 3-32.

Upon mine closure, backfilled waste rock will be submerged below the final water table to mitigate the long-term potential for ARD development, as per *Mines Act* Permit M-243. As such, no unsaturated waste rock backfill term has been developed for Post-closure.

Table 3-32:
Source Terms for Waste Rock Backfill

Parameter	Units	Acidic Rock		P1		S3		ANDX		P2		Silicified Cap		VSF	
		Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/t/wk	1,320	3,440	68	317	564	2,930	300	918	897	2,120	169	512	306	1,040
Ag	mg/t/wk	0.0010	0.00038	0.00028	0.000081	0.00013	0.00013	0.00029	0.00015	0.000086	0.00048	0.00014	0.0011	0.00020	0.00089
As	mg/t/wk	0.21	0.23	0.025	0.034	0.0078	0.012	0.035	0.048	0.038	0.52	0.015	0.047	0.17	1.0
Ba	mg/t/wk	0.079	0.10	0.13	0.15	0.093	0.11	0.12	0.17	0.11	0.29	0.12	0.37	0.11	0.35
Ca	mg/t/wk	196	241	73	80	274	260	158	153	372	924	92	232	151	421
Cd	mg/t/wk	0.33	0.28	0.000064	0.00010	0.017	0.0076	0.00086	0.00049	0.0044	0.016	0.015	0.047	0.0011	0.0038
Co	mg/t/wk	0.33	0.20	0.00011	0.00050	0.17	0.092	0.0056	0.0032	0.0042	0.019	0.0020	0.0062	0.024	0.11
Cr	mg/t/wk	0.025	0.021	0.00066	0.00042	0.0035	0.0067	0.0041	0.0042	0.00043	0.014	0.00044	0.014	0.0054	0.015
Cu	mg/t/wk	3.4	1.7	0.0033	0.0067	1.0	0.13	0.0074	0.0077	0.0061	0.024	0.0068	0.022	0.0077	0.030
Fe	mg/t/wk	184	125	0.081	0.098	0.073	0.047	0.32	0.068	0.094	0.49	0.095	0.21	0.064	0.46
Hg	mg/t/wk	0.00016	0.00014	0.00014	0.00014	0.00013	0.00014	0.00014	0.00014	0.00014	0.00028	0.00014	0.00029	0.00014	0.00041
K	mg/t/wk	6.9	9.2	5.4	9.9	8.5	14	5.5	9.7	5.6	37	2.4	13	14	106
Mg	mg/t/wk	16	26	12	13	1.3	2.5	7.9	7.5	4.8	20	8.1	23	9.7	30
Mn	mg/t/wk	11	13	0.097	0.29	5.0	4.8	1.2	1.5	3.5	9.7	0.90	2.8	1.8	6.1
Mo	mg/t/wk	0.0031	0.0033	0.0078	0.0098	0.019	0.027	0.011	0.024	0.0044	0.027	0.0060	0.025	0.064	0.24
Na	mg/t/wk	1.4	1.8	1.0	1.7	1.1	1.5	0.84	2.0	1.4	17	0.69	3.0	1.9	232
Ni	mg/t/wk	0.13	0.095	0.0014	0.0014	0.030	0.015	0.0028	0.0023	0.0014	0.0095	0.0028	0.0086	0.050	0.21
Pb	mg/t/wk	0.42	0.11	0.00051	0.00100	0.12	0.021	0.0030	0.0047	0.0013	0.0054	0.00095	0.0041	0.0011	0.0070
Sb	mg/t/wk	0.0037	0.0050	0.0068	0.013	0.025	0.044	0.028	0.050	0.022	0.20	0.044	0.18	0.060	0.33
Se	mg/t/wk	0.026	0.033	0.0021	0.0032	0.028	0.032	0.013	0.016	0.085	0.30	0.028	0.11	0.018	0.074
Si	mg/t/wk	16	14	3.7	5.0	5.5	6.4	4.7	6.9	4.6	15	4.3	13	6.6	26
Sr	mg/t/wk	1.7	2.6	0.60	0.96	2.5	2.9	1.5	2.2	4.8	13	0.61	2.2	2.8	10
Tl	mg/t/wk	0.00086	0.00090	0.00012	0.00012	0.00082	0.0013	0.00024	0.00041	0.00015	0.0011	0.000074	0.00057	0.00045	0.0028
U	mg/t/wk	0.047	0.053	0.0025	0.0045	0.035	0.024	0.0021	0.0041	0.0019	0.013	0.0029	0.011	0.0054	0.031
Zn	mg/t/wk	15	13	0.019	0.014	1.7	0.74	0.054	0.026	0.039	0.17	0.26	0.98	0.041	0.15

3.4.3.4 Paste Backfill Operations

Paste backfill will be placed in underground voids for ground support. The schedule for placement of paste backfill to the underground mine and the tonnage that will remain above the final water table in Post-closure is provided in Table 3-33. The source term for paste backfill is derived by scaling humidity cell loading rates to field conditions, as described in MA-EMA Permits Application. The paste backfill source term has been updated with new kinetic test data since the 2016 Annual Report.

The only humidity cell used to represent paste backfill is T12; updates to the source term include additional results acquired through August 2017. The median and 90th percentile loading rates from this humidity cell were used to calculate Base Case and Upper Case source terms operations source terms, respectively (Table 3-34). The loading rate from the final 5 cycles of T12 were used to estimate both Base Case and Upper Case Post-closure paste tailings source terms. These loading rates were scaled as described in MA-EMA Permits Application, resulting in the paste backfill source terms shown in Table 3-32.

Table 3-33:
Tonnage of Paste Tailings Placed in Underground Mine

Year	Scenario 1	Scenario 2
	tonnes	tonnes
Y01	231,109	231,109
Y02	684,328	810,696
Y03	972,318	1,471,326
Y04	1,555,953	2,130,151
Y05	1,964,843	2,788,976
Y06	2,387,428	3,447,801
Y07	2,819,893	4,108,431
Y08	3,163,035	4,767,256
Y09	3,525,342	5,426,081
Y10	3,910,789	6,084,906
Y11	4,325,236	6,745,536
Y12	4,705,157	7,404,361
Y13	5,092,684	8,063,186
Y14	5,533,222	8,722,011
Unsaturated Post-Closure	3,496,332	3,496,332

Table 3-34:
Loading Rate Statistics of Humidity Cell T12 Used in Paste Source Term Calculation

Parameter	Units	Median	P90	Final
Sulfate	mg/kg/wk	2.55	116	2.47
Ag	mg/kg/wk	0.0000206	0.0000302	0.0000209
As	mg/kg/wk	0.0681	0.0836	0.0645
Ba	mg/kg/wk	0.0117	0.0165	0.0107
Ca	mg/kg/wk	10.1	46.8	10.2
Cd	mg/kg/wk	0.00000131	0.00000665	0.00000126
Co	mg/kg/wk	0.0000176	0.0000667	0.0000151
Cr	mg/kg/wk	0.000172	0.00153	0.000177
Cu	mg/kg/wk	0.000185	0.000731	0.00013
Fe	mg/kg/wk	0.00298	0.00335	0.00293
Hg	mg/kg/wk	0.00000419	0.00000462	0.00000419
K	mg/kg/wk	0.909	5.10	0.526
Mg	mg/kg/wk	0.341	0.700	0.246
Mn	mg/kg/wk	0.000443	0.000792	0.000355
Mo	mg/kg/wk	0.00105	0.0164	0.000833
Na	mg/kg/wk	0.0784	1.59	0.0454
Ni	mg/kg/wk	0.0000425	0.000244	0.0000419
Pb	mg/kg/wk	0.00000475	0.0000209	0.00000838
Sb	mg/kg/wk	0.00727	0.0200	0.00448
Se	mg/kg/wk	0.00112	0.00672	0.000812
Si	mg/kg/wk	4.82	5.97	4.23
Sr	mg/kg/wk	0.0452	0.134	0.0444
Tl	mg/kg/wk	0.0000033	0.0000136	0.00000209
U	mg/kg/wk	0.000513	0.000606	0.000473
Zn	mg/kg/wk	0.000838	0.000925	0.000838

Table 3-35: Source Terms for Paste Tailings

Parameter	Units	Operations		Post Closure	
		Base Case	Upper Case	Base Case	Upper Case
Sulfate	mg/kg/wk	0.0191	3.48	0.0185	0.0741
Ag	mg/kg/wk	0.000000155	0.000000906	0.000000157	0.000000627
As	mg/kg/wk	0.000511	0.00251	0.000484	0.00194
Ba	mg/kg/wk	0.0000878	0.000495	0.0000803	0.000321
Ca	mg/kg/wk	0.0758	1.40	0.0765	0.306
Cd	mg/kg/wk	9.83E-09	0.0000002	9.45E-09	3.78E-08
Co	mg/kg/wk	0.000000132	0.000002	0.000000113	0.000000453
Cr	mg/kg/wk	0.00000129	0.0000459	0.000000945	0.00000378
Cu	mg/kg/wk	0.00000139	0.0000219	0.000000975	0.0000039
Fe	mg/kg/wk	0.0000224	0.000101	0.000022	0.0000879
Hg	mg/kg/wk	3.14E-08	0.000000139	3.14E-08	0.000000126
K	mg/kg/wk	0.00682	0.153	0.00395	0.0158
Mg	mg/kg/wk	0.00256	0.021	0.00185	0.00738
Mn	mg/kg/wk	0.00000332	0.0000238	0.00000266	0.0000107
Mo	mg/kg/wk	0.00000788	0.000492	0.00000625	0.000025
Na	mg/kg/wk	0.000588	0.0477	0.000341	0.00136
Ni	mg/kg/wk	0.000000319	0.00000732	0.000000314	0.00000126
Pb	mg/kg/wk	3.56E-08	0.000000627	6.29E-08	0.000000251
Sb	mg/kg/wk	0.0000545	0.0006	0.0000336	0.000134
Se	mg/kg/wk	0.0000084	0.000202	0.00000609	0.0000244
Si	mg/kg/wk	0.0362	0.179	0.0317	0.127
Sr	mg/kg/wk	0.000339	0.00402	0.000333	0.00133
Tl	mg/kg/wk	2.48E-08	0.000000408	1.57E-08	6.27E-08
U	mg/kg/wk	0.00000385	0.0000182	0.00000355	0.0000142
Zn	mg/kg/wk	0.00000629	0.0000278	0.00000629	0.0000251

3.4.3.5 Paste Backfill Closure

Upon mine closure the water table will rebound and saturate much of the underground mine workings. This rebound in the water table will submerge the paste tailings, wall rock exposures and rock fill. Saturated conditions will inhibit acid generation and metal leaching associated with sulfide mineral oxidation; however, some metal leaching may continue from dissolution of oxide minerals. The paste backfill source term has been updated with new kinetic test data since the 2016 Annual Report (Pretivm, 2017).

The flooded mine workings source term was developed using the approach described in the MA-EMA Permits Application (Pretivm, 2015). This approach estimates the concentration of waste rock backfill porewater, tailings porewater, and wall rock contact groundwater to calculate the flooded mine workings source term. It is assumed that groundwater infiltrating through saturated mine workings will interact with all three saturated mine components, and as a conservative assumption, the saturated mine workings source term is the highest concentration associated with any one mine component.

Data used to represent the mine components include: saturated columns 1 and 2 for backfilled waste rock; saturated columns 2 and 3 for paste backfill; and, mine portal water quality from time periods when mine workings were flooded and passively discharging (to estimate background water quality). Revised saturated column results were used to re-calculate the flooded mine source terms for the rockfill and paste backfill components by incorporating saturated column results up until August 2017. The background groundwater component has not been updated. The updated 90th percentile values and final saturated column concentrations used in the Base Case and Upper Case Post-closure scenario are provided in Table 3-36. The resulting flooded mine source term is presented in Table 3-37.

Table 3-36:
Concentrations Applied to Different Components of Underground Mine Workings to Predict Saturated Mine Workings Source Terms

Parameter	Units	Paste Tailings (Col 3 and Col 5)		Rock Fill (Col 1 and Col 2)		Wall Rock/ Groundwater (Adit Drainage)	
		90th Percentile	Final	90th Percentile	Final	Max	Median
pH	s.u.	8.0	8.0	8.0	8.0	8.1	8.0
Alkalinity	$mgCaCO_3/L$	102	88	112	79	90	86
Sulfate	mg/L	146	20	81	73	118	116
Ag	mg/L	0.000021	0.0000035	0.000050	0.000050	0.000020	0.000010
Al	mg/L	0.034	0.0045	0.041	0.0035	0.092	0.026
As	mg/L	0.12	0.057	0.16	0.019	0.0077	0.0021
Ba	mg/L	0.063	0.056	0.067	0.039	0.033	0.019
Ca	mg/L	51	29	57	51	61	54
Cd	mg/L	0.000023	0.000014	0.000023	0.0000060	0.00037	0.00011
Co	mg/L	0.00015	0.000012	0.00016	0.000027	0.00070	0.00035
Cr	mg/L	0.00055	0.000040	0.00050	0.00024	0.0010	0.00031
Cu	mg/L	0.0017	0.00062	0.0012	0.00026	0.0034	0.00050
Fe	mg/L	0.027	0.015	0.069	0.019	0.84	0.030
Hg	mg/L	0.015	0.010	0.010	0.010	0.000010	0.000010
K	mg/L	29	4.9	14	2.8	2.0	1.8
Mg	mg/L	9.8	5.6	6.8	5.6	5.3	4.9
Mn	mg/L	0.13	0.068	0.43	0.26	0.20	0.15
Mo	mg/L	0.058	0.041	0.0080	0.0068	0.0017	0.0016
Na	mg/L	12	0.95	17	0.61	19	15
Ni	mg/L	0.00083	0.00020	0.0014	0.00015	0.0010	0.00060
Pb	mg/L	0.00012	0.000040	0.00018	0.000045	0.0060	0.000083
Sb	mg/L	0.0025	0.00055	0.0028	0.0010	0.0016	0.0013
Se	mg/L	0.00099	0.00025	0.00054	0.000070	0.0010	0.00024
Si	mg/L	103	5.7	22	3.7	3.1	3.0
Sr	mg/L	1.2	0.71	1.3	0.84	1.1	1.1
Tl	mg/L	0.000076	0.000013	0.000020	0.0000065	0.00020	0.000065
U	mg/L	0.0018	0.00090	0.0078	0.00089	0.00022	0.00021
Zn	mg/L	0.0063	0.0020	0.0050	0.0020	0.046	0.019

Table 3-37:
Source Term for Flooded Underground Mine Workings

Parameter	Units	Base Case	Upper Case
pH	s.u.	8.0	8.1
Alkalinity	$mgCaCO_3/L$	88	112
Sulfate	mg/L	116	146
Ag	mg/L	0.000050	0.000050
Al	mg/L	0.026	0.092
As	mg/L	0.057	0.16
Ba	mg/L	0.056	0.067
Ca	mg/L	54	61
Cd	mg/L	0.00011	0.00037
Co	mg/L	0.00035	0.00070
Cr	mg/L	0.00031	0.0010
Cu	mg/L	0.00062	0.0034
Fe	mg/L	0.030	0.84
Hg	mg/L	0.010	0.015
K	mg/L	4.9	29
Mg	mg/L	5.6	9.8
Mn	mg/L	0.26	0.43
Mo	mg/L	0.041	0.058
Na	mg/L	15	19
Ni	mg/L	0.00060	0.0014
Pb	mg/L	0.000083	0.0060
Sb	mg/L	0.0013	0.0028
Se	mg/L	0.00025	0.0010
Si	mg/L	5.7	103
Sr	mg/L	1.1	1.3
Tl	mg/L	0.000065	0.00020
U	mg/L	0.00090	0.0078
Zn	mg/L	0.019	0.046

3.4.3.6 Underground Mine Water Source Term

Potentially acid generating wall rock and backfill (Scenario 2 only) will be unsaturated in the mine workings during Operations. Upon mine closure, the water table will rebound, submerging all backfilled PAG waste rock. However, some PAG wall rock will remain above the final water table in Post-closure.

During mine operations, gradual acidification of the wall rock is incorporated into source term predictions. In Post-closure, it is assumed that all PAG exposures are acid generating.

The rate at which wall rock from the different lithologies becomes acid generating is described in Appendix E.4 of the 2015 ME-EMA Permits Application. No updates have been made to assumptions regarding acid generation in the underground mine workings.

Upscaling humidity cell loading rates often results in unrealistic concentrations, particularly when large numbers of detection limit values are incorporated into upscaling calculations. In order to ensure that the predicted concentrations are realistic, a number of final concentration adjustments were made. These concentration adjustments have been applied to elements which were generally below detection limits in field data and laboratory testwork, and for elements which field evidence indicates are pH controlled. The final adjustments described in the MA-EMA Permits Application are still considered valid except that the time period of adit drainage data used to set Zn, Cd, Cu and Ni solubility controls has been updated.

The solubility of metal cations, such as Zn, Cd, Cu and Ni, is strongly tied to pH. An inverse relationship with pH is evident in adit drainage, as described MA-EMA Permits Application. Specifically, Zn and Cd concentrations decline in adit drainage when mine workings are dewatered which is attributed to an increase in pH that occurs over this transition. In the Base Case it is assumed that the current pH observed in adit drainage will be maintained in the future. The solubility of these parameters was originally set to the maximum concentration observed from beginning of mine dewatering in 2011 to early 2014. The mine workings were not continuously dewatered during this time period, and a peak in concentrations was observed when dewatering was suspended. The solubility caps have been updated to only consider data collected since the beginning of Construction (June 2015 to September 2017). The original and updated solubility controls for these parameters are shown in Table 3-38. No final adjustment in concentrations has been applied to the Upper Case scenarios for these parameters.

Table 3-38:
Solubility Controls Applied to MA-EMA Permits Application and Updated Solubility Caps Applied to Current 2018 Application for Cd, Cu, Ni and Zn

Parameter	Units	MA-EMA Permits Application	2017 Application
		Base Case	Base Case
Cd	mg/L	0.00044	0.0001
Cu	mg/L	0.0057	0.0013
Ni	mg/L	0.0017	0.0089
Zn	mg/L	0.073	0.0197

The end of Operations and Post-closure source terms for underground mine water are provided in Table 3-39. This source term combines the loadings described in Section 3.4.3, in addition to paste bleed water which is described in Section 3.6. Note that the underground source term is calculated on an annual basis, taking into account the schedules for the various mine components and the volume of groundwater inflow.

In general, the updated Operations source term concentrations are higher than predictions from the 2015 MA-EMA Permits Application for a number of parameters (*e.g.*, As, Sb and sulfate), while Post-closure concentrations are relatively unchanged. This is in large part related to changes in predicted dewatering rates. The mean dewatering rates decreased from 108,800 m^3/month in the 2015 MA-EMA Permits Application model to 33,900 m^3/month in the current model predictions.

3.5 Operations Water Treatment Plant

3.5.1 Overview

The Operations WTP receives and treats underground mine water from mine dewatering, surface contact water and WTP effluent collected in the CWP, and recycled process water from the Mill. The WTP is designed to chemically precipitate targeted dissolved metals and remove resultant chemical precipitates and influent total suspended solids (TSS), at flow rates between 1,400 m^3/day and 10,000 m^3/day. The water treatment design, metals and solids removal process, and effluent design criteria are described in the 2015 MA-EMA Permits Application (Pretivm, 2015). Key components of the WTP treatment process include a pre-treatment Clarifier (for coarse TSS removal), Primary Metal Precipitation Stage (for sulfide metal precipitation and TSS removal), Secondary Metal Precipitation Stage (for hydroxide metal precipitation and TSS removal) and Final Metal Polishing by filtration (for small particulate TSS removal). The WTP will operate through LOM and into the Closure phase for as long as necessary.

The WTP generates a solid waste product (sludge) that requires management and disposal. The mass of the sludge produced depends on the TSS content of the influent, the chemical composition of the influent, the flow rate, and the nature of the solid particles. The estimates of the total amount of sludge to be produced during the Operations phase is predicted to be approximately 40 kt, with sludge generation estimated at 7 tpd. The total amount of sludge generated is estimated to represent approximately 1 to 2% of the total tailings generated on-site. Sludge generated from the WTP is currently being co-deposited with thickened tailings into Brucejack Lake.

Table 3-39:
Source Term Predictions for Underground Mine Water Compared to Predictions from MA-EMA Permits Application (Pretivm, 2015)

Parameter	Units	2017 Application								MA-EMA Permits Application			
		Scenario 1		Scenario 2		Scenario 1		Scenario 2		Base Case		Upper Case	
		Base Case		Base Case		Upper Case		Upper Case					
		Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure	Operations	Post-Closure
NH_3	mg-N/L	34.7	0	36.4	0	53.8	0	54.9	0	3.05	0	6.63	0
NO_3	mg-N/L	79.6	0	83.8	0	123	0	126	0	16.7	0	36.3	0
NO_2	mg-N/L	6.26	0	6.58	0	9.72	0	9.92	0	0.865	0	1.88	0
Sulfate	mg/L	789	356	885	356	4410	583	3880	583	535	424	2090	786
Ag	mg/L	0.000313	0.000122	0.000318	0.000122	0.00101	0.000197	0.00109	0.000197	0.000084	0.0000558	0.000324	0.000222
As	mg/L	0.609	0.161	0.506	0.161	2.34	0.373	1.90	0.373	0.146	0.178	0.389	0.365
Ba	mg/L	0.288	0.0688	0.305	0.0688	0.78	0.128	0.756	0.128	0.345	0.116	0.591	0.184
Ca	mg/L	317	120	344	120	1670	178	1420	178	245	93.3	650	174
Cd	mg/L	0.0001	0.0001	0.0001	0.0001	0.00637	0.00407	0.0879	0.00407	0.0004	0.0004	0.068	0.0118
Co	mg/L	0.00308	0.00245	0.0119	0.00245	0.00846	0.00288	0.1	0.00288	0.0219	0.0156	0.0608	0.016
Cr	mg/L	0.0174	0.00839	0.0185	0.00839	0.0658	0.00963	0.0615	0.00963	0.0222	0.00318	0.492	0.00527
Cu	mg/L	0.00128	0.00128	0.00128	0.00128	0.0706	0.0321	0.722	0.0321	0.0057	0.0035	0.752	0.461
Fe	mg/L	0.0295	57.5	0.0295	57.5	64	58.4	64.7	58.4	0.03	42.5	64.7	68
Hg	mg/L	0.00001	0.00001	0.00001	0.00001	0.000028	0.000026	0.000028	0.000026	0.00001	0.00001	0.000028	0.000028
K	mg/L	39	6.65	40.7	6.65	210	10.1	196	10.1	35.5	10.2	219	62.8
Mg	mg/L	21	11.2	23.8	11.2	52.7	14.5	62.7	14.5	18.8	10.7	42.1	25.1
Mn	mg/L	1.1	0.859	1.82	0.859	2.09	0.9	8.4	0.9	1.2	0.86	52.7	3.54
Mo	mg/L	0.0846	0.0057	0.095	0.0057	0.525	0.00853	0.409	0.00853	0.0869	0.0411	0.461	0.113
Na	mg/L	57.7	17.4	56.7	17.4	172	20.2	196	20.2	29.2	15.5	209	67.2
Ni	mg/L	0.00823	0.00394	0.00886	0.00394	0.0218	0.00458	0.0971	0.00458	0.0017	0.0017	0.145	0.0364
Pb	mg/L	0.010	0.0165	0.0122	0.0165	0.0475	0.0237	0.136	0.0237	0.00115	0.000218	0.0133	0.00639
Sb	mg/L	0.336	0.0228	0.335	0.0228	0.962	0.0374	0.832	0.0374	0.0966	0.00794	0.202	0.0269
Se	mg/L	0.0126	0.00231	0.0155	0.00231	0.186	0.00573	0.152	0.00573	0.00408	0.000864	0.0187	0.00269
Si	mg/L	45	10.6	35.8	10.6	180	25	134	25	15.8	14.9	72.3	189
Sr	mg/L	5.26	1.85	5.96	1.85	12.6	2.34	14.8	2.34	4.55	1.45	8.36	3.08
Tl	mg/L	0.00127	0.000411	0.00141	0.000411	0.00393	0.000689	0.00521	0.000689	0.000503	0.000166	0.00135	0.000316
U	mg/L	0.0269	0.0238	0.0285	0.0238	0.0811	0.0254	0.122	0.0254	0.0167	0.0115	0.0598	0.024
Zn	mg/L	0.0197	0.0197	0.0197	0.0197	0.417	0.291	3.87	0.291	0.073	0.073	9.61	5.67

As summarized in Section 2.2.2, a portion of WTP effluent supplies water to the Mill and a portion is discharged to Brucejack Lake via the discharge line at a depth of approximately 36 m. Source terms were developed for: 1) WTP effluent; and 2) WTP sludge co-deposited with tailings in Brucejack Lake. The approach for deriving the WTP effluent source term is described in the following section, whereas the geochemical source term applied for sludge is described in Section 3.6.5.

3.5.2 WTP Influent

The Operations WTP influent quality was derived from influent flows as prescribed by the Brucejack Gold Mine water balance and source terms developed for the contributing sources: underground mine water (Section 3.4.3), Mine Site Runoff (Section 3.3.2) and process water (Section 3.6). The modelled WTP influent parameter concentrations for both mine scenarios as compared to corresponding values in the 2015 MA-EMA Permits Application are presented in Table 3-40. The maximum predicted influent concentrations of dissolved metals treated by the WTP (Ag, Al, As, Cd, Co, Cu, Fe, Mn, P, Pb, and Zn) are generally within 3 times the 2015 MA-EMA Permits Application predicted values, and all are within an order of magnitude of the previously modelled values.

Table 3-40:
Maximum Operations Water Treatment Plant (WTP) Influent Predictions as Compared to Predictions from the MA-EMA Permits Application (Pretivm, 2015)

Parameter	Units	2017 Application				2015 MA-EMA Application	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2		
		Base Case		Upper Case		Base Case	Upper Case
NH_3-N	mg/L	35.0	36.2	57.1	58.2	3.0	6.6
NO_3-N	mg/L	80	83	131	134	17	36
NO_2-N	mg/L	6.3	6.5	10.3	10.5	0.86	1.9
Chloride	mg/L	17	19	62	56	7.5	29
Fluoride	mg/L	2.1	2.3	2.9	3.5	0.94	3.8
Sulfate	mg/L	1202	1304	4432	3981	535	2091
Ag	mg/L	0.00044	0.00044	0.00064	0.00068	0.000084	0.00032
Al	mg/L	0.19	0.19	7.90	11.1	0.094	29
As	mg/L	0.36	0.30	1.36	1.10	0.15	0.39
B	mg/L	1.5	1.5	3.2	3.0	0.73	1.6
Ba	mg/L	0.29	0.31	0.73	0.71	0.35	0.59
Be	mg/L	0.00010	0.00010	0.014	0.014	0.0010	0.017
Bi	mg/L	0.0005	0.0005	0.0109	0.0109	0.00050	0.0012
Ca	mg/L	285	311	1511	1287	245	650
Cd	mg/L	0.00010	0.00010	0.0037	0.050	0.00040	0.068
Co	mg/L	0.0028	0.011	0.0076	0.061	0.022	0.061
Cr	mg/L	0.016	0.017	0.059	0.056	0.022	0.49
Cu	mg/L	0.0012	0.0012	0.044	0.416	0.0057	0.75
Fe	mg/L	0.028	0.028	42	44	0.030	65
Hg	mg/L	0.000010	0.000010	0.000025	0.000025	0.000010	0.000028
K	mg/L	69	72	219	208	35	219
Li	mg/L	1.8	1.9	7.5	7.5	0.42	1.7
Mg	mg/L	20	23	48	58	19	42
Mn	mg/L	1.0	1.7	1.9	7.7	1.2	53
Mo	mg/L	0.15	0.16	0.54	0.43	0.087	0.46
Na	mg/L	199	203	279	304	29	209
Ni	mg/L	0.0072	0.0076	0.020	0.088	0.0017	0.14
P	mg/L	0.16	0.19	0.29	0.34	0.038	0.14
Pb	mg/L	0.0076	0.0088	0.030	0.079	0.0012	0.013
Sb	mg/L	0.33	0.33	0.89	0.78	0.097	0.20
Se	mg/L	0.02	0.02	0.17	0.14	0.0041	0.019
Si	mg/L	41	33	164	122	16	72
Sn	mg/L	0.0011	0.0013	0.0047	0.0056	0.0011	0.0031
Sr	mg/L	7.9	8.4	24	25	4.5	8.4
Ti	mg/L	0.086	0.087	0.14	0.14	0.13	0.19
Tl	mg/L	0.0013	0.0014	0.0036	0.0048	0.0005	0.0014
U	mg/L	0.03	0.03	0.075	0.11	0.017	0.060
V	mg/L	0.0013	0.0013	0.0068	0.0068	0.0010	0.0073
Zn	mg/L	0.017	0.017	0.24	2.21	0.073	9.6

Notes:
The modelled metals are dissolved values; TSS was not included in the water quality model.
The concentrations provided are maximum values predicted for the Operations Phase.
Grey shading indicates the modelled value is 3-fold or more above the corresponding value in the 2015 MA-EMA Permits Application.

3.5.3 WTP Effluent

Modelled Operations WTP effluent quality is based on predicted influent quality (Table 3-40) and assumptions regarding the efficacy of the treatment process, following the same general approach as outlined in the 2015 MA-EMA Permits Application (Pretivm, 2015). The concentration of parameters targeted for treatment are capped at Design Criteria concentrations (Table 3-41) that were developed from bench scale experiments conducted by Veolia (Appendices 7-V and 7-W of Pretivm, 2015); these values were adopted as WTP effluent discharge guidelines in the Brucejack Gold Mine Effluent Permit (PE-107835). Sulfate (SO_4) is not treated, rather it is added to the effluent from the reagents that are used for treatment; therefore, the water quality model conservatively increases the Operations WTP influent sulfate concentration by the maximum Design Criteria incremental amount (400 mg/L).

The Design Criteria effluent concentrations applied to the MA-EMA Permits Application model are considered to be valid for the increased mill production water quality model. The ability of the WTP to treat maximum predicted influent concentrations of targeted parameters (TSS, Ag, Al, As, Cd, Co, Cu, Fe, Mn, P, Pb, and Zn) to effluent design criteria is supported by bench scale testing conducted in 2015 (Table 3-41), the performance of the Construction WTP from May 2015 through June 2017, and the performance of the Operations WTP since commissioning in July 2017. The Construction WTP treatment process was similar to the secondary metal precipitation and final filtration stages of the Operations WTP and monitoring data indicate effluent concentrations were lower than the Design Criteria for the duration of the Construction WTP operational period (performance data is summarized in the 2015 and 2016 Annual Reports (Pretivm 2016a; 2017)). Similarly, monitoring data indicate that the Operations WTP has consistently produced effluent concentrations that are lower than Design Criteria since it was commissioned in 2017.

The influent water quality observed to date is well below modelled maximum concentrations for most targeted dissolved metals and thus the Operations WTP treatment efficacy at modelled concentrations is evaluated from bench scale testing conducted in 2015. Three separate studies were conducted. The first two studies were completed prior to, and included with, the MA-EMA Permits Application (Pretivm, 2015); the third investigation was completed July 25, 2015 and is provided in Appendix 1, *Operation Water Treatment Plant Additional Metals Removal Bench Tests* (*i.e.*, bench test #3). The MA-EMA Permits Application Operations WTP influent Upper Case maximum values for dissolved metals were used as target values for the preparation of synthetic influent solutions for bench testing.

Table 3-41:
Summary of Maximum Operations Water Treatment Plant (WTP) Influent and Effluent Predictions Compared to Bench Test Results and Effluent Design Criteria for Targeted Parameters

Parameter	Units	Influent			Effluent			
		Modelled Base Case	Modelled Upper Case	Bench Test Result	Design Criteria	Bench Test Result	Modelled Base Case	Modelled Upper Case
SO_4	mg/L	1304	4432	-	+ 400	-	1704	4832
Ag	mg/L	0.00044	0.00068	<0.00010	0.00010	<0.000050	0.00010	0.00010
Al	mg/L	0.19	11	9.49	0.30	0.00835	0.19	0.30
As	mg/L	0.36	1.4	0.223	0.010	<0.00050	0.010	0.010
Cd	mg/L	0.00010	0.050	0.0684	0.00025	0.0000770	0.00010	0.00025
Co	mg/L	0.011	0.061	0.0824	0.010	0.00141	0.010	0.010
Cu	mg/L	0.0012	0.42	0.783	0.010	<0.0010	0.001	0.010
Fe	mg/L	0.028	44	45.2	0.50	<0.050	0.028	0.50
Mn	mg/L	1.7	7.7	57.5	21	1.20	1.7	7.7
P	mg/L	0.19	0.34	7.68	0.20	<0.30	0.19	0.20
Pb	mg/L	0.0088	0.079	0.00564	0.0050	<0.00025	0.0050	0.0050
Zn	mg/L	0.017	2.2	10.1	0.020	<0.0075	0.017	0.020

Notes:
Metals are dissolved values; TSS was not included in the water quality model.
Design Criteria were developed for total metal parameters and confirmed by bench scale testing. Metal precipitation processes are relevant for dissolved metal removal and were evaluated based on the dissolved metal bench scale test results presented in the table.
The modelled influent and effluent concentrations are the maximum of the Scenario 1 and Scenario 2 values predicted for the Operations Phase.
Bench test results are from bench test Report #3 (Appendix 1), except Al and P which are from bench test Report #2. The Ag and Cu results are from the primary treatment stage test results.
SO_4 is not treated by the WTP. Treatment reagents are modelled to contribute the maximum amount indicated to influent concentrations.
Grey shading indicates the modelled maximum influent value is 3-fold or more above the corresponding bench test influent concentration.

Due to the complex composition of the synthetic influent, certain parameters (*e.g.*, Ag, As and Fe) were subject to continuous precipitation reactions and were therefore difficult to maintain at measurable or elevated dissolved concentrations even through repeated pH adjustments and supplementary additions of soluble metal salts. This indirectly suggests that these parameters will be effectively treated within the WTP. The removal of Ag was only evaluated in the precipitated form (measured as total Ag); however, this was due to the difficulty in maintaining Ag in a dissolved form (measured as dissolved Ag) during bench scale testing and indirectly indicates Ag insolubility at concentrations below the design criteria (0.0001 mg/L). Similarly, dissolved As was unstable in the synthetic influent and rapidly converted to particle bound As that was measured as a constituent of the total As parameter. The bench test data indicate dissolved As is effectively removed to well below design criteria effluent concentrations (0.01 mg/L). Although Pb was not evaluated at the Upper Case maximum concentration (0.079 mg/L for dissolved Pb) it was

effectively removed to well below the design criteria concentration (0.005 mg/L), indicating the effluent design criteria are achievable for the maximum modelled dissolved Pb concentrations.

Overall, the target parameter influent concentrations achieved for bench scale testing were higher than, or similar to, the modelled Base Case and Upper Case concentrations for Operations WTP influent, and therefore strongly support that the Operations WTP process will achieve Design Criteria effluent quality, or better, for maximum modelled influent concentrations.

3.6 Mill

3.6.1 Overview

The Brucejack Gold Mine mill processes ore using conventional bulk sulfide flotation and gravity concentration to recover gold and silver. The mill produces a gold-silver bearing flotation concentrate which is shipped off-site for further processing. The gravity concentrate is refined on site to produce gold-silver doré ingots.

The revised mine production schedule will result in an estimated total of 18.4 Mt of ore being processed through the mill over LOM, which will generate approximately 17.4 Mt of thickened tailings (Table 3-42). Tailings are managed through subaqueous deposition in Brucejack Lake and through placement in the underground mine as cemented paste backfill.

Schedules for the two deposition scenarios are summarized in Table 3-42. Scenario 1 assumes that 50% of the tailings (8.7 Mt going forward) will be deposited in Brucejack Lake and 50% will be placed as cemented paste backfill. Scenario 2 has a significantly higher proportion of tailings being placed in Brucejack Lake (68%; 11.9 Mt) to accommodate the placement of waste rock backfill in the underground mine.

The mill components of the GoldSim water quality model have been reconfigured as compared to the original MA-EMA Permits Application based on revisions to flows within the mill circuit. The model has also been updated with revised or new source terms developed for inputs to the mill. The inputs include:

- WTP effluent (described in Section 3.5.3);
- WTP sludge slurry, comprised of approximately 2.5% solids. The WTP sludge slurry is combined with the flotation tailings which are then thickened prior to discharge. Authorization for co-deposition of sludge with tailings was issued via amendment of *Mines Act* Permit M-243 and Effluent Permit 107835 in March/April, 2017 and this term is now incorporated into the water quality model,

where the WTP sludge slurry water is assumed to have the same composition as WTP effluent;

- Reclaim water from Brucejack Lake: make-up water supplied to the mill;
- Recycled process water: water from ore processing that is treated by the WTP and circulated back into the mill process as feed water. This is a new model component and the model allows for concentrations of untreated parameters to build up over time;
- Ore moisture: water that is on the surface of ore processed through the mill;
- Slime water: water associated with the fines that will processed through the mill; and
- Tailings loads: loads added from processed ore.

The tracked outputs include the tailings slurry discharged to Brucejack Lake, the process water that is recycled to the mill via the WTP and paste backfill discharged to the underground mine. The following sections describe the source terms developed for the various mill components.

Table 3-42:
Scheduled Ore and Predicted Tailings Tonnages to Brucejack Lake and to the Underground Mine as Paste Backfill

Phase	Year	Scheduled Ore for Processing	Total Tailings Generated	Scenario 1		Scenario 2	
				Tailings to Brucejack Lake	Tailings to Paste Backfill	Tailings to Brucejack Lake	Tailings to Paste Backfill
Operations	Y01	486,545	462,218	231,109	231,109	231,109	231,109
	Y02	1,220,183	1,159,174	579,587	579,587	705,954	453,219
	Y03	1,390,800	1,321,260	660,630	660,630	1,033,270	287,990
	Y04	1,387,000	1,317,650	658,825	658,825	734,015	583,635
	Y05	1,387,000	1,317,650	658,825	658,825	908,761	408,889
	Y06	1,387,000	1,317,650	658,825	658,825	895,064	422,586
	Y07	1,390,800	1,321,260	660,630	660,630	888,795	432,465
	Y08	1,387,000	1,317,650	658,825	658,825	974,508	343,142
	Y09	1,387,000	1,317,650	658,825	658,825	955,344	362,306
	Y10	1,387,000	1,317,650	658,825	658,825	932,202	385,448
	Y11	1,390,800	1,321,260	660,630	660,630	906,814	414,446
	Y12	1,387,000	1,317,650	658,825	658,825	937,728	379,922
	Y13	1,387,000	1,317,650	658,825	658,825	930,123	387,527
	Y14	1,387,000	1,317,650	658,825	658,825	877,112	440,538
Total (LOM)		**18,362,128**	**17,444,022**	**8,722,011**	**8,722,011**	**11,910,799**	**5,533,222**

3.6.2 Reclaim Water

The Mill water supply is supplemented by reclaim water pumped from the weir located at the outlet of Brucejack Lake (BJ 3.10) as authorized under Conditional Water License C133725. Pretivm is applying to replace this water licensing for the proposed production increase, as the updated water balance flow model (BGC, 2018) predicts a water shortfall during the low flow months of the year (*i.e.*, based on the current water license conditions). The water quality of reclaim water in the model was set to Brucejack Lake values predicted for BJ 3.10 by the water quality model.

3.6.3 Slime Water

Slimes are settled fines generated during mine operations as a result of mucking, blasting and other underground development activities. Slimes are anticipated to have relatively high gold and silver concentrations and are pumped to the mill from the underflow stream of the WTP's clarifier. The slimes, estimated to consist of approximately 30% solids, are processed through a dedicated flotation circuit before reporting to the head of the cleaner flotation circuit for the ore stream. Tailings generated from slimes are estimated to represent approximately 1 to 2% of the total tailings generated from ore processing. The geochemical characteristics of slimes have been described in the MA-EMA Permits Application (Pretivm, 2015) and the Annual Reports (Pretivm, 2016a; 2017). In general, slimes are PAG with elevated concentrations of Ag, As, Cd, Pb, S, Sb, Se, and Tl.

Water quality associated with slime-related flows to the mill is assumed in the water quality model to be equivalent to the underground mine water quality (Section 3.4.3).

3.6.4 Ore Moisture

During ore excavation, mine water from the underground workings becomes entrained in the ore muck pile. The water balance model assigns a flow to the water that is associated with ore to be processed through the mill, termed ore moisture. The water quality of ore moisture is assumed in the water quality model to be equivalent to the underground mine water quality (Section 3.4.3).

3.6.5 Tailings and WTP Sludge Loads

The physical grinding and chemical processing of ore results in the release of chemical loads into the mill's process water. These instantaneous loads are added to loads already present in process water from the various contributing sources (*i.e.*, WTP effluent, WTP sludge slurry water, reclaim water, ore moisture and slime water). The combined mill loads are discharged to Brucejack Lake with the tailings slurry and to the underground mine with the paste backfill. The tailings discharged to Brucejack Lake are co-deposited with WTP

sludge, and following deposition, loads may be released to Brucejack Lake through diffusive processes.

The following section describes the approach for deriving: 1) instantaneous tailings loads introduced to the mill; and 2) diffusive loads added to Brucejack Lake from tailings and WTP sludge.

3.6.5.1 Instantaneous Tailings Loads to Mill

The approach for deriving tailings loads has been updated since the 2015 MA-EMA Permits Application. Previously, the loads associated with tailings discharged to Brucejack Lake were calculated based on the supernatant water quality from laboratory-based metallurgical tests carried out on the 2013 10,000 tonne Bulk Sample. The current approach for estimating tailings loads applied in the updated water quality model is based on operational monitoring data collected in July 2017 for thickened tailings (supernatant water quality, water content and mass) and mill feed water (flow and water quality). The GoldSim model has been updated to account for recycling of mill process water and tracks the changing chemistry of all flow-related mill inputs. The loads released during ore processing (*i.e.,* the tailings loads) will likely vary with the changing ore composition, but for the purposes of modelling, the loads are assumed to be constant for a given tonnage of ore processed through the mill. The model tracks all inputs and calculates the composition of the tailings slurry water that is discharged to Brucejack Lake.

Tailings loads were calculated as the difference between the total monthly loads (input) to the mill (as feedwater) and the total monthly loads discharged (output) from the mill. Monitoring data from July 2017 were used for development of the tailings load source term since detailed flow and water quality records were available for mill inputs and outputs at the time of reporting. Furthermore, the feed water to the mill during the July 2017 sampling period was composed exclusively of Brucejack Lake water, which simplified the calculations. In subsequent months, the feed water was composed of a combination of WTP effluent, Brucejack Lake water and recycled process water.

The total mill input loads for July 2017 were calculated from measured Brucejack Lake water quality and mill input flow data, and the discharge loads were calculated from the thickened tailings supernatant water quality, the measured solids content (63 wt.%) and the mass of tailings discharged to the lake during this time period (76,924 tonnes; Table 3-43). The loads added to the mill from tailings are calculated from the difference between mill inputs and outputs, where Base Case and Upper Case loads were derived from 75th percentile and 90th percentile thickened tailings supernatant quality results, respectively. The predicted Base Case and Upper Case instantaneous tailings loads added to the mill,

presented in Table 3-44 and Table 3-45, were calculated from the per tonne loadings and the annual tailings schedule (Table 3-42).

Table 3-43:
Mill Input and Output Loads for July 2017

Parameter	July 2017 Load to the Mill from Brucejack Lake (g)	July 2017 Base Case Load to Brucejack Lake from the Mill (g)	July 2017 Upper Case Loads to Brucejack Lake from the Mill (g)
Chloride	24,015	749,948	792,415
Fluoride	1,859	78,157	90,988
Sulfate	1,010,975	22,272,551	25,218,129
Ag	0.39	3.7	35
Al	1,138	4,473	4,816
As	137	1,274	1,644
B	1,162	19,697	22,489
Ba	2,304	4,314	4,807
Be	3.9	0.90	0.90
Bi	1.9	2.3	2.3
Ca	859,910	939,694	1,071,612
Cd	0.39	1.6	2.1
Co	3.9	4.5	6.3
Cr	3.9	4.5	5.1
Cu	7.8	9.0	9.0
Fe	387	452	452
Hg	0.19	0.23	0.23
K	80,568	2,873,295	3,145,264
Li	465	15,270	18,767
Mg	30,988	135,533	146,556
Mn	290	1,690	1,951
Mo	55	5,828	6,397
Na	295,933	11,836,528	13,336,424
Ni	19	23	25
P	39	379	507
Pb	2.4	7.6	11
Sb	156	1,992	2,436
Se	12	430	487
Si	39,896	103,908	111,679
Sn	3.9	4.5	4.5
Sr	10,652	51,502	58,098
Ti	387	14	14
Tl	1.2	10	11
U	19	193	203
V	19	23	29
Zn	39	54	100

Table 3-44:
Base Case Tailings Slurry Instantaneous Loads (g) to Brucjack Lake for Operations phase

Parameter	Tailings Supernatant (75th PCTL)	Y01*	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14	Total
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	
	mg/L	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g
Chloride	17	4,361,953	10,939,133	12,468,742	12,434,674	12,434,674	12,434,674	12,468,742	12,434,674	12,434,674	12,434,674	12,468,742	12,434,674	12,434,674	12,434,674	209,855,479
Fluoride	1.7	458,456	1,149,740	1,310,507	1,306,926	1,306,926	1,306,926	1,310,507	1,306,926	1,306,926	1,306,926	1,310,507	1,306,926	1,306,926	1,306,926	22,056,522
Sulfate	493	127,755,672	320,392,356	365,192,507	364,194,713	364,194,713	364,194,713	365,192,507	364,194,712	364,194,713	364,194,713	365,192,507	364,194,713	364,194,713	364,194,713	6,146,381,900
Al	0.099	20,032	50,237	57,262	57,105	57,105	57,105	57,262	57,105	57,105	57,105	57,262	57,105	57,105	57,105	963,743
Sb	0.044	11,036	27,676	31,546	31,460	31,460	31,460	31,546	31,460	31,460	31,460	31,546	31,460	31,460	31,460	530,937
As	0.028	6,831	17,132	19,527	19,474	19,474	19,474	19,527	19,474	19,474	19,474	19,527	19,474	19,474	19,474	328,656
Ba	0.096	12,076	30,285	34,520	34,425	34,425	34,425	34,520	34,425	34,425	34,425	34,520	34,425	34,425	34,425	580,985
Be	0.000020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bi	0.000050	1.9	4.9	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	93
B	0.44	111,375	279,311	318,367	317,497	317,497	317,497	318,367	317,497	317,497	317,497	318,367	317,497	317,497	317,497	5,358,285
Cd	0.000035	7.2	18	20	20	20	20	20	20	20	20	20	20	20	20	344
Ca	21	479,400	1,202,264	1,370,375	1,366,631	1,366,631	1,366,631	1,370,375	1,366,631	1,366,631	1,366,631	1,370,375	1,366,631	1,366,631	1,366,631	23,064,129
Cr	0.00010	3.9	9.7	11	11	11	11	11	11	11	11	11	11	11	11	186
Co	0.00010	3.9	9.7	11	11	11	11	11	11	11	11	11	11	11	11	186
Cu	0.00020	7.7	19	22	22	22	22	22	22	22	22	22	22	22	22	373
Fe	0.010	387	971	1,107	1,104	1,104	1,104	1,107	1,104	1,104	1,104	1,107	1,104	1,104	1,104	18,625
Pb	0.00017	32	79	91	90	90	90	91	90	90	90	91	90	90	90	1524
Li	0.34	88,961	223,101	254,297	253,602	253,602	253,602	254,297	253,602	253,602	253,602	254,297	253,602	253,602	253,602	4,279,949
Mg	3.0	628,186	1,575,397	1,795,683	1,790,777	1,790,777	1,790,777	1,795,683	1,790,777	1,790,777	1,790,777	1,795,683	1,790,777	1,790,777	1,790,777	30,222,291
Mn	0.037	8,409	21,089	24,038	23,973	23,973	23,973	24,038	23,973	23,973	23,973	24,038	23,973	23,973	23,973	404,579
Hg	0.0000050	0.19	0.49	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	9.3
Mo	0.13	34,690	86,998	99,163	98,892	98,892	98,892	99,163	98,892	98,892	98,892	99,163	98,892	98,892	98,892	1,668,967
Ni	0.00050	19	49	55	55	55	55	55	55	55	55	55	55	55	55	931
P	0.0084	2,048	5,135	5,853	5,837	5,837	5,837	5,853	5,837	5,837	5,837	5,853	5,837	5,837	5,837	98,507
K	64	16,780,819	42,083,815	47,968,354	47,837,293	47,837,293	47,837,293	47,968,354	47,837,293	47,837,293	47,837,293	47,968,354	47,837,293	47,837,293	47,837,293	807,332,616
Se	0.0095	2,515	6,307	7,188	7,169	7,169	7,169	7,188	7,169	7,169	7,169	7,188	7,169	7,169	7,169	120,984
Si	2.3	384,631	964,598	1,099,476	1,096,472	1,096,472	1,096,472	1,099,476	1,096,472	1,096,472	1,096,472	1,099,476	1,096,472	1,096,472	1,096,472	18,504,763
Ag	0.000081	20	49	56	56	56	56	56	56	56	56	56	56	56	56	946
Na	262	69,344,648	173,906,137	198,223,262	197,681,669	197,681,669	197,681,669	198,223,262	197,681,668	197,681,669	197,681,669	198,223,262	197,681,669	197,681,669	197,681,668	3,336,201,726
Sr	1.1	245,460	615,578	701,654	699,737	699,737	699,737	701,654	699,737	699,737	699,737	701,654	699,737	699,737	699,737	11,809,201
Tl	0.00023	55	138	157	157	157	157	157	157	157	157	157	157	157	157	2,646
Sn	0.00010	3.9	9.7	11	11	11	11	11	11	11	11	11	11	11	11	186
Ti	0.00030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U	0.0043	1,047	2,625	2,992	2,984	2,984	2,984	2,992	2,984	2,984	2,984	2,992	2,984	2,984	2,984	50,355
V	0.00050	19	49	55	55	55	55	55	55	55	55	55	55	55	55	931
Zn	0.0012	93	233	266	265	265	265	266	265	265	265	266	265	265	265	4,475

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-45:
Upper Case Tailings Slurry Instantaneous Loads (g) to Brucejack Lake for Operations Phase

Parameter	Tailings Supernatant (90th PCTL)	Y01*	Y02	Y03	Y04	Y05	Y06	Y07	Y08	Y09	Y10	Y11	Y12	Y13	Y14	Total
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	
	mg/L	g	g	g	g	g	g	g	g	g	g	g	g	g	g	g
Chloride	17.54	4,617,126	11,579,071	13,198,161	13,162,101	13,162,101	13,162,101	13,198,161	13,162,101	13,162,101	13,162,101	13,198,161	13,162,101	13,162,101	13,162,101	174,249,586
Fluoride	2.014	535,551	1,343,083	1,530,885	1,526,702	1,526,702	1,526,702	1,530,885	1,526,702	1,526,702	1,526,702	1,530,885	1,526,702	1,526,702	1,526,702	20,211,607
Sulfate	558.2	145,454,943	364,779,515	415,786,279	414,650,251	414,650,251	414,650,250	415,786,279	414,650,249	414,650,251	414,650,251	415,786,279	414,650,251	414,650,251	414,650,250	5,489,445,548
Al	0.1066	22,095	55,411	63,159	62,986	62,986	62,986	63,159	62,986	62,986	62,986	63,159	62,986	62,986	62,986	833,861
Sb	0.05392	13,702	34,361	39,166	39,059	39,059	39,059	39,166	39,059	39,059	39,059	39,166	39,059	39,059	39,059	517,094
As	0.03638	9,052	22,701	25,875	25,804	25,804	25,804	25,875	25,804	25,804	25,804	25,875	25,804	25,804	25,804	341,615
Ba	0.1064	15,035	37,706	42,978	42,860	42,860	42,860	42,978	42,860	42,860	42,860	42,978	42,860	42,860	42,860	567,418
Be	0.00002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bi	0.00005	1.9	4.9	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	73
B	0.4978	128,151	321,384	366,322	365,322	365,322	365,322	366,322	365,322	365,322	365,322	366,322	365,322	365,322	365,322	4,836,396
Cd	0.000047	10	26	30	30	30	30	30	30	30	30	30	30	30	30	393
Ca	23.72	1,272,066	3,190,155	3,636,231	3,626,296	3,626,296	3,626,296	3,636,231	3,626,296	3,626,296	3,626,296	3,636,231	3,626,296	3,626,296	3,626,296	48,007,576
Cr	0.000112	7.1	18	20	20	20	20	20	20	20	20	20	20	20	20	269
Co	0.00014	15	37	42	42	42	42	42	42	42	42	42	42	42	42	556
Cu	0.0002	7.7	19	22	22	22	22	22	22	22	22	22	22	22	22	292
Fe	0.01	387	971	1107	1104	1104	1104	1107	1104	1104	1104	1107	1104	1104	1104	14611
Pb	0.0002388	51	127	145	144	144	144	145	144	144	144	145	144	144	144	1911
Li	0.4154	109,972	275,794	314,358	313,499	313,499	313,499	314,358	313,499	313,499	313,499	314,358	313,499	313,499	313,499	4,150,326
Mg	3.244	694,422	1,741,508	1,985,022	1,979,598	1,979,598	1,979,598	1,985,022	1,979,598	1,979,598	1,979,598	1,985,022	1,979,598	1,979,598	1,979,598	26,207,380
Mn	0.04318	9,978	25,024	28,524	28,446	28,446	28,446	28,524	28,446	28,446	28,446	28,524	28,446	28,446	28,446	376,584
Hg	0.000005	0.19	0.49	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	7.3
Mo	0.1416	38,111	95,576	108,940	108,643	108,643	108,643	108,940	108,643	108,643	108,643	108,940	108,643	108,643	108,643	1,438,293
Ni	0.00056	36	89	102	102	102	102	102	102	102	102	102	102	102	102	1345
P	0.01122	2,813	7,055	8,041	8,019	8,019	8,019	8,041	8,019	8,019	8,019	8,041	8,019	8,019	8,019	106,164
K	69.62	18,415,015	46,182,139	52,639,742	52,495,918	52,495,918	52,495,917	52,639,742	52,495,917	52,495,918	52,495,918	52,639,742	52,495,918	52,495,918	52,495,917	694,979,637
Se	0.01078	2,857	7,164	8,166	8,144	8,144	8,144	8,166	8,144	8,144	8,144	8,166	8,144	8,144	8,144	107,814
Si	2.472	431,322	1,081,692	1,232,944	1,229,576	1,229,576	1,229,576	1,232,944	1,229,576	1,229,576	1,229,576	1,232,944	1,229,576	1,229,576	1,229,576	16,278,030
Ag	0.0007636	205	514	586	584	584	584	586	584	584	584	586	584	584	584	7,735
Na	295.2	78,357,161	196,508,187	223,985,735	223,373,752	223,373,752	223,373,752	223,985,735	223,373,752	223,373,752	223,373,752	223,985,735	223,373,752	223,373,752	223,373,752	2,957,186,322
Sr	1.286	285,094	714,973	814,946	812,720	812,720	812,720	814,946	812,720	812,720	812,720	814,946	812,720	812,720	812,720	10,759,384
Tl	0.0002476	60	150	171	170	170	170	171	170	170	170	171	170	170	170	2,256
Sn	0.0001	3.9	9.7	11	11	11	11	11	11	11	11	11	11	11	11	146
Ti	0.0003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U	0.004494	1,105	2,771	3,158	3,149	3,149	3,149	3,158	3,149	3,149	3,149	3,158	3,149	3,149	3,149	41,693
V	0.000642	58	145	166	165	165	165	166	165	165	165	166	165	165	165	2,185
Zn	0.00222	370	928	1,057	1,054	1,054	1,054	1,057	1,054	1,054	1,054	1,057	1,054	1,054	1,054	13,960

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.6.5.2 Diffusive Loads from Tailings and WTP Sludge to Brucejack Lake

Diffusion-related loads from co-deposited tailings and WTP sludge to Brucejack Lake were estimated based on saturated column results and assumptions regarding diffusional transport. A brief overview of how the diffusive flux values were calculated is presented below. Additional discussion related to diffusional transport processes, contaminant behaviour and potential water quality impacts with respect to the co-deposition of sludge with tailings in Brucejack Lake is provided in a report (*Brucejack Gold Mine: Assessment of Long-Term Sludge Stability for In-Lake and Underground Deposition* (Lorax, 2016a)) that was submitted for the *Mines Act* Permit M-243 and Effluent Permit 107835 amendment applications approved in March/April 2017.

The rate of diffusional transport in sediment porewaters is a function of the concentration gradient, temperature, sediment grain size, porosity and solute size, and can be described by Fick's First Law (Eqn. 1):

$$Jz = \frac{Doj}{F} \phi \frac{dc}{dz}$$

where J_z is the diffusive flux; D^o_j = *in situ* diffusion coefficient; F = formation factor; ϕ = porosity; and dc/dz = the concentration gradient. Formation factor is a measure of tortuosity, and takes into account the convoluted path ions must follow to circumvent sediment particles (Li and Gregory, 1974). Diffusion coefficients are temperature dependent, with values increasing commensurately with temperature.

To simplify the calculations, a common diffusion coefficient (5×10^{-6} cm^2/s) was assumed for all parameters, as per values presented in Li and Gregory (1974), normalized to 5ºC. Flux calculations also assumed a formation factor of 2 (Ullman and Aller, 1982) and an estimated porosity of 0.7 for silt-sized materials. Leachate data from saturated column test TCol 14 comprising tailings and WTP sludge were used to calculate the concentration gradient (dc/dz).

Calculation of the concentration gradient (dc/dz) included the following assumptions:

- Concentration endmembers in sludge-bearing porewater were set equal to the maximum values measured in saturated column TCol 14;
- Concentration endmembers in the lake bottom water were set equal to mean annual baseline conditions measured at station BJ 3.10;
- The sediment depth over which diffusion is assumed to apply is 3 cm; and

- Flux calculations do not account for sorption processes within the uppermost oxic sediment layers. This imparts a considerable degree of conservatism since a significant fraction of the upward diffusing Mn and Fe can be expected to re-precipitate as their respective oxide phases in the near-surface sediments and remove trace elements that show strong binding affinities for Fe and Mn oxide surfaces (*e.g.*, As, Cd, Co, Cu, Pb, Ni and Zn).

Derived fluxes (J_z) were used to calculate the annual diffusive load for each parameter to the lake water column by multiplying the diffusive flux (µg/cm^2/year) for each parameter by the estimated annual tailings surface area (m^2). The annual tailings surface areas are assumed to grow at a steady rate up to a final estimated tailings surface area of 382,250 m^2. The annual diffusion-related loads contributing to Brucejack Lake from co-deposited tailings and WTP sludge are presented in Table 3-46.

Table 3-46:
Diffusive Loads from Tailings and WTP Sludge Deposited in Brucejack Lake

Assumed Tailings Area (m²)		*27,304*	*54,607*	*81,911*	*109,214*	*136,518*	*163,821*	*191,125*	*218,429*	*245,732*	*273,036*	*300,339*	*327,643*	*354,946*	*382,250*	*382,250*
Parameter	**Diffusive Flux**	**Y01***	**Y02**	**Y03**	**Y04**	**Y05**	**Y06**	**Y07**	**Y08**	**Y09**	**Y10**	**Y11**	**Y12**	**Y13**	**Y14**	**Closure and Post-Closure**
		Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	
	(µg/cm²/y)	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**	**g**
Chloride	363	99,174	198,348	297,522	396,696	495,870	595,044	694,218	793,392	892,566	991,740	1,090,914	1,190,088	1,289,262	1,388,436	1,388,436
Fluoride	25	6,914	13,828	20,742	27,656	34,571	41,485	48,399	55,313	62,227	69,141	76,055	82,969	89,884	96,798	96,798
Sulfate	51709	14,118,348	28,236,696	42,355,044	56,473,392	70,591,741	84,710,089	98,828,437	112,946,785	127,065,133	141,183,481	155,301,829	169,420,177	183,538,525	197,656,873	197,656,873
Al	0.45	124	248	371	495	619	743	866	990	1,114	1,238	1,361	1,485	1,609	1,733	1,733
Sb	0.40	110	221	331	441	551	662	772	882	993	1,103	1,213	1,324	1,434	1,544	1,544
As	0.71	193	386	578	771	964	1,157	1,350	1,543	1,735	1,928	2,121	2,314	2,507	2,699	2,699
Ba	0.32	86	172	258	344	430	516	602	688	774	860	946	1,032	1,118	1,204	1,204
Be	-0.0035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bi	-0.0083	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B	0.57	156	313	469	626	782	939	1,095	1,252	1,408	1,565	1,721	1,878	2,034	2,191	2,191
Cd	0.0059	1.6	3.2	4.8	6.5	8.1	9.7	11	13	15	16	18	19	21	23	23
Ca	9528	2,601,406	5,202,813	7,804,219	10,405,625	13,007,032	15,608,438	18,209,844	20,811,251	23,412,657	26,014,064	28,615,470	31,216,876	33,818,283	36,419,689	36,419,689
Cr	-0.0045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Co	0.017	4.6	9.1	14	18	23	27	32	37	41	46	50	55	59	64	64
Cu	0.049	13	27	40	53	67	80	93	107	120	133	147	160	173	187	187
Fe	-0.39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pb	0.0010	0.28	0.55	0.83	1.1	1.4	1.7	1.9	2.2	2.5	2.8	3.0	3.3	3.6	3.9	3.9
Li	4.2	1,135	2,270	3,406	4,541	5,676	6,811	7,946	9,081	10,217	11,352	12,487	13,622	14,757	15,893	15,893
Mg	3977	1,085,867	2,171,734	3,257,602	4,343,469	5,429,336	6,515,203	7,601,070	8,686,937	9,772,805	10,858,672	11,944,539	13,030,406	14,116,273	15,202,140	15,202,140
Mn	510	139,254	278,508	417,761	557,015	696,269	835,523	974,776	1,114,030	1,253,284	1,392,538	1,531,791	1,671,045	1,810,299	1,949,553	1,949,553
Hg	-0.00017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mo	1.5	397	794	1,191	1,588	1,985	2,382	2,779	3,176	3,573	3,970	4,367	4,764	5,161	5,558	5,558
Ni	0.12	33	67	100	133	167	200	233	266	300	333	366	400	433	466	466
K	3206	875,467	1,750,933	2,626,400	3,501,867	4,377,333	5,252,800	6,128,267	7,003,733	7,879,200	8,754,667	9,630,134	10,505,600	11,381,067	12,256,534	12,256,534
Se	0.11	29	58	86	115	144	173	202	231	259	288	317	346	375	404	404
Si	53	14,339	28,679	43,018	57,358	71,697	86,036	100,376	114,715	129,055	143,394	157,733	172,073	186,412	200,752	200,752
Ag	0.000017	0.0046	0.0092	0.014	0.018	0.023	0.028	0.032	0.037	0.042	0.046	0.051	0.055	0.060	0.065	0.065
Na	2135	583,051	1,166,102	1,749,152	2,332,203	2,915,254	3,498,305	4,081,355	4,664,406	5,247,457	5,830,508	6,413,558	6,996,609	7,579,660	8,162,711	8,162,711
Sr	271	73,918	147,835	221,753	295,671	369,589	443,506	517,424	591,342	665,259	739,177	813,095	887,013	960,930	1,034,848	1,034,848
Tl	0.00020	0.055	0.11	0.17	0.22	0.28	0.33	0.39	0.44	0.50	0.55	0.61	0.66	0.72	0.77	0.77
Sn	0.00070	0.19	0.38	0.57	0.76	0.95	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	2.7
Ti	-0.17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
U	0.00075	0.20	0.41	0.61	0.82	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.9	2.9
V	-0.017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zn	0.075	20	41	61	82	102	123	143	164	184	205	225	246	266	287	287

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.6.6 Paste Backfill Bleed Water

Porewater contained in paste backfill that is not consumed during the cement curing process will be released as bleed water. The bleed water source term applied in the 2015 MA-EMA Permits Application was assumed to have a constant concentration and was based on the initial flushing results from paste backfill humidity cell HC 37 (median and maximum of the first 5 results for Base Case and Upper Case, respectively). The approach for derivation of the paste backfill bleed water term has been revised. Specifically, bleed water quality was assumed to be equivalent to the predicted mill process water composition for all parameters except Cr, which is dominantly introduced from the cement during paste generation.

The predicted mill process water composition was calculated in GoldSim considering the flows and concentrations of components introduced to the mill (*i.e.*., WTP effluent, reclaim water, ore moisture and slime water), along with the loads added from the processed ore (the instantaneous tailings loads). Base Case and Upper Case process water predictions are based on the Base Case and Upper Case terms for the components introduced to the mill.

Chromium concentrations in paste backfill bleed water were calculated following a similar approach to that described in the 2015 MA-EMA Permits Application, whereby values were based on the initial flushing results of a paste backfill humidity cell (T12). Humidity cell T12 was initiated in March 2016 and comprises thickened tailings generated from metallurgical testwork carried out on the Bulk Sample mixed with 3.9% cement binder (provided by the Brucejack Gold Mine cement supplier). The new data are considered to be more representative of bleed water than the original paste backfill humidity cell (HC 37) which used cement sourced from a different supplier with higher Cr concentrations. Base Case and Upper Case bleed water Cr concentrations were based on the median (0.040 mg/L) and the maximum (0.10 mg/L) concentrations observed in the first 3 cycles of humidity cell T12. The full set of results for humidity cell T12, along with all other humidity cells results, are presented on an annual basis in the Annual Reports.

3.7 Sewage Treatment Plant

3.7.1 Overview

STP effluent is discharged to Brucejack Lake at a depth of 36 m and contains elevated nutrient levels compared to background. An STP source term was therefore included in the water quality model to account for the potential effect of these nutrient contributions reporting to Brucejack Lake.

The STP design is unchanged from that described in the MA-EMA Permits Application (Pretivm, 2015), with one Filterboxx STP unit with a rated treatment capacity of 75 m^3/day. Two units are currently in place at the camp resulting in a total treatment capacity of 150 m^3/day. STP effluent is monitored on a monthly basis and performance is reported on an annual basis in the Annual Reports (Pretivm, 2016a; 2017).

3.7.2 STP Effluent

For the STP source term, nutrient concentrations (total P, ammonia, nitrite, and nitrate) as defined by the Filterboxx plant vendor and Municipal Wastewater Regulations were employed. For all other parameters (total and dissolved metals, physical parameters, anions), Smart Quarter background terms derived from the Brucejack Lake outlet (BJ 3.10) dataset were used (Section 3.1). Source terms for nutrient concentrations in STP discharge are summarized in Table 3-47. The model incorporates flows for 2 Filterboxx STP units (=150 m^3/day) throughout Operations.

Table 3-47:
Sewage Treatment Plant Discharge Source Terms for Nutrients in Operations Phase

Parameter	Concentration (mg/L)
Total P	2.8
Ammonia (as N)	122
Nitrate (as N)	20
Nitrite (as N)	1.0

3.8 Nitrogen Source Terms

3.8.1 Overview

Blasting residues originating from the use of explosives represent the dominant source of nitrogen (N) species (ammonia, nitrite and nitrate) in Brucejack Lake. Therefore, the N source terms are finite and distinct from the geochemical source terms arising from rock minerals. The explosives used at Brucejack Gold Mine contain approximately 25% N in the form of ammonia and nitrate; nitrite is created as a by-product of the explosion reaction and through the oxidation of ammonia in mine drainages (Pommen, 1983). The N source terms provided here rely on the implementation of best management practices for explosives handling and blasting as described in the Nitrogen Management Plan (Pretivm, 2016b).

Explosives-related nitrogen species are currently introduced to Brucejack Lake from WTP effluent, waste rock deposition in Brucejack Lake, tailings slurry discharge, NPAG Quarry rock contact water, and Mine Site surface runoff. Nitrogen source terms arising from

background inputs and STP effluent are described in Section 3.1 and Section 3.7, respectively, and are not discussed further in this section.

Nitrogen source terms have been updated from those described in the 2015 MA-EMA Permits Application (Pretivm, 2015) and the subsequent update to the water quality model (Lorax, 2016b), due to availability of additional site-specific monitoring data and mining records. Nitrogen species are water-soluble, and therefore source terms were modelled as instantaneous loads to contact water. The updated methods used to derive water quality model inputs for ammonia, nitrite and nitrate are summarized in the sections below, and described in detail in Appendix 2.

The explosives quantities used per tonne of blasted rock for surface blasting, underground development blasting, and underground production (ore) blasting were assumed to be 0.3 kg/t, 1.54 kg/t, and 0.8 kg/t, respectively, for LOM.

3.8.2 Nitrogen Speciation

The relative distributions of ammonia, nitrite and nitrate used in the 2015 MA-EMA Permits Application (Pretivm, 2015) were based on median value ratios observed in mine water during mine exploration (Table 3-48). Ammonia, nitrite and nitrate were assumed to behave conservatively in Brucejack Lake, therefore mine water distributions were applied to source terms and at the lake outlet (BJ 3.10). During the Construction phase the N species distributions in mine water were distinct from previous observations, and distributions at the lake outlet (BJ 3.10) were found to be enriched in nitrate and depleted of ammonia and nitrite, compared to mine water. Therefore, the N species distributions were revised in the 2016 water quality model update report (Lorax, 2016b), based on observations during mine construction, and set to ratios approximating median values observed in mine water (for N source terms) and Brucejack Lake outlet (for BJ 3.10 discharge).

Table 3-48:
Nitrogen (N) Species Relative Distributions for Source Terms and Brucejack Lake Discharge (BJ 3.10), Applied in the 2015 MA-EMA Permits Application, the 2016 Water Quality Model Update and the Current (2018) Water Quality Model

Model Term	Relative Distribution of N Species (% as N)		
	Ammonia	Nitrite	Nitrate
All N source terms and lake outlet (2015)	14.8 %	4.2 %	81 %
All N source terms (2016, 2018)	28.8 %	5.2 %	66 %
Brucejack Lake outlet (BJ 3.10) (2016)	4.0 %	2.0 %	94 %
Brucejack Lake outlet (BJ 3.10) (2018)	32.2 %	2.3 %	99.7 %

The enrichment of nitrate at the lake outlet as compared to lake inputs is inferred to reflect ammonia and nitrite oxidation (nitrification) in the lake water column. Nitrification is a microbially-mediated process that converts ammonia to nitrite and nitrite to nitrate. Microbially-mediated nitrification processes occur naturally in cold water lakes and can control the distribution of nitrogen species in the water column (Sterner, 2007), typically promoting an increase in the proportion of N in the form of nitrate. Nitrification rates in these environments are affected by temperature, nutrient levels, substrate and other environmental factors (Dvir & Neori, 1999; Kaplan *et al.*, 2000; Gerardi, 2002; Ward *et al.*, 2011; Bristow *et al.*, 2015) which may cause variations of the relative proportions of ammonia, nitrite and nitrate in the water column. Temporary decoupling of the rates of oxidation of N species by microbial communities can also occur, leading to temporary accumulation of ammonia or nitrite. The microbially-mediated oxidation of ammonia to nitrite is considered to be the rate-limiting step for overall nitrification (Ginestet *et al.*,1998).

The current (2018) N distributions presented in Table 3-48 were applied to the water quality model for source term N loads. The 2016 distributions listed in Table 3-48 approximate the median proportional distributions observed in mine water from January 2016 through February 4, 2018; therefore, the 2016 distributions were carried forward for the current (2018) modelling of N loads for all source terms. The N species distributions modelled for the outlet of Brucejack Lake (BJ 3.10) were revised to capture endpoints for low and high nitrification rates in the lake, where a low nitrification rate would yield ammonia at a ratio similar to that observed in mine water, whereas nitrate would be enriched relative to mine water at elevated nitrification rates.

The maximum ratios of N species in the combined mine water and BJ 3.10 monitoring data (January 2016 through January 2018) were used to derive a low nitrification endpoint (ammonia equal to 32.2% of N reporting to BJ 3.10), and high nitrification endpoint (nitrate equal to 99.7 % of N reporting to BJ 3.10). The Brucejack Lake monitoring data indicate that the proportion of nitrite remains low for both endpoints; therefore, the maximum ratio observed at BJ 3.10 (2.3 % of N reporting to BJ 3.10) was used for nitrite. Although the revised distributions sum to 134.6% of the total N predicted to report to BJ 3.10, this approach is considered appropriate as it addresses the uncertainty associated with nitrification processes. The N species distributions will continue to be monitored throughout LOM to validate and refine the modelling assumptions.

3.8.3 Mine Site

3.8.3.1 Overview

As indicated in Section 3.3.1 and Table 3-6, approximately 1,500 kt of waste rock was blasted and excavated from the Mine Site surface to develop the site for various facilities including the Mill, Truck Shop, Camp and CWP in preparation for operations. Construction of the Mine Site was initiated in September 2015 and continued during 2016, with the majority of excavation occurring in Q1 and Q2 of 2016 (Table 3-6). NPAG Quarry rock was used as fill for pad and road construction (excavation schedule provided in Table 3-49). A distinction is made for NPAG Quarry rock placed within the Mine Site which is included in the Mine Site runoff term, and for the NPAG Quarry rock placed outside the Mine Site, which reports to Brucejack Lake directly and is included with the NPAG Quarry N source terms (Section 3.8.4).

Table 3-49:
NPAG Quarry Excavation and Surface Fill Tonnages for Construction Phase

Year	Month	NPAG Quarry Excavation (t)	NPAG Fill (outside Mine Site) (t)	NPAG Fill (within Mine Site) (t)
Y-2	Sep-15	43,848	32,548	11,300
	Oct-15	167,916	148,690	51,622
	Nov-15	58,464	43,397	15,067
	Dec-15	2,268	1,684	584
	Jan-16	0	0	0
	Feb-16	16,604	12,325	4,279
	Mar-16	50,540	37,515	13,025
	Apr-16	82,180	35,848	15,364
	May-16	113,736	50,333	21,571
Y-1	Jun-16	69,356	41,532	17,800
	Jul-16	14,756	20,266	8,686
	Aug-16	9,244	10,114	4,334
	Sep-16	48,092	12,015	5,149
	Oct-16	42,160	20,129	8,627
	Nov-16	11,542	11,995	5,141
	Dec-16	608	3,979	1,705
	Jan-17	330	0	0
	Feb-17	988	0	0
	Mar-17	720	0	0
	Apr-17	1,580	0	0
	May-17	6,612	0	0
Total		**741,544**	**482,370**	**184,254**

Source terms for N species were developed as instantaneous loads, and capture contributions from Mine Site runoff associated with exposures from surface excavation and placement of NPAG Quarry fill, as well as deposition of surface waste rock in Brucejack Lake. The surface waste rock load represents the mass of available soluble N species that is instantaneously released into solution upon contact with surface runoff or subaqueous deposition. The approach for derivation of each of these water quality model inputs are described in the sections below.

3.8.3.2 Surface Waste Rock

The method for deriving N species source terms for surface waste rock was modified from the approach developed for the 2015 MA-EMA Permits Application (Pretivm, 2015). The MA-EMA Permits Application estimated the total N loads from the explosive quantities and the excavation schedule based on literature values for surface mining (Ferguson and Leask, 1988; Cameron *et al.*, 2007; Baily *et al.*, 2013). The current (2018) modelling approach assigned a N loading rate that was estimated from: 1) the observed changes in the lake total N inventory attributable to waste rock deposition, and 2) the tracked tonnages of waste rock deposited to Brucejack Lake for the period January 2016 to January 2018. Surface waste rock and underground waste rock were deposited concurrently to Brucejack Lake, but at varying proportions over time; therefore, N load rates were derived for both surface and underground materials to fully account for the incremental change in the lake N inventory between each monitoring event. Mine Site construction was completed in early 2017; therefore, no significant amount of surface waste rock was deposited to the lake after December 2016.

The total N loading rate of surface waste rock was calculated to be 0.004 kg-N/t for the January 2016 to January 2017 monitoring period. The modelled surface waste rock loading rates were conservatively rounded up to 0.005 kg-N/t for the Base Case and 0.008 kg-N/t for the Upper Case. Further, 100% of the loads were assumed to be instantaneously released to the lake. The quantity of explosives used per tonne of surface rock blasted was assumed to be 0.3 kg/t (as reported by the blasting contractor).

The N species loading rates and total surface waste rock deposition records to Brucejack Lake (Table 3-6) were used to derive N loads for surface waste rock (Table 3-50). The total N loads were distributed between ammonia, nitrite and nitrate using the distribution for N source terms described in Table 3-48. Mine Site surface excavation is not expected to occur during the Operations Phase, and therefore surface waste rock loads were only derived for the Construction Phase.

Table 3-50:
Nitrogen Loads for Surface Waste Rock to Brucejack Lake

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Construction	Y-2	Sep-15	48	9.0	109	76	14	175
		Oct-15	91	16	209	146	26	334
		Nov-15	246	44	564	394	71	903
		Dec-15	254	46	582	406	73	931
		Jan-16	486	88	1114	778	140	1783
		Feb-16	348	63	797	557	100	1275
		Mar-16	260	47	595	415	75	952
		Apr-16	95	17	217	152	27	347
		May-16	99	18	226	158	29	362
	Y-1	Jun-16	62	11	142	99	18	227
		Jul-16	13	2.0	29	20	4.0	46
		Aug-16	0	0	0	0	0	0
		Sep-16	17	3.0	39	27	5.0	63
		Oct-16	49	9.0	113	79	14	181
		Nov-16	93	17	212	148	27	339
		Dec-16	2	0	5	4	1	8
		Jan-17	0	0	0	0	0	0
		Feb-17	0	0	0	0	0	0
		Mar-17	0	0	0	0	0	0
		Apr-17	0	0	0	0	0	0
		May-17	0	0	0	0	0	0

3.8.3.3 Mine Site Runoff

Mine Site runoff within the contact water management area is collected in the CWP and pumped to the WTP for treatment, ultimately reporting the Brucejack Lake via the WTP effluent or tailings slurry discharge. Surface runoff is described in Section 3.3.2. The Mine Site runoff source term includes CWP catchment drainage from all exposed blasted rock surfaces and from NPAG Quarry fill used for the construction of pads and roads.

The derivation of N species loads for Mine Site runoff was modified from the approach developed for the MA-EMA Permits Application (Pretivm, 2015), which was based on explosive quantities, excavation and construction schedules, as well as literature values for surface mining (Ferguson and Leask, 1988; Cameron *et al.*, 2007; Baily *et al.*, 2013). For the current modelling approach, a Mine Site runoff N loading rate was estimated to be a proportion of the loading rate derived for surface waste rock (Section 3.8.3.2), at 0.001 kg-

N/t and 0.002 kg-N/t for Base Case and Upper Case, respectively. These are considered reasonable estimates as only a small proportion of the excavation blasting residues will report to runoff (*i.e.*, the majority will remain on the waste rock surfaces deposited in the lake). Further, infiltration and rinsing of surfaces filled with NPAG Quarry rock is limited by building coverage; the water shedding characteristics of road and pad surfacing; and by winter snow removal, which reduces road, and mill and camp pad runoff during the spring melt period.

The N loads for Mine Site runoff were calculated using the N loading rates, surface excavation records, and the NPAG Quarry rock placement schedule (Table 3-49). Calculated N species loads for surface runoff during the Construction phase are presented in Table 3-51 below, with 100% of the loads assumed to report to Brucejack Lake instantaneously. The N loads were distributed between ammonia, nitrite and nitrate based on the distribution for N source terms presented in Table 3-48.

Table 3-51:
Nitrogen Loads for Runoff Associated with Surface Excavations

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Construction	Y-2	Sep-15	13	2	29	26	5	59
		Oct-15	33	6	76	66	12	152
		Nov-15	54	10	123	107	19	246
		Dec-15	51	9	117	102	18	234
		Jan-16	97	18	223	195	35	446
		Feb-16	71	13	162	142	26	324
		Mar-16	56	10	128	111	20	255
		Apr-16	23	4	54	47	8	107
		May-16	26	5	59	52	9	119
	Y-1	Jun-16	17	3	40	35	6	80
		Jul-16	5	1	12	10	2	23
		Aug-16	1	0	3	2	0	6
		Sep-16	5	1	11	10	2	22
		Oct-16	12	2	28	25	4	57
		Nov-16	20	4	46	40	7	92
		Dec-16	1	0	2	2	0	4
		Jan-17	0	0	0	0	0	0
		Feb-17	0	0	0	0	0	0
		Mar-17	0	0	0	0	0	0
		Apr-17	0	0	0	0	0	0
		May-17	0	0	0	0	0	0

3.8.4 NPAG Quarry

3.8.4.1 Overview

The NPAG Quarry is located near the southeast end of Brucejack Lake, with runoff from this area reporting directly to Brucejack Lake. Approximately 886 kt of rock has been excavated from the NPAG Quarry since January 2015 to provide material for building foundations, roads, and other construction activities at the Mine Site. The excavation and surface fill schedules for the Construction Phase are provided in Table 3-49. During Operations, the excavated quarry rock is crushed and placed in the underground mine for road surfacing. The NPAG Quarry rock excavation schedule is assumed to be 54,000 t/yr for LOM. N species source terms were developed for drainage in contact with exposures in the NPAG Quarry as well as drainage from roads and pads constructed from NPAG Quarry rock.

Drainage from NPAG Quarry rock used for surface roads and pads constructed outside the Mine Site is assumed to report to Brucejack Lake and is included with the N loads for quarry runoff described below. The N loads associated with NPAG Quarry rock placement within the Mine Site catchment are included with Mine Site runoff (see Section 3.8.3.3). NPAG Quarry rock is also used for road surfacing in the underground mine and N contributions from this placement are captured in the derivation of mine water N source terms (Section 3.8.5.4).

3.8.4.2 NPAG Quarry Runoff

The N source terms for NPAG Quarry runoff were derived using the same methodology applied to Mine Site runoff that was described in Section 3.8.3.3, yielding loading rates of 0.001 kg-N/t and 0.002 kg-N/t for Base Case and Upper Case, respectively. The loading rates, along with schedules for NPAG quarry excavation and NPAG Quarry fill placement, were used to calculate N loads attributed to NPAG Quarry runoff.

The nitrogen loads associated with NPAG quarry runoff are presented in Table 3-52 and are applicable to both Scenario 1 and Scenario 2 mine waste schedules. The total N loads were distributed between ammonia, nitrite and nitrate based on the distribution for N source terms presented in Table 3-48.

Table 3-52:
Nitrogen Loads for NPAG Quarry Runoff

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Construction	Y-2	Sep-15	22	4	50	44	8	101
		Oct-15	91	16	209	182	33	418
		Nov-15	29	5	67	59	11	134
		Dec-15	1	0	3	2	0	5
		Jan-16	0	0	0	0	0	0
		Feb-16	8	2	19	17	3	38
		Mar-16	25	5	58	51	9	116
		Apr-16	34	6	78	68	12	156
		May-16	47	9	108	95	17	217
	Y-1	Jun-16	32	6	73	64	12	146
		Jul-16	10	2	23	20	4	46
		Aug-16	6	1	13	11	2	26
		Sep-16	17	3	40	35	6	79
		Oct-16	18	3	41	36	6	82
		Nov-16	7	1	16	14	2	31
		Dec-16	1	0	3	3	0	6
		Jan-17	0	0	0	0	0	0
		Feb-17	0	0	1	1	0	1
		Mar-17	0	0	0	0	0	1
		Apr-17	0	0	1	1	0	2
		May-17	2	0	4	4	1	9
Operations	Y01*	Year 1	16	3	36	31	6	71
	Y02	Year 2	16	3	36	31	6	71
	Y03	Year 3	16	3	36	31	6	71
	Y04	Year 4	16	3	36	31	6	71
	Y05	Year 5	16	3	36	31	6	71
	Y06	Year 6	16	3	36	31	6	71
	Y07	Year 7	16	3	36	31	6	71
	Y08	Year 8	16	3	36	31	6	71
	Y09	Year 9	16	3	36	31	6	71
	Y10	Year 10	16	3	36	31	6	71
	Y11	Year 11	16	3	36	31	6	71
	Y12	Year 12	16	3	36	31	6	71
	Y13	Year 13	16	3	36	31	6	71
	Y14	Year 14	16	3	36	31	6	71

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.8.5 Underground Mine

3.8.5.1 Overview

As described previously in Sections 3.4.2 and 3.6.1, remaining LOM development of the Brucejack underground mine will result in excavation of an estimated 5.3 Mt of waste rock and 18.4 Mt of ore. The waste deposition schedules for the two scenarios are provided in Table 3-13 (Scenario 1, to lake), Table 3-14 (Scenario 2, to lake) and Table 3-15 (Scenario 2, to backfill); whereas the ore schedule is presented in Section 3.6.1.

N source terms were developed for: 1) underground mine waste rock deposited in Brucejack Lake, and 2) contact water from the underground mine. Underground waste rock and mine water were derived as instantaneous loads. The underground mine water N loads represent the transfer of ore and waste blasting residues to mine water, whereas the waste rock N loads are transferred to Brucejack Lake or to backfill (Scenario 2).

3.8.5.2 Underground Mine Waste Rock

The method for deriving N species source terms for underground waste rock was modified from the approach used for the 2015 MA-EMA Permits Application (Pretivm, 2015), which estimated the total N loads from the explosive quantities and the excavation schedule based on literature values for surface mining (Ferguson and Leask, 1988; Cameron *et al.*, 2007; Baily *et al.*, 2013) and observations from field bin monitoring data. Subsequently, in the 2016 water quality model update for nitrogen compounds (Lorax, 2016b), the observed N loading from waste rock deposition to Brucejack Lake was used to derive N loads for waste rock based on explosives quantities and the excavation schedule.

The current (2018) methodology estimates N loading rates from the observed changes in total N inventory in Brucejack Lake attributable to waste rock deposition, and the tracked tonnages of waste rock deposited to the lake for the periods of January 2017 through January 2018 (Base Case) and September 2017 through January 2018 (Upper Case). During the period of record (January 2015 through January 2018), surface waste rock and underground waste rock were deposited concurrently to Brucejack Lake, but at varying proportions over time. As described previously in Section 3.8.3.2, the N loading rates for both surface and underground rock were derived to fully account for the incremental change in the lake N inventory between each monitoring event.

The N loading rate attributable to underground waste was estimated to be 0.14 kg-N/t for the period of record, which represents the Base Case source term. The underground waste N loads for September 2017 through January 2018 were observed to be slightly higher, with an estimated load rate of 0.17 kg-N/t, which is used to represent the Upper Case N

source term. Waste rock deposited in Brucejack Lake is assumed to instantaneously release 100% of the N load at the time of deposition. The mine development waste rock blasting methods consumed explosives at an average rate of 1.54 kg/t of blasted rock; it is assumed explosives will be used at a similar rate for the LOM.

The N loading rates and projected waste rock schedules (refer to Section 3.4.2) were used to calculate N loads for the Operations phase for both Scenario 1 (all underground waste rock is deposited in Brucejack Lake) and Scenario 2 (the amount of waste rock placed as backfill is maximized to the extent possible (3.4 Mt), with the remaining portion placed in Brucejack Lake) (Table 3-53 and Table 3-54 for Scenario 1 and 2, respectively). The total N loads were distributed between ammonia, nitrite and nitrate based on the distribution for N source terms presented in Table 3-48.

Table 3-53:
Scenario 1 Nitrogen Loads for Underground Mine Waste Rock to Brucejack Lake

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Construction	Y-2	Sep-15	882	159	2,022	1,071	193	2,455
		Oct-15	904	163	2,072	1,098	198	2,516
		Nov-15	1,298	234	2,975	1,576	285	3,612
		Dec-15	857	155	1,963	1,040	188	2,383
		Jan-16	528	95	1,211	642	116	1,471
		Feb-16	760	137	1,743	923	167	2,116
		Mar-16	1,514	273	3,470	1,839	332	4,214
		Apr-16	2,762	499	6,329	3,353	605	7,685
		May-16	2,691	486	6,167	3,268	590	7,489
	Y-1	Jun-16	2,991	540	6,854	3,632	656	8,323
		Jul-16	2,913	526	6,676	3,537	639	8,106
		Aug-16	4,373	790	10,022	5,311	959	12,170
		Sep-16	3,514	634	8,052	4,266	770	9,777
		Oct-16	1,721	311	3,944	2,090	377	4,790
		Nov-16	2,340	423	5,363	2,842	513	6,512
		Dec-16	2,592	468	5,939	3,147	568	7,212
		Jan-17	897	162	2,056	1,089	197	2,496
		Feb-17	1,558	281	3,571	1,892	342	4,336
		Mar-17	1,639	296	3,756	1,990	359	4,561
		Apr-17	707	128	1,619	858	155	1,966
		May-17	1,157	209	2,651	1,404	254	3,218
Operations	Y01*	Year 1	22,857	4,127	52,381	27,755	5,011	63,605
	Y02	Year 2	19,680	3,553	45,101	23,897	4,315	54,765
	Y03	Year 3	16,098	2,907	36,891	19,548	3,529	44,797
	Y04	Year 4	16,851	3,043	38,616	20,462	3,694	46,891
	Y05	Year 5	16,463	2,972	37,727	19,990	3,609	45,811
	Y06	Year 6	16,803	3,034	38,507	20,404	3,684	46,758
	Y07	Year 7	16,298	2,943	37,350	19,791	3,573	45,354
	Y08	Year 8	15,112	2,729	34,631	18,350	3,313	42,052
	Y09	Year 9	12,810	2,313	29,355	15,555	2,808	35,646
	Y10	Year 10	11,810	2,132	27,064	14,341	2,589	32,864
	Y11	Year 11	12,103	2,185	27,735	14,696	2,653	33,679
	Y12	Year 12	12,049	2,175	27,611	14,630	2,642	33,528
	Y13	Year 13	11,720	2,116	26,859	14,232	2,570	32,614
	Y14	Year 14	13,083	2,362	29,982	15,887	2,868	36,407

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

Table 3-54:
Scenario 2 Nitrogen Loads for Underground Mine Waste Rock to Brucejack Lake

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Construction	Y-2	Sep-15	882	159	2,022	1,071	193	2,455
		Oct-15	904	163	2,072	1,098	198	2,516
		Nov-15	1,298	234	2,975	1,576	285	3,612
		Dec-15	857	155	1,963	1,040	188	2,383
		Jan-16	528	95	1,211	642	116	1,471
		Feb-16	760	137	1,743	923	167	2,116
		Mar-16	1,514	273	3,470	1,839	332	4,214
		Apr-16	2,762	499	6,329	3,353	605	7,685
		May-16	2,691	486	6,167	3,268	590	7,489
	Y-1	Jun-16	2,991	540	6,854	3,632	656	8,323
		Jul-16	2,913	526	6,676	3,537	639	8,106
		Aug-16	4,373	790	10,022	5,311	959	12,170
		Sep-16	3,514	634	8,052	4,266	770	9,777
		Oct-16	1,721	311	3,944	2,090	377	4,790
		Nov-16	2,340	423	5,363	2,842	513	6,512
		Dec-16	2,592	468	5,939	3,147	568	7,212
		Jan-17	897	162	2,056	1,089	197	2,496
		Feb-17	1,558	281	3,571	1,892	342	4,336
		Mar-17	1,639	296	3,756	1,990	359	4,561
		Apr-17	707	128	1,619	858	155	1,966
		May-17	1,157	209	2,651	1,404	254	3,218
Operations	Y01*	Year 1	22,857	4,127	52,381	27,755	5,011	63,605
	Y02	Year 2	14,221	2,568	32,590	17,269	3,118	39,574
	Y03	Year 3	0	0	0	0	0	0
	Y04	Year 4	13,603	2,456	31,173	16,517	2,982	37,853
	Y05	Year 5	5,665	1,023	12,983	6,879	1,242	15,765
	Y06	Year 6	6,597	1,191	15,119	8,011	1,446	18,359
	Y07	Year 7	6,442	1,163	14,762	7,822	1,412	17,925
	Y08	Year 8	1,474	266	3,378	1,790	323	4,102
	Y09	Year 9	0	0	0	0	0	0
	Y10	Year 10	0	0	0	0	0	0
	Y11	Year 11	1,468	265	3,363	1,782	322	4,084
	Y12	Year 12	0	0	0	0	0	0
	Y13	Year 13	0	0	0	0	0	0
	Y14	Year 14	3,653	660	8,372	4,436	801	10,166

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.8.5.3 Waste Rock Backfill

For the 2015 MA-EMA Permits Application (Pretivm, 2015) and the 2016 model update (Lorax, 2016b), the total N loads for waste backfill were derived in the same manner as for waste placed in the lake (described previously in Section 3.8.5.2), with the N loads reporting instantaneously to Brucejack Lake. The current modelling approach uses the N source terms derived in Section 3.8.5.2, with an attenuation factor to estimate N loads released from waste backfill to mine water.

Under Scenario 2, waste rock will be backfilled into secondary mined out stopes with cemented paste backfill. The backfilled paste will likely limit groundwater contact with waste rock and it is expected that the majority of nitrogen species will remain within the backfill. Therefore, it is assumed that 80% of the N load associated with underground waste rock will be retained within the backfill, with the remainder instantaneously released to mine water. If waste rock is placed underground, monitoring of seepage from backfilled waste will be conducted to validate the modelling assumptions.

The Operations Phase N loads for waste backfill presented in Table 3-55 were estimated using the N loading rates for underground waste rock (Section 3.8.5.2), an 80% attenuation factor, and the Scenario 2 waste backfill schedule (Table 3-15). The loads were distributed between ammonia, nitrite and nitrate based on the distribution for N source terms presented in Table 3-48.

Table 3-55:
Nitrogen Loads for Underground Mine Waste Rock to Backfill (Scenario 2)

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Operations	**Y01***	Year 1	0	0	0	0	0	0
	Y02	Year 2	1,092	197	2,502	1,326	239	3,038
	Y03	Year 3	3,220	581	7,378	3,910	706	8,959
	Y04	Year 4	650	117	1,489	789	142	1,808
	Y05	Year 5	2,159	390	4,949	2,622	473	6,009
	Y06	Year 6	2,041	369	4,678	2,478	448	5,680
	Y07	Year 7	1,971	356	4,518	2,394	432	5,486
	Y08	Year 8	2,728	492	6,251	3,312	598	7,590
	Y09	Year 9	2,562	463	5,871	3,111	562	7,129
	Y10	Year 10	2,362	426	5,413	2,868	518	6,573
	Y11	Year 11	2,127	384	4,874	2,583	466	5,919
	Y12	Year 12	2,410	435	5,522	2,926	528	6,706
	Y13	Year 13	2,344	423	5,372	2,846	514	6,523
	Y14	Year 14	1,886	341	4,322	2,290	413	5,248

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.8.5.4 Underground Mine Water

As described in Section 3.4.3, the underground mine workings at the Brucejack Gold Mine occur primarily below the groundwater table, and thus dewatering of the workings is required for all active phases of the mine. The N species arising from explosives used for blasting waste rock and ore are transferred to underground mine water through the dissolution of N species at the blast location, both through contact with groundwater that enters the mine and contact with mine water used for dust suppression. Backfilled waste and cement paste will also contribute N to mine water; however, these contributions are accounted for separately in Section 3.8.5.3 (for waste) and Section 3.8.6.3 (for ore). The NPAG Quarry rock used for underground mine road surfacing contributes comparatively small loads to mine water; these loads are assumed to be captured in the derivation of the mine water N loading rate.

In the 2015 MA-EMA Permits Application (Pretivm, 2015) and the 2016 update to the water quality model for nitrogen compounds (Lorax, 2016b), the N loads from explosives to mine water were derived from water quality monitoring and records of explosives use, which were used to estimate an explosives loss rate. For the current study, mine water N loading rates were derived using water quality, dewatering, and excavation records from January 2015 through July 2017. Specifically, the N loads exported in the mine water and tonnages of underground mine rock excavated (blasted) were used to derive N loading rates per tonne of rock blasted. An N loading rate of 0.022 kg-N/t was calculated for the monitoring period of February 2015 through July 2017, and applied as the Base Case source term.

An elevated loading rate of 0.033 kg-N/t was observed during the September to December 2016 time period, when challenging blasting conditions were encountered that led to excessive explosives loss to mine water. Therefore, 0.033 kg-N/t was used for the Upper Case source term. It is assumed the explosives used per tonne of rock will remain relatively constant throughout the LOM, similar to observed rates of 1.54 kg/t for development (waste) blasting and 0.8 kg/t for production (ore) blasting.

The N loading rates and the waste rock and ore excavation schedules (refer to Section 3.4.2, Table 3-13, Table 3-14 and Table 3-15; and, Section 3.6.1, Table 3-42) were used to model N loads to mine water from underground blasting for the Construction and Operations phases. Predicted N loads for underground mine water for both Scenario 1 and Scenario 2 are presented in Table 3-56. The total N was distributed between ammonia, nitrite and nitrate based on the species distributions for N source terms presented in Table 3-48.

Table 3-56:
Nitrogen Loads for Underground Mine Water

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Construction	Y-2	Sep-15	139	25	318	208	38	477
		Oct-15	142	26	326	213	38	488
		Nov-15	204	37	467	306	55	701
		Dec-15	135	24	308	202	36	463
		Jan-16	83	15	190	125	22	285
		Feb-16	119	22	274	179	32	411
		Mar-16	238	43	545	357	64	818
		Apr-16	434	78	994	651	118	1,492
		May-16	423	76	969	634	115	1,454
	Y-1	Jun-16	470	85	1,077	705	127	1,616
		Jul-16	458	83	1,049	687	124	1,574
		Aug-16	687	124	1,575	1,031	186	2,362
		Sep-16	552	100	1,265	828	150	1,898
		Oct-16	270	49	620	406	73	930
		Nov-16	534	96	1,223	801	145	1,835
		Dec-16	599	108	1,372	898	162	2,058
		Jan-17	516	93	1,183	775	140	1,775
		Feb-17	457	82	1,046	685	124	1,569
		Mar-17	481	87	1,103	722	130	1,654
		Apr-17	301	54	691	452	82	1,036
		May-17	239	43	547	358	65	821
Operations	Y01*	Year 1	6,675	1,205	15,296	10,012	1,808	22,944
	Y02	Year 2	10,824	1,954	24,804	16,236	2,931	37,206
	Y03	Year 3	11,342	2,048	25,992	17,013	3,072	38,987
	Y04	Year 4	11,436	2,065	26,208	17,154	3,097	39,311
	Y05	Year 5	11,375	2,054	26,068	17,063	3,081	39,102
	Y06	Year 6	11,428	2,063	26,190	17,143	3,095	39,285
	Y07	Year 7	11,373	2,054	26,064	17,060	3,080	39,096
	Y08	Year 8	11,163	2,015	25,581	16,744	3,023	38,372
	Y09	Year 9	10,801	1,950	24,752	16,201	2,925	37,128
	Y10	Year 10	10,644	1,922	24,392	15,966	2,883	36,588
	Y11	Year 11	10,714	1,934	24,553	16,071	2,902	36,829
	Y12	Year 12	10,681	1,929	24,478	16,022	2,893	36,717
	Y13	Year 13	10,630	1,919	24,360	15,945	2,879	36,540
	Y14	Year 14	10,844	1,958	24,851	16,266	2,937	37,276

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.8.6 Mill Components

3.8.6.1 Overview

Nitrogen enters the mill through ore, mine water, slimes, and reclaim water from Brucejack Lake. The export of N from the mill (including via the WTP located within it) occurs by water supplied to the underground mine, backfill tailings paste, as well as discharges of WTP effluent and thickened tailings to the lake. The water quality model uses all the N source terms described in previous sections, as well as for ore (described below) to derive N species concentrations in the mill components of the GoldSim model as described in Section 3.6.1. The following sections describe N source terms developed for ore and the assumptions regarding the release of N loads from tailings and paste backfill.

3.8.6.2 Ore

The methods for estimating N loads from ore were modified from the approaches previously used in the 2015 MA-EMA Permits Application (Pretivm, 2015) and the 2016 update to the water quality model for N compounds (Lorax, 2016b). For the 2015 MA-EMA Permits Application, ore N source terms were not derived; rather, metallurgical test results from ore bulk samples were used to estimate N loads in Mill tailings slurry. Subsequently, in the 2016 water quality model update for N compounds, the observed loading rates from waste rock deposition to Brucejack Lake were used to derive N loads for ore. As per other N loads, it was assumed that 100% of the N residues on the ore surfaces would be transferred to tailings and report instantaneously to Brucejack Lake regardless of whether tailings were discharged to the lake or placed underground as paste backfill.

For the current assessment, the approach for estimating ore-related loads was updated based on mining records and monitoring data collected from the commencement of ore excavation and milling (June 2017) through January 2018. The production (ore) mining method uses the long-hole blasting technique rather than the short rounds used for mine development (waste) blasting. For the period of record the observed explosives consumption rate averaged 0.8 kg/t of ore, approximately 50% lower than observed for waste excavation (1.54 kg/t). It is assumed explosive usage for ore will average approximately 0.8 kg/t for the LOM.

The N loads on ore were derived from weekly monitoring conducted at the SAG mill, which is fed both ore and recycled process water for the ore grinding operation. The SAG mill influent and effluent water were monitored for nitrogen compounds (ammonia, nitrite, nitrate, and total nitrogen). The change in process water total N concentration was derived for each monitoring event, with the corresponding instantaneous process water flow and ore feed rates used to derive an instantaneous total N load rate per tonne of ore. Calculated

75th and 90th percentiles of load rates of 0.028 kg-N/t and 0.054 kg-N/t, respectively, were used to represent Base Case and Upper Case N loads for ore based on the projected ore production schedule (Table 3-42). The total N loads were distributed between ammonia, nitrite and nitrate based on the species distribution for N source terms presented in Table 3-48. The Operations phase ore-related N species loads, which apply to both Scenario 1 and Scenario 2, are presented in Table 3-57.

Table 3-57:
Nitrogen Loads for Ore to Mill

Phase	Year		Base Case			Upper Case		
			NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)	NH_3 Load (kg-N)	NO_2 Load (kg-N)	NO_3 Load (kg-N)
Operations	**Y01***	Year 1	3,923	708	8,991	7,567	1,366	17,340
	Y02	Year 2	9,840	1,777	22,549	18,976	3,426	43,487
	Y03	Year 3	11,215	2,025	25,702	21,630	3,905	49,568
	Y04	Year 4	11,185	2,019	25,632	21,571	3,895	49,433
	Y05	Year 5	11,185	2,019	25,632	21,571	3,895	49,433
	Y06	Year 6	11,185	2,019	25,632	21,571	3,895	49,433
	Y07	Year 7	11,215	2,025	25,702	21,630	3,905	49,568
	Y08	Year 8	11,185	2,019	25,632	21,571	3,895	49,433
	Y09	Year 9	11,185	2,019	25,632	21,571	3,895	49,433
	Y10	Year 10	11,185	2,019	25,632	21,571	3,895	49,433
	Y11	Year 11	11,215	2,025	25,702	21,630	3,905	49,568
	Y12	Year 12	11,185	2,019	25,632	21,571	3,895	49,433
	Y13	Year 13	11,185	2,019	25,632	21,571	3,895	49,433
	Y14	Year 14	11,185	2,019	25,632	21,571	3,895	49,433

Notes: * Year 1 (Y01) of operations consists of only seven months (June through December of 2017).

3.8.6.3 Tailings and Paste Backfill Loads

As described above, the methods for deriving N loads for tailings and paste backfill were modified from the approaches previously used in the 2015 MA-EMA Permits Application (Pretivm, 2015) and the 2016 update to the water quality model for nitrogen compounds (Lorax, 2016b). For the 2015 MA-EMA Permits Application, metallurgical test results from ore bulk samples were used to estimate nitrogen loads in Mill tailings. Subsequently, in the 2016 water quality model update for nitrogen compounds, 100% of the derived N loads for ore were assumed to be transferred to tailings and report instantaneously to Brucejack Lake regardless of whether tailings were discharged to the lake or placed underground as paste backfill.

For this assessment, N loads associated with tailings discharged to the lake or placed underground as backfill were calculated by the GoldSim model on a monthly time step and

assigned entirely to the process water associated with the tailings. The predicted mill process water composition was calculated in GoldSim considering the flows and concentrations of components introduced to the mill (*i.e.*, WTP effluent, reclaim water, ore moisture and slime water), along with the loads added from the processed ore. Base Case and Upper Case process water quality predictions were based on the Base Case and Upper Case terms for the components introduced to the mill. The tailings placement schedule is provided in Table 3-42.

Tailings discharged to Brucejack Lake are assumed to instantaneously release 100% of the N loads into the lake. In contrast, tailings placed underground as paste backfill are assumed to sequester the majority of the nitrogen compounds within the cured cemented paste. As described previously in Section 3.6.6, porewater contained in paste backfill that is not consumed during the cement curing process will be released as bleed water. Bleed water quality is assumed to be equivalent to the predicted mill process water composition, representing a volume equal to approximately 2.5% of the water content in the paste. Although it is expected that the remaining N loads will be retained within the cured cemented paste, it is conservatively assumed that 80% of the N load remaining in the paste backfill (after accounting for bleed water) will be retained, and 20% will be instantaneously released to mine water. Monitoring of seepage from backfilled paste will be used to validate and refine modelling assumptions.

4. Results

4. Results

4.1 Overview

This section presents updated Brucejack Gold Mine water quality predictions for the proposed 3800 tpd production increase for two monitoring sites: 1) BJ 3.10, the mine's regulated discharge location at the outlet of Brucejack Lake; and 2) BJ 2.62, a downstream monitoring location in Brucejack Creek that will receive underground mine loads via groundwater pathways once the mine is flooded (Figure 1-1). Results for BJ 3.10 are therefore presented for the Operations, Closure and Post-closure mine phases; whereas water quality results at BJ 2.62 are only presented for the Closure and Post-closure phases. Water quality predictions at each monitoring site are discussed separately below.

For each monitoring site, results are presented for the two waste rock and tailings management strategies (*i.e.*., Scenario 1 and Scenario 2, Section 1 and 2.2.4) and compared to predictions presented in the 2015 MA-EMA Permits Application and relevant water quality guidelines or limits. As described in Section 1, the two scenarios represent the extremes of waste rock deposition to Brucejack Lake versus backfilled underground, with tailings discharge and paste tailings backfill balanced accordingly. Pretivm is seeking the authorization to manage these wastes according to operational needs. The water quality modelling approach is based on the logic that if both waste deposition extremes are acceptable, an 'in-between' approach would also be acceptable.

Predictions at BJ 3.10 are compared to discharge limits defined by Brucejack Gold Mine Effluent Permit 107835, whereas predictions at BJ 2.62 are compared to BC FWAL guidelines. Base Case and Upper Case water quality predictions are presented. The Base Case is considered to represent a conservative expected case; whereas the Upper Case incorporates the combined effects of upper case geochemical source terms for all inputs. Base Case and Upper Case maximum monthly predictions for both scenarios at BJ 3.10 and BJ 2.62 are presented in Appendix 3.

The discussion of the water quality predictions is focused on environmentally-relevant parameters showing mine-related signatures. Emphasis is placed on parameters which show significant changes from the 2015 MA-EMA Permits Application. Overall, general patterns observed for water quality predictions are related to: 1) the seasonal water balance and corresponding water quality; 2) geochemical behaviour of waste rock as a function of time (*e.g.*, the onset of ARD generation); and 3) deposition schedules for the various inputs to the lake (*e.g.*, waste rock, tailings, WTP effluent).

The water quality model predictions discussed in the following sections are presented as time series plots based on the current mine schedule. The Operations phase of the current mine plan is 14 years and is based on a calendar year (Section 2.2.1), whereas the 2015 MA-EMA Permits Application model was based on an 18-year Operations phase with mine years and associated mine phases starting in June of specified years. In order to provide a direct comparison of current and 2015 MA-EMA Permits Application results from the different mine phases, Operation phase results for the 2015 MA-EMA Permits Application model are not shown beyond year 14, and Closure and Post-closure predictions have been shifted accordingly.

4.2 Water Quality Predictions for BJ 3.10

4.2.1 Base Case Results

This section presents the Base Case water quality predictions for sulfate, nitrate, total arsenic (T-As) and total antimony (T-Sb) to illustrate how water quality in Brucejack Lake responds to key loading terms. Water quality time series plots are presented for these parameters alongside applicable water quality guidelines or discharge limits for reference. Tabulated results for all parameters are provided in Appendix 3-1. A summary of maximum Base Case BJ 3.10 water quality predictions as compared to the 2015 MA-EMA Permits Application predictions is presented in Table 4-1.

The BJ 3.10 comparisons show that maximum modelled predictions for several parameters are higher in the current Base Case model as compared to the 2015 MA-EMA Permits Application. These parameters include ammonia, nitrite, nitrate, dissolved aluminum (D-Al), T-Sb, T-As, dissolved iron (D-Fe), total lithium (T-Li) and total selenium (T-Se). Maximum predictions for D-Al, D-Fe, T-Li and T-Se are below BC FWAL guidelines and thus will not be discussed in detail in this application. Revised nitrogen predictions were presented in a previous amendment application (submitted in November 2016), but have been updated based on the increased ore production schedule and are therefore discussed below. Parameters which were previously predicted to exceed relevant guidelines, including nitrite, total phosphorus (T-P), total Chromium (T-Cr), total silver (T-Ag) and total zinc (T-Zn), are also discussed.

Table 4-1:
Maximum Concentrations from the BJ 3.10 Base Case Water Quality Model, for All Mine Phases, Compared to the Maximum from the 2015 MA-EMA Permits Application, BC Water Quality Guidelines, and PE-107835 Effluent Discharge Limits

Parameter	Units	Maximum Modelled		BC FWAL Guidelines		Effluent Discharge Limit
		2017 Application	2015 MA-EMA	Long-term	Short-term	
Ammonia	mg-N/L	**2.8**	0.48	1.1	5.7	1.0
Nitrite	mg-N/L	***0.2***	**0.049**	0.020	0.060	0.24
Nitrate	mg-N/L	**8.7**	0.94	3.0	33	11.5
Chloride	mg/L	1.4	1.3	150	600	NP
Fluoride	mg/L	0.14	0.14	NP	0.82	NP
Sulfate	mg/L	95	101	128	NP	128
Aluminum-D	mg/L	0.039	0.028	0.050	0.10	0.050
Antimony-T	mg/L	**0.013**	**0.010**	0.0090	NP	NP
Arsenic-T	mg/L	***0.0070***	***0.0060***	NP	0.0050	0.0050
Boron-T	mg/L	0.069	0.077	1.2	NP	NP
Barium-T	mg/L	0.072	0.086	1.0	NP	NP
Beryllium-T	mg/L	0.000070	**0.00023**	0.00013	NP	0.0010
Cadmium-D	mg/L	0.000012	0.000036	0.000083	0.00016	0.000050
Chromium-T	mg/L	**0.0013**	**0.012**	0.0010	NP	0.0090
Cobalt-T	mg/L	0.00050	0.0015	0.0040	0.11	NP
Copper-T	mg/L	0.00060	**0.0022**	0.0020	0.0046	0.0020
Iron-D	mg/L	0.040	0.030	NP	0.35	NP
Iron-T	mg/L	0.19	0.65	NP	1.0	1.7
Lead-T	mg/L	0.00050	0.0011	0.0040	0.016	0.0046
Lithium-T	mg/L	0.074	0.039	NP	NP	0.090
Mercury-T	mg/L	0.0000050	0.000017	0.000020	NP	0.000020
Manganese	mg/L	0.22	0.28	0.73	0.85	0.80
Molybdenum-T	mg/L	0.009	0.011	1.0	2.0	NP
Nickel-T	mg/L	0.00090	0.0021	0.25	NP	NP
Phosphorus-T	mg/L	0.027	0.045	NP	NP	NP
Selenium-T	mg/L	0.0010	0.00090	0.0020	NP	0.0020
Silver-T	mg/L	0.000040	**0.000060**	0.000050	0.00010	0.00046
Thallium	mg/L	0.00010	0.00016	0.00080	NP	NP
Uranium-T	mg/L	0.0010	0.0015	0.0085	NP	NP
Zinc-T	mg/L	0.0029	0.0051	0.0075	0.033	0.0075

Notes: BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that are higher in the current application than the 2015 MA-EMA Permits Application are shaded in grey.
Concentrations that exceed long-term guidelines are shown in **bold** font.
Concentrations that exceed short-term guidelines are shown as ***bold italic underlined*** font.
Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assumes a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).
NP=none proposed.

4.2.1.1 Sulfate

Although sulfate concentrations are not predicted to exceed the discharge limit, sulfate results are presented to provide context for ML/ARD-related processes. Sulfate concentrations within Brucejack Lake are predicted to gradually increase from background levels to maximum concentrations at the end of Operations (Figure 4-1). Lower sulfate concentrations are predicted for Scenario 1 (all future waste rock (5.3 Mt) is placed in Brucejack Lake) as compared to Scenario 2 (backfilling 3.4 Mt of waste rock in the underground mine), with maximum sulfate concentrations predicted to reach approximately 60 mg/L. Scenario 2 predictions are consistent with predictions from the 2015 MA-EMA Permits Application model (which incorporated waste rock backfill) and approach 100 mg/L SO_4 (Figure 4-2).

The observed increase in sulfate over the Operations phase is primarily due to the expansion of the underground mine and corresponding increased annual loading associated with tailings slurry discharges to Brucejack Lake (Figure 4-2 and Figure 4-3). The WTP does not treat for sulfate, and thus loadings from the WTP during periods of discharge will also contribute to the sulfate loads in Brucejack Lake and at BJ 3.10 (*i.e.*, during approximately one month of the year when the water is not recycled to the mill).

Sulfate concentrations are predicted to decrease through Closure, as ore processing, tailings disposal and effluent discharges from the WTP cease, and are expected to return to background levels within approximately five years following mine closure.

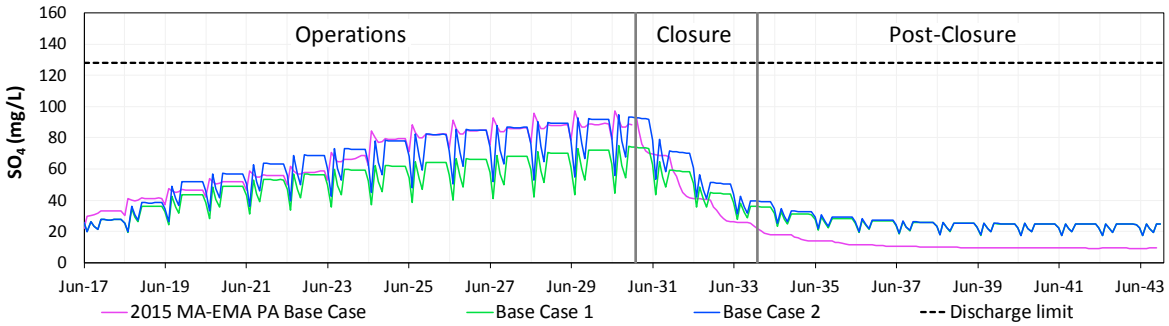


Figure 4-1: Base Case sulfate concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

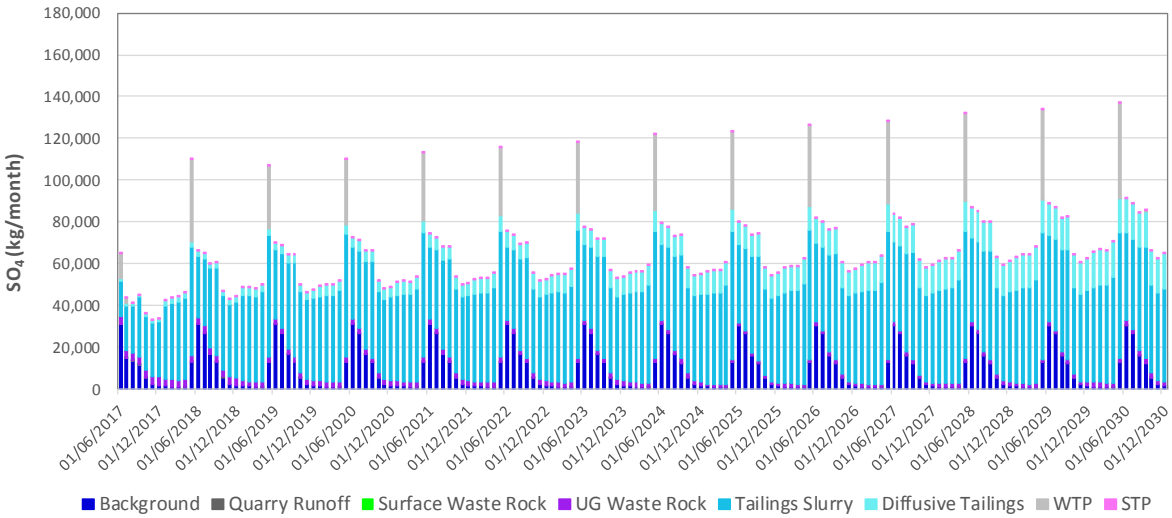


Figure 4-2: Sources of sulfate loadings (kg/month) to Brucejack Lake during Operations phase for the Scenario 1 Mine Schedule.

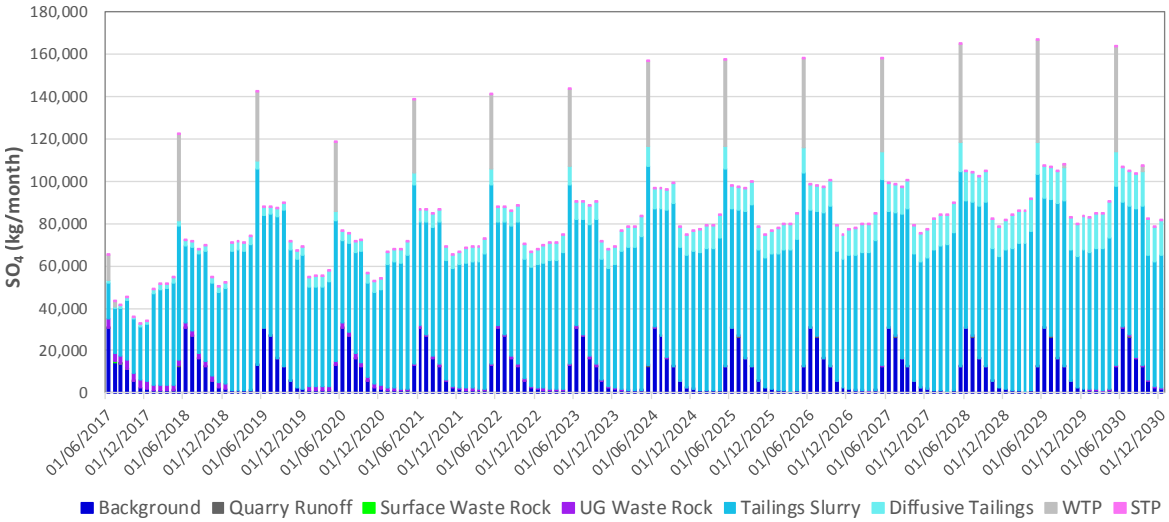


Figure 4-3: Sources of sulfate loadings (kg/month) to Brucejack Lake during Operations phase for the Scenario 2 Mine Schedule.

4.2.1.2 Ammonia

Concentrations of ammonia in Brucejack Lake are predicted to increase through the first few years of Operations, as mining activities progress, and remain relatively stable at approximately 2.5 mg/L throughout most of Operations (Figure 4-4). Slightly lower ammonia concentrations are predicted for Scenario 2, where a portion of the waste rock is backfilled in the underground mine. Ammonia originates primarily from blasting residues arising from explosives use; therefore, ammonia concentrations in Brucejack Lake are largely associated with placement of waste rock and tailings in the lake (Figure 4-5 and Figure 4-6). As described previously (Section 3.8.2) secondary microbially-mediated

nitrification processes promote non-conservative behavior of ammonia in Brucejack Lake. However, to address uncertainty regarding the rate of nitrification, conservative behaviour is modelled for ammonia and this represents an upper ammonia concentration endpoint for low rates of nitrification.

Concentrations of ammonia for the 3800 tpd updated water quality model are predicted to be higher than those predicted in the 2015 MA-EMA Permits Application model and exceed the discharge limit (1.0 mg/L) throughout Operations (Figure 4-4). The reason for the increase in ammonia predictions in the current model as compared to the 2015 MA-EMA Permits Application model relates to the approach for deriving N source terms, rather than the proposed ore production increase. Ammonia source terms for the 2015 MA-EMA Permits Application (Pretivm, 2015) were derived using generally accepted approaches for modelling nitrogen species (ammonia, nitrite and nitrate) based on literature values for surface mines, Exploration phase monitoring data and metallurgical bench scale testing. Site-specific monitoring data collected during the Construction and early Operation phases of Brucejack Gold Mine were used to review and revise N source terms as described in Section 3.8 and in a previous amendment application (submitted in November 2016). The data indicates that the original (2015) model assumptions underestimated the quantity of nitrogen released from ore and waste, noting that blasting residues on ore are transferred to tailings during milling. The updated ammonia source terms, in addition to the increased excavation and explosives use projected for the current (2018) amendment application, account for the increase in predicted ammonia concentrations compared to the previous (2015) predictions.

The concentration of ammonia is expected to decrease steadily after Operations, decreasing below the discharge limit during Closure, and returning to background levels within approximately five years of mine closure.

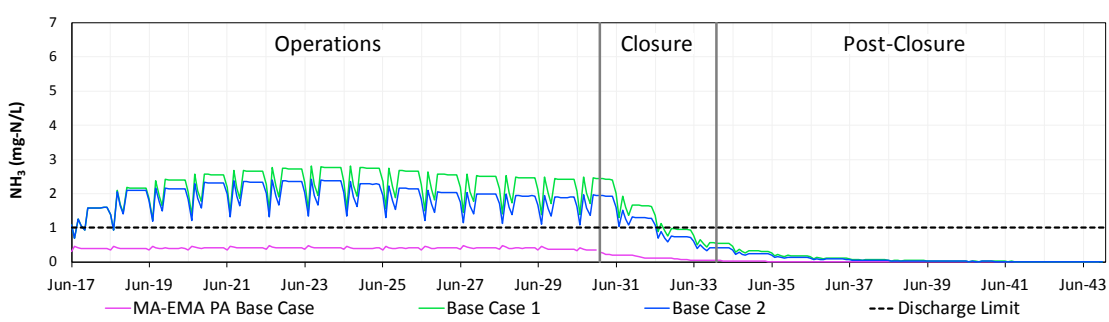


Figure 4-4: Base Case ammonia concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

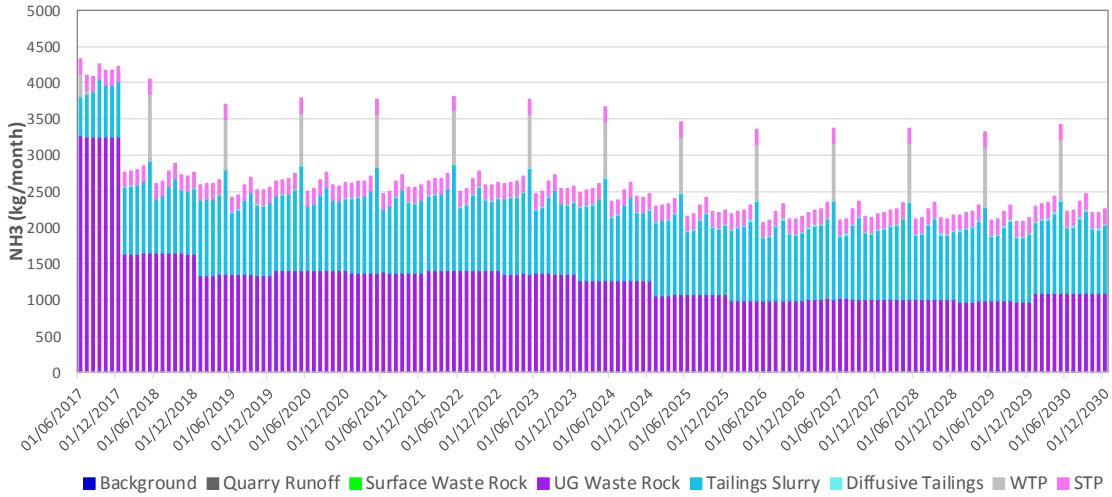


Figure 4-5: Sources of ammonia loadings to Brucejack Lake during Operations phase for Scenario 1 Mine Schedule.

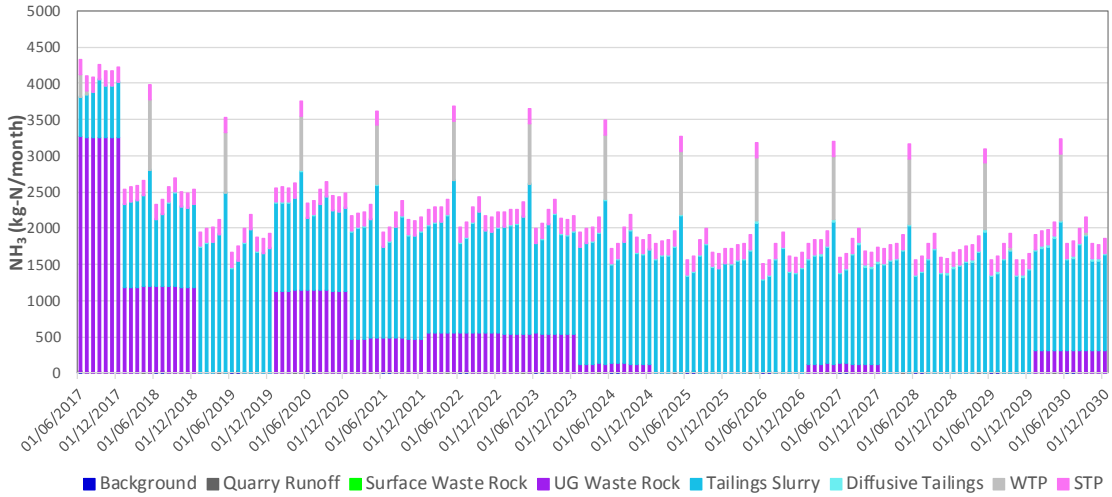


Figure 4-6: Sources of ammonia loadings to Brucejack Lake during Operations phase for Scenario 2 Mine Schedule.

4.2.1.3 Nitrite

Nitrite concentrations within Brucejack Lake are predicted to gradually increase through the first few years of Operations, as blasting activities in the mine increase, and reach a maximum of 0.20 mg/L (Figure 4-7). Slightly lower nitrite concentrations are predicted for Scenario 2. As described in Section 3.8, and for ammonia (Section 4.2.1.2), the extensive investigations undertaken since 2015 quantify nitrogen release from waste rock and tailings at a higher rate than previously assumed for the 2015 predictions; but nitrite

concentrations are not expected to exceed the discharge limit (0.24 mg/L) at any point throughout LOM for both Base Case scenarios.

Nitrite originates primarily from blasting residues arising from explosives use. Therefore, concentrations of nitrite decrease later in mine life, as mining shifts to the West Zone, and the rate of blasting and explosives quantities used for blasting decrease. The concentration is expected to decrease steadily through Closure, after the cessation of blasting, with concentrations returning to background levels within approximately five years of mine closure.

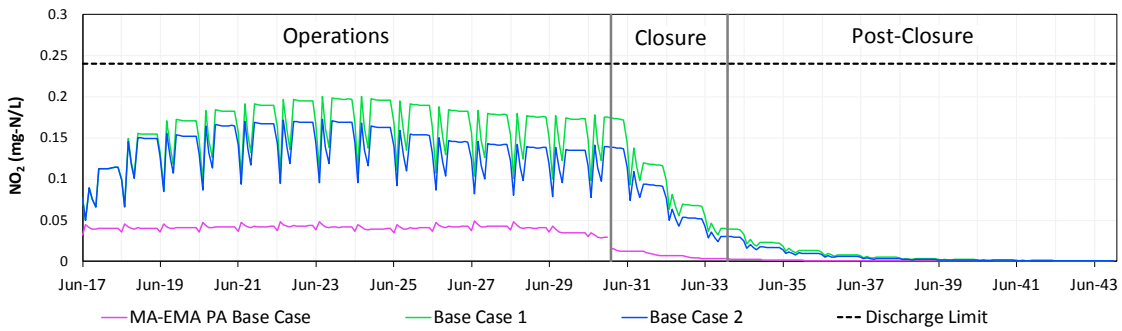


Figure 4-7: Base Case nitrite concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.1.4 Nitrate

Concentrations of nitrate in Brucejack Lake for both Base Case scenarios are predicted to increase through the first few years of Operations, as mining activities progress, and reach a maximum of 8.7 mg/L (Figure 4-8). Values are predicted to be slightly lower (up to 7.5 mg/L) for Scenario 2 where a portion of the waste rock is backfilled in the underground mine. The nitrate concentrations are largely associated with waste rock and tailings placement in the lake (Figure 4-9 and Figure 4-10).

Nitrate originates primarily from blasting residues arising from explosives use. As described in Section 3.8, and for ammonia (Section 4.2.1.2) and nitrite (Section 4.2.1.3), the extensive investigations undertaken since 2015 quantify nitrogen release from waste rock and tailings at a higher rate than derived for the 2015 predictions. As described in Section 3.8.2 and Section 4.2.1.2, secondary microbially-mediated nitrification processes in Brucejack Lake convert ammonia and nitrite to nitrate. Nitrate predictions conservatively assume a high nitrification rate and thus represent upper nitrate concentration endpoints. The predicted concentrations of nitrate are not expected to exceed the discharge limit (11.5 mg/L) at any point during LOM.

Concentrations of nitrate are predicted to decrease later in mine life, as mining shifts to the West Zone, and the rate of blasting decreases. The concentration of nitrate is expected to

decrease steadily through Closure, with concentrations returning to background levels within approximately five years of mine closure.

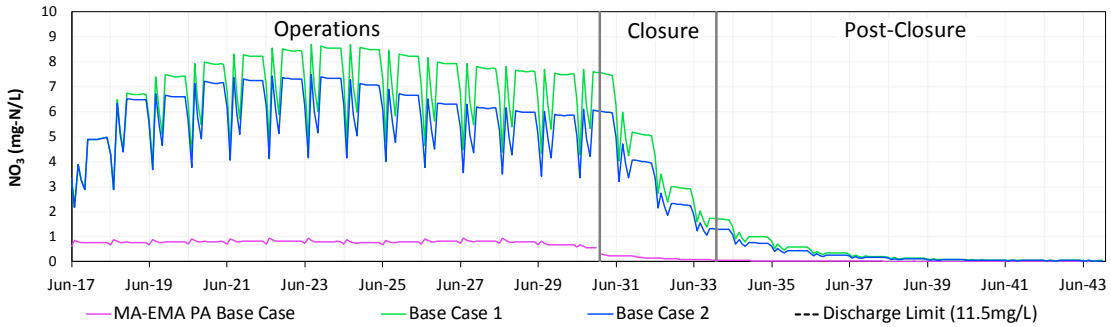


Figure 4-8: Base Case nitrate concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

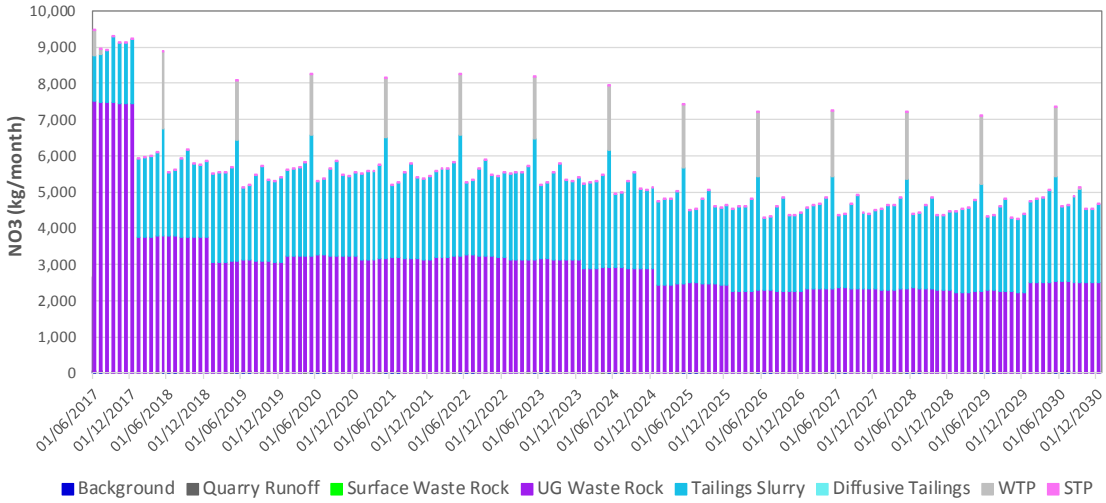


Figure 4-9: Sources of nitrate loadings to Brucejack Lake during Operations phase for Scenario 1 Mine Schedule.

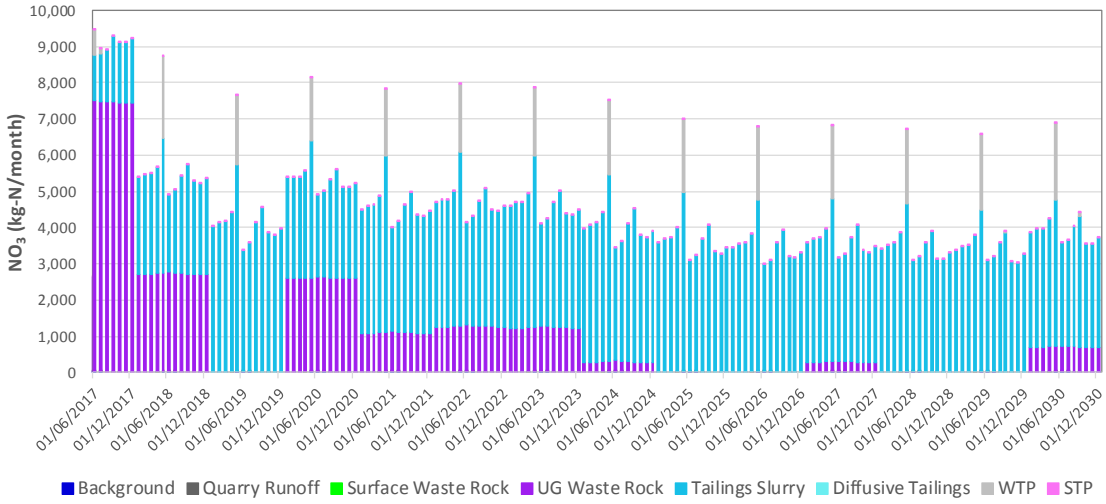


Figure 4-10: Sources of nitrate loadings to Brucejack Lake during Operations phase for Scenario 2 Mine Schedule.

4.2.1.5 Arsenic

Concentrations of T-As in Brucejack Lake are predicted to increase above the discharge limit (0.005 mg/L) early in the Operations phase (Figure 4-11). Concentrations of As are predicted to be higher for Scenario 1, which places all future waste rock in the lake, with concentrations predicted to reach a maximum of 0.0065 mg/L in Y03, and continue to periodically exceed the discharge limit throughout the Operations phase. Concentrations of As in Brucejack Lake are predicted to be lower for Scenario 2 in comparison to Scenario 1 (by 0.0010 to 0.0015 mg/L), with a maximum of 0.0058 mg/L As attained by Y03. Concentrations of As are predicted to progressively decrease after Y03, decreasing below the discharge limit by Y05.

Concentrations of As in Brucejack Lake are primarily influenced by the proportion of underground waste rock submerged in the lake (Figure 4-12 and Figure 4-13) and to a lesser extent the tailings slurry. Background levels are also relatively high, and are expected to contribute to the elevated concentrations of As in Brucejack Lake during Operations.

Concentrations are expected to diminish to near background levels in Brucejack Lake Post-closure for Scenario 2; however, the model predicts that As will be sustained at a slightly higher concentration (0.003 mg/L) throughout Post-closure if all waste rock is placed in the lake (Scenario 1).

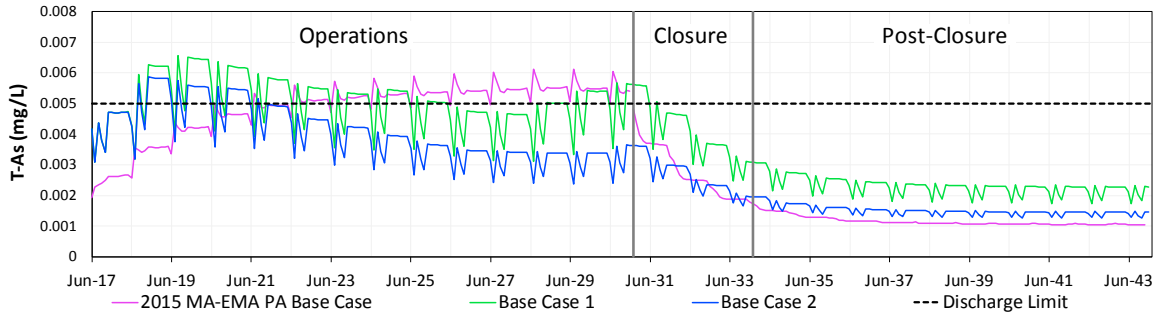


Figure 4-11: Base Case total arsenic concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

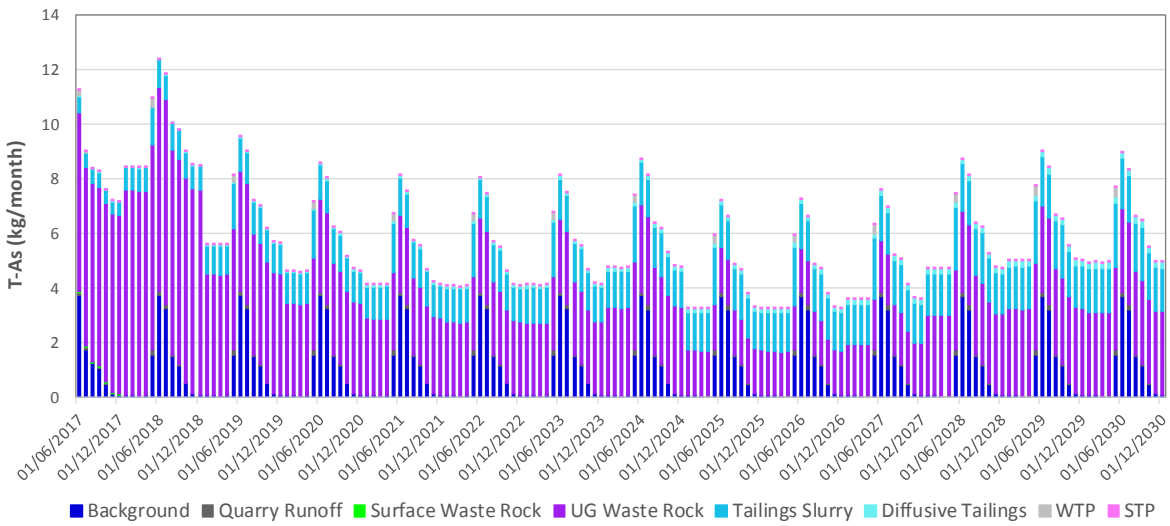


Figure 4-12: Sources of total arsenic loadings to Brucejack Lake during Operations phase for Scenario 1 Mine Schedule.

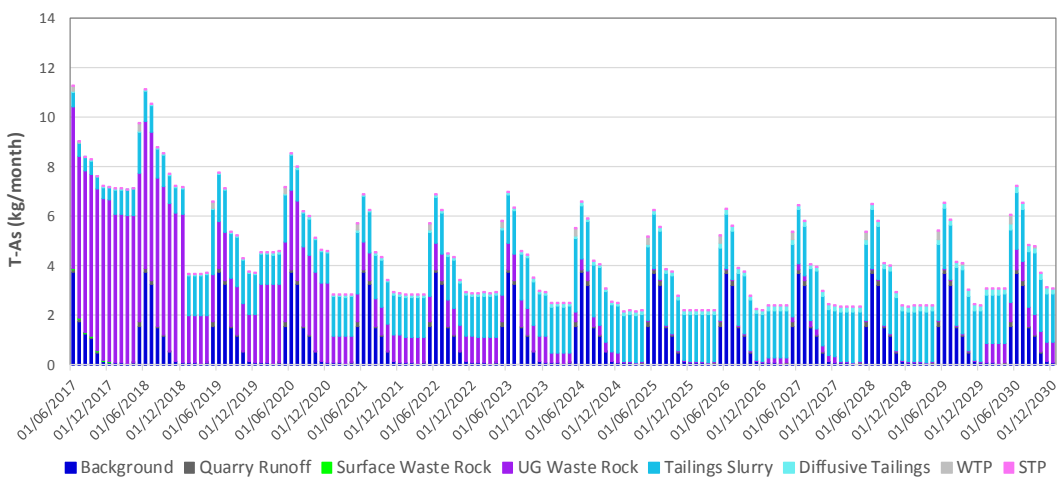


Figure 4-13: Sources of total arsenic loadings to Brucejack Lake during Operations phase for Scenario 2 Mine Schedule.

4.2.1.6 Antimony

Concentrations of T-Sb are predicted to gradually increase in Brucejack Lake throughout Operations for both Base Case scenarios and reach a maximum of 0.013 mg/L at the end of Operations (Figure 4-14). Concentrations are predicted to exceed the BC FWAL working guideline (0.009 mg/L) by Y05 and continue to exceed the guideline on a seasonal basis throughout Operations. The concentrations of Sb are predicted to be higher than the concentrations predicted by the 2015 MA-EMA model.

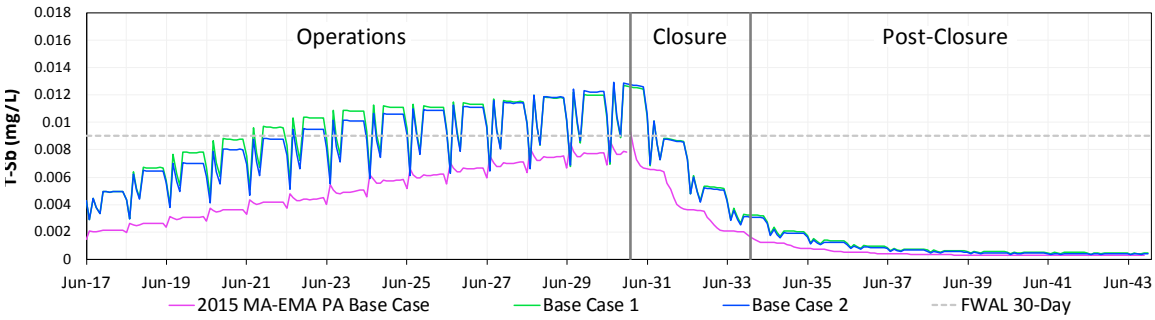


Figure 4-14: Base Case total antimony concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

The Sb load to Brucejack Lake is primarily associated with tailings slurry discharges (Figure 4-15 and Figure 4-16). The WTP does not treat for antimony, and thus loadings from the WTP during periods of discharge will also contribute to the antimony loads in Brucejack Lake and at BJ 3.10 (*i.e.*, during approximately one month of the year, when the water is not recycled to the mill).

Concentrations are predicted to decrease through Closure, as ore processing, tailings disposal and effluent discharges from the WTP cease, and are expected to return to background levels within approximately five years of mine closure.

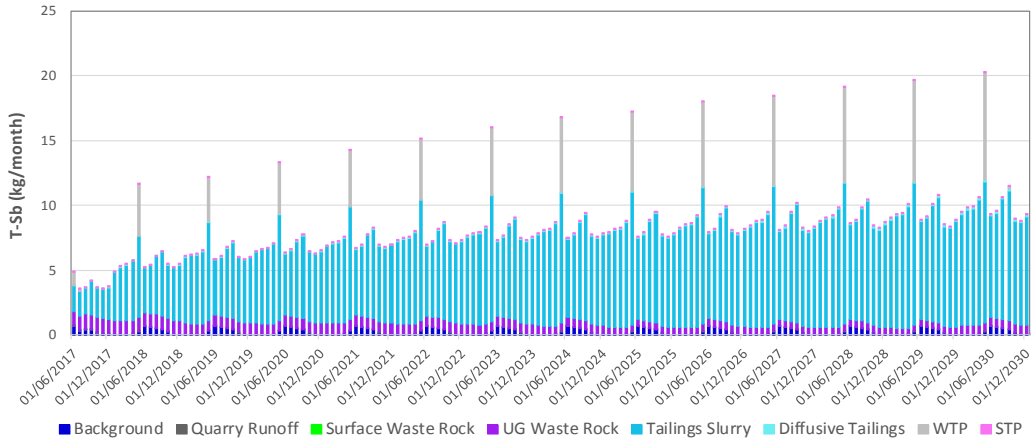


Figure 4-15: Sources of total antimony loadings (kg/month) to Brucejack Lake during Operations phase for Scenario 1 Mine Schedule.

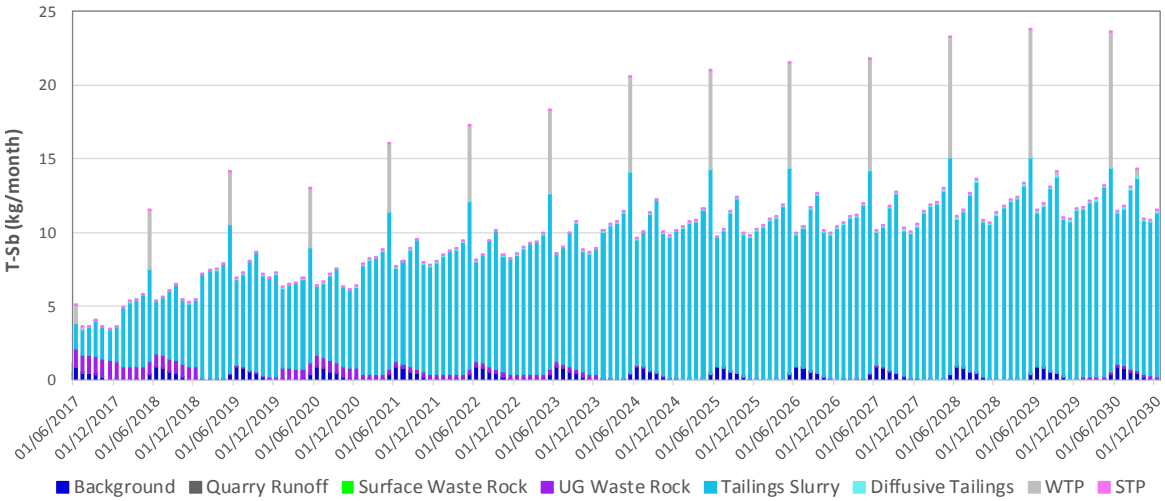


Figure 4-16: Sources of total antimony loadings (kg/month) to Brucejack Lake during Operations phase for Scenario 2 Mine Schedule.

4.2.1.7 Phosphorus

Total P is predicted to increase steadily in Brucejack Lake throughout Operations and reach a maximum of 0.027 mg/L (Figure 4-17). Concentrations of P are predicted to be lower than the concentrations predicted by the 2015 MA-EMA model. The increase in P over time is attributed to a number of different sources, including STP effluent, WTP effluent and Tailings slurry discharge. Concentrations are predicted to decrease through Closure and return to background levels early in Post-Closure.

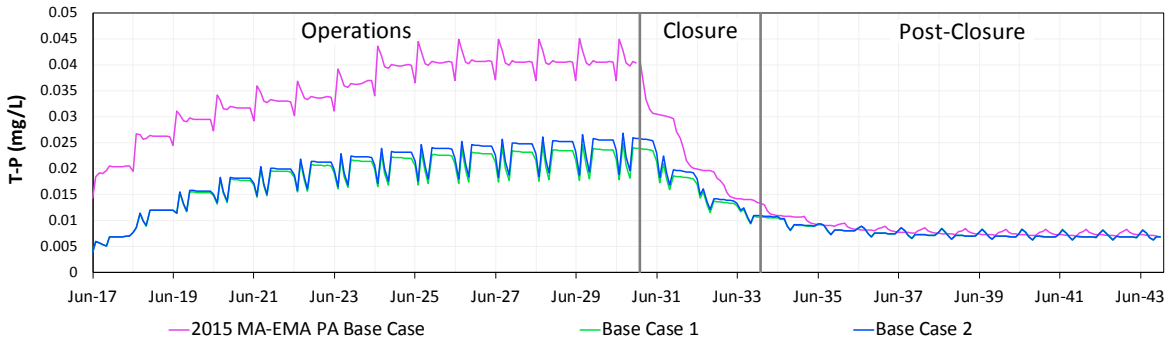


Figure 4-17: Base Case total phosphorus concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.1.8 Chromium

Concentrations of T-Cr in Brucejack Lake are predicted to be low and remain low (<0.0005 mg/L) throughout most of Operations for both Base Case scenarios following an initial influx of approximately 0.0010 mg/L. Concentrations of Cr are primarily associated with tailings discharges, background contributions and effluent from the WTP. Total Cr is expected to leach from cemented paste backfill underground, which will be primarily in

hexavalent form (Cr(VI)). The WTP does not treat for Cr(VI), only Cr(III), and thus loadings from the WTP during periods of discharge are expected to contribute to the total Cr loads in Brucejack Lake and at BJ 3.10 (*i.e.*, during one month of the year, when the water is not recycled to the mill).

The 2015 MA-EMA model had predicted that Cr concentrations would increase in steps through early Operations, to a maximum concentration of approximately 0.010 mg/L in Brucejack Lake when it would exceed the discharge limit of 0.009 mg/L (Figure 4-18). The elevated predictions resulted in evaluation of potential source control contingency measures that reduce Cr(VI) to Cr(III) using emerging industry best practices (Chromium Management Plan). In contrast, Operational monitoring of influent water quality to the WTP has shown that the Cr(VI) level has remained below the discharge limit and well below the original predictions.

Total Cr is expected to decrease further through Closure and return to background levels Post-closure, when cemented paste backfill is no longer being placed underground.

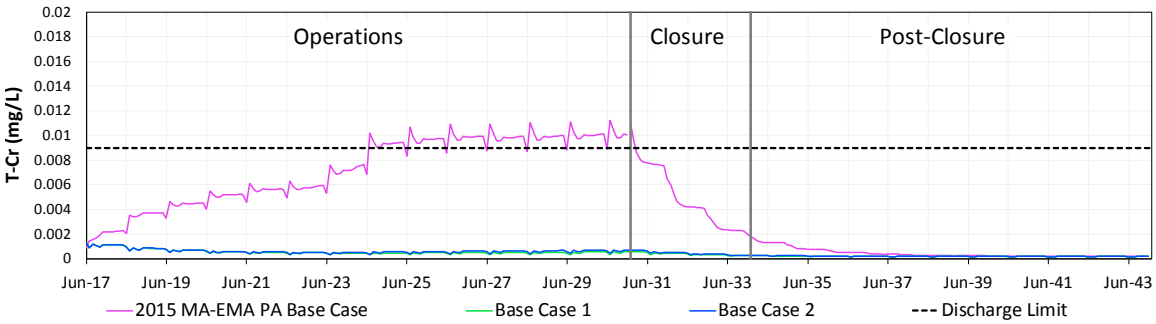


Figure 4-18: Base Case total chromium concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.1.9 Silver

For both Base Case scenarios, concentrations of T-Ag are predicted to increase in Brucejack Lake throughout Operations from relatively high background levels to steady-state concentrations lower than the 2015 MA-EMA model predictions and an order of magnitude below the discharge limit (0.00046 mg/L) (Figure 4-19). Silver is naturally elevated in the upper Brucejack system and occurs in economic concentrations within the mine. The primary sources of Ag to Brucejack Lake are therefore anticipated to be tailings slurry discharges and background contributions. As a result, concentrations of Ag are predicted to be higher for Scenario 2 in comparison to Scenario 1, reflecting the increased tailings deposition in the lake.

Concentrations are predicted to decrease throughout Closure and return to background levels early in Post-Closure.

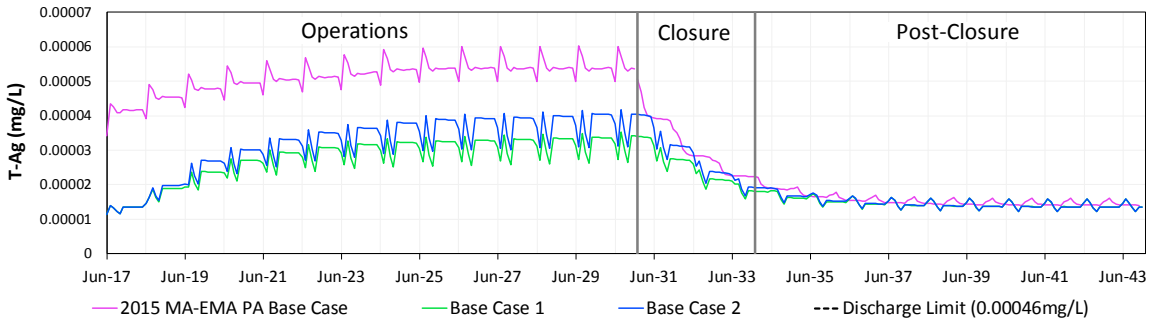


Figure 4-19: Base Case total silver concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.1.10 Zinc

Concentrations of T-Zn in Brucejack Lake are predicted to decrease at the beginning of Operations to steady state concentrations of approximately 0.0020 mg/L throughout Operations for both 3800 tpd production increase Base Case scenarios (Figure 4-20). These updated predictions for Zn are lower in comparison to the 2015 MA-EMA model, which predicted that concentrations would initially increase in Brucejack Lake to a maximum of 0.0051 mg/L and remain elevated throughout Operations.

Similar to total As and Ag, background levels are predicted to be the dominant source of Zn to Brucejack Lake. Tailings slurry discharges to the lake are also expected to contribute to the initial minor increase in Zn above the background concentration. Concentrations of Zn are expected to return to background levels during the Closure phase.

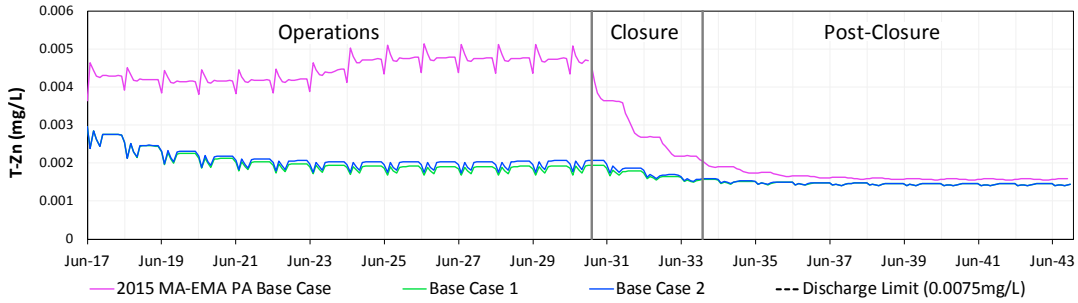


Figure 4-20: Base Case total zinc concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.2 Upper Case Results

In general, the Base Case results summarized above represent conservative water quality predictions for the Brucejack Gold Mine Project, which make a reasonable allowance for any potential variability in model input, and generally do not account for secondary reactions that may occur underground or in Brucejack Lake that could potentially attenuate elevated concentrations of nutrients and other anions, and metals. However, some residual

uncertainty remains, and an Upper Case scenario, whereby ML/ARD develops more rapidly and to a greater extent than expected in the underground mine, was modelled to evaluate potential effects of factors that could lead to higher than expected concentrations for certain water quality parameters.

As discussed in Section 3, the Upper Case source terms are generally based on 90th percentile values from geochemical datasets for all mine-related flows and employs highly conservative assumptions with respect to both contact water chemistry (as 90th percentiles) and onset of acidity. Not surprisingly, this model case predicts notable increases for several parameters compared to the Base Case.

Predicted Upper Case concentrations for sulfate, T-As and T-Sb in Brucejack Lake are presented, as these parameters are strongly influenced by the time to onset and severity of ML/ARD. The predicted Upper Case concentrations of nitrite and nitrate are also presented as revised predictions (Lorax, 2016b) since these were updated in a previous amendment application (submitted in November 2016). Water quality time series plots are presented for these parameters. Tabulated results for all parameters (as monthly maxima by mine phase) are provided in Appendix 3-1.

4.2.2.1 Sulfate

Upper Case predictions of sulfate in Brucejack Lake show a progressive increase throughout Operations for both scenarios and exceed the BC FWAL 30-day guideline (128 mg/L) (Figure 4-21). Concentrations of sulfate for Scenario 2 (a portion of waste rock is backfilled in the underground mine) are predicted to increase to approximately 175 mg/L by the end of Operations, whereas concentrations for Scenario 1 (all waste rock is placed in Brucejack Lake) are predicted to be slightly lower (up to 150 mg/L).

Concentrations of sulfate for both scenarios are predicted to decrease through Closure and return to background levels early in Post-closure.

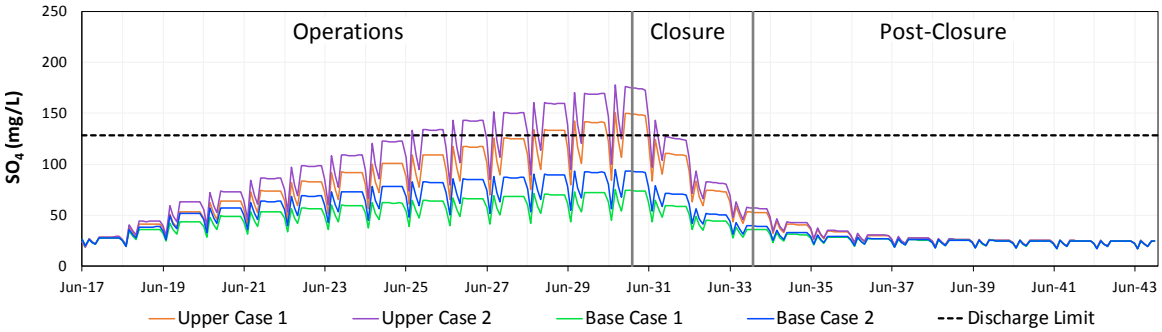


Figure 4-21: Upper Case sulfate concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.2.2 Ammonia

Upper Case predictions of ammonia in Brucejack Lake follow the same trend as the Base Case predictions under both Mine Schedule scenarios (Figure 4-22), with Scenario 1 predicting slightly higher concentrations. Upper Case predictions increase during the first half of Operations to a maximum of 4.0 mg/L and are predicted to exceed the discharge limit (1.0 mg/L) throughout all of Operations. Conservative behaviour is modelled for ammonia and this represents an upper ammonia concentration endpoint for low rates of nitrification. The concentration of ammonia is predicted to decrease rapidly during Closure and return to background levels during Post-Closure.

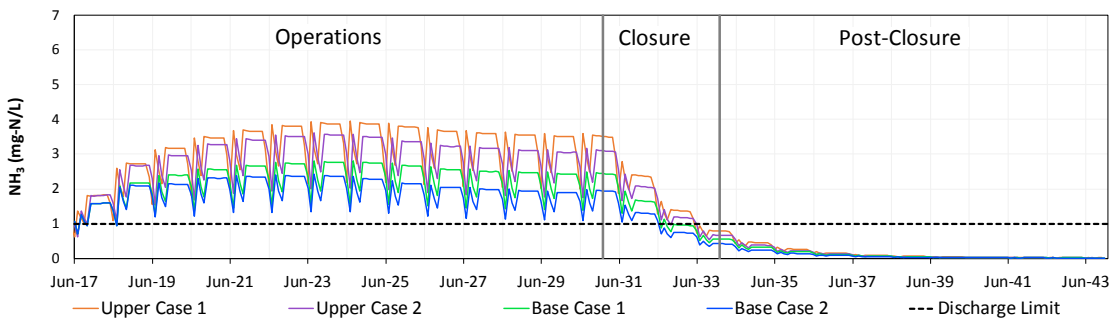


Figure 4-22: Upper Case ammonia concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.2.3 Nitrite

Upper Case predictions of nitrite in Brucejack Lake follow the same trend as the Base Case predictions under both Mine Schedule scenarios (Figure 4-23), with Scenario 1 predicting slightly higher concentrations. Upper Case predictions increase during the first half of Operations to a maximum of 0.28 mg/L, slightly above the discharge limit (0.24 mg/L). The concentration of nitrite is predicted to decrease rapidly during Closure and return to background levels during Post-Closure.

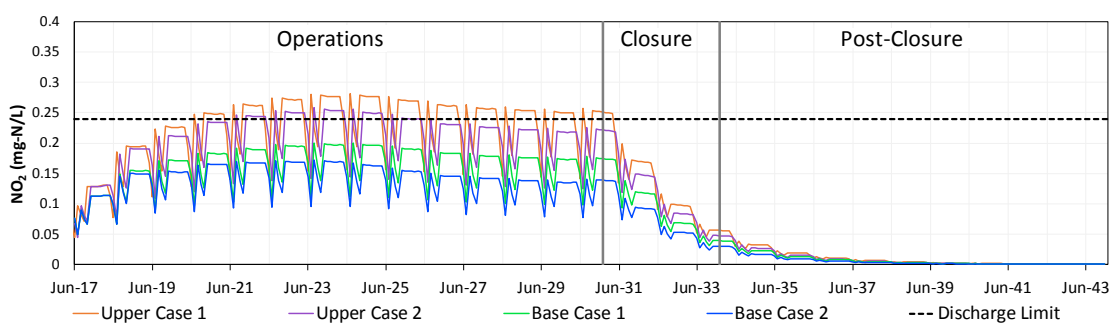


Figure 4-23: Upper Case nitrite concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.2.4 Nitrate

Upper Case predictions for nitrate in Brucejack Lake follow a similar profile for both scenarios but at higher concentrations than the Base Case predictions (Figure 4-24). A high nitrification rate that enriches nitrate in the lake is conservatively assumed for nitrate predictions representing an upper endpoint for nitrate concentrations. Upper Case concentrations of nitrate show an increase over the first six years of Operations to a maximum of approximately 12.2 mg/L, slightly above the discharge limit (11.5 mg/L). The concentration of nitrate is only slightly lower for Scenario 2, where a portion of the waste rock is backfilled in the underground mine. Concentrations of nitrate are predicted to decrease rapidly throughout Closure as blasting activities cease and return to background levels early in Post-closure.

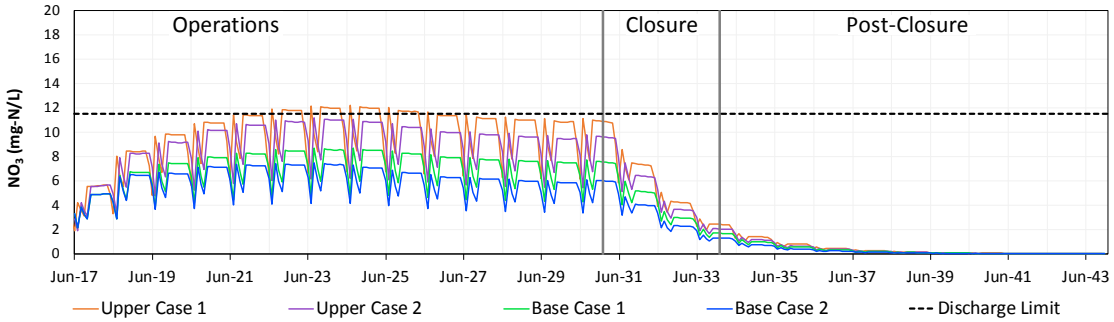


Figure 4-24: Upper Case nitrate concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.2.5 Arsenic

Upper Case predictions of T-As in Brucejack Lake show notably different concentration profiles for the two scenarios (Figure 4-25), reflecting the different waste rock placement strategies. Upper Case concentrations of As at BJ 3.10 for Scenario 1 are predicted to increase rapidly over the first four years of Operations to values nearly twice the predicted values for Base Case and well above the discharge limit (0.005 mg/L). Under this scenario which places all waste rock in Brucejack Lake, Upper Case predictions for As would consistently exceed the current discharge limit at BJ 3.10 throughout the LOM, and reach a maximum of 0.010 mg/L near the end of Operations. Upper Case concentrations of As at BJ 3.10 for Scenario 2 are predicted to reach a maximum of 0.0078 mg/L in Y02 and progressively decrease throughout the rest of Operations, only exceeding the discharge limit on a seasonal basis.

Concentrations of As are predicted to decrease below the discharge limit for both scenarios during the Closure phase and remain low throughout Post-closure (<0.0025 mg/L).

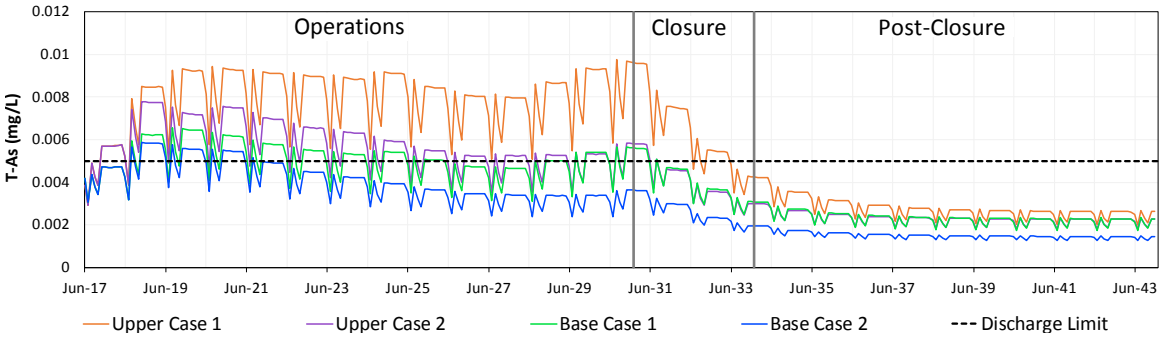


Figure 4-25: Upper Case total arsenic concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.2.2.6 Antimony

Upper Case concentrations of T-Sb at BJ 3.10 are predicted to increase consistently throughout Operations for both scenarios to a maximum of approximately 0.028 mg/L at the end of the Operations phase (Figure 4-26). Upper Case concentrations of Sb would increase above the BC FWAL 30-day guideline (0.009 mg/L) in Y03 and remain above the guideline until the end of the Closure period. Concentrations of Sb at BJ 3.10 would be expected to return to background levels (~0.00050 mg/L) early in the Post-closure period.

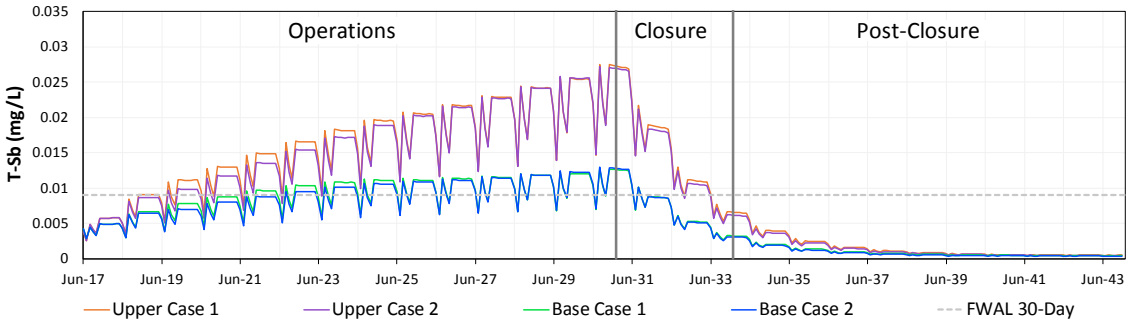


Figure 4-26: Upper Case total antimony concentration predictions at BJ 3.10 (Brucejack Lake) through Operations and Post-closure mine phases.

4.3 Water Quality Predictions for BJ 2.62

4.3.1 Base Case Results

The section presents Base Case water quality predictions at the downstream monitoring location in Brucejack Creek (BJ 2.62) for sulfate, ammonia, nitrite, nitrate, T-As, T-Sb and T- and D-Fe to illustrate how water quality in Brucejack Creek is predicted to respond to loads from the flooded underground mine via groundwater pathways during Closure and Post-Closure project phases. Water quality time series plots are presented for these parameters alongside applicable water quality guidelines and the 2015 MA-EMA predictions for reference. Tabulated results for all parameters are provided in Appendix 3-2.

A summary of maximum Base Case model results during LOM is presented in Table 4-2. The BJ 2.62 comparisons show that predictions for the 3800 tpd production increase application are higher than predictions in the 2015 MA-EMA Permits Application for ammonia, nitrite, nitrate, Cl, F, D-Al, T-Sb, T-As and D-Fe, T-Se and T-Zn. Revised nitrogen predictions were presented in a previous amendment application (submitted in November 2016), but have been updated based on the increased ore production schedule and are therefore discussed below. Maximum predictions for Cl, F, D-Al and T-Se are below BC FWAL guidelines and will not be discussed in this application. Parameters which were previously predicted to exceed relevant guidelines, including T-Ag, T-Be, T-Cr, T-Cu, T-P and T-Zn, are also presented.

Table 4-2:
Maximum Concentrations from the BJ 2.62 Base Case Water Quality Model for Operations and Post-closure Mine Phases, Compared to the Maximum from the 2015 MA-EMA Permits Application, BC Water Quality Guidelines, and PE-107835 Effluent Discharge Limits

Parameter	Units	Maximum Modelled		BC FWAL Guidelines		Effluent Discharge Limit
		2017 Application	2015 MA-EMA	Long-term	Short-term	
Ammonia	mg-N/L	**2.8**	0.44	1.1	5.7	1.0
Nitrite	mg-N/L	***0.20***	**0.045**	0.020	0.060	0.24
Nitrate	mg-N/L	**8.5**	0.88	3.0	33	12
Chloride	mg/L	2.3	1.5	150	600	NP
Fluoride	mg/L	0.14	0.13	NP	0.82	NP
Sulfate	mg/L	94	96	128	NP	128
Aluminum-D	mg/L	0.039	0.034	0.050	0.10	0.050
Antimony-T	mg/L	**0.014**	**0.0090**	0.0090	NP	NP
Arsenic-T	mg/L	***0.013***	***0.012***	NP	0.0050	0.0050
Boron-T	mg/L	0.074	0.078	1.2	NP	NP
Barium-T	mg/L	0.071	0.087	1.0	NP	NP
Beryllium-T	mg/L	0.00012	**0.00023**	0.00013	NP	0.0010
Cadmium-D	mg/L	0.000041	0.000057	0.000083	0.00016	0.000050
Chromium-T	mg/L	**0.0012**	**0.011**	0.0010	NP	0.0090
Cobalt-T	mg/L	0.00080	0.0016	0.0040	0.11	NP
Copper-T	mg/L	0.0016	**0.0028**	0.0020	0.0046	0.0020
Iron-D	mg/L	***3.13***	***2.7***	NP	0.35	NP
Iron-T	mg/L	***3.34***	***2.8***	NP	1.0	1.7
Lead-T	mg/L	0.0012	0.0015	0.0040	0.016	0.0046
Lithium-T	mg/L	0.085	0.036	NP	NP	0.090
Mercury-T	mg/L	0.0000080	0.000019	0.000020	NP	0.000020
Manganese	mg/L	0.26	0.29	0.73	0.85	0.80

Parameter	Units	Maximum Modelled		BC FWAL Guidelines		Effluent Discharge Limit
		2017 Application	2015 MA-EMA	Long-term	Short-term	
Molybdenum-T	mg/L	0.0090	0.010	1.0	2.0	NP
Nickel-T	mg/L	0.00090	0.0021	0.25	NP	NP
Phosphorous-T	mg/L	0.026	0.042	NP	NP	NP
Selenium-T	mg/L	0.0010	0.00090	0.0020	NP	0.0020
Silver-T	mg/L	**0.000060**	***0.00011***	0.000050	0.00010	0.00046
Thallium	mg/L	0.00010	0.00016	0.00080	NP	NP
Uranium-T	mg/L	0.0016	0.0014	0.0085	NP	NP
Zinc-T	mg/L	**0.0086**	**0.0085**	0.0075	0.033	0.0075

Notes: BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that are higher in the current application than the 2015 MA-EMA Permits Application are shaded in grey.
Concentrations that exceed long-term guidelines are shown in **bold** font.
Concentrations that exceed short-term guidelines are shown as **bold italic underlined** font.
Hardness dependent guidelines *calculated using the baseline median hardness of* 28 mg/L as $CaCO_3$.
Ammonia guidelines assumes a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).
NP=none proposed.

4.3.1.1 Sulfate

Concentrations of sulfate within Brucejack Creek (Figure 4-27) are predicted to be similar to predictions made in the 2015 MA-EMA model and remain below the BC FWAL 30-day guideline. The concentration profile for sulfate at BJ 2.62 shows seasonal fluctuations and an overall gradual decrease throughout Closure, with values returning to background ranges during Post-Closure.

Concentrations of sulfate at BJ 2.62 reflect concentrations at BJ 3.10, which are primarily derived from tailings slurry deposition in Brucejack Lake and seasonal background contributions from Camp Creek (Table 3-2, Figure 4-2 and Figure 4-3). No additional contributions of sulfate are anticipated via groundwater flow from the flooded mine.

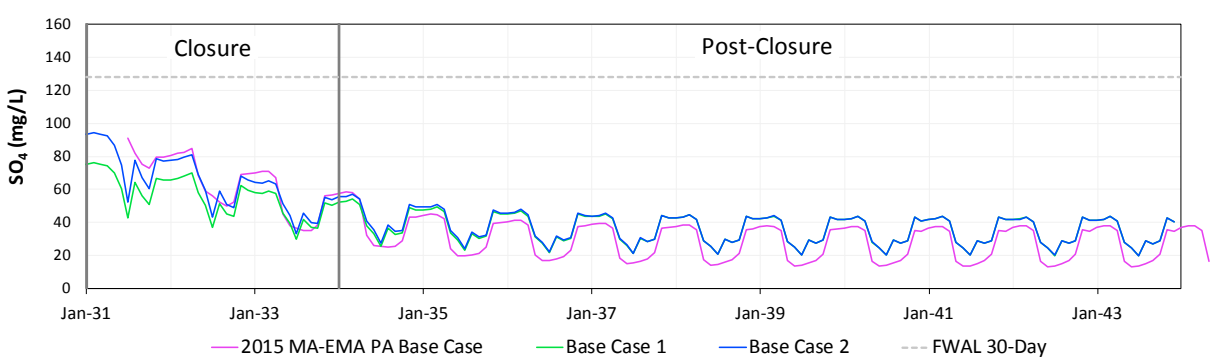


Figure 4-27: Base Case sulfate concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.2 Ammonia

Concentrations of ammonia at BJ 2.62 in upper Brucejack Creek are predicted to be initially elevated above the FWAL 30-day (1.1 mg/L) guideline, but below the FWAL maximum (5.7 mg/L) at the beginning of Closure for both scenarios (Figure 4-28). During Closure, the concentrations of ammonia are predicted to be higher than modelled for the 2015 MA-EMA Permits Application due to revisions to the approach for deriving N loads and the increased production rate. Ammonia concentrations are predicted to decrease below the FWAL 30-day guideline during Closure due to the cessation of blasting and deposition of waste in Brucejack Lake.

Concentrations of ammonia at BJ 2.62 reflect the elevated concentrations at BJ 3.10 (Figure 4-4), which are principally from blasting residues on waste rock and tailings deposited in Brucejack Lake. As described previously (Section 3.8.2) secondary microbially-mediated nitrification processes promote non-conservative behavior of ammonia in Brucejack Lake. To address uncertainty regarding the rate of nitrification, conservative behaviour is modelled for ammonia to represent an upper ammonia concentration endpoint consistent low rates of nitrification. Once blasting activities cease, no additional contributions are expected via groundwater flow from the flooded underground mine.

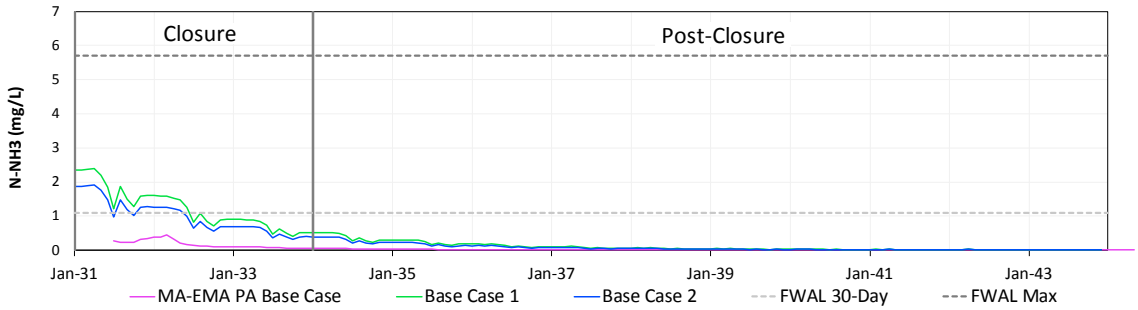


Figure 4-28: Base Case ammonia concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.3 Nitrite

Concentrations of nitrite at BJ 2.62 in upper Brucejack Creek are predicted to be initially elevated above the FWAL 30-day (0.020 mg/L) and maximum (0.060 mg/L) guidelines at the beginning of Closure for both scenarios (Figure 4-29). During Closure, the concentrations of nitrite are predicted to be higher than modelled for the 2015 MA-EMA Permits Application due to revision of the nitrite source terms as was discussed previously in Section 4.2.1.2. Nitrite concentrations are predicted to decrease below the maximum guideline during Closure and below the 30-day guideline during Post-Closure due to the cessation of blasting and deposition of waste in Brucejack Lake.

Concentrations of nitrite at BJ 2.62 reflect the elevated concentrations at BJ 3.10 (Figure 4-7), which are principally from blasting residues on waste rock and tailings deposited in Brucejack Lake. Once blasting activities cease, no additional contributions are expected via groundwater flow from the flooded underground mine.

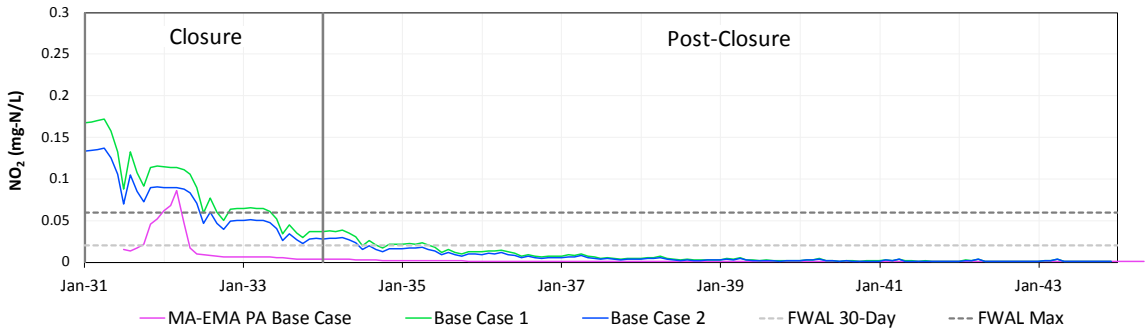


Figure 4-29: Base Case nitrite concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.4 Nitrate

Concentrations of nitrate at BJ 2.62 in upper Brucejack Creek are predicted to be initially elevated above the FWAL 30-day (3.0 mg/L) guideline at the beginning of Closure for both scenarios (Figure 4-30) and higher than the concentrations predicted by the 2015 MA-EMA model. The increase is due to revision of the nitrite source terms for the current (2018) water quality model as was discussed previously in Section 4.2.1.3. Slightly higher concentrations of nitrate are predicted for Scenario 1 (5.8 mg/L) in comparison to Scenario 2 (5.3 mg/L), reflecting the increased waste rock placement in the lake for Scenario 1. Concentrations of nitrate are predicted to decrease rapidly to concentrations below the guideline during Closure and return to background levels Post-closure.

Concentrations of nitrate at BJ 2.62 reflect the elevated concentrations at BJ 3.10 Figure 4-8), which are derived primarily from blasting residues on waste rock and tailings deposited in Brucejack Lake. As described in Section 3.8.2, secondary microbially-mediated nitrification processes in Brucejack Lake convert ammonia and nitrite to nitrate. Nitrate predictions conservatively assume a high nitrification rate in the lake and thus represent upper nitrate concentration endpoints. Once blasting activities cease, no additional contributions are expected via groundwater flow from the flooded underground mine.

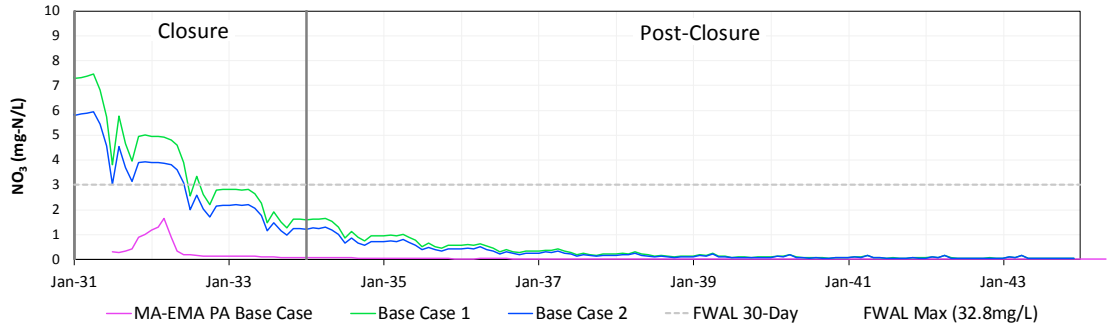


Figure 4-30: Base Case nitrate concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.5 Arsenic

Concentrations of T-As at BJ 2.62 in upper Brucejack Creek are predicted to show strong seasonal fluctuations and exceed the BC FWAL maximum guideline (0.005 mg/L) on a seasonal basis throughout Closure and Post-closure for both scenarios (Figure 4-31). Seasonally high concentrations of ~0.010 mg/L As are predicted for both Base Case scenarios. Concentrations of As are predicted to be lower than the concentrations predicted by the 2015 MA-EMA model, which predicted maximum values of 0.033 mg/L As during Closure.

Concentrations of As in Upper Brucejack Creek throughout the Closure and Post-closure phases are predicted to be higher by up to an order of magnitude in comparison to concentrations in Brucejack Lake (Figure 4-11), reflecting the additional As contributions in groundwater flow from the flooded underground mine.

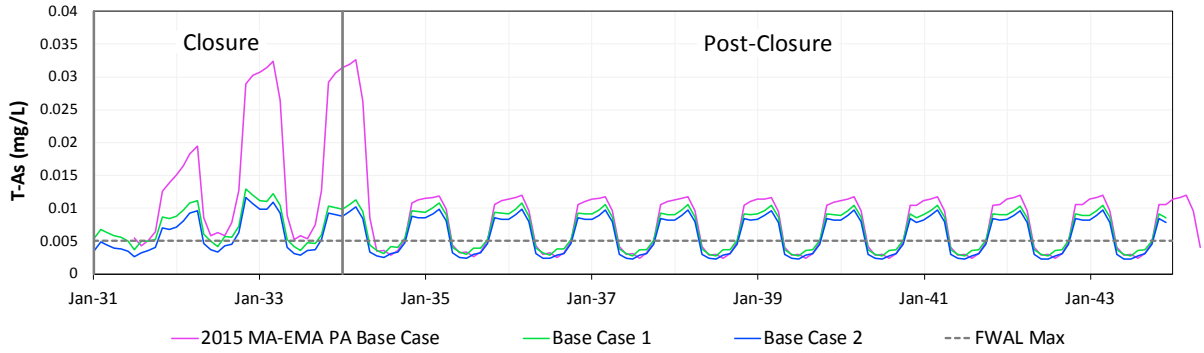


Figure 4-31: Base Case total arsenic concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.6 Antimony

Concentrations of T-Sb at BJ 2.62 in upper Brucejack Creek are predicted to exceed the BC FWAL maximum guideline (0.009 mg/L) on a seasonal basis throughout the Closure phase for both Base Case scenarios (Figure 4-32). Concentrations of Sb are predicted to

decrease from ~0.014 mg/L to below the FWAL guideline at the end of Closure and remain low (0.0020 mg/L) throughout Post-closure.

Concentrations of Sb in upper Brucejack Creek are predicted to be slightly higher in comparison to the concentrations predicted for Brucejack Lake (BJ 3.10) Post-closure (<0.0010 mg/L), reflecting minor contributions from the flooded underground mine via subsurface flow.

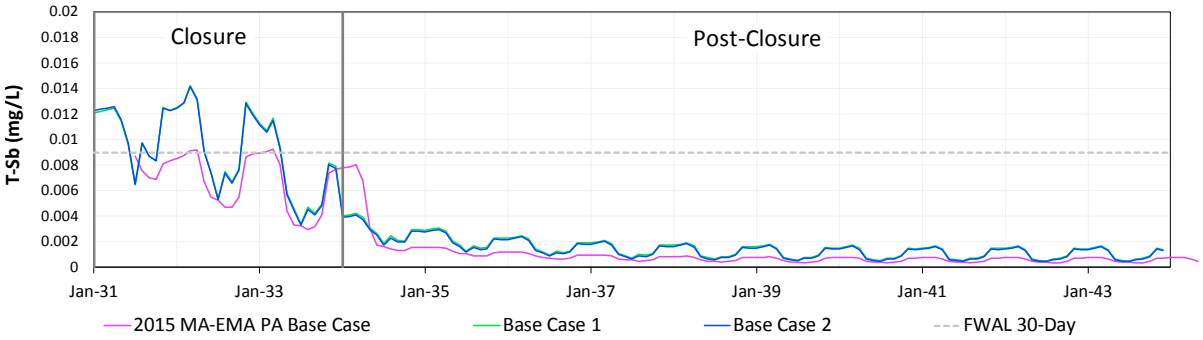


Figure 4-32: Base Case total antimony concentration predictions at BJ 2.62 through Closure and Post-closure mine phases. Note that the current Base Case profiles overlap.

4.3.1.7 Iron

Concentrations of T-Fe and D-Fe show strong seasonal fluctuations in upper Brucejack Creek and are predicted to exceed the respective BC FWAL maximum guidelines (1.0 and 0.30 mg/L) on a seasonal basis at BJ 2.62 throughout Closure and Post-closure for both Base Case scenarios (Figure 4-33). Concentrations of Fe in Brucejack Creek are initially below the guideline at the beginning of Closure, but are predicted to increase to seasonal maxima of approximately 3.3 mg/L T-Fe and 3.0 mg/L D-Fe during Post-closure. Higher concentrations of Fe are predicted in comparison to the 2015 MA-EMA model, with D-Fe comprising a majority of the T-Fe.

Concentrations of T-Fe in Brucejack Lake is predicted to be relatively stable at 0.20 mg/L throughout Closure and Post-closure (Appendix 3.2), demonstrating that the elevated concentrations of T-Fe and D-Fe during the Post-closure phases are primarily attributed to inputs via groundwater flow from the flooded underground workings, and seasonal background contributions from Camp Creek (Table 3-2).

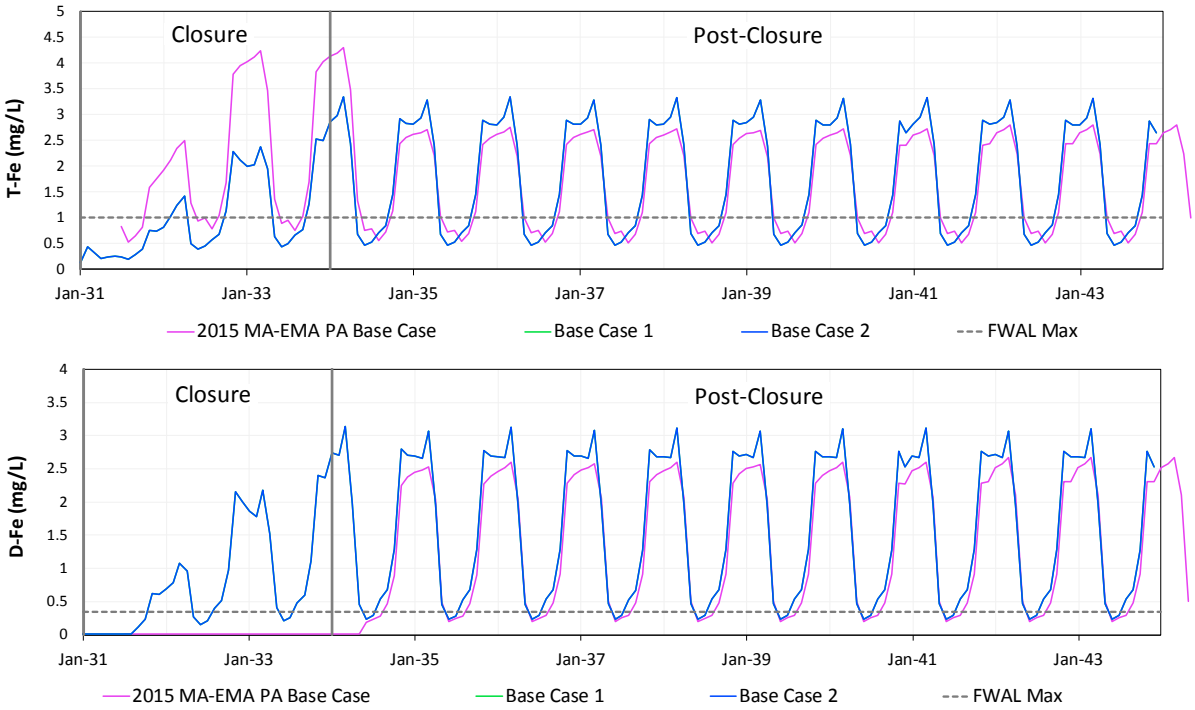


Figure 4-33: Base Case concentration predictions for total iron (upper plot) and dissolved iron (lower plot) at BJ 2.62 through Closure and Post-closure mine phases. Note that the current Base Case profiles overlap.

4.3.1.8 Silver

Concentrations of T-Ag in upper Brucejack Creek are predicted to exceed the BC FWAL 30-day guideline (0.000050 mg/L) on a seasonal basis during Closure for both Base Case scenarios (Figure 4-34). Silver is predicted to decrease through Closure and remain low (<0.000045 mg/L) and below the guidelines throughout Post-closure. Predicted values for silver are lower by nearly an order of magnitude in comparison to concentrations predicted by the 2015 MA-EMA model.

The concentration profile for Ag in Brucejack Creek is similar to that of Brucejack Lake; however, a slightly higher concentration is noted in the creek through Post-closure. The slightly higher concentrations of Ag in Brucejack Creek in comparison to Brucejack Lake indicate a potential minor contribution of Ag to the creek via groundwater flows from the flooded underground mine and/or seasonal background contributions from Camp Creek (Table 3-2).

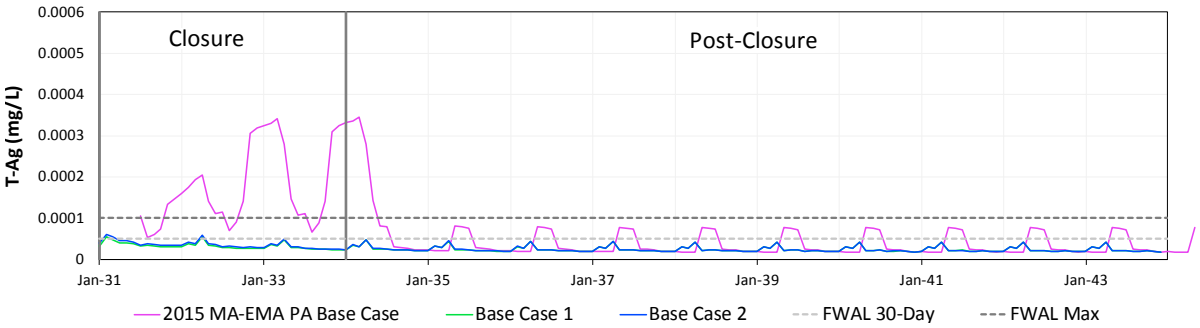


Figure 4-34: Base Case concentration predictions for total silver at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.9 Zinc

Concentrations of T-Zn at BJ 2.62 in upper Brucejack Creek show seasonal fluctuations (~0.0035 to ~0.0075 mg/L) which are predicted to periodically approach the BC FWAL 30-day guideline (0.0075 mg/L) during the Closure and Post-closure phases for both Base Case scenarios (Figure 4-35). The current predictions are slightly lower in comparison to the 2015 MA-EMA model predictions. Concentration ranges in Brucejack Creek are higher in comparison to Brucejack Lake (~0.0020 mg/L), reflecting seasonally high background contributions from Camp Creek (Table 3-2).

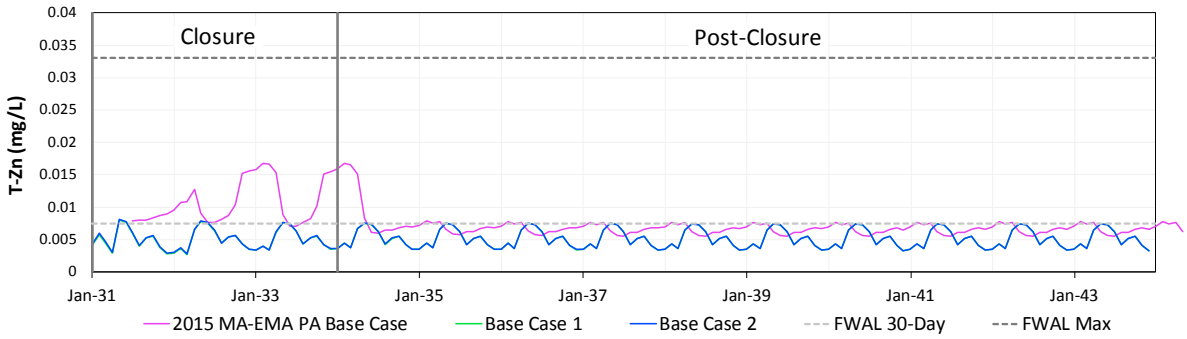


Figure 4-35: Base Case total zinc concentration predictions at BJ 2.62 through Closure and Post-closure mine phases. Note that the current Base Case profiles overlap.

4.3.1.10 Phosphorus

Concentrations of T-P at BJ 2.62 in Brucejack Creek are predicted to be low at the end of Operations (0.020 mg/L) and decrease throughout Closure and Post-closure (Figure 4-36). Current predictions are lower in comparison to the 2015 MA-EMA model, which predicted that P would show large seasonal fluctuations in Brucejack Creek and reach a maximum value of 0.12 mg/L during Closure. Concentrations of P in Brucejack Creek during Post-closure reflect concentrations predicted for Brucejack Lake indicating little to no additional contributions from other sources.

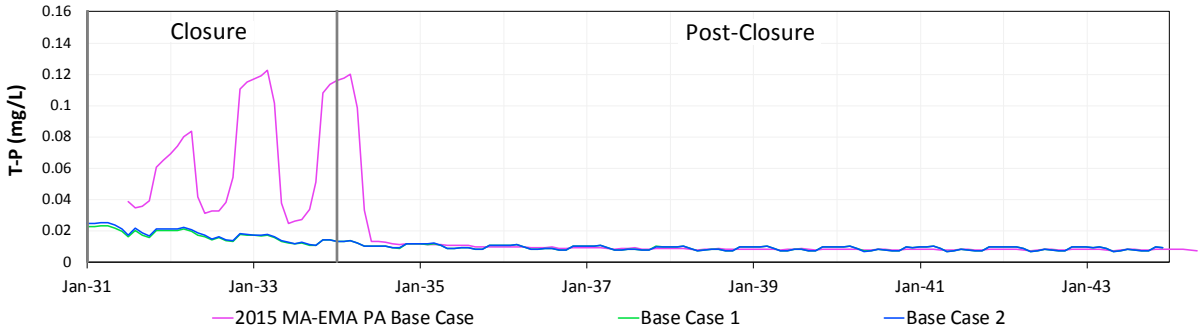


Figure 4-36: Base Case total phosphorus concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.11 Chromium

Concentrations of T-Cr at BJ 2.62 in Brucejack Creek are predicted to be low and below the BC FWAL 30-day guideline (0.0010 mg/L) throughout Closure and Post-closure for both Base Case scenarios (Figure 4-37). Current model predictions are lower throughout the Closure phase in comparison to the 2015 MA-EMA model, which predicted that Cr would be elevated in Brucejack Creek at the end of Operations and decrease in steps throughout mine Closure. Concentrations of Cr in Brucejack Creek are predicted to have minor seasonal fluctuations (0.00020 to ~0.00065 mg/L), but at ranges generally slightly higher than in Brucejack Lake (0.00015 to ~0.00018 mg/L) through Post-closure, reflecting minor contributions from the flooded underground mine as well as seasonal background contributions from Camp Creek (Table 3-2).

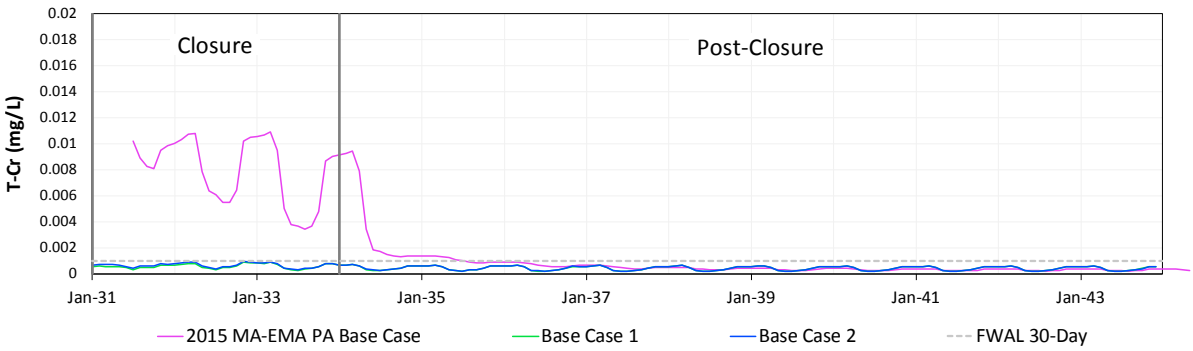


Figure 4-37: Base Case total chromium concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.1.12 Copper

Concentration of T-Cu at BJ 2.62 in Brucejack Creek are predicted to show seasonal fluctuations ranging from 0.00056 to 0.0016 mg/L, but remain stable and well below the BC FWAL 30-day (0.0020 mg/L) and maximum (0.0046 mg/L) guidelines through Closure and Post-closure for both Base Case scenarios (Figure 4-38). Current predictions

for Closure are lower in comparison to the 2015 MA-EMA predictions, which showed large seasonal fluctuations of up to a maximum of nearly 0.007 mg/L T-Cu and exceeded the maximum guideline on a seasonal basis. Predicted concentrations of Cu in Brucejack Creek are similar to the predicted concentrations in Brucejack Lake (~0.00047 – 0.00053 mg/L), reflecting natural background concentration ranges in the creek (Table 3-3).

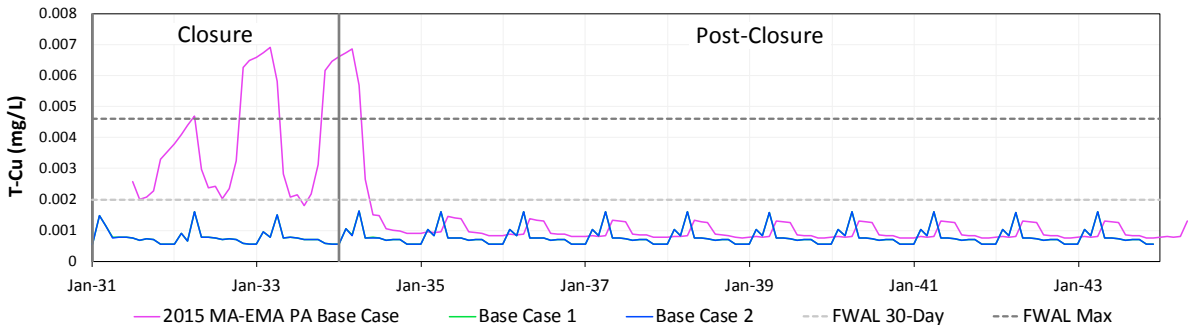


Figure 4-38: Base Case total chromium concentration predictions at BJ 2.62 through Closure and Post-closure mine phases. Note that the current Base Case profiles overlap.

4.3.2 Upper Case Results

The Base Case results summarized above represent conservative water quality predictions for upper Brucejack Creek and make a reasonable allowance for any potential variability in model input. However, as discussed in Section 4.2.2, some residual uncertainty remains and an Upper Case scenario, whereby ML/ARD develops more rapidly and to a greater extent than expected in the underground mine after Operations have ceased, was modelled to evaluate potential effects from groundwater flow that could lead to higher than expected concentrations for certain water quality parameters once the mine has flooded.

Upper Case predictions for sulfate, T-As and T-Sb in Brucejack Creek are presented, as these parameters are strongly influenced by the time to onset and severity of ML/ARD. Water quality time series plots are presented for these parameters below. Tabulated results for all parameters (as monthly maxima by mine phase) are provided in Appendix 3-2.

4.3.2.1 Sulfate

Upper Case predictions of sulfate at BJ 2.62 in Brucejack Creek exceed the BC FWAL 30-day guideline (128 mg/L) on a seasonal basis for both scenarios at the beginning of the Closure phase (Figure 4-39). Upper Case concentrations of sulfate are predicted to progressively decrease through Closure and approach the predicted Base Case concentration ranges Post-closure.

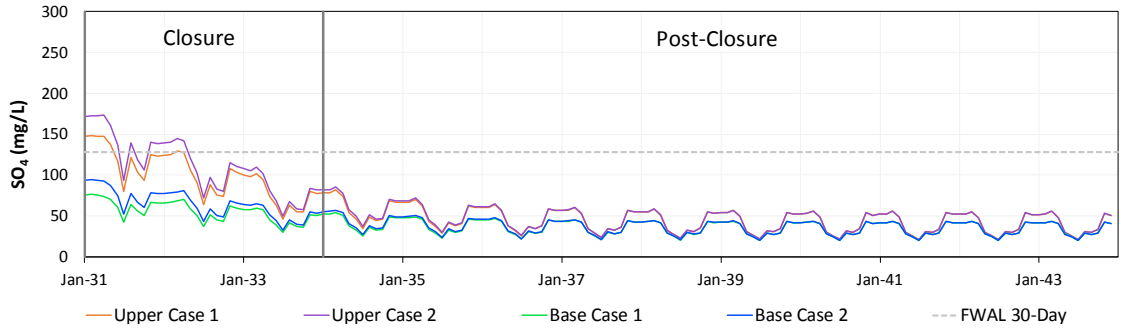


Figure 4-39: Upper Case sulfate concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.2.2 Arsenic

Upper Case predictions for T-As at BJ 2.62 in Brucejack Creek show strong seasonal fluctuations and generally exceed the BC FWAL maximum guideline (0.005 mg/L) through Closure and Post-closure for both scenarios (Figure 4-40). The concentration profile for Upper Case predictions mirrors the concentration profile for Base Case, but at concentrations nearly twice that predicted for Base Case.

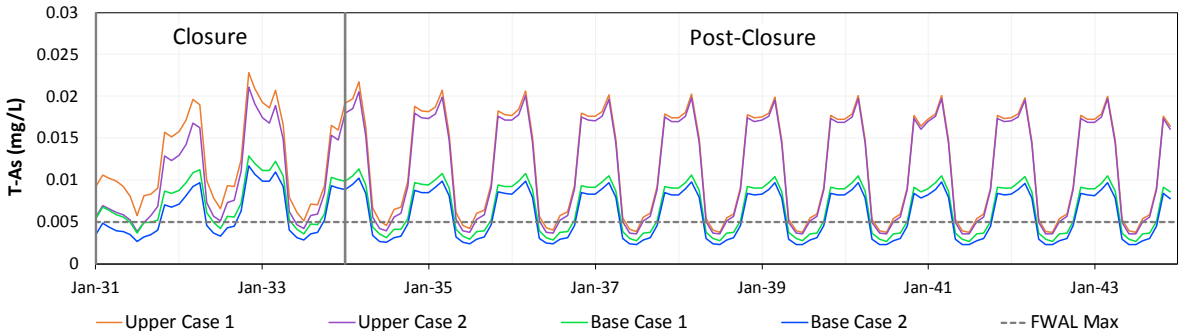


Figure 4-40: Upper Case total arsenic concentration predictions at BJ 2.62 through Closure and Post-closure mine phases.

4.3.2.3 Antimony

Upper Case concentrations of T-Sb at BJ 2.62 in Brucejack Creek are predicted to exceed the BC FWAL 30-day guideline (0.009 mg/L) throughout most of the Closure phase for both scenarios (Figure 4-41). Upper Case predictions show a progressive decrease from ~0.026 mg/L to below the guideline at the end of the Closure phase and return to background levels (~0.00050 mg/L) during the Post-closure period.

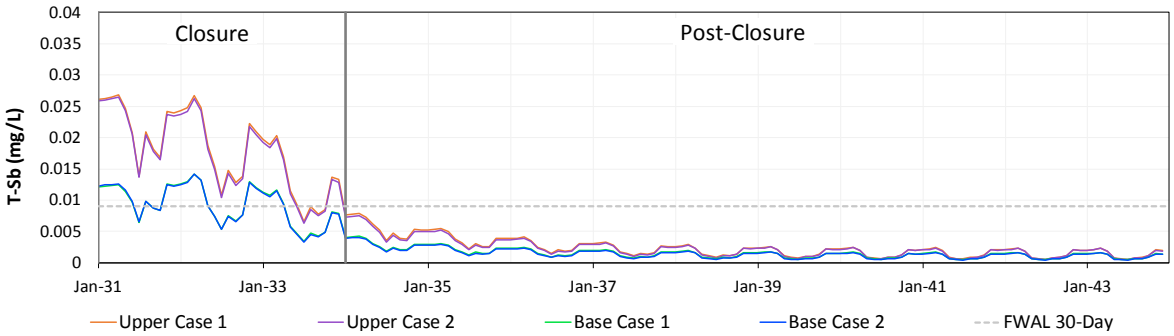


Figure 4-41: Upper Case total antimony concentration predictions at BJ 2.62 through Closure and Post-closure mine phases. Note that the current Upper Case profiles overlap.

5. Effects Assessment

PRETIVM

5. Effects Assessment

5.1 Residual Effects Assessment

5.1.1 Risk Assessment Process

Potential risks to water quality from the proposed mining rate are initially assessed by identifying parameters of potential concern (Section 5.1.2). These are parameters that the Base Case water quality model predicts will have a higher concentration than has previously been assessed for any phase of mine life. Potential effects to receptors (Figure 5-1) are then assessed for each parameter of potential concern (POPC). The primary assessment endpoint is the potential for chronic toxicity to occur through exposure to a POPC.

Human health (Section 5.3) is assessed, although humans will not be exposed to mine effluent through drinking water. Aquatic life that may be exposed to contaminants are described in the Ecological Context section of the effects assessment. Terrestrial wildlife may be exposed to POPCs by using Brucejack Creek as drinking water. Exposure of terrestrial wildlife to POPCs in Brucejack Creek will be infrequent due to it being a high elevation stream surrounded by glaciers, and due to the short growing season. In contrast, aquatic life in Brucejack Creek will experience continuous exposure to POPCs in effluent. BC water quality guidelines indicate that aquatic life is more sensitive than terrestrial wildlife to toxicity from most contaminants in water; therefore, potential effects to terrestrial wildlife are assessed only for POPCs that have the potential to cause significant effects to aquatic life. If the potential for significant effects to aquatic life is considered low or not significant, then it is assumed that potential effects to terrestrial wildlife are not significant.

Bioaccumulation is not considered in the effects assessment, because the aquatic life communities do not possess the potential for significant bioaccumulation to occur. The aquatic life community in the receiving environment is limited to primary producers (periphyton) and secondary producers (benthic invertebrates). There is negligible potential for transfer of contaminants in benthic invertebrate tissues to fish, because fish habitat is too far downstream from Brucejack Creek (approximately 20 km) for invertebrates from this stream to serve as food to fish.

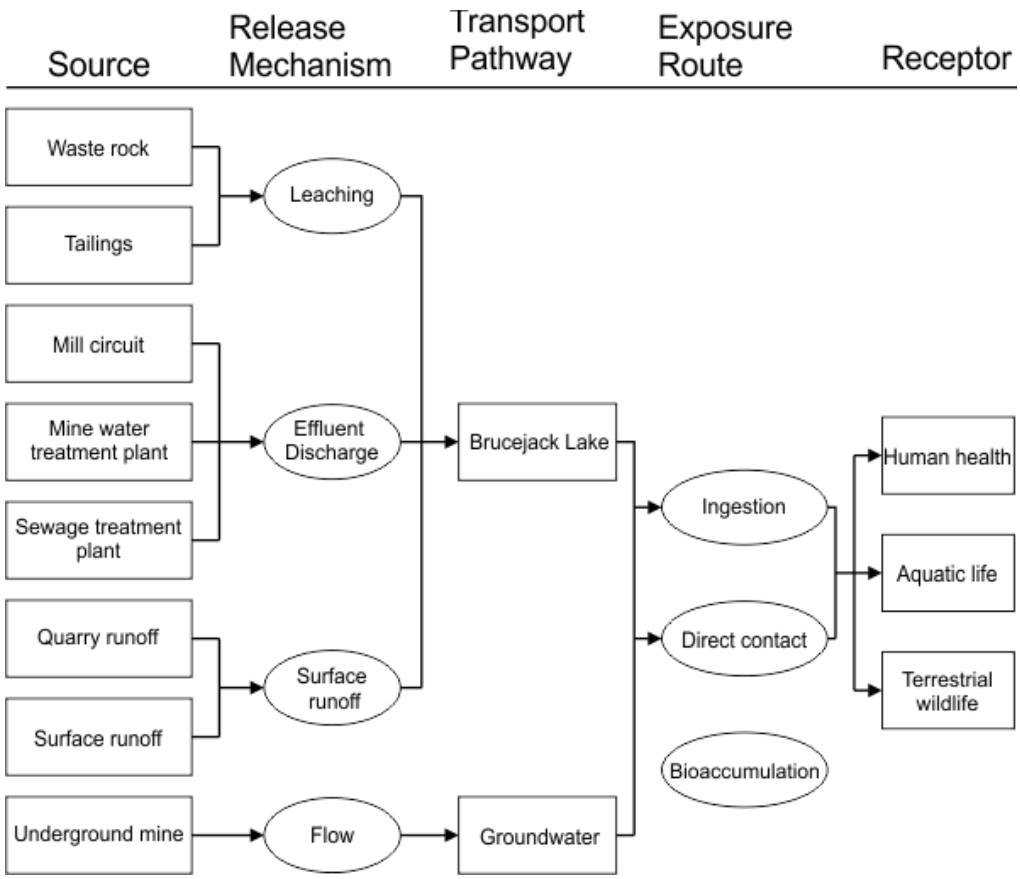


Figure 5-1: Conceptual model of contaminant transport to receptors.

5.1.2 Parameters of Potential Concern

Parameters of potential concern (POPCs) that were evaluated in the 2015 MA-EMA Permits Application and subsequent amendment applications were nitrate, nitrite, total arsenic, total beryllium, total chromium, total copper, total and dissolved iron, total phosphorus, total silver, and total zinc. The residual effects assessments of these parameters concluded that the maximum predicted Base Case concentrations would not have a significant effect on aquatic life (NO_2, NO_3, T-As, T-Be, T-Cr, T-Cu, T-Ag, T-Zn) or would have an effect of low significance (D-Fe, T-Fe, P-T).

The updated Base Case model for the production increase application predicts that the concentration of most parameters will be less than the concentrations evaluated previously, except for ammonia, antimony, arsenic, iron, and zinc. Other parameters have maximum modelled concentrations that are less than BC FWAL guidelines (Table 4-1). Ammonia, antimony, arsenic, iron, and zinc are the parameters in the updated model with Base Case predicted concentrations that are greater than previously assessed and that are greater at some stage of mine life than either the effluent discharge limit in PE-107835 or the BC

FWAL guideline (Table 5-1 and Table 5-2). These parameters will be assessed for potential residual effects and, as applicable, cumulative effects.

Table 5-1:
Maximum Concentrations from the BJ 3.10 Base Case Water Quality Model for All Mine Phases, Compared to the Maximum from the 2015 MA-EMA Permits Application, BC Water Quality Guidelines, and Effluent Discharge Limits

		Maximum Modelled		BC FWAL Guidelines		Effluent Discharge Limit
Parameter	**Units**	**2017 3800 tpd Application**	**2015 MA-EMA**	**Long-term**	**Short-term**	
Ammonia	mg/L	**2.8**	0.48	1.1	5.7	1.0
Antimony-T	µg/L	**13**	**10**	9	NP	NP
Arsenic-T	µg/L	***7***	***6***	NP	5	5

Notes: BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Ammonia guideline applies to pH 8.0 and 15 °C.
Concentrations that exceed long-term guidelines are shown in **bold** font.
Concentrations that exceed short-term guidelines are shown as ***bold italic underlined*** font.
NP=none proposed.

Table 5-2:
Maximum Concentrations from the BJ 2.62 Base Case Water Quality Model, for Closure and Post-closure Project Phases, Compared to the Maximum from the MA-EMA Permits Application, BC Water Quality Guidelines, and Effluent Discharge Limits

		Maximum Modelled		BC FWAL Guidelines		Effluent Discharge Limit
Parameter	**Units**	**2017 3800 tpd Application**	**2015 MA-EMA**	**Long-term**	**Short-term**	
Ammonia	mg/L	**2.8**	0.44	1.1	5.7	1.0
Antimony-T	µg/L	**14**	2	9	NP	NP
Arsenic-T	µg/L	***13***	***12***	NP	5	5
Iron-D	mg/L	***3.13***	***2.67***	NP	0.35	NP
Iron-T	mg/L	***3.34***	***2.80***	NP	1.00	1.7
Zinc-T	µg/L	**8.6**	**8.5**	7.5	33	7.5

Notes: BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Ammonia guideline applies to pH 8.0 and 15 °C.
Concentrations that exceed long-term guidelines are shown in **bold** font.
Concentrations that exceed short-term guidelines are shown as ***bold italic underlined*** font.
Zinc guidelines calculated assuming a median baseline hardness of 28 mg/L as $CaCO_3$.
NP=none proposed.

5.1.3 Method of Characterizing Residual Effects

Potential residual effects of predicted water quality on the aquatic community in Brucejack Creek were assessed using the following criteria:

- **Geographic Extent**: the spatial scale over which the residual effect is expected to occur;

- **Ecological Context**: the ecological value or unique attributes of the aquatic community;
- **Toxicity**: characterization of potential toxic effects to the aquatic community;
- **Magnitude**: the expected magnitude or severity of the residual effect;
- **Duration**: the length of time the effect lasts;
- **Frequency**: how often the effect occurs;
- **Reversibility**: the degree to which effects to water quality can be mitigated or reversed; and
- **Resiliency**: the capacity of the aquatic community to recover from major changes in structure and function following disturbances.

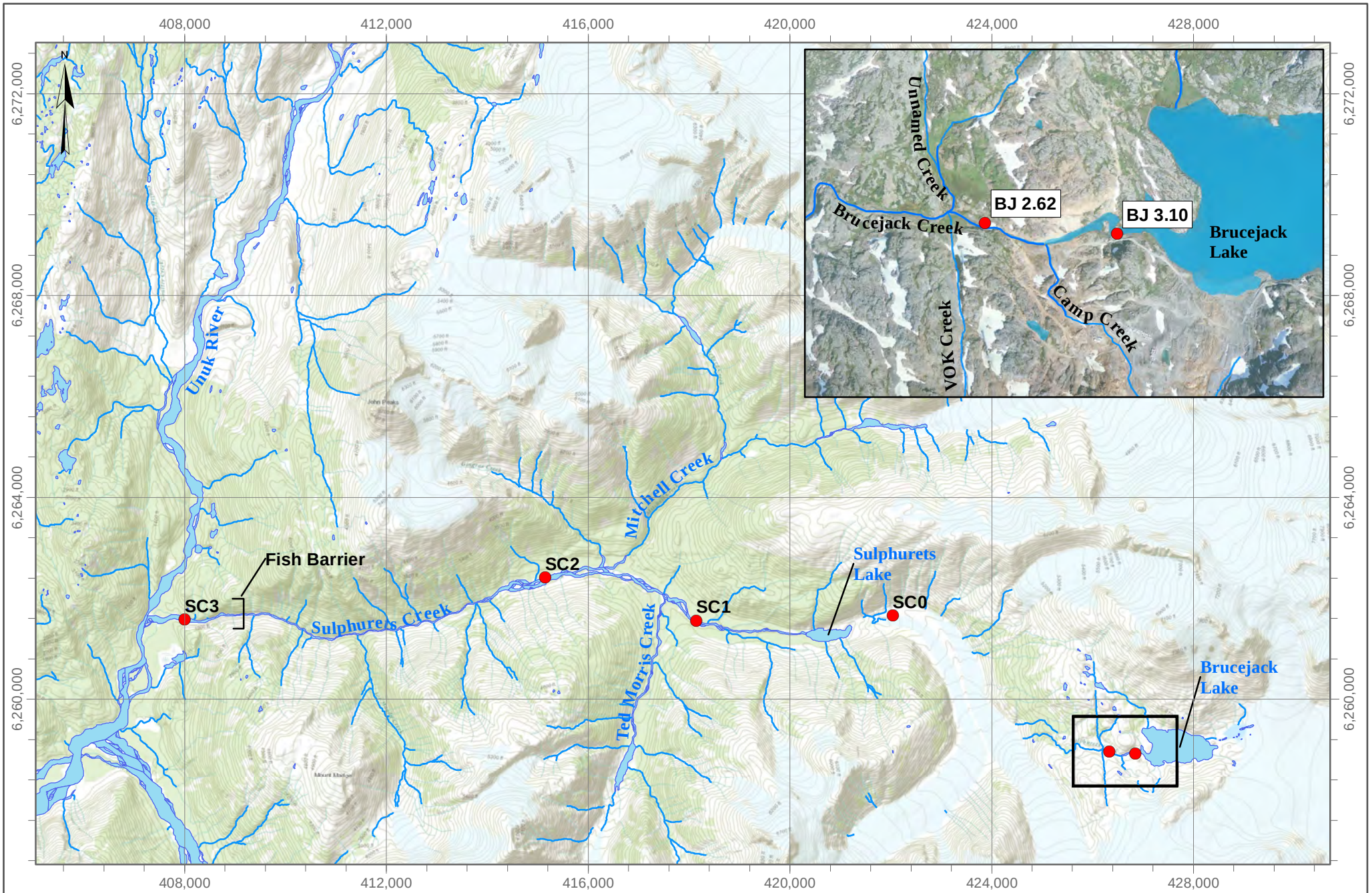
A determination of significance was assigned for each POPC based on the characterization of these criteria. An assessment of the likelihood that a significant effect to aquatic life will occur was made, as well as a rating of the confidence in the assessment. These are described in the following subsections for each POPC. Monitoring sites in the receiving environment that are relevant to the effects assessment are presented in Figure 5-2.

5.1.4 Geographic Extent

The geographic extent of potential effects is defined by the area which is predicted to have a POPC concentration that is above a BC FWAL guideline, using the following classification:

- **Local:** predicted concentration is above the BW FWAL guideline in Brucejack Creek only;
- **Landscape:** predicted concentration is above the BW FWAL guideline in Sulphurets Creek at site SC0 (Figure 5-2); and
- **Regional:** predicted concentration is above the BW FWAL guideline at the mouth of Sulphurets Creek at site SC3 (Figure 5-2).

There is little dilution between the headwaters of Brucejack Creek and the confluence with Sulphurets Creek under the Sulphurets Glacier; therefore, it can be assumed that a predicted POPC concentration that is above the current discharge limit at BJ 3.10 will be above the limit throughout the 3 km length of Brucejack Creek.



LEGEND

● Water Quality Monitoring Station

DATE SAVED:	Dec 11, 2017
DRAWN BY:	GM
REVIEWED:	AS
VERSION:	1

Coordinate System: *NAD 1983 UTM Zone 9N*
Projection: *Transverse Mercator*
Datum: *North American 1983*
Units: *Meter*

1:100,000

0 1 2
Kilometers

CLIENT: PRETIVM

LORAX ENVIRONMENTAL

PROJECT: **Brucejack Mine Water Quality Model Update**

TITLE: Receiving Environment Water Quality Monitoring Sites

PROJECT #: A406-5

FIGURE: 5-2

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The amount of mixing with Sulphurets Creek water that will be required to lower the concentration of a POPC to equal the BC FWAL guideline can be calculated using the following mass balance equation:

$$V_2 = \frac{C_1 V_1 - C_f V_1}{C_f - C_2}$$

where: C_1 = concentration at BJ 3.10
C_2 = background concentration
C_f = final concentration, set to the BC FWAL guideline
V_1 = discharge at BJ 3.10 (set to 1)
V_2 = discharge at SC0

The mixing requirement to produce a concentration that is equal to the BC FWAL guideline can be compared to estimates of mixing of Brucejack Lake effluent that occur at various locations in Sulphurets Creek (Figure 5-3). The proportion of Brucejack Lake effluent that makes up the total flow varies seasonally. Highest dilution occurs in summer months (July through October). Lower dilution is estimated during the rest of the year (November through June). This seasonality in mixing ratios will be taken into account when evaluating geographic extent of an effect on water quality. Monthly predictions of concentrations of POPCs were typically highest during low flow months (October through April) than during high flow months (May through September). Thus, highest annual predictions occur during lowest annual potential dilution in Sulphurets Creek. Therefore, geographic extent will be evaluated separately for high flow months and low flow months.

At the site SC0, just below the Sulphurets Glacier and the confluence with Brucejack Creek, the minimum ratio of 6:1 (6 parts background Sulphurets Creek water to 1 part Brucejack Lake effluent) occurs in December (Figure 5-3). Therefore, if the dilution required to meet the BC FWAL guideline for a POPC is <6:1, the geographic extent for the effects assessment is considered **local**. If the required dilution is >6:1, then the seasonality of the predicted concentration for a given POPC will be evaluated to determine if the geographic extent is **landscape** or **regional**.

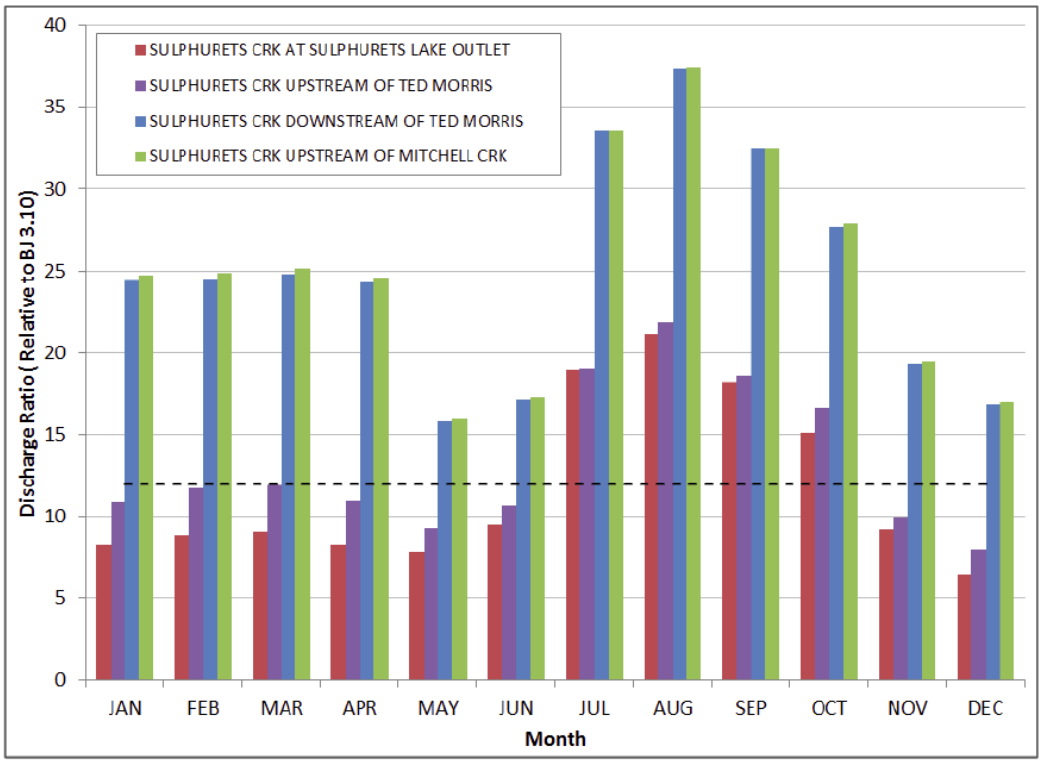

Figure 5-3: Streamflow discharge ratios at nodes along Sulphurets Creek relative to discharge at BJ 3.10. Figure is copied from Plate 1 in ERM's Hydrology memo included as Appendix 4.

5.1.5 Ecological Context

The ecological context of the receiving environment is the same for all POPCs. Brucejack Creek and most of Sulphurets Creek are non-fish-bearing streams. In Sulphurets Creek, the upper limit of fish distribution is defined by a fish barrier approximately 1.3 km upstream of the Unuk River confluence (Figure 5-2). Overall, the distance between the outlet of Brucejack Lake and fish habitat is approximately 20 km. No amphibians have been noted during ecological surveys of these streams. Aquatic life in these non-fish-bearing water courses is therefore limited to benthic invertebrates and periphyton.

Baseline surveys in 2014 and 2015, and Operations phase surveys in 2016 and 2017, of benthic invertebrate communities in Brucejack Creek show that the assemblage is composed predominantly of chironomids (midges) and annelids (oligochaete worms) (Figure 5-4). Other taxa were rarely captured. The highest relative percentage of other taxa was 9% Ephemeroptera (mayflies) at BJ 0.27 in 2015, although it should be noted that total abundance of invertebrates at that station was low compared to other stations surveyed that year. Only chironomids were found at SC0, in both the 2014 and 2015 surveys. Stoneflies were present at SC0 in 2016 and 2017, but total abundance of invertebrates at

SC0 was very low compared to Brucejack Creek sites. The Brucejack and Sulphurets communities differed markedly from the reference creek (site L3 OF) which had a high proportion of mayflies and stoneflies.

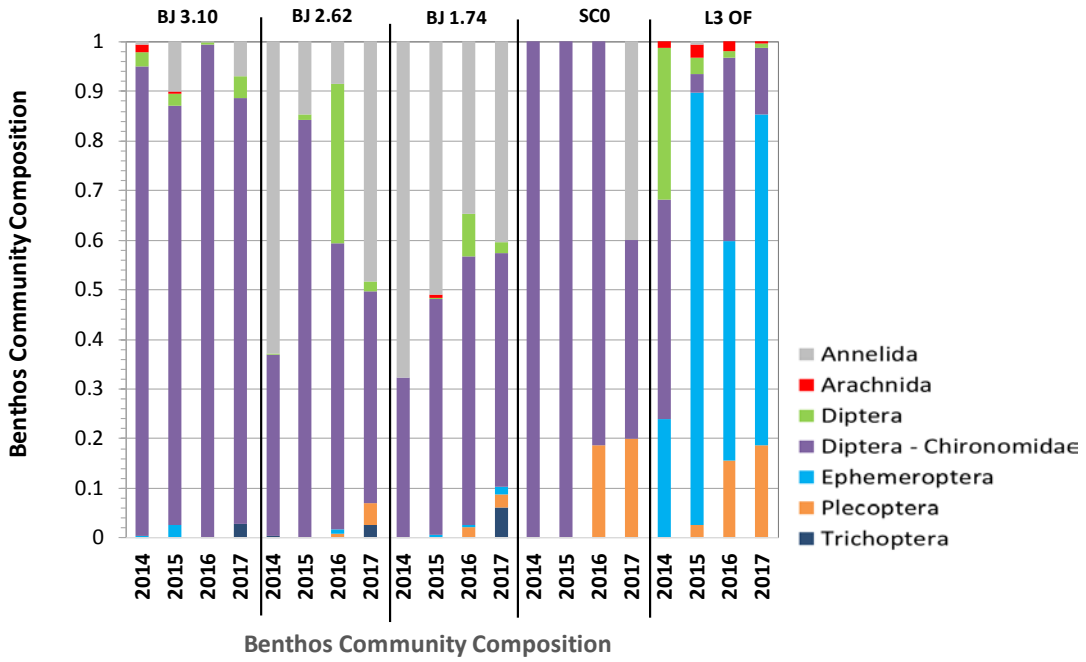

Figure 5-4: Benthic invertebrate community composition by major taxon for Brucejack Creek, upper Sulphurets Creek, & reference lake L3 outfall.

Periphyton surveys in Brucejack Creek have found algal slimes on rocks composed of chlorophytes and diatom species. Macroalgae were not present.

Based on the biological monitoring data for Brucejack Creek and Sulphurets Creek, the ecological context of the receiving environment is considered **low**. There are no fish present for 20 km from the effluent discharge point. Brucejack Creek benthic invertebrate community does not represent a food source to fish at the mouth of Sulphurets Creek. The benthic invertebrate communities include a low number of taxa, almost entirely chironomids and annelids. These taxa are common throughout the province.

5.1.6 Ammonia

5.1.6.1 Introduction

The ammonia concentration in Brucejack Creek is predicted to increase during the Operations phase of mining, then decrease during Closure and Post-closure (Figure 4-4). The Base Case model predicts ammonia will increase to a maximum of 2.8 mg-N/L (Table 5-1) during Operations. The Upper Case model predicts a maximum of 4.0 mg-N/L (Figure 4-22). Pretivm is requesting that PE-107835 be amended to change the ammonia

discharge limit at BJ 3.10 from 1 to 4 mg-N/L. Therefore, the potential effect to aquatic life of discharging effluent with an ammonia concentration of 4 mg-N/L is assessed below.

5.1.6.2 Geographic Extent

The mixing ratio to lower the concentration of ammonia from 4 mg-N/L in Brucejack Creek to 0.88 mg-N/L at SC0 is 3.5:1, in both high flow and low flow months (Table 5-3). A final concentration of 0.88 mg-N/L is used because that value is a minimum BC FWAL guideline for ammonia at SC0, calculated from a pH of 8.1 and temperature of 12 °C. A pH of 8.1 is the 95th percentile baseline pH at SC0 and 12 °C is a maximum temperature at SC0. Baseline ammonia concentration at site SC0 was 0.0025 mg-N/L during high flow months, and 0.0065 mg-N/L during low flow months. Since the discharge ratio at SC0 is 6:1 or higher at all time of the year (Figure 5-3); the ammonia concentration in the entire length of Sulphurets Creek will be less than the BC FWAL guideline.

Table 5-3:
Mixing Required to Equal the Ammonia BC Water Quality Guidelines in Sulphurets Creek

Parameter	Flow[1]	C1 [BJ 3.10 (mg-N/L)]	C2 [SC0 (mg-N/L)]	Cf [WQG[2] (mg-N/L)]	V2:V1 Required Mixing
Ammonia	High	4	0.0025	1	3.5 : 1
	Low	4	0.0065	1	3.5 : 1

Notes: 1. High flow months are May through September, low flow October through April.
2. BC working water quality guideline for protection of freshwater aquatic life.

Because mixing of Brucejack Creek water with background water under the Sulphurets Glacier is calculated to reduce the ammonia concentration to less that the BC FWAL guidelines at all times of the year, the geographic extent of potential residual effects is classified as **local**.

5.1.6.3 Toxicity

The BC FWAL guidelines for ammonia (Nordin and Pommen, 2001) were not revised as part of the 2009 update of BC nitrogen guidelines, but it was noted in the overview report that the US EPA was planning an update, and that the BC guidelines would be re-evaluated based on new scientific literature included in the updated US EPA guideline. The US EPA published the updated ammonia guideline in 2013 (USEPA, 2013). The update included new toxicity data showing that freshwater molluscs (mussels and snails) were the most sensitive taxa to ammonia toxicity.

The chronic toxicity data compiled as part the US EPA ammonia guideline derivation show that molluscs (mussels and snails) were the most sensitive taxon to ammonia chronic

toxicity, followed by fish, crustaceans, and insects (Table 5-4). The data available regarding the toxicity of ammonia to freshwater phytoplankton and vascular plants indicate that aquatic plants appear to be two orders of magnitude less sensitive than the aquatic animals tested; therefore, it is assumed that any ammonia criterion appropriate for the protection of freshwater aquatic animals will also be protective of aquatic vegetation (USEPA, 2013).

There were no annelid chronic toxicity data, but annelids were included in the compilation of acute toxicity data (Table 5-5). The ranked acute toxicity data in USEPA (2013) show that molluscs were also the most sensitive taxon to acute toxicity, followed by fish, amphibians, crustaceans, insects, then annelids.

USEPA (2013) derived an acute-to-chronic ratio (ACR) of 6.32 for invertebrates. An ACR is a tool that provides a general idea how sensitive a species is to chronic toxicity, based on the measured acute toxicity data for that species. The value derived from an ACR is not a direct measure of chronic toxicity. Using the ACR to convert acute data to chronic data, the most sensitive species of invertebrate or annelid, which are the taxa found in Brucejack Creek, was the damselfly *Enallagma* sp. (Table 5-5).

Looking at the details of the studies of the most sensitive insects to ammonia toxicity (Table 5-6) shows that the pH at which the tests were conducted (7.7 – 8.0) are close to the pH measured at BJ 3.10 in 2017 (median = 7.8, 95th percentile = 7.9). There were two endpoints for the most sensitive species in chronic toxicity tests, the damselfly *Pteronarcella badia*, which were used to calculate the species mean chronic value of 73.74 mg-N/L (Table 5-4), which were quite different. The lower endpoint was 21.66 mg-N/L (Table 5-6). After converting acute to chronic data, there are two insects with more sensitive endpoints, 14.7 mg-N/L for the damselfly *Enallagma* sp. and 17.1 mg-N/L for the mayfly *Callibaetis* sp. (Table 5-6).

Overall, the toxicity of ammonia to aquatic life is one of the most comprehensively studied of all contaminants. Review of the compiled toxicity dataset for ammonia shows that the benthic invertebrate community in Brucejack Creek, which is comprised of insects and annelid worms, are relatively insensitive to chronic toxicity from ammonia. A discharge of 4 mg-N/L ammonia from BJ 3.10 is 3.7 to 5.4 times lower than the most sensitive chronic endpoints in the literature for invertebrates representative of the Brucejack Creek community. Periphyton are also present in Brucejack Creek, but are much less sensitive to toxicity from ammonia than invertebrates. Therefore, a discharge limit of 4 mg-N/L is considered **unlikely** to cause toxicity to aquatic life in the receiving environment.

Table 5-4:
Ranked Ammonia Chronic Toxicity Endpoints

Rank	Taxon	Common Name	Species	SMCV[1] (mg-N/L)
1	Mollusc	Wavy-rayed lamp mussel	*Lampsilis fasciola*	1.408
2	Mollusc	Fatmucket	*Lampsilis siliquoidea*	3.211
3	Fish	Bluegill	*Lepomis macrochirus*	3.273
4	Mollusc	Rainbow mussel	*Villosa iris*	3.501
5	Fish	Rainbow trout	*Oncorhynchus mykiss*	6.663
6	Mollusc	Long fingernail clam	*Musculium transversum*	7.547
7	Mollusc	Pebblesnail	*Fluminicola* sp.	7.828
8	Fish	Fathead minnow	*Pimephales promelas*	9.187
9	Fish	Sockeye salmon	*Oncorhynchus nerka*	10.09
10	Fish	Smallmouth bass	*Micropterus dolomieu*	11.07
11	Fish	White sucker	*Catostomus commersonii*	11.62
12	Fish	Green sunfish	*Lepomis cyanellus*	14.63
13	Fish	Common carp	*Cyprinus carpio*	16.53
14	Fish	Northern pike	*Esox Lucius*	20.38
15	Fish	Channel catfish	*Ictalurus punctatus*	21.36
16	Fish	Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi*	25.83
17	Crustacean	Amphipod	*Hyalella azteca*	29.17
18	Crustacean	Water flea	*Daphnia magna*	41.46
19	Crustacean	Water flea	*Ceriodaphnia dubia*	45.08
20	Crustacean	Water flea	*Ceriodaphnia acanthine*	64.10
21	Insect	Stonefly	*Pteronarcella badia*	73.74

Notes: 1. SMCV is the species mean chronic value normalized to pH 7.0 and 20 °C.

Table 5-5:
Ranked Acute Toxicity and Converted Species Mean Chronic Values

Taxon	Common Name	Species	SMAV[1]	ACR[2]	SMCV[3]
Crustacean	Water flea	*Daphnia pulicaria*	99.03	6.32	15.7
Crustacean	Amphipod	*Crangonyx* sp.	122.2	6.32	19.3
Crustacean	Water flea	*Ceriodaphnia dubia*	134.2	6.32	21.2
Crustacean	Red swamp crayfish	*Procambarus clarkii*	138	6.32	21.8
Crustacean	Water flea	*Simocephalus vetulus*	142.9	6.32	22.6
Crustacean	Water flea	*Ceriodaphnia acanthine*	154.3	6.32	24.4
Crustacean	Water flea	*Daphnia magna*	157.7	6.32	25.0
Crustacean	Water flea	*Chydorus sphaericus*	162.6	6.32	25.7
Insect	Damselfly	*Enallagma* sp.	164	6.32	25.9
Insect	Mayfly	*Callibaetis* sp.	166.7	6.32	26.4
Annelid	Oligochaete worm	*Limnodrilus hoffmeisteri*	170.2	6.32	26.9
Insect	Stonefly	*Skwala americana*	192.4	6.32	30.4
Crustacean	Amphipod	*Hyalella azteca*	192.6	6.32	30.5
Annelid	Oligochaete worm	*Tubifex tubifex*	216.5	6.32	34.3
Annelid	Oligochaete worm	*Lumbriculus variegatus*	218.7	6.32	34.6
Insect	Dragonfly	*Pachydiplax longipennis*	233	6.32	36.9
Crustacean	Amphipod	*Crangonyx pseudogracilis*	270.5	6.32	42.8
Insect	Mayfly	*Callibaetis skokianus*	364.6	6.32	57.7
Crustacean	Isopod	*Asellus aquaticus*	378.2	6.32	59.8
Insect	Mayfly	*Drunella grandis*	442.4	6.32	70.0
Insect	Midge	*Chironomus tentans*	451.8	6.32	71.5
Insect	Caddisfly	*Philarctus quaeris*	994.5	6.32	157.4
Insect	Midge	*Chironomus riparius*	1029	6.32	162.8
Insect	Damselfly	*Erythromma najas*	2515	6.32	397.9

Notes: 1. SMAV is the species mean acute value normalized to pH 7.0 and 20 °C.
2. ACR is acute-to-chronic ratio.
3. SMCV is the species mean chronic value normalized to pH 7.0 and 20 °C.

Table 5-6:
Test Conditions of the Most Sensitive Insect Species to Chronic Toxicity from Ammonia

Common name	Species	Duration	pH	Temperature	Chronic Endpoint	Acute Endpoint	Reference
Stonefly	*Pteronarcella badia*	30 d	8.04	12.1	133.8		Thurston *et al*. 1984
Stonefly	*Pteronarcella badia*	24 d	7.81	13.2	21.66		Thurston *et al*. 1984
Damselfly	*Enallagma* sp.	4 d	7.9	11.5	*14.7*	93.1	Williams *et al*. 1986
Mayfly	*Callibaetis skokianus*	4 d	7.7	10.8	*41.7*	263.5	Arthur *et al*. 1987
Mayfly	*Callibaetis skokianus*	4 d	7.9	13.3	*33.5*	211.7	West, 1985
Mayfly	*Callibaetis* sp.	4 d	7.81	11.9	*17.1*	107.8	Thurston *et al*. 1984

5.1.6.4 Magnitude, Duration, Frequency, Reversibility, and Resiliency

The magnitude of potential effects to aquatic life from an ammonia discharge limit of 4 mg-N/L is **low**, since toxicity to aquatic life in Brucejack Creek is unlikely.

The duration of potential effects to aquatic life is **long-term** since ammonia levels are predicted to be up to 4 mg-N/L throughout the 14 year Operations phase of the mine.

The frequency of potential effects to aquatic life is **constant**, since ammonia level is predicted to be elevated throughout the year.

The concentration of ammonia is predicted to decrease to below the BC FWAL guideline during the Closure phase of the mine; therefore, the effect on water quality is **reversible**.

No fish are present in Brucejack Creek. The aquatic community consists of periphyton and benthic invertebrates. The resiliency of these aquatic communities is considered **high**.

5.1.6.5 Significance of Potential Effects

Potential effects to aquatic life from effluent with ammonia concentration of 4 mg-N/L is considered **not significant** (Table 5-7). This discharge limit will not cause ammonia levels to be greater than the BC FWAL guideline in Sulphurets Creek. The low ecological context of potential effects to aquatic communities in Brucejack Creek and the unlikelihood of toxicity to aquatic life in Brucejack Creek support the conclusion that the potential for adverse effects is not significant.

Table 5-7:
Residual Effects Criteria Ratings for an Ammonia Discharge Limit of 4 mg-N/L

Criterion	Rating	Comment
Geographic extent	Local	Restricted to Brucejack Creek.
Ecological context	Low	No effects predicted to fish, fish habitat, or uncommon species.
Magnitude	Low	No toxicity is expected to any species in Brucejack Ck.
Duration	Long-term	Ammonia predictions are above the BC FWAL guideline for multiple years during Operations phase.
Frequency	Constant	Predicted concentrations are relatively constant throughout the year.
Reversibility	Reversible	Ammonia levels are predicted to decrease to less than the BC FWAL guideline during Closure phase.
Resiliency	High	The benthic invertebrates in Brucejack Lake are common throughout British Columbia
Likelihood	Low	Adverse effects to aquatic life are unlikely.
Significance	Not significant	The unlikelihood that ammonia concentration of 4 mg-N/L would cause toxicity, combined with the low ecological context and favourable ratings for other criteria indicate that the potential for adverse effects is not significant.
Confidence	High	The literature on chronic toxicity of ammonia to aquatic life is comprehensive and includes species representative of aquatic life present in Brucejack Creek during baseline monitoring.

5.1.7 Antimony

5.1.7.1 Introduction

The antimony concentration in Brucejack Creek is predicted to increase during the Operations phase of mining, and then decrease during Closure and Post-closure (Figure 4-14). The Base Case model predicts T-Sb will increase to a maximum of 14 µg/L (Table 5-2) during Operations. This is above the BC FWAL guideline of 9 µg/L. Effluent permit 107835 does not have a discharge limit for T-Sb. In anticipation that T-Sb levels at BJ 3.10 may rise above the BC FWAL guideline, Pretivm is requesting that PE-107835 be amended to add a T-Sb discharge limit. The limit requested is the maximum Upper Case model prediction at BJ 3.10 of 28 µg/L (Figure 4-26). Therefore, the effects assessment will focus on the potential for the Upper Case prediction to cause adverse effects.

5.1.7.2 Geographic Extent

The mixing ratio to lower the concentration of T-Sb from 28 µg/L in Brucejack Creek to equal the BC FWAL working guideline of 9 µg/L at SC0 is 3.3:1 during high flow months and 2.6:1 during low flow months (Table 5-8). Baseline T-Sb concentration at site SC0

was 3.2 µg/L during high flow months, and 1.6 µg/L during low flow months. Since the discharge ratio at SC0 is 6:1 or higher at all times of the year (Figure 5-3), the T-Sb concentration in the entire length of Sulphurets Creek will be less than the BC FWAL working guideline.

Table 5-8:
Mixing Required to Equal BC Water Quality Guidelines in Sulphurets Creek

Parameter	Flow[1]	C1 [BJ 3.10 (µg/L)]	C2 [SC0 (µg/L)]	Cf [WQG[2] (µg/L)]	V2:V1 Required Mixing
Total Antimony	**High**	**28**	**3.2**	**9**	**3.3:1**
	Low	**28**	**1.6**	**9**	**2.6:1**

Notes: 1. High flow months are May through September, low flow October through April.
2. BC working water quality guideline for protection of freshwater aquatic life.

Because mixing of Brucejack Creek water with background water under the Sulphurets Glacier is calculated to reduce the T-Sb concentration to <9 µg/L at all times of the year, the geographic extent of potential residual effects is classified as **local**.

5.1.7.3 Toxicity

The BC FWAL working guideline for T-Sb was adopted from the Australia and New Zealand guideline document (ANZECC, 2000) which states:

> *A freshwater low reliability trigger value of 9 µg/L was derived for antimony (III) from the fish figure using an AF of 1000. This figure should only be used as an indicative interim working level. Collection of more data would assist in revision of this figure.*

That is, the guideline of 9 µg/L was derived by applying a safety factor of 1000 to an acute toxicity endpoint (LC50) of 9000 µg/L for the fish *Pimephales promelas* (fathead minnow).

A literature search of antimony toxicity studies found that the lowest toxicity endpoint is a median growth inhibition (EC50) of the alga *Selenastrum capricornutum* of 740 µg/L (Appendix 5). This algal test can be considered representative of potential toxicity to periphyton in Brucejack Creek and it indicates that toxicity to aquatic life in Brucejack Creek from exposure to 28 µg/L T-Sb is **unlikely**.

5.1.7.4 Magnitude, Duration, Frequency, Reversibility, and Resiliency

The magnitude of potential effects to aquatic life from a T-Sb discharge limit of 28 µg/L is **low**, since toxicity to aquatic life in Brucejack Creek is unlikely.

The duration of potential effects to aquatic life is **long-term** since T-Sb levels are predicted to increase throughout the 14-year Operations phase of the mine.

The frequency of potential effects to aquatic life is **constant**, since T-Sb level is predicted to be elevated throughout the year.

The concentration of T-Sb is predicted to decrease to below the BC FWAL guideline during the Closure phase of the mine; therefore, the effect on water quality is **reversible**.

No fish are present in Brucejack Creek. The aquatic community consists of periphyton and benthic invertebrates. The resiliency of these aquatic communities is considered **high**.

5.1.7.5 Significance of Potential Effects

Potential effects to aquatic life from effluent with 28 µg/L T-Sb is considered **not significant** (Table 5-9). This discharge limit will not cause T-Sb levels to be greater than the BC FWAL guideline in Sulphurets Creek. The low ecological context of potential effects to aquatic communities in Brucejack Creek and the unlikelihood of toxicity to aquatic life in Brucejack Creek support the conclusion that the potential for adverse effects is not significant.

Table 5-9:
Residual Effects Criteria Ratings for an Antimony Discharge Limit of 28 µg/L

Criterion	Rating	Comment
Geographic extent	Local	Restricted to Brucejack Creek.
Ecological context	Low	No effects predicted to fish, fish habitat, or uncommon species.
Magnitude	Low	No toxicity is expected to any species in Brucejack Ck.
Duration	Long-term	Antimony predictions are above the BC FWAL guideline for multiple years during Operations phase.
Frequency	Constant	Predicted concentrations are relatively constant throughout the year.
Reversibility	Reversible	Antimony levels are predicted to decrease to less than the BC FWAL guideline during Closure phase.
Resiliency	High	The benthic invertebrates in Brucejack Lake are common throughout British Columbia
Likelihood	Low	Adverse effects to aquatic life are unlikely.
Significance	Not significant	The unlikelihood that 28 µg/L T-Sb would cause toxicity, combined with the low ecological context and favourable ratings for other criteria indicate that the potential for adverse effects is not significant.
Confidence	Medium	The literature on chronic toxicity of antimony to aquatic life is limited, but does include species of algae and invertebrates.

5.1.8 Arsenic

5.1.8.1 Introduction

The production increase application Base Case model results for total arsenic (T-As) are slightly higher than the concentrations evaluated in the 2015 MA-EMA Permits Application. The maximum BJ 3.10 prediction increases from 6 µg/L to 7 µg/L (Table 5-1). The maximum BJ 2.62 prediction increases from 12 µg/L to 13 µg/L (Table 5-2). The BJ 3.10 predictions are that the current effluent discharge limit of 5 µg/L will be exceeded during Operations (Figure 4-11). The limit of 5 µg/L is equal to the BC FWAL guideline.

The model results are monthly average concentrations. It is expected that there will be variability in the results of weekly samples at BJ 3.10, resulting in some samples that are greater than the monthly average. For this reason, Pretivm is applying to increase the effluent discharge limit to 10 µg/L, which is equal to the maximum Upper Case model result for BJ 3.10 (Figure 4-25).

The water quality model predicts that the maximum T-As concentration of 13 µg/L will occur at BJ 2.62 during Closure, and the maximum Post-closure concentration at BJ 2.62 will be 11 µg/L (Figure 4-31). The residual effects assessment will evaluate the potential for adverse effects to aquatic communities in Brucejack Creek from exposure to 13 µg/L T-As, which is the maximum Base Case prediction at BJ 2.62.

5.1.8.2 Geographic Extent

The geographic extent of water with T-As levels above the BC FWAL guideline of 5 µg/L is calculated in the same way described for T-Sb (Section 5.1.7.2) and results are presented in Table 5-10. During high flow months, the baseline T-As concentration at Sulphurets Creek site SC0 is 17 µg/L; therefore, T-As levels at SC0 during high flow months are naturally elevated above the BC FWAL guideline of 5 µg/L and no mixing ratio would reduce concentrations to 5 µg/L. Further downstream of Sulphurets Lake in Sulphurets Creek, at site SC1, the baseline T-As concentration is 3.4 µg/L (Table 5-10). A mixing ratio of 5 parts SC1 water with 1 part Brucejack Creek water with 13 µg/L T-As is required to produce a concentration equal to 5 µg/L during high flow months. During low flow months, a mixing ratio of 2:1 will result in 5 µg/L in Sulphurets Creek at SC0 and SC1 (Table 5-10).

Table 5-10:
Mixing Required to Equal the BC Arsenic Water Quality Guideline in Sulphurets Creek

Location	Flow[1]	C1 [BJ 2.62 (µg/L)]	C2 [SC0 (µg/L)]	Cf [WQG[2] (µg/L)]	V2:V1 Required Mixing
SC0	High	13	17	5	not applicable
SC0	Low	13	1	5	2.1:1
SC1	High	13	3.4	5	5.1:1
SC1	Low	13	0.4	5	1.7:1

Notes: 1. High flow months are May through September, low flow October through April.
2. BC water quality guideline for protection of freshwater aquatic life.

The mixing ratio of Brucejack Creek water with Sulphurets Creek water varies seasonally, with a minimum of 6:1 in December (Figure 5-3). A mixing ratio of 6:1 or more will result in T-As concentrations in Sulphurets Creek that are <5 µg/L; therefore, only Brucejack Creek is modelled to have T-As above BC FWAL guideline, and the geographic extent of potential residual effects is classified as **local**.

5.1.8.3 Ecological Context

The ecological context of potential effects of predicted T-As levels is classified as **low**, because there are no fish in Brucejack Creek; Brucejack Creek is not fish habitat; and the benthic invertebrates present in the stream are common in British Columbia.

5.1.8.4 Toxicity

The BC FWAL guideline for T-As of 5 µg/L was derived from the lowest relevant toxicity endpoint of 50 µg/L (EC50 for growth of the green alga *Scenedesmus obliquus* (Vocke *et al.*, 1980) and a safety factor of 10. A literature search did not reveal any recent studies (after 2000) which found a species more sensitive to arsenic toxicity.

The BC arsenic guideline Overview Report also cites a toxicity test using the invertebrate *Daphnia magna* that had a Lowest Observed Effect Concentration (LOEC) of 38 µg/L for reproduction. This study was reviewed by the European Chemicals Agency and classified as not reliable. The U.S. ECOTOX database reports five other studies of growth or reproduction in *Daphna magna*, with reported endpoints ranging from 880 to 3,700 µg/L. The anomalously low endpoint cited in the BC Overview Report lends support to the conclusion that this study is not reliable.

Pretivm commissioned a site-specific toxicity test of BJ 3.10 water with added arsenic and antimony (Appendix 6). BJ 3.10 water was collected on October 30th, 2017 and shipped

to Nautilus Environmental in Burnaby, BC. Nautilus conducted a growth test using the green alga *Pseudokirchneriella subcapitata*, which is a taxon known to be sensitive to arsenic toxicity. The test solutions were spiked with both arsenic and antimony, in the ratio that had been observed in monitoring of water quality at BJ 3.10.

The EC50 for T-As in the BJ 3.10 test was 74.1 µg/L. The Lowest Observable Effect Concentration (LOEC) from the BJ 3.10 test was 18.7 µg/L. These results indicate that the predicted concentration of 13 µg/L T-As during Post-closure is **unlikely** to produce toxicity to aquatic life in Brucejack Creek.

5.1.8.5 Magnitude, Duration, Frequency, Reversibility, and Resiliency

The magnitude of potential effects to aquatic life from a T-As concentration of 13 µg/L is **low**, since toxicity to aquatic life in Brucejack Creek is unlikely.

The duration of potential effects to aquatic life is **permanent** since T-As levels greater that the BC FWAL guideline are predicted to occur during Post-closure.

The frequency of potential effects to aquatic life is **constant**, since T-As level is predicted to be elevated throughout the year.

The potential effect is classified as **irreversible**, since the T-As levels greater the BC FWAL guideline are predicted to occur during Post-closure.

No fish are present in Brucejack Creek. The aquatic community consists of periphyton and benthic invertebrates. The resiliency of these aquatic communities is considered **high**.

5.1.8.6 Significance of Potential Effects

Potential effects to aquatic life from exposure to 13 µg/L T-As is considered **not significant** (Table 5-11). The predicted T-As concentration is greater than the BC FWAL guideline only in Brucejack Creek. The low ecological context of potential effects to aquatic communities in Brucejack Creek and the unlikelihood of toxicity to aquatic life in Brucejack Creek support the conclusion that the potential for adverse effects is not significant.

Table 5-11:
Residual Effects Criteria Ratings for an Arsenic Concentration of 13 µg/L

Criterion	Rating	Comment
Geographic extent	Local	Restricted to Brucejack Creek.
Ecological context	Low	No effects predicted to fish, fish habitat, or uncommon species.
Magnitude	Low	No toxicity is expected to any species in Brucejack Creek.
Duration	Permanent	Arsenic predictions are above the BC FWAL guideline during Post-closure phase.
Frequency	Constant	Predicted concentrations are relatively constant throughout the year.
Reversibility	Irreversible	Arsenic predictions are above the BC FWAL guideline during Post-closure phase.
Resiliency	High	The benthic invertebrates in Brucejack Lake are common throughout British Columbia.
Likelihood	Low	Adverse effects to aquatic life are unlikely.
Significance	Not significant	The unlikelihood that 13 µg/L T-As would cause toxicity, combined with the low ecological context indicate that the potential for adverse effects is not significant.
Confidence	High	The effects assessment is supported by site-specific toxicity testing of species known to be sensitive to arsenic.

5.1.9 Iron

Iron is predicted to remain below BC FWAL guidelines during Operations phase, then to increase above the guidelines at BJ 2.62 as the underground floods and groundwater flows to Brucejack Creek during Closure and Post-closure (Figure 4-33). Because the source is groundwater, most of the iron is predicted to occur as dissolved iron (D-Fe). The updated Base Case iron predictions are about 17% higher than predictions reported in the 2105 MA-EMA Permits Application (Table 5-12).

Table 5-12:
Maximum Concentrations from the BJ 2.62 Base Case Water Quality Model Compared to the Maximum from the 2015 MA-EMA Permits Application and BC Water Quality Guidelines

		Maximum Modelled		BC FWAL Guidelines	
Parameter	**Units**	**2017 3800 tpd application**	**MA-EMA**	**Long-term**	**Short-term**
Iron-D	mg/L	***3.13***	***2.67***	NP	0.35
Iron-T	mg/L	***3.34***	***2.80***	NP	1.00

Notes: BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed short-term guidelines are shown as ***bold italic underlined*** font.
NP=none proposed.

The water quality model assumes that there is no attenuation of metals along flow paths or in the receiving environment. This conservative approach to water quality prediction can result in unrealistic concentrations, particularly for pH sensitive metals which are subject to thermodynamic solubility controls, such as iron.

The Closure and Post-closure underground water source term in the water quality model assumes that iron will exist in solution in the ferrous (Fe^{2+}) oxidation state. Once these groundwater flow paths daylight and interact with atmospheric oxygen, Fe^{2+} iron will rapidly be oxidized to ferric iron (Fe^{3+}) which is relatively insoluble under neutral pH conditions. Iron oxidation will result in the formation of Fe-oxyhydroxides.

In order to predict Fe solubility in Brucejack Creek, a PHREEQC solubility model was constructed using the minteq.v4 database (Parkhurst and Apello, 1999). The solubility of ferrihydrite [$Fe(OH)_3$] and goethite [α-FeO(OH)] was calculated using a solution containing the highest predicted concentrations for Brucejack Creek in the Post closure scenario. The solution was assumed to be in equilibrium with atmospheric oxygen. The solubility of these phases is highly sensitive to pH (Figure 5-5). Median pH of Brucejack Creek at BJ 3.10 is 7.8, which is at the lower end of the range of iron solubility. The PHREEQC model results show that Fe solubility between a pH of 6.0 and 8.0 ferrihydrite precipitation can be expected to reduce dissolved Fe concentrations to between 0.026 mg/L to 0.0003 mg/L. With time, ferrihydrite will convert to goethite which is considerably less soluble.

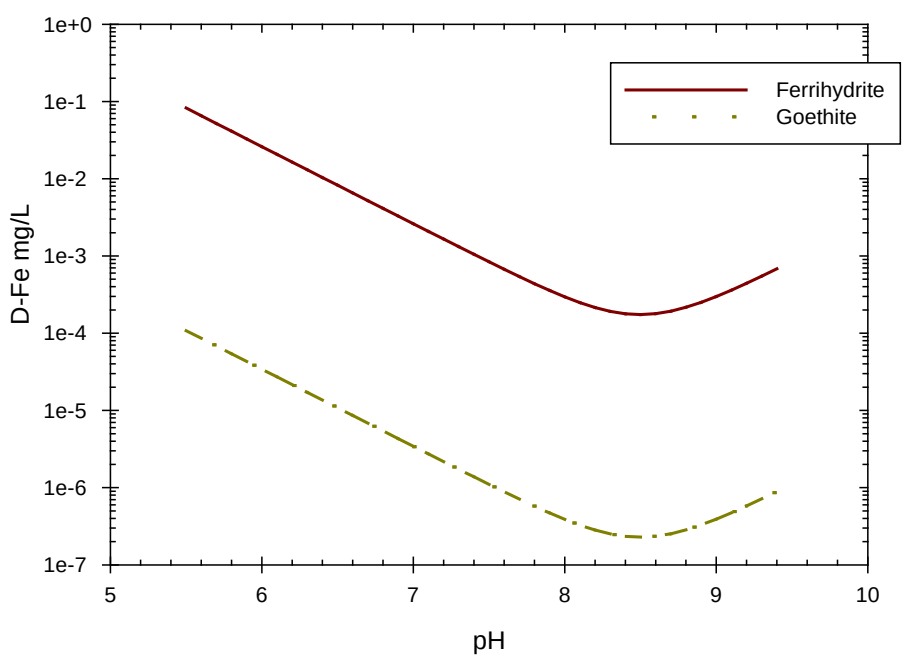

Figure 5-5: Modelled solubility of expected forms of iron in flowing to Brucejack Creek along groundwater flow paths.

Since redox reactions are expected to result in iron concentrations below BC FWAL guidelines, no significant effects to aquatic life are expected. Precipitation of Fe-oxyhydroxides would increase the sediment iron concentration in Brucejack Creek, but it is not possible to predict the final sediment Fe concentration. Increased iron levels in sediment could cause toxicity to sensitive benthic organisms in Brucejack Creek. The geographic extent of elevated sediment Fe levels is expected to be local. Sediment export from Brucejack Creek is small relative to the sediment loading that comes from Sulphurets Glacier. This is evidenced by total suspended solids (TSS) measurements made as part of the receiving environment monitoring program, which are routinely <3 mg/L (detection limit) in Brucejack Creek and >100 mg/L at SC0 in Sulphurets Creek below the glacier. There is no potential to increase the iron levels in lower Sulphurets Creek, which receives high iron loadings from Mitchel Creek.

Since water is expected to have Fe concentrations below BC FWAL guidelines, there is no significant effect expected to aquatic life. Sediment iron levels may increase and may have a localized effect on benthic organisms. The overall significance of iron predictions is considered low (Table 5-13).

Table 5-13:
Residual Effects Criteria Ratings for Iron

Criterion	Rating	Comment
Geographic extent	Local	Restricted to Brucejack Creek.
Ecological context	Low	No effects predicted to fish, fish habitat, or uncommon species.
Magnitude	Moderate	There may be toxicity to sensitive benthic organisms from precipitated iron.
Duration	Permanent	Iron is predicted to increase during Post-closure phase.
Frequency	Constant	Predicted iron is from groundwater, which will flow all year.
Reversibility	Irreversible	Iron in water in contact with the flooded underground mine will continue to have iron during Post-closure.
Resiliency	High	The benthic invertebrates in Brucejack Lake are common throughout British Columbia.
Likelihood	Moderate	Increased sediment iron levels are expected.
Significance	Low	There is potential for localized effects to benthic organisms from precipitation of iron.
Confidence	High	The slow significance rating is based on the low ecological context of the waterbody which may receive increased sediment iron levels, and the high iron levels that are present in fish habitat in lower Sulphurets Creek.

5.1.10 Zinc

Base Case predictions for total zinc (Zn-T) are that it will remain below the discharge limit at BJ 3.10 of 7.5 µg/L during all phases of the mine (Figure 4-20), which is equal to the BC FWAL guideline. The maximum prediction at BJ 2.62 is 8.6 µg/L (Table 5-2), which is slightly above the guideline. This prediction is essentially the same as for the 2015 MA-EMA Permits Application, which had a maximum of 8.5 µg/L. Since the update model has the same predictions as was evaluated in the 2015 MA-EMA Permits Application, the residual effects assessment does not change from what was presented in that application. It concluded that a Science Based Environmental Benchmark of 60 µg/L is appropriate for Brucejack Creek. Since the predicted maximum Zn-T concentration of 8.6 µg/L is well below this benchmark, no significant adverse effect to aquatic life from Zn-T is expected.

5.2 Cumulative Effects Assessment

5.2.1 Cumulative Concentration Calculations

Cumulative environmental effects are changes to the environment caused by the combined effect of past, present and reasonably foreseeable future activities. Construction of the Kerr-Sulphurets-Mitchell (KSM) mine is a potential future activity that would affect water quality in the Brucejack Mine receiving environment. An Environmental Assessment Certificate was issued in July 2014 to Seabridge Gold Inc. for the KSM project. The project description for KSM is for a 5-year Construction phase, 51.5-year Operation phase, 3-year Closure phase, and Post-closure. A water quality effects assessment was conducted for KSM which included predictions of water quality in Sulphurets Creek downstream of mine facilities, at site SC3 (Figure 5-2).

The Brucejack residual effects assessment (Section 5.1) identified ammonia, antimony and arsenic as parameters which are expected to have concentrations at the mouth of Brucejack Creek that are greater than BC FWAL guidelines. An effluent discharge limit of 4 mg-N/L ammonia, 28 µg/L T-Sb and 10 µg/L T-As is being applied for by Pretivm. Ammonia and antimony levels are expected to decrease during Closure and Post-closure, while the maximum T-As concentration expected in Brucejack Creek (13 µg/L) will occur during low-flow months of Post-closure. Thus, ammonia and antimony from Brucejack Gold Mine effluent have the potential to cause cumulative changes to water quality at Sulphurets Creek site SC3 during Construction and Operation phases of the KSM project. Arsenic from Brucejack Gold Mine has the potential to cause cumulative changes to water quality at SC3 during all of the KSM mine phases.

Cumulative effects to water quality at SC3 were calculated using the mass balance equation:

$$C_f = \frac{C_1V_1 + C_2V_2}{V_1 + V_2}$$

where: C_f = final concentration
C_1 = concentration at BJ 3.10
C_2 = predicted concentration at SC3 for the KSM mine
V_1 = discharge at BJ 3.10
V_2 = discharge at SC3

This is the same mass balance equation that was used for calculating residual effects to water quality in Brucejack Creek and Sulphurets Creek (Section 5.1).

For the cumulative effects assessment, it was assumed that concentration of ammonia is 4 mg-N/L during low and high flow months, T-Sb is 28 µg/L during low and high flow months, and T-As is 13 µg/L during low flow months and 10 µg/L during high flow months. These concentrations were used for variable C_1 in the mass balance equation.

Water quality predictions for the KSM project were presented in Chapter 14 of the KSM Application/EIS (Rescan, 2013), which was posted on the BC Environmental Assessment Office website. Expected Case predictions were presented as summary statistics (minimum, mean, median, and maximum) from monthly predictions in each project phase (Table 5-14). The maximum ammonia prediction occurred during Operations phase. The maximum antimony prediction did not differ between project phases. The maximum arsenic prediction occurred during Construction and Operation phases (Table 5-14). Predictions from the Operations phase were used for variable C_2 in the mass balance equation, as an upper estimate of water quality from the KSM mine.

Table 5-14:
Predicted Concentrations of Ammonia, Antimony and Arsenic for the KSM Project

Parameter	Project Phase	Units	Min.	Mean	Median	Max
Ammonia	Construction	mg-N/L	0.0020	0.0990	0.0990	0.1910
	Operations	mg-N/L	0.0025	0.0334	0.0185	0.2337
	Closure	mg-N/L	0.0025	0.0035	0.0025	0.0082
	Post-closure	mg-N/L	0.0025	0.0033	0.0025	0.0082
Antimony-T	Construction	µg/L	0.4	0.7	0.6	1.2
	Operations	µg/L	0.4	0.7	0.6	1.2
	Closure	µg/L	0.4	0.7	0.6	1.2
	Post-closure	µg/L	0.4	0.7	0.6	1.2
Arsenic-T	Construction	µg/L	0.1	2.4	0.6	10.9
	Operations	µg/L	0.1	2.5	0.7	10.9
	Closure	µg/L	0.4	0.7	0.7	1.2
	Post-closure	µg/L	0.4	0.7	0.7	1.2

Notes: Data are extracted from Tables 14.7-27, through -30 of Rescan (2013).

Discharge ratios used in the residual effects assessment determination of geographical extent (Figure 5-3 and Appendix 4) do not extend far enough downstream on Sulphurets Creek to where cumulative effects to water quality may occur. Discharge ratios between sites BJ 3.10 and SC3 are available in Chapter 10 (Surface Water Hydrology Predictive Study) of the Brucejack Mine Application/EIS (Rescan, 2013). Discharge ratios were available for mean annual flows as well as peak flows, low flows, and 7-day low flows for return years ranging from Q2 to Q200 for peak flows and Q2 to Q20 for low flows (Table 5-15). Discharge ratios estimates were lowest during peak flow and highest during low flows. For the cumulative effects assessment, a mean annual discharge ratio of 34.6 and minimum ratio of 10.2 (peak flow, Q200) were used for the V_1:V_2 variables in the mass balance equation.

Table 5-15:
Estimated Discharge Ratio Between Sites BJ 3.10 and SC3

Condition	Location	Return Period							
		Q1	Q2	Q5	Q10	Q20	Q50	Q100	Q200
Mean Annual	BJ 3.10 (m^3/s)	0.65	-	-	-	-	-	-	-
	SC3 (m^3/s)	22.5	-	-	-	-	-	-	-
	ratio	**34.6**	-	-	-	-	-	-	-
Peak Flow	BJ 3.10 (m^3/s)	-	11	20	26	31	39	44	50
	SC3 (m^3/s)	-	146	223	276	329	399	453	508
	ratio	-	**13.3**	**11.2**	**10.6**	**10.6**	**10.2**	**10.3**	**10.2**
Annual 7-d Low Flow	BJ 3.10 (m^3/s)	-	0.05	0.03	0.02	0.02	-	-	-
	SC3 (m^3/s)	-	1.26	0.91	0.77	0.65	-	-	-
	ratio	-	**25.2**	**30.3**	**38.5**	**32.5**	-	-	-
Jun-Sep 7-d Low Flow	BJ 3.10 (m^3/s)	-	0.33	0.21	0.17	0.14	-	-	-
	SC3 (m^3/s)	-	10.31	7.43	6.27	5.48	-	-	-
	ratio	-	**31.2**	**35.4**	**36.9**	**39.1**	-	-	-

Notes: Data are extracted from Tables 10.3-5, -7, and -8, and -9 of Pretivm (2014).

Calculations of cumulative concentrations of ammonia at SC3 range from 0.13 to 0.34 mg-N/L (Table 5-16) during mean annual flows, and from 0.37 to 0.57 mg-N/L during 1 in 200 peak flows (Table 5-17). All estimates of cumulative ammonia concentration are below the BC FWAL guideline of 1.0 mg-N/L for a baseline pH of 8.0 at SC3 and a temperature of 16 °C.

Calculations of cumulative concentrations at T-Sb at SC3 range from 1.2 to 2.0 µg/L for mean annual flow and range from 2.9 to 3.6 µg/L for Q200 peak flow. All estimated T-Sb concentrations are less than the BC FWAL guideline of 9 µg/L.

Table 5-16:
Cumulative Predicted Concentrations of Ammonia, Antimony and Arsenic at Site SC3 for Mean Annual Flows

Parameter	Statistic	Units	C_1 (BJ 3.10) (µg/L)	C_2 (SC3) (µg/L)	V_1 (BJ 3.10)	V_2 (SC3)	C_f (final concentration)
Ammonia	min	mg-N/L	4	0.0025	1	34.6	**0.134**
	mean	mg-N/L	4	0.0334	1	34.6	**0.145**
	median	mg-N/L	4	0.0185	1	34.6	**0.130**
	max	mg-N/L	4	0.2337	1	34.6	**0.339**
Antimony-T	min	µg/L	28	0.4	1	34.6	**1.2**
	mean	µg/L	28	0.7	1	34.6	**1.5**
	median	µg/L	28	0.6	1	34.6	**1.4**
	max	µg/L	28	1.2	1	34.6	**2.0**
Arsenic-T	min	µg/L	13	0.1	1	34.6	**0.5**
	mean	µg/L	13	2.5	1	34.6	**2.8**
	median	µg/L	13	0.7	1	34.6	**1.0**
	max	µg/L	13	10.9	1	34.6	**11.0**

Table 5-17:
Cumulative Predicted Concentrations of Ammonia, Antimony and Arsenic at Site SC3 for Peak Flows

Parameter	Statistic	Units	C_1 (BJ 3.10)	C_2 (SC3)	V_1 (BJ 3.10)	V_2 (SC3)	C_f (final concentration)
Ammonia	min	mg-N/L	4	0.0025	1	10.2	**0.378**
	mean	mg-N/L	4	0.0334	1	10.2	**0.388**
	median	mg-N/L	4	0.0185	1	10.2	**0.374**
	max	mg-N/L	4	0.2337	1	10.2	**0.570**
Antimony-T	min	µg/L	28	0.4	1	10.2	**2.9**
	mean	µg/L	28	0.7	1	10.2	**3.1**
	median	µg/L	28	0.6	1	10.2	**3.0**
	max	µg/L	28	1.2	1	10.2	**3.6**
Arsenic-T	min	µg/L	10	0.1	1	10.2	**1.0**
	mean	µg/L	10	2.5	1	10.2	**3.2**
	median	µg/L	10	0.7	1	10.2	**1.5**
	max	µg/L	10	10.9	1	10.2	**10.8**

Calculations of cumulative concentrations at T-As at SC3 range from 0.5 to 10.0 µg/L for annual mean flow (Table 5-16) and range from 1.0 to 10.8 µg/L for peak flow (Table 5-17). Estimated T-As concentrations for minimum, mean, and median KSM predictions are less than the BC FWAL guideline of 5 µg/L. The maximum KSM prediction for T-As is 10.9 µg/L. This is likely the result of arsenic associated with high suspended solids

concentrations at SC3. Evidence of this is from baseline measurements at SC3 during high flow months (May through October), which had mean T-As of 11.0 µg/L and mean As-D of 0.2 µg/L (data from Table 14-1.1 of Rescan, 2013). Discharge of Brucejack Creek water with 13 µg/L T-As during mean annual flows would result in a change of maximum concentration at SC3 from 10.9 to 11.0 µg/L. During peak flows, the discharge of effluent with 10 µg/L T-As from Brucejack Gold Mine would change the maximum cumulative concentration at SC3 from 10.9 µg/L to 10.8 µg/L.

5.2.2 Cumulative Effects Ratings

The cumulative effects calculations indicate that the discharge of effluent from Brucejack Gold Mine with an ammonia concentration of 4 mg-N/L will not cause concentrations to go above the BC FWAL guideline of 1.0 mg-N/L in Sulphurets Creek under any of the scenarios assessed. Similarly, the discharge of effluent with 28 µg/L T-Sb will not cause concentrations to go above the BC FWAL guideline of 9 µg/L in Sulphurets Creek under any of the scenarios assessed. Therefore, no significant cumulative effect to water quality is expected from an ammonia discharge limit of 4 mg-N/L or a T-Sb discharge limit of 28 µg/L.

The cumulative effects calculations for T-As indicate that discharge of effluent with a proposed limit of 10 µg/L will not cause concentrations at SC3 to go above the BC FWAL guideline of 5 µg/L, except when levels at SC3 are naturally greater than 5 µg/L. Under that scenario, the discharge of effluent with 10 µg/L T-As will cause a negligible decrease (from 10.9 to 10.8 µg/L) to the maximum KSM prediction at SC3. Therefore, no significant cumulative effect to water quality is expected from a T-As discharge limit of 10 µg/L.

During Post-closure, when the model predicts that T-As predictions at BJ 2.62 will increase to 13 µg/L during low flow months, the cumulative concentration calculations at SC3 are less than the BC FWAL guideline of 5 µg/L, except when levels at SC3 are naturally greater than 5 µg/L. Under that scenario, the discharge of BJ 2.62 water with 13 µg/L T-As will cause a negligible increase (from 10.9 to 11.0 µg/L) to the maximum predictions at SC3. Therefore, no significant cumulative effect to water quality is expected from Post-closure predictions of 13 µg/L T-As at BJ 2.62.

5.3 Human Health Assessment

The proposed T-Sb discharge limit of 28 µg/L is above the Health Canada drinking water guideline of 6 µg/L. The proposed T-As discharge limit of 10 µg/L is equal to the Health Canada drinking water guideline. Health Canada currently does not recommend a drinking water guideline for ammonia (Health Canada, 2013). Health Canada drinking water

guidelines are designed to protect the health of the most vulnerable members of society, such as children and the elderly, from long-term exposure.

Since the proposed Sb discharge limit will cause Sb levels in Brucejack Creek to be greater than drinking water guideline, Brucejack Creek water should not be used as the drinking water source for the mine camp. Mine camp drinking water is currently taken from a potable water well, which will continue to be the source of drinking water for the camp during Operations and Closure phases.

The Assessment of Potential Health Effects carried out for the Application/EIS (Chapter 21 of Rescan, 2013) concluded that it is unlikely that people drink water from the Brucejack watershed. This conclusion was based on the inaccessibility of the watershed, the cold weather during winter, absence of country foods such as fish in the area, and general low use of the Brucejack watershed by individuals from First Nations groups or the general public (Appendix 21-A of Chapter 21 of the Application/EIS; Rescan, 2013). There was no indication of Skii km Lax Ha or other First Nations obtaining drinking water from the Mine Site Area.

Effluent with the proposed discharge limits for ammonia, Sb, and As is predicted to result in little or no increase to the concentrations of these parameters in Sulphurets Creek where fish are present. The predicted cumulative effects concentrations (Table 5-16) are less than the BC water quality guidelines for the protection of freshwater aquatic life. The low predicted concentrations in Sulphurets Creek, as well as the low abundance of fish in baseline surveys of lower Sulphurets Creek (Appendix 15-A of Rescan, 2013), and the low expectation that fish will be captured from Sulphurets Creek for eating, provide lines of evidence that no significant effect to human health is expected from the proposed effluent discharge limits.

6. Summary

6. Summary

The Brucejack Gold Mine water quality model has been updated with revised mine schedules and updated source terms to reflect water quality predictions for the proposed ore production rate increase. Additional revisions to the water quality model have been carried out based on new geochemical data sets, an updated water balance, operational data acquired through the various monitoring programs and changes to water management plans.

Separate model updates were completed for the two mine waste management scenarios considered in this application (*i.e.*, Scenario 1, where all waste rock is placed in Brucejack Lake; and Scenario 2, where a portion of waste rock is backfilled in the underground mine). Base Case and Upper Case water quality predictions for each scenario were modelled and are presented for two stations: BJ 3.10, the mine's regulated discharge point, located at the outlet of Brucejack Lake; and BJ 2.62, a downstream monitoring location in Brucejack Creek.

The water quality model results and the associated effects assessment are summarized as follows:

- Base Case BJ 3.10 water quality predictions for ammonia, nitrite, nitrate, D-Al, T-Sb, T-As, D-Fe, T-Li and T-Se are higher than predicted in the 2015 MA-EMA Permits Application model; however, maximum Base Case predictions for nitrite, nitrate, D-Al, D-Fe, T-Li and T-Se are below PE-107835 discharge limits or BC FWAL guidelines.
- Base Case BJ 2.62 water quality predictions are higher than predictions in the 2015 MA-EMA Permits Application for ammonia, nitrite, nitrate, Cl, F, D-Al, T-Sb, T-As, D-Fe, T-Fe, T-Li, T-Se, T-U and T-Zn; however, only T-Sb, T-As, T-Fe, D-Fe and T-Zn exceed PE-107835 discharge limits or applicable BC FWAL guidelines.
- In general, water quality predictions for Scenario 1 are similar to Scenario 2, indicating that placement of waste rock in the lake or placement underground will have little influence on the water quality in the receiving environment.
- Based on predicted water quality for Operation, Closure and Post-Closure phases, ammonia, Sb, As, Fe and Zn were identified as parameters of potential concern. These parameters were assessed for potential residual and cumulative effects.
- The Maximum Base Case prediction for ammonia (2.8 mg-N/L) occurs during the Operations phase at BJ 3.10 and is higher than previously predicted values due to revisions applied to ammonia source terms which conservatively assume low

nitrification rates. The predicted value is above the PE-107835 discharge limit of 1.0 mg/L. Base Case ammonia concentrations at both BJ 3.10 and BJ 2.62 are predicted to decrease to background levels by the end of the Closure phase. The predicted concentrations are less than the lowest chronic toxicity endpoint in the literature applicable to aquatic life in Brucejack Creek; therefore no significant effects to aquatic life are expected, and residual effects were assessed to be not significant.

- The maximum Base Case prediction for antimony (14 µg/L) occurs during the Closure phase at BJ 2.62. This value is slightly higher than the maximum prediction in the 2015 MA-EMA Permits Application (10 µg/L) and higher than the BC FWAL working guideline (9 µg/L). Base Case Sb concentrations at both BJ 3.10 and BJ 2.62 are predicted to decrease to background levels by the end of the Closure phase. The predicted concentrations are well below the lowest toxicity endpoint applicable to aquatic biota in Brucejack Creek, therefore no toxicity to aquatic life in the receiving environment from Sb is expected, and residual effects were assessed as not significant.
- Base Case arsenic predictions at BJ 3.10 during Operations are approximately the same as the predictions in the 2015 MA-EMA Permits Application, with a maximum concentration of 6.5 µg/L, which is greater than the PE-107835 discharge limit of 5 µg/L. The updated predictions are that T-As will exceed the discharge limit earlier during Operations than was predicted for the 2015 MA-EMA Permits Application. Closure and Post-Closure predictions at BJ 2.62 are lower than in the MA-EMA application, with a maximum of 13 µg/L. The 2015 MA-EMA Permits Application concluded that T-As predictions would not have significan adverse effects to aquatic life. This conclusion is supported by a recent site specific toxicity test on species known to be sensitive to arsenic toxicity, since the maximum predicted concentration is lower than the No Observable Effect Concentration from the toxicity test.
- Fe concentrations are only predicted to exceed BC FWAL guidelines at BJ 2.62 during the Closure and Post-Closure phases when the underground mine is flooded and groundwater flows to Brucejack Creek. Post-closure iron in groundwater from the underground mine is expected to have solubility constraints when it enters Brucejack Creek. Redox-controlled reactions in Brucejack Creek will cause Fe to come out of solution and lower the dissolved concentrations to less than the BC water quality guidelines. Potential effects from precipitation of iron in Brucejack Creek were assessed as having low significance.

- The maximum Base Case Zn prediction (8.6 µg/L) is almost the same as the maximum prediction in the 2015 MA-EMA Permits Application (8.5 µg/L). These predictions are slightly above the BC FWAL guideline of 7.5 µg/L. The residual effects assessment in the 2015 MA-EMA Permits Application that concluded potential effects to aquatic life from predicted Zn concentrations are not significant is also valid for the updated Zn predictions.
- Discharge limits based on Operations phase Upper Case BJ 3.10 predictions are proposed for ammonia (4 mg-N/L), T-Sb (28 µg/L) and T-As (10 µg/L). The Base Case model results represent monthly average concentrations, whereas the Upper Case predictions are expected to capture the variability of BJ 3.10 sample measurements, which will be greater than the monthly average.
- The proposed effluent discharge limits for ammonia, T-Sb and T-As are below the most sensitive applicable toxicity endpoints for these parameters. As well, T-As predictions are below the No Observable Effects Concentration from a site-specific toxicity test. Based on these toxicity data, the proposed discharge limits are expected to be protective of aquatic life in the receiving environment.
- Cumulative effects of the proposed ammonia, Sb and As discharge limits and water quality predictions for the KSM mine in lower Sulphurets Creek were considererd not significant. The maximum loadings of ammonia, T-Sb or T-As from Brucejack Mine effluent would not cause the cumulative concentration to go above the BC FWAL guideline. Maximum KSM arsenic predictions of 10.9 µg/L would be negligibly changed by Brucejack Mine effluent with 10 µg/L As or Post-closure Brucejack Creek water with 13 µg/L T-As.

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Appendices

PRETIVM

Appendix 1: Operations Water Treatment Plant (WTP) Additional Metals Removal Bench Tests Report

PRETIVM

PRETIVM RESOURCES INC.

Operations Water Treatment Plant (WTP)

ADDITIONAL METALS REMOVAL BENCH TESTS REPORT

2015-07-25, REVISION 1
PROJECT # 5000196003

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EXECUTIVE SUMMARY

Based on predicted influent water quality and flow, Veolia has proposed a process design for the Operations Water Treatment Plant (WTP). The Operations WTP design consists of:

- Primary metals removal using the Actiflo® process;
- Polishing metals removal using the Actiflo process; and
- Filtration of final effluent using Hydrotech Discfilter filtration process.

The treatment chain, which includes metals precipitation reactors, two Actiflo® process units and a Hydrotech Discfilter unit, was validated using bench-scale testing for the predicted influent upper-case maximum values (without Hydrotech filtration). Additional tests were needed to validate that higher As, Cd and Zn concentrations can be treated by the proposed design. These tests demonstrate that the treatment process as designed can meet the criteria for these metals. Specifically, the tests found that:

- Using the Actiflo® process bench-scale test for the primary metals removal step, the following combination of reagents and conditions was shown to work well: pH increase to 10.00 using a lime dosage of 340 mg/L, then addition of 35.0 mg S/L of sulfide (Na_2S), 27.5 mg Fe/L of Hydrex™ 6253 coagulant for metals removal, and 2.0 mg/L of Hydrex™ 6183 polymer to improve turbidity and metals removal with the Actiflo® process; and
- Using the Actiflo® process bench-scale test for the polishing metals removal step, the following combination of reagents and conditions was shown to provide water that met the criteria after polishing: pH decrease to 7.25, addition of 22.0 mg Fe/L of Hydrex™ 6253 coagulant for metals removal, and 1.5 mg/L of Hydrex™ 6183 polymer to improve metals removal.

A test with higher dissolved Arsenic concentration in the influent was also completed on a modified synthetic water to prove the efficiency of the arsenic removal of the process design proposed.

The details relating to the full-scale implementation, including the process flow diagrams, the design data and the annual chemicals consumption, are included in the "Brucejack Gold Mine Project Application for Mines Act and Environmental Management Act Permits" document.

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SECTION 1. INTRODUCTION

Pretium Resources Inc. (Pretivm) is developing the Brucejack Mine Project (Brucejack Project), a high grade, large-scale gold project located in Northern British Columbia (BC).

On-site mine water treatment at the Brucejack Project will be managed in three phases:

- Exploration Phase;
- Construction Phase; and
- Operations Phase.

This report concerns the Operations Phase.

Pretivm has retained the services of Veolia Water Technologies Canada Inc. (Veolia) to design the Operations Water Treatment Plant (WTP). Bench testing was already done in February to April 2015 to demonstrate the efficiency of Actiflo® process for metals and total suspended solids (TSS) removal, in accordance to the raw water quality issued at this time. Two reports have been issued to present the obtained results of these tests (primary metals removal only and primary metals removal followed by polishing step) and the design of the Operations WTP has been completed accordingly. These reports, issued on April 24th and May 4th 2015, are presented in Appendix A ("5000196003_Brucejack_ Bench_test_Rev6_20150424" and "5000196003_Brucejack_Polishing_Rev3_20150504"). The process selected for the Operations WTP is described as follow:

- Primary metals removal using metal precipitation, ballasted flocculation and clarification (Actiflo®);
- Polishing metals removal using metal precipitation, ballasted flocculation and clarification (Actiflo®).

Results obtained during the Operations bench testing were meeting expectations, but the raw water quality used from both bench testing of the Operations WTP had lower than expected dissolved Arsenic (As), Cadmium (Cd) and Zinc (Zn) concentrations. Nonetheless,

these higher concentrations for As, Cd and Zn in the influent water are expected to be removed just as well with the proposed treatment processes, by adjusting the chemical dosage, coagulant and sulfide dosages mostly.

In order to validate the metals removal of the final expected upper-case raw water quality during Operations WTP exploitation, a new bench test program was therefore developed using the same technologies (modification of the chemical dosages only).

For this validation testing program, the following information has been considered:

- Predicted influent water quality as per Lorax Environmental (Lorax) simulations, issued on May 19th 2015 in a technical memo titled "Next round of bench-scale testing for the Brucejack Project", presented in Appendix B, adjusted with OLI simulation influent water (balancing of the influent water anions and cations concentrations) which Reconciliation Report is presented in Appendix C;
- Treated water quality targets to respect discharge criteria, as per Process Performance Guarantee, issued by Veolia according to previous bench testing conducted in February to May 2015 (Process Performance Guarantee is presented in Appendix D);
- Operations bench-scale laboratory testing results from previous testing (for TSS and metals removal in primary metals removal (bench test #1) and for metals removal in primary metals removal completed by polishing step (bench test #2)) for process validation and chemical dosage optimisation.

This report presents the materials and methods used to simulate the metals removal process at bench scale laboratory. Furthermore, this report provides the predicted treated water quality obtained according to this third bench-scale laboratory testing, and the metals removal process operating parameters which should be expected in the full-scale implementation (in worst-case influent composition) of the Operations WTP.

SECTION 2. OBJECTIVES

The main objectives of the bench-scale laboratory testing are to validate that the achievable treated water quality is in line with the Operations Phase water quality targets for metals removal with higher influent As, Cd and Zn concentrations and to validate the maximum chemical dosages required to meet total suspended solids (TSS), sulfate, sulfide and metal concentrations defined in the Performance Guarantee for Operations WTP.

Specifically, the following steps were taken to optimize treatment parameters during the bench scale tests:

- Preparation of a synthetic raw water to match the predicted influent water quality as closely as possible, with a particular attention to As, Cd and Zn dissolved concentrations; and,
- Simulation of the metals removal process in bench-scale laboratory (jar tests), i.e. using precipitation, coagulation-flocculation, settling and filtration for both the primary metals removal step and the polishing metals removal step.

The parameters to be optimised were the coagulant dosages (in primary metals removal and polishing metals removal steps) and sulfide dosage (in primary metals removal step only), as contact times, dosage sequencing and pH for metals precipitation were already optimised on the previous Operations bench testing program. Table 1 presents Veolia Performance guarantee for Operations WTP.

Table 1 Operations WTP Process Performance Guarantee (Monthly Average except where stated otherwise)

Parameters	Units	Final Effluent water quality (Veolia Process Guarantee for Operations Phase)
Total Suspended Solids (TSS)	**mg/L**	15
Sulfate	**mg/L**	Increase <200 through facility
Sulfide	**mg/L**	Increase <0.25 through facility
Phosphorus	**mg P/L**	0.1
Aluminium	**mg/L**	0.15
Arsenic	**mg/L**	0.005

Parameters	Units	Final Effluent water quality (Veolia Process Guarantee for Operations Phase)
Cadmium	**mg/L**	0.00012
Cobalt	**mg/L**	0.005
Copper	**mg/L**	0.005
Iron	**mg/L**	0.25
Lead	**mg/L**	0.0025
Manganese	**mg/L**	10
Silver	**mg/L**	0.0001 (Grab sample)
Zinc	**mg/L**	0.01

SECTION 3. SYNTHETIC RAW WATER

The Brucejack mine as not yet advanced to the Operations Phase and therefore does not produce influent water to be treated by the Operations WTP. The information regarding the influent water quality was obtained in Lorax technical memo, issued on May 19th 2015 and presented in Appendix C, and modified according to a simulation software (OLI) to ensure ionic balance. The OLI Reconciliation report is presented in Appendix C.

In order to simulate the metals removal process in jar tests, synthetic raw water was produced for the tests carried out in Veolia's laboratory using city water and commercially-available chemicals.

Veolia prepared synthetic raw water based on influent water quality predicted by Lorax, with adjustments to create a realistic composition based on OLI simulation software.

The influent water quality estimate does not represent a point in time, but includes the maximum concentration values for each parameter expected throughout the mine life, and is neither chemically nor electrically balanced. OLI simulation software was used to calculate the amount of sulfates ion (SO_4^{2-}) or salinity required to electrically balance the solution. No TSS was added to the synthetic water as Bench Test #1 (primary metals removal only, presented in Appendix A) validates the efficiency of the Actiflo process for TSS removal.

The synthetic raw water was prepared as follows:

1. City water was used to fill a 208-L plastic calibrated drum. Refer to Table 2 for the city water composition;
2. The City water was conditioned by letting it off-gas over a 24-hour period to remove chlorine. Two 2-L beakers were set aside for dissolution of monovalent and divalent salts prior to the addition in the drum.
3. Calcium sulfate was added to the city water and mixed for 24 hours to allow its complete dissolution. Refer to Table 3 for the quantity of calcium sulfate used;

4. During dissolution of calcium sulfate, in a separate 100 mL beaker, low mass salts were completely dissolved by adding 100X the concentration actually needed (sodium hexametaphosphate, lead chloride, nickel sulfate, sodium arsenate, sodium selenite and antimony sulfate);
5. 1 mL of the 100 mL beaker content, once dissolved, was added to the monovalent and divalent salts solution (corresponding to the salts addition required in low masses);
6. The metals solutions were added to the city water drum. Refer to Table 3 for the masses of chemicals added to the city water;
7. The synthetic raw water was mixed during a minimum of 2 days; and
8. After the mixing period, sufficient synthetic raw water was sampled from the drum without stopping the mixing and sent to ALS for completing the synthetic water characterization. Refer to Section **Erreur ! Source du renvoi introuvable.** for the compiled results of the ALS analysis and refer to Appendix E for the complete analysis and method used for the analyses (ALS certificates).

Table 2 shows the composition of the city water used to produce the synthetic raw water. Also, the target synthetic raw water composition is presented, as predicted by Lorax, once balanced with an OLI simulation conducted by Veolia in May 2015 (Appendix C).

Table 3 presents the chemicals and dosages used to produce the synthetic raw water.

Section 5.1 presents the resulting synthetic raw water quality used for the Operations WTP bench-testing program and Section 6.2 provides comments on the synthetic water composition (based on the raw water composition received from Lorax on May 19th 2015, once equilibrated with OLI simulation software by Veolia).

Since the dissolved arsenic concentration was lower than expected for the synthetic water constructed in Veolia's laboratory, it was modified by decreasing the pH and adding arsenic salt in order to achieve a higher dissolved As influent. This modified synthetic water is used to validate that arsenic can be removed at required Process Performance

Guarantee discharge criteria. The original synthetic water (before pH drop and excessive As dosage) is used to validate the removal efficiency of the process to achieve the Process Performance Guarantee for all metals concentration and is considered the real validation for this Operations WTP validation Bench test (the synthetic water is more representative to the expected Operations WTP influent in worst-case scenario). Validation of the arsenic removal is further tested with the modified synthetic water as higher dissolved arsenic concentration was achieved in the modified synthetic water.

Table 2: City Water Composition and Target Concentrations in Synthetic Raw Water from May 19th 2015 Influent Water Quality issued by Lorax, once balanced by OLI software

Parameters (Dissolved Metals, Anions, TSS)	Values	
	City Water[1]	Synthetic Water Target[2] Concentrations
	mg/L	mg/L
Ammonia-N	0.0259	6.5983
Nitrate-N	0.411	36.3591
Nitrite-N	0.00350	1.8993
Chloride	26.9	29.2917
Sulphate-S	9.53	882.567
Phosphorus-P	0.0337	0.1398
Fluorine	0.106	3.7989
Aluminum	0.0125	28.5919
Antimony	0.000150	0.2001
Arsenic	0.000760	0.3898
Cadmium	0.0000210	0.0680
Calcium	34.7	649.816
Chromium	< 0.000100	0.4899
Cobalt	< 0.000100	0.0610
Copper	0.0424	0.7498
Iron	0.014	64.6816
Lead	<0.0000500	0.0130
Magnesium	8.21	41.9881
Manganese	0.0967	52.985
Nickel	0.000670	0.1400
Potassium	1.60	218.938
Selenium	0.000160	0.0190

[1] The complete analyses were performed by ALS and are presented in Appendix D.
[2] The synthetic raw water target concentrations are based on Lorax predicted influent water quality on May 19th, balanced with OLI simulation software by Veolia, and are expressed in total mg/L (addition of salts and standards are based on total basic to ensure equilibrium and desired dissolved concentrations).

Parameters (Dissolved Metals, Anions, TSS)	Values	
	City Water[1]	Synthetic Water Target[2] Concentrations
	mg/L	mg/L
Silver	0.000023	0.000320
Sodium	15.4	208.941
Zinc	0.0025	9.5973

Table 3: Chemicals Used to Produce the Synthetic Raw Water and the Modified Synthetic Water

Components[3]		Units	Original Synthetic water (for chemical optimisation)			Modified Synthetic water (for higher As influent concentration validation)		
			Initial Addition of Chemical	Spiked on June 18th	Final original chemical composition	Spiked on June 25th	Spiked on June 29th	Final modified chemical composition
Synthetic Water Volume		**L**	**208**	**208**	**208**	**36**	**20**	**36**
pH		**-**	4.90	4.64	4.26	3.05	3.07	3.07
Aluminum (Al)	$Al_2(SO_4)_3 \times 14H_2O$	**g**	72.0038	-	72.0038	-	-	12.4622
Ammonia (N^{-3})	NH_4Cl	**g**	5.7427	-	5.7427	-	-	0.9939
Antimony (Sb^{+3})	$Sb_2(SO_4)_3$	**g**	0.0998	-	0.0998	-	-	0.0173
Arsenic (As^{+3})	As_2O_3	**g**	0.1331	0.2656	0.3987	0.0227	0.0154	0.0735
Cadmium (Cd)	**AAS Standard Cd**	**mL**	14.13	-	14.13	-	-	2.45
Calcium (Ca)	$CaSO_4.2H_2O$	**g**	604.5050	-	604.5050	-	-	104.6259
Chromium (Cr^{+3})	$Cr(NO_3)_3.9H_2O$	**g**	0.8622	-	0.8622	-	-	0.1492
Cobalt (Co)	**AAS Standard Co**	**mL**	12.66	-	12.66	-	-	2.19
Copper (Cu)	$CuSO_4.5H_2O$	**g**	0.5671	-	0.5671	-	-	0.0981
Fluor (F)	NaF	**g**	1.8690	-	1.8690	-	-	0.3235
Iron (Fe^{+2})	$FeSO_4$		40.2468	27.7105	67.9573	-	-	11.7618
Lead (Pb)	$PbCl_2$	**g**	0.0039	-	0.0039	-	-	0.0007
Magnesium (Mg)	$MgSO_4$	**g**	38.6030	-	38.6030	-	-	6.6813
Manganese (Mn)	$MnSO_4.1H_2O$	**g**	37.2938	-	37.2938	-	-	6.4547
Nickel (Ni)	$NiSO_4.6H_2O$	**g**	0.1427	-	0.1427	-	-	0.0247
Nitrate (N^{+5})	$NaNO_3$	**g**	10.2291	-	10.2291	-	-	1.7704
Nitrite (N^{+3})	$NaNO_2$	**g**	0.6506	-	0.6506	-	-	0.1126
Phosphorus (P)	$(NaPO_3)_6$	**g**	0.0325	-	0.0325	-	-	0.0056
Potassium (K)	K_2SO_4	**g**	110.8720	-	110.8720	-	-	19.1894
Selenium (Se^{+6})	Na_2O_3Se	**g**	0.0095	-	0.0095	-	-	0.0016
Silver (Ag)	Ag_2SO_4	**g**	0.0001	-	0.0001	-	-	1.7737×10^{-5}
Sodium (Na)	Na_2SO_4	**g**	126.0565	-	126.0565	-	-	21.8175
Zinc (Zn)	$ZnSO_4.7H_2O$	**g**	7.5140	1.4898	9.0038	-	-	1.5584

[3] Note that all Atomic Absorption Spectroscopy (AAS) standards are 1000 ppm and contain 1% nitric acid.

SECTION 4. MATERIALS AND METHODS

This section presents the materials and methods used to simulate the primary metals removal and the polishing metals removal processes in jar tests, using the synthetic raw waters (original for process validation and dosage determination, and modified at lower pH for validation of dissolved As removal) both produced in Veolia's laboratory.

4.1 Materials

The bench-scale testing was performed using a Phipps & Bird jar tester and 1-L cylindrical beakers, as shown in Figure 1.

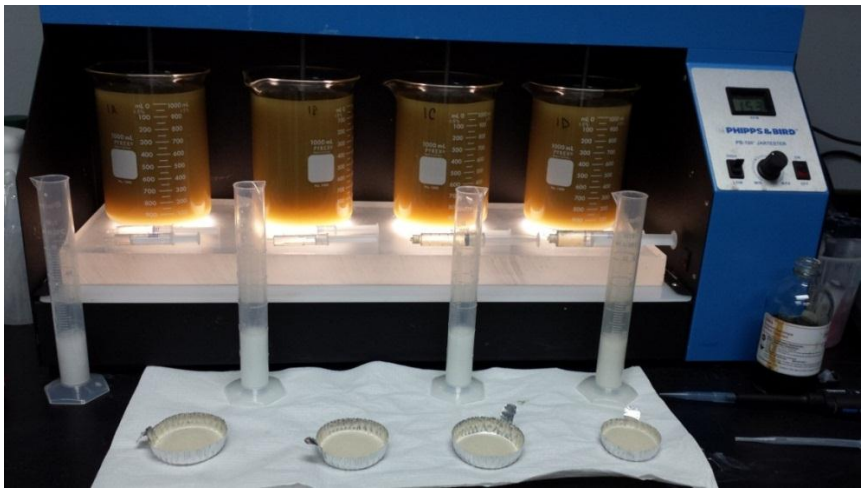

Figure 1: Jar Test Set-Up

Table 4 summarizes the chemicals used during the jar tests program. The Material Safety Data Sheets (MSDS) of the chemicals used can be found in Appendix F.

Hydrated lime ($Ca(OH)_2$) is an inorganic compound use to raise the pH and to precipitate metals. The pH was raised to 10.0 for the primary metals removal and lowered to 7.25 for the polishing metals removal step. Lime was required to reach a pH of 7.25 during the polishing step even if the initial primary metals removal clarified water is at pH 10.0; the addition of coagulant in the polishing step, combined with the very low alkalinity of the water at this point in the process, cause a pH drop superior to what is needed to reach 7.25. Therefore, lime dosage might be needed in polishing step, as shown in the actual

Operations WTP Bench test. However, in full-scale implementation, sulfuric acid might be needed to lower the pH as the coagulant dosage will be inferior (the Operations WTP influent will not be as concentrate as the worst-case scenario synthetic water created in laboratory).

Sodium sulfide (Na_2S) was used to precipitate metals as sulfides in the primary metals removal process step. Many metal sulfides have much lower solubility than the corresponding metal hydroxide, thus allowing a lower residual metals concentration in the treated water. This is especially significant for cadmium and copper, as it would be difficult to reduce their concentration without sulfide. A high pH is required for the process to be efficient.

Metal hydroxides and sulfides form colloidal particles, whose removal requires the addition of a coagulant, in this case ferric sulfate (Hydrex™ 6253), to allow better solid-liquid separation downstream of the Actiflo®. Ferric sulfate forms a ferric hydroxide floc, which acts both as a bridge to bind colloidal particles together, and as an active surface which forms complexes with many metals, providing further metals removal in addition to the precipitation already achieved using hydroxides and sulfides.

The purpose of the polishing step is first to capture any solids remaining after the primary metals removal step and second, to trap anions such as arsenates, arsenites, antimonates, molybdates and chromates on the freshly-formed ferric hydroxide floc. In general, the capture of anions on the ferric hydroxide floc is more efficient at a lower pH.

An anionic polymer (Hydrex™ 6183) is used for flocculation.

The chemicals used were selected based on Veolia's experience and previous experimental and full-scale results. These were also the chemicals used in the two previous bench testing completed for the Operations WTP, which mean to be validated in the present bench testing.

Table 4: Chemicals Used During the Metals Removal Jar Testing

Chemicals	Formula	Purpose
Hydrated lime (15 g/L)	$Ca(OH)_2$	pH adjustment and metals precipitation
Sodium sulfide (14 g/L[4])	Na_2S	Metals precipitation in primary metals removal
Anionic polymer	Hydrex™ 6183	Flocculation
Ferric sulfate	Hydrex™ 6253	Coagulation
Actisand	Hydrex™	Ballasted decantation
Sulfuric Acid	H_2SO_4 98%	pH adjustment in polishing metals removal (if needed)

Each chemical's MSDS can be found in Appendix F.

All glassware and laboratory equipment that came into contact with the clarified primary metals removal effluent and with the final effluent was washed, rinsed with distilled water, rinsed with a 5% nitric acid solution and finally rinsed with distilled water. This procedure was applied to prevent and limit contamination since it has been a problem issue in previous bench tests, especially for the Operations WTP.

4.2 Methodology

Tests were performed in Veolia's laboratory, in Montreal, Quebec. Metal, anions and nutrients analyses were performed by the ALS Environmental (ALS) certified laboratory in Vancouver, BC (ISO 17025:2005 Accredited Laboratory). All samples were sent in duplicate for results validation purpose.

[4] The concentration of the sodium sulfide solution was measured using the Iodometric Method (4500-S2- F) of Standard Methods (2005).

4.2.1 Jar Tests Procedure

The synthetic raw water prepared as described in SECTION 3 was treated using jar tests to simulate the primary metals removal process, i.e. TSS and metals removal. Treated water resulting from the optimized primary metals removal process was replicated and treated using jar tests to simulate the polishing metals removal process, i.e. metals removal.

At full scale operation, the primary metals removal and the polishing metals removal processes are each achieved by Metals Removal Reactors and an Actiflo® unit.

Metals Removal Reactors are tanks to which chemicals are added, and which provide a reaction time as a function of their volume.

An Actiflo® unit is a sand-ballasted settling system designed to remove suspended solids present in the water. The Actiflo® is a high-rate coagulation/flocculation/sedimentation process that utilizes microsand as a seed for floc formation. The microsand provides a surface area that enhances flocculation and acts as a ballast or weight. The resulting floc settles very quickly, allowing for compact clarifier designs compared to conventional clarifiers, with high overflow rates and short retention times. The use of microsand also permits the unit to perform well under dramatically changing flow rates without affecting effluent quality.

The primary metals removal and the polishing metals removal processes are summarized respectively in Table 5 and in Table 6, where the chemicals used for each are summarized.

Table 5: Process Treatment Chain for Primary Metals Removal

Process Step	Process Name	Chemicals Added	Objectives
1	Primary Metals Reactors	hydrated lime sodium sulfide coagulant	pH adjustment and metals precipitation
2	ACTIFLO® (clarification using ballasted flocculation, currently used on-site)	anionic polymer actisand	decantation

Table 6: Process Treatment Chain for Polishing Metals Removal;

Process Step	Process Name	Chemicals Added	Objectives
1	Polishing Reactors	hydrated lime coagulant	pH adjustment and metals precipitation
2	ACTIFLO® (clarification using ballasted flocculation, currently used on-site)	anionic polymer actisand	decantation
3	Hydrotech Discfilter filtration[5]	None	Clarified water polishing

The jar test program is designed to reproduce the retention time in the Metals Removal Reactors and to simulate Veolia's Actiflo® ballasted flocculation technology. The test procedure to simulate the Actiflo® process is as per the paper included in Appendix G and published in Water Research (2002)[6]. The total retention time in the reactors is 20 minutes, divided into three equal compartments, and the time between chemical additions is calculated to match the expected addition sequence in the full scale plant. The test procedure used to simulate the primary metals removal process was the following:

1. Adjustment of pH using lime to bring the synthetic raw water to optimum metals removal conditions found in the previous bench tests, i.e. between pH 9.5 and 10.5;
2. Addition of sodium sulfide to the synthetic raw water after a defined contact time of 6.6 minutes (a retention time equivalent to one metal removal tank);
3. Addition of the ferric sulfate (coagulant-Hydrex™ 6253) a few seconds later to complete the metals removal reaction;
4. Addition of the anionic polymer (Hydrex™ 6183) and sand after 13.3 minutes (a retention time equivalent to two metal removal tank) to start the ballasted

[5] The full scale Operations plant is designed to allow for intercoagulation before the final filtration step. This intercoagulation, as well as the discfilter filtration, are difficult to reproduce on a lab scale, and are therefore not included in this test.

[6] Desjardins, C., Koudjonou, B., & Desjardins, R. (2002). 'Laboratory study of ballasted flocculation'. *Water Research*, 36, 744-754

flocculation process on the synthetic raw water and to complete the metals removal reaction;

5. Sampling of the clarified water produced after flocculation and settling and measurement of the TSS and metals concentrations. The tests were held at room temperature.

This test procedure was repeated with different coagulant and sulfide dosages. Sequence of dosage and optimal pH were taken from the two previous Operations WTP bench testing. The hydrated lime, sodium sulfide and coagulant dosages were optimised given the difference in water quality between the actual synthetic water and the second synthetic water produced for Operations WTP bench testing (higher As, Cd and Zn concentrations). Section 5.2 describes the different optimization tests made on this validation bench testing. The complete jar test results sheet can be found in Appendix H.

For the simulation of the polishing metals removal process, the test procedure is as follows:

1. Addition of the ferric sulfate (coagulant-Hydrex™ 6253);
2. Immediately after coagulant dosage, adjustment of pH using lime or sulfuric acid[7] to bring the synthetic raw water to optimum metals removal conditions, i.e. between pH 7.0 and 7.5;
3. After 20 minutes of retention time, the anionic polymer (Hydrex™ 6183) and sand were added to start the ballasted flocculation process on the synthetic primary-treated water and to complete the metals removal reaction;

[7] In the full scale plant sulfuric acid will be added; the coagulant dosage will be lower from the dosages currently tested and acidification of the water will then be needed. Because the water used in the tests has very little buffering capacity, it was extremely difficult to adjust the pH for polishing in at laboratory scale (in the 1 L samples).

4. The clarified water produced after flocculation and settling was sampled and the TSS and metals concentrations in it were measured. The tests were held at room temperature.

This test procedure was repeated with different coagulant concentrations. Section 5.3 describes the optimization made on the polishing step for this performance validation bench testing. The complete jar test results sheet can be found in Appendix H.

The effect of using a Discfilter was not evaluated as part of this test. The Discfilter is not especially beneficial at the lab scale where TSS concentrations of less than 3 mg/L are routinely achieved. In the full-scale plant, where TSS removal is often not as efficient, the Discfilter provides a reliable last line of defense, especially when combined with an intercoagulation step.

4.2.2 Monitoring

Monitoring during the two steps of the bench-scale test program (primary metals removal and polishing metals removal) was performed in two steps:

- The clarified water samples were first analysed in Veolia's laboratory to have an initial idea of the performance of the primary metals removal process jar tests. Refer to Table 7 for the parameters monitored during Primary Metals Removal Jar Tests and Polishing Metals Removal Jar Tests and their expected ranges; and,
- Samples with parameter values within the expected range and that were visually acceptable, i.e. with low turbidity, were then sent for analysis to ALS for chemical testing. The methods used for measuring the clarified water parameters are described in Table 8. All laboratory equipment was calibrated according to the supplier's operation manual prior to starting the jar testing program.

Table 7: Parameters Monitored during Primary Metals Removal and Polishing Metals Removal Jar Tests

Parameter	Unit	Clarified Water Samples	Expected Range
Turbidity	NTU	X	<5
pH	--	X	9.5 to 10.3
Copper	mg/L	X	Refer to method indicated in Table 8

Table 8: Methods of Measurement for the Primary Metals Removal and the Polishing Metal Removal Far tests

Parameters	Veolia/External Laboratory	Equipment	Method[8]
Turbidity	Veolia	HACH 2100N turbidimeter	-
pH	Veolia	Hach HQ-40	-
Copper	Veolia	Hach DR3900	Method 8143 Porphyrin Method
Anions	External laboratory	--	EPA 300.1 Ion Chromatography
Total Metals	External laboratory	--	EPA 3005A/6010B - ICP Optical EPA 200.2/6020A(mod) - ICPMS
Dissolved Metals	External laboratory	--	EPA 3005A/6010B - ICP Optical EPA 3030B/6020A(mod) - ICPMS

[8] The acronyms and methods mentioned here are described in Standard Methods Manual

SECTION 5. RESULTS

5.1 Synthetic Raw Water Quality Results

5.1.1 Original Synthetic Raw Water Quality

The synthetic raw water quality used for the validation Operations bench testing is presented in Table 9. An adjustment on the As, Fe and Zn concentrations was made accordingly to the difference between the targeted synthetic water concentrations and the initial synthetic water composition obtained for Operations WTP validation bench test. Table 10 presents the quality of the adjusted synthetic water; Influent 3 presents the validation of the composition of the synthetic water prior to carry on with the bench testing and Influent 4 and 5 are samples representing the influent quality the day the bench testing was performed.

Table 9: Synthetic Raw Water Composition before Chemical Adjustment

Elements	Unit	Influent 1 2015-06-15		Influent 2 2015-06-15	
		Total	Dissolved	Total	Dissolved
pH		4.97	-	4.89	-
Total suspended solids (TSS)	mg/L	473	-	421	-
Chloride (Cl)	mg/L	-	46	-	46
Total Nitrogen	mg N/L	-	17.9	-	17.4
Ammonia (NH_4)	mg N/L	-	6.81	-	6.38
Nitrate (NO_3)	mg N/L	-	10.3	-	10.3
Nitrite (NO_2)	mg N/L	-	0.283	-	0.280
Sulfate (SO_4)	mg S/L	-	823.3	-	823.3
Aluminum (Al)	mg/L	15.0	5.64	15.0	5.32
Antimony (Sb)	mg/L	0.189	0.120	0.190	0.116
Arsenic (As)	mg/L	0.317	0.0031	0.338	0.0030
Barium (Ba)	mg/L	0.0274	0.0559	0.0270	0.0504
Beryllium (Be)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)	mg/L	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	mg/L	0.0651	0.0638	0.0654	0.0613
Calcium (Ca)	mg/L	669	514	679	489
Chromium (Cr)	mg/L	0.497	0.0043	0.499	0.0043
Cobalt (Co)	mg/L	0.0744	0.0732	0.0750	0.0702
Copper (Cu)	mg/L	0.737	0.685	0.745	0.662
Iron (Fe)	mg/L	35.9	25.9	35.8	25.1
Lead (Pb)	mg/L	0.0122	0.00740	0.0118	0.00715

Elements	Unit	Influent 1 2015-06-15		Influent 2 2015-06-15	
		Total	Dissolved	Total	Dissolved
Lithium (Li)	mg/L	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	mg/L	45.6	44.0	45.1	41.6
Manganese (Mn)	mg/L	54.6	52.6	54.7	50.5
Molybdenum (Mo)	mg/L	0.00201	<0.00050	0.00194	<0.00050
Nickel (Ni)	mg/L	0.136	0.134	0.139	0.130
Phosphorus (P)	mg P/L	<0.30	<0.30	<0.30	<0.30
Orthophosphate (PO_4)	mg P/L	-	<0.0010	-	<0.0010
Potassium (K)	mg/L	240	225	239	216
Selenium (Se)	mg/L	0.0166	0.0150	0.0170	0.0152
Silicon (Si)	mg/L	0.453	0.379	0.451	0.347
Silver (Ag)	mg/L	0.00036	<0.00010	0.00035	0.00014
Sodium (Na)	mg/L	216	207	215	198
Strontium (Sr)	mg/L	0.313	0.279	0.312	0.271
Thallium (Tl)	mg/L	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)	mg/L	<0.010	<0.010	<0.010	<0.010
Uranium (U)	mg/L	0.00034	0.00028	0.00036	0.00027
Vanadium (V)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050
Zinc (Zn)	mg/L	7.69	7.54	7.71	7.21

Table 10: Synthetic Raw Water Composition after chemical adjustment

Elements	Unit	Average before chemical adjustment		Influent 3 2015-06-18		Influent 4 2015-06-25		Influent 5 2015-06-25	
		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
pH		4.93	-	4.64	-	4.26	-	4.26	-
Total suspended solids (TSS)	mg/L	447	-	544	-	769	-	811	-
Chloride (Cl^-)	mg/L	-	46	-	46	-	48	-	48
Total Nitrogen	mg N/L	-	17.7	-	17.3	-	18.1	-	18.1
Ammonia (NH_4)	mg N/L	-	6.60	-	7.28	-	7.39	-	7.35
Nitrate (NO_3)	mg N/L	-	10.3	-	10.3	-	10.7	-	10.8
Nitrite (NO_2)	mg N/L	-	0.282	-	0.245	-	0.144	-	0.136
Sulfate (SO_4)	mg S/L	-	823.3	-	836.7	-	836.7	-	843.3
Aluminum (Al)	mg/L	15	5.48	16.6	8.53	15.1	10.0	15.3	9.94
Antimony (Sb)	mg/L	0.1895	0.118	0.197	0.0823	0.206	0.0339	0.219	0.0320
Arsenic (As)	mg/L	0.3275	0.00305	0.595	0.0078	0.907	0.0836	0.911	0.0797
Barium (Ba)	mg/L	0.0272	0.05315	0.0280	0.0617	0.0282	0.0577	0.0293	0.0461
Beryllium (Be)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	mg/L	0.06525	0.06255	0.0716	0.0673	0.0711	0.0704	0.0742	0.0675
Calcium (Ca)	mg/L	674	501.5	649	513	663	499	629	457

Elements	Unit	Average before chemical adjustment		Influent 3 2015-06-18		Influent 4 2015-06-25		Influent 5 2015-06-25	
		Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Chromium (Cr)	mg/L	0.498	0.0043	0.580	0.0109	0.557	0.0075	0.579	0.0075
Cobalt (Co)	mg/L	0.0747	0.0717	0.0895	0.0826	0.0846	0.0841	0.0866	0.0805
Copper (Cu)	mg/L	0.741	0.6735	0.842	0.774	0.819	0.811	0.847	0.765
Iron (Fe)	mg/L	35.85	25.5	70.2	48.7	68.9	44.2	71.7	42.6
Lead (Pb)	mg/L	0.012	0.007275	0.0125	0.00605	0.0138	0.00555	0.0143	0.00532
Lithium (Li)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	mg/L	45.35	42.8	45.0	46.0	44.4	42.8	39.8	41.2
Manganese (Mn)	mg/L	54.65	51.55	61.7	56.0	59.1	59.4	61.9	57.0
Molybdenum (Mo)	mg/L	0.001975	<0.00050	0.00211	<0.00050	0.00297	0.00068	0.00308	0.00065
Nickel (Ni)	mg/L	0.1375	0.132	0.166	0.153	0.158	0.155	0.162	0.153
Phosphorus (P)	mg P/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Orthophosphate (PO_4)	mg P/L	-	<0.0010	-	<0.0010	-	<0.0010	-	<0.0010
Potassium (K)	mg/L	239.5	220.5	271	249	247	252	254	246
Selenium (Se)	mg/L	0.0168	0.0151	0.0202	0.0158	0.0191	0.0178	0.0201	0.0175
Silicon (Si)	mg/L	0.452	0.363	0.468	0.391	0.418	0.400	0.429	0.359
Silver (Ag)	mg/L	0.000355	0.00014	0.00040	<0.00010	0.00042	<0.00010	0.00045	<0.00010
Sodium (Na)	mg/L	215.5	202.5	252	235	238	235	241	230
Strontium (Sr)	mg/L	0.3125	0.275	0.325	0.279	0.338	0.302	0.359	0.292
Thallium (Tl)	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)	mg/L	<0.010	<0.010	<0.010	<0.010	0.010	0.010	0.012	0.010
Uranium (U)	mg/L	0.00035	0.000275	0.00039	0.00027	0.00040	0.00033	0.00041	0.00032
Vanadium (V)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Zinc (Zn)	mg/L	7.7	7.375	10.6	9.89	10.2	10.3	10.7	10.0

5.1.2 Modified Synthetic Raw Water Quality (for additional testing)

No matter the quantity of arsenic salt added to the synthetic water, the targeted dissolved As concentration could not be reached with the expected pH for the Operations WTP's influent. In order to prove the efficiency of dissolved arsenic removal in Actiflo process, additional tests were asked to Veolia on June 22nd via an email sent by Robert Goldblatt. It consists on lowering the pH of the dissolved fraction of the synthetic water, followed by the addition of arsenic salt.

Due to complication awaited by having only the dissolved fraction of the synthetic water for a large volume to prepare a new synthetic water and the delay it would have caused, settled water from the original synthetic water was taken instead.

pH adjustment was made using sulfuric acid and addition of arsenic was overdosed to make sure there was enough dissolved arsenic in the modified synthetic water. Water quality of the modified synthetic water is presented in Table 11.

Table 11: Modified Synthetic Raw Water Composition before Chemical Adjustment

Elements	Unit	Average before modification of synthetic water		Influent 10 2015-06-25		Influent 11 2015-06-29	
		Total	Dissolved	Total	Dissolved	Total	Dissolved
pH		4.26	-	3.04	-	3.07	-
Total suspended solids (TSS)	**mg/L**	790	-	29.5	-	775	-
Chloride (Cl^-)	**mg/L**	-	48	-	44	-	47
Total Nitrogen	**mg N/L**	-	18.1	-	16.9	-	18.7
Ammonia (NH_4)	**mg N/L**	-	7.37	-	6.77	-	7.37
Nitrate (NO_3)	**mg N/L**	-	10.8	-	9.72	-	10.7
Nitrite (NO_2)	**mg N/L**	-	0.140	-	0.091	-	0.111
Sulfate (SO_4)	**mg S/L**	-	840.0	-	803.3	-	886.7
Sulfide (S)	**mg S/L**	<2	-	<2	-	<2	-
Aluminum (Al)	**mg/L**	15.2	9.97	12.3	10.1	16.5	10.4
Antimony (Sb)	**mg/L**	0.2125	0.03295	0.140	0.0395	0.248	0.0393
Arsenic (As)	**mg/L**	0.909	0.08165	0.684	0.154	1.25	0.192
Barium (Ba)	**mg/L**	0.02875	0.0519	0.0258	0.0254	0.0300	0.0277
Beryllium (Be)	**mg/L**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	**mg/L**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cadmium (Cd)	**mg/L**	0.07265	0.06895	0.0669	0.0657	0.0726	0.0699
Calcium (Ca)	**mg/L**	646	478	416	419	713	517
Chromium (Cr)	**mg/L**	0.568	0.0075	0.339	0.0380	0.727	0.0295
Cobalt (Co)	**mg/L**	0.0856	0.0823	0.0788	0.0794	0.0864	0.0837
Copper (Cu)	**mg/L**	0.833	0.788	0.818	0.795	0.917	0.846
Iron (Fe)	**mg/L**	70.3	43.4	56.3	43.5	77.3	45.4
Lead (Pb)	**mg/L**	0.01405	0.005435	0.0103	0.00739	0.0160	0.00920
Lithium (Li)	**mg/L**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	**mg/L**	42.1	42	36.4	38.0	47.6	47.6
Manganese (Mn)	**mg/L**	60.5	58.2	55.0	55.1	60.8	58.5
Molybdenum (Mo)	**mg/L**	0.003025	0.000665	0.00209	0.00061	0.00368	0.00064
Nickel (Ni)	**mg/L**	0.16	0.154	0.149	0.146	0.161	0.155
Phosphorus (P)	**mg P/L**	<0.30	<0.30	<0.30	<0.30	<0.60	<0.60
Orthophosphate (PO_4)	**mg P/L**	-	<0.0010	-	0.0042	-	0.0036
Potassium (K)	**mg/L**	250.5	249	226	235	252	244
Selenium (Se)	**mg/L**	0.0196	0.01765	0.0177	0.0171	0.0206	0.0176
Silicon (Si)	**mg/L**	0.4235	0.3795	0.373	0.332	0.49	0.41
Silver (Ag)	**mg/L**	0.000435	<0.00010	0.00017	<0.00010	0.00042	<0.00010

Elements	Unit	Average before modification of synthetic water		Influent 10 2015-06-25		Influent 11 2015-06-29	
		Total	Dissolved	Total	Dissolved	Total	Dissolved
Sodium (Na)	**mg/L**	239.5	232.5	219	220	242	232
Strontium (Sr)	**mg/L**	0.3485	0.297	0.294	0.262	0.346	0.287
Thallium (Tl)	**mg/L**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)	**mg/L**	0.011	0.01	0.011	0.011	<0.020	<0.020
Uranium (U)	**mg/L**	0.000405	0.000325	0.00034	0.00031	0.00039	0.00033
Vanadium (V)	**mg/L**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Zinc (Zn)	**mg/L**	10.45	10.15	10.0	10.1	11.0	10.7

The modified synthetic water was still not in compliance with the targeted dissolved arsenic concentration, but was increased compared to the original synthetic water for Operations validation bench tests. Arsenic (As) concentration was therefore adjusted prior to the launch of the additional bench test program. The chemically adjusted modified synthetic water for the additional arsenic removal bench testing is presented in Table 12.

Table 12: Modified Synthetic Raw Water Composition after Chemical Adjustment

Elements	Unit	Average before chemical adjustment		Influent 12 2015-06-18		Influent 13 2015-06-25	
		Total	Dissolved	Total	Dissolved	Total	Dissolved
pH		3.01	-	3.08	-	3.07	-
Total suspended solids (TSS)	**mg/L**	402.3	-	106	-	94.1	-
Chloride (Cl^-)	**mg/L**	-	45.5	-	45	-	46
Total Nitrogen	**mg N/L**	-	17.8	-	17.6	-	17.4
Ammonia (NH_4)	**mg N/L**	-	7.07	-	6.90	-	6.92
Nitrate (NO_3)	**mg N/L**	-	10.21	-	10.1	-	10.3
Nitrite (NO_2)	**mg N/L**	-	0.101	-	0.035	-	0.041
Sulfate (SO_4)	**mg S/L**	-	845.0	-	840.0	-	853.3
Sulfide (S)	**mg S/L**	<2.0	-	n/a	-	n/a	-
Aluminum (Al)	**mg/L**	14.4	10.25	14.4	12.3	13.9	11.5
Antimony (Sb)	**mg/L**	0.194	0.0394	0.151	0.0437	0.168	0.0443
Arsenic (As)	**mg/L**	0.967	0.173	1.07	0.231	1.19	0.214
Barium (Ba)	**mg/L**	0.0279	0.02655	0.0271	0.0588	0.0275	0.0552
Beryllium (Be)	**mg/L**	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	**mg/L**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10

Elements	Unit	Average before chemical adjustment		Influent 12 2015-06-18		Influent 13 2015-06-25	
		Total	Dissolved	Total	Dissolved	Total	Dissolved
Cadmium (Cd)	**mg/L**	0.06975	0.0678	0.0668	0.0628	0.0660	0.0603
Calcium (Ca)	**mg/L**	564.5	468	504	483	512	482
Chromium (Cr)	**mg/L**	0.533	0.03375	0.430	0.166	0.432	0.160
Cobalt (Co)	**mg/L**	0.0826	0.08155	0.0832	0.0787	0.0823	0.0736
Copper (Cu)	**mg/L**	0.8675	0.8205	0.850	0.802	0.844	0.766
Iron (Fe)	**mg/L**	66.8	44.45	61.2	45.6	59.4	44.4
Lead (Pb)	**mg/L**	0.01315	0.008295	0.0108	0.00935	0.0120	0.00959
Lithium (Li)	**mg/L**	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)	**mg/L**	42	42.8	47.4	45.3	47.3	44.6
Manganese (Mn)	**mg/L**	57.9	56.8	55.5	52.2	55.6	49.5
Molybdenum (Mo)	**mg/L**	0.002885	0.000625	0.00243	0.00084	0.00256	0.00081
Nickel (Ni)	**mg/L**	0.155	0.1505	0.155	0.146	0.156	0.139
Phosphorus (P)	**mg P/L**	<0.60	<0.60	<0.30	<0.30	<0.30	<0.30
Orthophosphate (PO_4)	**mg P/L**	-	0.0039	-	0.0021	-	0.0022
Potassium (K)	**mg/L**	239	239.5	249	232	246	218
Selenium (Se)	**mg/L**	0.01915	0.01735	0.0175	0.0152	0.0174	0.0142
Silicon (Si)	**mg/L**	0.4315	0.371	0.486	0.410	0.489	0.414
Silver (Ag)	**mg/L**	0.000295	<0.00010	0.00021	<0.00010	0.00025	<0.00010
Sodium (Na)	**mg/L**	230.5	226	236	217	231	204
Strontium (Sr)	**mg/L**	0.32	0.2745	0.282	0.263	0.307	0.270
Thallium (Tl)	**mg/L**	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)	**mg/L**	0.011	0.011	<0.010	<0.010	<0.010	<0.010
Uranium (U)	**mg/L**	0.000365	0.00032	0.00033	0.00032	0.00036	0.00032
Vanadium (V)	**mg/L**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Zinc (Zn)	**mg/L**	10.5	10.4	10.6	10.1	10.5	9.66

n/a: not available (not measured).

5.2 Primary Metals and TSS Removal Jar Test Results- Original synthetic water

In order to simplify the reading of this section, Table 13 presents a resume of all the testing done for primary metals removal step. The pH target for all the presented tests was 10.0, as previously found in last Operations WTP bench testing programs.

Table 13: Overview of the tests done for primary metals removal step in Operations WTP validation bench testing program

Test ID	Sulfide dosage (mg S/L)	Coagulant dosage (mg Fe/L)	Purpose	Observations
o-1	42.0	18.3	Coagulant dosage selection	Green supernatant
o-2	42.0	22.9	Coagulant dosage selection	Clear supernatant

o-3	42.0	27.5	Coagulant dosage selection	Clear supernatant; dosage selected
o-4	42.0	32.0	Coagulant dosage selection	Clear supernatant
o-5	28.0	27.5	Sulfide dosage selection	Clear supernatant
o-6	35.0	27.5	Sulfide dosage selection	Clear supernatant; sent to ALS
o-7	42.0	27.5	Sulfide dosage selection	Clear supernatant
o-8	56.0	27.5	Sulfide dosage selection	Clear supernatant
o-Blank1er	35.0	27.5	Validation of contamination through chemical dosage on distilled water Discussed in Section 6.3	Pitch black and opaque supernatant; formation of big fluffy flocs after several hours- not considered
o-6A	35.0	27.5	Water production for polishing	Clear supernatant; sent to ALS
o-6B	35.0	27.5	Water production for polishing	Clear supernatant; sent to ALS
o-6P1	35.0	27.5	Water production for polishing	Clear supernatant; used for polishing

5.2.1 Coagulant Dosage Optimization

Optimization of the dosage sequence and the pH level, completed in the two previous Operations bench testing, showed that the best sequence of dosage is Lime addition, Sulfide/Coagulant addition, followed by the Actiflo ballasted flocculation process. The target pH level during the jar testing for primary metals removal was fixed at 10.0.

Four different coagulant dosages were tested to determine the best conditions for metals and TSS removal.

Table 14 presents a summary of the tests performed for the coagulant dosage optimization tests. Detailed results can be found in Appendix H.

Table 14: Coagulant Optimization Test for primary metals removal

Chemical dosages	Sulfide dosage: 42.0 mg S/L Polymer dosage (Hydrex™ 6183): 1.5 mg/L Target pH : 10.0 Lime addition, Sulfide/Coagulant addition, Actiflo©				
Sample ID	Coagulant dosage (Hydrex™ 6253)	Lime Dose	pH	Turbidity	Copper
	mg Fe/L	mg/L	-	NTU	mg/L
Influent	-	-	4.26	-	-
o-1	18.3	345	10.27	6.76	0.001
o-2	22.9	337.5	10.24	5.23	<0.001
o-3	***27.5***	***307.5***	***9.92***	***2.38***	***<0.001***
o-4	32.0	345	10.00	2.37	0

Sample o-1 presents a green coloration in the dissolved fraction of its supernatant, showing a lack of coagulant dosage. For all the tested coagulant dosages, the copper concentration measured was similar and low (below detection limit of the HACH method except for sample o-1). Turbidity of the clarified water was measured to be lower at higher coagulant dosage, with stagnation at a dosage of 27.5 mg Fe/L. For these reasons, and since the objective of the current bench testing is validation of the proposed Operations WTP process efficiency to treat influent higher As, Cd and Zn concentrations, a coagulant dosage of 27.5 mg Fe/L is selected as optimal for primary metals removal. Further optimisation will be possible later if requested or on the full-scale process itself. In the previous bench testing done for Operations WTP, with low TSS concentration (Bench Test #2; primary metals removal and polishing), the required coagulant dosage for the primary metals removal step was identified at 27.5 mg Fe/L. Even with higher As, Cd and Zn concentration in the influent, the coagulant dosage remains sufficient in the primary metals removal step of this validation Operations WTP bench testing.

5.2.2 Sulfide dosage Optimization

Four different sulfide dosages were tested to optimise its concentration in the metals and TSS removal tests. Note that maintaining the pH at a constant value is a challenge while varying sulfide concentration, as sodium sulfide increases the pH after lime addition. For this reason, pH was adjusted during the whole contact time, as it will be in the full-scale process.

Table 15 presents a summary of the tests performed for the adjustment of sulfide dosage. Detailed results can be found in Appendix H.

Table 15: Sulfide Optimization Test for primary metals removal

Chemical dosages	Coagulant dosage: 27.5 mg Fe/L				
	Polymer dosage (Hydrex™ 6183): 2.0 mg/L				
	Target pH : 10.0				
	Lime addition, Sulfide/Coagulant addition, Actiflo©				
Sample	Sulfide dosage	Lime	pH	Turbidity	Copper

ID	Na_2S	Dose			
	mg S/L	mg/L	-	NTU	mg/L
Influent	-	-	4.26	-	-
o-5	28.0	345	9.84	1.16	0.002
o-6	***35.0***	***360***	***9.99***	***1.72***	***0***
o-7	42.0	292.5	9.81	2.67	0
o-8	56.0	285	9.98	4.86	0

Little difference was seen between the water qualities for the primary metals removal with sulfide optimisation. Since sample o-5 presents higher copper concentration (removed mainly by sulfide precipitation) and that higher sulfide dosage causes higher turbidity at the clarified water, a sulfide dosage of 35.0 mg S/L was selected as the optimal one for this validation bench testing. At the previous tests done on Operations WTP projected influent, a sulfide dosage of 19.2 mg S/L was selected with lower As, Cd and Zn concentrations in the synthetic water.

This dosage was therefore selected to produce water in order to complete the polishing step of the Operations WTP. Table 16 presents the jar-test done to produce enough water to carry on the polishing tests and to analyse the water quality from the primary metals removal step. Table 17 presents the clarified water quality obtained from the primary metals removal step. Both o-6P samples were done applying the same jar-testing procedure, but using a 20-L pail and a mixer to produce a greater volume of primary metals removal clarified water.

Table 16: Water production for primary metals removal (influent to the polishing metal removal step)

Chemical dosages	Coagulant dosage: 27.5 mg Fe/L		
	Sulfide dosage: 35.0 mg S/L		
	Polymer dosage (Hydrex™ 6183): 2.0 mg/L		
	Target pH : 10.0		
	Lime addition, Sulfide/Coagulant addition, Actiflo©		
Sample ID	Lime Dose	pH	Turbidity
	mg/L	-	NTU

Influent	-	4.26	-
o-6A	337.5	9.79	n/a
o-6A	322.5		
o-6P	330	9.70	n/a
o-6P	358.5		

Table 17: ALS Analyses for Operations WTP Primary metals removal step

Elements (All Metals as Dissolved)	Unit	Water production o-6		Water production o-6P		*Average*	
		Total	Dissolved	Total	Dissolved	*Total*	*Dissolved*
TSS	**mg/L**	9.5	-	10.6	-	10.1	-
Alkalinity -$CaCO_3$	**mg/L**	33.8	-	29.7	-	31.8	-
pH	**-**	9.36	-	9.26	-	9.31	-
Total Nitrogen	**mg N/L**	-	18.0	-	17.3	-	17.7
Ammonia	**mg N/L**	-	6.91	-	6.96	-	6.93
Nitrate	**mg N/L**	-	10.3	-	10.3	-	10.3
Nitrite	**mg N/L**	-	0.137	-	0.117	-	0.127
Chloride	**mg/L**	-	46	-	46	-	46
Fluoride	**mg/L**	-	3.56	-	3.57	-	3.57
Orthophosphate	**mg P/L**	-	<0.020	-	<0.020	-	<0.020
Sulfate	**mg S/L**	-	826.7	-	823.3	-	825.0
Sulfide	**mg S/L**	0.033	-	0.026	-	0.030	-
Aluminum (Al)	**mg/L**	0.632	0.601	0.524	0.461	0.578	0.531
Antimony (Sb)	**mg/L**	0.0155	0.0153	0.0140	0.0123	0.01475	0.0138
Arsenic (As)	**mg/L**	0.00597	0.00460	0.00729	0.00385	0.00663	0.004225
Barium (Ba)	**mg/L**	0.0266	0.0270	0.0279	0.0258	0.02725	0.0264
Beryllium (Be)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Boron (B)	**mg/L**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cadmium (Cd)	**mg/L**	0.000255	0.000052	0.000221	<0.000025	0.000238	0.000052
Calcium (Ca)	**mg/L**	639	641	645	651	642	646
Chromium (Cr)	**mg/L**	0.00059	<0.00050	0.00055	<0.00050	0.00057	<0.00050
Cobalt (Co)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Copper (Cu)	**mg/L**	<0.0025	<0.0010	<0.0025	<0.0010	<0.0025	<0.0010
Iron (Fe)	**mg/L**	0.085	<0.050	0.116	<0.050	0.1005	<0.050
Lead (Pb)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Lithium (Li)	**mg/L**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)	**mg/L**	26.4	26.3	26.9	26.4	26.65	26.35
Manganese (Mn)	**mg/L**	1.41	1.37	1.59	1.35	1.5	1.36
Molybdenum (Mo)	**mg/L**	0.00064	0.00069	0.00067	0.00061	0.000655	0.00065
Nickel (Ni)	**mg/L**	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Phosphorus (P)	**mg/L**	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Potassium (K)	**mg/L**	258	260	264	244	261	252
Selenium (Se)	**mg/L**	0.0185	0.0187	0.0189	0.0182	0.0187	0.01845

Elements (All Metals as Dissolved)	Unit	Water production o-6		Water production o-6P		*Average*	
		Total	Dissolved	Total	Dissolved	*Total*	*Dissolved*
Silicon (Si)	**mg/L**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver (Ag)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)	**mg/L**	277	277	286	259	281.5	268
Strontium (Sr)	**mg/L**	0.363	0.365	0.369	0.328	0.366	0.3465
Thallium (Tl)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium (Ti)	**mg/L**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Uranium (U)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Vanadium (V)	**mg/L**	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Zinc (Zn)	**mg/L**	<0.015	<0.0050	0.027	<0.0050	<0.021	<0.0050

5.3 Effluent Polishing- Original synthetic water

In order to simplify the reading of this section, Table 18 presents a resume of all the testing done for polishing metals removal step. The pH target for all the presented tests was 7.25.

Table 18: Overview of the tests done for polishing metals removal step in Operations WTP validation bench testing program

Test ID	Coagulant dosage (mg Fe/L)	Clarified water source	Purpose	Observations
o-11	18.3	o-6P	Coagulant dosage selection	Clear supernatant
o-12	22.0	o-6P	Coagulant dosage selection	Clear supernatant; dosage selected
o-13	25.6	o-6P	Coagulant dosage selection	Clear supernatant
o-14	29.3	o-6P	Coagulant dosage selection	Clear supernatant; dosage selected
o-12A	22.0	o-6P	Water production for ALS sampling	Clear supernatant; sent to ALS
o-12B	22.0	o-6P	Water production for ALS sampling (duplicate)	Clear supernatant; sent to ALS
o-14A	29.3	o-6P	Water production for ALS sampling	Clear supernatant; sent to ALS
o-14B	29.3	o-6P	Water production for ALS sampling (duplicate)	Clear supernatant; sent to ALS
o-Blank2e	29.3	Distilled water	Validation of contamination through chemical dosage on distilled water Discussed in Section 6.3	Clear supernatant; sent to ALS

5.3.1 Coagulant Dosage Optimization

Four coagulant dosages were tested to determine the best conditions for polishing metals removal. Table 19 presents a summary of the tests performed for the coagulant dosage optimization tests. Table 20 presents a summary of the tests for water production, once the coagulant dosages selected, in order to produce enough water for external laboratory analyses. Detailed results can be found in Appendix H. Table 21 and Table 22 present the certified external laboratory results from ALS for the polishing metals removal clarified water, issued from the polishing metals removal water production (for low coagulant dosage and for high coagulant dosage).

Table 19: Coagulant Optimization Test for polishing metals removal step

Chemical dosages	Polymer dosage (Hydrex™ 6183): 1.0 mg/L Target pH : 7.25 Coagulant addition, Lime addition, Actiflo©				
Sample ID	Coagulant dosage (Hydrex™ 6253)	Lime Dose	Sulfuric acid addition	pH	Turbidity
	mg Fe/L	mg/L	mg/L	-	NTU
o-6P (influent)	-	-	-	9.26	-
o-11	18.3	28.5	1.96	6.59	0.17
o-12	***22.0***	***33.0***	***-***	***6.70***	***0.168***
o-13	25.6	39.0	-	6.92	0.168
o-14	***29.3***	***51.0***	***-***	***6.98***	***0.188***

Visually, there is no difference between the quality of all the samples; all supernatant are clear and metals concentrations are below the detection limits of the internal laboratory analysis. Turbidity for the four samples is also similar. In order to validate the process, the higher dosage was therefore selected, as well as an intermediate one, to compare both removal performances. Therefore, samples o-12 and o-14 were selected, with coagulant dosage of respectively 22.0 mg Fe/L and 29.3 mg Fe/L.

These dosages were therefore selected to produce water in order to complete the polishing step of the Operations WTP. Table 20 presents the jar-test done to produce enough water to analyse the water quality from the polishing metals removal step. Table 21 and Table 22 present the clarified water quality obtained from the polishing metals

removal step. All o-12A samples, o-12B samples, o-14A samples and o-14B samples were done applying the regular jar-testing procedure (in 1L beakers), but the final samples o-12A, o-12B, o-14A and o-14B are a mix of 3 different jar-test (with the same dosages and sequencing) in order to accumulate enough water to carry on all the required analyses on the polishing metals removal clarified water.

Table 20: Water production for polishing metals removal (final effluent of Operations WTP bench testing)

Chemical Dosages	Polymer dosage (Hydrex™ 6183): 1.5 mg/L Target pH : 7.25 Lime addition, Sulfide/Coagulant addition, Actiflo©			
Sample ID	Coagulant dosage (Hydrex™ 6253)	Lime Dose	Sulfuric acid addition	pH
	mg Fe/L	mg/L	mg/L	-
o-6P (Influent)	-	-	-	9.26
o-12	22.0	33	2.94	7.04
o-12A	22.0	40.5	1.96	
o-12A	22.0	54	-	
o-12B	22.0	39	0.245	7.14
o-12B	22.0	36	-	
o-12B	22.0	84	10.78	
o-14	29.3	51	-	7.30
o-14A	29.3	60	-	
o-14A	29.3	49.5	10.29	
o-14B	29.3	54	-	7.07
o-14B	29.3	57	-	
o-14B	29.3	109.5	9.31	

Table 21: ALS Analyses for Operations WTP Polishing metals removal Step (low dosage; 22.0 mg Fe/L)

Elements (All Metals as Dissolved)	**Unit**	**Water production o-12A**		**Water production o-12B**		***Average (22.0 mg Fe/L)***	
		Total	**Dissolved**	**Total**	**Dissolved**	***Total***	***Dissolved***
TSS	**mg/L**	<3.0	-	10.9	-	<7.0	-
Alkalinity -$CaCO_3$	**mg/L**	8.7	-	9.6	-	9.2	-
pH	**-**	7.04	-	7.14	-	7.09	-
Total Nitrogen	**mg N/L**	-	18.0	-	18.5	-	18.3
Ammonia	**mg N/L**	-	6.81	-	6.82	-	6.82
Nitrate	**mg N/L**	-	10.3	-	10.3	-	10.3

Elements (All Metals as Dissolved)	Unit	Water production o-12A		Water production o-12B		*Average (22.0 mg Fe/L)*	
		Total	Dissolved	Total	Dissolved	*Total*	*Dissolved*
Nitrite	mg N/L	-	0.105	-	0.110	-	0.108
Chloride	mg/L	-	46	-	46	-	46
Fluoride	mg/L	-	3.42	-	3.42	-	3.42
Phosphate	mg P/L	-	<0.0010	-	<0.0010	-	<0.0010
Sulfate	mg S/L	-	843.3	-	843.3	-	843.3
Sulfide	mg S/L	<0.020	-	<0.020	-	<0.020	-
Aluminum (Al)	mg/L	<0.015	0.0079	<0.015	0.0088	0.016	0.00835
Antimony (Sb)	mg/L	0.00453	0.00438	0.00447	0.00407	0.00327	0.004225
Arsenic (As)	mg/L	<0.00050	<0.00050	0.00216	<0.00050	<0.00050	<0.00050
Barium (Ba)	mg/L	0.0299	0.0286	0.0285	0.0286	0.0291	0.0286
Beryllium (Be)	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Boron (B)	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cadmium (Cd)	mg/L	0.000099	0.000084	0.000066	0.000070	0.000059	0.000077
Calcium (Ca)	mg/L	652	660	643	653	663	656.5
Chromium (Cr)	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.00162	0.00158	0.00126	0.00124	0.00128	0.00141
Copper (Cu)	mg/L	<0.0025	0.0024	<0.0025	0.0036	<0.0025	0.003
Iron (Fe)	mg/L	0.067	<0.050	<0.050	<0.050	<0.050	<0.050
Lead (Pb)	mg/L	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Lithium (Li)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)	mg/L	26.3	26.2	25.9	25.8	26.7	26
Manganese (Mn)	mg/L	1.32	1.23	1.28	1.23	1.11	1.23
Molybdenum (Mo)	mg/L	0.00026	0.00025	0.00029	0.00029	<0.00025	0.00027
Nickel (Ni)	mg/L	0.0051	0.0049	0.0051	0.0048	0.0040	0.00485
Phosphorus (P)	mg/L	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Potassium (K)	mg/L	261	250	253	252	261	251
Selenium (Se)	mg/L	0.0190	0.0183	0.0183	0.0183	0.0183	0.0183
Silicon (Si)	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver (Ag)	mg/L	0.000112	0.000088	0.000071	0.000063	0.000097	0.0000755
Sodium (Na)	mg/L	281	267	271	264	277	265.5
Strontium (Sr)	mg/L	0.367	0.353	0.377	0.361	0.377	0.357
Thallium (Tl)	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium (Ti)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Uranium (U)	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Vanadium (V)	mg/L	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Zinc (Zn)	mg/L	<0.015	<0.0050	<0.015	0.0110	<0.015	<0.0075

Table 22: ALS Analyses for Operations WTP Polishing metals removal Step (high dosage; 29.3 mg Fe/L)

Elements (All Metals as	Unit	Water production o-14A	Water production o-14B	*Average (29.3 mg Fe/L)*

Dissolved)		Total	Dissolved	Total	Dissolved	*Total*	*Dissolved*
TSS	**mg/L**	<3.0	-	12.2	-	<7.6	-
Alkalinity -$CaCO_3$	**mg/L**	9.6	-	9.2	-	9.4	-
pH	**-**	7.30	-	7.07	-	7.19	-
Total Nitrogen	**mg N/L**	-	17.4	-	17.9	-	17.7
Ammonia	**mg N/L**	-	7.10	-	6.81	-	6.96
Nitrate	**mg N/L**	-	10.3	-	10.4	-	10.4
Nitrite	**mg N/L**	-	0.119	-	0.111	-	0.115
Chloride	**mg/L**	-	46	-	47	-	46.5
Fluoride	**mg/L**	-	3.39	-	3.41	-	3.40
Phosphate	**mg P/L**	-	<0.0020	-	<0.0020	-	<0.0020
Sulfate	**mg S/L**	-	843.3	-	856.7	-	850.0
Sulfide	**mg S/L**	<0.020	-	<0.020	-	<0.020	-
Aluminum (Al)	**mg/L**	0.016	0.0111	<0.015	0.0053	<0.016	0.0082
Antimony (Sb)	**mg/L**	0.00327	0.00294	0.00341	0.00277	0.00334	0.002855
Arsenic (As)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Barium (Ba)	**mg/L**	0.0291	0.0268	0.0280	0.0276	0.02855	0.0272
Beryllium (Be)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Boron (B)	**mg/L**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cadmium (Cd)	**mg/L**	0.000059	0.000062	0.000083	0.000088	0.000071	0.000075
Calcium (Ca)	**mg/L**	663	674	671	655	667	664.5
Chromium (Cr)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	**mg/L**	0.00128	0.00117	0.00183	0.00174	0.001555	0.001455
Copper (Cu)	**mg/L**	<0.0025	0.0016	0.0025	0.0033	<0.0025	0.00245
Iron (Fe)	**mg/L**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Lead (Pb)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Lithium (Li)	**mg/L**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)	**mg/L**	26.7	26.4	26.4	25.5	26.55	25.95
Manganese (Mn)	**mg/L**	1.11	1.04	1.29	1.23	1.2	1.135
Molybdenum (Mo)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
Nickel (Ni)	**mg/L**	0.0040	0.0039	0.0060	0.0058	0.005	0.00485
Phosphorus (P)	**mg/L**	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
Potassium (K)	**mg/L**	261	248	250	250	255.5	249
Selenium (Se)	**mg/L**	0.0183	0.0171	0.0185	0.0169	0.0184	0.017
Silicon (Si)	**mg/L**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver (Ag)	**mg/L**	0.000097	0.000078	0.000131	0.000091	0.000114	0.0000845
Sodium (Na)	**mg/L**	277	258	268	261	272.5	259.5
Strontium (Sr)	**mg/L**	0.377	0.344	0.380	0.324	0.3785	0.334
Thallium (Tl)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Titanium (Ti)	**mg/L**	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Uranium (U)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Vanadium (V)	**mg/L**	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Zinc (Zn)	**mg/L**	<0.015	<0.0050	<0.015	<0.0050	<0.015	<0.0050

Once all results were received, it was found that a 22.0 mg Fe/L coagulant dosage is sufficient to meet the Process Performance Guarantee of the Operations WTP. Should the concentration of cadmium increase, or should the criteria become stricter, the dosage of ferric iron could be increased as needed as the addition of ferric coagulant decreases the polished clarified water Cd concentration. No conclusion can be done for As and Zn, as both are below detection limits and no variation can be seen on the concentration of those metals with coagulation variation.

5.4 Additional testing for dissolved As removal- Modified synthetic water

The synthetic water quality was not exactly up to Lorax prediction, as the dissolved arsenic concentration was lower than expected even at high total concentration levels. In order to prove that the arsenic concentration at the synthetic water will not affect the performance of the Operations WTP, and it will still meet the Process Performance Guarantee, additional tests were asked. Those tests consist to lower the synthetic water pH and add arsenic. The preparation for this synthetic water was discussed in SECTION 3.

Since the validation of the process was already completed for Operations WTP at this point, the additional jar test was done on the higher polishing dosage sequence tested (same dosages and sequence were applied on the primary metals removal step than found for the validation bench tests described in Sections 5.2 and 5.3). The additional jar tests completed on June 29th, with higher arsenic concentration, are presented in Table 23 and Table 25 (for primary metals removal and for polishing metals removal). Table 24 and Table 26 present respectively the water quality obtained from the primary metal removal step and the polishing metal removal step of these additional tests, as measured by ALS.

Table 23: Chemical dosages for additional As removal- Primary metals removal step

Chemical dosages	Coagulant dosage (Hydrex™ 6253): 27.5 mg Fe/L
	Polymer dosage (Hydrex™ 6183): 2.0 mg/L

	pH Target : 10.0			
	Lime Addition, Sulfide/Coagulant Addition, Actiflo©			
Sample ID	Sulfide dosage	Lime Dosage	pH	Turbidity
	mg S/L	mg/L	-	NTU
Influent	-	-	4.26	-
Primary	35	411	9.92	1.77

Table 24: ALS Analyses for Operations Primary metals removal Step- Higher As concentration in influent

Elements	Unit	Primary 1 2015-06-29		Primary 2 2015-06-29	
		Total	Dissolved	Total	Dissolved
TSS	**mg/L**	4.7	-	5.0	-
Alkalinity -$CaCO_3$	**mg/L**	-	29.8	-	30.5
Total Nitrogen	**mg N/L**	-	17.4	-	17.3
Ammonia	**mg N/L**	-	6.58	-	6.66
Nitrate	**mg N/L**	-	10.0	-	10.2
Nitrite	**mg N/L**	-	0.044	-	0.051
Chloride	**mg/L**	-	45	-	45
Fluoride	**mg/L**	-	3.51	-	3.57
Phosphate	**mg P/L**	-	<0.0010	-	<0.0010
Sulfate	**mg S/L**		840		853
Sulfide	**mg S/L**	-	n/a	-	n/a
Aluminum (Al)	**mg/L**	0.744	0.699	0.750	0.682
Antimony (Sb)	**mg/L**	0.0110	0.0111	0.0110	0.00989
Arsenic (As)	**mg/L**	0.00251	0.00189	0.00256	0.00189
Barium (Ba)	**mg/L**	0.0254	0.0249	0.0262	0.0243
Beryllium (Be)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025
Boron (B)	**mg/L**	<0.050	<0.050	<0.050	<0.050
Cadmium (Cd)	**mg/L**	0.000175	<0.000025	0.000162	<0.000025
Calcium (Ca)	**mg/L**	626	637	630	634
Chromium (Cr)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	**mg/L**	<0.00050	<0.00050	<0.00050	<0.00050
Copper (Cu)	**mg/L**	<0.0025	<0.0010	<0.0025	<0.0010
Iron (Fe)	**mg/L**	0.104	<0.050	0.101	<0.050
Lead (Pb)	**mg/L**	<0.00025	<0.00025	<0.00025	<0.00025
Lithium (Li)	**mg/L**	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)	**mg/L**	27.8	26.9	27.8	26.8
Manganese (Mn)	**mg/L**	1.70	1.56	1.73	1.53
Molybdenum (Mo)	**mg/L**	0.00075	0.00074	0.00073	0.00066
Nickel (Ni)	**mg/L**	<0.0025	<0.0025	<0.0025	<0.0025

Elements	Unit	Primary 1 2015-06-29		Primary 2 2015-06-29	
		Total	Dissolved	Total	Dissolved
Phosphorus (P)	**mg/L**	<0.30	<0.30	<0.30	<0.30
Potassium (K)	**mg/L**	245	235	245	229
Selenium (Se)	**mg/L**	0.0170	0.0166	0.0169	0.0156
Silicon (Si)	**mg/L**	0.052	0.051	<0.050	0.052
Silver (Ag)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050
Sodium (Na)	**mg/L**	263	249	263	240
Strontium (Sr)	**mg/L**	0.348	0.361	0.358	0.325
Thallium (Tl)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050
Titanium (Ti)	**mg/L**	<0.010	<0.010	<0.010	<0.010
Uranium (U)	**mg/L**	<0.000050	<0.000050	<0.000050	<0.000050
Vanadium (V)	**mg/L**	<0.0025	<0.0025	<0.0025	<0.0025
Zinc (Zn)	**mg/L**	0.016	<0.0050	0.016	<0.0050

Table 25: Chemical dosages for additional As removal- Polishing metals removal step

Chemical dosages	Polymer dosage (Hydrex™ 6183): 1.0 mg/L Target pH : 7.25 Coagulant addition, Lime addition, Actiflo©				
Sample ID	Coagulant dosage (Hydrex™ 6253)	Lime Dose	Sulfuric acid addition	pH[9]	Turbidity
	mg Fe/L	mg/L	mg/L	-	NTU
Primary	-	-	-	9.92	1.77
Polishing 1	29.3	72	-	6.52	0.265
Polishing 1	29.3	75	-		
Polishing 2	29.3	60	-	6.35	0.152
Polishing 2	29.3	72	-		

Table 26: ALS Analyses for Operations WTP Polishing metals removal Step- Higher As concentration in influent

Elements	Unit	Polishing 1 2015-06-29		Polishing 2 2015-06-29	
		Total	Dissolved	Total	Dissolved
TSS	**mg/L**	<3.0	-	4.6	-
Alkalinity -$CaCO_3$	**mg/L**	-	10.0	-	8.2

[9] The pH was maintained over 7.50 up to the addition of sand and polymer (at the end of the coagulation and hydroxylation processes). It drops during the flocculation while no pH follow-up was made (the sand would be abrasive to the probe). Final pH is presented in this column, showing the drop of pH during flocculation and settling.

Elements	Unit	Polishing 1 2015-06-29		Polishing 2 2015-06-29	
		Total	Dissolved	Total	Dissolved
Total Nitrogen	mg N/L	-	17.4	-	17.3
Ammonia	mg N/L	-	6.38	-	6.55
Nitrate	mg N/L	-	10.0	-	10.1
Nitrite	mg N/L	-	0.050	-	0.051
Chloride	mg/L	-	45	-	45
Fluoride	mg/L	-	3.25	-	3.23
Phosphate	mg P/L	-	<0.0010	-	<0.0010
Sulfate	mg S/L	-	860	-	860
Sulfide	mg S/L	0.027	-	0.025	-
Aluminum (Al)	mg/L	<0.015	<0.0050	<0.015	0.0051
Antimony (Sb)	mg/L	0.00244	0.00221	0.00229	0.00221
Arsenic (As)	mg/L	<0.00050	<0.00050	0.00091	<0.00050
Barium (Ba)	mg/L	0.0281	0.0269	0.0273	0.0262
Beryllium (Be)	mg/L	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L	<0.00025	<0.00025	<0.00025	<0.00025
Boron (B)	mg/L	<0.050	<0.050	<0.050	<0.050
Cadmium (Cd)	mg/L	0.000591	0.00112	0.000080	0.000113
Calcium (Ca)	mg/L	649	643	641	656
Chromium (Cr)	mg/L	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.00219	0.00209	0.00253	0.00246
Copper (Cu)	mg/L	<0.0025	0.0049	<0.0025	0.0021
Iron (Fe)	mg/L	0.087	<0.050	<0.050	<0.050
Lead (Pb)	mg/L	<0.00025	<0.00025	<0.00025	<0.00025
Lithium (Li)	mg/L	<0.0050	<0.0050	<0.0050	<0.0050
Magnesium (Mg)	mg/L	28.4	26.4	26.9	27.0
Manganese (Mn)	mg/L	1.52	1.45	1.55	1.50
Molybdenum (Mo)	mg/L	<0.00025	<0.00025	<0.00025	<0.00025
Nickel (Ni)	mg/L	0.0088	0.0086	0.0109	0.0106
Phosphorus (P)	mg/L	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L	241	227	237	228
Selenium (Se)	mg/L	0.0169	0.0162	0.0157	0.0153
Silicon (Si)	mg/L	<0.050	<0.050	0.052	0.058
Silver (Ag)	mg/L	0.000114	0.000092	0.000101	0.000079
Sodium (Na)	mg/L	256	237	248	235
Strontium (Sr)	mg/L	0.360	0.342	0.346	0.338
Thallium (Tl)	mg/L	<0.000050	<0.000050	<0.000050	<0.000050
Titanium (Ti)	mg/L	<0.010	<0.010	<0.010	<0.010
Uranium (U)	mg/L	<0.000050	<0.000050	<0.000050	<0.000050
Vanadium (V)	mg/L	<0.0025	<0.0025	<0.0025	<0.0025
Zinc (Zn)	mg/L	<0.015	0.0062	<0.015	0.0056

SECTION 6. DISCUSSION

6.1 Review of Synthetic Raw Water Target concentrations selection

In order to produce a synthetic water representative of the Brucejack Mine Operations WTP, the water composition targeted (Target at Equilibrium) was the modelled influent water predicted by Lorax and presented in the technical memo "Next round of bench-scale testing for the Brucejack Project" issued on May 19th, once chemically balanced with OLI software. The comparison of the Target at Equilibrium and the final synthetic water composition is presented in Section 6.2. The Target at Equilibrium is based on total species, in order to achieve dissolved targeted concentrations in the synthetic water after chemical addition.

This Target at Equilibrium could differ on the modelled water composition as provided by Lorax, as it was considered impossible to have these concentrations while keeping the synthetic water chemically and electronically balanced. The differences between the model issued by Lorax on May 19th, and its balanced match, are presented in Table 27.

Table 27: Comparison of Synthetic Raw Water targeted Composition with Lorax's influent predictions

Parameters	Lorax Influent modeling (Dissolved) May 19th 2015	Target at Equilibrium[10] (Dissolved)
	mg/L	mg/L
Total suspended solids	n/a	n/a
Ammonia-N	6.6	6.6
Nitrate-N	8.2	8.2
Nitrite-N	0.58	0.58
Chloride	29.3	29.3
Fluor (F)	3.8	3.8
Sulphate-S	697	882.6
Orthophosphate-P	0.046	0.046
Aluminum (Al)	28.6	28.6
Antimony (Sb)	0.20	0.20
Arsenic (As)	0.39	0.39

[10] Values as per May 19th Influent modelling, after balancing with OLI software by Veolia

Parameters	Lorax Influent modeling (Dissolved) May 19th 2015	Target at Equilibrium[10] (Dissolved)
	mg/L	mg/L
Cadmium (Cd)	0.068	0.068
Calcium (Ca)	650	650
Chromium (Cr)	0.49	0.49
Cobalt (Co)	0.061	0.061
Copper (Cu)	0.75	0.75
Iron (Fe)	64.7	64.7
Lead (Pb)	0.013	0.013
Magnesium (Mg)	42	42
Manganese (Mn)	53.0	53.0
Nickel (Ni)	0.14	0.14
Potassium (K)	219	219
Selenium (Se)	0.019	0.019
Silver (Ag)	0.00032	0.00032
Sodium (Na)	209	209
Zinc (Zn)	9.6	9.6

n/a: no target determined for these parameters (no addition in the synthetic water required)

The composition of the Operation WTP influent by Lorax, provided on May 19th, is at equilibrium; the target at equilibrium, obtained through OLI simulation, presents the same concentrations as expected from Lorax modeling. Therefore, the tested synthetic water should be as expected from the worst case scenario influent of the Operations WTP.

6.2 Review of Synthetic Raw Water Production

The city water was analyzed and found to have lower concentrations of all dissolved species than the predicted influent water quality provided by Lorax on May 19th 2015, and balanced by OLI software by Veolia. The concentrations of chemicals to be added to the synthetic raw water were calculated by taking into account the total target concentrations, and those of the dissolved species already present in the city water.

Three samples were sent for analysis of the final synthetic raw water used for the Operations metals removal validation Jar Test. An additional three samples were sent for

analysis for the additional high As concentration jar tests (modified synthetic water with lower pH and higher dissolved As concentration).

6.2.1 Original synthetic water composition

The analyses on the original synthetic water, used for the validation of the process with higher Cd and Zn concentration, were completed on June 15th, 2015 before chemical adjustment and after the chemical adjustment made on June 18th, 2015. These analyses show that the synthetic raw water quality is stable over the time it was completed and the moment the Operations bench tests were hold. The composition of the synthetic raw water used for the Operations bench tests was then compared with the target for its composition, as supplied by Lorax and modified for chemical balance by OLI software, by Veolia (see discussion in Section 6.1).

Table 28 compares the mean concentrations of the stabilized synthetic raw water in total and dissolved fractions, for both the synthetic water composition before and after chemical adjustment, with the target concentrations at equilibrium as predicted by Lorax on May 19th, 2015, modified according to OLI simulation on equilibrium proceed by Veolia.

Table 28: Comparison of Synthetic Raw Water Composition (Average on Stabilized Water Date) with Predicted Brucejack Influent Water Quality (Dissolved Fraction)

Parameters	Values				
	Synthetic Raw Water (Mean Values Used for Optimised Tests), Total		Synthetic Raw Water (Mean Values Used for Optimised Tests), Dissolved		Target at Equilibrium (Dissolved)
	Before adjustment	After adjustment	Before adjustment	After adjustment	mg/L
	mg/L	mg/L	mg/L	mg/L	mg/L
Total suspended solids	447	708	-	-	n/a
pH	4.93	4.39	-	-	4.30
Ammonia-N	-	-	6.60	7.37	6.60
Nitrate-N	-	-	10.3	10.6	8.2
Nitrite-N	-	-	0.2815	0.175	0.58
Chloride (Cl^-)	-	-	46	47	29.3
Fluor (F^-)	-	-	3.78	3.95	3.80
Sulphate (SO_4^{2-})	-	-	823	839	883

Parameters	Values				
	Synthetic Raw Water (Mean Values Used for Optimised Tests), Total		Synthetic Raw Water (Mean Values Used for Optimised Tests), Dissolved		Target at Equilibrium (Dissolved)
	Before adjustment	After adjustment	Before adjustment	After adjustment	mg/L
	mg/L	mg/L	mg/L	mg/L	mg/L
Orthophosphate	-	-	<0.0010	<0.0010	n/a
Aluminum (Al)	15	15.7	5.48	9.49	28.6
Antimony (Sb)	0.190	0.207	0.118	0.0494	0.200
Arsenic (As)*	0.3275	0.804	0.00305	0.0570	0.390
Barium (Ba)	0.0272	0.0285	0.0532	0.0552	n/a
Beryllium (Be)	<0.0010	<0.0010	<0.0010	<0.0010	n/a
Bismuth (Bi)	<0.00050	<0.00050	<0.00050	<0.00050	n/a
Boron (B)	<0.10	<0.10	<0.10	<0.10	n/a
Cadmium (Cd)	0.06525	0.0723	0.06255	0.0684	0.0680
Calcium (Ca)	674	647	502	490	650
Chromium (Cr)	0.498	0.572	0.0043	0.0086	0.490
Cobalt (Co)	0.0747	0.0869	0.0717	0.0824	0.0610
Copper (Cu)	0.741	0.836	0.674	0.783	0.750
Iron (Fe)*	35.9	70.3	25.5	45.2	64.7
Lead (Pb)	0.012	0.0135	0.0073	0.00564	0.0130
Lithium (Li)	<0.010	<0.010	<0.010	<0.010	n/a
Magnesium (Mg)	45.4	43.1	42.8	43.3	42.0
Manganese (Mn)	54.65	60.9	51.55	57.5	53.0
Molybdenum (Mo)	0.00198	0.00272	<0.00050	0.00067	n/a
Nickel (Ni)	0.138	0.162	0.132	0.154	0.140
Phosphorus (P)	<0.30	<0.30	<0.30	<0.30	0.14
Potassium (K)	239.5	257	220.5	249	219
Selenium (Se)	0.0168	0.0198	0.0151	0.0170	0.0190
Silicon (Si)	0.452	0.438	0.363	0.383	n/a
Silver (Ag)	0.00036	0.00042	0.00014	<0.00010	0.00032
Sodium (Na)	215.5	244	202.5	233	208.9
Strontium (Sr)	0.313	0.341	0.275	0.291	n/a
Thallium (Tl)	<0.00010	<0.00010	<0.00010	<0.00010	n/a
Titanium (Ti)	<0.010	0.011	<0.010	0.010	n/a
Uranium (U)	0.00035	0.00040	0.00028	0.00031	n/a
Vanadium (V)	<0.0050	<0.0050	<0.0050	<0.0050	n/a
Zinc (Zn)*	7.7	10.5	7.4	10.1	9.6

n/a: not available

* Adjusted concentrations on June 18th, 2015.

The highlighting of values presented in the previous table is explained below.

Most of the metals concentrations in the synthetic raw water are close to the target values of Lorax. When comparing the synthetic raw water to predicted influent water concentration, after the chemical adjustment (final influent water quality), the following observations can be made:

- Cl, K, Na and nitrate concentrations are above the targeted value for the synthetic water. This can be explained as these elements were added by salts needed for other metal concentrations, which were considered more critical. Chloride concentration was also higher than targeted in the City water. These elements are presented in underlined green in Table 28;
- As and Zn, being considered critical elements of the validation bench test for Operations WTP testing, and Fe, being essential in determining the chemical dosage needed to obtain sufficient removal efficiencies, had lower dissolved concentration prior adjustment (but the total concentration was meeting the targeted concentration for the synthetic water). They are shown is blue in Table 28. Addition of As, Fe and Zn was made during adjustment of the synthetic water on June 18th, 2015. This addition was sufficient to meet the targeted dissolved concentration of Zn by increasing the total concentration over the targeted value, but target was not achieved for neither dissolved As and dissolved Fe. Dissolved Fe is however considered as sufficient after chemical adjustment, being nearer from its target. Further adjustment was also discourage in order to prevent any disequilibrium of the actual chemical equilibrium;
- Sb, Cr, Pb and Ag, presented in red in Table 28, show total concentrations according to the target concentrations for these metals. However, the dissolved concentrations in the synthetic water are below the target value. In order to prevent any disequilibrium of the synthetic water chemistry, and since none of these concentrations were critical to be removed during the bench testing, these metal concentrations were kept like this for the Operations bench testing; and

- Al and nitrite, presented in highlighted red in Table 28, have concentrations below the expected synthetic water composition. Since those two parameters are not critical to meet the Process Performance Guarantee requirements, Operations bench testing was made with those lower metal concentrations.

Overall, the final quality of the synthetic raw water, for total fraction and dissolved fraction, is representative of the Lorax model provided on May 19th 2015, and ionic balance by OLI software by Veolia. Target concentrations are modelled concentrations, and may be hard to reach in real influent water. Considering the complex chemistry of the synthetic raw water, the synthetic raw water blended for the metals removal demonstration is considered representative of the Lorax modeled influent water once chemically balanced, as provided on May 19th 2015. The validation bench testing was therefore made on this synthetic water quality.

6.2.2 Modified synthetic water composition

Arsenic dissolved concentration was below the expected concentration from Lorax's modelisation, no matter the quantity of salt added to the synthetic water. In order to prevent the modification of the chemical balance of the synthetic water, as all the other chemical elements were up to their targeted concentration, a modified synthetic water was created after the process validation to validate the As removal only. This modified synthetic water comes from the settled synthetic water (dissolved fraction mainly) of the original synthetic water, which was acidified before adding more As salt to it. Table 29 compares the mean concentrations of the modified synthetic raw water in total and dissolved fractions, for both the modified synthetic water composition before (with pH modification and As concentration modification, on June 25th 2015) and after chemical adjustment (June 29th 2015, with As concentration modification only), with the target concentrations at equilibrium as predicted by Lorax on May 19th, 2015, modified according to OLI simulation on equilibrium proceed by Veolia.

Table 29: Comparison of Modified Synthetic Raw Water Composition (Average on Stabilized Water Date) with Predicted Brucejack Influent Water Quality (Dissolved Fraction)

Parameters	Values				
	Modified Synthetic Raw Water (Mean Values Used for Optimised Tests), Total		Modified Synthetic Raw Water (Mean Values Used for Optimised Tests), Dissolved		Target at Equilibrium (Dissolved)
	Before adjustment	After adjustment	Before adjustment	After adjustment	mg/L
	mg/L	mg/L	mg/L	mg/L	mg/L
Total suspended solids	402	100	-	-	n/a
pH	3.06	3.08	-	-	3.00
Ammonia-N	-	-	7.07	6.91	6.60
Nitrate-N	-	-	10.2	10.2	8.2
Nitrite-N	-	-	0.101	0.038	0.58
Chloride (Cl^-)	-	-	46.0	45.5	29.3
Fluor (F^-)	-	-	3.70	3.88	3.80
Sulphate (SO_4^{2-})	-	-	845	847	883
Orthophosphate	-	-	0.0039	0.00215	n/a
Aluminum (Al)	14.4	14.15	10.3	11.9	28.6
Antimony (Sb)	0.194	0.1595	0.0394	0.044	0.200
Arsenic (As)*	0.97	1.13	0.173	0.2225	0.390
Barium (Ba)	0.0279	0.0273	0.0266	0.057	n/a
Beryllium (Be)	<0.0010	<0.0010	<0.0010	<0.0010	n/a
Bismuth (Bi)	<0.00050	<0.00050	<0.00050	<0.00050	n/a
Boron (B)	<0.10	<0.10	<0.10	<0.10	n/a
Cadmium (Cd)	0.0698	0.0664	0.0678	0.06155	0.0680
Calcium (Ca)	565	508	468	482.5	650
Chromium (Cr)	0.533	0.431	0.0338	0.163	0.490
Cobalt (Co)	0.0826	0.08275	0.0816	0.07615	0.0610
Copper (Cu)	0.868	0.847	0.821	0.784	0.750
Iron (Fe)	66.8	60.3	44.5	45	64.7
Lead (Pb)	0.0132	0.0114	0.00830	0.00947	0.0130
Lithium (Li)	<0.010	<0.010	<0.010	<0.010	n/a
Magnesium (Mg)	42.0	47.35	42.8	44.95	42.0
Manganese (Mn)	57.9	55.55	56.8	50.85	53.0
Molybdenum (Mo)	0.00289	0.002495	0.00063	0.000825	n/a
Nickel (Ni)	0.155	0.1555	0.151	0.1425	0.140
Phosphorus (P)	<0.60	<0.30	<0.60	<0.30	0.14
Potassium (K)	239	247.5	240	225	219
Selenium (Se)	0.0192	0.01745	0.0174	0.0147	0.0190
Silicon (Si)	0.43	0.4875	0.37	0.412	n/a
Silver (Ag)	0.00030	0.00023	<0.00010	<0.00010	0.00032
Sodium (Na)	231	233.5	226	210.5	208.9
Strontium (Sr)	0.320	0.2945	0.275	0.2665	n/a

Parameters	Values				
	Modified Synthetic Raw Water (Mean Values Used for Optimised Tests), Total		Modified Synthetic Raw Water (Mean Values Used for Optimised Tests), Dissolved		Target at Equilibrium (Dissolved)
	Before adjustment	After adjustment	Before adjustment	After adjustment	mg/L
	mg/L	mg/L	mg/L	mg/L	mg/L
Thallium (Tl)	<0.00010	<0.00010	<0.00010	<0.00010	n/a
Titanium (Ti)	0.011	<0.010	0.011	<0.010	n/a
Uranium (U)	0.00037	0.000345	0.00032	0.00032	n/a
Vanadium (V)	<0.0050	<0.0050	<0.0050	<0.0050	n/a
Zinc (Zn)	10.5	10.55	10.4	9.88	9.6

n/a.: not available

* Adjusted concentrations on June 29th, 2015.

The highlighting of values presented in the previous table is explained below.

Most of the metals concentrations in the synthetic raw water are close to the target values of Lorax, or at least close to the analysis made in Table 28. When comparing the modified synthetic raw water to predicted influent water concentration, after the chemical adjustment (final influent water quality for high As concentration testing), the following observations can be made:

- As, being considered a critical element of the validation bench test for Operations WTP additional testing, had lower dissolved concentration prior adjustment (but the total concentration was exceeding the targeted concentration for the synthetic water). It is shown is blue in Table 28. Addition of As was made during adjustment of the synthetic water on June 29th, 2015. This addition was still not sufficient to meet the targeted dissolved concentration of As, even at low pH conditions. Considering the total As concentration, and considering the predicted water is the worst-case scenario, it was state that it would be really hard to reach the proposed As dissolved concentration in real-life Operations water and additional testing was made with this As concentration.

6.3 Contamination of the clarified water

During previous bench test done for Construction and Operations WTP, questioning was made on the possible contamination of the samples due to the injection of coagulant, polymer and acid/base, especially between the primary metals removal step and the polishing step. In order to prevent any further interrogation on the subject, a blank test was done between those two critical steps. It consists of a regular Actiflo bench test procedure, but applied on distilled water instead of the raw synthetic water. The same dosage was applied on this blank sample than the water production for the polishing step (the most affected by the contamination). The higher chemical dosage tested was used for this verification (coagulant dosage of 27.5 mg Fe/L and sulfide dosage of 35.0 mg S/L for the primary metal removal step prior to this test, and coagulant dosage of 23.9 mg Fe/L for the polishing step now tested.

No contamination test was done for the primary metal removal, as sulfide and coagulant react together creating a black and opaque supernatant, which later flocculates with big fluffy brown flocs. For this reason, the blank contamination test was not further carried for the primary metals removal step and is only presented for the polishing metal removal step.

The same laboratory material (beaker, pipet, pH probes) were used for this blank test than for the regular Operations bench test. The results from this blank bench tests are presented in Table 30.

Table 30: ALS analysis results for blank bench tests (testing done on June 25th 2015)

Elements	Unit	o-Blank2e	
		Total	Dissolved
pH	**-**	7.10	-
Total suspended solids (TSS)	**mg/L**	<3.0	-
Chloride (Cl^-)	**mg/L**	-	<0.50
Total Nitrogen	**mg N/L**	-	0.108
Ammonia (NH_4^+)	**mg N/L**	-	0.0099
Nitrate (NO_3^-)	**mg N/L**	-	0.0118
Nitrite (NO_2^-)	**mg N/L**	-	<0.0010
Sulfate (SO_4^{2-})	**mg S/L**	-	25.9
Sulfide (S)	**mg S/L**	<0.020	-
Aluminum (Al)	**mg/L**	0.0035	0.0022

Antimony (Sb)	**mg/L**	<0.00010	<0.00010
Arsenic (As)	**mg/L**	0.00044	<0.00010
Barium (Ba)	**mg/L**	0.00159	0.00157
Beryllium (Be)	**mg/L**	<0.00010	<0.00010
Bismuth (Bi)	**mg/L**	<0.000050	<0.000050
Boron (B)	**mg/L**	<0.010	<0.010
Cadmium (Cd)	**mg/L**	<0.0000050	0.0000053
Calcium (Ca)	**mg/L**	34.7	35.5
Chromium (Cr)	**mg/L**	0.00020	0.00014
Cobalt (Co)	**mg/L**	0.00012	0.00011
Copper (Cu)	**mg/L**	0.00112	0.00060
Iron (Fe)	**mg/L**	0.046	<0.010
Lead (Pb)	**mg/L**	<0.000050	<0.000050
Lithium (Li)	**mg/L**	<0.0010	<0.0010
Magnesium (Mg)	**mg/L**	0.21	0.22
Manganese (Mn)	**mg/L**	0.00145	0.00163
Molybdenum (Mo)	**mg/L**	<0.000050	<0.000050
Nickel (Ni)	**mg/L**	0.00068	0.00073
Phosphorus (P)	**mg/L**	<0.30	<0.30
Potassium (K)	**mg/L**	0.093	0.095
Selenium (Se)	**mg/L**	<0.000050	<0.000050
Silicon (Si)	**mg/L**	<0.050	<0.050
Silver (Ag)	**mg/L**	<0.000010	<0.000010
Sodium (Na)	**mg/L**	0.201	0.195
Strontium (Sr)	**mg/L**	0.0163	0.0157
Thallium (Tl)	**mg/L**	<0.000010	<0.000010
Titanium (Ti)	**mg/L**	<0.010	<0.010
Uranium (U)	**mg/L**	<0.000010	<0.000010
Vanadium (V)	**mg/L**	<0.00050	<0.00050
Zinc (Zn)	**mg/L**	<0.0030	0.0015

No major contamination can be seen with the blank bench testing. All metals concentrations are low and far from the Process Performance Guarantee discharge criteria, which proves the chemicals injected in the process for metal removal do not interfere with the removal efficiency of the said process.

Moreover, no serious contamination, due to chemical dosage, was seen while executing the blank bench test on distilled water with the higher tested dosages of Operations WTP bench testing, which was executed in worst-case scenario dosages (higher contamination risks).

6.4 Clarified and filtered Water Quality with Respect to Process Performance Guarantee

Table 31 provides the Process Performance Guarantees as set by Veolia for Operations WTP, compared with the polished (clarified) Operations bench test water. The lower coagulant dosage is represented in the following comparison as it meets all performance guarantees for the Operations WTP.

Table 31: Validation of Operations WTP Bench Testing in accordance with Process Performance Guarantee

Parameters	Units	Performance guarantee (Monthly average except otherwise noted)	Primary Metals Removal Results, Mean Value of Duplicate Optimised Reagent Concentrations		Polishing Metals Removal Results, Mean Value of Duplicate Optimised Reagent Concentrations	
			Total	Dissolved	Total	Dissolved
Total suspended solids (TSS)	mg/L	15	10.1	-	<7.0	-
Phosphorus (P)	mg P/L	0.1	<0.0020	-	0.0255	-
Sulfate (SO_4)	mg S/L	907[11]	-	825	-	843
Sulfide	mg S/L	0.25[12]	-	0.0295	-	<0.020
Aluminum (Al)	mg/L	0.15	0.578	0.531	<0.015	0.00835
Arsenic (As)	mg/L	0.005	0.00663	0.004225	0.00216	<0.00050
Cadmium (Cd)	mg/L	0.00012	0.000238	0.000052	0.0000825	0.000077
Cobalt (Co)	mg/L	0.005	<0.00050	<0.00050	0.00144	0.00141
Copper (Cu)	mg/L	0.005	<0.0025	<0.0010	<0.0025	0.003
Iron (Fe)	mg/L	0.25	0.1005	<0.050	<0.050	<0.050
Lead (Pb)	mg/L	0.0025	<0.00025	<0.00025	<0.00025	<0.00025
Manganese (Mn)	mg/L	10	1.5	1.4	1.3	1.2
Silver (Ag)	mg/L	0.0001 (Grab sample)	<0.000050	<0.000050	0.0000915	0.0000755
Zinc (Zn)	mg/L	0.01	0.021	<0.0050	<0.015	<0.0075

There is to be noted that some contamination was seen during these jar test, even with all the precautions taken to prevent it. Higher Cobalt, Copper and Silver concentrations are

[11] Value depending on the influent concentration; the maximum concentration at the discharge is an addition of 200 mg/L of sulfate to the initial influent concentration (addition of 200 mg/L in the process)

[12] Value depending on the influent concentration; the maximum concentration at the discharge is an addition of 0.25 mg/L of sulfide to the initial influent concentration (addition of 0.25 mg/L in the process)

seen in the polishing effluent than in the primary metal removal step. These elements are shown in blue in Table 31.

Otherwise, all results presented in Table 31 show that all the metals were treated to below the required Process Performance Guarantee, even with higher As, Cd and Zn metals concentrations in the influent water than already tested with this process and at the lower coagulant dosage tested for polishing metals removal.

With all due considerations, validation of the chosen process design is therefore complete for the Operations WTP at the tested conditions (with slightly lower dissolved As concentration at the influent). Additional testing with higher As concentration at the influent is presented in the following section.

6.5 Clarified and filtered Water Quality with Respect to Process Performance Guarantee- Validation of As removal test on Modified Synthetic Water

Table 32 provides the Process Performance Guarantees as set by Veolia for Operations WTP, compared with the polished clarified Operations bench test water obtained during the validation of the process at higher As concentrations at the influent (Modified Synthetic Water bench testing).

Table 32: Validation of Operations WTP Bench Testing in accordance with Process Performance Guarantee- Validation for higher As concentrations with Modified Synthetic Water

Parameters	Units	Performance guarantee (Monthly average except otherwise noted)	Primary Metals Removal Results, Mean Value of Duplicate		Polishing Metals Removal Results, Mean Value of Duplicate	
			Total	Dissolved	Total	Dissolved
Total suspended solids (TSS)	mg/L	15	4.9	-	<3.8	-
Phosphorus (P)	mg P/L	0.1	-		-	<0.020
Sulfate (SO_4)	mg S/L	907[13]	-	847	-	860

[13] Value depending on the influent concentration; the maximum concentration at the discharge is an addition of 200 mg/L of sulfate to the initial influent concentration (addition of 200 mg/L in the process)

Parameters	Units	Performance guarantee (Monthly average except	Primary Metals Removal Results, Mean Value of Duplicate		Polishing Metals Removal Results, Mean Value of Duplicate	
Sulfide	**mg S/L**	<0.25[14]	n/a	-	0.026	-
Aluminum (Al)	**mg/L**	0.15	0.747	0.6905	<0.015	0.0051
Arsenic (As)	**mg/L**	0.005	0.002535	0.00189	<0.00071	<0.00050
Cadmium (Cd)	**mg/L**	0.00012	0.00017	<0.000025	0.00034	0.00062
Cobalt (Co)	**mg/L**	0.005	<0.00050	<0.00050	0.00236	0.002275
Copper (Cu)	**mg/L**	0.005	<0.0025	<0.0010	<0.0025	0.0035
Iron (Fe)	**mg/L**	0.25	0.1025	<0.050	0.069	<0.050
Lead (Pb)	**mg/L**	0.0025	<0.00025	<0.00025	<0.00025	<0.00025
Manganese (Mn)	**mg/L**	10	1.7	1.5	1.5	1.5
Silver (Ag)	**mg/L**	0.0001 (Grab sample)	<0.000050	<0.000050	0.000108	0.0000855
Zinc (Zn)	**mg/L**	0.01	0.016	<0.0050	<0.015	0.0059

All the metals were treated to below the required design criteria, with the exception of cadmium and silver, presented in red in Table 32.

- Silver was removed by the primary metals removal; however it was detected after the polishing step. It is shown in red in Table 32. Silver concentration must be due to contamination introduced between the primary metals removal step and the polishing metals removal step during the laboratory bench testing.
- One of the sample for the polishing step shows a higher cadmium concentration than after primary metals removal step, increasing the average. Contamination had therefore being introduced between the primary metals removal and polishing metals removal for only one of the samples, probably while sampling the polishing effluent.

Cobalt and Copper also show sign of contamination, the polishing step concentrations being higher than the primary metal removal step. These elements are presented in blue in Table 32.

[14] Value depending on the influent concentration; the maximum concentration at the discharge is an addition of 0.25 mg/L of sulfide to the initial influent concentration (addition of 0.25 mg/L in the process)

Controlled source of contamination, which would be the chemical injection during the bench testing (coagulant, lime and flocculent) were proven to be non-existent at the working dosage. Therefore, this contamination could only be explained by a manipulation in the laboratory, which would not be reproduced in the full-scale application. The efficiency of silver removal, rightfully removed during primary metal removal step, as well as the efficiency of cadmium removal, being proved on one of the sample (the other sample being over the primary metal removal step concentration) are therefore satisfactory, which leads to the conclusion that the polishing metals removal effluent is meeting all the Process Performance Guarantee.

The removal of the higher arsenic influent is therefore validates through this additional bench testing.

SECTION 7. CONCLUSION

Bench testing using synthetic raw water produced in Veolia's laboratory were performed to test TSS and metals removal using a process treatment chain composed of metal precipitation and Actiflo® ballasted flocculation primary metals removal, followed a second metal precipitation and Actiflo® ballasted flocculation system for polishing metals removal. The clarified water thus produced allowed treatment of all metals to below the Operations WTP Process Performance Guarantee. The main conclusions of the Operations WTP removal process bench scale tests are the following:

- The synthetic raw water can be treated to meet the Operations Process Performance Guarantee using two consecutive Actiflo® clarification processed for primary metals removal and for polishing metals removal;
- The reagent dosage sequence used during those tests was the following: pH adjustment, then sulfide and coagulant dosage (near simultaneous) for metal conditioning, followed by Actisand and polymer dosage for flocculation and precipitate removal using the Actiflo® process for the primary metals removal. The reagent dosage sequence used for the polishing metal removal was the following: pH adjustment, than coagulant dosage for metal conditioning, followed by Actisand and polymer dosage for flocculation and precipitation using the Actiflo® process;
- Using the Actiflo® process bench-scale test for the primary metals removal and for the polishing metals removal, the following combination and concentrations of reagents was shown to produce treated water with a quality exceeding the water quality target (Process Performance Guarantee for Operations WTP): 27.5 mg Fe/L of Hydrex™ 6253 coagulant for metals removal, 35.0 mg S/L of sulfide (Na_2S), Actisand dosage of 10 g/L and 2.0 mg/L of Hydrex™ 6183 polymer to improve turbidity and metals removal for primary metals removal. For polishing metal removal, the reagents used were: 22.0 mg Fe/L of Hydrex™ 6253 coagulant for metals removal, Actisand dosage of 10 g/L and 1.5 mg/L of Hydrex™ 6183 polymer to improve metals removal for polishing metals removal;
- The optimum pH for metals removal under test conditions is 10.0 for primary metals removal, with a hydrated lime dosage of 340 mg/L, and 7.25 for polishing metals removal, with a

hydrated lime dosage of 36 mg/L (the pH drops lower than 7.25 with the addition of coagulant, needing lime to stabilise the pH to 7.25; and

- Additional tests, with higher As concentrations at the influent, proved the achievement of the target concentrations for Process Performance Guarantees with a slightly higher dosage for the polishing metal removal (29.3 mg Fe/L instead of 22.0 mg Fe/L).

Additional improvement of most metals (As, Cd, Cu, Cr, Fe, Pb and Zn) removal could be accomplished if needed by simply increasing the coagulant dosage, as proved with this validation bench-testing with higher As, Cd and Zn concentration in the synthetic water than the previous bench-testing performed for the Operations WTP (presented in Appendix A).

APPENDIX A. OPERATIONS WTP BENCH TESTS REPORTS

-“5000196003_BRUCEJACK_ BENCH_TEST_REV6_20150424”

-“5000196003_BRUCEJACK_ POLISHING_REV3_20150504”

APPENDIX B. LORAX'S TECHNICAL MEMO FOR INFLUENT WATER QUALITY "NEXT ROUND OF BENCH-SCALE TESTING FOR THE BRUCEJACK PROJECT"

TECHNICAL MEMO

To:	Marc Laliberte (Veolia)
From:	Robert Goldblatt (Lorax)
cc:	Adam King (Pretivm), Patrick Mueller (Lorax)
Date:	19-March-2015 **Project #**: 384-2 (WTP)
Subject:	Next round of bench-scale testing for the Brucejack Project

1. Introduction

This memo is intended to provide Veolia Water Technologies Canada (Veolia) with details of the next round of bench scale testing of water treatment plants being designed for the Brucejack Mine Project (the Project). The primary objective of these tests is to provide solid evidence of the expected treated effluent concentrations that were used to model water quality during Construction and Operations phases of the Brucejack Gold Mine Project. A second objective is to provide data on sulphide concentration in treated effluent. A third objective is to repeat the Operations phase bench-scale test, which had a contamination issue for some metals, to provide results that are free of contamination.

Veolia will be constructing and operating two different mine water treatment plants (MWTP) for the Project, one for the Construction phase and another Operations phase. The two plants are designed with different treatment processes designed to treat the modeled influent quality for Construction and Operations phases of the mine. Bench-scale testing has been conducted by Veolia in order to optimize the treatment processes, including determining optimal pH and chemical dosing. The results of these bench-scale tests, as well as data from the existing Exploration phase MWTP, have been used by Lorax and Veolia to derive conservative estimates of expected effluent quality. MWTP effluent quality is an important component of the water quality estimates of water quality in Brucejack Creek, which were presented in Pretivm's application for *Mines Act/Environmental Management Act* permits.

Reviewers of the *MA/EMA* application may have questions about the MWTP effluent source terms used in the water quality model. In order to be able to quickly address possible questions from reviewers, Lorax has reviewed bench-scale results to date and identified strengths and potential questions that may arise. The tests to date have demonstrated the ability of the MWTPs to remove suspended solids and associated particulate metals. Dissolved metals are also removed from influent to the levels equal to or lower than the concentrations used in the water quality model. A potential comment from reviewers may be that some the influent concentrations tested are lower than the maximum upper case predictions, for certain parameters of interest. In particular, the water quality model assumptions regarding effluent

quality would be strengthened by bench-scale tests of higher influent concentrations of dissolved forms as As, Cd, and Zn for the Construction WTP and dissolved As for the Operations WTP.

As with previous bench-scale tests, Veolia will prepare a synthetic raw water which will be treated using the MWTPs processes, at a bench-scale in the Veolia laboratory. Details regarding these bench-scale tests are provided below.

2. Synthetic Raw Water

Lorax is requesting testing of influent that approximates the highest potential concentration of each parameter of interest during the Construction and Operations phases of the Project (Table 2-1). It is recognized that it is highly unlikely that the highest concentration of all parameters would occur together in influent to the MWTP. Nonetheless, it is desirable to test this mixture of parameters in order to prove to reviewers that the MWTPs can address the worst-case scenario for each parameter.

It is also recognized that the chemical mixture in Table 2-1 is not chemically stable, therefore Veolia is requested to modify the chemical balance of the synthetic raw water to produce a chemically stable synthetic raw water for testing. Seeing as the primary objective is to test upper case concentrations of As, Cd, and Zn, the balancing of other parameters should be done to ensure stable concentrations of As, Cd, Zn that are close to the concentrations in Table 2-1

Table 2-1
Target Concentrations of Parameters of Interest in Synthetic Raw Water

		Synthetic Raw Water Concentration	
Parameter	**Unit**	**Construction WTP**	**Operations WTP**
Ammonia	mg/L	3.1	6.6
Nitrate	mg/L	17.2	36.3
Nitrite	mg/L	0.89	1.9
Dissolved orthophosphate	mg/L	0.041	0.14
Chloride	mg/L	6.9	29.3
Fluoride	mg/L	0.90	3.8
Sulphate	mg/L	493	2091
Al-D	mg/L	0.23	28.6
Sb-D	mg/L	0.042	0.20
As-D[1]	mg/L	0.14	0.39
Cd-D[1]	mg/L	0.0078	0.068
Cr-D	mg/L	0.0028	0.49
Co-D	mg/L	0.014	0.061
Cu-D	mg/L	0.22	0.75
Fe-D	mg/L	0.030	64.7

		Synthetic Raw Water Concentration	
Parameter	**Unit**	**Construction WTP**	**Operations WTP**
Pb-D	mg/L	0.0063	0.013
Mn-D	mg/L	2.5	53
Ni-D	mg/L	0.041	0.14
Se-D	mg/L	0.004	0.019
Ag-D	mg/L	0.000050	0.00032
Zn-D[1]	mg/L	3.3	9.6
Ca-D	mg/L	167	650
Mg-D	mg/L	15	42
K-D	mg/L	17	219
Na-D	mg/L	44	209

1. When balancing the chemical stability of the influent solution, other parameter should be adjusted to derive concentrations of As, Cd, and Zn close to the values listed.

Since chemical speciation affects treatment of some metals, it is necessary to specify speciation of arsenic, chromium, iron, and selenium.

For Construction Phase tests, synthetic raw water will be created using As(V), Cr(III), and Se(VI). No iron will be added, since addition of Fe(III) to raw water may remove parameters of interest.

For Operations Phase, synthetic raw water will be created using As(III), Cr(III), Fe(II), and Se(IV). It should be noted that although Cr will leach as Cr(VI) from cemented paste backfill during Operations, the chromium management plan will be followed to reduce Cr(VI) to Cr(III) before it is treated in the MWTP.

Only the dissolved form of metals will be used when creating synthetic raw water. Removal of particulate metals has been demonstrated in previous bench-scale tests, therefore no suspended solids will be added for this round of testing.

3. Bench-scale Test Procedures

The following points should be incorporated into the upcoming bench-scale test procedures:

- Bench-scale tests will be run at the optimal pH and reagent doses determined in previous tests.
- Construction plant tests will collect & analyze samples of influent and treated water.
- Operations plant tests will collect & analyze samples of influent, after the primary metal removal step, and after the polishing step.
- Duplicates of each sample will be collected and analyzed.

- Operations plant test will add sulphide to the list of parameters analyzed.
- Samples will be analyzed at ALS Environmental in Burnaby, BC. Lorax will arrange for ALS to ship sample bottles and preservative to Veolia. Samples will be analysed for anions and metals.

4. Quality Control

ALS will ship deionized water for use as a blank. Deionized water is typically shipped in 4 L jugs.

A blank sample will be collected by transferring deionized water to sample bottles and preserving.

Prior to testing synthetic raw water, a procedure blank sample will be tested. The procedure blank will be deionized water that is subjected to the same bench-scale test as the synthetic raw water.

APPENDIX C. OLI OPERATIONS WTP RECONCILATION REPORT FOR TARGETED SYNTHETIC WATER COMPOSITION

Reconciliation Summary

	Specification
Charge Balance Method	Dominant Ion
pH Reconciliation Type	No reconciliation

	Measured	Calculated	Difference
			%
Temperature, degree Celsius	10.0000		
Pressure, atm	1.00000		
pH	0.0	4.09699	100.00
Density, g/ml		1.00345	
Water, mg/L	1.00000e6	9.99770e5	

Stream Inflows

Row Filter Applied: Only Non Zero Values

Species	mg/L
H2O	9.99770e5
NH4+1	8.49759
NO3-1	160.954
NO2-1	6.23823
Cl-1	29.2917
F-1	3.79892
SO4-2	2644.00
Ag+1	3.19909e-4
Al+3	28.5919
HAsO3-2	0.644817
Ca+2	649.816
Cd+2	0.0679807
Co+2	0.0609827
Cr+3	0.489861
Cu+2	0.749787
Fe+2	64.6816
K+1	218.938
Mg+2	41.9881
Mn+2	52.9850
Na+1	208.941
Ni+2	0.139960
H2PO4-1	0.437876
Pb+2	0.0129963
Sb(OH)3	0.283919
HSeO3-1	0.0307913
Zn+2	9.59728

Charge Balance

Cation Charge:	0.0588364 eq/L
Anion Charge:	-0.0472867 eq/L
Imbalance:	0.0115497 eq/L
Adjusted Species:	SO4-2

Charged Species	Input	Balanced	Difference
	mg/L	mg/L	%
NH4+1	8.50000	8.50000	
NO3-1	161.000	161.000	
NO2-1	6.24000	6.24000	
Cl-1	29.3000	29.3000	
F-1	3.80000	3.80000	
SO4-2	2090.00	2644.75	26.54
Ag+1	3.20000e-4	3.20000e-4	
Al+3	28.6000	28.6000	
HAsO3-2	0.645000	0.645000	
Ca+2	650.000	650.000	
Cd+2	0.0680000	0.0680000	
Co+2	0.0610000	0.0610000	
Cr+3	0.490000	0.490000	
Cu+2	0.750000	0.750000	
Fe+2	64.7000	64.7000	
K+1	219.000	219.000	
Mg+2	42.0000	42.0000	
Mn+2	53.0000	53.0000	
Na+1	209.000	209.000	
Ni+2	0.140000	0.140000	
H2PO4-1	0.438000	0.438000	
Pb+2	0.0130000	0.0130000	
HSeO3-1	0.0308000	0.0308000	
Zn+2	9.60000	9.60000	

Stream Parameters

Row Filter Applied: Only Non Zero Values
column Filter Applied: Only Non Zero Values

Mixture Properties

StrAmt	1.00028	L
Temp	10.0000	degree Celsius
Pres	1.00000	atm

Aqueous Properties

pH	4.09699	
Ionic Strength (x-based)	1.45538e-3	mol/mol
Ionic Strength (m-based)	0.0808669	mol/kg
Osmotic Pressure	1.12234	atm
Elec Cond, specific	0.257324	mho/m
Elec Cond, molar	4.52430e-3	m2/ohm-mol
Viscosity, absolute	1.32227	cP

Viscosity, relative	1.01273	
Standard Liquid Volume	1.00409	L
Volume, Std. Conditions	1.00336	L

Solid Properties

Standard Liquid Volume	3.56498e-4	L

	Unit	Total	Aqueous	Solid
Density	**g/ml**	1.00390	1.00345	2.58809
Enthalpy	**cal**	-3.81656e6	-3.81449e6	-2072.45

Total and Phase Flows (Amounts)

column Filter Applied: Only Non Zero Values

	Total	Aqueous	Solid
	mol	mol	mol
Mole (True)	55.5629	55.5586	4.29899e-3
Mole (App)	55.5556	55.5513	4.29899e-3
	g	**g**	**g**
Mass	1004.19	1003.45	0.734734
	L	**L**	**cm3**
Volume	1.00028	1.00000	0.283890

Scaling Tendencies

Row Filter Applied: Values > 1.0e-4

Solids	**Post-Scale**
CaSO4.2H2O (Gypsum)	1.00000
Al(OH)3 (Bayerite)	1.00000
CaSO4 (Anhydrite)	0.564758
CoHPO4.1.5H2O	0.0137450
AlPO4 (Berlinite)	0.0135069
AgCl	0.0114850
PbSO4 (Anglesite)	5.57505e-3
Sb2O3 (Senarmontite)	2.98110e-3
FeSO4.7H2O (Melanterite)	2.17040e-3
CoSeO3	1.95822e-3
ZnCr2O4 (Zincochromite)	5.42809e-4
MgSO4.7H2O (Epsomite)	4.41420e-4
FeSeO3	3.59744e-4
MnSO4.5H2O (Jokokuite)	3.25662e-4
KAl(SO4)2.12H2O (Potassium alum)	1.61085e-4
NiSeO3	1.12872e-4

Species Output (True Species)

Row Filter Applied: Only Non Zero Values
column Filter Applied: Only Non Zero Values

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
H2O	9.99614e5	9.99898e5	0.0
H+1	0.104386	0.104415	0.0
OH-1	8.13271e-7	8.13502e-7	0.0
NH3	1.35079e-5	1.35118e-5	0.0
NH4+1	7.75755	7.75975	0.0
HNO3	3.57933e-8	3.58035e-8	0.0
NH4NO3	0.230262	0.230327	0.0
NO3-1	158.92	158.965	0.0
HNO2	0.793077	0.793302	0.0
NO2-1	5.45701	5.45856	0.0
Cl-1	29.2618	29.2701	0.0
HCl	4.205e-10	4.20619e-10	0.0
F-1	4.93446e-3	4.93586e-3	0.0
(HF)2	4.00782e-16	4.00896e-16	0.0
HF2-1	6.22188e-11	6.22365e-11	0.0
HF	5.00084e-4	5.00226e-4	0.0
H2SO4	1.27146e-14	1.27182e-14	0.0
HSO4-1	4.50097	4.50225	0.0
NH4SO4-1	4.35192	4.35315	0.0
SO3	1.15541e-18	1.15574e-18	0.0
SO4-2	1939.24	1939.79	0.0
AgCl2-1	4.53467e-5	4.53596e-5	0.0
AgCl3-2	8.79145e-13	8.79394e-13	0.0
AgCl	2.03853e-4	2.0391e-4	0.0
AgF	4.61664e-11	4.61795e-11	0.0
Ag+1	1.16384e-4	1.16417e-4	0.0
Ag(NH3)2+1	5.26874e-15	5.27024e-15	0.0
Ag(NO2)2-1	4.79469e-8	4.79605e-8	0.0
AgNO2	3.3453e-6	3.34625e-6	0.0
AgNO3	2.30249e-7	2.30314e-7	0.0
Ag(OH)2-1	2.65087e-21	2.65162e-21	0.0
AgOH	4.10364e-13	4.10481e-13	0.0
AgSO4-1	3.82283e-5	3.82392e-5	0.0
AlF2+1	0.43438	0.434503	0.0
AlF3	8.56383e-4	8.56627e-4	0.0
AlF4-1	7.14088e-8	7.14291e-8	0.0
AlF5-2	7.72059e-13	7.72278e-13	0.0
AlF6-3	2.11958e-18	2.12018e-18	0.0
AlF+2	8.56468	8.56711	0.0
Al+3	9.03616	9.03872	0.0
Al(OH)2Cl	4.67943e-22	4.68075e-22	0.0
Al(OH)2+1	2.36707e-3	2.36774e-3	0.0
Al(OH)3	4.49942	5.49695e-5	4.50065
Al(OH)4-1	1.7185e-7	1.71899e-7	0.0
AlOHCl+1	3.66169e-4	3.66273e-4	0.0
AlOH+2	0.180002	0.180054	0.0

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
Al(SO4)2-1	37.2016	37.2121	0.0
AlSO4+1	36.9397	36.9502	0.0
AsO2-1	2.94434e-6	2.94518e-6	0.0
AsO3-3	2.26553e-26	2.26618e-26	0.0
AsO+1	6.97034e-5	6.97232e-5	0.0
HAsO3-2	1.93182e-16	1.93237e-16	0.0
HAsO2	0.561484	0.561643	0.0
CaCl2	6.51738e-25	6.51923e-25	0.0
CaCl+1	1.72466e-6	1.72515e-6	0.0
CaF+1	1.61857e-6	1.61903e-6	0.0
Ca+2	437.965	438.09	0.0
Ca(NO3)+1	2.77071	2.7715	0.0
CaOH+1	1.56479e-7	1.56523e-7	0.0
CaSO4	138.67	138.71	0.0
CdCl2	1.75613e-5	1.75663e-5	0.0
CdCl3-1	7.51021e-10	7.51234e-10	0.0
CdCl4-2	2.87225e-12	2.87306e-12	0.0
CdCl+1	1.22861e-3	1.22896e-3	0.0
CdF2	6.56346e-16	6.56532e-16	0.0
CdF+1	9.97324e-9	9.97607e-9	0.0
Cd+2	0.0338503	0.0338599	0.0
Cd(NH3)2+2	1.82023e-15	1.82075e-15	0.0
Cd(NH3)3+2	4.72311e-23	4.72445e-23	0.0
Cd(NH3)4+2	3.17989e-31	3.1808e-31	0.0
Cd(NH3)5+2	1.57492e-40	1.57536e-40	0.0
Cd(NH3)6+2	2.9686e-51	2.96944e-51	0.0
CdNH3+2	1.48617e-8	1.48659e-8	0.0
Cd(NO2)2	5.19235e-5	5.19383e-5	0.0
Cd(NO2)3-1	1.44028e-7	1.44069e-7	0.0
CdNO2+1	4.54826e-3	4.54955e-3	0.0
CdNO3+1	1.46102e-4	1.46143e-4	0.0
Cd(OH)2	1.60185e-15	1.60231e-15	0.0
Cd(OH)3-1	1.52674e-24	1.52718e-24	0.0
Cd(OH)4-2	4.24393e-35	4.24514e-35	0.0
CdOH+1	5.19245e-9	5.19392e-9	0.0
CdSO4	0.0553323	0.055348	0.0
CoCl+1	3.29794e-5	3.29887e-5	0.0
Co+2	0.0366655	0.0366759	0.0
Co(NH3)2+2	1.85776e-16	1.85829e-16	0.0
Co(NH3)3+2	2.1531e-24	2.15371e-24	0.0
Co(NH3)4+2	1.19813e-32	1.19847e-32	0.0
Co(NH3)5+2	1.63944e-41	1.6399e-41	0.0
Co(NH3)6+2	3.06885e-51	3.06972e-51	0.0
Co(NH3)+2	3.72854e-9	3.7296e-9	0.0
CoNO3+1	1.66099e-4	1.66146e-4	0.0
Co(OH)2	6.70823e-14	6.71014e-14	0.0

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
Co(OH)3-1	1.04e-22	1.0403e-22	0.0
Co(OH)4-2	9.69395e-34	9.69671e-34	0.0
CoOH+1	2.0046e-8	2.00517e-8	0.0
CoSO4	0.0636883	0.0637063	0.0
CrF+2	2.58099e-4	2.58172e-4	0.0
CrCl2+1	1.64683e-11	1.6473e-11	0.0
CrCl+2	3.63671e-7	3.63775e-7	0.0
Cr+3	3.01175e-5	3.01261e-5	0.0
CrNO3+2	5.87419e-5	5.87586e-5	0.0
Cr(OH)2+1	2.83184e-8	2.83264e-8	0.0
Cr(OH)3	4.38431e-11	4.38556e-11	0.0
Cr(OH)4-1	1.3072e-18	1.30757e-18	0.0
CrOH+2	6.66504e-6	6.66694e-6	0.0
CrSO4+1	1.38903	1.38942	0.0
CuCl2	6.85782e-7	6.85976e-7	0.0
CuCl3-1	1.78741e-12	1.78792e-12	0.0
CuCl+1	1.70804e-3	1.70853e-3	0.0
Cu+2	0.740502	0.740712	0.0
Cu(NH3)2+2	2.27919e-9	2.27984e-9	0.0
Cu(NH3)3+2	2.15864e-15	2.15925e-15	0.0
Cu(NH3)4+2	3.3548e-22	3.35575e-22	0.0
Cu(NH3)5+2	1.22874e-31	1.22909e-31	0.0
CuNH3+2	5.69541e-4	5.69703e-4	0.0
Cu(NO2)2	1.05061e-5	1.0509e-5	0.0
CuNO2+1	7.95335e-3	7.9556e-3	0.0
Cu(NO3)2	2.10538e-6	2.10597e-6	0.0
CuNO3+1	6.16105e-3	6.1628e-3	0.0
Cu(OH)2	8.01384e-11	8.01612e-11	0.0
Cu(OH)3-1	6.10684e-16	6.10858e-16	0.0
Cu(OH)4-2	1.18699e-25	1.18732e-25	0.0
CuOH+1	3.15403e-6	3.15493e-6	0.0
FeCl2	5.19126e-11	5.19273e-11	0.0
FeCl+1	2.13576e-5	2.13636e-5	0.0
Fe+2	64.6812	64.6996	0.0
Fe(NH3)2+2	1.09382e-13	1.09413e-13	0.0
Fe(NH3)3+2	1.98605e-21	1.98662e-21	0.0
Fe(NH3)4+2	2.77785e-32	2.77864e-32	0.0
Fe(NH3)5+2	3.81088e-43	3.81197e-43	0.0
Fe(NH3)6+2	5.15326e-54	5.15473e-54	0.0
Fe(NH3)+2	1.31779e-6	1.31816e-6	0.0
FeOH+1	7.99876e-5	8.00103e-5	0.0
FeO	1.5949e-12	1.59536e-12	0.0
HFeO2-1	2.16689e-20	2.16751e-20	0.0
KCl	1.16717e-3	1.1675e-3	0.0
KHSO4	3.1198e-4	3.12068e-4	0.0
K+1	207.854	207.913	0.0

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
KSO4-1	38.3128	38.3237	0.0
MgF+1	5.27071e-8	5.27221e-8	0.0
Mg+2	38.0573	38.0681	0.0
MgOH+1	1.72229e-7	1.72278e-7	0.0
MgSO4	19.467	19.4725	0.0
MnCl+1	0.068933	0.0689526	0.0
Mn+2	35.2347	35.2447	0.0
Mn(NO3)2	1.07096e-3	1.07126e-3	0.0
MnNO3+1	0.139534	0.139574	0.0
Mn(OH)2	2.23725e-14	2.23789e-14	0.0
Mn(OH)3-1	4.53236e-23	4.53364e-23	0.0
Mn(OH)4-2	2.21558e-32	2.21621e-32	0.0
Mn(OH)+1	4.2384e-6	4.23961e-6	0.0
MnSO4	48.4918	48.5056	0.0
Na2F+1	5.53452e-9	5.53609e-9	0.0
NaF	4.7717e-5	4.77305e-5	0.0
Na+1	195.667	195.722	0.0
NaNO3	0.086823	0.0868477	0.0
NaSO4-1	68.6169	68.6364	0.0
Ni2OH+3	1.86056e-13	1.86109e-13	0.0
Ni4(OH)4+4	2.2778e-31	2.27845e-31	0.0
NiCl+1	4.48824e-6	4.48952e-6	0.0
NiF+1	2.75903e-8	2.75982e-8	0.0
Ni+2	0.0984908	0.0985188	0.0
Ni(NH3)2+2	1.46915e-14	1.46956e-14	0.0
Ni(NH3)3+2	8.59586e-22	8.5983e-22	0.0
Ni(NH3)4+2	1.40897e-27	1.40937e-27	0.0
Ni(NH3)5+2	1.7719e-39	1.77241e-39	0.0
Ni(NH3)6+2	1.98232e-48	1.98289e-48	0.0
NiNH3+2	7.31554e-8	7.31761e-8	0.0
NiNO3+1	7.54219e-4	7.54433e-4	0.0
Ni(OH)2	3.67814e-21	3.67919e-21	0.0
Ni(OH)3-1	2.77103e-22	2.77182e-22	0.0
Ni(OH)4-2	2.06971e-32	2.0703e-32	0.0
NiOH+1	2.02251e-7	2.02308e-7	0.0
NiSO4	0.108395	0.108425	0.0
CaH2PO4+1	0.0190518	0.0190572	0.0
CaHPO4	4.3137e-4	4.31492e-4	0.0
CaPO4-1	1.72869e-8	1.72919e-8	0.0
CrH2PO4+2	9.14478e-5	9.14738e-5	0.0
CrHPO4+1	5.05417e-3	5.0556e-3	0.0
FeH2PO4+1	1.01077e-3	1.01105e-3	0.0
FeHPO4	2.66626e-6	2.66701e-6	0.0
H2P2O7-2	1.35955e-8	1.35994e-8	0.0
H2PO4-1	0.414891	0.415009	0.0
H3P2O7-1	1.10138e-10	1.10169e-10	0.0

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
H3PO4	3.38505e-3	3.38601e-3	0.0
H4P2O7	2.12091e-13	2.12151e-13	0.0
HP2O7-3	1.36209e-10	1.36248e-10	0.0
HPO4-2	6.09464e-4	6.09637e-4	0.0
MgH2PO4+1	2.16229e-5	2.1629e-5	0.0
MgHPO4	8.0358e-5	8.03808e-5	0.0
MgP2O7-2	2.5184e-12	2.51912e-12	0.0
MgPO4-1	2.83103e-9	2.83184e-9	0.0
Ni(OH)2(HPO4)-2	8.07635e-25	8.07864e-25	0.0
Ni(OH)3(H2PO4)-2	3.774e-19	3.77507e-19	0.0
P2O7-4	4.15489e-15	4.15607e-15	0.0
PO4-3	9.05855e-12	9.06112e-12	0.0
HPbO2-1	3.55724e-20	3.55825e-20	0.0
PbCl2	1.0043e-7	1.00458e-7	0.0
PbCl3-1	4.7782e-11	4.77956e-11	0.0
PbCl4-2	6.81494e-14	6.81687e-14	0.0
PbCl+1	4.98765e-5	4.98906e-5	0.0
PbF2	1.24305e-14	1.2434e-14	0.0
PbF3-1	5.29253e-20	5.29404e-20	0.0
PbF4-2	1.11231e-26	1.11262e-26	0.0
PbF+1	7.73877e-9	7.74096e-9	0.0
PbH2PO4+1	4.83858e-7	4.83995e-7	0.0
PbHPO4	8.22348e-9	8.22582e-9	0.0
Pb+2	5.09795e-3	5.09939e-3	0.0
Pb(NO2)2	9.86215e-6	9.86495e-6	0.0
Pb(NO2)3-1	2.64111e-8	2.64186e-8	0.0
PbNO2+1	2.48837e-3	2.48908e-3	0.0
Pb(NO3)2	1.66111e-7	1.66158e-7	0.0
Pb(NO3)3-1	1.58902e-10	1.58947e-10	0.0
PbNO3+1	1.12814e-4	1.12846e-4	0.0
PbO	1.11483e-13	1.11515e-13	0.0
PbOH+1	1.4916e-5	1.49202e-5	0.0
PbSO4	8.35957e-3	8.36194e-3	0.0
Sb(OH)2+1	6.64765e-4	6.64953e-4	0.0
Sb(OH)3	0.283182	0.283262	0.0
Sb(OH)4-1	2.44447e-9	2.44517e-9	0.0
H2SeO3	6.28808e-4	6.28987e-4	0.0
HSeO3-1	0.030131	0.0301395	0.0
SeO3-2	3.60884e-5	3.60987e-5	0.0
ZnCl2	3.10735e-6	3.10824e-6	0.0
ZnCl3-1	1.40513e-9	1.40553e-9	0.0
ZnCl+1	3.10085e-3	3.10173e-3	0.0
ZnF+1	3.89921e-6	3.90031e-6	0.0
ZnH2PO4+1	1.863e-3	1.86352e-3	0.0
ZnHPO4	3.30595e-5	3.30689e-5	0.0
Zn+2	9.56117	9.56388	0.0

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
Zn(NH3)2+2	4.73303e-13	4.73437e-13	0.0
Zn(NH3)3+2	1.36846e-19	1.36885e-19	0.0
Zn(NH3)4+2	1.96833e-26	1.96889e-26	0.0
ZnNH3+2	1.95991e-6	1.96047e-6	0.0
Zn(NO3)2	3.74145e-5	3.74251e-5	0.0
ZnNO3+1	0.0648903	0.0649087	0.0
Zn(OH)2	6.09973e-10	6.10146e-10	0.0
Zn(OH)3-1	3.29153e-17	3.29247e-17	0.0
Zn(OH)4-2	5.43601e-26	5.43756e-26	0.0
ZnOH+1	1.1798e-5	1.18014e-5	0.0
CaSO4.2H2O (Gypsum)	730.026	0.0	730.233
Total (by phase)	1.0039e6	1.00345e6	734.734

Element Balance

Row Filter Applied: Only Non Zero Values
column Filter Applied: Only Non Zero Values

	Total	Aqueous	Solid
	mg/L	mg/L	mg/L
H(+1)	1.11877e5	1.11892e5	17.2749
K(+1)	218.938	219.0	0.0
Na(+1)	208.941	209.0	0.0
N(-3)	6.59825	6.60013	0.0
Ca(+2)	649.816	480.017	169.983
Zn(+2)	9.59728	9.6	0.0
Cu(+2)	0.749787	0.75	0.0
Fe(+2)	64.6816	64.7	0.0
Mg(+2)	41.9881	42.0	0.0
Pb(+2)	0.0129963	0.013	0.0
Al(+3)	28.5919	27.0432	1.55678
Mn(+2)	52.985	53.0	0.0
Ni(+2)	0.13996	0.14	0.0
F(-1)	3.79892	3.8	0.0
O(-2)	8.89785e5	8.89628e5	409.918
Cl(-1)	29.2917	29.3	0.0
P(+5)	0.13984	0.139879	0.0
S(+6)	882.567	746.817	136.001
N(+3)	1.89928	1.89981	0.0
N(+5)	36.3591	36.3694	0.0
As(+3)	0.38983	0.38994	0.0
Se(+4)	0.0189994	0.0190048	0.0
Co(+2)	0.0609827	0.061	0.0
Cd(+2)	0.0679807	0.068	0.0
Ag(+1)	3.19909e-4	3.2e-4	0.0
Cr(+3)	0.489861	0.49	0.0
Sb(+3)	0.200074	0.200131	0.0

APPENDIX D. VEOLIA OPERATIONS PROCESS PERFORMANCE GUARANTEE

PRETIUM RESOURCES INC.

BRUCEJACK MINE

Attention: Adam King

DRAFT PROCESS GUARANTEE

BRUCEJACK OPERATIONS WTP

2015-04-28, REVISION 2

PROPOSAL NUMBER TIH73855

PREPARED BY:
MARC LALIBERTÉ, SENIOR PROCESS ENGINEER, INDUSTRIAL

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PROPRIETARY NOTICE
This proposal is confidential and contains proprietary information.
It is not to be disclosed to a third party without the written consent of Veolia Water Technologies Canada.

SECTION 1. DEFINITIONS

Supplier: Veolia Water Technologies Canada Inc. ("Veolia")

Owner: Pretium Resources Inc.

Facility: Operations Water Treatment Plant at Brucejack Mine, British Columbia, as defined in the Process Flow Diagram revision PP.

Guarantee Period: As long as conditions in section 2.1 are met

SECTION 2. PROCESS GUARANTEE

2.1 CONDITIONS OF APPLICATION

This Process Guarantee will only be applicable if all of the following conditions are met:

- The WTP Facility is operated and maintained by Veolia or under the direct supervision of Veolia; and
- The chemical products dosed are supplied or approved by Veolia; and
- The Microsand is supplied by Veolia; and
- The Facility Influent characteristics are generally similar to the predicted values for the case "Upper Case Adit Treatment v3 2015-03-19", an extract of which is presented in Table 1; and
- The Facility Influent flow rate and Total Suspended Solid content do not exceed the values in Table 1; and
- The Facility Influent does not contain any inhibitor or components that could affect or interfere with the normal performance of the Facility, including but not limited to, as a result of a chemical spill.

Table 1 Influent Characteristics

Parameter	Median Conditions	Worst Case Conditions
Flow rate	4 500 m^3/d	10 000 m^3/d
Total Suspended Solids	1 300 mg/L	2 000 mg/L
Total Silver	0.0089 mg/L	0.0097 mg/L
Total Aluminium	42 mg/L	47 mg/L
Total Arsenic	0.86 mg/L	1.1 mg/L
Total Cadmium	0.034 mg/L	0.072 mg/L
Total Cobalt	0.055 mg/L	0.090 mg/L
Total Copper	0.53 mg/L	0.90 mg/L
Total Iron	140 mg/L	150 mg/L

Parameter	Median Conditions	Worst Case Conditions
Total Manganese	50 mg/L	55 mg/L
Total Phosphorus	2.3 mg/L as P	2.6 mg/L as P
Total Lead	0.12 mg/L	0.14 mg/L
Total Zinc	5.7 mg/L	10 mg/L

2.2 PERFORMANCE CRITERIA

During the Guarantee Period and while conditions stated in section 2.1 are met, Veolia guarantees that the characteristics of the Facility Effluent shall meet the criteria specified in Table 2:

Table 2 Effluent Criteria

Parameter	Grab Sample Criteria	Monthly Average Criteria	Note
Total Suspended Solids	25 mg/L	15 mg/L	
Total Aluminium	0.3 mg/L	0.15 mg/L	
Total Arsenic	0.01 mg/L	0.005 mg/L	
Total Cadmium	0.00025 mg/L	0.00012 mg/L	
Total Cobalt	0.01 mg/L	0.005 mg/L	
Total Copper	0.01 mg/L	0.005 mg/L	
Total Iron	0.5 mg/L	0.25 mg/L	
Total Manganese	22 mg/L	10 mg/L	
Total Phosphorus	0.2 mg/L as P	0.1 mg/L as P	
Total Lead	0.005 mg/L	0.0025 mg/L	
Total Silver	0.0001 mg/L	No criteria	The criteria is established at 2 times the detection limit.
Dissolved Sulfates	An increase of no more than 400 mg/L through the Facility	An increase of no more than 200 mg/L through the Facility	
Sulfide	An increase of no more than 0.5 mg/L through the Facility	An increase of no more than 0.25 mg/L through the Facility	

Parameter	Grab Sample Criteria	Monthly Average Criteria	Note
Total Zinc	0.02 mg/L	0.01 mg/L	

APPENDIX E. EXTERNAL LABORATORY CERTIFICATES (ALS)

PRETIUM EXPLORATIONS INC.
ATTN: Max Holtby
1600 - 570 Granville Street
Vancouver BC V6C 3P1

Date Received: 17-JUN-15
Report Date: 19-JUN-15 17:02 (MT)
Version: FINAL

Client Phone: 604-558-1784

Certificate of Analysis

Lab Work Order #: L1628194

Project P.O. #: NOT SUBMITTED
Job Reference: BRUCEJACK-WTP BENCH TESTING
C of C Numbers: A384-2 OP WTP BST
Legal Site Desc:

Dean Watt, B.Sc.
Account Manager

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ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1628194-1	L1628194-2			
	Description	Water	Water			
	Sampled Date	15-JUN-15	15-JUN-15			
	Sampled Time	12:45	12:45			
	Client ID	OPER_INFLUENT 1	OPER_INFLUENT 2			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	3780	3950			
	Hardness (as CaCO3) (mg/L)	1460	1390			
	pH (pH)	4.97	4.89			
	Total Suspended Solids (mg/L)	473	421			
	Total Dissolved Solids (mg/L)	3750	3740			
	Turbidity (NTU)	103	95.4			
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0			
	Alkalinity, Total (as CaCO3) (mg/L)	<1.0	<1.0			
	Ammonia, Total (as N) (mg/L)	6.81	6.38			
	Bromide (Br) (mg/L)	<1.0 DLM	<1.0 DLM			
	Chloride (Cl) (mg/L)	46	46			
	Fluoride (F) (mg/L)	3.81	3.78			
	Nitrate (as N) (mg/L)	10.3	10.3			
	Nitrite (as N) (mg/L)	0.283	0.280			
	Total Kjeldahl Nitrogen (mg/L)	7.3	6.8			
	Total Nitrogen (mg/L)	17.9	17.4			
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010			
	Phosphorus (P)-Total (mg/L)	<0.20 DLM	<0.20 DLM			
	Sulfate (SO4) (mg/L)	2470	2470			
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	3.83	3.81			
Total Metals	Aluminum (Al)-Total (mg/L)	15.0	15.0			
	Antimony (Sb)-Total (mg/L)	0.189	0.190			
	Arsenic (As)-Total (mg/L)	0.317	0.338			
	Barium (Ba)-Total (mg/L)	0.0274	0.0270			
	Beryllium (Be)-Total (mg/L)	<0.0010 DLA	<0.0010 DLA			
	Bismuth (Bi)-Total (mg/L)	<0.00050 DLA	<0.00050 DLA			
	Boron (B)-Total (mg/L)	<0.10 DLA	<0.10 DLA			
	Cadmium (Cd)-Total (mg/L)	0.0651	0.0654			
	Calcium (Ca)-Total (mg/L)	669	679			
	Chromium (Cr)-Total (mg/L)	0.497	0.499			
	Cobalt (Co)-Total (mg/L)	0.0744	0.0750			
	Copper (Cu)-Total (mg/L)	0.737	0.745			
	Iron (Fe)-Total (mg/L)	35.9	35.8			
	Lead (Pb)-Total (mg/L)	0.0122	0.0118			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1628194-1	L1628194-2			
	Description	Water	Water			
	Sampled Date	15-JUN-15	15-JUN-15			
	Sampled Time	12:45	12:45			
	Client ID	OPER_INFLUENT 1	OPER_INFLUENT 2			
Grouping	**Analyte**					
WATER						
Total Metals	Lithium (Li)-Total (mg/L)	<0.010 DLA	<0.010 DLA			
	Magnesium (Mg)-Total (mg/L)	45.6	45.1			
	Manganese (Mn)-Total (mg/L)	54.6	54.7			
	Molybdenum (Mo)-Total (mg/L)	0.00201	0.00194			
	Nickel (Ni)-Total (mg/L)	0.136	0.139			
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30			
	Potassium (K)-Total (mg/L)	240	239			
	Selenium (Se)-Total (mg/L)	0.0166	0.0170			
	Silicon (Si)-Total (mg/L)	0.453	0.451			
	Silver (Ag)-Total (mg/L)	0.00036	0.00035			
	Sodium (Na)-Total (mg/L)	216	215			
	Strontium (Sr)-Total (mg/L)	0.313	0.312			
	Thallium (Tl)-Total (mg/L)	<0.00010 DLA	<0.00010 DLA			
	Tin (Sn)-Total (mg/L)	<0.0010 DLA	<0.0010 DLA			
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010			
	Uranium (U)-Total (mg/L)	0.00034	0.00036			
	Vanadium (V)-Total (mg/L)	<0.0050 DLA	<0.0050 DLA			
	Zinc (Zn)-Total (mg/L)	7.69	7.71			
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD			
	Aluminum (Al)-Dissolved (mg/L)	5.64	5.32			
	Antimony (Sb)-Dissolved (mg/L)	0.120	0.116			
	Arsenic (As)-Dissolved (mg/L)	0.0031	0.0030			
	Barium (Ba)-Dissolved (mg/L)	0.0559 DTC	0.0504 DTC			
	Beryllium (Be)-Dissolved (mg/L)	<0.0010 DLA	<0.0010 DLA			
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050 DLA	<0.00050 DLA			
	Boron (B)-Dissolved (mg/L)	<0.10 DLA	<0.10 DLA			
	Cadmium (Cd)-Dissolved (mg/L)	0.0638	0.0613			
	Calcium (Ca)-Dissolved (mg/L)	514	489			
	Chromium (Cr)-Dissolved (mg/L)	0.0043	0.0043			
	Cobalt (Co)-Dissolved (mg/L)	0.0732	0.0702			
	Copper (Cu)-Dissolved (mg/L)	0.685	0.662			
	Iron (Fe)-Dissolved (mg/L)	25.9	25.1			
	Lead (Pb)-Dissolved (mg/L)	0.00740	0.00715			
	Lithium (Li)-Dissolved (mg/L)	<0.010 DLA	<0.010 DLA			
	Magnesium (Mg)-Dissolved (mg/L)	44.0	41.6			
	Manganese (Mn)-Dissolved (mg/L)	52.6	50.5			
	Molybdenum (Mo)-Dissolved (mg/L)	<0.00050 DLA	<0.00050 DLA			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1628194-1	L1628194-2			
	Description	Water	Water			
	Sampled Date	15-JUN-15	15-JUN-15			
	Sampled Time	12:45	12:45			
	Client ID	OPER_INFLUENT 1	OPER_INFLUENT 2			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Nickel (Ni)-Dissolved (mg/L)	0.134	0.130			
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30			
	Potassium (K)-Dissolved (mg/L)	225	216			
	Selenium (Se)-Dissolved (mg/L)	0.0150	0.0152			
	Silicon (Si)-Dissolved (mg/L)	0.379	0.347			
	Silver (Ag)-Dissolved (mg/L)	<0.00010 DLA	0.00014			
	Sodium (Na)-Dissolved (mg/L)	207	198			
	Strontium (Sr)-Dissolved (mg/L)	0.279	0.271			
	Thallium (Tl)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA			
	Tin (Sn)-Dissolved (mg/L)	<0.0010 DLA	<0.0010 DLA			
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010			
	Uranium (U)-Dissolved (mg/L)	0.00028	0.00027			
	Vanadium (V)-Dissolved (mg/L)	<0.0050 DLA	<0.0050 DLA			
	Zinc (Zn)-Dissolved (mg/L)	7.54	7.21			
Aggregate Organics	COD (mg/L)	79	80			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Alkalinity, Total (as CaCO3)	B	L1628194-1, -2
Method Blank	Conductivity	B	L1628194-1, -2
Matrix Spike	Total Organic Carbon	MS-B	L1628194-1, -2
Matrix Spike	Total Organic Carbon	MS-B	L1628194-1, -2
Matrix Spike	Total Organic Carbon	MS-B	L1628194-1, -2
Matrix Spike	Orthophosphate-Dissolved (as P)	MS-B	L1628194-1, -2
Matrix Spike	Orthophosphate-Dissolved (as P)	MS-B	L1628194-1, -2
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1628194-1, -2
Matrix Spike	Silicon (Si)-Dissolved	MS-B	L1628194-1, -2

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
DLA	Detection Limit adjusted for required dilution
DLM	Detection Limit Adjusted due to sample matrix effects.
DTC	Dissolved concentration exceeds total. Results were confirmed by re-analysis.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Reference Information

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA Water Total Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-T-COL-VA Water Total Nitrogen in water by Colour APHA Method 4500-P (J) / NEMI 5735

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA Water Ammonia in Water by Fluorescence APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA Water Ammonia in Water by Fluorescence J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA Water Nitrite in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA Water Nitrate in Water by IC (Low Level) EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA Water Total P in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA Water Diss. Orthophosphate in Water by Colour APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-VA Water Sulfate in Water by IC EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-CALC-VA Water TKN in Water (Calculation) BC MOE LABORATORY MANUAL (2005)

Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

TSS-VA Water Total Suspended Solids by Gravimetric APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA Water Turbidity by Meter APHA 2130 Turbidity

Reference Information

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

A384-2 OP WTP BST

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # A384-2 OP WTP BST

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	○ Regular (Standard Turnaround Times - Business Days)
Contact:	Max Holtby	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	1600-570 Granville St.	Email 1: Refer to Special Instructions for email list	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6C 3P1	Email 2:	◉ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(604)558-1784 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information	Analysis Request
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack - WTP Bench Testing	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE:	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: Veolia

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients/ TOC / TN	Total Metals	Dissolved Metals	Total Mercury	Dissolved Mercury						Number of Containers
						P	P	F/P								
	Oper_Influent 1	15-Jun-15	12h45	Water	x	x	x	x								4
	Oper_Influent 2	15-Jun-15	12h45	Water	x	x	x	x								4

L1628194-COFC

RUSH

Priority processing

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Test for Total Nitrogen (not TKN). Email SRC and test reports to: mholtby@pretivm.com, invoices@pretivm.com, svanzalingen@pretivm.com, patrick.mueller@lorax.ca, robert.goldblatt@lorax.ca, simon.vincent@veolia.com, myriam.deladurantaye@veolia.com, marc.laliberte@veolia.com

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Myriam De Ladurantaye	15-Jun-15		ISAAC	June 17	09:40	10 °C				

PRETIUM EXPLORATIONS INC.
ATTN: Max Holtby
1600 - 570 Granville Street
Vancouver BC V6C 3P1

Date Received: 19-JUN-15
Report Date: 20-JUN-15 11:14 (MT)
Version: FINAL

Client Phone: 604-558-1784

Certificate of Analysis

Lab Work Order #: L1629665

Project P.O. #: NOT SUBMITTED
Job Reference: BRUCEJACK-WTP BENCH TESTING
C of C Numbers: A384-2 OP WTP BST
Legal Site Desc:

Dean Watt, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1629665-1				
	Description	Water				
	Sampled Date	18-JUN-15				
	Sampled Time	12:45				
	Client ID	OPER_INFLUENT 3				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	3970				
	Hardness (as CaCO3) (mg/L)	1470				
	pH (pH)	4.64				
	Total Suspended Solids (mg/L)	544				
	Total Dissolved Solids (mg/L)	3820				
	Turbidity (NTU)	106				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	<1.0				
	Ammonia, Total (as N) (mg/L)	7.28				
	Bromide (Br) (mg/L)	<1.0 DLM				
	Chloride (Cl) (mg/L)	46				
	Fluoride (F) (mg/L)	3.81				
	Nitrate (as N) (mg/L)	10.3				
	Nitrite (as N) (mg/L)	0.245				
	Total Kjeldahl Nitrogen (mg/L)	6.8				
	Total Nitrogen (mg/L)	17.3				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	0.042				
	Sulfate (SO4) (mg/L)	2510				
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	3.31				
Total Metals	Aluminum (Al)-Total (mg/L)	16.6				
	Antimony (Sb)-Total (mg/L)	0.197				
	Arsenic (As)-Total (mg/L)	0.595				
	Barium (Ba)-Total (mg/L)	0.0280				
	Beryllium (Be)-Total (mg/L)	<0.0010 DLA				
	Bismuth (Bi)-Total (mg/L)	<0.00050 DLA				
	Boron (B)-Total (mg/L)	<0.10 DLA				
	Cadmium (Cd)-Total (mg/L)	0.0716				
	Calcium (Ca)-Total (mg/L)	649				
	Chromium (Cr)-Total (mg/L)	0.580				
	Cobalt (Co)-Total (mg/L)	0.0895				
	Copper (Cu)-Total (mg/L)	0.842				
	Iron (Fe)-Total (mg/L)	70.2				
	Lead (Pb)-Total (mg/L)	0.0125				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1629665-1				
	Description	Water				
	Sampled Date	18-JUN-15				
	Sampled Time	12:45				
	Client ID	OPER_INFLUENT 3				
Grouping	**Analyte**					
WATER						
Total Metals	Lithium (Li)-Total (mg/L)	<0.010 DLA				
	Magnesium (Mg)-Total (mg/L)	45.0				
	Manganese (Mn)-Total (mg/L)	61.7				
	Molybdenum (Mo)-Total (mg/L)	0.00211				
	Nickel (Ni)-Total (mg/L)	0.166				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	271				
	Selenium (Se)-Total (mg/L)	0.0202				
	Silicon (Si)-Total (mg/L)	0.468				
	Silver (Ag)-Total (mg/L)	0.00040				
	Sodium (Na)-Total (mg/L)	252				
	Strontium (Sr)-Total (mg/L)	0.325				
	Thallium (Tl)-Total (mg/L)	<0.00010 DLA				
	Tin (Sn)-Total (mg/L)	<0.0010 DLA				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	0.00039				
	Vanadium (V)-Total (mg/L)	<0.0050 DLA				
	Zinc (Zn)-Total (mg/L)	10.6				
Dissolved Metals	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	8.53				
	Antimony (Sb)-Dissolved (mg/L)	0.0823				
	Arsenic (As)-Dissolved (mg/L)	0.0078				
	Barium (Ba)-Dissolved (mg/L)	0.0617 DTC				
	Beryllium (Be)-Dissolved (mg/L)	<0.0010 DLA				
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050 DLA				
	Boron (B)-Dissolved (mg/L)	<0.10 DLA				
	Cadmium (Cd)-Dissolved (mg/L)	0.0673				
	Calcium (Ca)-Dissolved (mg/L)	513				
	Chromium (Cr)-Dissolved (mg/L)	0.0109				
	Cobalt (Co)-Dissolved (mg/L)	0.0826				
	Copper (Cu)-Dissolved (mg/L)	0.774				
	Iron (Fe)-Dissolved (mg/L)	48.7				
	Lead (Pb)-Dissolved (mg/L)	0.00605				
	Lithium (Li)-Dissolved (mg/L)	<0.010 DLA				
	Magnesium (Mg)-Dissolved (mg/L)	46.0				
	Manganese (Mn)-Dissolved (mg/L)	56.0				
	Molybdenum (Mo)-Dissolved (mg/L)	<0.00050 DLA				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1629665-1				
	Description	Water				
	Sampled Date	18-JUN-15				
	Sampled Time	12:45				
	Client ID	OPER_INFLUENT 3				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Nickel (Ni)-Dissolved (mg/L)	0.153				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	249				
	Selenium (Se)-Dissolved (mg/L)	0.0158				
	Silicon (Si)-Dissolved (mg/L)	0.391				
	Silver (Ag)-Dissolved (mg/L)	<0.00010 DLA				
	Sodium (Na)-Dissolved (mg/L)	235				
	Strontium (Sr)-Dissolved (mg/L)	0.279				
	Thallium (Tl)-Dissolved (mg/L)	<0.00010 DLA				
	Tin (Sn)-Dissolved (mg/L)	<0.0010 DLA				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	0.00027				
	Vanadium (V)-Dissolved (mg/L)	<0.0050 DLA				
	Zinc (Zn)-Dissolved (mg/L)	9.89				
Aggregate Organics	COD (mg/L)	90				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	COD	MS-B	L1629665-1
Matrix Spike	Total Organic Carbon	MS-B	L1629665-1
Matrix Spike	Phosphorus (P)-Total	MS-B	L1629665-1
Matrix Spike	Total Nitrogen	MS-B	L1629665-1

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLM	Detection Limit Adjusted due to sample matrix effects.
DTC	Dissolved concentration exceeds total. Results were confirmed by re-analysis.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method

Reference Information

6010B).

N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA Method 4500-P (J) / NEMI 5735

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-CALC-VA	Water	TKN in Water (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location

Reference Information

VA ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

A384-2 OP WTP BST

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # A384-2 OP WTP BST

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		○ Regular (Standard Turnaround Times - Business Days)
Contact:	Max Holtby	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	1600-570 Granville St.	Email 1:	Refer to Special Instructions for email list	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6C 3P1	Email 2:		◉ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(604)558-1784 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Analysis Request
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack - WTP Bench Testing	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE:		
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: Veolia	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients/ TOC / TN (P)	Total Metals (P)	Dissolved Metals (F/P)	Total Mercury	Dissolved Mercury						Number of Containers
	Oper_Influent 3	18-Jun-15	12h45	Water	x	x	x	x								4

RUSH

Priority processing

L1629665-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Test for Total Nitrogen (not TKN). Email SRC and test reports to: mholtby@pretivm.com, invoices@pretivm.com, svanzalingen@pretivm.com, patrick.mueller@lorax.ca, robert.goldblatt@lorax.ca, simon.vincent@veolia.com, myriam.deladurantaye@veolia.com, marc.laliberte@veolia.com

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Myriam De Ladurantaye	18-Jun-15		lady	06/19	8:30am	13.1 °C				

PRETIUM EXPLORATIONS INC.
ATTN: Max Holtby
1600 - 570 Granville Street
Vancouver BC V6C 3P1

Date Received: 26-JUN-15
Report Date: 27-JUN-15 14:16 (MT)
Version: FINAL

Client Phone: 604-558-1784

Certificate of Analysis

Lab Work Order #: L1633456

Project P.O. #: NOT SUBMITTED
Job Reference: BRUCEJACK-WTP BENCH TESTING
C of C Numbers: A384-2 OP WTP BST
Legal Site Desc:

Dean Watt, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-1	L1633456-2	L1633456-3	L1633456-4	L1633456-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15
	Sampled Time					
	Client ID	OPER_INFLUENT 4	OPER_INFLUENT 5	OPER_INFLUENT 10	OPER_INFLUENT 11	OPER_O-6
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	3990	3980	4110	4380	4020
	Hardness (as CaCO3) (mg/L)	1420	1310	1200	1490	1710
	pH (pH)	4.26	4.26	3.04	3.07	9.36
	Total Suspended Solids (mg/L)	769	811	29.5	775	9.5
	Total Dissolved Solids (mg/L)	3980	3930	3710	4040	3830
	Turbidity (NTU)	133	129	19.8	98.9	1.56
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	3.6
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	30.2
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	33.8
	Ammonia, Total (as N) (mg/L)	7.39	7.35	6.77	7.37	6.91
	Bromide (Br) (mg/L)	<1.0 DLM	<1.0 DLM	<1.0 DLM	<2.5 DLM	<1.0 DLM
	Chloride (Cl) (mg/L)	48	48	44	47	46
	Fluoride (F) (mg/L)	4.02	4.02	3.66	3.8	3.56
	Nitrate (as N) (mg/L)	10.7	10.8	9.72	10.7	10.3
	Nitrite (as N) (mg/L)	0.144	0.136	0.091	0.111	0.137
	Total Kjeldahl Nitrogen (mg/L)	7.3	7.2	7.1	8.0	7.6
	Total Nitrogen (mg/L)	18.1	18.1	16.9	18.7	18.0
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	0.0042	0.0036	<0.0010
	Phosphorus (P)-Total (mg/L)	<0.20 DLM	<0.20 DLM	<0.020 DLM	<0.20 DLM	<0.020 DLM
	Sulfate (SO4) (mg/L)	2510	2530	2410	2660	2480
	Sulphide as S (mg/L)	<2.0 DLM	<2.0 DLM	<2.0 DLM	<2.0 DLM	0.033
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	3.83	4.23	3.39	4.44	3.01
Total Metals	Aluminum (Al)-Total (mg/L)	15.1	15.3	12.3	16.5	0.632
	Antimony (Sb)-Total (mg/L)	0.206	0.219	0.140	0.248	0.0155
	Arsenic (As)-Total (mg/L)	0.907	0.911	0.684	1.25	0.00597
	Barium (Ba)-Total (mg/L)	0.0282	0.0293	0.0258	0.0300	0.0266
	Beryllium (Be)-Total (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.00050 DLA
	Bismuth (Bi)-Total (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00025 DLA
	Boron (B)-Total (mg/L)	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.050 DLA
	Cadmium (Cd)-Total (mg/L)	0.0711	0.0742	0.0669	0.0726	0.000255
	Calcium (Ca)-Total (mg/L)	663	629	416	713	639
	Chromium (Cr)-Total (mg/L)	0.557	0.579	0.339	0.727	0.00059
	Cobalt (Co)-Total (mg/L)	0.0846	0.0866	0.0788	0.0864	<0.00050 DLA
	Copper (Cu)-Total (mg/L)	0.819	0.847	0.818	0.917	<0.0025 DLA
	Iron (Fe)-Total (mg/L)	68.9	71.7	56.3	77.3	0.085

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-6	L1633456-7	L1633456-8	L1633456-9	L1633456-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15
	Sampled Time					
	Client ID	OPER_O-6P	OPER_O-12A	OPER_O-12B	OPER_O-14A	OPER_O-14B
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	4030	4060	4080	4090	4070
	Hardness (as CaCO3) (mg/L)	1730	1760	1740	1790	1740
	pH (pH)	9.26	7.04	7.14	7.30	7.07
	Total Suspended Solids (mg/L)	10.6	<3.0	10.9	<3.0	12.2
	Total Dissolved Solids (mg/L)	3880	3930	3960	3950	3960
	Turbidity (NTU)	4.70	0.25	0.22	0.18	0.14
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	4.3	8.7	9.6	9.6	9.2
	Alkalinity, Carbonate (as CaCO3) (mg/L)	25.4	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	29.7	8.7	9.6	9.6	9.2
	Ammonia, Total (as N) (mg/L)	6.96	6.81	6.82	7.10	6.81
	Bromide (Br) (mg/L)	<1.0 DLM	<1.0 DLM	<1.0 DLM	<1.0 DLM	<1.0 DLM
	Chloride (Cl) (mg/L)	46	46	46	46	47
	Fluoride (F) (mg/L)	3.57	3.42	3.42	3.39	3.41
	Nitrate (as N) (mg/L)	10.3	10.3	10.3	10.3	10.4
	Nitrite (as N) (mg/L)	0.117	0.105	0.110	0.119	0.111
	Total Kjeldahl Nitrogen (mg/L)	7.0	7.6	8.1	7.0	7.4
	Total Nitrogen (mg/L)	17.3	18.0	18.5	17.4	17.9
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	<0.020 DLM	0.030	0.021	<0.0020	<0.0020
	Sulfate (SO4) (mg/L)	2470	2530	2530	2530	2570
	Sulphide as S (mg/L)	0.026	<0.020	<0.020	<0.020	<0.020
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	2.75	3.31	3.63	3.94	3.79
Total Metals	Aluminum (Al)-Total (mg/L)	0.524	<0.015 DLA	<0.015 DLA	0.016	<0.015 DLA
	Antimony (Sb)-Total (mg/L)	0.0140	0.00453	0.00447	0.00327	0.00341
	Arsenic (As)-Total (mg/L)	0.00729	<0.00050 DLA	0.00216	<0.00050 DLA	<0.00050 DLA
	Barium (Ba)-Total (mg/L)	0.0279	0.0299	0.0285	0.0291	0.0280
	Beryllium (Be)-Total (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Bismuth (Bi)-Total (mg/L)	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA
	Boron (B)-Total (mg/L)	<0.050 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA
	Cadmium (Cd)-Total (mg/L)	0.000221	0.000099	0.000066	0.000059	0.000083
	Calcium (Ca)-Total (mg/L)	645	652	643	663	671
	Chromium (Cr)-Total (mg/L)	0.00055	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Cobalt (Co)-Total (mg/L)	<0.00050 DLA	0.00162	0.00126	0.00128	0.00183
	Copper (Cu)-Total (mg/L)	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA	0.0025
	Iron (Fe)-Total (mg/L)	0.116	0.067	<0.050 DLA	<0.050 DLA	<0.050 DLA

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-11				
	Description	Water				
	Sampled Date	25-JUN-15				
	Sampled Time					
	Client ID	OPER_BLANK2E				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	186				
	Hardness (as CaCO3) (mg/L)	89.4				
	pH (pH)	7.10				
	Total Suspended Solids (mg/L)	<3.0				
	Total Dissolved Solids (mg/L)	135				
	Turbidity (NTU)	0.11				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	6.1				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	6.1				
	Ammonia, Total (as N) (mg/L)	0.0099				
	Bromide (Br) (mg/L)	<0.050				
	Chloride (Cl) (mg/L)	<0.50				
	Fluoride (F) (mg/L)	<0.020				
	Nitrate (as N) (mg/L)	0.0118				
	Nitrite (as N) (mg/L)	<0.0010				
	Total Kjeldahl Nitrogen (mg/L)	0.096				
	Total Nitrogen (mg/L)	0.108				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	<0.0020				
	Sulfate (SO4) (mg/L)	77.7				
	Sulphide as S (mg/L)	<0.020				
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	0.56				
Total Metals	Aluminum (Al)-Total (mg/L)	0.0035				
	Antimony (Sb)-Total (mg/L)	<0.00010				
	Arsenic (As)-Total (mg/L)	0.00044				
	Barium (Ba)-Total (mg/L)	0.00159				
	Beryllium (Be)-Total (mg/L)	<0.00010				
	Bismuth (Bi)-Total (mg/L)	<0.000050				
	Boron (B)-Total (mg/L)	<0.010				
	Cadmium (Cd)-Total (mg/L)	<0.0000050				
	Calcium (Ca)-Total (mg/L)	34.7				
	Chromium (Cr)-Total (mg/L)	0.00020				
	Cobalt (Co)-Total (mg/L)	0.00012				
	Copper (Cu)-Total (mg/L)	0.00112				
	Iron (Fe)-Total (mg/L)	0.046				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-1	L1633456-2	L1633456-3	L1633456-4	L1633456-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15
	Sampled Time					
	Client ID	OPER_INFLUENT 4	OPER_INFLUENT 5	OPER_INFLUENT 10	OPER_INFLUENT 11	OPER_O-6
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	0.0138	0.0143	0.0103	0.0160	<0.00025 DLA
	Lithium (Li)-Total (mg/L)	<0.010 DLA	<0.010 DLA	<0.010 DLA	<0.010 DLA	<0.0050 DLA
	Magnesium (Mg)-Total (mg/L)	44.4	39.8	36.4	47.6	26.4
	Manganese (Mn)-Total (mg/L)	59.1	61.9	55.0	60.8	1.41
	Molybdenum (Mo)-Total (mg/L)	0.00297	0.00308	0.00209	0.00368	0.00064
	Nickel (Ni)-Total (mg/L)	0.158	0.162	0.149	0.161	<0.0025 DLA
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.60 DLA	<0.60 DLA
	Potassium (K)-Total (mg/L)	247	254	226	252	258
	Selenium (Se)-Total (mg/L)	0.0191	0.0201	0.0177	0.0206	0.0185
	Silicon (Si)-Total (mg/L)	0.418	0.429	0.373	0.49	<0.10 DLA
	Silver (Ag)-Total (mg/L)	0.00042	0.00045	0.00017	0.00042	<0.000050 DLA
	Sodium (Na)-Total (mg/L)	238	241	219	242	277
	Strontium (Sr)-Total (mg/L)	0.338	0.359	0.294	0.346	0.363
	Sulfur (S)-Total (mg/L)	945	864	714	1060	843
	Thallium (Tl)-Total (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.00010 DLA	<0.00010 DLA	<0.000050 DLA
	Tin (Sn)-Total (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.00050 DLA
	Titanium (Ti)-Total (mg/L)	0.010	0.012	0.011	<0.020 DLA	<0.020 DLA
	Uranium (U)-Total (mg/L)	0.00040	0.00041	0.00034	0.00039	<0.000050 DLA
	Vanadium (V)-Total (mg/L)	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0025 DLA
	Zinc (Zn)-Total (mg/L)	10.2	10.7	10.0	11.0	<0.015 DLA
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	10.0	9.94	10.1	10.4	0.601
	Antimony (Sb)-Dissolved (mg/L)	0.0339	0.0320	0.0395	0.0393	0.0153
	Arsenic (As)-Dissolved (mg/L)	0.0836	0.0797	0.154	0.192	0.00460
	Barium (Ba)-Dissolved (mg/L)	0.0577	0.0461	0.0254	0.0277	0.0270
	Beryllium (Be)-Dissolved (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.00050 DLA
	Bismuth (Bi)-Dissolved (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00025 DLA
	Boron (B)-Dissolved (mg/L)	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.050 DLA
	Cadmium (Cd)-Dissolved (mg/L)	0.0704	0.0675	0.0657	0.0699	0.000052
	Calcium (Ca)-Dissolved (mg/L)	499	457	419	517	641
	Chromium (Cr)-Dissolved (mg/L)	0.0075	0.0075	0.0380	0.0295	<0.00050 DLA
	Cobalt (Co)-Dissolved (mg/L)	0.0841	0.0805	0.0794	0.0837	<0.00050 DLA
	Copper (Cu)-Dissolved (mg/L)	0.811	0.765	0.795	0.846	<0.0010 DLA
	Iron (Fe)-Dissolved (mg/L)	44.2	42.6	43.5	45.4	<0.050 DLA
	Lead (Pb)-Dissolved (mg/L)	0.00555	0.00532	0.00739	0.00920	<0.00025 DLA
	Lithium (Li)-Dissolved (mg/L)	<0.010 DLA	<0.010 DLA	<0.010 DLA	<0.010 DLA	<0.0050 DLA
	Magnesium (Mg)-Dissolved (mg/L)	42.8	41.2	38.0	47.6	26.3

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-6	L1633456-7	L1633456-8	L1633456-9	L1633456-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15
	Sampled Time					
	Client ID	OPER_O-6P	OPER_O-12A	OPER_O-12B	OPER_O-14A	OPER_O-14B
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA
	Lithium (Li)-Total (mg/L)	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA
	Magnesium (Mg)-Total (mg/L)	26.9	26.3	25.9	26.7	26.4
	Manganese (Mn)-Total (mg/L)	1.59	1.32	1.28	1.11	1.29
	Molybdenum (Mo)-Total (mg/L)	0.00067	0.00026	0.00029	<0.00025 DLA	<0.00025 DLA
	Nickel (Ni)-Total (mg/L)	<0.0025 DLA	0.0051	0.0051	0.0040	0.0060
	Phosphorus (P)-Total (mg/L)	<0.60 DLA	<0.60 DLA	<0.60 DLA	<0.60 DLA	<0.60 DLA
	Potassium (K)-Total (mg/L)	264	261	253	261	250
	Selenium (Se)-Total (mg/L)	0.0189	0.0190	0.0183	0.0183	0.0185
	Silicon (Si)-Total (mg/L)	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.10 DLA
	Silver (Ag)-Total (mg/L)	<0.000050 DLA	0.000112	0.000071	0.000097	0.000131
	Sodium (Na)-Total (mg/L)	286	281	271	277	268
	Strontium (Sr)-Total (mg/L)	0.369	0.367	0.377	0.377	0.380
	Sulfur (S)-Total (mg/L)	863	864	851	886	879
	Thallium (Tl)-Total (mg/L)	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA
	Tin (Sn)-Total (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Titanium (Ti)-Total (mg/L)	<0.020 DLA	<0.020 DLA	<0.020 DLA	<0.020 DLA	<0.020 DLA
	Uranium (U)-Total (mg/L)	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA
	Vanadium (V)-Total (mg/L)	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA
	Zinc (Zn)-Total (mg/L)	0.027	<0.015 DLA	<0.015 DLA	<0.015 DLA	<0.015 DLA
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.461	0.0079	0.0088	0.0111	0.0053
	Antimony (Sb)-Dissolved (mg/L)	0.0123	0.00438	0.00407	0.00294	0.00277
	Arsenic (As)-Dissolved (mg/L)	0.00385	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Barium (Ba)-Dissolved (mg/L)	0.0258	0.0286	0.0286	0.0268	0.0276
	Beryllium (Be)-Dissolved (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Bismuth (Bi)-Dissolved (mg/L)	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA
	Boron (B)-Dissolved (mg/L)	<0.050 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA
	Cadmium (Cd)-Dissolved (mg/L)	<0.000025 DLA	0.000084	0.000070	0.000062	0.000088
	Calcium (Ca)-Dissolved (mg/L)	651	660	653	674	655
	Chromium (Cr)-Dissolved (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Cobalt (Co)-Dissolved (mg/L)	<0.00050 DLA	0.00158	0.00124	0.00117	0.00174
	Copper (Cu)-Dissolved (mg/L)	<0.0010 DLA	0.0024	0.0036	0.0016	0.0033
	Iron (Fe)-Dissolved (mg/L)	<0.050 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA
	Lead (Pb)-Dissolved (mg/L)	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA
	Lithium (Li)-Dissolved (mg/L)	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA
	Magnesium (Mg)-Dissolved (mg/L)	26.4	26.2	25.8	26.4	25.5

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-11				
	Description	Water				
	Sampled Date	25-JUN-15				
	Sampled Time					
	Client ID	OPER_BLANK2E				
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	<0.000050				
	Lithium (Li)-Total (mg/L)	<0.0010				
	Magnesium (Mg)-Total (mg/L)	0.21				
	Manganese (Mn)-Total (mg/L)	0.00145				
	Molybdenum (Mo)-Total (mg/L)	<0.000050				
	Nickel (Ni)-Total (mg/L)	0.00068				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	0.093				
	Selenium (Se)-Total (mg/L)	<0.000050				
	Silicon (Si)-Total (mg/L)	<0.050				
	Silver (Ag)-Total (mg/L)	<0.000010				
	Sodium (Na)-Total (mg/L)	0.201				
	Strontium (Sr)-Total (mg/L)	0.0163				
	Sulfur (S)-Total (mg/L)	26.3				
	Thallium (Tl)-Total (mg/L)	<0.000010				
	Tin (Sn)-Total (mg/L)	<0.00010				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	<0.000010				
	Vanadium (V)-Total (mg/L)	<0.00050				
	Zinc (Zn)-Total (mg/L)	<0.0030				
Dissolved Metals	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0022				
	Antimony (Sb)-Dissolved (mg/L)	<0.00010				
	Arsenic (As)-Dissolved (mg/L)	<0.00010				
	Barium (Ba)-Dissolved (mg/L)	0.00157				
	Beryllium (Be)-Dissolved (mg/L)	<0.00010				
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050				
	Boron (B)-Dissolved (mg/L)	<0.010				
	Cadmium (Cd)-Dissolved (mg/L)	0.0000053				
	Calcium (Ca)-Dissolved (mg/L)	35.5				
	Chromium (Cr)-Dissolved (mg/L)	0.00014				
	Cobalt (Co)-Dissolved (mg/L)	0.00011				
	Copper (Cu)-Dissolved (mg/L)	0.00060				
	Iron (Fe)-Dissolved (mg/L)	<0.010				
	Lead (Pb)-Dissolved (mg/L)	<0.000050				
	Lithium (Li)-Dissolved (mg/L)	<0.0010				
	Magnesium (Mg)-Dissolved (mg/L)	0.22				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-1	L1633456-2	L1633456-3	L1633456-4	L1633456-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15
	Sampled Time					
	Client ID	OPER_INFLUENT 4	OPER_INFLUENT 5	OPER_INFLUENT 10	OPER_INFLUENT 11	OPER_O-6
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	59.4	57.0	55.1	58.5	1.37
	Molybdenum (Mo)-Dissolved (mg/L)	0.00068	0.00065	0.00061	0.00064	0.00069
	Nickel (Ni)-Dissolved (mg/L)	0.155	0.153	0.146	0.155	<0.0025 DLA
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.60 DLA	<0.60 DLA
	Potassium (K)-Dissolved (mg/L)	252	246	235	244	260
	Selenium (Se)-Dissolved (mg/L)	0.0178	0.0175	0.0171	0.0176	0.0187
	Silicon (Si)-Dissolved (mg/L)	0.400	0.359	0.332	0.41	<0.10 DLA
	Silver (Ag)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.00010 DLA	<0.00010 DLA	<0.000050 DLA
	Sodium (Na)-Dissolved (mg/L)	235	230	220	232	277
	Strontium (Sr)-Dissolved (mg/L)	0.302	0.292	0.262	0.287	0.365
	Sulfur (S)-Dissolved (mg/L)	764	753	744	901	853
	Thallium (Tl)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.00010 DLA	<0.00010 DLA	<0.000050 DLA
	Tin (Sn)-Dissolved (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.0010 DLA	<0.00050 DLA
	Titanium (Ti)-Dissolved (mg/L)	0.010	0.010	0.011	<0.020 DLA	<0.020 DLA
	Uranium (U)-Dissolved (mg/L)	0.00033	0.00032	0.00031	0.00033	<0.000050 DLA
	Vanadium (V)-Dissolved (mg/L)	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0050 DLA	<0.0025 DLA
	Zinc (Zn)-Dissolved (mg/L)	10.3	10.0	10.1	10.7	<0.0050
Aggregate Organics	COD (mg/L)	75	76	68	73	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-6	L1633456-7	L1633456-8	L1633456-9	L1633456-10
	Description	Water	Water	Water	Water	Water
	Sampled Date	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15	25-JUN-15
	Sampled Time					
	Client ID	OPER_O-6P	OPER_O-12A	OPER_O-12B	OPER_O-14A	OPER_O-14B
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	1.35	1.23	1.23	1.04	1.23
	Molybdenum (Mo)-Dissolved (mg/L)	0.00061	0.00025	0.00029	<0.00025 DLA	<0.00025 DLA
	Nickel (Ni)-Dissolved (mg/L)	<0.0025 DLA	0.0049	0.0048	0.0039	0.0058
	Phosphorus (P)-Dissolved (mg/L)	<0.60 DLA	<0.60 DLA	<0.60 DLA	<0.60 DLA	<0.60 DLA
	Potassium (K)-Dissolved (mg/L)	244	250	252	248	250
	Selenium (Se)-Dissolved (mg/L)	0.0182	0.0183	0.0183	0.0171	0.0169
	Silicon (Si)-Dissolved (mg/L)	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.10 DLA	<0.10 DLA
	Silver (Ag)-Dissolved (mg/L)	<0.000050 DLA	0.000088	0.000063	0.000078	0.000091
	Sodium (Na)-Dissolved (mg/L)	259	267	264	258	261
	Strontium (Sr)-Dissolved (mg/L)	0.328	0.353	0.361	0.344	0.324
	Sulfur (S)-Dissolved (mg/L)	851	874	869	871	877
	Thallium (Tl)-Dissolved (mg/L)	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA
	Tin (Sn)-Dissolved (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Titanium (Ti)-Dissolved (mg/L)	<0.020 DLA	<0.020 DLA	<0.020 DLA	<0.020 DLA	<0.020 DLA
	Uranium (U)-Dissolved (mg/L)	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA
	Vanadium (V)-Dissolved (mg/L)	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA
	Zinc (Zn)-Dissolved (mg/L)	<0.0050 DLA	<0.0050 DLA	0.0110	<0.0050 DLA	<0.0050 DLA
Aggregate Organics	COD (mg/L)	<20	<20	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1633456-11				
	Description	Water				
	Sampled Date	25-JUN-15				
	Sampled Time					
	Client ID	OPER_BLANK2E				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	0.00163				
	Molybdenum (Mo)-Dissolved (mg/L)	<0.000050				
	Nickel (Ni)-Dissolved (mg/L)	0.00073				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	0.095				
	Selenium (Se)-Dissolved (mg/L)	<0.000050				
	Silicon (Si)-Dissolved (mg/L)	<0.050				
	Silver (Ag)-Dissolved (mg/L)	<0.000010				
	Sodium (Na)-Dissolved (mg/L)	0.195				
	Strontium (Sr)-Dissolved (mg/L)	0.0157				
	Sulfur (S)-Dissolved (mg/L)	26.1				
	Thallium (Tl)-Dissolved (mg/L)	<0.000010				
	Tin (Sn)-Dissolved (mg/L)	<0.00010				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	<0.000010				
	Vanadium (V)-Dissolved (mg/L)	<0.00050				
	Zinc (Zn)-Dissolved (mg/L)	0.0015				
Aggregate Organics	COD (mg/L)	<20				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Duplicate	Sulphide as S	DLM	L1633456-1, -2, -3, -4
Matrix Spike	Ammonia, Total (as N)	MS-B	L1633456-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Total Nitrogen	MS-B	L1633456-1, -10, -11, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLM	Detection Limit Adjusted due to sample matrix effects.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA Method 4500-P (J) / NEMI 5735

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

S-TOT-ICP-VA	Water	Total Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

S2-T-COL-VA	Water	Total Sulphide by Colorimetric	APHA 4500-S2 Sulphide

This analysis is carried out using procedures adapted from APHA Method 4500-S2 "Sulphide". Sulphide is determined using the methlyene blue colourimetric method.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids

Reference Information

(TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-CALC-VA	Water	TKN in Water (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

A384-2 OP WTP BST

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

PRETIUM EXPLORATIONS INC.
ATTN: Max Holtby
1600 - 570 Granville Street
Vancouver BC V6C 3P1

Date Received: 30-JUN-15
Report Date: 02-JUL-15 14:02 (MT)
Version: FINAL

Client Phone: 604-558-1784

Certificate of Analysis

Lab Work Order #: L1634769

Project P.O. #: NOT SUBMITTED
Job Reference: BRUCEJACK-WTP BENCH TESTING
C of C Numbers: A384-2 OP WTP BST
Legal Site Desc:

Dean Watt, B.Sc.
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L1634769-1	L1634769-2	L1634769-3	L1634769-4	L1634769-5
Description		Water	Water	Water	Water	Water
Sampled Date		29-JUN-15	29-JUN-15	29-JUN-15	29-JUN-15	29-JUN-15
Sampled Time						
Client ID		OPER_INFLUENT 12	OPER_INFLUENT 13	OPER_PRIMARY 1	OPER_PRIMARY 2	OPER_POLISHING 1
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	4200	4210	3990	3990	4060
	Hardness (as CaCO3) (mg/L)	1390	1390	1700	1690	1710
	pH (pH)	3.08	3.07	9.24	9.25	7.04
	Total Suspended Solids (mg/L)	106	94.1	4.7	5.0	<3.0
	Total Dissolved Solids (mg/L)	3720	3740	3710	3740	3730
	Turbidity (NTU)	29.5	30.6	4.75	4.91	0.29
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	<1.0	<1.0	6.4	6.5	10.0
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0	<1.0	23.4	24.0	<1.0
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0	<1.0	<1.0	<1.0	<1.0
	Alkalinity, Total (as CaCO3) (mg/L)	<1.0	<1.0	29.8	30.5	10.0
	Ammonia, Total (as N) (mg/L)	6.90	6.92	6.58	6.66	6.38
	Bromide (Br) (mg/L)	<1.0 DLM	<1.0 DLM	<1.0 DLM	<1.0 DLM	<1.0 DLM
	Chloride (Cl) (mg/L)	45	46	45	45	45
	Fluoride (F) (mg/L)	3.85	3.91	3.51	3.57	3.25
	Nitrate (as N) (mg/L)	10.1	10.3	10.0	10.2	10.0
	Nitrite (as N) (mg/L)	0.035	0.041	0.044	0.051	0.050
	Total Kjeldahl Nitrogen (mg/L)	7.5	7.1	7.3	7.1	7.3
	Total Nitrogen (mg/L)	17.6	17.4	17.4	17.3	17.4
	Orthophosphate-Dissolved (as P) (mg/L)	0.0021	0.0022	<0.0010	<0.0010	<0.0010
	Phosphorus (P)-Total (mg/L)	<0.020 DLM	<0.020 DLM	<0.020 DLM	<0.020 DLM	<0.020 DLM
	Sulfate (SO4) (mg/L)	2520	2560	2520	2560	2580
	Sulphide as S (mg/L)					0.027
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	3.51	3.44	2.72	2.76	2.97
Total Metals	Aluminum (Al)-Total (mg/L)	14.4	13.9	0.744	0.750	<0.015 DLA
	Antimony (Sb)-Total (mg/L)	0.151	0.168	0.0110	0.0110	0.00244
	Arsenic (As)-Total (mg/L)	1.07	1.19	0.00251	0.00256	<0.00050 DLA
	Barium (Ba)-Total (mg/L)	0.0271	0.0275	0.0254	0.0262	0.0281
	Beryllium (Be)-Total (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Bismuth (Bi)-Total (mg/L)	<0.00050 DLA	<0.00050 DLA	<0.00025 DLA	<0.00025 DLA	<0.00025 DLA
	Boron (B)-Total (mg/L)	<0.10 DLA	<0.10 DLA	<0.050 DLA	<0.050 DLA	<0.050 DLA
	Cadmium (Cd)-Total (mg/L)	0.0668	0.0660	0.000175	0.000162	0.000591
	Calcium (Ca)-Total (mg/L)	504	512	626	630	649
	Chromium (Cr)-Total (mg/L)	0.430	0.432	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Cobalt (Co)-Total (mg/L)	0.0832	0.0823	<0.00050 DLA	<0.00050 DLA	0.00219
	Copper (Cu)-Total (mg/L)	0.850	0.844	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA
	Iron (Fe)-Total (mg/L)	61.2	59.4	0.104	0.101	0.087

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1634769-6				
	Description	Water				
	Sampled Date	29-JUN-15				
	Sampled Time					
	Client ID	OPER_POLISHING 2				
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	4010				
	Hardness (as CaCO3) (mg/L)	1750				
	pH (pH)	7.01				
	Total Suspended Solids (mg/L)	4.6				
	Total Dissolved Solids (mg/L)	3720				
	Turbidity (NTU)	0.26				
Anions and Nutrients	Alkalinity, Bicarbonate (as CaCO3) (mg/L)	8.2				
	Alkalinity, Carbonate (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Hydroxide (as CaCO3) (mg/L)	<1.0				
	Alkalinity, Total (as CaCO3) (mg/L)	8.2				
	Ammonia, Total (as N) (mg/L)	6.55				
	Bromide (Br) (mg/L)	<1.0 DLM				
	Chloride (Cl) (mg/L)	45				
	Fluoride (F) (mg/L)	3.23				
	Nitrate (as N) (mg/L)	10.1				
	Nitrite (as N) (mg/L)	0.051				
	Total Kjeldahl Nitrogen (mg/L)	7.2				
	Total Nitrogen (mg/L)	17.3				
	Orthophosphate-Dissolved (as P) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	<0.020 DLM				
	Sulfate (SO4) (mg/L)	2580				
	Sulphide as S (mg/L)	0.025				
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	2.85				
Total Metals	Aluminum (Al)-Total (mg/L)	<0.015 DLA				
	Antimony (Sb)-Total (mg/L)	0.00229				
	Arsenic (As)-Total (mg/L)	0.00091				
	Barium (Ba)-Total (mg/L)	0.0273				
	Beryllium (Be)-Total (mg/L)	<0.00050 DLA				
	Bismuth (Bi)-Total (mg/L)	<0.00025 DLA				
	Boron (B)-Total (mg/L)	<0.050 DLA				
	Cadmium (Cd)-Total (mg/L)	0.000080				
	Calcium (Ca)-Total (mg/L)	641				
	Chromium (Cr)-Total (mg/L)	<0.00050 DLA				
	Cobalt (Co)-Total (mg/L)	0.00253				
	Copper (Cu)-Total (mg/L)	<0.0025 DLA				
	Iron (Fe)-Total (mg/L)	<0.050 DLA				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1634769-1	L1634769-2	L1634769-3	L1634769-4	L1634769-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	29-JUN-15	29-JUN-15	29-JUN-15	29-JUN-15	29-JUN-15
	Sampled Time					
	Client ID	OPER_INFLUENT 12	OPER_INFLUENT 13	OPER_PRIMARY 1	OPER_PRIMARY 2	OPER_POLISHING 1
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	0.0108	0.0120	DLA <0.00025	DLA <0.00025	DLA <0.00025
	Lithium (Li)-Total (mg/L)	DLA <0.010	DLA <0.010	DLA <0.0050	DLA <0.0050	DLA <0.0050
	Magnesium (Mg)-Total (mg/L)	47.4	47.3	27.8	27.8	28.4
	Manganese (Mn)-Total (mg/L)	55.5	55.6	1.70	1.73	1.52
	Molybdenum (Mo)-Total (mg/L)	0.00243	0.00256	0.00075	0.00073	DLA <0.00025
	Nickel (Ni)-Total (mg/L)	0.155	0.156	DLA <0.0025	DLA <0.0025	0.0088
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	249	246	245	245	241
	Selenium (Se)-Total (mg/L)	0.0175	0.0174	0.0170	0.0169	0.0169
	Silicon (Si)-Total (mg/L)	0.486	0.489	0.052	<0.050	<0.050
	Silver (Ag)-Total (mg/L)	0.00021	0.00025	DLA <0.000050	DLA <0.000050	0.000114
	Sodium (Na)-Total (mg/L)	236	231	263	263	256
	Strontium (Sr)-Total (mg/L)	0.282	0.307	0.348	0.358	0.360
	Sulfur (S)-Total (mg/L)					869
	Thallium (Tl)-Total (mg/L)	DLA <0.00010	DLA <0.00010	DLA <0.000050	DLA <0.000050	DLA <0.000050
	Tin (Sn)-Total (mg/L)	DLA <0.0010	DLA <0.0010	DLA <0.00050	DLA <0.00050	DLA <0.00050
	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	0.00033	0.00036	DLA <0.000050	DLA <0.000050	DLA <0.000050
	Vanadium (V)-Total (mg/L)	DLA <0.0050	DLA <0.0050	DLA <0.0025	DLA <0.0025	DLA <0.0025
	Zinc (Zn)-Total (mg/L)	10.6	10.5	0.016	0.016	DLA <0.015
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	12.3	11.5	0.699	0.682	DLA <0.0050
	Antimony (Sb)-Dissolved (mg/L)	0.0437	0.0443	0.0111	0.00989	0.00221
	Arsenic (As)-Dissolved (mg/L)	0.231	0.214	0.00189	0.00189	DLA <0.00050
	Barium (Ba)-Dissolved (mg/L)	DTC 0.0588	DTC 0.0552	0.0249	0.0243	0.0269
	Beryllium (Be)-Dissolved (mg/L)	DLA <0.0010	DLA <0.0010	DLA <0.00050	DLA <0.00050	DLA <0.00050
	Bismuth (Bi)-Dissolved (mg/L)	DLA <0.00050	DLA <0.00050	DLA <0.00025	DLA <0.00025	DLA <0.00025
	Boron (B)-Dissolved (mg/L)	DLA <0.10	DLA <0.10	DLA <0.050	DLA <0.050	DLA <0.050
	Cadmium (Cd)-Dissolved (mg/L)	0.0628	0.0603	DLA <0.000025	DLA <0.000025	DTC 0.00112
	Calcium (Ca)-Dissolved (mg/L)	483	482	637	634	643
	Chromium (Cr)-Dissolved (mg/L)	0.166	0.160	DLA <0.00050	DLA <0.00050	DLA <0.00050
	Cobalt (Co)-Dissolved (mg/L)	0.0787	0.0736	DLA <0.00050	DLA <0.00050	0.00209
	Copper (Cu)-Dissolved (mg/L)	0.802	0.766	DLA <0.0010	DLA <0.0010	0.0049
	Iron (Fe)-Dissolved (mg/L)	45.6	44.4	DLA <0.050	DLA <0.050	DLA <0.050
	Lead (Pb)-Dissolved (mg/L)	0.00935	0.00959	DLA <0.00025	DLA <0.00025	DLA <0.00025
	Lithium (Li)-Dissolved (mg/L)	DLA <0.010	DLA <0.010	DLA <0.0050	DLA <0.0050	DLA <0.0050
	Magnesium (Mg)-Dissolved (mg/L)	45.3	44.6	26.9	26.8	26.4

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1634769-6				
	Description	Water				
	Sampled Date	29-JUN-15				
	Sampled Time					
	Client ID	OPER_POLISHING 2				
Grouping	**Analyte**					
WATER						
Total Metals	Lead (Pb)-Total (mg/L)	<0.00025 DLA				
	Lithium (Li)-Total (mg/L)	<0.0050 DLA				
	Magnesium (Mg)-Total (mg/L)	26.9				
	Manganese (Mn)-Total (mg/L)	1.55				
	Molybdenum (Mo)-Total (mg/L)	<0.00025 DLA				
	Nickel (Ni)-Total (mg/L)	0.0109				
	Phosphorus (P)-Total (mg/L)	<0.30				
	Potassium (K)-Total (mg/L)	237				
	Selenium (Se)-Total (mg/L)	0.0157				
	Silicon (Si)-Total (mg/L)	0.052				
	Silver (Ag)-Total (mg/L)	0.000101				
	Sodium (Na)-Total (mg/L)	248				
	Strontium (Sr)-Total (mg/L)	0.346				
	Sulfur (S)-Total (mg/L)	848				
	Thallium (Tl)-Total (mg/L)	<0.000050 DLA				
	Tin (Sn)-Total (mg/L)	<0.00050 DLA				
	Titanium (Ti)-Total (mg/L)	<0.010				
	Uranium (U)-Total (mg/L)	<0.000050 DLA				
	Vanadium (V)-Total (mg/L)	<0.0025 DLA				
	Zinc (Zn)-Total (mg/L)	<0.015 DLA				
Dissolved Metals	Dissolved Metals Filtration Location	FIELD				
	Aluminum (Al)-Dissolved (mg/L)	0.0051				
	Antimony (Sb)-Dissolved (mg/L)	0.00221				
	Arsenic (As)-Dissolved (mg/L)	<0.00050 DLA				
	Barium (Ba)-Dissolved (mg/L)	0.0262				
	Beryllium (Be)-Dissolved (mg/L)	<0.00050 DLA				
	Bismuth (Bi)-Dissolved (mg/L)	<0.00025 DLA				
	Boron (B)-Dissolved (mg/L)	<0.050 DLA				
	Cadmium (Cd)-Dissolved (mg/L)	0.000113				
	Calcium (Ca)-Dissolved (mg/L)	656				
	Chromium (Cr)-Dissolved (mg/L)	<0.00050 DLA				
	Cobalt (Co)-Dissolved (mg/L)	0.00246				
	Copper (Cu)-Dissolved (mg/L)	0.0021				
	Iron (Fe)-Dissolved (mg/L)	<0.050 DLA				
	Lead (Pb)-Dissolved (mg/L)	<0.00025 DLA				
	Lithium (Li)-Dissolved (mg/L)	<0.0050 DLA				
	Magnesium (Mg)-Dissolved (mg/L)	27.0				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1634769-1	L1634769-2	L1634769-3	L1634769-4	L1634769-5
	Description	Water	Water	Water	Water	Water
	Sampled Date	29-JUN-15	29-JUN-15	29-JUN-15	29-JUN-15	29-JUN-15
	Sampled Time					
	Client ID	OPER_INFLUENT 12	OPER_INFLUENT 13	OPER_PRIMARY 1	OPER_PRIMARY 2	OPER_POLISHING 1
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	52.2	49.5	1.56	1.53	1.45
	Molybdenum (Mo)-Dissolved (mg/L)	0.00084	0.00081	0.00074	0.00066	<0.00025 DLA
	Nickel (Ni)-Dissolved (mg/L)	0.146	0.139	<0.0025 DLA	<0.0025 DLA	0.0086
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	232	218	235	229	227
	Selenium (Se)-Dissolved (mg/L)	0.0152	0.0142	0.0166	0.0156	0.0162
	Silicon (Si)-Dissolved (mg/L)	0.410	0.414	0.051	0.052	<0.050
	Silver (Ag)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.000050 DLA	<0.000050 DLA	0.000092
	Sodium (Na)-Dissolved (mg/L)	217	204	249	240	237
	Strontium (Sr)-Dissolved (mg/L)	0.263	0.270	0.361	0.325	0.342
	Sulfur (S)-Dissolved (mg/L)					851
	Thallium (Tl)-Dissolved (mg/L)	<0.00010 DLA	<0.00010 DLA	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA
	Tin (Sn)-Dissolved (mg/L)	<0.0010 DLA	<0.0010 DLA	<0.00050 DLA	<0.00050 DLA	<0.00050 DLA
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00032	0.00032	<0.000050 DLA	<0.000050 DLA	<0.000050 DLA
	Vanadium (V)-Dissolved (mg/L)	<0.0050 DLA	<0.0050 DLA	<0.0025 DLA	<0.0025 DLA	<0.0025 DLA
	Zinc (Zn)-Dissolved (mg/L)	10.1	9.66	<0.0050 DLA	<0.0050 DLA	0.0062
Aggregate Organics	COD (mg/L)	74	79	<20	<20	<20

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1634769-6				
	Description	Water				
	Sampled Date	29-JUN-15				
	Sampled Time					
	Client ID	OPER_POLISHING 2				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Manganese (Mn)-Dissolved (mg/L)	1.50				
	Molybdenum (Mo)-Dissolved (mg/L)	<0.00025 DLA				
	Nickel (Ni)-Dissolved (mg/L)	0.0106				
	Phosphorus (P)-Dissolved (mg/L)	<0.30				
	Potassium (K)-Dissolved (mg/L)	228				
	Selenium (Se)-Dissolved (mg/L)	0.0153				
	Silicon (Si)-Dissolved (mg/L)	0.058				
	Silver (Ag)-Dissolved (mg/L)	0.000079				
	Sodium (Na)-Dissolved (mg/L)	235				
	Strontium (Sr)-Dissolved (mg/L)	0.338				
	Sulfur (S)-Dissolved (mg/L)	846				
	Thallium (Tl)-Dissolved (mg/L)	<0.000050 DLA				
	Tin (Sn)-Dissolved (mg/L)	<0.00050 DLA				
	Titanium (Ti)-Dissolved (mg/L)	<0.010				
	Uranium (U)-Dissolved (mg/L)	<0.000050 DLA				
	Vanadium (V)-Dissolved (mg/L)	<0.0025 DLA				
	Zinc (Zn)-Dissolved (mg/L)	0.0056				
Aggregate Organics	COD (mg/L)	<20				

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Total Organic Carbon	MS-B	L1634769-1, -2, -3, -4, -5, -6

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLA	Detection Limit adjusted for required dilution
DLM	Detection Limit Adjusted due to sample matrix effects.
DTC	Dissolved concentration exceeds total. Results were confirmed by re-analysis.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

BR-L-IC-N-VA	Water	Bromide in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310B TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

COD-COL-VA	Water	Chemical Oxygen Demand by Colorimetric	APHA 5220 D. CHEMICAL OXYGEN DEMAND

This analysis is carried out using procedures adapted from APHA Method 5220 "Chemical Oxygen Demand (COD)". Chemical oxygen demand is determined using the closed reflux colourimetric method.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

F-IC-N-VA	Water	Fluoride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-TOT-ICP-VA	Water	Total Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

N-T-COL-VA	Water	Total Nitrogen in water by Colour	APHA Method 4500-P (J) / NEMI 5735

Reference Information

This analysis is carried out using procedures adapted from APHA Method 4500-P (J) "Persulphate Method for Simultaneous Determination of Total Nitrogen and Total Phosphorus" and National Environmental Methods Index - Nemi method 5735.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	APHA 4500 NH3-NITROGEN (AMMONIA)

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

It is recommended that this analysis be conducted in the field.

PO4-DO-COL-VA	Water	Diss. Orthophosphate in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter.

S-DIS-ICP-VA	Water	Dissolved Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

S-TOT-ICP-VA	Water	Total Sulfur in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method will not give total sulfur results for all samples. Sulfide or other volatile forms of sulfur that may be present in submitted samples, is often lost during the sampling, preservation and analysis process. The data reported as total and/or dissolved sulfur represents all non-volatile forms of sulfur present in a particular sample.

S2-T-COL-VA	Water	Total Sulphide by Colorimetric	APHA 4500-S2 Sulphide

This analysis is carried out using procedures adapted from APHA Method 4500-S2 "Sulphide". Sulphide is determined using the methlyene blue colourimetric method.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids

Reference Information

(TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TKN-CALC-VA	Water	TKN in Water (Calculation)	BC MOE LABORATORY MANUAL (2005)

Total Kjeldahl Nitrogen is a calculated parameter. Total Kjeldahl Nitrogen (calc) = Total Nitrogen - [Nitrite (as N) + Nitrate (as N)].

TSS-VA	Water	Total Suspended Solids by Gravimetric	APHA 2540 D - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Suspended Solids (TSS) are determined by filtering a sample through a glass fibre filter, TSS is determined by drying the filter at 104 degrees celsius.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 "Turbidity"

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

TURBIDITY-VA	Water	Turbidity by Meter	APHA 2130 Turbidity

This analysis is carried out using procedures adapted from APHA Method 2130 "Turbidity". Turbidity is determined by the nephelometric method.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

A384-2 OP WTP BST

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # A384-2 OP WTP BST

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other		○ Regular (Standard Turnaround Times - Business Days)
Contact:	Max Holtby	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	1600-570 Granville St.	Email 1:	Refer to Special Instructions for email list	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6C 3P1	Email 2:		◉ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(604)558-1784 Fax: (604) 558-4784	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Brucejack - WTP Bench Testing	
Company:		PO / AFE:		
Contact:		LSD:		
Address:	invoices@pretivm.com			
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: Veolia	

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients/ TOC / TN	Total Metals	Dissolved Metals	Total Mercury	Dissolved Mercury	Sulfide					Number of Containers
						P	P	F/P			P					
	Oper_Influent 12	29-Jun-15		Water	X	X	X	X								4
	Oper_Influent 13	29-Jun-15		Water	X	X	X	X								4
	Oper_primary 1	29-Jun-15		Water	X	X	X	X								4
	Oper_primary 2	29-Jun-15		Water	X	X	X	X								4
	Oper_polishing 1	29-Jun-15		Water	X	X	X	X			X					5
	Oper_polishing 2	29-Jun-15		Water	X	X	X	X			X					5

RUSH

Priority processing

L1634769-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Test for Total Nitrogen (not TKN). Email SRC and test reports to: mholtby@pretivm.com, aking@pretivm.com, invoices@pretivm.com, svanzalingen@pretivm.com, patrick.mueller@lorax.ca, robert.goldblatt@lorax.ca, simon.vincent@veolia.com, myriam.deladurantaye@veolia.com, marc.laliberte@veolia.com

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Myriam De Ladurantaye	29-Jun-15		Jean	30 JUN 2015	8:30	15.1 °C				

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # A384-2 OP WTP BST

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.	☑ Standard ☐ Other	○ Regular (Standard Turnaround Times - Business Days)
Contact:	Max Holtby	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	1600-570 Granville St.	Email 1: Refer to Special Instructions for email list	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6C 3P1	Email 2:	◉ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(604)558-1784 Fax: (604) 558-4784	Email 3:	
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information	Analysis Request
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #: Brucejack - WTP Bench Testing	Please indicate below Filtered, Preserved or both (F, P, F/P)
Company:		PO / AFE:	
Contact:		LSD:	
Address:	invoices@pretivm.com		
Phone:	Fax:	Quote #:	
Lab Work Order # (lab use only)		ALS Contact: Dean Watt	Sampler: Veolia

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	General	Nutrients/ TOC / TN	Total Metals	Dissolved Metals	Total Mercury	Dissolved Mercury						Number of Containers
						P	P	F/P								
	Oper_Influent 1	15-Jun-15	12h45	Water	x	x	x	x								4
	Oper_Influent 2	15-Jun-15	12h45	Water	x	x	x	x								4

L1628194-COFC

RUSH

Priority processing

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Test for Total Nitrogen (not TKN). Email SRC and test reports to: mholtby@pretivm.com, invoices@pretivm.com, svanzalingen@pretivm.com, patrick.mueller@lorax.ca, robert.goldblatt@lorax.ca, simon.vincent@veolia.com, myriam.deladurantaye@veolia.com, marc.laliberte@veolia.com

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Myriam De Ladurantaye	15-Jun-15		ISAAC	June 17	09:40	10 °C				

APPENDIX F. MATERIAL SAFETY DATA SHEETS FOR CHEMICALS USED DURING THE TESTS

SAFETY DATA SHEET

Version 4.8
Revision Date 02/28/2015
Print Date 04/07/2015

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Calcium hydroxide
Product Number	:	239232
Brand	:	Sigma-Aldrich
Product Use	:	For laboratory research purposes.
Supplier	:	Sigma-Aldrich Canada Co. 2149 Winston Park Drive OAKVILLE ON L6H 6J8 CANADA
Telephone	:	+1 9058299500
Fax	:	+1 9058299292
Emergency Phone # (For both supplier and manufacturer)	:	1-800-424-9300
Preparation Information	:	Sigma-Aldrich Corporation Product Safety - Americas Region 1-800-521-8956

Manufacturer : Sigma-Aldrich Corporation
3050 Spruce St.
St. Louis, Missouri 63103
USA

2. HAZARDS IDENTIFICATION

Emergency Overview

WHMIS Classification

D2B	Toxic Material Causing Other Toxic Effects	Moderate skin irritant Moderate respiratory irritant Moderate eye irritant

GHS Classification

Skin corrosion/irritation (Category 2)
Serious eye damage/eye irritation (Category 1)
Specific target organ toxicity - single exposure (Category 3), Respiratory system
Acute aquatic toxicity (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H315	Causes skin irritation.
H318	Causes serious eye damage.
H335	May cause respiratory irritation.
H402	Harmful to aquatic life.

Precautionary statement(s)

P261	Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
P280	Wear protective gloves/ eye protection/ face protection.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

HMIS Classification

Health hazard: 2

Flammability: 0
Physical hazards: 0

Potential Health Effects

Inhalation May be harmful if inhaled. May cause respiratory tract irritation.
Skin May be harmful if absorbed through skin. May cause skin irritation.
Eyes May cause eye irritation.
Ingestion May be harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : H_2CaO_2
Molecular weight : 74.09 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Calcium dihydroxide			
1305-62-0	215-137-3	-	<=100%

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIREFIGHTING MEASURES

Conditions of flammability
Not flammable or combustible.

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for firefighters
Wear self-contained breathing apparatus for firefighting if necessary.

Hazardous combustion products
Hazardous decomposition products formed under fire conditions. - Calcium oxide

Explosion data - sensitivity to mechanical impact
No data available

Explosion data - sensitivity to static discharge
No data available

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.

Keep in a dry place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Basis
Calcium dihydroxide	1305-62-0	TWA	5.000000 mg/m3	Canada. British Columbia OEL
		TWA	5.000000 mg/m3	Canada. Alberta, Occupational Health and Safety Code (table 2: OEL)
Remarks	Occupational exposure limit is based on irritation effects and its adjustment to compensate for unusual work schedules is not required			
		TWAEV	5.000000 mg/m3	Canada. Ontario OELs
		TWAEV	5.000000 mg/m3	Québec. Regulation respecting occupational health and safety, Schedule 1, Part 1: Permissible exposure values for airborne contaminants
		TWAEV	5 mg/m3	Québec. Regulation respecting occupational health and safety, Schedule 1, Part 1: Permissible exposure values for airborne contaminants
		TWA	5 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		TWA	5.000000 mg/m3	USA. ACGIH Threshold Limit Values (TLV)

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber

Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Eye protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

Specific engineering controls
Use mechanical exhaust or laboratory fumehood to avoid exposure.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder
Colour	beige

Safety data

pH	12.4 - 12.6 at 20 °C (68 °F)
Melting point/freezing point	>= 450 °C (>= 842 °F)
Boiling point	No data available
Flash point	Not applicable
Flammability (solid, gas)	The product is not flammable.
Ignition temperature	No data available
Auto-ignition temperature	No data available
Lower explosion limit	No data available
Upper explosion limit	No data available
Vapour pressure	No data available
Density	2.24 g/mL at 25 °C (77 °F)
Water solubility	0.99 g/l at 20 °C (68 °F)
Partition coefficient: n-octanol/water	No data available
Relative vapour density	No data available
Odour	No data available
Odour Threshold	No data available
Evaporation rate	No data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Possibility of hazardous reactions
No data available

Conditions to avoid
No data available

Materials to avoid
Strong acids

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Calcium oxide
Other decomposition products - No data available

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
LD50 Oral - Rat - 7,340 mg/kg

Inhalation LC50
No data available

Dermal LD50
Other information on acute toxicity
No data available

Skin corrosion/irritation
Skin - Rabbit - Irritating to skin. - OECD Test Guideline 404

Serious eye damage/eye irritation
Eyes - Rabbit - Severe eye irritation - OECD Test Guideline 405

Respiratory or skin sensitisation
No data available

Germ cell mutagenicity
No data available

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

Reproductive toxicity

No data available

Teratogenicity

No data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
Inhalation - May cause respiratory irritation.

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
No data available

Aspiration hazard
No data available

Potential health effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation.
Ingestion	May be harmful if swallowed.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.

Synergistic effects
No data available

Additional Information
RTECS: EW2800000

12. ECOLOGICAL INFORMATION

Toxicity

Toxicity to fish	LC50 - Clarias gariepinus - 33.884 mg/l - 96 h
Toxicity to daphnia and other aquatic invertebrates	EC50 - Daphnia magna (Water flea) - 49.1 mg/l - 48 h Method: OECD Test Guideline 202
Toxicity to algae	EC50 - Pseudokirchneriella subcapitata (green algae) - 184.6 mg/l - 72 h Method: OECD Test Guideline 201

Persistence and degradability
The methods for determining biodegradability are not applicable to inorganic substances.

Bioaccumulative potential
Does not bioaccumulate.

Mobility in soil
No data available

PBT and vPvB assessment
No data available

Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Harmful to aquatic life.

No data available

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

WHMIS Classification

D2B	Toxic Material Causing Other Toxic Effects	Moderate skin irritant Moderate respiratory irritant Moderate eye irritant

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

16. OTHER INFORMATION

Text of H-code(s) and R-phrase(s) mentioned in Section 3

Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Corporation and its Affiliates shall not be held liable for any damage resulting from handling or from contact with the above product. See www.sigma-aldrich.com and/or the reverse side of invoice or packing slip for additional terms and conditions of sale.

Hydrex

MATERIAL SAFETY DATA SHEET

1. Product and Company Identification

Product identifier	**Hydrex 3253**
Version #	02
Issue date	07-09-2014
Revision date	09-09-2014
Supersedes date	07-09-2014
CAS #	Mixture
Product use	Coagulant
Manufacturer	
Supplier	VWS Canada
Address	2000 Argentia Road, Plaza IV, Suite 430 Mississauga, ON L5N 1W1 Canada
Contact Person	Hydrex Product Specialist
Telephone	(905) 286-4846
Fax	(905) 286-0488
e-mail	vwscanada.hydrex@veoliawater.com
24-Hour Emergency telephone	+1-760-476-3962 (Code:333239)

2. Hazards Identification

Emergency overview	DANGER Corrosive. Causes skin and eye burns. Prolonged exposure may cause chronic effects.
Potential health effects	
Routes of exposure	Inhalation. Ingestion. Skin contact. Eye contact.
Eyes	Corrosive to the eyes and may cause severe damage including blindness. Causes chemical burns. Do not get this material in contact with eyes.
Skin	Causes chemical burns. Do not get this material in contact with skin.
Inhalation	May cause cancer by inhalation. May cause irritation of respiratory tract. Prolonged inhalation may be harmful. Do not breathe dust/fume/gas/mist/vapors/spray.
Ingestion	Harmful if swallowed. Ingestion causes burns of the upper digestive and respiratory tracts. Do not ingest.
Chronic effects	Frequent or prolonged contact may defat and dry the skin, leading to discomfort and dermatitis.
Signs and symptoms	Contact with this material will cause burns to the skin, eyes and mucous membranes.
Potential environmental effects	Components of this product are hazardous to aquatic life.

3. Composition / Information on Ingredients

Non-hazardous components	CAS #	Percent
IRON, WATER-SOLUBLE SALTS, N.O.S.	10028-22-5	40 - 70
Other components below reportable levels		30 - 60

4. First Aid Measures

First aid procedures

Eye contact	Immediately flush eyes with plenty of water for at least 15 minutes. If a contact lens is present, DO NOT delay irrigation or attempt to remove the lens. Continue rinsing. Get medical attention immediately.
Skin contact	Remove and isolate contaminated clothing and shoes. Immediately flush skin with plenty of water. Get medical attention immediately. For minor skin contact, avoid spreading material on unaffected skin. Wash clothing separately before reuse.

Inhalation	Move to fresh air. Oxygen or artificial respiration if needed. Do not use mouth-to-mouth method if victim inhaled the substance. Induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Get medical attention, if needed.
Ingestion	IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician. Never give anything by mouth to a victim who is unconscious or is having convulsions. Rinse mouth thoroughly. Do not induce vomiting without advice from poison control center. If vomiting occurs, keep head low so that stomach content doesn't get into the lungs. Induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device.
Notes to physician	In case of shortness of breath, give oxygen. Keep victim warm. Symptoms may be delayed.
General advice	In case of shortness of breath, give oxygen. Keep victim warm. Keep victim under observation. Get medical attention if symptoms occur. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. Show this safety data sheet to the doctor in attendance. Do not use mouth-to-mouth method if victim ingested the substance.

5. Fire Fighting Measures

Flammable properties	Not flammable by WHMIS criteria.
Extinguishing media	
Suitable extinguishing media	Water fog.
Fire fighting equipment/instructions	Not available.
Explosion data	
Sensitivity to static discharge	Not available.
Sensitivity to mechanical impact	Not available.

6. Accidental Release Measures

Personal precautions	Keep unnecessary personnel away. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Keep people away from and upwind of spill/leak.
Environmental precautions	Prevent further leakage or spillage if safe to do so. Do not contaminate water.
Methods for containment	Stop leak if you can do so without risk. Dike the spilled material, where this is possible. Prevent entry into waterways, sewer, basements or confined areas.
Methods for cleaning up	Should not be released into the environment. The product is immiscible with water and will spread on the water surface. Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Following product recovery, flush area with water. Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination. Never return spills in original containers for re-use. Clean up in accordance with all applicable regulations. For waste disposal, see section 13 of the MSDS.
Other information	Clean up in accordance with all applicable regulations.

7. Handling and Storage

Handling	Do not breathe dust/fume/gas/mist/vapors/spray. Do not get this material in contact with eyes. Do not get this material in contact with skin. Do not get this material on clothing. Wear personal protective equipment. Do not use in areas without adequate ventilation. Avoid prolonged exposure. Wash thoroughly after handling. Avoid release to the environment.
Storage	Store in a closed container away from incompatible materials. Keep out of the reach of children.

8. Exposure Controls / Personal Protection

Occupational exposure limits

US. ACGIH Threshold Limit Values

Components	Type	Value
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)	TWA	1 mg/m3

Canada. Alberta OELs (Occupational Health & Safety Code, Schedule 1, Table 2)

Components	Type	Value
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)	TWA	1 mg/m3

Canada. British Columbia OELs. (Occupational Exposure Limits for Chemical Substances, Occupational Health and Safety Regulation 296/97, as amended)

Components	Type	Value
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)	STEL	2 mg/m3
	TWA	1 mg/m3

Canada. Manitoba OELs (Reg. 217/2006, The Workplace Safety And Health Act)

Components	Type	Value
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)	TWA	1 mg/m3

Canada. Ontario OELs. (Control of Exposure to Biological or Chemical Agents)

Components	Type	Value
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)	TWA	1 mg/m3

Canada. Quebec OELs. (Ministry of Labor - Regulation Respecting the Quality of the Work Environment)

Components	Type	Value
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)	TWA	1 mg/m3

Biological limit values No biological exposure limits noted for the ingredient(s).

Engineering controls Ensure adequate ventilation, especially in confined areas.

Personal protective equipment

Eye / face protection Do not get in eyes. Chemical goggles are recommended.

Skin protection Do not get this material in contact with skin. Chemical resistant gloves. It may provide little or no thermal protection.

Respiratory protection Use a positive-pressure air-supplied respirator if there is any potential for an uncontrolled release, exposure levels are not known, or any other circumstances where air-purifying respirators may not provide adequate protection.

9. Physical & Chemical Properties

Appearance Not available.

Physical state Liquid.

Form Liquid

Color Red brown.

Odor Not available.

pH < 2

Vapor pressure Not available.

Vapor density Not available.

Boiling point	Not available.
Melting point/Freezing point	-0.4 °F (-18 °C)
Solubility (water)	Not available.
Specific gravity	1.45 - 1.59
Flash point	Not available.
Auto-ignition temperature	Not available.

10. Chemical Stability & Reactivity Information

Chemical stability	Material is stable under normal conditions.
Conditions to avoid	Reacts violently with strong alkaline substances. This product may react with reducing agents. Do not mix with other chemicals.
Incompatible materials	Incompatible with bases. This product may react with reducing agents.
Hazardous decomposition products	Sulfur oxides
Possibility of hazardous reactions	Hazardous polymerization does not occur.

11. Toxicological Information

Toxicological data

Product	**Species**	**Test Results**
Hydrex 3253 (CAS Mixture)		
Acute		
Dermal		
LD50	Mouse	292.9044 mg/kg estimated
Inhalation		
LC50	Guinea pig	7.2173 mg/l, 8 Hours estimated
Oral		
LD50	Rat	500 mg/kg

Components	**Species**	**Test Results**
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)		
Acute		
Dermal		
LD50	Mouse	168 mg/kg
Oral		
LD50	Rat	500 mg/kg

* Estimates for product may be based on additional component data not shown.

Acute effects	Causes burns.
Local effects	May produce corrosive solutions on contact with water.
Chronic effects	Hazardous by WHMIS criteria. Prolonged inhalation may be harmful. Prolonged exposure may cause chronic effects.
Carcinogenicity	Hazardous by WHMIS criteria. Cancer Hazard.

12. Ecological Information

Ecotoxicological data

Product		**Species**	**Test Results**
Hydrex 3253 (CAS Mixture)			
Fish	LC50	Fish	64.6086 mg/l, 96 hours estimated

Components		Species	Test Results
IRON, WATER-SOLUBLE SALTS, N.O.S. (CAS 10028-22-5)			
Aquatic			
Fish	LC50	Western mosquitofish (Gambusia affinis)	37.2 mg/l, 96 hours

* Estimates for product may be based on additional component data not shown.

Ecotoxicity Components of this product are hazardous to aquatic life. Because of the low pH of this product, it would be expected to produce significant ecotoxicity upon exposure to aquatic organisms and aquatic systems.

Environmental effects Harmful to aquatic organisms.

Persistence and degradability Not available.

Mobility in environmental media The product is immiscible with water and will spread on the water surface.

13. Disposal Considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Do not allow this material to drain into sewers/water supplies. Dispose in accordance with all applicable regulations.

Contaminated packaging Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport Information

TDG

- **UN number** UN3264
- **UN proper shipping name** CORROSIVE LIQUID, ACIDIC, INORGANIC, N.O.S. (Ferric Sulfate Solution)
- **Transport hazard class(es)**
  - **Class** 8
  - **Subsidiary risk** -
- **Packing group** III
- **Environmental hazards** Not available.
- **Special precautions for user** Not available.

IATA

- **UN number** UN3287
- **UN proper shipping name** Toxic liquid, inorganic, n.o.s.
- **Transport hazard class(es)**
  - **Class** 6.1(PGIII)
  - **Subsidiary risk** -
- **Packing group** III
- **Environmental hazards** No.
- **ERG Code** 6L
- **Special precautions for user** Not available.
- **Other information**
  - **Passenger and cargo aircraft** Allowed.
  - **Cargo aircraft only** Allowed.

IMDG

- **UN number** UN3287
- **UN proper shipping name** TOXIC LIQUID, INORGANIC, N.O.S.
- **Transport hazard class(es)**
  - **Class** 6.1(PGIII)
  - **Subsidiary risk** -
- **Packing group** III
- **Environmental hazards**
  - **Marine pollutant** No.
- **EmS** F-A, S-A
- **Special precautions for user** Not available.

IATA; IMDG

TDG

15. Regulatory Information

Canadian regulations This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

WHMIS status Controlled

WHMIS classification D1B - Immediate/Serious-TOXIC
D2A - Other Toxic Effects-VERY TOXIC
E - Corrosive

WHMIS labeling

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	Yes
Europe	European List of Notified Chemical Substances (ELINCS)	No
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other Information

Further information HMIS® is a registered trade and service mark of the NPCA.

HMIS® ratings Health: 2
Flammability: 0
Physical hazard: 0

NFPA ratings	Health: 2 Flammability: 0 Instability: 0
Disclaimer	Veolia Water Solutions & Technologies is not able to anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use and or non respect of Veolia Water Solutions & Technologies' requirement.
This data sheet contains changes from the previous version in section(s):	Composition / Information on Ingredients: Ingredients Transport Information: Material Transportation Information

MATERIAL SAFETY DATA SHEET

1. Product and Company Identification

Product identifier	**Hydrex 6183**
Version #	01
Issue date	11-07-2014
CAS #	Mixture
Product use	Wastewater Flocculant
Manufacturer	
Supplier	VWS Canada
Address	2000 Argentia Road, Plaza IV, Suite 430 Mississauga, ON L5N 1W1 Canada
Contact Person	Hydrex Product Specialist
Telephone	(905) 286-4846
Fax	(905) 286-0488
e-mail	vwscanada.hydrex@veoliawater.com
24-Hour Emergency telephone	+1-760-476-3962 (Code:333239)

2. Hazards Identification

Emergency overview	May be irritating to eyes.
Potential health effects	
Eyes	May cause eye irritation.
Skin	Health injuries are not known or expected under normal use.
Inhalation	Health injuries are not known or expected under normal use.
Ingestion	Health injuries are not known or expected under normal use.

3. Composition / Information on Ingredients

The components are not hazardous or are below required disclosure limits.

4. First Aid Measures

First aid procedures	
Eye contact	Rinse with water. Get medical attention if irritation develops and persists.
Skin contact	Rinse skin with water/shower. Get medical attention if irritation develops and persists.
Inhalation	If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing. Call a physician if symptoms develop or persist.
Ingestion	Rinse mouth. If ingestion of a large amount does occur, call a poison control center immediately.
General advice	If you feel unwell, seek medical advice (show the label where possible). Show this safety data sheet to the doctor in attendance.

5. Fire Fighting Measures

Flammable properties	Not flammable by WHMIS criteria. Dust accumulation from this product may present an explosion hazard in the presence of an ignition source.
Extinguishing media	
Suitable extinguishing media	Water spray, fog, CO_2, dry chemical, or alcohol resistant foam.
Protection of firefighters	
Protective equipment for firefighters	In the event of fire, wear self-contained breathing apparatus.
Fire fighting equipment/instructions	Use water spray to cool unopened containers. Dust may form an explosive mixture in the atmosphere.
Specific methods	Use water spray to cool unopened containers.

Explosion data

Sensitivity to static discharge	Not available.
Sensitivity to mechanical impact	Not available.

6. Accidental Release Measures

Personal precautions	Slippery when wet.
Environmental precautions	Prevent further leakage or spillage if safe to do so. Do not contaminate water.
Methods for cleaning up	Should not be released into the environment. Following product recovery, flush area with water. For waste disposal, see section 13 of the MSDS.

7. Handling and Storage

Handling	Avoid release to the environment. Material can be slippery when wet.
Storage	Store in a dry area. Store in closed original container at temperatures between 5°C and 30°C.

8. Exposure Controls / Personal Protection

Biological limit values	No biological exposure limits noted for the ingredient(s).

Personal protective equipment

Skin protection	Normal work clothing (long sleeved shirts and long pants) is recommended.
Respiratory protection	No personal respiratory protective equipment normally required.

9. Physical & Chemical Properties

Appearance	Not available.
Physical state	Solid.
Form	Not available.
Color	Off-white.
Odor	Not available.
pH	Not available.
Vapor pressure	Not available.
Vapor density	Not available.
Boiling point	Not available.
Melting point/Freezing point	Not available.
Solubility (water)	Not available.
Specific gravity	0.7 - 0.9
Flash point	Not available.
Auto-ignition temperature	Not available.
Ph Of 1% Solution	6 - 8.5

10. Chemical Stability & Reactivity Information

Chemical stability	Material is stable under normal conditions.
Conditions to avoid	None under normal conditions.
Incompatible materials	Not available.
Hazardous decomposition products	Upon decomposition, this product may yield oxides of nitrogen and ammonia, carbon dioxide, carbon monoxide and other low molecular weight hydrocarbons.

11. Toxicological Information

Toxicological data

Product	Species	Test Results
Hydrex 6183 (CAS Mixture)		
Acute		
Oral		
LD50	Rat	> 5000 mg/kg

* Estimates for product may be based on additional component data not shown.

Chronic effects Not expected to be hazardous by WHMIS criteria.

12. Ecological Information

Ecotoxicological data

Product		Species	Test Results
Hydrex 6183 (CAS Mixture)			
Algae	IC50	Algae	> 1000 mg/l, 72 hr
Crustacea	EC50	Daphnia	> 200 mg/l, 48 hr
Fish	LC50	Fish	> 200 mg/l, 96 hr
Aquatic			
Fish	LC50	Zebra danio (Danio rerio)	> 100 mg/l, 96 hr

* Estimates for product may be based on additional component data not shown.

Ecotoxicity Contains a substance which causes risk of hazardous effects to the environment.

Environmental effects An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Persistence and degradability Not available.

13. Disposal Considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Do not allow this material to drain into sewers/water supplies. Dispose in accordance with all applicable regulations.

Contaminated packaging Empty containers should be taken to an approved waste handling site for recycling or disposal.

14. Transport Information

TDG

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

Not regulated as dangerous goods.

15. Regulatory Information

Canadian regulations This product has been classified in accordance with the hazard criteria of the CPR and the MSDS contains all the information required by the CPR.

WHMIS status Non-controlled

Inventory status

Country(s) or region	Inventory name	On inventory (yes/no)*
Australia	Australian Inventory of Chemical Substances (AICS)	Yes
Canada	Domestic Substances List (DSL)	Yes
Canada	Non-Domestic Substances List (NDSL)	No
China	Inventory of Existing Chemical Substances in China (IECSC)	Yes
Europe	European Inventory of Existing Commercial Chemical Substances (EINECS)	No
Europe	European List of Notified Chemical Substances (ELINCS)	No

Country(s) or region	Inventory name	On inventory (yes/no)*
Japan	Inventory of Existing and New Chemical Substances (ENCS)	Yes
Korea	Existing Chemicals List (ECL)	Yes
New Zealand	New Zealand Inventory	Yes
Philippines	Philippine Inventory of Chemicals and Chemical Substances (PICCS)	Yes
United States & Puerto Rico	Toxic Substances Control Act (TSCA) Inventory	Yes

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s)
A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

16. Other Information

Further information

HMIS® is a registered trade and service mark of the NPCA.

HMIS® ratings

Health: 0
Flammability: 1
Physical hazard: 0

NFPA ratings

Health: 0
Flammability: 1
Instability: 0

Disclaimer

Veolia Water Solutions & Technologies is not able to anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use and or non respect of Veolia Water Solutions & Technologies' requirement.

This data sheet contains changes from the previous version in section(s):

Product and Company Identification: Product Review
Hazards Identification: Emergency overview
Hazards Identification: Eyes

SAFETY DATA SHEET

Version 4.8
Revision Date 08/04/2014
Print Date 04/07/2015

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Sodium sulfide
Product Number	:	407410
Brand	:	Aldrich
Product Use	:	For laboratory research purposes.
Supplier	:	Sigma-Aldrich Canada Co. 2149 Winston Park Drive OAKVILLE ON L6H 6J8 CANADA
Telephone	:	+1 9058299500
Fax	:	+1 9058299292
Emergency Phone # (For both supplier and manufacturer)	:	1-800-424-9300
Preparation Information	:	Sigma-Aldrich Corporation Product Safety - Americas Region 1-800-521-8956

Manufacturer	:	Sigma-Aldrich Corporation 3050 Spruce St. St. Louis, Missouri 63103 USA

2. HAZARDS IDENTIFICATION

Emergency Overview

WHMIS Classification

D1B	Toxic Material Causing Immediate and Serious Toxic Effects	Toxic by ingestion
D2B	Toxic Material Causing Other Toxic Effects	Severe eye irritant
E	Corrosive Material	Corrosive
F	Dangerously Reactive Material	Unstable Reactive

GHS Classification

Self-heating substances (Category 1)
Corrosive to metals (Category 1)
Acute toxicity, Oral (Category 3)
Skin corrosion (Category 1B)
Serious eye damage (Category 1)
Acute aquatic toxicity (Category 1)

GHS Label elements, including precautionary statements

Pictogram

Signal word: Danger

Hazard statement(s)

H251	Self-heating: may catch fire.
H290	May be corrosive to metals.
H301	Toxic if swallowed.
H314	Causes severe skin burns and eye damage.
H400	Very toxic to aquatic life.

Precautionary statement(s)

P235 + P410	Keep cool. Protect from sunlight.
P273	Avoid release to the environment.

P280	Wear protective gloves/ protective clothing/ eye protection/ face protection.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P310	Immediately call a POISON CENTER or doctor/ physician.

HMIS Classification

Health hazard: 3
Flammability: 4
Physical hazards: 0

Potential Health Effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract.
Skin	May be harmful if absorbed through skin. Causes skin burns.
Eyes	Causes eye burns.
Ingestion	Toxic if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : Na_2S
Molecular Weight : 78.04 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Sodium sulphide			
1313-82-2	215-211-5	016-009-00-8	<=100%

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Take off contaminated clothing and shoes immediately. Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.Continue rinsing eyes during transport to hospital.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIREFIGHTING MEASURES

Conditions of flammability
Not flammable or combustible.

Suitable extinguishing media
Dry powder

Special protective equipment for firefighters
Wear self contained breathing apparatus for fire fighting if necessary.

Hazardous combustion products

Explosion data - sensitivity to mechanical impact
no data available

Explosion data - sensitivity to static discharge
no data available

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Wear respiratory protection. Avoid dust formation. Avoid breathing vapours, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up
Sweep up and shovel. Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13). Do not flush with water. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed. Keep away from sources of ignition - No smoking.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.
Never allow product to get in contact with water during storage. Do not store near acids.

Recommended storage temperature: 2 - 8 °C

hygroscopic Air and light sensitive.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face particle respirator type N100 (US) or type P3 (EN 143) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Full contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

Splash contact
Material: Nitrile rubber
Minimum layer thickness: 0.11 mm
Break through time: 480 min
Material tested:Dermatril® (KCL 740 / Aldrich Z677272, Size M)

data source: KCL GmbH, D-36124 Eichenzell, phone +49 (0)6659 87300, e-mail sales@kcl.de, test method: EN374
If used in solution, or mixed with other substances, and under conditions which differ from EN 374, contact the supplier of the CE approved gloves. This recommendation is advisory only and must be evaluated by an industrial hygienist and safety officer familiar with the specific situation of anticipated use by our customers. It should not be construed as offering an approval for any specific use scenario.

Eye protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, The type of protective equipment must be selected according to the

concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

Specific engineering controls
Use mechanical exhaust or laboratory fumehood to avoid exposure.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	solid
Colour	no data available

Safety data

pH	no data available
Melting point/freezing point	Melting point/range: 950 °C (1,742 °F) - lit.
Boiling point	no data available
Flash point	not applicable
Ignition temperature	no data available
Auto-ignition temperature	The substance or mixture is classified as self heating with the category 1.
Lower explosion limit	no data available
Upper explosion limit	no data available
Vapour pressure	no data available
Density	1.86 g/mL at 25 °C (77 °F)
Water solubility	no data available
Partition coefficient: n-octanol/water	no data available
Relative vapour density	no data available
Odour	no data available
Odour Threshold	no data available
Evapouration rate	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Possibility of hazardous reactions
no data available

Conditions to avoid
Air Avoid moisture. Light.

Materials to avoid
Oxidizing agents, Copper, Zinc

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Sulphur oxides, Sodium oxides
Other decomposition products - no data available

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
LD50 Oral - rat - 246 mg/kg

Inhalation LC50
no data available

Dermal LD50
no data available

Other information on acute toxicity
no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitisation
no data available

Germ cell mutagenicity

Genotoxicity in vitro - mouse - lymphocyte - with and without metabolic activation - negative

Genotoxicity in vivo - mouse - male and female - negative

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

Reproductive toxicity

no data available

Teratogenicity

no data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. Material is extremely destructive to the tissue of the mucous membranes and upper respiratory tract.
Ingestion	Toxic if swallowed.
Skin	May be harmful if absorbed through skin. Causes skin burns.
Eyes	Causes eye burns.

Signs and Symptoms of Exposure
Material is extremely destructive to tissue of the mucous membranes and upper respiratory tract, eyes, and skin., Cough, Shortness of breath, Headache, Nausea

Synergistic effects
no data available

Additional Information

RTECS: WE1905000

12. ECOLOGICAL INFORMATION

Toxicity

Toxicity to fish	LC50 - Lepomis macrochirus (Bluegill sunfish) - 0.032 mg/l - 96 h Method: OECD Test Guideline 203
Toxicity to daphnia and other aquatic invertebrates	LC50 - Daphnia magna (Water flea) - 2.1 mg/l - 48 h
Toxicity to algae	Growth inhibition EC50 - Chlorella pyrenoidosa - 75 mg/l - 96 h

Persistence and degradability
no data available

Bioaccumulative potential

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Very toxic to aquatic life.

no data available

13. DISPOSAL CONSIDERATIONS

Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material. Dissolve or mix the material with a combustible solvent and burn in a chemical incinerator equipped with an afterburner and scrubber.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1385 Class: 4.2 Packing group: II
Proper shipping name: Sodium sulfide, anhydrous
Reportable Quantity (RQ):
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 1385 Class: 4.2 Packing group: II EMS-No: F-A, S-J
Proper shipping name: SODIUM SULPHIDE, ANHYDROUS
Marine pollutant: No

IATA
UN number: 1385 Class: 4.2 Packing group: II
Proper shipping name: Sodium sulphide, anhydrous

15. REGULATORY INFORMATION

WHMIS Classification

D1B Toxic Material Causing Immediate and Serious Toxic by ingestion

	Toxic Effects	
D2B	Toxic Material Causing Other Toxic Effects	Severe eye irritant
E	Corrosive Material	Corrosive
F	Dangerously Reactive Material	Unstable Reactive

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all the information required by the Controlled Products Regulations.

16. OTHER INFORMATION

Further information

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APPENDIX G. WATER RESEARCH PAPER THAT DESCRIBES THE ACTIFLO® ADAPTED JAR-TEST PROCEDURE

PERGAMON

Water Research 36 (2002) 744–754

WATER RESEARCH

www.elsevier.com/locate/watres

Laboratory study of ballasted flocculation

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Abstract

Ballasted flocculation is applied successfully in the water treatment industry, but the concept has not yet been subject to extended experimental studies. The use of a microsand and a polymer together to increase the weight of the flocs and the rate at which they settle is radically changing the coagulation–flocculation-settling methodology. The objective of this research is to study ballasted flocculation in the laboratory by means of a modified jar-test procedure. The first tests, conducted using a statistical approach, enabled us to identify those parameters that have a significant influence on the quality of settled water. The principal treatment parameters considered in this study were the chemical dosage, the contact times in the different basins, the pH of coagulation and the dosage of microsand. The parameters used to evaluate the quality of the settled water, and hence treatment performances, were turbidity, UV absorbance, TOC and membrane filterability. The results showed that the coagulant dosage and the coagulation pH have a preponderant effect on the variability of the quality of the settled water. By contrast, filterability as measured by the laboratory filter tests, was found to be more sensitive to coagulant and microsand dosages. It was dependent on the ratio of microsand to polymer dosage, and improved when this ratio increased. © 2002 Elsevier Science Ltd. All rights reserved.

Keywords: Ballasted flocculation; ACTIFLO®; Cold water; Microsand; Filterability; Statistical experimental design

1. Introduction

Most drinking water plants, which treat surface waters, use coagulation–flocculation-settling and filtration, with the objective of removing a large proportion of the colloids and organic matter contained in raw waters. Over the past 30 years, a number of technological innovations have led to substantial space reduction [1]. A more recent innovation involves ballasted flocculation [2]. This process, trade-named ACTIFLO®, was introduced in the 1990s. The weight of the flocs is increased by causing the attachment of grains of high-density microsand (about 2700 kg/m^3) [2]. The quality of water produced by this process is equal to or better than that of the current conventional treatment [1] and requires less space. This new treatment concept was developed by OTV, France, and is shown in Fig. 1. The process takes place in four tanks, one for each part of the process: coagulation, injection of microsand and polymer, maturation of flocs and lamella settling.

At common design conditions, the rapid mixing tank (coagulation) allows for two minutes contact time. The coagulated water then enters the injection basin where polymer and microsand are introduced simultaneously. A 2-min contact time is allowed to initiate flocs formation. Both the coagulation and injection tanks are equipped with mixers which provide high mixing intensity. The flocs grow up in the "maturation tank" which allows for 6 min contact time at a lower mixing intensity. The average design criteria of the ACTIFLO® unit is based on a 40 m^3/h/m^2 of projected surface in the

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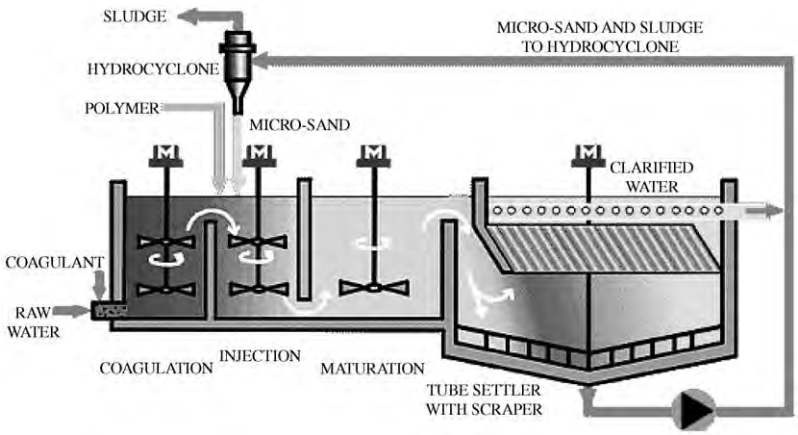

Fig. 1. Schematic description of the ACTIFLO® process.

settling tank. This corresponds to a 2–2–6–3 design, which means 2 min detention time in the coagulation tank, 2 min in the flocculation tank, 6 min of maturation and finally 3 min in the settling tank. The settled mixture of sludge and microsand is recirculated, and the microsand is separated from the sludge by the intense vortex created in a hydrocyclone and then redirected into the injection tank in order to maintain a typical microsand concentration of between 2 and 4 g/L. The microsand-free sludge is diverted into the sewer.

Since its introduction in the 1990s, the use of the ACTIFLO® process in the drinking water industry is constantly on the increase. Table 1 summarises the geographical location of full-scale plants using ACTIFLO® by the year 2000.

The aim of this study is to validate a lab-scale method that allows prediction of the performances of the ACTIFLO® process for different raw water characteristics and treatment parameters. Such a method should help reduce the number of pilot-scale or full-scale tests resulting in substantial savings during plant design and optimisation. In the present case, the laboratory method used is a jar test that is modified to take into account the sequence of addition of coagulant, microsand and polymer.

The results of these tests are used to explain the effects of a number of control parameters or treatment variables (coagulant and polymer dosages, coagulation pH, microsand dosage, contact times and temperature) on process performances. The study is divided into three stages: (1) verify whether or not the performance of the full-scale ACTIFLO® process may be accurately described by a modified jar test; (2) identify the parameters that have the most influence on ballasted flocculation and (3) study the effects of polymer and microsand dosages on process performances.

Table 1
Geographical allocation of the plants using the full-scale ACTIFLO® process in the drinking water industry at the end of 2000

Country	No. of installations	Capacity range (m^3/d)
Canada	25	720–240,000
France	19	1440–800,000
United States	25	1300–151,000
Great Britain	6	7000–270,000
Malaysia	1	1000,000
Denmark	1	2880
Turkey	2	230,000–318,000

2. Current state of knowledge

2.1. Effects of pH and temperature on coagulation–flocculation-settling

The objective of coagulation is to destabilise particles and natural organic matter in order to favour aggregation and physical removal by settling and filtration. The two most widely used types of coagulants are aluminium salts and iron salts, such as aluminium sulphate and ferric chloride. pH and temperature have a significant impact on the efficiency of the coagulation process. The rates of chemical reactions decrease as the temperature drops. In order to ensure complete reaction of the coagulants without an increase in retention time (hence tank size), pre-hydrolysed and pre-polymerised coagulants are often used at low temperature. The most common of these are polyaluminosulphate (PAS), polyaluminosulphate silicate (PASS), polyaluminochloride (PACl) and SPIC, which is a mixture of pre-hydrolysed aluminium sulphate and ferric chloride [3].

A number of researchers [4–8] have shown that each coagulant requires an optimal pH range. This zone corresponds to a minimal solubility of the coagulant, and thus to a minimal concentration of dissolved metals in the water. Some [7] have compared the performances of alum and PACl at 25°C and at 4°C, and shown that the optimal coagulation pH varies as a function of temperature for alum: pH 6 at 25°C and pH 6.8 at 4°C. According to Camp et al. [9], weak coagulation performance in cold water is also due to the poor dispersion of coagulant associated with increased water viscosity, which results in a reduction in the settling velocity of particles. These authors propose two solutions: (1) increase the mixing intensity to improve dispersion and agglomeration and (2) increase pH to minimise solubility of the coagulant.

2.2. Ballasted flocculation

The ACTIFLO® process has previously been described by Plum et al. [10]. The method has been applied to the treatment of surface water to produce drinking water around the world, the capacity of the units being as high as 800,000 m^3/d [11,1]. The process has proved to be efficient and stable enough to meet treatment standards, even under great load variations [11]. Besides coagulant, ballasted flocculation requires the addition of microsand and a polymer. The polymer helps the microsand become attached to the flocs. Dianous and Dernaucourt [12] compared the kinetics of floc formation in the conventional processes to those in the ballasted flocculation process. They showed that during ballasted flocculation the speed gradient G could be as high as 700/s without floc breakage, while in conventional flocculation it is lower by a factor of ten. Although the mixing intensity could be increased up to 700/s during floc maturation, in the full-scale systems the G values are more typically of the order of 160–200/s. This low mixing intensity proved to be adequate, besides being cost-effective. The impellers provide good mixing, which keeps all the ballasted flocs in suspension. The ballasted flocs are heavier than they are in the conventional system, which increases the settling velocity in the lamella separator. The settled ballasted sludge is pumped to a hydrocyclone, where the microsand is recovered for in-line reuse in the injection tank. The recycled flow typically makes up 6% of the total water flow treated [10]. The microsand-free sludge is sent to the sewer or to the sludge treatment units. The flocs produced in conventional treatment seem to be more fragile than ballasted flocs. Dianous and Dernaucourt [12] also showed that the time required for an 80% removal of turbidity drops from 10 to 3 min when conventional flocculation is replaced with ballasted flocculation. For optimal efficiency, they propose that the effective size of microsand be less than 160 μm, in accordance with what had previously been suggested by Guibelin [2]: 100 μm. Typical microsand dosages in the injection tank range from 2 to 4 kg/m^3.

3. Equipment and methods

3.1. Description of the modified jar-test procedure

The tests were conducted using a modified jar-test method: transparent 1-L beakers were placed on a programmable standard jar test apparatus (Phipps and Bird, Richmond, Virginia) designed to reach a rotation speed of 300 rpm and equipped with a single, flat impeller. In each beaker, the impeller was lowered in order to reach a distance less than 3 mm from the bottom of the beaker, to ensure that the ballasted flocs were maintained in suspension. The various products (coagulants, coagulation aids, microsand and polymer) were added in the same order as in the full-scale plant. The elapsed times between additions of the various chemicals were calculated to match the treatment conditions at the plants simulated. The duration of coagulation, injection and maturation for the full-scale installation was simply duplicated in the laboratory. Since lamellar settling cannot be reproduced in jar tests, preliminary tests were performed on the settling time necessary to achieve good settled water quality. The results showed that 15 s were sufficient but a 3-min settling time was kept for more practical reasons. In the laboratory procedure, stirring of the raw water in the beakers was initiated and coagulant injected at time zero. The pre-weighted amount of microsand was introduced 2 min later, along with 30–70% of the required polymer dosage (% depends on the plant simulated). After 2 min of mixing, the residual polymer (70–30%) was added and allowed a 6-min maturation. A constant mixing was maintained at 150 rpm (G in the range of 95/s) from coagulation to maturation. The mixing was then stopped and the flocs allowed to settle. Finally, the required volume of settled water was siphoned from 6 cm below the surface for analysis. Turbidity, TOC and UV were then measured directly on the collected settled water whereas a 200-mL volume of the settled water was filtered through a 0.45 μm membrane to assess membrane filterability.

3.2. Chemicals

The following coagulants and polymers were used during the tests:

- liquid alum, $Al_2(SO_4)_3 \cdot 14H_2O$ (density = 1.32–1.33; 8.3% Al_2O_3; <0.07% of insoluble substances; provided by Alcan Corp., Québec, Canada).

- Polyaluminium silicate sulphate, PASS-100®, polymerised inorganic coagulant, cationic and high molecular weight (density = 1.32–1.34; 10.0% Al_2O_3; <0.07% of insoluble substances; provided by Eaglebrook, Montreal, Canada).
- Aquafloc™ 464 (cationic, high molecular weight organic polymer provided by BetzDearborne Inc., Québec, Canada).
- Percol™ LT-27 (medium anionic organic polymer provided by Ciba Chemical Products, Québec, Canada).

Where pH adjustment was required, preliminary tests were performed in order to predetermine the amounts of acid or alkali required prior to coagulation. Two types of microsand were used, with effective diameters of 85 and 110 μm (John Meunier Inc., Quebec, Canada).

For tests on cold water, the beakers were placed in containers filled with water and ice in order to reach the desired temperature. When very low temperatures were required, the beakers were stored in a freezer at −22°C for 20 min. Under these conditions, the raw water rapidly reaches a temperature between 0°C and 1°C. The ice bath maintained the temperature of the water between 1°C and 2°C during the test.

3.3. Analytical methods

Water quality parameters were measured using standard methods [13]:

- Turbidity: method 2130 B, (Turbidimeter HACH 0-200, John Meunier Inc, Quebec, Canada).
- TOC: method 5310c, (UV-persulphate oxidation—Dorhman-180).
- UV absorbance: measured at 254 nm using a Milton Roy SPECTRONIC 1001 Plus spectrophotometer with a quartz cell having a 10-mm optical length.

Specific ultra violet absorbance (SUVA) is an index corresponding to the ratio of UV absorbance (as 1/m) to TOC (as mg C/L).

- Settled water filterability was determined using an ad hoc method. It was defined as the time required (min) for a given volume (200 mL) of settled water to pass through a 0.45 μm AcetatePlus™ filter (Fischer, Quebec, Canada) under a constant vacuum of 640 mm of mercury.

3.4. Experimental approaches

To meet the three objectives of this research, three experimental approaches were employed.

3.4.1. First approach: laboratory method to predict full-scale ballasted flocculation performance

The modified jar-test procedure (lab-scale) was used to predict ballasted flocculation (full-scale) performances. The actual dosages of chemicals and the contact times at the full-scale systems are duplicated during the laboratory tests.

3.4.2. Second approach: statistical design

The second study aimed at identifying the critical parameters in ballasted flocculation. The statistical experimental approach provides useful and critical information on ballasted flocculation and reveals the relative importance of each of the control parameters considered. Another major advantage is a significant reduction in the number of tests to be conducted, which is achieved by using a fractional factorial design. These designs are much more useful than the one-factor-at-a-time designs that are unable to detect interaction effects. However, caution must be exercised with respect to the choice of the ranges of variation of the control parameters: too wide or too narrow a range can significantly affect the impact of a control parameter on the response parameters.

The seven control parameters listed in Table 2 have been identified as possible key parameters affecting the response parameters. The main response parameters are turbidity, total organic carbon (TOC), UV absorbance and membrane filterability. The complete 2-level factorial design for seven parameters would have required $2^7 = 128$ runs. The statistical design given in Table 2 is a fractional design with coded coefficients, which are unit free $(-1, 0, 1)$ for each of the control parameters. The coefficients −1 and 1 indicate that the value tested is less than or greater than the reference coefficient coded 0. The reference values may vary for each plant; hence, the reference pH values are 6.6, 7.4 and 7.0 for plants #1, 2 and 3. For plant #1, the range of variation of pH is 6.6 ± 0.3 which means that the tests were performed at pH 6.3 (coded −1), pH 6.6 (coded 0) and pH 6.9 (coded 1). The same reasoning is applied to Runs #1 through 17 in Table 2. The 16 runs of the 2-level statistical design (−1 and 1) were replicated once (total 32 runs). Five (5) identical runs (#17) using mid-values (0) for each control parameters are added to the 32 runs, for a total 37 runs.

For each of the output response parameters Y (turbidity, TOC, UV absorbance and filterability), the data may be analysed with a second-order polynomial model:

$$Y = \beta_0 + \sum_{j=1}^{7} \beta_j x_j + \sum_{j \neq j'} \sum \beta_{jj'} x_j x_{j'}, \quad (1)$$

where x_j are the input parameters in coded form. There are several ways to present the results. A Pareto chart of the effects (main effects and interactions) gives a visual

Table 2
Statistical experimental design with coded value matrix (unit-free) and range of variation of the control parameters

Run#	Replicates	Coagulant dosage	Polymer dosage	pH	Coagulation time	Flocculation time	Settling time	MS[a] dosage
1	2	−1	−1	−1	−1	−1	−1	−1
2	2	1	−1	−1	−1	−1	1	1
3	2	−1	1	−1	−1	1	−1	1
4	2	1	1	−1	−1	1	1	−1
5	2	−1	−1	1	−1	1	1	1
6	2	1	−1	1	−1	1	−1	−1
7	2	−1	1	1	−1	−1	1	−1
8	2	1	1	1	−1	−1	−1	1
9	2	−1	−1	−1	1	1	1	−1
10	2	1	−1	−1	1	1	−1	1
11	2	−1	1	−1	1	−1	1	1
12	2	1	1	−1	1	−1	−1	−1
13	2	−1	−1	1	1	−1	−1	1
14	2	1	−1	1	1	−1	1	−1
15	2	−1	1	1	1	1	−1	−1
16	2	1	1	1	1	1	1	1
17	5	0	0	0	0	0	0	0
Range of variation[b]								
TP1		9.3±2.5	0.4±0.15	6.6±0.3	4±1	4±1	6±1.5	3±2
TP2		2.2±1.2	0.1±0.05	7.4±0.4	3±0.75	3±0.75	4±1	3±2
TP3		6.1±2.2	0.4±0.2	7.0±0.4	3±1.2	3±1.2	4±1.6	3±2
Units		mg/l as Al_2O_3	mg/l		min	min	min	mg/l

[a] MS = Microsand.
[b] These ranges represent the conditions applied on full-scale and the range of variation. Example: for TP1 the pH values in the laboratory tests were 6.6 (coded 0), 6.3 (coded –1) and 6.9 (coded 1).

representation of the analysis of variance decomposition. An example of such a Pareto chart is given in Fig. 4. This type of representation allows determination of the extent to which any input parameter or group of parameters contributes to the variability of the results.

3.4.3. Third approach: a case study of a complete 4-level factorial design

From the second experimental approach, microsand and polymer were shown to be the most important parameters in their effect on the filterability of settled water as measured by laboratory membrane filter tests. In the third approach, a complete factorial design is applied to these parameters (four values each), for a total of sixteen tests.

4. Results and discussion

4.1. Impact of laboratory settling time on water quality

The modified jar-test procedure was set up to preserve the retention times in each basin. However, full-scale hydraulics and dynamics cannot be reproduced in a jar.

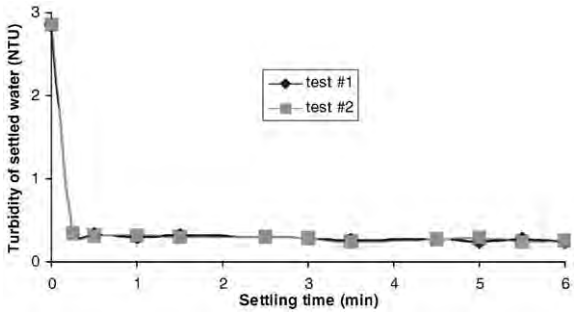

Fig. 2. Evolution of the turbidity of settled water versus the settling time during two duplicate tests.

Hence, preliminary tests were performed to determine the impact of the settling time on turbidity removal efficiency. To do this, turbidity was measured for various settling times and plotted in Fig. 2. Due to the practical delay in sampling, the first sample was collected after 15 s of settling; however, visual observations showed that settling of microsand weighted flocs occurred within 3–5 s following the end of mixing. Fig. 2 shows that settled water final turbidity is reached in a very short period of time; this will be confirmed in

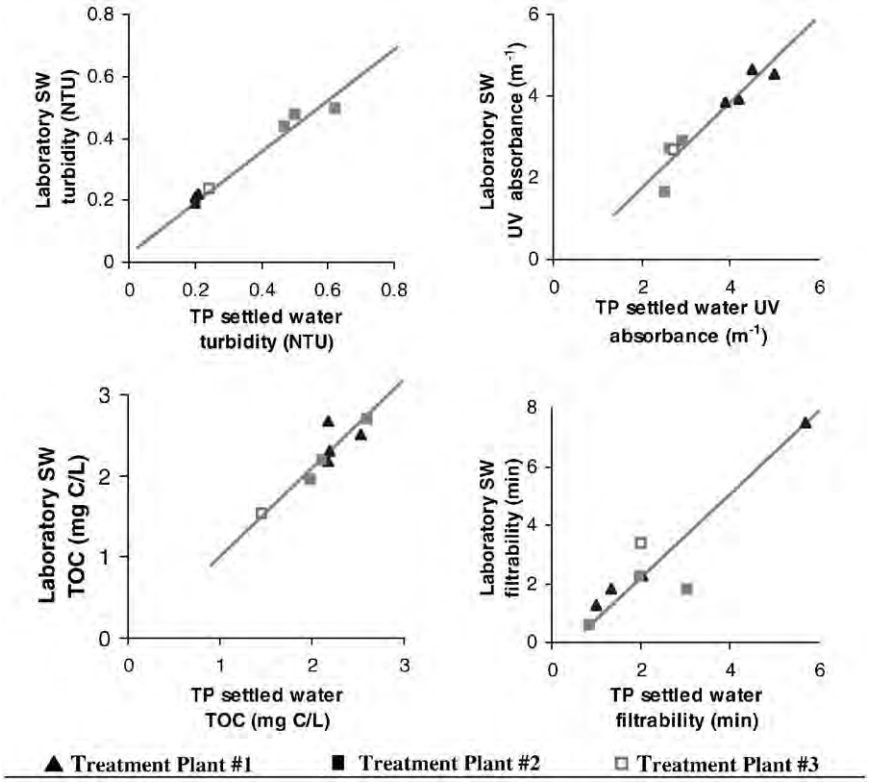

Fig. 3. Simulations of various treatment plants using ballasted flocculation (TP = treatment plant; SW = settled water).

Table 4 where settling time never appeared as a key parameter.

4.2. Laboratory evaluation of full-scale ballasted flocculation

To evaluate the capacity of the jar-test method to predict ballasted flocculation results, the modified jar-test procedure was applied to three types of raw water from the three selected plants where ballasted flocculation technology was applied. The characteristics of these waters are described in Table 3. The same dosages and contact times applied at the plants were accurately replicated in the laboratory. The characteristics of the settled water from full-scale and the lab method are compared in Fig. 3. This comparison reveals that there is a good fit between lab results and full-scale results in terms of turbidity, UV absorbance and TOC of settled water; the percentages of variance between the two sets of results is less than 7%. It should be noted that settled water samples from full-scale settlers and from the jar test did not undergo any other treatment before turbidity, TOC, UV absorbance and membrane filterability were measured.

The aim of the laboratory method was not to recreate the mixing regime applied at full scale; this is not feasible anyway, since many factors are different: impeller design, shape of beaker, lamella in the clarifier, upflow velocity, etc. Thus in the lab method, the mixing intensity was maintained constant from coagulation through maturation to keep the simulation method simple. The results in Fig. 3 confirm that these mixing conditions were appropriate and reproduction of the exact full-scale velocity gradient was not required.

The good fit proves the effectiveness of microsand in ballasting micro-flocs, and hence in ensuring a minimum variation in the quality of settled water between the laboratory and the full-scale plant. As observed, ballasted flocculation is much less sensitive to settling time than conventional techniques, and helps explain the good correlation between full-scale operation and bench-scale experiments. In conventional systems, the occurrence of light micro-flocs in settled water makes the quality of settled water highly dependent on settling time.

As stated earlier, filterability is measured using an ad hoc method. Contrary to the other parameters, the membrane filterability results varied from 3% to 70% when applied to settled water from laboratory jar tests

Table 3
Mean characteristics of raw waters and some operational parameters at the time of simulation

Treatment plant #	1		2		3
Location	St-Jérôme, Qc		St-Lambert, Qc		St-Anselme, Qc
Temperature of raw water (°C)	10	4	9	4	1
Turbidity (NTU)	1.9	2.2	1.4	2.8	0.6
Alkalinity (mg $CaCO_3$/L)	26	30	87	100	29
pH	7.1	7	8	7.9	7
Colour (apparent colour unit)	40	47	5	5	15
UV absorbance (1/m)	20.7	21.8	4.4	5.5	10.4
TOC (mg/L)	5.0	4.9	2.5	2.5	3.0
SUVA (L/mg/m)	4.14	4.4	1.76	2.2	3.4
Operation parameters					
Coagulant type	Alum	Alum	Alum	Alum	PASS
Coagulant dose (as mg/L Al_2O_3)	9.3	9.3	2.2	2.2	6.1
Polymer type	Aquafloc 464	Aquafloc 464	Percol LT-27	Percol LT-27	Percol LT-27
Polymer dosage (mg/L)	0.3	0.3	0.1	0.1	0.4
NaOH dosage (mg/L)	18	18	—	—	—
pH of coagulation	6.7	6.8	7.2	7.2	7
Microsand effective size (μm)	85	85	110	110	85
Microsand dosage (g/L)	3	3	3	3	3
Hydraulic loading rate ($m^3/m^2/h$)	20	20	30	30	30

versus settled water from the full-scale. However, the membrane filterability measurements, are highly repeatable when applied to the same sample. Polymer residuals or the type of turbidity found in the settled water of both scales of treatment could well explain the difference between the measurements. Particle counts and a more detailed characterisation of the settled water could help in understanding such discrepancies.

4.3. Statistical design: key input control parameters

The key input control parameters considered for each of the three treatment plants are given in Table 4.

In general, no common input parameters were found to have a decisive impact on the quality of settled water; the treatment conditions should therefore be considered site-specific. However, certain parameters appear more frequently in Table 4: alum dosage, coagulation pH, microsand dosage and coagulation time. Microsand dosage emerged to have an important impact on the settled water quality mainly on membrane filterability. In fact, the role of microsand is unquestionable since ballasted flocculation is based on the use of microsand and polymer.

4.3.1. Treatment plant #1

For plant 1, the coagulant dosage explains most of the variation in turbidity, UV absorbance and TOC. For these three response parameters, the coagulant dosage is the key parameter to control in order to improve treatment performance, independent of the raw water temperature. The seasonal variation of the impact of alum on the removal of TOC may be ascribed to temperature-variable kinetics and reaction mechanisms, and also to the different forms of organic matter according to the temperature. These results are in agreement with the usual observations made at the plant, and confirm that optimising the coagulant dosage is essential in achieving an effective clarification.

4.3.2. Treatment plant #2

The characteristics of the raw water at plant #2 are different from those at plant #1. The results obtained are also different. Here, the coagulant dosage has very little impact on the quality of the settled water.

The results on plant #2 are not very conclusive because of the characteristics of the raw water: low values of turbidity, colour and low SUVA index. The results confirm the conclusions of Van Benschoten and Edzwald [14] that a SUVA index in the order of 2 or less indicates a low effectiveness for removal of organics. In such a case, the impacts of the parameters on treatment performances are somewhat unpredictable.

4.3.3. Treatment plant #3

At plant #3, the tests were carried out during winter. The characteristics of the raw water were quite similar to those at plant #1. The SUVA index, 3 L/mg/m, is considered to be moderately high according to Van Benschoten and Edzwald [14], while turbidity and

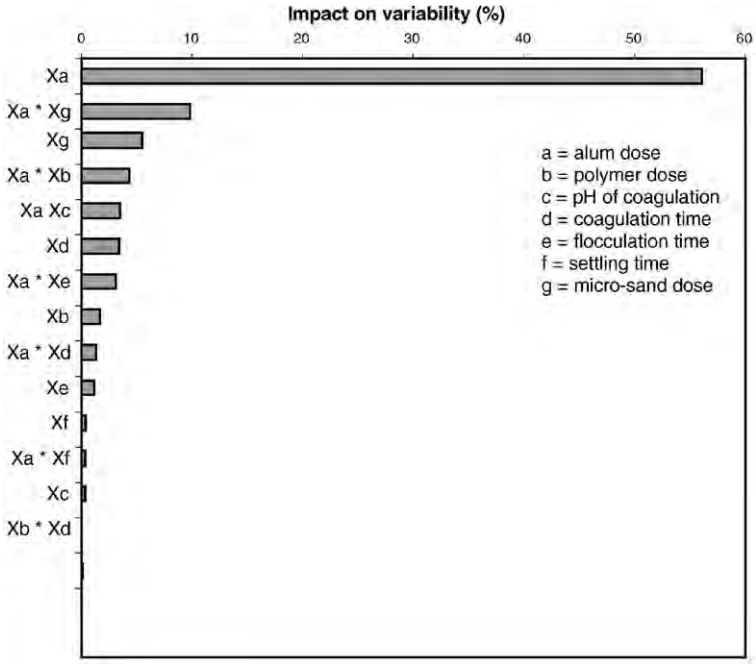

Fig. 4. Pareto chart to explain the % of variability of turbidity removal due to each control parameter and interactions (TP #1, St Jérôme).

Table 4
Key input parameters having an impact on water quality[a]

Treatment plant #	1		2		3
Location	St-Jérôme, Qc		St-Lambert, Qc		St-Anselme, Qc
Settled water parameters (output variables)	Most important operational parameters (input variables)				
	Warm water	*Cold water*	*Warm water*	*Cold water*	*Cold water*
Turbidity	Alum dosage (56%) MS[b] Alum (10%)	Alum dosage (58%) pH of coagulation (9%)	MS (72%)	No significant parameter	Coagulation time (49%) Flocculation time (19%)
TOC	Alum dosage (73%)	Alum dosage (12%)	pH of coagulation (35%)	No significant parameter	Flocculation time (19%)
UV	Alum dosage (31%)	Alum dosage (32%)	MS (51%) pH of coagulation (30%)	No significant parameter	Coagulation time (48%) Flocculation time (20%)
Filterability	MS (38%) Alum dosage (36%)	MS (38%)	pH of coagulation (17%)	pH of coagulation (30%)	MS (65%) Coagulation time (15%)

[a] The data in parentheses are the contribution (in %) of a given input variable (operational parameter) to the variation of a given output parameter (settled water quality).
[b] MS = microsand dosage.

alkalinity remain low. A particular feature of this plant is the use of a pre-hydrolysed coagulant, PASS-100. Statistically, almost 50% of turbidity and UV removal are explained by the coagulation time. This result at first appears surprising, since pre-hydrolysed coagulants were developed mainly for use in cold water conditions. However, the differences in the hydraulic loading rates must be considered: 30 m/h hydraulic loading rate in plant #3 versus 20 m/h for plant #1. This means that the contact times in coagulation, injection, maturation and settling tanks in plant #1 are 4, 4, 12 and 6 min versus 2.7, 2.7, 5.3 and 4 min for plant #3.

Based on Table 4, coagulation time and flocculation time are the most significant parameters at 4°C: as reaction kinetics decrease when temperature drops, a longer contact time will favour floc growth in cold water.

5. Case study of a complete 4-level factorial design: influence of microsand and polymer dosages

The principle of ballasted flocculation is rigorously associated with the use of microsand and polymer. Their impact on the quality of settled water is studied in the laboratory on the raw water from plant #1.

Four dosages of microsand were applied (1, 3, 5 and 7 mg/L). The results (Fig. 5) show that the best performances are achieved with a dosage of microsand of around 5 g/L, which confirms the conclusions derived from the statistical analysis. This dosage is higher than those commonly applied at full-scale (3 mg/L on average). According to Fig. 5, the overall benefit of increasing microsand to 5 mg/L is marginal and does not justify such additional expenses. Moreover, an excess of microsand (7 mg/L) would cause erosion of the flocs, while low dosages (1 mg/L) would result in a poor ballasting effect.

No correlation seems to exist between turbidity and membrane filterability (Figs. 5a and d). The degradation in filterability observed in the laboratory for high dosages of polymer may be caused by post-flocculation on the membranes used in the ad hoc method to assess filterability. One can hypothesise that the excess polymer would trap the coagulated particles present in the settled water by bridging them on the membrane and clog it. Under these conditions, an increase in the dosage of microsand would cause the residual polymer to be consumed and eliminated during settling and hence result in better filterability. This is the reason why for low dosages of polymer, the effect of the dosage of microsand is negligible. It should be noted that the presence of an excess of microsand does not directly degrade membrane filterability, since it is eliminated during settling. For each polymer dosage, Fig. 5d shows that membrane filterability improves with increasing

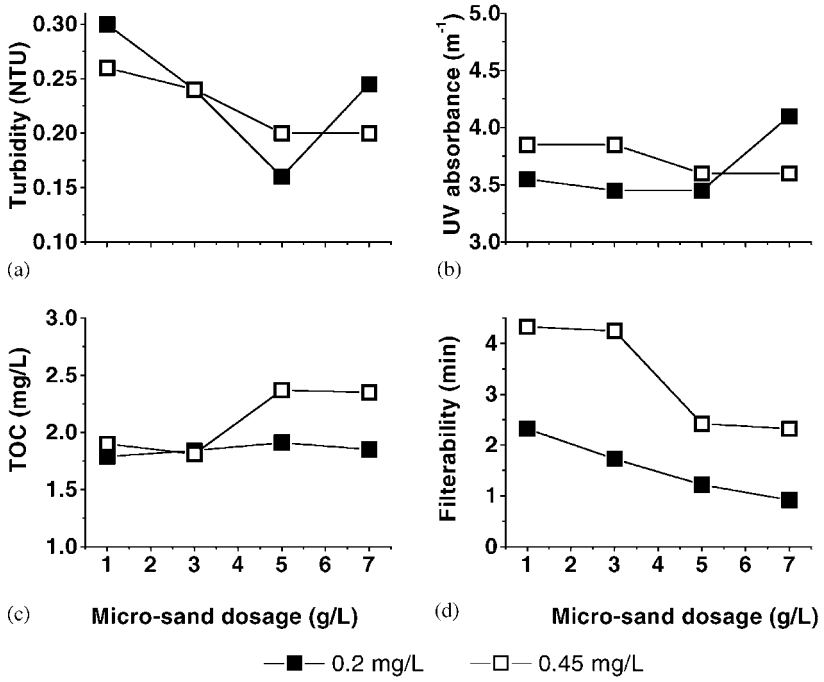

Fig. 5. Settled water quality parameters versus microsand dosage for two different polymer dosages. (a) Turbidity; (b) UV absorbance; (c) TOC; (d) Filterability.

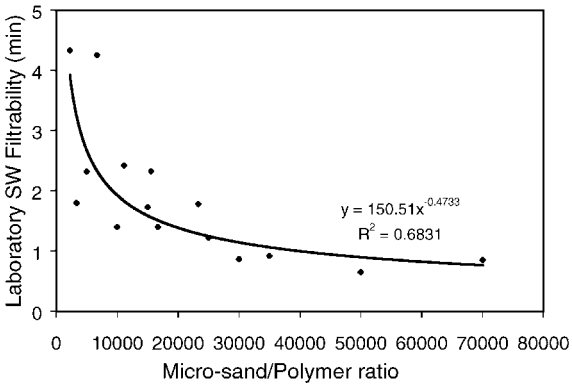

Fig. 6. Settled water membrane filterability versus microsand/polymer ratio.

dosages of microsand. This trend is showed in Fig. 6, where filterability is plotted as a function of the microsand to polymer dosage ratio. For low ratios (below 15,000), filterability is poor, which means that a low dosage is ineffective if a high dosage of polymer is applied. However, high ratios (above 30,000) improve membrane filterability of the settled water.

6. Conclusions

This study has permitted the development of a laboratory methodology that predicts the performance of ballasted flocculation. The ballasted flocculation technology is based on the addition of microsand and polymer during coagulation–flocculation. Three drinking water production plants using the ballasted flocculation process were studied. The modified jar-test procedure was able to predict the performance of the full-scale process with good accuracy.

The use of an optimised statistical approach enables identification of the principal parameters controlling ballasted flocculation through a reduced number of experiments. Besides the microsand and polymer, the major parameters were the coagulant dosage and the pH of coagulation, as in conventional coagulation–flocculation-settling. In both conventional systems and in the ACTIFLO® process, coagulation is not very efficient for raw waters with a low SUVA (UV absorbance to TOC ratio).

No evident correlation was found between the turbidity and membrane filterability of settled water as measured by laboratory membrane filter tests. Membrane filterability is mainly affected by the microsand to polymer ratio; it improves for high ratios. Ballasted flocculation is a dynamic physical process which ensures high stability of the quality of settled water undergoing reasonable changes in operational parameters. This is likely due to the use of microsand which satisfactorily eliminates the micro-flocs that are most often responsible for degradation in the quality of settled water in conventional clarifiers.

Acknowledgements

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APPENDIX H. COMPLETE JAR TESTS RESULTS

-JAR TESTS FOR ORIGINAL SYNTHETIC WATER

-ADDITIONAL JAR TESTS FOR AS REMOVAL VALIDATION ON MODIFIED SYNTHETIC WATER

Project: BruceJack WTP Bench Test- Operations

Project number: 5000196003

Technician:_____ MDLN & NB

Jar Test Results

Date	Sample	Sequence	Rise rate	T	Coagulant		Na2S		Polymer		Sand	pH adjustment					Clarified water			Comments
					Type	Dose	Dose		Type	Dose	Dose	Target	Ca(OH)2		H2SO4		Turbidity	pH	Cu	
			m/h	C		mg Fe /L	mL	mg S /L		mg/L	g/L		mL	mg/L	mL	mg/L	NTU		ug/L	
Raw water (Synthetic water #2)																				
Coagulant optimization			**60**	**20**	**3253**		**3,0**	**42**	**6183**	**1,5**	**10**	**10**								
2015-06-25	o-1	S/C	60	20	3253	18,3	3,0	42,0	6183	1,50	10	10	23	345			6,76	10,27	1,00	Colored water (greenish supernatant)
2015-06-25	o-2	S/C	60	20	3253	22,9	3,0	42,0	6183	1,50	10	10	22,5	337,5			5,23	10,24	<1	
2015-06-25	o-3	S/C	60	20	3253	27,5	3,0	42,0	6183	1,50	10	10	20,5	307,5			2,38	9,92	<1	
2015-06-25	o-4	S/C	60	20	3253	32,0	3,0	42,0	6183	1,50	10	10	23	345			2,37	10,00	0,00	
Sulfur optimization			**60**	**20**	**3253**	**27,5**	**tbd**		**6183**	**2**	**10**	**10**								
2015-06-25	o-5	S/C	60	20	3253	27,5	2,0	28,0	6183	2,00	10	10	23	345			1,16	9,84	2,00	
2015-06-25	o-6	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	24	360			1,72	9,99	0,00	Sent to ALS; chosen dosage for sulfur and coagulant in primary metal removal step: Oper_o-6
2015-06-25	o-7	S/C	60	20	3253	27,5	3,0	42,0	6183	2,00	10	10	19,5	292,5			2,67	9,81	0,00	
2015-06-25	o-8	S/C	60	20	3253	27,5	4,0	56,0	6183	2,00	10	10	19	285			4,86	9,98	0,0	
Water production primary step			**60**	**20**	**3253**	**27,5**	**2,5**	**35**	**6183**	**2**	**10**	**10**								
2015-06-25	o-Blank1er	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	1	15						Water black, which create large and fluffy flocs over time. Blank test was no concluant with sulfur dosage
2015-06-25	o-Blank1er	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	1	15						Water black, which create large and fluffy flocs over time. Blank test was no concluant with sulfur dosage
2015-06-25	o-6A	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	22,5	337,5				9,79		Sent to ALS: Oper_o-6
2015-06-25	o-6A	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	21,5	322,5						Sent to ALS: Oper_o-6
														0						
2015-06-25	o-6P1	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	22	330						Water production for polishing step influent and sampling of primary metal removal step (in 20L jar-test); sent to ALS: Oper_o-6P
2015-06-25	o-6P2	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	23,9	358,5						Water production for polishing step influent and sampling of primary metal removal step (in 20L jar-test); sent to ALS: Oper_o-6P
Polishing step- Coagulant optimization			**60**	**20**	**3253**				**6183**	**1,00**	**10**	**7,25**								
2015-06-25	o-11	C	60	20	3253	18,3			6183	1,00	10	7,25	1,9	28,5	2	1,96	0,17	6,59	11	Influent from o-6P
2015-06-25	o-12	C	60	20	3253	22,0			6183	1,00	10	7,25	2,2	33			0,168	6,7	7	Influent from o-6P; sent to ALS: Oper_o_12A
2015-06-25	o-13	C	60	20	3253	25,6			6183	1,00	10	7,25	2,6	39			0,168	6,92	8	Influent from o-6P
2015-06-25	o-14	C	60	20	3253	29,3			6183	1,00	10	7,25	3,4	51			0,188	6,98	10	Influent from o-6P; sent to ALS: Oper_o_14A
Water production Polishing step			**60**	**20**	**3253**	**22,0**			**6183**	**1,50**	**10**	**7,25**								
2015-06-25	o-12 A	C	60	20	3253	22,0			6183	1,50	10	7,25	2,7	40,5	3	2,94				Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-12A
2015-06-25	o-12 A	C	60	20	3253	22,0			6183	1,50	10	7,25	3,6	54	2	1,96				Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-12A
2015-06-25	o-12 B	C	60	20	3253	22,0			6183	1,50	10	7,25	2,6	39	0,25	0,245				Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-12B
2015-06-25	o-12 B	C	60	20	3253	22,0			6183	1,50	10	7,25	2,4	36						Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-12B
Water production Polishing step			**60**	**20**	**3253**	**29,3**			**6183**	**1,50**	**10**	**7,25**								
2015-06-25	o-14 A	C	60	20	3253	29,3			6183	1,50	10	7,25	4	60						Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-14A
2015-06-25	o-14 A	C	60	20	3253	29,3			6183	1,50	10	7,25	3,3	49,5	10,5	10,29				Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-14A
2015-06-25	o-14 B	C	60	20	3253	29,3			6183	1,50	10	7,25	3,6	54						Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-14B
2015-06-25	o-14 B	C	60	20	3253	29,3			6183	1,50	10	7,25	3,8	57						Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-14B
Water production Polishing step			**60**	**20**	**3253**				**6183**	**1,50**	**10**	**7,25**								
2015-06-25	o-12 B	C	60	20	3253	22,0			6183	1,50	10	7,25	5,6	84	11	10,78				Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-12B
2015-06-25	o-14 B	C	60	20	3253	29,3			6183	1,50	10	7,25	7,3	109,5	9,5	9,31				Influent from o-6P; water production for final effluent quality; sent to ALS: Oper_o-14B
2015-06-25	o-Blank2e	C	60	20	3253	29,3			6183	1,50	10	7,25	3,9	58,5	11	10,78				Influent from o-6P; chemical dosage in distilled water for contamination study on polished water; sent to ALS: Oper_Blank2e
2015-06-25	o-Blank2e	C	60	20	3253	29,3			6183	1,50	10	7,25	3,8	57	4,5	4,41				Influent from o-6P; chemical dosage in distilled water for contamination study on polished water; sent to ALS: Oper_Blank2e

Sulfur concentration: 14 g S/L

Ca(OH)2 concentration: 15 g/L

H2SO4 concentration: 0,98 g/L

/: Right after

Project: BruceJack WTP Bench Test- Operations (adjusted raw water)

Project number: 5000196003

Technician:_____ MDLN & CD

Jar Test Results

Date	Sample	Sequence	Rise rate	T	Coagulant		Na2S		Polymer		Sand	pH adjustment					Clarified water		Comments
					Type	Dose	Dose		Type	Dose	Dose	Target	Ca(OH)2		H2SO4		Turbidity	pH	
			m/h	C		mg Fe /L	mL	mg S /L		mg/L	g/L		mL	mg/L	mL	mg/L	NTU		
Raw water (Synthetic water)																		**2,90**	
Water production primary step			**60**	**20**	**3253**	**27,5**	**2,5**	**35**	**6183**	**2**	**10**	**10**							
2015-06-29	primary	S/C	60	20	3253	27,5	2,5	35,0	6183	2,00	10	10	27,4	411			1,77	9,92	Sent to ALS in duplicate: Oper_primary 1 and Oper_primary 2
Water production Polishing step			**60**	**20**	**3253**	**22,0**			**6183**	**1,00**	**10**	**7,25**							
2015-06-29	polishing 1	C	60	20	3253	29,3			6183	1,00	10	7,25	4,8	72		0	0,265	6,52	Sent to ALS: Oper_polishing 1
2015-06-29	polishing 1	C	60	20	3253	29,3			6183	1,00	10	7,25	5	75		0			
2015-06-29	polishing 2	C	60	20	3253	29,3			6183	1,00	10	7,25	4	60		0	0,152	6,35	Sent to ALS: Oper_polishing 2
2015-06-29	polishing 2	C	60	20	3253	29,3			6183	1,00	10	7,25	4,8	72		0			

Sulfur concentration:	14	g S/L		
Ca(OH)2 concentration:	15	g/L	/:	Right after
H2SO4 concentration:	0,98	g/L		

Appendix 2: Derivation of Modelled Nitrogen Loading Rates and Speciation

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Appendix 2: Derivation of Modelled Nitrogen Loading Rates and Speciation

1. Introduction

This document describes the empirical methods used to quantify nitrogen (N) loads derived from blasting activities at the Brucejack Gold Mine. These loads have been applied to the site-specific water quality model developed in support of Pretium Resources Inc.'s (Pretivm's) application to increase their ore production rate from 2700 tpd to 3800 tpd.

Ammonium nitrate (AN) explosives widely used for mining contain approximately 20% to 34% N by weight and are typically the principal source of N in mine contact waters. The inorganic N compounds in explosive mixtures are readily water-soluble and the release of N occurs from explosives loaded in boreholes and from blasting residues (Pommen, 1983; Ferguson & Leask, 1988; Revey, 1996). The explosives and blasting residues contain water-soluble N species, ammonia (representing $NH_3 + NH_4^+$; hereafter referred to as simply NH_3), nitrite (NO_2^-) and nitrate (NO_3^-), that are exported from the blast site in contact water and on blasted rock surfaces. Naturally-occurring microbially-mediated nitrification reactions can subsequently oxidize NH_3 and NO_2^- to NO_3^- in sediments and in the water column of lakes and streams.

Blasting residues originating from the use of explosives represent the dominant source of N species in Brucejack Lake. The sources of explosive-related N loads to Brucejack Lake include:

- Mine water discharged to Brucejack Lake via the Water Treatment Plant (WTP);
- Waste rock (surface and underground) deposited in the lake;
- Mill discharges (tailings solids and supernatant);
- Discharges from the contact water pond (CWP), which receives surface runoff from the mine site and recirculated effluent from the WTP, and is discharged to Brucejack Lake via the WTP; and
- Run-off from the NPAG Quarry located at the east end of Brucejack Lake.

This document describes the loading rates and proportional distributions of N species in contact water, waste rock and ore, attributable to explosives use, that are used to calculate source terms for water quality modelling. Section 2 is an overview of blasting and explosive usage at the Brucejack Gold Mine. The data and approach for deriving N loading rates are presented in Section 3, followed by a description of the data used to estimate N speciation of mine water and Brucejack Lake discharges in Section 4.

2. Overview of Explosives Usage at the Brucejack Gold Mine

2.1 Background

Blasting associated with exploration activities occurred intermittently at Brucejack Gold Mine during advanced exploration by Newhawk in the late 1980's and again beginning in 2012 following Pretivm's acquisition of the property, but ramped up in recent years with development of the mine. Blasting associated with large-scale surface excavations began with Construction in late 2015 and continued, along with pre-production underground development, through much of 2016. Further underground mine development has occurred following the mine's transition into Operations, beginning in June 2017.

Current explosives usage is dominantly associated with development of the underground mine and ore excavation. Blasting techniques, blasting products, explosive usage and explosive management have evolved at the Brucejack Gold Mine since development began. Best management practices are implemented as outlined in the Nitrogen Management Plan (Pretivm, 2016).

2.2 Blasting Methods

The release of N compounds from blasting is directly related to the quantity of explosives used for blasting a tonne of rock (also known as a powder factor, or PF) and the blasting method used. Blasting conditions (and PF) may vary daily but are generally consistent over the long-term. Assuming generally steady-state blasting conditions, N loadings from explosives use can be predicted using blasted rock quantities. The different blasting methods used at Brucejack Gold Mine include: 1) surface blasting for site preparation and quarrying; and, 2) underground blasting for mine development and ore production. The following sections summarize these methods, and the PF corresponding to each.

2.2.1 Surface Blasting

Surface blasting is typically conducted by drilling a pattern of 50 to 100 holes (0.10 to 0.14 m diameter) to a specified depth (3 m to 18 m) with 2.5 to 5 m spacing between the holes. The holes are filled with packaged AN emulsion explosives and subsequently detonated. Waste rock from the completed Construction phase surface excavation is stored in Brucejack Lake, with all waste rock placed. Construction grade rock from the NPAG Quarry is used as fill for surface construction and underground mine tunnel floors; therefore, intermittent small-scale blasting is expected to continue at the NPAG Quarry through life of mine (LOM).

The PF for surface blasting is considerably lower than for underground blasting (discussed in Section 2.2.2); therefore, N loadings in runoff and on rock surfaces at surface are expected to be low in comparison to underground. A full data evaluation of surface blasting records was not

conducted; however, review of individual blast reports indicates a PF generally between 0.15 and 0.3 kg/t.

2.2.2 Underground Blasting

Underground access tunnels are excavated using development blasting methods. This method utilizes a pattern (round) of 60 to 80 horizontal holes (0.04 m diameter) drilled into a 6 m by 5.5 m vertical rock face to a depth of 2.8 m to 4 m. The holes are filled with AN emulsion and subsequently detonated. Tunnel dimensions for drifts used to access the ore body are smaller (5 m by 5 m or 4.5 m by 5 m). The design PF for development blasting is 1.5 kg/t, an order of magnitude higher than surface blasting; therefore, N loading rates associated with underground blasting are expected to be higher.

Underground stopes (and ore) are excavated using production (long hole) blasting methods. The stope block is accessed on uppercut or undercut levels through 4.5 m by 5 m development drifts. Large diameter holes (0.09 to 0.1 m) are drilled from 5 m to 30 m depths, upward and sidelong in a radiating fan configuration, to blast a volume of rock approximately 30 m by 15 m (height and width) with a depth that varies from 10 to 30 m. The holes are filled with AN emulsion and subsequently detonated. Production blasting is also conducted from the top of stopes, with holes drilled downward. The initial design PF for production blasting is 0.7 kg/t, which is expected to contribute lower N loads to mine water and rock surfaces in comparison to development blasting.

2.3 Underground Excavation and Explosives Use

From January 2015 through January 2018, a total of 1,727,502 tonnes of rock were excavated from the underground mine using development blasting methods and 2,661,293 kg explosives (Figure 1, Table 1). Production (ore) blasting commenced in June 2017 and a total of 492,889 tonnes of ore were excavated using 388,787 kg explosives through January 2018. Mining rates increased from approximately 20,000 t/month in 2015 to 110,000 t/month in 2016 and 2017, approaching the 150,000 t/month expected with the proposed 3800 tpd production increase.

The PF for development blasting at the Brucejack Gold Mine fluctuates on a short-term (monthly) basis ranging from 0.77 to 2.93 kg/t (Figure 2, Table 1). The short-term PF is influenced by lithology and blasting conditions (*e.g.*, rock competence and presence of water). A longer period is more representative of the average blasting conditions and incorporates all short-term fluctuations, therefore the long-term PF is compared to the design PF. The long-term development blasting PF for the January 2015 through January 2018 period is 1.54 kg/t (Figure 2, Table 1). This is close to the design PF of 1.5 kg/t, which indicates the long-term explosives consumption rate is close to expected levels. The PF for production blasting is relatively consistent, with short-term (monthly) values ranging from 0.71 to 0.87 kg/t (and a long-term PF of 0.8 kg/t over the eight-month monitoring period, compared to the design PF of 0.7 kg/t). These results demonstrate

that production blasting is significantly (approximately 50%) more efficient than development blasting with respect to explosives usage.

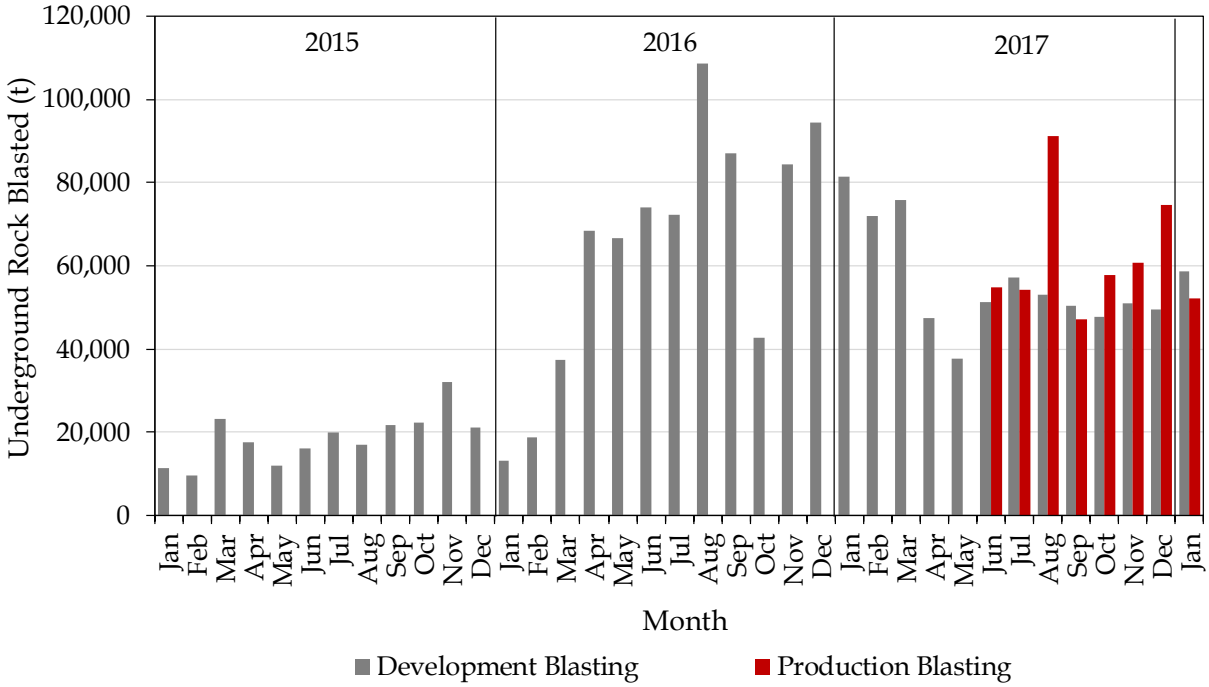

Figure 1: Underground development (waste) and production (ore) blasted tonnages from January 2015 through January 2018.

Table 1:
Underground Blasting Tonnages and Explosives Use (January 2015 through January 2018)

Month or Period	Development Blasted Rock (t)	Development Explosives Use (kg)	Development PF (kg/t)	Production Blasted Ore (t)	Production Explosives Use (kg)	Production PF (kg/t)
Jan-15	11,480	8,875	0.770	-	-	-
Feb-15	9,716	16,012	1.65	-	-	-
Mar-15	23,128	21,025	0.91	-	-	-
Apr-15	17,584	25,790	1.47	-	-	-
May-15	12,152	15,912	1.31	-	-	-
Jun-15	16,268	27,112	1.67	-	-	-
Jul-15	19,964	30,019	1.50	-	-	-
Aug-15	17,192	22,205	1.29	-	-	-
Sep-15	21,884	26,125	1.19	-	-	-
Oct-15	22,421	30,050	1.34	-	-	-
Nov-15	32,195	45,012	1.40	-	-	-
Dec-15	21,243	20,943	0.99	-	-	-
Jan-16	13,107	16,620	1.27	-	-	-
Feb-16	18,860	31,100	1.65	-	-	-
Mar-16	37,555	77,049	2.05	-	-	-
Apr-16	68,491	98,090	1.43	-	-	-
May-16	66,746	112,723	1.69	-	-	-
Jun-16	74,177	119,028	1.60	-	-	-
Jul-16	72,246	147,724	2.04	-	-	-
Aug-16	108,466	140,020	1.29	-	-	-
Sep-16	87,142	118,858	1.36	-	-	-
Oct-16	42,687	125,032	2.93	-	-	-
Nov-16	84,252	123,318	1.46	-	-	-
Dec-16	94,508	134,076	1.42	-	-	-
Jan-17	81,504	115,348	1.42	-	-	-
Feb-17	72,057	100,639	1.40	-	-	-
Mar-17	75,941	95,379	1.26	-	-	-
Apr-17	47,581	54,895	1.15	-	-	-
May-17	37,694	76,702	2.03	-	-	-
Jun-17	51,244	89,780	1.75	54,953	39,045	0.711
Jul-17	57,117	89,079	1.56	54,332	41,628	0.766
Aug-17	53,215	88,576	1.66	91,270	66,177	0.725
Sep-17	50,536	78,397	1.55	47,123	38,589	0.819
Oct-17	47,720	74,580	1.56	57,810	50,235	0.869
Nov-17	51,073	89,502	1.75	60,787	50,618	0.833
Dec-17	49,582	79,986	1.61	74,564	59,917	0.804
Jan-18	58,774	95,712	1.63	52,050	42,578	0.818
Jan-15 through Jan-18	1,727,502	2,661,293	1.54	492,889	388,787	0.789

Notes: PF = powder factor

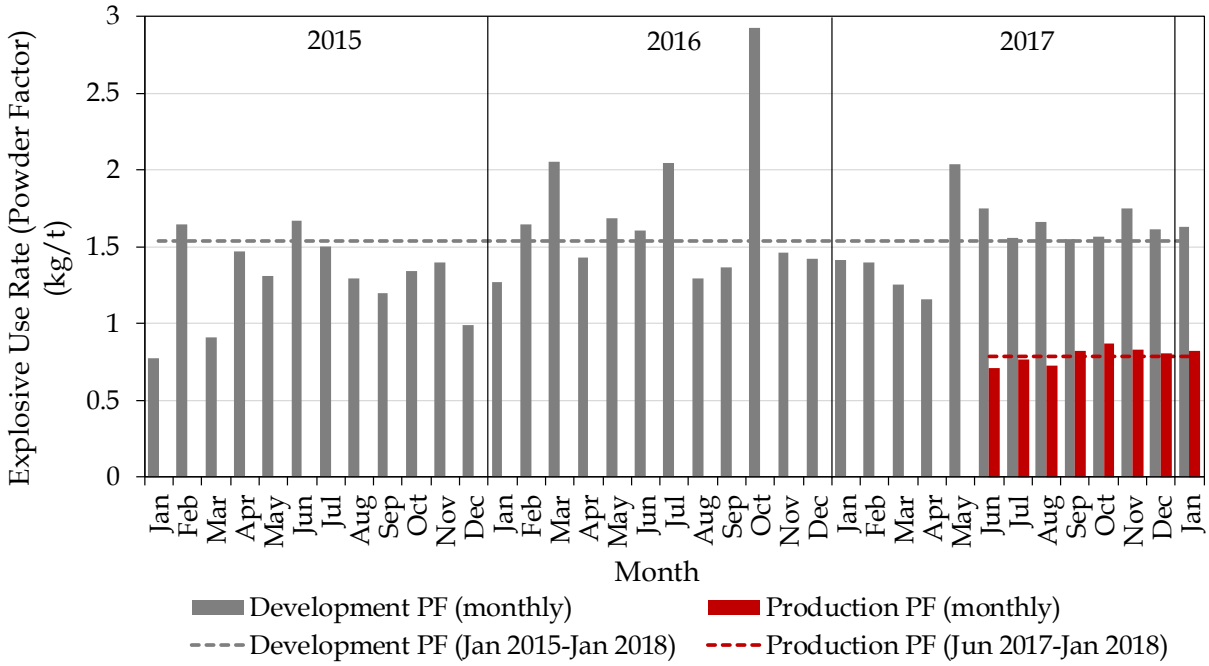

Figure 2: Explosives use rate (powder factor, PF) for underground development (waste) and production (ore) blasting from January 2015 through January 2018.

2.4 Source Control

Concentrations of N species in mine site effluents depend on the type and quantity of explosives used for blasting and the blasting efficiency (Forsyth *et al.*, 1995; Revey, 1996). Nitrogen export is influenced by explosives handling and blasting practices, as well as site-specific conditions. The export of N at Brucejack Gold Mine is managed by implementing blasting best practices, which maximize blast efficiency through selection of appropriate explosives products and appropriate blasting methods.

To prevent loss of non-detonated explosives (*i.e.*, transfer of NH_3 and NO_3^-) to contact water, and promote efficient explosives consumption, Brucejack Gold Mine uses a water-resistant AN emulsion product (Dyno Nobel TITAN 7000). The product contains approximately 25% N almost equally distributed between NH_3 and NO_3^-. A similar packaged product is used for surface blasting, and small amounts of other packaged AN emulsion products are used for specialized applications in the underground Mine.

The consistent implementation of source control measures is achieved through regular blast practices inspections and monitoring of N species in mine water and are further described in the Brucejack Gold Mine Nitrogen Management Plan (Pretivm, 2016).

3. Nitrogen Loading Rates

3.1 Overview

For water quality modelling, it is necessary to estimate the quantity of N species that will be released to the aquatic receiving environment from blasting. N loadings from explosives use are dependent upon numerous site-specific operational factors including: explosives type, explosives usage rate (PF), quantity of rock blasted, blasting methods, blasting conditions and secondary processes that alter N speciation. Ferguson and Leask (1988) describe an empirical approach for estimating N loadings to waste rock derived from observations at surface coal mines. Similarly, site-specific monitoring records for Brucejack Gold Mine are suitable for the derivation of empirical N loading rates for underground waste and ore, surface waste and fill, mine water and surface runoff.

Brucejack Gold Mine monitoring data and excavation records are used to estimate N loading rates to contact water and to rock surfaces, expressed as total N per tonne of blasted rock. Two loading rates are developed for each term to estimate uncertainty associated with the derivation methodology: 1) Base Case, which represents reasonably expected loading rates, and 2) Upper Case, which represents an upper limit. To derive source terms for water quality modelling the N loading rates are used with the mine schedule to calculate the total N loads for model terms, these are proportioned between N species (NH_3, NO_2^- and NO_3^-) for each term according site-specific distributions (Section 4).

This section describes the derivation of N loading rates for:

- Mine water;
- Underground waste;
- Surface waste and quarry rock;
- Ore; and
- Surface runoff.

3.2 Mine Water

The mine water N loading rate is empirically derived from WTP influent mine water monitoring data and underground blasting records. Observations during Construction indicate the initial N signal from a blast is detected at the WTP influent within 12 to 24 hours. Investigations at an analogue underground mine with similar dewatering rates indicate a majority of N loadings from mine water are flushed from underground workings on the order of days to weeks following blasting (Mueller *et al.*, 2015). Under steady-state conditions (*i.e.*, relatively consistent excavation rates and explosives use) it is assumed that most of the N load introduced to mine water within a

given month is exported within the same month. Therefore, N loads exported in mine water can be correlated to tonnages excavated and expressed in terms of rock tonnage blasted.

The total nitrogen (T-N) water quality parameter provides a non-specific measure of inorganic and organically bound N and is used with WTP influent (*i.e.*, mine water) flows to estimate daily N loads in mine water, per Equation 1 and Equation 2:

Equation 1: $C_N = C_{N-1} + \frac{(D-D_1)(C_{N-2} - C_{N-1})}{D_2 - D_1}$

where:

C_N = interpolated T-N concentration (mg/L)

C_{N-1} = measured T-N concentration of sample 1 (mg/L)

C_{N-2} = measured T-N concentration of sample 2 (mg/L)

D = day for interpolated value

D_1 = sampling day of sample 1

D_2 = sampling day of sample 2

Equation 2: $L_N = C_N * Q_{WTP\ Influent} * 0.001$

where:

L_N = instantaneous total N load (kg-N/day)

C_N = T-N concentration (mg/L)

$Q_{WTP\ Influent}$ = flow rate of WTP influent (m^3/day)

The daily N loads are summed to determine the cumulative N load over distinct time periods:

1. January 2015 through July 2017 for derivation of the Base Case source term;
2. September 2015 through December 2015 for derivation of the Upper Case source term (*i.e.*, when challenging blasting conditions were encountered in the underground mine); and,
3. Monthly time steps to calculate short-term variations in the mine water loading rate.

Development and production blasting records are summed to determine the total tonnage of ore and waste rock blasted for the defined time periods, as this represents the total explosives used.

The monthly, Base Case and Upper Case mine water loading rates are determined using the cumulative N load and the total tonnage of ore and waste rock blasted for each respective monitoring period, per Equation 3:

Equation 3: $LR_N = \frac{L_{N-cumulative}}{T}$

where:

LR_N = N loading rate per tonne of blasted rock (kg-N/t)

$L_{N\text{-cumulative}}$ = cumulative total N load (kg-N)

T = Quantity of blasted rock (t) corresponding to L_N

The derived N loading rates for mine water in terms of blasted tonnage are 0.022 kg-N/t and 0.033 kg-N/t for Base Case and Upper Case, respectively. Monthly loading rates presented in Figure 3 are relatively consistent over the monitoring period and illustrate typical short-term fluctuations reflecting variations in blasting conditions. Anomalous peaks in N loadings were observed in May 2015, October 2015, October 2016 and May 2017. These short duration increases in N loadings are attributable to challenging blasting conditions (*e.g.*, blasting through water-bearing faults with significant flows at the blast face), which are known to increase the N losses from explosives.

Mine excavation records are presented in Table 1 above. Monthly WTP influent flows and N loading rates and WTP influent mine water monitoring records are presented in Table 2 and Table 3, respectively.

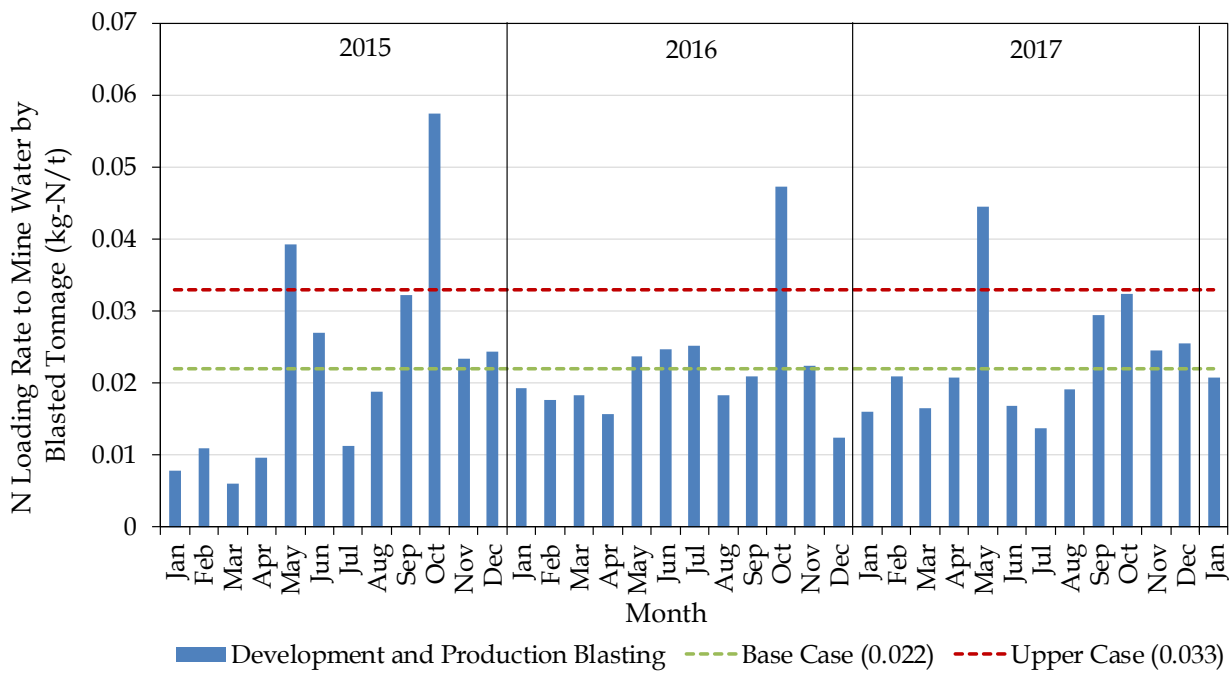

Figure 3: Observed monthly and derived Base Case and Upper Case N loading rates (kg-N/t) for mine water expressed in terms of blasted rock tonnages from January 2015 through January 2018; Base Case and Upper Case assumptions for modelling are indicated with dashed lines.

Table 2:
WTP Influent Mine Water Monthly Flows and Calculated Monthly and Period N Loading Rates (January 2015 to January 2018)

Month	Mine Water WTP Influent Total Monthly Flow (m^3)	N Load (kg-N/t)
Jan-15	26,851	0.0080
Feb-15	22,741	0.011
Mar-15	21,493	0.0060
Apr-15	17,040	0.010
May-15	34,893	0.039
Jun-15	53,970	0.027
Jul-15	52,426	0.011
Aug-15	57,352	0.019
Sep-15	55,688	0.032
Oct-15	60,859	0.057
Nov-15	42,789	0.023
Dec-15	32,450	0.024
Jan-16	26,843	0.019
Feb-16	23,973	0.018
Mar-16	22,818	0.018
Apr-16	27,217	0.016
May-16	51,703	0.024
Jun-16	64,498	0.025
Jul-16	55,446	0.025
Aug-16	48,254	0.018
Sep-16	49,015	0.021
Oct-16	47,259	0.047
Nov-16	36,068	0.022
Dec-16	25,033	0.012
Jan-17	24,925	0.016
Feb-17	24,659	0.021
Mar-17	25,139	0.017
Apr-17	23,789	0.021
May-17	38,689	0.044
Jun-17	59,416	0.017
Jul-17	55,805	0.014
Aug-17	63,363	0.019
Sep-17	67,352	0.029
Oct-17	71,498	0.032
Nov-17	64,170	0.024
Dec-17	57,070	0.025
Jan-18	48,702	0.021
Sep-15 through Dec-15	-	0.033
Jan-15 through Jul-17	-	0.022

Notes: WTP = Water Treatment Plant

Table 3:
Summary of N Species Monitoring Data for WTP Influent Mine Water
(January 1, 2015 to February 4, 2018)

Sample Date	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Ammonia (as N) (mg/L)	Total Nitrogen (mg/L)	Sum of Species (mg/L)
01-Jan-15	2.70	0.112	0.837	3.65	3.65
02-Jan-15	2.67	0.110	0.791	3.57	3.57
03-Jan-15	2.77	0.119	0.748	3.64	3.64
04-Jan-15	2.72	0.123	0.727	3.57	3.57
05-Jan-15	2.70	0.122	0.703	3.53	3.53
06-Jan-15	2.67	0.125	0.645	3.44	3.44
07-Jan-15	2.67	0.138	0.622	3.43	3.43
08-Jan-15	2.64	0.135	0.583	3.36	3.36
09-Jan-15	2.63	0.146	0.565	3.34	3.34
10-Jan-15	2.46	0.140	0.516	3.12	3.12
11-Jan-15	2.46	0.145	0.488	3.09	3.09
12-Jan-15	2.43	0.137	0.437	3.00	3.00
13-Jan-15	2.55	0.156	0.491	3.20	3.20
14-Jan-15	2.57	0.157	0.454	3.18	3.18
15-Jan-15	2.74	0.157	0.546	3.44	3.44
16-Jan-15	2.66	0.158	0.467	3.29	3.29
17-Jan-15	2.65	0.155	0.461	3.27	3.27
18-Jan-15	2.71	0.165	0.506	3.38	3.38
19-Jan-15	2.86	0.149	0.466	3.48	3.48
20-Jan-15	2.89	0.156	0.471	3.52	3.52
21-Jan-15	2.89	0.155	0.437	3.48	3.48
22-Jan-15	2.81	0.154	0.403	3.37	3.37
23-Jan-15	2.81	0.137	0.366	3.31	3.31
24-Jan-15	2.68	0.142	0.358	3.18	3.18
25-Jan-15	2.71	0.151	0.189	3.05	3.05
26-Jan-15	2.70	0.148	0.351	3.20	3.20
27-Jan-15	2.66	0.137	0.330	3.13	3.13
28-Jan-15	2.37	0.132	0.252	2.75	2.75
29-Jan-15	2.35	0.130	0.308	2.79	2.79
30-Jan-15	2.71	0.125	0.305	3.14	3.14
31-Jan-15	2.87	0.0958	0.356	3.32	3.32
01-Feb-15	2.81	0.124	0.345	3.28	3.28
02-Feb-15	2.90	0.125	0.424	3.45	3.45
03-Feb-15	3.09	0.129	0.493	3.71	3.71
04-Feb-15	3.20	0.134	0.578	3.91	3.91
05-Feb-15	3.23	0.120	0.565	3.92	3.92
06-Feb-15	3.29	0.118	0.517	3.93	3.93
07-Feb-15	3.34	0.109	0.641	4.09	4.09

Sample Date	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Ammonia (as N) (mg/L)	Total Nitrogen (mg/L)	Sum of Species (mg/L)
08-Feb-15	3.31	0.105	0.608	4.02	4.02
09-Feb-15	3.43	0.107	0.676	4.21	4.21
10-Feb-15	3.61	0.109	0.697	4.42	4.42
11-Feb-15	3.68	0.109	0.657	4.45	4.45
12-Feb-15	3.76	0.0924	0.697	4.55	4.55
13-Feb-15	3.66	0.0913	0.714	4.47	4.47
14-Feb-15	3.65	0.0960	0.705	4.45	4.45
15-Feb-15	3.65	0.0928	0.704	4.45	4.45
16-Feb-15	3.81	0.0965	0.735	4.64	4.64
17-Feb-15	3.78	0.0882	0.780	4.77	4.65
18-Feb-15	3.86	0.0926	0.728	4.70	4.68
19-Feb-15	3.98	0.0859	0.840	4.94	4.91
20-Feb-15	4.06	0.0784	0.859	5.05	5.00
21-Feb-15	4.09	0.0923	0.837	5.06	5.02
22-Feb-15	4.14	0.0898	0.827	5.06	5.06
23-Feb-15	4.20	0.108	0.876	5.32	5.18
24-Feb-15	4.40	0.108	0.870	5.49	5.38
25-Feb-15	4.55	0.112	0.988	5.82	5.65
26-Feb-15	4.48	0.111	0.956	5.80	5.55
27-Feb-15	4.59	0.0979	0.956	5.79	5.64
28-Feb-15	4.75	0.115	1.01	7.02	5.88
01-Mar-15	4.79	0.121	1.03	6.03	5.94
02-Mar-15	4.86	0.124	1.08	6.25	6.06
03-Mar-15	5.00	0.135	1.05	6.28	6.19
04-Mar-15	5.12	0.125	1.06	6.50	6.31
05-Mar-15	5.26	0.129	1.19	6.61	6.58
06-Mar-15	5.58	0.100	1.21	7.05	6.89
08-Mar-15	5.50	0.118	1.24	6.87	6.86
10-Mar-15	5.40	0.116	1.15	6.63	6.67
12-Mar-15	4.98	0.118	1.06	6.29	6.16
15-Mar-15	4.74	0.124	1.06	6.12	5.92
17-Mar-15	4.66	0.127	0.996	5.95	5.78
19-Mar-15	4.64	0.111	1.13	5.92	5.88
22-Mar-15	4.93	0.110	1.19	6.21	6.23
24-Mar-15	4.98	0.113	1.10	6.31	6.19
26-Mar-15	5.17	0.104	1.19	6.63	6.46
29-Mar-15	5.19	0.0807	1.15	6.35	6.42
02-Apr-15	5.41	0.0432	1.18	6.60	6.63
05-Apr-15	6.15	0.0717	1.44	7.39	7.66
07-Apr-15	6.71	0.130	1.42	8.32	8.26
09-Apr-15	7.48	0.173	1.76	9.23	9.41

Sample Date	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Ammonia (as N) (mg/L)	Total Nitrogen (mg/L)	Sum of Species (mg/L)
12-Apr-15	7.94	0.166	2.11	10.1	10.2
14-Apr-15	8.43	0.229	2.13	10.6	10.8
16-Apr-15	8.71	0.147	2.20	10.9	11.1
18-Apr-15	9.28	0.135	2.01	11.5	11.4
21-Apr-15	9.65	0.111	1.97	11.8	11.7
23-Apr-15	10.0	0.0591	1.91	12.1	12.0
26-Apr-15	10.1	0.0631	2.00	12.1	12.2
28-Apr-15	9.86	0.0266	1.92	11.4	11.8
01-May-15	9.70	0.0638	1.80	11.9	11.6
02-May-15	9.82	0.0904	2.24	12.3	12.2
05-May-15	11.0	0.207	3.02	13.9	14.2
07-May-15	11.5	0.278	3.18	15.1	15.0
10-May-15	12.0	0.368	4.28	16.8	16.6
12-May-15	11.5	0.421	3.95	16.2	15.9
15-May-15	12.0	0.477	3.98	16.1	16.5
17-May-15	11.4	0.511	4.20	16.0	16.1
19-May-15	11.0	0.379	3.17	14.7	14.5
21-May-15	10.4	0.491	3.38	14.0	14.3
24-May-15	9.92	0.508	3.04	13.3	13.5
26-May-15	8.87	0.490	2.85	12.4	12.2
28-May-15	7.79	0.396	2.62	10.7	10.8
31-May-15	7.55	0.314	2.59	10.9	10.5
02-Jun-15	7.29	0.363	2.42	10.1	10.1
04-Jun-15	8.21	0.364	2.76	11.8	11.3
07-Jun-15	6.76	0.235	2.39	9.38	9.39
09-Jun-15	6.73	0.206	2.31	9.35	9.25
11-Jun-15	6.55	0.0781	1.82	8.50	8.45
14-Jun-15	6.10	0.206	1.75	8.28	8.06
16-Jun-15	5.99	0.184	1.72	9.08	7.89
18-Jun-15	5.86	0.215	2.06	8.11	8.14
21-Jun-15	5.09	0.187	1.90	7.10	7.18
23-Jun-15	4.51	0.147	1.50	6.69	6.16
25-Jun-15	4.17	0.149	1.58	6.17	5.90
28-Jun-15	3.87	0.163	1.34	5.51	5.37
30-Jun-15	3.70	0.119	1.05	5.21	4.87
02-Jul-15	3.45	0.133	0.912	4.50	4.50
05-Jul-15	3.64	0.101	0.944	4.46	4.69
07-Jul-15	3.55	0.0988	0.899	4.88	4.55
09-Jul-15	3.56	0.0718	0.996	4.81	4.63
12-Jul-15	3.20	0.0660	0.884	4.27	4.15
14-Jul-15	3.13	0.0644	0.885	4.26	4.08

Sample Date	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Ammonia (as N) (mg/L)	Total Nitrogen (mg/L)	Sum of Species (mg/L)
16-Jul-15	3.13	0.0473	0.883	4.26	4.06
19-Jul-15	2.62	0.126	1.01	3.76	3.76
26-Jul-15	2.70	0.128	1.16	4.11	3.99
03-Aug-15	2.49	0.143	1.06	4.24	3.69
09-Aug-15	3.03	0.148	1.22	5.07	4.40
16-Aug-15	3.18	0.176	1.48	5.51	4.84
23-Aug-15	3.48	0.176	1.61	6.50	5.27
30-Aug-15	3.83	0.185	1.87	6.77	5.89
07-Sep-15	5.85	0.219	2.88	9.72	8.95
13-Sep-15	5.60	0.269	2.96	9.28	8.83
20-Sep-15	7.28	0.281	4.11	12.1	11.7
04-Oct-15	18.4	0.442	11.2	29.2	30.0
07-Oct-15	18.5	0.469	11.1	29.9	30.1
15-Oct-15	16.0	0.520	8.89	25.1	25.4
16-Oct-15	12.3	0.478	6.91	19.5	19.7
17-Oct-15	16.0	0.520	8.89	25.1	25.4
19-Oct-15	12.3	0.478	6.91	19.5	19.7
25-Oct-15	7.30	0.409	3.68	11.8	11.4
02-Nov-15	5.61	0.351	2.57	8.45	8.53
08-Nov-15	12.5	0.505	6.83	19.7	19.8
15-Nov-15	12.5	0.559	6.13	18.8	19.2
22-Nov-15	13.3	0.640	5.83	19.8	19.8
30-Nov-15	13.6	0.710	5.52	19.6	19.8
07-Dec-15	11.5	0.673	5.04	17.0	17.2
15-Dec-15	12.5	0.705	5.35	18.7	18.6
20-Dec-15	11.7	0.708	0.423	17.5	12.8
28-Dec-15	6.41	0.541	0.395	9.71	7.35
04-Jan-16	4.95	0.498	1.86	7.61	7.31
18-Jan-16	5.77	0.577	2.21	8.99	8.56
01-Feb-16	8.85	0.633	3.90	13.7	13.4
08-Feb-16	7.85	0.650	3.25	12.0	11.8
23-Feb-16	9.52	0.818	4.10	14.5	14.4
07-Mar-16	15.4	1.14	6.28	23.9	22.8
21-Mar-16	23.8	1.63	9.03	35.7	34.5
03-Apr-16	23.8	1.61	7.36	34.7	32.8
18-Apr-16	30.4	1.66	11.8	44.2	43.9
09-May-16	21.0	1.67	7.86	30.7	30.5
23-May-16	21.0	1.49	7.43	29.8	29.9
06-Jun-16	19.3	1.48	7.39	27.9	28.2
20-Jun-16	19.0	1.60	7.12	28.1	27.7
11-Jul-16	20.4	1.59	8.50	30.7	30.5

Sample Date	Nitrate (as N) (mg/L)	Nitrite (as N) (mg/L)	Ammonia (as N) (mg/L)	Total Nitrogen (mg/L)	Sum of Species (mg/L)
18-Jul-16	21.3	1.74	8.70	31.5	31.7
09-Aug-16	30.8	2.09	11.4	44.3	44.3
31-Aug-16	27.7	2.38	10.5	37.2	40.6
05-Sep-16	29.9	2.37	11.1	42.4	43.4
21-Sep-16	21.7	2.13	9.77	33.3	33.6
03-Oct-16	23.6	1.94	10.5	37.8	36.0
16-Oct-16	29.4	1.86	11.8	43.2	43.1
09-Nov-16	32.0	2.80	13.7	52.8	48.5
20-Nov-16	35.6	2.87	14.6	55.0	53.1
07-Dec-16	27.7	3.05	10.1	41.9	40.9
19-Dec-16	29.5	3.12	10.2	46.9	42.8
09-Jan-17	36.5	3.22	12.7	55.3	52.4
25-Jan-17	28.7	3.85	9.22	45.9	41.8
07-Feb-17	35.8	5.97	13.7	55.6	55.5
20-Feb-17	44.3	4.55	14.7	67.1	63.6
06-Mar-17	36.9	4.15	13.2	54.9	54.3
19-Mar-17	32.0	3.78	9.71	47.7	45.5
10-Apr-17	27.5	3.11	7.95	40.4	38.6
24-Apr-17	29.8	2.77	8.56	41.6	41.1
08-May-17	30.9	2.64	9.40	43.8	42.9
22-May-17	31.7	2.30	10.0	47.2	44.0
05-Jun-17	19.9	1.49	6.71	28.8	28.1
19-Jun-17	19.9	1.53	7.02	27.0	28.5
03-Jul-17	15.1	1.02	5.07	21.7	21.2
18-Jul-17	18.7	1.10	6.64	25.7	26.4
03-Aug-17	25.7	0.835	4.86	31.7	31.4
08-Aug-17	19.7	1.49	7.55	29.1	28.7
21-Aug-17	41.2	1.42	20.0	60.6	62.6
04-Sep-17	20.7	1.12	8.24	28.9	30.1
17-Sep-17	34.7	1.52	13.3	50.9	49.5
09-Oct-17	30.8	1.23	12.7	42.4	44.7
23-Oct-17	46.5	1.79	15.4	62.3	63.7
31-Oct-17	25.3	1.19	10.2	33.6	36.7
07-Nov-17	30.9	1.11	13.6	46.0	45.6
12-Nov-17	29.6	1.07	11.4	41.9	42.1
27-Nov-17	29.5	1.25	12.7	43.0	43.5
12-Dec-17	49.6	1.77	24.4	77.1	75.8
25-Dec-17	29.2	1.53	7.94	34.6	38.7
07-Jan-18	34.5	1.39	11.5	47.4	47.4
22-Jan-18	32.9	1.66	9.83	43.9	44.4
04-Feb-18	35.6	2.29	10.7	64.4	48.6

3.3 Waste Rock

The N loading rates for waste rock have been empirically derived using Brucejack Lake monitoring data collected during the Construction and early Operations phases. All N species arising from blasting activities at the Brucejack Gold Mine ultimately report to Brucejack Lake. The dominant N loads are derived from waste rock and tailings deposition, and, to a lesser extent, from WTP and STP discharges. Contributions from NPAG Quarry excavation are minor relative to other sources. Likewise, baseline water quality monitoring indicates there is no significant contribution of N from natural inflows.

The N budget for the lake is calculated to empirically derive N loads contributed from blasted rock submerged in Brucejack Lake. Monitoring data from WTP, STP, tailings and lake discharges are used to calculate N loads input to and exported from the lake. These data, combined with measured changes in the lake N inventory, allow estimation of N loads from waste rock surfaces using known tonnages placed in the lake. The monitoring records used for the derivation of N loading rates are summarized in Table 4.

Table 4:
Monitoring Records Used for the Derivation of Waste Rock N Loading Rates

N Load Term	Records		
	Water Quality	Volume	Tonnage
N Input			
WTP Effluent	✓	✓	
STP Effluent	✓	✓	
Tailings Discharge	✓	✓	✓
Surface Rock Placement			✓
Underground Rock Placement			✓
N Export			
Lake Outlet (BJ 3.10)	✓	✓	
N Inventory			
Lake Water Column	✓	✓	

Notes: WTP = Operations Water treatment plant; STP = Sewage Treatment Plant

The monitoring data are divided into discrete periods (time-steps) defined by the date on which the N lake inventory is measured through water column sampling at multiple depths from the surface to the bottom. The duration of each time step varies due to safety considerations; water column samples are only collected when conditions allow safe access by boat or on ice.

The input, export and inventory of N loads are calculated for each time step according to Equation 4:

Equation 4: $$L_N = \frac{C_N * V}{1000}$$

where:

L_N = N load (kg)
C_N = T-N concentration (mg/L)
V = Volume of water (m^3) for the time-step

For N inventory calculations, the lake is divided into layers (defined by the depth of each sample) and the layer volume is estimated from a previously defined fill curve (Table 5). The layer volume and the corresponding T-N concentration (Table 6) are used in Equation 4 to calculate the N load for each layer, and the sum of all the layers equals the N inventory. Observations of spatially dispersed same-day water column profiles indicate lateral mixing throughout the water column; therefore, the N inventory is assumed to account for all N input and export during each time-step. The N inventory from the previous time-step is subtracted to determine the change in N inventory for the current period.

Weekly BJ 3.10 water quality results for N species are presented in Table 7. Time-step volumes and period average T-N concentrations for WTP effluent, tailings and BJ 3.10 are summarized in Table 8 and used in Equation 4 to calculate N loads for each stream. For thickened tailings, the N load is assumed to be carried entirely in the supernatant water as the N species are highly water-soluble; therefore, tailings discharge volumes are corrected for the solids content (approximately 60% solids by weight) to determine the volume of water contained in the tailings discharge. The time-step STP effluent volumes are estimated from monthly flow records.

The derived N load terms are combined in Equation 5 to calculate the amount of N added to the lake from blasted rock surfaces. The N contributions from background input and NPAG quarry runoff are not measured and are therefore conservatively included the blasted rock N load term. The change in N inventory is adjusted for measured N input and N export to calculate the N load attributable to blasted rock surfaces.

Equation 5: $$L_{N\text{-}BR} = L_{N\text{-}\Delta I} + L_{N\text{-}LD} - L_{N\text{-}WTP} - L_{N\text{-}STP} - L_{N\text{-}T}$$

where:

$L_{N\text{-}BR}$ = N load (kg) attributed to blasted rock

$L_{N\text{-}\Delta I}$ = Change in N inventory (kg) measured in the lake water column

$L_{N\text{-}LD}$ = N load (kg) measured in the lake discharge

$L_{N\text{-}WTP}$ = N load (kg) measured in the WTP effluent

$L_{N\text{-}STP}$ = N load (kg) measured in the STP effluent (treated domestic wastewater)

$L_{N\text{-}T}$ = N load (kg) measured in tailings

Surface and underground waste rock were deposited in Brucejack Lake simultaneously for most of the period of record; however, the relative amount of underground waste rock varies from 3% to 100% of the total rock deposited. The N loads and deposition tonnages for time-steps when only underground rock was deposited in the lake (January 13, 2017 to February 1, 2018) are input to Equation 6 and Equation 7 to estimate N loading rates associated with development blasting. For time-steps when both surface and underground waste rock were deposited in the lake, the loading rates are adjusted to account for the N load from all deposited blasted rock.

Equation 6: $L_{N\text{-}BR} = L_{N\text{-}SR} + L_{N\text{-}UR}$

where:

$L_{N\text{-}BR}$ = N load (kg) attributed to all blasted rock deposited in the lake

$L_{N\text{-}SR}$ = N load (kg) attributed to surface rock deposited in the lake

$L_{N\text{-}LD}$ = N load (kg) attributed to underground rock deposited in the lake

Equation 7: $LR_N = \frac{L_N}{T}$

where:

LR_N = N loading rate per tonne of blasted rock (kg/t)

L_N = N load (kg)

T = Quantity of blasted rock (t) corresponding to L_N

Results of N loading rate derivations are summarized in Table 9. A total of 19 time-steps were defined spanning January 1, 2015 through February 1, 2018. The relative amount of underground rock varies from 3% to 100% of the total rock deposited, with predominantly underground waste rock from development blasting deposited prior to and after Construction (before September 2015 and after January 2017). The incremental N loading rate derived for time steps 2 through 4 (February 4 to August 21, 2015) and steps 13 through 19 (January 13, 2017 to Feb 1, 2018), when only development blasted underground rock was submerged in the lake, ranged from 0.049 to 0.185 kg-N/t, indicating significant N residues are present on the blasted rock (Table 9). This is likely a function of both the high explosives use rate (PF) required for development blasting and the challenging conditions (*i.e.*, flowing water) of underground blasting, reducing the efficiency of explosives consumption.

During time steps 6 and 7 (January 9 to February 25, 2016), deposition of waste rock was predominantly from surface blasting (97% and 93% of total waste rock, respectively), with surface blasting N loading rates of 0.0027 kg-N/t and 0.0037 kg-N/t, respectively, indicating the N loading from surface blasting is an order of magnitude lower than that of underground development

blasting. This is consistent with the significantly lower PF associated with surface blasting (Section 2.2.1).

Table 5:
Brucejack Lake Fill Curve

Interval	Volume (m³)	Cumulative Volume (m³)	Cumulative Volume (%)	Reverse (%)
0	771,302	771,302	3%	97%
1	747,149	1,518,451	5%	95%
2	723,704	2,242,155	7%	93%
3	702,747	2,944,902	10%	90%
4	679,703	3,624,604	12%	88%
5	652,816	4,277,420	14%	86%
6	641,858	4,919,277	16%	84%
7	631,074	5,550,352	18%	82%
8	620,374	6,170,725	20%	80%
9	609,734	6,780,460	22%	78%
10	597,256	7,377,716	24%	76%
11	587,997	7,965,712	26%	74%
12	578,976	8,544,688	28%	72%
13	570,150	9,114,839	30%	70%
14	561,495	9,676,334	32%	68%
15	549,736	10,226,069	34%	66%
16	541,288	10,767,357	36%	64%
17	533,011	11,300,368	37%	63%
18	524,879	11,825,247	39%	61%
19	516,866	12,342,113	41%	59%
20	504,226	12,846,339	42%	58%
21	495,930	13,342,269	44%	56%
22	487,772	13,830,040	46%	54%
23	479,734	14,309,775	47%	53%
24	471,800	14,781,574	49%	51%
25	460,581	15,242,156	50%	50%
26	453,200	15,695,356	52%	48%
27	446,097	16,141,453	53%	47%
28	439,257	16,580,709	55%	45%
29	432,672	17,013,381	56%	44%
30	423,966	17,437,348	58%	42%
31	418,401	17,855,749	59%	41%
32	412,942	18,268,691	60%	40%
33	407,574	18,676,265	62%	38%
34	402,283	19,078,547	63%	37%
35	396,226	19,474,773	64%	36%
36	390,470	19,865,243	66%	34%
37	384,867	20,250,110	67%	33%
38	379,407	20,629,517	68%	32%
39	374,068	21,003,585	69%	31%

Interval	Volume (m³)	Cumulative Volume (m³)	Cumulative Volume (%)	Reverse (%)
40	361,196	21,364,780	71%	29%
41	354,032	21,718,812	72%	28%
42	347,297	22,066,110	73%	27%
43	340,983	22,407,093	74%	26%
44	335,078	22,742,171	75%	25%
45	328,767	23,070,938	76%	24%
46	324,451	23,395,389	77%	23%
47	320,213	23,715,601	78%	22%
48	316,042	24,031,644	79%	21%
49	311,924	24,343,568	80%	20%
50	307,165	24,650,733	81%	19%
51	302,181	24,952,914	82%	18%
52	297,200	25,250,113	83%	17%
53	292,226	25,542,339	84%	16%
54	287,228	25,829,567	85%	15%
55	276,304	26,105,871	86%	14%
56	268,934	26,374,805	87%	13%
57	261,592	26,636,397	88%	12%
58	254,267	26,890,664	89%	11%
59	246,937	27,137,600	90%	10%
60	232,694	27,370,294	90%	10%
61	225,476	27,595,770	91%	9%
62	218,464	27,814,233	92%	8%
63	211,642	28,025,875	93%	7%
64	204,983	28,230,858	93%	7%
65	189,570	28,420,428	94%	6%
66	180,553	28,600,981	94%	6%
67	171,806	28,772,787	95%	5%
68	163,323	28,936,110	96%	4%
69	155,064	29,091,174	96%	4%
70	126,143	29,217,317	96%	4%
71	118,988	29,336,305	97%	3%
72	112,142	29,448,447	97%	3%
73	105,601	29,554,049	98%	2%
74	99,350	29,653,399	98%	2%
75	88,216	29,741,614	98%	2%
76	82,179	29,823,793	98%	2%
77	76,459	29,900,252	99%	1%
78	71,049	29,971,301	99%	1%
79	65,940	30,037,241	99%	1%
80	57,493	30,094,733	99%	1%
81	53,197	30,147,930	100%	0%
82	49,131	30,197,061	100%	0%
83	45,290	30,242,352	100%	0%
84	41,658	30,284,009	100%	0%

Table 6:
Summary of Brucejack Lake Water Column N Species Concentrations
(February 2015 to February 2018)

Sample Date	Depth	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Nitrogen
	m	mg/L	mg/L	mg/L	mg/L
03-Feb-15	1	0.014	0.046	<0.0010	-
	15	0.0068	0.051	<0.0010	-
	30	<0.0050	0.057	<0.0010	-
	50	<0.0050	0.091	<0.0010	-
	70	0.014	0.11	<0.0010	-
05-May-15	5	-	<0.0050	<0.0010	-
	10	-	0.0604	<0.0010	-
	15	-	0.0676	<0.0010	-
	20	-	0.128	<0.0010	-
	30	-	0.213	<0.0010	-
	50	-	0.247	<0.0010	-
	80	-	0.245	<0.0010	-
28-Jul-15	15	0.0065	0.21	0.0011	0.22
	30	<0.0050	0.26	<0.0010	0.26
	40	-	0.35	<0.0010	-
	55	<0.0050	0.36	<0.0010	0.35
	75	<0.0050	0.38	0.0010	0.36
21-Aug-15	1	<0.0050	0.17	0.0015	0.17
	15	<0.0050	0.21	<0.0010	0.20
	30	<0.0050	0.33	<0.0010	0.33
	50	0.011	0.46	<0.0010	0.43
	70	0.039	0.51	0.0094	0.49
07-Jan-16 and 08-Jan-16	2	<0.0050	0.46	<0.0010	0.48
	7	<0.0050	0.54	<0.0010	0.55
	15	<0.0050	0.64	<0.0010	0.65
	25	<0.0050	0.67	<0.0010	0.67
	38	<0.0050	0.71	<0.0010	0.76
	50	<0.0050	0.70	<0.0010	0.70
	60	<0.0050	0.72	<0.0010	0.70
	70	<0.0050	0.68	<0.0010	0.68
	80	<0.0050	0.69	<0.0010	0.69
31-Jan-16	2	<0.0050	0.62	<0.0010	0.60
	7	<0.0050	0.70	<0.0010	0.69
	15	<0.0050	0.71	<0.0010	0.69
	38	<0.0050	0.72	<0.0010	0.71
	60	0.0069	0.72	<0.0010	0.73
	70	<0.0050	0.75	<0.0010	0.75
	80	0.0082	0.76	<0.0010	0.78

Sample Date	Depth	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Nitrogen
	m	mg/L	mg/L	mg/L	mg/L
25-Feb-16	2	<0.0050	0.69	<0.0010	0.69
	7	<0.0050	0.72	<0.0010	0.73
	15	<0.0050	0.72	<0.0010	0.72
	38	<0.0050	0.76	<0.0010	0.77
	60	<0.0050	0.78	<0.0010	0.79
	70	<0.0050	0.78	<0.0010	0.80
	80	<0.0050	0.78	<0.0010	0.81
24-Mar-16	2	0.012	0.70	<0.0010	0.76
	7	<0.0050	0.74	<0.0010	0.78
	15	<0.0050	0.80	<0.0010	0.84
	38	0.0073	0.91	<0.0010	0.95
	60	0.022	0.95	0.0032	1.0
	70	0.036	0.99	0.0063	1.1
	80	0.019	1.2	<0.0010	1.2
21-Apr-16	2	<0.0050	0.69	<0.0010	0.70
	7	<0.0050	0.81	<0.0010	0.82
	15	<0.0050	0.93	<0.0010	0.97
	38	<0.0050	1.2	<0.0010	1.2
	60	0.036	1.2	<0.0010	1.3
	70	0.035	1.3	0.0021	1.3
	80	0.053	1.3	0.0057	1.3
27-Jul-16	2	<0.0050	1.0	0.0064	1.1
	7	0.011	1.3	0.0069	1.3
	15	0.014	1.3	0.0061	1.4
	38	0.063	1.4	0.0047	1.5
	60	0.11	1.5	0.0072	1.6
	70	0.11	1.5	0.0067	1.6
	80	0.16	1.6	0.011	1.8
25-Aug-16	2	0.026	1.1	0.011	1.1
	7	0.058	1.2	0.014	1.3
	15	<0.0050	1.6	0.0018	1.6
	38	<0.0050	1.9	0.0024	1.9
	60	0.067	2.0	0.031	2.0
	70	0.10	2.0	0.052	2.1
	80	0.088	2.0	0.059	2.1
01-Oct-16	2	0.0052	2.0	<0.0010	2.0
	7	<0.0050	2.0	<0.0010	2.0
	15	<0.0050	2.0	<0.0010	2.0
	25	<0.0050	2.1	<0.0010	2.2
	38	<0.0050	2.3	<0.0010	2.4
	60	0.024	2.3	0.0038	2.4

Sample Date	Depth	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Nitrogen
	m	mg/L	mg/L	mg/L	mg/L
	70	0.033	2.3	0.0071	2.3
	80	0.034	2.3	0.0082	2.3
12-Jan-17	2	0.0074	2.5	0.0014	-
	7	<0.0050	2.5	0.0010	-
	15	<0.0050	2.8	<0.0010	-
	38	<0.0050	3.0	<0.0010	-
	60	0.034	3.1	0.0074	-
	70	0.041	3.1	0.0083	-
	80	0.056	3.1	0.012	-
08-Mar-17	2	<0.0050	2.4	0.0016	2.5
	7	<0.0050	3.1	<0.0010	3.2
	15	0.019	3.3	0.0049	3.4
	25	0.054	3.3	0.0075	3.4
	38	0.077	3.3	0.0083	3.4
	60	0.092	3.3	0.0089	3.5
	70	0.11	3.3	0.0061	3.5
	80	0.14	3.4	0.0074	3.6
01-May-17	2	<0.0050	2.6	<0.0010	2.6
	7	<0.0050	3.3	<0.0010	3.3
	15	<0.0050	3.4	<0.0010	3.5
	25	<0.0050	3.6	<0.0010	3.6
	38	<0.0050	3.6	<0.0010	3.7
	60	0.014	3.6	0.013	3.7
	70	0.025	3.7	0.012	3.7
	80	0.016	3.5	0.010	3.5
13-Jul-17	2	0.019	3.5	0.0078	3.4
	7	0.022	3.5	0.0078	3.4
	15	0.018	3.5	0.0074	3.4
	38	0.020	3.5	0.0071	3.4
	50	0.049	3.6	0.0079	3.6
	60	0.40	4.5	0.0043	5.0
	70	0.32	4.2	0.023	4.5
	80	0.31	4.2	0.023	4.5
02-Sep-2017	2	0.094	3.2	0.0073	3.2
	7	0.099	3.3	0.0076	3.3
	15	0.16	3.6	0.0020	3.6
	25	0.19	3.6	0.0062	3.7
	38	0.22	3.7	0.0089	3.8
	50	0.24	3.7	0.0080	3.9
	60	0.27	3.8	0.0110	4.0
	70	0.51	4.2	0.0079	4.7

Sample Date	Depth	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Nitrogen
	m	mg/L	mg/L	mg/L	mg/L
	80	0.49	4.1	0.0084	4.3
28-Oct-2017	2	0.25	3.8	0.0100	4.0
	7	0.25	3.8	0.0099	4.1
	15	0.25	3.8	0.0106	4.0
	25	0.25	3.7	0.0099	4.1
	38	0.26	3.8	0.0103	4.1
	60	0.33	3.9	0.0100	4.3
	70	0.53	4.4	0.0109	4.9
	80	0.53	4.3	0.0158	4.8
01-Feb-2018	2	0.25	3.6	0.0073	3.8
	7	0.31	4.4	0.0738	4.5
	15	0.50	4.6	0.0194	4.9
	38	0.56	4.7	0.0083	5.2
	50	0.59	4.8	0.0073	5.4
	60	0.81	5.2	0.0037	6.0
	70	0.99	5.5	0.0031	6.5
	76	1.2	5.3	0.0746	7.1

Notes:< indicates that values are below the analytical detection limit.

Table 7:
Summary of N Species Concentrations in Brucejack Lake Discharge (BJ 3.10)
(January 4, 2016 to January 29, 2018)

Sample Date	Nitrate (as N) mg/L	Nitrite (as N) mg/L	Ammonia (as N) mg/L	Total Nitrogen mg/L	Sum of Species mg/L
04-Jan-16	0.51	0.0020	<0.005	0.54	0.52
14-Jan-16	0.48	0.0030	0.012	0.50	0.50
18-Jan-16	0.50	0.0030	0.010	0.51	0.51
25-Jan-16	0.56	0.0030	0.012	0.55	0.57
01-Feb-16	0.60	0.0030	0.010	0.61	0.61
10-Feb-16	0.64	<0.001	<0.005	0.62	0.65
15-Feb-16	0.64	<0.001	<0.005	0.63	0.64
22-Feb-16	0.65	<0.001	<0.005	0.65	0.65
01-Mar-16	0.70	<0.001	<0.005	0.68	0.70
07-Mar-16	0.71	<0.001	<0.005	0.67	0.71
16-Mar-16	0.74	0.0010	<0.005	-	0.75
21-Mar-16	0.80	0.0010	<0.005	0.81	0.80
28-Mar-16	0.78	0.0020	<0.005	0.78	0.79
04-Apr-16	0.81	0.0010	<0.005	0.84	0.82
10-Apr-16	0.78	0.0030	<0.005	0.81	0.79
19-Apr-16	0.78	0.0030	<0.005	0.78	0.78
25-Apr-16	0.77	0.0020	<0.005	0.77	0.77
11-May-16	0.61	0.0050	0.020	-	0.63
16-May-16	0.66	0.0050	0.021	-	0.69
25-May-16	0.60	0.0060	0.015	0.63	0.63
30-May-16	0.53	0.0040	0.021	0.55	0.55
06-Jun-16	0.64	0.0030	0.013	0.67	0.66
13-Jun-16	0.63	0.0040	0.013	0.63	0.64
20-Jun-16	1.01	0.0040	0.012	1.10	1.03
27-Jun-16	1.29	0.0010	0.017	1.35	1.31
04-Jul-16	1.31	0.0060	0.032	1.37	1.35
11-Jul-16	1.28	0.0050	0.031	1.38	1.32
18-Jul-16	1.16	0.0070	0.021	1.20	1.19
26-Jul-16	1.07	0.0090	0.0080	1.14	1.09
01-Aug-16	1.17	0.0080	0.010	1.21	1.19
09-Aug-16	1.09	0.012	0.015	1.20	1.12
15-Aug-16	0.99	0.013	0.010	1.13	1.01
23-Aug-16	1.22	0.012	0.051	1.33	1.28
28-Aug-16	1.07	0.010	0.011	1.13	1.09
05-Sep-16	1.29	0.013	0.028	1.36	1.33
12-Sep-16	1.58	0.010	0.022	1.69	1.61
17-Sep-16	1.57	0.0050	0.025	1.52	1.60
28-Sep-16	1.96	0.0040	0.017	1.97	1.98
02-Oct-16	1.98	0.0030	0.028	2.00	2.01
11-Oct-16	2.14	0.0040	0.021	2.15	2.16
13-Oct-16	2.23	0.0050	0.033	2.28	2.27
16-Oct-16	2.24	0.0040	0.028	2.24	2.27
24-Oct-16	2.23	0.0090	0.034	2.21	2.27
31-Oct-16	2.31	0.014	0.017	2.34	2.34

Sample Date	Nitrate (as N) mg/L	Nitrite (as N) mg/L	Ammonia (as N) mg/L	Total Nitrogen mg/L	Sum of Species mg/L
06-Nov-16	2.28	0.024	0.031	2.45	2.33
16-Nov-16	2.48	0.034	0.032	2.61	2.55
23-Nov-16	2.39	0.054	0.011	2.40	2.46
28-Nov-16	2.34	0.056	0.0060	2.48	2.40
07-Dec-16	2.36	0.036	<0.005	2.38	2.40
12-Dec-16	2.42	0.025	<0.005	2.37	2.45
19-Dec-16	2.40	0.018	0.019	2.50	2.44
27-Dec-16	2.26	0.0060	<0.005	2.33	2.27
02-Jan-17	2.26	0.0090	<0.005	2.35	2.27
08-Jan-17	2.26	0.0070	0.0060	2.32	2.27
16-Jan-17	2.34	0.0090	0.012	2.49	2.36
23-Jan-17	2.48	0.0070	0.011	2.41	2.50
31-Jan-17	2.26	0.0050	<0.005	2.33	2.27
05-Feb-17	2.26	0.0040	0.0050	2.27	2.27
14-Feb-17	2.32	0.0020	<0.005	2.39	2.33
20-Feb-17	2.45	0.0030	0.0060	2.41	2.46
25-Feb-17	2.45	0.0030	<0.005	2.50	2.46
09-Mar-17	2.86	0.0040	0.031	3.02	2.90
13-Mar-17	2.81	0.0070	0.028	2.86	2.84
19-Mar-17	2.85	0.0060	0.022	2.97	2.88
27-Mar-17	2.83	0.0060	0.014	2.66	2.85
05-Apr-17	2.92	0.0070	0.013	2.98	2.94
10-Apr-17	2.84	0.0080	0.011	2.89	2.86
17-Apr-17	2.78	0.0080	0.011	2.65	2.80
24-Apr-17	2.77	0.0090	0.0060	2.73	2.79
01-May-17	2.71	0.0070	<0.005	2.68	2.72
08-May-17	2.52	0.0050	<0.005	2.62	2.53
14-May-17	2.91	0.0080	0.0070	2.79	2.92
22-May-17	2.73	0.0040	0.012	2.64	2.75
29-May-17	2.52	0.0060	0.034	2.52	2.56
04-Jun-17	2.02	0.0060	0.038	2.14	2.06
12-Jun-17	2.10	0.0050	0.011	2.21	2.12
19-Jun-17	1.67	0.0040	0.0060	1.64	1.68
27-Jun-17	2.97	0.0080	0.078	3.00	3.06
03-Jul-17	3.09	0.0080	0.011	3.12	3.11
09-Jul-17	3.31	0.010	0.021	3.25	3.34
17-Jul-17	3.41	0.0090	0.0060	3.21	3.42
24-Jul-17	3.40	0.011	0.034	3.50	3.44
31-Jul-17	3.25	0.014	0.022	3.20	3.29
07-Aug-17	2.96	0.015	0.018	2.90	2.99
13-Aug-17	2.64	0.016	0.010	2.64	2.67
21-Aug-17	2.98	0.011	0.025	2.97	3.02
28-Aug-17	3.24	0.0065	0.072	3.21	3.32
04-Sep-17	3.19	0.0080	0.093	3.21	3.29
18-Sep-17	3.41	0.0082	0.131	3.44	3.55
25-Sep-17	3.38	0.011	0.155	3.59	3.55
02-Oct-17	3.42	0.010	0.169	3.71	3.60

Sample Date	Nitrate (as N) mg/L	Nitrite (as N) mg/L	Ammonia (as N) mg/L	Total Nitrogen mg/L	Sum of Species mg/L
09-Oct-17	3.51	0.011	0.177	3.78	3.70
16-Oct-17	3.48	0.013	0.186	3.79	3.68
23-Oct-17	3.74	0.013	0.216	3.81	3.97
30-Oct-17	3.73	0.012	0.249	3.83	3.99
05-Nov-17	3.83	0.010	0.267	4.06	4.11
13-Nov-17	3.71	0.011	0.250	3.94	3.97
20-Nov-17	3.66	0.010	0.234	3.95	3.90
27-Nov-17	3.57	0.010	0.268	3.95	3.85
03-Dec-17	3.51	0.010	0.245	3.83	3.76
11-Dec-17	3.57	0.0091	0.249	4.00	3.83
18-Dec-17	3.62	0.0059	0.249	3.90	3.87
26-Dec-17	3.40	0.0056	0.246	3.62	3.65
01-Jan-18	3.58	0.0050	0.261	4.01	3.85
08-Jan-18	3.67	0.0046	0.265	3.96	3.94
15-Jan-18	3.66	0.0077	0.273	4.08	3.94
22-Jan-18	3.76	0.0077	0.235	3.92	4.00
29-Jan-18	3.87	0.029	0.268	4.06	4.17

Notes: < indicates that values are below the analytical detection limit.

Table 8:
Summary of Discharges to and from Brucejack Lake and Average Total Nitrogen (T-N) Concentrations During Specifed Time Periods

Time Step	Time Step Start Date	Time Step End Date	Time Step Duration (days)	UG Waste Rock (t)	Surface Waste Rock (t)	% UG Rock of total Rock	BJ3.10 flows (m^3)	BJ3.10 T-N (mg/L)	WTP Effluent flows (m^3)	WTP Effluent T-N (mg/L)	STP flow (m^3)	STP T-N (mg/L)	Tailings Supernatant volume (m^3)	Tailings Supernatant T-N (mg/L)
1	01-Jan-15	03-Feb-15	33	18,508	3,220	85%	164,506	0.053	-	-	-	-	-	-
2	04-Feb-15	05-May-15	90	51,072	0	100%	517,363	0.051	-	-	-	-	-	-
3	06-May-15	28-Jul-15	83	45,108	168	100%	6,943,363	0.10	-	-	-	-	-	-
4	29-Jul-15	21-Aug-15	23	14,868	0	100%	1,174,349	0.17	-	-	-	-	-	-
5	22-Aug-15	08-Jan-16	139	104,636	424,387	20%	4,228,613	0.39	15,056	8	-	-	-	-
6	09-Jan-16	31-Jan-16	22	9,724	338,842	3%	246,453	0.55	19,318	9	-	-	-	-
7	01-Feb-16	25-Feb-16	24	16,839	217,510	7%	333,966	0.65	20,865	11	-	-	-	-
8	26-Feb-16	24-Mar-16	27	31,095	186,992	14%	230,579	0.74	21,000	22	-	-	-	-
9	25-Mar-16	21-Apr-16	27	56,424	78,988	42%	122,165	0.79	22,237	30	1,064	9	-	-
10	22-Apr-16	27-Jul-16	96	224,394	80,304	74%	7,298,595	0.91	198,036	25	3,805	15	-	-
11	28-Jul-16	25-Aug-16	28	96,795	5,144	95%	1,289,693	1.15	46,835	31	1,505	38	-	-
12	26-Aug-16	01-Oct-16	36	109,513	25,462	81%	1,854,835	1.52	95,406	27	1,989	35	-	-
13	02-Oct-16	12-Jan-17	102	172,234	109,483	61%	1,281,233	2.32	138,707	43	6,807	71	-	-
14	13-Jan-17	08-Mar-17	54	62,774	0	100%	321,579	2.38	39,913	56	6,063	66	-	-
15	09-Mar-17	01-May-17	53	48,609	0	100%	232,694	2.84	32,180	43	6,586	116	-	-
16	02-May-17	13-Jul-17	72	88,389	0	100%	5,254,693	2.61	184,277	24	6,433	59	73,701	49
17	14-Jul-17	2-Sep-17	51	83,452	0	100%	3,469,911	3.00	102,930	33	4,038	5	98,390	32
18	3-Sep-17	28-Oct-17	55	90,936	0	100%	2,007,341	3.67	46,658	39	1,893	33	104,991	20
19	29-Oct-17	1-Feb-18	95	148,275	0	100%	1,039,486	3.91	42,268	46	7,845	50	157,537	51

Notes: WTP (Water treatment Plant) Effluent discharge to lake commenced Dec 2015.
STP (Sewage Treatment Plant) effluent discharge to lake commenced April 2016.
Tailings discharge to lake commenced June 2017.

Table 9:
Summary of the N Budget for Brucejack Lake During Specified Time Periods

Time Step	Time Step End Date	Time Step Duration (days)	Lake Discharge (kg-N)	Change in Lake Inventory (kg N)	WTP Effluent (kg-N)	Treated Domestic Wastewater (kg-N)	Tailings (kg-N)	UG Waste Rock (t)	Surface Waste Rock (t)	UG Waste Rock	N load attributed to Waste Rock (kg-N)	Estimated Load Rate UG Waste (kg N/t)	Estimated Load rate Surface Waste (kg N/t)	Estimated N load from UG rock (kg-N)	Estimated N load from surface rock (kg-N)
1	03-Feb-15	34	9	748	-	-	-	18,508	3,220	85%	757	0.040	0.0050	740	16
2	05-May-15	91	27	2,454	-	-	-	51,072	0	100%	2,481	0.049	0.0050	2,477	0
3	28-Jul-15	84	724	3,712	-	-	-	45,108	168	100%	4,436	0.098	0.0050	4,421	1
4	21-Aug-15	24	198	2,402	-	-	-	14,868	0	100%	2,600	0.175	0.0050	2,602	0
5	08-Jan-16	140	1,646	9,024	115	-	-	104,636	424,387	20%	10,555	0.081	0.0052	8,476	2,207
6	31-Jan-16	23	135	1,229	169	-	-	9,724	338,842	3%	1,196	0.030	0.0027	292	898
7	25-Feb-16	25	216	1,632	227	-	-	16,839	217,510	7%	1,621	0.049	0.0037	825	805
8	24-Mar-16	28	171	5,090	459	-	-	31,095	186,992	14%	4,802	0.121	0.0055	3,775	1,028
9	21-Apr-16	28	97	5,396	670	10	-	56,424	78,988	42%	4,813	0.080	0.0035	4,531	276
10	27-Jul-16	97	6,651	10,023	5,002	59	-	224,394	80,304	74%	11,614	0.051	0.0030	11,377	241
11	25-Aug-16	29	1,482	9,403	1,428	57	-	96,795	5,144	95%	9,399	0.097	0.0050	9,370	26
12	01-Oct-16	37	2,825	14,414	2,551	70	-	109,513	25,462	81%	14,618	0.132	0.0050	14,500	127
13	12-Jan-17	103	3,027	21,348	5,895	484	-	172,234	109,483	61%	17,946	0.101	0.0050	17,396	547
14	08-Mar-17	55	1,639	11,828	2,235	400	-	62,774	0	100%	9,958	0.158	-	9,931	-
15	01-May-17	54	1,732	6,242	1,390	764	-	48,609	0	100%	4,749	0.098	-	4,739	-
16	13-Jul-17	73	13,582	4,920	4,404	533	3,591	88,389	0	100%	10,274	0.116	-	10,227	-
17	2-Sep-17	51	10,406	1,908	3,383	22	3,196	83,452	0	100%	5,714	0.069	-	5,716	-
18	28-Oct-17	55	7,357	13,462	1,796	62	2,139	90,936	0	100%	16,822	0.185	-	16,823	-
19	1-Feb-18	95	4,066	30,342	1,953	389	7,961	148,275	0	100%	24,104	0.163	-	24,109	-
2016 January 9 to 2017 January 12								717,019	1,042,725	-	66,009	0.087	0.0040	62,064	3,949
2017 January 13 to 2018 February 1								522,434	16,658	-	71,620	0.137	0.0050	71,546	83
2017 September 3 to 2018 February 1								239,211	0	-	40,926	0.171	-	40,933	-

Notes: WTP (Water treatment Plant) Effluent discharge to lake commenced Dec 2015.
STP (Sewage Treatment Plant) effluent discharge to lake commenced April 2016.
Tailings discharge to lake commenced June 2017.

3.3.1 Underground Waste Rock

The current (2018) methodology estimates N loading rates from the lake N budget based on: 1) the observed changes in total N inventory in Brucejack Lake attributable to waste rock deposition, and 2) the tracked tonnages of waste rock deposited to the lake for the periods of January 2017 through January 2018 (Base Case) and September 2017 through January 2018 (Upper Case) (Table 9). During the period of record (January 2015 through January 2018), surface waste rock and underground waste rock were deposited concurrently to Brucejack Lake, but at varying proportions over time. The N loading rates for both surface and underground rock were derived to fully account for the incremental change in the lake N inventory between each monitoring event.

The time step N loading rates for development blasting are shown in Figure 4, and range from 0.030 to 0.185 kg-N/t. The long-term N loading rate (January 13, 2017 through February 1, 2018) attributed to underground waste is estimated to be 0.137 kg-N/t (Table 9, Figure 4), and this value is rounded up to 0.14 kg-N/t to represent the Base Case. The short-term N loading rate of 0.171 mg-N/t (September 3, 2017 through February 1, 2018) is rounded to 0.17 kg-N/t for the Upper Case. Waste rock deposited in Brucejack Lake is assumed to instantaneously release 100% of the N load at the time of deposition. The mine development blasting long-term PF was 1.54 kg/t of blasted rock (Section 2.2.2); it is assumed that explosives use rate will remain similar for the LOM.

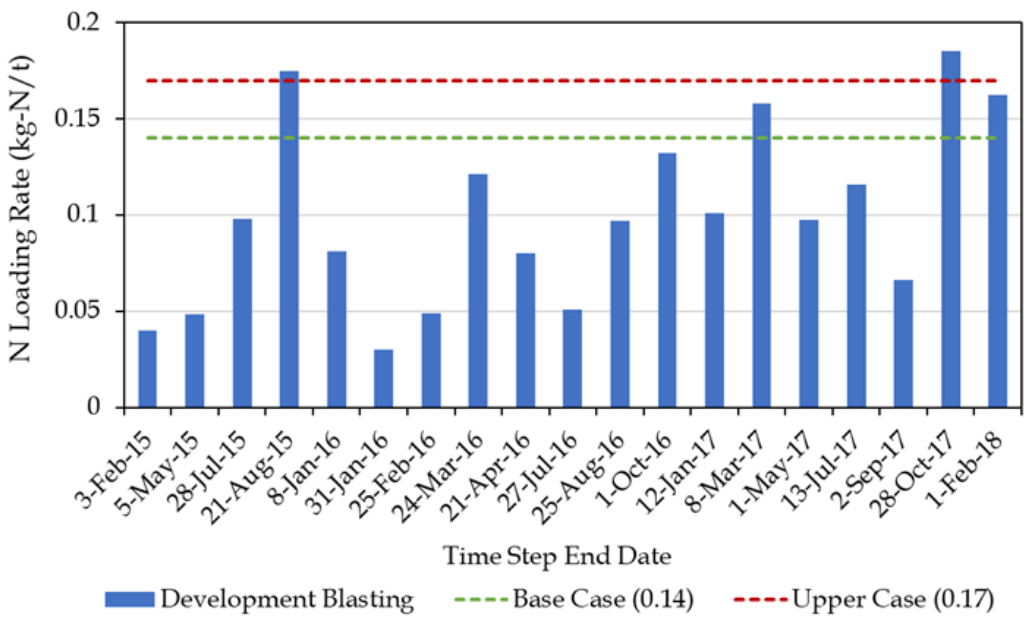

Figure 4: Inferred N loading rate for waste rock produced by underground development blasting from January 1, 2015 through February 1, 2018; Base Case and Upper Case assumptions used for modelling are indicated with dashed lines.

3.3.2 Surface Waste Rock

Approximately 1,500 kt of waste rock was blasted and excavated from the Mine Site surface to develop the site for various facilities including the Mill, Camp and CWP in preparation for Operations. Full-scale construction of the Mine Site was initiated in September 2015 and continued during 2016, with the majority of excavation occurring in Q1 and Q2 of 2016 (Table 9). Excavated NPAG Quarry rock was used as fill for pad and road construction.

The current (2018) modelling approach assigned a N loading rate that was estimated from: 1) the observed changes in the lake total N inventory attributable to waste rock deposition, and 2) the tracked tonnages of waste rock deposited to Brucejack Lake for the period of January 2015 through December 2016. Surface waste rock and underground waste rock were deposited concurrently to Brucejack Lake, but at varying proportions over time; therefore, N load rates were derived for both surface and underground materials to fully account for the incremental change in the lake N inventory for each time step. Mine construction was completed in early 2017; therefore, surface blasting ceased, and no surface waste rock was deposited to the lake after December 2016.

Figure 5 shows the time-step N loading rates for surface blasting range from 0.0027 to 0.0055 kg-N/t. The long-term (January 9, 2016 to January 12, 2017) N loading rate for surface blasted waste rock is 0.004 kg-N/t (Table 9). The modelled surface waste rock loading rates are conservatively rounded up to 0.005 kg-N/t for the Base Case and 0.008 kg-N/t for the Upper Case. Further, 100% of the loads are assumed to be instantaneously released to the lake. The PF for surface blasting is assumed to be 0.3 kg/t, the upper range of observed values (Section 2.2.1).

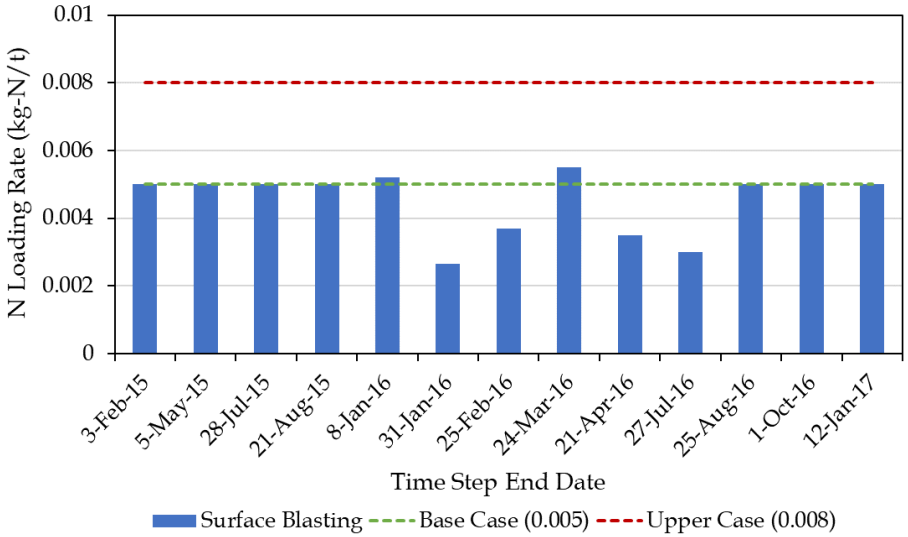

Figure 5: Inferred N loading rate for waste rock produced by surface blasting from January 1, 2015 to January 12, 2017; Base Case and Upper Case assumptions for modelling are indicated with dashed lines.

3.4 Ore

The ore N loading rate is derived from monitoring data collected at the Semi-Autogenous Grinding (SAG) Mill from June 2017 through February 2018. Within the Mill circuit, the SAG Mill was identified as the best monitoring location for the purposes of developing the nitrogen ore loading rate because: 1) all crushed ore is first processed through the SAG Mill, and 2) the SAG Mill effluent quality is solely influenced by ore throughput and the quality of the influent process water. The inorganic N species (NH_3, NO_2^- and NO_3^-) are water soluble and considering the grinding and mixing that occurs in the SAG Mill, it is assumed that all N residues on the ore are transferred to the liquid phase of the SAG effluent slurry. Process water input and SAG effluent locations are accessible for sampling upstream and downstream of the SAG Mill, respectively.

The N load attributable to the ore is derived from water quality data, and instantaneous ore and process water feed rates. The change in the process water T-N concentration is calculated for each sampling event, as per Equation 8:

Equation 8: $\Delta C_N = C_{N-SAG\ Mill\ Discharge} - C_{N-SAG\ Mill\ Influent}$

where:

ΔC_N = Change in T-N concentration (mg/L)

$C_{N\text{-}SAG\ Mill\ Discharge}$ = T-N concentration of SAG Mill discharge (mg/L)

$C_{N\text{-}SAG\ Mill\ Influent}$ = T-N concentration of SAG Mill influent (mg/L)

Ore and process water feed rates are used to calculate the instantaneous total N loading rates, as per Equation 9:

Equation 9: $L_N = \Delta C_N * \frac{Q_{SAG\ Mill\ Influent}}{F_{SAG\ Mill\ Ore}} * 0.001$

where:

L_N = N load (kg)

ΔC_N = Change in T-N concentration (mg/L)

$Q_{SAG\ Mill\ Influent}$ = Flow rate of SAG Mill Influent (m^3/hr)

$F_{SAG\ Mill\ Ore}$ = SAG Mill ore feed rate (t/hr)

The instantaneous N loading rate calculated for each of the 25 sampling events ranged from 0.005 to 0.056 kg-N/t (Figure 6, Table 10). Overall, the observed loading rates are significantly lower than for development waste rock blasting, consistent with the lower PF observed for production blasting (Section 2.2.2 and Section 2.3). The monitoring of the SAG Mill process represents discrete instantaneous measurements of N loads on ore, therefore the 75th and 90th percentiles of this SAG Mill dataset (June 12, 2017 through September 24, 2017) were conservatively used to

represent production blasted ore N loading rates for the Base Case (0.028 kg-N/t) and Upper Case (0.054 kg-N/t), respectively. Figure 6 shows the discrete total N loading rates for ore in comparison to the Base Case and Upper Case loading rates. Table 10 presents the monitoring data and calculated results for the derivation of the ore loading rate.

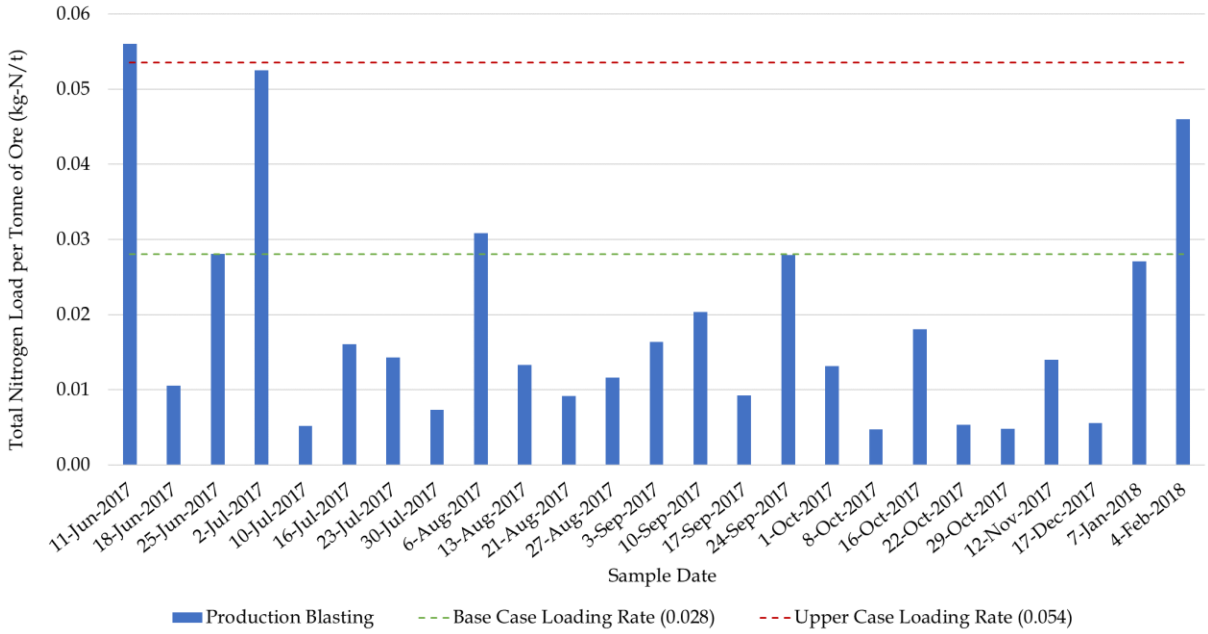

Figure 6: Total N loading rates for ore excavated using production (long-hole) blasting measured at the SAG mill on weekly (June to October 2017) and monthly (November 2017 to February 2018) frequencies; Base Case and Upper Case assumptions for modelling are indicated with dashed lines.

Table 10:
SAG Mill Weekly Monitoring Results and Production Blasting Instantaneous Ore N Loading Rates from June 11, 2017 through February 4, 2018

Sample Date	T-N SAG Mill Influent	T-N SAG Mill Effluent	T-N Delta (effluent - influent)	Process Water Flow Rate	Ore Through-put	N Loading Rate from Ore
	mg/L	mg/L	mg/L	m^3/hr	t/hr	kg-N/t
11-Jun-17	72	282	210	33	124	0.056
18-Jun-17	37	77	40	35	133	0.011
25-Jun-17	47	144	97	46	157	0.028
02-Jul-17	77	249	172	46	151	0.053
10-Jul-17	29	46	17	42	140	0.0052
16-Jul-17	49	93	44	49	134	0.016
23-Jul-17	68	113	46	46	146	0.014
30-Jul-17	47	70	24	47	151	0.0073
06-Aug-17	40	144	104	48	160	0.031
13-Aug-17	40	86	46	41	140	0.013
21-Aug-17	40	71	31	39	130	0.0092
27-Aug-17	56	88	31	46	124	0.012
03-Sep-17	33	84	51	32	100	0.016
10-Sep-17	55	124	69	39	133	0.020
17-Sep-17	39	64	26	48	133	0.0092
24-Sep-17	55	146	91	40	130	0.028
01-Oct-2017	45	85	40	49	150	0.013
08-Oct-2017	39	55	16	37	125	0.0047
16-Oct-2017	45	102	57	43	135	0.018
22-Oct-2017	42	57	15	43	120	0.0053
29-Oct-2017	27	43	16	36	115	0.0048
12-Nov-2017	45	92	47	47	160	0.014
17-Dec-2017	49	67	18	36	115	0.0056
07-Jan-2018	74	171	97	39	140	0.027
04-Feb-2018	86	261	175	40	150	0.046
75th Percentile (June 11, 2017 through September 24, 2017)						**0.028**
90th Percentile (June 11, 2017 through September 24, 2017)						**0.054**

3.5 Surface Runoff

Mine Site runoff within the contact water management area is collected in the CWP and pumped to the WTP for treatment, ultimately reporting the Brucejack Lake via the WTP effluent or tailings slurry discharge. The Mine Site runoff source term includes CWP catchment drainage from all exposed blasted rock surfaces and from NPAG Quarry fill used for the construction of pads and

roads. The NPAG Quarry is located near the southeast end of Brucejack Lake, with runoff from this area reporting directly to Brucejack Lake. Drainage from NPAG Quarry surface fill used for road and pad construction outside the contact water management area also reports directly to Brucejack Lake.

Surface runoff from blasted and/or filled areas is generally not observed. Consequently, empirical methods are not available for derivation of N loading rates. Only a small proportion of the excavation blasting residues report to runoff (*i.e.*, the majority remains on the waste rock surfaces) as has been observed elsewhere (Ferguson & Leask, 1988; Cameron *et al.*, 2007; Baily *et al.*, 2013). Infiltration and rinsing of surfaces filled with NPAG Quarry rock is limited by building coverage, the water shedding characteristics of road and pad surfacing, and by winter snow removal, which reduces road, and mill and camp pad runoff during the spring melt period. Therefore, considering literature values and site characteristics, the surface blasting N loading rate to runoff is estimated to be a proportion (25%) of the loading rates derived for surface waste rock (Section 3.3.2), at 0.001 kg-N/t and 0.002 kg-N/t of blasted rock for Base Case and Upper Case, respectively.

Field observations described in the literature indicate surface runoff N loads from rock piles can be released over several years. However, considering the small magnitude of these N source terms compared to other sources, the N source term derivations are simplified to assume all surface and Mine Site runoff N loads report to Brucejack Lake the same year the surface rock is excavated and placed.

4. N Speciation

4.1 Overview

At Brucejack Gold Mine the N species (NH_3, NO_2^- and NO_3^-) originate primarily from explosives in which N is approximately equally distributed between NH_3 and NO_3^-. Blasting residuals release NH_3, NO_2^- and NO_3^- to contact water and rock surfaces at the blast location, the NO_2^- originates as an explosion by-product. Near the blast location NH_3 and NO_3^- are the dominant N species, however enrichment of NO_3^- as a proportion of the total N is generally observed in downstream mine-influenced waters. The proportional distribution of N species can be affected by secondary processes such as naturally occurring microbially-mediated reactions that oxidize NH_3 and NO_2^- to NO_3^-, referred to as nitrification (Hall, 1981; Ward *et al.*, 2011). These processes are variable and subject to complex environmental influences, therefore endpoints of nitrification processes based on site monitoring data are used to conservatively model the distribution of NH_3, NO_2^- and NO_3^- as a proportion of the modelled N loads.

This section summarizes the N species distributions observed in mine and lake waters, and the methods used to estimate the distributions used for water quality modeling. The N speciation applied to N source terms and modelled lake discharge (BJ 3.10) water quality are described.

4.2 Mine Water N Speciation

Mine water quality is monitored at the influent to the WTP. The inorganic N species (NH_3, NO_2^- and NO_3^-) are introduced to mine water through the dissolution of blasting residues at blast sites. Total nitrogen (T-N) is also monitored and provides a measure of N from all inorganic and organic compounds that contain N. The relative proportions of N species in mine water, shown in Figure 7, are derived by dividing the parameter concentration (as mg-N/L) by the sum of NH_3, NO_2^- and NO_3^- (as mg-N/L) and converting the ratio to a percentage. The proportion of T-N is compared to the sum of the N species to confirm that the N budget in the mine water is balanced. Monitoring data indicate that the sum of the measured inorganic N species is generally consistent with measured T-N values, indicating that N is predominantly present as inorganic species in mine water.

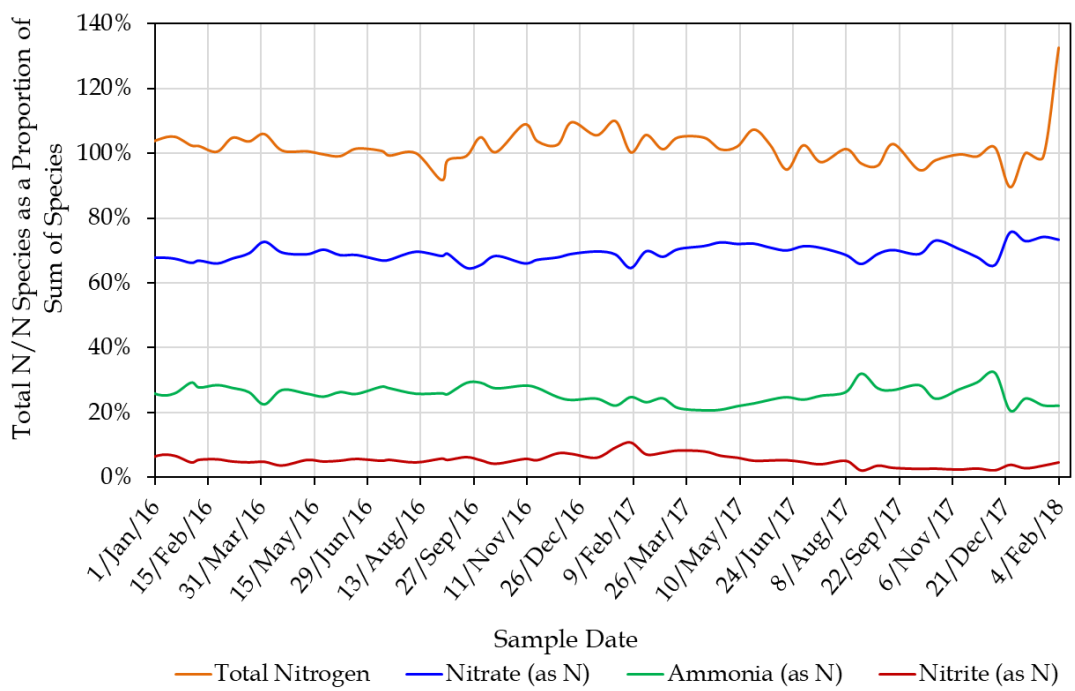

Figure 7: Mine water distribution of individual N species and total nitrogen as a proportion of the sum of the inorganic N species, from January 4, 2016 through February 4, 2018.

As shown in Figure 7, the N species distributions are relatively stable for the period of record, with NO_3^- proportions ranging between approximately 65 to 76%, the proportions of NH_3 typically between 21 to 32% and NO_2^- between 2 to 11%. Median and maximum values shown in Table 11

are calculated using the January 4, 2016 through February 4, 2018 data (Table 3). The median values from the data set are normalized to 100% through recalculation of the relative proportions over the sum of the median values. Monitoring data support the mine water N species distribution derived for the November 2016 water quality model update (Lorax, 2016). Therefore, the assumed proportions for the 2016 model are carried forward for current modelling of N species distribution for all N source terms (66.0%, 5.2%, 28.8% for NO_3^-, NO_2^- and NH_3, respectively).

Table 11:
Summary of N Species Distributions in Mine Water as a Proportion of the Sum of Species

Basis of N Species Distribution	NO_3^-	NO_2^-	NH_3
2016 water quality model update (Lorax, 2016)	66.0%	5.2%	28.8%
Jan 4, 2016 – Feb 4, 2018; median	68.9%	5.3%	25.7%
Jan 4, 2016 – Feb 4, 2018; median (normalized)	68.0%	5.2%	25.4%
Jan 4, 2016 – Feb 4, 2018; maximum	75.5%	10.8%	32.2%

4.3 Brucejack Lake Water

Brucejack Lake receives N loads that originate from mining activities at the Brucejack Gold Mine through surface runoff, STP effluent discharge, WTP effluent discharge, tailings discharge and waste rock deposition. The dominant N loads are from WTP effluent, tailings and waste rock. The N loads are dissolved and mixed into lake water prior to discharge from the lake outlet (BJ 3.10) as the inorganic N species (*i.e.*, NH_3, NO_2^- and NO_3^-). Vertical mixing is promoted year-round by waste rock deposition, although seasonal stratification constrains the mixing to the deeper waters except during late Spring and early Autumn lake turnover events when mixing extends to the surface waters. The entire lake volume is discharged every two to three years.

Nitrifying microbes have been previously detected in mine slimes, mine water and lake water as described in the November 2016 water quality model update (Lorax, 2016). Microbially-mediated nitrification processes occur naturally in cold water lakes and can control the distribution of nitrogen species in the water column (Sterner *et al.*, 2007) typically promoting an increase in the proportion of N in the form of NO_3^-. Nitrification rates in these environments are affected by temperature, nutrient levels, substrate and other environmental factors (Dvir & Neori, 1999; Kaplan *et al.*, 2000; Gerardi, 2002; Ward *et al.*, 2011; Bristow *et al.*, 2015) which may cause variations of the relative proportions of NH_3, NO_2^- and NO_3^- in the water column. Temporary decoupling of the rates of oxidation of N species by microbial communities can also occur, leading to temporary accumulation of NH_3 or NO_2^-. The microbially mediated oxidation of NH_3 to NO_2^- is considered to be the rate-limiting step for overall nitrification (Ginestet *et al.*,1998).

Monitoring data from January 4, 2016 through January 29, 2018 indicate that the proportion of NO_3^- observed in lake discharge (BJ 3.10) ranges from 92.8 to 99.7%, whereas NH_3 and NO_2^- range

from 0.2 to 7.0% and 0.1 to 2.3%, respectively (Figure 8). The proportion of T-N relative to the sum of the N species indicates inorganic N species fully account for all N loads exported from the lake. The enrichment of NO_3^- at BJ 3.10 relative to mine water (Section 4.2) is inferred to reflect nitrification (naturally occurring NH_3 and NO_2^- oxidation) in the Brucejack Lake water column. Recent monitoring data indicate the proportion of N as NH_3 has increased at the lake outlet suggesting the nitrification rate in the lake is not keeping pace with the NH_3 loads added to the lake. The proportion of NO_2^- has remained stable indicating nitrification is occurring, however the proportional build-up of NH_3 suggests that the nitrification rate is limited by the microbially-mediated oxidation of NH_3 to NO_2^-.

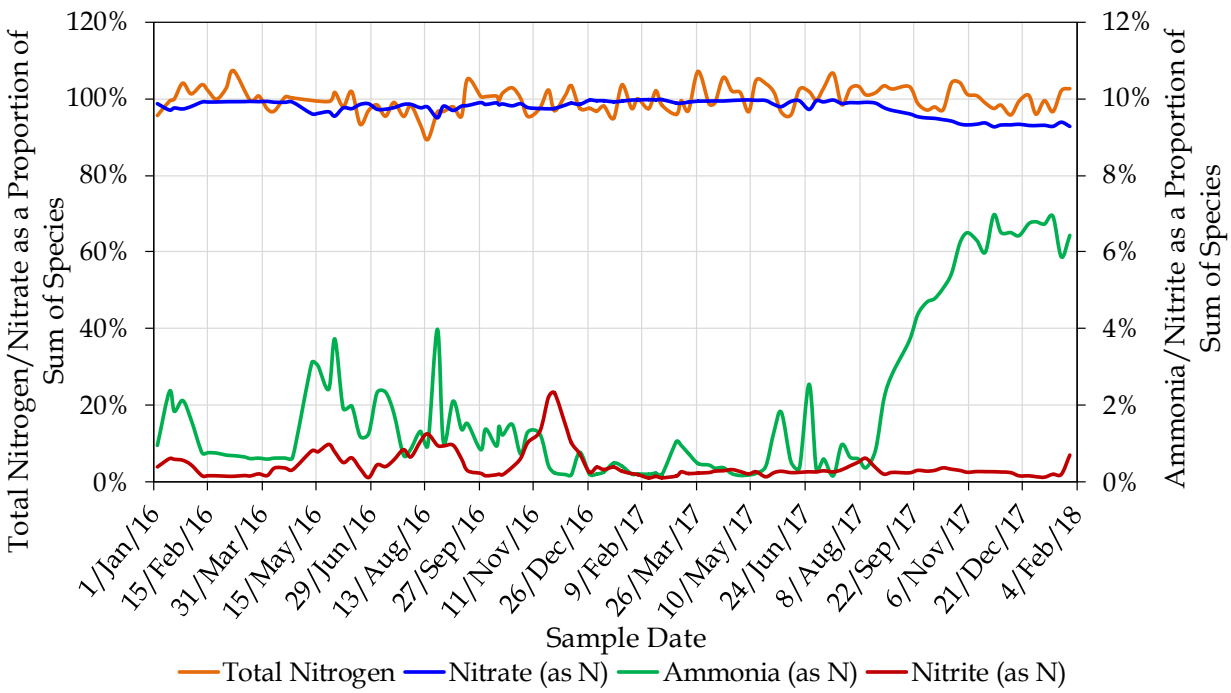

Figure 8: Brucejack Lake outlet (BJ 3.10) N species and total nitrogen distribution as a proportion of the sum of the species, from January 4, 2016 through February 4, 2018.

The BJ 3.10 median and maximum values shown in Table 12 are calculated using monitoring data collected between January 4, 2016 and January 29, 2018 (Table 7). For reference, the distributions used in the 2016 revision of the water quality model (Lorax, 2016) are also included in Table 12. The normalized N speciation at BJ 3.10 derived from median values is similar to the 2016 water quality model assumptions (Lorax, 2016), however the median values do not reflect the recent increase in the proportion of NH_3 (Figure 8).

Table 12:
Summary of N Species Distribution at Brucejack Lake Outlet (BJ 3.10)

Basis of N Species Distribution	NO_3^-	NO_2^-	NH_3
2016 Water Quality Model Update	94.0%	2.0%	4.0%
Jan 4, 2016 – Jan 29, 2018; median	98.5%	0.3%	1.0%
Jan 4, 2016 – Jan 29, 2018; median (normalized)	98.9%	0.3%	1.0%
Jan 4, 2016 – Jan 29, 2018; maximum	99.7%	2.3%	7.0%

A recent investigation of the lake water column indicates NH_3 constitutes a significant proportion of the N at all depths. Lake water column samples collected on February 1, 2018 monitored eight depth intervals ranging from 2 to 76 m (Figure 9). The relative proportion of NH_3 increases from 6.4 to 18.2%, from the 2 to 76 m depths, respectively. The proportion of NH_3 in the surface water is similar to observations at BJ 3.10, consistent with the expectation that lake waters from the stratified surface layer are discharging at the lake outlet. Lake stratification is confirmed by a thermocline measured at approximately 7 m depth and is illustrated by the abrupt increase in the proportion of NH_3 from the 7 m depth (6.5%) to the 15 m depth (9.8%). The proportion of NO_2^- is consistently low (generally < 1%) throughout the water column. The observation of increasing proportions of NH_3 in deeper waters coupled with the consistent proportion of NO_2^- at all depths indicates that nitrification is occurring, and that NH_3 oxidation is the rate-limiting step for nitrification processes at all depths in the lake. As described previously, these data suggest that the nitrification rate in the lake is not keeping pace with the NH_3 loads added to the lake, leading to NH_3 accumulation in the water column.

As noted previously, microbially-mediated nitrification rates are influenced by seasonal factors such as water temperature (*i.e.*, nitrification rates decrease with decreasing temperature); therefore, lower rates may be observed in the lake water during ice-covered winter conditions. Low temperatures reduce microbial population growth rates, thereby increasing the lag time for microbial community response to increased NH_3 concentration. This lag time would be reflected by a temporary accumulation of NH_3 that peaks and then decreases as microbial populations (and the nitrification rate) increase. The recent monitoring data indicate that nitrification is occurring; however, the present nitrification rate is insufficient to keep pace with the rate of NH_3 loading to the lake and consequently, NH_3 is accumulating in the deeper lake waters. If nitrification rates remain low, it is possible that the proportion of NH_3 at the lake outlet could approach the distribution of N loads added to the lake, principally from WTP effluent, tailings and waste rock.

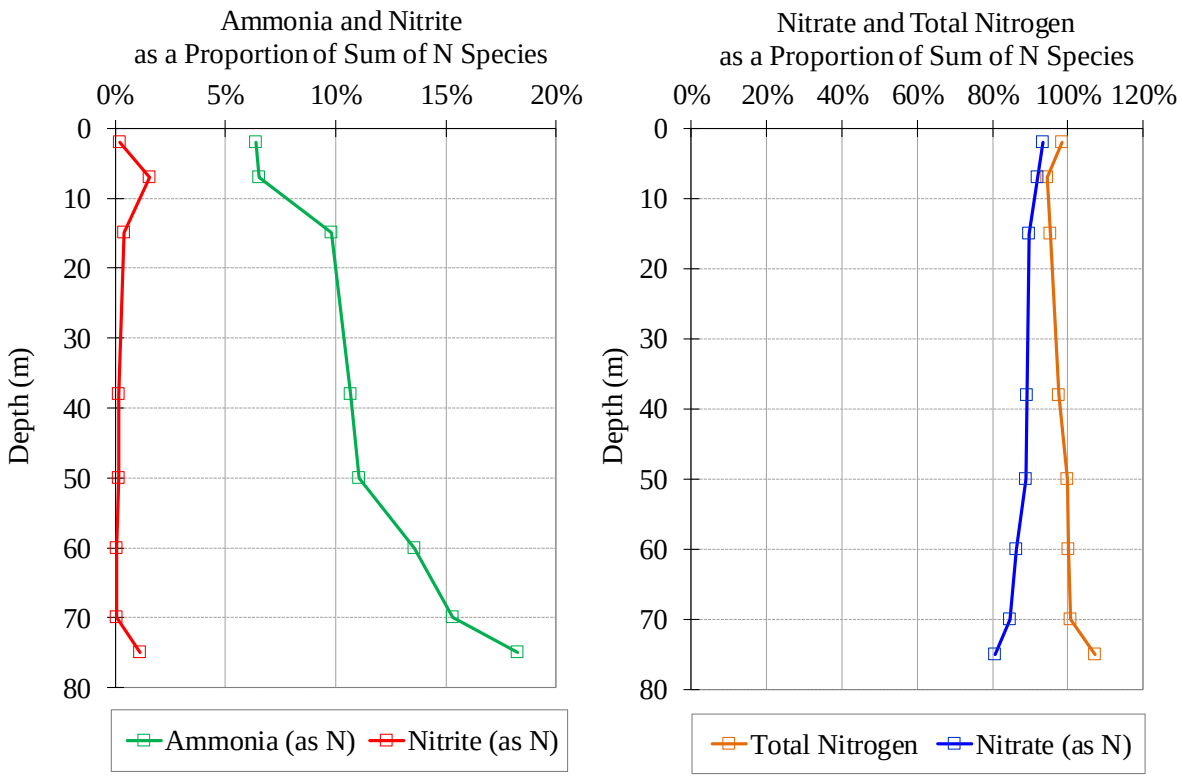

Figure 9: Brucejack Lake water column N species and total nitrogen distribution as a proportion of the sum of the species as measured on February 1, 2018.

To address the uncertainty associated with variable nitrification rates, N species distribution endpoints are used to model N species concentrations at the lake outlet (BJ 3.10). For high rates of nitrification, it is assumed that NH_3 is substantially converted to NO_3^-; whereas for low nitrification rates, is it assumed that NH_3 behaves conservatively in the lake. Under both nitrification scenarios, NO_2^- is assumed to represent a small proportion of the total N at the lake outlet. For modelling, the NO_3^- and NO_2^- are assumed to be 99.7% and 2.7% of the total N, respectively (Table 12, BJ 3.10 maximum values), whereas for NH_3 32.2% is assumed (Table 11, maximum value). Although these proportions sum to 134.6% of the total N modelled for BJ 3.10, this approach is considered to conservatively represent both low and high rates of nitrification. The nitrification rates and the associated N distribution in Brucejack Lake will continue to be monitored throughout LOM to validate the modelling assumptions.

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Appendix 3: Water Quality Model Results

APPENDIX 3.1: WATER QUALITY PREDICTIONS AT STATION BJ 3.10

APPENDIX 3.2: WATER QUALITY PREDICTIONS AT STATION BJ 2.62

PRETIVM

APPENDIX 3.1: WATER QUALITY PREDICTIONS AT STATION BJ 3.10

Appendix 3.1-1: Maximum Base Case Predictions for Scenario 1 at BJ 3.10

Operations Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.8	8.6	**0.20**	1.1	0.11	72	0.000025	0.039	0.0060	0.050	0.059	0.000058	0.00023	22	0.000011	0.00012	0.00043	0.00027	0.015	0.0000052	4.1	0.055
Feb	2.8	8.6	**0.20**	1.1	0.11	72	0.000025	0.038	0.0060	0.050	0.059	0.000059	0.00023	22	0.000011	0.00012	0.00043	0.00027	0.015	0.0000052	4.1	0.055
Mar	2.8	8.6	**0.20**	1.1	0.11	72	0.000025	0.038	0.0060	0.050	0.059	0.000059	0.00023	22	0.000011	0.00012	0.00043	0.00027	0.015	0.0000052	4.1	0.055
Apr	2.8	8.6	**0.20**	1.1	0.11	72	0.000025	0.038	0.0060	0.050	0.059	0.000059	0.00023	22	0.000011	0.00012	0.00043	0.00027	0.015	0.0000052	4.1	0.055
May	2.8	8.5	**0.20**	1.1	0.11	72	0.000025	0.038	0.0060	0.050	0.058	0.000059	0.00023	22	0.000011	0.00012	0.00043	0.00027	0.015	0.0000052	4.1	0.055
Jun	2.4	7.3	**0.17**	1.0	0.094	63	0.000022	0.035	0.0052	0.044	0.064	0.000057	0.00024	25	0.000012	0.00011	0.00038	0.00027	0.015	0.0000052	3.5	0.047
Jul	1.6	4.8	**0.11**	0.74	0.065	45	0.000016	0.027	0.0035	0.030	0.052	0.000053	0.00023	19	0.0000094	0.000089	0.00026	0.00025	0.014	0.0000049	2.4	0.031
Aug	2.8	8.7	**0.20**	1.2	0.11	75	0.000025	0.039	0.0060	0.052	0.061	0.000056	0.00023	24	0.000012	0.00013	0.00045	0.00027	0.014	0.0000051	4.2	0.058
Sep	2.3	7.0	**0.16**	0.98	0.091	62	0.000021	0.033	0.0050	0.043	0.057	0.000054	0.00023	21	0.000011	0.00011	0.00037	0.00027	0.014	0.0000050	3.4	0.047
Oct	1.9	6.0	**0.14**	0.87	0.079	54	0.000019	0.030	0.0043	0.037	0.053	0.000052	0.00023	19	0.0000097	0.00010	0.00033	0.00026	0.014	0.0000050	3.0	0.040
Nov	2.8	8.6	**0.20**	1.2	0.11	74	0.000025	0.039	0.0060	0.052	0.059	0.000055	0.00023	22	0.000011	0.00013	0.00045	0.00028	0.014	0.0000052	4.2	0.057
Dec	2.8	8.6	**0.20**	1.2	0.11	74	0.000025	0.039	0.0060	0.052	0.059	0.000057	0.00023	22	0.000011	0.00013	0.00045	0.00027	0.015	0.0000052	4.2	0.057
Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.4	7.6	**0.18**	1.2	0.11	74	0.000025	0.034	0.0052	0.051	0.039	0.000058	0.00023	18	0.0000098	0.00013	0.00045	0.00027	0.026	0.0000051	4.2	0.057
Feb	2.4	7.5	**0.17**	1.1	0.11	74	0.000025	0.034	0.0052	0.051	0.039	0.000059	0.00023	18	0.0000098	0.00013	0.00045	0.00027	0.027	0.0000051	4.2	0.057
Mar	2.4	7.5	**0.17**	1.1	0.11	74	0.000025	0.034	0.0052	0.051	0.039	0.000059	0.00023	18	0.0000098	0.00013	0.00045	0.00027	0.027	0.0000051	4.2	0.056
Apr	2.4	7.5	**0.17**	1.1	0.11	74	0.000025	0.034	0.0052	0.051	0.039	0.000059	0.00023	18	0.0000098	0.00013	0.00045	0.00027	0.028	0.0000051	4.2	0.056
May	2.4	7.5	**0.17**	1.1	0.11	73	0.000025	0.033	0.0051	0.051	0.039	0.000058	0.00023	18	0.0000098	0.00013	0.00044	0.00027	0.028	0.0000051	4.1	0.056
Jun	2.0	6.2	**0.14**	0.99	0.092	63	0.000022	0.030	0.0044	0.043	0.038	0.000057	0.00024	16	0.0000090	0.00011	0.00038	0.00027	0.027	0.0000051	3.5	0.047
Jul	1.3	4.0	**0.093**	0.72	0.063	44	0.000016	0.023	0.0030	0.030	0.035	0.000052	0.00023	13	0.0000074	0.000089	0.00026	0.00025	0.023	0.0000048	2.3	0.030
Aug	1.9	6.0	**0.14**	0.98	0.090	65	0.000021	0.029	0.0046	0.042	0.037	0.000056	0.00023	17	0.0000092	0.00011	0.00036	0.00027	0.028	0.0000049	3.6	0.045
Sep	1.6	5.0	**0.11**	0.85	0.076	55	0.000018	0.026	0.0039	0.035	0.036	0.000054	0.00023	15	0.0000084	0.000100	0.00031	0.00026	0.026	0.0000049	3.0	0.038
Oct	1.4	4.3	**0.098**	0.76	0.067	48	0.000016	0.024	0.0034	0.031	0.035	0.000052	0.00023	14	0.0000079	0.000092	0.00027	0.00025	0.025	0.0000048	2.6	0.032
Nov	1.7	5.2	**0.12**	0.90	0.080	59	0.000019	0.026	0.0043	0.037	0.036	0.000054	0.00023	16	0.0000089	0.00010	0.00032	0.00026	0.030	0.0000049	3.3	0.040
Dec	1.7	5.2	**0.12**	0.90	0.080	59	0.000019	0.026	0.0042	0.037	0.037	0.000056	0.00023	16	0.0000089	0.00010	0.00032	0.00026	0.031	0.0000049	3.3	0.039
Post-Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.55	1.7	0.040	0.52	0.038	36	0.0000092	0.015	0.0027	0.015	0.032	0.000057	0.00023	13	0.0000074	0.000069	0.00015	0.00024	0.042	0.0000047	1.9	0.015
Feb	0.55	1.7	0.039	0.52	0.038	36	0.0000092	0.015	0.0026	0.015	0.032	0.000058	0.00023	13	0.0000074	0.000069	0.00015	0.00024	0.042	0.0000047	1.9	0.014
Mar	0.55	1.7	0.039	0.52	0.038	36	0.0000092	0.015	0.0026	0.015	0.033	0.000058	0.00023	13	0.0000074	0.000069	0.00015	0.00024	0.043	0.0000047	1.9	0.014
Apr	0.55	1.7	0.039	0.52	0.038	36	0.0000092	0.015	0.0026	0.015	0.033	0.000058	0.00023	13	0.0000074	0.000069	0.00015	0.00024	0.043	0.0000047	1.8	0.014
May	0.54	1.7	0.039	0.52	0.038	36	0.0000092	0.015	0.0026	0.015	0.033	0.000058	0.00023	13	0.0000074	0.000069	0.00015	0.00024	0.044	0.0000047	1.8	0.014
Jun	0.46	1.4	0.033	0.48	0.034	32	0.0000085	0.015	0.0023	0.014	0.032	0.000057	0.00023	12	0.0000071	0.000066	0.00013	0.00024	0.040	0.0000047	1.6	0.012
Jul	0.30	0.92	0.021	0.39	0.025	23	0.0000071	0.013	0.0016	0.010	0.031	0.000052	0.00023	10	0.0000061	0.000058	0.00010	0.00024	0.031	0.0000046	1.1	0.0079
Aug	0.38	1.2	0.027	0.47	0.032	33	0.0000077	0.014	0.0024	0.012	0.031	0.000055	0.00023	12	0.0000071	0.000063	0.00012	0.00024	0.039	0.0000046	1.7	0.011
Sep	0.31	0.95	0.022	0.42	0.027	28	0.0000071	0.013	0.0020	0.011	0.031	0.000053	0.00023	11	0.0000066	0.000060	0.00010	0.00024	0.035	0.0000046	1.3	0.0085
Oct	0.26	0.80	0.019	0.39	0.024	25	0.0000067	0.013	0.0018	0.0096	0.031	0.000051	0.00022	11	0.0000063	0.000057	0.000095	0.00024	0.033	0.0000046	1.2	0.0073
Nov	0.33	1.0	0.023	0.45	0.029	31	0.0000073	0.013	0.0023	0.011	0.031	0.000054	0.00023	12	0.0000070	0.000062	0.00011	0.00024	0.040	0.0000046	1.6	0.0093
Dec	0.33	1.0	0.023	0.45	0.029	31	0.0000073	0.013	0.0023	0.011	0.032	0.000056	0.00023	12	0.0000071	0.000062	0.00011	0.00024	0.041	0.0000046	1.6	0.0092
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as CaCO3.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-1: Maximum Base Case Predictions for Scenario 1 at BJ 3.10

Operations Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	1.8	0.16	0.0067	12	0.00045	0.016	0.00018	0.012	0.00078	1.5	0.000070	0.31	0.0065	0.000047	0.00074	0.00055	0.0018	0.000034	0.33	**0.0065**	0.052	0.066	0.000071	0.0054	21
Feb	1.8	0.16	0.0067	12	0.00045	0.016	0.00018	0.012	0.00078	1.5	0.000070	0.31	0.0065	0.000047	0.00074	0.00055	0.0018	0.000034	0.33	**0.0065**	0.052	0.066	0.000073	0.0058	21
Mar	1.8	0.16	0.0067	12	0.00045	0.016	0.00018	0.012	0.00078	1.5	0.000070	0.31	0.0065	0.000047	0.00074	0.00055	0.0018	0.000034	0.33	**0.0065**	0.052	0.066	0.000073	0.0058	21
Apr	1.9	0.16	0.0067	12	0.00045	0.016	0.00018	0.012	0.00078	1.5	0.000070	0.31	0.0065	0.000047	0.00074	0.00055	0.0018	0.000034	0.32	**0.0065**	0.052	0.066	0.000073	0.0058	21
May	1.9	0.16	0.0067	12	0.00045	0.016	0.00018	0.012	0.00078	1.5	0.000070	0.31	0.0065	0.000047	0.00074	0.00055	0.0018	0.000034	0.32	**0.0064**	0.052	0.066	0.000073	0.0058	21
Jun	1.6	0.14	0.0058	11	0.00042	0.014	0.00016	0.010	0.00068	1.4	0.000067	0.29	0.0062	0.000041	0.00064	0.00055	0.0018	0.000032	0.35	**0.0057**	0.046	0.072	0.000069	0.0049	23
Jul	1.2	0.096	0.0039	7.2	0.00035	0.0091	0.00011	0.0069	0.00047	1.1	0.000059	0.21	0.0056	0.000029	0.00043	0.00051	0.0016	0.000027	0.32	0.0041	0.032	0.060	0.000061	0.0033	18
Aug	2.0	0.18	0.0069	12	0.00046	0.016	0.00019	0.013	0.00081	1.6	0.000071	0.33	0.0065	0.000050	0.00079	0.00055	0.0018	0.000035	0.35	**0.0066**	0.054	0.069	0.000066	0.0045	22
Sep	1.6	0.14	0.0057	10	0.00041	0.013	0.00016	0.010	0.00067	1.4	0.000066	0.27	0.0062	0.000041	0.00064	0.00053	0.0018	0.000030	0.32	**0.0054**	0.044	0.064	0.000062	0.0037	20
Oct	1.4	0.12	0.0049	8.8	0.00039	0.011	0.00014	0.0088	0.00058	1.2	0.000063	0.24	0.0059	0.000036	0.00055	0.00052	0.0017	0.000026	0.29	0.0048	0.039	0.060	0.000060	0.0032	18
Nov	2.0	0.18	0.0069	12	0.00046	0.016	0.00019	0.013	0.00081	1.6	0.000071	0.33	0.0065	0.000049	0.00079	0.00055	0.0019	0.000034	0.33	**0.0065**	0.053	0.067	0.000064	0.0040	21
Dec	2.0	0.18	0.0069	12	0.00046	0.016	0.00019	0.013	0.00080	1.6	0.000071	0.33	0.0065	0.000050	0.00078	0.00055	0.0018	0.000034	0.33	**0.0065**	0.054	0.067	0.000069	0.0049	21
Closure Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.0	0.18	0.0068	12	0.00046	0.016	0.00019	0.013	0.00080	1.6	0.000071	0.33	0.0065	0.000050	0.00078	0.00055	0.0018	0.000034	0.22	**0.0056**	0.054	0.045	0.000071	0.0057	18
Feb	2.0	0.18	0.0068	12	0.00046	0.016	0.00019	0.013	0.00080	1.6	0.000071	0.33	0.0065	0.000050	0.00078	0.00055	0.0018	0.000034	0.22	**0.0056**	0.054	0.045	0.000074	0.0063	18
Mar	2.0	0.18	0.0068	12	0.00046	0.016	0.00019	0.013	0.00080	1.6	0.000071	0.32	0.0065	0.000050	0.00078	0.00055	0.0018	0.000034	0.21	**0.0056**	0.054	0.045	0.000073	0.0063	18
Apr	2.0	0.18	0.0068	12	0.00046	0.016	0.00019	0.013	0.00080	1.6	0.000071	0.32	0.0065	0.000050	0.00078	0.00055	0.0018	0.000034	0.21	**0.0056**	0.054	0.045	0.000073	0.0063	18
May	1.9	0.18	0.0067	12	0.00046	0.016	0.00019	0.012	0.00079	1.6	0.000071	0.32	0.0065	0.000050	0.00077	0.00055	0.0018	0.000034	0.21	**0.0056**	0.053	0.045	0.000073	0.0062	18
Jun	1.7	0.16	0.0057	10	0.00042	0.013	0.00016	0.010	0.00067	1.4	0.000067	0.28	0.0062	0.000042	0.00065	0.00054	0.0018	0.000032	0.22	0.0049	0.045	0.044	0.000069	0.0053	16
Jul	1.2	0.10	0.0038	6.9	0.00035	0.0087	0.00011	0.0068	0.00045	1.1	0.000059	0.20	0.0056	0.000029	0.00042	0.00051	0.0016	0.000027	0.23	0.0035	0.031	0.041	0.000060	0.0035	13
Aug	2.0	0.19	0.0056	9.7	0.00042	0.013	0.00015	0.010	0.00065	1.3	0.000065	0.29	0.0061	0.000041	0.00062	0.00053	0.0017	0.000031	0.22	**0.0051**	0.044	0.043	0.000067	0.0049	17
Sep	1.7	0.16	0.0047	8.2	0.00039	0.011	0.00013	0.0084	0.00055	1.2	0.000062	0.25	0.0058	0.000035	0.00052	0.00052	0.0017	0.000027	0.21	0.0043	0.037	0.042	0.000063	0.0040	15
Oct	1.5	0.13	0.0040	7.1	0.00036	0.0091	0.00012	0.0072	0.00048	1.1	0.000059	0.22	0.0056	0.000030	0.00045	0.00051	0.0016	0.000024	0.20	0.0038	0.032	0.041	0.000060	0.0034	14
Nov	1.9	0.18	0.0049	8.5	0.00040	0.011	0.00014	0.0088	0.00058	1.2	0.000063	0.27	0.0059	0.000036	0.00054	0.00052	0.0017	0.000028	0.21	0.0047	0.038	0.043	0.000064	0.0042	16
Dec	1.9	0.18	0.0049	8.5	0.00040	0.011	0.00014	0.0088	0.00057	1.2	0.000063	0.27	0.0059	0.000036	0.00054	0.00052	0.0017	0.000028	0.21	0.0047	0.039	0.043	0.000069	0.0053	16
Post-Closure Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	1.6	0.17	0.0021	3.4	0.00031	0.0040	0.000065	0.0032	0.00024	0.75	0.000051	0.18	0.0050	0.000017	0.00020	0.00048	0.0015	0.000018	0.20	0.0031	0.018	0.039	0.000072	0.0062	13
Feb	1.6	0.17	0.0021	3.4	0.00031	0.0040	0.000065	0.0032	0.00024	0.75	0.000051	0.18	0.0050	0.000017	0.00020	0.00048	0.0014	0.000018	0.20	0.0031	0.018	0.038	0.000074	0.0067	13
Mar	1.6	0.17	0.0021	3.4	0.00031	0.0040	0.000065	0.0032	0.00024	0.75	0.000051	0.18	0.0050	0.000017	0.00020	0.00048	0.0014	0.000018	0.20	0.0031	0.018	0.038	0.000074	0.0067	13
Apr	1.6	0.17	0.0021	3.4	0.00031	0.0040	0.000065	0.0032	0.00024	0.75	0.000051	0.18	0.0050	0.000017	0.00020	0.00048	0.0014	0.000018	0.19	0.0031	0.018	0.038	0.000074	0.0066	13
May	1.6	0.17	0.0021	3.3	0.00031	0.0040	0.000065	0.0031	0.00024	0.75	0.000051	0.18	0.0050	0.000017	0.00020	0.00048	0.0014	0.000018	0.19	0.0031	0.018	0.038	0.000074	0.0066	13
Jun	1.4	0.15	0.0018	3.0	0.00030	0.0035	0.000059	0.0027	0.00021	0.72	0.000051	0.16	0.0050	0.000015	0.00017	0.00049	0.0015	0.000018	0.21	0.0028	0.016	0.039	0.000070	0.0056	12
Jul	1.0	0.098	0.0013	2.2	0.00027	0.0024	0.000046	0.0018	0.00015	0.63	0.000048	0.12	0.0048	0.000011	0.00012	0.00047	0.0014	0.000018	0.22	0.0022	0.012	0.038	0.000061	0.0037	10
Aug	1.6	0.17	0.0017	2.6	0.00030	0.0029	0.000054	0.0023	0.00019	0.67	0.000049	0.17	0.0048	0.000014	0.00015	0.00047	0.0014	0.000018	0.21	0.0029	0.014	0.038	0.000067	0.0052	12
Sep	1.4	0.14	0.0014	2.3	0.00028	0.0025	0.000048	0.0019	0.00016	0.64	0.000048	0.15	0.0048	0.000012	0.00012	0.00047	0.0014	0.000016	0.19	0.0025	0.012	0.037	0.000063	0.0042	11
Oct	1.2	0.12	0.0013	2.0	0.00027	0.0022	0.000044	0.0017	0.00015	0.61	0.000048	0.13	0.0047	0.000011	0.00011	0.00046	0.0014	0.000014	0.19	0.0022	0.011	0.037	0.000060	0.0036	11
Nov	1.6	0.17	0.0016	2.4	0.00029	0.0026	0.000051	0.0020	0.00018	0.65	0.000049	0.16	0.0048	0.000012	0.00013	0.00047	0.0014	0.000016	0.20	0.0028	0.013	0.038	0.000064	0.0045	12
Dec	1.6	0.17	0.0016	2.3	0.00029	0.0026	0.000051	0.0020	0.00018	0.65	0.000049	0.16	0.0048	0.000013	0.00013	0.00047	0.0014	0.000016	0.20	0.0028	0.013	0.038	0.000069	0.0055	12
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as CaCO3.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-1: Maximum Base Case Predictions for Scenario 1 at BJ 3.10

Operations Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000012	0.00024	0.0011	0.00054	0.15	0.0000052	4.2	0.055	1.9	0.17	0.0067	12	0.00079	0.024	0.00046	0.012	0.00082	1.8	0.00040	0.31	0.0065	0.000085	0.00076	0.00081	0.0028
Feb	0.000012	0.00025	0.0011	0.00054	0.15	0.0000052	4.2	0.055	1.9	0.17	0.0067	12	0.00078	0.024	0.00046	0.012	0.00082	1.8	0.00040	0.31	0.0065	0.000085	0.00076	0.00080	0.0028
Mar	0.000012	0.00025	0.0011	0.00054	0.14	0.0000052	4.2	0.055	1.9	0.17	0.0067	12	0.00078	0.024	0.00046	0.012	0.00082	1.8	0.00040	0.31	0.0065	0.000085	0.00076	0.00080	0.0028
Apr	0.000012	0.00025	0.0011	0.00054	0.14	0.0000052	4.2	0.055	1.9	0.17	0.0068	12	0.00078	0.024	0.00046	0.012	0.00082	1.8	0.00040	0.31	0.0065	0.000085	0.00076	0.00080	0.0028
May	0.000012	0.00025	0.0011	0.00054	0.14	0.0000052	4.2	0.055	1.9	0.17	0.0067	12	0.00078	0.024	0.00046	0.012	0.00082	1.8	0.00040	0.31	0.0065	0.000085	0.00076	0.00080	0.0027
Jun	0.000013	0.00023	0.0013	0.00056	0.16	0.0000052	3.6	0.047	1.7	0.15	0.0058	11	0.00090	0.022	0.00051	0.010	0.00071	1.7	0.00048	0.28	0.0062	0.000080	0.00066	0.00085	0.0030
Jul	0.000010	0.00019	0.00090	0.00057	0.18	0.0000049	2.5	0.031	1.2	0.11	0.0040	7.2	0.00066	0.018	0.00041	0.0069	0.00049	1.5	0.00033	0.20	0.0056	0.000068	0.00045	0.00071	0.0024
Aug	0.000013	0.00024	0.0012	0.00057	0.16	0.0000052	4.3	0.058	2.0	0.19	0.0070	12	0.00084	0.025	0.00049	0.013	0.00084	1.9	0.00044	0.33	0.0065	0.000087	0.00080	0.00083	0.0029
Sep	0.000012	0.00021	0.0011	0.00052	0.14	0.0000051	3.5	0.047	1.7	0.15	0.0057	10	0.00074	0.021	0.00044	0.010	0.00069	1.7	0.00038	0.28	0.0062	0.000079	0.00066	0.00077	0.0026
Oct	0.000011	0.00019	0.00095	0.00050	0.13	0.0000050	3.1	0.040	1.5	0.13	0.0049	8.8	0.00067	0.018	0.00040	0.0089	0.00061	1.6	0.00033	0.24	0.0059	0.000074	0.00057	0.00073	0.0024
Nov	0.000012	0.00023	0.0011	0.00054	0.15	0.0000052	4.3	0.057	2.0	0.19	0.0069	12	0.00079	0.024	0.00046	0.013	0.00084	1.9	0.00040	0.33	0.0065	0.000088	0.00080	0.00081	0.0027
Dec	0.000012	0.00024	0.0011	0.00054	0.15	0.0000052	4.3	0.057	2.0	0.18	0.0069	12	0.00079	0.024	0.00046	0.013	0.00084	1.9	0.00040	0.33	0.0065	0.000088	0.00080	0.00081	0.0028
Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000010	0.00025	0.00057	0.00054	0.16	0.0000051	4.3	0.057	2.0	0.19	0.0069	12	0.00047	0.024	0.00037	0.013	0.00084	1.9	0.000082	0.33	0.0065	0.000088	0.00080	0.00055	0.0019
Feb	0.000010	0.00025	0.00057	0.00054	0.16	0.0000051	4.3	0.057	2.0	0.19	0.0068	12	0.00047	0.024	0.00037	0.013	0.00084	1.9	0.000083	0.33	0.0065	0.000088	0.00079	0.00055	0.0019
Mar	0.000010	0.00025	0.00057	0.00054	0.16	0.0000051	4.3	0.057	2.0	0.19	0.0068	12	0.00047	0.024	0.00037	0.013	0.00083	1.9	0.000083	0.33	0.0065	0.000087	0.00079	0.00055	0.0019
Apr	0.000010	0.00025	0.00057	0.00054	0.16	0.0000051	4.3	0.056	2.0	0.19	0.0068	12	0.00047	0.024	0.00037	0.013	0.00083	1.9	0.000083	0.32	0.0065	0.000087	0.00079	0.00055	0.0019
May	0.000010	0.00025	0.00056	0.00054	0.16	0.0000051	4.2	0.056	2.0	0.19	0.0068	12	0.00047	0.024	0.00037	0.012	0.00083	1.9	0.000083	0.32	0.0065	0.000087	0.00079	0.00055	0.0019
Jun	0.0000095	0.00023	0.00049	0.00056	0.17	0.0000051	3.6	0.047	1.7	0.17	0.0057	10	0.00043	0.021	0.00035	0.011	0.00070	1.7	0.000077	0.28	0.0062	0.000081	0.00066	0.00054	0.0019
Jul	0.0000077	0.00019	0.00035	0.00057	0.19	0.0000048	2.4	0.031	1.2	0.11	0.0038	6.9	0.00036	0.017	0.00031	0.0069	0.00047	1.4	0.000065	0.20	0.0056	0.000068	0.00044	0.00051	0.0017
Aug	0.0000096	0.00023	0.00047	0.00056	0.18	0.0000049	3.7	0.045	2.0	0.20	0.0056	9.7	0.00043	0.021	0.00034	0.010	0.00068	1.7	0.000075	0.29	0.0061	0.000079	0.00064	0.00053	0.0018
Sep	0.0000090	0.00020	0.00043	0.00052	0.15	0.0000049	3.1	0.038	1.7	0.16	0.0047	8.2	0.00040	0.018	0.00031	0.0084	0.00058	1.6	0.000070	0.25	0.0058	0.000073	0.00053	0.00052	0.0017
Oct	0.0000086	0.00018	0.00040	0.00049	0.14	0.0000048	2.7	0.033	1.5	0.14	0.0041	7.1	0.00037	0.016	0.00029	0.0073	0.00051	1.4	0.000066	0.22	0.0056	0.000069	0.00046	0.00051	0.0017
Nov	0.0000095	0.00021	0.00044	0.00053	0.16	0.0000049	3.4	0.040	1.9	0.19	0.0049	8.5	0.00041	0.019	0.00032	0.0088	0.00061	1.6	0.000071	0.27	0.0059	0.000074	0.00056	0.00052	0.0018
Dec	0.0000095	0.00022	0.00044	0.00053	0.16	0.0000049	3.4	0.040	1.9	0.19	0.0049	8.5	0.00041	0.019	0.00032	0.0088	0.00061	1.6	0.000073	0.27	0.0059	0.000074	0.00056	0.00052	0.0018
Post-Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.0000080	0.00020	0.00027	0.00051	0.17	0.0000047	2.0	0.015	1.7	0.18	0.0022	3.4	0.00033	0.011	0.00025	0.0032	0.00028	1.1	0.000063	0.18	0.0050	0.000055	0.00022	0.00048	0.0016
Feb	0.0000080	0.00021	0.00027	0.00051	0.17	0.0000047	2.0	0.015	1.7	0.18	0.0021	3.4	0.00033	0.011	0.00025	0.0032	0.00028	1.1	0.000064	0.18	0.0050	0.000055	0.00022	0.00048	0.0016
Mar	0.0000080	0.00021	0.00027	0.00051	0.17	0.0000047	2.0	0.015	1.7	0.18	0.0021	3.4	0.00033	0.011	0.00025	0.0032	0.00028	1.1	0.000064	0.18	0.0050	0.000055	0.00022	0.00048	0.0016
Apr	0.0000080	0.00020	0.00027	0.00051	0.17	0.0000047	2.0	0.015	1.7	0.18	0.0021	3.4	0.00033	0.011	0.00025	0.0032	0.00028	1.1	0.000064	0.18	0.0050	0.000055	0.00021	0.00048	0.0016
May	0.0000080	0.00020	0.00027	0.00051	0.17	0.0000047	2.0	0.014	1.7	0.18	0.0021	3.3	0.00033	0.011	0.00025	0.0032	0.00028	1.1	0.000064	0.18	0.0050	0.000055	0.00021	0.00048	0.0016
Jun	0.0000075	0.00019	0.00025	0.00053	0.18	0.0000047	1.7	0.012	1.5	0.16	0.0019	3.0	0.00031	0.011	0.00025	0.0027	0.00024	1.1	0.000061	0.16	0.0050	0.000054	0.00019	0.00049	0.0016
Jul	0.0000064	0.00016	0.00020	0.00055	0.19	0.0000046	1.2	0.0080	1.1	0.11	0.0013	2.2	0.00028	0.010	0.00024	0.0018	0.00017	1.0	0.000055	0.12	0.0048	0.000050	0.00013	0.00047	0.0015
Aug	0.0000075	0.00018	0.00022	0.00054	0.19	0.0000046	1.8	0.011	1.7	0.18	0.0017	2.6	0.00031	0.010	0.00024	0.0024	0.00022	1.0	0.000059	0.17	0.0048	0.000052	0.00016	0.00047	0.0015
Sep	0.0000073	0.00016	0.00023	0.00050	0.16	0.0000046	1.5	0.0087	1.4	0.15	0.0014	2.3	0.00029	0.0088	0.00023	0.0019	0.00019	0.98	0.000056	0.15	0.0048	0.000050	0.00014	0.00047	0.0015
Oct	0.0000071	0.00015	0.00023	0.00047	0.15	0.0000046	1.3	0.0076	1.2	0.13	0.0013	2.0	0.00028	0.0080	0.00022	0.0017	0.00018	0.95	0.000054	0.13	0.0047	0.000049	0.00012	0.00046	0.0015
Nov	0.0000076	0.00017	0.00023	0.00051	0.17	0.0000046	1.7	0.0094	1.6	0.18	0.0016	2.4	0.00030	0.0091	0.00023	0.0021	0.00021	1.00	0.000057	0.16	0.0048	0.000051	0.00014	0.00047	0.0015
Dec	0.0000077	0.00018	0.00023	0.00051	0.17	0.0000046	1.7	0.0094	1.6	0.18	0.0016	2.3	0.00031	0.0091	0.00024	0.0021	0.00021	1.00	0.000059	0.16	0.0048	0.000051	0.00015	0.00047	0.0015
Long-Term BC FWAL	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as CaCO3.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-2: Maximum Base Case Predictions for Scenario 2 at BJ 3.10

Operations Phase																								
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**	**D-Mn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.4	7.3	**0.17**	1.4	0.14	92	0.000032	0.036	0.0053	0.065	0.059	0.000058	0.00024	22	0.000011	0.00036	0.00058	0.00027	0.014	0.0000052	5.0	0.072	2.1	0.19
Feb	2.4	7.3	**0.17**	1.4	0.14	92	0.000032	0.036	0.0053	0.065	0.059	0.000059	0.00024	22	0.000011	0.00036	0.00058	0.00027	0.014	0.0000052	5.0	0.072	2.1	0.19
Mar	2.4	7.3	**0.17**	1.4	0.14	92	0.000032	0.036	0.0053	0.065	0.059	0.000059	0.00024	22	0.000011	0.00036	0.00058	0.00027	0.014	0.0000052	5.0	0.072	2.1	0.19
Apr	2.4	7.3	**0.17**	1.4	0.14	92	0.000032	0.036	0.0053	0.066	0.059	0.000059	0.00024	22	0.000011	0.00036	0.00058	0.00027	0.014	0.0000052	5.0	0.072	2.1	0.19
May	2.4	7.3	**0.17**	1.4	0.14	92	0.000032	0.036	0.0053	0.066	0.058	0.000059	0.00024	22	0.000011	0.00036	0.00058	0.00027	0.014	0.0000052	5.0	0.072	2.1	0.19
Jun	2.0	6.3	**0.15**	1.2	0.12	80	0.000028	0.033	0.0046	0.057	0.064	0.000057	0.00024	25	0.000012	0.00032	0.00050	0.00027	0.014	0.0000051	4.4	0.062	1.8	0.16
Jul	1.3	4.2	**0.096**	0.88	0.084	56	0.000020	0.025	0.0032	0.039	0.052	0.000053	0.00023	19	0.0000094	0.00023	0.00035	0.00025	0.014	0.0000049	2.9	0.041	1.3	0.11
Aug	2.4	7.5	**0.17**	1.4	0.14	95	0.000032	0.036	0.0052	0.067	0.061	0.000055	0.00023	24	0.000012	0.00038	0.00060	0.00027	0.014	0.0000051	5.2	0.074	2.2	0.20
Sep	2.0	6.0	**0.14**	1.2	0.12	78	0.000027	0.031	0.0043	0.055	0.057	0.000054	0.00023	21	0.000011	0.00032	0.00049	0.00026	0.014	0.0000050	4.2	0.060	1.8	0.16
Oct	1.7	5.2	**0.12**	1.0	0.10	68	0.000023	0.028	0.0038	0.048	0.053	0.000052	0.00023	19	0.0000097	0.00028	0.00043	0.00026	0.014	0.0000050	3.6	0.052	1.6	0.14
Nov	2.4	7.4	**0.17**	1.4	0.14	93	0.000032	0.036	0.0054	0.067	0.059	0.000055	0.00023	22	0.000011	0.00038	0.00060	0.00028	0.014	0.0000051	5.1	0.073	2.2	0.20
Dec	2.4	7.4	**0.17**	1.4	0.14	93	0.000032	0.036	0.0053	0.066	0.059	0.000057	0.00024	22	0.000011	0.00038	0.00060	0.00027	0.014	0.0000052	5.1	0.073	2.2	0.20
Closure Phase																								
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**	**D-Mn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.0	6.0	**0.14**	1.4	0.14	93	0.000032	0.019	0.0032	0.066	0.041	0.000057	0.00024	21	0.000011	0.00038	0.00060	0.00027	0.027	0.0000048	5.1	0.073	2.2	0.20
Feb	1.9	6.0	**0.14**	1.4	0.14	93	0.000032	0.019	0.0032	0.066	0.041	0.000058	0.00024	21	0.000011	0.00038	0.00059	0.00027	0.027	0.0000048	5.1	0.073	2.2	0.20
Mar	1.9	6.0	**0.14**	1.4	0.14	92	0.000031	0.019	0.0032	0.066	0.041	0.000058	0.00024	21	0.000011	0.00038	0.00059	0.00027	0.028	0.0000048	5.1	0.072	2.2	0.20
Apr	1.9	6.0	**0.14**	1.4	0.14	92	0.000031	0.019	0.0032	0.066	0.041	0.000058	0.00024	21	0.000011	0.00038	0.00059	0.00027	0.028	0.0000048	5.1	0.072	2.2	0.20
May	1.9	5.9	**0.14**	1.4	0.14	92	0.000031	0.019	0.0032	0.065	0.041	0.000058	0.00024	21	0.000011	0.00038	0.00059	0.00027	0.029	0.0000048	5.0	0.072	2.2	0.20
Jun	1.6	5.0	**0.12**	1.2	0.12	78	0.000027	0.018	0.0028	0.056	0.040	0.000057	0.00024	19	0.0000100	0.00032	0.00050	0.00027	0.027	0.0000049	4.2	0.060	1.9	0.17
Jul	1.0	3.2	**0.074**	0.84	0.080	54	0.000019	0.015	0.0019	0.038	0.036	0.000052	0.00023	15	0.0000080	0.00022	0.00034	0.00025	0.023	0.0000047	2.8	0.039	1.3	0.11
Aug	1.5	4.7	**0.11**	1.2	0.11	79	0.000026	0.017	0.0028	0.053	0.038	0.000055	0.00023	19	0.000010	0.00031	0.00048	0.00027	0.028	0.0000048	4.3	0.057	2.1	0.21
Sep	1.3	3.9	**0.090**	0.99	0.096	67	0.000022	0.016	0.0024	0.044	0.037	0.000054	0.00023	17	0.0000092	0.00027	0.00040	0.00026	0.026	0.0000047	3.6	0.048	1.8	0.17
Oct	1.1	3.4	**0.078**	0.88	0.084	59	0.000020	0.015	0.0021	0.039	0.036	0.000052	0.00023	16	0.0000085	0.00023	0.00035	0.00025	0.025	0.0000047	3.1	0.041	1.6	0.15
Nov	1.3	4.1	**0.094**	1.0	0.10	71	0.000023	0.016	0.0026	0.046	0.038	0.000054	0.00023	18	0.0000096	0.00027	0.00042	0.00026	0.030	0.0000047	3.8	0.050	2.1	0.20
Dec	1.3	4.1	**0.094**	1.0	0.10	71	0.000023	0.016	0.0026	0.046	0.038	0.000056	0.00023	18	0.0000097	0.00027	0.00042	0.00026	0.031	0.0000048	3.8	0.050	2.1	0.20
Post-Closure Phase																								
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**	**D-Mn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.42	1.3	0.030	0.56	0.044	39	0.000010	0.012	0.0015	0.018	0.033	0.000057	0.00023	13	0.0000076	0.00012	0.00018	0.00024	0.042	0.0000046	2.0	0.017	1.7	0.18
Feb	0.42	1.3	0.030	0.56	0.044	39	0.000010	0.012	0.0015	0.018	0.033	0.000058	0.00023	13	0.0000076	0.00012	0.00018	0.00024	0.042	0.0000046	2.0	0.017	1.7	0.18
Mar	0.42	1.3	0.030	0.56	0.044	39	0.000010	0.012	0.0015	0.018	0.033	0.000058	0.00023	13	0.0000076	0.00012	0.00018	0.00024	0.043	0.0000046	2.0	0.017	1.7	0.18
Apr	0.42	1.3	0.030	0.56	0.043	39	0.000010	0.012	0.0015	0.018	0.033	0.000058	0.00023	13	0.0000076	0.00012	0.00018	0.00024	0.043	0.0000046	2.0	0.017	1.7	0.18
May	0.41	1.3	0.030	0.56	0.043	39	0.000010	0.012	0.0015	0.018	0.033	0.000058	0.00023	13	0.0000076	0.00012	0.00018	0.00024	0.044	0.0000046	2.0	0.017	1.7	0.18
Jun	0.35	1.1	0.025	0.51	0.038	35	0.0000095	0.012	0.0014	0.016	0.033	0.000057	0.00023	12	0.0000072	0.00011	0.00016	0.00024	0.040	0.0000047	1.7	0.014	1.5	0.15
Jul	0.23	0.70	0.016	0.41	0.028	25	0.0000077	0.012	0.0010	0.012	0.031	0.000052	0.00023	11	0.0000062	0.000086	0.00012	0.00024	0.031	0.0000046	1.1	0.0094	1.1	0.10
Aug	0.29	0.89	0.021	0.49	0.035	35	0.0000084	0.011	0.0014	0.014	0.031	0.000055	0.00023	12	0.0000073	0.000099	0.00014	0.00024	0.039	0.0000046	1.8	0.012	1.7	0.18
Sep	0.23	0.72	0.017	0.44	0.030	30	0.0000077	0.011	0.0012	0.012	0.031	0.000053	0.00023	12	0.0000067	0.000088	0.00012	0.00024	0.035	0.0000046	1.4	0.0099	1.4	0.14
Oct	0.20	0.61	0.014	0.41	0.027	26	0.0000072	0.011	0.0011	0.011	0.031	0.000051	0.00022	11	0.0000064	0.000081	0.00011	0.00024	0.033	0.0000045	1.2	0.0086	1.2	0.12
Nov	0.25	0.76	0.018	0.47	0.033	33	0.0000079	0.011	0.0013	0.012	0.032	0.000054	0.00023	12	0.0000071	0.000092	0.00012	0.00024	0.040	0.0000046	1.6	0.011	1.6	0.17
Dec	0.24	0.76	0.018	0.47	0.032	33	0.0000079	0.011	0.0013	0.012	0.032	0.000056	0.00023	12	0.0000072	0.000092	0.00013	0.00024	0.041	0.0000046	1.6	0.011	1.6	0.17
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-2: Maximum Base Case Predictions for Scenario 2 at BJ 3.10

Operations Phase																						
Month	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.0093	15	0.00053	0.018	0.00025	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000056	0.00098	0.00051	0.0020	0.000040	0.33	**0.0058**	0.068	0.066	0.000071	0.0054
Feb	0.0093	15	0.00053	0.018	0.00025	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000057	0.00098	0.00051	0.0020	0.000040	0.33	**0.0058**	0.068	0.066	0.000073	0.0058
Mar	0.0093	15	0.00053	0.018	0.00025	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000057	0.00098	0.00051	0.0020	0.000040	0.33	**0.0058**	0.068	0.066	0.000073	0.0058
Apr	0.0093	15	0.00053	0.018	0.00025	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000057	0.00099	0.00051	0.0020	0.000040	0.32	**0.0058**	0.068	0.066	0.000073	0.0058
May	0.0093	15	0.00053	0.018	0.00025	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000057	0.00099	0.00051	0.0020	0.000040	0.32	**0.0058**	0.068	0.066	0.000072	0.0057
Jun	0.0080	13	0.00049	0.015	0.00022	0.011	0.00082	1.4	0.000080	0.34	0.0069	0.000050	0.00085	0.00051	0.0019	0.000038	0.35	**0.0052**	0.059	0.072	0.000069	0.0049
Jul	0.0054	8.7	0.00040	0.010	0.00015	0.0071	0.00056	1.1	0.000068	0.24	0.0061	0.000034	0.00057	0.00049	0.0017	0.000031	0.32	0.0038	0.041	0.060	0.000060	0.0033
Aug	0.0095	15	0.00053	0.018	0.00025	0.013	0.00098	1.6	0.000086	0.40	0.0072	0.000059	0.0010	0.00050	0.0020	0.000042	0.35	**0.0058**	0.069	0.069	0.000066	0.0045
Sep	0.0077	12	0.00048	0.015	0.00021	0.010	0.00080	1.4	0.000079	0.33	0.0067	0.000048	0.00084	0.00050	0.0019	0.000035	0.32	0.0048	0.057	0.064	0.000062	0.0036
Oct	0.0066	11	0.00044	0.013	0.00018	0.0090	0.00069	1.3	0.000074	0.29	0.0064	0.000042	0.00072	0.00049	0.0018	0.000031	0.29	0.0042	0.049	0.060	0.000059	0.0031
Nov	0.0093	15	0.00054	0.018	0.00025	0.013	0.00097	1.6	0.000086	0.40	0.0072	0.000058	0.0010	0.00051	0.0020	0.000041	0.33	**0.0059**	0.068	0.067	0.000064	0.0039
Dec	0.0093	15	0.00054	0.018	0.00025	0.013	0.00097	1.6	0.000086	0.40	0.0073	0.000058	0.0010	0.00051	0.0020	0.000041	0.33	**0.0059**	0.068	0.067	0.000068	0.0049
Closure Phase																						
Month	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.0093	15	0.00054	0.018	0.00025	0.013	0.00096	1.6	0.000086	0.40	0.0072	0.000058	0.0010	0.00050	0.0020	0.000040	0.20	0.0036	0.069	0.047	0.000071	0.0057
Feb	0.0092	14	0.00053	0.018	0.00025	0.013	0.00096	1.6	0.000086	0.40	0.0072	0.000059	0.0010	0.00050	0.0020	0.000040	0.20	0.0036	0.069	0.047	0.000073	0.0063
Mar	0.0092	14	0.00053	0.018	0.00024	0.013	0.00096	1.6	0.000086	0.40	0.0072	0.000058	0.0010	0.00050	0.0020	0.000040	0.20	0.0036	0.068	0.047	0.000073	0.0063
Apr	0.0092	14	0.00053	0.018	0.00024	0.013	0.00096	1.6	0.000086	0.40	0.0072	0.000058	0.0010	0.00050	0.0020	0.000040	0.20	0.0036	0.068	0.047	0.000073	0.0062
May	0.0091	14	0.00053	0.018	0.00024	0.013	0.00095	1.6	0.000086	0.39	0.0072	0.000058	0.0010	0.00050	0.0020	0.000040	0.20	0.0036	0.068	0.047	0.000073	0.0062
Jun	0.0077	12	0.00048	0.015	0.00021	0.011	0.00081	1.4	0.000080	0.34	0.0068	0.000049	0.00084	0.00050	0.0019	0.000037	0.21	0.0032	0.058	0.046	0.000069	0.0053
Jul	0.0051	8.1	0.00039	0.0098	0.00014	0.0069	0.00054	1.1	0.000067	0.24	0.0060	0.000033	0.00055	0.00048	0.0017	0.000030	0.22	0.0024	0.039	0.042	0.000060	0.0035
Aug	0.0074	11	0.00048	0.014	0.00020	0.010	0.00077	1.4	0.000077	0.34	0.0066	0.000047	0.00080	0.00049	0.0018	0.000036	0.21	0.0033	0.055	0.045	0.000066	0.0049
Sep	0.0062	9.6	0.00044	0.012	0.00017	0.0084	0.00065	1.2	0.000072	0.29	0.0063	0.000040	0.00067	0.00048	0.0018	0.000031	0.20	0.0028	0.046	0.043	0.000063	0.0040
Oct	0.0054	8.4	0.00040	0.010	0.00015	0.0072	0.00056	1.1	0.000068	0.26	0.0060	0.000035	0.00058	0.00048	0.0017	0.000027	0.19	0.0025	0.040	0.042	0.000060	0.0034
Nov	0.0065	10.0	0.00045	0.012	0.00017	0.0088	0.00068	1.3	0.000073	0.32	0.0064	0.000041	0.00069	0.00049	0.0018	0.000032	0.20	0.0030	0.048	0.044	0.000064	0.0042
Dec	0.0065	9.9	0.00045	0.012	0.00017	0.0087	0.00068	1.3	0.000073	0.32	0.0064	0.000042	0.00069	0.00049	0.0018	0.000032	0.20	0.0030	0.048	0.044	0.000068	0.0052
Post-Closure Phase																						
Month	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.0026	3.8	0.00033	0.0043	0.000076	0.0031	0.00027	0.75	0.000054	0.19	0.0051	0.000018	0.00024	0.00047	0.0015	0.000019	0.19	0.0020	0.021	0.039	0.000072	0.0061
Feb	0.0026	3.8	0.00033	0.0043	0.000076	0.0030	0.00027	0.75	0.000054	0.19	0.0051	0.000019	0.00024	0.00047	0.0015	0.000019	0.19	0.0020	0.021	0.039	0.000074	0.0067
Mar	0.0026	3.7	0.00033	0.0043	0.000076	0.0030	0.00027	0.75	0.000054	0.19	0.0051	0.000019	0.00024	0.00047	0.0015	0.000019	0.19	0.0020	0.021	0.039	0.000074	0.0066
Apr	0.0026	3.7	0.00033	0.0042	0.000076	0.0030	0.00027	0.74	0.000054	0.19	0.0051	0.000019	0.00024	0.00047	0.0015	0.000019	0.19	0.0020	0.021	0.039	0.000074	0.0066
May	0.0025	3.7	0.00032	0.0042	0.000076	0.0030	0.00027	0.74	0.000054	0.19	0.0051	0.000018	0.00024	0.00047	0.0015	0.000019	0.19	0.0019	0.021	0.039	0.000074	0.0066
Jun	0.0022	3.3	0.00031	0.0037	0.000068	0.0026	0.00023	0.72	0.000053	0.17	0.0051	0.000016	0.00021	0.00048	0.0015	0.000019	0.20	0.0018	0.018	0.039	0.000070	0.0056
Jul	0.0015	2.4	0.00028	0.0026	0.000052	0.0017	0.00017	0.63	0.000050	0.13	0.0048	0.000012	0.00014	0.00046	0.0014	0.000019	0.22	0.0015	0.013	0.038	0.000061	0.0037
Aug	0.0020	2.8	0.00030	0.0031	0.000061	0.0022	0.00021	0.67	0.000051	0.18	0.0049	0.000014	0.00017	0.00046	0.0014	0.000019	0.21	0.0018	0.016	0.038	0.000067	0.0052
Sep	0.0017	2.4	0.00029	0.0026	0.000053	0.0018	0.00018	0.63	0.000050	0.15	0.0048	0.000012	0.00014	0.00046	0.0014	0.000016	0.19	0.0016	0.014	0.038	0.000063	0.0042
Oct	0.0015	2.2	0.00028	0.0023	0.000049	0.0016	0.00016	0.61	0.000049	0.14	0.0047	0.000011	0.00013	0.00046	0.0014	0.000015	0.18	0.0015	0.012	0.037	0.000060	0.0036
Nov	0.0018	2.5	0.00030	0.0027	0.000056	0.0019	0.00019	0.64	0.000050	0.17	0.0048	0.000013	0.00015	0.00046	0.0014	0.000017	0.20	0.0018	0.014	0.038	0.000064	0.0044
Dec	0.0018	2.5	0.00030	0.0027	0.000057	0.0019	0.00019	0.65	0.000051	0.17	0.0049	0.000013	0.00015	0.00047	0.0014	0.000017	0.19	0.0017	0.015	0.038	0.000069	0.0055
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-2: Maximum Base Case Predictions for Scenario 2 at BJ 3.10

Operations Phase																											
Month	**T-Ca**	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	21	0.000012	0.00048	0.0011	0.00054	0.14	0.0000052	5.1	0.072	2.1	0.20	0.0093	15	0.00079	0.026	0.00046	0.012	0.00097	1.9	0.00040	0.39	0.0072	0.000094	0.00100	0.00081	0.0028
Feb	21	0.000012	0.00049	0.0011	0.00054	0.14	0.0000052	5.1	0.072	2.1	0.20	0.0093	15	0.00078	0.026	0.00046	0.012	0.00097	1.9	0.00040	0.39	0.0072	0.000094	0.00100	0.00080	0.0028
Mar	21	0.000012	0.00049	0.0011	0.00054	0.14	0.0000052	5.1	0.072	2.1	0.20	0.0093	15	0.00078	0.026	0.00046	0.012	0.00097	1.9	0.00040	0.39	0.0072	0.000094	0.00100	0.00080	0.0028
Apr	21	0.000012	0.00049	0.0011	0.00054	0.14	0.0000052	5.2	0.072	2.1	0.20	0.0093	15	0.00078	0.026	0.00046	0.012	0.00098	1.9	0.00040	0.39	0.0072	0.000094	0.0010	0.00080	0.0028
May	21	0.000012	0.00049	0.0011	0.00053	0.14	0.0000052	5.1	0.072	2.1	0.20	0.0093	15	0.00078	0.026	0.00046	0.012	0.00097	1.9	0.00040	0.39	0.0072	0.000094	0.0010	0.00080	0.0027
Jun	23	0.000013	0.00044	0.0013	0.00055	0.16	0.0000051	4.5	0.062	1.9	0.17	0.0081	13	0.00090	0.024	0.00051	0.011	0.00085	1.8	0.00048	0.34	0.0069	0.000088	0.00087	0.00085	0.0030
Jul	18	0.000010	0.00032	0.00090	0.00057	0.18	0.0000049	3.0	0.041	1.3	0.12	0.0054	8.7	0.00066	0.019	0.00041	0.0071	0.00058	1.5	0.00033	0.24	0.0061	0.000073	0.00059	0.00071	0.0024
Aug	22	0.000013	0.00049	0.0012	0.00056	0.16	0.0000051	5.3	0.074	2.2	0.21	0.0095	15	0.00084	0.027	0.00049	0.013	0.0010	2.0	0.00044	0.40	0.0072	0.000096	0.0011	0.00083	0.0029
Sep	20	0.000012	0.00041	0.0011	0.00052	0.14	0.0000050	4.3	0.060	1.9	0.17	0.0077	12	0.00074	0.022	0.00044	0.011	0.00083	1.7	0.00038	0.33	0.0067	0.000086	0.00085	0.00077	0.0026
Oct	18	0.000011	0.00037	0.00095	0.00049	0.13	0.0000050	3.7	0.052	1.6	0.15	0.0067	11	0.00067	0.020	0.00040	0.0090	0.00072	1.6	0.00033	0.29	0.0064	0.000080	0.00074	0.00073	0.0024
Nov	21	0.000012	0.00048	0.0011	0.00054	0.15	0.0000051	5.2	0.074	2.2	0.21	0.0094	15	0.00079	0.026	0.00046	0.013	0.00100	2.0	0.00040	0.40	0.0072	0.000096	0.0010	0.00081	0.0027
Dec	21	0.000012	0.00049	0.0011	0.00054	0.14	0.0000052	5.2	0.073	2.2	0.21	0.0093	15	0.00079	0.026	0.00046	0.013	0.00100	2.0	0.00040	0.40	0.0073	0.000096	0.0010	0.00081	0.0028
Closure Phase																											
Month	**T-Ca**	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	21	0.000012	0.00050	0.00071	0.00054	0.16	0.0000049	5.2	0.073	2.2	0.21	0.0093	15	0.00055	0.026	0.00043	0.013	0.00100	2.0	0.000097	0.40	0.0072	0.000096	0.0010	0.00050	0.0021
Feb	21	0.000012	0.00051	0.00071	0.00054	0.16	0.0000049	5.2	0.073	2.2	0.21	0.0093	14	0.00055	0.026	0.00043	0.013	0.00100	1.9	0.000098	0.40	0.0072	0.000096	0.0010	0.00050	0.0021
Mar	21	0.000012	0.00051	0.00071	0.00054	0.16	0.0000049	5.2	0.073	2.2	0.21	0.0092	14	0.00055	0.026	0.00043	0.013	0.00100	1.9	0.000098	0.40	0.0072	0.000096	0.0010	0.00050	0.0021
Apr	21	0.000012	0.00050	0.00071	0.00054	0.16	0.0000049	5.2	0.073	2.2	0.21	0.0092	14	0.00055	0.026	0.00042	0.013	0.00099	1.9	0.000098	0.40	0.0072	0.000096	0.0010	0.00050	0.0021
May	21	0.000012	0.00050	0.00071	0.00054	0.16	0.0000049	5.1	0.072	2.2	0.21	0.0092	14	0.00055	0.025	0.00042	0.013	0.00099	1.9	0.000097	0.39	0.0072	0.000095	0.0010	0.00050	0.0021
Jun	19	0.000010	0.00044	0.00061	0.00055	0.17	0.0000049	4.3	0.060	1.9	0.18	0.0077	12	0.00050	0.023	0.00039	0.011	0.00083	1.8	0.000089	0.34	0.0068	0.000088	0.00086	0.00050	0.0020
Jul	15	0.0000083	0.00032	0.00043	0.00057	0.19	0.0000047	2.9	0.039	1.3	0.12	0.0051	8.1	0.00040	0.018	0.00034	0.0069	0.00056	1.5	0.000073	0.24	0.0060	0.000072	0.00057	0.00048	0.0017
Aug	19	0.000011	0.00042	0.00058	0.00056	0.18	0.0000048	4.4	0.057	2.2	0.22	0.0074	11	0.00049	0.022	0.00038	0.010	0.00080	1.7	0.000086	0.34	0.0066	0.000085	0.00081	0.00049	0.0019
Sep	17	0.0000098	0.00037	0.00052	0.00052	0.15	0.0000047	3.7	0.048	1.9	0.18	0.0062	9.6	0.00045	0.019	0.00035	0.0084	0.00068	1.6	0.000079	0.29	0.0063	0.000078	0.00068	0.00049	0.0018
Oct	16	0.0000092	0.00032	0.00048	0.00049	0.14	0.0000047	3.2	0.041	1.6	0.16	0.0054	8.4	0.00041	0.017	0.00032	0.0073	0.00059	1.5	0.000074	0.26	0.0060	0.000073	0.00059	0.00048	0.0018
Nov	18	0.000010	0.00038	0.00054	0.00053	0.16	0.0000048	4.0	0.050	2.1	0.21	0.0065	10.0	0.00046	0.020	0.00036	0.0088	0.00071	1.6	0.000081	0.32	0.0064	0.000079	0.00071	0.00049	0.0019
Dec	18	0.000010	0.00039	0.00054	0.00053	0.16	0.0000048	4.0	0.050	2.1	0.21	0.0065	9.9	0.00046	0.020	0.00036	0.0088	0.00071	1.6	0.000083	0.32	0.0064	0.000080	0.00071	0.00049	0.0019
Post-Closure Phase																											
Month	**T-Ca**	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	13	0.0000082	0.00025	0.00030	0.00051	0.17	0.0000046	2.1	0.018	1.7	0.19	0.0026	3.8	0.00034	0.011	0.00026	0.0031	0.00031	1.1	0.000066	0.19	0.0051	0.000056	0.00026	0.00047	0.0016
Feb	13	0.0000082	0.00026	0.00030	0.00051	0.17	0.0000046	2.1	0.017	1.7	0.18	0.0026	3.8	0.00034	0.011	0.00026	0.0031	0.00031	1.1	0.000067	0.19	0.0051	0.000056	0.00026	0.00047	0.0016
Mar	13	0.0000082	0.00026	0.00030	0.00051	0.17	0.0000046	2.1	0.017	1.7	0.18	0.0026	3.7	0.00034	0.011	0.00026	0.0031	0.00031	1.1	0.000067	0.19	0.0051	0.000056	0.00026	0.00047	0.0016
Apr	13	0.0000082	0.00026	0.00030	0.00051	0.17	0.0000047	2.1	0.017	1.7	0.18	0.0026	3.7	0.00034	0.011	0.00026	0.0031	0.00031	1.1	0.000067	0.19	0.0051	0.000056	0.00026	0.00047	0.0016
May	13	0.0000082	0.00026	0.00030	0.00051	0.17	0.0000047	2.1	0.017	1.7	0.18	0.0026	3.7	0.00034	0.011	0.00026	0.0030	0.00030	1.1	0.000067	0.19	0.0051	0.000056	0.00025	0.00047	0.0016
Jun	12	0.0000077	0.00023	0.00027	0.00053	0.18	0.0000047	1.8	0.015	1.5	0.16	0.0022	3.3	0.00033	0.011	0.00026	0.0026	0.00027	1.1	0.000064	0.17	0.0051	0.000055	0.00022	0.00048	0.0016
Jul	11	0.0000066	0.00019	0.00021	0.00055	0.19	0.0000046	1.3	0.0095	1.1	0.11	0.0015	2.4	0.00029	0.010	0.00025	0.0018	0.00019	1.0	0.000057	0.13	0.0048	0.000051	0.00015	0.00047	0.0015
Aug	12	0.0000077	0.00022	0.00024	0.00054	0.19	0.0000046	1.9	0.012	1.7	0.19	0.0020	2.8	0.00032	0.010	0.00025	0.0022	0.00024	1.0	0.000061	0.18	0.0049	0.000052	0.00019	0.00046	0.0015
Sep	12	0.0000074	0.00019	0.00024	0.00050	0.16	0.0000046	1.5	0.010	1.4	0.15	0.0017	2.4	0.00030	0.0089	0.00024	0.0018	0.00021	0.98	0.000058	0.15	0.0048	0.000051	0.00016	0.00046	0.0015
Oct	11	0.0000072	0.00017	0.00024	0.00047	0.15	0.0000046	1.4	0.0088	1.2	0.13	0.0015	2.2	0.00029	0.0081	0.00023	0.0016	0.00019	0.95	0.000055	0.14	0.0047	0.000050	0.00014	0.00046	0.0015
Nov	12	0.0000077	0.00020	0.00024	0.00051	0.17	0.0000046	1.8	0.011	1.7	0.18	0.0018	2.5	0.00031	0.0092	0.00024	0.0019	0.00022	0.99	0.000059	0.17	0.0048	0.000051	0.00017	0.00046	0.0015
Dec	12	0.0000078	0.00021	0.00025	0.00051	0.17	0.0000046	1.8	0.011	1.6	0.18	0.0018	2.5	0.00031	0.0092	0.00024	0.0019	0.00022	0.99	0.000061	0.17	0.0049	0.000052	0.00017	0.00047	0.0015
Long-Term BC FWAL	-	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-3: Maximum Upper Case Predictions for Scenario 1 at BJ 3.10

Operations Phase																							
Month	**N-NH_3**	**N-NO_3**	**N-NO_2**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.9	12	**0.28**	2.1	0.12	141	0.000017	0.060	0.0089	0.087	0.059	0.00042	0.00050	44	0.000021	0.00047	0.0014	0.00063	0.10	0.0000064	7.3	0.18	2.5
Feb	3.9	12	**0.28**	2.1	0.12	141	0.000017	0.060	0.0089	0.087	0.059	0.00042	0.00050	44	0.000021	0.00047	0.0014	0.00062	0.10	0.0000064	7.3	0.18	2.5
Mar	3.9	12	**0.28**	2.1	0.12	141	0.000017	0.060	0.0089	0.087	0.059	0.00042	0.00050	44	0.000021	0.00047	0.0014	0.00062	0.10	0.0000064	7.3	0.18	2.5
Apr	3.9	12	**0.28**	2.2	0.12	141	0.000017	0.060	0.0089	0.087	0.059	0.00042	0.00050	44	0.000021	0.00047	0.0014	0.00063	0.10	0.0000064	7.3	0.18	2.5
May	3.9	12	**0.28**	2.1	0.12	141	0.000017	0.060	0.0089	0.087	0.059	0.00042	0.00050	44	0.000021	0.00047	0.0014	0.00062	0.10	0.0000064	7.3	0.18	2.5
Jun	3.3	10	**0.24**	1.9	0.11	122	0.000016	0.055	0.0078	0.076	0.061	0.00037	0.00046	39	0.000019	0.00041	0.0012	0.00058	0.088	0.0000063	6.3	0.16	2.2
Jul	2.2	6.8	**0.16**	1.3	0.074	84	0.000012	0.041	0.0053	0.052	0.050	0.00026	0.00038	28	0.000014	0.00028	0.00080	0.00046	0.063	0.0000058	4.2	0.11	1.5
Aug	4.0	12	**0.28**	2.3	0.13	150	0.000017	0.062	0.0093	0.092	0.061	0.00043	0.00051	47	0.000022	0.00047	0.0015	0.00064	0.10	0.0000064	7.8	0.20	2.7
Sep	3.2	9.9	**0.23**	1.9	0.11	123	0.000015	0.052	0.0076	0.075	0.057	0.00036	0.00045	39	0.000018	0.00039	0.0012	0.00056	0.085	0.0000061	6.3	0.16	2.2
Oct	2.7	8.4	**0.20**	1.6	0.091	106	0.000014	0.047	0.0066	0.065	0.053	0.00031	0.00042	35	0.000017	0.00034	0.0010	0.00051	0.075	0.0000059	5.4	0.14	1.9
Nov	3.9	12	**0.28**	2.3	0.13	150	0.000017	0.061	0.0092	0.092	0.059	0.00043	0.00051	47	0.000022	0.00047	0.0015	0.00064	0.10	0.0000064	7.7	0.19	2.7
Dec	3.9	12	**0.28**	2.3	0.13	149	0.000017	0.061	0.0092	0.091	0.059	0.00043	0.00051	47	0.000022	0.00047	0.0015	0.00064	0.10	0.0000064	7.7	0.19	2.7
Closure Phase																							
Month	**N-NH_3**	**N-NO_3**	**N-NO_2**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.5	11	**0.25**	2.3	0.13	149	0.000016	0.061	0.0092	0.091	0.052	0.00043	0.00051	47	0.000022	0.00041	0.0015	0.00063	0.10	0.0000061	7.7	0.19	2.7
Feb	3.5	11	**0.25**	2.2	0.13	148	0.000015	0.061	0.0092	0.091	0.052	0.00043	0.00051	46	0.000022	0.00041	0.0015	0.00063	0.10	0.0000061	7.7	0.19	2.7
Mar	3.5	11	**0.25**	2.2	0.13	148	0.000015	0.060	0.0092	0.091	0.052	0.00043	0.00051	46	0.000022	0.00041	0.0015	0.00063	0.10	0.0000061	7.6	0.19	2.7
Apr	3.5	11	**0.25**	2.2	0.13	148	0.000015	0.060	0.0091	0.090	0.052	0.00043	0.00051	46	0.000022	0.00041	0.0015	0.00063	0.11	0.0000061	7.6	0.19	2.7
May	3.5	11	**0.25**	2.2	0.12	147	0.000015	0.060	0.0091	0.090	0.052	0.00043	0.00050	46	0.000022	0.00040	0.0014	0.00063	0.11	0.0000061	7.6	0.19	2.6
Jun	2.9	9.0	**0.21**	1.9	0.11	125	0.000014	0.054	0.0078	0.076	0.049	0.00037	0.00046	40	0.000019	0.00035	0.0012	0.00057	0.091	0.0000060	6.4	0.16	2.3
Jul	1.9	5.8	**0.14**	1.3	0.072	84	0.000011	0.039	0.0052	0.051	0.042	0.00025	0.00038	29	0.000014	0.00024	0.00080	0.00045	0.065	0.0000055	4.2	0.10	1.6
Aug	2.8	8.6	**0.20**	1.9	0.10	124	0.000013	0.051	0.0079	0.073	0.047	0.00035	0.00045	39	0.000019	0.00033	0.0012	0.00056	0.092	0.0000058	6.4	0.15	2.5
Sep	2.3	7.1	**0.17**	1.6	0.087	104	0.000012	0.044	0.0066	0.061	0.045	0.00030	0.00041	34	0.000017	0.00029	0.00097	0.00050	0.080	0.0000056	5.3	0.13	2.2
Oct	2.0	6.1	**0.14**	1.4	0.076	90	0.000011	0.040	0.0058	0.053	0.043	0.00027	0.00038	30	0.000015	0.00025	0.00084	0.00046	0.072	0.0000055	4.6	0.11	1.9
Nov	2.4	7.5	**0.17**	1.7	0.092	111	0.000012	0.046	0.0071	0.064	0.045	0.00031	0.00042	36	0.000018	0.00030	0.0010	0.00052	0.088	0.0000057	5.7	0.13	2.4
Dec	2.4	7.4	**0.17**	1.7	0.092	110	0.000012	0.045	0.0071	0.064	0.046	0.00032	0.00042	36	0.000018	0.00030	0.0010	0.00052	0.089	0.0000057	5.7	0.13	2.4
Post-Closure Phase																							
Month	**N-NH_3**	**N-NO_3**	**N-NO_2**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.80	2.5	0.057	0.78	0.042	53	0.0000074	0.023	0.0038	0.025	0.036	0.00015	0.00029	19	0.000013	0.00013	0.00038	0.00035	0.064	0.0000051	2.7	0.046	1.8
Feb	0.79	2.5	0.057	0.77	0.042	53	0.0000074	0.023	0.0038	0.024	0.036	0.00015	0.00029	19	0.000013	0.00013	0.00038	0.00034	0.065	0.0000051	2.7	0.046	1.8
Mar	0.79	2.4	0.056	0.77	0.042	53	0.0000074	0.023	0.0038	0.024	0.036	0.00015	0.00029	19	0.000013	0.00013	0.00038	0.00034	0.065	0.0000051	2.7	0.046	1.8
Apr	0.78	2.4	0.056	0.77	0.042	52	0.0000074	0.023	0.0038	0.024	0.036	0.00015	0.00029	19	0.000013	0.00013	0.00038	0.00034	0.066	0.0000051	2.7	0.045	1.8
May	0.78	2.4	0.056	0.77	0.042	52	0.0000074	0.023	0.0038	0.024	0.036	0.00015	0.00029	19	0.000013	0.00013	0.00037	0.00034	0.066	0.0000051	2.6	0.045	1.8
Jun	0.66	2.0	0.047	0.69	0.037	46	0.0000072	0.023	0.0034	0.021	0.036	0.00013	0.00028	17	0.000012	0.00012	0.00032	0.00033	0.059	0.0000052	2.3	0.038	1.6
Jul	0.42	1.3	0.030	0.52	0.027	32	0.0000063	0.019	0.0023	0.015	0.033	0.00010	0.00026	14	0.0000092	0.000093	0.00022	0.00030	0.044	0.0000050	1.5	0.025	1.1
Aug	0.54	1.7	0.039	0.64	0.035	44	0.0000066	0.020	0.0033	0.018	0.034	0.00012	0.00027	17	0.000011	0.00011	0.00027	0.00032	0.055	0.0000050	2.2	0.032	1.7
Sep	0.44	1.4	0.031	0.56	0.030	37	0.0000063	0.018	0.0028	0.016	0.034	0.00010	0.00026	15	0.0000099	0.000095	0.00023	0.00030	0.048	0.0000049	1.8	0.026	1.5
Oct	0.37	1.2	0.026	0.51	0.027	33	0.0000060	0.018	0.0025	0.014	0.033	0.000094	0.00025	14	0.0000092	0.000088	0.00020	0.00029	0.044	0.0000049	1.6	0.022	1.3
Nov	0.47	1.4	0.033	0.60	0.032	41	0.0000064	0.019	0.0031	0.016	0.034	0.00011	0.00026	16	0.000011	0.000100	0.00024	0.00031	0.054	0.0000049	2.0	0.028	1.7
Dec	0.46	1.4	0.033	0.60	0.032	41	0.0000064	0.019	0.0031	0.016	0.034	0.00011	0.00027	16	0.000011	0.000099	0.00024	0.00031	0.055	0.0000050	2.0	0.027	1.7
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-3: Maximum Upper Case Predictions for Scenario 1 at BJ 3.10

Operations Phase																								
Month	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.19	0.015	14	0.00080	0.018	0.013	0.025	0.0041	4.1	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0024	0.000026	0.33	**0.0093**	0.089	0.067	0.00043	0.0056
Feb	0.19	0.015	14	0.00080	0.018	0.013	0.025	0.0041	4.1	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0024	0.000026	0.33	**0.0093**	0.089	0.066	0.00043	0.0060
Mar	0.19	0.015	14	0.00080	0.018	0.013	0.025	0.0041	4.1	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0024	0.000026	0.33	**0.0093**	0.089	0.066	0.00043	0.0060
Apr	0.19	0.015	14	0.00080	0.019	0.013	0.025	0.0041	4.1	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0024	0.000026	0.33	**0.0093**	0.089	0.066	0.00043	0.0060
May	0.19	0.015	14	0.00080	0.018	0.013	0.025	0.0041	4.1	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0024	0.000026	0.33	**0.0093**	0.089	0.066	0.00043	0.0060
Jun	0.17	0.013	12	0.00072	0.016	0.012	0.022	0.0035	3.6	0.00015	0.50	0.0073	0.000098	0.0017	0.00083	0.0023	0.000025	0.34	**0.0082**	0.078	0.068	0.00038	0.0051
Jul	0.11	0.0086	8.1	0.00055	0.011	0.0076	0.015	0.0024	2.6	0.00012	0.35	0.0064	0.000066	0.0011	0.00071	0.0020	0.000023	0.31	**0.0058**	0.053	0.058	0.00027	0.0034
Aug	0.21	0.016	14	0.00083	0.019	0.014	0.027	0.0045	4.4	0.00018	0.60	0.0079	0.00012	0.0021	0.00087	0.0025	0.000027	0.35	**0.0098**	0.094	0.069	0.00044	0.0047
Sep	0.17	0.013	12	0.00071	0.015	0.011	0.022	0.0036	3.6	0.00015	0.50	0.0072	0.000097	0.0017	0.00080	0.0023	0.000023	0.32	**0.0080**	0.077	0.064	0.00037	0.0038
Oct	0.14	0.011	10.0	0.00064	0.013	0.0093	0.019	0.0031	3.2	0.00014	0.43	0.0068	0.000084	0.0014	0.00075	0.0021	0.000021	0.29	**0.0070**	0.066	0.060	0.00032	0.0033
Nov	0.21	0.016	14	0.00083	0.019	0.013	0.027	0.0045	4.4	0.00018	0.60	0.0079	0.00012	0.0021	0.00087	0.0025	0.000026	0.33	**0.0097**	0.093	0.067	0.00044	0.0042
Dec	0.21	0.016	14	0.00083	0.019	0.013	0.027	0.0044	4.4	0.00018	0.60	0.0079	0.00012	0.0020	0.00087	0.0025	0.000026	0.33	**0.0097**	0.093	0.067	0.00045	0.0051
Closure Phase																								
Month	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.21	0.016	14	0.00082	0.019	0.0071	0.027	0.0044	4.4	0.00018	0.60	0.0079	0.00012	0.0020	0.00087	0.0024	0.000024	0.24	**0.0096**	0.093	0.058	0.00045	0.0058
Feb	0.20	0.016	14	0.00082	0.019	0.0071	0.027	0.0044	4.4	0.00018	0.60	0.0078	0.00012	0.0020	0.00087	0.0024	0.000024	0.24	**0.0096**	0.093	0.058	0.00045	0.0064
Mar	0.20	0.016	14	0.00082	0.019	0.0071	0.027	0.0044	4.3	0.00018	0.59	0.0078	0.00012	0.0020	0.00087	0.0024	0.000024	0.24	**0.0096**	0.093	0.058	0.00045	0.0064
Apr	0.20	0.016	14	0.00082	0.018	0.0071	0.027	0.0044	4.3	0.00018	0.59	0.0078	0.00012	0.0020	0.00087	0.0024	0.000024	0.24	**0.0096**	0.093	0.058	0.00045	0.0064
May	0.20	0.016	14	0.00082	0.018	0.0070	0.027	0.0044	4.3	0.00017	0.59	0.0078	0.00012	0.0020	0.00087	0.0024	0.000024	0.24	**0.0095**	0.092	0.058	0.00044	0.0063
Jun	0.17	0.013	12	0.00072	0.016	0.0059	0.023	0.0037	3.7	0.00016	0.50	0.0074	0.000099	0.0017	0.00082	0.0023	0.000024	0.25	**0.0082**	0.078	0.055	0.00038	0.0054
Jul	0.12	0.0085	7.8	0.00055	0.010	0.0038	0.015	0.0024	2.6	0.00012	0.34	0.0063	0.000066	0.0011	0.00069	0.0020	0.000022	0.25	**0.0057**	0.052	0.049	0.00026	0.0036
Aug	0.21	0.013	11	0.00071	0.015	0.0056	0.022	0.0035	3.6	0.00015	0.50	0.0071	0.000095	0.0016	0.00079	0.0023	0.000023	0.24	**0.0083**	0.075	0.054	0.00036	0.0050
Sep	0.18	0.011	9.3	0.00063	0.012	0.0046	0.018	0.0029	3.0	0.00013	0.42	0.0067	0.000080	0.0013	0.00073	0.0021	0.000021	0.23	**0.0071**	0.063	0.051	0.00031	0.0041
Oct	0.15	0.0090	8.1	0.00057	0.011	0.0040	0.016	0.0025	2.7	0.00012	0.37	0.0064	0.000069	0.0012	0.00070	0.0020	0.000019	0.21	**0.0062**	0.055	0.049	0.00027	0.0035
Nov	0.20	0.011	9.7	0.00065	0.013	0.0049	0.019	0.0031	3.2	0.00014	0.45	0.0068	0.000083	0.0014	0.00075	0.0022	0.000021	0.23	**0.0076**	0.066	0.052	0.00032	0.0043
Dec	0.20	0.011	9.7	0.00065	0.013	0.0048	0.019	0.0031	3.1	0.00014	0.45	0.0068	0.000084	0.0014	0.00075	0.0022	0.000021	0.23	**0.0076**	0.066	0.052	0.00033	0.0053
Post-Closure Phase																								
Month	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.18	0.0041	3.8	0.00040	0.0048	0.0016	0.0065	0.0011	1.4	0.000077	0.24	0.0053	0.000033	0.00049	0.00057	0.0017	0.000016	0.21	0.0042	0.027	0.042	0.00016	0.0062
Feb	0.18	0.0041	3.8	0.00040	0.0047	0.0016	0.0065	0.0011	1.4	0.000077	0.24	0.0053	0.000033	0.00049	0.00057	0.0017	0.000016	0.20	0.0042	0.027	0.042	0.00016	0.0067
Mar	0.18	0.0041	3.8	0.00040	0.0047	0.0016	0.0065	0.0011	1.4	0.000077	0.24	0.0053	0.000033	0.00049	0.00057	0.0017	0.000016	0.20	0.0042	0.027	0.042	0.00016	0.0067
Apr	0.18	0.0041	3.8	0.00039	0.0047	0.0016	0.0065	0.0010	1.4	0.000077	0.24	0.0053	0.000033	0.00049	0.00057	0.0017	0.000016	0.20	0.0042	0.027	0.042	0.00016	0.0067
May	0.18	0.0041	3.7	0.00039	0.0047	0.0016	0.0064	0.0010	1.4	0.000077	0.24	0.0053	0.000033	0.00048	0.00057	0.0017	0.000016	0.20	0.0042	0.027	0.042	0.00016	0.0066
Jun	0.15	0.0035	3.3	0.00037	0.0042	0.0013	0.0055	0.00089	1.2	0.000074	0.21	0.0053	0.000028	0.00041	0.00057	0.0017	0.000017	0.21	0.0038	0.024	0.042	0.00015	0.0056
Jul	0.10	0.0023	2.5	0.00032	0.0029	0.00087	0.0036	0.00058	0.97	0.000064	0.15	0.0050	0.000020	0.00027	0.00053	0.0016	0.000018	0.23	0.0029	0.017	0.040	0.00011	0.0037
Aug	0.18	0.0031	2.9	0.00035	0.0035	0.0011	0.0046	0.00075	1.1	0.000067	0.21	0.0051	0.000024	0.00034	0.00054	0.0016	0.000017	0.21	0.0038	0.020	0.040	0.00013	0.0052
Sep	0.14	0.0025	2.5	0.00033	0.0029	0.00089	0.0037	0.00061	0.98	0.000063	0.18	0.0050	0.000020	0.00028	0.00053	0.0016	0.000015	0.20	0.0032	0.017	0.040	0.00011	0.0042
Oct	0.12	0.0022	2.2	0.00031	0.0026	0.00076	0.0032	0.00052	0.91	0.000061	0.16	0.0049	0.000018	0.00024	0.00052	0.0016	0.000014	0.19	0.0029	0.015	0.039	0.00010	0.0036
Nov	0.17	0.0027	2.6	0.00034	0.0031	0.00095	0.0040	0.00065	1.0	0.000065	0.20	0.0050	0.000022	0.00030	0.00053	0.0016	0.000015	0.20	0.0036	0.018	0.040	0.00012	0.0045
Dec	0.17	0.0027	2.6	0.00034	0.0031	0.00095	0.0040	0.00065	1.0	0.000065	0.20	0.0050	0.000022	0.00030	0.00054	0.0016	0.000015	0.20	0.0036	0.019	0.040	0.00012	0.0055
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-3: Maximum Upper Case Predictions for Scenario 1 at BJ 3.10

Operations Phase																										
Month	**T-Ca**	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	44	0.000022	0.00059	0.0015	0.00089	0.23	0.0000088	7.4	0.18	2.5	0.20	0.015	14	0.00081	0.027	0.014	0.025	0.0041	4.4	0.00040	0.57	0.0077	0.00015	0.0019	0.00093	0.0028
Feb	44	0.000022	0.00059	0.0015	0.00089	0.23	0.0000088	7.4	0.18	2.5	0.20	0.015	14	0.00081	0.027	0.014	0.025	0.0041	4.4	0.00040	0.57	0.0077	0.00015	0.0019	0.00093	0.0028
Mar	44	0.000022	0.00059	0.0015	0.00089	0.23	0.0000088	7.4	0.18	2.5	0.20	0.015	14	0.00081	0.027	0.014	0.025	0.0041	4.4	0.00040	0.57	0.0077	0.00015	0.0019	0.00093	0.0028
Apr	44	0.000022	0.00059	0.0015	0.00089	0.23	0.0000088	7.4	0.18	2.5	0.20	0.015	14	0.00081	0.027	0.014	0.025	0.0041	4.4	0.00040	0.57	0.0077	0.00015	0.0019	0.00093	0.0028
May	44	0.000022	0.00059	0.0015	0.00089	0.23	0.0000088	7.4	0.18	2.5	0.20	0.015	14	0.00081	0.026	0.014	0.025	0.0041	4.4	0.00039	0.57	0.0077	0.00015	0.0019	0.00093	0.0028
Jun	39	0.000019	0.00052	0.0013	0.00086	0.23	0.0000097	6.4	0.16	2.2	0.17	0.013	12	0.00082	0.024	0.012	0.022	0.0036	3.9	0.00043	0.50	0.0073	0.00014	0.0017	0.00088	0.0028
Jul	28	0.000015	0.00038	0.00089	0.00078	0.23	0.0000086	4.3	0.11	1.6	0.12	0.0086	8.1	0.00061	0.020	0.0078	0.015	0.0024	2.9	0.00030	0.35	0.0064	0.00011	0.0011	0.00074	0.0023
Aug	47	0.000022	0.00058	0.0016	0.00093	0.25	0.0000089	7.9	0.20	2.7	0.22	0.016	14	0.00084	0.028	0.014	0.027	0.0045	4.8	0.00043	0.60	0.0079	0.00016	0.0021	0.00093	0.0028
Sep	39	0.000019	0.00048	0.0013	0.00082	0.21	0.0000084	6.4	0.16	2.2	0.17	0.013	12	0.00074	0.023	0.011	0.022	0.0036	4.0	0.00037	0.50	0.0072	0.00014	0.0017	0.00084	0.0026
Oct	35	0.000017	0.00043	0.0012	0.00075	0.19	0.0000083	5.5	0.14	2.0	0.15	0.011	10.0	0.00067	0.020	0.0095	0.019	0.0031	3.5	0.00033	0.43	0.0068	0.00012	0.0014	0.00079	0.0024
Nov	47	0.000022	0.00057	0.0016	0.00090	0.24	0.0000088	7.8	0.19	2.7	0.21	0.016	14	0.00084	0.027	0.014	0.027	0.0045	4.7	0.00040	0.60	0.0079	0.00016	0.0021	0.00094	0.0028
Dec	47	0.000022	0.00058	0.0016	0.00090	0.23	0.0000088	7.8	0.19	2.7	0.21	0.016	14	0.00084	0.027	0.014	0.027	0.0045	4.7	0.00040	0.60	0.0079	0.00016	0.0021	0.00094	0.0028
Closure Phase																										
Month	**T-Ca**	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	47	0.000022	0.00053	0.0016	0.00090	0.23	0.0000085	7.8	0.19	2.7	0.21	0.016	14	0.00084	0.027	0.0073	0.027	0.0045	4.7	0.00019	0.60	0.0079	0.00016	0.0021	0.00087	0.0026
Feb	46	0.000022	0.00053	0.0016	0.00090	0.23	0.0000085	7.8	0.19	2.7	0.21	0.016	14	0.00084	0.027	0.0073	0.027	0.0045	4.7	0.00019	0.60	0.0078	0.00016	0.0020	0.00087	0.0026
Mar	46	0.000022	0.00053	0.0016	0.00090	0.23	0.0000085	7.8	0.19	2.7	0.21	0.016	14	0.00084	0.027	0.0073	0.027	0.0044	4.7	0.00019	0.60	0.0078	0.00016	0.0020	0.00087	0.0026
Apr	46	0.000022	0.00053	0.0016	0.00090	0.23	0.0000085	7.7	0.19	2.7	0.21	0.016	14	0.00083	0.026	0.0072	0.027	0.0044	4.7	0.00019	0.59	0.0078	0.00016	0.0020	0.00087	0.0026
May	46	0.000022	0.00053	0.0016	0.00090	0.23	0.0000085	7.7	0.19	2.7	0.21	0.016	14	0.00083	0.026	0.0072	0.027	0.0044	4.7	0.00019	0.59	0.0078	0.00016	0.0020	0.00087	0.0026
Jun	40	0.000020	0.00046	0.0013	0.00086	0.23	0.0000094	6.5	0.16	2.3	0.18	0.013	12	0.00074	0.024	0.0061	0.023	0.0037	4.1	0.00017	0.50	0.0074	0.00014	0.0017	0.00082	0.0024
Jul	28	0.000014	0.00034	0.00089	0.00077	0.23	0.0000084	4.3	0.10	1.6	0.13	0.0085	7.8	0.00055	0.019	0.0040	0.015	0.0024	2.9	0.00012	0.34	0.0063	0.00010	0.0011	0.00069	0.0020
Aug	39	0.000020	0.00045	0.0013	0.00085	0.24	0.0000083	6.5	0.15	2.6	0.22	0.013	11	0.00072	0.023	0.0058	0.022	0.0035	3.9	0.00016	0.50	0.0071	0.00013	0.0016	0.00079	0.0023
Sep	34	0.000018	0.00039	0.0011	0.00076	0.21	0.0000079	5.4	0.13	2.2	0.18	0.011	9.3	0.00064	0.020	0.0048	0.018	0.0030	3.4	0.00014	0.42	0.0067	0.00012	0.0014	0.00073	0.0022
Oct	30	0.000016	0.00034	0.00097	0.00070	0.19	0.0000079	4.7	0.11	1.9	0.16	0.0091	8.1	0.00058	0.018	0.0042	0.016	0.0025	3.0	0.00013	0.37	0.0064	0.00011	0.0012	0.00070	0.0021
Nov	36	0.000019	0.00040	0.0011	0.00079	0.22	0.0000081	5.8	0.13	2.4	0.21	0.011	9.7	0.00066	0.021	0.0050	0.019	0.0031	3.5	0.00014	0.45	0.0068	0.00012	0.0014	0.00075	0.0023
Dec	36	0.000019	0.00041	0.0011	0.00079	0.22	0.0000081	5.8	0.13	2.4	0.21	0.011	9.7	0.00066	0.020	0.0050	0.019	0.0031	3.5	0.00015	0.45	0.0068	0.00012	0.0014	0.00075	0.0023
Post-Closure Phase																										
Month	**T-Ca**	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	19	0.000013	0.00026	0.00050	0.00062	0.20	0.0000074	2.8	0.046	1.8	0.19	0.0041	3.8	0.00041	0.011	0.0018	0.0066	0.0011	1.7	0.000088	0.24	0.0053	0.000071	0.00051	0.00057	0.0018
Feb	19	0.000013	0.00027	0.00050	0.00062	0.19	0.0000074	2.8	0.046	1.8	0.19	0.0041	3.8	0.00041	0.011	0.0018	0.0065	0.0011	1.7	0.000089	0.24	0.0053	0.000071	0.00050	0.00057	0.0018
Mar	19	0.000013	0.00027	0.00050	0.00062	0.19	0.0000074	2.8	0.046	1.8	0.19	0.0041	3.8	0.00041	0.011	0.0018	0.0065	0.0011	1.7	0.000089	0.24	0.0053	0.000071	0.00050	0.00057	0.0019
Apr	19	0.000013	0.00027	0.00050	0.00061	0.19	0.0000074	2.8	0.046	1.8	0.19	0.0041	3.8	0.00041	0.011	0.0018	0.0065	0.0011	1.7	0.000089	0.24	0.0053	0.000071	0.00050	0.00057	0.0019
May	19	0.000013	0.00027	0.00049	0.00061	0.19	0.0000074	2.7	0.045	1.8	0.19	0.0041	3.7	0.00041	0.011	0.0018	0.0065	0.0011	1.7	0.000089	0.24	0.0053	0.000071	0.00050	0.00057	0.0019
Jun	17	0.000012	0.00024	0.00044	0.00062	0.20	0.0000085	2.4	0.038	1.6	0.16	0.0035	3.3	0.00038	0.011	0.0015	0.0055	0.00092	1.6	0.000084	0.21	0.0053	0.000067	0.00043	0.00057	0.0018
Jul	14	0.0000095	0.00020	0.00032	0.00061	0.21	0.0000078	1.6	0.025	1.2	0.11	0.0024	2.5	0.00033	0.011	0.0011	0.0036	0.00061	1.3	0.000070	0.15	0.0050	0.000059	0.00028	0.00053	0.0016
Aug	16	0.000012	0.00023	0.00038	0.00061	0.20	0.0000074	2.3	0.032	1.8	0.19	0.0031	2.9	0.00037	0.011	0.0013	0.0046	0.00077	1.5	0.000077	0.21	0.0051	0.000062	0.00036	0.00054	0.0017
Sep	15	0.000011	0.00020	0.00035	0.00056	0.18	0.0000072	1.9	0.026	1.5	0.15	0.0025	2.5	0.00034	0.0093	0.0011	0.0038	0.00064	1.3	0.000071	0.18	0.0050	0.000059	0.00029	0.00053	0.0017
Oct	14	0.0000100	0.00018	0.00034	0.00053	0.16	0.0000072	1.7	0.022	1.3	0.13	0.0022	2.2	0.00032	0.0084	0.00094	0.0032	0.00055	1.3	0.000067	0.16	0.0049	0.000057	0.00026	0.00052	0.0016
Nov	16	0.000011	0.00021	0.00036	0.00058	0.19	0.0000073	2.2	0.028	1.7	0.18	0.0027	2.6	0.00035	0.0096	0.0011	0.0040	0.00068	1.4	0.000073	0.20	0.0050	0.000060	0.00031	0.00053	0.0017
Dec	16	0.000012	0.00022	0.00037	0.00058	0.19	0.0000073	2.2	0.028	1.7	0.18	0.0027	2.6	0.00036	0.0096	0.0011	0.0040	0.00068	1.4	0.000075	0.20	0.0050	0.000060	0.00031	0.00054	0.0017
Long-Term BC FWAL	-	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-4: Maximum Upper Case Predictions for Scenario 2 at BJ 3.10

Operations Phase																								
Month	**N-NH_3**	**N-NO_3**	**N-NO_2**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.6	11	**0.25**	2.5	0.17	168	0.000014	0.055	0.0072	0.11	0.059	0.00057	0.00060	49	0.00013	0.00059	0.0017	0.0016	0.14	0.0000058	9.0	0.25	3.1
Feb	3.6	11	**0.25**	2.5	0.17	168	0.000014	0.055	0.0072	0.11	0.059	0.00057	0.00060	49	0.00013	0.00059	0.0017	0.0016	0.14	0.0000058	9.0	0.25	3.1
Mar	3.6	11	**0.25**	2.5	0.17	168	0.000014	0.055	0.0072	0.11	0.059	0.00057	0.00060	49	0.00013	0.00059	0.0017	0.0016	0.14	0.0000058	9.0	0.25	3.1
Apr	3.6	11	**0.25**	2.5	0.17	169	0.000014	0.055	0.0073	0.11	0.059	0.00057	0.00060	49	0.00013	0.00059	0.0017	0.0016	0.14	0.0000058	9.0	0.25	3.1
May	3.6	11	**0.25**	2.5	0.17	169	0.000014	0.055	0.0072	0.11	0.059	0.00057	0.00060	49	0.00013	0.00059	0.0017	0.0016	0.14	0.0000058	9.0	0.25	3.1
Jun	3.1	9.4	**0.22**	2.2	0.15	147	0.000013	0.051	0.0063	0.096	0.061	0.00050	0.00055	43	0.00011	0.00052	0.0015	0.0014	0.12	0.0000058	7.8	0.21	2.7
Jul	2.0	6.3	**0.14**	1.5	0.10	100	0.000010	0.038	0.0043	0.065	0.050	0.00035	0.00044	31	0.000077	0.00036	0.0010	0.00100	0.084	0.0000054	5.2	0.14	1.9
Aug	3.6	11	**0.26**	2.6	0.17	177	0.000014	0.058	0.0070	0.12	0.061	0.00058	0.00060	51	0.00014	0.00062	0.0018	0.0017	0.14	0.0000058	9.4	0.26	3.3
Sep	2.9	9.0	**0.21**	2.1	0.14	144	0.000012	0.049	0.0058	0.093	0.057	0.00047	0.00053	43	0.00011	0.00051	0.0015	0.0014	0.11	0.0000056	7.6	0.21	2.7
Oct	2.5	7.7	**0.18**	1.9	0.12	125	0.000011	0.044	0.0050	0.081	0.053	0.00041	0.00049	38	0.000099	0.00044	0.0013	0.0012	0.100	0.0000055	6.6	0.18	2.4
Nov	3.6	11	**0.26**	2.6	0.17	176	0.000014	0.058	0.0073	0.11	0.059	0.00058	0.00061	51	0.00014	0.00062	0.0018	0.0017	0.14	0.0000058	9.3	0.26	3.3
Dec	3.6	11	**0.26**	2.6	0.17	175	0.000014	0.058	0.0073	0.11	0.059	0.00058	0.00061	51	0.00014	0.00061	0.0018	0.0016	0.14	0.0000058	9.3	0.26	3.3
Closure Phase																								
Month	**N-NH_3**	**N-NO_3**	**N-NO_2**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.1	9.6	**0.22**	2.6	0.17	175	0.000013	0.058	0.0054	0.11	0.056	0.00058	0.00061	51	0.00014	0.00061	0.0018	0.0016	0.14	0.0000057	9.3	0.26	3.3
Feb	3.1	9.6	**0.22**	2.5	0.17	174	0.000013	0.057	0.0054	0.11	0.055	0.00058	0.00060	51	0.00014	0.00061	0.0018	0.0016	0.14	0.0000057	9.3	0.25	3.3
Mar	3.1	9.6	**0.22**	2.5	0.17	174	0.000013	0.057	0.0054	0.11	0.055	0.00058	0.00060	51	0.00014	0.00061	0.0018	0.0016	0.14	0.0000057	9.2	0.25	3.3
Apr	3.1	9.5	**0.22**	2.5	0.17	173	0.000013	0.057	0.0054	0.11	0.055	0.00057	0.00060	51	0.00014	0.00061	0.0018	0.0016	0.14	0.0000057	9.2	0.25	3.3
May	3.1	9.5	**0.22**	2.5	0.17	172	0.000013	0.057	0.0054	0.11	0.055	0.00057	0.00060	51	0.00014	0.00061	0.0018	0.0016	0.14	0.0000057	9.2	0.25	3.3
Jun	2.6	7.9	**0.18**	2.2	0.14	146	0.000012	0.051	0.0046	0.094	0.052	0.00049	0.00054	44	0.00012	0.00052	0.0015	0.0014	0.12	0.0000057	7.7	0.21	2.8
Jul	1.7	5.1	**0.12**	1.5	0.096	97	0.0000095	0.037	0.0032	0.062	0.044	0.00033	0.00043	31	0.000077	0.00035	0.00099	0.00099	0.083	0.0000053	5.0	0.14	1.9
Aug	2.4	7.5	**0.17**	2.1	0.14	143	0.000012	0.048	0.0046	0.089	0.050	0.00046	0.00052	43	0.00011	0.00049	0.0014	0.0013	0.12	0.0000055	7.6	0.20	3.0
Sep	2.0	6.2	**0.14**	1.8	0.12	120	0.000010	0.042	0.0039	0.075	0.047	0.00039	0.00047	37	0.000094	0.00042	0.0012	0.0012	0.10	0.0000053	6.3	0.17	2.6
Oct	1.7	5.3	**0.12**	1.5	0.10	104	0.0000096	0.038	0.0035	0.065	0.045	0.00034	0.00043	33	0.000081	0.00036	0.0010	0.0010	0.091	0.0000052	5.4	0.14	2.2
Nov	2.1	6.5	**0.15**	1.8	0.12	127	0.000011	0.043	0.0042	0.078	0.048	0.00041	0.00048	38	0.000098	0.00043	0.0012	0.0012	0.11	0.0000054	6.7	0.17	2.8
Dec	2.1	6.5	**0.15**	1.8	0.12	126	0.000011	0.043	0.0042	0.077	0.048	0.00041	0.00048	38	0.000098	0.00043	0.0012	0.0012	0.11	0.0000054	6.7	0.17	2.8
Post-Closure Phase																								
Month	**N-NH_3**	**N-NO_3**	**N-NO_2**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**	**D-Mg**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.67	2.1	0.048	0.82	0.051	57	0.0000068	0.022	0.0026	0.028	0.037	0.00017	0.00031	20	0.000038	0.00017	0.00044	0.00056	0.071	0.0000050	2.9	0.057	1.9
Feb	0.66	2.1	0.047	0.81	0.050	57	0.0000068	0.022	0.0026	0.028	0.037	0.00017	0.00031	20	0.000037	0.00017	0.00044	0.00055	0.072	0.0000050	2.9	0.057	1.9
Mar	0.66	2.0	0.047	0.81	0.050	57	0.0000068	0.022	0.0026	0.028	0.037	0.00017	0.00031	20	0.000037	0.00017	0.00043	0.00055	0.072	0.0000050	2.9	0.057	1.9
Apr	0.66	2.0	0.047	0.81	0.050	56	0.0000068	0.022	0.0026	0.028	0.037	0.00017	0.00031	20	0.000037	0.00017	0.00043	0.00055	0.072	0.0000050	2.9	0.056	1.9
May	0.65	2.0	0.047	0.81	0.050	56	0.0000068	0.022	0.0026	0.028	0.037	0.00017	0.00031	20	0.000037	0.00017	0.00043	0.00055	0.073	0.0000050	2.9	0.056	1.9
Jun	0.55	1.7	0.040	0.72	0.044	49	0.0000067	0.022	0.0023	0.024	0.036	0.00015	0.00030	18	0.000032	0.00015	0.00037	0.00051	0.065	0.0000051	2.5	0.047	1.7
Jul	0.36	1.1	0.025	0.55	0.032	35	0.0000060	0.018	0.0017	0.017	0.034	0.00011	0.00027	14	0.000023	0.00011	0.00026	0.00041	0.047	0.0000049	1.7	0.031	1.2
Aug	0.45	1.4	0.032	0.66	0.040	47	0.0000062	0.019	0.0023	0.021	0.034	0.00013	0.00028	17	0.000028	0.00013	0.00031	0.00046	0.059	0.0000049	2.4	0.039	1.8
Sep	0.36	1.1	0.026	0.58	0.034	39	0.0000059	0.018	0.0020	0.017	0.034	0.00012	0.00027	15	0.000023	0.00012	0.00026	0.00041	0.051	0.0000049	1.9	0.031	1.5
Oct	0.31	0.95	0.022	0.52	0.030	34	0.0000058	0.017	0.0018	0.015	0.034	0.00011	0.00026	14	0.000021	0.00011	0.00023	0.00038	0.047	0.0000048	1.7	0.027	1.3
Nov	0.39	1.2	0.028	0.62	0.037	43	0.0000060	0.018	0.0022	0.018	0.034	0.00012	0.00027	16	0.000025	0.00012	0.00027	0.00043	0.058	0.0000049	2.2	0.033	1.8
Dec	0.38	1.2	0.027	0.61	0.037	43	0.0000060	0.018	0.0022	0.018	0.034	0.00012	0.00027	16	0.000025	0.00012	0.00027	0.00043	0.058	0.0000049	2.2	0.033	1.8
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-4: Maximum Upper Case Predictions for Scenario 2 at BJ 3.10

Operations Phase																								
Month	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.35	0.017	17	0.0028	0.020	0.0039	0.025	0.0045	4.1	0.00022	0.76	0.0089	0.00016	0.0035	0.00076	0.0071	0.000023	0.33	**0.0077**	0.11	0.067	0.00058	0.0057	49
Feb	0.35	0.017	17	0.0028	0.020	0.0039	0.025	0.0045	4.1	0.00022	0.76	0.0089	0.00016	0.0035	0.00076	0.0071	0.000023	0.33	**0.0077**	0.11	0.066	0.00058	0.0061	49
Mar	0.35	0.017	17	0.0028	0.020	0.0039	0.025	0.0045	4.1	0.00022	0.76	0.0089	0.00016	0.0035	0.00076	0.0071	0.000023	0.33	**0.0077**	0.11	0.066	0.00058	0.0061	49
Apr	0.35	0.017	17	0.0028	0.020	0.0039	0.026	0.0045	4.2	0.00022	0.76	0.0089	0.00016	0.0035	0.00076	0.0071	0.000023	0.33	**0.0077**	0.11	0.066	0.00059	0.0061	49
May	0.35	0.017	17	0.0028	0.020	0.0039	0.026	0.0045	4.2	0.00022	0.76	0.0089	0.00016	0.0035	0.00076	0.0071	0.000023	0.33	**0.0077**	0.11	0.066	0.00059	0.0061	49
Jun	0.31	0.015	15	0.0024	0.018	0.0033	0.022	0.0039	3.7	0.00020	0.66	0.0084	0.00014	0.0030	0.00074	0.0064	0.000023	0.34	**0.0069**	0.098	0.068	0.00051	0.0052	43
Jul	0.21	0.0100	10	0.0017	0.012	0.0022	0.015	0.0026	2.6	0.00015	0.46	0.0071	0.000094	0.0020	0.00065	0.0047	0.000022	0.31	0.0049	0.066	0.058	0.00035	0.0035	31
Aug	0.39	0.018	18	0.0030	0.021	0.0038	0.027	0.0048	4.4	0.00023	0.79	0.0090	0.00017	0.0037	0.00076	0.0076	0.000024	0.35	**0.0075**	0.12	0.069	0.00059	0.0048	51
Sep	0.31	0.015	15	0.0025	0.017	0.0030	0.022	0.0039	3.6	0.00019	0.65	0.0082	0.00014	0.0030	0.00071	0.0064	0.000021	0.32	**0.0062**	0.095	0.064	0.00048	0.0039	43
Oct	0.27	0.013	13	0.0021	0.015	0.0026	0.019	0.0033	3.2	0.00017	0.56	0.0077	0.00012	0.0026	0.00067	0.0057	0.000019	0.29	**0.0055**	0.082	0.060	0.00042	0.0034	38
Nov	0.39	0.018	18	0.0030	0.021	0.0039	0.027	0.0048	4.4	0.00023	0.79	0.0090	0.00017	0.0037	0.00076	0.0076	0.000023	0.33	**0.0078**	0.12	0.067	0.00059	0.0043	51
Dec	0.38	0.018	17	0.0030	0.020	0.0039	0.027	0.0048	4.4	0.00023	0.79	0.0090	0.00017	0.0037	0.00076	0.0075	0.000023	0.33	**0.0078**	0.12	0.067	0.00059	0.0052	51
Closure Phase																								
Month	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.38	0.018	17	0.0030	0.020	0.0013	0.027	0.0047	4.4	0.00023	0.79	0.0090	0.00017	0.0037	0.00074	0.0075	0.000022	0.24	**0.0058**	0.12	0.062	0.00059	0.0058	51
Feb	0.38	0.018	17	0.0030	0.020	0.0013	0.027	0.0047	4.3	0.00023	0.78	0.0090	0.00017	0.0036	0.00074	0.0075	0.000022	0.24	**0.0058**	0.12	0.061	0.00059	0.0064	51
Mar	0.38	0.018	17	0.0030	0.020	0.0013	0.027	0.0047	4.3	0.00023	0.78	0.0090	0.00017	0.0036	0.00074	0.0075	0.000022	0.24	**0.0058**	0.12	0.061	0.00059	0.0064	51
Apr	0.38	0.018	17	0.0029	0.020	0.0013	0.027	0.0047	4.3	0.00023	0.78	0.0090	0.00017	0.0036	0.00074	0.0075	0.000022	0.23	**0.0058**	0.11	0.061	0.00059	0.0064	51
May	0.38	0.017	17	0.0029	0.020	0.0013	0.027	0.0047	4.3	0.00023	0.77	0.0090	0.00017	0.0036	0.00074	0.0074	0.000022	0.23	**0.0058**	0.11	0.061	0.00059	0.0063	51
Jun	0.32	0.015	15	0.0025	0.017	0.0011	0.022	0.0039	3.7	0.00020	0.66	0.0083	0.00014	0.0030	0.00072	0.0065	0.000022	0.24	**0.0051**	0.096	0.058	0.00050	0.0054	44
Jul	0.21	0.0096	9.7	0.0017	0.011	0.00072	0.014	0.0026	2.6	0.00014	0.44	0.0069	0.000092	0.0020	0.00063	0.0047	0.000021	0.24	0.0037	0.064	0.051	0.00034	0.0036	31
Aug	0.35	0.014	14	0.0024	0.016	0.0011	0.021	0.0037	3.5	0.00019	0.64	0.0080	0.00013	0.0029	0.00069	0.0062	0.000022	0.24	**0.0051**	0.091	0.056	0.00047	0.0050	43
Sep	0.29	0.012	12	0.0020	0.014	0.00092	0.018	0.0031	3.0	0.00017	0.54	0.0074	0.00011	0.0024	0.00065	0.0054	0.000019	0.22	0.0044	0.076	0.053	0.00040	0.0041	37
Oct	0.25	0.010	10.0	0.0018	0.012	0.00080	0.015	0.0027	2.6	0.00015	0.47	0.0070	0.000096	0.0020	0.00062	0.0048	0.000017	0.21	0.0039	0.066	0.051	0.00035	0.0036	33
Nov	0.33	0.012	12	0.0021	0.014	0.00096	0.018	0.0032	3.1	0.00017	0.57	0.0076	0.00012	0.0025	0.00066	0.0056	0.000020	0.23	0.0046	0.079	0.054	0.00042	0.0043	38
Dec	0.32	0.012	12	0.0021	0.014	0.00096	0.018	0.0032	3.1	0.00017	0.57	0.0076	0.00012	0.0025	0.00066	0.0056	0.000020	0.22	0.0046	0.080	0.054	0.00042	0.0053	38
Post-Closure Phase																								
Month	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.22	0.0044	4.4	0.00085	0.0050	0.00033	0.0061	0.0011	1.3	0.000087	0.27	0.0056	0.000042	0.00081	0.00054	0.0028	0.000016	0.20	0.0030	0.031	0.043	0.00019	0.0061	20
Feb	0.22	0.0044	4.4	0.00084	0.0049	0.00033	0.0061	0.0011	1.3	0.000087	0.27	0.0056	0.000042	0.00081	0.00054	0.0028	0.000016	0.20	0.0030	0.031	0.043	0.00019	0.0067	20
Mar	0.21	0.0043	4.4	0.00084	0.0049	0.00033	0.0061	0.0011	1.3	0.000086	0.27	0.0055	0.000042	0.00080	0.00054	0.0028	0.000016	0.20	0.0030	0.031	0.043	0.00019	0.0067	20
Apr	0.21	0.0043	4.4	0.00084	0.0049	0.00033	0.0060	0.0011	1.3	0.000086	0.27	0.0055	0.000042	0.00080	0.00054	0.0028	0.000016	0.20	0.0030	0.031	0.043	0.00019	0.0066	20
May	0.21	0.0043	4.3	0.00083	0.0049	0.00033	0.0060	0.0011	1.3	0.000086	0.27	0.0055	0.000042	0.00080	0.00054	0.0028	0.000016	0.20	0.0030	0.030	0.042	0.00019	0.0066	20
Jun	0.18	0.0037	3.8	0.00074	0.0043	0.00028	0.0051	0.00090	1.2	0.000082	0.24	0.0055	0.000036	0.00068	0.00055	0.0026	0.000016	0.21	0.0028	0.027	0.043	0.00017	0.0056	18
Jul	0.12	0.0025	2.8	0.00056	0.0030	0.00019	0.0034	0.00059	0.95	0.000069	0.17	0.0051	0.000025	0.00044	0.00052	0.0021	0.000017	0.23	0.0022	0.019	0.040	0.00012	0.0037	14
Aug	0.20	0.0032	3.3	0.00065	0.0036	0.00024	0.0042	0.00075	1.1	0.000074	0.23	0.0052	0.000030	0.00055	0.00052	0.0024	0.000016	0.21	0.0028	0.023	0.041	0.00015	0.0052	17
Sep	0.16	0.0026	2.8	0.00057	0.0030	0.00019	0.0035	0.00061	0.95	0.000068	0.20	0.0051	0.000025	0.00045	0.00051	0.0022	0.000015	0.20	0.0024	0.019	0.040	0.00013	0.0042	15
Oct	0.14	0.0023	2.5	0.00052	0.0027	0.00017	0.0030	0.00052	0.88	0.000065	0.17	0.0050	0.000022	0.00038	0.00050	0.0020	0.000013	0.19	0.0022	0.017	0.039	0.00011	0.0036	14
Nov	0.20	0.0028	2.9	0.00060	0.0032	0.00021	0.0037	0.00065	0.98	0.000070	0.22	0.0051	0.000027	0.00048	0.00052	0.0022	0.000015	0.20	0.0027	0.020	0.040	0.00013	0.0044	16
Dec	0.19	0.0028	2.9	0.00060	0.0031	0.00021	0.0037	0.00065	0.98	0.000070	0.22	0.0051	0.000027	0.00047	0.00052	0.0022	0.000015	0.20	0.0027	0.020	0.040	0.00014	0.0055	16
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.1-4: Maximum Upper Case Predictions for Scenario 2 at BJ 3.10

Operations Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00013	0.00071	0.0018	0.0018	0.27	0.0000081	9.1	0.25	3.1	0.36	0.017	17	0.0028	0.028	0.0041	0.026	0.0045	4.5	0.00040	0.76	0.0089	0.00020	0.0035	0.00091	0.0072
Feb	0.00013	0.00072	0.0018	0.0018	0.27	0.0000081	9.1	0.25	3.1	0.36	0.017	17	0.0028	0.028	0.0041	0.025	0.0045	4.5	0.00040	0.76	0.0089	0.00020	0.0035	0.00091	0.0072
Mar	0.00013	0.00072	0.0018	0.0018	0.27	0.0000081	9.1	0.25	3.2	0.36	0.017	17	0.0028	0.028	0.0041	0.026	0.0045	4.5	0.00040	0.76	0.0089	0.00020	0.0035	0.00091	0.0072
Apr	0.00013	0.00072	0.0018	0.0018	0.27	0.0000081	9.1	0.25	3.2	0.36	0.017	17	0.0028	0.028	0.0041	0.026	0.0045	4.5	0.00040	0.76	0.0089	0.00020	0.0035	0.00091	0.0073
May	0.00013	0.00072	0.0018	0.0018	0.26	0.0000081	9.1	0.25	3.2	0.36	0.017	17	0.0028	0.028	0.0041	0.026	0.0045	4.5	0.00039	0.76	0.0089	0.00020	0.0035	0.00091	0.0073
Jun	0.00011	0.00063	0.0016	0.0017	0.26	0.0000091	7.9	0.21	2.8	0.32	0.015	15	0.0024	0.026	0.0035	0.022	0.0039	4.0	0.00043	0.66	0.0084	0.00018	0.0030	0.00086	0.0065
Jul	0.000078	0.00046	0.0011	0.0013	0.25	0.0000082	5.3	0.14	1.9	0.22	0.0100	10	0.0017	0.021	0.0024	0.015	0.0026	3.0	0.00030	0.46	0.0071	0.00013	0.0020	0.00073	0.0047
Aug	0.00014	0.00073	0.0019	0.0019	0.28	0.0000082	9.5	0.26	3.4	0.39	0.018	18	0.0030	0.029	0.0040	0.027	0.0048	4.7	0.00043	0.79	0.0090	0.00021	0.0037	0.00091	0.0076
Sep	0.00012	0.00060	0.0016	0.0016	0.24	0.0000078	7.7	0.21	2.8	0.32	0.015	15	0.0025	0.024	0.0032	0.022	0.0039	4.0	0.00037	0.65	0.0082	0.00018	0.0030	0.00083	0.0064
Oct	0.000099	0.00053	0.0014	0.0015	0.22	0.0000078	6.7	0.18	2.4	0.27	0.013	13	0.0021	0.021	0.0028	0.019	0.0034	3.5	0.00033	0.56	0.0077	0.00016	0.0026	0.00078	0.0057
Nov	0.00014	0.00071	0.0019	0.0019	0.27	0.0000081	9.5	0.26	3.3	0.39	0.018	18	0.0030	0.029	0.0041	0.027	0.0048	4.7	0.00040	0.79	0.0090	0.00021	0.0037	0.00091	0.0076
Dec	0.00014	0.00073	0.0019	0.0019	0.27	0.0000081	9.4	0.26	3.3	0.39	0.018	17	0.0030	0.028	0.0041	0.027	0.0048	4.7	0.00040	0.79	0.0090	0.00021	0.0037	0.00091	0.0076
Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00014	0.00073	0.0019	0.0019	0.27	0.0000081	9.4	0.26	3.3	0.39	0.018	17	0.0030	0.028	0.0015	0.027	0.0048	4.7	0.00024	0.79	0.0090	0.00021	0.0037	0.00075	0.0076
Feb	0.00014	0.00074	0.0019	0.0019	0.27	0.0000081	9.4	0.25	3.3	0.39	0.018	17	0.0030	0.028	0.0015	0.027	0.0048	4.7	0.00024	0.78	0.0090	0.00021	0.0037	0.00074	0.0076
Mar	0.00014	0.00073	0.0019	0.0019	0.27	0.0000081	9.4	0.25	3.3	0.39	0.018	17	0.0030	0.028	0.0015	0.027	0.0048	4.7	0.00024	0.78	0.0090	0.00021	0.0036	0.00074	0.0076
Apr	0.00014	0.00073	0.0019	0.0019	0.27	0.0000080	9.3	0.25	3.3	0.39	0.018	17	0.0030	0.028	0.0015	0.027	0.0047	4.7	0.00024	0.78	0.0090	0.00020	0.0036	0.00074	0.0076
May	0.00014	0.00073	0.0019	0.0019	0.27	0.0000081	9.3	0.25	3.3	0.39	0.017	17	0.0029	0.028	0.0015	0.027	0.0047	4.6	0.00024	0.78	0.0090	0.00020	0.0036	0.00074	0.0076
Jun	0.00012	0.00063	0.0016	0.0017	0.26	0.0000090	7.8	0.21	2.8	0.33	0.015	15	0.0025	0.025	0.0013	0.022	0.0040	4.0	0.00021	0.66	0.0083	0.00018	0.0030	0.00072	0.0066
Jul	0.000077	0.00045	0.0011	0.0013	0.25	0.0000081	5.1	0.14	1.9	0.22	0.0096	9.7	0.0017	0.020	0.00092	0.015	0.0026	2.9	0.00015	0.44	0.0069	0.00013	0.0020	0.00063	0.0047
Aug	0.00011	0.00060	0.0015	0.0016	0.26	0.0000079	7.7	0.20	3.0	0.36	0.014	14	0.0024	0.024	0.0013	0.021	0.0038	3.9	0.00020	0.64	0.0080	0.00017	0.0029	0.00069	0.0063
Sep	0.000094	0.00052	0.0013	0.0014	0.23	0.0000076	6.4	0.17	2.6	0.30	0.012	12	0.0020	0.021	0.0011	0.018	0.0031	3.3	0.00017	0.54	0.0074	0.00015	0.0024	0.00065	0.0055
Oct	0.000082	0.00045	0.0012	0.0013	0.21	0.0000077	5.6	0.14	2.3	0.26	0.010	10.0	0.0018	0.018	0.00097	0.015	0.0027	3.0	0.00015	0.47	0.0070	0.00013	0.0021	0.00062	0.0049
Nov	0.000099	0.00053	0.0014	0.0015	0.24	0.0000078	6.8	0.17	2.8	0.33	0.012	12	0.0021	0.022	0.0011	0.018	0.0033	3.5	0.00018	0.57	0.0076	0.00015	0.0025	0.00066	0.0057
Dec	0.000098	0.00054	0.0014	0.0015	0.24	0.0000078	6.8	0.17	2.8	0.33	0.012	12	0.0021	0.021	0.0011	0.018	0.0033	3.4	0.00018	0.57	0.0076	0.00015	0.0025	0.00066	0.0057
Post-Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000038	0.00030	0.00056	0.00083	0.20	0.0000073	3.1	0.057	2.0	0.22	0.0044	4.4	0.00086	0.012	0.00052	0.0062	0.0011	1.7	0.000098	0.27	0.0056	0.000080	0.00083	0.00054	0.0029
Feb	0.000038	0.00031	0.00056	0.00082	0.20	0.0000073	3.0	0.057	2.0	0.22	0.0044	4.4	0.00086	0.012	0.00052	0.0061	0.0011	1.7	0.000099	0.27	0.0056	0.000080	0.00082	0.00054	0.0029
Mar	0.000038	0.00031	0.00056	0.00082	0.20	0.0000073	3.0	0.057	2.0	0.22	0.0044	4.4	0.00086	0.011	0.00051	0.0061	0.0011	1.7	0.000099	0.27	0.0055	0.000080	0.00082	0.00054	0.0029
Apr	0.000038	0.00031	0.00055	0.00082	0.20	0.0000073	3.0	0.057	1.9	0.22	0.0043	4.4	0.00085	0.011	0.00051	0.0061	0.0011	1.7	0.000099	0.27	0.0055	0.000080	0.00082	0.00054	0.0029
May	0.000038	0.00031	0.00055	0.00082	0.20	0.0000073	3.0	0.056	1.9	0.22	0.0043	4.3	0.00085	0.011	0.00051	0.0060	0.0011	1.7	0.000098	0.27	0.0055	0.000080	0.00081	0.00054	0.0029
Jun	0.000033	0.00028	0.00048	0.00080	0.21	0.0000084	2.6	0.048	1.7	0.19	0.0037	3.8	0.00076	0.011	0.00047	0.0052	0.00093	1.6	0.000092	0.24	0.0055	0.000075	0.00069	0.00055	0.0027
Jul	0.000023	0.00022	0.00035	0.00072	0.21	0.0000077	1.8	0.031	1.2	0.13	0.0025	2.8	0.00057	0.011	0.00039	0.0034	0.00062	1.3	0.000076	0.17	0.0051	0.000064	0.00045	0.00052	0.0022
Aug	0.000028	0.00025	0.00041	0.00075	0.21	0.0000074	2.5	0.039	1.9	0.21	0.0032	3.3	0.00067	0.011	0.00042	0.0043	0.00078	1.4	0.000083	0.23	0.0052	0.000068	0.00057	0.00052	0.0024
Sep	0.000024	0.00022	0.00038	0.00067	0.18	0.0000071	2.1	0.032	1.5	0.17	0.0026	2.8	0.00058	0.0093	0.00038	0.0035	0.00064	1.3	0.000076	0.20	0.0051	0.000064	0.00046	0.00051	0.0022
Oct	0.000021	0.00020	0.00036	0.00062	0.16	0.0000072	1.8	0.027	1.4	0.15	0.0023	2.5	0.00053	0.0084	0.00035	0.0030	0.00055	1.2	0.000072	0.17	0.0050	0.000061	0.00040	0.00050	0.0021
Nov	0.000026	0.00023	0.00039	0.00069	0.19	0.0000073	2.3	0.034	1.8	0.20	0.0028	2.9	0.00061	0.0096	0.00039	0.0037	0.00068	1.3	0.000078	0.22	0.0051	0.000065	0.00049	0.00052	0.0023
Dec	0.000026	0.00024	0.00040	0.00070	0.19	0.0000073	2.3	0.033	1.8	0.20	0.0028	2.9	0.00061	0.0096	0.00039	0.0037	0.00068	1.3	0.000080	0.22	0.0051	0.000065	0.00049	0.00052	0.0023
Long-Term BC FWAL	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

APPENDIX 3.2: WATER QUALITY PREDICTIONS AT STATION BJ 2.62

Appendix 3.2-1: Maximum Base Case Predictions for Scenario 1 at BJ 2.62

Operations Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.7	8.4	**0.19**	1.2	0.11	73	0.000025	0.037	0.0057	0.049	0.057	0.000066	0.00024	22	0.000015	0.00014	0.00042	0.00028	0.015	0.0000052	4.0	0.054
Feb	2.7	8.5	**0.20**	1.5	0.11	73	0.000025	0.037	0.0057	0.050	0.058	0.000059	0.00023	22	0.000020	0.00017	0.00042	0.00028	0.014	0.0000052	4.0	0.054
Mar	2.8	8.5	**0.20**	1.3	0.11	72	0.000025	0.037	0.0058	0.050	0.058	0.000059	0.00023	22	0.000013	0.00014	0.00043	0.00027	0.015	0.0000052	4.1	0.054
Apr	2.7	8.3	**0.19**	2.1	0.11	75	0.000024	0.037	0.0057	0.050	0.058	0.000060	0.00023	23	0.000035	0.00024	0.00042	0.00029	0.014	0.0000053	4.0	0.053
May	2.5	7.9	**0.18**	1.2	0.10	69	0.000024	0.036	0.0055	0.047	0.056	0.000062	0.00022	21	0.000029	0.00019	0.00040	0.00030	0.014	0.0000052	3.8	0.050
Jun	2.2	6.7	**0.16**	1.1	0.090	61	0.000021	0.034	0.0048	0.041	0.062	0.000060	0.00022	24	0.000031	0.00018	0.00035	0.00030	0.014	0.0000051	3.2	0.043
Jul	1.5	4.5	**0.10**	0.86	0.064	44	0.000016	0.026	0.0033	0.029	0.051	0.000056	0.00022	19	0.000024	0.00015	0.00025	0.00028	0.014	0.0000049	2.2	0.029
Aug	2.7	8.3	**0.19**	1.2	0.11	74	0.000025	0.039	0.0058	0.054	0.060	0.000057	0.00023	23	0.000025	0.00021	0.00047	0.00031	0.015	0.0000053	4.1	0.055
Sep	2.1	6.6	**0.15**	1.0	0.090	62	0.000021	0.033	0.0047	0.045	0.055	0.000056	0.00022	21	0.000029	0.00022	0.00040	0.00032	0.015	0.0000053	3.3	0.044
Oct	1.8	5.6	**0.13**	0.92	0.079	54	0.000019	0.030	0.0040	0.040	0.052	0.000055	0.00022	19	0.000030	0.00022	0.00036	0.00031	0.015	0.0000052	2.9	0.038
Nov	2.7	8.3	**0.19**	1.3	0.11	75	0.000025	0.037	0.0056	0.051	0.057	0.000065	0.00024	22	0.000021	0.00016	0.00044	0.00029	0.015	0.0000053	4.1	0.055
Dec	2.7	8.4	**0.19**	1.2	0.11	75	0.000025	0.037	0.0057	0.051	0.058	0.000065	0.00024	22	0.000016	0.00014	0.00044	0.00028	0.015	0.0000052	4.1	0.056
Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.3	7.3	**0.17**	1.3	0.11	75	0.000025	0.033	0.011	0.054	0.039	0.000061	0.00024	19	0.000026	0.00020	0.00070	0.00030	**1.9**	0.0000052	4.0	0.067
Feb	2.3	7.3	**0.17**	2.1	0.11	76	0.000024	0.033	0.010	0.056	0.040	0.000060	0.00024	20	0.000035	0.00025	0.00067	0.00029	**1.8**	0.0000052	4.1	0.066
Mar	2.4	7.4	**0.17**	1.8	0.11	75	0.000025	0.033	0.012	0.062	0.040	0.000060	0.00024	20	0.000027	0.00022	0.00076	0.00030	**2.2**	0.0000052	4.1	0.075
Apr	2.4	7.5	**0.17**	2.1	0.11	74	0.000025	0.033	0.0093	0.059	0.040	0.000061	0.00023	21	0.000040	0.00030	0.00063	0.00030	**1.5**	0.0000052	4.1	0.068
May	2.2	6.8	**0.16**	1.3	0.10	70	0.000024	0.032	0.0052	0.047	0.039	0.000061	0.00022	18	0.000029	0.00020	0.00041	0.00030	**0.41**	0.0000051	3.8	0.051
Jun	1.9	5.7	**0.13**	1.1	0.089	60	0.000021	0.029	0.0040	0.041	0.038	0.000060	0.00022	16	0.000028	0.00018	0.00036	0.00030	0.21	0.0000050	3.2	0.043
Jul	1.2	3.8	**0.088**	0.83	0.062	43	0.000015	0.023	0.0033	0.028	0.035	0.000055	0.00022	13	0.000023	0.00015	0.00025	0.00027	0.26	0.0000048	2.2	0.029
Aug	1.9	5.8	**0.13**	1.0	0.089	64	0.000021	0.029	0.0052	0.043	0.037	0.000057	0.00023	17	0.000024	0.00019	0.00038	0.00030	**0.48**	0.0000051	3.5	0.044
Sep	1.5	4.7	**0.11**	0.92	0.078	56	0.000018	0.026	0.0051	0.041	0.036	0.000056	0.00022	16	0.000029	0.00022	0.00038	0.00031	**0.60**	0.0000051	3.0	0.040
Oct	1.3	4.0	**0.091**	0.85	0.071	51	0.000017	0.025	0.0067	0.041	0.036	0.000055	0.00022	16	0.000031	0.00025	0.00049	0.00032	**1.1**	0.0000051	2.7	0.043
Nov	1.6	5.0	**0.11**	1.1	0.093	67	0.000021	0.027	0.013	0.061	0.038	0.000059	0.00025	21	0.000025	0.00023	0.00081	0.00031	**2.4**	0.0000051	3.5	0.078
Dec	1.6	5.0	**0.12**	1.0	0.092	66	0.000021	0.027	0.012	0.057	0.038	0.000060	0.00024	20	0.000020	0.00021	0.00075	0.00030	**2.4**	0.0000051	3.5	0.072
Post-Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.52	1.6	0.037	0.83	0.053	52	0.000014	0.019	0.0095	0.026	0.034	0.000061	0.00025	18	0.000020	0.00020	0.00054	0.00030	**2.8**	0.0000050	2.0	0.034
Feb	0.52	1.6	0.038	1.3	0.054	53	0.000014	0.019	0.0094	0.027	0.034	0.000061	0.00024	19	0.000025	0.00025	0.00053	0.00030	**2.7**	0.0000050	2.1	0.034
Mar	0.51	1.6	0.037	1.1	0.055	54	0.000015	0.019	0.011	0.028	0.035	0.000061	0.00024	19	0.000020	0.00024	0.00059	0.00030	**3.1**	0.0000050	2.1	0.037
Apr	0.51	1.7	0.038	1.8	0.054	51	0.000013	0.018	0.0075	0.024	0.034	0.000061	0.00023	18	0.000040	0.00029	0.00042	0.00030	**2.0**	0.0000051	2.0	0.028
May	0.49	1.5	0.035	0.72	0.041	38	0.0000100	0.016	0.0035	0.016	0.033	0.000061	0.00022	14	0.000027	0.00016	0.00020	0.00028	**0.47**	0.0000048	1.8	0.016
Jun	0.42	1.3	0.030	0.66	0.036	33	0.0000090	0.016	0.0027	0.014	0.033	0.000060	0.00022	13	0.000026	0.00015	0.00016	0.00028	0.24	0.0000048	1.5	0.013
Jul	0.28	0.86	0.020	0.55	0.028	26	0.0000077	0.014	0.0022	0.011	0.031	0.000055	0.00022	11	0.000022	0.00013	0.00014	0.00027	0.29	0.0000047	1.0	0.0094
Aug	0.36	1.1	0.026	0.56	0.036	36	0.0000091	0.015	0.0036	0.017	0.032	0.000057	0.00022	13	0.000023	0.00017	0.00022	0.00029	**0.54**	0.0000049	1.7	0.014
Sep	0.28	0.89	0.020	0.54	0.033	33	0.0000090	0.015	0.0036	0.018	0.032	0.000056	0.00022	13	0.000028	0.00020	0.00024	0.00030	**0.68**	0.0000049	1.4	0.013
Oct	0.24	0.74	0.017	0.57	0.034	34	0.0000098	0.016	0.0050	0.019	0.032	0.000055	0.00022	14	0.000030	0.00023	0.00032	0.00031	**1.3**	0.0000050	1.3	0.017
Nov	0.30	0.94	0.021	0.81	0.046	49	0.000013	0.017	0.0093	0.022	0.033	0.000059	0.00025	18	0.000024	0.00021	0.00051	0.00030	**2.8**	0.0000050	1.8	0.030
Dec	0.30	0.95	0.022	0.75	0.044	48	0.000013	0.017	0.0091	0.022	0.033	0.000060	0.00024	18	0.000019	0.00019	0.00050	0.00030	**2.7**	0.0000050	1.8	0.029
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-1: Maximum Base Case Predictions for Scenario 1 at BJ 2.62

Operations Phase																										
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	1.8	0.16	0.0066	12	0.00046	0.015	0.00018	0.012	0.00077	1.5	0.000070	0.31	0.0065	0.000047	0.00073	0.00056	0.0026	0.000033	0.31	**0.0062**	0.052	0.065	0.000087	0.0087	21
Feb	1.9	0.17	0.0066	12	0.00046	0.015	0.00018	0.012	0.00079	1.5	0.000070	0.32	0.0065	0.000047	0.00073	0.00055	0.0021	0.000042	0.36	**0.0066**	0.052	0.067	0.000089	0.0057	21
Mar	1.9	0.17	0.0067	12	0.00045	0.015	0.00018	0.012	0.00078	1.5	0.000070	0.32	0.0065	0.000047	0.00074	0.00055	0.0019	0.000036	0.33	**0.0064**	0.052	0.066	0.000078	0.0058	21
Apr	1.9	0.19	0.0065	12	0.00047	0.015	0.00018	0.012	0.00080	1.5	0.000071	0.32	0.0066	0.000048	0.00072	0.00055	0.0024	0.000055	0.46	**0.0073**	0.052	0.071	0.00011	0.0056	22
May	1.8	0.16	0.0062	11	0.00049	0.014	0.00017	0.011	0.00073	1.5	0.000072	0.29	0.0067	0.000045	0.00068	0.00055	0.0054	0.000039	0.37	**0.0064**	0.049	0.064	0.000074	0.0053	20
Jun	1.5	0.14	0.0053	9.8	0.00047	0.012	0.00015	0.0095	0.00063	1.3	0.000069	0.27	0.0065	0.000040	0.00059	0.00054	0.0054	0.000037	0.40	**0.0057**	0.043	0.070	0.000071	0.0045	22
Jul	1.1	0.10	0.0037	6.9	0.00040	0.0086	0.00011	0.0064	0.00044	1.1	0.000062	0.20	0.0059	0.000028	0.00040	0.00051	0.0046	0.000032	0.35	0.0042	0.030	0.059	0.000063	0.0031	17
Aug	1.9	0.19	0.0067	12	0.00050	0.015	0.00020	0.012	0.00078	1.6	0.000086	0.32	0.0066	0.000055	0.00076	0.00056	0.0033	0.000039	0.36	**0.0063**	0.055	0.069	0.000067	0.0043	22
Sep	1.6	0.16	0.0054	9.6	0.00047	0.012	0.00017	0.0097	0.00063	1.4	0.000087	0.26	0.0063	0.000048	0.00061	0.00055	0.0037	0.000034	0.34	**0.0052**	0.047	0.063	0.000064	0.0034	20
Oct	1.4	0.14	0.0047	8.4	0.00045	0.011	0.00016	0.0083	0.00055	1.2	0.000085	0.23	0.0061	0.000044	0.00053	0.00054	0.0037	0.000032	0.31	0.0045	0.042	0.059	0.000062	0.0030	18
Nov	2.0	0.18	0.0067	12	0.00049	0.015	0.00018	0.012	0.00079	1.6	0.000072	0.32	0.0066	0.000049	0.00076	0.00056	0.0034	0.000034	0.31	**0.0061**	0.052	0.064	0.000086	0.0084	21
Dec	2.0	0.18	0.0068	12	0.00048	0.016	0.00019	0.012	0.00079	1.6	0.000071	0.32	0.0066	0.000049	0.00077	0.00056	0.0027	0.000034	0.31	**0.0062**	0.053	0.065	0.000086	0.0085	21
Closure Phase																										
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.1	0.21	0.0066	12	0.00059	0.015	0.00066	0.013	0.00077	1.6	0.000074	0.32	0.0072	0.000057	0.0013	0.00056	0.0041	0.000033	0.21	**0.011**	0.057	0.044	0.000075	0.0061	19
Feb	2.1	0.21	0.0066	12	0.00056	0.015	0.00063	0.013	0.00081	1.6	0.000075	0.34	0.0072	0.000057	0.0012	0.00055	0.0025	0.000055	0.38	**0.011**	0.059	0.052	0.00011	0.0060	20
Mar	2.1	0.21	0.0066	12	0.00060	0.015	0.00075	0.014	0.00081	1.6	0.000079	0.33	0.0075	0.000063	0.0014	0.00055	0.0025	0.000048	0.32	**0.012**	0.065	0.050	0.000099	0.0059	20
Apr	2.2	0.23	0.0067	12	0.00058	0.015	0.00055	0.013	0.00080	1.6	0.000078	0.34	0.0074	0.000060	0.0011	0.00055	0.0028	0.000055	0.39	**0.011**	0.061	0.053	0.00012	0.0058	21
May	1.8	0.18	0.0062	11	0.00050	0.014	0.00021	0.011	0.00073	1.5	0.000073	0.30	0.0068	0.000047	0.00071	0.00054	0.0056	0.000039	0.28	**0.0061**	0.050	0.045	0.000075	0.0057	18
Jun	1.6	0.16	0.0052	9.5	0.00047	0.012	0.00016	0.0096	0.00062	1.4	0.000069	0.26	0.0065	0.000040	0.00060	0.00054	0.0054	0.000037	0.28	0.0050	0.042	0.045	0.000071	0.0049	16
Jul	1.2	0.11	0.0036	6.6	0.00039	0.0082	0.00014	0.0064	0.00043	1.1	0.000061	0.19	0.0058	0.000028	0.00040	0.00051	0.0045	0.000031	0.28	0.0042	0.030	0.042	0.000063	0.0033	13
Aug	1.9	0.20	0.0054	9.4	0.00045	0.012	0.00024	0.0097	0.00063	1.3	0.000078	0.28	0.0062	0.000045	0.00060	0.00054	0.0032	0.000034	0.24	**0.0057**	0.045	0.044	0.000068	0.0046	17
Sep	1.7	0.17	0.0046	7.8	0.00046	0.010	0.00026	0.0086	0.00053	1.2	0.000085	0.25	0.0062	0.000045	0.00057	0.00054	0.0037	0.000032	0.24	**0.0056**	0.043	0.043	0.000065	0.0037	16
Oct	1.5	0.16	0.0042	6.8	0.00050	0.0093	0.00041	0.0083	0.00048	1.2	0.000087	0.23	0.0064	0.000048	0.00078	0.00053	0.0040	0.000030	0.23	**0.0072**	0.043	0.043	0.000062	0.0032	16
Nov	2.2	0.21	0.0056	8.3	0.00066	0.013	0.00078	0.013	0.00062	1.4	0.000079	0.31	0.0077	0.000065	0.0015	0.00054	0.0042	0.000030	0.20	**0.013**	0.063	0.044	0.000071	0.0049	21
Dec	2.1	0.21	0.0056	8.3	0.00061	0.013	0.00077	0.012	0.00062	1.4	0.000076	0.31	0.0074	0.000061	0.0014	0.00053	0.0034	0.000030	0.21	**0.012**	0.059	0.044	0.000074	0.0057	20
Post-Closure Phase																										
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.1	0.21	0.0022	4.0	0.00051	0.0069	0.00084	0.0040	0.00033	1.2	0.000062	0.26	0.0059	0.000036	0.0013	0.00051	0.0034	0.000023	0.19	**0.0099**	0.029	0.040	0.000077	0.0065	18
Feb	2.1	0.22	0.0023	4.3	0.00050	0.0069	0.00083	0.0040	0.00035	1.2	0.000062	0.27	0.0059	0.000036	0.0013	0.00051	0.0026	0.000034	0.28	**0.011**	0.029	0.044	0.000097	0.0062	19
Mar	2.2	0.22	0.0023	4.3	0.00052	0.0073	0.00095	0.0042	0.00036	1.2	0.000063	0.27	0.0060	0.000039	0.0015	0.00051	0.0026	0.000030	0.24	**0.011**	0.031	0.042	0.000088	0.0062	19
Apr	2.0	0.22	0.0022	4.4	0.00047	0.0060	0.00062	0.0038	0.00035	1.1	0.000061	0.25	0.0058	0.000032	0.0010	0.00050	0.0028	0.000047	0.38	**0.0095**	0.027	0.048	0.00012	0.0061	19
May	1.6	0.17	0.0020	3.3	0.00039	0.0042	0.00019	0.0030	0.00024	0.84	0.000056	0.18	0.0055	0.000020	0.00036	0.00049	0.0053	0.000026	0.26	0.0044	0.019	0.039	0.000076	0.0060	14
Jun	1.4	0.15	0.0017	2.9	0.00037	0.0035	0.00012	0.0025	0.00021	0.78	0.000055	0.16	0.0054	0.000017	0.00024	0.00049	0.0051	0.000025	0.27	0.0036	0.016	0.040	0.000072	0.0052	13
Jul	1.0	0.11	0.0012	2.3	0.00034	0.0026	0.00012	0.0018	0.00016	0.71	0.000052	0.13	0.0051	0.000014	0.00022	0.00048	0.0044	0.000024	0.27	0.0031	0.013	0.038	0.000063	0.0035	11
Aug	1.7	0.19	0.0017	2.7	0.00037	0.0034	0.00021	0.0024	0.00021	0.77	0.000067	0.18	0.0051	0.000024	0.00035	0.00049	0.0030	0.000023	0.23	0.0041	0.019	0.038	0.000068	0.0049	13
Sep	1.5	0.16	0.0014	2.4	0.00039	0.0031	0.00026	0.0020	0.00018	0.77	0.000073	0.16	0.0052	0.000025	0.00039	0.00050	0.0036	0.000022	0.23	0.0041	0.019	0.039	0.000065	0.0039	13
Oct	1.4	0.15	0.0013	2.4	0.00042	0.0035	0.00043	0.0020	0.00019	0.85	0.000075	0.17	0.0053	0.000029	0.00063	0.00050	0.0038	0.000022	0.22	**0.0054**	0.021	0.039	0.000063	0.0033	14
Nov	2.1	0.21	0.0017	3.1	0.00051	0.0056	0.00084	0.0029	0.00027	1.1	0.000060	0.24	0.0058	0.000032	0.0013	0.00051	0.0041	0.000021	0.19	**0.0097**	0.024	0.039	0.000071	0.0051	18
Dec	2.0	0.20	0.0017	3.0	0.00049	0.0055	0.00081	0.0029	0.00026	1.1	0.000060	0.24	0.0057	0.000031	0.0012	0.00051	0.0033	0.000021	0.19	**0.0095**	0.024	0.039	0.000074	0.0059	18
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-1: Maximum Base Case Predictions for Scenario 1 at BJ 2.62

Operations Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000017	0.00027	0.0011	0.00055	0.14	0.0000052	4.1	0.054	1.9	0.17	0.0066	12	0.00078	0.023	0.00045	0.012	0.00081	1.8	0.00039	0.31	0.0065	0.000084	0.00075	0.00079	0.0034
Feb	0.000026	0.00035	0.0011	0.00092	0.26	0.0000052	4.2	0.054	1.9	0.18	0.0067	12	0.00079	0.023	0.00054	0.012	0.00082	2.0	0.00038	0.32	0.0080	0.000086	0.00076	0.00085	0.0039
Mar	0.000015	0.00028	0.0011	0.00066	0.18	0.0000052	4.2	0.055	1.9	0.18	0.0067	12	0.00077	0.024	0.00047	0.012	0.00082	1.9	0.00039	0.32	0.0070	0.000085	0.00076	0.00081	0.0030
Apr	0.000050	0.00050	0.0011	0.0015	0.43	0.0000053	4.2	0.053	2.0	0.21	0.0066	12	0.00084	0.023	0.00072	0.012	0.00083	2.2	0.00038	0.33	0.010	0.000087	0.00077	0.00097	0.0062
May	0.000031	0.00034	0.0010	0.00077	0.23	0.0000084	3.9	0.051	1.8	0.17	0.0062	11	0.00080	0.022	0.00057	0.011	0.00076	1.8	0.00037	0.29	0.0069	0.000083	0.00070	0.00081	0.0082
Jun	0.000033	0.00033	0.0012	0.00079	0.25	0.0000084	3.4	0.043	1.6	0.16	0.0054	9.8	0.00092	0.020	0.00062	0.0095	0.00066	1.7	0.00045	0.26	0.0067	0.000078	0.00061	0.00086	0.0086
Jul	0.000025	0.00027	0.00086	0.00076	0.25	0.0000076	2.3	0.029	1.2	0.11	0.0037	6.9	0.00069	0.017	0.00049	0.0065	0.00046	1.5	0.00032	0.19	0.0060	0.000068	0.00042	0.00072	0.0068
Aug	0.000030	0.00036	0.0012	0.00071	0.20	0.0000053	4.2	0.055	2.0	0.20	0.0067	12	0.00086	0.024	0.00050	0.012	0.00081	1.9	0.00044	0.32	0.0066	0.000091	0.00078	0.00083	0.0050
Sep	0.000036	0.00038	0.0010	0.00072	0.19	0.0000053	3.4	0.044	1.6	0.17	0.0054	9.6	0.00079	0.020	0.00046	0.0097	0.00066	1.8	0.00038	0.27	0.0063	0.000085	0.00063	0.00077	0.0058
Oct	0.000036	0.00037	0.00093	0.00071	0.18	0.0000052	3.0	0.038	1.4	0.15	0.0047	8.4	0.00072	0.017	0.00042	0.0084	0.00058	1.6	0.00033	0.24	0.0061	0.000080	0.00054	0.00073	0.0058
Nov	0.000022	0.00029	0.0011	0.00056	0.14	0.0000053	4.2	0.056	2.0	0.19	0.0067	12	0.00079	0.023	0.00045	0.012	0.00082	1.9	0.00039	0.32	0.0066	0.000086	0.00078	0.00079	0.0040
Dec	0.000016	0.00027	0.0011	0.00055	0.14	0.0000052	4.2	0.056	2.0	0.19	0.0068	12	0.00078	0.024	0.00045	0.013	0.00083	1.9	0.00039	0.33	0.0066	0.000087	0.00079	0.00080	0.0033
Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000027	0.00033	0.00082	0.00057	**2.0**	0.0000053	4.1	0.067	2.1	0.21	0.0066	12	0.00060	0.023	0.00084	0.013	0.00081	1.9	0.000086	0.32	0.0072	0.000093	0.0013	0.00057	0.0042
Feb	0.000051	0.00051	0.00080	0.0015	**2.0**	0.0000053	4.3	0.067	2.1	0.22	0.0066	12	0.00060	0.023	0.00094	0.013	0.00085	2.2	0.000087	0.34	0.010	0.000095	0.0013	0.00075	0.0058
Mar	0.000037	0.00042	0.00089	0.0012	**2.4**	0.0000052	4.3	0.075	2.2	0.22	0.0067	12	0.00063	0.023	0.0010	0.014	0.00084	2.1	0.000090	0.33	0.0091	0.000100	0.0015	0.00068	0.0045
Apr	0.000057	0.00058	0.00079	0.0016	**2.0**	0.0000052	4.3	0.069	2.2	0.25	0.0067	12	0.00067	0.023	0.0010	0.013	0.00084	2.1	0.000090	0.34	0.012	0.000099	0.0011	0.00077	0.0065
May	0.000031	0.00035	0.00054	0.00078	0.63	0.0000085	3.9	0.051	1.9	0.20	0.0062	11	0.00053	0.022	0.00053	0.011	0.00077	1.9	0.000083	0.30	0.0070	0.000085	0.00072	0.00059	0.0079
Jun	0.000029	0.00033	0.00047	0.00079	0.44	0.0000083	3.3	0.043	1.6	0.17	0.0053	9.5	0.00049	0.020	0.00048	0.0096	0.00065	1.8	0.000078	0.26	0.0067	0.000079	0.00061	0.00058	0.0076
Jul	0.000024	0.00027	0.00035	0.00075	0.50	0.0000074	2.3	0.029	1.2	0.12	0.0036	6.6	0.00041	0.016	0.00045	0.0065	0.00045	1.5	0.000067	0.19	0.0060	0.000067	0.00042	0.00054	0.0064
Aug	0.000029	0.00035	0.00048	0.00070	0.66	0.0000051	3.6	0.044	2.0	0.21	0.0054	9.4	0.00048	0.020	0.00043	0.0098	0.00066	1.7	0.000087	0.28	0.0062	0.000082	0.00062	0.00054	0.0044
Sep	0.000036	0.00038	0.00050	0.00072	0.77	0.0000051	3.1	0.040	1.7	0.18	0.0046	7.8	0.00049	0.017	0.00046	0.0087	0.00056	1.6	0.000092	0.25	0.0062	0.000082	0.00059	0.00054	0.0053
Oct	0.000038	0.00039	0.00062	0.00071	**1.3**	0.0000051	2.8	0.044	1.6	0.17	0.0042	6.8	0.00053	0.016	0.00060	0.0083	0.00051	1.5	0.000092	0.23	0.0064	0.000084	0.00079	0.00053	0.0056
Nov	0.000026	0.00034	0.00092	0.00057	**2.5**	0.0000051	3.6	0.078	2.2	0.22	0.0056	8.3	0.00067	0.020	0.00095	0.013	0.00065	1.7	0.000088	0.31	0.0077	0.000100	0.0015	0.00054	0.0043
Dec	0.000020	0.00033	0.00087	0.00056	**2.5**	0.0000051	3.6	0.072	2.1	0.22	0.0056	8.3	0.00062	0.020	0.00094	0.012	0.00065	1.7	0.000087	0.31	0.0074	0.000096	0.0014	0.00053	0.0035
Post-Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000021	0.00033	0.00065	0.00056	**2.9**	0.0000050	2.2	0.035	2.1	0.21	0.0023	4.0	0.00052	0.013	0.0010	0.0040	0.00037	1.5	0.000075	0.26	0.0059	0.000071	0.0013	0.00051	0.0036
Feb	0.000034	0.00045	0.00067	0.0011	**3.0**	0.0000050	2.2	0.034	2.2	0.23	0.0023	4.3	0.00055	0.013	0.0012	0.0041	0.00039	1.7	0.000074	0.27	0.0079	0.000073	0.0013	0.00062	0.0045
Mar	0.000025	0.00041	0.00072	0.00084	**3.3**	0.0000050	2.2	0.038	2.2	0.23	0.0023	4.2	0.00055	0.013	0.0012	0.0042	0.00039	1.7	0.000075	0.27	0.0071	0.000075	0.0015	0.00057	0.0037
Apr	0.000058	0.00058	0.00059	0.0016	**2.4**	0.0000051	2.2	0.029	2.1	0.24	0.0022	4.4	0.00056	0.012	0.0012	0.0039	0.00038	1.8	0.000073	0.26	0.010	0.000071	0.0011	0.00074	0.0066
May	0.000029	0.00032	0.00033	0.00075	0.69	0.0000081	1.9	0.017	1.7	0.19	0.0020	3.3	0.00042	0.010	0.00050	0.0031	0.00028	1.2	0.000068	0.18	0.0057	0.000058	0.00038	0.00053	0.0076
Jun	0.000028	0.00030	0.00027	0.00077	0.47	0.0000080	1.6	0.013	1.4	0.16	0.0017	2.9	0.00040	0.010	0.00044	0.0026	0.00024	1.2	0.000065	0.16	0.0056	0.000056	0.00026	0.00053	0.0073
Jul	0.000023	0.00026	0.00024	0.00074	0.53	0.0000073	1.2	0.0095	1.1	0.12	0.0012	2.3	0.00036	0.0100	0.00043	0.0018	0.00018	1.1	0.000059	0.13	0.0053	0.000053	0.00023	0.00051	0.0062
Aug	0.000028	0.00033	0.00032	0.00069	0.72	0.0000049	1.8	0.014	1.7	0.20	0.0017	2.7	0.00040	0.010	0.00041	0.0024	0.00024	1.2	0.000076	0.18	0.0051	0.000060	0.00037	0.00049	0.0043
Sep	0.000035	0.00036	0.00036	0.00071	0.86	0.0000049	1.5	0.013	1.5	0.17	0.0015	2.4	0.00042	0.0090	0.00045	0.0021	0.00021	1.2	0.000080	0.16	0.0052	0.000062	0.00041	0.00050	0.0052
Oct	0.000037	0.00038	0.00045	0.00070	**1.5**	0.0000050	1.4	0.017	1.4	0.16	0.0013	2.4	0.00045	0.0089	0.00062	0.0020	0.00022	1.2	0.000081	0.17	0.0053	0.000065	0.00064	0.00050	0.0055
Nov	0.000025	0.00032	0.00062	0.00056	**2.9**	0.0000050	1.9	0.030	2.1	0.22	0.0017	3.1	0.00052	0.012	0.0010	0.0029	0.00030	1.4	0.000070	0.24	0.0058	0.000067	0.0013	0.00051	0.0042
Dec	0.000020	0.00032	0.00061	0.00056	**2.8**	0.0000050	1.9	0.029	2.1	0.21	0.0017	3.0	0.00050	0.012	0.00099	0.0029	0.00030	1.4	0.000071	0.24	0.0057	0.000067	0.0012	0.00051	0.0035
Long-Term BC FWAL	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-2: Maximum Base Case Predictions for Scenario 2 at BJ 2.62

Operations Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.3	7.2	**0.17**	1.4	0.14	92	0.000031	0.035	0.0051	0.065	0.058	0.000065	0.00024	22	0.000016	0.00037	0.00057	0.00028	0.015	0.0000052	5.0	0.071
Feb	2.3	7.3	**0.17**	1.7	0.14	92	0.000031	0.035	0.0051	0.065	0.058	0.000059	0.00023	22	0.000020	0.00040	0.00057	0.00028	0.014	0.0000052	5.0	0.070
Mar	2.4	7.3	**0.17**	1.5	0.14	92	0.000032	0.035	0.0052	0.065	0.058	0.000059	0.00023	22	0.000014	0.00037	0.00057	0.00027	0.014	0.0000052	5.0	0.071
Apr	2.3	7.2	**0.17**	2.2	0.14	94	0.000031	0.034	0.0051	0.065	0.058	0.000060	0.00023	23	0.000034	0.00047	0.00056	0.00028	0.014	0.0000053	4.9	0.069
May	2.2	6.8	**0.16**	1.5	0.13	87	0.000030	0.034	0.0049	0.061	0.056	0.000061	0.00022	21	0.000029	0.00041	0.00054	0.00030	0.014	0.0000051	4.7	0.066
Jun	1.9	5.8	**0.13**	1.3	0.12	77	0.000026	0.031	0.0043	0.053	0.062	0.000060	0.00022	24	0.000031	0.00037	0.00047	0.00030	0.014	0.0000051	4.0	0.057
Jul	1.3	3.9	**0.090**	0.99	0.082	55	0.000019	0.024	0.0030	0.037	0.051	0.000055	0.00022	19	0.000024	0.00028	0.00033	0.00028	0.014	0.0000049	2.7	0.038
Aug	2.3	7.1	**0.16**	1.4	0.14	93	0.000031	0.036	0.0050	0.068		0.000057	0.00023	23	0.000026	0.00045	0.00061	0.00031	0.015	0.0000053	5.0	0.071
Sep	1.8	5.6	**0.13**	1.2	0.12	76	0.000026	0.031	0.0041	0.057	0.055	0.000056	0.00022	21	0.000030	0.00042	0.00051	0.00031	0.015	0.0000053	4.0	0.057
Oct	1.5	4.8	**0.11**	1.1	0.10	67	0.000023	0.028	0.0035	0.050	0.052	0.000055	0.00022	19	0.000030	0.00038	0.00045	0.00031	0.015	0.0000052	3.5	0.049
Nov	2.2	6.9	**0.16**	1.5	0.14	94	0.000031	0.034	0.0050	0.065	0.057	0.000065	0.00024	22	0.000022	0.00040	0.00058	0.00029	0.015	0.0000052	5.0	0.071
Dec	2.3	7.1	**0.16**	1.4	0.14	93	0.000031	0.035	0.0051	0.066	0.058	0.000065	0.00024	22	0.000016	0.00039	0.00059	0.00028	0.015	0.0000052	5.0	0.072
Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	1.9	5.8	**0.13**	1.5	0.14	94	0.000031	0.019	0.0095	0.064	0.041	0.000061	0.00025	22	0.000027	0.00041	0.00075	0.00030	**1.9**	0.0000050	4.9	0.074
Feb	1.9	5.9	**0.14**	2.3	0.14	94	0.000031	0.019	0.0089	0.065	0.041	0.000060	0.00024	22	0.000037	0.00049	0.00071	0.00029	**1.8**	0.0000050	5.0	0.076
Mar	1.9	5.9	**0.14**	2.0	0.14	93	0.000031	0.019	0.010	0.071	0.041	0.000060	0.00024	22	0.000028	0.00045	0.00081	0.00030	**2.2**	0.0000050	5.0	0.085
Apr	1.9	5.9	**0.14**	2.2	0.14	93	0.000031	0.019	0.0077	0.067	0.041	0.000061	0.00023	23	0.000041	0.00046	0.00072	0.00030	**1.5**	0.0000051	5.0	0.078
May	1.8	5.4	**0.13**	1.5	0.13	87	0.000029	0.019	0.0037	0.061	0.041	0.000061	0.00022	20	0.000031	0.00042	0.00055	0.00030	**0.41**	0.0000049	4.6	0.066
Jun	1.5	4.6	**0.11**	1.3	0.11	75	0.000026	0.018	0.0028	0.052	0.039	0.000060	0.00022	18	0.000029	0.00037	0.00047	0.00030	0.21	0.0000049	3.9	0.055
Jul	0.98	3.0	**0.070**	0.94	0.078	52	0.000018	0.015	0.0025	0.036	0.036	0.000055	0.00022	15	0.000023	0.00027	0.00032	0.00027	0.26	0.0000047	2.6	0.037
Aug	1.5	4.6	**0.11**	1.2	0.11	78	0.000025	0.018	0.0038	0.054	0.038	0.000057	0.00023	19	0.000025	0.00037	0.00049	0.00030	**0.48**	0.0000049	4.2	0.055
Sep	1.2	3.7	**0.085**	1.1	0.097	67	0.000022	0.017	0.0040	0.050	0.038	0.000056	0.00022	18	0.000029	0.00037	0.00047	0.00031	**0.60**	0.0000050	3.5	0.050
Oct	1.0	3.1	**0.072**	0.96	0.087	60	0.000020	0.017	0.0058	0.048	0.037	0.000055	0.00022	17	0.000031	0.00036	0.00053	0.00032	**1.1**	0.0000050	3.1	0.048
Nov	1.3	3.9	**0.090**	1.2	0.11	78	0.000025	0.018	0.011	0.066	0.039	0.000059	0.00025	21	0.000025	0.00034	0.00086	0.00031	**2.4**	0.0000051	4.1	0.083
Dec	1.3	3.9	**0.091**	1.2	0.11	77	0.000025	0.017	0.010	0.062	0.039	0.000060	0.00024	21	0.000020	0.00032	0.00080	0.00030	**2.4**	0.0000050	4.1	0.077
Post-Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.39	1.2	0.028	0.86	0.058	56	0.000015	0.016	0.0084	0.029	0.034	0.000061	0.00025	19	0.000020	0.00025	0.00056	0.00030	**2.8**	0.0000050	2.2	0.037
Feb	0.39	1.3	0.029	1.3	0.060	56	0.000015	0.016	0.0084	0.029	0.035	0.000061	0.00024	19	0.000026	0.00030	0.00056	0.00030	**2.7**	0.0000050	2.2	0.037
Mar	0.39	1.2	0.028	1.1	0.060	57	0.000016	0.016	0.0094	0.030	0.035	0.000061	0.00024	19	0.000020	0.00029	0.00062	0.00030	**3.1**	0.0000050	2.3	0.040
Apr	0.39	1.3	0.030	1.8	0.059	54	0.000014	0.015	0.0065	0.027	0.035	0.000061	0.00023	19	0.000040	0.00034	0.00045	0.00029	**2.0**	0.0000050	2.2	0.031
May	0.38	1.2	0.027	0.75	0.046	41	0.000011	0.013	0.0025	0.019	0.033	0.000061	0.00022	14	0.000028	0.00021	0.00023	0.00028	**0.47**	0.0000047	1.9	0.019
Jun	0.32	1.0	0.023	0.69	0.041	36	0.0000098	0.013	0.0018	0.016	0.033	0.000060	0.00022	13	0.000026	0.00019	0.00018	0.00028	0.24	0.0000047	1.6	0.015
Jul	0.21	0.66	0.015	0.57	0.031	27	0.0000083	0.012	0.0016	0.013	0.031	0.000055	0.00022	11	0.000022	0.00015	0.00015	0.00027	0.29	0.0000046	1.1	0.011
Aug	0.27	0.85	0.020	0.58	0.039	38	0.0000098	0.013	0.0026	0.019	0.032	0.000057	0.00022	14	0.000023	0.00020	0.00024	0.00029	**0.54**	0.0000048	1.8	0.016
Sep	0.22	0.67	0.015	0.56	0.036	35	0.0000095	0.013	0.0028	0.019	0.032	0.000056	0.00022	13	0.000028	0.00023	0.00025	0.00030	**0.68**	0.0000049	1.5	0.015
Oct	0.18	0.56	0.013	0.58	0.036	35	0.000010	0.014	0.0043	0.020	0.032	0.000055	0.00022	14	0.000030	0.00025	0.00033	0.00031	**1.3**	0.0000049	1.4	0.018
Nov	0.23	0.72	0.016	0.83	0.048	51	0.000013	0.015	0.0084	0.023	0.033	0.000059	0.00025	18	0.000024	0.00024	0.00052	0.00030	**2.8**	0.0000050	1.8	0.031
Dec	0.23	0.71	0.016	0.77	0.047	49	0.000013	0.015	0.0081	0.023	0.033	0.000060	0.00025	18	0.000019	0.00022	0.00051	0.00030	**2.7**	0.0000050	1.8	0.031
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-2: Maximum Base Case Predictions for Scenario 2 at BJ 2.62

Operations Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.1	0.19	0.0092	15	0.00054	0.017	0.00024	0.012	0.00092	1.6	0.000085	0.38	0.0072	0.000056	0.00097	0.00051	0.0027	0.000040	0.31	**0.0056**	0.067	0.065	0.000086	0.0085	21
Feb	2.1	0.20	0.0092	15	0.00054	0.017	0.00024	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000057	0.00097	0.00051	0.0022	0.000048	0.36	**0.0060**	0.067	0.067	0.000087	0.0057	21
Mar	2.1	0.19	0.0093	15	0.00053	0.017	0.00024	0.012	0.00094	1.6	0.000085	0.39	0.0072	0.000057	0.00098	0.00051	0.0020	0.000043	0.33	**0.0058**	0.068	0.066	0.000077	0.0058	21
Apr	2.1	0.21	0.0090	15	0.00055	0.017	0.00024	0.012	0.00095	1.6	0.000085	0.39	0.0073	0.000057	0.00096	0.00051	0.0025	0.000060	0.46	**0.0066**	0.067	0.071	0.00011	0.0056	22
May	2.0	0.19	0.0086	14	0.00057	0.016	0.00023	0.011	0.00087	1.5	0.000085	0.36	0.0074	0.000054	0.00091	0.00051	0.0055	0.000045	0.37	**0.0058**	0.063	0.064	0.000074	0.0053	20
Jun	1.7	0.16	0.0074	12	0.00053	0.014	0.00020	0.0097	0.00076	1.4	0.000081	0.32	0.0071	0.000047	0.00078	0.00051	0.0055	0.000043	0.40	**0.0052**	0.055	0.070	0.000071	0.0045	22
Jul	1.3	0.12	0.0051	8.3	0.00044	0.0097	0.00014	0.0066	0.00052	1.1	0.000070	0.23	0.0063	0.000033	0.00053	0.00049	0.0047	0.000036	0.35	0.0039	0.039	0.059	0.000063	0.0031	17
Aug	2.2	0.21	0.0091	14	0.00057	0.017	0.00026	0.012	0.00094	1.6	0.00010	0.39	0.0073	0.000063	0.00099	0.00052	0.0034	0.000045	0.36	**0.0056**	0.070	0.069	0.000067	0.0043	22
Sep	1.8	0.18	0.0073	12	0.00053	0.014	0.00022	0.0099	0.00076	1.4	0.000099	0.32	0.0069	0.000055	0.00080	0.00052	0.0038	0.000039	0.34	0.0046	0.058	0.063	0.000064	0.0034	20
Oct	1.6	0.16	0.0063	10	0.00050	0.012	0.00019	0.0085	0.00066	1.3	0.000095	0.28	0.0066	0.000050	0.00069	0.00051	0.0038	0.000036	0.31	0.0040	0.051	0.059	0.000061	0.0030	18
Nov	2.2	0.21	0.0091	14	0.00056	0.017	0.00024	0.013	0.00095	1.6	0.000086	0.39	0.0073	0.000057	0.00100	0.00052	0.0035	0.000040	0.31	**0.0055**	0.067	0.064	0.000084	0.0082	22
Dec	2.2	0.20	0.0092	15	0.00055	0.018	0.00024	0.013	0.00095	1.6	0.000086	0.40	0.0073	0.000058	0.0010	0.00051	0.0027	0.000040	0.31	**0.0056**	0.068	0.065	0.000085	0.0083	21
Closure Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.2	0.21	0.0089	14	0.00061	0.017	0.00068	0.012	0.00093	1.6	0.000086	0.39	0.0075	0.000060	0.0014	0.00052	0.0042	0.000039	0.19	**0.0099**	0.066	0.046	0.000075	0.0061	22
Feb	2.2	0.23	0.0089	15	0.00059	0.017	0.00065	0.013	0.00097	1.6	0.000086	0.40	0.0076	0.000062	0.0013	0.00050	0.0026	0.000061	0.36	**0.0098**	0.068	0.054	0.00011	0.0059	22
Mar	2.3	0.22	0.0090	14	0.00062	0.017	0.00077	0.014	0.00096	1.6	0.000088	0.40	0.0080	0.000068	0.0015	0.00050	0.0025	0.000054	0.31	**0.011**	0.074	0.052	0.000099	0.0059	22
Apr	2.3	0.24	0.0091	14	0.00063	0.017	0.00057	0.013	0.00096	1.6	0.000087	0.40	0.0078	0.000064	0.0012	0.00050	0.0028	0.000058	0.38	**0.0096**	0.070	0.054	0.00012	0.0058	23
May	2.0	0.20	0.0084	13	0.00057	0.016	0.00024	0.012	0.00088	1.6	0.000086	0.37	0.0074	0.000055	0.00092	0.00050	0.0057	0.000045	0.26	0.0046	0.063	0.047	0.000075	0.0057	20
Jun	1.8	0.17	0.0071	11	0.00053	0.014	0.00019	0.0097	0.00075	1.4	0.000081	0.32	0.0070	0.000047	0.00078	0.00050	0.0055	0.000042	0.27	0.0037	0.054	0.046	0.000071	0.0049	18
Jul	1.3	0.12	0.0048	7.8	0.00043	0.0092	0.00016	0.0065	0.00051	1.1	0.000068	0.23	0.0062	0.000033	0.00052	0.00048	0.0046	0.000035	0.27	0.0033	0.037	0.043	0.000063	0.0033	15
Aug	2.1	0.22	0.0072	11	0.00051	0.014	0.00026	0.0097	0.00075	1.4	0.000089	0.33	0.0067	0.000051	0.00078	0.00050	0.0032	0.000038	0.23	0.0043	0.056	0.045	0.000068	0.0046	19
Sep	1.8	0.19	0.0060	9.2	0.00051	0.012	0.00028	0.0086	0.00063	1.2	0.000094	0.29	0.0066	0.000050	0.00071	0.00051	0.0037	0.000036	0.23	0.0045	0.052	0.044	0.000065	0.0037	18
Oct	1.6	0.17	0.0054	7.9	0.00052	0.010	0.00042	0.0083	0.00056	1.2	0.000094	0.27	0.0066	0.000050	0.00084	0.00051	0.0040	0.000033	0.22	**0.0063**	0.050	0.044	0.000062	0.0031	17
Nov	2.2	0.22	0.0071	9.7	0.00068	0.014	0.00079	0.013	0.00071	1.4	0.000084	0.36	0.0079	0.000067	0.0016	0.00051	0.0042	0.000033	0.19	**0.012**	0.068	0.045	0.000070	0.0049	21
Dec	2.2	0.22	0.0071	9.7	0.00064	0.014	0.00078	0.012	0.00072	1.4	0.000083	0.35	0.0076	0.000063	0.0015	0.00051	0.0034	0.000034	0.19	**0.011**	0.065	0.045	0.000074	0.0057	21
Post-Closure Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.1	0.21	0.0027	4.4	0.00052	0.0072	0.00085	0.0039	0.00035	1.2	0.000065	0.27	0.0060	0.000037	0.0014	0.00050	0.0035	0.000024	0.19	**0.0088**	0.031	0.040	0.000077	0.0065	19
Feb	2.1	0.22	0.0027	4.6	0.00051	0.0071	0.00084	0.0039	0.00037	1.2	0.000065	0.28	0.0060	0.000037	0.0013	0.00050	0.0026	0.000035	0.28	**0.0095**	0.032	0.044	0.000097	0.0062	19
Mar	2.2	0.22	0.0027	4.6	0.00053	0.0076	0.00096	0.0040	0.00038	1.2	0.000066	0.28	0.0061	0.000040	0.0015	0.00050	0.0026	0.000031	0.24	**0.010**	0.033	0.042	0.000088	0.0062	19
Apr	2.0	0.23	0.0026	4.7	0.00049	0.0062	0.00063	0.0037	0.00037	1.1	0.000063	0.27	0.0059	0.000033	0.0010	0.00049	0.0028	0.000048	0.38	**0.0084**	0.029	0.048	0.00012	0.0061	19
May	1.7	0.18	0.0024	3.7	0.00041	0.0044	0.00019	0.0029	0.00027	0.84	0.000059	0.19	0.0056	0.000021	0.00039	0.00048	0.0053	0.000026	0.25	0.0034	0.021	0.040	0.000076	0.0060	14
Jun	1.4	0.15	0.0020	3.2	0.00038	0.0037	0.00012	0.0024	0.00023	0.78	0.000057	0.17	0.0055	0.000018	0.00027	0.00048	0.0051	0.000026	0.26	0.0027	0.018	0.040	0.000072	0.0052	13
Jul	1.1	0.11	0.0014	2.5	0.00034	0.0028	0.00013	0.0017	0.00017	0.70	0.000054	0.13	0.0052	0.000014	0.00024	0.00047	0.0044	0.000025	0.27	0.0025	0.014	0.039	0.000063	0.0035	11
Aug	1.7	0.19	0.0020	2.9	0.00038	0.0036	0.00022	0.0023	0.00022	0.77	0.000069	0.19	0.0052	0.000024	0.00038	0.00049	0.0030	0.000023	0.23	0.0031	0.021	0.039	0.000068	0.0049	14
Sep	1.5	0.17	0.0017	2.6	0.00039	0.0032	0.00026	0.0019	0.00020	0.77	0.000074	0.17	0.0053	0.000026	0.00041	0.00049	0.0036	0.000023	0.23	0.0033	0.020	0.039	0.000065	0.0039	13
Oct	1.4	0.16	0.0015	2.5	0.00043	0.0036	0.00043	0.0019	0.00020	0.84	0.000077	0.17	0.0054	0.000029	0.00065	0.00050	0.0039	0.000023	0.22	0.0048	0.022	0.039	0.000063	0.0033	14
Nov	2.1	0.21	0.0019	3.2	0.00051	0.0057	0.00085	0.0028	0.00028	1.1	0.000062	0.25	0.0058	0.000032	0.0013	0.00050	0.0041	0.000022	0.19	**0.0088**	0.026	0.039	0.000071	0.0051	18
Dec	2.1	0.21	0.0019	3.2	0.00049	0.0057	0.00082	0.0028	0.00028	1.1	0.000061	0.25	0.0058	0.000032	0.0012	0.00050	0.0033	0.000021	0.19	**0.0085**	0.026	0.039	0.000074	0.0059	18
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-2: Maximum Base Case Predictions for Scenario 2 at BJ 2.62

Operations Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000017	0.00049	0.0011	0.00054	0.14	0.0000052	5.1	0.071	2.1	0.20	0.0092	15	0.00078	0.025	0.00045	0.012	0.00096	1.9	0.00039	0.38	0.0072	0.000093	0.00098	0.00080	0.0034
Feb	0.000027	0.00058	0.0011	0.00088	0.25	0.0000052	5.1	0.071	2.1	0.21	0.0092	15	0.00079	0.025	0.00054	0.012	0.00097	2.0	0.00038	0.39	0.0086	0.000094	0.00100	0.00085	0.0039
Mar	0.000016	0.00052	0.0011	0.00065	0.18	0.0000052	5.1	0.071	2.1	0.20	0.0093	15	0.00077	0.025	0.00047	0.012	0.00097	1.9	0.00039	0.39	0.0076	0.000094	0.00100	0.00081	0.0030
Apr	0.000049	0.00072	0.0011	0.0014	0.41	0.0000053	5.1	0.069	2.2	0.23	0.0090	15	0.00083	0.025	0.00071	0.012	0.00098	2.2	0.00038	0.40	0.011	0.000095	0.0010	0.00096	0.0061
May	0.000031	0.00056	0.0010	0.00076	0.23	0.0000083	4.8	0.066	2.0	0.20	0.0086	14	0.00080	0.024	0.00057	0.011	0.00091	1.9	0.00037	0.36	0.0076	0.000091	0.00093	0.00081	0.0082
Jun	0.000033	0.00052	0.0012	0.00079	0.25	0.0000084	4.1	0.057	1.8	0.18	0.0074	12	0.00092	0.022	0.00062	0.0098	0.00078	1.8	0.00045	0.32	0.0073	0.000086	0.00080	0.00086	0.0086
Jul	0.000025	0.00040	0.00086	0.00076	0.25	0.0000076	2.9	0.038	1.3	0.13	0.0051	8.3	0.00069	0.018	0.00049	0.0067	0.00054	1.5	0.00032	0.23	0.0064	0.000072	0.00055	0.00072	0.0068
Aug	0.000031	0.00060	0.0012	0.00071	0.19	0.0000053	5.1	0.071	2.2	0.22	0.0091	14	0.00086	0.026	0.00050	0.012	0.00097	2.0	0.00044	0.39	0.0073	0.000100	0.0010	0.00083	0.0050
Sep	0.000036	0.00057	0.0010	0.00072	0.19	0.0000053	4.2	0.057	1.8	0.19	0.0073	12	0.00079	0.021	0.00046	0.0099	0.00079	1.8	0.00038	0.32	0.0069	0.000092	0.00081	0.00077	0.0058
Oct	0.000037	0.00053	0.00093	0.00070	0.18	0.0000052	3.6	0.049	1.6	0.17	0.0063	10	0.00072	0.019	0.00042	0.0085	0.00069	1.7	0.00033	0.28	0.0066	0.000086	0.00070	0.00073	0.0058
Nov	0.000022	0.00051	0.0011	0.00055	0.14	0.0000052	5.1	0.072	2.2	0.22	0.0091	14	0.00079	0.025	0.00045	0.013	0.00098	2.0	0.00039	0.39	0.0073	0.000094	0.0010	0.00079	0.0040
Dec	0.000017	0.00051	0.0011	0.00055	0.14	0.0000052	5.1	0.072	2.2	0.21	0.0092	15	0.00078	0.026	0.00045	0.013	0.00099	2.0	0.00039	0.40	0.0073	0.000095	0.0010	0.00080	0.0033
Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000028	0.00054	0.00087	0.00056	**2.0**	0.0000050	5.0	0.074	2.2	0.22	0.0089	14	0.00063	0.025	0.00086	0.013	0.00096	1.9	0.000098	0.39	0.0075	0.000096	0.0014	0.00052	0.0044
Feb	0.000052	0.00075	0.00085	0.0015	**2.0**	0.0000050	5.1	0.076	2.3	0.24	0.0089	14	0.00064	0.025	0.00096	0.013	0.0010	2.3	0.000098	0.41	0.011	0.000099	0.0013	0.00071	0.0059
Mar	0.000038	0.00067	0.00093	0.0012	**2.4**	0.0000050	5.1	0.085	2.3	0.23	0.0090	14	0.00065	0.025	0.0010	0.014	0.00100	2.1	0.000100	0.40	0.0098	0.00011	0.0015	0.00064	0.0046
Apr	0.000058	0.00074	0.00088	0.0016	**2.0**	0.0000051	5.1	0.078	2.4	0.26	0.0091	14	0.00071	0.025	0.0011	0.013	0.00100	2.1	0.000098	0.40	0.012	0.00010	0.0013	0.00074	0.0066
May	0.000032	0.00058	0.00067	0.00078	0.63	0.0000083	4.7	0.066	2.1	0.21	0.0084	13	0.00060	0.023	0.00056	0.012	0.00091	1.9	0.000097	0.37	0.0076	0.000092	0.00094	0.00054	0.0081
Jun	0.000030	0.00052	0.00058	0.00079	0.44	0.0000081	4.0	0.056	1.8	0.18	0.0071	11	0.00055	0.021	0.00052	0.0098	0.00078	1.8	0.000089	0.32	0.0072	0.000085	0.00079	0.00054	0.0077
Jul	0.000024	0.00039	0.00042	0.00075	0.49	0.0000074	2.7	0.037	1.3	0.13	0.0048	7.8	0.00045	0.017	0.00047	0.0065	0.00053	1.5	0.000074	0.23	0.0063	0.000071	0.00054	0.00051	0.0064
Aug	0.000029	0.00052	0.00059	0.00070	0.66	0.0000049	4.3	0.056	2.1	0.23	0.0072	11	0.00053	0.022	0.00045	0.0098	0.00078	1.7	0.000098	0.34	0.0067	0.000088	0.00079	0.00050	0.0044
Sep	0.000036	0.00053	0.00059	0.00072	0.77	0.0000050	3.6	0.050	1.9	0.20	0.0060	9.2	0.00054	0.019	0.00047	0.0087	0.00066	1.6	0.00010	0.29	0.0066	0.000087	0.00072	0.00051	0.0054
Oct	0.000038	0.00051	0.00066	0.00071	**1.3**	0.0000050	3.2	0.048	1.7	0.18	0.0054	7.9	0.00055	0.017	0.00060	0.0083	0.00059	1.6	0.00010	0.27	0.0066	0.000086	0.00085	0.00051	0.0057
Nov	0.000026	0.00045	0.00097	0.00057	**2.5**	0.0000051	4.2	0.083	2.3	0.23	0.0071	9.7	0.00069	0.021	0.00096	0.013	0.00075	1.7	0.000093	0.36	0.0079	0.00010	0.0016	0.00051	0.0043
Dec	0.000021	0.00044	0.00092	0.00056	**2.5**	0.0000050	4.2	0.077	2.2	0.23	0.0071	9.7	0.00065	0.021	0.00095	0.012	0.00075	1.7	0.000093	0.35	0.0076	0.000099	0.0015	0.00051	0.0036
Post-Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000021	0.00038	0.00068	0.00056	**2.9**	0.0000050	2.3	0.037	2.2	0.22	0.0027	4.4	0.00054	0.013	0.0010	0.0039	0.00039	1.5	0.000077	0.27	0.0060	0.000072	0.0014	0.00050	0.0036
Feb	0.000034	0.00050	0.00069	0.0011	**3.0**	0.0000050	2.4	0.037	2.2	0.23	0.0027	4.6	0.00056	0.013	0.0012	0.0040	0.00041	1.7	0.000077	0.28	0.0080	0.000074	0.0014	0.00061	0.0045
Mar	0.000026	0.00045	0.00074	0.00084	**3.3**	0.0000050	2.4	0.040	2.2	0.23	0.0027	4.6	0.00056	0.014	0.0012	0.0041	0.00042	1.7	0.000078	0.29	0.0073	0.000076	0.0015	0.00056	0.0037
Apr	0.000058	0.00063	0.00061	0.0016	**2.4**	0.0000050	2.3	0.031	2.1	0.25	0.0026	4.7	0.00057	0.012	0.0012	0.0038	0.00041	1.8	0.000075	0.27	0.010	0.000072	0.0011	0.00073	0.0067
May	0.000029	0.00037	0.00035	0.00075	0.69	0.0000080	2.0	0.019	1.7	0.19	0.0024	3.7	0.00043	0.010	0.00051	0.0030	0.00030	1.2	0.000070	0.19	0.0058	0.000059	0.00041	0.00052	0.0076
Jun	0.000028	0.00034	0.00029	0.00077	0.47	0.0000080	1.7	0.015	1.5	0.17	0.0021	3.2	0.00041	0.010	0.00045	0.0025	0.00026	1.2	0.000067	0.17	0.0057	0.000057	0.00029	0.00052	0.0074
Jul	0.000023	0.00028	0.00025	0.00074	0.53	0.0000073	1.2	0.011	1.1	0.12	0.0015	2.5	0.00036	0.010	0.00043	0.0018	0.00019	1.1	0.000060	0.13	0.0054	0.000053	0.00026	0.00050	0.0063
Aug	0.000028	0.00036	0.00034	0.00069	0.72	0.0000048	1.9	0.016	1.8	0.20	0.0020	2.9	0.00041	0.010	0.00042	0.0023	0.00025	1.2	0.000078	0.19	0.0052	0.000061	0.00039	0.00049	0.0043
Sep	0.000035	0.00039	0.00037	0.00071	0.86	0.0000049	1.6	0.015	1.5	0.18	0.0017	2.6	0.00043	0.0091	0.00045	0.0020	0.00023	1.2	0.000081	0.17	0.0053	0.000062	0.00042	0.00049	0.0052
Oct	0.000037	0.00040	0.00046	0.00070	**1.5**	0.0000050	1.5	0.018	1.5	0.17	0.0015	2.5	0.00046	0.0090	0.00062	0.0020	0.00023	1.2	0.000083	0.17	0.0054	0.000065	0.00066	0.00050	0.0055
Nov	0.000025	0.00035	0.00063	0.00056	**2.9**	0.0000050	1.9	0.031	2.1	0.22	0.0019	3.2	0.00053	0.012	0.0010	0.0028	0.00031	1.4	0.000071	0.25	0.0058	0.000068	0.0013	0.00050	0.0042
Dec	0.000020	0.00035	0.00062	0.00056	**2.8**	0.0000050	2.0	0.031	2.1	0.21	0.0019	3.2	0.00051	0.012	0.00099	0.0028	0.00031	1.4	0.000072	0.25	0.0058	0.000068	0.0013	0.00050	0.0035
Long-Term BC FWAL	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-3: Maximum Upper Case Predictions for Scenario 1 at BJ 2.62

Operations Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.8	12	**0.27**	2.2	0.12	140	0.000017	0.060	0.0087	0.086	0.058	0.00041	0.00050	44	0.000027	0.00048	0.0013	0.00063	0.099	0.0000064	7.2	0.18
Feb	3.8	12	**0.27**	2.5	0.12	140	0.000017	0.060	0.0087	0.086	0.058	0.00041	0.00049	44	0.000031	0.00051	0.0013	0.00062	0.099	0.0000065	7.2	0.18
Mar	3.9	12	**0.28**	2.3	0.12	141	0.000017	0.060	0.0088	0.087	0.058	0.00042	0.00050	44	0.000024	0.00048	0.0014	0.00062	0.100	0.0000064	7.3	0.18
Apr	3.7	12	**0.27**	3.0	0.12	141	0.000017	0.058	0.0086	0.085	0.058	0.00041	0.00048	44	0.000046	0.00057	0.0013	0.00063	0.097	0.0000065	7.1	0.18
May	3.6	11	**0.25**	2.2	0.12	132	0.000017	0.057	0.0082	0.081	0.057	0.00039	0.00046	41	0.000039	0.00050	0.0013	0.00062	0.093	0.0000063	6.7	0.17
Jun	3.0	9.4	**0.22**	1.9	0.10	115	0.000015	0.052	0.0071	0.070	0.058	0.00034	0.00043	37	0.000037	0.00045	0.0011	0.00058	0.082	0.0000062	5.8	0.15
Jul	2.0	6.3	**0.15**	1.4	0.073	81	0.000012	0.039	0.0050	0.049	0.049	0.00025	0.00036	27	0.000029	0.00033	0.00075	0.00047	0.060	0.0000057	4.0	0.098
Aug	3.8	12	**0.27**	2.2	0.13	146	0.000017	0.061	0.0089	0.092	0.060	0.00042	0.00049	46	0.000036	0.00053	0.0014	0.00066	0.099	0.0000065	7.5	0.19
Sep	3.0	9.3	**0.21**	1.9	0.10	119	0.000015	0.051	0.0072	0.076	0.055	0.00034	0.00043	38	0.000038	0.00048	0.0012	0.00059	0.082	0.0000062	6.0	0.15
Oct	2.6	7.9	**0.18**	1.6	0.090	103	0.000014	0.046	0.0062	0.066	0.052	0.00030	0.00040	34	0.000037	0.00044	0.0010	0.00055	0.072	0.0000061	5.2	0.13
Nov	3.8	12	**0.27**	2.3	0.13	149	0.000017	0.060	0.0090	0.089	0.057	0.00043	0.00051	47	0.000032	0.00049	0.0014	0.00064	0.10	0.0000065	7.5	0.19
Dec	3.8	12	**0.27**	2.3	0.13	149	0.000017	0.060	0.0091	0.090	0.058	0.00043	0.00051	47	0.000027	0.00048	0.0014	0.00064	0.10	0.0000065	7.6	0.19
Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.4	11	**0.24**	2.4	0.12	147	0.000018	0.059	0.019	0.094	0.051	0.00081	0.00051	46	**0.00025**	0.00044	0.0014	0.0022	**3.2**	0.0000062	7.4	0.24
Feb	3.4	11	**0.24**	3.1	0.13	148	0.000018	0.059	0.018	0.097	0.052	0.00076	0.00049	47	**0.00023**	0.00052	0.0014	0.0021	**2.9**	0.0000062	7.5	0.25
Mar	3.4	11	**0.25**	2.8	0.13	148	0.000020	0.059	0.020	0.11	0.052	0.00087	0.00049	47	**0.00027**	0.00048	0.0015	0.0024	**3.5**	0.0000062	7.5	0.28
Apr	3.5	11	**0.25**	2.9	0.13	148	0.000018	0.060	0.017	0.099	0.052	0.00066	0.00050	46	**0.00021**	0.00053	0.0014	0.0018	**2.4**	0.0000061	7.6	0.25
May	3.2	9.9	**0.23**	2.3	0.12	137	0.000015	0.056	0.0091	0.083	0.050	0.00040	0.00047	43	0.000076	0.00045	0.0013	0.00083	**0.66**	0.0000060	7.0	0.17
Jun	2.7	8.3	**0.19**	2.0	0.10	117	0.000014	0.051	0.0071	0.071	0.048	0.00035	0.00043	38	0.000054	0.00039	0.0011	0.00065	0.34	0.0000059	5.9	0.15
Jul	1.8	5.5	**0.13**	1.4	0.071	81	0.000011	0.038	0.0057	0.048	0.042	0.00025	0.00036	28	0.000055	0.00028	0.00076	0.00063	**0.42**	0.0000055	3.9	0.097
Aug	2.7	8.3	**0.19**	1.8	0.10	121	0.000013	0.050	0.0088	0.073	0.047	0.00036	0.00043	39	0.000082	0.00039	0.0012	0.00089	**0.78**	0.0000059	6.2	0.15
Sep	2.2	6.7	**0.16**	1.6	0.090	104	0.000013	0.044	0.0087	0.068	0.045	0.00036	0.00039	34	0.00010	0.00040	0.0010	0.00098	**0.96**	0.0000059	5.3	0.14
Oct	1.8	5.7	**0.13**	1.5	0.083	93	0.000014	0.040	0.012	0.067	0.044	0.00050	0.00036	32	0.00016	0.00039	0.00097	0.0014	**1.8**	0.0000058	4.7	0.16
Nov	2.3	7.1	**0.16**	2.0	0.11	125	0.000021	0.046	0.022	0.10	0.048	0.00093	0.00042	41	**0.00030**	0.00042	0.0014	0.0026	**3.8**	0.0000060	6.4	0.29
Dec	2.3	7.2	**0.17**	1.9	0.11	123	0.000019	0.046	0.020	0.094	0.049	0.00086	0.00042	40	**0.00027**	0.00039	0.0013	0.0024	**3.4**	0.0000059	6.4	0.26
Post-Closure Phase																						
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.74	2.3	0.053	1.1	0.065	79	0.000016	0.029	0.019	0.039	0.040	0.00067	0.00086	27	**0.00021**	0.00028	0.00080	0.0018	**2.8**	0.0000062	2.9	0.067
Feb	0.74	2.3	0.054	1.5	0.066	79	0.000015	0.029	0.019	0.039	0.040	0.00066	0.00084	27	**0.00022**	0.00033	0.00079	0.0018	**2.8**	0.0000062	3.0	0.066
Mar	0.73	2.3	0.053	1.4	0.068	82	0.000017	0.029	0.021	0.041	0.041	0.00075	0.00093	28	**0.00024**	0.00032	0.00086	0.0021	**3.2**	0.0000063	3.0	0.070
Apr	0.73	2.3	0.054	2.1	0.063	74	0.000013	0.027	0.014	0.035	0.039	0.00052	0.00069	26	**0.00018**	0.00037	0.00067	0.0014	**2.0**	0.0000060	2.9	0.059
May	0.71	2.2	0.051	0.95	0.046	55	0.0000088	0.023	0.0058	0.025	0.037	0.00022	0.00036	20	0.000061	0.00022	0.00042	0.00060	**0.49**	0.0000052	2.5	0.045
Jun	0.60	1.9	0.043	0.86	0.040	47	0.0000080	0.023	0.0042	0.021	0.036	0.00017	0.00031	18	0.000044	0.00020	0.00034	0.00047	0.26	0.0000053	2.1	0.037
Jul	0.40	1.2	0.028	0.68	0.031	35	0.0000073	0.020	0.0037	0.016	0.034	0.00015	0.00030	15	0.000043	0.00016	0.00026	0.00046	0.31	0.0000051	1.5	0.025
Aug	0.52	1.6	0.037	0.73	0.040	49	0.0000086	0.022	0.0060	0.024	0.035	0.00021	0.00037	18	0.000062	0.00021	0.00038	0.00063	**0.56**	0.0000053	2.3	0.035
Sep	0.41	1.3	0.029	0.69	0.037	44	0.0000089	0.021	0.0062	0.023	0.035	0.00023	0.00039	17	0.000076	0.00024	0.00037	0.00071	**0.71**	0.0000054	1.9	0.030
Oct	0.34	1.1	0.024	0.70	0.040	46	0.000011	0.021	0.0094	0.025	0.035	0.00034	0.00051	18	0.00012	0.00027	0.00044	0.0010	**1.3**	0.0000056	1.7	0.032
Nov	0.43	1.3	0.031	1.0	0.056	69	0.000015	0.025	0.018	0.031	0.038	0.00065	0.00085	24	**0.00022**	0.00027	0.00068	0.0018	**2.9**	0.0000062	2.4	0.050
Dec	0.43	1.4	0.031	0.94	0.055	67	0.000015	0.025	0.018	0.031	0.038	0.00063	0.00083	23	**0.00021**	0.00025	0.00067	0.0018	**2.8**	0.0000061	2.4	0.049
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-3: Maximum Upper Case Predictions for Scenario 1 at BJ 2.62

Operations Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.5	0.19	0.015	13	0.00081	0.018	0.013	0.025	0.0040	4.0	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0032	0.000026	0.32	**0.0092**	0.088	0.065	0.00043	0.0089	44
Feb	2.5	0.20	0.015	14	0.00080	0.018	0.013	0.025	0.0040	4.0	0.00017	0.57	0.0077	0.00011	0.0019	0.00086	0.0027	0.000034	0.37	**0.0097**	0.088	0.067	0.00044	0.0059	44
Mar	2.5	0.19	0.015	14	0.00080	0.018	0.013	0.025	0.0041	4.1	0.00017	0.57	0.0077	0.00011	0.0019	0.00087	0.0025	0.000029	0.33	**0.0094**	0.089	0.066	0.00044	0.0060	44
Apr	2.5	0.22	0.014	14	0.00081	0.018	0.013	0.025	0.0040	4.0	0.00017	0.57	0.0078	0.00011	0.0019	0.00086	0.0030	0.000047	0.46	**0.010**	0.087	0.071	0.00046	0.0058	44
May	2.4	0.19	0.014	13	0.00081	0.017	0.012	0.023	0.0038	3.8	0.00016	0.53	0.0078	0.00011	0.0018	0.00084	0.0059	0.000032	0.37	**0.0091**	0.083	0.065	0.00041	0.0055	41
Jun	2.1	0.17	0.012	11	0.00074	0.015	0.011	0.020	0.0032	3.4	0.00015	0.46	0.0075	0.000091	0.0015	0.00080	0.0059	0.000032	0.39	**0.0081**	0.072	0.067	0.00035	0.0047	37
Jul	1.5	0.12	0.0080	7.7	0.00058	0.010	0.0071	0.014	0.0022	2.5	0.00012	0.33	0.0066	0.000063	0.0010	0.00070	0.0049	0.000029	0.35	**0.0059**	0.050	0.057	0.00025	0.0032	27
Aug	2.6	0.21	0.015	14	0.00085	0.018	0.013	0.026	0.0043	4.3	0.00019	0.58	0.0079	0.00012	0.0020	0.00088	0.0039	0.000031	0.36	**0.0094**	0.094	0.068	0.00043	0.0045	46
Sep	2.1	0.18	0.012	11	0.00075	0.015	0.010	0.021	0.0034	3.5	0.00017	0.47	0.0073	0.00010	0.0016	0.00080	0.0042	0.000028	0.34	**0.0077**	0.077	0.063	0.00035	0.0036	38
Oct	1.9	0.16	0.010	9.5	0.00069	0.013	0.0088	0.018	0.0029	3.1	0.00015	0.41	0.0070	0.000089	0.0014	0.00076	0.0041	0.000026	0.32	**0.0067**	0.067	0.060	0.00031	0.0031	34
Nov	2.7	0.21	0.015	14	0.00085	0.018	0.013	0.027	0.0043	4.3	0.00017	0.59	0.0079	0.00012	0.0020	0.00087	0.0040	0.000026	0.31	**0.0094**	0.091	0.064	0.00044	0.0086	47
Dec	2.7	0.21	0.016	14	0.00084	0.018	0.013	0.027	0.0044	4.3	0.00018	0.59	0.0079	0.00012	0.0020	0.00087	0.0033	0.000026	0.32	**0.0095**	0.092	0.065	0.00044	0.0087	47
Closure Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.8	0.24	0.015	13	0.00087	0.018	0.0068	0.026	0.0042	4.3	0.00017	0.58	0.0088	0.00013	0.0026	0.00090	0.017	0.000027	0.24	**0.019**	0.096	0.057	0.00082	0.0062	46
Feb	2.8	0.24	0.015	14	0.00088	0.018	0.0068	0.026	0.0043	4.2	0.00017	0.59	0.0089	0.00013	0.0025	0.00087	0.015	0.000046	0.40	**0.019**	0.099	0.064	0.00079	0.0061	47
Mar	2.9	0.24	0.015	14	0.00094	0.018	0.0069	0.027	0.0043	4.3	0.00017	0.59	0.0095	0.00015	0.0028	0.00092	0.018	0.000039	0.35	**0.021**	0.11	0.062	0.00090	0.0060	47
Apr	2.9	0.26	0.015	14	0.00092	0.018	0.0070	0.027	0.0044	4.3	0.00017	0.59	0.0092	0.00014	0.0026	0.00087	0.013	0.000052	0.41	**0.019**	0.10	0.063	0.00071	0.0060	46
May	2.5	0.21	0.014	13	0.00083	0.017	0.0064	0.025	0.0040	4.0	0.00017	0.55	0.0079	0.00011	0.0018	0.00084	0.0082	0.000031	0.30	**0.0100**	0.085	0.057	0.00041	0.0058	43
Jun	2.1	0.18	0.012	11	0.00075	0.014	0.0054	0.021	0.0034	3.5	0.00015	0.47	0.0075	0.000093	0.0016	0.00079	0.0068	0.000030	0.30	**0.0081**	0.072	0.055	0.00036	0.0050	38
Jul	1.5	0.12	0.0080	7.4	0.00057	0.0097	0.0036	0.014	0.0022	2.5	0.00012	0.33	0.0065	0.000063	0.0010	0.00068	0.0064	0.000027	0.29	**0.0066**	0.049	0.049	0.00026	0.0033	28
Aug	2.5	0.22	0.012	11	0.00073	0.014	0.0054	0.021	0.0034	3.5	0.00016	0.48	0.0072	0.000098	0.0016	0.00079	0.0066	0.000026	0.26	**0.0094**	0.075	0.053	0.00037	0.0047	39
Sep	2.2	0.19	0.010	9.1	0.00071	0.012	0.0045	0.018	0.0028	3.0	0.00015	0.42	0.0072	0.000093	0.0015	0.00076	0.0079	0.000027	0.26	**0.0092**	0.070	0.052	0.00037	0.0038	34
Oct	2.0	0.18	0.0089	8.1	0.00069	0.012	0.0040	0.017	0.0024	2.7	0.00015	0.39	0.0075	0.000095	0.0017	0.00076	0.012	0.000027	0.25	**0.012**	0.068	0.050	0.00051	0.0033	32
Nov	2.9	0.25	0.012	11	0.00097	0.016	0.0054	0.024	0.0030	3.3	0.00015	0.53	0.0097	0.00015	0.0031	0.00095	0.021	0.000029	0.22	**0.023**	0.10	0.054	0.00094	0.0049	41
Dec	2.8	0.24	0.012	11	0.00090	0.016	0.0054	0.024	0.0031	3.3	0.00015	0.53	0.0092	0.00014	0.0028	0.00092	0.018	0.000028	0.23	**0.021**	0.096	0.054	0.00088	0.0057	40
Post-Closure Phase																									
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.4	0.21	0.0042	4.5	0.00061	0.0099	0.0026	0.0076	0.0012	2.3	0.00011	0.33	0.0062	0.000063	0.0016	0.00089	0.016	0.000024	0.20	**0.019**	0.041	0.045	0.00069	0.0071	27
Feb	2.4	0.22	0.0042	4.8	0.00060	0.0098	0.0026	0.0077	0.0012	2.3	0.00011	0.34	0.0062	0.000063	0.0016	0.00088	0.015	0.000036	0.29	**0.020**	0.042	0.049	0.00070	0.0068	27
Mar	2.5	0.22	0.0042	4.8	0.00063	0.011	0.0028	0.0079	0.0013	2.5	0.00011	0.35	0.0063	0.000068	0.0018	0.00093	0.017	0.000032	0.25	**0.022**	0.044	0.048	0.00077	0.0069	28
Apr	2.3	0.23	0.0041	4.9	0.00057	0.0082	0.0023	0.0072	0.0012	2.1	0.000100	0.32	0.0061	0.000055	0.0013	0.00079	0.012	0.000047	0.39	**0.016**	0.038	0.053	0.00058	0.0065	26
May	1.8	0.18	0.0038	3.7	0.00047	0.0052	0.0016	0.0061	0.00099	1.5	0.000083	0.24	0.0058	0.000036	0.00062	0.00061	0.0075	0.000024	0.26	**0.0067**	0.028	0.043	0.00024	0.0061	20
Jun	1.5	0.16	0.0032	3.3	0.00044	0.0043	0.0013	0.0051	0.00083	1.3	0.000077	0.21	0.0057	0.000030	0.00046	0.00059	0.0063	0.000024	0.27	**0.0051**	0.023	0.043	0.00018	0.0052	18
Jul	1.1	0.11	0.0022	2.5	0.00038	0.0033	0.00092	0.0035	0.00057	1.1	0.000069	0.16	0.0053	0.000023	0.00037	0.00056	0.0058	0.000024	0.28	0.0046	0.018	0.041	0.00016	0.0035	15
Aug	1.8	0.19	0.0030	3.0	0.00043	0.0044	0.0013	0.0047	0.00076	1.3	0.000089	0.22	0.0054	0.000036	0.00055	0.00061	0.0056	0.000022	0.24	**0.0065**	0.026	0.042	0.00023	0.0050	18
Sep	1.6	0.17	0.0025	2.6	0.00044	0.0041	0.0011	0.0039	0.00063	1.2	0.000092	0.20	0.0054	0.000036	0.00055	0.00063	0.0068	0.000022	0.23	**0.0068**	0.025	0.041	0.00024	0.0040	17
Oct	1.5	0.16	0.0022	2.6	0.00047	0.0050	0.0012	0.0037	0.00060	1.4	0.000098	0.20	0.0055	0.000042	0.00078	0.00069	0.0099	0.000023	0.22	**0.0098**	0.026	0.042	0.00035	0.0036	18
Nov	2.3	0.21	0.0029	3.4	0.00058	0.0084	0.0020	0.0053	0.00084	2.0	0.000098	0.30	0.0060	0.000053	0.0015	0.00086	0.017	0.000023	0.20	**0.019**	0.033	0.043	0.00066	0.0056	24
Dec	2.3	0.21	0.0029	3.4	0.00056	0.0082	0.0020	0.0052	0.00084	2.0	0.000097	0.29	0.0059	0.000053	0.0014	0.00085	0.016	0.000023	0.20	**0.018**	0.033	0.044	0.00064	0.0065	23
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-3: Maximum Upper Case Predictions for Scenario 1 at BJ 2.62

Operations Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.000027	0.00060	0.0015	0.00090	0.23	0.0000088	7.3	0.18	2.5	0.20	0.015	13	0.00082	0.026	0.013	0.025	0.0041	4.4	0.00039	0.57	0.0077	0.00015	0.0019	0.00092	0.0034
Feb	0.000038	0.00069	0.0015	0.0013	0.34	0.0000088	7.3	0.18	2.5	0.21	0.015	14	0.00084	0.026	0.014	0.025	0.0041	4.5	0.00038	0.57	0.0092	0.00015	0.0019	0.00098	0.0040
Mar	0.000027	0.00062	0.0015	0.0010	0.27	0.0000088	7.4	0.18	2.5	0.20	0.015	14	0.00082	0.026	0.014	0.025	0.0041	4.4	0.00039	0.57	0.0082	0.00015	0.0019	0.00094	0.0030
Apr	0.000061	0.00083	0.0015	0.0018	0.51	0.0000088	7.3	0.18	2.6	0.23	0.014	14	0.00089	0.025	0.013	0.025	0.0040	4.6	0.00038	0.57	0.012	0.00015	0.0019	0.0011	0.0063
May	0.000040	0.00066	0.0014	0.0011	0.31	0.000012	6.9	0.17	2.4	0.20	0.014	13	0.00084	0.025	0.013	0.023	0.0038	4.2	0.00037	0.53	0.0080	0.00014	0.0018	0.00093	0.0082
Jun	0.000039	0.00060	0.0012	0.0011	0.32	0.000013	5.9	0.15	2.1	0.18	0.012	11	0.00084	0.023	0.011	0.020	0.0033	3.8	0.00040	0.46	0.0077	0.00013	0.0015	0.00089	0.0084
Jul	0.000031	0.00045	0.00085	0.00095	0.30	0.000011	4.1	0.098	1.5	0.13	0.0080	7.7	0.00064	0.018	0.0074	0.014	0.0022	2.9	0.00029	0.33	0.0067	0.00010	0.0011	0.00076	0.0069
Aug	0.000041	0.00069	0.0015	0.0011	0.28	0.0000089	7.6	0.19	2.6	0.23	0.015	14	0.00088	0.027	0.013	0.026	0.0043	4.6	0.00043	0.58	0.0079	0.00016	0.0020	0.00093	0.0051
Sep	0.000045	0.00064	0.0013	0.0010	0.26	0.0000084	6.1	0.15	2.2	0.19	0.012	11	0.00079	0.022	0.011	0.021	0.0034	3.9	0.00037	0.47	0.0073	0.00014	0.0016	0.00085	0.0058
Oct	0.000044	0.00059	0.0011	0.00094	0.24	0.0000083	5.3	0.13	1.9	0.17	0.011	9.5	0.00072	0.019	0.0090	0.018	0.0029	3.5	0.00033	0.41	0.0070	0.00013	0.0014	0.00079	0.0058
Nov	0.000033	0.00059	0.0015	0.00091	0.23	0.0000088	7.6	0.19	2.7	0.22	0.015	14	0.00086	0.026	0.013	0.027	0.0044	4.7	0.00039	0.59	0.0079	0.00015	0.0020	0.00092	0.0041
Dec	0.000028	0.00059	0.0016	0.00091	0.23	0.0000088	7.7	0.19	2.7	0.22	0.016	14	0.00085	0.026	0.013	0.027	0.0044	4.7	0.00039	0.59	0.0079	0.00016	0.0020	0.00092	0.0034
Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00025	0.00056	0.0015	0.0025	**3.3**	0.0000085	7.5	0.24	2.8	0.24	0.015	13	0.00088	0.026	0.0070	0.026	0.0043	4.6	0.00018	0.58	0.0088	0.00017	0.0027	0.00090	0.017
Feb	0.00024	0.00078	0.0016	0.0028	**3.2**	0.0000085	7.6	0.25	2.9	0.25	0.015	14	0.00092	0.026	0.0073	0.026	0.0043	4.9	0.00018	0.60	0.012	0.00017	0.0025	0.0011	0.017
Mar	0.00028	0.00070	0.0016	0.0029	**3.7**	0.0000085	7.6	0.28	3.0	0.25	0.015	14	0.00096	0.026	0.0073	0.027	0.0043	4.8	0.00019	0.60	0.010	0.00019	0.0028	0.00100	0.018
Apr	0.00023	0.00081	0.0016	0.0030	**2.9**	0.0000085	7.7	0.25	2.9	0.28	0.016	14	0.0010	0.026	0.0072	0.027	0.0044	4.7	0.00019	0.59	0.013	0.00018	0.0026	0.0011	0.017
May	0.000078	0.00061	0.0014	0.0013	0.88	0.000012	7.1	0.17	2.5	0.22	0.014	13	0.00086	0.024	0.0067	0.025	0.0040	4.4	0.00018	0.55	0.0082	0.00015	0.0019	0.00088	0.011
Jun	0.000056	0.00054	0.0012	0.0011	0.57	0.000012	6.0	0.15	2.2	0.19	0.012	11	0.00077	0.022	0.0057	0.021	0.0034	3.9	0.00016	0.47	0.0077	0.00013	0.0016	0.00083	0.0091
Jul	0.000056	0.00041	0.00085	0.0011	0.66	0.000011	4.1	0.097	1.5	0.14	0.0080	7.4	0.00059	0.018	0.0039	0.014	0.0023	2.9	0.00012	0.33	0.0067	0.00010	0.0011	0.00071	0.0082
Aug	0.000087	0.00054	0.0013	0.0013	0.96	0.0000083	6.3	0.15	2.5	0.23	0.012	11	0.00076	0.022	0.0056	0.021	0.0034	3.9	0.00017	0.48	0.0072	0.00013	0.0016	0.00079	0.0078
Sep	0.00011	0.00056	0.0011	0.0014	**1.1**	0.0000080	5.4	0.14	2.2	0.20	0.010	9.1	0.00074	0.019	0.0047	0.018	0.0028	3.4	0.00016	0.42	0.0072	0.00013	0.0015	0.00076	0.0095
Oct	0.00017	0.00054	0.0011	0.0018	**1.9**	0.0000081	4.8	0.16	2.0	0.19	0.0089	8.1	0.00073	0.018	0.0042	0.017	0.0024	3.1	0.00015	0.39	0.0075	0.00013	0.0017	0.00076	0.013
Nov	0.00030	0.00053	0.0015	0.0029	**3.9**	0.0000083	6.5	0.29	2.9	0.26	0.012	11	0.00098	0.023	0.0055	0.024	0.0031	3.7	0.00016	0.53	0.0097	0.00018	0.0031	0.00095	0.021
Dec	0.00027	0.00051	0.0014	0.0027	**3.6**	0.0000083	6.5	0.26	2.8	0.25	0.012	11	0.00091	0.023	0.0055	0.024	0.0031	3.7	0.00016	0.53	0.0092	0.00017	0.0028	0.00092	0.018
Post-Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00021	0.00041	0.00092	0.0021	**2.9**	0.0000084	3.1	0.067	2.4	0.22	0.0042	4.5	0.00063	0.016	0.0028	0.0077	0.0013	2.7	0.00012	0.33	0.0062	0.000099	0.0017	0.00089	0.017
Feb	0.00022	0.00053	0.00093	0.0026	**3.1**	0.0000084	3.1	0.067	2.4	0.24	0.0042	4.8	0.00065	0.016	0.0029	0.0077	0.0013	2.8	0.00012	0.34	0.0082	0.00010	0.0017	0.00099	0.017
Mar	0.00024	0.00049	0.00099	0.0026	**3.4**	0.0000085	3.1	0.070	2.5	0.23	0.0043	4.8	0.00066	0.017	0.0030	0.0079	0.0013	2.9	0.00012	0.35	0.0075	0.00010	0.0018	0.00099	0.019
Apr	0.00020	0.00065	0.00083	0.0028	**2.5**	0.0000082	3.0	0.059	2.3	0.25	0.0041	4.8	0.00066	0.014	0.0028	0.0073	0.0012	2.8	0.00011	0.33	0.010	0.000094	0.0014	0.0010	0.016
May	0.000063	0.00038	0.00054	0.0011	0.71	0.000011	2.6	0.045	1.8	0.19	0.0038	3.7	0.00050	0.011	0.0019	0.0061	0.0010	1.9	0.000094	0.24	0.0060	0.000074	0.00064	0.00065	0.0098
Jun	0.000046	0.00035	0.00045	0.00096	0.49	0.000012	2.3	0.037	1.6	0.17	0.0032	3.3	0.00046	0.011	0.0016	0.0052	0.00087	1.7	0.000087	0.21	0.0059	0.000069	0.00048	0.00063	0.0085
Jul	0.000044	0.00029	0.00036	0.00094	0.54	0.000010	1.6	0.025	1.2	0.12	0.0022	2.5	0.00040	0.011	0.0012	0.0035	0.00059	1.5	0.000075	0.16	0.0055	0.000062	0.00038	0.00059	0.0076
Aug	0.000066	0.00037	0.00048	0.0010	0.74	0.0000077	2.4	0.035	1.9	0.21	0.0030	3.0	0.00046	0.011	0.0015	0.0047	0.00078	1.7	0.000098	0.22	0.0054	0.000073	0.00056	0.00061	0.0068
Sep	0.000083	0.00040	0.00049	0.0011	0.88	0.0000075	2.0	0.030	1.6	0.18	0.0025	2.6	0.00047	0.010	0.0013	0.0039	0.00066	1.6	0.000099	0.20	0.0054	0.000073	0.00057	0.00063	0.0084
Oct	0.00013	0.00042	0.00057	0.0014	**1.5**	0.0000078	1.8	0.032	1.6	0.17	0.0022	2.6	0.00050	0.010	0.0014	0.0037	0.00063	1.8	0.00010	0.20	0.0055	0.000078	0.00079	0.00069	0.012
Nov	0.00022	0.00038	0.00080	0.0021	**3.0**	0.0000083	2.5	0.050	2.3	0.22	0.0029	3.4	0.00059	0.014	0.0022	0.0053	0.00087	2.4	0.00011	0.30	0.0060	0.000088	0.0015	0.00087	0.017
Dec	0.00021	0.00037	0.00079	0.0021	**2.9**	0.0000083	2.5	0.050	2.3	0.22	0.0029	3.4	0.00057	0.014	0.0022	0.0053	0.00087	2.3	0.00011	0.29	0.0059	0.000088	0.0015	0.00085	0.016
Long-Term BC FWAL	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-4: Maximum Upper Case Predictions for Scenario 2 at BJ 2.62

Operations Phase																							
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.5	11	**0.25**	2.5	0.17	167	0.000014	0.055	0.0069	0.11	0.058	0.00056	0.00060	49	0.00013	0.00060	0.0017	0.0016	0.14	0.0000059	8.9	0.25
Feb	3.5	11	**0.25**	2.8	0.17	168	0.000014	0.054	0.0069	0.11	0.058	0.00056	0.00059	49	0.00014	0.00063	0.0017	0.0015	0.14	0.0000059	8.9	0.24
Mar	3.5	11	**0.25**	2.6	0.17	168	0.000014	0.055	0.0070	0.11	0.058	0.00057	0.00060	49	0.00013	0.00060	0.0017	0.0016	0.14	0.0000058	9.0	0.25
Apr	3.4	11	**0.25**	3.3	0.17	167	0.000014	0.054	0.0069	0.11	0.058	0.00055	0.00058	49	0.00015	0.00069	0.0017	0.0015	0.13	0.0000059	8.8	0.24
May	3.3	10	**0.23**	2.5	0.16	158	0.000014	0.052	0.0066	0.10	0.057	0.00053	0.00056	46	0.00014	0.00062	0.0016	0.0015	0.13	0.0000058	8.3	0.23
Jun	2.8	8.7	**0.20**	2.2	0.14	137	0.000013	0.048	0.0058	0.088	0.058	0.00046	0.00051	41	0.00012	0.00055	0.0014	0.0013	0.11	0.0000058	7.2	0.20
Jul	1.9	5.8	**0.13**	1.6	0.097	96	0.000010	0.037	0.0040	0.061	0.049	0.00033	0.00042	30	0.000088	0.00040	0.00094	0.00097	0.079	0.0000054	4.9	0.13
Aug	3.4	11	**0.25**	2.5	0.17	172	0.000014	0.057	0.0067	0.11	0.060	0.00056	0.00058	50	0.00015	0.00068	0.0018	0.0016	0.13	0.0000059	9.1	0.25
Sep	2.7	8.4	**0.19**	2.1	0.14	139	0.000013	0.048	0.0054	0.093	0.055	0.00045	0.00051	42	0.00013	0.00059	0.0014	0.0014	0.11	0.0000058	7.3	0.20
Oct	2.3	7.2	**0.17**	1.8	0.12	121	0.000012	0.043	0.0047	0.081	0.052	0.00039	0.00046	37	0.00011	0.00053	0.0013	0.0012	0.095	0.0000057	6.3	0.17
Nov	3.4	11	**0.24**	2.6	0.17	174	0.000014	0.057	0.0068	0.11	0.057	0.00057	0.00060	51	0.00015	0.00063	0.0018	0.0016	0.14	0.0000059	9.1	0.25
Dec	3.5	11	**0.25**	2.6	0.17	174	0.000014	0.057	0.0069	0.11	0.058	0.00057	0.00060	51	0.00014	0.00062	0.0018	0.0016	0.14	0.0000059	9.2	0.25
Closure Phase																							
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.0	9.2	**0.21**	2.7	0.17	172	0.000017	0.056	0.017	0.11	0.054	0.00085	0.00060	51	**0.00029**	0.00063	0.0017	0.0026	**3.2**	0.0000058	8.9	0.27
Feb	3.0	9.3	**0.21**	3.4	0.17	172	0.000017	0.056	0.016	0.11	0.055	0.00081	0.00058	51	**0.00028**	0.00071	0.0017	0.0024	**3.0**	0.0000058	9.0	0.28
Mar	3.0	9.4	**0.22**	3.1	0.17	172	0.000018	0.056	0.018	0.12	0.055	0.00092	0.00059	51	**0.00031**	0.00068	0.0018	0.0028	**3.5**	0.0000058	9.1	0.32
Apr	3.1	9.5	**0.22**	3.1	0.17	173	0.000017	0.057	0.014	0.11	0.055	0.00073	0.00060	51	**0.00027**	0.00065	0.0018	0.0023	**2.4**	0.0000058	9.2	0.29
May	2.8	8.7	**0.20**	2.5	0.16	160	0.000013	0.053	0.0064	0.10	0.053	0.00053	0.00056	47	0.00015	0.00063	0.0016	0.0015	**0.67**	0.0000056	8.4	0.23
Jun	2.4	7.3	**0.17**	2.2	0.14	137	0.000012	0.049	0.0047	0.087	0.051	0.00045	0.00050	41	0.00013	0.00055	0.0014	0.0013	**0.36**	0.0000056	7.1	0.19
Jul	1.6	4.8	**0.11**	1.5	0.093	93	0.0000094	0.036	0.0042	0.059	0.043	0.00032	0.00041	30	0.000094	0.00039	0.00093	0.00096	**0.43**	0.0000053	4.8	0.13
Aug	2.3	7.2	**0.17**	2.1	0.14	140	0.000012	0.048	0.0067	0.089	0.049	0.00045	0.00050	42	0.00013	0.00054	0.0014	0.0013	**0.79**	0.0000056	7.4	0.19
Sep	1.9	5.9	**0.14**	1.8	0.12	118	0.000012	0.042	0.0071	0.081	0.047	0.00042	0.00045	37	0.00014	0.00052	0.0012	0.0013	**0.97**	0.0000056	6.2	0.18
Oct	1.6	5.0	**0.12**	1.6	0.11	106	0.000013	0.038	0.011	0.077	0.045	0.00054	0.00041	34	**0.00019**	0.00050	0.0011	0.0017	**1.8**	0.0000056	5.5	0.17
Nov	2.0	6.2	**0.14**	2.1	0.14	140	0.000020	0.044	0.021	0.11	0.050	0.00098	0.00048	43	**0.00034**	0.00054	0.0015	0.0030	**3.8**	0.0000057	7.4	0.31
Dec	2.0	6.3	**0.14**	2.1	0.14	138	0.000018	0.044	0.019	0.11	0.051	0.00091	0.00048	43	**0.00031**	0.00052	0.0015	0.0028	**3.5**	0.0000057	7.4	0.28
Post-Closure Phase																							
Month	**N-NH$_3$**	**N-NO$_3$**	**N-NO$_2$**	**Chloride**	**Fluoride**	**Sulfate**	**D-Ag**	**D-Al**	**D-As**	**D-B**	**D-Ba**	**D-Be**	**D-Bi**	**D-Ca**	**D-Cd**	**D-Co**	**D-Cr**	**D-Cu**	**D-Fe**	**D-Hg**	**D-K**	**D-Li**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.62	1.9	0.044	1.2	0.073	82	0.000015	0.028	0.018	0.042	0.040	0.00070	0.00087	27	**0.00024**	0.00032	0.00086	0.0020	**2.8**	0.0000061	3.2	0.077
Feb	0.62	2.0	0.045	1.6	0.074	82	0.000015	0.027	0.017	0.042	0.041	0.00069	0.00086	27	**0.00024**	0.00036	0.00085	0.0020	**2.8**	0.0000061	3.2	0.077
Mar	0.62	1.9	0.044	1.4	0.076	85	0.000016	0.028	0.020	0.044	0.041	0.00077	0.00095	28	**0.00026**	0.00035	0.00092	0.0022	**3.2**	0.0000062	3.3	0.080
Apr	0.61	2.0	0.045	2.1	0.071	77	0.000013	0.026	0.013	0.039	0.040	0.00054	0.00070	27	**0.00020**	0.00040	0.00072	0.0016	**2.0**	0.0000059	3.1	0.069
May	0.59	1.9	0.043	0.99	0.054	58	0.0000083	0.022	0.0047	0.028	0.037	0.00025	0.00038	20	0.000084	0.00025	0.00047	0.00079	**0.50**	0.0000052	2.7	0.055
Jun	0.51	1.6	0.036	0.89	0.047	50	0.0000075	0.022	0.0033	0.024	0.037	0.00019	0.00032	18	0.000063	0.00023	0.00038	0.00063	0.26	0.0000052	2.3	0.045
Jul	0.33	1.0	0.024	0.70	0.036	37	0.0000070	0.019	0.0030	0.018	0.034	0.00016	0.00031	15	0.000055	0.00018	0.00029	0.00057	0.31	0.0000050	1.6	0.031
Aug	0.43	1.3	0.031	0.76	0.045	52	0.0000082	0.021	0.0050	0.026	0.035	0.00023	0.00038	18	0.000077	0.00024	0.00041	0.00076	**0.57**	0.0000053	2.4	0.042
Sep	0.34	1.1	0.024	0.71	0.041	46	0.0000086	0.020	0.0055	0.025	0.035	0.00024	0.00039	17	0.000089	0.00026	0.00040	0.00081	**0.71**	0.0000054	2.0	0.035
Oct	0.28	0.88	0.020	0.72	0.043	47	0.000010	0.021	0.0087	0.027	0.036	0.00035	0.00051	18	0.00013	0.00028	0.00047	0.0011	**1.3**	0.0000056	1.8	0.036
Nov	0.35	1.1	0.025	1.0	0.060	71	0.000015	0.024	0.018	0.033	0.038	0.00066	0.00086	24	**0.00023**	0.00029	0.00071	0.0020	**2.9**	0.0000061	2.5	0.055
Dec	0.36	1.1	0.026	0.96	0.059	69	0.000014	0.024	0.017	0.032	0.038	0.00064	0.00084	24	**0.00022**	0.00027	0.00070	0.0019	**2.8**	0.0000060	2.5	0.055
Long-Term BC FWAL	1.1	3.0	0.020	150	-	-	-	0.050	-	-	-	-	-	-	0.000083	-	-	-	-	-	-	-
Short-Term BC FWAL	5.7	33	0.060	600	0.82	-	-	0.10	-	-	-	-	-	-	0.00016	-	-	-	0.35	-	-	-
Discharge Limit	1.0	12	0.24	-	-	-	-	0.050	-	-	-	-	-	-	0.000050	-	-	-	-	-	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-4: Maximum Upper Case Predictions for Scenario 2 at BJ 2.62

Operations Phase																										
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.1	0.35	0.017	17	0.0028	0.020	0.0038	0.025	0.0044	4.1	0.00022	0.76	0.0089	0.00016	0.0034	0.00076	0.0078	0.000023	0.32	**0.0074**	0.11	0.065	0.00058	0.0088	49
Feb	3.1	0.36	0.017	17	0.0027	0.020	0.0038	0.025	0.0044	4.1	0.00022	0.76	0.0089	0.00016	0.0034	0.00076	0.0073	0.000030	0.37	**0.0079**	0.11	0.067	0.00059	0.0060	49
Mar	3.1	0.36	0.017	17	0.0028	0.020	0.0039	0.025	0.0044	4.1	0.00022	0.76	0.0089	0.00016	0.0034	0.00076	0.0072	0.000025	0.33	**0.0077**	0.11	0.066	0.00059	0.0061	49
Apr	3.1	0.37	0.017	17	0.0027	0.020	0.0038	0.025	0.0043	4.1	0.00021	0.76	0.0089	0.00016	0.0033	0.00075	0.0075	0.000042	0.46	**0.0084**	0.11	0.071	0.00060	0.0059	49
May	2.9	0.34	0.016	16	0.0026	0.019	0.0036	0.024	0.0041	3.9	0.00021	0.71	0.0089	0.00015	0.0032	0.00074	0.010	0.000029	0.37	**0.0076**	0.10	0.065	0.00055	0.0056	46
Jun	2.6	0.30	0.014	14	0.0023	0.016	0.0031	0.020	0.0036	3.4	0.00019	0.61	0.0084	0.00013	0.0027	0.00072	0.0096	0.000029	0.39	**0.0068**	0.090	0.067	0.00048	0.0048	41
Jul	1.8	0.20	0.0093	9.7	0.0017	0.011	0.0020	0.014	0.0024	2.5	0.00014	0.43	0.0072	0.000089	0.0019	0.00064	0.0075	0.000027	0.35	0.0050	0.062	0.057	0.00034	0.0032	30
Aug	3.2	0.39	0.017	17	0.0029	0.020	0.0036	0.026	0.0046	4.3	0.00024	0.76	0.0090	0.00017	0.0035	0.00077	0.0087	0.000028	0.36	**0.0073**	0.12	0.068	0.00057	0.0046	50
Sep	2.6	0.32	0.014	14	0.0024	0.016	0.0029	0.021	0.0037	3.5	0.00021	0.62	0.0082	0.00014	0.0028	0.00072	0.0080	0.000026	0.34	**0.0060**	0.094	0.063	0.00046	0.0037	42
Oct	2.3	0.28	0.012	12	0.0021	0.014	0.0024	0.018	0.0031	3.1	0.00019	0.53	0.0077	0.00012	0.0024	0.00068	0.0074	0.000024	0.32	**0.0052**	0.082	0.060	0.00040	0.0032	37
Nov	3.3	0.38	0.017	17	0.0029	0.020	0.0037	0.026	0.0046	4.3	0.00023	0.77	0.0090	0.00016	0.0036	0.00076	0.0089	0.000022	0.31	**0.0073**	0.11	0.064	0.00058	0.0084	51
Dec	3.3	0.38	0.018	17	0.0030	0.020	0.0038	0.027	0.0047	4.3	0.00023	0.78	0.0090	0.00017	0.0036	0.00076	0.0082	0.000023	0.32	**0.0074**	0.11	0.065	0.00058	0.0086	51
Closure Phase																										
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	3.2	0.38	0.017	17	0.0029	0.020	0.0019	0.026	0.0045	4.2	0.00022	0.76	0.0094	0.00016	0.0035	0.00085	0.019	0.000026	0.23	**0.017**	0.11	0.060	0.00087	0.0062	51
Feb	3.3	0.40	0.017	17	0.0029	0.020	0.0018	0.026	0.0046	4.2	0.00022	0.77	0.0096	0.00017	0.0035	0.00082	0.017	0.000044	0.40	**0.017**	0.11	0.068	0.00084	0.0061	51
Mar	3.3	0.39	0.017	17	0.0029	0.020	0.0020	0.026	0.0046	4.3	0.00022	0.77	0.010	0.00018	0.0038	0.00087	0.019	0.000036	0.34	**0.019**	0.12	0.065	0.00094	0.0060	51
Apr	3.3	0.38	0.017	17	0.0029	0.020	0.0018	0.026	0.0047	4.3	0.00023	0.78	0.0099	0.00017	0.0036	0.00079	0.015	0.000050	0.40	**0.016**	0.11	0.065	0.00078	0.0060	51
May	3.0	0.36	0.016	16	0.0028	0.018	0.0012	0.024	0.0043	4.0	0.00021	0.71	0.0090	0.00015	0.0033	0.00072	0.011	0.000029	0.29	**0.0073**	0.11	0.060	0.00054	0.0058	47
Jun	2.6	0.31	0.013	14	0.0024	0.016	0.0010	0.020	0.0036	3.5	0.00019	0.61	0.0084	0.00013	0.0028	0.00070	0.0097	0.000028	0.30	**0.0056**	0.089	0.057	0.00046	0.0050	41
Jul	1.8	0.21	0.0090	9.2	0.0017	0.011	0.00068	0.014	0.0024	2.5	0.00014	0.42	0.0071	0.000088	0.0018	0.00062	0.0081	0.000026	0.29	**0.0051**	0.060	0.050	0.00032	0.0033	30
Aug	2.9	0.35	0.014	13	0.0023	0.016	0.0011	0.020	0.0036	3.4	0.00020	0.62	0.0080	0.00013	0.0028	0.00069	0.0087	0.000025	0.26	**0.0073**	0.091	0.056	0.00046	0.0048	42
Sep	2.5	0.30	0.011	11	0.0020	0.013	0.0010	0.018	0.0029	2.9	0.00018	0.53	0.0079	0.00012	0.0024	0.00068	0.0096	0.000025	0.25	**0.0076**	0.082	0.053	0.00043	0.0039	37
Oct	2.3	0.27	0.0098	9.9	0.0018	0.012	0.0012	0.016	0.0025	2.6	0.00017	0.48	0.0078	0.00012	0.0023	0.00072	0.013	0.000026	0.24	**0.011**	0.079	0.052	0.00054	0.0033	34
Nov	3.2	0.35	0.013	13	0.0023	0.017	0.0022	0.024	0.0032	3.3	0.00019	0.65	0.010	0.00016	0.0036	0.00090	0.022	0.000028	0.22	**0.021**	0.11	0.056	0.00099	0.0049	43
Dec	3.1	0.34	0.013	13	0.0022	0.017	0.0020	0.023	0.0032	3.3	0.00019	0.64	0.0096	0.00016	0.0034	0.00087	0.020	0.000027	0.22	**0.019**	0.11	0.056	0.00092	0.0057	43
Post-Closure Phase																										
Month	**D-Mg**	**D-Mn**	**D-Mo**	**D-Na**	**D-Ni**	**D-P**	**D-Pb**	**D-Sb**	**D-Se**	**D-Si**	**D-Sn**	**D-Sr**	**D-Ti**	**D-Tl**	**D-U**	**D-V**	**D-Zn**	**T-Ag**	**T-Al**	**T-As**	**T-B**	**T-Ba**	**T-Be**	**T-Bi**	**T-Ca**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	2.5	0.25	0.0044	5.1	0.0010	0.010	0.0014	0.0073	0.0012	2.3	0.00012	0.37	0.0064	0.000072	0.0019	0.00086	0.017	0.000023	0.20	**0.018**	0.045	0.046	0.00071	0.0071	27
Feb	2.5	0.26	0.0044	5.3	0.0010	0.0099	0.0014	0.0073	0.0013	2.3	0.00012	0.37	0.0064	0.000072	0.0019	0.00085	0.016	0.000035	0.29	**0.019**	0.045	0.050	0.00072	0.0068	27
Mar	2.6	0.26	0.0045	5.3	0.0010	0.011	0.0016	0.0075	0.0013	2.4	0.00012	0.38	0.0065	0.000076	0.0021	0.00090	0.018	0.000031	0.25	**0.021**	0.047	0.049	0.00080	0.0068	28
Apr	2.4	0.26	0.0043	5.4	0.00098	0.0084	0.0011	0.0068	0.0012	2.0	0.00011	0.35	0.0063	0.000064	0.0016	0.00076	0.013	0.000047	0.39	**0.015**	0.041	0.053	0.00060	0.0065	27
May	1.9	0.21	0.0040	4.3	0.00087	0.0054	0.00048	0.0057	0.0010	1.5	0.000091	0.27	0.0060	0.000045	0.00091	0.00059	0.0085	0.000024	0.26	**0.0056**	0.031	0.043	0.00026	0.0061	20
Jun	1.6	0.18	0.0034	3.7	0.00078	0.0044	0.00035	0.0048	0.00085	1.3	0.000085	0.23	0.0058	0.000037	0.00071	0.00057	0.0071	0.000024	0.27	0.0042	0.026	0.043	0.00020	0.0052	18
Jul	1.2	0.13	0.0023	2.8	0.00060	0.0034	0.00029	0.0033	0.00058	1.1	0.000073	0.17	0.0054	0.000027	0.00052	0.00055	0.0064	0.000024	0.27	0.0039	0.019	0.041	0.00017	0.0035	15
Aug	1.9	0.22	0.0031	3.3	0.00072	0.0044	0.00045	0.0043	0.00076	1.3	0.000095	0.24	0.0055	0.000042	0.00075	0.00059	0.0063	0.000022	0.24	**0.0056**	0.028	0.042	0.00024	0.0050	18
Sep	1.6	0.19	0.0026	2.9	0.00066	0.0041	0.00047	0.0036	0.00063	1.2	0.000097	0.21	0.0055	0.000041	0.00071	0.00061	0.0073	0.000022	0.23	**0.0060**	0.026	0.042	0.00025	0.0040	17
Oct	1.6	0.17	0.0023	2.8	0.00066	0.0050	0.00070	0.0035	0.00060	1.4	0.00010	0.21	0.0056	0.000045	0.00091	0.00068	0.010	0.000023	0.22	**0.0092**	0.028	0.042	0.00036	0.0036	18
Nov	2.4	0.23	0.0030	3.7	0.00082	0.0084	0.0013	0.0050	0.00084	2.0	0.00010	0.31	0.0061	0.000058	0.0016	0.00085	0.018	0.000023	0.20	**0.018**	0.035	0.044	0.00067	0.0056	24
Dec	2.3	0.23	0.0030	3.7	0.00080	0.0083	0.0013	0.0049	0.00084	2.0	0.00010	0.31	0.0060	0.000057	0.0016	0.00083	0.017	0.000023	0.20	**0.018**	0.035	0.044	0.00066	0.0064	24
Long-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.000050	-	-	1.2	1.0	0.00013	-	-
Short-Term BC FWAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00010	-	0.0050	-	-	-	-	-
Discharge Limit	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00046	-	0.0050	-	-	0.0010	-	-

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 3.2-4: Maximum Upper Case Predictions for Scenario 2 at BJ 2.62

Operations Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00014	0.00072	0.0018	0.0018	0.26	0.0000081	9.0	0.25	3.1	0.36	0.017	17	0.0028	0.028	0.0040	0.025	0.0044	4.4	0.00039	0.76	0.0089	0.00020	0.0034	0.00090	0.0079
Feb	0.00014	0.00080	0.0018	0.0022	0.37	0.0000081	9.0	0.25	3.2	0.37	0.017	17	0.0028	0.028	0.0041	0.025	0.0044	4.6	0.00038	0.76	0.010	0.00020	0.0034	0.00096	0.0086
Mar	0.00014	0.00074	0.0018	0.0019	0.30	0.0000081	9.1	0.25	3.2	0.36	0.017	17	0.0028	0.028	0.0041	0.025	0.0045	4.5	0.00039	0.76	0.0093	0.00020	0.0035	0.00092	0.0077
Apr	0.00016	0.00094	0.0018	0.0026	0.53	0.0000081	8.9	0.24	3.2	0.39	0.017	17	0.0028	0.027	0.0042	0.025	0.0044	4.7	0.00038	0.76	0.012	0.00020	0.0034	0.0011	0.011
May	0.00014	0.00077	0.0017	0.0020	0.34	0.000011	8.4	0.23	3.0	0.35	0.016	16	0.0027	0.026	0.0039	0.024	0.0042	4.3	0.00037	0.71	0.0091	0.00019	0.0032	0.00091	0.012
Jun	0.00013	0.00070	0.0015	0.0018	0.34	0.000012	7.3	0.20	2.6	0.31	0.014	14	0.0023	0.024	0.0034	0.020	0.0036	3.8	0.00040	0.61	0.0086	0.00017	0.0028	0.00087	0.012
Jul	0.000089	0.00052	0.0010	0.0015	0.32	0.000011	5.0	0.13	1.9	0.22	0.0093	9.7	0.0017	0.019	0.0024	0.014	0.0024	2.9	0.00029	0.43	0.0074	0.00013	0.0019	0.00074	0.0093
Aug	0.00016	0.00083	0.0019	0.0020	0.31	0.0000082	9.2	0.25	3.3	0.40	0.017	17	0.0029	0.028	0.0038	0.026	0.0046	4.6	0.00043	0.76	0.0090	0.00021	0.0036	0.00091	0.0100
Sep	0.00014	0.00075	0.0016	0.0018	0.28	0.0000079	7.4	0.20	2.7	0.33	0.014	14	0.0024	0.023	0.0031	0.021	0.0037	3.9	0.00037	0.62	0.0082	0.00018	0.0028	0.00083	0.0096
Oct	0.00012	0.00068	0.0014	0.0016	0.26	0.0000079	6.4	0.17	2.3	0.29	0.012	12	0.0021	0.020	0.0026	0.018	0.0032	3.5	0.00033	0.54	0.0077	0.00016	0.0024	0.00078	0.0091
Nov	0.00015	0.00073	0.0019	0.0019	0.26	0.0000081	9.2	0.25	3.3	0.39	0.017	17	0.0030	0.028	0.0039	0.026	0.0047	4.6	0.00039	0.77	0.0090	0.00020	0.0036	0.00089	0.0090
Dec	0.00014	0.00073	0.0019	0.0019	0.26	0.0000081	9.3	0.25	3.3	0.39	0.018	17	0.0030	0.028	0.0040	0.027	0.0047	4.7	0.00039	0.78	0.0090	0.00020	0.0036	0.00090	0.0083
Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00029	0.00076	0.0019	0.0028	**3.3**	0.0000081	9.0	0.27	3.3	0.39	0.017	17	0.0029	0.027	0.0021	0.026	0.0046	4.6	0.00023	0.76	0.0094	0.00020	0.0035	0.00085	0.019
Feb	0.00028	0.00097	0.0019	0.0031	**3.2**	0.0000081	9.1	0.28	3.3	0.42	0.017	17	0.0030	0.027	0.0021	0.026	0.0046	4.9	0.00023	0.78	0.013	0.00020	0.0036	0.00094	0.018
Mar	0.00032	0.00089	0.0019	0.0033	**3.7**	0.0000081	9.2	0.32	3.4	0.41	0.017	17	0.0030	0.027	0.0023	0.026	0.0046	4.8	0.00024	0.78	0.012	0.00022	0.0039	0.00092	0.020
Apr	0.00028	0.00093	0.0019	0.0036	**2.9**	0.0000081	9.3	0.29	3.3	0.40	0.017	17	0.0030	0.028	0.0023	0.027	0.0047	4.7	0.00024	0.78	0.014	0.00021	0.0036	0.0010	0.019
May	0.00015	0.00079	0.0018	0.0020	0.89	0.000011	8.5	0.23	3.1	0.37	0.016	16	0.0028	0.026	0.0015	0.024	0.0043	4.4	0.00023	0.71	0.0092	0.00019	0.0033	0.00076	0.014
Jun	0.00013	0.00070	0.0015	0.0018	0.59	0.000012	7.2	0.19	2.6	0.32	0.014	14	0.0024	0.023	0.0013	0.021	0.0036	3.9	0.00020	0.61	0.0086	0.00017	0.0028	0.00074	0.012
Jul	0.000095	0.00051	0.0010	0.0014	0.67	0.000011	4.9	0.13	1.9	0.22	0.0090	9.2	0.0017	0.019	0.00098	0.014	0.0024	2.9	0.00015	0.42	0.0072	0.00013	0.0019	0.00065	0.0099
Aug	0.00014	0.00069	0.0015	0.0017	0.97	0.0000080	7.5	0.19	3.0	0.36	0.014	13	0.0024	0.024	0.0013	0.020	0.0036	3.8	0.00021	0.62	0.0080	0.00017	0.0028	0.00069	0.0100
Sep	0.00015	0.00068	0.0013	0.0017	**1.2**	0.0000078	6.3	0.18	2.6	0.31	0.011	11	0.0020	0.020	0.0012	0.018	0.0030	3.3	0.00019	0.53	0.0079	0.00016	0.0024	0.00068	0.011
Oct	0.00020	0.00065	0.0013	0.0021	**1.9**	0.0000078	5.6	0.17	2.3	0.28	0.0098	9.9	0.0018	0.019	0.0014	0.016	0.0026	3.0	0.00018	0.48	0.0078	0.00015	0.0023	0.00072	0.015
Nov	0.00034	0.00064	0.0017	0.0033	**3.9**	0.0000080	7.5	0.31	3.2	0.36	0.013	13	0.0023	0.024	0.0024	0.024	0.0032	3.6	0.00020	0.65	0.010	0.00020	0.0036	0.00090	0.022
Dec	0.00031	0.00063	0.0016	0.0030	**3.6**	0.0000080	7.5	0.28	3.2	0.35	0.013	13	0.0023	0.024	0.0022	0.023	0.0033	3.6	0.00020	0.64	0.0096	0.00019	0.0034	0.00087	0.020
Post-Closure Phase																									
Month	**T-Cd**	**T-Co**	**T-Cr**	**T-Cu**	**T-Fe**	**T-Hg**	**T-K**	**T-Li**	**T-Mg**	**T-Mn**	**T-Mo**	**T-Na**	**T-Ni**	**T-P**	**T-Pb**	**T-Sb**	**T-Se**	**T-Si**	**T-Sn**	**T-Sr**	**T-Ti**	**T-Tl**	**T-U**	**T-V**	**T-Zn**
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
Jan	0.00024	0.00045	0.00097	0.0023	**2.9**	0.0000083	3.3	0.077	2.5	0.26	0.0044	5.1	0.0011	0.016	0.0016	0.0073	0.0013	2.6	0.00013	0.37	0.0064	0.00011	0.0020	0.00086	0.018
Feb	0.00025	0.00056	0.00099	0.0028	**3.1**	0.0000083	3.4	0.077	2.6	0.27	0.0045	5.3	0.0011	0.016	0.0018	0.0073	0.0013	2.8	0.00013	0.37	0.0084	0.00011	0.0020	0.00096	0.018
Mar	0.00027	0.00052	0.0010	0.0028	**3.4**	0.0000084	3.4	0.080	2.6	0.27	0.0045	5.3	0.0011	0.017	0.0019	0.0075	0.0013	2.8	0.00013	0.38	0.0077	0.00011	0.0021	0.00096	0.020
Apr	0.00022	0.00069	0.00089	0.0029	**2.5**	0.0000081	3.3	0.069	2.4	0.28	0.0043	5.4	0.0011	0.014	0.0016	0.0069	0.0012	2.7	0.00012	0.36	0.011	0.00010	0.0017	0.0010	0.017
May	0.000085	0.00042	0.00059	0.0013	0.72	0.000011	2.9	0.055	1.9	0.23	0.0040	4.3	0.00090	0.011	0.00080	0.0058	0.0010	1.8	0.00010	0.27	0.0062	0.000082	0.00093	0.00063	0.011
Jun	0.000065	0.00038	0.00050	0.0011	0.50	0.000011	2.5	0.045	1.7	0.20	0.0034	3.7	0.00080	0.011	0.00067	0.0049	0.00088	1.7	0.000094	0.23	0.0060	0.000076	0.00073	0.00061	0.0093
Jul	0.000057	0.00031	0.00038	0.0010	0.55	0.000010	1.7	0.031	1.2	0.14	0.0024	2.8	0.00062	0.011	0.00059	0.0033	0.00060	1.5	0.000080	0.17	0.0056	0.000066	0.00054	0.00058	0.0082
Aug	0.000082	0.00040	0.00051	0.0012	0.75	0.0000076	2.5	0.042	1.9	0.23	0.0031	3.3	0.00075	0.011	0.00064	0.0044	0.00079	1.6	0.00010	0.24	0.0055	0.000078	0.00076	0.00059	0.0075
Sep	0.000095	0.00042	0.00051	0.0012	0.88	0.0000075	2.1	0.035	1.7	0.20	0.0026	2.9	0.00069	0.010	0.00067	0.0037	0.00066	1.6	0.00010	0.21	0.0055	0.000077	0.00072	0.00061	0.0090
Oct	0.00014	0.00043	0.00059	0.0015	**1.5**	0.0000077	2.0	0.036	1.6	0.18	0.0023	2.8	0.00069	0.010	0.00089	0.0035	0.00063	1.7	0.00011	0.22	0.0056	0.000081	0.00093	0.00068	0.012
Nov	0.00023	0.00040	0.00082	0.0022	**3.0**	0.0000083	2.6	0.055	2.4	0.24	0.0030	3.7	0.00083	0.014	0.0015	0.0050	0.00087	2.3	0.00011	0.31	0.0061	0.000093	0.0017	0.00085	0.018
Dec	0.00022	0.00039	0.00081	0.0022	**2.9**	0.0000082	2.6	0.055	2.4	0.24	0.0030	3.7	0.00081	0.014	0.0015	0.0050	0.00087	2.3	0.00011	0.31	0.0060	0.000093	0.0016	0.00083	0.017
Long-Term BC FWAL	-	0.0040	0.0010	0.0020	-	0.000020	-	-	-	0.73	1.0	-	0.25	-	0.0040	0.0090	0.0020	-	-	-	-	0.00080	0.0085	-	0.0075
Short-Term BC FWAL	-	0.11	-	0.0046	1.0	-	-	-	-	0.85	2.0	-	-	-	0.016	-	-	-	-	-	-	-	-	-	0.033
Discharge Limit	-	-	0.0090	0.0020	1.7	0.000020	-	0.090	-	0.80	-	-	-	-	0.0046	-	0.0020	-	-	-	-	-	-	-	0.0075

Notes:
BC FWAL = BC water quality guidelines for protection of freshwater aquatic life.
Concentrations that exceed long-term guidelines are shown as underlined font.
Concentrations that exceed short-term guidelines are shown as bold font.
Concentrations that exceed the discharge limit are shaded in grey.
Hardness dependent guidelines are calculated using the baseline median hardness of 28 mg/L as $CaCO_3$.
Ammonia guidelines assume a pH of 8.0 and temperature of 15°C.
Chromium guideline is for Cr(VI).

Appendix 4: Streamflow Ratios Supporting Dilution Analyses in Brucejack Creek and Sulphurets Creek

PRETIVM

Memorandum

Date: January 18, 2017

To: Robert Goldblatt, Lorax Environmental Services Ltd., and Sylvia Van Zalingen, Environmental Manager, Pretium Resources Inc.

CC: Greg Norton, ERM Partner

From: ERM Consultants Canada Ltd.

Subject: **Streamflow Ratios Supporting Dilution Analyses in Brucejack Creek and Sulphurets Creek**

1. INTRODUCTION

The geographic extent of potential effects from elevated nitrate and nitrite are defined as waters (i.e. receiving environment) with predicted concentrations greater than the British Columbia Water Quality Guidelines (BCWQGs) for the protection of aquatic life. Brucejack Creek at BJ 3.10 is predicted to have concentrations of nitrate and nitrite greater than their respective BCWQGs. Brucejack Creek flows into Sulphurets Creek at SC0, where nitrate and nitrite concentrations are below the BCWQGs (Table 1).

Table 1. Dilution required to equal BC Water Quality Guidelines in Sulphurets Creek

Parameter	Model case	BJ 3.10 (mg-N/L)	SC0 (mg-N/L)	BCWQG (mg-N/L)	Required Dilution
Nitrate	Expected Case	5.1	0.05	3.0	1:1
	Upper Case	11.5	0.05	3.0	3:1
Nitrite	Expected Case	0.11	0.001	0.02	5:1
	Upper Case	0.24	0.001	0.02	12:1

The maximum required dilution is 12:1 Brucejack Creek at BJ 3.10 to Sulphurets Creek at SC0 (to produce NO_2 <0.02 mg-N/L). This memorandum provides an update to the assessment of streamflow ratios along Sulphurets Creek, and includes the results of previous studies, as well as a description of the methodology used to assess ratios used in this update.

2. BACKGROUND

ERM (2014) provided streamflow ratio estimates that support a dilution analysis of flows from Brucejack Creek into Sulphurets Creek. Three approaches were used to estimate streamflow ratio:

a) *use of drainage area as a surrogate for streamflow ratio;*

b) *analysis of data collected during the baseline monitoring program (open water season only); and*

c) *regional hydrologic analysis.*

The ratio of streamflow at Sulphurets Lake Outflow (at hydrometric station SL-H1) to streamflow at Brucejack Creek (at hydrometric station BJ 1.74, also known as BJL-H1a), using *Methods a*, *b*, and *c*, were 8.8, 14.6, and 9.7, respectively (ERM 2014). Based on these results, ERM (2014) concluded that the drainage area approach (i.e., *Method a*) provides the most conservative estimates for streamflow ratios, with 8:1 being the ratio selected for the Sulphurets Lake Inflow compared to Brucejack Creek at BJ 1.74. This conclusion assumes that drainage area ratios (*Method a*) may be used as a surrogate for streamflow ratios, which may further be used as a surrogate for dilution ratios.

ERM (2016) was completed and superseded ERM (2014) following collection of additional 366 concurrent daily streamflow records (June to September 2013-2015). It was found that additional data did not change ERM (2014) recommendations (ERM 2016). Catchment area ratios consistently provided the most conservative streamflow ratio and so was recommended.

Streamflow ratios, determined from the ratio of measured discharge, is the preferred method (*Method b*), but these results were not chosen in the previous study (*Method a*) due to the limited extent of site record available, and use of open water season data only.

3. 2017 STREAMFLOW RATIOS

ERM has recently completed a detailed hydrologic analysis of the major tributaries of the Sulphurets Valley, which resulted in the development of a series of long-term transposed streamflow records for select hydrometric monitoring stations (Table 2). These records (each 66 years in length) were derived by integrating project hydrometric records, with long-term regional Water Survey of Canada records, using the empirical frequency pairing method described in Butt (2013).

The monthly distribution of average streamflow in Brucejack Creek is different from Sulphurets Creek (Plate 1), and these differences impact streamflow ratios at different times of the year. The highest monthly flows in Brucejack Creek occur during the prominent freshet peak, while for Sulphurets Creek, the highest flows occur during the summer months, in response to melting of large, lower elevation glaciers. Thus, major differences in runoff between Brucejack Creek and Sulphurets Creek result from the presence, size, orientation and elevation of glaciers, and that the catchment area ratio (*Method a*) did not reflect these differences accurately.

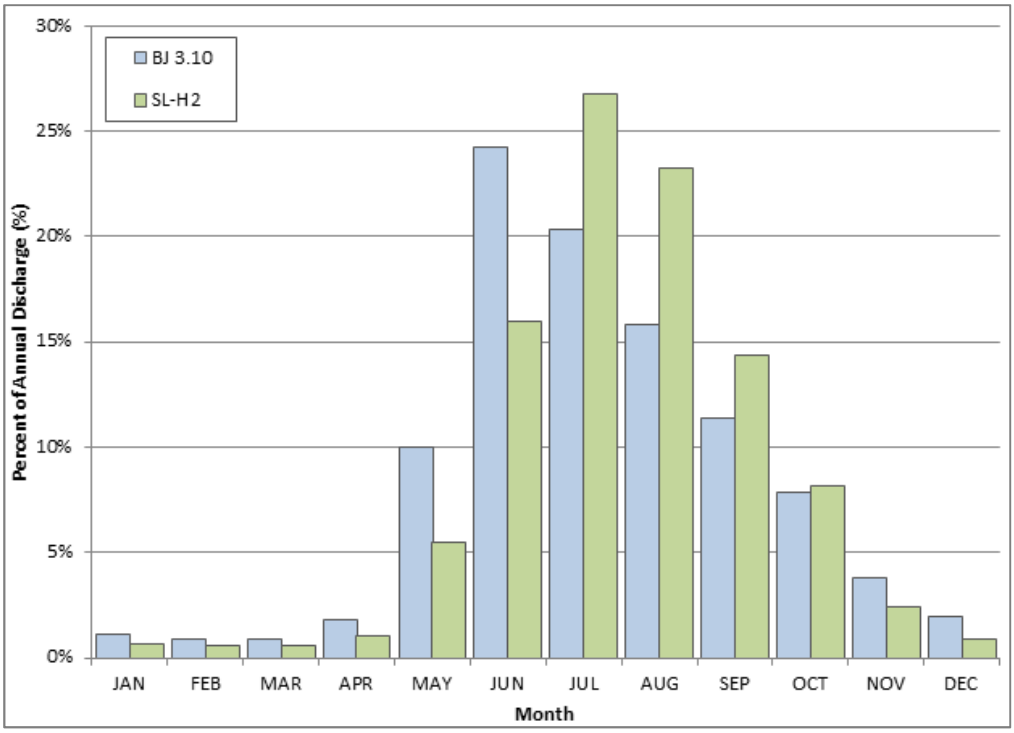

Plate 1. Monthly Distribution of Streamflow

The long-term transposed streamflow records were used to more accurately determine the ratios of streamflow at Brucejack Creek (at BJ 3.10), to various nodes along Sulphurets Creek using average monthly flows (Table 3). The process was straight forward, though some nodes were not located at specific monitoring stations, and thus minor spatial extrapolation of runoff was necessary. Extrapolation was achieved by assuming that flows downstream of monitoring stations were a function of non-glaciated runoff conditions, which was calculated for each node as proportional runoff, based on a mass balance of flows in the Sulphurets Valley.

Table 2. Hydrometric Stations with Long-Term Transposed Streamflow Records

#	Node	Description	Easting	Northing	Catchment (km^2)
1	BJ 1.74	Brucejack Creek, 1.74 km upstream of Confluence	425737	6259076	8.5
2	SL-H2	Sulphurets Creek, downstream of Sulphurets Lake	419769	6261350	75.6
3	TMC-H1	Ted Morris Creek	416883	6259497	56.6
4	MC-H2	Mitchell Creek, immediately upstream of Confluence	416740	6262837	87.9
5	GC-H1	Gingras Creek, immediately upstream of Confluence	416277	6262834	9.8
6	SC-H1	Sulphurets Creek, at the Mouth	408256	6261490	289.4

Table 3. Sulphurets Valley Dilution Ratio Node Details

Node	Alias	Easting	Northing	Catchment (km^2)	Catchment Ratio[1]
Brucejack Lk (BJ 3.10)	BJ 3.10	427030	6258895	6.7	1
Sulphurets Creek d/s Sulphurets Lk	SL-H2	419769	6261350	75.6	11
Sulphurets Creek, u/s Ted Morris Crk	SC-TMU	417520	6261990	86.8	13
Sulphurets Creek, d/s Ted Morris Crk	SC-TMD	417285	6262111	149.8	22
Sulphurets Creek, u/s Mitchell Crk	SC-MCU	416354	6262487	151.5	23

Notes:

1. *Catchment Ratio provided as a reference, using the methodology described in ERM (2014), Method "a"*

Previous studies were based on discharge data from BJ 1.74. Therefore, streamflow for BJ 1.74 was transposed to BJ 3.10 by catchment area proration. Long-term streamflow were then determined at other nodes by using the long-term streamflow records from nearby monitoring stations, and integrating where necessary to provide reasonable estimates of discharge at the specific node.

- SL-H2 used the long-term transposed records of the monitoring station SL-H2,
- SC-TMU used SL-H2, with the addition of runoff from the non-glaciated catchment area downstream of the monitoring station SL-H2,
- SC-TMD used SC-TMU, with the addition of runoff from the monitoring station TMC-H1, and the addition of runoff from the non-glaciated Ted Morris Valley catchment downstream of TMC-H1,
- SC-MCU used SC-TMD, with the addition of runoff from the non-glaciated catchment Sulphurets Valley catchment area downstream of SC-TMD.

Monthly streamflow is included in Table 4, and monthly ratios are included in Table 5 and Plate 2 (the dashed line represents the 12:1 discharge ratio).

Table 4. Average Monthly Streamflow (m^3/s) at nodes along Sulphurets Valley

Node	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
BJ 3.10	0.06	0.05	0.05	0.10	0.55	1.32	1.1	0.86	0.62	0.43	0.20	0.10
SL-H2	0.51	0.45	0.45	0.81	4.31	12.5	21.0	18.2	11.2	6.41	1.88	0.68
SC-TMU	10.9	11.8	11.9	11.0	9.30	10.7	19.0	21.8	18.6	16.7	9.97	7.99
SC-TMD	24.5	24.5	24.8	24.3	15.8	17.7	33.6	37.4	32.4	27.7	19.3	16.8
SC-MCU	24.8	24.9	25.1	24.6	15.9	17.3	33.6	37.4	32.5	27.9	19.4	17.0

Table 5. Monthly Streamflow ratios at nodes along Sulphurets Valley

Node	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
BJ 3.10	1	1	1	1	1	1	1	1	1	1	1	1
SL-H2	8	9	9	8	8	9	19	21	18	15	9	6
SC-TMU	11	12	12	11	9	11	19	22	19	17	10	8
SC-TMD	24	25	25	24	16	17	34	37	32	28	19	17
SC-MCU	25	25	25	25	16	17	34	37	32	28	19	17

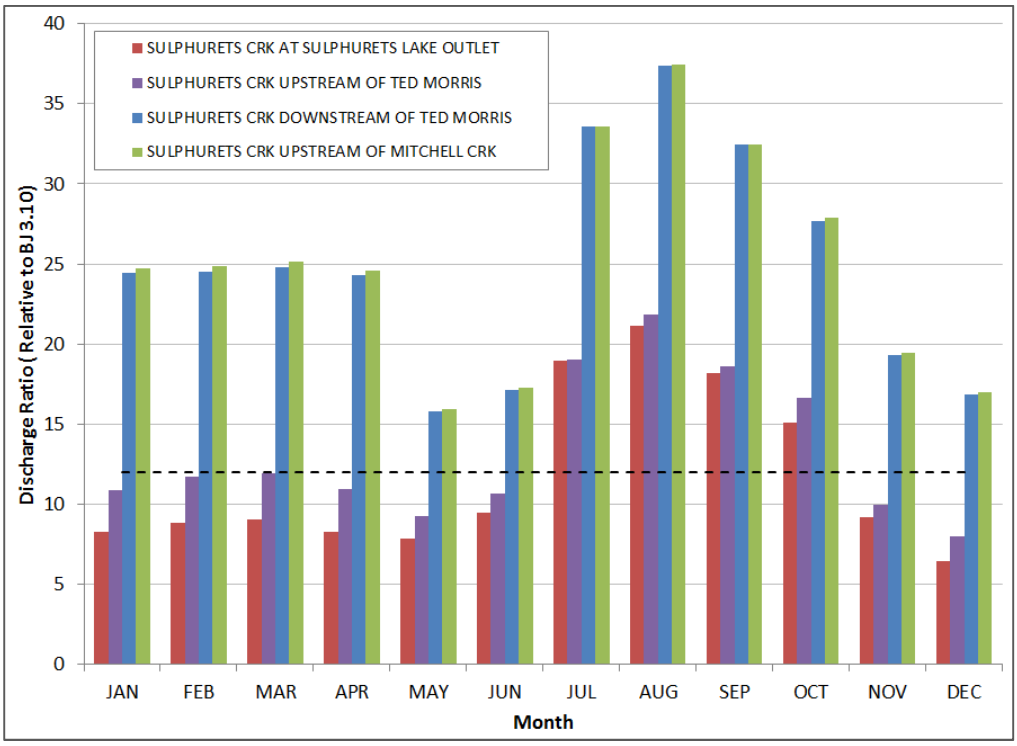

Plate 1. Streamflow Ratios at Nodes Along Sulphurets Valley

4. CLOSING

ERM used long-term streamflow estimates to derive estimates of streamflow ratios at nodes along the Sulphurets Valley. It was found that the required 12:1 streamflow ratio (compared to streamflow in Brucejack Creek at BJ 3.10) will be comfortably achieved in all months, immediately below the Ted Morris confluence, at SC-TMD.

Should you have any questions or concerns, please do not hesitate to contact ERM.

ERM Consultants Canada Ltd.

Cameron McCarthy, M.A.Sc., P.Eng., P.Geo.
Principal Consultant – Water Resources Manager

Allyson Longmuir, M.Sc., R.P.Bio.
ERM Project Manager

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ERM 2014. *Streamflow ratio estimates for selected locations downstream of Brucejack Creek*. Memorandum prepared by ERM, December 2014.ERM, 2016

ERM 2016. *Investigating potential effects of 2013-2015 streamflow data on the estimate of the ratio of streamflows at Sulphuretes Lake Inflow to streamflows at BJL-H1a.* Memorandum prepared by ERM, April, 2016

Appendix 5: Review of As and Sb Aquatic Toxicity Literature

PRETIVM

MEMORANDUM

To:	**Sylvia Van Zalingen and Max Holtby (Pretivm)**	**Date:18 December 2017**
From:	**Meghan Goertzen and Robert Goldblatt (Lorax)**	**Project: A406-1**
Subject:	**Antimony and arsenic toxicity literature review and site-specific toxicity test**	

1. Introduction

This memorandum presents an antimony and arsenic toxicity literature review and results of a site-specific toxicity test completed in support of Pretium Resources Inc.'s (Pretivm's) application to amend Brucejack Gold Mine Effluent Permit 107835 to (1) include a discharge limit for antimony (Sb) of 28 µg/L and (2) increase the arsenic (As) discharge limit from 5 µg/L to 10 µg/L. The memorandum provides a review of literature-based Sb and As toxicity data sets, and presents results of a toxicity using site water and added As and Sb. The memorandum provides an assessment of the proposed discharge limits in relation to these toxicity data.

Section 2 provides a summary of aquatic toxicity literature that was used to derive the BC freshwater aquatic life (FWAL) guidelines for Sb and As. Also included are the results from a search of toxicity studies published after the BC FWAL guidelines were published, to assess whether more recent data would change the derivation of the guideline. The summary of all published toxicity data is used to assess the potential for toxicity resulting from the proposed discharge limits.

Section 3 presents the results of a toxicity test performed on effluent from Brucejack Gold Mine amended with various concentrations of As and Sb. The test was designed to determine toxicity endpoints of these elements in site water, using a species that is known to be particularly sensitive to arsenic. The results of the toxicity test provide a second line of evidence for the assessment of potential toxic effects from the proposed discharge limits. The memorandum concludes with a summary (Section 4).

2. Literature Review of Toxicity Data

2.1 Antimony

The BC working freshwater aquatic life (FWAL) guideline for antimony is 9 µg/L for Sb(III). The guideline specifies the trivalent form of antimony because the majority of toxicological studies were done using Sb(III). The other form of antimony that may occur in natural water is Sb(V), which predominates in highly oxidizing environments (ANZECC, 2000). Routine water quality monitoring for Brucejack Gold Mine measures total Sb, rather than individual Sb species such as Sb(III) or Sb(V); therefore, it is necessary to compare T-Sb measurements to the BC FWAL guideline for Sb(III).

The BC FWAL guideline was adopted from the Australia and New Zealand water quality guidelines (ANZECC, 2000), which states:

> *A freshwater low reliability trigger value of 9 µg/L was derived for antimony (III) from the fish figure using an AF of 1000. This figure should only be used as an indicative interim working level. Collection of more data would assist in revision of this figure.*

ANZECC classified the trigger as "low reliability" due to the paucity of acceptable Sb toxicity data, particularly chronic toxicity tests. The trigger was derived from the lowest acceptable toxicity test endpoint, a 96-h LC50 of 9000 µg/L for *Pimephales promelas* (fathead minnow), and an uncertainty factor of 0.001. This is an unusually conservative degree of safety for deriving long-term guidelines from an acute toxicity endpoint, which is why the ANZECC guideline classifies it as a low reliability trigger.

Antimony toxicity literature has been reviewed for the development of an Interim Provincial Water Quality Objective by Ontario (Fletcher *et al.*, 1996) and for a review of the acute ecotoxicity data for Sb for the Environmental Hazard Identification in the U.S. (PricewaterhouseCoopers, 2001). Both reviews found that many of the published studies with high toxicity endpoints were not reliable because the actual concentration of Sb in the test solutions was not measured. Most studies used antimony trioxide (Sb_2O_3) or antimony trichloride ($SbCl_3$) to make stock solutions, both of which are not readily soluble in water. For these studies, the nominal concentrations used to calculate toxicity statistics likely overestimated the actual concentration that organisms were exposed to.

Fletcher classified nine acute toxicity endpoints as primary (having acceptable data) and five chronic toxicity endpoints as primary (Table 2-1). PricewaterhouseCoopers (2001) classified 3 of the 16 acute endpoints that they reviewed as reliable (Table 2-1). The lowest reliable endpoint is 300 µg/L for survival of eggs of the narrow-mouthed toad in a 7-day exposure (Birge, 1978). In the same publication by Birge (1978), a 28-day rainbow trout egg survival endpoint of 560 µg/L is reported, but Fletcher *et al*. (1996) classify this endpoint as secondary (*i.e.*, less reliable than primary data).

No Sb toxicity endpoints have been reported in literature after 2001 that are more sensitive than those described above. The U.S. ECOTOX database reports two Sb toxicity endpoints published after 2000 (Borgmann et al., 2005; Khangarot & Das, 2009), both of which report Sb toxicity endpoints at >1,300 µg/L. A search of the primary literature for recent studies not in the ECOTOX database revealed one other study by Nam *et al.* (2009) which reported an effect on growth of a green alga at 206,000 µg/L.

Table 2-1:
Antimony Toxicity Studies

Scientific Name	Common Name	Test Duration	Effect	Endpoint[3]	Concentration (ug/L)	Source	Reliability
Acute							
Gastrophryne carolinensis	Eastern narrow-mouthed toad	7 d	Mortality	LC_{50}	300	Birge (1978)	Primary[1]
Hydra oligactis	Brown hydra	96 h	Immobility	EC_{50}	500	Brooke *et al*. (1986)	
Tubifex tubifex	Sludge worm	48 h	Mortality	LC_{50}	1,080	Khangarot (1991)	
Hyalella azteca	Scud	7 d	Mortality	LC_{50}	>1,300	Borgmann *et al*. (2005)	
Daphnia magna	Water flea	48 h	Mortality	LC_{50}	2,700	Doe *et al*. (1987)	Primary[1]
Ceriodaphnia dubia	Water flea	48 h	Mortality	LC_{50}	3,470	Spehar (1987)	
Daphnia magna	Water flea	48 h	Mortality	LC_{50}	5,000	Doe *et al*. (1987)	Primary[1]
Daphnia magna	Water flea	48 h	Mortality	LC_{50}	6,700	Doe *et al*. (1987)	Primary[1]
Pimephales promelas	Fathead minnow	96 h	Mortality	LC_{50}	9,000	ANZECC (2000)	
Carassius auratus	Goldfish	7 d	Mortality	LC_{50}	11,300	Birge (1978)	Primary[1]
Daphnia magna	Water flea	48 h	Immobility	EC_{50}	12,100	ANZECC (2000)	
Daphnia magna	Water flea	48 h	Mortality	LC_{50}	18,800	Kimball (1978)	Primary[1] & Reliable[2]
Pimephales promelas	Fathead minnow	4 d	Mortality	LC_{50}	21,000 22,700	Kimball (1978)	Primary[1] & Reliable[2]
Pimephales promelas	Fathead minnow	8 d	Mortality	LC_{50}	19,300 21,000	Kimball (1978)	Primary[1] & Reliable[2]
Gammarus pseudolimnaeus	Scud	96 h	Mortality	LC_{50}	25,700	Brooke *et al*. (1986)	
Pycnopsyche sp.	Caddisfly	96 h	Mortality	NOEC	25,700	Brooke *et al*. (1986)	
Lumbriculus variegatus	Annelid	96 h	Mortality	NOEC	25,700	Brooke *et al*. (1986)	
Oncorhynchus mykiss	Rainbow trout	96 h	Mortality	LC_{50}	37,000	Doe *et al*. (1987)	Primary[1]

Scientific Name	Common Name	Test Duration	Effect	Endpoint[3]	Concentration (ug/L)	Source	Reliability
Cypris subglobosa	Ostracod	2 d	Immobility	EC_{50}	560,000	Khangarot & Das (2009)	
Tubifex tubifex	Sludge worm	96 h	Mortality	LC_{50}	678,000	ANZECC (2000)	
Chronic							
Salmo gairdneri	Rainbow trout	28 d	Mortality	LC_{50}	560	Birge (1978)	
Selenastrum capricornutum	Green alga	96 h	Growth	EC_{50}	740	US EPA (1978)	
Daphnia magna	Water flea	30 d	Mortality	LC_{50}	1,700	Doe *et al*. (1987)	Primary[1]
Pimephales promelas	Fathead minnow	30 d	Growth	LOEC	2,310	Kimball (1978)	Primary[1] & Reliable[2]
Daphnia magna	Water flea	28 d	Mortality	LC_{50}	4,510	Kimball (1978)	Primary[1]
Tetrahymena pyriformis	Ciliate protozoan	36 h	Growth	EC50	6,000	Sauvant *et al.*, 1995	Reliable[2]
Chlorella vulgaris	Alga	4 -mo	Growth	Adverse effect	7,800	den Dooren de Jong (1965)	
Pimephales promelas	Fathead minnow	30 d	Mortality	LOEC	9,300	Kimball (1978)	Primary[1]
Oncorhynchus mykiss	Rainbow trout	30 d	Mortality	LC_{50}	16,000	Doe *et al*. (1987)	Primary[1]
Lemna minor	Duckweed	96 h	Growth	EC_{50}	25,500	Brooke *et al*. (1986)	
Pseudokirchneriella subcapitata	Alga	72 h	Growth	EC_{50}	206,000	Nam *et al*. (2009)	

1. Fletcher *et al*. 1996 classify this endpoint as primary data.
2. PricewaterhouseCoopers classify this endpoint as reliable.
3. Endpoints are median lethal (LC50) or median effect (EC50) concentration, or Lowest Observed Effect Concentration.
   Rows shown as blue font are studies that have been classified as secondary or not reliable.

The lowest reliable Sb toxicity endpoint in the literature that is directly relevant to the aquatic community in Brucejack Creek is the 30-day *Daphnia magna* median lethal endpoint (LC50) of 1,700 µg/L (Doe *et al.*, 1987). This is considered a chronic endpoint because the average lifespan of *D. magna* is about 40 days at 25 °C. The green alga endpoint of 740 µg/L (USEPA, 1978) is also relevant to aquatic life in Brucejack Creek, but the validity of the data from this study is uncertain (PricewaterhouseCoopers, 2001). The data on Sb toxicity in the literature provide a high confidence that the proposed effluent discharge limit of 28 µg/L will not produce toxic effects to the aquatic community in the receiving environment.

2.2 Arsenic

The BC FWAL guideline for total arsenic is 5 µg/L. This value was adopted from the CCME (2001) guideline which applied an uncertainty factor of 0.1 to the lowest endpoint in the literature of 50 µg/L [a EC_{50} for growth of the green alga *Scenedesmus obliquus* (Vocke *et al.*, 1980)]. CCME also reported that two other algal species were the next most sensitive species to arsenic toxicity, and that invertebrates and fish were less sensitive than algae.

The BC arsenic guideline Overview Report (BCMOE, 2002) states that the CCME guideline of 5 µg/L was judged to be sufficiently protective of water uses in the province of B.C., and this guideline was adopted without change. The Overview Report notes that there is one arsenic study that reports a toxicity endpoint that is lower than the 50 µg/L EC50 *S. obliquus* endpoint used to derive the guideline. A *D. magna* 21-day growth study yielded a Lowest Observed Effect Concentration of 38 µg/L for arsenic acid (US EPA, 1992). This study was reviewed by the European Chemicals Agency and classified as “not reliable” (ECHA, 2011). The ECHA is an agency of the European Union that manages the technical, scientific, and administrative aspects of implementation of the EU’s Registration, Evaluation, Authorisation and Restriction of Chemicals.

A compilation of other *D. magna* chronic endpoints indicates that the 38 µg/L endpoint cited by BCMOE (2002) is anomalously lower than other chronic endpoints for the same species, even from the same USEPA (1992) study (Table 2-2). There are only 3 other publications in the ECOTOX database that report chronic toxicity of arsenic to any daphnid species (all are *D. magna*) and these provide supporting evidence to support the ECHA conclusion that the USEPA (1992) endpoint is not reliable.

Table 2-2:
***Daphnia magna* Chronic Toxicity Endpoints**

Duration	Endpoint	Effect	Concentration (µg/L)	Reference
21 d	LOEC	Growth	38	USEPA (1992)
21 d	LOEC	Growth	880	USEPA (1992)
21 d	LOEC	Reproduction	880	USEPA (1992)
21 d	EC_{50}	Reproduction	1,400	Biesinger and Christensen (1972)
21 d	IC_{25}	Reproduction	1,900	Tisler and Zagorc-Koncan (2002)
21 d	LC_{50}	Mortality	2,850	Biesinger and Christensen (1972)
21 d	LOEC	Growth	3,400	Enserink *et al*. (1991)
21 d	LOEC	Reproduction	3,700	Tisler and Zagorc-Koncan (2002)
21 d	LC_{50}	Mortality	5,800	Enserink *et al.* (1991)

The ECOTOX database includes 26 references that were published after the CCME (2001) arsenic guideline; these studies report arsenic toxicity endpoints for 24 different species which range from. 172 µg/L to >10,000 µg/L. Thus, the basis for the BC FWAL guideline of an EC_{50} of 50 µg/L for a green alga species would not change based on more recent studies. This updated toxicity dataset provides a high level of confidence that the proposed arsenic discharge limit of 10 µg/L will not produce toxic effects to the aquatic community in the receiving environment.

3. Site Specific Toxicity Test

Pretivm commissioned a toxicity test using water collected from the Brucejack Lake outlet (site BJ 3.10) with various concentrations of arsenic and antimony added (Appendix 6 of Lorax, 2017). The test was conducted using the green algal species *Pseudokirchneriella subcapitata* (formerly called *Selenastrum capricornutum*) since the literature shows that green algae are sensitive to arsenic toxicity. Both As and Sb were added to the test solutions because these two metals were observed to be gradually increasing in Brucejack Lake following start of mine construction. Arsenic and antimony were added at a ratio of 1:1.25, by atomic weight, which is the same ratio that has been consistently measured at BJ 3.10 in 2017. This is a molar ratio of 1:0.77 As:Sb.

BJ 3.10 water was collected on October 30, 2017 and arrived at Nautilus Environmental Company Inc. in Burnaby B.C. on November 1, 2017. The test was conducted according to the procedure described by Environment Canada (2007). The test measured the growth of algae in site water with added As and Sb and compared the site water results to growth in laboratory

control water. The concentrations of As and Sb in each test solution were analyzed by ALS Environmental, and statistics were calculated using the measured concentrations. The test conducted met all quality assurance requirements.

The results listed in Table 3-1 are the combined effects of As and Sb added to each test solution. The literature review of toxicity of antimony and arsenic shows that arsenic is more toxic than antimony. The lowest As toxicity endpoint in the literature is 50 µg/L and the lowest Sb toxicity endpoint is 300 µg/L. Therefore, it is almost certain that the toxicity observed in the BJ 3.10 test was due to As, and the calculated Sb endpoints should not be interpreted as a concentration where toxicity due to Sb is expected. A test without any additions other than Sb would be required to determine Sb toxicity endpoints.

The median effect concentration (IC50) in BJ 3.10 water was 74 µg/L T-As (Table 3-1), which is a little higher than the median effect concentration that the BC FWAL guideline is based on (EC50 = 50 µg/L T-As). There was no effect on growth in the BJ 3.10 water control or of the T-As = 11.4 µg/L solution, compared to growth in the laboratory control water. The lowest observed effect concentration was 18.7 µg/L T-As. These test results, on a species that is known to be sensitive to arsenic toxicity, indicate that no adverse effects to aquatic life in Brucejack Creek are expected from the proposed discharge limit of 10 µg/L.

Table 3-1:
***Pseudokrchneriella subcapitata* Growth Inhibition Test Results**

Treatment	T-As (ug/L)	T-Sb (ug/L)	Cell Yield ($\times 10^4$cells/ml) (Mean ± 1 SD)
Laboratory control	0	0	27.6 ± 2.4
Un-amended BJ 3.10	4.55	6.17	152.8 ± 10.2
Concentration 1	11.4	14.1	152.5 ± 9.1
Concentration 2	18.7	23.2	132.8 ± 4.8
Concentration 3	31.6	39.4	132.8 ± 8.2
Concentration 4	60.4	78.6	93.5 ± 6.5
Concentration 5	115	144	39.2 ± 4.2
Concentration 6	224	289	19 ± 2.2
Concentration 7	461	573	4 ± 0.8
Test Endpoints			
IC50 (95% CL)	74.1 (67.5–81.7)	95.2 (85.6–101.5)	
LOEC	18.7	23.2	
NOEC	11.4	14.1	

4. Summary

The results of this memorandum are summarized as follows:

- The lowest antimony toxicity endpoint in the literature is 300 µg/L, for toxicity to frog embryo.
- The lowest antimony toxicity endpoint in the literature for species that may be representative of the Brucejack Creek aquatic community is 1,700 µg/L for toxicity to *Daphnia magna*.
- The lowest arsenic toxicity endpoint in the literature is 50 µg/L, for green algae, which is representative of periphyton present in Brucejack Creek.
- The lowest observed effect concentration (LOEC) for arsenic from a toxicity test using a green alga species and BJ 3.10 water is 18.7 µg/L.
- Literature-based toxicity tests and the site-specific toxicity test results support the conclusion that the proposed effluent discharge limits of 28 µg/L T-Sb and 10 µg/L T-As will not cause significant adverse effects to aquatic life in Brucejack Creek.

5. Closure

We trust that this memorandum meets your requirements.

Original signed by

Robert Goldblatt, B.Sc.
Senior Biologist
Lorax Environmental Services Ltd.

Original signed by

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Appendix 6: Site Specific Toxicity Test Results

PRETIVM

Toxicity testing on sample Weir at 3.10 and laboratory water amended with arsenic and antimony

Sample collected October 30, 2017

Final Report

December 15, 2017

Submitted to: **Pretium Exploration**
Vancouver, BC

8664 Commerce Court, Burnaby, BC V5A 4N7

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SIGNATURE PAGE

Report By: Mimi Tran, Dipl. T. Laboratory Biologist	Reviewed By: Edmund Canaria, R.P.Bio Environmental Biologist- Senior Analyst

This report has been prepared by Nautilus Environmental Company Inc. based on data and/or samples provided by our client and the results of this study are for their sole benefit. Any reliance on the data by a third party is at the sole and exclusive risk of that party. The results presented here relate only to the samples tested.

SUMMARY

Sample Information and Test Type

Sample IDs and Treatment	Weir at 3.10 and laboratory water amended with arsenic (As) and antimony (Sb)
Collection date	October 30, 2017 (Weir at 3.10)
Receipt date	November 1, 2017 (Weir at 3.10)
Sample test treatment preparation/amendment date	November 1, 2017 for Weir at 3.10 and laboratory water
Receipt temperature	8.8°C (Weir at 3.10)
Test types	72-h *Pseudokirchneriella subcapitata* growth inhibition

Summary of Results (amended laboratory water test)

Endpoint	µg/L As	µg/L Sb
P. subcapitata		
Growth IC25 (95% CL)	10.9 (3.8 – 90.6)	17.0 (9.3 – 121.9)
Growth IC50 (95% CL)	122.6 (92.8 – 143.6)	162.6 (121.2 – 193.4)
NOEC	3.5	8.5
LOEC	7.1	12.8

IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

Summary of Results (amended Weir at 3.10 test)

Endpoint	µg/L As	µg/L Sb
P. subcapitata		
Growth IC25 (95% CL)	42.7 (33.3 – 48.0)	54.3 (42.6 – 60.7)
Growth IC50 (95% CL)	74.1 (67.5 – 81.7)	95.2 (85.6 – 101.5)
NOEC	11.4	14.1
LOEC	18.7	23.2

IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

1.0 INTRODUCTION

Nautilus Environmental Company Inc. conducted 72-h *Pseudokirchneriella subcapitata* growth inhibition tests for Pretium Exploration. Sample Weir at 3.10 was collected on October 30, 2017 and delivered to the Nautilus Environmental laboratory in Burnaby, BC on November 1, 2017. The sample was transported in one 20-L plastic container and was received at a temperature of 8.8°C. The sample was stored in the dark at 4 ± 2°C prior to testing.

Sample Weir at 3.10 was amended with a range of arsenic (As) and antimony (Sb) concentrations, according to instructions provided by Lorax Environmental prior to testing. A concurrent test, using *P. subcapitata* laboratory control water, amended to the same arsenic and antimony concentrations as the sample, was also performed. Testing was initiated on November 1, 2017.

This report describes the results of the toxicity tests. Copies of raw laboratory data sheets and statistical analyses are provided in Appendix A. Copies of analytical chemistry analyses supplied by Lorax Environmental are provided in Appendix B. The chain-of-custody form is provided in Appendix C.

2.0 METHODS

Methods for the toxicity tests are summarized in Table 1. Testing using *P. subcapitata* was conducted according to procedure described by Environment Canada (2007).

The amended Weir at 3.10 and laboratory water test solutions were prepared at the Nautilus Environmental laboratory using an in-house concentrated arsenic stock solution, and a concentrated antimony stock solution supplied by Lorax Environmental. Aliquots of each prepared test solution were sent to ALS Environmental, Burnaby, BC for measurement of total and dissolved arsenic and antimony. Analytical results were reported directly to Lorax Environmental, and subsequently supplied to Nautilus Environmental for inclusion in the final report. Table 1 provides a summary of the nominal and total measured arsenic and antimony concentrations.

Statistical analyses for the tests were performed using CETIS (Tidepool Scientific Software, 2013). The test endpoints were calculated using total measured arsenic and antimony values, as instructed by Lorax Environmental.

Table 1. Nominal and total measured As and Sb concentrations in laboratory water and sample Weir at 3.10.

Test Treatment	µg/L As		µg/L Sb	
	Nominal	Total Measured	Nominal	Total Measured
Laboratory Water				
Laboratory Control	0	0	0	0
Concentration 1	3.5	3.5	4.4	8.47
Concentration 2	7	7.09	8.8	12.8
Concentration 3	14	13.9	18	20
Concentration 4	28	28.4	35	37.3
Concentration 5	56	56.2	70	76.6
Concentration 6	112	110	141	146
Concentration 7	224	220	282	291
Concentration 8	448	441	563	593
Weir at 3.10				
Laboratory Control	0	0	0	0
Un-amended Weir at 3.10	3.33	4.55	4.55	6.17
Concentration 1	7	11.4	8.8	14.1
Concentration 2	14	18.7	18	23.2
Concentration 3	28	31.6	35	39.4
Concentration 4	56	60.4	70	78.6
Concentration 5	112	115	141	144
Concentration 6	224	224	282	289
Concentration 7	448	461	563	573

Table 2. Summary of test conditions: 72-h *Pseudokirchneriella subcapitata* growth inhibition test.

Test species	*Pseudokirchneriella subcapitata*, strain UTCC# 37
Organism source	In-house axenic culture, obtained from Canadian Phycological Culture Center, and originally isolated from Nivelta River, Norway.
Organism age	3-to 7-day old culture in logarithmic growth phase
Test type	Static
Test duration	72 hours
Test vessel	Microplate
Test volume	220 µL
Test concentrations	Full strength sample diluted to 95.2% (v/v) with nutrients (site control), full strength sample diluted to 95.2% (v/v) with nutrients and amended with a range of seven As and Sb concentrations, plus laboratory control. Laboratory control/dilution water amended with a range of eight As and Sb concentrations, plus laboratory control.
Test replicates	4 per treatment; 8 for laboratory control and site control
Number of organisms	10,000 cells/mL
Laboratory control water	Deionized water supplemented with nutrients
Site control dilution water	Full strength sample (Weir at 3.10) diluted to 95.2% (v/v) with nutrients
Test solution renewal	None
Test temperature	24 ± 2°C
Feeding	None
Light intensity	3600 to 4400 lux
Photoperiod	24 hours light
Aeration	None
Test measurements	Test area temperature measured daily; temperature and pH measured at test initiation; pH of two control wells measured at test termination
Test protocol	Environment Canada (2007b), EPS 1/RM/25
Statistical software	CETIS Version 1.8.7
Test endpoint	Algal cell growth inhibition
Test acceptability criteria for controls	>16-fold increase in number of algal cells; CV ≤ 20%; no trend when analyzed using Mann-Kendall test
Reference toxicant	Zinc (added as $ZnCl_2$)

3.0 RESULTS

Results of the toxicity test with *P. subcapitata* are summarized in Table 3. An inhibitory effect on cell yield was observed in the laboratory water spiked with both As and Sb. Analyzing the test data for individual measured total metal, the IC25 and IC50 for arsenic were 10.9 and 122.6 µg/L As, respectively; and with respect to antimony, the IC25 value was 17.0 µg/L Sb and the IC50 value was 162.6 µg/L Sb. The arsenic NOEC for cell yield was 3.5 µg/L As and the LOEC was 7.1 µg/L As. The NOEC and LOEC values for antimony were 8.5 and 12.8 µg/L Sb, respectively.

Results of the toxicity test with *P. subcapitata* on the arsenic and antimony amended Weir at 3.19 sample are summarized in Table 4. Adverse effects on cell yield were also observed in the sample spiked with As and Sb. Note that these results were based on the combined effects of As and Sb. If analyzed for each measured total metal, the resulting IC25 and IC50 values for arsenic were 42.7 and 74.1 µg/L As, respectively; and the IC25 and IC50 values for antimony were 54.3 and 95.2 µg/L, respectively. The NOEC for arsenic was 11.4 µg/L As and the LOEC was 18.7 µg/L As. With respect to antimony, the NOEC was 14.1 µg/L Sb and the LOEC was 23.2 µg/L Sb.

Table 3. Results: 72-h *Pseudokirchneriella subcapitata* growth inhibition test (laboratory control water amended with As and Sb).

Test Treatment	Total Measured As (µg/L)	Total Measured Sb (µg/L)	Cell Yield ($x10^4$ cells/mL) (Mean ±SD)
Laboratory Control	0	0	27.6 ± 1.7
Concentration 1	3.5	8.47	27.2 ± 2.2
Concentration 2	7.09	12.8	21.2 ± 2.2
Concentration 3	13.9	20	20.2 ± 1.7
Concentration 4	28.4	37.3	20.0 ± 2.2
Concentration 5	56.2	76.6	21.0 ± 2.2
Concentration 6	110	146	14.8 ± 1.5
Concentration 7	220	291	8.8 ± 1.5
Concentration 8	441	593	2.8 ± 1.0
Test Endpoint (µg/L As or Sb)			
IC25 (95% CL)	10.9 (3.8 – 90.6)	17.0 (9.3 – 121.9)	--
IC50 (95% CL)	122.6 (92.8 – 143.6)	162.6 (121.2 – 193.4)	--
NOEC	3.5	8.5	--
LOEC	7.1	12.8	--

SD = Standard Deviation, IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

Table 4. Results: 72-h *Pseudokirchneriella subcapitata* growth inhibition test (Weir at 3.10 amended with As and Sb).

Test Treatment	Total Measured As (µg/L)	Total Measured Sb (µg/L)	Cell Yield ($x10^4$ cells/mL) (Mean ±SD)
Laboratory Control	0	0	27.6 ± 2.4
Un-amended Weir at 3.10	4.55	6.17	152.8 ± 10.2
Concentration 1	11.4	14.1	152.5 ± 9.1
Concentration 2	18.7	23.2	132.8 ± 4.8
Concentration 3	31.6	39.4	132.8 ± 8.2
Concentration 4	60.4	78.6	93.5 ± 6.5
Concentration 5	115	144	39.2 ± 4.2
Concentration 6	224	289	19.0 ± 2.2
Concentration 7	461	573	4.0 ± 0.8
Test Endpoint (µg/L As or Sb)			
IC25 (95% CL)	42.7 (33.3 – 48.0)	54.3 (42.6 – 60.7)	--
IC50 (95% CL)	74.1 (67.5 – 81.7)	95.2 (85.6 – 101.5)	--
NOEC	11.4	14.1	--
LOEC	18.7	23.2	--

SD = Standard Deviation, IC = Inhibition Concentration, NOEC = No Observed Effect Concentration, LOEC = Lowest Observed Effect Concentration, CL = Confidence Limits

4.0 QA/QC

The health history of the test organism used in the exposures was acceptable and met the requirements of the test protocol. The tests met all control acceptability criteria and water quality parameters remained within ranges specified in the protocols throughout the tests. Uncertainty associated with the tests is best described by the standard deviation around the mean and/or the confidence intervals around the point estimates.

Results of the reference toxicant test conducted during the testing program are summarized in Table 7. Results for this test fell within the acceptable range for organism performance of mean and two standard deviation range, based on historical results obtained by the laboratory with these tests. Thus, the sensitivity of the organism used in these tests were appropriate. The reference toxicant test was performed under the same conditions as those used for the samples.

Table 5. Reference toxicant test results.

Test Species	Endpoint	Historical Mean (2 SD Range)	CV (%)	Test Date
P. subcapitata	Growth (IC50): 28.6 µg/L Zn	32.8 (26.5 – 40.6)	11	October 25, 2017

SD = Standard Deviation, CV = Coefficient of Variation, IC = Inhibition Concentration

5.0 REFERENCES

Environment Canada. 2007. Biological test method: growth inhibition test using the freshwater alga. Environmental Protection Series, Report EPS 1/RM/25. Second Edition, March 2007. Environment Canada, Method Development and Application Section, Environmental Science and Technology Centre, Science and Technology Branch, Ottawa, ON. 53 pp.

Tidepool Scientific Software. 2013. CETIS comprehensive environmental toxicity information system, version 1.8.7.16 Tidepool Scientific Software, McKinleyville, CA. 222 pp.

APPENDIX A – *Pseudokirchneriella subcapitata* Toxicity Test Data

Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax/Pretium Exploration
Work Order No.: 171295

Start Date: Nov 2/17
Set up by: MG

Sample Information:

Sample ID: lab control spiked with Sb and As.
Sample Date: Nov 2/17
Date Received: Nov 2/17
Sample Volume: n/a

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8 - 34.9) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5 - 40.6) µg/L Zn CV (%): 11

Test Results:

µg/L Sb	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	17.0 (9.3 - 121.9)
IC50 ~~%(v/v)~~ mg (95% CL)	162.6 (121.2 - 193.4)
µg/L Sb NOEC	8.5
LOEC	12.8

Reviewed by: JCh

Date reviewed: Dec. 8/17

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax / Pretium Setup by: MG

Sample ID: Lab ~~Control~~ water MG Spiked with Sb and As. Test Date/Time: Nov 2/17 @ 1900h.

Work Order No.: 171295 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: 04 17/17 Age of Culture: 6d Culture Health: Good

Culture Count: 1 500 2 530 Average: 515 Culture Cell Density (c1): 515 x 10^4 cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 515 x 10^4 cells/ml = 4.27 mL

Time Zero Counts: 1 20 2 22 Average: 21

No. of Cells/mL: 21 x 10^4 Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9545 cells/mL.

Concentration ~~%(v/v)~~ mg ~~mg/L~~ Sb and As.	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control 7.3	~~6.9~~ MG	23.0	24.0	24.0	24.0	24.0	✓	✓	✓	✓
Concentration 1	7.3	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Concentration 2	7.3	23.0					✓	✓	✓	✓
Concentration 3	7.3	23.0					✓	✓	✓	✓
Concentration 4	7.3	23.0					✓	✓	✓	✓
Concentration 5	7.2	23.0					✓	✓	✓	✓
Concentration 6	7.2	23.0					✓	✓	✓	✓
Concentration 7	7.2	23.0					✓	✓	✓	✓
Concentration 8	7.1	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	A	A	MG	MG	A	A

Initial control pH: Well 1: 7.3 Well 2: 7.3

Final control pH: Well 1: 7.0 Well 2: 7.0

Light intensity (lux): 4030 Date measured: Nov 2/17

Thermometer: 4 Light meter: 1 pH meter/probe: 1/1

Sample Description: clear, colourless, odourless, no particulates.

Comments:

Reviewed: JGL Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax/Pretium
Start Date/Time: Nov 2/17 @ 1900h
Work Order #: 171295
Termination Date: Nov 5/17 @ 1900h
Sample ID: Lab water spiked with ~~%(v/v)~~ mg/L Sb and As.
Test set up by: MLT Sb and As.

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	31					MLT
	B	27					
	C	30					
	D	28					
	E	30					
	F	26					
	G	28					
	H	29					
Concentration 1	A	26					
	B	29					
	C	27					
	D	31					
Concentration 2	A	20					
	B	25					
	C	23					
	D	21					
Concentration 3	A	19					
	B	21					
	C	23					
	D	22					
Concentration 4	A	24					
	B	21					
	C	20					
	D	19					
Concentration 5	A	25					
	B	21					
	C	22					
	D	20					
Concentration 6	A	15					
	B	17					
	C	17					
	D	14					
Concentration 7	A	8					
	B	11					
	C	9					
	D	11					

Comments:

Reviewed by: JGL
Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax/Pretium Start Date/Time: Nov 2/17 @ 1900h
Work Order #: 171295 Termination Date: Nov 5/17 @ 1900h
Sample ID: Lab water spiked with sband As. Test set up by: MLJ

~~%(v/v)~~ mg/L sband As. Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
Concentration mg/L ~~7~~ 8	A	4					MLJ
	B	3					↓
	C	5					↓
	D	3					↓
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JGb Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1900h
WO#:	171295	Termination Date/Tim	5-Nov-17 @ 1900h
Sample ID:	Lab Control		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	31				31	30.0	mean	27.7
	B	27				27	26.0	SD	1.685018
	C	30				30	29.0	CV	6.089593
	D	28				28	27.0		
	E	30				30	29.0		
	F	26				26	25.0		
	G	28				28	27.0		
	H	29				29	28.0		
Concentration 1	A	26				26	25.0		
	B	29				29	28.0		
	C	27				27	26.0		
	D	31				31	30.0		
Concentration 2	A	20				20	19.0		
	B	25				25	24.0		
	C	23				23	22.0		
	D	21				21	20.0		
Concentration 3	A	19				19	18.0		
	B	21				21	20.0		
	C	23				23	22.0		
	D	22				22	21.0		
Concentration 4	A	24				24	23.0		
	B	21				21	20.0		
	C	20				20	19.0		
	D	19				19	18.0		
Concentration 5	A	25				25	24.0		
	B	21				21	20.0		
	C	22				22	21.0		
	D	20				20	19.0		
Concentration 6	A	15				15	14.0		
	B	17				17	16.0		
	C	17				17	16.0		
	D	14				14	13.0		
Concentration 7	A	8				8	7.0		
	B	11				11	10.0		
	C	9				9	8.0		
	D	11				11	10.0		

Reviewed by: JGh

Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1900h
WO#:	171295	Termination Date/Time	5-Nov-17 @ 1900h
Sample ID:	Lab Control		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	31				31	30.0	mean	27.7
	B	27				27	26.0	SD	1.685018
	C	30				30	29.0	CV	6.089593
	D	28				28	27.0		
	E	30				30	29.0		
	F	26				26	25.0		
	G	28				28	27.0		
	H	29				29	28.0		
Concentration 8	A	4				4	3.0		
	B	3				3	2.0		
	C	5				5	4.0		
	D	3				3	2.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JM

Date reviewed: Dec. 8/17

CETIS Summary Report

Report Date: 29 Nov-17 16:02 (p 1 of 1)
Test Code: 171295b Sb | 20-9906-2629

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	04-7911-7254	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
17-2527-4361	Cell Yield	IC5	9.087	N/A	9.814		Linear Interpolation (ICPIN)
		IC10	10	7.976	11.24		
		IC15	11	9.162	13.49		
		IC20	12.08	10.43	18.77		
		IC25	17.04	9.279	121.9		
		IC40	118.7	94.1	140.2		
		IC50	162.6	121.2	193.4		

Cell Yield Summary

(1) C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	25	30	0.5957	1.685	6.1%	0.0%
8.47		4	27.25	23.72	30.78	25	30	1.109	2.217	8.14%	1.36%
12.8		4	21.25	17.72	24.78	19	24	1.109	2.217	10.43%	23.08%
20		4	20.25	17.53	22.97	18	22	0.8539	1.708	8.43%	26.7%
37.3		4	20	16.56	23.44	18	23	1.08	2.16	10.8%	27.6%
76.6		4	21	17.56	24.44	19	24	1.08	2.16	10.29%	23.98%
146		4	14.75	12.36	17.14	13	16	0.75	1.5	10.17%	46.61%
291		4	8.75	6.363	11.14	7	10	0.75	1.5	17.14%	68.33%
593		4	2.75	1.227	4.273	2	4	0.4787	0.9574	34.82%	90.05%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
8.47		25	28	26	30				
12.8		19	24	22	20				
20		18	20	22	21				
37.3		23	20	19	18				
76.6		24	20	21	19				
146		14	16	16	13				
291		7	10	8	10				
593		3	2	4	2				

(1) sample analyzed for Sb ~~using Sb concentrations~~ in the mixture. MT

CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	17-2527-4361	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:52	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	04-7911-7254	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	1964978	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	9.087	N/A	9.814
IC10	10	7.976	11.24
IC15	11	9.162	13.49
IC20	12.08	10.43	18.77
IC25	17.04	9.279	121.9
IC40	118.7	94.1	140.2
IC50	162.6	121.2	193.4

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25	30	0.5957	1.685	6.1%	0.0%
8.47		4	27.25	25	30	1.109	2.217	8.14%	1.36%
12.8		4	21.25	19	24	1.109	2.217	10.43%	23.08%
20		4	20.25	18	22	0.8539	1.708	8.43%	26.7%
37.3		4	20	18	23	1.08	2.16	10.8%	27.6%
76.6		4	21	19	24	1.08	2.16	10.29%	23.98%
146		4	14.75	13	16	0.75	1.5	10.17%	46.61%
291		4	8.75	7	10	0.75	1.5	17.14%	68.33%
593		4	2.75	2	4	0.4787	0.9574	34.82%	90.05%

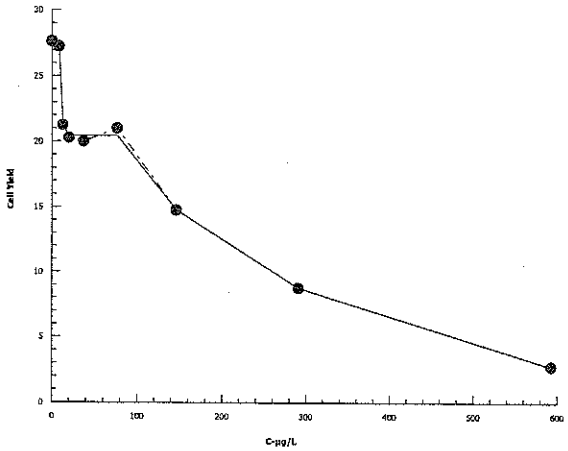
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
8.47		25	28	26	30				
12.8		19	24	22	20				
20		18	20	22	21				
37.3		23	20	19	18				
76.6		24	20	21	19				
146		14	16	16	13				
291		7	10	8	10				
593		3	2	4	2				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	17-2527-4361	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:52	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-0828-4955	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:51	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	04-7911-7254	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	10.3%	8.47	12.8	10.41	

Dunnett Multiple Comparison Test

Control vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	8.47	0.337	2.563	2.852	10	0.8622	CDF	Non-Significant Effect
	12.8*	5.729	2.563	2.852	10	<0.0001	CDF	Significant Effect
	20*	6.627	2.563	2.852	10	<0.0001	CDF	Significant Effect
	37.3*	6.852	2.563	2.852	10	<0.0001	CDF	Significant Effect
	76.6*	5.953	2.563	2.852	10	<0.0001	CDF	Significant Effect
	146*	11.57	2.563	2.852	10	<0.0001	CDF	Significant Effect
	291*	16.96	2.563	2.852	10	<0.0001	CDF	Significant Effect
	593*	22.35	2.563	2.852	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2462	307.75	8	93.19	<0.0001	Significant Effect
Error	102.375	3.302419	31			
Total	2564.375		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	2.792	20.09	0.9467	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.952	0.9236	0.0892	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	27.5	25	30	0.5957	6.1%	0.0%
8.47		4	27.25	23.72	30.78	27	25	30	1.109	8.14%	1.36%
12.8		4	21.25	17.72	24.78	21	19	24	1.109	10.43%	23.08%
20		4	20.25	17.53	22.97	20.5	18	22	0.8539	8.43%	26.7%
37.3		4	20	16.56	23.44	19.5	18	23	1.08	10.8%	27.6%
76.6		4	21	17.56	24.44	20.5	19	24	1.08	10.29%	23.98%
146		4	14.75	12.36	17.14	15	13	16	0.75	10.17%	46.61%
291		4	8.75	6.363	11.14	9	7	10	0.75	17.14%	68.33%
593		4	2.75	1.227	4.273	2.5	2	4	0.4787	34.82%	90.05%

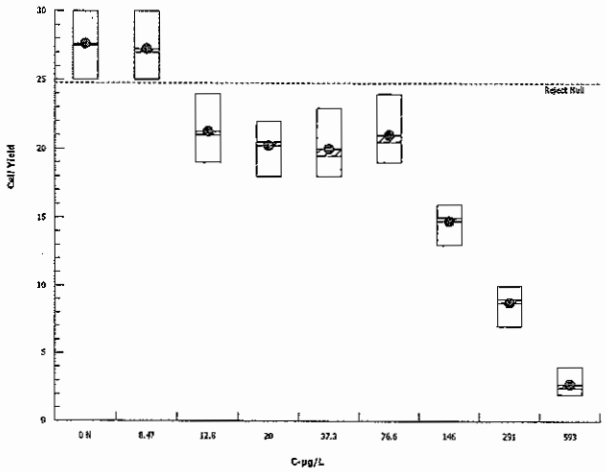
EC Alga Growth Inhibition Test — **Nautilus Environmental**

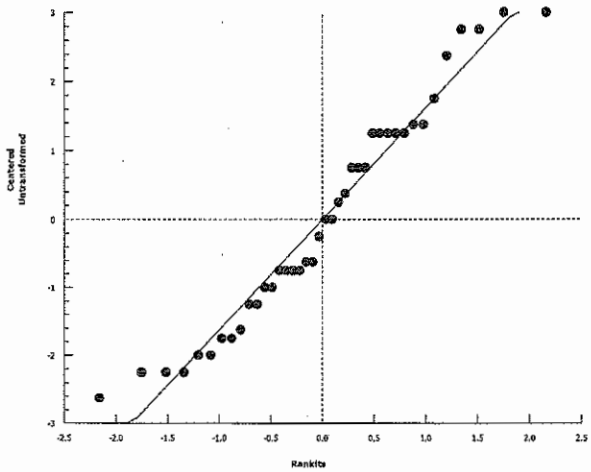
Analysis ID:	07-0828-4955	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:51	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
8.47		25	28	26	30				
12.8		19	24	22	20				
20		18	20	22	21				
37.3		23	20	19	18				
76.6		24	20	21	19				
146		14	16	16	13				
291		7	10	8	10				
593		3	2	4	2				

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax / Pretium Exploration
Start Date: Nov 2/17
Work Order No.: 171295
Set up by: MG.

Sample Information:

Sample ID: Lab control spiked with Sb and As.
Sample Date: Nov 2/17
Date Received: Nov 2/17
Sample Volume: n/a

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8 - 34.9) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5 - 40.6) ug/L Zn CV (%): 11

Test Results:

ug/L As	Algal Growth
IC25 ~~%(v/v)~~ mg/L (95% CL)	10.9 (3.8 - 90.6)
IC50 ~~%(v/v)~~ ug/L As mg/L (95% CL)	122.6 (92.8 - 143.6)
NOEC	3.5
LOEC	7.1

Reviewed by: JGu
Date reviewed: Dec. 13/17

CETIS Summary Report

Report Date: 11 Dec-17 11:37 (p 1 of 1)
Test Code: 171295b As | 13-2504-1330

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	09-7866-4338	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
03-2867-9649	Cell Yield	3.5	7.09	4.981	10.3%		Dunnett Multiple Comparison Test

Cell Yield Summary

①

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	25	30	0.5957	1.685	6.1%	0.0%
3.5		4	27.25	23.72	30.78	25	30	1.109	2.217	8.14%	1.36%
7.09		4	21.25	17.72	24.78	19	24	1.109	2.217	10.43%	23.08%
13.9		4	20.25	17.53	22.97	18	22	0.8539	1.708	8.43%	26.7%
28.4		4	20	16.56	23.44	18	23	1.08	2.16	10.8%	27.6%
56.2		4	21	17.56	24.44	19	24	1.08	2.16	10.29%	23.98%
110		4	14.75	12.36	17.14	13	16	0.75	1.5	10.17%	46.61%
220		4	8.75	6.363	11.14	7	10	0.75	1.5	17.14%	68.33%
441		4	2.75	1.227	4.273	2	4	0.4787	0.9574	34.82%	90.05%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
3.5		25	28	26	30				
7.09		19	24	22	20				
13.9		18	20	22	21				
28.4		23	20	19	18				
56.2		24	20	21	19				
110		14	16	16	13				
220		7	10	8	10				
441		3	2	4	2				

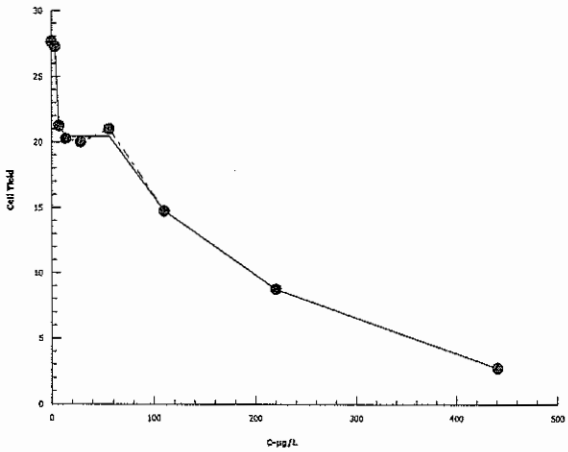
① analyzed ~~As~~ Mo for As in the mixture.

Analyst: MT QA: JGH Dec-13/17

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-9813-6067	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:35	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 11 Dec-17 11:37 (p 1 of 2)
Test Code: 171295b As | 13-2504-1330

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	07-9813-6067	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:35	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	09-7866-4338	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	934656	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	3.965	0.2366	4.634
IC10	4.683	3.31	6.029
IC15	5.505	4.195	7.667
IC20	6.445	5.003	13.21
IC25	10.94	3.83	90.58
IC40	88.66	70.73	105.5
IC50	122.6	92.77	143.6

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25	30	0.5957	1.685	6.1%	0.0%
3.5		4	27.25	25	30	1.109	2.217	8.14%	1.36%
7.09		4	21.25	19	24	1.109	2.217	10.43%	23.08%
13.9		4	20.25	18	22	0.8539	1.708	8.43%	26.7%
28.4		4	20	18	23	1.08	2.16	10.8%	27.6%
56.2		4	21	19	24	1.08	2.16	10.29%	23.98%
110		4	14.75	13	16	0.75	1.5	10.17%	46.61%
220		4	8.75	7	10	0.75	1.5	17.14%	68.33%
441		4	2.75	2	4	0.4787	0.9574	34.82%	90.05%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
3.5		25	28	26	30				
7.09		19	24	22	20				
13.9		18	20	22	21				
28.4		23	20	19	18				
56.2		24	20	21	19				
110		14	16	16	13				
220		7	10	8	10				
441		3	2	4	2				

Analyst: MT QA: JGu Dec. 13/17

CETIS Analytical Report

Report Date: 11 Dec-17 11:37 (p 1 of 2)
Test Code: 171295b As | 13-2504-1330

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	03-2867-9649	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:37	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	09-7866-4338	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:00	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Deionized Water + nutrients
Ending Date:	05 Nov-17 19:00	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	00-7482-3503	**Code:**	475B74F	**Client:**	Pretium Exploration
Sample Date:	02 Nov-17	**Material:**	Water Sample	**Project:**	
Receive Date:	02 Nov-17	**Source:**	Pretium Exploration		
Sample Age:	19h	**Station:**	Lab Control		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	10.3%	3.5	7.09	4.981	

Dunnett Multiple Comparison Test

Control vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control	3.5	0.337	2.563	2.852	10	0.8622	CDF	Non-Significant Effect
	7.09*	5.729	2.563	2.852	10	<0.0001	CDF	Significant Effect
	13.9*	6.627	2.563	2.852	10	<0.0001	CDF	Significant Effect
	28.4*	6.852	2.563	2.852	10	<0.0001	CDF	Significant Effect
	56.2*	5.953	2.563	2.852	10	<0.0001	CDF	Significant Effect
	110*	11.57	2.563	2.852	10	<0.0001	CDF	Significant Effect
	220*	16.96	2.563	2.852	10	<0.0001	CDF	Significant Effect
	441*	22.35	2.563	2.852	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.4054	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	2462	307.75	8	93.19	<0.0001	Significant Effect
Error	102.375	3.302419	31			
Total	2564.375		39			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	2.792	20.09	0.9467	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.952	0.9236	0.0892	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	26.22	29.03	27.5	25	30	0.5957	6.1%	0.0%
3.5		4	27.25	23.72	30.78	27	25	30	1.109	8.14%	1.36%
7.09		4	21.25	17.72	24.78	21	19	24	1.109	10.43%	23.08%
13.9		4	20.25	17.53	22.97	20.5	18	22	0.8539	8.43%	26.7%
28.4		4	20	16.56	23.44	19.5	18	23	1.08	10.8%	27.6%
56.2		4	21	17.56	24.44	20.5	19	24	1.08	10.29%	23.98%
110		4	14.75	12.36	17.14	15	13	16	0.75	10.17%	46.61%
220		4	8.75	6.363	11.14	9	7	10	0.75	17.14%	68.33%
441		4	2.75	1.227	4.273	2.5	2	4	0.4787	34.82%	90.05%

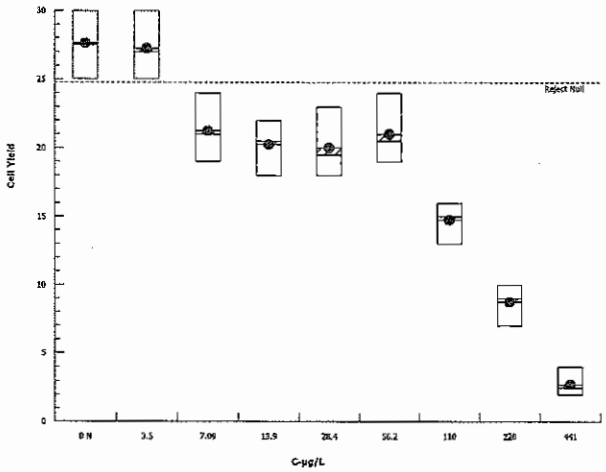
EC Alga Growth Inhibition Test — **Nautilus Environmental**

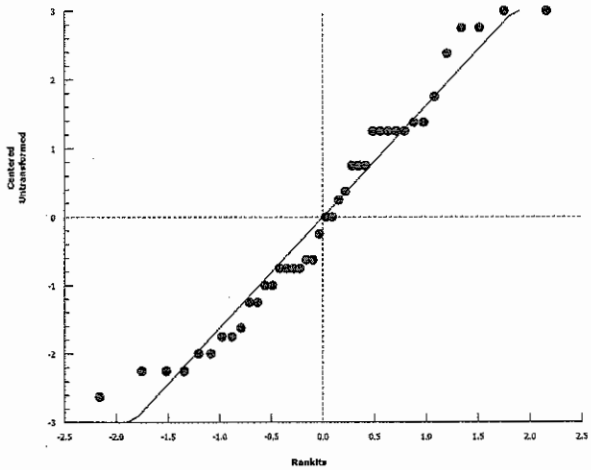
Analysis ID:	03-2867-9649	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	11 Dec-17 11:37	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	30	26	29	27	29	25	27	28
3.5		25	28	26	30				
7.09		19	24	22	20				
13.9		18	20	22	21				
28.4		23	20	19	18				
56.2		24	20	21	19				
110		14	16	16	13				
220		7	10	8	10				
441		3	2	4	2				

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: Lorax/Pretium Exploration
Start Date: Nov 2/17
Work Order No.: 171295
Set up by: MG

Sample Information:

Sample ID: Weir at 3.10 spiked with Sb and As.
Sample Date: Oct 30/17
Date Received: Nov 1/17
Sample Volume: 1x20L

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8-34.9) ug/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5-40.6) ug/L Zn CV (%): 11

Test Results:

ug/L Sb	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	54.3 (42.6-60.7)
IC50 ~~%(v/v)~~ mg (95% CL)	95.2 (85.6-101.5)
ug/L Sb NOEC	14.1
LOEC	23.2

Reviewed by: JGu
Date reviewed: Dec. 8/17

72-h Algal Growth Inhibition Toxicity Test
Water Quality Measurements

Client: Lorax / Pretium Setup by: MG

Sample ID: Weir at 3.10 spiked with Sb and As Test Date/Time: Nov 2/17 @ 1910h

Work Order No.: 171295 CER #: 4

Test Species: *Pseudokirchneriella subcapitata*

Culture Date: Oct 27/17 Age of Culture: 6d Culture Health: Good

Culture Count: 1 560 2 530 Average: 515 Culture Cell Density (c1): 515 x 10^4 cells/mL

v1 = 220,000 cells/ml x 100 ml / (c1) 515 x 10^4 cells/ml = 4.27 mL

Time Zero Counts: 1 20 2 22 Average: 21

No. of Cells/mL: 21 x 10^4 Initial Density: # cells/mL ÷ 220 µL x 10 µL = 9545 cells/mL

Concentration ~~%(v/v)~~ mg ~~mg/L~~ Sb and As.	Water Quality pH 0 h	Water Quality Temp (°C) 0 h	Incubator Temperature (°C) 0 h	24 h	48 h	72 h	Microplates rotated 2X per day? 0 h	24 h	48 h	72 h
Control	7.3	23.0	24.0	24.0	24.0	24.0	✓	✓	✓	✓
(site control) ~~GHLF mg~~ (Weir at 3.10)	7.8	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Concentration 1	7.9	23.0					✓	✓	✓	✓
Concentration 2	7.9	23.0					✓	✓	✓	✓
Concentration 3	8.0	23.0					✓	✓	✓	✓
Concentration 4	8.0	23.0					✓	✓	✓	✓
Concentration 5	7.9	23.0					✓	✓	✓	✓
Concentration 6	7.9	23.0					✓	✓	✓	✓
Concentration 7	7.9	23.0	↓	↓	↓	↓	✓	✓	✓	✓
Initials	MG	MG	MG	MG	[illegible]	[illegible]	MG	MG	[illegible]	[illegible]

Initial control pH: Well 1: 7.3 Well 2: 7.3

Final control pH: Well 1: 7.0 Well 2: 7.0

Light intensity (lux): 4160 Date measured: Nov 2/17

Thermometer: 4 Light meter: 1 pH meter/probe: 1/1

Sample Description: clear, colourless, odourless, no particulates

Comments:

Reviewed: [illegible] Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Loxax/Pretium
Start Date/Time: Nov 2/17 @ 1910h
Work Order #: 171295
Termination Date: Nov 5/17 @ 1910h
Sample ID: weir at ~~BJ~~ MLT 3,10 spiked with Sb and As
Test set up by: MLT

mg/L Sb and ~~As%(v/v)~~ mg

Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A	28					MLT
	B	30					
	C	27					
	D	33					
	E	26					
	F	27					
	G	31					
	H	27					
weir at ~~BJ~~ MLT 3,10 (site control)	A	~~144~~ ~~164~~ MLT 141					
	B	170					
	C	161					
	D	150					
(95.2%v/v)	~~E~~ A MLT	145					
	~~F~~ B	153					
	~~G~~ C	146					
	~~H~~ D	MLT ~~141~~					
Concentration 1	A	163					
	B	142					
	C	151					
	D	158					
Concentration 2	A	136					
	B	139					
	C	128					
	D	132					
Concentration 3	A	141					
	B	140					
	C	130					
	D	124					
Concentration 4	A	90					
	B	101					
	C	99					
	D	88					
Concentration 5	A	40					
	B	36					
	C	39					
	D	46					

Comments:

Reviewed by: JGu
Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Toxicity Test Data Sheet
72-h Algal Cell Counts

Client: Lorax/Pretium
Start Date/Time: Nov 2/17 @ 1910h
Work Order #: 171295
Termination Date: Nov 5/17 @ 1910h
Sample ID: ~~B7~~ 3.10 spiked with Sb and As
Test set up by: MG

ug/L ~~%(v/v)~~ weirat

Sb and As Concentration	Rep	Count 1	Count 2	Count 3	Count 4	Comments	Initials
Control	A						
	B						
	C						
	D						
	E						
	F						
	G						
	H						
Concentration 6	A	17					MG
	B	21					
	C	20					
	D	22					
Concentration 7	A	5					
	B	4					
	C	5					
	D	6					
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						
	A						
	B						
	C						
	D						

Comments:

Reviewed by: JGh
Date Reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1910h
WO#:	171295	Termination Date/Tim	5-Nov-17 @ 1910h
Sample ID:	Weir at 3.10		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	28				28	27.0	mean	27.7
	B	30				30	29.0	SD	2.445842
	C	27				27	26.0	CV	8.839182
	D	33				33	32.0		
	E	26				26	25.0		
	F	27				27	26.0		
	G	31				31	30.0		
	H	27				27	26.0		
Weir at 3.10 (Site Control)	A	141				141	140.0		
	B	170				170	169.0		
	C	161				161	160.0		
	D	150				150	149.0		
	E	145				145	144.0		
	F	153				153	152.0		
	G	146				146	145.0		
	H	164				164	163.0		
Concentration 1	A	163				163	162.0		
	B	142				142	141.0		
	C	151				151	150.0		
	D	158				158	157.0		
Concentration 2	A	136				136	135.0		
	B	139				139	138.0		
	C	128				128	127.0		
	D	132				132	131.0		
Concentration 3	A	141				141	140.0		
	B	140				140	139.0		
	C	130				130	129.0		
	D	124				124	123.0		
Concentration 4	A	90				90	89.0		
	B	101				101	100.0		
	C	99				99	98.0		
	D	88				88	87.0		
Concentration 5	A	40				40	39.0		
	B	36				36	35.0		
	C	39				39	38.0		
	D	46				46	45.0		

Reviewed by: JGh

Date reviewed: Dec. 8/17

Pseudokirchneriella subcapitata Algal Counts

Client:	Pretium Exploration	Start Date/Time:	2-Nov-17 @ 1910h
WO#:	171295	Termination Date/Tim	5-Nov-17 @ 1910h
Sample ID:	Weir at 3.10		
		Initial Cell Density:	9545 cell/mL

	210000
	0.22
	0.01
	9545.455

Concentration ug/L	Rep	Count 1 (x 10^4)	Count 2 (x 10^4)	Count 3 (x 10^4)	Count 4 (x 10^4)	Mean (x 10^4)	Cell Yield (x 10^4) cell/mL		
Control	A	28				28	27.0	mean	27.7
	B	30				30	29.0	SD	2.445842
	C	27				27	26.0	CV	8.839182
	D	33				33	32.0		
	E	26				26	25.0		
	F	27				27	26.0		
	G	31				31	30.0		
	H	27				27	26.0		
Concentration 6	A	17				17	16.0		
	B	21				21	20.0		
	C	20				20	19.0		
	D	22				22	21.0		
Concentration 7	A	5				5	4.0		
	B	4				4	3.0		
	C	5				5	4.0		
	D	6				6	5.0		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		
	A					#DIV/0!	#DIV/0!		
	B					#DIV/0!	#DIV/0!		
	C					#DIV/0!	#DIV/0!		
	D					#DIV/0!	#DIV/0!		

Reviewed by: JGu

Date reviewed: Dec. 8/17

CETIS Summary Report

Report Date: 17 Nov-17 16:41 (p 1 of 1)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
09-4967-9773	Cell Yield	14.1	23.2	18.09	7.28%		Dunnett Multiple Comparison Test

Cell Yield Summary

① C-µg/L Sb	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	25	32	0.8647	2.446	8.85%	0.0%
6.17	Dilution Water	8	152.8	144.2	161.3	140	169	3.624	10.25	6.71%	-452.9%
14.1		4	152.5	138	167	141	162	4.555	9.11	5.97%	-452.0%
23.2		4	132.8	125.1	140.4	127	138	2.394	4.787	3.61%	-380.5%
39.4		4	132.8	119.7	145.8	123	140	4.09	8.18	6.16%	-380.5%
78.6		4	93.5	83.23	103.8	87	100	3.227	6.455	6.9%	-238.5%
144		4	39.25	32.58	45.92	35	45	2.097	4.193	10.68%	-42.08%
289		4	19	15.56	22.44	16	21	1.08	2.16	11.37%	31.22%
573		4	4	2.701	5.299	3	5	0.4082	0.8165	20.41%	85.52%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
6.17	Dilution Water	140	169	160	149	144	152	145	163
14.1		162	141	150	157				
23.2		135	138	127	131				
39.4		140	139	129	123				
78.6		89	100	98	87				
144		39	35	38	45				
289		16	20	19	21				
573		4	3	4	5				

① analyzed for Sb in the mixture.

Analyst: MLT QA: JGM Dec. 8/17

CETIS Analytical Report

Report Date: 17 Nov-17 16:41 (p 1 of 2)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	13-9524-6339	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	266003	200	Yes	Two-Point Interpolation

Residual Analysis

Attribute	Method	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	17.01	9.582	19.06
IC10	20.62	15.27	45.73
IC15	41.49	9.493	46.5
IC20	47.48	34.8	53.1
IC25	54.32	42.56	60.69
IC40	80.24	68.05	87.12
IC50	95.19	85.56	101.5

Cell Yield Summary

			Calculated Variate						
C-µg/L	Control Type	Count	Mean	Min	Max	Std Err	Std Dev	CV%	%Effect
6.17	Dilution Water	8	152.8	140	169	3.624	10.25	6.71%	0.0%
14.1		4	152.5	141	162	4.555	9.11	5.97%	0.16%
23.2		4	132.8	127	138	2.394	4.787	3.61%	13.09%
39.4		4	132.8	123	140	4.09	8.18	6.16%	13.09%
78.6		4	93.5	87	100	3.227	6.455	6.9%	38.79%
144		4	39.25	35	45	2.097	4.193	10.68%	74.3%
289		4	19	16	21	1.08	2.16	11.37%	87.56%
573		4	4	3	5	0.4082	0.8165	20.41%	97.38%

Cell Yield Detail

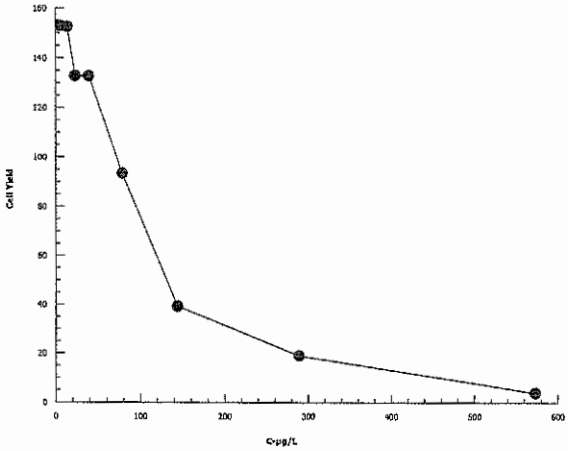
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
6.17	Dilution Water	140	169	160	149	144	152	145	163
14.1		162	141	150	157				
23.2		135	138	127	131				
39.4		140	139	129	123				
78.6		89	100	98	87				
144		39	35	38	45				
289		16	20	19	21				
573		4	3	4	5				

Analyst: MLT QA: JOH Dec-8/17

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	13-9524-6339	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 17 Nov-17 16:41 (p 1 of 2)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-4967-9773	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	7.28%	14.1	23.2	18.09	

Dunnett Multiple Comparison Test

Control	vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
6.17		14.1	0.05677	2.526	11.12	10	0.9157	CDF	Non-Significant Effect
6.17		23.2*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
6.17		39.4*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
6.17		78.6*	13.46	2.526	11.12	10	<0.0001	CDF	Significant Effect
6.17		144*	25.78	2.526	11.12	10	<0.0001	CDF	Significant Effect
6.17		289*	30.37	2.526	11.12	10	<0.0001	CDF	Significant Effect
6.17		573*	33.78	2.526	11.12	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	119713.9	17101.98	7	330.8	<0.0001	Significant Effect
Error	1447.75	51.70536	28			
Total	121161.6		35			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	17.41	18.48	0.0149	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.989	0.9166	0.9717	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
6.17	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	0.0%
14.1		4	152.5	138	167	153.5	141	162	4.555	5.97%	0.16%
23.2		4	132.8	125.1	140.4	133	127	138	2.394	3.61%	13.09%
39.4		4	132.8	119.7	145.8	134	123	140	4.09	6.16%	13.09%
78.6		4	93.5	83.23	103.8	93.5	87	100	3.227	6.9%	38.79%
144		4	39.25	32.58	45.92	38.5	35	45	2.097	10.68%	74.3%
289		4	19	15.56	22.44	19.5	16	21	1.08	11.37%	87.56%
573		4	4	2.701	5.299	4	3	5	0.4082	20.41%	97.38%

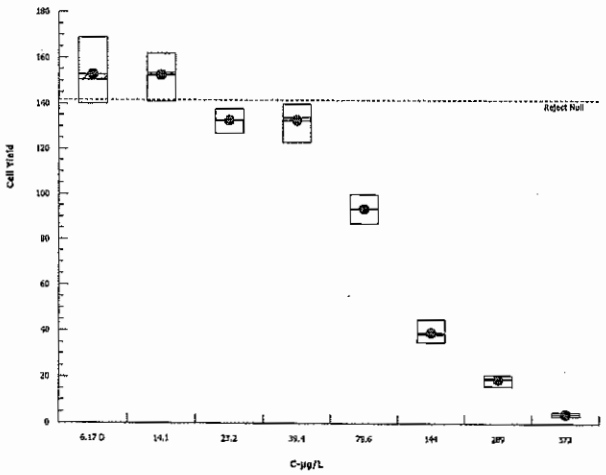
EC Alga Growth Inhibition Test — **Nautilus Environmental**

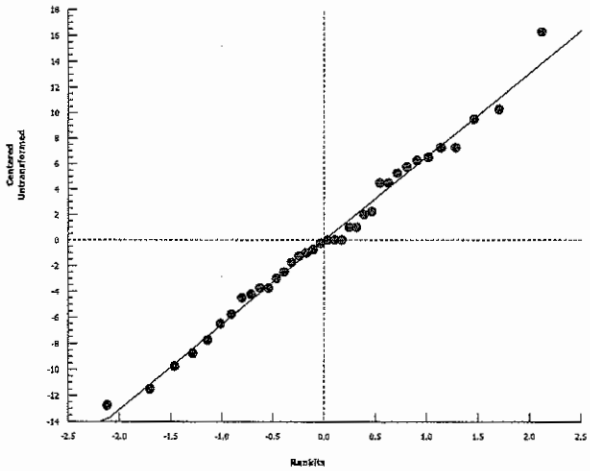
Analysis ID:	09-4967-9773	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
6.17	Dilution Water	140	169	160	149	144	152	145	163
14.1		162	141	150	157				
23.2		135	138	127	131				
39.4		140	139	129	123				
78.6		89	100	98	87				
144		39	35	38	45				
289		16	20	19	21				
573		4	3	4	5				

Graphics





CETIS Analytical Report

Report Date: 17 Nov-17 16:41 (p 1 of 2)
Test Code: 171295a Sb | 09-1636-5727

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-2910-9010	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	13-2680-9119	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	25.6%	Fails cell yield

Unequal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		6.17*	33.58	1.895	7.059	7	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.5634	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	62625.06	62625.06	1	1128	<0.0001	Significant Effect
Error	777.375	55.52679	14			
Total	63402.44		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	17.56	8.885	0.0012	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.9637	0.8408	0.7300	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	26.5	25	32	0.8647	8.85%	0.0%
6.17	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	-452.9%

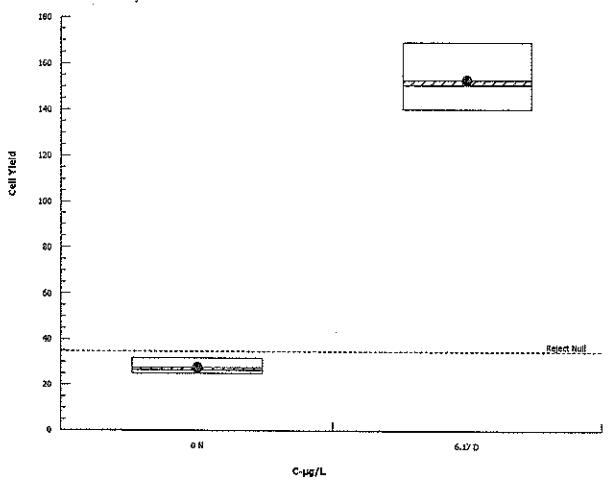
Cell Yield Detail

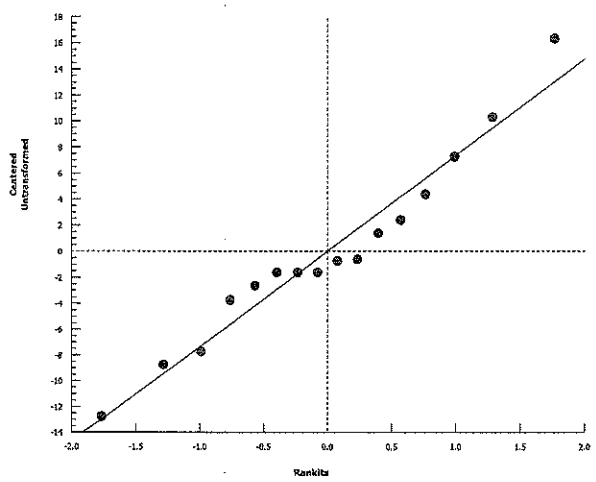
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
6.17	Dilution Water	140	169	160	149	144	152	145	163

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	15-2910-9010	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:40	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





Pseudokirchneriella subcapitata Summary Sheet

Client: LorGx / Pretium Exploration
Start Date: Nov 2/17
Work Order No.: 171295
Set up by: MG

Sample Information:

Sample ID: Weir at 3.10 spiked with Sb and As.
Sample Date: Oct 30/17
Date Received: Nov 1/17
Sample Volume: 1x20L

Test Organism Information:

Culture Date: Oct 27/17
Age of culture (Day 0): 6d

Zinc Reference Toxicant Results:

Reference Toxicant ID: SC162
Stock Solution ID: 17Zn03
Date Initiated: Oct 25/17

72-h IC50 (95% CL): 28.6 (22.8 - 34.9) µg/L Zn

72-h IC50 Reference Toxicant Mean and Range: 32.8 (26.5 - 40.6) µg/L Zn CV (%): 11

Test Results:

µg/L As	Algal Growth
IC25 ~~%(v/v)~~ mg (95% CL)	42.7 (33.3 - 48.0)
IC50 ~~%(v/v)~~ mg (95% CL)	74.1 (67.5 - 81.7)
µg/L As. NOEC	11.4
LOEC	18.7

Reviewed by: JOL
Date reviewed: Dec. 8/17

CETIS Summary Report

Report Date: 17 Nov-17 16:47 (p 1 of 1)
Test Code: 171295a As | 08-8019-8931

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Comparison Summary

Analysis ID	Endpoint	NOEL	LOEL	TOEL	PMSD	TU	Method
09-2717-2239	Cell Yield	<4.55	4.55	NA	25.6%		Unequal Variance t Two-Sample Test
12-5267-1525	Cell Yield	11.4	18.7	14.6	7.28%		Dunnett Multiple Comparison Test

Point Estimate Summary

Analysis ID	Endpoint	Level	µg/L	95% LCL	95% UCL	TU	Method
16-8163-3805	Cell Yield	IC5	13.74	8.588	15.82		Linear Interpolation (ICPIN)
		IC10	16.63	12.69	41.53		
		IC15	33.17	7.979	37.36		
		IC20	37.65	28.76	42.19		
		IC25	42.71	33.3	48.01		
		IC40	61.75	52.98	69.43		
		IC50	74.06	67.49	81.69		

Cell Yield Summary

① C-µg/L As	Control Type	Count	Mean	95% LCL	95% UCL	Min	Max	Std Err	Std Dev	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	25	32	0.8647	2.446	8.85%	0.0%
4.55	Dilution Water	8	152.8	144.2	161.3	140	169	3.624	10.25	6.71%	-452.9%
11.4		4	152.5	138	167	141	162	4.555	9.11	5.97%	-452.0%
18.7		4	132.8	125.1	140.4	127	138	2.394	4.787	3.61%	-380.5%
31.6		4	132.8	119.7	145.8	123	140	4.09	8.18	6.16%	-380.5%
60.4		4	93.5	83.23	103.8	87	100	3.227	6.455	6.9%	-238.5%
115		4	39.25	32.58	45.92	35	45	2.097	4.193	10.68%	-42.08%
224		4	19	15.56	22.44	16	21	1.08	2.16	11.37%	31.22%
461		4	4	2.701	5.299	3	5	0.4082	0.8165	20.41%	85.52%

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
4.55	Dilution Water	140	169	160	149	144	152	145	163
11.4		162	141	150	157				
18.7		135	138	127	131				
31.6		140	139	129	123				
60.4		89	100	98	87				
115		39	35	38	45				
224		16	20	19	21				
461		4	3	4	5				

① analyzed for As in the mixture

CETIS Analytical Report

Test Code: 171295a As | 08-8019-8931

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-8163-3805	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:47	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Linear Interpolation Options

X Transform	Y Transform	Seed	Resamples	Exp 95% CL	Method
Log(X+1)	Linear	696220	200	Yes	Two-Point Interpolation

Point Estimates

Level	µg/L	95% LCL	95% UCL
IC5	13.74	8.588	15.82
IC10	16.63	12.69	41.53
IC15	33.17	7.979	37.36
IC20	37.65	28.76	42.19
IC25	42.71	33.3	48.01
IC40	61.75	52.98	69.43
IC50	74.06	67.49	81.69

Cell Yield Summary

			Calculated Variate						
C-µg/L	**Control Type**	**Count**	**Mean**	**Min**	**Max**	**Std Err**	**Std Dev**	**CV%**	**%Effect**
4.55	Dilution Water	8	152.8	140	169	3.624	10.25	6.71%	0.0%
11.4		4	152.5	141	162	4.555	9.11	5.97%	0.16%
18.7		4	132.8	127	138	2.394	4.787	3.61%	13.09%
31.6		4	132.8	123	140	4.09	8.18	6.16%	13.09%
60.4		4	93.5	87	100	3.227	6.455	6.9%	38.79%
115		4	39.25	35	45	2.097	4.193	10.68%	74.3%
224		4	19	16	21	1.08	2.16	11.37%	87.56%
461		4	4	3	5	0.4082	0.8165	20.41%	97.38%

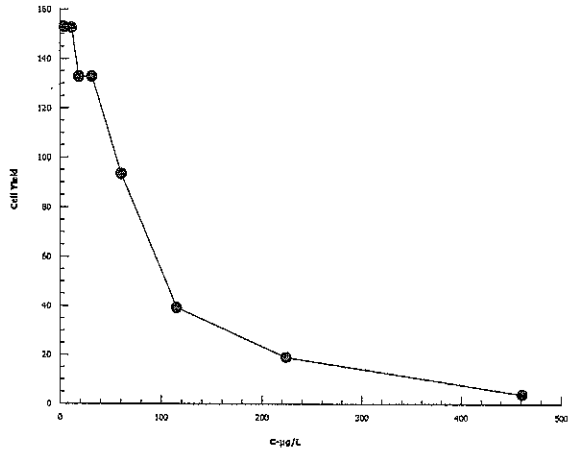
Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.55	Dilution Water	140	169	160	149	144	152	145	163
11.4		162	141	150	157				
18.7		135	138	127	131				
31.6		140	139	129	123				
60.4		89	100	98	87				
115		39	35	38	45				
224		16	20	19	21				
461		4	3	4	5				

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	16-8163-3805	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:47	**Analysis:**	Linear Interpolation (ICPIN)	**Official Results:**	Yes

Graphics



CETIS Analytical Report

Report Date: 17 Nov-17 16:47 (p 1 of 4)
Test Code: 171295a As | 08-8019-8931

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	12-5267-1525	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	NOEL	LOEL	TOEL	TU
Untransformed	NA	C > T	NA	NA	7.28%	11.4	18.7	14.6	

Dunnett Multiple Comparison Test

Control	vs	C-µg/L	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
4.55		11.4	0.05677	2.526	11.12	10	0.9157	CDF	Non-Significant Effect
4.55		18.7*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
4.55		31.6*	4.542	2.526	11.12	10	0.0003	CDF	Significant Effect
4.55		60.4*	13.46	2.526	11.12	10	<0.0001	CDF	Significant Effect
4.55		115*	25.78	2.526	11.12	10	<0.0001	CDF	Significant Effect
4.55		224*	30.37	2.526	11.12	10	<0.0001	CDF	Significant Effect
4.55		461*	33.78	2.526	11.12	10	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.9049	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	119713.9	17101.98	7	330.8	<0.0001	Significant Effect
Error	1447.75	51.70536	28			
Total	121161.6		35			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Bartlett Equality of Variance	17.41	18.48	0.0149	Equal Variances
Distribution	Shapiro-Wilk W Normality	0.989	0.9166	0.9717	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
4.55	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	0.0%
11.4		4	152.5	138	167	153.5	141	162	4.555	5.97%	0.16%
18.7		4	132.8	125.1	140.4	133	127	138	2.394	3.61%	13.09%
31.6		4	132.8	119.7	145.8	134	123	140	4.09	6.16%	13.09%
60.4		4	93.5	83.23	103.8	93.5	87	100	3.227	6.9%	38.79%
115		4	39.25	32.58	45.92	38.5	35	45	2.097	10.68%	74.3%
224		4	19	15.56	22.44	19.5	16	21	1.08	11.37%	87.56%
461		4	4	2.701	5.299	4	3	5	0.4082	20.41%	97.38%

Analyst: MLT QA: JCle Dec. 8/17

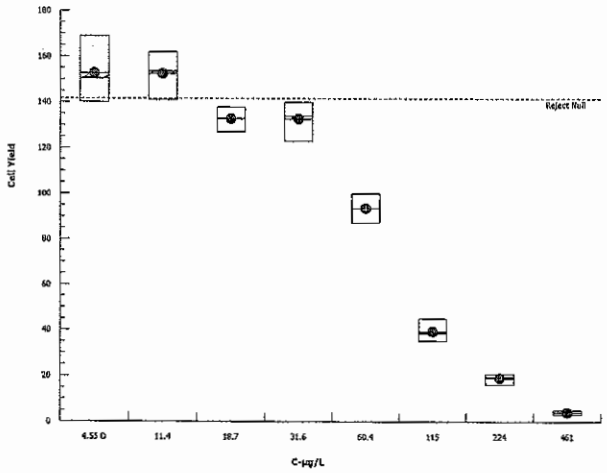
EC Alga Growth Inhibition Test — **Nautilus Environmental**

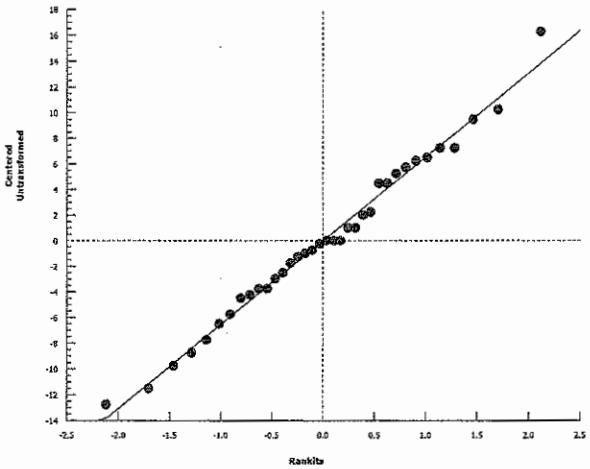
Analysis ID:	12-5267-1525	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Control vs Treatments	**Official Results:**	Yes

Cell Yield Detail

C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
4.55	Dilution Water	140	169	160	149	144	152	145	163
11.4		162	141	150	157				
18.7		135	138	127	131				
31.6		140	139	129	123				
60.4		89	100	98	87				
115		39	35	38	45				
224		16	20	19	21				
461		4	3	4	5				

Graphics





EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-2717-2239	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Batch ID:	04-0640-4382	**Test Type:**	Cell Growth	**Analyst:**	Mimi Tran
Start Date:	02 Nov-17 19:10	**Protocol:**	EC/EPS 1/RM/25	**Diluent:**	Site Control (Weir at 3.10)
Ending Date:	05 Nov-17 19:10	**Species:**	Pseudokirchneriella subcapitata	**Brine:**	
Duration:	72h	**Source:**	In-House Culture	**Age:**	6d

Sample ID:	18-1567-1718	**Code:**	6C38F3A6	**Client:**	Pretium Exploration
Sample Date:	30 Oct-17 15:09	**Material:**	Water Sample	**Project:**	
Receive Date:	01 Nov-17 14:50	**Source:**	Pretium Exploration		
Sample Age:	76h (8.8 °C)	**Station:**	Weir at 3.10		

Data Transform	Zeta	Alt Hyp	Trials	Seed	PMSD	Test Result
Untransformed	NA	C < T	NA	NA	25.6%	Fails cell yield

Unequal Variance t Two-Sample Test

Control	vs	Control	Test Stat	Critical	MSD	DF	P-Value	P-Type	Decision(α:5%)
Negative Control		4.55*	33.58	1.895	7.059	7	<0.0001	CDF	Significant Effect

Auxiliary Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:5%)
Control Trend	Mann-Kendall Trend			0.5634	Non-significant Trend in Controls

ANOVA Table

Source	Sum Squares	Mean Square	DF	F Stat	P-Value	Decision(α:5%)
Between	62625.06	62625.06	1	1128	<0.0001	Significant Effect
Error	777.375	55.52679	14			
Total	63402.44		15			

Distributional Tests

Attribute	Test	Test Stat	Critical	P-Value	Decision(α:1%)
Variances	Variance Ratio F	17.56	8.885	0.0012	Unequal Variances
Distribution	Shapiro-Wilk W Normality	0.9637	0.8408	0.7300	Normal Distribution

Cell Yield Summary

C-µg/L	Control Type	Count	Mean	95% LCL	95% UCL	Median	Min	Max	Std Err	CV%	%Effect
0	Negative Control	8	27.63	25.58	29.67	26.5	25	32	0.8647	8.85%	0.0%
4.55	Dilution Water	8	152.8	144.2	161.3	150.5	140	169	3.624	6.71%	-452.9%

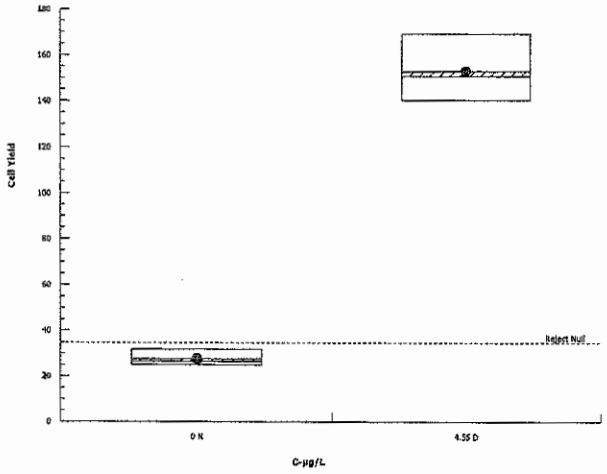
Cell Yield Detail

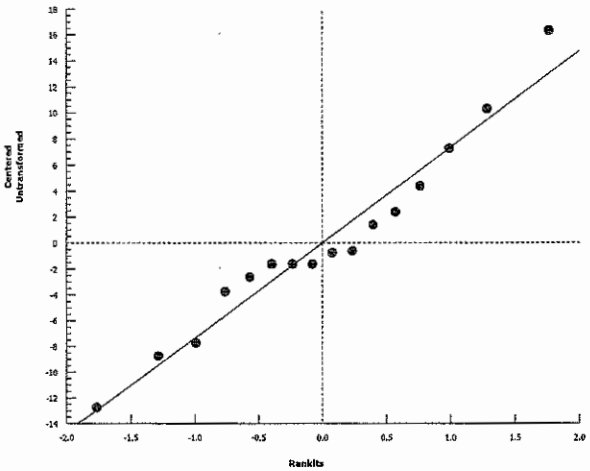
C-µg/L	Control Type	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Rep 7	Rep 8
0	Negative Control	27	29	26	32	25	26	30	26
4.55	Dilution Water	140	169	160	149	144	152	145	163

EC Alga Growth Inhibition Test — **Nautilus Environmental**

Analysis ID:	09-2717-2239	**Endpoint:**	Cell Yield	**CETIS Version:**	CETISv1.8.7
Analyzed:	17 Nov-17 16:46	**Analysis:**	Parametric-Two Sample	**Official Results:**	Yes

Graphics





APPENDIX B – Analytical Chemistry

LORAX ENVIRONMENTAL SERVICES
ATTN: Robert Goldblatt
2289 Burrard Street
Vancouver BC V6J 3H9

Date Received: 03-NOV-17
Report Date: 21-NOV-17 14:38 (MT)
Version: FINAL

Client Phone: 604-688-7173

Certificate of Analysis

Lab Work Order #: L2018129
Project P.O. #: NOT SUBMITTED
Job Reference:
C of C Numbers:
Legal Site Desc:

Shane Stack
Account Manager

[This report shall not be reproduced except in full without the written authority of the Laboratory.]

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-1	L2018129-2	L2018129-3	L2018129-4	L2018129-5
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONTROL	P. SUB LAB WATER CONCENTRATION 1	P. SUB LAB WATER CONCENTRATION 2	P. SUB LAB WATER CONCENTRATION 3	P. SUB LAB WATER CONCENTRATION 4
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	53.0				
	Hardness (as CaCO3) (mg/L)	8.91	8.85	9.20	9.28	8.99
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)	5.8				
	Ammonia, Total (as N) (mg/L)	<0.0050				
	Chloride (Cl) (mg/L)	3.54				
	Nitrate (as N) (mg/L)	2.66				
	Nitrite (as N) (mg/L)	<0.0010				
	Phosphorus (P)-Total (mg/L)	0.106				
	Sulfate (SO4) (mg/L)	3.44				
Total Metals	Aluminum (Al)-Total (mg/L)	0.0031	<0.0030	<0.0030	0.0030	<0.0030
	Antimony (Sb)-Total (mg/L)	<0.00010	0.00847	0.0128	0.0200	0.0373
	Arsenic (As)-Total (mg/L)	<0.00010	0.00350	0.00709	0.0139	0.0284
	Barium (Ba)-Total (mg/L)	0.00295	0.00273	0.00264	0.00268	0.00264
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.030	0.028	0.029	0.029	0.030
	Cadmium (Cd)-Total (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000058
	Calcium (Ca)-Total (mg/L)	0.852	0.800	0.814	0.795	0.803
	Chromium (Cr)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Total (mg/L)	0.00022	0.00022	0.00021	0.00022	0.00022
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000056
	Lithium (Li)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Magnesium (Mg)-Total (mg/L)	1.62	1.56	1.66	1.74	1.77
	Manganese (Mn)-Total (mg/L)	0.0685	0.0650	0.0674	0.0675	0.0701
	Molybdenum (Mo)-Total (mg/L)	0.00175	0.00185	0.00190	0.00185	0.00180
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Total (mg/L)	0.31	0.31	0.32	0.31	0.32
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	6.5	6.2	6.5	6.4	6.6
	Strontium (Sr)-Total (mg/L)	0.00066	0.00039	0.00034	0.00040	0.00036
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-6	L2018129-7	L2018129-8	L2018129-9	L2018129-10
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONCENTRATION 5	P. SUB LAB WATER CONCENTRATION 6	P. SUB LAB WATER CONCENTRATION 7	P. SUB LAB WATER CONCENTRATION 8	P. SUB BJ3.10 SITE WATER CONTROL
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)					236
	Hardness (as CaCO3) (mg/L)	8.81	8.98	9.18	8.85	69.1
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					51.8
	Ammonia, Total (as N) (mg/L)					0.251
	Chloride (Cl) (mg/L)					4.32
	Nitrate (as N) (mg/L)					6.38
	Nitrite (as N) (mg/L)					0.0111
	Phosphorus (P)-Total (mg/L)					0.118
	Sulfate (SO4) (mg/L)					34.9
Total Metals	Aluminum (Al)-Total (mg/L)	<0.0030	0.0075	<0.0030	<0.0030	0.0277
	Antimony (Sb)-Total (mg/L)	0.0766	0.146	0.291	0.593	0.00617
	Arsenic (As)-Total (mg/L)	0.0562	0.110	0.220	0.441	0.00455
	Barium (Ba)-Total (mg/L)	0.00279	0.00324	0.00339	0.00452	0.0552
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.030	0.032	0.031	0.028	0.068
	Cadmium (Cd)-Total (mg/L)	0.0000091	0.0000144	<0.0000050	<0.0000050	0.0000110
	Calcium (Ca)-Total (mg/L)	0.815	0.889	0.804	0.806	24.4
	Chromium (Cr)-Total (mg/L)	<0.00010	0.00012	<0.00010	<0.00010	0.00010
	Cobalt (Co)-Total (mg/L)	0.00023	0.00021	0.00022	0.00022	0.00025
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	<0.030	0.038	<0.030	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	0.000094	0.000194	<0.000050	<0.000050	0.000055
	Lithium (Li)-Total (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0151
	Magnesium (Mg)-Total (mg/L)	1.77	1.59	1.64	1.66	2.57
	Manganese (Mn)-Total (mg/L)	0.0683	0.0689	0.0688	0.0691	0.0883
	Molybdenum (Mo)-Total (mg/L)	0.00183	0.00183	0.00183	0.00177	0.00287
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	<2.0	<2.0	<2.0	<2.0	3.8
	Selenium (Se)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000454
	Silicon (Si)-Total (mg/L)	0.32	0.32	0.31	0.31	1.26
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	6.7	6.5	6.5	6.6	16.2
	Strontium (Sr)-Total (mg/L)	0.00035	0.00036	0.00035	0.00032	0.349
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-11	L2018129-12	L2018129-13	L2018129-14	L2018129-15
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 1	P. SUB BJ3.10 CONCENTRATION 2	P. SUB BJ3.10 CONCENTRATION 3	P. SUB BJ3.10 CONCENTRATION 4	P. SUB BJ3.10 CONCENTRATION 5
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)					
	Hardness (as CaCO3) (mg/L)	67.4	65.9	65.8	69.1	68.9
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					
	Ammonia, Total (as N) (mg/L)					
	Chloride (Cl) (mg/L)					
	Nitrate (as N) (mg/L)					
	Nitrite (as N) (mg/L)					
	Phosphorus (P)-Total (mg/L)					
	Sulfate (SO4) (mg/L)					
Total Metals	Aluminum (Al)-Total (mg/L)	0.0359	0.0308	0.0248	0.0284	0.0247
	Antimony (Sb)-Total (mg/L)	0.0141	0.0232	0.0394	0.0786	0.144
	Arsenic (As)-Total (mg/L)	0.0114	0.0187	0.0316	0.0604	0.115
	Barium (Ba)-Total (mg/L)	0.0567	0.0562	0.0546	0.0555	0.0567
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Total (mg/L)	0.067	0.066	0.068	0.068	0.067
	Cadmium (Cd)-Total (mg/L)	0.0000071	<0.0000050	0.0000097	0.0000097	0.0000107
	Calcium (Ca)-Total (mg/L)	23.6	22.8	23.0	23.6	23.3
	Chromium (Cr)-Total (mg/L)	0.00011	0.00010	<0.00010	<0.00010	0.00010
	Cobalt (Co)-Total (mg/L)	0.00026	0.00027	0.00025	0.00026	0.00025
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Total (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Total (mg/L)	0.000064	0.000064	0.000055	0.000057	0.000061
	Lithium (Li)-Total (mg/L)	0.0149	0.0147	0.0147	0.0161	0.0157
	Magnesium (Mg)-Total (mg/L)	2.66	2.69	2.58	2.73	2.51
	Manganese (Mn)-Total (mg/L)	0.0885	0.0910	0.0859	0.0870	0.0874
	Molybdenum (Mo)-Total (mg/L)	0.00292	0.00303	0.00294	0.00285	0.00290
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Total (mg/L)	3.9	3.8	3.7	3.8	3.8
	Selenium (Se)-Total (mg/L)	0.000438	0.000478	0.000401	0.000409	0.000424
	Silicon (Si)-Total (mg/L)	1.28	1.27	1.29	1.25	1.28
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Total (mg/L)	16.7	16.9	16.0	16.8	16.4
	Strontium (Sr)-Total (mg/L)	0.334	0.348	0.341	0.348	0.352
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-16	L2018129-17			
	Description					
	Sampled Date	02-NOV-17	02-NOV-17			
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 6	P. SUB BJ3.10 CONCENTRATION 7			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)					
	Hardness (as CaCO3) (mg/L)	68.8	69.9			
Anions and Nutrients	Alkalinity, Total (as CaCO3) (mg/L)					
	Ammonia, Total (as N) (mg/L)					
	Chloride (Cl) (mg/L)					
	Nitrate (as N) (mg/L)					
	Nitrite (as N) (mg/L)					
	Phosphorus (P)-Total (mg/L)					
	Sulfate (SO4) (mg/L)					
Total Metals	Aluminum (Al)-Total (mg/L)	0.0271	0.0310			
	Antimony (Sb)-Total (mg/L)	0.289	0.573			
	Arsenic (As)-Total (mg/L)	0.224	0.461			
	Barium (Ba)-Total (mg/L)	0.0559	0.0599			
	Beryllium (Be)-Total (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Total (mg/L)	<0.000050	<0.000050			
	Boron (B)-Total (mg/L)	0.068	0.067			
	Cadmium (Cd)-Total (mg/L)	0.0000121	0.0000086			
	Calcium (Ca)-Total (mg/L)	23.5	23.9			
	Chromium (Cr)-Total (mg/L)	0.00012	0.00011			
	Cobalt (Co)-Total (mg/L)	0.00026	0.00026			
	Copper (Cu)-Total (mg/L)	<0.00050	<0.00050			
	Iron (Fe)-Total (mg/L)	<0.030	<0.030			
	Lead (Pb)-Total (mg/L)	0.000063	0.000055			
	Lithium (Li)-Total (mg/L)	0.0150	0.0150			
	Magnesium (Mg)-Total (mg/L)	2.60	2.74			
	Manganese (Mn)-Total (mg/L)	0.0868	0.0895			
	Molybdenum (Mo)-Total (mg/L)	0.00292	0.00279			
	Nickel (Ni)-Total (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Total (mg/L)	<0.30	<0.30			
	Potassium (K)-Total (mg/L)	3.9	4.1			
	Selenium (Se)-Total (mg/L)	0.000457	0.000454			
	Silicon (Si)-Total (mg/L)	1.28	1.28			
	Silver (Ag)-Total (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Total (mg/L)	16.7	17.1			
	Strontium (Sr)-Total (mg/L)	0.348	0.341			
	Thallium (Tl)-Total (mg/L)	<0.00010	<0.00010			
	Tin (Sn)-Total (mg/L)	<0.00010	<0.00010			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-1	L2018129-2	L2018129-3	L2018129-4	L2018129-5
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONTROL	P. SUB LAB WATER CONCENTRATION 1	P. SUB LAB WATER CONCENTRATION 2	P. SUB LAB WATER CONCENTRATION 3	P. SUB LAB WATER CONCENTRATION 4
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Antimony (Sb)-Dissolved (mg/L)	<0.00010	0.00618	0.00966	0.0167	0.0334
	Arsenic (As)-Dissolved (mg/L)	<0.00010	0.00392	0.00756	0.0149	0.0302
	Barium (Ba)-Dissolved (mg/L)	0.00310	0.00251	0.00264	0.00289	0.00310
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.024	0.024	0.025	0.025	0.025
	Cadmium (Cd)-Dissolved (mg/L)	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
	Calcium (Ca)-Dissolved (mg/L)	0.764	0.759	0.776	0.787	0.768
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00022	0.00021	0.00021	0.00022	0.00022
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Magnesium (Mg)-Dissolved (mg/L)	1.70	1.69	1.76	1.78	1.72
	Manganese (Mn)-Dissolved (mg/L)	0.0721	0.0732	0.0728	0.0736	0.0742
	Molybdenum (Mo)-Dissolved (mg/L)	0.00156	0.00159	0.00159	0.00168	0.00169
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Silicon (Si)-Dissolved (mg/L)	0.270	0.267	0.267	0.265	0.278
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	7.4	7.9	7.7	7.8	7.4
	Strontium (Sr)-Dissolved (mg/L)	0.00032	0.00039	0.00034	0.00041	0.00038
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0010	0.0012	0.0013	0.0013	0.0012

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-6	L2018129-7	L2018129-8	L2018129-9	L2018129-10
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB LAB WATER CONCENTRATION 5	P. SUB LAB WATER CONCENTRATION 6	P. SUB LAB WATER CONCENTRATION 7	P. SUB LAB WATER CONCENTRATION 8	P. SUB BJ3.10 SITE WATER CONTROL
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000480
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	0.0038	0.0035	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	<0.0010	<0.0010	0.0012	0.0014	0.0291
	Antimony (Sb)-Dissolved (mg/L)	0.0637	0.125	0.239	0.483	0.00739
	Arsenic (As)-Dissolved (mg/L)	0.0572	0.116	0.224	0.445	0.00429
	Barium (Ba)-Dissolved (mg/L)	0.00284	0.00314	0.00342	0.00430	0.0570
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.027	0.028	0.027	0.027	0.062
	Cadmium (Cd)-Dissolved (mg/L)	0.0000116	0.0000188	<0.0000050	<0.0000050	0.0000127
	Calcium (Ca)-Dissolved (mg/L)	0.794	0.790	0.767	0.789	23.1
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00021	0.00022	0.00021	0.00021	0.00026
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	0.00022	0.00021	<0.00020
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	0.000083	0.000173	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	0.0162
	Magnesium (Mg)-Dissolved (mg/L)	1.66	1.70	1.76	1.67	2.79
	Manganese (Mn)-Dissolved (mg/L)	0.0718	0.0724	0.0723	0.0717	0.0958
	Molybdenum (Mo)-Dissolved (mg/L)	0.00169	0.00171	0.00168	0.00166	0.00230
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	<2.0	<2.0	<2.0	4.2
	Selenium (Se)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	0.000473
	Silicon (Si)-Dissolved (mg/L)	0.271	0.276	0.268	0.271	1.27
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	7.5	7.6	7.7	7.5	19.6
	Strontium (Sr)-Dissolved (mg/L)	0.00038	0.00035	0.00035	0.00036	0.379
	Thallium (Tl)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000044
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	0.000374
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0014	0.0013	0.0014	0.0028	0.0015

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-11	L2018129-12	L2018129-13	L2018129-14	L2018129-15
	Description					
	Sampled Date	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17	02-NOV-17
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 1	P. SUB BJ3.10 CONCENTRATION 2	P. SUB BJ3.10 CONCENTRATION 3	P. SUB BJ3.10 CONCENTRATION 4	P. SUB BJ3.10 CONCENTRATION 5
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Total (mg/L)	0.000495	0.000475	0.000499	0.000472	0.000490
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD	FIELD	FIELD	FIELD
	Aluminum (Al)-Dissolved (mg/L)	0.0263	0.0262	0.0229	0.0276	0.0247
	Antimony (Sb)-Dissolved (mg/L)	0.0133	0.0196	0.0342	0.0630	0.113
	Arsenic (As)-Dissolved (mg/L)	0.0111	0.0179	0.0320	0.0598	0.115
	Barium (Ba)-Dissolved (mg/L)	0.0581	0.0565	0.0566	0.0560	0.0563
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Boron (B)-Dissolved (mg/L)	0.059	0.058	0.059	0.059	0.061
	Cadmium (Cd)-Dissolved (mg/L)	0.0000107	0.0000127	0.0000103	0.0000113	0.0000098
	Calcium (Ca)-Dissolved (mg/L)	22.6	22.1	22.0	23.3	23.2
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Cobalt (Co)-Dissolved (mg/L)	0.00024	0.00024	0.00025	0.00024	0.00024
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Lithium (Li)-Dissolved (mg/L)	0.0172	0.0152	0.0157	0.0158	0.0165
	Magnesium (Mg)-Dissolved (mg/L)	2.65	2.57	2.64	2.65	2.63
	Manganese (Mn)-Dissolved (mg/L)	0.0919	0.0892	0.0915	0.0905	0.0909
	Molybdenum (Mo)-Dissolved (mg/L)	0.00222	0.00225	0.00226	0.00225	0.00221
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	4.1	3.9	4.0	4.0	4.2
	Selenium (Se)-Dissolved (mg/L)	0.000419	0.000427	0.000455	0.000416	0.000464
	Silicon (Si)-Dissolved (mg/L)	1.20	1.24	1.22	1.19	1.22
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Sodium (Na)-Dissolved (mg/L)	19.2	18.0	18.5	18.5	18.8
	Strontium (Sr)-Dissolved (mg/L)	0.363	0.361	0.367	0.366	0.355
	Thallium (Tl)-Dissolved (mg/L)	0.000043	0.000041	0.000042	0.000045	0.000043
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.000373	0.000380	0.000378	0.000369	0.000387
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Zinc (Zn)-Dissolved (mg/L)	0.0017	0.0014	0.0013	0.0023	0.0018

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L2018129-16	L2018129-17			
	Description					
	Sampled Date	02-NOV-17	02-NOV-17			
	Sampled Time					
	Client ID	P. SUB BJ3.10 CONCENTRATION 6	P. SUB BJ3.10 CONCENTRATION 7			
Grouping	**Analyte**					
WATER						
Total Metals	Titanium (Ti)-Total (mg/L)	<0.010	<0.010			
	Uranium (U)-Total (mg/L)	0.000486	0.000474			
	Vanadium (V)-Total (mg/L)	<0.00050	<0.00050			
	Zinc (Zn)-Total (mg/L)	<0.0030	<0.0030			
Dissolved Metals	Dissolved Metals Filtration Location	FIELD	FIELD			
	Aluminum (Al)-Dissolved (mg/L)	0.0261	0.0293			
	Antimony (Sb)-Dissolved (mg/L)	0.238	0.466			
	Arsenic (As)-Dissolved (mg/L)	0.226	0.448			
	Barium (Ba)-Dissolved (mg/L)	0.0571	0.0568			
	Beryllium (Be)-Dissolved (mg/L)	<0.00010	<0.00010			
	Bismuth (Bi)-Dissolved (mg/L)	<0.000050	<0.000050			
	Boron (B)-Dissolved (mg/L)	0.060	0.062			
	Cadmium (Cd)-Dissolved (mg/L)	0.0000122	0.0000119			
	Calcium (Ca)-Dissolved (mg/L)	23.3	23.6			
	Chromium (Cr)-Dissolved (mg/L)	<0.00010	<0.00010			
	Cobalt (Co)-Dissolved (mg/L)	0.00024	0.00025			
	Copper (Cu)-Dissolved (mg/L)	<0.00020	<0.00020			
	Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030			
	Lead (Pb)-Dissolved (mg/L)	0.000056	0.000051			
	Lithium (Li)-Dissolved (mg/L)	0.0161	0.0160			
	Magnesium (Mg)-Dissolved (mg/L)	2.56	2.65			
	Manganese (Mn)-Dissolved (mg/L)	0.0901	0.0899			
	Molybdenum (Mo)-Dissolved (mg/L)	0.00234	0.00238			
	Nickel (Ni)-Dissolved (mg/L)	<0.00050	<0.00050			
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30			
	Potassium (K)-Dissolved (mg/L)	4.1	4.3			
	Selenium (Se)-Dissolved (mg/L)	0.000439	0.000427			
	Silicon (Si)-Dissolved (mg/L)	1.19	1.18			
	Silver (Ag)-Dissolved (mg/L)	<0.000010	<0.000010			
	Sodium (Na)-Dissolved (mg/L)	18.1	18.2			
	Strontium (Sr)-Dissolved (mg/L)	0.375	0.367			
	Thallium (Tl)-Dissolved (mg/L)	0.000043	0.000045			
	Tin (Sn)-Dissolved (mg/L)	<0.00010	<0.00010			
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010			
	Uranium (U)-Dissolved (mg/L)	0.000385	0.000411			
	Vanadium (V)-Dissolved (mg/L)	<0.00050	<0.00050			
	Zinc (Zn)-Dissolved (mg/L)	0.0021	0.0015			

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Matrix Spike	Magnesium (Mg)-Dissolved	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Dissolved	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Dissolved	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Magnesium (Mg)-Total	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Manganese (Mn)-Total	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9
Matrix Spike	Sodium (Na)-Total	MS-B	L2018129-1, -10, -11, -12, -13, -14, -15, -16, -17, -2, -3, -4, -5, -6, -7, -8, -9

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-TITR-VA	Water	Alkalinity Species by Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

CL-IC-N-VA	Water	Chloride in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EC-SCREEN-VA	Water	Conductivity Screen (Internal Use Only)	APHA 2510

Qualitative analysis of conductivity where required during preparation of other tests - e.g. TDS, metals, etc.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness (also known as Total Hardness) is calculated from the sum of Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. Dissolved Calcium and Magnesium concentrations are preferentially used for the hardness calculation.

MET-D-CCMS-VA	Water	Dissolved Metals in Water by CRC ICPMS	APHA 3030B/6020A (mod)

Water samples are filtered (0.45 um), preserved with nitric acid, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

MET-T-CCMS-VA	Water	Total Metals in Water by CRC ICPMS	EPA 200.2/6020A (mod)

Water samples are digested with nitric and hydrochloric acids, and analyzed by CRC ICPMS.

Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.

NH3-F-VA	Water	Ammonia in Water by Fluorescence	J. ENVIRON. MONIT., 2005, 7, 37-42, RSC

This analysis is carried out, on sulfuric acid preserved samples, using procedures modified from J. Environ. Monit., 2005, 7, 37 - 42, The Royal Society of Chemistry, "Flow-injection analysis with fluorescence detection for the determination of trace levels of ammonium in seawater", Roslyn J. Waston et al.

NO2-L-IC-N-VA	Water	Nitrite in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

NO3-L-IC-N-VA	Water	Nitrate in Water by IC (Low Level)	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

P-T-PRES-COL-VA	Water	Total P in Water by Colour	APHA 4500-P Phosphorus

This analysis is carried out using procedures adapted from APHA Method 4500-P "Phosphorus". Total Phosphorus is determined colourimetrically after persulphate digestion of the sample.
Samples with very high dissolved solids (i.e. seawaters, brackish waters) may produce a negative bias by this method. Alternate methods are available for these types of samples.

Reference Information

Arsenic (5+), at elevated levels, is a positive interference on colourimetric phosphate analysis.

SO4-IC-N-VA	Water	Sulfate in Water by IC	EPA 300.1 (mod)

Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS Environmer

L2018129-COFC

of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC #

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Lorax Environmental	☑ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robert Goldblatt	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2289 Burrard Street	Email 1:	Robert.Goldblatt@lorax.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6J 3H9	Email 2:		○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-688-7173 Fax:	Email 3:		**Analysis Request**
Invoice To	Same as Report ? ☐ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☐ Yes ☐ No	Job #:		
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:		
Lab Work Order # (lab use only)		ALS Contact:	Sampler:	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Tot. low level metals ICP+MS (P)	Diss. low level metals ICP+MS (F/P)	Conductivity	Hardness	Total Alkalinity	Chloride	Ammonia	Nitrite	Nitrate	Total Phosphorus	Sulphate		Number of Containers
	P. sub lab water control	02-Nov-17			X	X	X	X	X	X	X	X	X	X	X		3
	P. sub lab water concentration 1	02-Nov-17			X	X											2
	P. sub lab water concentration 2	02-Nov-17			X	X											2
	P. sub lab water concentration 3	02-Nov-17			X	X											2
	P. sub lab water concentration 4	02-Nov-17			X	X											2
	P. sub lab water concentration 5	02-Nov-17			X	X											2
	P. sub lab water concentration 6	02-Nov-17			X	X											2
	P. sub lab water concentration 7	02-Nov-17			X	X											2
	P. sub lab water concentration 8	02-Nov-17			X	X											2

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Mimi Tran	02-Nov-17		TP	NOV 3	20:35	12.8 °C				

ALS Environmental

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

Report To		Report Format / Distribution	Service Requested (Rush for routine analysis subject to availability)
Company:	Lorax Environmental	☑ Standard ☐ Other	◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Robert Goldblatt	☑ PDF ☑ Excel ☐ Digital ☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	2289 Burrard Street	Email 1: Robert. Goldblatt@lorax.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V6J 3H9	Email 2:	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-688-7173 Fax:	Email 3:	**Analysis Request**
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**	Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☐ Yes ☐ No	Job #:	
Company:		PO / AFE:	
Contact:		LSD:	
Address:			
Phone:	Fax:	Quote #:	
[redacted] Lab Work Order # [redacted] (lab use only)	[redacted]	ALS Contact:	Sampler:

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Tot. low level metals ICP+MS (P)	Diss. low level metals ICP+MS (F/P)	Conductivity	Hardness	Total Alkalinity	Chloride	Ammonia	Nitrite	Nitrate	Total Phosphorus	Sulphate		Number of Containers
[redacted]	P. sub BJ3.10 site water control	02-Nov-17			X	X	X	X	X	X	X	X	X	X	X		3
[redacted]	P. sub BJ3.10 concentration 1	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 2	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 3	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 4	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 5	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 6	02-Nov-17			X	X											2
[redacted]	P. sub BJ3.10 concentration 7	02-Nov-17			X	X											2
[redacted]																	
[redacted]																	
[redacted]																	
[redacted]																	

L2018129-COFC

Special Instructions / Regulations with water or land use (CCME-Freshwa... ...ommercial/AB Tier 1 - Natural, etc) / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

[redacted] SHIPMENT RELEASE (client use) [redacted]			[redacted] SHIPMENT RECEPTION (lab use only) [redacted]				[redacted] SHIPMENT VERIFICATION (lab use only) [redacted]			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
Mini Tran	02-Nov-17		TP	Nov 3	20:35	12.8 °C				

APPENDIX C – Chain-of-Custody Forms

Nautilus Environmental

Chain of Custody (electronic)

[X] British Columbia: 8664 Commerce Court, Burnaby, BC, V5A 4N7

WO# 171295

Sample Collection By:	DB/BDT	
	Report to:	**Invoice to:**
Company	Pretivm Resources Inc.	Same
Address	Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.	
City/Prov/Postal Code	Vancouver, BC V7X 1L4 Box 49334	
Contact	Max Holtby	
Phone	(604) 558-1784	
Email	mholtby@pretivm.com svanzalingen@pretivm.com	invoices@pretivm.com

ANALYSES REQUIRED

	SAMPLE ID	DATE	TIME	MATRIX	CONTAINER TYPE	# OF CONTAINERS	COMMENTS	Ceriodaphnia 3-brood test (100% only) (Chronic -	Daphnia Magna 48 hrs (100% only) (Acute -EPS1/RM/14)		Ceriodaphnia 3-brood test (with dilutions) (Chronic - EPS1/RM/21)	Daphnia Magna 48 hrs (with dilutions) (Acute -EPS1/RM/14)		Rainbow Trout 96 hrs (100% only) (Acute-EPS1/RM/13)	Algal Growth Inhibition Test (100% Only) (ESP 1/RM/25)	724 P Subcontracted Spiked BJ 3.10 testing			Receipt Temperature (°C)
1	① Weir at 3.10	30-Oct-17	15:09	Water	20L	1	Grab									X			8.8
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			

PROJECT INFORMATION	SAMPLE RECEIPT		RELIQUINSHED BY (CLIENT)	RELIQUINSHED BY (COURIER)
Client:	**Total # Containers:**	1	**Signature:**	**Signature:**
P.O. No.: 20329B	**Good Condition?**	Y	**Print:** Darcie Blackall	**Print:**
Shipped Via:	**Matches Schedule?**	Y	**Company:** Pretivm	**Company:**
			Time/Date: October 30, 2017; 18:00	**Time/Date:**
				RECEIVED BY (LABORATORY)
			Signature:	**Signature:** NY
			Print:	**Print:** Nair Yamamoto
			Company:	**Company:** Nautilus Environmental
			Time/Date:	**Time/Date:** NOV 01/17 @ 14:50

SPECIAL INSTRUCTIONS/COMMENTS: Please cc report to environmental@pretivm.com, svanzalingen@pretivm.com, rmccall@pretivm.com, robert.goldblatt@lorax.ca. Attn: Mimi Tran & Krysta Pearcy. Please refer to the instructions provided by Robert Goldblatt.

Sample description: clear, colourless, odourless, no particulates

Additional costs may be required for sample disposal or storage. Net 30 unless otherwise contracted.

① client requested a ~~lab~~ MQ concurrent lab water test. Please see attached.

END OF REPORT

Appendix 5-6: Discharge Authorization Amendment Forms

Ministry of Environment and Climate Change Strategy

FINAL Application Form for an Authorization AMENDMENT

for authorization to discharge waste under the *Environmental Management Act*

Permit, Approval, or Operational Certificate

FORM REFERENCE CODE: EPD-EMA-05.2

INSTRUCTIONS:

The amendment application process comprises of multi-steps that requires submission of a preliminary application and fee, followed by meetings with Ministry staff, and submission of a final application. **This form may be used for submission of a Final Application to amend a Permit, Approval or Operational Certificate.**

Before completing this application form, please review the following:

- Waste Discharge Regulation under the *Environmental Management Act* at www.bclaws.ca; and,
- Ministry information and guidance documents that will assist in understanding the registration process and any other documents that may be required at http://www2.gov.bc.ca/gov/content?id=0876E90DA4744A449423D35EB4E09785.

It is preferred that this form is completed using a computer or typewriter. If completing this form by hand, please PRINT clearly.

Mandatory fields are marked with an asterisk (*). Please ensure all required fields are completed or the application form may not be accepted.

Once the Final Application has been submitted, the application will be screened for completeness before proceeding through the Screening Phase.

A Tracking Number has been assigned to your request. Both the Authorization number and the Tracking Number should be referenced on all further documents submitted to support the amendment application request.

Under *Environmental Management Act, a* person is prohibited from introducing waste into the environment without authorization. Submitting an application to discharge is NOT an authorization to discharge.

This application form can be submitted to the Ministry by email (preferred), mail or by courier.

Mail or Email	Courier
Environmental Protection Division Business Services PO Box 9377 Stn Prov Govt Victoria, BC V8W 9M6 **Email:** PermitAdministration.VictoriaEPD@gov.bc.ca	Ministry of Environment & Climate Change Strategy Environmental Protection Division Business Services 3rd Floor, 525 Superior Street Victoria, BC V8V 0C5

Section 1: Application Information

***Tracking Number**	418137	1
***Authorization Number**	107835	2
***Applicant Name**	Pretium Resources Inc.	3
***Facility Name**	Brucejack Mine	4
***Name of person completing this application**	Sylvia Van Zalingen	5
***The person submitting this application is**	☒ The Applicant as named on the Preliminary Application for Amendment Form, Section 2 ☐ The Agent, as named on the Preliminary Application for Amendment Form, Section 4	6

The Application Package must include the following components or the application may be returned. Please refer to the guidance documents or contact the Ministry for further information on these requirements.

	Included	Not required / applicable	Submitted with Preliminary Application
Application Instruction Document (AID)	☒	☐	
Information Requirements Table (IRT)	☒	☐	☒
Technical Assessment Report	☒	☐	☐
Consultation Report	☐	☒	☐
Discharge Factor Amendment Form (Form EPD-EMA-06)	☒	☐	☒
Clause Amendment Form (Form EPD-EMA-07)	☒	☐	☒
Site Plan Form (Form EPD-EMA-09)	☐	☒	☐
Location Map Form (Form EPD-EMA-08)	☐	☒	☐

Section 2: Declaration and Signature

Please carefully read the following before placing your signature.

By completing this Application for an authorization, the Applicant understands and agrees with the following terms and conditions:

1. In this section:

   "Applicant" means the applicant as identified in section 2 of this application form;

   "Authorization" means the permit, approval, operational certificate, or amended permit, approval, operational certificate, sought pursuant to this application;

   "Director" means any statutory decision maker under EMA;

   "EMA" means the *Environmental Management Act*, S.B.C. 2003, c. 53, as amended or replaced from time to time;

   "FOIPPA" means the Freedom of Information and Protection of Privacy Act, R.S.B.C. 1996, c. 165, as amended or replaced from time to time;

   "Province" means Her Majesty the Queen in Right of British Columbia;

   "Regulatory Document" means:

   a) this application form,
   b) any document that the Applicant submits or causes to be provided submitted to the Province or the Director in support of this application, and
   c) any document that the Applicant submitted or causes to be submitted to the Director or the Province pursuant to
      i. the Authorization;
      ii. any regulation made under EMA that regulates the facility described above or the discharge of waste from that facility; or
      iii. any order issued under EMA directed against the Applicant that is related to the facility described above or the discharge of waste from that facility.

2. In consideration of the Province receiving this application, subject to paragraph 3, the Applicant hereby irrevocably authorizes the Province to publish on the B.C. government website the entirety of any Regulatory Document.

3. Despite paragraph 2, if the Applicant clearly identifies on the face of a Regulatory Document that the Regulatory Document, or clearly identified portions of it, are confidential and provides in writing with the document a rationale for why the document or portion thereof could not be disclosed under FOIPPA, the Applicant does not consent to the Province publishing the document or any portion of it if, in the opinion of the Director, the document or portion could not be disclosed under FOIPPA, if it were subject to a request under section 5 of FOIPPA.

4. In consideration of the Province receiving this application, the Applicant agrees that it will indemnify and save harmless the Province and the Province's employees and agents from any claim for infringement of copyright or other intellectual property rights that the Province or any of the Province's employees or agents may sustain, incur, suffer or be put to at any time that arise from the publication of a Regulatory Document.

5. The Applicant certifies that the information provided in this registration form is true, complete and accurate, and acknowledges that the submission of insufficient information may result in this registration being returned causing delays in the registration review process.

*Name of Applicant or Agent (print)	*Signature of Applicant or Agent	*Date
Sylvia Van Zalingen	Sylvia VanZalingen	November 01, 2023

Ministry of Environment and Climate Change Strategy

Clause Amendment Form

for authorization to discharge waste under the *Environmental Management Act*

AMENDMENT to Permit, Approval, or Operational Certificate

FORM REFERENCE CODE: EPD-EMA-07.2

INSTRUCTIONS:

The amendment application process is comprised of multiple steps that requires submission of a preliminary application and fee, followed by meetings with Ministry staff, and submission of a final application. **This form may be used in conjunction with the submission of a Preliminary Application to amend a Permit, Approval or Operational Certificate.**

Before completing this application form, please review the following:

- Waste Discharge Regulation under the *Environmental Management Act* at www.bclaws.ca; and,
- Ministry information and guidance documents that will assist in understanding the registration process and any other documents that may be required at http://www2.gov.bc.ca/gov/content?id=0876E90DA4744A449423D35EB4E09785.

It is preferred that this form is completed using a computer or typewriter. If completing this form by hand, please PRINT clearly.

Mandatory fields are marked with an asterisk (*). Please ensure all required fields are completed or the application form may not be accepted.

Once the final application has been submitted, the application will be proceed through the Screening Phase to verify administrative and technical completeness.

A Tracking Number will be assigned to your request. Both the Authorization Number and Tracking Number should be referenced on all further documents submitted to support the amendment application request.

Under *Environmental Management Act, a* person is prohibited from introducing waste into the environment without authorization. Submitting an application to discharge is NOT an authorization to discharge.

This application form can be submitted to the Ministry by email (preferred), mail or by courier.

Mail or Email	Courier
Environmental Protection Division Business Services PO Box 9377 Stn Prov Govt Victoria, BC V8W 9M6 **Email:** PermitAdministration.VictoriaEPD@gov.bc.ca	Ministry of Environment & Climate Change Strategy Environmental Protection Division Business Services 3rd Floor, 525 Superior Street Victoria, BC V8V 0C5

Section 1: Application Information

***Authorization Number**	107835	1
***Tracking Number**	418137	2
***Applicant Name**	Pretium Resources Inc.	3
***Facility Name**	Brucejack Mine	4
***Name of person completing this form**	Sylvia Van Zalingen	5
***This person completing this form is:**	☒ The Applicant, as named on the Preliminary Application for Amendment Form, Section 2 ☐ The Agent, as named on the Preliminary Application for Amendment Form, Section 4	6
***Number of clause changes requested**	2	7

A copy of Section 2 must be completed for each clause amendment. I.e. If there are three clauses that changes are being requested to, there should be three versions of Section 2 completed and submitted.

Section 2: Clause change details

***Clause number**	1.5.3	1
***Existing clause language**	The discharge is authorized from Authorized Works, which are Brucejack Lake and three Filterboxx C75 treatment units, or an equivalent unit(s) approved by the director, and related appurtenances including a deep lake outfall.	2
***Proposed changes** Please highlight changes to the clause using bold and/or colour to ensure clarity.	The discharge is authorized from Authorized Works, which are Brucejack Lake and **four** Filterboxx C75 treatment units, or an equivalent unit(s) approved by the director, and related appurtenances including a deep lake outfall.	3
***Rationale**	To provide redundancy by maintaining one unit as entirely redundant - this clause change request is only to change the number of authorized Filterboxx C75 treatment units. No requested change to the authorized rate of discharge (Clause 1.5.1), the characteristics of the treated effluent (Clause 1.5.2), or the location (Clause 1.5.4).	4

Ministry of Environment and Climate Change Strategy

Clause Amendment Form

for authorization to discharge waste under the *Environmental Management Act*

AMENDMENT to Permit, Approval, or Operational Certificate

FORM REFERENCE CODE: EPD-EMA-07.2

INSTRUCTIONS:

The amendment application process is comprised of multiple steps that requires submission of a preliminary application and fee, followed by meetings with Ministry staff, and submission of a final application. **This form may be used in conjunction with the submission of a Preliminary Application to amend a Permit, Approval or Operational Certificate.**

Before completing this application form, please review the following:

- Waste Discharge Regulation under the *Environmental Management Act* at www.bclaws.ca; and,
- Ministry information and guidance documents that will assist in understanding the registration process and any other documents that may be required at http://www2.gov.bc.ca/gov/content?id=0876E90DA4744A449423D35EB4E09785.

It is preferred that this form is completed using a computer or typewriter. If completing this form by hand, please PRINT clearly.

Mandatory fields are marked with an asterisk (*). Please ensure all required fields are completed or the application form may not be accepted.

Once the final application has been submitted, the application will be proceed through the Screening Phase to verify administrative and technical completeness.

A Tracking Number will be assigned to your request. Both the Authorization Number and Tracking Number should be referenced on all further documents submitted to support the amendment application request.

Under *Environmental Management Act, a* person is prohibited from introducing waste into the environment without authorization. Submitting an application to discharge is NOT an authorization to discharge.

This application form can be submitted to the Ministry by email (preferred), mail or by courier.

Mail or Email	Courier
Environmental Protection Division Business Services PO Box 9377 Stn Prov Govt Victoria, BC V8W 9M6 **Email:** PermitAdministration.VictoriaEPD@gov.bc.ca	Ministry of Environment & Climate Change Strategy Environmental Protection Division Business Services 3rd Floor, 525 Superior Street Victoria, BC V8V 0C5

Section 1: Application Information

***Authorization Number**	107835	1
***Tracking Number**	418137	2
***Applicant Name**	Pretium Resources Inc.	3
***Facility Name**	Brucejack Mine	4
***Name of person completing this form**	Sylvia Van Zalingen	5
***This person completing this form is:**	☒ The Applicant, as named on the Preliminary Application for Amendment Form, Section 2 ☐ The Agent, as named on the Preliminary Application for Amendment Form, Section 4	6
***Number of clause changes requested**	2	7

A copy of Section 2 must be completed for each clause amendment. I.e. If there are three clauses that changes are being requested to, there should be three versions of Section 2 completed and submitted.

Section 2: Clause change details

***Clause number**	1.1.1	1
***Existing clause language**	The characteristics of the Brucejack Lake Outlet (BJ3.10) water quality must not exceed the following: Nitrate: 11.5 mg/L as N Total Arsenic: 10 µg/L	2
***Proposed changes** Please highlight changes to the clause using bold and/or colour to ensure clarity.	The characteristics of the Brucejack Lake Outlet (BJ3.10) water quality must not exceed the following: Nitrate: **20** mg/L as N Total Arsenic: **26** µg/L **Dissolved Copper: 0.9 µg/L** **Total Selenium: 6.2 µg/L**	3
***Rationale**	The results of water quality modeling for the 4950 tpd mine plan indicate the potential for nitrate and T-As concentrations at BJ 3.10 to exceed their current discharge limits, and for D-Cu and T-Se levels at BJ 3.10 to be greater than their long-term water quality guidelines for protection of aquatic life. Pretium is requesting an amendment to its effluent discharge permit to reflect the updated water quality model results as well as results of an effects assessment of the modelled concentrations of these four parameters, and the results of a Best Achievable Technology assessment.	4

Ministry of Environment and Climate Change Strategy

Discharge Factor Amendment Form

for an Authorization to discharge waste under the *Environmental Management Act*

AMENDMENT to Permit, Approval, or Operational Certificate

FORM REFERENCE CODE: EPD-EMA-06.2

INSTRUCTIONS:

The amendment application process is comprised of multiple steps that requires submission of a preliminary application and fee, followed by meetings with Ministry staff, and submission of a final application. **This form may be used in conjunction with the submission of a Preliminary Application to amend a Permit, Approval or Operational Certificate.**

Before completing this application form, please review the following:

- Waste Discharge Regulation under the *Environmental Management Act* at www.bclaws.ca; and,
- Ministry information and guidance documents that will assist in understanding the registration process and any other documents that may be required at http://www2.gov.bc.ca/gov/content?id=0876E90DA4744A449423D35EB4E09785.

It is preferred that this form is completed using a computer or typewriter. If completing this form by hand, please PRINT clearly.

Mandatory fields are marked with an asterisk (*). Please ensure all required fields are completed or the application form may not be accepted.

Once the final application has been submitted, the application will be proceed through the Screening Phase to verify administrative and technical completeness.

A Tracking Number will be assigned to your request. Both the Authorization Number and Tracking Number should be referenced on all further documents submitted to support the amendment application request.

Under *Environmental Management Act, a* person is prohibited from introducing waste into the environment without authorization. Submitting an application to discharge is NOT an authorization to discharge.

This application form can be submitted to the Ministry by email (preferred), mail or by courier.

Mail or Email	Courier
Environmental Protection Division Business Services PO Box 9377 Stn Prov Govt Victoria, BC V8W 9M6 **Email:** PermitAdministration.VictoriaEPD@gov.bc.ca	Ministry of Environment & Climate Change Strategy Environmental Protection Division Business Services 3rd Floor, 525 Superior Street Victoria, BC V8V 0C5

Section 1: Application Information

***Authorization Number**	107835	1
***Tracking Number**	418137	2
***Applicant Name**	Pretium Resources Inc.	3
***Facility Name**	Brucejack Mine	4
***Number of discharge points**	1	7

A copy of Section 2 must be completed for each discharge point. I.e. If there are three points of discharge, there should be three copies of Section 2 completed and submitted.

Section 2: Discharge Details

***Discharge Name** e.g. Planer Mill Cyclone #2	Brucejack Lake Outflow (BJ3.10)		1
***This discharge point is**	☒ Existing point of discharge ☐ New point of discharge		2
***Discharge Type**	☐ Air ☒ Effluent ☐ Refuse		3
***EMS ID** (existing) **OR Site ID** (new as referenced on Site Map[1]) e.g. Site A	E298312		4
Additional description (if needed)	Weir at Brucejack Lake (waste rock and tailings storage facility - WRTSF) Outlet - Final discharge point		5
Proposed treatment method and equipment to be used e.g. UV Disinfection, baghouse	N/A		6
Discharge location description e.g. end of pipe, landfill, stack #1, etc	Low-level weir at the WRTSF outlet, discharging to Brucejack Creek.		7
***Discharge location position** i.e. end of pipe coordinates *must be in decimal degree format to 4 decimal places*	Latitude (e.g., 49.8952) N 56.4696	Longitude (e.g., 116.8177) W 130.1878	8
***Source of Data**	☐ GPS ☐ Survey ☐ Google Earth ☒ Other (specify): BC EMS Surface Water Quality Monitoring Sites website		9
If the Legal Land Description for the facility location is different than this discharge location			
Legal Land Description (Lot/Block/Plan) OR PID/PIN/Crown File No.			10

[1] For each point of discharge, there must be a corresponding point displayed on a map using the Site Form (Form EPD-EMA-09).

*Table A: Proposed Flows

INSTRUCTIONS: Complete the maximum rate of discharge, and if applicable, the minimum, and/or average rate. Typically, only a maximum is needed. Include the duration of the discharge (e.g., hours/day) and the frequency of the discharge (e.g., days/week, days/month or days/year). Typically, a discharge may start when the authorization is issued and continues until the authorization is cancelled. If this discharge is to be time limited, this should be discussed at your pre-application meeting. All units are to be in System International (SI) metric units.

	Minimum Discharge Rate	Average Discharge Rate	Maximum Discharge Rate	Units (e.g. m^3/day)	Duration	Duration Units (e.g. hrs/day)	Frequency	Frequency units (days/weeks)
Existing Authorized Limit		50,000		m3/day	24	hrs/day	7	days/week
Change requested		None		None	None	None	None	None

*Table B: Proposed Contaminant Concentrations

INSTRUCTIONS: The contaminant data should be the characteristics of the waste when it enters the environment. Guidance on acceptable discharge quality may be found in applicable Provincial and Federal Regulations, Objectives, Guidelines, Criteria, Policies, Codes of Practice, Best Achievable Control Technology (BACT), Best Management Practices and, in some cases, draft documents.

Enter the contaminant and its maximum concentration and if applicable, the minimum, and/or average concentrations. All units are to be SI metric units. If the contaminant is to be discharged for a period less than the life of the authorization, enter the start and/or end dates. All air discharge rates are to be corrected to 20ºC, 1 atmosphere pressure, and zero water vapour.

Parameter or Contaminant Name	EXISTING Authorized Limit and Units	AMENDMENT REQUESTED Limit and Units
Total Arsenic	10 µg/L	26 µg/L
Nitrate	11.5 mg/L as N	20 mg/L as N
Dissolved Copper	-	0.9 µg/L
Total Selenium	-	6.2 µg/L

Chapter 9 Appendices

Appendix 9-1. BC EAC #M15-01 Component Management Plans

Appendix 9-1-1. Aboriginal Consultation Plan

BRUCEJACK MINE

Aboriginal Consultation Plan

Date: January 2022

Pretium Resources Inc.
Suite 2300, Four Bentall Centre
1055 Dunsmuir Street
PO Box 49334
Vancouver, BC V7X 1L4
T: (604) 558-1784
F: (604) 558-4784

VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
1	June 2015	Pretium Exploration Inc.	Original
2	July 2015	Pretium Exploration Inc.	Updates to Sections 1, 4, 6, and 7
3	October 2015	Pretium Exploration Inc.	Updates to Sections 1, 3, 4, 5, 6, and 7
4	July 2016	Pretium Exploration Inc.	Updates to Sections 1, 4, 5, and 6
5	August 2016	Pretium Exploration Inc.	Updates to Sections 4, and 5
6	September 2016	Pretium Exploration Inc.	Updates to Sections 1, 4, 5, and 6
6a	December 2018	Pretium Resources Inc.	Updates to version control table
6b	March 2021	Pretium Resources Inc.	Updates to named Pretivm employees, reference to Spill Response Plan
7	January 2022	Pretium Resources Inc.	Update to section 7, Key Contacts

ACKNOWLEDGEMENTS

The original version of the Aboriginal Consultation Plan was prepared in 2015 by ERM Consultants Canada Ltd. for Pretium Resources Inc. The current version of the plan has been reviewed and edited by Pretivm Environmental Staff.

BRUCEJACK MINE
Aboriginal Consultation Plan

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Appendix A Component Plans and Relevant Regulatory Authority

ACRONYMS AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

ACP	Aboriginal Consultation Plan
BC	British Columbia
BC EAO	British Columbia Environmental Assessment Office
BC FLNRO	British Columbia Forests, Lands, and Natural Resources Office
BC MEM	British Columbia Ministry of Energy and Mines
BC MEMLCI	British Columbia Ministry of Energy Mines, and Lowe Carbon Innovation
BC MOE	British Columbia Ministry of Environment
BC MECCI	British Columbia Ministry of Environment and Climate Change Strategy
CEA Agency	Canadian Environmental Assessment Agency
EAC	Environmental Assessment Certificate
EOC	Emergency Operations Centre
Holder	Environmental Assessment Certificate Holder
MERP	Mine Emergency Response Plan
NFA	Nisga’a Final Agreement
NLG	Nisga’a Lisims Government
TCG	Tahltan Central Government
TSKLH	Tsetsaut/Skii km Lax Ha

1 INTRODUCTION

Pretium Resources Inc. (Pretivm or the Holder) intends to manage and operate the Brucejack Gold Mine (the Mine). This document sets out Pretivm's plan for consultation with Aboriginal groups during the Operation and Closure phases of the Project.

This Aboriginal Consultation Plan (ACP) has been developed in accordance with the Environmental Assessment Certificate (EAC) #M15-01 (BC EAO 2015) which was granted by the BC Environmental Assessment Office (BC EAO) on March 26, 2015.

Condition No. 5 of the EAC's Schedule B Table of Conditions (BC EAO 2015) requires the development of an ACP which indicates how Pretivm will share information and consult with Aboriginal groups including the Tsetsaut/Skii km Lax Ha (TSKLH), Nisga'a Lisims Government (NLG), and the Tahltan Central Government (TCG)[1]. The EAC Condition No. 5 (BC EAO 2015) states:

> *The Holder must prepare an ACP to identify how the Holder will share information and consult with Aboriginal Groups related to mitigation measures, monitoring, adaptive management and compensation programs.*
>
> *The Holder must consult with NLG, Tahltan and TSKLH on the content and implementation of the ACP.*
>
> *The Holder must submit the updated ACP to EAO no later than 30 days prior to the commencement of Construction.*
>
> *The Holder must implement the ACP prior to commencement of Construction. The ACP applies to Construction, Operation, and Closure Project Phases.*

Consultation outlined in this ACP is complementary to consultation activities outlined in Condition No. 2 of the EAC, which states that "*The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5*" (Appendix A).[2]

As required by the EAC Condition No. 5, Pretivm provided an initial draft of the ACP to the NLG, TCG, and TSKLH on June 8, 2015 and requested input on its content and implementation by June 26, 2015. A response was provided by the TSKLH on June 19, 2015.

TSKLH's comments related to:

---

[1] Tahltan Central Government was formerly referred to as Tahltan Central Council.

[2] Consultation associated with the Component Plans was conducted primarily through a Mine Review Committee. The NLG, TCG, and TSKLH were members of the Mine Review Committee and participated in the review of all Component Plans with Relevant Regulatory Authorities. Through the Committee, Aboriginal group members had the opportunity to review application information and propose accommodation and mitigation, including but not limited to receiving and sharing information, and, where appropriate, contribute to the development of proposed mitigation measures for potential adverse environmental effects. Any additional consultation activities undertaken in the development of the Component Plans will be reported separately and as needed in accordance to the specifications outlined by each Component Plan. Separate and direct engagement is being conducted for Component Plans for which the BC EAO is the Relevant Regulatory Authority.

- level of consultation;
- role in consultation;
- consultation and reporting timelines;
- wording (e.g., “where required, or appropriate”; “in consultation with”; “consideration of input”);
- Aboriginal consultation principles and objectives; and
- information distribution and consultation.

In accordance with the proposed approach for modifications to the ACP, a draft Pre-Operations Phase ACP was provided to NLG, TCG, and TSKLH on August 5, 2016, with a request for comments by September 9, 2016. No comments were received by September 14, 2016. This updated version of the Pre-Operations ACP was provided to NLG, TCG, and TSKLH on March 26, 2021.

This document is organized as follows:

- Chapter 2 provides a brief overview of the Mine.
- Chapter 3 introduces the principles and objectives for consultation with Aboriginal groups.
- Chapter 4 outlines the consultation approaches and main activities that will be implemented during the Operation, and Closure phases of the Mine.
- Chapter 5 describes the process of revision of the ACP, during the life of the Mine.
- Chapter 6 outlines the consultation reporting framework of the ACP.
- Chapter 7 provides the designated representatives from Pretivm, NLG, TCG, and TSKLH with respect to this Plan.

2 BRUCEJACK MINE OVERVIEW

Pretivm is developing an underground gold and silver mine. Over an estimated 18-year mine life, the mine will produce approximately 19 Mt of ore at a rate of approximately 3,800 tonnes per day. The Brucejack property is located at 56°28′20″ N latitude by 130°11′31″ W longitude, approximately 950 km northwest of Vancouver, and 65 km north-northwest of Stewart (Figure 2-1). The Mine is located within the Kitimat-Stikine Regional District. Portions of the Mine lie within the asserted traditional territories of the Tsetsaut /Skii km Lax Ha and Tahltan First Nation, and the Nass Area of Nisga'a Nation as defined in the Nisga'a Final Agreement (NFA; Government of Canada, Government of BC, and Nisga'a Nation 2000; Figures 2-2 to 2-4).[3]

The mine site area is located near Brucejack Lake. The Mine is accessed by a 73.5 km road connecting with Highway 37 about 30 km south of Bell II. The road will be used year-round to mobilize personnel, equipment and supplies to the mine site and to truck concentrate to rail facilities along the Highway 16 corridor. A transmission line will connect the mine site to the provincial power grid near Stewart.

Construction of the Mine will occur over a two-year period, from 2015 into 2017. Operations are planned to commence in 2017 for an expected duration of 18 years of mine life. Closure is expected to occur over a minimum of five years and will include decommissioning, abandonment, reclamation activities, and monitoring.

The Mine is expected to provide positive economic benefits to local communities as a result of direct training and employment opportunities generated by the Mine; the Mine will support an estimated 500 person-years of employment during Construction and at least 4,800 person-years of employment during Operations. Indirect employment opportunities (e.g., goods and services contract providers to the mining industry) will also increase, creating positive spin-off effects in the local, regional, and provincial economies. The Mine will also generate annual revenues (e.g., property tax, licensing fees, royalties, and income tax) for local, provincial, and federal governments.

[3] Tsetsaut / Skii km Lax Ha asserted traditional territory extends from the north side of the Cranberry River to Ningunsaw Pass, along the Nass and Bell-Irving rivers, and overlaps with the location of proposed Project infrastructure (Figure 2-2).
The asserted traditional territory of the Tahltan Nation lies to the north of the Project (Figure 2-3). The territory includes the areas surrounding the Stikine River drainage basin in the Coast and Cassiar mountains. The southern boundary of the territory follows the Unuk River drainage from the BC/Alaska border and a portion of Treaty Creek and the Nass River.
Nisga'a Nation is a treaty nation with a constitutionally recognized government and specific rights and interests set out in the NFA, which came into effect in May 2000. Proposed Project infrastructure is located within the Nass Area as defined in the Nisga'a Final Agreement (NFA; Figure 2-4).

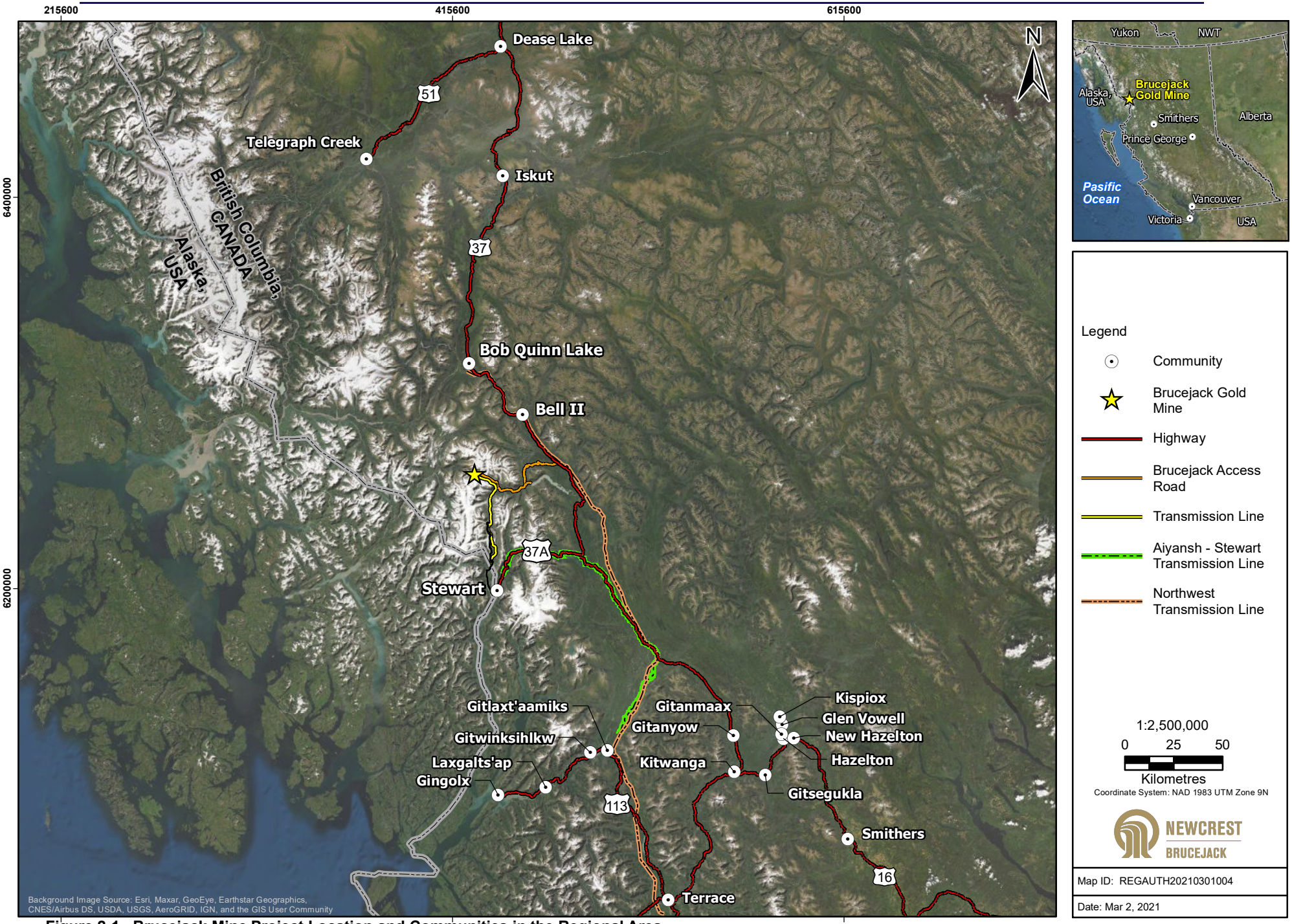

Figure 2-1. Brucejack Mine Project Location and Communities in the Regional Area

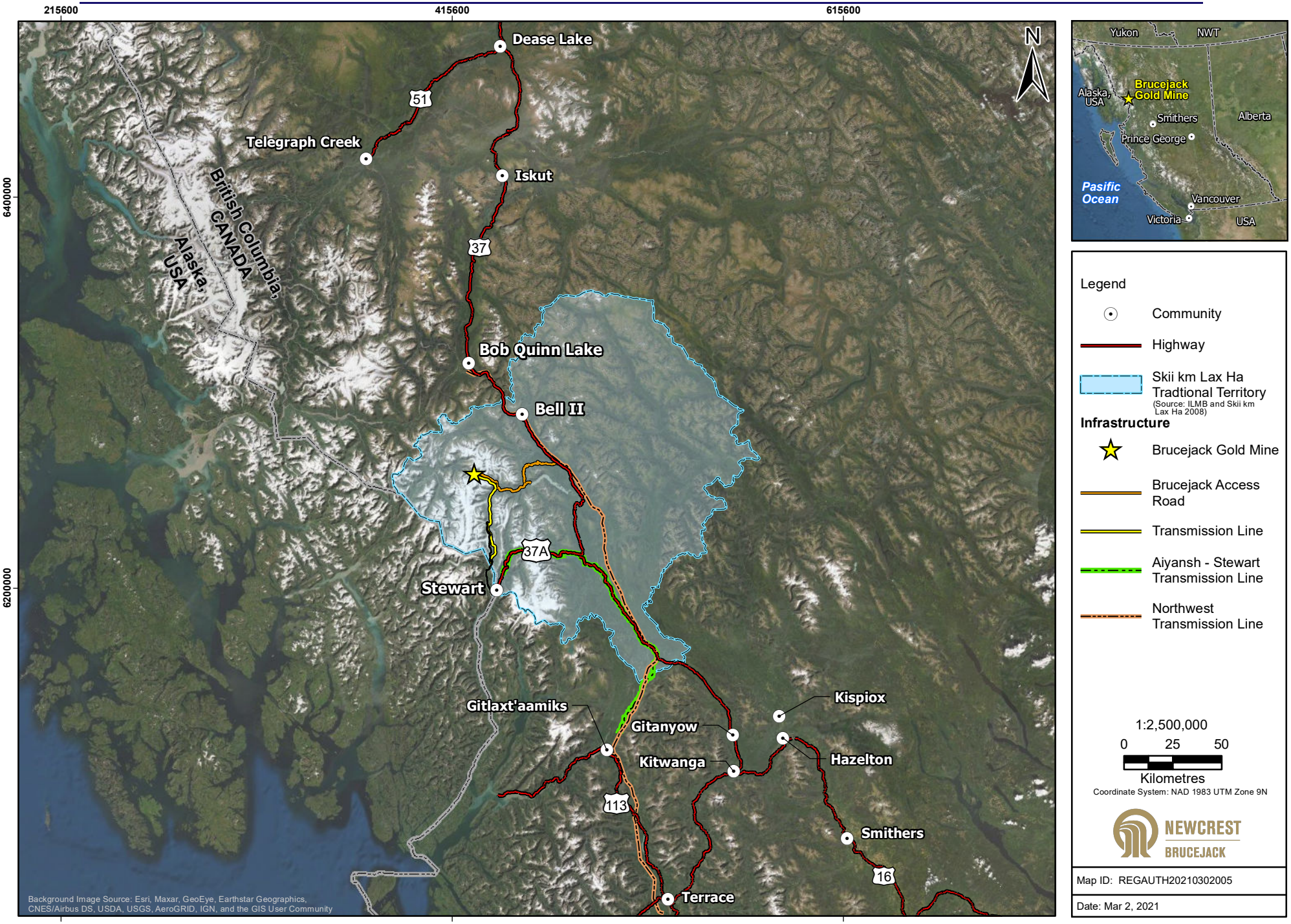

Figure 2-2. Tsetsaut/Skii km Lax Ha Traditional Territory

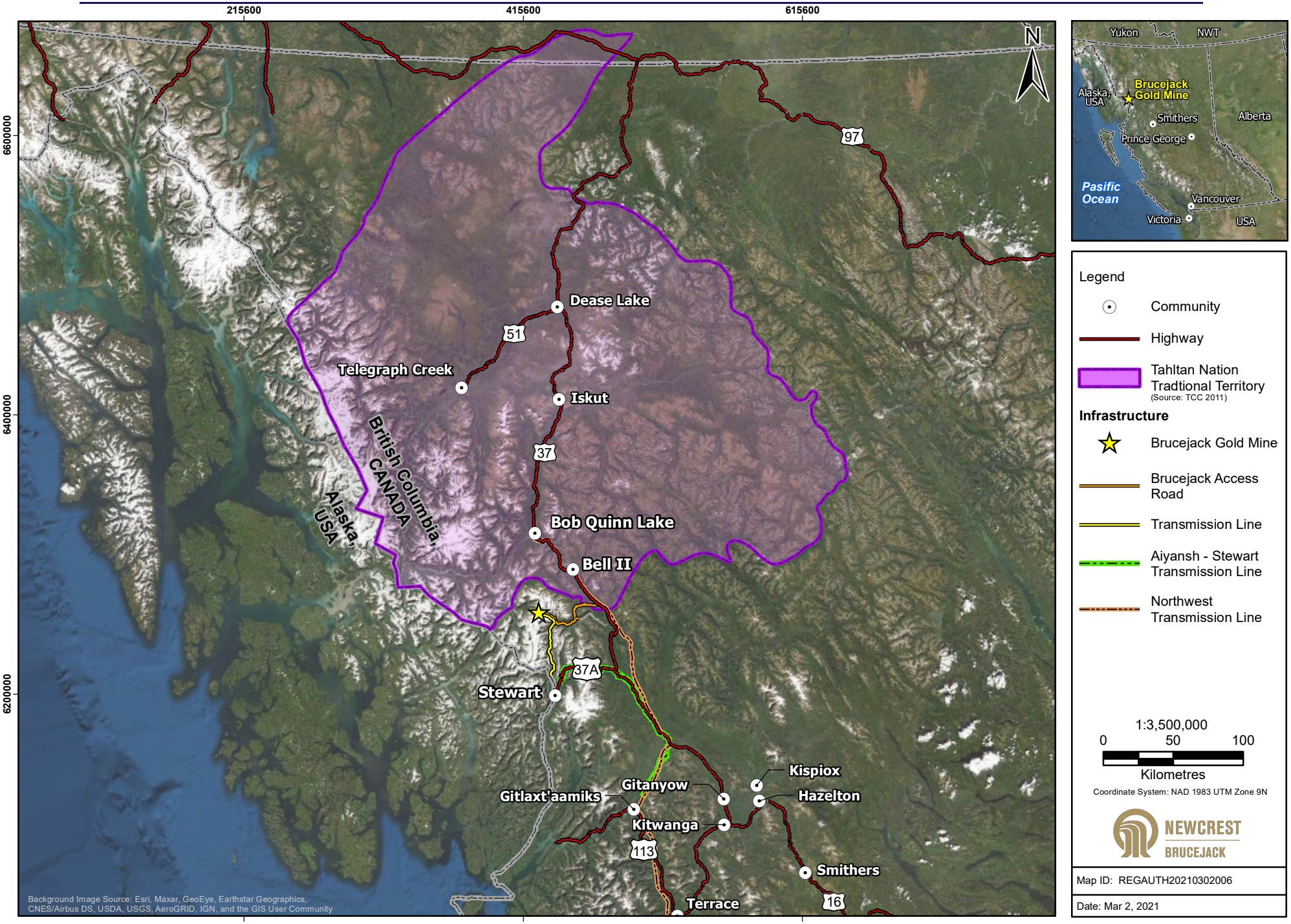

Figure 2-3. Tahltan Nation Traditional Territory

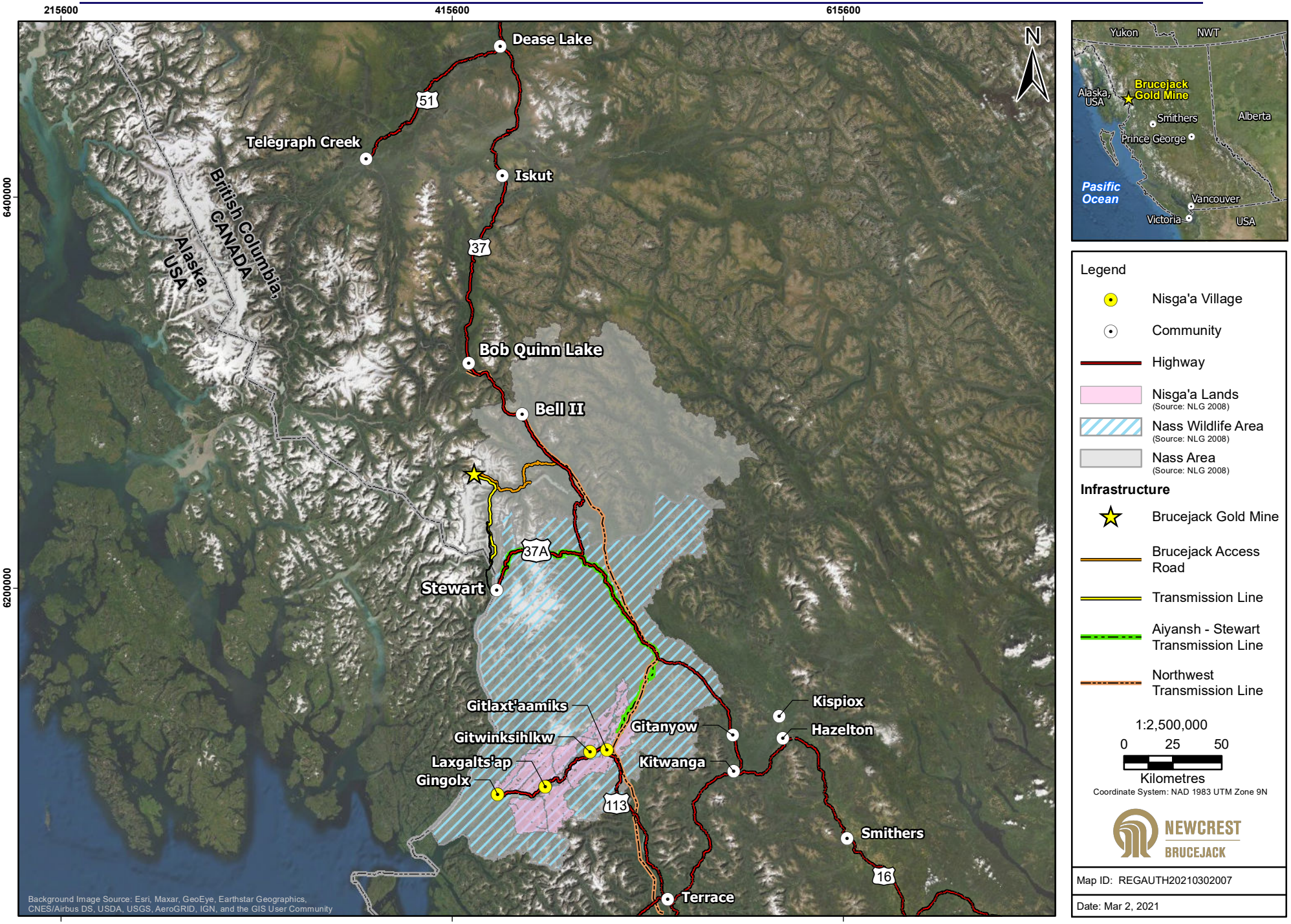

Figure 2-4. Nisga'a Lands, the Nass Wildlife Area and the Nass Area

3 ABORIGINAL CONSULTATION PRINCIPLES AND OBJECTIVES

The core principles for Aboriginal consultation are guided by Pretivm's Social Responsibility Policy, which at a high level defines the company's policy standard for its relationship with communities. The Social Responsibility Policy (Pretium Resources Inc. n.d.) includes the recognition of the importance of building and maintaining relationships with Aboriginal groups.

Pretivm will consult with TSKLH, NLG, and the TCG on the content and implementation of the ACP. The approach to communication and consultation is guided by the following principles:

- share information and consult on mitigation measures, monitoring, adaptive management and compensation programs in a mutually agreeable way;
- distribute Mine information regularly and provide regular opportunities for consultation;
- make Mine information readily available, using both hardcopy and digital formats; and provide for a variety of dissemination platforms, including physical mailings and distribution, as well as web and email;
- conduct communication with respect for the style and frequency preferences of particular communities;
- consideration of and, wherever practicable, incorporation of input received by Aboriginal groups into decisions made concerning Mine activities;
- implement the updated consultation approach (as outlined in this ACP) prior to commencement of Operation and Closure phases of the Mine;
- economic participation in all phases of the Mine by First Nations; and
- foster long-term relationships and establish a positive community presence.

Chapters 4, 5, and 6 provide details on the practical application of these principles and on the consultation and communication processes.

4 CONSULTATION APPROACH AND ACTIVITIES

4.1 CONSULTATION MANAGEMENT

Pretivm's Community Relations Group is responsible for managing consultation activities with Aboriginal groups throughout the Construction, Operation, and Closure phases of the Mine. The Corporate Relations Group will report on these consultation activities to the BC EAO or respective provincial authority pursuant to the conditions in Environmental Assessment Certificate #M15-01. Members of the Aboriginal leadership for the TSKLH, NLG, and TCG are the main points of contact; however, consultation activities will include the broader community members.

The Corporate Relations Group will be responsible for the implementation and adherence to the ACP, including: the publication of Mine information; the coordination of information distribution; the planning of consultation activities (including processes and schedules); the collection, receipt of and response to input received by Aboriginal groups; and the tracking and reporting on consultation activities.

Pretivm tracks all correspondence and engagement with Aboriginal groups using an internal database management system. This system is intended to provide for a thorough record of engagement for reporting purposes, enable Pretivm to record, track and resolve issues of community concern, and support a coordinated approach to responding to feedback and information gathered for adaptive management purposes.

Pretivm has established a permanent community liaison role for the life of the Mine. The community liaison is the designated point of first contact for Aboriginal members, and provides information about the Mine, including employment opportunities. The community liaison is responsible for addressing comments, questions and concerns from Aboriginal members. In the event that in-depth consultation is required, the Mine General Manager and/or Vice President, Corporate participate through a process coordinated by the Corporate Relations Group.

The primary contacts for the Corporate Relations Group are included in the document (Chapter 7).

4.2 INFORMATION SHARING AND CONSULTATION

4.2.1 Information Sharing

Pretivm will develop outreach materials to effectively convey information on Operations and Closure activities to Aboriginal groups, including mitigation measures, monitoring, adaptive management, and compensation programs.

Throughout all phases of the Mine, Pretivm will continue to produce and disseminate an annual newsletter which describes Mine activities including but not limited to: construction, development and operations highlights; descriptions of technical processes for a non-technical audience; the effectiveness of environmental mitigation; and highlights of Pretivm's involvement with communities in the area. Contact information will continue to be included for community members to provide comment and feedback on the newsletters. The newsletter will continue to be distributed via email to members of Aboriginal leadership for the TSKLH, NLG, and TCG and community members who sign up for Pretivm's distribution list (maintained by Pretivm's community liaison). The newsletter will also be

made available in hard copy format and distributed in desired quantity to points designated by members of the Aboriginal leadership, as well as at community events and meetings. The newsletter will also be available on the company website, with a link for sign-up.

During the Construction phase, Pretivm provided Mine construction updates on its web site as construction progressed. The Mine update feature on the web site will be maintained after the Construction phase, however Pretivm anticipates fewer updates throughout the Operations and Closure phases when Mine activity is at steady-state.

Pretivm will continue to produce an annual sustainability report which will be distributed via email to the leadership for the TSKLH, NLG, and TCG and to members of the community liaison distribution list. The sustainability reports will be available on Pretivm's web site (http://www.pretivm.com).

A repository of general Mine information about the Mine is and will continue to be maintained on the Mine website (https://pretivm.com/home/default.aspx). Mine and information about Pretivm will include:

- annual reports (e.g., sustainability report and other public reports filed with regulatory agencies);
- technical reports including documents and maps;
- presentations;
- investment information (e.g., presentations, events and factsheets);
- news and announcements; and
- photo gallery.

Pretivm will regularly consult with Aboriginal groups about the communication platforms to assess the effectiveness of content and frequency of communication. The approach will be modified on the basis of feedback received. Additionally, the newsletter will include a request for feedback or input.[4]

Pretivm has and will continue to host Mine site visits for delegations of Aboriginal communities. Scheduled Mine site visits will be programmed in consultation with the leadership of the TSKLH, NLG, and TCG.

In addition, Pretivm will communicate the occurrence of and information on reportable spills with potential for downstream impacts to the First Nations downstream of the Bowser, Bell-Irving, and Nass Rivers (Tsetsaut Skii km Lax Ha, Nisga'a Nation, Gitanyow First Nation, Tahltan Nation) pursuant to the Brucejack Mine Spill Response Plan (SRP, Pretivm 2021 or more recent).

4.2.2 Consultation Framework

Consultation between Pretivm and Aboriginal communities is intended to be flexible to address the individual communication preferences of each community, as well as the respective intensity of their involvement with the Mine. Consultation is expected to incorporate individual and group interactions with formal and regularly occurring face-to-face meetings, written correspondence via letters and email, and verbal dialogue both formal and informal. Pretivm will conduct formal consultation in

[4] At the time of drafting the Operation Phase ACP, Pretivm has not received input regarding the effectiveness of content or frequency of communication through Aboriginal engagement or communication methods.

accordance with any established communication protocols agreed upon (see Chapter 4.4 of this ACP). For NLG the confidential Cooperation and Benefits Agreement provides for communication, collaboration and a consultation process. For other Aboriginal communities Pretivm is committed to continuing development of Communications Protocols and/or Agreements which will include consultation protocols. Pretivm remains open to suggested engagement approaches and to foster continuous dialogue about the Mine.

Consultation and engagement activities with Aboriginal communities throughout the life of the Mine include, but are not limited to:

- responding to appointments or inquires made at Pretivm's Smithers or Vancouver offices whenever they may be requested;
- participation in community events (e.g., career fair or education and training events) to which Pretivm has been invited;
- hosting workshops and information sessions in local communities about the Mine as well as about employment and contracting opportunities. These workshops and information sessions also provide an opportunity to solicit and respond to questions or comments about the Mine;
- in accordance with the Terms of Reference of the Mine Permit Review Committee, consulting on the development of EAC Component Plans (see Chapter 4.3 of this ACP);
- consulting as outlined in agreements developed between Pretivm and Aboriginal communities (see Chapter 4.4 of this ACP);
- consulting and reporting on modifications to this ACP (see Chapter 5 of this ACP);
- reporting on consultation activities (see Chapter 6 of this ACP); and
- other consultation activities including activities suggested by Aboriginal groups.

As part of the Wildlife Management Plan, Pretivm will continue to chair a Wildlife Committee (active since the fall of 2015). NLG, TCG, and TSKLH will continue to be invited to participate on the Wildlife Committee. The Wildlife Committee has developed terms of reference that will include processes for addressing comments raised by committee members.

Pretivm will continue to host annual open houses within the local communities over the course of the life of the Mine. During Operations and Closure, the annual open houses will provide information about the Mine, including employment opportunities, and will continue to facilitate questions and comments from attendees. Notification about these open houses will be provided by email to Aboriginal leadership to the TSKLH, NLG and TCG, to members of the community liaison distribution list, and will be posted in local newspapers at least 30 days in advance of the event.

Pretivm is responsible for the conduct of Mine activities in accordance with the terms of EA Certificate #M15-01 and related conditions and bears sole liability for safe and environmentally sound operation of the Mine. Pretivm will consider and incorporate input from Aboriginal communities in order to satisfy these requirements or, the requirements for mitigation measures, monitoring, adaptive management and compensation programs as part of it adaptive management process. Input from Aboriginal communities will be responded to in accordance with the steps described under the Consultation Management section (Chapter 4.1). Pretivm will respond to input or suggestions regarding the conduct of its activities with a response acknowledging whether and how the input will be incorporated. In the case that changes are not implemented the response will outline the reason (e.g., the suggestion may inhibit Pretivm from meeting regulatory obligations). Pretivm aims to provide a response within 30 days of receiving the

comment or suggestion, however in the case that multiple departments are involved in addressing the response, more time may be required. Table 4.2-1 provides a summary of the communication and consultation activities.

Table 4.2-1. Communication and Consultation Implementation

Method	Implementation	Timing / Frequency
Website	Content provided on Pretivm's website will include employment and contracting opportunities, Mine milestones and updates, and other information or announcements.	Ongoing
Head Office/ Regional Office	Pretivm's Smithers-based Community Relations Manager is responsible for outreach to local communities including TSKLH, NLG, and TCG communities regarding Mine information and employment and training opportunities.	Ongoing
Newsletter	Pretivm will produce an annual newsletter describing Mine highlights. The newsletter will summarize Mine information including employment, procurement, training, Aboriginal group and stakeholder engagement, and contributions to local economic development. It will also provide up-to-date contact information for the company. A PDF of the newsletter will be posted to Pretivm's website, and emailed to community and/or Aboriginal contacts; hard copies available at the regional office and may be provided upon request.	Annual
Open Houses	Pretivm will host open houses to provide Mine updates to local communities. Notification of these open houses/presentations will be provided at least 30 days in advance of the event. When invited and appropriate, Pretivm will participate in community events such as open houses or career fairs.	Annually
Site Visits	Pretivm will host site visits for delegations of Aboriginal communities Scheduled site visits will be programmed in consultation with the leadership of the TSKLH, NLG, and TCG.	As programmed
Response to Aboriginal group or Aboriginal community member	In the case of formal input or feedback (i.e., submitted by email or letter), Pretivm will provide a response outlining the how the company is addressing the input. Pretivm aims to provide a response within 30 days of receiving the comment or suggestion, however in the case that multiple departments are involved in developing the response, more time may be required.	Based on submission of comments and feedback
Meetings. Formal (e.g., face to face meetings) and Informal (Regional Office drop in).	Pretivm will consult with Aboriginal groups about the effectiveness of the communication platforms and will modify its approaches on the basis of this feedback. Additionally, the newsletter will include a request for feedback or input.	Ongoing

4.3 MANAGEMENT PLANS

The Condition No. 5 of the EAC Schedule B – Table of Conditions requires consultation related to mitigation measures, monitoring, adaptive management and compensation programs. Additionally, as indicated in Condition No. 2, Pretivm will consult with the TSKLH, NLG, and Tahltan Nation with respect to Component Plans (Appendix A).

The development of most of the Component Plans was managed by a Mine Review Committee ("Committee").[5] The Committee was established by the Province and chaired by the Ministry of Forests, Lands and Natural Resource Operations (BC FLNRO). TSKLH, NLG, and Tahltan Nation

[5] The Health Services Monitoring Plan Economic (HSMP), Social Effect Mitigation Plan (ESEMP), and this ACP were not reviewed by the Committee, but included consultation with Aboriginal groups on the individual plans.

were members of the Committee. The Committee provided a forum for authorization processes related to the construction, development, operations, reclamation and closure of mines including the *Mines Act* permit (mine infrastructure, reclamation, bonding), *Environmental Management Act* permits (waste management), and others. The Committee facilitated a harmonized review by Aboriginal groups and multiple natural resource agencies. Through the Committee, Aboriginal group members had an opportunity to review application information and propose accommodation and mitigation, including but not limited to receiving and sharing information, and, where appropriate, contribute to the development of proposed mitigation measures for potential adverse environmental effects. The Terms of Reference of the Committee outlined an approach to tracking and responding to comments received by Committee members. Component Plans are listed in Appendix A.

Component Plans are "living documents". If a Component Plan requires updating, the relevant regulatory authority is involved in the review and approval of the Component Plan. For those Component Plans that apply to the Mine Site (under the *Mines Act* Permit) in the case of any revision, Pretivm will abide by the consultation requirements outlined in the Plan and according to the *Mines Act* Permit.

Where annual updating for a Component Plan may be required (i.e., Economic and Social Effect Mitigation Plan (ESEMP), due no later than April 1 each year), Pretivm will provide the draft reports to TSKLH, NLG, and Tahltan Nation for input a minimum of 30 days prior to submission to the appropriate regulatory agency. Input received on the draft reports will be considered in the development of the final reports and a response will be provided outlining how input was addressed.

In accordance with the *Mines Act* (1996) and *Environmental Management Act* (2003), management plans have been developed for the Mine. Appendix A presents the management plans outlined in the EAC, and describes where required, the information sharing, reporting and consultation activities with the TSKLH, NLG, and Tahltan Nation as contained in Pretivm's joint application for *Mines Act* and *Environmental Management Act* permits (Pretium Resources Inc. 2015a).

The Aboriginal Consultation Plan does not cover information sharing committed to as per individual management plans or as required per conditions for other authorizations or permits.

4.4 MINE AGREEMENTS AND ABORIGINAL ECONOMIC PARTICIPATION

Pretivm will enter into Mine agreements with Aboriginal groups to provide economic and other benefits associated with the Mine. Pretivm will work with each Aboriginal group to determine the best approach to providing them with long-term benefits that reflect their particular circumstances.

An example of this is the April 2015 comprehensive and long-term *Cooperation and Benefits Agreement* signed between Pretivm and the Nisga'a Nation in respect of the Mine (Pretium Resources Inc. 2015b). As stated in the press release, "Under the terms of the agreement, the Nisga'a Nation will provide ongoing support for the development and operation of Brucejack as a safe, environmentally sound mine with participation in its economic benefits, and Pretivm will honour commitments to the Nisga'a Nation regarding jobs and contracting opportunities at the Mine, education and training and financial payments." This agreement provides for communication, collaboration and cooperation between Pretivm and the Nisga'a Nation.

Pretivm is in the process of developing agreements with the TSKLH and Tahltan Nation that will provide for communication, collaboration, and cooperation related to the Mine.

5 MODIFICATIONS TO THE ABORIGINAL CONSULTATION PLAN

The Brucejack Gold Mine is anticipated to have an approximately 18 year mine life. Pretivm will consult with the TSKLH, NLG, and the TCG about necessary modifications to the ACP to address the distinct nature of the Mine during Construction, Operation, and Closure phases. The following outlines the proposed minimum schedule for consultation on the ACP that may lead to modifications:

- Pre-Construction Phase: The draft ACP provided to the BC EAO prior to Construction was developed in consultation with Aboriginal groups. As outlined in Chapter 1, Pretivm provided an initial draft of this ACP to the NLG, TCG, and TSKLH on June 8, 2015 and requested input on its content and implementation by June 26, 2015. A response was provided by the TSKLH on June 19, 2015 and Pretivm revised the ACP in consideration of the feedback received. The revised ACP was submitted to the BC EAO on July 13, 2015, and was also provided to the TSKLH, TCG, and NLG at this time. On October 7, 2015, TCG provided comments to Pretivm regarding the July 15 2015 draft ACP, and these comments were incorporated in the October 2015 version.
- Pre-Operation Phase: No later than six (6) months prior to the start of the Operations phase, Pretivm will consult with Aboriginal leadership on suggested modifications to the ACP. Pretivm provided an initial draft of this ACP to the NLG, TCG, and TSKLH on August 5, 2016 and requested input on its content and implementation. No comments were received by September 14, 2016. A digital version of this Operations ACP was submitted to the BC EAO and the Aboriginal groups in September 2016.
- Pre-Closure Phase: Prior to the Closure phase, Pretivm will consult with Aboriginal leadership on suggested modifications to the ACP. The same review process outlined for the Pre-Operation phase will be implemented, unless feedback or comments provided by Aboriginal groups result in modifications to this approach.

Pretivm will provide the BC EAO with a letter indicating what updates, if any, are made to the ACP.

6 REPORTING

Pretivm will provide the following ACP reports to Aboriginal groups and the BC EAO according to the timeline outlined below:

- The Holder will submit the ACP to BC EAO no later than 30 days prior to the commencement of Construction (i.e., October 2015 version of the ACP).
- If modifications are made to the ACP throughout the lifespan of the Mine, a letter will be provided to Aboriginal groups and the BC EAO outlining the ACP modifications made and reason for any changes based on input received from Aboriginal groups (see Chapter 5 for approach to consultation and schedule of ACP review).

As required by Condition No. 2 of the EAC, Pretivm will consult with the NLG, Tahltan Nation, and TSKLH on the content and implementation of Component Plans by way of the Mine Permit Review Committee. As noted in Chapter 4.3 of this ACP, where annual updates for a Component Plan may be required no later than April 1 each year (i.e., Economic and Social Effect Mitigation Plan), Pretivm will provide the draft reports to TSKLH, NLG, and Tahltan Nation for input at least 30 days prior to submission to the BC EAO. Annual reports due January 31 will be submitted to the Aboriginal groups at the same time as they are submitted to the BC EAO for concurrent review. Pretivm will provide a response to input received by Aboriginal groups outlining how that input has been addressed.

7 KEY CONTACTS

Comments or questions on this plan are welcome and may be directed to the following individuals.

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The following individuals have been designated as representatives of NLG, TSKLH, Tahltan, and Gitanyow with respect to the ACP.

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Tahltan Central Government:

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Gitanyow Hereditary Chiefs Office:

Joel Starlund/Sk'a 'nism 'Win'Giit, Executive Director
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8 REFERENCES

Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

1996. *Mines Act*, RSBC. C. 293.

2003. *Environmental Management Act*, SBC.

BC EAO. 2015. *Environmental Assessment Certificate M15-01 for the Brucejack Gold Mine Project.* British Columbia Environmental Assessment Office: Victoria, BC.

Government of Canada, Government of BC, and Nisga'a Nation. 2000. *Nisga'a Final Agreement.*

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Pretium Resources Inc. 2015b. *Pretivm and Nisga'a Nation Sign Brucejack Project Cooperation and Benefits Agreement.* Pretium Resources Inc. press release. April 2, 2015. http://www.pretivm.com/news/news-details/2015/Pretivm-and-Nisgaa-Nation-Sign-Brucejack-Project-Cooperation-and-Benefits-Agreement/default.aspx (accessed April 2015).

Appendix A

Component Plans and Relevant Regulatory Authority

Appendix A. Component Plans and Relevant Regulatory Authority

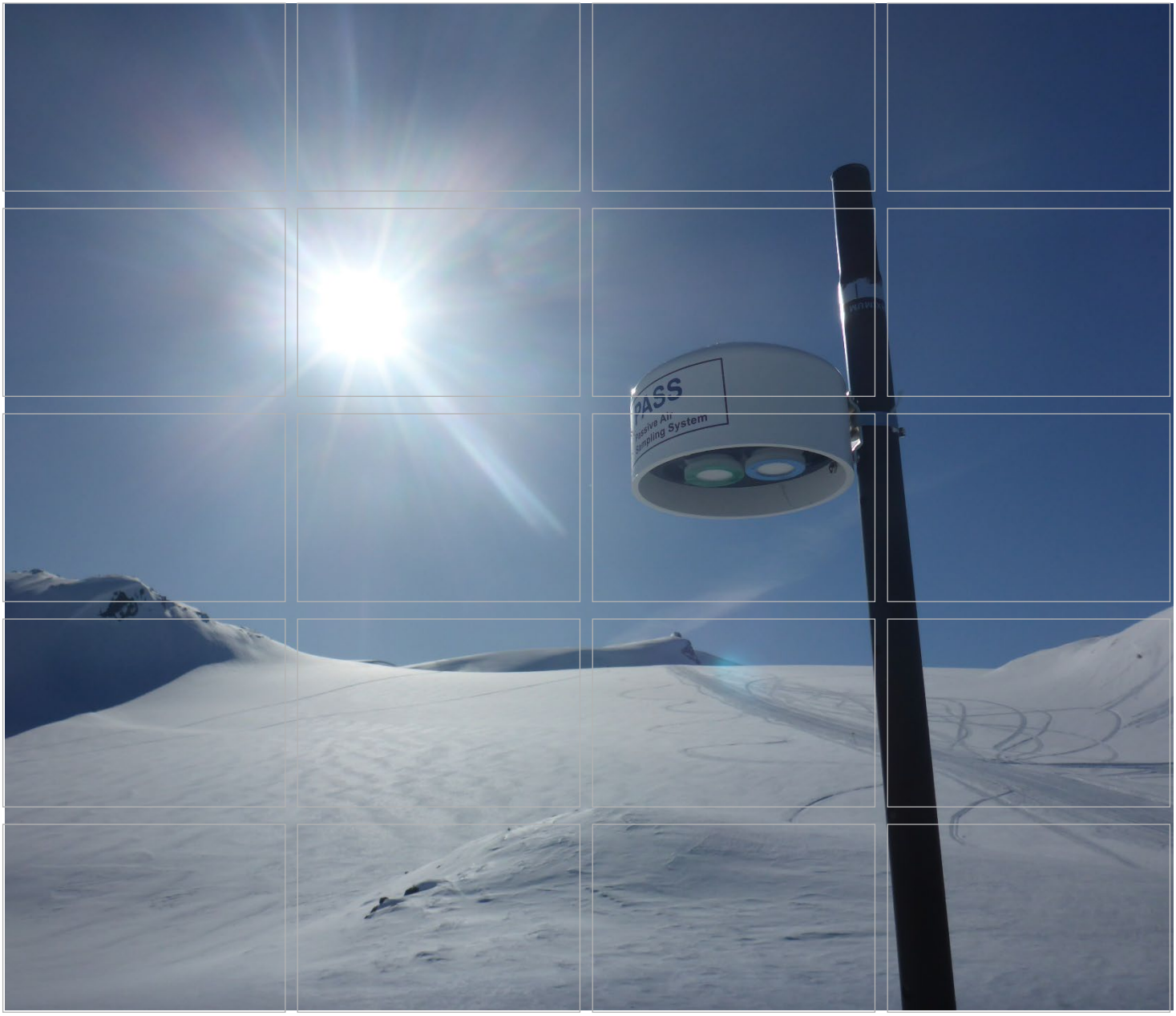
Component Plan	Regulatory Authority	Consultation Requirement
Aboriginal Consultation Plan	BC EAO	Developed in consultation with Aboriginal groups (see Chapter 1 of this document)
Air Quality Management Plan	MOE	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Ancillary Infrastructure Decommissioning and Reclamation Plan; Reclamation and Closure Plan; and Soils Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee All aspects of decommissioning and reclamation for ancillary infrastructure have been incorporated into the Reclamation and Closure Plan submitted as part of Pretivm's application for a *Mines Act* permit and has been reviewed by the MEM and FLNRO. Aspects of soils management have been incorporated into the Reclamation and Closure Plan and a Surface Erosion Prevention and Sediment Control Plan submitted as part of Pretivm's application for a *Mines Act* permit and has been reviewed by the MEM and FLNRO.
Aquatic Effects Monitoring Plan	MOE	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Chemicals and Materials Storage and Handling Plan	MEM/MOE	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Economic and Social Effect Mitigation Plan	BC EAO	Developed in consultation with Aboriginal groups according to Condition 2
Geohazards Management Plan		Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Ground Control Management Plan		Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Health Services Monitoring Plan	BC EAO	Developed in consultation with Aboriginal groups according to Condition 2
Heritage Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Invasive Plans Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Preliminary Avalanche Hazard Management Plan for Mine Construction and Operations	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process

(continued)

Appendix A. Component Plans and Relevant Regulatory Authority (completed)

Component Plan	Regulatory Authority	Consultation Requirement
Metal Leaching and Acid Rock Drainage Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Mine Emergency Response Plan	MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Reclamation and Closure Plan	MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process (see Ancillary Infrastructure Decommissioning and Reclamation Plan)
Soils Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process (see Ancillary Infrastructure Decommissioning and Reclamation Plan)
Spill Response Plan	MEM/MOE	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Tailings and Subaqueous Waste Rock Deposition Management Plan	MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Traffic and Access Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Vegetation Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Waste Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Water Management Plan	MEM/MOE	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process
Wildlife Management Plan	FLNRO/MEM	Developed in consultation with Aboriginal groups according to Condition 2, through the Mine Review Committee process

Appendix 9-1-2. Air Quality Management Plan



NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Air Quality Management Plan

January 2022

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Air Quality Management Plan

Date: January 2022

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
1	May 2015	Pretium Exploration Inc.	Original
1a	December 2018	Pretium Resources Inc.	Input to version control table and cover page added
2	January 2021	Pretium Resources Inc.	Address comments from Nisga'a Lisims Government; removed reference to construction phase; update to present verb tense
2a	January 2022	Pretium Resources Inc.	Updated figures and made minor formatting changes/edits

BRUCEJACK GOLD MINE
Air Quality Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Air Quality Standards	Objectives for maximum concentrations air contaminants in the atmosphere developed to ensure long-term protection of public health and the environment.
Ambient Air Quality	The outdoor air quality at a particular site.
BC	British Columbia
BJAR	Brucejack Access Road
CAAQS	Canadian Ambient Air Quality Standards
CWS	Canada-wide Standards
Dioxins	Polychlorinated dibenzodioxins (PCDDs), or simply dioxins, are a group of polyhalogenated organic compounds that can act as environmental pollutants. They are commonly referred to as dioxins for simplicity in scientific publications because every PCDD molecule contains a dioxin skeletal structure. Members of the PCDD family have been shown to bioaccumulate in humans and wildlife due to their lipophilic properties.
ERM	Environmental Resource Management Group, Inc.
Fugitive Dust	Particulate matter, often sand or mineral dust, released to the atmosphere by mechanical disruption of soil or by wind scouring.
Furans	Polychlorinated dibenzofurans (PCDFs), or simply furans, are a group of halogenated organic compounds which are toxic environmental pollutants. PCDFs tend to co-occur with polychlorinated dibenzodioxins (PCDDs). PCDFs can be formed by pyrolysis or incineration at temperatures below 1,200 °C of chlorine containing products, such as polyvinyl chloride (PVC), polychlorinated biphenyls (PCBs), and other organochlorides, or of non-chlorine containing products in the presence of chlorine donors.
GHG	Greenhouse gas
m	Metre
Mercury	Mercury is a natural and persistent bioaccumulative element which can be transported many kilometers in the atmosphere. Mercury can be deposited to waterbodies from anthropogenic emissions and poses a threat to human and ecosystem health. Mercury also enters the environment through the disposal (e.g., land filling, incineration) of certain products. Products containing mercury include: auto parts, batteries, fluorescent bulbs, medical products, thermometers, and thermostats.
NAAQO	National Ambient Air Quality Objectives

NLG	Nisga'a Lisims Government
NPRI	National Pollutant Release Inventory
Oxides of Nitrogen (NO_x)	NO_x gas primarily consists of nitrogen oxide (NO) and nitrogen dioxide (NO_2). The gases are emitted with exhaust from combustion engines and are by-products of blasting operations. NO_x can be converted to nitric acid in the atmosphere and thus contribute to acid deposition.
PASS	Passive Air Sampling System
PCDD	Polychlorinated dibenzodioxins
PM_{10}	Inhalable particulate matter. PM_{10} particles are airborne particles that have a diameter of 10 µm or less. The majority of PM_{10} particles are from fugitive dust sources. PM_{10} can enter the respiratory system and has been linked to respiratory problems.
$PM_{2.5}$	Respirable particulate matter ($PM_{2.5}$) is a subset of PM_{10} and defined as particles with a diameter less than 2.5 µm. These particles are small enough to enter deep into the respiratory system. Most of particulate matter emitted in diesel engine exhaust is $PM_{2.5}$.
Pretivm	Pretium Resources Inc.
s	Second
SOP	Standard operating procedure
Sulphur Dioxide (SO_2)	Fossil fuel contains a small amount of sulphur-containing organic compounds. During fuel combustion, the sulphur is oxidized and emitted as SO_2 gas with the engine exhaust. In the atmosphere, SO_2 can further oxidize to sulphate, which contributes to acid deposition.
US EPA	United States Environmental Protection Agency The US EPA has promulgated a variety of guidelines, objectives, emission factors, air dispersion modelling procedures and statutes for the protection of ambient air quality.
VOK	Valley of the Kings

1 PURPOSE

The purpose of the Air Quality Management Plan is to discuss the mitigation measures that are implemented to manage and reduce air emissions resulting from the Operations of Brucejack Mine (the Mine) and to outline the continual assessment, monitoring, and reporting of emissions that will take place throughout the mine life.

2 PERFORMANCE OBJECTIVES

The objective of the Air Quality Management Plan is to mitigate for, monitor, and report on air emissions resulting from Mine related activities, and to comply with required conditions in Permit 107025.

3 SCOPE

The Air Quality Management Plan applies to the Brucejack Mine Site, the Brucejack Access Road (BJAR), the Knipple Transfer Area and the Bowser Aerodrome during Mine Operations.

4 RELEVANT LEGISLATION, REGULATIONS, AND AEC CONDITIONS

4.1 AIR QUALITY

The federal government has set National Ambient Air Quality Objectives (NAAQOs) and Canada-wide Standards (CWSs) under the *Canadian Environmental Protection Act, 1999* (1999). CWSs are intended to be achievable targets that will reduce health and environmental risks within a specific timeframe, whereas NAAQOs identify benchmark levels of protection for people and the environment. The new Canadian Ambient Air Quality Standards (CAAQS), adopted in 2013, are in effect since 2020, and supersede the CWSs. There are also several federal regulations relating to specific emission sources, such as incinerators, off-road engines, and open burning. In addition to federal legislation, British Columbia (BC) has also developed air quality objectives for some contaminants. Previously established criteria for NO_2 and SO_2 were developed in the 1970s. New CAAQS for NO_2 and SO_2 were adopted in 2017; however, new provincial criteria are not yet available and interim criteria (2014 and 2016) are still in use. Table 4.1-1 summarizes the federal and provincial ambient air quality criteria.

The applicable standards, objectives, legislation, and regulations relevant to the Mine include:

- NAAQOs (CCME 1999);
- CAAQS (CCME 2020);
- *British Columbia Ambient Air Quality Objectives* (BC MOE 2018);
- *Interim Ambient Air Quality Objectives* (BC MOE 2018);
- *Pollution Control Objectives for the Mining, Smelting, and Related Industries* (BC MOE 1979);
- CWS for dioxins and furans (CCME 2009);
- CWS for mercury emissions (CCME 2010);
- Sulphur in Diesel Fuel Regulation (SOR/2002-254);
- Code of Practice for the Concrete and Concrete Products Industry (BC Reg. 329/2007); and
- Open Burning Smoke Control Regulation (BC Reg. 145/93).

Pretium Resources Inc. (Pretivm) is currently authorized to discharge emissions of air contaminants from underground ventilation, a dust collection system, smelting furnace, assay labs, refuse incinerators, open burning of clean wood waste as well as fugitive dust associated with the Mine as per Permit 107025 issued under the provisions of the *Environmental Management Act* (2003) on January 9, 2014 and most recently amended on July 8, 2021.

Table 4.1-1. Federal and Provincial Ambient Air Quality Criteria

Pollutant	Averaging Period	Concentrations (µg/m^3) and Acid Deposition (eq/ha/year)	
		Air Quality Criteria	
		Canada	BC
NO_2	1-hour	113 (2020) [a] and 79 (2025)	188[c]
	Annual	32 (2020) [b] and 23 (2025)	60[d]
SO_2	1-hour	183 (2020) [e] and 170 (2025)	*
	Annual	13(2020) [f] and 10 (2025)	*
PM_{10}	24-hour	-	50
$PM_{2.5}$	24-hour	27[g]	25[h]
	Annual	8.8[i]	8[j]

Notes:
Dash (-) indicates information not available or applicable. Bold indicates exceedance over criteria.
(2020) and (2025) indicate the criteria will come into effect in 2020 and 2025, respectively.
a The 3-year average of the annual 98th percentile of the daily maximum 1-hour average concentrations.
c Based on annual 98th percentile of daily 1-hour maximum , over one year
b, d, f Average over a single calendar year of all 1-hour average concentrations.
e The 3-year average of the annual 99th percentile of the daily maximum 1-hour average concentrations.
g The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
h The 3-year average of the annual average of all 1-hour average concentrations.
i Based on annual 98th percentile of daily average, over one year.
j Annual average over one year.
** Superseded by CAAQS, effective January 1, 2020.*

In addition to established air quality standards and objectives, there are also reporting requirements. Under the authority of the *Canadian Environmental Protection Act, 1999* (1999), owners or operators of facilities that meet published reporting requirements are required to report to Environment Canada's National Pollutant Release Inventory (NPRI; Environment Canada 2014a). Details about NPRI reporting are described in Section 7.1.1.2.

4.2 GREENHOUSE GAS

There is currently no national or provincial legislation in place regarding greenhouse gas (GHG) emission limits at the project level. There are, however, provincial and national reporting requirements regarding the emission of GHGs.

In support of Canada's GHG mitigation targets, since 2010, facilities emitting over 10,000 tonnes CO_2e have been required to report emissions to Environment Canada for the Greenhouse Gas Emissions Reporting Program (Environment Canada 2014b), under the jurisdiction of Section 46 of the *Canadian Environmental Protection Act, 1999* (1999).

In BC, since January 1, 2010, facilities emitting over 10,000 tonnes CO_2e must report to the BC Ministry of Environment, and those emitting over 25,000 tonnes CO_2 must also have their emissions verified by an independent and accredited third party under the BC Reporting Regulation (BC Reg. 272/2009) of the *Greenhouse Gas Reduction (Cap and Trade) Act* (2008).

4.3 RELEVANT EAC CONDITIONS

Pretivm was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions associated with the Certificate. This management plan fulfills Condition #2, in relation to a Component Plan for air quality management, presented within Schedule B of the Certificate and copied below.

Condition 2

"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.

Component Plans, at minimum, must include the following information:

- *Purpose of Component Plan;*
- *Performance objectives;*
- *Effects mitigation measures;*
- *Monitoring programs;*
- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

5.1 MITIGATION MEASURES AND BEST MANAGEMENT PRACTICES

Air emissions are/will be generated during the Mine's Operations and Closure phases from the following sources/activities.

- Diesel exhaust from:
  - mining equipment and vehicles operating both underground and on surface; and
  - diesel generators operating as back-up power sources.
- Fugitive dust generated from:
  - surface blasting and earthworks at the Brucejack Mine Site;
  - upgrades to the BJAR during Operations;
  - underground blasting and mining activities;
  - ore handling both underground and at surface; and
  - use of the BJAR, Knipple Transfer Area, Bowser Aerodrome, and Brucejack Mine Site roads (unpaved surfaces).
- Emissions from the smelting furnace and from the assay laboratory located at the Brucejack Mine Site.
- Emissions resulting from incineration of:
  - inorganic and organic wastes in the incinerators located at the Brucejack Mine Site and Knipple Transfer Area; and
  - non-hazardous organic wastes (i.e., clean wood waste, paper packaging) from four open burn pits located at the Brucejack Mine Site, Knipple Transfer Area, Bowser Aerodrome, and Wildfire Camp.

The following sections describe the environmental protection measures that are implemented to effectively manage air emissions.

5.1.1 Mine Equipment and Vehicles

Poorly maintained engines can use up to 50% more fuel than those that are properly maintained (D. Cope Enterprises 2004). Studies have also shown that 1995 model-year and older vehicles produce smog-causing pollutants at a rate up to 19 times greater than a new vehicle (Summerhill 2013). Equipment and vehicles are scheduled for regular maintenance to optimize operating conditions and, at that time, parts showing signs of excessive wear that indicate near-term failure are promptly replaced. Additionally, equipment and vehicles purchased by Pretivm are newer model-years than 1995. Diesel fuel purchased will have a sulphur content of 0.0015% (15 milligrams/kilogram) or less, as regulated by the Sulphur in Diesel Fuel Regulation (SOR/2002-254) for off-road engines and on-road vehicles. Idling of vehicles is to be avoided as much as feasible.

5.1.2 Generators and Incinerators

Generators were used during the Construction phase before the transmission line was completed. Currently generators are only used as a source of backup power.

Through proper operation of the incinerators, in addition to proper waste segregation and following manufacturer maintenance/inspection suggestions, emissions from the incinerators are expected to comply with the CWS for dioxins and furans (CCME 2009) and the CWS for mercury emissions (CCME 2010).

5.1.3 Burn Pits

Open burn pits are managed as per the conditions outlined in Pretivm's existing Permit 107025 for the open burn pit at the Brucejack Mine Site. Additional burn pits located at the Wildfire and Knipple camps, and at the Bowser Aerodrome, are operated periodically throughout the year. Acceptable materials for open burning include only dry, unpainted, untreated demolition and construction wood wastes, broken lumber and pallets, slabs, log ends and branches, brush and miscellaneous, non-recyclable cardboard and paper products. Excluded open burning materials include nuisance-causing combustibles such as painted and treated wood, sawdust, mulch, wood chips, stumps, rubber, plastics, tars, insulation, etc.

All reasonable alternatives for reducing, reusing, or recycling wood are pursued to minimize the amount of material open burned. The burn piles have been constructed in a manner to minimize smoke emissions and open burning is conducted in accordance with the Open Burning Smoke Control Regulation (BC Reg. 145/93). The closest ventilation index publicly available is from Stewart, approximately 65 kilometres south of the Brucejack Mine Site. Open burning will not be initiated unless the ventilation index is forecast as "good" for the day the open burning is to be started, and "good" or "fair" on the second day the debris is anticipated to release smoke. If the ventilation index is not available, a small test burn (maximum 60 minutes duration) constructed of a material like what will be burned may be completed. A full-scale burn will follow if the test burn shows the weather conditions are adequate to provide good smoke dispersion.

Ash from burn pits and incinerators are to be sent offsite to an approved landfill facility or buried and covered at designated locations. At the end of mine life, burn pits will be buried.

5.1.4 Fugitive Dust from Ore Processing and Concrete Batch Plant

Crushing is the first step in ore processing. Crushing of low- and high-moisture ore produces significantly different amounts of particulate matter. Primary crushing of ore at the Mine will take place underground, thereby minimizing dust emissions to the environment. Moreover, the ore is wet, resulting in minimal dust generation during primary crushing.

The crushed ore is transported to the mill through the conveyor decline where the ore is further handled. A high differential air velocity between the conveyor and air flowing through the decline will lead to the suspension of dust. The differential air velocity was considered in the design to minimize fugitive dust. When the drift velocity and the conveyed material are moving in opposition, a reduced drift velocity is required. Given the planned conveyor speed of 1.0 m/second (s) and the designed maximum air velocity of 5.5 m/s, the drift velocity in the conveyor decline should be less than 4.5 m/s.

Dust generated from ore handling, plus dust generated from the cement hoppers in the concrete batch plant, is managed by dust collectors at transfer points, surge bins, and hoppers. Fabric filters generally collect particles with sizes ranging from submicron to several hundred microns in diameter at efficiencies more than 99% (US EPA 2002). The dust collectors are operated and maintained per manufacturer recommendations.

5.1.5 Fugitive Dust from Unpaved Surfaces

Fugitive dust generated from use of the unpaved BJAR and other site roads, as well as unpaved surfaces at the Knipple Transfer Area and Bowser Aerodrome, are managed through the application of water. Watering increases the moisture content and conglomerates particles, effectively reducing the likelihood of them becoming re-suspended. Additionally, a dust suppression agent (e.g., Ca/Mg brine mixture) may be applied to roadways and some unpaved surface areas annually, or as needed, to help reduce dust generation. Roadways are also properly graded, compacted, and maintained to reduce silt content, and topped with gravel during upgrades.

5.1.6 Smelting Furnace and Assay Laboratory

In the gold refining process, gold-silver concentrate recovered by gravity concentration is smelted at the Brucejack Mine Site into gold and silver doré. During the smelting process, sulphur from the gravity concentration may be released to the air, producing SO_2. Exhaust from the assay laboratory may contain acidic moisture and particulate matter resulting from sample preparation. Scrubbers are equipped to these exhaust points to mitigate SO_2 emissions. The scrubbers use lime solutions or other alkane solutions such as NaOH or Na_2CO_3. The scrubbers are operated and maintained per manufacturer recommendations.

5.2 STANDARD OPERATING PROCEDURE, POLICIES, ETC.

The following Standard Operating Procedure (SOP) has been developed to support this plan:

- Dustfall Setup SOP (Appendix A);
- Dustfall Swap SOP (Appendix B); and
- Passive Air Sampling System (PASS) SOP (Appendix C).

Additional SOPs and/or policies will be added to this plan on an as-needed basis.

6 ENVIRONMENTAL MONITORING

The air quality monitoring program consists of the following components:

- meteorological monitoring;
- dustfall monitoring of particulates, anions, cations and metals; and
- passive air quality monitoring of NO_2 and SO_2.

6.1 PERFORMANCE MONITORING

Monitoring is a mechanism to gauge the effectiveness of site wide mitigation measures.

6.1.1 Meteorology

There are currently three meteorology stations operating as part of the Mine, which will continue to be monitored during the life of mine. These stations include the Bowser Station used to advise on flying conditions, Scott Pass Station used to advise on conditions along the BJAR, and the Valley of the Kings (VOK) Station used to provide meteorological conditions at the Brucejack Mine Site. The current locations of the meteorological stations are shown in Figure 6.1-1.

Each of the stations consists of a standard 10-m meteorological tower with instrumentations to measure the following parameters:

- wind speed and wind direction;
- air temperature;
- barometric pressure;
- relative humidity;
- snow depth;
- net radiation;
- solar radiation; and
- precipitation (as rainfall and total precipitation).

The meteorological monitoring program was initially designed to monitor meteorological conditions in the area to support mine infrastructure design and management and is not considered a necessary component of the air quality monitoring program; however, data obtained from the meteorological monitoring stations such as wind speeds and directions are informative when considering results of the dustfall and PASS monitoring described below.

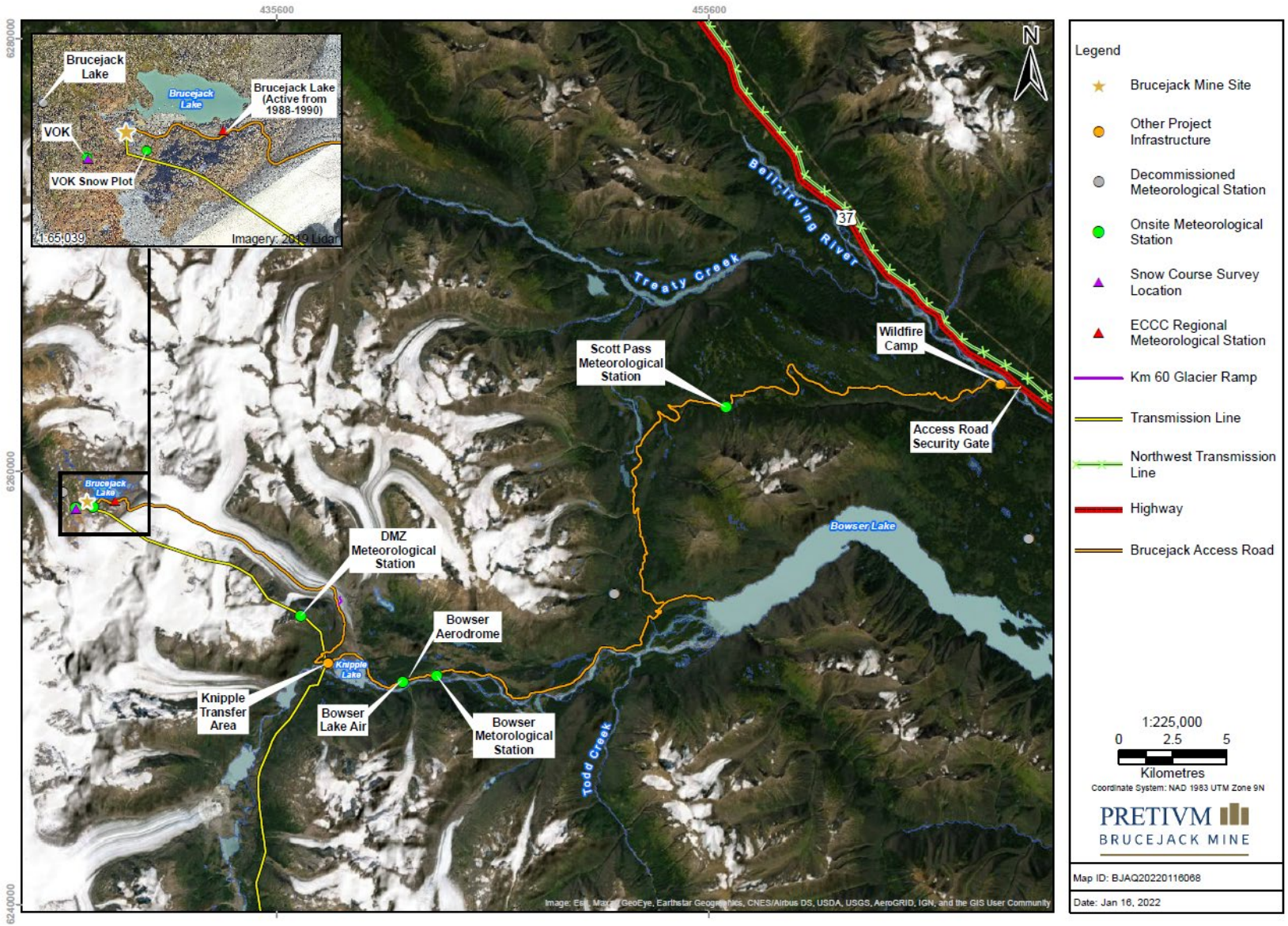

Figure 6.1-1. Meteorological Monitoring Stations

6.1.2 Air Quality

Site-specific air quality monitoring consists of dustfall monitoring of particulates; anions; cations; total metals, and a Passive Air Sampling System (PASS) for NO_2 and SO_2..

6.1.2.1 Dustfall

Dustfall monitoring is completed in accordance with sampling method ASTM D1739-98 (ASTM 2010). Each station monitors consecutive 30-day periods during the summer and early fall (essentially months when it is not below freezing). The dustfall monitoring stations collect particulates small enough to pass through a 1-millimetre screen and large enough to settle by virtue of their own weight. This requires containers of a standard size and shape, which are partially filled with deionised water and algaecide to prevent the growth of algae in the canisters. Each station consists of two canisters each surrounded by a wind screen and mounted on a 2-metre pole. Windscreens are erected around the sample containers to improve the dustfall collection efficiency, and bird spikes are used to minimize contaminants from bird faeces. One of the canisters is analyzed for particulates (total, soluble, and insoluble) and anions (sulphate, nitrate, chloride, and ammonia) and the other for total metals and various cations.

Monitoring is conducted at two dustfall monitoring stations at the Brucejack Mine Site: one downwind of the Crusher Air Raise (DF7) and one located between the VOK Raise 1 and the VOK Raise 4 (DF8). An existing background station (DF5) continues to monitor to provide background conditions (Figure 6.1-2). However, this station may be relocated farther from the access road if results indicate influence from road traffic.

6.1.2.2 Passive Air Sampling System (PASS)

Emissions of NO_2 and SO_2 resulting from fuel combustion monitored during Operations with a PASS. The PASS monitors gas or vapour pollutants through the process of diffusion through a static air layer or permeation through a membrane. The sample media is installed in the field and exposed in protective shelters that are mounted to a support pole for a period of 30 days. Following the exposure period, the sample media is to be retrieved, replaced, and sent to the laboratory for analysis along with meteorological data including air temperature, wind speed, and relative humidity, to allow the ambient concentration of the compound over the sampling period to be determined.

One PASS is located at the Brucejack Mine Site between the VOK Raise 1 and the VOK Raise 4 (PASS3). An existing background station (PASS2) monitors background conditions. However, this station may be relocated farther from the access road if results indicate influence from road traffic. The PASS monitoring stations will be collected with the dustfall monitoring stations and are shown in Figure 6.1-2.

Sampling frequency will provide a 1-month average ground-level concentration for each contaminant.

6.2 WORK PLANNING AND SCHEDULE

During the Operations phase, meteorological monitoring is continuous, and dustfall and PASS monitoring is conducted monthly. Dustfall monitoring takes place only during the summer months of July through September, as the dustfall canisters may freeze during the winter and snow accumulation in the canister prevents accurate dustfall monitoring. Summer months will capture the period during which the highest emissions would be expected to occur.

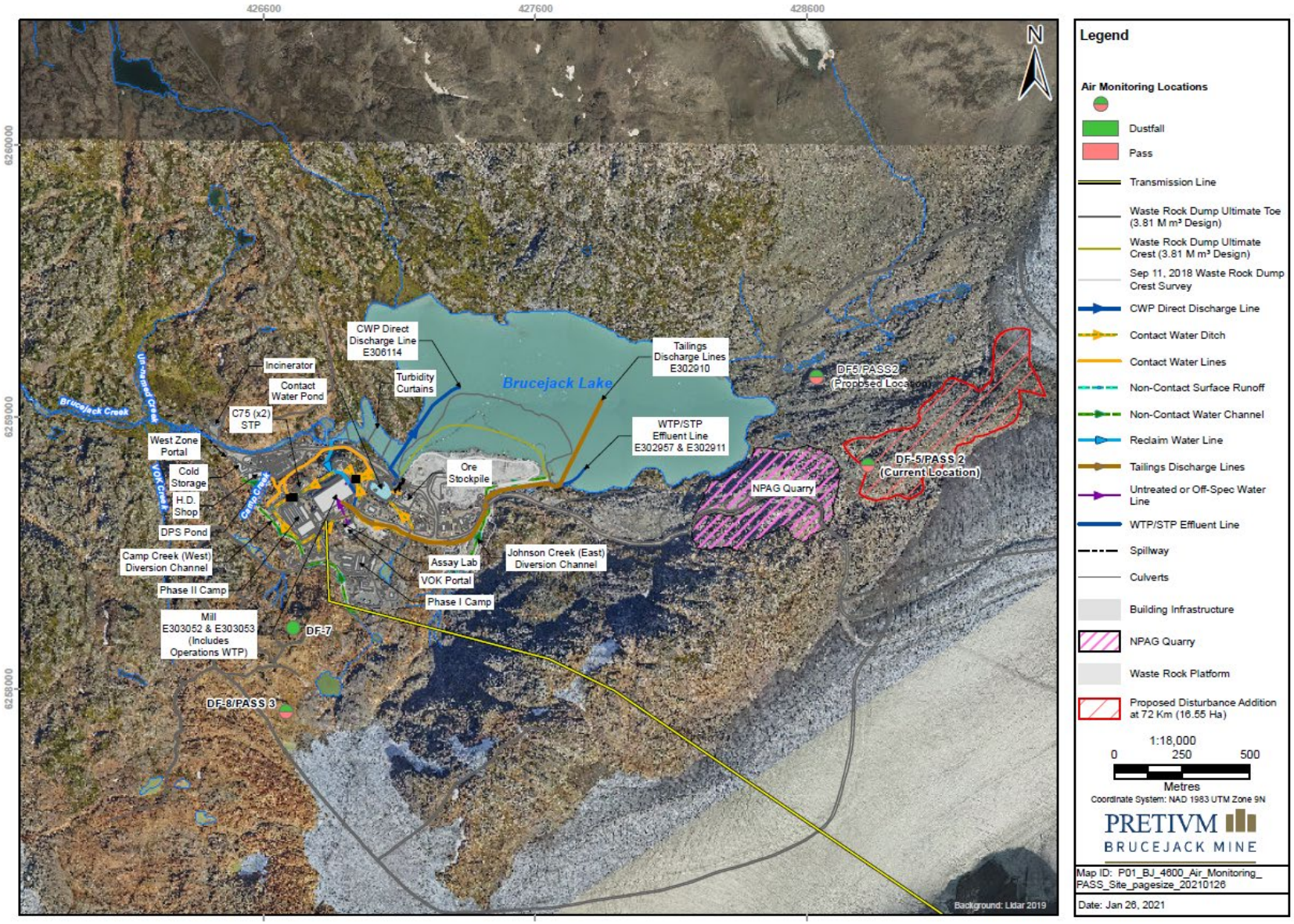

Figure 6.1-2. Dustfall and PASS Monitoring Stations

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance Reporting

7.1.1.1 ***Environmental Management Act*** **Permit Reporting**

Results from PASS monitoring, and non-compliances will be reported to the BC Ministry of Environment and Climate Change Strategy (ENV) at a frequency and in a format defined by the following conditions in permit PA 107025: *5.8 Non-Compliance Reporting* and *5.9 Annual Reporting*.

7.1.1.2 National Pollutant Release Inventory Reporting

If the amounts of any pollutant released are above the reporting threshold, reporting to the NPRI is undertaken. Emissions are estimated annually based on fuel usage and equipment activity levels. Results are compared to the NPRI reporting threshold.

7.1.1.3 Greenhouse Gas Emission Reporting

Greenhouse gas emissions are calculated annually based on fuel usage. Annual emissions are compared to the federal reporting requirements (10,000 tonnes) and provincial reporting requirements (10,000 tonnes). If the facility-level GHG emissions surpass the federal and provincial reporting requirements, GHG emissions are assessed and reported to the federal and provincial reporting systems and verified (if over 25,000 tonnes) by an independent third party for the provincial reporting.

The provincial and national reporting regulations specified Greenhouse Gas Emissions Reporting Program (Environment Canada 2014b) and *Greenhouse Gas Reduction (Cap and Trade) Act* (2008) only pertain to facility-level emissions, and do not include indirect emissions.

7.1.2 External / Internal Reporting

A copy of the report of the results from dustfall and PASS monitoring (7.1.1.1 above) is submitted to the Nisga'a Lisims Government (NLG).

7.2 RECORD KEEPING / TRACKING

7.2.1 Fuel Usage and Activity Levels

In order to determine if reporting of GHGs and other contaminant emissions is required, fuel usage from power, mobile, and stationary equipment is tracked. Equipment and vehicle activities such as distance travelled and grading are tracked to a feasible extent.

7.2.2 Monitoring Results

Pretivm assumes the responsibility of data management and record keeping of monitoring results. Data are entered into suitable electronic databases and have quality control checks completed upon

receipt of results. Data are entered in a format and program that allows for comparison between years, and stored in a single file format for each type of survey or monitoring activity. Monitoring data is stored for the life of the mine, and is made available for review upon request.

7.2.3 Continuous Improvement, Follow-up, and Adaptive Management

If monitoring data are out of compliance with permit conditions or are showing an increasing trend in contaminant concentrations, adaptive management options are assessed. The need for any corrective actions to reduce on-site emissions or install additional control measures will is determined on a case-by-case basis.

Monitoring data are also used to provide feedback to modify the dust management measures implemented at the site, if required. This plan is designed to be adaptive, effective, and achievable in both the short and long term. Components of the Air Quality Management Plan may need to be revised over the life of the Mine, based on regulatory changes and/or technological advances. Any modifications made to the overall Plan is communicated to regulatory authorities where applicable.

7.2.4 Incident Response Records

Incident response records is stored for a minimum of five years and made available for review upon request.

7.2.5 Permit Database and Amendments

The following permits related to air quality are currently held for the Mine:

- *Environmental Management Act* (2003) - Air Discharge Permit 107025.

Additional permit and permit amendments will be added on an as-needed basis.

8 REFERENCES

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Appendix A

Standard Operating Procedure: Dustfall Setup Instructions

APPENDIX A. STANDARD OPERATING PROCEDURE: DUSTFALL COLLECTION SITE SET UP

Equipment Required: Hand auger, shovel, screw driver and/or drill, zip ties, screws, felt marker

***Material Required*:** 5-foot pole (x2), wind shield, bird spikes, dustfall container, long bolts, washers, nuts.

The dustfall collection site should be placed in an open area, free of structures higher than 1 m within a 20-m radius of the container. It should be placed away from objects that could affect the settling of particulate matter such as nearby trees and local sources of pollution. Site accessibility should also be taken into consideration in the selection of a site.

The dustfall container is housed inside the wind shield which is mounted on the dustfall pole (Plate 1). The orifice of the dustfall bottle should not be lower than 6 feet from the ground. Dustfall sites typically consist of two dustfall collectors approximately 15 feet apart (Plate 2).

Plate 1. Dustfall container inside wind shield housing.

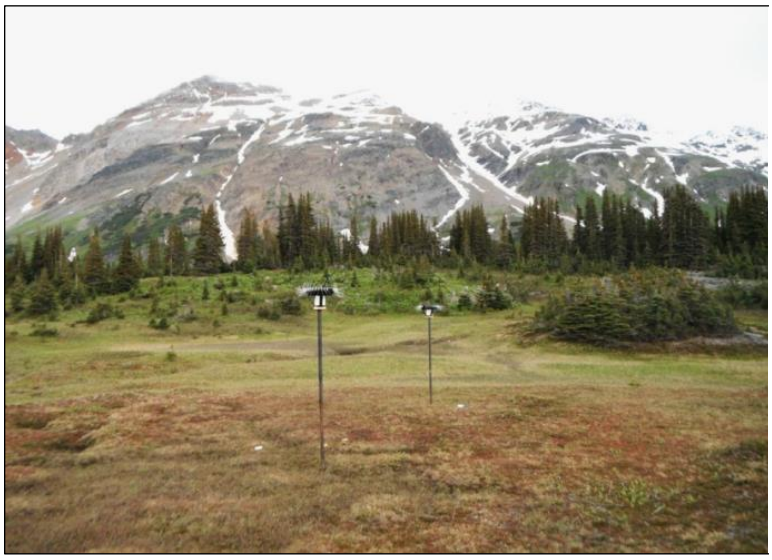

Plate 2. Typical dustfall collection site.

Installing and setting up a Dustfall collector site is a straight forward process that should take approximately 20 minutes to complete. The following are instructions on how-to set up the dustfall site once an appropriate location has been selected:

1. Assemble the pipe stand by coupling the two lengths of 5-foot pipe together with long bolts and nuts.
2. Connect the metal flange and treated wood block to the top of the stand with screws.

3. Attach the wind shield (Figure 1) to the dustfall stand by screwing the base of the shield to the wooden block at the top of the pole. There should be four holes predrilled in the base of the plastic shield where the screws can be placed.

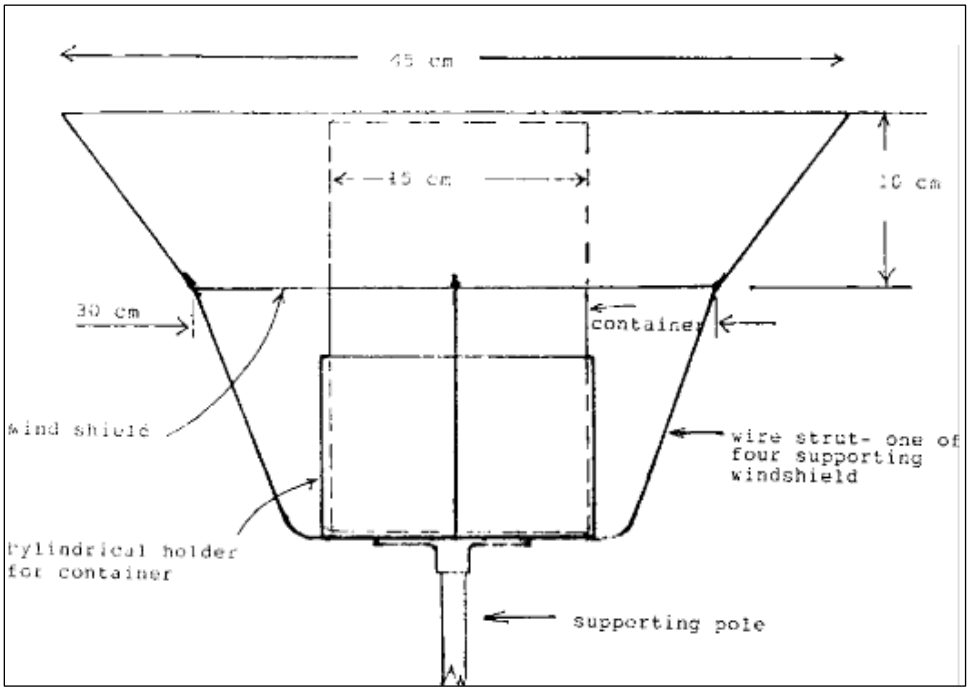

Figure 1. Wind Shield for Dustfall Container

4. Use zip ties to install the bird spikes at the top of the wind shield. Typically two sets are bird spikes are required to cover the circumference of the wind shield. Three evenly spaced zip ties should be used for each set of bird spike to ensure it does not slip down.
5. Use the hand auger to remove a column of soil at least 1.5 feet to 2 feet deep. If the ground is too hard, large rocks can be used to assist in propping up the dustfall pole. Do not use snow to hold the pole in place as it is prone to shifting and melting.

   (NOTE): Rather than using the hand auger, it may be easier to pound in the lower portion of the stand by placing a piece of scrap wood (2x4) on lower portion (to protect the threads) and using a medium sized sledge hammer to pound the lower portion in AND THEN attach the rest of the pole.

6. Place the bottom of the dustfall pole into the hole and ensure that it is able to stand freely. The stand should be stable enough to withstand strong gusts of wind.
7. By writing on a piece of flagging with sharpie or on the dustfall screen with a white marker, write **Total Metals (TM**) on one dustfall stand and **Total Particulate (TP)** on the other stand.
8. Retrieve the dustfall containers and use the felt marker to label the following information:
   a. Site Name (i.e., DF-1).
   b. Write Total Metals (TM) on one canister and Total Particulate (TP) on the other canister.

c. Project Name.

d. Date and Time Installed.

9. Remove the protective plastic wrap around the top of the collection containers.
10. Gently unscrew the white plastic lids on the collection containers.
11. Place the open dustfall container labeled Total Metals (TM) in the dustfall stand labeled Total Metals (TM) by placing it in the white PVC pipe that resides in the wind shield while ensuring not to touch the inside of the collection vessel (Figure 2).

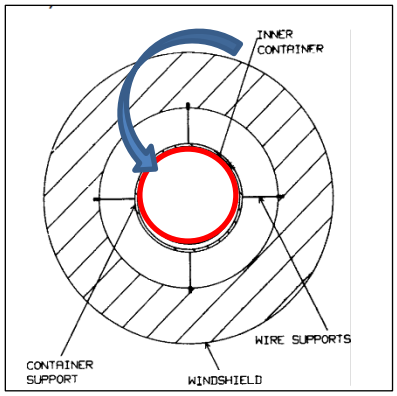

Figure 2. Plan view of wind shield.

12. Place the open dustfall container labeled Total Particulate (TP) in the dustfall stand labeled Total Particulate (TP) by placing it in the white PVC pipe that resides in the wind shield while ensuring not to touch the inside of the collection vessel (Figure 2).
13. Place all the lids in a ziplock bag to ensure the lids will not be contaminated. These lids will not be used again till the final demobilization in the fall, and they should be kept in a location where they will be found again.
14. Take photos of the apparatus, ensuring that in the photos it can be discerned which stand is **Total Particulate (TP)** and **Total Metals (TM)**.

Appendix B

Standard Operating Procedure: Dustfall Swap Instructions

APPENDIX B. STANDARD OPERATING PROCEDURES: DUSTFALL SWAP INSTRUCTIONS

1. There will be two dustfall stands at each dustfall station. One will be labeled by white marker or with sharpie on flagging, **Total Particulate (TP)** and the other will be labeled **Total Metals (TM)**.
2. The dustfall sample bottles are to be swapped at 30 day intervals, ± 1 or 2 days is fine.
3. On the new dustfall containers, use the felt marker to label the following information:
   a. Site Name (i.e., DF-1) on both canisters.
   b. Write **Total Metals (TM)** on one canister and **Total Particulate (TP)** on the other canister corresponding to the labels on the stand from which each canister was retrieved.
   c. Project Name on both canisters.
   d. Date and Time Installed on both canisters.
4. Remove the lid from the fresh bottle and put it on the bottle being recovered. **Write the date and time on the bottle being recovered**.
5. If the sample has been overfilled with rain or snow it should be noted during collection and sample may be voided. Bugs are fine to send to the lab. Make note if there is bird feces in the sample (**this would void the sample and it should not be sent to the lab**). Make a note of anything else which may impact the results, including if the sample was found on the ground, if there was anything else within the container or if there was anything surrounding the container which may have influence the results e.g. construction activities nearby. If there is anything else in the canister other than bugs (birds have been found) it will more than likely void the sample.
6. Put the canister labeled **Total Metals (TM)** in the stand labeled **Total Metals (TM)**. Put the other canister labeled **Total Particulate (TP)** in the stand labeled **Total Particulate (TP)**.
7. Take photos, ensuring that in the photos it can be discerned which stand is **Total Particulate (TP)** and **Total Metals (TM)**.
8. Fill out the Chain of Custody form. Examples have been provided. If anything noteworthy occurred then put this in the chain of custody form clearly marking which container was affected. Examples of noteworthy items are, if the stand was damaged by wildlife, if the sample canister was found on the ground, whether the sample canister had bird feces or had anything else that may have contaminated the sample. If one of the two samples at a site is void, clearly state that the sample which is being sent to the laboratory should be analyzed for <u>both</u> **Total Particulate (TP)** and **Total Metals (TM)**.
9. Bring the bottles back to camp and ship the two coolers to ALS Environmental in Burnaby. You can fit 8 bottles per cooler, maybe split the 10 bottles up between two coolers and add some stuffing in the coolers to ensure the bottles don't tip over during shipping.

10. Ship to:

ALS Environmental
8081 Lougheed Highway
Burnaby, BC
V5A 1W9
Attn: Amber Springer
Phone: (604) 253-4188

Appendix C

Standard Operating Procedure: Pass Installation and Swaps

APPENDIX C. STANDARD OPERATING PROCEDURE: PASS INSTALLATION AND SWAPS

Equipment and Materials Required: PASS rain shelter (Plate 1), hose clamps, mounting pole, passive filter medium.

Plate 1. SO_2, NO_2, and O_3 sample filters attached to the rain shelter.

Site Selection Requirements: The PASS collection site should not be located near pollution sources that can cause inappropriately high measurement. Monitoring sites should not be close to roadways. There should be a distance of more than 10 m between the site and a roadway. The site should be selected to represent a typical air pollution concentration. The site should be flat, and located away from nearby obstructions such as buildings or trees. The site should be more than 20 m from the nearest tree canopy defined by the drip line. Be aware that the last requirement may be very difficult to meet in many sampling locations.

Installation: It is recommended to at least duplicate samplers for each monitoring location. To validate results, travel blanks must be included. The requirements for Alberta Environment are as follows:

- Rain shelter should be 1 – 3 m above ground;
- Election angle should be less than 30° from the rain shelter to the top of any obstacle (Figure 1); and
- The distance from the obstacle to the rain shelter should be greater than 10 times the obstacle height.

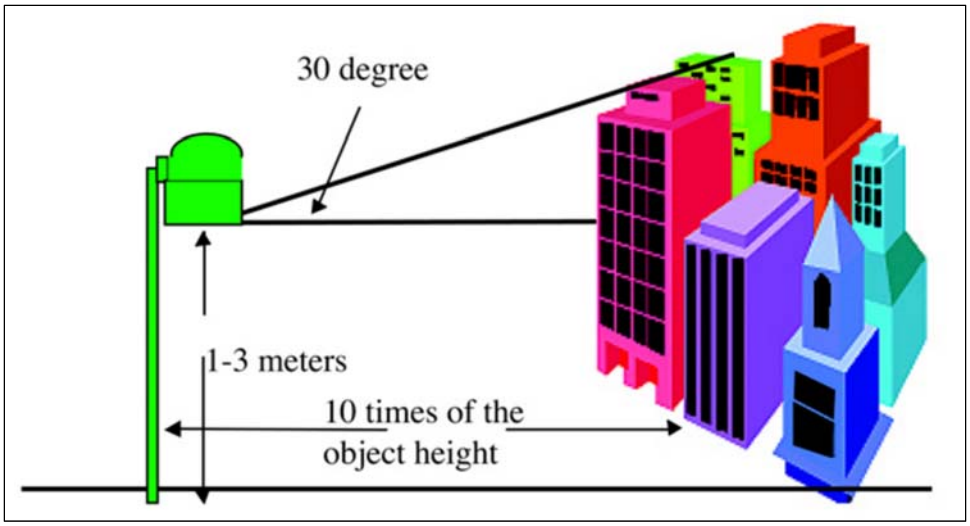

Figure 1. PASS Rain Shelter Installation Recommendations (as per Alberta Environment)

The rain shelter should be installed to prevent interference from animals/humans or the surroundings. More than 1 shelter in one location can be installed together. The exposure start and end times should be recorded on a field sampling sheet.

Typically the PASS shelter is mounted on the dustfall pole (Plates 2 and 3).

Plate 2. Pass Filters in Rain shelter attached to wood dustfall stand.

Plate 3. Pass filters in rain shelter attached to metal dustfall stand.

One side of the PASS shelter has a slot to insert a hose clamp or strapping to attaché the shelter to a metal pole or a wooden one.

A set of travel blanks must be taken when the samples are recovered and sent to the laboratory for analysis.

Instructions for Swapping PASS sample filters:

1. Take a set of filters labeled blanks and a new set of filters to be deployed.
2. On the filters to be deployed, write the station ID and installation date on the plastic on the back of the filter (not on the removable plastic cap or on the filter paper).
3. Remove the current set of filters from the rain shelter and write down the removal date, then replace with the new round of filters. Be sure to remove the white plastic cap on the new filter.
4. Put the old filter in the container that the new filter came in.
5. Take photos.
6. Fill out the CoC form and ship to:

Maxxam Analytics
Attn: Passive Air
6716 – 50th St.
Edmonton AB
T6B 3M9

Appendix 9-1-3. Ancillary Infrastructure Decommissioning and Reclamation Plan

BRUCEJACK GOLD MINE

Ancillary Infrastructure Decommissioning and Reclamation Plan

December 2018

PRETIVM

BRUCEJACK GOLD MINE

Ancillary Infrastructure Decommissioning and Reclamation Plan

Date: December 2018

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
1	May 2015	M. Holtby, S. van Zalingen	Chapter 5, submitted as part of the Brucejack MAEMA Application
2	December 15, 2018	Pretium Resources Inc.	Revised from proposed infrastructure to current ancillary facilities

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The Ancillary Infrastructure Decommissioning and Reclamation Plan was originally prepared by ERM for Pretium Resources Inc. and formed part of the **Ancillary Infrastructure Decommissioning and Reclamation Plan, Reclamation and Closure Plan, and Soils Management Plan**, the content of which was comprised of parts of Chapter 5: Reclamation Planning and Effective Mine Closure of the joint *Mines Act* and *Environmental Management Act* permit application submitted in May 2015.

This version of the Ancillary Infrastructure Decommissioning and Reclamation Plan is updated by Pretivm to reflect the progression from proposed facilities to constructed facilities and to separate those facilities where reclamation obligations are under *Mines Act* Permit M-243 from facilities where reclamation obligations fall under other licensing, permits and Acts.

BRUCEJACK GOLD MINE

Ancillary Infrastructure Decommissioning and Reclamation Plan

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GLOSSARY AND ABBREVIATIONS

ACP	Aboriginal Consultation Plan
Application	Application for an Environmental Assessment Certificate
BC	British Columbia
BEC	Biogeoclimatic Ecosystem Classification
cm	Centimetre(s)
Code, the	*Health, Safety and Reclamation Code for Mines in British Columbia* (BC MEMPR 2017)
EAC	Environmental Assessment Certificate
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
ESSFwv	Engelmann Spruce-Subalpine Fir Wet Very Cold subzone
Ha	Hectare(s)
HDPE	High-density Polyethylene
ICHvc	Very Wet Cold Interior Cedar Hemlock subzone
kg	Kilogram(s)
km	Kilometre(s)
kW	Kilowatt(s)
L	Litre(s)
LOM	Life of mine
LOO	Licence of Occupation
m	Metre(s)
masl	Metres above sea level
MEMPR	British Columbia Ministry of Energy, Mines and Petroleum Resources
MECCS	British Columbia Ministry of Environment and Climate Change Strategy
MFLNRORD	British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development

MHmm2	Mountain Hemlock-Leeward Moist Maritime Variant subzone
NLG	Nisga'a Lisims Government
NPAG	Not potentially acid generating
NPK	Nitrogen, phosphorus, and potassium
Pretivm	Pretium Resource Inc.
RRA	Relevant Regulatory Agency
ROW	Right-of-way
SUP	Special Use Permit
TSKLH	Tsetsaut Skii km Lax Ha First Nation
V	Volt
WTP	Water treatment plant

1 PURPOSE, SCOPE, AND PERFORMANCE OBJECTIVES

The purpose of the Ancillary Infrastructure Decommissioning and Reclamation Plan for the Brucejack Gold Mine is to provide a reclamation and closure plan for all ancillary mine infrastructure built in support of the Brucejack Gold Mine but not included under auspices of the *Mines Act* Permit M-243. The Plan specifically takes into account the conditions of the Licenses of Occupation Management Plans, MFLNRORD Engineering Manual road deactivation techniques and general reclamation performance objectives of Environmental Assessment Certificate M#15-01. The plan is applicable during the Operations and Closure phases of the mine.

The scope of this reclamation plan includes the Special Use Permit area (access road) and Licenses of Occupation areas: Knipple Transfer Area, Bowser Aerodrome and beacons, Bowser Camp, Wildfire Camp, southern 36 km of the Brucejack Transmission Line, explosive storage areas, communications towers, avalanche control systems, and meteorological stations.

2 RELEVANT LEGISLATION, REGULATIONS, AND EAC CONDITIONS

2.1 RELEVANT LEGISLATION AND REGULATIONS

The access road Special Use Permit is subject to the regulations and standards of the *Forest Act, Forest Practices Code of British Columbia Act, Forest and Range Practices Act, Mining Right of Way Act, Nisga'a Final Agreement* and the *Wildfire Act*. Licenses of Occupation are subject to each specific license and management plan, the *Land Act* and the *Heritage Conservation Act*. The ancillary facilities reclamation and closure are subject to conditions of the *Environmental Assessment Act* Environmental Assessment Certificate # M15-01 and acts and regulations pertaining to silviculture practices.

2.2 RELEVANT EAC CONDITIONS

Pretivm was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015, that included a series of conditions associated with the Certificate. This management plan is in support of Condition #2, in relation to a Component Plan for Ancillary Infrastructure Decommissioning and Reclamation, presented within Schedule B of the Certificate and copied below.

> *Condition 2*
>
> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

2.3 RELEVANT PERMIT CONDITIONS

The Licenses of Occupation and associated Management Plans require that each site be returned in a safe, clean and sanitary condition, and that any improvements the tenure holder wishes to remove or the Ministry of Forests, Lands, Natural Resource Operations and Rural Development require to be removed within 90 days of termination of the license. The surface of the site is to be returned to the condition that the land was in at the time of license issuance unless an improvement is to remain.

The road under Special Use Permit S25923 is to be deactivated to the satisfaction of the Ministry of Forests, Lands, Natural Resource Operations and Rural Development District Manager. Future use by others will preclude the need for permanent deactivation.

3 ANCILLARY FACILITES & ENVIRONMENTAL PROTECTION

3.1 INTRODUCTION

The Ancillary Infrastructure Decommissioning and Reclamation Plan follows the structure outlined by the FLNRORD Licenses of Occupation Management Plans and Engineering Manual for road deactivation. Major topics include end land use and capability objectives, reclamation approaches, and a conceptual final reclamation plan. The content while building on the conceptual plan provided in the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS; ERM Rescan 2014) is modified for conditions and structures built on the LOOs.

Reclamation and closure planning of the mine has been integrated with overall mine planning and design. The mine and its support facilities have been planned and designed to minimize the terrestrial development footprint and to prevent significant adverse effects on the environment.

The duration of the mine itself Closure phase is estimated at three years. A monitoring period of five years has been planned for the beginning of the Post-closure phase. Ancillary Infrastructure will be decommissioned at a rate commensurate with manpower and equipment requirements at the mine site and the need for transmission line power and for road access to the mine site. Individual facilities will be reclaimed as their need or extent becomes unnecessary.

The Ancillary Infrastructure Decommissioning and Reclamation Plan addresses infrastructure components authorized under Licences of Occupation (LOOs) and the Special Use Permit (SUP), as follows:

- Brucejack access road (Special Use Permit);
- Licenses of Occupation (LOO):
    1. Bowser Aerodrome with beacons;
    2. Bowser Camp;
    3. Knipple Transfer Area;
    4. Wildfire Camp;
    5. Explosives Staging areas;
    6. Communications towers;
    7. Avalanche control systems;
    8. Meteorological stations; and
    9. Southern 38 km of the Brucejack Transmission Line, extending north from the tie-in with the Long Lake Hydro substation.

Surface disturbance areas are generally quite small compared to the entire area of the Licenses of Occupation and Special Use Permit, particularly for non-camp licenses. Table 3.1-1 lists the licensed

areas and disturbance areas (i.e., areas involving surficial soil/overburden disturbance) and in the case of the transmission line primarily the area of tree cutting. See Figure 1 for locations. The total disturbance areas for ancillary infrastructure is approximately 313.3 ha, one-half that being solely tree clearing for the transmission line.

Table 3.1-1. Ancillary Facilities Licensed Areas and Disturbed Areas

Ancillary Component	License Area (ha) [1]	Disturbed Area (ha) [1]
Avalanche Control Sites (3)	18.16	0.30
Explosive Storage Sites (2)	14.86	2.10
Bowser Camp	18.23	10.78
Bowser Aerodrome and beacons	106.68	27.25
Communication Towers	3.28	0.09
Knipple Transfer Area	27.77	7.79
Wildfire Camp and Laydown	4.06	0.61
SUP Access Road (km 0-59)	1,168.44	104.83
Weather Station	0.25	0.02
Transmission Line – southern 38 km	2941.182	159.55
TOTAL	**4,299.382**	**313.32**

[1] *LOO disturbances are exclusive of overlapping Special Use Permit areas.*

3.2 FACILITIES

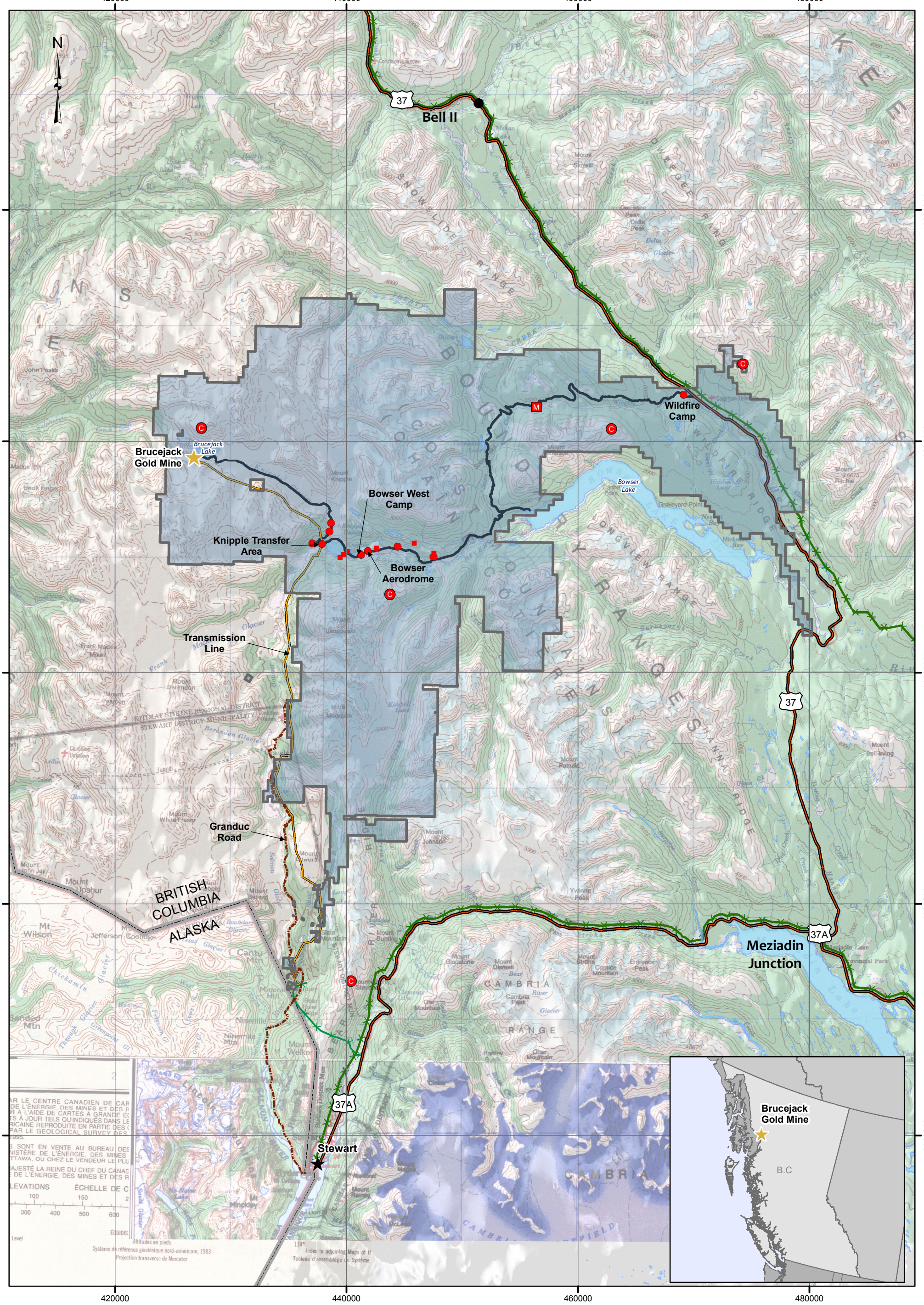
3.2.1 Access Road

Road access to the Mine Site is via the 73-km Brucejack Access Road from km 215 on Highway 37 (Figure 2). The road comprises a 58-km all-weather gravel surfaced segment extending from Highway 37 to the Knipple Glacier; a 12 km segment across the glacier; and a 3-km all-weather gravel surfaced segment (Lakeshore Drive) from the upper exit off Knipple Glacier to the Mine Site. The Lakeshore Drive segment is included in the Mine Site Area and is not subject to this management plan.

The access road includes a 2.5 km side road to Bowser Lake, 23 bridges, 5 toad tunnels, 1 modified bridge for toad access, about 310 culverts and the intersection with Highway 37. Included within the road permit SUP are gravel pits and rock quarries where materials are sources for road construction/ maintenance.

3.2.2 Wildfire Camp

Wildfire Camp is located at km 1 on the access road. Included in the infrastructure of Wildfire Camp is the gate and gatehouse at the intersection with Highway 37, a security building and gate on the east side of the camp, bunkhouses, kitchen facilities, septic field, potable water well with a pipeline and treatment facilities, storage facilities, parking and laydown areas (Figure 3). The camp occupies approximately 0.6 ha with all other disturbance within the road SUP.



Facilities on LOO
Aerodrome Beacons
Communication Towers
Meteorological Station
Gold Mines selection
Pretium Mineral Claim Boundary
Highway 37 / 37A
Granduc Road
Transmission Line
Brucejack Access Road
BC Hydro Transmission Line
Long Lake Transmission Line

5 2.5 0 5
Kilometers

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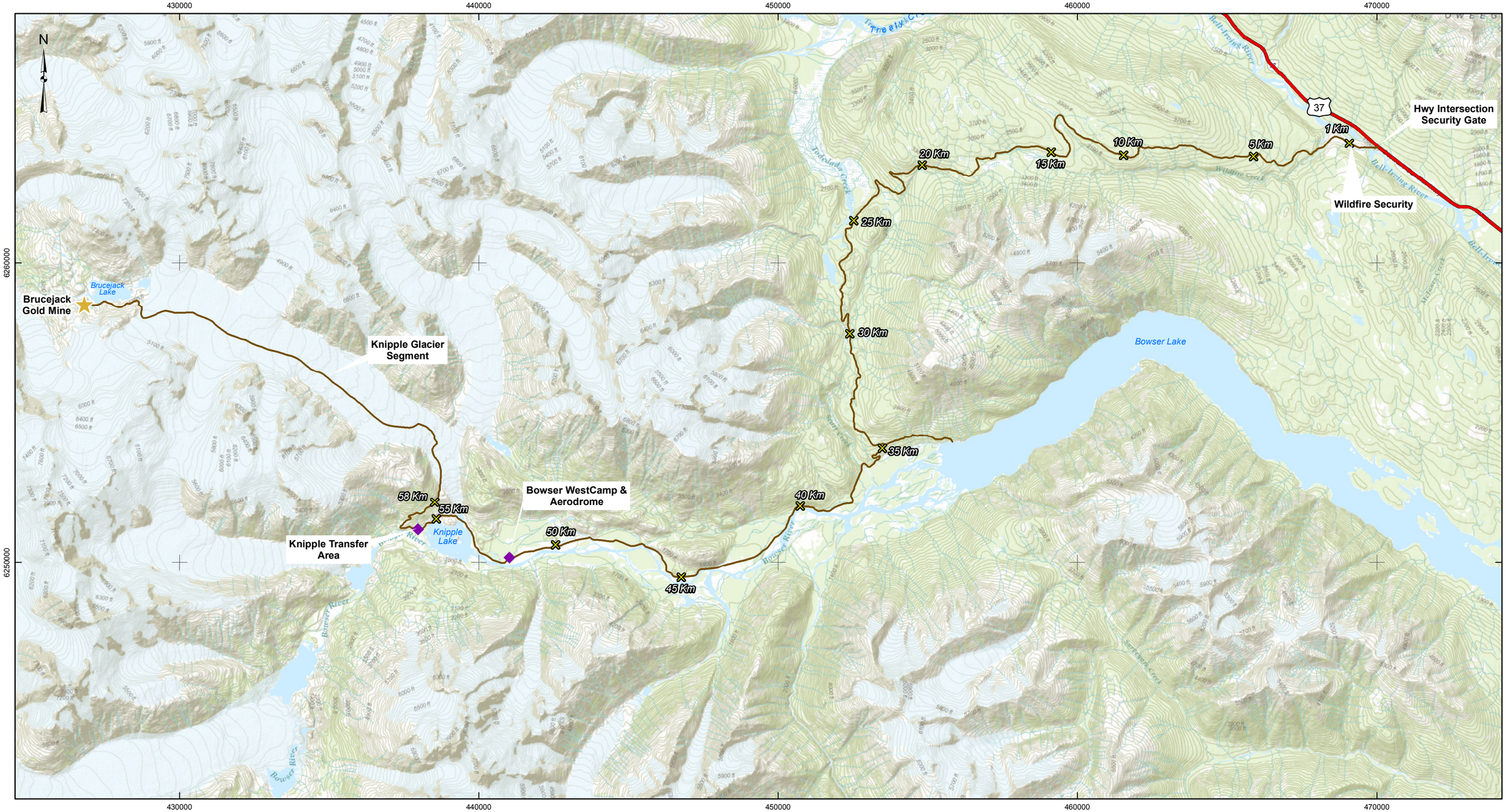
PRETIUM RESOURCES INC.
Brucejack Gold Mine

Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 1
Facilities & Licenses

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_BJ_1200_General_Location_Map_11X17_20181205		1:300,000	13 Dec 2018		1

PROJECTION: UTM Zone 9 (NAD 83)



Brucejack Gold Mine

Camp Sites

Surveyed Km Markers

Brucejack Access Road

0 1 2 3 4 5

Kilometers

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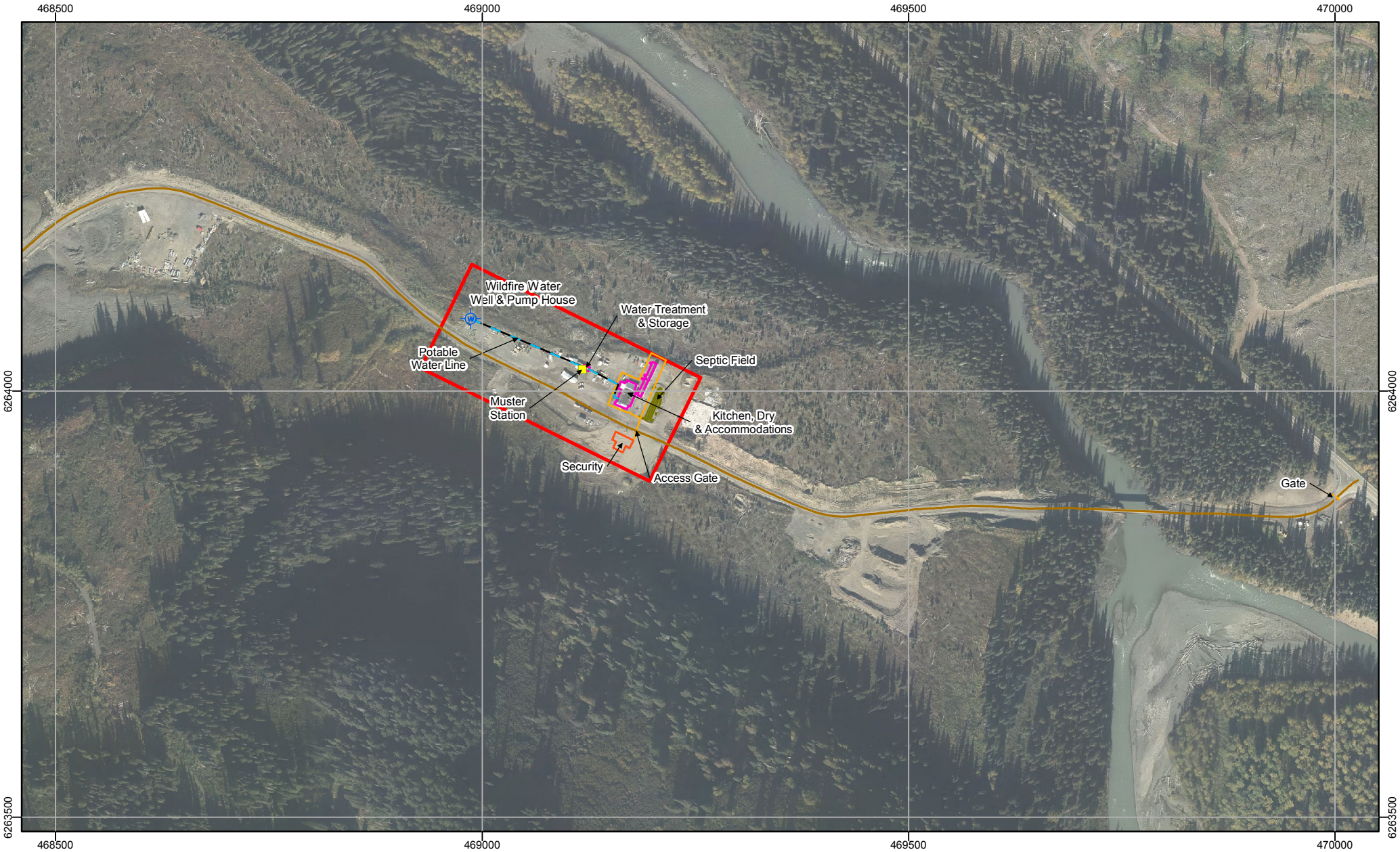
Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 2
Brucejack Access Road

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_BJ_1050_Access_Road_11x17_20181206	UTM Zone 9 (NAD 83)		1:120,000	13 Dec 2018		2



Muster Station
Wildfire Water Well & Pump House
Brucejack Access Road
Potable Water Line
Security
Buildings
Seasonally Electrified Fence
Septic Field End Boards
Inside Toe-Septic Field
LOO (SK920877)

0 100 200 300
Meters

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PROJECTION: UTM Zone 9 (NAD 83)

Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 3
Wildfire Camp

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_WF_1000_85x11_20181212		1:6,000	13 Dec 2018		3

3.2.3 *Scott Pass Weather Station*

Scott Pass weather station is located at km 18 on the access road, Plate 3.2-1. It is located in a small clearing on the north side of the road and comprises a 10-m tower with instruments and a battery with solar panels for a power source, and a 3-m tower with a precipitation gauge.

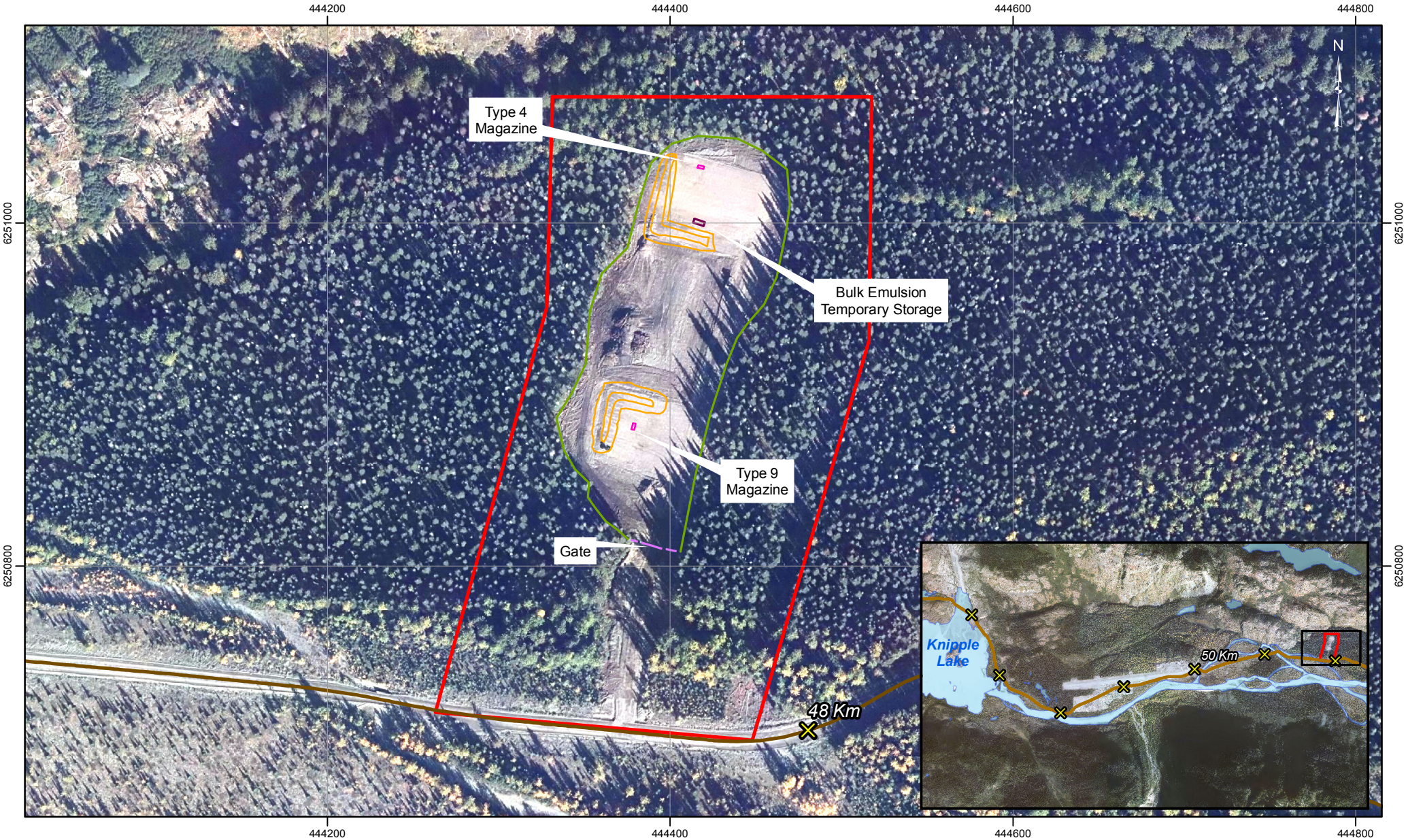
Plate 3.2-1. Scott Pass weather station.

3.2.4 *Bowser Explosives Storage Area*

Located at km 48, this explosives storage area is one of two LOO licensed for the purposes of temporary storage of bulk explosives should immediate delivery to the mine not be feasible due to weather or other causes. Also, magazines for storage of explosives for avalanche control or quarry purposes are kept at this location. The site comprises a fenced and gated clearing in the forest with an access road and berms between the magazine storage areas (Figure 4).

3.2.5 *Bowser Camp and Aerodrome*

Bowser Camp is located at 51 km on the access road. The site has undergone several iterations from an early exploration camp to a construction and road maintenance station with extensive laydown areas for construction materials. The old camps (original Bowser Camp and the temporary construction camp) have been abandoned due the discovery of a potential landslide hazard on a mountain side along a tributary creek south of Bowser River. At the time of this management plan revision the older camps are partially dismantled and are actively undergoing reclamation.



Surveyed Km Markers
Explosive LOO
Berm
Fence
Emulsion
Magazine
Trees

0 25 50 100 150
Meters

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PROJECTION: UTM Zone 9 (NAD83)

Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 4
Bowser Explosives Storage Area

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
P01	BOW_7100_Explosives_Km48_85x11_20181206		1:3,000	13 Dec 2018		4

To avoid the landslide hazard a new camp, Bowser West, was established on the north side of the access road in the northwestern corner of Bowser LOO. Bowser West Camp is used by regional exploration crews not connected with mine operations. The camp has bunkhouses, a kitchen, a water well with a pipeline and treatment facility, offices, and drill core logging and sampling facilities. Also located within Bowser LOO are a soils with hydrocarbon contamination treatment facility, drill core storage, storage facilities and laydown yards.

Tsetsaut Skii km Lax Ha have a cabin at Bowser West.

Bowser Aerodrome is located in a separate LOO along the north side of Bowser LOO. A 5,395-foot long by 75-foot wide gravel surfaced runway has been constructed with cleared areas along the sides and ends (Figure 5). Included within the Aerodrome LOO are 6 aviation beacon sites on hills to the east, west and northeast of the runway. The airstrip is in the early stages of use with further facilities to be added as per the original design.

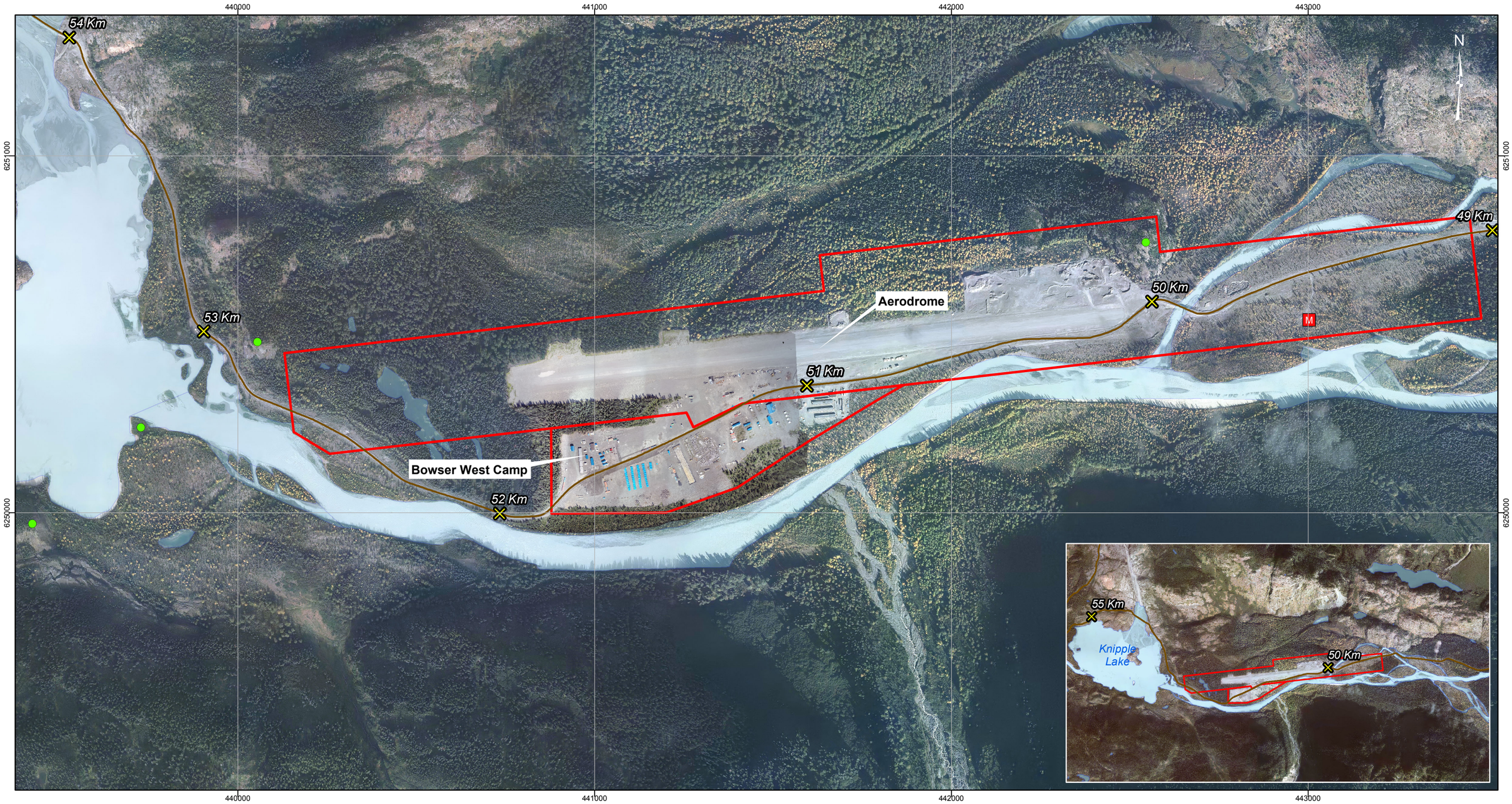
3.2.6 Knipple Transfer Area

Knipple Transfer is located at 55 km on the access road. It is the camp for road maintenance crews and logistical personnel associated with transport of materials to the mine. Materials are trucked in to Knipple Transfer by highway transport vehicles and then transferred to vehicles for delivery to the mine. Cold storage is provided for food stores, silos for storage of cement binder used in paste backfill operations at the mine, a laboratory for testing mill processes and acid rock drainage potential of mined material and tailings, an electric substation where the transmission line voltage of 138 kW is reduced to 69 kW before transmission to the mine, a camp for personnel, bulk storage of fuels required at the mine, a truck maintenance shop, an emergency vehicle storage building and a waste handling facility with an incinerator (Figure 6).

The fuel dispensing system with facilities for diesel, gasoline, and aviation fuel includes double-walled tanks and an HDPE lined retention pad under the refueling area that is equipped with an oil/water separator.

3.2.7 Transmission Line

Beginning near the Long Lake Hydroelectric Substation in the south, this area extends approximately 57 km to the mine. The LOO only comprises the southern 38 km of the transmission line as the northern 19 km is permitted under *Mines Act* permit M-243. While this Ancillary Infrastructure Decommissioning and Reclamation Plan is intended to inform about those facilities off the *Mines Act* permit similar reclamation activities to those described herein apply to the northern 19 km of the transmission line. The transmission line is a 138 kW hydroelectric line connected to the BC grid via the Long Lake Hydroelectric line. The line consists of 135 towers, primarily monopoles but also 13 four-leg poles (Plates 3.2-2 and 3.2-3). There is a control station located about 1 km north of the Long Lake substation and a substation at Knipple Transfer Area where line wattage is stepped down to 69 kW for transmission to the mine (Figure 7). The substation was sited at Knipple Transfer Area following determination that grounding of the 138 kW line at the mine would not be safe for underground operations. BC Hydro control of power transmission extends to the control station 1 km north of the Long Lake substation.



Beacons

LOO

Bowser Meteorological Station

Surveyed Km Markers

Brucejack Access Road

0 100 200 400

Meters

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Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 5
Bowser Camp & Aerodrome

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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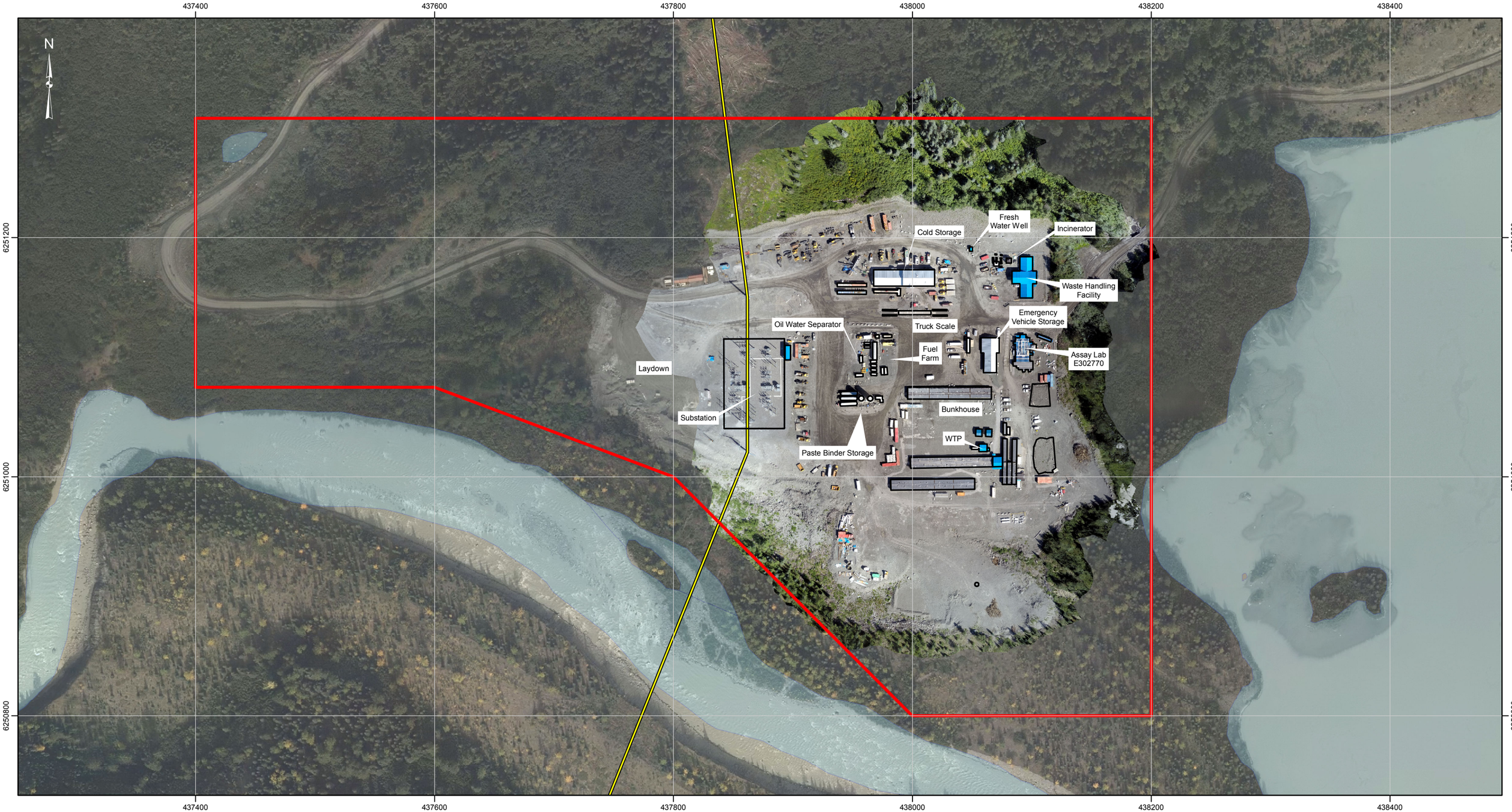

Transmission Line

Knipple Layout (Not Surveyed)

Licence of Occupation (LoO)

0 25 50 100 150

Meters

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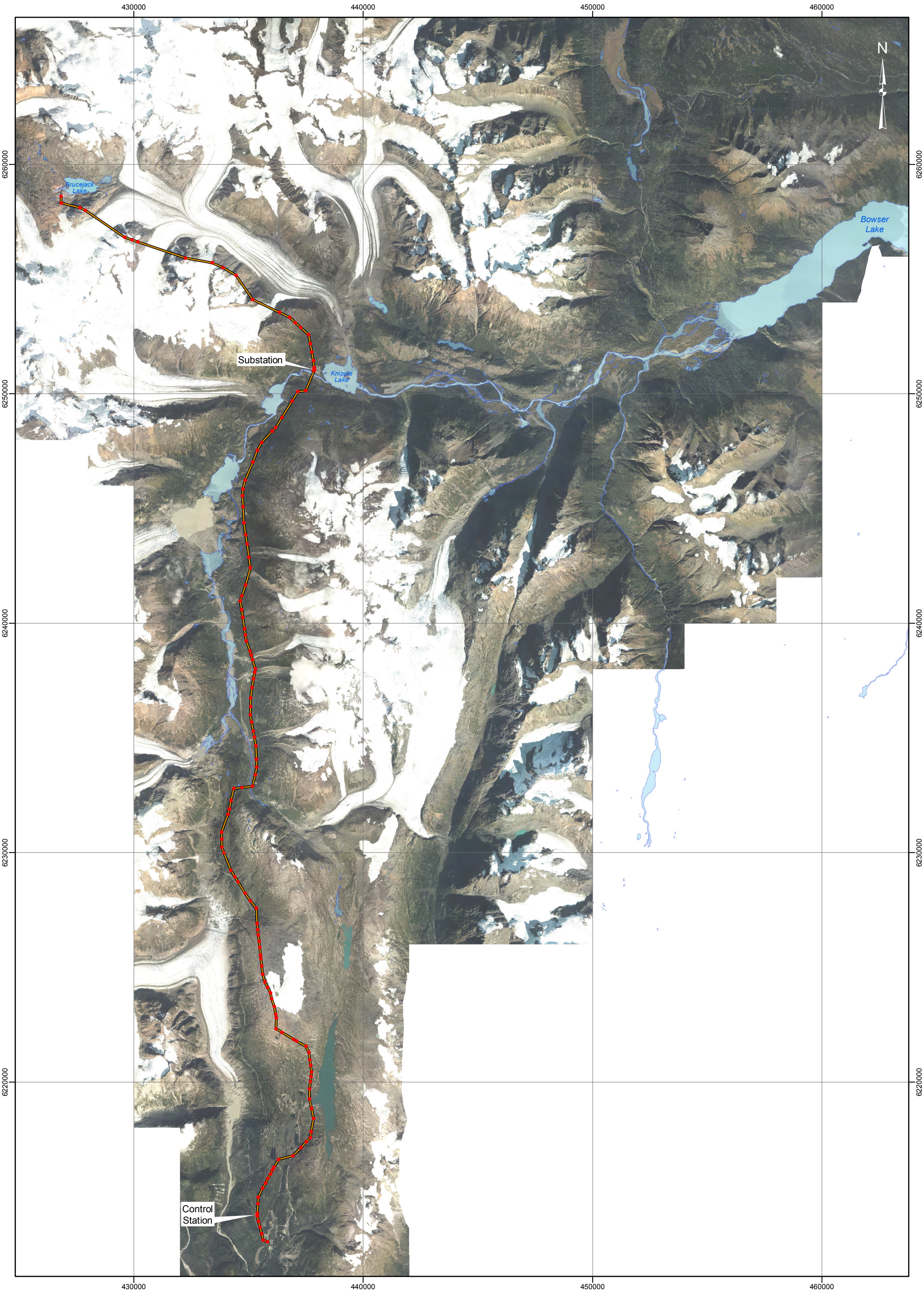
Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 6
Knipple Transfer Area

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_KN_1000_11x17_20181206	NAD 1983 UTM Zone 9N		1:3,000	13 Dec 2018		6



Transmission Towers

Transmission Line

0 2.5 5

Kilometers

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Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 7
Transmission Line

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_BJ_1400_Transmission_11x17_20181205		1:150,000	13 Dec 2018		7

PROJECTION: UTM Zone 9 (NAD 83)

Plate 3.2-2. Typical monopole.

Plate 3.2-3. Typical four-leg pole.

3.2.8 Communication Towers

Communication towers are located on mountain sides or ridges where line-of-sight microwave distribution is possible from Brucejack to Stewart via a tower overlooking Stewart and between Wildfire, Bowser and Brucejack. Five LOO are shown on Figure 1; Plate 3.2-4 shows a typical communication system. They comprise a tower with Microwave reflector, radio repeater, electronics container and power source.

Plate 3.2-4. Typical communications site.

3.2.9 Miscellaneous Sites Used during Construction

During construction of the transmission line 3 sites along the Granduc Mine road were used for camp or laydown and materials mobilization. These were Troy Flats, Redeye and Tide Staging, locations are shown on Figure 8.

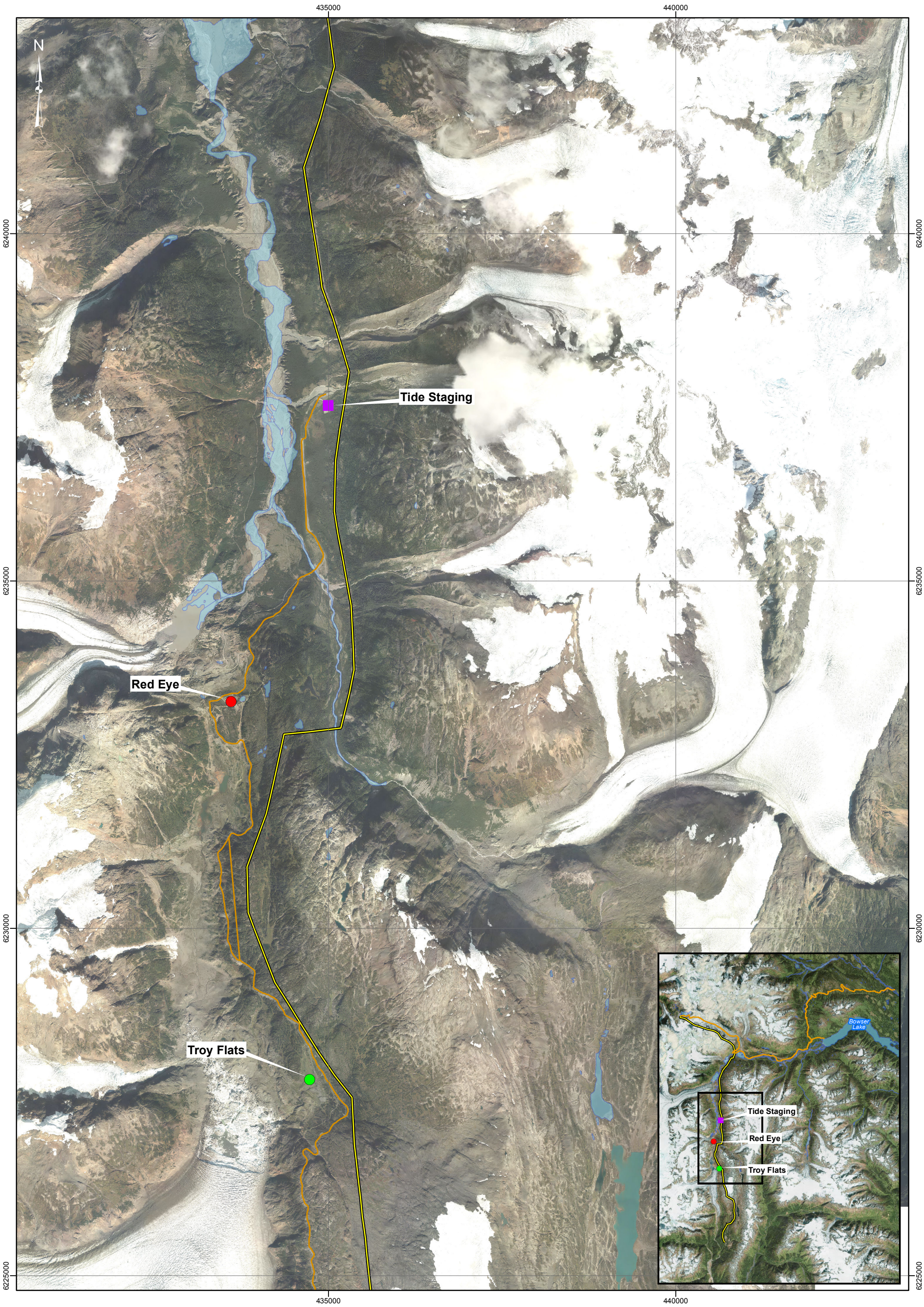
3.2.9.1 Troy Flats

Troy Flats was used as a laydown for a short period during construction of the southern portion of the transmission line. Troy Flats was the site of a construction camp during Granduc Mine access road construction in the early 1960s and there are remnants of old mine workings that appear to date from the early 20th Century. It consists of four distinct pads: the northern area is a rocky prepared laydown without vegetation cover, and three southern laydown areas with vegetation are on the periphery of each area (Figure 9). There is evidence of repeated use by various mineral exploration crews.

The site was abandoned on orders of EAO and became an active reclamation site soon after. An appropriately qualified R. P. Bio. prepared a reclamation plan which was forwarded to EAO for comment and approval. The objective of the reclamation is to bring disturbed areas to a stable condition vis-a-vis erosion and re-establish vegetation on those areas that were previously vegetated.

3.2.9.2 Redeye

Redeye was a construction camp developed in agreement with the private landowner. It is located immediately east of the Granduc Mine road at the eastern margin of Granduc Mine site (Figure 10). Following the end of construction of the transmission line south of Knipple Transfer Area the camp was removed and the site cleaned.



Tide Staging
Troy Flats
Red Eye
Granduc Road
Transmission Line

0 0.5 1 2
Kilometers

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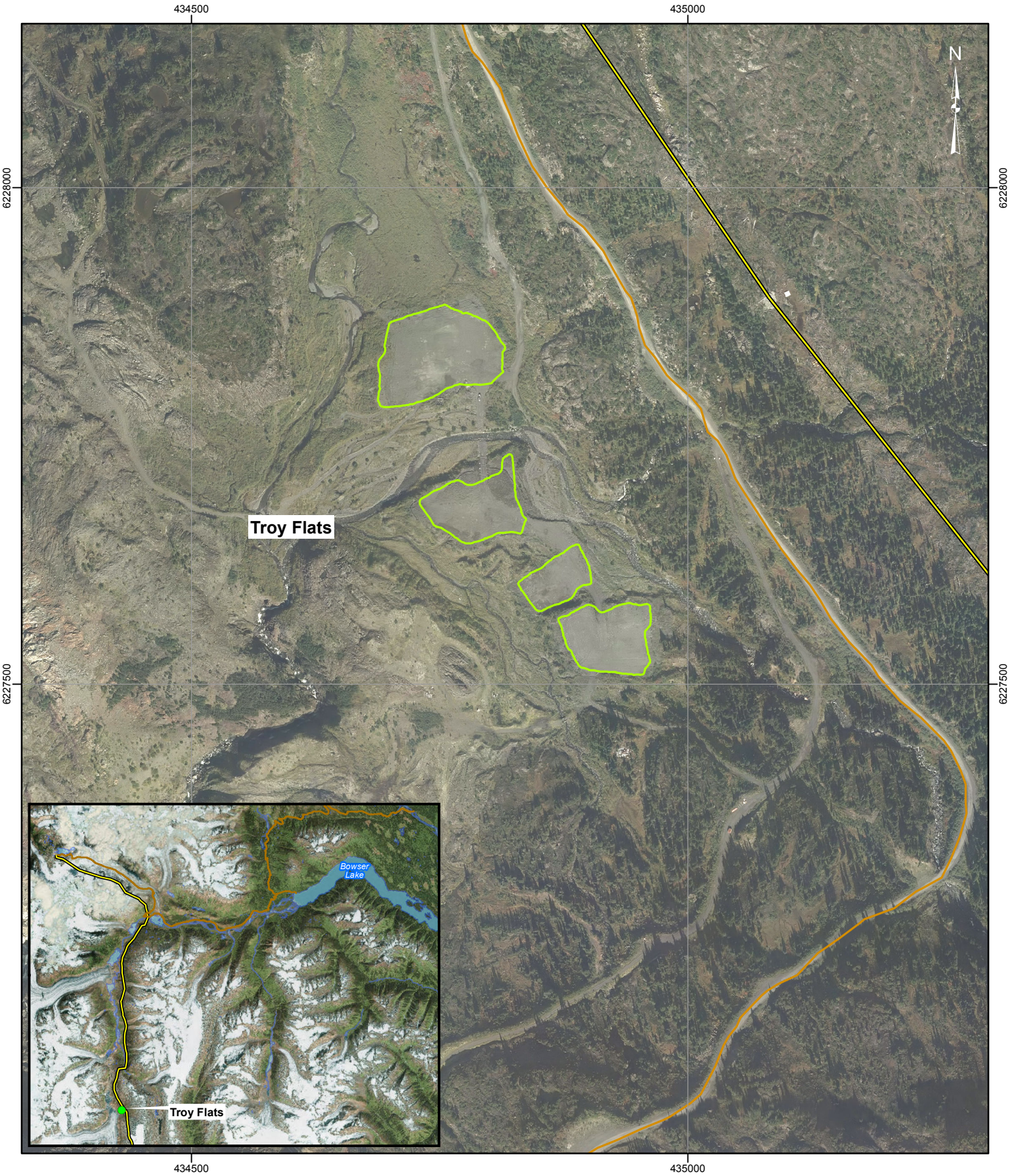
PRETIUM RESOURCES INC.
Brucejack Gold Mine

Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 8
Granduc Road
Miscellaneous Sites

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_RE_TS_TF_0000_Location_11x17_20181207			13 Dec 2018		8

PROJECTION: UTM Zone 9 (NAD 83)



Troy Flats

Granduc Road

Transmission Line

0 50 100

Meters

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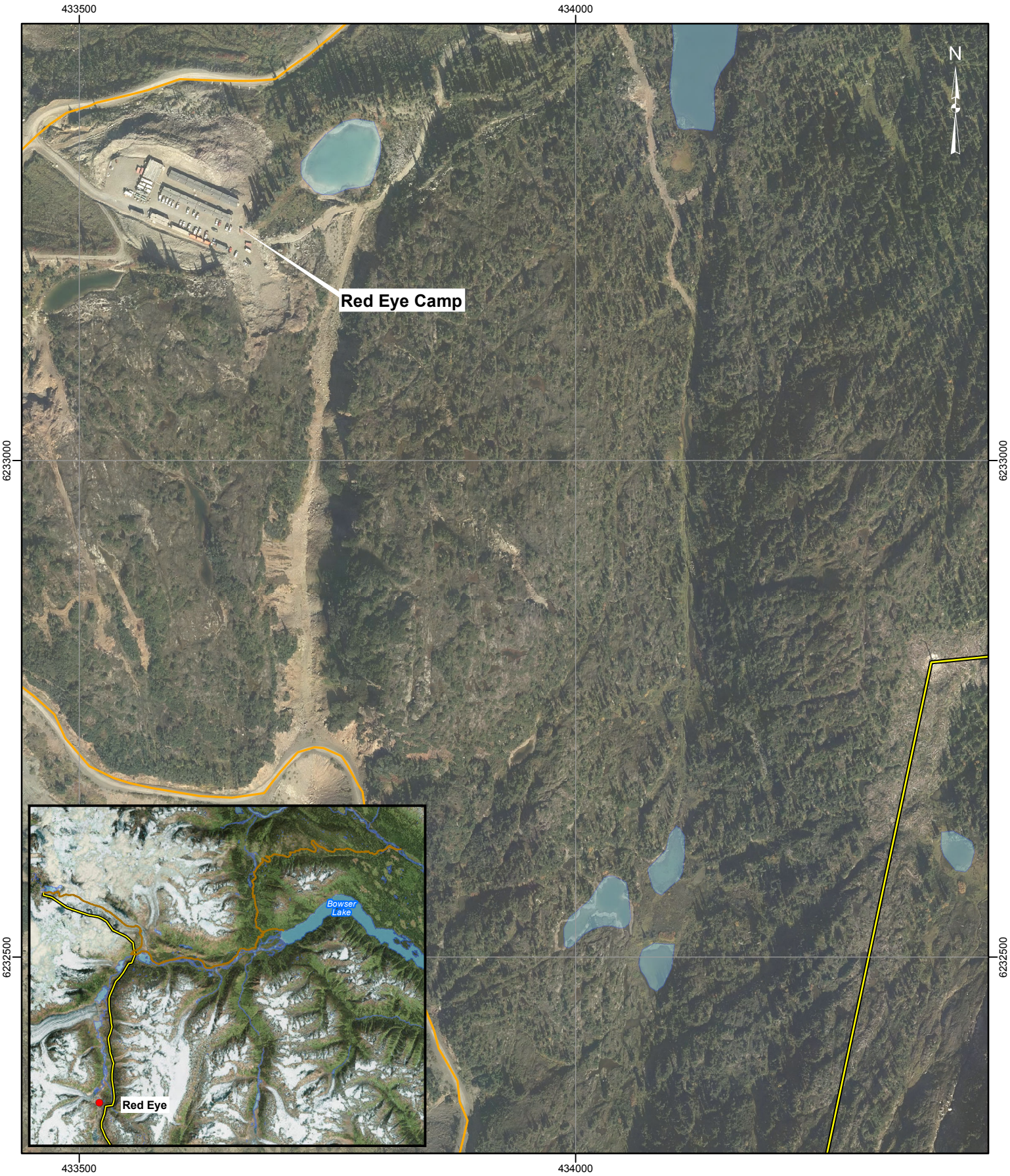
PRETIUM RESOURCES INC.
Brucejack Gold Mine

Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 9
Troy Flats

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_TF_0000_Location_85x11_20181207		1:5,000	13 Dec 2018		9

PROJECTION: UTM Zone 9 (NAD 83)



Granduc Road

Transmission Line

0 50 100

Meters

PRETIVM

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PRETIUM RESOURCES INC.
Brucejack Gold Mine

Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 10
Red Eye Camp

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_RE_0000_Location_85x11_20181207		1:5,000	13 Dec 2018		10

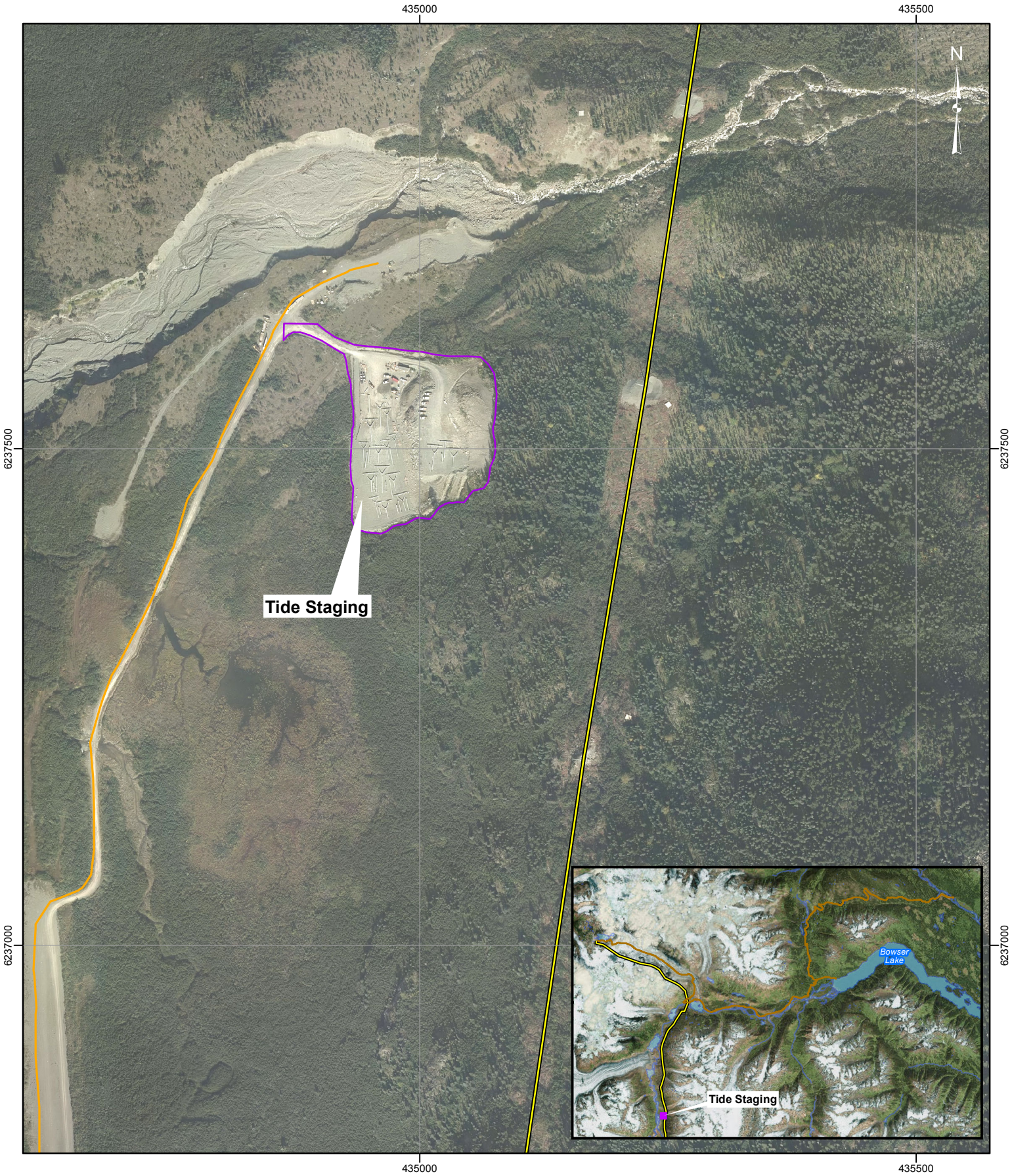
PROJECTION: UTM Zone 9 (NAD 83)

Unfortunately, site preparation for the camp was undertaken in the early winter with the result that the camp pad included snow mixed with rock and soil. This mixture of snow with soil and rock resulted in an unstable mixture that has slumped off the northern edge of the pad. Reclamation began with northern slope stabilization and exposing entrained snow in 2017 followed in 2018 by initiation of a program to reduce the northern slope angle. In 2019 these reclamation efforts will continue by further cutting back the slope and reduction in angle of the pad's northern slope, removal of entrained snow and stabilization of the pad materials.

The private land owner has an agreement with the local heli-skiing company whereby helicopters refuel at a tank located on the pad. Reclamation efforts will not interfere with the heli-skiing company's ability to refuel helicopters at the site.

3.2.9.3 Tide Staging

Tide Staging is located at the northern end of the Granduc road system on the east side of Bowser River (Figure 11). The site is located on a Pretivm mineral claim and was permitted and prepared as a staging/camp location for mineral exploration on Pretivm mineral claim holdings south of Bowser Camp and as a staging location for equipment and personnel transport to Brucejack during early underground exploration efforts. In 2012 the facility was permitted under *Mines Act* permit MX-1-881 and was used for staging of equipment and crews to Brucejack and as a base for exploration crews working elsewhere on Pretivm mineral claims. It was used as a staging area for construction of the transmission line between Granduc and Knipple Transfer Area. The site has reverted to its original purpose as a staging area for mineral exploration on Pretivm mineral claims, and remains permitted for such activity. For the foreseeable future it will only be reclaimed to the extent of surface stabilization and water protection measures similar to any mineral exploration site. Should any of the site not be required for exploration purposes reclamation will follow requirements of the *Mines Act* permit and Health, Safety and Reclamation Code for Mines in British Columbia.



Tide Staging

Granduc Road

Transmission Line

0 50 100

Meters

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PRETIUM RESOURCES INC.
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Ancillary Infrastructure Decommissioning & Reclamation Plan
Figure 11
Tide Staging

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_TS_0000_Location_85x11_20181207		1:5,000	13 Dec 2018		11

PROJECTION: UTM Zone 9 (NAD 83)

4 END LAND USE AND CAPABILITY OBJECTIVES

4.1 INTRODUCTION

Pre-development land use and conditions generally form the basis for identifying the end land use and capability objectives. End land use and capability objectives have been integrated with planning and design to optimize successful reclamation and closure.

This Ancillary Infrastructure Decommissioning and Reclamation Plan provides the plan of how end land use and land capability objectives will be achieved to the extent feasible by the end of the Closure period. The following subsections describe existing conditions and end land use and land capability objectives for the various components. Biophysical information for the components has been obtained from the environmental baseline studies presented in the Project's Application/EIS (ERM Rescan 2014) and from additional site updates as relevant.

4.2 SITES ALONG THE ACCESS ROAD FROM HIGHWAY 37 TO KNIPPLE GLACIER

Lower elevation portions at the eastern end of the access road occur at approximately 500 masl, predominantly in forested ecosystems, with minor areas of wetlands and floodplain ecosystems (Plate 4.2-1). Most of the forests are mature. Shrub-dominated and young seral forests occur in areas that were recently harvested or are in younger stages due to recent wildfire disturbance.

Plate 4.2-1. Mature forested ecosystems close to Highway 37, along the Brucejack Access Road.

At higher elevations, including through Scott Pass, the road traverses upland ecosystems within the Very Wet Cold Interior Cedar Hemlock (ICHvc) subzone. This subzone is typified by a dense cover of hybrid white spruce and western hemlock trees. Subalpine-fir becomes the dominant tree species at higher elevations and in areas where colder air persists. Subalpine-fir (*Abies lasiocarpa*) is also the dominant tree species within the floodplain ecosystems of the ICHvc subzone, along with black cottonwood (*Populus balsamifera*) and some hybrid white spruce (*Picea glauca* × *engelmannii*).

The access road descends southwest from Scott Pass to the Bowser River. The road then follows the Bowser River westward to approximately road km 55, traversing early seral ecosystems on fluvial deposits. Floodplain ecosystems present in this area along the Bowser River include low, medium, and high bench ecosystems. The low bench ecosystems are often dominated by willows (*Salix* spp.) including variable willow (*Salix commutata*) and Barclay's willow (*Salix barclayii*). Medium and high bench floodplain ecosystems typically occur on soils with relatively xeric to submesic moisture regimes with edaphic indicator species such as smooth-leaved mountain-avens (*Dryas integrifolia*), soopolallie (*Shepherdia canadensis*), and various species of lichens. Near Knipple Lake, the road continues along the high bench floodplain, bounded by steep colluvial slopes to the north, and the outflow to the south. Forested ecosystems are less common in this area due to recent deglaciation and soils are either poorly developed or absent. The edaphic climatic influence of the existing glaciers reduces the length of the growing season in this area.

Along Bowser River treed ecosystems often occur as elevated islands within braided stream systems; very common in the Bowser River delta and between Bowser and Knipple lakes (road segment between road kms 35 and 55). The Bowser Aerodrome is located near road km 50 on a lower bench of the Bowser River floodplain; this is an area of immature (mostly less than 30 years), deciduous tree cover, much of it located on coarse cobble substrates in the Engelmann Spruce-Subalpine Fir Wet Very Cold subzone (ESSFwv) BEC subzone. Review of historical air photographs indicates that all but about 6 ha in the northwestern corner of Bowser Aerodrome was scoured clear of trees and soils during the various floods from the 1850s to 1930 when Tide Lake discharged down Bowser River after the ice dam at Frank Mackie Glacier was breached. Vegetation did not begin to re-establish until the early 1970s because of the very limited soil remaining after the flood scouring. The area along this segment of the lower Brucejack Access Road is vegetated with deciduous shrubs and trees including willow, hybrid spruce, subalpine fir, soopolallie (*Shepherdia canadensis*), and dryas (*Dryas drummondii;* Plate 4.2-2).

The main wildlife habitat values along the lower elevation portions of Brucejack Access Road and at the various adjacent infrastructure areas are moose and bear habitat.

Two end land use objectives for the lower elevation infrastructure components are for wildlife habitat (early seral moose and bear) and to ensure an unhampered access for Indigenous traditional activities, both for Treaty and non-treaty nations. Reclamation methods will include spreading any salvaged soils or woody debris, woody species planting, and seeding with native grass and to plant native forest species; it is anticipated that vegetation establishment will be sparse in many areas due to the limited soil development. Re-vegetation will concentrate on establishment of alder, willow and cottonwood with grasses providing an early ground cover. Unhampered access for First Nations/Treaty Nations activities means that traditional access routes, by trails or water, will not be blocked by fallen timber or road reclamation activities; it does not refer to access via the Brucejack Access Road after mine closure.

Plate 4.2-2. Vegetation common in the Bowser Aerodrome area.

4.3 BRUCEJACK TRANSMISSION LINE

The Brucejack Transmission Line overlaps the greatest number of BEC units and grades from old forest in the south to early seral ecosystems and non-vegetated areas, such as barren rock and snowfields in the north. Beginning near the Long Lake Hydroelectric Substation in the south, this area extends approximately 53 km to the top of the Knipple Glacier (southeast of the Brucejack Camp). The southern reaches are comprised of shallow colluvial veneers over bedrock and steep slopes, often exceeding 60% (Plate 4.3-1). Ecosystems in this area are transitional; within this transition area there is a marked and observable difference in vegetation communities between site series. As the corridor proceeds north, western hemlock becomes a minor component of the canopy, eventually being replaced by mountain hemlock (*Tsuga mertensiana*). The understory becomes less vigorous and diverse as the climate becomes colder and wetter. Colluvium, moraine, rock, and ice are the dominant surficial materials mapped.

Much of the Brucejack Transmission Line route is located either above tree line or in high elevation subalpine areas. Brucejack Transmission Line construction was helicopter supported, with road-based support limited to use of existing roads. Transmission Line towers are sited on bedrock as much as possible with monopole towers where feasible. Surface disturbance is the result of tower bases and anchor installation and effects on vegetation as a result of the Brucejack Transmission Line are limited with the primary effect being tree falling and fallen trees left in place to inhibit access along the transmission line.

Plate 4.3-1. Forests along the south end of the Brucejack Transmission Line.

The Brucejack Transmission Line infrastructure will be removed during final reclamation. There is generally minimal surface disturbance associated with the Brucejack Transmission Line construction and use, and therefore vegetation cover will have essentially the same extent at Closure as it did pre-development, with the exception of the small areas of the tower bases. Within forested sections of the Brucejack Transmission Line right-of-way (ROW), tree and other woody species heights will have been controlled during mine Operations.

Wildlife occurs along the Transmission Line ROW. The open alpine areas of exposed rock are used as matrix habitat (movement areas) by mountain goat and grizzly to travel between areas of better quality, vegetated habitat. Construction did not materially alter or change these areas of matrix habitat. At Closure, the end land use objective will be to provide matrix habitat for goat and grizzly bear. Structures will be removed to maintain the matrix habitat as movement area for wildlife. No active reclamation beyond seeding grasses is proposed.

Below treeline, the forested area is used by moose and grizzly bear. During Operations, the ROW will regrow naturally to a low, shrub community which will be managed for height; this is anticipated to provide good quality habitat for moose and bear. At Closure, the end land use objective will be moose and grizzly bear habitat. The vegetation cover will be allowed to grow, uninhibited; no active reclamation is planned. During the early years of Post-closure, the ROW will continue to provide a shrub community for bears and moose. Over time, the ROW will undergo succession to a forested vegetation community which will provide moderate quality habitat for moose and grizzly bears, similar to or the same as what was present pre-mine.

5 RECLAMATION APPROACHES

The general reclamation approaches are to:

- conserve as much soil (or growth media, where soil is not present) as feasible in areas that will be disturbed, for use in reclamation when the mine is closed; and
- following mine infrastructure removal and site re-contouring, re-vegetate growth media that are present or have been placed on facility areas as part of reclamation, with native species including grasses, shrubs, and tree seedlings suited to the various areas.

An additional approach will be to carry out as much progressive reclamation as feasible to allow the opportunity for ecosystem development and progression during the course of mine life. Opportunities for progressive reclamation are, however, very limited, for infrastructure must remain in place to the end of mine life and sufficient facilities to support any ongoing monitoring/water treatment at the mine. Pretivm will, however, undertake what limited progressive reclamation is feasible.

5.1 SOIL MANAGEMENT STRATEGY

Soils in all Ancillary Facility Sites are generally developed on gravelly; glaciofluvial deposits. Due to the coarse texture, these soils generally have poor productivity. Soils will be windrowed or piled adjacent to cleared areas along with any entrained vegetation or woody debris. At closure these materials will be spread out to the extent possible by bulldozer. Any stockpiles will be placed outside riparian zones and surface erosion will be limited by such techniques as sediment fencing where necessary.

5.2 RE-VEGETATION STRATEGY

The Knipple Transfer Area site is located in the Mountain Hemlock-Leeward Moist Maritime Variant (MHmm2) BEC subzone and had a cover of immature, deciduous trees (Plate 4.2-2).

Bowser Aerodrome, Bowser and Wildfire Camps and the Explosive Storage Sites occur in the Engelmann Spruce-Subalpine Fir Wet Very Cold subzone (ESSFwv). Bowser is currently subject to occasional flooding.

The areas will be planted with willow, cottonwood and alder which are suited to the area. The sites will also be lightly seeded with a native grass mixture such as the following:

- alpine bluegrass (*Poa alpina*);
- spike trisetum (T*risetum spicatum*); and
- blue wildrye (*Elymus glaucus*).

The seed will be certified weed free and will be applied at 40 kg/ha to allow for successful establishment of the shrubs and tree seedlings. As the soils will have a low organic matter content and low fertility, fertilizer (16-16-16 NPK) will be applied at 40 kg/ha to promote plant establishment. The

seed is suitable for erosion control and will provide surface coverage but should allow for the establishment of tree seedlings due to the relatively low seeding rate. The planting of the shrubs, tree seedlings, and grasses will provide early seral moose and bear habitat.

The re-vegetation strategy is to reclaim disturbed areas with native species, including grasses, shrubs, and tree seedlings suited to the various infrastructure development areas and site specific conditions. For example, those areas above the tree line will not subject to tree planting. There disturbed areas will be seeded with native grasses when appropriate.

The general re-vegetation strategy is to accelerate re-vegetation of growth media that are present or have been placed on facility areas as part of reclamation. As the components are located in relatively isolated locations with variable natural settings, the general strategy is to reclaim with native plants such that the reclaimed areas will develop into more complex ecosystems that will support the range of wildlife endemic to these sites. Seeding or planting with palatable and locally adapted native vegetation species will support wildlife use of the reclaimed areas and accelerate the reclaimed areas to a more natural condition. The variety of species will be able to accommodate variation in site conditions which will provide for more successful re-vegetation across an area. Some grasses will become better established than others depending on site conditions. Monitoring will indicate where plant materials may not be suitable to niche conditions and require different species composition. Soils and other growth media will be salvaged to the extent feasible; these reclamation materials will be used to achieve plant establishment and growth.

The re-vegetation strategy in lower elevation areas will be to plant native grasses at a rate that will allow for the trees and shrubs to become established. That is, the seeding rate will be controlled to reduce excessive competition for nutrients and moisture with the tree seedlings and shrubs, thereby resulting in a more rapid development of a complex forested ecosystem. As the planted areas mature, the shrubs and trees affect soil moisture and temperature regimes below their canopy which will affect the plant species occurring as some species will be shaded out, for example, and other shade tolerant plants will become established. Wildlife and wind will carry seed to the areas as they pass through or use them, increasing the complexity of the ecosystem. Further, the development of a complex ecosystem will provide with time, shelter, browse, and lower air temperatures as the vegetative community matures.

Implementation of the above strategies is expected to result in accelerating the establishment of post-mine ecosystems resembling and functioning as natural ecosystems.

5.3 RECLAMATION PLAN

This section describes the approaches for final reclamation of ancillary infrastructure. Final closure of the mine is anticipated to take approximately three years and will be designed to provide for long-term stable landforms and site conditions. The ancillary areas to be reclaimed will be closed and reclaimed when reclamation of the Brucejack Mine Site is sufficiently complete that treatment of discharge waters is unlikely due to achievement of objectives for post mine closure. Access for monitoring is unlikely to require road access or transmission line power.

Reclamation of all LOO sites will follow the same basic principles. Facilities at each site include modular sleeping and kitchen buildings, fuel dispensing systems, helipads, water wells and potable water distribution systems, laydown areas and septic fields. Additional facilities at Knipple Transfer Station include an incinerator/waste sorting area, laboratory, oil/water separator system, electrical substation.

All facilities at LOO sites will be dismantled:

- all hydrocarbons will be drained from stationary equipment and sent to a designated facility for disposal;
- stationary equipment will be removed for resale, recycling or scrapping;
- any frame built buildings will be dismantled, metal cladding recycled, unpainted wood burnt, painted wood and plywood disposed at a waste disposal facility;
- oil/water separators will be drained, hydrocarbons disposed of at a designated facility, HDPE liners removed and recycled if possible or sent to a waste disposal facility;
- the electric substation will be dismantled, transformer oils removed and disposed of at a designated facility, equipment either sold , recycled, or scrapped;
- modular camp and other buildings will be sold, recycled or scrapped;
- concrete foundations will be covered with site subsoil/soil (predominantly glacial gravels with minor vegetation debris and soil);
- water wells will be closed as per regulations to prevent any potential contamination of groundwater; and
- all mobile equipment will be removed and sold.

Reclamation will be carried out in most areas and will include spreading of any retained soils/surficial materials and re-vegetation with suitable native plant species.

5.3.1 Wildfire Camp

The existing Wildfire Camp and laydown area are located in a previously logged area near the junction with Highway 37. The Wildfire Camp occupies approximately 0.6 ha and the laydown area within the SUP also occupies approximately 3 ha. Timber debris and soils were salvaged at the time of camp development and placed in windrows at several locations around the camp. The soils were mixed with gravel. They will be loosely spread over the site once the camp facilities have been removed. Care will be taken to not compact the soils.

Beyond the reclamation steps common to all Ancillary Infrastructure sites there are gravel borrow sites along the SUP in the Wildfire Camp area that will require grading and tree planting.

The security building at the camp and the gate and gatehouse at the highway will be dismantled once reclamation of the road is complete and the Bell Irving Bridge is removed.

5.3.2 Knipple Transfer Area

The facility is located on glacial gravel deposits which have been compacted where necessary to provide pads for structures and occupies approximately 8 ha.

Initially it was estimated 25,730 m^3 of gravelly, coarse-textured soil would be stockpiled adjacent to the Knipple Transfer Area pad for reclamation. However, the expected gravelly soil was in fact mainly gravel similar to Bowser site and less could be stockpiled. Minor quantities are stockpiled on the southern side of the site. What was stockpiled will be spread across the site during reclamation.

Following building and electrical substation removal the site will require decompaction before soil and woody debris spreading and tree/grass planting.

5.3.3 Bowser Aerodrome and Bowser West Camp

At Bowser LOO the aerodrome, camps and laydown areas all occur on gravel till deposits with minimal soil development. Review of historical air photographs indicates that all but about 6 ha in the northwestern corner of Bowser was scoured clear of trees and soils during the various floods when Tide Lake was released. Soils salvaged are minimal and are stored along the northern edge of the aerodrome. All the Bowser site infrastructure is highly compacted, either for the aerodrome runway or vehicle usage and building pads. Reclamation of the original Bowser camp site, construction laydown and temporary camp location will be completed in the first few years of mining, once these areas are no longer required.

Reclamation of Bowser sites will include decompaction by ripping to allow for root penetration. Alder and willow shrubs along with native grass seeds will be broadcasted over the disturbed areas. Reclamation success can be expected to be a slow process given the general lack of soils for redistribution across the site. The Bowser Aerodrome currently comprises a 5,392-foot long by 75-foot wide runway in a 100 m wide clearing with an apron for aircraft parking just north of Bowser West Camp. In the future the full infrastructure as outlined in the original document filings will be completed and that infrastructure will be removed at the time of decommissioning and reclamation.

The existing Bowser West Camp is located on the north side of the Brucejack Access Road. It includes several cabins, an office, kitchen, a dry and washrooms, fuel tanks for aviation and trucks, and two power generators, as well as a burn pit, pump house, a well house, a core storage area, septic field, and water line.

The aerodrome will be closed when it is no longer required. The aviation lighting will be disconnected from the power source and taken off site to be sold. The aerodrome building will be dismantled. This will include removing all furniture and equipment, wiring, and insulation. These components will be taken off site for reuse, disposal in a regulated facility, or recycled. The foundations will be left in place and covered with the gravelly material stored at the aerodrome.

5.3.4 Brucejack Transmission Line

The Brucejack Transmission Line will remain in operation until this power supply is no longer required at the Mine Site; this is anticipated to be when the Operations WTP is no longer required.

There may be some disturbance in the areas around the towers during the dismantling of the towers. Soils that are disturbed will be seeded with the same native seed mixture as other LOO. Such seeding will re-establish vegetation in disturbed areas and reduce the potential for erosion.

The Brucejack Transmission Line will be dismantled when no longer required. The towers will be de-strung and the towers, conductors, and lines will be removed. Helicopters will be used to remove the lines and towers from along the route. The tower foundations will be mostly constructed of concrete and are limited in size. These will be left in place.

In the alpine areas, the transmission line ROW will continue to be used for goats and grizzly bears, as matrix habitat between areas of better quality vegetation. For areas below treeline, vegetation above 1 to 1.5 m in height remained in place during Construction. During Operations, the ROW will regrow naturally to a low shrub community which will be managed for height and will be good quality habitat for moose and bears. At Closure, the vegetation will be allowed to grow uninhibited. During the early stages of Post-closure, the vegetation will continue to provide a shrub community for bears and moose. With time, the ROW will undergo succession to a forested vegetation community which will be moderate quality habitat for moose and grizzly bears, who currently use the area.

5.3.5 Access Road

Road access will be required for as long as water treatment is required at the Mine Site. Once the WTP is no longer required, the Brucejack Access Road will be decommissioned and reclaimed. Access or monitoring in the Post-closure phase will be via helicopter.

Road decommissioning will require the removal of 23 bridges and 310 culverts to restore natural drainage. The bridges are mainly constructed of a steel frame with wood or concrete decking. The culverts are generally corrugated steel pipe. Erosion prevention and sediment control measures will be implemented to prevent sediment entering waterways during the removal of these structures.

Larger bridges will be dismantled and lifted out using a crane. Bridge structures will be hauled out and taken for recycling or reuse as appropriate. Culverts will be taken off site for disposal, recycling, or reuse. The road surface will be reclaimed as the bridges and culverts are removed. Natural drainage will be restored. The gate at Highway 37 will be removed and public access discouraged by the construction of physical barriers and removal of the Bell Irving Bridge.

The Brucejack Access Road includes gravel/borrow sources, laydown areas, quarries, and spoil areas. The laydown and spoil areas and the road surface will require decompaction. These areas will be ripped to allow for surface infiltration of water which will reduce the potential for slumping and erosion. This material may be suitable for reclamation and will be assessed for its suitability at Closure, if required. The plan is to use the material salvaged for reclamation, and potentially the spoil material, to reclaim the road surface in areas as close as possible to the areas where it is stockpiled. Stockpiles

are sited to not erode into waterways and are not used for road maintenance. Spoil along the road is often a mix of poor soils, gravels, woody debris and plants that are stored along the road verge. These stored materials have been seeded with appropriate weed and clover-free seeds; they will also be used for the reclamation of the road, laydown and spoil areas.

The grasses and the shrubs and trees that will re-colonize the reclaimed road alignment will provide early seral moose and bear habitat.

There are and may be additional gravel/borrow sources and quarries along the lower Brucejack Access Road.

The gravel borrow area will be sloped at closure to maximum 2:1 slopes, and quarries will configured to ensure that they are stable and allow for escape by wildlife. Where necessary compacted areas on the floors of gravel borrow areas will be ripped to provide decompaction. Any soil/overburden that was feasible to salvage pre-development will be spread over the gravel source area and quarry floors. Soil/overburden areas and other areas with soil sized material at surface will be seeded with native grasses and planted with native shrubs such as willows. The quarries are developed in rock and so, with the exception of quarries where it has been feasible to salvage some soil/overburden, these sites will not be re-vegetated.

6 CLOSURE AND POST-CLOSURE MONITORING

Monitoring is required to demonstrate that reclamation and environmental protection objectives including land use, productivity, water quality, and stability of structures are being achieved. The results of the monitoring program are to be included in Annual Reports. The following is a description of conceptual Post-closure monitoring proposed. Monitoring is planned for five years following Closure, however, the length of time required for monitoring will depend upon the results of reclamation.

Access for monitoring in the Post-closure phase will be via helicopter.

Monitoring will be carried out on the following:

- landform stability,;
- surface stability (absence of erosion; effectiveness of erosion control and sediment protection measures); and
- re-vegetation establishment;

6.1 SURFACE STABILITY

The surface of the reclaimed and decommissioned sites will be checked bi-annually (high precipitation periods in spring and fall) for erosion, and remediated as appropriate. This will include the presence of rills, gullies, cracking, and signs of slumping, particularly around removed bridges, culverts and road fill areas.

6.2 RECLAMATION MONITORING

The areas which have been reclaimed will be checked annually for vegetation establishment and growth. Bare areas may indicate that the soils are compacted and roughing the surface soils may be required before reseeding. Areas with sparse vegetation will be reseeded if they are not rock exposures. The planted species may be changed to reflect individual site conditions. For example, plants on coarse-textured soils may be affected by insufficient moisture and may indicate that areas need to be reseeded with a more drought resistant species. As well, fertilizer may be required to promote plant establishment where vegetation is sparse. Reclaimed sites will also be checked for noxious weeds.

6.3 INDIGENOUS ACCESS FOR TRADITIONAL ACTIVITIES

Tsetsaut Skii km Lax Ha, Nisga'a Lisims and Tahltan will be informed through their respective governments of reclamation monitoring results and discussions will be held to assess their ability to access the area for traditional activities or potential impingements on rights.

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Appendix 9-1-4. Aquatic Effects Monitoring Plan

PRETIVM
BRUCEJACK MINE

BRUCEJACK GOLD MINE

Aquatic Effects Monitoring Plan

February 2022

PRETIVM
BRUCEJACK MINE

BRUCEJACK GOLD MINE

Aquatic Effects Monitoring Plan

Date: February 2022

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment
1	May 2015	Pretium Exploration Inc.	Provided as part of the EA/MAEMA Application package
2	December 2018	Pretium Resources Inc.	Updated to align with effluent permit PE-107835 and updates to the MDMER legislation
3	July 2019	Pretium Resources Inc.	Revise metals monitored
4	February 2020	Pretium Resources Inc.	Updated per BC ENV edits
5	March 2021	Pretium Resources Inc.	Added zinc triggers
6	February 2022	Pretium Resources Inc.	No major changes. Update cited references.

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BRUCEJACK GOLD MINE

Aquatic Effects Monitoring Plan

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Appendix A. Statistical Power Modeling for BACI ANOVA

GLOSSARY AND ABBREVIATIONS

AEMP	Aquatic Effects Monitoring Plan
BACI	Before-After/Control-Impact
BC	British Columbia
BTEX	Benzene-toluene-ethylbenzene-xylenes
CES	Critical effect size
Chl *a*	Chlorophyll *a*
HEPH	Heavy extractable petroleum hydrocarbons
EA	Environmental assessment
EEM	Environmental effects monitoring
EMS	Environmental Management System
EPH	Extractable petroleum hydrocarbons
LEPH	Light extractable petroleum hydrocarbons
MDMER	Metal and Diamond Mining Effluent Regulations (SOR/2002-222)
Mine	Brucejack Mine
MTBE	Methyl t-butyl ether
QA/QC	Quality assurance / quality control
RCA	Reference Condition Approach
SD	Standard deviation
SOP	Standard operating procedure
VPH	Volatile petroleum hydrocarbons
WRTSF	Waste Rock and Tailing Storage Facility

1 PURPOSE

The Brucejack Mine (the Mine) has been designed to minimize, mitigate, and/or manage potential adverse effects on the environment. The Aquatic Effects Monitoring Plan (AEMP) is one component of the overall Environmental Management System (EMS), with the specific purpose to provide information on the aquatic receiving environment necessary to achieve the following goals:

- detect mine-related effects on the aquatic ecosystem components, including water quality, aquatic resources, and sediment quality;
- evaluate the predictions of the environmental assessment (EA);
- meet permit and regulatory requirements for effluent and receiving environment quality;
- assess the performance of mitigation and management measures; and
- provide the necessary feedback and information for the adaptive management of potential mine-related effects.

2 PERFORMANCE OBJECTIVES

The AEMP is intended to ensure that mitigation and management measures related to potential aquatic ecosystem effects are effective, and the requirements of relevant laws and regulations are met. To meet these goals, the AEMP is designed to generate data needed to accomplish the following objectives:

1. determine the short- and long-term effects in the aquatic environment resulting from the mine;
2. evaluate the accuracy of mine effect predictions;
3. assess the effectiveness of mitigation and management measures;
4. identify additional mitigation measures as appropriate to avert or reduce environmental effects due to mine activities (adaptive management); and
5. comply with regulatory and permit requirements.

The first objective is met by monitoring the receiving environment in the short term (on an annual basis) and the long term (across all phases of the mine), augmented by more frequent effluent and receiving environment water quality monitoring. Physical, chemical, and biological characteristics of the aquatic environment are monitored to detect mine effects, and to determine the pathways and the magnitude of the effects.

The accuracy of mine effect predictions (Objective 2) are evaluated based on the results of the monitoring plan addressed in Objective 1, and are evaluated as part of the regular reporting process.

The AEMP allows for an assessment of the effectiveness of mitigation and management measures designed to eliminate or reduce potential mine effects (Objective 3) by comparing the conditions in the receiving environment to baseline conditions and to a reference site, prior to and throughout the mine. The effectiveness of mitigation measures are determined by identifying changes in the receiving environment, and communicating those changes to mine management. The results of the AEMP are analysed and reported in the Annual Report for *Mines Act* Permit M-243 and *Environmental Management Act* Permits PE-107835 and PA-107025 (the Annual Report).

The development of additional mitigation and management measures (Objective 4) will follow the identification of unanticipated effects or poor performance of existing measures. These additional mitigation and management strategies will be described in the annual AEMP reports, which includes the Annual Report, along with the relevant environmental monitoring information.

The monitoring plan provides the required information to demonstrate compliance with the provincial *Environmental Management Act* (EMA) effluent discharge permit (#107835). Section 4.5 of the EMA permit stipulates the requirements for an AEMP. These environmental components are evaluated for effects by the methods outlined in the AEMP, which conform to the methods outlined in guidance documents (BCMOE 2016b; Environment Canada 2012c; ENV 2013). Further, sampling follows the requirements outlined in Section 4 of the EMA permit. Specifically, as specified in Section 5.5 of the EMA permit, the AEMP annual report includes results and interpretation of toxicity testing (acute and chronic), sediment

and biological monitoring, key water quality trends, environmental effects, and an assessment of the protectiveness of the discharge limits. As such, the AEMP focuses on WRTSF discharge and the receiving environment monitoring requirements listed in the EMA permit, and does not include the required EMA permit monitoring for the characterization of inputs to the WRTSF. These components are reported separately from the AEMP. The MDMER study design and results are also reported separately from the AEMP.

3 SCOPE

This document presents the proposed components of the AEMP; it is intended to be a "living document" and may be updated based on regulatory changes, changes in the mine, or changes to mitigation and management measures. The document is divided into three sections:

- Section 4 describes the components of the monitoring plan.
- Section 5 outlines triggers for additional monitoring and/or data review.
- Section 6 describes the reporting and record keeping components.

These components were developed within the broader framework of the Mine's EMS as well as applicable legislation, regulations, permits, and EA conditions.

Implementation of the AEMP is intended to monitor components of the aquatic environment in the Mine Site Area and the downstream receiving environment, as well as a reference monitoring environment. The original version of the AEMP was created in 2015. This 2022 update will be in place at the Brucejack Mine through the phases of operations and closure.

3.1 APPLICABLE ENVIRONMENTAL MANAGEMENT PLANS

The AEMP is the monitoring plan for detecting mine-related effects on the aquatic receiving environment. The mine has the potential to interact with the aquatic environment through a number of pathways. The EMS (Section 6.2) describes the overall framework. Mitigation and management measures are implemented to reduce or eliminate mine effects on the aquatic environment. Mitigation and management measures have been drawn from knowledge and experience contained in guidelines and research documents, and the adaptive management strategy includes seeking new knowledge and strategies to minimize mine effects on the aquatic environment. The mitigation and management measures relevant to the aquatic environment are detailed in specific pathway-associated management plans that include:

- Metal Leaching and Acid Rock Drainage Management Plan;
- Surface Erosion Prevention and Sediment Control Management Plan
- Spill Response Plan;
- Tailings and Waste Rock Subaqueous Deposition Management Plan;
- Water Management Plan;
- Nitrogen Management Plan;
- Chromium Management Plan; and
- Closure Underground Water Quality Adaptive Management Plan.

3.2 APPLICABLE LEGISLATION, REGULATIONS, AND ENVIRONMENTAL ASSESSMENT CERTIFICATE CONDITIONS

3.2.1 Applicable Legislation and Regulations

This AEMP has been designed to comply with existing regulations and follow the available guidelines provided by the federal government and the government of British Columbia (BC). Relevant legislation and regulations include:

- *Environmental ManagementAct* (2003);
- MDMER (SOR/2002-222) under the *Fisheries Act* (1985); and
- *Mines Act* (1996a).

Note that while MDMER (SOR/2002-222) is relevant to the AEMP, the AEMP focuses on the provincial legislation and regulations. Further details on the MDMER monitoring requirements are provided in MDMER (SOR/2002-222) under the *Fisheries Act* (1985).

Relevant guidelines for the monitoring plans presented in the AEMP include:

- *British Columbia Approved and Working Water Quality Guidelines*;
- *Canadian Environmental Quality Guidelines* (CCME guidelines);
- *Federal Environmental Quality Guidelines* (Ministry of Environment and Climate Change);
- *British Columbia Field Sampling Manual Part A: Quality Control and Quality Assurance* and *Part E: Water and Wastewater Sampling* (ENV 2013);
- *Metal Mining Technical Guidance for Environmental Effects Monitoring* (Environment Canada 2012c);
- *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* version 2 (BCMOE 2016a); and
- *Annual Reporting Under the Environmental Management Act: A Guide for Mines in British Columbia* (BCMOE 2016b).

3.2.2 Relevant EAC Conditions

Pretivm was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions. This management plan fulfills Condition #2, in relation to a Component Plan for aquatic effects monitoring, presented within Schedule B of the Certificate and copied below.

<u>Condition 2</u>

> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*

- *Purpose of Component Plan;*
- *Performance objectives;*
- *Effects mitigation measures;*
- *Monitoring programs;*
- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

4 AQUATIC EFFECTS MONITORING PLAN

4.1 STUDY AREA AND SAMPLING LOCATIONS

4.1.1 Mine Site Area and Downstream Receiving Environment

The AEMP study area comprises those areas potentially influenced by mine activities in the Mine Site Area (exposure) and areas beyond potential Mine influences (reference). The primary Mine-related activities that could affect the aquatic environment, and thus were considered in the AEMP design, include:

- discharge of water from the WRTSF, which is the location of subaqueous disposal of waste rock and tailings, as well as the discharge point for effluent from the mine water treatment plant and the sewage treatment plant. The WRTSF outflow is the mine's discharge point into the Brucejack Creek receiving environment, and is the point of compliance for the EMA permit and MDMER;
- runoff from mine infrastructure, including pads, stockpiles, and roads; and
- changes in streamflow related to mine water management and discharges.

Potential effects on the aquatic receiving environment are anticipated to be restricted primarily to the Mine Site Area and Brucejack Creek. The suite of sampling sites is designed to monitor the receiving environment along the downstream gradient from the WRTSF to the inflow to Sulphurets Lake (Table 4.1-1 and Figure 4.1-1).

Table 4.1-1. AEMP Sampling Locations, Descriptions, and Purposes

Site	EMS ID	Location[a]		Description	Purpose
		Easting	Northing		
Mine Site Area					
BJ 3.10 (Weir)	E298312	426,820	6,258,983	WRTSF outflow	Mine discharge location; final discharge point for MDMER and effluent compliance conditions for EMA Permit
CC 0.87[b]	E298331	426,951	6,258,242	Headwaters of Camp Creek	Upstream control site
CC 0.01[b]	E298334	426,601	6,258,868	Mouth of Camp Creek	Site to estimate non-contact water contributions from Camp Creek to Brucejack Creek.
BJ 2.62[b]	E298332	426,330	6,258,959	Brucejack Creek, immediately downstream of cascades	Monitor the receiving environment on Brucejack Creek approximately 0.5 km downstream of WRTSF outflow and downstream of Camp Creek.
BJ 1.74[b]	E298333	425,773	6,259,026	Brucejack Creek, downstream of VOK Creek	Monitor the receiving environment on Brucejack Creek approximately 1.4 km downstream of WRTSF outflow
SC0[b]	E303050	422,038	6,261,659	Sulphurets Creek, downstream of Sulphurets Glacier, inflow to Sulphurets Lake	Far-field exposure site.
Access Road					
KG 0.4	-	439,360	6,251,460	Creek flowing from Knipple Glacier, upstream of bridge	Hydrocarbon monitoring location; not included in EMA permit
Reference Areas					
L3 Outflow[b]	E303051	413,622	6,270,435	Reference stream; lake-headed high alpine reference stream comparable to Brucejack Creek, located 17 km northwest of Brucejack Lake	Brucejack Creek reference stream site
T2 0.09	-	427,106	6,259,483	Catear Creek; northern tributary to Brucejack Lake	Applicable to MDMER sampling only. Upstream reference site for Brucejack Creek; downstream of historical Catear Mine site; Environment and Climate Change Canada recommended MDMER biological reference site

[a] *UTM Zone 9, NAD83*

[b] *Sampling schedule may be adjusted during the winter months depending on conditions (i.e., flying, creek frozen to ground) and avalanche hazard.*

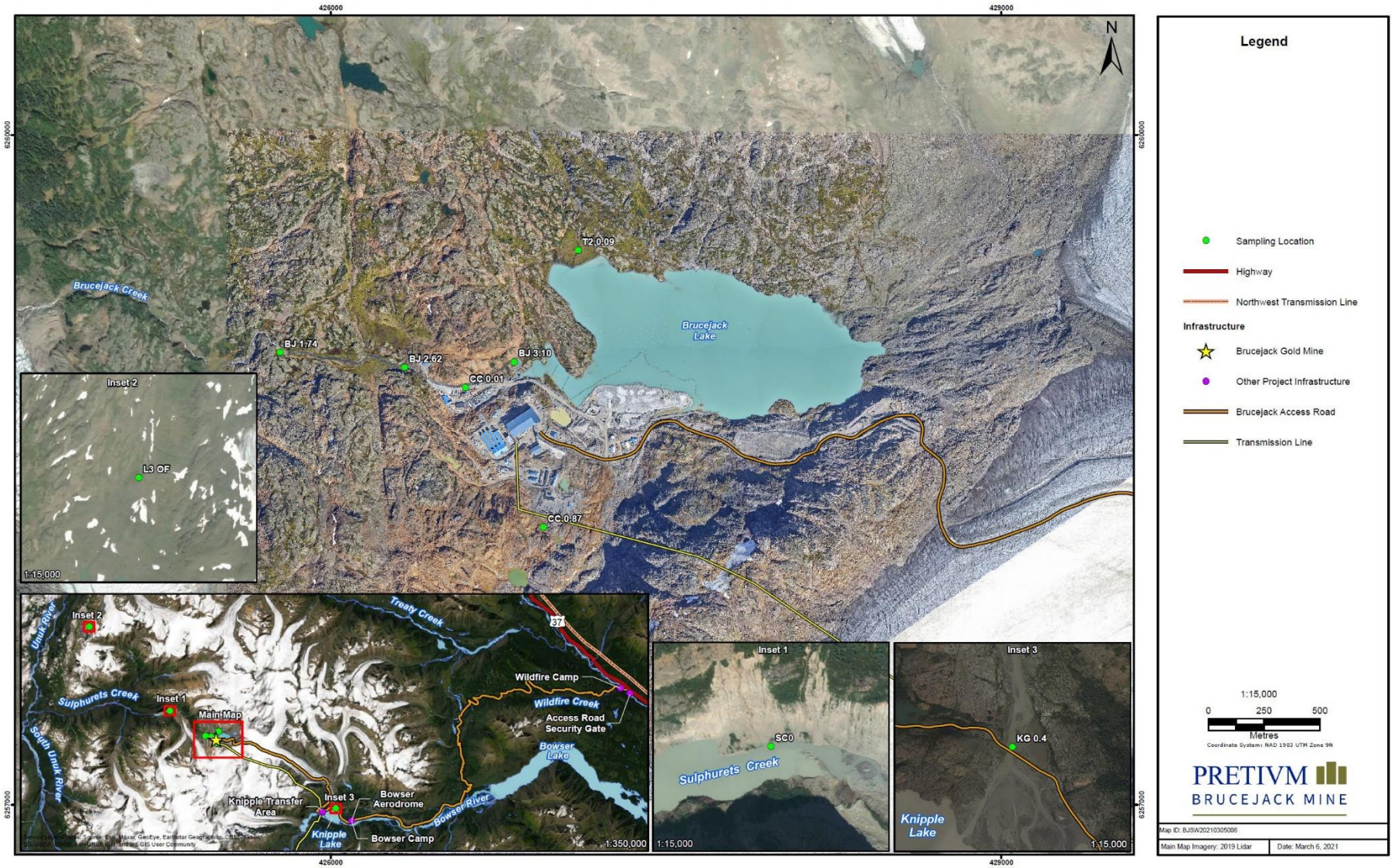

Figure 4.1-1. AEMP Sampling Locations

4.1.2 Ancillary Infrastructure Areas

Areas with potential effects on the aquatic environment from infrastructure outside of the Mine Site Area include the Brucejack Access Road. A monitoring location (KG 0.4) for petroleum hydrocarbons is maintained on the creek downstream of Knipple Glacier to identify unanticipated effects from the operation of vehicles and the transport of fuels on the glacier.

4.2 SAMPLING DESIGN

The sampling design for the AEMP is conceived to provide information for a statistical analysis incorporating a Before-After/Control-Impact (BACI) design on aquatic receiving environment indicators. Baseline information for the sampling locations (Table 4.1-1) is available from 1987 to 2014 (see Sections 13.3 and 14.3 in Chapters 13 and 14 of the *Application for an Environmental Assessment Certificate/Environmental Impact Statement*, ERM Rescan 2014), and are the basis for the "Before" category in AEMP statistical analyses. Monitoring for the "After" category commenced in 2015, when the Construction Phase of the mine was initiated, with commercial production achieved on July 1, 2017.

The monitoring components, with their respective sampling frequency and replication are provided in Table 4.2-1. The number of replicate samples for each monitored component is informed by guidance documents and by a statistical power simulation. As a starting point, the sampling design considered five replicates (BCMOE 2016a), which also follows the Environment Canada recommendation for one-factor ANOVA EEM designs for benthic invertebrates to control for equal false-positive and false-negative probabilities ($\alpha = \beta = 0.1$; Environment Canada 2012c). To corroborate these suggested sample sizes, a simulation model was constructed (see Appendix A for details). The simulation model used baseline data from the reference site and a candidate monitoring site as input parameters, along with a critical effect size (CES) of 2x standard deviation (SD) to simulate a hypothetic effect at the monitoring site. The simulation model estimated that five replicate sediment samples would be sufficient to detect a 2 SD change with a 0.90 power (i.e., $\beta = 0.1$) in sediment quality, based on the observed sample variation in the baseline program (Table 4.2-2). The number of replicates for periphyton biomass (as chlorophyll *a* [chl *a*]) was determined to be six, based on the power analysis and the BC MOE guidance document (Table 4.2-2; BCMOE 2106). The number of replicates for periphyton taxonomy analyses is five, based on the recommendations of Biggs and Kilroy (2000) that stated the variation in richness indices reaches a plateau between three and nine replicates.

The BACI analysis considers the effects of period (i.e., "Before" and "After" the start of construction), natural differences between monitored and reference sites, and the interaction between the period effects and the site effects. This site-specific change between the "Before" and "After" periods is the crucial question in a BACI design. A significant mine-related effect would be observed as a site-specific change at a monitored site than is not observed at the reference site over time. If a change is observed at both sites, then it is most likely attributable to natural phenomena unrelated to mine activities. Data analysis use established methods and assumptions are detailed and examined using graphical techniques, statistical analysis, and best professional judgment as part of the analytical process.

Table 4.2-1. Physical, Chemical, and Biological Components in the AEMP Sampling Program

Component	Frequency	Monitoring Location (EMS ID)							
		BJ 3.10 (E298312)	CC 0.87 (E298331)	CC 0.01 (E298334)	BJ 2.62 (E298332)	BJ 1.74 (E298333)	SC0 (E303050)	L3 OF (E303051)	KG 0.4 -
Flow	Continuous + Manual Checks Quarterly	1	-	-	-	-	-	-	-
	Manually 4 x summer, with no recent precipitation	-	-	-	-	1	-	-	-
Water Quality	Weekly	1	-	-	-	-	-	-	-
	Monthly	-	1	1	1	-	-	-	-
	Monthly (May to October) / Quarterly (November to April)	-	-	-	-	1	-	-	-
	Quarterly[a]	-	-	-	-	-	1	1	1
	Freshet and Fall 5-in-30 once every 3 years	-	-	-	-	-	1	1	-
Toxicity [b]	Quarterly	1	-	-	-	-	-	-	-
Sediment [c]	Annually	5	-	-	5	-	-	-	5
	Once every 3 years	-	-		-	5	5	5	-
Periphyton Biomass (chl *a*)[c]	Annually	6	-	-	6	6	-	-	-
	Once every 3 years	-	-	-	-	-	6	6	-
Periphyton Taxonomy [c]	Annually	5	-	-	5	-	-	-	-
	Once every 3 years	-	-	-	-	-	-	5	-
Benthic Invertebrates (CABIN) [c]	Annually	1	-	-	1	1	-	-	-
	Once every 3 years	-	-	-	-	-	1	1	-

Note:
Values represent the number of replicate samples collected per site. Values do not include QA/QC.
[a] *Shifted Quarterly: sQtr1 (February to April), sQtr2 (May to July), sQtr3 (August to October), and sQtr 4 (November to January).*
[b] *Toxicity: of 100% lake outlet effluent (single concentration) for acute 48h Daphnia magna (EPS 1/RM/14), acute 72h freshwater algae (EPS 1/RM/25), and long-term survival and growth of Chironomus dilutus (EPS 1/RM/32, water only).*
[c] *Sampled during fall low flow*

Table 4.2-2. Statistical Power for Simulated BACI AEMP for Selected Parameters for a Range of Sampling Replication Designs

Parameter	Model Characteristics	Power (1 – β)		
		n = 3	n = 5	n = 7
Sediment Arsenic	Model uses $\log_{10}$-transformed data to stabilize variances.	0.79	0.92	0.96
Periphyton Biomass (chl *a*)	Model uses non-transformed chlorophyll *a* concentrations	0.72	0.81	0.93

4.3 MONITORING COMPONENTS

Each of the monitoring components summarized in Table 4.1-1 are described in the following sections. Several components, including sediment quality, periphyton, and benthic invertebrates are collected concurrently during early fall low flow, as per EMA permit specifications and as the most biologically relevant period. Required water quality sampling will also be collected concurrently with these samples, when feasible.

4.3.1 Flow

4.3.1.1 Description

A weir at site BJ 3.10 (the outflow from the WRTSF) provides continuous flow gauging (see Water Management Plan for details on flow monitoring), which is checked manually on a quarterly basis. Manual measurements are also recorded at BJ 1.74 four times during the summer, when no recent precipitation has occurred.

4.3.1.2 Quality Assurance/Quality Control

Flow monitoring follows recommendations in the *Manual of British Columbia Hydrometric Standards* (RISC 2018).

4.3.2 Water Quality

4.3.2.1 Description

Table 4.3-1 provides a list of the parameters to be monitored under the AEMP, including the parameters required for the EMA permit. Other water quality monitoring components are described in the ML/ARD Management Plan and MDMER EEM regulations, and include components such as water treatment plant effluent monitoring, quarry runoff monitoring, and post-closure monitoring of seepage from any adit plug.

Stream water quality samples are collected monthly, except for sampling at the far-field SC0 and reference sites that are sampled quarterly (see Section 4.2). Due to potential access and avalanche hazards at BJ 1.74, sampling is shifted to quarterly during the winter months (November to April).

Table 4.3-1. Water Quality Parameters

Water Quality Parameters			
Field	**Nutrients**	**Total and Dissolved Metals**	
pH	Ammonia (as N)	Aluminum (Al)	Magnesium (Mg)
Temperature	Nitrate (as N)	Antimony (Sb)	Manganese (Mn)
Turbidity	Nitrite	Arsenic (As)	Mercury (Hg)
Conductivity	Total Phosphorus	Barium (Ba)	Molybdenum (Mo)
Dissolved Oxygen	Dissolved Ortho-phosphate	Beryllium (Be)	Nickel (Ni)
Physical and Chemical Parameters	Total Organic Carbon	Bismuth (Bi)	Selenium (Se)
pH	**Anions**	Calcium (Ca)	Silver (Ag)
Conductivity	Chloride (Cl)	Cadmium (Cd)	Sodium (S)
Total Hardness	Fluoride (F)	Chromium (Cr)	Strontium (Sr)
Total Alkalinity	Sulphate (SO_4)	Cobalt (Co	Thallium (Tl)
Total Suspended Solids		Copper (Cu)	Tin (Sn)
Total Dissolved Solids		Iron (Fe)	Uranium (U)
Turbidity		Lead (Pb)	Vanadium (V)
		Lithium (Li)	Zinc (Zn)

The site KG 0.4 was originally sampled monthly, until June 2019 when sampling frequency was updated to a quarterly schedule. Weekly water sampling is conducted at BJ 3.10 as required for effluent monitoring (Table 4.2-1). The timing of quarterly sampling is designed to capture representative periods during winter low-flow conditions, freshet, summer low flow, and the increased streamflow in fall. Quarterly sampling is conducted within the same shifted quarters used for the water quality modeling and described in Appendix B of the EMA permit. Finally, 5-in-30 samples are collected during freshet and fall at SC0 and L3 OF every three years to characterize the variability in water quality during these peak flow periods. Dissolved oxygen, temperature, turbidity, conductivity, and pH measurements are collected in the field to characterize the physical and chemical environment of the stream sites.

Water samples from the KG 0.4 hydrocarbon monitoring site are collected quarterly along the shifted quarter schedule and analyzed for petroleum volatile organic compounds and hydrocarbons, which includes the following compounds and classes of compounds:

- BTEX (benzene-toluene-ethylbenzene-xylenes);
- VPH (volatile petroleum hydrocarbons); and
- MTBE (Methyl t-butyl ether).

The hydrocarbon water sampling at the KG 0.4 site is designed as a surveillance program and will not be incorporated into the Before-After-Control-Impact analysis. If a chemical or reagent spill for another substance occurs on the glacier monitoring will include analysis for that substance.

4.3.2.2 Quality Assurance/Quality Control

Field replicate samples are collected from a subset (10%) of all samples collected to quantify environmental variability and analytical consistency. Travel and field blanks are collected to detect potential sources of contamination. Field instruments are calibrated regularly according to the manufacturer's specifications and ENV (2013), and calibration logs are maintained.

Quality assurance/quality control (QA/QC) principles follow those outlined in guidance documents throughout the field sample collection and laboratory analysis phases (BCMOE 2016a; Environment Canada 2012c; ENV 2013). All water quality samples are collected by qualified personnel using suitable sampling equipment. Samples are preserved (where applicable) in appropriate containers, and transported and stored following accepted procedures. Chain-of-Custody forms are used to track the samples and analyses are conducted by an accredited laboratory.

4.3.3 Sediment Quality

4.3.3.1 Description

Sediment quality samples are collected annually at sites BJ 3.10, BJ 2.62, and KG 0.4 and every three years at the remaining sites. These samples are collected in conjunction with the periphyton and benthic macroinvertebrate surveys to assess for potential mine effects on aquatic sediments, and by extension to the aquatic community. Sediment quality samples measure the total organic carbon and metals concentrations as well as particle size distribution at each site, to provide contextual information for the benthic macroinvertebrate community analysis. Sediment samples destined for metals analysis (Table 4.3-2) are collected with a plastic spoon and bowl. Metal and total organic carbon concentrations are measured on the <63 µm fraction, as recommended by BCMOE (2016a) and specified in the EMA permit.

Table 4.3-2. Sediment Quality Parameters

Physical and Chemical Parameters	Total Metals		
% Moisture	Aluminum (Al)	Copper (Cu)	Silver (Ag)
pH	Antimony (Sb)	Iron (Fe)	Strontium (Sr)
% Gravel (> 2 mm)	Arsenic (As)	Lead (Pb)	Thallium (Tl)
% Sand (0.063 to 2 mm)	Barium (Ba)	Lithium (Li)	Tin (Sn)
% Silt (4 to 63 µm)	Beryllium (Be)	Manganese (Mn)	Uranium (U)
% Clay (< 4 µm)	Bismuth (Bi)	Mercury (Hg)	Vanadium (V)
Total Organic Carbon	Cadmium (Cd)	Molybdenum (Mo)	Zinc (Zn)
	Chromium (Cr)	Nickel (Ni)	
	Cobalt (Co)	Selenium (Se)	

Sediment samples from the KG 0.4 hydrocarbon monitoring site are analyzed for petroleum organic compounds and hydrocarbons, which includes the following compounds and classes of compounds:

- BTEX;

- VPH;
- MTBE;
- EPH (Extractable petroleum hydrocarbons);
- LEPH (Light extractable petroleum hydrocarbons); and
- HEPH (Heavy extractable petroleum hydrocarbons).

Sediment samples destined for hydrocarbon analysis are collected with a metal spoon and bowl. The hydrocarbon sediment sampling at the KG 0.4 site is designed as a surveillance program and will not be incorporated into the Before-After-Control-Impact analysis.

The statistical analysis for mine effects on sediment quality requires estimation of the size of the effects on the quantitative measures of metal concentrations, organic carbon concentrations, and particle size composition. Adequate sample size was determined using power analysis and estimates of parameter variability from the baseline and historical sampling programs. Five replicates per site are collected.

4.3.3.2 Quality Assurance/Quality Control

QA/QC principles follow those outlined in guidance documents during sample collection and laboratory analyses (BCMOE 2016a; Environment Canada 2012c; ENV 2013). Field splits are conducted for approximately 25% of the replicates. All sediment quality samples are collected by qualified personnel using suitable sampling equipment. Samples are stored in appropriate containers and transported following accepted procedures. Chain-of-Custody forms are used, and the analyses are conducted by an accredited external laboratory.

4.3.4 Primary Producers

4.3.4.1 Description

Primary producer (periphyton) biomass and taxonomy samples are collected annually at sites in Brucejack Creek (BJ 3.10, BJ 2.62, and BJ 1.74) and every three years at far-field and reference sites (SC0 and L3 OF). Primary producer biomass (as chlorophyll *a*) is also the criterion for phosphorus management in BC streams. Primary producers are monitored by collecting periphyton biomass samples following established protocols using a scraping template (ENV 2013). Primary producer biomass is estimated by measuring the concentration of chlorophyll *a*, a pigment associated with photosynthesis.

Periphyton samples for enumeration and taxonomic identification are collected to measure changes in the abundance and composition of the primary producer community. Samples are collected using the same template protocol as used for the chlorophyll *a* sampling (ENV 2013). The periphyton samples are preserved, kept cool, and transported to a qualified taxonomist for identification and enumeration. The periphyton taxonomic data are analyzed using the following effects indicators: density, Simpson's evenness index, and taxonomic richness.

4.3.4.2 Quality Assurance/Quality Control

QA/QC principles for periphyton biomass sampling follow those outlined in the *British Columbia Field Sampling Manual* (ENV 2013). Samples are stored in appropriate containers and transported following accepted procedures. Chain-of-Custody forms are used. The analysis of chlorophyll *a* concentration is conducted by an accredited laboratory. A qualified taxonomist conducts the identification and enumeration of the periphyton samples and follows standard protocols for subsampling, reference collections, and data quality assurance.

4.3.5 Benthic Invertebrate Community

4.3.5.1 Description

Benthic macroinvertebrate surveys are conducted annually at Brucejack Creek sites (BJ 3.10, BJ 2.62, and BJ 1.74) and every three years at far-field and reference sites (SC0 and L3 OF) to measure the effects of mine activities on the lower trophic levels of the aquatic environment. As per Section 4.1 of the EMA permit, benthic invertebrate sampling at BJ 2.62 and BJ 1.74 is done annually over three years (i.e., 2019, 2020, and 2021), after which the sampling frequency may be re-evaluated to every three years. The benthic macroinvertebrate community is sampled and analyzed using the reference condition approach (RCA) following the CABIN protocol (Environment Canada 2012b, 2012a) for the EMA permit.

Samples are collected from erosional zones, according to CABIN methods (Environment Canada, 2012a), to allow use of the RCA and comparison to previous surveys. Benthic macroinvertebrate surveys are planned for mid-August to mid-September, which is the time of year typically recommended for baseline surveys (BCMOE 2016a), and recommended by CABIN (Environment Canada, 2012a). Benthic macroinvertebrate surveys coincide with water quality, primary producer (periphyton), and sediment sample collections.

4.3.5.2 Quality Assurance/Quality Control

QA/QC principles follow those outlined in the EEM guidance documents for the collection of samples and subsequent laboratory analyses (BCMOE 2016a; Environment Canada 2012c; ENV 2013). Samples are collected by qualified personnel using suitable sampling equipment. Samples are uniformly pre-sieved and preserved in appropriate containers. Samples are stored and transported using accepted procedures.

All laboratory processing and taxonomic identification is conducted by expert taxonomists and appropriate sub-sampling and random re-sorting techniques are used. Data quality is verified by screening for potential data entry errors. All samples are stored for six years following analysis and a reference collection is maintained.

4.3.6 Toxicity Testing

4.3.6.1 Description

Toxicity testing of effluent is conducted quarterly on water collected at at BJ 3.10 following the procedures described in the *British Columbia Field Sampling Manual Part E: Water and Wastewater Sampling* (ENV 2013), as per Section 4.3 and 4.4 of the EMA permit. Testing is completed for a single concentration of 100% effluent, with effluent grab samples collected and processed without delay at an accredited facility. All test reports are recorded and reported according to the schedule outlined in Section 5.1 of this document. Additional toxicity testing is required as per the MDMER requirements which are not included in the AEMP.

Toxicity Testing

- 48-hour acute lethality assay *Daphnia magna* (EPS 1/RM/14; Environment Canada 2000).
- 72-hour growth inhibition test using a freshwater algae (EPS 1/RM/25; Environment Canada 2007).

Long-Term Trend Toxicity Testing

- Survival and growth of the freshwater midge *Chironomus dilutus* (EPS 1/RM/32; Environment Canada 1996).

Results of the long-term toxicity testing are examined for trends in survival and growth, compared to previous tests, and placed into ecological context.

4.3.6.2 Quality Assurance/Quality Control

QA/QC principles follow those outlined in the *British Columbia Field Sampling Manual Part A: Quality Control and Quality Assurance* (ENV 2013), the EEM guidance document (Environment Canada 2012c), and the reference methods for the collection of samples and subsequent laboratory analyses (Environment Canada 1996, 2000, 2007). Samples are collected by qualified personnel using suitable sampling equipment and are stored and transported using accepted procedures. Chain-of-Custody forms are used.

All laboratory processing and assays are conducted by accredited facilities. Data quality is verified by screening for potential data entry errors.

4.3.7 MDMER Monitoring Components

As previously mentioned, the MDMER monitoring components are not included in the AEMP and can be found in MDMER (SOR/2002-222) under the *Fisheries Act* (1985). Monitoring components of MDMER include:

- Effluent quality monitoring;
- Volume of effluent deposited;

- Acute toxicity testing using rainbow trout and *Daphnia magna* monitoring tests;
- Environmental Effect Monitoring (EEM) Studies;
    - Effluent and water quality monitoring studies;
        - Water quality monitoring;
        - Sublethal toxicity testing;
    - Biological monitoring studies;
        - Benthic invertebrate community;
        - Fish population; and
        - Fish tissues.

4.4 QUALITY ASSURANCE AND QUALITY CONTROL

The QA/QC for the AEMP includes the processes already identified for each component (as discussed in Section 4.3) as well as EMS processes related to data management and documentation. Recordkeeping is conducted by Pretium Resources Inc. and its consultants. Standard operating procedures (SOPs) are in place for environmental data collection and will be updated as needed. Sampling personnel have necessary training and accreditations.

SOPs cover all aspects of data collection, data processing, data QA/QC, and data management. SOPs include duplicate sampling, relevant blanks, chain-of-custody procedures, and recordkeeping. SOPs are reassessed and updated when necessary, as part of the iterative QA/QC process.

Data analysis is conducted using established and standardized workflows, and analytical results are cross-checked and validated. Data are entered into suitable electronic databases, checked for quality control, and stored for at least the life of mine. Data are entered in a format and program that allow for comparison between years and storage in a single file format for each type of survey or monitoring activity. Data that have undergone QA/QC are appended to the annual AEMP report and the compilation of all cumulative data is transferred for storage to the appropriate agency.

Internal quality audits are conducted to record and analyze quality issues and are subjected to quality assurance procedures for documenting, tracking, and resolving QA/QC issues. The Annual Report includes detailed descriptions of the analytical methods, such as the relevant validation and QC procedures.

All formal documents and reports follow version-control procedures with revision tracking and version numbers. Version control information are required for all documents and data that are issued, and approval will be given and tracked before issue. Designated personnel coordinates preparation, review, and distribution, as appropriate, of the data and reports required for regulatory purposes.

The iterative QA/QC procedures continuously improve the effectiveness of the AEMP to detect mine-related effects in the aquatic environment. These QA/QC processes are important in the overall adaptive management of mine effects, and support the goals of the mine to minimize, mitigate, and/or manage potential adverse effects on the environment.

5 TRIGGERS

Triggers for additional mitigation and management measures are required by the EMA permit. If unanticipated effects or poor performance of existing measures are identified, additional mitigation and management strategies will be described in the Annual Report. In addition, the need for zinc concentration triggers at BJ 3.10 and WTP effluent were identified following review of potential effects to water quality due to use of a corrosion inhibitor in ore processing. A summary of AEMP triggers is presented in Table 5-1.

Table 5-1: Summary of Triggers

Component	Trigger	Action
Water Quality	BJ 3.10 greater than limits in Condition 1.1.1 of effluent permit	As per Sections 5.3 and 5.4 of the EMA permit, if an effluent concentration limit is exceeded, notification of the exceedance will be made within 24 hours of receiving water quality results from the laboratory, an investigation into the cause of the exceedance will be conducted, and actions will be identified and implemented to prevent similar exceedances from occurring. A non-compliance report will be submitted within 30 days of the non-compliance notification.
	BJ 3.10 greater than permit limits or WQGs	As per Section 4.8 of the EMA permit, exceedance of permit limits or British Columbia Water Quality Guidelines at BJ 3.10 may trigger the direction to require additional information. This may include, but is not limited to, additional sampling and monitoring, a risk assessment, and an environmental management plan.
	BJ 3.10 T-Zn >6 µg/L or WTP Effluent T-Zn >16 µg/L	Review continued use of CT788 corrosion inhibitor in gland water supply. Compare observed concentrations to water quality model predictions. If observed zinc concentrations are confirmed to be related to the use of CT788, use of the reagent will be suspended, and alternative options will be investigated.
Toxicity Testing	Failure of 48 hour acute lethality assay *Daphnia magna* Failure of 72 hour growth inhibition test using a freshwater algae	Failure of either toxicity test, as defined by the EMA permit, will require the notification of the Ministry and an immediate repeat of the failed toxicity test (EMA permit Section 5.3). For an acute toxicity 48 hour *Daphnia magna* failure, the repeated test will include multiple concentrations to determine the lethal concentration to 50% of the test population (LC_{50}).

6 REPORTING AND RECORDING

6.1 REPORTING

The core report is the Annual Report which describes the status of the aquatic environment and any observed trends associated with mine operations.

Reporting of environmental monitoring data is conducted in accordance with all permits and approvals. Regulatory requirements are anticipated to entail formal annual reports, including discussion of issues of non-conformance (Table 5-1). The Annual Report includes the following:

- a description of mine activities during the monitoring interval;
- a compilation of AEMP monitoring data obtained during the most recent reporting period;
- description of the methods used for sample and data collection;
- an evaluation of the impacts of effluent discharge on the receiving environment, adequacy of monitoring, and recommendations;
- results from the evaluation of effects, in text and figures;
- conclusions from the evaluation of effects;
- description of mitigation measures in place, and a discussion of effectiveness; and
- identification of additional mitigation measures as required.

Annual reports are issued in a standardized format and are kept on file and made available upon request.

6.1.1 Compliance and Permit Reporting

The Annual Report contains the information to comply with conditions listed in Section 5.5 of the EMA permit. The AEMP includes the methods, results, and interpretation for:

- Analyses of key water quality trends;
- Sediment and biological monitoring;
- Acute and chronic toxicity testing;
- Environmental effects; and
- Assessment of the protectiveness of the discharge limits.

The MDMER EEM studies are reported separately from the Annual Report.

6.1.2 External Reporting

As part of environmental reporting, Pretivm distributes copies of the annual AEMP report to relevant entities.

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Appendix A

Statistical Power Modeling for BACI ANOVA

APPENDIX A. STATISTICAL POWER MODELING FOR BACI ANOVA

Simulations are an established method for estimating statistical power in the absence of analytical solutions (Bolker 2008). Although analytical estimates are available for simple statistical designs, such as linear regression or one-factor ANOVA, these methods are not applicable to the two-factor ANOVA required for BACI analyses (Environment Canada 2012c). The design of this power modeling analysis follows from the basic principles of frequentist statistics, where the false-positive rate (Type I error, a) and the false-negative rate (Type II error, β) describe the acceptable levels of uncertainty in the statistical analysis (in a narrow sense). The standard ANOVA approach is design to control the false-positive rate, whereas the false-negative rate is determined by a number of factors, including sample size and experimental design.

For this power analysis, the effect is fixed to a minimum critical effect size (CES) of 2 standard deviations (SD). With this known effect size, the model simulates the results of a monitoring plan comparing observations of a component of the aquatic ecosystem at an exposure site and a reference site. Observations are drawn as random values from a normal distribution determined by baseline sampling, and including the +2 SD effect at the exposure site. For each run of the simulation, these modeled observations are analyzed with a two-factor BACI model, and the significance of the interaction term between *period* (Before-After) and *treatment* (Control-Impact) was compared against an a = 0.1 (as suggested in the *Metal Mining Technical Guidance for Environmental Effects Monitoring*). If the simulation run did not identify the change in the monitoring parameter to be significant, even though the value increased by 2 SD, then the run was flagged as a false-negative. The simulation was repeated for 1,000 iterations, and the frequency of false-negative flags was used to estimate the power of the statistical test under those simulated conditions. The simulation was the run across a series of sampling sizes to determine the replication necessary to results in a power of 0.9 (or β = 0.1).

Table A-1 describes the source data and specific model characteristics used in the simulations. The R (http://www.r-project.org/) code for the model, which includes a tool for presenting the simulation results, is included below.

Table A-1. BACI ANOVA Power Analysis Model Inputs and Settings

Parameter	Site	*n*	Mean	SD	Model Characteristics
Sediment Arsenic	BJ 1.74	3	253 mg/kg	42 mg/kg	Model uses log_{10}-transformed data to stabilize variances.
	L3 OF	3	12.6 mg/kg	0.1 mg/kg	
Periphyton Biomass (chl. *a*)	BJ 1.74	3	3.23 µg/L	1.29 µg/L	Model uses non-transformed chlorophyll *a* concentrations
	L3 OF	3	1.14 µg/L	0.65 µg/L	

R Code for the BACI ANOVA Power Analysis

```
# Simulation model for calculation power for two-factor ANOVA
# with an interaction term. Corresponds to a one-site vs. one-site
# sampling design, without a term for inter-annual variation.

# setting starting conditions; nsim = number of simulations,
# nbase is the number of baseline samples (generally 3 to 5),
# nmon = levels of AEMP sampling replication,
# meanexp = mean value of the parameter in a exposure site,
# sdexp = standard deviation of the parameter at the exposure site,
# meancon = mean value at the control site,
# sdcon = standard deviation of the parametr at the control site,
# alpha = defined probably of Type I error (false negative),
# ces = defined threshold of an effect (2 standard deviations),
# log.flag = flag for log-10 transformation of data prior to model

# simulation model for power (1-beta) for each of the
# levels of AEMP sampling replication defined above. Power
# is calculated as the frequency of simulated data with significant
# interaction terms (site*treat) at the defined alpha.

power.sim.anova2<-function(nbase, nmon, meanexp, sdexp,
                           meancon, sdcon, alpha, ces, nsim,
                           log.flag,
                           setseed=1001){

  power.n <- numeric(length(nmon))

  for (i in 1:length(nmon)) {
    naemp <- nmon[i]
    pval <- numeric(length(nsim))
    for (j in 1:nsim){
      con.before <- rnorm(nbase, meancon, sdcon)
      con.after <- rnorm(naemp, meancon, sdcon)
      exp.before <- rnorm(nbase, meanexp, sdexp)
      exp.after <- rnorm(naemp, meanexp + ces * sdexp,
                         sdexp)

      value <- c(con.before, con.after, exp.before, exp.after)
      site <- c(rep("control", nbase + naemp),
                rep("exposure", nbase + naemp))
      treat <- rep(c(rep("before", nbase), rep("after", naemp)), 2)

      data.f <- data.frame(site, treat, value)
      ifelse(log.flag == 1,
             m <- lm(log(value,10) ~ site * treat, data = data.f),
             m  <- lm(value ~ site * treat, data = data.f))
      pval[j] <- coef(summary(m))[4,4]
```

```
    }
    power.n[i] = sum(pval < alpha)/nsim
  }
  power.summ <- cbind(nmon, power.n)
  #find first occurrence of value greater than power = 0.9
  pfin<-power.summ[which(power.summ[,2]>=0.9, arr.ind = TRUE)[1],1]
  #print to console
  print(power.summ)
  #plot power function
  scatter.smooth(power.summ, span=2/3, type="p",
                 xlab="Number of Samples", ylab="Power", pch=19)
  options(warn=-1)
  #add sample size at power =0.9 to plot
  legend("topleft", legend=c("lowess fit", "simulated\nscores"),
         title=paste("Power >0.9 @ N =", pfin),
         lty=c(1,0), pch=c(26,19), bty="n")
  options(warn=0)
}

#function call: provides plot of power, identifies sample size and prints
      dataframe of values to console
power.sim.anova2(nbase=5, nmon=seq(3,20,1),
                 meanexp=3.23, sdexp=1.29,
                 meancon=1.14, sdcon=0.65,
                 alpha=0.1, ces=2, nsim=100,
                 log.flag = 0,
                 setseed=1001)
```

Appendix 9-1-5. Avalanche Safety Plan

PRETIVM
BRUCEJACK MINE

BRUCEJACK MINE

Avalanche Safety Plan

February 2022

PRETIVM
BRUCEJACK MINE

BRUCEJACK MINE

Avalanche Safety Plan

Date: February 2022

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
2021.0	March 2021	Pretivm's Mountain Safety, Health & Safety and Environment & Regulatory Affairs Departments	Updated references to regulations, added reference section, updated SOP section, formatted document
2022.0	March 2022	Pretivm's Mountain Safety, Health & Safety and Environment & Regulatory Affairs Departments	Minor updates to Sections 5 (Organizational Structure and Personnel) and 7 (Equipment and Infrastructure)

DISCLAIMER AND ACKNOWLEDGEMENTS

The Avalanche Safety Plan (ASP) provides an overview of operations for the Brucejack Mine, managed and operated by Pretivm Resources Inc (Pretivm). The ASP intent is to provide a comprehensive guide to all the individual components of the avalanche safety program, which is managed by the Mountain Safety Department of Pretivm Resources Inc. This ASP is a living document and will be reviewed annually to reflect improvements and changes implemented into the avalanche safety program.

Avalanches are a chaotic natural phenomenon, and consequently have a varying degree of unpredictability and uncertainty. This creates a level of risk for anyone working in or travelling through avalanche terrain. The avalanche hazard at a workplace may range from nil (outside of avalanche paths) to extreme (workplace is exposed to multiple avalanche paths with very poor snow stability). This risk may not be eliminated but is kept as low as reasonably practical by following the mitigation measures outlined in this ASP. These measures follow industry best practices for the reduction of avalanche hazards and risk.

The history of previous avalanche occurrences within and surrounding the Mine area has been collected and added into a database for the past ten years. Long-term experience and observation in a specific area improves understanding of local avalanche phenomena and increases forecasting accuracy. Regular snowpack, weather and avalanche occurrence observations by qualified personnel are important components of the ASP implementation.

Although other geo-hazards exist in the region, risk reduction measures in this ASP are limited exclusively to snow avalanches and cornice fall. In addition, any artificial or natural alteration of the landscape or terrain due to earthworks, forest fire, deforestation, landslides, or other geological events may change the nature of avalanche hazard, necessitating a reassessment for the area affected.

Each workplace within an avalanche risk zone requires site specific risk management strategies determined by a qualified Mountain Safety Technician. Qualified personnel will provide Pretivm management, employees, and contractors an avalanche hazard evaluation, related recommendations, and other services as required, whenever a workplace requires ASP implementation. The subsequent actions or inactions of any Pretivm personnel are not the responsibility of the Mountain Safety department.

The Mountain Safety Department of Pretivm will provide ongoing recommendations and services to manage avalanche hazards on the Mine. The authority and final decision to implement any recommendations resides with the Pretivm General Manager or designate.

This ASP provides all Pretivm Brucejack Mine workers, contractors and authorized industrial road users with safe working and driving conditions. However, if specific information is required and it is not addressed in this document, it is the responsibility of every manager, supervisor, and worker involved to seek out that information immediately.

The Pretivm Mountain Safety Department has prepared this document for the Brucejack Mine. The material included in this document reflects their best judgement considering the information available at the time of preparation. Any use of this plan by a third party, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Pretivm accepts no responsibilities for damages, if any, suffered by any third party resulting from decisions made or actions taken, based on this plan.

BRUCEJACK MINE

Avalanche Safety Plan

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GLOSSARY AND ABBREVIATIONS

ASP	Avalanche Safety Plan
ATES	Avalanche Terrain Exposure Scale
BC	British Columbia
Brucejack Access Road	Access road connecting from ~km 215 of Highway 37 to the Brucejack Mine
CAA	Canadian Avalanche Association
ERT	Emergency Response Team
HSRC	Health, Safety and Reclamation Code for Mines in BC (2017)
km	Kilometre
MEMLCI	BC Ministry of Energy, Mines and Low Carbon Innovation
Mine Site	Infrastructure area at the southwest end of Brucejack Lake
Mine Site Area	Infrastructure area west of upper Knipple Glacier
PPE	Avalanche personal protective equipment
Pretivm	Pretium Resources Inc.
SOP	Standard Operating Procedures
TVL	Tsetsaut Ventures Ltd.
WSBC	WorkSafeBC – Workers' Compensation Board of British Columbia

DEFINITIONS AND TERMS

Avalanche risk zone: A workplace or part of a workplace where an avalanche risk assessment determines that avalanches pose a risk to any person working at the workplace or infrastructure of the Mine site and risk control measures are required to make the area for work safe to be conducted (WorkSafe BC, 2014).

Avalanche hazard: The potential for an avalanche to cause damage to something of value. It is a function of the likelihood of triggering or frequency, and the avalanche size or magnitude (CAA, 2016a).

*Note – hazard and danger may be used synonymously when referring to avalanche hazard ratings used for Mine work in this ASP.

Acceptable risk: Describes the likelihood of an event where the probability of occurrence is small, the consequences are so slight, or the benefits (perceived or real) are so great, that the individuals or groups in society are willing to take or be subjected to the risk that the event might occur (Encyclopedia of Public Health).

Workplace: Any place where a worker is, or is likely to be, engaged in any work and includes any vessel, vehicle or mobile equipment used by a worker in work (BC Workers Compensation Act – Section 106, Definitions (Part 3)).

Note: For purposes of this ASP, reference to "workplace" also includes ground and air access routes to workplace locations.

1 INTRODUCTION

This document is the Avalanche Safety Plan (ASP) for the Pretivm Resources Inc. (Pretivm) Brucejack Mine.

An Avalanche Risk Assessment and Avalanche Hazard Zoning have been completed for the Brucejack Mine (Appendix A) as well as detailed Avalanche Hazard Zoning for the Mine Site Area (infrastructure area west of the Knipple Glacier; Appendix B). These documents should be referenced in consideration of appropriate avalanche mitigation measures prior to placement and construction of temporary or permanent infrastructure within the Mine Site Area. Infrastructure placed outside of the Mine Site Area should initially reference the Avalanche Risk Assessment and Avalanche Hazard Zoning documents; however, it will require detailed avalanche mapping to be completed in the planning stages to provide a higher degree of certainty regarding potential avalanche hazard (WSBC 2009).

The Mountain Safety Department is responsible for providing operational avalanche safety services to implement the ASP. This team of professional Avalanche Technicians provide 24-hour avalanche risk management for workers, haul road traffic and infrastructure on the Brucejack Mine.

The team use a network of remote telemetry and manual weather stations, assess reports of regional avalanche conditions, observe avalanche occurrences, and investigate the structure of the snowpack. When the conditions warrant, road or worksite closures are initiated to ensure the safety of all Mine workers. Efforts are made to ensure that closures are as short as possible, and that road and worksites are reopened as soon as the avalanche risk is reduced to an acceptable level.

During closures, explosives may be used to trigger avalanches. Traditional means of explosives control is by case and hand charging, and the deployment of explosives from a helicopter.

At two critical locations on the lower access road, Pretium has invested in avalanche control devices that can be remotely triggered. The Remote Avalanche Control System (RACS) provides reliable deployment of explosive control devices in any type of weather.

In several locations, the team builds snow catchments along the access road and in Brucejack camp to reduce or eliminate the effect of avalanches.

This ASP establishes on-going avalanche safety procedures. These are developed to meet or exceed Health, Safety and Reclamation Code for Mines in British Columbia (HSRC), WorkSafeBC, and Canadian Avalanche Association's (CAA) regulations, guidelines, and avalanche industry best practices.

Risk mitigation measures outlined in this ASP include but are not limited to:

- Avalanche education and rescue training, including use of avalanche personal protective equipment (PPE)
- Preparation and maintenance of avalanche rescue equipment

- Worksite risk classification planning tools
- Avalanche-related Standard Operating Procedures (SOPs), including communication standards check in / check-out procedures
- Assessment and communication of current and forecast avalanche hazards
- Worksite Avalanche Assessments, including hazard identification, signage, and closures
- Daily snowpack, weather, and avalanche observations
- Avalanche control using explosives and other means
- Emergency response and avalanche rescue

2 REGULATORY FRAMEWORK

The health and safety of workers at the Brucejack Mine falls under two different jurisdictions. The Mine site, km 71.6 and up on the haul road is under the jurisdiction of The Ministry of Energy and Mines. The remaining camps and haul road from km 0 to km 71.6 and all further exploration areas fall under the jurisdiction of WorkSafeBC.

This ASP is in accordance with all requirements of the following applicable regulations and guidelines:

- Health, Safety and Reclamation Code for Mines in British Columbia (MEM, 2017);
- Workers Compensation Act. Occupational Health and Safety Regulation. B.C. Reg. 296/97 (WCB, 2020);
- Technical Aspects of Snow Avalanche Risk Management (TASARM): Resources and guidelines for Avalanche Practitioners in Canada (CAA, 2016a); and
- Recommended Generic Table of Contents -Avalanche Safety Plan (CAA, 2009)

The latter two guidelines are recognized by WorkSafeBC and accepted as industry standards for ASP development for operations in avalanche terrain in British Columbia.

Workplaces are typically assessed for avalanche return periods in the range of less than 30 to 100 years, depending on the permanence of occupation of the work site, with a critical avalanche Size 2 or greater (Table 2-1). An ASP is implemented when the return period at a workplace is within this range.

Recommended avalanche risk mitigation measures in this ASP are based on these WorkSafeBC and Canadian Avalanche Association guidelines.

Table 23.1-1. Risk Assessment & Mitigation Guidelines – Industrial Mines (CAA, 2016a)

Land Use	Typical Return Period (years)	Typical Avalanche Size	Typical Action or Planning	Typical Maps
Work sites (e.g. 9,400 m2, Laydown, Portal)	≤30	≥1	• Operational avalanche safety plan • Avalanche Forecast and control program	Locator or avalanche atlas mapping
Occupied Structures (e.g. Camp, Office)	≤300	≥1 or an impact load of ≥1 kPa	• Location Panning • Structural protection • Short-term operational measures including a comprehensive avalanche control program, closures, and evacuations	Site specific mapping
Resource Road	≤30	≥2	• Operational avalanche safety plan • Avalanche forecast and control	Locator or avalanche atlas mapping

3 DESCRIPTION

3.1 LOCATION OVERVIEW

The Brucejack Mine lies within the Boundary Ranges of the Coast Mountains of Northern British Columbia (Figure 3.1-1). The closest communities, approximately 60 km south, are Stewart, British Columbia and Hyder, Alaska.

The Mine Site Area is in the alpine eco-region, at an elevation of 1435m. It is situated on the south shore of Brucejack Lake, at the head of the Knipple Glacier, 56°27′56″ north latitude, 130°11′08″ west longitude.

The Brucejack Access Road begins at km 215 of Highway 37, near the confluence of Wildfire Creek and the Bell Irving River. It follows the Wildfire Creek, Scott Creek, and Bowser River valleys, then ascends the Knipple Glacier to the Mine Site (infrastructure located at the southwest end of Brucejack Lake) (Figure 3.1-2).

The operational area intersects several distinct geographic and climate zones. For practical purposes they have been divided into 7 distinct Avalanche hazard forecast zones, further subdivided based on the regular three elevation-based hazard zones (Alpine, Treeline, and Below Treeline).

The hazard zones are:

- Zone A – Brucejack Mine Site (including Brucejack Camp);
- Zone B – Lakeshore Drive Km 71.6-74;
- Zone C – VOK Road and Control Roads;
- Zone F – Knipple Corner Exit Km 56-59.5;
- Zone G – Scott Creek to Bowser Km 37-56;
- Zone H – Wildfire to Scott Creek Km 3-37; and,
- Wildfire Hill Km 2-3.

Figure 3.1-3 depicts the avalanche hazard zones relative to Brucejack Mine and Access Road infrastructure.

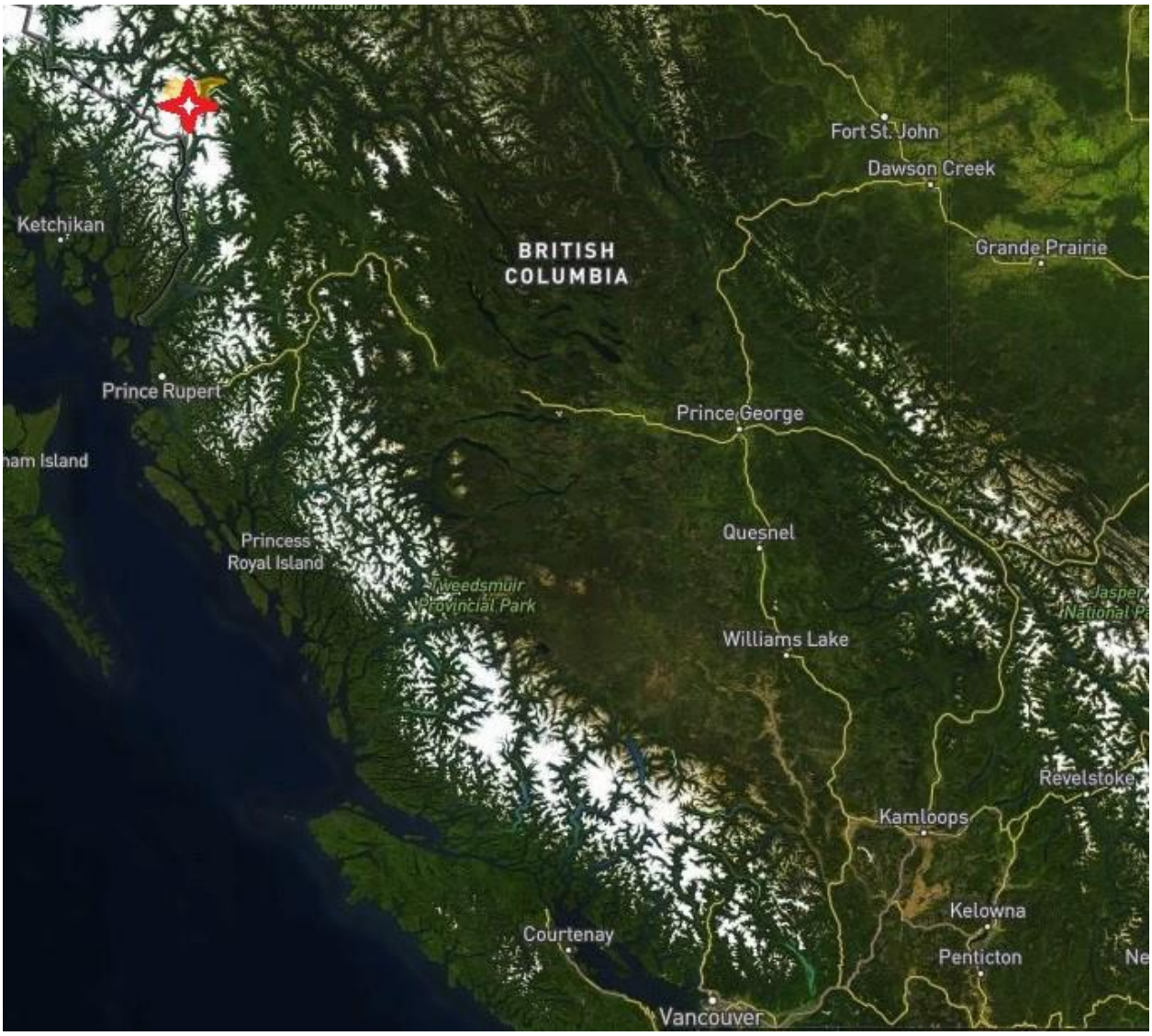

Figure 3.1-1. Location of the Brucejack Mine Relative to British Columbia

Figure 3.1-2. Brucejack Mine Operating Area

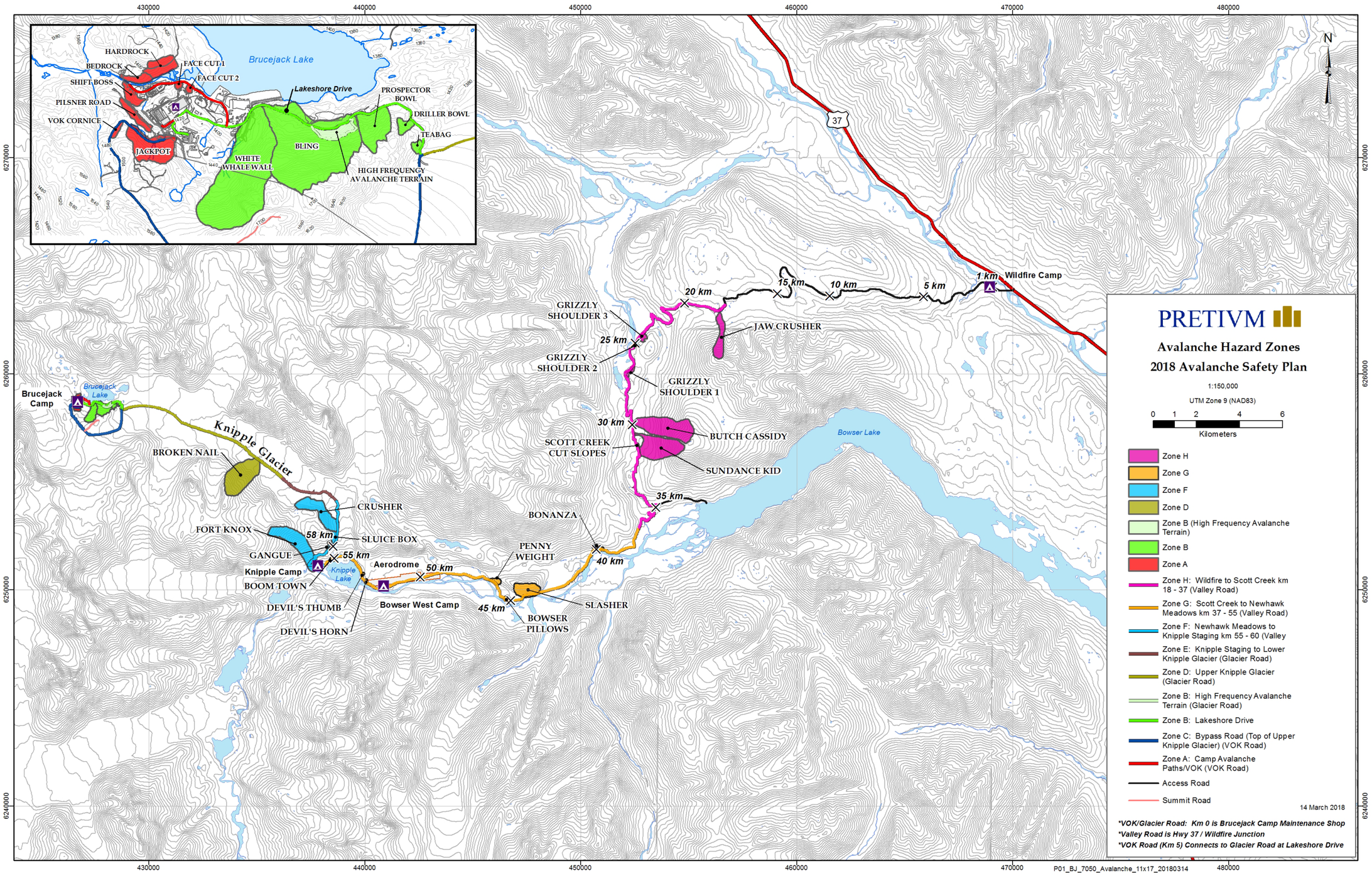

Figure 3.1-3 Mine Site Area and Access Road Area Map Relative to Avalanche Hazard Zones

3.2 MINE PHYSIOGRAPHY AND SNOW AVALANCHE CLIMATE

The terrain surrounding the Brucejack Mine is rugged and mountainous. Mine avalanche terrain includes Alpine, Treeline and Below treeline vegetation zones (Table 3.2-1). The land is glaciated in all directions surrounding the Mine site and the glaciers descend to elevations below treeline. Winter weather in the area is historically severe. This is largely due to the height of the mountains and proximity to the ocean. The mountains cause rapid orographic lifting of prevailing weather systems from the western quadrant.

The Mine Site, including the Brucejack Camp, is in a mountain pass that creates a localized microclimate of variable strong winds which compounds the effects of regional weather systems, often contrary to prevailing winds.

The combination of rugged glaciated topography, latitude, and coastal weather systems creates severe winter conditions. The region receives some of the heaviest snowfall in North America, with settled seasonal snowpack depths ranging from 3 to 6 metres. Local drifting snow creates highly variable snow deposition, often to depths much greater than the regional average. Although there are obvious conditions favorable for avalanches throughout the winter, the potential also extends into summer; therefore, avalanche season ranges from October to June.

Table 3.2-1. Brucejack Mine Reference Elevations (CAA, 2016b)

Feature	Approximate Elevation(m)	Description / Notes
Ridgetop	1600	Height of land in project area.
Alpine	Above 1400	Upper mountain elevations where trees are very sparse to nonexistent*
Tree line	1200-1400	Elevation band describing the transitional area between closed forest below and open treeless areas above.*
Below Teeline	Sea level (0) to 1200	Terrain from valley bottom to where the mountain side forest begins to thin*
Stewart BC	0	

3.3 AVALANCHE MAGNITUDE AND FREQUENCY

The relation between the frequency and magnitude of an avalanche is complex, encompassing several variables such as the number and type of snowfalls, effects of wind transported snow, snowpack structure, and terrain. Regularly occurring large storms often, but not always, cause avalanches. Important terrain characteristics are slope shape, size, and incline. Snow structure can also affect the magnitude and frequency of avalanches. For example, a weak layer buried deeply in the snowpack can result in large avalanches.

Avalanche frequency (avalanche return period) is typically given a range from 1 to 300 years. An avalanche reaching a location every year is considered high frequency, whereas an avalanche reaching

a location every 300 years has a very low frequency. In general, it is expected that lower frequency avalanches will reach further down the path in the runout zone. The annual probability of the avalanche is the reciprocal of the return period. The annual probability of a 100-year return period avalanche is 0.01 (1%, or 1:100 annually).

The magnitude of avalanches is described by the Canadian Avalanche Size Classification (Table 3.3-1). Typically, a size 1 or 2 avalanche will not damage conventional structures. A size 3 may damage or destroy a typical wood frame structure. A size 4 or 5 avalanche can destroy multiple typical wood frame, steel, and concrete structures.

Avalanche magnitude is also related to frequency in that large destructive avalanches will occur less frequently than smaller ones in each avalanche path. The frequency of reaching a specific location in an avalanche path decreases with the locations distance from a start zone.

Table 3.3-1. Canadian Avalanche Size Classifications (CAA, 2016b)

Size	Destructive Potential	Typical Mass (t)	Typical Path Length (m)	Typical Impact Pressure (kPa)
1	Relatively harmless to people	<10	10	1
2	Could bury, injure, or kill a person	100	100	10
3	Could bury and destroy a car, damage a truck, destroy a wood framed house, or destroy a few trees	1,000	1,000	100
4	Could destroy a railway car, large truck, several buildings, or forest area of approx. 4 ha	10,000	2,000	500
5	Largest snow avalanche known. Could destroy a village or a forest area of approx. 40 ha	100,00	3,00	1,00

3.4 AVALANCHE TERRAIN CLASSIFICATION

Avalanche terrain within the study area is categorized into four separate classes, based on the level of potential avalanche exposure as determined by terrain variables, using an industry standard terrain classification scheme (Table 3.4-1)

The terrain classes used in some of the mapping are identified for field work planning and general navigation only. To navigate safe routes through avalanche terrain the ability to recognize specific avalanche prone terrain features is necessary. These features include:

- Slope angle – any open slope greater than 25° has the potential to produce avalanches.
- Slope shape – convex shaped slopes are more prone to avalanches than concave shaped slopes.

- Wind exposure – leeward slopes near ridge crests are often more prone to avalanches, especially in the afternoon.
- Terrain traps – trees, cliffs, open water, abrupt transitions, etc. can increase the consequence of being caught in an avalanche.

Table 3.4-1. Avalanche Terrain Exposure Scale (ATES).

	Class 0	Class 1	Class 2	Class 3
Slope angle	Angles< 20°	Angles generally < 30°	***Mostly low angle, isolated slopes > 35°***	***Variable with large % > 35°***
Slope shape	Uniform of concave	Uniform	Some convexities	Convoluted
Forest Density	Densely Forested or low-angle openings	Primarily treed with some forest openings	Mixed trees and open terrain	Large expanses of open terrain. Isolated tree bands
Terrain Traps	None	Minimal, some creek slopes or cutbanks	Some depressions, gullies and/or overhead avalanche terrain	***Many depressions, gullies, cliffs, hidden slopes above gullies, cornices***
Avalanche frequency (events: years)	No avalanches > size 1	1:30 ≥ size 2	1:1 for < size 2 ***1:3 for ≥ size 2***	1:1 for < size 3 ***1:3 for ≥ size 3***
Start zone density	No open terrain > 15°	Limited open terrain	Some open terrain, isolated avalanche paths leading to valley bottom	Large expanses of open terrain. Multiple avalanche paths leading to valley bottom
Runout zone characteristics	No exposure to runouts	Solitary, well defined areas, smooth transitions, spread deposits	Abrupt transitions or depressions with deep deposits	Multiple converging runout zones, confined deposition area, steep tracks overhead
Interaction with avalanche paths	None	Runout zones only	Single path or paths with separation	***Numerous and overlapping paths***
Route options	Unlimited	Numerous terrains allows multiple choices	A selection of choices of varying exposure, options to avoid avalanche paths	***Limited chances to reduce exposure, avoidance not possible***
Exposure time	None	None, or limited exposure crossing runouts only	***Isolated exposure to start zones and tracks***	***Frequent exposure to start zones and tracks***

Parameters in bold type default assessed locations into that class (Parks Canada, 2017; Statham et al, 2006)

4 OPERATIONAL OBJECTIVES

The primary objective of this Avalanche Safety Plan is to protect workers and infrastructure from avalanche hazards while maintaining a safe and productive operation.

Secondary objectives include:

- protecting equipment and infrastructure from damage and loss;
- minimizing road closures and operational disruptions;
- ensuring all work and travel meets regulations and best practices as prescribed and maintained by Health, Safety and Reclamation Code for Mines in British Columbia (HSRC), WorksafeBC (WSBC), and The Canadian Avalanche Association (CAA); and
- planning for incident response.

Complexity is present in any safety plan; however, by focusing on areas such as Early Planning, Hazard avoidance, Hazard Reduction, Risk reduction, Defense Structures, Hazard Monitoring and Training, this ASP is intended to minimize operational impacts while maintaining a high degree of safety.

5 ORGANIZATIONAL STRUCTURE AND PERSONNEL

5.1 MOUNTAIN SAFETY DEPARTMENT

The department is an integral member of the Brucejack Surface Operations Department. Up to nine Mountain Safety Avalanche Technicians are on duty at the Brucejack Mine and lower access road at any time during the avalanche season. Technician teams operate out of two camp locations (Brucejack and Knipple Camps). They provide 24-hour management of avalanche risk to workers at Brucejack and its supporting infrastructure. A supervisor covers both camps, and up to two dayshift and two nightshift technicians at each camp.

5.1.1 Mountain Safety Supervisor

Reports to Health, Safety and Security Manager. Oversees the Mountain Safety Department and Avalanche Technicians. Responsible for scheduling, training, planning, logistics, and quality assurance. Makes recommendations to management for implementation of ASP. Liaises with management and other departments for all operations.

5.1.2 Mountain Safety Lead Hands

Report to the Mountain Safety Supervisor. In the absence of the Mountain Safety Supervisors, they oversee the Mountain Safety Department. Oversee Avalanche technicians under their direct supervision. They are responsible for collecting snow and avalanche information, assessing avalanche hazard at worksites, and disseminating snow and avalanche information in a daily avalanche hazard bulletin. Conduct routine snow stability tests and hazard reduction work. Liaise with management and other departments for all Brucejack daily avalanche safety operations. Provides input into Procedures and plans.

5.1.3 Mountain Safety Technicians

Report to the Mountain Safety Supervisor and Lead Hands. They are responsible for collecting snow and avalanche information, assessing avalanche hazard at worksites, and disseminating snow and avalanche information in a daily avalanche hazard bulletin. Conduct routine snow stability tests and hazard reduction work. Liaise with management and other departments for all Brucejack daily avalanche safety operations.

6 TRAINING

6.1 WORKERS REGULARLY EXPOSED TO AVALANCHE HAZARD

6.1.1 Mountain Safety Technicians

All technicians will hold at a minimum a Canadian Avalanche Association (CAA) Level 2 certificate, Transportation of Dangerous Goods (TDG), Advanced First aid, BC Worker Compensation Board (WCB) and Mines blasting certificates as well as a current professional membership to the Canadian Avalanche Association. Further certification is desirable and encouraged, such as Level 3 CAA certificate, Association of Canadian Mountain Guides (ACMG) Ski or Mountain Guide status, Incident Command System certification and advanced first aid.

The technician's skills and training are commensurate with the responsibilities of their current position; however, the technician is encouraged to improve their skills and training levels to facilitate continued professional development.

Technicians require continued exposure to training opportunities to remain current, capable, and qualified for their duties. Avalanche knowledge and standards are constantly improving. Therefore, providing continued support for improvement of employee skills is integral to the effectiveness of the avalanche program.

The CAA has established training guidelines for avalanche safety workers. Workers and the managers overseeing avalanche programs can review these guidelines and strive to ensure that the work performed on behalf of Pretivm is undertaken by skilled, competent, and engaged workers.

Formal training courses aligned with on-the-job training of the technician's skill development will benefit Pretivm. Courses include advanced weather forecasting; avalanche search and rescue; applied avalanche risk management; and numerous seminars and conferences focused on avalanche research, education, and safety.

The Mountain Safety Department conducts annual training throughout the avalanche season. All training is documented on a digital tracking sheet. Training includes:

- annual reviews of all SOPs;
- avalanche rescue;
- first aid and triage;
- field work best practices such as route selection, travel techniques, and snow profile procedures; and
- a minimum of 8 hours of explosives training.

6.1.2 Equipment Operators and Environmental Scientists

All Equipment Operators, Environmental Scientists, Personnel and Contractors who have been designated as having higher avalanche terrain exposure or higher vulnerability are required to complete annual avalanche safety training delivered by the Mountain Safety Department.

Department and Contractor Supervisors are responsible for ensuring all workers who need Avalanche Safety Training are trained prior to being exposed to hazard.

The avalanche risk potential for equipment operators and environmental scientists is much higher than that of general road users; therefore, a higher level of training is provided to these groups.

Pretivm's customized avalanche safety training course includes classroom and outdoor sessions. The sessions cover theoretical and practical aspects of avalanche safety including, but not limited to:

- Formation of avalanches
- Hazard Rating Safe Work Procedures
- Standard Operating Procedures
- Worksite Avalanche Assessment and associated procedures
- Use of avalanche companion rescue equipment (Avalanche PPE)
- Check-in/Check-out procedures
- Avalanche signage
- Encountering unexploded ordinance
- Avalanche and weather observation reporting
- Familiarity with identified avalanche zones within the Mine
- Mountain hazards awareness and recognition
- Best practices if caught in or witness to an avalanche.
- Avalanche rescue, including practice basic rescue scenario

Avalanche PPE is provided to designated workers, including all Equipment Operators working in avalanche terrain during daily work.

The Safety Department maintains worker avalanche safety training and exam records.

6.2 ALL OTHER PERSONNEL AND CONTRACTORS

Most Mine workers travel through identified avalanche zones to and from Mine worksites/camp locations; therefore, all workers are required to annually attend an introductory avalanche safety seminar. The training session focus on Safe Work Procedures including hazard communication, signage, and introduces avalanche phenomena, basic safety measures, Mine avalanche hazard

warning and closure system, with the emphasis being on safe road travel procedures. This course is developed by the Mountain Safety Department and delivered by the Safety Department during the site orientation seminar.

At times, personnel will need to conduct work within avalanche areas. In this case, the need to undertake the work will be established with the Mountain Safety Department who will identify the appropriate level of instruction, supervision and use of personal protective equipment.

6.3 EMERGENCY RESPONSE TEAM

The Emergency Response Team (ERT) is on 24-hour standby to assist with rescue response in the event of an avalanche incident. Therefore, they require a higher level of training, acquired from two distinct training courses. The first course provides knowledge on advanced companion rescue skills including avalanche transceiver use, probing, and shovelling techniques. The second course explores organized avalanche response training including communications, command structure and scope, with a focus on second party tasks (Recco use, search strategies, spot probing, and deep burials.) Practice field scenarios occur regularly to ensure the ERT teams are competent in avalanche rescue. These courses are based on the CAA's current best practices, adjusted to the appropriate skill levels and experience of the ERT team.

6.4 DISPATCH

Dispatch plays an integral role in emergency response on the Brucejack Mine. They receive an annual review of the avalanche emergency response plan (Appendix D) and participate in mock avalanche rescue scenarios to allow for familiarization with response procedures, as well as providing feedback for ongoing improvements.

7 EQUIPMENT AND INFRASTRUCTURE

7.1 SNOW AND WEATHER

Manual and remote telemetry weather stations as well as snow study plots have been established in the Mine area. Weather telemetry is hosted on software (Aquarius Webportal v.2020.1) which graphs and stores all relevant data including: wind speed and direction, humidity, temperature, and atmospheric pressure. Snowpack telemetry includes snowpack height and hourly precipitation amounts. Mountain Safety personnel collect twice daily weather observations alongside regular snowpack observations and update the CAA Infoex database with all relevant observations.

7.2 RADIOS AND COMMUNICATIONS

Radios are the most effective means of communication on the Brucejack Mine. Pretivm has licensed several radio frequencies, including both simplex (line of sight) channels and three repeater frequencies (Appendix E).

All Brucejack Mine workers operate on designated Pretivm frequencies to maintain a direct line of communications with the Mine Manager, Dispatch, Surface Operations Supervisor, Equipment Operators, Mountain Safety, Yellowhead Helicopter pilots and each other.

Radio communication along the Mine haul roads follows the Pretivm Standard Road Procedures SOP.

7.3 AVALANCHE CONTROL

Pretivm has purchased and installed 2 separate systems for remote firing of charges to trigger avalanches:

- A series of 6 Gazex exploders installed at km 44.5 and
- A set of 12 Wyssen towers mounted at km 60.

If any person comes upon undetonated explosives, they are instructed not to touch the explosive, to stop in a safe area and call Dispatch immediately, relaying the location of the explosive. Dispatch will notify the Mountain Safety Department who will guard the area until the explosive can be detonated.

A wildlife management plan is in place to ensure all regulations and best practices are followed for igniting explosives in a mountain environment that may be habitat for various sensitive animal species including mountain goats, moose, wolverine, and bear. Pre-control wildlife surveys are performed and recorded digitally

7.4 EXPLOSIVES STORAGE, TRANSPORTATION AND USE

Mountain Safety staff are certified to purchase, handle, store, transport, and fire explosives in BC in accordance with all federal and provincial regulations. These regulations are overseen by the following bodies:

Transportation of Explosives - Transport Canada, Transportation of Dangerous Goods Directorate is the federal body responsible for the Transportation of Dangerous Goods Regulation.

Vehicles transporting explosives are in proper running condition, have 4 orange TDG diamond shaped placards placed on the front, rear and sides, have a separate compartment for the explosives and detonators and are equipped with suitable fire extinguishers.

Explosives are delivered directly by the explosive supplier to the Mine. Explosives are stored in licensed magazines, where only authorized and trained persons are permitted access. Authorization includes holding current BC and HSRC blasting permits; approved clearance letters from Natural Resources Canada (NRCAN) Explosives Regulatory Division; and sign-off on the key management plan, site safety plan and fire safety plan for the magazine they are accessing.

Storage of Explosives - Natural Resources Canada, Explosive Safety and Security Branch, is responsible for administering the federal Explosives Act and regulations. Through the Explosives Regulatory Division (ERD), the Branch provides services and support to the explosives industry.

Explosive Use off the Mine site - WorkSafeBC regulation dictates how explosives are used in BC. They also examine and certify individual blasters for specific types of blasting operations. WorkSafeBC regulation also describes the conditions under which explosives are transported or stored.

Magazines for the storage of explosives used in avalanche control (1 x type 4 and 1 x Type 9 magazine at km 48, 1 x Type 4 and 1 x Type 9 magazines at Brucejack Camp), are maintained in full compliance with the Health Safety and Reclamation in Mines in British Columbia Act Part 8 and NRCAN regulations.

Explosive Use on the Mine site – Blasters on the Mine site are examined and certified for specific blasting procedures as defined in the Health, Safety and Reclamation Code for Mines in BC (2017).

Explosives used shall be licensed as per the Explosives Act (Canada),and shall be used in accordance with the manufacturer's recommendations. All avalanche control blasting procedures are approved by WorkSafeBC.

7.4.1 Blasting Procedures

The use of explosives for avalanche control is detailed in the Pretivm Avalanche Blasting Procedures (Appendix F), which follows all Ministry of Energy and Mines, and Low Carbon Innovation (MEMLCI) and WorkSafeBC procedures.

In addition to avalanche closure procedures, other considerations prior to commencing avalanche control with the use of explosives are covered in SOP's. Mountain Safety will provide communication, either through an avalanche control flash email, the Daily Advisory Bulletin (Appendix G), or over the radio about location and timing of blasts.

Blasting Procedures, like the ASP, are living documents requiring continual (annual at a minimum) review. Upon recognizing a situation where procedural changes could increase worker safety and/or reduce avalanche or other hazards, the Mountain Safety Department will conduct an internal review and any updates will be submitted to WorkSafeBC and MEMLCI for approval before implementation.

7.4.2 Avalanche Control in Proximity to Structures and Equipment

Mountain Safety will pre plan with the Surface Operations Supervisor and provide further communication about probable timing for the buildings to be cleared of personnel. A physical sweep is done in all buildings and roadways/parking areas to ensure all workers and vehicles are out of the danger area prior to the blast. Guards remain in place until after the blast and are removed when instructed by Mountain Safety that it is safe to open the area.

Explosive quantity is restricted to minimize damage to structures, as referenced in the Pre-blast Checklist (Appendix H) in the Pre-Blast Procedures SOP.

7.4.3 Emergency Response Assistance Plan

Mountain Safety Technicians will be required to respond in the event of an explosive spill occurring during transportation. A copy of the Emergency Response Assistance Plan is placed in the vehicles used for transporting explosives. The Mountain Safety technicians use Dyno Nobel's Emergency Response and Assistance Plan (ERAP #2-1037) as a procedural response to an explosive-related emergency (Appendix I). Technicians are required to carry out an annual refresher on the Emergency Response Assistance Plan.

7.5 SIGNS AND NOTICES

Avalanche signage is located at key locations at the Brucejack Mine. The signage provides awareness of the potential of avalanche hazard (Plate 7.5.1).

Plate 7.5-1. Avalanche sign

Standardized road signs (Plate 7.5-2) warn road users when they are entering and exiting identified avalanche zones. NO STOPPING AVALANCHE AREA signs indicate that an avalanche hazard exists and stopping is prohibited. END AVALANCHE AREA indicates the end of the avalanche area.

Plate 7.5-2. Standardized road signs identifying avalanche zones.

Warning signage notifies workers of the explosive avalanche control program and alerts to procedures for encountering unexploded charges (Plate 7.5-3, see below). These signs are placed at key traffic locations throughout the Brucejack Mine. Signage warning of unexploded avalanche control devices are posted year-round to inform of the possibility of encountering an unexploded device.

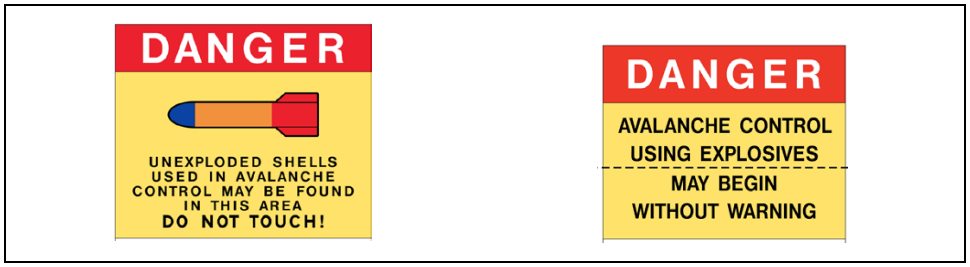

Plate 7.5-3. Warning signage instructing caution around explosives.

Barriers may be used to control traffic and ensure they are safely stopped outside of avalanche areas. They are placed at strategic locations around camp and on access roads. They present a physical barrier with a closed sign to warn personnel that an area is closed for high avalanche hazard or avalanche control work (Plate 7.5-4).

Plate 7.5-4. Road closure. Physical barrier and closed sign.

Portable signs and fixed closure points may be used to keep traffic or personnel out of avalanche areas. When an area is CLOSED the barrier will be put across the road and "CLOSED AVALANCHE DANGER" will be displayed (Plate 7.5-5).

Plate 7.5-5. Fixed closure point sign warning either caution or danger as determined by traffic control personnel.

Avalanche Rescue Equipment locations are identified by signs that will help rescue personnel rapidly access the avalanche rescue equipment (Plate 7.5-6).

Plate 7.5-6. Avalanche Rescue Equipment cache location sign.

Explosives magazine signs are posted at each usual approach to the magazines. They are posted so that they do not attract unwanted attention (Plate 7.5.7).

Plate 7.5-7. Explosives Magazine Signage

7.6 VEHICLES, OFFICE AND STORAGE, INFORMATION AND DATA MANAGEMENT

The Mountain Safety department is provided exclusive use of the following vehicles:

- Two – 4x4 pickup trucks, customized to meet all regulatory requirements from Transport Canada, WorkSafeBC and the Mines Act for transporting explosives. These trucks are equipped with base radios, beacons, chains, spotlights, and spill kits. Vehicles that are carrying explosives also carry a copy of the Emergency Response Plan 2-1037
- One 4x4 truck to assist logistics between camps and efficient use of manpower.
- Three – Mountain Snowmobiles
- One – Trooper snowcat

The following vehicles are available to assist Mountain Operations as required:

- Several snowcats for over snow transfer of personnel, road construction and maintenance
- Helicopter for explosive control and field support
- A variety of heavy equipment to support catchment construction and debris clearing. (Loaders, excavators, bobcats, rock trucks, grader, and bulldozer)

Two dedicated office spaces exist for the mountain safety department – one in Knipple camp and one in Brucejack camp. Within or nearby these offices are lockers, drying and storage areas, work benches and training facilities.

All data collected, including snowpack and avalanche observations, are stored digitally and backed up either by Pretivm's internal IT department or the CAA's InfoEx platform.

7.7 FIRST AID AND MEDICAL EQUIPMENT

Advanced medical treatment centres are in the Brucejack, Knipple and Wildfire camps. These facilities include Automated External Defibrillators (AEDs), oxygen and extensive specialized first aid equipment. Mobile Treatment Centre vehicles are located at all three camps for road evacuation. There is also a Trooper snow cat located at Brucejack camp that is prepared and dedicated for over snow medical evacuation.

7.8 COMPANION RESCUE EQUIPMENT (PPE) AND RESCUE CACHE LOCATIONS

7.8.1 Companion Rescue Equipment

Avalanche personal protective equipment (PPE) has no protective properties and in the avalanche industry is referred to as companion rescue equipment. However, for better integration with resource industry personnel, in this document and on the jobsite, it is referred to as avalanche PPE.

At the beginning of each avalanche season, personnel who are designated to have a higher exposure or higher vulnerability are issued avalanche PPE packs. Each pack includes an avalanche transceiver,

probe, and shovel. It is the responsibility of supervisors to ensure that all designated personnel are always trained and carry their gear when working in or traveling through rated Avalanche Hazard Zones during the winter season. This training is provided by the Mountain Safety department. It is the responsibility of the personnel to look after their PPE and contact their Supervisor or the Mountain Safety Department immediately in the event of breakage or malfunction.

Supervisors are responsible for collecting all avalanche PPE and returning it to Mountain Safety Department for bench testing at the end of each winter avalanche season. If the gear is not returned and tested the Supervisor assumes sole responsibility for the liability of potentially faulty equipment. The Mountain Safety Department checks and documents all PPE to ensure it is in proper working order. Avalanche transceivers are tested annually and software is updated with the most up to date version. If the equipment is not functioning properly, it is sent back to the manufacturer for further testing and calibration.

Daily function checks must be carried out by all workers using avalanche PPE in avalanche terrain. Functionality in both Transmit and Receive modes must be tested. Replace batteries if battery life displays below 40%.

Mountain Safety carry personal avalanche PPE / rescue packs in the field, which include equipment needed to conduct avalanche hazard assessments and small party self-rescue. These generally include a portable radio, avalanche transceiver, snow shovel, avalanche probe, snow saw, basic first aid, snow study kit, field notebook, head lamp, winter survival equipment, and crevasse rescue gear (if glacier travel is required).

7.8.2 Rescue Cache Contents and Storage Locations

ERT Avalanche Rescue Caches are kept in clean, dry conditions in designated locations at either Knipple or Brucejack camp Firehall building. The location of each rescue cache is well marked by signs and access to the cache is never locked during the avalanche season. Knowledge of the exact locations of the rescue cache locations and their contents is reviewed annually with trained emergency response personnel. See (Appendix J) for current rescue cache locations and contents.

Other rescue caches/packs, each consisting of 6 shovels and 6 probes, are located hung on posts at 73.3km magazine, 71.6km turnaround, 58.5km lay down and at 44.4km. Additionally, rescue packs are stored in both Knipple and Brucejack Surface Operations Supervisors and Mountain Safety trucks.

The Mountain Safety department is responsible for the safe and secure storage of the Avalanche Rescue Cache equipment. At a minimum, monthly checks are carried out on the Rescue cache contents. Avalanche technicians are responsible to ensure that all rescue equipment which requires batteries is checked for condition and function, and the batteries replaced with new batteries annually prior to the avalanche season. Batteries are removed from the equipment at the end of the avalanche season.

8 OPERATIONAL PROCEDURES

The avalanche advisory scale (Plate 8.5-1) and Standard Operating Procedures (Appendix C) identify procedures that must be followed throughout the avalanche season.

The avalanche advisory scale and associated standard operating procedures (SOPs) are designed specifically for the Brucejack Mine. The procedures assigned to each of the three status levels are intended to provide safe road and worksite procedures. Worksite and travel procedures alongside risk levels, expected avalanche activity, and potential avalanche control and closures are intended to safeguard travel and maintenance work on the Brucejack Mine. All other travel on the access road can maintain an acceptable level of safety by moving through the avalanche areas without stopping.

The avalanche advisory scale provides simple, effective operational communication of forecast avalanche activity and clearly identifies the specific safety measures workers are required to follow for each level

The timing of the avalanche season is highly variable but generally begins in October and lasts until June. Operational procedures become active for a specific Hazard Zone the day that it becomes rated. De-rated Hazard Zones are deemed to be below threshold for avalanche hazards.

8.1 PRE-SEASON TASKS AND CHECKLISTS

Before winter, a management-level meeting is held with the Mountain Safety Department and other Mine stakeholders. The ASP and general winter operational safety are discussed, necessary revisions to the ASP are addressed. The attendees sign off on the ASP and their organizational responsibilities.

8.2 DATA COLLECTION

All weather, snowpack, and avalanche activity data are recorded by Mountain Safety and stored digitally for easy reference. Weather telemetry is hosted and stored by a software program (Aquarius Webportal v.2020.1), all avalanche and snowpack information is stored on InfoEx, and a manual Time Profile summary is kept current on the wall of each office for backup and ease of use.

8.3 DAILY AGENDA

The Mountain Safety Department follows industry best practices for forecasting avalanche hazard and communicating risk. The department uses the CAA's InfoEx platform which is based on the conceptual model of avalanche hazard, which then informs a list for all avalanche zones. Finally, an Avalanche Advisory Scale is populated for all the avalanche zones and emailed out to communicate the risk level for travel and worksites. A copy of these procedures is available to all workers and is posted on the main camp bulletin board adjacent to the Daily Hazard Bulletin.

8.4 AVALANCHE HAZARD AND RISK EVALUATION

Mountain Safety staff collect data and information from various sources and analyze them to evaluate and forecast avalanche hazard using the CAA's Conceptual Model for Avalanche Hazard (Appendix M). These data are recorded twice at Brucejack and Knipple camps and archived on the CAA Infoex. The resulting avalanche hazard rating dictates potential avalanche control requirements, road and terrain use guidelines, and specific Standard Operating Procedures to be followed. An area that has been de-rated has been deemed to be below threshold for avalanche hazards to the road or worksite in question.

8.5 AVALANCHE ADVISORY RATING AND HAZARD BULLETIN

Mountain Safety issues an Avalanche Hazard Bulletin daily, updated as conditions dictate (Appendix G). The internal Pretivm Avalanche Advisory Bulletin includes a rating of the current and forecast avalanche risk for the 7 distinct Avalanche Hazard Forecast Zones using Pretivm's 3-level Avalanche Advisory Scale for clear, simple messaging to workers (Plate 8.5-1). Each zone is subdivided into main paths for clarity. Areas where regular operations are carried out are identified and emailed to a group of supervisors and operators who may be working in those zones. This allows for clear communication and serves as a planning tool for all affected departments. These are posted at designated locations and e-mailed directly to relevant personnel for dissemination to workers. These steps are described in the SOP Avalanche Hazard Communication.

PRETIVM AVALANCHE ADVISORY SCALE

STATUS	RISK	AVALANCHE CONTROL AND CLOSURES	FORECAST AVALANCHE ACTIVITY	WORKSITE AND TRAVEL PROCEDURES
GREEN	LOW	• No control planned • No closures anticipated	Avalanche debris: Unlikely to reach the worksite or road	**Worksite** • Standard worksite procedures apply • Work permitted with avalanche PPE and training • Consultation with Mountain Safety is required for stationary work in or outside vehicles **Travel** • No stopping in avalanche zones
YELLOW	MEDIUM	• Control and closures possible	Avalanche debris: Possible to Likely to reach the worksite or road	**Worksite** • Consultation with Mountain Safety is required for stationary work in or outside vehicles **Travel** • No stopping in avalanche zones • 300m convoy spacing mandatory
RED	HIGH	• Ongoing control likely • Closures imminent and/or ongoing	Substantial avalanche debris: Likely to reach the worksite or road	**Worksite** • Essential work to support Mountain Safety as required • Basic road maintenance only **Travel** • Essential travel only • No stopping in avalanche zones • 300m convoy spacing mandatory

Adhere to Avalanche Safety Plan, Standard Operating Procedures and Site-Specific Work Procedures

Plate 8.5-1. – Pretivm Avalanche Advisory Scale

Supervisors are responsible to ensure that all personnel working in avalanche terrain are aware of the current avalanche hazard and the associated Standard Operating Procedures; however, workers remain responsible for their personal safety.

Hazard updates are broadcast on Repeater 1 and Ladd 2 at Brucejack Camp and Repeater 2 and Pretivm Road channel at Knipple camp by Mountain Safety and recorded and repeated by Dispatch on the Repeater channel. When practical the hazard bulletins are emailed with the updated status. Supervisors must ensure that workers adjust their work to comply with the relevant Standard Operating Procedures.

8.6 WORKSITE AVALANCHE ASSESSMENT

Worksite hazard assessments (Appendix K) are performed when a new, temporary project encroaches into or near avalanche terrain. The Work Hazard Assessments should be used as a pre-planning tool for Site Maintenance. These are evolving documents updated frequently throughout the life of the Mine, in contrast to updating the ASP and/or creating Standard Operating Procedures which will be done for long-term projects, permanent projects, or infrastructure changes (Appendix C).

The worksite hazard assessments are designed to work in tandem with the Avalanche Standard Operating Procedures.

When contemplating a new project or development, management and planners will first consult the engineering document 'Avalanche Risk Assessment and Avalanche Hazard Zoning completed for the Brucejack Mine' (Appendix A) as well as the detailed 'Avalanche Hazard Zoning for Mine Site Area' (Appendix B) and determine if the project falls within, or is exposed to avalanche terrain. If it is exposed, or if there is uncertainty, a Mountain Safety Technician will be contacted to perform a Worksite Avalanche Hazard Assessment before any worker is exposed.

Under no circumstances will any new structure or project be allowed to be started or built in avalanche terrain without the approval of the General Manager.

It is the responsibility of the contractor or supervisor, before beginning a new project to reference the Avalanche Hazard Zoning Map (located at key points across the camp as well as in a shared computer drive) and determine if the project falls within or is exposed to avalanche terrain. If it is exposed, or there is uncertainty, Mountain Safety will be contacted to perform a Worksite Avalanche Hazard Assessment Prior to any worker being exposed.

During site introduction training and avalanche awareness training, workers are provided with a basic ability to identify avalanche terrain. If a worker or supervisor recognizes that they are to be exposed to avalanche terrain, they must request that Mountain Safety perform an assessment.

As a final preventative measure, Mountain Safety perform routine patrols around the worksite. If they notice a new project encroaching into avalanche terrain they will inquire as to the details of the project, speak with the supervisor as to the potential need for an assessment, and perform one if necessary.

8.7 ROAD TRAFFIC

Workers and contractors with no avalanche training can travel safely through the Mine transportation corridor, without any specific avalanche training, if their travel is monitored/supervised, and avalanche risk is actively reduced to an acceptable level by the Mountain Safety department.

Workers and contractors signed off on "SOP Standard Road Procedures" are permitted to travel through the transportation corridor on their own each day. They must understand the Avalanche Advisory Ratings and associated Safe Work Procedures (Plate 8-5.1, Appendix C).

In the event an untrained person must unexpectedly stop or work within an avalanche area (e.g., a vehicle breakdown), they must stay in their vehicle and immediately contact Dispatch who will contact the Mountain Safety Department on the corresponding repeater channel. Mountain Safety will assess and provide the appropriate level of instruction, supervision and PPE to conduct the work safely.

8.8 MAINTENANCE ACTIVITIES

Any work in avalanche terrain will take place at the discretion of the Mountain Safety Department.

All operators must follow relevant SOP's for the type of work being undertaken. If any Operator is unsure if they are working in a safe location, they will contact Mountain Safety immediately.

Operators must pass any avalanche observations onto Dispatch and/or Mountain Safety.

Mountain Safety will provide a Worksite Avalanche Assessment for any work activities that fall outside of the regular road maintenance regime.

8.9 RISK MITIGATIONS

8.9.1 Avalanche Hazard Closures

Temporary road and worksite closures are important avalanche risk reduction tools during times of elevated hazard or during avalanche control. Worker access is restricted until the hazard is reduced, either by natural snow stabilization or by artificial means (which may include the use of explosives, ski or snowmobile slope cutting, cornice control, or heavy equipment). The Mountain Safety Department has developed robust Standard Operating Procedures for closing areas and for operating in and around avalanche closures.

8.9.2 Berm and Catchment Construction

Where practical, snow mounds or berms will be constructed to reduce impact forces and/or the volume of avalanche debris on roadways. The berms allow for a reduction in road closures and increase the safety of workers in the event of a low likelihood, high consequence natural avalanche.

8.10 COMMUNICATIONS

8.10.1 Event Reporting

Pretivm has a system in place to ensure all notable near misses, accidents and property damage are reported and analysed to allow for improvements. Mountain Safety takes an active role in embracing this approach to risk management. Furthermore, Mountain Safety will ensure any external regulatory

requirements for incident reporting are also met. Outside agencies may include WorkSafeBC, Natural Resources Canada ERD, BC Ministry of Mines, Energy and Low Carbon Innovation, and the CAA.

8.10.2 Information Sharing

Conference calls are held twice daily between the 2 camps, to seek advice or feedback or simply communicate operational plans and forecast hazards.

Nearest neighbours such as highway forecasting operations, public avalanche bulletin writers and heliskiing operations in the greater area have access to Pretivm's InfoEx data as avalanche professionals.

8.10.3 Check in Procedures

Pretivm uses a system of Check-in/Check-out procedures to continually monitor workers in avalanche terrain. This system includes a timed-out component of regular radio check-ins, expediting incident identification, and response in the event of a failed Check-in. The Check-ins also help Dispatch monitor worker locations, hazard updates, and avalanche explosive control updates.

These Procedures are encapsulated into Standard Operating Procedures that are maintained and reviewed annually.

8.10.4 Post Season Summary

Season summaries are compiled at the end of each winter, including a list of improvements for the following season. Equipment and gear are collected, tested, inventoried, and replaced as needed.

8.11 STANDARD OPERATING PROCEDURES

In addition to Safe Work Procedures, there are multiple Standard Operating Procedures (SOPs) in place that govern specific tasks or day-to-day operations of the Mine. These procedures establish a systematic approach to minimize avalanche risk to personnel traveling and working in avalanche terrain. Additional Standard Operating Procedures pertaining to travel and working in avalanche terrain shall be added to this document as they are required and developed. Following is a list of SOPs in place.

- BJ-AVL-SOP-001 – Worksite Avalanche Assessment
- BJ-AVL-SOP-002 – Snowmobile Operation
- BJ-AVL-SOP-003 – Ski Cutting
- BJ-AVL-SOP-004 – Night Time Avalanche Control
- BJ-AVL-SOP-005 – Guarding and Sweeping
- BJ-AVL-SOP-006 – Field Trip on Skis
- BJ-AVL-SOP-007 – Avalanche Debris Clearing

- BJ-AVL-SOP-008 – Avalanche Hazard Communication
- BJ-AVL-SOP-009 – Pre-Blast Considerations
- BJ-AVL-SOP-010 – Avalanche Closure Procedures
- BJ-AVL-SOP-011 – Communications for Snow Removal and Road Maintenance in Avalanche Areas
- BJ-AVL-SOP-012 – Repeater Egress on Skis
- BJ-AVL-SOP-013 – Tower Climbing
- BJ-AVL-SOP-015 – Terrain Assessment Management Plan
- BJ-AVL-SOP-018 – Avalanche Related Road Closure Sustainability Plan
- BJ-AVL-SOP-024 – Wyssen Helicopter Operations
- BJ-AVL-SOP-026A – Wyssen Charge Construction
- BJ-AVL-SOP-026B – Wyssen Charge Priming
- BJ-AVL-SOP-026C – Wyssen Box Loading Procedure
- BJ-AVL-SOP-027 – Wyssen Accidental Ignition
- BJ-AVL-SOP-028 – Helicopter Flight Ops During ILI Hazards
- BJ-AVL-SOP-029 – Wildfire Weather Observations
- BJ-AVL-SOP-031 – Crevasse Rescue
- BJ-AVL-SOP-035 – Transceiver Maintenance
- BJ-AVL-SOP-039 – Gazex Lockout Tagout
- BJ-AVL-SOP-041 – Gazex Firing Procedures
- BJ-AVL-SOP-042 – Magazine Checks
- BJ-OHS-PLN-001 – Mine Emergency Resposne Plan (MERP)
- BJ-OHS-SOP-002 – Code One Call Out & Response
- BJ-OHS-SOP-015 – Extreme Weather Conditions
- BJ-OHS-SOP-007 – Working Alone or in High Risk Remote Locations

8.12 ACCIDENT/INCIDENT REPORTING

All avalanche incidents or near misses are immediately reported to the Mountain Safety Department, Health Safety and Security Manager, Mine Manager, and Surface Operations Supervisor.

Mountain Safety staff must complete an Initial Incident Report which the Mine Manager will forward to appropriate authorities (Mines Inspector, WorkSafeBC, CAA) as dictated by HSRC and WorkSafeBC regulations. Incident analysis and report forms are provided in Appendix L.

9 AVALANCHE SEARCH AND RESCUE

The Pretivm Avalanche Emergency Response Plan (Section 6 of the Mine Emergency Response Plan) was developed by the Mountain Safety Department in conjunction with the Mine Emergency Response Team Coordinator and the Health, Safety and Security Manager. The document outlines emergency action plans, guidelines, and organizational structure in the event of an emergency. It is kept in key locations around the Mine and available on a shared internal drive. The plan is reviewed and updated annually or more frequently when changes are required.

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Appendix A

Avalanche Risk Assessment and Avalanche Hazard Zoning

PRETIUM RESOURCES INC.

BRUCEJACK PROJECT

AVALANCHE HAZARD ZONING FOR MINE SITE AREA

DRAFT

PROJECT NO:	1204-006	DISTRIBUTION:	
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EXECUTIVE SUMMARY

This report provides supporting documentation for the development of an avalanche hazard zone map for the Brucejack mine site area. The zone map was requested by Pretium in order to plan the development of permanent and temporary occupied structures, and related facilities, in and around the mine site area. Avalanche hazard zone mapping for occupied structures is a requirement for development in several mountain based regional districts, and their application is supported by regulatory agencies that issue permits for commercial and/or industrial development. Further information on the development and use of these maps is described in CAA (2002).

The analysis undertaken for the mine site avalanche hazard zone map builds on previous avalanche hazard assessment work completed for Pretium by Alpine Solutions. Additional work required to create the zone map included:

- analysis of terrain from maps, imagery, and field study,
- review of avalanche occurrence information provided by mine site avalanche technicians,
- review of an a recent destructive avalanche occurrence which damaged and moved a building at the mine site,
- review of snow climate records, and
- application of topographical-statistical and dynamic models.

The avalanche hazard zone map is included as an attachment and the following recommendations are provided:

1. Pretium should provide this report and attached hazard zone map to all departments and stakeholders involved with planning construction of both permanent and temporary buildings, as well as managing worker safety at the mine site area.
2. All new building construction or placement should follow guidelines indicated in CAA (2002) and recommendations presented in Section 3.4. Any existing buildings or structures in the Blue or Red zones should be incorporated into the site wide avalanche risk management program.
3. Although avalanches large enough to damage a wood frame building are captured in the hazard zoning map, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches that may runout into terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. It is recommended that these small slopes continue to be assessed and monitored as a work site (or access route), within the scope of the site wide avalanche risk management program.

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1.0 INTRODUCTION

1.1. General

This report summarizes a detailed analysis of avalanche hazards in and around the planned Brucejack Project mine site, which was completed for the purposes of developing an avalanche hazard zone map. The zone map was requested by Pretium Resources Inc. (Pretium) in order to plan the development of both temporary and permanent facilities in and around the mine site area.

The analysis undertaken for the mine site avalanche hazard zone map builds on work completed previously for Pretium including Alpine Solutions (2013 & 2015a) in which several avalanche paths are identified, and avalanche hazard to specific proposed infrastructure for the mine was determined. The hazard zone map is included as an attachment and recommendations of its use are included.

1.2. Background

Over the past few years, Pretium has been advancing the Brucejack Project from an exploration phase to a physical development phase. During this process numerous temporary bunkhouses, offices, workshops, maintenance facilities, and other related infrastructure have been built in and around the project mine site (Photograph 1-1). Within the mine site area several avalanche paths and slopes that affect proposed infrastructure and roads have been identified and mapped (Alpine Solutions, 2013 & 2015).

As the development at the mine site area has been expanding, these slopes have been managed using short term mitigation methods that mainly involve evacuation of hazard zones, and avalanche explosive control to release avalanches. In the course of development at the site, at least one building was placed in an avalanche path, and it was recently damaged and moved off of its foundations by a controlled avalanche (no people were involved as the building was evacuated).

Photograph 1-1: Brucejack Project mine site area as viewed from the northeast.

Options for the placement of buildings and structures at the mine site are becoming limited, and the planned construction of the mine over the next few years is expected to require several more facilities, resulting in the need to use available space efficiently, while ensuring risk to people and facilities remains low. As a result, there is a need for a longer term strategy for placement of permanent and temporary infrastructure in the mine site area. Normally this type of need is resolved by incorporating an avalanche hazard zone map into the planning of all facilities.

2.0 LIMITATIONS

The analysis completed for the hazard zone map included in this report is based on modern methods, which includes:

- analysis of terrain from maps, imagery, and field study,
- review of avalanche occurrence information provided by mine site avalanche technicians,
- analysis and review of an a recent destructive avalanche occurrence which damaged and moved a building at the mine site,
- review of snow climate records, and
- application of topographical-statistical and dynamic models.

There is uncertainty in runout extent and avalanche magnitude and frequency estimates due to limited extent of avalanche occurrence records for the paths studied, non-existent vegetative indicators that are typically only found at lower elevations, and wide variation of results from the avalanche models used. As a result, hazard zone boundaries have been drawn conservatively where uncertainty is greatest.

Zoning boundaries illustrated on the attached hazard zone map are based on a snapshot in time of the terrain. Artificial or natural alteration of the landscape or terrain due to landslides, construction earthworks, glacial advance or retreat may change the location and extent of avalanche runout, necessitating a re-assessment of avalanche hazard zones. Construction earthworks specifically intended to retard or redirect avalanche flow may change avalanche hazard zone boundaries but temporary defecting structures, such as seasonal berms made from snow, would not.

The hazard zone map included with this report is intended as a planning tool for buildings and structures. Smaller avalanche slopes that may pose a risk to workers or vulnerable equipment are still present (or may be created during course of constructdion) in zones designated as low hazard (white zone), and as a result will still require assessment and management from on-site avalanche technicians.

Although other geohazards exist in the area, the scope of the hazard zoning is limited exclusively to snow avalanche hazards.

3.0 Avalanche Hazard Zone Mapping

3.1. Background on Avalanche Hazard Zone Maps

Avalanche hazard zone maps for occupied structures are a requirement in many mountain based regional districts, and their application is supported by regulatory agencies that issue permits for commercial and/or industrial development. The *Guidelines for Snow Avalanche Risk Determination and Mapping in Canada* (CAA, 2002) are the generally accepted guidelines for land development and operations located in avalanche terrain. According to CAA (2002), recommended zones for land use planning include:

1. **White Zone** – an area with an estimated avalanche return period of greater than 300 years, or impact pressures less than 1 kPa and a return period greater than 30 years.

2. **Red Zone** – an area where the return period is less than 30 years and/or impact pressures are greater than or equal to 30 kPa, or where the product of impact pressure (kPa) and the reciprocal of the return period (years) exceeds 0.1 for return periods between 30 and 300 years.

3. **Blue Zone** – an area in between the Red and White Zones, for return periods between 30 and 300 years, the product of impact pressure and frequency is less than 0.1 kPa/years and the impact pressure is greater than or equal to 1 kPa.

A graphical representation of the expected magnitude and frequency in these zones are provided in Figure 3-1.

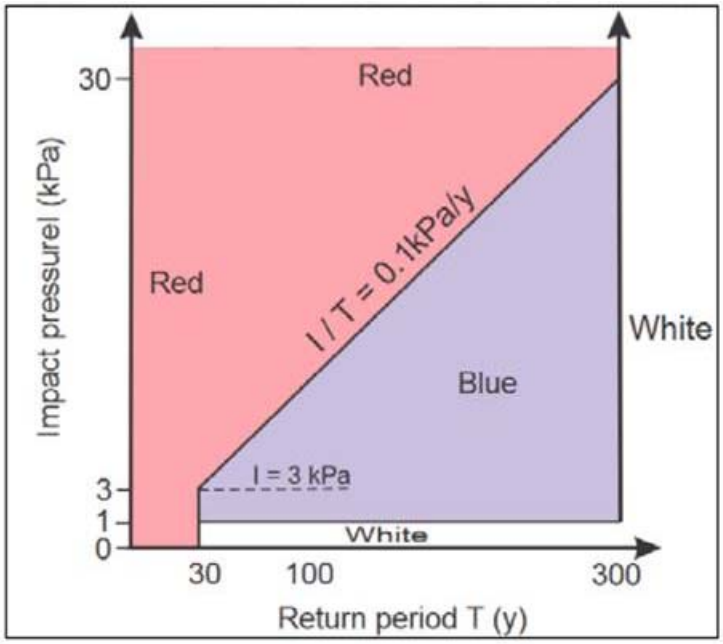

Figure 3-1: Definition of avalanche zones for land-use planning

The blue zone represents an area where minor damage could be expected infrequently (30 to 300 year return period) and include broken tree branches, broken windows, and blowing snow inside buildings.

Recommended activities according to zone color in Canada are indicated in Table 3-1.

Table 3-1. Recommended activities according to Zone (CAA, 2002)

Hazard[1] Zone	Recommended Activities
White Zone (low hazard)	Construction of new buildings, including permanently occupied structures, normally permitted.
Blue Zone (moderate hazard)	Construction of new buildings such as industrial plants and temporarily occupied structures possibly permitted with specified conditions. Conditions may include structures reinforced for avalanche forces, construction of avalanche defenses, and requirement for evacuation plans (or a combination of these).
Red Zone (high hazard)	Construction of new buildings not normally permitted.

3.2. Methods

Information regarding avalanche hazards affecting the Brucejack project has been provided previously in Alpine Solutions (2013, 2015a & 2015b); general project, terrain, and snow climate information is provided in these documents. For the hazard zoning analysis, the following methods were used:

- Analysis of terrain using contours generated from LiDAR data.
- Field identification of the extent of locations of large avalanche occurrences observed by site avalanche technicians in the past few years.
- Review of snow climate patterns from winter photographs of the area from various sources.
- Analysis of a destructive avalanche which damaged and moved a building from its foundation on March 13, 2015 (Soucie Construction, 2015)
- Application of topographical-statistical models for short slopes including
    - Alpha-regression model (Jones and Jamieson, 2004)
    - Runout ratio method (McClung & Mears, 1991; Jones and Jamieson, 2004)
- Application of dynamic models including:
    - PCM (Perla, et.al., 1982)
    - LEM (McClung and Mears, 1995; Jones and Jamieson, 2003).

[1] Although CAA (2002) refers to these zones as 'risk zones', they are now more commonly referred to as 'hazard zones'; this will be reflected in a soon-to-be-published update of CAA (2002)

3.3. Analysis

The analysis of avalanche hazard extent focused on avalanche paths MS2, MS3, MS5, and MS8, which are described and mapped in Alpine Solutions (2013 & 2015a). All of these paths are less than 300 m in vertical elevation, and as a result are considered 'short slopes' from an avalanche path modelling perspective. All paths are located above tree-line elevation, and as a result there are no vegetative indications of past events.

Winter photographs taken by Alpine Solutions in 2012 & 2013, as well as by site avalanche technicians provided information regarding snow and wind patterns, as well as a few notable avalanche occurrences (example in Photograph 3-1).

Photograph 3-1: Path MS8 (Camp Creep Path) notable avalanche occurrence (looking south).

A large explosives controlled avalanche in Path MS5 on March 13, 2015 impacted an office building creating damage and moving it off of its foundations (Photograph 3-2). The estimated runout distance of destructive flow was incorporated into the analysis.

Photograph 3-2: Path MS5 - Approximate direction (blue arrow) and extent of deposit (red dashed line) of avalanche impacting building on March 13, 2015 (looking southwest).

Both topographical-statistical and dynamic avalanche models (indicated in Section 3.2) were applied to several potential flows in order to model avalanche runout and estimate speed and impact pressure at various points along the path. Results varied considerably depending on input parameters used. Combined with other methods of analysis, as well as judgement, models could be calibrated to provide realistic speeds and impact pressures in order to determine values for a determination of Red and Blue Zone boundaries (CAA, 2002). Assumptions for avalanche flow models are included in Appendix A.

Once the avalanche hazard zone map was complete, it was reviewed by Soucie Construction (site avalanche operations team) to ensure consensus of zoning boundaries with avalanche technicians who have been monitoring and controlling avalanches at the mine site for the past three winters.

3.4. Use of the Avalanche Hazard Zone Map

According to Section 3.1, construction of new buildings would normally only be permitted in the white zone, and this is recommended for all bunkhouse facilities, and or buildings where large numbers of people may gather. Industrial facilities including maintenance facilities and plants may be constructed in a blue zone, but they either require reinforcement for avalanche forces, construction of mitigation measures such as temporary snow berms, or an

acceptance of potential damage to the structure. In addition, an evacuation plan would be required for periods of high hazard, or during avalanche explosive control.

Normally no new buildings should be constructed in the red zone, unless there is a specific requirement that outweighs the normal accepted risk to a standard non-reinforced wood frame building. Construction of a building in a red zone would need to be examined on a case by case basis, and similar to the blue zone, normally the building would either be reinforced, or the risk of damage is accepted. In addition, the building would be treated as a worksite in avalanche terrain, and incorporated into the site wide avalanche management program (the slopes above would be regularly monitored, and the building and area evacuated during periods of high avalanche hazard).

Currently there are existing structures in the red zone including a ‘core shack’, and a few other small buildings that are presently not occupied. Avalanche hazard to these facilities should continue to be assessed on an ongoing basis in the context of the site wide operational avalanche management plan. If at any point these structures are occupied on a regular basis, it must be clearly understood that the buildings are in a high hazard zone, and may need to be evacuated at any time during winter or spring.

As indicated in Section 2.0, there are limitations of the hazard zone map which must be understood. Although avalanches large enough to damage a wood frame building are captured, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches with terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. These small slopes still need to be assessed and monitored as a work site (or access route) from a worker safety perspective, within the scope of the site wide avalanche risk management program.

4.0 Conclusions and Recommendations

An avalanche hazard zoning map has been developed for the Brucejack mine site area, and is attached to this report. Alpine Solutions provides the following recommendations:

1. Pretium should provide this report and attached hazard zone map to all departments and stakeholders involved with planning construction of both permanent and temporary buildings, as well as managing worker safety at the mine site area.
2. All new building construction or placement should follow guidelines indicated in CAA (2002) and recommendations presented in Section 3.4. Any existing buildings or structures in the Blue or Red zones should be incorporated into the site wide avalanche risk management program.
3. Although avalanches large enough to damage a wood frame building are captured in the hazard zoning map, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches that may runout into terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. It is recommended that these small slopes continue to be assessed and monitored as a work site (or access route), within the scope of the site wide avalanche risk management program.

5.0 CLOSURE

This document was prepared by Alpine Solutions Avalanche Services (Alpine Solutions) for the account of Pretium Resources Inc. The material in it reflects Alpine Solutions' best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this report.

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We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

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per:

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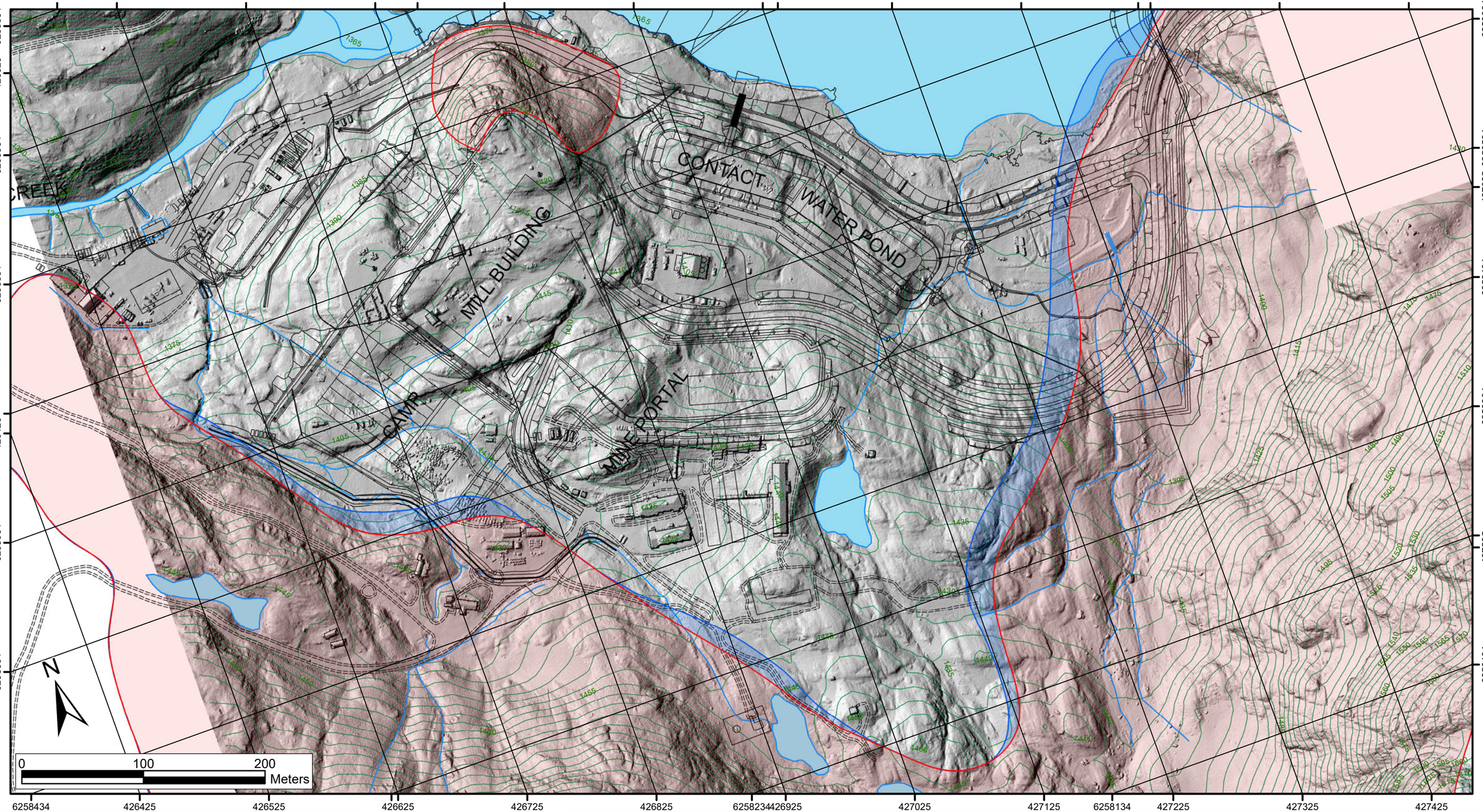
APPENDIX A
ASSUMPTIONS USED FOR AVALANCHE MODELS

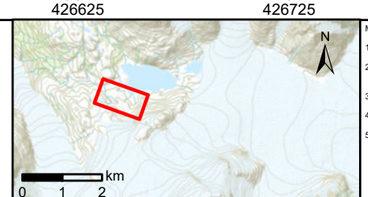
Model	**Assumptions**
PCM	Start zone, track and runout: $\mu = 0.25$ $M/D = 0.8H_o$
LEM	$\mu = 0.515 + 0.578H_o y'' - 0.107TP$ V_{max} estimated from PCM
Runout Ratio	$P = 0.9$

AVALANCHE HAZARD ZONE MAP



LEGEND

- RED ZONE - HIGH HAZARD
- BLUE ZONE - MODERATE HAZARD
- WHITE ZONE (NO SHADING) - LOW HAZARD



MAP NOTES:

1) DATUM: NAD 83. PROJECTION: TRANSVERSE MERCATOR. UTM ZONE: 9N

2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:3000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

3) DATA/BASEMAP SOURCE: PRETIUM RESOURCES, ARCGIS ONLINE.

4) CONTOUR INTERVAL: 5 M

5) THIS MAP IS INTENDED TO PROVIDE ZONING GUIDANCE FOR THE CONSTRUCTION OF BUILDINGS IN AND AROUND THE BRUCEJACK MINE SITE AREA, AND SHOULD BE READ WITH THE ACCOMPANYING REPORT.

SCALE:	1:3,000
DATE:	09 Oct 2015
DESIGNED:	CC
DRAWN:	CC
CHECKED:	BG
APPROVED:	DRAFT

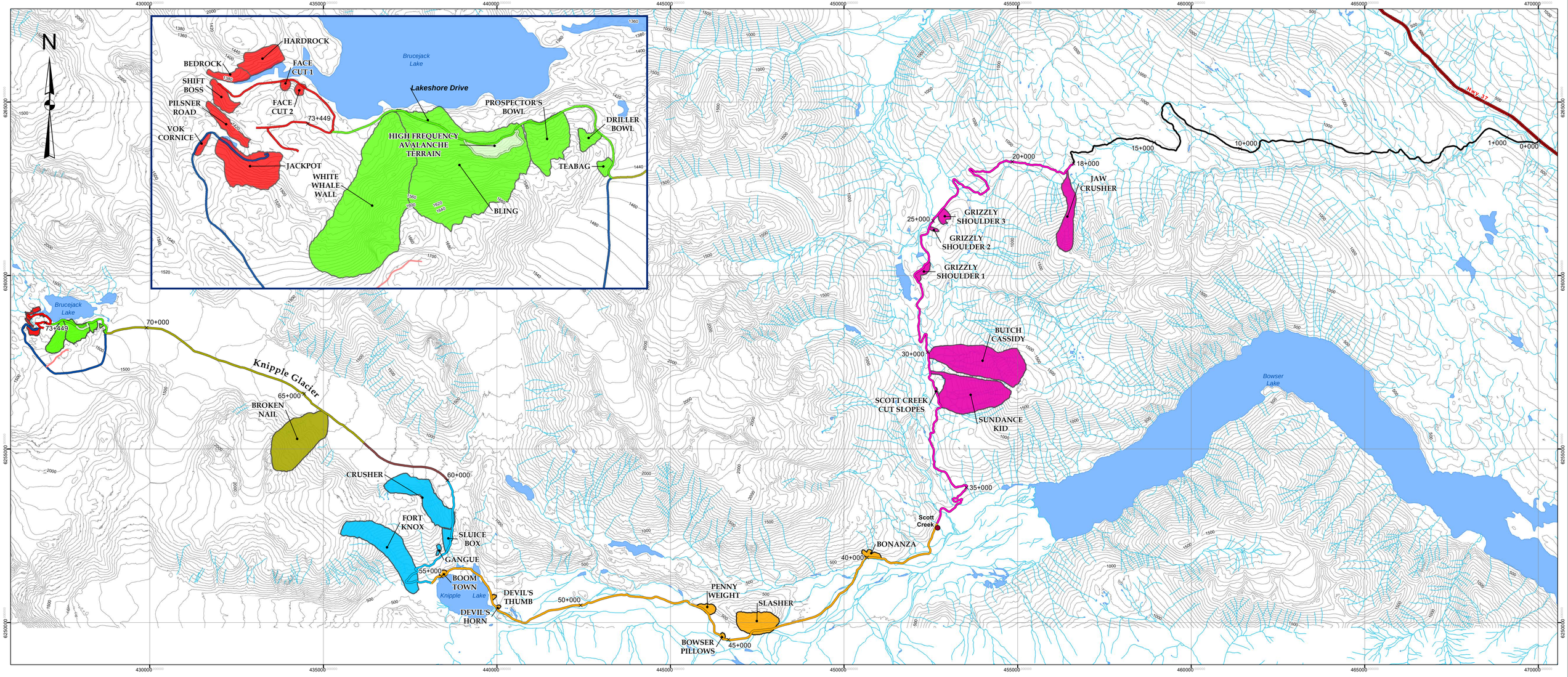
CLIENT: PRETIVM

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK MINE

TITLE: MINE SITE AVALANCHE HAZARD ZONING

REGION:	MAP NO:	REV:
NORTH COAST	1204-006-1	-



Legend

- Zone H
- Zone G
- Zone F
- Zone D
- Zone B (High Frequency Avalanche Terrain)
- Zone B
- Zone A
- Highway
- Waterline
- Lake

Valley Road
- Zone H: Wildfire to Scott Creek km 18 - 37
- Zone G: Scott Creek to Newhawk Meadows km 37 - 55
- Zone F: Newhawk Meadows to Knipple Staging km 55 - 60

Glacier Road
- Zone E: Knipple Staging to Lower Knipple Glacier
- Zone D: Upper Knipple Glacier
- Zone B: High Frequency Avalanche Terrain
- Zone B: Lakeshore Drive

VOK Road
- Zone C: Bypass Road (Top of Upper Knipple Glacier)
- Zone A: Camp Avalanche Paths/VOK

- Access Road
- Summit Road
- Contour

**VOK/Glacier Road: Km 0 is Brucejack Camp Maintenance Shop*
**Valley Road is Hwy 37 / Wildfire Junction*
**VOK Road (Km 5) Connects to Glacier Road at Lakeshore Drive*

PRETIVM

Drawing: LAU	BRUCEJACK PROJECT
Date: 5 Apr 2013	Avalanche Zone Overview Map
Scale: 1:50,000	UTM Zone 9 (NAD83)

0 1 2 4 6
Km

Scale is 1:50,000 when printed at 24"x36" paper.

Document Path: Z:\ArcGIS_Projects\MXD\BJ_Avalanche Maps\Avalanche_Overview_24x36_21-03-2013.mxd

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MEMORANDUM

Date: February 29, 2012
To: Norma Jean Adzich, OH&S Coordinator, Pretium Resources Inc.
From: Brian Gould, P. Eng.; Senior Avalanche Specialist; Rod Gee, Avalanche Technician; Cam Campbell, M.Sc. Avalanche Specialist;
Re: Wildfire Access and Brucejack Site Workplace Avalanche Risk Assessment

1.0 Introduction

Alpine Solutions recently completed workplace avalanche risk assessments for the Wildfire drill site access route and Brucejack site area. The purpose of these assessments were to identify avalanche terrain with potential to affect worksites and access routes, and then to determine the current risk to workers transiting or working in that terrain based on usage (exposure, vulnerability), and site snowpack conditions. This memorandum provides an overview summary of both assessments. Comments regarding current concerns, and recommendations are provided.

Further assessment is required to provide a complete risk assessment for proposed (future) mine operations (provided at a later date).

2.0 Wildfire Access Road

The Wildfire Area was visited by Rod Gee on February 19. 2012. The Wildfire Camp is located approximately 500 m west of Highway 37, and approximately 32 km south of Bell 2. A potential hazard area was identified previously (by Pretium) approximately 2 km along the access road to a drill site (Figure 1 and Photograph 1).

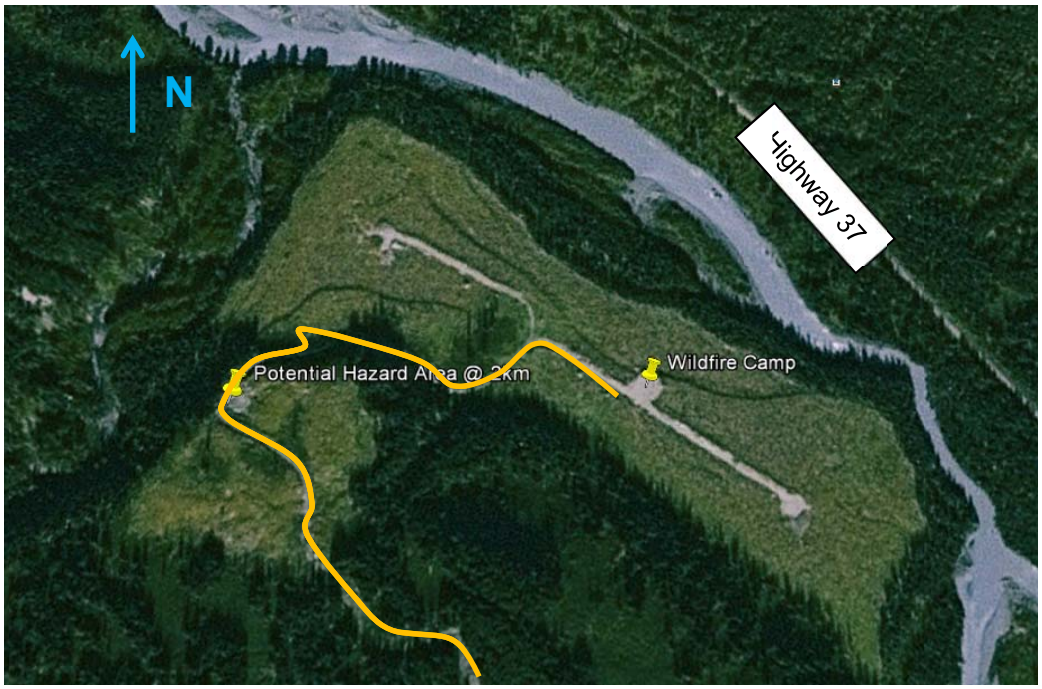
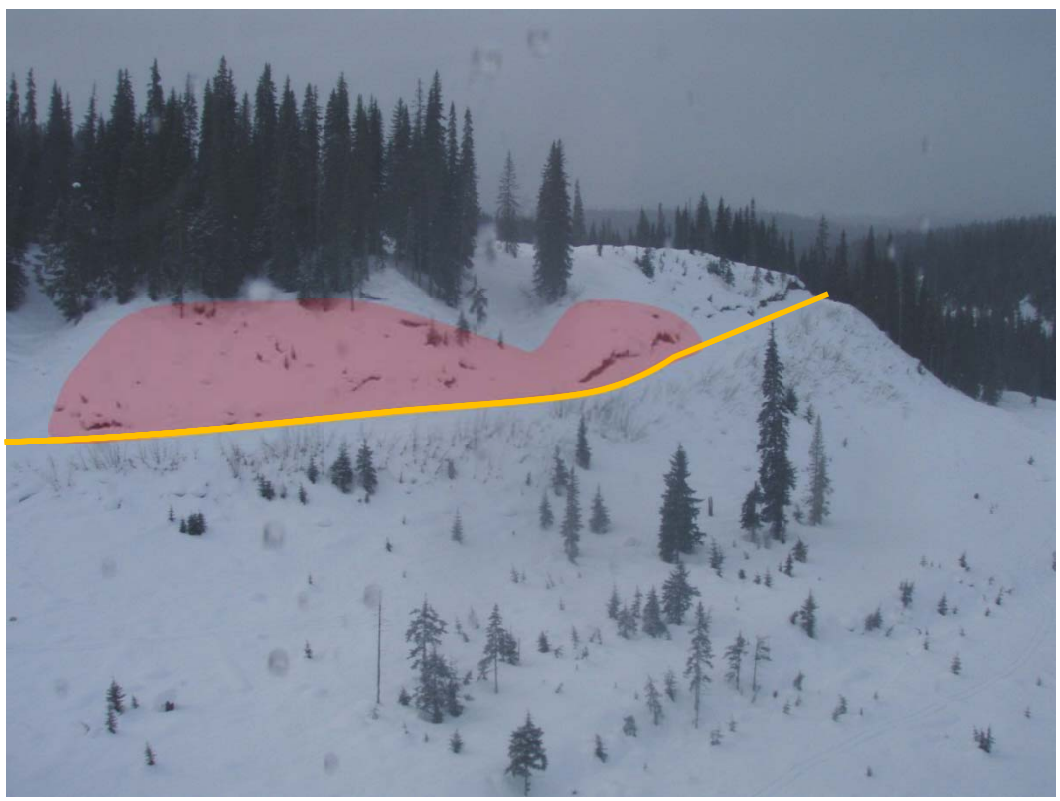


Figure 1 – Google Earth screenshot of Wildfire Camp and Potential Hazard area



Photograph 1 – Potential Hazard area near Wildfire Camp (Access Road orange)

The hazard area is a relatively steep cut slope above the access road. The road crosses the avalanche path from an approximate elevation of 475 m elevation to 500 m elevation, over a linear road distance of approximately 300 m. The potential exists for avalanche activity to occur

on the small and more moderately inclined slopes below the mature forest cover in the upper left of Photograph 1. The small size of the slope limits avalanche activity to a maximum of Size 2 (See Table 1), and the frequency of avalanches this size is estimated to be once per year on average.

2.1 Wildfire Snowpack Assessment

Valley elevation snowpack water equivalent data is unavailable for this region. However, long-term local area knowledge, combined with snow pillow data for Granduc mine, suggests valley elevation snowpacks are at or slightly above normal, while alpine snowpacks are at near-record levels. The Wildfire site was near or slightly above normal at the time of observation.

A brief mid-January Arctic air outbreak resulted in a rapid air temperature drop in the Wildfire area. This created an extremely strong temperature gradient in near-surface snowpack layers that had previously been relatively warm. The development of a weakened 7cm thick layer of faceted grains at the snowpack surface was the result.

Snowfall in late January and early February buried and preserved the faceted layer. This weakness was gradually overloaded by steady snowfall, reaching a very fine strength/stress balance that was overcome by vehicles loading the base of the slope when travelling across the road cut. This final loading triggered the soft slab failure at the top of the slope, stopping just above and on the road.

The overall risk assessment included a snow profile observation adjacent to the path's starting zone. The facet layer was gaining strength but remained easily observed and capable of testing to moderate and hard sudden planar failure. No other significant weaknesses were noted in the 150 cm deep snowpack.

There is currently little load on this slowly strengthening layer, as virtually the entire path's starting zone has already failed and there has been little snowfall since the avalanche activity occurred. Therefore, there is virtually no risk to workers unless snow stability markedly deteriorates.

2.2 Worker Risk from Avalanches at Wildfire

Considering the estimated size and frequency of avalanches at this site, the limited exposure time due to workers transiting through the area, and the current snowpack conditions, this site is determined to be very low risk. However, recent natural slab avalanche activity, likely failing on the same faceted layer as discussed above, was observed on slopes of similar aspect and incline in the area, including in the creek valley upstream of Wildfire Camp, above where road construction is taking place on the opposite side of the creek. The construction is occurring in low-risk terrain, but all workers should avoid travelling off established routes for work or recreational purposes.

3.0 Brucejack Site

The Brucejack site was visited by Cam Campbell on February 25-26, 2012. The site is located immediately southwest of Brucejack Lake, approximately 43 km west of the Wildfire Camp. Figure 2 illustrates the general layout of some of the planned drill sites, existing snow-cat roads, and some of the facilities that were observed at site. Avalanche paths and areas in the vicinity of the Brucejack Site are indicated in red in Figure 2.

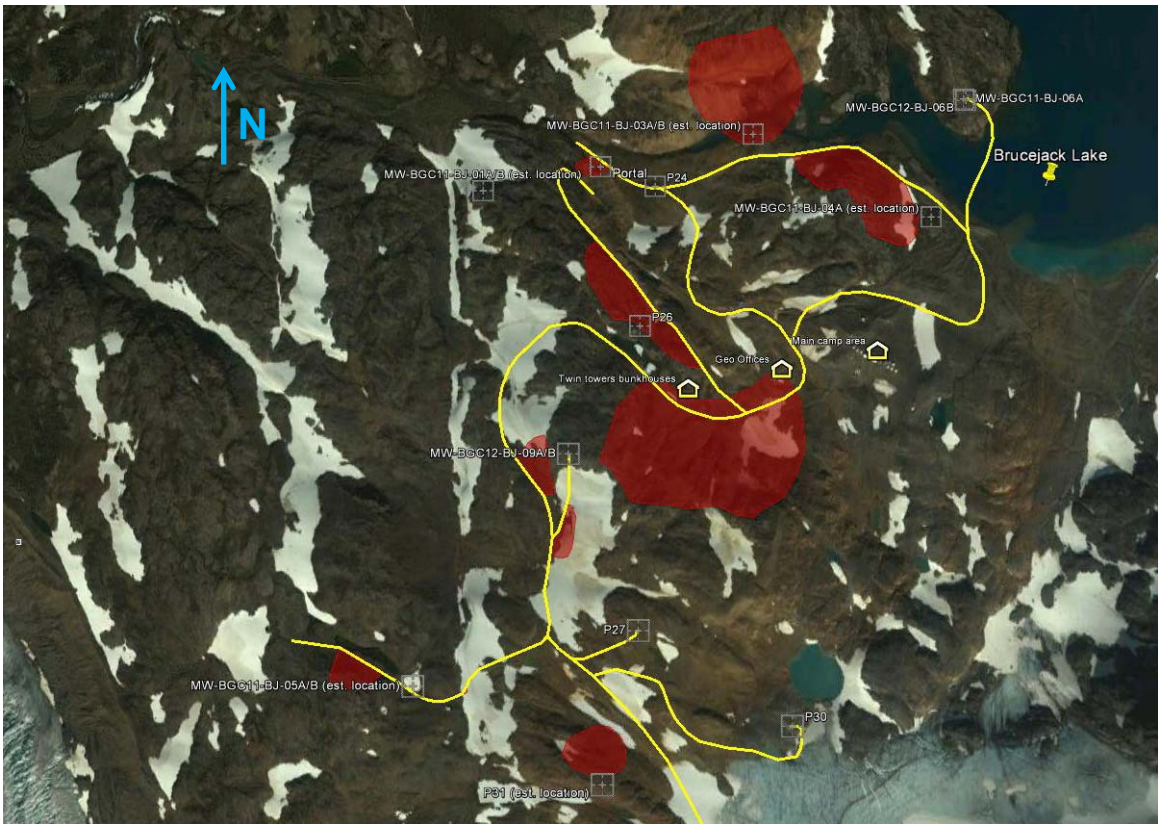


Figure 2 – Google Earth screenshot of Brucejack Site – avalanche paths in red, snow-cat roads in yellow

3.1 Avalanche Hazard Areas

A number of potential avalanche hazard areas were identified:

- The Geo-offices and the Twin Towers bunk houses are potentially exposed to a large avalanche path directly to the south. It is estimated that avalanches up to Size 3 (See Table 1) may occur in this path.
- Seven separate avalanche paths are estimated to affect current snow-cat and snowmobile roads at site (indicated as yellow lines in Figure 2). It is estimated that avalanches up to Size 2 could occur in most of these paths, except for one path which may produce up to Size 3 avalanches.
- Existing well sites (indicated on the attached BGC drawing, and planned drill sites (indicated by site staff) are not estimated to be in high risk areas. However, some access routes to these sites are exposed. In addition these sites lie on the border of avalanche path areas.

3.2 Avalanche Safety Observations

The following was determined during the visit to site:

- There is no established weather plot
- No avalanche safety gear on site
- The area is a remote location with helicopter access only
- Experienced part-time avalanche safety attendant on staff (James Smids), however no qualified Avalanche Technicians (CAA Professional Members) providing guidance.
- Workers free to roam in surrounding avalanche terrain for skiing/snowboarding/snowmobiling (tracks were noted within identified avalanche terrain)

4.0 Recommendations

Based on the above assessment, we recommend the following:

1. Complete Avalanche Atlas Mapping for the Brucejack site based on data from recent site visits. Establish Avalanche Area warning signs (No stopping) for areas which affect established access routes (snowcat roads).These maps and signs may be used to communicate hazard areas to different work groups as they arrive at site.

2. Limit all work to currently established sites and non-exposed routes at Brucejack site, and restrict any workers from recreational (skiing, snowboarding, etc.) activities in surrounding terrain. If necessary, safe recreation areas close to camp area could be established by an Avalanche Technician.

3. An Active Avalanche Safety Plan should be prepared for the Brucejack site to determine risk management approach for access routes and exposed sites over the next few months. Included in this plan should be procedures for determining risk levels on a daily basis and potential location restrictions based on the daily risk level.

4. All workers that travel the exposed snowcat access roads, or surrounding terrain should wear avalanche PPE (transceivers), and be trained in avalanche rescue. Avalanche rescue packs with lightweight shovels and probes should be carried by workers, or else an avalanche rescue cache should be established at the site.

5. A qualified Avalanche Technician should visit the site on a frequent basis over the next month to assess snowpack, and provide risk management guidance. The avalanche safety attendant on staff at Brucejack could provide assistance with this if available and at site.

6. In consideration of the above recommendation, a weather plot should be established at site with twice-daily manual observations. A remote weather station could be established for long term use.

7. Check in/checkout procedures should be established for workers leaving the camp area for work at site.

Table 1 : *Canadian classification system for avalanche size (McClung & Schaerer, 1993)*

Size	Destructive Potential	Typical Mass	Typical Path Length	Typical Impact Pressures
1	Relatively harmless to people.	<10 tonnes	10 m	1 kPa
2	Could bury, injure or kill a person.	10^2 tonnes	100 m	10 kPa
3	Could bury a car, destroy a small building, or break a few trees.	10^3 tonnes	1000 m	100 kPa
4	Could destroy a large truck, several buildings, or a forest with an area up to 4 hectares.	10^4 tonnes	2000 m	500 kPa
5	Largest snow avalanches known. Could destroy a village or a 40 ha forest.	10^5 tonnes	3000 m	1000 kPa

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PROJECT MEMORANDUM

Date: May 31, 2012
To: Pretivm Resources Inc.
Attn: Ian Chang, M.Sc., P. Eng., VP Project Development
From: Brian Gould, P. Eng.
Re: Brucejack Avalanche Hazard Assessment and Risk Analysis- DRAFT

1.0 Introduction

1.1 General

Pretivm Resources Inc. (Pretivm) is proposing to develop a mine in the Coast Range of northwestern British Columbia, approximately 42 km north of Stewart, BC (Figure 1-1). The project includes several minesite facilities, a transmission line, an access road, and minesite trails. Previous studies indicate that the project is in the vicinity of snow avalanche terrain. Pretivm requested that Alpine Solutions undertake a preliminary avalanche hazard assessment and risk analysis to determine the likelihood and potential consequences of avalanches affecting the project. Options for avalanche risk mitigation are provided, and the memorandum concludes with recommendations. The results of this assessment will be used for mine permitting, and operational planning.

Figure 1-1 Brucejack Project Location

1.2 Work Scope

Pretivm provided Alpine Solutions with the following maps and documents:

- Figure 18.11 Brucejack Overall Site Plan GA – Mine and Process Plant
- 3 maps by Cypress Forest Consultants illustrating Access Road General Arrangement (including Glacier Road)
- Figure 8.2-2 Brucejack Project: Alternative Power Line Routes
- Brucejack Road Risk Rating and Inspection Procedure

In addition, numerous aerial photographs (1:20,000 scale), and digital shape-files representing facility layout were provided by BGC Engineering Inc. The proposed transmission line digital shape-files was provided by Vallard Construction Ltd.

The avalanche hazard assessment and risk analysis was completed for the mine site area, one of the proposed transmission line alignments, and the access road from Highway 37. The work included terrain analysis from topographic maps and aerial imagery. A helicopter overview flight was undertaken to confirm the avalanche path locations and terrain characteristics.

This memorandum provides the following information:

- A tabulated summary of avalanche paths and hazard areas that affect proposed facilities and access roads.
- Seventeen drawings illustrating locations of avalanche paths and exposure that affect proposed facilities and access roads.
- An estimate of potential consequences of avalanches, and a discussion of associated exposure and risk.
- Options for mitigation.
- Recommendations for further work.

2.0 Limitations

This document provides an overview of snow[1] avalanche hazards which affect the proposed Brucejack mine project. Estimated magnitudes, frequencies, and areal extent of individual avalanche paths are based on a base climate analysis, map and imagery interpretation, and a helicopter overview flight completed March 19, 2012. Boundaries of avalanche terrain indicated on the accompanying drawings are estimated and have not been confirmed with ground based survey or with numerical analysis.

Although other geohazards exist in the region, the scope of this assessment is limited exclusively to avalanches. In addition, any significant artificial or natural alteration of the landscape or terrain due to forest fire, landslides, may change the nature (magnitude/frequency/intensity/runout) of avalanche hazard, necessitating a re-assessment for the area affected.

[1] The qualifier "snow" will not be included from here on. It was added here to make it clear that there is no mention of "rock avalanches" or "debris avalanches" in this report.

3.0 Physiography

3.1 Location

The Pretivm minesite is located at the head of the Knipple Glacier, approximately 60 km north of Stewart, BC, and 38 km southwest of Bell 2. The proposed transmission line alignment extends from the BC Hydro 230 kV line north of Stewart (adjacent to Highway 37A) to the mine via a route over Mt. Bunting south ridge and across to the Salmon and Knipple Glacier valleys. The access road begins at the intersection of Highway 37 and Wildfire Creek, approximately 30 km south of Bell 2, and extends to the minesite via the Wildfire Creek, Scott Creek, Bowser River, and Knipple Glacier valleys.

3.2 Snow Climate

Snow climate refers to the general character of climate factors that contribute to snowpack and avalanche formation. Historical meteorological records often provide information on the frequency, timing, and sometimes magnitude of future avalanches. In addition, estimates of average and maximum snowpack depth can provide information on how often thresholds for avalanche triggering are exceeded.

Although historical climate and avalanche records for the Brucejack area is limited, BC Government snow pillow and snow survey records in the region were reviewed. In addition, Alpine Solutions has previous experience with this region of BC.

The proposed Brucejack mine area is located in a transition zone between maritime and continental climate zones. As a result, there are significant temperature and moisture fluctuations that occur in an average winter. These fluctuations often contribute to a layered snowpack, which leads to lingering avalanche conditions most winters. In addition, the effects of wind and terrain orientation lead to increased snowpack variability which can contribute to challenging avalanche forecasting conditions.

Avalanche season typically begins in October at the higher elevations (above 1400 m), and often extends until late June or early July. At valley bottom elevations, avalanches can be expected from November to late May though can occur earlier or end later in extreme years.

Typical storm patterns can produce high intensity snowfall with strong winds depositing significant amounts of snow on lee (the side of slopes away from the principal wind direction) aspects. Temperature increases associated with some storms can produce rain-on-snow conditions up to treeline elevations (1200-1400 m), and sometimes above. An average winter will include 10-20 large storm events, most of which can produce widespread avalanche conditions.

4.0 Avalanche Hazard Assessment

4.1 Background on Snow Avalanches

Snow avalanches generally occur in areas where there are steep open slopes or gullies, and deep (>50 cm) mountain snowpacks. Risk associated with avalanches is normally due to exposure to the high forces that occur, as well as the effects of extended burial for any person caught in an avalanche. Impact

forces vary significantly depending on avalanche size. Although the smallest avalanches can be insignificant to a human, larger avalanches may produce impact forces capable of destroying several hectares of mature forest.

Characteristics of Snow Avalanches:

Avalanches may initiate in either *dry* or *wet* snow. Although an avalanche may start in dry snow, it could become *moist* or *wet* during its descent. Terrain features including gullies deflect and often channel wet snow avalanches. Conversely, large, fast-flowing dry avalanches tend to flow in a straighter path, and may overrun terrain features.

Most large, dry avalanches consist of a dense component that flows primarily along the ground, and a less dense powder component that travels above and sometimes ahead of the flowing component. In some cases these components can separate and move independently. The dense-flowing component and powder component may reach speeds up to 60 m/s (200 km/h). Impact pressures from dense flow are much greater than the powder component due to the density of the snow.

Avalanche terrain is usually associated with steep open slopes in the mountains that allow an accumulation of snow before it releases in a destructive event. In addition to the steep slopes that the snow accumulates on, any area exposed to this release of snow is also considered avalanche terrain. Terrain is often subdivided into features that are connected, and generally contain or channel the volume of avalanche events into a common deposition area. These features are called *avalanche paths.*

Avalanche Path:

An avalanche path generally consists of a *starting zone*, a *track*, and a *runout zone*. Avalanches start and accelerate in the starting zone which typically has slope incline greater than 30°. Downslope of the starting zone, most large avalanche paths have a distinct track in which the slope angle is typically in the range of 15° to 30°. Large avalanches decelerate and stop in the runout zone where incline is usually less than 15°. Smaller avalanches may decelerate and even stop on steeper slopes (15° to 24°).

Within forested terrain, larger avalanche paths are often discernible as vertically oriented swaths of open forest terrain bordered by *trim lines* (mature forest on either side of the swath). Smaller avalanches however can occur in more subtle paths, and can occur on large cutbanks in a road cut.

Runout zones generally have vague trim lines, and analysis by an experienced avalanche specialist is required to determine estimates of maximum avalanche extent (often extends into mature forest). Some avalanche paths in terrain around cliffs can be much more subtle to observe, and can be confused with rockfall and or geotechnical events.

Avalanche Frequency:

Avalanche *frequency* is the reciprocal of avalanche *return period* and is typically referred to as an order of magnitude ranging from 1:1 (annual) up to 1:300 (1 in 300) years. Each winter, the probability of an avalanche with a specified return period is constant.

Avalanche frequency is dependent upon *snow supply* and *terrain.* Frequency decreases with distance downslope in the track and runout zone. Snow supply is determined by:

- Frequency of snowfalls and amount of snow; and
- Wind transport of snow into the starting zone.

Snow and weather conditions vary from year to year, and the frequency of avalanches is not uniform.

The primary terrain factors in avalanche formation are incline, slope orientation (aspect) with respect to wind and sun, slope configuration and size, and ground surface roughness. Slope configuration is important because features such as gullies will often have more frequent and larger avalanches than open slopes. Ground roughness determines the threshold snow depth for avalanches to occur. This is particularly important in light snow climates where snow may not exceed threshold depths some winters.

Avalanche Magnitude:

Avalanche *magnitude* relates to the destructive potential of an avalanche and is defined according to the Canadian avalanche size classification system. A general description of destructive potential, magnitude, and typical path length under this classification system is provided in Table 1.

Magnitude is often related to frequency. In general, large destructive avalanches occur less frequency, while smaller ones occur on a more regular basis. Magnitude and frequency of effect are also related to location in the overall path. For example a road location near the toe of an avalanche path will be affected by avalanches on a less frequent basis, but they will be larger avalanches. Both low frequency large avalanches and higher frequency small avalanches may affect a road crossing in the middle of an avalanche path.

Table 1 : *Canadian classification system for avalanche size (McClung & Schaerer, 1993)*

Size	Destructive Potential	Typical Mass	Typical Path Length	Typical Impact Pressures
1	Relatively harmless to people.	<10 tonnes	10 m	1 kPa
2	Could bury, injure or kill a person.	10^2 tonnes	100 m	10 kPa
3	Could bury a car, destroy a small building, or break a few trees.	10^3 tonnes	1000 m	100 kPa
4	Could destroy a large truck, several buildings, or a forest with an area up to 4 hectares.	10^4 tonnes	2000 m	500 kPa
5	Largest snow avalanches known. Could destroy a village or a 40 ha forest.	10^5 tonnes	3000 m	1000 kPa

4.2 Brucejack Avalanche Hazard

Avalanche paths and hazard areas that affect the Brucejack project were identified by reviewing topographic relief and vegetation features on maps and aerial photos, as well as Google Earth ortho-imagery and digital elevation model (DEM). In addition, a field reconnaissance (including helicopter overview flights) was completed March 19, 2012. During this flight numerous photographs were collected and subsequently reviewed.

Forty-three avalanche paths or hazard areas reach project sites or access roads, and some paths are estimated to affect sites on an annual basis. Avalanche paths and hazard areas are summarized in three tables in Appendix A, and illustrated on seventeen drawings in Appendix B. Avalanche Paths referred to in Appendix A and B are labelled according to Table 4-1, referring to the element at risk, with the exception of paths along the Knipple Glacier which affect both the transmission line and access road.

Table 4-1 – Avalanche Path Label and corresponding Element at Risk

Avalanche Path Label	Element at Risk
TL1, TL2, …, TLx	Primarily Transmission Line, with some affecting Access Road
AR1, AR2, …, ARx	Access Road
MS1, MS2, …, MSx	Primarily Minesite facilities as well as Access Road, Transmission line, and trails at minesite
KG1, KG2, …, KGx	Transmission Line and Access Road

The following three sub-sections provide details of avalanche hazard, and potential consequences to each facility.

4.2.1 Minesite

The minesite is located on a broad alpine plateau in undulating terrain on the west side of Brucejack Lake. The area is bounded by the Knipple Glacier to the east and south, the Sulphurets Glacier to the west, and steep alpine slopes to the north. Elevations at the minesite range from 1350 m to over 2000 m. Proposed facilities include the following (Drawing 1):

- Fuel Storage
- 150 person camp
- Warehouse
- Existing camp Portal
- Truckshop/ Mine Dry
- Mill Building
- Helipad
- WZR Air Raise
- VOKR Air Raise
- CAD Fresh Air Raise

- Gossan Hill Pit
- Bridge Zone Pit
- Galena Hill Pit
- Several minesite trails

Avalanches are estimated to affect the Bridge Zone Pit, 150 Person Camp, Gossan Hill Pit, CAD Fresh Air Raise, and several minesite trails northwest of Brucejack Lake. Details regarding avalanche hazard and potential consequences are included in the following five sub-sections.

4.2.1.1 Bridge Zone Pit

The Bridge Zone Pit is located approximately 1.5 km southwest of the west end of Brucejack Lake at approximately 1580 m to 1630 m elevation. Size 2 avalanches are estimate to affect the Bridge Zone Pit on an annual basis, and Size 3 avalanches with 3 to 10 year return. Since the pit is located in the start zone of the path, avalanches may be more frequent due to work activities occurring in the start zone. Construction of the pit is expected to modify the terrain, which may increase or decrease the potential of the slope. Potential consequences include damage to equipment as well as worker injury or fatality.

4.2.1.2 150 Person Camp

The 150 Person Camp is located directly south of the west end of Brucejack Lake. Size 3 avalanches from Path MS2 are estimated to reach the east end of the camp with return frequency of approximately 10 to 30 years. Potential consequences include damage to infrastructure and worker injury or fatality.

4.2.1.3 Gossan Hill Pit

The Gossan Hill Pit is located at the south end of Brucejack Lake. Size 2 avalanches are estimate to affect the Bridge Zone Pit on an annual basis. Since the pit is located in the start zone of the path, avalanches may be more frequent due to work activities occurring in the start zone. Construction of the pit is expected to modify the terrain, which may increase or decrease the potential of the slope. Potential consequences include damage to equipment as well as worker injury or fatality.

4.2.1.4 CAD Fresh Air Raise

The CAD Fresh Air Raise is located approximately 600 m southwest of the southern end of Brucejack Lake. Size 2 avalanches are expected to occur annually, and Size 3 avalanches are expected to occur once in 3 to 10 years. Due to its orientation in the track of the path, avalanche impact pressures may be high. Potential consequences include damage to fixed infrastructure, and worker injury or fatality if workers are on site when the avalanche occurs.

4.2.1.5 Minesite Trails

Several minesite trails traverse steep terrain approximately 2 km northwest of Brucejack Lake (Drawing 1). Size 2 and 3 avalanches are estimated to affect several kilometers of roads on an annual basis. A size 4 avalanche may be expected once in 10 years. Potential consequences include damage to vehicles, occupant injury or fatality, and road delays for avalanche debris cleanup.

4.2.2 Transmission Line

The proposed transmission line alignment begins at Highway 37A, approximately 17 km from Stewart BC. The line ascends steeply from 150 m to over 1750 m elevation to a high alpine ridge just south of Mt. Bunting before descending down to the south end of Long Lake, and the Granduc Road. From here the transmission line extends north primarily along the east side of the Salmon Glacier Valley. During this segment it parallels much of the Granduc access road to Granduc, and then extends north to the toe of the Knipple Glacier. The line then follows a route along the southwest side of the Knipple Glacier to minesite.

Approximately 27 km (accumulated distance) of the alignment is affected by avalanche paths (Table A-2). The estimated frequency of avalanches reaching the alignment varies from annual to once in 30 years. Potential consequences include damage to supporting structures (towers), or the transmission line depending on the height of the line above the avalanche paths. Associated consequences include interruption of service to the mine. In addition, workers may be at risk during the construction phase if the line is built during avalanche season.

4.2.3 Access Road

The proposed mine access road begins at Highway 37 near the confluence of Wildfire Creek and the Bell Irving River, approximately 30 km south of the Bell 2 establishment. The road extends northwest along following the Wildfire Creek drainage for approximately 12 km before heading west to Scott Pass (677 m elevation) and then down Scott Creek drainage to the Bowser River valley (400 m elevation), 35 km from Highway 37. A short (approximately 3 km long) branch road leaves the access road and extends east to reach the west end of Bowser Lake.

The main access continues west along the Bowser River valley before ascending steep slopes to reach the south side of the toe of the Knipple Glacier. From here the road extends up the centre of the Knipple Glacier to the mine site, at an elevation of approximately 1400 m. The last 15 km of the access road is a glacier road at the centre of the Knipple Glacier, and as a result the location may vary depending on crevasse restrictions.

Eleven avalanche paths are estimated to affect the access road, and 2 paths approach to within 100 m. Several avalanche paths on the southwest and northeast side of the Knipple Glacier are expected to affect the road if it was realigned to avoid crevasses. Potential consequences include damage to vehicles, occupant injury or fatality, and road delays for avalanche debris cleanup. Avalanche path characteristics for the Knipple Glacier segment are expected to change with glacial recession, so this segment will need to be reassessed regularly.

5.0 Avalanche Risk Analysis

Guidelines for determining avalanche risk to fixed facilities, worksites and industrial roads within Canada have been developed, and are outlined in the Guidelines for Snow Avalanche Risk Determination and Mapping in Canada (CAA, 2002). Risk determination is not only based on magnitude and frequency of avalanches, but also considers the differences in vulnerability and exposure time of the elements at risk.

Avalanche risk planning for a mining project with a combination of fixed facilities, worksites, and access roads involves the consideration of maximum size avalanches that generally have avalanche return periods of 100 years or more.

The Brucejack project is proposed to operate year round. Elements at risk include fixed facilities, equipment, vehicles, and workers. The vulnerability of each element at risk depends on the ability to sustain the effect of the avalanche. In general avalanches of Size 2 or greater are expected to pose a risk to personnel, and avalanches of Size 3 and greater will pose a risk to fixed facilities, equipment, and medium to large size vehicles. This does not take into account the effect of terrain features which may augment the effect of an avalanche (eg. a worker pushed over a cliff by a Size 1 avalanche; or a vehicle being pushed into a river by a Size 2 avalanche). Fixed infrastructure under development, and specific construction equipment may be damaged (depending on ability to sustain avalanche effects), or lost in avalanche debris or flowing waterways.

Potential consequences of avalanches reaching facilities, worksites and access roads may include:

- damage to facilities, equipment and vehicles;
- worker injury or fatality;
- impact to the environment from any spills associated the avalanche; and
- construction delays due to road and worksite area blockages.

Associated consequences may include economic losses resulting from the above, and impact to company reputation.

A complete risk assessment for each individual scenario involving avalanches cannot be undertaken without further details regarding worksite locations, and timing of exposure. However, considering the baseline details which include:

- proposed year round mining schedule,
- high number of worksites and access roads in avalanche paths, and
- anticipated high number of personnel and vehicles associated with the construction project,

it is estimated that the risk from avalanches to the Brucejack project is high. This estimation assumes no mitigation is utilized.

6.0 Options for Mitigation

Risk reduction strategies typically incorporate location planning (for fixed facilities), avoidance during avalanche season, or the implementation of an active avalanche management plan (generally for access roads and worksites). They type of mitigation depends on the element at risk, and requirement for unhindered access (or not).

For the transmission line, the risk to the towers may be reduced by location planning (locating towers away from the centre of avalanche paths, and spanning avalanche paths. When this is not feasible, risk

to towers may be reduced by constructing splitting wedges or berms (Figure 6-1). Alternatively towers may be reinforced with concrete or steel (Figure 6-2)

Figure 6-1 – Example of Splitting Wedge to protect structure (McClung & Schaerer, 2006)

Figure 6-2 – Example of Steel Reinforced tower

Avalanche mitigation for worksites, access roads, and trails often involve an active avalanche management plan. An active avalanche management plan typically details a daily risk assessment process for worksites and access routes. Avalanche hazard is normally assessed by a combination of daily weather and snowpack analysis accomplished by avalanche technicians. Daily risk is assessed according to nature of the specific worksite project and access requirements (exposure and consequence components). Measures to reduce risk in an avalanche management plan include both active and passive measures. Active measures include temporary evacuation of sites and avalanche control by explosives or other means. Passive measures include:

- limiting exposure or implementing safety measures during high hazard;
- worker safety training sessions;
- Personal Protective Equipment (eg. avalanche transceivers) and rescue equipment; and
- An Avalanche Emergency Response Plan.

Additional measures to reduce risk may include permanent or semi-permanent earthworks to contain or divert avalanches away from worksites, access roads or facilities. Typically this would only be considered for longer term risk management for fixed infrastructure or intensively used access routes.

7.0 Conclusions and Recommendations

An avalanche hazard assessment and risk analysis has been completed for the Brucejack mine project. Facilities and access routes are exposed to approximately forty-three avalanche paths or areas. Avalanche magnitude varies between Size 2 and 4. Avalanche frequency varies between annual and 1:100 years. Potential consequences of avalanches reaching Brucejack mine facilities, transmission line, worksites, and roads include damage to infrastructure, worker injury (or fatality), and project delays. If avalanche mitigation is not employed, there is a high likelihood of the above consequences affecting operations.

A complete risk assessment for each individual scenario involving avalanches cannot be undertaken without further details regarding worksite locations, and timing. However, considering the baseline details which include:

- proposed year round mining schedule,
- high number of worksites and access roads in avalanche paths, and
- anticipated high number of personnel and vehicles associated with the construction project,

it is estimated that the risk from avalanches to the Brucejack project is high.

Alpine Solutions recommends the following:

- Any proposed infrastructure (fixed facilities and semi-permanent worksites) that are exposed to avalanches should be relocated away from avalanche paths or hazard areas.
- If relocation is not feasible, proposed infrastructure exposed to avalanches should be assessed in greater detail to determine potential impact forces and loading. This may include ground survey and numerical modelling of paths. Detailed ground survey should be completed during summer months if possible.
- The segment of the Access Road which transits the Knipple Glacier should be reassessed on a regular basis due to the effects of glacial recession on avalanche runout.
- An avalanche management program which includes options for avalanche explosive control should be developed and implemented for any operations during avalanche season.
- Any changes to layout of facilities and roads should be reassessed for avalanche hazard.

8.0 Closure

This report was prepared by Alpine Solutions Avalanche Services (Alpine Solutions) for the account of Pretivm Resources Inc. The material in it reflects Alpine Solutions' best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this report.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending Alpine Solutions' written approval. If this document is issued in an electronic format, an original paper copy is on file at Alpine Solutions and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

Yours sincerely,
Alpine Solutions Avalanche Services
Per:

Brian Gould, P. Eng., CAA-QAP
Senior Avalanche Specialist

APPENDIX A – AVALANCHE HAZARD TABLES

Table A1 - Minesite

PATH ID	AVALANCHE ATLAS POLYGON LABEL	FACILITY AREA AFFECTED	REFERENCE ELEVATION (m)	FACILITY POSITION IN PATH	LENGTH OF FACILITY AFFECTED (m)	START ZONE	TRACK	RUNOUT	Size 2	Size 3	Size 4
Mine Site 1	MS1	Access Road	1440 - 1370	RZ	1000	North, 30 - 40 degree, benched, rocky ridge	Open, benched, slope, rocky outcrops	Fan/ lake	1:3	1:10	1:100
Mine Site 2	MS2	Access Road, 150 Person Camp	1370	RZ	100	Northwest, 30 - 40 degree, dish-shaped bowl	Broad open slope	Fan/ lake	~	1:30	~
Mine Site 3	MS3	Transmission Line	1630 - 1440	SZ, Track, RZ	500	Northwest, 30 - 40 degree bowl and rock rib	Broad open slope	Fan	1:3	1:10	~
Mine Site 4	MS4	Bridge Zone Pit	1630 - 1580	SZ, Track	250	West-northwest, 30 -35 degree, crevassed bowl, rocky outcrop	Open slope	Bench	1:3	~	~
Mine Site 5	MS5	CAD Fresh Air Raise	1470	Track	50	West-northwest, 40 degree, with large fetch to southeast	Open slope, bowl shaped	Bench	1:1	1:3	
Mine Site 6	MS6	Gossan Hill Pit	1430-1390	SZ, Track	50	East-southeast, 40 degree bowl	Open slope	Bench with catchment	1:1	~	
Mine Site 7	MS7	Minesite Trails	1800 - 1280	Track, RZ	3000	Southwest, 35 - 40 degree, uniform slope with rocky outcrops	Broad open slope	Bench/slope break	1:1	1:1	1:10

Table A2 - Transmission Line

PATH ID	AVALANCHE ATLAS POLYGON LABEL	FACILITY AREA AFFECTED	REFERENCE ELEVATION (m)	FACILITY POSITION IN PATH	LENGTH OF FACILITY AFFECTED (m)	START ZONE	TRACK	RUNOUT	Size 2	Size 3	Size 4
Transmission Line 1	TL1	Transmission Line	280 - 110	RZ	690	East through southwest, 40 - 45 degree, rocky, bowl	30-40 degree, gully	Fan	~	~	1:30
Transmission Line 2	TL2	Transmission Line	1840 - 110	SZ, Track, RZ	3300	East, 30 - 40 degree, rocky, open slope	40 - 50 degree, slopes to gully	Fan	1:1	1:1	1:3
Transmission Line 3	TL3	Transmission Line	280 - 110	RZ	690	East, 40 - 45 degree, rocky open slope	50 - 60 degree, slopes to gully	Fan		~	1:30
Transmission Line 4	TL4	Transmission Line	1820 - 1120	SZ, Track	1700	West, 30 - 35 degree, open slope	Open slope with multiple gullies	Creek	1:1	1:1	1:3
Transmission Line 5	TL5	Transmission Line	1060 - 980	RZ	600	West, 30 - 35 degree, open slope	Open slope with shallow gully	Bench/slope break	1:1	~	~
Transmission Line 6	TL6	Transmission Line	1000 - 850	Track, RZ	300	Southeast, 35 - 40 degree, opening in treed slope	Open slope	Creek/ bench	1:1	~	~
Transmission Line 7	TL7	Transmission Line	980 - 740	SZ, Track	820	Northwest, 40 - 45 degree, slope, rocky outcrops and sparse trees	Multiple gullies	Bench	1:1	1:10	~
Transmission Line 8	TL8	Transmission Line	810 - 760	RZ	400	Southwest, 30 degree, opening in treed slope	Open slope	Road/ slope break	1:3	~	~
Transmission Line 9	TL9	Transmission Line	1000	Track	100	West, open convex roll	Gully	Creek	1:1	1:3	~
Transmission Line 10	TL10	Transmission Line	1020 - 980	Track	350	West, open convex roll	Slope with 2 distinct gullies	Fan	1:1	1:3	~
Transmission Line 11	TL11	Transmission Line	1080 - 1000	SZ	800	West, 30 - 35 degree, shallow bowl, sparse trees	Sparsely treed slope, multiple shallow gullies	Fan	1:3	~	~
Transmission Line 12	TL12	Transmission Line	980 - 960	RZ	200	Northwest, open shallow bowl	Open slope, multiple shallow gullies	Creek	`	1:30	`
Transmission Line 13	TL13	Transmission Line	1040 - 860	Track	1650	West, open shoulder, sparse trees	Open slope	Fan/bench	1:1	1:3	~
Transmission Line 14	TL14	Transmission Line	~	~	~	East, open shoulder	Open Slope	Bench	~	~	~
Transmission Line 15	TL15	Transmission Line	880	Track	350	North-northwest, open shallow bowl	Open slope	Bench	~	1:10	~
Transmission Line 16	TL16	Transmission Line	660	RZ	2300	East, 35 - 45 degree, open slope, convex rolls	Open slope	Fan/ river	~	~	1:30
Transmission Line 17	TL17	Transmission Line	720 - 640	RZ	1000	West, 40 - 50 degree, open bowl	Open slope	Bench/ river	~	1:10	~
Transmission Line 18	TL18	Transmission Line	660 - 580	RZ	400	Northwest, large alpine bowl	Wide distinct gullies with 2 branches	Fan	~	~	1:30
Transmission Line 19	TL19	Transmission Line	~	~	~	Southeast, 30 - 40 degree opening on treed slope	Open slope	Slope break	~	~	~
Transmission Line 20	TL20	Access Road	710 - 660	SZ, Track	560	South, ?	Open slope	Fan	1:1	1:1	~
Transmission Line 21	TL21	Access Road	~	SZ	100	East, steep, rocky face, sparse trees	Open slope, multiple shallow gullies	Slope break/ glacier	1:1	1:3	~
Knipple Glacier 1	KG1	Access Road	900 - 740	Track	1300	Northeast, steep, rocky face	Open slope, multiple shallow gullies	Slope break/ glacier	~	1:3	1:30
Knipple Glacier 2	KG2	Access Road, Transmission Line	915 - 900	RZ	700	North, steep, rocky face	Open slope	Slope break/ glacier	~	1:3	1:10
Knipple Glacier 2	KG2	Transmission Line	1280 - 945	SZ, Track, RZ	900	North, steep, rocky face	Open slope	Slope break/ glacier	1:1	1:3	1:10
Knipple Glacier 3	KG3	Transmission Line	970 - 955	RZ	500	Northeast, open glaciated bowl	Steep, crevassed, glacial slope	Fan/ glacier	~	~	1:30
Knipple Glacier 4	KG4	Transmission Line	970	RZ	100	Northeast, shallow bowl, multiple rocky knolls	Broad, undulating, open slope	Fan/ glacier	~	~	1:30
Knipple Glacier 5	KG5	Transmission Line	1050 - 1040	RZ	300	Northeast, glaciated bowl	Steep, broad gully	Fan/ glacier	~	~	1:30
Knipple Glacier 6	KG6	Transmission Line	1100 - 1040	RZ	1100	Northeast, broad, steep glaciated bowl	Steep rock bands, deep, V-shaped gully	Fan/ glacier	~	~	1:30
Knipple Glacier 7	KG7	Transmission Line	1270 - 1100	RZ	780	Northeast, broad, shallow bowl	Broad rock bands, rocky outcrops	Fan/ glacier	~	1:3	1:10
Knipple Glacier 8	KG8	Transmission Line	1330 - 1280	Track, RZ	1800	North-northeast, steep glacial slope with large seracs and rocky buttress	Broad open slope	Fan/ glacier	~	1:3	1:10
Knipple Glacier 9	KG9	Transmission Line	1460 - 1340	Track, RZ	1400	North to northeast, 40 - 50 degree bowl and cliff bands	slope and rock bands	Fan/ glacier	~	1:3	1:10
Mine Site 2	MS2	Transmission Line	1650 - 1630	SZ	100	Northwest, 30 - 40 degree, dish-shaped bowl	Broad open slope	Fan	1:3	1:10	~
Mine Site 3	MS3	Transmission Line	1630 - 1440	SZ, Track, RZ	500	Northwest, 30 - 40 degree bowl and rock rib	Broad open slope	Fan	1:3	1:10	~

Table A3 - Access Road

PATH ID	AVALANCHE ATLAS POLYGON LABEL	FACILITY AREA AFFECTED	REFERENCE ELEVATION (m)	FACILITY POSITION IN PATH	LENGTH OF FACILITY AFFECTED (m)	START ZONE	TRACK	RUNOUT	Size 2	Size 3	Size 4
Access Road 1	AR1	Access Road	~	~	~	West, 40 - 45 degree, broad treeline slope	Open slope, narrows to gulley	Creek	~	~	~
Access Road 2	AR2	Access Road	~	~	~	West, 40 - 45 degree, shallow bowl and open slope	Open slope, narrows to gulley	Creek	~	~	~
Access Road 3	AR3	Access Road	470 - 430	RZ	500	South, 35 - 40 degree broad open shoulder	Open slope, sparse trees	River	~	~	1:30
Access Road 4	AR4	Access Road	405 - 395	RZ	600	South, 30 - 40 degree, treeline slope, shallow gullies	Treed slope with shallow gullies	River	~	1:30	~
Access Road 5	AR5	Access Road	440	RZ	540	South, steep, open rocky slope, cliff bands	Open slope	River	1:3	1:30	~
Access Road 6	AR6	Access Road	420	RZ	140	Southwest, steep short knoll	Slope	Road/river	1:3	~	~
Transmission Line 19	TL19	~	~	~	~	Southeast, 30 - 40 degree opening on treed slope	Open slope	Slope break	~	~	~
Transmission Line 20	TL20	Access Road	710 - 660	SZ, Track	560	South for Upper bench and west for open slope	Open slope	Fan	1:1	1:1	~
Transmission Line 21	TL21	Access Road	740	SZ	100	East, steep, rocky face, sparse trees	Open slope, multiple shallow gullies	Slope break/ glacier	1:1	1:3	~
Knipple Glacier 1	KG1	Access Road	900 - 740	Track	1300	Northeast, steep, rocky face	Open slope, multiple shallow gullies	Slope break/ glacier	~	1:3	1:30
Knipple Glacier 2	KG2	Access Road, Transmission Line	915 - 900	RZ	700	North, steep, rocky face	Open slope	Slope break/ glacier	~	1:3	1:10
Knipple Glacier 3	KG3	~	970 - 955	RZ	500	Northeast, open glaciated bowl	Steep, crevassed, glacial slope	Fan/ glacier	~	~	1:30
Knipple Glacier 4	KG4	~	970	RZ	100	Northeast, shallow bowl, multiple rocky knolls	Broad, undulating, open slope	Fan/ glacier	~	~	1:30
Knipple Glacier 5	KG5	~	1050 - 1040	RZ	300	Northeast, glaciated bowl	Steep, broad gully	Fan/ glacier	~	~	1:30
Knipple Glacier 6	KG6	~	1100 - 1040	RZ	1100	Northeast, broad, steep glaciated bowl	Steep rock bands, deep, V-shaped gully	Fan/ glacier	~	~	1:30
Knipple Glacier 7	KG7	~	1270 - 1100	RZ	780	Northeast, broad, shallow bowl	Broad rock bands, rocky outcrops	Fan/ glacier	~	1:3	1:10
Knipple Glacier 8	KG8	~	1330 - 1280	Track, RZ	1800	North-northeast, steep glacial slope with large seracs and rocky buttress	Broad open slope	Fan/ glacier	~	1:3	1:10
Knipple Glacier 9	KG9	~	1460 - 1340	Track, RZ	1400	North to northeast, 40 - 50 degree bowl and cliff bands	slope and rock bands	Fan/ glacier	~	1:3	1:10
Mine Site 1	MS1	Access Road	1440 - 1370	RZ	1000	North, 30 - 40 degree, benched, rocky ridge	Open, benched, slope, rocky outcrops	Fan/ lake	1:3	1:10	1:100
Mine Site 2	MS2	Access Road	1370	RZ	300	Northwest, 30 - 40 degree, dish-shaped bowl	Broad open slope	Fan/ lake	~	1:30	~

APPENDIX B - DRAWINGS

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PROJECT MEMORANDUM

Date: May 9, 2013
To: Pretivm Resources Inc.
Attn: Ian Chang, M.Sc., P. Eng., VP Project Development;
From: Brian Gould, P. Eng.
Re: Brucejack Avalanche Hazard Assessment and Risk Analysis – 20130509 DRAFT

1.0 Introduction

1.1 General

Pretivm Resources Inc. (Pretivm) is proposing to develop a mine in the Coast Range of northwestern British Columbia, approximately 42 km north of Stewart, BC (Figure 1-1). The project includes several mine site facilities, a transmission line, and an access road. Previous studies indicate that the project is in the vicinity of snow avalanche terrain. Pretivm requested that Alpine Solutions Avalanche Services (Alpine Solutions) undertake an avalanche hazard assessment and risk analysis to determine the likelihood and potential consequences of avalanches affecting the project. Options for avalanche risk mitigation are provided, and the memorandum concludes with recommendations. The results of this assessment will be used for mine permitting, and operational planning.

Figure 1-1 Brucejack Project Location

1.2 Work Scope

Pretivm initially provided Alpine Solutions with the following maps and documents:

- Figure 18.11 Brucejack Overall Site Plan GA – Mine and Process Plant.
- 3 maps by Cypress Forest Consultants illustrating Access Road General Arrangement (including Glacier Road).
- Figure 8.2-2 Brucejack Project: Alternative Power Line Routes.
- Brucejack Road Risk Rating and Inspection Procedure.

In addition, numerous aerial photographs (1:20,000 scale), and digital shape-files representing facility layout were provided by BGC Engineering Inc. The proposed transmission line digital shape-files were provided by Vallard Construction Ltd.

Subsequent to an initial avalanche hazard memorandum completed by Alpine Solutions (2012), the following drawings were provided:

- Tetratech - Pretivm Feasibility Study Drawings 100000-20-000, 001, 002, 101, 102, 103, 104, 105, 201, 301, 302, 303, 304, 305, 306, 501.

The avalanche hazard assessment and risk analysis was completed for the proposed mine site area, the preferred transmission line alignment, and the access road from Highway 37. The work included terrain analysis from topographic maps and aerial imagery. A helicopter overview flight was undertaken in March 2012 to confirm the avalanche path locations and terrain characteristics. Ground survey was completed April 28-29, 2013.

This memorandum provides the following information:

- Identification and description of avalanche hazard to mine operations.
- An estimate of potential consequences of avalanches, and a discussion of associated exposure and risk.
- A tabulated summary of avalanche paths and hazard areas that affect proposed facilities and access roads.
- Seventeen drawings illustrating locations of avalanche paths that affect proposed facilities and access roads.
- Options for mitigation.
- Recommendations.

Section 4.0 and 7.0 are to be inserted into the Brucejack Mine Feasibility Study, expected to be finalized in July, 2013.

2.0 Limitations

This document provides an overview of snow[1] avalanche hazards which affect the proposed Brucejack mine project. Estimated magnitudes, frequencies, and areal extent of individual avalanche paths are based on a climate analysis, map and imagery interpretation, helicopter overview flights, and ground analysis for specific fixed infrastructure that is potentially affected by avalanches. Analysis of individual avalanche paths was limited to vegetation and overview terrain analysis; no numerical modeling has been completed.

Sources of uncertainty associated with avalanche runout boundaries illustrated on avalanche hazard mapping include:

- limited avalanche occurrence history (data) for the area; and
- lack of vegetation indicators (trim lines) where avalanches runout into non-forested terrain.

Although other geohazards exist in the region, the scope of this assessment is limited exclusively to avalanches. In addition, any significant artificial or natural alteration of the landscape or terrain due to forest fire, landslides, or other geotechnical event may change the nature (magnitude/frequency/intensity/runout) of avalanche hazard, necessitating a re-assessment for the area affected.

[1] The qualifier “snow” will not be included from here on. It was added here to make it clear that there is no mention of “rock avalanches” or “debris avalanches” in this report.

3.0 Physiography

3.1 Location

The Pretivm minesite is located at the head of the Knipple Glacier, approximately 60 km north of Stewart, BC, and 38 km southwest of Bell 2. The access road begins at the intersection of Highway 37 and Wildfire Creek, approximately 30 km south of Bell 2, and extends to the minesite via the Wildfire Creek, Scott Creek, Bowser River, and Knipple Glacier valleys. The preferred transmission line route extends from the Long Lake Hydroelectric Project north of Stewart to the mine via the Salmon Glacier valley and the ridge on the south side of the Knipple Glacier. A second optional route for the transmission line follows the access road corridor.

3.2 Snow Climate

Snow climate refers to the general character of climate factors that contribute to snowpack and avalanche formation. Historical meteorological records often provide information on the frequency, timing, and sometimes magnitude of future avalanches. In addition, estimates of average and maximum snowpack depth can provide information on how often thresholds for avalanche triggering are exceeded.

Although historical climate and avalanche records for the Brucejack area is limited, regional BC Government snow pillow and snow survey records in the region provide baseline snowpack information. In addition, avalanche technicians working on site for the past winter have collected avalanche occurrence records for several avalanche paths in the area.

The proposed Brucejack mine area is located in a transition zone between maritime and continental climate zones. As a result, there are significant temperature and moisture fluctuations that occur in an average winter. These fluctuations often contribute to a layered snowpack, which leads to lingering avalanche conditions most winters. In addition, the effects of wind and terrain orientation lead to increased snowpack variability which can contribute to challenging avalanche forecasting conditions.

Avalanche season typically begins in October at the higher elevations (above 1400 m), and often extends until late June or early July. At valley bottom elevations, avalanches can be expected from November to late May though can occur earlier or end later in extreme years.

Typical storm patterns can produce high intensity snowfall with strong winds depositing significant amounts of snow on lee (the side of slopes away from the principal wind direction) aspects. Temperature increases associated with some storms can produce rain-on-snow conditions up to treeline elevations (1200-1400 m), and sometimes above. An average winter will include 10-20 large storm events, most of which can produce widespread avalanche conditions.

4.0 Avalanche Hazard Assessment

4.1 Background on Snow Avalanches

Snow avalanches generally occur in areas where there are steep open slopes or gullies, and deep (>50 cm) mountain snowpacks. Risk associated with avalanches is normally due to exposure to the high forces that occur, as well as the effects of extended burial for any person caught in an avalanche. Impact forces vary significantly depending on avalanche size. Although the smallest avalanches can be insignificant to a human, larger avalanches may produce impact forces capable of destroying trucks, buildings, or several hectares of mature forest.

Characteristics of Snow Avalanches:

Avalanches may initiate in either *dry* or *wet* snow. Although an avalanche may start in dry snow, it could become *moist* or *wet* during its descent. Terrain features including gullies deflect and often channel wet snow avalanches. Conversely, large, fast-flowing dry avalanches tend to flow in a straighter path, and may overrun terrain features.

Most large, dry avalanches consist of a dense component that flows primarily along the ground, and a less dense powder component that travels above and sometimes ahead of the flowing component. In some cases these components can separate and move independently. The dense-flowing component and powder component may reach speeds up to 60 m/s (200 km/h). Impact pressures from dense flow are much greater than the powder component due to the density of the snow.

Avalanche terrain is usually associated with steep open slopes in the mountains that allow an accumulation of snow before it releases in a destructive event. In addition to the steep slopes that the snow accumulates on, any area exposed to this release of snow is also considered avalanche terrain. Terrain is often subdivided into features that are connected, and generally contain or channel the volume of avalanche events into a common deposition area. These features are called *avalanche paths.*

Avalanche Season is the time of year when avalanches may occur, and is dependent on when the ground roughness in starting zones has been covered by snow, and threshold for avalanches has been exceeded. For the Brucejack area, avalanche season below 1000 m generally occurs between November and May. For higher elevations above 1200 m, avalanche season can extend to include October and June, or even summer months if cool wet conditions persist.

Avalanche Path:

An avalanche path generally consists of a *starting zone*, a *track*, and a *runout zone*. Avalanches start and accelerate in the starting zone which typically has slope incline greater than 30°. Downslope of the starting zone, most large avalanche paths have a distinct track in which the slope angle is typically in the range of 15° to 30°. Large avalanches decelerate and stop in the runout zone where incline is usually less than 15°. Smaller avalanches may decelerate and even stop on steeper slopes (15° to 24°).

Within forested terrain, larger avalanche paths are often discernible as vertically oriented swaths of open forest terrain bordered by *trim lines* (mature forest on either side of the swath). Smaller avalanches however can occur in more subtle paths, and can occur on large cutbanks in a road cut.

Runout zones generally have vague trim lines, and analysis by an experienced avalanche specialist is required to determine estimates of maximum avalanche extent (often extends into mature forest). Some avalanche paths in terrain around cliffs can be much more subtle to observe, and can be confused with rockfall and or geotechnical events.

Avalanche Frequency:

Avalanche *frequency* is the reciprocal of avalanche *return period* and is typically referred to as an order of magnitude ranging from 1:1 (annual) up to 1:300 (1 in 300) years. Each winter, the probability of an avalanche with a specified return period is constant.

Avalanche frequency is dependent upon *snow supply* and *terrain.* Frequency decreases with distance downslope in the track and runout zone. Snow supply is determined by:

- Frequency of snowfalls and amount of snow; and
- Wind transport of snow into the starting zone.

Snow and weather conditions vary from year to year, and the frequency of avalanches is not uniform.

The primary terrain factors in avalanche formation are incline, slope orientation (aspect) with respect to wind and sun, slope configuration and size, and ground surface roughness. Slope configuration is important because features such as gullies will often have more frequent and larger avalanches than open slopes. Ground roughness determines the threshold snow depth for avalanches to occur. This is particularly important in light snow climates where snow may not exceed threshold depths some winters.

Avalanche Magnitude:

Avalanche *magnitude* relates to the destructive potential of an avalanche and is defined according to the Canadian avalanche size classification system. A general description of destructive potential, magnitude, and typical path length under this classification system is provided in Table 1.

Magnitude is often related to frequency. In general, large destructive avalanches occur less frequency, while smaller ones occur on a more regular basis. Magnitude and frequency of effect are also related to location in the overall path. For example a road location near the toe of an avalanche path will be affected by avalanches on a less frequent basis, but they will be larger avalanches. Both low frequency large avalanches and higher frequency small avalanches may affect a road crossing in the middle of an avalanche path.

Table 1 : *Canadian classification system for avalanche size (McClung & Schaerer, 1993)*				
Size	Destructive Potential	Typical Mass	Typical Path Length	Typical Impact Pressures
1	Relatively harmless to people.	<10 tonnes	10 m	1 kPa
2	Could bury, injure or kill a person.	10^2 tonnes	100 m	10 kPa
3	Could bury a car, destroy a small building, or break a few trees.	10^3 tonnes	1000 m	100 kPa
4	Could destroy a large truck, several buildings, or a forest with an area up to 4 hectares.	10^4 tonnes	2000 m	500 kPa
5	Largest snow avalanches known. Could destroy a village or a 40 ha forest.	10^5 tonnes	3000 m	1000 kPa

4.2 Brucejack Avalanche Hazard

Avalanche paths and hazard areas that affect the Brucejack Project were identified by reviewing topographic relief and vegetation features on maps and aerial photos, as well as available Google Earth ortho-imagery and digital elevation models (DEM). In addition, field reconnaissance (helicopter overview flights and ground based survey) was completed March 19, 2012, and April 28-29, 2013.

Forty-one avalanche paths or hazard areas reach project infrastructure or access roads, and many locations are estimated to be affected on an annual basis. Avalanche paths and hazard areas are summarized in three tables in Appendix A, and illustrated on drawings in Appendix B. Avalanche Paths referred to in Appendix A and B are labelled according to Table 4-1, referring to the element at risk, with the exception of paths along the Knipple Glacier which may affect both the transmission line and access road.

Table 4-1 – Avalanche Path Label and corresponding Element at Risk

Avalanche Path Label	**Element at Risk**
TL1, TL2, …, TLx	Preferred transmission line alignment
AR1, AR2, …, ARx	Access road and Knipple Transfer Station
MS1, MS2, …, MSx	Facilities at or near the mine site, access road, and transmission line
KG1, KG2, …, KGx	Access road and transmission line corridor on glacier

The following four sub-sections provide details of avalanche hazard, and potential consequences to each facility.

4.2.1 Minesite

The minesite is located on a broad alpine plateau in undulating terrain on the southwest side of Brucejack Lake. The area is bounded by the Knipple Glacier to the east and south, the Sulphurets Glacier to the west, and rising alpine slopes to the north. Elevations at the minesite area range from 1350 m to

over 2000 m. Proposed facilities assesse in the mine site area near Brucejack Lake include the following (Tetratech Drawing 100000-10-003):

- Explosives and Detonator Storage
- Electrical Substation
- Water Treatment Plant
- Existing Portal
- Portal Fuel Storage
- Garbage and Incinerator area
- Operations Camp Pad
- Pre-production Ore Storage
- Mill Building including Admin, Mine Dry, Truckshop, Warehouse
- Water Reclaim Barge
- Tailings Pipeline
- Batch Plant
- Aviation Fuel Tank
- Scale House
- Water Pumps and Storage Tank
- Truck Portal
- Helipad
- Existing Office
- Four Air Raise Locations.
- Tailings Discharge
- Site Access Roads

The above facilities are all away from avalanche paths with the exception of the Operations Camp Pad, some sections of the site access roads, the existing office location, and the Pre-production Ore Storage. Short slopes (ranging from 20 to 40 m in height) that currently exist, or will be created during construction, may be expected to affect other facility areas however the hazard and consequences would normally be assessed on a site specific basis during construction and operations.

The following four sections describe the nature of the hazard to facilities at the mine site, and a fifth section discusses hazard associated with avalanches reaching Brucejack Lake.

4.2.1.1 Operations Camp Pad

Size 2 avalanches from Path MS8 are estimated to reach the southwest end of the Operations Camp Pad with an annual return frequency. Potential consequences include damage vulnerable infrastructure (e.g. window or non-structural component of building if built within the runout area) and worker injury or fatality if workers are in the runout area when the avalanche occurs.

4.1.2.2 Site Access Roads

Size 2 and 3 avalanches from Path MS5 and Size 2 avalanches from Path MS9 are estimated to reach site access roads annually (Drawing 1). Potential consequences include damage infrastructure, vehicles, and worker injury or fatality if workers are in the runout area when the avalanche occurs.

4.2.1.3 Existing Office

The Existing Office is located in the runout zone of Path MS5. Size 2 to 3 avalanches are expected to reach the facility with return frequency of three years on average. Potential consequences may include damage to infrastructure and worker injury or fatality if workers are in the runout area when the avalanche occurs.

4.2.1.4 Pre-production Ore Storage

The Pre-production Ore Storage, and associated laydown area are exposed to Size 3 avalanches from Path MS2 approximately once every ten years. Potential consequences include damage to any vulnerable materials located in the runout area when the avalanche occurs.

4.2.1.5 Avalanches Reaching Brucejack Lake

Avalanches up to Size 3 may reach Brucejack Lake from Path MS1 and short steep slopes on the north side of Brucejack Lake may produce avalanches to Size 3 reaching the lake. If avalanches reach the lake when the surface is not frozen, waves may develop. However, these waves are not expected to be destructive due to avalanches being either small or slow moving when they reach the lake.

4.2.2 Access Road

The mine access road begins at Highway 37 near the confluence of Wildfire Creek and the Bell Irving River, approximately 30 km south of the Bell 2 establishment. The road extends northwest along following the Wildfire Creek drainage for approximately 12 km before heading west to Scott Pass (677 m elevation) and then down Scott Creek drainage to the Bowser River valley (400 m elevation), 35 km from Highway 37. The access continues west along the Bowser River valley for approximately 15 km to the Knipple Transfer Station (KTS).

From the KTS, the road ascends slopes to the northwest to reach the south side of the toe of the Knipple Glacier, and along a short ramp to the Knipple Glacier. From here the road extends as a glacier road up the center of the Knipple Glacier for approximately 15 km to the mine site at approximately 1400 m. The glacier road is proposed to be near the centre of the Knipple Glacier, although the location may vary depending on crevasse restrictions.

Eleven avalanche paths or areas are estimated to affect the access road, and two paths approach to within 50 m (Table A1 and Drawing 2 to 6). One area is (Path AR8) is affected by large ice blocks falling off bluffs above the road. Several avalanche paths on the southwest and northeast side of the Knipple Glacier could affect the road if it was realigned to avoid crevasses. Potential consequences include damage to vehicles, occupant injury or fatality, and road delays for avalanche debris cleanup. Avalanche path characteristics for the Knipple Glacier segment are expected to change with glacial recession, so this segment will need to be reassessed regularly.

The highest hazard areas include sections of road that are located within Paths AR4, AR8, and KG1 due to their high frequency of avalanches and icefalls reaching the affected areas, and magnitudes large enough to damage vehicles, injure occupants, and delay the flow of traffic during storms when avalanche control is not feasible.

4.2.3 Knipple Transfer Station

The Knipple Transfer Station is located at valley bottom near the confluence of the Salmon and Knipple valleys (Drawings 2 and 3). Extreme avalanches occurring in Path AR6 are estimated to reach the west end of the KTS pad with an estimated return period of at least 100 years. Potential consequences of both mass and powder debris reaching the site include damage to infrastructure and injury or fatality for any personnel located in the runout area (at the west end of the facility footprint).

4.2.4 Transmission Line

4.2.4.1 Avalanche Hazard

The preferred transmission line alignment begins at Long Lake where a hydroelectric generation facility is currently being built, approximately 14 km north of Stewart BC. The line extends north primarily along the east side of the Salmon Glacier Valley. During this segment it parallels much of the Granduc access road to Granduc, and then extends north to the toe of the Knipple Glacier. The line is then proposed to follow a route along a ridge on the southwest side of the Knipple Glacier to minesite, however the exact alignment is uncertain at this time. An optional transmission line route follows the access road alignment from the BC Hydro Northern Transmission Line (NTL) at Highway 37.

Over 20 km (accumulated distance) of the preferred alignment is affected by avalanche paths (Table A-2). The estimated frequency of avalanches reaching the alignment varies from annual to once in 30 years. Potential consequences include damage to supporting structures (towers) if they are built within areas affected by avalanche paths, or to the conductors, depending on the height of the conductors above the avalanche paths. Associated consequences include interruption of service to the mine. In addition, worker injury of fatality may be may occur during the construction phase if the line is built, or if maintenance if undertaken, during avalanche season.

Avalanches that affect the access road are also expected to affect the optional transmission line alignment which parallels the access road from the NTL adjacent to Highway 37. Locations include all avalanche paths indicated that affect the access road. There may also be additional paths that affect the line depending on the extent of deviation of the final alignment from the access road. Potential consequences to the project would be the same as the consequences of avalanches reaching the preferred transmission line alignment.

4.2.4.2 Static Snow Forces

In addition to avalanche hazard, transmission line towers may be subject to forces of snow creep and glide, depending on their location. Although snow creep and glide are not fast moving events, they may generate forces that may exceed the bending strength of the tower or the strength of the foundation. If towers built on slopes are not designed to withstand these forces, potential consequences may include damage to towers and associated impact to conductors resulting in interruption of services to the mine.

5.0 Avalanche Risk Analysis

Guidelines for determining avalanche risk to fixed facilities, worksites and industrial roads within Canada have been developed, and are outlined in the Guidelines for Snow Avalanche Risk Determination and Mapping in Canada (CAA, 2002). Risk determination is not only based on magnitude and frequency of avalanches, but also considers the differences in vulnerability and exposure time of the elements at risk. Avalanche risk planning for a mining project with a combination of fixed facilities, worksites, and access roads involves the consideration of maximum size avalanches that generally have avalanche return periods of 100 years or more.

The Brucejack project is proposed to operate year round. Elements at risk include fixed facilities, equipment, vehicles, and workers. The vulnerability of each element at risk depends on the ability to sustain the effect of the avalanche. In general avalanches of Size 2 or greater are expected to pose a risk to personnel, and avalanches of Size 3 and greater will pose a risk to fixed facilities, equipment, and medium to large size vehicles. This does not take into account the effect of terrain features which may augment the effect of an avalanche (eg. a worker pushed over a cliff by a Size 1 avalanche; or a vehicle being pushed into a river by a Size 2 avalanche). Fixed infrastructure under development, and specific construction equipment may be damaged (depending on ability to sustain avalanche effects), or lost in avalanche debris or flowing waterways.

Potential consequences of avalanches reaching facilities, worksites and access roads may include:

- damage to facilities, equipment and vehicles;
- worker injury or fatality;
- impact to the environment from any spills associated the avalanche; and
- construction delays due to road and worksite area blockages.

Associated consequences may include economic losses resulting from the above, and impact to company reputation.

A complete risk assessment for each individual scenario involving avalanches cannot be undertaken without further details regarding worksite locations, and timing of exposure. However, considering the baseline details which include:

- proposed year round mining schedule,
- high number of worksites and access roads in avalanche paths, and
- anticipated high number of personnel and vehicles associated with the construction project,

it is estimated that the risk from avalanches to the Brucejack project is high. This estimation assumes no mitigation is utilized.

6.0 Options for Mitigation

Mitigation strategies typically incorporate location planning (for fixed facilities), avoidance during avalanche season, or the implementation of an active avalanche management plan (generally for access roads and worksites). They type of mitigation depends on the element at risk, and requirement for un-interrupted access (or not).

For the transmission line, the hazard to the towers may be reduced by location planning (locating towers away from the centre of avalanche paths, and spanning avalanche paths. When this is not feasible, the constructing of splitting wedges (Figure 6-1) or earthworks can reduce or eliminate the hazard. Alternatively towers may be designed (reinforced with concrete or steel) to protect from avalanche impact forces (Figure 6-2) and snow creep and glide forces.

Figure 6-1 – Example of Splitting Wedge to Protect Structure (McClung & Schaerer, 2006)

Figure 6-2 – Example of Reinforced Tower

Avalanche mitigation for worksites and access roads typically involve an active avalanche management plan. An active avalanche management plan normally involves a daily risk assessment process for worksites and access routes. Avalanche hazard is normally assessed by detailed weather and snowpack analysis by avalanche technicians. Daily risk is assessed according to nature of the specific worksite project and access requirements (exposure and consequence components). Measures to reduce risk in an avalanche management plan include both active and passive measures. Active measures include temporary evacuation of sites and avalanche control by explosives or other means. Passive measures include:

- limiting exposure or implementing safety measures during high hazard;
- worker safety training sessions;
- Personal Protective Equipment (eg. avalanche transceivers) and rescue equipment; and
- An Avalanche Emergency Response Plan.

Additional measures to reduce risk to roads and worksites may include permanent or semi-permanent mitigation including:

- earthworks (diversion and catchment berms) to contain or divert avalanches away from worksites, access roads, or facilities;
- snow berms to contain or divert avalanches away from worksites, access roads, or facilities;
- structural walls or snow sheds.

Due to high costs of building structural walls or snow sheds, the feasibility of these are typically evaluated in a business case comparison of options that would balance cost of construction and maintenance versus loss associated with temporary closure of areas during periods of high hazard.

7.0 Summary and Recommendations

7.1 Summary

An avalanche hazard assessment has been completed for the Brucejack mine project. Facilities and access routes are exposed to approximately forty-one avalanche paths or areas. Avalanche magnitude varies between Size 2 and 4. Avalanche frequency varies between annual and 1:100 years. Potential consequences of avalanches reaching Brucejack mine facilities, transmission line, worksites, and roads include damage to infrastructure, worker injury (or fatality), and project delays. Potential consequences of static snow loads on transmission towers include damage to towers and foundations, and potential loss of electrical service to the mine. Without mitigation to the effects of avalanches and static snow loading, there is a high likelihood of some of the above consequences affecting operations on an annual basis.

A complete risk assessment for each individual scenario involving avalanches cannot be undertaken without further details regarding worksite locations, and timing. However, considering the baseline details which include:

- proposed year round mining schedule,
- high number of worksites and access roads in avalanche paths, and
- anticipated high number of personnel and vehicles associated with the construction project,

it is estimated that the unmitigated risk from avalanches to the Brucejack project is high.

7.2 Recommendations

Alpine Solutions recommends the following:

- Operation of the mine during regular avalanche season (October through June) should involve an avalanche management program to reduce risk to project personnel and equipment. The program should include weather and avalanche monitoring to forecast periods of elevated avalanche hazard and closure of hazard areas until hazard us reduced by means of avalanche explosive control or natural settlement. Avalanche explosive control methods may include helicopter explosive control as well as use of an avalauncher.
- Sections of the access road affected by Paths, AR4, AR8 and KG1 are exposed to high frequency events that may have high consequences to traffic. Depending on traffic volume along the access road and the tolerance for extended closures of these sections, consideration should be given to the installation of fixed Remote Control Avalanche Systems (RACS) in the starting zones of these paths. These RACS would facilitate the ability to conduct avalanche control remotely during reduced visibility when helicopters cannot fly (night, and during storms).
- The area affected by icefall hazard at Path AR8 should be monitored throughout the winter, and regularly controlled using explosives to limit the chance of large icefall events impacting a vehicle.
- The segment of the Access Road which transits the Knipple Glacier should be reassessed on a regular basis due to the effects of glacial recession on avalanche runout distance on the glacier.

- Transmission line structures (towers) should be located away from avalanche paths in order to reduce the requirement for avalanche mitigation. If this is not possible, additional analysis should be completed to determine the most optimal mitigation option. Mitigation may include designing towers for avalanche impact, diversion structures, or earthworks upslope of the tower.
- The final design of the transmission line should involve collaboration with an Avalanche Specialist in order to optimize structure (tower) and conductor locations.
- Construction of the transmission line during avalanche season should include an avalanche management program to reduce risk to personnel and infrastructure.
- Any changes to layout of facilities and roads should be reassessed for avalanche hazard

8.0 Closure

This report was prepared by Alpine Solutions Avalanche Services (Alpine Solutions) for the account of Pretivm Resources Inc. The material in it reflects Alpine Solutions' best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this report.

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Yours sincerely,
Alpine Solutions Avalanche Services
Per:

Brian Gould, P. Eng., CAA-QAP
Senior Avalanche Specialist

References

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APPENDIX A – AVALANCHE HAZARD TABLES

APPENDIX B - DRAWINGS

PRETIUM RESOURCES INC.

BRUCEJACK PROJECT

AVALANCHE HAZARD ASSESSMENT

PROJECT NO:	1204-001	DISTRIBUTION:	
DATE:	June 5, 2013	RECIPIENT:	2 copies
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ALPINE SOLUTIONS
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June 5, 2013
Project No: 1204-001

Mr. Ian Chang, M.Sc., P. Eng., VP Project Development
Pretium Resources Inc.
570 Granville Street
Suite 1600
Vancouver, BC, V6C 3P1

Dear Mr. Chang,

Re: <u>Brucejack Avalanche Hazard Assessment</u>

Please find attached our report on avalanche hazard for the Brucejack Project. Thank you for the opportunity to complete this work.

Yours sincerely,

Alpine Solutions Avalanche Services
per:

Brian Gould, P.Eng.

EXECUTIVE SUMMARY

Pretium Resources Inc. (Pretium) is planning to develop a mine in the Coast Range of northwestern British Columbia, approximately 60 km north of Stewart, BC (Figure 1-1). The project includes several mine site facilities, a transmission line, and an access road. Studies that have been completed previously indicate that the project is in the vicinity of snow avalanche terrain. Pretium requested that Alpine Solutions Avalanche Services (Alpine Solutions) undertake an avalanche hazard assessment to determine the locations, likelihood and potential consequences of avalanches affecting the project.

The avalanche hazard assessment identified approximately 15 avalanche paths (or avalanche hazard areas where there are multiple overlapping paths) that affect planned facility locations and access roads, and several of these locations are affected annually. The preferred transmission line route traverses though numerous avalanche hazard areas although avalanche hazard to the line cannot be determined accurately until the alignment and structure (tower) locations are finalized. Potential consequences of avalanches reaching Brucejack mine facilities, transmission line, worksites, and roads include damage to infrastructure, worker injury (or fatality), and project delays. Potential consequences of static snow loads on transmission towers include damage to towers and foundations, and potential loss of electrical service to the mine. Options for avalanche mitigation are provided, and the memorandum concludes with the following recommendations:

- Operation of the mine during regular avalanche season (October through June) should involve an active avalanche management program to reduce risk to project personnel and equipment. The program should include the use of personal protective equipment (PPE) as well as avalanche safety training for all workers exposed to avalanche hazards. In addition, daily hazard and risk assessments by a qualified Avalanche Technician (or team of technicians) to forecast periods of elevated avalanche hazard so that closure of hazard areas can be implemented until hazard is reduced by means of avalanche explosive control or natural settlement. Avalanche explosive control methods may include hand charging, helicopter explosive control, and pneumatic explosive launchers (avalaunchers).
- Sections of the access road affected by Paths AR4, AR8 and KG1 are exposed to high frequency events that may have high consequences to traffic. Depending on traffic volume along the access road and the tolerance for extended closures of these sections, consideration should be given to the installation of fixed Remote Control Avalanche Systems (RACS) in the starting zones of these paths. The RACS would facilitate the ability to conduct avalanche control remotely during reduced visibility when helicopters cannot fly (darkness, and during storms).
- The area affected by icefall hazard at Path AR8 should receive constant monitoring throughout the winter, and regularly controlled using explosives to limit the chance of large icefall events impacting a vehicle.

- The segment of the Access Road which transits the Knipple Glacier should be reassessed on a regular basis due to the effects of glacial recession on avalanche runout distance on the glacier.
- During winter, snow berms should be constructed in areas at the mine site affected by short slopes or avalanches to Size 2, in order to reduce the frequency of small avalanches reaching facilities.
- If possible, transmission line structures (towers) should be located away from avalanche paths in order to reduce the requirement for avalanche mitigation. If this is not possible, additional analysis should be completed to determine the most optimal mitigation option. Mitigation may include designing towers for avalanche impact, diversion structures, or earthworks upslope of the tower.
- The final design of the transmission line should involve collaboration with an Avalanche Specialist/Engineer in order to optimize structure (tower) and conductor locations.
- Construction of the transmission line during avalanche season should include an avalanche management program to reduce risk to personnel and infrastructure.
- Any changes to layout of facilities and roads, in subsequent stages of mine development, should be reassessed for avalanche hazard.

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1.0 INTRODUCTION

1.1. General

Pretium Resources Inc. (Pretium) is planning to develop a mine in the Coast Range of northwestern British Columbia, approximately 60 km north of Stewart, BC (Figure 1-1). The project includes several mine site facilities, a transmission line, and an access road. Studies that have been completed previously indicate that the project is in the vicinity of snow avalanche terrain. Pretium requested that Alpine Solutions Avalanche Services (Alpine Solutions) undertake an avalanche hazard assessment to determine the locations, likelihood and potential consequences of avalanches affecting the project. Options for avalanche mitigation are provided, and the memorandum concludes with recommendations. The results of this assessment will be used for mine permitting, and operational planning.

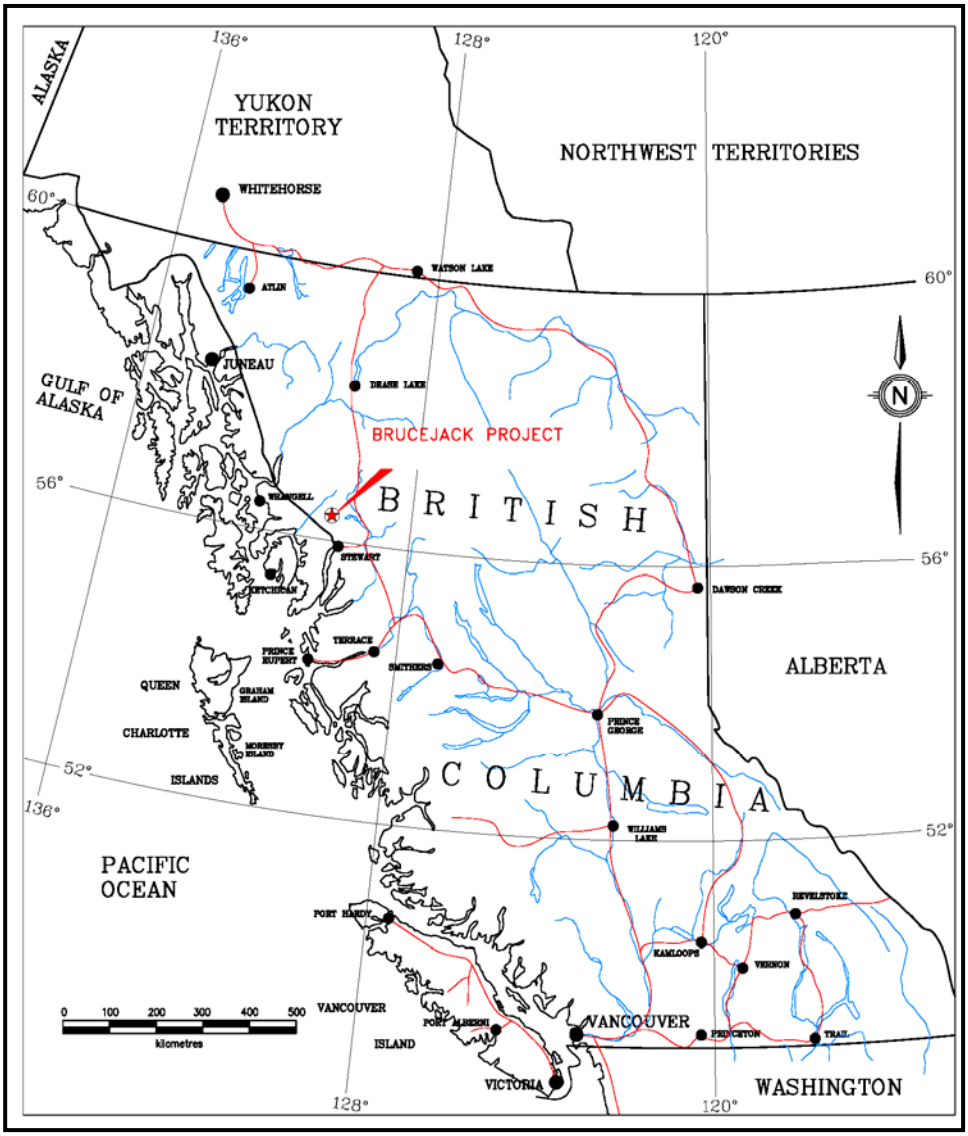

Figure 1-1. Brucejack Project Location

1.2. Scope of Work

The following maps and documents were provided by Pretium:

- Figure 18.11 Brucejack Overall Site Plan GA – Mine and Process Plant.
- Tetratech - Pretium Feasibility Study Drawings 100000-20-000, 001, 002, 101, 102, 103, 104, 105, 201, 301, 302, 303, 304, 305, 306, 501.
- Digital shape-files representing facility layout.
- 3 maps by Cypress Forest Consultants illustrating Access Road General Arrangement (including Glacier Road).
- Figure 8.2-2 Brucejack Project: Alternative Power Line Routes.
- Brucejack Road Risk Rating and Inspection Procedure.

In addition, numerous aerial photographs (1:20,000 scale), were provided by BGC Engineering Inc. Sketches of the preferred transmission line route were provided by Valard Construction Ltd.

The avalanche hazard assessment was completed for the mine site area and the access road from Highway 37. The preferred transmission line route was also reviewed for general avalanche hazard areas. The work included terrain analysis from topographic maps and aerial imagery. A helicopter overview flight was undertaken in March 2012 to confirm the avalanche path locations and terrain characteristics. Ground survey was completed April 28-29, 2013.

This report provides the following information:

- Identification and description of avalanche hazard to facilities and mine operations.
- An estimate of potential consequences of avalanches to facilities and mine operations.
- Fifteen drawings illustrating locations of avalanche paths that affect proposed facilities and access roads.
- Options for mitigation.
- Recommendations.

2.0 LIMITATIONS

This document provides an overview of snow[1] avalanche hazards which affect the proposed Brucejack mine project. Estimated magnitudes, frequencies, and areal extent of individual avalanche paths are based on a climate analysis, map and imagery interpretation, helicopter overview flights, and ground analysis for specific fixed infrastructure that is potentially affected by avalanches. Analysis of individual avalanche paths was limited to terrain and vegetation analysis; no numerical modeling has been completed.

Sources of uncertainty associated with avalanche runout boundaries illustrated on avalanche hazard mapping include:

- limited avalanche occurrence history (data) for the area; and
- lack of vegetation indicators (trim lines) where avalanches runout into non-forested terrain.

Although other geohazards exist in the region, the scope of this assessment is limited exclusively to avalanches. In addition, any significant artificial or natural alteration of the landscape or terrain due to forest fire, landslides, or other geotechnical event may change the nature (magnitude/frequency/intensity/runout) of avalanche hazard, necessitating a re-assessment for the area affected.

[1] The qualifier “snow” will not be included from here on. It was added here to make it clear that there is no mention of “rock avalanches” or “debris avalanches” in this report.

3.0 PHYSIOGRAPHY

3.1. Location

The Pretium mine site is located at the head of the Knipple Glacier, approximately 60 km north of Stewart, BC, and 38 km southwest of Bell II. The access road begins at the intersection of Highway 37 and Wildfire Creek, approximately 30 km south of Bell II, and extends to the mine site via the Wildfire Creek, Scott Creek, Bowser River, and Knipple Glacier valleys. The preferred transmission line route extends from the Long Lake Hydroelectric Project north of Stewart to the mine via the Salmon Glacier valley and the ridge on the south side of the Knipple Glacier. A second optional route for the transmission line follows the access road corridor from a potential connection point to the Northern Transmission Line at Highway 37.

3.2. Snow Climate

Snow climate refers to the general character of climate factors that contribute to snowpack and avalanche formation. Historical meteorological records often provide information on the frequency, timing, and sometimes magnitude of future avalanches. In addition, estimates of average and maximum snowpack depth can provide information on how often thresholds for avalanche triggering are exceeded.

Although historical climate and avalanche records for the Brucejack area is limited, regional BC Government snow pillow and snow survey records in the region provide baseline snowpack information. In addition, avalanche technicians working on site during winter 2012/2013 have collected avalanche occurrence records for several avalanche paths in the area.

The proposed Brucejack mine area is located in a transition zone between maritime and continental climate zones. As a result, there are significant temperature and moisture fluctuations that occur in an average winter. These fluctuations often contribute to a layered snowpack, which leads to lingering avalanche conditions most winters. In addition, the effects of wind and terrain orientation lead to increased snowpack variability which can contribute to challenging avalanche forecasting conditions.

Avalanche season typically begins in October at the higher elevations (above 1400 m), and often extends until late June or early July. At valley bottom elevations, avalanches can be expected from November to late May though can occur earlier or end later in extreme years.

Typical storm patterns can produce high intensity snowfall with strong winds depositing significant amounts of snow on lee (the side of slopes away from the principal wind direction) aspects. Temperature increases associated with some storms can produce rain-on-snow conditions up to treeline elevations (1200-1400 m), and sometimes above. An average winter will include 10-20 large storm events, most of which can produce widespread avalanche conditions.

4.0 AVALANCHE HAZARD ASSESSMENT

4.1. Background on Snow Avalanches

Snow avalanches generally occur in areas where there are steep open slopes or gullies, and deep (more than 50 cm) mountain snow packs. Risks associated with avalanches are normally due to exposure to the high impact forces that occur, as well as the effects of extended burial for any person caught in an avalanche. Impact forces vary significantly depending on avalanche size. Although the smallest avalanches can be insignificant to a human, larger avalanches may produce impact forces capable of destroying trucks, buildings, or several hectares of mature forest.

Characteristics of Snow Avalanches:

Avalanches may initiate in either dry or wet snow. Although an avalanche may start in dry snow, it could become moist or wet during its descent. Wet snow avalanches can be deflected and often channeled by terrain features, including gullies. Conversely, large, fast-flowing dry avalanches tend to flow in a straighter path, and may overrun terrain features.

Most large, dry avalanches consist of a dense component that flows primarily along the ground, and a less dense powder component that travels above and sometimes ahead of the flowing component. In some cases these components can separate and move independently. The dense-flowing component and powder component may reach speeds up to 60 m/s (200 km/h). Impact pressures from dense flows are much greater than the powder component due to the density of the snow.

Avalanche terrain is usually associated with steep, open slopes in the mountains that allow an accumulation of snow before it releases in a destructive event. In addition to the steep slopes that the snow accumulates on, any area exposed to this release of snow is also considered avalanche terrain. Terrain is often subdivided into features that are connected, which generally contain or channel the volume of avalanche events into a common deposition area. These features are called avalanche paths.

Avalanche season is the time of year when avalanches may occur, and is dependent on when the ground roughness in starting zones is covered by snow, and the threshold for avalanches is exceeded. For the Brucejack area, avalanche season below 1,000 m generally occurs between November and May. For elevations above 1,200 m, avalanche season can extend into October and June, or even summer months if cool, wet conditions persist.

Avalanche Path:

An avalanche path generally consists of a starting zone, a track, and a runout zone. Avalanches start and accelerate in the starting zone, which typically has a slope incline greater than 30°. Downslope of the starting zone, most large avalanche paths have a distinct track in which the slope angle is typically in the range of 15 to 30°. Large avalanches

decelerate and stop in the runout zone where incline is usually less than 15°. Smaller avalanches may decelerate and even stop on steeper slopes (15 to 24°).

Within forested terrain, larger avalanche paths are often discernible as vertically oriented swaths of open forest terrain, bordered by trim lines (mature forest on either side of the swath). Smaller avalanches, however, can occur in more subtle paths, and can occur on large cut banks in a road cut.

Runout zones generally have vague trim lines, and analysis is required by an experienced avalanche specialist to determine estimates of maximum avalanche extent (often extends into mature forest). In terrain around cliffs, some avalanche paths can be much more subtle to observe, and can be confused with rock fall and/or geotechnical events.

Avalanche Frequency:

Avalanche frequency is the reciprocal of avalanche return period and is typically referred to as an order of magnitude ranging from 1:1 (annual) up to 1:300 (1 in 300) years. Each winter, the probability of an avalanche with a specified return period is constant.

Avalanche frequency is dependent upon snow supply and terrain. Frequency decreases with distance downslope in the track and runout zone. Snow supply is determined by:

- the frequency of snowfalls and amount of snow; and
- the wind transport of snow into the starting zone.

Snow and weather conditions vary from year to year; therefore, the frequency of avalanches is not uniform.

The primary terrain factors in avalanche formation are incline, slope orientation (aspect) with respect to wind and sun, slope configuration and size, and ground surface roughness. Slope configuration is important because features such as gullies will often have more frequent and larger avalanches than open slopes. Ground roughness determines the threshold snow depth for avalanches to occur, which is particularly important in light snow climates where snow may not exceed threshold depths during some winters.

Avalanche Magnitude:

Avalanche magnitude relates to the destructive potential of an avalanche and is defined according to the Canadian avalanche size classification system. This classification system is summarized in Table 4.1, which provides a general description of destructive potential, magnitude, and typical path length.

Table 4-1. Canadian classification system for avalanche size (McClung & Schaerer, 2006)

Size	Destructive Potential	Typical Mass (t)	Typical Path Length (m)	Typical Impact Pressures (KPa)
1	Relatively harmless to people.	<10	10	1
2	Could bury, injure or kill a person.	10^2	100	10
3	Could bury a car, destroy a small building, or break a few trees.	10^3	1000	100
4	Could destroy a large truck, several buildings, or a forest with an area up to 4 hectares.	10^4	2000	500
5	Largest snow avalanches known. Could destroy a village or a 40 ha forest.	10^5	3000	1000

Magnitude is often related to frequency. In general, large destructive avalanches occur less frequently, while smaller ones occur on a more regular basis. Magnitude and frequency are also co-related to a specific location in an avalanche path. For example, a road location near the toe of an avalanche path will be affected by avalanches on a less frequent basis, but they will be larger avalanches. Both low-frequency large avalanches and higher-frequency small avalanches may affect a road crossing that is higher up in the avalanche path.

4.2. Brucejack Avalanche Hazard

Avalanche paths (and hazard areas where multiple overlapping paths exist) that affect the Project were identified by reviewing topographic relief and vegetation features on maps and aerial photos, as well as available Google Earth ortho-imagery and digital elevation models (DEM). In addition, field reconnaissance (helicopter overview flights and ground based survey) was completed on March 19, 2012, and from April 28 to 29, 2013.

Approximately 15 avalanche paths or hazard areas reach (or potentially reach) project infrastructure or access roads, and many locations are estimated to be affected on an annual basis. Drawings of the avalanche paths and hazard areas are illustrated in Appendix A. Avalanche paths and hazard areas are labeled according to Table 4-1, referring to the element at risk, with the exception of paths along the Knipple Glacier which may affect both the transmission line and access road.

Table 4-1. Avalanche Path Label and corresponding Element at Risk.

Avalanche Path Label	Element at Risk
TL1, TL2, …, TLx	Preferred transmission line route
AR1, AR2, …, ARx	Access road and Knipple Transfer Station
MS1, MS2, …, MSx	Facilities at or near the mine site, access road, and transmission line
KG1, KG2, …, KGx	Access road and transmission line corridor on glacier

Details of avalanche hazards, and potential consequences are outlined in the following sections for the mine site, access road, Knipple Transfer Station, and transmission line.

4.2.1. Mine Site

The mine site is located on a broad alpine plateau in undulating terrain on the southwest side of Brucejack Lake. The area is bounded by the Knipple Glacier to the east and south, the Sulphurets Glacier to the west, and rising alpine slopes to the north. Elevations at the mine site area range from 1350 m to over 2000 m. The proposed facilities assessed include:

- two explosives and storage facilities – preliminary position;
- detonator storage – preliminary position;
- topsoil stockpile;
- substation;
- water treatment plant;
- portal fuel storage;
- conveyor portal and truck portal;
- overhead electrical;
- mill building including administration, mine dry, truck shop and warehouse;

- tailings pipeline;
- helipad;
- upper and lower laydown area;
- batch plant, fuel storage, and aviation fuel tank;
- pre-production ore storage;
- diversion channel;
- waste rock transfer storage;
- garbage and incinerator area;
- operations camp;
- sewage system, water pumps, and storage tank;
- proposed new transmission tower location;
- scale house;
- four air raise locations; and
- site access roads (not including mine access road).

These facilities are all located away from avalanche paths and areas with the exception of the operations camp, some sections of the site access roads, and the pre-production ore storage and diversion channel area. Short slopes that currently exist (ranging from 10 to 40 m in height), or will be created during construction, may be expected to affect other facility areas; however the hazard and consequences would normally be assessed on a site specific basis during construction and operations.

Table 4-2 provides a summary of avalanches reaching the mine site area and Drawing 1 in Appendix A illustrates the approximate hazard locations.

Table 4-2. Mine site avalanche hazards.

Path or Area ID	Avalanche Atlas Polygon Label	Facility Affected	Approximate Elevation of Facility (m)	Facility Position in Path	Length of Facility Affected (m)	Return Frequency		
						Size 2	Size 3	Size 4
Mine Site 2	MS2	Pre-production ore storage and diversion channel	1,390 to 1,370	RZ	300	-	1:10	-
Mine Site 5	MS5	Site access roads	1,460 to 1,420	RZ	800	1:1	1:3	-
Mine Site 8	MS8	Operations camp and site access roads	1,450	RZ	300	1:1	-	-

Notes: RZ = Runout Zone

The nature of the hazards to facilities at the mine site, and the nature of hazards associated with avalanches reaching Brucejack Lake are described in the following sections.

4.2.1.1. Operations Camp

Size 2 avalanches from Path MS8 are estimated to reach the southwest end of the operations camp with an annual return frequency. Potential consequences include damage to vulnerable infrastructure (e.g. windows or non-structural component of building if built within the runout area) and worker injury or fatality if workers are in the runout area when the avalanche occurs.

4.2.1.2. Site Access Roads

Size 2 and 3 avalanches from Path MS5 and Size 2 avalanches from Path MS8 are estimated to reach site access roads annually. Potential consequences include damage to infrastructure and vehicles, and worker injury or fatality if workers are in the runout area when the avalanche occurs.

4.2.1.3. Pre-production Ore Storage and Diversion Channel Area

The pre-production ore storage, and diversion channel area are exposed to Size 3 avalanches from Path MS2 approximately once every ten years. Potential consequences are limited to damage to any vulnerable materials stored in this area during avalanche season, as well as worker injury or fatality if workers are in the runout area when the avalanche occurs. The diversion channel is expected to be buried during avalanche season.

4.2.1.4. Avalanches Reaching Brucejack Lake

Avalanches up to Size 3 may reach Brucejack Lake from Path MS1 as well as short steep slopes on the north side of Brucejack Lake. If avalanches reach the lake when the surface is not frozen, waves may develop. As a result of the small size or slow speed of the avalanches when they reach the lake, these waves are not expected to be destructive.

4.2.2. Access Road

The mine access road begins at Highway 37 near the confluence of Wildfire Creek and the Bell Irving River, approximately 30 km south of Bell II. The road extends northwest following the Wildfire Creek drainage for approximately 12 km before heading west to Scott Pass (677 m elevation) and then down Scott Creek drainage to the Bowser River valley (400 m elevation), 35 km from Highway 37. The access continues west along the Bowser River valley for approximately 15 km to the Knipple Transfer Station.

From the Knipple Transfer Station, the road ascends to the northwest to reach the south side of the toe of the Knipple Glacier, and along a short ramp to the Knipple Glacier. From here a glacier road extends up the center of the Knipple Glacier for approximately 15 km to the mine

site at approximately 1400 m. The glacier road is proposed to be located near the centre of the Knipple Glacier, although the location may vary depending on crevasse restrictions.

Fourteen avalanche paths or areas are estimated to affect the access road, and two paths approach within 50 m (Table 4-3 and Drawing 2 to 6). One area (Path AR8) is affected by large ice blocks falling off bluffs above the road. Several avalanche paths on the southwest and northeast side of the Knipple Glacier could affect the road if it was realigned during the project (to avoid crevasses). Potential consequences include damage to vehicles, occupant injury or fatality, and road delays for avalanche debris cleanup. Avalanche path characteristics for the Knipple Glacier segment are expected to change with glacial recession, so this segment will need to be reassessed regularly.

Areas within Paths AR4, AR8, and KG1 have increased hazard and consequences due to the high frequency of avalanches and ice falls reaching the affected areas, as well as magnitudes large enough to severely damage vehicles, injure occupants, and delay the flow of traffic during storms when helicopter avalanche control is not feasible.

Table 4-3. Access Road Avalanche Hazards (table continues over 2 pages).

Path or Area ID	Avalanche Atlas Polygon Label	Facility Affected	Approximate Elevation of Facility (m)	Facility Position in Path	Approximate Length of Facility Affected (m)	Return Frequency		
						Size 2	Size 3	Size 4
Access Road 1	AR1	Access Road	580	-	-	-	-	P
Access Road 2	AR2	Access Road	580	-	-	-	-	P
Access Road 4	AR4	Access Road	400	RZ	600	1:1	1:3	-
Access Road 5	AR5	Access Road	440	RZ	540	>1:1	1:1	-
Access Road 6	AR6	Access Road	420	RZ	140	>1:1	-	-
Access Road 6.5	AR6.5	Access Road	470	RZ	250	1:1	-	-
Access Road 7	AR7	Access Road	600 to 470	RZ	1,000	-	1:3	1:10
Access Road 7	AR7	Knipple Transfer Station (west end only)	470	RZ	100	-	-	1:100
Access Road 8	AR8	Access Road	730 to 660	RZ	700	1:1	1:3	-
Knipple Glacier 1	KG1	Access Road	730 to 650	RZ	700	1:1	1:3	-

Path or Area ID	Avalanche Atlas Polygon Label	Facility Affected	Approximate Elevation of Facility (m)	Facility Position in Path	Approximate Length of Facility Affected (m)	Return Frequency		
						Size 2	Size 3	Size 4
Mine Site 1	MS1	Access Road	1,440 to 1,370	RZ	2,000	>1:1	1:1	-
Mine Site 2	MS2	Access Road	1,370	RZ	300	1:1	1:10	-
Mine Site 5	MS5	Access Road	1,420 to 1,440	RZ	600	>1:1	1:3	-
Mine Site 9	MS9	Access Road	1,455	RZ	100	1:3	-	-
Mine Site 10	MS10	Access Road	1,455	RZ	150	1:3	-	-

Notes: RZ = Runout Zone; P = Potential to reach access road or facility

4.2.3. Knipple Transfer Station

The Knipple Transfer Station is located at the valley bottom near the confluence of the Salmon and Knipple valleys (Drawings 2 and 3). Large avalanches occurring in Path AR6 are estimated to reach the west end (approximately 20%) of the Knipple Transfer Station pad with an estimated return period of at least 100 years. Avalanches are not expected to reach the eastern side of the Knipple Lake Transfer Station pad where primary fixed facilities (camp) are located. Potential consequences of avalanches reaching the site include damage to infrastructure and injury or fatality for any personnel located in the runout area.

4.2.4. Transmission Line

4.2.4.1. Avalanche Hazard

The preferred transmission line route begins at Long Lake where a hydroelectric generation facility is currently being built, approximately 14 km north of Stewart BC. Although the exact alignment has not been finalized, the line is proposed to follow a route on the east side of the Salmon Glacier Valley to the proposed Knipple Transfer Station area. The line is then proposed to follow a route along a ridge on the southwest side of the Knipple Glacier to the mine site. The preferred route is illustrated in Drawings 7 to 15 (Appendix A). An optional transmission line route for the project follows the access road alignment from the BC Hydro Northern Transmission Line (NTL) at Highway 37.

Initial analysis indicates that there are approximately 20 to 25 avalanche paths that affect the preferred transmission line route, although they would only pose a hazard if supporting structures (towers) were built in avalanche paths, or conductors were low enough to the ground to be affected by the powder (airbourne) component of the flow. Potential consequences include damage to towers or conductors, and interruption of service to the mine. In addition, worker injury or fatality may occur if the line is built, or if maintenance is undertaken, in avalanche hazard areas during avalanche season. The final alignment of the transmission line (including specific structure locations) is expected to be detailed during the next phase of the Project, and will be assessed further for avalanches at that time.

The optional transmission line alignment parallels the access road from the NTL adjacent to Highway 37, and is potentially affected by the same avalanche paths that affect the access road. There may be additional paths that affect the line depending on the final alignment. Potential consequences to the Project would be the same as the consequences of avalanches reaching the preferred transmission line alignment.

4.2.4.2. Static Snow Forces

In addition to avalanche hazard, transmission line towers may be subject to forces of snow creep and glide, depending on their location. Although snow creep and glide are not fast moving events, they may generate forces that may exceed the bending strength of the tower

or the strength of the foundation. If towers built on slopes are not designed to withstand these forces, potential consequences may include damage to towers and associated impact to conductors resulting in interruption of services to the mine.

5.0 Options for Mitigation

Avalanche mitigation strategies typically incorporate location planning (for fixed facilities), structural or earthworks mitigation, avoidance during avalanche season, or the implementation of an active avalanche management plan (generally for access roads and worksites that can be evacuated). The type of mitigation often depends on the element at risk, and its requirement for un-interrupted access (or not).

The hazard to the structures (towers) along the transmission line may be reduced by location planning which may include locating towers away from the centre of avalanche paths, and spanning avalanche paths as much as possible. If this is not feasible, the construction of splitting wedges (Figure 5-1) or earthworks can reduce or eliminate the hazard to towers. Alternatively towers may be reinforced with concrete and/or steel to protect from avalanche impact forces and snow creep and glide forces (Figure 5-2).

Figure 5-1. – Example of Splitting Wedge to Protect Structure (McClung & Schaerer, 2006)

Figure 5-2. Example of Reinforced Tower.

Measures to reduce risk to roads and worksites may include permanent or semi-permanent mitigation including:

- earthworks (diversion and catchment berms) to contain or divert avalanches away from worksites, access roads, or facilities;
- snow berms (constructed annually) to contain or divert avalanches away from worksites, access roads, or facilities; and
- structural walls or snow sheds.

Due to high costs of building structural walls or snow sheds, the feasibility of these are typically evaluated in a business case comparison of options that would balance cost of construction and maintenance versus costs associated with temporary closure of areas or roads during periods of high hazard.

Avalanche mitigation for worksites and access roads typically involve an active avalanche management plan. An active avalanche management plan normally includes a daily hazard and risk assessment process by Avalanche Technicians for all affected worksites and access routes. When hazard is high, sites are evacuated until hazard is reduced by application of explosives, or natural settlement. Other measures in an avalanche management plan include:

- worker safety training sessions;
- the use of Personal Protective Equipment (e.g. avalanche transceivers) and rescue equipment; and
- an Avalanche Emergency Response Plan.

For avalanche hazard areas that require high reliability (i.e. reduced closure time), Remote Control Avalanche Systems (RACS) can be used. Further details regarding RACS are provided in Section 5.1.

5.1. Remote Avalanche Control Systems

Remote avalanche control systems (RACS) utilize fixed infrastructure installed in or near avalanche starting zones. The systems are designed to deploy explosive charges and trigger avalanches in any weather, and anytime day or night, via a remote communications link. Remote systems generally have high initial cost, but this may be offset by costs savings due to reduced operational delays.

Types of RACS that are currently available include gas exploders, sophisticated remote control mortar systems, and other remote devices which can remotely deliver explosives to starting zones. During times when avalanche control is required, a technician establishes a communications link between the infrastructure and a control computer, and a firing sequence is initiated. This can be accomplished from an office or field computer.

Remote control gas exploders are currently the most prominent type of remote systems in use today. In addition to hundreds of operations in Europe and Asia, several highways, parks, and ski areas in North America, and some mining operations in South America rely on them for effective control in active areas. Other systems that either launch explosives into starting zones, or hang charges above starting zones, may be preferred for some situations.

Examples of three different types of RACS are illustrated in Figure 5-3, 5-4, and 5-5. Figure 5-3 illustrates a single remote control gas exploder and associated control shelter (which would support an array of exploders), Figure 5-4 illustrates a mortar based system, and Figure 5-5 illustrates a tethered (air-blast) explosive system (Wyssen Tower).

Typically a business case study is undertaken prior to installing RACS system. Cost savings from reduced closure time and the efficiency and safety gained in using RACS typically must offset cost of installation and operation.

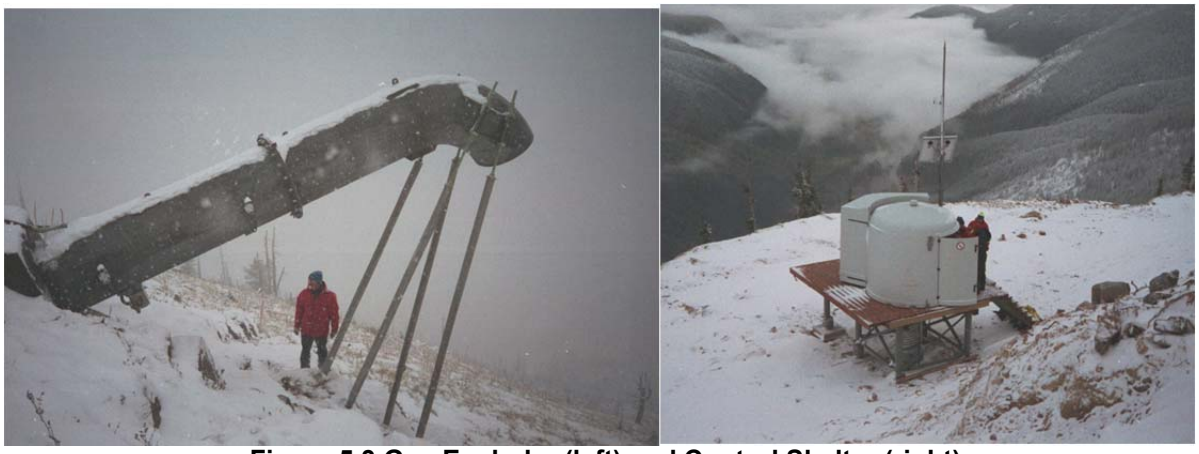

Figure 5.3 Gas-Exploder (left) and Control Shelter (right).

Figure 5-4. Mortar Based RACS.

Figure 5-5. Wyssen Tower (courtesy of Wyssen Avalanche Control AG).

6.0 Summary and Recommendations

6.1. Summary

An avalanche hazard assessment has been completed for the Brucejack mine project. Mine facilities and access routes are exposed to 15 avalanche paths (or avalanche hazard areas where there are multiple overlapping paths) that affect planned facility locations and access roads, and several of these locations are affected annually. The preferred transmission line route traverses though 20 to 25 avalanche hazard areas although avalanche hazard to the line cannot be determined accurately until the alignment and structure (tower) locations are finalized. Potential consequences of avalanches reaching Brucejack mine facilities, transmission line, worksites, and roads include damage to infrastructure, worker injury (or fatality), and project delays. Potential consequences of static snow loads on transmission towers include damage to towers and foundations, and potential loss of electrical service to the mine.

6.2. Recommendations

Alpine Solutions recommends the following:

- Operation of the mine during regular avalanche season (October through June) should involve an active avalanche management program to reduce risk to project personnel and equipment. The program should include the use of personal protective equipment (PPE) as well as avalanche safety training for all workers exposed to avalanche hazards. In addition, daily hazard and risk assessments by a qualified Avalanche Technician (or team of technicians) to forecast periods of elevated avalanche hazard so that closure of hazard areas can be implemented until hazard is reduced by means of avalanche explosive control or natural settlement. Avalanche explosive control methods may include hand charging, helicopter explosive control, and pneumatic explosive launchers (avalaunchers).
- Sections of the access road affected by Paths AR4, AR8 and KG1 are exposed to high frequency events that may have high consequences to traffic. Depending on traffic volume along the access road and the tolerance for extended closures of these sections, consideration should be given to the installation of fixed Remote Control Avalanche Systems (RACS) in the starting zones of these paths. The RACS would facilitate the ability to conduct avalanche control remotely during reduced visibility when helicopters cannot fly (darkness, and during storms).
- The area affected by icefall hazard at Path AR8 should receive constant monitoring throughout the winter, and regularly controlled using explosives to limit the chance of large icefall events impacting a vehicle.
- The segment of the Access Road which transits the Knipple Glacier should be reassessed on a regular basis due to the effects of glacial recession on avalanche runout distance on the glacier.

- During winter, snow berms should be constructed in areas at the mine site affected by short slopes or avalanches to Size 2, in order to reduce the frequency of small avalanches reaching facilities.
- If possible, transmission line structures (towers) should be located away from avalanche paths in order to reduce the requirement for avalanche mitigation. If this is not possible, additional analysis should be completed to determine the most optimal mitigation option. Mitigation may include designing towers for avalanche impact, diversion structures, or earthworks upslope of the tower.
- The final design of the transmission line should involve collaboration with an Avalanche Specialist/Engineer in order to optimize structure (tower) and conductor locations.
- Construction of the transmission line during avalanche season should include an avalanche management program to reduce risk to personnel and infrastructure.
- Any changes to layout of facilities and roads, in subsequent stages of mine development, should be reassessed for avalanche hazard.

7.0 CLOSURE

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We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

ALPINE SOLUTIONS AVALANCHE SERVICES
per:

Brian Gould, P.Eng.
Senior Avalanche Specialist

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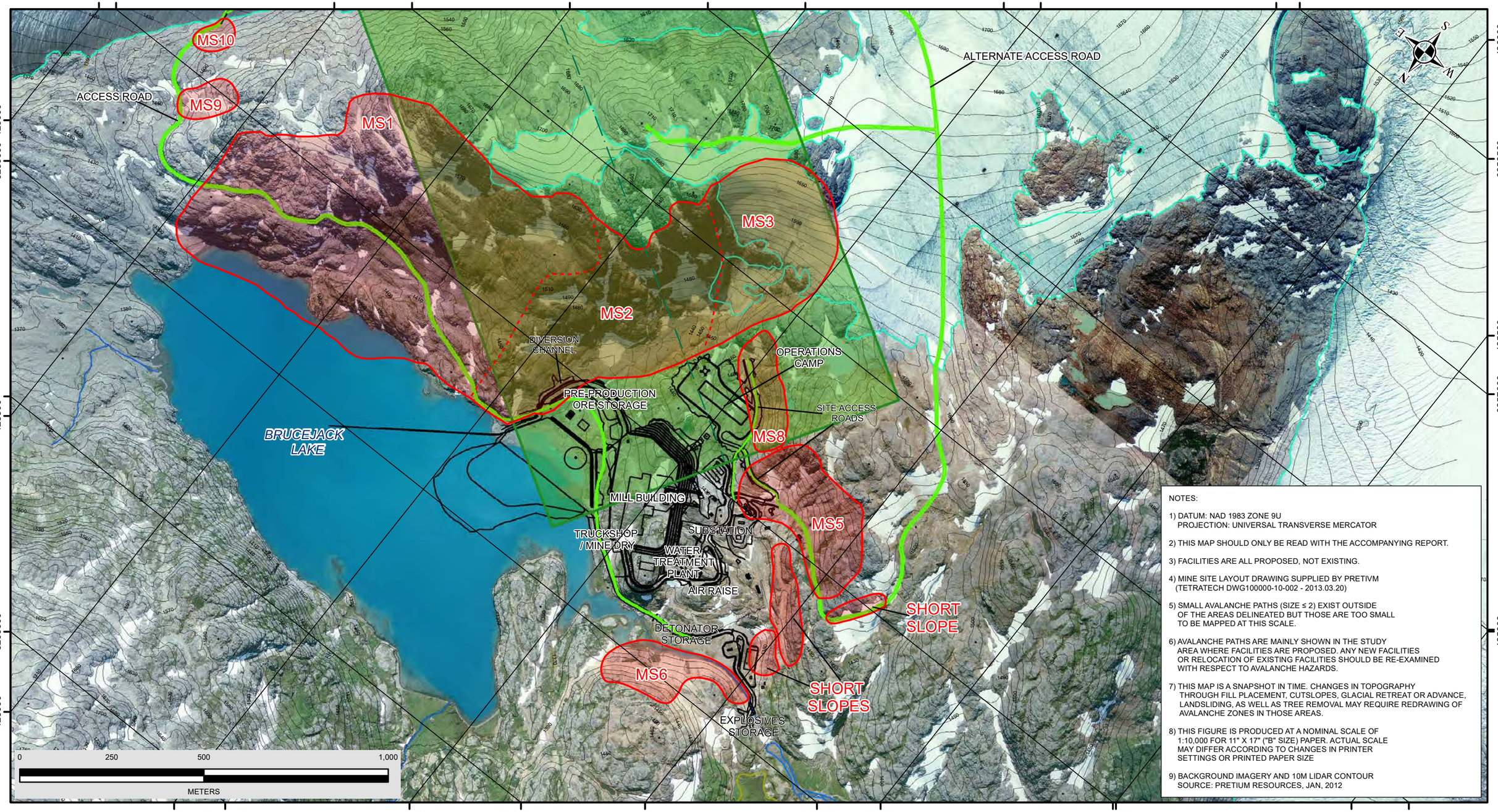
APPENDIX A – AVALANCHE HAZARD AREA DRAWINGS



NOTES:

1) DATUM: NAD 1983 ZONE 9U
PROJECTION: UNIVERSAL TRANSVERSE MERCATOR

2) THIS MAP SHOULD ONLY BE READ WITH THE ACCOMPANYING REPORT.

3) FACILITIES ARE ALL PROPOSED, NOT EXISTING.

4) MINE SITE LAYOUT DRAWING SUPPLIED BY PRETIVM (TETRATECH DWG100000-10-002 - 2013.03.20)

5) SMALL AVALANCHE PATHS (SIZE ≤ 2) EXIST OUTSIDE OF THE AREAS DELINEATED BUT THOSE ARE TOO SMALL TO BE MAPPED AT THIS SCALE.

6) AVALANCHE PATHS ARE MAINLY SHOWN IN THE STUDY AREA WHERE FACILITIES ARE PROPOSED. ANY NEW FACILITIES OR RELOCATION OF EXISTING FACILITIES SHOULD BE RE-EXAMINED WITH RESPECT TO AVALANCHE HAZARDS.

7) THIS MAP IS A SNAPSHOT IN TIME. CHANGES IN TOPOGRAPHY THROUGH FILL PLACEMENT, CUTSLOPES, GLACIAL RETREAT OR ADVANCE, LANDSLIDING, AS WELL AS TREE REMOVAL MAY REQUIRE REDRAWING OF AVALANCHE ZONES IN THOSE AREAS.

8) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:10,000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE

9) BACKGROUND IMAGERY AND 10M LIDAR CONTOUR SOURCE: PRETIUM RESOURCES, JAN, 2012

LEGEND

- AVALANCHE PATH OR AREA
- 10M CONTOUR
- STREAM
- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED).
- PROPOSED MINE ACCESS ROAD
- MINE FACILITIES

SCALE:	1:10,000
DATE:	JULY 10, 2013
DESIGNED:	BG
DRAWN:	JN
CHECKED:	BG
APPROVED:	BG

PROFESSIONAL SEAL:

CLIENT: **PRETIVM RESOURCES**

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

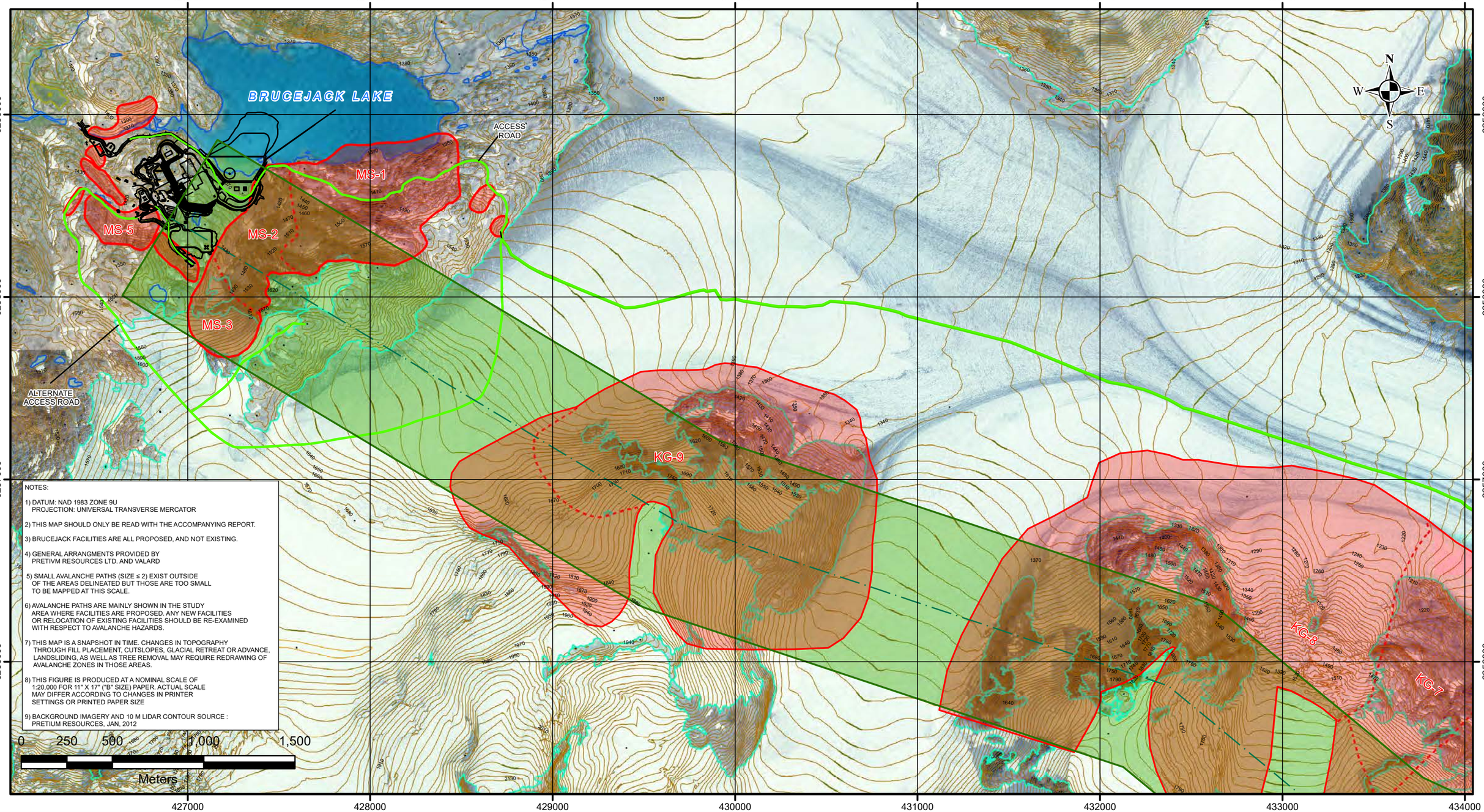
PROJECT: BRUCEJACK PROJECT

TITLE: MINESITE

PROJECT NO:

DWG NO: 1

REV:



NOTES:

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PROJECTION: UNIVERSAL TRANSVERSE MERCATOR

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9) BACKGROUND IMAGERY AND 10 M LIDAR CONTOUR SOURCE : PRETIUM RESOURCES, JAN, 2012

LEGEND

- AVALANCHE PATH OR AREA
- 10M CONTOUR
- STREAM / LAKE
- PROPOSED MINE ACCESS ROAD
- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED).

SCALE:	1:20,000
DATE:	JULY 10, 2013
DESIGNED:	BG
DRAWN:	JN
CHECKED:	BG
APPROVED:	BG

PROFESSIONAL SEAL:

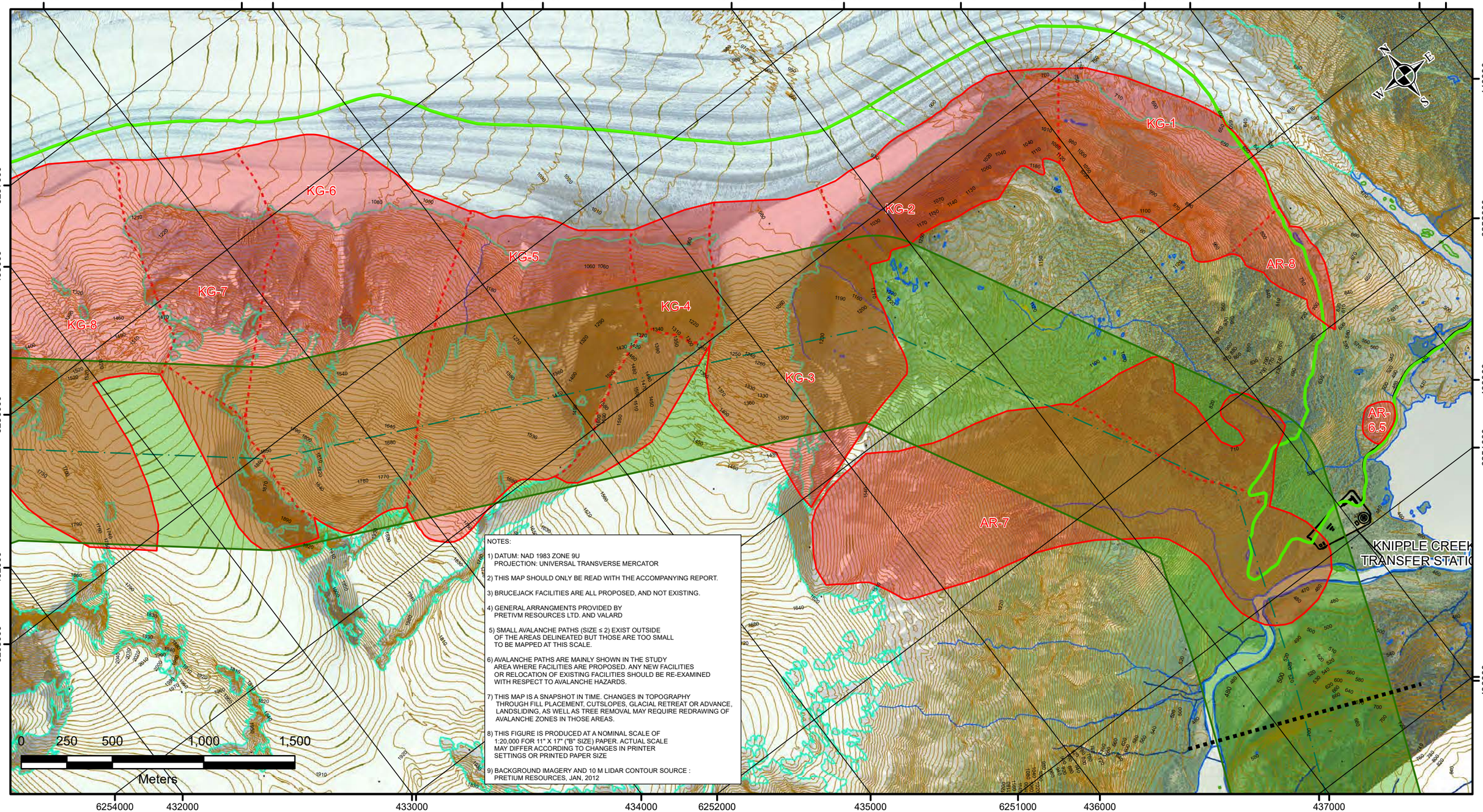
CLIENT: **PRETIVM RESOURCES**

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK PROJECT

TITLE: ACCESS ROAD AVALANCHE HAZARDS

PROJECT NO:	DWG NO:	REV:
	2	A



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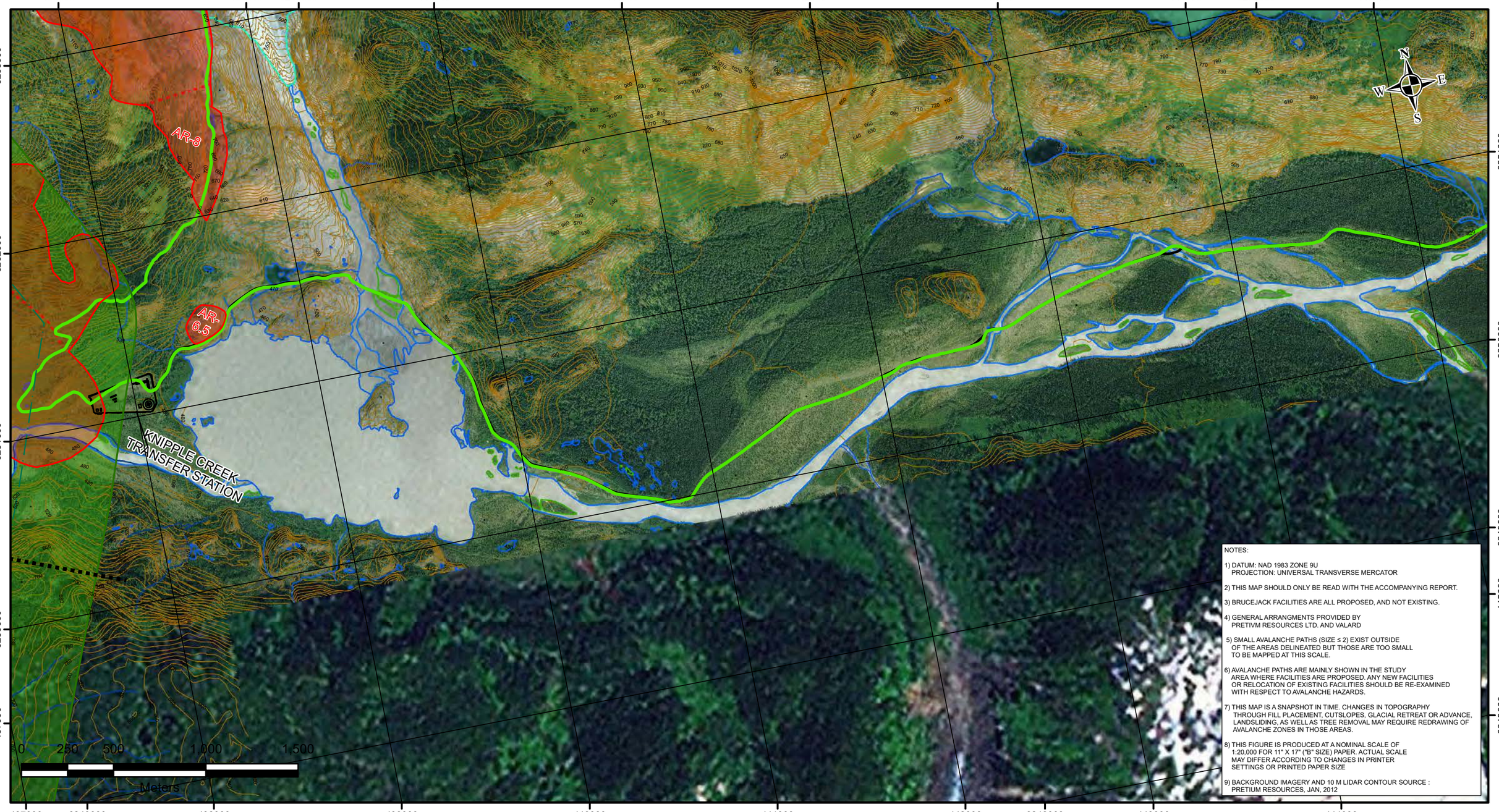
PROJECT: BRUCEJACK PROJECT

TITLE: ACCESS ROAD AVALANCHE HAZARDS

PROJECT NO:	DWG NO:	REV:
	3	A



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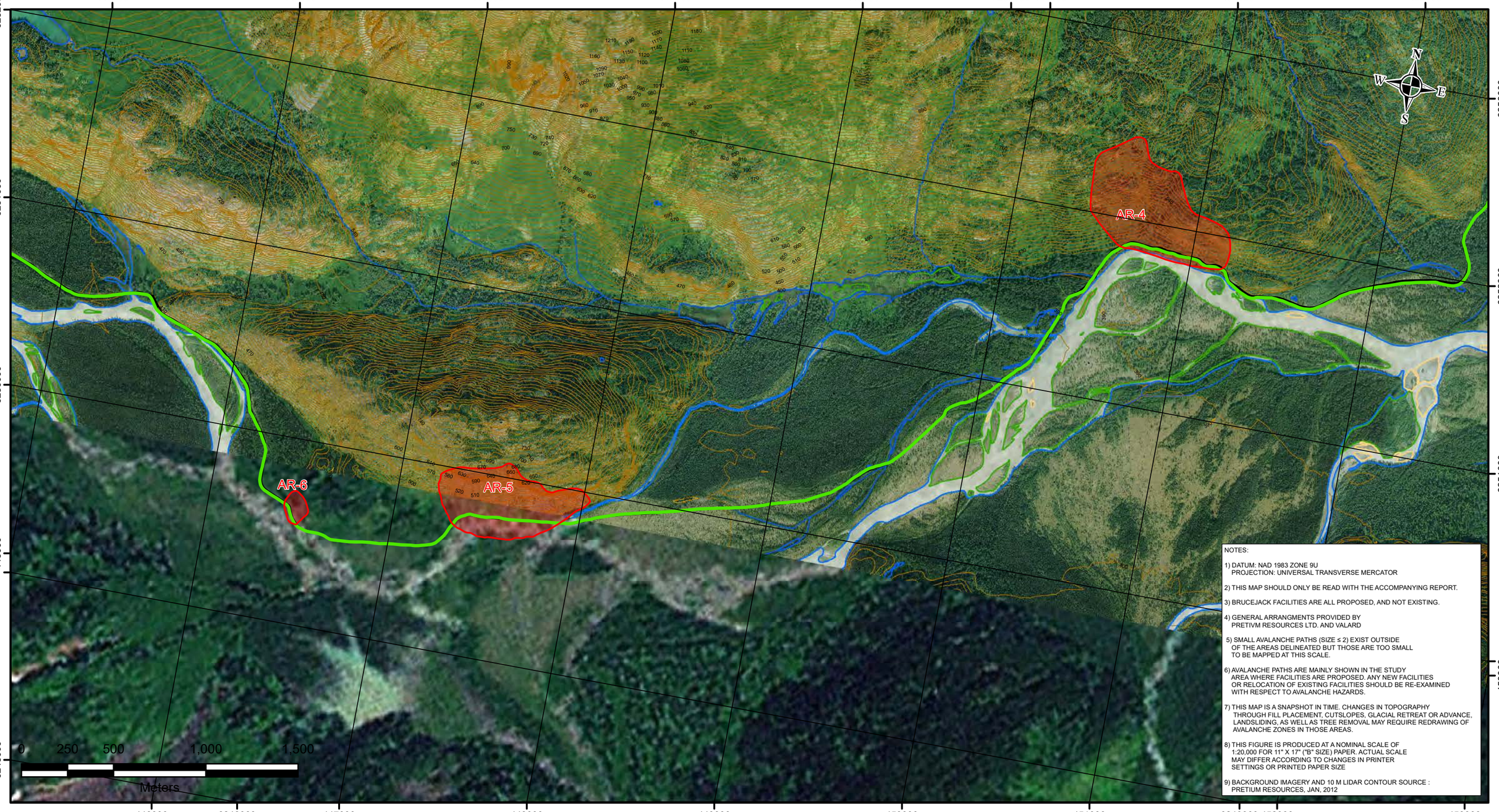
PROJECT: BRUCEJACK PROJECT

TITLE: ACCESS ROAD AVALANCHE HAZARDS

PROJECT NO:	DWG NO:	REV:
	4	A



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TITLE: ACCESS ROAD AVALANCHE HAZARDS

PROJECT NO:	DWG NO:	REV:
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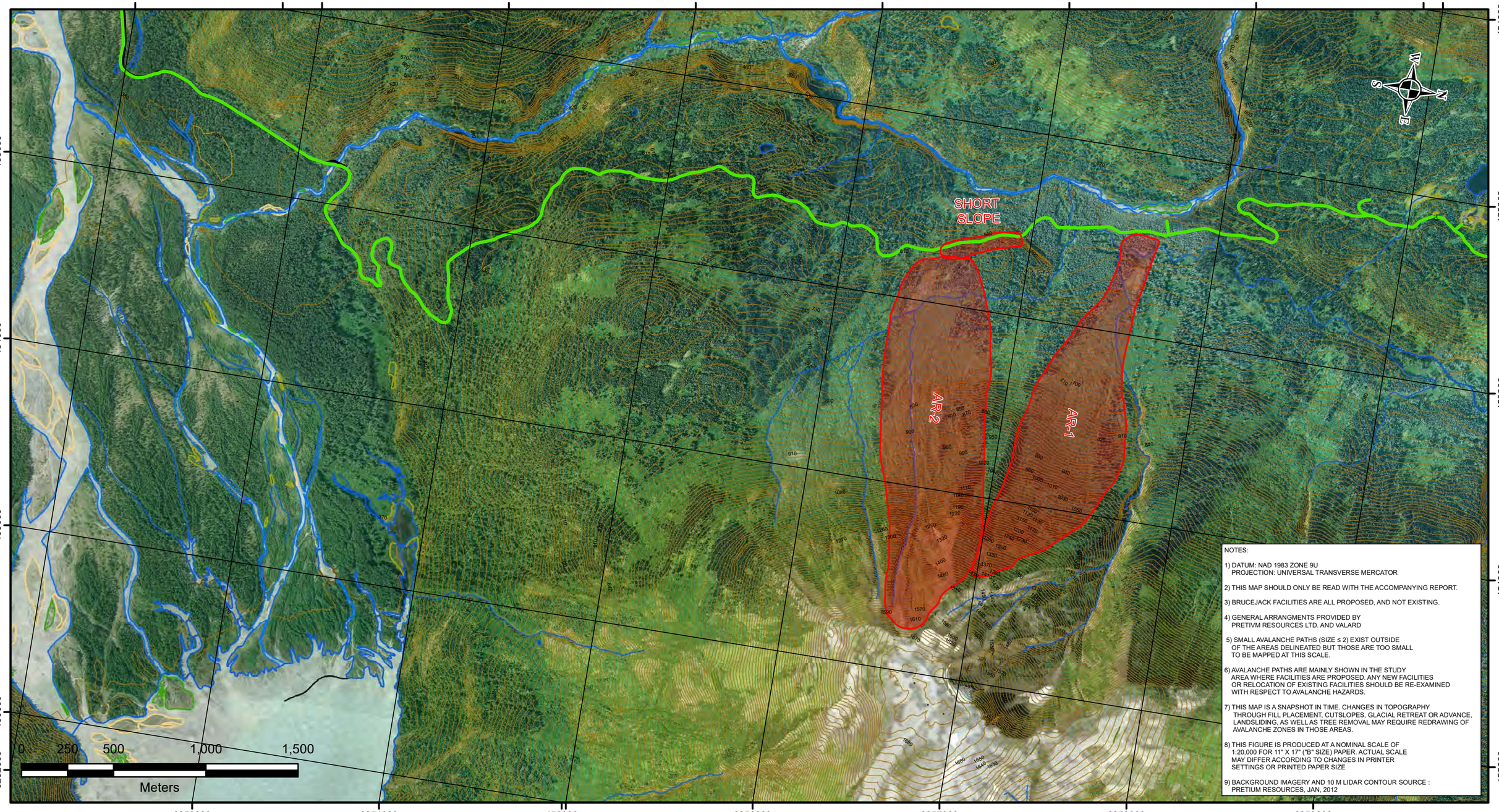

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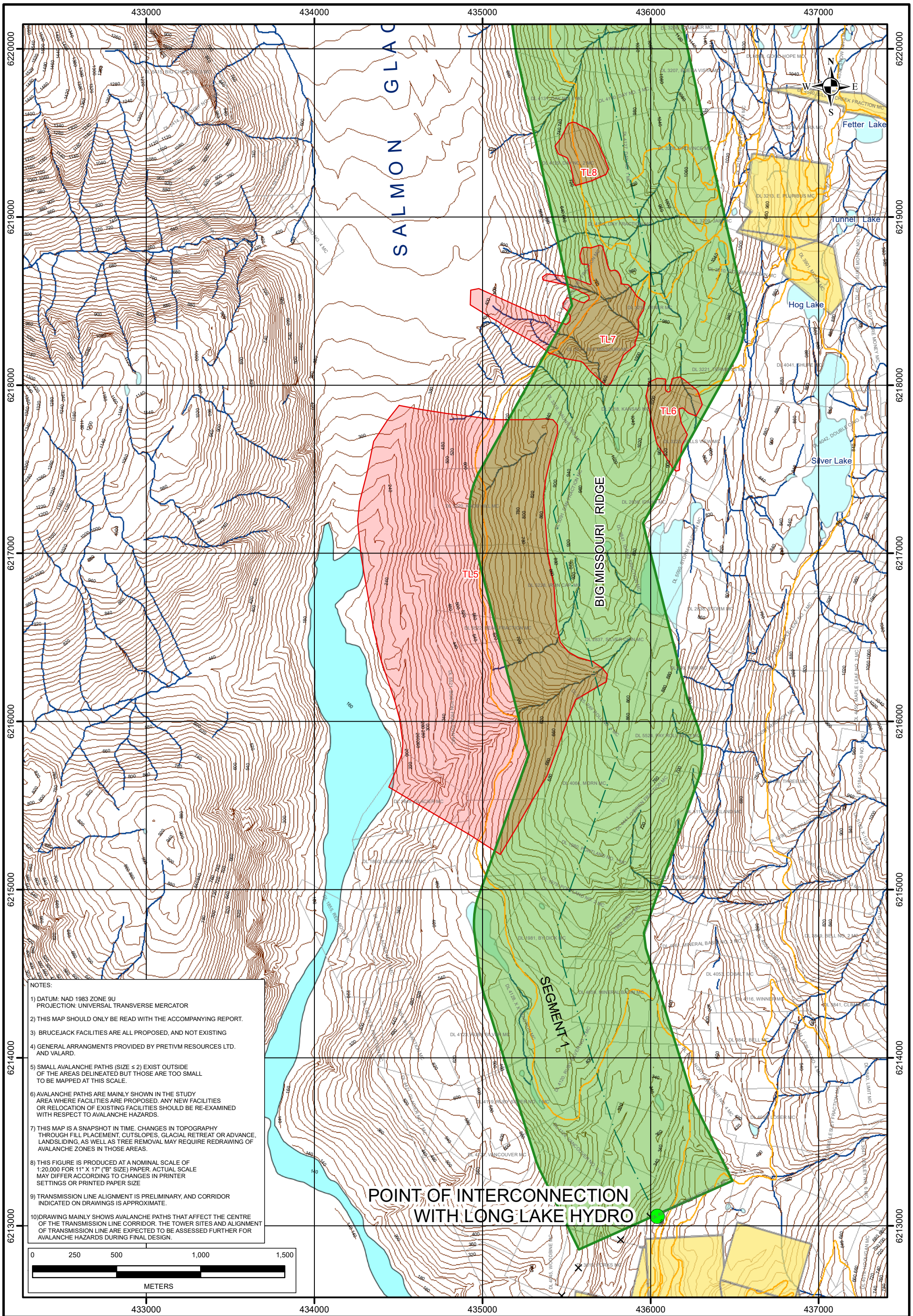
PROJECT: BRUCEJACK PROJECT

TITLE: ACCESS ROAD AVALANCHE HAZARDS

PROJECT NO:	DWG NO:	REV:
	6	A



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LEGEND

- AVALANCHE PATH OR AREA
- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED)
- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
- STREAM
- DISTRICT LOT
- PRIVATE SURVEY PARCEL (SELECT DISTRICT LOTS)

SCALE:	1:20,000
DATE:	JULY 10, 2013
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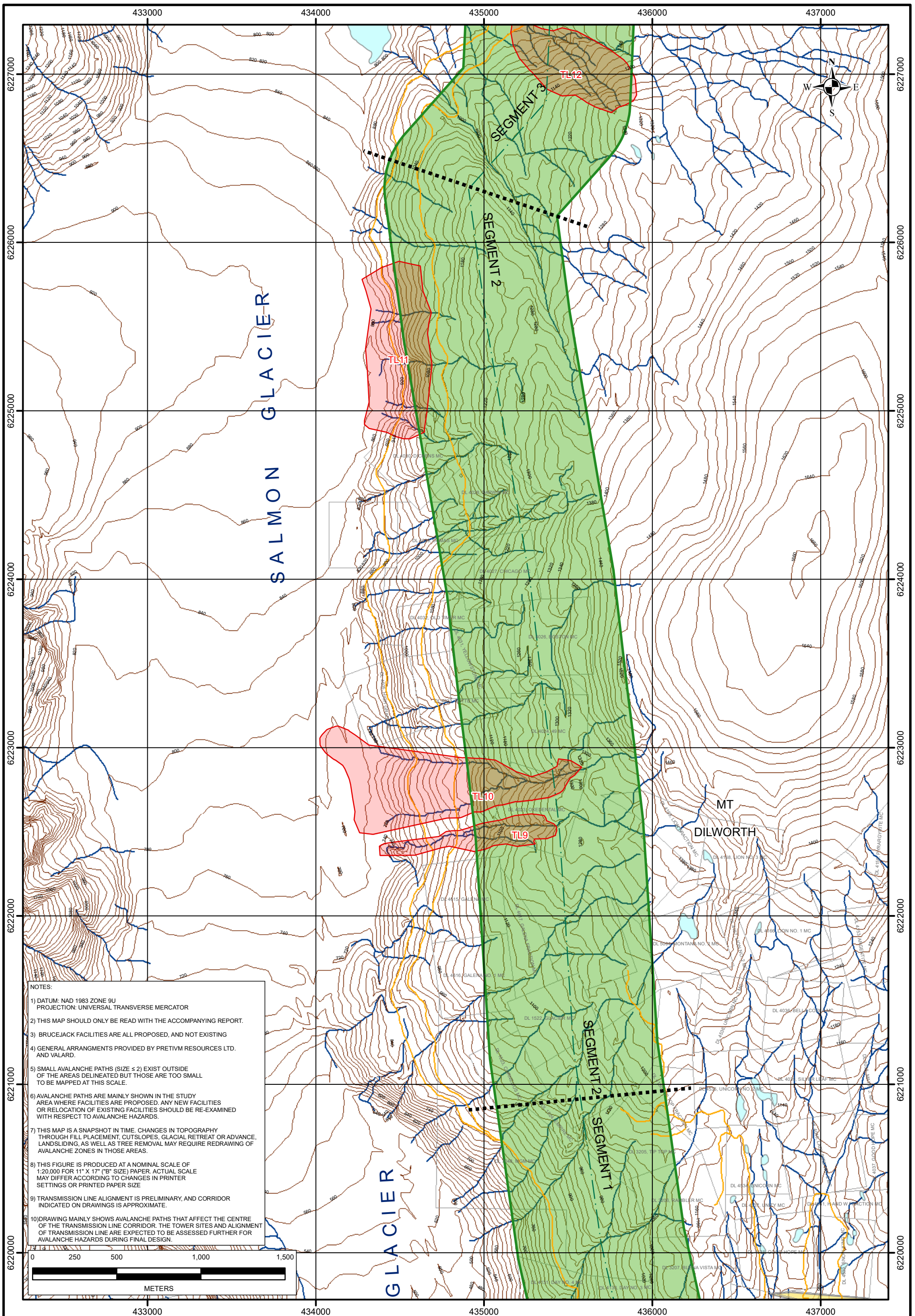
PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

PROJECT NO:	DWG NO:	REV:
	7	A



LEGEND

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- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED)
- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
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PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

PROJECT NO:	DWG NO:	REV:
	8	A

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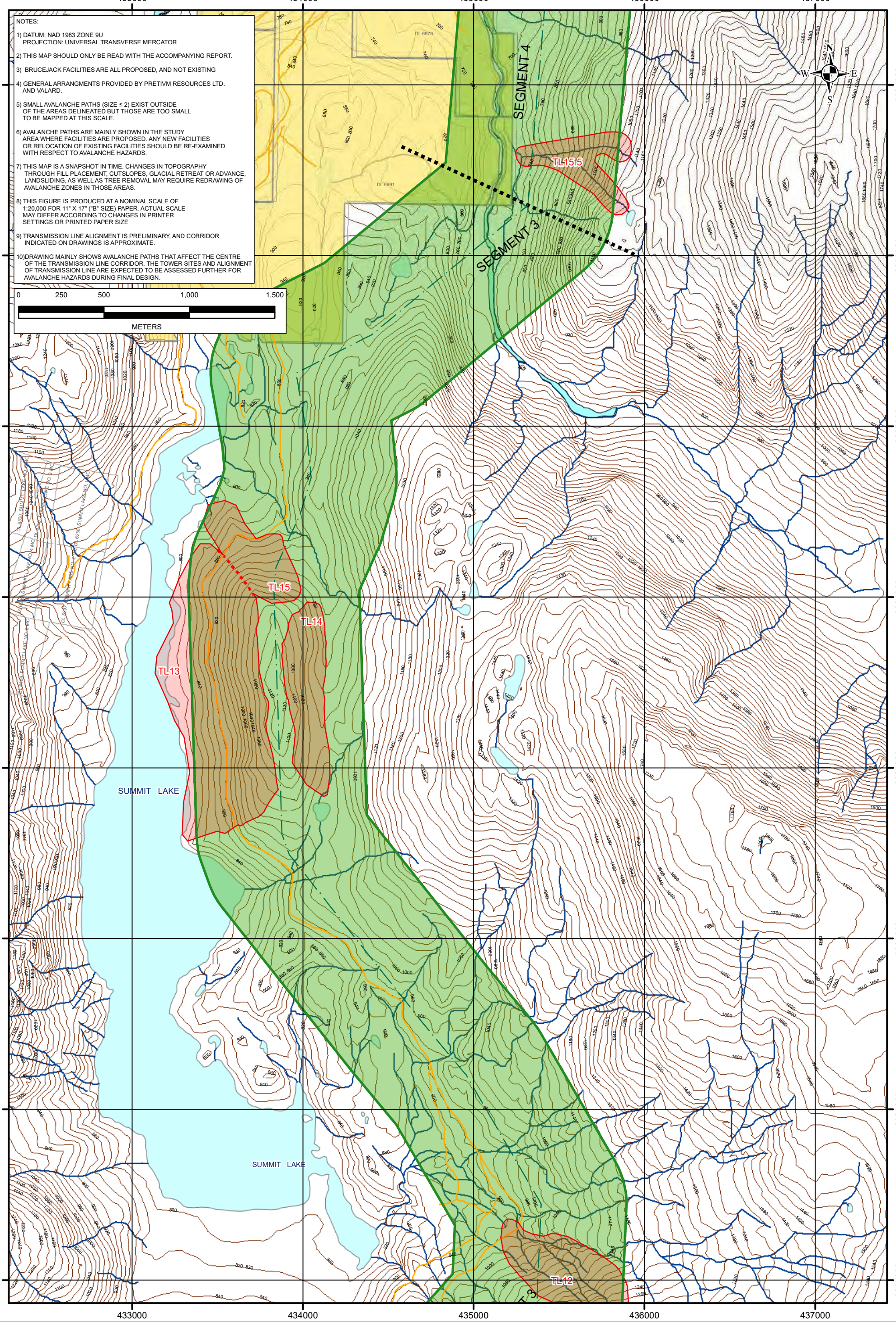

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- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED)
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PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

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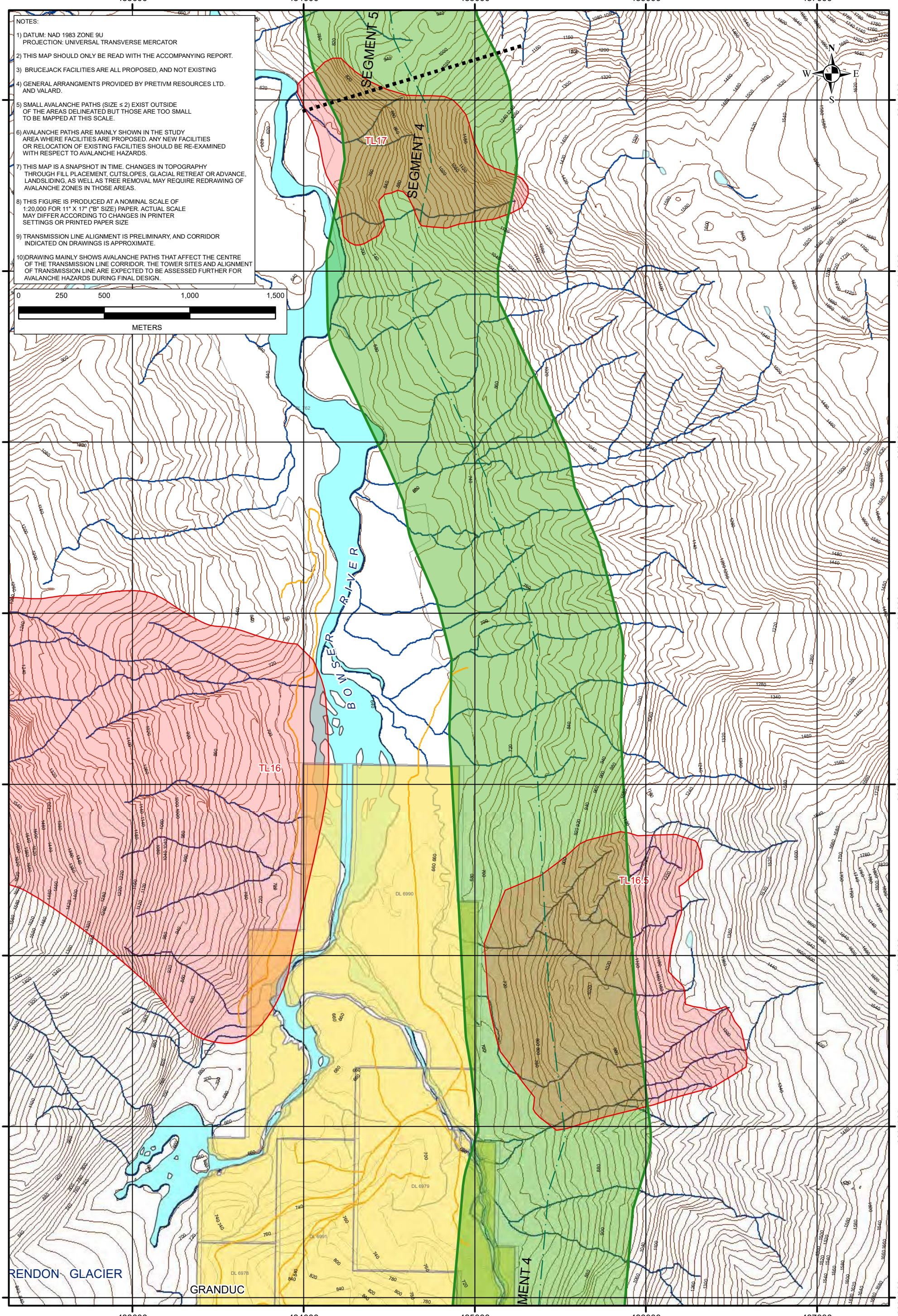
0 250 500 1,000 1,500
METERS



LEGEND

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- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
- STREAM
- DISTRICT LOT
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PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

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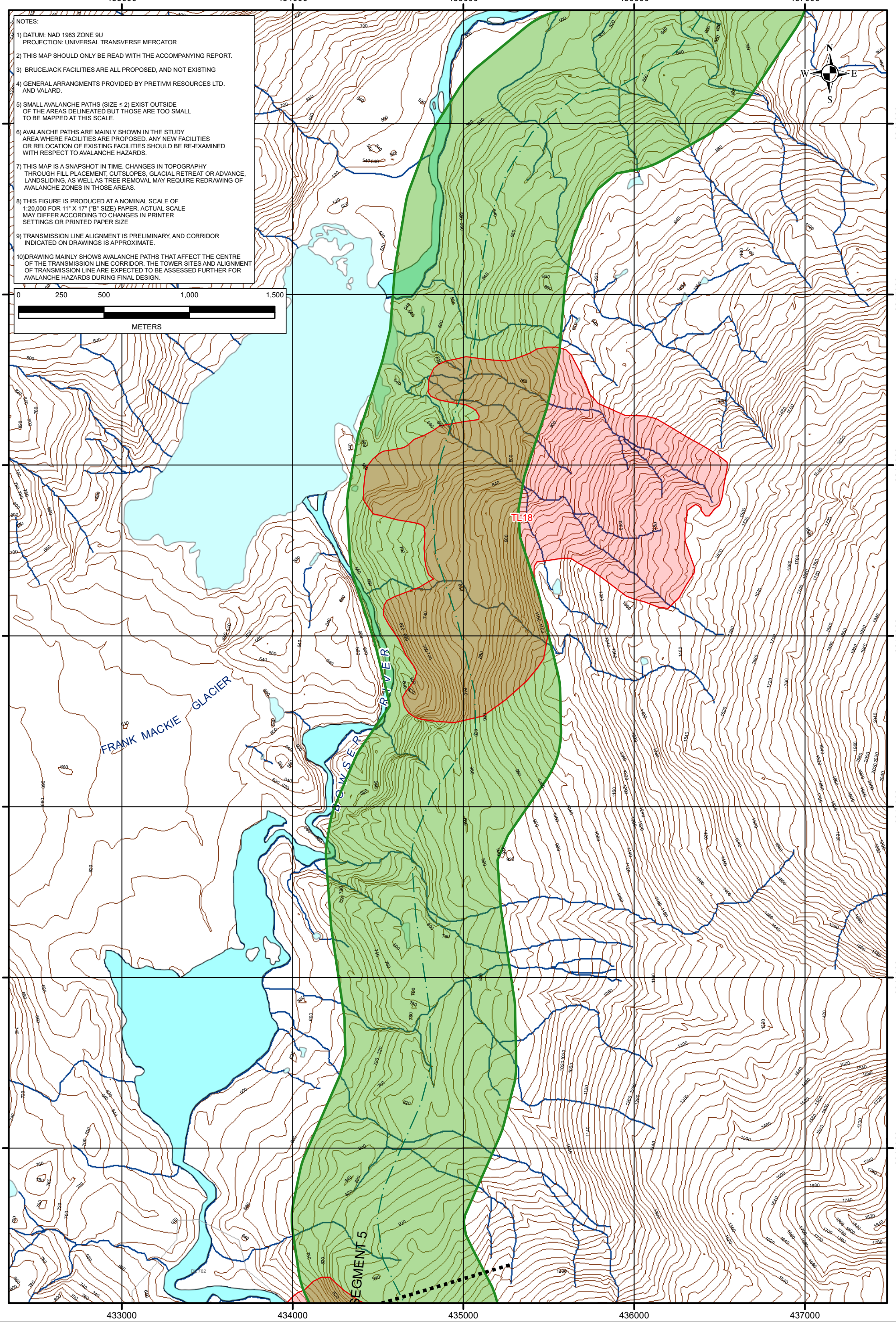

LEGEND

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- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED)
- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
- STREAM
- DISTRICT LOT
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PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

PROJECT NO:	DWG NO:	REV:
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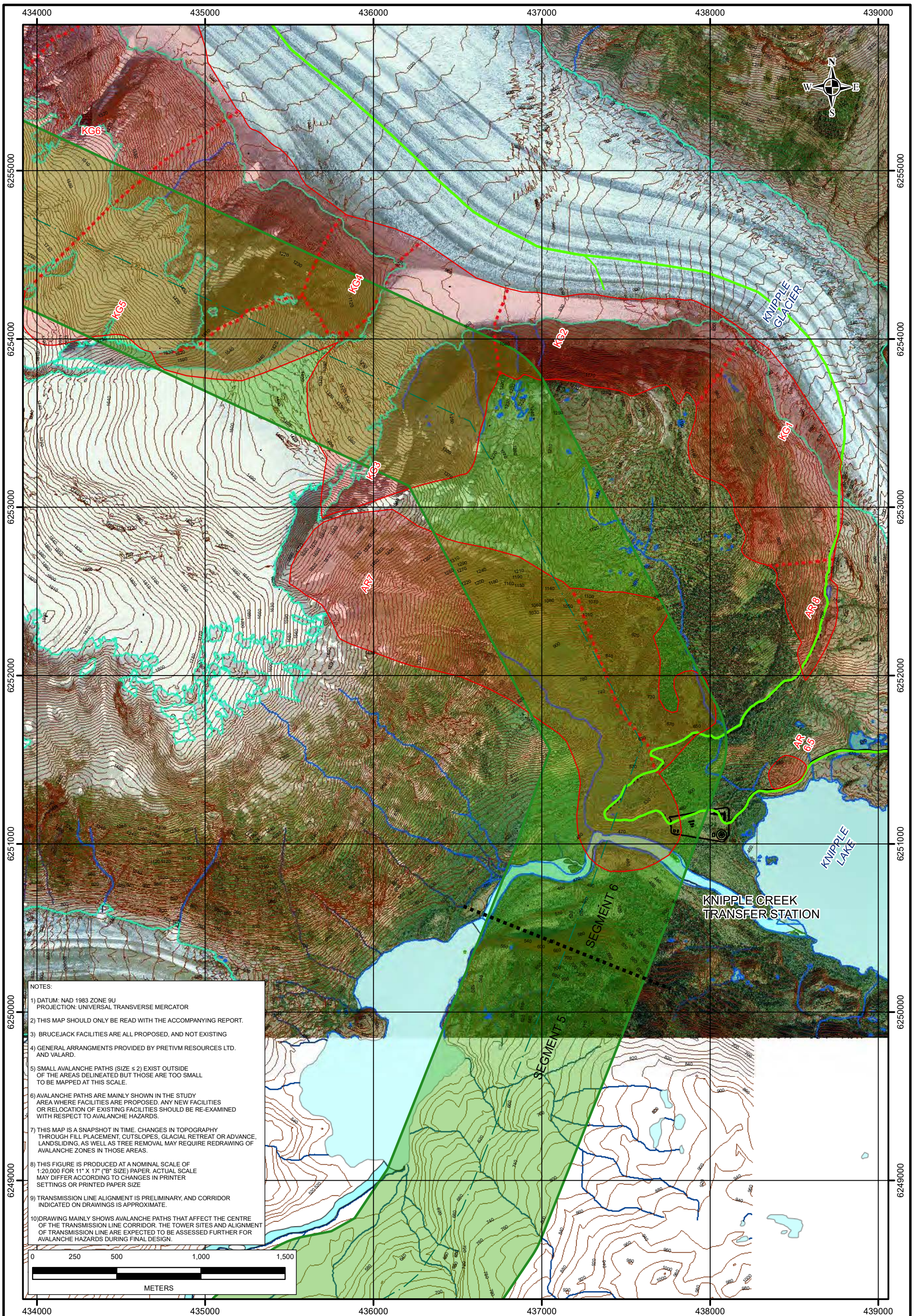

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10) DRAWING MAINLY SHOWS AVALANCHE PATHS THAT AFFECT THE CENTRE OF THE TRANSMISSION LINE CORRIDOR. THE TOWER SITES AND ALIGNMENT OF TRANSMISSION LINE ARE EXPECTED TO BE ASSESSED FURTHER FOR AVALANCHE HAZARDS DURING FINAL DESIGN.

LEGEND

- AVALANCHE PATH OR AREA
- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED)
- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
- STREAM
- DISTRICT LOT
- PRIVATE SURVEY PARCEL (SELECT DISTRICT LOTS)

SCALE:	1:20,000
DATE:	JULY 10, 2013
DESIGNED:	BG
DRAWN:	JN
CHECKED:	BG
APPROVED:	BG

PROFESSIONAL SEAL:

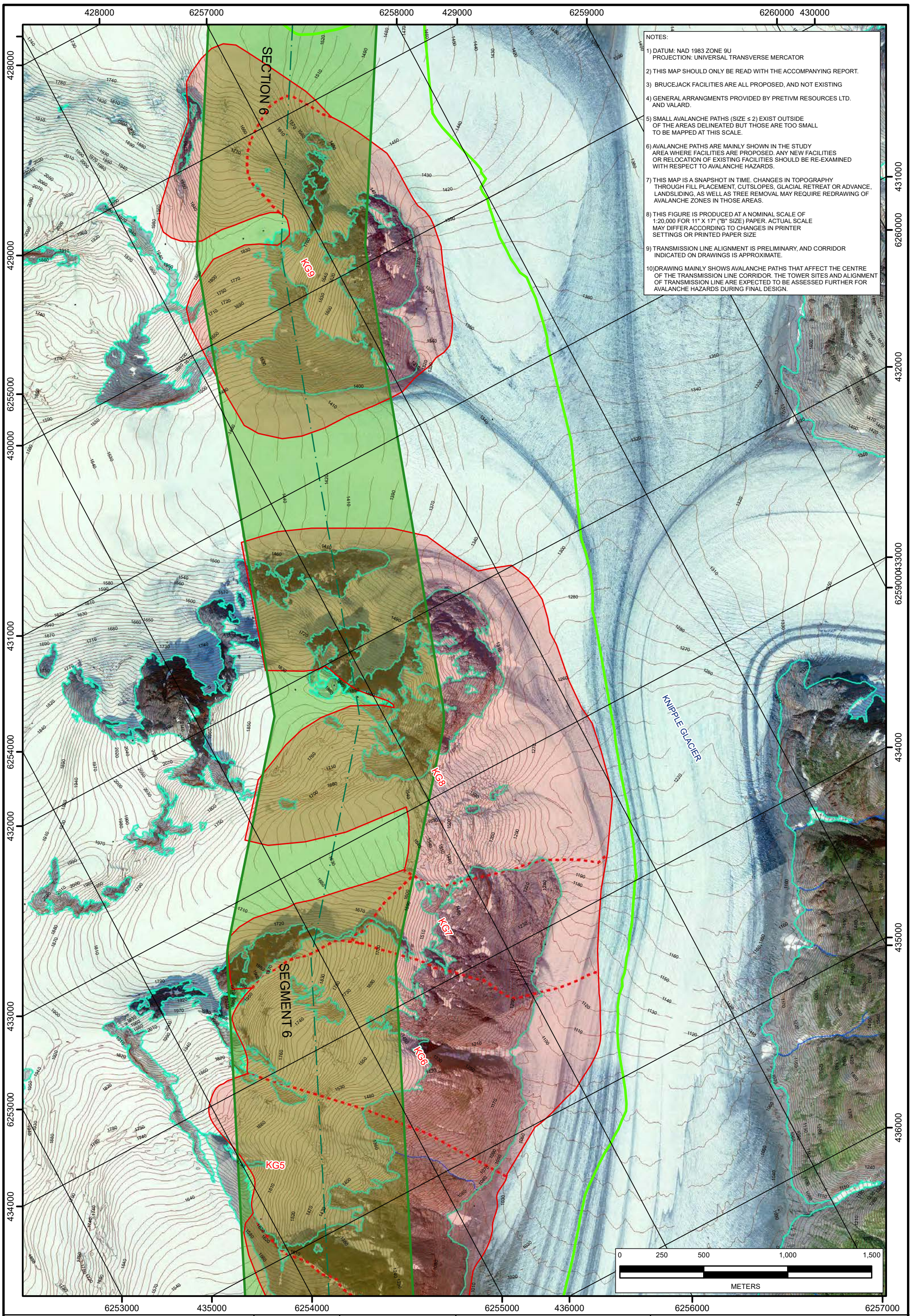
CLIENT: **PRETIVM RESOURCES**

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

PROJECT NO:	DWG NO:	REV:
	12	A



NOTES:

1) DATUM: NAD 1983 ZONE 9U
PROJECTION: UNIVERSAL TRANSVERSE MERCATOR

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3) BRUCEJACK FACILITIES ARE ALL PROPOSED, AND NOT EXISTING

4) GENERAL ARRANGMENTS PROVIDED BY PRETIVM RESOURCES LTD. AND VALARD.

5) SMALL AVALANCHE PATHS (SIZE ≤ 2) EXIST OUTSIDE OF THE AREAS DELINEATED BUT THOSE ARE TOO SMALL TO BE MAPPED AT THIS SCALE.

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LEGEND

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- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
- STREAM
- DISTRICT LOT
- PRIVATE SURVEY PARCEL (SELECT DISTRICT LOTS)

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PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE

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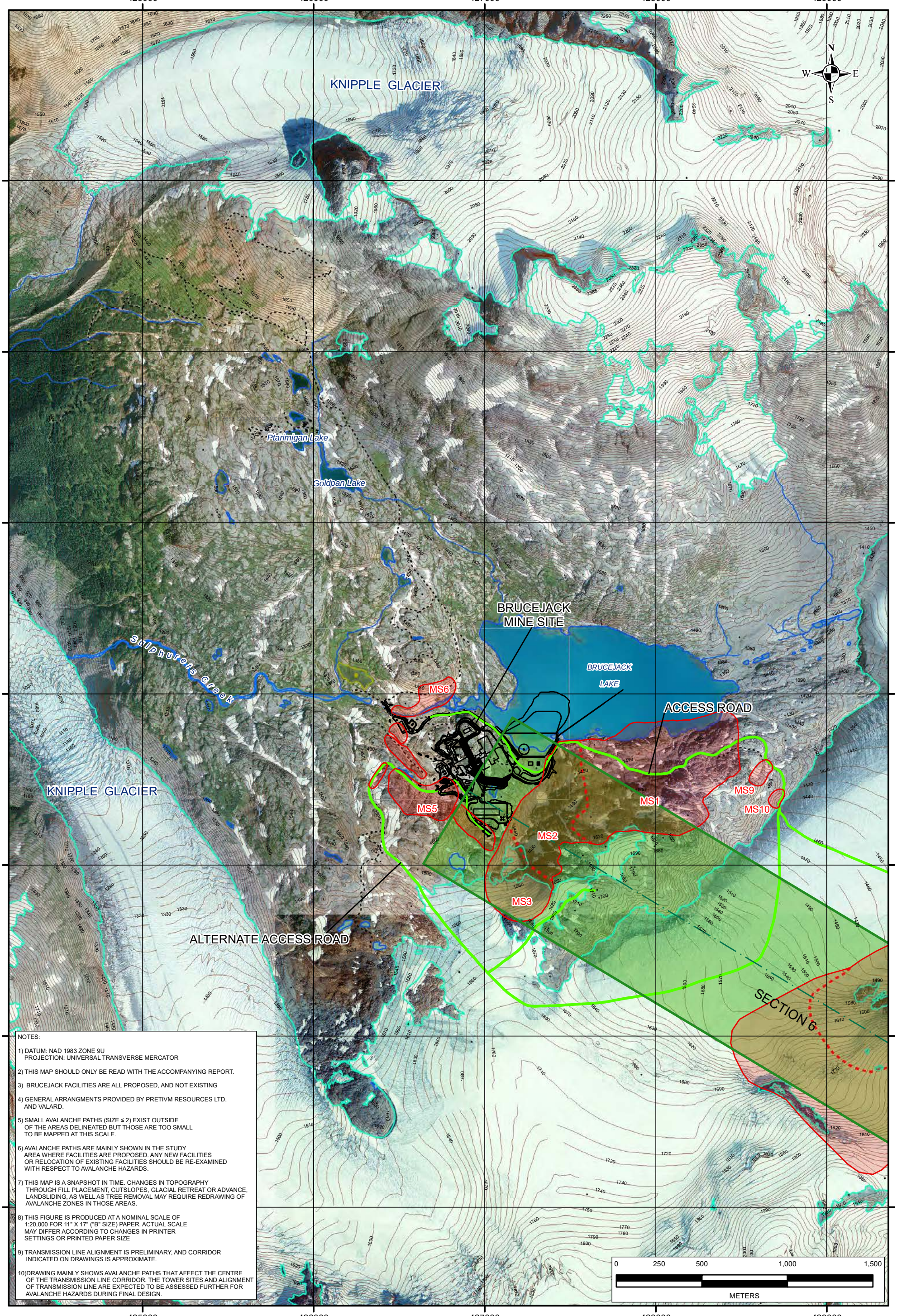

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LEGEND

- AVALANCHE PATH OR AREA
- PROPOSED TRANSMISSION LINE CORRIDOR (ALIGNMENT NOT FINALIZED)
- PROPOSED BRUCEJACK ACCESS ROAD
- 20M CONTOUR
- EXISTING ROAD
- STREAM
- DISTRICT LOT
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TITLE: TRANSMISSION LINE

PROJECT NO:	DWG NO:	REV:
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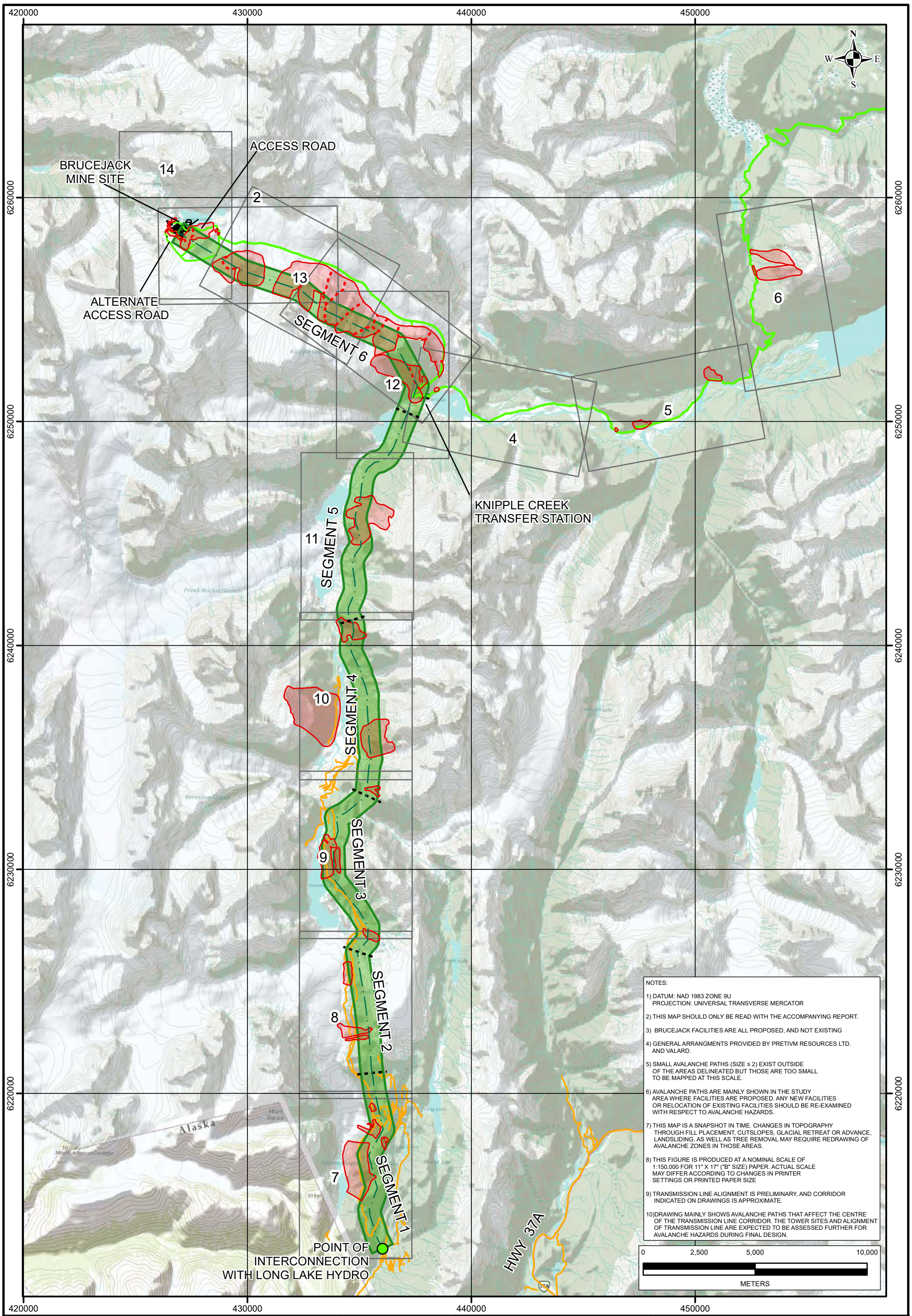

LEGEND

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- AVALANCHE PATH OR AREA
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- PROPOSED BRUCEJACK ACCESS ROAD
- EXISTING ROAD

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PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK PROJECT

TITLE: TRANSMISSION LINE AND ACCESS ROAD INDEX MAP

PROJECT NO:	DWG NO:	REV:
	15	A

PRETIUM RESOURCES INC.

BRUCEJACK PROJECT

AVALANCHE HAZARD ZONING FOR MINE SITE AREA

DRAFT

PROJECT NO:	1204-006	DISTRIBUTION:	
DATE:	October 8, 2015	CLIENT:	2 copies
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EXECUTIVE SUMMARY

This report provides supporting documentation for the development of an avalanche hazard zone map for the Brucejack mine site area. The zone map was requested by Pretium in order to plan the development of permanent and temporary occupied structures, and related facilities, in and around the mine site area. Avalanche hazard zone mapping for occupied structures is a requirement for development in several mountain based regional districts, and their application is supported by regulatory agencies that issue permits for commercial and/or industrial development. Further information on the development and use of these maps is described in CAA (2002).

The analysis undertaken for the mine site avalanche hazard zone map builds on previous avalanche hazard assessment work completed for Pretium by Alpine Solutions. Additional work required to create the zone map included:

- analysis of terrain from maps, imagery, and field study,
- review of avalanche occurrence information provided by mine site avalanche technicians,
- review of an a recent destructive avalanche occurrence which damaged and moved a building at the mine site,
- review of snow climate records, and
- application of topographical-statistical and dynamic models.

The avalanche hazard zone map is included as an attachment and the following recommendations are provided:

1. Pretium should provide this report and attached hazard zone map to all departments and stakeholders involved with planning construction of both permanent and temporary buildings, as well as managing worker safety at the mine site area.
2. All new building construction or placement should follow guidelines indicated in CAA (2002) and recommendations presented in Section 3.4. Any existing buildings or structures in the Blue or Red zones should be incorporated into the site wide avalanche risk management program.
3. Although avalanches large enough to damage a wood frame building are captured in the hazard zoning map, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches that may runout into terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. It is recommended that these small slopes continue to be assessed and monitored as a work site (or access route), within the scope of the site wide avalanche risk management program.

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1.0 INTRODUCTION

1.1. General

This report summarizes a detailed analysis of avalanche hazards in and around the planned Brucejack Project mine site, which was completed for the purposes of developing an avalanche hazard zone map. The zone map was requested by Pretium Resources Inc. (Pretium) in order to plan the development of both temporary and permanent facilities in and around the mine site area.

The analysis undertaken for the mine site avalanche hazard zone map builds on work completed previously for Pretium including Alpine Solutions (2013 & 2015a) in which several avalanche paths are identified, and avalanche hazard to specific proposed infrastructure for the mine was determined. The hazard zone map is included as an attachment and recommendations of its use are included.

1.2. Background

Over the past few years, Pretium has been advancing the Brucejack Project from an exploration phase to a physical development phase. During this process numerous temporary bunkhouses, offices, workshops, maintenance facilities, and other related infrastructure have been built in and around the project mine site (Photograph 1-1). Within the mine site area several avalanche paths and slopes that affect proposed infrastructure and roads have been identified and mapped (Alpine Solutions, 2013 & 2015).

As the development at the mine site area has been expanding, these slopes have been managed using short term mitigation methods that mainly involve evacuation of hazard zones, and avalanche explosive control to release avalanches. In the course of development at the site, at least one building was placed in an avalanche path, and it was recently damaged and moved off of its foundations by a controlled avalanche (no people were involved as the building was evacuated).

Photograph 1-1: Brucejack Project mine site area as viewed from the northeast.

Options for the placement of buildings and structures at the mine site are becoming limited, and the planned construction of the mine over the next few years is expected to require several more facilities, resulting in the need to use available space efficiently, while ensuring risk to people and facilities remains low. As a result, there is a need for a longer term strategy for placement of permanent and temporary infrastructure in the mine site area. Normally this type of need is resolved by incorporating an avalanche hazard zone map into the planning of all facilities.

2.0 LIMITATIONS

The analysis completed for the hazard zone map included in this report is based on modern methods, which includes:

- analysis of terrain from maps, imagery, and field study,
- review of avalanche occurrence information provided by mine site avalanche technicians,
- analysis and review of an a recent destructive avalanche occurrence which damaged and moved a building at the mine site,
- review of snow climate records, and
- application of topographical-statistical and dynamic models.

There is uncertainty in runout extent and avalanche magnitude and frequency estimates due to limited extent of avalanche occurrence records for the paths studied, non-existent vegetative indicators that are typically only found at lower elevations, and wide variation of results from the avalanche models used. As a result, hazard zone boundaries have been drawn conservatively where uncertainty is greatest.

Zoning boundaries illustrated on the attached hazard zone map are based on a snapshot in time of the terrain. Artificial or natural alteration of the landscape or terrain due to landslides, construction earthworks, glacial advance or retreat may change the location and extent of avalanche runout, necessitating a re-assessment of avalanche hazard zones. Construction earthworks specifically intended to retard or redirect avalanche flow may change avalanche hazard zone boundaries but temporary defecting structures, such as seasonal berms made from snow, would not.

The hazard zone map included with this report is intended as a planning tool for buildings and structures. Smaller avalanche slopes that may pose a risk to workers or vulnerable equipment are still present (or may be created during course of constructdion) in zones designated as low hazard (white zone), and as a result will still require assessment and management from on-site avalanche technicians.

Although other geohazards exist in the area, the scope of the hazard zoning is limited exclusively to snow avalanche hazards.

3.0 Avalanche Hazard Zone Mapping

3.1. Background on Avalanche Hazard Zone Maps

Avalanche hazard zone maps for occupied structures are a requirement in many mountain based regional districts, and their application is supported by regulatory agencies that issue permits for commercial and/or industrial development. The *Guidelines for Snow Avalanche Risk Determination and Mapping in Canada* (CAA, 2002) are the generally accepted guidelines for land development and operations located in avalanche terrain. According to CAA (2002), recommended zones for land use planning include:

1. **White Zone** – an area with an estimated avalanche return period of greater than 300 years, or impact pressures less than 1 kPa and a return period greater than 30 years.

2. **Red Zone** – an area where the return period is less than 30 years and/or impact pressures are greater than or equal to 30 kPa, or where the product of impact pressure (kPa) and the reciprocal of the return period (years) exceeds 0.1 for return periods between 30 and 300 years.

3. **Blue Zone** – an area in between the Red and White Zones, for return periods between 30 and 300 years, the product of impact pressure and frequency is less than 0.1 kPa/years and the impact pressure is greater than or equal to 1 kPa.

A graphical representation of the expected magnitude and frequency in these zones are provided in Figure 3-1.

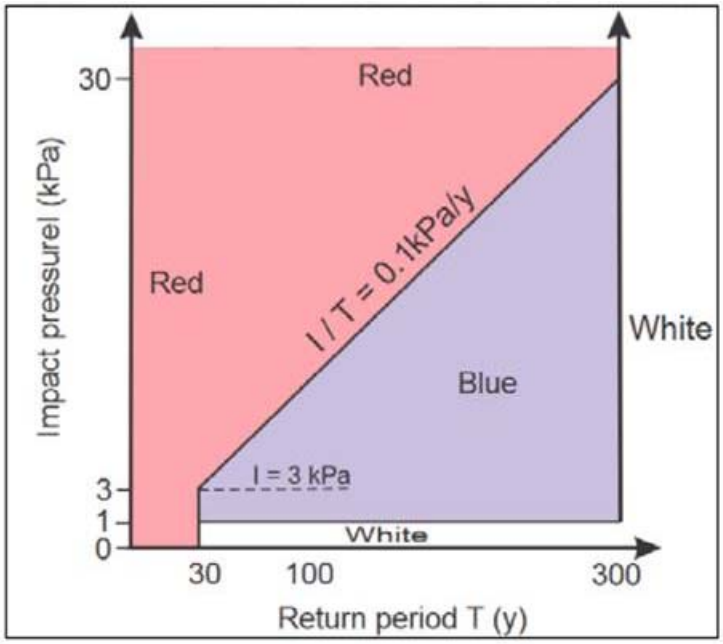

Figure 3-1: Definition of avalanche zones for land-use planning

The blue zone represents an area where minor damage could be expected infrequently (30 to 300 year return period) and include broken tree branches, broken windows, and blowing snow inside buildings.

Recommended activities according to zone color in Canada are indicated in Table 3-1.

Table 3-1. Recommended activities according to Zone (CAA, 2002)

Hazard[1] Zone	Recommended Activities
White Zone (low hazard)	Construction of new buildings, including permanently occupied structures, normally permitted.
Blue Zone (moderate hazard)	Construction of new buildings such as industrial plants and temporarily occupied structures possibly permitted with specified conditions. Conditions may include structures reinforced for avalanche forces, construction of avalanche defenses, and requirement for evacuation plans (or a combination of these).
Red Zone (high hazard)	Construction of new buildings not normally permitted.

3.2. Methods

Information regarding avalanche hazards affecting the Brucejack project has been provided previously in Alpine Solutions (2013, 2015a & 2015b); general project, terrain, and snow climate information is provided in these documents. For the hazard zoning analysis, the following methods were used:

- Analysis of terrain using contours generated from LiDAR data.
- Field identification of the extent of locations of large avalanche occurrences observed by site avalanche technicians in the past few years.
- Review of snow climate patterns from winter photographs of the area from various sources.
- Analysis of a destructive avalanche which damaged and moved a building from its foundation on March 13, 2015 (Soucie Construction, 2015)
- Application of topographical-statistical models for short slopes including
    - Alpha-regression model (Jones and Jamieson, 2004)
    - Runout ratio method (McClung & Mears, 1991; Jones and Jamieson, 2004)
- Application of dynamic models including:
    - PCM (Perla, et.al., 1982)
    - LEM (McClung and Mears, 1995; Jones and Jamieson, 2003).

[1] Although CAA (2002) refers to these zones as 'risk zones', they are now more commonly referred to as 'hazard zones'; this will be reflected in a soon-to-be-published update of CAA (2002)

3.3. Analysis

The analysis of avalanche hazard extent focused on avalanche paths MS2, MS3, MS5, and MS8, which are described and mapped in Alpine Solutions (2013 & 2015a). All of these paths are less than 300 m in vertical elevation, and as a result are considered 'short slopes' from an avalanche path modelling perspective. All paths are located above tree-line elevation, and as a result there are no vegetative indications of past events.

Winter photographs taken by Alpine Solutions in 2012 & 2013, as well as by site avalanche technicians provided information regarding snow and wind patterns, as well as a few notable avalanche occurrences (example in Photograph 3-1).

Photograph 3-1: Path MS8 (Camp Creep Path) notable avalanche occurrence (looking south).

A large explosives controlled avalanche in Path MS5 on March 13, 2015 impacted an office building creating damage and moving it off of its foundations (Photograph 3-2). The estimated runout distance of destructive flow was incorporated into the analysis.

Photograph 3-2: Path MS5 - Approximate direction (blue arrow) and extent of deposit (red dashed line) of avalanche impacting building on March 13, 2015 (looking southwest).

Both topographical-statistical and dynamic avalanche models (indicated in Section 3.2) were applied to several potential flows in order to model avalanche runout and estimate speed and impact pressure at various points along the path. Results varied considerably depending on input parameters used. Combined with other methods of analysis, as well as judgement, models could be calibrated to provide realistic speeds and impact pressures in order to determine values for a determination of Red and Blue Zone boundaries (CAA, 2002). Assumptions for avalanche flow models are included in Appendix A.

Once the avalanche hazard zone map was complete, it was reviewed by Soucie Construction (site avalanche operations team) to ensure consensus of zoning boundaries with avalanche technicians who have been monitoring and controlling avalanches at the mine site for the past three winters.

3.4. Use of the Avalanche Hazard Zone Map

According to Section 3.1, construction of new buildings would normally only be permitted in the white zone, and this is recommended for all bunkhouse facilities, and or buildings where large numbers of people may gather. Industrial facilities including maintenance facilities and plants may be constructed in a blue zone, but they either require reinforcement for avalanche forces, construction of mitigation measures such as temporary snow berms, or an

acceptance of potential damage to the structure. In addition, an evacuation plan would be required for periods of high hazard, or during avalanche explosive control.

Normally no new buildings should be constructed in the red zone, unless there is a specific requirement that outweighs the normal accepted risk to a standard non-reinforced wood frame building. Construction of a building in a red zone would need to be examined on a case by case basis, and similar to the blue zone, normally the building would either be reinforced, or the risk of damage is accepted. In addition, the building would be treated as a worksite in avalanche terrain, and incorporated into the site wide avalanche management program (the slopes above would be regularly monitored, and the building and area evacuated during periods of high avalanche hazard).

Currently there are existing structures in the red zone including a ‘core shack’, and a few other small buildings that are presently not occupied. Avalanche hazard to these facilities should continue to be assessed on an ongoing basis in the context of the site wide operational avalanche management plan. If at any point these structures are occupied on a regular basis, it must be clearly understood that the buildings are in a high hazard zone, and may need to be evacuated at any time during winter or spring.

As indicated in Section 2.0, there are limitations of the hazard zone map which must be understood. Although avalanches large enough to damage a wood frame building are captured, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches with terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. These small slopes still need to be assessed and monitored as a work site (or access route) from a worker safety perspective, within the scope of the site wide avalanche risk management program.

4.0 Conclusions and Recommendations

An avalanche hazard zoning map has been developed for the Brucejack mine site area, and is attached to this report. Alpine Solutions provides the following recommendations:

1. Pretium should provide this report and attached hazard zone map to all departments and stakeholders involved with planning construction of both permanent and temporary buildings, as well as managing worker safety at the mine site area.
2. All new building construction or placement should follow guidelines indicated in CAA (2002) and recommendations presented in Section 3.4. Any existing buildings or structures in the Blue or Red zones should be incorporated into the site wide avalanche risk management program.
3. Although avalanches large enough to damage a wood frame building are captured in the hazard zoning map, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches that may runout into terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. It is recommended that these small slopes continue to be assessed and monitored as a work site (or access route), within the scope of the site wide avalanche risk management program.

5.0 CLOSURE

This document was prepared by Alpine Solutions Avalanche Services (Alpine Solutions) for the account of Pretium Resources Inc. The material in it reflects Alpine Solutions' best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this report.

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We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

ALPINE SOLUTIONS AVALANCHE SERVICES
per:

Brian Gould, P. Eng.
Senior Avalanche Specialist

Cam Campbell, M.Sc.
Avalanche Specialist

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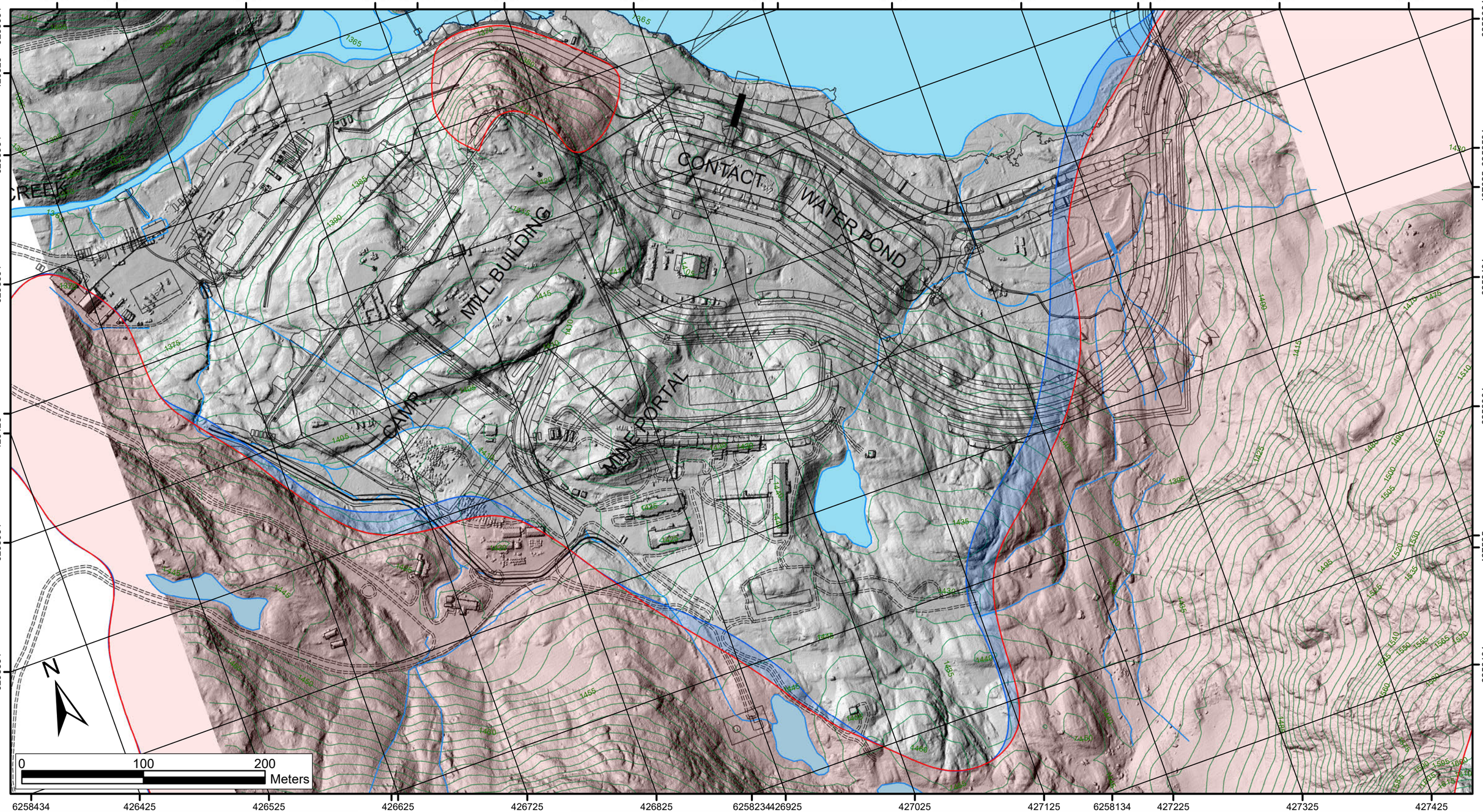
APPENDIX A
ASSUMPTIONS USED FOR AVALANCHE MODELS

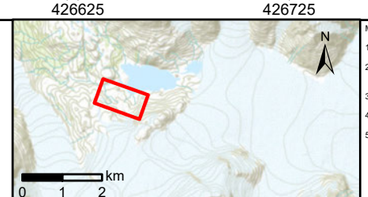
Model	**Assumptions**
PCM	Start zone, track and runout: $\mu = 0.25$ $M/D = 0.8H_o$
LEM	$\mu = 0.515 + 0.578H_o y'' - 0.107TP$ V_{max} estimated from PCM
Runout Ratio	$P = 0.9$

AVALANCHE HAZARD ZONE MAP



LEGEND

- RED ZONE - HIGH HAZARD
- BLUE ZONE - MODERATE HAZARD
- WHITE ZONE (NO SHADING) - LOW HAZARD



MAP NOTES:

1) DATUM: NAD 83. PROJECTION: TRANSVERSE MERCATOR. UTM ZONE: 9N

2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:3000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

3) DATA/BASEMAP SOURCE: PRETIUM RESOURCES, ARCGIS ONLINE.

4) CONTOUR INTERVAL: 5 M

5) THIS MAP IS INTENDED TO PROVIDE ZONING GUIDANCE FOR THE CONSTRUCTION OF BUILDINGS IN AND AROUND THE BRUCEJACK MINE SITE AREA, AND SHOULD BE READ WITH THE ACCOMPANYING REPORT.

SCALE:	1:3,000
DATE:	09 Oct 2015
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CHECKED:	BG
APPROVED:	DRAFT

CLIENT: PRETIVM

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK MINE

TITLE: MINE SITE AVALANCHE HAZARD ZONING

REGION:	MAP NO:	REV:
NORTH COAST	1204-006-1	-

Appendix B

Avalanche Hazard Zoning for Mine Site Area

PRETIUM RESOURCES INC.

BRUCEJACK PROJECT

AVALANCHE HAZARD ZONING FOR MINE SITE AREA

DRAFT

PROJECT NO:	1204-006	DISTRIBUTION:	
DATE:	October 8, 2015	CLIENT:	2 copies
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EXECUTIVE SUMMARY

This report provides supporting documentation for the development of an avalanche hazard zone map for the Brucejack mine site area. The zone map was requested by Pretium in order to plan the development of permanent and temporary occupied structures, and related facilities, in and around the mine site area. Avalanche hazard zone mapping for occupied structures is a requirement for development in several mountain based regional districts, and their application is supported by regulatory agencies that issue permits for commercial and/or industrial development. Further information on the development and use of these maps is described in CAA (2002).

The analysis undertaken for the mine site avalanche hazard zone map builds on previous avalanche hazard assessment work completed for Pretium by Alpine Solutions. Additional work required to create the zone map included:

- analysis of terrain from maps, imagery, and field study,
- review of avalanche occurrence information provided by mine site avalanche technicians,
- review of an a recent destructive avalanche occurrence which damaged and moved a building at the mine site,
- review of snow climate records, and
- application of topographical-statistical and dynamic models.

The avalanche hazard zone map is included as an attachment and the following recommendations are provided:

1. Pretium should provide this report and attached hazard zone map to all departments and stakeholders involved with planning construction of both permanent and temporary buildings, as well as managing worker safety at the mine site area.
2. All new building construction or placement should follow guidelines indicated in CAA (2002) and recommendations presented in Section 3.4. Any existing buildings or structures in the Blue or Red zones should be incorporated into the site wide avalanche risk management program.
3. Although avalanches large enough to damage a wood frame building are captured in the hazard zoning map, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches that may runout into terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. It is recommended that these small slopes continue to be assessed and monitored as a work site (or access route), within the scope of the site wide avalanche risk management program.

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1.0 INTRODUCTION

1.1. General

This report summarizes a detailed analysis of avalanche hazards in and around the planned Brucejack Project mine site, which was completed for the purposes of developing an avalanche hazard zone map. The zone map was requested by Pretium Resources Inc. (Pretium) in order to plan the development of both temporary and permanent facilities in and around the mine site area.

The analysis undertaken for the mine site avalanche hazard zone map builds on work completed previously for Pretium including Alpine Solutions (2013 & 2015a) in which several avalanche paths are identified, and avalanche hazard to specific proposed infrastructure for the mine was determined. The hazard zone map is included as an attachment and recommendations of its use are included.

1.2. Background

Over the past few years, Pretium has been advancing the Brucejack Project from an exploration phase to a physical development phase. During this process numerous temporary bunkhouses, offices, workshops, maintenance facilities, and other related infrastructure have been built in and around the project mine site (Photograph 1-1). Within the mine site area several avalanche paths and slopes that affect proposed infrastructure and roads have been identified and mapped (Alpine Solutions, 2013 & 2015).

As the development at the mine site area has been expanding, these slopes have been managed using short term mitigation methods that mainly involve evacuation of hazard zones, and avalanche explosive control to release avalanches. In the course of development at the site, at least one building was placed in an avalanche path, and it was recently damaged and moved off of its foundations by a controlled avalanche (no people were involved as the building was evacuated).

Photograph 1-1: Brucejack Project mine site area as viewed from the northeast.

Options for the placement of buildings and structures at the mine site are becoming limited, and the planned construction of the mine over the next few years is expected to require several more facilities, resulting in the need to use available space efficiently, while ensuring risk to people and facilities remains low. As a result, there is a need for a longer term strategy for placement of permanent and temporary infrastructure in the mine site area. Normally this type of need is resolved by incorporating an avalanche hazard zone map into the planning of all facilities.

2.0 LIMITATIONS

The analysis completed for the hazard zone map included in this report is based on modern methods, which includes:

- analysis of terrain from maps, imagery, and field study,
- review of avalanche occurrence information provided by mine site avalanche technicians,
- analysis and review of an a recent destructive avalanche occurrence which damaged and moved a building at the mine site,
- review of snow climate records, and
- application of topographical-statistical and dynamic models.

There is uncertainty in runout extent and avalanche magnitude and frequency estimates due to limited extent of avalanche occurrence records for the paths studied, non-existent vegetative indicators that are typically only found at lower elevations, and wide variation of results from the avalanche models used. As a result, hazard zone boundaries have been drawn conservatively where uncertainty is greatest.

Zoning boundaries illustrated on the attached hazard zone map are based on a snapshot in time of the terrain. Artificial or natural alteration of the landscape or terrain due to landslides, construction earthworks, glacial advance or retreat may change the location and extent of avalanche runout, necessitating a re-assessment of avalanche hazard zones. Construction earthworks specifically intended to retard or redirect avalanche flow may change avalanche hazard zone boundaries but temporary defecting structures, such as seasonal berms made from snow, would not.

The hazard zone map included with this report is intended as a planning tool for buildings and structures. Smaller avalanche slopes that may pose a risk to workers or vulnerable equipment are still present (or may be created during course of constructdion) in zones designated as low hazard (white zone), and as a result will still require assessment and management from on-site avalanche technicians.

Although other geohazards exist in the area, the scope of the hazard zoning is limited exclusively to snow avalanche hazards.

3.0 Avalanche Hazard Zone Mapping

3.1. Background on Avalanche Hazard Zone Maps

Avalanche hazard zone maps for occupied structures are a requirement in many mountain based regional districts, and their application is supported by regulatory agencies that issue permits for commercial and/or industrial development. The *Guidelines for Snow Avalanche Risk Determination and Mapping in Canada* (CAA, 2002) are the generally accepted guidelines for land development and operations located in avalanche terrain. According to CAA (2002), recommended zones for land use planning include:

1. **White Zone** – an area with an estimated avalanche return period of greater than 300 years, or impact pressures less than 1 kPa and a return period greater than 30 years.

2. **Red Zone** – an area where the return period is less than 30 years and/or impact pressures are greater than or equal to 30 kPa, or where the product of impact pressure (kPa) and the reciprocal of the return period (years) exceeds 0.1 for return periods between 30 and 300 years.

3. **Blue Zone** – an area in between the Red and White Zones, for return periods between 30 and 300 years, the product of impact pressure and frequency is less than 0.1 kPa/years and the impact pressure is greater than or equal to 1 kPa.

A graphical representation of the expected magnitude and frequency in these zones are provided in Figure 3-1.

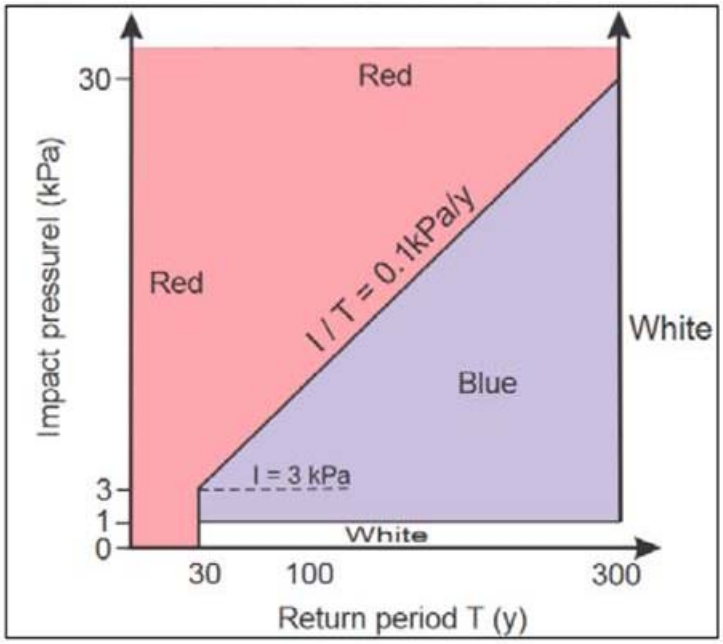

Figure 3-1: Definition of avalanche zones for land-use planning

The blue zone represents an area where minor damage could be expected infrequently (30 to 300 year return period) and include broken tree branches, broken windows, and blowing snow inside buildings.

Recommended activities according to zone color in Canada are indicated in Table 3-1.

Table 3-1. Recommended activities according to Zone (CAA, 2002)

Hazard[1] Zone	Recommended Activities
White Zone (low hazard)	Construction of new buildings, including permanently occupied structures, normally permitted.
Blue Zone (moderate hazard)	Construction of new buildings such as industrial plants and temporarily occupied structures possibly permitted with specified conditions. Conditions may include structures reinforced for avalanche forces, construction of avalanche defenses, and requirement for evacuation plans (or a combination of these).
Red Zone (high hazard)	Construction of new buildings not normally permitted.

3.2. Methods

Information regarding avalanche hazards affecting the Brucejack project has been provided previously in Alpine Solutions (2013, 2015a & 2015b); general project, terrain, and snow climate information is provided in these documents. For the hazard zoning analysis, the following methods were used:

- Analysis of terrain using contours generated from LiDAR data.
- Field identification of the extent of locations of large avalanche occurrences observed by site avalanche technicians in the past few years.
- Review of snow climate patterns from winter photographs of the area from various sources.
- Analysis of a destructive avalanche which damaged and moved a building from its foundation on March 13, 2015 (Soucie Construction, 2015)
- Application of topographical-statistical models for short slopes including
    - Alpha-regression model (Jones and Jamieson, 2004)
    - Runout ratio method (McClung & Mears, 1991; Jones and Jamieson, 2004)
- Application of dynamic models including:
    - PCM (Perla, et.al., 1982)
    - LEM (McClung and Mears, 1995; Jones and Jamieson, 2003).

[1] Although CAA (2002) refers to these zones as 'risk zones', they are now more commonly referred to as 'hazard zones'; this will be reflected in a soon-to-be-published update of CAA (2002)

3.3. Analysis

The analysis of avalanche hazard extent focused on avalanche paths MS2, MS3, MS5, and MS8, which are described and mapped in Alpine Solutions (2013 & 2015a). All of these paths are less than 300 m in vertical elevation, and as a result are considered 'short slopes' from an avalanche path modelling perspective. All paths are located above tree-line elevation, and as a result there are no vegetative indications of past events.

Winter photographs taken by Alpine Solutions in 2012 & 2013, as well as by site avalanche technicians provided information regarding snow and wind patterns, as well as a few notable avalanche occurrences (example in Photograph 3-1).

Photograph 3-1: Path MS8 (Camp Creep Path) notable avalanche occurrence (looking south).

A large explosives controlled avalanche in Path MS5 on March 13, 2015 impacted an office building creating damage and moving it off of its foundations (Photograph 3-2). The estimated runout distance of destructive flow was incorporated into the analysis.

Photograph 3-2: Path MS5 - Approximate direction (blue arrow) and extent of deposit (red dashed line) of avalanche impacting building on March 13, 2015 (looking southwest).

Both topographical-statistical and dynamic avalanche models (indicated in Section 3.2) were applied to several potential flows in order to model avalanche runout and estimate speed and impact pressure at various points along the path. Results varied considerably depending on input parameters used. Combined with other methods of analysis, as well as judgement, models could be calibrated to provide realistic speeds and impact pressures in order to determine values for a determination of Red and Blue Zone boundaries (CAA, 2002). Assumptions for avalanche flow models are included in Appendix A.

Once the avalanche hazard zone map was complete, it was reviewed by Soucie Construction (site avalanche operations team) to ensure consensus of zoning boundaries with avalanche technicians who have been monitoring and controlling avalanches at the mine site for the past three winters.

3.4. Use of the Avalanche Hazard Zone Map

According to Section 3.1, construction of new buildings would normally only be permitted in the white zone, and this is recommended for all bunkhouse facilities, and or buildings where large numbers of people may gather. Industrial facilities including maintenance facilities and plants may be constructed in a blue zone, but they either require reinforcement for avalanche forces, construction of mitigation measures such as temporary snow berms, or an

acceptance of potential damage to the structure. In addition, an evacuation plan would be required for periods of high hazard, or during avalanche explosive control.

Normally no new buildings should be constructed in the red zone, unless there is a specific requirement that outweighs the normal accepted risk to a standard non-reinforced wood frame building. Construction of a building in a red zone would need to be examined on a case by case basis, and similar to the blue zone, normally the building would either be reinforced, or the risk of damage is accepted. In addition, the building would be treated as a worksite in avalanche terrain, and incorporated into the site wide avalanche management program (the slopes above would be regularly monitored, and the building and area evacuated during periods of high avalanche hazard).

Currently there are existing structures in the red zone including a ‘core shack’, and a few other small buildings that are presently not occupied. Avalanche hazard to these facilities should continue to be assessed on an ongoing basis in the context of the site wide operational avalanche management plan. If at any point these structures are occupied on a regular basis, it must be clearly understood that the buildings are in a high hazard zone, and may need to be evacuated at any time during winter or spring.

As indicated in Section 2.0, there are limitations of the hazard zone map which must be understood. Although avalanches large enough to damage a wood frame building are captured, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches with terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. These small slopes still need to be assessed and monitored as a work site (or access route) from a worker safety perspective, within the scope of the site wide avalanche risk management program.

4.0 Conclusions and Recommendations

An avalanche hazard zoning map has been developed for the Brucejack mine site area, and is attached to this report. Alpine Solutions provides the following recommendations:

1. Pretium should provide this report and attached hazard zone map to all departments and stakeholders involved with planning construction of both permanent and temporary buildings, as well as managing worker safety at the mine site area.
2. All new building construction or placement should follow guidelines indicated in CAA (2002) and recommendations presented in Section 3.4. Any existing buildings or structures in the Blue or Red zones should be incorporated into the site wide avalanche risk management program.
3. Although avalanches large enough to damage a wood frame building are captured in the hazard zoning map, small avalanches (≤ Size 2) still may occur in the White (low hazard) zone, including Size 1 avalanches that may runout into terrain traps (e.g. gullies or ditches). In addition, cut slopes may be created during the course of construction. It is recommended that these small slopes continue to be assessed and monitored as a work site (or access route), within the scope of the site wide avalanche risk management program.

5.0 CLOSURE

This document was prepared by Alpine Solutions Avalanche Services (Alpine Solutions) for the account of Pretium Resources Inc. The material in it reflects Alpine Solutions' best judgment in light of the information available to Alpine Solutions at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Alpine Solutions accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions, based on this report.

As a mutual protection to our client, the public, and ourselves, all documents and drawings are submitted for the confidential information of our client for a specific project. Authorization for any use and/or publication of this document or any data, statements, conclusions or abstracts from or regarding our documents and drawings, through any form of print or electronic media, including without limitation, posting or reproduction of same on any website, is reserved pending Alpine Solutions' written approval. If this document is issued in an electronic format, an original paper copy is on file at Alpine Solutions and that copy is the primary reference with precedence over any electronic copy of the document, or any extracts from our documents published by others.

We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

ALPINE SOLUTIONS AVALANCHE SERVICES
per:

Brian Gould, P. Eng.
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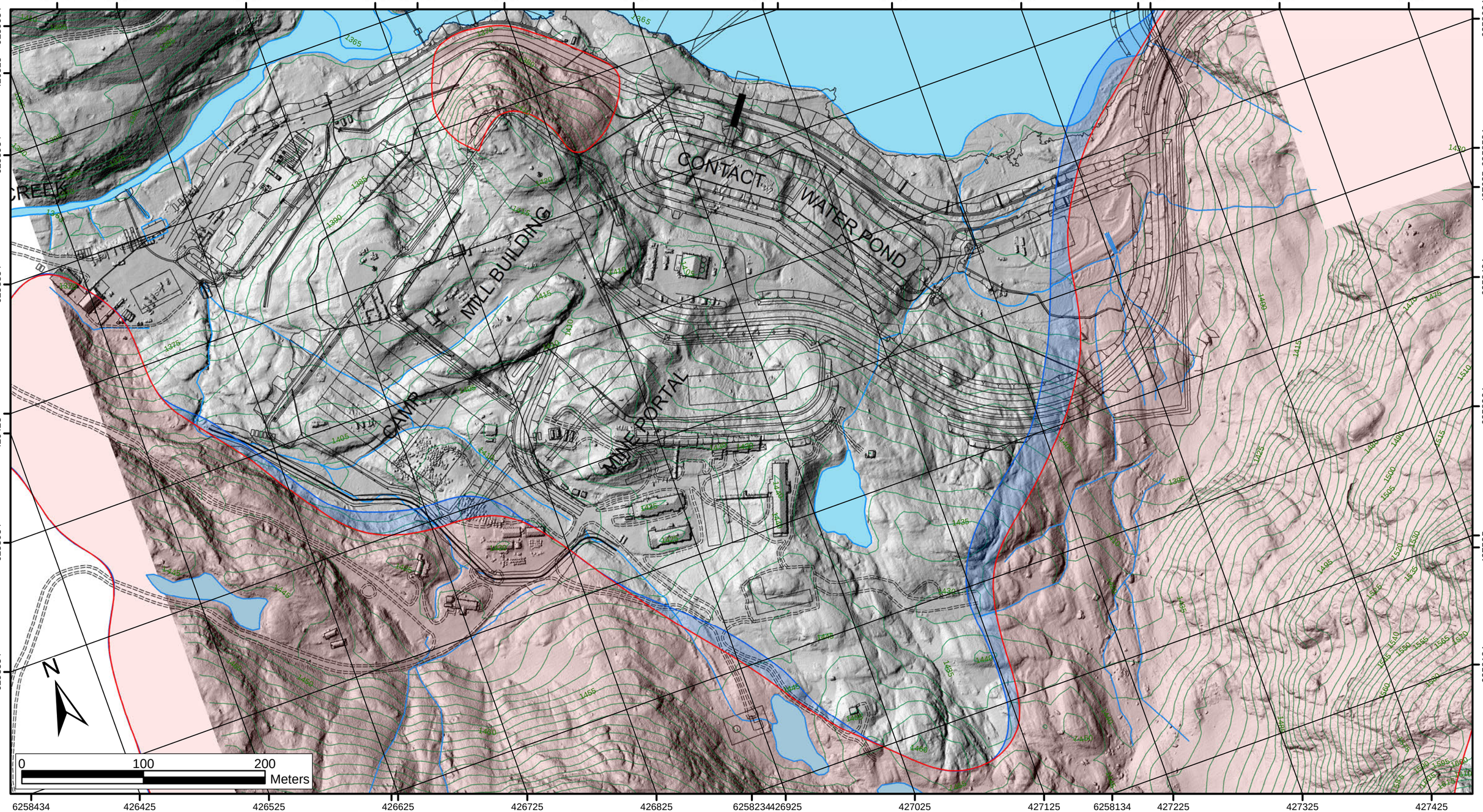
APPENDIX A
ASSUMPTIONS USED FOR AVALANCHE MODELS

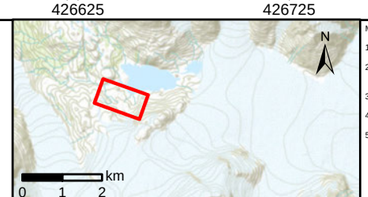
Model	**Assumptions**
PCM	Start zone, track and runout: $\mu = 0.25$ $M/D = 0.8H_o$
LEM	$\mu = 0.515 + 0.578H_o y'' - 0.107TP$ V_{max} estimated from PCM
Runout Ratio	$P = 0.9$

AVALANCHE HAZARD ZONE MAP



LEGEND

- RED ZONE - HIGH HAZARD
- BLUE ZONE - MODERATE HAZARD
- WHITE ZONE (NO SHADING) - LOW HAZARD



MAP NOTES:

1) DATUM: NAD 83. PROJECTION: TRANSVERSE MERCATOR. UTM ZONE: 9N

2) THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:3000 FOR 11" X 17" ("B" SIZE) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

3) DATA/BASEMAP SOURCE: PRETIUM RESOURCES, ARCGIS ONLINE.

4) CONTOUR INTERVAL: 5 M

5) THIS MAP IS INTENDED TO PROVIDE ZONING GUIDANCE FOR THE CONSTRUCTION OF BUILDINGS IN AND AROUND THE BRUCEJACK MINE SITE AREA, AND SHOULD BE READ WITH THE ACCOMPANYING REPORT.

SCALE:	1:3,000
DATE:	09 Oct 2015
DESIGNED:	CC
DRAWN:	CC
CHECKED:	BG
APPROVED:	DRAFT

CLIENT: PRETIVM

PREPARED BY: ALPINE SOLUTIONS AVALANCHE SERVICES

PROJECT: BRUCEJACK MINE

TITLE: MINE SITE AVALANCHE HAZARD ZONING

REGION:	MAP NO:	REV:
NORTH COAST	1204-006-1	-

Appendix C

Standard Operating Procedures

Appendix C.1

BJ-AVL-SOP-001 – Worksite Avalanche Assessment

PRETIVM		BJ-AVL-SOP-001 Worksite Avalanche Assessment	
Owner: Mountain Safety	**Approver**: Ken Black / Jim Franken	**Revision Number**: V2.2	**Creation Date**: 2017-04-08 **Revision Date**: 2020-06-13

Objective

Worksite hazard assessments are performed when a new, temporary project encroaches into or near avalanche terrain.

Individual short-term projects may have specific written procedures while longer term projects will use the Avalanche Safe Work Procedures in tandem with the Daily Avalanche Hazard bulletins

Scope

Any department planning work in potential avalanche terrain outside camp roads and facilities.

Health, Safety & Reclamation Code of BC

- WSBC G4.1.1 Avalanche Assessment, G4.1.2 (c) Avalanche Planning
- HSRC Part 2.2 Hazards, 3.3.1 Hazardous Work, 6.1.1 Qualified Persons

Definitions

- Avalanche Terrain – Any terrain features capable of producing an avalanche given the correct snowpack conditions

Preparation

Hazards

- Avalanches
- Failure to recognize avalanche terrain and/or unstable conditions.

Tools

- Avalanche Companion Rescue Gear

Requirements

- Worksite Avalanche Hazard assessment form
- Avalanche Hazard Safe Work Procedures
- Worker avalanche awareness training

Job Step

- A department requests an Avalanche Hazard Assessment for any work in or exposed to avalanche terrain
- Mtn safety will consult with the requesting department to determine job scope.
- Mountain Safety team will carry out a Worksite Avalanche Hazard Assessment including:
  - Access and egress hazards
  - Terrain description and concerns
  - Mountain hazards and snowpack concerns
  - Risk Management and controls recommendations
  - Requirement for avalanche companion rescue equipment and training
- The technician will first assess the site for their personal safety and implement control measures prior to carrying out the Worksite Avalanche Assessment

- A completed Worksite Hazard Assessment form will be issued to department for procedures to follow until job completion.
- Copies of the Plan will be posted in Mountain Safety office for continuity with all techs until job completion.
- Ongoing projects will be reassessed at regular intervals and site specific procedures may be updated based on overhead hazard changes.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2020-06-14	Simplified entire document		1

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.2

BJ-AVL-SOP-002 – Snowmobile Operation

PRETIVM		BJ-AVL-SOP-002 SNOWMOBILE OPERATION	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.1	Creation Date: 17/11/03 Revision Date: 17/12/28

Rational

Snowmobiles are used in a mountain environment to efficiently access terrain, sled ski, recover snowmobiles, perform rescues, deliver supplies and explosives, and for general travel.

Regulations

WSBC OHS G4.1.1 Avalanche, G8.12 Helmets, [16.4, 16.51-55, 16.34 (1)-(3) Vehicle]

Definitions

Tandem operation

- **Side by side** –the practice of riding a snowmobile where two operators each ride standing on one running board while sharing control of the snow machine
- **Two up** – The traditional means for two people ride a snowmobile. One operator drives while the passenger sits on the passenger seat.

Footwell – The fore most part of the running board, usually into the engine cowl

Fogpole – A bamboo marker on a snow road for delineation in poor visibility

Piste – Snowroad

Skiff – trailer for snowmobile

Dry bag – Watertight PVC bag

Hazards

Unqualified operator, Asked to perform tasks beyond skills, Unfamiliar with machine, Getting lost, No one aware of location, Coms Failure, Avalanche hazard, Glacier hazard, Weather hazards, Road Hazards, Buried Hazards, Explosives Hazards, Running out of fuel, Running out of oil, Damaged machine, Snowmobile overheating, Vehicle movement upon starting (stuck throttle), Malfunctioning brakes, Worn Belt, Snowmobile frozen to ground, Ice and snow blown and frozen to machine, Traveling alone, Traveling after dark, Excessive speed, Changing Snow Conditions, Falling off machine, Getting stuck, Run away machine, Strain injuries, Run away sled, Sled breakdown, Unfamiliar terrain, Collision with objects or other road users, Roll over, Foot stuck in footwell, Locking brakes while descending, Skis/Gear on rack interfering with operation/ contacting snow, Flipping over while reversing, being thrown into throttle, Increased fall hazard, Less control, Getting caught in system, Heavy load , Inadequately secured load, Fire, Hitch failure, Trailer rollover, Unsecure load, Excess load, Further damage to machine, Collision between Snowmobiles, Pinch points.

Scope

The following procedures have been developed specifically for safe operation of mountain snowmobiles; characterized by powerful engines, long tracks and single seat design.

Preparation

Training

- Training session with mechanic on vehicle inspection
- Complete training and assessment with supervisor which include but are not limited to:

  - PPE
  - SOP
  - Operating Skills
  - Basic Mechanical
  - Loading and unloading
  - Towing
  - Tandem Operation
- Ongoing mountain sled training with experienced riders in safe terrain
- Operators will not undertake tasks beyond skills

Pre plan

- Plan your route according to conditions
- Is the mission necessary in inclement condition
- Discuss road conditions with cat operators and cross shift
- Check weather forecast
- Consider working in a team
- Consider alternate means of transport
- Discuss Avalanche hazard and plan route to minimize exposure
- Inform dispatch of route
- If weather dictates stick to Fog Pole/Marked Roads
- Establish check in procedures and provide a rough route plan to work partner and dispatch that will includes checking in upon leaving camp, travel route, arrival at destination, hourly check-ins (or less), leaving destination and return to camp

Pre-operation

- Follow pre-operation snowmobile inspection checklist
- Follow recommended vehicle servicing (marked on side of sled)

Requirements

- Snowmobile
- PPE
- Avalanche Travel Kit
- Glacier Gear
- Appropriate clothing, footwear, eye, and ear protection
- Appropriate helmet
- Fully charged radio

Job Step

Snowmobile Travel

- DOT helmet >20kph or irregular terrain (off piste)
- CSA or Ski Helmet for <20kph with no significant risk of rollover is acceptable
- Wear safety tether
- Avoid travel on haul and camp roads where possible
- When in camp or on haul road call your location and destination over appropriate radio channel
- Follow best practices for travel in avalanche terrain

- No snowmobiling on or near avalanche slopes during night shift
- In poor visibility stick to marked roads
- Be aware of the snow conditions you are traveling on (ice, frozen lake, dry roads, deep powder, wet snow and compensate accordingly
- Travel at a speed that is safe for the conditions and your riding ability
- Be aware of possible hazards, both manmade and natural that can develop on cat roads and off piste
- At night use a powerful head lamp to supplement the sled light especially in powder conditions
- Pump brakes and use throttle (to engage clutch) to decelerate when descending steep hills
- Stay seated while reversing
- Take road banks and junctions straight on, not at an angle, especially when there is a height difference from one to another
- Before merging onto KM 71.5 from VOK road announce on LAD2 and R 1 location and check for conflicts (blind spot)
- When practicable use snow road at 71.5-72
- If snowmobile is not running properly, tag out and contact mechanics
- If breakdown occurs, contact heavy shop and arrange transport
- If machine becomes stuck and unmanageable call for assistance
- Monitor engine temperature and dip in to soft snow if getting warm, scratchers down, snow chunks on tunnel or stop to cool machine

Traveling with a load

- Be aware if increased dimensions with gear/skis attached
- Secure load

Tandem Operations

- Side by side tandem operation is only acceptable method on mountain sled
- Two up operation for snowmobiles with passenger seats (environmental)
- Proper speed and operation
- Good communication between operators
- Throttle operator is in charge of steering
- Both feet on the rails

Transporting Explosives

- Attach detonator box with 2 BC fire extinguishers and placards
- Manage speed to load and snow conditions
- Secure load as close to seat as possible
- 2 snowmobiles where possible
- 2 bag MAX limit on tunnel
    - Stacked as close to seat as possible
    - Consider removing rack
- Limit operations to cat roads as much as practicable
- Follow explosive fire safety plan
- Drive to conditions
- Consider skiff
- Dry-bags or box

- Anticipate control work and have snowcat drivers maintain roads
- No transport during an electrical storm
- Consider using snowcat to transport
- No tandem operation while carrying explosives

Towing

- Use back up strap
- Secure load
- Drive at appropriate speeds
- Use limited to conditions
- Consider Snow Cat
- Mechanic
- Tow from control arm
- Remove belt
- Operator on both machines
- Take most direct/flat route to road access
- Call yourself back into camp
- Follow check in plan

Post operation

- Clean snow from machine
- Fuel up (Jerry cans, Spill tray, Spill Kit)
- Add oil if required
- Inside storage or covers
- Lock out, Tag out if not serviceable
- Incident report
- Submit pre-op sheets to Supervisor who will sign and deliver to Maintenance Planners

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
JOHSC Co-chair or Member			

Appendix C.3

BJ-AVL-SOP-003 – Ski Cutting

PRETIVM		BJ-AVL-SOP-003 Ski Cutting	
Owner: Mountain Safety	Approver: Joe Nicholson or Ken Black	Revision Number: 1.0	Creation Date: 17/11/04 Revision Date:

Rational

Ski Cutting will be used to test surface instabilities while travelling through avalanche terrain as well as control small, low consequence features where explosive control is not practical.

Regulations

WSBC G4.1.1 Avalanche Assessment, G8.11(2) Helmets

Definitions

Companion Rescue – Immediate, improvised avalanche rescue

Companion Rescue Equipment – Transceiver, Shovel, Probe

Slope History – History of snowpack and previous avalanche control

InReach – Satellite Communications devise

GIS Tools – Geographic Information System software, e.g. Google earth, GPS devices, online maps

Scope

These procedures will apply to all Mountain Safety personnel as well as all workers in the affected terrain below.

Hazards

Potential avalanche involvement; terrain traps; inherent risk of skiing; potential avalanche involvement for both team members; injury; congested radio; failure to locate victim if buried in an avalanche, resulting in inability to perform companion rescue; failing batteries; damaged equipment or injured workers; potential avalanche involvement for single team member; partner loses site of person on the slope; loss of equipment; multi burial; larger than anticipated results with road open.

Preparation

Tools

- PPE
- Radio, (optional InReach as well)
- Skis
- Avalanche Companion Rescue Equipment
- First aid Kit
- Snow Study Kit
- Skins
- Snowmobile/Snowcat
- Helmet (CSA or Ski)
- Rescue Toboggans

Requirements

- Prior assessment of ski skills by Mountain Safety Supervisor/Lead Hand
- Training including review of SOP, practical training and assessment

Job Step

- Determine if ski cutting is the appropriate method of terrain management
  - Minimal risk exposure to achieve objectives.
  - Knowledge of terrain specifics, current avalanche hazard and slope history.
  - Use explosives if high degree of uncertainty, if ski cutting may result in triggering an avalanche size 2 or greater, or if terrain traps present a hazard.
  - Discuss as a team and decide best method of avalanche control.
  - Check weather and conditions
  - Discuss goals and hazards.
  - Ski to conditions.
- Make a plan and communicate with partners and dispatch. Visualize terrain and discuss plan to link safe zones throughout the terrain.
  - Avoid working in the terrain if unfamiliar and the visibility is obscured.
  - Get multiple views of the terrain from different angles to properly assess if safe zones are actually safe.
  - Identify any potential terrain traps and likely spots where avalanches may be triggered.
  - Discuss hazards such as terrain management, shallow snowpack areas, buried rocks and cliffs.
  - Review slope history.
  - Use GIS tools.
  - Build intimacy with the terrain by regularly skiing it during periods of reduced hazard.
  - Potential designated channel.
  - Establish Check in procedure with dispatch and/or team members
- Perform a proper avalanche transceiver check prior to traveling in any avalanche terrain.
  - Buddy check for all equipment prior to leaving office.
  - Daily battery checks ,
  - Training .
- Ensure zone of affect is controlled.
  - Put out closure lines, use guards if required.
  - Follow guarding and sweep JHA .
  - Spotter .
  - Illuminate slope if after dark.
- Ski cut the slope
  - Visualize route from top of the slope.
  - Maintain visual contact with partner at all times.
  - Collect on slope data .
  - Ski from safe spot to safe spot.
  - Use test features.
  - Move through terrain one at a time limiting exposure.
  - If conditions do not match assessment abort plan.

- Use releasable bindings.
- Use qualified individuals to ski cut.
- Frequent equipment inspections.
- Appropriate rescue gear for evacuations.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.4

BJ-AVL-SOP-004 – Nighttime Avalanche Control

PRETIVM		BJ-AVL-SOP-004 Night time Avalanche Control	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.2	Creation Date: 17/11/06 Revision Date: 17/12/29

Objective/Rational

At times of elevated Avalanche Hazard it is sometimes deemed necessary to perform avalanche control after dark. This is in opposition to closing the road which introduces several alternate hazards such as difficult/lengthy emergency egress from the mine site and the associated work stoppages. This will generally only be achieved by case charging targets on the road or by using Gazex cannons. If overhead hazard is deemed too high or unable to achieve desired results, road closures will be implemented.

Regulations

WSBC G4.1.1 Avalanche assessment and planning; OHSR Part 21 Blasting; Health, Safety and Reclamation Code for Mines in BC Section 8.1-8.6, 8.8-8.10 Blasting

Definitions

- **Night Time** –Civil twilight, the apex of the sun is 6° below the horizon
- **Gazex** – A fixed propane and oxygen exploder for avalanche control
- **SFA** – Safety Fuse Assembly, pre-built fuse and detonator
- **Terrain Trap** – A terrain feature that magnifies consequences of an avalanche
- **Hang-Fire Avalanche** – Snow remaining in an avalanche start zone post release
- **Hang Fire Explosive** – a charge that detonates in unplanned delayed manner

Affected Departments

Mountain Safety, Surface Operations, Logistics, Roof Shovelers

Hazards

Poor visibility due to darkness, snow and/or cloud; underestimating potential avalanche hazard to the site; potential closure of Lakeshore Drive if/when upper targets have not been controlled by day shift or due to snow cat unavailability, major storm or impassable control roads; incoming night time Av-Techs at shift exchange are a subjective hazard due to circadian rhythm offsets; fatigue; logistical delays and slowdowns; excessive radio traffic; cognitive overload, (making mistakes that have been previously identified & avoided); buried electrical lines; proximity to buildings ; damaged equipment, infrastructure or injured workers; overhead hazard; sympathetic avalanches; poor communication between personnel and stakeholders; personnel at risk still in the blast area; darkness and poor visibility; avalanche burial, injury or death for personnel; incorrectly priming the explosive ; mixing up SFA lengths or miscalculating the burn time; avalanche burial in vehicle, injury to personnel; damage to vehicle; slow rescue response due to rescue personnel being off duty/asleep; no Dispatcher or Supervisors at Knipple Camp; terrain traps; slope could fail and bury personnel, the truck, and primed charge; avalanche burial, injury or death for personnel; terrain traps from lack of snow removal on outside edge of road; primed explosives ; miss-lights ; DUDS; burns; flying debris; un-exploded ordnance; hang-fire

Preparation

Tools

- PPE
- Radio
- Harness

- Avalanche Rescue Gear
- Lighting
- Bamboo
- Vehicle (snowmobile, truck, snowcat)
- Gazex tablet, antenna. charger

Requirements

- Licensed Blaster
- Site explosives training including Night Time AC SOP
- Pre blast considerations SOP
- Explosives Checklist
- Snowcat

Job Step

- Blasting in and around camp for **maintenance** purposes will be restricted to between 0300h-0900h and 1500h-2100h
    - Jacks slopes/VOK need to be clear at 0500 and 1700 for underground blast
- LSD upper targets can only be controlled at night with snowcat and competent operator support.
    - Claim cornice 50kg is ideal shot. Summit road targets should not be used.
    - Road is pushed in first
        - Mountain Safety should accompany to assess overhead hazard
    - Early communication with Surface Operations to ensure night shift snowcat driver is available and well rested
    - Only used if absolutely necessary (storm or program gets away from us), day shift should still support upper targets
    - Mandatory discussion with day shift
- Identify the avalanche and weather hazards for the specific terrain above the site at that time
    - Knowledge of current conditions, recorded weather information and forecast
    - Illuminate work area
    - Good information hand off from day shift
    - Good communication with other technician on duty
    - Review slope history and GIS information
    - Day shift prioritizing overhead hazard slopes to allow for safe night time case charging
    - Good planning for cross shift coverage. Possible hotel rooms should be planned to avoid unsafe driving.
    - Abort mission if hazard is undetermined or too high
    - Good self-assessment of fatigue
    - PPE check
- Notify Dispatch and stakeholders (Dispatch, Logistics, Surface Operations, TVL, Operators, and Shuttle Drivers)
- Print and follow Avalanche Control Checklist
    - Adhere to Pretivm Blasting Procedures
    - Appropriate quantity of explosives (see: Pre-Blast Considerations SOP)

    - Review updated cables and pipelines map
- Ensure the Danger Zone and Zone of Effect are closed off to traffic, swept and guarded
    - Follow Sweep and Guarding JHA
    - Ensure closure zone encapsulates possible sympathetic avalanches
- Blaster visually sweeps the Danger Area, confirms closure with guards, and notifies Dispatch by radio that avalanche control is commencing
    - Radio communications must have confirmation between parties
    - Working light plants staged at strategic locations & high power flashlights
- Assemble explosives at pre-determined locations prior to entering exposed section of road
    - Limit exposure time for team in avalanche terrain.
    - Follow Avalanche control blasting procedures.
    - Minimum length of fuse is 2m for case charging.
- Access the area the safest way possible.
    - Stay in vehicle, no unnecessary stopping in avalanche terrain
    - Visualize terrain from safe zone
    - Adequate lighting in place to aid in assessment of the terrain
    - Good communications with Dispatch & frequent check-ins
    - Abort mission if overhead hazard is undetermined or too high
    - Consider placing the vehicle on the outside lane away from the slopes.
    - Ensure Surface Operations consistently builds and maintains snow roads for avalanche control (72km, Claim High, Summit Drive, Jack Slopes summit, VOK bypass, and Pilsner bypass)
    - Adequate catchment clearing and snow removal during periods of LOW hazard.
    - A visual of the slopes should be maintained by the passenger.
- Placement of the explosive in relation to the path being controlled
    - Place the explosives as far from the slope as practicable
    - Consider placing the truck between the slope and the explosives placement/AvTech
    - Only one Av tech will get out of the vehicle if practical. Driver will remain in the vehicle unless needed to hold tripod.
- Initiating explosive
    - Assemble explosives in a safe location as per SOP and safe handling techniques
    - Wear glove on grip hand
    - Have a pre-defined egress route.
    - Take time on stopwatch
    - If DUD or Mislight follow DUD disposal procedure
    - Retreat to magazine side of closure to potentially deal with DUD
- Once blasting mission is complete and Danger Area is clear, Blaster contacts closure personnel and hands road responsibility over to Surface Operations for road-clearing procedures (see Debris and Catchment Clearing SOP). Assess area prior to allowing full entry.
    - Visual inspection of the area to ensure all explosives have discharged
    - Reassess potential overhead hazard
    - More control work
    - If remaining hazard is undetermined or too high close the road

- Consider keeping the road closed longer for post control releases (weather inputs, rain)
- Consider having a loader act as a pilot car with convey spacing behind to flush traffic

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
JOHSC Co-chair or Member			

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Appendix C.5

BJ-AVL-SOP-005 – Guarding and Sweeping

PRETIVM		BJ-AVL-SOP-005 Guarding and Sweeping	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.0	Creation Date: 17/11/06 Revision Date:

Objective/Rational

To maintain a safe working environment and access roads, avalanche control will need to be performed on various slopes. It is necessary to control the zone of effect so as to minimize the risk to workers during active blasting or possibly ski cutting. Guards will be used to control access and a sweep vehicle will be employed to make sure the area is clear.

Regulations

WSBC G4.1.1 Avalanche planning, HSRMBC 4.9 Mobile equipment

Definitions

Guard – A worker in a vehicle or equipment used to physically block the road

Ski cutting – a means of testing and breaking up of surface instabilities. It involves having a Mountain Safety Technician skiing on slope

Sweep – Physical check of the danger area

Avalanche Gate – Fixed rope and signage barrier

Danger Area – entire area affected by blasting and subsequent hazards, includes fly rock and avalanches

Natural avalanche – An avalanche that is triggered without human intervention

Affected Departments

Mountain Safety, Safety, Surface Operations, Logistics, all vehicle traffic, Warehouse/Shipping and receiving, Shuttles

Hazards

Untimely length of closure due to communication and resource limitations; untrained staff are used; team not understanding plan; untimely length of closure due to communication and resource limitations; guards in wrong location leading to possible close proximity to explosives and / or potential involvement with avalanche; natural avalanche occurrence blocks the road; guards are potentially taken from important work leading to inefficiency; guards let traffic through; communications failure; natural avalanche occurrence blocks the road or strikes the sweep vehicle; vehicles/people left in blast area; untimely length of closure; explosives; post control release; traffic moving before directed.

Preparation

Tools

- PPE
- Avalanche PPE
- Radio
- Heavy Equipment
- Truck

- Closure Gates
- Closure map
- Binoculars
- Lighting

Requirements

- Pre-Blast Considerations SOP
- Avalanche Control Checklist

Job Step

- When planning a blast, Mountain Safety contacts Surface Operations Supervisor and Dispatch. Mountain Safety will provide estimated timeline and request resources (guards, sweep, and equipment). (Ideally 12h CONTROL FLASH). 0600 and 1700 Night shift
    - Mountain Safety will confirm with Surface Operations Supervisor of safe locations for guards, and time road needs to be closed and swept.
    - Prior training
    - Communication
    - Reference Avalanche Safety Plan (ASP), and closure gate maps (attached).
    - Dispatch will monitor radio for irregularities.
- Supervisor will relay plan to trained closure team
    - Surface Operations Supervisor will complete pre-work safety meeting and JHA with closure personnel prior to work.
    - Supervisor will review steps of the job, locations, gate closure map, closure limitations and communications plan with team.
    - Reference ASP and closure gate maps (attached).
    - Ensure all team members have been trained on SOP
    - Supervisor will ensure workers have been trained in, are wearing, and check avalanche PPE.
- Guards and Sweep will head to their location prior to the closure time (on que of 30 minute Blast warning), close the gates and block the road. All traffic entering the control area will be stopped.
    - Supervisor will review steps of the job, locations, gate closure map and good communications plan with team and ensure understanding.
    - Contact Mountain Safety if any changes to plan are to be made.
    - Once they are in place and the road is blocked they will inform the sweeper on the radio. **"I am in position and the road is blocked"**
- The Sweep will travel from the first guard to the second guard. They will check every possible side road, worksite and building in the closure area, and make sure everyone is out of the Danger Area.
    - Sweep vehicle will not stop in exposed avalanche terrain and will travel on outside edge of the road.
    - Contact Mountain Safety if natural avalanche is observed
    - Sweeper needs to be familiar with all areas and ensure they are empty of staff
    - All staff to follow avalanche training provided in indoctrination
    - Catchments maintained
    - Windows opened

- In times of elevated avalanche hazard Mountain safety will sweep the road.
  - Once they reach the second guard they will call Mountain Safety and inform them that the **"Area has been swept and all guards are in place"**

- Mountain Safety will contact dispatch and avalanche control will commence.
  - Inform dispatch that **"The area has been cleared and swept and guards are in place"** Dispatch will repeat this back to Mountain Safety.
  - Follow Blasting Procedures
- Once avalanche control is complete Mountain Safety will assess hazard and hand over control of the road to surface operations (see avalanche debris and catchment clearing SOP).
  - Mountain Safety to assess results before releasing guards
  - More control work
  - Extended closure
  - Road operators will inform dispatch when road is open and what traffic direction, or both can be released first

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.6

BJ-AVL-SOP-006 – Field Trip on Skis

PRETIVM		BJ-AVL-SOP-006 Field Trip on Skis	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.0	Creation Date: 17/11/07 Revision Date:

Objective/Rational

Often times, travel on skis is the most effective way to collect snowpack information. It is also useful for terrain assessments, terrain familiarization/professional development, supporting the environmental program, and is the accepted avalanche industry standard for moving in the mountains.

Regulations

WSBC G4.1.1 Avalanche Assessment, G8.11 (2) Helmets

Definitions

InReach – Satellite and GPS communication devise

PWL – Persistent Weak Layer in the Snowpack

InfoEx – Online avalanche information exchange platform and hazard assessment tool

Companion rescue PPE – Transceiver, shovel and probe

Affected Departments

Mountain Safety, Safety, Logistics

Preparation

Tools

- PPE
- Companion Rescue PPE
- Radio
- Releasable Bindings
- Skins
- Saw
- Snow Study Kit
- InReach
- First Aid Kit
- Shelter/Tarp
- Rope
- Glacier Gear
- Snowmobile

Requirements

- Min CAA ITP 2 training (consider taking team member with higher level of training [ACMG/IFMGA] to supervise)
- Understand scope and rational for field trip

Hazards

Missing a weather component or poor objective for the conditions; dispatch doesn't receive communication therefore unable to initiate rescue response; equipment is not in working order or not in an organized kit; poor radio communications; avalanche involvement; falling; natural hazards (creeks, rocks, alders, tree wells); inherent risks of skiing; underestimating PWL's and other avalanche problems; lost gear; malfunctioning gear; communications; fail to check in in timely fashion put others at risk; driving home; fatigue.

Job Step

- Check weather and conditions, CAA/Avalanche Hazard Rating, InfoEX nearest neighbours history and hazard rating.
    - Discuss goal, avalanche and mountain hazards and determine best trip objective
- Do a hazard assessment using the InfoEx terrain module
- Fill out route plan and email Field Trip Report to Dispatch and other Av Techs on site
    - Call dispatch or receive email confirmation and confirm with other Av Techs on site.
- Assemble all applicable equipment and companion rescue PPE for the task.
    - Buddy check for all equipment prior to leaving office.
    - Perform safety and operational checks.
    - Spot beacon
- Travel to field trip area and check in with dispatch prior to commencing ski tour
    - Follow SOP Standard Road Procedures, JHA's for snowcat, snowmobile or helicopter.
    - Make sure dispatch copies radio transmission, and establish check in time interval.
    - Turn InReach on and into tracking mode
- Traveling on Skis
    - Gather relevant snowpack info with minimal exposure to hazards.
    - Ski one at a time, in control, with spotter
    - Ski to conditions and ability
    - Avoid working in the terrain if the visibility is obscured.
    - Get multiple views of the terrain from different angles to properly assess safe zones
    - Identify any potential terrain traps and likely spots where avalanches may be triggered.
    - Plan route accordingly
    - Use InReach tracker (dispatch and other team members have access to weblink)
    - Continue to reassess snow and weather conditions in relation to terrain and adjust the route accordingly or abort plan.
    - Follow SOP for Ski cutting
- Check in with dispatch at scheduled intervals and at end of trip
    - Check in with dispatch once arriving back.
    - Half hour after missed check in initiate IRP
    - InReach can be used for OK
    - If communications failure, abort trip and check in
- Concluding field trip
    - Properly put away your PPE.
    - Stretch and rehydrate.

- Debrief
- Drive to conditions

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
JOHSC Co-chair or Member			

Appendix C.7

BJ-AVL-SOP-007 – Avalanche Debris Clearing

PRETIVM		BJ-AVL-SOP-007 Avalanche Debris Clearing	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.0	Creation Date: 17/11/07 Revision Date: 17/11/22

Objective/Rational

After avalanche control is completed or a natural avalanche cycle, avalanche debris will need to be cleared and if safe to do so, the road reopened.

Regulations

WSBC G4.1.1 Avalanche Assessment, HSRC 4.6 Mobile Equipment

Definitions

Companion Rescue PPE – Transceiver, shovel, and probe

Danger Area – Area of potential negative effects from explosives control; includes avalanche and fly rock.

Slope History – a record of all control work and observations for that piece of terrain for the current season.

Affected Departments

Mountain Safety, All

Preparation

Tools

- PPE
- Companion Rescue PPE
- Lighting
- Heavy Equipment

Requirements

- Understanding of SOP

Hazards

Un-exploded ordnance; post control avalanches; underestimating the remaining avalanche hazard; weather factors; lack of radio communications; loss of control zone; vehicle collisions; damaged equipment; injured workers; backed up traffic in avalanche areas; logistical delays and extended closure; cognitive overload, making mistakes that have been previously identified; extended exposure to overhead hazards; getting stuck; collisions; too narrow single lane; improper vehicle spacing; logistical delays, road blockage; vehicles stopped in avalanche areas; contact between snow removal equipment and traffic; vehicle collisions.

Job Step

- Mountain Safety ensure blasting mission is complete and Danger Area is clear of explosives.
  - Visual inspection of the area to ensure all explosives have discharged
  - Previous slope history
  - Further control work
  - Use of trained spotters
- Mountain Safety will assess the remaining avalanche and weather hazards for the road clearing crew.
  - Slope history (explosives use and avalanche occurrences)
  - Determine forecast and current weather influence on hazard trend
    - Use of spotter if deemed necessary
  - Further control work
  - Extended closure if hazard is unmanageable or high degree of uncertainty
  - Lighting
- If required, Mountain Safety will communicate Avalanche hazard update to Dispatch
- Mountain Safety will hand over control of the road to Surface Operations.
  - Road status. Road remains closed for deposit clearing, or open to traffic
  - Approx. time for debris clearing communicated to dispatch
  - Ensure that if equipment operator leaves guard position another guard is designated
  - Gates remain closed
  - Contact Mountain Safety if post control activity is observed
- Surface Operations will provide a **spotter** (watching for further avalanches from a predetermined safe location) or second operator if deemed necessary by AvTechs and ensure road is effectively closed off to traffic.
  - Work in teams of two
  - Maintain closure gates and take over guard duty for clearing if necessary
  - Establish secure radio channel and understand emergency egress paths
  - Spotter will have visual of avalanche terrain above crew clearing debris
  - No spotter will leave before confirming with their team and AvTechs
- Surface Operations will follow site specific check in and out procedures with Dispatch. Dispatch will update stakeholders.
  - Working knowledge and job specific training for working in avalanche terrain
  - Good communications
- Surface Operations will provide competent operators and adhere to safe machinery operating procedures.
  - JHA, SOP's
  - Clearly defined roads
  - Maintain catchments and banks
- Surface Operations will remove enough snow to create a single lane of traffic at a minimum.
  - Operator has control of the road and relays to dispatch road opening plan
  - No stopping in avalanche terrain
  - Widest practicable single lane (outside lane)
- Once the single lane is open the operator will coordinate with dispatch/designate regarding traffic control until adequate clearing is done to allow two way traffic.
  - Radio communication

    - Manage traffic approaching single lane
    - No stopping in avalanche terrain
    - Working knowledge and job specific training for working in avalanche terrain
    - Adequate snow clearing
    - 300m convoy spacing
    - Remain in vehicle and contact Av tech if post control issues prevent passage
    - Close road if post control avalanche activity is unmanageable.
- At times a loader may act as pace car to lead convoy spaced traffic through intermittent closures.
- Operator contacts dispatch to notify when two lanes open. Normal operation resumes as per hazard rating.
    - Monitor slope, weather and hazard
    - Follow SOP Standard Road Procedures
    - No stopping in avalanche terrain
- Mountain Safety Personnel will monitor radio traffic and note clean up times for single lane opening and insert into Pretivm Explosives Summary

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.8

BJ-AVL-SOP-008 – Avalanche Hazard Communication

PRETIVM		BJ-AVL-SOP-008 Avalanche Hazard Communication	
Owner: Jim Franken/Ken Black	Approver: Joe Nicholson	Revision Number: 1.0	Creation Date: 17/11/08 Revision Date:

Objective

To standardize avalanche hazard communications and how hazard rating changes are passed on for safe work procedures.

Health, Safety & Reclamation Code of BC

WSBC G4.1.1 Avalanche Planning

Definitions

Hazard Boards – Large boards with sliders indicating the hazard in specific zones

Run List – A specific list of terrain features with associated hazard levels, work procedures or work tasks. It is used as an internal form of hazard assessment and communication.

InfoEX – The Canadian Avalanche Association's online hazard assessment tool.

Affected Departments

Mountain Safety, Logistics, All Departments

Preparation

Tools

- Radio
- E-mail
- Hazard Board
- Hazard Bulletin
- Avalanche Bulletin Board next to kitchen

Job Step

- Every morning Mountain Safety produces a Daily Avalanche Hazard Bulletin by using information from various sources and analyzes it to evaluate and forecast avalanche hazard using the Canadian Avalanche Association's Conceptual Model for Avalanche Hazard.
    - Hazard is valid for 24hrs unless a 'Hazard bulletin update' is issued
- Mountain Safety will distribute a 'Run List' to relevant Supervisors and Operators via the InfoEX
- Mountain Safety distributes the Daily Avalanche Hazard Bulletin by email.
    - In the **BCC line** to the email group 'All Users – Brucejack Hazard'
    - From the mountainsafety@pretivm.com email address
    - The NERDS will manage 'ALL' Pretivm email sub-groups
    - Mountain Safety will manage 'Hazard Non-Pretivm' email list
- Supervisors will print off the Hazard bulletin and post it in an area where all workers have access to it.
- The Daily Avalanche Hazard Bulletin form is printed and posted on the Avalanche Bulletin Board in the Surface Operations bootroom, across from the new kitchen in Civeo camp (new camp) at the mine site, and in the boot room in Knipple camp.

- Mountain Safety will update 3 of the large hazard boards to reflect the most up to date rating. Wildfire gate security will update the large Hazard Board at wildfire. Each Board rates the local hazard as well as on the roads between it and the next sign.
    - At the mine site the board is located beneath the mill building conveyer attached to the support structure.
        - Zone A – Camp, Zone B - Lakeshore Drive Km 71.6-74, Zone C - VOK Road and Control Roads, Zone F – Knipple Corner Exit Km 56-59.5
    - Knipple camp has 2 boards, both located across from the fire hall above the incinerator fence. One board is clearly marked for the uphill traffic to Brucejack and the second is for downhill traffic to Wildfire.
        - To Brucejack -, Zone F – Knipple Corner Exit Km 56-59.5, Zone B - Lakeshore Drive Km 71.6-74, Zone A – Brucejack Camp
        - To Wildfire - Zone G – Scott Creek to Bowser Km 37-56, Zone H – Wildfire to Scott Creek Km 3-37,Wildfire Hill Km 2-3
    - Wildfires board is located on the gatehouse as you enter the haul road
        - Zone G – Wildfire Hill Km 2-3, Wildfire to Scott Creek Km 3-37, Zone H –, Scott Creek to Bowser Km 37-56,
- Supervisors are responsible to ensure that all staff working in avalanche terrain are aware of the current avalanche hazard and the associated safe work procedures; however, workers are still responsible for their personal safety.
    - Workers are made aware of how to access avalanche hazard information in Camp orientation and annual avalanche procedures training
    - See SOP - Standard Road Procedures
- Throughout the operational period the hazard may increase or decrease based on the current weather inputs (wind, temperature, snowfall…) or avalanche control being conducted. If a change in hazard level occurs Mountain Safety will make an announcement over the radio on the repeater and the local road channel.
    - "All stations, all stations this is an avalanche hazard update. The avalanche hazard in zone __ has increased/decreased to_____"
    - This is broadcast on Repeater 1 and Ladd2 in Brucejack camp and on Repeater 2 and Pretivm Road Channel in Knipple camp and below
    - Dispatch then repeats the message over the repeater channel
    - Hazards Updates should ideally be made in the business day (no later than 6pm) so that on shift supervisors can plan night duties accordingly
- At the next practicable moment, Mountain Safety will update the Hazard Bulletin with an email titled 'Hazard Update' and also update the Hazard Boards. This may take some time depending on the nature of the hazard and associated workload.
    - Emailed in the **BCC line** to: 'All Users – Brucejack Hazard'
- Supervisors and workers will ensure that they adjust their work to comply with the Avalanche Hazard Safe Work Procedures.
- Supervisors will contact Mountain Safety to request permission to continue working in avalanche terrain in hazard zones rated moderate and considerable.
- In the event that there are IT disruptions, a radio call will be made by Mountain Safety broadcasting the current hazard rating at 0600h and again at 0700h followed up by the email blast once internet connection is regained.
- To have contractor staff added to the Brucejack email lists please contact mountainsafety@pretivm.com

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.9

BJ-AVL-SOP-009 – Pre-Blast Considerations

PRETIVM		BJ-AVL-SOP-009 Pre-Blast Considerations	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.0	Creation Date: 17/10/15 Revision Date: 18/01/09

Objective

To clarify and standardize all pre blasting procedures.

Regulations

WSBC G4.1.1 Avalanche Assessment, G21.66 Control of a blast zone, G21.71Returning to the blast site

Affected Departments

Mountain Safety, Safety, Surface Operations, All Departments

Definitions

- **Danger Area** - the area potentially affected by the blast concussion, resulting avalanche or fly rock.
- **Blaster of Record** - the supervising blaster

Preparation

Hazards

- Avalanche
- Explosives
- Vehicle/Equipment/ Snowcat interactions
- Transmission line

Tools

- Crimpers
- Explosives
- Pull wire igniters
- SFAs
- Truck/Heli/Snowcat
- Gazex Tablet
- Closure Gates
- Lighting

Requirements

- Avalanche Control Checklist for relevant Zone
- Pretivm Blasting Procedures
- SOP Guarding and Sweeping
- SOP Avalanche Closure Procedures
- TDG shipping document
- Blasting ticket
- HSRC of BC Part 8 Blasting
- TDG ticket

- Avalanche Hazards Utilities Map (Avalanche Hazard Zoning for Mine Site Area)

Job Step

- Blasting in and around camp for maintenance purposes will be restricted to between 0300h-0900h and 1500h-2100h
    - Jacks slopes/VOK need to be clear at 0500 and 1700 for underground blast
- Blaster of Record identifies the blasting Danger Area and communicates planned avalanche control with the use of explosives with an "AVALANCHE CONTROL FLASH" email to appropriate email groups.
    - Email from mountainsafety@pretivm.com
    - Email addresses in **BCC** line
    - Estimated time, closure points, zones, expected closure time.
    - If practicable email "AVALANCHE CONTROL FLASH" update at 0600h or 1800h ideally 24hrs before, on the shift prior.
    - Morning Hazard Bulletin will include above information if practicable.
- Ensure NOTAM has been issued and is up to date
    - Process is under Explosives\NOTAM
    - Avalanche Technician Supervisor/Lead Hand to Maintain
- Plan and review control mission, fill out the Avalanche Control Checklist for Avalanche control. If control is within ZONE A Brucejack Camp review the Avalanche Hazards Utilities Map to ensure you are not placing charges on surface utilities.
    - Blast Quantities
        - No more than 12.5kg charge detonating at once near camp structures (think V.O.K., Jack Slopes, Low Grade)
    - Helicopter missions
        - Shots will not be delivered to both sides of the transmission line at once
        - Zone G, H, and F pre sweep for goats – *Reference: Pretivm Goat Management Plan*
            - If hazard is elevated and goats are observed in the control area, inform Mine Manger and Dispatch and leave the area CLOSED until they vacate the area or as instructed by the Mine Manager.
        - Quantity of product (Load/Fuel, Jettison)
        - Guard for product left at heli pad
- Follow Pretivm Blasting Procedures.
    - TDG requirements
        - Placards/Signs
        - Shipping Documents
- Broadcast an estimated one hour blast warning over the appropriate radio channel(s), incl. Repeater, LAD 2, and Pretium, "All stations, all stations this is a one hour blast warning for avalanche control on (***Lakeshore drive).***"
- Supervisors will start to plan to remove workers and vehicles from affected zones 30min prior to blast.
- All workers should be clear of affected area 15min prior to blast.
- When practical, prior to commencing explosive avalanche control, update Dispatch with the number of charges and estimated time of closure.
- Conveyance of explosives must follow TDG regulations under both the Health Safety and Reclamation Code for Mines in British Columbia, WCB and Transport Canada.

- Close, Guard and Sweep all areas as per SOP Guarding and Sweeping, SOP Avalanche Closure Procedures.
- Once the closure is in place, Blaster of Record radio broadcasts to Dispatch, "The road/area at (location) is swept, closed and guards are in place for avalanche control blasting". Receive confirmation from Dispatch that they copy.
- Once control commences, provide a 2.5,5 or 7 minute blast warning (depending on length of fuse) for each blast.
- If controlling above the Contractor offices issue an additional 1 minute warning prior to the charge detonation.

Avalanche Control with Explosives Above / Upslope of Structures

- Guards must sweep all buildings and open windows, ensuring all workers and vehicles are out of the Danger Area during the blast.
- Gates must be closed with guards in place.
- Restrict explosive quantity to minimize damage to structures.
    - Jack Slopes 12.5kg
    - High Grade and Low Grade 12.5kg
    - Face Cut 6kg
- If possible to achieve similar results it is preferable to use several small shots with different timings rather than larger bags.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.10

BJ-AVL-SOP-010 – Avalanche Closure Procedures

PRETIVM		BJ-AVL-SOP-010 Avalanche Closure Procedures	
Owner: Ken Black/Jim Franken	Approver: Joe Nicholson	Revision Number: 1.0	Creation Date: 17/10/15 Revision Date: 18/01/08

Objective/Rational

Temporary road and worksite closures are an important avalanche risk reduction tools during times of elevated hazard or during avalanche control. Worker access is restricted until such time as the hazard is reduced, either by natural snow stabilization, or by artificial means (which may include the use of explosives, ski or snowmobile slope cutting, cornice control, or heavy equipment).

Regulations

WSBC G4.1.1, G21.66, G21.71, HSRC 8.6.2

Definitions

See J:\Mountain Safety\Avalanche Safety Plan\Avalanche Definitions.doc for a list of Avalanche Technical Language.

Affected Departments

Mountain Safety, Safety, Surface Operations, Logistics, All Departments

Preparation

Hazards

- Avalanche
- Explosives
- Heavy equipment
- Traffic

Tools

- Closure gates
- Heavy Equipment
- Hazard Bulletin
- Radio

Requirements

- BJ-AVL-SOP-005 Guarding and Sweeping
- Gates Map

Job Step

- Some micro avalanche terrain features are permanently signed with 'avalanche closed' signs
    - Workers wishing to access the slope will contact Mountain Safety for a Worksite Avalanche Assessment
- With as much notice as possible, Avalanche Technicians will communicate the timing and location of worksite or haul road closures.
- All staff are notified of the closure by email Hazard bulletin update and/or by radio communication through Dispatch.
    - Mountain Safety or Designate will close any relevant gates

  - Workers wishing to access snow roads and micro terrain behind gates will contact Mountain Safety
- During active avalanche control, the closure area is swept and guarded as per Guarding and Sweeping SOP and gates may be closed
- Closures for high avalanche hazard without control may be swept or may rely on check out check in procedures as well as worker accounting.
- For blasting operations follow and complete Avalanche Control Checklist
- Operators inform Dispatch when the avalanche debris has been cleared and the road or worksite is open.
- On completion of control Mountain Safety reassess hazard area and will hand over control of the road and worksite to Surface Operations.
- Guards to remove any physical barriers once debris is cleared.
- If extended closures are expected Mountain Safety will advise the Surface Operations Supervisor, TVL, Mine Manger, Road Superintendent, and Dispatch to the specifics so they are able to alter work procedures, update travel plans and positon equipment and resources accordingly for snow clearing.
- Surface Operations and TVL are responsible for providing personnel and equipment to assist with the closure.
- Closure gates will be used during periods of elevated avalanche hazard and typically requires various means of support; guards, sweep vehicles, and standby road clearing equipment.
- Guards may be used in place of, or in conjunction with closure gates.
- The only personnel allowed into avalanche closures are Mountain Safety and equipment operators working under Mountain Safety supervision.
- All personnel working in the closure area need to be under direct Mountain Safety supervision, be wearing and trained how to use companion rescue equipment, and follow relevant SOP (Avalanche Debris Clearing SOP, Guarding and Sweeping SOP).

Special Wildfire Hill Considerations

- Contact Wildfire Camp Supervisor prior to storm events, reminding them to monitor 25cm threshold snow board for potential closure at 2km.
- Knipple Avalanche Technicians will advise of potential closure and should be in contact with Wildfire camp and Dispatch.

Zone A gates map can be found in:

J:\Mountain Safety\Maps and Photos\Camp maps and photos

Closure Points:

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.11

BJ-AVL-SOP-011 – Communications for Snow Removal and Road Maintenance in Avalanche Areas

PRETIVM		BJ-AVL-SOP-011 Communications for Snow Removal and Road Maintenance in Avalanche Areas	
Owner: Ken Black/ Jim Franken	Approver: Jeff Stewart/ Chris Homister	Revision Number: 1.0	Creation Date: March 5, 2018 Revision Date:

Objective/Rationale

To establish and follow a systematic method of communication and supervision to safely and efficiently maintain snow in avalanche areas on the main access road.

Regulations

- WSBC G4.1.1 Avalanche Assessment, G4.1.2 (c) Avalanche Planning
- HSRC Part 1.11.1 Training, 2.2 Hazards, 3.3.1 Hazardous Work, 6.1.1 Qualified Persons
- WCB 3.12 Refusal of Unsafe Work

Definitions

Qualified Person: means person who, in the opinion of the mine manager, is

(a) Qualified because the persons knowledge, training and experience to design, organize, supervise and perform the duties for which the person is appointed,
(b) Familiar with the provisions of this Act, the code and the regulations that apply to the duties for which the person is appointed, and
(c) Capable of identifying any potential or actual danger to health or safety in the workplace;

Supervisor: means a person who instructs, directs or controls workers in the performance of their duties and who is authorized by the manager to take or recommend disciplinary action against workers;

Worker: a person who is an employee but does not include a supervisor

Workplace: a place where work is carried out in, on or about the mine.

Standard Road Maintenance: Any work in avalanche areas will follow Hazard Specific Safe Work Procedures document.

Normal Winter Operation Procedures: Any work on the access road itself. No work on the uphill side of the access road in avalanche areas without direction from your supervisor in consultation with Mountain Safety.

Hang fire: remaining avalanche hazard on slope after control or uphill maintenance work, potentially causing a secondary avalanche

Workers right to refuse unsafe work: The right to refuse work. The Occupational Health and Safety Act (OHSA) gives a worker the right to refuse work that he or she believes is unsafe to himself/ herself or another worker. A worker who believes that he or she is endangered by workplace violence may also refuse work.

Affected Departments

Mountain Safety, Surface Operations, Road Maintenance Contractor, All other departments travelling the road

Preparation

Hazards

Undetonated explosives; post control avalanches; underestimating the remaining avalanche hazard; triggering an avalanche from below, removing the toe support of the slope (snow cone); rock fall; weather factors; lack of radio communications; unsecure work area; damaged equipment; injured workers; backed up traffic in avalanche areas; logistical delays and extended closure; cognitive overload, making mistakes that have been previously identified; extended exposure to overhead hazards; getting stuck in avalanche terrain; collisions; too narrow single lane; inadequate machine for the task; mechanical failure in avalanche terrain; inadequate vehicle spacing; logistical delays, road blockage; vehicles stopped in avalanche areas; contact between snow removal equipment and traffic; blind corners; vehicle collisions; hang fire.

Tools

- Lighting
- Avalanche Companion Rescue PPE
- Loader
- Excavator
- Snowcat
- Grader
- Radios
- Pylons and hazard identifiers

Requirements

- 17-18 Avalanche Safety Plan
- BJ-AVL-SOP-001 - Worksite Avalanche Assessments
- BJ-AVL-SOP-004 - Night Time Avalanche Control
- BJ-AVL-SOP-005 - Guarding and Sweeping
- BJ-AVL-SOP-007 - Avalanche Debris Removal
- BJ-AVL-SOP-008 - Avalanche Hazard Communication
- BJ-AVL-SOP-010 - Avalanche Closure Procedures
- SOP Standard Road Procedures
- SOP Working Alone or in High Risk Remote Locations
- SOP - Extreme Weather Conditions 2016 01 31
- Hazard Specific Safe Work Procedures
- Preseason Avalanche training and Companion Rescue

Job Step

Attend morning and / or evening tool box meeting with Supervisor and Mountain Safety

- Prior to TVL Operators leaving camp they check in with TVL Supervisor at Brucejack to see if there are any weather advisories or worksite restrictions. If there are any weather advisories in affect a worksite avalanche assessment must be carried out prior to work. The assessment will be carried out when safe to do so.
- TVL Supervisor at Brucejack to review twice daily emails from Mountain Safety outlining site specific requests for maintenance work outside normal winter operations procedures.
- Mountain Safety will communicate a general overview of the current Avalanche Hazard, forecast weather, potential avalanche control and revisit any work tasks outside of normal winter operations procedures with TVL Supervisors at the tool box meetings
- TVL Supervisor at Brucejack will communicate 'line up' to workers ensuring they understand their tasks, ensure workers follow surface operations SOPs and they follow associated Hazard Specific Safe Work Procedures. Work will not commence until hazards to associated tasks have been identified.
- Workers will turn on their avalanche transceivers, carry out a function check and ensure all PPE is in safe working condition.
- Initiate FLHA with current hazard and worksite restrictions

Mountain Safety will:

- Contact Avalanche Supervisor or lead hand prior to directing surface operations supervisor
- Communicate with supervisor who in turn will direct workers
- Provide hazard updates
- Carry out Worksite Avalanche Assessments
- Identify and mark hazards with pylons, snow berms etc.
- Follow SOPs relevant to working in avalanche terrain

TVL Supervisors will ensure Workers are:

- Working under their supervision and following normal winter operation procedures
- Qualified worker and equipment is adequate for the task.
- Signed off on associated surface operations SOPs.
- Wearing appropriate PPE
- Filling out FLHAs and adhering to the necessary control measures
- Checking in when avalanche communication hazard updates and or weather advisories are broadcast. Adjusting work as outline by hazard specific procedures
- Will ensure workers are following hazard specific safe work procedures
- Requesting JHAs be built for tasks outside SOPs
- Calling in any natural avalanche activity that the worker observes and that they are removing themselves from the hazard prior to a reassessment from Mountain Safety

Workers will:

- Meet with TVL supervisor at Brucejack prior to commencing work
- Check in with Dispatch every hour and or as directed.
- Read and sign off on all SOPs prior to working in avalanche terrain. If there is no SOP for the task, workers will contact their supervisor and draft a JHA prior to carrying out the work.
- Sign off on all associated surface operations SOPs pertaining to their job tasks.
- Carry out Pre Ops in designated safe areas.
- Fill out FLHA and update prior to each new task.
- Park pickups and extra equipment in designated safe areas.
- Listen to designated road channel for work area and monitor the repeater.
- Listen for avalanche hazard updates, adjust work as per the Hazard Specific Safe Work Procedures
- Follow all SOPs relevant to working in avalanche terrain
- Ensure parked equipment, potentially affected, will be moved or windows opened during explosive avalanche control.
- Call in any natural avalanche activity that the worker observes and that they move to a designated safe are, away from the hazard. Wait for a reassessment and direction from Mountain Safety and Supervisor prior to commencing work

Work outside Normal Winter Operations Procedures

- Workers will contact TVL supervisor at Brucejack prior to performing any work outside of normal winter operations procedures.
- TVL Supervisors at Brucejack will consult with the Avalanche Supervisor or lead hand prior to preforming any work outside of normal winter operations
- Avalanche Supervisor or lead hand will instruct mountain safety to carry out an avalanche worksite assessment prior to the task being carried out.
- TVL Supervisor at Brucejack will ensure worker is qualified for the task, equipment is adequate and worker is following appropriate surface operations SOP or JHA prior to starting work and sign off on the updated FLHA.

PRETIVM

AVALANCHE FORECASTS AND SAFE WORK PROCEDURES

AVALANCHE FORECAST	DEFINITION	ACTION TAKEN BY CONTRACTOR OR SURFACE OPERATIONS
LOW	Avalanches are unlikely. OR Small avalanches are possible, but are expected to terminate far above the access road	When the Avalanche Forecast is "LOW" the Contractor and or Surface Operations may proceed with normal winter operation procedures. The Contractor or Surface Operations will: • Contact Mountain Safety prior to removing snow from avalanche catchment areas • Avalanche PPE is required for all 'rated' avalanche terrain, including low hazard • Maintain previously announced road closures to allow for avalanche patrols and for the removal of snow and/or deposits from the access roads
MODERATE	Small avalanches are probable but are expected to terminate above the access road. AND/OR Large avalanches are possible, but are expected to terminate far above the access road.	When the Avalanche Forecast is "MODERATE" the Contractor and or Surface Operations will: • Notify Avalanche Technician if there is a change in weather, such as, increased wind speed, rise of temperature and/or increased snowfall intensity • Notify Avalanche Technician immediately after observing NEW avalanche occurrences • Contact Mountain Safety prior to any personnel working outside of vehicles within avalanche areas • Ensure there is no equipment working outside of the access road within avalanche areas • Take interval weather and/or avalanche occurrence observations, as requested by the Avalanche Technician • Be prepared for road closures/delays, as a result of unexpected natural avalanche activity on the access road or explosives avalanche control, as requested by the Avalanche Technician • Maintain previously announced road closures to allow for avalanche patrols and for the removal of snow and/or deposits from the access road (stationary or mobile equipment okay for deposit removal)
CONSIDERABLE	Small avalanches may affect the access road. AND/OR Large avalanches are probable, but are expected to terminate above the access road. AND/OR Snow dust events may affect the access road.	When the Avalanche Forecast is "CONSIDERABLE" the Contractor and or Surface Operations will: • Notify Avalanche Technician if there is a change in weather, such as, increased wind speed, rise of temperature and/or increased snowfall intensity • Notify Avalanche Technician immediately after observing NEW avalanche occurrences • Ensure there are no personnel working outside of vehicles within avalanche areas • Ensure there is no equipment working outside of the access road within avalanche areas • Ensure there is no stationary equipment working within avalanche area • Contact Mountain Safety for HIGH PRIORITY work inside avalanche terrain • Ensure safety of personnel by performing one of the following: o Radio call-in when entering and exiting avalanche areas* o Radio call-in at least every 30 minutes* o Plow in tandem (second vehicle may be a pick-up or another plow truck) * The person receiving the radio call may or may not be working in avalanche areas, but must be available 100% of the forecast time period • Take interval weather and/or avalanche occurrence observations, as requested by the Avalanche Technician • Be prepared for road closures/delays, as a result of unexpected natural avalanche activity on the access road or explosives avalanche control, as requested by the Avalanche Technician • Maintain previously announced road closures to allow for avalanche patrols and for the removal of snow and/or deposits from the access road (mobile equipment only for deposit removal) • Convoy spacing of 300m between vehicles when travelling through avalanche areas.
HIGH	Numerous small avalanches are expected to affect the access road. AND/OR One or more large avalanches are expected to affect the access road.	When the Avalanche Forecast is "HIGH" the Contractor and or Surface Operations will: • Close and sweep the access road between Standard Closure Locations (as determined by the Avalanche Technician) using Standard Closure Procedures • Ensure there is no equipment or personnel working within the avalanche closure area except for: o Sweep vehicles o Avalanche Program vehicles and personnel o Snow maintenance equipment, provided they operate in safe areas and do not enter avalanche hazard areas (as determined by the Avalanche Technician) * * This is possible because many Standard Closure Locations are located outside of avalanche hazard boundary locations • Take interval weather observations from weather stations with safe access, as requested by the Avalanche Technician
EXTREME	Numerous, large avalanches are expected to affect the access road.	When the Avalanche Forecast is "EXTREME" the Contractor and or Surface Operations will: • Close and sweep the access road between Standard Closure Locations (as determined by the Avalanche Technician) using Standard Closure Procedures • Ensure there is no equipment or personnel working within the avalanche closure area • Take interval weather observations from weather stations with safe access, as requested by the Avalanche Technician.

Avalanche Deposit Removal

If the Avalanche Technician determines that conditions are safe, the Contractor may be instructed to commence avalanche deposit removal from specific locations where avalanches have affected the access road, even though adjacent avalanche areas may be rated at different forecast levels.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety Supervisor	[redacted]		
Health and Safety Manager/ Designate			
Surface Operations Supervisor			
Access Road Superintendent			
Logistics			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.12

BJ-AVL-SOP-012 – Repeater Egress on Skis

PRETIVM		BJ-AVL-SOP-012 Repeater Egress on Skis	
Owner: Ken Black	Approver: Joe Nicholson	Revision Number: 1.1	Creation Date: 18/01/15 Revision Date: 18/01/25

Objective

Regular site visits to the repeater stations by Mountain Safety are necessary to maintain and repair project radio communication and internet. Due to the remote mountaintop locations and the unpredictability of local weather it may become necessary to descend on skis to a lower elevation pick up.

Scope

Descending from the repeaters is to be viewed as a last resort measure. It is a response to unforeseen and unpredictable changes in weather. Go/No Go decisions are to be made following the Repeater Access Go/No Go Flow Chart, which will act as a guideline and support tool in the planning stages and execution of the mission.

This SOP covers the safest egress routes on skis from each repeater site. They have been developed using the avalanche industry's best practices for travelling through mountain terrain.

Health, Safety & Reclamation Code of BC

- WSBC G4.1.1 Avalanche Assessment, G8.11 (2) Helmets

Definitions

- Avalanche Terrain Exposure Scale (ATES) Definitions:
  - SIMPLE: Exposure to low angle or primarily forested terrain. Some forest openings may involve the runout zones of infrequent avalanches. Many options to reduce or eliminate exposure. No glacier travel.
  - CHALLENGING: Exposure to well defined avalanche paths, starting zones or terrain traps; options exist to reduce or eliminate exposure with careful route-finding. Glacier travel is straightforward but crevasse hazards may exist.
  - COMPLEX: Exposure to multiple overlapping avalanche paths or large expanses of steep, open terrain; multiple avalanche starting zones and terrain traps below; minimal options to reduce exposure. Complicated glacier travel with extensive crevasse bands or icefalls.

Preparation

Hazards

- Potential avalanche involvement; terrain traps; inherent risk of skiing (injury); crevasses; severe weather exposure/ hypothermia; loss of communication; dehydration; lack of adequate food supply; wild animal encounters; risks of helicopter use ; overnighting at lower elevations without proper gear.

Tools

- Avalanche PPE/Rescue equipment (Transceiver with batteries >50%, shovel, probe, backpack, helmet)
- Outdoor clothing, spare gloves and mid layers
- Radio, InReach satellite communication device with charged battery
- Minimum one external USB battery charger
- Cell phone with preloaded mapping applications
- Skis, ski boots, poles, climbing skins
- Glacier Rescue gear (harness, rope, rope grab/ascension device, carabiners)
- Saw

- Gas Detector
- First Aid kit
- Emergency tarp/rescue toboggan
- Bamboo markers
- Helicopter landing stakes

Requirements

- Knowledge of route by all members of the party; on-the-ground familiarity of the route by the route leader
- Communication with pilot of possible pickup locations and methods of communication if no or limited radio contact (VIH, Dispatch relay, email Dispatch with InReach)
- Route marked with high pickup(s) staked
- Route studied and discussed before landing at repeater site
- Avalanche conditions favorable for selected route
- Training, including review of SOP, practical training and assessment

Repeaters

JABBA (BRUCEJACK) REPEATER

Jabba repeater sits at 7800ft/2377m just SW of the rounded, semi-glaciated summit of Jabba Peak, NNE of Brucejack camp.

TERRAIN AND ATES RATINGS: 2 options work through CHALLENGING glaciated terrain – one to the SE, the other to the west. COMPLEX terrain prevails in all other directions

KNIPPLE REPEATER

Knipple repeater is on a small sub-peak off the Mt. Jankowski massif at approx. 5900ft/1800m.

TERRAIN AND ATES RATINGS: High ground to the NW and a lower angled bowl to the W is the safest egress option through SIMPLE (upper third) and CHALLENGING terrain. A high pickup at treeline would keep the exposure minimal through mostly SIMPLE terrain. The east side of the peak is COMPLEX avalanche terrain, with numerous start zones to the NE and a large bowl-shaped start zone for a path that runs to the valley floor. To the west is also complex avalanche terrain with numerous overlapping paths that converge in the main drainage

WILDFIRE REPEATER

Wildfire repeater is on a ridgeline that runs from generally N to S at 5100ft/1550m.

TERRAIN AND ATES RATINGS: The North and East sides of the sub-peak are CHALLENGING to COMPLEX terrain with steep corniced start zones. The main ridge to the SE becomes a narrow exposed corniced ridge and is not an option. To the west is CHALLENGING avalanche terrain with no options to avoid exposure. A route exists through largely simple terrain with a few short steeper sections.

SHORTY REPEATER

Shorty repeater sits at 6500ft/1980m on a prominent NE-SW running glaciated ridge between deep valleys.

TERRAIN AND ATES RATINGS: COMPLEX terrain in all directions, with a dropping traverse route through CHALLENGING glaciated terrain immediately to the NW.

Job steps

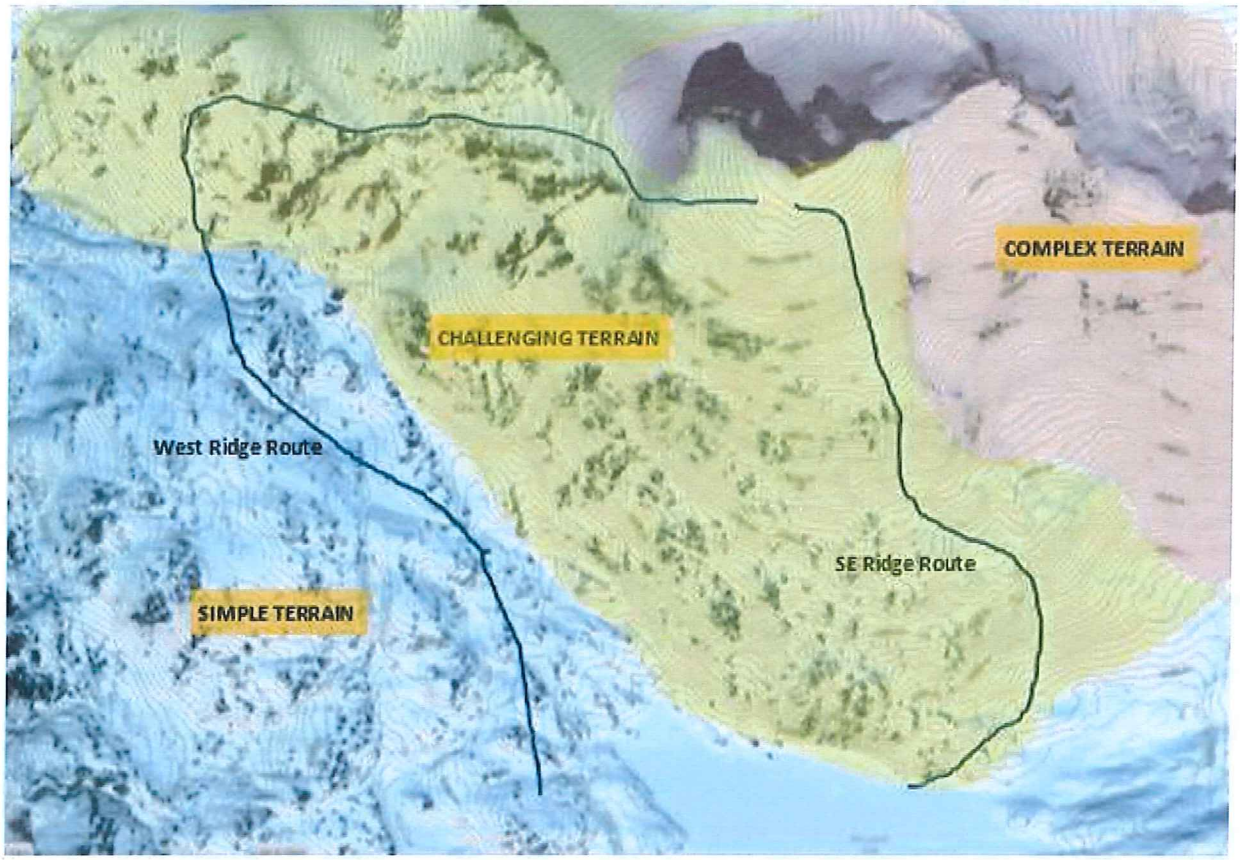
- Use Repeater Access Go/No Go Flowchart to determine when access is appropriate
- Once on site be efficient with tasks to limit chance of bivouac
- Continuously monitor weather while on site for any deterioration
- Leave immediately if un-flyable weather approaches
- Descend on skis/foot for pickup only if safe, prepared and pickup is assured, otherwise shelter in place and wait for conditions to improve

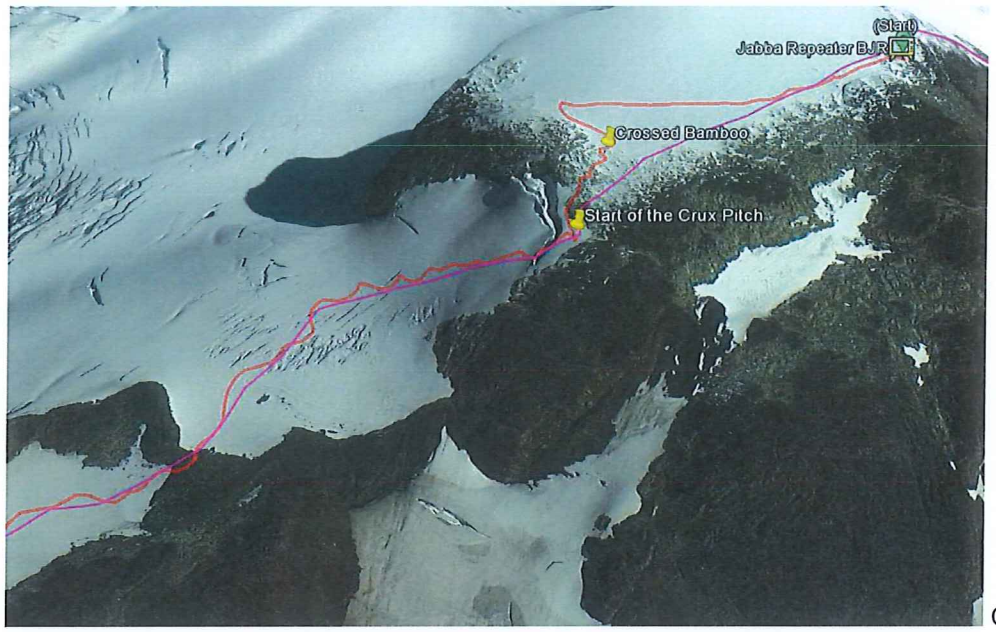
JABBA (BRUCEJACK) REPEATER EGRESS ROUTES

OPTION 1: Travel due west from the repeater to a steep glaciated roll just to the North (right) of the ridge proper, several hundred metres down from the repeater. A short, committing diagonal NW descent through the skier's left of this feature finds lower angled terrain on the glacier. If unskiable, use the exposed rocks on the left to travel/handrail through the steep section (caution bergschrund on pitch.) Follow to the WNW into a broad gully feature that ends with a short descent to the SW. From here continue west across a bench in the terrain to access the final slopes that descend to the SW to flat ground several km N of camp. Numerous options exist for this final pitch, including following the ridgeline further to the NW before wrapping around on lower angled terrain to reach the flats to the S.

OPTION 2: Requires some visibility and a relatively low avalanche hazard. From the repeater traverse a short ways to the E to find the fall-line route that avoids the more exposed, glaciated terrain further to the E (left). Work through various gullies with numerous options, following a SSW fall-line descent. When the angle eases take a slightly more E (left) line to avoid a bench feature, then follow fall-line to the flats NE of Brucejack Lake.

ATES Overview





Option 1

Option 2

KNIPPLE REPEATER EGRESS ROUTES

OPTION 1: If helicopter is able to fly to treeline, this is the safest and least exposed option. Start by descending north on open slopes to approx. 5200ft/1600m, taking care to keep distance from the cornice to the east (right). Continue in the same general direction across a bench and climb slightly to gain a broad undulating ridge that descends NW initially then turns back to the north. Follow the high ground (will require some uphill travel if unsure of traversing across slopes) to a small saddle below a sparsely treed knob. A helicopter LZ has been cut here on a small high point which allows visibility from the forest to the valley floor.

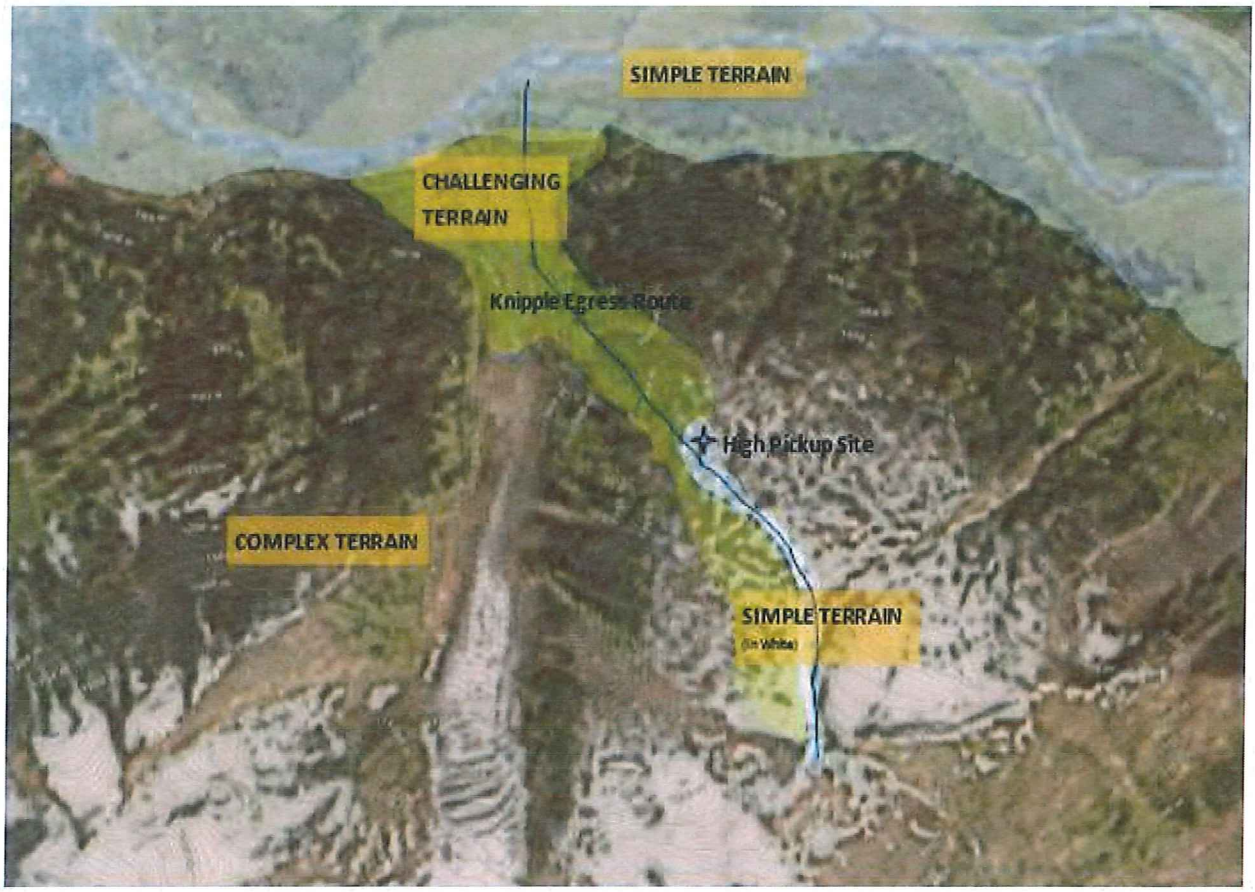
OPTION 2: As per above, then to continue to valley bottom. It will be necessary to work numerous small slopes and side-hills on the right-hand side that may require some ski cuts and micro terrain management.

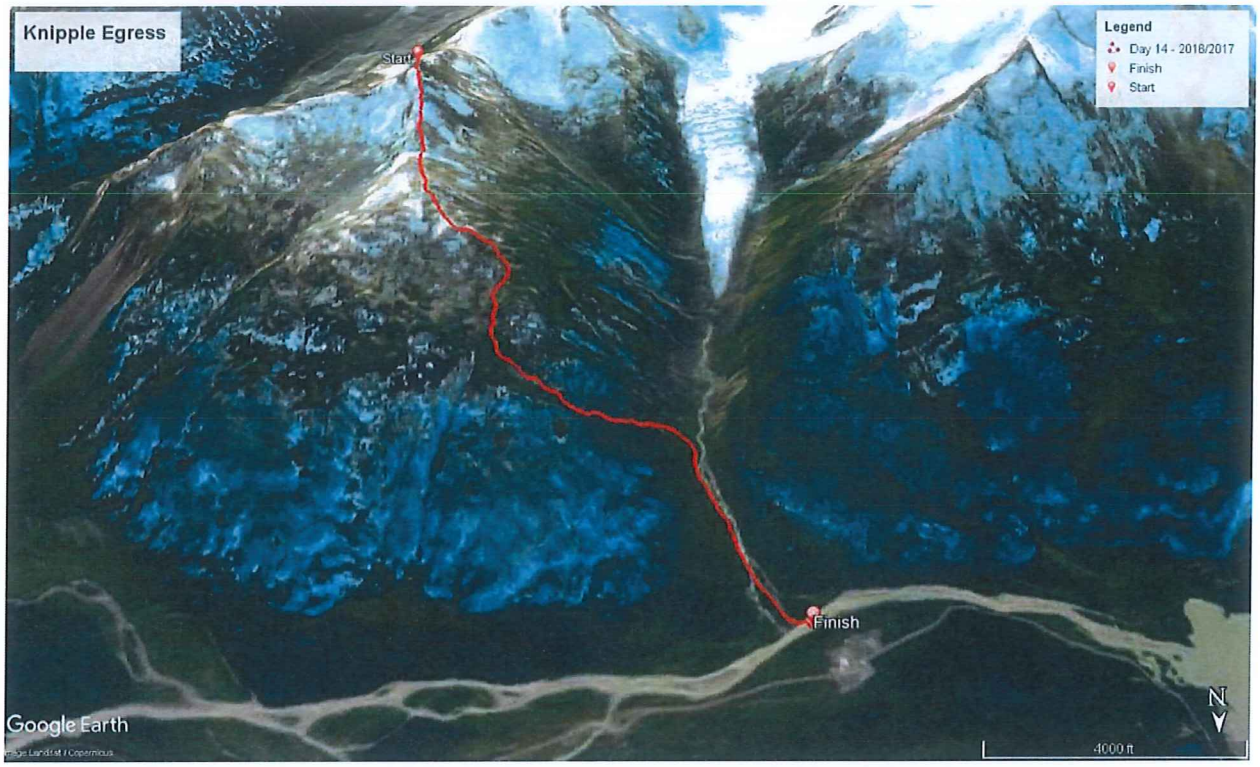
This will take you to approx. 3700ft/1100m where you will look for a gully system going west. The gully system is steep and sometimes tight and difficult in early season with open creek holes and unsupported pillows to consider. Descend 1300ft to another gully formed by an old faint lateral moraine that parallels the main creek. Follow this to the valley floor or climb over and descend short steep slopes into the main creek.

It is important to note that the lower half of this egress is continuously steep and has significant early season hazards and thick alder. This area would be difficult/impossible to enact a rescue other than from a HETS system.

OPTION 3: The bowl to the West. This would require good visibility and a low avalanche hazard level as it travels through Complex terrain. The route is straightforward: a descent to the WNW for 1.5 km brings you to a steep sidewall at approx. 3500ft./1050m . This short slope brings you to the main creek bottom which you follow to the NNW and the Bowser River with lots of potential pickup spots enroute. While the overall ski route is not that steep, the exposure from both sides is largely continuous as you descend, with minimal views of the overhead.

ATES Overview




Knipple Egress
Legend
Day 14 - 2016/2017
Finish
Start
Start
Finish
Google Earth
N
4000 ft

WILDFIRE REPEATER EGRESS ROUTE

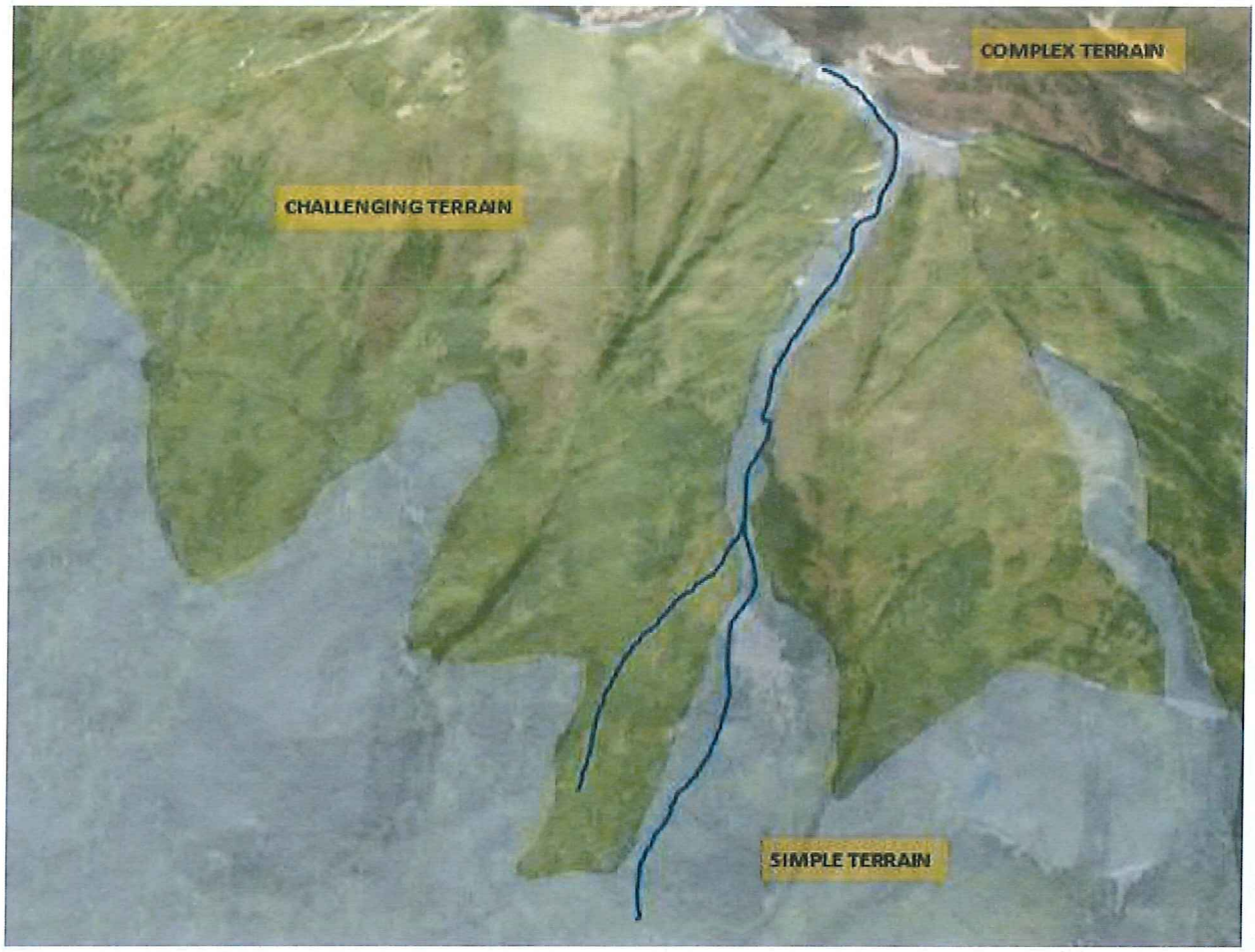
Descend the ridge proper to the SE for 250m (brief uphill section - vertical drop of only 30-40m) then follow a spur ridge to the SW.

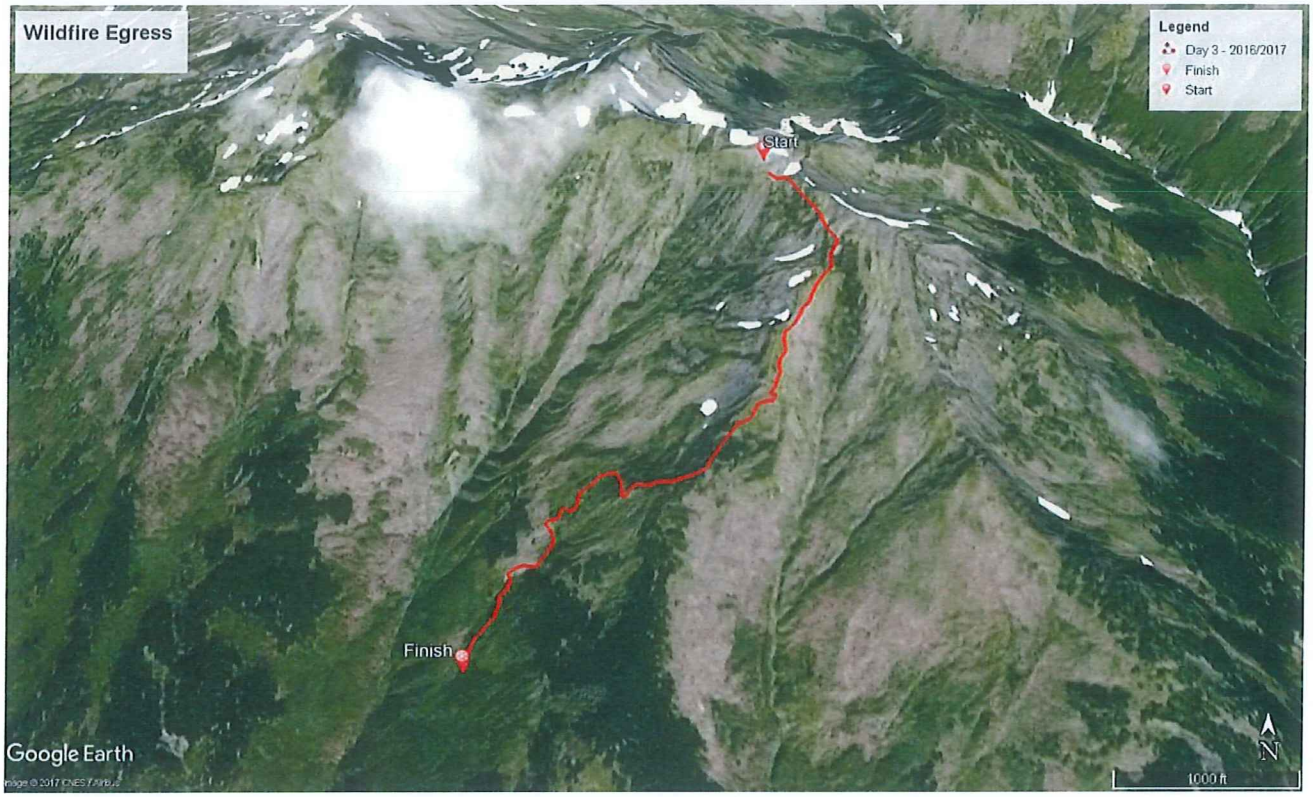
Caution initially required with a cornice to the East (left) and start zones to the West (right.)

Once on the Spur ridge at 5000 Ft./1500m, the high ground of the ridge should be maintained while descending to minimize hazard from avalanche slopes on either side until into the sparse trees at approx. 4300ft./1300m. From this point you can descend the SW side of the Spur ridge through mostly protected Simple terrain with increasing vegetation and small glades to pickup locations that will start to be available around 3400ft./1000m. Be cautious to avoid moving too far to the West (right), which would expose you to the SW bowl and steep-sided gully immediately below the repeater.

If no high pick up is available with a helicopter then continuing in a Southerly direction through low angled terrain (logging roads exist) for 3-3.5 kilometres will bring you to the Stewart - Cassiar Highway.

ATES Overview

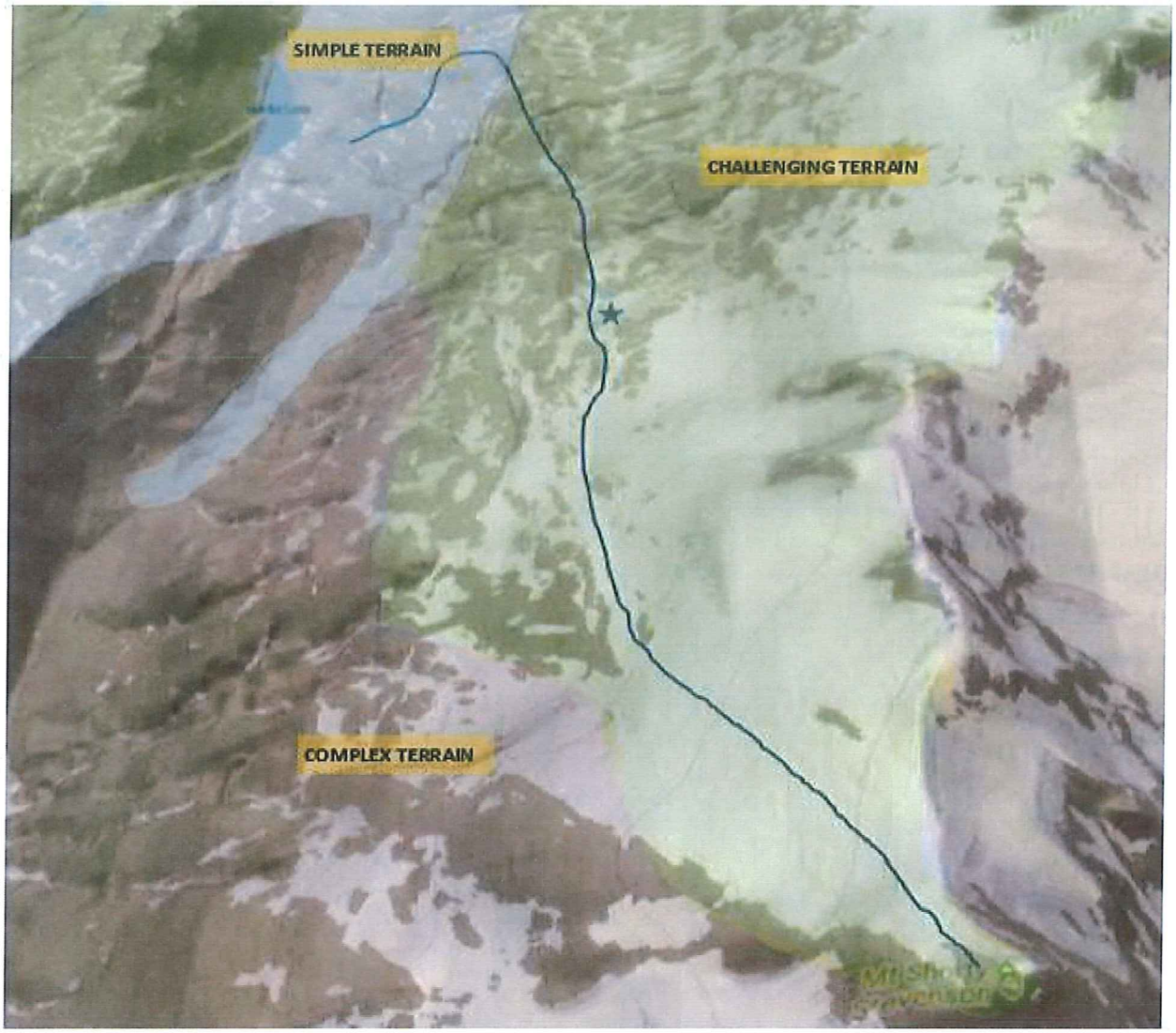


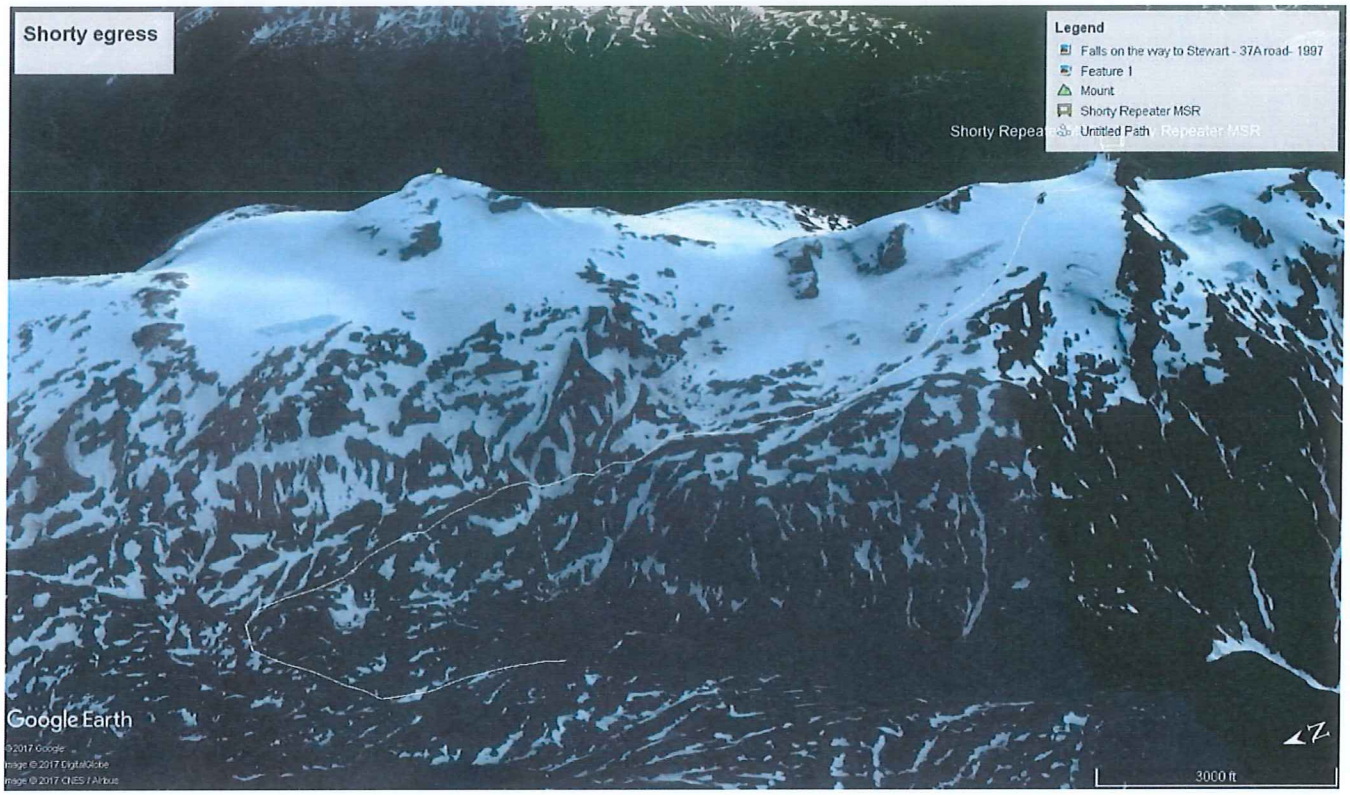

Wildfire Egress
Legend
Day 3 - 2016/2017
Finish
Start
Start
Finish
Google Earth
N
1000 ft

SHORTY REPEATER EGRESS ROUTE:

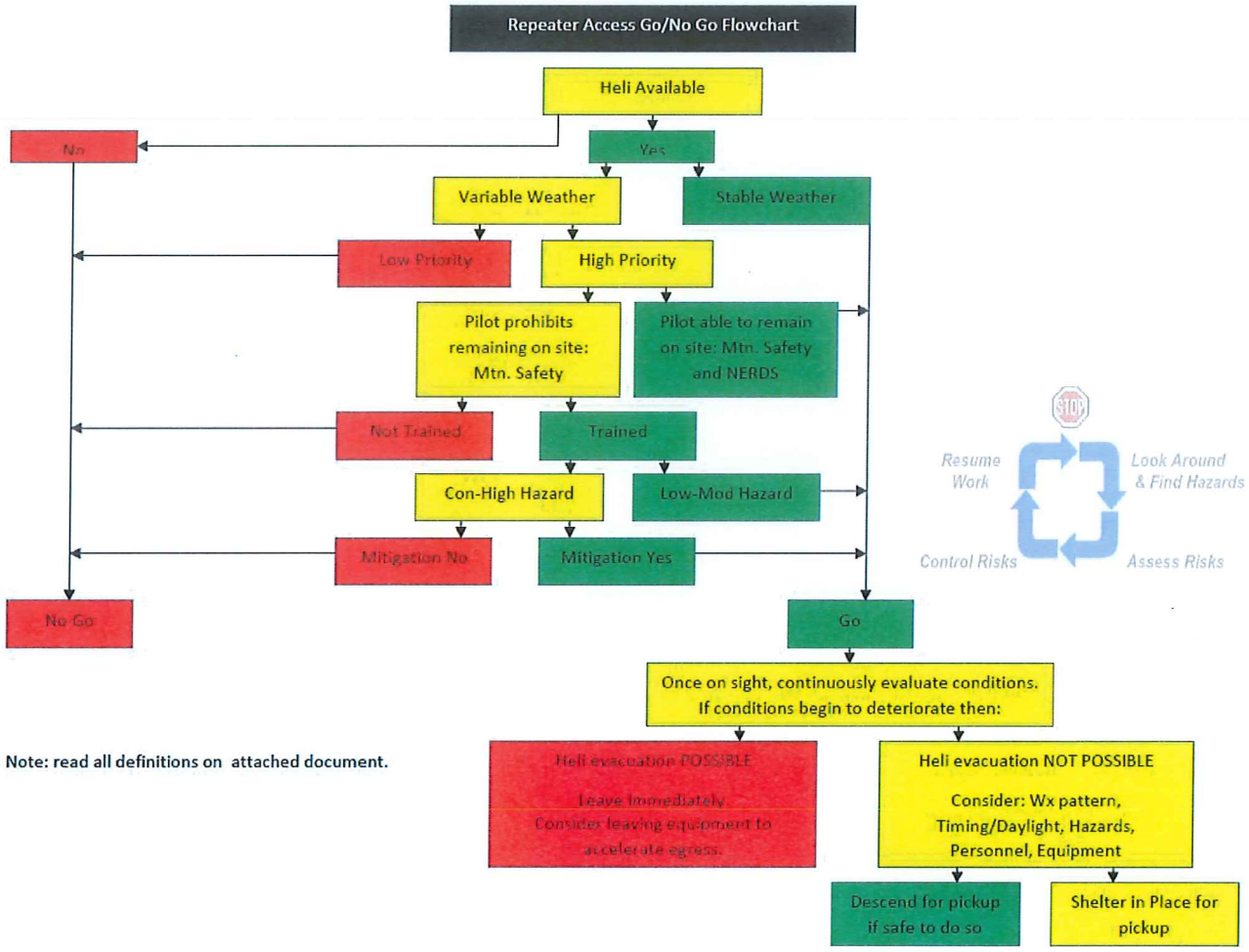
Low avalanche hazard and glacier safety precautions required for this egress. Travel on the ridge a short distance to the NNW and continue on this line to descend the skier's left flank of a large bowl. Minimize exposure to steep headwalls to the E (right) and work through rolling terrain towards a bench at 4800ft/1460m. High pickup site here (bring heli stakes if planning on pick up here). From here continue the line of traverse below a large steep slope, or to turn to the West (left) and find a more fall-line route through steep rolling semi-forested (still Challenging) terrain. Numerous pickup areas exist in the valley, and if needed the Premier Mine complex is within reach several km's down the valley, due W of the repeater site at approx. 200m elevation. Late in the season and with Low avalanche hazard follow the first drainage below the egress route to the SW until the service road is reached. In elevated hazard and/or earlier season conditions, continue on the NW-trending route toward the Western shore of Long Lake, then follow the road down (SSW) to the Premier mine camp.

ATES Overview




Shorty egress
Legend
Falls on the way to Stewart - 37A road- 1997
Feature 1
Mount
Shorty Repeater MSR
Untitled Path
Shorty Repeater MSR
Google Earth
©2017 Google
Image © 2017 DigitalGlobe
Image © 2017 CNES / Airbus
3000 ft

Repeater Access Go/No-Go flowchart and definitions



Note: read all definitions on attached document.

Note: Priority definitions are subjective when combined with timing of incoming storms or length of current storm.

Stable Wx (Weather)

- Clear skies or high overcast combined with calm to light winds. Forecast will reflect stable conditions with no expectations for any significant change. This will allow the helicopter to stay on site at the repeater to ensure easy egress.

Variable Wx

- Scattered to Broken skies with light to moderate winds. Forecast will reflect reasonable expectation of conditions not worsening. The helicopter may not be able to stay at the repeater but should have suitable secondary landing to stay close by with clear line of sight on the repeater and overall weather pattern.

Low Priority

- De-riming, De-Icing, Refuel levels >50%, Restocking Supplies

High Priority

- Fuel levels <35%, Imminent system failure predicted, Power system offline/failed and operating on batteries, System offline/failed.

Trained

- Familiar with all maintenance requirements/procedures for the mission, access/egress for the repeater in question (has physically skied the route), physically capable for all possibilities.

Not Trained

- Unfamiliar with any aspect of the maintenance requirements/procedures for the mission, access/egress for the repeater in question (has not physically skied the route), injured, sick, unfit.

Hazard

- As per CAA OGRS

Mitigation YES

- Able to reduce hazard to Low-Moderate with explosives to the satisfaction of the mission team in conference with Avalanche Supervisor or Lead Hand.

Mitigation NO

- Hazard mitigation is unachievable/unreasonable

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety	[redacted]		
Safety			
Site Maintenance			
Surface Operations			
Environment			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.13

BJ-AVL-SOP-015 – Terrain Assessment Management Plan

PRETIVM		BJ-AVL-SOP-013 Tower Climbing	
Owner: Ken Black/ Jim Franken	Approver: Jim Barbondy/ Don Sather	Revision Number: 1.0	Creation Date: 03/05/2018 Revision Date:

Objective

To provide a safe work procedure for climbing the tower structures, working at heights including work positioning systems, and efficient and safe companion rescue should a worker require rescue from height.

Scope

This SWP applies to anyone working on maintenance or repair of the Brucejack MET and repeater stations at a height above 3m. The main tasks/duties associated are clearing ice/rime off of the instruments and solar panels, battery checks and swaps, Geonor fluid changes (due to volume capacity or seasonal changes), and any repairs required.

All rescues are situational dependent; that is why we train to be prepared for worst-case scenarios. Our philosophy to working safely is by taking a proactive preventative approach. With proper job planning, hazard assessment and risk management procedures, we are able to manage and mitigate the hazards.

Health, Safety & Reclamation Code of BC

- Air Quality Permit 107025 - July 12, 2016
- HSRC Part 1.11.1 Training, 2.2 Hazards, 3.3.1 Hazardous Work, 6.1.1 Qualified Persons
- WSBC 3.12 Refusal of Unsafe Work, G34 Rope Access

Definitions

- MET - Meteorological
- Geonor – all weather precipitation rain gauge
- High Angle Rope Rescue – rescue in which the load (technician) is predominantly supported by the rope rescue system
- Rime – the accumulation of granular frost on the windward sides of exposed objects that is built out directly against the wind.
- Petzl I.D. – self-braking descender used for technical rescue
- Petzl ASAP – mobile fall arrester for workers at height
- Petzl Sorber or Absorbica – a shock absorber used in conjunction with the ASAP to dissipate fall force on the rope in the event of a fall
- Scaffold Hooks – Oversized connectors that hook over scaffold and oversize anchor points to form the basis of mobile fall arrest systems
- ANSI – American National Standards Institute
- CSA – Canadian Standards Association

Preparation

Hazards

- Falling from heights.
- Snow and ice falling from above (accumulated on tower equipment and/or structure).
- Working at heights errors such as improper use of climbing equipment or improper rigging of anchors.
- Sharp/abrasive surfaces.
- Communication difficulty due to wind or passing vehicles or loss/malfunction of handheld radio.

- Dropped tools or materials while working at height.
- Prolonged exposure to the elements, severe winds, cold/freezing temperatures.
- Electrical shock when working with batteries, solar panels, instrumentation.

Tools

- 2 x ANSI/ CSA Approved full body harness (with basic rope tech gear/work positioning equipment i.e. grillon's)
- 2 x Fall Arrest lanyards and Scaffold hooks with appropriate shock pack.
- 30m 11mm Kernmantle rope (rope double the length of the Tower)
- Steel Anchor slings
- Pulleys
- ASAP
- Rope Grabs (Ascender/Kroll)
- Cable clamp
- Connectors/Carabiners
- Petzl Jag System (4:1 pulley system)
- Petzl I.D. (Descender)

Requirements

- Tower Access and Companion Rescue training provided by Mountain Safety
- Fall Arrest training package provided by Pretivm
- Standard First Aid Training
- First Aid Kit

Job Step

TRAINING:

Mountain Safety Technicians performing tower climbing duties will hold a valid rope access ticket and be restricted to scope of practice. Environmental technicians that have rope access training from an approved source or have fall protection training may climb towers.

TOWER ACCESS and WORK POSITIONING:

1. Tower will be accessed by Tower Climbing Techniques. The use of these techniques is situationally dependent and also depends on the level of training of the individual performing the work. For practical purposes, Tower Climbing Techniques will be employed by the majority of personnel performing maintenance work on the MET stations.
2. Tower Climbing involves the use of CSA approved Scaffold Hooks or an appropriate cable clamp (Photo 2: Cable grab) to attach the worker to the metal tower structure or climbing cable. The Scaffold hooks are attached to the worker's ventral D-ring on their harness and have a built in lanyard shock pack that ensures your impact force will not exceed 6kN or 600kgs; see Photo 1: Scaffold Hooks.
3. Work positioning involves employing a positioning lanyard attached to a descent controller which is used to position a worker at height. In this case, the work positioning system employs a Petzl Grillon attached to the lateral D-rings on each side of the worker's harness. A properly rigged work positioning system essentially allows the worker to perform tasks with both hands while being safely supported by the tower structure. See Photo 3: Work positioning for the proper set-up.

Photo 1: Scaffold Hooks

Photo 2 Cable Rope Grab

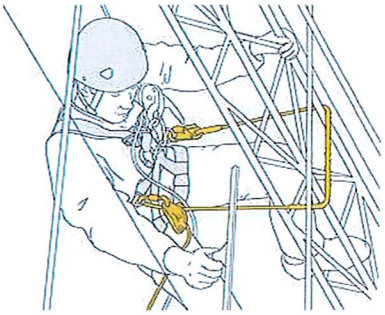


Photo 3: Work Positioning

HAULING LOADS:

4. Workers needing to transport equipment, materials, tools, etc., up the towers will utilize a high point anchor to rig a rope and pulley system and employ a rope grab such as a basic ascender or progress capture pulley. Utilizing a rope grab will limit the effort required to haul the load as well as preventing the load from being dropped accidentally.

EGRESS/COMPANION RESCUE:

5. Rescuer will utilize a high point anchor to rig a two rope lower system with Petzl I.D, ASAP and one 11mm rope. If the casualty is unconscious and/or suspended, the rescuer will then 'pick' casualty from suspension with a pre-rigged 4:1 haul (Petzl Jag) and lower to ground. If casualty is not suspended then a 'pick' is not necessary and casualty can be lowered directly to ground. See Photo 3: Properly set-up Rope Rescue System for the equipment and set-up required for a companion rescue.

Photo 3: Properly Set-up Rope Rescue System

Responsibilities

Mine Manager or designate is responsible for:

- Ensuring this SOP is implemented and maintained.
- Ensuring on-site personnel have up-to-date information regarding this SOP.

Departmental Manager / supervisor is responsible for:

- Ensuring that this SOP is read and understood by the employees who will be conducting the work.
- Ensuring persons conducting the work have the proper training.

Pretium Mountain Safety is responsible for:

- Assisting in developing and delivering a training package for MET station tower climbing and companion rescue.

Health and Safety Manager/Coordinator is responsible for:

- Monitoring the implementation of this procedure.

Personnel performing this task are responsible for:

- Being fit and ready to work safely and within the scope of their training.

Employees are responsible for:

- Following this SOP as outlined and directed by the Environmental Supervisor and Certified Rope Access Technicians.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety Supervisor or Designate	[redacted]		
Health and Safety Manager or Designate			
Environmental Supervisor or Designate			
Tsetsaut Ventures Ltd Representative			
JOHSC Co-chair or Member			

Appendix C.14

BJ-AVL-SOP-018 – Avalanche Related Road Closure Sustainability Plan

PRETIVM		BJ-AVL-SOP-018 Avalanche Related Road Closure Sustainability Plan	
Owner: Mountain Safety	Approver: Ken Black	Revision Number: 1.2	Creation Date: 01/08/2019 Revision Date: 02/26/2019

Objective

To establish structure in the advent of an extended road closure due to elevated avalanche hazard to roads and/or work areas with no means to mitigate it in a timely fashion. This procedure ensures worker safety site wide while minimizing business interruptions and allowing for business continuity and resiliency.

Scope

This SOP applies to all personnel at the Brucejack Project. As weather conditions deteriorate and avalanche hazard increases, it is the responsibility of everyone working outdoors to monitor and report these conditions to their supervisor. This SOP describes escalating levels of avalanche road closures and classifies them based on duration of closure and impact to site safety and site operations sustainability. It outlines the appropriate actions to minimize exposure and its impact on workers and the operation. The Mine Manager or designate shall be kept informed by the Mountain Safety Superintendent or designate, and at the discretion of the Mine Manager, activates IMT.

Health, Safety & Reclamation Code of BC

- 1.9.1 – Workplace Conditions
- 3.13.1 – Evacuation, Procedures and instructions.
- WSBC G4.1.1 Avalanche Assessment, G4.1.2 (c) Avalanche Planning
- 3.7.1 – Mine Emergency Response Plan
- Part 3 Rights and Responsibilities WSBC 3.3
- HSRC Part 1 Section 1.6 Health and Safety Program

Definitions

- IMT – Incident Management Team
- Avalanche Terrain – Any terrain feature capable of producing an avalanche given the correct snowpack conditions
- Avalanche Terrain Map – a map produced by the Mountain Safety Department, the Engineering Department, and outside Engineering Contractors
- Restricted visibility- Visibility in certain areas limits safe operation of equipment, to see pedestrians and to fly helicopters.

Preparation

Hazards

- Extreme weather reduces likelihood of a helicopter landing at Brucejack, as well, it can lead to closures of both Lakeshore and VOK ground egress from Brucejack. If a serious injury was to occur during extreme weather it would be very difficult to safely escort the injured person from site.
- Loss of process with Operations

Tools

- Two way radio.
- Proper winter clothing and PPE.
- Avalanche packs (beacon, shovel, probe) whenever traveling in avalanche zones.

Requirements

- Knowledge of Code 1 procedure
- Knowledge of Avalanche hazards
- IMT
- Interdepartmental SOP's

Job Step

The following Action Levels will take place in the event of avalanche road closures.

Action Level 1

Condition – CONSIDERABLE OR HIGH avalanche hazard. Estimate 3 hour closure

- Timing of control may be affected by prolonged or extended conditions of reduced visibility
- Control work may be affected if snow roads are not maintained or weather is not suitable for heli control work.
- MINOR impact to essential freight or road travel, road closures < 3hrs, MINOR impact to mill operations
- Intermittent closures expected, km 2, km 44, km 58 to km 59.5, Lakeshore Drive, VOK glacier road and VOK glacier bypass road.

Action Required

- Mountain Safety Superintendent or designate notifies the Surface Operations Supervisor or Road Access Superintendent, Dispatch and the Mine Manager.
    - Work restrictions possible.
- Surface Operations or Road Access Superintendent allocates support as required; equipment and trained operators and will communicate unforeseen delays or limitations.
- Surface operations or Road Access Superintendent to monitor and relay any significant changes in the conditions and road clearing to Mountain Safety Superintendent or designate and Dispatch.
- Haul road contingency plan. I.e. Timing of essential freight.
- Scheduled avalanche control work as planned.
- Convoy spacing (minimum 300m) in high risk areas is required. Traffic control possible to spot and coordinate traffic.
- If required VOK bypass glacier road to be maintained in case of emergency.
- May escalate to Action Level 2

Action Level 2

Condition – estimate 3 to 6 hour closures

- Timing of control work will be affected if access roads to upper targets are not safe to travel due to visibility or drifting snow and have not been maintained or equipment is not available to support.
- Extended closures due to a variety of factors such as restricted weather, avalanche control and debris clearing.
- MODERATE impact to essential freight or road travel, 3-6hr road closures likely, higher planning priority to limit potential impact to mill operations and critical freight and emergencies.
- Km 2, km 44, km 58 to km 59.5, Lakeshore Drive and VOK glacier bypass road may be closed.

Action Required

- Mountain Safety Superintendent or designate notifies the Surface Operations Supervisor or Road Access Superintendent, Dispatch and the Mine Manager.
- Surface Operations or Road Access Superintendent allocates support as required; equipment and trained operators and will communicate unforeseen delays or limitations.
- Haul road contingency plan.
- Prioritize avalanche control work, closures along the road or worksites may be in effect in order to safely reduce the risk in one area before moving to another.
- Convoy spacing (minimum 300m) in high risk areas is required. Traffic control possible to spot and coordinate traffic.
- If required, VOK bypass glacier road to be maintained in case of emergency.
- Mine Manager or designate will activate the IMT
    - High-risk tasks shall be restricted.
    - Haul road contingency plan. I.e. Timing of essential freight.
    - Consider extending closure boundaries to stop traffic going under the mill or roof lines.
    - As directed by Mine Manager, Logistics shall issue a travel advisory which could include no travel allowed from Wildfire to Knipple access road, the Knipple Glacier and Lakeshore Drive.
    - As directed by Mine Manager, Supervisors shall communicate appropriately with their crews and contractors/visitors under their area of responsibility.
- Emergency Response Team on standby if required.
- May escalate to Action level 3

Action Level 3

Condition – extended though undetermined road closure duration

- Control work is suspended until safe access can be assured.
- Closures in place. Km 2, km, 44, km 58 to km 59.5, Lakeshore Drive and VOK glacier bypass road may be closed.

Action Required

- Mountain Safety Superintendent or designate notifies the Surface Operations Supervisor or Road Access Superintendent, Dispatch and the Mine Manager.
- Surface Operations or Road Access Superintendent allocates support as required; equipment and trained operators and will communicate unforeseen delays or limitations.
- Mine Manager or designate will activate the IMT
    - High-risk tasks shall be restricted.
    - Mountain Safety Superintendent to advise IMT of prolonged storm and elevated hazards.
    - High priority planning as delays for essential freight, production, and emergencies are certain, due to road closures.
    - Prohibited outside travel except in emergency conditions, or if authorized by Mine Manager or designate.
- IF BOTH ROADS are impassable and no aircraft can land, the Mine Manager or designate has the authority to suspend ALL work on site until one of the access roads is open or an aircraft can land.
- IF ALL WORK on site is suspended, ALL supervisors shall ensure that ALL employees/workers are all accounted for.
- ALL PERSONNEL shall muster in the kitchen or a designated safe zone and wait for further instructions.

- Emergency Response Team required to be on standby.

Restrictions during a Level 3

- Only critical areas determined by the Mine Manager shall be in operation.
- If operations are suspended all personnel shall retreat to a designated safe location.
- Escorted travel will be established between the safe location and bunk houses as directed by Mine Manager or designate.
- NO person shall return to work without the approval from the Mine Manager or designate.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager	[redacted]		
Road Manager or Designate			
Safety Manager or Designate			
Knipple Safety Superintendent			
Surface Operations Manager or Designate			
Mountain Safety Superintendent			
JOHSC			

Appendix C.15

BJ-AVL-SOP-024 – Wyssen Helicopter Operations

PRETIVM		BJ-AVL-SOP-015 Terrain Assessment Management Plan	
Owner: Mountain Safety	Approver: Jim Barbondy	Revision Number:	Creation Date: Sep 14, 2017 Revision Date: Jun 25, 2018

Objective/Rationale

The purpose of this evaluation is to provide Pretivm supervisors and contractors with a detailed hazard assessment of terrain prior to starting work. The Best Practice herein sets out in general principal the actions necessary when conducting operations in any type of terrain. This step by step process will categorize the terrain, identify hazards and set in motion planning and mitigation strategies to reduce risk to personnel working on the site. Due to the need for Mtn Safety to assess terrain for both planning and rescue needs, these guidelines will be used in the operation as part of a jobsite hazard assessment.

Regulations

- OHS G4.20.1, G4.20.2, G4.21 HSRC 3.3.1, 3.4.2, CAGC – Terrain Assessment Guidelines

Definitions

Helicopter External Transportation System (HETS): A system used to provide prompt evacuation of sick or injured workers from rugged areas

See work book for definitions for Terrain Classification, Terrain Steepness, Rockfall hazard

Affected Departments

Mountain Safety, Safety, Geology, Surface Operations, Planning Department and Trades, Environment

Preparation

Hazards

- Rockfall, landslips, serac fall, ice fall, crevasses, avalanches, access egress routes, slips trips falls, weather, rain, snow, wildlife, lack of communication, remote location, Fall from heights, complex terrain increasing planning for rescue and evacuation, weather, lightening, wildlife, helicopter hazards, heat cramps, heat exhaustion, heat stroke, snow blindness, human hazards, heuristics, untrained worker, inadequate gear, overnighting, dehydration, bush whacking

Tools

- Foot wear appropriate to walking conditions
- Head protection with chin straps
- Overnight survival kit
- Radio and extra battery
- Bear spray, Bear bangers
- Bush saw
- Headlamp
- GPS
- First Aid kit
- Proper PPE for the task
- Satellite phone
- Inreach beacons
- Avalanche PPE
- Glacier PPE
- CDFL HETS kit

- Hilti and anchor building kit
- Belay kit and harnesses

Requirements

- Helicopter Orientation, hover exit if appropriate
- Established Check In
- Bear awareness course
- SOP Working Alone or in High Risk Remote Locations
- JHA or SOP for the task
- First Aid Trained
- CDFL HETS certification

Primary Assessment

- Terrain Classification Assessment, as set forth in this document, must be performed by a competent person. The terrain classification information must be documented and available to all persons who have access to the project; any safety concerns that result from terrain assessments must be communicated during all safety orientations.
- Due to a multitude of factors such as weather, snow, ice and seasonal changes, Rock fall, fall potential, danger trees, wildlife and environmental hazards, terrain classifications are subject to change. Be prepared to reclassify terrain on an ongoing basis. Any safety concerns that result from changing terrain conditions must be communicated during all safety orientations.
- Persons working in all terrain classifications must be qualified, certified and at a minimum trained in the following.
- Minimum provincial standard of First Aid
- Wildlife and mountain awareness training
- Be physically capable of carry out the assigned duties
- The higher the class of terrain, the more training and certification is needed in order to work
- safely in these areas.
- Terrain Classification Assessment Guidelines
- Design – In order to minimize or avoid the hazard, consider terrain implications when designing the project. If class 3, 4, 5 and 6 terrain is identified during the project design, consider the impact if managing steep terrain with the project. Consider methods of rescue and evacuation
- Planning – Use maps and other sources to classify terrain steepness (C1-6), terrain surface condition (S1-4) and Rockfall hazard (R1-4). Understand terrain hazards. Determine project needs to manage the terrain hazards appropriately.
- Terrain Management Plan – Walk or fly over the project to classify terrain steepness, terrain surface condition and rockfall hazard. A terrain management plan must be developed in order to mitigate risk of any classes greater than class 3. The plan should include but not be limited to the following:
- Methods of keeping untrained workers out of the area.
- Methods of how the workers will be moving around the steep terrain.
- Methods of entering and exiting steep terrain.
- Methods of managing terrain hazards.
- Qualification and training of workers required for that area.
- Methods of rescue and evacuation.
- A map that identifies class 3,4,5 and 6 terrain
- Mapping and Zoning – Terrain classification, maps can be made to help identify areas where both travel and rescue will be difficult. Zones may be created to make it easy to identify levels of

difficulty. A map reflecting zones will dictate 'go' or 'no go' decisions relative to working when the helicopter is unable to fly.

- Green zone = Class 1 and 2 terrain – open to all field personal who meet training requirements.
- Yellow zone = Class 3 and 4 terrain – Greater slip trip and fall hazards, greater risk of rockfall hazards. Accessible to only personal who meet minimum fitness requirements, have been trained, and have demonstrated competency in more rugged terrain. Yellow zones may only be accessed when rescue and evacuation systems are available.
- Red zone = class 5 and 6 terrain – Significant slip, trip and fall hazards, greater risk of falls from heights and greater rockfall hazards. Accessible only to personal who have been trained in the use of fall protection and rope access systems. Red zones may only be accessed when rescue and evacuation systems are available.
- Traverse Planning – As the traverse progresses, reevaluate the terrain to confirm steepness classification, terrain surface conditions and rockfall hazard. Use terrain management techniques to reduce hazards where possible. Communication at this stage is extremely important and can be achieved at meetings, updating maps and terrain assessments.
- Continuous Evaluation – Throughout the project continuously reevaluate the terrain and re-rank classification when necessary in response to changes in ground surface conditions; such as slippery due to snow, ice water, overhead rockfall or avalanche hazard, etc. Communication at this stage is extremely important and can be achieved at meetings, updating maps and terrain assessments.

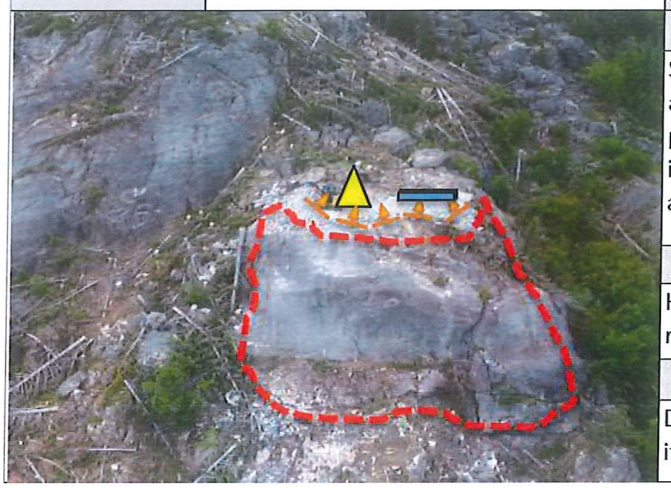
Job Step

- When contemplating a new project or development in mountainous terrain the associated department will first consult with Mountain Safety and determine if the project is exposed to potential risk due to the terrain (see attached). The associated department and Mountain Safety will carry out an initial assessment and go through a pre planning JHA exercise prior to the work being carried out.
- Or if a worker or supervisor recognizes that they are to be exposed to potential terrain hazards they are to request Mountain Safety to perform an assessment.
- Mountain Safety will then:
- Gather geographic information about the sites location, elevation and transportation.
- Provide definitions and classifications of terrain for the purpose of evaluating terrain steepness in order to:
- Prevent falls from heights
- Plan for rescue and evacuation
- Comply with Occupational health and Safety (OHS) and HSRC regulations related to;
- Hazard assessment
- Fall protection and working at heights
- Plan for rescue and evacuation.
- Determine the terrains classification by using the terrain classification scale in the workbook. Include the egress and access to the site.
- Provide definitions and classifications of terrain for the purpose of evaluating terrain surface condition (reference the workbook) in order to:
- Prevent slips trips and falls
- Plan for rescue and evacuation
- Create a safe work place
- Comply with all Provincial OHS and HSRC Regulations related to:
- Hazard assessment
- Rescue evacuation

- Use the terrain classification scale in the workbook to rate the exposure to rockfall.
- Determine Rescue and Evacuation Concerns use the chart in workbook.
- Input all this information into the terrain assessment form. See example below.

Pretivm Terrain Assessment

Site Location:	4007	Revision Date:	6/11/2016
Site UTM:	9V 435298.00 m E 6233382.00 m N	Name:	Steve Parsons
Site Elevation:	746m	Terrain Class:	Class 4
Activity at site:	TL Construction	Terrain Surface:	S4
Contractor:	BJTL Contractors	Rockfall Hazard:	R3
		Rescue/Evacuation:	Class 4



Site Description

Site location number 4007 is a high priority planning area, access and egress to the site from the helicopter pad travels through a large talus rock slope. The trail is steep and overgrown. The worksite is situated above a cliff greater than 10m in height.

General Access / Egress

Helicopter pad access only. Access is challenging and requires slashing to provide safe access for crews.

Rescue Access / Egress

Depending on injury, standard helicopter pad or HETS if patient is unable to move or immobilized.

Hazard Rating/ Planning Priority

Use the Planning Rating Table to score the hazard rating for the site. Use the definitions provided to help you find the appropriate score for each item listed on the terrain assessment form.

PLANNING RATING

Probability of Exposure	Impact to Life	Impact the hazard has on the ability to do a rescue	Total Score	Explanation
5= Frequent 4= Often 3= Occasional 2= Possible 1= Improbable 0 = Impossible	5= Permanent disability or death 4= Critical injury or possible death. 3= Severe injury of possible disability 2= Moderate injury 1= Minor injury 0 = Impossible	5= Severe impact, will make rescue in the golden hour unlikely, rescue will place rescuers at risk. 4= High Impact, rescue in the golden hour difficult and might place rescuers at risk. 3= Moderate impact, rescue in the golden hour possible. 2= Low impact, rescue in the golden hour possible, 1= No impact on rescue 0 = won't happen	**13 to 15 =**	**Very high** planning priority for training and hazard mitigation. Either avoid area or use special teams trained to manage this type of hazard. Special evacuation and rescue measures may need to be taken.
			10 to 12 =	**High** planning priority for training and hazard mitigation. Either avoid area, use special teams trained to manage this type of hazard or provide training to workers. Special evacuation and rescue measures may need to be taken.
			7 to 9 =	**Moderate** planning priority for training and hazard mitigation. Provide training to workers in basic wilderness safety. Reinforce training often.
			3 to 6 =	**Low** planning priority for training and hazard mitigation. Basic mountain/wilderness safety training should be sufficient.
			1 to 2 =	**Very low** planning priority for training and hazard mitigation.
			0 =	Don't need any planning, the hazard does not exist

- List the concerns in the boxes provided across from the score given.
- The overall goals are to
- Identify and understand terrain hazards
- Determine project needs to manage the terrain hazards appropriately.

Step 2: Hazard Rating/Planning Priority		
Item	Score	Explanation
Probability of exposure to hazard	3	Exposure to occasional slip and falls traveling to site and possible fall beyond marked working edge off cliff.
Impact to life or limb	5	Slips, trips and environmental exposure. Access to site from heli pad. Cliff/ fall potential. Excavator roll-over.
Hazard and/or terrain's impact on ability to rescue worker	4	Helicopter rescue only. HETS required for all injuries where patient is immobilized.
Total Score	12	
Planning/training priority for hazard management		STOP - HIGH PRIORITY PLANNING

- Add up the total and determine the planning priority for the site.
- See table below:

RISK ACCEPTABILITY

Score	Definition
1-3	Acceptable Risk- Hazards can be eliminated or avoided.
4-7	Controllable Risk-Required action Rules, PPE, Skills training or other hazard mitigation techniques
8-11	Moderate- Controllable with conditions-Required action= qualified personnel only, special procedures, work practices, skills and training required along with rescue system. Conditions will be constantly re-evaluated throughout the job and at any time the conditions may be downgraded to unacceptable.
12-15	Unacceptable Risk-STOP=It is unsafe to perform tasks, hazards cannot be managed.

Hazard Management Controls and Conditions

- Provide controls and safety solutions that once implemented will effectively minimize or completely eliminate the workers exposure to risk of identified hazards at a work site. Follow The Terrain management plan which should include but not be limited to:
- Method of keeping untrained workers out of the area
- Methods of how the workers will be moving around the terrain
- Methods of entering and exiting steep terrain
- Methods of marking and managing terrain hazards
- Qualification and training of workers required for that area
- Determine rescue requirements, Implement an emergency action plan that will make rescue from the site more efficient therefore decreasing the time required for transporting an injured worker to higher care. Predetermined access routes and systems for extrication.
- A map that identifies class 3,4,5 and 6 terrain
- Continuous evaluation of the terrain and change of the classification when necessary to reflect the changes in ground surface conditions (slippery due to snow, ice water, machine altered ground)
- This should be constructed prior to work beginning at a site.
- Communication at this stage is extremely important and can be achieved at meetings, updating maps and terrain assessments.
- See example below:

Step 3: Hazard Management/Controls/Conditions
Daily JHA to promote situational awareness.
Capable personnel. Fit and strong enough to deal with rough terrain.
Standard PPE,high quality footwear, chin straps on helmets, appropriate mountain clothing.
Train for hazard identification and avoidance, safe work practices, safe travel procedures.
Define work site perimeter, establish safe working edge and well marked and cleared access/egress.
Slash and clear work site and access to tower site. Mark obvious trip hazards at work site.
Consider fall protection where required as per Part 11 Fall Protection Regulation.
Consider rope access techniques and properly certified personnel where required .Part 34 Rope Access Regulation.
Design a site specific rescue plan, additional heli pads. Identify staging points for ground and HETS rescue.

Determine Risk after Controls

- Determine if the hazard is acceptable after applying hazard management controls. Score the individual items again and determine if the risk is now manageable once the controls are in place and maintained.
- Re-access work site once work has commenced and the site has been altered. Mitigate new hazards and adjust the emergency action plan if required.
- Communication at this stage is extremely important and can be achieved at meetings, updating maps and terrain assessments.
- See example below:
-

Step 4: Determine if hazard is Acceptable-After applying hazard management controls		
Item		Explanation
Probability of exposure to hazard	2	Identify and mark hazards, clear access/egress routes. Mark and respect safe working edge. Possible
Impact to life or limb	4	as above
Hazard and/or terrain's impact on ability to rescue worker	4	Reduce rescue time for certain injuries with access improvements. Look at closer Heli pad for rescue.
Total score after mitigation techniques applied	10	
Risk tolerability after controls are in place		MODERATE RISK - CONTROLLABLE WITH CONDITIONS

If hazards are completely unmanageable for a site and a high planning priority cannot be managed due to hazards, discuss moving the site to a more suitable location with the Department head or Supervisor.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mountain Safety Superintendent or Designate	[redacted]		
Health and Safety Manager or Designate			
Mine Manager or Designate			
JOHSC Co-chair or Member			

Appendix C.16

BJ-AVL-SOP-026A – Wyssen Charge Construction

Objective

To provide the user with a process for constructing Wyssen charges in a methodical safe manner.

Scope

Wyssen Deployment boxes (void of explosive charges) will be stored in sea-cans at km 48 magazine laydown, approximately 100m off the Brucejack Access road. The storage sea-cans are located approximately 12m away from a Type 9 magazine used for storage of explosives for the use of avalanche control.

During fall commissioning, the deployment boxes will be removed from the storage sea-cans and lined up systematically between the storage sea-cans and the Type 9 magazine. Assembly and priming of the Wyssen charges will take place in an "arming shack" (sea-can).

An accidental ignition pit (in the event of a misfire) is located behind the arming seacan. It is about 3 feet deep, lined with old ¾" rubber belt matts with 12" of fines over top. Surrounding the pit are 8 concrete barriers.

Health, Safety & Reclamation Code of BC

- Not applicable

WorkSafe BC Regulations

- 21.3 Dangerous incident reports
  - (1) If a blasting accident occurs which causes personal injury, or if there is any other dangerous incident involving explosives, whether or not there is personal injury, the employer must
  - (a) report the incident immediately to the Board, and
  - (b) forward a written report of the incident to the Board without undue delay.
  - (2) The written report of the incident must contain
  - (a) the date, time and location of the incident,
  - (b) the names and certificate numbers of all blasters involved,
  - (c) the names and occupations of any persons injured,
- 21.5 Authority to blast
  - (1) Only the holder of a valid blaster's certificate issued by the Board or acceptable to the Board is permitted to conduct or direct a blasting operation, and then only if the work involved is within the scope of that certificate.
  - (2) All work within the blasting area must be done under the authorization of the designated blaster of record responsible for that area.
  - (3) A blaster may be assisted by persons who do not hold blaster's certificates, but the blaster must have authority over the assistants and must exercise visual supervision over them and be responsible for their work during explosive loading, priming, fixing or firing.
- 21.7 Training
  - A worker engaged in loading, unloading, or conveying explosives must be trained in the proper means for handling the explosives, the hazards of fire and mishandling and the procedures to follow in the event of a fire or explosion.
- 21.16 Detonators
  - (1) Detonator products must not be kept in a store or receptacle in which explosives or safety fuses, fuse lighters, igniter cords or connectors are stored.
  - (2) At the loading site, detonator products must be stored separately from other explosives, and in a crush resistant box which is clearly identified.

- 21.17 Worksite storage
  - Explosives at the worksite must be guarded or contained in secured day boxes until used or returned to storage magazines.
- 21.18 Communication
  - (1) The employer must ensure that the location of a magazine in which explosives are stored, and any restrictions on access or activity around the magazine area, are clearly communicated to all workers.
  - (2) A day box and receptacle used for day storage of explosives on a work site must, when they contain explosives, display signs indicating the presence of explosives in a conspicuous manner, and the signs must be removed when they are empty.
- 21.19 Magazine condition
  - (3) Any article or substance likely to cause a fire or explosion must be kept out of and at a safe distance from an explosives magazine.
- 21.37 Defective explosives
  - Explosive materials or accessories which have deteriorated, or are believed to be defective, must not be used and must be handled and disposed of in a safe manner following the manufacturer's recommendations.
- 21.38 Cold temperatures
  - If the sensitivity of an explosive is affected by cold temperatures the explosive may be brought to a working temperature in a manner recommended by the manufacturer, but must not be warmed near an open fire or a steam boiler nor by direct contact with steam or hot water.
- 21.40 Ignition sources prohibited
  - (1) Smoking is prohibited within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes.
  - (2) Open flame ignition sources must not be permitted within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes, unless the blaster of record gives consent.
- 21.41 Containers
  - (1) Containers, known or suspected to contain explosives or explosive residue, must be handled with care to prevent undue impact or exposure to excessive heat or flame.
  - (2) All empty explosives containers must be disposed of by burning or as recommended by the manufacturer.
- 21.45 Priming
  - A primer must not be made up until immediately before placing the explosives.
- 21.49 Electrical storms
  - If there is any sign of thunder or lightning storm activity, all blasting activity must be suspended and the danger area must be cleared and guarded if explosives are present at the blast site.
- 21.56 Safety fuse assemblies
  - (1) Only safety fuse assemblies with antistatic protection may be used for safety fuse blasting.
  - (2) Safety fuse assemblies less than 1 m (3.3 ft) in length must not be used.
  - (3) Safety fuse assemblies must be handled with care to avoid pinching or kinking and damaged fuse assemblies must not be used.
- Safety fuse assembly length
- The Regulation states that "safety fuse assemblies less than 1 m (3.3 ft) in length must not be used." A safety fuse from a manufacturer is 1 metre or 3 feet 3 inches long. As provided by section 21.57(2) of the Regulation, this fuse length may be trimmed to expose fresh powder or to remove the igniter cord connector. The minimum trimmed length cannot be less than 90 cm or 3 feet.
- 21.57 Lighting safety fuse

- (1) When lighting a single safety fuse assembly a match may be used.
- (2) When multiple safety fuses are to be lit, a suitable safety fuse lighting device must be used to ensure that a minimum 90 cm (3 ft) fuse length safety factor is maintained.

- 21.73 Misfires
  - (1) If there is evidence or suspicion of a misfire after a blast is initiated, the blaster of record must not permit anyone to enter the danger area until the later of the following:
    - (d) if a safety fuse was used to initiate the blast, 30 minutes after the estimated time of detonation;
    - (e) the waiting period stated in the manufacturer's instructions.
- (2) If there is evidence or suspicion of a misfire after a blast is initiated and a charge is known or suspected to be burning, the blaster of record must not permit anyone to enter the danger area until the later of the following:
    - (a) one hour after the smoke clears;
    - (b) the waiting period stated in the manufacturer's instructions.
- 21.79 Relighting a safety fuse is prohibited.
- 21.85 Avalanche control
- (1) Explosive charges must not be placed manually on site by workers or projected by any means for the purpose of avalanche control, until the proposed work procedures have been submitted to and accepted by the Board.
- (2) Explosives must not be primed until the last most practicable moment which means that point in time when the explosives are as close to the control route as possible, in a safe, sheltered location excluded from public access.
- (3) The pull-wire lighter must not be placed on the safety fuse assembly until immediately before placing the charge.
- (4) The employer must ensure that procedures are reviewed annually and that proposed changes to the procedures are submitted to the Board for approval before implementation.

Definitions

- *"blaster of record"* means the blaster who is designated to be in charge of a blasting operation.
- *"blasting area"* means an area extending at least 50 m (165 ft) in every direction from a place where explosive materials are being prepared or fixed, or where an unexploded charge is known or believed to exist;
- *"blasting operation"* includes preparing, placing, and firing a charge, handling a misfire, and destroying or disposing of explosive materials;
- *"charge"* means explosive materials which may or may not contain a primer, and which are placed for the purpose of detonation.
- *"danger area"* means an area in which there may be danger to persons or property from flying material or other hazardous condition resulting from a blast;
- *"dangerous incident"* means an accident or near miss occurrence caused by or as a result of the use of explosives, and also includes an unexpected result or problem with explosive products.
- *"detonator" or "detonator products"* includes those explosives commonly called blasting caps, or electric caps, or other similar devices used to detonate commercial explosives;
- *"initiating device"* means a blasting machine, non-electric starter, fuse lighter and any other device used to initiate a deflagration or detonation but does not include a detonator or electric igniter;
- *"explosive"* means a substance that is made, manufactured or used to produce an explosion or detonation, including but not limited to blasting explosives, pyrotechnic devices and accessories containing explosives;
- *"primer"* means an explosive to which a detonator is attached or into which a detonator is inserted;
- *"safety fuse assembly"* means a manufactured blasting accessory consisting of a precut length of safety fuse, an igniter cord connector, and a detonator.

- **Qualified Personnel** – Personnel operating the Wyssen Avalanche Towers or Wyssen Helicopter Latch must be officially approved by the company management. They must possess personal certification of training on the installations carried out by the manufacturer as well as a nationally valid license for the artificial release of avalanches with explosives for operating the avalanche towers. Instruction by colleagues within the company are not valid as a replacement for the installation training by the supplier. Persons who have not been trained by the supplier and who do not have the above-mentioned certification may not operate this installation

Preparation

Hazards

- Explosion
- Personal injury
- Property damage
- Fly rock
- Proximity to charge
- Wildlife in area
- Proximity to Explosive magazine
- Unauthorized personnel in the work area
- Slips, trips and falls
- Lightning
- Wildfire
- Static / electrical / Generator fire

Requirements

- Approved Variance VR201900088 for Section 21.56(2) of the OHSR and follow special terms
- Wyssen Manual
- Pretium Blasting Procedures
- BJ-AVL-SOP-026A Wyssen Charge Construction
- BJ-AVL-SOP-026B Wyssen Charge Priming
- BJ-AVL-SOP-026C Wyssen Box loading
- Brucejack Mine Fire Safety Plan 48 km Magazine Site 2020
- Brucejack Mine Security Plan 48 km Magazine Site 2020
- Brucejack Mine Key Management Plan 48 km Magazine Site 2020
- Annex B - Cleared Employee List
- Blaster of Record must hold a valid avalanche control blasting certification
- Storage and handling of explosives
- TDG, TDG IATA and WHMIS
- SDS
- Personal training certification by the supplier of the Wyssen Tower
- Never leave explosives unattended
- Ensure explosives, safety fuse and percussion igniters SZ83 are compatible and approved by regulatory bodies and sufficient to a temperature of -30°C.

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

- **Ensure Blasting Codes are in a secure Lockbox**
- **Site Preparation**
  - Gate is closed and locked and primary closure established at the haul road junction.
  - No unauthorized personnel in the worksite.
  - The deployment box must be placed on a flat surface, ensure that there is not more than 30cm under the deployment box
  - Ensure deployment boxes are located close to the worksite where the charges are prepared (maximum distance 50m)
  - Ensure route from worksite to deployment boxes is free of obstacles
  - Ensure assembly table is stable, free of any sparking material and unnecessary objects or tools.
  - Turn off heater in the arming seacan.
  - Open doors of the arming seacan and ensure clear pathway to the Accidental ignition pit
- In the event of accidental ignition during charge construction, priming and loading of explosives follow BJ-AVL-SOP-027 Wyssen Accidental Ignition

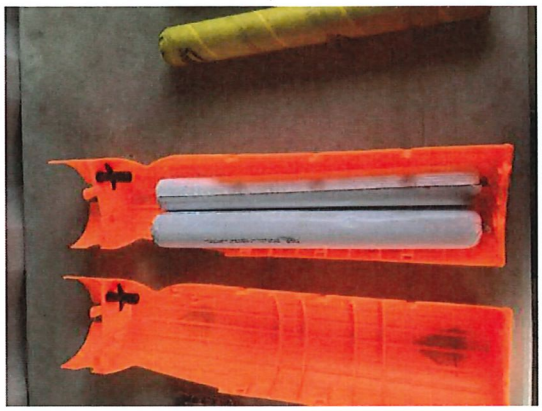
- **Gather all equipment and supplies at the 48km magazine area**
  - Km 48 gate key
  - Deployment box key
  - Magazine keys
  - Measuring tape
  - 12" Brass punch tool
  - Crimpers
  - Electrical tape
  - Wyssen Charge Assembly and charge control check list
  - Generator, gas and duck pond
  - Electrical cords
  - Wyssen battery chargers
  - Nitrile gloves

- **Charge construction components**
  - 2 charge container half shells
  - 1 short retaining cord
  - 1 hangar cord with pull wire clips and ring
  - 1 1kg Unimax stick
  - 3 1kg Dyno TX stick
  - Foam Stopper
  - Recco sticker

Preparation of the charge container

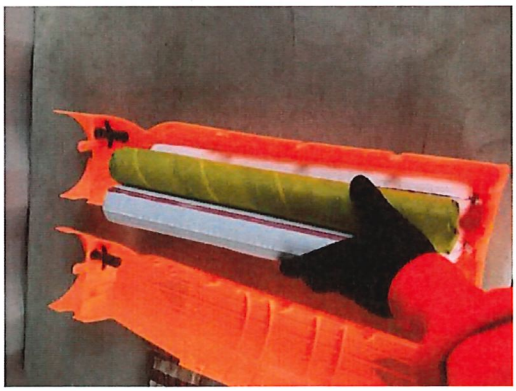
- **Inspect charge container half shells for defects**
  - Ensure all tabs are in place and there are no obvious cracks

- **Place two of the Dyno TX sticks inside one of the half shells**
  - Ensure slight angle to leave access to the 2 fuse holding tabs
  - Leave slight gap between charges and bottom of casing to ensure bottom tabs connect with another casing half

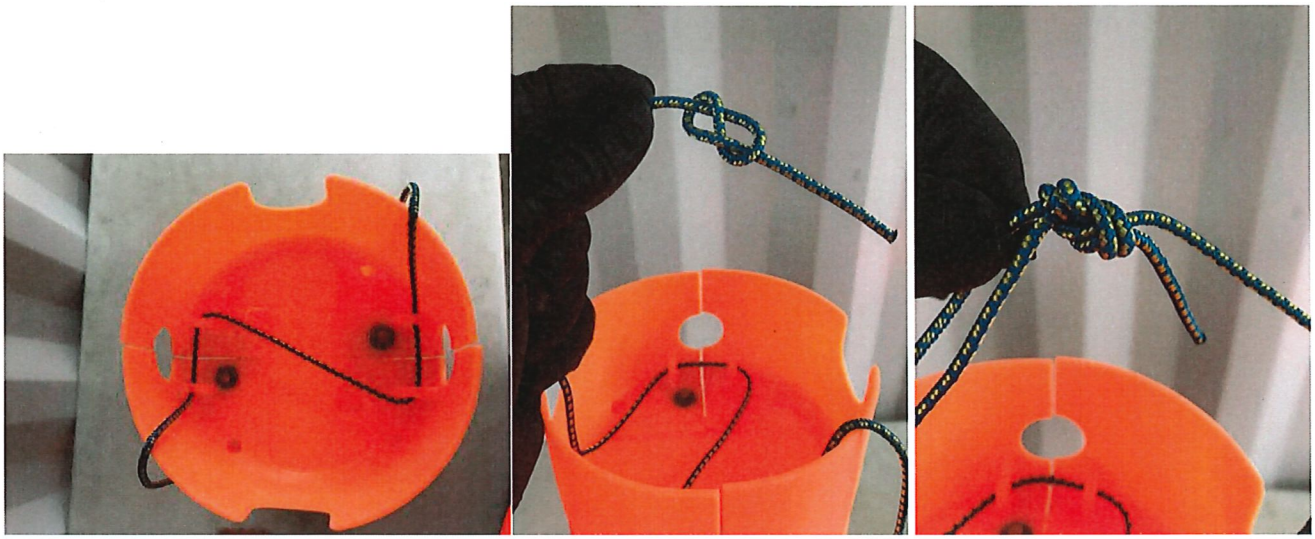


- **Load Remaining Dyno TX and Unimax sticks**
  - Ensure Unimax is placed on the right immediately below the igniter
  - Leave slight gap between charges and bottom of half shell to ensure bottom tabs connect with other half shell

- **Assemble casing**
  - Start from bottom and work tabs together slowly and firmly to bring together the two half shells
  - If one side tab is broken in the process tape can be applied to continue using the half shell
  - If one of the bottom or top tabs are damaged then unassemble the charge container and discard the damaged side
  - Push the charges to the bottom of the charge container



- **Thread and tie off the Retaining Cord (Short Piece)**
  - Thread the short string through both halves of the charge container in a Z pattern
  - Tie a figure eight on one end
  - Follow through the figure eight to complete the knot



- **Prepare the tied off Retaining Cord**
  - Move the knot off to one side
  - Gather both strands and equalize above the center of the casing

- **Prepare the Hanger rope (long piece) and connect Long Hanger cord to Retaining Cord**
  - Pull off the taped on top section of cord
  - Look for two spring clips
  - Inspect loop and knot at end
  - Connect long to short with a girth hitch and center hitch on Retaining Cord

- **Connect Spring Clips into the eyelets of the percussion igniter SZ83**
  - Ensure both side of each clip is through pull wire hole
  - Ensure cords are aligned/not twisted

- **Place remaining cord bag on top**
  - Ensure cord bag has ring on top
  - Ensure no snag potential with charge container holes
  - Remove tape holding ring on top of bag

- **Charge Assembly Quality Control Checklist**
- Follow Wyssen Charge Assembly and charge control check list -Carried out by designated person
  - 2 Bottom tabs - secure fit / no cracks
  - 3 Side tabs - secure fit / no cracks
  - Cartridge orientation - Unimax positioned correctly (for detonator placement)
  - Retaining cord -Tied through all 4 tabs, figure 8 follow through knot used and secure)
  - 2 Top tabs - secure fit / no cracks
  - Girth hitch - Tied, weight test
  - Spring hooks - Both arms clipped through igniter
  - Cord sack - Placed neatly, ring facing up
  - Recco chip – Place Recco chip inside charge container

- **Place foam on top to protect from premature pulling of igniters and to indicate QC complete**
- **Place charges back in boxes in preparation for priming phase**

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.17

BJ-AVL-SOP-026B – Wyssen Charge Priming

Objective

To provide the user with a safe and methodical process for priming the Wyssen charge containers with safety fuse assemblies.

Scope

Wyssen Deployment boxes (void of explosive charges) will be stored in sea-cans at km 48 magazine laydown, approximately 100m off the Brucejack Access road. The storage sea-cans are located approximately 12m away from a Type 9 magazine used for storage of explosives for the use of avalanche control.

During fall commissioning, the deployment boxes will be removed from the storage sea-cans and lined up systematically between the storage sea-cans and the Type 9 magazine. Assembly and priming of the Wyssen charges will take place in an "arming shack" (sea-can).

An accidental ignition pit (in the event of a misfire) is located behind the arming seacan. It is about 3 feet deep, lined with old ¾" rubber belt matts with 12" of fines over top. Surrounding the pit are 8 concrete barriers.

Health, Safety & Reclamation Code of BC

- Not Applicable

WorkSafe BC Regulations

- 21.3 Dangerous incident reports
  - (1) If a blasting accident occurs which causes personal injury, or if there is any other dangerous incident involving explosives, whether or not there is personal injury, the employer must
  - (a) report the incident immediately to the Board, and
  - (b) forward a written report of the incident to the Board without undue delay.
  - (2) The written report of the incident must contain
  - (a) the date, time and location of the incident,
  - (b) the names and certificate numbers of all blasters involved,
  - (c) the names and occupations of any persons injured,
- 21.5 Authority to blast
  - (1) Only the holder of a valid blaster's certificate issued by the Board or acceptable to the Board is permitted to conduct or direct a blasting operation, and then only if the work involved is within the scope of that certificate.
  - (2) All work within the blasting area must be done under the authorization of the designated blaster of record responsible for that area.
  - (3) A blaster may be assisted by persons who do not hold blaster's certificates, but the blaster must have authority over the assistants and must exercise visual supervision over them and be responsible for their work during explosive loading, priming, fixing or firing.
- 21.7 Training
  - A worker engaged in loading, unloading, or conveying explosives must be trained in the proper means for handling the explosives, the hazards of fire and mishandling and the procedures to follow in the event of a fire or explosion.
- 21.16 Detonators

    - (1) Detonator products must not be kept in a store or receptacle in which explosives or safety fuses, fuse lighters, igniter cords or connectors are stored.
    - (2) At the loading site, detonator products must be stored separately from other explosives, and in a crush resistant box which is clearly identified.
- 21.17 Worksite storage
    - Explosives at the worksite must be guarded or contained in secured day boxes until used or returned to storage magazines.
- 21.18 Communication
    - (1) The employer must ensure that the location of a magazine in which explosives are stored, and any restrictions on access or activity around the magazine area, are clearly communicated to all workers.
    - (2) A day box and receptacle used for day storage of explosives on a work site must, when they contain explosives, display signs indicating the presence of explosives in a conspicuous manner, and the signs must be removed when they are empty.
- 21.19 Magazine condition
    - (3) Any article or substance likely to cause a fire or explosion must be kept out of and at a safe distance from an explosives magazine.
- 21.37 Defective explosives
    - Explosive materials or accessories which have deteriorated, or are believed to be defective, must not be used and must be handled and disposed of in a safe manner following the manufacturer's recommendations.
- 21.38 Cold temperatures
    - If the sensitivity of an explosive is affected by cold temperatures the explosive may be brought to a working temperature in a manner recommended by the manufacturer, but must not be warmed near an open fire or a steam boiler nor by direct contact with steam or hot water.
- 21.40 Ignition sources prohibited
    - (1) Smoking is prohibited within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes.
    - (2) Open flame ignition sources must not be permitted within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes, unless the blaster of record gives consent.
- 21.41 Containers
    - (1) Containers, known or suspected to contain explosives or explosive residue, must be handled with care to prevent undue impact or exposure to excessive heat or flame.
    - (2) All empty explosives containers must be disposed of by burning or as recommended by the manufacturer.
- 21.45 Priming
    - A primer must not be made up until immediately before placing the explosives.
- 21.49 Electrical storms
    - If there is any sign of thunder or lightning storm activity, all blasting activity must be suspended and the danger area must be cleared and guarded if explosives are present at the blast site.
- 21.56 Safety fuse assemblies
    - (1) Only safety fuse assemblies with antistatic protection may be used for safety fuse blasting.
    - (2) Safety fuse assemblies less than 1 m (3.3 ft) in length must not be used.
    - (3) Safety fuse assemblies must be handled with care to avoid pinching or kinking and damaged fuse assemblies must not be used.
- Safety fuse assembly length

- The Regulation states that "safety fuse assemblies less than 1 m (3.3 ft) in length must not be used." A safety fuse from a manufacturer is 1 metre or 3 feet 3 inches long. As provided by section 21.57(2) of the Regulation, this fuse length may be trimmed to expose fresh powder or to remove the igniter cord connector. The minimum trimmed length cannot be less than 90 cm or 3 feet.
- 21.57 Lighting safety fuse
    - (1) When lighting a single safety fuse assembly a match may be used.
    - (2) When multiple safety fuses are to be lit, a suitable safety fuse lighting device must be used to ensure that a minimum 90 cm (3 ft) fuse length safety factor is maintained.
- 21.73 Misfires
    - (1) If there is evidence or suspicion of a misfire after a blast is initiated, the blaster of record must not permit anyone to enter the danger area until the later of the following:
        - (d) if a safety fuse was used to initiate the blast, 30 minutes after the estimated time of detonation;
        - (e) the waiting period stated in the manufacturer's instructions.
- (2) If there is evidence or suspicion of a misfire after a blast is initiated and a charge is known or suspected to be burning, the blaster of record must not permit anyone to enter the danger area until the later of the following:
        - (a) one hour after the smoke clears;
        - (b) the waiting period stated in the manufacturer's instructions.
- 21.79 Relighting a safety fuse is prohibited.
- 21.85 Avalanche control
- (1) Explosive charges must not be placed manually on site by workers or projected by any means for the purpose of avalanche control, until the proposed work procedures have been submitted to and accepted by the Board.
- (2) Explosives must not be primed until the last most practicable moment which means that point in time when the explosives are as close to the control route as possible, in a safe, sheltered location excluded from public access.
- (3) The pull-wire lighter must not be placed on the safety fuse assembly until immediately before placing the charge.
- (4) The employer must ensure that procedures are reviewed annually and that proposed changes to the procedures are submitted to the Board for approval before implementation.

Definitions

- *"blaster of record"* means the blaster who is designated to be in charge of a blasting operation;
- *"blasting area"* means an area extending at least 50 m (165 ft) in every direction from a place where explosive materials are being prepared or fixed, or where an unexploded charge is known or believed to exist;
- *"blasting operation"* includes preparing, placing, and firing a charge, handling a misfire, and destroying or disposing of explosive materials;
- *"charge"* means explosive materials which may or may not contain a primer, and which are placed for the purpose of detonation;
- *"danger area"* means an area in which there may be danger to persons or property from flying material or other hazardous condition resulting from a blast;
- *"dangerous incident"* means an accident or near miss occurrence caused by or as a result of the use of explosives, and also includes an unexpected result or problem with explosive products;
- *"detonator" or "detonator products"* includes those explosives commonly called blasting caps, or electric caps, or other similar devices used to detonate commercial explosives;
- *"initiating device"* means a blasting machine, non-electric starter, fuse lighter and any other device used to initiate a deflagration or detonation but does not include a detonator or electric igniter;

- *"explosive"* means a substance that is made, manufactured or used to produce an explosion or detonation, including but not limited to blasting explosives, pyrotechnic devices and accessories containing explosives;
- *"primer"* means an explosive to which a detonator is attached or into which a detonator is inserted;
- *"safety fuse assembly"* means a manufactured blasting accessory consisting of a precut length of safety fuse, an igniter cord connector, and a detonator;
- **Qualified Personnel** – Personnel operating the Wyssen Avalanche Towers or Wyssen Helicopter Latch must be officially approved by the company management. They must possess personal certification of training on the installations carried out by the manufacturer as well as a nationally valid license for the artificial release of avalanches with explosives for operating the avalanche towers. Instruction by colleagues within the company are not valid as a replacement for the installation training by the supplier. Persons who have not been trained by the supplier and who do not have the above-mentioned certification may not operate this installation

Preparation

Hazards

- Explosion
- Personal injury
- Property damage
- Fly rock
- Proximity to charge
- Wildlife in area
- Proximity to Explosive magazine
- Unauthorized personnel in the work area
- Slips, trips, and falls
- Lightning
- Wildfire
- Static / electrical / generator fire

Requirements

- Approved Variance VR201900088 for Section 21.56(2) of the OHSR and follow special terms
- Wyssen Manual
- Pretium Blasting Procedures
- BJ-AVL-SOP-026A Wyssen Charge Construction
- BJ-AVL-SOP-026B Wyssen Charge Priming
- BJ-AVL-SOP-026C Wyssen Box loading
- Brucejack Mine Fire Safety Plan 48 km Magazine Site 2020
- Brucejack Mine Security Plan 48 km Magazine Site 2020
- Brucejack Mine Key Management Plan 48 km Magazine Site 2020
- Annex B - Cleared Employee List
- Blaster of Record must hold a valid avalanche control blasting certification
- Storage and handling of explosives
- TDG, TDG IATA and WHMIS
- SDS
- Personal training certification by the supplier of the Wyssen Tower
- Never leave explosives unattended

- Ensure explosives, safety fuse and percussion igniters SZ83 are compatible and approved by regulatory bodies and sufficient to a temperature of -30°C.
- Energy Resources Department

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

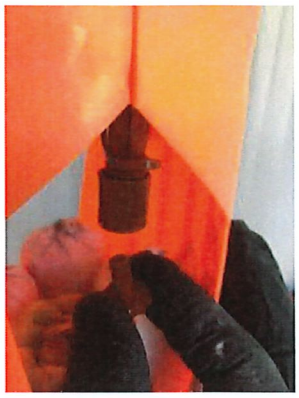
- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

- **Ensure Blasting Codes are in a secure Lockbox**
- **Site Preparation**
  - Gate is closed and locked and primary closure established at the haul road junction.
  - No unauthorized personnel in the worksite.
  - The deployment box must be placed on a flat surface, ensure that there is not more than 30cm under the deployment box
  - Ensure deployment boxes are located close to the worksite where the charges are prepared (maximum distance 50m)
  - Ensure route from worksite to deployment boxes is free of obstacles
  - Ensure assembly table is stable, free of any sparking material and unnecessary objects or tools.
  - Turn off heater in the arming seacan.
  - Open doors of the arming seacan and ensure clear pathway to the Accidental ignition pit
- In the event of accidental ignition during charge construction, priming and loading of explosives follow BJ-AVL-SOP-027 Wyssen Accidental Ignition

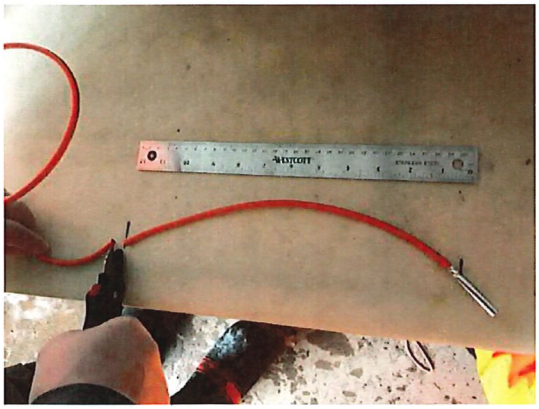
- **Gather required elements**
  - 2 - 1m Cobra Safety fuse assemblies
  - 12" Brass punch tool
  - Fuse Crimpers
  - Nitrile gloves
  - Wyssen Charge Assembly and charge control check list

- **Place prepared charge on the table and remove protective plug from bottom of igniter**
  - Loosen the screw sleeve at the bottom of the percussion igniter
  - One full turn on each Igniter
  - Hold the percussion igniter SZ83 at the top to prevent twisting
  - If the percussion igniter becomes completely unscrewed, do not screw it together again. Discard the half shell.

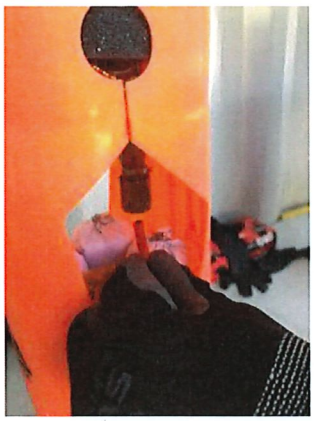


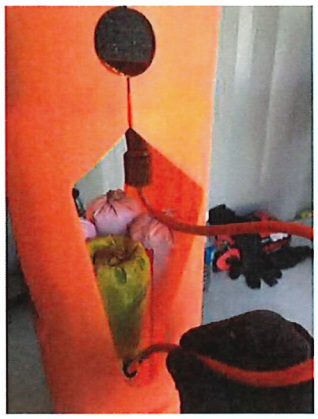
- **Puncture both Dyno TX and Unimax stick in preparation for cap insertion**
  - Use caution to ensure punch does not go through

- **Cut Fuse to length**
  - Measure and cut SFA down to 30cm. Only one fuse can be cut at a time.
  - Fuses once cut cannot be stored in the magazine, any cut fuses will need to be destroyed.
  - Discarded ends can be burned in incinerator in small bundles.

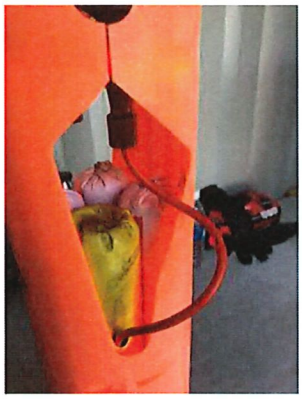
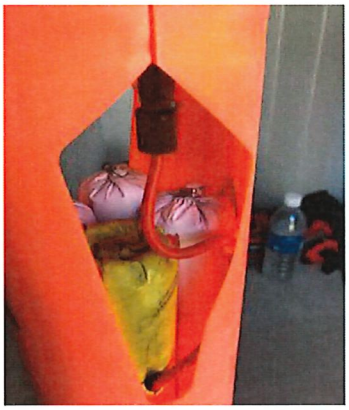


- **Insert and secure the SFA on the Unimax Side**
  - Insert the free end of the SFA into the percussion igniter SZ83
  - Firmly tighten the crew sleeve by the lug prevent twisting





- **Cap placement Fuse routing and securement**
  - Place the blasting cap into the punctured stick and ensure it is fully embedded
  - Do not pull the SFA out of the percussion igniter SZ83
  - At this point the charge is primed
  - With gentle pressure route safety fuse into the two sets of plastic clips in an **S** pattern
  - Ensure smooth bends and avoid kinking the safety fuse
  - Create a bend from upper plastic clip to igniter for creating upward pressure on the safety fuse
  - Ensure safety fuse is not protruding from the opening in the side of the casing
  - Insert and secure the safety fuse to the plastic clips on the Dyno TX side and repeat for Unimax

- **Quality Control of completed Primed Charge** -Carried out by designated person
- Follow Wyssen Charge Assembly and charge control check list
  - Detonator Placement - well placed in cartridge (one Unimax, One Dyno TX**)**
  - Fuse Routing - Clean routing no fuse protruding beyond shell, fused clipped in two plastic clips
  - Ignitor tightness - Igniters screwed tightly
  - **Important note – Never leave the primed charge unattended.**
  - Immediately after inspection the primed charge should be placed into the deployment box

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.18

BJ-AVL-SOP-026C – Wyssen Box Loading Procedure

Objective

To provide the user with a process for loading the Wyssen tower boxes in a methodical safe manner

Scope

Wyssen Deployment boxes (void of explosive charges) will be stored in sea-cans at km 48 magazine laydown, approximately 100m off the Brucejack Access road. The storage sea-cans are located approximately 12m away from a Type 9 magazine used for storage of explosives for the use of avalanche control.

During fall commissioning, the deployment boxes will be removed from the storage sea-cans and lined up systematically between the storage sea-cans and the Type 9 magazine. Assembly and priming of the Wyssen charges will take place in an "arming shack" (sea-can).

An accidental ignition pit (in the event of a misfire) is located behind the arming seacan. It is about 3 feet deep, lined with old ¾" rubber belt matts with 12" of fines over top. Surrounding the pit are 8 concrete barriers.

Health, Safety & Reclamation Code of BC

- Not Applicable

WorkSafe BC Regulations

- 21.3 Dangerous incident reports
  - (1) If a blasting accident occurs which causes personal injury, or if there is any other dangerous incident involving explosives, whether or not there is personal injury, the employer must
  - (a) report the incident immediately to the Board, and
  - (b) forward a written report of the incident to the Board without undue delay.
  - (2) The written report of the incident must contain
  - (a) the date, time and location of the incident,
  - (b) the names and certificate numbers of all blasters involved,
  - (c) the names and occupations of any persons injured,
- 21.5 Authority to blast
  - (1) Only the holder of a valid blaster's certificate issued by the Board or acceptable to the Board is permitted to conduct or direct a blasting operation, and then only if the work involved is within the scope of that certificate.
  - (2) All work within the blasting area must be done under the authorization of the designated blaster of record responsible for that area.
  - (3) A blaster may be assisted by persons who do not hold blaster's certificates, but the blaster must have authority over the assistants and must exercise visual supervision over them and be responsible for their work during explosive loading, priming, fixing or firing.
- 21.7 Training
  - A worker engaged in loading, unloading, or conveying explosives must be trained in the proper means for handling the explosives, the hazards of fire and mishandling and the procedures to follow in the event of a fire or explosion.
- 21.16 Detonators

    - (1) Detonator products must not be kept in a store or receptacle in which explosives or safety fuses, fuse lighters, igniter cords or connectors are stored.
    - (2) At the loading site, detonator products must be stored separately from other explosives, and in a crush resistant box which is clearly identified.
- 21.17 Worksite storage
    - Explosives at the worksite must be guarded or contained in secured day boxes until used or returned to storage magazines.
- 21.18 Communication
    - (1) The employer must ensure that the location of a magazine in which explosives are stored, and any restrictions on access or activity around the magazine area, are clearly communicated to all workers.
    - (2) A day box and receptacle used for day storage of explosives on a work site must, when they contain explosives, display signs indicating the presence of explosives in a conspicuous manner, and the signs must be removed when they are empty.
- 21.19 Magazine condition
    - (3) Any article or substance likely to cause a fire or explosion must be kept out of and at a safe distance from an explosives magazine.
- 21.37 Defective explosives
    - Explosive materials or accessories which have deteriorated, or are believed to be defective, must not be used and must be handled and disposed of in a safe manner following the manufacturer's recommendations.
- 21.38 Cold temperatures
    - If the sensitivity of an explosive is affected by cold temperatures the explosive may be brought to a working temperature in a manner recommended by the manufacturer, but must not be warmed near an open fire or a steam boiler nor by direct contact with steam or hot water.
- 21.40 Ignition sources prohibited
    - (1) Smoking is prohibited within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes.
    - (2) Open flame ignition sources must not be permitted within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes, unless the blaster of record gives consent.
- 21.41 Containers
    - (1) Containers, known or suspected to contain explosives or explosive residue, must be handled with care to prevent undue impact or exposure to excessive heat or flame.
    - (2) All empty explosives containers must be disposed of by burning or as recommended by the manufacturer.
- 21.45 Priming
    - A primer must not be made up until immediately before placing the explosives.
- 21.49 Electrical storms
    - If there is any sign of thunder or lightning storm activity, all blasting activity must be suspended and the danger area must be cleared and guarded if explosives are present at the blast site.
- 21.56 Safety fuse assemblies
    - (1) Only safety fuse assemblies with antistatic protection may be used for safety fuse blasting.
    - (2) Safety fuse assemblies less than 1 m (3.3 ft) in length must not be used.
    - (3) Safety fuse assemblies must be handled with care to avoid pinching or kinking and damaged fuse assemblies must not be used.
- Safety fuse assembly length

- The Regulation states that "safety fuse assemblies less than 1 m (3.3 ft) in length must not be used." A safety fuse from a manufacturer is 1 metre or 3 feet 3 inches long. As provided by section 21.57(2) of the Regulation, this fuse length may be trimmed to expose fresh powder or to remove the igniter cord connector. The minimum trimmed length cannot be less than 90 cm or 3 feet.
- 21.57 Lighting safety fuse
    - (1) When lighting a single safety fuse assembly a match may be used.
    - (2) When multiple safety fuses are to be lit, a suitable safety fuse lighting device must be used to ensure that a minimum 90 cm (3 ft) fuse length safety factor is maintained.
- 21.73 Misfires
    - (1) If there is evidence or suspicion of a misfire after a blast is initiated, the blaster of record must not permit anyone to enter the danger area until the later of the following:
        - (d) if a safety fuse was used to initiate the blast, 30 minutes after the estimated time of detonation;
        - (e) the waiting period stated in the manufacturer's instructions.
- (2) If there is evidence or suspicion of a misfire after a blast is initiated and a charge is known or suspected to be burning, the blaster of record must not permit anyone to enter the danger area until the later of the following:
        - (a) one hour after the smoke clears;
        - (b) the waiting period stated in the manufacturer's instructions.
- 21.79 Relighting a safety fuse is prohibited.
- 21.85 Avalanche control
- (1) Explosive charges must not be placed manually on site by workers or projected by any means for the purpose of avalanche control, until the proposed work procedures have been submitted to and accepted by the Board.
- (2) Explosives must not be primed until the last most practicable moment which means that point in time when the explosives are as close to the control route as possible, in a safe, sheltered location excluded from public access.
- (3) The pull-wire lighter must not be placed on the safety fuse assembly until immediately before placing the charge.
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Preparation

Hazards

- Explosion
- Personal injury
- Property damage
- Fly rock
- Proximity to charge
- Wildlife in area
- Proximity to Explosive magazine
- Unauthorized personnel in the work area
- Slips, trips and falls
- Lightning
- Wildfire
- Static / electrical / Generator fire

Requirements

- Approved Variance VR201900088 for Section 21.56(2) of the OHSR and follow special terms
- Pretium Blasting Procedures
- Wyssen Manual
- BJ-AVL-SOP-026A Wyssen Charge Construction
- BJ-AVL-SOP-026B Wyssen Charge Priming
- BJ-AVL-SOP-026C Wyssen Box loading
- Brucejack Mine Fire Safety Plan 48 km Magazine Site 2020
- Brucejack Mine Security Plan 48 km Magazine Site 2020
- Brucejack Mine Key Management Plan 48 km Magazine Site 2020
- Annex B - Cleared Employee List
- Blaster of Record must hold a valid avalanche control blasting certification
- Storage and handling of explosives
- TDG, TDG IATA, SDS and WHMIS
- Personal training certification by the supplier of the Wyssen Tower
- Never leave explosives unattended

- Ensure explosives, safety fuse and percussion igniters SZ83 are compatible and approved by regulatory bodies and sufficient to a temperature of -30°C.

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

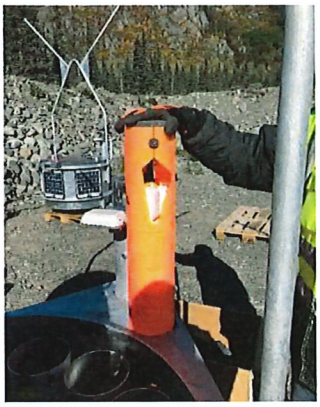
Workers

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

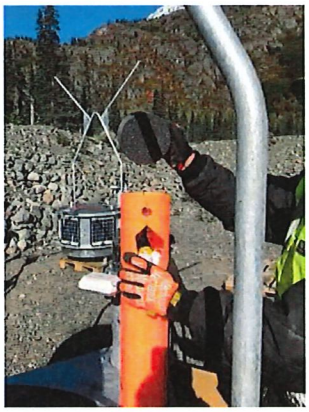
- **Ensure Blasting Codes are in a secure Lockbox**
- **Site Preparation**
  - Gate is closed and locked and primary closure established at the haul road junction.
  - No unauthorized personnel in the worksite.
  - The deployment box must be placed on a flat surface, ensure that there is not more than 30cm under the deployment box
  - Ensure deployment boxes are located close to the worksite where the charges are prepared (maximum distance 50m)
  - Ensure route from worksite to deployment boxes is free of obstacles
  - Ensure assembly table is stable, free of any sparking material and unnecessary objects or tools.
  - Turn off heater in the arming seacan.
  - Open doors of the arming seacan and ensure clear pathway to the Accidental ignition pit
  - In the event of accidental ignition during charge construction, priming and loading of explosives follow BJ-AVL-SOP-027 Wyssen Accidental Ignition
- **Prepare Wyssen Box**
  - Open the padlocks with the key and turn locking levers
  - Lift cover until safety catch engages
  - Press all sliders of the cord dropper into the rear position
  - Remove the plexi glass cover
  - Keep surface towards the antenna free so that prepared charges can be set down

- **Carry charge to Wyssen Box and place on rim of box**
  - Cradle primed charge with two hands
  - Set charge near antenna
  - Charges are loaded in order starting at tube 12

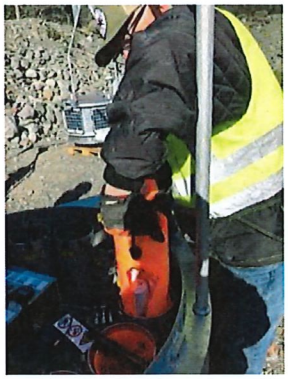
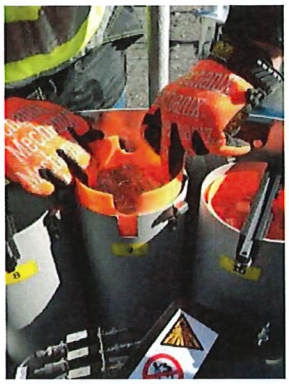


- **Remove cord dropper**
  - Place cord dropper next to charge on rim of box

- **Remove foam from top of charge**
  - Careful to ensure the cord or ignitor connectors inside do not pull out with foam

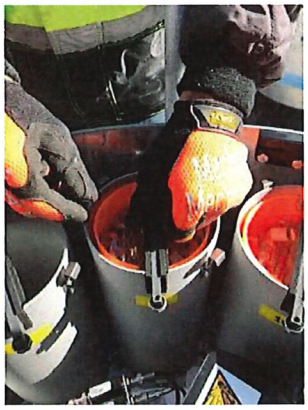
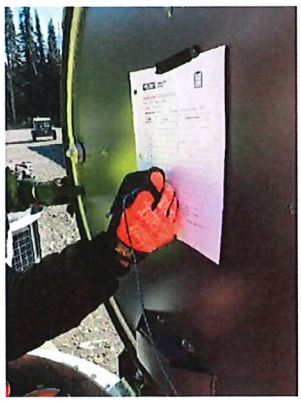


- **Take hold of charge container on the inside through the holes at the upper edge**
  - Take care to not pinch/disturb deployment cords
  - Carefully insert into tube holder
  - Ensure to load in decreasing order from 12 backwards to 1 for the control system to correctly register the number of charges in a test run
  - Align charge in tube for placement of cord dropper

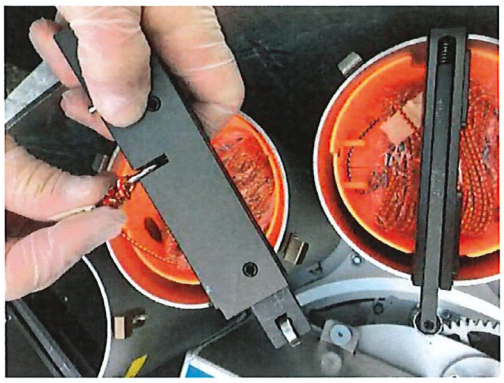
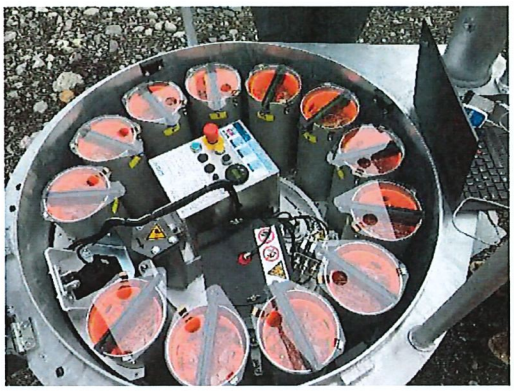



- **Prepare cord dropper and insert retaining ring to the cord dropper**
  - Ensure cord dropper is in the open position
  - The retaining ring is attached to the cord dropper and the slider is brought to the front extended position. The ring is held by the cord dropper

- **Place cord dropper back into the notches of the tube holder**
  - Ensure ball bearings point to center of deployment box
  - Ensure mechanism is flush with top of tube
  - Ensure wheel is facing the inside of box
  - After cord dropper has been placed, check that the retaining ring is correctly mounted
  - **Sign off QA / QC sheet**

- **Final QA / QC check –** Carried out by designated person
- Follow Wyssen Charge Assembly and charge control check list
  - Ring placement - Ring secure in cord dropper (not pinched, moves freely)
  - Place tube cover to protect charge
  - Complete Test Run (Follow instruction on top of control box)
  - Visual check of deployment hole – Complete closure and seal
  - Close and lock deployment box lid

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.19

BJ-AVL-SOP-027 – Wyssen Accidental Ignition

Objective

To provide the user with complete information and all necessary details in order to safely and properly dispose of accidentally ignited explosive charges.

Scope

Wyssen Deployment boxes (void of explosive charges) will be stored in sea-cans at km 48 magazine laydown, approximately 100m off the Brucejack Access road. The storage sea-cans are located approximately 12m away from a Type 9 magazine used for storage of explosives for the use of avalanche control.

During fall commissioning, the deployment boxes will be removed from the storage sea-cans and lined up systematically between the storage sea-cans and the Type 9 magazine. Assembly and priming of the Wyssen charges will take place in an "arming shack" (sea-can).

An accidental ignition pit (in the event of a misfire) is located behind the arming seacan. It is about 3 feet deep, lined with old ¾" rubber belt matts with 12" of fines over top. Surrounding the pit are 8 concrete barriers.

Km 48 magazine layout

Accidental Ignition Pit

Health, Safety & Reclamation Code of BC

- Not Applicable

WorkSafe BC Regulations

- 21.3 Dangerous incident reports
  - (1) If a blasting accident occurs which causes personal injury, or if there is any other dangerous incident involving explosives, whether or not there is personal injury, the employer must
  - (a) report the incident immediately to the Board, and
  - (b) forward a written report of the incident to the Board without undue delay.
  - (2) The written report of the incident must contain
  - (a) the date, time and location of the incident,
  - (b) the names and certificate numbers of all blasters involved,
  - (c) the names and occupations of any persons injured,
- 21.5 Authority to blast
  - (1) Only the holder of a valid blaster's certificate issued by the Board or acceptable to the Board is permitted to conduct or direct a blasting operation, and then only if the work involved is within the scope of that certificate.
  - (2) All work within the blasting area must be done under the authorization of the designated blaster of record responsible for that area.
  - (3) A blaster may be assisted by persons who do not hold blaster's certificates, but the blaster must have authority over the assistants and must exercise visual supervision over them and be responsible for their work during explosive loading, priming, fixing or firing.
- 21.7 Training
  - A worker engaged in loading, unloading, or conveying explosives must be trained in the proper means for handling the explosives, the hazards of fire and mishandling and the procedures to follow in the event of a fire or explosion.
- 21.16 Detonators
  - (1) Detonator products must not be kept in a store or receptacle in which explosives or safety fuses, fuse lighters, igniter cords or connectors are stored.
  - (2) At the loading site, detonator products must be stored separately from other explosives, and in a crush resistant box which is clearly identified.
- 21.17 Worksite storage
  - Explosives at the worksite must be guarded or contained in secured day boxes until used or returned to storage magazines.
- 21.18 Communication
  - (1) The employer must ensure that the location of a magazine in which explosives are stored, and any restrictions on access or activity around the magazine area, are clearly communicated to all workers.
  - (2) A day box and receptacle used for day storage of explosives on a work site must, when they contain explosives, display signs indicating the presence of explosives in a conspicuous manner, and the signs must be removed when they are empty.
- 21.19 Magazine condition
  - (3) Any article or substance likely to cause a fire or explosion must be kept out of and at a safe distance from an explosives magazine.
- 21.37 Defective explosives
  - Explosive materials or accessories which have deteriorated, or are believed to be defective, must not be used and must be handled and disposed of in a safe manner following the manufacturer's recommendations.
- 21.38 Cold temperatures

    - If the sensitivity of an explosive is affected by cold temperatures the explosive may be brought to a working temperature in a manner recommended by the manufacturer, but must not be warmed near an open fire or a steam boiler nor by direct contact with steam or hot water.
- 21.40 Ignition sources prohibited
    - (1) Smoking is prohibited within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes.
    - (2) Open flame ignition sources must not be permitted within 15 m (50 ft) of where explosives are stored, being handled, or are in loaded holes, unless the blaster of record gives consent.
- 21.41 Containers
    - (1) Containers, known or suspected to contain explosives or explosive residue, must be handled with care to prevent undue impact or exposure to excessive heat or flame.
    - (2) All empty explosives containers must be disposed of by burning or as recommended by the manufacturer.
- 21.45 Priming
    - A primer must not be made up until immediately before placing the explosives.
- 21.49 Electrical storms
    - If there is any sign of thunder or lightning storm activity, all blasting activity must be suspended and the danger area must be cleared and guarded if explosives are present at the blast site.
- 21.56 Safety fuse assemblies
    - (1) Only safety fuse assemblies with antistatic protection may be used for safety fuse blasting.
    - (2) Safety fuse assemblies less than 1 m (3.3 ft) in length must not be used.
    - (3) Safety fuse assemblies must be handled with care to avoid pinching or kinking and damaged fuse assemblies must not be used.
- Safety fuse assembly length
- The Regulation states that "safety fuse assemblies less than 1 m (3.3 ft) in length must not be used." A safety fuse from a manufacturer is 1 metre or 3 feet 3 inches long. As provided by section 21.57(2) of the Regulation, this fuse length may be trimmed to expose fresh powder or to remove the igniter cord connector. The minimum trimmed length cannot be less than 90 cm or 3 feet.
- 21.57 Lighting safety fuse
    - (1) When lighting a single safety fuse assembly a match may be used.
    - (2) When multiple safety fuses are to be lit, a suitable safety fuse lighting device must be used to ensure that a minimum 90 cm (3 ft) fuse length safety factor is maintained.
- 21.73 Misfires
    - (1) If there is evidence or suspicion of a misfire after a blast is initiated, the blaster of record must not permit anyone to enter the danger area until the later of the following:
        - (d) if a safety fuse was used to initiate the blast, 30 minutes after the estimated time of detonation;
        - (e) the waiting period stated in the manufacturer's instructions.
- (2) If there is evidence or suspicion of a misfire after a blast is initiated and a charge is known or suspected to be burning, the blaster of record must not permit anyone to enter the danger area until the later of the following:
        - (a) one hour after the smoke clears;
        - (b) the waiting period stated in the manufacturer's instructions.
- 21.79 Relighting a safety fuse is prohibited.
- 21.85 Avalanche control

- (1) Explosive charges must not be placed manually on site by workers or projected by any means for the purpose of avalanche control, until the proposed work procedures have been submitted to and accepted by the Board.
- (2) Explosives must not be primed until the last most practicable moment which means that point in time when the explosives are as close to the control route as possible, in a safe, sheltered location excluded from public access.
- (3) The pull-wire lighter must not be placed on the safety fuse assembly until immediately before placing the charge.
- (4) The employer must ensure that procedures are reviewed annually and that proposed changes to the procedures are submitted to the Board for approval before implementation.

Definitions

- *"blaster of record"* means the blaster who is designated to be in charge of a blasting operation;
- *"blasting area"* means an area extending at least 50 m (165 ft) in every direction from a place where explosive materials are being prepared or fixed, or where an unexploded charge is known or believed to exist;
- *"blasting operation"* includes preparing, placing, and firing a charge, handling a misfire, and destroying or disposing of explosive materials;
- *"charge"* means explosive materials which may or may not contain a primer, and which are placed for the purpose of detonation;
- *"danger area"* means an area in which there may be danger to persons or property from flying material or other hazardous condition resulting from a blast;
- *"dangerous incident"* means an accident or near miss occurrence caused by or as a result of the use of explosives, and also includes an unexpected result or problem with explosive products;
- *"detonator" or "detonator products"* includes those explosives commonly called blasting caps, or electric caps, or other similar devices used to detonate commercial explosives;
- *"initiating device"* means a blasting machine, non-electric starter, fuse lighter and any other device used to initiate a deflagration or detonation but does not include a detonator or electric igniter;
- *"explosive"* means a substance that is made, manufactured or used to produce an explosion or detonation, including but not limited to blasting explosives, pyrotechnic devices and accessories containing explosives;
- *"primer"* means an explosive to which a detonator is attached or into which a detonator is inserted;
- *"safety fuse assembly"* means a manufactured blasting accessory consisting of a precut length of safety fuse, an igniter cord connector, and a detonator;

Preparation

Hazards

- Explosion
- Personal injury
- Property damage
- Fly rock
- Proximity to charge
- Wildlife in area
- Proximity to Explosive magazine
- Unauthorized personnel in the work area
- Slips, trips and falls
- Lightening
- Wildfire

Requirements

- Approved Variance VR201900088 for Section 21.56(2) of the OHSR and follow special terms
- Pretium Blasting Procedures
- Wyssen Manual
- BJ-AVL-SOP-026A Wyssen Charge Construction
- BJ-AVL-SOP-026B Wyssen Charge Priming
- BJ-AVL-SOP-026C Wyssen Box loading
- Brucejack Mine Fire Safety Plan 48 km Magazine Site 2020
- Brucejack Mine Security Plan 48 km Magazine Site 2020
- Brucejack Mine Key Management Plan 48 km Magazine Site 2020
- Annex B - Cleared Employee List
- Pretium Health and Safety Manual Dangerous incidents and Reporting
- Blaster of Record must hold a valid avalanche control blasting certification
- Storage and handling of explosives
- TDG, TDG IATA and WHMIS
- SDS
- Personal training certification by the supplier of the Wyssen Tower
- Never leave explosives unattended
- Ensure explosives, safety fuse and percussion igniters SZ83 are compatible and approved by regulatory bodies and sufficient to a temperature of -30°C.

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

- **Ensure Blasting Codes are in a secure Lockbox**
- **Site Preparation**
  - Gate is closed and locked and primary closure established at the haul road junction.
  - No unauthorized personnel in the worksite.
  - The deployment box must be placed on a flat surface, ensure that there is not more than 30cm under the deployment box
  - Ensure deployment boxes are located close to the worksite where the charges are prepared (maximum distance 50m)
  - Ensure route from worksite to deployment boxes is free of obstacles
  - Ensure assembly table is stable, free of any sparking material and unnecessary objects or tools.
  - Turn off heater in the arming seacan.
  - Open doors of the arming seacan and ensure clear pathway to the Accidental ignition pit

In the event of accidental ignition during charge construction, priming and loading of explosives, the following steps will be followed. **Approx. 40 second fuse**

- Call "IGNITION, IGNITION, IGNITION"
- Person assembling explosive (builder) hands primed charge to Explosive QC (at arming seacan door)
- Explosive QC takes primed charge and discards in accidental ignition pit
  - Builder(s) and Explosive QC move into the arming seacan and confirm audible detonation.
- Follow manufacturers recommendation and Pretium Blasting Procedures in the event of a misfire. Minimum 30-minute wait time before returning to site. Do not leave seacan until after confirmation of audible detonation or minimum 30 minute wait time in the event of a misfire.
- Cease assembly of operations.
- Report incident to the Road and Mine Manager.
- Fill out an Incident Report as per Pretium Health and Safety Manual.
- Report the incident immediately to the Workers Compensation Board Inspector and forward a written report of the incident to the Board without undue delay.
- Fill out F07-01_E(1) incident report form for explosives and Restricted C...
- Review incident

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager Health and Safety or Designate			
JOHSC Co-chair or Member			

Appendix C.20

BJ-AVL-SOP-028 – Helicopter Flight Ops During ILI Hazards

PRETIVM		BJC-AVL-SOP-028 Helicopter Flight Ops during ILI Hazards	
Owner: Mountain Safety	**Approver**: Ken Black, Jim Franken	**Revision Number**: 1	**Creation Date**: 2020-06-13 **Revision Date**:

Objective

Outline procedures and protocols for managing worker safety during heli copter explosives avalanche control work when there is increased hazard from transmittable diseases.

Scope

This SOP applies to explosives avalanche control work performed from a helicopter by the Mountain Safety Department.

Health, Safety & Reclamation Code of BC

- 1.8.1 Personal Protective Equipment
- 1.9.1 Workplace Conditions
- 8.4.2 Transportation of explosives
- WCB Blasting Regulations
- WSCB Covid-19 Safety Plan
- WSBC COVID-19 information and resources
- TDG IATA
- TDG

Definitions

- ILI – Influenza Like Illness
- Xh - Explosives avalanche control from helicopter

Preparation

Hazards

- Influenza type virus transmission
- Reduced vision of team members due to mask use
- Overheating from mask use

Tools

- PPE (Gloves, Masks, Goggles), Sanitizers.
- Xh heli kit (harness etc.)

Requirements

- All team members up to date with latest protocols and PPE use.
- Follow current YHL protocols (Covid-19 Pandemic Flight Operations, 2020-05-14)
- Follow current Pretium protocols for social distancing and sanitization
- Pre-control checklist including wellness checks
- Always consider selecting protocols for your workplace; Elimination, Engineering controls, Administrative Controls, PPE

Job Step

1. Identify period of increased concern. Examples: Pandemics, epidemics, local area outbreaks, onsite outbreaks, recent illness within Mtn. Safety team.
2. Identify team members (essential team only-limit number) and perform ILI screening
3. Ensure enough stock of PPE and sanitizer for mission
4. Follow current protocols for travel to magazine/staging areas. ie. Sanitize vehicles, limit team size and number of people in each vehicle. If it is not possible to ensure 2 meters of distance between workers in a vehicle the use of a mask should be considered.
5. Explosives prep: All team members don gloves and maintain social distancing during preparation of charges. Discuss roles to limit cross contamination during process.
6. Confirm high touch surfaces and headsets/microphones have been sanitized prior by YHL staff (microphones should have latex covers to allow easy sanitization).
7. Prepare and load helicopter as per Xh SOP
8. Remove gloves and sanitize hands immediately after charge and helicopter preparation.
9. Follow all Transport Canada and TDG IATA regulations.
10. Spotter and Bombardier to wear gloves, mask and glasses or goggles. Consider issues of eyewear/mask interactions creating fogging (experiment prior to avoid mission interruptions)
11. Sanitize high touch surfaces and headsets post mission.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

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REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.21

BJ-AVL-SOP-029 – Wildfire Weather Observations

Objective

- To ensure all personnel doing weather observation at Wildfire camp use a standardized method. Not following this procedure could result in wrong assessment of avalanche hazard.

Scope

- This procedure will outline the standard practice to note and report weather observations. This procedure is to ensure avalanche hazard is properly assessed.

Health, Safety & Reclamation Code of BC

- 4.13 Risk assessment
  - (1) The employer must conduct a risk assessment in any workplace in which a need to rescue or evacuate workers may arise.
  - (2) If the risk assessment required by subsection (1) shows a need for evacuation or rescue, appropriate written procedures must be developed and implemented, and a worker assigned to coordinate their implementation.

WorkSafe BC Regulations

- Not Applicable

Definitions

- HS – Height of snow
- H2D board – Snow board on which snow measurements are taken twice a day at 12hrs interval
- Ruler- Rigid measuring instrument graduated in centimeters

Preparation

Hazards

- Slips Trips and Fall
- Adverse weather
- Slippery surfaces

Tools

- PPE
- HS stick
- H2D board
- Thermometer
- Ruler
- Notebook

Requirements

- Signed off on BJ-AVL-SOP-018

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

- At 0600 and 1800hrs measure/observe and note the following weather observations
  - **H2D**
    - With the ruler, vertically measure the height of snow on the H2D board (See image 1).
    - Round up or down to the nearest cm.
    - Once noted, clear the H2D board of all its snow.
    - H2D board should be kept level with the snow. Use scraped snow to fill in depression and level out the snow surface before replacing board.
  - **HS**
    - While standing at about 1m from the HS stick (so to not disturb the snow around it), note the height of snow around the HS stick.
    - Make sure to get rid of the snow cone that often forms around the HS stick with a bamboo so the snow is leveled with the surrounding. (See image 2).
  - **Temperature**
    - Note the temperature on the thermometer in Celsius without touching the thermometer.
    - Thermometer should be kept in shadowed area so that solar radiation does not skew its reading.
  - **Precipitation**
    - Note the type of precipitation and its estimated intensity; light, moderate, heavy.
    - It is also important to note if there is no precipitation. E.g. light snow, heavy rain, no precipitation.
- Email weather observation to mountainsafety@pretivm.com
  - Title the email yymmdd AM/PM Wildfire Weather Observation. E.g. 190130 PM Wildfire Weather Observation.

- Email should include:
  - Time of observation
  - H2D
  - HS
  - Temperature
  - Precipitation
  - Any relevant change in weather.

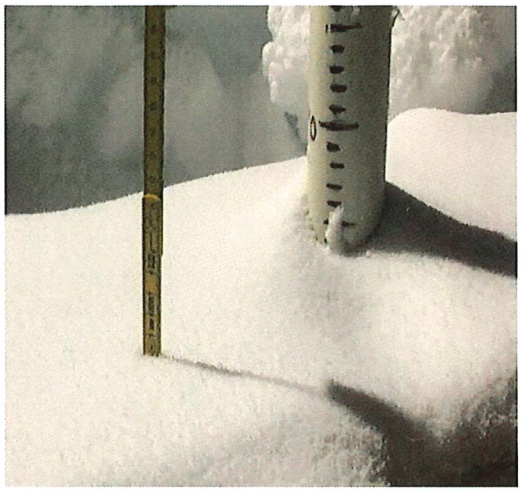

Image 1 - H2D reading

Image 2 - HS reading

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

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Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager Health and Safety or Designate			
JOHSC Co-chair or Member			

Appendix C.22

BJ-AVL-SOP-031 – Crevasse Rescue

PRETIVM		BJ-AVL-SOP-031 Crevasse Rescue	
Owner: Mountain Safety	**Approver**: Ken Black Jim Franken	**Revision Number**: V1.1	**Creation Date**: 2018-10-22 **Revision Date**: 2020-06-19

Objective

To ensure the safety of rescuers and reduce the potential further risk to a person or persons who have fallen into a crevasse, millwell, bergschrund or similar (all referred to as "Crevasse" for ease of use in this SOP).

Scope

This procedure will outline the steps needed to perform a crevasse rescue using the tools available to Mountain Safety and ERT.

Health, Safety & Reclamation Code of BC

- WSBC Part 32 – Evacuation and Rescue

Definitions

- Crevasse - a deep crack, or fracture, found in an ice sheet or glacier
- Mill well – Open hole in the glacier formed by running water
- Bergschrund – A crevasse that forms where the glacier separates from firn snow or rock face above
- Snow bridge - An arch across a crevasse. It is typically formed by snow drift, which first creates a cornice, and may gradually grow to reach the other side of the opening while remaining open underneath.
- Litter/SKED – spinal immobilization/extraction device to raise victim in vertical rescue situations
- "Mauthner Mound" – a step at the lip, with a mound of snow roughly 1 meter from edge. Backpack or similar item placed on top to prevent ropes from digging in.
- RAD kit – Purpose built compact rescue and descent rope kit
- Screamer Suit – A triangular diaper style harness that can be put on quickly
- Fresh Eyes – A component or system check by a team member not involved in the original task
- Danger Zone – Delineated area where rescuers are always required to be on rope.

Preparation

Hazards

- Crevasse or other falls for rescuers
- Mechanical failure
- Rope failure
- Human error
- Weather (visual limitations)
- Environmental exposure
- Overhead Hazard for persons in crevasse
- Avalanches
- Sharp points (ice tools, crampons, etc)

Tools (will vary with location and season)

- Dual rope rescue kits
- Glacier RAD rescue kit
- Vehicles – sled, snow cat, truck, other heavy equipment.

- Rescue Tripod. Terradaptor in BJ firehall. Carbon tripod at KNP firehall (Mountain Safety Seacan).
- Aztec
- Glacier Travel PPE
- Avalanche Safety gear
- Helmet
- Crampons
- Ice Axe
- Skis
- Rope handling gloves
- First aid kit
-

Requirements

- PPE for rescuers
- Knowledge of rope rescue equipment being used
- Proper anchor building techniques for use with "live (human) loads"

Job Step

Crevasse preamble

Personal injury is possible but not always certain with a fall. Swift and safely executed rescue is paramount due to the cold environment that exists in the glacier.

Initial report of incident

In the event of a crevasse fall a CODE ONE call will be made by the person involved or by a reporting party who has either witnessed the fall or who discovers the event initially. This CODE ONE call may be downgraded depending on the level of risk to the subject in the crevasse.

Rescue site preparation

- Establish safe area for rescue operation.
  - Incident Command System (ICS) structure to organize site. Notify IC and dispatch of who will be acting Operations Chief
  - Ops Chief to identify safe area for rescuers to be un-roped/off belay
  - Probe area, complete visual sweep for depressions in snow (snow bridges, etc.) Use belayed approach if necessary
  - Use delineators (marking paint, bamboo, flagging tape etc.), guards, flares or lights to safeguard work zone
- Ops Chief to determine type of rope rescue system required
  - Where possible, a Dual Capability Twin Tension Rope System should be used
  - Crews must be trained prior to use in rescue situation
- Build reliable anchor and back up anchor
  - Adequate training for personnel required
  - All anchor systems must be reliable, with backup anchors to guard against failure. (Redundancy in system)
  - All rescuers must always be connected to anchors when in danger zone (beyond the safe work area)
  - All connections and harnesses must be double checked

  - The rescuers must proceed as quickly as possible using efficient, thorough execution of every step
  - Use proper equipment in its designated manner in accordance with manufacturer. Use of adequate breaking strength, including a safety factor for size of load
  - If man power allows a check with "Fresh Eyes" will be completed.
- Rescuer approaches the lip of the crevasse while on belay.
  - Partner belays rescuer to edge or rescuer self-belays with prussik or similar device
- Rescuer probes the lip of the crevasse
  - Rescuer probes to find the edge of crevasse with avalanche probe or another appropriate tool. (ie: hiking pole, bamboo stake)
  - Rescuer assesses the strength and condition of the crevasse lip
  - If inadequate, unstable, or directly above the victim (risk of falling ice or equipment on the victim) slightly offset the crevasse entrance location or completely reestablish anchors in safer location (ie on the other side)
- Rescuer visually and verbally assesses victim
  - Visually and verbally assess the victim for life threatening injury
  - Rescuer relays information to Ops Chief to prepare for handoff and assess urgency of the situation
  - Rescuer should assess the depth of the victim and other potential hazards
- Rescuer cleans the lip if necessary and builds "Mauthner mound", in summer a backpack alone may suffice.

Rescue Ops with Glacier Rescue Kit and Capable Victim

- Prep edge
- Lower drop loop or single strand of rope, and locking carabiner to victim
- Haul or build additional mechanical advantage into system
- Assess edge transition often
- Administer first aid if required

Rescue Ops with Glacier Rescue Kit and Non-Capable Victim

- Prep edge
- Rappel into crevasse
- Secure victim to safety line
- Administer critical first aid if required
- Ascend out of crevasse
- Haul or build additional mechanical advantage into system
- Assess edge transition often
- Administer first aid if required

Rescue Ops with Dual Rope Rescue Kit and Capable Victim

- Crews must be trained prior to use in rescue situation
- Resultant angles must be considered relative to anchor strength

- Rescuer visually assesses the victim's condition, depth, accessibility and other objective hazards in the crevasse itself. If the victim is capable and in a precarious position, the rescuer can lower equipment to victim (fixed rope or screws and slings to secure from falling deeper)
- Prepare the lip of the crevasse
- Lower rescuer and any additional gear required (i.e. "screamer suit" or chest harness, first aid materials) to victim
- Rescuer connects victim, double-checks all connections and hanging distances
- Set up mechanical advantage Edge transition (vector)
- Raise rescuer and victim using appropriate mechanical advantage (add or subtract as required)
- Administer further first aid, if required

Rescue Ops with Dual Rope Rescue Kit and Non-capable victim

- Crews must be trained prior to use in rescue situation
- Resultant angles must be considered relative to anchor strength
- Prepare the rescue litter/SKED
- Lower rescuer with litter/SKED to victim (bringing any extra gear required, ie first aid materials)
- Rescuer connects victim
- Second rescuer may need to be lowered to assist with loading and edge transfer
- Rescuer(s) load victim into litter/SKED
- Raise rescuer and victim using appropriate mechanical advantage (add or subtract as required)
- Set up mechanical advantage Edge transition (vector)
- Perform further first aid as required

Site Demobilization

- Evacuate patient
- Remove all gear from "danger zone"
- Pack up all gear; check and dry before re-packing
- Incident debrief with all parties involved as soon as possible

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2020-06-19	Changes made throughout for clarity and brevity	Mark Stanley	

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.23

BJ-AVL-SOP-035 – Transceiver Maintenance

PRETIVM		BJC-AVL-SOP-035 Transceiver Maintenance	
Owner: Mountain Safety	**Approver**: Ken Black Jim Franken	**Revision Number**: V1	**Creation Date**: 2020-06-20 **Revision Date**: 2020-11-09

Objective

Ensure transceiver fleet is maintained in good working order with record keeping twice a year both spring and fall

Scope

This applies to all Pretivm owned Transceivers managed by the Mountain Safety department

Health, Safety & Reclamation Code of BC

- HSRCBC 1.8.1(2) Ensure workers are instructed in the use and maintenance of the equipment, the reasons for it, and also it location and limitations. And to ensure the equipment is adequate for its purpose

WorkSafe BC Regulations

- 12.10 Identifying unsafe equipment
  - An unsafe tool, machine or piece of equipment must be removed from service and identified in a manner which will ensure it is not inadvertently returned to service until it has been made safe for use.
  - **Note**: The procedure for determining whether the tool, machine or piece of equipment is unsafe for use is provided by the requirements on the correction of unsafe conditions and refusal of unsafe work in Part 3 (Rights and Responsibilities).

Definitions

- Dongle. Manufacturer supplied device that attaches via USB to desktop computer to provide a link to service software.
- Transceiver - An avalanche transceiver is a type of emergency locator beacon, a radio transceiver (a transmitter and receiver in one unit) operating at 457 kHz for the purpose of finding people buried under snow.

Preparation

Hazards

- Lack of understanding of Software program, not identifying transceivers that require outside agency maintenance.
- Missing unit
- Industrial use of recreational device

Tools

- Dongle
- Barryvox Tester 2.0
- W-Link Stick 2.0
- Computer

Requirements

- Training
- Transceiver specific software
- Transceiver knowledge

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

Spring Round Up

1. Gather all transceivers and ensure all still have batteries with more than 40% charge
2. Remove from Harness
3. Place in numerical order close to computer. Dongle in groups of 20.
4. Plug in dongle to computer
5. There are two programs, one for each model of Transceiver. Open appropriate program on desktop. If you do not have them or need them updating you will need to have the IT department provide the permission for this download.
6. Click "Add devices" (Green "+" sign)
7. Turn on each unit **ONE at a time in sequential order**. Wait until startup of each transceiver has completed by listening for the 3 tone beeps before turning on next numbered transceiver in sequence.
8. Program will show each unit as you turn it on. Look at list and ensure all units are showing.
9. Click "Stop Searching"
10. Note any units that did not pass the self-test or are scheduled for maintenance or in the next six months. Note ones that are close to maintenance (*3 year maintenance schedule)
11. Note which units have below 75% battery
12. Save file under Jdrive, Mtn. Safety, Operations, Transceivers and Avi PPE, YYYY-MM-DD Transceiver and Avi PPE, Post season Transceiver tests YYYY-MM-DD

13. File name example "Elements 1-20 YYYY-MM-DD" or "New units 1-20 YYYY-MM-DD"
14. If some units are missing note that in the file name. ie. "New units 1-20 missing 21,23,24 YYYY-MM-DD"
15. Highlight all units on computer screen and click "Remove devices" (Red "x"). You are now ready to dongle the next 20 units.
16. Separate out units that need to go back for maintenance.
17. Remove batteries from all units, recycle if less than 75%, store batteries in file cabinet for next year if more than 75%.
18. Store units that do not need maintenance in storage room with harnesses.
19. Package and send back units to manufacturer's representative that require maintenance.
20. **Note** there is a quirk to using the dongle. Occasionally units will show as "unreachable". If this occurs, you can turn off the unit manually and restart it or click device on the program and choose restart from the drop-down menu. Sometimes this error does self-correct.

Fall Prep and Issue

1. Replace batteries in all transceivers (battery strength 75% or more)
2. Place in numerical order close to computer. Dongle in groups of 20.
3. Plug in dongle to computer
4. **Note** The dongle we have is good for only firmware updates on Pulse and Element transceivers. Not the Barryvox S or Barryvox. The newer models need to be updated by a distributer, Barryvox Tester 2.0, or W-Link Stick 2.0.
5. Use appropriate service software as described above (Spring Round Up Step 5).
6. Click "Add devices" (Green "+" sign)
7. Turn on each unit **ONE at a time in sequential order**. Wait until startup of each beacon has completed by listening for the 3 tone beeps before turning on next numbered beacon in sequence.
8. Program will show each unit as you turn it on. Look at list and ensure all units are showing.
9. Click "Stop Searching"
10. Note any units that show below 75% battery strength and replace before issue.
11. Save file under Jdrive, Mtn. Safety, Operations, Transceivers and Avi PPE, YYYY-MM-DD Transceiver and Avi PPE, Post season Transceiver tests YYYY-MM-DD
12. File name example "Elements 1-20 YYYY-MM-DD" or "New units 1-20 YYYY-MM-DD"
13. If some units are missing note that in the file name. ie. "New units 1-20 missing 21,23,24 YYYY-MM-DD"
14. Highlight all units on computer screen and click "Remove devices" (Red "x"). You are now ready to dongle the next 20 units.
15. After units are Dongled place transceivers into corresponding numbered pack
16. Create a spreadsheet showing each department and the unit numbers they are receiving.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Appendix C.24

BJ-AVL-SOP-037 – Longline Operations

Objective

To provide detailed methodology and establish a safe and efficient system for sending and receiving suspended loads from a helicopter which would include cargo nets, oxygen cradles and Wyssen deployment boxes

Scope

This SOP applies to any Pretium personnel that may be participating in these tasks as a designated grounds receiver. Furthermore, this SOP is written to ensure that all aforementioned personnel are aware of the hazards associated with these tasks.

Health, Safety & Reclamation Code of BC

- HSRC – Section 2.2.1 (Hazard Free Workspace)
- HSRC – Section 4.9 (Mobile Equipment)
- HSRC – Section 4.20 (Rigging)
- HSRC – Section 4.21 (Slings)

WorkSafe BC Regulations

- OHS Part 29.3 Pre-job planning and training
- OHS 29.5 Communications
- OHS 29.9 Airlifted loads
- OHS 29.12 Unstable materials

Definitions

- Pretivm Grounds Personnel: Pretium employee responsible for sending and receiving suspended loads from a helicopter
- Spotter: A person who looks or observes a particular activity, one that keeps watch, one who assists another during exercise(s). Essential for Gazex and Wyssen longlining.
- Pinch Point/Crush Point: A place or point of where two objects more toward each other or when a moving object approaches a stationary object.

Preparation

Hazards

- No pre-flight briefing
- Helicopter hazards, rotor downwash, noise, static discharge, cross loaded electric or dead hook to long line attachment point
- Untrained or inexperienced ground crew, fatigue, rushing or taking chances
- Loose items (helmet no strap, loose clothing, harness clipping into hook)
- Flying over roads or infrastructure with suspended loads.

- Visual distraction for haul traffic vehicles
- TDG, Compressed gases and explosives
- Pinch Points; keep hands out of line of fire and use gloves.
- Caught between load and fixed object. (I.e. Oxygen cradles)
- Sharp metal or wood splinters
- Fall hazard (Particularly Gazex shelter and removal of guard rails for flight operations)
- Trip hazard (Particularly railing support on Gazex deck)
- Suspended, spinning, swinging, unsecured or dropped load
- Small landing footprint
- Damage to infrastructure
- Crush point
- Miscommunication (radio channel and hand signals)
- Environmental, Poor visibility
- Lack of vision between the helicopter pilot and grounds personnel
- Human (Blasting at the km 59 quarry) and helicopter interactions
- Slipping hazards due to wet and/or snow-covered ground

Equipment

PPE must be appropriate for the weather, very high wind and noise conditions

- Hard hat with secure chin strap, Hi-Vis, ear protection, protective work gloves, safety glasses / googles, and appropriate boots.

Tools

- Slings, Wyssen heli latch, electric or manual hook

Requirements

- Review Construction Health and Safety Manual – Helicopter lifting
- Grounds Personnel must have read and signed off on the Helicopter Slinging SOP.
- Familiar with Wyssen and Gazex SOPS
- TDG ticket (Wyssen and Gazex)
- WCB Blasting ticket (Wyssen)

Responsibilities

Mine Manager

- Review, comment and sign off on the procedures

Supervisors

- Ensuring this SOP is implemented and maintained.
- Ensuring field personnel have all necessary training and information to safely complete the job.

Workers

- Following this SOP as outlined and directed by the supervisor.
- Proper helicopter orientation training has been completed.
- Ensuring safe practices are maintained at all times.

Job Step

The key element in a helicopter lift is planning. This requires the participation and cooperation of all workplace parties. Planning includes, but is not limited to, the following points.

- Planning meetings will be arrange with all flight operations members prior to the operations.
- Some training and review of current SOPS or JHAS are essential to ensure safe operations.
- Communication- Pre plan, assign individual assignments and responsibilities designated radio channels, hand signals
- Load weights- Consider helicopter limited lifting capacity
- Load shape, orientation and packaging- affect in flight handling
- Rigging plans – rigging devices and assemblies, briefing on load rigging
- Flight plan- designate staging area, flight path (consider roads and infrastructure)
- Lifting plan- include load line, hook up device and configuration, cable lengths, static discharge,
- Risk assessment- Identify, assess, and eliminate or provide protection against risks
- Rigging inspection- Inspect, record and have certificates of testing for rigging components and assemblies
- Site Safety- Follow up on all points covered in the risk assessment. Site cleanup. Remove loose materials. Minimize dust.
- Security and notification- Notify workplace parties of where and when helicopter lifts will be conducted. Prohibit access to nonessential personnel.

Site Preparation:

- Grounds personnel must ensure that the slinging area is clear of all non-essential personnel and that nearby personnel are aware of helicopter activities.
- Any loose articles or debris must be removed or secured before arrival of the helicopter.
- All personnel must be wearing the required PPE.

Receiving external loads:

- Stay in a safe location with spotter until it is determined to approach the load. Spotter will observe flight operations and signal the pilot of any safety concerns.
- Approach the load when it is at eye level and face the load at all times.
- Consider controlling the load with the use of tag lines. If the load is spinning, the pilot can touch down to stop the spin.
- Use hand signals to guide the load into position. Never get under the load as precise control of loads is not possible with a hovering aircraft.
- Always keep eye contact with the load. Watch for pinch points, crush points, and tripping hazards while receiving the load.
- Ensure load is released from the helicopters' long-line before notifying the pilot (hand signals or radio communications) that he is clear to depart.

Hooking Up external loads:

The procedures used for hooking up must be confirmed during the pre-flight briefing.

- There must be no loose wrapping, packing or objects on the load.
- The hook-up person stands with back to the wind while the aircraft approached into the wind.
- Spotter will remain in a safe location, observe flight operations and signal the pilot of any safety concerns.
- The hook-up person stays with the load.
- The aircraft will approach and hover over the hook-up person.
- Place the pear ring or other attachment point onto the hook and contact the pilot to start lifting

- If using tag lines; consider synthetic fiber rope and keep them shorter that the load line.

Before the load clears the ground:

- Stay with the load and ensure the hook does not become cross loaded.
- Don't turn your back on the load.
- Double-check that the loads center of gravity is below the rigging attachment points.

Lift-off

- When satisfied with load rigging, the hook-up person will walk out from beneath the helicopter to a safe area.
- Once the hook-up person is in a safe position, a signal can be given to the helicopter to continue lifting until the load is clear.
- The helicopter is now free to deliver the load.

Revisions

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Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager of Health and Safety or designate			
JOHSC Co-chair or Member			

Mountain Safety.

Appendix C.25

BJ-AVL-SOP-039 – Gazex Lockout Tagout

PRETIVM		BJ-AVL-SOP-039 Gazex Lockout/Tagout	
Owner: Mountain Safety	Approver: Ken Black Jim Franken	Revision Number: V1	Creation Date:2020-10-23 Revision Date:

Objective

To provide guidelines for achieving energy isolation on equipment and processes for the purpose of performing maintenance on or near all potential forms of hazardous energy. Ensure all personnel are using the proper lockout and de-energization procedures to guarantee their safety and that of others from accidental ignition while performing maintenance on the Gazex system. Failing to do so could result in serious injury.

Scope

This procedure pertains to all personnel performing work on the Gazex system at both the shelter and exploder locations. This document is a necessary compliment to the Gazex maintenance manual

Health, Safety & Reclamation Code of BC

- Health, Safety and Reclamation Code for B.C Section 4.11 – Lock Out Procedures

WorkSafe BC Regulations

- WSBC OH&S Regulation Part 10: De-energization and Lockout
- 10.3 When lockout required
  - (1) If machinery or equipment is shut down for maintenance, no work may be done until
    - (a) all parts and attachments have been secured against inadvertent movement,
    - (b) where the work will expose workers to energy sources, the hazard has been effectively controlled, and
    - (c) the energy isolating devices have been locked out as required by this Part.
  - (2) If machinery or equipment is in use for normal production work, subsection (1) applies if a work activity creates a risk of injury to workers from the movement of the machinery or equipment, or exposure to an energy source, and the machinery or equipment is not effectively safeguarded to protect the workers from the risk.
- 10.4 Lockout procedures
  - (1) When lockout of energy isolating devices is required, the devices must be secured in the safe position using locks in accordance with procedures that are made available to all workers who are required to work on the machinery or equipment.
  - (2) The employer must ensure that each worker required to lock out has ready access to sufficient personal locks to implement the required lockout procedure.
  - (3) Combination locks must not be used for lockout.
  - (4) Each personal lock must be marked or tagged to identify the person applying it.
  - (5) Procedures must be implemented for shift or personnel changes, including the orderly transfer of control of locked out energy isolating devices between outgoing and incoming workers.
  - (6) If the use of a personal lock is not practicable for lockout, another effective means, if approved by the Board, may be used in place of a personal lock to secure an energy isolating device in the safe position.
- 10.5 Access to energy isolating devices
  - When an energy isolating device is locked out, the lock must not prevent access to other energy isolating devices supplying machinery or equipment that could cause injury to workers.

- 10.6 Checking locked out equipment
  - (1) Effective means of verifying lockout must be provided and used.
  - (2) Before commencing work, a worker must verify that all energy sources have been effectively locked out.
- 10.7 Worker responsibilities
  - Each worker who works on machinery or equipment requiring lockout is responsible for
    - (a) locking out the energy isolating devices before starting work, except as provided by section 10.9,
    - (b) removing personal locks on the completion of his or her work, and
    - (c) maintaining immediate control of the key(s) to personal locks throughout the duration of the work.
- 10.8 Removal of locks
  - (1) A personal lock must only be removed by the worker who installed it, or if this is not possible, the matter must be referred to the supervisor or manager in charge, who will be responsible for its removal.
  - (2) The supervisor or manager in charge must
    - (a) make every reasonable effort to contact the worker who installed the lock, and
    - (b) ensure that the machinery or equipment can be operated safely before removing the lock.
  - (3) A worker must be notified at the start of his or her next shift if the worker's personal lock(s) have been removed since the worker's previous shift.
- 10.9 Group lockout procedure
  - (1) If a large number of workers are working on machinery or equipment or a large number of energy isolating devices must be locked out, a group lockout procedure that meets the requirements of subsections (2) to (7) may be used.
  - (2) In a group lockout procedure 2 qualified workers must be responsible for
    - (a) independently locking out the energy isolating devices,
    - (b) securing the keys for the locks used under paragraph (a) with personal locks or other positive sealing devices acceptable to the Board, and
    - (c) completing, signing and posting a checklist that identifies the machinery or equipment components covered by the lockout.
  - (3) Before commencing work each worker working on the locked out components must apply a personal lock to the key securing system used in subsection (2)(b).
  - (4) Workers may lock out a secondary key securing system if 2 qualified workers lock out the primary key securing system and place their keys in the secondary system.
  - (5) On completion of his or her work, each worker referred to in subsections (3) and (4) must remove his or her personal lock from the key securing system.
  - (6) When the requirements of subsection (5) have been met and it has been determined that it is safe to end the group lockout, 2 qualified workers must be responsible for removing their personal locks or the positive sealing device(s) from the key securing system or systems containing the keys for the locks used under subsection (2)(a), and once those keys are released, the system is no longer considered to be locked out.
  - (7) The written group lockout procedure must be conspicuously posted at the place where the system is in use.
- 10.10 Alternative procedures
  - (1) If lockout of energy isolating devices as required by section 10.3 is not practicable,
    - (a) in the case of a power system as defined in Part 19 (Electrical Safety), the requirements of that Part must be followed,

        - (c) in the case of machinery or equipment designed and equipped with effective control system isolating devices, the devices must be locked out as required by sections 10.4 to 10.9, and 10.10(2), and
        - (d) in an emergency, the energy isolating devices or control system devices must be effectively controlled to prevent inadvertent start up or hazardous energy release.
    - (2) Control system isolating devices and the procedures for using them must be approved in writing by the Board and must be used by workers qualified and authorized to carry out the work.
- 10.11 Locks not required
    - The application of a lock is not required under section 10.3 or 10.10 if
        - (a) the energy isolating device is under the exclusive and immediate control of the worker at all times while working on the machinery or equipment, or
        - (b) a tool, machine or piece of equipment which receives power through a readily disconnected supply, such as an electrical cord or quick release air or hydraulic line, is disconnected from its power supply and its connection point is kept under the immediate control of the worker at all times while work is being done.

Definitions

- **De-energization** – means removing the energy from machinery or equipment.
- **Lockout** – refers to using lock(s) to isolate energy source or to ensure machinery or equipment is inoperable.
- **Control system isolating device** - means a device that physically prevents activation of a system used for controlling the operation of machinery or equipment
- **Energy isolating device** - means a device that physically prevents the transmission or release of an energy source to machinery or equipment
- **Energy source** - means any electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other source of energy of potential harm to workers
- **Key securing system** - means a system which physically prevents access to keys when locks or positive sealing devices are applied in a group lockout procedure
- **Lockout** - means the use of a lock or locks to render machinery or equipment inoperable or to isolate an energy source in accordance with a written procedure
- **Maintenance** - means work performed to keep machinery or equipment in a safe operating condition, including installing, repairing, cleaning, lubricating and the clearing of obstructions to the normal flow of material
- **Normal production** - means work that is routine, repetitive, and integral to the normal use of machinery or equipment for production
- Applying a Danger Tag or "Tag out" - the process of attaching a sign or label to an isolating device in order to warn others not to restore energy to the system or equipment bearing the label. The practice of using tags is done in conjunction with locks to increase the visibility and awareness that equipment is not to be energized or activated until such devices are removed. The Tag must be dated with the name of the person who applied the lock out. The Tag must have a date and the name of the person's supervisor. All information on the tag must be legible. The danger tag is also applied in conjunction with a Departmental lock when mechanical or electrical devices are not to be operated for purposes of protecting the equipment from damage.
- **Personal Locks - RED** - A uniquely keyed lock or lock set issued to an employee after completing training in Pretivm Isolation and Lookout Procedure. The personal lock(s) identifier # is kept on a master list along with the name of the employee. Personal locks are used as a primary lock for jobs involving up to three (3) isolating devices. Personal locks are also used in conjunction with group locks to secure a lock box when more than three (3) isolation points are involved.

- **Group Lockout** - In instances where more than five (5) workers are working on machinery that must be locked out, or when more than three (3) energy-isolating devices require isolation, a group lookout will be required. Follow Group lookout procedure.
- **Lock Box** - A device used as a primary key securing system during a group lookout. The lock box must be approved by a Supervisor prior to using.
- Group Lookout Checklist - List of energy-isolating devices that are subject to lookout according to the JHA for the work to be performed. Qualified persons de-energizing equipment and performing lockout/tagout will initial the checklist as each item is isolated. The two qualified persons will also do a bump test on each piece of equipment and initial on the checklist that it is complete.
- Completed Group Lookout Checklist will be attached to Lookout Board and accompany the Group Lock Box.

Preparation

Hazards

- Pressurized vessels, propane and oxygen, gas explosions, misfires, grease/oxygen interaction, cold burns from propane, miscommunication, stored energy, personnel in line of fire, unfamiliarity with task
- Gazex system stored energies
    - 100Ah Gel Battery Nominal Voltage 12VDC
    - Propane Source (high pressure) 100LBS bottles x4 @ 24.8bar @ 70 degrees C
    - Oxygen Source (high pressure) 3 cradles 18 bottles @150bar @ 20 degrees C
    - Propane Dosing Tank (low pressure) One tank per exploder, 454 Litres vaporized gas @ 1.4bar @ 20 degrees C
    - Oxygen Dosing Tank (low pressure) One tank per shelter, 454 Litres vaporized gas @ 6.5bar @ 20 degrees C
    - Ignition batteries are 8x 2.5Ah, 1.5VDC AA batteries in series making 12VDC @2.5Ah
    - Capacitor/Igniters -I have no data for the capacitors or igniters in the ignition box. The series packs of AA cells in the ignition box charge the capacitors only when pressure is sent to the ignition hose and pressostate switch.

Tools

- Locks for all workers
- Lock out tags

Requirements

- Pretivm Lock out / tag out training for all workers
- BJ-OHS-SOP-014 – Energy Isolation Lockout must be referenced
- Personal Locks
- Familiarity and high level of training with the Gazex system
- Ongoing communication (prior to any steps being carried out) between personnel at the exploder and at the shelter is imperative for safe operation of maintenance duties.

Responsibilities

- **Mine Manager or Designate**
    - Ensure this SOP is implemented and maintained.
    - Ensure personnel have up-to-date information regarding this SOP.

- **Department Manager/Supervisor**
  - Ensure that all workers perform tasks in a safe manner
  - Review procedure with any persons performing tasks pertaining to this SOP
- **Health and Safety Manager or Designate**
  - Monitoring the implementation of this SOP
- **Workers**
  - Ensure that they authorized to perform tasks as required
  - Report to their supervisor any issues pertaining to the above procedure
  - Stop work if unsure and report to supervisor

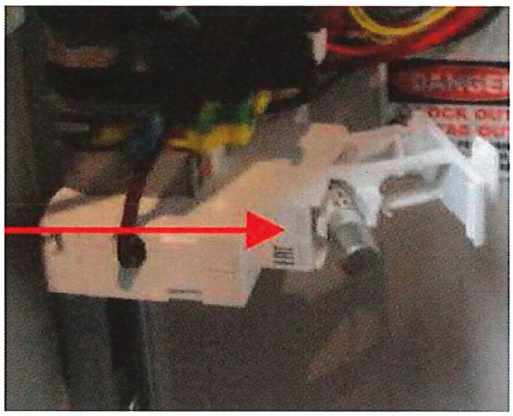
Job Step

Two options are possible for lockout depending on the maintenance to be carried out.

Option A (Electrical lockout with Guard)
Requires an electrical lockout and a trained guard to stay at shelter and manage dosage tanks for Pipeline pressure testing. Follow applicable guidelines in BJ-OHS-SOP-014 – Energy Isolation Lockout

All workers gather at shelter

- Open the electrical compartment on the door of the shelter.
- Locate the main fuse on the terminal strip
- Open the fuse normally and entirely to disconnect. De-energization is made automatically after disconnecting.



- Ensure system is deenergized by noting no lights on the communication system for a period of 2 minutes. The blue light must never be lit, confirming that there is no power source. This removes all power and controls from the electromagnetic control valves within the shelter.

- Close door for Electrical components and lock with Scissor Hasp secured with a lock from all personnel working on the system.

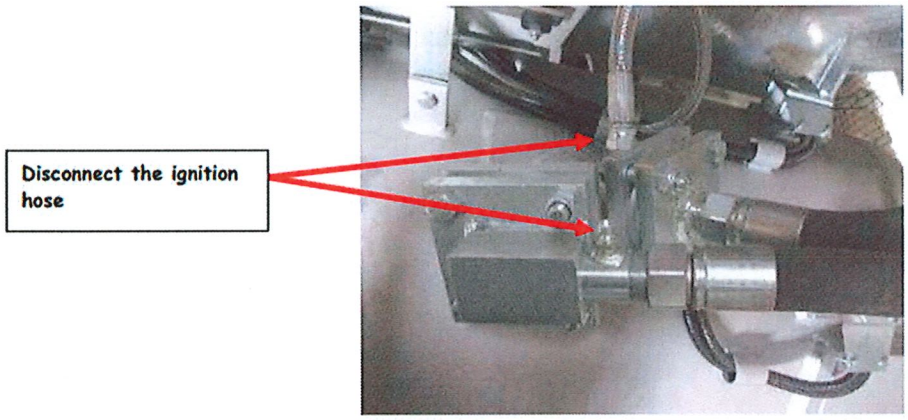
- Consider the electrical Lockout-Tagout as effective at this point

Opening the shelter door

- Wait one minute for ventilation of the space before entering the shelter.
- Trained personnel to remain at the shelter for security and to assist with pressure testing of pipes.

Personnel descend to Gazex exploders

- Upon approaching an exploder immediately remove the ignition hose, this in return removes any possibility of spark



- Personnel at the exploder location then confirm via the radio with the guard at shelter that the ignition line has been disconnected from chosen exploder (I.e. number #1)
- Begin maintenance on the exploder as per BJ-AVL-SOP-15 Gazex Annual Maintenance

Live Testing

Is done to pressure test the pipelines and repair any possible leaks. **Note*** When pressure testing of pipes is to be performed, personnel must gather at only one exploder location prior to test. During this procedure only one technician is within 30m of the shelter being tested.

- The Gazex electrical components remains locked out and tagged out.
- The exploder being tested has its ignition hoses removed, this removes any possibility of spark.
- The main supply lines are then removed and capped with hydraulic plugs and gauges.

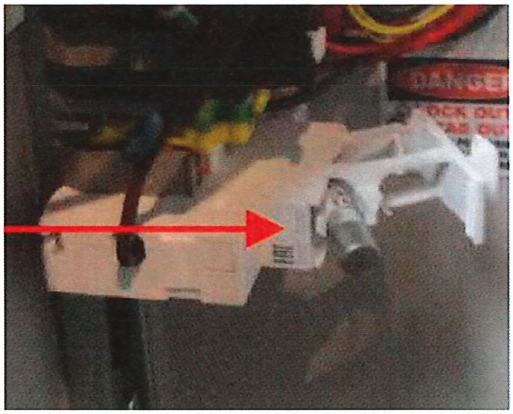
- Once communication has been established with the guard at the shelter and confirmation of chosen exploder is confirmed. The guard then overrides the pneumatic valve associated with the chosen exploder. This charges the lines with gas pressure to perform measurements.
- Oxygen is always tested first and vented to the atmosphere before testing propane.

Option B (Full electrical and pneumatic lockout)

Requires no guard and involves a full electrical and pneumatic lockout. Follow applicable guidelines in BJ-OHS-SOP-014 – Energy Isolation Lockout.

All workers gather at shelter

- Open the electrical compartment on the door of the shelter.
- Locate the main fuse on the terminal strip
- Open the fuse normally and entirely to disconnect. De-energization is made automatically after disconnecting.

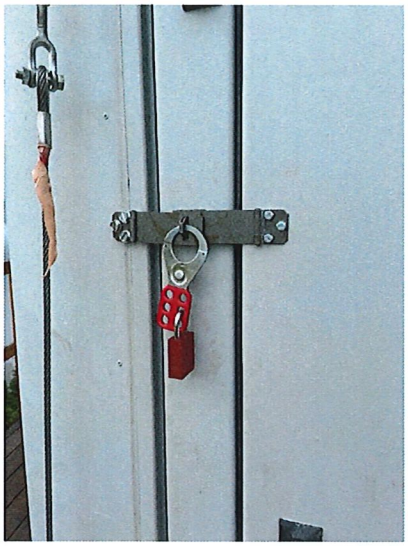


- Ensure system is deenergized by noting no lights on the communication system for a period of 2 minutes. The blue light must never be lit, confirming that there is no power source. This removes all power and controls from the electromagnetic control valves within the shelter.

Opening the shelter door

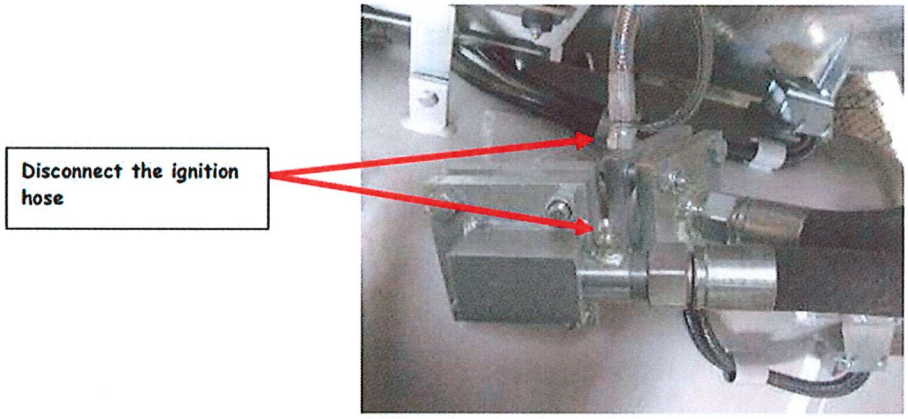
- Wait one minute for ventilation of the space before entering the shelter.
- Close the O2 valve supplying the electromagnetic valves. This mechanically isolates the electromagnetic valves from shifting the dosing tanks pneumatic valves and removes any risk of accidentally sending gas to the exploder.

- Close doors and lock both electrical and shelter doors with Scissor Hasp secured with a lock from all personnel working on the system.



Personnel descend to Gazex exploders

- Upon approaching an exploder immediately remove the ignition hose, this in return removes any possibility of spark



- Personnel at the exploder location then confirm via the radio with the guard at shelter that the ignition line has been disconnected from said exploder (I.e. number #1)
- Begin maintenance on the exploder as per BJ-AVL-SOP-15 Gazex Annual Maintenance

Revisions

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Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager Health and Safety or Designate			
JOHSC Co-chair or Member			

Appendix C.26

BJ-AVL-SOP-041 – Gazex Firing Procedures

Objective

The purpose of this procedure is to ensure that all safety precautions are taken to protect all employees and contractors and provide safe and consistent Gazex firing for all personnel associated with the Pretivm Avalanche Control program.

Scope

Mountain Safety team members participating in avalanche control using the Gazex RAC system.

Health, Safety & Reclamation Code of BC

- HSRC 8.0 Explosives
  - **Guarding 8.6.2** Before blasting, the blaster, or person designated responsible for blasting, shall (1) clear the blast danger zone of all persons, (2) ensure that all entrances to the blast danger zone are guarded to prevent access, and not rely only on signs for the purpose, and (3) when blasting on the surface of a mine, ensure that an effective audible warning is given.

WorkSafe BC Regulations

- WSBC G4.1.1 Avalanche Assessment
- 21.5 Authority to blast
  - (1) Only the holder of a valid blaster's certificate issued by the Board or acceptable to the Board is permitted to conduct or direct a blasting operation, and then only if the work involved is within the scope of that certificate.
  - (2) All work within the blasting area must be done under the authorization of the designated blaster of record responsible for that area.
  - (3) A blaster may be assisted by persons who do not hold blaster's certificates, but the blaster must have authority over the assistants and must exercise visual supervision over them and be responsible for their work during explosive loading, priming, fixing or firing.
- 21.7 Training
  - A worker engaged in loading, unloading, or conveying explosives must be trained in the proper means for handling the explosives, the hazards of fire and mishandling and the procedures to follow in the event of a fire or explosion.

Definitions

- *"hazard"* means a thing or condition that may expose a person to a risk of injury or occupational disease;
- *"hazard area"* means an area in a workplace where a hazard exists, or is created, due to a condition in the area or the activities conducted in it;
- *"incident"* includes an accident or other occurrence which resulted in or had the potential for causing an injury or occupational disease;
- *"qualified"* means being knowledgeable of the work, the hazards involved and the means to control the hazards, by reason of education, training, experience or a combination thereof;

- *"risk"* means a chance of injury or occupational disease;
- *"supervisor"* means a person who instructs, directs and controls workers in the performance of their duties;

Preparation

Hazards

- Un-exploded ordnance; post control avalanches; underestimating the remaining avalanche hazard, natural avalanches during debris clearing, weather factors; lack of radio communications; loss of control zone; vehicle collisions; damaged equipment; injured workers; backed up traffic in avalanche areas; logistical delays; cognitive overload, making mistakes that have been previously identified; extended exposure to overhead hazards; getting stuck; too narrow single lane; improper vehicle spacing; logistical delays; miscommunication between snow removal equipment and traffic, lack of equipment available to carry out the task, vehicle breakdowns, loss of process from extended closure, inadequate equipment, inexperienced operator, river, rockfall, icefall, equipment proximity to area of concern, hazards left over from clearing, terrain traps, snow (uphill side of the road) falling from debris cones onto roads / vehicles, loose rock slabs near gun #5

Tools

- PPE
- Companion Rescue Equipment
- Radio
- Suitable heavy equipment (Loader, Excavator, Snowcat)
- Truck
- Closure Gates
- Lighting (Light Plants)
- Gazex Tablet / Gazex Firing Codes
- Allen Key and Gazex tablet maintenance tools
- Antenna and DC Adapter

Requirements

- Avalanche Safety Plan (ASP)
- Avalanche Safety Equipment
- Equipment training
- Prior Training/Familiarity
- BJ-AVL-SOP-005 Guarding and Sweeping
- BJ-AVL-SOP-007 Avalanche Debris Clearing
- BJ-AVL-SOP-009 Pre-Blast Considerations / Avalanche Control Checklist
- BJ-AVL-SOP-018 Avalanche Related Road Closure Sustainability Plan

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

- Ensure that they are authorized and trained to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

1. Inform shareholders of avalanche control via:
    - Face-to-Face with surface ops manager if possible, to coordinate guarding/sweeping, clearing and spotting personnel.
    - Brucejack Control flash.
    - Two-hour, one hour, 30 min blast warning over Road channel and Repeater 2.
2. Complete pre-blast check list.
    - Discuss mission details (Timing, what guns will be fired and in what succession, etc..).
3. Ensure the tablet is charged, with required DC adaptor and antenna.
4. Drive to Km 44.4, ensure guards are in place and area is swept and secure.
5. Notify dispatch that the area is secure, AC is ready to commence and provide 5 min blast warning.
    - Repeat 5 min blast warning over the Road channel.
6. Attach DC adaptor and antenna to the truck and Gazex case. (Ensure red switch is on DC)
    - Turn the tablet on (top left button)
    - Select the Gazex icon.
    - Click the Trigger Icon.
    - Choose the user (BOR)
    - Type in your password and hit enter.
    - Choose the Slasher shelter (your only option) by hitting enter.
    - Wait for a connection with the shelter.
    - Select an exploder. (1,2,7(2.5),3,4, or 5) (ensure not simu-blast)
        - When firing both guns 2 and 7(2.5) in the same mission, fire one first and the other last as they are on the same line and require 15 minutes because of longer gas fill times.
    - Enter the firing code.
    - The gases will then enter the guns and initiate the explosion.
7. Once fired, seismic information will be displayed, and the screen will return to select an exploder.
    - Wait a “timed 5 minutes” before firing the next shot, this ensures proper dosage tank fill level and avoids backburn.
8. Monitor results per shot and determine whether further control work is required.
9. Once the mission is complete, evaluate the paths to determine whether hazard remains on the slope and if it is safe to proceed into debris clearing operations.
    - It is required to wait approximately 20 mins post control when missions are being conducted with a spring-like snowpack, and post control releases.
    - Refer to Avalanche Debris Clearing SOP (BJ-AVL-SOP-007).

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager Health and Safety or Designate			
JOHSC Co-chair or Member			

Appendix C.27

BJ-AVL-SOP-042 – Magazine Checks

Objective

To fulfill our regulatory requirements Mountain Safety will conduct weekly and monthly inspections of our explosives magazines. This SOP aims to establish clear, consistent and safe practices.

Scope

Applies to mountain safety team members who are required to do weekly and monthly explosive magazine checks at both km 73.3 and km 48.

Health, Safety & Reclamation Code of BC

- HSRCBC 8.1.6 (1) Magazine rules
- Canada Explosives Act, Part 6, 157

WorkSafe BC Regulations

- OHS Regulation Part 21: Blasting Operations
- TDG

Definitions

- **SFA** – Safety Fuse Assembly, pre-built fuse and detonator
- **ANFO** – Prilled ammonium nitrate bulk explosive
- **Booster** – detonator sensitive, high density, high energy explosive cast into a shell

Preparation

Hazards

- Explosive hazards
- Powder headache (Nitroglycerin exposure)
- Heavy magazine doors
- Uneven and/or slippery ground
- Vehicle blind spots and collisions
- Driving hazards
- Wildlife
- Deep snow (hidden hazards)
- Heavy lifting
- Lost, stolen or misplaced keys
- Frozen door (pulling/kicking/etc)

Tools

- Magazine keys
- Gate keys

- InReach GPS communication device (charged)
- Lighting (headlamp)
- Gloves (nitrile) and standard worksite PPE
- Shovel, ice chipper, dead blow
- Sand or salt as required
- L6 Graphite Spray

Requirements

- Annual review of Fire Safety Plan
- Annual review of Key Control Plan
- Annual review of Site Security Plan
- Criminal background check and Clearance letter updated on the Cleared Employee document
- Minimum 2 workers at site (one worker must have a valid blasting certificate and be signed off on Key control plan)
- Fire extinguisher (up to date check both monthly and six year)
- ERAP in vehicle for transport
- TDG for transport
- Placards for transport
- Shipping documents

Responsibilities

Mine Manager or Designate

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

Department Manager/Supervisor

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

Health and Safety Manager or Designate

- Monitoring the implementation of this SOP

Workers

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Job Step

Preplan

- Check charge on InReach before departure
- DO NOT enter Magazine area if there is any chance of an electrical storm (e.g. thunderstorm)
- Collect required items before leaving office
    - Magazine keys (including sign in and out)
    - Gate keys if required (including sign in and out)
    - InReach

    - Pencil and notebook
    - Headlamp
    - Tools listed above as required

At magazine

- Inspect area surrounding magazine
    - No flammable materials within 10m
    - Fire extinguisher
        - Charged and in good condition
        - Monthly inspection, tag clipped
        - Expiry date checked
    - Signage in place
    - Integrity of magazine
        - Grounding cable intact
        - Groundcover is stable and level
        - No signs of damage or attempted break-in (walk around entire magazine)
    - Send InReach message from site for magazine inspection
    - Clear snow from entrances to magazines

In Magazine

- Ensure magazine license is current, up to date and posted
- Ensure Magazine rules are posted
- No excess flammable materials inside the magazine (empty boxes, etc)
- No broken or spilled explosives
- Contents organized
- Ensure all boxes are labeled with correct license number
- Count product and update in/out record in magazine with partner assisting
    - Trace back any errors
        - Implement any corrective actions
- Record inventories in field book (2 initials required)
- Clean and sweep magazine

Receiving Product

- Check shipping documents for quantity to be received.
- Load product into appropriate Magazine ensuring no broken or spilled explosives
- Contents organized with old stock rotated to front
- Label all boxes with correct magazine license number
- Count product and update in/out record in magazine with partner assisting
    - Trace back any errors
        - Implement any corrective actions
- Record inventories in field book (2 initials required)
- File Shipping document in office

Transferring Product

- Fill out TDG shipping documents for all transfers between Magazines at Km 48 and Km 73.3
- Update IN/OUT record in Magazine

- Load product into truck ensuring to not exceed 80% of GVW
- Ensure separation of Detonators and Anfo/Boosters
- Ensure correct placards are in place on all four sides of truck
- When driving on glacier notify dispatch of explosives shipment
- At destination Magazine update IN/OUT record in Magazine
- Load product into magazine with contents organized and old stock rotated to front
- Cross out old magazine license number and relabel products with new magazine license number

Before Departing Magazine

- Thoroughly clean door seals and sweep out all snow
- Partner checks that all doors are locked
- Ensure InReach and Magazine keys are accounted for
- Wait and listen to radio for any nearby traffic on road before exiting magazine area
- Close and lock gates as required

Upon Return to Office

- Dispose of empty boxes if required
- Input inventories in J drive: Daily Workflow: Pretivm Explosives Summary: Explosive Inventory
- Return all keys (sign back in)
- Return and charge InReach
- Move email message from InReach to appropriate folder

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Department Manager or Designate			
Manager Health and Safety or Designate			
JOHSC Co-chair or Member			

Appendix C.28

BJ-OHS-PLN-001 – MERP

BRUCEJACK MINE

Avalanche Safety Plan

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Mine Emergency Response Plan

February 2022

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Mine Emergency Response Plan

Date: February 2022

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VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
1	May 15, 2015	J. Nicholson	First release of the plan
2	July 14, 2016	J. Nicholson	Review and edits, add Code 1
3	December 2018	J. Barbondy	Align with 2017 MEMPR Guidance (v1.4)
2021.0	February 2021	R. Geddes	Updated to align with current safety standards and practices
2022.0	February 2022	R. Geddes	Review and edits

COMMUNICATIONS AND CONTACT LISTS

Communications at Brucejack is available by VHF radio, satellite phones, and satellite Internet. Tables 1 to 3 provide internal and external contacts as well as other useful communications related references. Planning Managers will direct the maintenance team to maintain and monitor the communications system.

Table 1. Medical Emergency Contacts

Service	Party	Contact Number
Ambulance	BC Road and Air Ambulance	1-800-461-9911
	Back-up BC Ambulance	1-800-561-8011
	Terrace	1-250-638-1102
	Stewart Lora Lee Murray	1-250-636-2676
Hospitals	Stewart – Stewart General Hospital and Nurse On-duty	1-250-636-2221
	Terrace – Terrace Mills Memorial Hospital	1-250-635-2211

Table 2. Mine Camp Coordinates

	UTM NAD 83 Zone 9		WGS 84	
Locations	Easting	Northing	Latitude	Longitude
Brucejack Camp	427,080	6,258,695	N 56°28’01”	W 130°11’01”
Wildfire Camp	469,101	6,264,071	N 56°31’12”	W 129°30’8”
Bowser Aerodrome	44,367	6,250,234	N 56°23’35”	W 129°56’59”
Knipple Camp	43,795	6,251,226	N 56°24’44”	W 130°19’

Brucejack Camp is approximately 65 km by air north-northwest of the town of Stewart. It is 73 km via the Brucejack Access Road west from km 215 on Highway 37.

It is approximately 240 km by air from Terrace to Brucejack Camp, and about 370 km by road from Terrace to Brucejack Camp.

Table 3. General Emergency Contacts

Service	Party	Contact Number
Avalanche	MOTI – Stewart Avalanche Tech (if not in office call Burnaby)	1-250-636-2625
	Burnaby Dispatch Rapid Phone	1-604-660-9770
	MOTI – Avalanche Tech Stewart – Ryan Boyle	1-250-636-9055
	Last Frontier Heli-skiing - Bell II Lodge (Jan to April)	1-250-275-4770
	Northern Escape Heli-skiing	1-250-615-3154
	Canadian Avalanche Centre	1-250-837-2141
Ministry of Energy, Mines and Petroleum Resources (MEMPR)	Mines Inspector – Doug Flynn	1-250-847 7386
	Northwest Regional Office (Smithers)	1-250-847 7383
	Senior Inspector of Mines, Health and Safety – Jordan Whynot	1-250-876-6703
WorkSafeBC	Worker's Compensation Board (Vancouver)	1-604-561-3700
PEP	Provincial Emergency Program (24 hours)	1-800-663-3456
SAR	Stewart SAR – Erin Boyle	1-250-636-9055
	Stewart	1-250-636-2233
RCMP	Terrace	1-250-638-7400
Fire	Forest Fire Reporting	1-800-663-5555
Poison Control	B.C. Poison Control Centre (Vancouver)	1-800-567-8911
Environment	Enforcement & Environmental Emergencies (Victoria)	1-250-356-9302
	Environment Canada (Emergency Spill Reports)	1-604-666-6100
	Conservation Officer	1-800-663-9453
	Provincial Emergency Program – 24 hour (Spills)	1-800-663-3456
	Northwest Response Ltd. (Ray Hollenberg)	1-250-847-4556
	Transport Canada (TDG – Vancouver)	1-604-666-2955
Highways	Transport Emergency Centre (CANUTEC)	1-613-996-6666
Helicopters	Yellowhead Helicopters	1-250-963-9884
	Canadian Helicopters	1-250-635-2430
Other Companies	Soucie Construction	1-250-636-2389 office
	Seabridge Camp	403-387-2322
	Seabridge Camp Manager	403-387-2323

BRUCEJACK SITE EMERGENCY PHONE CONTACTS

The main Brucejack Phone Number is **778-724-4186**.

The primary means of communications on site is VHF Radio. There are three repeater channels allowing for long distance VHF communications and a number of shorter ranges "Talk Around" channels that require line of site with the receiving party (Table 4).

Table 4. Brucejack Radio Frequencies

Channel	Name	RX Frequency	TX Frequency	Tone
Ch 1	New Road **(NEW)**	166.080	166.080	
Ch 2	Repeater 1 **(Brucejack)**	162.735	167.715	71.9
Ch 3	Talk Around 1	162.735	162.735	
Ch 4	Repeater 2 **(Bowser)**	162.810	167.790	123.0
Ch 5	Talk Around 2	162.810	162.810	
Ch 6	Repeater 3 **(Wildfire)**	162.105	167.085	156.7
Ch 7	Talk Around 3	162.105	162.105	
Ch 8	Lad 1	154.100	154.100	
Ch 9	Lad 2	158.940	158.940	
Ch 10	Lad 3	154.325	154.325	
Ch 11	Lad 4	173.370	173.370	
Ch 12	VIH	166.470	166.470	

ACKNOWLEDGEMENTS, DISCLAIMER, AND SIGN-OFF

This Mine Emergency Response Plan (MERP) has been compiled for Pretium Resources Inc. (Pretium) from various public and private information sources, including the *Health, Safety and Reclamation Code for Mines in BC*, 2021, the *Handbook for Mineral and Coal Exploration in BC*, 2008/09 and the *Mine Emergency Response Plan Guidelines for the Mining Industry*, 2017, version 1.4.

This version of the Brucejack MERP is a revision of the 2021 version.

Any use of, or reliance on this Plan by any third party is at that party's sole risk.

Statutory authority:

	Mine Manager
	Health and Safety Manager

BRUCEJACK MINE

Mine Emergency Response Plan

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GLOSSARY AND ABBREVIATIONS

Avi-tech	Avalanche (or glacier) technician
BC	British Columbia
CO_2	Carbon dioxide
EOC	Emergency Operations Centre
EMP	Environmental Management Plan
ERC	Emergency Response Coordinator
ERCC	Mine Emergency Response Plan Coordinator
ERMT	Emergency Response Management Team
ERP	Emergency Response Plan
ERPC	Emergency Response Planning Committee
ERT	Mine rescue Emergency Response Team
HSE	Health, Safety and Environment
HSRC	*Health, Safety and Reclamation Code for Mines in BC* (2017)
IMT	Incident Management Team
ICS	Incident Command System
IMR	Incident Management Room
JOHSC	Joint Occupational Health and Safety Committee
OFA 3	Person with minimum Level 3 first aid qualifications
L	Litre(s)
m	Metre(s)
MEMPR	Ministry of Energy, Mines and Petroleum Resources
MEMLCI	Ministry of Energy, Mines and Low Carbon Innovation
MERP	Mine Emergency Response Plan
MHz	Megahertz
mm	Millimetre(s)
MST	Mountain Safety Technician

OHS	Occupational Health and Safety
PEP	Provincial Emergency Program
PPE	Personal protective equipment
Pretium	Pretium Resources Inc.
SAR	Search and Rescue
UG	Underground
VHF	Very high frequency

1 MINE EMERGENCY RESPONSE PLAN (MERP)

1.1 MERP OBJECTIVES

The goal of this Mine Emergency Response Plan (MERP) is to provide Pretium Resources Inc. (Pretium) employees, contractors and their employees with guidance to prepare and respond to an emergency situation in an organized and effective manner (formal structure). An organized response will contain and control the situation, and will mitigate consequences to people, property and the environment. The MERP outlines the response procedures and preventive measures that will achieve effective and timely management of an emergency.

This MERP is proposed to cover all the Brucejack Mine facilities and work areas, which include the access road, satellite camps (i.e., Knipple, Bowser and Wildfire camps), construction activities and in mine site production operations for the surface and underground areas.

The MERP, dependent on the nature of the emergency, can be activated when a project-related emergency and/or incident occurs anywhere on the mine.

This plan also outlines the responsibilities and duties of an Emergency Response Team (ERT) as required by Pretium in the event of an emergency at the mine.

The MERP is intended to meet the following objectives:

- Provide a pre-determined course of action during a mine site emergency situation;
- Provide a listing of the duties and responsibilities of personnel;
- Assist personnel in determining appropriate responses to emergency situations;
- Provide guidance to prevent and minimize personal injury during a mine-site emergency situation;
- Provide guidelines for initial first aid treatment of injured personnel;
- Provide guidance for initial emergency response to minimize damage to property, equipment and the environment;
- Enable communication and co-operation between corporate personnel, site personnel, mutual aid organizations, agency officials, and the community at large;
- Provide guidelines for ensuring the safety of site personnel, visitors, and community members;
- Provide guidance to reduce the magnitude of environmental impacts;
- Assist response personnel to determine and perform remedial actions quickly;
- Comply with legal requirements in response related matters in case of emergencies;
- Reduce recovery time and cost;
- Inspire confidence in response personnel;

- Ensure procedures comply with OHS and environmental requirements; and
- Safely restore operations to normal.

Anyone discovering a potential emergency should know the immediate steps to take and will follow the "decision flow chart" included in this plan (See Section 2.1). The MERP will provide guidance when the initial attempts to control a situation are not successful.

1.2 MERP POLICY DIRECTIVE

A Mine Emergency Response Plan is required by Part 3.7.1 of the *Health, Safety and Reclamation Code for Mines in BC*, 2017 (MEMPR 2017), and must be in general accordance with the *Mine Emergency Response Plan Guidelines for the Mining Industry*, 2017, version 1.4.

Pretium management is dedicated to providing a safe workplace for its employees and contractors. The goals of this MERP are, in order of priority, to protect the health and safety of workers and the public, protect the environment, avoid adverse social and economic effects, preserve heritage, as well as protect and minimize damage to company properties.

This MERP was developed to assist in protecting personnel and company facilities in the event of an emergency. An emergency is the unforeseen combination of circumstances, unusual occurrences or resulting state which may result in endangerment to lives or areas of the mine. This emergency may call for the immediate action from management and/or trained mine rescue, fire and first aid personnel.

Possible situations with the potential to create an emergency under some circumstances might include:

- avalanches;
- wildlife and human interaction;
- fire (electrical/mechanical);
- spills of fuel or hazardous substances;
- contact water pond and tailings line discharge;
- underground mine emergencies: ground failures, main fan ventilation failure, etc.;
- unexpected/unplanned explosions;
- aircraft/ground vehicle accidents;
- non-life- and life-threatening injury or fatality;
- flooding/snowstorm/blizzards/ice storms; and
- natural disaster.

In order to protect site personnel, Pretium will use specific evacuation procedures to remove all personnel from the source of danger and to account for all personnel on shift.

During the operation and closure phases of the Brucejack Mine, senior management will assign various responsibilities to specific personnel, and will provide overall supervision and monitoring.

Pretium will ensure that the MERP is current and maintained at all times. The Mine Manager will ensure that there is a budget is in place to address the requirements of the MERP, including related training. As per the annual budgets, funding is provided for emergency response team training, high level scenarios, incident management team tabletop and mock scenarios. Additional funds are also provided for emergency and auxiliary equipment used during the scenarios. The Mine Rescue Team will be compensated if a call out occurs after their working hours. Copies of the MERP will be posted in common locations for workers to review. Each worker will be required to become familiar with the details of the MERP, and the location of all emergency services at the time of the initial mine site familiarization training.

Pretium is strongly committed to having in place an efficient MERP resulting in an organized and effective response at containing and controlling the situation, as well as mitigating consequences to people, property and the environment. In meeting this commitment Pretium will:

- Provide training to all employees, contractors and their employees for their roles in all emergency plans;
- Ensure that ALL site personnel are familiar with and are able to call a CODE 1 for any type of emergency, BJ-OHS-SOP-002 - Code One Call Out & Response;
- Ensure all supervisors are responsible that their employees are aware of, and trained in, the proper emergency response procedures and that procedures and contact information are posted in all work areas. Supervisors are also responsible for ensuring that all employees follow safe work procedures and follow regulations to prevent emergencies from occurring, and that they are provided with the proper tools to do so, including PPE;
- Ensure all personnel (including Pretium employees, contractors and their employees) will participate in emergency response drills on a regular basis;
- Appoint a qualified person as a trainer for mine rescue members as per Part 3.7.9 or the HSRC;
- Procure the necessary mine rescue and emergency response equipment, and ensure adequate training in the use of this equipment is provided by the qualified person(s);
- Develop the required Emergency Response Teams as per Part 3.7.2 of the HSRC;
- Appoint a Mine Emergency Response Plan Coordinator and Planning Committee;
- Set up and continually improve the long-term goals of the plan;
- Establish a budget for the emergency response program, including hiring and training qualified personnel, to ensure the successful implementation of the MERP; and
- Support all other activities necessary to develop and implement an effective Emergency Response Plan.

All Pretium employees, contractors and their employees will need to be aware of the normal hazards associated with their work area. A sudden change from the norm may result in an unusual and dangerous situation. Being prepared for an emergency will mean quicker action and ensure proper manner of action in cases of individual injury, help for individuals or of a mine problem area.

All Pretium employees, contractors and their employees will be shown at the time of initial mine site familiarization:

- the emergency response and first-aid procedures and where are they posted;
- the procedure to summon the emergency response team in the event of any emergency by using the CODE 1 emergency procedures;
- the procedure to summon first aid;
- the procedure to follow in the event of a fire;
- the ability to access information for emergency facilities such as air ambulance, police, and hospital; and
- the location of their assembly area in case of an emergency; they will be given names of emergency personnel, their qualifications, and their contact information. This information will be posted at each individual working area and updated as necessary.

All Pretium employees, contractors and their employees will also receive the Brucejack Project Occupational Health and Safety Plan (OHSP) at the initial mine site orientation. After a general presentation of the company's Health and Safety Program, each worker will be required to complete a written sign-off and acknowledgement of understanding this material.

Emergency response drills will be undertaken for the following reasons:

- to validate the adequacy of the organizational infrastructure to effectively deal with emergencies;
- to test the initial communications sequences;
- to verify contact numbers are correct;
- to familiarize personnel with their duties and responsibilities;
- to evaluate the preparedness of each party involved in the Emergency Response Program;
- to identify and correct deficiencies in the Emergency Response Program;
- to verify the availability of support services;
- to exercise tactical site-specific responses; and
- to examine the interaction between the individuals, support groups, organizations, and agencies named in the Emergency Response Program, and to address identifiable shortfalls in the established lines of authority.

1.3 MERP LINKAGES TO OTHER ENVIRONMENTAL MANAGEMENT PLANS

Pretium is committed to providing safe and healthy working conditions, and protecting the health, safety and the environment as vital elements of the mine. This commitment is essential to achieving a successful long-term operation. Throughout the various mine phases, Pretium plans to conduct activities to minimize impacts on the environment.

The commitment to this objective will be achieved with the preparation and integration of Environmental Management Plans (EMPs) into mine operations. Each plan will provide methods, procedures, and actions to be utilized by Pretium personnel and/or its contractors to ensure that their activities comply with appropriate environmental legislation, mine commitments, and applicable environmental standards. This MERP is one of several plans that form part of the Brucejack Mine Environmental Management System (EMS).

Other Mine EMPs related to this MERP include:

- Occupational Health and Safety Manual (OHSM);
- Chemicals and Materials Storage and Handling Management Plan (CMSHMP);
- Fuel Management Plan (FMP);
- Spill Response Plan (SRP)
- Hydrocarbon Contaminated Soil Management Plan (HCSMP);
- Construction Environmental Management Plan (CEMP); and
- Waste Management Plan (IDWMP).

1.4 MERP Coordinator and Planning Committee

On the Brucejack Mine, the Mine Manager will appoint the Health and Safety Manager, or a designate, to act as the Mine Emergency Response Plan Coordinator (ERCC) for the site. The ERCC will have the full support of Pretium to successfully implement the MERP. Currently the ERCC is the Emergency Response Team Coordinator.

The Mine Manager will select members for a Mine Emergency Response Planning Committee (ERPC), and will integrate the ERPC, ERCC and the Joint Occupational Health and Safety Committee (JOHSC).

The ERPC will perform the following duties:

- Examine possible eventualities for each area of the mine, together with the possible measures of prevention and protection and resulting actions. The outcome of this pre-planning exercise will be reviewed periodically as conditions change over time. Initially, all areas and processes of the mine will be inspected to determine the risks associated with the work environment, including confined spaces, mine fires, explosions, rock-bursts, falls of ground, runs of muck, inrushes of water and avalanches.
- Review mitigation measures designed to prevent emergency events from occurring and reduce the adverse effects of such events. The review will assess the effectiveness of the mitigation and consider alternatives where necessary.
- Confirm the appropriateness of training and procedures, safe working practices, housekeeping programs, and first aid training to prevent a minor emergency escalating to a crisis or a disaster.
- Review the MERP annually to verify its effectiveness. As the Brucejack Mine develops, a re-assessment of emergencies and incidents will be undertaken. Findings from this periodic assessment will be used to update and revise procedures associated with the MERP.

Updates will be made based on corrective actions noted during tabletop and mock high-level exercises. Pretium Resources/Brucejack Mine has set the standard to run a minimum of three tabletop scenarios and one mock scenario per calendar year. The scenarios need involve the Brucejack Site Emergency Response Team and Incident Management Team, as well as the corporate office in Vancouver.

1.5 ERPC DUTIES AND RESPONSIBILITIES IN REGARD TO THE MERP

Regarding the MERP, specific members of the ERPC have various duties and responsibilities, as detailed below.

1.5.1 Mine Manager

The Mine Manager shall:

- ensure that personnel, equipment and resources are adequate to effectively deploy the MERP;
- ensure that a MERP has been developed and communicated to site staff and contractors;
- participate in the emergency response evaluation meeting after each emergency response; and
- interface and communicate with corporate senior management.

1.5.2 Health and Safety Manager

The Health and Safety Manger is a member of the ERPC, which develops, maintains and implements the MERP that is comprehensive and is regularly updated to meet the changing needs of mine activities.

The Health and Safety Manager shall:

- ensure that mine orientation and safety meetings include training for ERP roles and responsibilities;
- participate in post-incident evaluation meeting to review emergency response, MERP effectiveness and opportunities for improvement;
- work with the Mine Manager to identify and implement improvements to the MERP;
- coordinate annual fire drill and “man-down” drills to test and evaluate emergency preparedness; and
- update and post the MERP, telephone lists and plot plans (i.e., muster areas; location of emergency/medical equipment).

1.5.3 Operations Supervisors

The Operations Supervisors shall effectively communicate MERP roles and responsibilities to new employees.

1.5.4 Joint Occupational Health and Safety Committee (JOHSC)

The JOHSC committee is made up of worker and employer representatives consulting in a cooperative atmosphere to identify and resolve health and safety issues/concerns in support of the MERP.

The JOHSC shall:

- participate in the identification of dangers to safety and health in places of employment, and recommend means of controlling the hazards;
- obtain information from the employer and from additional sources regarding the identification of existing or potential dangers to safety and health;
- receive, consider, and where necessary, investigate complaints respecting safety and health of workers at this workplace, and where necessary, make recommendations to the employer;
- participate in workplace inspections; and
- participate in incident investigations.

1.6 PROJECT HAZARD IDENTIFICATION, PREVENTION AND PROTECTION

The Brucejack Mine has developed a Risk Assessment document that will continue to be used through mine operation and closure. The purpose of this document is to provide direction to personnel related to hazard identification and risk assessment. This is a multi-page Excel spreadsheet used to identify the steps, associated hazards, controls in place, and additional controls needed after the assessment has been completed. The additional controls are assigned to a specific worker and have a completion date. These processes will continue to be used to identify and evaluate both existing and potential hazards throughout the mine site. They will also assist in defining methods to control and/or eliminate the hazards identified.

As part of the Hazards Identification program, all Pretium employees, contractors and their employees shall assess their worksite and complete a Job Hazard Analysis form (available in supervisor's office). This assessment process must be completed prior to the start of all jobs, particularly new jobs to identify existing or potential hazards to workers and then to eliminate and/or control these hazards through the use of appropriate engineering or administrative controls, proper training or the use of personal protective equipment.

All company staff and contractors are required to take a proactive approach to managing and reporting hazards. When they observe a hazard, they shall take steps to manage that hazard directly (provided they are knowledgeable / trained to safely do so) – eliminate the hazard or get assistance from appropriate persons to do so whenever reasonably possible. Where hazards cannot be eliminated immediately, take necessary steps to warn others of the hazard. Report hazardous or potentially hazardous conditions and acts to a supervisor or your site contact if a contractor.

1.7 EMERGENCY RESPONSE PROGRAM (ERP) OUTLINE

As part of the MERP, the Brucejack Mine has proposed the Emergency Response Program (ERP) for the mine site, described in Section 2. The ERP details emergency response levels, emergency management team, planning and training, emergency response team structure, etc.

1.8 RELEVANT ENVIRONMENTAL ASSESSMENT CERTIFICATE CONDITIONS

On March 26, 2015, Pretium was granted an Environmental Assessment Certificate (#M15-01) which included a series of conditions. This MERP fulfills Condition #2, in relation to a Component Plan for mine emergency response planning, presented within Schedule B of the Certificate and copied below.

Condition 2

> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5. The Aboriginal Consultation Plan outlines the notification process if there is an emergency at the Brucejack Mine.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

1.9 FIRST RESPONDER CONSULTATION

The MERP will be provided to all mutual aid parties, British Columbia Ambulance Service, Stewart RCMP and Stuart Hospital. A map with helicopter landing zones will also be provided to Yellowhead Helicopters, BCA, Canadian Helicopters and Lakelse Helicopters.

2 EMERGENCY RESPONSE PROGRAM (ERP)

The Brucejack Mine has developed an Emergency Response Program (ERP) for the mine site. Details regarding certain aspects covered in the following sub-sections include:

- Emergency Response Levels: contains the emergency criteria, emergency level characteristics, reporting sequence and implementation summary;
- Emergency Response Management Team (ERMT): identifies who is on the Emergency Response Management Team(s) and identifies responsibilities and duties; and
- Planning and Training: documents pre-planning activities such as the development of the organization's emergency plans, education and training.

2.1 EMERGENCY CRISIS PROCESS

The Emergency Crisis Process assesses the consequence and severity level of an emergency (Figure 2.1-1). The Severity Table is provided in Appendix B.

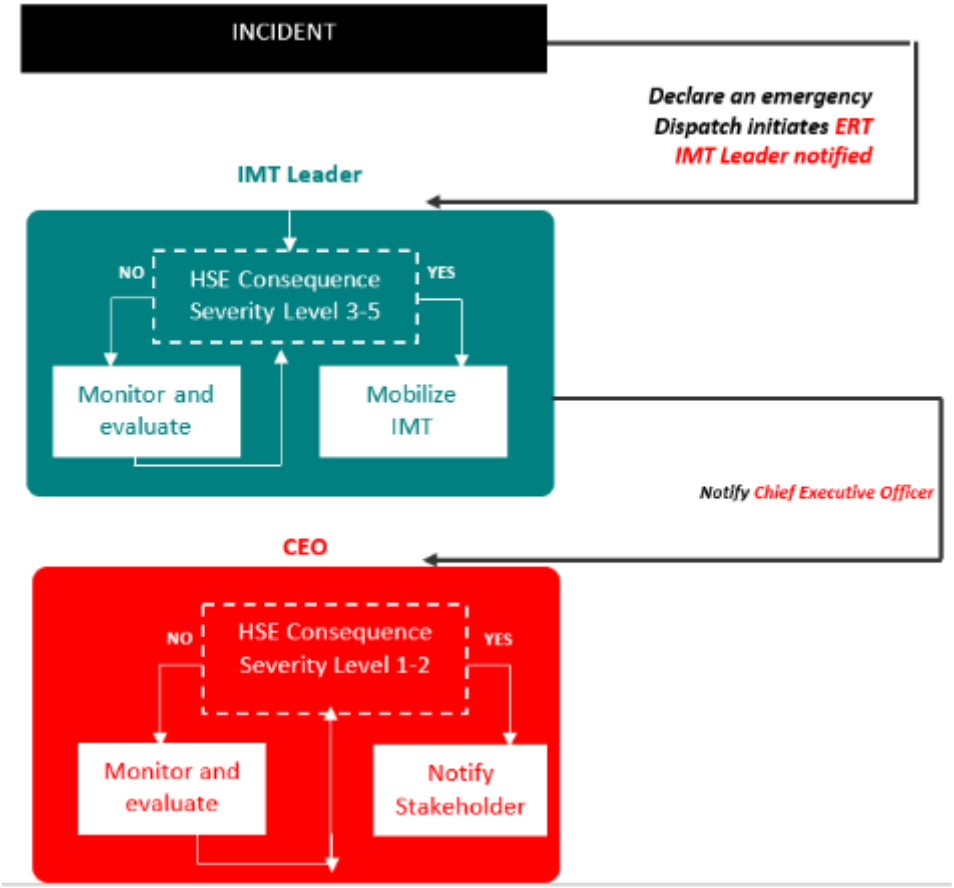


Figure 2.1-1. Emergency Crisis Process

2.2 EMERGENCY RESPONSE LEVELS

2.2.1 Introduction

The following emergency response level concept was originally conceived by Galore Creek Mining Corporation as part of their Emergency Response Plan v. 2.1 (GCMC ERP v. 2.1). This concept will be adopted in this MERP because it provides sound directions, procedures, and courses of action to follow in the event of a mine site emergency.

An emergency can be defined as any incident, or event that causes or creates the potential for a serious injury, loss of life, significant loss or damage to property, or environmental damage. Although emergencies by definition are unexpected events, the relative risk of some occurrences can be identified and preparations (policy and procedures) put in place for timely and effective response. Remember, this identification is the first step in ensuring adequate response.

Pretium incident reporting policy requires all levels of emergencies to be reported to the Health and Safety Manager (or designate). The urgency shall depend on the severity of the situation.

Emergency response criteria, definitions of Level 1, 2 and 3 emergencies and emergency level decision flow chart are discussed in the following sections of this MERP. It is anticipated that Pretium employees, contractors and their employees will be able to utilize this system, to aid in making appropriate decisions regarding the emergency response.

2.2.2 Emergency Response Criteria

The Risk Ranking Matrix presented in Figure 2.2-1 will be used by the Emergency Response Coordinator (ERC; or designate) to determine the level of emergency and deployment of emergency response personnel as follows:

- Activities with Low risk or acceptable risk level are denoted in **Green** in the Matrix
- If the Ranking Matrix indicates a low potential (**Blue**), the ERC (or designate) will initiate a Level 1 Alert.
- If the Ranking Matrix indicates medium potential (Yellow), the ERC (or designate) will initiate a Level 2 Alert and review the situation.
- If the Ranking Matrix indicates high potential (**Red**), the ERC (or designate) will initiate a full Level 3 Alert.

2.2.3 Emergency Level Characteristics

The Emergency Decision Flow Chart provides a summary of emergency level characteristics and processes for the Brucejack Mine (Figure 2.2-2). The flow chart will be utilized to assist management and employees in ensuring that a proper approach is taken in case of an emergency incident.

STEP 1 DETERMINE LIKELIHOOD

Likelihood (L)			
A	Almost Certain	Happens often	More than one event per month
B	Likely	Could easily happen	More than one event per year
C	Possible	Could happen and has occurred here or elsewhere	One (1) event per 1 to 10 years
D	Unlikely	Hasn't happened yet, but could	One (1) event per 10 to 100 years (within a single mine life)
E	Rare	Conceivable but only in extreme circumstances	Less than one (1) event per 100 years (life of Pretivm Resources Inc.)

STEP 2 DETERMINE CONSEQUENCES

Consequence/Severity (C)						
Rank	Consequence	People	Damage/Loss	Environment	Business	Reputation
1	Catastrophic	Fatality	Extreme Financial Loss (>US$1,000,000)	Irreparable Damage, very serious long term impairment of the eco-system	>48 Hours Production Delay	Major Damage to Reputation receiving national or international negative media OR production to cease as a result of statutory concerns
2	Major	Permanent and total disability	Major Financial Loss (US$500K – 1,000K)	Major Impact, serious medium term environmental impact effecting the whole eco-system	24 to 48 Hours Production Delay	Major Damage to reputation receiving province-wide negative media OR non-compliance with statutory requirements resulting in a major fine
3	Moderate	Loss Time Injury	Moderate Financial Loss (US$100K – 500K)	Minor Impact, moderate short term effects affecting part, but not affecting whole eco-system	12 to 24 Hours Production Delay	Moderate Damage to reputation localized to regional media OR non-compliance with statutory requirements resulting in minor fine
4	Minor	Disabling Injury	Minor Financial Loss (US$ 10K – 100K)	Minor Impact on biological or physical environment	6 to 12 Hours Production Delay	Minor Impact to reputation localized to communities OR technical divergence that may attract attention from statutory authorities
5	Low	First Aid/Medical Aid with no time lost or change of duties	Low Financial Loss (US$ <10K)	Limited Damage to minimal area of low significance or previously disturbed areas	<6 Hours Production Delay	No Impact on stakeholder or reputation

STEP 3 CALCULATE RISK

		Consequence / Severity (C)				
Likelihood (L)		1 Catastrophic	2 Major	3 Moderate	4 Minor	5 Low
A	Almost Certain	1 (Ex)	2 (Ex)	4 (Ex)	7 (H)	11 (H)
B	Likely	3 (Ex)	5 (Ex)	8 (H)	12 (H)	16 (M)
C	Possible	6 (H)	9 (H)	13 (H)	17 (M)	20 (M)
D	Unlikely	10 (H)	14 (M)	18 (M)	21 (L)	23 (L)
E	Rare	15 (M)	19 (M)	22 (L)	24 (L)	25 (L)

Consequence Severity Table												
SEVERITY LEVEL	Severity Rating	Financial		Operations						Compliance	Strategic	
		Liquid Cash	Project Budget Variance	Mine Shutdowns	Project Delays	Security	Health	Safety	Environment	Legal/Regulatory	Community Perception/Stakeholder Relations	Strategy
5	Catastrophic	>$40M	>20%	>15% impact on production volume	> 6 months	Security breach resulting in material theft and loss of significant assets	Multiple fatalities or serious disabling illness to multiple people.	Multiple Fatalities; or Permanent impairment to multiple people.	Extensive impact (>20 years) to land, biodiversity, ecosystem services, water resources or air	Fines and prosecutions relating to criminal breaches including jail terms and being the subject of a royal commission	Prolonged (>2months) international multi-NGO and media condemnation Extensive long-term social impacts and serious infringements of cultural heritage	Loss of significant business capability
4	Major	$30 -$ 40M	15 - 20%	7.5 – 15% impact on production volume	3 - 6 months		Single fatality or irreversible health effects or disabling illness.	Single fatality or Permanent impairment to > 30% of the body	Major impact (5-20 years) to land, biodiversity, ecosystem services, water resources or air	Major civil litigation including class actions	Major adverse international multi-NGO and media condemnation Major long-term social impacts and infringement of cultural heritage	Significant reduction in business capability
3	Serious	$20M - $30M	10 - 15%	2.5 – 7.5% impact on production volume	1 - 3 months	Security breach resulting in serious theft and/or loss of significant assets	Severe, reversible health effects of concern that would typically result in a lost time illness.	Permanent impairment, < 30% of the body to 1 or more Days lost due to injury/illness	Serious impact (1-5 years) to land, biodiversity, ecosystem services, water resources or air	Breach of regulations and lack of exploration title	Serious public or national media outcry, damaging NGO campaign Moderate medium-term social impacts	Temporary loss of service or business capability
2	Moderate	$10M - $20M	5 - 10%	0.5 – 2.5% impact on production volume	2 - 4 weeks	Security breach resulting in moderate theft and/or loss of low value assets	Reversible health effects of concern that would typically result in medical treatment.	Objective but reversible impairment Medical treatment for injury/illness	Moderate impact (<1 year) to land, biodiversity, ecosystem services, water resources or air	Minor legal issues, non-compliances and breaches of regulation	Non-material reputation damage Attention from regional media and local public attention and complaints Minor social impacts	Temporary delay in reaching objectives
1	Low / Minor	<$10M	<5%	< 0.5% impact on production volume	< 2 weeks	Security breach resulting in small theft	Reversible health effects of little concern, requiring first aid treatment at most.	Low-level short-term subjective symptoms or inconvenience. No medical treatment required	Minor disturbances and/or Low-level impact to land, biodiversity, ecosystem services, water resources or air	Low-level legal issues	Public concern restricted to local complaints Low-level interest from local media and/or regulator Low-level social impacts	No material impact on the achievement of business objectives

RISK MATRIX

LIKELIHOOD	Score	1	2	3	4	5
	Rating	Rare	Not Likely	Possible	Highly Likely	Expected
Chance of the potential consequence occurring considering the controls in place	Frequency	Greater than 100 year event	Every 10 to 100 years	Every 1 to 10 Years	Every 2 to 3 years	Almost Yearly

Risk Level	Actions Required
Critical	STOP - Manager approval required. Controls to reduce risk must be identified and implemented before performing work.
High	STOP - Superintendent approval required. Controls to reduce risk must be identified and implemented before performing work.
Moderate	STOP - Review and follow Work Instruction or complete Group JHA with team members and Team Leader.
Low	Worker conducts personal JHA prior to performing task and continually assesses risks.

Figure 2.2-1. Risk Ranking Matrix

Emergency levels are classified into three categories, based on different criteria described below. Generally, Level 1 emergencies can be controlled entirely by personnel within the immediate vicinity of the incident/accident. Notification will be made immediately with documentation to the safety department within 24 hours of the incident. As for Level 2 and 3 emergencies, they may force temporary suspension or shut down of operations indefinitely. These incidents must be reported immediately to the Mine Manager.

Level 1 – Potential Emergency (Containment Level)

- Can be controlled entirely by mine site personnel and operations;
- Located within the immediate vicinity of the incident/accident site;
- No danger outside of the mine site;
- Immediate control of the hazard/sources is possible;
- No threat to the public;
- Minimal environmental impact; and
- Little or no media interest.

Level 2 – Emergency (Notification Level)

- A section of the operation is temporarily shut down;
- Can be controlled by the personnel and equipment that are readily available at the mine;
- Potential exists for the emergency to extend beyond the mine site;
- Outside agencies (MEMPR, police, fire, etc.) must be alerted and kept informed of the situation;
- Imminent control of the emergency is probable;
- Some threats to the public exist;
- Moderate environmental impact; and
- Local/regional media interest is probable.

Level 3 – Major Emergency (Mobilization Level)

- Forces the indefinite shut down of operations;
- External emergency support services are required;
- Safe operating control has been lost;
- Actual or potential severe injuries or fatalities;
- Public safety jeopardized;
- Significant and ongoing environmental impact;
- Significant media interest;
- Immediate multi-agency involvement; and

- Assistance from outside parties required.

2.2.4 Emergency Level Decision Flow Chart

This flowchart, provided in Figure 2.2-2 is a simplified decision guide to assist management and particularly employees in taking appropriate actions in case of an emergency.

2.2.5 Emergency Response Plan Implementation Summary

Table 2.2-1 provides additional information for Pretium employees, contractors and their employees to ensure decisions are commensurate with the level of emergency.

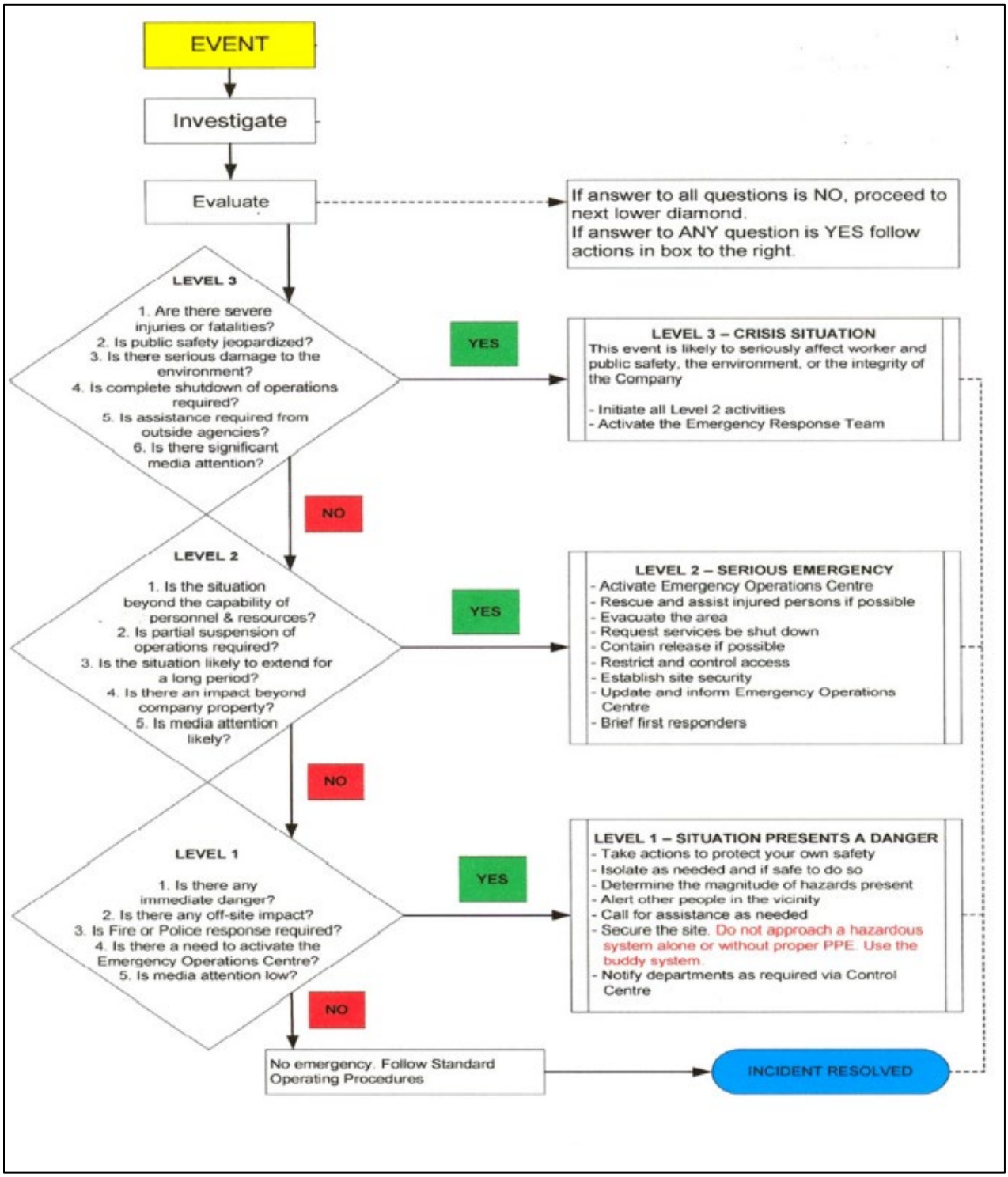


Figure 2.2-2. Emergency Decision Flow Chart (after GCMC Emergency Response Plan v. 2.1)

Table 2.2-1. Emergency Response Summary

Level	Criteria	Examples	Pretium Actions	Government Agency Actions
Level 1: ERT members to the initial response	• No danger outside of company property. • Immediate control of hazard/ source. • No immediate danger to public exists. • Minimal environmental impact. • Little or no media interest. • Situation handled entirely by company personnel.	• Potential for a small spill or small release of product confined to company property • Company/Contractor. Personnel minor injury or property damage. • Complaint telephone call received. • Trespassers on company property. • Spot fire/minor explosion	• Operational response made. • Reported as required internally. • Comply with appropriate government reporting after the fact. • Additional company personnel may be placed on standby status • Pretium initial response is undertaken as per the site specific ERP.	• No actions required. • Monitors response if advised.
Level 2 Mobilize IMT	• No immediate danger outside of company property, potential exists for emergency to extend beyond company property. • Outside services and Provincial Government agencies must be alerted • Imminent control of hazard is probable. • Some threat to workers or the public. • Moderate environmental impacts. • Local/regional media interest.	• Confirmed release with imminent control of the hazard probable. • Injuries/accidents involving workers. • Mischievous acts by trespassers threatening worker or public safety. • Fire/explosion that has a direct impact on worker/public safety.	• Pretium fully activates its ERP - internal resources mobilized - External resources mobilized. • Pretium mobilized and the emergency operations centre (EOC) may be on standby. • Lead agency notified (Smithers). • Public safety actions begin which could involve sheltering or evacuation. • External communications to media prepared and executed.	• Pretium has the capability to manage and control the incident using its own resources and expertise with limited assistance from local agencies and government authorities (MEMPR and WorkSafe BC, if necessary). • Lead agency notifies other agencies that may be affected. • Lead agency puts government EOC on standby. • Agencies with direct involvement may establish direct contact with Pretium. • Government agencies activate their
Level 3 Mutual aid mobilized to assist.	• Worker and/or public safety jeopardized. • Uncontrolled hazard. • Significant and ongoing environmental impacts. • Immediate multi-agency municipal and provincial government involvement. • Assistance from outside parties is required.	• Major accident impacting on workers or the public • Explosion with extensive damage to facilities • Mischievous acts which result in major damage • Major fire in a populated area and/or major wild fire	• Pretium emergency response is at maximum. • Pretium notifies lead agency • Pretium dispatches representative to Government EOC. • Pretium mobilizes corporate emergency response capabilities including Public Affairs, Legal, Executive, etc.	• Hospitals in Terrace and Stewart notified of potential trauma patients. • Government agencies with direct involvement dispatch staff to Pretium Operations. • Full activation of the Government Emergency Response Support Program to support Pretium.

2.3 EMERGENCY RESPONSE MANAGEMENT TEAM (ERMT)

Overall command to activate the Emergency Response Program shall be the responsibility of Pretium senior management at the incident site and/or the ERMT. Pretium personnel and contractor employees have the responsibility to implement the Brucejack Mine ERP.

Depending on the emergency level and the type of emergency, the Brucejack Mine - ERMT described below shall be formed to respond to an emergency.

In the event of an emergency at the mine, the chain of command structure provided in the Incident Command Emergency Management Organizational Chart will be enacted (Figure 2.3-1). The lead person for the chain of command will be the Emergency Response Coordinator (ERC), or alternatively the Mine Manager. This organization chart will expand or contract depending on the type and severity of the incident/emergency.

2.3.1 Emergency Operations Center (EOC)

The EOC will be established at the On-site Conference and Training Room following notification of an emergency. The site ERC (or designate) and facilitators of the site Mine Rescue Emergency Response Team (ERT) shall converge at this office. Requirements may include activities such as the allocation of on-site resources (personnel and equipment), setting up a communications center and external reporting of the incident/accident to government agencies, etc.

Should conditions dictate evacuation due to imminent danger; the EOC will be located at another defined location that is farthest from the imminent danger zone.

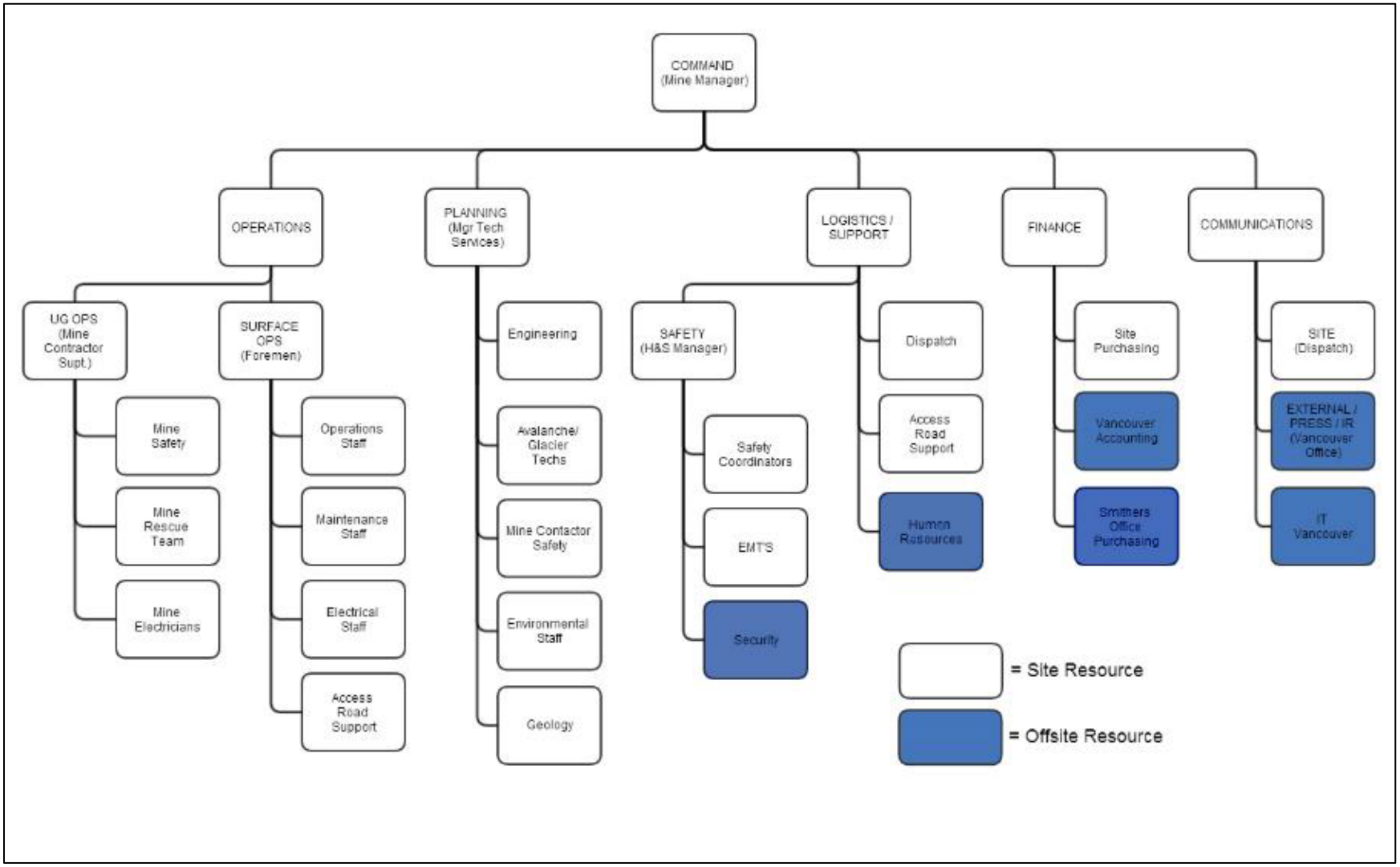


Figure 2.3-1. ICS Emergency Management Organizational Chart

Once established, EOC personnel will manage the emergency and undertake the following functions:

- Ensure that the Brucejack Mine ERP has been properly implemented;
- Monitor the health and safety of workers at the site;
- Monitor Security; and
- Provide appropriate technical information related to the incident.

2.3.2 Emergency Response Responsibilities and Duties

The following personnel involvement or requirements will depend solely on the Level emergency response (i.e. Level 1, 2, or 3).

All major emergencies require senior management personnel to form an ERMT. This team will direct emergency operations and assign tasks to individuals or groups. Responsibilities for each group are described in the following subsections. Note the list is not exhaustive and additional responsibilities may be identified commensurate with the type of incident.

2.3.2.1 Mine Rescue Emergency Response Team

The on-site surface and/or underground ERTs will consist of personnel trained as required of Part 3.7.7 of the *Health, Safety and Reclamation Code for Mines in BC*, 2017. They will be notified and requested as necessary.

2.3.2.2 First Responders – Level 1, 2, or 3 Emergency

- Take action to ensure their own safety;
- Alert other personnel in the immediate vicinity of the incident/accident;
- Determine the magnitude of hazards present, contact the Health and Safety Department and provide particulars of the emergency and request appropriate help;
- Perform duties as directed by the on-site supervisor (or designate). These initial duties may be as follows:
  - Providing assistance to injured personnel;
  - Assisting with procedures to control or minimize the effects of the emergency;
  - Determine if Personal Protective Equipment (PPE), safety equipment and supplies are adequate; and
  - Initiate an Event Log for the emergency.

No worker will approach a hazardous condition alone or without the proper PPE. First Responders will wait for the arrival of additional personnel and equipment.

2.3.2.3 Medic/Advanced First Aider – Level 1, 2, or 3 Emergency

When an injury requiring medical attention is reported, the Health and Safety Department will call the Medic/Advanced First Aider who will assess the degree of response required. All events shall be recorded in the Treatment Logbook. The Medic/Advanced First Aider shall:

- Take action to ensure your own safety;
- Alert other personnel in the immediate vicinity of the incident;
- Upon notification, the on-site supervisor (or designate) will meet with the Medic/Advanced First Aiders at the incident/accident scene (unless in radio contact). On-site supervisor (or designate) ensures that the Medic/Advanced First Aiders have the required supplies and that the area is secured and does not present any further danger to personnel; and
- The Medic/Advanced First Aiders will stabilize casualties and prepare for transportation. If transported, an Advanced First Aider will be required to attend.

2.3.2.4 Emergency Response Coordinator (ERC)

Upon hearing of and/or arrival at the scene of an emergency, the on-site Emergency Response Coordinator (or designate) will assume full command for the emergency response actions. Sometimes the ERC will work in conjunction with the on-site Mine Manager who will act as the representative of the company. In the event of an emergency the ERC will be responsible for:

- Determining the Level response of the emergency;
- Coordinating all emergency procedures through various levels of company personnel and delegate authority where appropriate;
- Making available the resources necessary to set up the ECO to deal effectively with the emergency including rehabilitation;
- Informing the Health and Safety Office of the emergency and have them remain on standby at the phones;
- Designating a person for traffic control who shall not allow any person to leave or enter the property via the glacier road or aircraft. The exception will be the following personnel who will be directed to the appropriate site locations:
    - Mine Rescue Emergency Response Personnel;
    - Emergency Response Team (ERT);
    - Mines Inspectors – BC Ministry of Energy, Mine, and Petroleum Resources; and
    - Other approved essential personnel.
- Conducting, in conjunction with the Health and Safety Office, all aspects of the investigations both at and away from the emergency scene, and report to the on-site Mine Manager; and
- Maintaining a log of occurrences.

Note the person designated for traffic control shall record the names and affiliations of any persons entering or leaving the property (after permission is given) and direct incoming workers to the mine dry to await instructions from the EMT.

2.3.2.5 Mine Manager

If the Emergency Response Coordinator is not immediately available, then upon hearing of and/or arrival at the scene of an emergency, the Mine Manager will assume full command for the emergency response actions until the ERC arrives at the EOC.

Otherwise in the event of an emergency the Mine Manager will be responsible for:

- Requesting assistance from agencies and others as required;
- Contacting local Mine's inspector as per the Mines Act requirements;
- Contacting R.C.M.P., Coroner, and senior management, as required;
- Activating the Mutual Aid Agreement; and
- Reviewing and making recommendations on emergency reports submitted by the ERC.

All public and press inquiries shall be directed to the Vancouver office.

2.3.2.6 Operations Superintendent

The Operations Superintendent (or designate) will ensure that Pretium employees, contractors and their employees are aware of their responsibilities under the plan. When notified of an occurrence, the Operations Superintendent will delegate authority to those on the scene, and relay pertinent information to those as required.

The Operations Superintendent will coordinate the efforts of response groups focusing on the following:

- **Evacuating the Mine:**
  - accounting for all employees and their locations;
  - evaluate the situation and estimate the number of personnel to handle the situation;
  - have mine rescue teams prepare and go on standby; and
  - in conjunction with the Mine Manager, arrange to have appropriate tasks assigned to all outside agencies and personnel on site as required.

- **If men are underground the Operations Superintendent will:**
  - devise a plan for rescue operations;
  - if fire, will devise a plan for control and extinguishment;
  - instruct / brief response group; and
  - send rescue teams underground.

- **As information from underground comes in, decide if additional rescue teams are required, change in rescue/procedures are required.**

- **If all men are accounted for and evacuated:**
  - locate the fire;
  - control and extinguishment of the fire;
  - ventilate the mine;
  - check the rest of the mine and assess damage;
  - determine causes and make reports; and
  - rehabilitation of damaged area.

- **In conjunction with the Mine Manager and ERC, will arrange to have appropriate tasks assigned to all outside agencies and on-site personnel as required.**

2.3.2.7 Mine Foreman or Shift Boss

The Mine Foreman or Shift Boss at the scene will assume command of the emergency until control is passed onto the Operations Superintendent. The Mine Foreman or Shift Boss will then work under the direction of the Operations Superintendent to implement rescue and rehab procedures. The Mine Foreman will take on the same responsibilities as the ones listed for the Operations Superintendent until the Superintendent arrives on the scene.

2.3.2.8 Security/Safety Manager

The Security/Safety Manager (or designate) will report directly to the Operations Superintendent and will be responsible for:

- Supervising all first aid, security and mine rescue operations;
- Ensuring all first aid, firefighting and mine rescue equipment is available to the accident scene;
- Coordinating call out of outside emergency agencies (Air Medivac, Ambulance) or other as required; and
- Coordinating investigation team, findings and reporting of emergency.

2.3.2.9 Maintenance Superintendent

Upon being notified of an emergency, the Maintenance Superintendent (or designate) will report to the EOC.

The Maintenance Superintendent will assist in mechanical/electrical matters relating to:

- mechanical/electrical problems and personnel;
- supply of compressed air;
- supply of tools and equipment that may be needed for the rescue operation;
- technical matters relating to power distribution and communication systems; and
- will ensure adequate water supply to the mine and servicing of pumping equipment underground.

2.3.2.10 Engineering Department

The Engineering Department will report to the Operations Superintendent and will provide up to date 1:250 and/or 1:3,000 scale plans showing:

- refuge stations;
- exit routes;
- fire-fighting equipment locations;
- an up to date ventilation plan showing directions and volumes of air flowing, fans and vent tubing extensions; and
- all vent doors being closed or open.

Upon the location of a fire, the Engineering Department designate along with the Operations Superintendent will assist in identifying locations of workers and equipment underground.

2.4 PLANNING AND TRAINING

2.4.1 Pre-incident Planning

2.4.1.1 Safety Precautions and Personnel Training

In preparation for implementation of this ERP, the Mine Manager shall verify the following measures are taken:

- Conduct safety meetings and orientation sessions with ERT Members to review the contents of the ERP;
- Ensure personnel on the mine site are familiar with their roles, duties, and safety responsibilities;
- Conduct ERP exercises four times per year to familiarize personnel with the correct emergency reporting and response procedures. On completion of each exercise, evaluate how efficiently the exercise was conducted, and address any areas of concern;
- ERT members respond in all mock scenarios as a training exercise. This is in addition to weekly planned training which is organized by the ERCC to cover all aspects of emergency response. Which includes specific focus on actual incidents in the mining industry;
- The Incident Management Team (IMT) planning manager and the rest of the IMT participate in all tabletop and mock scenarios where the focus is on incident management and business continuity planning;
- Ensure personnel are familiar with equipment they may be required to use; and
- Verify adequate safety equipment is available to meet the requirements in an emergency.

2.4.1.2 Mine Rescue Emergency Response Program Exercises

An emergency response exercise is a mechanism used to review the level of emergency preparedness within an organizational infrastructure and to evaluate the ability of the infrastructure to respond to potential emergencies that could arise (Table 2.4-1).

Table 2.4-1. Incident Management Team Training

Team	Induction (role specific)	Desktop Exercise	Mock Exercise (frequency/participants)
IMT	Within 2 months of joining (at a maximum)	Quarterly (four times a year)	Every 1-2 years

Prior to becoming an Incident Management Team Member, an individual must complete practical training with the ERT Coordinator. This will be achieved in one of two ways:

- One-on-One training: The new member and the ERT Coordinator will go through the IMT Room, IMT status boards, breakout room, communication systems, and general workflow of an IMT incident.
- Desktop Scenario: The new member will participate in an IMT desktop scenario, either as a primary, alternate, or observer. Every 1 to 2 years this will include all external offices to participate.

Once the member is trained, they become an Incident Management Team Member.

Objectives

Emergency Response Exercises are to be conducted for the following reasons:

- to validate the adequacy of the organizational infrastructure to effectively deal with emergencies;
- to test the initial communications sequences;
- to verify contact numbers are correct when required;
- to familiarize personnel with their duties and responsibilities;
- to evaluate the preparedness of each party involved in the ERP;
- to identify and correct deficiencies in the ERP;
- to verify the availability of support services;
- to exercise tactical site-specific responses; and
- to examine the interaction between the individuals, support groups, organizations, and agencies named in the ERP, and to address identifiable shortfalls in the established lines of authority.

Once scenarios are completed a debrief will be conducted to determine where changes need to be made. A record will be kept and followed up on until all items have been completed.

Scope

Emergency response exercises are held to review and evaluate existing ERPs. Normally a programmed scenario is developed to present a set of hypothetical emergency conditions, relevant to activities that fall under the scope of an existing ERP.

Emergency response exercise scenarios can be targeted to evaluate the initial response to potential emergency situations that may develop at both the site-specific level or at the senior management level.

Hypothetical criteria can be targeted to measure immediate tactical response or the extent of initial administrative support, depending upon how the scenario is devised.

Emergency response exercises may involve active communications from personnel within the organization, from government agencies, contract support services, and other parties involved in the ERP. Only those communication responses as described in the scenario will be activated.

A performance review meeting should be held immediately following the exercise. At the conclusion of the exercise a report will be generated to describe the outcomes for further analysis and to initiate remedial action and follow up.

2.4.2 Post-incident Review

2.4.2.1 Critical Incident Stress Debrief (CISD)

A critical incident stress debrief is a short (30 to 45 minute) non-judgmental session with all personnel involved in responding to a workplace incident. An incident is any workplace event like an accident, injury, or fatality that causes emotional or psychological trauma.

The critical incident Stress Debrief should occur no longer than 6 hours after the incident and should be carried out by professionals. The group will consist of personnel involved in the incident. Topics will vary but should include: what happened, what was learned, what was done well, as well as actions needing further improvement. The CISD should be a constructive experience for all those involved.

2.5 POSSIBLE FUTURE INCLUSIONS TO THE MERP

Further to the Emergency Response Process there are additional components, which are only outlined and/or not included in this initial MERP document. These additional MERP components should be developed by the Brucejack Mine operations management. They may include:

- **Detailed Emergency Response Team Structure:** Outlining the infrastructure of personnel that will be established to respond to an emergency and to provide further details on their assigned responsibilities.
- **Detailed Alerts and Warnings:** Documentation on how the organization will be alerted to an event or incident, and how the emergency communications sequence will be implemented for the Emergency Response Program.
- **Assessment and Notification:** Documentation of communications protocols within the organization and with outside agencies, including relationships with the media, before and after the event. Provisions for assessing and documenting the nature and severity of the

incident will also need to be developed. The MERP includes a family liaison, external affairs and human resource manager which is responsible for contacting and updating next of kin, managing press and social media.

- **Comprehensive Emergency Response Details:** Description of procedures needed to test the efficiency of the Emergency Response Program. This would document how members of the emergency management group would respond to emergencies within the context of the organization's EOC. Full comprehensive procedures combined with charts with tactical maps will need to be developed for both the alert and activation phases of the EOC.

3 EMERGENCY EVACUATIONS

3.1 OVERVIEW OF EVACUATION PROCEDURES

Structural fires may present the highest potential hazard at the Brucejack Mine. This is because of the flammable nature of the materials used in the construction of most buildings (camp, offices and administration complex).

The following functions listed below are essential in maintaining the integrity of the fire suppression systems and also providing adequate and effective response in the case of a fire.

Evacuation procedures will need to be further developed for the administration, processing and maintenance facilities. However, if there is an alarm or initiation of an evacuation order (administration facility, processing plant, etc.) or stench warning (underground), ensure you follow these procedures immediately:

- Evacuate the facilities, area of work or underground;
- Warn others of the emergency if you encounter them during your evacuation;
- Notify appropriate emergency services and your supervisor;
- All personnel will assemble in the designated (muster) areas and will remain there until ordered to move by the supervisor or the emergency services;
- If you did not evacuate to the designated area immediately you could be classified as missing, therefore immediately report to the supervisor in charge to get checked off the list;
- Some personnel may elect to use emergency equipment to control and/or extinguish flames, spills, etc. but at no time is any worker to remain in the facilities or underground if further exposure shall increase the risk hazard to the worker;
- No worker shall re-enter the workplace and/or return into the buildings after an evacuation until authorized by the Mine Manager and the emergency services; and
- Appoint a person to direct emergency vehicle(s) or personnel to the emergency site.

In the event of an emergency response, the responsibility for directing the response will be the ERC. The Supervisor(s) and Mine Rescue Emergency Response Team will assemble with the ERC at the EOC, who will then direct rescue and firefighting operations.

The response group will assess any reporting on anyone missing and/or details concerning the fire. The response group will then locate and rescue anyone not accounted for, and deal with the emergency response.

3.2 MEDICAL EMERGENCIES

In the event of an incident requiring first aid and/or evacuation, the Medic/Advance First Aider will attend immediately to the scene of the accident to provide first aid and to assess the requirement

for evacuation of the injured. The Medic/Advance First Aider, upon deciding to evacuate these person(s), will inform the ERC and Mine Manager who will then decide upon an appropriate course of evacuation for the injured.

Monthly fire suppression systems inspections will be essential to ensure their integrity. Scheduled maintenance and repairs will be undertaken in order to maintain the integrity of fire suppression systems.

Particular attention to housekeeping and observing the BC Fire Code will ensure that fire protection remains effective at all times. Combustibles shall not be stored inside buildings unless they are part of a work process. Flammable materials such as paints and aerosols shall be stored in approved and appropriate storage cabinets.

Fire drills and evacuation drills will be conducted periodically by management, and all persons shall co-operate during these drills.

3.3 General Mine Emergency Response Procedures – Surface Operations

Surface Operations include all surface activities such as the mill and maintenance operations, administration, camp, vehicle use, access roads, glacier travel routes, quarries, snow dump, etc.

In the event of a surface operations emergency, announce a Code One as per the Code One SOP.

3.3.1.1 Emergency Notification Plan, BJ-OHS-SOP-002 - Code One Call Out & Response

The person(s) discovering the emergency shall do the following.

If you have a radio, announce the "**Code 1**" three times on radio **Channel 2, Repeater 1** and stay on this channel until you receive confirmation that your notification was received by Dispatch. Make sure you pass on all details of the emergency, including:

- your name;
- nature of the emergency;
- location of the emergency;
- requirements for handling the emergency (i.e., first aid, rescue team, ambulance, firefighting);
- number of injured personnel; and
- description of the injuries.

When notification is received by Dispatch, they will instruct **"Radio silence – Code 1"** three times on **Channel 2, Repeater 1** as this channel is monitored at all times. All nonessential radio traffic and work activity will cease until further notice.

The onsite clinic personnel will be monitoring the repeater channels at all times.

If only a surface emergency, the Medic/Advanced First Aider assumes command and coordinates with Medical Aid and Air Operations. If it is a Code 1 then the ERCC assumes command and follows the ERP protocols.

3.3.2 Administration Facilities Emergency Evacuation

The procedure for evacuation from the facilities is clear. If some personnel elect to use emergency equipment to control and/or extinguish flames, spills, etc. they may do so until further exposure increases the risk hazard to that worker. If a risk hazard increase than all personnel will need to evacuate from the facilities immediately.

3.3.3 Camp Muster Areas

All emergencies will be coordinated through the senior on-site supervisor or designated person. All radio traffic will be cleared in the event of an emergency. All Camp mustering stations are clearly marked on-site.

3.3.4 Employee Responsibilities during All Emergencies

In an emergency, employees shall:

- ensure their own personal safety;
- assist others, alert others;
- check work area for others;
- close doors and windows;
- report to the muster station during an emergency or drill;
- bring appropriate PPE and clothing for the weather;
- report to their supervisor at the muster station; and
- remain in the muster area until directed by their supervisor.

3.3.5 Supervisor Responsibilities during All Emergency

All supervisors shall:

- Report to the muster station during an emergency or drill;
- Account for all employees under their direction;
- Provide a report to the ERC, if applicable regarding status of head count;
- Report all unaccounted employees including the last known whereabouts of the employee(s); and
- Instruct employees to remain at the muster station until the emergency is over.

3.4 MOBILE EQUIPMENT/VEHICLE ACCIDENTS

There is a potential for vehicle accidents involving multiple casualties on the Mine Access road.

In the event of these accidents it is highly likely to encounter multiple casualties because of the high volume of traffic on the road and the type of vehicles used (buses and multi-passenger vehicles).

In the event of an accident of this type the following procedures must be followed:

- Assess the accident scene for hazards, such as:
  - fire;
  - spills – hazardous cargo (chemicals or fuels);
  - equipment stability; and
  - electrical hazards from downed wires, etc.
- If you have a radio, announce the "**Code 1**" three times on radio **Channel 2, Repeater 1** and stay on this channel until you receive confirmation that your notification was received by Dispatch. Make sure you pass on all details of the Emergency:
  - your name;
  - nature of the emergency;
  - location of the emergency;
  - requirements for handling the emergency (i.e., first aid, rescue team, ambulance, firefighting);
  - number of injured personnel; and
  - description of the injuries.
- If it is not safe to approach the accident scene, stay clear, until appropriately trained mine rescue emergency response team arrives.

Figure 3.4-1 summarizes these procedures in flow chart format.

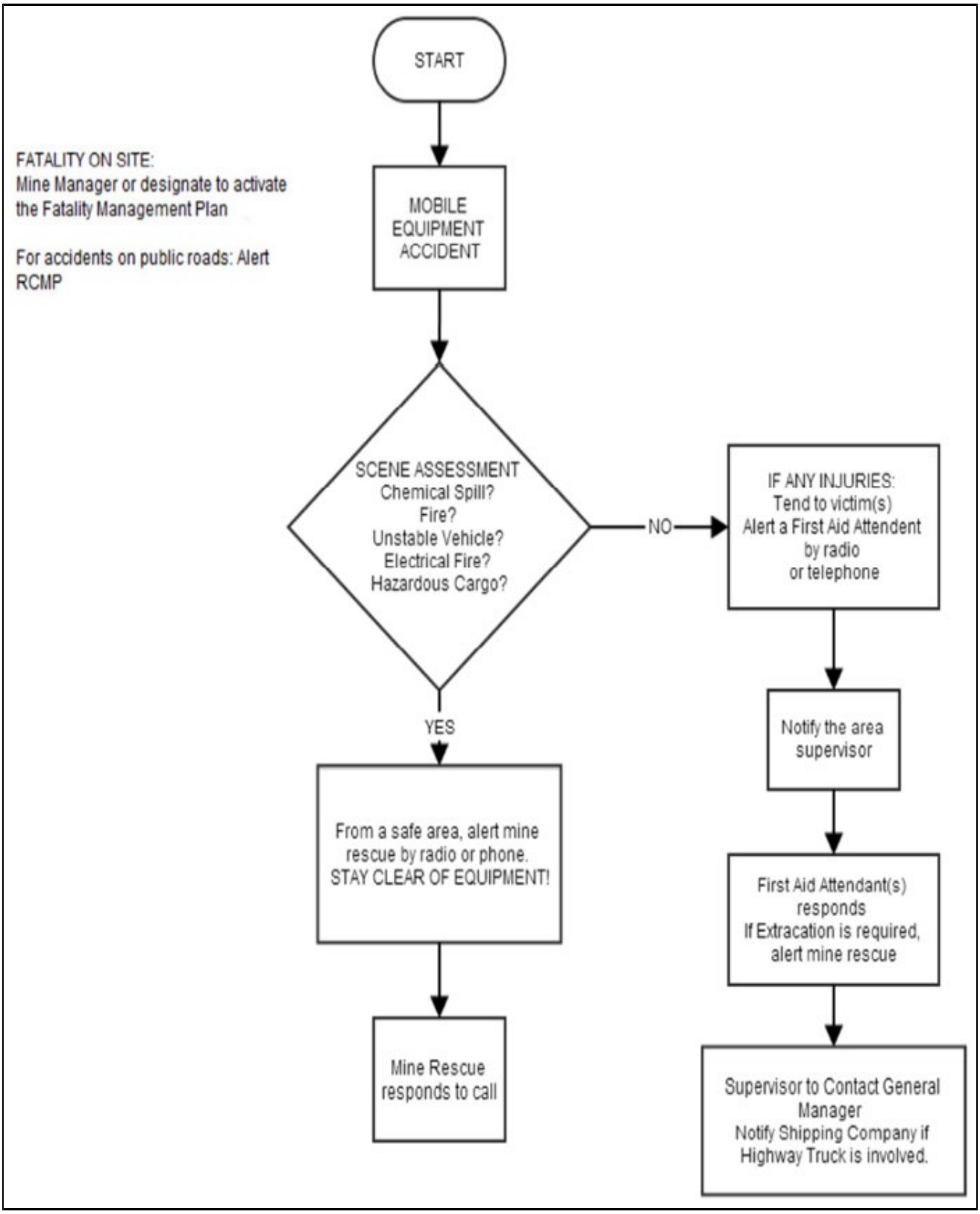


Figure 3.4-1. Mobile Equipment Accident Response Flow Chart

3.5 GENERAL MINE EMERGENCY RESPONSE PROCEDURES – UNDERGROUND OPERATIONS

The following ERP outlines the basic procedures to follow should any emergency occur in the underground operations at the Brucejack Mine. This section deals specifically with the underground; however, several of the other components of this plan are as relevant for the entire operation including fire and emergency procedures.

Some of the information in this section was sourced from the SOP "Underground Emergency Response Plan – Brucejack". Review the SOP for additional details.

Underground emergencies are those events that could cause an immediate threat to life. Types of underground emergencies could include the following but not limited to:

- injury to, or people requiring rescue;
- loss of life;
- unexpected/unplanned explosion;
- fire/heat/smoke;
- falls of ground;
- equipment electrical - failure/damage;
- loss of main ventilation; and
- any other situation that may jeopardize the safety of workers and/or the mine.

It is very important that all personnel be prepared. In order to accomplish this the following should be undertaken:

- Every employee should be trained and familiar with the MERP;
- Each employee must be familiar with the stench gas warning system, how it works and must understand what to do upon smelling it;
- All management personnel must be familiar with their roles in an emergency;
- Mine rescue personnel should be properly trained. Locations in where they can be reached shall be posted and their personnel in/out tags should be marked so they can be located easily;
- Refuge stations must be located where needed, maintained in good condition, well equipped, and with instructions for procedures to be followed posted in each station;
- Fire extinguishing equipment must be located where needed, must be ready for use and inspected regularly;
- The communication system underground must be kept in good condition;
- Ventilation doors if installed must be well located, kept in good repair and clearly marked "OPEN" or "CLOSED";

- Mine plans showing exit routes, refuge station locations must be posted; and
- All underground employees will receive basic training in the use of fire extinguishers and water hoses as well as survival mine rescue and first aid.

3.5.1 General Underground Emergency Response Procedure

3.5.1.1 Emergency Notification Plan, BJ-OHS-SOP-002 - Code One Call Out & Response

The person or persons discovering the emergency shall do the following:

- If you have a radio, or are at an underground phone (Femco), announce "**Code 1**" three times on your radio – UG All Dispatch **Channel 1** and stay on this channel until you receive confirmation that your notification was received by Dispatch. Note*: Underground Emergency – Code 1 will deploy UGIC if stench has been released.* Make sure you pass on all details of the Emergency:
  - your name;
  - nature of the emergency;
  - location of the emergency;
  - requirements for handling the emergency (i.e., first aid, rescue team, ambulance, firefighting);
  - number of injured personnel; and
  - description of the injuries.
- Remain on the radio or phone and wait for further directions.
- If you do not have a radio, go to the nearest Femco phone and announce the Code 1. Ensure supervisor has heard and will pass on to Dispatch.
- Warn all personnel in the area by releasing the stench gas in the ventilation system. Releasing the stench gas in compressed airlines requires approval from the Mine Manager.
- According to your skills and training, do what you can do to correct the situation with whatever you may have at hand to do so. Remember; do not jeopardize your own personal safety.
- When calling out ensure you give as complete information as possible to ensure correct and appropriate response.
- If there is any sign of fire or smoke put on your W65 self-rescuer, retreat to a refuge station or fresh air escape way and advise others in the area.
- If surface visibility is compromised due to whiteout snow conditions, the mine manager or designate shall organize for a guideline to be strung between the portal and truck shop.

3.5.2 Underground Fire Emergency Procedures

3.5.2.1 Discovery of Smoke Underground

If you encounter smoke anywhere in the underground mine workings:

- Assess the type of smoke you have encountered. Is this blasting smoke, diesel smoke or possible smoke from a fire? You will have to use your sense of smell and judgment to distinguish between the different types of smoke.
- If you suspect the smoke is from a fire, go to the nearest phone and call site dispatcher/ supervisor or the surface shops/offices and pass on all details of the emergency and have them call a **"Code 1"** three times on the UG Emergency **Channel 4**.
- Make sure you pass on all details of the emergency and ask for the stench gas to be injected:
  - provide your name and location of the emergency;
  - the precise location, nature of the fire and what is burning;
  - the size of the fire; and
  - your planned destination after the call.
- Put on your self-rescuer and proceed to the portal. If egress through the portal is not possible, proceed to the nearest refuge station or place of safety and await further instructions.
- Advise other workers that you encounter of the emergency.
- If your passage to the nearest refuge station or place of safety is blocked proceed to the nearest dead-end drift that has air and water available and seal yourself in using any available materials. Use your jacket, oiler jacket or shirt to make a tent over your head and the air header and crack open the airline and wait for help.
- **Do not panic and enter smoke** – trained rescue personnel will get you out.
- Occasionally beat on a pipe in a series of three (3) taps to indicate your location.
- If you reach the portal, proceed immediately to the tag board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine.
- Do not leave the truck shop area until authorized to do so by your supervisor.

3.5.2.2 Discovering Fire or Emergency

Persons discovering the fire or emergency shall:

- Immediately try to extinguish the fire with whatever means are available. Fire extinguishers are located at all refuge stations, shops, electrical sub-stations, storage areas, fuse and powder magazines and on all pieces of mobile equipment.
- If you cannot put the fire out quickly, try to warn everyone that you can and or get to a phone or radio and call your supervisor or the surface shops/offices and pass on all details of the emergency and have them call a **"Code 1"** three times on UG Emergency Channel 4. Make sure you pass on all details of the emergency and ask for the stench gas to be injected:

- your name and location of the emergency;
- the precise location, nature of the fire and what is burning;
- the size of the fire; and
- your planned destination after the call.

When the alarm is turned on, a stench gas warning will be introduced into the airline and ventilation system in the mine and all persons underground should proceed as follows:

- Put on your self-rescuer and proceed to the portal. If egress through the portal is not possible, proceed to the nearest refuge station or place of safety and await further instructions.
- Advise other workers that you encounter of the emergency.
- Upon reaching the portal, proceed immediately to the tab board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine. Remain at the pre-arranged safe designated place.
- Do not leave the truck shop area until authorized to do so by your supervisor.

3.5.2.3 Fire on Piece of Underground Equipment

If there is a fire on a piece of equipment in the underground mine workings:

- Stop the piece of equipment and shut down the engine.
- Turn off the master switch.
- Extinguish the fire using the handheld fire extinguisher from the piece of equipment first. If you are unsuccessful activate the fire suppression system from one of the two activation points located on most pieces of underground equipment.
- Do not expose yourself to smoke or gases.
- Even if you succeed in extinguishing the fire do not delay in announcing an emergency. Go to the nearest phone and call your supervisor or the surface shops/offices and pass on all details of the emergency and have them call "**Code 1**" three times on the **UG Emergency Channel 4.** Make sure you pass on all details of the emergency and ask for the stench gas to be injected:
  - your name and location of the emergency;
  - the precise location, nature of the fire and what is burning;
  - the size of the fire; and
  - your planned destination after the call.

When the alarm is turned on, a stench gas warning will be introduced into the airline and ventilation system in the mine and all persons underground should proceed as follows:

- Put on your self-rescuer and proceed to the portal. If egress through the portal is not possible, proceed to the nearest refuge station or place of safety and await further instructions.
- Advise other workers that you encounter of the emergency.

- Upon reaching the portal, proceed immediately to the tab board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine. Remain at the pre-arranged safe designated place.
- Do not leave the truck shop area until authorized to do so by your supervisor.

3.5.3 Emergency Activation System (Stench Gas)

3.5.3.1 Stench Gas Activation

Stench gas is normally injected for emergencies requiring mine evacuation or refuge such as fires. In the event of a stench gas deployment, all persons shall:

- Evacuate to a safe area where communication can be maintained unless immediately requested to assist.
- Evacuate to a designated assembly area for a head count or further instruction.
- Not leave the assembly areas or go back into the area until authorized.
- Not make any off-site phone calls with details of the emergency.
- If underground proceed to the portal. If egress is not possible, proceed to the refuge station and contact surface via the mine phones.

In order to release the stench gas underground follow BJ-OHS-SOP-004 Stench Gas Release.

3.5.3.2 Person Encountering Stench Gas

If you smell stench gas (ethyl mercaptan/rotten egg smell) anywhere in the mine:

- Stop working immediately and make sure others in the area are aware of the emergency.
- Shut down and secure any equipment you have been using. Make sure it is not parked blocking the roadway or access to emergency or electrical equipment.
- If egress to the portal is not possible (do not go past a refuge station), proceed to the refuge station.
- Travel quickly but calmly and do not run. Take any available tools with you. If there is any indication of the smell of smoke put on your W65 self-rescuer or Ocenco 6.5 EBA.
- Always stay on the fresh air side; never travel in air containing smoke.
- Do not change the ventilation system.
- Warn anyone you meet along the way of the emergency.
- Upon reaching the portal, proceed immediately to the tag board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine.
- Do not leave the tag board area until authorized to do so by your supervisor.

3.5.4 Loss of Ventilation

If ventilation is lost in the mine:

- In the event of an auxiliary fan failure:
  - leave the area;
  - shutdown all diesel-powered equipment;
  - notify your shift boss of the problem;
  - the shift boss will call an electrician to evaluate the problem;
  - once evaluated and fixed the ventilation will be turned on to flush out the affected area for 20 minutes prior to resuming work in the area; and
  - work will not resume in the heading until adequate ventilation can be established.
- In the event of a main fan failure:
  - shut down all diesel-powered equipment and notify shift boss;
  - small diesel-powered tractors or utility vehicles may be used to egress;
  - all personnel should proceed to the refuge station;
  - roll call will be completed from the tag board to ensure all personnel are accounted for;
  - work will not resume in the mine until adequate ventilation has been established; and
  - a gas tests as well as flow and velocity checks in all work areas will be completed prior to work resuming.
- If smoke or fire is encountered at any point refer to Section 3.5.2 of this MERP.

3.5.5 Refuge Station

3.5.5.1 Action Steps for Refuge Station Procedures

Step I – General Actions

1. A responsible person will take charge immediately (Does not have to be a supervisor).
2. Determine if there is compressed air coming in or not (airline).
3. Follow Step II or Step III, depending on compressed air.
4. Call in (phone/radio) and report all persons in refuge station. Double-check all names and those present. Make certain all present have been reported in.

Step II – When Compressed Air Is Available

1. Go in through the first door and close it behind you.
2. Purge contaminated air in the air lock with provided compressed air cylinders.
3. Open second door to enter chamber and close behind you.
4. Ensure compressed air is on.
5. Keep a check on pressure inside refuge station (must be positive). This can be determined by holding a string or piece of paper, etc. in exhaust pipe opening.
6. Conserve oxygen by keeping quiet and still.
7. Mix the air by having one-person walk around every fifteen (15) minutes or so.

8. Keep off the floor. The exhaled air containing CO_2 is heavier than normal air and settles to the floor.
9. Conserve cap lamps. One on per group is adequate.
10. Remain in station until you receive official instructions.
11. “NO SMOKING “at any time during Emergency Stench Warning.
12. Remain calm, follow Emergency refuge conduct procedures.
13. Ensure continuous gas monitoring to ensure air quality is sufficient.

Step III – If Compressed Air Is Not Available

***Note**: When compressed air (airline) is not available extra care must be exercised.*

1. Go in through the first door and close it behind you.
2. Purge contaminated air in the air lock with provided compressed air cylinders.
3. Open second door to enter chamber and close behind you.
4. Ensure the compressed air valve is closed.
5. Turn on oxygen and refuge chamber continuous gas monitor. This will continually measure the air quality in the chamber.
6. Ensure names of those in refuge station are phoned/radioed in and update information as necessary.
7. Frequently check sealed openings for possible leaks and maintain positive air pressure.
8. Conserve oxygen by keeping quiet and still.
9. Mix the air by having one-person walk around every fifteen (15) minutes or so.
10. Keep off the floor. The exhaled air containing CO_2 is heavier than normal air and settles to the floor.
11. Conserve cap lamp batteries – use only one cap lamp at a time.
12. Remain in the refuge station until you receive official instructions that it is safe to leave.
13. **NO SMOKING** at any time in the refuge station during the emergency.
14. Remain calm, you will eventually be rescued.

3.5.5.2 Duties of Person in Charge of Station

Duties of person in charge of station (a responsible person or as designated by Supervisor):

- Phone/radio mine office. If phone/radio is out of order, stay at your location until rescued.
- Report number and names of personnel in refuge station, injuries if any, location of fire if known, smoke conditions, ventilation, locations of other persons if known.
- Maintain discipline in the refuge station.
- Keep use of phone/radio to a minimum.

- Remain in refuge station until instructed otherwise.

3.5.5.3 Persons Entering Refuge Station

Duties of person entering a refuse station (a responsible person or as designated by Supervisor):

- Report your name and working place to person in charge.
- Follow any instructions by the person in charge.
- Sit down and remain calm and quiet.
- Do not smoke in the refuge station.
- Turn off your cap lamp to conserve the life of your battery. One lamp on per group is sufficient to illuminate the station.
- Save any food or liquid in case your rescue may be delayed.
- If you are alone in the refuge station, follow instructions given above or as posted in the refuge station.

REMEMBER: You are in no danger if you remain where you are. You will be advised via telephone/ radio by someone in authority or by the Mine Rescue Emergency Response Team when it is safe for you to leave and by what route you should travel to reach surface.

3.5.5.4 Refuge Station Locations

All refuge station locations must be constructed and equipped in accordance with Part 6.13.3 of the HSRC, 2017.

3.5.5.5 Refuge Station Required Emergency Supplies

The following items are to be stocked in each refuge station. No person may use or consume any of these supplies unless it is an emergency.

- first aid supplies and blankets;
- oxygen therapy unit;
- radio communications;
- phone (Femco or other);
- CO_2 scrubber;
- oxygen bottles;
- food rations;
- drinking water;
- portable toilet;
- sealant; and

- compressed air.

If inventory is taken from the refuge station, the safety department must be notified immediately so it may be restocked.

3.5.6 Employee Tally Procedures

In the event of an emergency a systematic check must be conducted to account for all persons underground at the time of the emergency. To achieve this, the following procedures must be followed.

1. Once an emergency has been established, the Shift Boss or designate will begin a roll call of all employees known to have gone underground. This firstly can be assessed by checking the tag board located in the main dry/shifters area. All employees going underground are required to place their personal ID tag on the board. All others such as visitors or contractors would be tagged accordingly. A back up check would be to do a mine lamp count and compare to tag count.
2. Should anyone be unaccounted for, the Shift Boss or designate would then determine their job description (miner, electrician, mechanic, etc.) and the last location where the person was working.
3. Once the Incident Command Group has been assembled a search and rescue plan shall be initiated.

4 GENERAL PROCEDURES TO FOLLOW FOR ACCIDENTS AND FIRST AID TREATMENTS

4.1 FIRST AID AND MEDICAL SERVICES

As per requirement of Part 3.6.1 of the *Health, Safety and Reclamation Code for Mines in BC*, 2017, Pretium Resources/ Brucejack Mine is providing and maintaining first aid supplies and services as required by WorkSafeBC. As part of the emergency response plan, Pretium Resources/ Brucejack Mine has mutual aid partnerships with Silvertip Mine and New Gold and will mutually provide resources and compensation as required.

The fully equipped first aid facility is located in a designated facility on the property. The facility and equipment are clearly identified and reserved for the treatment of injured personnel. The Medic/OFA 3 can be reached by radio at all times, On Channel 2, Repeater 1 in case of emergency, or if underground call on Channel 1.

All personnel working on site, including laborers and equipment operators are required to:

- have general knowledge of how to summon first aid help, and general knowledge of securing the scene and helping (as per the level they are trained at); and
- be authorized to call for transportation for injured workers and must be trained in the procedures.

The mine site should have a percentage of employees who have Level 1 and Transport first aid tickets while working on the mine site.

Any work site that requires specialized equipment for the rescue or transport of injured personnel is clearly identified. The equipment is properly stored to prevent damage or deterioration. Clear access to this equipment will be always maintained, and a regular inspection program has been established to check for deficiencies.

To complement the first aid services, Pretium has enacted the general procedures described in Section 4.2. All employees, contractors and their employees should follow these procedures in case of first aid treatments, accidents, and dangerous occurrences.

An Emergency Response Coordinator (or designate) will be in command during Code 1 emergencies.

To ensure that appropriate information is gathered during a site emergency or during a first aid response, checklists will need to be developed. An example form is provided in Section 9.

4.2 FIRST AID, MEDICAL AID AND TREATMENT PROCEDURES

4.2.1 First Aid Treatment Procedure

Any worker who sustains an injury or illness that is, or may be, work related shall report for treatment as soon as possible. The following three (3) situations below highlight, depending on the type of injury, what type of actions are required:

- If you suffer a minor injury that requires First Aid, the first three (3) action items are required.
- If you suffer a significant injury and are unable to continue work, and/or will not return to work the next day or for a period of time, all five (5) action items are required.
- If you suffer a significant injury and will not return to work the next day or for a period of time, all five (5) action items are required.

Action items to follow depending on the type of injury situation:

1. Report injury to First Aid Attendant.
2. Ensure you receive proper treatment.
3. Document in treatment record book.
4. Notify supervisor, who will initiate an investigation.
5. Complete required paperwork and forms.

If you encounter these typical first aid scenarios, be prepared and know how to treat them:

- bleeding from cuts and abrasions;
- slips and falls – injuries such strains, sprains and broken bones (fractures) or concussions;
- burns; and
- allergic reactions.

4.2.2 Procedures for Handling Medical Emergencies

The following assessment will be necessary during any medical emergency. Whether it is minor or life threatening, use the following simplified **Priority Action Approach:**

1. **Scene Assessment:** Mechanism of Injury? Hazards? Environment?

   First: Keep yourself safe

   Second: Observe for bleeding/deformities/eyes

   Third: Observe the skin/level of consciousness – moving/verbal

   Fourth: Spinal Precautions

   Fifth: **Airways** – With C-spine: Open/Clear – manually stabilize head

   Breathing – Rate and Quality

   Circulation – Radial/Carotid, skin – color, temperature and condition

   Sixth: Rapid Body Search (RBS) – Rapid/Through Life Threatening

Seventh: Warmth – Blankets/Reassurance/Support Injuries

2. **Transport Decision:** Load and Go (Hospital and/or Call for an ambulance)/Stay and Play (Administer First Aid).
3. **Communicate to Emergency Services:** Stewart or Terrace Hospital or call for help from other persons on-site.
4. **Secondary Assessment:** Vital, History, Head to Toe Evaluation.
5. **Definitive Treatment:** Ice, Dressings, Splitting, Wound Cleaning, etc.

Once relieved by the Medic/Advanced First Aider, continue to assist if required and pass on any information gathered during assessment of patient.

If the injury requires offsite medical aid, it will be the sole responsibility of the Medic/Advance First Aider on duty to do all Medical Aid Referrals, by making the decision to transport, the choice of methods and the decision to accompany the patient, if necessary. The direct supervisor is then solely responsible to arrange for the required transportation for the injured worker. If the transport is by helicopter than the Medic/Advanced First Aider will call the Site Dispatcher who will contact VIH Helicopters on radio Channel 2 or at the VIH Hanger in Stewart at 1-250-636-2498. Advise them if a litter stretcher is required. **THE LITTER STRETCHER IS REQUIRED FOR ALL SPINEBOARD SCENARIOS**.

If ambulance transportation is required from the Stewart Airport to the Stewart Health Centre or there is more than one injured person, contact BC Ambulance Services at 1-800-461-9911.

It is the responsibility of the Medic/Advance First Aider to complete the proper forms and submit them to WCB; as well to distribute a copy to the Mine Manager and if necessary, provide a copy for Pretium Resources Inc. head office. A record of every injury or illness that requires first aid treatment is kept in the Accident Record Book. Each record must be signed and dated by the person providing treatment. The First Aid statistics shall be reviewed monthly at a safety meeting to determine trends and recommend corrective action.

4.2.3 Procedures to Follow in Case of a Serious Accident or Fatality

The following basic procedures should be followed in the event of a serious (life-threatening) accident requiring first aid treatment or a fatality. It is imperative that you ensure there is no further danger to yourself and to the patient before starting treatment.

If you have a radio, call “Code 1” three times on UG Emergency Channel 4 and stay on this channel until you receive confirmation that your notification was received by Supervisor/Site Dispatcher/ Security/Safety Manager. If you are near a phone call extension 100 to dispatch and call a Code 1. ***Note:*** *Code 1 Emergency will deploy ERMT. Make sure you pass on all details of the Emergency*.

- Then follow the appropriate Emergency Evacuation Procedures that have been established for your area of operations;
- Ask Supervisor/Site Dispatcher/Security/Safety Manager to notify the Medic/Advanced First Aider (by radio) and indicate there is a medical emergency – **STAY CALM**;

- All work at the area of the accident, must cease, all equipment is to be shut off and made secure, except for those required to assist in the emergency; and
- ENSURE THAT THE ACCIDENT SCENE IS SAFE TO APPROACH – If not, report what you see.

If the scene is safe and you are able to approach the injured person, report and complete the Procedures for Handling Medical Emergencies as noted in Section 4.2.2.

REMEMBER: Call for help, stop or control bleeding, restore breathing, and avoid panic. Do no more than is necessary until help arrives.

Even if not in danger, **DO NOT MOVE** the injured patient but provide the best available first aid treatment that does not exceed your level of training. Provide comfort and warmth to the patient.

Ensure that, except for the purpose of saving a life or relieving human suffering, the scene of the accident or occurrence is not disturbed without appropriate approvals as required by Part 1.7.1 (2) of the HSRC, 2017.

If the injury is an obvious **fatality**, immediately contact the Mine Manager, who in turn will contact the appropriate authorities (RCMP and Chief Inspector of Mines). Every serious accident must be reported immediately to the Mine Manager, by the first aid attendant on duty after requesting an ambulance or helicopter. The Mine Manager will then contact MEMLCI, who will advise whether the Ministry will investigate the accident.

4.2.4 Procedures to Follow when Calling for a Provincial Ambulance

When instructed by the Medic/Advance First Aider or the Direct Supervisor, follow these steps:

1. Call AMBULANCE: Phone 1-800-561-8011 or 911;
2. When asked “For what place?” answer “Pretium – Brucejack Mine”;
3. As the mine does not have a municipal address, the dispatcher may not be familiar with the locations. If that is the case, pass along the following information that fits the 911 dispatch system:
   - First Name: Brucejack Camp
   - Last Name: Pretium Exploration Inc.
   - Street Number: Northern BC
   - Street Name: Near KM 215, Highway 37, Down 73 km Haul Road
   - City: Between Meziadin Junction and Bell 2
   - Other Information: LAT 56°27’57.64’N LON 130°11’11.32”W
     Elevation 1,440 m asl, 73 KM Haul Road Access off Hwy 37
4. State that “We have life threatening injuries and request vehicle or helicopter evacuation”;
5. There will be several questions the dispatcher will ask including:
   - “Your exact location?”
   - The Brucejack Camp co-ordinates are?”

     Latitude: 56 degrees 28 minutes 01 seconds

Longitude: 130 degrees 11 minutes 01 seconds

Map Coordinates: NAD 83 UTM: 9V East: 427080 North: 6258695

- What is the phone number you are calling from?
- What happened exactly?
- What are the injuries?
- Are you with the injured person now?
- How many people are hurt?
- How old is the patient?
- Is the patient conscious or unconscious?
- Is the patient on a spine board?
- Is the patient breathing?
- What is the weather at site?
- Is there an accessible area to safely land a helicopter?
- Is the patient accessible?
- How many daylight hours are left?

Triage is done based on the information you are able to provide. A road or air ambulance will be dispatched to the required location. If the ambulance crew from Stewart is required, they will come in a helicopter from Stewart. Flying conditions will be reviewed and Medevac will proceed at the discretion of the pilot in command.

The **one-way** flight lengths to Stewart:

- Direct: 60 km (approximately 20 minutes)
- Via the Granduc Valley and Knipple Glacier: 76 km (approximately 30 minutes).

Flight lengths to the Terrace airport:

- Direct: 245 km (approximately 80 minutes).

If you are calling for an air ambulance, then you must prepare a helicopter landing pad/area. This area must be clearly marked and cleared of debris that could become airborne when the helicopter approaches and damage the rotors in the machine. A guard must be posted in this area and all traffic in the vicinity stopped. The helicopter will be looking for this area and can be guided into the landing area.

4.2.5 Reporting of Illness or Injury

Every Pretium employee, contractor and contractor employee at the Brucejack Mine must report any work-related injury or illness to their immediate supervisor, immediately. It is the responsibility of the supervisor and/or Medic/Advanced First Aider to ensure that the ill or injured worker receives appropriate first aid or medical treatment immediately.

Failure to report any work-related injury or illness is grounds for discipline, up to and including dismissal.

Any non-work-related injury or illness that will result in a worker being absent from work, for any reason, must be reported to their immediate supervisor as soon as possible after the worker learns of his or her inability to work. All personnel (management, direct employees and contractor employees) with non-work-related injury or illness shall provide the immediate supervisor with any information they have as to the expected duration of the injury recovery or illness to allow for efficient manpower planning.

Prior to returning to work (from a work caused illness or injury or nonwork-related illness or injury) the person shall contact the immediate supervisor to confirm their return-to-work date.

5 SURFACE FIRE EMERGENCIES

Fires could be one of the most common incidents on the job. Therefore, it is important to have some general fire protection rules that must be adhered to by all Pretium employees and contractors.

5.1 GENERAL FIRE PROTECTION RULES

General protection rules include, but are not limited to the following:

- There will be no smoking on the job, other than those areas designated as “smoking areas.”
- Evacuation routes are to be posted at various locations throughout the mine site. Every person shall be familiar with the emergency escape routes and the evacuation procedures from their workplaces to the assigned assembly area.
- No person shall tamper with fire protection equipment or issue a false alarm.
- Discharged fire extinguishers and non-serviceable fire protection equipment shall be reported immediately to the supervisor on duty. Discharged and expired fire extinguishers shall be returned immediately to the Warehouse for a replacement, and the replacement shall be installed in its proper location.
- Any fire, and use of fire protection equipment regardless of severity, shall immediately be reported to management.
- Except for during an emergency, no work shall be performed on any fire protection system, including fire alarms and fire water supply, without the prior approval of the Mine Manager. In the case of emergency work being performed on fire protection system, the Mine Manager shall be immediately notified.
- Fire hazard areas shall be identified by warning signs, and no person shall smoke or use open flames in designated fire hazard areas.
- All persons shall be familiar with the location, and the use of the fire extinguishers, and know how to summon assistance.
- Fire extinguishers and fire suppression systems shall be inspected annually by an authorized person, and a written record of the inspection will be reported to management.
- Open flames, welding, and cutting and similar activities in certain locations shall not be permitted without following protocol as noted in the maintenance (welding) section.
- Flammable liquids shall be labeled, stored in a separate area, and transported and disposed of in an approved manner.
- When using gasoline-powered engines, do not refuel hot or running engines. After refueling, clean up all spills before starting.
- Never use gasoline or other flammable materials as a cleaner.
- When using propane for heating or other purposes in an enclosed area ensure that the gas supply is turned off at the cylinder, or the torch is removed from the area when the flame is extinguished.

5.2 PROCEDURES TO FOLLOW IN CASE OF A FIRE

If you encounter smoke and/or a fire, follow the rules listed below. A fire/explosion emergency response flowchart is provided in Figure 5.1-1.

- Attempt to extinguish the fire only if you can do so safely.
- If you encounter smoke, shout “FIRE” and sound an alarm or have someone do it and/or call on the mobile radio the situation.
- Evacuate the area and **call a Code 1 on Channel 2**, **repeater 1**.
- Immediately notify the supervisor on duty and/or Mine Manager.

If you are in a building and hear an alarm, the following procedures shall be followed:

- Leave the building immediately by the nearest fire exit, alerting people on the way.
- Close the doors behind you when exiting the building – REMAIN CALM.
- When exiting the building shout “FIRE” and knock on doors as you go out, but do not wait for an answer as the person may be off shift or working elsewhere.
- When you have reached the outside, move away from the building.
- Go to the designated assembly area.
- Wait for further instructions from either the supervisor on duty or the Mine Manager. If you are part of the emergency response team, at your discretion, attempt to control the fire with available fire equipment.
- DO NOT GO BACK INTO THE BUILDING FOR ANY REASON.

Record information about the fire; someone must keep notes on the situation, such as:

- Where was the fire?
- When was it discovered and by whom?
- Whom did you contact and when?
- What actions were taken to contain the fire?
- What is the extent of damage?
- Your name and telephone (contact) information.

5.3 PROCEDURES FOR USE OF FIRE EXTINGUISHERS

Attempt to extinguish a fire with an extinguisher only if the following conditions exist:

- There is a clear exit and the fire is small;
- The person using the fire extinguisher is familiar with its use; and
- The extinguisher is in working order.

When using a portable fire extinguisher:

- never place the fire between yourself and the exit;
- never turn your back on the fire;
- always keep your back to the exit; and
- remember PASS: Pull – Aim – Squeeze – Sweep.

A person shall not attempt to extinguish a fire if:

- the fire is quickly spreading beyond its point of origin; and
- the fire could block the exit, or the person is unsure how to use a fire extinguisher.

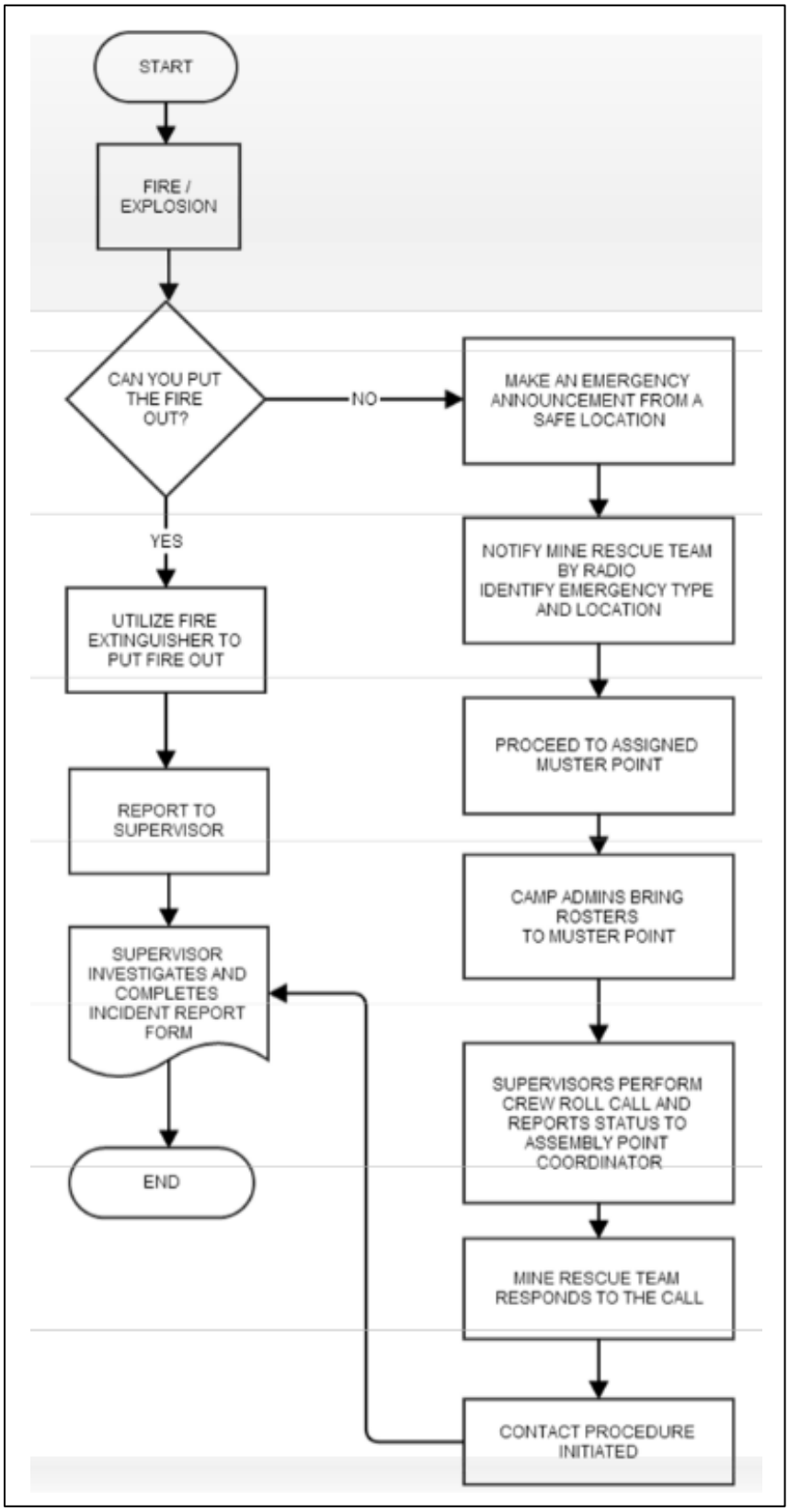


Figure 5.1-1. Fire/Explosion Emergency Response Flow Chart

6 AVALANCHE EMERGENCIES

6.1 INTRODUCTION

The Brucejack Mine operates in a high snowfall area with steep terrain subject to snow avalanches. At this time, some infrastructure facilities are located outside of known avalanche-prone areas, however personnel do work in avalanche-prone areas. During periods of (high) snow, advice on current (avalanche) risks must be obtained from an avalanche technician. As well all personnel must be equipped with appropriate safety gear and trained to use avalanche beacons.

At the mine, the Mine Rescue Emergency Response Team(s) will be trained in avalanche rescue techniques in case an avalanche affects facilities and personnel. Avalanche rescue will not be attempted unless the site is considered to be safe from further danger by Pretium's Mountain Safety personnel.

Pretium currently has an avalanche safety plan (ASP, Brucejack Mine Avalanche Safety Plan, updated March 2021) developed by Pretium's Mountain Safety Department. Some of the information in this section was obtained from the ASP, which will remain current for avalanche safety during mine operation and closure.

The ASP contains pertinent information on the following:

- Organization Structure and Personnel – Roles and Responsibility of Pretium and the Avalanche Contractor;
- Avalanche Training;
- Equipment and Infrastructure;
- Operational Procedures; and
- Search and Rescue, etc.

Pretium management, as part of the on-site training, will ensure that all employees, contractors and their employees have reviewed the ASP. Further, the ASP will be accessible on-site and available for future review.

6.2 GENERAL AVALANCHE SAFE OPERATIONAL PROCEDURES

All Pretium employees, contractors and their employees will be required to adhere to the General Avalanche Safe Operational Procedures. These procedures ensure work is conducted safely within avalanche areas and are effective at all hazard levels. General procedures include:

- attending scheduled avalanche safety training sessions;
- familiarizing themselves with avalanche hazard zones;
- familiarizing themselves with the location and use of rescue equipment;
- knowing how to properly use avalanche PPE, including the rescue transceiver;

- reading the Avalanche Hazard form every day, and adjusting work and PPE accordingly;
- following check-in, check-out procedures as per the Underground Incident Command Procedure;
- ensure that personal avalanche PPE is maintained and ready for use;
- reporting avalanche accidents or near misses immediately to Mountain Safety technicians, the Mine Manager, Health and Safety Manager and Operator Supervisor; and
- contacting Mountain Safety Technicians (MSTs) to update them of unusual weather or snow conditions.

6.3 AVALANCHE ACCIDENT/INCIDENT REPORTING AND REVIEW

All avalanche accidents, incidents or near misses will be immediately reported to MSTs, the Health and Safety Manager and the Mine Manager and Operator Supervisor. MSTs will complete the avalanche incident investigation reports and depending on the severity of the incident will be reported to the appropriate authorities as necessary (MEMPR, JHSC, WorkSafeBC, the CAA (Infoex) and Insurance agents if applicable). Standard WorkSafeBC protocols will be followed for accident investigation.

6.4 SEARCH AND RESCUE

In the event of an avalanche involvement, rescue must be initiated immediately. TIME IS OF THE ESSENCE. If people are buried in a vehicle, they may have several hours of available oxygen if they are not injured. If buried on foot, then they may only have 10 to 15 minutes, or less.

Rescuer safety is of paramount importance in an avalanche rescue. Under no circumstance should a rescue party enter an avalanche area unless it is certain that the area is safe. If in doubt, consult with MSTs.

There are three (3) separate documents that make up the overall Avalanche Emergency Response Plan for an avalanche accident/incident:

1. **Avalanche Rescue Card** – for those involved in or witnessing an avalanche.
2. **Site Rescue Leader (Commander)** (cheat sheet) – for the site rescue leader.
3. **Emergency/Incident Response Plan** – for base/office personnel.

6.4.1 Avalanche Rescue Card

Immediate Action for Vehicle or Worksite

IF YOU ARE BURIED IN A VEHICLE, DO THE FOLLOWING:

1. Shut off the engine and lights.
2. DO NOT smoke.
3. CALL a “Code 1” three times on the radio.
4. Make sure your avalanche beacon is on.

5. Turn on your four-way flashers.
6. Honk briefly 2 to 3 times/minute.
7. If you are completely buried, try pushing a probe out of the snow.
8. Stay calm and wait to be rescued.
9. DO NOT GET OUT OF VEHICLE, ANOTHER AVALANCHE COULD COME DOWN.
10. WAIT FOR INSTRUCTIONS FROM THE MOUNTAIN SAFETY TECHNICIANS.

If you witness an avalanche accident, follow these steps:

1. Note the last seen point and number of people caught in avalanche.
2. Ensure personal and/or group safety.
3. CALL “Code 1” three times on the radio and initiate the Incident Response Plan.
4. Reference the Site Rescue Leader (Commander) (Cheat Sheet).
5. WAIT FOR INSTRUCTIONS FROM MOUNTAIN SAFETY.

6.4.2 Site Rescue Leader (Commander) (Cheat Sheet)

Guidelines contained in the Site Rescue Leader Cheat Sheet are shown in Figure 6.4-1.

6.4.3 Avalanche Emergency Response Plan

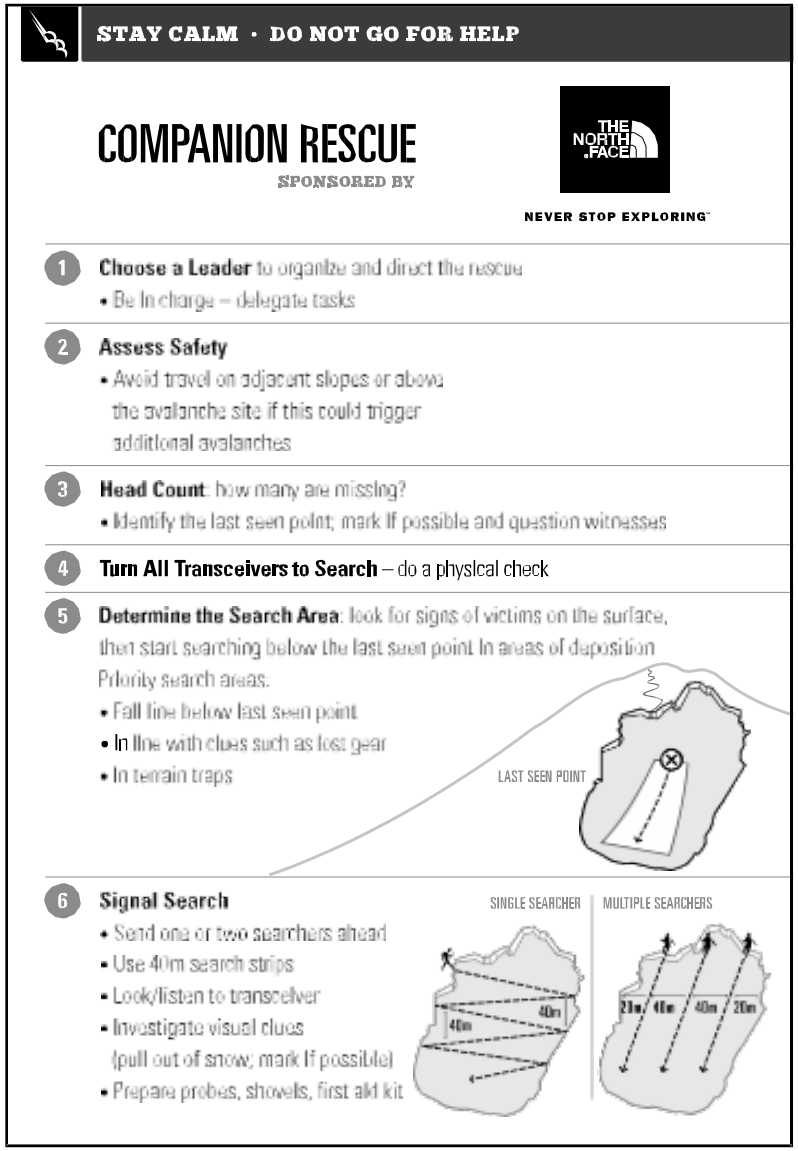
The Avalanche Emergency Response Plan has been developed for a Level 1, 2 or 3 incidents at the Brucejack Mine. The plan is based on the Incident Command System (ICS) structure. It is envisioned that on-site resources will complete the rescue in the first Operational Period (1 to 2 hours) dependent on size and location of incident.

In the event of a Code 1 avalanche being called, Emergency Response Teams (including Mountain Safety) will mobilize to the scene, the Fire Hall or be put on standby.

The Incident Management Team (IMT) will convene in the Incident Management Room (IMR) which is the boardroom in the Main Camp.

The IMT will define the Objectives, the Response Level and Strategies to be adopted as well as assigning resources to the rescue.

In the event of a large avalanche or an incident involving occupied buildings being damaged or destroyed, a Second Operational period would likely be required and the initial ICS structure expanded.



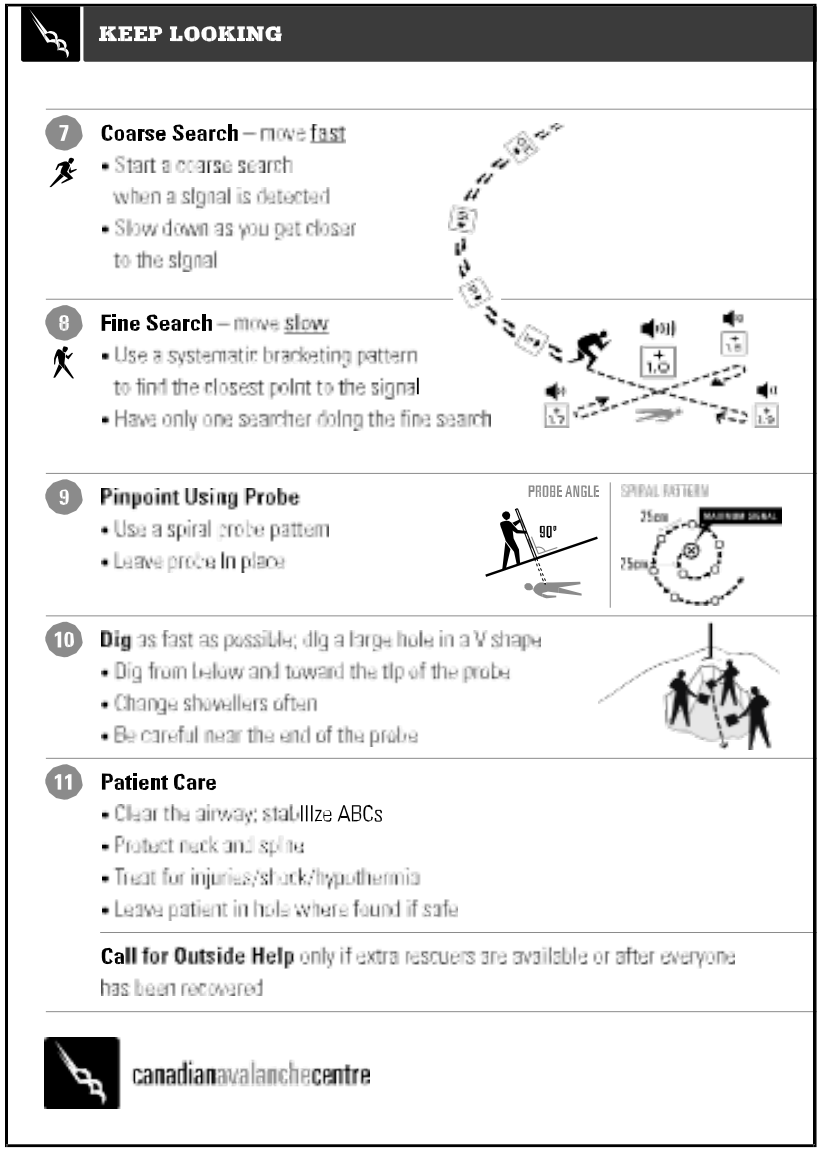


Figure 6.4-1. Site Rescue Leader Cheat Sheet

7 ON-SITE MINE RESCUE

7.1 MINE RESCUE EMERGENCY RESPONSE TRAINING

Pretium's underground contractor (Procon) has a fully developed underground MERP, that includes a fully trained mine rescue team equipped with all required emergency equipment, according to Part 3.7.1 of the HSRC, 2017. Pretium will continue to utilize the underground MERP and will develop and implement as well a surface MERP for the Brucejack Mine.

As per requirements of Parts 3.7.1 to 3.7.13 of the HSRC, 2017, the Brucejack Mine will have in place the appropriate mine rescue response capabilities. To this end several Pretium employees and contractors will be certified mine rescue personnel. They will meet the requirements of the Code and will have appropriate training.

The Mine Rescue Emergency Response Team will have qualified trainers, who will conduct classroom and field training/practice for not less than eight (8) hours in each three-month period of mine operations.

A training record/logbook is maintained on site. The surface/underground training programs will include both theory and practical training, in such things as:

- Mine Rescue Operations;
- Mine Gases – Recognition, Effects and Treatment;
- Oxygen Therapy;
- Gas-Detection Instruments;
- Fire Emergencies and Safe Firefighting Practices;
- Respiratory Protection Equipment Training;
- Mine Ventilation and Fire Suppression Underground;
- Emergency in Underground Mining Operations;
- Electrical Safety;
- Rescue Rigging;
- Rescue Operations, and
- Special Hazards of Winter Conditions.

7.2 UNDERGROUND MINE RESCUE EQUIPMENT INVENTORY

The Brucejack Mine will maintain the underground mine rescue equipment inventory shown in Table 7.2-1.

Table 7.2-1. Underground Mine Rescue Inventory

Description	Quantity	Part #
Dräger BG4's breathing apparatus	23	PSS BG4 PLUS
Ambulance – Miller Toyota	1	
BG4 oxygen bottles - spare (full)	34	B30230
BG4 filter mats (50)	3	4058167
BG4 ice molds	5	4056449
BG4 Tramix kit	1	R33777
BG4 dryer	1	R28305
Masterline Oxygen Booster Pump	1	
18 kg keg of Drägersorb	20	6737985
Filling stand for reusable canister	2	R33752
Dräger Tester RZ 7000	1	AG02690
Drager Quaestor 5000	1	
Airkem A-33 disinfectant	2	DIN 02035707
Klar-pilot anti fog	33	D40699
BC Level 3 first aid kit, soft case	1	EMFBC309
Basket stretcher	2	EMF34000
Spine board	2	EMF34100
Clam shell	1	
Set of spider straps	2	FOW770C
Adjustable hard collar	2	ABU000-281-000
Multipurpose splint	6	GEEM100
Gray utility blanket	14	SAFC125
50 ft canvas fire hose	4	ANG014909-1IF
200 ft Bag of 12 mm rescue rope	1	MSASRP504866SL200
100 ft Bag of 11 mm rescue rope	1	MSASRO544000100
30 m roll of 25 mm webbing	1	7901-RD
50 mm minding pulleys	4	610014
13 mm pulleys	4	610013
Scarab descender	2	NFPA128701
Full body harness	5	MLRRDT-TB/UBK
6 ft shock absorbing lanyard	5	DBI1240211C
Carabiners	25	NGSN263G
Mine rescue whistle	1	73-0646-0
8.5 x 11 clip board	2	97123
Scales	4	987-18-4

7.3 SURFACE MINE RESCUE EQUIPMENT INVENTORY

The Brucejack Mine maintains two sets of surface/crevasse rope rescue equipment. The first set is located in the Brucejack Mine Rescue Room (Table 7.3-1). The other set is located in the km 59 staging area shipping container (Table 7.3-2).

Table 7.3-1. Brucejack Surface/Crevasse Rescue Equipment Inventory-Brucejack Mine Rescue Room

Description	Quantity
70 L dry bag	1
60 m x 11 mm rope	1
Climbing harness (BD, large)	1
PSS 7000 SCBA	14
Petzl Bermuda Triangle evacuation sling	1
Camp helmet	1
Crampons	1
Petzl tikka headlamps	2
Picket	1
G3 steel probe (350 cm)	1
Edge protector	1
Ice screws	4
BD ascenders	2
ATC	1
MPD industrial device	1
Industrial pulley (1 single sheave, 1 double sheave)	1
Small pulley	1
Carabiners (non-locking)	4
Munter carabiners (locking)	2
Steel master link carabiner	1
SMC rigging plate	1
Locking carabiners	13
Yates sewn sling (yellow)	1
Bulk 1# tape sling material	2
7 mm prussic slings	4
8 mm prussic slings (long)	5
8 mm prussic slings (short/knotted or sewn)	4

Table 7.3-2. Knipple Staging Surface/Crevasse Rescue Equipment Inventory-KM 59 Staging

Description	Quantity
70 L dry bag	1
PSS 5000 SCBA	8
60 m x 11mm rope	1
Harness (medium)	1
Petzl Bermuda triangle evacuation sling	1
Camp helmet	1
Petzl Tikka headlamps	2
Picket	1
G3 steel probe (350cm)	1
Ice screws	4
BD ascenders	2
ATC	1
MPD industrial device	1
Industrial pulley (1 single sheave, 1 double sheave)	1
Small pulley	1
Carabiners (non-locking)	4
Munter carabiners (locking)	2
Steel master link carabiner	1
SMC rigging plate	1
Locking carabiners	12
Yates sewn sling (yellow)	1
Bulk 1# tape sling material	2
7 mm prussic slings	3
8 mm prussic slings (long)	5
8 mm prussic slings (short/knotted or sewn)	4

7.4 ACTIVATING THE MINE RESCUE MUTUAL AID PARTNERS

Pretium Brucejack Mine has a written agreement with mutual aid partners for on-site assistance, as needed. These partners are: New Gold based in Kamloops, BC, and Silvertip Mine located in northeast BC.

The decision to activate the mine rescue mutual aid partners shall be made in conjunction with the General Manager, the Mine Manager (or designate) and the Emergency Response Coordinator (ERC).

7.4.1 Standby Status

Once an emergency which has the potential need for mutual aid response is identified, Pretium's Mine Manager (or designate) or ERC will notify the mutual aid partner(s) to be prepared to respond.

Pretium's staff will begin evaluating transportation options and notifying Granmac Services and VIH Helicopters to standby and be ready to mobilize personnel, vehicles, and equipment.

Contact information for all mutual aid partners is included in the Emergency Contact List. The Mine Manager will notify the MEMLCI of this decision.

7.4.2 Activation Status

Once it is clear that additional assistance is required, the Mutual Aid Partners will be activated. At this time, Pretium staff will begin making transportation requirements. All mutual aid partners requested to help will start transporting personnel and equipment to site as directed by Pretium's staff.

The Mine Manager will notify the MEMLCI of this decision.

8 EARTHQUAKE RESPONSE

8.1 INTRODUCTION

The Brucejack Mine is located on the Pacific Rim and earthquakes of varying magnitudes are a possibility. An earthquake at site could affect:

- personnel safety;
- building structural integrity;
- fixed equipment integrity;
- waste dump stability;
- underground geotechnical conditions;
- avalanche slopes; and
- rock slope stability.

The following response protocols will be initiated in the event of a significant earthquake. For the purposes of this document a significant earthquake is an event during which buildings can be felt to sway or that will cause some noticeable damage.

8.2 INCIDENT MANAGEMENT

Depending on the severity of damage, the Mine Manager will decide if implementation of the Incident Command System is required.

8.3 PRIORITIES FOR RESPONSE

During or following an earthquake, the following actions will take priority:

- **Save Lives**: The preservation of life will be the top priority of managers and first responders and take precedence over any and all other considerations.
- **Diminish Suffering**: All possible efforts will be made to diminish suffering by providing basic human needs, including medical care, heated shelter, food, and water.
- **Protect Property:** All possible efforts will be made to protect Pretium and contractor property from further damage.
- **Protect the environment:** All possible efforts will be made to protect the environment from further damage. Protection of waterways will take priority.
- **Restore Basic Services: P**ower, heat, sanitation, and medical services will be restored as quickly as possible to enable the camp to function.

- **Restore Production:** Once the above items have been accomplished efforts to restore production will begin. Some production restoration items may be completed in parallel with the prior activities.

8.4 ROLES AND RESPONSIBILITIES

8.4.1 Brucejack Mine Site

In the event of an earthquake, the Mine Manager will be responsible for coordinating emergency medical response, environmental response, and facilities inspections. The various department heads will report to the Mine Manager.

8.4.2 Mine Manager

The Mine Manager will assign roles to the Incident Command system if necessary.

Once site conditions are assessed and response efforts are underway, the Mine Manager shall notify the senior management in the Vancouver and Smithers offices of the incident and any support required.

If damage or injuries fall under any immediately reportable category as defined by HSRC Section 1.7.1 and 1.7.3, the Mine Manager shall immediately report the incident to a BC MEMPR Inspector of Mines.

As soon as particle after the incident, the Mine Manager shall assign a qualified person to complete an incident report.

8.4.3 Access Road Manager

The Access Road Manager is responsible for coordinate response and doing inspections along the access road from km 0 to the base of the glacier. He is also responsible for coordinating response and inspections at Wildfire, Bowser, and Knipple Transfer Station camps.

8.4.3.1 Camp Inspections

Each Camp Manager shall be responsible for inspecting their camp's facilities in the event of a significant earthquake. All camp personnel shall report to their camp's muster location for roll call. Any personnel unaccounted for at the muster stations should be contracted on the radio. Searches will be completed for any personnel not accounted for during roll call.

The Camp Managers shall inspect or appoint a competent person to inspect the following items:

- **Propane tanks**: Propane supply valves should be shut off if it is safe to do so. They should not be turned on again until an inspection of the propane distribution system is completed.
- **Propane pipes**: The propane distribution pipes should be inspected for damage. If any rotten-egg smell from ethyl mercaptan in the propane is noted, the area should be evacuated and the propane supply isolated. Repairs to the propane piping shall be repaired and pressure tested by a qualified person prior to use.

- **Structural damage**: All buildings shall be inspected for damage to the structure or foundations. Damage should be documented so that repair planning can be implemented. The Mine Manager shall decide if damage is severe enough to require restrictions on building use.
- **Fuel stations**: All fuel storage areas shall be checked for damage. The inspection shall include the tanks, piping, and containment systems. If damage is noted to one or more tanks, efforts shall be made to immediately stop any leaks by plugging or transferring of fuel to another tank if possible. All spills shall be reported to the Environmental Manager. All spills over regulatory thresholds will be immediately reported to the Emergency Management BC.
- **Drinking Water Systems**: The drinking water system shall be inspected. Short term silting of the potable water system may be expected. If silting is sustained, bottled water should be used until confirmatory water analysis can be completed.

8.4.3.2 Road Conditions

The Access Road Manager shall inspect or appoint a qualified individual to do an inspection of the entire road. Areas of concern are:

- loose rock falling on the road;
- avalanches triggered by the earthquake;
- cracks in the road surface, particularly near the Bowser River and an elevated road surfaces; and
- cracks in any fill slopes above and below the road surface.

Any damage shall be reported to the Access Road Manager so that repairs can be planned. The Access Road Manager will determine if any road closures or restrictions are required.

8.4.3.3 Bridge Inspections

There are fifteen bridge along the access road between Hwy 37 and the Knipple Glacier. In the event of an earthquake, each of the bridges listed in Table 8.4-1 shall be inspected. The Access Road Manager shall inspect or appoint a competent person to perform a visual inspection of the bridge deck and footings prior to authorizing traffic over the bridges. If inspections show damage to the bridges, a qualified bridge engineer will be contacted to complete a formal inspection and make recommendations for repairs and any necessary load restrictions.

8.4.3.4 Airstrip Inspections

The Access Road Manager shall inspect or assign a competent person to inspect the airstrip. The runway and apron surfaces shall be inspected for any damage that would make it unsafe to land airplanes. The airstrip navigation lights and instrumentation shall also be checked for functionality.

If any airplanes are inbound at the time of an earthquake, the airstrip staff will attempt to divert the plane until an inspection of the runway surface can be completed.

Table 8.4-1. Access Road Bridges

Bridge	Road Kilometre	Notes
1	0.5	Bell Irving River
2	2.2	Wildfire Creek
3	4.3	
4	8.9	
5	12.6	
6	23.8	
7	30.6	
8	38	Scott Creek
9	40.3	
10	40.9	
11	46.9	
12	48.7	
13	49.7	
14	53.7	Knipple Causeway
15	53.9	Knipple Causeway

8.4.4 Emergency Response Staff

All paramedics, nurses, and OFA 3's shall call inform dispatch of their location and ability to respond to medical emergencies. All emergency response staff shall remain on standby until notified by dispatch that they may return to normal duties.

8.4.5 Dispatch

8.4.5.1 Roll Call

In the event of an emergency, the dispatcher shall report to the muster area with a copy of the current camp roster. The dispatcher shall confirm the presence of each individual by performing a roll call. Personnel unaccounted for at the muster station shall be contacted by radio. The mine tag board shall be checked to confirm which employees are underground. In the event that individuals are still not accounted for, the Mine Manager will be notified so that he may assign a person to perform a search.

8.4.5.2 Confirm Communications Systems Operational

The following communications procedures will take place following an earthquake:

- **Radio:** The Brucejack Mine Site dispatcher will verify radio functionality over all frequencies. If service is disrupted on a repeated channel, the Mine Manager will authorize helicopter mobilization so that the repeater(s) in question can be inspected.

- **Phone**: The IT department will verify phone system functionality. If service is disrupted, the satellite dish should be inspected for damage and alignment.
- **Internet**: The IT department will verify internet functionality. If service is disrupted, the satellite dish should be inspected for damage and alignment.

8.4.5.3 Notify Pretium Senior Management

At the Mine Manager's instruction or in the event the Mine Manager is unable, the Dispatcher shall attempt to contact Pretium's Senior Management Team in Smithers and Vancouver. Those contacts are listed in Appendix A-3.

8.4.6 Surface Foremen

In the event of a significant earthquake, the first duties for surface supervisors are as follows:

1. Recall all personnel and equipment from the Brucejack Lake waste rock dump site.
2. Conduct a roll call to confirm the location and wellbeing of their direct reports.
3. Check in with the dispatcher and Mine Manger.
4. Perform inspections of the following facilities:

- propane storage and distribution facilities;
- fuel storage and containment facilities;
- generators;
- waste rock dump;
- maintenance shops; and
- other active work areas.

8.4.7 Mine Superintendent

The Mine Superintendent is responsible for confirming the safety of all underground employees and the status of all underground workings and infrastructure. The Mine Superintendent will also coordinate any rescue or repair work required. The Mine Superintendent will report his findings and any updates to the Mine Manager. The Mine Superintendent will advise if Mine Rescue Teams should be placed on standby or if they can be assigned to assist with surface rescue needs.

8.4.8 Underground Shift Boss

In the event of an earthquake, the first priority for the Shift Boss is to account for the safety and whereabouts of his crews. Following that, he should report that status to the Mine Superintendent and standby for further instructions.

If a mine evacuation is warranted due to fire or other underground emergency, the Shift Boss will assign a person to guard the mine entrance against further entry. The Shift Boss will report to the mine tag in board to make sure all underground personnel are accounted for. Attempts shall be

made to contact any missing personnel by radio or by calling the mine refuge stations. If persons are still missing, the mine rescue team shall be assembled and prepared for an underground search. Once the mine has been evacuated no personnel shall enter the mine until authorized by the Mine Manager.

Once mine entry is authorized by the Mine Manager, all underground work areas shall be inspected for physical damage and adequacy of ventilation. The Shift Boss shall check and document gas readings in all headings prior to the Mine Manager authorizing re-entry.

In addition to active headings, the following infrastructure areas will be inspected for damage:

- Main fan;
- Mine heater and propane lines;
- Portal structures;
- Infrastructure areas;
- Refuge stations;
- Maintenance facilities;
- Crusher chamber;
- Fan Installations;
- Fuel storage bays;
- Substations;
- Conveyor declines;
- Explosives storage bays; and
- Active stope areas.

8.4.9 Mine Rescue Team

In the event of a significant earthquake, all members of the mine rescue team shall check in with the Mine Superintendent and standby for instructions.

8.4.10 Mill Manager

The Mill Manager shall inspect or appoint a competent person to inspect the mill facilities for damage to the process plant, paste backfill plant, mine water treatment plant, and tailings infrastructure.

8.4.11 Avalanche Technicians

In the event of a significant earthquake, the Mountain Safety Technicians (MSTs) should immediately call in to dispatch and report their availability to assist as needed.

The MSTs shall report current avalanche conditions to the Mine Manager and await his instructions in case inspections along the road are required. Depending on snow conditions, the MSTs may issue short-term closures or restrictions for certain sections of the mine, specially for Lake Shore Drive.

9 EMERGENCY CHECKLISTS AND REPORTING FORMS

As part of the revisions to this MERP, it is expected that Brucejack Mine management will develop and document critical information such as EOC location, EOC staffing and layout, building descriptions, personnel assets, transportation assets, communications assets, emergency equipment and supply assets, and medical staff and supplies. The revisions will also include current contact numbers, forms, site plans, and a controlled product inventory.

To ensure that appropriate information is gathered during a site emergency or during a first aid response, checklists will be developed for the Brucejack Mine. An example of an Incident reporting form is provided in Figure 9.1-1, the Brucejack evacuation map is provided in Figure 9.1-2, Figures 9.1-3 and 9.1-4 show the locations of primary and secondary muster stations for the main and upper camps, Figure 9.1-5 shows the layout of underground workings, and Figure 9.1-6 shows the underground evacuation.

In addition, Duty Cards are provided in the following sections:

- Section 10: Duty Cards for the Incident Management Team
- Section 11: Duty Cards for the Underground Incident Command Team Figure 9.1-1. Example Incident Reporting Form

Figure 9.1-1. Example Incident Reporting Form

This form needs to be completed before the end of the shift and sent directly to safety@Pretium.com					
Date:		Time:		Equipment Involved (if any):	
Supervisor:		Location (be specific):		Department/Contractor:	
Incident Category					NM - Near Miss High Potential
Injury/Illness		Property Damage		Other	
	FA – First Aid		PD – Property Damage		Loss of process
			FR – Fire		**DO** – Dangerous Occurrence

Occupation:		Task experience:	
Shift:	Day ☐ Night ☐	Regular schedule ☐	Overtime ☐

Description of the event: (What happened? How? What was the current task?)
IMMEDIATE CORRECTIVE ACTIONS TAKEN:
(Actions taken immediately to prevent re-occurrence, to make the scene safe for others)

Nature of material damage (if applicable):			
A. Was the workplace and/or equipment in good order?		Yes ☐	No ☐
B. Was the working method adequate (procedure respected)?		Yes ☐	No ☐
C. Was the employee trained to perform the task?		Yes ☐	No ☐
D. Did the employee wear the correct PPE to perform the task?		Yes ☐	No ☐
If you answered 'no' to any of the points A – D, explain the reason:			
For severity levels, refer to below chart of the incident report form			
Real severity:	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐	Potential severity:	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Is an A required?	Yes ☐ No ☐	(the supervisor is responsible for initiating the Analysis process)	

In order to determine the level of intervention, the following gravity codes have been established:

Classification of accidents/incidents:

Impact Category	Actual & Potential Impact Rating				
	1 – Low	**2 – Minor**	**3 – Moderate**	**4 – Major**	**5 Catastrophic**
Health and Safety	First Aid assessment only	First Aid Treatment	Lost Time Injury Restricted Work Medical Treatment	Serious injury, significant lost time > than two rotations	Permanent disability or fatality
Cost	> $50,000 > 1 hr. production delay	$50,000 - $250,000 1 - 4 hr. production delay	$250,000 - $1 Million 4 - 18 hr. production delay	$1 Million -$5 Million 18 hr. - 4 d production delay	> $5 Million > 4 d production delay

Incidents OR Potential of category 3, 4 or 5 must be incident analysis. Repeat incidents of category 2 or 1 that could have a higher severity level must also be investigated. The following table shows the times of investigation, analysis and report production.

Deadlines for the investigation, analysis, preparation and transmission of the investigation report:

Actual & Potential Impact Rating			
	4 or 5	**3**	**1&2**
Investigation	Immediately	Immediately	
Analysis and report production	Immediate verbal summary report max. 12h or less	Max. 72h	Potential is >3 completed 72h
Temporary corrective measure	Immediately	Immediately	Immediately
Permanent corrective action/preventative measure must be realized in:	3 days	5 days	5 Days

SPACE RESERVED FOR HEALTH & SAFETY DEPARTMENT					
		Nature of injury:			
		Nature of care:			
		Date:		Time:	
		Nurse:			
		Without injury		**With injury**	
		Material damage	☐	Reported:	☐
		Incident	☐	First aid:	☐
		Fire	☐	Medical aid:	☐
Front	Back			Restricted work:	☐
				Lost time:	☐

1. Must be submitted by end of shift

2. Supervisor must complete the D&A Post Incident Checklist.
3. If D&A test is recommended by supervisor, then Department Manager must approve test please consult with General Manager.
4. Complete an initial incident report and submit within Incident Severity Scale timeline.
5. Complete an incident analysis if the actual or potential impact is than 3, 4 and 5.
6. As per section 1.7.1, all dangerous occurrences listed in section 1.73 must be reported to the General Manager and JOHSC immediately.

Position	Print Name	Signature	Date
Worker			
Comments:			
JOHSC Rep.			
9.1 COMMENTS:			
Supervisor			
Comments:			
Safety Department			
9.2 COMMENTS:			
Departmental Manager			
Comments:			
If the Actual & Potential Impact Rating is a 3, 4 or 5 will require the following Signatures			

Position	Print Name	Signature	Date
Health & Safety Manager			
General Manager			

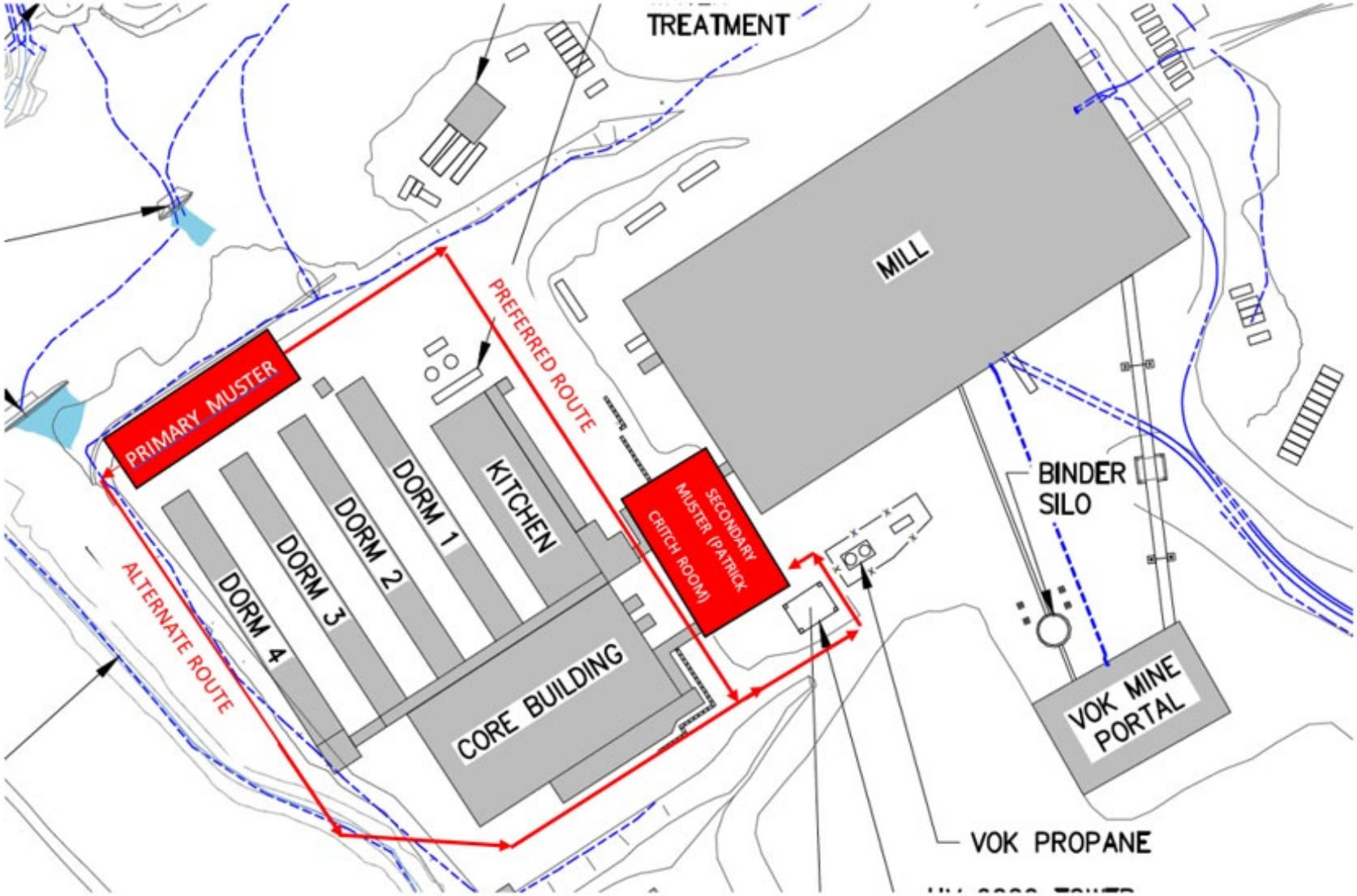


Figure 9.1-1. Brucejack Evacuation Map

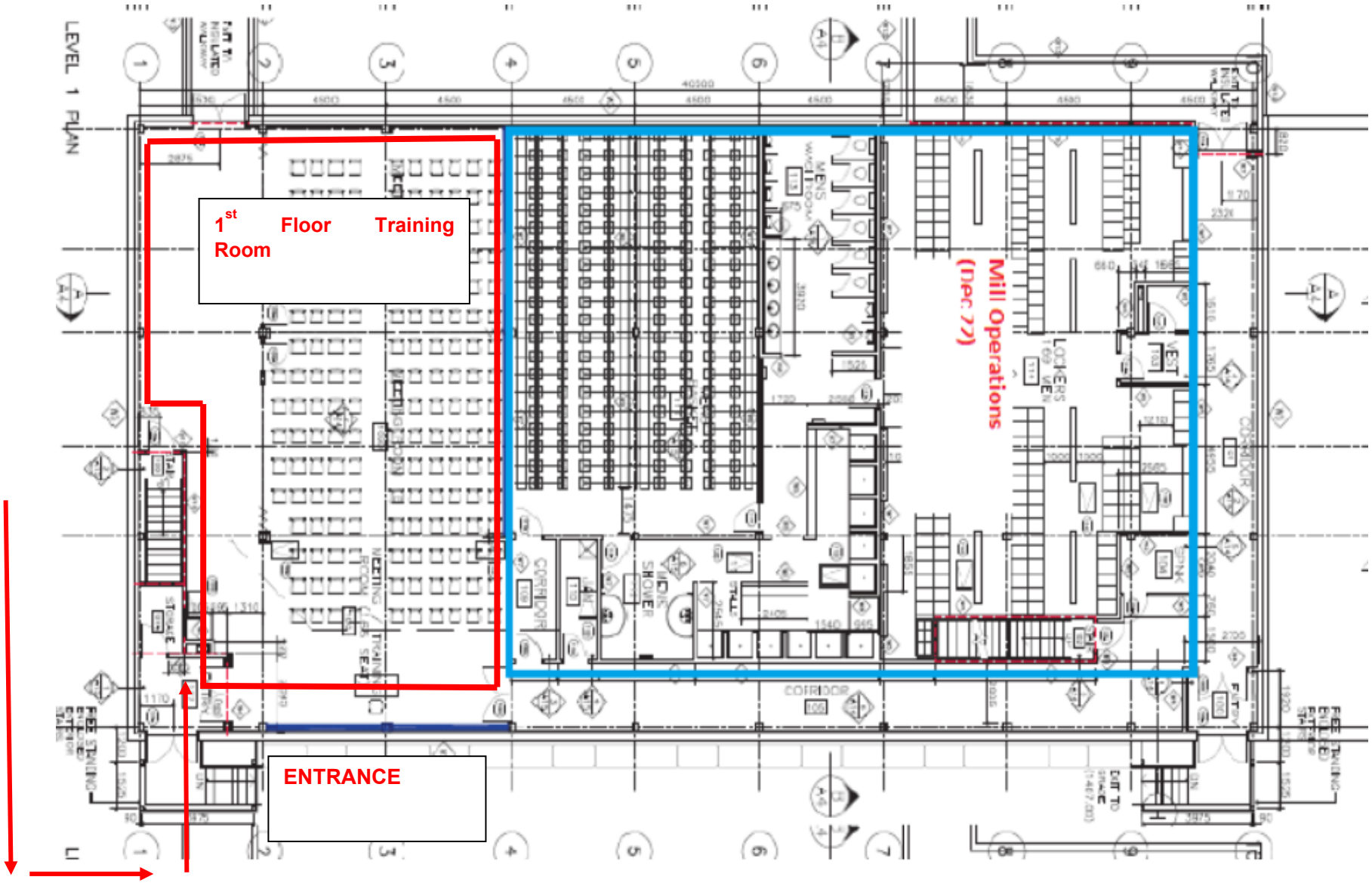


Figure 9.1-2. Secondary Muster Location. Mill Dry Floor Plan to get to Meeting Room – Secondary Muster Point – 1st floor meeting room

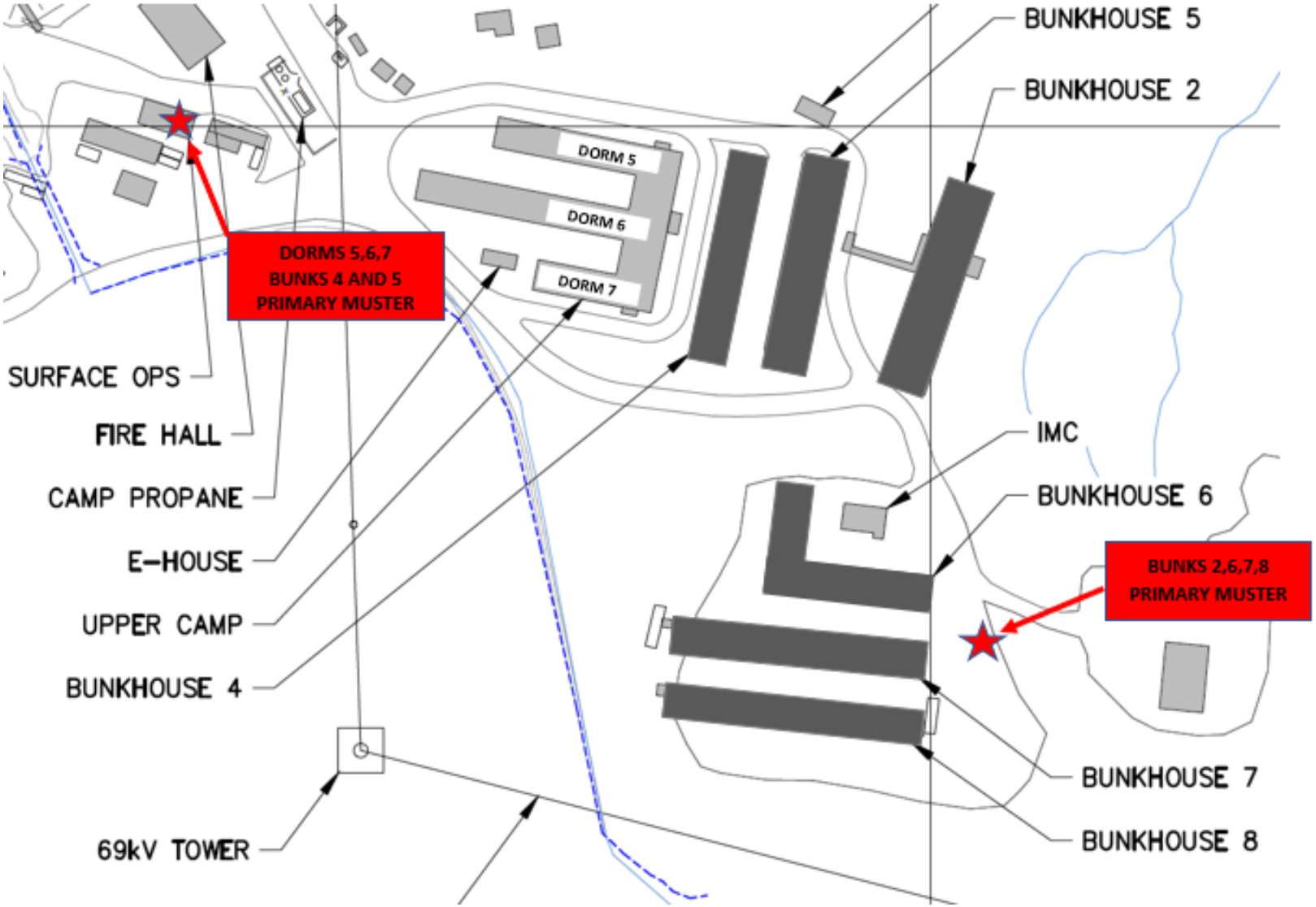


Figure 9.1-3 Primary Muster Station Upper Camp

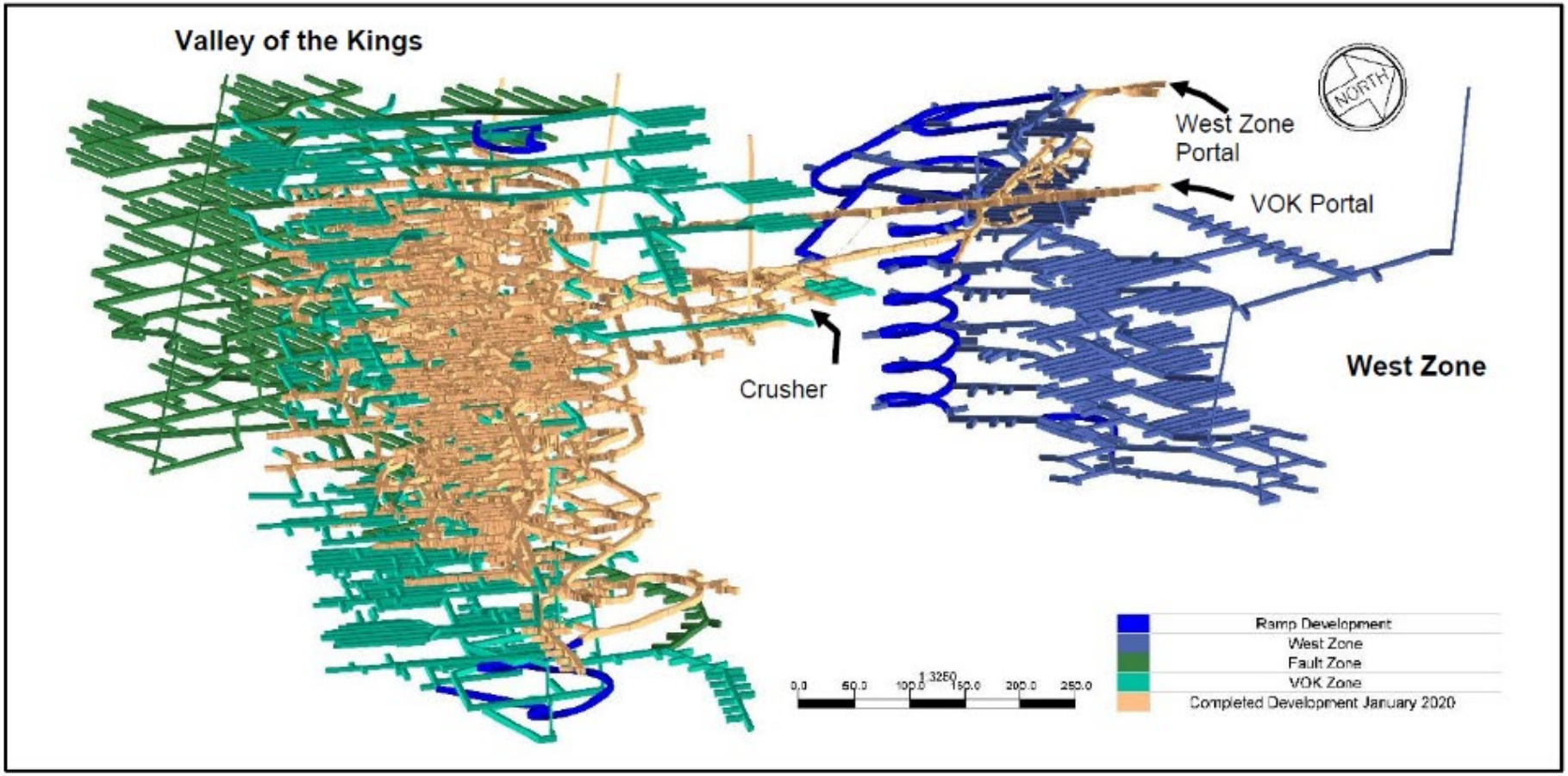


Figure 9.1-4. Layout of Underground

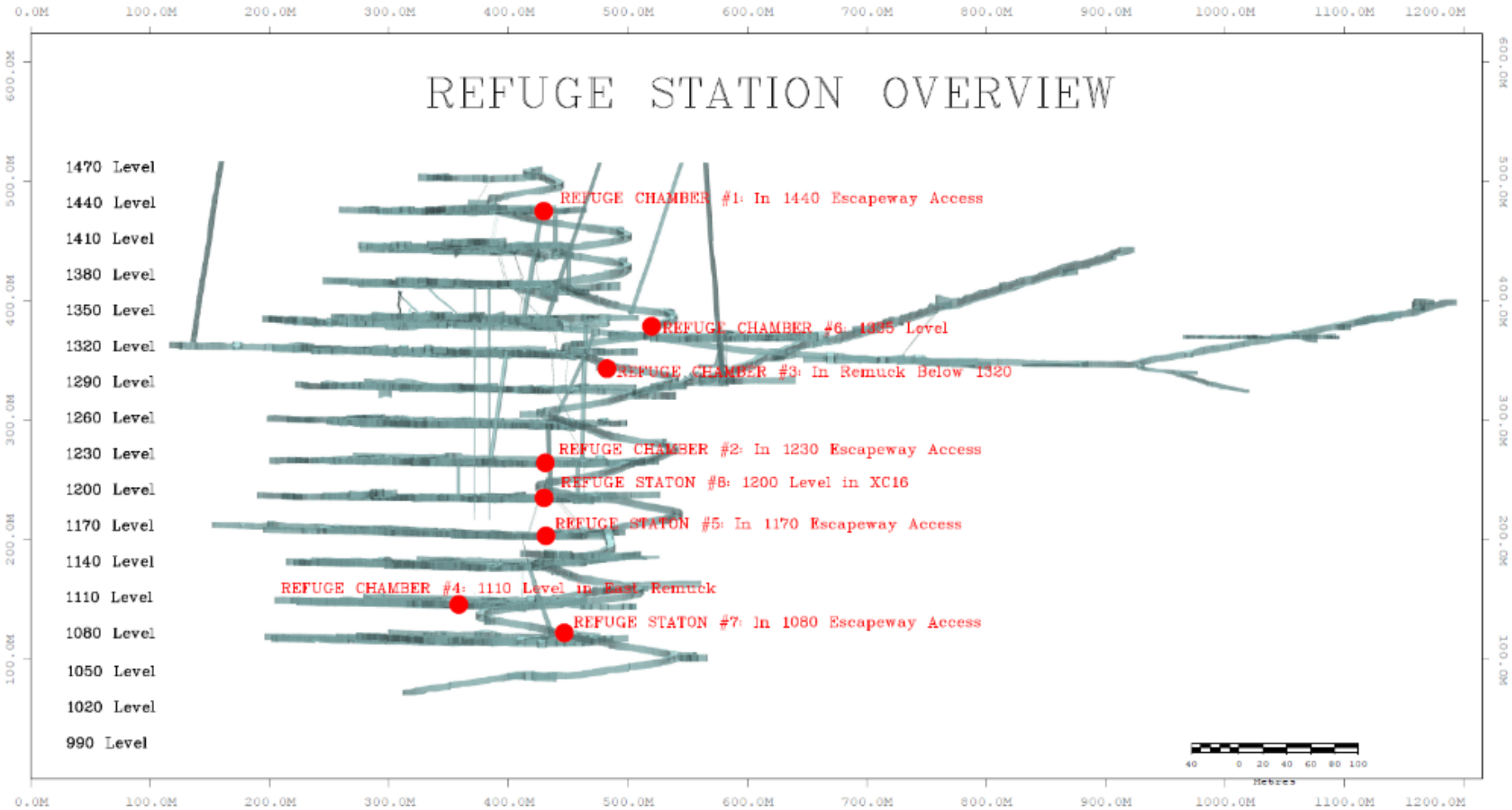


Figure 9.1-5. Underground Escapeway Plan

10 DUTY CARDS FOR THE INCIDENT MANAGEMENT TEAM

10.1 IMT LEADER

DUTY CARD 1 — IMT LEADER Reports to: Brucejack Mine President & CEO
Objective: The IMT Leader has overall responsibility for the management of the Incident Management Team (IMT). The IMT Leader leads and supervises the activities of IMT staff, develops objectives, approves plans and ensures that the response is carried out in a safe and legally sound manner. The IMT Leader interacts with appropriate government officials, the media, the community, and company management. The IMT Leader can delegate authority to IMT members to act on their behalf but retains the final responsibility for IMT response actions and decisions.
RESPONSIBILITIES
PRE-INCIDENT
☐ Ensure the operational readiness of the IMT; ☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Obtain a verbal briefing outlining the incident from the relevant manager and on-scene coordinator (if deployed); ☐ Start an individual log; ☐ Proceed to the IMR; ☐ Assess the level of the incident/issue using the Brucejack Mine Severity Table; ☐ Decide the level of IMT activation required to respond to the incident and activate the IMT if required via Dispatch ext 108; ☐ Authorize any additional resources or specialist advisors required; ☐ Obtain a current situation update on the incident; ☐ Confirm the IMT appointments required for the crisis; ☐ Conduct an initial team brief and detailed initial response priority to the IMT Managers; and, ☐ Ensure that relevant regulatory authorities are notified.
DURING INCIDENT
☐ Lead the IMT; ☐ Ensure the ERT are supported in their emergency response activities; ☐ Establish communications, exchange information and coordinate activities with other relevant response organisations (ERT, Emergency Services) and appropriate management personnel; ☐ Ensure that all necessary and required internal and external notifications have been made, ☐ Especially to government agencies and key stakeholders; ○ Doug Flynn Senior Inspector of mines (acting) - 1-250-847-7386 or 250-877-9747(cell) ○ Jacque Perron, President & CEO – 778-357-0809, 1-604-209-5456 cell ○ Patrick Godin, VP Operations & COO – 604-566-8784 ○ Sean Masse, General Manager – 250-202-2038 (140), 1 (604)754-9671 cell ☐ Manage the activities of the IMT and maintain overall control at the operational level. ☐ Ensure all IMT Group Managers are briefed and understand their individual and team responsibilities;

☐ Request additional specialist support if required; ☐ Regularly review the response by convening IMT update briefings at regular intervals; ☐ Oversee planning and set recovery and business resumption goals; ☐ Approve and authorise implementation of incident specific response and recovery plans; ☐ Monitor and control access to the IMR; ☐ Keep the President informed of the situation via regular situation reports; ☐ Remain aware of the communication strategy and be prepared to act as a media spokesperson; ☐ Authorise dissemination of press releases and statements to the public and media; ☐ Ensure active and on-going engagement with all relevant local stakeholders; ☐ Ensure all actions, decisions and events are accurately recorded and documented; ☐ Document all personal actions and decisions on an individual log; ☐ Decide when the crisis is over, inform IMT members; and, ☐ Communicate end of crisis response internally and externally.
POST-INCIDENT
☐ Oversee the conduct of an investigation; ☐ Review and approve the incident report; ☐ Allocate and supervise the implementation of the recovery plan; ☐ Chair the incident post-crisis review and ensure all lessons learned are recorded and implemented; ☐ Ensure all ERT and IMT members are debriefed and receive feedback; and, ☐ Debrief the IMT Deputy and IMT Group Managers and provide feedback;

10.2 DEPUTY IMT LEADER

DUTY CARD 2 — DEPUTY IMT LEADER Reports to: IMT Leader
Objective: The Deputy IMT Leader reports to the IMT Leader and is responsible for assisting the IMT Leader in managing the team's response to an incident. The Deputy IMT Leader assists in developing incident objectives, supervises the activities of the IMT Managers and manages set-up of the IMR. The Deputy IMT Leader conducts assessment meetings, oversees implementation of approved plans and ensures that safety of all responders is the highest priority. The Deputy IMT Leader assumes the responsibilities of the IMT Leader in their absence.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Confirm the arrival of all IMT members; ☐ Facilitate the initial team brief for the IMT Leader; ☐ Advise on the mobilisation of additional resources or specialist advisors required; ☐ Advise on the notification of the relevant Health Safety Environment Community (HSEC) related stakeholders; and, ☐ Draft relevant HSEC related reports for approval by the IMT Leader prior to releasing to external stakeholders.
DURING INCIDENT
☐ Understudy the IMT Leader; ☐ Ensure all IMT Control Group members are briefed and understand their individual responsibilities; ☐ Coordinate the activities of the IMT and manage work effort between groups as required; ☐ Facilitate regular IMT update briefings; ☐ Ensure regular situation reports are distributed to key stakeholders; ○ Doug Flynn Senior Inspector of mines (acting) - 1-250-847-7386 or 250-877-9747(cell) ○ Jacque Perron, President & CEO – 778-357-0809, 1-604-209-5456 cell ○ Patrick Godin, VP Operations & COO – 604-566-8784 ○ Sean Masse, General Manager – 250-202-2038 (140), 1 (604)754-9671 cell ☐ Assume the IMT Leader's role when he/she is unavailable; ☐ Supervise the activities of the IMT Group Managers, ensuring they act in a manner;

☐ Consistent with corporate policy and applicable government regulations and directives; ☐ Take the lead in the coordination, development and review of the response plan including: ☐ Coordinating of the plan and any sub-plans; ☐ Documenting response decisions; ☐ Consulting with specialist advisers and use of additional resources; ☐ Oversee the operation of the IMR, including status board updates and the flow of information; ☐ Keep the IMT Leader updated on the nature and status of the response operations; ☐ Check all correspondence drafted for release prior to approval by the IMT Leader; ☐ Remain aware of the communications strategy set by Brucejack Mine; ☐ Ensure regular liaison and reporting with Brucejack Mine employees; ☐ Ensure team rotations occur and back-up shifts are arranged for the ERT and IMT; ☐ Document all personal actions and decisions on an individual log; and, ☐ Ensure all ERT and IMT actions, decisions and events are recorded.
POST-INCIDENT
☐ Oversee post-crisis actions on behalf of the IMT Leader when required; ☐ Coordinate the incident post-crisis review; ☐ Debrief all Control Group members and provide them with feedback; and, ☐ Coordinate the development of the incident report.

10.3 IMT COORDINATOR

DUTY CARD 3 — IMT COORDINATOR Reports to: Deputy IMT Leader
Objective: The IMT Coordinator reports to the Deputy IMT Leader. This role is responsible for coordinating IMT preparation activities, overseeing the management of IMT information, and providing for the administrative requirements of the IMT.
RESPONSIBILITIES
PRE-INCIDENT
☐ Coordinate and attend all training activities organised for the IMT;
IMMEDIATE ACTIONS
☐ Proceed to the IMR; ☐ Start an individual log; ☐ Obtain a current situation update; ☐ Provide the IMT Leader with regular updates; ☐ Ensure the IMR is set-up as required; ☐ Ensure that the Log Keeper has commenced the IMT log; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Establish communications, exchange information and coordinate activities; ☐ Ensure the status boards are regularly updated by the Recorder; ☐ Assist the Log Keeper in maintaining a chronological log of events and make tape recordings as appropriate (pay special attention to times of significant activities and events); ☐ Ensure IMT members are present for briefs as required by the IMT Leader and Deputy; ☐ Ensure that any IMT member not able to attend a briefing session is updated with the relevant information; ☐ Manage the flow of hard copy information and retain copies for the permanent log; ☐ Provide administrative support to the IMT as required; ☐ Regularly collate the notes (logs) from other IMT groups into the IMT log; ☐ Collate all documentation for follow-up investigation, compensation, insurance and litigation purposes; ☐ Provide administrative, IT and catering support to the IMT; ☐ Monitor health, fatigue, morale and stress levels of the group and advise the Deputy as required; and, ☐ Document all personal actions and decisions on an individual log sheet.
POST-INCIDENT
☐ Participate in the post-crisis review; ☐ Contribute to the development of the incident report; ☐ Evaluate the effectiveness of the IMR during the response and implement any necessary changes to the room or associated procedures.

10.4 OPERATIONS MANAGER

DUTY CARD 4 — OPERATIONS MANAGER Reports to: IMT Leader
Objective: The Operations Manager reports to the IMT Leader and manages operations directly related to the IMT's field response. He/she activates, organises, assigns and directs all resources and activities in the field. He/she implements all operational plans to achieve the response objectives and protect people, the environment and property. He/she communicates frequently with the IMT Leader and Deputy IMT Leader to keep them updated on the progress of response operations.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT and the Operations Group.
IMMEDIATE ACTIONS
☐ Proceed to the IMR; ☐ Obtain all available information on the situation from the ERT, Dispatch, Underground Command Centre and/or Medical Clinic; ☐ Start an Individual log; ☐ Recommend to the IMT Leader the incident categorisation and the level of response required; ☐ Mobilise any additional resources or specialist advisors immediately required to assist with the crisis; ☐ Activate initial personnel required in the Operations Group; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Manage the activities of the Operations Group (including shift rosters); ☐ Ensure communications are maintained with the ERT; ☐ Ensure all Operations Group members are briefed and understand their individual and team responsibilities, and assess the need for additional specialist support; ☐ Attend IMT briefs and keep the IMT informed of progress on resolving the issue; ☐ Oversee and monitor the ERT response; ☐ Support the ERT; ☐ Ensure the Incident Dispatch and/or Medical Team are kept informed of the IMT response; ☐ Manage the development of the Response Plan; ☐ Manage the implementation of the Response Plan; ☐ Contribute to IMT situation reports; ☐ Allocate tasks to Operations Group members; ☐ Ensure that the Operations Group and the ERT are aware of and are following applicable Brucejack Mine policies and government agency directives; ☐ Document all personal actions, decisions and instructions on an individual log sheet; and ☐ Ensure all group actions, decisions, instructions and events are accurately recorded and documented in the IMT Log.
POST-INCIDENT

- Inform the ERT and Operations Group members when the crisis is over;
- Identify any group follow-on actions required and allocate responsibilities, resources and deadlines;
- Conduct Operations Group incident review and consolidate group feedback points;
- Attend the ERT debrief;
- Attend the post-crisis review;
- Debrief all Operations Group members and provide feedback; and,
- Contribute to the incident report.

10.5 RECORDER

DUTY CARD 5 — Recorder Reports to: Deputy IMT Leader
Objective: The Recorder reports to the Deputy IMT Leader and is responsible for updating the status boards, managing and equipping the Incident Management Room and providing for administrative requirements of the IMT.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; ☐ Ensure status boards, charts, maps and other tools/aids are readily available; ☐ Remain familiar with your responsibilities within the IMT; ☐ Confirm that there are sufficient quantities of consumables available for the IMT; and, ☐ Understand where the Incident Management Room equipment is stored and its use.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the Incident Management Room; ☐ Assist the IMT Coordinator in the set-up of the Incident Management Room; ☐ Start an Individual Log; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Record key incident information on the status boards; ☐ Manage the flow of hard copy information and retain copies for the permanent log; ☐ Assist the Log Keeper with the IMT Log as required; ☐ Alert other IMT members to major changes, issues and outstanding actions; ☐ Take digital photos of status boards before they are updated; ☐ Proactively monitor all communications and record pertinent points as they arise; and, ☐ Document all personal actions and decisions in an Individual Log.
POST-INCIDENT
☐ Assist with the collection and filing of all documentation from all groups; ☐ Ensure allocated post-crisis follow-up actions are completed; ☐ Participate in the IMT post-crisis review; ☐ Assist with refurbishing the IMR back to a ‘ready’ state; and, ☐ Assist the incident investigation as required.

10.6 LOG KEEPER

DUTY CARD 6 — Log Keeper Reports to: Deputy IMT Leader
Objective: The Log Keeper reports to the Deputy IMT Leader and is responsible for maintaining an accurate, up-to-date record of the decisions and actions of the IMT.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; ☐ Remain familiar with your responsibilities within the IMT; ☐ Understand where the Incident Management Room equipment is stored and its use; and, ☐ Assist the Recorder in maintaining the readiness of the Incident Management Room.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the Incident Management Room; ☐ Assist the IMT Coordinator in the set-up of the Incident Management Room; ☐ Start an individual log; ☐ Start the IMT log; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Assist the Recorder with updating the status boards; ☐ Request additional Log Keeper support as required; ☐ Maintain a chronological log of events and make tape recordings as appropriate (pay special attention to times of significant activities and events); ☐ Manage the flow of hard copy information and retain copies for the permanent log; ☐ Collect and retain a copy of all relevant IMT documents and incorporate into the incident log; ☐ Regularly collate the notes (logs) from other IMT groups into the IMT log; ☐ Remind the Deputy IMT Leader of outstanding issues or actions from the log; and, ☐ Proactively monitor all communications and record pertinent points as they arise.
POST-INCIDENT
☐ Assist with the collection and filing of all documentation from all groups; ☐ Ensure allocated post-crisis follow-up actions are completed; ☐ Participate in the IMT post-crisis review; ☐ Contribute to the development of the incident report; ☐ Assist with refurbishing the Incident Management Room back to a ‘ready’ state; and, ☐ Assist the incident investigation as required.

10.7 PLANNING MANAGER

DUTY CARD 7 — PLANNING MANAGER Reports to: IMT Leader
Objective: The Planning Manager reports to the Deputy IMT Leader and manages IMT related planning for the detailed recovery and resumption of normal operations. He/she oversees preparation of the Recovery Plan and assists in the development of other specialist plans, if required.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT and the Planning Group.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Attend the IMT initial briefing; ☐ Confirm the level of activation of the Planning Group in consultation with the IMT Leader; and, ☐ Mobilise any additional resources or specialist advisors required for the Planning Group.
DURING INCIDENT
☐ Manage the activities of the Planning Group; ☐ Ensure all Planning Group members are briefed and understand their individual and team Responsibilities; ☐ Ensure that the response plan and the recovery plan flow logically and are coordinated; ☐ Attend IMT briefs and keep the IMT informed of progress on the recovery plan; ☐ Manage the business continuity response including the implementation of workarounds; ☐ Lead the development of the business recovery plan and manage its implementation; ☐ Consult with specialist advisers (if required) for their input into the recovery plan (Maintenance, engineering, etc.); ☐ Contribute to the IMT Update Meetings; ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Ensure all group actions, decisions and events are accurately recorded and documented, and recorded in the IMT Log.
POST-INCIDENT
☐ Inform Planning Group members when the crisis is over; ☐ Identify any group follow-up actions required and allocate responsibilities and deadlines; ☐ Conduct Planning Group post-crisis review and record outcomes; ☐ Attend the incident post-crisis review; ☐ Debrief all Planning Group members and provide feedback; and, ☐ Contribute to the incident report.

10.8 SURFACE OPERATIONS SUPERVISOR

DUTY CARD 8 — SURFACE OPERATIONS SUPERVISOR Reports to: IMT Leader
Objective: The Surface operations supervisor reports to the IMT Leader and manages IMT related-support and service activities for the response. He/she is responsible for obtaining personnel, equipment, facilities and material needed to carry out response operations. He/she provides food, shelter, transportation, facilities, security, communications and other necessities for response personnel who are located both in the field and at the IMR. The Surface operations supervisor is to ensure that internal and external service needs are met.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT and the Logistics Group.
IMMEDIATE ACTIONS
☐ Respond to IMT activation ☐ Proceed to the IMR; ☐ Activate initial personnel required for Dispatch upon activation of the IMT ☐ Start an individual log ☐ Attend the IMT initial briefing ☐ Mobilize any additional resources or specialist advisors required for Dispatch; and, ☐ Conduct an initial group briefing.
DURING INCIDENT
☐ Manage the activities of Dispatch; ☐ Ensure Dispatch has been briefed and understand their individual and team responsibilities, and assess the need for additional specialist support; ☐ Identify the location and status of off-site equipment and personnel suitable to deal with the issue and coordinate their deployment as required; ☐ Liaise with the Operations Manager to provide transport and care/accommodation for employees and relatives if necessary. ☐ Ensure an overall inventory is maintained of all equipment, materials and supplies purchased, rented, borrowed or otherwise obtained; ☐ Inform the IMT Leader of logistical movements (include names and locations); ☐ Develop a resource plan in support of the response plan to: ○ Prioritize needs; ○ Identify alternative resources and supplies; ○ Coordinate delivery/deployment; ☐ Attend IMT briefings and keep the IMT informed on the actions of Dispatch; ☐ Contribute to the development of the response plan; ☐ Contribute to the development of the recovery plan;

☐ Contribute to the IMT situation reports; ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Ensure group actions, decisions and events are accurately documented, are recorded in the IMT Log.
POST-INCIDENT
☐ Inform Dispatch when the crisis is over; ☐ Identify any group follow-up actions required and allocate responsibilities and deadlines; ☐ Conduct Dispatch post-crisis review and record outcomes; ☐ Attend the incident post-crisis review; ☐ Debrief Dispatch and provide feedback; and, ☐ Contribute to the incident report.

10.9 HUMAN RESOURCES OFFICER

DUTY CARD 9 — HUMAN RESOURCES OFFICER Reports to: External IMT Coordinator
Objectives: The Human Resources Officer identifies and tracks all personnel involved in the incident. He/she coordinates and provides feedback to employees, ensures that consistent messages are conveyed to all concerned, and provides counselling services as required.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Participate in the initial group briefing.
DURING INCIDENT
☐ Work with Operations Group to establish the facts relating to casualties/numbers/severity of injuries/location etc.; ☐ Track casualties progress and inform the Family Liaison Officer; ☐ Ensure that Casualty Board is kept up to date; ☐ Verify any discrepancies relating to casualties; ☐ Provide advice to the IMT on ○ Employee relations; ○ Industrial relations; ○ Company HR Policy; ☐ Ensure that appropriate resources are available. Consider alerting all employers of personnel working at the site and/or within the asset/operation; ☐ Consider arrangements for handling / assisting employees, contractors, next-of-kin and public affected by the emergency; ☐ Ensure that appropriate systems are in place for managing Human Resource issues; ☐ Arrange grief counselling where needed for employees and families; ☐ Verify and maintain a record of location and status of persons involved in the incident; ☐ Verify details of fatalities, casualties, missing people and survivors; ☐ Arrange survivor reception and support for evacuees; ☐ Liaise with the Family Liaison Officer and External Affairs Officer to provide verified facts on the situation; ☐ Establish the Next-of-Kin room with the Family Liaison Officer; ☐ Work with External Affairs to draft internal messages and site notices; and, ☐ Document all personal actions and decisions on an individual log sheet.
POST-INCIDENT
☐ Complete any follow-up actions as directed; ☐ Contribute to the dispatch post-crisis review; and, ☐ Contribute to the incident report.

10.10 External Affairs Officer

DUTY CARD 10 — EXTERNAL AFFAIRS OFFICER Reports to: External IMT Coordinator
Objectives: The IMT External Affairs Officer reports to the External IMT Coordinator and manages IMT-related media and community issues for the response. He/she compiles and releases information on the incident and response efforts to the media and organises IMT press conferences and briefings. He/she works closely with the Family Liaison Officer to develop a community and stakeholder response strategy and arranges community outreach programs.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and,
IMMEDIATE ACTIONS
☐ Proceed to the IMR and set-up for operations; ☐ Start an individual log; ☐ Attend the IMT initial briefing; and, ☐ Advise the IMT Leader on potential community and media-related issues.
DURING INCIDENT
☐ In conjunction with the Investor Relations Spokesperson, determine the media strategy to be adopted for the incident and who will handle various aspects of the company's external affairs effort; ☐ Serve as the principal advisor to the IMT Leader regarding interactions with the media and advise him of any pressing media issues, concerns, or problems; ☐ Manage the Media Response Team (MRT); ☐ Establish a media briefing room onsite; ☐ Prepare and disseminate media holding statements, press releases and "fact sheets" for approval by the IMT Leader, as appropriate; ☐ Ensure proper and complete distribution of all approved press releases and fact sheets; ☐ Assist the IMT Leader in preparing for press conferences and interviews; ☐ Pass on all press releases as soon as possible to the IMT Leader; ☐ As appropriate, arrange and manage tours for the media, provided that they do not jeopardise personal safety or inhibit operations; ☐ Be available to respond to inquiries from the media; ☐ Monitor and maintain a record of media and internet coverage of the incident; and, ☐ Prior to demobilisation, ensure that all media, government relations and community issues and concerns have been resolved; Work with the Team Leader, Community Development to ☐ Identify community concerns and key issues; ☐ Identify community stakeholders and determine the best way to communicate with the community ☐ Develop a community management plan, if appropriate;

- Determine the optimum timing for and arrange and manage, community and "Town Hall" meetings;
- Determine whether additional community coordination personnel are needed, and if so, coordinate their activation and supervise their activities;
- Work closely and coordinate activities with the Family Liaison Officer;
- Assess the impact of the incident on the community, including:
- Duration;
- Health and safety issues;
- Impacts on housing and accommodations and the need for shelters;
- Disruptions to utilities and services such as electricity, water, heat, gas, transportation, sewage, etc.;
- Impacts on schools, hospitals, businesses and other institutions; and
- Other issues or causes for concern.
- Serve as the principal advisor to the IMT Leader regarding interactions with the community and advise him/her of concerning pressing issues or problems;
- Assist the IMT Leader or other IMT personnel in preparing for community meetings;
- Be the principal point of contact for the community;
- Attend IMT briefs and keep the IMT informed of community issues;
- Ensure the response plan and the recovery plan adequately considers community issues;
- Establish and maintain contact with relevant community groups;
- Assist the Services Coordinator with drafting internal messaging and site notices;
- Document all personal actions and decisions on an individual log sheet; and,
- Other duties as directed by the External IMT Coordinator.

POST-INCIDENT

- Complete any follow-up actions as directed;
- Contribute to the Dispatch post-crisis review;
- Attend the incident post-crisis review and ensure community issues are captured;
- Work with the Team Leader, Community Development to:
  - Ensure that all community-related concerns have been addressed and the best possible relations with the community are maintained;
  - Continue to monitor community attitudes concerning the incident and keep management advised of any which may have a substantial impact on the company or its operations;
  - Evaluate effectiveness of the community outreach program during the response and make appropriate modifications to IMT strategies and plans; and,
- Contribute to the incident report as required.

10.11 Family Liaison Officer

DUTY CARD 11 — FAMILY LIAISON OFFICER Reports to: External IMT Coordinator
Objectives: To provide support to the employee's family and friends during the incident. The Family Liaison Officer is to be the main point of contact for next-of-kin and friends and works closely with the Human Resources Officer and External Affairs Officer in gaining the latest information on the incident to be passed to the families.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Prepare for the initial briefing.
DURING INCIDENT
☐ If applicable, manage the Next-of-kin support Team ☐ Work with the IMT in communicating factual personnel information on the incident: ○ Pass on casualty/fatality list (including next-of-kin details); ○ Identify other stakeholders and ensure close liaison; ○ Provide liaison with Police and any incident investigation teams; ○ Determine the nature, tone and format of communication with employees and families; ○ Conduct post-incident debriefing as soon as possible; ○ Arrange transportation for families; ○ Plan accommodations; ○ Consider need for cash / clothing / communications with families etc.; and ☐ Establish call schedules as appropriate. ☐ Facilitate visits to hospitals by relatives, as requested by IMT; ☐ Provide support for families. Consider: ○ Transportation to hospital / point of arrival; ○ Childcare; ○ Accommodation; ○ Passport / Visa issues; ○ Financial Support; ○ Counselling support; ○ Reassurance, as appropriate. ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Other duties as directed by the External IMT Coordinator.
POST-INCIDENT
☐ Complete any follow-up actions as directed; ☐ Contribute to Dispatch post-crisis review; and ☐ Contribute to the incident report as required.

10.12 Dispatch and Aviation

DUTY CARD 12 — Dispatch/Aviation Reports to: IMT Leader
Objective: The Dispatch/Aviation reports to the IMT Leader and manages IMT related support and service activities for the response. He/she provides and coordinates radio communications and other necessities for ground/air transportation in the field and at the IMR. Dispatch/Aviation is to ensure that internal and external service needs are met.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Respond to IMT activation ☐ Activate initial personnel required for dispatch upon activation of the IMT ☐ Contact and assist in mobilizing additional resources or specialist advisors ☐ Start an individual log ☐ Attend the IMT initial briefing
DURING INCIDENT
☐ Identify the location and status of off-site equipment and personnel suitable to deal with the issue and coordinate their deployment as required; ☐ Liaise with the Operations Manager to provide transport and care/accommodation for employees and relatives if necessary. **Medivac will be arranged by Iridia Personnel with the assistance of Dispatch.** ☐ Inform the IMT Leader of logistical movements (include names and locations); ☐ Develop a resource plan in support of the response plan to: ○ Prioritise needs; ○ Identify alternative resources and supplies; ○ Coordinate delivery/deployment; ☐ Attend IMT briefings and keep the IMT informed on the actions of Dispatch/Aviation; ☐ Contribute to the development of the response plan; ☐ Contribute to the development of the recovery plan; ☐ Contribute to the IMT situation reports; ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Ensure group actions, decisions and events are accurately documented, and recorded in the IMT Log.
POST-INCIDENT
☐ Identify any group follow-on actions required and allocate responsibilities and deadlines; ☐ Attend the incident post-crisis review; ☐ Contribute to the incident report.

11 DUTY CARDS FOR THE UNDERGROUND INCIDENT COMMAND TEAM

11.1 INCIDENT COMMAND DUTY CARD

INCIDENT COMMANDER - **Checklist**		
☐	1)	In the event that there is an Underground CODE 1 **fire** emergency, it is critical that the Underground Emergency warning system is activated without delay, and that the accounting for personnel begins. These Three Actions must be taken FIRST before the Underground Incident Command Team musters: • Ensure the Main fan (WZ and VOK) Stench Gas has been released: • Only if required, have the electricians manually release the stench in the compressed airlines • Ensure Code One was called on all channels (Dispatch is responsible for this action); • Secure the UG tag-in board by placing a guard at the board. Non-fire emergencies require Code One call, and radio message to clear the ramp to the scene.
☐	2)	Ensure the Underground Incident Command Team positions are fulfilled: Operations Coordinator; Engineering Coordinator; Maintenance Coordinator; and Recorders. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444

☐	3)	Obtain a verbal briefing outlining the incident from the relevant Underground Team Captain and/or ERT Advisor (ext 444 Fire Hall).
☐	4)	Conduct an initial team brief and detail initial response priorities to the Underground Incident Command Team.
☐	5)	Start an individual log, document all personal actions and decisions. Ensure the Recorder has posted the status boards and is recording relevant information.
☐	6)	If the fire is in a heading with charged explosives (Operations Coordinator will confirm) and communicate this with the ERT Coordinator. The ERT Coordinator will instruct the ERT not to fight the fire.
☐	7)	In consultation with ERT Coordinator decide on a response plan for the Mine Rescue Team and whether or not to activate the Incident Management Team. Ventilation cannot be changed until the mine manager has approved changes and all personnel are accounted for. As well, everyone must be made aware of the ventilation change.
☐	8)	Determine staging areas for the extra people and traffic that are in the area effected by the code one.
☐	9)	Follow up and monitor assigned responsibilities.
☐	10)	Consult with ERT Coordinator and Mechanical Supervisor to determine if a mechanical inspection of any mobile equipment involved is required prior to calling the Code One over.
☐	11)	In consultation with the ERT Coordinator, decide when the incident is over. The ERT Coordinator will make arrangements for the “Code One Over” message to be relayed and broadcast. Dispatch will receive confirmation from the Incident Commander prior to broadcasting “Code one over”
☐	12)	Ensure all relevant information is entered in Incident Commander Log sheet.
☐	13)	At the conclusion of the incident, sign the Incident Commander log sheets.
Post Incident - **Checklist**		
☐	1)	Ensure the ERT Coordinator replenishes the Duty Card Packets.
☐	2)	Debrief the Underground Incident Command Team and provide feedback.
☐	3)	Confirm recommended changes to the Underground Incident Command Manual and other relevant documents have been completed (ERT Coordinator is responsible).

11.2 ERT COORDINATOR DUTY CARD

ERT Coordinator - Checklist		
☐	1)	Coordinate with Incident Commander and Underground Incident Command Team to plan the Mine Rescue Teams actions while underground. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	Brief Mine Rescue Team 1 on incident and plan of action. When Team 2 is travelling to Underground, Team 1 will get under air. Once Team 2 enters the Underground surface building, Team 1 can commence with their rescue operation.
☐	3)	Record all actions and orders given to Mine Rescue Team in your action log. Record the time Team 1 enters the underground in the ERT Coordinator Logbook (Approximately 1 bar for every 1-minute Underground with the BG4). Check in every 15mins and record all air supply levels of the team.
☐	4)	Maintain contact with Mine Rescue Team while underground and provide direction as required. Always follow the Mine Rescue Principals in order: Safety of the team; Safety of the trapped/injured; Protection of mine property; Rehabilitation of mine property.
☐	5)	Consult with Incident Commander and Mechanical Supervisor to determine if a mechanical inspection is required prior to calling the Code One over.
☐	6)	Check with Incident Command on areas underground where pre-loading of emulsion explosives are located. **NOTE: Under no circumstances will the Mine Rescue Team fight fires in a heading with charged explosives**
☐	7)	Contact Incident Command to relay 'The Code One is over' once the final Team is finished.
☐	8)	Replenish incident command cards
Post Incident- Checklist		
☐	1)	Debrief with ERT members at the Fire Hall.
☐	2)	Follow-up with Incident Commander and Engineering Coordinator on the Underground Incident Command Team debrief. Gather notes and action items.

11.3 ERT ADVISOR DUTY CARD

ERT Advisor - Checklist		
☐	1)	Gather cap lamps, tag-in cards, and W65's for incoming teams.
☐	2)	Report to Dispatch (108) or ADMIN CH 1 (ERT CHANNEL) when ERT arrives at the Fire Hall (both Team 1 and 2).
☐	3)	Brief Mine Rescue Team 1 on incident and plan of action. When Team 2 is travelling to Underground, Team 1 will get under air. Once Team 2 enters the Underground surface building, Team 1 can commence with their rescue operation.
☐	4)	Contact ERT Coordinator via Channel 1 (ERT Channel) <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
Post Incident- Checklist		
☐	1)	Debrief with ERT members at the Fire Hall.
☐	2)	Follow-up with Incident Commander and Engineering Coordinator on the Underground Incident Command Team debrief. Gather notes and action items.
☐	3)	Collect all information from rescue and make any necessary changes to procedure.

11.4 OPERATIONS COORDINATOR DUTY CARD

Operations Coordinator - Checklist		
☐	1)	Record all relevant information in the Operations Coordinator log sheet.

☐	2)	Oversee all immediate needs of the Incident Commander.
☐	3)	Assign the following responsibilities: Check-in Coordinator – Name: Mine Entrance Guards – Names: West Zone portal guard: VOK portal guard: Office Entrance Guard(security) – Name: Door guard: Transportation Coordinator (not required unless operation is extensive) Transportation Coordinator name:
☐	4)	Confirm with ERT Coordinator to ensure the Underground Mine Rescue Team has been notified and all necessary radio calls have been made.
☐	5)	If applicable, barricade or post guards at the incident area to prevent any unauthorized access and remove all non-essential personnel.
☐	6)	Brief and keep the Incident Commander informed. This communication must include any area that has the potential for explosives.
☐	7)	Monitor assigned responsibilities.
☐	8)	Sign the Operations Coordinator log sheet and return to Recorder when emergency is over.

Post Incident - Checklist		
☐	1)	Participate in the post crisis review
☐	2)	Evaluate the effectiveness of the Underground Incident Management Team during the response and implement any necessary changes to the room or associated procedures

11.5 Engineering Coordinator Duty Card

Engineering Coordinator - Checklist		
☐	1)	Set up personal workstation.

		Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	Enter all relevant information on the Engineering Coordinator log Sheet.
☐	3)	Assign a Ventilation Engineer and provide instructions and support throughout the incident.
☐	4)	Provide copy of current ventilation plans. Review plans showing mining areas, ventilation flows and controls, refuge stations, escape ways, explosives magazines, etc.
☐	5)	Provide technical assistance to the Incident Commander.
☐	6)	Ensure main surface fans are operating as required.
☐	7)	Follow up and monitor all assigned responsibilities.
☐	8)	Sign the Engineering Coordinator log sheet and return to the Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups. Pass the information onto the ERT Advisor.
☐	2)	Participate in the post-crisis debrief.
☐	3)	Ensure allocated post-crisis follow-up actions are completed.

11.6 MAINTENANCE COORDINATOR DUTY CARD

Maintenance Coordinator - Checklist		
☐	1)	Assign Mechanical Supervisor and Electrical Supervisor, if required: Name of Mechanical Supervisor:

		Name of Electrical Supervisor:
☐	2)	Confirm that Stench at the main fans has been released (by radio). Only if required, check to make sure the stench gas has been released in the compressed lines.
☐	3)	Report to Incident Commander that stench has been released.
☐	4)	Under the direction of the Incident Commander, identify and work to remedy any maintenance related issues.
☐	5)	Discuss with the ERT Coordinator the need to have a mechanic inspect equipment involved in the incident prior to calling the Code One over.
☐	6)	Record relevant information in the Maintenance Coordinator log sheet.
☐	7)	Sign the Maintenance Coordinator log sheet and return to Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Participate in the post crisis review
☐	2)	Evaluate the effectiveness of the Underground Incident Management Team during the response and implement any necessary changes to the room or associated procedures
☐	3)	Provide a list of what equipment is locked out and/or need repair.

11.7 RECORDER DUTY CARD #1

Recorder - Checklist		
☐	1)	Set up personal workstation and start recorder.
☐	2)	Record key incident information on the event log and/or the status boards (rolled up poster sheets located in the auxiliary room). This must include times.
☐	3)	Update the status boards and manage administrative functions.
☐	4)	Manage the flow of hard copy information and retain copies for the permanent log.
☐	5)	Assist the Incident Commander in record keeping.
☐	6)	Alert team members of major changes, issues and outstanding actions.
☐	7)	Take digital photos of status boards before they are updated.
☐	8)	Proactively monitor all communications and record pertinent points as they arise.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups.
☐	2)	Participate in the IMT post-crisis interview.
☐	3)	Assist with refurbishing the Incident Management Room back to a ready state.

11.8 RECORDER DUTY CARD #2

Recorder - Checklist		
☐	1)	Set up personal workstation.
☐	2)	Record key incident information on the event log. This must include times.
☐	3)	Assist Dispatch in all aspects.
☐	4)	Manage the flow of hard copy information and retain copies for the permanent log.
☐	5)	Record all pertinent information from radio and telephone communication
☐	6)	Alert team members of major changes, issues and outstanding actions.
☐	7)	Take digital photos of information received
☐	8)	Proactively monitor all communications and record pertinent points as they arise.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups.
☐	2)	Participate in the IMT post-crisis interview.
☐	3)	Assist with refurbishing the Incident Management Room back to a ready state.

11.9 DISPATCH DUTY CARD

Dispatch - Checklist		
☐	1)	If an underground emergency is called on any UG channel, immediately relay the message without delay to Senior Management as per site extensions. Ch2 days Event: _____ Location of Event: _____ Person Reporting Event: _____ Injuries: _____ <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	If it is a medical emergency, inform all personnel on all underground channels to clear all ramps to the incident scene.
☐	3)	Monitor channel “all dispatch” and record any information in the Dispatch logbook.
☐	4)	If calls are received from a refuge station to report people present tell the caller that someone will contact them shortly. If the caller has information regarding the emergency record on log sheet. Relay information to Operations Coordinator.
☐	5)	Relay relevant information received from the UG channels to the Operations Coordinator.
☐	6)	When requested, provide any information on the location of personnel or equipment to the Operations Coordinator.
☐	7)	Record relevant information on Dispatch log sheet.
Post Incident - Checklist		
☐	1)	Participate in the IMT post-crisis interview

11.10 Check-In Coordinator Duty Card

Check-In Coordinator - Checklist		
☐	1)	Start your Check in Coordinator log sheet. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	Designate the West Zone shop area and VOK Portal entrance as the muster area.
☐	3)	Assign one of the people mustering to direct, supervise & monitor personnel in the muster area. Instruct them to ensure all personnel remain in the muster area. Name: _____ Assign one Tag Board Check-In Assistant to oversee/guard the tag board. Instruct them not to let anyone remove a tag from the board until all workers are accounted for and the Check-In Coordinator has given approval. Tag board check in assistant: _____
☐	4)	Install the TAG BOARD “NO ENTRY” BARRICADES around the tag board to prevent persons from entering the TAG BOARD area.
☐	5)	Assign two Refuge Station Check-In Assistants. Designate each person specific refuge stations. Distribute refuge station records accordingly.
☐	6)	Delegate two Check-In Assistants to sit in the Shifter’s office to start call ins. Refuge Station Check-In Assistants #1: Refuge Station Check-In Assistants #2: Ensure the Check-In Assistants have their appropriate Refuge Station Check-In sheets (#1 and #2). The refuge stations are split up between Assistants to increase efficiency.
☐	7)	Monitor and direct the activities of the Check-In Assistants and UG Office muster area.
☐	8)	Provide a list of personnel accounted and unaccounted for and any Refuge Stations that were not contacted to the Operations Coordinator
☐	9)	Inform Operations Coordinator when all personnel are accounted for.
☐	10)	Release persons in the UG Offices muster area once the Code One is over.

☐	11)	Ensure all relevant information is entered in Check-In Coordinator log sheet, sign, then give to the recorder.
Post Incident - Checklist		
☐	1)	Participate in the IMT post-crisis interview

11.11 Check-In Assistant Duty Card

Check in Assistant - Checklist		
☐	1)	Use the REFUGE STATION RECORD sheets to phone all assigned refuge stations and record the name, employer/company name, refuge location, and condition of all personnel. Repeat the names to the refuge station attendant for verification. Ensure to include the refuge station attendant name. If a refuge station cannot be contacted by phone inform the Check-In Coordinator who will provide a radio. Attempt to contact the refuge station on radio channel 1, 2, and 3. Use a separate sheet for each refuge station and circle the refuge station location at the top of the sheet. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	After all refuge stations have been contacted once, take the REFUGE STATION RECORD to the tag board and read the names one at a time to the Tag Board Check in Assistants. The Tag Board Check in Assistant will flip the tags as you read them. The Refuge Station Check in Assistant will mark an X in the column on the REFUGE STATION RECORD beside the person's name to indicate their tag has been flipped. Once all names have been read from the Refuge Station Check in Assistants list, compile a list of people not accounted for and notify the Check-In Coordinator.
☐	3)	Return to designated office and contact all the refuge stations again for any new arrivals. Repeat process at tag board of confirming names and flipping tags.
☐	4)	Provide a list of personnel unaccounted-for to the Check-In Coordinator.
☐	5)	Follow all directions from the Check in Coordinator.

☐	6)	Record all relevant information in the Refuge Station Check in Assistants Log sheet
☐	7)	Sign the Refuge Station Check in Assistant's Log sheet and return all paperwork to Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Attend the incident post-crisis review

11.12 Entrance Guard Duty Card

Entrance Guards - Checklist		
☐	1)	There are two locations that need to be guarded: West Zone Portal; VOK Portal; The Operations Coordinator will brief the two individuals with all pertinent information.
☐	2)	Obtain communications radio (Channel 2 RPT 1) and proceed to your designated location.
☐	3)	Record all relevant information in the Entrance Guard log sheet.
☐	4)	Position yourself, or vehicle: West Zone Portal - In a location that allows visual surveillance of the portal without being exposed to mine exhaust flow. VOK Portal - In a location that allows visual surveillance of the portal without being exposed to mine exhaust flow.
☐	5)	Stop anyone: West Zone Portal – Who attempts to enter the mine via the West Zone Portal. Contact Operations Coordinator to advise. VOK Portal – Who attempts to enter the mine via the VOK Portal. Contact Operations Coordinator to advise.
☐	6)	Identify anyone who exits the mine via the West Zone or VOK Portal. Contact the Operations Coordinator (Channel 2) to request transportation or first aid treatment of personnel exiting the mine.
☐	7)	Follow all directions from the Operations Coordinator.
☐	8)	Duties are not relieved until the Operations Coordinator instructs you to leave your post.
☐	9)	Sign the entrance guard log sheet and return to Underground Incident Command Team when emergency is over.

Appendix C.29

BJ-OHS-SOP-002 – Code One Call Out & Response

Objective

To provide clear details for the Code One response process and the associated responsibilities for all departments involved.

Scope

The requirements of this procedure apply to all Brucejack operations and activities.

Health, Safety & Reclamation Code of BC

- 3.7.1 – Mine Emergency Response Plan.
- 3.13.1 – Procedures for Safe Evacuation.

Occupational Health & Safety (OHS) Regulation (WorkSafe BC)

- 3.17 First Aid Procedures
- 4.14 Emergency Procedures
- 4.16 Training

Workers Compensation Act

- Part 2 Division 4 - General Duties of Employers, Workers and Others

Definitions

- Code One - Notification that an emergency is in progress.
- Code One Termination - Radio announcement once the emergency is over is transmitted on the radio channels. Normal work may resume in all areas.
- Emergency Response Team (ERT) - Designated team members trained for responding to site emergencies.
- Incident Coordinator - ERT member in the field providing direction to the Captain of the ERT at the scene and communicating with Dispatch.
- MERP – Mine Emergency Response Plan
- Brucejack Dispatch - Brucejack dispatch staff monitoring telephones and radio channels.
- RCO – Roll Call Officer.
- Resume Operation - Radio announcement once ERT has arrived at the scene and performed initial assessment. Message will be transmitted on all radio channels except for area affected by the Code One

Preparation

Hazards

- Miscommunication
- High stress scenarios

Tools

- Radio
- Emergency response equipment

Roles and Responsibilities

Brucejack Dispatch Is responsible for:

- Transmitting all Code One emergencies in an easily understandable manner.
- Transmitting "Resume Operation" and "Code One is Over" termination messages.
- Provide assistance to the Incident coordinators regarding logistics.
- Maintain a log of the progress of the emergency situation.

Incident Commander (Mine Manager or Designate) is responsible for:

- Overall Authorization and oversight of the Emergency situation.
- Ensure the emergency situation is managed in line with the Brucejack MERP.
- Shall ensure that normal operations can resume
- Will determined when to call the Incident Management Team.

Incident Coordinator is responsible for:

- Application and authorization of appropriate equipment and personnel for the response.
- Keep the Incident Commander up to date on the emergency situation as it progresses.
- Determines if the incident is completed (i.e. return to normal operations) or if the incident is escalating.
- Demobilize the ERT once the incident has concluded.
- Conduct a debrief with the ERT members, the Incident Commander and Dispatch.

Supervisor of the Affected Area is responsible for:

- Provide assistance as needed.
- Monitor radio Channel 2 Repeater 1 in case assistance is required by ERT.
- Standby in the area but not close to the emergency.

All Workers are responsible for:

- Assist in response when requested.
- Understanding and adhere to this Procedure.

Job Steps

When to Declare a Code ONE

Pretivm is dedicated to providing a safe workplace for its employees and contractors. The goals of this SOP and our MERP are, in order of priority, to protect the health and safety of workers and the public, protect the environment, avoid adverse social and economic effects, and preserve heritage, as well as protect and minimize damage to company properties.

An emergency is the unforeseen combination of circumstances, unusual occurrences or resulting state which may result in endangerment to lives or areas of the mine. This emergency may call for the immediate action from management and/or trained mine rescue, fire and first aid personnel.

Possible situations with the potential to create an emergency under some circumstances might include:

- Fire (electrical/mechanical) on surface or underground;
- Spills of fuel or hazardous substances;
- Unexpected/unplanned Explosions;
- Vehicle Accidents;
- Non-life and Life-Threatening Injury or Fatality; and,

- Avalanches.

A Code ONE must be declared in the following situations without delay:

- If the underground emergency is a fire*;
- A fire alarm is activated;
- A fire extinguisher is discharged to put out a fire*;
- The fire suppression system goes off on a vehicle for no reason; and
- A chemical spill with toxic vapor emissions.

***Note:** Even if the fire has been extinguished, a Code ONE must be called.

Examples of underground emergencies where a Code ONE will be called (and whether or not the stench will be released) include, but are not limited to, the following situations:

- Serious Injuries to, or people requiring rescue; (Code ONE, no stench release);
- Loss of life; (Code ONE, no stench release);
- Unexpected/unplanned explosion; (Code ONE, Stench is released);
- Flame or where fire extinguisher has been used or fire suppression has been released. (Code ONE, Stench is released). If the fire suppression is obviously triggered accidently, no Code ONE is required;
- A Fall of ground with trapped or injured workers; (Code ONE, no stench released);
- Equipment electrical - failure/damage and there are flames. (Code ONE, Stench is released);
- Loss of power and ventilation underground – NO Code ONE, stench is not released. Workers report and go to surface if extended beyond 30 minutes; and,
- Any other situation that may jeopardize the safety of workers and / or the mine.

In the event of a Code ONE, workers shall only proceed to the refuge station if the stench gas is released. Otherwise workers will remain in their respective headings and wait for further instructions.

Declaring an Code ONE

CODE ONE, CODE ONE, CODE ONE on radio Channel 2, Repeater 1 (for Brucejack), Channel 4 Repeater 2 (for Knipple) or Channel 6 Repeater 3 (for Wildfire) or Underground radio Channel 1 ALL: DISPATCH or a phone call to ext. 108 will initiate an emergency.

The radio call will be answered by Brucejack dispatch and will activate the Emergency Response Call-Out System.

If known, all the following information should be relayed when reporting an emergency:

- Name of the person calling
- Description of exactly what happened;
- Specific location and time;
- Extent of injuries and/or damages;
- What risks still exist; and,
- What action has been taken so far and who is involved.

Once a CODE ONE has been initiated, the CODE ONE shall not be interrupted or overridden by any individual. The CODE ONE must continue until investigated and deemed "over" by the Emergency Response Team Coordinator or designate.

Brucejack Dispatch Response

Once Dispatch is notified of a Code ONE, the following will occur:

- Brucejack Dispatch announces on all radio channels (Admin Channel 2 – ALL: ERT, Admin Channel 7 BCST: EMERG_CALL, Analog Channel 2 repeater 1, Analog Channel 9 Ladd 2, Analog Channel 10 Ladd 3):

Example: **"CODE ONE, CODE ONE, CODE ONE.**

There is a FIRE / MEDICAL/ SPILL emergency etc. at given LOCATION

Radio silence is now in effect."

Note: Announcement must indicate the type of emergency and precise location of the emergency

In the event of a Bunk fire, Dispatch/Logistics to supply a room list to the muster station to complete a roll call for the affected bunks. Supervisors are responsible for their crew head count. The ERT Coordinator will appoint an ERT member to assist and communicate with the RCO from the muster locations. They are to report any missing personnel with their room numbers.

Resume Operation Notification

The Incident Coordinator will notify Dispatch that operations may resume in all areas other than the affected area once they determine that there are no other associated hazards and that sufficient Emergency Response Team members are standing by and available in the event of another simultaneous emergency. Once the Incident Commander (Mine Manager or Designate) receives notification from Dispatch that operations may resume in all areas other than the affected area, the Incident Commander (Mine Manager or Designate) will instruct Dispatch to transmit the "Resume Operation" on all repeater radio channels.

Example: "Except for the Underground, all operations may resume."

Code One Termination

The Incident Coordinator will notify Dispatch when a Code ONE is over. Upon receiving notification from the Incident Coordinator, the Incident Commander (Mine Manager or Designate) will instruct Dispatch to announce that the "Code One is over" on all radio channels.

Example: "The Code ONE for the Underground area is over."

Emergency Response Team (ERT)/ Maintenance/ Mill Control Room Response

Maintenance and or the Mill Control Room can direct the ERT to the identified location of the alarm based on the alarm panel. Main Camp and Upper Bunk panels cannot be accessed by Maintenance personnel until the area has been inspected and deemed safe and accessible by the ERT.

Personnel Response to a Code One Announcement

If the Code ONE announcement is for an area you are working in, follow the Emergency Response Procedures for that area.

All persons operating light vehicles or mobile equipment on Surface Roads or Underground Ramps must pull over and stop the equipment in a safe manner and wait for the 'Resume Operation' authorization before returning to normal operating conditions.

If the emergency is not in your work area all crews are to continue working safely. If there is a task that presents a risk unusual to normal operating conditions, report to the supervisor for specific directives. Dependent on the emergency response capabilities of the ERT, work in all or some areas may have to remain stopped until the emergency is over.

If while you are driving and there are emergency vehicles approaching with flashing lights, pull over, stop your equipment in a safe manner, and wait until the 'Resume Operation' authorization from Dispatch has been given before returning to normal operations. If you are unsure of the status of the Code One in your area, contact your supervisor.

Once notified of a Code ONE, all personnel are required to maintain radio silence until the 'Resume Operation' for their work area has been announced by dispatch. Radio silence may be broken if relaying important information about the emergency.

Resume Operation Response

Upon hearing the 'Resume Operation' message, non-affected areas can return to normal operating conditions.

Code ONE Termination Response

Upon hearing the "CODE ONE termination" message, affected areas can return to normal operating conditions.

Supervisor Responsibility

If a supervisor or designate has important information relating to the emergency, the supervisor is responsible to notify the Incident Coordinator or Dispatch (on Channel 2 Repeater 1) as soon as possible, and to break radio-silence if necessary.

Supervisors of the affected area are to stand by and monitor Channel 2 Repeater 1 in case their assistance is required.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
	Added RCO to definitions		1
	Added "The ERT Coordinator will appoint an ERT member to assist and communicate with the RCO from the muster locations. They are to report any missing personnel with their room numbers."		2
02/17/2020	Added ERT/ Maintenance / Mill Control Room Response Procedures		2
04/13/2020	Changed Title to "Code 1 Call Out and Response"		1

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
ERT Coordinator			
Health and Safety Manager			
Logistics/ Dispatch			
JOHSC Co-chair or Member			

Appendix C.30

BJ-OHS-SOP-015 – Extreme Weather Conditions

PRETIVM		BJ-OHS-SOP-015 Extreme Weather Conditions	
Department: Safety	**Manager/Designate**: George Friesen	**Revision Number**: 2	**Creation Date**: Nov. 21, 2015 **Revision Date**: Feb. 26, 2021

Objective

The purpose of this procedure is to ensure the safety of all employees and contractors during extreme weather conditions, either by restricting employee's movements and work activities, or if necessary, suspend all work activities on site until the weather conditions improve.

Scope

This SOP applies to all personnel working at the Brucejack Project and access road. As weather conditions deteriorate, it is the responsibility of everyone working outdoors to monitor and report poor or worsening weather conditions to their supervisor, and if required to STOP work if it becomes unsafe to travel. The Mine Manager or designate shall be kept informed of the conditions by site supervisors, and if necessary, the Mine Manager shall restrict all work.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.9.1 – Workplace Conditions
- 3.13.1 – Evacuation, Procedures, and instructions
- 3.3.1 – Mine Emergency Response Plan

Occupational Health & Safety (OHS) Regulation (WorkSafe BC)

- G4.1.1 Avalanche assessment and planning

Definitions

- Reduced Visibility – Winds and blowing snow begin to restrict visibility of equipment operators.
- Restricted Visibility – Visibility in some areas of the mine limit safe operation and only essential equipment and traffic are permitted. Outside pedestrian travel should be prohibited.
- Total Whiteout – Weather conditions have deteriorated to a point where all work is deemed hazardous due to lack of egress for emergency.
- Essential Equipment and Traffic – Snow Removal and emergency equipment.

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this SOP is implemented and maintained.
- Ensure personnel have up-to-date information regarding this SOP.

The Health and Safety Manager or Designate is responsible for:

- Monitoring the implementation of this SOP

The Area Manager or Designate is responsible for:

- Ensure that all workers perform tasks in a safe manner
- Review procedure with any persons performing tasks pertaining to this SOP

The Worker is responsible for:

- Ensure that they are authorized to perform tasks as required
- Report to their supervisor any issues pertaining to the above procedure
- Stop work if unsure and report to supervisor

Preparation

Hazards

- Low visibility due to fog, low cloud, blowing snow and whiteout conditions can cause vehicle operators to stray off the road, or to cause pedestrians to become lost and disorientated. When combined with extreme cold, whiteout conditions pose a greater potential for personal harm to persons' working in outdoor conditions.
- Extreme weather and blowing snow reduce egress on the entire access road out of site. If a serious injury was to occur during an extreme weather event it would be difficult to safely transfer an injured person from the site.

Tools

- Two-way radio.
- Proper winter clothing and PPE.
- Avalanche packs (beacon, shovel, probe) whenever traveling in avalanche zones.

Requirements

- Knowledge of the Extreme Weather SOP.
- Knowledge of the Extreme Weather SOP.
- BJ-AVL-SOP -018 Avalanche Related Road Sustainability Plan

Job Step

In the event of any change in weather resulting in limited visibility any person on site can initiate a Weather Advisory Level 1 update based on change in weather conditions in their work area. Higher level weather advisories will be confirmed by Mountain Safety and Supervisors.

After initiation:

- The Mine Manager will be updated on weather conditions and the resources available for authorization.
- Dispatch will issue a Weather Advisory Level Update on all channels; defining the weather condition and road status (if road closures in place; kilometer location and estimated time of opening) and associated action required.
- Dispatch will issue an email outlining the Weather Advisory Level, defining the weather condition and road status (if road closures in place; kilometer location and estimated time of opening) and associated action required.
- Supervisors will restrict any high-risk work, if necessary.

Level 1 Weather Advisory

Condition – Reduced Visibility

- Weather conditions such as high winds, drifting snow or fog causing limited visibility during driving and/or operating conditions.
- Avalanche hazard will be monitored.

Action Required

- Personnel will monitor conditions and report any changes to their Supervisor or Dispatch.
- Persons driving or working outside shall limit their speed and work activity to levels appropriate to conditions.

Level 2 Weather Advisory

Condition – Restricted Work

- Weather conditions in some areas of the project have reduced visibility to such an extent that some work may be restricted, and travel to specific areas may be restricted.
- High-risk tasks outside the scope of normal duties for inside work shall be restricted. Including underground.
- Avalanche hazards will likely be elevated; personnel movement may be limited.
- Site access or egress can be acquired within 3 hours.
- Road closures and avalanche control can be expected.

Action Required

- Supervisors shall determine if restricted work or travel is required.
- Supervisors shall notify the Mine Manager of any area closures or work restrictions.
- Supervisors shall communicate appropriately with their crews and contractors/visitors under their area of responsibility. Work and travel activities may be restricted in certain areas.
- Outside pedestrian travel shall be prohibited.
- Surface Operations equipment and operator's priorities shift to maintaining site egress and emergency access.

- Emergency Response Team on standby if required.

- Restrict work activities in the event of an escalation to a Level 3 Weather Advisory

Action Level 3

Condition - Total Whiteout

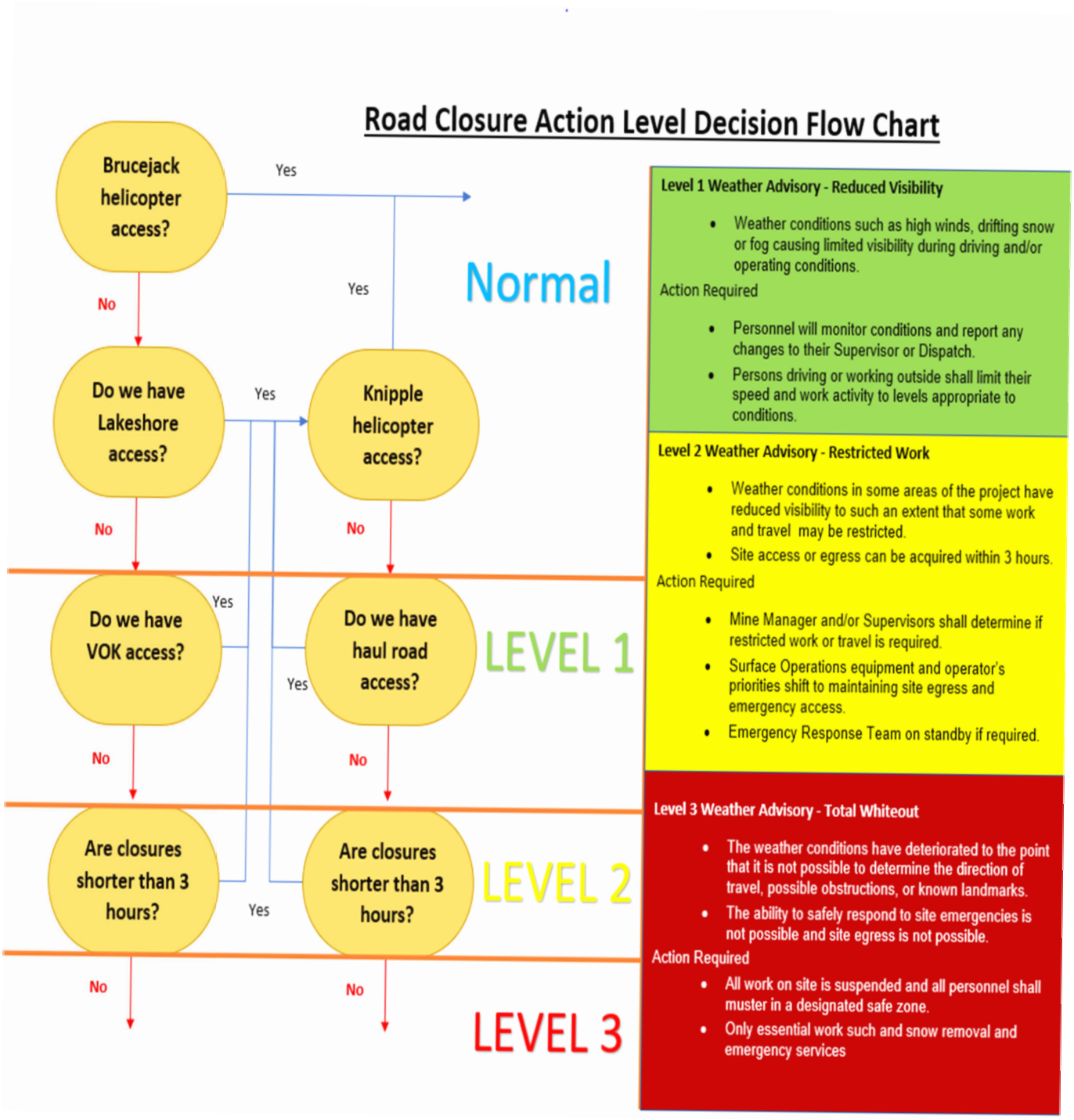
- The weather conditions have deteriorated to the point that it is not possible to determine the direction of travel, possible obstructions, or known landmarks.
- Avalanche hazards could be at high and personnel are removed from avalanche zones, unless direct supervision of Mountain Safety at the approval of the Mine Manager.
- The ability to safely respond to site emergencies is not possible.
- Site egress is not possible.

Action Required

- Mine Manager will implement the IMT so that level of work restrictions, emergencies response and priorities will be determined.
- Supervisors shall suspend all work including underground for crews and contractors/visitors within their area of responsibility.
- Emergency Response Team shall by escorted by surface snow clearing equipment for responding to emergencies.
- IF ALL WORK on site is suspended, ALL supervisors shall ensure that ALL employees/workers are all accounted for.
- ALL PERSONNEL shall muster in a designated safe zone and wait for further instructions.

Restrictions during a Level 3

- Prohibited outside travel except in emergency conditions.
- Operations suspended, and all personnel shall retreat to a safe location.
- Only essential workers authorized by the Mine Manager may continue work as directed, such as emergency services and snow removal.
- Outdoor pedestrian traffic is prohibited.
- Only critical areas determined by the Mine Manager shall be in operation.
- NO person shall return to work without the approval from the Mine Manager or designate.


Road Closure Action Level Decision Flow Chart
Brucejack helicopter access?
Yes
No
Yes
Normal
Do we have Lakeshore access?
Yes
Knipple helicopter access?
No
No
Do we have VOK access?
Yes
Do we have haul road access?
Yes
LEVEL 1
No
No
Are closures shorter than 3 hours?
Yes
Are closures shorter than 3 hours?
LEVEL 2
No
No
LEVEL 3
Level 1 Weather Advisory - Reduced Visibility
• Weather conditions such as high winds, drifting snow or fog causing limited visibility during driving and/or operating conditions.
Action Required
• Personnel will monitor conditions and report any changes to their Supervisor or Dispatch.
• Persons driving or working outside shall limit their speed and work activity to levels appropriate to conditions.
Level 2 Weather Advisory - Restricted Work
• Weather conditions in some areas of the project have reduced visibility to such an extent that some work and travel may be restricted.
• Site access or egress can be acquired within 3 hours.
Action Required
• Mine Manager and/or Supervisors shall determine if restricted work or travel is required.
• Surface Operations equipment and operator's priorities shift to maintaining site egress and emergency access.
• Emergency Response Team on standby if required.
Level 3 Weather Advisory - Total Whiteout
• The weather conditions have deteriorated to the point that it is not possible to determine the direction of travel, possible obstructions, or known landmarks.
• The ability to safely respond to site emergencies is not possible and site egress is not possible.
Action Required
• All work on site is suspended and all personnel shall muster in a designated safe zone.
• Only essential work such and snow removal and emergency services

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	[redacted]		
Health & Safety Manager / Designate			
Mine Manager / Designate			
JOHSC Co-chair or Member			

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mtn Safety Superintendent	[redacted]		

SOP Review Sign Off	PRETIVM
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Completed copy to be forwarded to the Safety/Training Department

Appendix C.31

BJ-OHS-SOP-007 – Working Alone or in High Risk Remote Locations

PRETIVM		BJ-OHS-SOP-007 Working Alone or High Risk Remote Locations	
Owner: Joe Nicholson	Approver: Wayne Osborne	Revision Number: 2.0	Creation Date: 5/10/2017 Revision Date: 5/10/2018

Objective

To ensure all personnel working alone or in high risk areas are accounted for and working safely.

Scope

This SOP applies to anyone working alone or groups that work in remote locations. It will be administered by the immediate supervisor of any worker that is in the position of working alone or working in high risk areas while on this mine site, and it is the sole responsibility of the immediate supervisor to ensure that employees are continuously in contact to ensure their safety and return back to camp.

Health, Safety & Reclamation Code of BC

- 3.2.3 - When a worker is working alone and may not be able to secure assistance in the event of an injury or other misfortune, the manager shall ensure that a means exists for checking the well-being of the worker and that interval between checks does not exceed 2.5 hours.
- OHS Regulations - 4.21 Procedures for checking well-being of worker

Definitions

- Working Alone - Any person who is working by themselves at any work site or anywhere on the Project

  * A person working alone in high risk areas or performing high risk activities off site require one (1) hour check-ins with dispatch.
- High Risk Areas - Known Avalanche zones, rock fall areas, steep slopes, mountain tops, glaciers and lakes/rivers, or any other area off site that would not have immediate access to emergency response or immediate assistance.

  * A person working alone in high risk areas or performing high risk activities off site require one (1) hour check-ins with dispatch.
- Designated Check-In Person - A person assigned by the workers supervisors' or a company assigned individual that is responsible to be in regular contact with person(s) working alone or in high risk areas.
- Brucejack Logistics & Dispatch - A 24/7 monitored dispatch team that monitors all road traffic, air traffic, people working alone and site emergencies.

Preparation

Hazards

- Mountainous terrain, fog, rain, blowing snow and extreme cold temperatures
- Wildlife encounters
- Failure to follow the working alone procedure will put people at risk and could result in serious injury or death

Tools

- Two way radios
- GPS trackers - SPOT or InReach Explorer
- Satellite Phones
- Bear bangers and bear spray
- FLHA and/or JHA

- Proper PPE and safety equipment for the area that the person(s) are working in

Requirements

All personnel that intend to work alone or companies that intend to have employees to work alone who DO NOT have a supervisor or assigned person to check on people working alone, shall inform Brucejack Dispatch and make prior arrangements for regular radio check-ins through the Brucejack Dispatch.

Responsibilities

Mine Manager or designate is responsible for:

- Ensuring this SOP is implemented and maintained.
- Ensuring on-site personnel have up-to-date information regarding this SOP.

Departmental Manager / supervisor is responsible for:

- Ensure employees are aware of the working alone procedures
- Ensure that dispatch is notified whenever a person is working alone or a group is working in a remote location

Health and Safety Manager/Coordinator is responsible for:

- Monitoring the implementation of this procedure.
- Auditing this procedure

Logistics & Dispatch

- Track those working alone or in groups in hazardous areas and ensure regular check-ins occur, and log all call-ins in spreadsheet

Personnel performing this task are responsible for:

- Performing one (1) hour check-ins with dispatch
- Informing dispatch and their supervisor when their work location has changed
- Responding to dispatch when they call

Job Step

Safe Work Instruction for working alone on surface at the BruceJack Site

Where an employee working at this mine site is not in frequent communication with, or is not within sight or sound of another person, for a period exceeding one (1) hour in high risk areas, the following procedure must be followed.

*Working alone in the Underground shall follow the guidelines of the HSRC section 3.2.3

The employee's supervisor must:

- Ensure the employee who is working alone is trained and qualified for the work they are undertaking.
- Ensure the employee is comfortable with the working alone situation, and familiar with the procedure and check-ins
- Complete an FLHA with the employee to identify hazards and risks, and document risk controls
- Inform Brucejack dispatch that an employee is going to be working alone and the location of the person working alone

- Ensure that the employee knows to contact dispatch if job location changes or the person is no longer working alone.

Personal Contact System: (no voice communication available)

- A supervisor or designate must visit the employee at the work place at intervals not to exceed 2 hours (a risk assessment will determine interval time of contact for higher risk activities).
- If the supervisor or designate cannot complete the contact as arranged, another contact must be assigned with enough lead time to meet the arranged 2 hour contact time.
- If physical contact cannot be made then a failsafe voice communication check-in must be implement and dispatch must be informed if this is the case.

Voice Communication System: (radio, telephone, cell etc.)

- A supervisor or designate must set up a contact system whereby the worker calls the supervisor or designate at minimal of one (1) hour intervals.
- If the supervisor cannot set up a contact system then dispatch must be notified and they shall take over as the primary contact for the person working alone.
- Supervisor and worker will complete a FLHA to determine the hazards/risk of the job and implement controls to mitigate risks.
- All personal/voice contact and check-ins will be recorded by supervision, the designated contact person or dispatch.

Groups working in remote locations or hazardous terrain:

All workgroups that intend to work in remote locations or in hazardous terrain shall contact dispatch and give them the location that they are working, what activity they are planning on performing and the duration of the work.

The work group shall contact dispatch and inform them that they have completed the required work and that they are safely back in camp.

If working in a High Risk area the check-in duration shall be one (1) hour with Dispatch

Failure of check-in or missed check-in:

- In the event the worker does not answer a check-in at the designated time interval, the contact person shall continue trying to call every 10 minutes until contact is made.
- If no contact can be made within 30 minutes, dispatch shall inform the workers supervisor that the worker is not responding to the calls and a plan must be implemented to go and check on the worker at the last known location.
- Dispatch will inform the Mine Manager and the ERT Coordinator of the situation. The ERT Coordinator will organize a response team if required.
- If the worker requires emergency attention follow the site emergency procedure by activating the CODE1 radio call.

Document and Records

- FLHA
- Contact persons logbook of check-in calls (Logistics & Dispatch)
- Communication notes if a Code 1 is instituted

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Health and Safety Manager/Designate	Joe Nicholson/Jim Barbondy	[redacted]	[redacted]
ERT Coordinators	Peter Devolder/ Tom Cheveldave	[redacted]	[redacted]
Mine Manager/ Designate	Wayne Osborne/ Scott Smith	[redacted]	[redacted]
Logistics and Dispatch	Cei Sullivan	[redacted]	[redacted]
Tsetsaut Ventures Ltd. Representative		[redacted]	[redacted]
JOHSC Co-chair or Designate	TRAVIS BEEBE	[redacted]	[redacted]
		[redacted]	[redacted]

Appendix D

Avalanche Emergency Response Plan

Initial Emergency Actions

At any time, a worker may witness an incident and/or be called upon to assist with an avalanche emergency. Therefore, it is important that all workers at Brucejack Mine know and understand these initial emergency response procedures.

Declaring an Avalanche Emergency

CODE ONE – CODE ONE – CODE ONE

Repeater Channel or call Dispatch at **#108** who will then initiate the Avalanche Emergency Response Plan.

The radio call is received by Dispatch, at which time they will contact Mountain Safety and activate the Emergency Response Team. (ERT) All areas at Pretivm Resources must stand down until told otherwise. Supervisors are responsible for ensuring no one is working in their area. All vehicles will go to the nearest safe pull out and remain there until instructed by Dispatch.

ALL THE EMERGENCY PROCEDURES IN THIS

MANUAL ASSUME THE CALL HAS

BEEN INITIATED

It is critical to respond to any issue in an appropriate and timely manner to ensure it is resolved as soon as possible. When considering the level of activation then it is better to over-react and rapidly de-escalate than the opposite reaction.

Mobilization

In the event of a Code 1 avalanche being called Mountain Safety will mobilize members to the incident scene. The Emergency Response Team will mobilize at the fire hall.

The Incident Management Team (IMT) will convene in the Incident Management Room (IMR) in the boardroom at Main Camp.

In the event of a major avalanche incident involving occupied buildings, multiple workers or multiple vehicles, a second operational period would likely be required, and the initial ICS structure would need to be expanded

First Operational Period (1-3hrs)

The IMT will define the objectives, the response level and strategies to be adopted as well as assigning resources to the rescue.

For the First Operational Period (1 to 3 hours) appointments would include:

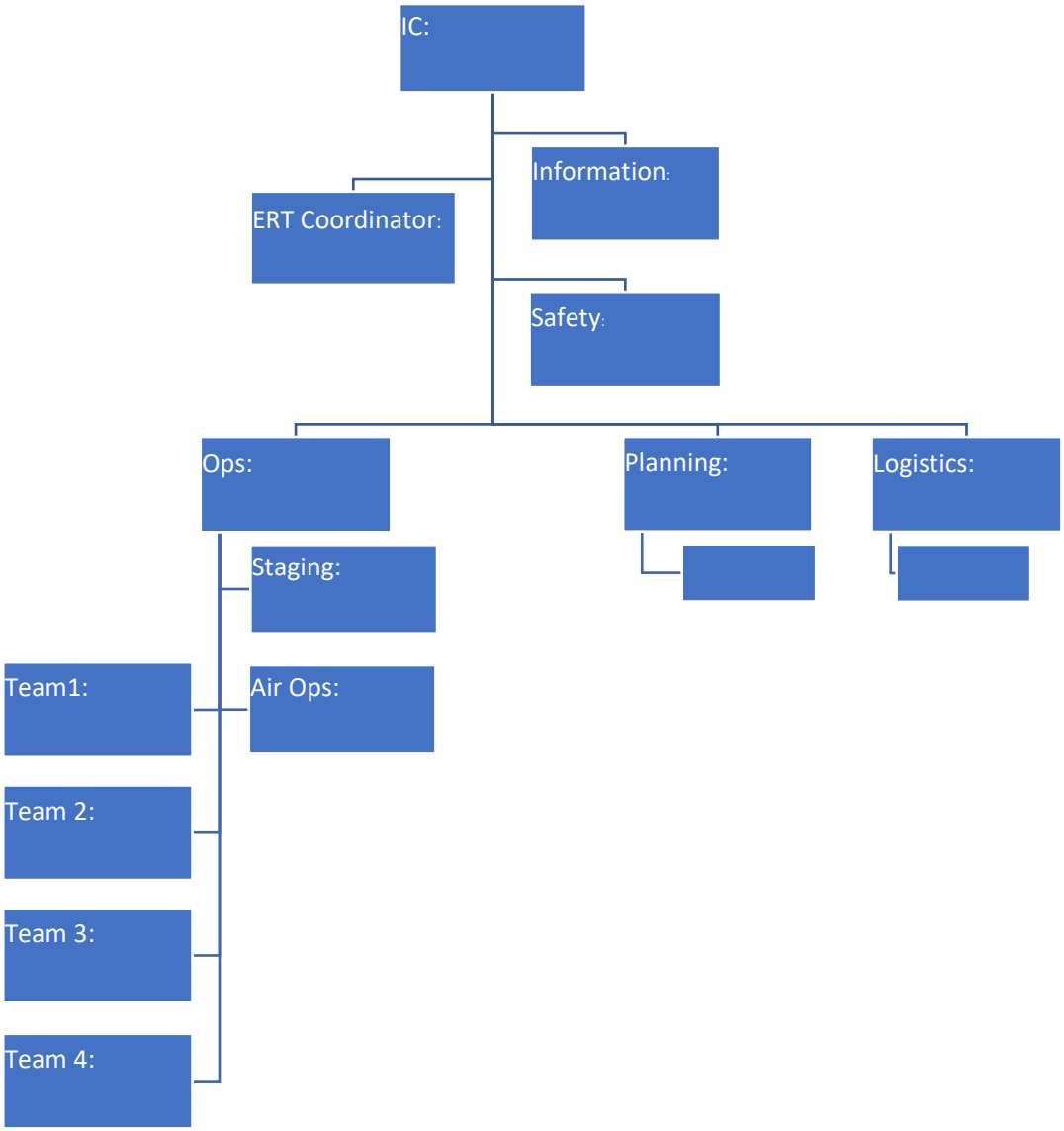
Incident Commander/Incident Management Team Leader (IC)
The Incident Commander is responsible for management and decision making in relation to incident assessment and the on-going management of the Avalanche Emergency Response Plan. The Incident Commander is the final decision maker in plan development, analysis, selection and execution.

Operations Chief (OC, Op's)
The Operations Chief role will initially be filled by the first Mountain Safety personnel on scene and they will be responsible for organizing the rescue, recovery and evacuation of patients from the scene. If the rescue expands into a second period, becomes more complex or outside the scope of Mountain Safety (ex. Vehicle in river at KM 44) then the role will be transferred to a more qualified person.

ERT Coordinator
ERT Coordinator will be filled by one of first ERT members arriving at the Fire Hall. They are responsible for managing and organizing ERT members into teams as well as distributing specialist equipment and ensuring individuals are correctly equipped and trained for the avalanche rescue.

Staging Coordinator
Staging Coordinator will be filled by a member of the first ERT on scene at the avalanche. They are responsible for managing the Staging area and liaising with the Operations Manager/Chief as well as organizing personnel prior to being deployed onto the rescue site.

Dispatch
Role to be filled by the regular Dispatcher. Their responsibility is to call the Code 1, alert ERT and IMT, gather essential information from the Reporting Person, activate rescue personnel and alert off site (Level 3) resources.



Possible ICS structure for first Operational Period

Level	Criteria	Examples	Pretivm Actions	Government Agency Actions
Level 1	• No danger outside of company property. • Immediate control of hazard • Minimal environmental impact.	• Avalanche hits a vehicle on the road but vehicle can drive on • Minor injury or property damage. • Worker caught	• Mountain Safety respond to scene • Pretivm initial response is undertaken as per the site specific ERP.	• No actions required. • Monitors response if advised.
Level 2	• No immediate danger outside of company property • Imminent control of hazard is probable. • Moderate environmental impacts. • Local/regional media interest.	• Worker(s) out of vehicle partially or fully buried • Vehicle(s) buried in avalanche • Facilities partially damaged by avalanche	• Pretivm fully activates its ERP • Internal resources mobilized • External resources alerted • Pretivm mobilized and the emergency operations centre (EOC) may be on	• Pretivm has the capability to manage and control the incident using its own resources and expertise • Lead agency notifies other agencies that may be affected. • Agencies with direct
Level 3	• Worker safety jeopardized. • Significant and ongoing environmental impacts. • Assistance from outside parties is required.	• Major avalanche impacting vehicles and/or facilities • Multiple workers caught outside their vehicle in an avalanche	• Pretivm emergency response is at maximum. • Pretivm notifies lead agency • Pretivm dispatches representative to	• Hospitals in Terrace and Stewart notified of potential trauma patients. • Government agencies with direct involvement dispatch staff to Pretivm

Second Operational Period – Level 3 Response

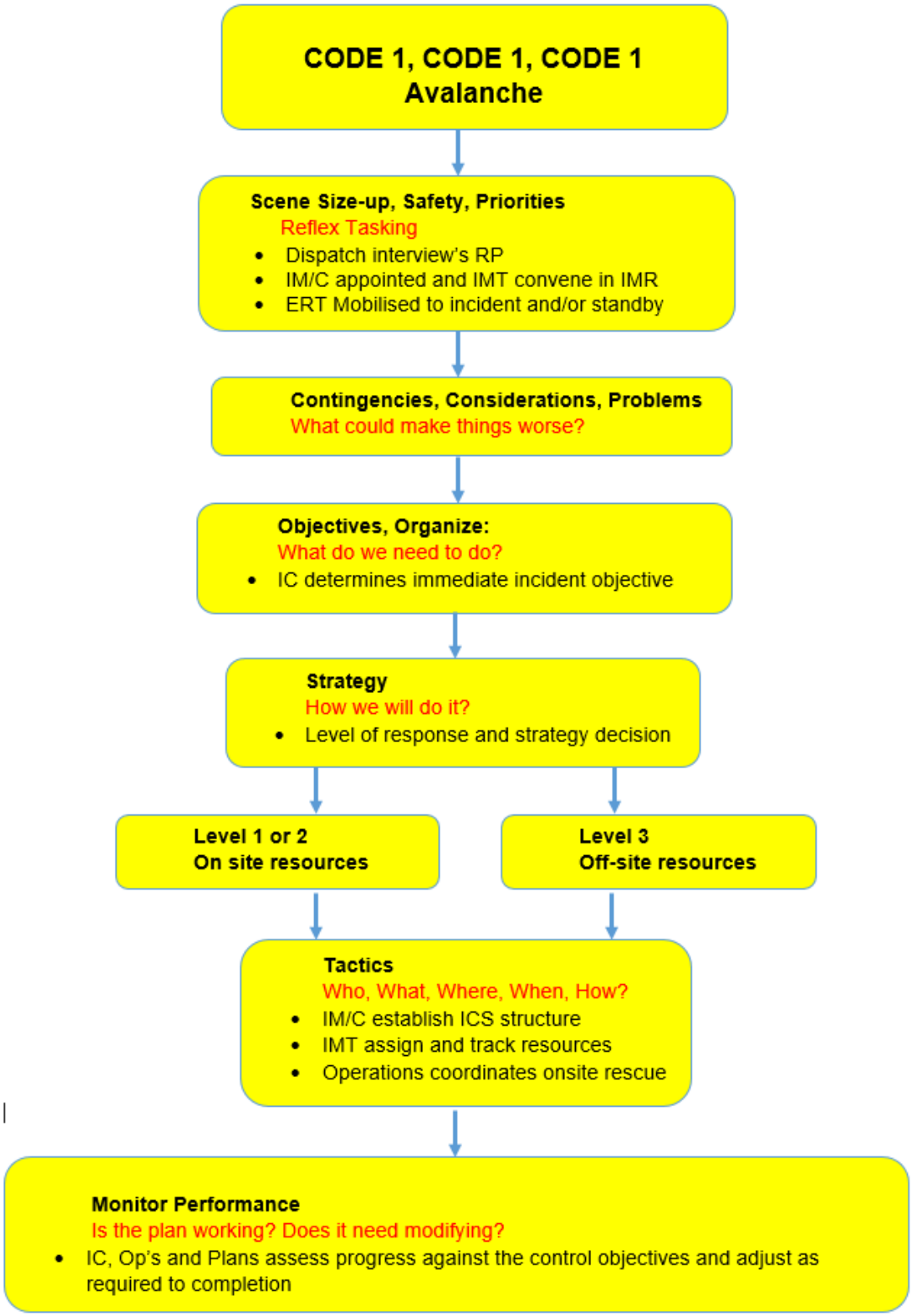
In the event the incident requires extensive outside resources the RCMP will be contacted and they will activate Emergency Management BC (EMBC). Brucejack will maintain command of the situation and the organization chart will be expanded as resources arrive until a higher authority (RCMP, Mine Inspector, EMBC) arrives to take command. Once command has been handed over, Brucejack resources will continue to support the incident response.

Outside Resources Call Out List 2020-21

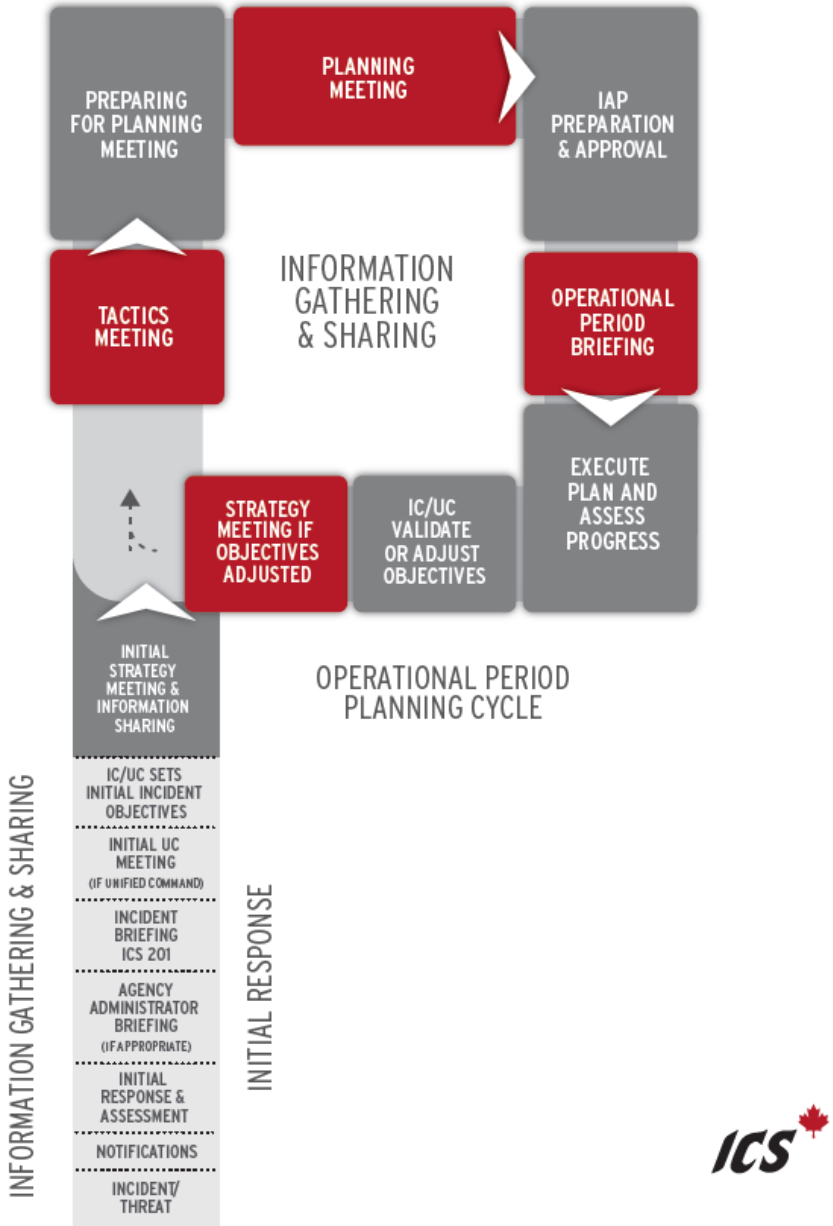
ORGANIZATION	CONTACT	CONTACT NUMBERS
Nearest Neighbours – (Trained avalanche personnel or trained rescue coordinators with plan)		
MOT Stewart Avalanche Tech	(*if not in office call Burnaby*)	250-636-2625
Burnaby Dispatch Rapid Phone	Request Stewart Tech by radio	1-866-707-7862
MOT Avalanche Tech Stewart	Ryan Boyle	C 250-631-9276 C 778-794-9935 H 250-636-9055
MOT Avalanche Tech Stewart	Bree Stefanson	C 250-842-8689 H 250-638-7015
Last Frontier Heli-skiing	LFH Bell 2 Lodge **9am-7pm**	250-275-4770 Operations begin MID-JANUARY 2021
Last Frontier Heli-skiing	Ripley Creek Lodge	250-636-2620 CLOSED FOR COVID 2020-21
Emergency Services		
RCMP (call to initiate EMBC)	24 hr Stewart Office	**Call 911 1st** F 250-636-2233
Stewart SAR	Erin Boyle	C 250-877-8115 H 250-636-9055
Stewart SAR	Bree Stefanson	C 250-842-8689 H 250-638-7015
BC Ambulance	24 hr Unit Chief Brock Nelson Stewart – Main Office	**Call 911 1st** /800-461-9911 778-870-2538 250-636-2676
Stewart Clinic	Nurse On Call	Office 250-636-2221
Terrace Emergency		250-638-4060
Emergency Management British Columbia (EMBC) (PEP)		1-800-663-3456
Dog Handlers (CARDA)		
CARDA	None available in North	
RCMP Terrace Dispatch	North District OCC	250-638-7400 (0800-1630hrs otherwise 911) Request dog handler
Helicopter Companies		
Mustang Helicopters	Smithers Base	250-877-7544
Mustang Helicopters	Alberta Base	403-885-5220
Yellowhead Helicopters	Stewart Base	250-636-2498
Yellowhead Helicopters	Stewart Hanger	250-636-2498(Line One) 250-636-2442(Secondary)
Yellowhead Helicopters	Operations Support Ctr.	250-963-9884

Other Agencies		
Northern Escape Heli-skiing	Terrace	Heli Operations begin around Xmas 2020 1: 250-615-3184 Office 2: 250-615-6043 John 3: 250-615-8250 Jody
Independent-Terrace Based	Leah Zhecheva	C 250-641-8545
Skeena Heli-skiing	Phone	P 206-201-2265 C 250 643 2948 Martin Wehren CLOSED FOR WINTER 2020-21 DUE TO COVID

Lat N 56°27.938' **Long W** 130°11.16 **PH** 778 724 4186 **RX** 162.735 **TX** 167.715 **Tone** 71.9


CODE 1, CODE 1, CODE 1
Avalanche
Scene Size-up, Safety, Priorities
Reflex Tasking
• Dispatch interview's RP
• IM/C appointed and IMT convene in IMR
• ERT Mobilised to incident and/or standby
Contingencies, Considerations, Problems
What could make things worse?
Objectives, Organize:
What do we need to do?
• IC determines immediate incident objective
Strategy
How we will do it?
• Level of response and strategy decision
Level 1 or 2
On site resources
Level 3
Off-site resources
Tactics
Who, What, Where, When, How?
• IM/C establish ICS structure
• IMT assign and track resources
• Operations coordinates onsite rescue
Monitor Performance
Is the plan working? Does it need modifying?
• IC, Op's and Plans assess progress against the control objectives and adjust as required to completion

PLANNING P


PREPARING FOR PLANNING MEETING
PLANNING MEETING
IAP PREPARATION & APPROVAL
TACTICS MEETING
INFORMATION GATHERING & SHARING
OPERATIONAL PERIOD BRIEFING
EXECUTE PLAN AND ASSESS PROGRESS
STRATEGY MEETING IF OBJECTIVES ADJUSTED
IC/UC VALIDATE OR ADJUST OBJECTIVES
INITIAL STRATEGY MEETING & INFORMATION SHARING
OPERATIONAL PERIOD PLANNING CYCLE
IC/UC SETS INITIAL INCIDENT OBJECTIVES
INITIAL UC MEETING (IF UNIFIED COMMAND)
INCIDENT BRIEFING ICS 201
AGENCY ADMINISTRATOR BRIEFING (IF APPROPRIATE)
INITIAL RESPONSE & ASSESSMENT
NOTIFICATIONS
INCIDENT/ THREAT
INFORMATION GATHERING & SHARING
INITIAL RESPONSE
ICS

Duty Card – Incident Commander

AVALANCHE INCIDENT - Checklist		
☐	1)	Announce you are IC on radio – "IC"
☐	2)	Proceed to Incident Management Room (IMR) and join Incident Management Team (IMT)
☐	3)	Receive incident report from Dispatch

☐ **4)** **Scene Size-up, Priorities**

Code 1 Avalanche - Reflex Tasking

Already mobilizing

- Mountain Safety travelling to avalanche site
- Mountain Safety from other camp mobilizing (utilize helicopter)
- ERT mobilizing to Fire Hall
- ERT ambulance and ambulance Trooper warmed up
- Surface Operations equipment for snow removal on standby
- Cat on standby for snow removal or VOK ('crummy' for crew and warmth)
- Paramedics on standby at both camps
- Knipple helicopter mobilizing to avalanche site (weather permitting)
- All traffic stops in safe locations (out of avalanche area, collision hazard)

☐ **5)** **Contingencies, Considerations, Problems**

What could make things worse or more complicated? - Checklist		
☐	1)	Scene stable? - *Other hazards (avalanche, rock, icefall), avalanche control needed, medically stable, stable in terrain (steep ground, scree, cliffs), all traffic stopped in safe area (out of avalanche terrain)*
☐	2)	Weather- *visibility, ground/air travel, outside assistance from Stewart or Terrace weather forecast for those areas*
☐	3)	Darkness - *sunrise/sunset time, light plant required*
☐	4)	On/off road incident – *road access, snowcat, steep ground, water, river*
☐	5)	Communications – *announce radio channel to be used, ERT digital only works for mine site, Repeater 2 (Bowser Valley) or Repeater 3 (Wildfire)*
☐	6)	Location from camp – *road, overland or flying,*
☐	7)	Experience - *of reporting person, rescuers (trained, equipped)*

☐	8)	Code 1 – *Mine shut down, road closures and/or traffic and work restrictions, mine site or entire project*

☐ 6) **Objectives, Organize**

What do we need to do?

- **Determine immediate incident objective**

Keep it S.M.A.R.T. (Specific. Measurable. Attainable. Realistic. Timely)

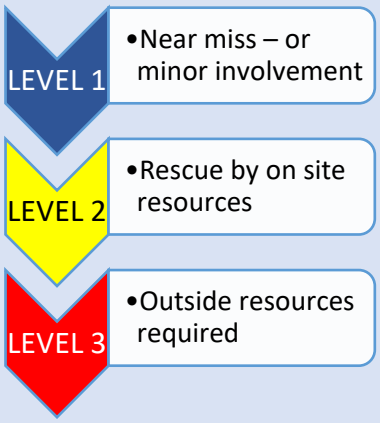
- **Example – "Recover and evacuate all avalanche victims from avalanche on Lake Shore Drive within next hour"**

Objective		
☐	1)	
☐	2)	

☐ 7) **Strategy(s)**

How will we do it?

- **Liaise with Op's Chief to determine incident level of response 1, 2 or 3**



- **Liaise with Operation's Chief to determine strategy**
  - **Example**
    - **Strategy #1 – ERT's locate and evacuate victims to forward staging**
    - **Strategy #2 – Evacuate casualties to Terrace by helicopter**

Strategy		
☐	1)	
☐	2)	
☐	3)	

☐ 8) **Tactics**

Who, What, Where, When, How?

- **Establish initial ICS structure**
- **Assign Resources to Org Chart**

See Fig 2.

Level 2 On Site Resources – Checklist – add to Org Chart		
☐	1)	Mountain Safety (MS) • On scene and becomes Op's Chief • All Av Techs mobilizing - conditions dependent - day/night shift and from other camp
☐	2)	ERT • ERT Coordinator to advise when first team is ready to deploy from Fire Hall to staging area (by truck, ambulance or snowcat) • Second team prepping • Ambulance Trooper being warmed up
☐	3)	**Surface Op's** • Loader and excavators for snow removal to forward staging with Avi PPE • **Snow Cat with 'crummy" mobilized for transport or shelter**
☐	4)	Paramedics (other camp on standby or mobilizing to site) • Mobilize to forward staging
☐	5)	**Knipple Helicopter** • **On route to forward staging with other camp Av Techs**
☐	6)	**Off-site resources alerted –** Reference Outside Resources (conditions for flying)

Level 3 Off Site Resources Support – Checklist – add to Org Chart		
☐	1)	• Reference Outside Resources • Ex. Last Frontier, Northern Escape, Eskay Creek
☐	2)	**Ministry of Transportation and Infrastructure** • Terrace / Stewart
☐	3)	**Helicopters** • YHL, Stewart or Mustang, Smithers

☐	4)	**Ambulance**
☐	5)	**Hospitals**
☐	6)	**RCMP (can activate EMBC, issue NOTAM to keep aircraft out of area, organise rescue dogs)**

☐ **9)** **Monitor Performance**

Is the plan working? Does it need modifying?

- **IC, Op's and Planning assess progress against the control objectives and adjust as required**
- **Command staff conduct strategy and tactics meetings and plan next operational period if required**

See Fig 4.

Post Incident - Checklist

☐ **10)** Reference: Pretivm MERP 2020 document

Duty Card – Dispatch

AVALANCHE INCIDENT - Checklist		
☐	1)	Role to be filled by regular Dispatcher
☐	2)	Your role is to gather initial information from Reporting Person (RP)
☐	3)	Initial report (below) to be passed onto Incident Management Team ASAP
☐	4)	

Incident Details			
☐	**1)**	Incident name and number	
☐	**2)**	Date and Time	
☐	**3)**	Code 1 called on all 5 Channels and relayed to traffic on Pretivm road channel	Time:
☐	**4)**	All traffic to stop in safe location (out of avalanche area)	Time:
☐	**5)**	Incident Commander	Name:
☐	**6)**		
☐	**7)**		

☐	5)	**Code 1 Avalanche - Reflex Tasking** **Check and record status and location** ☐ Mountain Safety (MS) travelling to avalanche site ☐ Mountain Safety from other camp mobilizing (utilize helicopter) ☐ ERT mobilizing to Fire Hall ☐ Ambulance/ Ambulance Trooper warmed up ☐ Surface Operations equipment for snow removal on standby ☐ Cat on standby for snow removal or VOK (‘crummy’ for crew and warmth) ☐ Paramedics on standby at both camps

- ☐ Knipple helicopter mobilizing to avalanche site (weather permitting)
- ☐ All traffic stops in safe locations (out of avalanche area, collision hazard)

☐ 6)

DISPATCHER – repeat all calls from RP			
☐	**1)**	Reporting Party (RP) name	
☐	**2)**	Nature of incident (repeat back)	
☐	**3)**	Remind RP - they are in charge until relieved by more experienced person	
☐	**4)**	Location of incident and RP (KM, GPS)	
☐	**5)**	Immediate safety of RP – scene stabilized (other avalanches, incoming vehicles, personnel)	
☐	**6)**	Number of people involved or buried – partial or fully buried	
☐	**7)**	Number and type of vehicles involved or buried – partial or fully buried	
☐	**8)**	RP and victims equipped with avalanche PPE	
☐	**9)**	Others at scene - names	
☐	**10)**	First aid being given?	
☐	**11)**	**Nature of injuries, Level Of Consciousness (LOC - AVPU) and vital signs (breaths, pulse, colour, pupils)**	
☐	**12)**	Equipment on scene – first aid, overnight gear, shelter	
☐	**13)**	Terrain – roadside, flat, steep, scree, cliffs, glacial	

☐	**14)**	Heli pick up site nearby		
☐	**15)**	Weather conditions, visibility, precipitation, temperature, wind speed and direction		
☐	**16)**	Egress or descent routes		
☐	**17)**	Contact information (if required) – radio channel, satellite phone number		

☐ 7)

Additionally Mobilize			
Team	Time	Names	Present Location
Mountain Safety at both camps to be woken up			
Alert Level 3 Resources (IC to verify)			

☐	8)	Deliver this report to the IMT in the boardroom
☐	9)	Continue with normal Dispatch duties
Post Incident - Checklist		
☐	10)	Reference: Brucejack MERP 2020 document

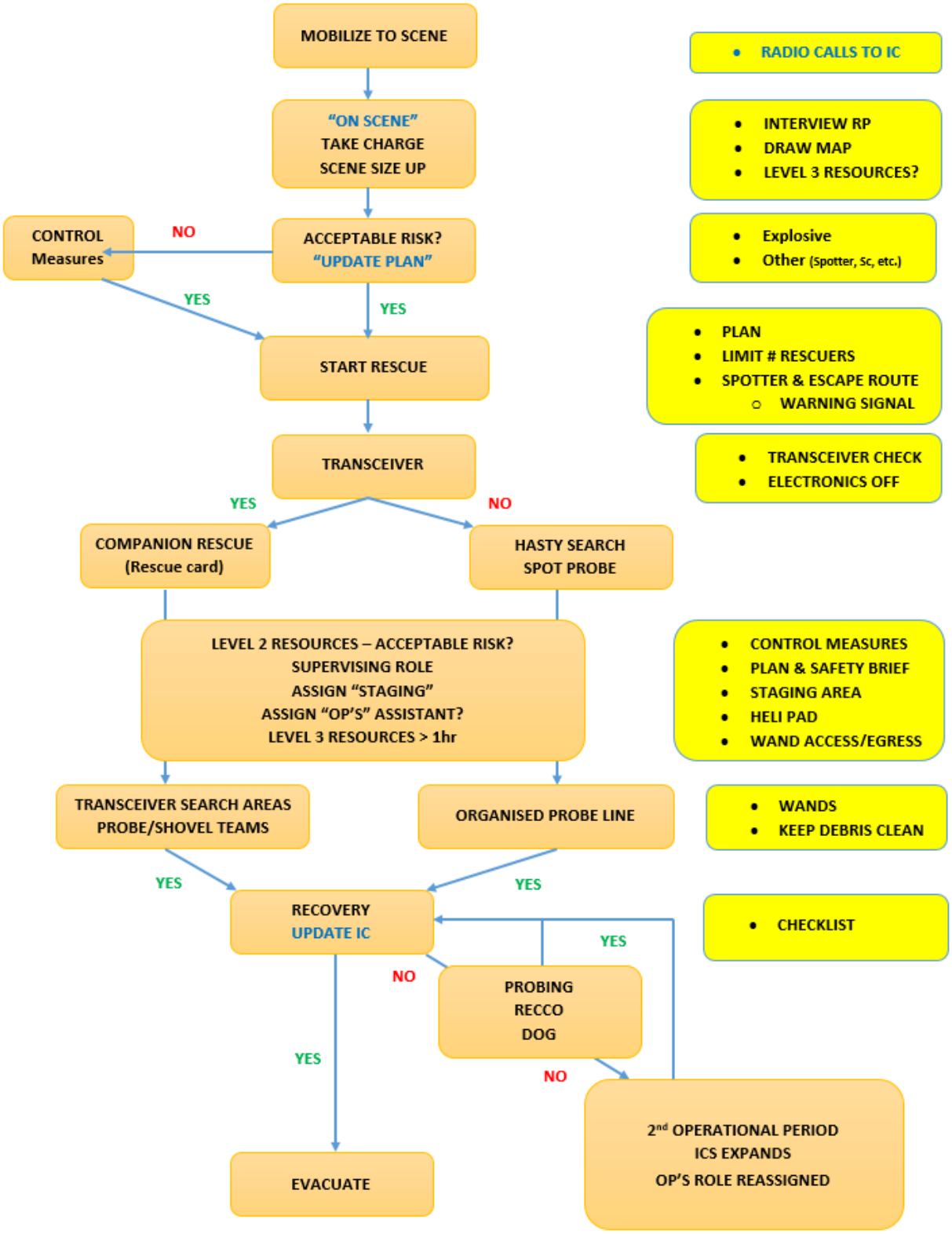
Notes:

Duty Card – Operations Chief

AVALANCHE INCIDENT - Checklist		
☐	1)	Role to be filled by primary Mountain Safety on scene
☐	2)	Role is to organize all the rescue operation in the field.
☐	3)	Inform the IC that you are on scene and are Operations Chief “Op’s, OC”

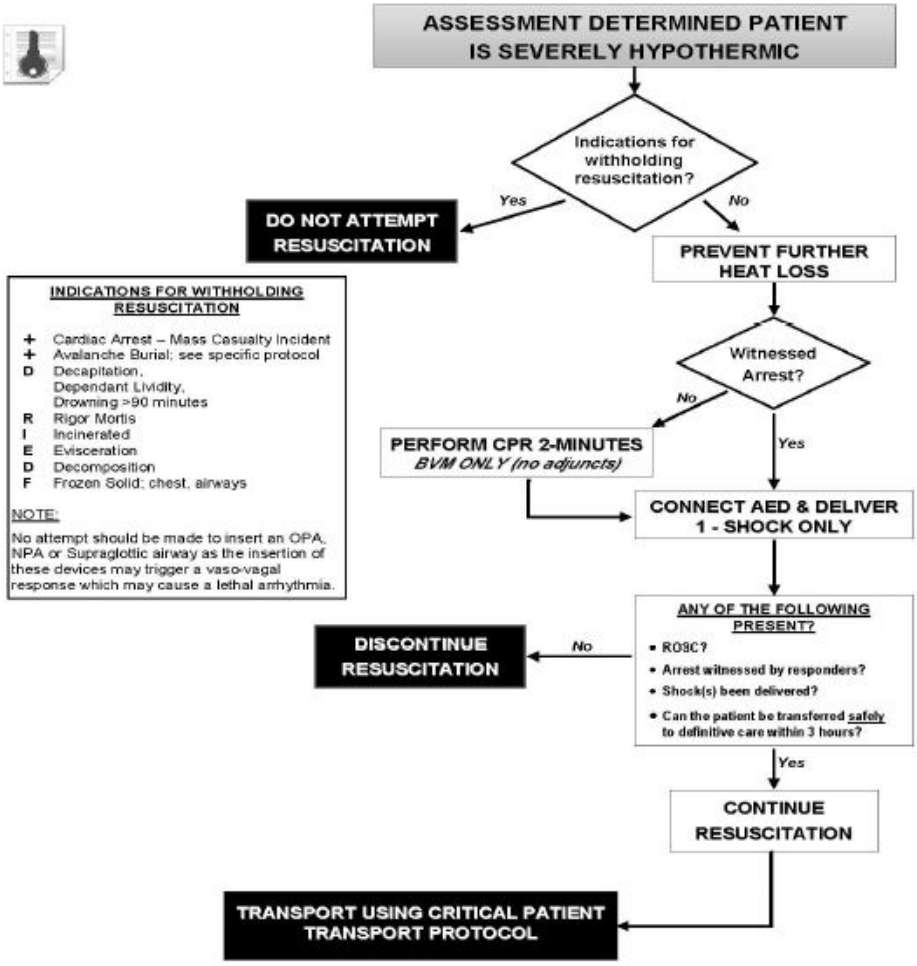
Gear Arriving with First ERT		
☐	**1)**	Avalanche rescue party pack #1
☐	**2)**	Vacuum mattress #1, Vacuum splints and Scoop stretcher
☐	**3)**	Jump kit, oxygen and AED
☐	**4)**	RECCO unit
☐	**5)**	2 extra avalanche packs for Surface Ops personnel (Loader, Cat Driver)
☐	**6)**	6 steel shovel,
☐	**7)**	2 x helicopter stakes
☐	**8)**	Forward Staging Checklist

Gear Arriving with Second ERT		
☐	**1)**	Rescue toboggan #1 (with warming kit) - Brucejack
☐	**2)**	Megaphone
☐	**3)**	Avalanche rescue party pack #2
☐	**4)**	Rescue toboggan #2 (with warming kit) - Brucejack
☐	**5)**	At night – headlamps, light plant (Pinto hitch) For deep snow conditions – snow shoes
☐	**6)**	6 steel shovels



Overview of Avalanche Rescue

HYPOTHERMIC SUBJECTS



AVI BURIAL: ≤60 MINUTES or UNKNOWN

- ✚ Assessment: If no signs of life are present (inc. ≤10-60 sec pulse check) begin CPR without delay
- ✚ Initiate AED Protocol as follows:
  - Complete (6) cycles of CPR & AED:

  (Cycle = 2 min of CPR, AED Analysis with Shock / No-Shock)
- ✚ Patients with ROSC should be transported immediately with continual observation: AED should remain attached to the patient during transport
- ✚ All avalanche burial victims should be treated as trauma patients with full spinal immobilization if resources permit

AVI BURIAL: ≥60 MINUTES CONFIRMED

- ✚ Assessment: If no signs of life are present (including ≤10-60 second pulse check) assess for:

FINDING	ECG	ACTION
- Air Pocket Absent; and/or - Snow/Ice Plug Present	Asystole	- Do not initiate resuscitation
- Air Pocket Present; and - Snow/Ice Plug Absent	VT, VF	- Initiate Hypothermia Cardiac Arrest Protocol with Spinal Immobilization
- Air Pocket Present or Absent; and - Snow/Ice Plug Absent	PEA	- Initiate Hypothermia Cardiac Arrest Protocol with Spinal Immobilization
- Air Pocket Uncertain; and - Snow/Ice Plug Absent	VT, VF PEA	- Initiate Hypothermia Cardiac Arrest Protocol with Spinal Immobilization
- Air Pocket Uncertain; and - Avalung Deployed	VT, VF PEA	- Initiate Hypothermia Cardiac Arrest Protocol with Spinal Immobilization

Avalanche Victim resuscitation Checklist (ICAR)

Post Incident - Checklist		
☐	1)	Reference: Brucejack MERP 2020 document

Duty Card – ERT Coordinator

AVALANCHE INCIDENT - Checklist		
☐	1)	Role to be filled by one of first ERT members arriving at Fire Hall
☐	2)	Role is to manage teams leaving the Fire Hall
☐	3)	Inform the IMT that you are ERT Coordinator *(conference room ext. 640)*
☐	4)	**Staging - Checklist**

☐	**1)**	Organize ERT members into Teams with a designated leader
☐	**2)**	Check team members have avalanche packs, are wearing transceivers (physical check and **sending**), dressed appropriately for being in the field for several hours and have required training
☐	**3)**	Distribute first aid and rescue gear to teams – Ops Chief to advise
☐	**4)**	Record teams' details, PPE checked and gear issued
☐	**5)**	Inform IC once each team is ready to mobilize
☐	**6)**	Update Plans group with team name and details *(Brucejack IMR ext. 640)*
☐	**7)**	Warm up Trooper ambulance/ambulance

☐ 5)

Team name	Team Leader	Date	Time dispatched
Members	Avalanche pack	Transceiver checked	Appropriate winter clothing
1			
2			
3			
4			
5			
6			
			Time checked in

Team name	Team leader	Date	Time dispatched
Members	Avalanche pack	Transceiver checked	Appropriate winter clothing
1			
2			
3			
4			
5			
6			
			Time checked in

Team name	Team leader	Date	Time Dispatched
Members	Avalanche pack	Transceiver checked	Appropriate winter clothing
1			
2			
3			
4			
5			
6			
			Time checked in

Team name	Team leader	Date	Time dispatched
Members	Avalanche pack	Transceiver checked	Appropriate winter clothing
1			
2			
3			
4			
5			
6			
			Time checked in

☐	6)	**Priority First Aid and Rescue Gear – Checklist**		
		☐	**1)**	Avalanche rescue party pack #1
		☐	**2)**	Vacuum mattress #1, Vacuum splints and Scoop stretcher
		☐	**3)**	Jump kit, oxygen and AED
		☐	**4)**	RECCO unit
		☐	**5)**	2 extra avalanche packs for Surface Ops personnel (Loader, Cat Driver)
		☐	**6)**	6 steel shovels
		☐	**7)**	2 x helicopter stakes
		☐	**8)**	Forward Staging Checklist
☐	7)	**Secondary First Aid and Rescue Gear – Checklist**		
		☐	**1)**	Rescue toboggan #1 (with warming kit) - Brucejack
		☐	**2)**	Megaphone
		☐	**3)**	Avalanche rescue party pack #2
		☐	**4)**	Rescue toboggan #2 (with warming kit) - Brucejack
		☐	**5)**	At night – headlamps, light plant (Pinto hitch)
		☐	**6)**	For deep snow conditions – snow shoes
		☐	**7)**	6 steel shovels
		☐	**8)**	
Post Incident - Checklist				
☐	8)	Reference: Brucejack MERP 2020 document		

Duty Card – Staging Coordinator

AVALANCHE INCIDENT - Checklist		
☐	1)	Role to be filled by member of the first ERT arriving on scene – Use Checklist
☐	2)	Your role is to liaise with the Operations Chief “Ops” as well as manage the Staging area
☐	3)	Inform IMT that you are Staging Coordinator “Staging”
☐	4)	**Staging - Checklist**

☐	**1)**	Check all rescuers have avalanche packs and the correct gear
☐	**2)**	Organize first aid kits and specialist rescue gear for deployment
☐	**3)**	Inform Op’s when teams and equipment are ready to be deployed
☐	**4)**	Direct teams on how to access the site and where to report to Ops. Mark with wands if necessary
☐	**5)**	Transceiver **check of all personnel entering rescue site (ERT already checked). Op’s Chief to advise if transceivers on send or search mode**
☐	**6)**	Select a secure landing site for rescue helicopter and mark with heli stakes (5m apart) for upwind landing
☐	**7)**	**Update IC/Logistics on the arrival and departure of all personnel (non ERT) in and out of forward staging**

☐	5)	**Priority First Aid and Rescue Gear – with 1st ERT**		
		☐	**1)**	Avalanche rescue party pack #1
		☐	**2)**	Vacuum mattress #1, Vacuum splints and Scoop stretcher
		☐	**3)**	Jump kit, oxygen and AED
		☐	**4)**	RECCO unit
		☐	**5)**	2 extra avalanche packs for Surface Ops personnel
		☐	**6)**	6 steel shovels
		☐	**7)**	2 x helicopter stakes
		☐	**8)**	Forward Staging Checklist
☐	6)	**Secondary First Aid and Rescue Gear – with 2nd ERT**		
		☐	**1)**	Rescue toboggan #1 (with warming kit)
		☐	**2)**	Megaphone
		☐	**3)**	Avalanche rescue party pack #2
		☐	**4)**	Rescue toboggan #2 (with warming kit)
		☐	**5)**	At night – headlamps, light plant (Pinto hitch)
		☐	**6)**	For deep snow conditions – snow shoes
		☐	**7)**	6 steel shovels
		☐	**8)**	

☐	7)	

Level 3 Off Site Resources – Checklist – Update ICT of personnel when deploying from the Forward Staging area		
☐	**1)**	Local Heli Ski guides
☐	**2)**	Yellowhead helicopter - Stewart
☐	**3)**	MOTI – Stewart or Terrace
☐	**4)**	CARDA dog handler
☐	**5)**	
☐	**6)**	
☐	**7)**	
☐	**8)**	

☐ 8) **ADDITIONAL RESCUE PERSONNEL – (Non ERT)**

Team Name	Team Leader	Date	Time Dispatched
Member	Avalanche Pack	Transceiver Checked	Radio – on ERT or Repeater
1			
2			
3			
4			
5			
6			
			Time Checked In

Team Name	Team Leader	Date	Time Dispatched
Member	Avalanche Pack	Transceiver Checked	Radio – on ERT or Repeater
1			
2			
3			
4			
5			
6			
			Time Checked In

Team Name	Team Leader	Date	Time Dispatched
Member	Avalanche Pack	Transceiver Checked	Radio – on ERT or Repeater
1			
2			
3			
4			
5			
6			
			Time Checked In

Team Name	Team Leader	Date	Time Dispatched
Member	Avalanche Pack	Transceiver Checked	Radio – on ERT or Repeater
1			
2			
3			
4			
5			
6			
			Time Checked In

Outside Resources 2020-21

2020-11-09

ORGANIZATION	CONTACT	CONTACT NUMBERS
Nearest Neighbours – (Trained avalanche personnel or trained rescue coordinators with plan)		
MOT Stewart Avalanche Tech	(*if not in office call Burnaby*)	250-636-2625
Burnaby Dispatch Rapid Phone	Request Stewart Tech by radio	1-866-707-7862
MOT Avalanche Tech Stewart	Ryan Boyle	C 250-631-9276 C 778-794-9935 H 250-636-9055
MOT Avalanche Tech Stewart	Bree Stefanson	C 250-842-8689 H 250-638-7015
Last Frontier Heli-skiing	LFH Bell 2 Lodge **9am-7pm**	250-275-4770 Operations begin MID-JANUARY 2021
Last Frontier Heli-skiing	Ripley Creek Lodge	250-636-2620 CLOSED FOR COVID 2020-21
Emergency Services		
RCMP (call to initiate EMBC)	24 hr Stewart Office	**Call 911 1st** F 250-636-2233
Stewart SAR	Erin Boyle	C 250-877-8115 H 250-636-9055
Stewart SAR	Bree Stefanson	C 250-842-8689 H 250-638-7015
BC Ambulance	24 hr Unit Chief Brock Nelson Stewart – Main Office	**Call 911 1st** /800-461-9911 778-870-2538 250-636-2676
Stewart Clinic	Nurse On Call	Office 250-636-2221
Terrace Emergency		250-638-4060
Emergency Management British Columbia (EMBC) (PEP)		1-800-663-3456
Dog Handlers (CARDA)		
CARDA	None available in North	
RCMP Terrace Dispatch	North District OCC	250-638-7400 (0800-1630hrs otherwise 911) Request dog handler
Helicopter Companies		
Mustang Helicopters	Smithers Base	250-877-7544
Mustang Helicopters	Alberta Base	403-885-5220
Yellowhead Helicopters	Stewart Base	250-636-2498
Yellowhead Helicopters	Stewart Hanger	250-636-2498(Line One) 250-636-2442(Secondary)

PRETIVM
BRUCEJACK PROJECT

Outside Resources 2020-21

2020-11-09

Yellowhead Helicopters	Operations Support Ctr.	250-963-9884
Other Agencies		
Northern Escape Heli-skiing	Terrace	Heli Operations begin around Xmas 2020 1: 250-615-3184 Office 2: 250-615-6043 John 3: 250-615-8250 Jody
Independent-Terrace Based	Leah Zhecheva	C 250-641-8545
Skeena Heli-skiing	Phone	P 206-201-2265 C 250 643 2948 Martin Wehren CLOSED FOR WINTER 2020-21 DUE TO COVID

Lat N 56°27.938' **Long W** 130°11.16 **PH** 778 724 4186 **RX** 162.735 **TX** 167.715 **Tone** 71.9

Appendix E

Radio Channel List

Brucejack Radio Frequencies

	Name	RX Frequency	TX Frequency	Tone
Ch 1	New Road **(NEW)**	166.080	166.080	
Ch 2	Repeater 1 **(Brucejack)**	162.735	167.715	71.9
Ch 3	Talk Around 1	162.735	162.735	
Ch 4	Repeater 2 **(Bowser)**	162.810	167.790	123.0
Ch 5	Talk Around 2	162.810	162.810	
Ch 6	Repeater 3 **(Wildfire)**	162.105	167.085	156.7
Ch 7	Talk Around 3	162.105	162.105	
Ch 8	Lad 1	154.100	154.100	
Ch 9	Lad 2	158.940	158.940	
Ch 10	Lad 3	154.325	154.325	
Ch 11	Lad 4	173.370	173.370	
Ch 12	VIH	166.470	166.470	

Appendix F

Pretivm Blasting Procedures

Pretium Resources Inc.
Avalanche Control Blasting Procedures

Revised September, 2019

Pretium Resources Inc.
1242 Main Street
PO Box 10
Smithers BC
V0J 2N0
(P) 778-724-4186

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1.0 INTRODUCTION

The Pretium Resources Inc. avalanche control blasting procedures described here detail company procedures and policies that ensure “industry best practices” are followed during all avalanche-blasting activities. These blasting procedures comply with WSBC and ERD. Specific safe work procedures are detailed for each type of blasting that may be used at the operation. Pretium Resources and all Mountain Safety team members will review avalanche control blasting procedures annually. At a minimum, all Mountain Safety team members will complete onsite training annually.

2.0 AVALANCHE CONTROL JUSTIFICATION

When the Mountain Safety department's avalanche hazard analysis concludes that the avalanche risk to workers is at acceptable levels, Mountain Safety staff may initiate avalanches under controlled circumstances with the use of explosives. This decreases road closure times, as well as work-site delays and creates a safer environment for workers.

3.0 PERSONNEL

3.1 CERTIFICATION

All Mountain Safety personnel using explosives for avalanche control shall have a valid WorkSafeBC Blasting Certificate, Mines Blasting Certificate (for control work in the zones surrounding the Brucejack camp) and a valid Transportation of Dangerous Goods (TDG) certificate. The Blaster (Mountain Safety) shall be compliant with explosive manufacturers' recommendations, current industry standards, procedures, and legislation surrounding the use of explosives. All Blasters will be familiar with all Standard Operating Procedures (described in the Avalanche Safety Plan (ASP)), pre-identified hazards (described in the Avalanche Atlas and/or ASP), the local terrain and the current and historical snowpack.

3.2 TEAMS

Blasting missions are performed in teams comprised of a minimum of two workers that are trained, equipped, and able to conduct an effective companion rescue: a team leader (Blaster of Record, Blaster) and Assistant(s). They shall have direct communication at all times, via radio or voice, with guards maintaining the closure area free of all non-essential personnel (i.e. all workers who are not part of the blasting team). The team shall be rested, alert, and in good physical and mental condition. All team members shall be capable of moving through difficult mountainous terrain under variable weather conditions. The Blaster and Assistant(s) shall be clothed and equipped to safely conduct avalanche blasting, in accordance with recommendations of the Canadian Avalanche Association or as required by WorksafeBC Occupational Health and Safety Regulations (OSHR) (Part 8: Personal Protective Clothing and Equipment). Such items shall include, but not be limited to: ski helmets (OHSR Section 8.11(2) – Ski Helmets), two-way radio, avalanche transceiver, snow probe, shovel, and first aid kit.

3.2.1 BLASTER OF RECORD

The Blaster of Record will determine if explosives use is required, and will decide on the type and size. They will be responsible for all aspects of the explosive mission, including charge preparation, placement, detonation, and disposal of misfires. The Blaster will determine the number of charges required and will not assemble these until the last most practicable moment, "…that point in time when the explosives are as close to the control route as possible, in a safe, sheltered location excluded from public access," (OHSR Section 21.85 2), which may depend on weather, terrain, and visibility.

Persons who do not hold valid blasters certificates may assist a Blaster of Record, but the blaster must have authority over the assistants and must exercise direct visual supervision and be responsible for their work during explosive loading, priming, fixing or firing (OHSR sec 21.5(3).

3.2.2 ASSISTANT

The Assistant will aid the Blaster as required and be responsible for recording all aspects of the blasting mission. The Assistant shall at all times work under the direct supervision of the Blaster of Record.

3.3 REPORTING

The employer will immediately report theft of, or problems with explosives to the RCMP and Chief Inspector of Explosives - Natural Resources Canada - Explosives Regulatory Division first, then WorkSafeBC. Any repeat or critical failure of explosives, accidents, injuries, or near misses regarding explosives will be reported immediately to WorkSafeBC (OHSR Section 21.3). A written report must be forwarded within 3 days of the incident.

3.4 VEHICLES

Personnel transporting explosives in a vehicle, including snowmobiles, snowcats and ATVs, must comply with all applicable regulations under the Canadian Explosives Act, HSRC for Mines in BC, WorkSafeBC OHSR (Section 21.18.3), and British Columbia Motor Vehicle Act. They shall be certified for the Transportation of Dangerous Goods. All vehicles used for transport will have specified explosives transport containers and appropriate placards on all sides of the vehicle indicating the presence of explosives. The placards will be removed when explosives are not being transported. All vehicles transporting explosives will be equipped with at least two fire extinguishers capable of quickly extinguishing gasoline, oil or electrical fires, which meet the guidelines listed below:

NRC/ERD Part 9 Section 191(8):

> There are to be two fire extinguishers rated at 4A: 40BC in vehicles transporting explosives

OHSR Section G21.23:

> Reasonable quantities of flammable or combustible materials may be carried by a vehicle transporting explosives, but will be contained in a manner which will not cause or transmit a fire or explosion and will be adequately separated from any explosives containers on the conveyance.

HSRC for Mines in BC Part 8.4.2 and 8.4.3

> A vehicle used to transport explosives shall be provided with orange diamond shaped placards and clearly visible signs marked “Explosives” in letters less than 150mm in height which are posted on the front, rear and sides of the vehicle.

3.5 PUBLIC

No members of the public will be allowed to have direct or indirect contact with explosives, or ride in vehicles that are transporting explosives.

4.0 EXPLOSIVES HANDLING

During all Pretium blasting operations and blasting-related activities, Industry best practices will be adhered to. Explosives materials will be stored, transported, handled, and used in a manner recommended by the manufacturer and complying with Federal and Provincial regulations, acts, and current legislation.

NATURAL RESOURCES CANADA – NRC/ERD (EXPLOSIVES ACT) Transportation and storage of explosives will be at all times in accordance with requirements of the Explosives Act (Canada).

The Explosives Act pertains to the manufacture, testing, sale, storage, transportation, and importation of explosives and the use of fireworks.

Magazines will be locked and secured at all times, located, inspected, marked, and constructed in accordance with the Explosives Act of Canada. Appropriate licenses and logbooks will be current and available at magazines, it shall be in the charge of an authorized person and only certified Blasters will make entries into the magazine logbook.

Magazines shall be organized and have an up to date inventory, oldest stock being used first, be kept clean and dry and arranged in a clean and tidy manner. Magazines shall contain an up-to-date inventory and be organized in a clean and tidy manner. The oldest stock is to be used first.

4.1 TRANSPORT CANADA (TRANSPORTATION OF DANGEROUS GOODS ACT)

Transportation of explosives will at all times be in accordance with requirements of The Transport of Dangerous Goods Act (Canada).

Pretium has been approved by NRCAN to follow DYNO NOBEL's Emergency Response Assistance Plan (ERAP # 2-1037)) that has been approved by Transport Canada.

The object of an ERAP is to ensure the immediate availability of a suitable response to emergency situations involving dangerous goods in transport. Assistance from the plan holder may be in the form of telephone advice (based on information from personnel at the emergency scene), or travel to the scene with specialized personnel and equipment.

Any Pretium Blaster or representative who handles, offers for transport, or transports dangerous goods, will be adequately trained and hold a valid Transportation of Dangerous Goods (TDG) training certificate in accordance with the TDG act (Canada).

4.2 WORKSAFE BC (OHSR)

All blasting activities will adhere to WorkSafeBC regulations (OSHR). Specifically:

Explosive charges must not be placed manually on site by workers or projected by any means for the purpose of avalanche control, until the proposed work procedures have been submitted and accepted by the board (OHSR sec 21.85).

Explosives materials must be stored, transported, handled and used in the manner recommended by the manufacturer (OHSH sec 21.36).

Explosives are not be primed until the last most practicable moment, which is that point in time when explosives are as close to the control route as possible, in a safe, sheltered location excluded from public access (OHSR sec 21.85).

Safety fuse assemblies are transported or carried in a crush-resistant container until such time that is deemed the last most practicable moment (OHSR sec 21.16).

Pull wire fuse lighters are transported separately from any explosive or safety fuse assembly. Igniters are not attached to a safety fuse assembly until the fuse is ready to be ignited. (OHSR sec 21.85)

Relighting a safety fuse is prohibited. (OHSR sec 21.79)

If a misfired charge contains a safety fuse and is re-blasted, workers must not return to the blast site until 30 minutes after the detonation.

The location of magazines in which explosives are stored, and restrictions on access or activity around the magazine area will be clearly communicated to all workers. Any day box and receptacle used for day storage of explosives on the work site must, when they contain explosives, display signs indicating the presence of explosives in a conspicuous manner, and the signs must be removed when they are empty (OHSR sec 21.18).

5.0 EXPLOSIVES USED

Pretium Mountain Safety teams may use hand charging, cornice charging, case charging, Avalauncher control, Wyssen Avalanche Tower (WAT) and helicopter deployment techniques to mitigate avalanche risk. Blasters will be familiar with and have a copy of the Pretium Avalanche Control Blasting Procedures readily available, and all personnel involved in the blasting operations will adhere to manufacturers' recommendations. Product literature regarding the explosives materials being used will be readily available. For the various techniques used in explosive avalanche control, a number of explosive products may be used, the most common being:

5.1 PRIMERS

"Primer" generally refers to a cast booster or cartridge that has been connected to an initiating device. Primers may be used on their own, linked together (as for cornice charging), or used to initiate blasting agents. Avalanche personnel may deliver these on foot or skis, by Avalauncher gun, by helicopter or remotely with the Wyssen Avalanche Towers. All regulations regarding length of safety fuse and transportation will be met. The Wyssen Avalanche Towers require a variance (VR201900088) for 30cm safety fuse length.

5.2 BLASTING AGENTS

"Blasting Agent" generally refers to ANFO (Ammonium Nitrate - Fuel Oil). A primer must initiate the blasting agent. These may be utilized by avalanche personnel on foot, skis, or by helicopter.

6.0 CLOSURES / SWEEPS

Danger Area - the area that has potential to be affected by concussion from the blast and/or the resulting avalanches and debris. The Danger Area must be closed, swept (visually and manually), and cleared of all persons.

The Blaster of Record is responsible for contacting the road foreman or work-site supervisor on duty, clearly outlining the Danger Area, and identifying standard closure locations to be used. The supervisor then coordinates traffic control (sweep vehicle, road maintenance equipment, and personnel) for the closure. The Blaster of Record notifies Dispatch and the worksite Supervisor of the closure location and expected duration.

Trained guards / traffic control personnel, with appropriate warning signs and PPE will physically block the road or work-site access at closure locations specified in the Avalanche Safety Plan (ASP).

The danger area is then swept. The person in charge of sweep contacts the Blaster, to confirm that the Danger Area has been swept and is secure.

Once the closure is in place, the Blaster announces the start of blasting operations on the main operational radio frequency and any other relevant frequencies, which all personnel involved with blasting must monitor.

Once control work is complete and the Blaster has completed post blast inspection(s) the road is turned over to the surface operations supervisor for debris clearing.

6.1 SEASONAL WARNING SIGNS

General information signs related to avalanches and explosive use shall be placed at appropriate road / work site locations. These signs warns all users that avalanche control using explosives can start at any time. These signs provide blasting information and a contact number.

7.0 RECORDING OF BLASTING MISSIONS

For every explosive charge used, standard observation records are made and filed by the Blaster in the Blasting Logs. This information includes: explosive placement, results, time, date, location, type, and size, detonation status, avalanche characteristics, resulting damage, closure start, sweep, and end times. These are standard as per the Canadian Avalanche Association's *Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches* (2016).

Two Blasting records must be maintained, one for the Blaster of Record, and one for the company. These records (logbooks or digital files) must be complete, current, and available at the work site (OHSR sec 21.4). The blaster must ensure that type and quantity of explosives recorded in their logbooks match the type and quantity of explosives removed from the magazines and input in the magazine inventory logbook. The blaster must maintain a personal log of all blasting work that the blaster performed (sec 21.4(4)). The employer must ensure that blasting logs are kept for at least 5 years after the completion of the blasting operation (sec 21.4(3)).

8.0 DISPOSAL OF EXPLOSIVES

8.1 MISFIRE DISPOSAL

Hangfire – delay in detonation

Mislight – Uncertainty whether the fuse is lit or not.

Misfire - a charge, or part of a charge, which, on initiation, fails to detonate or function,

All misfires shall be recorded in the Blasting Log (OHSR sec 21.4).

If an explosive charge/primer is known or suspected to have misfired, the Blaster shall suspend the blasting mission and ensure that the danger area remains closed and that no one approaches the misfire until the greater of the explosive manufacturer's recommendations or at least 30 minutes has elapsed since the time at which detonation should have occurred. (OHSR sec 21.73(2) and 21.78).

The blaster must make a thorough examination of the blast site after charges have been fired to determine that there are no unexploded charges remaining. (OHSR 21.74)

If there is evidence or suspicion of misfired charges or undetonated explosives, all loose unfired explosives must be collected and destroyed in a safe manner. Metallic equipment must not be used during this procedure. The area shall be adequately illuminated and only the Blaster and essential personal shall remain in the area. (OHSR 21.75)

The misfired charge/primer is not to be disturbed at any time. Placing and detonating a second primed charge beside it shall destroy it. The new charge shall not touch or disturb the misfired charge (OHSR sec 21.77). After the misfire is blown in place (BIP) the site will remain closed and under observation for an additional 30 minutes (OHSR sec. 21.78).

If misfires are suspected in an avalanche debris deposit, and machinery is required to clear the debris, the blaster of record must be onsite. The blaster of record is to keep to a minimum, the number of workers required to clear the debris and must be in direct control and supervise the work. Any misfires located or suspected will be handled as required by the OHSR 21.75(c)).

If the misfired charge/primer is not located, or the area is unsafe to approach, the zone affected shall be cordoned off. Attempts to locate the misfire shall be continued during and after spring snowpack "melt off" until the charge/primer is found and detonated. To facilitate these searches, if practicable all suspected misfires locations are to be recorded using GPS and photographed so that the area to be searched is minimized. Appropriate signage is placed to warn users of the hazard and to instruct what to do if they come upon a misfire. Signs must include contact telephone numbers. Signage will be located at access points to the area. Pretium management will be notified of the location, status, and plan to eliminate or mitigate the hazard of any misfire that occurs during blasting operations. Mountain Safety will subsequently inform the landowner and other involved parties (OHSR sec 21.77).

In the event that a misfire is discovered, only an experienced and qualified Blaster will carry out and ensure its destruction. The immediate area will be treated as highly hazardous and restricted to the absolute minimum personnel required to safely complete the task.

Proper belaying techniques must be used when accessing misfires in hazardous terrain with a potential to fall (OHSR Part 34). Non-sparking shovels will be used when digging for misfires within the snowpack. Confirmation of misfire disposal will be recorded in the Blasting Log (Manufacturers recommended safe working practices).

8.2 EXPLOSIVE DISPOSAL

Any explosive products requiring disposal will be dealt with according to the manufacturers' recommended procedures or as recommended by NRC/ERD.

9.0 REVIEW AND REVISION OF BLASTING PROCEDURES

Pretium Resources avalanche control blasting procedures will be reviewed annually, at a minimum, to ensure that industry standard best practices are being met or exceeded.

Blasting procedures are living documents, which will be continually reviewed. If Mountain Safety personnel recognize any situation where a change in procedure would increase safety and/or more effectively mitigate risk, the procedure will be presented to the Mountain Safety Superintendent for review and evaluation. Improvements to the blasting procedures and avalanche safety program will be submitted to WorkSafeBC for approval. The new procedure will be implemented only after WorkSafeBC has approved the procedure and operational personnel have been informed, educated, and trained.

10.0 SAFE WORK PLAN - AVALANCHE CONTROL BLASTING

Prior to every decision to initiate explosive avalanche control, the Blaster of Record and Mountain Safety team will complete an assessment of the area(s) identified for avalanche control.

The Blaster of Record leads the Mountain Safety team, required maintenance personnel, and pilot (if required) in completing a Safe Work Plan (worksheet found in ASP). This identifies potential hazards and applicable risk treatments to safeguard the entire team during the proposed avalanche control mission. The Safe Work Plan selects and documents:

- Safest and most effective control method
- Specific mis-light procedures
- Site-specific hazards and mitigations
- Danger Area: to choose appropriate locations of safe access and egress, and sweep route
- Communication channels and check-in procedures
- Equipment required for closure, sweep and clearing of debris
- Procedures for potential incidents or equipment failure (i.e. Helicopter malfunction, Vehicle breakdown)
- PPE - clothing, rescue equipment and blasting supplies
- Mental and physical preparedness of the Blasting team (including pilot for helicopter use)

The Mountain Safety team then makes a final “go” or “no go” decision to implement the Safe Work Plan and start the mission. Any member of the team (including the pilot in helicopter operations) has veto power to cancel the mission.

Road maintenance and traffic control personnel, as directed by the Blaster of Record, will follow road/work-site closure procedures to close and sweep the Danger Area (manually and visually). The Danger Area must be guarded and supporting personnel in communication with the Mountain Safety team (on main operational radio frequency).

The Danger area must be guarded by personnel in direct communication with the Mountain Safety team.

Once the Blaster of Record is satisfied that the Danger Area is secure, blasting may begin. The Blaster first leads a “dry” test run of the control method. The blasting team will fly to selected targets (no charges will be deployed) to ensure that flying conditions are adequate, and communication and shot placements are understood by all members of the team. The blasting procedures described in this document and any site-specific measures identified in the Safe Work Plan are followed.

<u>At the end of mission, the Blaster of Record will return to the site, by ground or air, to:</u>

- Observe and record avalanche control results (to CAA industry standard)
- Fully document the mission in the Blasting Log
- Re-assess site safety
- Notify road maintenance personnel (on main operational radio frequency) when the control mission is complete and it is safe to begin debris clearing. Mountain Safety then turns the area over to the Surface Ops Supervisor who directs that operation.
- Update personal Blasting logbook
- Debrief

11.0 OPERATIONAL PROCEDURES

11.1 AVALANCHE CONTROL WITH HELICOPTER DEPLOYMENT

Helicopter deployment of explosives is used as a risk reduction strategy, which allows for precision explosive placements in start zones, visual confirmation of road closures and control of multiple paths within a short time frame. Weather is the main constraint on the use of helicopters for avalanche control work.

Helicopter companies are required to have approval from regulatory bodies, which permits them to transport explosives. CAR 527 sets standards for personal safety and restraint systems.

11.1.1 EQUIPMENT

- Helicopter with radio on road/area closure frequency,
- Intercom headsets - 1 per team member (hot mikes required),
- Approved safety harness, slings and carabiners,
- Stopwatch,
- Field notebook and pencils,
- Explosives container for fused primers,
- Primers,
- ANFO Blasting Agent- up to 75% of the remaining allowable load,
- Zap Straps or electrical tape for closing ANFO bags after placing primers inside,
- Pull-wire lighters,
- Blasting tools and accessories,
- Camera and GPS to record misfire placements.
- Fuse cutters

11.1.2 PERSONNEL RESPONSIBILITIES

- All personnel must be TDG certified.

11.1.2.1 PILOT

- Operation and safety of the aircraft and occupants,
- Knowledgeable and experienced in helicopter avalanche control procedures,
- Familiar with the area

11.1.2.2 BOMBARDIER

- Responsible for the entire blasting mission (ref 3.2.1)
- Safety with the use of explosives,
- Direct pilot to do a test run of the area,
- Test all equipment prior to take off,
- Direct pilot to desired start zones,
- Ensure road closure is in place,
- Preparation of, ignition, and deployment of explosives,
- Observation of all results (and confirmation with Assistant).

11.1.2.3 ASSISTANT (OPTIONAL)

- Assist with visual closure sweep during fly-by check,
- Record closure confirmation,
- Aid the bombardier in directing the pilot to placements,
- Record the time of burning fuses,
- Record and spot the placement of charges,
- Record detonation times,
- Photos
- Record the observations, results, photograph or sketch areas where misfire has been dropped.

11.1.3 EXPLOSIVES PREPARATION

A minimum 1 meter fuse length is used on all explosive charges deployed from a helicopter. Primed charges are prepared prior to boarding the aircraft, at the last practicable moment, and as safely close to the helicopter landing as possible. Primed charges are carried and secured in easily jettisoned containers.

Pull wire igniters are transported separately from charges. Only pull wires are used to light safety fuse assemblies, and only one attempt at ignition is made (per manufacturers' requirements). Relighting a safety fuse is prohibited.

Primed ANFO charges may be carried in the helicopter under the following conditions (based on BC Ministry of Transportation – Avalanche and Weather Programs – Explosives Use Operational Plan):

- A minimum amount of fuse should be exposed outside of the bag (10-25cm),
- ANFO bags must be securely placed upright in the foot well of the helicopter or, if necessary, on the seat beside the bombardier,
- ANFO bags must be placed so as not to interfere with safety or efficiency of the mission (i.e. bags must not be stepped on to avoid crimping fuses or ripping bags),
- Only the amount of ANFO required for the mission and capable of being jettisoned by the Bombardier will be permitted on the flight.

11.1.4 PREFLIGHT SAFETY CHECKLIST AND PROCEDURES

All personnel involved in the blasting mission or working around the helicopter are required to be present for a pre-flight safety briefing, which includes:

- Safety in and around the helicopter,
- Safe refueling, explosive assembly, and helicopter loading areas,
- Individual and team experience levels,
- Weather conditions and related terrain access limitations,
- Fuel, personnel, and explosive load limits,
- Removal of door and/or seat cushion and/or practice opening and closing door,

• Safety instructions for ground support personnel,
• Mission-specific terrain considerations and safe standoff distances from blasts and avalanches in motion (dust clouds, airborne debris),
• Seating arrangements and associated pilot visibility limitations,
• Radio call signs and channels / frequencies for support and closure personnel,
• Intercom check,
• Targeting and guiding pilot to targets,
• Bombing run verbal commands,
• Emergency explosive jettison,
• Timing methods, especially for 90 seconds after first fuse of bombing run is lit,
• Mislight, misfire, and disposal procedures,
• Ensure understanding that any team member can abort the mission if they feel unsafe conditions are arising,
• Ground "dry" run to test: intercom, stopwatch and radio.
• Securing and testing Bombardier safety harness - approved harness with non-instantaneous release system, attached to the helicopter via Transport Canada certified anchor point, also wearing approved helicopter seatbelt. Ensure all required blasting tools are within easy reach of the bombardier. Verbal communication:

• Pilot: "Check your tie in"
• Bombardier: "Tie in checked and locked".
• Harness & tie-ins checked by Assistant

11.1.5 IN FLIGHT PROCEDURES

• Assistant starts recording - take off time, helicopter, pilot, date, avalanche area,
• Fly-by of Danger Area and road closure to ensure that the area is secure and clear of people & machinery.
• Pilot is directed to the first bombing location, target and elevation. Complete a test run over the area to determine wind and weather factors,
• Identify alternate safe misfire/mislight (see Sec 11.1.7 below) deposit site (ridge top or flat area) along the same path of travel, which can be reached in 15 seconds. Jettison time for misfires/mislights will follow the manufacturers' recommendations (0 to 15 sec),
• Bombardier readies primer and lighter on approach to target,
• Bombardier trims fuse and attaches pull wire igniter,

IN FLIGHT PROCEDURES VERBAL COMMUNICATION

- Verbal Communication:
    - Bombardier: “Pull wire on”
    - Assistant: “Pull wire on”,
- Bombardier directs pilot to shot placement,
- Bombardier removes pull wire safety mechanism,
- Verbal Communication:
    - Bombardier: “Safety is off”
    - Assistant: “Safety is off”,
- Bombardier lights fuse (directing lighter toward open door),
- Bombardier confirms ignition,
    - Bombardier: “Fuse ignited”
    - Assistant: “Fuse ignited”,
- Assistant starts stop watch/timer,
- Time is recorded,
- Bombardier sites target and drops charge forward, down and away from the helicopter, only when the helicopter is in slow flight speed or hovering,
    - Bombardier: “Shot is away, Shot stuck”
    - Assistant: “Shot is away, Shot stuck”
- If shot does not stick, helicopter will pull back to ensure to watch where the bag slides to, allowing confirmation of detonation.

- Verbal communication when all lit shots have been placed:
    - Bombardier: “All shots away”
    - Assistant: “All shots away”
    - Pilot: “All shots away”

- When more than one shot is being placed, placement will stop 90 seconds after lighting the first fuse to allow helicopter to move to safe location for observation of detonation and results,
- Assistant records results,
- Another bombing run can be initiated after confirmation of detonation,
- Once the bombing mission is concluded and the area deemed secure by the blaster of record, the area is turned over to the Surface Ops supervisor for debris clearing.

11.1.6 SAFETY PRECAUTIONS

• Helicopter standoff distances, including surrounding terrain and vegetation, are always monitored by all team members,
• Blaster of Record must visually evaluate Danger Area prior to blasting,
• Bombardier seating position has unobstructed views of shot placement.
• A charge (if primer only; not ANFO) is pushed down and away from the helicopter, while helicopter is facing uphill of slope. Bombardier's hand is on top of the charge with thumb facing down toward the ground,
• No more than three charges ignited on one run,
• Helicopter moves to identified safe zones while awaiting detonation,
• Bombardier keeps pull wire igniters separate from the primers, with igniters placed on primers at last possible moment,
• Bombardier must inform the pilot immediately of need to jettison explosives due to emergency situation or malfunctioning explosives,
• Pilot directs Bombardier to jettison explosives in event of aircraft malfunction, Assistant records location of discarded explosives,
• Pilot makes all go/ no-go decisions regarding safe flying conditions,
• Pilot always in direct communication with base and following standard check-in procedures,
• Combined weight of explosives and personnel not to exceed 75% of helicopter carrying capacity,
• No extra personnel or passengers allowed on or near aircraft during mission,
• Primers never assembled or dismantled in the helicopter,
• Explosive storage container constructed of non-conductive, non-sparking material.

11.1.7 MISLIGHT PROCEDURES

In the case of a mislight

- Pull wire igniters may not be removed once in place. If pull wire igniters come off while trying to light the safety fuse the charge must be treated as a mislight.

- <u>Verbal Communication of a mislight</u>
- The Bombardier notifies pilot immediately of a mislight.
    - Verbal Communication:
        - Bombardier: “I have a mislight”
        - Pilot:“Mislight”
        - Bombardier: “Can you safely make it to the alternate location (ridge top or flat area that is in the same direction of travel and immediately adjacent to target)?”
        - Pilot: Answers “Yes” or ”No”

        IF “NO”

        - Proceed calmly with original target and normal verbal communication.
            - Bombardier: “Shot’s away”
            - Pilot: “Shot’s away”

        IF “YES”

        - Proceed to the predetermined safe mislight location and use normal verbal communication (mislight will not be in the helicopter for more than 15 seconds total)
            - Bombardier: “Shot is away”
            - Pilot: “Shot is away”
    - This is not an emergency situation. Act calmly and ensure helicopter is clear of the Danger Area within 90 seconds of the first fuse being lit.
    - From a safe distance, landmark and observe blast to confirm detonation.
    - If charge detonates within normal expected time frame, record as normal, take note of suspected reason for mislight, and continue with mission.
    - If the charge does not detonate within expected time, record as misfire. Secure the Danger Area.
    - Follow Misfire and Disposal instructions (Sec. 8.1).

11.2 CASE CHARGING

Case charging is used as a control method for avalanche paths extending only a short distance above the road/worksite, which can be triggered by a charge placed on the road. Case charge procedures are reviewed and a Safe Work Plan completed prior to each mission to ensure team safety and mission effectiveness.

11.2.1 EQUIPMENT

• Appropriate vehicle,
• ANFO Blasting Agent,
• Boosters,
• Safety fuse assemblies,
• Pull wire igniters,
• Stopwatch,
• Field book and pencils,
• Radios on road closure frequency,
• Blasting tools and accessories,
• Hearing protection.

11.2.2 PERSONNEL RESPONSIBILTIES

The case charging team consists of a minimum of two people; Blaster of Record, Assistant, danger area Guard spotter as necessary. Only the Blaster of Record and Assistant shall be in the blasting area. If the spotter is used as the second person he/she must have a visual on the Blaster of Record, have communication protocol in place and be able to conduct an effective companion rescue in the event of an avalanche (OHSR 21.5(3)).

11.2.2.1 BLASTER OF RECORD

• Responsible for safe use of explosives,
• Tests all equipment prior to blasting,
• Ensures road closure,
• Selects safe location for spotter,
• Selects safe priming location close to the blasting site,
• Prepares, ignites, and deploys explosives on the slopes,
• Observes all results and confirms with the assistant,
• Destroys any misfires.

11.2.2.2 ASSISTANT REPONSIBILITIES

• Drives vehicle,
• Assists with closure confirmation,
• Records closure details,
• Keeps watch for natural avalanche activity that would be a safety concern and warning the Blaster in that event.

11.2.2.3 SPOTTER / ROAD GUARD(S)

• Maintain the danger area closure from a safe location outside of the danger area.

• Ensure that no personnel other than the Blaster and Assistant are in the danger area

• Warn the Blaster and / or Assistant of any natural avalanche activity that may become a safety concern.

11.2.3 EXPLOSIVES PREPARATION

A safe location (i.e. not subject to avalanche hazard), as close as possible to the blast site and specific to the target and avalanche path, is selected to prepare primers. Primer fuses are a minimum of 1 meter long and at the discretion of the Blaster of Record may be double fused to ensure ignition. Primer assembly occurs at the last practicable moment (OHSR sec. 21.85.2). All pull wire igniters are transported in a waterproof container, separate from the blasting agent and primers.

11.2.4 PROCEDURES

• Close and sweep Danger Area to be clear of people,

• Place /guard outside of Danger Area, equipped with signal device and radio,

• Prepare explosives,

• Any assembled primers transported for a short duration (path and target specific) must be kept separate (OHSR sec. 21.24) from other explosive products,

• Drive to target location,

• Park vehicle, with engine running, between the slope & the charge location to protect the blaster.

• Place explosives for maximum effectiveness, at pre-selected location on a bamboo tripod, pillow of snow or above gravel shoulder opposite path being controlled,

• If fuse is confirmed not lit, Blaster alerts the team by announcing “mislight”. Other members of team repeat, “mislight” to acknowledge. Refer to mislight procedures (Sec 11.2.6),

• If fuse is confirmed lit, Blaster and Assistant(s) drive out of Danger Area to pre-determined safe location and await detonation. In event of vehicle malfunction, team walks quickly to exit Danger Area,

• Observations are recorded,

• When the mission is completed, the Blaster contacts the road supervisor who then initiates road clearing procedures.

11.2.5 SAFETY PRECAUTIONS

• If natural avalanche activity is noted on the slopes to be controlled, the blasting mission will be suspended.
• Clear line of sight between case charging location and start zone,
• Case charge short slopes only,
Spotter/guard properly equipped and trained in avalanche companion rescue.
• Multiple charges detonated sequentially and separately,
• All personnel leave the Danger Area after ignition,
• All team members to wear hearing PPE.

11.2.6 MISLIGHT PROCEDURES

• Pull wire igniters will not be removed once in place. If pull wires come off while attempting to light the safety fuse, the charge will be treated as a mislight.
• Blaster calls out “mislight”, and team member(s) acknowledge.
Follow Misfire and Disposal procedures (sec. 8.1).

11.3 HAND CHARGING

Avalanche control by hand charging is carried out by a blasting team on skis who use explosives to trigger start zones from safe terrain. Hand charging enables the blaster to conduct effective avalanche control in weather unsuitable for helicopter flight and where case charging is unfeasible due to avalanche path characteristics.

The Blaster and Assistant(s) shall be clothed and equipped to safely conduct avalanche blasting in severe weather conditions. Both will be competent in companion rescue.

All safety procedures and regulations shall be adhered to when transporting explosives on skis.

11.3.1 EQUIPMENT

1. Explosives
2. Safety fuse assemblies (minimum 1m length),
3. Pull wire igniters,
4. Stopwatch,
5. Field book and pencils,
6. Radios - on appropriate frequency,
7. Blasting tools and accessories,
8. Hearing protection,
9. Ski and rescue equipment, including beacon, probe, and shovel.

11.3.2 PERSONNEL RESPONSIBILTIES

Blaster of Record and one assistant make up the blasting team. Both must be: proficient in backcountry travel on skis, capable of moving through mountainous terrain in adverse weather conditions, prepared for emergency situations (including equipment to spend the night in the backcountry if required), proficient in avalanche search and rescue techniques, and carrying portable radios (OHSR 21.5(3)).

11.3.2.1 BLASTER

• Safety with the use of explosives and the entire blasting mission,
• Test all equipment prior to blasting,
• Ensure road/area closure completion,
• Ensure all members are familiar with the route plan and blasting procedures,
• Select safe priming location close to the blasting site,
• Select hand charging placements
• Prepares, ignites and deploys explosives,
• Observe results and confirms with the assistant,
• Construction of primers,
• Place pull wire igniters on primed charges,
• Throw hand charges,
• Destruction of misfires

11.3.2.2 ASSISTANT

• Assist with closure confirmation,
• Record closure confirmation,
• Keep watch for natural avalanche activity that could be a safety concern,
• Ensure all members are familiar with the route plan and blasting procedures,
• Construct of primers,
• Select hand charging placements,
• Place pull wire igniters on primed charges,
• Throw hand charges.

11.3.3 EXPLOSIVES PREPARATION

Assembly of hand charges takes place at the last practicable moment and in a safe, sheltered location as close as possible to the control route. In ideal circumstances, assembly takes place at the blast site.

Primers are placed in their carrying packs, with no flammable or sparking materials present. Pull wire igniters are transported in waterproof bags in a separate pack from the primed charges.

Disassemble as per manufactures instructions.

11.3.4 PROCEDURES

- Initiate closure procedures and proceed to the first target area,
- Ensure closure and sweep completion, such that all areas affected by the blast are clear of people, via both radio and visual confirmation, as per :
- Prepare primers at the last practicable moment and location. In the case of pre- assembled primers, remove from pack and put pack back on, as per:
- Trim fuses immediately before attaching pull-wire igniters. Once attached, verbally communicate, “pull wire on” and ensure the other team member understands.
- Light the igniters, observing for at least 5 seconds, and no more than 15 seconds, to ensure ignition. Verbally communicate, “fuse lit” and ensure the other team member understands. Verbally communicate “fire in the hole”.
- If the fuse is not burning, blaster will announce “mislight” to the assistant, who will repeat “mislight” to ensure that they understand. Refer to mislight procedures.
- If the fuse is lit, the blaster will toss the charge into the desired location,
- Move quickly and safely to a predetermined safe location and, , await detonation,
- Record blast observations, and repeat the above procedures for each additional hand charging location.
- Visually inspect blast site to verify detonation of all charges
- In the case of misfire, refer to misfire procedures.
- Contact surface ops supervisor or designate upon completion of blasting mission to initiate road clearing procedures.

11.3.5 SAFETY PRECAUTIONS

- Blasting team will be in direct communication at all times;
- Pull wire igniters will not be attached to primers until both team members are prepared to move to the predetermined safe location;
- Both members will leave the danger area after the fuse is lit;
- The length of the safety fuse will be increased as necessary to ensure adequate time for the team to reach the safe location;
- Disassembly of cast explosive primers may only be done if recommended by the manufacturers of both primer and SFA. Any other type of explosive must be detonated. The control team trained for each shipment and type of explosives must review the manufacturer's recommendations.

11.3.6 MISLIGHT PROCEDURES

- Follow Misfire and Disposal instructions (Sec. 8.1).

11.4 NITRO EXPRESS AVALAUNCHER

Prior to active explosives control with these guns, all Avalauncher endorsed Blasters must read and understand the Nitro Xpress user manual and go through on-site training. Copies of the manual will be found in the avalanche office(s), on the shared electronic drive and a copy is to be brought to each shoot location and procedures are to be followed step by step.

11.4.1 ABOUT AVALAUNCHERS

The Avalauncher is a two-chambered pneumatic cannon, designed for projecting an impact-detonated explosive projectile into otherwise inaccessible targets. Limitations occur during strong crosswind conditions, which adversely effects projectile flight trajectory.

The Avalauncher is capable of delivering up to a +/-1.4 kilogram explosive projectile (using a 15' launch tube) to avalanche start zone locations within a range of 1200 meters. The Avalauncher can either be mounted on a mobile vehicle or a fixed platform. Mobile units can be transported to access targets on avalanche paths where fixed units have not been established.

Avalauncher explosive payloads and detonators will be transported separately, with detonators in a crush proof container. Tailfin assemblies will be transported in a secure container. Nitrogen used for pressurizing the cannon will be securely mounted on the mobile unit such that it does not obstruct the gun's range of motion. All persons and explosives must be behind the barrel at a minimum distance of 100 feet and the remote firing device must be used when firing is occurring. Firing will be done from a safe distance (11.4.5).

11.4.1a BASIC OPERATION:

- Test fire the gun as per manufacturer's instruction.
- The gun is aimed by altering the azimuth of the gun on the turntable, and raising and locking the barrel to the desired elevation, as marked on the target sheet.
- The projectile is placed in the breech and the safety pin is removed.
- Nitrogen is let into the cylinder until the required pressure is reached
- When the safety and fire valve are released, the measured amount of Nitrogen is released behind the piston. Tank pressure then forces the piston back to clear the muzzle gland, which frees the gas in the tank(s) to enter the launch tube to accelerate the projectile out of the barrel via the base plate.
- Once the projectile is in the air, the base plate is pulled off by air resistance, the spring loaded flight safety cross pin is ejected, and the charge is armed.
- When the projectile impacts snow or rock, the striker pin is dislodged from the magnet holding it in place, so the pin slides forward, igniting the shot shell primer, which sets off the detonator, and subsequently the payload.

11.4.1b EQUIPMENT

- 4X4 truck, snow cat, trailer or tower with Avalauncher securely mounted,
- Compressed Nitrogen,
- Electric firing switch
- Measumax Digital Protractor
- Nitrogen Regulator and filling hose
- 10” crescent wrench,
- Field book and pencils,
- Shot cards,
- Radios – on road closure frequency,
- Hearing protection,
- Transceiver , probe, shovel
- Avalauncher repair kit,
- Shovel and broom,
- Chainsaw file,

- Projectile, consisting of:
    - Payload with a cap well - 1.1 kg,
    - CIL Avalauncher High strength detonator,
    - Plastazote pillow spacer
    - Plastic tailfin assembly (see below),

- Tailfin, consisting of:
    - ’Base-plate’ - holds a spring-loaded striker pin, which is held in place via the ‘arming wire’,
    - Flight safety cross pin’ and compressed spring, which is a second safety for the striker pin,
    - ‘Magnet’ - holds the striker pin in place until impact,
    - ‘Ferrule’ - small charge located between the striker pin and the detonator placement,
    - ‘Magnet Anvil’ – strikes the ferrule on Impact,
    - ‘Thumbscrew’- prevents the fin from unscrewing.

11.4.2 PERSONNEL RESPONSIBILTIES

The Avalauncher crew consists of a Gunner (Blaster of Record) and Assistant gunner. The Gunner must hold a valid WCB blasting certificate with an Avalauncher endorsement and is responsible for the entire blasting mission.

Any member of the blasting team may call a halt to the avalanche control mission if they believe that worker safety is, compromised.

Both crew members must be proficient in avalanche companion rescue techniques and carry portable radios.

11.4.2.1 GUNNER

- Safety with the use of explosives and the entire blasting mission (OHSR 21.5(3)),
- Assembly of charge
- Transportation of explosives,
- Test all equipment prior to blasting,
- Ensure road closure,
- Set and check required pressures, elevations and azimuths,
- Handle the safety lever and the fire valve,
- Fire the gun,
- Ensure all members are familiar with the control plan and blasting procedures,
- Train the Assistant Gunner.

11.4.2.2 ASSISTANT GUNNER

- Transportation of explosives,
- Check pressure in Nitrogen cylinders,
- Crack valve on Nitrogen cylinder to remove any snow,
- Attach regulator to nitrogen cylinder,
- Handle the barrel,
- Load the projectiles,
- Remove the cotter key rings and pins,
- Visually check that the closure area is clear,
- Record the observations.

11.4.2.3 GUNNER AND ASSISTANT GUNNER

- Clean the deck of snow and ice. Check pressure in Nitrogen cylinders,
- Projectile preparation
- Equipment preparation

11.4.3 MATERIAL TRANSPORTATION AND EXPLOSIVES PREPARATION

Avalauncher charges, detonators and tailfins are transported separately to the gun and are primed at the gun (OHSR 21.21). The detonators are transported in a crush proof container. The nitrogen is secured in two aluminum boxes on the deck of the trailer with the shipping caps protecting the valves. When practicable the cylinders should be transported in an upright position (OHSR5.3.8 (2)). Minimums of two bottles are to be on the deck and replaced as necessary.

At the shooting location:

- The assembly of the Avalauncher round will take place at the last most practicable moment at the site, immediately prior to placing each projectile in the breech. Projectiles are to be assembled one at a time. Follow manufactures assembly procedures in APPENDIX C for the Classic Snowlauncher.

11.4.4 FIRING PROCEDURES

For preparation and firing sequence of the B2000 MK2 follow manufacturer's instructions step by step in APPENDIX A.

11.4.4.1 PROCEDURE FOR SHUTDOWN

Follow manufacturers' instructions step for step in APPENDIX A

• Inform closure control personnel of the termination of the Avalauncher mission

• Return the unused explosives and detonators (if any) to their respective magazines.

• Cover and secure the Avalauncher.

11.4.5 SAFETY PRECAUTIONS

- Fire remotely using the Electric Firing Switch and or behind a blast shield
- No talking, other than shooting sequence commands, shall occur during or immediately preceding firing.
- Cotter keys and pins shall be shown to the gunner to ensure that the projectile firing train is in the armed position.
- Cylinders of compressed nitrogen must be transported and secured from movement with their protective caps in place.

11.4.6 MISLIGHT SAFETY PRECAUTIONS

- Fire remotely using the Electric Firing Switch and or behind a blast shield
- No talking, other than shooting sequence commands, shall occur during or immediately preceding firing.
- Cotter keys and pins shall be shown to the gunner to ensure that the projectile firing train is in the armed position.
- Cylinders of compressed nitrogen must be transported and secured from movement with their protective caps in place.

11.4.7 MISFIRE – FAIL TO CLEAR – DROP SHORT PROCEDURES

- From a safe distance, landmark and observe the blast to attempt to confirm detonation.
- If the charge detonates within the normal expected timeframe, record as per normal, and continue with mission.
- If the charge does not detonate within the expected timeframe record the charge as a Misfire. Treat the Danger Area as highly dangerous, keep the area secure and suspend the control mission for at least 30 min or as recommended by the manufacturer.
- If an undetonated payload is suspected in the avalanche debris, the Blaster of Record works with the snow clearing operator and equipment until the Avalauncher round is located or the debris is cleared.
- Follow Misfire and Disposal instructions (Sec. 8.1)
- Since most Avalauncher target areas are inaccessible in winter and the projectiles bury themselves deep in snow, they may be left in place until spring melt-off if disposal attempts are deemed unsafe. After melt-off, a blasting team conducts a search; any misfire located is detonated on the spot by a live primer placed beside, but not touching, the misfired charge. All payloads contain a Recco tab to allow for use of the Recco wand to assist in locating Misfires.

- Hazard warning signs describing the various misfires that may be found will be posted for easy public notice and left in place throughout the year.
- If the projectile does not clear the barrel upon firing:
- Push the projectile back to the breech end of the barrel as per manufacturer recommendation. Ensure the flight safety cross pin is properly secured to the striker pin prior to removing the avalauncher round from the barrel for inspection.
- If the projectile drops short of correct flight after clearing the barrel:
    - Stop the control mission.
    - Treat as Misfire (see above)
    - Inspect gun thoroughly, contact manufacturer as required (OHSR 21.36).

11.4.8 STORAGE

- Per manufacturer's recommendation, storage in the summer months should be in an enclosed building with the gun barrel at a negative inclination. Prior to storage, perform general maintenance outlined in the manufacturer's instructions.
- Grease the nipples on the turntable.
- Cover the end of the barrel.
- Pressurize the chamber to 5psi.

11.5 CORNICE CONTROL

Cornice control is performed with the use of explosives when cornices build up to unsafe proportions. This is often done with a trunk line of explosives, which combines a series of explosives connected with detonating cord to detonate them simultaneously. The Blaster and Assistant(s) shall be clothed and equipped to safely conduct avalanche blasting, in accordance with recommendations of the Canadian Avalanche Association or as required by Worksafe BC Occupational Health and Safety Regulations (OSHR) (Part 8: Personal Protective Clothing and Equipment). Approved activity specific headgear will be worn as per Section 8.11(2)-2 Safety headgear must be worn by a worker in any work area where there is a danger of head injury from falling, flying or thrown, objects, or other harmful contacts. Blasters will be trained and ensure a fall restraint system is in place and the blaster is on belay if working in any hazardous terrain with the potential for a fall as per (OHSR Part 34 and Part 11).

11.5.1 EQUIPMENT

1. Detonating cord
2. Pentex Boosters and/or ANFO,
3. Safety fuse assemblies,
4. Approved sit harness
5. UIAA approved rope
6. Webbing/locking carabiners,
7. PVC Punch or Ice auger,
8. Pull wire igniters,
9. Blasting Log
10. Time piece,
11. Radios on road closure frequency,
12. Blasting tools and accessories,
13. Hearing protection.

11.5.2 PERSONNEL RESPONSIBILITIES

The team consists of a Blaster of Record (OHSR 21.5(3)) and Assistant. The Blaster is responsible for all aspects of the mission. There shall be a minimum of two persons, in certain instances additional personnel maybe required to provide an effective belay system for the working area (OHSR Part 34, Part 11).

11.5.2.1 BLASTER

- Safety with use of explosives,
- Trained in fall restraint (OHSR Part 11) or qualified rope technician (OHSR Part 34)
- Test all equipment prior to blasting,
- Check and test of rope safety system used,
- Ensure road closure completion,
- Select location of watchman,
- Select safe priming location close to the blast site,
- Prepare, ignite and deploy explosives,
- Observe all results and confirm with the assistant,
- Destruction of misfires.

11.5.2.2 ASSISTANT

- Assist with closure confirmation,
- Record closure and blasting information,
- Trained in fall restraint (OHSR Part 11) or qualified rope technician (OHSR Part 34) Check and test rope safety system,
- Keep watch for natural avalanche activity that could become a safety concern.

11.5.3 EXPLOSIVES PREPARATION

A safe location, not subject to avalanche hazard, as close as possible to the blast site, is selected to prepare primers. Fuses on primers are a minimum of 1 meter in length. Assembly occurs at the last practicable moment (OHS sec 21.85.2)

All pull wire igniters are transported in a waterproof container, separate from the blasting agent and primers.

11.5.4 PROCEDURES

- Ensure Danger Area is closed and swept of people.
- Follow Cornice Control Procedure Access Work Plan and JHA
- Build and test anchor
- Both Blaster and Assistant inspect all aspects of the belay system.
- Blaster finds edge of ground where the snow becomes cornice, by probing while harnessed on belay. Where the snow becomes cornice is known as the Safe Line. Workers must be harnessed and on belay while approaching this line and no one will work beyond it.
- The person preparing the holes is harnessed and belayed from an anchor point behind the Safe Line.
- Prepare holes for the insertion of the explosives near the edge of the ridge where the cornice leaves the rock.
- Holes can be punched into the cornice with a 4” diameter PVC pipe, having a webbing loop to retract the pipe, or with a manual snow auger. Holes should be at least 1 meter deep or into harder mature layers of cornice. The distance between holes varies with size and nature of the cornice and will be determined by the Blaster of Record.
- Arm the explosive with 2 to 3 meters of detonating cord. The detonating cord must be long enough to extend out from the hole to behind the Safe Line where the trunk line can be connected.
- Pentex Boosters have the detonating cord passed through the charge and tied with an overhand knot on the end to prevent it from pulling through. The length of detonating cord leading from the explosive is referred to as the branch line.
- Holes are lightly back filled with snow to contain the explosion behind the cornice.
- The trunk line of detonating cord is laid out at a ninety-degree angle from each branch line placed in a hole. Branch lines are only connected to the trunk line once all branch lines have been extended into the safe working area beyond the working line and the blaster is not on the cornice roof. The branch lines are then connected to the trunk line with a double half hitch or clove hitch. It is very important to ensure the trunk lines and branch lines run in straight paths so the detonating cord does not cross over itself, which

can interrupt the explosion series.

- Blaster double checks that there are no crosses in either the trunk line or the branch lines and that each connection to the trunk line is tight and secure.
- Blaster connects a safety fuse assembly to one end of the trunk line by folding 3” of the trunk line end over and securing the detonating end of the safety fuse assembly with electrical tape, directing the charge in line with the trunk line.
- The trunk line is now armed and ready for ignition.
- Blaster visually sweeps the Danger Area, confirms closure with guards, and notifies Dispatch by radio that avalanche control is commencing.
- Blaster places the igniter on the safety fuse assembly and verbalizes for team members “igniter on”,” safety off”, “3, 2, 1, fire”. Blaster confirms ignition, verbalizes “fire in the hole (cornice name here)” over the radio, and retreats to a pre-designated safe area with the Assistant to await detonation.
- If Blaster is sure the fuse is not burning, they alert Assistant by announcing, “mislight”, Assistant repeats to acknowledge. Refer to mislight procedures (Sec 11.6.6).
- After detonation, Blaster inspects site for complete consumption of explosive materials. If explosive materials remain or a “dud’” is suspected, Blaster informs Dispatch, posts a guard, and follows WorkSafeBC and manufacturers’ recommended disposal procedures.
- Once blasting mission is complete and Danger Area is clear, Blaster contacts closure personnel whom initiate road-clearing procedures.
- Blaster may decide to blast the cornice by lowering a primer or primed bag of ANFO over the cornice lip, using resulting concussive blast to lift and break the cornice.

11.5.5 SAFETY PRECAUTIONS

- Persons performing cornice control with the use of explosives will have the WCB cornice control endorsement.
- Persons performing cornice control will have training and follow Cornice Control Procedure Access Work Plan and JHA
- Training for this procedure will be done prior to the start of the control mission.

11.5.6 MISLIGHT PROCEDURES

- Pull wire igniters must not be removed once in place In the event of a mislight, follow mislight procedures
- The Blaster notifies the blasting team by announcing “Mislight”, Assistant repeats, “Mislight” to acknowledge.
- From a safe distance, Blaster landmarks and observes the blast to attempt confirmation of detonation.
- If the charge detonates within the normal expected timeframe, record as per normal and note possible reason for mislight, continue with mission.
- If the charge does not detonate within the expected timeframe, record charge as misfire. Treat Danger Area as highly dangerous, keep secure, and suspend the control mission for at least 30 min.
- Follow Misfire and Disposal instructions (sec 8.1).

12. WYSSEN AVALANCHE TOWER: EXPLOSIVES USE PROCEDURE

12.1 INTRODUCTION

Wyssen Avalanche Towers (WAT) is used for avalanche control between kilometer 58 and 61.5. A WAT is a remote avalanche control system (RACS) that an avalanche technician with a valid blasting certificate uses to deploy explosives into an avalanche starting zone. The system is operated from a safe location on the access road/base computer by means of a digital interface (e.g. tablet or laptop computer) connected to an encrypted communication system (e.g. radio). Explosives are dropped by remote mechanism from a removable deployment box installed at the top of a tower and are suspended several metres above the snow surface. The deployment box holds up to twelve explosive charges (up to 5 kg) that are detonated individually.

These procedures describe blasting equipment used with the WAT, personnel training, the assembly and loading of explosives in the tower deployment box, flight operations for transport of the tower deployment box by helicopter, deployment of the explosives using the remote system, and misfires.

Procedures are in accordance with the following:

- WorkSafe BC (WSBC) Occupational Health and Safety Regulations (OHSR)
    - Part 21 – Blasting Operations
    - Part 29 - Aerial Operations
- Natural Resources Canada Explosive Regulations
- Transportation of Dangerous Goods Regulations Part 12.12 – Aerial Work
- Wyssen Avalanche Tower LS12-5 G3 Instruction Manual (v 3.8, July 2017).

12.2 EQUIPMENT FOR BLASTING

The WAT system components and the equipment used for the assembly, loading and transport of the explosives and tower deployment box are listed below. Further detail of the system components can be found in the WAT Instruction Manual, Wyssen Avalanche

12.2.1 SYSYEM COMPONENTS

- Wyssen Avalanche Tower LS12-5 G3;
    - The tower deployment box (Figure 1);
    - The complete Wyssen Avalanche Tower (Figure 2);
- Wyssen Helicopter Latch HK-02 (Figure 3);
- Web-enabled device (PC, notebook, tablet, smartphone)
- WAC.3 base for radio communication with avalanche tower

12.2.2 EXPLOSIVE CHARGE COMPONENTS (Materials per Charge)

- Explosives charge (up to 5 kg);
- Safety fuse assemblies, 30 cm (variance (VR201900088), 2 units;
- Wyssen percussion fuse lighters, 2 units;
- Wyssen charge container, 1 unit;
- Cord, 3 mm, approx. 7.5 m in cord sack for charge suspension, 1 unit;
- Wire hooks for connecting pull wire lighters to cord, 2 units;
- Retaining ring to connect suspension line to the cable dropper, 1 unit;

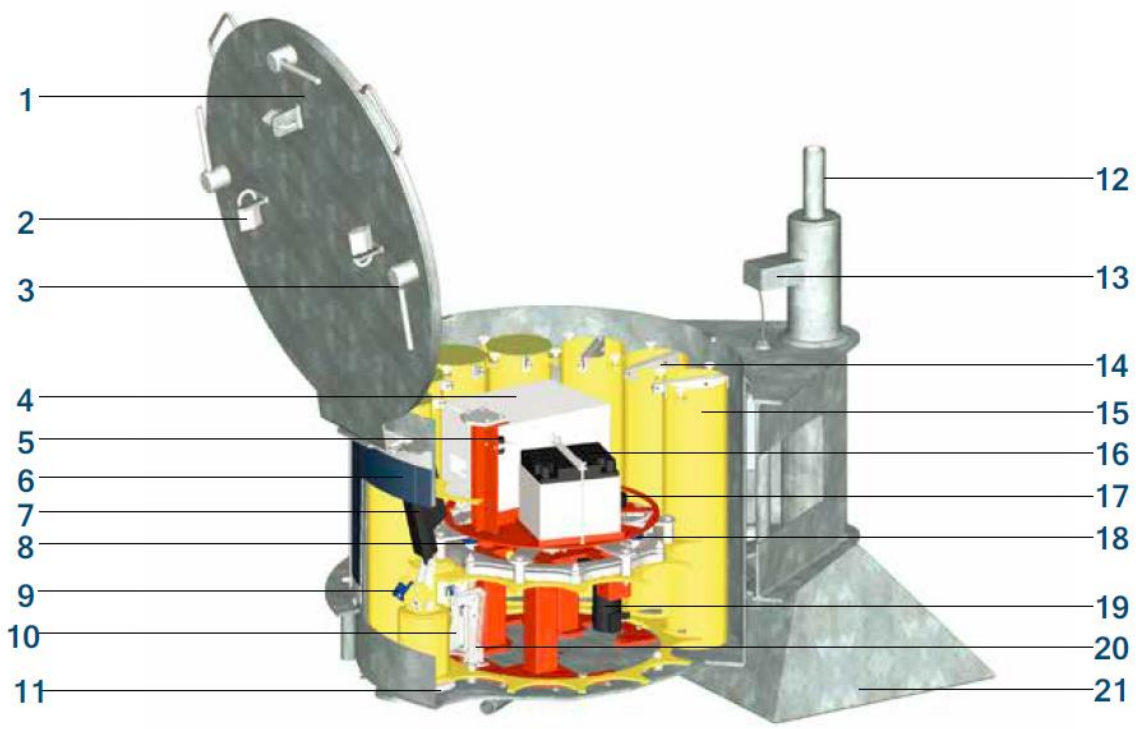
- RECCO reflector, 1 unit.

12.2.3 Accessory Tools

- Fuse cutters;
- Punch tool;
- Eye protection;
- Gloves

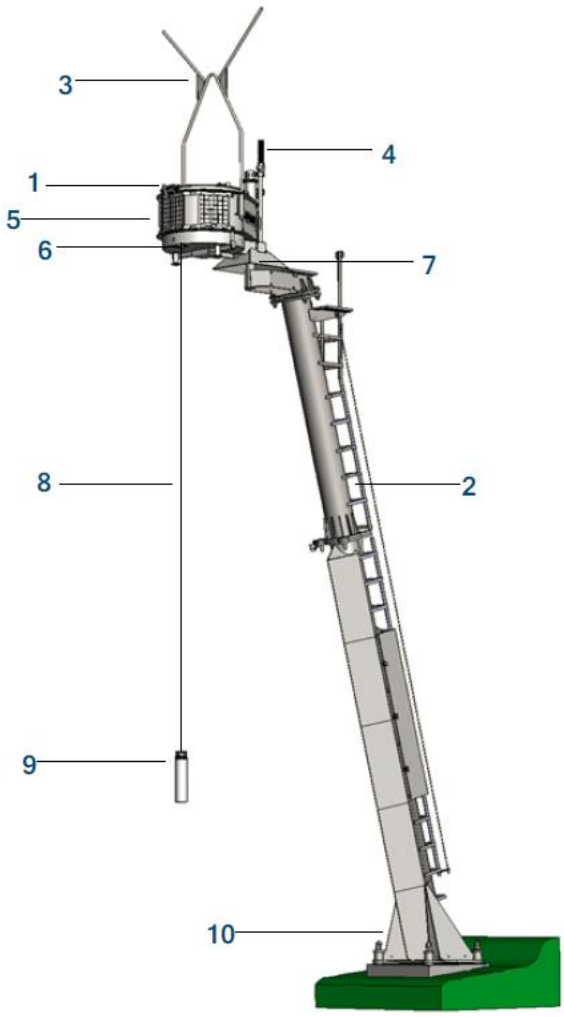
12.2.4 Other

- Portable radio(s)
- Keys for WAT deployment boxes and control unit.
- Locks for WAT deployment boxes
- Container for safety fuse assemblies
- Quality control checklist



1	Magazine-box cover	12	Antenna holder (antenna not shown)
2	Padlock 3 items	13	Monitoring sensor for the correct position of the magazine-box on the tower
3	Turn lock		
4	Control system with operating buttons on top	14	Cable dropper
5	Seismometer	15	Tube holder
6	Solar panels	16	Battery 12V
7	Lock cylinder	17	APOS: Goniometer potentiometer, analogue
8	DPOS: Carousel position switch, cam-controlled	18	RPOS: Carousel rest position end switch
9	Lock cylinder position switch	19	Gear motor
10	LPOS2. Charge detection switch	20	LPOS1. Charge drop detection switch
11	Dropping hole	21	Insertion funnel

Figure 1. Components of the tower deployment box.



1	Magazine-box	6	Dropping hole
2	Tower	7	Mounting installation
3	Transport hanger for helicopter	8	Retaining line for the charge
4	Radio aerial	9	Dropped charge
5	Solar panel	10	Foundation plate with rock anchors or micropiles

Figure 2. Components of the complete Wyssen Avalanche Tower system.

Figure 3. Wyssen Helicopter Latch HK-02.

Figure 4. Assembled WAT explosive charge.

12.3 DOCUMENTATION

Inspection, testing, maintenance, loading, and use of the Wyssen Avalanche Towers will be carried out in accordance with the manufacturer's recommendations and following the standard procedures outlined in the WAT Instruction Manual, including recommendations for:

- Charge construction;
- Loading and unloading the deployment box with explosive charges;
- Transport of the deployment box by helicopter;
- Seasonal recommissioning and decommissioning; and
- Maintenance.

The maintenance section of the manual includes inspection and maintenance instructions, maintenance schedule and procedures in case of a malfunction. The supplier provides a 24-hour telephone service in the case of a system malfunction.
Records of inspections, pre-season and post-season maintenance, and testing will be maintained. A copy of the Avalanche Safety Plan, WAT Instruction Manual and Explosive Use Procedures will be kept at the work site and made available to technicians using the system.

12.4 PERSONNEL ROLES AND RESPONSIBILITIES

12.4.1 TRAINING AND CERTIFICATION

Personnel who perform charge assembly, loading, coordinating aerial transport and operating the WAT (either for testing or operational use) will have the following training and certifications:

- Site orientation;
- WHMIS training;
- TDG certification;
- WorkSafe BC blasting certificate for avalanche control;
- Wyssen Avalanche Tower specific training provided by an authorized Wyssen representative, covering the following topics:
    - System components, including maintenance and function tests;
    - Communication system operation and tests;
    - Pre-season maintenance requirements;
    - Charge assembly and loading;
    - Aerial transport operations;
    - Misfire procedures; and
    - Post-season decommissioning.

12.4.2 PERSONNEL

The avalanche control team consists of a Blaster of Record (Team Leader) and Assistant(s).
The **Blaster of Record** will be an experienced person meeting the training and certification requirements listed in Section 12.4.1 of these procedures. The Blaster of Record is responsible for safety of the entire operation, including the direct supervision of all aspects of the assembly of charges, loading, testing, operational use and unloading of explosives during post-season decommissioning.
The **Assistant(s)** is responsible for assisting the Blaster of Record with the same tasks described above, as well as observing for anomalies during assembly and loading of explosives.

12.5 OPERATIONAL PROCEDURES

The operational procedures are presented in three sections for each of the following periods of use: commissioning the system at the start of the season, operational use and decommissioning the system at the end the winter season. Personnel performing the tasks described below will meet the training and certification requirements list in Section 12.4.1 of the procedures. A Blaster of Record will be designated for explosive charge assembly, loading, and helicopter transport of the deployment box, testing and operations.

12.5.1 PRE-SEASON COMMISSIONING

Prior to the start of each winter season, several tasks are required to prepare the system for use. This includes inspecting all system components, assembling the explosive charges, loading the deployment boxes and transporting the deployment boxes to the towers. The charge assembly and loading area will be least 400 m from inhabited areas and if necessary the privately travelled road will be closed. This area will be secured a minimum of 50m in all directions during arming of the system to

prevent unauthorized access.

12.5.1.1 PREPARING THE DEPLOYMENT BOX

1. The docking system spike on the tower is to be cleaned and greased. Smooth out any irregularities, burrs, or edges with a coarse file. Apply a thick layer of waterproof and low temperature grease to the spike (grease brand/properties approved by Wyssen).
2. The battery (ies) on the deployment box are charged with a voltage of 12.8 V.
3. Position the deployment box to ensure that there is not more than 30 cm of free height below the bottom of the deployment box (deployment hole).
4. Prior to loading, each deployment box is located such that it is moved less than 50 m to the helicopter attachment point.
5. Open all padlocks on the cover and turn the locking level through 90°.
6. Lift the cover using handles provided until the safety catch engages.
7. Set all sliders of the cable droppers into the rear (open) position.
8. Remove the tube holder covers.
9. Remove cable droppers from the tube holders.

12.5.1.2 EXPLOSIVE CHARGE CONSTRUCTION

1. <u>Preparation of the charge container:</u>

a. Insert the explosive cartridge(s) into one half of the plastic shell. Ensure the cartridge(s) sits at the bottom end of the plastic shell.
b. Snap the second half of the plastic shell together with the first one, starting with the tabs at the bottom of the shell working upwards.

2. <u>Preparation of the retaining cord:</u>

a. Guide the retaining cord through the four holes on the top end of the plastic shell join the two ends with a Flemish bend (aka Figure-8 follow–through knot).
b. Release the cord attached to the back of the pre-assembled cord sack and then fasten the sack with a girth hitch to the retaining cord.
c. Clip the spring hooks into the eyelets of the percussion fuse ignitor and insert the cord sack with the end (ring) on top.
d. A quality control inspection is conducted for each charge by a second trained person, completely independent of the construction process. This inspection will confirm the charge is assembled correctly following the procedure described above.
e. The inspecting person places a RECCO reflector on the inside of the charge container.
f. The inspecting person then places the foam stopper on the top of the cord sack to secure the inserted retaining cord and percussion fuse ignitor.
g. Charges are temporarily stored in a secure manner, e.g. in the charge container box.

3. <u>Preparation of the safety fuse:</u>

a. Prepare the safety fuse assemblies by cutting the fuse to a length of 30 cm, only cut safety fuse assemblies as needed to assemble a charge. Then move onto the next charge. **Do not precut safety fuse assemblies!**

4. <u>Priming of the charge:</u>

a. Loosen the screw sleeves at the bottom of the percussion fuse ignitors by approximately 1 turn and remove the plug. Do not unscrew completely. Hold the ignitor at the top with one hand to prevent twisting. ***NOTE: If the ignitor should be completely unscrewed, do not reassemble; this ignitor must not be used.***
b. Push the free end of the safety fuse assembly fully up into the ignitor and firmly tighten the screw sleeve (compression fitting). Hold the ignitor by the lug with one hand while tightening the screw sleeve in order to prevent twisting. Repeat for the second safety fuse assembly.
c. Pierce explosive cartridge(s) with the punch tool through the side holes in the plastic shell and insert the detonator on the safety fuse assembly securely into the cartridge. Repeat for the second safety fuse assembly.
d. Clip the safety fuse assemblies into the plastic clips on the inside of the plastic shell.
e. A quality control inspection is conducted for each charge by a second trained person, completely independent of the construction process. This inspection will confirm the charge is primed correctly following the priming procedure described above.

12.5.1.3 LOADING THE DEPLOYMENT BOX WITH EXPLOSIVE CHARGES

1. Bring the prepared explosive charge to the deployment box and set it down on the surface next to the flashing light. The prepared charges should never be handled or transported one-handed.
2. Carefully remove the foam stopper from the charge while ensuring the retaining cord stays in place.
3. Take hold of the explosive charge on the inside of the plastic shell through the holes at the upper edge of the tube and carefully insert the charge into the tube holder, beginning with Tube #12 and working in descending order.
4. Attach the ring on the end of the retaining cord to the cable dropper by inserting the ring into the center slot on cable dropper and push the slider to the front extended (closed) position, which holds the ring. The slider is released into the front position by pressing the metal pin at the bottom of the cable dropper.
5. Lay the cable dropper into the notches of the tube holder so that the ball bearings point to the center of the deployment box. Both recesses in the cable dropper must lie within the tube holder to prevent the cable dropper from shifting.

6. Ensure the retaining ring is correctly mounted in the cable dropper. After this check, avoid touching the cable dropper.
7. Once the deployment box is fully loaded, a quality control inspection is conducted for each charge by a second trained person, completely independent of the construction process. This inspection will confirm the charge is assembled correctly following the procedure describing the preparation of the retaining cord, the attachment of the cord sack, spring hooks and the ring.
8. The inspecting person replaces the tube holder cover and tightens the hand screws if the cover is not a snap fit.
9. The inspecting person then conducts a test run with the operating buttons on the control system (per section 12.5.1.4).

12.5.1.4 TEST RUN WITH OPERATING BUTTONS

Prior to transporting the unit, a test run is carried out using the operating switches on the control system. The display serves to indicate important information about the system.

1. Pull out the emergency stop master switch until the yellow marking is visible.
2. Press the test button until the hourglass on the display switches off again (5 seconds). The flashing warning triangle signals test operation.
3. Press the start button until the hourglass on the display turns off again (2 seconds).
4. The test run now proceeds automatically and lasts about 8 minutes, depending on the number of charges.
5. When the warning triangle switches off, the test run has been successfully concluded. **Do not switch off the control system or carry out another test run prior to transportation.**
6. Once the system test is completed, close the deployment box, attach the padlocks, and prepare for transportation.

12.5.2 TRANSPORTATION OF THE DEPLOYMENT BOX BY HELICOPTER

The transportation of the deployment box by air is regulated by WorkSafe BC and the Transportation of Dangerous Goods Regulations. Personnel performing the tasks described below will meet the training and certification requirements list in Section 12.4.1 of the procedures.

The Wyssen deployment box is a small means of containment designed and secured to prevent the accidental release and detonation of the explosives during transport. Further safety measures are described in the procedures below to minimize risk to workers and the public.

The helicopter loading area and flight corridor will be least 400 m from inhabited areas and privately travelled roads will be closed if required. This area will be secured 50m in all directions to prevent unauthorized access during the arming process. If the flight path requires that a private travelled road be crossed, specific procedures must be developed in accordance with WSBC OHSR Part 18 and the managing agency of the roadway.

12.5.2 PRE-PLANNING FOR HELICOPTER TRANSPORTATION

1. The pilot-in-command is provided with written information for each of the dangerous goods being transported, including:
    a. The shipping name, UN number and class; and
    b. The net explosive quantity (NEQ).
2. The pilot-in-command and ground crew review the operational procedures, operation of the load-carrying equipment, the flight plan, dangers when flying external loads and emergency procedures in addition to the standard pre-work tailboard (safety) meeting.
3. A long-line with an automatic electrical latch is used for transporting the deployment box. The helicopter company is responsible for ensuring good working condition of all load-bearing elements. The elements must be designed to carry loads of at least 700 kg.
4. No passengers are allowed in the helicopter during transportation of the deployment box.

12.5.2.2 HELICOPTER ATTACHMENT

1. In addition to the 400 m distance requirement, the staging area/receiving point of the loaded deployment box must be suitable for helicopter operations with appropriate approach and departure corridors.
2. Ensure weather conditions are suitable for helicopter operations.
3. The ground staff must wear an approved helmet or hardhat with chin strap, safety glasses, high visibility vest, gloves, suitable clothing and solid footwear.
4. No use of the Wyssen Avalanche Control Centre software is allowed during transportation of the deployment boxes. Use of the software is only permitted after the deployment box has been placed on the tower and the helicopter has left the danger area.
5. The Blaster of Record is responsible for a final check of each deployment box prior to transport to ensure the charge-dropping mechanism is on stand-by and the latch, padlocks and dropping hole are closed and secure.
6. During the approach to the receiving point, the pilot must establish contact with the ground staff as a communication check. If this attempt fails, the helicopter must land, and the malfunction rectified prior to transportation.
7. The electric latch is connected directly to the transport hanger of the deployment box.
8. After attaching the deployment box to the helicopter, no persons are allowed to be under the suspended load.

12.5.2.3 PLACEMENT OF THE DEPLOYMENT BOX ON THE TOWER

1. The pilot brings the insertion funnel directly over the docking spike on the top of the tower, following the range of permitted approach angle in Figure 4.
2. As the deployment box is lowered onto the docking spike, the deployment box will automatically turn into the correct alignment. A flashing light on top of the deployment box blinks for 1 minute as soon as it is correctly positioned.

3. If during the positioning maneuver, the deployment box hits the tower heavily or is positioned roughly, the internal mechanism may be damaged, and the pilot should not release the latch and must return the deployment box to the staging area for a test run.
4. Once the pilot confirms the deployment box sits firmly on the docking spike and is correctly positioned, the latch can then be released.
    a. In the case the deployment box is released but not positioned correctly (i.e. no flashing light), the deployment box must be retrieved using the HK-02 latch and returned to the staging area.

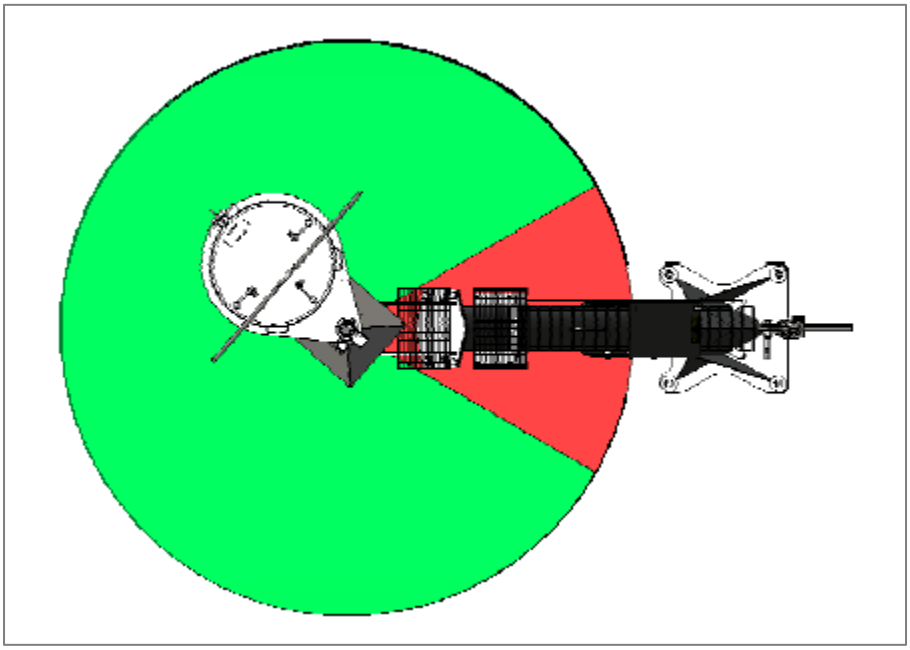


Figure 4. Range of permitted approach angle when placing the deployment box on the tower.

12.5.3 LIVE TESTING AND OPERATIONAL USE

12.5.3.1 AREA CLOSURE

An area closure will be implemented as described in existing avalanche control procedures.
The general sequence of events from initiating the closure to re-opening the area following explosive control will be as follows:

1. Initiate the area closure.
2. Proceed to a safe firing location.
3. Ensure that the closure is effective, and the danger area is clear.
4. Use the firing control system (Section 12.5.3.2) to control the selected WAT on the selected target.
5. Confirm detonation of the WAT using one or more of the following means: system detection by geophone, acoustically, or visually.
6. Misfire check.
7. Record the results.
8. Repeat steps 4 through 7 for the next target(s).

9. Notify closure control personnel that blasting has been completed.

12.5.3.2 FIRING THE SYSTEM

The WAT are controlled using a web application (control.wyssenavalanche.com) to access the firing system. Individual login credentials and a code list are used in order to maintain a high standard of safety and security. The entry of login credentials and a single-use numeric code from the code list is required prior to accessing the firing system. The firing system communicates with the towers via an encrypted radio communication system.
<u>To fire the system:</u>

1. Load the web application and enter your login credentials (internet access) or connect to the WAC.3 base (radio connection).
2. Enter the 8-digit numerical code.
3. The firing system is now activated until a charge is deployed, or until the time-out limit of 15 minutes is reached.
4. After deploying the charge, detonation must be confirmed. Detonation can be confirmed in three ways:
    a. Automatic detection by the geophone and displayed in the firing system.
    b. Acoustically.
    c. Visually.
5. The firing system will display a “Closed and Secure” status for the tower, indicating that dropping hole is sealed and the firing system connection is terminated.

12.5.3.3 SYSTEM MALFUNCTIONS

If a fault occurs during the firing sequence, it is treated as a misfire the misfire procedures in Section 12.5.3.4 are followed. The Wyssen Avalanche Control 24-hour support line should be contacted immediately.

12.5.3.4 MISFIRE PROCEDURE

A misfire occurs when detonation cannot be confirmed by any of the three methods described in Section 12.5.3.2. Four types of misfires can occur (Type A1, A2, B1 and B2). Type A misfires are those which are hanging on the cord and Type B misfires are those which are lying in the snow. All types of misfires will be handled using the following procedures:

1. Maintain the area closure.
2. Observe the minimum waiting period of 30 minutes before approaching the danger, either by foot or in a helicopter.
3. Locate and visualize the misfire. This may require the use of a helicopter for towers that are difficult to access. Consider that misfires could potentially slide away from the tower and may have the potential to trigger an avalanche and be carried downslope to access road elevation.
4. Under no circumstances may a deployment box be transported beneath a helicopter with a suspended misfire.
5. If a cord is found in the area of a misfire, it must not be pulled since this can activate the percussion fuse lighter and detonate the charge.

6. A misfire must not be moved.
7. For both Type A and B misfires, confirm the wire hooks are evident on the cord, which confirms the percussion fuse lighter was activated. If the wire hooks are not evident (i.e. still attached to the percussion fuse lighter), the percussion fuse lighter may not have been activated and extra caution is required.
8. For Type A misfires, remotely release the charge retaining cord from the deployment box.
9. Once the misfire is on the snow surface (Type B) or already on the surface (Type B), deploy a conventional explosive to detonate or destroy the misfire, as per the helicopter control or hand charging misfire procedure described in Section 8.1 Misfire Procedure. The additional explosive can be deployed either by helicopter, or if the misfire can be safely accessed on foot, by hand.
10. Confirm the detonation and perform a post-blast inspection to confirm the misfire was destroyed.

12.5.4 POST-SEASON DECOMMISSIONING

During the summer, it is preferable to house to the deployment boxes in secure, dry storage. Explosive charges that have not been used are preferably detonated prior to deployment box removal, but if this is not possible (e.g. malfunction of the deployment box), the charges must be removed from the deployment box. If approved by manufacturer, the charges can then be disassembled.

12.5.4.1 RETURN TRANSPORTATION OF THE DEPLOYMENT BOX BY HELICOPTER

The Wyssen helicopter latch is attached to the automatic electrical latch on the long line to retrieve the deployment box.
The Wyssen helicopter latch must be regularly inspected and tested for proper functioning and damage prior to each transport of the deployment box as follows:

- The latch must be free to move upwards as far as the stop;
- The latch must drop and close independently through its own weight;
- In the closed state, the notch of the latch must lie on top of the supporting bolt;
- No cracks shall be visible on the latch or handle; and
- The latch and the handle must not be deformed.

If any defects are found or if there are any uncertainties, the helicopter latch in question must not be used.
The Wyssen helicopter latch is used for the return transport of the deployment box only. This allows the attachment of the deployment box to the helicopter longline without the assistance of ground personnel. Under no circumstance may the latch be used for the lifting of other loads. During the lifting of the deployment box, no personnel are permitted to be on or near the tower.
The following procedure is used to retrieve the deployment box from the tower.

1. The pilot then flies over the deployment box and lowers the Wyssen helicopter latch over the fork of the transport hanger on the deployment box.

Once lowered far enough, the latch on the Wyssen helicopter hanger will catch the transport hanger and secure the deployment box to the helicopter longline.

2. As the pilot lifts the deployment box off the tower, they must ensure that they are lifting vertically to ensure that they do not cause damage to the tower.
3. As soon as the deployment box is lifted off the tower, the monitoring switch automatically deactivates the power supply in order to prevent an accidental release of a charge, should any charges remain in the deployment box.
4. The deployment box is transported to the staging area and set down carefully.
5. The deployment box must be resting on the ground and the helicopter longline not under tension prior to uncoupling. The latch must only be opened by the black lever on the Wyssen helicopter hanger by ground staff.
6. Once the deployment box is released, the pilot is signaled so they can depart.

12.5.4.2 UNLOADING EXPLOSIVES FROM THE DEPLOYMENT BOX

If the deployment box is returned to the staging area with explosive charges still inside, the following steps are followed when unloading:

1. Open all padlocks on the cover and turn the locking level through 90°.
2. Lift the cover using handles provided until the safety catch engages.
3. Press the emergency stop master switch to ensure the system is deactivated and to protect the batteries during summer storage.
4. Activate all sliders on the cable dropper by pressing the side of the ball bearings toward the back.
5. Ensure the retaining ring is disengaged from the cable dropper.
6. Remove the cable dropper from the tube holder.
7. Take hold of the charge through the holes at the top of the plastic shell and lift out of the tube holder.
8. The primed charge is placed and secured in the temporary storage rack until the blaster is prepared to destroy or disassemble the charge.
9. Close the deployment box.

12.5.4.3 CHARGE DISASSEMBLY

1. Charges may only be disassembled if authorized by the manufacturer.
2. Loosen the screw sleeves at the bottom of the percussion fuse lighter by one turn.
3. Remove both safety fuse assemblies from the percussion fuse lighter through the openings on the side of the plastic shell.
4. With a slow, smooth and even pressure, remove both safety fuse assemblies from the charges. If resistance is encountered, the charge should not be disabled and must be destroyed in an appropriate safe location using the misfire procedure.
5. The safety fuse assemblies may not be stored or transported because they are shorter than the 1 m minimum for length required by WSBC OHS

Regulation 21.56(2). The safety fuse assemblies must be destroyed in an appropriate safe location using the misfire procedure in Section 8.1.

6. Re-open charge containers to remove the explosive cartridges. Explosive cartridges must be re-packaged in appropriate certified and labeled boxes for transportation and storage. Expiration dates should be noted and must not be exceeded during subsequent use.
7. Plugs must be re-inserted into the percussion fuse ignitors to protect them from moisture contamination.

12.5.4.4 PREPARING THE DEPLOYMENT BOX FOR STORGE

In order to ensure that the battery survives the summer without any damage, it should be completely charged prior to being placed in storage. Connect the battery to the charger for at least 24 hours. The battery must only be charged with a designated battery charger which has temperature-controlled charging voltage. Battery chargers such as those used for car batteries are not suitable and damage the battery.

12.5.5 EMERGENCY PROCEDURE – DROPPED DEPLOYMENT BOX

In the unlikely event the deployment box is dropped during helicopter transport, it will be known to the Blaster of Record whether or not the deployment box contains explosives. If it does not, then a plan can be put in place to safely recover the deployment box. If the deployment box does contain explosives, the following procedure is followed by the Blaster of Record:

1. **Dial 911** to activate required emergency services (police, fire and/or ambulance). Plus initiate Dynyo Nobel Canada Inc. (DNCI) Emergency Response Assistance Plan (ERAP 2-1037) by calling **1-800-367- 4629**. Give name and phone number and keep the telephone connection open until they have completed the initial report.
2. Begin evacuation of the area around the deployment box to a distance of 1600 m in all directions.

3. Contact the following:
   a. Local RCMP Detachment (detachment listings can be found here: http://www.rcmp-grc.gc.ca/detach/index-eng.htm);
   b. Provincial Emergency Program (PEP) **1-800-663-3456** (24 hours)
   c. Provincial Transportation Management Centre **1-866-706-7862** (24 hours)
   d. Explosive technical advisors as necessary
   e. Wyssen Avalanche Control Inc. (Switzerland) **+41 79 628 10 83**
   f. Notify Explosives Regulatory Division – Pacific Region **604-666-0366**[1].
   g. Notify WorkSafeBC **1-888-621-7233**.

4. Assist the Emergency Response Personnel (Incident Commander and/or Accident Site Commander) in the role of Technical Advisor in order to safely and efficiently recover and dispose of explosive products.

[1] Use form F07-01 for reporting incidents to the Explosive Regulatory Division.

a. Assess explosive division type(s), quantity and conditions at the accident site to determine minimum evacuation distance.
b. Arrange for the delivery of explosives clean up materials and equipment as necessary for the severity and extent of spilled explosives.
c. Confirm with Incident Commander and/or Accident Site Commander that assistance from outside agencies (e.g. RCMP, PEP and CANUTEC) has been requested and dispatched as necessary. Ensure that essential personnel only are involved in the transfer and clean-up of spilled explosive products in order to minimize risk.
d. In consultation with external expertise (e.g. Wyssen, WorkSafeBC), advise the Incident Commander and/or Accident Site Commander of the most appropriate actions to ensure safety of all personnel involved.
e. Liaise closely with the Incident Commander and/or Accident Site Commander and outside agencies at the accident site (e.g. RCMP) to ensure that all decisions made reflect the utmost concern for safety of involved personnel.
f. Ensure that the area has been thoroughly searched to confirm that all spilled explosive materials have been removed prior to re-opening the evacuated area.

12.6 CLOSURE

These procedures have been developed for use by Pretium Resources Inc. with the Wyssen Avalanche Tower (WAT).
They describe blasting equipment used with the WAT, personnel training, the assembly and loading of explosives in the tower deployment box, flight operations for the helicopter transport of the tower deployment box, deployment of the explosives using the remote system and misfires.
Procedures are in accordance with WorkSafe BC (WSBC) Occupational Health and Safety Regulations (OHSR) Part 21 – Blasting Operations and Part 29 - Aerial Operations, Natural Resources Canada Explosive Regulations, Transportation of Dangerous Goods Regulations Part 12.12 – Aerial Work and the Wyssen Avalanche Tower LS12-5 G3 Instruction Manual (v 3.8, July 2017).
These procedures will be reviewed annually and if any changes are made, they must be approved in writing by WorkSafeBC.

APPENDIX A – Nitro Express User Manual

Nitro Express User Manual

www.snowteksystems.com

NITRO Xpress™

USER & PARTS MANUAL

Version 1.2

© PREPARED BY
SNOWTEK
Systems Ltd

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WARNINGS

1. Snowtek Systems Ltd recommends for shots greater than 300PSI that remote firing be used.

2. It is manditory for shots greater than 400PSI that the electric firing option be used and high pressure regulator needs to be fitted PN AC 03. (Appendix D)

3. Never fire an Avalanche round without first checking the Avalanche round manufacturers' maximum pressure rating and never exceed this pressure.

4. The practice of extending the pneumatic firing lines to achieve remote firing is prohibited with the Nitro Xpress. This will cause uncommanded firing when the safety valve is opened. Remote firing must be either done with the lanyard system or using the optional electric firing control. (Appendix D)

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Safety:

The Nitro Xpress is a nitrogen powered Avalauncher designed for the safe and efficient delivery of an Avalanche Explosive Round to the Intended target.

This manual addresses the safe and correct operation of the Nitro Xpress.

The Nitro Xpress has been designed with Operator and Public safety in mind.

The handling of explosives is to be carried out by a Blaster of Record only as per Governmental and or OHS Jurisdictional regulations.

It is a requirement to follow all good and safe practice when handling Explosives.

The firing of the delivery system requires 2 trained personel. One is called the Gunner and the other is called the Loader. A minimum of one operator must be a certified blaster for the OHS Juristiction.

It is essential that all staff and public are clear of the barrel when any pressure checks or firing is being carried out.

Compressed gas cylinders must be handled as per supplier's recommendations or by jurisdictional regulations.

Snowtek Systems Ltd recommends remote firing for shots with a greater charge pressure than 300 PSI.

Snowtek Systems Ltd states it is manditory to use the electric remote firing control for shots with a greater charge pressure than 400 PSI.

SnowTek Systems Ltd requires the operators of the Nitro Xpress Avalauncher to follow these operation procedures fully!

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Terms:

Blaster of Record:
A person approved by the statutory authority to handle and use explosives.

Gunner:
The Gunner is required to be a Blaster of Record by certification as they are responsible for overseeing the co-ordination of the blasting operation while using the Nitro Xpress. They are responsible for all staff and public safety while operating the Nitro Xpress. The Gunner is also responsible for keeping a record of all firing.

Loader:
The Loader is required to be trained in the use of handling explosives as they are responsible for the safe handling and loading of the explosive avalanche round. The loader will also work with the Gunner to ensure the safe operation of the Nitro Xpress.

Main Valve:
This is the valve between the nitrogen pressure tanks and the barrel.

Pressure Release Valve:
This is the valve located on the control panel that is used to release the pressure from the Nitro Xpress pressure tanks.

Main Control Valve:
This is the valve located on the control panel that seats the main valve and allows nitrogen to flow into the Nitro Xpress pressure tanks.

Breech:
The mechanism that opens to allow loading of the Avalaunche round into the Nitro Xpress.

Breech Plug:
The plug which is removable to allow the avalanche round to be inserted into the barrel.

Firing Safety Valve:
The valve mounted on the gun as part of the interlock safety system.

Firing Valve:
A squeeze or pull valve that is actuated to release the main valve.

Interlock Safety System:
The locking system that prohibits the Nitro Xpress being fired when the breech is open or unlocked.

Shot Pressure:
The pressure required to deliver the avalanche round to its target.

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Elevation Ram:
The mechanism for changing the elevation (angle) of the Nitro Xpress.

Directional Gearbox:
The mechanism for rotating the Nitro Xpress on its turn table.

Barrel Receiver:
The recess in the front of the Nitro Xpress the takes the machined end of the barrel.

Barrel Clamp:
The locking clamp that retains the barrel in the Nitro Xpress.

Safety Pressure Valve:
The over pressure release mechanism.

Holding Brake:
The friction device locking the turntable in place.

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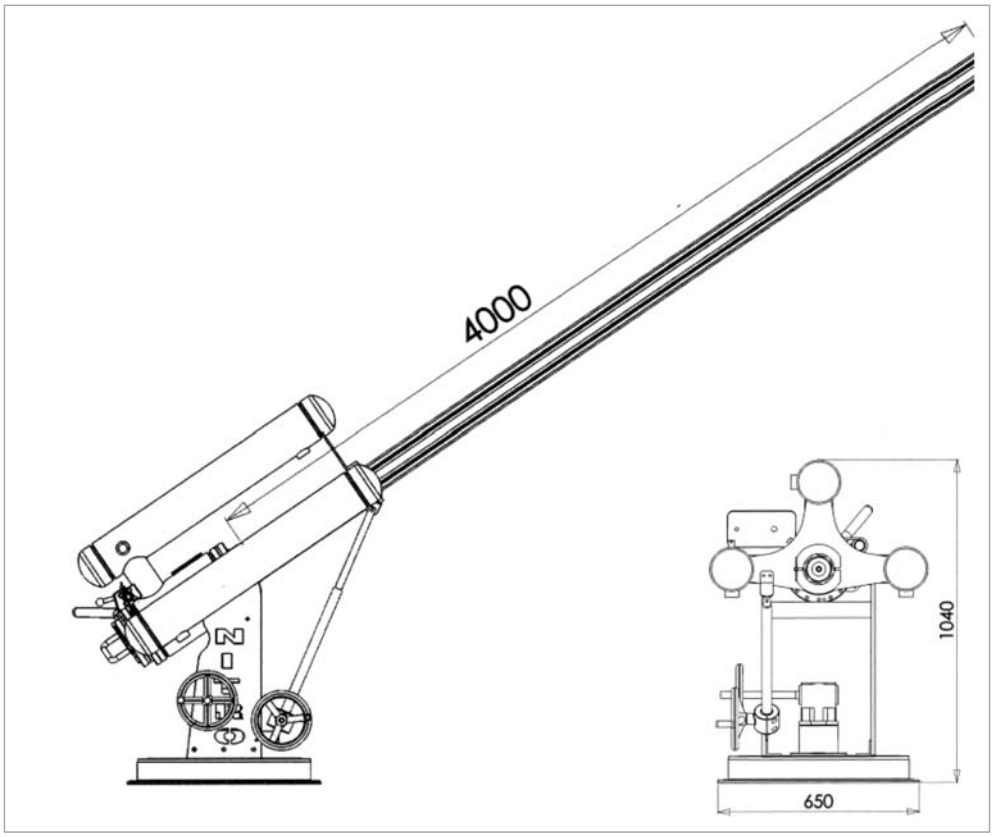
SPECIFICATIONS:



Nitro Xpress Height at 0°(minus barrel)	1040mm (40.9”)
Nitro Xpress Height at 65°(minus barrel)	1375mm (54.1”)
Barrel Length	4000mm (9.8’)
Barrel Internal Diameter’s	ID82.3mm (3.24")
Barrel Outside Diameter’s	OD99.88mm (3.93")
Round Diameter’s	80mm - 82mm (3.14" - 3.22")
Overall Length	4585mm (180.5”)
Turntable Diameter	650mm (25.5”)
Footprint (minus barrel)	1455mm x 710mm (57.2” x 27.9”)
Propellant/Gas:	Dry Nitrogen
Design Pressure:	4136KPa (600psi)
Working Pressure	200 – 3450KPa(29 – 500psi)
Design Temperature	-25°C to 50°C (-13°F to 122°F)
Tank Capacity	45 litres
Weight (excluding barrel)	235kg (518lbs)
Barrel Weight	16kg (35lbs)
Pressure Vessel Standards	ASME 8, AS1210 Category 3 Canadian CNN.....

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OVERVIEW:

Pressure Release Valve
Firing Valve
Main Valve
Barrel Clamp
Main Control Valve
Safety Pressure Valve
Interlock Safety System
Pressure Data Plate
Measumax
Breech
Safety Lockout
Brake Handle
Breech Plug
Directional Gearbox
Barrel Receiver
Main Tank Pressure Gauge
Firing Safety Valve
Elevation Ram
Main Valve Pressure Gauge
SnowTeks Avalauncher Identication Plate

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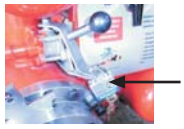
ORDER OF OPERATION:

SnowTek Systems Ltd requires the operators of the
Nitro Xpress Avalauncher to follow the operation procedures fully!

1 NITRO XPRESS SETUP INSPECTION

1.0
Remove and store cover.



1.1
Remove lockout lock from the safety lever.
Open the pressure release valve on the main control panel to vent any residual pressure in the main tanks.

1.2
Release the brake lever.

1.3
Ensure the elevation ram and direction gearbox handles turn freely.

1.4
Remove barrel receiver cap and inspect receiver for foreign objects (e.g. ice or grit).
Wipe if necessary.

1.5
Ensure the barrel clamp is unlocked and free to move.

1.6
Open the breech and inspect the breech, breech plug and breech locking ring for foreign objects (e.g. ice or grit). If foreign objects are present carefully remove.

1.7
Inspect the safety pressure release valve for foreign objects (e.g. ice or grit) and remove if necessary.

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1.8
Inspect the 2 pressure gauges for icing and remove ice if present.

1.9
Inspect filling hose and filler socket for foreign objects (e.g. ice or grit) and remove if necessary.

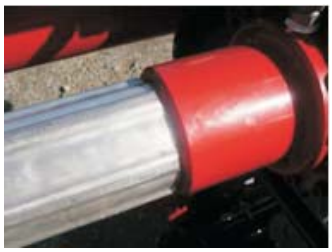
2 ATTACHING BARREL:

2.1
Remove the barrel from its storage tube.

2.2
Inspect the barrel for dents. If any are present refer to Trouble Shooting Guide.

2.3
Look through the barrel and ensure there are no foreign objects inside. Remove any objects before continuing.

2.4
Slide the recessed end of the barrel into the end of the Nitro Xpress through the barrel clamp and into the barrel receiver. Take care to avoid denting the end of the barrel.



2.5
Check the barrel is fully located into the barrel receiver and the yellow indicator ring is not showing.

2.6
Close and lock the barrel clamp. Ensure the barrel is secure and will not move under pressure.

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3 ATTACHING THE MEASUMAX DIGITAL PROTRACTOR:

3.1
Clip the Measumax Digital Proctractor into place.
Make sure it is firmly locked in place.

3.2
Turn the Measumax Digital Protractor on as per instructions (APPENDIX: B)

4 ATTACHING NITROGEN REGULATOR AND FILLING HOSE:

4.1
Secure the cylinder to an appropriate support that prevents the cylinder from falling as per supplier's instructions.

4.2
Open the cylinder valve slightly and close. This will clear the valve of any dust, water, or dirt which could be carried into the regulator and cause damage or an accident.

4.3
Fit the regulator onto the valve and tighten as per regulator manufacturer's recommendations (Appendix A).

4.4
Insert the filler hose end into the filler socket.

4.5
Push filler socket outer collar backwards to allow the filler hose end to snap home.

4.6
Release the filler socket outer ring to lock the filler hose end into place.

4.7
Give the filler hose end a gentle pull to ensure it is locked.

5.0
Electric Firing Control Option (for shots above 400 PSI).
Refer to Appendix D

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6.0 OPERATIONAL SAFETY CHECK:

This operation is carried out by filling the Nitro Xpress to 50psi and firing. This operation is to be carried out twice. This is to check the operation of all components of the Nitro Xpress and ensure it is in safe working order.

Seal and operation check

6.1
Close the pressure release valve on the main control panel if open.

6.2
Ensure the breech plug is inserted and the breech locking ring is fully rotated to the left to lock the breech plug into place.

6.3
Aim the Nitro Xpress in a safe direction and raise the barrel using the elevation handle.

6.4
Open the nitrogen cylinder valve SLOWLY to allow pressure to gradually build up in the regulator thus preventing damage and or injury.
(Never lean over the regulator while opening the cylinder valve).

6.5
Check the connections between the cylinder and regulator for leaks. A leak is evidenced by a hissing sound. If a leak occurs close the cylinder valve and consult the nitrogen regulators operator instructions Appendix A.

6.6
Set the nitrogen regulator to 100psi.

6.7
Turn the main control valve to the "SEAT" position.

6.8
Allow the pressure to build on the valve pressure gauge to 70psi.

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6.9
Turn the main control valve to the “OFF” position.

6.10
Watch the valve pressure gauge for 20 seconds to see if it maintains 70psi. A slow decrease is acceptable. If it falls at a fast rate reseat the main valve (see 6.7). If it continues to fall at a fast rate consult the Trouble Shooting Guide.

6.11
Adjust the pressure on the valve pressure gauge to 70psi by repeating steps 6.7 to 6.10.

6.12
Turn the main control valve to the "CHARGE" position to allow the pressure to build in the main tanks. Watch the tank pressure gauge and turn the main control valve to the "OFF" position when it reaches 50psi.

6.13
Listen for leaks from the pipe work and watch for major pressure drops on both gauges. If a major pressure drop occurs consult the Trouble Shooting Guide.

6.14
At this point the nitrogen will equalize in the main tanks and the pressure will drop approximately 10 - 20psi. If the pressure continues to drop consult the Trouble Shooting Guide.

6.15
Allow the pressure to equalize in the tanks and then adjust the pressure returning it to 50psi using the main control valve (see 6.12).

6.16
Ensure the Breech is closed and locked.

6.17
As the gun is about to discharge from the barrel ensure the firing area is clear of all public and staff. Personnel must be behind the Nitro Xpress.

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6.18
OPEN the firing safety valve by rotating it to the left.

6.19
If manual firing, fire the Nitro Xpress by pulling the firing valve.
If electric firing, as per Appendix D

6.20
After firing, release the firing valve and move the firing safety valve right to the closed position.
If electric firing, as per Appendix D

6.21
Repeat steps 6.1 to 6.20 for second operation check.

7 CHECKING THE UNIDIRECTIONAL SAFETY VALVE:

Unidirectional Safety Valve Test

7.1
Turn the main control valve to "SEAT" position this will close the main piston and then allow the pressure on the main valve to build up to 20 PSI.

7.2
Turn the main control valve to the “CHARGE” position, as the main presuure tanks rise above 20 PSI check to see if the main valve pressure gauge rises with the main pressure gauge.

7.3
This checks the operation of the unidirectional safety valve, if the main valve pressure gauge doesn’t rise once the tank pressure exceeds the main valve pressure the unidirectional safety valve has failed to function. Consult trouble shooting guide.

7.4
Open the Pressure release valve to vent the main tanks.

If the Nitro Xpress passes all these tests you can now proceed to fire avalanche rounds.

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8 CHARGING THE NITRO XPRESS FOR FIRING:

Close the Breech

8.1
Ensure the Breech plug is in and the Breech is closed and locked.

8.2
Set the Nitro Xpress to the required direction and elevation.

Seat the Main Valve

8.3
Set the nitrogen regulator to 50psi above the required shot pressure.

8.4
Close the pressure release valve on the main control panel if open.

8.5
Turn the main control valve to the "SEAT"position,

8.6
Allow the pressure to build on the valve pressure gauge to a least 20psi above shot pressure.

8.7
Turn the main control valve to the "OFF" position.

Charge the Shot

8.8
Turn the main control valve to the "CHARGE" position to allow the pressure to build in the main tanks while observing the tank pressure gauge. When the Nitro Xpress reaches the required **shot pressure** turn the main control valve to the "OFF" position.

Is the Charge Holding?

8.9
At this point the nitrogen will equalize in the main tanks and the pressure will drop approximately 10 - 20psi. If the pressure continues to fall past 50psi below shot pressure and continues falling, release the main tank pressure by opening the Pressure Release Valve to release the pressure in the main tanks to leave the Nitro Xpress in a safe state. Now consult the Trouble Shooting Guide.

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8.10
Allow the pressure to equalize in the tanks and then adjust the pressure as required to the shot pressure.

8.11
Inspect both gauges to ensure they are holding the correct pressure.

9 LOADING AND ARMING AN AVALANCHE ROUND:

9.0
Ensure the gun is holding the required pressure.

9.1
Check the Nitro Xpress is set to the required direction and elevation and make sure the brake is engaged.

Open Breech.

9.2
Move the breech locking ring handle to the RIGHT. Ensure the firing safety valve closes as it moves.

9.3
Remove the breech plug and swing it clear of the Breech.

Insert Avalanche Round.

9.4
Insert the round into the breech and arm as per the avalanche round manufacturers' instructions.

9.4A
Make sure that Wads/Arming discs are retained on the round as per round manufacturers' instructions.
2 examples are given.

9.5
Check you have removed the transport safety pin to arm the avalanche round as per manufacturers' instructions.

Close and Lock Breech.

9.6
Swing the breech plug to line it up with the breech. Care should be taken **to retain any arming mechanisms on the avalanche round.**

9.7
Push the round into the breech with the breech plug until the breech plug is fully engaged.

9.7A
Warning!!
Never pull an Avalanche Round out of the breech once it has been loaded into the Nitro Xpress. This has the potential to arm the round producing a very hazzardous condition. Once a round is inserted into the breech it must be fired.

9.8
Move the breech locking ring handle to the LEFT to lock the breech.

9.9
Pull on the breech plug handle to ensure it is engaged and locked.

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10 FIRING:

10.1
Before firing re-check the Nitro Xpress is set to the required direction and elevation and make sure the brake is engaged.

10.2
Check the target area is clear and safe for firing. All staff and public must be aware of the firing and in a safe location.

10.3
Move the firing safety valve to the LEFT to open.

10.3A
For shots above 300psi Snowtek recommends remote firing

Firing

10.4
For electric firing consult Appendix D.
For manual firing pull and hold the firing valve until the Nitro Xpress has completely discharged. (via lanyard).
(this will open the main valve and release the nitrogen behind the round propelling it out of the barrel).
The Nitro Xpress will fire.

10.5
After firing release the firing valve and move the firing safety valve right to the closed position.
If electric firing, refer to Appendix D.

11 FLIGHT CHECK OF ROUND:

11.1
It is important to check the flight, impact and detonation of the avalanche round.

11.2
Record the direction, elevation, pressure and type of avalanche round fired.
(This information is useful to repeat the shot at a later date)

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12 SHUTDOWN PROCEDURE:

After all firing has been completed.

Seat the Valve.

12.1
Set the nitrogen regulator to 50psi.

12.2
Turn the main control valve to the "SEAT" position.

12.3
Allow the pressure to build on the valve pressure gauge to 20psi to seat the main valve.
Then turn it to the "OFF" position.

12.4
Turn the main control valve to the "CHARGE" position to allow the pressure to build to 20psi in the main tanks.
Then turn to the "OFF" position.
(This maintains a positive pressure in the Nitro Xpress to prevent the ingress of moisture).

12.5
Lock out firing safety valve.

12.5A
Release brake.

Remove the regulator and hose.

12.6
Turn the nitrogen cylinder valve to the "CLOSED" or "OFF" position.

12.7
Relieve the pressure in the regulator by turning the adjusting knob clockwise fully. This will release any residual gas in the regulator and between the regulator and cylinder.

12.8
Remove the filler hose from the filler socket by pushing the filler socket collar ring backwards. This will unlock the filler hose end and then it can be removed.

12.9
Loosen the regulator by turning counter-clockwise and continue turning until the regulator is disengaged from the cylinder valve.

12.10
Store the regulator and filling hose carefully with inlet and outlet connections covered to avoid contamination and damage.

12.11
Replace cylinder cap on cylinder if supplied (as per cylinder supplier's recommendations).

12.12
Store the nitrogen cylinder as per supplier's recommendations.

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Remove the Barrel.

12.13
Unlock the barrel clamp, rotate the barrel to loosen the seal, and remove the barrel from the Nitro Xpress.

12.14
Place the barrel into its storage tube, care should be taken not to damage the barrel in this process.

12.15
Replace the barrel receiver cap onto the barrel receiver.

Remove the Digital Protractor.

12.16
Turn off the Measumax Digital Protractor with its "ON/OFF" button, unclip and store in a safe dry location.
The “Measumax” must be removed from the Nitro Xpress between firings.

12.17
Cover the Nitro Xpress.

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TROUBLE SHOOTING

Problem	Possible Cause	What to Do
Small dent on the receiver end of barrel Dent in barrel large enough to see from inside	Hitting barrel receiver when inserting barrel Mishandling	Dress outside and inside of barrel to remove minor Damage Replace Barrel Call your Nitro Xpress Service Center
Valve pressure gauge fails to rise	Nitrogen cylinder empty Nitrogen regulator is not set correctly Filling hose not connected correctly Leak in pipe work	Replace with full cylinder repeat steps 6.4 to 6.6 repeat steps 4.4 to 4.7 Call your Nitro Xpress Service Center
Sound of leak from pipe work	Fitting becoming lose with heating and cooling Crack in pipe work or gauge Main valve not seating	Release the pressure from the Nitro Xpress using release valve and tighten lose fitting with appropriate size spanner Call your Nitro Xpress Service Center Call your Nitro Xpress Service Center
Major pressure drop on main tank pressure gauge	Pressure release valve open	Close valve
	Leak in pipe work	Identifiy leak, use spanner to tighten leaking fitting or
	Main valve not seating	Call your Nitro Xpress Service Center
Main valve gauge fails to rise	Unidirectional safety valve iced up Unidirectional safety valve damaged	warm and de-ice Call your Nitro Xpress Service Center
Main tanks gauge still drops pressure	Pressure release valve open Leak in pipe work Safety pressure release valve tripped Main valve not seating	Close valve Use spanner to gently tighten fitting Call your Nitro Xpress Service Center Call your Nitro Xpress Service Center

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APPENDIX A:

Operating Instructions for BOC Nitrogen High Pressure Regulator used in the Refrigerant Flush System
Model Number: NZRT50HP
Developed in conjunction with BOC Gases Australia Limited
Manufactured by Gasgep Pty Limited Melb

This Nitrogen Regulator has been designed for use in the BOC Refrigerant Flush System, with 0-3500 kPa (high pressure) regulated output for use with the new T50 Valve Cylinders.

Please follow the instructions provided for correct use.

SAFETY PRECAUTIONS

- Compressed gas cylinders must be handled with care and should be stored and secured in an upright position in a secure place where they will not be knocked over.
- Store and use cylinders in a well ventilated area and ensure they are not subjected to ambient temperatures above 55C or any source of radiant heat.
- Close the cylinder valve whenever the cylinder is being moved, not in use or empty.
- Cylinders should only be filled by the cylinder owner or with written permission of the cylinder owner in accordance with AS2030.I and State Dangerous Goods Regulations.
- Read and understand the instructions and labels that accompany your compressed gas equipment and cylinder. Further information s available in the BOC Gases' Material Safety Data Sheet (MSDS) No. 030 available on request from the BOC Customer Service Centre.
- Additional information for compressed gases can be found in AS4332 "The Storage and Handling of Gas Cylinders".
- Check the cylinder label for fill pressure. Only Nitrogen gas cylinders with a fill pressure of 5Mpa at 15 degrees C (20Mpa max. inlet) should be connected to this regulator.
- Always remove the regulator before moving or transporting the cylinder (see "Closing the cylinder & removing the regulator" section of this leaflet).
- Never hold the regulator to lift the cylinder.

OPERATING INSTRUCTIONS

Attaching the regulator to the cylinder

1. Secure the cylinder to prevent the cylinder from falling.
2. Open the cylinder valve slightly and close. This will clear the valve of any dust, water or dirt that could be carried into the regulator and cause damage or accident.
3. Fit the regulator into the valve and hand tighten. Do not use a spanner or over tighten as this will damage the connector o-ring.
4. Open the cylinder valve S-L-O-W-L-Y to allow pressure to gradually build up in the regulator thus preventing damage and/or injury. Never lean over the regulator.
5. Check the connections for leaks. A leak is evidenced by a hissing sound. If a leak occurs refer to the "Faulty Operation and Maintenance" section of this leaflet.

Closing the cylinder & removing the regulator

1. After use turn the cylinder valve to the "close" or "off" position.
2. Relieve the pressure in the regulator by turning the adjusting knob clockwise fully in. This will release any residual gas in the regulator.
3. Loosen the regulator by turning counter clockwise and continue turning until the regulator is disengaged from the cylinder valve.
4. Store the regulator carefully with inlet and outlet connection covered to avoid contamination and prevent damage.
5. Replace the cylinder cap on cylinder if supplied with one.

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FAULTY OPERATION AND MAINTENANCE

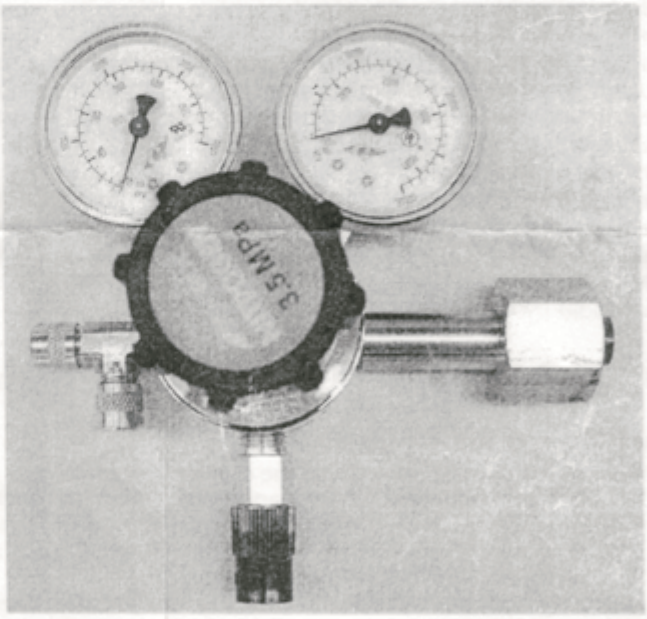
In the event of a leak from a cylinder or regulator, turn off the valve and do not attempt to use the cylinder.

No maintenance is to be performed on the regulator by the user.

Do not tamper with the regulator or cylinder under any circumstances.

For further information, please contact BOC on 1300 133 286 in Australia

or 0800 262 374 in New Zealand.



Made in Austr
BOC Limi
ACN 000 029

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APPENDIX B:

MeasumaX MX

Digital Protractor 35-204

Calibration

The Measumax DP-360 Digital protractor needs to be calibrated only before being used for the first time, or if the ON/OFF button is pressed for longer than 6 seconds.

<1>

Place the unit on a flat machined surface facing you with the lettering on the face right side up. Align with an edge or a line, then press
ON/OFF button
The screen will display "-1-"

<2>

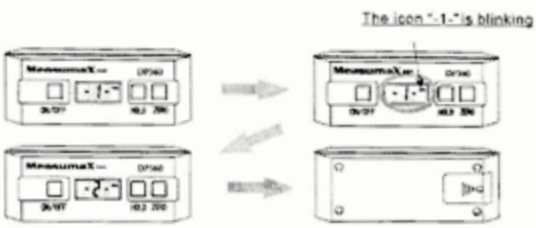
Press the ZERO button and the "-1-" will begin to flash

<3>

Wait six seconds until "-2-" is displayed

<4>

Rotate the unit in the horizontal plane 180 degrees, so that the lettering is facing away from you, but still the right side up. Align with the same edge or line Press the ZERO button and "-2-" will flash. Wait six seconds until the actual angle is displayed.. The calibration is now finished



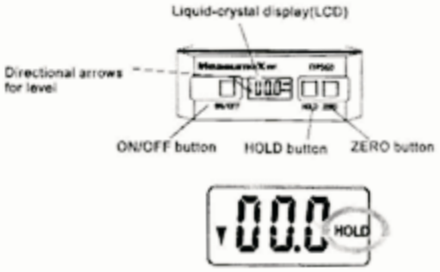
Functions

ON/OFF Button

For measurement mode simply press the button and the angle will be displayed.
To refresh the reading press the button again.
To switch off press the button and hold for 6 seconds
NOTE! If you press the button for longer than 6 seconds the "-1-" will be displayed and the unit will have to be recalibrated as above.

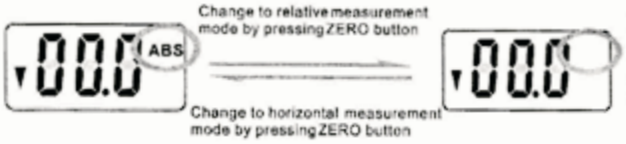
HOLD Button

To freeze the display for reading where the unit has to be moved before you can see the display first ensure that the unit has been sitting in the position for more than six seconds, then press the HOLD button once. The display will show the angle and display a flashing "HOLD". Wait until the "HOLD" symbol on the LCD stops flashing and remains static, or wait at least 6 seconds, then the unit cn be moved to view the
To cancel the reading press the HOLD button once again.



ZERO Button

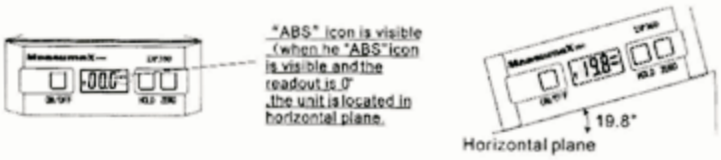
HORIZONTAL MEASUREMENT
When the "ABS" icon is displayed the unit is in the horizontal measurement mode



RELATIVE MEASUREMENT
If the "ABS" icon is not displayed
the unit is in relative measurement mode

HORIZONTAL MEASUREMENT

In the horizontal neasument mode the "ABS" icon will be displayed. Place the unit on the surface to be measured. Hold the unit
in place for 6 seconds and the protractor will
display the angle off the horizontal plane.



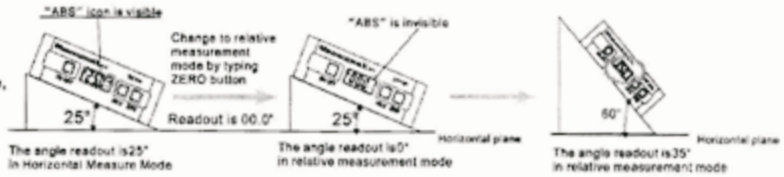
RELATIVE MEASUREMENT

Setting the alternate reference point. This function allows you to set any angle as the 0.00 reference point from which a measurement can be taken. E.G. You can set a surface that is 25 degrees off the horizontal plane as 0.00 so that you can use that surface to measure all other angles from

1. In the horizontal mode the "ABS" icon will be displayed. Put the digital protractor on a surface 25 degrees off the horizontal plane

2. Press the "ZERO" button to change to relative mode. (0.00 will be displayed)

3. Place the protractor on a surface 60 degrees off the horizontal plane and 35 degrees will be displayed



Technical Data. Full 360 degree range (90 x 4) - Resolution 0.1 degree. - Stainless Steel frame - Battery CR2032

Note ! The battery is not installed and is supplied only to test the system and may not have enough charge for nomal use

www.measumax.com

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APPENDIX C:

RECOMMENDED FIRING CALLS FOR THE NITRO XPRESS

SnowTek Systems Ltd recommends the following calls be adopted by the Gunner and Loader as part of the operation of the Nitro Xpress.

Gunner selects target and calls "Target (e.g. Rockbridge)."

Loader replies "Target (e.g. Rockbridge)."

Gunner sets direction and elevation and calls (e.g. Direction 25?, Elevation 55?).

Loader confirms settings and calls (e.g. Direction 25?, Elevation 55?).

Close the Breech.

Gunner calls "Seating Valve", then when the valve is seated calls "Valve Seated".

Loader replies "Valve Seated".

Gunner calls "Pressurizing to (e.g. 150PSI)".

Loader replies "(e.g. 150PSI)".

Gunner calls when the pressure is reached and holding Pressure Holding".

Gunner calls "Opening Breech".

Loader replies Opening Breech".

Gunner calls "Load Round".

Loader calls "Loading Round".

Loader calls "Round Loaded and Armed".

Gunner replies "Round Loaded and Armed".

Gunner calls "Locking Breech, Breech Locked".

Loader calls "Breech Locked".

Gunner Calls "Firing Safety Valve Open".

Loader replies "Firing Safety Valve Open".

Gunner calls "All Clear".

Loader replies "All Clear".

Gunner Calls "Ready to Fire, 5, 4, 3, 2, 1, Fire".

Gunner Calls "Firing Safety Valve Closed".

Loader call "Wadd Or Arming Disk Away".

Gunner calls "Round Armed".

Loader confirms impact and detonation.

Gunner to record shot setting and result.

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APPENDIX D:

ELECTRIC FIRING CONTROL:

Note: For shots above 300 PSI Snowtek recommends remote firing.
For shots greater than 400 PSI it is manditory to use the electric remote firing control.

1. Firing Valve.

2. Electric Connection.

3. Electric Firing Control.

4. Charger Unit.

Fitting Firing Control Valve.
(must be fitted with no pressure/rounds in the Nitro Xpress).

1. Pull back collar on firing line.

2. Fit Firing Valve.

3. Connect Electrical Connection.

4. Turn key on, push firing button.
(valve should be heard clicking).

5. Make sure key is turned off and removed.

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To Electrically Fire.

1.1
Insert firing key

1.2
Turn key on, firing light will illuminate.

1.3
Push and hold firing button down until the Nitro Xpress has discharged.

1.4
Release the firing button.

1.5
Turn off the firing control and remove the firing key.

Recharge firing control every100 shots or 3 months,
or if firing light fails to light.

When Firing Completed The Electric Valve Must Be Removed.

To Remove Electric Firing System.

2.0
Turn off Firing Control and remove key.

2.1
Disconnect Electric Connection.

2.2
Pull back collar on firing coupling and remove valve.

It is not recommended to leave electric firing valve on Nitro between sessions freezing could cause problems.

2.3
Put firing valve back in tool box.

2.4
Charge firing control every 3 months or after 100 shots.

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APPENDIX E:

RECOMMENDED MAINTENANCE

1. Charge Electric Remote Firing Control, if option taken.

2. Pre-season maintenance

2.1 Grease turntable at grease nipples on base.

3.Grease lifting cylinders.

Disconnect top clevis on cylinder while supporting tank assembly.
Wind the elevation handle to extend cyclinder until cylinder extends no further, pull on cylinder, the top section will come away.
Grease thread with a waterproof grease and re-assemble.

4. Liberally spray WD40 over all moving parts.

AT THE END OF THE SEASON liberally spray all moving parts with DW40 lubricant spray.

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PARTS LIST APPENDIX F

Part No. **TR 001**
Description **Valve Cylinder**

Part No. **TR 002**
Description **Valve Inner**

Part No. **TR 003**
Description **Nose Cone**

Part No. **TR 004**
Description **Piston**

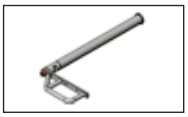
Part No. **TR 005**
Description **Breech End Plate**

Part No. **TR 006**
Description **Locking Ring Retainer**

Part No. **TR 007**
Description **Breech Plug**

Part No. **TR 008**
Description **Breech Locking Ring**

Part No. **TR 009**
Description **Breech Locking Ring Handle**



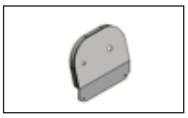
Part No. **TR 010**
Description **Breech Slide**

Part No. **TR 011**
Description **Breech Slide Guide**

Part No. **TR 012**
Description **Seal Kit**

Part No. **TR 013**
Description **Barrel Locking Clamp**

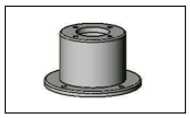
Part No. **TR 014**
Description **Elevating Ram Top Retainer**



Part No. **TR 015**
Description **Control Panel**

Part No. **BR 001**
Description **Elevating Ram**

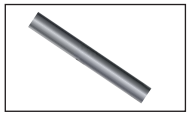
Part No. **BR 002**
Description **Side Plate**



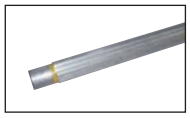
Part No. **BR 003**
Description **Gearbox Spacer**

Part No. **BR 004**
Description **Gearbox**

Part No. **BR 005**
Description **Coupling**



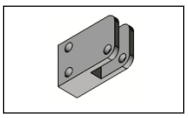
Part No. **BR 006**
Description **Side Plate Support**



Part No. **CR 001**
Description **Barrel**

Part No. **BR 007**
Description **Hand Wheel**

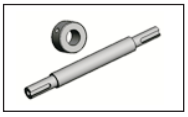
Part No. **BR 008**
Description **Trunnion Bearing**



Part No. **BR 009**
Description **Elevating Ram Bottom Retainer**

Part No. **BR 010**
Description **Brake Shoe**

Part No. **BR 011**
Description **Brake Actuator**



Part No. **BR 012**
Description **Gearbox Handwheel Shaft & Collar**

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Part No. **VR 001**
Description **Main Pressure Gauge**

Part No. **VR 002**
Description **Valve Pressure Gauge**

Part No. **VR 003**
Description **Gas Regulator And Hose**

Part No. **VR 004**
Description **Safety Valve**

Part No. **VR 005**
Description **Safety Valve Actuator**

Part No. **VR 006**
Description **Seat/Charge Valve**

Part No. **VR 007**
Description **Release Valve**

Part No. **VR 008**
Description **Pressure Relief Valve**

Part No. **VR 009**
Description **Unidirectional Check Valve**

Part No. **VR 010**
Description **5/8 Pipe Tee**

Part No. **VR 011**
Description **1/4 Tee**

Part No. **VR 012**
Description **5/8 Elbow**

Part No. **VR 013**
Description **1/4 Elbow**

Part No. **VR 014**
Description **5/8 Coupler**

Part No. **VR 015**
Description **1/4 Coupler**

Part No. **VR 016**
Description **Inlet Snap Coupler**

Part No. **VR 017**
Description **Firing Silencer**

Part No. **VR 018**
Description **Manual Firing Valve**

Part No. **ER 001**
Description **Electric Release Charger**

Part No. **ER 002**
Description **Electric Release Firing Control**

Part No. **ER 003**
Description **Electric Firing Valve**

Part No. **ER 004**
Description **Spare Battery for Firing Control**

Part No. **ER 005**
Description **Firing Snap Coupler**

Part No. **AC 01**
Description **Elevation Meter**

Part No. **AC 03**
Description **High Pressure Gas Regulator and Hose for shots over 450 PSI**

Part No. **AC 02**
Description **Cover**

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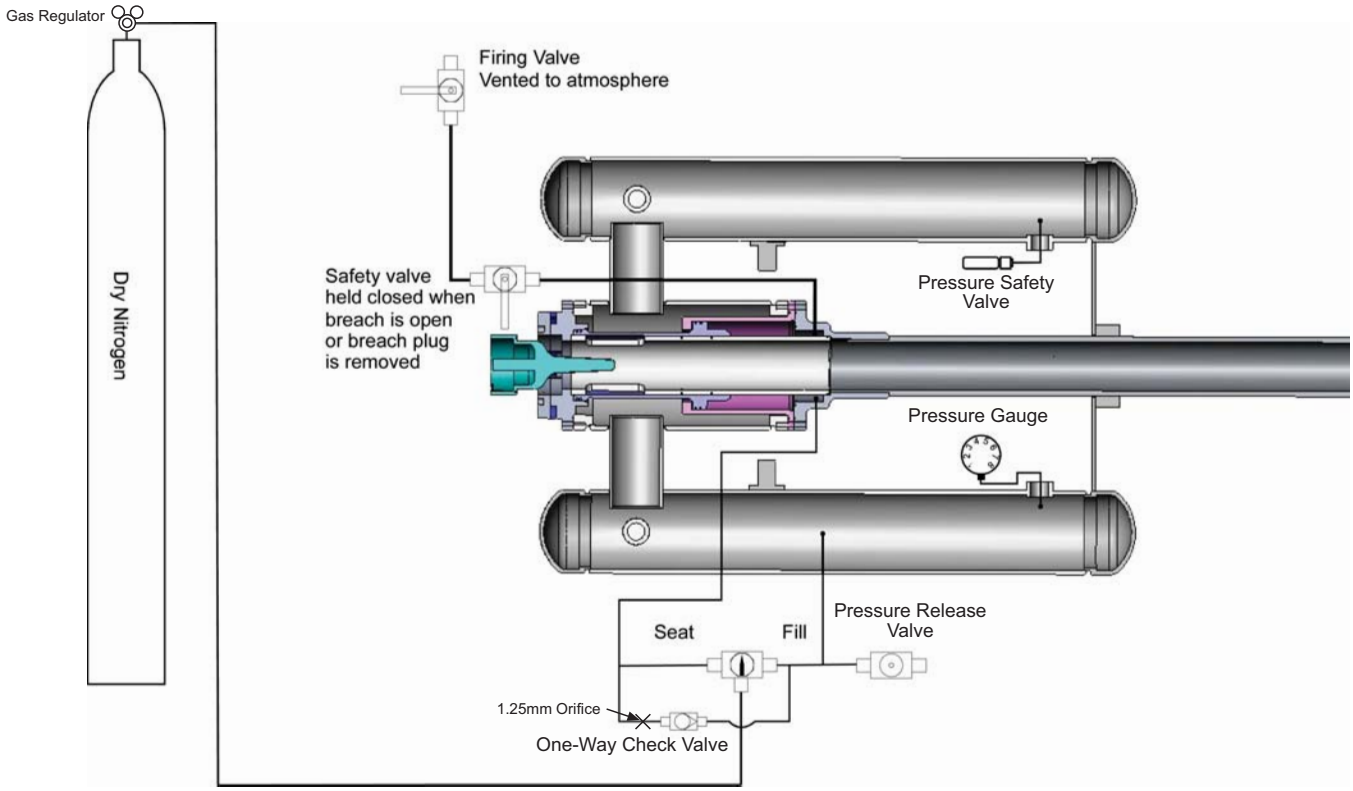
PNEUMATIC CONTROL DIAGRAM APPENDIX G



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APPENDIX B – Classic Procedures User Manual

Classic Procedures User Manual

C·I·L / ORION

Div: EVANinc

Explosives EXPERTS Explosifs

November 14 2014

Classic Snowlauncher System
Loading Procedures

The following are procedures to be followed for loading, and firing the Classic Snowlauncher System, used for avalanche control by Snow Avalanche Programs in British Columbia Canada.

The Classic Snowlauncher system is comprised of three main parts

1) The fore-body 1.1 kg TNT pay-load
2) The arming tail fin assembly
3) CIL Avalauncher High strength detonator
4) Plastazote pillow spacer 10mm length

Parts 1 & 2 are fitted together by means of a friction fitted connection.

Additional Equipment for loading

- Dry approved container for detonators
- Dry container for tail fins
- Federally Licensed magazine for 1.1kg TNT fore-bodies
- Federally licensed magazine for detonators
- Container for transporting fore-bodies from magazine to gun site

Prepare the gun for firing with approved CIL procedures

3. **Personnel**

Two people are required to fire the Classic system. The blasting crew consists of a team leader or gunner and one assistant. **No other personnel should be in the blasting area while loading and firing these rounds**

i) **Team Leader** - is responsible for the following:

a) Safety of the entire operation
b) Operation of the gun
c) Supervision of the blast area
d) Confirming the charge detonation
e) Preparing the rounds
f) Loading and firing the rounds

ii) **Assistant** - is responsible for the following:

a) Recording the shots
b) Double checking the system assembly
c) Observing the projectile in flight
d) Confirming base plate separation in flight
e) Confirming the targets and detonation of the charge

4. **Classic Snowlauncher Loading Procedures**

Check to ensure the Classic Snowlauncher fits properly in the gun barrel. Do this by manually pushing an inert assembled round or a fitted testing gauge made of wood, plastic, brass or aluminum, through the entire length of the barrel, both ways, to ensure there are no foreign objects in the barrel and there are no restrictions in the barrel

4.1 **Preparing the Classic for Loading**

On arrival at the launching device, proceed as follows:

a) Check fore-body for external marks, protrusions, dents, and general condition. The fore-body should be smooth, clean and free of any foreign grit or objects.
b) Check to insure the nose cone is on straight and snapped on all the way
c) Check to ensure the cap well is clear of any foreign objects and proper depth
d) Take two 10 mm plastazote pillows found inside a baggy inside the tail fins box, and load them into the top of the detonator well. Using the detonator well

depth- checking tool, push the plastazote pillows all the way to the bottom of the detonator well

e) Check general condition of tail fin. There should be no dents, creases or foreign objects on the outside of the fin.

f) Check the spring tension on the bore-rider pin. The pin should depress and withdraw freely against the external washer, preventing the spring from jamming in the bore-rider pin hole, in the side of the tail fin.

g) Check to ensure the safety cotter pin is in place

h) Check to ensure the base plate is properly fixed to the bottom of the tail fin.

i) Check to ensure the arming wire is properly fitted into the pore-rider pin and properly secured to the base plate. The arming pin should be slid as far forward, towards the booster charge, as possible

j) Check to ensure the striker-pin magnet is properly secured in the bottom of the striker-pin channel

k) Check to ensure the striker-pin is properly in place in the striker pin channel

l) Check to ensure the detonator ferule is properly in place inside the top cup section of the tail fin

m) Check to ensure there is no grit or foreign objects inside the of the top cup section of the tail fin

n) Check the high strength detonator. Ensure there are no foreign objects inside the open bottom section of the detonator. There should not be any rust or condensation visible. The yellowish primary charge of lead-azide should be visible inside the detonator, well down inside the aluminum shell

o) Place the detonator over top of the ferule

p) Place the fore-body overtop of the detonator ensuring that it fits properly inside the fore-body cap well and push the two parts together.

q) Ensure the two parts are tightly pushed all the way on to each other preventing any air pressure from entering into the tail fin

r) Load the assembled charge into the barrel of the gun with the nose cone forward and the bore-rider pin facing downward

s) Positioning of the hands while loading the round is important. One hand should underneath and cupping the round in the area of the bore-rider pin. This will prevent the bore-rider pin from inadvertently ejecting from the assembled round. **Do not hold the round by grasping the base plate. If loading the assembled round into a try loader the cupping of the round is not necessary as the round can be cradled on the tray, which will also prevent the bore-rider pin from inadvertently ejecting.**

t) Remove the safety cotter pin and discard with the hand which is not cupping the assembled round. If loading the assembled round into a breach loader, using the free hand that is not cupping the assembled round, slide the entire round into the breach by pushing on the bottom of the base plate. This step can often best be done by using a fist on the bottom of the base plate to push. **Do Not Grasp the base plate and finesse the assembled round into the breach. This could cause the arming wire to inadvertently slip out of the bore-rider pin.**

The assembled charge is now ready to fire. Follow approved submitted firing procedures for appropriate gun.

u) Check to ensure base plate separates and falls off in flight after firing

v) Confirm detonation audibly and/or visually where possible

Always fire the Classic Snowlauncher from engineer approved protection and/or remote location. Never stand beside the gun and fire the Classic Snowlauncher System. Always confirm with CIL prior to firing these rounds that your firing procedures are safe

5. **Safety Precautions**

a) The team leader and assistant(s) must be in contact at all times.

b) No flammable or sparking materials may be carried in the same containers as the explosives, detonators or tail fins

c) Only approved CIL Explosives parts may be used to fire this system

d) Only personnel directly involved in the shoot should be present when firing the Classic Snowlauncher system

e) CIL Snowlaunchers should not be shot with firing pressures exceeding 350 psi

f) CIL Snowlaunchers should not be shot with firing pressures below 80 psi

g) Always check with the gun manufacturer for the maximum and minimum gun firing pressures prior to deciding on target pressures

f) Never fire a Claasic Snowlauncher with a firing pressure lower than 80 psi

g) Never fire a Classic Snowlauncher with a firing pressure greater than 325 psi

6.**Deteriorated or Damaged Product**

If any significant damage is detected, to any of the components in the assembled parts, Do NOT Use these and advice CIL Explosives of the issue.

If any of the parts appear to compromised or deteriorated to any degree, Do Not Use these, and advise CIL Explosive of the issue.

7. **Wait time for Misfired Round**

CIL insists on a 30-minute wait time before approaching any misfired avalauncher round.

8. **Misfires and Disposal**

Refer to approved procedures for the jurisdiction working in

MSDS sheets for the fore-body, detonator and tail fin are available from CIL Explosives.

CIL Explosives provides on-site technical training service for all customers using this system

APPENDIX C – Electric Firing Switch

Electric Firing Procedures for Nitro Express Avalauncher Device

APPENDIX D:

ELECTRIC FIRING CONTROL:

Note: For shots above 300 PSI Snowtek recommends remote firing.
For shots greater than 400 PSI it is manditory to use the electric remote firing control.

1. Firing Valve.

2. Electric Connection.

3. Electric Firing Control.

4. Charger Unit.

Fitting Firing Control Valve.
(must be fitted with no pressure/rounds in the Nitro Xpress).

1. Pull back collar on firing line.

2. Fit Firing Valve.

3. Connect Electrical Connection.

4. Turn key on, push firing button.
(valve should be heard clicking).

5. Make sure key is turned off and removed.

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To Electrically Fire.

1.1
Insert firing key

1.2
Turn key on, firing light will illuminate.

1.3
Push and hold firing button down until the Nitro Xpress has discharged.

1.4
Release the firing button.

1.5
Turn off the firing control and remove the firing key.

Recharge firing control every100 shots or 3 months,
or if firing light fails to light.

When Firing Completed The Electric Valve Must Be Removed.

To Remove Electric Firing System.

2.0
Turn off Firing Control and remove key.

2.1
Disconnect Electric Connection.

2.2
Pull back collar on firing coupling and remove valve.

It is not recommended to leave electric firing valve on Nitro between sessions freezing could cause problems.

2.3
Put firing valve back in tool box.

2.4
Charge firing control every 3 months or after 100 shots.

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THE NITRO XPRESS
IS TO BE OPERATED
AUTHORISED PERSON
ONLY
FIRE
SAFE ARMED

FIRING VALVE
Pull To Fire

APPENDIX D – Cornice Control Procedure Access Work Plan and JHA

Access Work Plan and JHA

Job Safety Analysis (JSA) & Rope-Access Work Plan

Project Name	Mountain Safety Division, Soucie Construction Ltd.- Brucejack	Date Prepared	
Client/Host	Pretium Resources	Start Date	
Location Description	Brucejack	Finish Date	
Host Facility Manager		Phone email	
Host Facility Operator		Phone email	

Personnel

Position	Name Sign only after reading	Contact phone/email	Training Current	Emerg. Form (on location)
Prepared by	Brian Cruikshank	250 344-0075	☒Y ☐N	☒Y ☐N
Safety Supervisor			☐Y ☐N	☐Y ☐N
Technician			☐Y ☐N	☐Y ☐N
Technician			☐Y ☐N	☐Y ☐N
Technician			☐Y ☐N	☐Y ☐N
Technician			☐Y ☐N	☐Y ☐N
other			☐Y ☐N	☐Y ☐N
other			☐Y ☐N	☐Y ☐N
other			☐Y ☐N	☐Y ☐N

Emergency Information

EMS Phone	Radio: Repeater 1 Brucejack	Police Phone	
Fire/Rescue Team Phone	Repeater 1 Rx 162.735 Tx 167.715 Tone 71.9	Company Contact Name & Phone	
Emergency Access to Site	Brucejack Camp Lat N 56°27.938’ Long W 130°11.168’		

Communication: ☐ Cell Phone (Check service on site ☐Y ☐N) ☒ Radio (Channel:1 Repeater)
☐ Phone (Note phone number, location, special dialing, other contacts, etc)

Dispatch 1 778 724 4186 (internal ph Ext 100) Av Tech office Ext 102

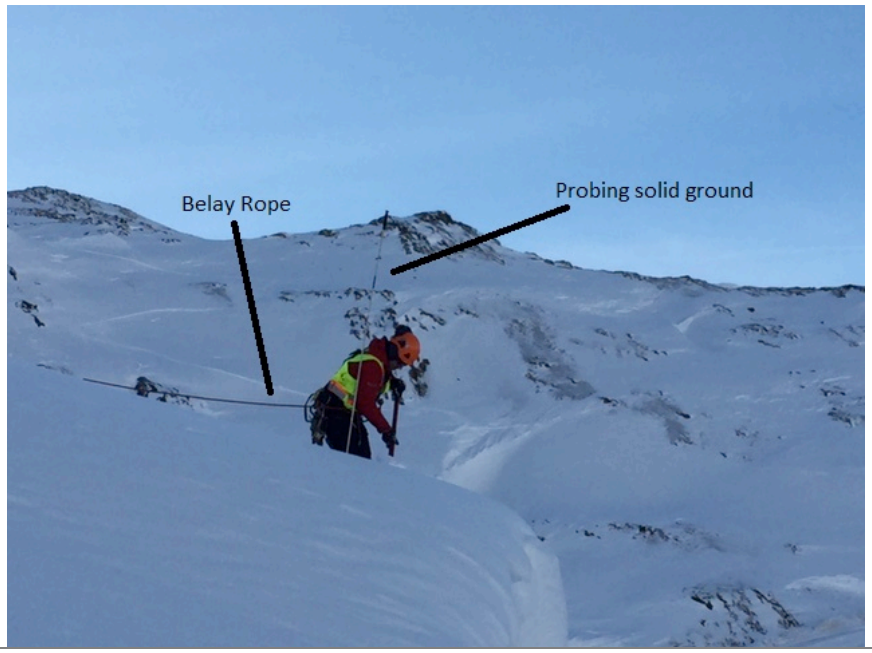
Refer to Brucejack –Incident Response Plan (IRP)

Work Plan

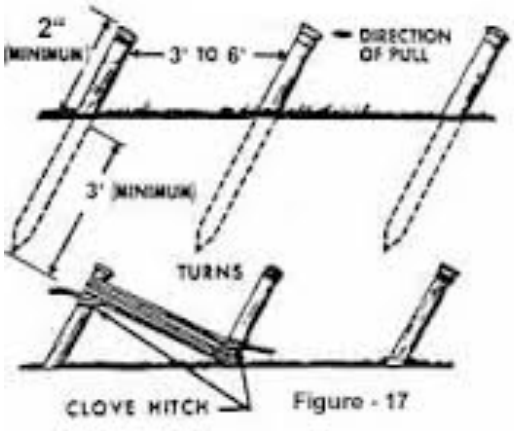
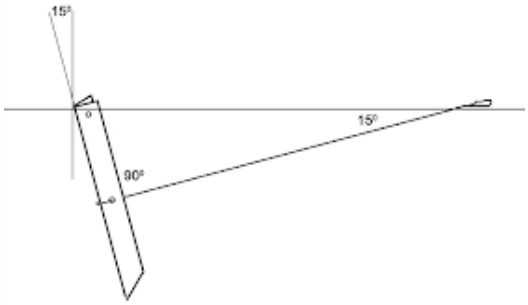
Description of Work	Safe access to conduct cornice control and hazard removal. Scope of work can involve the use of explosives as well manual hazard removal • Cornice control is performed when cornices build up to unsafe proportions. This is may be accomplished with a variety of explosive techniques and each situation may require individualized treatment. • **PERSONNEL RESPONSIBILTIES** The team consists of a Blaster of Record (OHSR 21.5(3)) and Assistant. The Blaster is responsible for all aspects of the mission. There shall be a minimum of two persons, in certain instances additional personnel maybe required. • **BLASTER RESPONSIBILTIES** ☐ Safety with use of explosives, ☐ Test and inspect all equipment prior to blasting ☐ Check and test of rope safety system used ☐ Ensure road closure completion ☐ Select location of watchman ☐ Select safe priming location close to the blast site

Rope-access Methods	☐ Standard practices outlined in Guidelines for Rope Access Work Belay technique with a direct anchor belay. In the case of an emergency the system is capable to: • lower victim on dual ropes to a safe location • raise victim on dual ropes • lower a rescue rope for victim to ascend on, with a back up belay **BELAY ANCHORS** Belay anchors for cornice and/or avalanche control must meet the requirements set out in Work Safe BC Rope access (New) Part 34 Rope Access 34.13 Temporary anchors (2). • A temporary anchor for a rope access system must have an ultimate load capacity, in any direction in which the load may be applied, of a MBS 22 KN (5000 lbs.). The regulation states 12kn (2700lbs per person) all systems are designed for a 2 person load capacity in the case of rescue; therefore anchors must might a MBS 22KN standard. • For the purpose of cornice and or avalanche control an anchor may include large snow vehicles, mature trees, or appropriate snow anchors such as "deadman", snow picket, buried "T-Slot" anchors or if appropriate, ice screws. • The blaster and assistant will determine the location for the anchor making sure that the location is far enough away that cornice breaking away will not affect the integrity of the anchor. • Both will inspect the entire system to be sure it is adequate for the possible forces involved. As per Work Safe BC Rope access (New) Part 34 Rope Access 34.13 Temporary anchors (2). • Belayer will belay the person that will set and prepare the charges using a dynamic or low stretch rope. UIAA Standard 101 Mountaineering and Climbing Equipment – Dynamic Ropes or UIAA Standard 107 Mountaineering and Climbing Equipment – Low Stretch Ropes. • Once work is complete and before ignition of explosives all equipment including anchors will be removed and taken with workers to a safe location.

Individual Equipment	☐ Helmet ☐ Eye protection ☐ Foot protection ☐ Gloves ☐ Protective clothing ☐ Reflective Clothing ☐ Handle Ascender & foot loop ☐ Hearing Protection ☐ Harness ☐ Connectors ☐ Descender (I'D/RIG) ☐ Belay Device (Gri-Gri) ☐ 2 x Backup Devices ☐ Lanyards ☐ Pulleys ☐ headlamp ☐ Multi-tool ☐ other
Group Equipment	☐ Ropes (1 x 50m dyanmic rope) ☐ Edge Protection (PVC tube / steel bar/ CMC edge protection/ SMS edge protection) ☐ Rigging Straps ☐ Connectors ☐ other **EQUIPMENT: EXPLOSIVES** ☐ Detonating cord if applicable ☐ Appropriate boosters and explosives ☐ Safety fuse assemblies ☐ PVC Punch or Ice auger ☐ Pull wire igniters ☐ Blasting Log Time piece ☐ Blasting tools and accessories ☐ Hearing protection ☐ Radios on road closure frequency **EQUIPMENT: FALL PROTECTION** ☐ 2 x ANSI/ CSA Approved full body harness or sit harness ☐ UIAA approved dynamic single belay rope – 10.5-11mm diameter x 50m (enough rope to use for lower and rescue) ☐ 2 x 4' sewn slings, 6' sewn sling, 5m tubular webbing 22KN ☐ 4 x locking carabiners ☐ 1x Petzl ID or RIG with locking carabiner for direct anchor belay (Petzl Gri Gri or ATC for body belay) ☐ 1 x Petzl ID or RIG with locking carabiner for access in the case of an emergency ☐ Safety back up Petzl ASAP, or KONG back up ☐ Handle ascender with foot loop (*Mountain guides* wearing sit harness use asymmetrical dynamic lanyard with handle ascender and basic ascender, with 2 foot loops) ☐ Edge protection
Team Communication	☒ Visual (Hand Signals) ☒ Verbal (unassisted) ☒ Radio (Repeater 1 Brucejack)
Equipment/Tool Management	☐ Other...(describe... attach additional pages if necessary)

Access Zone	Access zone is well back from the cornice on solid ground, minimum 2 meters back from the last probed area of solid ground. Important to have adequate room with a large safety margin for the unpredictable characteristics of cornices 

Hazard Zone	Within 2 meters from last probed area of solid ground back from the cornice feature. Also the drop zone and runout zone below the cornice **CAUTION** It is difficult, and at times impossible, to predict the strength of cornices or the time of collapse. Some of the indicators of natural collapse are: • Fresh build up of the lip during snow storms • Moderate to high winds with snow available for transport • Rainfall: (It weakens the snows and add weight) • Rise in air temperatures (Weakens the snow) • Solar radiation input (Weakens the snow The shape of the ridges or peaks where cornices form influences the density and harness strength of the cornices. Long, uniform ridges generally produce dense and hard cornices due to high wind velocities. The same applies to cornices on peaks, sub-peaks, cliffs, outcrops and points. In bay features, between rock buttresses with low points in between them, snow is deposited easier due to lower wind velocity; this generally results in large and soft (weak) cornices. (Canadian Avalanche Association-Hazards of working on and around cornices) These many variations and characteristics have to be kept in mind when estimating where the potential fracture line is. It is also helpful to know the shape and make-up of the ground in the snow free season (summer/ Fall). Take some photos and add to Access Plan and JHA. The fact that we add the weight of the worker preparing the blast can be critical to the cornice failing. Further more we weaken the cornice considerably by tamping or drilling holes for the explosives or digging holes for large charges. If a cornice fails along the belayed worker's path it generally is of little consequence to the worker or the belayer. **If the cornice should fail behind the worker's path, behind the shot holes, even a belayed worker could be seriously hurt. Forces could be large enough (entrapment under cornice debris) as to cause failure of equipment, systems, anchors, etc… Critical importance to design systems with proper safety margins/ factor - 10:1 to account for additional forces. As well, only qualified personal trained in procedure.** A rule for cornice controllers is to do the work early in the morning because of the lower air temperature and less solar radiation n input. Avoid working on or around cornices after warm night temperatures and during, or after rainfalls.

Anchors	☒ Standard anchors outlined in Guidelines: as described by Work Safe BC rope access regulation 34.14 Temporary Anchors, (2) Create temporary access with 1/2inch x 3 3/4inch hilti expansion bolts - 22kn MBS. Minimum 2 x expansion bolts per anchor Hilti Stainless Steel KB- TZ anchors are made of type 304 or 316. ½" 8543lbs. Shear strength / 12364lbs. tension. Refer to the Hilti manufacture installation procedures. Snow anchors may be utilized into pencil density snow minimum 60cm deep. Must use 2 x independent anchors. • 3 x 3-4ft pieces of ¼"angle iron or snow stakes, stacked vertically and back tied to one another is an acceptable anchor in pencil density snow   • T-slots are highly effective in pencil density snow

	Vehicles, snow cats and heavy machinery once locked out (keys with team leader, wheels choked) can be utilized as anchor points (axles/ structural steel frame) Anchor slings around large rocks that are well seated and absolutely no chance of movement Snowmobile anchors can be utilized when well anchored into snow (rear track is submerged below the snow surface by reversing and spinning track) and a reversed incline slope (Min 10 degrees) to the access zone. (LOAD test data to follow)

Rescue and Retrieval Methods	Direct anchor belay has raise and lower capabilities. The rescue rope will be used in the case of an emergency to lower to victim/ tech so they can ascend the rope The belay rope will be long enough for a lowering system. Very important to properly prepare edge/ lip with edge protection. In the case that the worker is seriously injured the rescue rope can be used for the technician to descend on 2 ropes to assist and connect the safety back up to worker. The technician will ascend back up rope and prepare the haul system (3:1, 6:1 if 6:1 if needed) If the worker is not injured the brake hand end of the belay rope will be secured with a "figure 8 on a bite" and be long enough (50m rope) to be lowered to worker to ascend up the rope—Make sure there is a knot in the end of the rope. Very important to properly prepare edge with edge protection to prevent the rope from digging into the edge. The belay rope will be used as a safety back up while worker ascends rope. • All workers onsite allocated to this task will carry the right certification and level of training to perform a standard rope access rescue when needed. • In the case of rescue all work stops and **Av Tech** onsite team leader takes charge of situation. • The rescue plan will take into account that the majority of rescues will always be easier and faster to descend, but in case of cornice control it will most likely be advantageous to raise victim • Rescue technician will utilize standard rope access pick-off rescue technique. • There will always be a staged rescue kit, with First aid and spinal immobilization equipment, rescue ropes and rigging whenever work is commencing. • Rescuers will access incapacitated technician. Technicians always work with a minimum team of 2 workers • Rescuers will communicate any needed resources, mobilizing outside resources; patient care, first aid and packaging will commence as situation dictates. All rescues are situational dependent; **the Av Techs** trains to be prepared for worst-case scenarios. Our philosophy to work is a proactive preventative approach. With proper job planning, hazard assessment and risk management procedures, we are able to manage and mitigate hazards. ACCESS: Top EGRESS: Ascend or raise worker back up on top, and if situation dictates lower worker down slope TASK SPECIFIC RESCUE PROCEDURES: In the case of a cornice failure, there is a very good chance the belay rope will dig into the cornice edge and make it challenging to climb back up. The rescue rope will be lowered over a well prepared edge with the use of edge protection, making it much easier and safer for the technician to climb back up, and minimize exposure.

Rescue Kit	☒ First Aid Kit ☐ Patient Packaging ☐ Pulleys ☐ Rope Grabs ☐ Connectors ☐ Spare Equipment ☐ other…Rescue Ropes, 2nd descender and safety backup

○ RA Equipment: Wire & nylon industrial Slings	○ Communication: Radios, Whistle, Air Horn
○ Steel carabiners	○ Rescue headlamps
○ Rescue Ropes (Red) 2 x 125 m 12.5 mm	○ Rescue Pole
○ Access & safety lines, 11 mm ropes	○ ANSI approved Back up device
○ Basket (Cascade style) stretcher & bridal system ○ With 5m x 11mm attendant rope or 4-5m Grillon	○ Anchor plates
○ Spine board	○ Passing rescue pulleys
○ Oregon spine splint	○ 8mm cord
○ Stretcher O ring	○ Prussic minding pulley
○ Set of spider straps to package patient on spine board.	○ Canvas and Plastic edge guards, roller guards, Velcro rope guards
○ Attendant attachments (5m of 11mm rope).	○ Knot Pass Pulley
○ MPD, Petzl ID	○ Track line and tag line 11-12.5 mm rescue ropes. ○ 2 x ID's or sets of tandom prussics
○	○

Personnel Performing Task			
Brian Cruikshank			

Work Task(s) to be Carried out from							
Web Deck/Pre-built	☐	Aid Climbing	☐	Ladder (fixed)	☐	Tensioned Line	☐
Suspension	☐	Dual rope system	☐	Ladder (portable)	☐	Back up belay system	☒

Rescue Personnel					
Lead Rescuer	TBD upon award	Cell Phone	TBD upon award	Radio Channel	TBD
Secondary Rescuer	TBD upon award	Cell Phone	TBD upon award	Radio Channel	TBD

Available Rescue Equipment			
Helicopter	☐	Snowmobile	☒
Onsite Assistance	☐	Toboggan	☐
Ladder	☐	EMT Vehicle / Truck	☐

1.0 Operational Objective for the Av Tech Rescue Team:

To efficiently return incapacitated worker(s) to where best patient care can be administered, rescuers will utilize standard training techniques that will be situation dependent. The Action Plan will be based upon the complexity of the rescue weighed against the subjects transport category and limitations of the subject(s) disposition.

1.1 Call received:

- Rescue Leader initiates rescue plan and contacts Dispatch, Operating HSE Supervisor.
- Radio silence is initiated, work stops and technicians return to grade.
- Crew musters at **Av Tech** Rescue Cache and awaits notification.

1.2 Scene size up:

- Location
- Number of subjects
- Nature of the injury

1.3 Mitigate or Control Hazards:
***Hazard controls and mitigation to be decided upon award**

1.4 Risk Benefit Analysis Performed:

- Hazards Identified
- Environment concerns and Extrication issues
- Urgency – Rescue or Recovery
- Subjects injury and Transport Category

1.5 Implementation:

- The Rescue Team musters
- Field Rescue leader is appointed
- Operating HSE Supervisor is notified to activate ERP

Notification **Emergency x 3**	- Radio silence and switch to channel 1 - Stand down work and return to designated muster zones
Rescue Considerations	- Rescue ropes will be of sufficient length to rappel with casualty down to the bottom. - The use of work platform is a possibility depending on situation - Orthostatic incompetence will be managed as required by the nature of the incident.
Transfer of Command	- Once the subject has been lowered safely to grade, the rescue team will administer primary first aid care and package the subject for transport. - Rescue team will assist until transfer of care is complete.
Demobilization	- Technical debrief will be completed with the Rescue Team Crew, record keeping and documentation.

	Condition Human Environment Equipment	Description of Hazards	Hazard rating: LOW MOD HIGH		Control Measures
☒	**Falling**	• Gravity-induced injury or death	HIGH	☐ ☐	Always use appropriate fall-protection or rope-access equipment when 6 feet from unprotected edge with a fall potential of 6 feet or more All personnel must be properly trained
☒	**Human Error**	• Rigging Errors	MOD	☐ ☐ ☐	Use 2-rope system when working line is primary means of support Use independent anchorages Always do 4-point check: Ropes (including anchors), Hardware, Harness, Helmet
☒	**Communication Difficulty**	• Loud ambient noise (traffic, machinery, running water, wind, etc.) • Malfunctioning or dropped radios • Conditions change	MOD	☐ ☐ ☐ ☐	Agree upon and use standardized communication signals Check communication system Designate alternate communication system in case conditions change or technical difficulties arise Review hand signals (as appropriate)
☒	**Sharp/abrasive surfaces**	• Rope or anchor damage and/or failure • Abrasions or cuts to hands	MOD	☐ ☐ ☐	Use proper edge protection and padding Use re-direct or intermediate anchors as needed Wear gloves and proper clothing
☐	**Electrical Lines**	• Inadvertent contact with energized lines • Burns or electrocution from contact		☐ ☐ ☐	Examine lines that might be contacted by wind-blown ropes Get appropriate clearances Follow lock-out/tag-out procedure
☐	**Machinery**	• Inadvertent operation of machinery • Injury sustained from machinery • Hazardous condition created (e.g. release of water)		☐ ☐ ☐	Get appropriate clearances Follow lock-out/tag-out procedure Confirm lock-out/tag-out
☐	**Injury from Tools**	• Hazards depend on tools used • Damage to rope-access or fall-protection system		☐ ☐	Follow all manufacturers instructions and keep all protective guards in place Separate suspension rope may be required for tools greater than 10 kg
☐	**Dropped Tools or Materials**	• Possible injury to personnel and public • Loss of important tools for work or egress • Damage to structures or equipment		☐ ☐ ☐ ☐ ☐	Clearly mark and barricade Hazard Zone Helmets or hard hats must be worn in Hazard Zone Keep a clean and orderly worksite All tools and devices must be tethered or secured Avoid working or standing below other workers
☐	**Rock fall or loose detritus**	• Possible injury to personnel and public • Damage to structures or equipment • Severed ropes		☐ ☐ ☐	Careful scaling or clearing of slope prior to work Loose materials or rock may need to be secured (either temporarily or permanently) Manage ropes carefully to avoid dislodging loose materials
☒	**Rain/Wet/ Wx Conditions**	• Insulating qualities of wet clothing decreases • Possible hypothermia (dangerously low body temperature) • Wet surfaces can be slippery • Decreased friction on descent and rope-grab devices • Danger of stray current near improperly insulated and grounded equipment • Decreased visibility	MOD	☐ ☐ ☐ ☐ ☐	Stop work if conditions become dangerous Wear proper footwear and clothing Waterproof rain gear should be available Be aware of slippery conditions Electrical equipment must be adequately grounded and equipped with GFCI's.
☒	**Snow/Ice**	• Insulating qualities of wet clothing decreases • Possible hypothermia (dangerously low body temperature) and frostbite	MOD	☐ ☐ ☐	Stop work if conditions become dangerous Wear proper footwear and clothing, including gloves and hat Waterproof rain gear should be available

	Condition Human Environment Equipment	Description of Hazards	Hazard rating: LOW MOD HIGH		Control Measures
		• Loss of dexterity in extremities • Wet and icy surfaces are slippery • Decreased friction on descent and rope-grab devices • Danger of stray current around improperly insulated and grounded electrical equipment • Decreased visibility		☐ ☐ ☐	Be aware of slippery conditions Use appropriate rope access equipment for conditions Electrical equipment must be adequately grounded and equipped with GFCI's. Hand warmers should be available in case of emergency
☐	**Water** (working around/over moving/standing water)	• Wet surfaces can be slippery • Potential for Drowning • Trapped in current while tied off (drowning hazard) •		☐ ☐ ☐ ☐	Stop work if conditions become dangerous Rescue boat shall be readily available if working directly over water, especially if descent is a viable method of egress. Fall protection or rope access equipment must not allow worker to fall into water (especially moving water) Personal flotation devices not required if proper fall protection in place
☐	**Sun/Heat**	• Possible dehydration, heat exhaustion or heat stroke • Burns from tools, equipment, and structural steel • Adhesives and first-aid supplies may be degraded by heat		☐ ☐ ☐ ☐ ☐	Stop work if conditions become dangerous Ample water and/or electrolytes must be on hand for workers Schedule proper breaks and work in morning or evening to avoid peak temperatures Wear gloves and proper clothing to protect hands from hot surfaces Use and frequently re-apply adequate sunscreen
☒	**Cold/Freezing Temperatures**	• Possible hypothermia, frostbite, loss of dexterity in extremities • Decrease in efficiency, adhesives and first-aid supplies may not function properly due to cold, water for drinking and work may be frozen; slippery surfaces	MOD	☐ ☐ ☐	Stop work if conditions become dangerous Wear proper footwear and clothing, including gloves and hat Warm liquids should be available to workers
☒	**Wind**	• Possible increased cooling or hypothermia risk, increased dehydration risk in dry humidity • Decrease in efficiency, hindrance to communications between team members • Danger of unsecured equipment or material being blown into the access zone • Difficulty communicating	MOD	☐ ☐ ☐ ☐	Stop work if conditions become dangerous Wear proper footwear and clothing, including gloves and hat Secure loose materials at work site Be wary of wind developing slack in ropes where they may be blown in to areas making retrieval difficult
☐	**Lightning**	• Possible electrocution due to lightning strike, loss of consciousness or life • Rope-access equipment may provide a pathway to the operative for electrical strikes		☐	Stop work when lightning threatens
☐	**Dimly lit or night work**	• Sharp or protruding objects (metal, nails, bolts, etc.) may not be visible to moving operatives, drowsiness of employees		☐ ☐	Provide adequate lighting: area lighting and/or head- and hand-lamps Provide spare batteries, light sources, and bulbs
☐	**Dust**	• Difficulty in breathing, possible allergic reaction • Possible long-term exposure hazard		☐ ☐	Provide adequate engineering controls Provide PPE where engineering controls not possible or impractical
☐	**Chemical exposure**	• Difficulty in breathing, dizziness, unconsciousness • Chemical burns to skin, eyes, internal organs		☐ ☐	Workers must have MSDS on site for all chemicals used in work Proper PPE and engineering controls must be in place

	Condition Human Environment Equipment	Description of Hazards	Hazard rating: LOW MOD HIGH		Control Measures
				☐	Respirators must be the correct type for the exposure
☐	**Confined space entry**	• Work areas may contain toxic gases or insufficient oxygen levels for work. • Space may have restricted entry/exit making access difficult,		☐ ☐	Follow confined space procedures Toxic rescue plan required and in force prior to entry
☐	**High-noise area**	• Permanent or temporary damage to hearing • Difficult Communications • High-noise levels may mask warning buzzers or other alert sounds		☐ ☐ ☐	Hearing protection required, in extremely loud environments (+120 dBA), multiple types of protection may be necessary. Agree on hand signals before work starts Workers may be equipped with sound-isolating hearing protection for radios.
☒	**Use of Explosives**	• Use of explosives on a dynamic surface • Lowering explosives over the edge of a cornice	HIGH	☐ ☐ ☐ ☐ ☐	Careful assessment of cornice size, temperatures, solar influence, snow conditions, etc… Use of gloves at all times Use of belay system with rescue system in place. Trained and qualified personal Follow SWP for explosive operations
☒	**Vehicular Traffic**	• Control work above active roads	MOD	☐ ☐ ☐ ☐ ☐	Careful delineation of access and hazard zones, Use flags, signs, guards, lighting as needed Closure points, sweep closure before going live Affective communication with dispatch and informing all personal over Repeater Ch and road ch
☒	**Cornice Failure**	• Fresh build up of the lip during snow storms • Moderate to high winds with snow available for transport • Rainfall: (It weakens the snows and add weight) • Rise in air temperatures (Weakens the snow) • Solar radiation input (Weakens the snow	HIGH	☐ ☐ ☐ ☐ ☐ ☐ ☐	Try and conduct mission first thing in the AM Do not work during heat of day Avoid after warm air temps during night or rainfall Use probe to determine solid ground The use of belay rope when necessary with rescue plan in place
☒	**Work at Height Fall Protection Equipment**	• Equipment being misused • Equipment not being used for the intendant purpose • Exposed to shock loading • Damaged equipment	MOD	☐ ☐ ☐ ☐ ☐	Inspect equipment before every use Formalized inspection records Qualified technicians Proper training on Work at height, Rope Access and Rescue Plan in place Follow manufacture speciifcations
		•			

Post-Job Debrief

Date/Time Completed		Debrief Prepared by:	
Safety Considerations	Were adequate safety measures taken to insure the safety of personnel and public? Note any additional safety measure taken or recommended.		
Anchorages Used / Special Techniques	Describe the anchorage set-up used and any special techniques used		
Near Miss or Accidents	Describe any near misses or accidents. If none, write "none". Attach additional pages if necessary.		

APPENDIX 1:

Snow Anchors: Reference ACMG TechFiles

Many factors contribute to the strength of snow anchors. The four main ones are:

The strength of the snow
The type of anchor built
The direction of pull
The strength and surface area of the equipment used to build the anchor

Tests done in recent years have focused on how snow strength affects anchor strength and the differences between traditional horizontal t-slot and vertical picket type anchors.

Terminology

Upright: Any anchor placed perpendicular or at an angle from perpendicular to the surface

Horizontal: Any anchor placed horizontally and at a right angle to the direction of load (T-Slot)

Top-Clip: Any upright anchor attached at the snow surface (see illustration below)

Mid-Clip: Any upright anchor attached at or near its mid-point below the snow surface (see illustration below)

Potential loads in snow applications

Climbing ropes are designed to keep the forces transferred to the anchor or climber to less than 12kN. Most manufacturers exceed this standard with many limiting the maximum force to 8-9kN. It is unlikely that one would use a snow anchor in situations where a climber can freefall onto the anchor without introducing other forms of friction. The friction generated while sliding on a 45° snow-slope will reduce the forces produced by a fall by as much as 30%.

Anchor strength vs. snow hardness

Tests show that if the snow is moist (able to make a snowball), it is advisable to compact it before building the anchor. If the snow if dry and cold, it is best to leave it undisturbed. It was also noted that in tests where the anchor failed at greater than 10kN, the failure involved a component of the anchor (picket, cable, sling) and not a failure of the snow structure. Most standard picket and ice axe anchors fail at ~7kN in hard snow (>1F) however, often fail at much lower loads in softer snow conditions. Snow anchor strength is directly related to four factors;

- Surface area and strength of buried anchor
- Direction of pull
- Snow harness
- Craftsmanship

Horizontal vs. Upright anchors

Although buried ice axe t-slot anchors have been a mainstay of Canadian guiding for many years, recent studies have shown that upright pickets clipped at their mid point can achieve strengths equal to or greater than many t-slot anchors. All other factors being equal, a t-slot needs to be buried the same depth as the bottom of a vertical picket to achieve the same strength. In shallow snow conditions or when using an ice axe as the buried anchor, T-slot anchors are often a preferable option to vertical mid-clipped pickets.

Considerations -Building upright anchors

Mid clipped upright anchors

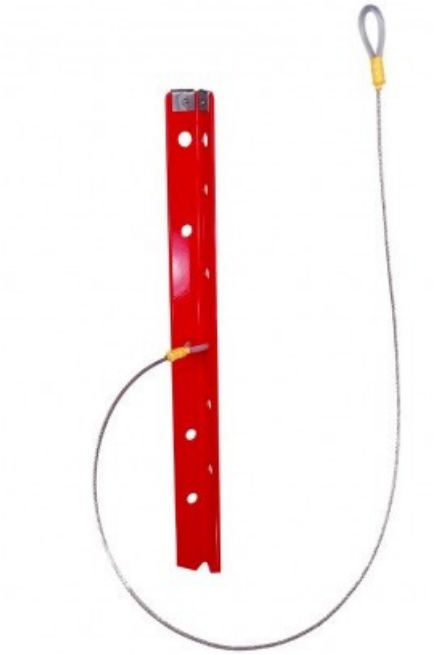
Difficult to build without a purposely designed 'picket'
Sling or cable should be at least twice the length of picket
25 degrees from perpendicular to snow surface is optimal angle of placement
Runner or cable attached to picket at approximate mid point is generally much stronger than clipping top of picket at surface of snow
A 4mm swaged cable or thin sling (Dyneema) have the least affect on the integrity of the snow in front of the picket
In less than 1m of snow over a hard surface (rock slab or ice) picket may deflect when pulled deeper into snow under load. Consider using t-slot in these conditions.

Top clipped upright anchors

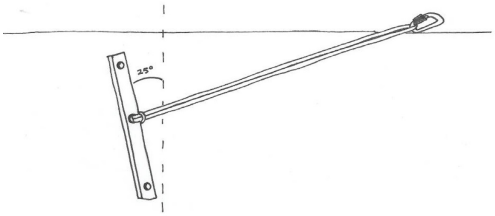
Can be built with ice axe or picket
Very limited anchor strength in all but hardest snow conditions
Typically only considered reliable for moderate loads when snow is sufficiently hard that the anchor must be

placed using hammer

Yates Climbing Equipment is currently making a mid clip picket with swaged cable



Upright picket with mid-clip
(25° back from perpendicular to surface)



Upright picket with top-clip
(25° back from perpendicular to surface)

Building horizontal anchors (T-Slots)

Should be placed at least 15cm below start of 1F snow and a minimum of 30cm deep

Sling must be attached as close to centre of balance as possible

Should be buried if used for rescue or if an upward pull is possible. This should be considered to add security, not strength.

Belaying from snow anchors

Great care must be taken when choosing the belay method to be used with snow anchors. Direction of pull must be considered in construction and care to avoid upward pull must be taken. Avoid shock loading the anchor. If using the anchor to back-up a body belay, ensure the belayer is positioned far enough below the anchor an upward pull on the anchor so

they will not be created when holding a load.

Strategies for building strong anchors in weak snow

In weak snow conditions, consider using the following tactics to achieve an anchor that will be strong enough to hold the anticipated load.

- Compact the snow if it is "moist"- as illustrated by temp or the "snowball test"
- Bury larger items (packs, skis)
- Build and equalize multiple snow anchors (at least 1.5m apart)
- Add other items to the anchor to provide greater surface area (Saxon Cross)

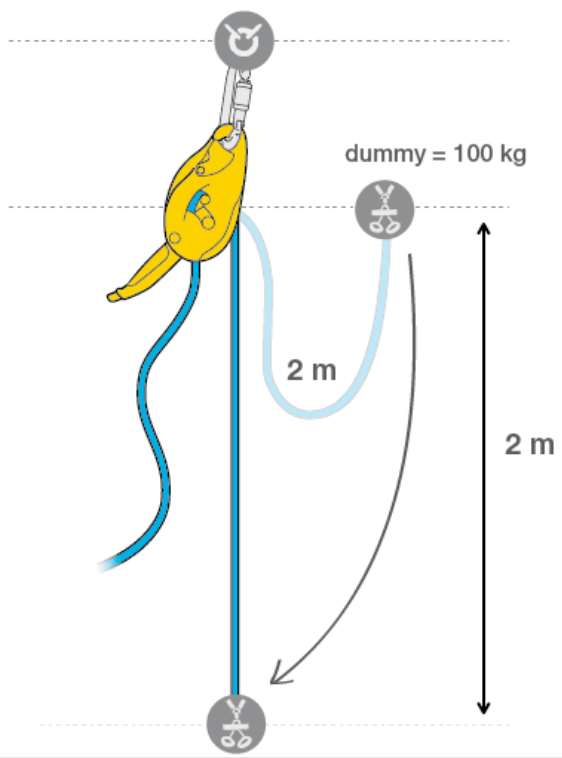
APPENDIX 2:

- Petzl Gri Gri is not designed for direct anchor belays according to the manufactures specifications
- Belaying the leader on dynamic rope using climbing techniques
- The I'D has not been certified with dynamic ropes. Outside the standards framework, it is possible to use the I'D with dynamic rope, following the usual minimum and maximum diameter recommendation.

WARNINGS

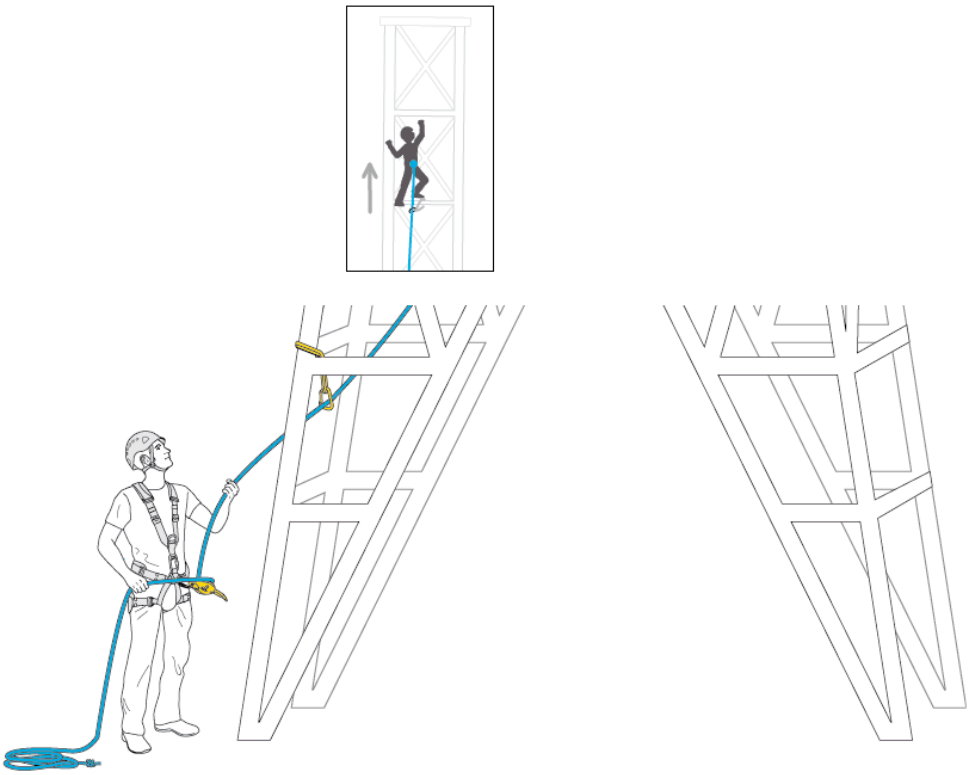
- Read the technical notice before viewing the following techniques.
- It is important to fully understand the information provided in the technical notice before using this complementary information
- Mastering these techniques requires training.
- Consult a professional before attempting to perform these techniques on your own.

I'D S performance test, fall arrest on small-diameter dynamic rope:



Rope type	Impact force	Onset of rope slippage in the I'D
Petzl CONTACT rope	3.6 kN	160 cm

In access situations using climbing technique, a dynamic rope can reduce the impact force experienced by the leader if he falls.



The belayer must always hold the brake side of the rope.

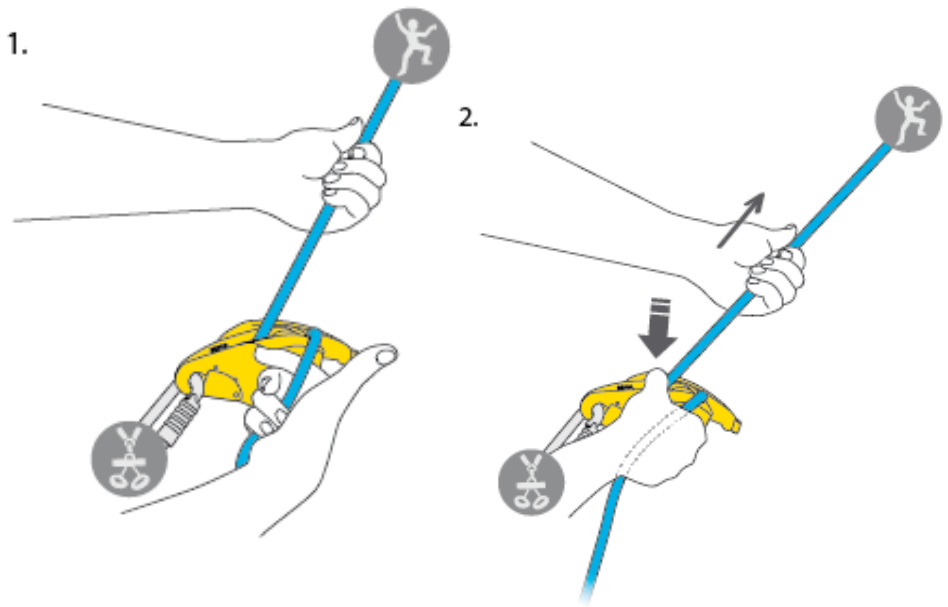
The belayer must be vigilant and anticipate the climber's movements.

Warning: though dynamic ropes can improve comfort when belaying the leader, they are generally less effective in other work situations due to their greater elasticity:

- Work positioning is less precise.
- Greater clearance is required for fall arrest.
- At each loading / unloading, dynamic rope stretches more than a semi-static rope. Rope chafing against the structure can be greater.

During progression, a special technique is required in order to smoothly give slack:

The I'D must be held between the index finger and thumb, and angled downward, while always holding the brake side of the rope. This allows rope to be fed to the climber fast enough to keep pace with his progress.



Belaying the leader

We recommend using a dynamic rope (EN 892) for belaying the leader. Dynamic ropes are designed to hold and reduce the impact of a leader fall.

Fall factor 1 tests have shown (at the climber level) shock forces less than 6 kN with dynamic ropes, and greater than 6 kN with semi-static ropes (new ropes).

When there is a risk of a fall factor 1 or greater fall, use a dynamic rope.

Warning: When there is drag (significant rubbing friction on the belay rope) the actual fall factor can be greater than 1.

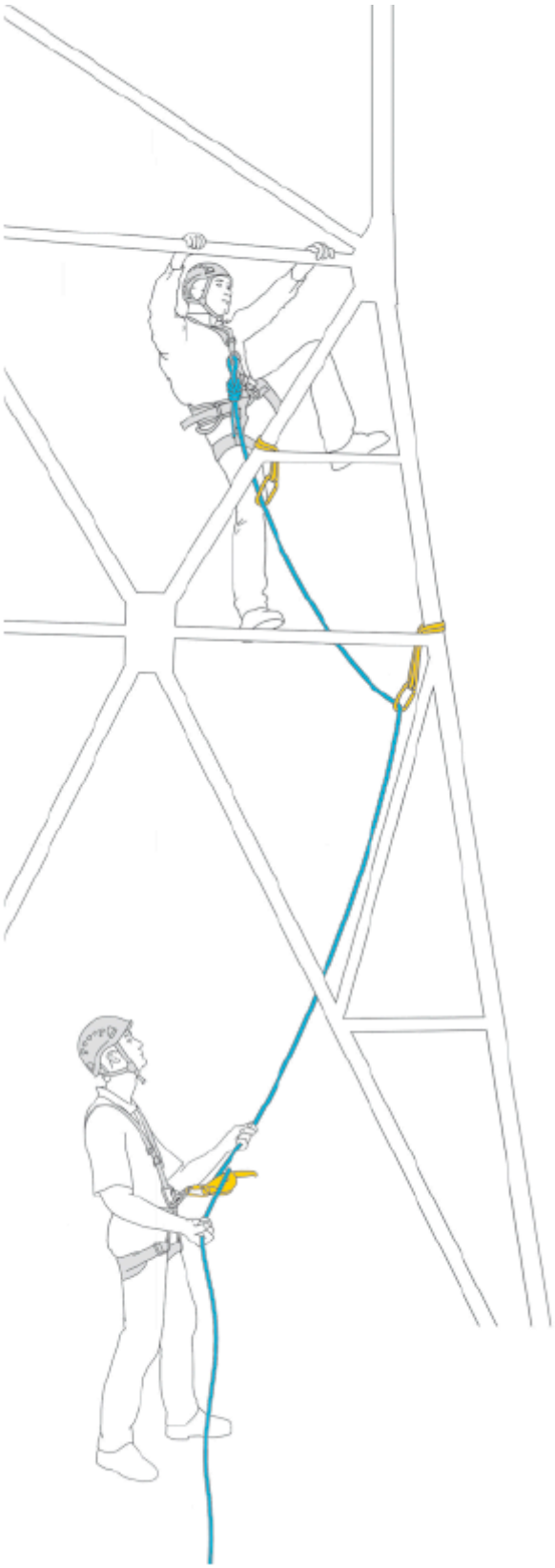
Device attached to the harness (position c) – Sternum connection best practice
Verify the rope is correctly installed before use.

You belay your partner by holding the brake side of the rope in one hand, and the climber side in the other.

To facilitate rope glide, focus more on pushing the brake side of the rope into the device rather than pulling the climber side of the rope.

To stop a fall, firmly grip the brake side of the rope.

To lower a climber, the manipulation of the device is similar to the description found under "Descent".



Belaying loads up to 250 kg with the I'D S

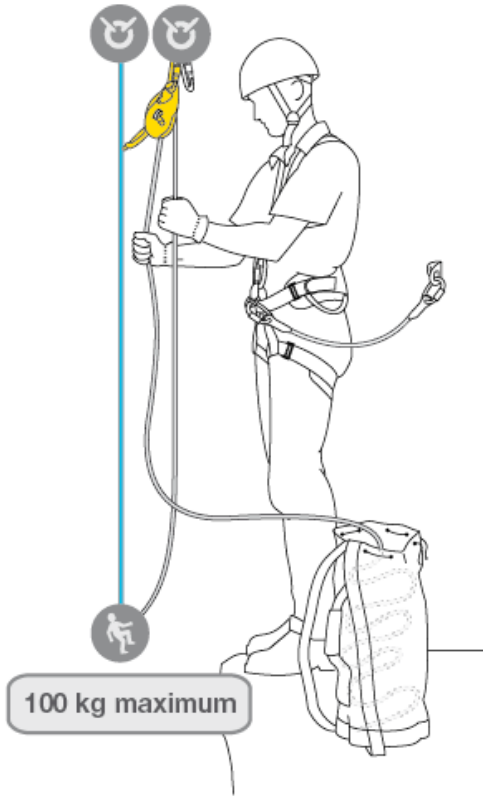
The belay rope must hold the falling load in case of primary system failure. It can thus be subjected to a sudden load equivalent to stopping a fall.

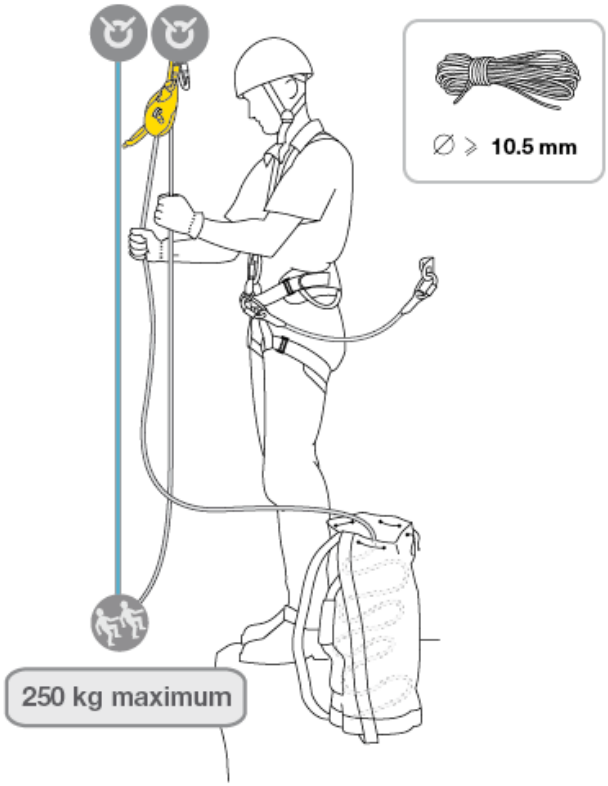
Remember:

The energy developed in a fall increases considerably as the load increases. Above 100 kg and up to 250 kg, the user must be experienced and trained.

Precautions:

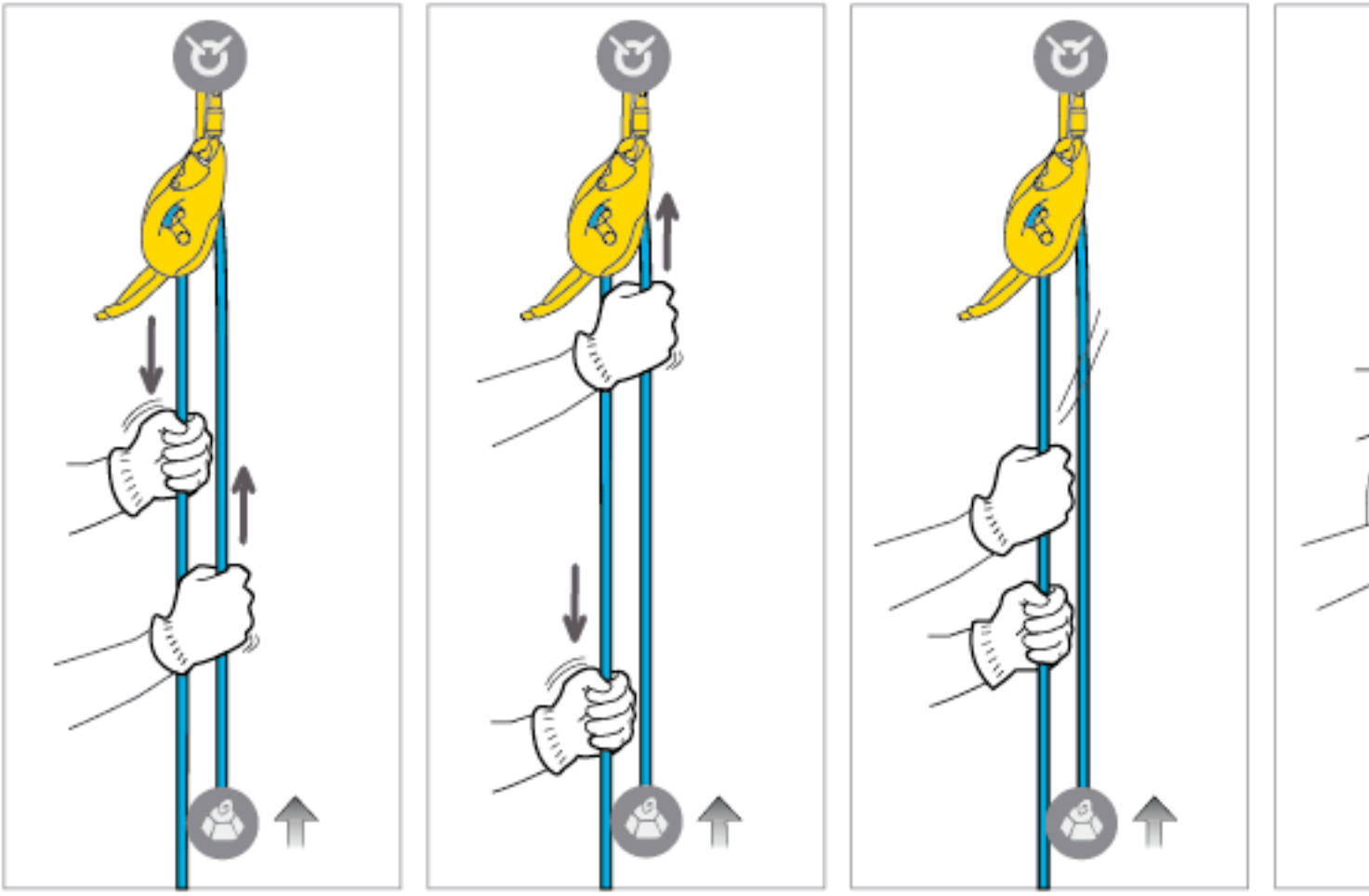
- The user must always hold the brake side of the rope.
- The belay rope should always be taut to minimize impact force if the work rope breaks.
- Be mindful of the clearance; if the work rope breaks, the load will drop to a lower level due to stretch in the belay rope.





Belay technique for raising:

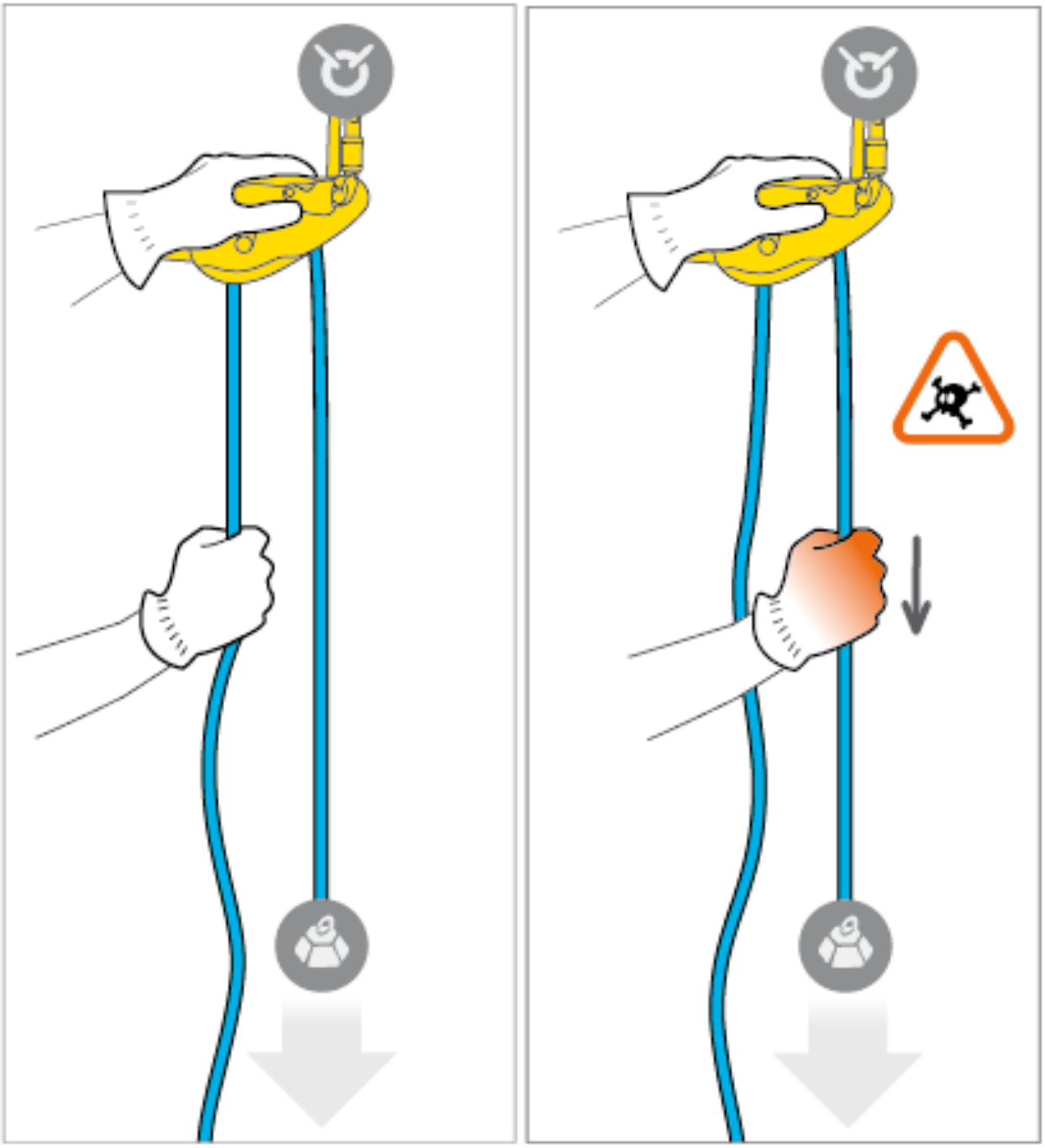
The user must always hold the brake side of the rope.



Belay technique for lowering:

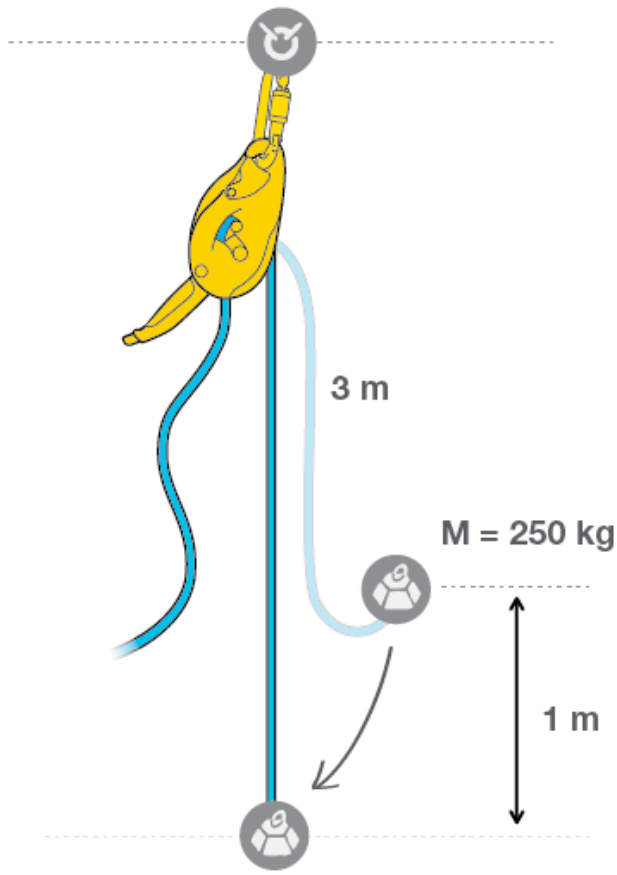
The user must always hold the brake side of the rope.

Tilt the I'D to facilitate the rope sliding through the device.



Fall arrest tests with 250 kg and the I'D S:
To ensure the ability of the I'D S to belay a load up to 250 kg, tests were done to simulate an unfavorable situation, on various new ropes that are compatible with the device.

This situation represents incorrect usage: brake rope not held and slack in the belay rope.



Results:

- The impact force is acceptable (around 6 kN) due to rope slippage in the device.
- Rope slippage in the device can be significant (1 to 2 m), plan for this in determining the required clearance.
- The mass could be lowered after the test.

APPENDIX E - Wyssen Avalanche Tower LS12-5 G3 Instruction Manual (v 3.6, June 2016).

Operating Instructions
(translated from german)

Wyssen avalanche tower LS12-5 G3
Wyssen Heli Link HK-02

Safety through innovation.

wyssen switzerland avalanche control

V 4.4-EN
04 / 2023

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1 General safety instructions

1.1 Presentation of the safety instructions

Safety instructions on hazards, warnings, prohibitions and commands are provided with the following pictograms in the operating instructions and marked on the products:

Please follow the instructions for use

Use safety harness

General prohibition sign

Unauthorized access forbidden

No open flames; fire, open ignition source and smoking is prohibited

Climbing is prohibited

Caution lightning voltage

Warning about explosive substances

Warning of risk of automatic start-up

Danger due to heavy lifting

Warning of risk of hand injuries

Warning of risk of crushing

First aid

First aid Unauthorized operation

1.2 Safety notes

This manual contains instructions that must be followed to ensure your personal safety, the safety of others, and to prevent damage to property. The instructions are highlighted with a warning triangle and marked according to the hazard level as described below.

Hazard
Indicates an imminent danger. If not avoided, this will result in death or very severe injuries.

Warning
Indicates a potential imminent danger. If not avoided, this can result in death or very severe injuries.

Caution
Indicates a potential imminent danger. If not avoided, this can result in slight or minor injuries.

Hint
Indicates useful or necessary user instructions.

1.3 Intended use

The Wyssen avalanche tower is used for controlled avalanche triggering by blasting. This is intended to secure avalanche-prone facilities, ski slopes, buildings, traffic routes, etc., where uncontrolled avalanches can cause personal injury or property damage.

This system is intended exclusively for the controlled triggering of avalanches and may only be operated by trained personnel in compliance with the regulations and after an accurate assessment of the situation with regard to any residual risks.

The system may also be used exclusively in conjunction with the third-party devices and components recommended or approved by Wyssen Avalanche Control AG.

Correct transportation, installation, storage and careful operation and maintenance are prerequisites for the trouble-free and safe use of the product.

1.4 Preface

The aim of the present operating instructions is to provide the user with complete information, with all the necessary data to allow the safe and correct use of the equipment.

These operating instructions are specifically intended for the personnel responsible for operation and maintenance, who have the appropriate qualifications and training with the corresponding certificates.

The construction of the foundation as well as the assembly or disassembly of the tower are explained in a separate documentation, which is addressed to the responsible engineers and the executing construction personnel.

The proposed SOP amendment listed in the annex is addressed to the heli companies that perform transport flights with the avalanche tower deployment box. In order to be able to carry out the order, they must have the SOP supplemented with this specific operation description approved by the state aviation authority.

These operating instructions must be carefully read and understood before commissioning the equipment and must be available to personnel at all times during the operation and maintenance of the equipment. If, for any reason, this document is no longer available or has become illegible, a new document must be requested or made available immediately.

Separate courses and literature are necessary for a sound analysis of the avalanche situation on-site.

1.5 Qualified personnel

The personnel who operate the Wyssen avalanche towers or the Wyssen heli link must be officially appointed by the management. They must also be in possession of a personal confirmation of a training course on the equipment conducted by the manufacturer, as well as for the operation of the Wyssen avalanche tower of a nationally valid license to handle explosives for the artificial triggering of avalanches.

Instruction by in-house colleagues is not considered a substitute for the supplier›s equipment training. Persons who have not been trained by the supplier and are not in possession of the above confirmation may not operate these systems.

Refresher training can be requested from the supplier at any time by the operator of the system

1.6 Service & support on the Internet

In addition to this documentation, we are also happy to provide you with our expertise online at the following link: www.wyssenavalanche.com

You will find the following useful information at these addresses:

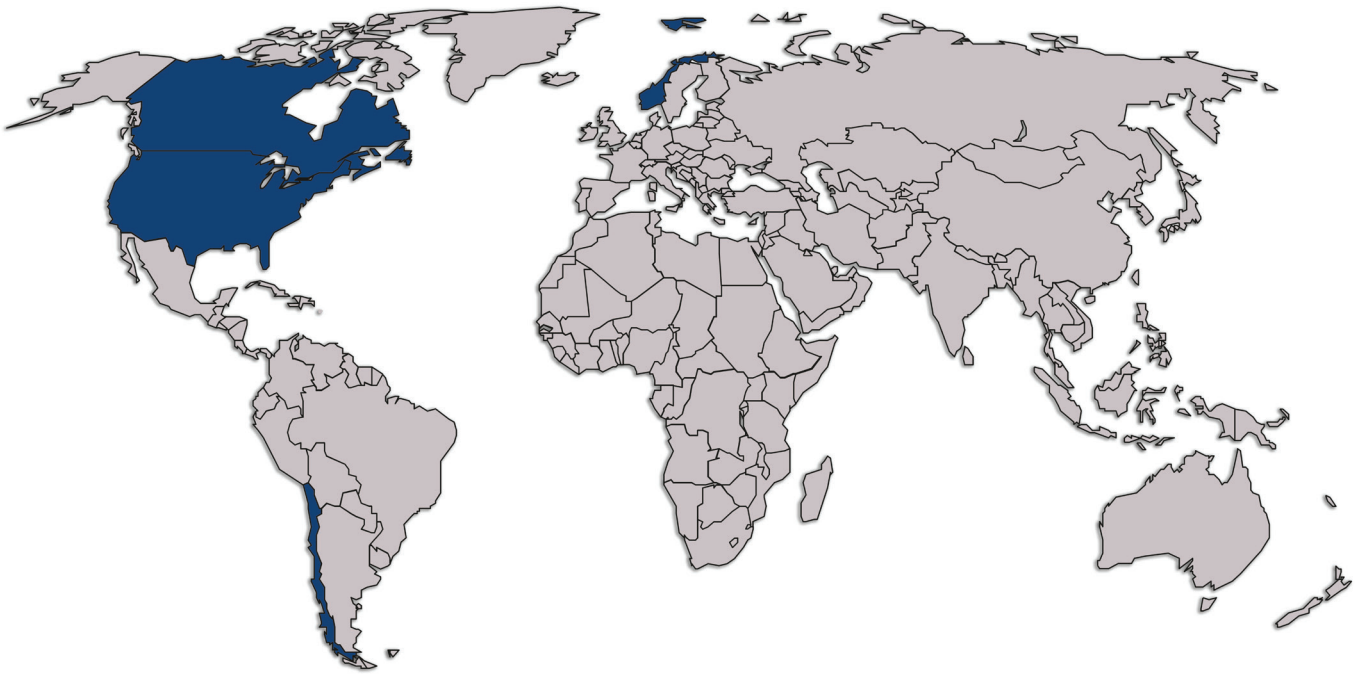
- Product-specific information
- Newsletter containing current information about our products

1.7 Certifications

The Wyssen Avalanche Control Wyssen Avalanche tower LS12-5 (item No: 411.100E) is in conformity with the relevant provisions of the CE Machinery Directive (CE Directive 2006/42/EC, 2014/30/EU and 2014/53/EU)), including its amendments, as well as with the corresponding legal decree transposing the Directive into national law.

1.8 Technical Support

Our well-trained technical support team is available worldwide for answering your questions and providing solutions to problems at any time.



Switzerland	Austria	Norway
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Canada	Chile	USA
Tel: +1 236 836 4164 E-Mail: service.ca@wyssen.com	Tel: +56 9 5843 2997 E-Mail: service.cl@wyssen.com	Tel: +1(720)360-0744 E-Mail: service.us@wyssen.com

Andorra
Tel: +41 33 676 76 99 E-Mail: service.ch@wyssen.com

2 Description of the system

The Wyssen avalanche tower is used for the controlled triggering of avalanches by means of remote-controlled blasting. It can be used to secure avalanche-prone facilities, ski slopes, buildings, roads, etc., where uncontrolled avalanches could cause personal injury or property damage.

To trigger an avalanche, a command is sent from the command center to the Control of the deployment box for initiating the explosion.

The deployment box contains 12 prepared explosive charges, which can be dropped individually. By dropping the explosive charge, two detonators are pulled and the explosion is triggered after a time delay.

The charge remains suspended on a cord at a previously set height above the snow surface until the explosion, which is dropped completely after detonation. To reload explosive charges, the entire deployment box is lifted from the tower by helicopter and brought to a station building.

In addition to the function of the charge drop, a system test, a «test run», can also be performed. The test run is used to check the function of the entire mechanism and control in the deployment box as well as to determine whether explosive charges have been stolen by theft.

2.1 Advantages

Smallest residual risk thanks to the largest range of action

- Over-snow blasting with a large charge (4.2 kg) results in a maximum effective range of up to 240 m (787 ft) in diameter.
- Explosive with high-frequency, N-shaped pressure wave has been proven to lead to the best triggering effect, in particular at a greater distance from the blast point.
- The possibility to position the system on elevated places as well as two different tower heights enables effective operation of places in the pressure shadow (in corridors, behind terrain ribs).
- Smallest amounts of snow can be triggered, thanks to the best effect
- Very good stability test for estimating the local avalanche risk

Maximum reliability

- Thanks to clever planning, no critical and moving parts are exposed to the weather
- Thanks to solar power supply or wind generator no susceptible supply lines in the terrain necessary
- Thanks to annual maintenance, maximum reliability can be guaranteed

Reduced downtimes thanks to fast triggering, 24 / 7 in any weather

- Remotely controlled systems allow use around the clock.
- Speedy use and simultaneous triggering of several towers possible
- Short downtimes
- Clearance of avalanche snow is normally not necessary, thanks to shorter avalanche runout distances due to the triggering of small portions

Maximum economic efficiency

- Low investment and operating costs compared to permanent structural protection measures
- Lowest operating costs thanks to ingenious system planning
- Damage to infrastructure is avoided by triggering small portions
- Economic benefits thanks to reduced down times

Maximum safety for the operating personnel

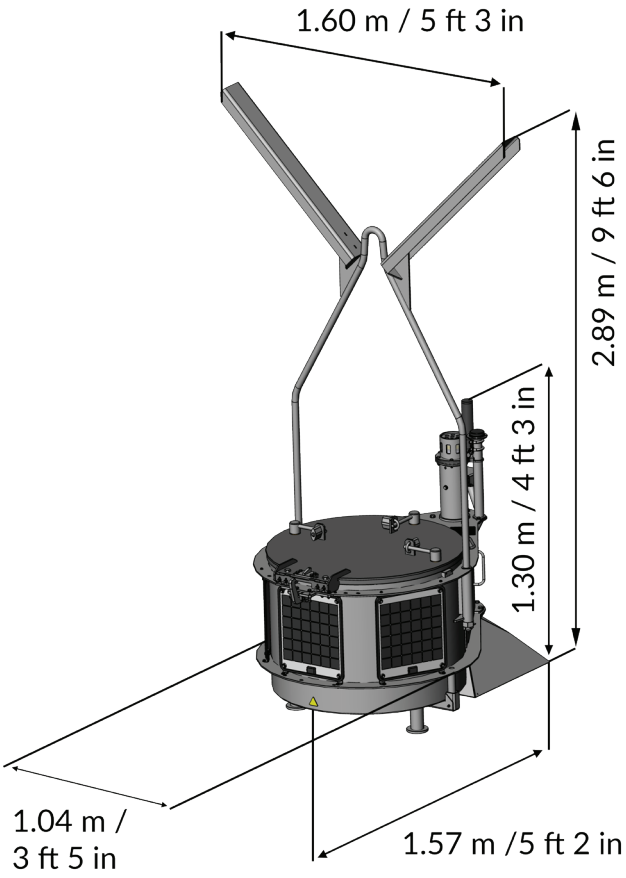
- Thanks to remote control of triggering, no personnel in the danger zone
- Cargo preparation takes place in sheltered areas
- Thanks to the mobility of the deployment box, virtually no maintenance in the field is necessary

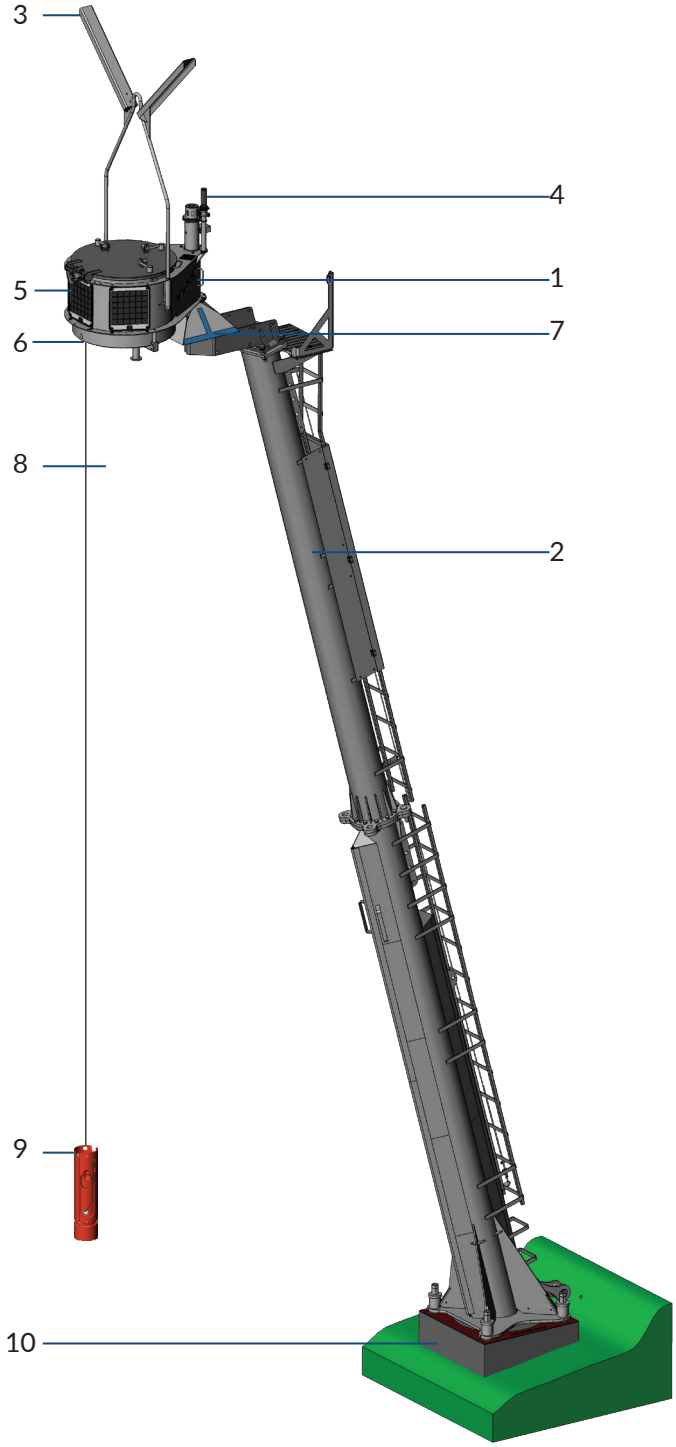
Very environmentally friendly thanks to the smallest possible impact on nature

- Foundation occupies only 1 m^2
- Short construction times on site simplifies planning and implementation
- Blasting over the ground prevents damage to the vegetation cover
- Easily dismantled after service life

2.2 Structure of the overall system

1. Deployment box
2. Tower
3. Transport bracket for helicopter
4. Radio antenna
5. Solar panel
6. Drop hole
7. Pick-up device
8. Charge holder cord
9. Dumped Charge
10. Foundation (option: concreteless foundation)





2.3 Technical data deployment box

2.3.1 General

Title:	Wyssen avalanche tower
Short name:	LS12-5
Weight deployment box complete incl. Load:	530 kg (older models acc. Type plate)
Dimensions charge magazine (l x w x h):	1570 mm x 1040 mm x 1300 mm / 5 ft 2 in x 3 ft 5 in x 4 ft 3 in
Height deployment box with transport bracket (w x h):	1600 mm x 1890 mm / 5 ft 3 in x 9 ft 6 in
Protection class with closed magazine:	IP43

2.3.2 Payload

Number of charges per deployment box:	12 pcs.
Net explosive mass:	4-5 kg (8.8 - 11 lb)

2.3.3 Power supply

Battery in the deployment box powered by solar panel:	12 V

2.3.4 Data transfer

- EGSM 850 / 900 / 1800 / 1900 MHz
- GSM / GPRS Protocol stack 3GPP Release 4 compilant
- Transmission in the concession-free data channels in the 430 MHz or 868 MHz range

2.3.5 Tower

Standard heights: 10 m or 12 m / 32 ft 10 in or 39 ft 5 in

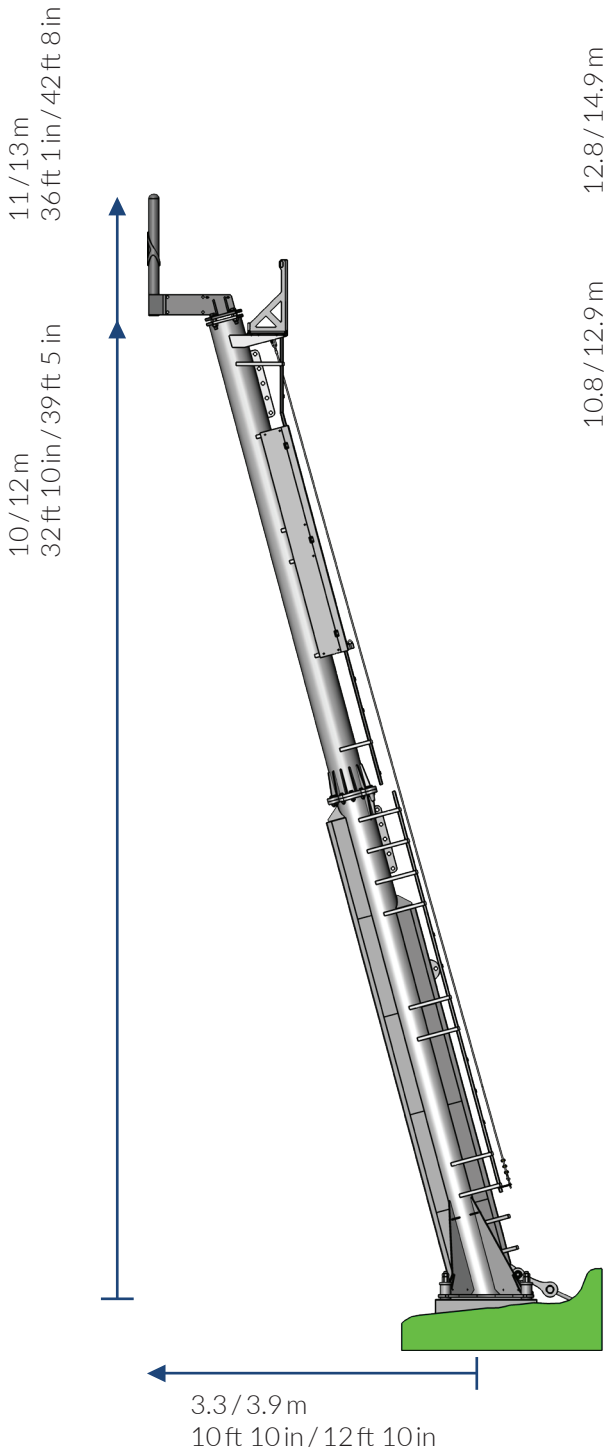
Detailed information about the towers can be found in the foundation instructions.

2.3.6 Temperature

The permitted temperature range of the deployment box extends from -20°C to 40°C.
Test runs and blasting may only be carried out if the temperature is within this range.

2.4 Mass of blasting tower

Tower in summer without deployment box:



Tower in winter with deployment box:

3 General safety regulations

3.1 General principles

Warning
Incorrect operation can lead to the triggering of explosions at the wrong time, or while people are located in the danger zone, which may cause fatal injuries or property damage,
see chapter 3.6.1 Danger zone 1 (G1) on page 19

The system described here corresponds to the state of the art and the recognized safety rules. Nevertheless, dangers can arise, especially when handling explosive substances and the controlled triggering of avalanches. It must therefore be ensured that the system is only operated in perfect condition and in compliance with the present operating instructions.
The legislation applicable in the country of use for the handling of explosives must be followed in all circumstances. This applies in particular to the purchase, transport, storage, handling, use and destruction / disposal of explosives and pyrotechnic objects.

3.2 General

This operating manual must be read carefully before commissioning and the instructions contained in it must be followed strictly. If you have any doubts or if you identify any defects in the product, contact the supplier immediately.

Warning
This operating manual must be read carefully before commissioning and the instructions contained in it must be followed strictly. If you have any doubts or if you identify any defects in the product, contact the supplier immediately.

The above-mentioned danger zone may only be opened up to the access of persons when the avalanche starting area has been secured and considered to be safe.

This cannot be definitively guaranteed by blasting with the Wyssen avalanche tower described here.

The danger of avalanche must be declared safe by a local responsible avalanche expert prior to clearance for access to people.

Any liability for damage due to pressure effects or avalanche subsidence caused by or after blasting with the Wyssen avalanche tower is rejected by the manufacturer. If, for unknown reasons, blasting cannot be carried out with the equipment described in this document, or can only be carried out inadequately (e.g. if the equipment does not work), alternative securing methods must be used, or the area must be closed to people.

It is the responsibility of the local avalanche expert to determine if and at what time an explosion is carried out. However, it is also their responsibility whether and when an area endangered by avalanches can be reopened to people after blasting has taken place.

There is also the residual risk of charge failure in the Wyssen avalanche tower. These must be salvaged and defused in accordance with the statutory provisions. Any liability for personal injury or property damage due to failure is rejected by the manufacturer.

It is strictly prohibited to dismantle, bypass or override safety and monitoring devices.

An emergency response plan for emergency situations (such as the unintentional triggering of the detonating devices during charge assembly) must be developed by the person in charge of explosive operations and the operating personnel must be instructed accordingly.

3.3 Authorization and training of personnel

The personnel who operate the Wyssen avalanche tower must be officially appointed by the management and have been trained by the supplier of the system by means of training with appropriate, personal confirmation.

Persons who have not been trained by the supplier and are not in possession of the corresponding confirmation may not operate the system, even if they have been instructed to do so internally by colleagues.

The operator can order additional refresher courses from the supplier if necessary.

The personnel must also be authorized and identified to handle explosives for artificial triggering in accordance with national requirements.

Switzerland
Personnel must have a valid permit for the artificial triggering of avalanches issued by the Swiss State Secretariat for Education, Research and Innovation (SERI).

Austria
Proof of expertise for avalanche triggering blasting work according to the Proof of Expertise Ordinance

Norway
Personnel must be registered at the Norwegian Directorate for Civil Protection (DSB) and the employer has to have a sufficient amount of personnel with a technical blasting license registered at DSB

Only the service and maintenance work described in these operating instructions may be carried out on the system. Further work must be carried out by specialist personnel of the supplier.

If faults occur in the system, the supplier must be informed under all circumstances, regardless of whether they have to be rectified by the supplier itself or by specialist personnel.

It is forbidden to carry out mechanical conversions and changes to the system as well as reprogramming of the operating software independently.

3.4 Initial commissioning

The initial commissioning of the system may only be carried out by personnel of the supplier of the system.
The official handover of the system is carried out and confirmed after commissioning by the operator and the supplier in accordance with the acceptance and test protocol.

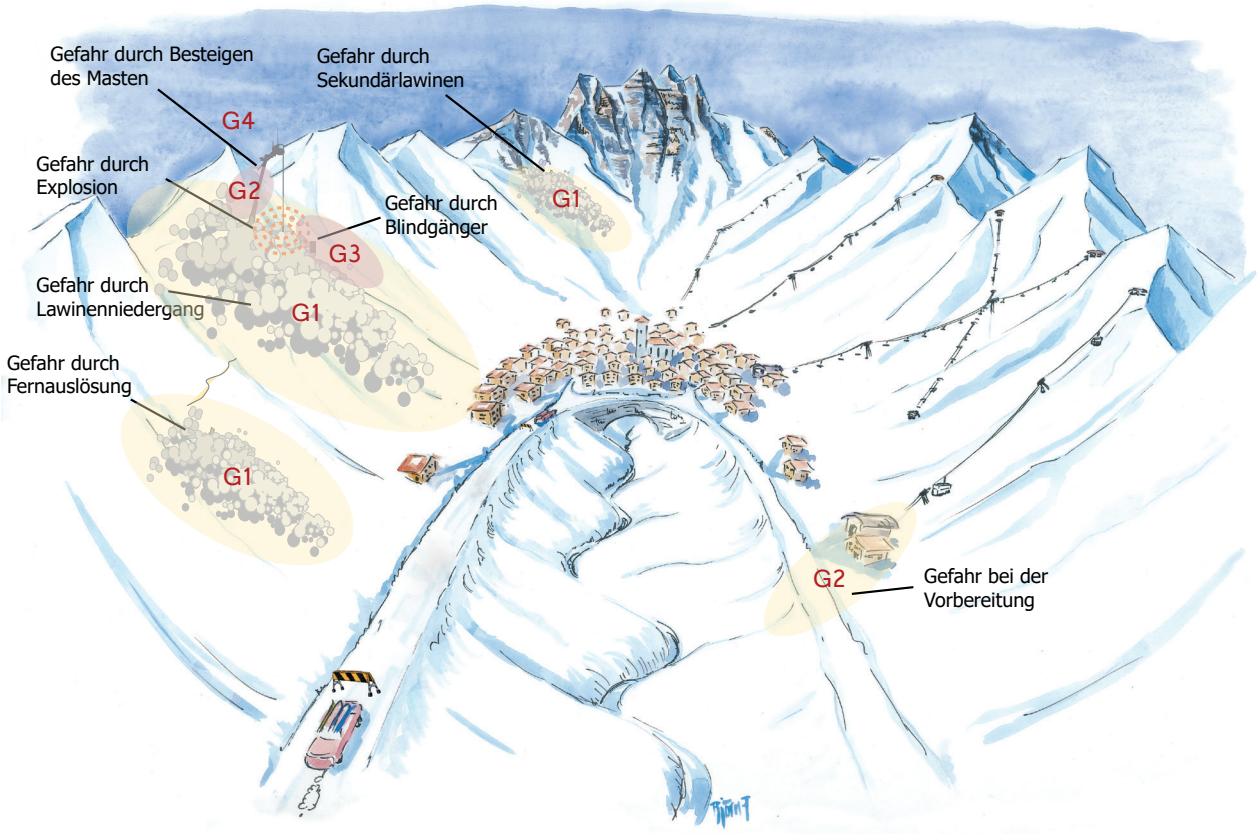
The recommissioning after the seasonal interruption of operations can be carried out independently by the personnel trained by the supplier and qualified in accordance with this manual.

3.5 Maintenance

The operator of the system is obliged to carry out maintenance for each individual system that is installed by specialist personnel commissioned by the manufacturer or its authorized representative. This includes an annual inspection with maintenance and servicing of the system by the supplier, see chapter 9.1.4 Annual maintenance work carried out by the supplier on the system before seasonal commissioning on page 47

3.6 System-specific hazards

The various sources of danger that can occur in the different areas around the system are explained below.



3.6.1 Danger zone 1 (G1)

Area during the triggering of an avalanche.
The following dangers exist when blasting with the Wyssen avalanche tower.

Danger due to avalanches
Before each blasting, checkpoints must be set up to ensure that no one is in the area of the avalanche›s descent (in accordance with national regulations).
Danger due to unexpectedly long run-out of the avalanche
Based on the snow conditions (high risk after heavy snowfalls), it must be assessed whether a controlled triggering can be carried out at all.

Danger due to remote triggering
The risk of triggering secondary avalanches must be estimated on the basis of snowpack stability, topography, propagation of seismic waves or air pressure.
Danger due to explosion
Before each blasting, checkpoints must be set up to ensure that no one is in the danger zone of the explosion. The following safety distances according to the avalanche blasting guidelines from SERI (as of 09.01.2021, [18]) for free charges with 8 kg of explosives must be observed:

- Hearing protection: 29 m (95 ft)
- Hearing unprotected: 60 m (196 ft)

Summary
To avoid personal injury, the evacuation,
blocking and securing of the entire danger area by checkpoints is a prerequisite for a controlled remote triggering of avalanches.

3.6.2 Danger zone 2 (G2)

Area for the preparation and reloading of explosive charges.
In this area, there is a risk of unintentional triggering of an explosion during handling (reloading or maintenance work). Therefore, this work may only be carried out by trained personnel.
Unauthorized access to the following areas is forbidden during this time.

Explosives storage incl. transport route to the place of assembly of the cargoes
Area around the workplace during the assembly of explosive charges
Area of short-term interim storage of the explosive after the assembly of the charge
Area on the transport route from the assembly workstation to the deployment box
Area around deployment box during loading and unloading of charges

3.6.3 Danger zone 3 (G3)

Area around a failed charge.
If a charge dropped by the Wyssen avalanche blasting tower does not detonate, there is a failure. This carries special dangers, which must be taken into account, see chapter 11 Failures on page 48.
It is possible that the detonators of the explosive charge have not been pulled, which means that the charge is still live.

Duds can potentially slide off the tower or be carried away in an avalanche. In this way, they can reach areas that are frequented by people.
Furthermore, if the holder cord of a failure is found by an uninvolved person and that person pulls on it, it can lead to the detonation of the explosive charge with severe consequences.

For these reasons, it is important that failures are located and defused as quickly as possible in accordance with national explosives legislation.

3.6.4 Danger zone 4 (G4)

Area when climbing a tower.
To carry out maintenance on the towers or to remedy faults, the tower must be climbed. There is a risk of life-threatening injuries due to falling.
As soon as the tower is climbed, the personnel must protect themselves with a safety belt and a tether from a possible fall, see chapter 4.3 Tower on page 25. The rescue plan is the responsibility of the operator.

3.6.5 Danger zone 5 (G5)

Area for heli transport.
In the area of the heli flight route during the transport of the deployment box between the pick-up / unloading point and the tower, there is a risk of the deployment box loaded with Wyssen 2K® charges falling due to an intentional or unintentional emergency drop or breakage of a load-bearing component.

Explosive material
A distance of at least 500 m (1641 ft) to uninvolved persons or public buildings must be kept. The loading areas and flight routes must be approved by the competent aviation authority. (CH: BAZL; AT: Austro Control)

Wyssen 2K®
The flight route must be selected in accordance with national regulations for underload flights. Because of the Wyssen 2K® charge, the safety radius of 500 m (1641 ft) for the flight route is inapplicable.

3.7 Safety functions

The safety of the vehicle depends on the electronic control of the deployment box. The electronic control of the deployment box includes a part in which safety functions according to ISO 13849-1:2021 have been implemented.

In summary, functional safety ensures that the vehicle does not start under any circumstances without this being desired by the operator. These basic functions, which are actually trivial and logical, must also function reliably if any component fails.

In the event of failure, all safety functions can cause unintentional avalanches to be triggered and thus cause fatal injuries to persons. Therefore, all safety functions meet the following requirement level:

ISO 13849-1:2021 Category 3 PL d

All safety functions are implemented by the electronic control. The finger switch B1 is additionally used for the safety function SIF3.

There is only one mode of operation. The override button does not bypass the safety functions, but is simply another way of enabling the supply to the motors.

3.7.1 Troubleshooting and maintenance

Troubleshooting and maintenance work may only be carried out by the manufacturer.

In the event of failure of the safety functions, the undesired start-up of the vehicle cannot be ruled out. In this case, there is a risk of undesirable triggering of avalanches by explosives. Category 3 includes single-fault safety, a single accidental fault can therefore not lead to a hazard.

Errors in safety functions are automatically displayed on the control panel. See also error 32 in the error list, see chapter 20 Error list Release V1.4.10 on page 61.

The safety functions cannot be bridged (no muting).

The safety functions are implemented in the electronic control system and designed for the following environmental conditions:

Power supply:	12 V (battery)
Temperature:	-45°C bis +70°C

ZFor easy troubleshooting, the four LEDs on the control board are used:

H11	Off	Switched off (or LED defective)
	Flashing	Safety channel 1 running, finger not detected
	Double flashing	Safety channel 1 running, finger detected
	Lights on permanently	Error in safety channel
H12	Off	Safety channel 1 is in the safe state (disconnects the supply to the motors)
	Lights up	Safety channel 1 is in the active state (supply to the motors enabled)
H21	Off	Switched off (or LED defective)
	Blinken	Safety channel 2 running, finger not detected
	Doppeltes Blinken	Safety channel 2 running, finger not detected
	Leuchtet dauerhaft	Error in safety channell
H22	Off	Safety channel 2 is in the safe state (disconnects the supply to the motors)
	Lights up	Safety channel 2 is in the active state (supply to the motors enabled)

3.7.2 SIF1 Prevent remote start-up without a valid explosive code

In order for the drive motors to be released in the deployment box, a valid explosive code must be entered and transmitted to the deployment box without errors.

When the drive motors are disconnected, they are safely disconnected from the power supply after a maximum of 15 minutes. However, they can be separated from the control unit (e.g. after successful blasting) at an early stage.

3.7.3 SIF2 Prevent unwanted start-up without intentional actuation of the override button

To enable a test run to be started even without a radio connection (e.g. during loading in the bunker), an override button (S2, test button) is provided which, when actuated, activates the actuators for a maximum of 15 minutes.

In order to prevent unintentional actuation of the button, the actuators must be actuated for 5 seconds (more precisely 4 to 6 seconds). Actuation for too short (<4 s) or too long (>6 s, permanent) a period does not unlock the motors.

3.7.4 SIF3 Preventing remote start-up during flight

During transport with a helicopter, there is a risk of an explosive charge being dropped via the control panel. An explosive charge detonating under the helicopter could endanger the helicopter and the pilot.

To reduce this risk, a switch is used to monitor whether the deployment box is placed on a tower. It is only when it is placed on a tower that the entry of explosive codes is made possible.

This effectively prevents an explosive charge from being triggered during the flight.

4 Structure of the system

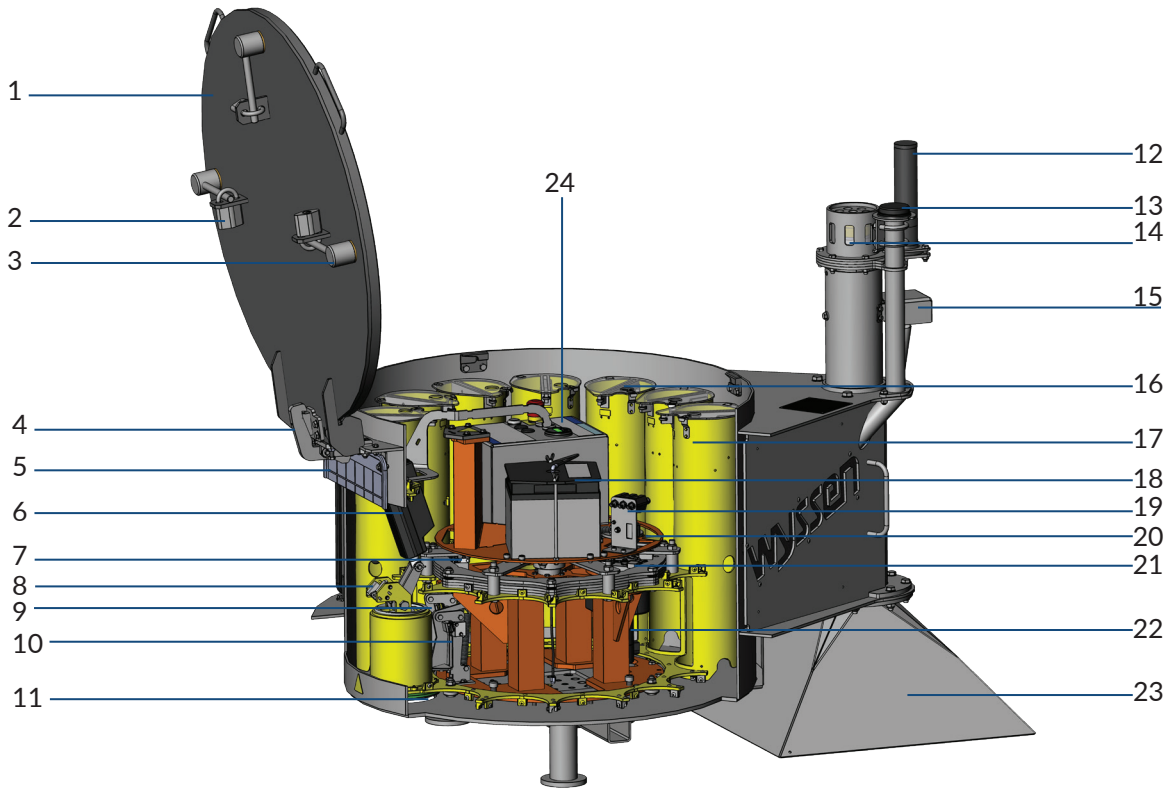
4.1 Assemblies

The system basically consists of the following modules:

- Deployment box
- Tower
- Wyssen 2K® Charges or Explosive Charges
- Wyssen heli link HK-02
- WAC.3 Base (radio remote control optional)

4.2 Deployment box

The deployment box contains the prepared Wyssen 2K® or or the prepared explosive charge 07, the complete mechanics and control as well as the radio transmission elements.



1. Deployment box cover
2. Padlock 3 pieces
3. Twist lock
4. Safety latch
5. Solar panel
6. Shutter Cylinder
7. DPOS: Position switch carousel, cam-controlled
8. Lock cylinder position switch
9. LPOS2: Charge Detection Switch
10. LPOS1: Charge Drop Detection Switch
11. Drop hole
12. Radio antenna
13. GSM / GPS antenna
14. Flas light
15. Monitoring sensor of the correct position of the Deployment box on the tower
16. Rope ejector
17. Quiver tube
18. Battery 12 V
19. Seismometer
20. APOS: Angle measuring potentiometer, analogue or digital
21. RPOS: Rest position limit switch carousel
22. Drive motor
23. Entry funnel
24. Control with control buttons at the top

4.3 Tower

The toweris used to accommodate the deployment box in the terrain.
Its position is preferably located in the upper part of the fracture area of an avalanche slope.

Depending on the substrate, the tower is anchored by a conventional concrete foundation or a concreteless variant.
As a result, only a small foundation (1 m x 1 m) / (3 ft 3.4 in x 3 ft 3.4 in) is needed to secure the towers.
The tower itself is subsequently virtually maintenance-free. Only the finger requires maintenance before the start of each season, see chapter 8.2 Recommissioning before the start of the season on page 44

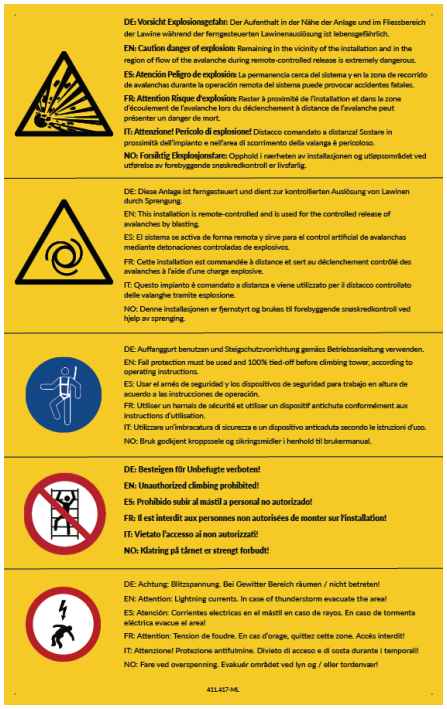
The climbing device consists of a ladder with fixed rungs, a locking door with a padlock, a platform and safety devices to protect against falling. In order to climb the tower, a safety harness corresponding to the nationally valid standards must be worn.

4.3.1 Safety regulations for climbing the tower

The towers may never be climbed without the supervision of a second person. This means that there must always be someone in the immediate vicinity when climbing a tower. This is to provide assistance in case of emergency or to call for rescue.

Only the ladder fixed to the tower may be used. Any liability for ladders installed by the customer or by third parties is strictly rejected.

At the foot of the tower there is a sign, which informs uninvolved and uninstructed persons about the function and the dangers that could arise from the Wyssen avalanche towers of Wyssen Avalanche Control AG.



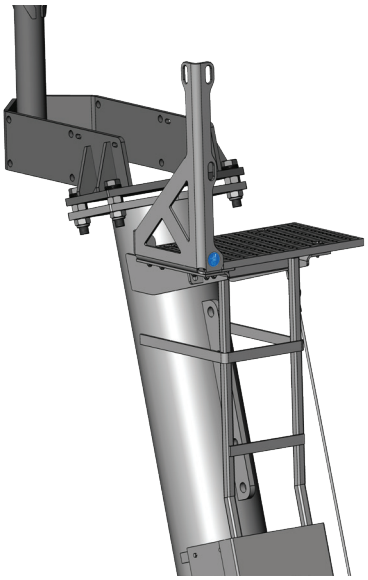
4.3.2 Personal protective equipment

To secure against falling, a safety harness in accordance with nationally applicable standards with a fall arrester and two Y-shaped tethers with fall arresters must be worn to climb the tower.
The tethers must each be equipped with a large safety carabiner.

Only the Fallbloc 2, supplied by IMMOOS GmbH in 6414 Oberarth, Switzerland, may be used as a fall arrester.
To operate this fall arrester, it is essential to follow the operating instructions enclosed with the delivery.

4.3.3 Securing device on the tower

A steel wire rope with a diameter of 8 mm must be installed along the ladder to which the accompanying fall arrester (see description above) can be attached. Above the ladder at the small pedestal is a holding post with three recesses at the upper end. Before releasing the safety catch to the Fallbloc fall arrester and leaving the ladder, the safety carabiner must be securely hooked onto one of these openings.
At least one safety carabiner must remain hooked in for the entire duration from the ground.



Warning
The anchor point may only be used for the PPE. Attaching loads is prohibited.

4.3.4 Protection against unauthorized access

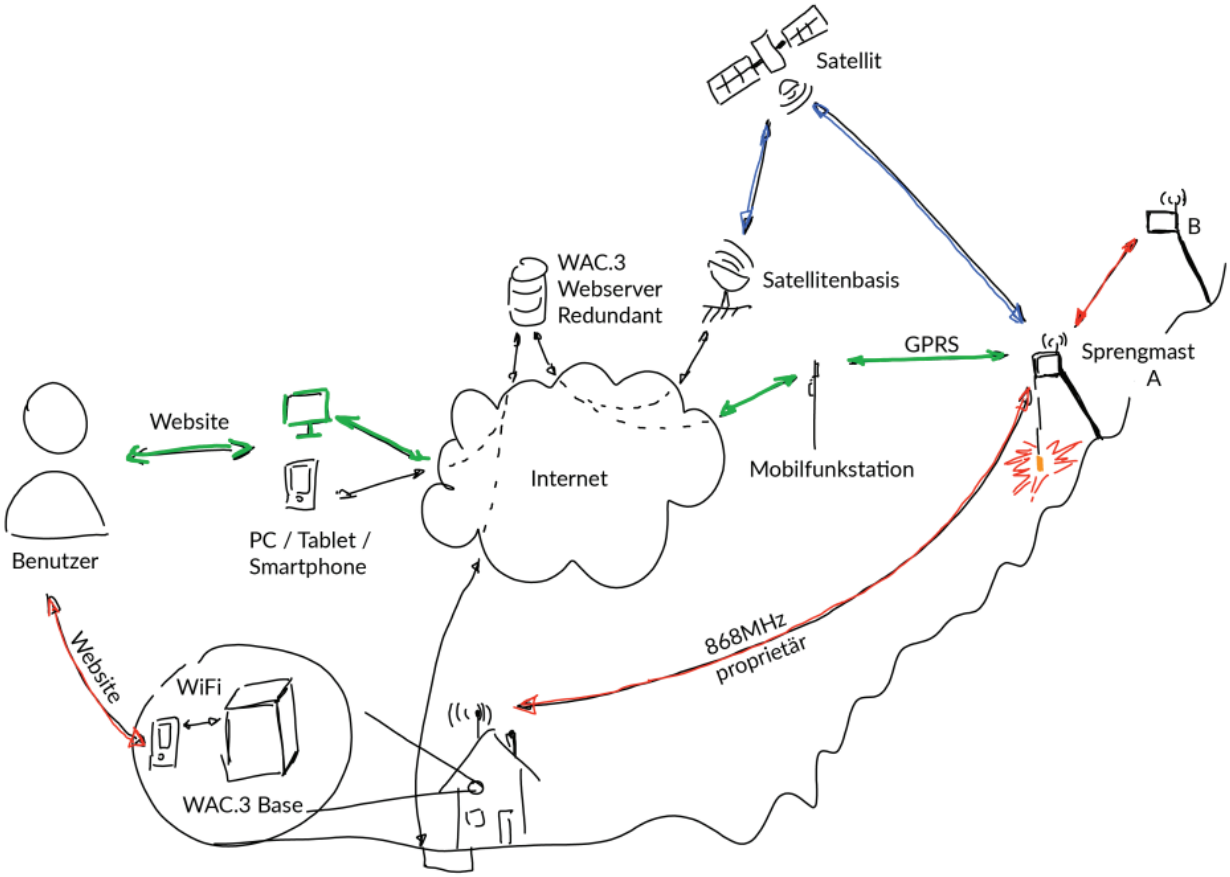
In order to prevent unauthorized persons from climbing the ladder, the ladder is equipped with a safety door. The safety door must be secured with a padlock against unauthorized opening.

4.4 Communication

Communication operates through the following elements.

- Web-enabled device with Internet connection
- WAC.3 base optional for direct connection with the Wyssen avalanche towers
- Wyssen Avalanche Control Center

DThe system can be operated from different locations via an Internet-capable device or by radio using WAC.3 Base. Due to the fact that the systems are permanently connected to the Internet, the supplier can access the system externally and therefore assist the customer at any time in the event of problems or malfunctions.



4.5 Wyssen heli link HK-02

4.5.1 Intended use

The Wyssen heli link is used to transport the deployment box of the Wyssen avalanche towers back from the tower to the depot. With the help of the Wyssen heli link, the heli pilot can lift the deployment box from the tower independently, without additional personnel assistance. The Wyssen heli link may under no circumstances be used to lift other loads.

The transport of the deployment box onto the tower is carried out without this Wyssen heli link, but is also possible without additional assistance. An electrical Heli hook must be used. Only by using this can the pilot independently unhook the deployment box above the finger.

Hazard
The orange Wyssen heli link made of round steel may no longer be used. Only the Wyssen heli link with serial number **411.600C.XXX** must be used!

Hazard
It is strictly forbidden for people to be located on and around the towers during the lifting of the deployment box.

Caution
Due to its high weight, the Wyssen heli link may be carried only by at least two people. Carrying too heavy a load can cause permanent damage to your health.

4.5.2 Safety regulations when handling the Wyssen heli link

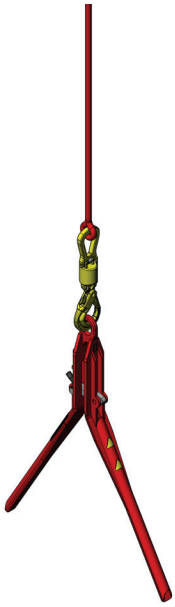
Working with the Wyssen heli link without training and education from the supplier and the responsible helicopter company is prohibited.

The attachment of the Wyssen heli link to the swivel hook attached to the helicopter is only permitted by personnel of the helicopter company or by personnel who have been instructed by the helicopter company.

While working with the helicopter, persons who are not directly involved in the flight maneuver are prohibited from being located in the danger zone of the landing zone.

For unhooking, the Wyssen heli link may only be opened by means of the black bracket on the outside of the link. Otherwise, there is a risk of injury due to prevailing and undefinable forces.

For further safety regulations and the basic procedure for a helicopter transport, see chapter 7 Transport of the deployment box by helicopter on page 39.



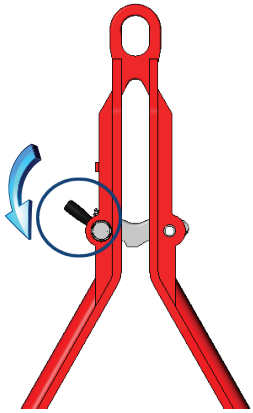
Hazard
The Wyssen heli link may only be attached to the heli by means of a swivel hook. This prevents the Wyssen heli link from being unhooked on its own.
Electric heli hooks are prohibited.

4.5.3 Unhook the deployment box

The release of the deployment box may only be initiated when the deployment box is resting still on the ground, and the holder cord on the helicopter is no longer under tension.

The Wyssen heli link may only be opened by operating the black lever. Otherwise, injuries to fingers, hands or arms may occur due to prevailing forces.

After opening, the pilot can be shown that he can lift the helicopter again.



4.5.4 Maintenance

Before each flight of a deployment box with the Wyssen heli link, it must be visually checked for functionality. Please note the following points, see chapter 7.1.16 Testing of the Wyssen heli link on page 40 zu beachten.

If one of these points is not correct, the Wyssen heli link must not be used.
You must contact the supplier immediately to discuss the further procedure.

In the course of the annual service carried out by the supplier on the system, the Wyssen heli link is checked and maintained.
After 1,000 flight rotations, each Wyssen heli link is additionally subjected to a large test (magnetic crack test, new painting) by the supplier.

The maximum lifespan of a Wyssen heli link is 20 years or 5,000 transport sessions.

5 Loading and unloading the deployment box

5.1 Safety regulations for loading and unloading

The deployment box must stand on a level surface for this work.

It must be ensured that there are no objects in the entry funnel that could trigger an activation of the monitoring sensor.

The workplace during assembly of the charges, the transport path to the deployment box and the area around the deployment box must be closed off to prevent access by unauthorized persons.

The deployment box must be loaded outdoors so that it does not have to be transported more than approx. 50 m (only with pallet truck) and can be attached directly to the helicopter.

Warning
The deployment box must never be transported directly with the fork of a lifting device in the hanger. This can cause damage to the hanger and affect its breaking / and load capacity.

5.2 Preparation of the deployment box

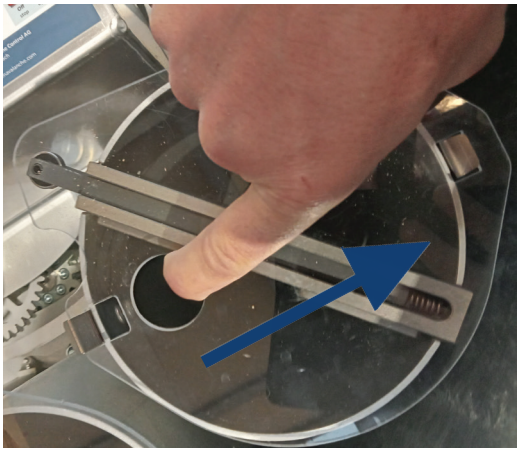
- Open the padlocks on the deployment box lid with the key and turn the three locking levers 90°.
- Lift the lid by using the designated handles until (2) the safety latch is engaged.
- The opening and closing of the.old deployment box lid is to be performed due to the high weight in each case by two persons.
- Push all slides of the rope ejectors into the rear position.
- (3) Unhinge the plexiglass cover by sliding and remove (4) (for old versions, loosen the screws and then remove the metal cover).
- Remove rope ejectors from notches (for loading only with unloaded quiver tube)
- Keep the area near the deployment box towards the antenna unobstructed so that the prepared charges can be placed there.

Caution
There is a risk that during opening and closing, hands may be seriously injured or trapped between the lid and the hanger due to the deployment box cover falling down. Therefore, do not hold your hands over the edge of the deployment box, move the handle slowly past the hanger and make sure that the catch is correctly engaged.

1

2

3



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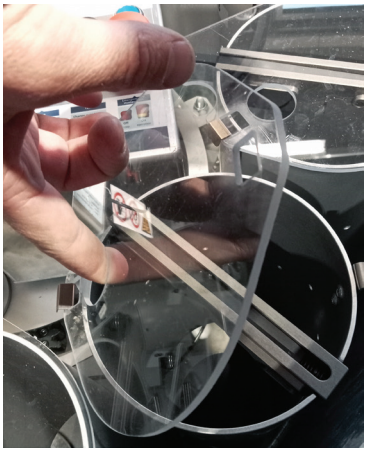
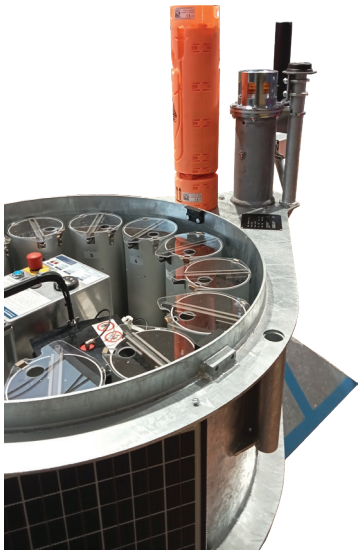


5.3 Loading of Explosive Charges

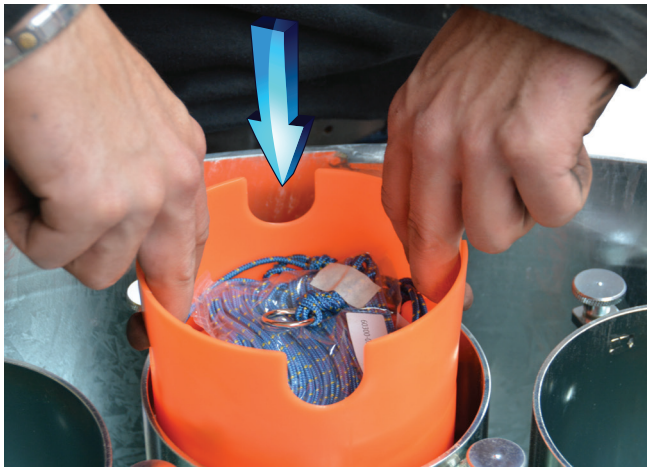
The loading of the deployment box is performed according to the following work steps.

Caution
It is absolutely essential to observe the following sequence for loading the deployment box. The loading with the Wyssen 2K® is shown, it is however, the same procedure as with the charge 07.

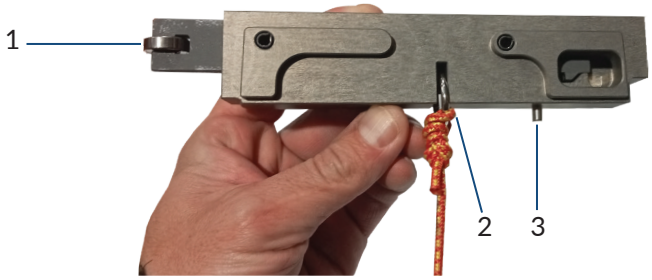
- Transport along with the foam plugs delivered with the magazine. This prevents the cord bag from falling out.
- Carrying the charge must never be done with just one hand.
- During transport, always carry the charge as shown in the illustration.
- Bring the deployment box and place it on the surface next to the flashlight and remove the foam plug.

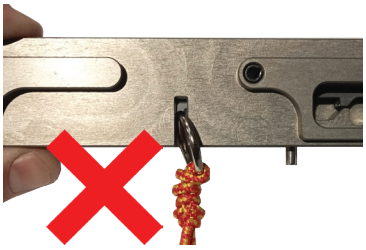


- Clean the standing area of the explosive charge if necessary.
- Grab the explosive charges on the inside through the holes at the top of the tube and insert them carefully into the quiver tube. Turn the recess in the direction of the rope ejector and guide the charge all the way down.
- If the deployment box is not fully loaded, the charges must be filled from the last quiver tube (No. 12) so that the controller can correctly detect the number of charges during the test run.

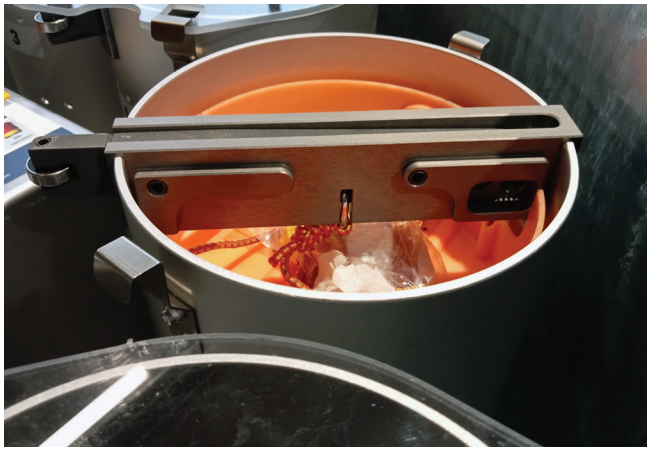


- (1) The retaining ring is hooked onto the rope ejector and the slider is moved to the forward, extended position so that the (2) ring is held by the rope ejector. (3) The slider moves to the front position by pressing the metal pin at the bottom of the rope ejector.



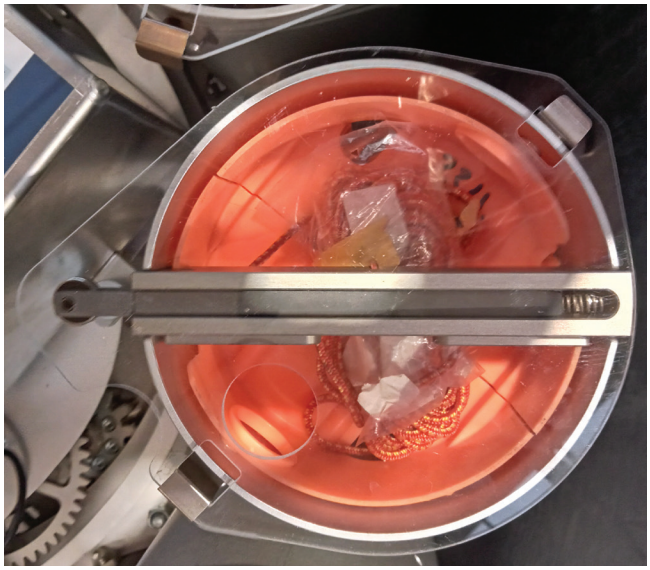


- Subsequently, the rope ejector is placed in the notches of the quiver tube so that the ball bearing points towards the centre of the deployment box. The rope ejector must be in the mounted position in the notches against displacement, i.e. both shoulders must lie within the quiver tube.



Important
After the cord ejector has been inserted, check the holding ring by hand to make sure that it is mounted properly.
After that, the cord ejector must not be touched any more as there is a risk that the holding ring might get unhooked. This would result in a dud.

At the end of the loading of the deployment box, the lid is placed on the quiver tube and in old metal versions, tightened well with hand screws.
Before the deployment box is closed again and made ready for transport, a test run according to chapter 5.5 must be carried out.
Then close the magazine with the three locks supplied by the manufacturer

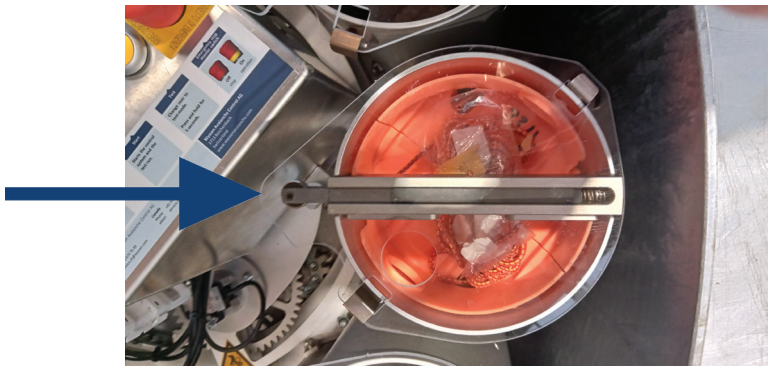


5.4 Unloading of explosive charges

In the event that charges should still be present in the deployment box after the winter season, these must be removed according to the following work steps.

Hazard
When removing the charge from the quiver tube, make sure that the retaining ring and the line do not get stuck on the deployment box. (Use foam plugs!)
A pulling movement on the eyelet of the detonators SZ83 will lead to the initialization of the charge.

- Operate allthe sliders of the rope ejectors by pushing towards the rear on the side of the ball bearing.
- Open and remove the quiver tube cover.



Hazard
Before the rope ejectors can be lifted out of the quiver tube, it must be checked that the retaining rings are no longer suspended. When removing the charge from the quiver tube, make sure that the retaining ring and the line do not get stuck on the deployment box. (Use foam plugs!)
A pulling movement on the eyelet of the detonators SZ83 will lead to the initialization of the charge.

- Carefully remove the rope ejector from the quiver tube.
- Grasp the charge through the holes at the top of the tube and carefully lift it out of the quiver tube.
- Place the charge on a stable table.

Hint
Dismantling and defusing the load are described in the instructions for assembling the Wyssen 2K® / Charge 07.

5.5 Test run with control buttons in the magazine control

Der Testlauf wird mit den Schaltern auf der Steuerung durchgeführt.
Das Display dient zur Anzeige wichtiger Informationen über das System.

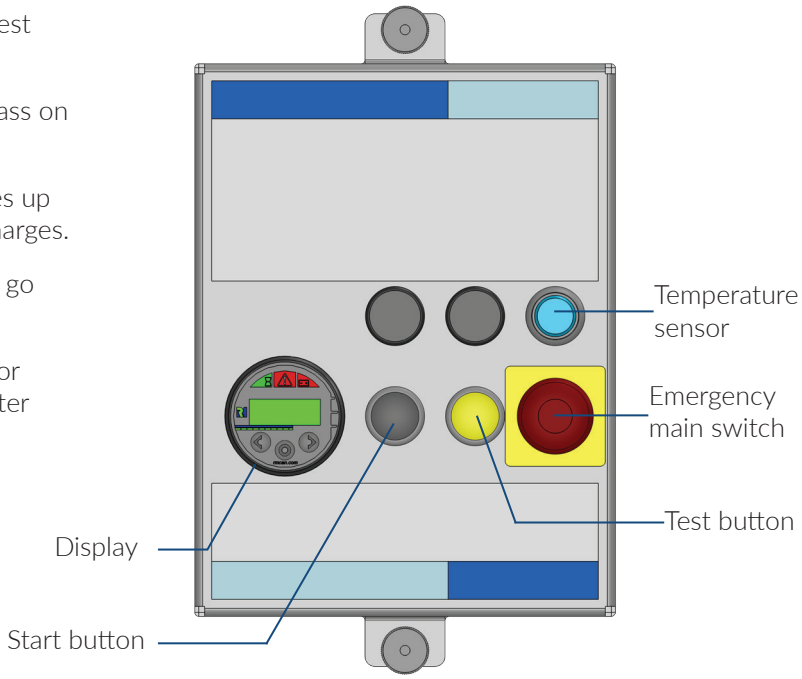
5.5.1 Emergency / main switch

After loading the deployment box with charges (preferably immediately before transport), this must be carried out as follows:

- Pull out the emergency / main switch until the yellow mark is visible.
- Briefly press the start button (black) to wake up the control (1-2 s)
- Press the test button (yellow) until the hourglass on the display goes out again (5 s).
- The illuminated warning triangle signals the test operation.
- Press the start button (black) until the hourglass on the display goes out (3-4 s).
- The test run now runs automatically and takes up to 8 minutes, depending on the number of charges.
- If the red warning triangle and the flash lamp go out, the test run is successfully completed.
- Do not switch off the control until transport or carry out another test run before the helicopter transport.

Operation / On

Stop / Off



Warning
As long as the red warning symbol and the flash lamp are illuminated, the deployment box is in test operation and may not be flown under any circumstances. The deployment box may only be flown in perfect condition. Likewise, the closure cylinder of the discharge hole must be completely closed.

If the system is now in perfect condition, the lid of the deployment box can be closed again and secured with the padlocks.

5.5.2 Mains disconnection device

The mains disconnection device is the battery plug X20. When working on the electrical device, always operate the emergency stop and disconnect the battery.

6 Remote control via the Wyssen Avalanche Control Center WAC.3

The Wyssen avalanche towers are controlled via an intuitive web application.
This can be accessed at https://control.wyssenavalanche.com or by using the QR code below.

After accessing the page, the login window appears. Every user of the Wyssen Avalanche Control Center WAC.3 must have a personal login with a password issued by Wyssen Avalanche Control AG, which can be changed by the user at any time.

A login must be created by the manufacturer of the system. It is forbidden to use the same login with more than one user.

Log in with your personal password at
https://control.wyssenavalanche.com

Hint
If the login data is lost, a new one can be requested at the above address.
The transfer of the login data to internal and external parties is prohibited. The login data is used for traceability and is personal.

During the normal use of the software, informative and clear assistance will be available to you at any time. The help can be found with a click on the ? symbol.

6.1 Blasting

The charge shedding is controlled in the Wyssen avalanche tower by an electronic control system. The control of the Wyssen avalanche tower is developed according to the latest standards in such a way that malfunctions cannot lead to undesired charge discharge.

In order to comply with the high security standards, a code list is used. If you are using the Wyssen Avalanche Control Center WAC.3 and you want to start an explosion or a test run, you will be asked for an explosive code. With the number of the explosive code, you read the eight-digit explosive code from the code list and enter it in the numeric field.

Hazard
By entering an explosive code, the power supply for the drive motors is unlocked by the discharge mechanism. As soon as you enter an explosive code, the controller can explode for the following max. 15 minutes.

As soon as the explosion / test run is completed, the release is automatically terminated. This is done in the Wyssen Avalanche Control Center WAC.3 by the state «Closed and secured».
In this case, a charge can no longer be dropped.

Hint
If the code list is used up or lost, a new code list can be ordered from the responsible support team.

6.2 Service und Support

Upon introduction of the Wyssen Avalanche Control Center WAC. 3, our service personnel will fully set up and thoroughly explain the system to you. If you have any questions or problems during operation, please do not hesitate to contact us at the 24/7 hotline, see chapter 1.8 Technical Support on page 10.

7 Transport of the deployment box by helicopter

7.1 Safety Regulations

7.1.1 Authorization of the helicopter company

Transport flights with the deployment box of the Wyssen avalanche tower may only be performed by helicopter companies that have described and officially approved these operations in the Mini-Standard Operation Manual (Mini-SOP).
This can be done, for example, in Switzerland or in Austria by the competent civil authority.

7.1.2 Agreements between pilot and ground crew

Before the first flight transport order, the pilot must hold a meeting with the personnel designated for this work regarding the procedure and the special hazards. The personnel must be instructed in particular about the operation of the load handling equipment, the hook and the general hazards during underload flight.

7.1.3 Communication control by radio

During the approach to the reception area, the pilot must make radio contact with the ground personnel for communication control. If this attempt fails, the helicopter must be dropped off before transport and the fault must be rectified.

7.1.4 Personal protective equipment of ground personnel

The ground staff must wear the following protective equipment to hang and unhook the charge magazine under the hovering helicopter: helmet, safety goggles, gloves, suitable clothing and sturdy shoes.

7.1.5 Conditions at the pick-up / unloading point

The pick-up / unloading location of the loaded deployment box must be flat and sufficiently large for the flight maneuver. There must be an approach and departure track available, so that no inhabited area and others with Persons occupied areas must be flown over. In the area of the pick-up / unloading location, there must be no objects which, under certain conditions, could activate the monitoring sensor in the entry funnel of the deployment box.

7.1.6 No unauthorized persons in the danger area

During the flight maneuver, no unauthorized persons or persons uninvolved in the maneuver may be present in the area of the pickup / unloading location. If the deployment box is not equipped with the Wyssen 2K®, the space must be locked with a safety distance of 500 m (1641 ft).

7.1.7 No manipulations with the Wyssen Avalanche Control Center during transports of magazines

No manipulations may be made with the Wyssen Avalanche Control Center as long as transports with the deployment box are carried out. Only after the helicopter has left the danger zone may manipulations be carried out via the Wyssen Avalanche Control Center.

7.1.8 Impeccable condition of the deployment box

Prior to any transport to or from the blasting site, the responsible blasting officer must ensure that the load-discharge mechanism of the deployment box is in the rest position, both discharge holes are closed, and the entire system is in perfect condition.

7.1.9 Weather

Wind and weather conditions must be taken into account. If conditions do not permit safe flight maneuvers, the flight transport must be postponed.

7.1.10 Passengers

No passengers may be carried during the transport of the deployment box.

7.1.11 Flight route

Wyssen 2K®.
The transport of deployment boxes that are loaded with Wyssen 2K® charges does not require any precautions or requirements that exceed the scope of other underload flights.

Charge 07
Operations operating flights to supply the Wyssen avalanche towers with original explosive charge (charge 07) shall ensure that:

A) densely populated area, busy roads as well as staffed technical facilities (e.g. mountain railways, mountain restaurants and relay stations) and ski slopes are not flown over and densely populated area, busy roads as well as staffed technical facilities (e.g. mountain railways, mountain restaurants and relay stations) and ski slopes are not flown over

B) and the routes on which magazines of the conventional Wyssen avalanche blasting system are transported are chosen in such a way that a distance of 500 m (1641 ft) from persons not directly necessary for the operation is maintained at all times in all directions from the load receiving station to the blasting tower.

7.1.12 Attaching the deployment box

If the deployment box is hit too hard against the tower during the deployment maneuver or is placed jerkily, the internal mechanics can become damaged.

7.1.13 Functional test

A test run must be carried out each time the deployment box is replaced in order to check that it is functioning correctly. The test may only be started after the helicopter has moved out of the danger zone of the explosive tower.

7.1.14 Do not stand under a suspended load

No persons may be under the suspended load after the attachment and before the deployment box is suspended from the helicopter.

7.1.15 Load hangers and load-bearing parts on the helicopter

An electric heli hook is used to transport the deployment box. The helicopter company is responsible for the perfect condition of the load-bearing elements and their functionality. These elements must be designed for a load capacity of at least 700 kg. (1545 lbs)

7.1.16 Testing of the Wyssen heli link

The Wyssen heli link must be checked regularly and before each transport of the deployment box for proper functioning and damage as follows:

- The Wyssen heli link must be lubricated annually on the grease nipple provided for this purpose, we recommend the product «Fuchs UNITEMP 2»
- It must be possible to move the link freely upwards as far as it will go
- The link must fall through its own weight and close
- In the closed state, the notch of the link must lie on the one of the support bolts.
- No cracks may be visible on the link and bracket
- Neither the link nor the bracket may be bent.
- If defects are detected or there are uncertainties about this, the said Wyssen heli link must not be used.

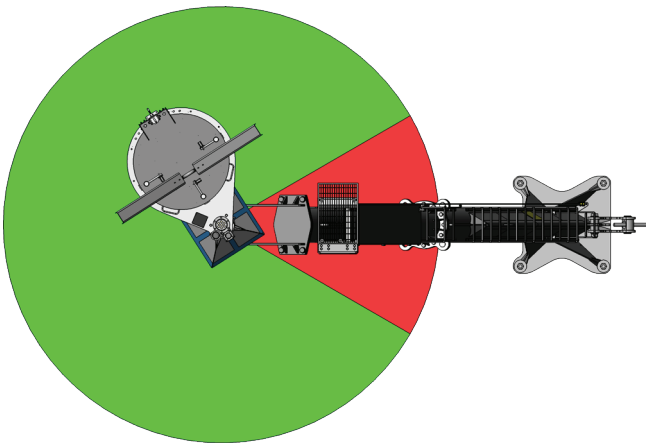
7.2 Moving the deployment box onto the tower

Before the deployment box is moved to the tower for operation, the maintenance work and a test run must be carried out in accordance with these operating instructions. In addition, the magazine must be closed and closed.
For the transport of the deployment box on the towers, an electric heli hook with a suspension length of approx. 10–30 m (30 - 100 ft) must be mounted on the helicopter, so that the pilot can unhook the load independently from the cockpit after correct positioning.

- The electrical heli hook is hooked directly onto the transport bracket of the deployment box.
- In order to place the deployment box on the towers, the pilot must bring the introduction funnel exactly over the finger on the tower tip. The blue markings on the funnel show the pilot the middle of the funnel.
- Then lower the deployment box. It thus rotates independently into the correct position, usually in the direction of the valley.
- As soon as the pilot ascertains that the deployment box has turned to the correct position and is firmly seated on the finger, the pilot can relieve the suspension by further lowering and releasing the helicopter hook.
  A flash lamp at the top of the deployment box starts to flash for about 1 minute as soon as it is correctly placed.

If the deployment box is not correctly positioned on the tower (flashing light does not start to flash), no test run can be carried out via the command center. According to the description, see chapter 7.3 Return transport of the deployment box from the tower on page 42, the deployment box with the Wyssen heli link must be retrieved from the tower in order to remedy the fault.

Warning
The position of the deployment box is automatically monitored with GPS. However, an error of position monitoring using GPS cannot be ruled out. Therefore, after the deployment box has been placed by a third person (not the pilot), it must be checked that each magazine has been placed on the intended tower.



Green: allowed angle of attachment

Hint
To ensure that the magazine works properly after placing it on, it is recommended to carry out a test run.

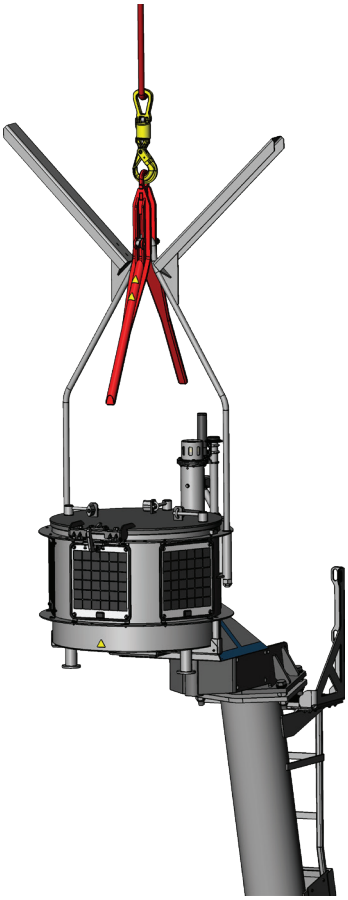
7.3 Return transport of the deployment box from the tower

If all charges have been dropped or no further detonations are carried out after the end of the season, the deployment box must be transported back from the tower by helicopter.
As soon as the deployment box is lifted from the tower, the monitoring sensor switches off, and the power supply to the system is interrupted to prevent unintentional discharge of charges. The Wyssen heli link must be connected to the helicopter by means of a swivel hook.

Before returning the deployment box, the pilot must find out whether there are still explosive charges in the deployment box.

Warning
The Wyssen heli link must be checked for proper functioning and damage before each transport of the deployment box. If defects are detected, the said Wyssen heli link must not be used.

- The pilot must then fly over the deployment box and lower the Wyssen heli link above the fork of the transport bracket. As a result, the Wyssen heli link is opened and closes again after further lowering. Thus, the deployment box is attached
- Lift off the deployment box.(Make sure that the pull on the deployment box takes place exactly vertically.
- Otherwise, it can tilt on the tower.)
- Transport the deployment box to the unloading location and park it carefully
- Release the Wyssen heli link, see chapter 4.5.3 Unhook the deployment box on page 30



8 Seasonal decommissioning / recommissioning

8.1 Decommissioning after the end of the season

8.1.1 Deployment box

The deployment box of the Wyssen avalanche tower is to be removed from the tower as soon as possible after the end of the season in order to exclude the risk of lightning damage. During the summer time it should be housed in a sheltered and dry warehouse. Unused explosive charges must be removed from the deployment box. The charges and igniters must be stored in accordance with the national explosives law / dangerous goods ordinance. See also the instructions for assembling the Wyssen 2K® or the instructions for assembling the charge 07.
To ensure that the battery does not drain after decommissioning, it is important to press the emergency / main switch and unplug the battery plug X20.

Operation / On

Stopp / Off

Hazard
When removing the charge from the quiver tube, make sure that the retaining ring and the line do not get stuck on the deployment box.
A pulling movement on the eyelet of the detonators SZ83 will lead to the initialization of the charge.

In order for the battery to survive the summertime without damage, it should be fully charged before storage with a charger provided for this purpose. Connect the charger to the battery for at least 24 hours. A corresponding charger can be purchased from Wyssen Avalanche Control AG.

Caution
The battery may only be connected to a charger provided for this purpose with a temperature-controlled charging voltage. Chargers such as those used for car batteries are not suitable and may damage the battery.
The allowed chargers, see chapter 8.3 Charging the battery on page 44.

8.2 Recommissioning before the start of the season

8.2.1 WAC.3 Base

Start up the optional WAC.3 Base according to the separate operating instructions.

8.2.2 Tower

Before recommissioning, the finger on the tower must be cleaned.
With a coarse file, even out any unevenness, raised ridges and edges and apply a thick layer of water-resistant and low-temperature-resistant (down to -30 °C) Fuchs Unitemp 2 grease (can be purchased from Wyssen Avalanche Control AG). The climbing ladder and safety devices on the tower as well as the personal protective equipment must be checked for damage and functionality before each ascent of the tower.

Warning
Risk of death as a result of a fall: As soon as the tower is climbed, the personnel must secure themselves against falling with the corresponding personal protective equipment, safety equipment and tether.

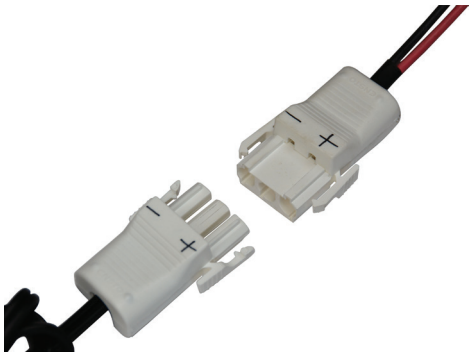
8.2.3 Charge deployment box

- Charging the battery, see chapter 8.3 Charging the battery on page 44
- Measure the battery voltage with the white plug X20 disconnected. It should be at least 12.8 V. Then reassemble the plug.
- Activate the power supply by switching on the emergency / main switch.
- Test run with the control buttons, see chapter 5.5 Test run with control buttons in the magazine control on page 36, to ensure that the magazine works properly.
- Check the connection to WAC.3 before loading the charges onto the deployment box.
- Load the magazine and then run a test run again, see chapter 5.5 Test run with control buttons in the magazine control on page 36

8.3 Charging the battery

The battery must be charged by a charger supplied by the manufacturer.

- Connect the charger to the mains
- Connect the battery to the charger with the white
- plug.
- Start the charging process according to the corresponding note below



Warning
Never charge the battery with a car charger or fast charger, otherwise the battery will be damaged! If an additional charger is required, a suitable device can be obtained from the supplier.

8.3.1 Batterieladegeräte

From 2000 to 2010

Voltcraft
The first charger used is easy to use. Only the two connecting cables have to be plugged into the corresponding ports to start the charging cycle.

When the green indicator light appears, the battery is fully charged and ready to use.

From 2011 to 2013

Voltcraft VC2000
The Voltcraft VC2000 is slightly more complex to use than its predecessor. After connecting the primary voltage 230V, the correct charging setting must be selected by means of the mode button.

After the device is plugged in, it will start to glow green. By pressing the mode button three times, the light should start to light at the battery symbol with the three bars.
Now the charger can be connected to the battery for charging.

From 2014 to today

Yu-Power YPC4A12
By connecting the two cables to the battery and the 230V, the Yu-Power charger already starts charging the battery.

When the green indicator light appears, the battery is fully charged and ready to use.

9 Maintenance

Maintenance may only be carried out by personnel in accordance with the description, see chapter 3.3 Authorization and training of personnel on page 18. To ensure the proper and safe operation of the system, the maintenance described below must be carried out in good time.

The operator of the system is obliged to carry out maintenance by the supplier. This includes an annual inspection of the system and execution of the necessary maintenance and service work.

Caution
Before maintenance work is carried out in the deployment box, the emergency / main switch in the deployment box must be set to OFF.

9.1 Maintenance plan

9.1.1 Maintenance work with each reload of the deployment box

- General visual inspection
- The Wyssen heli link must be checked for proper functioning and damage before each transport of the deployment box, see chapter 7.1.16 Testing of the Wyssen heli link on page 40
- It must be checked that all rope ejectors are functioning properly.
- Carrying out the test run with the control buttons in the deployment box, see chapter 5.5 Test run with control buttons in the magazine control on page 36 with empty deployment box to determine any faults.
- Perform the test run with the control buttons in the deployment box after loading, before the deployment box is transported back to the tower, see chapter 5.5 Test run with control buttons in the magazine control on page 36

9.1.2 Maintenance work before seasonal decommissioning

- see chapter 8.1 Decommissioning after the end of the season on page 43
- After the end of the season, the deployment box must be lifted from the tower as quickly as possible and stored in a protected dry room after the remaining explosive charges have been removed.
- Functional check / test run with control buttons and message to the supplier if malfunctions are known and special maintenance work is necessary.

9.1.3 Maintenance work before seasonal commissioning

- see chapter 8.2 Recommissioning before the start of the season on page 44
- Maintenance work before seasonal commissioning.

9.1.4 Annual maintenance work carried out by the supplier on the system before seasonal commissioning

In order to ensure trouble-free and maintenance-free operation during the season, each system must be checked once a year by specialist personnel commissioned by the manufacturer or its authorized representative.

During this work, the mechanics and the control system are checked for defects and signs of wear. In the event of a newly available update of the software or changes to the mechanics, the systems are brought up to date

In order to be able to guarantee a forwarding service, the system owner must first complete certain work steps.

- The magazines, the Wyssen heli link and, if available, the WAC.3 Base must be stored in a dry, easily accessible place.
- The batteries of all deployment boxes and, if available, the WAC.3 Base, must be charged.
- If possible, a crane or other lifting device should be present to lift the deployment box so that the maintenance work can be carried out.

10 Faults

The Wyssen avalanche tower is designed in such a way that it is as immune as possible to interference. However, since a fault can never be completely ruled out, the procedure for fault elimination is described here.

10.1 Procedure in the event of a fault

If a fault occurs during an explosion or a test run (e.g. connection interruption, error message from the magazine, etc.), the following measures must be taken in each case.

- Continue to secure and maintain danger zone G1.
- Contact the manufacturer immediately. The manufacturer will be happy to support you with its 24-hour hotline for troubleshooting.

10.1.1 Termination of the GPRS or radio connection

If after a successful command transmission to the blast tower the connection is broken, this command will be executed normally until the end. I.e. an already started test run or charge discharge is executed after the radio connection is interrupted until the carousel is turned back and the discharge hole is subsequently closed. If a connection is no longer possible, a visual check (possibly by means of a reconnaissance flight) must be made to ensure that the deployment box is completely closed before flying.

11 Failures

Hazard
If there is a failure in the area, proceed according to the regulations for the recovery and destructionof the failure in the respective country.
The deployment box may under no circumstances be transported by helicopter with a suspended failed ordinance.

In the event of failure of explosive charges, a waiting time of at least 15 minutes must be observed before salvaging the failure. Failures shall be eliminated as soon as possible by trained personnel after the expiry of this period, taking into account the appropriate safety measures.

By default, the failures remain suspended and are not automatically dropped.
For discarding, the «reset» button in the operating software must be pressed while observing from a safe distance. We use it to drop the charge and the deployment box closes again.

Hazard
If a cord is found in the zone of the possible failure, it may not be pulled under any circumstances. The charge must also not be moved from the detonators without first separating the holder cord. This can lead to the activation of the detonators and there is a possibility that the explosive charge will detonate.

11.1 Determination of a failure

Whether the detonation of a discharged charge has taken place can be determined acoustically in most cases. The detonation of a dropped explosive charge is also displayed in the operating software. If this display does not appear, it must be assumed that there is a failure in the area. In the event of uncertainties, the supplier can determine whether it is a failure with further tests.

The various variants of failures as well as the procedure for recovery can be found in the instructions for assembling the Wyssen 2K® and the instructions for assembling the charge 07.

11.2 Creation of safety schedules

As a result of a failure, the person responsible for the blasting must prepare a safety schedule describing the procedure to be followed after such a failure occurs. Appropriate procedures must be described depending on the area.
A template can be found in the instructions for assembling the Wyssen 2K® V 1.7 and the instructions for assembling the load 07 V 1.1.

12 Emergencies

12.1 General and delimitation

The following scenarios describe emergencies with the increased possibility of serious consequences such as fatalities. An emergency response plan for emergency situations (such as the unintentional triggering of the detonating devices during charge assembly) must be developed by the person in charge of explosive operations and the operating personnel must be instructed accordingly. The supplier of the Wyssen avalanche tower must be notified immediately about all accidents, even if they do not result in any damage.

12.2 Emergency due to controlled triggered avalanche

Situations related to avalanches triggered in a controlled manner, such as burials of persons and equipment, are not considered in this manual. Personnel authorized to operate Wyssen avalanche towers have learned the appropriate procedures during training and must attend refresher courses.

12.3 Crash of a deployment box during helicopter transport

As a result of the emergency situation of the helicopter, pilot›s error, technical defect of the helicopter or the load handling equipment, a crash of a deployment box loaded with or without charges cannot be excluded.
If it comes to that, no one should approach the crashed parts. The crash site must be large-scale, i.e. within a radius of at least 1 km from persons to be evacuated, cordoned off and secured by checkpoints.
The following places should be alerted immediately:

- Competent authority (police)
- Supplier of the system (Wyssen Avalanche Control AG)

These bodies must then determine the further procedure together with the explosion controller on site.

13 Appendix

13.1 AppendixTable of Contents

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14 Permitted explosive agents

14.1.1 Switzerland

Designation (manufacturer, EU type examination certificate) no.)	Supplier	Charge size	Ignition
Wyssen 2K® 0589.EXP.2168/20	Wyssen Avalanche Control AG	4.2 kg (ø136 x 585 mm, zusammengebaut)	Detonator No. 8 without booster
Riomon T1 (Maxam)	SSE CH-3900 Brig	4.5 kg (ø115 x 480 mm)	Detonator No. 8 without booster
Tovex Avalanche (SSE)	SSE CH-3900 Brig	4.5 kg (ø115 x 480 mm)	Detonator No. 8 without booster

14.1.2 Austria

Designation (manufacturer, EU type examination certificate) no.)	Supplier	Charge size	Ignition
Wyssen 2K® 0589.EXP.2168/20	Wyssen Avalanche Control AG	4.2 kg (ø136 x 585 mm, zusammengebaut)	Detonator No. 8 without booster
Riomon T1 (Maxam)	Mc Pyro AT-6842 Koblach	4.5 kg (ø115 x 480 mm) 5.0 kg (ø118 x 480 mm)	Detonator No. 8 without booster
Emulex AV (Austin Powder GmbH)	Mc Pyro AT-6842 Koblach	3.3 kg (ø95 x 470 mm)	Detonator No. 8 without booster

14.1.3 Norwegen

Designation (manufacturer, EU type examination certificate) no.)	Supplier	Charge size	Ignition
Wyssen 2K® 0589.EXP.2168/20	Wyssen Avalanche Control AG	4.2 kg (ø136 x 585 mm, zusammengebaut)	Detonator No. 8 without booster
Riomon T1 (Maxam)	Maxam Norge AS NO-2120 Sagstua	4.5 kg (ø115 x 480 mm)	Detonator No. 8 without booster

14.1.4 Canada

Name (manufacturer)	Lieferant	Ladungsgrösse	Zündung
Dyno TX (Dyno Nobel)	Dyno Nobel V0E Revelstoke	4x 0.96 kg (ø2 x 16 Zoll)	Detonator No. 8 without booster
Dyno TX + Unimax (Dyno Nobel)	Dyno Nobel V0E Revelstoke	3x 0.96 kg Dyno TX(ø2 x 16”) 1x 0.90 kg UNIMAX (ø2 x 16”)	Detonator No. 8 without booster

14.1.5 USA

Name (manufacturer)	Lieferant	Ladungsgrösse	Zündung
Dyno TX (Dyno Nobel)	WESCO / Dyno Nobel 84054 Salt Lake City	4x 0.96 kg (ø2 x 16 Zoll)	Detonator No. 8 without booster
Dyno TX + Unimax (Dyno Nobel)	WESCO / Dyno Nobel 84054 Salt Lake City	3x 0.96 kg Dyno TX(ø2 x 16") 1x 0.90 kg UNIMAX (ø2 x 16")	Detonator No. 8 without booster

14.1.8 Chile

Name (manufacturer)	Lieferant	Ladungsgrösse	Zündung
Emultex CN (Enaex)	Enaex 4253 Las Condes	4x 0.96 kg (ø2 x 16 Zoll)	Detonator No. 8 Booster APD UP-Hole 150g

14.1.7 Andorra

Designation (manufacturer, EU type examination certificate) no.)	Supplier	Charge size	Ignition
Wyssen 2K® 0589.EXP.2168/20	Wyssen Avalanche Control AG	4.2 kg (ø136 x 585 mm, zusammengebaut)	Detonator No. 8 without booster

14.1.6 Island

Name (manufacturer)	Lieferant	Ladungsgrösse	Zündung
Riomon T1 (Maxam)	Not set	4.5 kg (ø115 x 480 mm)	Detonator No. 8 without booster

15 SOP "Standart Operation Manual"

1. General

A) Training of pilots and flight assistants
The pilot and flight assistant who are used in the transport of deployment boxes to the Wyssen avalanche tower must be trained by the manufacturer in advance and made aware of the existing risks.

B) Compliance with safety measures
Pilots and flight assistants are entitled and obliged to reject the flight order if no safety measures are taken, especially with regard to blocking and evacuation at the pick-up and unloading point.

C) System description
The mini-SOP (accessible to the helicopter companies) contains a detailed description of the Wyssen avalanche tower.

D) System security
A monitoring sensor in the deployment box will only turn on the main power supply of the charge discharge mechanism when the deployment box is correctly positioned on the tower. During a transport flight, therefore, no unintentional triggering can occur.

E) State of command center
As an additional safeguard to the above item, immediately prior to the flight, the pilot must obtain confirmation from the responsible blasting officer that the code list is inaccessible to all operators.

F) State of deployment box
Prior to transport, the pilot must have the responsible blasting officer of the client confirm that the load-discharge mechanism of the deployment box is in the rest position, the discharge hole is closed, and the entire system is in perfect condition.

G) State of heli link
The Wyssen heli link required to hang and lift the deployment box from the tower must be checked for proper functioning and damage such as cracks and bending before each use. If defects are detected or there are uncertainties about this, the said Wyssen heli link must not be used.

H) Regulations
The regulations of the explosives legislation (Explosives Act, Explosives Ordinance) as well as the explosives supplier must be observed.

I) Weather conditions
Wind and weather conditions must be taken into account. If conditions do not permit safe flight maneuvers, the transport must be postponed.

J) Crew
Only persons directly involved in the transport mission may be carried in the helicopter.

K) Flight route – safety corridor
The transport from the deployment box, which is exclusively loaded with Wyssen 2K® charges, does not require any precautions or requirements that exceed the scope of other underload flights.

L) Weight
The weight of the loaded deployment box is about 540 kg (empty weight about 400 kg).

M) Due diligence
It is very important that the deployment boxs are carefully placed on the blasting towers. If the deployment box is hit too hard against the tower during the deployment maneuver or is placed jerkily, the internal mechanics can become damaged. This leads to failures during subsequent operation, among other things. If the pilot or the responsible blasting personnel determines that the deployment box was jerked up or hit the tower exceptionally hard, it must be flown down again for inspection.

N) Emergency situation
If the deployment box crashes due to technical defect, faulty manipulation or emergency situation, no one should approach the crashed parts. The pilot must immediately report this event to the local explosives officer so that the necessary measures can be taken:
The competent authorities (police / WFD) and the manufacturer of the system (Wyssen Avalanche Control AG) must be informed.

2. Preparation

A) Pick-up location
The pick-up location of the loaded deployment box must be flat and sufficiently large for the flight maneuver.
In the area of the pick-up location, there must be no objects which, under certain conditions, could activate the monitoring sensor in the entry funnel of the deployment box.

B) Briefing
Before the first flight transport order, the pilot must hold a meeting with the ground personnel designated for this work regarding the procedure and the special hazards. The personnel must also be instructed in particular about the operation of the load handling equipment (the Wyssen heli link) and the general hazards during underload flight.

C) Personal protective equipment
The ground staff must wear the following protective equipment to suspend and unhook the deployment box under the hovering helicopter: helmet, safety goggles, gloves, suitable clothing and sturdy shoes.

D) Uninvolved persons
No uninvolved persons may be present at the pick-up and unloading location. It must be closed off if necessary.

E) Communication control
Before starting work, a radio check must be made between the pilot and the ground crew to ensure proper communication.

3. Moving the deployment box onto the towers

A) Load bearing capacity
The deployment box is hooked directly onto the transport bracket provided for this purpose on the electrical heli hook.

B) Placing the deployment box on the tower
The pilot brings the deployment box with the introduction funnel vertically over the finger of the tower.
By lowering this automatically rotates itself into the correct position (on the valley side).
The flash light on the deployment box starts to flash for the pilot›s information as soon as it has been correctly placed.

C) Releasing the load
As soon as the pilot has ascertained that the deployment box has turned to the correct, valley-side position, the pilot can relieve the mounting line and actuate the electrical heli hook to release it.

D) Leaving the danger zone
After correctly placing the deployment box on the tower, the pilot should quickly move out of the danger zone of the Wyssen avalanche towers.

4. Return transport of the deployment box

A) Deployment box flight readiness
The pilot must check if the deployment box is closed and secured before the return transport. The deployment box must not be flown with a dropped, suspended charge.

B) Transport hangers
For the return transport, the Wyssen heli link is suspended on the mounting line with swivel hooks, so that the pilot can attach the deployment box independently on the tower.

C) Load bearing capacity
The deployment box can be attached independently by the pilot by bringing the fork of the Wyssen heli link over the transport bracket on the deployment box. By lowering, the Wyssen heli link opens and then closes independently.

D) Lifting the deployment box from the tower
To take off, the pilot must hover exactly vertically above the deployment box and climb at least 1 m rise so that the deployment box detaches from the finger.
It may be that the mounted flashlight starts to flash, but this does not matter.

16 Instructions for dud recovery

Failure recovery for Austria
Appropriately adopted and adapted from the Austrian Explosion Protection Ordinance and the provisions for the blasting of avalanches from the helicopter.

Failure elimination:

- Failed charges shall be recovered without undue delay after at least 15 minutes of waiting.
- Failed charges must be professionally defused after salvage.
- Charges that are still attached to the cord and / or connected to the deployment box must not be touched. In this case, according to the description, see chapter 11 Failures on page 48, the charge must be deliberately dropped. A person authorized to carry out explosiions should observe from a safe distance where the charge falls, so that it is easier to find it for subsequent salvage. After the dud has been dropped, a waiting time of at least 15 minutes must be observed again.
- If the danger from avalanches is too great, personnel can be transported by helicopter on the rope to the site of the dud:
- This must be carried out by an avalanche blasting officer and a trained flight rescuer under the following conditions:
- Use of a twin-engine helicopter (performance class 1 cat. A approval) and suitable recovery equipment or officially approved hook.
- Use of a suitable standard-compliant safety harness with standard-compliant safety carabiner.
- Use of a protective helmet which is equipped with a transmitting and receiving device as well as with a microphone and receiver.
- It is forbidden to unhook the avalanche officer and the flight rescuer at the mountain site.
- If immediate recovery is not possible due to avalanche danger and bad weather conditions, the danger zone of the explosive charge as well as the possible avalanche run-off must be secured in a suitable manner against uninvolved persons.
- Any remaining explosive charges ready for ignition must be defused immediately after completion of the explosive work or after completion of the failure salvage, taking into account all necessary safety measures.

17 List of abbreviations

Austro Control
Austro Control is responsible for the safe and economical operation of air traffic in Austrian airspace, with up to 4,000 aircraft checked daily.

BAKOM
The Federal Office of Communications BAKOM is a federal agency of the Swiss Confederation.

BAZL
The Federal Office of Civil Aviation (BAZL) is responsible for aviation development and the supervision of civil aviation

FOM
Flight Operation Manual (FOM)

SBFI
The State Secretariat for Education, Research and Innovation SBFI in the Federal Department of Economic Affairs, Education and Research WBF is the federal government›s competence center for nationally and internationally oriented issues of education, research and innovation policy.

SLF
The tasks of the WSL Institute for Snow and Avalanche Research SLF are research, scientific services, teaching and public relations.
In close connection with research, the SLF offers a range of services. This includes consulting mandates, expert opinions on avalanche accidents and avalanche protection, as well as the development of warning systems for alpine natural hazards. The best-known service is the avalanche warning for the Swiss Alps, which is published twice a day in winter

SUVA
The Swiss National Accident Insurance Fund (SUVA) is the largest accident insurance company in Switzerland. The independent company under public law, headquartered in Lucerne, insures around 1.95 million working people against occupational accidents, occupational diseases and leisure accidents. Likewise, self-employed persons can insure themselves against the consequences of accidents with the business insurance.

GPRS
General Packet Radio Service. Data transmission service in GSM networks (Global System for Mobile Communications).

SIF
Safety function

GPS
Global Positioning System. Satellite positioning technology.

18 Recommended literature

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17. Wyssen Avalanche Control AG, instructions for the construction of the foundation and the assembly of the towers

18. SBFI, Training in Artificial Avalanche Triggering (Avalanche Blasting LA), Guidelines for Blasting as of 09/01/2021

19. Wyssen Avalanche Control AG, Instructions for assembling the Wyssen 2K®

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21. Wyssen Avalanche Control AG, instructions for building the foundation

19 Glossary

Emergency / main switch
The emergency/main switch of the charge magazine. It is located on the control housing in the magazine itself. It is used to switch off the entire magazine and disconnect it from the power supply.

WAC.3
Wyssen Avalanche Control Center. Web application for operating the blasting towers.

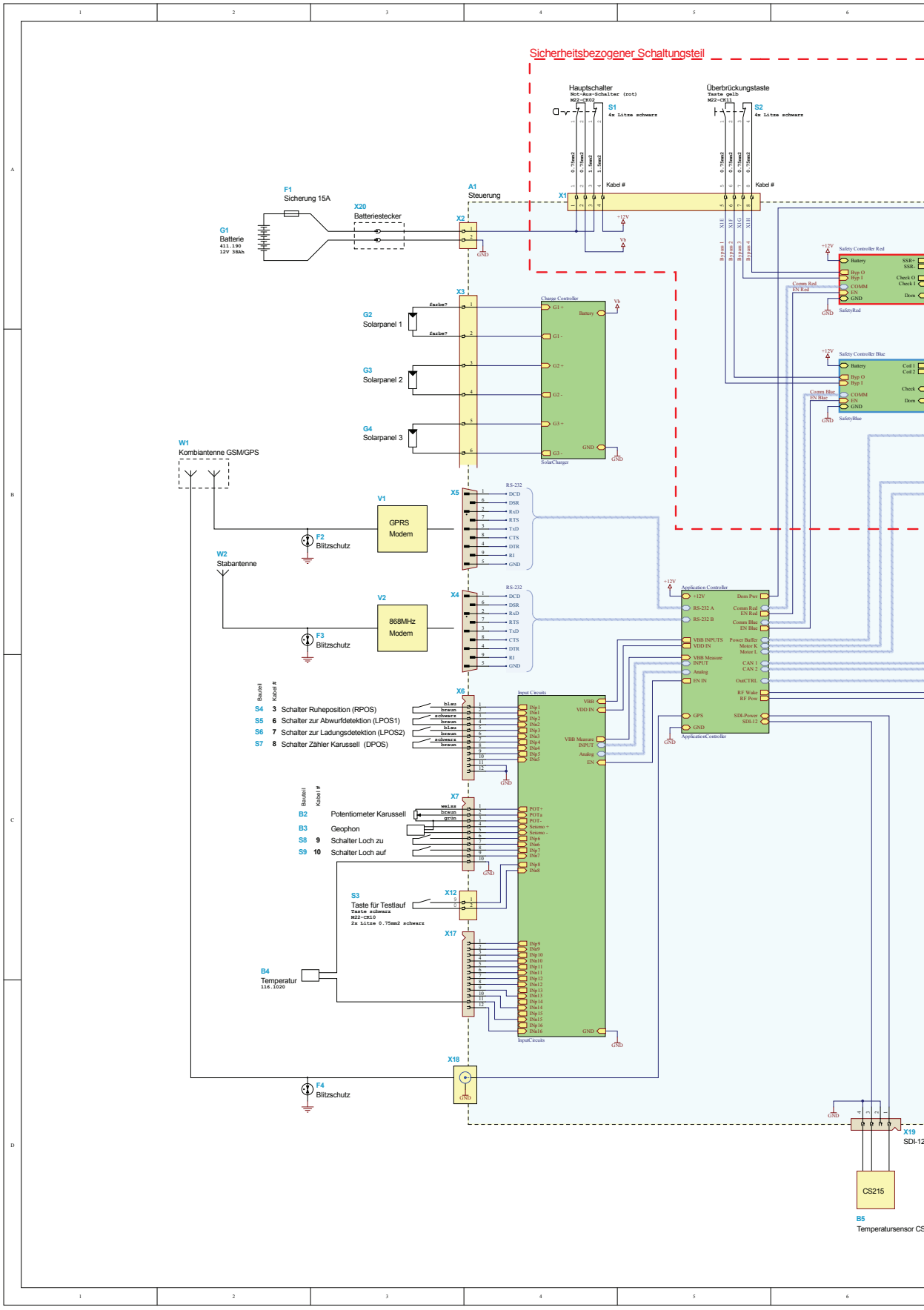
WAC.3 Base
Remote control with built-in radio modem to operate the blasting towers without internet.

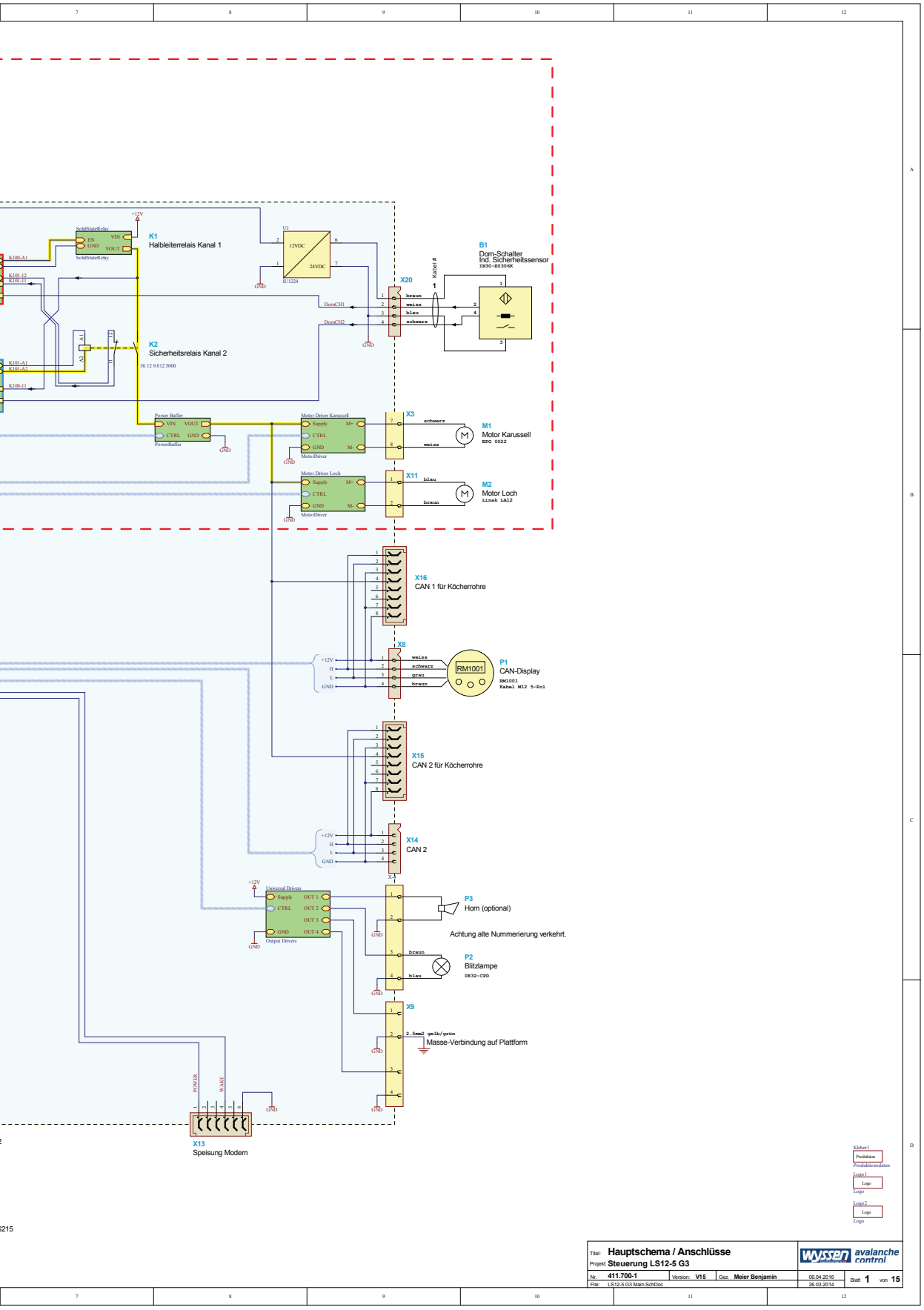
20 Error list Release V1.4.10

Errors may occur during an explosion or test run. The error number is displayed in the user interface or on the display in the deployment box. In the event of any errors, please contact the fault service immediately.

Code:	Description:
1	Timeout, lid does not open
2	No motor current while opening the lid
3	The overcurrent protection is active.
4	Timeout, lid does not close
5	No current is flowing in the motor.
6	The overcurrent protection is active.
7	No current is flowing in the motor.
8	The overcurrent protection is active.
9	The switch for the charge detection is active.
10	The switch for the charge detection is active.
11	The switch for the dropping detection is inactive.
12	The deviation of the angle sensor is too high.
13	The pulse switch is active.
14	No current is flowing in the motor.
15	The overcurrent protection is active.
16	The pulse switch does not react.
17	The deviation of the angle sensor is too high.
18	The reference switch sticks.
19	The switch for the charge detection does not react.
20	The maximum rotation angle has been exceeded.
21	No current is flowing in the motor.
22	The overcurrent protection is active.
23	The switch for the charge detection has been activated.
24	The pulse switch does not react.
25	The deviation of the angle sensor is too high.
26	Time exceeded, no detonation detected.
27	Charge has not been dropped.
28	No current is flowing in the motor.
29	The overcurrent protection is active.
30	The next charge has been detected at the deployment.
31	The dropping switch sticks.
32	Error in the safety module.
33	Battery charge level too low.
80	Command is not supported by this machine
81	ST: Release switch broken
82	Carousel home switch (R-POS) broken
83	Current limitation while closing the lid
84	ST: Carousel rotates not far enough
113	Deployment box is shoot out

21 Wiring diagram




K1
Halbleiterrelais Kanal 1
K2
Sicherheitsrelais Kanal 2
50.12.9.012.5000
B1
Dorn-Schalter
Ind. Sicherheitssensor
IN30-R0306K
X20
braun
weiss
blau
schwarz
DornCH1
DornCH2
X3
M1
Motor Karussell
ESG 0022
X11
M2
Motor Loch
Linak LA12
X16
CAN 1 für Köcherrohre
X8
P1
CAN-Display
RM1001
Kabel M12 5-Pol
X15
CAN 2 für Köcherrohre
X14
CAN 2
P3
Horn (optional)
Achtung alte Nummerierung verkehrt.
P2
Blitzlampe
0832-CPD
X9
2.5mm2 gelb/grün
Masse-Verbindung auf Plattform
X13
Speisung Modem
Titel: Hauptschema / Anschlüsse
Projekt: Steuerung LS12-5 G3
Nr. 411.700-1
Version: V15
Gez. Meier Benjamin
06.04.2016
26.03.2014
Blatt 1 von 15
File: LS12-5 G3 Main.SchDoc

22 CE declaration of conformity LS12-5

CE-KONFORMITÄTSERKLÄRUNG FÜR MASCHINEN

Entspricht Maschinenrichtlinie 2006/42/EG Anhang II A

Wir,	Wyssen Avalanche Control AG Feld 1 CH-3713 Reichenbach i.K.
Erklären hiermit, dass das Produkt Typ	Sprengmast LS12-5 411.100E
allen grundlegenden Anforderungen der nebenstehenden Richtlinien entspricht:	2006/42/EG mit deren Änderungen 2014/30/EU 2014/53/EU
Bevollmächtigte Person für das Zusammenstellen der technischen Unterlagen gemäss Anhang VII A der Richtlinie 2006/42/EG:	Wyssen Avalanche Control AG Benjamin Meier Feld 1 CH-3713 Reichenbach i.K.
Angewendete Normen:	EN ISO 13849, EN 60204-1, EN 61784-3, EN 61000-6-3:2007 + A1:2011+AC:2012, IEC 61000-6-3:2006 + A1:2010, EN 61000-6-2:2005, IEC 61000-6-2:2005 (ed2.0), ETSI EN 301 489-1:2011 & -3:2013, ETSI EN 301 489-7:2005 & -24:2010, EN 50272-2

Reichenbach i.K., 23. August 2021

Christian Wyssen, CEO

Andreas Egger, CTO

23 CE declaration of conformity HK-02

CE-KONFORMITÄTSERKLÄRUNG FÜR MASCHINEN

Entspricht Maschinenrichtlinie 2006/42/EG Anhang II A

Wir,	Wyssen Avalanche Control AG Feld 1 CH-3713 Reichenbach i.K.
Erklären hiermit, dass das Produkt Typ Seriennummer	Wyssen Heliklinke HK-02 411.600C
allen grundlegenden Anforderungen der nebenstehenden Richtlinien entspricht:	2006/42/EG mit deren Änderungen
Bevollmächtigte Person für das Zusammenstellen der technischen Unterlagen gemäss Anhang VII A der Richtlinie 2006/42/EG:	Wyssen Avalanche Control AG Andreas Egger Feld 1 CH-3713 Reichenbach i.K.
Konformitätsbewertungsstelle für die Durchführung der Baumusterprüfung:	SUVA Bereich Technik Zertifizierungsstelle SCESp 008 Europäisch notifiziert, Kenn-Nr. 1246 Postfach 4358 CH-6002 Luzern
Baumusterprüfbescheinigung Nr.:	E 7075
Angewendete Normen:	EN 13155:2022-03 EN ISO 12100

Reichenbach i.K., 1. November 2022

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wyssen switzerland avalanche control

Appendix G

Daily Advisory Bulletin

BRUCEJACK MOUNTAIN SAFETY ADVISORY

Date Issued:	January 8, 2021	Time:	600	Valid Until:	January 9, 2021

AVALANCHE HAZARD RATING

ZONE A		Camp	ALERT
ZONE B	71.6km-73.3km	Lakeshore Drive	ALERT
	73.3km-Heavy Shop	Warehouse Slopes	CAUTION
ZONE C	Surface Ops, Enviros	VOK and Snow Cat Roads	ALERT
ZONE D	64.5km-71.6km	Glacier Access Road Cut Banks	ALERT
ZONE F	56km-60km	Knipple Corner Exit (DMZ)	CAUTION
ZONE G	37km-56km	Scott Creek-Bowser	CAUTION
ZONE H	3km-37km	Wildfire to Scott Creek	CAUTION
Wildfire Hill	2km–3km	Wildfire Hill	NORMAL

Adhere to Avalanche Safety Plan, Safe Work Procedures, Standard Operating Procedures, and Worksite Avalanche Assessments.
Note: Some avalanche paths (i.e. small road cut slopes) not marked with avalanche signage.

Avalanche Control					Notes: (expected closure times, number of shots, buildings to evacuate)
YES	Zone	B,C	Time	TBD	Timing depends on weather inputs

Brucejack Comments and Site Specific Procedures (Zones A, B, C, D)

All steep slopes and rooflines remain suspect - always check with Mountain Safety before any work in any avalanche zones.

Knipple Comments and Site Specific Procedures (Zones F,G,H)

Be wary of steep overhanging slopes along the glacier road from 70-71.6, as well as roof lines. Report any activity to Mountain Safety.

GLACIER HAZARD ROAD RATING

ZONE D	65km-71.6km	Upper Knipple Glacier	MODERATE (glacier road conditions)
ZONE E	59.5km-65km	Lower Knipple Glacier	MODERATE (glacier road conditions)

General Ice Hazards and Site Specific Procedures (Zones D and E)

Avalanches off the glacier high walls are possible. Please give these walls a wide margin and avoid driving directly underneath the slopes. Please advise Mountain Safety of any avalanche activity.
Report any unmarked hazards to Knipple Surface Op's Supervisor or Dispatch.
Recommended glacier speeds: LOW - Max 40km/hr. MODERATE - 30km/hr. CONSIDERABLE - <20km/hr.

WORKSITE AVALALANCHE ASSESSMENTS

Contact Mountain Safety prior to any work outside of normal operations, including tasks that have associated mountain or glacier hazards. We can help provide input into any JHA. The value of knowing where personnel are doing field work in case of an emergency is vital.

WEATHER

Station	Time	Temp °C	Wind		24 hr precip	Height Snow	Comments
			Value	Direction			
VOK	1600	-3	40	E	13	395	
DMZ	0400	-4	Calm	~	17	233	
Scott Pass	0400	-4	4	NE	15	177	

Brucejack 1400m	Today	Cloudy with scattered flurries. Accumulation: 4 cm. Alpine temperature: High -6 °C, Ridge wind south: 45-60 km/h. Freezing level: 800 metres.
	Tonight	Cloudy with clear periods and isolated flurries. Precipitation: Trace. Alpine temperature: Low -9 °C. Ridge wind southwest: 25-45 km/h. Freezing level at valley bottom.
Knipple 400m	Today	Overcast with light snowfall. Precipitation: 5cm. High: -0°C. Winds: Light from the NE
	Tonight	Overcast. Precipitation: Trace. Low: -4 °C. Winds: Light variable.

STAFF

Brucejack Camp :			Knipple Camp:		
Day shift	Brendan Martland	W3-118	Day shift		
	Norm Winter	W3-124		Mark Stanley	Bunk 1-109
	Jim Franken			Jerry Kesteven	Bunk 1-107
Night Shift	Mitch Ryan	W3-225	Night shift	Ali Hogg	Bunk 1-123
				Lee Green	Bunk 1-125

BruceJack:
Radio: Repeater 1/LAD2
Phone: 778-724-4186 ext. 102

Email: mountainsafety@pretivm.com

Knipple:
Radio: Repeater 1/Pretivm Road
Phone: 778-724-4186 est 142

Appendix H

Pre-Blast Checklist

Appendix H.1 AC Checklist

Appendix H.2 Goat Management Plan

Appendix H.1

AC Checklist

AVALANCHE CONTROL CHECKLIST

ZONE: _____

BOR/Asst: _____ **Date/Time:** _____

Control Flash email sent: YES / NO **Heli Request email sent: YES / NO / N/A**

Target/Path	Shots	Booster	SFA	Trigger (Xe)
Totals:				

Special Considerations:

Consider crew buses and essential freight when planning control missions

Charge Size	Fuse length	Misfires	Sliders/ bathtubs		Weather	Lightning
Air Traffic	Guards	People	Vehicles	Machines	Roof Crew	Rocks
Sympathetic releases while accessing - affecting road or snowcat					Goat Activity	
Knipple Receiving	West zone - Procon		Courtesy hours		Bowser Runway	
Utilities	Gazex gas Lines		Transmission line (50m)		Infrastructure	
Underground blast	*Hours for maintenance shots are between 0300-0900 and 1500-2100					
Traffic on the tailings lines		Quality Control				

Equipment list:		Crimpers	Pull wire	Radios	Crush Proof	
Binoculars	Drybag	Ear Pro	Headlamp	Shot Sheet	Timer	
Boom box for cat	Spot Light	Placards	Extinguisher	Bamboo	Burlap	
Tape	Rope	Heli Bag	Mag Keys	Shipping Document		

Human Factors:

Fatigue *Operational Pressures* *Experience* *Distractions* *Required Training*

Post Control:	InfoEx	Wildlife survey	Return explosives
Follow up clean up time	Flip Signs	Return mag keys	Dispose of cardboard
PVG Xe/Gazex Summary	Open Gates	Crimpers returned	Check Heli bag
Post tower Inspection	Reassess	Update Hazard	Remove Placards

Appendix H.2

Goat Management Plan

Table 5.1-1. Mitigation Activities for Mountain Goat during Vegetation Clearing and Construction

Timing	Habitat	Mitigation Activities
Winter (November 1 to June 14)	UWRs	The preferred option is to avoid activities within 500 m of UWR habitat during winter. If work is planned in these areas during winter, then conduct pre-clearing surveys. If goats are observed within a 500 m buffer of Project activities then pause work until goats have moved outside of this buffer.

(continued)

Table 5.1-1. Mitigation Activities for Mountain Goat during Vegetation Clearing and Construction (completed)

Timing	Habitat	Mitigation Activities
Summer (May 1 – July 15)	High-quality Summer Habitat – Kidding Areas	If goats with kids are observed between May 1 and July 15 within a 500 m buffer during clearing activities then pause work until goats have moved off. Avoid construction activities within 2 km of confirmed natal/kidding areas. Pre-clearing surveys may also be conducted less than 24 hours prior to activity.
Spring/Fall (April - November	High-quality Summer Habitat – Mineral Licks	Avoid destruction of mineral licks. Minimize disturbance within 100 m of licks.
All Year	All Habitats	If goats without kids (May 1 to July 15) and goats (July 16 to October 31) are incidentally observed in proximity to operational roads or facilities, then mountain goats will be given the right away.

5.3 Avalanche Management for Mountain Goats

5.3.1 *Management Activities*

Avalanche management will be conducted in the winter during the Construction, Operations and Closure phases. Mountain goats occupy alpine areas with steep, rocky cliffs during the summer and low elevation forested areas on southern slopes during the winter. During winter, mountain goats can occupy habitat in or below areas prone to avalanches, including alpine areas above the Brucejack Access Road, near Knipple Lake, and along the Knipple Glacier (Appendix A: Figure 5.1-4). Avalanche management activities will include management to avoid mortality or abandonment of habitats by mountain goats due to avalanches.

Avalanche management procedures typically use ground-based launchers and helicopter deployment of explosives (Soucie 2012). Both procedures require the avalanche area to be clear and visible prior to deployment. However, in-place concussive devices such as Gazex® avalanche release systems that are built into the start zone of avalanche tracks can be deployed during snow events or afterwards.

Mitigation activities to limit risks to mountain goats are primarily based on conducting surveys for goats prior to avalanche control and pausing control activities until goats have cleared avalanche paths. Mitigation activities depend on the choice of avalanche control. Four methods of avalanche control are currently used for the Project; each has an associated survey protocol to ensure the site is clear of people or wildlife prior to detonation. These include:

1. Hand-based blasting is conducted predominantly at the base of the avalanche path using case charges which consist of a high explosive suspended on a bamboo pole tripod and remotely detonated. These are placed on or slightly above the Access Road. Ski-touring and throwing hand charges may also be employed up slope from the road: prior to conducting hand-based blasting the crew conducts visual confirmation the site is clear of people or wildlife along avalanche path and start zone. If goats are present, blasting will be delayed until they have left the area. Air horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins.
2. Helicopter-based blasting is conducted at the top of avalanche paths and most often to be used in spring to clean up sites, It includes dropping of explosive charges out of the helicopter to initiate and avalanche from above: prior to conducting helicopter-based blasting, there is a detailed sweep of the slope to determine where best to place targets ensuring a thorough survey of the path and surrounding area for hazards such as goats. If the area and area immediately adjacent (within 100 m) to the avalanche path is clear, blasting will proceed. If not, air horns, or other suitable sounding devices will be used to herd the goats away to a safe distance before blasting begins.

   Over the past 4 winters during which helicopter based blasting has been conducted for avalanche control at the Mine Site and along the Brucejack Access Road, no mountain goats have been observed within or in proximity to the avalanche control sites at the time control was being conducted. Pre-blast visual inspections have been conducted as part of standard procedure to ensure that the areas are clear of both personnel and wildlife, including mountain goat.
3. In-place concussive devices, specifically the Gazex® avalanche release systems, are being installed at three of the most problematic sites along the Brucejack Access Road. These devices may be operated remotely during any weather and are used to initiate avalanches at the top of the path. During clear weather, a ground based survey of the avalanche track will be conducted from a safe location using a spotting scope or similar device. Site specific details are described in section 6.1.3. If goats are observed and safety is not compromised, then blasting will occur once mountain goats move out of the avalanche area. Air horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins. If blasting is planned during a obscured conditions with low lying cloud or fog, heavy snowfall or wind events,, pre-blast surveys may not be possible.
4. Ground-based avalaunchers including the Nitroexpress® are currently used for the most problematic sites, particularly at 44 Km. This control technique is expected to be phased out with installation of the Gazex® systems. During clear weather, a ground based survey of the avalanche track will be conducted from a safe location using a spotting scope or similar device. The site specific survey goat monitoring details are provided in section 6.1.3. If mountain goats are observed in the avalanche path, the avalanche control will be paused until goats are able to clear the area. Air horns or other suitable sounding devices may be

until goats are able to clear the area. All horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins.

All four methods may be used for avalanche control in the Project; however the Gazex® ground-based in-place concussive devices are being installed as the primary method of avalanche control for the two sites most likely to be in conflict with goats: 44 km and 58 km, as well as a third site at 59 km. Details of the avalanche control methodology were included in the Licence of Occupation applications submitted by Pretium Resources Inc. to BC FLNRO, which were subsequently approved.

5.3.2 Risk to Mountain Goat from Avalanche Control Measures

This section evaluates the risk to mountain goats at a site level using field data on the locations of proposed avalanche control measures, goat habitat, and goat occupancy collected during 2015. There are a number of avalanche zones identified along the Access Road and near the mine site. Within these zones there are areas that will be managed for avalanches; these include areas along the Access Road at 2 km, 30 km, 44 km, 56 km, 58 km, 59 km, and area around the Brucejack Camp and Mine Site (Figure 5.3-1; see map pocket). While the event frequency and size of avalanches vary, of the areas requiring most consistent control, areas at the Brucejack Camp and mine, 56 km, and 2 km are not identified as key goat winter habitat, and goats were not observed at any of these locations during inventory (Rescan 2011). Slopes above the access road at 30 km are near UWR, however goat were not identified in this area during inventory, the UWR is at the top of the avalanche zone, and control measures are only expected to be associated with the lower slope above the road. As such goat are not expected to occupy this area when avalanche control is required. Avalanche control at this location would be hand-based with some low elevation helicopter use.

Risk to goat from avalanche control at the Brucejack Camp and mine, 56 km, 30 km and 2 km is considered very low. Directed monitoring for goats is not proposed for these sites beyond the scanning protocol that currently occurs for avalanche control using helicopter-based or hand-based blasting described in section 5.3.1. If, for exceptional circumstances, goats are observed within avalanche tracks planned for blasting, avalanche control will be halted until the goats have cleared the area. Noise will be used as necessary to herd goats out of the danger area.

Control within areas at 44 km and 58 km is the most likely to provide a risk to mountain goat. The 59 km site has also been assessed for risk to mountain goat. All four methods of control may potentially be used at these sites, however the Ground-based Remote Avalanche Control Systems (RACS) Gazex® avalanche release systems represent the avalanche control of greatest consequence to goat in size of area, potential goat occupancy, and frequency of use. The Gazex® RACS are remotely fired with a charge of compressed oxygen and propane to initiate an avalanche. The volume of compressed gas can be changed to reflect the concussion charge required, with charges from between 0.8 m^3 and 3.0 m3 to be used for the Project. The RACS used to manage avalanche hazards will be installed at three key locations along the Brucejack Access Road. The Gazex® will be permanently fixed at the top of the avalanche paths at 44 km, 58 km and 59 km (Figure 5.3-2). A monitoring plan has been identified for use with RACS avalanche control in these areas and it can be extended to include all methods of avalanche control at these problematic sites.

In order to evaluate the potential risk to mountain goats at these three sites from the installation of the RACS and other avalanche control systems, a field survey was carried out in May, 2015 (June 17, 2015 Wildlife Trip Report). The survey was conducted, in part, to evaluate the likelihood that goat

2015 Wildlife Trip Report). The survey was conducted, in part, to evaluate the likelihood that goat would occupy the areas slated for avalanche control using habitat suitability, spatial distribution of habitat, and anticipated goat use. Locations at 44 km and 58 km were identified as potentially supporting use, while goat winter use at km 59 was not anticipated. The risk to mountain goat from avalanche control at these three sites was qualitatively evaluated based on professional judgement of habitat suitability and potential occupancy during the winter. The habitat value, and therefore likelihood of habitat use and risk to goats, was referenced to a local benchmark; the UWR unit on the north side of Bowser Lake which supports substantial goat numbers (12 observed in the winter 2011 survey at this location). This UWR is located approximately XX km away from km XX of the Brucejack Access Road.

The RACS unit at 44 km is at the edge of a large UWR complex that has potential to support a number of goats. This avalanche control site is at the lower, south and eastern edge of the complex, and while goat may occupy the site during winter, there is habitat of higher quality and greater connectivity north of the site. Within the UWR, goats were observed in May, 2015 (waypoint 043, Figure 3.5-2) up slope on the mountain within the UWR. Goats were observed in a favourable area of green vegetation near the large UWR polygon during the May 2015 reconnaissance. The 2011 winter ungulate surveys (Rescan 2011), did not detected goats in this area, but identified a total of 14 goats to the north and west of the 44 km UWR polygon unit. The RACS unit will affect a large area downslope from the UWR polygon unit (Plate 3.5-1). Considering the isolation of this unit at the periphery of a larger more suitable complex, the probability of it being occupied by goat during avalanche control is low and with monitoring, risk to goat is predicted as Low as well. The km 44 avalanche control area was checked for presence of mountain goat and other wildlife as part of standard pre-blast procedures during blasting that occurred over the past 4 winters; no mountain goat were observed within the blast areas.

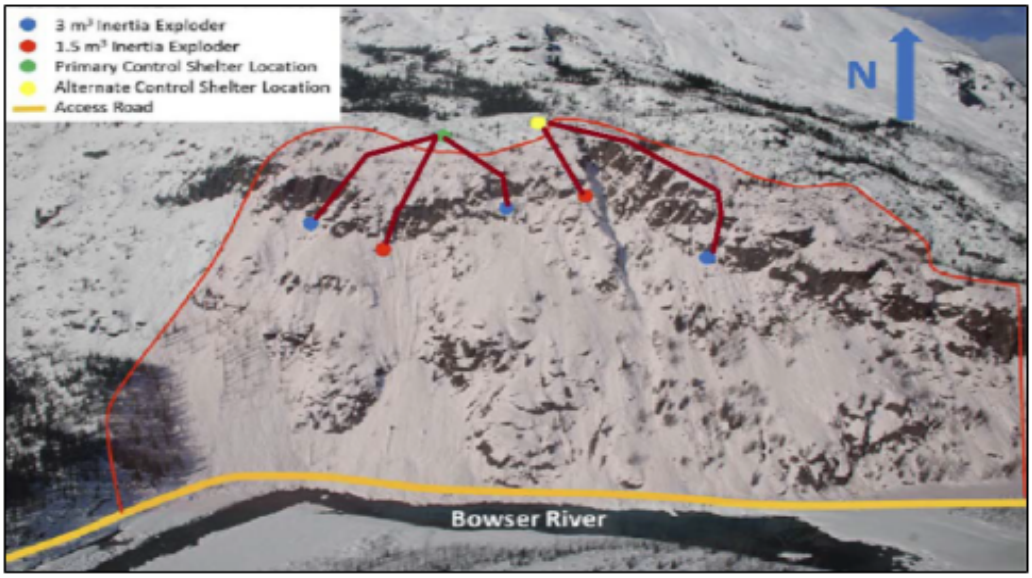

Plate 3.5-1. Location of RACS unit exploders at 44 km site.

The second RACS unit site is located at 58 km, above the parking lot at the southern end of the Knipple Glacier portion of the access road. One mountain goat was observed at this location during

the May 2015 reconnaissance, and goats with kids had been recorded near this site in 2011 prior to July 1 as recorded in the July 14, 2011 Vegetation and Wildlife Critical Review trip report. No goats were observed during winter 2011 survey near this location (Rescan 2011) and the survey unit associated with the site only had one goat observed during the winter 2011 surveys. The habitat was assessed as high quality winter habitat as it supports vegetation including conifer cover and shrubs adjacent to escape terrain. The area potentially affected by the RACS is at the lower elevation of the suitable habitat, where escape terrain is becoming fragmented, and connectivity to more contiguous habitat is reduced in winter (Plate 3.5-2). Considering the location at the edge of habitat and no documented winter use, it has a low probability of being occupied by goat during avalanche control, and risk to goat is predicted as Low with monitoring. As with the km 44 area, km 58 was also checked for mountain goat presence prior to blasting over the past four winters and no goats were observed within the avalanche zone.

The third RACS unit site is located at 59 km, was assessed as low quality winter habitat for goats. This site is in area recently exposed as the Knipple Glacier receded and has virtually no vegetation cover that would provide winter forage to goats. Its value as escape terrain is also marginal as it is small, and surrounded by more gently rolling topography (Plate 3.5-3), and only a small, low elevation area will be impacted by the RACS. No goats were observed near this site during the 2011 winter inventory (Rescan 2011) and only one goat was observed in SU 10. The probability of this site being used during winter by goat is very low and risk to goat is predicted as Very Low. No goats have been observed at this location during previous avalanche blasting activities.

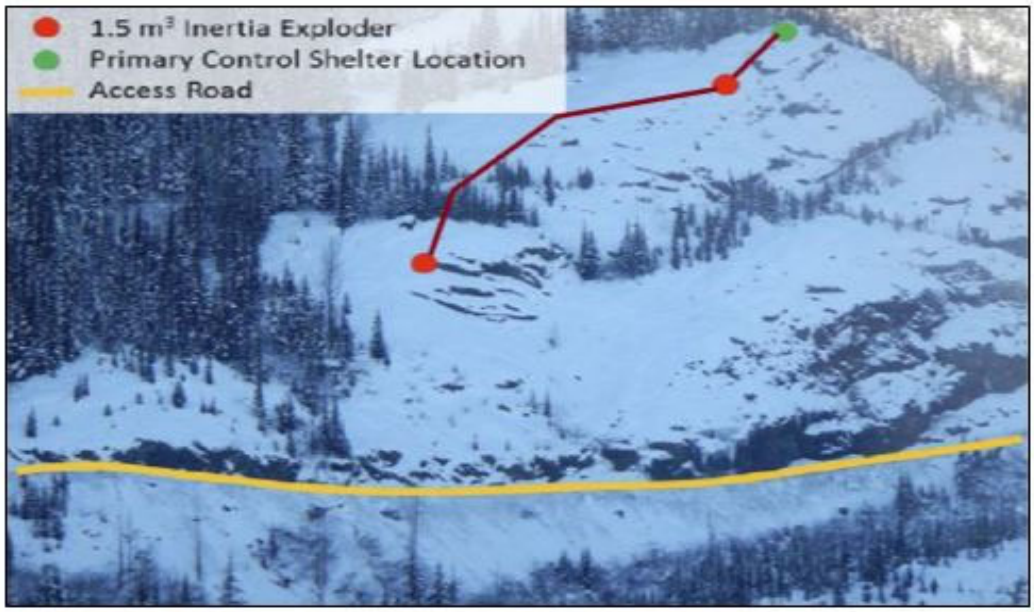

Plate 3.5-2. Location of RACS unit exploders at 58 km site.

Appendix I

Dyno Noble Emergency Response & Assistance Plan

EMERGENCY RESPONSE ASSISTANCE PLAN

(ERAP # 2-1037)

For Dyno Nobel Canada Inc. (DNCI)

This Emergency Response Assistance Plan (ERAP) addresses incidents and potential incidents involving the transportation of dangerous goods, as required by Transport Canada's "Transportation Of Dangerous Goods (TDG) Clear Language Regulations". Actions detailed within this plan are compulsory, having received approval and authorization by Sr. Vice President - Retail Sales & Field Operations – Americas – M. Sergio Lafratta.

1-800-EMR-GNCY
1-800-367-4629

"This document is a controlled document and represents the version currently in effect. All printed copies are uncontrolled documents and may not be current".

Note: Information provided within this document may be privileged and is not intended for general distribution.

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Section of document (printing purposes)

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EMERGENCY RESPONSE ASSISTANCE PLAN
Registration #: ERAP 2-1037

TO CALL FOR EMERGENCY ASSISTANCE
(Instructions to activate DNCI's Emergency Response Assistance Plan)

In the event of an emergency, accidental release or imminent accidental release involving the transportation of explosives or other chemicals, call **911** (or the local police number) for immediate assistance plus initiate DNCI's Emergency Response Assistance Plan (ERAP) by calling the 1-800-367-4629. Callers reporting an emergency should immediately give their name and phone number, and keep their telephone connection open until they've completed their initial report.

TO RESPOND TO AN EMERGENCY CALL

DNCI Corporate contact instructions:

Upon receiving a call for emergency response assistance, keep a log of all subsequent communications and actions, and do the following:

1. Immediately obtain the name and callback number of the caller, in case the telephone line is lost.

2. Obtain information to complete the Emergency Report Form (page 8) as fully and accurately as possible.

3. **WARN FIRST RESPONDERS OF EVACUATION DISTANCES IF RISK OF DETONATION.** Should there be explosive detonations, or the risk of detonations due to the presence of fire or other detonating factors, advise the First Responders of the risk and applicable safety distances per Table 9-1, page 21 . Note: See ERAP section 14, pg 34 for Evacuation Procedures.

4. Call an ER Advisor for the applicable Region (see page 7) and report the emergency situation. In turn, the ER Advisor will phone the emergency scene caller, establish ongoing contact, assess the emergency, determine what Company resources and/or contracted emergency response services are required and organize an Emergency Response Team – ERT (see ERAP pg. 18) to proceed to the emergency scene if required).

5. Assist the Emergency Response Advisor (ERA).

6. Liaise with Company Executive / Senior Managers.

Emergency Response Advisor (ERA) instructions:

1. Call the Branch/Plant Supervisor nearest the emergency scene plus provincial & federal authorities (see applicable appendix to Annex D) to advise them of the situation and the need for an emergency response.

2. Designate, assemble and dispatch an Emergency Response Team (ERT), made up of Groups 1 & 2 personnel (see ERAP pg. 15 and Annex D) under the leadership of an On Scene Coordinator (OSC), if required.

3. Authorize the dispatching of additional resources, communications, transportation and contracted services as necessary.

4. Contact and instruct the designated Emergency Response Team (ERT) to proceed to the emergency scene with the required vehicles and equipment.

5. Liaise with the Person in Charge of the First Responders, the vehicle driver or railway official (involved in the Emergency) and/or Local Authorities to obtain a situation update.

6. Advise local Authorities as appropriate, regarding the properties, hazards and handling procedures for the explosives involved in the emergency. In particular, advise the Local Authorities of appropriate evacuation distances per Table 9-1 (ERAP pg. 21).

7. Continue to consult with the Local Authorities as appropriate, plus the Company's On-Scene Coordinator (OSC), to stabilize and eliminate the emergency.

8. Respond to media requests in accordance with the Crisis Communication Plan (CCP).

9. Contact the explosives supplier and / or transporter (if other than DNCI) to advise them of the emergency and to request their assistance if/as required.

10. Organize and direct the Company's clean-up / recovery / restoration activities utilizing third-party resources as appropriate.

11. Authorize the development and submission of immediate and follow-up regulatory reports (see Part 8 of the TDG Clear Language Regulations).

DNCI Corporate contact

Name	Position	Cell number
Benoit Choquette	Environmental Manager Canada	(514) 249-6285
Pierre St-Georges	Regulatory Coordinator- Canada	(613) 677-1051
Robert Moreau	Fleet & Equipment / Canada	(403) 990-3136
Rick Chopp	HS Advisor– Central Canada	(705) 498-2855
Marco Giambagno	Operations Manager – Eastern Canada	(514) 235-4093
Ralph Olson	Sales & Operations Mgr. Southern B.C.	(250) 713-8720
Pierre Labelle	General Manager Central Canada	(705) 471-1864
Seamus Kilcommons	Manager HSEC Canada	(403) 837-2685
Allen Fontaine	HSE Advisor – Eastern Canada	(581) 444-1039

DNCI Technical Advisors per area

Name	Position	Cell number	Area (West, Central or East)
Denis Simard	Team Leader & Head - Lac St-Charles	(418) 580-8952	East
Nicolas Frenette	Site Supervisor - Lac St-Charles	(418) 571-0609	East
Patrick Pilon	Projects and Facilities Supervisor	(450) 660-4474	East
Alexis Ancel	Site Supervisor - Ste-Sophie	514-795-7042	East
Paul Purcell	Operations Supervisor Maritimes	(902) 456-0661	East
Patrice Charette	Site Supervisor Yoho	506-478-3118	East
Vaughn McDonald	Site Supervisor Bedford	902-237-3906	East
Stephane Pereira	Operations Manager, Quarry & Construction – Quebec	(514) 607-6255	East
Tyrone McLean	Operations Manager – Manitoba & Saskatchewan	(204) 687-0046	Central
Mark O'Neil	Ontario Manager	(705) 929-5871	Central
John Asselstine	Southern Ontario Manager	(613) 532-6976	Central
Tyler Matson	Site Supervisor Sudbury	(705) 655-1078	Central
Dale Wearmouth	Worksite Supervisor Minto Mine, YK	(403) 775-6143	West
Craig Nicolson	Regional Operations Mgr	(403) 512-5127	West
Tom Medak	Regional Operations Mgr	(403) 818-4434	West/Arctic
Darren Woodhead	Site Supervisor – Tumbler Ridge	(780) 223-4491	West

DNCI'S EMERGENCY REPORT FORM FOR INCIDENTS INVOLVING EXPLOSIVES

WHO IS CALLING? NAME:_____

PHONE #: _____ TIME:_____DATE:_____

CALLER'S ORGANIZATION:_____

LOCATION OF INCIDENT: _____

WHAT IS THE EMERGENCY?
PROBLEM**:** (Motor Vehicle Accident, Fire, Scattered Product, Disabled Truck, etc.)

_____

_____

PRODUCTS INVOLVED : VISIBLE PLACARDS ? YES_____ NO_____

SHIPPING NAME(S)_____

UN NUMBER(S)_____

HAZARD CLASSIFICATION (ex: 1.1 D) :_____

QUANTITY: _____

INJURIES: _____

PROPERTY DAMAGE:_____

EXPLOSIVES VEHICLE UNIT NUMBER:_____LICENSE NO._____

DRIVER:_____CARRIER:_____

WHEN DID INCIDENT OCCUR? DATE: _____TIME: _____

WHERE IS THE EMERGENCY? (City, Town, Rural Area, Lat. & Long., Specific Directions)

_____

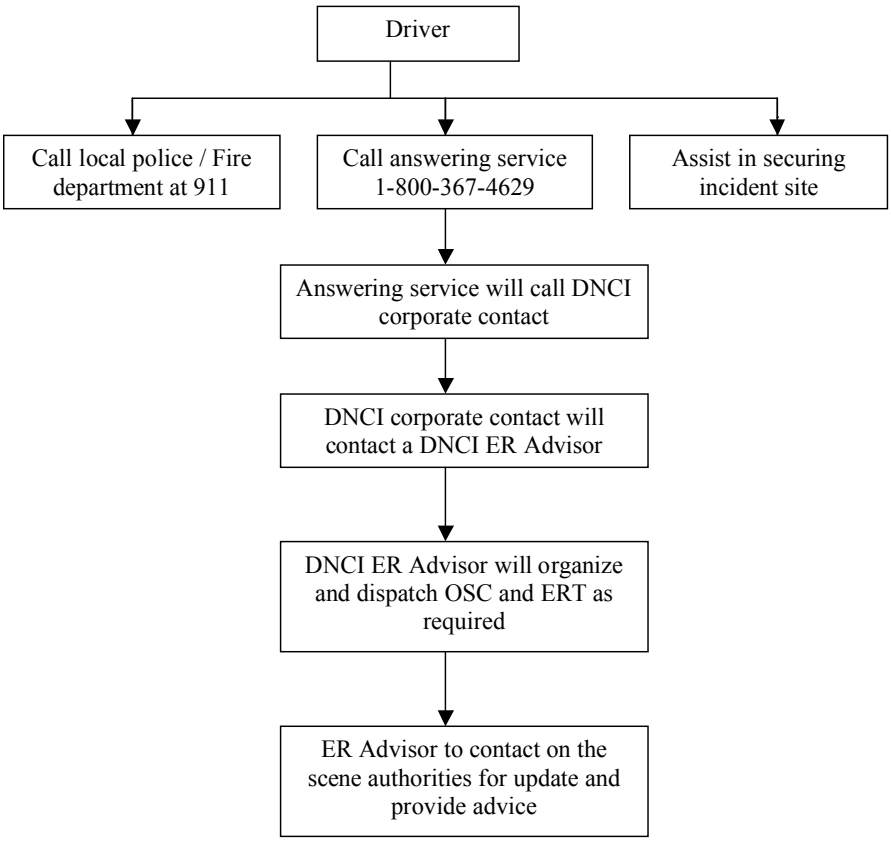
ARE THERE RESIDENCES, BUSINESSES, OR OTHER PUBLIC GATHERING PLACES WITHIN THE EVACUATION ZONE (what, where)?

_____

WHAT ACTION HAS BEEN TAKEN TO THIS POINT IN TIME?_____
(Medical, evacuation, fire fighting, etc.)

_____

EMERGENCY RESPONSE FLOW CHART



Abbreviations / Definitions:

Driver: Any person who is able to report an incident involving a DNCI road transportation delivery, be it the Driver, Driver's Assistant, a Good Samaritan or First Responder, plus, in the event of a rail transportation incident, a railroad representative, or in the event of an air incident, a member of the crew or airport authority.

DNCI Corporate contact : A DNCI corporate employee who is assigned to receive Emergency Calls at all times from the answering service.

ER Advisor: Emergency Response Advisor (ERA), who will normally be the applicable General Manager, Area Manager, or Technical Advisor (see table page 7) who will liaise with First Responders.

OSC: (DNCI) On Scene Coordinator, the Senior DNCI employee at an incident site who manages and controls DNCI resources in support of First Responders and incident recovery.

ERT: Emergency Response Team, DNCI personnel dispatched to an incident site to assist First Responders and conduct incident recovery under the direction of the OSC.

EMERGENCY RESPONSE ASSISTANCE PLAN
Registration #: ERAP 2-1037

Revision / Amendment History

Publication/ Amendment Date	Changes To Prior Edition	Pg.
30 Nov 2006	New document	All
4 April 2007	Minor changes Hazard Analysis checklist	30-34
14 Sept 2007	General Revision	All
20 Oct 2007	Partial revision	54-116
28 April 2008	Revision	Appendices
10 Feb 2009	Revision	All
8 Sept 2009	Revision	All
1 Feb 2011	Full revision	All.
15 Feb 2012	Full revision	All.
10 April 2013	Full revision	All
25 November 2013	Full revision	All
March 5 2015	Full Revision	All
22 June 2015	Partial revision	All

Persons and Locations of Primary Interest

(Copies of this document shall be made available to :)

1 All employees of DNCI ;

2 All DNCI worksites (only geographical sections that are relevant);

3 Customers, suppliers and service providers who have a "Mutual ERAP Assistance Agreement" with DNCI;

4 Regulatory Authorities as required, including Transport Canada.

5 Dyno Nobel America (DNA (Corporate Safety) – Salt Lake City, USA); and

6 Dyno Nobel Transportation Inc. (DNTI - Salt lake City, USA).

Note:

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EMERGENCY RESPONSE ASSISTANCE PLAN
Registration #: ERAP 2-1037

1. INTRODUCTION

This plan is designed to meet Emergency Response Assistance Plan (ERAP) requirements under Part 7 of the Transportation of Dangerous Goods (TDG) Clear Language Regulations. Furthermore, this ERAP is designed to support the transportation operations of DNCI "and" it's associated companies, which include:

Subsidiary & Associated Companies For Which This ERAP Applies:
Denesoline Western Explosives Inc. (DWEI)
Dyno Nobel America (DNA)
Dyno Nobel North America (DNNA)
Dyno Nobel Nunavut Inc. (DNNI)
Qaaqtuq Dyno Nobel Inc (QDNI)
Dyno Nobel Transport Inc. (DNTI)
Polar Explosives Ltd. (PEL)

This ERAP will be used to ensure DNCI takes planned action to preserve and protect life & limb, the environment and property in response to an incident involving the transportation of explosives and component chemicals by road, air, rail and marine modes.

It is Company policy that all employees know the contents of this plan, know their ERAP roles and responsibilities, and are aware of others' roles and responsibilities. As well, key personnel are to be able to quickly locate and dispatch qualified explosives personnel plus recovery vehicles, equipment and operators to help First Responders / Local Authorities stabilize and eliminate explosives-related emergencies.

2. SCOPE OF OPERATION

Dyno Nobel Canada Inc. (DNCI) plus its subsidiary and associated companies manufacture and distribute explosives and accessories throughout Canada. DNCI's has manufacturing and storage facilities as listed in Annex A.

DNCI also has assorted satellite manufacturing and storage facilities associated with temporary and other projects that are licensed with NRCan/ERD, on an "as needed" basis.

DNCI's products consist of packaged explosives (paper/plastic tubes of explosive material, plus bags of Ammonium Nitrate/Fuel Oil - ANFO), ranging from 1/8 kg to 25 kg per unit, plus accessories (detonators and detonating cord). As well, DNCI manufactures and distributes bulk explosives in the form of emulsion (a mayonnaise-like fluid explosive material) and granular ANFO. Constituent bulk explosive materials, such as Ammonium Nitrate (AN), Fuel Oil and sensitizers may be carried in limited quantities in "bulk explosives-carrying" vehicles (Process Vehicles) between bulk manufacturing / storage facilities and jobsites (see Annex B for Dangerous Goods transported by / for DNCI).

The majority of packaged products, including detonators, are imported from the United States, stored at Company magazine worksites throughout Canada, then sold and delivered to licensed customers in the construction, mining, lumber and seismic industries. DNCI frequently loans or leases mobile magazines (wheeled and skid) to buyers to store their purchased explosives during the operation of their project(s).

DNCI purchases packaged explosives primarily from Dyno Nobel America which manufactures detonators in Simsbury, Connecticut; Wolf Lake, Illinois; and manufactures packaged explosives in Carthage, Missouri. Explosives are typically delivered by the manufacturer in U.S.-based tractor-trailer trucks via hazardous goods routes to DNCI's magazine sites and subsequently delivered to customers in DNCI's 5, 3, 2, 1 and 3/4 ton trucks. "When necessary", packaged explosives and accessories, and/or raw materials to manufacture bulk explosives will be flown to remote Northern locations via dedicated air transport carriers under ICAO standards and procedures. As well, products may "occasionally" be shipped via rail. On occasion, packaged products can be shipped to customers by sea-can on a barge in accordance with TDG and IMDG codes. All explosives operations are conducted in accordance with NRC / ERD and TDG standards and authorizations.

Bulk ANFO is manufactured in DNCI plants Nanaimo, BC; Flin Flon, MB ;Red Lake,ON; Ormstown, QC; Rockyford, AB plants; and is subsequently transported in either 25 kg bags or 1 ton totes to customers in local and adjacent provinces via company or third-party trucks ranging from 2,000 to 20,000 kg loads.

Bulk emulsion explosive is manufactured at DNCI's Ormstown QC; Tumbler Ridge BC and North Bay ON plants, and is delivered in tractor trailer tankers and/or bulk Pump Trucks (Process Vehicles) to customers in local and adjacent provinces. As well, emulsion is manufactured in Biwabik, Minnesota (USA) for delivery in Manitoba and NW Ontario. Emulsion may be delivered from the manufacturing plant to the end-user's worksite, or it may be distributed to customers in two stages, by way of bulk storage & redistribution sites using Pump Trucks (Process Vehicles) or in 2,000kg (tote) cubic containers transported by dedicated tractor trailers and/or 2 – 5 ton cargo vans.
Emulsion and ANFO is also manufactured at Polar's Ekati, NT; DWE's Diavik, NT; QAAQTUQ Meadowbank,NU and DNCI's Mount Wright (Fermont) QC; worksites for use in locally controlled and restricted mining operations.

Dangerous Goods that are transported by or for DNCI are listed in Annex B.

Road Transportation

Subject to approved permits and regulations, explosive shipments may occur 24 hours per day, 7 days a week, depending upon environmental conditions and industry activity. All road transport vehicles are constructed, equipped and placarded to meet explosives standards and regulations. As well, workers offering for transport, handling and transporting explosives must be first trained in accordance with NRC / ERD and TDG Clear Language Regulations. Only company personnel authorized under ERD regulation and issued with a valid TDG training certificate are allowed to handle or transport explosives. It is also the responsibility of the driver and management to ensure that handling and transportation of explosives is carried out safely and legally.

Prior to transporting explosives, the Driver must ensure that the vehicle is properly serviced and in good operating order. As well, they must ensure that required safety equipment is present and operational; that the load is properly distributed and secured in an approved cargo space; that appropriate safety mark placards are displayed while transporting explosives; that required documentation is properly completed and placed within the cab, and that a delivery route plan is provided to the dispatching worksite.

The shipping documents list the Company's 24 hour telephone number 1-800-367-4629 which can be used by third parties to initiate the ERAP, should the Driver be incapacitated.

Rail Transportation:
DNCI will occasionally transport limited quantities of explosives in dedicated railcars pursuant to TDG regulations to remote locations that are not normally accessible by road. As well, rail transportation may be used to transport large (rail car) quantities of explosives "on infrequent occasions".

Air Transportation:
Packaged explosives and/or raw materials to manufacture explosives are periodically transported to remote Northern mine sites via third party transport aircraft operating under ICAO and TDG regulations.

Marine transportation:
Packaged explosives and/or raw materials to manufacture explosives are periodically transported to remote Northern Mines via third party barge operating under IMDG and TDG regulations. Also, sometimes road tankers cross waterways on ferries to access sites.

3. POTENTIAL TYPES OF ACCIDENTS / EMERGENCIES

The types of problems (accidental release, imminent accidental release, etc.) which may occur when transporting explosives include:

Road Transportation
The types of incidents that may occur when transporting explosives by road are:

- Vehicle accident (collision or upset) involving :
    - explosion of all or portions of transported explosives due to impact, fire or extraneous detonation;
    - fire or potential for fire giving rise to potential explosives detonation;

  - scattering or spill of explosive material into / onto water body;
  - scattering or spill of explosive material on the ground or frozen water body.
- Hijacking of vehicle or theft of explosive shipment.
- Incapacitation of vehicle driver.
- Mechanical breakdown of vehicle.

Note: See Hazard Analysis Checklist, ERAP Section 13, pg 30.

Rail Transportation

- Train accident (collision or derailment) involving :
  - explosion of all or portions of transported explosives due to impact, fire or extraneous detonation;
  - fire or potential for fire giving rise to potential explosives detonation;
  - scattering or spill of explosive material into / onto water body;
  - scattering or spill of explosive material on the ground or frozen water body.
- Hijacking or theft of explosive shipment.
- Mechanical breakdown of train.

Air Transportation

The types of incidents that may occur when transporting explosives by air are:

- Diversion of aircraft to an alternate airport due to:
  - destination and departure airports being closed (due to weather or other circumstance), or
  - aircraft malfunction while en route to destination.
- Hijacking of aircraft or theft of explosive shipment.
- Aircraft accident (crash/forced landing) while en route to destination airport.

Marine transportation

The types of incidents that may occur when transporting explosives by marine vessel are:

- Diversion of vessel to an alternate port due to:
  - destination and departure ports being closed (due to weather or other circumstance), or
  - vessel malfunction while en route to destination.
- Hijacking of vessel or theft of explosive shipment.
- Marine vessel accident (sinking, collision, capsizing, etc.) while en route to destination.

Road / Rail /Air/ Marine ERAP Objectives

DNCI's response, be it advising First Responders on the scene, assembling and transporting an Emergency Response Team (ERT) & recovery equipment, and/or contracting third party services, will always be carried out with the interests of public safety and security as the foremost objective. Available resources and effort will be devoted to protecting and preserving life and limb, the environment, property, and commercial/personal activities.

4. CORPORATE ADDRESS CORPORATE OFFICERS & SENIOR MANAGEMENT

Suite 210, 48 Quarry Park Blvd SE Calgary, AB T2C 5P2. Tel: **1-800-565-8375** Tel : 1-403-720-0905 Fax: **1-403-236-5625**	General Manager Western N.A. and Arctic.	Mike T Soter (cell : 1-801-580-5919)
	Regional Operations Manager	Craig Nicolson (cell : 403-512-5127)
	Regional Operations Manager	Tom Medak (cell: 403 818-4434)
	HSEC Manager Canada	Seamus Kilcommons (cell : 403 837-2685)
350 Dupont Rd, Box 900, North Bay, Ontario, P1B 8K2, Canada **Tel :** 1- 705- 472- 1300 **Fax:** 1- 705- 472 -3416	General Manager Central Canada	Pierre Labelle (cell : 704-471-1864)
	H&S Advisor – Central Canada	Rick Chopp (cell : 705-498-2855)
3665 Boul. Grande Allée. Boisbriand, QC, J7H 1H5 Tel: 1-450-437-1441 Tel : 1-866-550-1441 Fax: 1-450-437-2085	General Manager Eastern Canada	John Vazquez 514-209-7906
	Operations Manager – Eastern Canada	Marco Giambagno (cell : 514-235-4093)
	H&S Advisor – Eastern Canada	Allen Fontaine (581) 444-1039
	Environmental Manager Canada	Benoit Choquette (cell: 514-249-6285)
	Regulatory Affairs Coordinator Canada	Pierre St-Georges (cell: 613-677-1051)

5. EMERGENCY RESPONSE ORGANIZATION

DNCI has an answering service on call 24 hours a day, who can be contacted at 1-800-367-4629 to activate this ERAP.

DNCI staffs are organized into three functional ERAP groups, as follows:

Group 1 : DNCI Corporate contact : A DNCI corporate employee who is assigned to receive Emergency Calls at all times from the answering service. The list of Corporate contacts is presented in page 6.

Group 2 : Emergency Response Advisors – management and technical staff who will provide both distant and on-scene advice to First Responders and Local Authorities regarding the threat and handling of explosive products. When warranted, a Senior ERA will be dispatched to an accident scene where they will become the **On Scene Coordinator**

(OSC), providing direct advice to local authorities and coordinating (managing) DNCI resources in the stabilization and recovery of dangerous goods involved in an incident. The list of primary ER Advisors is presented in page 7.

Group 3 Emergency Response Team (ERT - Logistical Support) – branch, plant and sales staff who routinely handle, transport or sell explosive products and operate associated equipment, and who will assist and/or conduct on-scene recovery operations. The ERT will normally be lead by an **On Scene Coordinator (OSC**) at the emergency site. The ERT personnel is listed in Annex D for the various DNCI sites.

6. DUTIES OF KEY PERSONNEL

ROAD AND RAIL TRANSPORTATION

(1) DRIVER / TRAIN CONDUCTOR / ENGINEER EXPERIENCING EMERGENCY / POTENTIAL EMERGENCY

- **CALL FOR EMERGENCY ASSISTANCE**
  In the event of an emergency, accidental release or imminent accidental release involving the transportation of explosives, eliminate potential sources of detonation where possible (eg. turn off the ignition of a vehicle), call **911** (or the local police number) for immediate assistance and initiate DNCI's Emergency Response Assistance Plan by calling 1-800-367-4629.

- **WARN PUBLIC IF RISK OF DETONATION**
  Should there be explosive detonations, or the risk of detonations due to the presence of fire or other detonating factors, advise the First Responders (or anyone within the immediate vicinity if First Responders are not at the scene) of the risk of an explosion. Help organize perimeter guards to prevent people from entering the evacuation zone. The minimal distance to evacuate for a 20,000 kg tanker is 1.2 km or 4000 feet.
  Note: See ERAP section 14, pg 34 for Evacuation Procedures.

- **EXTINGUISH SMALL FIRES IF SAFE TO DO SO**
  Do not fight fires that have reached or have heated the explosives or ammonium nitrate cargo. Flood minor fires with fire suppressant (Dry Chemical, water, dirt, CO2) and monitor the situation to ensure the fire doesn't re-ignite.

- **ASSIST LOCAL AUTHORITIES**
  Assist First Responders and Local Authorities in eliminating the emergency situation, and liaise with DNCI's On-Call Employee / ERA until relieved by the Company's Emergency Response Team (ERT), or reassigned to other duties.

(2) CORPORATE CONTACT TO RESPONSE TO AN EMERGENCY CALL

- Upon receiving an emergency call, keep a log of all subsequent communications and actions, and do the following:

- Immediately obtain the name and callback number of the caller, in case the telephone line is lost.

- Obtain information to complete the Emergency Report Form (ERAP pg. 8) as fully and accurately as possible.

- **WARN FIRST RESPONDERS OF EVACUATION DISTANCES IF RISK OF DETONATION**
  Should there be explosive detonations, or the risk of detonations due to the presence of fire or other detonating factors, advise the First Responders of the risk and applicable safety distances per Table 9-1, page 21 .
  Note: See ERAP section 14, pg 34 for Evacuation Procedures.

- Call an Emergency Response Advisor (ERA) (see table page 7) and report the emergency situation. (In turn, the ERA will phone the emergency scene caller, establish ongoing contact, assess the emergency, determine what additional resources are required and organize an Emergency Response Team (ERT) made up of regional personnel to proceed to the emergency scene if required).

- Liaise with Company Executive / Senior Managers.

- Call CANUTEC (613) 996-6666 for any transportation incident involving spills.

(3) EMERGENCY RESPONSE ADVISOR (ERA)

- Call the Branch/Plant Supervisor nearest the emergency scene plus provincial & federal authorities to advise them of the situation and the need for an emergency response.

- Designate, assemble and dispatch an Emergency Response Team (ERT) under the leadership of an On Scene Coordinator (OSC), if required.

- Authorize the dispatching of additional resources, communications, transportation and contracted services as necessary.

- Contact and instruct the designated Emergency Response Team (ERT) to proceed to the emergency scene with the required vehicles and equipment.

- Liaise with the Person in Charge of the First Responders, the vehicle driver or railway official (involved in the Emergency) and/or Local Authorities to obtain a situation update.

- **WARN FIRST RESPONDERS OF EVACUATION DISTANCES IF RISK OF DETONATION**
  Advise Local Authorities as appropriate, regarding the properties, hazards and handling procedures for the explosives or ammonium nitrate involved in the emergency. In particular, advise the Local Authorities of appropriate evacuation distances per Table 9-1.

- Continue to consult with the Local Authorities as appropriate, plus the Company's On-Scene Coordinator (OSC), to stabilize and eliminate the emergency.

- Respond to media requests in accordance with the Crisis Communication Plan (CCP).

- Contact the explosives supplier and / or transporter (if other than DNCI) to advise them of the emergency and to request their assistance if/as required.

- Organize and direct the Company's clean-up / recovery / restoration activities utilizing third-party resources as appropriate.

- Authorize the development and submission of immediate and follow-up regulatory reports (see Part 8 of the TDG Clear Language Regulations).

(4) ON-SCENE CO-ORDINATOR (OSC)

- The On-Scene Coordinator (OSC) is the Company's representative and local authority in charge of all company actions and resources at the emergency scene. Once the OSC arrives at the emergency scene, the ERA will transfer communication with First Responders/Local Authorities to the OSC. In turn, the OSC will liaise with the ER Advisor as required. Throughout the Company's emergency response, the OSC will ensure that Company personnel (employees and contractors) observe all safety and regulatory standards and procedures.

- The OSC may revise / adjust the composition of the Emergency Response Team (ERT) and supporting resources as required. The OSC may, in consultation with the ER Advisor, contract commercial services to assist in addressing and restoring the emergency situation.

- The OSC will oversee the Company's local involvement with emergency services, government (municipal & provincial) and public interests until the emergency is fully resolved. Post-emergency activities (clean-up, restoration, etc.) may be delegated to an appropriate Branch, Plant or Area Manager.

(5) EMERGENCY RESPONSE TEAM (ERT)

- Selected emergency response personnel will take their direction to assemble and proceed to the emergency scene from the ERA or their representative. While preparing for and en route to the emergency scene, ER Team members will maintain periodic communication (at least every two hours) with the ERA. Upon arriving at the emergency scene, Team members will immediately report to the On-Scene-Coordinator and advise ERA of their arrival.

- The primary role of the ERT is to provide a competent and trained / certified workforce plus specialized equipment and material to assist First Responders / Local Authorities in the stabilizing and elimination of an 'explosives emergency', and to retrieve / recover, repackage and remove to safe and secure storage, non-detonated explosives.

- While at the emergency scene, ERT members will take their direction from the Company's OSC and remain available until released by the OSC.

NOTE:

ONLY INDIVIDUALS WHO HAVE RECEIVED TRAINING AS REQUIRED UNDER THE TRANSPORTATION OF DANGEROUS GOODS (CLEAR LANGUAGE) REGULATIONS, OR WHO ARE WORKING UNDER THE DIRECT AND CONTINUOUS SUPERVISION OF AN EMPLOYEE WHO HAS BEEN TRAINED FOR CLASS 1 DANGEROUS GOODS UNDER TDG, MAY PARTICIPATE IN SITE CLEAN-UP ACTIVITIES SUCH AS PICKING UP, REPACKAGING AND TRANSPORTING EXPLOSIVE MATERIAL.

(6) PILOT EXPERIENCING EMERGENCY OR UNPLANNED EVENTS DURING AIR TRANSPORTATION

Pilots experiencing emergencies or unplanned events may activate DNCI's ERAP.

- Call CANUTEC (613) 996-6666 and the nearest Regional Civil Aviation Office of the Department of Transport for any air transportation incident.

7. EMPLOYEE TRAINING, PLAN PREPARATION & ACTIVATION AND ON SCENE COMMUNICATION

(7.1) Employee Training

All employee's called upon to participate in / support DNCI's ERAP must have current training and qualification in WHMIS, TDG, DNCI's ERAP & Crisis Communication Plan (CCP) and Take 5 Hazard Assessment. Person's providing advices as an Emergency Response Advisor (ERA) will be management / supervisory personnel with significant experience and training in the manufacturing, handling and regulation of explosives. Personnel responding to incidents to assist in the recovery and removal of explosives will be experienced operations and/or sales personnel with knowledge and competency in handling the explosives involved in the incident.

(7.2) Plan Preparation

All Work Site Supervisors (Area, Branch & Plant) will ensure that:

- Staff review and/or conduct an exercise of DNCI's emergency plans (including this ERAP) at least annually.

- A transportable emergency cache of packaging, spill and safety materials, safety equipment, explosives placards and shipping documents is maintained in ready and good order to take to an emergency scene.

- Individual worksite plans are developed to: provide transportation of emergency response personnel and materials to an emergency scene; establish emergency response communications; and retrieve & transport explosives from an emergency scene.

- The emergency phone numbers will be tested at least annually and a record sheet of the test will be kept. A drill should be organized once a year.

(7.3) Plan Activation

When activated, the OSC and designated members of the Emergency Response Team (ERT) will proceed to the emergency scene as quickly as possible, using chartered air service, if distances and travel timeframes are excessive (note: Transport Canada expects organizations to be able to satisfactorily address an emergency within six hours of an incident).

(7.4) On Scene Communication

Company personnel that are dispatched to an emergency scene shall be provided with communication equipment that provides reliable contact with other ERT personnel/ vehicles /ER Advisor/ Corporate Contact. All emergency response personnel / units will normally report their progress to ER Advisor every two hours, until they arrive at the emergency scene, at which time they will take their direction from the OSC.

The On-Scene Coordinator will normally provide a situation update to the Emergency Response Advisor every hour, until the emergency situation is stabilized. While at the emergency scene, members of the Emergency Response Team will report to and take direction from the OSC.

EMERGENCY ACTIONS

9. WHAT TO DO IN CASE OF:
I. CLASS 1 EXPLOSIVE MATERIALS
(Emergency Response Guidebook reference: Guides #112 and #114)

(1) Explosions / Potential Explosions

Class 1 explosive material can be detonated by sparking, heat (fire), impact (shock), friction, lightning and electromagnetic (radio transmitter) activity. Accidents involving Class 1 **materials which are exploding or are likely to explode due to the presence of detonating influences require everyone to be evacuated from the area**. The initial response should therefore be to clear and secure the area of all personnel, setting up roadblocks, barriers and / or guards as appropriate. Personnel within or near the evacuation area should seek protection behind high terrain or large solid obstructions, taking care to stay away from windows and material that may shatter. Evacuation distances are based on the amount of explosive present, as outlined in Table 9-1.

Table 9 – 1
Evacuation Distances
(Based on NRCan Quantity-Distance Principles Table 1 : D8)

Explosive Quantity		Metric Distance		English Distance
700 kg or less		400 Meters		1315 Feet
1,000 kg		445 Meters		1460 Feet
2,000 kg		560 Meters		1840 Feet
2.500 kg		610 Meters		2,000 Feet
5,000 kg		760 Meters		2,500 Feet
7,500 kg		890 Meters		2,920 Feet
10,000 kg		960 Meters		3,150 Feet
14,000 kg		1,080 Meters		3,545 Feet
16,000 kg		1,120 Meters		3,675 Feet
20,000 kg		1,220 Meters		4,000 Feet

Upon resolution of the emergency, take a careful inventory of all remaining material, assess the likelihood of the missing material having been destroyed, and incorporate the information in applicable reports. Clean-up shall be as outlined under spill/scattered explosives procedures.

(2) Fire / Potential For Fire

In general, accidents involving fire and explosives should be treated as an impending explosion, which calls for the immediate evacuation of people from the area according to the evacuation distances. **Never fight fires that are likely to detonate explosives or ammonium nitrate. Evacuate and secure the area.**
Note: See ERAP section 14, pg. 34 for Evacuation Procedures.

Minor fires which do not immediately threaten the explosives cargo should be extinguished as quickly as possible using plenty of fire suppressants (flood the area with Dry Chemical, water, CO2 or dirt). Where possible and without undue risk, First Responders should use unmanned hose holders to suppress a fire and / or prevent it from spreading to the cargo area (monitor fire hose nozzles from a safe distance). Once the fire is extinguished, the area should be monitored to ensure re-ignition doesn't occur.

The decision to remove or separate explosive cargo from a detonating source must be made on a case by case basis, taking into consideration the risk of detonation. **Do not move explosive cargo or the vehicle if the cargo has been exposed to heat.**

Upon resolution of the emergency, take a careful inventory of all remaining material, assess the likelihood of the missing material having been destroyed, and incorporate the information in applicable reports. Clean-up shall be as outlined under spill/scattered explosives procedures.

(3 Scattering / Spill Of Explosive Material On Ground / Frozen Water

In the event explosive material has been scattered or spilled onto the ground, the area should be cleared of people and restricted to First Responders. The immediate concern should be; (1) to prevent detonation and fire; and (2) to prevent unauthorized removal of /tampering with explosive product. ER actions should therefore be:

- Eliminate all ignition sources (turn engines off, no smoking, do not use flares, sparking equipment or radio transmitters and turn-off cell phones in immediate area)
- Secure the area (restrict access by unauthorized people)
- Do not touch or walk through scattered / spilled material
- Do not operate radio transmitters within 100 meters / 330 feet of electric detonators
- Do not clean-up or dispose of scattered / spilled explosives except under the supervision of a specialist
- Ensure all equipment used in handling explosives is grounded or is made of non-sparking material
- Upon resolution of the emergency, take a careful inventory of all remaining material, assess the likelihood of the missing material having been destroyed, and incorporate the information in applicable reports.

Explosive material spilled or scattered on the ground will be in one of three forms. The three forms of explosives are (see ERAP Annex B for explosives characteristics):

- Packaged Products in cardboard containers (sticks/cartridges of explosives, and boosters (Class 1.1D); detonators (Class 1.1B); and detonating cord (Class 1.4*).
- ANFO (Granular) in 25 kg bags or 1000 kg totes (Class 1.5D).
- Bulk Emulsion in pump trucks, tanker trailers or 1000kg totes (Class 1.5D).

Packaged Products:

Packaged products scattered on the ground may be loose units of explosive material plus broken cardboard boxes/cases, or intact boxes/cases of explosive product, depending upon the situation. The primary concern will be to eliminate detonating influences to prevent explosion, and to secure the area to prevent theft or unauthorized handling of the material. Ground contamination is unlikely, but may require the removal/reclamation of a minimum

amount of soil/snow. In turn, members of the ER Team will retrieve the product, take inventory, repackage the explosives as necessary, and transport the explosives to a magazine for quality assessment and disposal/resale as appropriate.

ANFO (Granular):

ANFO is a mixture of granular Ammonium Nitrate and Fuel Oil, usually packaged in 25 kg plastic bags or 1000 kg totes. Spillage will most likely consist of broken and unbroken bags, resulting in granular product scattered upon the ground. The primary concern will be to eliminate detonating influences to prevent explosion and fire, and to secure the area to prevent untrained / unauthorized handling of the material. Surface soil contamination is likely, through minor leaching of fuel oil and chemicals into the ground. The product will also dissolve in water, thereby increasing the depth and area of contamination. Spills should therefore be covered with waterproof tarps in the event of rain and prevented from entering watercourses or drainage systems by forming dykes or dams to eliminate the possibility of runoff. In turn, the ER Team will recover the spilled ANFO from the ground, transferring the material with plastic or non-ferrous shovels into clean plastic containers.

The amount of recovered material should be recorded and the plastic containers labeled accordingly, prior to shipping the product to a magazine for quality assessment and disposal. Appropriate safety/environmental clothing (rubber gloves & boots) needs to be worn during the operation. As well, it may be necessary to remove/reclaim contaminated surface soil from the accident scene, sending it by contracted service to a reclamation facility.

Emulsion

Emulsion is a thick mayonnaise-like fluid that is transported in bulk, usually in a tanker trailer, pump truck, or rigid tote (cubic large container). A spillage will therefore amount to the fluid being spread across the surface of the ground, sticking to surface matter. Otherwise, ground contamination should be minimal.

Spilled emulsion should be prevented from entering watercourses, drainage systems or flowing onto lower ground by building dykes or dams out of nearby earth or sand. Emulsion will be recovered by using vacuum pumps and air compressors to pump the emulsion into another tanker or holding tanks. Limitations of pump suction are approximately 8 feet, with a pump discharge of approximately 30 feet. Therefore several pumps and additional hose will be required. Small amounts of spilled emulsion may be transferred into a clean plastic container with a plastic shovel. Emulsion may be neutralized (made non-explosive) by mixing it with sand or clay to the point that the mixture is granular (or there are no more globules), or by mixing it with liquid detergent to the point where the mixture is uniformly liquid. The amount/volume of recovered material should be recorded and the replacement containers labeled accordingly, prior to shipping the product to a magazine for quality assessment and disposal. Appropriate safety/environmental clothing (rubber gloves & boots) needs to be worn during the operation. As well, it may be necessary to remove/reclaim contaminated surface soil from the accident scene, sending it by contracted service to a reclamation facility.

(3) Scattering / Spill Of Explosive Material Into Water Body

The environmental effect and emergency response to explosives spilled / scattered into a water body will depend upon the form of explosive involved in the accident. The three forms of explosives are (see ERAP Annex B for explosives characteristics):

- Packaged Products in cardboard containers (sticks/cartridges of explosives, and boosters (Class 1.1D); detonators (Class 1.1B); and detonating cord (Class 1.4*).
- ANFO (Granular) in 25 kg bags or 1000 kg totes (Class 1.5D).
- Bulk Emulsion in pump trucks, tanker trailers or 1000 kg totes (Class 1.5D).

All three forms of explosives will sink in water . The degree of lateral scattering and settling will depend on whether the water is calm or how strong the current is, how large and deep the body of water is, and how long it takes the product to sink due to trapped air within the product container and water turbulence.

Packaged Products:
The greatest concern is to recover and remove packaged products from the water body. While there may be slow and minor leaching of chemical ingredients, the environmental effect should be minimal. If water movement is swift, it will be prudent to locate river-bed barriers downstream to prevent products being moved downstream by the current force of the water. Depending upon water depth, commercial divers may be required to retrieve the packaged product from the water bottom. In turn, retrieved product must be repackaged, loaded into authorized vehicles, and returned to a magazine for salvage or disposal by the ER Team.

ANFO (Granular)
ANFO is a mixture of granular Ammonium Nitrate and Fuel Oil, typically packaged in 25 kg bags or 1000 kg totes. The product is likely to sink quite quickly, however, the 25 kg bags have a fold-over closure mechanism that is not sealed or watertight. Therefore, water will seep into the bags through the closure, or more quickly through rips and tears in the bag. Upon contact with the water, the fuel oil will leach out of the ANFO and rise to the surface, creating an oil slick. At the same time, the AN will dissolve and contaminate the surrounding water body. The degree/extent of water contamination will depend upon the amount of ANFO spilled into the water body and the rate at which the ANFO dissolves (which in turn depends upon whether the water is calm, turbulent, or fast moving; plus if the bag is ripped and/or if the bag closure is opened). Emergency response will consist of (1) addressing the contaminated water and (2) retrieving the ANFO bags.

Surface booms located downstream will help contain an oil slick. In turn, the slick may be removed through the use of absorbent materials, which must be appropriately recovered, stored, transported and disposed of as a Class 4 waste material. Given that the AN contaminated water is not a small body that can be drained or chemically neutralized, response to dissolved Ammonium Nitrate will essentially consist of downstream monitoring, to determine the extent of the AN contamination, the effect on water organisms, and to forewarn water users of the hazard. Retrieval of un-dissolved bags of ANFO and/or empty/partially filled bags may require the assistance of commercial divers. In turn, the product in retrieved bags must be separated from contaminated water in the bags, the 'waste water" collected and stored in suitable containers (eg. settling tanks), the

recovered product repackaged, and both materials returned to authorized storage and disposal facilities by the ER Team and contracted services.

Emulsion:
Emulsion is a thick mayonnaise-like fluid that will sink in water. Constituent chemicals will slowly leach out into the water, and if the water is turbulent or flowing, globules of emulsion will break away from the main deposit and get moved about by the force of the water. As in the case of granulated ANFO, placement of down-stream surface booms and river-bed barriers will capture or restrict the spreading of surface slicks and globules of emulsion moving along the bottom. Generally, chemical contamination of the water will be minimal and localized. Pumps will be required to vacuum the emulsion from a submerged tanker trailer or the riverbed into holding/settling tanks, where the emulsion will be separated from vacuumed waste water. In turn, both materials will require appropriate (bulk) containment and transportation to authorized storage and disposal facilities by the ER Team and contracted services. In each of the three scenarios, an attempt should be made to measure/take an inventory of the recovered material and to account for lost product in subsequent reports.

(5) Hijacking / Theft Of Explosives

The hijacking of an explosives vehicle, or theft of explosives material, must be reported to the Police, DNCI's "on call employee" and Government Authorities as soon as the incident is discovered. While subsequent action by DNCI will be as directed by the Police/Authorities, DNCI will make preparations to provide personnel, vehicles and equipment to help retrieve and transport recovered explosives, if called upon. When the emergency is resolved, take a careful inventory of all recovered material, calculate the amount of missing material and incorporate the information in applicable reports.

(6) Mechanical Breakdown Of Vehicle

In accordance with government regulations, explosives can not be left unattended unless they are stored in a licensed magazine. In the event of a vehicle breakdown, the Driver is to alert the Police (911) of his situation and phone the on-call employee to initiate the ERAP (in this case, the appropriate response will involve organizing a replacement vehicle). Depending upon the circumstances (weather plus distance and time for a replacement vehicle to travel to the disabled truck, etc.), DNCI may have to send a qualified person in advance of the relief vehicle to assist in the safeguarding of the explosives cargo. If necessary, assistance may also be requested of the local police, until Company relief arrives.

(7) Incapacitation Of Driver

Should anyone learn that a Driver has become incapacitated while hauling explosives, they are to (1) immediately advise the Police of the situation and the need to safeguard the explosives in the vehicle, and (2) initiate the ERAP by calling the answering service. (The immediate reaction by the ER Advisor should be to verify/ensure that the Police are safeguarding the explosives (directly or through a third party). As well, in addition to sending a relief Driver by the fastest means available to take charge of the truck, it may be prudent to send an additional vehicle and Driver to help ensure the safe recovery and delivery of the explosives).

II. OTHER DANGEROUS GOODS

(1) Ammonium Nitrate Liquid (Solution) Spill / Release
(Emergency Response Guidebook reference Guide #140.

AN solution is shipped at approximately 200 degrees F. In the event of a spill, eliminate all sources of ignition and dyke the spill with dirt to prevent run-off to water-ways and drainage systems, making sure not to be exposed to the product which can cause serious burns. Prevent the product from mixing with organic material and allow it to cool below 120 degrees F, at which time it will change to a crystalline form. Shovel the crystalline material into non-combustible containers with non-sparking implements and label containers, wearing chemical-protective clothing. Recycle product, if possible; otherwise, dispose of waste according to prevailing environmental regulations / direction.

(2) Ammonium Nitrate Prill Spill / Release
(Emergency Response Guidebook reference Guide #140.

In the event of a spill, eliminate all sources of ignition and dyke the spill with dirt to prevent run-off to water-ways and drainage systems. As well, cover the spilled material with tarpaulins to prevent mixing and run-off in the event of rain or wetting from fire hoses. Prevent the product from mixing with organic material and shovel the material with non-sparking implements into non-combustible containers and label containers. Recycle product, if possible; otherwise, dispose of waste according to prevailing environmental regulations / direction.

(3) Fuel Oil Spill / Release
(Emergency Response Guidebook reference Guide #128.

In the event of a spill, eliminate all sources of ignition and dyke the spill with dirt to prevent run-off to water-ways and drainage systems. If the spill consists of a large amount of pooled liquid, recover the material with a pump and transfer it to an appropriate tank for removal and disposal. If the amount of pooled liquid is small, recover the liquid with an inert absorbent material and transfer the waste material into sealable plastic containers for removal and disposal. Contaminated earth will also require removal via sealable plastic containers. In turn, all waste will be disposed of according to prevailing environmental regulations / direction.

MISCELLANEOUS INFORMATION, GUIDELINES & PROCEDURES

10. EXPLOSIVES CLASSIFICATIONS & CHARACTERISITICS

A list of Dangerous Goods (and their characteristics) transported by or for DNCI is outlined in Annex B.

11. EMERGENCY RESPONSE KITS & MATERIAL

All DNCI worksites will maintain the following emergency response equipment, that is appropriately packaged, stored and easily loaded onto a pick-up truck and / or aircraft for immediate transfer to an accident scene:

I - Spill Recovery Material
1000 ft. of 3 inch fluorescent yellow security tape
3 explosion-proof lanterns / flashlights
1 roll (200 ft.) of 10 mil. clear plastic for ground or product cover
3 "explosives" signs plus assorted 1.1 / 1.5 "placards and labels"
4 polyethylene / non-ferrous 45 gal. drums with removable lids
1 doz. large heavy duty garbage bags (to line drums and for trash)
3 non-ferrous shovels
1 spill kit containing 1 - 25 lb. bag of granular absorbent material
30 ft. of 5 in. sorbent booms
10 ft of 3 in. sorbent socks
1 case of sorbent pads
1 - 3 ft. x 3 ft. neoprene sheet (drain seal)
6 heavy-duty cardboard boxes for repackaging broken boxes
2 rolls of 3" duct tape
2 rolls of 3" packing tape
1 push broom
6 blank (TDG) shipping documents

II – Personal Protective Equipment
6 reflective safety vests
6 safety "goggles"
6 particulate respirators (dust masks)
1 doz. disposable ear plugs
6 pr. nitrile gloves
6 pr. cotton gloves
Industrial First Aid Kit

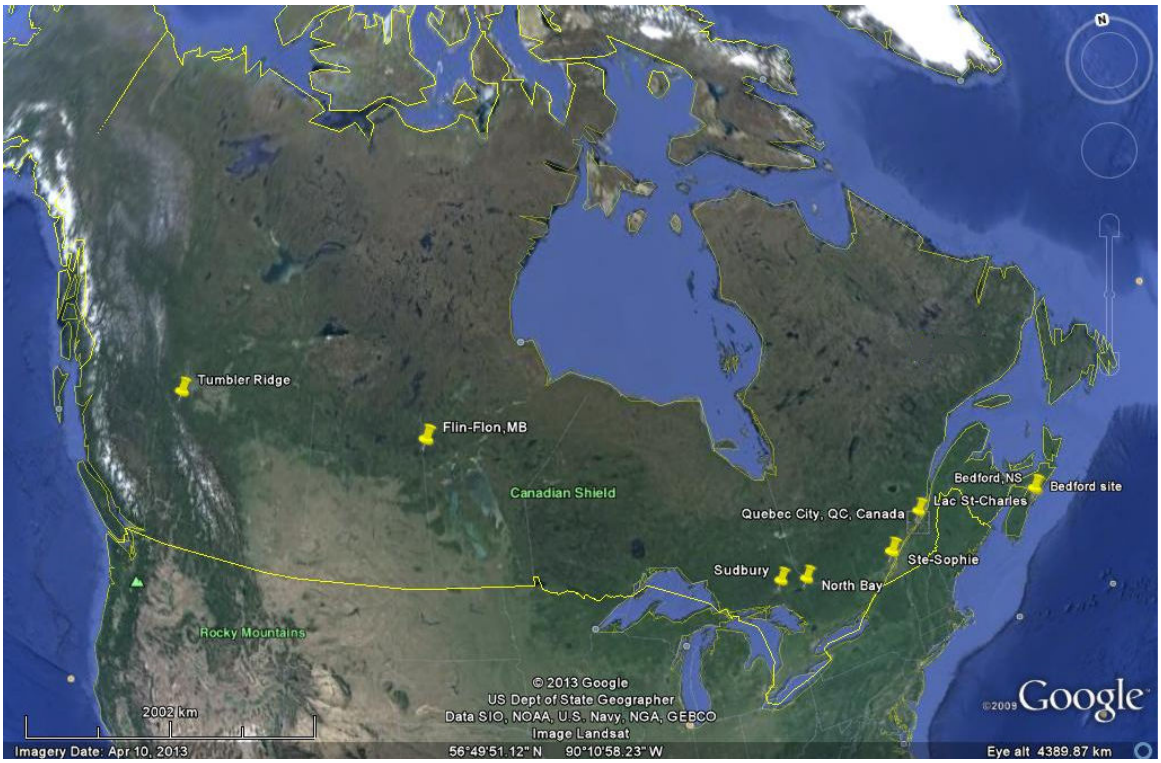
(Note: all DNCI Emergency Responders must wear CSA approved protective footwear and Type II (lateral protection) hard hats when on the job. As well, a camera should be readily available to photograph the scene of an accident and remedial measures for inclusion in the accident investigation report).

An inventory list of the emergency response kit/material will be kept with the cache, which must be inspected quarterly, to ensure the contents are present and in good working order (note: Emergency response kit cache may be witness/lock-wired closed, in which case only an annual verification that the contents are present and in good working order is necessary, so long as the witness/lock-wire is present and unbroken).

List of sites with bulk emulsion spill handling capabilities

The following DNCI Worksites (see pointers on image) should maintain or have timely access to the following equipment and material:

Site	Province
Tumbler Ridge	BC
North Bay	ON
Sudbury	ON
Flin Flon	MB
Ste-Sophie	QC
Quebec	QC
Bedford	Nova Scotia



- Either a back-up emulsion tanker,
  pump/mix truck(s) or several (3 or more) emulsion tote bins
- 2 air compressors and 200 ft. of 1 in. hose
- 3 diaphragm pumps with 100 ft of 3 in. hose and camlock couplers
- Emergency lighting

12. CONTRACT / SUPPLEMENTARY SERVICES

Depending upon the complexity and severity of an incident, DNCI may have to contract the services of third parties for ERAP assistance. As well, DNCI has agreed to provide ERAP assistance to several customers and associates. The names and phone numbers of third parties who have a standing agreement with DNCI for mutual ERAP assistance are identified in the workplace appendices.

DNCI has standing agreements with the following emergency response services:

National (Cross Canada)
NEWALTA (PSC) INDUSTRIAL SERVICES INC.
North American Spill Line
1-800-567-7455
Administration (Stoney Creek, ON.)
1-888-737-2911

13. HAZARD ANALYSIS CHECKLIST

Packaged Explosives

RISK	ACCIDENT SCENARIOS	CONSEQUENCES OF ACCIDENT	ACTION AT SCENE	BY WHOM
Low/modest frequency, Low consequences	SIMPLE MOTOR VEHICLE, RAILWAY, AIRCRAFT OR MARINE ACCIDENT, NO SCATTERED EXPLOSIVE	* POSSIBLE INJURIES OR DEATH FROM ACCIDENT	* MEDICAL ATTENTION	FIRST RESPONDERS
		* POSSIBLE TRAFFIC DISRUPTION	* DETOUR/HALT VEHICULAR, RAILWAY OR AIR TRAFFIC	DRIVER / RAILROAD REP. / AIRCREW / AIRPORT AUTHORITY / OSC
		* QUESTIONS RE PACKAGING	* PROVISION OF INFORMATION RE: PACKAGING OF EXPLOSIVES	ERA / OSC
		* PERCEIVED RISKS BY FIRST RESPONDERS FROM EXPLOSIVE	* ADVICE TO FIRST RESPONDERS REGARDING TRUE HAZARDS	ERA
		* POTENTIAL FOR THEFT	* CONSTANT SECURITY PROTECTION AGAINST THEFT	POLICE / OSC / ERA / ERT
			* TRANSFER LOAD OF EXPLOSIVE TO OPERATIONAL VEHICLE FOR SAFE AND LEGAL TRANSPORT	OSC / ERA / ERT
Consequences increase as accident escalates	MOTOR VEHICLE, RAILWAY ,AIRCRAFT OR MARINE ACCIDENT WITH SCATTERED EXPLOSIVES	* POSSIBLE INJURIES OR DEATH FROM ACCIDENT	* MEDICAL ATTENTION	FIRST RESPONDERS
		* INCREASED RISK TO PUBLIC SAFETY FROM SCATTERED EXPLOSIVES	* POSSIBLE EVACUATION ORDER BY CIVIL AUTHORITIES	ERA / OSC
		* QUESTIONS RE PACKAGING	* PROVISION OF INFORMATION RE: PACKAGING OF EXPLOSIVES	ERA / OSC
		* POTENTIAL FOR THEFT	* CONSTANT SECURITY PROTECT AGAINST THEFT	ERA / OSC / ERT
		* POSSIBLE EVACUATION	* ADVICE TO FIRST RESPONDERS REGARDING TRUE HAZARDS	ERA / OSC
		* TRAFFIC AND COMMERCE DISRUPTED UNTIL EXPLOSIVES PICKED UP AND REMOVED	* RECOVER SCATTERED EXPLOSIVES * SEARCH * LOCATE * INSPECT * ANALYZE DAMAGED EXPLOSIVES * RECOVER * REPACKAGE AND SHIP * DISPOSE IF NECESSARY	OSC / ERA / ERT

13. HAZARD ANALYSIS CHECKLIST

RISK	ACCIDENT SCENARIOS	CONSEQUENCES OF ACCIDEN	ACTION AT SCENE	BY WHOM
Low frequency with potentially severe consequences	MOTOR VEHICLE, RAILWAY, AIRCRAFT OR MARINE ACCIDENT WITH FIRE BUT NO DETONATION	* POSSIBLE INJURIES OR DEATI FROM ACCIDENT	* MEDICAL ATTENTION	First Responders
		* FIRE	* FIRE SUPPRESSION	First Responders/ Driver / Railway Representative / Aircrew / Airport Authority
		* EVACUATION OF HAZARD ZONE WELL BEYOND TRANSPORTATION CORRIDOR IMPLEMENTED	* EVACUATION ORDERED BY CIVIL AUTHORITIES	ERA
		* TRAFFIC AND COMMERCE DISRUPTED UNTIL THREAT OF DETONATION ELIMINATED	* TRAFFIC HALTED/DETOURED BUSINESSES CLOSE AND PEOPLE LEAVE HOMES	First Responders/ Driver / Railway Representative / Aircrew / Airport Authority / OSC
		* QUESTIONS RE PACKAGING	* PROVISION OF INFORMATION RE: PACKAGING OF EXPLOSIVES	ERA/OSC
		* POTENTIAL FOR THEFT	CONSTANT SECURITY PROTECTION AGAINST THEFT	ERA/OSC/ERT
		* SIGNIFICANT RISK TO PUBLIC SAFETY, POSSIBLE EVACUAT	* ADVICE TO FIRST RESPONDERS REGARDING HAZARDS, FIR FIGHTING OPTIONS AND ZONE LIMITS FOR EVACUATION	ERA/OSC
		* TRAFFIC AND COMMERCE DISRUPTED UNTIL EXPLOSIV PICKED UP AND REMOVED (I APPLICABLE)	* RECOVER SCATTERED EXPLOSIVES (SEARCH, LOCATE, INSPECT, ANALYZE DAMAGED EXPLOSIVES, RECOVER REPACKAGE AND SHIP, DISPOSE IF NECESSARY	OSC / ERA / ERT
Low frequency Severe consequences	MOTOR VEHICLE, RAILWAY , AIRCRAFT OR MARINE ACCIDENT WITH FIRE AND DETONATION	* INJURIES AND DEATH FROM FROM MVA AND FROM DETONATION	* MEDICAL ASSISTANCE	First responders
		* FIRES FROM DETONATION	* FIRE SUPPRESSION	First Responders
		* MAJOR DISRUPTION TO TRAFFIC AND COMMERCE	* TRAFFIC HALTED/DETOURED AND BUSINESSES FORCED CLOSED	First Responders/ Driver / Railway Representative / Aircrew / Airport Authority / OSC
		* PROPERTY DAMAGE POTENTIALLY VERY SIGNIFICANT	* PEOPLE'S HOMES NOT HABITABLE ARRANGE ALTERNATIVE HOUSING	Civil Authorities
		* HIGHEST RISK TO PUBLIC SAFETY, POSSIBLE EVACUATION	* ADVICE TO FIRST RESPONDERS REGARDING HAZARDS, FIRE FIGHTING OPTIONS AND ZONE LIMITS FOR EVACUATION	ERA / OSC
		* QUESTIONS RE PACKAGING	* PROVISION OF INFORMATION RE: PACKAGING OF EXPLOSIVES	ERA/OSC
		* POTENTIAL FOR THEFT	* CONSTANT SECURITY PROTECTION AGAINST THEFT IF APPLICABLE	Police/ERA/OSC/ ERT
		* TRAFFIC AND COMMERCE DISRUPTED UNTIL EXPLOSIV PICKED UP AND REMOVED (I APPLICABLE)	* RECOVER SCATTERED EXPLOSIVES IF APPLICABLE (SEARCH, (LOCATE, INSPECT,ANALYZE DAMAGED EXPLOSIVES,	OSC/ERA/ERT

			RECOVER, REPACKAGE AND SHIP, DISPOSE IF NECESSARY	
		* PUBLIC DEMAND FOR INQUIRY	* MAJOR ACCIDENT INVESTIGATION	Civil Authorities / HSE / DNCI MGT

13. HAZARD ANALYSIS CHECKLIST

Bulk Explosives

RISK	ACCIDENT SCENARIOS	CONSEQUENCES OF ACCIDENT	ACTION AT SCENE	BY WHOM
Low/modest frequency, Low consequences	* Vehicle / railroad car / Marine ship involved in a minor incident / accident	* Possible injuries or death from accident	* Medical Attention	First Responders
	*The tank / trailer / container is upright and appears undamaged.	* Possible traffic disruption	* Detour / Halt traffic	First Responders/ Driver / Railway Representative / OSC
	* No leak detected	* Questions regarding container integrity	* Provision of information regarding inspection of container	ERA/OSC/ Carrier Representative
		* Perceived risks by First Responders from explosives	* Advice to First Responders regarding true hazards	ERA/OSC
		* Potential for leak	* Conduct damage assessment	OSC/Carrier Representative
		* Vehicle damaged, unsafe to transport container / IBC	* Conduct product transfer to an approved tanker/container/vehicle to provide safe and legal transport if container/tanker deemed unsafe.	OSC/Carrier Representative/ ERT
Low/modest frequency, Modest consequences	* Vehicle / railway car/ Marine ship involved in an accident	* Possible injuries or death from accident.	* Medical Attention	First Responders
	* Truck / container are off the road / rail on its side	* Possible traffic disruption	* Detour / Halt traffic	First Responders/ Driver / Railway Representative / OSC
	* Valves accessible & operable	* Questions regarding container integrity	* Provision of information regarding inspection of container	OSC / Carrier Representative
	* Truck / tanker / container appear undamaged	* Perceived risks by First Responders from explosives	* Advice to First Responders regarding true hazards	ERA / OSC
		* Potential for leak	* Conduct damage assessment	OSC / Carrier Representative
		* Increased Risk to public / environment from potential spill of product	* Possible evacuation ordered by Civil Authorities. Contain spilled product to immediate area	OSC / ERA
		* Potential of theft	* Constant security protection against theft	Police / ERA / OSC / ERT
		* Questions re cleanup if spill occurs during transfer	* Provision of information regarding recovery of spilled product due to transfer and conduct transfer to an approved container to provide safe and legal transport	OSC / ERA / ERT/ Environment Contractor

13. HAZARD ANALYSIS CHECKLIST

RISK	ACCIDENT SCENARIOS	CONSEQUENCES OF ACCIDEN	ACTION AT SCENE	BY WHOM
Low/modest frequency, Modest to severe consequences	* Vehicle / rail car / Marine ship involved in an accident	* Possible injuries or death from accident	* Medical Attention	First Responders
	* Truck / container are off the road / rail on its side	* Possible traffic disruption	* Detour / Halt traffic	First Responders/ Driver / Railway Representative / OSC
	* Valves are NOT accessible or operable and the truck / container cannot be uprighted	* Questions regarding container integrity	* Provision of information regarding inspection of container	OSC/Carrier Representative
		* Perceived risks by First Responders from explosives	* Advice to First Responders regarding true hazards	ERA/OSC
		* Increased Risk to public / environment from potential leak during the transfer of product	* Possible evacuation ordered by Civil authorities. Prepare containment of spilled product in the immediate area	OSC/ERA
		* Potential of theft	* Constant security protection against theft	Police / ERA/OSC
		* Questions re cleanup if spill occurs during transfer	* Provision of information regarding of spilled product due to transfer.	ERA/OSC
			* Conduct transfer to an approved container to provide safe and legal transport	OSC/ ERT / Emergency Response Contractor
			* Conduct cleanup and decontamination of area affected and dispose of all waste	OSC/ ERT / Emergency Response Contractor
Low/modest frequency, Severe consequences	* Vehicle / rail car / marine ship involved in accident	* Possible injuries or death.	* Medical Attention	First Responders
	* Truck / container are off the road / rail on its side	* Possible traffic disruption	* Detour / Halt traffic	First Responders/ Driver / Railway Representative / OSC
	* Catastrophic failure of container and product spilled .	* Perceived risks by First Responders from explosives	* Advice to First Responders regarding true hazards	ERA/OSC
		* Increased Risk to public / environment from product leak	* Possible evacuation ordered by Civil authorities. Contain spilled product and monitor any spill beyond immediate area	OSC/ ERT/ Emergency Response Contractor
		* Media attention	* Provide trained media relations	DNCI Regional Manager
		* Potential of theft	* Constant security protection against theft	Police / ERA/OSC/ ERT
		* Questions re cleanup and transfer	* Provision of information regarding recovery of spilled product	OSC/ ERT/ Emergency Response Contractor.
			* Conduct transfer to an approved container to provide safe and legal transport	OSC/ERT/Emergency Response Contractor
			* Conduct cleanup and decontamination of area and dispose of all waste	OSC/ERT/ Environmental Contractor

14. EVACUATION PROCEDURES

Along public highways or within municipalities, advise the first emergency responders at the scene (police or fire) of the need to evacuate using the guidance in the Emergency Response Assistance Plan. It is the responsibility of municipal authorities to initiate such action but it is vitally important they understand the circumstances and take the appropriate evacuation actions if there is danger of a detonation. Employees at the scene should assist local emergency services to the best of their ability to accomplish this. However, if action is immediately required and there are no emergency services on scene, enlist the help of other motorists to prevent access into the hazard zone until such time as the fire department or police arrive. For incidents within a worksite such as a mine, quarry or construction operation, in most cases access is radio controlled. The quickest way of alerting people, therefore, is by site radio. Clearly state your location, situation and call for assistance in evacuating the area.

DO NOT FIGHT EXPLOSIVES FIRES. EVACUATE THE AREA AND LET THE FIRE BURN ITSELF OUT.

THE MINIMUM EVACUATION DISTANCE IS AS OUTLINED IN TABLE 9-1 (Pg. 21) FOR ALL DIRECTIONS (which is based on a higher traffic / risk / population density within the area, without benefit of protective features such as berms and hills. Distances may be extended to a minimum of 1,600 meters for situations that involve high risk surroundings).

15. INITIAL ON SITE RISK ASSESSMENT

In order to assure the highest level of safety at the scene of an accident the Truck Driver, Aircraft Crew Member, Railroad Representative, First Responder or Emergency Response Advisor (ERA) should follow this checklist before commencing any cleanup procedures.

ALWAYS ASSESS / APPROACH A SCENE FROM UPWIND

- Check for injuries and account for personnel involved in the accident (drivers and helpers, aircrew, train crew, third-party personnel)
- Determine probability of fire or chance of fire. Shut off electrical systems (disconnect batteries and auxiliary equipment if possible). Eliminate all sources of ignition.
- Determine the severity of the situation and order the evacuation of the scene if necessary.
- Assess the area for immediate safety and environmental risks and hazards such as equipment stability, downed power lines, evidence of smoke or fumes, potential for product or waste water from fire hoses to run downhill into a drainage system or enter a nearby water body.
- Alert and assemble a DNCI Emergency Response Team (ERT).
- Establish work zones or personnel exclusion zones.
- Consider Wind, Temperature, Precipitation (what's the weather forecast? – *it may have an effect on handling conditions*)
- Consider traffic control, site access, and proximity to public. (*defer to police as soon as they arrive)*
- Implement containment procedures if safe to do so. Stop flow of spilled material.
- Assess equipment requirement (transfer pumps, compressor, hoses, non-sparking tools, lighting, packaging, containment booms).
- Consider ERT requirements (food & fluids, warm up area, accommodation, etc).

- Consider safety equipment (rubber gloves, rubber boots, coveralls, hardhats, eye protection, dust masks, etc. – see ERAP section 11 pg. 27.
- Consider outside sources of aid, such as technical consultants, spill recovery specialists, transportation requirements, special equipment, etc.

16. ESTABLISHMENT OF WORK ZONES

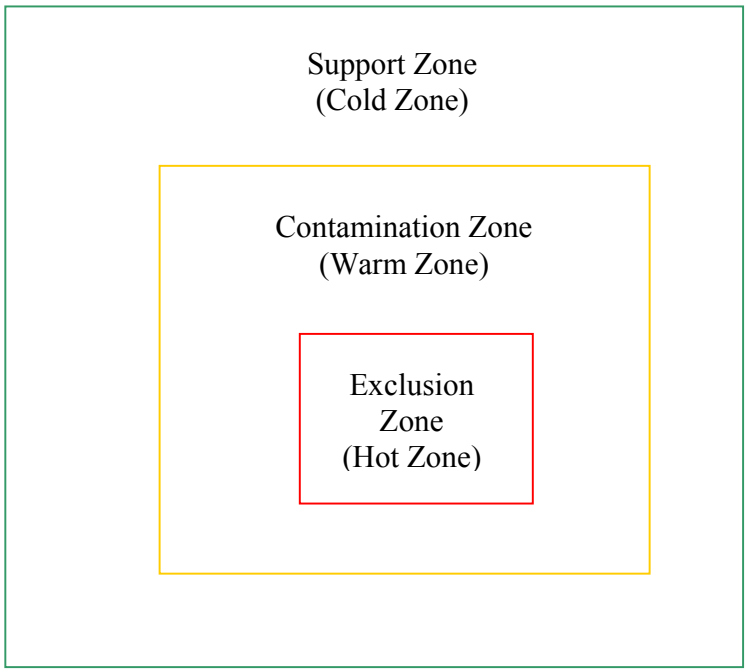
In instances where high risk factors have been identified by the On Scene Coordinator (OSC) during his initial assessment, he will need to establish work zones to provide the highest level of safety for response personnel and the public, as follows:

Exclusion Zone/Hot Zone
This is the zone posing the highest hazard. This area is to be cordoned off using "Caution" tape, to keep response workers out of this area. This zone may require specialized equipment or tasks assigned to specially trained or designated personnel.

Contamination Zone/Warm Zone
This is the zone where containment, cleanup and repackaging activities will be conducted. This area will be contaminated with explosives or ingredients and only people that are trained in the handling of those products will be allowed access. Protective equipment is necessary in this zone such as rubber gloves, rubber boots and eye protection. Only non-sparking tools are to be used in this zone.

Support Zone/Cold Zone
This is the zone where no contaminants are present and must remain so.
No protective equipment is necessary. This is the area where a command post could be established for communications, storage of special equipment, rest & food area and other such functions. Operations within the support zone should always be upwind of the incident scene.

Establishment of Work Zones



17. GUIDELINES FOR THE RECOVERY OF "BULK" EXPLOSIVES AND OTHER MATERIALS

The hauling of bulk explosives and explosives feedstock is most frequently carried out by contract trucking firms. However, DNCI also hauls bulk explosives in company pump trucks and cargo trailers and vans. **Because every accident scene and situation is different the following information will serve as a guideline for recovery crews.**

17.1 GUIDELINES FOR RECOVERY OF AMMONIUM NITRATE PRILL

Ammonium Nitrate Prill when mixed with any organic material such as fuel, oil, sawdust, coal dust etc. becomes an explosive product. Ammonium Nitrate Prill is extremely soluble in water and extremely toxic to fish.

Ammonium Nitrate in prilled (pelletized) form is commonly transported on public highways in bulk (grain-type) carriers, end dump trucks, one metric tonne fabric totes and 25 Kg. plastic bags. It is also transported in pump/mix trucks

Containment.
The single most important task in containing Ammonium Nitrate prill is to keep spilled fuel or any other organic material from mixing with the prill, and keeping it dry. Oil absorbent pads or Floor Dry type materials must be used to control and soak up spilled fuel and oil at the site. Fuel and oil sources can be from leaking tractor fuel tanks, power train components and in the case of pump/mix trucks, from the fuel mix tank.

Barricades of earth or sand should be used to dam/isolate fuel and other organic material, thereby preventing it from mixing with spilled AN prill. As well, the spilled AN prill should be covered with plastic to stop rain or water from dissolving the product, and dammed to prevent any run-off to adjacent drainage system or water way.

Recovery of Product.
Ammonium Nitrate prill is easily handled using non-sparking shovels and brooms. In the case of large spills front-end loaders can be used to load the material into an alternate means of transportation such as an end dump truck. Fabric totes may also be suitable as temporary packaging for transport to the disposal site.

Final cleanup of equipment and ground is carried out with brooms and approved vacuum cleaners. If water is used as a fire deterrent, it is to be kept to a minimum and every effort needs to be made to contain and collect the resulting solution.

The shipping document will indicate how much product is to be recovered, and will be valuable for shipments of Totes or 25 Kg bags. It is unlikely that 100% of the material will be recovered, however, an attempt should be made to estimate the amount of lost product.

Product Disposal and Environmental Remediation
Recovered AN prill that is contaminated with dirt and/or organic material will be loaded in boreholes and detonated or burned. In the event of a major spill, an environmental contractor should be hired to assess the level/degree of ground contamination and to make recommendations for remediation and disposal of contaminated soil.

17.2 GUIDELINES FOR RECOVERY OF BULK EMULSION EXPLOSIVES

Bulk emulsion is an explosive product. All caution must be taken to eliminate heat, impact or friction when working with this material.

Bulk emulsion explosives are transported on public roads by highway tanker (class MC 307 or MC 407) in quantities of around 20 metric tones, or in lesser quantities of around 10 metric tonnes in specialized pump/mix trucks.

Product Rheology
The rheology of bulk emulsion is such that when spilled it will not easily run or soak into the ground, and it is not water soluble. Therefore, containment of a bulk emulsion spill is simply achieved by containing it with a dyke or dam of sand or dirt.

Method of Recovery
The recovery of bulk emulsion explosives will vary depending on the severity of the accident, condition of the tanker and site conditions. Crews should consider up righting an overturned tanker first to stop further spillage if safe to do so. This may involve the recovery of some of the product from the overturned tanker first either through the valve system, hatch or exposure created through damage to the trailer. In extreme situations where no access to the product is available through the valve system or hatch, an opening may have to be created near the highest point in the damaged tanker using a hand-powered (manual) metal cutting hacksaw through which a hose can be inserted to pump the emulsion product from the tanker with a DNCI approved air operated diaphragm pump and hoses. The majority of spilled emulsion explosives will be cleaned up using a diaphragm pump. Such pumps are safe and efficient for the transfer of emulsion products, as they are air driven (requiring an air compressor of at least 100 CFM).

Location of Backup Equipment.
DNCI worksites listed in page 27 should maintain a list of sources where emergency back-up equipment can be obtained in short notice, should it be necessary to offload emulsion from one vehicle to another. Back-up equipment is to include:

- An approved tanker, vacuum pump truck(s), pump/mix truck(s) or emulsion tote tanks
- Air Compressor (of at least 100 CFM) and 1 inch hoses (at least 200 feet) to drive (diaphragm) pumps with 3" inlet/outlet.
- 3" (diaphragm) air driven pumps
- 100 feet of 3 inch hose with camlocks
- emergency lighting
- Other equipment as outlined in section 11, pg. 27-29.

Emergency / backup equipment may be sourced from:

- The trucking contractor's inventory
- DNCI's worksite inventory
- Customer's inventory (eg. the mine site receiving the emulsion deliveries)
- Commercial services/rentals

Recovery of Product.
Only clean emulsion product should be sucked up using the diaphragm pump, transferring the material to the backup vehicle/container. To transfer the emulsion:

- Position plastic/tarps under areas where there is the potential to leak, to collect product during transfer process
- Bond and ground disabled and recovery vehicles/containers
- Position diaphragm pump near the disabled vehicle, connect pump inlet hose to disabled vehicle's outlet, or place hose inside tank (to be emptied) through the hatch.
- Connect hose to outlet of pump and inlet of receiving vehicle/container or use top hatch.
- Connect compressor air line to diaphragm pump and start transfer slowly at first, increasing pump flow after a visual check for any leaks is complete.
- Squeegee all products possible from the damaged vehicle.
- Remove tarps and decontaminate any spilled emulsion with liquid detergent
- Transport disabled vehicle to worksite for complete decontamination of residual emulsion, before releasing vehicle for repair/scrap.

Contaminated emulsion product will be cleaned up using non-sparking scoop shovels and placed in non-sparking containers such as plastic garbage cans, plastic totes or garbage bags that can be properly marked for transport to a disposal site. *The use of garbage bags (clear if available) is the preferred method for gathering spilled product as they are easily dropped down a borehole for destruction.*

- Clean up spilled product and contaminated soil and place in buckets or drums.
- Decontaminate surfaces (black top, pavement) that cannot be removed by removing as much as possible with non-sparking shovel, then spread sand or clay on the spill, brush with a broom and collect waste in buckets or drums for return to the worksite for disposal.
- Label all containers **For Salvage – Explosives, Blasting, Type E, UN 0332, hazard label and markings, N.O.S.** per NRCan (use felt pen)

Product Disposal and Environmental Remediation
Contaminated emulsion will be loaded in boreholes and detonated or burned. In the event of a major spill, an environmental contractor should be hired to assess the level/degree of ground contamination and to make recommendations for remediation and disposal of any contaminated soil.

Assessment of Disabled Vehicles
DNCI's trucking contractors will normally be requested to provide their expertise in assessing damage and roadworthiness for their disabled tanker trailers and hauling equipment. This assessment will require a trucking representative to travel to the site before the damaged unit is moved on the road. Similarly, DNCI will normally arrange for a qualified mechanic to assess a disabled Company vehicle for road-worthiness, prior to allowing it back on the road. In the event that a vehicle is assessed as not being roadworthy, the unit will be placed on a trailer and moved to a site where it can be decontaminated prior to being repaired.

17.3. PROCEDURE FOR TRANSFERRING EMULSION TO ANOTHER TANKER (TRAILER UPRIGHT, NO DAMAGE)

17.3.1. Position tarp(s) under hatches or leaking areas to collect product escaping from trailer
17.3.2. Bond and ground tanker
17.3.3. Position diaphragm pumps near the trailer, connect loading hose to damaged tanker outlet and to inlet of pump. Secure with whip checks to avoid injury.
17.3.4. Connect hose to outlet of pump and inlet of spare trailer
17.3.5. Connect compressor air line to diaphragm pump and start transfer
17.3.6. Squeegee all product possible from the damaged tanker (DO NOT ENTER TANKER)
17.3.7. Clean all loose product from the damaged tanker area on trailer and collect in suitable containers (plastic buckets, etc…). Label containers as **For Salvage, Product Name, UN #, hazard label and markings, N.O.S.** per NRCan (use felt pen)
17.3.8. Collect all loose product on tarp and place in buckets
17.3.9. Clean all loose product on the ground with plastic shovel; collect all contaminated soil and place in buckets or drums.
Ship scrap to a DNCI plant site for treatment.

17.4. PROCEDURE FOR TRANSFERRING EMULSION TO ANOTHER TANKER (TRAILER ON SIDE, VALVES NOT OPERABLE OR ACCESSIBLE)

17.4.1. If trailer can be uprighted and valve can be operated, follow procedure 1 above
17.4.2. If trailer can be uprighted and the valve is not operable
17.4.3. Upright trailer
17.4.4. Bond and ground tanker
17.4.5. Insert loading hose from Wilden pump through hatch into emulsion
17.4.6. Connect compressor air line to diaphragm pump and start transfer to second tanker
17.4.7. Wipe all loose product from damaged areas of the trailer and collect in buckets
17.4.8. Collect all loose product on the ground wit plastic shovel and collect all contaminated soil and place in buckets
17.4.9. Label containers as **For Salvage, Product Name, UN #, hazard label and markings, N.O.S.** per NRCan (use felt pen)
17.4.10. Ship scrap to a DNCI plant for treatment.

17.5. PROCEDURE FOR TRANSFERRING EMULSION TO ANOTHER TANKER (TRUCK ON ITS SIDE, HATCH/VALVES NOT ACCESSIBLE OR NOT OPERABLE/CANNOT BE UPRIGHTED)- LAST RESORT PROCEDURE.

17.5.1. Position tarps under hatches or leaking area to collect as much product escaping from the trailer as possible
17.5.2. Bond and ground tanker
17.5.3. Under DNCI supervision, create an opening near the highest point in the damaged tanker using a hand-powered (manual) metal cutting hacksaw through which a hose can be inserted to pump the emulsion product from the tanker with a DNCI approved air operated diaphragm pump and hoses. If another hole must be subsequently cut to permit pumping of the emulsion (as in the case of the emulsion level too far from the hole for the pump to lift the emulsion), use this first hole as an inspection and measuring port so another access hole can be cut *above* the emulsion level in the tanker using the same hacksaw technique as above. Do not cut into the tanker *below* the emulsion level in the tank. Note that a hacksaw with the blade flush with its frame bottom will work best to penetrate the tank and a one-handed (or one-ended) hacksaw can then be used to finish the cut to make a hole in the tanker. Cutting first on the tanker curve or at the tanker ends on the curves with several new hacksaw blades could make the cutting process easier."
17.5.4. Place hose in hole and siphon remaining emulsion with the Wilden pump into another tanker or IBC's
17.5.5. Wipe all loose product from damaged areas of the trailer and collect in buckets
17.5.6. Collect all loose product on the ground wit plastic shovel and collect all contaminated soil and place in buckets
17.5.7. Label containers as **For Salvage, Product Name, UN #, hazard label and markings, N.O.S.** per NRCan (use felt pen)
17.5.8. Ship scrap to a DNCI plant for treatment.

ANNEX A To DNCI's ERAP 2-1037

Location of DNCI Factories (that are staffed by DNCI Employees/Reps)
(NRCan License Legend: F – Factory (manufacturing &/or bulk storage);

Northwest Territory & Nunavut *(remote sites with "restricted / controlled access" via winter ice road or air travel)*

Ekati Diamond Mine NT (F)
Diavik Diamond Mine NT (F)
Meadowbank NU (Baker Lake – Agnico-Eagle)(F)

British Columbia & Yukon Region

Nanaimo BC (F)
Texada Island BC (F)
Tumbler Ridge BC (F)
Minto Mine YT. (F)

Alberta, Saskatchewan & Northwest Territory
Rockyford AB (F)
Yellowknife NT (Office)
Calgary (Head Office)

Manitoba & NW Ontario (Central Canada)
Flin-Flon MB (F)
Balmertown ON (F)

Ontario
Garson/Sudbury ON (F)
Hagersville ON (F)
North Bay ON (F)
Timmins ON (F)
Lac Des Iles (F)
Red Lake ON (F)

Quebec
Lac-St-Charles QC (F)
Ormstown QC (F)
Ste-Sophie QC (F)
Val D'Or (F)

Maritimes
Fredericton NB (F)
Bedford NS (F)

ANNEX B To DNCI's ERAP 2-1037

(1) Dangerous Goods That DNCI Transports Throughout Canada and/or Imports From The USA.

Primary Responder	UN No	Shipping Name	Class	MODE OF TRANSPORTATION		
				ROAD	RAIL	AIR
		EXPLOSIVES				
DYNO	UN0029	Detonators, Non-Electric	**1.1B**	X		
DYNO	UN0030	Detonators, Electric	1.1B	X		
DYNO	UN0042	Boosters	1.1D	X		X
DYNO	UN0059	Charges, Shaped	1.1D	X		
DYNO	UN0065	Cord, Detonating	1.1D	X		X
DYNO	UN0066	Cord, Ignitor	1.4G	X		
DYNO	UN0081	Explosive, Blasting, Type A	1.1D	X	X	X
DYNO	UN0131	Lighters, Fuse	1.4S	X		
DYNO	UN0209	Trinitrotoluene	1.1D	X		
DYNO	UN0241	Explosive, Blasting, Type E	1.1D	X	X	X
DYNO	UN0255	Detonators, Electric	1.4B	X	X	X
DYNO	UN0267	Detonators, Non-Electric	1.4B	X		
DYNO	UN0289	Cord, Detonating	1.4D	X		
DYNO	UN0331	Explosive, Blasting, Type B	1.5D	X		
DYNO	UN0332	Explosive, Blasting, Type E	1.5D	X	X	X
DYNO	UN0349	Articles, Explosive N.O.S. (Shock Tube)	1.4S	X		
DYNO	UN0360	Detonator Assemblies, Non-Electric	1.1B	X	X	X
DYNO	UN0361	Detonator Assemblies, Non-Electric	1.4B	X		X
DYNO	UN0373	Signal Devices, Hand	1.4S	X		
DYNO	UN0456	Detonators, Electric	1.4S	X		X
DYNO	UN0463	Articles, Explosive, N.O.S.	1.1D	X		
DYNO	UN0482	Substance, Explosive, Very Insensitive NOS	1.5D	X		
DYNO	UN0500	Detonator Assemblies, Non-Electric	1.4S	X		
		OTHER				
EC	UN1498	Sodium Nitrate	5.1	X		
EC	UN1500	Sodium Nitrite	5.1	X		
EC	UN1942	Ammonium Nitrate	5.1	X	X	X
EC	UN2067	Ammonium Nitrate Fertilizers	5.1	X		
EC	UN2426	Ammonium Nitrate, Liquid	5.1	X		

EC = Emergency Contractor

(2) Divisions & Compatibility Groups Of Explosives
(Explosives are categorized as "Class 1" Dangerous Goods; and subdivided into 6 Divisions)

Class . **Division**
Class 1.**1** – **Mass Explosion Hazard**
Class 1.**2** – Projection Hazard (but not a mass explosion hazard)
Class 1.**3** – Fire Hazard and either a Minor Blast Hazard or Minor Projection Hazard (but not a mass Explosion hazard)
Class 1.**4** – No significant hazard beyond the package in the event of ignition or initiation
Class 1.**5** – Very Insensitive Substance with **Mass Explosion Hazard**
Class 1.**6** – Extremely insensitive article with no mass explosion hazard

Compatibility Group
B – Substances which are expected to explode or detonate en masse very soon after fire reaches them.
D – Substances which may explode en masse accompanied by a blast and fragment hazard, but may be exposed to fire for some time before exploding.
S – Packaged substances that, if accidentally initiated, produce effects that are usually confined to the immediate vicinity.

(3) Properties Of Explosives
IMPORTANT: Class 1.1 and 1.5 explosives will burn and may detonate en masse at any time. (Class 1.1 and 1.5 essentially cover all the explosives used by DNCI)

Class1.1B Detonators
Dyno Nobel Products: Electric Seismic Detonators, Non-electric, Electronic, Safety Fuse Assemblies, and MS Connectors

Packaging: Cardboard boxes, plastic bags

Hazards: **Explosion with Shrapnel**
Although blasting caps are carried in small quantities in separate and confined areas, they are capable of explosion from heat, concussion, abrasion, and lightning. When detonated, the danger of flying metal fragments is very likely.
Toxic Fumes
Burning may produce irritating, corrosive and/or poisonous gases.
Scattered / Spilled Material
Clear area of personnel and wait for assistance from trained personnel before handling or removing detonators.
Water Contamination
Usually a minor problem. Containing and retrieving packages from water body is an important requirement for public safety and security reasons.

Class1.1D Cap Sensitive Explosives

Dyno Nobel Products: Unigel, Unimax, Dynomax, Dynosplit, Dyno AP, Dyno SL, Blastex, Vibrogel, Trojan Geoprime.

Packaging: Waxed paper or plastic tubes/cartridges, chubs or coil packed in heavy cardboard boxes.

Hazards: **Explosion**
This is the most important concern because of the possibility of a major detonation. Detonation could be triggered by heat, impact or lightning.

Hazards: **Toxic Fumes**
Burning explosives give off toxic fumes (irritating, corrosive &/or poisonous gases). The area should be evacuated before this is a problem.
Scattered / Spilled Material
Clear area of personnel and wait for assistance from trained personnel before handling or removing explosive material.

Water Contamination
Usually water contamination is a very minor problem with Class 1.1D material. Containing and retrieving explosives packages from the water body is an important requirement for public safety and security reasons

First Aid: Remove contaminated clothing and shoes immediately.
In case of contact with material, immediately flush skin or eyes with running water for at least 15 minutes.
Obtain immediate medical attention. Ensure that attending medical personnel are aware of identity and nature of product(s) involved, and that they take precautions to protect themselves.

Dyno Nobel Products: Boosters

Packaging: Paper or plastic tubes/cartridges, packed in heavy cardboard boxes.

Hazards: **Explosion**
This is the most important concern because of the possibility of a major detonation. Detonation could be triggered by heat (fire), friction, impact (shock) or lightning.
Toxic Fumes
Burning explosives give off toxic fumes (irritating, corrosive &/or poisonous gases). The area should be evacuated before this is a problem.
Scattered / Spilled Material
Clear area of personnel and wait for assistance from trained personnel before handling or removing boosters.
Water Contamination
Usually water contamination is a very minor problem with Class 1.1D material. Containing and retrieving explosives packages from the water body is an important requirement for public safety and security reasons

First Aid: In the event of irritation, remove contaminated clothing and shoes and access fresh air. In case of contact with material particulates or dust, flush eyes with running water for at least 15 minutes and/or wash skin with soap and water. If irritation/adverse symptoms persist, seek medical attention and ensure that attending medical personnel are aware of identity and nature of product(s) involved

Class 1.4* No Significant Blast Hazard

Dyno Nobel Products: NONEL Lead-Line (non-electric detonating cord)

Hazards: **Fire or Explosion**
When subjected to heat, shock or friction, explosives of Division 1.4 (including 1.4S in the same shipment), may burn vigorously with localized detonations and projection of fragments. Risks are limited to the immediate vicinity. The effects of accidentally initiating packaged explosives of Division 1.4S should be confined to the immediate vicinity of the package.

Hazards: **Toxic Fumes**
Fire may produce irritating, corrosive and/or poisonous gases.
Scattered / Spilled Material
Clear area of personnel and wait for assistance from trained personnel before handling or removing explosive material.
Water Contamination
Usually water contamination is a very minor problem. Containing and retrieving explosives packages from the water body is an important requirement for public safety and security reasons

First Aid: In the event of irritation, remove contaminated clothing and shoes and access fresh air. In case of contact with material particulates or dust, flush eyes with running water for at least 15 minutes and/or wash skin with soap and water. If irritation/adverse symptoms persist, seek medical attention and ensure that attending medical personnel are aware of identity and nature of product(s) involved.

Class1.5D Stick Sensitive, Cap Insensitive

Dyno Nobel Products: ANFO, bulk EMULSION (Titan, Dyno Gold) or packaged products (Blastgel, Blastex).

Packaging: Plastic chubs, 25 kg. bags or bulk material (granular or thick fluid) in bulk containers .

Hazards: **Fire and Explosion**
Ammonium nitrate (AN) is an oxidizing agent therefore it will supply its own oxygen (O_2) to feed a fire. It can explode violently if overheated in a confined space, particularly if mixed with organic material such as fuel oil, which is what ANFO is made of.
Toxic Fumes
Will emit toxic fumes (yellow, red, or brown) of nitrogen oxides.
Scattered / Spilled Material

Clear area of personnel and wait for assistance from trained personnel before handling or removing explosive material.

Water Pollution

Ammonium nitrate is toxic to aquatic life in concentrations as low as 10-100 parts per million. AN can melt at 170 degrees C and begin to flow.

If there is no fire, contain or control any leakage or run off by digging a pit or corralling with dirt, using non-ferrous shovel. Cover prills with plastic to avoid dissolving by rain water. Call for assistance by trained personnel to assist in clean up.

First Aid: Remove contaminated clothing and shoes immediately.

In case of contact with material, wash with soap and water and/or flush eyes with running water for at least 15 minutes. If irritation /adverse symptoms persist, obtain medical attention. Ensure that attending medical personnel are aware of identity and nature of product(s) involved.

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DYNO NOBEL CONTACTS

NAME	FUNCTION	BUSINESS	CELL
Lance Tinney	Senior Vice President / Business Excellence and HSEC	(801) 328 6407	(801) 493 9026
Neal Olsen	DNA Environmental Manager Salt Lake City, UT	(801) 328 6434	(801) 556-5488
Jim Tucker	Senior Director H&S DNA	(801)328-6561	(801)819-6297
Mark Moats	Health & Safety Advisor / DNTI & Distribution	(801) 321-6986	(307) 274 - 7035
Clark Bonner	Global Explosives Equipment & Engineering Manager	(801) 566-1821	(801) 232-6257
Farrell Badger	North America Engineering Manager DNA	(801) 566 1821	(801) 735 8674
Dave Hunsaker	Bulk Technologies Manager	(801) 328-6458	(801) 560 0589
Kiel kemp	Director Operations Center of Excellence	(801) 566-1821	(801) 201-6749
David J Bullis	Vice President / International Business Development	(801) 321-7010	(801) 448-1370
Willard Pierce	Applications Technology Manager	(801) 328 6523	(801) 580 4170

MISCELLANEOUS RESOURCES / CONTACTS

CONTRACT / FEE FOR SERVICE COMPANIES

EMERGENCY RESPONSE
Newalta "North American Spill Line" (Canada-wide)
(TDG Emergency Response & Recovery Contractors)
Tel: 1-800-567-7455

(EMERGENCY) COMPRESSORS, PUMPS, HOSES & LIGHTING
United Rentals
Website: www.unitedrentals.com
Call 1-800-877-3687 for 24 hour order desk. Ask operator for location of United Rental branches closest to the incident.

CLEAN UP MATERIALS (SPILL CONTROL & CLEANUP SUPPLIES)
Acklands-Grainger Ltd.
Website: www.acklandsgrainger.com
Select "www.Acklandsgrainger.com / Branch Locator" on the internet to locate and contact the branches closest to the incident.

BULK CONTAINERS
Hawman Container Services
(Emulsion & Dangerous Goods Totes/Tanks)
Barrie, ON.
Tel: 1-888-895-1449
Website: www.hawman.com

UNDERWATER DIVING
CAN PAC Divers Inc. (explosives / demolition services)
983 West 3rd St.
North Vancouver, BC
Tel: (604) 984-8383 / 255-4828 (24 hr)
Fax: (604) 987-0007
Email: info@canpacdivers.com

ANNEX D To DNCI's ERAP 2-1037

Sites and personnel coordinates for DNCI

BRITISH COLUMBIA SITES

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FORT NELSON, BC

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Jimmy Donnison	Site Supervisor	Grande Prairie (780) 402-7094	(780) 876-6139
Dan Arnold	Sr. Account Manager	Grande Prairie 780 402-7094	780 876-6138
Craig Nicolson	Regional Operations Manager	(403) 236 9160	(403) 512-5127
Mike Soter	General Manager Western N.A. and Arctic.	(801) 328 6529	(801) 580-5919
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Fort Nelson	(250) 774 2777
Local Fire	Fort Nelson	(250) 774 3955
Local Ambulance	Fort Nelson	(250) 774 2344
BC Environment	Fort St. John	(250) 787-3411
BC WCB Health & Safety (Prevention)	Fort St. John	(250) 785-1283
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
RCMP "E" Division	Vancouver	1-604-264-3111
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
CAGC Emergency Response Number	Calgary	(403) 265-0045

KAMLOOPS, BC

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Todd Lenzi	Site supervisor	(250) 837-4505	(250) 837-1216
Ralph Olson	Sales & Operations Mgr. Southern B.C.	Nanaimo (250) 245-0830	(250) 713-8720
Jim O'Brien	Director Sales & Operations Pacific N.W.		(913) 940 5170
Kenneth Lemay	Health & Safety Advisor / Iron Range & Northwest	(801) 321 6994	(801) 201 6809
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Kamloops	911 / (250) 828-3111
Local Fire	Kamloops	911
Local Ambulance	Kamloops	911
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "E" Division	Vancouver	1-604-264-3111
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100

NANAIMO, BC

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Kevin Clark	Site Supervisor	(250) 245-0830	250 713-7942
Dean Morgan	Plant Foreman	Nanaimo (250) 245-0830	(250) 616-4665
Ralph Olson	Sales & Operations Mgr. Southern B.C.	Nanaimo (250) 245-0830	(250) 713-8720
Jim O'Brien	Director Sales & Operations Pacific N.W.		(913) 940 5170
Kenneth Lemay	Health & Safety Advisor / Iron Range & Northwest	(801) 321 6994	(801) 201 6809
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Nanaimo	911
Local Fire	Nanaimo	911
Local Ambulance	Nanaimo	911
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "E" Division	Vancouver	1-604-264-3111
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
BC Forestry Dept.	ILB	1-800-663-5555
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100
CARON Transportation	Edmonton, AB	(780) 499-9799
Weyerhauser (Site Lessor)	ILB	(250) 245-6300

REVELSTOKE, BC

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Todd Lenzi	Site Supervisor	(250) 837-4505	(250) 837-1216
Ralph Olson	Sales & Operations Mgr. Southern B.C.	Nanaimo (250) 245-0830	(250) 713-8720
Jim O'Brien	Director Sales & Operations Pacific N.W.		(913) 940 5170
Kenneth Lemay	Health & Safety Advisor / Iron Range & Northwest	(801) 321 6994	(801) 201 6809
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Revelstoke	911 / (250) 828-3111
Local Fire	Revelstoke	250 837-2884
Local Ambulance	Revelstoke	250 837-5885
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "E" Division	Vancouver	1-604-264-3111
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100

TERRACE, BC

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Rob Adami	Site Service Representative	Terrace (250) 635-3572	(250) 638-2809
Jim O'Brien	Director Sales & Operations Pacific N.W.		(913) 940 5170
Craig Nicolson	Regional Operations Manager – West	(403) 236 9160	(403) 512-5127
Mike Soter	General Manager Western N.A. and Arctic.	(801) 328 6529	(801) 580-5919
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police (RCMP)	Terrace	(250) 635-4911
Local Fire	Terrace	(250) 638-8121
Local Ambulance	Terrace	(250) 638-1102
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "E" Division	Vancouver	1-604-264-3111
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
Bob's Drilling & Blasting (Mutual Aid Agreement)	ILB	250-845-0044
Wayne Hansen Construction (Mutual Aid Agreement)	ILB	250-638-0914
Wee'Wane Trading Ltd. (Mutual Aid Agreement)	ILB	250-635-3407

TEXADA ISLAND, BC

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Glyn Isherwood	Service Representative	Texada Mine Site (604) 486-7627	(604) 414-8338
Kevin Clark	Supervisor	Nanaimo 250 245-0830	250 713-7942
Ralph Olson	Sales & Operations Mgr. Southern B.C.	Nanaimo (250) 245-0830	(250) 713-8720
Jim O'Brien	Director Sales & Operations Pacific N.W.		(913) 940 5170
Kenneth Lemay	Health & Safety Advisor / Iron Range & Northwest	(801) 321 6994	(801) 201 6809

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Gilles Bay	911 / (604) 486-7717
Local Fire	Gilles Bay	911
Local Ambulance	Gilles Bay	911
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "E" Division	Vancouver	1-604-264-3111
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100

TUMBLER RIDGE, BC

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Darren Woodhead	Site Supervisor	(250) 640 0343	780 223 4491
Rene Mercereau	Site Supervisor	(250) 640 0343	(780) 827-1511
Tom Medak	Regional Operations Manager – Arctic	(403) 236-9160	(403) 818-4434
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Tumbler Ridge	911 / (250) 242-5252
Local Fire	Tumbler Ridge	911
Local Ambulance	Tumbler Ridge	911
BC Provincial Emergency Program (PEP)	Victoria	1-800-663-3456
BC Environment (Spill Control) via PEP	Victoria	1-800-663-3456
BC OH&S	Victoria	1-888-922-3700
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "E" Division	Vancouver	1-604-264-3111
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100
CARON Transportation	Edmonton, AB	(780) 499-9799
Rosenau Transport Ltd	Dawson Creek, BC	(250) 782-2901

APPENDIX 2

Yukon Northwest Territory & Nunavut

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MINTO MINE, YT

MANAGEMENT AND MAGAZINE CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Dale Wearmouth Cris Short	Worksite Supervisors	Minto Mine, YK (403) 775-6143	
Tom Medak	Regional Operations Manager - Arctic	403-236-9160	(403) 818-4434
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Capstone Mine Manager – Ron Light	Minto Mine	(604) 759 0860
Whitehorse RCMP	Whitehorse	(867) 667-5555
YK OH&S Emergency	Whitehorse	(867) 667-5450
YK Environment (Spill Control)	Whitehorse	(867) 667-7244
RCMP "M" Division	Whitehorse	(867) 633-8612
Transport Canada – CANUTEC	Ottawa	(613) 996-6666
NRC/Explosives Branch	Ottawa	(613) 995-5555
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100
CARON Transportation	Edmonton, AB	(780) 499-9799
Rosenau Transport Ltd	Dawson Creek, BC	(250)782-2901

DIAVIK DIAMOND MINE (DWE), NT.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Al Mercereau, Greg Siemens	Worksite supervisors	(867) 766-5489	Calgary, AB. (403) 236-9160
Tom Medak	Regional Operations Manager - Arctic	Calgary, AB. (403) 236-9160	(403) 818-4434
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Diavik Emergency Response (24 hour Security)	Diavik Diamond Mine	(867) 766-5903 Radio Ch #1
DDMI First Aid	Diavik Diamond Mine	(867) 766-5901
Territorial RCMP	Yellowknife, NT.	(867) 669-1111
NT Oil & Chemical Spills	Yellowknife, NT	(867) 920-8130
Environment Canada, NT	Yellowknife, NT.	(867) 669-4700
RCMP "G" Division	Yellowknife, NT.	(867) 669-5100
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853

EKATI DIAMOND MINE (Polar), NT.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
John Zezel & Paul Dawkins	Polar Worksite Supervisors	Ekati, NT (867) 880-4613	ILB
Tom Medak	Regional Operations Manager - Arctic	Calgary, AB. (403) 236-9160	(403) 818-4434
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Ekati (BHP) Emergency Response	Ekati Diamond Mine	(867) 880-4444 Radio Ch #4
BHP Security (24 hr)	Ekati Diamond Mine	(867) 880-2201
Territorial RCMP	Yellowknife, NT.	(867) 669-1111
NT Oil & Chemical Spills	Yellowknife, NT	(867) 920-8130
Environment Canada, NT	Yellowknife, NT.	(867) 669-4700
RCMP "G" Division	Yellowknife, NT.	(867) 669-5100
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853

Yellowknife Magazine Site, NT.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Joshua Osmond	Site Supervisor	(867) 920-2343	(867) 444-0416
Tracy Levesque	Contract Administrator	(867) 920-2343	(867) 445-4250
Tom Medak	Regional Operations Manager - Arctic	Calgary, AB. (403) 236-9160	(403) 818-4434
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Territorial RCMP	Yellowknife, NT.	(867) 669-1111
NT Oil & Chemical Spills	Yellowknife, NT	(867) 920-8130
Environment Canada, NT	Yellowknife, NT.	(867) 669-4700
RCMP "G" Division	Yellowknife, NT.	(867) 669-5100
NRC/Explosives Branch	Ottawa	(613) 995-5555
NRC / Packaged Product	Calgary	(403) 292-4766
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853

MEADOWBANK, NU.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Patrick Piperell and Dennis Wall.	DNNI Worksite Supervisors	DNNI Baker Lake (867) 793-4610 Ext. 6804	(867) 222 3930
Tom Medak	Regional Operations Manager - Arctic	Calgary, AB. (403) 236-9160	(403) 818-4434
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Meadowbank (Agnico-Eagle) Julie Belanger	Baker lake, NU	(867) 793-461-ext 6721
Territorial RCMP	Baker lake, NU	(867) 793-1111
NT Oil & Chemical Spills	Iqaluit,NU	(867) 979-8130
Environment Canada, NT	Yellowknife, NT.	(867) 669-4700
RCMP "G" Division	Yellowknife, NT.	(867) 669-5100
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853

APPENDIX 3

Alberta

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CALGARY, AB		
Local Ambulance	*Calgary, AB*	*911*
RCMP	*Calgary, AB*	*(403) 230-6483*
NRC/Explosives Branch - Bulk	*Ottawa*	*(613) 995-5555*
NRC Explosives- Packaged product	*Calgary*	*(403) 292-4766*
Alberta Transport	*Edmonton*	*1-800-272-9600*
Alberta Environment	*Edmonton*	*1-800-222-6514* *1-780-422-4505*
NT Environment Canada	*Yellowknife, NT*	*(867) 669-4700*
BC Spill Control Centre	*ILB*	*1-800-663-3456*
SK Spill Control Centre	*ILB*	*1-800-667-7525*
Transport Canada - CANUTEC	*Ottawa*	*(613) 996-6666*
Transport Canada – Civil Operations Centre (Incident Reporting)	*ILB*	*1-877-992-6853*
Newalta "North American Spill Line" *(TDG Emergency Response & Recovery Contractors)*	*Stoney Creek, ON.*	*1-800-567-7455*
CEDA Emergency Response Team (CERT - BC & AB TDG Emergency Response & Recovery Contractors)	*Vancouver, BC*	*1-888-793-2378* *(604) 540-4100*
CAGC Emergency Response Number	*Calgary, AB*	*(403) 265-0045*
CHEMTREC	*USA*	*1-800-424-9300*

RAIL OPERATIONS / RESOURCES		
Canadian National Railway (CNR) Emergency Contact	*Winnipeg*	*1-800-465-9239*
CNR Customer Support Center (24 hrs.)	*Winnipeg*	*1-866-926-7245*

AIR OPERATIONS / RESOURCES		
SunWest Aviation	*Calgary, AB*	*(403) 275-8121*
Kenn Borek Air Ltd.	*Calgary, AB*	*(403) 291-3300*
Delta Helicopters Ltd. (Alberta)	*St. Albert, AB*	*(780) 458-3564*
First Air (TDG - Mike Billington)	*Yellowknife, NT*	*1-800-661-3591* *(Ext. 2508)*
Arctic SunWest (TDG - Jim Robillard)	*Yellowknife, NT*	*(867) 873-4464*
Air Tindi (TDG – Teri Arychuk)	*Yellowknife, NT*	*(867) 669-8200*
Great Slave Helicopters Ltd. (John Buckland, Operations Manager)	*Yellowknife, NT*	*(867) 873-2081*
Canadian Air Force Rescue Coordination Centre (RCC)	*Trenton, ON*	*1-800-267-7270*
Canadian Forces Joint Task Force North (Northern Command Ops Centre)	*Yellowknife, NT*	*(867)873-0700* *(Ext. 6818*
CF 440 Squadron Operations	*Yellowknife, NT*	*867)873-0700* *(Ext. 0906)*
TC Dangerous Goods, Aviation *Harold Brookman. Superintendent*	*Edmonton, AB*	*(780) 495-5278*
TC Dangerous Goods, Aviation *Keith McDonald, Inspector*	*Calgary, AB*	*(403) 292-5221*

GRANDE PRAIRIE, AB.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Jimmy Donnison	Site Supervisor	Grande Prairie (780) 402-7094	(780) 876-6139
Aaron Barkermeyer	Service Reps	(780) 402-7094	780-876-1914
Craig Nicolson	–Regional Operations Manager – West	403 236 9160	(403) 512-5127
Dan Arnold	Sr. Account Manager	Grande Prairie 780 402 7094	780 876-6138
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Grande Prairie	911 / (780) 538-5700
Local Fire	Grande Prairie	911 / (780) 538-0393
Local Ambulance	Grande Prairie	911 / (780) 538-1253
Alberta Transport	Edmonton	1-800-272-9600
Alberta Environment	Edmonton	1-800-222-6514
Alberta Workplace Safety	Edmonton	(1-866)415-8690
RCMP "K" Division	Edmonton	(780) 412-5424
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Weyerhaeuser Security (Road Control)	Greenview County	(780) 539-8500 Radio Frequency: 168 – 840 Broadcast: "Emergency 1033"
CAGC Emergency Response Number	Calgary	403-265-0045

ROCKYFORD, AB.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Shawn Kathol	Site Supervisor	Rockyford 403 533- 3838	403 369 - 6239
Craig Nicolson	–Regional Operations Manager – West	Calgary, AB 403 236-9160	(403) 512-5127
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Strathmore	911 / (403) 934-3535
Local Fire	Strathmore	911 / (403) 934-3022
Local Ambulance	Strathmore (Wheatland County)	911 / (403) 934-4079
Alberta Transport	Edmonton	1-800-272-9600
Alberta Environment	Edmonton	1-800-222-6514
Alberta Workplace Safety	Edmonton	(1-866)415-8690
RCMP "K" Division	Edmonton	(780) 412-5424
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
CEDA Emergency Response Team (Bulk Spill Recovery)	Vancouver	1-888-793-2378 (604) 540-4100

WESTLOCK, AB.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINES PHONE	CELL PHONE
Mike Besman	Site Supervisor	(780) 349 4839	(780) 350 8008
Craig Nicolson	Regional Operations Manager – West	403 236-9160	(403) 512-5127
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Westlock	911 / (780) 349-4491
Local Fire	Westlock	911 / (780) 349-4444
Local Ambulance	Westlock	911 / (780) 349-4111
Alberta Transport	Edmonton	(1-800) 272-9600
Alberta Environment	Edmonton	(1-800)222-6514
Alberta Workplace Safety	Edmonton	(1-866)415-8690
RCMP "K" Division	Edmonton	(780) 412-5424
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
CAGC Emergency Response Number	Calgary	403-265-0045

Weyburn, SK.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Shawn Kathol	Site Supervisor	Rockyford 403 533- 3838	403 369 - 6239
Johnny Knox	Branch operator		(306) 861-6582
Craig Nicolson	Regional Operations Manager – West	Calgary, AB 403 236-9160	(403) 512-5127
Hamish Mackenzie	Seismic Sales Manager	Calgary, AB 403 236-9160	403 921-3775
Seamus Kilcommons	Manager HSEC Canada	(403) 723-7547	(403) 837-2685

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
RCMP	Fillmore, SK	911 / (306) 869-4600
RCMP	Assiniboia, SK	911/ (306) 642-7110
Local Fire	Weyburn, SK	911 / (306) 848-3244
Local Ambulance	Weyburn, SK	911 / (306) 842-0223
Weyburn General Hospital	Weyburn, SK	911 / (306) 842-8400
Saskatchewan Highways Transport	Weyburn, SK	(306) 848-2435
Saskatchewan, Environment	Weyburn, SK	(306) 848-2344
Dangerous Goods Saskatchewan		
Workplace Safety	Edmonton	(1-866)415-8690
RCMP "K" Division	Edmonton	(780) 412-5424
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666

APPENDIX 4

Saskatchewan & Manitoba

INDEX TO WORKSITE APPENDICES

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GRIFFIN, SK.

MANAGEMENT AND BRANCH CONTACT LIST

NAME	TITLE	BUSINES PHONE	CELL PHONE
Shawn Kathol	Site Supervisor	Rockyford 403 533- 3838	403 369 - 6239
Johnny Knox	Branch operator		(306) 861-6582
Craig Nicolson	–Regional Operations Manager – West	Calgary, AB 403 236-9160	(403) 512-5127
Hamish Mackenzie	Seismic Sales Manager	Calgary, AB 403 236-9160	403 921-3775
Rick Chopp	HSE Advisor – Central Canada	(705) 498-2855	(705) 498-2855

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
RCMP	Fillmore, SK	911 / (306) 869-4600
RCMP	Assiniboia, SK	911/ (306) 642-7110
Local Fire	Weyburn, SK	911 / (306) 848-3244
Local Ambulance	Weyburn, SK	911 / (306) 842-0223
Weyburn General Hospital	Weyburn, SK	911 / (306) 842-8400
Saskatchewan Highways Transport	Weyburn, SK	(306) 848-2435
Saskatchewan, Environment	Weyburn, SK	(306) 848-2344
Sask. Environmental Spill Control Centre	Prince Albert, SK	(1-800) 667-7525
Saskatchewan OH&S	Saskatoon	(306) 933-5052 1-800-667-5023
RCMP "F " Division	Regina	(306) 310-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
CAGC Emergency Response Number	Calgary	403-265-0045

FLIN FLON, MB./ CREIGHTON, SK

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Tyrone McLean	Operations Manager – Manitoba & Saskatchewan	(306) 688-5209	(204) 687-0046
Wade Haggerty	Assistant Plant Manager	Flin Flon (306) 688-5209	(204) 687-0175
Rick Chopp	HSE Advisor – Central Canada	(705) 498-2855	(705) 498-2855
Jason Hastie	Plant Manager	(306)688-5209	(204) 687-0028

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
HBMS Security	Flin Flon, MB	(204) 687-2291
Local Police	Flin Flon, MB	(204) 687-3491
Local Police	Creighton, SK	(306) 688-8888
Local Fire	Flin Flon, MB	(204) 687-3100
Local Ambulance	Flin Flon, MB	(204) 687-7171
Sask. Environmental Spill Control Centre	Prince Albert, SK	(1-800) 667-7525
Manitoba Environmental Control Centre	Winnipeg	(204) 945-4888
Workplace Health & Safety Emergency Number	Winnipeg	(204) 945-0581
RCMP	Winnipeg	(204) 983-5462
RCMP "D" Division	Winnipeg	(204) 983-5420
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Canadian National Railway (CNR) Emergency Contact	Winnipeg	1-800-465-9239
CNR Customer Support Center	Winnipeg	1-866-926-7245
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Paul's Hauling Ltd.	Winnipeg	(1-800) 665-1749
Caron Transportation Systems	Edmonton	(780) 417-7700
Cambrian Blasting Co. Ltd. (Mutual Aid Agreement)	Winnipeg	(204) 895-9594

LAC DU BONNET / WINNIPEG, MB.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Al Bain	Driver	Winnipeg (204) 661-4260	(204)791-1930
Rick Chopp	HSE Advisor – Central Canada	(705) 498-2855	(705) 498-2855
Tyrone McLean	Operations Manager – Manitoba & Saskatchewan	(306) 688-5209	(204) 687-0046

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS		
ORGANIZATION/CONTACT	**LOCATION**	**PHONE NUMBER**
Lac du Bonnet RCMP	Lac du Bonnet	(204) 345-8685
Beausejour RCMP	Beausejour	(204) 268-1234
Winnipeg City Police	Winnipeg	(204) 986-6222
Winnipeg RCMP	Winnipeg	(204) 983-5462
Lac du Bonnet Fire Dept.	Lac du Bonnet	(204) 345-2997
Beausejour Fire Dept.	Beausejour	(204) 268-2100
Winnipeg Fire Dept.	Winnipeg	911
Lac du Bonnet Ambulance	Lac du Bonnet	(240) 345-2997
Beausejour Ambulance	Beausejour	(204) 268-2100
Winnipeg Ambulance	Winnipeg	911
Manitoba Environmental Control Centre	Winnipeg	(204) 945-4888
Workplace Health & Safety Emergency Number	Winnipeg	(204) 945-0581
NRC/Explosives Branch	Ottawa	(613) 995-5555
RCMP "D" Division	Winnipeg	(204) 983-5420
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	ILB	1-800-567-7455
Paul's Hauling Ltd.	Winnipeg	(1-800) 665-1749
Caron Transportation Systems	Edmonton	(780) 417-7700

APPENDIX 5

Ontario

WORKSITE	PROVINCE	PAGE
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RED LAKE / BALMERTOWN, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Scott Smith	Site Manager, Red Lake Ontario	Balmertown (807) 735-1222	(807) 727-7300
Rick Chopp	HSE Advisor – Central Canada	-	(705) 498- 2855

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Goldcorp Security	Red Lake	(807) 735-2077 (dial 1 & ext. 263)
Campbell Mine Security	Balmertown	(807) 735-2075 (dial 1 & ext. 157)
Local Police (OPP)	Balmertown	911 (807) 727-2418
Local Fire	Balmertown	911 (807) 735-2555
Local Ambulance	Balmertown	911 (807) 735-2555
Ontario Provincial Police	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Paul's Hauling Ltd.	Winnipeg	(1-800) 665-1749
Caron Transportation Systems	Edmonton	(780) 417-7700

ASHTON, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Dion Closs	Site Supervisor	Ashton (613) 237-7557	(613) 720-6973
Rick Chopp	HSE Advisor – Central Canada	-	(705) 498- 2855

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police (OPP)	Ashton	911 / (613) 257-5610
Local Fire	Ashton	911 / (613) 257-2222
Local Ambulance	Ashton	911 / (613) 257-4444
Ontario Provincial Police	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Thomas Cavanagh Construction Ltd. (Mag Site Lessor)	ILB	(613) 237-7030

GAMEBRIDGE, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Alain Saulnier	Site Supervisor	Barrie (705) 487-0344	(705) 790-5801
Rick Chopp	HSE Advisor, Central Canada	-	(705) 498- 2855

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	Orillia	911 / 705-329-6111
Local Fire	Orillia	911 / (705) 325-5201
Local Ambulance	Orillia	911 / (705) 325-7461
Ontario Provincial Police	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
James Dick Construction Ltd.	Quarry Weigh Scale	(705) 426-7381

GARSON / SUDBURY, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Mark O'Neil	Northern Ontario Manager	Sudbury (705) 693-3003	(705)-929-5871
Rick Chopp	HSE Advisor – Central Canada	-	(705) 498- 2855
Tyler Matson	Site Supervisor	Sudbury (705) 693-3003	(705) 655-1078

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Greater Sudbury Police Service	Sudbury	911 / (705) 675-9171
Greater Sudbury Fire Service	Sudbury	911 / (705) 693-3010
Greater Sudbury Ambulance Service	Sudbury	911 / (705)
Ontario Provincial Police	Sudbury	(705) 564-6900
Ontario Provincial Police (Province wide)	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

HAGERSVILLE, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Rick Chopp	HSE Advisor – Central Canada	-	(705) 498- 2855
Luis Redondo	Site Supervisor	(289) 439 0441	(289) 439-0441

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Ontario Provincial Police	Cayuga, ON	911 / (905) 318-5732 (Ext. 214)
Local Fire	ILB	911
Local Ambulance	ILB	911
Ontario Provincial Police (Province wide)	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455

LAC DES ILES, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Rick Chopp	HSE Advisor – Central Canada	-	(705) 498- 2855
Adam Matheson	Site Supervisor		(807) 727-7410

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Ontario Provincial Police		911 /
Local Fire	ILB	911
Local Ambulance	ILB	911
Ontario Provincial Police (Province wide)	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455

NORTH BAY, ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Rick Chopp	HSE Advisor – Central Canada Ontario	-	(705) 498- 2855
Gord Grasser	Group Leader	(705) 472-1300	(705) 477-1731

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Ontario Provincial Police	North Bay	(705) 495-3878
Fire Service	North Bay	911
Ambulance Service	North Bay	911
Ontario Provincial Police (Province wide)	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Canadian National Railway (CNR) Emergency Contact	Winnipeg	1-800-465-9239
CNR Customer Support Center	Winnipeg	1-866-926-7245
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463
Pro North Ontario	ILB	(705) 470-4411

TIMMINS. ON.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Matt Resetar	Site Supervisor		(705) 266-5192
Mark O'Neil	Northern Ontario Manager	Sudbury (705) 693-3003	(705)-929-5871
Rick Chopp	HSE Advisor – Central Canada	-	(705) 498- 2855

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Ontario Provincial Police	South Porcupine	(705) 235-3345
Local Fire	Timmins	911 / (705) 325-5201
Local Ambulance	Timmins	911 / (705) 325-7461
Ontario Provincial Police (Province wide)	ILB	(1-888) 310-1122
Ontario Emergency Measures	ILB	(416) 314-0472
Ontario Spills Action Centre	ILB	(416) 325-3000 1-800-268-6060
RCMP "O" Division	London	(519) 640-7267
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

APPENDIX 6

Quebec

WORKSITE	PROVINCE	PAGE
Canadian Royalties Inc.	QC	2
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CANADIAN ROYALTIES Inc. QC.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Marco Giambagno	Regional Operations Manager	450 508 2921	514 235 4093
Stéphane Perreira	Directeur des opérations - Carrières & Constructions Québec	Boisbriand (450) 508 2943	(514) 607-6255
Benoit Choquette	Environmental Manager Canada	(450) 508-2924	(514) 249-6285
Alexis Ancel	Superviseur de site / Carrières & Construction - Québec	(450) 438-8681 X104	(514) 795-7042
Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	ILB	911
Local Fire	ILB	911
Local Ambulance	ILB	911
Quebec Provincial Police	Quebec City Montreal	(418) 623-6262 (514) 598-4141
Quebec Ministry of Environment & Wildlife	**Montreal**	**(418) 643-4595** **1-866-694-5454**
RCMP "C" Division	Montreal	1-800-771-5401 (514) 939-8300
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

LAC ST. CHARLES QC.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
Nicolas Frenette	Site Supervisor - Lac St-Charles	(418) 849-0553	(418) 571-0609
Stéphane Perreira	Directeur des opérations - Carrières & Constructions Québec	Boisbriand (450) 508 2943	(514) 607-6255
Marco Giambagno	Regional Operations Manager	450 508 2921	514 235 4093
Benoit Choquette	Environmental Manager Canada	(450) 508-2924	(514) 249-6285
Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	ILB	911
Local Fire	ILB	911
Local Ambulance	ILB	911
Quebec Provincial Police	Quebec City Montreal	(418) 623-6262 (514) 598-4141
Quebec Ministry of Environment & Wildlife	Montreal	(418) 643-4595 1-866-694-5454
RCMP "C" Division	Montreal	1-800-771-5401 (514) 939-8300
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

ORMSTOWN QC.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
David Girard	Site Manager	450 825 2236 Ext. 23	514 212 3021
Marco Giambagno	Regional Operations Manager	450 508 2921	514 235 4093
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Benoit Choquette	Environmental Manager Canada	(450) 508-2924	(514) 249-6285

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	ILB	911
Local Fire	ILB	911
Local Ambulance	ILB	911
Quebec Provincial Police	Quebec City Montreal	(418) 623-6262 (514) 598-4141
Quebec Ministry of Environment & Wildlife	Montreal	(418) 643-4595 1-866-694-5454
RCMP "C" Division	Montreal	1-800-771-5401 (514) 939-8300
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

SHERBROOKE QC.

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Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039
Benoit Choquette	Environmental Manager Canada	(450) 508-2924	(514) 249-6285

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Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853

STE. SOPHIE QC.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
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Benoit Choquette	Environmental Manager Canada	(450) 508-2924	(514) 249-6285
Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039

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RCMP "C" Division	Montreal	1-800-771-5401 (514) 939-8300
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STORNOWAY DIAMOND QC.

MANAGEMENT AND PLANT CONTACT LIST

NAME	TITLE	BUSINESS PHONE	CELL PHONE
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Benoit Choquette	Environmental Manager Canada	(450) 508-2924	(514) 249-6285
Alexis Ancel	Superviseur de site / Carrières & Construction - Québec	(450) 438-8681 X104	(514) 795-7042
Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039

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Local Fire	ILB	911
Local Ambulance	ILB	911
Quebec Provincial Police	Quebec City Montreal	(418) 623-6262 (514) 598-4141
Quebec Ministry of Environment & Wildlife	**Montreal**	**(418) 643-4595** **1-866-694-5454**
RCMP "C" Division	Montreal	1-800-771-5401 (514) 939-8300
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

VAL D'OR QC.

MANAGEMENT AND PLANT CONTACT LIST

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Éric Desrosiers	Team Lead	(819) 825-5441	(819) 856-8718

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

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Local Ambulance	ILB	911
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Quebec Ministry of Environment & Wildlife	Montreal	(418) 643-4595 1-866-694-5454
RCMP "C" Division	Montreal	1-800-771-5401 (514) 939-8300
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Transport Nordique - Trucking	ILB	(514) 464-9463

APPENDIX 7

Maritimes

WORKSITE	PROVINCE	PAGE
Fredericton	NB	2
Bedford	NS	3

FREDERICTON NB.

MANAGEMENT AND PLANT CONTACT LIST

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Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039
Paul Purcell	Directeur des Opérations - Maritimes	(902) 865-8522 x222	(902) 497-6841
Pierre Lepage	Senior Account Manager - Maritimes	(902) 865-8522	(506) 378-4326

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	ILB	911
Local Fire	ILB	911
Local Ambulance	ILB	911
New Brunswick RCMP	Province-wide	1-800-665-6663
New Brunswick EMO	Fredericton	1-800-561-4034 (506) 453-2133
RCMP "J" Division	ILB	(506) 452-3400
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Seaboard Transport – Trucking	ILB	(902) 468-8610

BEDFORD NS.

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Paul Purcell	Directeur des Opérations - Maritimes	(902) 865-8522 x222	(902) 497-6841
Marco Giambagno	Regional Operations Manager	(450) 508-2921	(514) 235-4093
Benoit Choquette	Directeur Environnemental Canada	(450) 508-2924	(514) 249-6285
Allen Fontaine	HSE Advisor – Eastern Canada		(581) 444-1039
Pierre Lepage	Senior Account Manager - Maritimes	(902) 865-8522	(506) 378-4326

REGULATORY / EMERGENCY RESPONSE ORGANIZATIONS / CONTACTS

ORGANIZATION/CONTACT	LOCATION	PHONE NUMBER
Local Police	ILB	911
Local Fire	ILB	911
Local Ambulance	ILB	911
Nova Scotia RCMP	Province-wide	1-800-272-9569
Nova Scotia EMO	Dartmouth	(902) 424-5620
RCMP "H" Division	Halifax	(902) 426-7766
NRC/Explosives Branch	Ottawa	(613) 995-5555
Transport Canada - CANUTEC	Ottawa	(613) 996-6666
Transport Canada – Civil Operations Centre (Incident Reporting)	ILB	1-877-992-6853
Newalta "North American Spill Line" (TDG Emergency Response & Recovery Contractors)	Stoney Creek, ON	1-800-567-7455
Canadian American Tank Lines (CATL) Trucking & Road Tanker Rentals	ILB	(418) 286-2300
Seaboard Transport – Trucking	ILB	(902) 468-8610

Appendix J

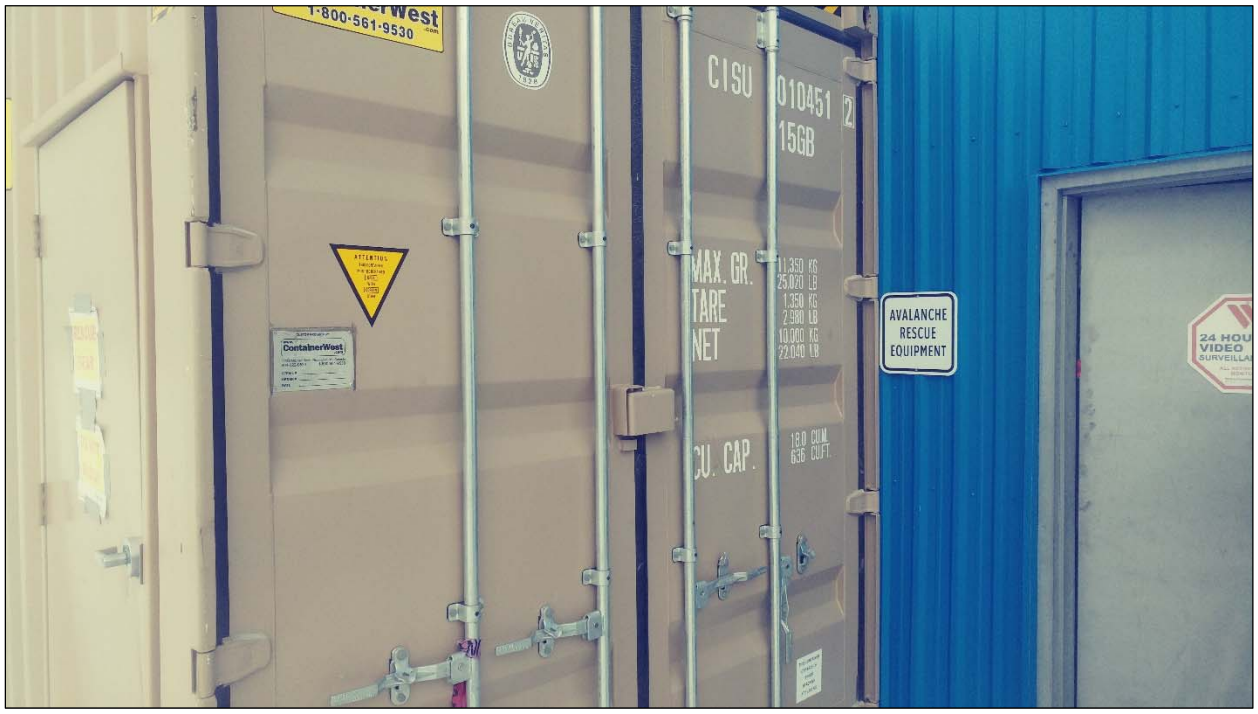
Avalanche Rescue Cache Contents and Locations

AVALANCHE RESCUE CACHE LOCATIONS

BRUCEJACK CAMP

Fire hall, ERT mine avalanche mine rescue storage

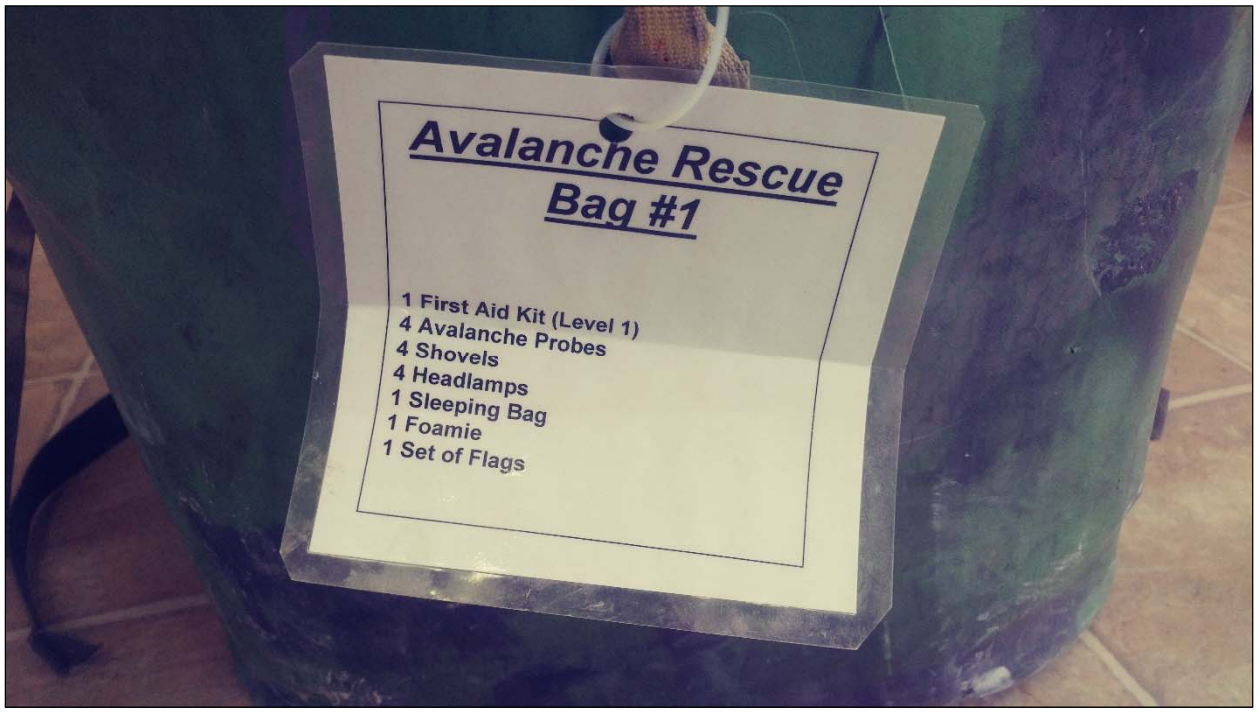
- Avalanche Rescue Pack x2 – located inside hall with ERT gear
- Glacier Rescue pack (brown seacan)
- Survival Kit (brown seacan)
- Rope Rescue equipment (brown seacan)



KNIPPLE CAMP

Inside ambulance bay, first aid building

- Avalanche Rescue Pack x2
- Survival Kit
- HETS rescue gear (Av-tech seacan)
- Rope Rescue equipment


Avalanche Rescue
Bag #1
1 First Aid Kit (Level 1)
4 Avalanche Probes
4 Shovels
4 Headlamps
1 Sleeping Bag
1 Foamie
1 Set of Flags

Gear Arriving with First ERT		
☐	**1)**	Avalanche rescue party pack #1
☐	**2)**	Vacuum mattress #1, Vacuum splints and Scoop stretcher
☐	**3)**	Jump kit, oxygen and AED
☐	**4)**	RECCO unit
☐	**5)**	2 extra avalanche packs for Surface Ops personnel (Loader, Cat Driver)
☐	**6)**	6 steel shovel,
☐	**7)**	2 x helicopter stakes
☐	**8)**	Forward Staging Checklist

Gear Arriving with Second ERT		
☐	**1)**	Rescue toboggan #1 (with warming kit) - Brucejack
☐	**2)**	Megaphone
☐	**3)**	Avalanche rescue party pack #2
☐	**4)**	Rescue toboggan #2 (with warming kit) - Brucejack
☐	**5)**	At night – headlamps, light plant (Pinto hitch) For deep snow conditions – snow shoes
☐	**6)**	6 steel shovels

Appendix K

Worksite Avalanche Hazard Assessment

PRETIVM
BRUCEJACK PROJECT

Worksite Avalanche Hazard Assessment

Site Maintenance or Surface Operations to fill out:			
Department Requesting:		Date:	
Site contact:		Email:	
Job Supervisor:		Email:	
Contractors:		Department:	
Location:			
Number of Workers:			
Start Date:		Finish Date:	
Description of work to be performed:			

For Mountain Safety's use only:			
Ongoing or One Off:		Follow Up Interval:	
Access/Egress:		Terrain Description and Concerns:	
Mountain Hazards and Snowpack Concerns:			
Risk Management and Controls:			
Avalanche PPE and Training?:			
Mountain Safety Technician:		Date:	

Appendix L

Incident Analysis and Report Forms

Brucejack Incident Investigation Checklist

Supervisor Field guide for data collection to support the incident investigation.

People

- ☐ Preserve evidence at the scene and secure. Cordon off area with yellow perimeter tape as needed or required
- ☐ Drug and Alcohol test required? Discuss with your Superintendent/Manager, or Safety Advisor.
- ☐ Interview all those involved either directly, or indirectly with the incident. Interview witnesses and workers involved as soon as safely possible after the event.
- ☐ Interview individuals separately, in a quiet and appropriate place away from other co-workers. Never interview in a group setting.
- ☐ Written statements by witnesses or those involved are acceptable and can support the investigation as a record. Date, time, name clearly and signed by the interviewee, or person writing the statement.
- ☐ Copy and date/sign your notes and scan/deliver to the HS Department Advisors.

Positions

- ☐ Drawings assist in visualizing the incident. Simple top down drawings are sufficient.
- ☐ Note location of people involved, key facilities or landmarks, equipment placement, etc.
- ☐ Take photos of incident. Photos from all sides. Take photos in 3's. Far/near/close-up for perspective. Send all photos to safety@Pretivm.com
- ☐ Use a pencil, or object of known size for close-up photo's for correct perspective.

Parts

- ☐ Analyse the tools or equipment and materials that people were using.
- ☐ Worn/improper equipment used? Equipment in useable condition per manufacturer specs?
- ☐ Guards in place? Safety features bypassed? Hazard warning labels noted on equipment?
- ☐ Is technical expertise required to analyse a mechanical failure?

Papers

- ☐ Assemble any written data for the Safety Advisors.
- ☐ Training records for affected employees of the incident? Obtain from training department.
- ☐ Maintenance logs or records as applicable? Planning schedules reviewed?
- ☐ Personal JHA's completed by all workers involved in the incident. Obtain these records.
- ☐ Work Instructions (WI's) that apply to the specific task.

**Assemble all documents and provide to the HS Department Advisors (Safety@Pretivm.com). All information is reviewed and supports the incident analysis. Questions? Contact the HS Advisors.

Appendix M

Conceptual Model for Avalanche Hazard

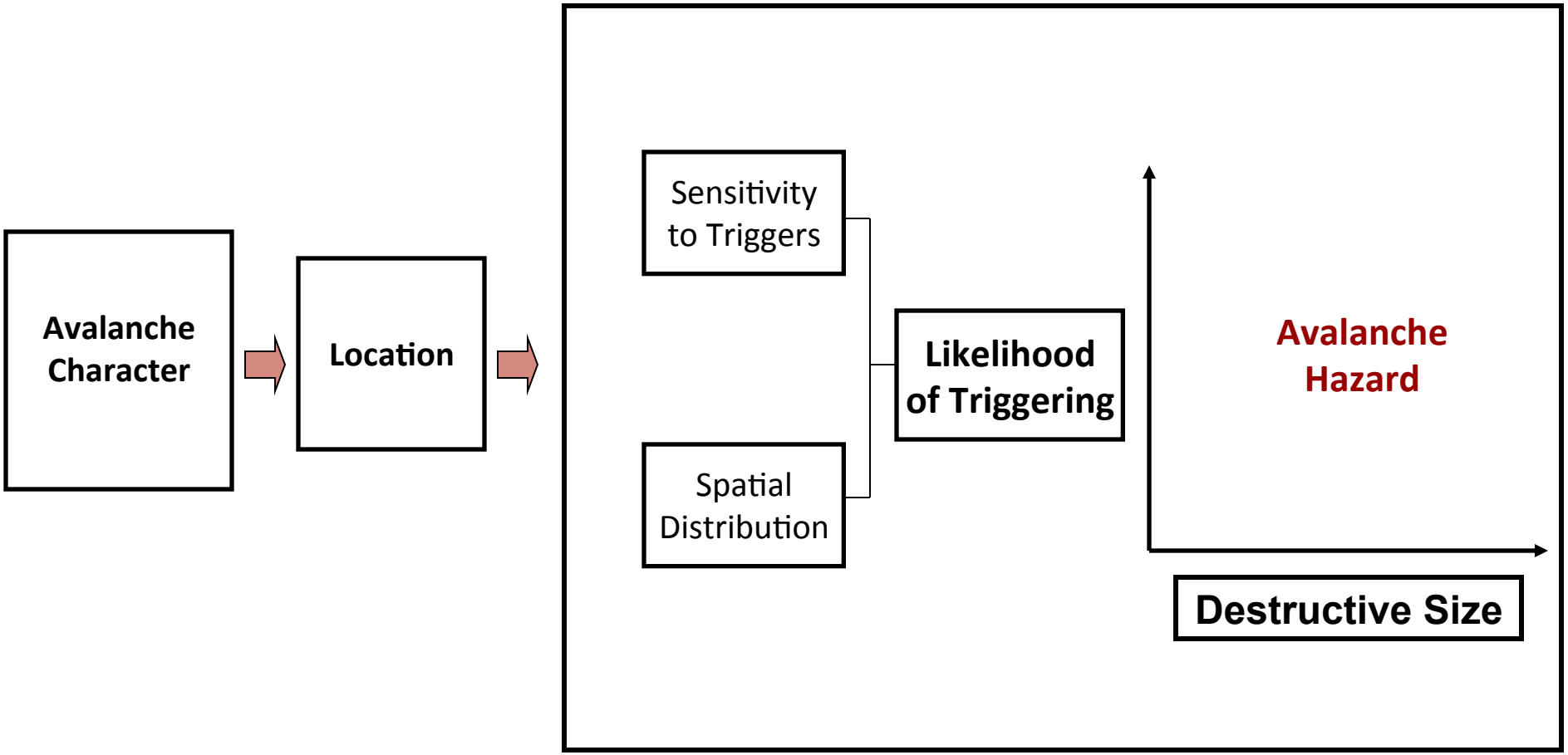
Conceptual Model of Avalanche Hazard

(Revised October 2012)

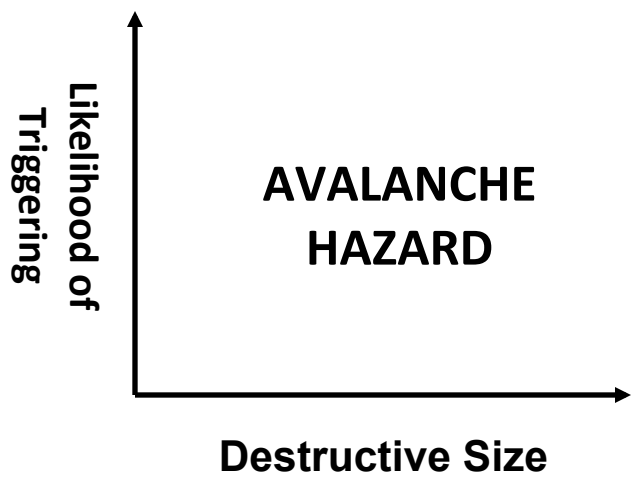
This workbook describes a conceptual model of avalanche hazard, and provides detailed reference material for use when evaluating avalanche hazard. The model was developed by systematically deconstructing avalanche hazard into its critical component pieces. Each piece was then further deconstructed to accommodate a detailed analysis. The model was then reassembled, and represents the analysis process for an avalanche hazard evaluation.

This model was developed by committee through the ADFAR2 project by Parks Canada and the Canadian Avalanche Centre. Committee members are: Grant Statham, Karl Birkeland, Pascal Haegeli, Ethan Greene, Chris Stethem, Bruce Tremper, Clair Israelson, John Kelly, Bruce McMahon and Brad White.

Avalanche Hazard Evaluation



Avalanche Hazard; Avalanche Danger is the potential for an avalanche(s) to cause damage to something of value. It is a function of the likelihood of triggering and the destructive size of the avalanche(s). It implies the potential to affect people, facilities or things of value, but does not incorporate vulnerability or exposure to avalanches. Avalanche hazard is commonly expressed using relative terms such as high, moderate and low.



Avalanche Risk is the probability or chance of harm resulting from interactions between avalanche hazard and a specific element(s) at risk. Avalanche risk is determined by the exposure of that element, and its vulnerability to the avalanche hazard.

Establish the Context

The first step in any avalanche hazard analysis is to **formulate the problem** for the analysis.

1. Operational application
2. Spatial scale
3. Temporal scale

Scale

SPATIAL SCALE	TEMPORAL SCALE
- Terrain feature	- Now
- Path/Run	- Hours
- Mountain	- Days
- Drainage	- Weeks
- Range	- Years
- Region	- Other: _____
- Other: _____	

Evidence and Data

Avalanche hazard factors (examples of commonly used factors)

The strength and weight given to these factors is a judgemental assessment with no hierarchy of data type

AVALANCHES

Observed and potential

-Character

-Type

-Trigger type

-Trigger size

-Size – destructive

-Size – relative

-Number & distribution

-Water (moisture)

-Runout distance

SNOWPACK

-Spatial/Temporal variability

-Weak layer/interface presence

-Weak layer type (storm/persistent)

-Weak layer depth

-Weak layer strength/stress

-Bed surface

-Slab thickness

-Slab stiffness

-Load on weak layer(s) – H20

-Snow surface condition

-Snow available for transport

-Snowpack temperatures

-Moisture content

-Propagation potential

-Compaction

WEATHER

Scale – space/time

-Current and future

-Precip (type, intensity, duration)

-Wind (speed, direction, duration)

-Temp (magnitude, trend)

-Energy balance (solar radiation)

-Humidity

-Sky condition

TERRAIN

Spatial Scale

-Incline

-Aspect

-Shape

-Forest cover

-Ground roughness

-Terrain size

-Elevation (vegetation band)

-Traps (terrain complexity)

-Overlapping terrain

-Glaciation

Avalanche Character

Identify the Avalanche Character(s) that best represents the avalanche problem(s) within the defined Location. When multiple characters exist, they should be prioritized in order of importance.

Character	Weak Layer / Interface	Slab Properties	Persistence	Weak Layer Location	Propagation Potential	Relative Size Potential (1-5)
Loose Dry	Various (no cohesion)	None	Hours/days	Near the surface	Down slope entrainment	R1-2
Loose Wet	Various (no cohesion)	None	Hours/days	Any level	Significant down slope entrainment	R1-3
Wind Slabs	PP, DF	4F-K Wind transported	Hours/days	Upper pack	Terrain feature	R1-3
Storm Slabs	PP, DF	F-P Soft – stiff	Hours/days	In or just below storm snow	Path	R1-4
Wet Slabs	Various Grains	4F-P Wet grains	Hours/days	Mid pack to deep	Path	R1-5 (climax)
Persistent Slabs	PWLs such as SH, FC, CR, FC/CR combo	4F-P Stiff-Hard	Weeks/months	Upper to mid pack	Path to adjacent paths	R2-4
Persistent Deep Slabs	PWLs such as DH, FC, CR, FC/CR combo	1F-K Hard	Weeks/months	Deep or basal	Path to adjacent paths	R3-5 (climax)
Cornices	~	~	Months with short peaks	~	~	~
Comment	Typical failure plane	Typical kind of slab	Typical duration of instability	Relative to HS	Typical expectation	Typical range of size relative to path

Location

Specifically describe where in the terrain a particular Avalanche Character is expected to be found.

Location
Describe the terrain using: Aspect Elevation Vegetation bands Operating zones Terrain features

Sensitivity to Triggers

Determine the Sensitivity to Triggers based on what kind of triggering will initiate avalanches of any size within the defined location.

Sensitivity	Natural Triggers	Human Triggers	Explosive Triggers		Cornice Triggers
			Size	Result	
Unreactive	No avalanches	No avalanches	Very large explosives	No slab	No slab from very large cornice fall
Stubborn	Few	Difficult to trigger	Large explosives & air blasts	Some	Large
Touchy	Several	Easy to trigger	Single hand charge	Many	Medium
Very Touchy	Numerous	Triggering certain	Any size	Numerous	Any size
Description of observation	Natural avalanche occurrences	Ease of triggering by a single human	Size of explosive and effect		Size of cornice fall that will trigger a slab

Spatial Distribution

Determine the density and distribution of the instability within the defined location.

Distribution	Density	Evidence
Isolated	The instability is spotty and found in few locations.	Evidence is rare and hard to find.
Specific	The instability exists in portions of terrain.	Evidence exists but is not always obvious.
Widespread	The instability is found in many locations.	Evidence is everywhere and easy to find.
Comment	How is the evidence distributed within the location identified?	How hard is it to find?

Likelihood of Triggering

Determine the Likelihood of Triggering within the defined location. This is a judgemental combining of both Sensitivity to Triggers and Spatial Distribution.

Likelihood of Triggering
Almost Certain
Very Likely
Likely
Possible
Unlikely

Destructive Size

Determine the destructive potential of the avalanche(s) resulting from a specific Avalanche Character within a defined location.

Destructive Size	Avalanche Destructive Potential (definition)	Typical mass	Typical impact pressure	Typical path length
1	Relatively harmless to people.	<10 t	1 kPa	10 m
2	Could bury, injure, or kill a person.	10^2 t	10 kPa	100 m
3	Could bury and destroy a car, damage a truck, destroy a wood frame house, or break a few trees.	10_3 t	100 kPa	1000 m
4	Could destroy a railway car, large truck, several buildings, or a forest area of approximately 4 hectares.	10_4 t	500 kPa	2000 m
5	Largest snow avalanche known. Could destroy a village or a forest area of approximately 40 hectares.	10_5 t	1000 kPa	3000 m

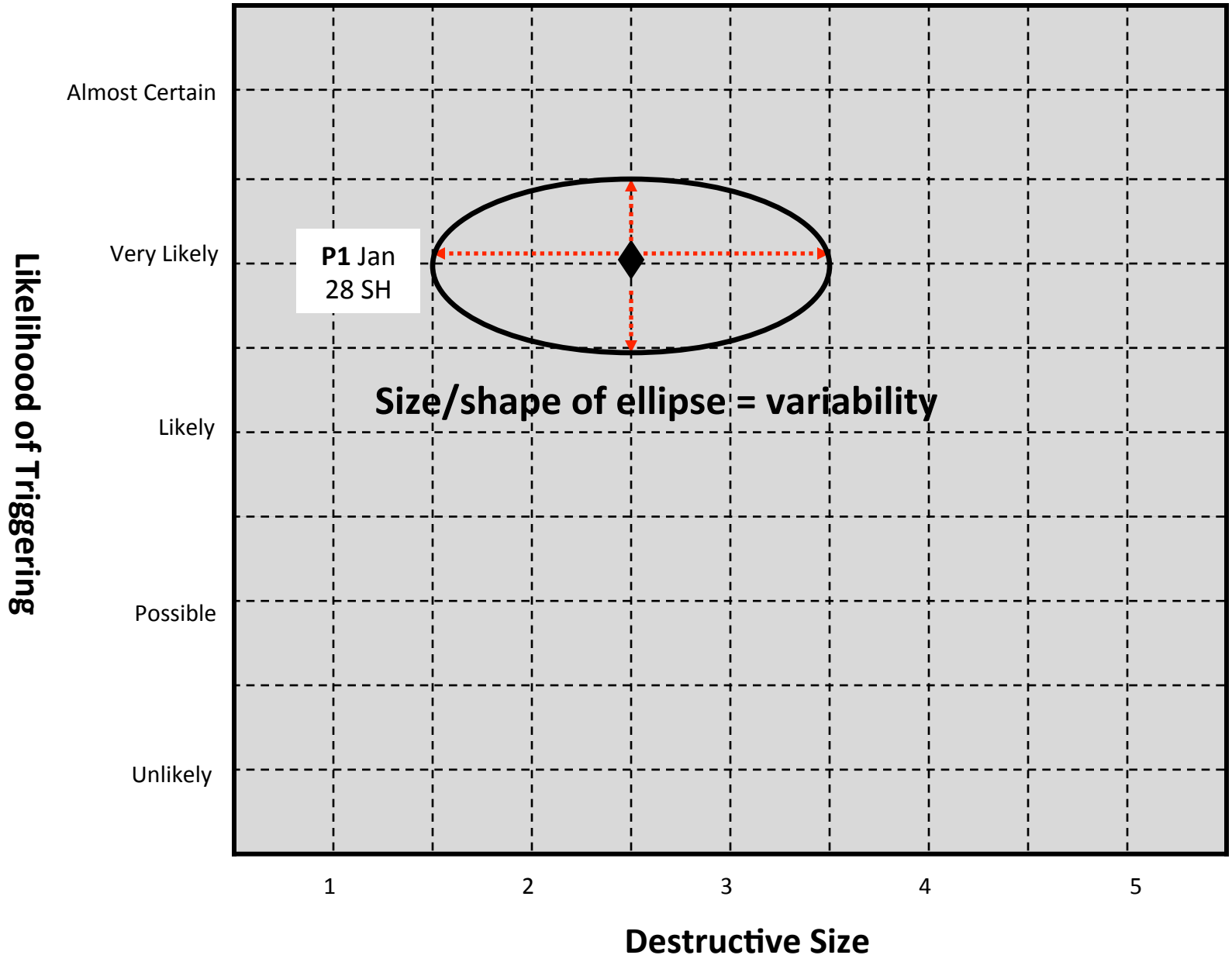
Confidence

Express the Forecaster's degree of confidence

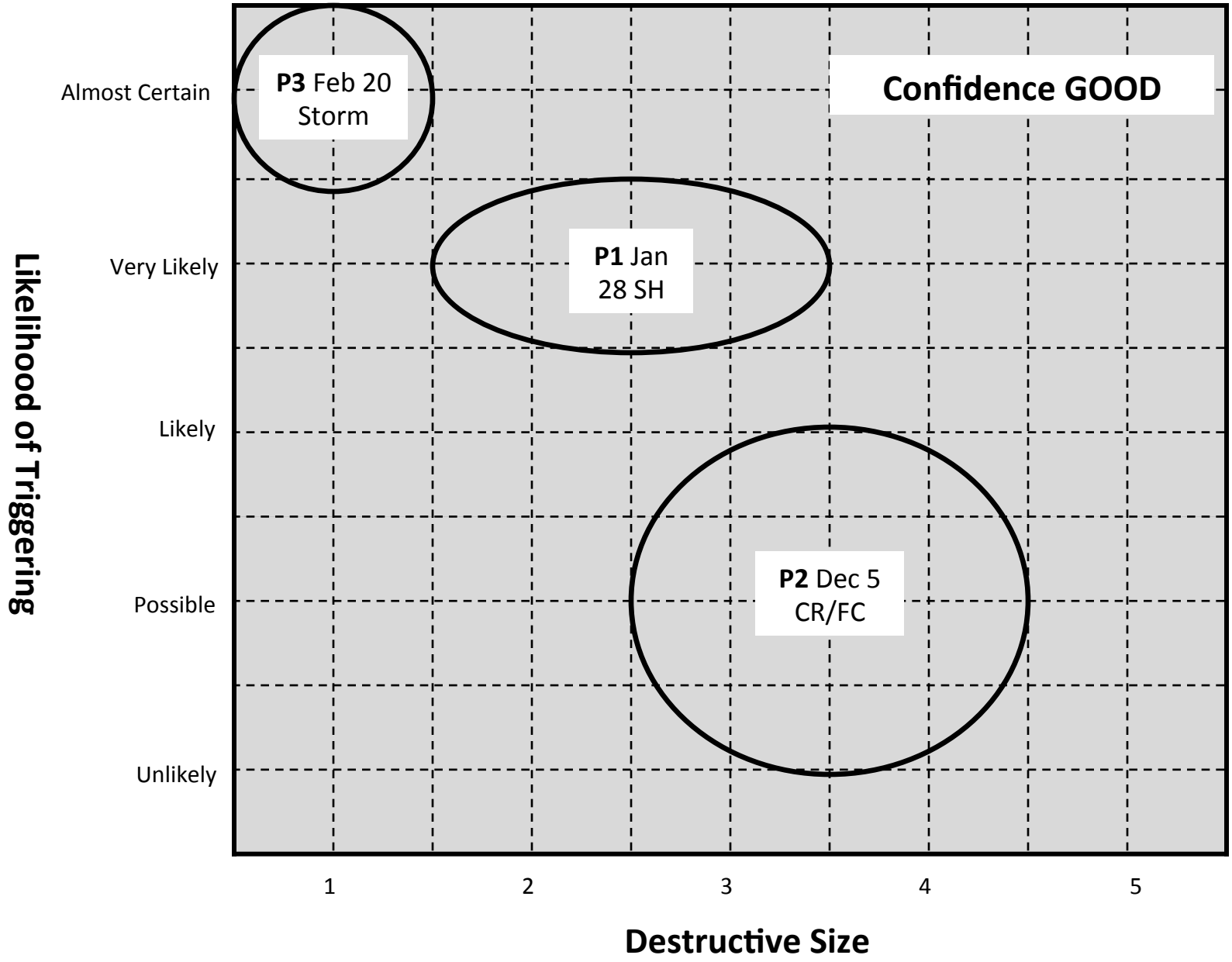
Degree: GOOD, FAIR, LOW

- Anomalies
- Unusual events
- Unprecedented events or conditions
- Amount of data
- Quality of data
- Spatial scale
- Temporal scale
- Spatial variability
- Temporal variability
- Lingering instability
- State of knowledge
- Forecaster's experience

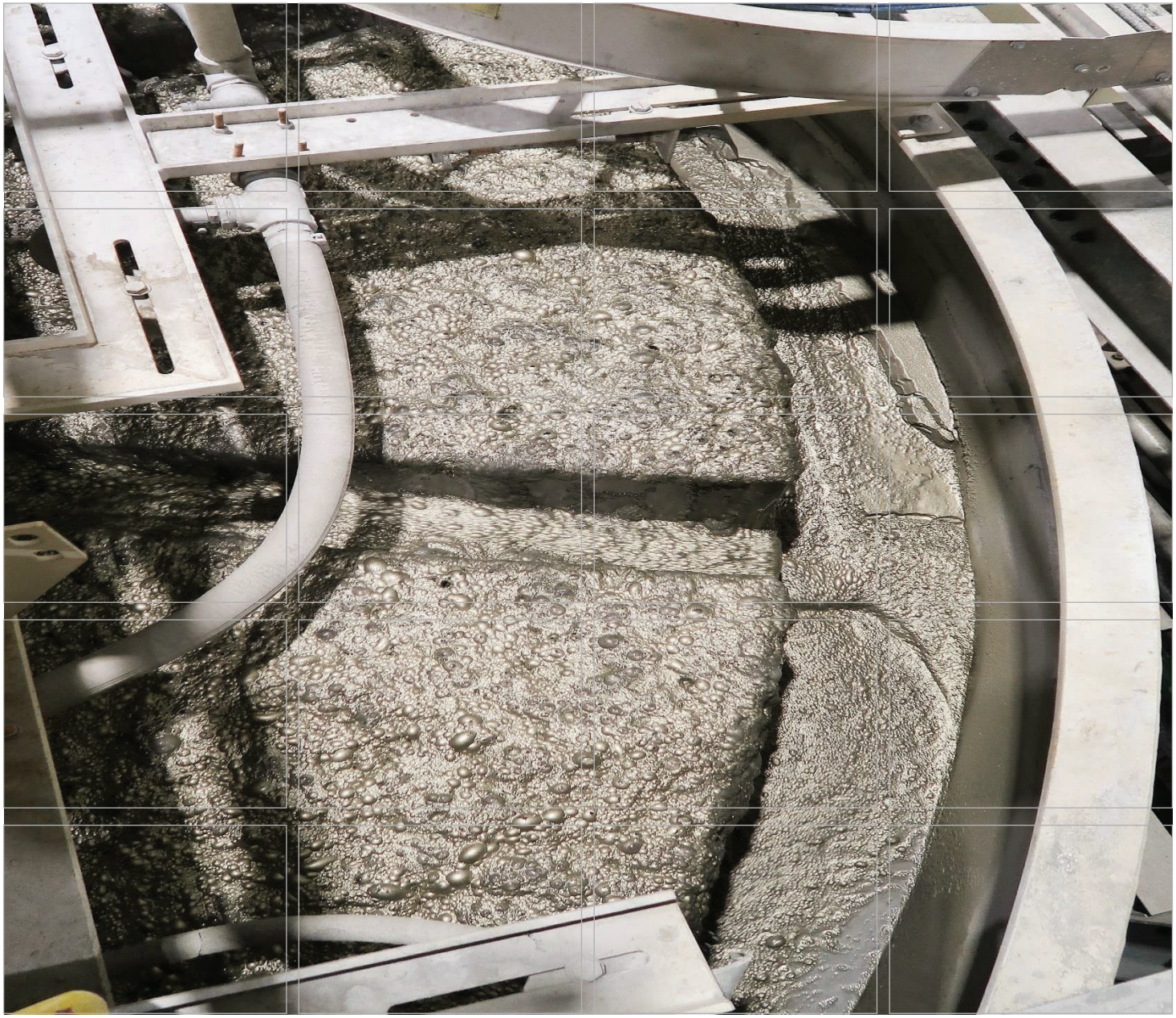
Avalanche Hazard Chart (example)



Avalanche Hazard Chart (example)



Appendix 9-1-6. Chemicals and Materials Storage and Handling Plan



NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Chemicals and Materials Storage and Handling Plan

January 2023

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Chemicals and Materials Storage and Handling Plan

Date: January 2023

Pretium Resources Inc.
Suite 2300, Four Bentall Centre
1055 Dunsmuir Street
PO Box 49334
Vancouver, BC V7X 1L4
T: (604) 558-1784
F: (604) 558-4784

VERSION CONTROL

Version #	Date Released	Amendment/Details
1	May 2015	Original
2	February 2017	Mill Reagent and WTP updated
3	March 2018	Mill Reagent, WTP, and STP updated
3a	December 2018	Version control table updated
4	March 2021	GHS classification, Table 6-1 updated
5	November 2022	Table 6-1 updated
6	January 2023	Updates to chemicals and related quantities (Table 6-1). Document format updated to NCM Brucejack template.

ACKNOWLEDGEMENTS

The May 2015 version of the Chemical and Materials Storage and Handling Plan was prepared by Ray Hollenberg, R.P.Bio. of NorthWest Response Ltd. and reviewed with input from Lauri Solsberg, P.Eng. of Counterspill Research Inc. The February 2017 revision was prepared by Scott Laliberte,. of Pretium Resources Inc., with updates in March 2018 completed by Brett DeHay-Turner with Pretium Resources Inc. March 2021 updates completed by Richelle Sussbauer with Pretium Resources Inc. January 2023 revision was prepared by Scott Laliberte Mill Operations Superintendent, Cameron Edwards, Mill Operations Superintendent, Richelle Sussbauer M.Sc., P.Chem, Environmental Coordinator and reviewed by Torence Sandhals M.Sc., P.Ag, Principal, Environment.

BRUCEJACK

Chemicals and Materials Storage and Handling Plan

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Mill Reagent Storage Plan

1 PURPOSE

The purpose of this plan is to describe the chemicals and materials storage and handling practices that will be used at the Brucejack Mine to achieve worker health, safety and environmental protection. The plan is focused on identification and implementation of best practices that comply with applicable regulatory requirements, are suitable for the particular application, and which will help prevent potential for spills of all chemicals and materials used at the mine. Note that this plan addresses the management of hazardous materials (including toxic substances) and dangerous goods. The management of wastes, including from the on-site incinerator and the sewage treatment plant, are covered in the Waste Management Plan.

2 PERFORMANCE OBJECTIVES

This Chemicals and Materials Storage and Handling Plan (C&M S&H Plan) is designed to meet the following primary performance objectives:

1. Identify the applicable legislative requirements that relate to chemicals and materials storage and handling. This includes both Provincial and Federal legislation and codes of practice. This C&M S&H Plan outlines the key components that Brucejack will adhere to. From these key legislative components site-specific procedures for storage and handling will be further developed.
2. The C&M S&H Plan will identify the existing chemicals and materials (including toxic substances) that are transported to the Brucejack Mine site. As this is an evolving list, the C&M S&H Plan will require frequent updates. The list of chemical products is supplemented with WHMIS and dangerous goods classifications, a summary of storage (including incompatibilities) and handling procedures, via Pretium's online SDS management database.
3. Expand Pretium's existing Workplace Hazardous Materials Information System (WHMIS) at Brucejack to cover additional requirements during Operations.
4. Pretium has adopted the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Health Canada is in the transition phase of aligning the GHS with WHMIS. GHS is a globally recognized system that defines and classifies the hazards of chemical products, and communicates health and safety information on labels and Safety Data Sheets (SDSs).
5. Develop an inspection procedure that confirms the adequacy and effectiveness of storage and handling equipment, facilities and procedures, including with respect to means of containment and transportation.
6. Outline a Prevention Plan for potential spills of chemicals and fuels. Additional procedures will be developed as site specific facilities are developed at the Brucejack Mine. The Prevention Plan will focus on preventing significant adverse environmental effects related to the transportation, on-site manufacturing, storage and handling of chemicals and, materials (including toxic substances).
7. The C&M S&H Plan will also identify the legislative criteria for storage and handling of hazardous and non-hazardous waste. As waste streams and volumes are identified, procedures will be further developed to ensure that the storage and handling, means of containment, transportation and disposal meets the legislative criteria.

To date Pretium has developed numerous plans and procedures to ensure that health, safety, and environmental protection are priorities during mineral exploration, construction, production, and closure.

Spill prevention measures are presented in Appendix A.

3 SCOPE

This Plan applies to all aspects and facilities associated with the Brucejack Mine, including the Brucejack mine site, Brucejack access road, Knipple Transfer Area, Bowser Aerodrome, Brucejack transmission line, and Wildlife and Bowser camps. The plan is applicable to all phases of mine development including construction, operation and closure and is relevant to any employees handling, using or transporting hazardous chemicals and materials.

Specifically, the scope of the Plan is to:

1. Identify the list of chemicals and materials used, stored or transported to the Brucejack Mine, including:
   - WHMIS applicable products;
   - Hazardous wastes which Pretium has currently included or will need to add to its hazardous waste generator registration; and
   - Any other chemicals and materials deemed sufficiently hazardous in the quantities to be used at Brucejack.
2. Use existing site plans and procedures when applicable.
3. Address transportation handling from Highway 37 to the Brucejack site via Brucejack Access Road for all applicable liquids and other materials; address differences, if any, between construction and operations.
4. Detail storage and handling requirements and procedures at the Wildfire Camp, Bowser aerodrome, Knipple Transfer Area, and Brucejack Mine Site.
5. Identify training in storage and handling for chemicals and other substances of concern.
6. Establish procedure to ensure current Plan is up-to-date and in accordance with applicable legislation, regulations and guidance documents.

4 RELEVANT LEGISLATIONS, REGULATIONS, AND EAC CONDITIONS

This Chemicals and Materials Handling Plan for the mine will adopt as a minimum standard compliance with the following federal and provincial legislation regarding hazardous, dangerous, or controlled substances, and general materials storage and handling:

4.1 FEDERAL

- *Transportation of Dangerous Goods Act* and Regulation;
- *Canadian Environmental Protection Act* and Regulation;
- Canada Occupational Health and Safety Regulation; and
- *Explosives Act* and Regulation.

4.2 PROVINCIAL

- BC Fire Code:
  - Sections 3.1, 3.2, 3.3, 4.1 and 4.2.
- BC *Environmental Management Act* and its regulations, including:
  - Petroleum Storage And Distribution Facilities Storm Water Regulation;
  - Spill Reporting Regulation; and
  - Hazardous Waste Regulation.
- BC *Mines Act* and Health, Safety and Reclamation Code for Mines in BC (Code);
- *Workers Compensation Act*:
  - Occupational Health and Safety Regulation.
- Other Best Management Practices/Guidelines; and
- 2014 BC Fuel Guidelines (for Class 3 products).

Natural Resources Canada (NRCan) is responsible for regulating the use of explosives under Part 7(1)(a) of the *Explosives Act*. Significant revisions were made to the regulation of explosives in 2013. As per the requirements of the *Explosives Act*, an Explosives Handling Plan will be completed by the explosives contractor. Additional plans required under the 2013 regulations will also be prepared as required: Security Plan, Fire Safety Plan, and Key Control Plan.

The BC Mine Code also regulates the transportation, use, care and handling of explosives. An Explosives Storage and Use Permit is required from the BC MEM before a magazine is located,

erected, built, put into service, or modified, or before carrying out any maintenance work, including the installation of lighting or heating.

Disclaimer: This plan is not a legal document. Acts, Regulations and Codes always take precedence over any interpretation given in this plan.

4.3 RELEVANT EAC CONDITIONS

Pretium was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions. This management plan fulfills Condition #2, in relation to a Component Plan for mine emergency response planning, presented within Schedule B of the Certificate and copied below.

> *Condition 2*
>
> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

5 PRODUCT CLASSIFICATIONS

5.1 DANGEROUS GOODS CLASSIFICATION

All hazardous materials or dangerous goods in Canada follow the international agreement on classification. This system allows dangerous goods to be transported around the world using a similar regulatory and identification system. Nine classes divide all dangerous goods into specific chemical categories according to their characteristics (Table 5.1-1: Hazardous Goods Classification System).

Table 5.1-1. Hazardous Goods Classification System

Hazardous Products Classification	Placard	Divisions Explanations	Compatibility Group Packing Group	Additional Information
Class 1 Explosives	 	1.1 Mass Explosion Hazard 1.2 Projection Hazard 1.3 Fire Hazard 1.4 Minor Hazard 1.5 Very Insensitive 1.6 Extremely Insensitive	COMPATIBILITY GROUP: A, B, C, D, E, F, G, H, J, K, L, N or S	
Class 2.1 Flammable Gases		2.1 Flammable Gases • Flammable	No Packing Groups	
Class 2.2 Non-Flammable, Non-Toxic Gases	 	2.2 Non-Flammable, Non-Toxic Gases	No Packing Groups	• The only hazard associated with these is that they are compressed gases • A special label and placard must be used for certain oxidizing gases. They are Class 2.2 and a subsidiary Class 5.1
Class 2.3 Toxic Gases		2.3 Toxic Gases • Poisonous or Corrosive	No Packing Groups	
Class 3 Flammable Liquids		No Divisions	<u>Packing Group:</u> I Great Danger II Moderate Danger III Minor Danger	<u>Associated Flash Point:</u> Any Less than 23°C 23°C to 60°C

(continued)

Table 5.1-1. Hazardous Goods Classification System (continued)

Hazardous Products Classification	Placard	Divisions Explanations	Compatibility Group Packing Group	Additional Information
Class 4.1 Flammable Solids		4.1 Flammable Solids • Catches fire easily • Friction sensitive • Difficult to extinguish	Packing Group: I Great Danger II Moderate Danger III Minor Danger	
Class 4.2 Spontaneously Combustible		4.2 Spontaneously Combustible • Ignites without warning • Friction Sensitive	Packing Group: I Great Danger II Moderate Danger III Minor Danger	
Class 4.3 Dangerous When Wet		4.3 Dangerous When Wet • Highly reactive with water	Packing Group: I Great Danger II Moderate Danger III Minor Danger	
Class 5.1 Oxidizers		5.1 Oxidizers • Will burn without oxygen	Packing Group: I Great Danger II Moderate Danger III Minor Danger	• Contains large amounts of readily available oxygen that will feed a fire
Class 5.2 Organic Peroxide		5.2 Organic Peroxides • Unstable and Reactive	Packing Group: I Great Danger II Moderate Danger III Minor Danger	
Class 6.1 Toxic Substances			Packing Group: I Great Danger II Moderate Danger III Minor Danger	
Class 6.2 Infectious Substances		6.2 Infectious Substances Categories: A - Most Hazardous B - Less Hazardous	Category A: • Affecting Humans • Affecting Animals	Category B: • Biological Substances
Class 7 Radioactive Materials		Category III: ***High Risk***, requires special handling	Category II: ***Medium Risk***, requires little special handling	Category I: ***Low Risk***, requires no special handling
Class 8 Corrosive Material		No Divisions	Packing Group: I Great Danger II Moderate Danger III Minor Danger	Associated Skin Damage: Rapid, severe, permanent Severe - moderate contact Severe - long contact
Class 9 Miscellaneous Dangerous Goods		No Divisions	Packing Group: II Moderate Danger III Minor Danger	No PG I - Great Danger

5.1.1 Transportation of Dangerous Goods

In Canada, all the Provinces have adopted the *Transportation of Dangerous Goods Act* and Regulation (with some minor alterations), federally coordinated legislation for the transportation of dangerous goods. The shipment of Dangerous Goods outlines a number of criteria including:

- Classification System for the Nine Classes of Dangerous Goods;
- Means of Containment to ensure good engineering standards are used for the product being transported;
- Placarding of Vehicles criteria based on volumes and product;
- Appropriate Marking of containers, tanks and other means of containment;
- Shipping Documents; and
- Training requirements.

5.2 WHMIS CLASSIFICATION

5.2.1 Workplace Hazardous Materials Information System (WHMIS)

WHMIS (2015) in Canada is now aligned with the Global Harmonized System (GHS) which is divided into class and category. WHMIS (2015) has 3 hazard classes: Health Hazards, Physical Hazards, and Environmental Hazards. There are 16 physical and 10 health hazards which are further divided in accordance to their severity levels (Table 5.2-1)

Table 5.2-1. WHMIS (2015) Classification System and Pictograms

Physical Hazards		Health Hazards		Environmental Hazards	
Hazard Class	**Associated Hazard Category**	**Hazard Class**	**Associated Hazard Category**	**Hazard Class**	**Associated Hazard Category**
Explosives	Divisions 1.1-1.6 (with 1.1 being the most hazardous, 1.6 the least hazardous)	Acute toxicity	Categories 1-4 (with 1 being the most dangerous)	Acute Aquatic Toxicity	Categories 1 -3
Flammable gases	Categories 1 and 2	Skin corrosion	Categories 1A, 1B, 1C, and 2	Chronic Aquatic Toxicity	Categories 1 - 4
Flammable aerosols	Categories 1 and 2	Skin irritation	Categories 1A, 1B, 1C, and 2	**Pictograms** Explosive Flammable Compressed gas Oxidizing Reactive Acute Harmful Health Hazard	
Oxidizing gases	Category 1	Eye Effects	Categories 1, 2A, and 2B		
Gases under pressure	4 Groups include: Compressed gas, Liquefied gas, Dissolved gas, and Refrigerated liquefied gas	Sensitization (Skin or Eye)	Category 1A and 1B		
Flammable liquids	Categories 1 - 4	Germ cell mutagenicity	Categories 1A, 1B, and 2		
Flammable solids	Categories 1 and 2	Carcinogenicity	Categories 1A, 1B, and 2		
Self-reactive substances	Types A-G	Reproductive toxicity	Categories 1A, 1B, 2, and additional category for effects on or via lactation		
Pyrophoric solids	Category 1	Target organ systemic toxicity: single and repeated exposure	Single: Categories 1-3 Repeated: Categories 1 and 2		
Pyrophoric liquids	Category 1	Aspiration toxicity	Category 1 and 2		
Self-heating substances	Categories 1 and 2	Biohazardous infectious materials	Category 1		
Substances which in contact with water emit flammable gases	Categories 1 - 3				
Oxidizing liquids	Categories 1 - 3				
Oxidizing solids	Categories 1 - 3				
Organic peroxides	Types A-G				
Substances corrosive to metal	Category 1				

Note that the *Workers Compensation Act* - Part 2 Section 108 (2) (a) exempts mines from the *Workers Compensation Act* as WHMIS is covered separately under the *Mines Act*.

In Canada, certain products are controlled by other regulations/legislation and are therefore exempt from the WHMIS legislation with regards to labeling and SDS requirements. These products are not, however, exempt from training requirements. Still other products are neither WHMIS-regulated nor controlled under any other legislation yet require training to ensure safe handling.

The products that are exempt from WHMIS legislation include:

- Hazardous Materials in Transit (regulated by the *Transportation of Dangerous Goods Act* and Regulation);
- Hazardous Waste (regulated by the *Environmental Management Act* and Hazardous Waste Regulation);
- Explosives (regulated by the *Explosives Act*);
- Pesticides (regulated by the *Pest Control Products Act*); and
- Radioactive Materials (regulated by the *Nuclear Safety and Control Act*).

5.2.2 WHMIS Regulation (Mines Act)

Applies to employers and workers with respect to controlled products used, stored or handled at a place of employment. The WHMIS framework includes these basic topics:

- Worker Education/Training;
- Labeling: Supplier/Workplace/Laboratory;
- Placarding;
- Identifiers: Pipes/Vessels/Tanks; and
- SDS Information.

5.3 HAZARDOUS WASTE CLASSIFICATION

As defined under the Hazardous Waste Regulation (BC *Environmental Management Act*) Part 1 Interpretation and Application, Hazardous Waste means:

- Dangerous goods if they:
  - are no longer used for their original purpose, and
  - meet the criteria for Class 2, 3, 4, 5, 6, 8 or 9 of the federal dangerous goods regulations, including those that are recycled, treated, abandoned, stored or disposed of, intended for recycling, treatment or disposal or in storage or transit before recycling, treatment or disposal;

- PCB wastes;
- Biomedical wastes;
- Wastes containing dioxin;
- Waste oil;
- Waste asbestos;
- Waste pest control product containers and wastes containing pest control products, including wastes produced in the production of treated wood products using pest control products;
- Leachable toxic waste;
- Waste containing tetrachloroethylene;
- Wastes listed in Schedule 7; and
- Waste containing polycyclic aromatic hydrocarbon.

5.3.1 Hazardous Waste Registration

In accordance with *Environmental Management Act* requirements under the Hazardous Waste Regulation, the Brucejack exploration site was registered for specified volumes of hazardous waste (waste oil and batteries) in September 2013. Pretium's Waste Generator Number for Brucejack is BCG 10829. This registration will be updated as required during Operations.

The following excerpt of the Hazardous Waste Regulation outlines the requirements. See Table 5.3-1 for Registration Quantities.

Table 5.3-1. Waste Regulation: Schedule 6 Registration Quantities

Ref.	Column I Category of Hazardous Waste	Column II Quantity
1	Dangerous Goods Meeting the Criteria for Class 2.1 of the Federal Dangerous Goods Regulation	500*
2	Dangerous Goods Meeting the Criteria for Class 2.2 of the Federal Dangerous Goods Regulation	1,000*
3	Dangerous Goods Meeting the Criteria for Class 2.3 of the Federal Dangerous Goods Regulation	50*
4	Dangerous Goods Meeting the Criteria for Class 3 of the Federal Dangerous Goods Regulation	500
5	Dangerous Goods Meeting the Criteria for Class 4.1 of the Federal Dangerous Goods Regulation	1,000
6	Dangerous Goods Meeting the Criteria for Class 4.2 of the Federal Dangerous Goods Regulation	100
7	Dangerous Goods Meeting the Criteria for Class 4.3 of the Federal Dangerous Goods Regulation	100
8	Dangerous Goods Meeting the Criteria for Class 5.1 of the Federal Dangerous Goods Regulation	100
9	Dangerous Goods Meeting the Criteria for Class 5.2 of the Federal Dangerous Goods Regulation	5
10	Dangerous Goods Meeting the Criteria for Class 6.1 of the Federal Dangerous Goods Regulation	100
11	Dangerous Goods Meeting the Criteria for Class 6.2 of the Federal Dangerous Goods Regulation	100
12	Dangerous Goods Meeting the Criteria for Class 8 of the Federal Dangerous Goods Regulation, Other than Waste Batteries	100

13	Dangerous Goods Meeting the Criteria for Class 9 of the Federal Dangerous Goods Regulation	500
14	PCB Waste	5
15	Biomedical Waste	100
16	Waste Containing Dioxin	5
17	Waste Oil Whether Or Not Contaminated With Lead	5,000
18	Waste Asbestos	1,000
19	Pest Control Product Containers	500
20	Waste Pest Control Product	100
21	Leachable Toxic Waste	500
22	Waste Containing Tetrachloroethylene	200
23	Waste Containing Polycyclic Aromatic Hydrocarbon	5
24	Waste Listed In Schedule 7	100
25	Batteries That Are Hazardous Waste	2,000

**Total Liquid volume of containers (kg or L as appropriate)*
From: Environmental Management Act; Hazardous Waste Regulation [en. B.C. Reg. 261/2006, s. 32.] Schedule 6

Administrative Requirements

- Registration of Hazardous Waste:
  - A person who,
    - within a 30 day period, produces, or
    - at any time, stores at an onsite facility a quantity of a category of hazardous waste greater than the quantity set out in Column II of Schedule 6 (see Table).

Additional Requirements

- Spill Protection and Reporting:
  - Provide and maintain a Spill Contingency Plan to contain on site any release of spilled hazardous waste.
  - Inspect the facility monthly, and where free liquid hazardous waste is stored at the facility:
    - Provide and maintain 24 hour spill alarm system; and
    - Inspect the facility weekly for any irregularities.
  - Maintain at the facility a record of inspection including:
    - Inspection dates;
    - Irregularities and maintenance; and
    - Corrective Action and dates.
- Contingency Plan:
  - Prepare and maintain in up-to-date readiness a contingency plan with the following:

    - Shut down procedures;
    - Communication networks;
    - Notification procedures;
    - Evacuation procedures;
    - Abatement measures; and
    - Inventories of spill response and cleanup equipment.
  - Appoint an Emergency Response Coordinator and an alternate with authority to carry out action in accordance with the contingency plan.
  - Provide copies of the Contingency Plan to:
    - Emergency Response Coordinator;
    - Alternate Emergency Response Coordinator; and
    - Director (regulatory).
  - Proved cleanup equipment, sorbents and other material and protective equipment and clothing, for all emergency staff at the facility, appropriate for all the hazardous wastes managed at the facility.

- Closure Plan:
  - A hazardous waste facility may not operate the facility unless a written closure plan has been approved by the director (regulatory). The closure plan must include:
    - A schedule of how and when the facility will be closed;
    - A description of the decontamination procedures to be followed; and
    - A description and estimate of the quantity of any hazardous waste residues which will remain at the site after closure.
  - Any changes to the facility, time frames, operational plans, closure dates, etc., must be submitted in an amendment to the plan for approval.

- Mixing and Dilution:
  - A person must not mix or dilute hazardous waste with any solid or liquid, including waste, water or rain water, or otherwise take action by dividing a hazardous waste to evade the Hazardous Waste Regulations or any other regulations.

6 PRODUCT INVENTORY AND SUMMARY

The current product inventory (Table 6-1) includes the chemicals and materials that are transported, stored, and consumed as well as waste materials generated at the Brucejack Mine. As the Operations phase continues, the chemicals and materials in Table 6-1 will continue to evolve and the table will be updated accordingly.

Table 6-1. Chemicals and Materials for Mine Operations

Item/ Description	Material	Quantity			
		Supply		Waste	
Reagents - Lab	Litharge (PbO)	4,000	kg/yr	-	kg/yr
	Pre-mixed flux (55% PbO)	66,000	kg/yr	-	kg/yr
	Pre- mixed flux (70% PbO)	11,000	kg/yr	-	kg/yr
	Borax ($Na_2B_4O_7$)	1,000	kg/yr	-	kg/yr
	Soda Ash (Na_2CO_3)	1,500	kg/yr	-	kg/yr
	Silica Flour (SiO_2)	1,000	kg/yr	-	kg/yr
	Flour ($C_6H_{10}O_5$)	240	kg/yr	-	kg/yr
	Nitric Acid (HNO_3)	1,000	L/yr	-	L/yr
	Hydrochloric Acid (HCl)	3000	L/yr	-	L/yr
	Hydrofluoric Acid (HF)	800	L/yr	-	L/yr
	Perchloric Acid ($HClO_4$)	420	L/yr	-	L/yr
	Lead Foil (Pb)	150	kg/yr	-	kg/yr
	Potassium Nitrate (KNO_3)	500	kg/yr	-	kg/yr
	Silver (Ag)	15	kg/yr	-	Kg/yr
	Others	0	kg/yr	-	kg/yr
	Acetylene	830	cylinders/yr	-	cylinders/yr
	Argon	10,000	cylinders/yr	-	cylinders/yr
	Solids Waste (test tubes, cupels, crucibles)	-		150	Mt/yr
	Ammonium hydroxide (NH_4OH)	40	L/yr		
	Gold stock solution (Au) 1,000 ppm	5	L/yr		
	Silver stock solution (Ag) 1,000 ppm	5	L/yr		
	Arsenic stock solution (As) 1,000 ppm	25	M^3/yr		
	Oxygen	1,180	M^3/yr		
	Sodium hydroxide (NaOH)				
	Copper inquart				
	Other metals stock solution	25	L/yr		
Reagents - WTP	Hydrated Lime ($Ca(OH)_2$)	146	t/yr		
	Ferric Sulphate ($Fe_2(SO_4)_3$)	260	t/yr		
	AN905 Polymer	4	t/yr		
	Microsand	4	t/yr		

	Sulphuric Acid (93%) (H_2SO_4)	8	t/yr		
	Sodium Sulphide (Na_2S)	TBD	t/yr		

(continued)

Table 6-1. Chemicals and Materials for Mine Operations (continued)

Item/ Description	Material	Quantity			
		Supply		Waste	
Reagents - STP	Sodium hypochlorite	4,000	L/yr		
	Sodium hydroxide	11,000	L/yr		
	Aluminum sulphate	15,000	L/yr		
	Citric acid	2,400	L/yr		
	Anti-foam	2,400	L/yr		
	CE 8057 polymer coagulant	2,400	L/yr		
	WTP Sludge	-	t/yr	0	t/yr
Reagents - Process	Silica (SiO2)	5	t/yr	-	t/yr
	Soda Ash	3	t/yr	-	t/yr
	Sodium Hydroxide	7000	L/yr	-	L/yr
	Vancol PAX 90%	113	t/yr		
	Vanfroth 250	29	t/yr		
	AN910 Polymer	133	t/yr	-	t/yr
	Antiscalant	6	t/yr	-	t/yr
	Binder Terraflow	30,000	t/yr	-	t/yr
	Sodium Nitrate	10	t/yr		
	Borax	6	t/yr	-	t/yr
	Manganese Dioxide	180	kg/yr	-	kg/yr
Explosive		2,300	t/yr	-	t/yr
Cement	Terrflow	36,000	t/yr	-	t/yr
Diesel		5,500,000	L/yr	-	L/yr
Fluids/Oils/Fuel	Lubricants	2,000	L/yr	830	L/yr
	Grease	2,160	KG/yr	1728	L/yr
	Smartwasher® Industrial Grade Cleaning Solution (OzzyJuice)	100	L/yr	100	L/yr
	Glycol	3500	L/yr		
	Engine Oils	25,220	L/yr	12,000	L/yr
	Hydraulic Oil	18,000	L/yr	14,400	L/yr
	Trans Fluid	300	L/yr	240	L/yr
	Brake Oil	30,000	L/yr	24,000	L/yr
	Transmission/Diff/Axel Oil	14,00	L/yr	8,800	L/yr
	Jet Fuel	80,500	L/yr	-	L/yr
Steel/metal	Ground Support Waste Steel		t/yr	190	t/yr
	Drill Steel, Bits and Shank		t/yr	17	t/yr
	Scrap Steel/Metals		t/yr	64	t/yr

	Steel Liners	180	t/yr	40	t/yr
	Steel Drums		pieces/yr	150	pieces/yr
	Grinding Circuit Steel Balls	1,100	t/yr	13	t/yr
	Cables		t/yr	1	t/yr

(continued)

Table 6-1. Chemicals and Materials for Mine Operations (completed)

Item/ Description	Material	Quantity			
		Supply		Waste	
Rubbers	steel/Rubber Liners (Composite)		t/yr	31	t/yr
	Rubber Liners			2	t/yr
	Conveyor Belts and Other Belts		t/yr	2	t/yr
	Rubber Tires		t/yr	13	t/yr
Camps	Cleaning Supplies, including bleach, dishwashing powder, soaps, detergent	12.78	t/yr	-	t/yr
	General Camp Waste, including bottles, cans and cups		t/yr	200	t/yr
	Waste Foods		t/yr	60	t/yr
	Propane – Brucejack Camp	526,497	L/yr	-	L/yr
Others	Plastic Drums		pieces/yr	150	pieces/yr
	Tote Bags	1100	pieces/yr	23	t/yr
	Cardboard Boxes		t/yr	30	t/yr
	Woods/Pallets		t/yr	20	t/yr
	Fluorescent tubes/bulbs		pieces/yr	100	pieces/yr
	Batteries		pieces/yr	800	pieces/yr
	Printer/Copier Toner Cartridges		pieces/yr	40	pieces/yr
	Paints		L/yr	250	L/yr
	HDPE Pipes		m/yr	1,700	m/yr
	Air Hose		m/yr	500	m/yr
	1" Water Hose		m/yr	500	m/yr
	Paint Cans		pieces/yr	3,500	pieces/yr
	Hydraulic Hose		m/yr	800	m/yr
	1200 mm Vent Bag		m/yr	1,000	m/yr
	Filters				
	Fuel Filter	800	piece/yr	800	piece/yr
	Air Filter	800	piece/yr	800	piece/yr
	Hydraulic Oil Return Filter	300	piece/yr	300	piece/yr
	Brake Hydraulic Oil Return Filter	600	piece/yr	600	piece/yr
	AC Filter	600	piece/yr	600	piece/yr
	Transmission Oil Filter	300	piece/yr	300	piece/yr
	Oil Filters	800	piece/pyr	800	piece/yr

Sewage Sludge		t/yr	10	t/yr
Tailings to lake		t/yr	899,685	t/yr
Waste Rock		t/yr	720,000	t/yr
Soda Ash for potential spill cleanup	2	t/stored		

Product summaries, including product name, the classification and placard, the WHMIS classification and label, and the storage and handling procedures are stored in Pretium's online SDS management system. This database is accessible to all Pretium staff and is the primary resource for product information at Brucejack.

7 STORAGE STANDARDS

The storage standards at Brucejack Mine will follow the Federal and Provincial legislative criteria, where applicable. The three specific legislative criteria that address storage standards for chemicals, hazardous and toxic substances can be found in the following:

1. BC Fire Code (Section 7.1);
2. Workplace Hazardous Information System (Section 7.2); and
3. *Transportation of Dangerous Goods Act* (Section 7.3).

Storage standards for dangerous goods are addressed in detail in the BC Fire Code. The Fire Code specifically details fire safety and chemical compatibility of indoor storage and outdoor storage. Requirements for stationary tanks for flammable and combustible products are noted in the Fire Code. The BC Fire Code requires dangerous goods to comply with secondary containment stipulations when stored on site. These storage standards are not chemical specific (except for compressed gases and ammonium nitrate).

Workplace Hazardous Information System (*Mines Act*) outlines the requirements for Safety Data Sheets (SDS). The supplier must prepare and send an SDS with all controlled and uncontrolled products that are shipped to the site. Storage criteria for each product are listed under a separate section of the SDS. The most significant aspect of storing dangerous goods is that they are separated from incompatible products.

The *Transportation of Dangerous Goods Act* (TDG) addresses the specific means of containment for dangerous goods. The means of containment under TDG are specific to mobile tanks; however, the requirements are also acceptable for stationary tanks.

7.1 FIRE CODE (PART 3) STORAGE REQUIREMENTS

Pretium will implement all of the applicable requirements to the indoor and outdoor storage of chemicals and materials at the Brucejack Mine, as per the BC Fire Code.

7.1.1 Indoor Storage

General Requirements for All Chemical and Material Stored Indoors

- Access aisles of 1 m wide will be maintained. Main access aisle will be 2.4 m wide with two (2) access points.
- Clearances of 1 m to top of ceiling will be maintained in buildings without sprinkler systems.
- Combustible pallets storage will not exceed 1.2 m in height by 7.5 m in width.
- Fire Safety Plan will identify:
  - Product classification and where it is stored;
  - Method of storage, aisle widths, heights and size;
  - Contact information of key personnel and suppliers in the event of an emergency;
  - Hazards associated with chemicals stored and any potential incompatibilities;
  - Cross reference to Spill Response Plan; and
  - Personal Protective Equipment and other precautions.
- Smoking will not be permitted in an indoor storage area with dangerous goods.
- Storage arrangements will be determined based on stability of the stored products.

Indoor Storage of Dangerous Goods

- Ignition sources will be eliminated and only intrinsically safe electrical systems will be used where storing Dangerous Goods.
- Ambient conditions will be dry and cool with adequate ventilation:
  - Ambient temperature – dangerous goods will not be stored in areas where ambient temperatures may cause them to become unstable or susceptible to undesirable reactions.
  - Ammonium nitrate (Class 5.1) and Compressed gases (Class 2) will not be stored in an area where ambient air temperature is higher than 52°C.
- Good housekeeping practices will ensure that the storage area will remain free of clutter and accumulation of products that are not used.
- Storage arrangements – only compatible dangerous goods will be stored together and incompatible dangerous goods will be separated.
- Packages and containers will be made of materials that are compatible with the product they contain and of a durable construction and design to resist damage from normal handling activities.
- Separation from other Dangerous Goods will conform to:
  - Table 7.1-1: Separation Chart for Storage of Dangerous Goods; and
  - SDS Information.

- Corrosion Protection – measures will be taken to prevent or minimize corrosion due to contact with specific corrosive products.
- Flooring material will be constructed and maintained as an impervious membrane.
- Fire suppression system will consist of a sprinkler system or other fire suppression system, designed in conformance with good engineering practice with respect to the specific dangerous goods stored.
- Smoke and toxic gas venting is required where the collective individual storage areas for the dangerous goods exceed 10 m² in a fire compartment. Table 7.1-1. Dangerous Goods Classification – Storage Separation Chart

Class	2.1	2.2	2.3	3	4.1	4.2	4.3	5.1	5.2	6	8
2.1	-	P	X	P	P	A	DS	X	X	X	X
2.2	P	-	P	P	P	P	P	P	P	P	P
2.3	X	P	-	X	A	A	DS	A	X	DS	A
3	P	P	X	-	P	A	A	X	X	DS	A
4.1	P	P	A	P	-	A	DS	X	X	DS	A
4.2	A	P	A	A	A	-	DS	X	X	DS	A
4.3	DS	P	DS	A	DS	DS	-	X	X	DS	X
5.1	X	P	A	X	X	X	X	-	X	A	X
5.2	X	P	X	X	X	X	X	X	-	X	X
6	X	P	DS	DS	DS	DS	DS	A	X	-	A
8	X	P	A	A	A	A	X	X	X	A	-

X = Incompatible goods: do not store goods together in the same fire compartment.
A = Incompatible goods: separate goods by a horizontal distance of not less than 1 m.
P = Permitted: goods are permitted to be stored together.
DS = Refer to Material Safety Data Sheet.
Source: BC Fire Code Section 3.2.7.6

- Spill control – measures to control spilled liquid or solid dangerous goods will be provided in conformance with Subsection 4.1.6 of the Fire Code.
  - Materials or liquids used in the cleanup of spills and leakages of dangerous goods will be compatible and non-reactive with the dangerous goods being cleaned up and disposed of in conformance with Subsection 4.1.6 of the Fire Code.
  - A spill will be prevented from flowing outside the spill area and from reaching waterways, sewer systems and potable water sources by constructing a non-combustible barrier capable of containing the spill or by grading the site or sloping the floor to divert the spill to a drainage system.
  - Barriers capable of containing a spill will conform to the requirements for secondary containment as outlined in Section 4.3.7 of the BC Fire Code.
- Fire/Emergency response access will be maintained at all times:
  - Access will be free of obstructions; and

  - Access includes windows, roof, building and response equipment stored at the site.
- Labels will be used to properly identify the classification of dangerous goods or waste product.
- Placards will be used for storage areas:
  - for a single product only a UN number will be posted;
  - for multiple products with the same class, the individual class and driving placard will be posted; and
  - for more than one class of products, a placard for each individual class will be posted at the entrance to the storage area.
- Training in the following areas will be provided for all employees involved in the storage and handling of dangerous goods:
  - safe storage and handling procedures;
  - personal protective equipment;
  - product inventory and SDS information; and
  - correct response to an emergency situation.
- Security and unauthorized access will be maintained where storage of chemicals require personal protective equipment and trained personnel.

Indoor Storage of Compressed Gases (Fire Code Section 3.2.8)

- Flammable Gases:
  - Class 2.1 gases will be stored in a room that is separate from the building;
  - along an exterior wall of the building;
  - that can be entered from the exterior;
  - is designed with good engineering practices to prevent critical structural or mechanical damage from an interior explosion;
  - is provided with natural or mechanical ventilation so that flammable vapours do not exceed 25% LEL; and
  - is provided with natural or mechanical ventilation capable of exhausting at least 18 $m^3/h/m^2$ of room area, but not less than 250 m^3/h.
- Indoor Storage of Poisonous, Corrosive or Oxidizing Gases
  - Class 2.3 toxic or corrosive gases or Class 2.2 (2.5) oxidizing gases will be stored in a room that is separate from the building;
  - along an exterior wall of the building;
  - that can be entered from the exterior;
  - is provided with ventilation to the outdoors; and
  - will not be stored in the same room as combustible materials.

Indoor Storage of Ammonium Nitrate (Class 5.1)

- Storage buildings with ammonium nitrate mixtures (Class 5.1 oxidizing substances) in quantities exceeding 1,000 kg inside buildings will:
  - meet venting requirements;
  - have flooring constructed of non-combustible materials;
  - meet specific building codes as outlined in Section 3.3.6.6 Division B of the BC Building Code; and
  - have ambient temperatures not exceeding 52˚C.
- Industrial trucks used to transport ammonium nitrate will:
  - not remain in the building with engine on;
  - not be refueled inside the building; and
  - be cleaned of any remaining product.
- Portable extinguishers with pressurized water having a rating of 2-A or larger will be installed:
  - dry chemical extinguishers are not permitted to fight fires involving ammonium nitrate.

7.1.2 Outdoor Storage

General Requirements for All Products including Dangerous Goods

- Height restrictions for outdoor storage must be stable, and not exceed limits specified in Subsection 3.3.3 (BC Fire Code*: Division B, Part 3, Section 3.3*).
- Individual storage areas and clearances are specified in Subsection 3.3.3 (BC Fire Code*: Division B, Part 3, Section 3.3*). Outdoor storage of any product covered in the BC Fire Code must be no less than 30 m between stored product and brush or forested areas and; no less than 6 m between stored product and uncontrolled grass or weeds.
- Storage Beneath Power Lines is prohibited.
- Fire access will be maintained at all times.
- Fencing will be installed to prevent accidental or unauthorized entry to a storage area containing dangerous goods.
- Maintenance requirements
  - any access route, gateway or clear space will be:
    - maintained to allow access by emergency response personnel; and
    - kept clear of obstructions and piles of snow.
- No ignition sources, open flames, sparks, or heat will be permitted in an outdoor storage area for dangerous goods.
- Fire Safety Plan will identify:
  - Product classification and where it is stored;

  - Method of storage, location, heights and volumes;
  - Contact information of key personnel and suppliers in the event of an emergency;
  - Hazards associated with chemicals stored and any potential incompatibilities;
  - Cross reference to Spill Response Plan; and
  - Personal Protective Equipment and other precautions.
- Portable extinguishers are required for on-site buildings and mobile equipment operating in an outdoor storage area.
- Site preparation will be level and solid ground or paved with asphalt, concrete or other hard surface material.
- Fuel dispensing will conform to Section 4.6 (Fuel Dispensing Stations):
  - 6 m clear spacing will be maintained between the stored product and fuel dispensers.
- Spill control – measures to control spilled liquid or solid dangerous goods will be provided in conformance with Subsection 4.1.6 of the Fire Code:
  - materials or liquids used in the cleanup of spills and leakages of dangerous goods will be compatible and non-reactive with the dangerous goods being cleaned up and disposed of in conformance with Subsection 4.1.6 of the Fire Code.
  - a spill will be prevented from flowing outside the spill area and from reaching waterways, sewer systems and potable water sources by constructing a non-combustible barrier capable of containing the spill, or grading the site or sloping the floor to divert the spill to a drainage system.
  - barriers capable of containing a spill will conform to the requirements for secondary containment as outlined in Section 4.3.7 of the BC Fire Code.
- Fire separation:
  - It is permitted to reduce the clearance space between individual storage areas if a non-combustible fire separation or dirt berm, not less than 1.5 times the height of the stored product, is provided.
- Fire protection:
  - The prescribed height and size of an individual storage area (BC Fire Code: *Division B, Part 3, Section 3.3, Subsection 3.3.3* and *3.3.4)* may be increased, if fire suppression/ extinguishing measures, conforming to good engineering practices, are provided.

Outdoor Storage of Dangerous Goods

- Individual Storage Areas and Clearances:
  - storage area for dangerous goods will not exceed 1,000 m^2.
  - 6 m clearance will be maintained around individual storage area of dangerous goods.
  - storage of dangerous goods will not exceed 6 m in height.

- Incompatible dangerous goods will be stored with a minimum horizontal distance of 3 m.
- Dangerous goods and other combustible products will not be stored in the same individual storage area.
- Labels will be used to properly identify the classification of dangerous goods or waste product (see Handling Standards).
- Training will be provided as follows for all employees involved in the storage, handling of dangerous goods:
  - safe storage and handling procedures;
  - personal protective equipment;
  - product inventory and SDS information; and
  - correct response to an emergency situation.
- Safety precautions will be taken when storing dangerous goods outside to ensure that undesirable reactions do not occur as a result of environmental exposure and atmospheric conditions.
- Intermodal Shipping Containers and their contents will be stored in conformance to the segregation requirements outlined in IMO 2006, "International Maritime Dangerous Goods Code."

Outdoor Storage of Compressed Gases

- Supported on a raised concrete or other non-combustible platform and located in a fenced enclosure.
- Clearances of cylinders of Class 2.1 flammable gases and Class 2.3 toxic or corrosive gases will be stored 15 m from any building opening if the aggregate capacity of expanding gas is 500 m^3 or more (see BC Fire Code - Part 3, Section 3.3.5.3 for more details).

7.2 WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM REGULATION (*MINES ACT*) STORAGE REQUIREMENTS

SDS (Safety Data Sheet) provides details on specific products. The SDS for each product is stored in Pretium's online SDS management database. The SDS is provided by the product supplier, however it is usually developed by the manufacturer.

WHMIS requires the following information to be included in every SDS:

- Identification
- Hazard Identification
  - Classification including pictograms, signal words and precautionary statements
- Composition/Information on ingredients
- First-aid measures

- Fire-fighting measures
- Accidental release measures
- Handling and storage
    - Precautions for safe handling, conditions for storage, including any incompatibilities.
- Exposure controls/Personal protection
- Physical and chemical properties
- Stability and reactivity
- Toxicological information
- Ecological information*
- Disposal considerations*
- Transport information*
- Regulatory information*
- Other information
    - Date of latest revision of the SDS

*headings are required to be present but the supplier has the option to not provide information

7.3 SDSS ARE REQUIRED TO BE ACCURATE AT THE TIME OF SALE. AN SDS WILL BE REQUIRED TO BE UPDATED WHEN THE SUPPLIER BECOMES AWARE OF ANY SIGNIFICANT NEW DATA. THE REQUIREMENT TO UPDATE EVERY 3 YEARS NO LONGER APPLIES UNDER WHMIS (2015).TRANSPORTATION OF DANGEROUS GOODS (TDG) STORAGE REQUIREMENTS

Table 7.3-1 outlines the most common means of containment for dangerous goods. Although these containers fall under the Transportation of Dangerous Goods Regulation, they do apply to storage of all dangerous goods. The TDG Regulations outline five sections that address means of containment:

- Explosives – Compatibility Chart;
- Gases;
- Small Means of Containment (<450 L);
- Large Means of Containment (≥450 L); and
- Radioactive Materials.

Table 7.3-1. Summary of the Most Common Means of Containment

Hazardous Products Classification	Small Containers (<230 L) Mobile and Stationary –secondary containment not required	Small Means of Containment (<450 L) Mobile	Large Means of Containment (>450 L and <3,000 L) Mobile	Aboveground Storage Tank (>230 L) Stationary – secondary containment is required	Other Acceptable Means of Containment and Exemptions or Special Packaging Instructions
Class 1, Explosives					CGSB-43.151 for Class 1, Explosives
Class 2, Gases		• CGSB-43.123 including Class 2.1 or 2.2	• CGSB-43.123 including Class 2.1 or 2.2	• CAN/CSA-B149.1-05 installations • CAN/CSA-B149.2 Propane Storage and Handling Code	• Other Standards • CSA B340 • CSA B342 • CSA B622 • CSA B625 • TP14877
Classes 3, 4, 5, 6.1, 8, and 9, Dangerous Goods	• TP14850	• CGSB-43.146 • TP14850	• CGSB-43.146 UN 31A and 31B IBC Portable Tanks • CSA B621 • CSA B625-13 UN Standardized Portable Tanks • TP14877 • ULC/ORD 142.13 (TC *Equivalency Permit no longer required*)	• ULC-S601 AST Horizontal Tanks • ULC-S602 AST Steel Tanks • ULC-S630 AST Vertical Tanks • ULC-S653 AST Steel Tanks	• CSA B376-M Portable Containers for Gasoline and Other Petroleum Fuels • ULC/ORD-30 Safety Containers • CSA B620
Diesel Class 3 UN1202					• Diesel Exemption: Small means of containment (<450L) a non-spec tank may be used
Class 7 Radioactive Materials					• Means of containment as per "Packaging and Transport of Nuclear Substance Regulations."

8 HANDLING STANDARDS

The Handling Standards provides an overview of the legislative criteria for labeling and marking the means of containment for the chemicals and materials on site. In addition, there are legislative criteria for spill preparedness, prevention and training.

The Transportation of Dangerous Goods Regulation (C&M S&H Plan - Section 8.1) specifically addresses how a means of containment will be marked and labeled and the responsibilities of consignor and consignee. Training requirements focus on the selection of proper means of containment for the product being transported as well as the classification system. Additional training is required for chemical specific substances.

The Workplace Hazardous Materials Information System - *Mines Act* (C&M S&H Plan - Section 8.2) addresses safe handling procedures under the Safety Data Sheet (SDS). The supplier will prepare and send an SDS with all controlled and uncontrolled products that are shipped to the site. Proper labeling, physical/chemical properties, product specific training, personal protective equipment, firefighting, first aid, and spill prevention and response are main focuses of the SDS.

The *Environmental Management Act* (C&M S&H Plan - Section 8.3) addresses spill prevention as a requirement in relation to managing the environment. Procedures for handling a substance capable of causing pollution will address the method for reducing or controlling the risk. The spill response plan will address control measures, safety measures and cleanup methods for substances capable of causing pollution.

The BC Fire Code (C&M S&H Plan - Section 8.4) requires all dangerous goods to be properly labeled and placarded. In addition, spill prevention and control is required for all dangerous goods.

Inspections (C&M S&H Plan - Section 8.5) are required for dangerous goods including flammable and combustible materials. The focus of the inspection process is on prevention, awareness and continual improvement. Inspections provide a tracking mechanism for ensuring that the operational procedures are adequate and functioning, that action items are being developed and that the risk to health, safety and the environment are managed. The inspection procedures at Brucejack Mine are risk based. The higher the risk, the more frequent the inspection.

8.1 TRANSPORTATION OF DANGEROUS GOODS REGULATION (TDG) HANDLING REQUIREMENTS

8.1.1 Marking and Labelling under the TDG

- A person will not offer for transport or import a means of containment that contains dangerous goods unless it displays the appropriate safety mark.

- The consignor (shipper) who prepares the dangerous goods for shipment is responsible for determining the following:
  - The correct classification of the dangerous goods being shipped;
  - Ensure the packaging is compatible with the dangerous good and secure the correct placards/markings or labels on the means of containment;
  - Complete the applicable shipping documents or waste manifest; and
  - Provide placards for the transport unit, if required.
- The consignee (receiver) who accepts, handles or unloads the dangerous goods has the responsibility to:
  - Understand the hazards of each class of dangerous goods;
  - Recognize the hazards shown by the labels and placards;
  - Carry a valid TDG Training Certificate;
  - Handle the dangerous goods carefully to prevent spills and leaks; and
  - Take appropriate emergency response actions in the event of a spill or leak.

8.1.2 Training Requirements under the TDG

- Everyone who handles, prepares for transport or carries dangerous goods will be trained and certified. The employer is responsible for determining the type and level of training that each person or position is required to maintain.
- Training will include:
  - Safety equipment for personal and environmental protection;
  - Selecting appropriate packaging;
  - How to classify a dangerous good;
  - Safe loading and unloading procedures; and
  - Product specific training for dangerous goods that require special attention including:
    - Explosives;
    - Radioactive Materials;
    - Unstable or Reactive Materials;
    - Peroxides; and
    - Corrosives with Subsidiary Classifications.

8.2 WHMIS REGULATION (*MINES ACT*) HANDLING REQUIREMENTS

8.2.1 Labels/Identifiers under WHMIS

- Includes a mark, sign, device, stamp, seal, sticker, ticket, tag or wrapper that identifies the product, brand name, chemical name, common name, generic name or trade name;

- All controlled products received at the workplace shall be labeled with a supplier label. If the supplier label is illegible, damaged, torn or missing, the employer shall replace the label with a supplier label or workplace label (if supplier label is not available);
- Bulk shipments shall be labeled with a supplier label or workplace label;
- Containers used for controlled products that are not from a supplier will be labeled with a workplace label;
- Piping systems, valves, conveyors, tank cars/trucks and vessels containing or transferring controlled products will be identified by the employer by color coding, label, placards or any other mode; and
- Workplace labels shall include:
  - Product name/identifier;
  - Classification and associated hazards;
  - Reference to SDS availability;
  - Risk phrase/Safe Handling Procedures;
  - Precautionary measures;
  - First aid; and
  - Personal Protective Equipment.

8.2.2 Safety Data Sheets (SDS) under WHMIS

- Preventative measures should provide clear direction on measures to protect worker health and safety during transportation, storage, use (handling) and disposal of the product as well as emergency procedures related to accidental release.
- Handling procedures may be needed for protection against primary and special hazards of controlled products.

8.2.3 Safety and PPE Requirements under WHMIS

- Employers must ensure that employees are trained to properly use, maintain and store PPE.
- Employees must have training with "hands on" instruction in the fit, use and maintenance of assigned PPE:
  - Understand the limitations of the PPE and know what to do in the event of exposure or device failure (e.g., how to use emergency showers, eyewash stations, first aid).
  - Understand when to discard/replace PPE (e.g., end of shift, every hour).
  - Report any missing or defective devices to the supervisor.

8.2.4 Education and Training Requirements under WHMIS

- Training requirements have been outlined in other Procedures and Plans. The following is a summary of these training requirements:
  - WHMIS (Workplace Hazardous Materials Information System);
  - TDG (Transportation of Dangerous Goods including Packaging);
  - PPE (Personal Protective Equipment);
  - Proper/Suitable Industrial Hygiene Procedures;
  - Safety Equipment:
    - First Aid
    - Eyewash Station
    - Fire Extinguisher
    - Spill Response Material
  - Emergency and Spill Response Procedures;
  - Safe Waste Storage and Handling Procedures;
  - Safe Solid and Liquid Waste Sampling and Characterization Procedures;
  - Inspection and Assessment Procedures; and
  - Record Keeping.
- Personal Protective Equipment. There are several sources outlining appropriate protective equipment (Table 8.2-1: *PPE Standards and Related WHMIS Symbols*).

Table 8.2-1. PPE Standards and Related WHMIS Symbols

Personal Protective Equipment (PPE)	Standards	WHMIS Symbol*
Chemical Splash Goggles	Follow CSA Standard Z94.3-M1982 for "Industrial Eye and Face Protectors"	
Face Shield	Follow CSA Standard Z94.3-M1982 for "Industrial Eye and Face Protectors"	
Protective Apron	Identify the appropriate chemical resistant material: Neoprene, nylon, PVC, polyurethane, etc.	
Disposable Dust Mask	Follow CSA Standard Z94.4-M1993 for the "Section Care and Use of Respirators"	
Chemical Cartridge Respirator	Follow CSA Standard Z94.4-M1993 for the "Section Care and Use of Respirators"	

Supplied Air Respirator	Usually required when product is known to be IDLH (immediately dangerous to life and health)	
Chemical Resistant Gloves	Identify the chemical hazard Identify the appropriate chemically resistant material	
Chemical Protective Footwear	Identify the chemical hazard Identify the appropriate chemically resistant material	

(continued)

Table 8.2-1. PPE Standards and Related WHMIS Symbols

Personal Protective Equipment (PPE)	Standards	WHMIS Symbol*
Full Body Protective Clothing	Usually required when product is known to be IDLH (immediately dangerous to life and health)	
Lab Coat	Example of appropriate chemical clothing for a specific hazardous or controlled product	
Fume Hood	Are engineered control systems that control the problem at the source, like exhaust ventilation	
Additional PPE may be related to specific activities or hazards	• Safety Headgear • Limb and Body Protection • High Visibility and Distinguishing Apparel • Buoyancy Equipment • Flame Resistant Clothing	

** Symbol supplied by WHMIS PPE and TRU.ca H&S*

8.2.5 WHMIS Procedures Outline for Handling Hazardous Chemical

WHMIS requires written safe work procedures to be prepared for hazardous operations, including work methods involving hazardous chemicals and spill response. Workers must be adequately instructed in and follow the procedures. Every worker required to handle hazardous chemicals will be trained in the safe work procedure including spill prevention and response.

8.3 BC *ENVIRONMENTAL MANAGEMENT ACT* (EMA) HANDLING REQUIREMENTS

Spill prevention requirements under EMA are listed in point form. When developing handling procedures, the following points will be addressed:

- Maintain and follow good handling procedures;

- Maintain inventory control;
- Assess and manage risk;
- Maintain proper means of containment;
- Maintain equipment and records;
- Good housekeeping – ongoing;
- Continual training requirements;
- Written roles and responsibilities;
- Record keeping; and
- Inspections and audits.

8.3.1 Spill Response Requirements Outlined under EMA

The following points are to be included in the Spill Response Plan for Brucejack Mine:

- Spill Response Plan that is approved and signed-off by the Mine Manager;
- Training requirements for all response personnel and staff involved in hazardous material response;
- Roles and Responsibilities for response personnel;
- Risk assessment of spill potential;
- Mitigation measures for all high risk spill potential;
- Assessment of the Spill:
  - Product identification through use of Placards, Manifest and Vehicle type;
  - Potential volumes;
  - Mixed loads or single product; and
  - Spill behavior under different environmental conditions (cold, hot, wet, dry, windy, etc., environmental conditions).
- Assessment of Environmental Impacts:
  - Knowledge of the receiving environment;
  - Knowledge of fish and wildlife within the high risk areas; and
  - Risk management and control measures.
- Assessment of Safety:
  - Hazards associated with the spilled product;
  - Response Strategy and Safety Plan; and
  - Required PPE and appropriate decontamination requirements.

- Stabilize, contain, remove and clean up the hazard or threat;
- Evacuation procedures for all persons;
- Recover and rehabilitate wildlife;
- Restore wildlife habitat; and
- Take other steps to address the long term impacts on the environment resulting from the spill.

8.4 FIRE CODE HANDLING REQUIREMENTS

8.4.1 Spill Control Requirements Outlined under the BC Fire Code (Section 3.2.7.11)

Measures to control spilt liquid or solid dangerous goods shall be provided in conformance with the Fire Code Subsection 4.1.6 – Spill Control:

- Materials or liquids used in the cleanup of spills and leakages of dangerous goods shall be compatible and non-reactive with the dangerous goods being cleaned up and disposed of in conformance with Subsection 4.1.6 of the Fire Code.
- A spill shall be prevented from flowing outside the spill area and from reaching waterways, sewer systems and potable water sources by constructing a non-combustible barrier capable of containing the spill, or grading the site or sloping the floor to divert the spill to a drainage system.
- Barriers capable of containing a spill shall conform to the requirements for secondary containment as outlined in Section 4.3.7 of the BC Fire Code.

8.4.2 Labelling Requirements under the BC Fire Code (Section 3.2.7.13)

Products classified as dangerous goods shall display appropriate identifying labels from the time they enter a facility until they are issued as finished products or waste material.

8.4.3 Placard and Marking Requirements under the BC Fire Code (Section 3.2.7.14)

- Individual storage areas used for the storage of dangerous goods shall be clearly designated as such by posted placards that conform to the TDG Regulations.
- Where storage consists of a single product, only the UN number need be posted.
- Where storage consists of multiple products within the same class, the individual class and division placard shall be posted.
- Where storage consists of more than one class of products, a placard for each individual class shall be posted at the entrance to the storage area.

8.5 INSPECTIONS

The following items will be inspected, at the frequency indicated.

8.5.1 Fuel and Chemical Handling Facilities

- Stationary fuel and dispensing stations shall be visually inspected on a daily basis by:
  - Assessing pipes, valves, flanges, connections and pumps;
  - Noting any leaks, discoloration, corrosion;
  - Written and Posted Procedures;
  - Secondary containments should be dry and clean of residue;
  - High-level alarms, leak detection, low pressure alarms, vacuum monitoring gauges have been tested, are functioning and correct; and
  - Document inspections, develop action plans and keep a record of inspection.
- Chemical transfer shall be visually inspected and assessed on a daily basis by:
  - Assessing pipes, valves, flanges, connections and pumps;
  - Noting any leaks, discoloration, corrosion;
  - Ensuring secondary containment systems are inspected:
    - Continuously, dry and clean of product.
  - Confirming alarms and gauges are functioning and correct:
    - High-level alarm, leak detection, low pressure, vacuum monitoring gauge.
  - Documenting inspections, developing action plans and keeping a record of inspections.
- Generator Facility and Fuel Storage Facility require daily inspection by:
  - Assessing Pipes, Valves, Flanges, Connections and Pumps;
  - Noting any leaks, discoloration, corrosion;
  - Ensuring secondary Containments are dry and clean of residue;
  - Confirming high-level, leak, low pressure and vacuum monitors are functioning and correct; and
  - Documenting inspections, developing action plans and keeping a record of inspections.

8.5.2 Spill Response Kits

- Spill Response Plan (dated);
- Containment products and procedures;
- Absorbent product;
- Neutralizing product;
- Safety and PPE products; and
- Additional specialized equipment for specific response capabilities.

8.6 PREVENTION

A prevention document is attached as an appendix. The prevention document reviews the high-risk activities at the Brucejack Mine. These include:

- Fuel Storage, Dispensing and Delivery; and
- Chemical Storage and Handling.

Prevention relies on the identification of risk. Risk is based on consequence and probability. Understanding the high-risk activities, provides an opportunity to manage risk.

The most common way to manage high-risk activities is by developing and implementing Standard Operating Procedures (SOPs). SOPs focus on reducing or managing the consequence and/or probability.

Prevention, as outlined in the appendix also relies on:

- Inspections;
- Maintenance;
- Housekeeping; and
- Training.

9 WASTE STORAGE AND HANDLING PROCEDURES

The waste storage and handling procedures are addressed through the *Environmental Management Act* and the Hazardous Waste Regulation. The production of a certain quantity of hazardous waste within a specific time frame is the qualifying factor that defines whether a waste requires a permit or registration or is exempt of both. The administrative requirements for storing, handling, transporting and disposing of hazardous wastes are prescriptive and are outlined below (C&M S&H Plan Section 9.1).

The Contaminated Sites Regulation outlines procedures for treating non-hazardous hydrocarbon contaminated soil (C&M S&H Plan Section 9.2). The outline is provided as a contingency plan as a means of addressing potential on-site soil contamination from any source of petroleum hydrocarbons including spills and leaks. Soils that are contaminated by petroleum hydrocarbons are defined as a waste. This section addresses the procedure that will be adopted by Brucejack Mine should it encounter waste soils contaminated by petroleum hydrocarbons.

9.1 BC *ENVIRONMENTAL MANAGEMENT ACT*

9.1.1 Hazardous Waste – Confinement (Part 2, Section 7)

- A person who produces, stores, transports, handles, treats, recycles, deals with, processes or owns a hazardous waste must keep the hazardous waste securely confined:
  - Containers must be designed and compatible with the specific waste product;
  - Containers used for hazardous waste must:
    - be clean, washed or new, and compatible with the hazardous waste;
    - be kept securely closed during storage and transport;
    - contain no residual product that might be incompatible with the waste product; and
    - be clearly labeled with Classification, Shipping Name of hazardous waste, and UN number.
- Except to the extent expressly authorized by a permit, an approval, an order, a waste management plan or the regulations, a person must not release a hazardous waste from the confinement into the environment.

Hazardous Waste Management Facility (EMA - Part 2, Part 8)

- A person must not construct, establish, alter, enlarge, extend, use or operate a facility for the treatment, recycling, storage, disposal or destruction of a hazardous waste except in accordance with the Hazardous Waste Regulation.

Administration of Hazardous Waste (EMA - Part 2, Part 7)

- Generator Registration Number is required for anyone who produces within a 30-day period, hazardous waste in quantities greater than the quantity set out in Column II of Schedule 6 of the Hazardous Waste Regulations:
  - The Generator Registration Number must be added to the Waste Manifest.
- Provincial ID Number is required for anyone who accepts hazardous waste for disposal or storage and is an authorized hazardous waste consignee:
  - The Provincial ID Number must be added to the Waste Manifest.
- Licence to transport hazardous waste is required by a carrier and the driver must be trained and show a valid certificate:
  - The licence number must be added to the Waste Manifest.
- Classification of Hazardous Waste is required to:
  - Verify that the waste is classified as hazardous;
  - Ensure the means of containment is acceptable; and
  - Clearly label the means of containment with shipping name, UN number, class and packing group (if applicable).

- Hazardous Waste Manifest must be completed prior to transport for all hazardous waste products leaving the site in accordance with the instructions on the waste manifest. Maintain copies of the Waste Manifest for a period of 2 years. The following general quantities of hazardous waste production will require Manifesting:
  - Solid Hazardous Waste: 5 kg;
  - Liquid Hazardous Waste: 5 L;
  - Waste Batteries: 1,000 kg; and
  - Waste Paint and Waste Oil: 210 L.
- Loads from Multiple Consignors may be transported by a carrier provided:
  - The hazardous waste has the same shipping name.
  - The carrier completes the multiple consignor's form and attaches it to the waste manifest.
  - The consignor completes the waste manifest accordingly for multiple consignors.
- Multiple Carrier Shipments; and
- Shipments of Multiple Different Wastes.

Hazardous Waste Storage and Disposal (EMA - Part 2, Section 9)

- A person must not store more than a prescribed amount of a hazardous waste except in accordance with any of the following that apply:
  - the regulations in relation to storing hazardous waste;
  - an order that requires the person to store that kind of hazardous waste; and
  - an approved waste management plan that provides for storage of hazardous waste.
- Any changes to the production, storage or disposal of Hazardous Waste must report the changes to the Director as per Hazardous Waste Regulation.

Transportation of Hazardous Waste (EMA - Part 2, Section 10)

- A person who produces or stores a hazardous waste
  - must not cause or allow more than a prescribed quantity of the hazardous waste to be transported from the property unless:
    - a Waste Manifest is properly completed; and
    - the manifest is filed in the manner prescribed.
  - must ensure that the carrier transporting more than the prescribed quantity of the hazardous waste from the place where it is produced or stored has a valid licence, is trained and has a valid Certificate.
  - must not cause or allow more than the prescribed quantity of the hazardous waste to be transported to a place unless:
    - an order, waste management plan or regulation authorizes or requires it to be stored at that place;

- a permit, approval, order, waste management plan or regulation authorizes or requires it to be introduced into the environment or treated at that place; or
- storage of the hazardous waste at that place is otherwise not prohibited under section 9 *[hazardous waste storage and disposal].*

9.2 PROCEDURE OUTLINED FOR WASTE CHARACTERIZATION AND TRANSPORTATION OF DANGEROUS GOODS

Characterize the Waste:

- Background information of waste generation:
  - Source of waste generation;
  - Classification;
  - Analytical Data for confirmation; and
  - Volume.
- Means of Containment:
  - Analytical data to determine waste characterization;
  - Check Packaging Instructions of Containment Standards; and
  - Select appropriate container standard and document.
- Potential Incompatibilities of Hazardous Waste.

Prepare for Shipment:

- Storage and Handling Requirements (Procedures);
- Verify appropriate packaging;
- Confirm labels and placards; and
- Documentation: shipping document or waste manifest.

Other Requirements:

- Training requirements;
- Storage and disposal permits/approvals; and
- Spill Response Plans.

9.3 TREATING HYDROCARBON CONTAMINATED SOIL

The outline is provided as a summary of the legislative criteria that must be addressed when treating non-hazardous soils contaminated with petroleum hydrocarbons.

Hydrocarbon Contaminated Soil

- Hydrocarbon contaminated soil (Hazardous Waste Regulations Section 41.1):

- Hydrocarbon contaminated soil is authorized for treatment and storage on the site where the hydrocarbon contaminated soil was generated, if the hydrocarbon contaminated soil meets all the following specifications:
- A person must not store, treat or use hydrocarbon contaminated soil unless:
  - prior written notification of any proposed storage or treatment is provided to a Director and the storage and treatment is carried out in accordance with the Director's requirements;
  - the hydrocarbon contaminated soil is a hazardous waste due only to the presence of one or more items listed in Table 9.3-1;
  - the hydrocarbon contaminated soil is spread in single layers not exceeding 0.3 metres in thickness per year or a greater thickness approved by the director, which approval must specify a method of aeration to be used with the greater thickness;
- Hydrocarbon contaminated soil which has been treated so that it is no longer a hazardous waste may be disposed of in a landfill.

Table 9.3-1. Standards for Management of Hydrocarbon Contaminated Soil

Parameter	Maximum Value
Total benzene	25 mg/kg
Total ethylbenzene	250 mg/kg
Total toluene	150 mg/kg
Total xylene	250 mg/kg
Total oil	10%

9.3.1 Protocol 15 for Contaminated Sites

This protocol is intended to provide provincial standards for the treatment of non-hazardous hydrocarbon contaminated soil. The protocol includes some key points:

- Siting Requirements refer to locations where a soil treatment facility may not be constructed:
  - Slope is greater than (>) 5%;
  - Seasonal high water table is less than (<) 1 m below ground surface; and
  - Boundaries of the facility would be within any area specified as a wildlife management area, wildlife area or sanctuary, ecological reserve or bird sanctuary.
- Site Access and Security to prevent unauthorized access into the treatment area;
- Treatment Facility Design:
  - Liner or equivalent barrier to prevent potential leaching into the subsurface;
  - Berms that will prevent runoff from the soil to enter the environment;
  - Cover the treatment piles to minimize leachate, erosion, fugitive dust and air emissions;

  - Leachate collection by sloping the base of the treatment area by 1% to 5% towards one or more collection sumps; and
  - Aeration measures by mechanical tilling or ventilation piping is required where soil is greater than 0.3 m.

- Operation and Maintenance:
  - Kept in good working order;
  - Inspected monthly and more frequently after major storm events;
  - Aerated every four (4) weeks if tilling during the operational period;
  - Monitor and maintain leachate collection; and
  - Optimize biodegradation of hydrocarbon contaminated soil.

- Monitoring and Sampling:
  - Baseline sampling should be taken of soil and groundwater upstream and downstream of treatment facility;
  - Take representative soil samples during treatment and prior to disposal. Parameters should be consistent with the contaminants of concern;
  - Annual groundwater samples should be taken:
    - One upstream of treatment facility; and
    - Two downstream sample locations.

- Decommissioning of the soil treatment facility must be completed once the facility is no longer active:
  - Confirmatory soil and groundwater samples of the site; and
  - Site re-contoured to original site; and
  - Treated soil should be reused where it originated or used as landfill cover or other means acceptable as per the *Environmental Management Act*.

- Record Keeping and Reporting:
  - Maintain a record of:
    - Background on site location and choice;
    - Facility design, drawings, etc.;
    - Source of contaminated soil and volumes;
    - Dates of scheduled treatment;
    - Monitoring/sample results;
    - Records of maintenance and inspections; and
    - Records of disposal locations based on soil treatment results.

Appendix A

Spill Prevention Measures

SPILL PREVENTION MEASURES

This appendix summarizes spill prevention measures outlined in BC regulations and guidelines that apply to Pretium's Brucejack Mine. The measures also reflect best operating practices. For additional site specific fuel storage and dispensing prevention measures refer to the Spill Response Plan, Appendix D (Storage Tanks & Fuelling Facilities). Fuels and chemical reagents have been addressed separately.

FUELS

Health and Safety (sites are equipped with minimum Level 2 first aid kit)

- Signage at fuel storage and dispensing areas clearly indicate:
  - No Smoking within 25 m
  - Turn off ignition
  - Operator always in attendance
  - Ground tanks
  - Emergency contact numbers
  - No operation of electronic devices
- Spill response kits are stocked according to the Pretium Spill Response Plan (see Spill Response Plan, Appendix B, for a complete inventory list that includes equipment and materials).
- Appropriately rated fire extinguishers are kept near all fuel storage and dispensing areas (a minimum 20 lb dry chemical).
- Spill response training emphasizes health and safety (Spill Response Plan, Appendix E).
- All site personnel are familiar with personal protective equipment (PPE).
- Electrical switchgear for the control of fuel dispensers and emergency shutoffs are installed at a safe distance away, clearly identified, and shielded from fires that may occur in the dispensing area.
- Mobile tanks are secured with certified tank tie-downs.
- There are vehicle speed restrictions along the Brucejack Access Road.

Fuel and Oil Storage

- Fuel and lube oil storage are located greater than 30 m from stream, lake or wetland. The exception is in the event of a fire when there is a need to fuel fire-fighting equipment.
- Storage sites do not drain to a watercourse.
- Fuel storage is located away from areas that may be impacted by natural hazards (e.g., rock falls, earthquakes, washouts, windfall trees).
- Containers greater than 230 L capacity meet BC Fire Code specifications (see secondary containment below).
- Containers are maintained in good condition.
- Containers are sealed with proper fitting lids, caps, bungs or valves.
- All containers are labelled in accordance with WHMIS and the *Fire Code*.
- Maximum fill level is 75% for cubes transported on Knipple Glacier. All other containers are

filled to a maximum 90% capacity.

- A clean and tidy site is maintained.
- Containment for tanks is always provided by secondary containment, including the following options:
  - double-walled tanks or single-walled fuel tanks with vaulted second outer tank
  - pre-cast concrete surfaces and sumps
  - perimeter berms
  - oil/water separators.

Spill Protection

- Absorbent spill pads and containment are kept at all pumps and fuel storage and transfer areas as part of a Spill Response Kit – see Spill Response Plan, Appendix B (Response Equipment).
- Absorbent spill pads or other spill sorbent materials are used to contain and recover spills that occur while field equipment is being fuelled.
- An emergency spill response kit is located at all active sites and at fuel storage and transfer sites.
- Spills are prevented from entering waterways, drains and ditches through:
  - secondary containment
  - diversion (storage/fueling site graded away from waterways or a trench to a holding area)
- Secondary containment is provided for containers greater than 230 L using:
- double-walled containers
- steel or concrete containment that holds 110% of the storage volume
- earth or clay dyke, lined with impermeable material that holds 110% of the storage volume, site sloped to divert spills into a collection system lined with an impervious geo-membrane to prevent subsurface contamination.
- Double-walled fuel tanks are protected from vehicle collision or impact by impact prevention concrete median blocks or equivalent on all sides.
- Training is provided for all individuals involved in the handling, transportation, and storage of fuels and lubricants.
- Site-specific plans or other spill containment techniques are used when and as necessary to contain fuel spills from off-loaded truck tanks, and to prevent the entry of spilled substances into soil and watercourses.

Fuel Delivery

- Fuel is delivered in compliance with all applicable regulations related to highway and off-highway roads and vehicles.
- Fuel delivery trucks carry Transportation of Dangerous Goods (TDG) documentation and placards.
- WHMIS and TDG placards are displayed where total capacity of a container in or on a vehicle warrants it. Relevant WHMIS signage is identifiable on all containers.
- Fuel truck drivers receive a site orientation and are apprised of the relevant sections in the *B.C. Mines Act*, WCC safety requirements, and site traffic protocol.
- Fuel delivery trucks carry initial spill response procedures.

- Drivers are familiar with the appropriate fire and spill response protocol and emergency equipment available.
- Diesel and gasoline fuel are delivered in approved containers.
- Bills of Lading to identify fuel type, quantity, and date of all deliveries to the Mine Site are retained on file at the contractor's head office for a period of two years following the completion of the contract.

Fuel Dispensing

Fuel dispensing procedures and requirements at both the Mine Site and other facility sites include the following directives that are followed by all Pretium employees and contractors:

- Only persons with knowledge of WHMIS and TDG requirements, and training on how to safely handle fuels, implement procedures for spill containment and safely dispose of contaminated materials will be authorized to dispense fuel.
- Select a fuel dispensing site that does not drain to a watercourse, is readily visible, and is located away from vehicle traffic.
- Do not refuel or service ground-based machinery within 70 m of watercourses.
- Establish and post maintenance and operating procedures to prevent spills.
- Do not fill containers beyond their safe filling level (90% capacity).
- The use of 'hold open' devices on delivery nozzles will NOT be permitted.
- Pretium and contractor employees will remain at the dispensing nozzle for the duration of the fuel transfer.
- Use an electric or manual fuel pump when dispensing from a drum or slip tank. Store and secure the fuel hose above the drum to prevent siphoning. Follow proper grounding procedures.
- If drums of Jet fuel are ever used (in addition to the Jet A double-walled tanks) these must be stored on their sides so that the bung is at the top to help prevent leaks.
- A daily fuel balance check is conducted at all fuel depots and a log of quantities of all fuel delivered and dispensed is maintained.
- Diesel fuel delivery vehicle tanks will be fitted with fail-safe equipment. Multi Cam-lock coupler systems should not be used on hoses for the purpose of loading and dispensing fuel. Hoses used for dispensing fuel from tanks over 2000 L will be fitted with a Breakaway valve.
- Propane fuel delivery vehicle tanks will be manufactured and certified in accordance with all relevant regulations and equipped to ensure the safe discharge of propane to a receiving tank.

Maintenance

Maintenance of Pretium facilities at Brucejack must conform to the following directives:

- Pretium contractors and employees will visually inspect all fueling depots daily. They must immediately report evidence of leakage, nozzle malfunction, or spillage to their Supervisor and the Health and Safety Coordinator, and record any malfunctions.
- Conduct regular written formal inspections. Keep all records and/or journal entries.
- Maintain spill response equipment and fire extinguishers in a condition to ensure that they are available for immediate use.
- Restock spill response kits after use.
- Post maintenance procedures.
- Maintain a clean and tidy site.
- Check dispensing equipment regularly to ensure it is in good working order.
- Repair faulty equipment promptly, using proper replacement parts and materials.

Inspection

Pretium's Environmental Department and Health and Safety Department or qualified designate will:

- Determine the cause of all spill incidents.
- Inspect the site of any spill incident over 100 L or where fuel has entered a watercourse and advise senior management of actions taken and recommendations.
- Inspect all locations where fuel is stored and/or dispensed at intervals not exceeding fifteen days (*Site Assessment Guide below*). Maintain a record of all such inspections, of any deficiencies observed and of remedial actions implemented.
- Ensure that all actions taken related to fuel management are satisfactory and complete.
- Ensure that all equipment used for transporting, storing, and dispensing fuel, and replacement parts comply with all regulatory requirements and company standards.
- Ensure that the manufacturer's approved specifications are maintained for all tanks to ensure their certification and compliance.
- Submit to the Mine Manager inspection reports on matters related to fuel management.

CHEMICAL REAGENTS

Inventory & Risk Assessment

An inventory of hazardous material quantities and locations is presented in the Chemicals and Materials Storage and Handling Plan. It is kept up-to-date and is supplemented with Pretium's online SDS management database. Should there be a spill or fire, the former information can be referenced to quickly identify resources at risk and the amount of material and packaging that could be involved.

Inspections of reagent storage are completed routinely, and include observations of the condition of containers and storage areas (e.g., potential ignition sources, signage, and other housekeeping aspects), evidence of leaks, and any related safety concerns.

Storage and Handling Requirements

General

- Facility design must include the selection and placement of piping, pumps, pallets, totes, and other containerization that reduces the potential for spills, fires, and other incidents.
- Hazardous materials must be segregated from incompatible chemicals, including fuels. Flammable products must be stored away from potential sources of ignition such as non-approved electrical equipment or heaters.
- Ventilation must be adequate to ensure vapours and dusts do not become concentrated enough to ignite.
- Ensure an emergency spill kit is readily available that includes neutralizers and sorbents.
- Hazardous materials must be stored and handled in a manner to reduce the potential risk to human life and critical assets. Do not store hazardous products near exits.
- If removed from its original container, a material must be placed in a container that is not damaged, is appropriate for the material, and is clearly labeled as such, in contrast to other printed labeling.
- Check and follow SDSs for any specific storage precautions.

Containers

- Containers used to store flammable or combustible liquids, having a capacity of not more than 230L, must be fully intact, undamaged, and conform with one of the following:
  - Transportation of Dangerous Goods Regulations
  - CSA B376-M (R2003) "Portable Containers for Gasoline and Other Petroleum Fuels" (up to 5 gallons/25L)
  - ULC/ORDC30 "Safety Containers"
  - CSA-B306, "Portable Fuel Tanks for Marine Use"
  - Section 6 of CSA-B620, "Highway Tanks and Portable Tanks for the Transportation of Dangerous Goods"
  - Note: original (untampered/undamaged) containers such as drums and totes are adequate
- Containers of not more than 1L capacity used for flammable liquids (5L for combustible liquids) are exempt from the above requirement.
- Ensure that all containers have WHMIS supplier labels affixed to them.
- Never use plastic or glass containers for storing flammable liquids unless storage in metal containers would affect the required liquid purity or if the liquid would cause excessive

corrosion of the metal container.

- Provide approved containers that close for the collection and disposal of cleaning or solvent soaked rags and used sorbents.

Storage Cabinets

Up to 250 L of flammable liquids (500 L of flammable and combustible liquids), in closed containers, may be stored in a metal cabinet. A total quantity of 750 L of Class 1 liquids as defined in the BC Fire Code (1,500 L of flammable or combustible liquids) may be stored in a group of cabinets in a single fire compartment. Quantities stored can be increased by using additional groups of cabinets, but there must be a minimum distance of 30 m between groups of cabinets. Cabinets must:

- Conform to ULC Standards C1275 "Storage Cabinets for Flammable Liquid Containers."
- Be labeled in conspicuous lettering to indicate that the cabinet contains flammable materials.
- Be isolated from open flames.

If the storage cabinet has ventilation openings, ensure that the ventilation openings are sealed or that the cabinet is vented outdoors. The sealant material or the vent piping must provide fire protection equal to that required for the construction of the cabinet.

Fire Extinguishers

- As a minimum, one 3A,10-B:C rated fire extinguisher must be located in the vicinity of a designated flammables/combustibles storage area.
- Vehicles (i.e., forklifts) operating within a designated storage area must be equipped with a fire extinguisher having a minimum rating of 2A, 10-B:C (a 3A,10-B:C is recommended).
- Vehicles used to transport drums and containers must have a 3A, 10-B:C fire extinguisher

Product Separation

- Flammables and combustibles must be separated from toxic or corrosive substances, oxidizers by a minimum of 2 m.
- Hazardous products must be segregated by chemical group, as possible, in all storage areas.
- Do not store compressed gases beside flammable and combustible material containers.

Access/Clearance

- Maintain a minimum of 1 m width for storage aisles.
- Access to fire-fighting panels and equipment must be kept clear.
- Aisles should be accessible from two different points.
- At least 400 mm clearance must be maintained between the containers and a wall.
- Individual Storage Areas must be separated by aisles of at least 2.4 m.

Containment

- Ensure that storage areas are designed to contain spills, including water used for fire-fighting purposes, and that they are liquid-tight where the walls join the floor.

- Do not store hazardous material containers directly over a drain. Drains must remain unobstructed for spilled product to flow into.
- Any accessible drains must terminate at a location where a spill will not create a fire hazard or any risk to public health or safety.
- The US National Fire Protection Association (NFPA) has published guidelines that Canadian companies must follow as part of insurance requirements. NFPA stipulates various means of spill containment to prevent the spread of a fire:
    - Non-combustible liquid-tight raised sills, curbs or ramps of suitable height at exterior and interior openings; interior openings can utilize other flow-diverting structures
    - Sloped floors (toward drainage if practical)
    - Open-gate trenches or floor drains connected to a properly designed drainage system, (i.e., one engineered in terms of materials, capacity, and safety (no fire risk)
    - Wall scuppers that discharge to a safe location or to a properly designed drainage system
    - Other means acceptable to the authority having jurisdiction
    - Where sills, curbs or ramps are used, the appropriate height will depend on the maximum expected volume, floor area, and the existence of any drainage system
    - Curbs and sills are often a standard 100 mm (4 inches) high
    - Note: 1 m^2 of water at a depth of 25 mm equals 25 L
    - Where open-grate trenches are used, the volume of the trench should contain the maximum expected spill volume or otherwise be connected to a properly designed drainage system

Ignition Sources

- Heating appliances are not permitted in a fire compartment used to store flammable and combustible liquids unless installed in a manner that will not create a fire or explosion hazard.
- Smoking is not permitted within an area used for storing flammables and combustibles.
- Wiring in a hazardous material storage area must conform to the BC Safety Standards Act -
- Electrical Safety Regulation (s.18, 20, 22).
- Any electrical equipment must meet requirements and approval for hazardous locations (FM Global standard 5-1 "Electrical equipment in hazardous locations").
- Precautions should be taken to prevent open flames, sparks or electric arcs – and otherwise prevent the introduction of any potential ignition source to storage areas.
- Do not store compressed gases beside flammable material containers.
- Dispensing must take place not less than 6 m from potential sources of ignition or be separated by fire separation (including the prevention of the passage of vapours).
- Self-closing faucets and safety bungs must be in place on all containers used for dispensing.
- Ground and bond all work and ignition-proof equipment within 6 m of flammable liquids or flammable liquid operations.
- Follow all hot work procedures when performing work that produces open flames, heat and/or sparks.

Housekeeping

- Ensure that storage areas for all chemical reagents are cool and dry
- Do not store combustible materials other than those used for the packaging of flammable or combustible liquids in the same individual storage area with such materials.

Signage

- Signs must be posted and be clearly visible indicating:
  - the presence of flammable and combustible products stored in that room or area
  - no smoking
  - emergency contact numbers

Ventilation and Exhaust

- Ensure that storage rooms have properly designed ventilation systems that are regularly maintained.
- Ventilation for flammables and combustibles storage areas must conform to the BC Building Code and the BC Fire Code (and NFPA) except if only closed containers are used and there is no dispensing.

Human Element/Change Management

Fire prevention and hazardous material management will be reviewed as part of the existing change management process. This will include:

- New product screening for hazardous properties and subsequent storage requirements (use new product SDS information as appropriate)
- For new projects, ensure proper design to prevent introduction of hazardous products to production processes, water treatment or areas that may generate a fire or other hazard.
- Reinforcement of the Hazard Identification procedure during maintenance and construction activities near designated hazardous material storage areas

SITE ASSESSMENT GUIDE

Many forms of site assessment that focus on spill prevention and response are currently in place at Pretium facilities and will continue to be used and updated throughout Operations. Examples of observations included in an assessment are presented below.

Perimeter Review	☐ indications of leaks and losses leaving the site ☐ blockage of any drainage systems • discoloured, oily or odorous liquid discharges • discoloured or dying vegetation
Fuel Storage & Transfer Areas	☐ spills or stains on the ground and contaminated runoff ☐ spill and drip collection during fuelling • spillage of waste oil from drums or tanks • unreconciled losses from storage tanks or drums • functioning shut-off systems • proper operational procedures posted • signage posted and visible
Spill Response	☐ equipment available matches list of equipment in kit • proper spill equipment (oil versus universal sorbents) • good access to spill equipment • storage drums, tanks well labelled • emergency response plan posted • spill prevention and response plan in place, up-to-date and tested
Waste Management	☐ wastes sorted and stored in one or more areas ☐ scrap steel, drums, equipment parts kept neatly • hazardous materials, paints stored separately • recycling program implemented for antifreeze, waste oils • oil filters crushed, spent batteries returned • waste containers properly labelled, manifested for transport • waste disposal conducted on regular basis • use of small containers minimized • all necessary permits obtained
Due Diligence Items	☐ Spill Response Plan ☐ Chemicals and Materials Storage and Handling Plan • Spill Response and Cleanup Training (see Spill Response Plan Appendix F) • Regular inspection program • Written documentation / recording of spills and inspections

Site Assessment Guide

TANK FARMS

- Double-wall tanks
- Single- wall tanks with dyke that holds 110% of contents or one of:
  - o Perimeter berm
  - o Oil/water separator (serviced)
  - o Pre-cast concrete block corral
- Collision protection steel pipe, logs, concrete, other barriers
- Covered containment with impervious floor
- Retractable hoses, drip holders lighting, remote shutoff
- Mark 90% of maximum fill volume

DRUMS

- Fuel drums stored on side
- Caps, bungs, drains tightly closed.
- Segregate fuels from solvents
- Ensure proper ventilation if sheds are used.
- Keep drums out of harm's way.

Location

- Does not drain to waterways, drains, ditches
- Locate >30 m from stream, lake or wetland.
- Does not allow sediment to enter water

Condition of Tanks and Area

- No corrosion, dents, significant damage to tanks or drums
- Maintain clean tidy site – no garbage, packaging in storage area
- No vegetation that obscures tanks, drums, piping, valves and fittings

Emergency Response

- Unobstructed access to emergency measures:
  - o Spill response kit with PPE
  - o Fire extinguisher
  - o First aid kit

Labelling and Signage

- Signage: No Smoking
  Operator always in attendance
  Report all spills
  Emergency contact numbers
- Label contents type and (for tanks) volume

Appendix B

Mill Reagent Storage Plan

Mill Chemical Reagent Storage Plan

The plan for storing reagents inside the mill is outlined in this section. Practices outlined in the Chemical Materials Storage and Handling plan are being implemented as part of the mill reagent storage plan.

Criteria Used for Storage

The following criteria was used for the determination of reagent transportation and storage inside the mill building. The reagents are transported and stored in the standard shipping containers until they are required for consumption.

Compatibility

Chemical and physical properties of all reagents are considered for allocation, details of incompatibility and storage procedures (refer to Pretium's SDS management database for details). Lab reagents are stored in corrosive cabinets, located inside seacans outside the mill in a designated laboratory supplies area and are kept away from other reagent storage. Special caution is taken for four main chemicals as they were identified as incompatible with other reagents that are also to be stored in the Brucejack mill:

- Vancol PAX 90% – Incompatible with acids, strong oxidizers, and metal salts (Class 4.2 Flammable substance). This chemical is incompatible with Sulfuric Acid and ferric sulphate and each will be stored away from the others.
- Flocculant - AN 910 PWG - Incompatible with metallic salts and moisture. This chemical is not compatible with Ferric Sulphate and will be stored away from each other.
- Sulfuric Acid – Incompatible with water, alkalis and sulfides. This is a liquid reagent and it will be stored separately in a custom-built shipment container with secondary containment.
- Hydrated lime – Incompatible with acids.

Warehouse delivery and stock holding times

The warehouse at Smithers will deliver reagents upon request. The metallurgy department monitors each reagent's consumption, and is responsible for ordering the required quantity of reagents once per week. An order for reagent delivery is placed with the warehouse allowing a minimum of 3 days' notice prior to expected delivery. Reagents are stored at Brucejack Camp, as well as Knipple Camp and Bowser aerodrome. Typically, a one week of supply of reagents is on-hand at Brucejack, and two week's supply is at the Bowser staging area. Consumption rates of each individual reagent, as well as restrictions of container availability are taken into consideration in the definition of the inventory period.

Location of Reagents

Reagents are primarily stored in the. Minor quantities of reagent are stored outside the mill in seacans. The sea-cans are stocked and positioned to ensure that only compatible reagents are in close proximity. PAX, Vanfroth, Sulphuric Acid are stored outside in seacans.

Reagent storage accommodates for safe retrieval by operators, primarily by skid steer loaders. Distribution of the sea-cans and the designated mill storage locations allow for sufficient maneuverability at the time of retrieval and deposit.

Laboratory reagents are stored in seacans located on the east side of the mill, south of the bulk gravity lab. A 20′ seacan with other non-hazardous supplies contains multiple locked corrosives cabinets containing HCl, HNO3, and HF acids. A 10′ seacan contains a corrosives cabinet and will store a single 2.5 liter bottle of $HClO_4$.

Four totes of Sulfuric Acid will be stored in a separate specially designed container with a secured containment tray (Figure B1). Outdoor sea-can storage is organized as per Figure B2.

Figure B1. Special container with secure containment tray for Sulfuric Acid.

Pax is stored in a special sea-can purposely built for PAX storage. This sea-can is elevated, kept dry and has an explosion proof fan, Figure B2.

Figure B2. Special Container for PAX Storage

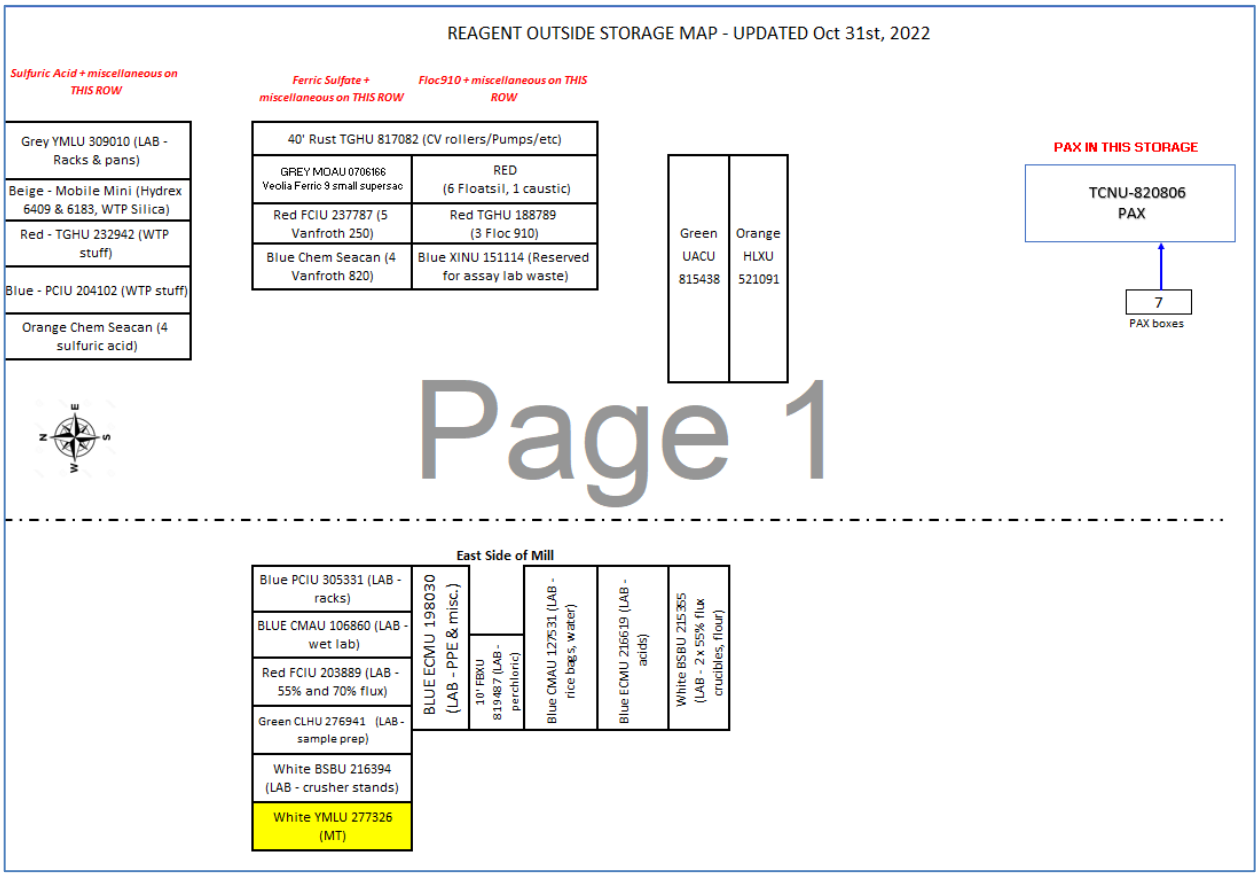
The desired reagent storage holding time is calculated based on the volumetric capacity of each reagent container and the consumption rate. Results of the calculations are shown in Table B1.

Table B1. Calculated Reagent Storage Holding Time.

					Unit Weight	**Storage Unit Volume (m2)**			
			Storage Unit	**Consumption (kg/day)**	**(kg/unit**	***Floor Area**	**Duration (Day/Unit)**		
#Item	Reagent Name	Unit						Stored Area	Indoor storage area
1	Vancol PAX 90%	SS	SS	311	950	1.49	3.1	PAX Specific outdoor Seacan	PAX preparation area
2	Vanfroth 250	Tote	Tote	80	1000	1.12	12.5	Outdoor seacan	Dewatering Floor
3	Flocculant - Thick	SS	SS	366	750	1.49	2	Outdoor seacan	Dewatering Floor
4	Millsperese - Anitscalant	Tote	Tote	17	1270	1.12	75.4	Not Stored outside	Safety Screen Area
5	Flocculant - WTP	bag	Pallet	9	800	1.24	86.5	Not Stored outside	WTP flocculant prep area
6	Hydrated Lime	SS	SS	359	800	1.49	2.2	Outdoor seacan	Lime preparation area
7	Microsand	bag	Pallet	11	800	1.24	73.9	Outdoor seacan	Top floor WTP
8	Ferric Sulphate - Double Stk	SS	SS	704	1000	1.49	1.4	Outdoor seacan	Ferric sulphate preparation area
9	Sulphuric Acid	Tote	Tote	15	1740	1.12	116	Outdoor special seacan	Not stored inside
10	Sodium Sulphide	SS	SS	0	800	1.49	0	Outdoor seacan	Not used
11	Pre-mixed Flux	SS	SS	180	500	1.49	2.8	Outdoor seacan	Assay lab sample area

Table B2. Reagent Outside Storage Map – Seacan/Storage Rows

Sulfuric Acid + Miscellaneous IN THIS ROW	Ferric Sulfate + Miscellaneous IN THIS ROW	Ferric Sulfate + Miscellaneous IN THIS ROW	Floc 910 IN THIS ROW	Lime IN THIS ROW	PAX IN THIS STORAGE



Reagents in Use

The reagents currently in use in the mill process are located as follows:

PAX – When PAX solution is prepared, a supersac is moved from the storage sea-can to the reagent transfer room, where an overhead crane lifts the supersac to the upper floor of the PAX preparation area. PAX is not stored in the mill, and is only retrieved from the PAX sea-can as needed.

Frother – Frother is stored as liquid in totes, with one tote located at the frother transfer location and one additional tote stored at the concentrate bagging station.

Flocculant – When flocculant is prepared, a supersac is moved from the storage location to the flocculant preparation tank using an overhead crane. Additionally, seven bags of flocculant is stored at the concentrate bagging station.

Anti-scalant – Only one anti-scalant is stored within the mill at the safety screen area. The tote is stored on a spill containment pallet until ready.

Hydrated Lime – When the lime slurry is prepared, a supersac of hydrated lime is removed from the storage shelves and taken to the reagent transfer room. An overhead crane lifts the supersac to the lime preparation area. Seven bags of lime are stored near the lime preparation crane on shelving.

Ferric sulphate - When ferric sulphate is prepared, a supersac is removed from the storage location and taken to the ferric sulphate overhead crane, where the supersac is lifted to the ferric sulphate preparation area. Seven supersacs of ferric sulphate are stored in the mill on shelving.

Anionic Polymer (AN905) – A pallet of 40-25kg bags is kept at the anionic polymer preparation area.

Microsand – Up to two pallets of 40-25kg bags of Microsand are kept on the top floor of the Operations Water Treatment Plant near the primary Actiflo unit.

ChemTreatCT788 – Corrosion inhibitor – Only one tote of CT788 is stored in the mill located near the gland water tank on a spill containment pallet.

Pre-mixed flux is used in the assay laboratory and is located on

ng area.

Reagent preparation and use locations are identified in Figure B3:

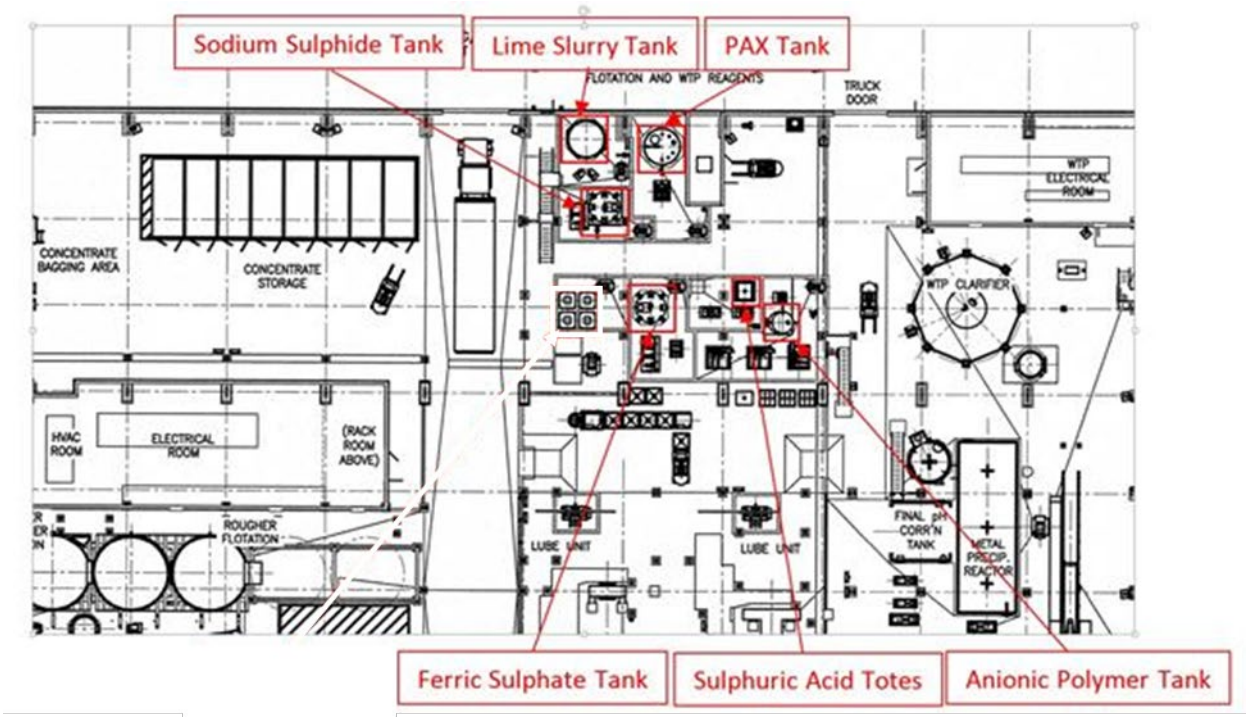


Figure B3. Mill Reagent and Preparation Locations.

UPDATES ON INVENTORY INFORMATION

Every week, a reagent inventory is completed, as well as a re-evaluation of reagent consumption by the Metallurgy Department. Any changes regarding practices for storing reagents in the mill are recorded and documented accordingly.

Appendix 9-1-7. Economic and Social Effects Mitigation Plan

BRUCEJACK MINE

Economic and Social Effects Mitigation Plan (ESEMP)

March 2022

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A Member of the Newcrest Group of Companies

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BRUCEJACK MINE

Economic and Social Effects Mitigation Plan (ESEMP)

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

ACP	Aboriginal Consultation Plan
Application, the	Application for an Environmental Assessment Certificate
BC	British Columbia
BCCA	British Columbia Construction Association
EA	Environmental Assessment
EAC	Environmental Assessment Certificate #M15-01
EAO	Environmental Assessment Office (BC)
EPCM	Engineering, Procurement and Construction Management
ESEMP	Economic and Social Effects Mitigation Plan
HSMP	Health Services Monitoring Plan
IR	Indian Reserve
LSA	Local Study Area
NLG	Nisga'a Lisims Government
NFA	Nisga'a Final Agreement
Proponent, the	Pretium Resources Inc. (Pretivm), a member of the Newcrest Group of Companies
STEP	Skilled Trades Employment Program
TCG	Tahltan Central Government
TDG	Transport of Dangerous Goods
TSKLH	Tsetsaut/Skii km Lax Ha
WHMIS	Workplace Hazardous Materials Information System

PREFACE

The Economic and Social Effects Mitigation Plan (ESEMP) was originally developed in October 2015 and is updated annually. This document updates and replaces the latest version of the ESEMP produced in March 2021. Updates reflect changes due to the completion of the construction phase in 2017, and the first four years of mine production between 2018 and 2021. It also provides for changes anticipated in 2022 as the Mine continues with production activities.

Notable updates to the ESEMP include:

- References to Newcrest Mining Limited, the new parent company of Pretium Resources Inc and the Brucejack Mine. Pretium Resources Inc is a member of the Newcrest Group of Companies effective March 9, 2022.
- Roles and responsibilities have been adjusted to align with Pretivm's corporate structure at this time.

1 MINE OVERVIEW

1.1 THE BRUCEJACK MINE

Pretium Resources Inc. ("Pretivm"), a member of Newcrest Group of Companies, operates the Brucejack Mine (the Mine), an underground gold and silver mine in northwest BC. The Mine is located at 56°28′20″ N latitude by 130°11′31″ W longitude, which is approximately 950 km northwest of Vancouver, and 65 km north-northwest of Stewart. The Mine is located in the Kitimat-Stikine Regional District. Portions of the Mine and associated infrastructure lie within the traditional territories claimed by the Tahltan Nation and Tsetsaut/Skii km Lax Ha (TSKLH), and in the Nass Area of Nisga'a Nation as defined in the Nisga'a Final Agreement (NFA; Government of Canada Government of BC and Nisga'a Nation 2000).

The mine site area is located near Brucejack Lake. The Mine is accessed by a 73.5 km road connecting with Highway 37 approximately 30 km south of Bell II. The road is used year-round to mobilize personnel, equipment and supplies to the mine site and to truck concentrate to port facilities. A transmission line connects the mine site to the provincial power grid near Stewart.

1.2 DEVELOPMENT SCHEDULE

Construction of the Mine began in 2015 and was completed in 2017. Commercial mine production commenced in 2017, with a planned operational mine life of 18 years. During operations, the Mine was originally planned to produce approximately 16.5 Mt of ore at a rate of approximately 2,700 tonnes per day. In December 2018, Pretivm received an amended EAC and permit amendment to increase the average daily production rate to 3,800 tonnes per day and a total production of 18.5 Mt. At the accelerated production rate, the Mine has a planned operational life of thirteen years to the year 2032. Closure is expected to occur over approximately five years and will include decommissioning, abandonment, reclamation activities, and monitoring.

<u>Summary of Work to Date (as of March 2022)</u>

2021 marked the fourth full year of operations at the Mine, and the third year of operations following approval for the Mine to increase the production rate by 40% to an annual average of 3,800 tonner per day (1.387 million tonnes per year). In 2021, Pretivm was able to maintain steady-state production at the increased production rate set in 2019, despite the ongoing challenges presented by the COVID-19 pandemic. Through 2021, the company took a number of steps to protect the Mine's workforce and limit the risk of COVID-19 exposure for workers, their families, and communities. Protocols were implemented to manage access to the Mine and camp, crew transportation, social distancing, hygiene, health checks, on-site medical services and communication. Throughout the year, however, numerous COVID-19 positive, and close contacts of COVID-19 positive individuals were managed at site.

Pretivm continues to work closely with Indigenous groups including the Nisga'a Nation, Tahltan Nation, Tsetsaut Skii km Lax Ha (TSKLH), and Gitanyow Hereditary Chiefs. In April 2015, Pretivm and the

Nisga'a Nation established a Cooperation and Benefits Agreement, and in October 2017, a comparable agreement was reached with the Tahltan Nation. Pretivm also maintains strong relationships with local communities. Through the challenges of the pandemic, Pretivm adapted its engagement activities and communication strategies to maintain strong ties with all Indigenous groups.

At the end of 2021, Pretivm's workforce comprised 894 direct employees, 44% of whom were residents of northwestern BC, and 29% of whom self-identified as Indigenous.

1.3 BENEFITS OF THE MINE

The Mine provides positive economic benefits to local communities as a result of direct training and employment opportunities generated by the Mine. Pretivm is committed to making local employment a priority, and to engaging educational and training institutions and other organizations to enhance the ability of local and regional residents to obtain employment related to the Mine. Pretivm is also committed to sourcing local contractors and supplies from northern BC where possible.

The actual benefits realized by the Mine—including local and Indigenous employment, procurement, training, and engagement—are monitored and reported annually as part of the ESEMP Annual Report (described in Section 11 of this report). Based on this information, Pretivm can adjust and adapt activities to ensure that local benefits are achieved, and that other impacts are appropriately managed.

1.4 PROPONENT CONTACT

Contact information for Newcrest Brucejack is provided below.

Corporate Office (Vancouver)
2300-1055 Dunsmuir Street
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Regional Office (Smithers)
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Website:
www.newcrest.com

Employment Applications:
resumes@pretivm.com

2 PURPOSE OF THE ESEMP

2.1 CONTEXT

The Mine has been designed to minimize, mitigate and/or manage potential adverse effects on communities while systematically seeking to enhance positive effects. In support of the Mine's Environmental Assessment Certificate (EAC) #M15-01 and conditions issued by the BC Environmental Assessment Office (EAO) on March 26, 2015, this document presents the Economic and Social Effects Mitigation Plan (ESEMP) that Pretivm will follow concurrent with the operation of the Mine.

The ESEMP has been developed in accordance with government regulatory requirements and internal company standards. It has been further informed by community-based research and a review of literature discussing the lessons learned of other proximally located mine projects, as well as the current efforts of service delivery organizations (including education and training institutions) operating in northwestern BC.

Pretivm is committed to managing the social and economic effects of the Mine and enhancing benefits to local and regional communities and Indigenous groups. To this end, the following ESEMP has been developed to guide the Mine's operation and eventual closure phases.

2.2 ENVIRONMENT ASSESSMENT CERTIFICATE CONDITION NO. 10

The Mine's EAC is subject to a number of conditions. The Minsters' decision (BC EAO 2015) noted the following considerations with respect to economic, health and social effects:

> *EAO acknowledged a wide range of potential economic, health and social effects that may occur due to Project development. EAO determined that increased demand for health, social and/or emergency services as well as the predicted increase in transient workers were the most plausible residual effects after mitigation.*
>
> *There are legally binding conditions that will require a Health Services Management Plan, consistent with guidelines established with the Northern Health Authority (NHA) as well as an Economic and Social Effects Mitigation Plan. These plans will demonstrate how the Proponent will mitigate potential impact on regional health services, communicate Project related activities and benefits for regional Aboriginal and non-Aboriginal communities and support regional training initiatives.*
>
> *We are confident that these are sufficient to ensure potential economic, health and social effects identified in the environmental assessment will be mitigated.*

These considerations are addressed through Condition No. 9 (Health Services Monitoring Plan) and Condition No. 10 (Economic and Social Effects Mitigation Plan) of the Certificate. A Health Services Monitoring Plan is under a separate cover from the ESEMP, and it is complementary to the ESEMP.

Condition No. 10 of the EA Certificate states that the ESEMP should include, at a minimum:

- Mine development schedule;
- communication protocol;
- summary of Mine contracting opportunities;
- summary of Mine employment opportunities;
- strategy for Mine-related training programs; and
- Mine contractor and employee transportation schedule.

The ESEMP meets the requirements of EAC Condition No. 10 and presents a number of management strategies developed to respond to, manage and/or mitigate the potential social and economic effects identified in the Application. The management strategies included within the ESEMP include the following:

- Employment Strategy (Section 6).
- Procurement Strategy (Section 7).
- Training Strategy (Section 8).
- Transportation Strategy (Section 9).
- Communications Protocol (Section 10).

In addition, Pretivm must consult with NLG, Tahltan Nation and TSKLH on the content and implementation of the ESEMP in accordance with the Aboriginal Consultation Plan (ACP). Pretivm was required to implement the ESEMP prior to the start of the Construction Phase (as achieved in 2015), and comply with the ESEMP during the construction, operations, and closure phases of the Mine. Ongoing implementation and reporting requirements are described in Section 11.

Sections 6 to 10 of this document address specific requirements identified in Condition No. 10 of the EA Certificate. Also included are the scope and objectives of the overall ESEMP (Section 2.3); a summary of stakeholders (Section 3), and effects and mitigation (Section 4); the proponent's approach to implementation and management of the ESEMP (Section 5); and associated annual reporting (Section 11).

2.3 ESEMP SCOPE AND OBJECTIVES

The purpose of the ESEMP is to reduce, manage and mitigate Mine-related economic and social impacts, while strategically supporting community benefits and engagement. The ESEMP provides guidance regarding community engagement and communications for the purposes of sharing information and maximizing the potential for local and regional residents to benefit from the Mine, while demonstrating the Mine's contribution to community development.

The ESEMP includes a number of specific strategies describing Brucejack's approach to employment, procurement, and training, along with expected opportunities for local and regional residents. The ESEMP is designed to tie together other plans, policies and commitments related to these subjects; where relevant, these documents are referenced and/or appended. The ESEMP is aligned with these documents but does not take their place; any changes in related plans, policies or other commitments will need to be reflected in the ESEMP. The ESEMP is a 'living document' and will be periodically updated based on management reviews, regulatory changes, consultation with the public and Indigenous groups or other Mine-related changes (e.g., changes to Mine activities or schedule).

Considering the above, and the requirements of Condition No. 10, the ESEMP has the following objectives:

- to describe the social and economic opportunities related to the Mine, including employment, procurement, and training, and the processes for applying to or accessing these opportunities;
- to provide a clear and transparent plan for how these opportunities will be communicated to local and regional communities—and, where relevant, developed in partnership with these communities—so as to enhance local and regional benefits;
- to provide information about the Mine schedule, progress, and plans for employee and contractor transportation through regional hubs, to local government and service providers, so as to reduce potential risks or adverse effects associated with the Mine; and
- to clearly identify roles and responsibilities, monitoring and reporting requirements, and points of contact, to be applied over the life of the Mine.

3 COMMUNITIES AND INDIGENOUS GROUPS

The ESEMP pertains to the communities and Indigenous groups as defined in Schedule B of the EAC:

- The "**Local Study Area (LSA)**" communities include the Nisga'a villages, Tahltan Indian Reserve communities, the Hazeltons (Hazelton and New Hazelton), Stewart, Smithers, Terrace, and Dease Lake.
- "**Indigenous Groups**" include the Tsetsaut Skii km Lax Ha (TSKLH), Nisga'a Nation (as represented by the Nisga'a Lisims Government [NLG]), and Tahltan Nation.

For the purposes of this document, "**Local Communities**" are defined to include the communities of the Local Study Area other than the Nisga'a villages and Tahltan on-reserve communities. As such, the Local Communities include:

- Hazelton and New Hazelton;
- District of Stewart;
- Town of Smithers;
- City of Terrace; and
- Dease Lake (unincorporated).

The "**Indigenous Communities**" include the four Nisga'a villages and the three Tahltan Indian Reserve communities. The Nisga'a villages include Gitlaxt'aamiks, Gitwinksihlkw, Laxgalts'ap, and Gingolx. The Tahltan[1] communities include the on-reserve communities in Telegraph Creek (Telegraph Creek IR 6 and IR 6A, and Guhthe Tah IR 12), Iskut (Iskut IR 6), and Dease Lake (Dease Lake IR 9; approximately 4 km north of the unincorporated community of Dease Lake). Tsetsaut/Skii km Lax Ha do not have reserve or treaty lands or a formal band structure under the *Indian Act* (1985); they have asserted rights and title over the Mine area, most members are based in and around Hazelton and New Hazelton.

Portions of the Mine and associated infrastructure are located within the asserted traditional territories of the Tahltan Nation and the TSKLH, and partially within the Nass Area (subject to treaty rights under the Nisga'a Final Agreement).

[1] The Tahltan Nation includes the Tahltan Band (based in Dease Lake and Telegraph Creek) and the Iskut First Nation (based in Iskut).

4 SOCIAL AND ECONOMIC EFFECTS AND MITIGATION

The ESEMP has been developed to promote the inclusion of local and regional residents in employment, procurement, and training opportunities. These actions contribute best practices in social responsibility as it relates to community engagement, capacity building, and realization of benefits from the Mine. Equally, engagement and consultation activities coupled with maintenance of existing relationships will provide relevant and timely information to enable Mine managers and community leaders to respond proactively to potential risks and socio-economic effects.

The Mine requires a skilled workforce for operation, and needs to procure goods and services. Maximizing the number of workers hired locally, and goods and services procured through local businesses, reduce costs, and support the economic viability of the Mine. However, the existing skilled labour supply within the region is limited and subject to competing demands from other industrial projects. To improve participation of the local and regional workforce, Pretivm advertises job opportunities locally and engages local education and training organizations to identify and plan appropriate training.

Table 4-1 summarizes the potential social and economic effects identified in the EAC Application for the Mine, as related to the objectives of the ESEMP, along with the mitigation measures presented for each effect.

The mitigation measures proposed within the EAC Application largely inform the content of Condition No. 10 and the ESEMP, which includes a communications protocol, Mine development and transportation schedules, summaries of Mine employment and contracting opportunities, and a training strategy.

Table 4-1. Social and Economic Effects Addressed by the ESEMP

Valued Component	Effect	Mitigation
Labour Market	Mine employment and expenditures will contribute to competition for skilled labour and induce wage inflation pressures.	Communications with Indigenous and non-Indigenous communities; communications with educational institutions, human resources policies and programs.
	Closure of the Mine will result in loss of employment; this may increase unemployment in LSA communities.	Communications with Indigenous and non-Indigenous communities; workforce transition programs.
Education Skills Development and Training	Increased demand for educational programs. Change in the educational profile of the LSA. Decreased demand for educational programs in the LSA (at closure).	Communicate Mine development and workforce schedule with communities in the LSA and with educational institutions.
Community Infrastructure, Services, and Housing	Increased demand for infrastructure and housing as a result of population in-migration. Increased demand on health and social services. Decreased demand for infrastructure and housing as a result of population out-migration (at closure).	Communicate Mine development and workforce schedule with communities in the LSA.
Worker and Family Well-being	Increase in transient workers in LSA communities.	Communication and information sharing on use of the camp, manage the work camp and behaviour of workers.
	Increased levels of stress and anxiety on workers and families at Mine closure.	Communicate Closure Plan, transition assistance for employees.

Source: Pretivm (2014)

5 PLAN IMPLEMENTATION AND MANAGEMENT

5.1 CORPORATE PLANS AND POLICIES

The ESEMP is currently informed by Pretivm's corporate plans and policies and will be reviewed against Newcrest corporate plans and policies in 2022. The core principles for the ESEMP are guided by Pretivm's **Social Responsibility Policy** (Appendix A), which at a high level defines the company's policy standard for its relationship with communities. The Social Responsibility Policy recognizes the importance of building and maintaining relationships with Indigenous groups, communities, and key stakeholders. The Social Responsibility Policy integrates the following objectives into the company's business activities:

- Assess the environmental and social effects of the Mine's projects and activities and develop appropriate corresponding management plans.
- Disclose mine-related information and pursue meaningful and culturally appropriate dialogue on mine-related effects with local First Nations and communities and key stakeholders early in the development phase of projects. Continue to engage First Nations, communities, and key stakeholders throughout the life of the Mine.
- Protect employee and community health and safety by supporting health and safety protection programs and by working cooperatively with those who may be affected by mine operations.
- Foster a workplace environment that is safe, free of discrimination and builds on a strong foundation of ethical behaviour, respecting human rights and ensuring equal access to employment opportunities for all.
- By incorporating local knowledge and building capacity, work cooperatively with local First Nations and communities to develop and support sustainable strategies to maximize the long-term benefits of mine development.
- Work with First Nations and relevant government authorities to protect or preserve heritage and cultural resources where they may be affected by mine operations.
- Establish management and monitoring systems that will provide opportunities for continual improvement to Pretivm's environment, health, safety, and social programs.

The ESEMP is further informed by Pretivm's **Environmental Policy** which contains the following provision for stakeholder engagement with respect to environmental concerns:

- Encourage dialogue on environmental issues with employees and the public and be responsive to concerns.

Pretivm may establish several operating rules and practices related to employment with the Mine. These rules and practices will apply to all mine employees, contractors, and subcontractors both at the Mine site and while in transit to the Mine site. Company rules and practices will govern activities and behaviour at the Mine site including, but not limited to, the use of drugs and alcohol, access to and from the site, use of land around the site, external communications, discrimination and harassment, and firearms.

5.2 AGREEMENTS WITH INDIGENOUS GROUPS

In addition to the strategies outlined with the ESEMP, Pretivm is engaged in agreements with Indigenous groups that are complementary to this strategy.

5.2.1 Nisga'a Nation: Cooperation and Benefits Agreement

In April 2015, Pretivm announced a comprehensive Cooperation and Benefits Agreement with the Nisga'a Nation. Under this agreement, the Nisga'a Nation will provide ongoing support for the development and operation of the Mine in an environmentally sound manner, with commitments from Pretivm regarding communication, employment, business, education, training, and other socio-economic opportunities. The Agreement also provides for communication, collaboration, and cooperation between Pretivm and the Nisga'a Nation. Highlights include:

- Nisga'a Nation collaboration with Pretivm in support of the completion of the operational permitting process for the Mine and subsequent regulatory authorizations;
- financial payments by Pretivm to the Nisga'a Nation upon the achievements of certain Mine milestones, and annual production payments based on a percentage of net profits;
- Pretivm's commitment to education and training of Nisga'a citizens so that they will be better able to take advantage of the economic benefits the Mine offers;
- a framework for the Nisga'a Nation and Pretivm to work together to achieve employment targets to ensure Nisga'a businesses will have preferred access to contracting opportunities; and
- mutual cooperation on responding to the social impacts which Nisga'a Villages may experience as a result of the Mine.

In 2021, Pretivm continued to work with the Nisga'a Lisims Government to build capacity in the local labour force through a new Workplace Essential Skills Training Program launched in 2020. The program was developed through a Memorandum of Understanding (MOU) with Nisga'a Employment Skills and Training (NEST).

5.2.2 Other Indigenous Groups

In October 2017, Pretivm and the Tahltan Nation established a Benefits Agreement. Pretivm also signed a Cooperation and Benefits Agreement with the Gitanyow Hereditary Chiefs in June 2016.

Pretivm continues to work with other First Nations to determine the best approach to providing long-term benefits that reflect their unique circumstances.

Pretivm will comply with the provisions of existing or future agreements with Indigenous groups, in addition to the provisions described in the ESEMP.

5.3 INDIGENOUS CONSULTATION

Pretivm has developed an Aboriginal Consultation Plan (ACP) in accordance with EAC Condition No. 3. The ACP describes how Pretivm will share information, engage, and consult with the TSKLH, NLG, and Tahltan Nation throughout the Operations and Closure phases of the Mine.

The ESEMP is complementary to the ACP and other component plans, as described in Condition No. 2 of the EAC which states that the content and implementation of each component plan is subject to consultation with the Indigenous groups in accordance with the ACP. As such, the content of this ESEMP has been shared with the TSKLH, NLG, and Tahltan Nation for review and comment.

5.4 ROLES, RESPONSIBILITIES, AND REPORTING

The overall implementation of the ESEMP – including communication and consultation with Indigenous groups, communities, and other stakeholders, as well as annual reporting – is led by Pretivm's Community Relations Group. The Community Relations Group is also responsible for responding to comments and queries and providing regular reports on the activities contained in this plan. The Community Relations Group may delegate responsibility for specific aspects of the ESEMP to other personnel. In particular, the Community Relations team is responsible for engagement and relationships with communities and Indigenous groups, including discussions and programs related to hiring, employment, and training. Other supporting roles and responsibilities will be identified during implementation based on needs.

Specific responsibilities for each component are identified in the respective sections below. In general, although overall responsibility for the implementation of the ESEMP lies with the Community Relations Group, the following positions assume responsibility for specific subject areas:

- Local hiring, employment and training: Human Resources Manager and Talent Acquisition Specialists with support from the Community Relations team.
- Site management: General Manager
- Procurement: Director, Supply Chain
- Indigenous Relations: VP Government Relations and Social Performance, with support from Community Relations team

5.5 CHANGE MANAGEMENT

Significant changes or alterations to Mine activities will be actively managed and may have implications for the ESEMP and other plans. Changes will be communicated to Indigenous groups, communities, and key stakeholders in accordance with the Communications Protocol and the Aboriginal Consultation Plan. Changes may include:

- planned changes to Mine activities, design and/or production during the remainder of the Operations Phase;
- planned transition from the Operations Phase to decommissioning, closure and post-closure activities; and/or
- temporary closure.

In addition, ongoing monitoring, and reporting (as described in Section 11) and feedback from Indigenous groups, communities and other stakeholders may identify areas for improvement. Changes will be made with appropriate consultation with regulators, local government, service providers, and/or Indigenous groups, and will be reflected in the ESEMP. This approach ensures the objectives and associated actions are relevant and appropriate. Updates will be made as necessary to better achieve desired outcomes.

6 EMPLOYMENT STRATEGY

6.1 PURPOSE

The purpose of the Employment Strategy is to identify activities undertaken to promote local and regional employment. The overall approach is to increase awareness of Mine-related employment opportunities and support local and regional residents in their ability to respond to these opportunities. The Employment Strategy is closely related to the Training Strategy (described in Section 8), which provides for job-related training and coordination with regional training institutions.

6.2 SCOPE AND OBJECTIVES

The Mine has the potential to enhance the employment, work experience, education, and skill levels of the regional workforce. These capabilities also help promote the retention of workers within the region and contribute to regional development of human capital. Workforce training to achieve these ends will also support the development of a workforce capable of meeting Mine-related needs (as described in the Training Strategy in Section 8).

The objectives of the Employment Strategy are to:

- describe the types of anticipated employment opportunities;
- identify the educational and skills requirements associated with the above employment opportunities;
- provide a transparent account of the general requirements of mining employment;
- describe considerations for local and regional recruitment; and
- comply with employment provisions defined in agreements with Indigenous groups.

The Employment Strategy provides an overview of employment opportunities including available positions, timing, necessary qualifications, commitment to local and regional hiring, how to apply, and contact information for enquires. This strategy applies primarily to the Operations Phase of the Mine, as most workers in the Construction Phase were employed through contractor companies.

Hiring and training is conducted with consideration for cultural awareness and sensitivity, gender equity, and non-discrimination. Equal opportunities and career advancement is provided to all individuals employed with the Mine.

6.3 EMPLOYMENT OPPORTUNITIES

Construction Phase Employment

Mine-related employment during the Construction Phase is detailed in the ESEMP Annual Reports for years 2015 to 2017. As anticipated in the original ESEMP (October 2015), the majority of hiring during the Construction Phase was done by site contractors. The predicted level of construction employment was shown to be accurate as, during the summer of 2016, construction activities utilized more than 900 contractors and employees.

Operations Phase Employment Opportunities

The feasibility study for the Mine predicted that Operations Phase employment would peak at approximately 500 workers. Pretivm exceeded this estimate with 619 direct employees and 280 contractors employed as of December 2018. As the approved production increase was implemented in 2019, the workforce continued to grow through 2019-2021 to reach 894 direct employees and 626 contractors employed as of December 2021.

Pretivm's recruitment and hiring efforts continue to focus on providing opportunities for workers from the northwest BC region and Indigenous groups.

Detailed employment (including Pretivm and on-site contractors) by department and/or contractor is provided in the ESEMP Annual Report, which also describes the participation of Indigenous and regional workers in the workforce. A wide range of positions and departments are staffed at the mine site, and in Pretivm's offices, including:

- Underground mining;
- Mill operations;
- Surface operations;
- Camp maintenance, housekeeping, and catering;
- Mill maintenance and surface maintenance;
- Technical services; and
- Health and safety.

Most positions at the mine site are based on a two-week on/two-week off shift schedule. Where employment requirements are met, preference for hiring is given to the Indigenous groups and local and regional residents (as described in Section 6.4).

6.3.1 Qualifications and Requirements

6.3.1.1 General Employment Requirements

There are a number of standard requirements for employment within the mining industry that promote safe work and optimize the working environment. Requirements for all applicants seeking employment with Pretivm include:

- Canadian citizenship or otherwise eligible to work in Canada;
- applicants must be 18 years of age or older;
- completion of a pre-employment drug and alcohol test;
- pre-employment medical; and
- criminal record check.

Other considerations are dependent on the type of position sought. A valid driver's licence (additional classes maybe be required) and driver's abstract may be required for some positions. The requirements associated with employment opportunities will depend on the position. For entry level (unskilled) positions, requirements may include completion of high school (or equivalent) and/or some level of work experience.

Once the basic employment requirements are met, the applicant's work experience and suitability to the position will also be considered.

Employees of the Mine (including workers employed by contractors) are required to comply with the Mine's code of conduct and company policies including non-discrimination, Fitness for Duty (covering drug and alcohol use), and safety, among others.

6.3.1.2 Education and Skills Requirements for Select Positions

Typical training requirements for a selection of specific job titles are provided in Appendix B, including whether a Red Seal trades certification is applicable. The availability and timing of forthcoming employment opportunities will be provided to regional educational institutions to inform course offerings and prepare the local workforce, in accordance with the Training Strategy described in Section 8.

Appendix B lists employment opportunities typically associated with mine operation, and includes the specific education, training, and certifications or designations required of each position. This general information will be communicated to education and training organizations to inform programming.

6.3.2 Job Postings and Applications

Employment opportunities are posted online on Pretivm's website (www.pretivm.com/Careers). The online postings include job-related information such as:

- a summary of the Mine and location;
- a stated preference for local candidates;
- a description of the position including tasks and duties;
- a description of the position requirements including education and training, experience and skills, certificates, and designations.
- a description of the type of capabilities sought (e.g., attention to details, strong math skills);
- details describing the physical requirements of the position;
- a summary of compensation and benefits; and
- a summary of travel arrangements (i.e., days on/off, compensation for travel days).

The online job postings also provide a means through which to apply for a posted position (i.e., an online form). Applications may also be sent to resumes@pretivm.com. If prospective applicants need help with computers or online access, Pretivm staff can help to identify resources to provide assistance (e.g., local agencies such as WorkBC, NEST, and TahltanWorks). Pretivm's contact information is provided in Section 1.

6.3.3 Preparation for Closure

In advance of the Closure and Decommissioning Phase, Pretivm will prepare a plan for communicating closure plans and schedules, and related implications (and opportunities), to employees. Closure planning will include support to help workers transition out of Mine employment and find new positions. This may include documentation of training and experience, and provision of references for employment.

6.4 SPECIAL CONSIDERATIONS FOR LOCAL AND REGIONAL RECRUITMENT

Pretivm supports the recruitment of local and regional workers by advertising available positions locally and providing local communities, Indigenous groups, and service providers with information about upcoming jobs and recruitment efforts. Although there is no strict target for local/regional employment, the following regional preferences are applied after basic requirements are met:

1. Members of Indigenous groups including the TSKLH, Nisga'a Nation, Tahltan Nation, and Gitanyow;
2. Individuals who reside within LSA communities (as described in Section 3);
3. Residents of northwestern BC; and
4. Residents of BC.

Workers are generally expected to live in, or arrange their own travel to, hub communities in northwest BC, including Smithers, Terrace, and nearby communities (e.g., along highways 16 and 37 en route to the mine site). However, transportation from other hub communities may be added or

adjusted depending on employment numbers. Transportation from various communities is described further in Section 9 (Transportation Strategy).

Awareness of Mine opportunities is enhanced through communication of job postings with relevant local institutions. Table 6.4-1 describes some of the avenues by which Pretivm communicates employment opportunities, including local employment offices, the Newcrest office in Smithers, and direct communications with Indigenous groups. Positions are also posted on a variety of online job boards.

Table 6.4-1. Recruitment and Job Posting Resources

Type	Job Posting Information
Pretivm	Online at: https://www.pretivm.com/careers/current-job-postings/default.aspx
	Newcrest office in Smithers
	Brucejack Mine Site (for existing employees)
Websites related to the mining industry	Various, including: • InfoMine • Mining Association of BC • Association for Mineral Exploration BC • Association of Professional Engineers and Geoscientists • Canadian Institute of Mining, Metallurgy & Petroleum • Environmental Operators Certification Program
Community resources	WorkBC online and offices: • Smithers • Terrace • Houston • Hazelton
	BC Construction Association (BCCA), notably through the Skilled Trades Employment Program (STEP) – Terrace Office
	General job boards: • Indeed.ca • BC Jobs
	Upper Skeena Development Centre
	Nisga'a Employment, Skills and Training (NEST): Prince Rupert, Terrace, and Gitlaxt'aamiks
	OnTrack, Tahltan Database, TCG
	Gitanyow Education and Training Institute
Websites targeted at Indigenous job seekers	Aboriginal Job Board
	NationTalk (national Indigenous news, employment, and tender network, www.nationtalk.ca)
	Tahltan and Nisga'a employment departments also advertise open positions on their webpages and social media

Prospective employees need to apply online for posted positions. Pretivm works with Indigenous groups to ensure that all interested applicants can efficiently access the online applications. If potential barriers to applications are identified (e.g., lack of computer access), Pretivm works with Indigenous groups to implement solutions. The Community Relations Manager works closely with employment contacts at Indigenous groups to connect job postings with eligible individuals in the communities, and to proactively identify and mitigate challenges. When a new position becomes available, Pretivm's Community Relations Manager emails the employment contacts at the Nisga'a Nation, Tahltan Nation, and Gitanyow. This notification is provided prior to an online job advertisement and is intended to give an advantage to local and Indigenous applicants.

Pretivm is committed to providing early and clear communications of hiring schedules and skill/certification requirements for positions via the Pretivm website and the contacts identified in Table 6.4-1. The Mine website provides public access to information about Mine-related employment, including the type of jobs that are available, a description of responsibilities, and the requirements for that type of employment, such as education and experience. Where possible, jobs will be posted and communicated at least two weeks prior to the application deadline.

Pretivm maintains regular contact with First Nations' employment representatives to communicate job postings, provide information about required skills and experience, and organize recruitment events.

6.5 RECENT ACTIVITIES

A summary of recent activities is provided in the ESEMP Annual Reports. At the time of writing, Annual Reports have been prepared for all calendar years from 2015 to 2021.

6.6 EVALUATION AND REPORTING REQUIREMENTS

The Employment Strategy is regularly reviewed and updated to ensure that it continues to be relevant and appropriate and facilitate the increased participation of local and regional residents in Mine employment. The strategy is reviewed annually and reported through the ESEMP Annual Report (described in Section 11). The following factors are reviewed and reported:

- a summary of Mine employment (number of applicants, number of people hired, duration of employment, type of employment [e.g., full-time, temporary]) for the following groups/areas:
  - Indigenous groups (and associated communities): TSKLH, Nisga'a Nation, Gitanyow and Tahltan Nation;
  - local communities: Smithers, Terrace, the Hazeltons, Stewart, and Dease Lake; and
  - northwest BC;
- comparison with preceding years to highlight trends;
- a summary of feedback from Indigenous groups, communities, and other stakeholders regarding employment process and/or outcomes; and

- upcoming actions or changes to the Employment Strategy.

6.7 ROLES AND RESPONSIBILITIES

Pretivm's Community Relations Manager is responsible for the implementation of the Employment Strategy including efforts for local and Indigenous hiring. Responsibilities include communication of employment opportunities to Indigenous groups and LSA communities. The Community Relations Manager is also responsible for the annual review of activities related to the Employment Strategy. The Community Relations Manager is supported by the Director, Human Resources, and the Talent Acquisition Specialists.

6.8 SUMMARY

Employment Strategy	
Purpose	To promote local and regional engagement in Mine employment.
Objectives	• Describe the type of employment opportunities that are anticipated to be available; • Identify the educational and skills requirements associated with the above employment opportunities; • Provide a transparent account of the general requirements of mining employment; • Describe considerations for local and regional recruitment; and • Comply with employment provisions defined in agreements with Indigenous groups.
Key Activities	Employment opportunities will be advertised locally and communicated to local communities, Indigenous groups, and other organizations to enhance local and regional employment.
Responsible	Community Relations Manager (Pretivm)
Timing and Schedule	Ongoing throughout Operations Phase.
Reporting	Annual ESEMP Report

7 PROCUREMENT STRATEGY

The Procurement Strategy summarizes Pretivm's procurement and contracting process, including the purpose, objectives, implementation, monitoring and reporting activities for the Mine.

7.1 PURPOSE

The Procurement Strategy describes Pretivm's overall procurement process and the activities that will be undertaken to maximize the number of local and regional businesses engaged in business contracts (and sub-contracts) associated with the Mine's procurement of goods and services. The involvement of suitable local and regional businesses enhances the economic benefits to local communities, Indigenous groups, and the broader region, and optimizes the economic viability of the Mine.

Pretivm recognizes that the Mine has the potential to positively affect local and regional economic development and is committed to enhancing this potential through both the direct and indirect expenditures through the purchase of goods and services on a competitive basis.

7.2 SCOPE AND OBJECTIVES

The Mine has the potential to attract and retain businesses in the local and regional area, and support the development these businesses, through contracts for goods and services. The involvement of local and regional businesses will further support indirect and induced employment and economic development associated with the Mine.

The Procurement Strategy has been developed to promote contract and subcontract opportunities for local and regional businesses, including Indigenous businesses. This will be achieved by ensuring businesses are aware of the Mine and understand Mine procurement practices and opportunities and are ultimately able to respond to procurement notices and become suppliers to the Mine.

The objectives of the Procurement Strategy are to:

- highlight existing commercial relationships with Indigenous businesses, and businesses located in the LSA communities;
- describe the types of anticipated business/contract opportunities;
- describe the processes and tools that will be used to manage procurement opportunities and suppliers;
- describe considerations for local and regional content; and
- comply with the business and contracting provisions defined in agreements with Indigenous groups.

7.3 PROCUREMENT OPPORTUNITIES

The Procurement Strategy is primarily relevant to the Operations Phase of the Mine rather than the Closure Phase.

7.3.1 Contracting Opportunities

Construction Phase

Mine supply and service contracts during the Construction Phase are listed in the ESEMP Annual Reports for years 2015 to 2017. As anticipated in the original ESEMP (October 2015), major contracts during the Construction Phase were managed by the EPCM contractor. However, several local and Indigenous business contracts were established or maintained throughout 2016 and 2017, including contracts with businesses in Smithers, Terrace, and other northwest BC communities. Local sourcing included food, fuel, office supplies, vehicles rentals/leases, road maintenance, transportation services, medical services, trades, environment, drilling, steel supply, and camp supplies.

Operations Phase

A variety of supply and service contracts are required during the Operations Phase, including but not limited to contracts related to: information and communication technology; legal, accounting, insurance, recruitment, and other services; medical/first aid services; travel and transportation; road maintenance; training; safety; camp catering; building maintenance; security; environmental monitoring; mill maintenance and supplies; underground mining equipment and supplies; underground mining services; consumables; waste management; and mobile equipment and maintenance.

Contracts for on-site services during mine operations include underground mining, drilling and on-site medical services. The current contract for medical services was awarded to Iridia (a Nisga'a-affiliated company) for the services of Registered Nurses and Advanced Care Paramedics at the mine site. The current underground mining contract was awarded to Procon Mining and Tunnelling Ltd. (based in Burnaby, BC); the contractor company is committed to hiring First Nations and local workers. Security services are currently contracted to Western Protection Alliance Inc. (WPA), based in Richmond BC; and the current drilling contract was awarded to Hy-Tech Drilling (based in Smithers, BC). Further detail about supply and service contracts is provided in the ESEMP Annual Reports.

7.3.2 Procurement and Contracting Process

Pretivm's procurement and contracting process begins with the provision of a request for expressions of interest (RFEOI) and invitation for bidders to submit their qualifications. Pretivm is then able to pre-qualify interested bidders, and then provides qualified bidders with a request for proposal (RFP). An evaluation of proposals is based on the technical and commercial components. Bidders are shortlisted for negotiations. Following negotiation, the contract is awarded. This process typically occurs over a two-month period.

Pretivm will maintain contact with First Nations to provide information about upcoming procurement opportunities and processes. First Nations are provided with advance notice of upcoming contracts to allow opportunities to develop joint ventures or partnerships with other companies, if needed. To date, First Nations have been actively engaged in the procurement process.

7.4 SPECIAL CONSIDERATIONS FOR LOCAL AND REGIONAL PROCUREMENT

Pretivm invites interested contractors to express interest in Mine work directly to Pretivm. In addition, the company's website lists current notifications for upcoming contracting opportunities, as well as notification of work awarded, to promote transparency and accountability. Where local firms have expressed an interest in working with the Mine, Pretivm may request a skills and experience inventory to match that company with current and potential future Mine contracts. Pretivm will support the procurement of supplies and services from local and regional businesses by considering local content in the evaluation of bids and proposals, including plans for partnerships and joint ventures. All other factors being equal, bidders that employ local residents will have an advantage over bidders who employ non-residents.

Although a strict target for local/regional content has not been established, the following regional preferences are anticipated after basic requirements (including safety) are met:

1. Indigenous businesses, including Nisga'a Nation, Tahltan Nation, Gitanyow and TSKLH;
2. Businesses based within LSA communities (as described in Section 3);
3. Businesses based in northwestern BC; and
4. Businesses based in other areas of BC.

As noted in Section 7.3.2, Pretivm provides advance notice of upcoming supply and service contracts to First Nations, to provide an opportunity for interested First Nations businesses to find partners, if needed.

In the evaluation of all bids, the extent of local content (e.g., the degree to which local employees/ business are included) is a weighted criterion. All other factors being equal, pre-qualified suppliers that employ local residents will have an advantage over suppliers who employ non-residents. In addition, those awarded contracts with the Mine will be encouraged to use local suppliers or subcontractors where possible. This provides a full and fair opportunity for suitable and registered local and regional companies to bid for the supply of good and services to the Mine.

Pretivm values relationships with Indigenous businesses and has established commercial relationships with local First Nations. Pretivm will continue to seek to engage in mutually successful commercial arrangements with the TSKLH, Nisga'a Nation, Tahltan Nation, and other regional First Nations. Where appropriate, early notice of opportunities will be provided so that Indigenous businesses have an extended period to develop proposals and/or identify potential business partners. Examples of contracts with Indigenous businesses to date include camp construction, access road maintenance, medical services, and waste rock disposal.

Awareness of Mine-related opportunities for Indigenous businesses will be enhanced through communications with the Indigenous groups, as per the Aboriginal Consultation Plan.

7.5 RECENT ACTIVITIES

A summary of recent activities is provided in the ESEMP Annual Reports. At the time of writing, Annual Reports have been prepared for all calendar years from 2015 to2021.

7.6 EVALUATION AND REPORTING REQUIREMENTS

The Procurement Strategy is regularly reviewed and updated to ensure that it continues to be relevant and appropriate and facilitate the increased participation of local and regional residents in Mine procurement. The strategy is reviewed annually and reported through the ESEMP Annual Report (described in Section 11).

The following factors are reviewed and reported annually:

- a summary of Mine procurement (number of bids received, number of contracts, duration, type of activities [e.g., road maintenance, catering]) for the following groups/areas:
  - Indigenous groups (and associated communities) including TSKLH, Nisga'a Nation, and Tahltan Nation;
  - local communities: Smithers, Terrace, the Hazeltons, Stewart, and Dease Lake; and
  - northwest BC;
- comparison with preceding years to highlight trends;
- a summary of feedback from Indigenous groups, communities, and other stakeholders regarding business involvement, procurement process, and/or outcomes; and
- upcoming actions or changes to the Procurement Strategy.

7.7 ROLES AND RESPONSIBILITIES

Pretivm's **Director of Supply Chain** is responsible for the implementation of the Procurement Strategy. Responsibilities include implementation of the Procurement Strategy, including communication of contracting opportunities and requirements to Indigenous groups, communities, and training institutions, with support from the Community Relations Manager. The General Manager is also responsible for the annual review and reporting of activities related to the Procurement Strategy.

7.8 SUMMARY

Procurement Strategy	
Purpose	To maximize the involvement of local businesses in Mine contract work.
Objectives	• Highlight existing commercial relationships with Indigenous businesses, and businesses located in the LSA communities; • Provide a description of the types of contract opportunities that are expected to be available; • Describe the processes and tools that will be used to manage procurement opportunities and suppliers; • Describe considerations for local and regional content; and • Comply with the business and contracting provisions defined in agreements with Indigenous groups.
Responsible	Director of Supply Chain (Pretivm)
Key Activities	Procurement contracts will consider the level of local content (including local, regional, and Indigenous businesses), in order to enhance local economic benefits.
Timing and Schedule	Ongoing throughout Operations Phase.
Reporting	Annual ESEMP Report

8 TRAINING STRATEGY

The Training Strategy outlines the purpose, objectives, implementation, monitoring and reporting activities for training activities related to the Mine.

8.1 PURPOSE

The purpose of the Training Strategy is to support the capacity of the local labour force and Mine workforce to meet the needs of the Mine, as well as to support regional educational and training organizations to develop and plan timely and relevant training programs. The strategy includes job-related training to enable employees to work safely and effectively, and supports the development of capacity within the local labour force through communication with local post-secondary education and training institutions. These actions are expected to enhance the number of local and regional residents with the specific skillsets required by the Mine, thereby enhancing local and regional employment and broader economic development. Support for training may also reduce potential competition for skilled labour by increasing the availability of skilled workers.

8.2 SCOPE AND OBJECTIVES

The Mine has the potential to enhance the work experience, education, and skill levels of the regional workforce. The Training Strategy seeks to maximize these benefits while also ensuring that Mine workers have the training and skills required to conduct their jobs safely and effectively. In order to promote local employment, experience, education, and skill levels, Pretivm will provide relevant on-the-job training and may also utilize services through external training institutions. Career development opportunities will also be provided to Mine employees to encourage internal advancement and to meet the demands of the Mine. To support the broader regional workforce and enhance the ability of residents to attain Mine-related employment, relevant information will also be provided to local and regional training institutions to support program planning and development.

The objectives of the Training Strategy are to:

- provide the necessary on-the-job training for Mine workers to conduct their jobs safely and effectively;
- provide information describing the educational and skills requirements of Mine employment to education and training organizations in order to inform course offerings;
- share information about employment and training opportunities with communities, Indigenous groups, and institutions;
- contribute to the further development and diversification of the regional labour force; and

- comply with education and training provisions defined in agreements with Indigenous groups.

These activities are expected to enhance prospects for local employment and retention within the Mine workforce. Pretivm will undertake a number of activities aim to communicate employment requirement and support training initiatives.

8.3 EDUCATION AND TRAINING OPPORTUNITIES

There are a number of education and training opportunities typically provided to a Mine's workforce to ensure a safe and effective working environment (e.g., Workplace Hazardous Materials Information System, or WHMIS). Certain training and certifications are expected to be provided on-the-job, while for some positions specific training and certifications are a pre-requisite to employment (see Appendix B). Apprenticeship opportunities will be available for applicable trades on a case-by-case basis. Pretivm will also work with local and regional training institutions to support mining-related training and education programs for prospective Mine employees, as described in Section 8.4.

In 2017, activities at the mine site progressed from construction into mine commissioning and production. Since 2018, as the first full year of operations, mine-related training has focused on operations-centric themes, and an increase in permanent employees corresponded with a reduction in the number of site orientations.

8.3.1 Job-related Training and Development

Training of the workforce at the Mine is on-going and job specific. Pretivm will ensure that all employees receive the necessary training to complete their work safely and effectively. On-the-job training will be provided to Mine employees depending on their job position, and may include:

- Bear Aware;
- WHMIS;
- Transportation of Dangerous Goods;
- Basic First Aid;
- Avalanche Training;
- Food Safe;
- Lock-out/Tag-out processes;
- Fire extinguisher training;
- Equipment training related to the use of heavy equipment, light vehicles, ATVs; and
- Other task-specific on-the-job training.

In addition, staff in supervisory positions receive training related to communication, conflict management, bullying and harassment, performance review processes, and additional health and safety training (e.g., identification of drug/alcohol use on the job). Pretivm may also utilize external training programs to achieve specific job-related training needs, either on-site or at an external facility.

To support the development of underground mining skills, Pretivm has partnered with the underground mining contractor to establish an entry-level Underground Mine Training Program. This program provides new workers with on-the-job training to build skills and experience related to a career in underground mining.

All workers using equipment will require confirmation from Pretivm that the necessary training has been completed.

8.3.2 Apprenticeships

The Mine will facilitate apprenticeship opportunities where possible and will work to increase the availability of these types of opportunities throughout the life of the Mine. During the Operations Phase, apprenticeships may cover the following areas, among others:

- Culinary services;
- Heavy duty technicians;
- Welding;
- Warehouse management; and
- Millwright.

8.4 SPECIAL CONSIDERATIONS FOR LOCAL AND REGIONAL EDUCATION AND TRAINING

8.4.1 Working with Local and Regional Educational Institutions

Support for locally available education and training programs relevant to the mining industry is expected to enhance the skills of the local labour force and maximize the number of local residents employed by the Mine. Pretivm will work with local educational institutions by sharing information about Mine-related employment opportunities (and related requirements for education and training) to inform future programming. Future discussions may lead to the development of more formal partnerships or other forms of support.

As information about employment needs becomes available, Pretivm will share information about positions, timing, and associated requirements for education, training and/or work experience. It is expected that this information, among other factors, will inform the course offerings provided by these

institutions. Information is shared with the following local and regional institutions and Indigenous groups (and others that may be later identified):

- Coast Mountain College, campuses in Smithers, Terrace, Hazelton, and Houston, including the School of Exploration and Mining in Smithers;
- Northern Lights College, campus in Dease Lake;
- Wilp Wilxo'oskwhl Nisga'a Institute (WWNI) in Gitwinksihlkw;
- Nisga'a Employment Skills and Training (NEST);
- Tahltan Works; and
- TSKLH.

Pretivm notifies regional educational institutions of the standard types of training provided to Mine employees at site (e.g., WHMIS, safety) to inform future course offerings. Communications with regional education institutions will be guided by the Communications Protocol (see Section 10).

8.4.2 Youth and Communities

In partnership with local service providers, Pretivm participates in educational sessions with youth at local and regional schools and training institutions. Participation can include speaking to students about mining employment, providing materials and other available information about careers in mining, and describing potential opportunities available with the Mine (e.g., support for apprenticeship programs, summer employment, scholarships). These activities aim to provide background and context about the mining industry, the types of employment available in the mining industry, and what it is like to be at a mine site. Information about training opportunities may also be provided.

Similar activities may also be conducted outside of schools, including Indigenous communities and rural locations such as Dease Lake. These events are designed to help people understand the opportunities associated with the Mine, the benefits, and challenges of mining employment (including family and cultural challenges), life in a mining camp, shift rotations, and the skills and training requirements for various types of positions. Where possible, connections with local and regional training institutions are made to enhance these events and connect prospective workers with relevant training.

8.5 RECENT ACTIVITIES

A summary of recent activities is provided in the ESEMP Annual Reports. At the time of writing, Annual Reports have been prepared for all calendar years from 2015 to 2021.

8.6 EVALUATION AND REPORTING REQUIREMENTS

The Training Strategy is regularly reviewed and updated to ensure that it continues to be relevant, appropriate and facilitate the increased participation of local and regional residents in mine

employment. The strategy is reviewed annually and reported through the ESEMP Annual Report (described in Section 11).

The following factors are reviewed and reported annually:

- a summary of on-the-job training courses (e.g., safety orientations, equipment training) attended by the Mine workforce (number of courses, number of attendees, etc.);
- a summary of external training courses conducted for Mine workers or otherwise supported by the Mine, as well as the number of course registrants for each. Indication of courses offered will include those offered for the following groups/areas:
    - Indigenous groups (and associated communities): TSKLH, Nisga'a Nation, Tahltan Nation; and
    - Local communities: Smithers, Terrace, the Hazeltons, Stewart, and Dease Lake;
- comparison with preceding years to highlight trends;
- a summary of feedback received regarding training programs, approach, course offerings and/or outcomes; and
- upcoming actions or changes to the Training Strategy.

8.7 ROLES AND RESPONSIBILITIES

Pretivm's **Community Relations Manager** is responsible for the implementation of the Training Strategy. Responsibilities include communication of upcoming and future employment opportunities and skills/training requirements to local and regional training institutions and Indigenous groups. The Community Relations Manager is also responsible for the annual review of activities related to the Training Strategy.

8.8 SUMMARY

Training Strategy	
Purpose	To enhance the number of local individuals engaged in Mine employment through communications with and support for the education and training organizations offering relevant programming.
Objectives	• Provide the necessary on-the-job training for Mine workers to conduct their jobs safely and effectively; • Provide information describing the educational and skills requirements of Mine employment to education and training organizations in order to inform course offerings; • Share information about employment and training opportunities with communities, Indigenous groups, and institutions; • Contribute to the further development and diversification of the regional labour force; and • Comply with education and training provisions defined in agreements with Indigenous groups.
Key Activities	To ensure suitable training for all workers, and to provide information about upcoming and future labour needs to regional education and training institutions so that they can develop relevant programming.
Responsible	Community Relations Manager (Pretivm)
Timing and Schedule	Ongoing throughout Operations Phase.
Reporting	Annual ESEMP Report

9 TRANSPORTATION STRATEGY

The following is a summary of Pretivm's Transportation Strategy, issued under a separate cover, dated December 2016, with additional updates, all distributed to stakeholders (including RCMP, LSA communities, Indigenous groups, Northern Health, and the Environmental Assessment Office).

9.1 PURPOSE

The purpose of the Transportation Strategy is to plan Mine-related workforce transportation (including employees and contractors) to and from the mine site and share this information with emergency response providers and other services in the region so that potential effects can be proactively identified and managed.

9.2 SCOPE AND OBJECTIVES

The Transportation Strategy outlines the planned workforce travel arrangements for the transportation of Mine workers to and from the mine site. This information includes routes, methods and timing of travel. The Strategy applies to Mine contractors and employees and has been established to minimize the effects of worker transportation on local community infrastructure and services. The objectives of the Strategy are to:

- provide information as to the routes, methods, and timing of workforce transportation;
- minimize the time spent by workers in local communities (e.g., travel hubs) while in transit between the Mine and their home community;
- ensure that local communities and service providers are informed of plans and schedules related to workforce transportation, so that they can plan accordingly; and
- comply with transportation provisions defined in agreements with Indigenous groups[2].

9.3 TRANSPORTATION ROUTES AND SCHEDULE

Workers are transported along standard routes by either bus or plane, or a combination, depending on their home community. Workers are responsible for getting to the appointed "pick-up points" for onward transportation to the site. As such, workers may live across BC or Canada, but—in general—will be responsible for their own transportation to one of the following pick-up points:

- ground travel (shuttle bus) from Terrace and Smithers, with pick-up points enroute including Kitwanga and Meziadin Junction; and

[2] At the time of writing, there were no transportation provisions in agreements with Indigenous groups.

- air travel based out of Terrace.

The same locations are be used on the return trip (i.e., returning home from site). The majority of Mine contractors and employees work shifts of two-weeks on, followed by two-weeks off.

9.3.1 Ground Travel

Workers are responsible for getting to the appointed "pick-up points" for onward transportation to the site by bus. The primary pick-up points, in south-north orientation, are:

- Western route (chartered bus):
  - Kitimat;
  - Terrace-Kitimat Regional Airport (to meet inbound flights);
  - Terrace;
  - Kitwanga;
- Eastern route (shuttle bus):
  - Smithers, with pick-ups along Highway 16 to Kitwanga;
  - Passengers transfer to chartered bus at Kitwanga;
- Highway 37 north of Kitwanga (chartered bus):
  - Meziadin Junction (to meet workers from Stewart and area); and
  - Wildfire Camp.

From the Wildfire Camp (at Kilometer 1 of the Brucejack access road, near the junction with Highway 37), workers are transported by bus to the site via the access road. The same points, in reverse, are used as drop-off points for buses transporting workers home from the site.

Workers residing outside of the Highway 16 and Highway 37 routes described above are responsible for their own travel to the nearest pick-up point. Workers from the Nisga'a villages typically meet the bus in Terrace, and workers from Stewart travel to Meziadin Junction.

9.3.2 Air Travel

Due to the Mine's proximity to Highway 37, and to reduce the risk of travel delays due to adverse weather conditions, Pretivm expects that the majority of workers will travel to the mine site by bus. Employees from outside of northwest BC travel by air to Terrace, using chartered flights from Vancouver and interior locations. Out of province employees take commercial air travel to Vancouver. Flights typically arrive in Terrace in mid-morning (around 10:30 am). Personnel are met at the Terrace Airport by the contracted bus company, for transportation by bus to the mine site (described in Section 9.3.1).

Where workers arriving at or departing from the mine require flight connections in Terrace, connections are generally made the same day. If overnight stays are required (e.g., to accommodate weather delays), workers will be expected to continue to abide by the Mine code of conduct, as expected when they are on-duty at the site.

9.4 COMMUNICATION AND CHANGE MANAGEMENT

9.4.1 Communication of the Transportation Schedule

Pretivm shares the transportation schedule (including timing and routes) for the Mine workforce with the emergency service providers and local governments in the LSA, particularly with those in Smithers and Terrace as the planned hub communities for workforce transportation. The schedule identifies the days of the week travel will occur as well as the number of Mine employees expected to be in transit.

9.5 RECENT ACTIVITIES

The majority of transportation to and from the Mine is by bus from Smithers and Terrace. There is no regular schedule of personnel flights. Transportation activities are included in the ESEMP Annual Reports. Roles and Responsibilities

Pretivm's **General Manager** is responsible for the implementation of the Transportation Strategy. Responsibilities include scheduling of transportation services and routes, communication of the transportation schedule to local communities and emergency service providers, and management and communication of any changes to this schedule.

9.6 SUMMARY

Transportation Strategy	
Purpose	To minimize the potential for Mine effects on emergency and other services in local communities associated with the transit of workers through communities during travel to/from the mine site.
Objectives	• Provide information as to the routes, methods, and timing of workforce transportation; • Minimize the time spent by workers in local communities (e.g., travel hubs) while in transit between the Mine and their home community; • Ensure that local communities and service providers are informed of plans and schedules related to workforce transportation, so that they can plan accordingly; and • Comply with transportation provisions defined in agreements with Indigenous groups.
Key Activities	Share plans and schedules for workforce transportation with local communities and service providers.
Responsible	General Manager (Pretivm)
Timing and Schedule	Ongoing throughout Operations Phase.
Reporting	None identified at this time.

10 COMMUNICATIONS PROTOCOL

The Communications Protocol complements the Mine's Aboriginal Consultation Plan and Pretivm's corporate communication policy. This Protocol outlines the purpose and objectives of Mine-related communications with communities and Indigenous groups, planned activities, monitoring and reporting.

10.1 PURPOSE

The purpose of the Communications Protocol is to guide communications between Pretivm, and the various communities, Indigenous groups, and other stakeholders involved in the Mine, and to establish a framework for effective response to all requests, issues, suggestions, and feedback. These activities will ultimately support positive and mutually beneficial relationships within the local and regional area and help Pretivm and the Mine maintain a positive public image.

As noted in Section 4, many of the mitigation measures designed to address potential social and economic effects (as identified in Section 4) are related to communications and the sharing of information about the Mine. Provisions for communication are also integrated into the employment, procurement, training and transportation strategies described above. This Communications Protocol describes the overarching process by which these communications will be conducted.

10.2 SCOPE AND OBJECTIVES

This Protocol is intended to guide communications related to the Mine—including those about potential employment procurement, training, or other opportunities—between Pretivm and the following communities and groups:

- the Local Communities (Stewart, Smithers, Terrace, Dease Lake, and the Hazeltons);
- Indigenous groups including TSKLH; the NLG and the Nisga'a villages; and the TCG and the Tahltan communities of Dease Lake, Telegraph Creek and Iskut;
- regional educational and training institutions including Coast Mountain College (and the School of Exploration and Mining), Northern Lights College, and Wilp Wilxo'oskwhl Nisga'a Institute; and
- health and emergency service providers including the RCMP and Northern Health.

Additional groups and organizations may be identified as Mine development progresses.

Pretivm is committed to working with residents, communities, and stakeholders to maintain and enhance current community relations. The objectives of the Communications Protocol are to:

- ensure communication processes are clearly identified;

- effectively manage issues as they arise by proactively identifying and addressing issues and concerns;
- share timely, relevant information about the Mine in a transparent and useful manner; and
- comply with consultation and communication provisions defined in agreements with Indigenous groups.

The Protocol defines the types and frequencies of communication and also describes the means by which communities, Indigenous groups and other stakeholders can provide input to the Mine and/or submit questions or concerns.

10.3 OUTGOING COMMUNICATIONS

Pretivm will utilize a number of different communication methods to convey information about the Mine, including milestones in Mine development, employment and procurement opportunities, transportation schedules, and other information. Table 10.3-1 lists some of the primary ways by which this information will be shared. Pretivm also welcomes communications from Indigenous groups, local communities, and other stakeholders at any time, as discussed in Section 10.4.

Table 10.3-1. Task Description and Implementation

Method	Implementation	Timing / Frequency
Website	Content provided on Pretivm's website will include employment and contracting opportunities, Mine milestones and updates, and other relevant information. Opportunities postings will include specifications (e.g., timing, requirements, etc.). The website may also be used for announcements including, for example, contracts awarded to local and regional businesses and other Mine highlights.	Ongoing
Regional Office	A regional office in Smithers will continue to be a source for information about employment, procurement, and other opportunities. Inquiries can be made in person or by phone or email. Information about mine-related training and education may also be available in partnership with regional training institutions. Questions and concerns can also be submitted at the office.	Ongoing
Newsletter	An annual newsletter describing highlights of the past year and a look ahead at the coming year will be produced. The newsletter will summarize notable achievements (and upcoming opportunities) in terms of employment, procurement, training, stakeholder engagement, and contributions to local economic development. It will also provide up-to-date contact information for the company. A PDF of the newsletter will be posted to Newcrest's website and emailed to community and/or Indigenous contacts; hard copies may be provided upon request.	Annual

(continued)

Table 10.3-1. Task Description and Implementation (completed)

Method	Implementation	Timing / Frequency
Open Houses	When appropriate, Pretivm will participate in events such as open houses or career fairs.	As warranted
Community Events	Pretivm will provide Mine updates and will answer questions about the Mine at relevant community events such as industry or business exhibitions, job fairs, or other events.	As warranted
Newspapers	Pretivm will advertise available jobs in local newspapers including the Smithers Interior News and the Terrace Standard, as well as other forums identified in Section 6.	As warranted
Information for service providers	As identified above, specific information will be shared with certain groups of stakeholders in order to facilitate broader planning and development and the effective management of socio-economic effects. This includes: • providing regional educational and training institution with indication of the types of employment opportunities associated with Mine work, as well as a description of the skills and educational requirements for each type of position; and • providing health and emergency service providers with information about transportation plans and schedules (for the transportation of the Mine-related workforce through LSA communities). Information will be shared by email unless otherwise requested.	As warranted
"Intro to Mining Employment" seminars	If there is interest amongst the LSA communities and/or Indigenous groups, Pretivm will hold local seminars/discussion sessions to help people understand the opportunities associated with the Mine, the benefits, and challenges of mining employment (including family and cultural challenges), life in a mining camp, shift rotations, and the skills and training requirements for various types of positions. Connections with local and regional training institutions may enhance these events.	As warranted

Preparation for Closure

In advance of the Closure and Decommissioning Phase, Pretivm will prepare a communication plan to engage communities and Indigenous groups and provide information about closure plans and related implications (and opportunities) for employees and contractors. Similar engagement will occur around any temporary shut-down that may be required. Further detail will be included in the Mine's forthcoming Reclamation and Closure Plan.

10.4 INCOMING COMMUNICATIONS

Pretivm welcomes communications from the public, local communities, government, Indigenous groups, and other stakeholders at any time, including questions, comments, suggestions, requests, concerns, or complaints. These communications can be expressed in person (e.g., at the Newcrest

regional office in Smithers, or at a company event), or by email, telephone, or post; contact information is provided in Section 1. Queries can also be submitted online via Newcrest's website.

Pretivm endeavours to respond to all questions, comments, or concerns to either provide an answer or explanation, or demonstrate how the information provided has been considered. Communications will be documented and tracked (as described in Section 10.5) to ensure that appropriate actions are taken in a timely manner.

10.5 COMMUNICATIONS MANAGEMENT

A record of Mine-related communications and feedback received from community members through all forums, including email, the website, community events, and via the Newcrest office in Smithers. The company's current communications/engagement tracking and management software, StakeTracker, will continue to be used for the foreseeable future.

Pretivm endeavours, where possible, to respond to incoming communications within five (5) business days. With the response, Pretivm provides the name of a contact person and their contact information (email, telephone). If the required information is not provided in the initial response, an estimated timeline for the complete response is provided.

All communications is treated with respect and attention. For complaints or grievances (e.g., unsafe driving, unauthorized emissions, discriminatory hiring practices), Pretivm will ensure that prompt and objective investigations are conducted and documented in a transparent manner, and that this information is communicated back to the person (or group) who registered the complaint/grievance. Updates are regularly provided to keep all parties informed until a solution is developed, agreed by all parties, and implemented.

10.6 EVALUATION AND REPORTING REQUIREMENTS

The Communications Protocol is regularly reviewed and updated to ensure that it continues to be relevant and appropriate and facilitate the increased participation of local and regional residents and businesses in the Mine. The strategy is reviewed annually and reported through the annual ESEMP Report (described in Section 11).

The following factors will be reviewed and reported annually:

- a summary of events, newsletter editions, workshops and other communications that occurred over the course of the year;
- a summary of feedback from Indigenous groups, communities, and other stakeholders, including key issues and how they were addressed; and
- upcoming actions or changes to the Communications Protocol.

10.7 ROLES AND RESPONSIBILITIES

Pretivm's **Community Relations Manager** leads communication and consultation with Indigenous groups, communities, and other stakeholders. Responsibilities include implementation of the Protocol and associated external communications (incoming and outgoing), annual reporting and review of the Protocol, and updates or revisions on an as-needed basis. The Community Relations Manager, who is based in Smithers, is also responsible for engagement related to employment, training, and procurement.

10.8 SUMMARY

Communications Protocol	
Purpose	The purpose of the Communications Protocol is to guide communications between Pretivm, and the various communities, Indigenous groups, and other stakeholders involved in the Mine, and to establish a framework for effective response to all requests, issues, suggestions, and feedback.
Objectives	• Ensure communication processes are clearly identified; • Effectively manage issues as they arise by proactively identifying and addressing issues and concerns; • Share timely and relevant information about the Mine in a transparent and useful manner; and • Comply with consultation and communication provisions defined in agreements with Indigenous groups.
Key Activities	Share information about the Mine with communities, Indigenous groups, and other stakeholders, and promptly and transparently respond to questions, comments, concerns, and complaints.
Responsible	Community Relations Manager (Pretivm)
Timing and Schedule	Ongoing throughout Operations Phase.
Reporting	Annual ESEMP Report

11 ANNUAL ESEMP REPORT

This section of the ESEMP outlines the reporting schedules and activities related to the Mine, for all the aspects described in the preceding sections, which are reported through an annual ESEMP Report. This annual report is shared with the BC EAO, Indigenous groups and LSA communities.

11.1 PURPOSE

The purpose of ESEMP reporting is to share information about the topics contained within this plan (e.g., employment, procurement, and training) with the communities and Indigenous groups of the LSA, and the BC EAO, in compliance with Condition No. 10 of the Mine's EAC. The Mine's performance in relation to each strategy and protocol will be monitored and included in the annual ESEMP Report. Monitoring and reporting enable Mine managers, governments, and community leaders alike to assess the extent to which the intended outcomes of the ESEMP are achieved.

11.2 SCOPE AND OBJECTIVES

An annual ESEMP Report was prepared each year throughout construction and will be prepared throughout operations and closure. The objectives of the ESEMP Report are to:

- document and share information pertaining to the ESEMP (including employment, procurement, and training) and the Mine's activities and performance, with the BC EAO, Indigenous groups, and LSA communities;
- summarize engagement with, and feedback from, local and regional residents;
- provide this information on an annual basis; and
- review and considerate the activities outlined in the ESEMP and make updates or modifications as needed.

11.3 REPORTING SCHEDULE

As outlined in the Condition No. 10, Pretivm will submit an annual ESEMP Report to the BC EAO, Indigenous groups, and the LSA communities, no later than January 31 each year, and will update the ESEMP no later than April 1 each year, for the duration of all the phases of the Mine. As such, a schedule for one reporting cycle is provided in Table 11.3-1.

11.4 REPORTING CONTENT

Specific content for the annual ESEMP Report is described, as relevant, for each strategy in the preceding sections. Table 11.4-1 provides a summary of all reporting requirements contained herein.

Pretivm may also choose to highlight additional information, such as sustainability or community investment achievements.

Table 11.3-1. Reporting Schedule

Date	Description
December	Compile information, feedback, and indicators from the calendar year.
January	Prepare annual ESEMP Report. Evaluate performance of ESEMP and related strategies and consider potential for improvement.
January 31	Submit annual ESEMP Report to the BC EAO, Indigenous groups and LSA communities.
February/March	Update ESEMP as needed.
April 1	Submit updated ESEMP to BC EAO.

Table 11.4-1. ESEMP Report – Example Content

Topic	Description
Introduction	Update of Mine development and achievements in the past year and expected highlights of the year ahead.
Employment	Summary of employment achievements for the past year, including: • total number of employees (current/peak, including Pretivm and direct contractors) • number of new hires, number of applicants, and duration/type of employment (e.g., seasonal) • number of workers from Indigenous groups and LSA communities, and northwest BC • comparison with preceding years to highlight trends • highlights of feedback received regarding employment processes and/or outcomes • proposed changes to the Employment Strategy or related processes
Procurement	Summary of procurement achievements for the past year, including: • number of contracts, duration, type of activities (e.g., road maintenance, catering) • number of contracts held/completed by Indigenous businesses, number of bids received, and businesses from the LSA and northwest BC • comparison with preceding years to highlight trends • highlights of feedback received regarding business involvement, procurement process and/or outcomes • proposed changes to the Procurement Strategy or related processes
Training	Summary of training achievements for the past year, including: • a summary of on-the-job training courses (e.g., safety orientations, equipment training) attended by the Mine workforce, including number of courses, number of attendees, etc. • a summary of external training courses conducted for Mine workers or otherwise supported by the Mine, including the number of registrants and number of completions for those offered for Indigenous groups and LSA communities • comparison with preceding years to highlight trends • a summary of feedback received regarding training programs, approach, course offerings and/or outcomes

	• proposed changes to the Training Strategy or related processes

(continued)

Table 11-4-1. ESEMP Report – Example Content (completed)

Topic	Description
Communications and Engagement	• A summary of events, newsletter editions, workshops and other communications that occurred over the course of the year; • a summary of feedback from Indigenous groups, LSA communities and other stakeholders, including key issues and how they were addressed; and • proposed changes to the Communications Protocol or related processes.
Contact and Request for Feedback	Contact information for questions, comments or concerns. Open request for feedback on the ESEMP or any of its components, to inform annual updates/revisions to the plan.

11.5 ROLES AND RESPONSIBILITIES

Newcrest's **VP Government Relations and Social Performance** is responsible for preparation of the ESEMP Report and all related activities.

11.6 SUMMARY

Annual ESEMP Report	
Purpose	To share information about the topics contained within this plan (e.g., employment, procurement, and training) with the communities and Indigenous groups of the LSA, and the BC EAO, in compliance with Condition No. 10 of the Mine's EAC.
Objectives	• Document and share information pertaining to the ESEMP (including employment, procurement, and training) and the Mine's activities and performance, with the BC EAO, Indigenous groups, and LSA communities; • Summarize engagement with, and feedback from, local and regional residents; • Provide this information on an annual basis; and • Review and considerate the activities outlined in the ESEMP and make updates or modifications as needed.
Key Activities	Prepare an annual ESEMP Report and share with the EAO, Indigenous groups, and communities by January 31 of each year. Make annual updates to the ESEMP, by April 1 of each year.
Responsible	EVP Corporate Affairs and Sustainability (Pretivm)
Timing and Schedule	Ongoing throughout Operations Phase.
Reporting	Annual

REFERENCES

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Appendix A — Social Responsibility Policy

PRETIUM RESOURCES INC.

Social Responsibility

Pretium Resources Inc. recognizes that the success of its operations relies on establishing positive, trusting relationships with our employees, local First Nations and communities and key stakeholders. We believe that these relationships are developed by working cooperatively to understand respective interests and concerns in order to maximize the benefits from mineral resource development. Pretium Resources Inc. will ensure social responsibility is integrated into its business activities in the following manner:

- Assess the environmental and social effects of our projects and activities and develop appropriate corresponding management plans.

- Disclose project information and pursue meaningful and culturally appropriate dialogue on project effects with local First Nations and communities and key stakeholders early in the development phase of projects. Continue to engage First Nations, communities and key stakeholders throughout the life of the project.

- Protect employee and community health and safety by supporting health and safety protection programs and by working cooperatively with those who may be affected by our operations.

- Foster a workplace environment that is safe, free of discrimination and builds on a strong foundation of ethical behavior, respecting human rights and ensuring equal access to employment opportunities for all.

- By incorporating local knowledge and building capacity, work cooperatively with local First Nations and communities to develop and support sustainable strategies to maximize the long term benefits of mine development.

- Work with First Nations and relevant government authorities to protect or preserve heritage and cultural resources where they may be affected by our operations.

- Establish management and monitoring systems that will provide opportunities for continual improvement in our environment, health, safety and social programs.

Appendix B — Potential Employment Positions and Requirements

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Laborer – Yard/ Surface/Shop	Construction Operations	Physically fit, able to follow safe work practices.	√	√	√		No
Camp Maintenance Worker	Construction Operations	Two years' experience in a similar position; proficient in word, excel, email, excellent written and verbal communications skills.	√	√	√		Preferred red seal in building trades
Housekeeping Manager	Construction Operations	Completion of secondary school, university degree or college diploma in hospital management, hotel management, or business administration is an asset.	√				High school, university, or college diploma
Camp Attendants (Housekeeping)	Construction Operations	Previous experience an asset, on the job training.	√				No
Executive Chef	Construction Operations	Completion of secondary school, Cook's trade certification, or equivalent credentials, training, or experience.	√				Red Seal, preferred
Kitchen Helper	Construction Operations	On the job training, food safe level 1, experience an asset.	√				Food Safe Level 1
Heavy Equipment Operator	Construction Operations	Previous experience with mine specific experience. Some high school, college, or industry courses in heavy equipment operating combined with on-the-job training. Heavy Equipment Operator certification is an asset.	√	√	√		Experience
Cook	Construction Operations	Completion of secondary school, completion of a three-year apprenticeship program for *or* completion of college or other program in cooking *or* several years of commercial cooking experience are required. Food Safe Level 1.	√				High school, post-secondary, or experience. Food Safe Level 1
Site Administrator/ Logistics	Construction Operations	Office administration certificate, previous related experience in logistics, ability to problem solve , prioritize, and multi-task, advanced computer skills , prior Mine Administration experience, experience with radio communications.					Office Administration certificate

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Controller/ Accountant	Construction Operations	Bachelor's degree in business administration, economics, commerce or a related field is required, a recognized accounting designation (CA, CMA, or CGA) may be required. A master's degree in business administration (concentration in finance), or another masters' level management program. Several years' experience.					University Degree, other
Human Resources Manager	Construction Operations	Bachelor's degree in a personnel management (e.g., business administration, industrial relations, commerce, or psychology) *or* a professional development program in personnel administration. Several years of experience in a similar position in the mining field.			√		University Degree, other
Human Resources Coordinator	Construction Operations	A university degree in a field related to personnel management (e.g., business administration, industrial relations, commerce, or psychology) *or* a professional development program in personnel administration, previous experience.			√		University Degree, other
Community Relations Coordinator	Construction Operations	Post-secondary education in human resources, education, or administration, *or* an equivalent combination of education and experience with planning, organizing, and coordinating activities in these areas. Communication, interpersonal, and organization skills. Computer literacy.			√		Post-secondary education, experience, other
Crane Operator	Construction Operations	Completion of a one-to-three-year apprenticeship program *or* high school, college or industry course in crane operating. Experience in construction and mine setting. May require provincial licence, internal company certification.			√		Red Seal, preferred
Grader Operator	Construction Operations	Previous experience in remote site. Some high school, college or industry courses in heavy equipment operating combined with on-the-job training. Heavy equipment operator certification would be an asset.	√	√	√		Experience

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Ironworkers	Construction Operations	Completion of a two-to three-year apprenticeship program *or* over three years work experience in the trade and some high school, college or industry courses in ironworking usually required for trade certification.	√		√		Red Seal, preferred
Maintenance Superintendent	Construction Operations	Several years' experience in the occupation supervised is required. Journeyman/woman trade certification in a relevant trade required.	√		√		Journeyman/woman trade certificate
Master Mechanic	Construction Operations	Completion of a three- to four-year apprenticeship program. Five years' experience in the trade and in industrial machinery repair or millwrighting.	√	√	√		Red Seal
Heavy Duty Mechanics	Construction Operations	Trade qualification as a Heavy-Duty Equipment Mechanic (Technician). Minimum four years' experience in the maintenance of diesel and gasoline mobile and stationary equipment, preferably in an industrial or heavy industry setting.	√	√	√		Red Seal
Welder	Construction Operations	Completion of high school and a three- to four-year apprenticeship program *or* a combination of over four years of work experience in the trade and some college or industry courses in structural steel and platework fabrication.	√	√			Red Seal
Industrial Electricians	Construction Operations	Trade qualification as a Journeyman Electrician. Minimum four years' experience in an underground mine setting, milling and site environment. Record of safety leadership. Proficient is Microsoft Office programs.			√		Red Seal
Instrument Technicians	Construction Operations	Completion of a four- or five-year apprenticeship program in industrial instrument repair. Four years work experience in a mine setting.			√		Certified Instrument Repair
Plumbers	Construction Operations	Completion of a four- or five-year apprenticeship program. Four years work experience in the trade, in a remote site.	√	√	√		Red Seal

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Gas Fitters	Construction Operations	Completion of a two- to three-year gas fitter apprenticeship program. Four-year experience in a pipefitting trade, a provincial gas fitter licence,	√	√	√		Certified Gas Fitter
Carpenters	Construction Operations	Journeyman/woman trade certificate as a carpenter. Experience as a qualified carpenter.	√	√	√		Certified Carpenter
Geotechnical Engineer	Construction Operations	Master's degree or doctorate in a related engineering discipline may be required. Geotechnical engineering degree or a mining or geology degree specializing in 'rock mechanics'. Three years' experience. P. Eng. certification. Five years practical and related experience in underground mine operations.	√	√	√		University Degree, P.Eng.
Senior Engineer	Construction Operations	Bachelor's degree in mining engineering or related engineering discipline. A master's or doctor in related engineering discipline may be required. Three years' experience in a similar position. P. Eng. certification.	√	√	√		University Degree, P.Eng.
Engineers	Construction Operations	A bachelor's degree in mining engineering or in related engineering discipline. Three years' experience in the mining field. P. Eng. certification.			√		University Degree, P.Eng.
Surveyors	Construction Operations	Bachelor's degree in geomatics engineering or survey engineering *or* college diploma in survey science or geomatics technology with additional academic credits and successful completion of equivalent examinations. Successful completions of professional land surveyor examinations. A federal or provincial land surveyor's licence. Three years' experience at mining site.			√		University Degree, other combination of education and experience
Senior Geologist	Construction Operations	Geology related university degree and eight years' experience, superior communication and safety skills, cost-effective innovation is expected.			√		University Degree

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Production Geologists	Construction Operations	B.Sc. in Geology or Geological Engineering. Five years' underground experience. Provincially registered Geologist. Knowledge of raw materials and production process. Highly developed communication and computer skills.			√		University Degree, provincial certification
Geological Technologist	Construction Operations	Two- to three-year college program in related field. Three years' experience in underground mining. Level 2 first aid ticket.			√	√	Certification in geological and mineral technology
Environmental Superintendent	Construction Operations	BS degree in environmental, biological or earth sciences. Five years' experience. Working knowledge of regulations, water quality monitoring and treatment systems. Ability to develop review and implement closure plans, proficient computer skills. Level 2 first aid.	√	√	√	√	University Degree,
Environmental Technician	Construction Operations	Certificate or diploma in Environmental Technology/ Management, Biological Sciences, or related field with two to three years' experience. Experience with remote site, ATVs, and snowmobiles. Level 2 first aid. Proficient computer skills.	√	√	√	√	Certificate or diploma in Environmental Technology/Management, Biological Sciences
Miners	Construction Operations	Formal training followed by specialized training, previous experience, provincial blasting licence and trade certification for miners may be required, level 2 first aid.	√	√	√	√	Formal training, other
Underground Service and Support Workers	Construction Operations	Formal training followed by specialized training, previous experience as a mine labourer, certified in basic common core program is an asset, level 2 first aid.	√	√	√	√	Formal training, other
Underground Mine Trainer	Construction Operations	Four years of underground training experience, ability to manage demands, various skills including leadership, presentation, communication, and computer. Level 2 first aid.	√	√	√	√	Four years of underground training experience
Mine Dry Labourer	Operations	Physically fit, able to follow safe work practices, may require drivers licence, level 2 first aid	√	√	√	√	None

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Mine Planner and Scheduling	Construction Operations	Mine engineering related university degree. Three years' experience, computer literate, underground experience, level 2 first aid.				√	University Degree
Core Splitters	Construction Operations	Completion of high school, introductory training, physically fit. Basic common core program an asset. Level 2 first aid.	√			√	High School
Water/Wastewater Treatment Plant Technician	Construction Operations	College, high school, or industry training courses in water distribution or treatments (Levels I, II, or III). Safety courses may be required. Previous experience an asset. Level 2 first aid.	√	√		√	Certification in water distribution or treatments
Backfill - Operators	Construction Operations	Completion of high school. Formal training with on-the-job training. Previous experience as a mine labourer. Basic common core program an asset. Equipment operator experience or certification. Level 2 first aid.			√	√	High School, experience
Underground Production and Development Crews	Construction Operations	Completion of high school. Formal training with on-the-job training. Previous experience as a mine labourer. Basic common core program Trade certification for miners. Level 2 First aid.			√	√	Basic common core, trade certification for miners
Helpers	Construction Operations	Experience operating a forklift, Level 2 fist aid.	√	√	√	√	Experience
Safety Coordinators	Construction Operations	Diploma for a Mining Technologist and a CSRP designation or actively pursuing CSRP, three to ten years' experience, Basic Joint Health Safety Certification training, Fall Protection, knowledge of TapRoot, Level 3 first aid.	√	√	√	√	Mining Tech Diploma, Basic Joint Health Safety Certification
Safety Training Coordinator	Construction Operations	Safety trainer certification, BC WCB supervisor certification. Five to seven years' experience. Knowledge of TapRoot, Supervisor's Common Core Certificate, Fall Protection, other experience, on-the-job training, level 3 first aid.	√	√		√	Certifications: Safety trainer, BC WCB supervisor, Supervisor's Common Core

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Site Administrator	Operations	One to two years' experience, computer skills, other experience and skills, level 3 first aid.					Experience
Paramedic	Construction Operations	Completion of a recognized paramedical or emergency medical technology program. Must be licenced.	√		√	√	Paramedic licence
Security Personnel	Construction Operations	One to year college, hospital-based or other paramedical or emergency medical technology program. Must be licenced. Experience, level 3 first aid.			√	√	Security or other law enforcement training
Warehouse Supervisor	Construction Operations	Post-secondary training in materials management/ purchasing. Ten years relevant experience. Computer, communication, and safety skills. Level 2 first aid.	√	√		√	Post-secondary education, experience
Inventory Handler	Construction Operations	Purchasing or inventory management courses, computer skills, experience operating forklift, bobcat, and telehandler.	√	√	√		Purchasing or inventory management
Warehouseperson/ Warehouse Yard Person	Construction Operations	Relevant training, three years' experience including forklift, bobcat, other operator. Level 2 first aid.	√	√	√	√	Relevant training, experience
Accounts Payable	Construction Operations	Accredited training or practical experience. Computer, communication, and organization and system skills.					Accredited training/practical experience
IT & Communications	Construction Operations	University degree in computer science, business administration, commerce, or engineering. Experience, level 2 first aid.			√	√	University Degree
Avalanche Control Tech	Construction Operations	Avalanche Operations Level 2 Certification or equivalent. Association of Canadian Mountain Guides Assistant Ski Guide certification or equivalent. Other certification, five to seven years' experience. Valid Blasting ticket, level 3 first aid.			√	√	Certified Mountain Guide, Avalanche Operations Level 2 and Assistant Ski Guide Certification or equivalent, Valid Blasting ticket

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Glacier Technician	Construction Operations	Bachelor of Science honors degree in geology. Five to seven years' experience. Level 3 first aid.			√	√	Relevant University Degree, Apprentice Alpine Guide or better
Surface Operations Superintendent	Construction Operations	Post-secondary education in mechanical or civil engineering or technology. Ten years' experience, heavy equipment maintenance management and supervision. Computer skills, level 2 first an asset.	√	√	√	√	Post-secondary education
Road Forman	Construction Operations	Journeyman/woman trade certification in relevant trade may be required, heavy equipment operator certification, Five to seven years of experience in similar position, computer skills, first aid.	√	√	√	√	Trade certification, heavy equipment operator
Mill Manager	Construction Operations	University degree in mining engineering, seven to ten years' experience.	√		√		University degree
Mill Superintendent	Construction Operations	Six to eight years' experience, floatation circuit and concentrate experience, leadership, communication and problem-solving skills.	√				Experience
General Mill Foreman	Operations	Experience, safety leader, good mechanical aptitude, computer, and communication skills.	√	√	√	√	Experience
Mill Shifter	Operations	Post-secondary education in metallurgy, sciences, or related field an asset, five to seven years' experience in similar position. Previous supervisory experience.	√				Experience
Millwrights	Construction Operations	Red Seal certification and underground mine experience, fabrication, and welding skills.	√	√	√	√	Red Seal
Mill Clerk	Operations	Completion of college business program, experience, level 2 first aid, experience in remote mine setting.	√	√	√	√	College

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Mill Trainer	Operations	Seven to ten years' experience in milling metal recovery, effective procedure writing, other experience, computer, organization, and communication skills.	√	√	√		Experience
Mill Operators	Operations	Experience in a similar position, experienced forklift, and bobcat operator.	√	√	√	√	Experience
Mill Labourers	Operations	Previous experience working at a remote camp setting as asset, experience operating forklift and bobcat.	√	√	√		None
Mill Maintenance Supervisor	Operations	Seven years' experience as a qualified journeyman/woman trade certification preferably millwright, five years' experience in a similar role.	√	√	√		Experience
Maintenance Planner	Operations	Completion of formal Computerized Maintenance Management System (CMMS), three to five years' experience, Red Seal Industrial ticket an asset	√	√	√		CMMS certification, experience, Red Seal preferred
Metallurgist	Operations	Bachelor of Science of Metallurgy or Materials Science, five years' experience, tertiary qualifications in metallurgy, other requirements, computer, communication, and other skills.	√	√	√		University Degree
Chief Assayer	Operations	University degree in Analytical Chemistry, Extractive Metallurgy, or related field, six to eight years' experience, other experience, and skills.	√	√	√		University Degree
Senior Assayer	Operations	University degree in degree in Analytical Chemistry, Extractive Metallurgy, or related field, experience in a supervisory role, other skills, and experience.	√	√	√		University Degree
Junior Assayer	Operations	College diploma/certificate or university degree in chemistry, geochemistry or other. One to three years' experience, computer skills, other skills and experience required.	√	√			College diploma/ Certificate or University degree
Gold Room Operator	Operations	University degree, three to five years' experience. Level 2 first aid an asset.	√	√	√	√	University Degree

APPENDIX B. POTENTIAL EMPLOYMENT POSITIONS AND REQUIREMENTS

Job Title	Phase(s)	Example Requirements	WHMIS	TDG	Driver Licence	First Aid	Designation
Sample Buckers	Construction Operations	Experience, math skills, ability to lift 40 pounds unassisted, other skills and requirements. Level 2 first aid an asset.	√	√		√	
Lab Technicians	Operations	Previous experience in an assay lab. Certifications, licences, designations an asset. Other skills and requirements.	√	√			Experience
Drivers	Construction Operations	Must have drivers licence relevant to any vehicle used for job (may include Classes 1 through 7)			√	√	Experience

Notes:
WHMIS – Workplace Hazardous Materials Information System certification.
TDG – Transportation of Dangerous Goods certification.
Driver licence – Valid driver's licence for any vehicle that may be utilized for the job.

Appendix 9-1-8. Heritage Management Plan

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Heritage Management Plan

January 2023

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Heritage Management Plan

Date: January 2023

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1a	December 2018	Version control table populated, and cover page added
2	January 2023	Document format updated to NCM Brucejack template.

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BRUCEJACK MINE

Heritage Management Plan

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Appendix A

Brucejack Heritage Chance Find Procedure

GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AIA	Archaeological Impact Assessment – An assessment carried out under a *Heritage Conservation Act* Heritage Inspection Permit to determine the impact of a development on archaeological sites.
Archaeology Branch	The Archaeology Branch of the British Columbia Ministry of Forests, Lands and Natural Resource Operations that administers the *Heritage Conservation Act*.
BC	British Columbia
CE	Common Era
CMT	Culturally Modified Tree – A tree that has been altered by Aboriginal people; for the purpose of this report only pre-1846 alterations are considered.
HCA	*Heritage Conservation Act* (1996) – The provincial law that authorizes and mandates British Columbia to manage heritage resources.
Heritage Inspection Permit	Heritage Inspection and Heritage Investigation Permits are issued under Section 14 of the *Heritage Conservation Act* subsequent to Archaeology Branch review and authorization.
Legacy Site	A site which has a record maintained in RAAD by the Archaeology Branch but is not protected by legislation. Examples include post-1846 CMT sites, non-designated historic sites (e.g., wagon roads), and prehistoric archaeological sites that have been completely destroyed and/or mitigated.
LSA	Local Study Area
M	Metre(s)
Plan	Heritage Management Plan
Pretium	Pretium Resources Inc.
Project	Pretium Resources Inc.'s Brucejack Project
RAAD	Remote Access to Archaeological Data; a web-based application, maintained by the Province of British Columbia, that enables authorized users to access data housed in the British Columbia Archaeological Site Inventory.
RSA	Regional Study Area

1 PURPOSE

The protection afforded to archaeological sites in British Columbia (BC) by legislation (refer to Section 4) applies to known and as yet unrecorded sites. Consequently, developments such as the Brucejack (the Project) that will involve surficial disturbance have the potential to affect archaeological sites. Certain types of sites, such as culturally modified trees (CMTs), can also be affected by logging or clearing of vegetation. For the Project, it is anticipated that earthwork activities (blasting, cutting, and filling) and vegetation clearing related to access road upgrades and transmission line construction will be the principle types of disturbances. As such, archaeological sites that may be present within or adjacent to the proposed Project development area could potentially be adversely affected.

The purpose of the Heritage Management Plan (the Plan) is to describe the protection of heritage resources and provide a framework to mitigate potential Project effects. This builds on extensive baseline heritage studies conducted for the Project (ERM Rescan 2014) that were conducted to enable implementation of mitigation measures at the planning stage, as appropriate. The Plan includes both heritage resources which have been identified adjacent to the planned work zone, as well as any that have not yet been identified but which could potentially be encountered during the course of the Construction, Operation, Closure, and Post-closure phases of the Project. Two heritage sites protected under the *Heritage Conservation Act* (HCA) have been identified within 1,000 m of the Project development footprint (refer to Section 5.1.1). There are no currently known heritage resources within the development footprint.

2 PERFORMANCE OBJECTIVES

The objective of the Plan is to reduce any potential adverse Project effects on archaeological sites to negligible significance through the implementation of management and mitigation measures, including avoidance or systematic data recovery.

Avoidance is the preferred management and protection measure for all archaeological sites within or adjacent to the planned work zone, whether known or as-yet unknown. It may be possible to achieve this by modifying the Project design. Where Project redesign is not feasible for the avoidance of archaeological sites, the management and mitigation strategies outlined in Section 5.3 will be followed.

3 SCOPE

During the Construction phase, activities such as clearing and grubbing, earthworks, excavations, and blasting have the potential to cause direct effects to protected archaeological sites, as well as protected paleontological sites, if present. As archaeological sites in this northwest BC often contain cultural materials present on the surface, archaeological sites can also be affected by increased human presence in the area during all Project phases. Thus, this Plan applies to all Project phases, components, and activities. The primary risk to heritage resources, however, will be during ground altering activities associated with the Construction phase.

4 RELEVANT LEGISLATION, REGULATIONS, AND EAC CONDITIONS

4.1 RELEVANT LEGISLATION AND REGULATIONS

In BC, the primary legislation protecting archaeological resources (both recorded and unrecorded) is the *Heritage Conservation Act* (HCA; 1996), which protects all sites predating 1846 CE on Crown and private land. Sites such as burials and Aboriginal rock art sites are protected regardless of age. The Archaeology Branch of the Ministry of Forests, Lands and Natural Resource Operations (Archaeology Branch) is the provincial ministry responsible for the administration of the HCA, issuing permits for heritage inspection, investigation, and site alterations, and maintaining a database of known archaeological sites. Burials and gravesites are also protected in BC by the *Cremation, Interment, and Funeral Services Act* (2004).

There is currently an open Heritage Inspection Permit (2014-0277) granted under Section 14 of the HCA for the Project. This permit is valid until March 31, 2016.

4.2 RELEVANT EAC CONDITIONS

Pretium was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions. This management plan fulfills Condition #2, in relation to a Component Plan for management of heritage sites, presented within Schedule B of the Certificate and copied below.

<u>Condition 2</u>

> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*

- *Effects mitigation measures;*
- *Monitoring programs;*
- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the Nisga'a Lisims Government (NLG), Tahltan and Tsetsaut / Skii km Lax Ha Nation (TSKLH) on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

The planned work zone considered in this Plan as well as the relevant Regional Study Area (RSA) and Local Study Area (LSA) are illustrated in Figure 5-1. Due to the sensitive nature of archaeological sites, locational information is not provided in this document but will be illustrated on construction maps. This section provides the mitigation measures and best management practices for archaeological sites within 1,000 metres (m) of the planned work zone. Sites that are within the RSA but are more than 1,000 m from the planned work zone will not be affected and are not considered further in this plan.

5.1 MITIGATION MEASURES AND BEST MANAGEMENT PRACTICES

This section provides mitigation measures for the two known protected archaeological sites and those sites that may be identified as a result of changes to the planned work zone and/or chance finds. It provides information on the steps required to conduct systematic data recovery at an archaeological site, if necessary.

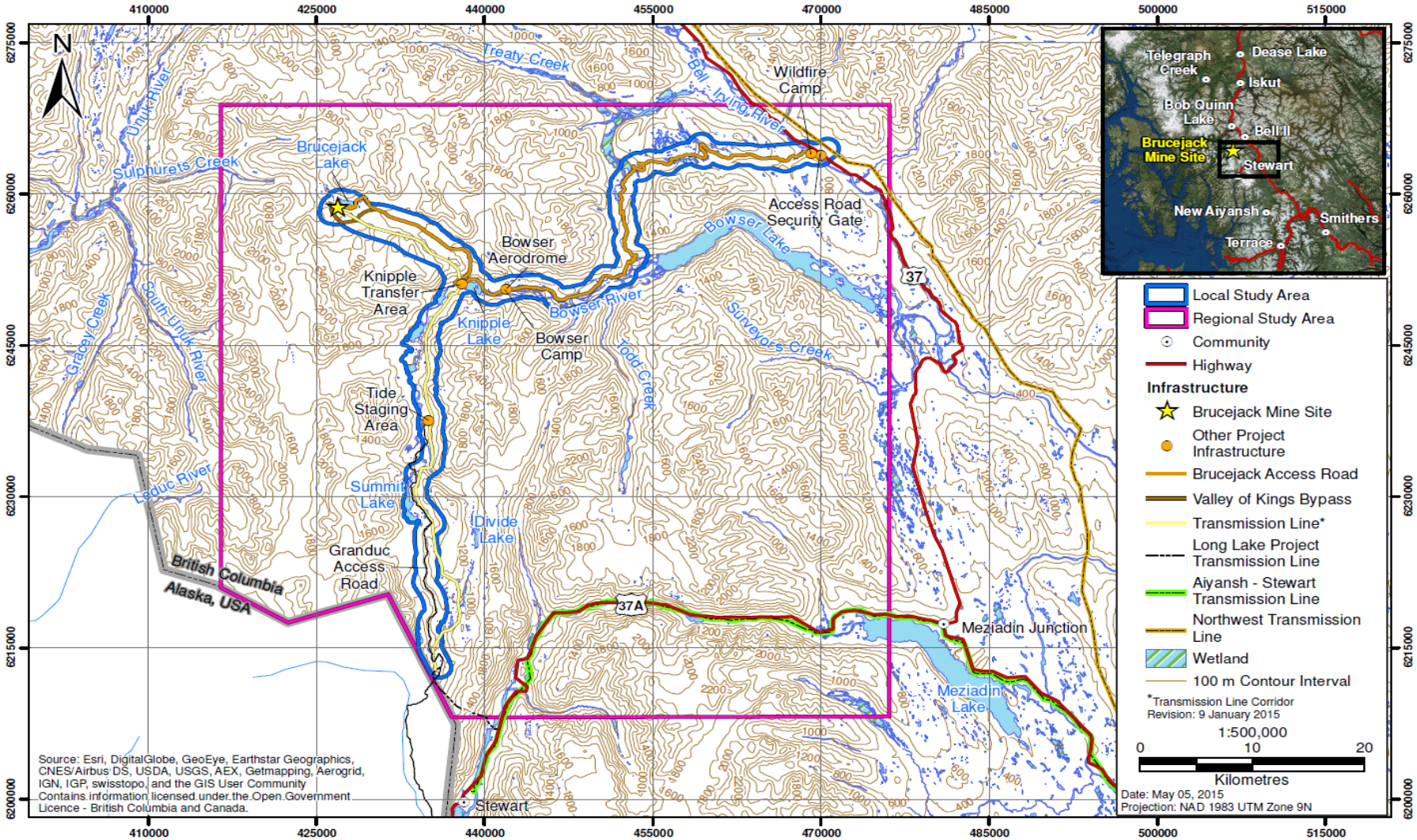
5.1.1 Mitigation for Known Archaeological Sites

There are four archaeological sites documented in the Archaeology Branch's Archaeological Site Inventory database which are located in the Project's LSA, within 1,000 m of the planned work zone. These sites, their general locations, and their protection status are summarized in Table 5.1-1. Two of these sites, HbTm-2 and HcTn-1, have been designated as Legacy Sites by the Archaeology Branch and are no longer protected by the HCA; they will not be discussed further. HbTm-1 and HcTk-1 are the only known archaeological sites protected by the HCA which fall within 1,000 m of the planned work zone.

Table 5.1-1. Archaeological Sites within the Local Study Area

Archaeological Site	Antiquity	Site Type	General Location	Overall Site Significance Evaluation	Distance to Closest Project Component	Protection Status and Legislation
HcTk-1	Pre-contact	Culturally Modified Tree	Brucejack Access Road	Low	15 m	Protected by the HCA
HbTm-1	Pre-contact	Prehistoric Lithic Scatter	Summit Lake	Low	453 m	Protected by the HCA
HbTm-2	Recent Historic	Aircraft Wreckage (associated with a movie production)	Summit Lake	Low	525 m	Legacy Site – Not protected by the HCA
HcTn-1	Pre-contact	Prehistoric Lithic Scatter	Brucejack Lake	Moderate	603 m	Legacy Site – Not protected by the HCA

Figure 5-1. Regional and Local Study Areas for Heritage Resources in the Brucejack Project



5.1.1.1 HbTm-1

Archaeological site HbTm-1 is approximately 525 m west of the Brucejack Transmission Line, and approximately 165 m from the Granduc Access Road between the road and Summit Lake. The site is located outside the proposed construction footprint and therefore no direct effects are anticipated. The site may be subject to potential indirect effects due to increased human presence during the installation of the transmission line and associated towers and use of the Granduc Access Road; therefore, the following mitigation measures have been developed:

- the site area will be marked as a "No Work Zone" on construction maps;
- the site will be inspected periodically to determine if impacts have occurred; and
- if, due to changes to the footprint, direct impacts are anticipated, or monitoring identifies impacts from increased human presence, mitigation measures will be required (see Section 5.1.4).

5.1.1.2 HcTk-1

Archaeological site HcTk-1 is a CMT located approximate 15 m from the centreline of the Brucejack Access Road. To protect HcTk-1 from effects associated with use and maintenance of the Brucejack Access Road during Operation, continued avoidance of the site is recommended. In addition, the area should be marked as a "No Work Zone" on construction maps and the trees marked/flagged as such.

Continued avoidance of the site is recommended. If avoidance is not possible and/or if the trees become a safety hazard, a site alteration permit issued under Section 12 of the HCA would be required (see Section 5.1.4). Issuance of a Section 12 Site Alteration Permit may require that additional study at HcTk-1 be conducted.

5.1.2 Mitigation Measures for As-yet Unknown Archaeological Sites

During the lifetime of the Project, additional archaeological sites may be discovered while conducting activities associated with the Project. These sites may be discovered through Archaeological Impact Assessments (AIAs) carried out for revisions to the planned work zone or through chance finds during construction, operation, and closure. Mitigation measures for currently unknown archaeological sites, if discovered, are discussed below.

5.1.2.1 Revisions to Planned Work Zone during Construction, Operation, and Closure

Any revisions to the planned work zone that have not been previously subject to an AIA will be assessed to determine if additional archaeological studies, Archaeological Overview Assessments, or AIAs are required. If necessary, AIAs will be carried out under an HCA Heritage Inspection Permit, issued by the Archaeology Branch. Any new archaeological sites within 1,000 m of the planned work zone will be subject to the same level of management and mitigation afforded to the currently known archaeological sites outlined in Section 5.1.

The transmission line corridor has been changed from the route assessed during the original AIAs of the Project area (Jollymore and Walker 2013). An Archaeological Overview Assessment has been conducted and an AIA has been recommended along the revised alignment prior to commencement of Construction phase activities.

5.1.2.2 Chance Finds

The Heritage Chance Find Procedure developed for the Project (Appendix A) provides a standard operating procedure should heritage sites not identified during baseline studies be discovered. Pretium will arrange for site orientation and training of construction personnel (including contractors) involved in new site surficial disturbance, with regards to compliance with the HCA. Training and site orientation will be provided for these construction personnel during their induction, with refresher training provided at the beginning of the second year of construction. Training will also be provided to Pretium environmental staff, with periodic refreshers during mine life. This training will focus on not disturbing known archaeological sites; the procedures in place for responding to newly identified sites, as outlined in the Project's Heritage Chance Find Procedure; and how to report these sites or observed site impacts. Copies of the Project's Heritage Chance Find Procedure will be kept on site for reference and on file by Pretium. In general, if personnel suspect archaeological materials or human remains have been discovered they will:

- immediately contact a Pretium or Contractor Environmental Monitor, Pretium Environmental Coordinator/Superintendent, or Pretium Construction Manager to implement a stop work order to reduce/minimize impacts to the site;
- leave the material in place and protect and/or mark the area around the site, and will not disturb or collect any archaeological materials or human remains; and
- report the discovery to the supervisor. The Mine Manager, the Principal, Environment, and the Project Archaeologist will also be notified. The Archaeology Branch and local Aboriginal groups/organizations will be advised of the discovery.

5.1.3 General Archaeological Management and Mitigation Strategies

If additional archaeological sites are identified during AIAs carried out for revisions to the footprint or through chance finds, the following general archaeological management and mitigation strategies are recommended. Final mitigation measures will be determined through consultation with the Archaeology Branch.

Note that the stipulations provided herein are generic and would only be activated if required. Specific management and mitigations measures for known heritage resources are described in Section 5.1.1.

Where an archaeological site is located within:

- **0 to 50 m** of ground-altering activities, direct impacts from Construction phase activities with a high potential for adverse impacts are anticipated;

- **50 to 500 m** from Project components, indirect impacts through increased human presence during the Construction, Operation, and Closure phases, with a low to moderate potential for adverse impacts are anticipated; and
- **500 to 1,000 m** from Project components, no impacts are anticipated and therefore are not considered.

Where sites fall within **0 to 50 m** of proposed ground altering activities, the risk of direct impacts from Construction activities is high. Areas within 50 m of archaeological site boundaries will be marked as "No Work Zones" on construction maps. Typically, site avoidance through Project redesign is the recommended management option. If avoidance is not possible, mitigation will be conducted prior to Construction phase activities. Mitigation measures will be determined in consultation with the BC Archaeological Branch and carried out by the Project Archaeologist under an HCA Heritage Investigation Permit. Mitigation may involve detailed mapping, photography, and systematic data recovery through surface collection and controlled excavations of evaluative units if subsurface deposits are present. The steps involved in permitting the alteration of an archaeological site are outline in Section 5.4. If the site will not be directly impacted then Construction Monitoring may be adequate within the "No Work Zone" (Section 6.1.1).

Where sites fall within **50 to 500 m** from Project components, the risk of indirect impacts through increased human presence during the Construction, Operation, and Closure phases is moderate. Sites may be inspected on a case-by-case basis to determine if impacts have occurred. If direct impacts at these sites are anticipated during construction and/or have occurred, mitigation measures will be required (Section 5.1.4). Archaeological site monitoring will occur during Construction phase activities near archaeological sites and/or site boundaries will be flagged or fenced to limit any indirect impacts (Section 6.1.2). Typically, site boundary flagging involves the use of rebar or wooden stakes with snow fencing or another visible barrier, running around the outside of the site boundary. Similarly, brightly coloured stakes installed at intervals around the boundaries of the site can be used if snow fencing or other visible barriers are impractical or constitute a barrier for wildlife. In either case, fencing will be visible above the anticipated snowline, particularly where sites are located adjacent to areas where construction will be undertaken when snow is still present. Caution will be exercised during construction activities near the site. Reporting pertaining to archaeological monitoring activities is described further in Section 7.1.2.1.

Sites which fall within 500 to 1,000 m from Project components are at low risk of direct and/or indirect impacts from construction and/or human presence, unless the planned work zone is revised during the Construction and/or Operation phases.

5.1.4 Mitigation through Systematic Data Recovery

Mitigation through systematic data recovery is not currently recommended at any of the known archaeological sites within the LSA. However, if mitigation through systematic data recovery is required due to revisions to the footprint or chance finds a final methodology will be determined in

consultation with the Archaeology Branch. The work will be carried out by a Professional Archaeologist under an HCA Section 14 Investigation Permit.

In order to impact an archaeological site the following steps are required.

1. Issuance of an Archaeological Investigation Permit under Section 14 of the HCA, by the Archaeology Branch.
2. Conduct the field investigations during snow-free conditions required to satisfy the provisions of the Section 14 Archaeological Investigation Permit.
3. Complete the permit report including recommendations to the satisfaction of the Archaeology Branch.
4. Apply for a Site Alteration Permit under Section 12 of the HCA.
5. Upon reception of the Section 12 Site Alteration Permit, impacts may proceed subject to any conditions stipulated in the permit.

All of the permit applications and approvals include an allowance by the Archaeology Branch for Aboriginal input and comments. Approval for impacts to archaeological sites is given, or not given, at the sole discretion of the Archaeology Branch. The process leading to a decision on issuance of a Site Alteration Permit generally takes at least one year to complete and therefore should be scheduled to begin well in advance of the Construction phase. From both an archaeological and permitting perspective, avoidance of a site is usually the preferred approach.

6 ENVIRONMENTAL MONITORING

This section describes how and when site monitoring will take place at the previously identified site (HbTm-1), as well as the use of the Project's Heritage Chance Find Procedure (Appendix A) for new site discoveries.

6.1 ARCHAEOLOGICAL MONITORING

This section described construction monitoring carried out by an archaeologist under an HCA Heritage Inspection Permit (Section 6.1.1) and archaeological site monitoring carried out by an Environmental Monitor (Section 6.1.2).

6.1.1 *Construction Monitoring*

If work is to occur within the "No Work Zone" around an archaeological site, an archaeologist will be present to communicate and work with operations personnel to ensure that unanticipated impacts to the site do not occur. This work will be carried out under an HCA Section 14 Heritage Inspection Permit by a qualified archaeologist. The archaeologist will examine soils being excavated and, should archaeological materials be encountered during monitoring activities, all work will cease in the immediate area of the find and the Archaeology Branch will be notified to determine next steps.

6.1.2 *Archaeological Site Monitoring*

If construction activities are between 50 to 100 m of archaeological site boundaries, an Environmental Monitor will be present or flagging/temporary fencing will be installed to serve as a visible barrier. Prior to the start of planned work activities, known archaeological sites within 100 m of a planned work zone will be located by an Environmental Monitor and a First Nations representative using available GPS coordinates and Project construction maps. The site will be checked to confirm that it is intact and then fenced or flagged to create a visible barrier. Upon completion of work, the site will be checked again to confirm that the site remains intact and was unaffected by work activities. Flagging/fencing will also be removed at this time to avoid drawing unnecessary attention to the archaeological site. The exception to the removal of fencing/flagging will be for a site within close proximity to an active Project area (i.e., known CMT along the Brucejack Access Road). In this case, fencing/flagging will be checked annually by the road maintenance crew to ensure it is still in place and visible.

Should impacts be observed at known archaeological sites, the Project Archaeologist and the Archaeology Branch will be contacted and notified of the impacts. Post-impact mitigation plans will be developed in consultation with the Archaeology Branch and local Aboriginal groups/ organizations on a case-by-case basis.

6.2 PERFORMANCE MONITORING

Once a site has been flagged/fenced, it will be visited during and after construction activities to determine if impacts have occurred. While fencing is in place Environmental Monitors will inspect and maintain these flagged/fenced boundaries on an annual basis.

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 *Compliance Reporting*

This section details the reporting requirements for activities carried out under the HCA.

7.1.1.1 Archaeological Impact Assessment Reporting

For archaeological work conducted under a Section 14 Inspection Permit, a final permit report will be prepared as per the *British Columbia Archaeological Impact Assessment Guidelines*.

7.1.1.2 Mitigation Reporting

For currently unknown archaeological sites which are discovered within 0 to 50 m of Project impacts, mitigation will be conducted prior to construction (see Section 5.3.1). In this case, BC Site Inventory Forms must be updated detailing the mitigation measures and submitted to the Archaeology Branch for inclusion in the Archaeology Branch's Archaeological Site Inventory database.

If mitigation is required and completed under an HCA Heritage Investigation Permit provided by the Archaeology Branch, reporting relating to the mitigation will be completed and will meet the submission date and be provided to Aboriginal groups as outlined in the permit. Approval to proceed in the area of the site is given by the Archaeology Branch, to allow for work to be conducted within the site boundaries under a Section 12 Site Alteration Permit. If work proceeds under a Site Alteration Permit, a report will be submitted to the Archaeology Branch, outlining the work carried out within the site boundaries.

7.1.1.3 Construction Monitoring Reporting

Construction monitoring will occur if avoidance of the "No Work Zone" is not feasible. This will be done under an HCA Heritage Inspection Permit and will be included in a final permit report prepared as per the *British Columbia Archaeological Impact Assessment Guidelines* (Archaeology Branch 1998). Details on the location, the extent of impacts, and the results of the monitoring will be included in the Permit Report.

7.1.1.4 Archaeological Site Monitoring

Pretium will work in collaboration with the Project Archaeologist and Environmental Monitor to coordinate archaeological site monitoring and site inspection, as required. If the monitoring activities outlined in Section 6.1.2 identify impacts to an archaeological site, the results will be summarized in an Archaeological Site Monitoring Report to be provided to the Project Archaeologist and the Archaeology Branch.

7.1.2 *Incident Reporting*

Pretium will work in collaboration with the Project Archaeologist to coordinate the documentation of chance finds or impacts to archaeological sites. Pretium will maintain documentation regarding archaeological monitoring and any chance finds which may be discovered during the course of the Construction and Operation phases, and will report any impacts to archaeological sites to the Project Archaeologist and the Archaeology Branch (see Section 5.3.2 and Appendix A).

The Environmental Monitor will document, by means of photographs and field notes, the type of construction and disturbance occurring near a site, weather conditions, personnel present, and other pertinent details.

Chance finds will be reported on using the Heritage Chance Find Procedure and will involve internal reporting to Pretium Management, the Project Archaeologist, and the Archaeology Branch.

7.2 RECORD KEEPING/TRACKING

The Environmental Monitor will document, by means of photographs and field notes, the type of construction and disturbance occurring near a site, weather conditions, personnel present, and other pertinent details. It is imperative that detailed field notes are recorded during monitoring activities. This information will be summarized in an Archaeological Site Monitoring Report to be provided to the Project Archaeologist and the Archaeology Branch if an archaeological site is impacted.

7.2.1 *Field Monitoring Data*

The following data will be collected during field monitoring and may be required for inclusion in compliance reports:

- site photographs;
- UTMs for any disturbances;
- details of any actions taken to protect the archaeological sites; and
- recommendations for any changes to the protective measures, if required.

7.2.2 *Continuous Improvement, Follow-up, and Adaptive Management*

The Plan will be reviewed and updated on an as-needed basis as the Project proceeds through detailed design, Construction, Operation, Closure, and Post-closure.

7.2.3 *Incident Response Records*

Archaeological sites discovered during Project activities will be reported through the Heritage Chance Find Procedure.

7.2.4 Permit Database and Amendments

Previous and current AIA permits issued under the HCA for the Project include:

- 2010-0255 (closed);
- 2011-0245 (closed);
- 2013-0174 (closed); and
- 2014-0277 (active).

Additional permits or permit amendments will be added on an as-needed basis.

8 REFERENCES

1996. *Heritage Conservation Act,* RSBC. C. 187.

2004. *Cremation, Interment, and Funeral Services Act*, SBC. C. 35.

Archaeology Branch. 1998. *British Columbia Archaeological Impact Assessment Guidelines.* Report on file at the Archaeology Branch: Victoria, BC.

ERM Rescan. 2014. *Brucejack Gold Mine Project: Application for an Environmental Assessment Certificate / Environmental Impact Statement*. Prepared for Pretium Resources Inc. by ERM Consultants Canada Ltd.: Vancouver, BC.

Jollymore, K., and D. Walker. 2013. *Brucejack Gold Mine Project: Archaeological Impact Assessment, Final Report, Heritage Inspection Permit 2011-0245*. Prepared for Pretium Resources Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Appendix A

Brucejack Heritage Chance Find Procedure

BRUCEJACK

Heritage Chance Find Procedure

1 INTRODUCTION

This Heritage Chance Find Procedure has been developed for the Brucejack Project by ERM Consultants Ltd. (ERM) for Pretium Resources Inc. (Pretium) to be used by Project personnel during ground altering activities.

The purpose of this document is to provide guidance for Project personnel who believe they may have discovered archaeological, historical, or paleontological materials or human remains during Project activities. Procedures outline best practices for protecting and reporting heritage chance finds and the protocols to follow in such cases.

This procedure will be included as part of the site orientation and training program during the Construction phase for personnel involved in new site surficial disturbance, so that they are trained and informed regarding compliance with the *Heritage Conservation Act* (1996) and the use of the this procedure. Training and site orientation will be provided for these construction personnel during their induction, with refresher training provided at the beginning of the second year of construction. Training will also be provided to Pretium environmental staff, with periodic refreshers during mine life. This training will outline relevant legislation in place to protect heritage resources and will focus on the protection of known heritage sites (including protected archaeological, historic, and paleontological sites), the procedures in place for responding to newly identified sites, and how to report these sites or observed site impacts. Copies of this document will be kept on-site for reference and on file by Pretium. The use of this procedure will promote the preservation of archaeological data while minimizing disruption of project schedules.

1.1 RELEVANT LEGISLATION

In British Columbia, the *Heritage Conservation Act* (1996) protects all heritage sites, whether on Provincial Crown or private land, that predate AD 1846. Burial and rock art sites are protected regardless of age. Burials and gravesites are protected in British Columbia by the *Cremation, Interment, and Funeral Services Act* (2004). Additionally, provincial legislation also protects significant paleontological sites (i.e., fossils).

A permit is required for any subsurface investigation of a heritage site or investigation with the intent to locate a site. The BC Archaeology Branch is the provincial government agency responsible for administering the *Heritage Conservation Act*, issuing permits, and maintaining a database of recorded heritage sites in the province. Disturbance and/or removal of artifacts from a site may result in penalties.

1.2 REMEDIES AND PENALTIES

The *Heritage Conservation Act* provides for heritage inspection or investigation orders, temporary protection orders, and civil remedies and penalties to limit contraventions. These powers provide:

- the Province with the ability to inspect a site or halt work to prevent site alteration; and
- the Courts with the ability to issue an injunction to restrain contravention of the Act or, where there has been a breach of the Act, impose penalties of not more than:
  - a fine of $50,000 and 2 years imprisonment for an individual;
  - a fine of not more than $1,000,000 for a corporation; or
  - a fine of $50,000 or 2 years imprisonment for an employee, officer, director or agent of the corporation.

1.3 HERITAGE SITE TYPES

In British Columbia, the material culture of the earliest cultures can be found on today's landscape which can relate to resource gathering, habitation, tool making, and ritual and ceremonial sites. Such sites can be discovered during Project activities and may become exposed as a result of cut-banks, excavation, eroding shorelines, or melting glacial ice. Some site types known to be present in northwest BC include:

- Culturally Modified Trees (CMTs) such as bark stripping, blazes, and removal of planks;
- rock art, including petroglyphs and pictographs;
- surface features such as cache pits, pit house depressions, and rock cairns;
- stone artifacts and the waste material from stone tool manufacture (flakes/chipped stone). Such artifacts can be found on the surface or subsurface and are often made from material such as obsidian, chert, or basalt;
- historic cabins related to significant historic events; and
- paleontological fossil sites.

2 HERITAGE CHANCE FIND PROCEDURE

If you believe that you may have encountered archaeological, historical, or paleontological materials, follow the procedure below:

- Immediately contact a Pretium or Contractor Environmental Monitor, Pretium Environmental Coordinator/Superintendent or Pretium Construction Manager to implement a stop work order, to **stop** all construction activities in the vicinity of the find to avoid damaging the site.
- **Do not disturb or remove any heritage material you may encounter**. Take a photo instead.
- Report your discovery to your supervisor. If unavailable, contact the Pretium Environmental Coordinator or Pretium Mine Manager to obtain further instructions.
- If possible, isolate and protect the area by hanging flagging tape, etc.
- Note the location of the find (GPS coordinates/sketch map/etc.), and leave the find in place.
- Prepare an initial Chance Find Reporting Form (see below) and provide this to the Mine Manager, who will also provide a copy to the Environmental Manager.
- Pretium Resources Inc. will contact the Project Archaeologist.

Once the Initial Chance Find Reporting Form has been submitted:

1. The Project Archaeologist will assess the potential significance of the find. If it is determined to be archaeological in nature, the Archaeology Branch will be contacted, as well as, the appropriate local First Nation.
2. The Project Archaeologist, in consultation with the Archaeology Branch, will determine what further steps are required.
3. If additional work is required, an investigation will be carried out under a Heritage Inspection Permit.
4. The Project Archaeologist will work with Pretium Resources Inc. and the Mine Manager to prepare instructions to recommence work in the area.
5. A site form and permit report will be submitted to Pretium Resources Inc., the Archaeology Branch, and local First Nations.

3 FOUND HUMAN REMAINS PROCEDURE

If you believe that you have discovered human remains, follow the procedure for *Found Human Remains*[1], summarized below:

1. Immediately contact a Pretium or Contractor Environmental Monitor, Pretium Environmental Coordinator/Superintendent or Pretium Construction Manager to implement a stop work order, to **stop** all construction activities in the vicinity of the find to avoid damaging the site.
2. **Do not disturb any possible human remains that you encounter**. Treat it like a crime scene.
3. Report your discovery to your supervisor. If unavailable, contact the Pretium Environmental Coordinator/Superintendent or Pretium Mine Manager to obtain further instructions.
4. Pretium Resources Inc. will contact the Project Archaeologist.

Once the initial report has been submitted:

1. The Coroner's Office and local policing authority will be notified as soon as possible by the Project Archaeologist.
2. The Coroner's Office will determine whether the matter is of contemporary forensic concern.
3. If the Coroner's Office determines the reported remains are not of forensic concern, the Archaeology Branch will attempt to facilitate disposition of the remains.
4. If a cultural affiliation for the remains can be reasonably determined, the Archaeology Branch will attempt to contact an organization representing that cultural group.
5. If remains are determined to be of aboriginal ancestry, the Archaeology Branch will attempt to contact the relevant First Nation(s).
6. Generally, if remains are still buried and are under no immediate threat of further disturbance, they will not be excavated or removed.
7. If the remains have been partially or completely removed, the Archaeology Branch will facilitate disposition.

[1] This is based largely on the Archaeology Branch's Found Human Remains Procedure with some changes to reflect Project specific conditions. Source: http://www.for.gov.bc.ca/archaeology/policies/found_human_remains.htm (accessed December 2013).

4 CONTACTS

ERM'sArchaeology Department

Lisa Seip, M.A., RPCA, CAHP Manager of Archaeology and Cultural Heritage	604-689-9460 lisa.seip@erm.com

BC Archaeology Branch

Doug Glaum Manager – Archaeology Branch	250-953-3357 doug.glaum@gov.bc.ca

Pretium Resources Inc.

Sean Masse	Local 165
Travis Murphy	Local 217
Torence Sandhals	Local 211
Sylvia Van Zalingen Director Permitting	250-877-9011 SVanZalingen@pretivm.com

RCMP – Stewart	250-636-2233

CHANCE FIND REPORT FORM

Recorder's Name/Affiliation: _____

Date: _____

Location of chance find (location description, UTM coordinates, road, quarter section, depth below surface):

_____

_____

_____

Photographs Taken (#s): _____

Description of find: _____

_____

_____

Method used to mark and protect find:

_____

_____

Distribution:

☐ Mine Manager or Supervisor	☐ Pretium Resources Inc.	☐ Project Archaeologist	☐ Archaeology Branch	☐ Local First Nation

Sketch Map

Appendix 9-1-9. Health Services Monitoring Plan

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Health Services Monitoring Plan

November 2023

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Health Services Monitoring Plan

Date: November 2023

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
1	June 2016	Pretium Exploration Inc.	Original
1a	December 2018	Pretium Resources Inc.	Title change, cover page added, and version control table updated
2	January 2023	Pretium Resources Inc.	Title page change and general updates to the entire document.
3	November 2023	Pretium Resources Inc.	Updated MSP and Medical Service Model changes

COMMUNICATIONS AND CONTACT LISTS

Communications at Brucejack are available by VHF Radio, Satellite Phones, and Satellite Internet. The following tables provide internal and external contacts as well as other communications related references.

MEDICAL EMERGENCY CONTACTS

Table 1. Medical Emergency Contacts

Service	Party	Contact Number
Ambulance	BC Road and Air Ambulance	1-800-461-9911
	Back-up BC Ambulance	1-800-561-8011
	Terrace	1-250-638-1102
	Stewart Brock Nelson Unit Chief	1-250-636-2676
NH Facilities	Stewart – Stewart Health Centre and after hours nurse on-call (emergency)	1-250-636-2221
	Terrace – Terrace Mills Memorial Hospital	1-250-635-2211
	Terrace Health Unit – Public Health Protection	1-250-631-4222
	Smithers Health Unit – Public Health Protection	1-250-847-6400
Medical Health Officer		1-250-565-2000

The Brucejack Mine is located approximately 65 km north-northwest of the town of Stewart. The distance by helicopter is approximately 77 km if the route flown follows the Granduc Road, Bowser River Valley and Knipple Glacier.

The mine is located approximately 245 km by air and 390 km by road from Terrace BC. Road access from Terrace is via Highway 16 to Kitwanga, then north via Highway 37N to the Brucejack access road intersection. The Brucejack access road intersection is located 62 km beyond Meziadin Junction, just south of Highway 37N km 215 marker board. Road travel to the mine is then westward for an additional 73 km via the access road.

ACKNOWLEDGEMENTS AND LIMITATIONS

This Health Services Monitoring Plan (HSMP) has been compiled by Pretium Resources Inc. (Pretium) a member of the Newcrest Group of companies and authored by Sarah Glover, Principal Health & Safety Manager, Brucejack Mine. The HSMP was reviewed, and inputs provided, by Andrew Adam, Camp Manager, Brucejack Mine, Vicki Thistle, Senior Industrial Hygiene Advisor, Brucejack Mine, Torence Sandhals, Principal, Environment, Brucejack Mine, Chad Hopkins, Environmental EIT, Brucejack Mine, Breann Hallstrom, Manager Medical Services, Ben Wither VP HSE & Permitting and CCI International.

Any use of, or reliance on, this Plan by any third party is at that party's sole risk.

BRUCEJACK MINE

Health Services Monitoring Plan

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ACRONYMS AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

'	foot or feet
"	inch(es)
ACP	Advanced Care Paramedic
Avi-tech	Avalanche (or glacier) Technician
EAP	Employee Assistance Program
ERP	Emergency Response Plan
ERPC	Emergency Response Planning Committee
Filterboxx	Filterboxx™ Water and Environmental Corp.
HMI	Human / Machine Interface
HSMP	Health Services Monitoring Plan
HSRC	Health, Safety and Reclamation Code for Mines in BC, 2008
JHSC	Joint Health and Safety Committee
km	Kilometre
MBR	Membrane Bio-Reactor
Medic/Advanced First Aider	Person with minimum OFA Level 3 first aid qualifications
MEM	Ministry of Energy and Mines
MERP	Mine Emergency Response Plan
MHO	Medical Health Officer
OFA	Occupational First Aid
OHS	Occupational Health and Safety
OPMT	Outbreak Prevention and Management Team
PLC	Process Logic Controller

PCP	Primary Care Paramedic
Pretium	Pretium Resources Inc.
PVC	Polyvinyl Chloride
RFP	Request for Proposal
RN	Registered Nurse
SAR	Search and Rescue
UCWTP	Upper Camp Water Treatment Plant
UV	Ultraviolet
VHF	Very High Frequency
WWTP	Waste Water Treatment Plant

1 BRUCEJACK MINE INFORMATION

1.1 OBJECTIVES

The objectives of the Health Services Monitoring plan are to outline the on-site medical services and programs to be delivered for the Brucejack Mine workforce and describe the measures to coordinate health service delivery with Northern Health. Given the remote location of the mine, distance to public health care, and limited health care resources in the surrounding communities, Pretium Resources Inc. (Pretium) recognizes the need to move beyond the minimum legislative WorkSafe BC requirements and develop a comprehensive Health Services Monitoring Plan (HSMP) for the Brucejack Mine. Pretium's overall goal is to not only minimize the impact on local resources, but to provide a better work environment for those employed by the company and to work in partnership with Northern Health to find ways to improve the healthcare of the community at large.

1.2 BRUCEJACK MINE INFORMATION

1.2.1 General

Mine Name:	Brucejack Mine
Mine Type:	Underground gold and silver mine
Mine Scope:	The Brucejack Mine has been in commercial production since July 3, 2017. Underground mining methods are used to extract gold and silver containing ore. The process plant extracts gold and silver in the form of both doré and flotation concentrate.
Company Name:	Pretium Resources Inc., a member of the Newcrest Group of companies
Healthcare provider:	Newcrest employee staff the medial clinics, with full time Occupational First Aid Level 3, Advanced Care Paramedics, and Registered Nurses [Remote certified] at Brucejack, Knipple and Wildfire camps. The medical services are overseen by the Manager Medical Services [Nurse Practitioner].
Camp provider:	Pretium provides food, accommodations, housekeeping and laundry facilities, and (for mine-supplied linens) laundry services.

1.2.2 Mine Location and Access

Address:	73 km by road from access road turnoff at KM 215 on Hwy 37N
Legal address:	800 – 1066 Hastings Street West Vancouver, BC V6E 3X1
GPS Coordinates:	Camp coordinates are provided below in Table 1-1

Table 1-1. Camp Coordinates

Locations	UTM NAD 83 Zone 9		WGS 84	
	Easting	Northing	Latitude	Longitude
Brucejack Mine Site	427,080	6,258,695	N 56°28′01″	W 130°11′01″
Wildfire Camp	469,101	6,264,071	N 56°31′12″	W 129°30′8″
Knipple Camp	437,957	6,251,097	N 56°24′01″	W 130°0′19″

The start of the Brucejack Access Road is located near km marker 215 on Hwy 37N, approximately 62 km north of Meziadin Junction (Figure 1-1).

Distances from populations centers are shown in Table 1-2 and highway distances from the start of the site access road to local population centers are shown in Table 1-2.

The mine site is located at the terminus of the Brucejack access road, approximately 73 km from Hwy 37. The access road (Figure 1-2) consists of the following sections:

- Kilometre 0 to 59 is a gravel road from the security gate at Hwy 37.
- Kilometre 59 to 71 traverses the Knipple Glacier. This is a snow road for much of the year and an ice road in the summer months.
- Kilometre 71 to 73 is a gravel road between the top of the Knipple Glacier and the Brucejack Mine Site.

The mine is in operation with activities ongoing both on surface and underground.

Table 1-2. Distances including Population Sites and Northern Health Services

City or Landmark	Highway Distance to Start of Access Road (km)
Bell II (north)	33
Meziadin Junction (south)	60
Stewart Health Centre (south)	120
New Aiyansh Health Centre (south)	202
Kitwanga (south)	216
Dease Lake (north)	272
Terrace - Mills Memorial (south)	300
Smithers - Buckley Valley (south)	326
Prince George Regional Hospital	697
Vancouver	1,476

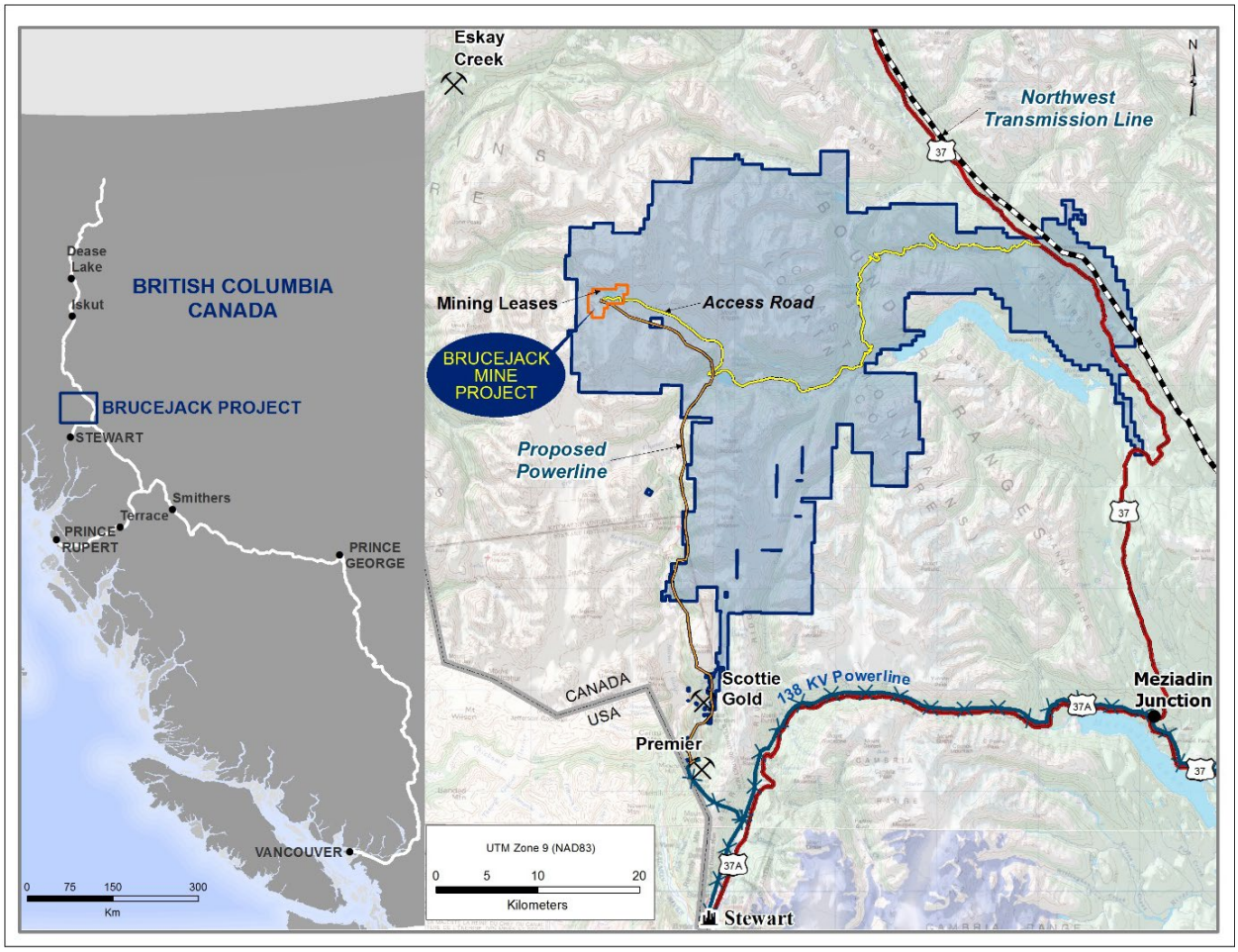

Figure 1-1. Brucejack Mine Location

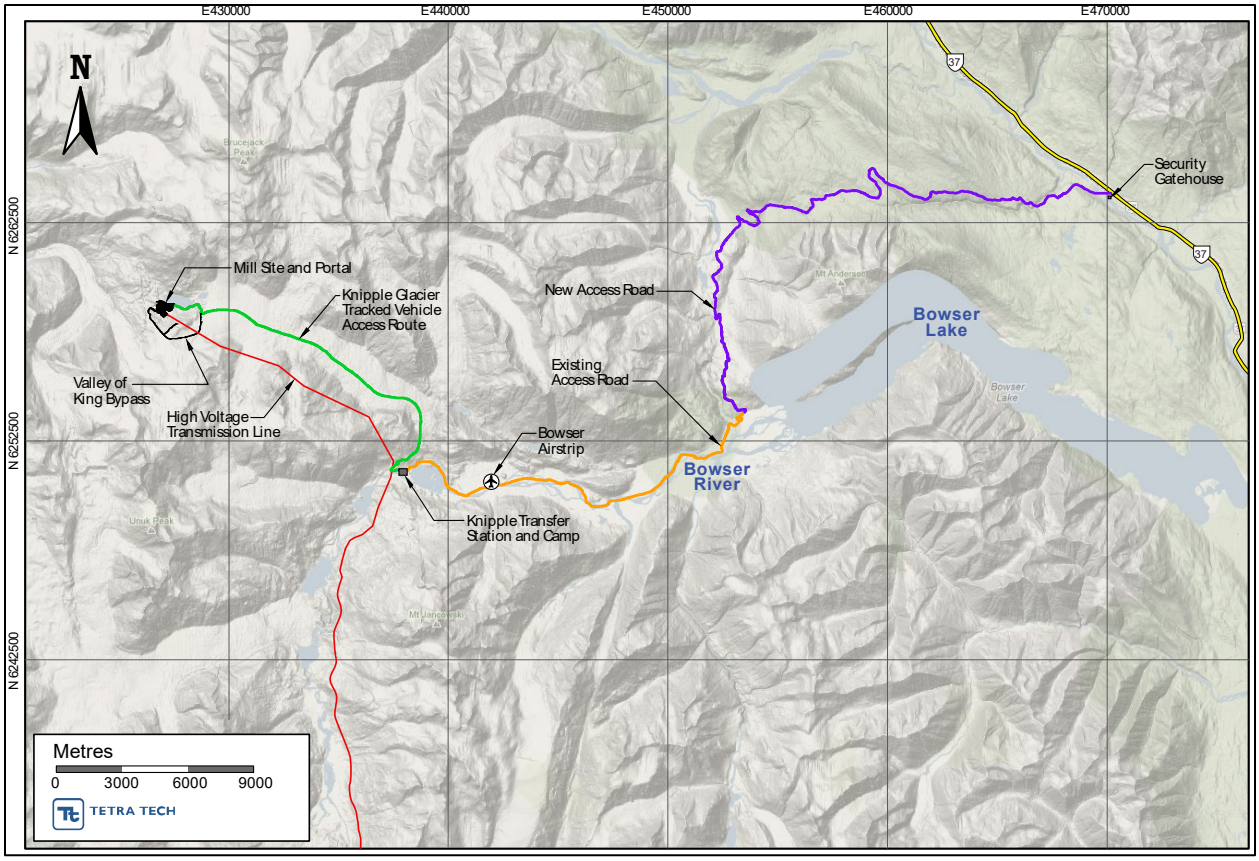

Figure 1-2. Access Road Extent

1.2.3 Brucejack Mine Camps

The Brucejack Mine has three camps: Wildfire Camp at km 1 of the access road, Knipple Camp at km 56, and Brucejack Camp at the mine site (km 73).

Camp populations vary, but the current bed space capacities are as follows: Wildfire Camp (25), Knipple Camp (142), and Brucejack Camp (746). The mine as currently defined will operate until the end of 2032. Table 1-3 summarizes the facilities at the smaller Wildfire and Knipple Camps.

1.2.3.1 Wildfire Camp

Located just off Highway 37 at km 1 of the access road, Wildfire Camp is used to maintain security of the access road and house road maintenance staff. Wildfire Camp has a modular construction permanent dormitory with 25 beds that was built in 2021. Rooms are single occupancy with ensuites. Wildfire Camp will be operational for life of mine.

Table 1-3. Camp Facilities Summary (Wildfire and Knipple Camps)

Facilities	Wildfire Camp	Bowser West	Knipple Camp
Bathroom and Shower Facilities	X		X
Kitchen	X		X
Dining Room	X		X
Camp Admin Office	X	X	X
Gym	X		X
First Aid Room	X		X
Security Checkpoint	X		
Security Screening Station	X		
Diesel Power Generators (back-up at Knipple)	X	X	X
Diesel, Gasoline and Jet-A Fuel Storage	X		X
Helicopter Pad	X	X	X
Maintenance shop			X
Laydown Yards		X	X

1.2.3.2 Knipple Camp

Knipple Camp is located at the km 56 of the access road and is currently used as a transfer point for incoming/outgoing freight and personnel working at the mine site. Freight is brought in via the access road on highway trucks and then offloaded and transferred to rubber tired off-highway trucks. Personnel travel in buses or vans which are chained up to travel across the Knipple Glacier to Brucejack. Knipple Camp has a modular construction permanent 142-person dormitory that was built in 2021, with similar amenities as Brucejack and Wildfire camps. Rooms are single occupancy with ensuites. The Knipple Camp and work area will operate for life of mine.

2 BRUCEJACK CAMP INFRASTRUCTURE

2.1 ACCOMMODATIONS

2.1.1 Introduction

Brucejack Camp accommodations infrastructure is comprised of two permanent dormitory complexes (Upper Camp and Lower Camp) and two modular mobile structures (bunkhouses 7 and 8). Combined total bed capacity is 746 persons.

2.1.2 Permanent Dormitories

Brucejack Camp has Upper and Lower Camp dormitory complexes, each with internally connected dormitory wings. All of the rooms are single occupancy with ensuite washrooms. Most of the Lower Camp was constructed in 2016, including three wings of 110 rooms each over 3 floors, kitchen, recreation facilities, housekeeping services area, and offices. A fourth wing was added to the Lower Camp in 2021, bringing its total bed capacity to 434 persons. The Upper Camp, with a bed capacity of 216, was also constructed in 2021. The Brucejack Camp permanent dormitories at site are built to the same modern standard, with the following best practices incorporated into the design:

- provide maximum access to natural daylight and views to the outdoors,
- provide superior ventilation;
- control sources of indoor air contamination;
- prevent unwanted moisture accumulation; and
- enhance the psychological and social aspects of space.

See Figure 2-1 for a schematic of the rooms.

The Brucejack Camp kitchen is located in the Lower Camp complex, and was expanded in 2021 when the permanent dormitory additions were constructed. Dry area and entry improvements were also part of the 2021 construction work.

Figure 2-1. Construction / Operations Camp Room Rendering

Each room is single occupancy and includes:

- 90.9 ft² of floor space (11'-1" × 8'-9 7/8");
- one bed (39" × 80") with high quality memory foam mattress;
- wardrobe closet with drawers;
- workstation including desk, padded chair, desk lamp, and internet connection;
- electric baseboard heater;
- television; and
- vanity sink.

Each room has its own ensuite bathroom which includes a shower enclosure and toilet. The bathroom has 25.3 ft² of floor space.

A rendering of the rooms is shown in Figure 2-1.

2.1.3 *Bunkhouses 7 and 8*

These modular structures each have 48 single occupancy rooms and common washroom facilities. The dry areas consist of coat hooks and benches, and there are washers/dryers in Bunk 8 to serve occupants of both bunks for both street and work clothes. There is also a separate laundry area for linens and towels (housekeeping use only).

2.2 LAUNDRY SERVICES

Separate laundry facilities, including washers and dryers, are provided for each of the following functions:

- Bedding and other linens: Housekeeping staff washes bedding and other catering supplied linens in dedicated washers and dryers. The general workforce is prohibited from using these laundry facilities. Bedding is provided by Pretium. It is changed and cleaned by the housekeeping staff each time personnel rotate out on days off. Fresh linens are available if personnel wish to have them changed more frequently.
- Work Clothes: Dedicated washers and dryers are provided for personnel to wash their own dirty work clothes. Work clothes are not permitted to be washed in any other washing machines.
- Non-work Clothes: Personnel have access to laundry facilities for washing their non-work, "street" clothes. Laundry soap is provided by Pretium.

Heated "mine and mill drys" are provided in the Lower Camp for personnel to store their work clothes, outerwear, and boots. This allows the clothing to dry and prevents dirt and grease from being tracked into the living areas. Dries are equipped with benches and either hooks or hanging baskets to store their gear as well as lockers, showers, toilets, and wash sinks. Personnel are encouraged to use slippers or other clean indoor footwear in the living areas. Boot covers are provided if personnel wish to cover their outdoor footwear.

2.3 POTABLE WATER SYSTEM

2.3.1 *Potable Water Monitoring*

The Ministry of Health as per the *Drinking Water Protection Regulation* prescribes water quality standards for potable water and the frequency of monitoring. Drinking water sampling is completed per BC Ministry of Environment, Health Canada, BC Ministry of Health, Environment Canada standards for a suite of parameters including fecal coliform, *E. coli*, metals, hardness, pH, turbidity, etc. Analysis is completed by a third party laboratory and results are posted on camp bulletin boards once received. An example of the third party analytical report is provided in Appendix A.

2.3.2 *Potable Water Supply*

The source of Brucejack Mine site drinking water is a drilled well titled "D3" in the Pilsner Valley, northwest of the mine site. This 83 m deep well is partly confined, with the well head protected by an

enclosed shipping container with all necessary instrumentation. The well is currently authorized to produce 75 m^3 of water per day. From the pump intake, raw water is pumped approximately 1.7 km to the Lower Camp Potable Water Treatment Plant (PWTP).

2.3.3 Potable Water Treatment

As the water arrives from the D3 Well it undergoes a four-stage filtration process at the PWTP, sodium hypochlorite injection, and ultraviolet (UV) disinfection prior to distribution. The PWTP can treat flowrates up to 200 GPM.

Stage 1 - Rapid Sand Filtration

The first stage inside the PWTP is sand filtration via five parallel sand filters using Next-Sand media. Next-Sand is capable of filtration to a 5-micron level when run at optimal bed depth and service flow rates. The Next-Sand filters take the bulk of the sediment load from the well water. After filtration, water flows back outside to two 75 m^3 primary storage tanks (total operating volume of 114 m^3). Having the Next-Sand filters before the tanks keeps sediment loading to a minimum. All further treatment is located inside the PWTP.

Stage 2 – Sodium Hypochlorite Injection

Sodium hypochlorite injection provides secondary, residual disinfection to the system. Sodium hypochlorite injection occurs in line as water is pumped into the two storage tanks. This system allows for sufficient contact time to take place in the tanks prior to further filtration and UV disinfection. A chlorine analyzer installed on the plant recirculation line monitors the free chlorine in the system.

A diaphragm pump alongside the chlorine analyzer is programed to ensure the free chlorine present in the system is kept between 0.4-0.6 ppm. Additionally, operators check the accuracy of the automated chlorine analyzer once per day using a handheld meter.

The remaining treatment stages are located after the primary raw water storage tanks.

Stage 3 - 5-Micron Cartridge Filtration

5-micron cartridge filtration consist of three filters in parallel. This stage provides protection to subsequent treatment steps if the Next-Sand filters ever need to be bypassed, or if they are overwhelmed by a significant surge in turbidity levels. They also assure that the 5-micron level pre-treatment has been completed prior to the 1-micron filters, in case the Next-Sand filters have not been able to reach this level on their own.

Stage 4 – 1-Micron (Nominal) Cartridge Filtration

1-micron cartridge filtration consists of three filters in parallel. This stage provides protection to the next filtration stage by filtering out as much particulate as possible beforehand.

Stage 5 - 1-Micron Absolute Cyst Removal Cartridge Filters

1-micron absolute cyst removal cartridge filtration consists of four filters in parallel. This level of filtration provides microbiological protection against many surface water pathogens such as *Cryptosporidium* and *Giardia* and removes ultra-fine sediments to improve UV transmittance and water clarity.

Stage 6 - UV Disinfection

UV treatment provides the primary pathogen disinfection. Seven units in parallel provide the suitable flow rate with redundancy. Each unit is protected by an independent automatic emergency solenoid shut-off valve and all the units are monitored by a single COMM Center.

2.3.4 Potable Water Distribution

Treated water leaves the PWTP and splits into three piping networks; first, to the Lower Camp; second, to the Mill building; and third, to the Heavy Shop storage tanks (60 m^3). There are additional branches off the Lower Camp and Heavy Shop piping networks, both supplying water to the Upper Camp Water Treatment Plant (UCWTP).

Water fed to the Lower Camp undergoes no further treatment due to proximity to the water treatment system.

Water to the Mill goes through additional 5-micron filtration and UV disinfection located inside the mill building before final distribution.

From the Lower Camp and Heavy Shop branches, water is pumped to two 20 m^3 cisterns in the UCWTP. The UCWTP can provide flowrates up to 120 GPM, the water is treated by two 5-micron filters in parallel followed by four UV units in parallel. From the UCWTP, treated water is pumped to the 216-person Upper Camp and Bunks 7 and 8, as well as former Bunk 2 (now used for exploration related purposes). Water pumped to the 216-person Upper Camp does not undergo further treatment.

Water pumped to Bunk 2 is treated by two 80-micron spin-down filters in parallel, two 5-micron filters in parallel, and two UV units in parallel. The treated water is then pumped to Bunk 2, 7, and 8.

2.4 FOOD SERVICES

2.4.1 Permanent kitchen and dining facilities

The Brucejack Camp kitchen and dining facility is centrally located and internally connected within the core camp complex. This kitchen operates under an approved Food Safety and Food Sanitation Plan and a current Health Operating Permit (#10188). Kitchen staff are FOODSAFE certified and undergo annual FOODSAFE training, Kitchen supervisors hold advanced FOODSAFE certification, Pretium's food safety and sanitation procedures are carried out through well-established policies and schedules following HACCP methodology and regularly audited. Pretium's temperature monitoring

and logging procedures for food transport, storage, service, and cooling are established and well maintained, often going beyond FOODSAFE guidelines through the use of automated temperature logging devices that eliminate human error.

The kitchen area including receiving, storage, production and service measures approx. 72′ x 76′ the dining area measures approx. 120′ x 88′ and holds a seated capacity of 450. The area also includes

- hot food services line;
- Lunch bag-up or grab-and-go room
- Hand washing facilities just outside the dining room;
- Washrooms just outside the dining room;
- Cold buffet and salad bar;
- refrigerated cabinets for condiments;
- refrigerated beverage coolers;
- refrigerated coolers for sack lunches;
- coffee and tea stations;
- drinking water dispenser; and
- toaster and microwave.

Privies

Indoor lavatories are located outside the dining hall in the entrance area, adjacent to hand wash stations. A lavatory with hand wash for kitchen staff only is located in the rear of the kitchen facilities and adjacent to space designated for chemical storage, and well-separated from food storage and preparation areas.

Separation of Dining Room from Kitchen

The kitchen is separated from the dining room by wall, with three access points: double swing doors for “kitchen staff only”, a pass-through counter window into the dishwashing area and a hot buffet service area. The buffet itself will be is behind glass and an open space above the buffet will allows clients to pass plates to servers, and vice versa.

Pests

Pests are kept from kitchen area by the use of screens on all windows and rodent-proof sweepers on all outer doors. All food is kept in secure pest-proof storage containers. Garbage will be is removed frequently and disposed of in a dumpster with a pest-proof lid which will be is kept closed at all times. Regular sanitation of kitchen, dining room, waste receptacles and dumpster will prevent attracting pests. A pest control service contract is in place and pest control technicians visit site bi-monthly; audit reports are issued and any required corrective actions are monitored until closed out.

Food Equipment Maintenance

All food equipment is maintained per manufacturer's instructions and serviced regularly. Equipment is fitted with safety lockouts where necessary, and all staff are trained on safe use. Equipment is cleaned and sanitized regularly according to daily, weekly, monthly, and on-demand cleaning schedules, established as part of Pretium's Food Safety and Sanitation Plans.

Kitchenware and Utensil Storage

Kitchenware and Utensils are stored on plastic coated wire rack shelving, or in stainless steel inserts on such shelves, all inserts and shelving are cleaned and sanitized regularly as part of Pretium's Sanitation Plan. Other ware and utensils are hanging above work areas from purpose-built stainless steel racks, and such racks are cleaned and sanitized regularly as part of Pretium's Sanitation Plan. All stored utensils are cleaned and sanitized regularly as part of Pretium's Sanitation Plan.

Protecting Food from Contamination

Food is protected from contamination in several manners which include: use of sealed containers; proper storage procedures (e.g., meats to be stored in designated areas apart from other food items and cooked foods to be stored in designated areas apart from uncooked food); regular cleaning and sanitation of all food storage areas and food storage containers as part of Pretium's Food Sanitation Plan; by storing potential allergens in sealed clearly labelled food safe containers and kept in designated areas apart from other foods; by storing chemicals and other non-food items in designated areas well-separated from food storage and preparation areas; by washing all knives, tools and cutting boards and cleaning and sanitizing work areas between tasks; food handlers change aprons and uniforms after handling meat, allergens, or other potential contaminants.

Food Storage

Food is stored in appropriate covered food safe containers in temperature controlled and monitored walk-in or reach-in coolers and freezers. Operating temperatures will be monitored and logged twice daily to maintain safe operating temperatures as per Pretium's Food Safety Plan or stored in designated pantry areas for dry foods. Food for service is served in hot or cold buffet areas at appropriate food safe temperatures, and temperatures is logged regularly as part of Pretium's Food Safety Plan. All food storage areas and containers are regularly cleaned and sanitized as part of Pretium's Food Sanitation Plan.

Procedures for Cleaning and Sanitizing Utensils and Non-absorbent Surfaces

Utensils are cleaned and sanitized by automatic heat-sanitizing dishwasher, and the temperature is checked and logged regularly to ensure proper sanitation. Utensils which can't be washed in automatic dishwasher are washed by 3-sink method, which includes washing in clean warm soapy water, then rinsed in clean water and finally sanitized in clean water containing appropriate amount of food safe sanitizing solution per the manufacturer's instructions and then air-dried. Non-absorbent surfaces are cleaned and sanitized by the 5-step method, which includes the removal of gross debris, thoroughly washing with clean warm soapy water, rinsing the surface of soap with clean water, wiping dry with clean cloth and then spraying with food safe sanitizer and air drying per manufacturer's instructions.

Procedure for Washing Dishes, Cutlery and Cookware

Dishes are cleaned and sanitized by 5-step method which includes, scrapping dishes to remove gross debris, racking and spraying down dishes, putting dishes through automatic heat-sanitizing dishwasher (temperature is logged regularly to ensure proper sanitation), and then air-drying. Dishes which cannot be washed in automatic dishwasher are scrapped, spray-rinsed, then washed and sanitized using 3-sink method.

FOODSAFE Certification

It is the intention to maintain 100% of kitchen staff FOODSAFE certified. Any new kitchen staff without certification are trained and certified within 3 months of hire, and at no time will less than 75% of kitchen staff on any shift are FOODSAFE certified.

2.5 LIQUID AND SOLID SEWAGE DISPOSAL

Liquid waste or sewage is currently treated by a proprietary Membrane Bio-Reactor (MBR) package waste water treatment plant (WWTP) manufactured by Filterboxx™ Water and Environmental Corp. (Filterboxx). The package plants have the capacity to treat up to 225 m^3/day of raw water flow and is designed to meet the requirements of the BC Ministry of Environment (MOE). The process consists of:

- lift stations or gravity feed from various site buildings;
- influent pre-screen;
- influent tank;
- aeration tank and associated blower;
- membrane filtration system;
- treated effluent tank;
- UV disinfection units;
- sludge holding tank;
- sludge dewatering;
- process logic controllers (PLC) and Human Machine Interface (HMI); and
- various transfer pumps.

Treated water is discharged to the Waste Rock Tailings Storage Facility (WRTSF) via an insulated, heat traced, pipeline.

Sludge is primarily dewatered and transferred offsite for disposal at Meziadin landfill. As needed, liquid sludge is transferred offsite for disposal at an approval disposal lagoon in Meziadin Junction.

2.6 SOLID WASTE DISPOSAL

Solid waste is managed in accordance with the Brucejack Waste Management Plan and Refuse Incinerator Management Plan.

2.7 OTHER FACILITIES THAT SUPPORT POSITIVE HEALTH OUTCOMES

All of Pretium's residence camps include the following amenities that promote positive health and mental health:

- gymnasium with a yoga/aerobics area, cardio machines, and weights;
- recreation facility that includes pool tables, ping pong tables, social areas, TV lounges;
- quiet area for reading/study;
- at Brucejack, marked walking/hiking/snowshoeing trails;
- private single rooms;
- public phones so workers can call home at no cost;
- Wi-Fi internet access throughout the facility; and
- 24/7 access to the dining room.

3 ON-SITE PROGRAMS AND SERVICES

3.1 HEALTH SERVICES

Pretium's goal is to continually improve the on-site health service delivery model that provides not only high-quality occupational illness prevention and initial injury care but also addresses the general health and primary care needs of the site workforce whenever possible. Pretium's aims to be self-sufficient to a reasonable extent; but should a patient's condition warrant care beyond the scope of practice or expertise of the on-site team(with the remote support of the primary and emergency physician telehealth MSP services), Pretium's collaborates closely with NH and BCAS to ensure an efficient and effective transfer of care.

3.1.1 Health Services at Brucejack

Pretium health services are detailed below but have been recently re-structured in order to be as self-sufficient as possible, minimizing impacts on NH and providing high-quality care to the site's workforce. The approach to minimizing impact on NH resources is multi-faceted:

- Comprehensive pre-deployment occupational health assessment: this ensures that personnel working at Pretium have been assessed as fit to work in a rural environment and, for patients with chronic diseases, there has been liaison between the on-site medical team and the patients' regular physicians to ensure a plan is in place for disease monitoring/surveillance and a crisis plan in the event of a deterioration while on-site.
- Experienced on-site healthcare team: Pretium employs remote-certified RNs and ACPs with more than seven years' experience. These individuals have experience of working in rural areas and have robust clinical judgment.
- Access to increasing breadth of diagnostic facilities at site: see Diagnostics section for further details. However, the aim is to give the on-site team more confidence to risk-stratify presentations at site and to dictate urgency with which patient needs further medical attention, either at home after the rotation finishes or at an NH facility.
- Access to comprehensive medications at site: Pretium maintains a comprehensive inventory of medications to treat both emergency presentations and minor illnesses or injuries that would otherwise precipitate a visit to a local NH facility.
- Working-hours primary care physician support: the on-site healthcare team is able to contact experienced primary care physicians during working hours for advice on non-urgent presentations in which there may be diagnostic uncertainty or where decision-making is complex. While a proportion of these calls will, inevitably, result in the need for the worker to attend an NH facility, this service will significantly reduce the number of presentations to NH facilities that would otherwise occur.

- 24/7 emergency telehealth support: where patients are critically ill or injured, access to 24/7 experienced critical care or emergency physicians will improve the immediate on-site response. Clinical decisions made in the first few minutes and hours after injury can have a dramatic impact on overall outcome, and through this service, Pretium's on-site healthcare team will be supported in managing these complex cases whenever they occur. In the event of a critically injured or ill patient, the service will not prevent the need for transfer or evacuation but will be able to improve the patient's condition, where possible, prior to departure from site and will be able to direct the patient to the most suitable receiving facility (see later discussion on transfer). Furthermore, the physicians will be able to pre-alert the receiving facility of the incoming case so that they are able to prepare and anticipate the patient's arrival.
- Quality of MSPs: Pretium has agreements with MSPs that cover the spectrum of care from non-urgent to urgent, emergent and critical cases. The primary care and emergency telehealth services are led by senior and engaged medical personnel who have extensive experience in the planning and delivery of health care services in rural communities and are fully aware of the regional and local context of Pretium's operations and the need to minimize impact on local health facilities, as well as the specific health challenges related to Pretium's activities. Pretium's MSPs are involved in health services above and beyond clinical care of patients and are committed to supporting corporate leadership and collaborating closely with all relevant stakeholders, including NH.
- Robust clinical governance processes: under the direction of the Manager Medical Services, Pretium will, in conjunction with its MSPs, ensure that health services on site are tightly governed, with routine audits of clinic activity and utilization metrics to inform future staffing levels and health promotion activities, regular debriefs of cases where evacuation from site is required, including where possible, the involvement of the receiving facility and MSPs. Health service and mine rescue (ERT) personnel at Pretium will undertake regular training including the use of in-situ simulation in order to prepare for anticipated health events so that the response to a future real event can be optimized.

Pretium currently employs a full time clinic working steady days and on-call for night shift.

Brucejack Clinic Team	Rotation Pattern
RN-C / NP	2 Full time positions on regular 2 weeks on: 2 weeks off rotation
ACP	2 Full time positions on regular 2 weeks on: 2 weeks off rotation
RN	>12 OFA3/First responder trained, located across site in various departments
Knipple Clinic Team	**Rotation Pattern**
ACP	2 Full time positions on regular 2 weeks on: 2 weeks off rotation
Wildfire Clinic Team	**Rotation Pattern**
OFA3 / Security Supervisor	2 Full time positions on regular 2 weeks on: 2 weeks off rotation

Role allocation within the team:

- The ACP's would be the primary attendant to emergencies occurring outside of the Clinic, to provide the advanced medical evacuation escort as required by patient severity.
- The RN (Remote Certified) and NP would primarily manage the medical cases within the clinic and should retain an advanced scope of practice. The RN fills the role of co-medical leads for the site and act in a "physician extender" role.
- The RN would provide support the management of medical cases within the clinic.
- We anticipate continuing with this baseline coverage but will look to add additional staff as the workload warrants.

The Clinic staff are supported by a 3rd party 24/7 emergency telehealth physician provider, staffed by emergency and critical care physicians with extensive experience of remote practice. This service is activated as required during situations requiring emergency response, when considering the need to transfer a patient off-site or in cases of diagnostic uncertainty.

By directly linking the on-site team with an on-call physician group with experience of the local environment, the team can collaborate on treatment plans and together develop a more extensive initial patient care plan than would be possible otherwise. This care plan includes the provision of higher levels of assessment and treatment plans including both prescription and non-prescription medications.

The Clinic staff also have access, during working hours, to primary care support provided by Total Medical Remote Doctor Services for cases that do not meet the threshold of requiring emergency physician engagement. Although not the primary purpose of the Clinic, a significant amount of primary care activity occurs on-site due to the nature of self-presentations to Clinic and the enthusiasm of the staff to care for colleagues. There are efforts to utilize Northern Health printed resource materials around workplace wellness and risk factors that can lead to injury, illness, and chronic disease.

3.1.2 On site Resources

The on-site medical team has access to the existing site medical clinic(s) located within the camp buildings or adjacent. The medical clinic meets or exceeds all current WorkSafe regulations and include amenities seen in a well-equipped Northern Health Diagnostic and Treatment centre. This includes a trauma area, observation area and the ability to monitor a patient overnight should a medevac not be possible due to weather.

Fully outfitted ambulances are located onsite and provide immediate access to the clinics.

The medical facility's are equipped with diagnostic equipment that aims to assist the on-site medical staff to quickly triage, assess, and treat the patient in the most self-sufficient way possible, and to assist telehealth physicians to risk-stratify potential emergencies with a view to assessing whether a patient needs to be transferred to NH facilities, or if they can in fact be cared for on-site.

The Clinics stocks a range of medications to treat emergency presentations and minor illnesses or injuries that would usually precipitate a visit to a family doctor or emergency department. These medications include first line prescription antibiotics, gastro-intestinal, cardiac, respiratory, and dermatologic medications to be dispensed by clinic staff under remote physician orders.

The Clinics do not stock medications for chronic conditions such as hypertension or diabetes. A formal medication management system is planned with an accurate inventory on-site and an arrangement with a regional pharmacist where, in collaboration with the on-call physician, new prescriptions can also be provided to the workforce. Workers are expected to be up to date with routine immunizations prior to going to site. Immunizations such as tetanus, Twinrix and seasonal influenza will be provided on-site at the medical clinic.

A wide array of non-prescription medications are available on-site to manage the common non-occupational illnesses such as flus, coughs, colds, local skin infections, skin rashes and others.

3.1.3 On-site Medical Clinic Areas of Practice

The following conditions will be within the scope of treatment for the medical team with or without engagement of a 3rd Party emergency telehealth and primary care physician:

- Treatment and care of illnesses, occupational injuries and injuries which can be treated using OTC (over the counter) medications.
- Treatments outlined in Schedule 2 of the Emergency Medical Assistants Regulations under the Advanced Care Paramedic licence category.
- Treatments outlined in the NNPBC (Nurses and Nurse Practitioners of BC) Decision Support Tools.
- Management of acute trauma and cardiac condition requiring Advanced Cardiac Life Support interventions and advanced airway management (intubation).
- Initial and ongoing treatment with IV and oral antibiotics for dental, skin, respiratory, urinary, and ear nose or throat infections.
- Oral and/or IV hydration for dehydration secondary to environment, gastro-intestinal illness, or other cause.
- Treatment for conditions requiring initial pain management such as lower back, musculoskeletal, overuse injuries and dental pain.
- Simple foreign body removal/lancing of abscesses/wound management.
- Short-term observation of various conditions such as minor head injuries, abdominal pain, or asthma exacerbation.
- Treatment on-site, whenever possible, for a wide array of non-urgent medical issues including prescribing/dispensing medications (starter packs).

Although the goal of the Hybrid health and medical services team will be to have workers assessed and treated so they can remain at site, there will inevitably be situations where a patient will require

a referral to a Northern Health facility or other service. Further detail on the referral and trauma transfer process is outlined in the sections below but the overall goal is to provide the highest standard of healthcare possible to patients requiring medical assistance by ensuring effective communications with Northern Health facilities before, during and after the transfer process. This will, where possible, include pre-alerting receiving facilities and transferring with the patient a summary of their medical records held on-site.

The following areas necessarily fall outside the scope of the on-site healthcare team:

- Patients requiring urgent laboratory or radiologic work-up.
- Patients requiring assessment or treatment above the capabilities of the on-site team including those requiring prolonged observation or hospital admission.
- Embedded foreign body removal from the eye and complex laceration repair.
- Fracture management, beyond initial stabilisation and reduction

3.1.4 Non-urgent Care Demands

Pretium recognizes that in addition to responding and treating occupational injuries or illnesses, many employees have chronic medical issues that require on-site monitoring and continuing care by the medical team. The medical staff, in collaboration with the engagement of the 3rd party primary care service and the patient's regular primary care physician, will make best efforts to coordinate and provide care consistent with the patient's care plan. As needed, best effort will be made to contact the person's home healthcare provider to best coordinate care when there are changes in the patient's condition.

Furthermore, Newcrest implements robust occupational health programs including pre-deployment medical screening for all employees travelling to NRC. Pre-employment medical screening aims to prevent illness, injury or loss of life by ensuring that individuals are placed in suitable work according to their physical and mental capabilities. The pre-employment assessment provides a snapshot of the worker's health as they begin their role in a new position. This helps to inform subsequent medical surveillance required on-site and facilitates discussion between the employee's home healthcare provider, Newcrest and NRC's MSPs prior to travel to site regarding risk management and surveillance plans.

3.1.5 Mental Health and Substance Use

Pretium strives to provide a safe and healthy working and living environment but recognizes that both employees may require assistance in managing mental health and substance use issues that may arise.

The on-site medical staff is well versed in mental health promotion and in the specific mental health and substance use issues relevant to camp life. The goal will be to have the medical staff continue to maintain a high level of competency in this key area of health through ongoing medical education programs as well as working closely with programs promoted by Northern Health.

The Pretium is a "dry camp", and no alcohol or illicit drugs are allowed anywhere on the property, it is still important for the medical team to have a significant understanding of substance use issues. Camp will be equipped with multiple naloxone kits and on-site medical team will have training in overdose response.

Additional programs focused on substance use awareness will be incorporated as part of their continuing professional development programs. The following resources are reviewed and incorporated into the on-site awareness program:

- Overdose prevention | Northern Health
- Health and Safety during the Opioid Overdose Emergency: Northern Health's Recommendations for Industrial Camps, Northern Health
- Infographics - University of Victoria (uvic.ca)
- http://www.ccsa.ca/eng/Pages/default.aspx

Pretium will work collaboratively with Northern Health and Pretium's Employee Assistance Provider (EAP) to distribute awareness and educational materials to support the areas of both mental health and addictions.

To help reduce stigma, mental health and substance use awareness health awareness promotional materials will be posted at site in high traffic areas. Supervisors and Managers will receive training on the company's policies and procedures as they relate substance use, thereby promoting consistent and equitable treatment for all employees. Site drug and alcohol policy allows for financial support for rehabilitation programs, and upon medical clearance and successful completion of the program, a return to work. Pretium's current practice of recovering used sharps via collection areas in restrooms will continue.

Overall, Pretium supports Northern Health's recommendations to promote health and safety on industrial camps with respect to the opioid overdose emergency.

Recommendation in NH guidance pertaining to health and safety during opioid overdose emergency	Pretium implementation
Promote mental wellness at work and in camp	1. Annual mental health and psychological safety at work promotion campaigns 2. Promote use of recreation facilities on-site 3. Promote use of EAP
Foster an open, respectful and well-informed working environment	1. Provision of information on drug and alcohol use/addiction to workforce as part of annual mental wellbeing campaign 2. Promote use of EAP
Prepare for the possibility of an opioid overdose	1. Include recognition and immediate management of suspected opioid overdose in first aid and Mine Rescue (Emergency Response Team) training, including conducting scenario-based training (in-situ simulation) on this topic to assess adequacy of response on-site 2. Refresher training for clinic staff on opioid overdose – signs, symptoms, management 3. Drafting of Opioid Overdose clinical protocol in accordance with BC Emergency Health Services treatment protocols
Provide confidential access to harm reduction supplies	1. Provision of education on substance use
Support employees with addictions to get help	1. Facilitate access to mental health and addiction programs, via EAP
Manage the risk of impairment in safety-sensitive positions	1. Continued use of drug and alcohol testing and enforcement of policies forbidding drug and alcohol use on site 2. Increase awareness among shift supervisors of behaviours that may suggest impairment 3. Provide training for clinic staff in how to approach workers who have been referred to the clinic by their supervisors' suspecting they may be impaired. The approach needs to balance the rights and wellbeing of the worker with the safety-sensitive nature of many roles at Pretium and the risks to others' safety

Pretium has engaged and secured an EAP to provide support for employees and their family members. On-site contractors will be strongly encouraged to have their own EAP programs for their employees. On-site contractors and their employees will have access to on-site facilities: telephone and internet to contact their service providers and best efforts made to provide a private location for this service. In a Crisis Management situation Pretium will make best efforts to ensure all camp residents will have access to the necessary counselling resources.

The EAP provides Counselling Services which are available by e-mail, telephone, or video. Appointments can be scheduled using any of the aforementioned. The model of counselling is short-term in focus with clearly defined goals and outcomes. It is designed to help employees understand their concerns and develop a plan of action to address them. All new employees are provided EAP information upon hiring. Posters and pamphlets promoting the EAP, with contact information, will be displayed in high traffic areas of camp.

EAP counselling is available and can include the following caregiving, life planning, career planning, and health management services:

- life balance services;
- new parent support;
- childcare and parenting (including online childcare resource locator);
- elder and family care (including online eldercare resource locator);
- financial consultation;
- legal advisory;
- relationship solutions;
- career smart services;
- career counselling;
- pre-retirement planning;
- shift worker support;
- health smart coaching;
- nutritional counselling; and
- smoking cessation program.

Each of these services has been developed to allow employees and family members to take a proactive approach to manage everyday challenges and life transitions, and to receive the information and support that suits each unique situation. All these services are delivered by phone or online and often include expert support and coaching, and/or personalized resource material. The EAP can be reached +1 800 663 1142 anytime day or night, 365 days of the year. In an emergency, immediate support is available.

Whenever this program is used, it is in complete confidentiality.

3.1.6 Sexual Health

Pretium is very aware that the camp environment and lifestyle can lead to poor sexual health choices. To address this important issue, Pretium ensures that the on-site medical team has the necessary training and qualifications to raise awareness on sexual health issues, that education and safe sex counselling may be required as well as coordination of testing and treatment in some cases.

Pretium's EAP provider will provide "safe sex" counselling when needed, and provide on-site awareness programs including posters, brochures, and pamphlets to reduce the risk of STDs and unplanned pregnancies. Additionally, we will ensure that the on-site medical team as well as camp workers are aware of the following resources:

- Health Link BC:
  - https://www.healthlinkbc.ca/health-topics/stdis
  - https://www.healthlinkbc.ca/healthlinkbc-files/preventing-sti
  - https://www.healthlinkbc.ca/services-and-resources/healthlinkbc-files/series#STD
- BCCDC:
  - https://smartsexresource.com/about-stis/got-symptoms

Should a patient have a potential STD or sexual health issue, the on-site medical team will look to initiate a treatment plan, collaborate with the person's home healthcare provider to develop and implement a patient specific follow-up treatment plan.

On-site interventions will include coordination of STD screening and treatment, birth control options, "safe sex" counselling, referral, and other supports for sexual health. Free sexual harm reduction supplies will be made available in discreet locations at camp. When specific laboratory testing and results reporting is required, a pre-established protocol has been developed in collaboration with Northern Health.

3.1.7 Diagnostics

As mentioned in a previous section, the goal is to equip the medical clinic, when possible, with diagnostic capabilities like those found in a diagnostic and treatment centre. Current equipment includes an observation machine (blood pressure, pulse, oxygen saturations, end-tidal carbon dioxide) ECG monitors with 12 lead capability, peak-flow meters, glucometers, urinalysis, pregnancy tests and target tests such as screening for respiratory viruses. In future, additional diagnostics may be procured in order to inform decision-making by clinical teams both on-site and when engaged for remote advice. Such diagnostic tests can significantly amplify the impact that the emergency and/or primary care physicians can have by providing biochemical data to support advanced clinical decision-making when used in conjunction with evidence-based clinical protocols in a well-governed system.

Pretium also maintains a program of pre-employment medicals, audiograms, and D&A testing for potential employees, and will require contractors to complete the same for their potential employees. Individuals who pose too great a risk to themselves or others related to their health will be prevented

from working at Pretium. The on-site medical staff will have the ability to test for drugs or alcohol where it is warranted.

It should be noted that an on-site x-ray facility is not usually eligible for accreditation from the College of Physicians and Surgeons Diagnostic Accreditation Program so there is no x-ray capability at site.

Any patients requiring x-rays or laboratory tests beyond the on-site medical clinic capability will be evaluated to determine the most efficient timing and location for the testing with the goal of minimizing the utilization and impact on Northern Health facilities. Where it is safe to do so e.g. chronic disease surveillance, individuals will be encouraged to have tests with their home provider during their next scheduled break. However, in the event of the on-site team, in conjunction with the MSPs, suspecting any acute pathology, the health of the individual will be prioritized, and efforts made to facilitate the investigation required with as minimal delay as possible.

3.1.8 Bridging with Providers in Home Communities and Northern Services

Pretium recognizes the fact that Northern Health is not funded by the Ministry to fully support temporary resident populations such as those in industrial camps. For this reason, Pretium will make best efforts to ensure patients requiring care for non-urgent illnesses or injury are able return to their home communities for treatment once it is determined that their condition is stable, and they are fit to travel to their home community.

Examples are patients requiring follow-up of injuries requiring a plastic or orthopaedic surgeon assessment or conditions requiring internal medicine or medical specialist assessment. Pretium will track and initially follow all patients who are referred to any Northern Health facilities and ensure they are aware of the option to be transported home should they choose this option.

Whenever follow-up care is required off-site or a change in an established treatment plan is deemed necessary for a camp patient there will be an expectation that the Pretium on-site healthcare team will directly contact the patient's home health care provider. This includes family and specialist physicians, dentists, physiotherapist, or other licensed health care providers. In some cases, this contact may include health authority services.

3.1.9 A Focus on Discretion, Privacy, and Confidentiality

Pretium recognizes workers' concern regarding discretion, privacy, and confidentiality can hinder whether they choose to use an on-site medical clinic. We continually strive to have all necessary measures in place to ensure patients can access care without any concern for repercussions related to their employment and continually seek to promote a high level of trust between employees and the on-site medical clinic staff.

Pretium and the various site contractors can only access first aid records as permitted by WorkSafe BC for occupational related illness or injury. Pretium understands the company is not legally permitted to access any patient's medical record unless they have the express written consent of the patient. Pretium recognizes that any Electronic Medical Records are strictly confidential and will be securely stored requiring electronic passwords and supported by an IT policy requiring staff to lock their computers when not at their computers. Any paper records will be kept in a secure storage area.

The discretion, privacy, and confidentially process outlined above will be posted in the medical clinic as well as communicated on a regular basis to camp workers. This information will also be placed in the worker orientation package.

3.1.10 On-site Management of Company Policy Requirements

Pretium will make best efforts to implement company policies, when possible, which can be implemented by the on-site medical team and not require the resources of Northern Health, especially their emergency departments. Pretium will require the same approach for all contractors on-site. Thus, sick notes, insurance forms or other forms (such as return to work) which require completion on behalf of employees, contractors, or WorkSafe shall be completed using on-site resources whenever possible.

Pretium recognizes that some occupational illnesses and injuries (e.g., those requiring x-rays for example) will be beyond the capabilities of the site medical staff and require referral to Northern Health facilities. To assist in these referrals, a Functional Abilities Form (FAF) will be created for all major work categories. Best efforts will be made to ensure any worker that is sent off-site for further medical assessment will have a FAF included in their referral paperwork to assist the attending physician or medical professional in their assessment of the patient and their ability to return to work, return with modified duties or be deemed not fit for work. Pretium will make best efforts to ensure the follow-up process will minimize the burden on local resources.

Modified duty programs are a requirement of WorkSafe BC as they have been proven to show that the quicker the person returns to work, the quicker the person will recuperate and become a productive employee again. Pretium will reassign the worker to modified work tasks until they are fully functional and healthy to return to work. Pretium will rely on the on-site medical staff and, with the support of off-site MSP's and additional third-party support, will determine when a worker may safety return to work, and to what degree of graduated return-to-work program they can undertake.

As noted previously Pretium has a zero-tolerance policy to drugs and alcohol in the workplace and is a "dry camp". To meet this objective, Pretium also has a comprehensive Drug & Alcohol Policy. It should be noted that any drug and alcohol substance use problems that are brought forward by employees will be supported by the company with guidance from Pretium's EAP provider and community resources.

3.1.11 Disease and Infection Prevention and Outbreak Protocols

The remote setting of Pretium poses unique challenges, and the camp has the potential to be a high-risk area for the transmission of communicable diseases and infections, as the inhabitants are often near each other in a confined living and working environment.

Pretium is committed to the proper management of communicable disease, infection, and outbreak occurrences and this will be achieved through prevention, rapid response and the collaboration of personnel and resources. A detailed Communicable Disease Control Plan has been developed for the following the Northern Health's Best Management Guide for Industrial Camp outline.

The Manager Medical Services is Communicable Disease Control Lead (CDCL), with nominated medical staff filling the onsite role.

The following section provides a high-level overview of the plan which is outlined in greater detail in Pandemic Response.

Prevention

The ideal approach to the prevention and containment of an infectious outbreak is to implement a series of controls as referenced in the BC Provincial Infection Control Network resources:

https://www.picnet.ca/ wpcontent/uploads/PHAC_Routine_Practices_and_Additional_ Precautions_2013.pdf.

Engineering Controls

The camp design incorporates best practice engineering controls which include single rooms, private toilets and sinks, designated areas for hand washing and hand hygiene dispensers. Appropriate ventilation will be implemented across the camp including natural ventilation when possible. A, a protocol to isolate an infectious patient to a private room is in place to limit their exposure to the rest of the worker population.

Administrative Controls

The administrative controls will be introduced to provide an infrastructure of policies, procedures and patient care practices intended to prevent exposure to and/or transmission of infectious disease within the camp. The on-site medical team will be well versed in the identification, diagnosis, and treatment of common camp illnesses such as URTIs, influenza, noroviruses and also the need to maintain vigilance for all reportable illnesses listed on the BC Centre for Disease Control website.

Appropriate occupational health and safety policies including work restrictions, sharps safety, prevention of exposure to bloodborne pathogens and immunization programs will be communicated to the workers through the introduction at safety meetings and awareness campaigns. Ongoing awareness campaigns for the need for hand hygiene and cough etiquette will be in place with special focus during the typical months for season influenza activity.

Routine environmental cleaning policies have been created for the housekeeping staff as well as the safe use and disposal of sharps, incorporation of safe practices for handling blood, body fluids and secretions as well as excretions by both housekeeping and medical staff.

In order to reduce the risk of food handling related to norovirus infection and consequent outbreaks, there will be an ongoing focus on the need to maintain food hygiene standards. Policies are in place to include attention to hand hygiene, prevention of gross contamination during food preparation, provision of adequate handwashing facilities for food handlers and ensuring that food handlers do not work while they have symptoms of gastroenteritis.

Personal Protective Equipment

PPE is available for the protection of on-site medical staff, housekeeping or other team members involved in an outbreak to minimize the risk of contact with an infectious disease. These barriers include gloves, gowns, masks, facial protection, eye protection (including face shields, or masks with visor attachments) and N-95 respirators as required. Simple face masks will be made available to patients with a cough and symptoms of a respiratory infection to help reduce their chances of disease spread.

Outbreak Management

Pretium, through the Manager Medical Services Western Canada, will ensure the onsite medical provider is well versed in all aspects of outbreak management including the requirement to notify Pretium HSE immediately and the Northern Health Medical Officer, within 24 hours of an outbreak or occurrence of any illness above the incident level that is normally expected at an industrial camp. The on-site medical team will maintain vigilant for all reportable illnesses listed on the *Health Act Communicable Disease Regulation* 7/2015, O.C. 14/2015) under the *Public Health Act*.

Pretium will work directly with medical, housekeeping and food preparation providers to prevent an outbreak of infectious disease from happening. If however, an outbreak does occur an outbreak protocol will be in place to provide a systematic approach developed in accordance with the recommendations of the "Provincial Infection Control Network of British Columbia." Pretium will make best efforts to ensure workers and contractors are remunerated financially if they are required to isolate to a private room and not able to work.

A protocol has been developed based on the toolkit created by Fraser Health (http://www.fraserhealth.ca/media/Respiratory-Outbreak-Protocol-and-Toolkit-for-Residential-Care-Facilities.pdf) as well as resources available from the Provincial Infection Control Network. There is a process in place to mobilize an Outbreak Prevention and Management Team as necessary, which will link directly with external partners such as Northern Health for their input, expertise, and guidance. Necessary protocols will be developed outline the following key areas to manage influenza, respiratory, and gastro-intestinal outbreaks:

1. Develop "alert stages" to ensure outbreaks are identified as early as possible.
1. Initiate action steps promptly when there are 2 or more people with new or worsening cough or other symptoms consistent with an infectious disease.
2. Notify the Northern Health Medical Officer on call within 24 hours of a suspected outbreak.
3. Initiate Daily Surveillance.
4. Implement the appropriate Outbreak Control Measures.
5. Distribute educational/awareness materials.
6. A process for patient placement, accommodation, and flow during an outbreak developed by the medical team. This will include developing a "holding area" if necessary.

3.2 HEALTH PROMOTION, DISEASE PREVENTION, AND ON-SITE WELLNESS PROGRAMS

Pretium supports a population-based approach to health promotion, disease prevention, and on-site wellness. We recognise that promoting a healthy lifestyle will not only reduce the potential for injury or illness for workers in camp, but it also is proven to reduce fatigue and enhance camp morale. Addressing risk factors that can lead to injury, illness, and chronic disease is a shared aim of Pretium.

Northern Health has developed some excellent web based and printed resource materials in the area of Workplace Wellness and Pretium will make best efforts to assist in making these resources available to the camp workers at no cost to NH. Pretium continues ongoing collaboration with Northern Health to support and implement future programs at the Brucejack site as they are developed.

The overall goal of Pretium's on-site Wellness Program is to address a spectrum of topics in the area of wellness and be consistent with the position papers developed by Northern Heath to address the areas of Health Communities and Preventing Injury. These topics include:

- Sedentary Behaviour and Physical Inactivity;
- Healthy Eating;
- Tobacco Reduction;
- Prevention of Problematic Substance Use; and
- Health, Weight and Obesity.

Specific Disease prevention and on-site wellness initiatives planned for the Brucejack site include:

- collaborating and supporting current Northern Health Wellness initiatives such as: making copies of *The MANual – A Men's Health Survival Guide* available in camp; posters to encourage the use of the website https://men.northernhealth.ca/ or other Northern Health resources as they become available;
- assessing the feasibility of implementing the BC Cancer Wellness Fits program or and the Working on Wellness (WOW) programs in the camp: www.bchealthyliving.ca/wat-we-do/working-on-wellness;
- embedding wellness programs into camp policies;
- incorporating wellness as a standing item on the joint health & safety committee;
- introducing a "health tip" of the week at any regular health and safety meetings;
- providing a healthy selection of food choices in the dining area;
- offering a recreation facility that includes pool tables, ping pong tables, social areas, TV lounge; and
- offering a recreational gym that has cardio, weights and a yoga room to all employees. Employees also have access to group fitness classes.

- having a recreation committee to encourage social activity and comradery.

Company Policies

Pretium recognizes that company policies can play a large role in determining the health of the camp. As mentioned previously, Pretium has a zero tolerance policy to drugs and alcohol in the workplace and the Brucejack Mine is a "dry camp". Pretium has a comprehensive Drug & Alcohol Policy (D&A), which will include pre-employment D&A screening and on-site "reasonable cause" testing if warranted. Pretium has a WorkSafe BC compliant policy on smoking and protecting workers from second hand smoke.

Pretium has developed a Respectful Workplace Policy to support the creation of a positive workplace environment and a respectful workplace. Pretium demonstrates commitment to this approach through the following:

- making a strong publicized commitment to the maintenance of a positive work environment;
- providing workplace skills training in conflict resolution;
- providing ongoing education, skills training, and monitoring of the Respectful Workplace Policy;
- having a culture that aims to prevent workplace conflict and effectively resolve conflicts that do arise;
- having a policy which describes unacceptable behaviour and defines workplace harassment;
- providing sufficient resources and training to those responsible for implementing the policy;
- implementing personnel policies that acknowledge and value the diverse personal and professional lives of members such as: parental leave, alternate work schedules and compassionate leave.

Collective Messaging

As referenced multiple times throughout this HSMP, Pretium is committed to ongoing collaboration with Northern Health to support and align efforts in all areas of medical care including health promotion and prevention. Pretium will make best efforts to utilize shared resourcing materials and messages as appropriate.

3.3 COLLABORATION, COMMUNICATION AND PROBLEM SOLVING

Pretium recognizes that clear and effective communication forms the basis for developing an effective partnership with Northern Health and is essential for the management of patient flow and trauma care, responding to emergencies and problem solving. To this end Pretium will establish a clear process for coordination of medical and health program delivery with Northern Health.

3.3.1 Identification of Communication Pathways

In collaboration with Pretium's medical service provider, Pretium will establish clear lines of communication with key Northern Health stakeholders including the Stewart Health Center, Mills Memorial Hospital, the local Health Services Administrator, BC Ambulance Service, local physicians, Northern Health Resource office, Medical Health Officers and all other identified stakeholders. The following communication plan is proposed:

1. Establish a single point of contact, Manager Medical Services Western Canada for any healthcare issues related to the Brucejack Mine and provide their name and contact information to the various Northern Health key contacts.
2. Convene an initial face to face meeting between representatives of Pretium, healthcare service provider and Northern Health to review in detail this Health Services Monitoring Plan. Key to the meeting will be the input of the NH Health Services Administrator to ensure the current plan meets with Northern Health expectations and review further ways in which we can mitigate the impact on the local health resources.
3. With the input from the HSA establish a long-term Brucejack Working Group/Committee to continue to review the HSMP on an on-going basis and provide a forum to address any issues that arise from the mine. An established meeting schedule will be established.
4. If practical, arrange an on-site tour for key members of Northern Health including any physicians able to attend. The goal of the visit will be to provide an orientation and background to the operations and seek any additional input from the NH team.
5. Connect regularly with Northern Health's Office of Health and Resource Development to ensure that the Brucejack Camp is linking with the necessary Northern Health Stakeholders and are up to date on best practice recommendations for industrial camps.

3.3.2 Patient Flow Information, Trauma Care, and Emergency Response

Pretium will work collaboratively with Stewart Health Centre and Mills Memorial Hospital and Northern Health to establish escalation protocols and ensure there is a venue for sharing information.

In the cases where the patient requires a higher level of care each patient will be triaged by the medical team including the physician on call as necessary to ensure proper procedures are followed so Northern Health resources are accessed in the most efficient manner.

1. For patient's acutely ill or injured and requiring immediate transport, a Brucejack Protocol will be established with the Stewart Health Centre and Mills Memorial to address the optimal medevac procedure from the camp (e.g., helicopter), utilizing BCAS as necessary and a protocol to ensure adequate notification of the healthcare staff.
2. For patients who are ill or injured patient but stable – e.g., foot/ankle/hand injuries requiring x-ray or medical complaints such abdominal pain, low risk chest pain, chronic disease exacerbation – a Brucejack Stable Patient Transfer Protocol will be established with the Health

Centre to ensure the patient is transported when it is appropriate so they can be seen during normal working hours.

3.3.3 Northern Health's Role in the Pretium ERP

Stewart Health Centre is identified as the closest medical facility to the Brucejack Camp. Stewart Health Centre and/or Mills Memorial Hospital in Terrace are identified as the receiving sites for any mass casualty incident with the expectation that they will be notified immediately should an event or potential event occur. We recognize this notice is essential in order to activate the Health Centre's own disaster plan.

It is understood that the Medical Health Officer's mandate is to protect public health under the *Public Health Act*, and Part 5 of the *Public Health Act* provides the ability to act in emergency situations to reduce an immediate and significant public health risk.

3.3.4 Hiring Considerations

Pretium is very mindful of Northern Health's significant efforts to recruit and retain health care professionals in the North. We recognize that while there is generally a focus to hire locally, we will not recruit local health care providers such as nurses or paramedics unless it is in the best interests of both Pretium and Northern Health.

We are very interested in working collaboratively with BC Ambulance and the Stewart Health Centre on how we can attract more health care professionals to the region and build capacity for more local hires.

3.3.5 Quality Improvement

Pretium will work with its medical service provider to develop a Quality Improvement Framework to continually seek ways to improve the health care delivery for the camp worker, minimize the impact on local resources and respond to unforeseen issues and changing conditions.

The following is Pretium's proposed Quality Improvement Framework:

1. Pretium will commit to meet regularly with the medical service team to review the effectiveness of the health services and update the plan as necessary.
2. Regular review of the HSMP with Northern Health to ensure Pretium's commitments are being met and adaptive to changes to the NH medical service delivery capacities.
3. Regular meetings with NH to maintain an open line of communication.
4. Regular reporting of NH utilization stats and measures taken to mitigate when areas of high impact are noted.
5. An ongoing review of each patient transferred to ensure it was appropriate and minimized local impact. An immediate review should NH identify a patient transfer concern.

3.3.6 Health Service Utilization Information and Reporting

Pretium will track, on an ongoing basis, specific utilization information on the number of times on-shift contract staff or employees utilize the services of Northern Health. These indicators will be reviewed as a component of the regular meetings. Specific data collected will include:

- date and time of visit;
- nature of the visit;
- type of visit: emergency/outpatient;
- duration of the service; and
- requirement for specialist referral.

Appendix A

Sample Potable Water Lab Analysis

APPENDIX A. SAMPLE POTABLE WATER LAB ANALYSIS

norlabs
Northern Laboratories (2010) Ltd.

ANALYTICAL REPORT

Page 1 of 2

Pretium
2300 - 1055 Dunsmuir Street, PO Box 49334
Vancouver, BC V7X 1L4
tsandhals@pretivm.com

Project: Brucejack - Drinking Water
Project Number: -
Project Manager: Torence Sandhals

Work Order: N23A094

RECEIVED: 18-Jan-2023

REPORTED: 23-Jan-2023

All analyses were performed in accordance with standard procedures published by BC MoE, Health Canada, Environment Canada, the American Public Health Association, or the US EPA.

Northern Laboratories (2010) Ltd.

Laboratory Manager

Northern Laboratories (2010) Ltd.
Address: 530 3rd Avenue West Prince Rupert, BC V8J 1L8
Phone: 250.627.1906 • Fax: 250.627.8214 • www.norlabsltd.com • info@norlabsltd.com

norlabs
Northern Laboratories (2010) Ltd.

ANALYTICAL REPORT

Pretium **Work Order:** N23A094

Analyte	Result	Guideline (CDWG)	MRL Units	Analyzed	Method Ref.	Notes
Sample ID: **KN First Aid CSCE-AQJKQY** (N23A094-01), Sampled: **17-Jan-2023 17:15**						
Microbiological Parameters						
Total Coliforms	<1	MAC = None Detected (<1)	1 CFU/100 mL	18-Jan-23	SM 9222 B	
E. coli	<1	MAC = None Detected (<1)	1 CFU/100 mL	18-Jan-23	SM 9222 B	
Sample ID: **KN Kitchen CSCE-A4MNAA** (N23A094-02), Sampled: **17-Jan-2023 17:15**						
Microbiological Parameters						
Total Coliforms	<1	MAC = None Detected (<1)	1 CFU/100 mL	18-Jan-23	SM 9222 B	
E. coli	<1	MAC = None Detected (<1)	1 CFU/100 mL	18-Jan-23	SM 9222 B	

Glossary of Terms

MRL	Method Reporting Limit
<	Less than the reported detection limit (RDL).
>	Greater than the reported value.

Units

CFU/100 mL	Colony Forming Units per 100 mL

Method

SM 9222 B	Standard Methods Online - Total coliforms by MF

Guidelines Referenced

CDWG	Canadian Drinking Water Quality Guidelines (2019) https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/ewh-semt/alt_formats/pdf/pubs/water-eau/sum_guide-res_recom/sum_guide-res_recom-eng.pdf
MAC	Maximum Acceptable Concentration. Values above MAC are formatted with red text and solid outline.
AO	Aesthetic Objective (not health related). Values above AO are formatted with underline and dashed outline.

Northern Laboratories (2010) Ltd.
Address: 530 3rd Avenue West Prince Rupert, BC V8J 1L8
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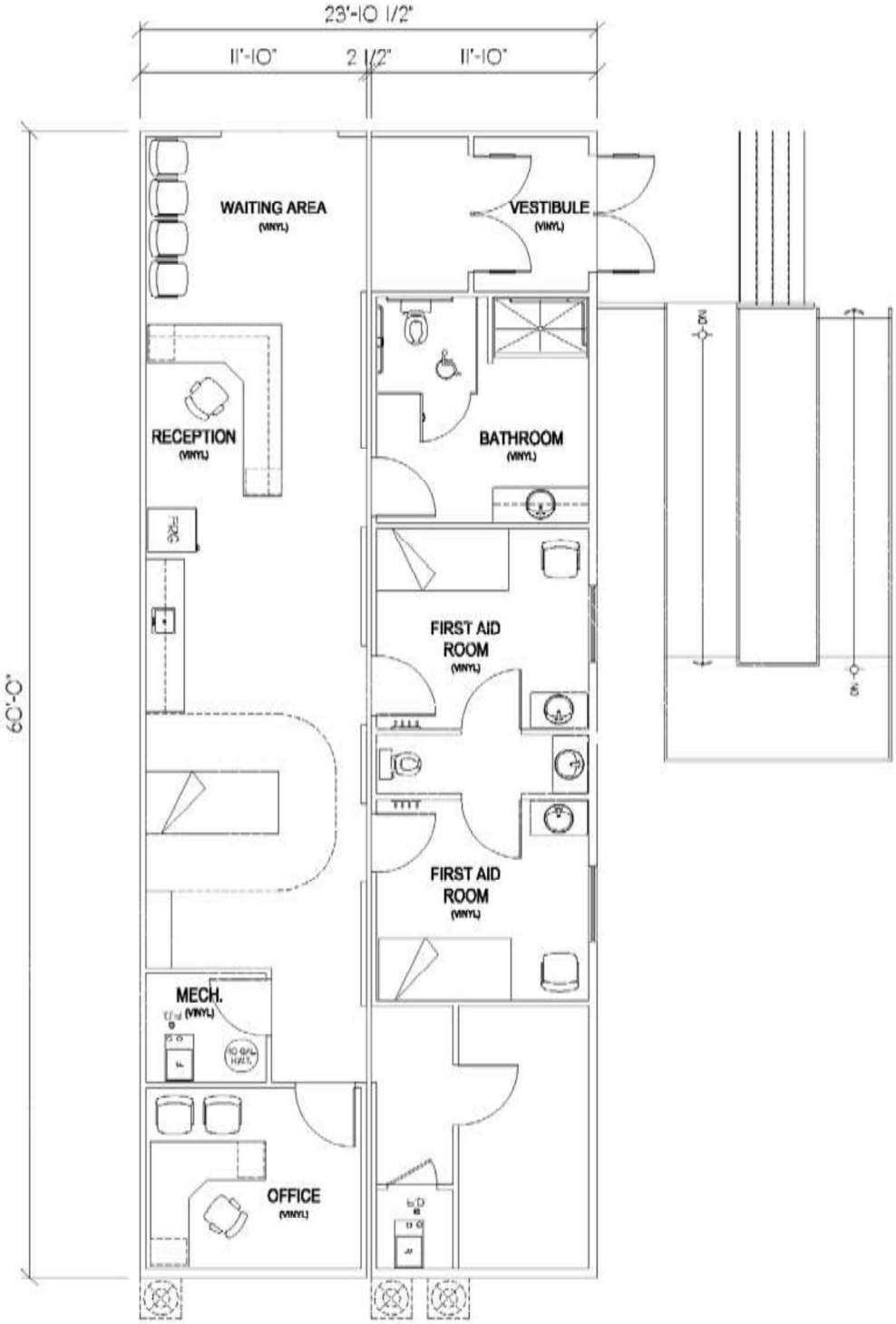
Appendix B

Medical Clinic

APPENDIX B. MEDICAL CLINIC



Appendix C

OPTM Roles and Responsibilities

APPENDIX C. OPTM ROLES AND RESPONSIBILITIES

ROLES AND RESPONSIBILITIES
Outbreak Prevention and Management Team (OPMT) Organizational leadership is essential in Brucejack to ensure effective outbreak prevention and control. This team is responsible for ensuring that procedures are in place for preventing outbreaks, and for directing and overseeing the management of all aspects relating to an outbreak. The OPMT team will have decision making authority for the regulation and direction regarding an outbreak within the Brucejack Project at these times. A team leader will be appointed to coordinate the meetings during an outbreak and link directly. Participation of OPMT members will include asymptomatic representatives from each major department appointed in an effort to ensure comprehensive collaboration, observation and communication during outbreak management.
Team Leader • Coordinate the meetings of the OPMT during an outbreak and ensure the team is working collaboratively • Provides timelines for reporting and implementing of control measures
Administration and Communications • Establishes communication and notification within the OPMT team and outside resources
Infection Control • Provides primary direction in outbreak pre-planning and implementation during an event (quarantine, discontinuing of group activities, etc.) to the OPMT
Occupational Health • Collaborates with Infection Control to ensure prevention, early recognition, and implementation of control strategies are in place
Environmental • Provides support to determine the source and means of spread of the agent where food or waterborne contamination may be involved
Support Services (Housekeeping/Laundry) • Assists in outbreak management by ensuring additional resources such as personnel, supplies, enhanced cleaning, etc., are available and best practices are in place

ROLES AND RESPONSIBILITIES
Foods Service • Implement additional precautions for safe food handling and common touch areas and items to prevent further spread (PPE, single server for food items, etc.)
Front Line Health Care Provider • Early recognition of outbreak, diligent use of treatment control strategies, symptom tacking and direct treatment of symptomatic patients
Northern Health Representative/External Partners • Provide input, expertise and guidance to the internal team to manage the outbreak

Appendix D

Appointee Action Chart

APPENDIX D. APPOINTEE ACTION CHART

Title	Name and Date Appointed	Role	Specific Action to be Taken	Time To Be Implemented/ Completed
Team Leader		Coordinate the meeting(s) of the OPMT during an outbreak and ensures the team is working in collaboration. Provides timelines for reporting and implementing of control measures		
Administration & Communications		Establishes communication and notification within the OPMT team and outside resources		
Infection Control		Provides primary direction in outbreak pre-planning and implementation during an event (quarantine, discontinuing of group activities, etc.) to the OPMT		
Occupational Health		Collaborates with Infection Control to ensure prevention, early recognition, and implementation of control strategies are in place		
Environmental		Provides support to determine the source and means of spread of the agent where food or waterborne contamination may be involved		
Support Services (Housekeeping/ Laundry)		Assists in outbreak management by ensuring additional resources such as personnel, supplies, enhanced cleaning, etc., are available and best practices are in place		
Foods Service		Implement additional precautions for safe food handling and common touch areas and items to prevent further spread (PPE, single server for food items)		
Front Line Health Care Provider (HCP)		Early recognition of outbreak, diligent use of treatment control strategies, symptom tacking and direct treatment of symptomatic patients		

Appendix E

Patient Symptom Tracking Sheet

APPENDIX E. PATIENT SYMPTOM TRACKING SHEET

Symptom	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time
Name						
Room						
Temperature						
Nausea						
Vomiting						
Diarrhea						
Other						
Other						
Other						
Other						
Other						
Other						

Appendix F

Patient Suspected Outbreak Document

APPENDIX F. PATIENT SUSPECTED OUTBREAK DOCUMENT

Patient name: Gender:
Room #: Type:
Occupation and location of work:
Date and time symptoms first began:
Date, time, and location of suspected initial exposure:
Recovery date:
Return to work date:

Appendix 9-1-10. Invasive Plants Management Plan

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Invasive Plants Management Plan

January 2023

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Invasive Plants Management Plan

Date: January 2023

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BRUCEJACK MINE

Invasive Plant Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BC	British Columbia
BC ILMB	British Columbia Integrated Land Management Bureau
BC MFLNRO	British Columbia Ministry of Forests, Lands and Natural Resource Operations
BC MOFR	British Columbia Ministry of Forests and Range
CIS LRMP	Cassiar Iskut-Stikine Land and Resource Management Plan
FRPA	*Forest and Range Practices Act* (2002a)
IAPP	Invasive Alien Plant Program
IPMP	Integrated Pest Management Plan
ISCBC	Invasive Species Council of British Columbia
m	Metre(s)
NWIPC	Northwest Invasive Plant Council
Pretium	Pretium Resources Inc.
Project	Brucejack Mine Project
SARA	*Species at Risk Act* (2002b)

1 PURPOSE

The purpose of the Invasive Plant Management Plan is to maintain ecosystem functions by avoiding the introduction and spread of invasive plants resulting from activities during the Construction, Operations, Closure, and Post-closure phases of the proposed Brucejack Mine Project (the Project). This plan provides strategies and mitigation measures for the ongoing management of invasive plants at the Project site and is based on the guiding principles outlined by:

- Northwest Invasive Plant Council (NWIPC; 2012a);
- Invasive Species Council of British Columbia (ISCBC; 2013);
- *Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia* (BC MOFR 2010b); and
- *The Invasive Alien Plant Program Reference Guide* (BC MOFR 2010a).

2 PERFORMANCE OBJECTIVES

The performance objective of the Invasive Plant Management Plan is to protect natural ecosystem composition, structure, function and resilience by preventing invasive plant establishment. The Invasive Plant Management Plan is designed to provide environmentally responsible, realistic, and operationally feasible guidance for ecosystem, soils, and vegetation management related to invasive plants.

3 SCOPE

The Invasive Plant Management Plan includes guidance on the inventory, prevention, management, and monitoring of invasive plants during the Construction, Operation, Closure, and Post-closure phases of the Project.

4 RELEVANT LEGISLATION, REGULATIONS, AND EAC CONDITIONS

4.1 RELEVANT LEGISLATION AND REGULATIONS

The following legislation, guidelines, management plans, and governing agencies are applicable or relevant to the management of invasive plant species:

- *Forest and Range Practices Act* (2002a). This act specifies that activities should not encourage the establishment or spread of invasive plants.
- *Weed Control Act* (1996). Administered by the British Columbia (BC) Ministry of Agriculture, this act imposes a duty on all land occupiers to control designated noxious plants, so they are not introduced or spread to unaffected areas.
- *Seeds Act* (1985). This act regulates the grading of seed sold, imported, and exported in Canada; requires that seed in Canada is free of prohibited noxious weeds; and ensures standards of purity are met.
- *Species at Risk Act* (SARA; 2002b). This act specifies that invasive plant species that threaten rare wildlife species' habitat must be controlled.
- BC *Integrated Pest Management Act* (Environment Canada 2003). This act regulates the use of herbicides to control weeds (invasive plants).
- *Cassiar Iskut-Stikine Land and Resource Management Plan* (CIS LRMP; BC ILMB 2000). The CIS LRMP identifies measures to be undertaken in the short- and long-term to control existing alien plants and to monitor and prevent the introduction of other alien species.
- *Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia* (BC MOFR 2010b). This plan, prepared in association with the BC Ministries of Environment, Agriculture and Lands, and Transportation and Infrastructure, provides:

  > *…the ability to meet obligations for invasive plant management as outlined in the* Weed Control Act *(1996) and the* Forest and Range Practices Act *(2002a) and facilitates the Government's partnerships in invasive plant management as outlined in the invasive plant management strategies developed by the NWIPC and the Northeast Invasive Plant Committee. It is developed in accordance with the* Integrated Pest Management Act *(Environment Canada 2003) and accompanying regulations* (BC MOFR 2010b).

- *The Invasive Alien Plant Program Reference Guide* (BC MOFR 2010a). A resource manual for all agencies and partners involved in invasive plant management in BC.

- ISCBC. This registered charity has a primary goal of educating the public and professionals about invasive species and their risk to ecosystems and economies. Relevant outreach materials include a variety of brochures, pamphlets, and booklets, including the T.I.P.S. series.
- NWIPC. This group comprises agencies, organizations, and individuals, and identifies plant species of regional significance or concern. Planning and strategy documents available through the council include the *NWIPC 2014 Plan and Profile* (NWIPC 2013), and the *Invasive Plant Strategy for British Columbia* (Invasive Plant Council of British Columbia).

4.2 RELEVANT EAC CONDITIONS

Pretium was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions. This management plan fulfills Condition #2, in relation to a Component Plan for invasive plant management, presented within Schedule B of the Certificate and copied below.

> *Condition 2*
>
> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the Nisga'a Lisims Government (NLG), Tahltan and Tsetsaut / Skii km Lax Ha Nation (TSKLH) on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

5.1 MITIGATION MEASURES AND BEST MANAGEMENT PRACTICES

5.1.1 General Measures

An ecology-based approach to vegetation and soil management will be used to effectively prevent the introduction and spread of invasive plants related to the Project. Ecosystems are complex interactions of abiotic and biotic components that result in unique species composition, structure, and functions. Reducing effects to these ecological processes and ecosystem integrity will reduce the likelihood of invasive plant establishment and spread. The following measures will reduce impacts to ecosystem integrity.

- Minimizing clearing dimensions during Construction phase activities (including pullouts and upgrades to the Brucejack Access Road) as invasive species thrive in recently disturbed areas.
- Minimizing soil degradation, i.e., erosion, by adhering to the Reclamation Plan and the Surface Erosion Prevention and Sediment Control Management Plan. Specifically, soil will be salvaged during appropriate weather conditions, transported to stockpiles within appropriate time frames of salvage, and managed for surface erosion prevention.
- Vehicle inspections for target invasive plants at designated Project checkpoints such as the entry to the Brucejack Access Road. Major Project vehicles (bulldozers, mine trucks, excavators, etc.) transported from other areas will be visually inspected; target species will be removed (if present) and disposed of properly. Where required by the inspection, vehicles will be properly washed at an appropriate location where the removal of dirt or plants can be effectively achieved without harm to natural ecosystems.
- Seed mixes will be sourced from reputable dealers, complete with a Certificate of Analysis for each species included in the mix.
- Detection and eradication of invasive plants will be managed, through an effective early detection system that includes an inventory, control, and monitoring program (detailed in the following sections).
- Follow-up monitoring of controlled sites will occur to evaluate efficacy of treatment and requirements for follow-up treatment.

The Principal, Environment is responsible for implementing the Invasive Plants Management Plan (IPMP) and will look to resources available through the ISCBC and the NWIPC for training, orientation, or support materials. Invasive species references currently available for use include:

- *Best Practices for Managing Invasive Plants Along Roadsides: A Pocket Guide for British Columbia's Maintenance Contractors* (ISCBC 2013);

- ISCBC website (T.I.P.S. brochures): identification of key plant species, with pictures and brief habitat and management information (ISCBC 2013);
- *Forest and Range Practices Act* (FRPA; 2002a) and *Invasive Plants Identification Field Guide* (Province of BC 2008): developed to help identify the FRPA-listed invasive plants throughout BC; also provides basic habitat and impact information;
- *Field Guide to Noxious and Other Selected Weeds of British Columbia* (Cranston, Ralph, and Wikeem 2002); and
- *A Guide to Weeds in British Columbia* (BC Ministry of Agriculture 2002).

As appropriate, additional training in existing provincial legislation, available data management tools, and reporting programs related to invasive plant management will be provided to the Project's Principal, Environment/Environmental Superintendent/Environmental Coordinator.

5.1.2 Specific Measures

The primary focus of the Invasive Plants Management Plan is to avoid the introduction of invasive plants. Pretium will work with the Northwest Invasive Plant Council (and/or the Invasive Plant Council, depending on availability) to determine the level of screening required in order to avoid the introduction of invasive plants. Pretium will also work with the NWIPC to identify high-priority species and site-specific best treatment options for invasive plant occurrences, in the event that they occur. The following section outlines prevention and treatment options for management of introduced invasive plants.

5.1.2.1 Prevention

Preventing the introduction of invasive plant species is typically the most efficient and cost effective approach to invasive plant management (Clark 2003; Polster 2005). Averting the movement of propagules into unaffected areas and creating or maintaining environments that do not favour the establishment of invasive plants are basic, effective approaches to minimize potential introduction. Specific preventative measures will include:

- Minimizing ground disturbance, where possible;
- Maintaining a healthy vegetation cover in disturbed/high traffic areas;
- Purchasing reclamation seed mixes from reputable dealers, complete with Certificates of Analysis for all species that have gone into the mix.
- Equipment from off site will be required to be washed prior to transport to site. Equipment from off-site will be screened at security to ensure it has been washed prior to arrival on site and if not will be washed at a designated wash station or transported offsite to be washed.
- Vehicle wash stations will be established according to the best management practices for vehicle wash stations.
- Waste material from wash stations will be disposed of according to regional best management practices for the disposal of invasive plants.

5.1.2.2 Pre-Construction Survey

A roadside survey for invasive species will be conducted along the Brucejack Access Road prior to the start of Construction. The survey will focus initially on areas that are planned for upgrading. The pre-Construction survey will ensure that existing invasive species in these locations are not reported as Project-caused and will enable spot treatments to minimize potential for further spread. Pre-construction surveys will occur early in the growing season (late June to early July).

Inventory surveys for the NWIPC priority species will be conducted every two years for the life of the Project. The surveys will target roadsides (particularly at entry points to the site), recently disturbed areas, lay-down areas, and forest edges (extending up to 100 metres [m] into the forest, if invasive species are identified adjacent to forest stands). The surveys will be conducted early in the growing season (July) to provide an opportunity to undertake control measures within the same season and prior to seed dispersal.

5.1.2.3 Treatment and Control

If invasive plants are identified on site, the NWIPC or an appropriate authority will be consulted to determine if control or monitoring is the optimal approach. If control is recommended or required, appropriate treatment options and timing will be identified. The appropriate treatment for invasive plants depends on the species involved, site conditions, and the size of infestation. Invasive plant species vary in their aggressiveness and ability to dominate a site. Some are inherently easier to eradicate than others. Larger infestations are also more difficult to control than smaller ones. The NWIPC ranks species and site conditions and provides a guide for determining if, when, and how to control different invasive plants in northwest BC (NWIPC 2012b).

Potential treatment options include mechanical, biological, and chemical methods. Mechanical control adopts physical means of removal, such as pulling by hand. Biological control uses living organisms, such as insects, to control invasive plants. Chemical control uses herbicides to reduce and eradicate invasive plants.

5.1.2.3.1 Chemical Control

If herbicide use is recommended, the *Handbook for Pesticide Applicators and Dispensers* (BC MOE 2005) provides guidance on application methods and includes measures to protect waterbodies and riparian areas. To the extent feasible, approved herbicides will be applied using spot-control methods rather than broad spraying techniques to minimize adverse effects to the surrounding environment.

Approved herbicides will be used on sites where the elimination or containment of invasive plant species can be best achieved through chemical control (BC MOFR 2007). Herbicide application will be performed in compliance with BC's *Integrated Pest Management Act* (Environment Canada 2003). Applications will be documented using the BC Ministry of Forests, Lands and Natural Resource Operations (BC MFLNRO) *Invasive Plant Chemical and Mechanical Treatment Record* (BC MOFR 2010a). Herbicides should not be used under the following conditions:

- site is within a Pesticide Free Zone (e.g., near water sources, see *Handbook for Pesticide Applicators and Dispensers* [BC MOE 2005]);
- site conditions exclude the use of herbicide treatment (e.g., coarse textured soils); and
- benefit of herbicide application is negligible.

5.1.2.3.2 Mechanical Control

Where herbicides are not permitted or practical, mechanical control methods, such as seeding, hand pulling and cutting, mowing, and burning will be used. Mechanical treatments will be documented using the *Invasive Plant Chemical and Mechanical Treatment Record* (BC MOFR 2010a).

5.1.2.3.3 Biological Control

Biological control uses living organisms to control pest populations. Effective bio-control reduces the competitive ability of invasive plants and allows native species to colonize affected areas (Harris 2002). Biological control agents are suitable for use in Pesticide Free Zones or for extensive infestations where mechanical or chemical control would not be effective (BC MOFR 2007). Sites considered for biological control will be assessed according to the *Invasive Alien Plant Program Reference Guide* (BC MOFR 2010a). Biological control treatments will be documented using the Biological Control Agent Release and Monitoring Form and the Photoplot Record Form (BC MOFR 2010a). In many cases biological control is most effective when combined with other control methods in an IPMP.

Further details regarding control methods, including legislation and site-specific use of herbicides (from storage and transport to application and disposal), is available within the *Pest Management Plan for Invasive Alien Plants on Provincial Crown Lands in Central and Northern British Columbia* (BC MOFR 2010b).

6 ENVIRONMENTAL MONITORING

The aim of the Monitoring Program is to evaluate and document if the IPMP is successfully preventing the introduction and spread of invasive plants resulting from Construction, Operation, Closure, and Post-closure activities.

6.1 PERFORMANCE MONITORING

Survey monitoring will follow the methodology outlined in the Invasive Alien Plant Program (IAPP): Reference Guide, Part I (BC MFLNRO 2014). The IAPP forms, will be used for inventory, monitoring and treatment records so that the data are collected as required by the provincial IAPP database. A trained observer will conduct surveys and monitoring. If invasive plants are observed, information will be collected to help determine appropriate response actions (i.e., ecosystem type, species present, soil texture, species density and distribution, proximity to water, structure, elevation, slope, and any other characteristics that may contribute to the way in which the site is managed). Biennial surveys will be conducted to determine the effectiveness of the treatment and control measures. The results will determine if follow up monitoring in the same year is required to ensure that the stated objectives are being achieved and to determine if future monitoring is required. This information will be collected using a monitoring form designed specifically for the Project.

6.2 WORK PLANNING AND SCHEDULE

The Principal, Environment (or designated qualified staff) will communicate the performance objectives and actions to Project personnel who have the potential to directly or indirectly influence vegetation, soils, or ecosystems on site during the Construction, Operation, Closure, and Post-closure activities, particularly those involved in ground disturbance works. Communication of this information and sign-off by individuals will be recorded, and tracked as a key performance indicator.

Monitoring will occur biennially (between June and September). The timing of the surveys will be determined by the Principal, Environment (or designated qualified personnel) based on plant phenology (e.g., timing of biological activities such as flowering, propagation, and seed dispersion). If herbicide treatment is required, it will be applied before the flowering stage (early spring) when plants are most susceptible (BC MOE 2005). A minimum of two weeks between treatments will be observed (BC MOFR 2010b). Treatments applied after flowering (autumn) will involve the removal and disposal of seed heads to an appropriate waste disposal location.

7 REPORTING AND RECORDING

7.1 REPORTING

Biennial reporting of the environmental monitoring inspection reports will include a description of the following:

- Records of inventory, treatment, monitoring, and reclamation activities. A photographic record of locations surveyed for invasive species, as well as a copy of all data forms filled in for that year, will be included in the report.
- Quality assurance and quality control methods employed to ensure data accuracy and assessments of the effectiveness of the inventory, treatment, and monitoring for invasive species control and actions taken to improve the program if relevant.
- Identification of any emerging negative environmental trends likely attributable to the Project.

Invasive species occurrences will be entered into the "Report-a-Weed" Program, a provincial online mapping and reporting tool associated with the IAPP Application, within the same year as the survey. Once the data (report) are entered, they are automatically compared to known locations of the reported species in the IAPP Application, and are then sent directly to a provincial Invasive Plant Specialist for the region.

7.2 RECORD KEEPING / TRACKING

7.2.1 Monitoring Results

Pretium will keep records and results of surveys and monitoring conducted. Data will be entered in a format and program that will allow for comparison between years. Monitoring data will be stored for the life of mine.

7.2.2 Continuous Improvement, Follow-up, and Adaptive Management

Results from the surveys and monitoring programs will be reviewed to determine if any trends are evident and if target criteria are being met. The need for any corrective actions to avoid the introduction and spread of invasive plant species will be determined on a case-by-case basis. Indications of the need for corrective action or additional control measures may include:

- monitoring data showing an increasing negative trend (e.g., increase in the presence, abundance, distribution or type of invasive plants).

The monitoring data will also be used to provide feedback to modify any management and monitoring procedures, as required. Measures described in the IPMP apply to all components for the life of the Project, unless otherwise indicated. Components of the IPMP may need to be revised over the life of the Project, based on regulatory changes and/or technological advances. Any modifications made to the overall Plan will be communicated to regulatory authorities where applicable.

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Appendix 9-1-11. Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Metal Leaching and Acid Rock Drainage Management Plan

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B.3	March 3, 2017	Revised to incorporate WTP sludge management and update Cr management
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AUTHORSHIP

This Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan was prepared for Pretium Resources Inc. (Pretium) by Lorax Environmental Services Ltd. (Lorax). The Management Plan has been updated by Brett DeHay Turner, MSc, P.Geo. and reviewed by Alison Shaw, PhD, P.Geo., the acting Qualified Professional (QP) for this plan.

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BRUCEJACK MINE

Metal Leaching / Acid Rock Drainage Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

ABA	Acid Base Accounting
BMP	Best Management Practice
EMS	Environmental Management System
GARD	Global Acid Rock Drainage (Guide)
INAP	International Network for Acid Prevention
ISO	International Organization for Standardization
MEND	Mine Environment Neutral Drainage (Program)
ML/ARD	Metal Leaching / Acid Rock Drainage
MMER	Metal Mine Effluent Regulations
NPAG	Non-Potentially Acid Generating
NPR	Neutralization Potential Ratio
OWTP	Operations Water Treatment Plant
PAG	Potentially Acid Generating
SFE	Shake Flask Extraction
SOP	Standard Operating Procedure
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant
T-C	Total Carbon
T-S	Total Sulphur

1 PURPOSE

The purpose of this Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan is to provide guidance and procedures for Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies, on how to avoid, minimize and mitigate potential ML/ARD at the Brucejack Mine. This includes:

1. Proper management, including excavation, handling, and disposal, of all bedrock that may be disturbed as a consequence of the development of the Brucejack Mine;
2. Management of rock surfaces that are newly exposed during the course of mine development; and
3. Management of water that comes into contact with disturbed and exposed potentially acid-generating (PAG) bedrock.

The primary objective of the plan is to avoid ML/ARD to the greatest possible extent and mitigate potential effects where bedrock disturbance is unavoidable. This document will be updated as appropriate during mine life, as additional relevant information becomes available.

Planned and potential bedrock disturbance and exposure has been assessed for all mine components. The main potential sources of ML/ARD associated with the Brucejack Mine include:

- Excavated rock and newly exposed rock surfaces resulting from mine development;
- Surface runoff that comes into contact with the newly exposed rock surfaces and excavated rock, both at the Mine Site Area and elsewhere;
- Rock that is excavated and newly exposed during mine Operations, including underground mine waste rock, and underground rock surface exposures;
- Cemented paste backfill; and
- Sludge from the Water Treatment Plant (WTP).

During Operations, the Brucejack Mine will generate approximately 6.5 Mt of waste rock from the underground mine; 17.5 Mt of tailings; and approximately 150 kt of sludge. In addition, some minor disturbance and/or exposure of rock may be required for Brucejack Access Road improvements and maintenance.

This ML/ARD Management Plan describes ML/ARD prevention and mitigation strategies for the Brucejack Mine, as well as contingency plans that will be implemented if and as needed. It also describes planned monitoring, reporting, and record keeping procedures.

2 PERFORMANCE OBJECTIVES

The general performance objectives with respect to ML/ARD are to:

1. Avoid and minimize bedrock disturbance;
2. Minimize the volume of disturbed PAG bedrock and rock surfaces that are exposed to oxidation, as well as the duration of sub-aerial storage of PAG materials;
3. Minimize the volume, and manage surface water that comes into contact with disturbed and exposed bedrock with potential for ML/ARD; and
4. Confirm and document geochemical characteristics and quantities of disturbed and exposed rock.

Specific measures to achieve these general objectives are described in more detail below.

The performance objectives are and will continue to be achieved through two principal strategies. The first strategy is and has been to address the general performance objectives noted above through design mitigation. The second is and has been to manage the construction and development of the mine in a systematic way, as part of an overall environmental management system (EMS). Both design mitigation and components of the overall EMS related to ML/ARD are described in section 5 below.

The mine has been designed such that no subaerial waste rock or tailings disposal facilities are required on surface. This is a major advantage and simplifies the ML/ARD Management Plan for the mine. More specifically, key waste management commitments are that:

- No waste rock has or will be disposed subaerially. All waste rock from the mine site has and will continue to be deposited in either the Waste Rock and Tailings Storage Facility (WRTSF) or in the deeper levels of the underground mine that will remain flooded post-closure. Both of these deposition methods allow a substantial water cover that is expected to be stable over the very long term.
- Most surface water that contacts exposed PAG rock surfaces on the Mine Site, and all water that is removed from underground workings, is and will continue to be treated to reduce suspended solids and metals to specified concentrations prior to discharge to the WRTSF (either immediately or ultimately).
- All tailings generated as a result of ore processing will be disposed either in the WRTSF, or as cemented paste backfill in underground workings, most of which will also be deposited below the final water level.

There is no segregation of PAG and non-potentially acid generating (NPAG) waste rock. Only a small proportion of the total volume of rock that has or will be disturbed or exposed at the Mine Site and within the underground mine is expected to be NPAG (between 10 and 15% based on the results of geochemical assessment undertaken to date). Pretium has committed to managing the mine such that no waste rock will be disposed subaerially, including both PAG and NPAG rock. Consequently, segregation is not required. This further simplifies the mine plan and ML/ARD Management Plan for the mine.

3 SCOPE

This ML/ARD Management Plan applies to any and all areas where any bedrock disturbance may occur as a result of development and operation of the Brucejack Mine, including the Mine Site Area (area within the Mining Lease and, in terms of bedrock excavation, confined to the headwaters of Brucejack Creek), as well as the facilities situated in the Nass watershed, including planned improvements to the lower Brucejack Access Road.

The ML/ARD Management Plan applies throughout Operations and Closure. The plan also extends into the Post-closure phase of the mine for as long as monitoring related to ML/ARD management is warranted.

The volumes of bedrock disturbance and surface areas of newly exposed rock that fall within the scope of this plan are summarized in Table 3-1 below.

Table 3-1. Summary of Volumes of Bedrock Disturbance and Areas of Bedrock Exposure Associated with Waste Rock Excavation at the Brucejack Mine

Facility	Volume of Rock to be Excavated (Mm^3)	Surface Area of Newly Exposed Rock (ha)
Mine Site	0.53	17
Underground Mine	2.32	463
Brucejack Access Road	To Be Determined*	To Be Determined*

** Excavation planning, including to minimize ML/ARD potential, to be completed as part of engineering design.*

The quarry site on the south side of the WRTSF is comprised of rock that is NPAG. This was a critical requirement when potential quarry sites were identified and evaluated.

Confirmation of geochemical characteristics and volume of rock disturbed and exposed is an important component of this ML/ARD Management Plan.

4 RELEVANT LEGISLATION AND REGULATIONS

This ML/ARD Management Plan for the Brucejack Mine has been developed in accordance with applicable legislation, regulations and guidelines. Development of a formal ML/ARD Management Plan for mining projects is required by Section 10.1.16 of the *Health, Safety and Reclamation Code for Mines in British Columbia* (BC EMLI 2022). The Code requires that ML/ARD Plans be prepared with reference to the *Guidelines for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia* (Price and Errington 1998). The Guidelines require that prediction, and, where necessary, prevention and mitigation be undertaken for both solid mine waste and contact water.

Undertaking work that results in generation of ML/ARD is not strictly prohibited in British Columbia, although appropriate management to prevent, minimize and mitigate such activity is a requirement of the BC *Mines Act* (1996) and the above-noted Code. At the Federal level, release of ML/ARD products into fish-bearing waters may constitute deposition of a deleterious substance, an offence as defined in section 36 (3) of the Federal *Fisheries Act* (1985). Discharge of mine effluent is regulated by the Metal and Diamond Mining Effluent Regulations (MDMER; SOR/2002-222), issued pursuant to sections 34(2), 36(5) and 38(9) of the *Fisheries Act* (1985).

In addition, discharge of waste from a mine (a prescribed industry or activity) without proper authorization is an offence pursuant to section 120 (3) of the BC *Environmental Management Act* (2003). The BC Ministry of Environment and Climate Change Strategy administers this Act, and has published *Guidance on Applications for Permits under the Environmental Management Act* (BC MOE 2010). Field sampling must be undertaken in accordance with the *British Columbia Field Sampling Manual For Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment and Biological Samples* (BC MWLAP 2003), and laboratory analyses must be completed in accordance with the *British Columbia Laboratory Manual* (2013 Approval holder Edition; BC MOE 2013). The BC *Spill Reporting Regulation (*BC Reg. 263/90), issued pursuant to the *Environmental Management Act* (2003), establishes reporting requirements for spills of substances, both as defined in the *Schedule – Reportable Levels for Certain Substances* included in the Regulation.

A number of other guidelines and reports have been published that document best management practices (BMPs) in ML/ARD prediction, prevention and mitigation. These include papers published by the Mine Environment Neutral Drainage (MEND) Program, the Canadian partner in the International Network for Acid Prevention (INAP), and the Global Acid Rock Drainage (GARD) Guide (INAP 2009).

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

Prevention, mitigation and management of ML/ARD are important components of environmental protection and management for the Brucejack Mine. The overarching objective is to avoid and minimize oxidation of sulphide minerals at the mine to the greatest possible extent.

The majority of the rock at the Mine Site contains relatively high concentrations of sulphide minerals, and variable proportions of carbonate minerals (which neutralize ML/ARD), with the result that the majority of the bedrock at Brucejack Mine is characterized as PAG, as noted in section 2 above.

This section describes how potential ML/ARD has and will be prevented, mitigated and managed through the life of the mine. Prevention, mitigation and BMPs for each component of the mine that may require disturbance or exposure of bedrock is set out below.

5.1 NPAG Quarry Development

The km 72 NPAG Quarry site has been operational since autumn 2015 and was selected specifically because it is reasonably accessible, proximal to the Mine Site, and because the rock in this location was and has continued to be characterized as NPAG. Bedrock at the km 72 NPAG Quarry site has low sulphide content, high neutralization potential, and overall has high net neutralization potential ratio (NPR) values. However, even rock that is not likely to produce ARD may still pose some metal leaching (ML) risk if metals are present that may be mobilized in circumneutral pH conditions.

Section 6 outlines confirmatory sampling to verify that rock sourced from the quarry is, in fact, NPAG, and that neutral metal leaching is not likely to occur. It also describes conditions that will trigger contingency actions and the nature of the contingency.

5.2 Mine Site Excavation

The plant, including the mill for processing ore, WTP, mine camp and all associated facilities, has been constructed in the same area where the exploration camp was located. The underlying bedrock has variable sulphide content and neutralization potential and has been characterized and confirmed as PAG. There is generally some neutralization potential available in the bedrock in this area, and time to ARD onset is expected to range from a decade or more to much longer time periods.

A concerted effort was made to minimize the footprint of the Mine Site; the total surface development footprint of the Mine Site is only approximately 38 ha.

Given the prevalence of PAG rock within the Mine Site area, it was recognized during planning and design that minimizing bedrock disturbance is a key mitigation strategy. The Mine Site has a number of advantages, including proximity to the mineralized zones targeted for mining (minimizing disturbance and distance between the underground mine and Mine Site), the fact that the site is already disturbed (minimizing incursion into adjacent areas that are not already disturbed), and proximity to the lake, where both waste rock and tailings are and will be deposited (minimizing disturbance and distance between the Mine Site and waste deposition areas).

Pads within the Mine Site have been levelled to provide a safe and efficient area for mining operations. PAG waste rock excavated from the Mine Site area was deposited in the WRTSF without delay. If future excavation is required, then the rate of deposition will be similar to the rate of excavation (drilling and blasting), such that only a small, temporary 'surge' pile of waste rock will be stored sub-aerially, as the material is moved onto (subaqueous) deposition slopes of the south shore of the WRTSF. Material will normally be exposed on surface for days or weeks, although residence time could be extended if necessary to address safety concerns associated with operating heavy machinery on newly placed fill (these considerations are discussed in the Operation, Maintenance and Surveillance Manual: Brucejack Mine Subaqueous Waste Rock and Tailings Deposition), and/or if necessary to minimize impacts to water quality at the outlet of the WRTSF (monitoring site BJ 3.10).

5.3 UNDERGROUND MINE

A total of approximately 5.3 Mt (1.9M m^3) of waste rock will be excavated underground during mine life. Of this, between 35 and 100% will be deposited in the WRTSF, with the remainder (up to 65%) to be backfilled in underground workings. It is expected that waste rock will be generated at a relatively steady rate of roughly 1000 t (374 m^3) per day through life of mine (and up to 3800 tonnes of ore will be mined per day, on average).

Rock that will be disturbed in the underground mine has been classified into six units, all of which are considered to be PAG. The median NPR values for the units range from 0.31 for the 'Fragmental' unit to 1.8 for the 'Office P1' unit. The results of ABA tests are summarized by lithological unit in Table 5.3-1 below. All units have some neutralization potential; time to onset of ML/ARD is generally expected to be delayed for at least a decade or more from the time of exposure, even for the units with the highest ML/ARD potential and is generally expected to be much longer.

Table 5.3-1. Summary of Underground Mine Waste Rock – Median ABA Results by Lithological Unit

Lithological Unit	TIC (%)	Total S (%)	AP (kg $CaCO_3$/t)	$CaCO_3$ NP (kg $CaCO_3$/t)	Carbonate NPR
Conglomerate	0.52	3.2	89	43	0.42
Fragmental	0.42	3.9	113	35	0.31
Office P1	1.1	1.9	52	92	1.8
Office P2	0.99	3.9	111	83	0.70
Silicified Cap	0.40	1.8	50	33	0.49
VSF	0.71	3.0	84	59	0.66

A summary of the total mass of rock to be disturbed, along with the maximum portion to be backfilled is provided in Table 5.3-2 below. The surface area and relative proportion of the six units that will be exposed underground is summarized in Table 5.3-3. Pretium will continue to map and record the underground lithologies as development proceeds. The geologic block model developed for the Brucejack Mine will be updated annually using information from both drilling and underground mapping.

Table 5.3-2. Summary of Underground Mine Waste Rock - Mass by Lithology

Lithological Unit	Total UG waste disturbed over LOM* (t)	Total UG waste disturbed over LOM (relative %)	Maximum Backfilled UG waste (t)	Maximum Backfilled UG waste (relative %)
Conglomerate	383,428	7.3	164,431	4.8
Fragmental	1,186,126	22.6	695,721	20.4
Office P1	933,257	17.6	739,507	21.6
Office P2	29,154	0.5	29,154	0.9
Silicified Cap	79,506	1.5	33,262	1.0
VSF	2,689,519	50.5	1,754,484	51.4
TOTAL	5,300,991	100.0	3,416,559	100.0

*Between 35 and 100% of the total UG waste rock disturbed will be placed in the WRTSF.

Table 5.3-3. Summary of Underground Mine Waste Rock – Surface Area by Lithology

Lithological Unit	Pre-Construction (m^2)	Construction (m^2)	Operations (m^2)	Total (m^2)	Total (relative %)
VSF	75,188	69,609	823,933	968,730	48
Fragmental	31,790	98,559	399,616	529,965	26
Conglomerate	-	64,403	126,597	191,000	9
Silicified Cap	-	4,715	26,168	30,883	1.5
Office P1	2,291	6,883	287,583	296,757	15
Office P2	216	-	8,811	9,027	0.45
Total	109,485	244,169	1,672,708	2,026,362	

All waste rock that is excavated underground has and will continue to either be deposited in the WRTSF or backfilled into underground workings below the final water level to achieve subaqueous disposal, in accordance with this ML/ARD Management Plan. Pretium recognizes that there is uncertainty with respect to the final water table in the underground workings. Water table predictions will be refined using data from groundwater monitoring wells, dewatering pump records and through further refinement of the predictive groundwater model as mining advances. Upper workings will not be backfilled with waste rock until the end of mine life and only to an elevation to maintain a minimum 10m water cover above waste rock. As a contingency measure, waste rock originally designated to remain underground late in mine life will be deposited into the lake instead, if necessary. Plans for waste rock deposition underground and in the WRTSF, estimated final water table, and associated water quality impacts will be updated on a regular basis, and reported to the B.C. Ministry of Energy, Mines and Petroleum Resources, every five years as part of required mine and reclamation plan updates.

5.4 TAILINGS AND SLUDGE

It is expected that a total of 17.4 Mt of thickened tailings will be generated through life of mine. Of this, up to approximately 11.9 Mt, or 68% will be deposited in the WRTSF with the remainder to be deposited underground in cemented paste backfill. It is expected that tailings will be generated at a

steady rate of approximately 3800 tonnes per day, on average. Sludge generated from the WTP, amounting to approximately 7 kt, will be co-deposited with tailings in the WRTSF.

Tailings will be deposited either as thickened tailings discharged to the WRTSF or in cemented paste backfill in underground voids. An overview of the anticipated physical and chemical characteristics of materials is provided below.

5.4.1 Thickened Tailings Deposition in the WRTSF

The discharge of tailings to the bottom of the WRTSF is expected to provide an effective means to stabilize these materials both physically and chemically. Tailings contain a minor quantity of oxidized minerals (e.g., ferric iron oxide or hydroxide) that are not expected to undergo dissolution when placed in a circumneutral pH and anoxic environment.

The pH of normal lake bottom water and porewater near the sediment-water interface is expected to remain circumneutral. Because of the alkaline nature of tailings, porewater of tailings deposited on and near the lake floor is expected to be circumneutral to alkaline. Under such pH conditions, metal oxides or hydroxides will generally be stable. Metal remobilization from tailings on the bottom of the WRTSF due to pH change is therefore considered unlikely.

On the lake floor, the dissolved oxygen content is generally low, but oxic conditions are expected to be sustained, except in porewater below the tailings-water interface where suboxic conditions may develop. The depths at which suboxic conditions occur, however, will depend on the sulphide content of tailings and the balance of organic matter and dissolved oxygen supplies from the water column to tailings and porewater. Given the high deposition rate of the sulphide-depleted tailings material and the limited organic matter supply from the water column, suboxic conditions are only expected to develop in porewater some distance below the tailings-water interface. In the suboxic zones, reductive dissolution of the oxidized minerals in tailings is expected to occur, and consequently, metals associated with the oxidized minerals will be remobilized to porewater. However, given the low abundances of the oxidized minerals identified in the ore and tailings materials (i.e., ≤ 0.2%), such metal remobilization would be minor.

Furthermore, the main pathway for the remobilized metals in porewater to enter the water column is through molecular diffusion, which is expected to be a slow process given the low metal concentration gradients in porewater. In addition, oxidation of dissolved iron and manganese by oxygen in porewater above the suboxic zone and trace metal co-precipitation will further reduce metal fluxes from tailings porewater to the water column. Given the low fluxes at the tailings-water interface, the deep water depth (≈40m at the top of the ultimate tailings deposition mass) and relatively short residence time of water in the lake (estimated to be approximately 18 months), diffusive fluxes from the submerged tailings are not expected to adversely affect water quality at monitoring site BJ 3.10. In the long term, following the cessation of tailings discharge, the progressive accumulation of natural sediments will serve to physically and chemically isolate the tailings materials from the water column and further reduce potential diffusive fluxes.

5.4.2 Tailings in Cemented Paste Backfill

The placement of tailings in the underground in cemented paste backfill, plus flooding upon mine closure, is expected to provide an effective means to reduce ML/ARD formation. Because the tailings

are expected to be NPAG and NP will be afforded by the paste cement, no ARD is expected to be generated from the backfilled tailings and paste materials. It is possible, however, that some metals may leach from cemented paste backfill at neutral or alkaline pH (neutral metal leaching) in the short-term. In particular, geochemical test work indicates that hexavalent chromium may leach from cement in paste when it is hydrated and for some time thereafter. A Chromium Management Plan has been developed for the mine and includes a monitoring program for underground mine water, the WRTSF and paste backfill cement. A trigger threshold level is defined for D-Cr in WTP influent and at BJ 3.10 such that control measures can be implemented as necessary. Pretium's preferred Cr mitigation strategy, should it be required, is the addition of ferrous sulphate to the paste backfill within the paste plant prior to placement underground; however, addition of ferrous sulphate to sump water is an alternate mitigation option that could be implemented.

5.4.3 Sludge

Sludge from the WTP is co-deposited with tailings in the WRTSF. Sludge is mixed with the tailings in the Tailings Disposal Surge Tank prior to subaqueous deposition in the WRTSF via the tailings pipeline. As described for tailings (Section 5.4.1), deposition of sludge with tailings at the bottom of the WRTSF is expected to provide an effective means to stabilize these materials both physically and chemically.

Static and kinetic test programs were developed to assess the potential impact of sludge deposition on BJ 3.10 water quality. Sequential extraction results on WTP sludge shows that metals are not easily soluble or mobilized under reducing conditions. Kinetic tests comprised of saturated columns with appropriate tailings and sludge mixtures were used to derive conservative flux estimates for parameters of interest. The results show insignificant changes to predicted BJ 3.10 water quality. The full set of results are reported in "Brucejack Gold Mine: Assessment of Long-term Sludge Stability for In-Lake and Underground Deposition" (Lorax, 2016).

5.5 BRUCEJACK ACCESS ROAD

The existing Brucejack Access Road, which provides access to the Mine Site from Highway 37, will require some upgrades and improvements, as well as ongoing maintenance. Engineering design for road improvements will avoid disturbance of PAG rock to the maximum extent possible while remaining within safe parameters for road usage. This ML/ARD Management Plan will be followed to develop plans for environmental protection as appropriate.

6 ML/ARD VERIFICATION AND MONITORING

Environmental monitoring required in the context of this ML/ARD Management Plan is focused on verifying the initial geochemical characterization of bedrock that will be disturbed and exposed, and the quality of contact water, as well as confirming the results of the geochemical assessment, and to verify that the ML/ARD Management Plan is proving to be effective. Sampling and analysis of Mine Site Area contact water from various sources is and will continue to be used to verify source terms used in the water quality model for the Brucejack Mine, and associated water quality predictions. This information will also be used to evaluate the potential onset of ML/ARD and the magnitude of any environmental effects.

6.1 NPAG QUARRY

6.1.1 Confirmatory Sampling

Confirming that rock to be excavated from the NPAG Quarry is NPAG was and remains essential given that the rock has and will continue to be widely distributed throughout the mine site for use in construction of building foundations, roads and other infrastructure. At least one composite sample comprising a minimum of 1 kg of rock that is representative of every 1,000 m^3 of rock to be excavated from the NPAG Quarry was obtained during the early stages of quarry development to confirm that rock obtained from the quarry is, in fact, NPAG.

The initial ML/ARD Management Plan allowed for sampling intensity to be reduced if initial sampling indicated that (i) the rock to be excavated from the quarry is consistently NPAG, and (ii) the lithology is consistent to the perimeter of the quarry, with lateral distance between samples of not more than 100m. In this case, the remaining 'infill' sampling intensity could be reduced to not less than one composite sample per 10,000 m^3 of rock, at the discretion, and under the direction of, a qualified professional. This reduction in sampling intensity was done when the above criteria were met.

In addition, material from the NPAG Quarry will continue to be evaluated through sampling and analysis of on-site field bins constructed of representative rock from the NPAG Quarry site. These have been constructed to assess the geochemical behaviour of this rock in the conditions that actually occur at the site, including climatic conditions such as precipitation and freeze-thaw cycles. Field bins are discussed in more detail in Section 6.9 below.

6.1.2 NPAG Quarry Runoff

Based on sampling and analysis completed to date, bedrock at the NPAG Quarry site has high neutralization potential, low sulphide content and high NPR values. Materials that are not likely to produce ARD conditions may still pose some risk, as some metals are mobile in neutral pH conditions. Therefore, runoff or seepage from the NPAG Quarry site will be sampled at least twice during every summer season when surface runoff is present (given that surface water will occur as ice and snow from mid-autumn until late spring or early summer) to identify any neutral metal leaching that may occur. NPAG Quarry runoff quality will be monitored throughout mine life.

Water quality sampling and analysis are focused on sulphate and dissolved metal concentrations. Sulphate is a good indicator of the onset of ML/ARD, and dissolved metal concentrations provide a reliable indication of neutral metal leaching, should it occur. Total suspended solids (TSS) and associated total metals in runoff from the NPAG Quarry, in contrast, may exceed FWAL Guidelines from time to time, due to natural variation associated with spring snowmelt and during major precipitation events in spring, summer and early autumn. These events are considered to be normal for the WRTSF catchment and will not trigger additional monitoring procedures.

6.1.3 Triggers and Contingency

Any rock samples for which analysis indicates that the NPR is less than 2 (indicating that the rock may be PAG) will trigger contingency measures. In this case, NPAG Quarry operations will be suspended within 50 m of the location of the sample of concern while a geologic and geochemical assessment of rock exposed at the NPAG Quarry in the general vicinity of the PAG rock is undertaken.

The purpose of the assessment will be to re-evaluate the geochemical nature of the rock to be quarried. If the PAG sample is considered to be an anomaly, a minimum of three additional composite samples will be obtained from the same area and analyzed. If analyses of all three (or more) samples indicate that the surrounding rock is NPAG, quarry operations will be resumed. If additional samples are deemed to be PAG, the suspension will remain in force, while additional geologic and geochemical characterization is undertaken and/or alternate sources of NPAG rock are identified. Excavation in other parts of the NPAG Quarry may continue while the analyses and assessments described above are carried out.

Should sulphate in NPAG Quarry runoff exceed 350 mg/L, and dissolved metal concentrations exceed the applicable BC Guidelines for the protection of aquatic life, the Environmental Principle will seek the advice of qualified professionals to assess whether or not mitigation of neutral metal leaching is necessary, and if so, what measures should be implemented.

6.2 MINE SITE

6.2.1 Confirmatory Sampling

Confirmatory sampling was undertaken for surface bedrock excavations at the Mine Site, and will be done for any future surface excavations, to provide a basis for further evaluation of the PAG potential of disturbed rock within the Mine Site. This was and will continue to be done to (i) confirm that subaerial storage for up to two years will not result in the onset of ML/ARD that could impact water quality at BJ 3.10, and (ii) to document the volume, characteristics and disposal location of this rock, as the information will be used to confirm predicted water quality at BJ 3.10 through life of mine and Post-closure.

A composite sample was and will continue to be obtained for every 25,000 m^3 of rock excavated from the Mine Site, at minimum. This sampling regime generally conforms to the guideline of one sample per 75 kt of waste, as recommended in the *Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials* (Price 2009).

6.2.2 Mine Site Surface Runoff

Surface runoff from most of the Mine Site is and will continue to be collected in the Contact Water Pond (CWP) via the contact water management system and directed to the WTP for treatment. Contact Water Pond water is and will continue to be monitored for pH and turbidity, and sampled quarterly for laboratory analysis of pH, acidity, alkalinity, TSS, nutrients, major anions and cations, and dissolved and total trace metals.

Due to the degree of recirculation of water to the CWP, two additional sampling locations were identified in 2019 for the specific purpose of identifying the onset of ML/ARD. These locations capture the majority of surface runoff into the CWP and samples will be collected a minimum of twice per year.

6.2.3 Triggers and Contingency

Rock excavated from the Mine Site is PAG as was predicted and has (and will continue to be if there is additional future surface excavation) been disposed in the WRTSF without delay, in accordance with this ML/ARD Management Plan and the Operation, Maintenance and Surveillance Manual: Brucejack Mine Subaqueous Waste Rock and Tailings Deposition. The subaerial exposure of PAG waste rock from the Mine Site will be limited to no more than two years.

In the event that sulphate or key metal species concentrations in surface runoff exceed upper case concentration levels defined by the water quality model, additional confirmatory samples will be obtained for immediate analysis.

If additional sampling confirms high concentration levels that exceed previous predictions, the data set will be evaluated and additional Mine Site testing may be required to more fully assess whether degradation of water quality can be attributed to a particular Mine Site source. The surface runoff water quality data will be used to (i) confirm that the WTP can treat the increased metal load to an acceptable level and (ii) update the Post-closure phase source term and predicted Post-closure water quality at BJ 3.10.

6.3 UNDERGROUND MINE

6.3.1 Confirmatory Sampling

The majority of the rock to be excavated in the underground mine is expected to be PAG, as noted above. Confirmatory sampling is required to verify water quality model predictions. Water quality that develops in the underground workings post-closure is an important consideration, as the majority of this water will ultimately flow as groundwater and discharge into the upper reaches of Brucejack Creek.

A minimum of one composite sample has and will continue to be obtained for every 25,000 m^3 of waste rock, as per the guideline of one sample per 75 kt in the *Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials* (Price 2009), recognizing that 25,000 m^3 of rock will have a mass of just under 75kt, given an estimated specific gravity for waste rock of about 2.8 (as compared to water).

Samples are obtained at this rate from underground workings, as they are developed. Samples must be comprised of at least 1 kg of recently exposed wall rock that is representative of a specific lithology.

The samples are sent to an accredited laboratory for analysis. All samples are analyzed for rinse pH, acid base accounting (ABA), solid phase element analysis and shake flask extraction (SFE).

6.3.2 Contact Water in Underground Workings (Operations Phase)

Contact water has and will continue to be pumped from underground mine workings and directed to the WTP for treatment, as noted above. In-situ pH and turbidity measurements will continue to be carried out on underground sumps and seeps on a quarterly basis. Bulk underground discharge will also be sampled quarterly for laboratory analysis of pH, acidity, alkalinity, TSS, nutrients, major anions and cations, and dissolved and total trace metals. The sampling will be used to verify the source terms used in the water quality model/predictions, and the rate of onset of ML/ARD.

Wall washing stations have been established for each major lithology in the underground mine. Additional stations will be installed as more lithologies are exposed and will be sampled on an annual basis for laboratory analysis of pH, acidity, alkalinity, major anions and cations, total ammonia and dissolved trace metals. Data from these stations will be used to estimate soluble load associated with flushing of the mine walls at closure when the mine is flooded.

6.3.3 Triggers and Contingency

With respect to PAG waste rock, no segregation is intended. All waste rock generated in the underground mine will ultimately be disposed underwater, whether in the WRTSF or backfilled into underground workings that are flooded. All waste rock backfilled underground (up to 65% of the total generated, as noted above) will be flooded following mine closure. Consequently, there are no triggers or contingency associated with underground mine rock sampling. The information is required primarily to verify water quality predictions and as an input to the mine closure and reclamation plan.

The geological block model developed for the underground mine is updated annually using information from drilling, underground mapping and the above-noted rock sampling. If revisions to the block model indicate significant increases to the exposures of lithological units with higher AP, or significant changes to the geochemical characteristics of any unit(s), then the water quality model will be updated.

With respect to contact water in underground workings, in the event that sulphate or key metal species exceed upper case model predictions of underground water quality, additional confirmatory samples will be obtained for immediate analysis.

If an exceedance occurs, the data set will be evaluated and additional testing may be warranted to more fully assess whether neutral metal leaching may be occurring, whether early onset of ML/ARD has occurred in some exposed rock units or if degradation of water quality can be attributed to some other source.

All monitoring results will be included in the Annual Reclamation Report, as per *Mines Act* permit M-243 part D 3. (f), and updated water quality predictions will be included in the Mine Plan and Reclamation Plan due every five years (the first by July 31, 2020), as per condition D 4. (e).

6.3.4 Flooded Underground Workings (Closure and Post-Closure Phases)

Upon mine closure, underground workings below the groundwater table will be flooded. The WTP will remain onsite through the Closure phase to treat underground mine water as necessary. In order to mitigate the potential impact of metal release from oxidation products that may have accumulated in the underground workings, water will be treated as the mine floods, following an adaptive management plan.

A Closure Water Quality Investigation Plan will be developed and appended to this ML/ARD Management Plan. This Plan will include an appropriate monitoring program, water quality triggers and management actions to ensure that groundwater that discharges from underground workings post-closure is protective of the receiving environment.

6.4 WTP INFLUENT AND EFFLUENT

Water treatment plant influent and effluent are monitored. Analytical results are used to verify water quality predictions for contact water from the underground mine.

6.4.1 Confirmatory Monitoring

Both influent and effluent flow volume are monitored on a continuous basis, along with pH and turbidity. In addition, both influent and effluent samples must be obtained and analyzed in the field for turbidity, pH, conductivity and temperature and at an external laboratory for a full suite of parameters, a minimum of twice per month.

6.4.2 Triggers and Contingency

The monitoring described above for the Mine Site, underground mine and WTP influent will provide the means to evaluate short- and long-term changes in influent composition. Short-term changes to influent quality will be evaluated based on WTP water quality measurements. Long-term changes to WTP influent quality will be evaluated on an annual basis to verify source term predictions, and to confirm that the capacity of the WTP is adequate to treat the volume and quality of water directed to the WTP from the Mine Site and underground workings.

If external laboratory analyses indicate that onset of ML/ARD is resulting in dissolved concentrations of key metals exceeding modelled predictions, then model predictions will be revised and WTP treatment capacity evaluated.

6.5 TAILINGS

6.5.1 Confirmatory Sampling

Confirmatory sampling is required to verify the geochemical characteristics of thickened tailings to be discharged to the WRTSF and cemented paste backfill. Both of these waste materials are expected to be NPAG, as noted in section 5.4 above.

Two types of tailings are collected for analysis; (i) thickened tailings from the Thickener underflow, and (ii) cemented tailings from the paste plant. Sampling frequency will gradually be reduced if these materials exhibit expected geochemical characteristics.

The sampling schedule for the tailings solids is:

- Weekly for the first quarter (the equivalent of approximately one sample per 10,000 tonnes of tailings);
- Monthly for as long as necessary to verify geochemical characteristics; and
- Quarterly thereafter.

After collection, all tailings slurry samples are left to settle before the solid phase and supernatant are collected for analysis. Samples of the solid tailings phases will be submitted to an accredited laboratory for the full suite of ABA, solid phase element determination by aqua regia digestion and SFE to confirm that the tailings are NPAG. Thickened tailings have been submitted for saturated column tests to evaluate potential short and long-term chemical loading, and potential impact on water quality in at BJ 3.10.

Solid phase samples from the paste plant will also be submitted for ABA, solid phase element determination and SFE tests as well as for kinetic testwork. Saturated column tests have been initiated to evaluate the long term geochemical behaviour of paste.

6.5.2 Mill Process Water Sampling

Tailings slurry for supernatant analysis will follow the sampling schedule defined above for tailings solids. Tailings supernatant samples will be analyzed at an accredited laboratory for pH, TSS or turbidity, acidity, alkalinity, nutrients, major anions and cations, and dissolved and total trace metals, so as to monitor changes in the aqueous portion of the tailings discharge, and to verify the source term used for tailings loads.

Water samples will be collected at the inlet and outlet to the Semi-Autogenous Grinding (SAG) Mill on a quarterly basis such that soluble tailings loads can be assessed and compared to modelled loads. Loads will be determined based on the input and output concentrations, the feedwater flow rate and the ore throughput. In this way, the loads associated with ground ore (i.e., pre-processed tailings) can be deconvolved from loads recirculated in the Mill.

Samples of SAG Mill influent and effluent will follow the sampling schedule defined above for tailings supernatant and solids. SAG Mill samples will be analyzed at an accredited laboratory for pH, TSS or turbidity, nutrients, major anions and cations, and dissolved and total trace metals. The SAG Mill samples provide additional characterization of loads from the ore.

6.5.3 Triggers and Contingency

If ABA results indicate that tailings are PAG, they will be directed to the WRTSF, not to paste backfill, and the reason for the production of PAG tailings will be investigated and process modifications undertaken as soon as possible to ensure tailings generated are NPAG.

The SFE and subaqueous column tests for thickened tailings, and saturated column tests for paste, will provide an indication of potential metal leaching from thickened tailings. The tests will be focused on the long-term geochemical behaviour of the material in various environments and will be used to verify source terms and water quality models. These predictions are an important consideration in the latter stages of the Operations phase and in the Post-Closure phase.

If the thickened tailings supernatant quality changes significantly such that concentrations of key parameters are higher than expected (as compared to values assumed for water quality model), an evaluation of the potential cause(s) in the feed and mill process will be undertaken. Data will be evaluated and corrective actions will be taken in the process plant if the source of the issue is identified as upset conditions.

If the supernatant quality change cannot be addressed in the process plant, source terms and water quality predictions will be updated if appropriate. Likewise, if the loads derived from the SAG Mill sampling program are significantly different than anticipated, then the water quality model inputs for tailings loads will be revised. If the changes result in a prediction of significant degradation of predicted water quality at BJ 3.10 compared to predictions, the update will be provided in the Annual Reclamation Report, and the Updated Mine and Reclamation Plan, due every five years.

6.6 SLUDGE

6.6.1 Confirmatory Sampling

Confirmatory sampling is required to verify the geochemical characteristics of WTP sludge to be co-deposited with tailings in the WRTSF. The sludge sampling program for WTP is described in Appendix 13. The sampling schedule for the WTP sludge is:

- Quarterly sampling for ABA and solid phase elemental abundances;
- Annual sampling for sequential extraction testing; and
- After activating the sulfide precipitation process of the WTP, should it be required, a sludge sample will be collected within three months for ABA, solid phase elemental abundance, sequential extraction and kinetic testing.

Samples of sludge will be submitted to an accredited laboratory for testwork and results will be assessed to evaluate the potential impact of sludge deposition on water quality at BJ 3.10.

6.6.2 Triggers and Contingency

The confirmatory data collected for sludge, including the ABA, solid phase elemental abundance and sequential extractions, will be compared to results used for preliminary sludge assessment. If the geochemical characteristics of sludge change significantly such that concentrations of key parameters are higher than expected (as compared to values assumed for water quality model), an evaluation of the potential cause(s) will be undertaken. Geochemical source terms and water quality predictions will be updated as appropriate. If revised water quality predictions indicate significant degradation of water quality at BJ 3.10, then sludge management options will be re-evaluated at that time. Updated water quality predictions will be provided in the Updated Mine and Reclamation Plan, due every five years.

6.7 Brucejack Access Road

The Brucejack Access Road will need maintenance throughout mine life; this will periodically require sourcing of quarried rock for road surfacing and related work. Pretium will minimize the disturbance of PAG rock. New quarries will be developed in NPAG rock only (based on geochemical assessment) to the extent that they are needed to provide road base or material for other aspects of road construction and maintenance.

6.8 Kinetic Tests

Materials from the NPAG Quarry, Mine Site and underground mine are being evaluated through sampling and analysis of on-site field bins constructed of representative rock from the respective locations. These have been constructed to assess the geochemical behaviour of this rock in the conditions that actually occur at the site, including climatic conditions such as precipitation and freeze-thaw cycles. The results of the field and laboratory kinetic tests are presented on an annual basis in the Annual Reclamation Report.

6.9 Communication and Operational Protocols

The Environmental Principle is responsible for the implementation of the ML/ARD Verification and Monitoring program. The Environmental Principle or designate is responsible for coordinating sampling and will arrange for sampling support by the mine geochemist, or by qualified geologists through requests to the Chief Mine Engineer or delegate. The Environmental Principle or designate is responsible for reviewing data and implementing contingency measures if required. The Qualified Professional responsible for the ML/ARD Management Plan will review the plan annually, at a minimum, and provide technical direction to the site geochemist and Environmental Principle as needed. Standard Operating Procedures for each part of the ML/ARD verification and monitoring program are included as Appendices 1 through 14 in the order that they appear in this section.

7 TEMPORARY OR EARLY MINE CLOSURE

Temporary mine suspension, or early mine closure, will require specific mitigation and management, including to address ML/ARD. Considerations related to the underground mine and deposition of waste materials in the WRTSF are most relevant.

7.1 UNDERGROUND MINE

In the event that mine development is temporarily suspended beyond ten years, or the mine is closed prematurely, Pretium will construct a portal plug and allow the mine to flood.

7.2 DEPOSITION OF WASTE MATERIALS IN THE WRTSF

Waste rock and tailings will be deposited in the WRTSF on an ongoing basis, adhering to the 2 year allowable subaerial exposure time limit. Tailings will be disposed in the WRTSF as they are generated via pipeline or underground as paste. If mine development is temporarily suspended, or the mine is closed prematurely, Pretium will dispose all residual waste rock, tailings, and WTP sludge in the WRTSF without delay.

8 RECORDING AND REPORTING

8.1 RECORD KEEPING / TRACKING

8.1.1 Monitoring Results

Field results are and will continue to be recorded when taken and external lab test results are transferred electronically into a database. The Environmental Principle is responsible to ensure the maintenance of the original records and database. Parameters of concern are also tracked graphically and reviewed periodically to identify trends. Routine monitoring includes, at minimum, the following, unless otherwise approved based on additional analytical results and assessment:

- NPAG Quarry rock 1 sample/10,000m^3;
- Mine Site rock 1 sample / 25,000m^3;
- Underground rock, collect one composite sample for every 25,000 m^3 of waste rock;
- Tailings solids and supernatant, quarterly lab analyses;
- SAG Mill sampling, quarterly lab analyses;
- WTP sludge, quarterly lab analyses;
- Water Quality field parameters, monthly and quarterly lab samples;
- Surface flows;
- Seeps quarterly; and
- Underground flows.

Investigation and corrective action will be undertaken if monitoring data indicate that actual geochemical characteristics are significantly less conservative than predicted or expected, based on initial geochemical assessment, or if specified trigger levels are exceeded, or other effects on the receiving environment are observed. The observed condition will be logged as an incident report for tracking purposes.

8.1.2 Continuous Improvement, Follow up, and Adaptive Management

Triggers and other performance indicators, corrective actions and mine plans will be reviewed to identify potential operational improvements. Management strategies will be assessed and updated using evidence-based approaches.

The Environmental Principle ensures that relevant information is included in the Annual Reclamation Report and will ensure that it is included in the updated Mine and Reclamation Plan to be submitted to the Chief Inspector of Mines every five years starting on July 31, 2020. These reports summarize monitoring data, the outcomes of continuous improvement measures and identify new measures that are to be implemented.

Environmental performance indicators that will be monitored include:

- Solid phase parameters from surface and underground blasted rock;
- Water quality parameters of concern compared to discharge limits, guidelines and SBEBs; and
- Long term trends for all parameters of interest.

8.2 REPORTING

8.2.1 Internal Reporting

Internal reporting will be undertaken by the Environmental Principle or designate as appropriate to advise Pretium's Senior Management of ML/ARD monitoring activities and results, and to highlight where improvements are needed.

8.2.2 External Reporting

ML/ARD-related information are reviewed and incorporated into external reports, as needed. These include:

1. The Annual Reclamation Report required under *Mines Act* Permit M-243 for Construction and Operations; and
2. The updated Mine and Reclamation Plan for the mine, which must be submitted every five years to the Chief Inspector of Mines.

REFERENCES

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INAP. 2009. *The Global Acid Rock Drainage Guide*. Prepared by the International Network for Acid Prevention: Salt Lake City, UT.

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List of Appendices

Appendix 1

Standard Operating Procedure:
General Water Sampling

PRETIVM		BJ-ENV-SOP-028 General Water Sampling	
Owner: Colleen Atherton	Approver: Torence Sandhals	Revision Number:	Creation Date: 12/05/2018 Revision Date:

Objective

To provide general sample handling instructions for the collection of representative, reproducible water samples using syringe with disc filter or a pump with inline filters.

Scope

This SOP applies to all water samples collected in support of the ML-ARD Management Plan.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- Aliquot: Portion of sample
- DI water: De-ionized water
- DO: Dissolved Oxygen
- Field parameters: DO, pH, and conductivity
- HDPE: High Density Polyethylene
- ML/ ARD: Metal Leaching/ Acid Rock Drainage
- TSS: Total Suspended Solids

Preparation

Hazards

- Working with hazardous chemicals

Tools

- pH/conductivity meter
- See sample specific SOP

Requirements

- Trained and qualified to conduct water-quality sampling

Job Step

1. **General considerations**
   - Schedule field work to meet laboratory hold times. Samples can only be collected Sunday to Wednesday for shipment Monday to Thursday.
   - All sample bottles must be certified clean by the laboratory. Certified clean bottles do not require rinsing.
   - All reusable equipment must be cleaned and rinsed three times prior to use. Blanks should be obtained to verify equipment cleaning procedures are effective.

2. Field preparation

- Calibrate pH/conductivity meter according to manufacturer's instructions. This step is conducted only at the beginning of the day.
- Collect frozen ice-packs from freezer and place in cooler.
- Collect and prepare field supplies in cooler. The number and type of sample bottles, filters and preservative required will depend on the specific sampling SOP being followed.
- Use either pre-printed labels provided by the laboratory or, using black marker, label the bottles with the Date, Sample ID and parameters of analysis provided in the sampling specific SOP and return the labeled bottles to the cooler.
- Always take at least one extra set of sample bottles in case a sample needs to be re-collected due to accidental contamination.

3. General sampling instructions

- Put on vinyl gloves.
- Gloves must be replaced between samples and if suspected of having made contact with a dirty surface.
- Measure field parameters using a separate aliquot of sample that will not be used in any other analysis. If in situ field parameters are being measured, measure field parameters after sample collection or downstream from/beside the sampling location.
- Fill unfiltered sample bottles, followed by filtered sample bottles.
- When filling bottles, remove the lid without touching the inner surface of either lid or bottle.
- Do not allow any equipment to make contact with the inner surface of either lid or bottle.
- Fill the sample bottle to capacity, leaving space for preservative if required, without making contact between the bottle and the sampling equipment.
- Add preservative, if required, and tightly replace the lid. Be careful not to spill the preservative as it may be a concentrated acid; may cause damage to skin, eyes and clothing; and will erase the label.
- Invert the bottle twice to mix.
- Place the bottle in the cooler with the ice packs.

4. Sample filtration using a syringe and filter cassette

Syringe filtering is conducted under two scenarios:

- when limited sample volumes are available, and/or
- when TSS is low.

If sample volumes are low and TSS is high, a sample aliquot can be collected in an extra 500 mL plastic bottle which may be taken back to the lab, allowed to settle and decanted for filtration.

- Remove a 50 mL syringe from its wrapper.
- A new syringe must be used for every sample.
- Remove a disc filter from its package
  - If disc filters are in bulk format, ensure remaining filters are not contaminated by gloves.
  - This can be accomplished by shaking the bag, so a single filter moves toward the opening.
  - Grasp the filter by the outside edge rather than the outlet.
- Fill the syringe with sample.
- Screw the disc filter onto the end of the syringe.
- Push a small volume of sample through the disc filter before collecting your sample. This will flush potential contaminants from the filter.
- Place the sample bottle below the filter (as shown in Figure 1), being careful not to touch the tip of the disc filter to anything.
- Depress the plunger to force the sample through the filter.

- Remove the disc filter, refill the syringe, and replace the disc filter as required to fill all the bottles requiring filtered sample.
- Multiple filters may be required if the sample contains high TSS.
- If a filter is punctured or defective, the sample will be contaminated. Discard the sample, bottle and filter. Collect another sample using a new bottle and filter.

5. Sample filtration using a peristaltic pump and in-line high capacity filter

Inline filters absorb a large volume of water before discharging filtered water. Inline filters are only used when sufficient sample volume is available.

- To prevent hand injuries, use only waterra cutters to cut tubing for the geopump.
- Cut two sections of HDPE peristaltic tubing: one section for between the sample source and pump and a second section for between the pump and sample bottle.
- Cut one 8" piece of silicone tubing.
- Thread the ends of the HDPE tubing into the ends of the silicone tubing.
- Thread the silicone tubing through the housing of the peristaltic pump (Figure 2).
- Ensure the flow direction switch is in the correct position.
- Turn the pumping speed down.
- Switch on the pump and gradually increase the flow until the desired flow rate is achieved.
- After collection of the unfiltered sample aliquots, place a 2" piece of silicone tubing on the sampling end of the HDPE tubing.
- Open a waterra inline filter and thread the barbed end of the filter into the 2" piece of silicone tubing (as shown in Figure 2). The filter housing has an arrow indicating flow direction.
- Be careful not to overpressure the waterra filter. If too much back pressure builds up in the tubing, the tubing will separate from the filter and risks contaminating the sample.
- Multiple filters may be required if the sample contains high TSS.
- If a filter is punctured or defective, the sample will be contaminated. Discard the sample, bottle and filter. Collect another sample using a new bottle and filter.

6. Complete COC

- Complete COC as indicated on the sampling specific SOP.

7. Shipping Samples

- Ship samples to the analytical laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure that the samples arrive at the laboratory <10°C.

Figure 1: Syringe and disc filter

Figure 2: Geopump and inline filter

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Environment Superintendent or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 2

Standard Operating Procedure:
Confirmatory Sampling of NPAG Quarry Rock

PRETIVM			BJ-ENV-SOP-033 NPAG Quarry Rock
Owner: Colleen Atherton	Approver: Torence Sandhals, Jason Gabora	Revision Number:	Creation Date: Jul 24, 2015 Revision Date: Aug 13, 2018

Objective

To provide guidance for confirmatory ML/ARD sampling during the development of the NPAG quarry.

Scope

All activities related to sampling of NPAG Quarry rocks through life of mine. This includes sample collection protocols, quality assurance and quality control (QA/QC) requirements, shipping and handling details, analytical procedures, parameters to be measured, communications with the analytical laboratories, the COC (chain of custody) and documenting the results.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training.
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment.

Definitions

- ABA: Acid Base Accounting.
- AP: Acid Potential.
- COC: Chain of Custody.
- NP: Neutralization Potential.
- NPAG: Non-Potentially Acid Generating.
- PPE: Personal Protective Equipment.
- QA/QC: Quality Assurance/ Quality Control.
- TIC: Total Inorganic Carbon.

Preparation

Hazards

- Slips and falls.
- Working near heavy machinery.
- Rotating equipment.
- Scaling and rock fall hazards.
- Noise.

Tools

- PPE.
- Hearing protection.
- Half mask respirator with P100 cartridges.
- Hand shovel.
- Field notebook, pen and markers.
- Sample bags, sample tags and zip ties.
- Hand lens.
- GPS.
- Camera.

Requirements

- Trained and qualified to identify lithological units.
- Fit tested and trained to use a half mask respirator and cartridges.
- Knowledge of the drill program and plans.
- Knowledge of this SOP.

Job Step

Samples will be collected from NPAG Quarry rock at a frequency of one samples per 10,000 m3.

1. Field Preparation

- The sampler must be clean shaven in case a respirator must be worn.
- Contact the Industrial Hygiene Advisor to obtain personal air monitoring equipment. Industrial Hygiene sampling will be conducted once project starts to determine if a respirator must be worn.
- One sample must be collected for every 10,000 m3 excavated. This SOP assumes that drilling will precede excavation and confirmatory samples can be collected from drill cuttings. To achieve one sample per 10,000 m3, create a 2D grid (plan view) of the quarry with a drill hole centered in each 30 x 30 m block.
- Ensure an appropriate number of sample bags and sample tags are available to collect two samples from each hole.

2. Mobilize to Quarry

- Check out of camp with Dispatch on Channel 2 – Repeater 1.
- Obtain permission from Surface Operations Supervisor (Channel 9 – LAD 2) before accessing site. Determine if any other quarry staff require notification of sampling activities.

3. Sampling

- If elevated levels of dust are present, don the half mask respirator with the particulate filters.
- Before sampling, communicate sampling plan with drill operator – communicate intended collar spacing and sampling intensity for each hole, including when QA/QC samples will be collected.
- At each drill hole, note surface lithology and GPS coordinates in your field book.
- Obtain a composite sample from each hole for every 10 m depth interval. Each sample should have a minimum mass of 1 kg.
- An additional sample should be collected if a lithologic change is observed in the drill cuttings. Note the depth of the change(s) and from which depth(s) the sample(s) are collected.
- Photograph and describe each lithology in your field book.
- Place a sample ID tag in each sample bag and record the tag number in your notebook. An example of field notes is provided in Figure 1.
- Obtain QA/QC samples as described in Section 4 below.
- Check in hourly with Dispatch if working alone.

4. QA/QC

- A field duplicate and laboratory duplicate must be collected for the first sample of every year and for one in every 20 samples thereafter.
- Collect a 3-4 kg sample, from which the field duplicate and laboratory duplicate will be sub-sampled.
- It is best to sub-sample from a large sample rather than collect duplicates sequential from the same hole and depth interval.
- The field duplicate is obtained by taking a 1 kg sub-sample from the larger sample and placing it in a separate sample bag with a unique sample tag number.
- The remaining 2-3 kg sample must be flagged by adding DUP to the sample tag number, in your notebook and on the COC (e.g., B0020####-DUP). This sample will be split at the laboratory following pulverization.

5. **Demobilize from Quarry**
   - Inform Surface Operations Supervisor that you are demobing from Quarry.
   - Check in to camp with Dispatch on Channel 2 – Repeater 1.
6. **Shipping and Analytical Parameters**
   - All samples are to be shipped to an accredited laboratory (currently SGS Laboratories in Burnaby, BC) for total sulphur (T-S) and total carbon (T-C) analysis.
   - Laboratory duplicate QA/QC samples are to be submitted for the full suite of ABA analyses and solid phase element determination by aqua regia digestion. The full list of parameters to be measured for the laboratory duplicates are listed in Table 1.
   - A completed COC form is to be shipped with the samples and an electronic version sent via e-mail to the accredited laboratory and any other appropriate parties. An example COC is provided in Appendix I.
7. **Data Tracking and Analysis**
   - Data will be compiled and evaluated by a Senior Geologist or Qualified Professional.
   - If exceedances of trigger limits as defined in the ML/ARD Management Plan occur, then the Mine Manager and the Environmental Manager must be informed and actions outlined in the ML/ARD Management Plan must be taken.

Figure 1 – Field Notes

Drill Hole	Northing	Easting	Accuracy	Sample ID	Sample Depth	Photo Number	Geologic Description

Table 1 – Analytical Parameters

ABA Analyses	Metals by Aqua Regia				
Paste pH	Ag	Cs	Lu	Sb	U
TIC	Al	Cu	Mg	Sc	V
CaCO3	As	Fe	Mn	Se	W
C(T)	Ba	Ga	Mo	Sn	Y
S(T)	Be	Ge	Na	Sr	Yb
S(SO4)	Bi	Hf	Nb	Ta	Zn
S(S-2)	Ca	Hg	Ni	Tb	Zr
Insoluble S	Cd	In	P	Te	
AP	Ce	K	Pb	Th	
Modified NP	Co	La	Rb	Ti	
Fizz Test	Cr	Li	S	Tl	

Appendix I – Chain of Custody

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\SGS\2018\COC\NPAG Quarry\ COC_SGS_NPAG Template.xlsx

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	2300-1055 Dunsmuir St, Four Bentall Centre, PO Box 49334 Vancouver, BC V7X 1L4	
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name:
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis								P.O. Number (if applicable)
	Total Sulphur	Total Carbon	Total Inorganic Carbon	Modified NP	Sulphate-Sulphur	Sulphide-Sulphur	Metals on Solids by ICP-MS		
NPAG Quarry sample (*#####* to *#####*)	x	x							
Duplicate (first sample of every year)	x	x	x	x	x	x	x		Special Instructions: Process samples designated as duplicates, then split the sample such that T-S and T-C are analysed on one split and the full ABA + metals are analysed on the other split.

CHAIN OF CUSTODY:						
Relinquished by:	Time:	Date:	Received by:	Time:	Date:
Relinquished by:	Time:	Date:	Received by:	Time:	Date:

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
Jul 24, 2015	Initial Issue		
Aug 31, 2015	Revised		
Aug 13, 2018	Updated to PVG template		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Environment Superintendent	[redacted]		
Assistant Environment Manager			
Surface Operations Superintendent			
Health and Safety Manager or Designate			
Mine Manager or Designate			
JOHSC Co-chair or Member			

Appendix 3

Standard Operating Procedure:
NPAG Quarry Runoff Sampling

PRETIVM		BJ-ENV-SOP-032 NPAG Quarry Run Off Sampling	
Owner: Colleen Atherton	Approver: Torence Sandhals, Jason Gabora	Revision Number:	Creation Date: 08/31/2015 Revision Date: 07/23/2018

Objective

To describe the steps required for collection of water samples from NPAG Quarry run-off as per the ML/ARD MP.

Scope

All activities related to the collection of water samples from the NPAG Quarry at the Brucejack Gold Mine.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training.
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment.
- 2.13 WHMIS.

Definitions

- BCMDG: British Columbia Mine Design Guidelines.
- COC: Chain of Custody.
- DI water: De-Ionized water.
- ML/ARD MP: Metal Leaching/ Acid Rock Drainage Management Plan.
- PPE: Personal Protective Equipment incl. hard hat, safety glasses, high visibility vest and steel toe boots.
- QA/QC: Quality Assurance and Quality Control.
- TOC: Total Organic Carbon.
- TSS: Total Suspended Solids.

Preparation

Hazards

- Slips and falls.
- Working near hazardous chemicals.
- Exposure to elements.
- Rock fall/overhead hazards.

Tools

- GPS.
- PH/conductivity meter.
- Syringe and disc filters.
- Vinyl gloves.
- DI water.
- Water-proof markers.
- Sample labels.
- Data sheets.
- Camera.
- Cooler containing sample bottles and preservatives as per Table 1.

Requirements

- Trained and qualified to conduct water-quality sampling.
- Knowledge of this SOP.

Job Step

Water samples will be collected from NPAG Quarry run-off twice per year during the unfrozen period.

1. **Scheduling**
   - NPAG Quarry runoff samples will be collected at least two times per year.
   - The first sample will ideally be collected in spring after freshet.
   - The second sample will ideally be collected in fall before freeze-up.
   - Each sampling event will include a minimum of three samples: one quarry run-off test sample, one field duplicate and one field blank.
   - If more than one run-off stream or pool is observed, then an additional set of bottles from Table 1 must be added to the supplies.
2. **Field Preparation**
   - Contact Mountain Safety (ext.102) several days before sampling to determine if the NPAG Quarry is safe to access or if a guide is required.
   - Calibrate pH/conductivity meter.
   - Collect and label field supplies and place in a cooler with ice packs.
   - Label sample bottles with the date, sample ID and parameters of analysis as provided in Table 1.
   - Samples are labeled "NPAG QUARRY". Add A, B, etc. as required if multiple seeps or pools are identified.
   - Prepare one duplicate sample and one field blank sample.
   - Add a bottle set for one extra sample to the cooler.
3. **Mobilize to NPAG Quarry**
   - Call Logistics on radio channel "Repeater 1" to check out of camp.
   - Call Logistics a second time when you arrive at the NPAG Quarry.
4. **Collection Methods**
   - Run-off/Seep: fill a bottle by holding the bottle below the seep or drip without allowing the mouth of the bottle to come in contact with the rock face. If there is a large volume, the sample should be taken near the surface at mid-flow.
   - Ponded/pooled: fill a bottle by holding the mouth just beneath the surface of the water with your hand well below the neck and placed downstream of the bottle opening. Do not disturb sediment or organic matter.
   - Low flow: a composite sample can be obtained by mixing equal volumes of discrete grab samples which may be collected at one point at regular time intervals or collected from multiple seep points on a rock exposure with consistent lithology.
5. **Leachate Sample Collection**
   - Review BJ-ENV-SOP-028 for general sample collection and handling procedures.
   - Fill the bottles in the order identified in Table 1.
   - Filter and preserve the sample as indicated in Table 1 using the syringe and disc filter.
   - Using a separate aliquot, measure pH, conductivity and temperature.
   - Record sampling observations using the template in Appendix I.
   - Take photographs of the sample location and record the GPS location.

6. **QA/QC Samples**
   - Collect one field duplicate by filling a second set of bottles with run-off water using the filtering and preservation procedure described in Table 1 and Steps 4 and 5. This sample is identified by -98, e.g., NPAG QUARRY-A-98.
   - Collect one field blank by filling an additional set of bottles with DI water at a run-off location using the filtering and preservation procedure described in Table 1 and Steps 3 and 4. This sample is identified by -99, e.g., NPAG QUARRY-A-99.
7. **Demobilize from NPAG Quarry**
   - Call Logistics when you return to your vehicle.
   - Call Logistics when you return to camp.
8. **Complete COC**
   - Complete COC as per Appendix II.
9. **Shipping Samples**
   - Ship samples to the analytical laboratory (currently ALS Global in Burnaby, BC).
   - Use adequate ice packs to ensure that the samples arrive at the laboratory <10°C.
10. **Data Tracking and Analysis**
   - Data will be compiled and evaluated by the Environmental Manager or designate.
   - If exceedances of threshold limits as defined in the ML/ARD Management Plan occur, then the Mine Manager must be informed and actions outlined in the ML/ARD Management Plan must be taken.

Table 1

Bottle Type and Volume	Field Preservation	Field Filter	Refrigerate (4°C)	Indicate on Bottle	Parameter(s)*
500 mL plastic	None	No	Yes	Generals	pH, conductivity, TSS, turbidity, alkalinity, acidity and anions
125 mL amber	1 mL 1:3 H2SO4	No	Yes	Nutrients	TOC, phosphorus, T-N and ammonia
60 mL plastic	0.8 mL 1:4 HNO3 (18%)	No	Yes	Total Metals	Total metals (BCMDG)
60 mL plastic	0.8 mL 1:4 HNO3 (18%)	Yes	Yes	Dissolved Metals	Dissolved Metals (BCMDG)

Appendix I – Data Sheets

Quarry Water Quality Sampling Data-Sheet:

Environmental Technician:_____ **Page** ____ **of** ____

Date:_____ **Time:**_____ **Weather:**_____

Sample ID:_____ **Type of Sample:** ☐ Runoff (i.e., surface flow)

GPS Coordinate: _____ ☐ Seep (i.e. from fracture in rock)

Estimated Water Volume: _____ ☐ Pool/pond

Description of sample site (i.e., rock unit from which seep is emanating; direction of flow; location, size and depth of pool; proximity to other water bodies, etc.):

_____

_____

_____

_____ **Photographs:**_____

Description of sample (colour, clarity, odor, etc):

_____

_____

_____

Field Measurements: pH: _____ Conductivity: _____ µS/cm

Temperature: _____ °C Turbidity: _____

Appendix II – COC

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\ALS\2018\COC\NPAG runoff\ COC_ALS_NAPG Quarry.xlsx

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 –

Page 1 of 1

Report To		Report Format / Distribution	Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report ☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked	E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2 Alison.Shaw@borax.ca	**Analysis Request**
Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Pretivm (Brucejack Project)	Email 1 or Fax invoices@pretivm.com	
Contact:	Accounts Payable (604-558-1784)	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:		Approver ID: / Cost Center:	
Job #:	NPAG Quarry	GL Account: / Routing Code:	
PO / AFE:	1024962	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		ALS Contact: Dean Watt / Sampler:	

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, conductivity, alkalinity, acidity, TSS, turbidity	Anions-all (Br, Cl, F, NO_2, SO_4)	nutrients (T-N, ammonia, and phosphate), TOC	MET-T-BCMDG-VA Incl Hg	MET-D-BCMDG-VA Incl Hg								Number of Containers
							P	P	F/P	F/P							
	NPAG Quarry			water	R	R	R	R	R								4
	NPAG Quarry-98				R	R	R	R	R								4
	NPAG Quarry-99				R	R	R	R	R								4

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	email 3: environmental@pretivm.com
Are samples for human drinking water use? ☐ Yes ☑ No	email 4: mholtby@pretivm.com
	email 5: svanzalingen@pretivm.com
	email 6: rmccall@pretivm.com

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐
Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐
Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
Aug 31, 2015	Initial Issue		
Jul 23, 2018	Updated to Pretivm template		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Environment Superintendent	[redacted]		
Assistant Environment Manager			
Health and Safety Manager or Designate			
Mine Manager or Designate			
JOHSC Co-chair or Member			

Appendix 4

Standard Operating Procedure:
Confirmatory Sampling of Mine Site Waste Rock

PRETIVM		BJ-ENV-SOP-036 Confirmatory Sampling of Mine Site Waste Rock	
Owner: Colleen Atherton	Approver: Torence Sandhals	Revision Number: 1	Creation Date: Aug 31, 2015 Revision Date: Oct 22, 2018

Objective

To provide guidance for Metal Leaching/ Acid Rock Drainage (ML/ARD) sampling of Mine Site waste rock including waste rock excavated from the Mill site, the Contact Water Pond (CWP), roads within the mine site boundary, diversion ditches, the laydown areas and the truck shop area and any other areas identified during mine operations.

Scope

All activities related to sampling of Mine Site waste rocks through life of mine. This includes sample collection protocols, shipping and handling details, analytical procedures, quality assurance and quality control (QA/QC) requirements, parameters to be measured, communications with the analytical laboratories, the COC (chain of custody) and documenting the results.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment

Definitions

- ABA: Acid Base Accounting
- AP: Acid Potential
- COC: Chain of Custody
- NPAG: Non-Potentially Acid Generating
- NP: Neutralization Potential
- PAG: Potentially Acid Generating
- PPE: Personal Protective Equipment
- QA/QC: Quality Assurance/ Quality Control
- SFE: Shake Flask Extraction
- TIC: Total Inorganic Carbon

Preparation

Hazards

- Slips and falls
- Working near heavy machinery
- Rotating equipment
- Scaling and rock fall hazards
- Noise

Tools

- PPE
- Hearing protection
- Hand shovel
- Field notebook, pen and markers
- Sample bags, sample tags and zip ties
- Hand lens

- GPS
- Camera

Requirements

- Trained and qualified to identify lithological units
- Knowledge of the drill program and plans

Job Step

One sample must be collected for every 25,000 m3 of each lithologic model unit excavated from the Mine Site Surface.

1. **Field Preparation**
   - Coordinate with Surface Operations Supervisor to ensure that samples can be collected from the muck pile hear the blast face.
   - Ensure appropriate number of sample bags and sample tags are available to collect composite samples from all lithologies present.
2. **Sampling**
   - Mobilize to site
   - Obtain a lithology-specific composite sample from the blasted muck pile amounting to at least 1 kg.
   - Note the location of the sample, and photograph and describe the sample in your field book.
   - Place a sample ID tag in each sample bag and note the tag number in your field book.
   - Obtain QA/QC samples as described in Section 3 below.
3. **Description of QA/QC Samples**
   - A field duplicate and laboratory duplicate must be collected for the first sample of every year and for one in every 10 samples thereafter.
   - Collect a 3-4 kg sample, from which the field duplicate and laboratory duplicate will be sub-sampled.
   - It is best to sub-sample from a large sample rather than collect duplicates sequentially.
   - The field duplicate is obtained by taking a 1 kg sub-sample from the larger sample and placing it in a separate sample bag with a unique sample tag number.
   - The remaining 2-3 kg sample must be flagged by adding DUP to the sample tag number, in your notebook and on the COC (e.g., B0020####-DUP). This sample will be split at the laboratory following pulverization.
4. **Shipping and Analytical Parameters**
   - All samples are to be shipped to an accredited laboratory (currently SGS Laboratories in Burnaby, BC) for total sulfur (T-S) and total carbon (T-C) analysis.
   - Laboratory duplicate QA/QC samples are to be submitted for the full suite of ABA analyses, solid phase element determination by aqua regia digestion and SFE tests. The full list of parameters to be measured for the laboratory duplicates are listed in Table 1.
   - A completed COC form is to be shipped with the samples and an electronic version sent via e-mail to the accredited laboratory and any other appropriate parties. An example COC is provided in Appendix I.
5. **Documents and Records**
   - Record the sample IDs, an estimate of the total Mine Site waste rock excavated to date since the beginning of Construction phase, sample location and a description of the lithology including the geological block model unit code in your field notes (in a similar manner as the table below). Where appropriate, photograph the exposed lithology and/or sample(s).
   - Complete the COC, including the date and time of collection, name of sampler, sample IDs and analyses to be conducted.

6. **Data Tracking and Analysis**
   - Data will be evaluated by the Geochemist or designate. If exceedances of trigger limits as defined in the ML/ARD Management Plan occur, then the Mine Manager and the Environmental Manager must be informed, and actions outlined in the ML/ARD Management Plan must be taken.

Figure 1 – Field Notes

Sample ID	Mine Site waste rock excavated to date	Sample location	Geologic Description	Photo #

Table 1 – Analytical Parameters

ABA Analyses	Metals by Aqua Regia					Shake Flask Extraction			
Paste pH	Ag	Cu	Mn	Sn	Yb	pH	Ag	Hg	S
TIC	Al	Fe	Mo	Sr	Zn	Redox	Al	K	Sb
CaCO3	As	Ga	Na	Ta	Zr	Conductivity	As	Li	Se
C(T)	Ba	Ge	Nb	Tb		Acidity (to pH 4.5)	Ba	Mg	Sn
S(T)	Be	Hf	Ni	Te		Total Acidity (to pH 8.3)	Be	Mn	Sr
S(SO4)	Bi	Hg	P	Th		Alkalinity	Bi	Mo	Ti
S(S-2)	Ca	In	Pb	Ti		Chloride	Ca	Na	Tl
Insoluble S	Cd	K	Rb	Tl		Fluoride	Cd	Ni	U
AP	Ce	La	S	U		Sulphate	Co	P	V
Modified NP	Co	Li	Sb	V		Hardness as CaCO3	Cr	Pb	Zn
Fizz Test	Cr	Lu	Sc	W			Cu	Rb	Zr
	Cs	Mg	Se	Y			Fe	S	

Appendix I – Chain of Custody

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\SGS\2018\COC\Mine Site\COC_SGS_Mine Site Template.xlsx

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	2300-1055 Dunsmuir St, Four Bentall Centre, PO Box 49334 Vancouver, BC V7X 1L4	
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name:
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis										P.O. Number (if applicable)
	Paste pH	Total Inorganic Carbon	Total Carbon	Total Sulphur	Sulphate-Sulphur	Sulphide-Sulphur	Modified NP	Metals on Solids by ICP-MS	Shake Flask Extraction		
Mine Site sample (#### to ####)			x	x							
Duplicate (first sample of every year)	x	x	x	x	x	x	x	x	x		Special Instructions: Process samples designated as duplicates, then split the sample such that T-S and T-C are analysed on one split and the full ABA + metals are analysed on the other split.

CHAIN OF CUSTODY:							
Relinquished by:	Time:	Date:	Received by:	Time:	Date:
Relinquished by:	Time:	Date:	Received by:	Time:	Date:

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2015-08-31	Initial issue		
2018-10-22	Update to Pretivm template		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Environment Superintendent or Designate			
Surface Operations Superintendent or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 5

Standard Operating Procedure:
Surface Contact Water Sampling

PRETIVM		BJ-ENV-SOP-070 Surface Contact Water Sampling	
Owner: Environment	**Approver**: Robin McCall	**Revision Number**:	**Creation Date**: 09/13/2019 **Revision Date**: 2020/10/06

Objective

To describe the steps required for collection of water samples from the Contact Water Management System (CWMS) to support ML/ARD monitoring.

Scope

All activities related to the collection of water samples from the CWMS at the Brucejack Gold Mine.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training.
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment.
- 2.13 WHMIS.

Definitions

- BCMDG: British Columbia Mine Design Guidelines.
- COC: Chain of Custody.
- CWMS: Contact Water Management System
- DI water: De-Ionized water.
- ML/ARD MP: Metal Leaching/ Acid Rock Drainage Management Plan.
- PPE: Personal Protective Equipment incl. hard hat, safety glasses, high visibility vest and steel toe boots.
- QA/QC: Quality Assurance and Quality Control.
- TOC: Total Organic Carbon.
- TSS: Total Suspended Solids.

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensure this procedure complies with H&S regulation.

The Area Manager or Designate is responsible for:

- Ensure this procedure is followed and sampling is completed on time.

The Worker is responsible for:

- Ensure this procedure is followed for all surface contact water sampling.

Preparation

Hazards

- Slips and falls.
- Working near hazardous chemicals.
- Exposure to elements.

Tools

- PH/conductivity meter.
- Long-handled sample dipper.
- Syringe and disc filters.
- Vinyl gloves.
- DI water.
- Water-proof markers.
- Sample labels.
- Data sheets.
- Camera.
- Cooler containing sample bottles and preservatives as per Table 1.

Requirements

- Trained and qualified to conduct water-quality sampling.
- Knowledge of this SOP.

Job Step

Water samples will be collected from CWMS run-off twice per year during the unfrozen period.

1. Scheduling

- CWMS samples will be collected at least two times per year.
- The first sample will ideally be collected in spring after freshet.
- The second sample will ideally be collected in fall before freeze-up.
- Each sampling event will include a minimum of two samples: one East Weir sample and one East Camp sample
- The first sampling event of the year will also include a field duplicate and a field blank sample.

2. Field Preparation

- Review BJ-ENV-SOP-028 for general sample collection and handling procedures.
- Calibrate pH/conductivity meter.
- Collect and label field supplies and place in a cooler with ice packs.
- Label sample bottles with the date, sample ID and parameters of analysis as provided in Table 1.
- Prepare one duplicate sample and one field blank sample for the first sampling event of the year.
- Add a bottle set for one extra sample to the cooler.

3. Collection Methods

- Figure 1 and 2 indicate sample locations.
- East Camp sample: fill a bottle by holding the bottle below the culvert without allowing the mouth of the bottle to come in contact with the culvert
- East Weir sample: use a long-handled sampler to retrieve water pooled behind the weir. Fill all bottles from the sampler.
- At the two locations measure and calculate the flow depending on flow conditions:
    - In low flow conditions measure flow from the culvert by timing how long it takes to fill a container of known volume (e.g. 1 L graduated cylinder). Repeat this procedure five (5) times and calculate the average flow rate in L/s.
    - In medium-to-high flow conditions measure flow using the FH-950 flow meter as described in **Appendix I**.
- Filter and preserve the sample as indicated in Table 1 using the syringe and disc filter.
- Unfiltered samples may be decanted directly into the sample bottle.

- Using a separate aliquot, measure pH, conductivity and temperature.
- Record sampling observations.
- Take photographs of the sample location.

4. QA/QC Samples

- Collect one field duplicate by filling a second set of bottles with contact water using the filtering and preservation procedure described in Table 1 and Step 3. This sample is identified by -98, e.g., East Weir-98.
- Collect one field blank by filling an additional set of bottles with DI water at a contact water location using the filtering and preservation procedure described in Table 1 and Steps 3. This sample is identified by -99, e.g., East Weir-99.

5. Complete COC

- Complete COC as per Appendix II.

6. Shipping Samples

- Ship samples to the analytical laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure that the samples arrive at the laboratory <10°C.

7. Data Tracking and Analysis

- Data will be compiled and evaluated by the Environmental Manager or designate.

Table 1

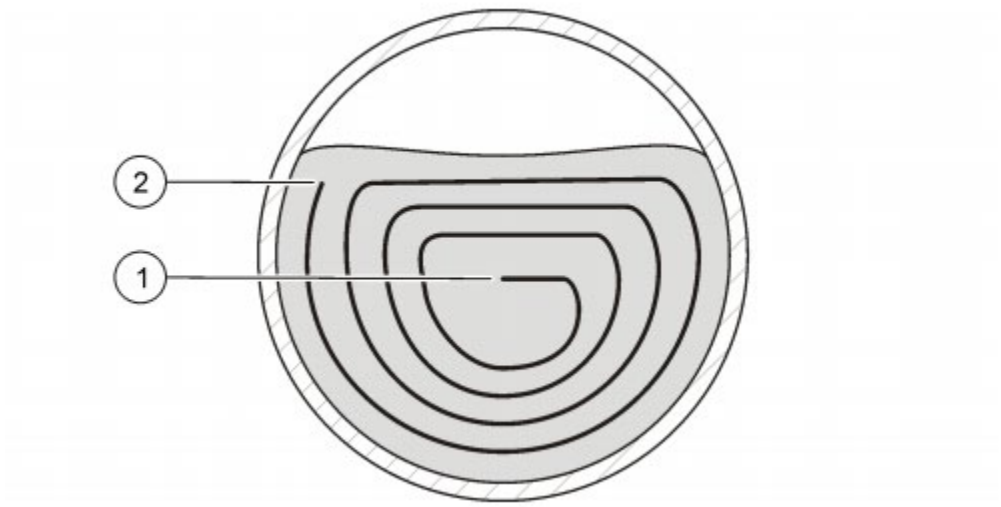
Bottle Type and Volume	Field Preservation	Field Filter	Refrigerate (4°C)	Indicate on Bottle	Parameter(s)*
500 mL plastic	None	No	Yes	Generals	pH, conductivity, TSS, turbidity, alkalinity, acidity and anions
125 mL amber	1 mL 1:3 H2SO4	No	Yes	Nutrients	TOC, phosphorus, T-N and ammonia
60 mL plastic	0.8 mL 1:4 HNO3 (18%)	No	Yes	Total Metals	Total metals (BCMDG)
40 mL glass	0.5 mL 1:1 HCl	No	Yes	Total Hg	Total Hg
60 mL plastic	0.8 mL 1:4 HNO3 (18%)	Yes	Yes	Dissolved Metals	Dissolved Metals (BCMDG)
40 mL glass	0.5 mL 1:1 HCl	Yes	Yes	Dissolved Hg	Dissolved Hg

Figure 1: East Camp sample UTM – 427145/6258590

Figure 2: East Camp sample UTM – 426660/6258725

Appendix II – Flow Measurement Using the FH-950 Meter

- Before heading out to the field conduct a meter “zero” calibration
- Measure the culvert diameter and the distance from the culvert crown (i.e. top) to the water surface
- In the FH-050 Select : **Profiler → Conduit → Circular**
- Enter the measured culvert diameter and distance from crown to water surface
- Select: **Method 2D→ Measure velocity**
- Place sensor at prompted depth and select **Capture**
- Once measurement starts, move sensor in a circular pattern (**Figure 3**) until the measurement is complete.
- Write down the calculated flow (m3/s)



- **Figure 3. Sensor circular pattern for flow measurement in a culvert. Start at point 1, finish at point 2.**

Appendix I – COC

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\ALS\Templates\Template_COC_ALS_Contact.xlsx

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -

Page 1 of 1

Report To		**Report Format / Distribution**		**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format:	☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution:	☑ ☐ ☐	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax	catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2	Alison.Shaw@lorax.ca	**Analysis Request**
Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**		Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution:	☑ ☐ ☐	
Company:	Pretivm (Brucejack Project)	Email 1 or Fax	invoices@pretivm.com	
Contact:	Accounts Payable (604-558-1784)	Email 2		
Project Information		**Oil and Gas Required Fields (client use)**		
ALS Quote #:		Approver ID:	Cost Center:	
Job #:	Contact Water	GL Account:	Routing Code:	
PO / AFE:	1025612	Activity Code:		
LSD:		Location:		
ALS Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:**	

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, conductivity, alkalinity, acidity, TSS, turbidity	Anions-all (Br, Cl, F, NO_2, NO_3, SO_4)	nutrients (T-N, ammonia, and phosphate), TOC	MET-T-BCMDG-VA incl Hg	MET-D-BCMDG-VA incl Hg								Number of Containers
							P	P	F/P	F/P							
	EAST WEIR			water	R	R	R	R	R								6
	EAST CAMP			water	R	R	R	R	R								6

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**	**SAMPLE CONDITION AS RECEIVED (lab use only)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	email 3: environmental@pretivm.com email 4: mholtby@pretivm.com email 5: svanzalingen@pretivm.com email 6: rmccall@pretivm.com	Frozen ☐ SIF Observations Yes ☐ No ☐ Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐ Cooling Initiated ☐
Are samples for human drinking water use? ☐ Yes ☑ No		INITIAL COOLER TEMPERATURES °C / FINAL COOLER TEMPERATURES °C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326e v09 Front/04 January 2014

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1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
Sep 13, 2019	Initial Issue		
October 6, 2020	Added roles and responsibilities section		1

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager/Designate	Robin McCall	[redacted]	
Health and Safety Manager or Designate			
Mine Manager or Designate			
JOHSC Co-chair or Member			

Appendix 6

Standard Operating Procedure:
Confirmatory Sampling of Underground Mine Waste Rock

PRETIVM		BJ-ENV-SOP-037 Confirmatory Sampling of Underground Mine Waste Rock	
Owner: Colleen Atherton	Approver: Torence Sandhals	Revision Number: 1	Creation Date: Aug 31, 2015 Revision Date: Oct 22, 2018

Objective

To provide guidance for Metal Leaching/ Acid Rock Drainage (ML/ARD) sampling of underground mine waste rock.

Scope

All activities related to sampling of underground waste rock through life of mine. This includes sample collection protocols, shipping and handling details, analytical procedures, quality assurance and quality control (QA/QC) requirements, parameters to be measured, communications with the analytical laboratories, the COC (chain of custody) and documenting the results.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment

Definitions

- ABA: Acid Base Accounting
- AP: Acid Potential
- COC: Chain of Custody
- NP: Neutralization Potential
- PAG: Potentially Acid Generating
- PPE: Personal Protective Equipment
- QA/QC: Quality Assurance/ Quality Control
- SFE: Shake Flask Extraction
- TIC: Total Inorganic Carbon

Preparation

Hazards

- Slips and falls
- Working near heavy machinery
- Scaling and rock fall hazards
- Noise
- Poor air quality

Tools

- PPE
- Hearing protection
- Rock hammer
- Field notebook, pen and markers
- Sample bags, sample tags and zip ties
- Hand lens
- Camera

Requirements

- Trained and qualified to identify lithological units
- Knowledge of blasting and excavation procedures
- Knowledge of the underground mine development plans and the geologic block model
- Underground orientation and driver training

Job Step

One sample must be collected for every 25,000 m3 of each lithologic model unit excavated from the underground mine.

1. Field Preparation

- Update underground ARD master sampling table to determine excavated volumes of each lithology.
- Identify model units that require additional sampling.
- Identify recently exposed areas for each model unit requiring additional sampling.
- Ensure appropriate number of sample bags and sample tags are available to collect composite samples from all lithologies requiring additional samples.

2. Sampling

- Mobilize to sampling site.
- Verify that the sampling site is in the expected lithology.
- Obtain a lithology-specific composite sample from rock collected from recently exposed rib amounting to at least 1 kg.
- Note the location of the sample, and photograph and describe the sample in your field book.
- Place a sample ID tag in each sample bag and note the tag number in your field book.
- Obtain QA/QC samples as described in Section 3 below.

3. Description of QA/QC Samples

- A field duplicate and laboratory duplicate must be collected for the first sample of every year and for one in every 20 samples thereafter.
- Collect a 3-4 kg sample, from which the field duplicate and laboratory duplicate will be sub-sampled.
- It is best to sub-sample from a large sample rather than collect duplicates sequentially from the same area of rib.
- The field duplicate is obtained by taking a 1 kg sub-sample from the larger sample and placing it in a separate sample bag with a unique sample tag number.
- The remaining 2-3 kg sample must be flagged by adding DUP to the sample tag number, in your notebook and on the COC (e.g., B0020####-DUP). This sample will be split at the laboratory following pulverization.

4. Shipping and Analytical Parameters

- All samples are to be shipped to an accredited laboratory (currently SGS Laboratories in Burnaby, BC) for rinse pH, the full suite of ABA analyses, solid phase element determination by aqua regia digestion and Shake Flask Extraction (SFE). The full list of parameters to be measured for the laboratory duplicates are listed in Table 1.
- Laboratory duplicate QA/QC samples are to be submitted for the same parameters as the primary samples.
- A completed COC form is to be shipped with the samples and an electronic version sent via e-mail to the accredited laboratory and any other appropriate parties. An example COC is provided in Appendix I.

5. **Documents and Records**
   - Update the underground ARD master sampling file on a quarterly basis, at minimum, and send to the Environmental Manager or Designate for review.
6. **Data tracking and analysis**
   - Data will be compiled and evaluated by a Geochemist or Qualified Professional.
   - If exceedances of threshold limits or triggers as defined in the ML/ARD Management Plan occur, then the Environmental Manager and the Mine Manager must be informed, and actions outlined in the ML/ARD Management Plan must be taken.

Figure 1 – Field Notes

Sample ID	Date Collected	Lithology	Heading Name	Composite Collected From	Description

Table 1 – Analytical Parameters

ABA Analyses	Metals by Aqua Regia					Shake Flask Extraction			
Rinse pH	Ag	Cu	Mn	Sn	Yb	pH	Ag	Hg	S
Paste pH	Al	Fe	Mo	Sr	Zn	Redox	Al	K	Sb
TIC	As	Ga	Na	Ta	Zr	Conductivity	As	Li	Se
CaCO3	Ba	Ge	Nb	Tb		Acidity (to pH 4.5)	Ba	Mg	Sn
C(T)	Be	Hf	Ni	Te		Total Acidity (to pH 8.3)	Be	Mn	Sr
S(T)	Bi	Hg	P	Th		Alkalinity	Bi	Mo	Ti
S(SO4)	Ca	In	Pb	Ti		Chloride	Ca	Na	Tl
S(S-2)	Cd	K	Rb	Tl		Fluoride	Cd	Ni	U
Insoluble S	Ce	La	S	U		Sulphate	Co	P	V
AP	Co	Li	Sb	V		Hardness as CaCO3	Cr	Pb	Zn
Modified NP	Cr	Lu	Sc	W			Cu	Rb	Zr
	Cs	Mg	Se	Y			Fe	S	

Appendix I – Chain of Custody

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\SGS\2018\COC\UG WR\ COC_SGS_UG WR Template.xlsx

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	2300-1055 Dunsmuir St, Four Bentall Centre, PO Box 49334 Vancouver, BC V7X 1L4	
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name:
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis													P.O. Number (if applicable)
	Rinse pH	Shake Flask Extraction	Total Sulphur	Total Inorganic Carbon	Total Carbon	Modified NP	Suphate-sulphur	Sulphide-sulphur	Metals on Solids by ICP-MS					
Underground mine sample (#### to ####)	x	x	x	x	x	x	x	x	x					
Duplicate (first sample of every year and every 20th thereafter)	x	x	x	x	x	x	x	x	x					

CHAIN OF CUSTODY:						
Relinquished by:	Time:	Date:	Received by:	Time:	Date:	
Relinquished by:	Time:	Date:	Received by:	Time:	Date:	

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2015-08-31	Initial Issue		
2018-10-22	Update to Pretivm template		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Environment Superintendent or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 7

Standard Operating Procedure:
Sump Sample Collection

PRETIVM		PVG-ENV-SOP-023 Sump Sampling Underground	
Department: Environment	**Manager/Designate**: Robin McCall	**Revision Number**: 3	**Creation Date**: 2018/06/27 **Revision Date**: 2020/10/06

Objective

To describe the steps required for collection of quarterly water samples from the underground sumps as per the ML/ARD MP.

Scope

This SOP applied to all personnel completing activities related to the collection of samples from underground sumps.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- Back: ceiling of the underground mine.
- BCMDG: British Columbia Mine Design Guidelines.
- COC: Chain of Custody.
- DI water: De-Ionized water.
- DO: Dissolved Oxygen.
- DOC: Dissolved Organic Carbon.
- HDPE: High Density Polyethylene.
- Loose: Rock on the ribs and back of the underground mine that may fall unexpectedly.
- ML/ARD MP: Metal Leaching/ Acid Rock Drainage Management Plan.
- Muck: blasted rock.
- PPE: Personal Protective Equipment incl. hearing protection, boots with meta-tarsal protection, coveralls, W-65 self-rescuer and miners belt.
- QA/QC: Quality Assurance and Quality Control.
- Rib: Vertical wall of the underground mine.
- Slimes: fine-grained sediment generated during mining activities.
- TOC: Total Organic Carbon.
- TSS: Total Suspended Solids.
- VOK: Valley of Kings.
- WZ: West Zone.

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensure this procedure complies with H&S regulation.

The Area Manager or Designate is responsible for:

- Ensure this procedure is followed and sampling is completed on time.

The Worker is responsible for:

- Ensure this procedure is followed for all sump monitoring and sampling.

Preparation

Hazards

- Noise.
- Air quality.
- Unstable ground.
- Loose.
- Unstable slimes.
- Heavy equipment interactions.
- Working near hazardous chemicals.
- Slips, trips, and falls.

Tools

- YSI ProPlus/DSS multi-meter (if available) or Oakton probe.
- Geopump and charged battery.
- Vinyl gloves.
- HDPE Peristaltic tubing.
- Masterflex silicon tubing.
- Waterra cutters.
- Waterra inline filters. (0.45 µm)
- DI water.
- Water-proof markers.
- Sample labels.
- Data sheets.
- Camera.
- Cooler containing sample bottles and preservatives as per Table 1.
- Blue flashing hard hat light.

Requirements

- Trained and qualified to conduct water-quality sampling – review and sign off on this SOP.
- FLHA completed at the job site.
- Underground driver training or chaperone.
- Underground orientation.
- Full underground PPE.

Job Step

1. Arrange Transportation

- Contact the Mine Captain and arrange access to a truck (only if you are trained and signed off to drive underground) or a chaperone.

2. Attend Underground Morning Meeting

- Inform Procon Superintendent that you will be conducting sump sampling and ask that an announcement be made to the miners to be aware of personnel working around the sumps.
- Obtain a copy of the production and development lineups or travel with someone knowledgeable about underground mining.

3. Field Preparation

- Calibrate pH/conductivity meter.
- Collect and label field supplies and place in a cooler with ice packs.
  - Label sample bottles with the date, sample ID and parameters of analysis as provided in Table 1.
  - Samples are labeled by elevation, e.g. “SUMP-1230” for the sump on the 1230 level.
  - Samples are collected at the sumps on 1110, 1170, 1230, 1290, 1380W, and 1410W if water is available.
  - Additional sumps may be added as mine development progresses.
- Prepare one duplicate sample and a field blank sample for every quarterly sample set.
- Add a bottle set for one extra sample to the cooler.

4. Mob to Sump

- Plan order of sample collection to minimize exposure to haul traffic e.g., if a scoop will be working on 1230 in the morning, but not in the afternoon, wait until the afternoon to sample SUMP-1230.

  Note: the mining plan may change over the course of the day so check with Superintendent or Shift Boss.
- **Alert haul traffic to your presence as you arrive at each sump.**
- **Use a hand-held radio to monitor haul truck traffic and be aware that a haul truck may pull into a level unexpectedly.**
- **If sump must be collected on a level with active hauling, use a spotter.**
- **If sampling cannot be conducted safely, do not sample.**
- **Do not walk on slimes as they may liquify.**

5. Collect Sump Sample

- Review BJ-ENV-SOP-028 for general sample collection and handling procedures.
- Set up the peristaltic pump, being careful to keep the tubing and the pump clean**.**
  - Place the pump case on a flat, stable surface near the sump and place the pump and battery on top of the case.
  - Cut an 8” piece of silicon tubing.
  - Cut one 18” piece of HDPE tubing, and a second piece long enough to reach from the pump location to the sump.
  - Attach the HDPE tubing to the silicon tubing and feed the silicon tubing into the pump housing.
  - Ensure the flow is in the correct direction by toggling the flow direction switch.
  - **When selecting a location, be aware that water levels in the sump can change rapidly when pumps cycle on or off.**
- Put on vinyl gloves. Replace gloves if they become contaminated and between each sample.
- The sample should be collected from the ponded sump water, but may be collected from the inflow into the sump if access restricted by presence of slimes.
- When filling bottles, keep end of tubing near surface of sump to minimize entrainment of slimes.
- Fill and preserve (as specified in Table 1) bottles for general parameters, total metals and nutrients.
- Attach waterra inline filter and fill and preserve (as specified in Table 1) bottles for dissolved metals and DOC and total dissolved P.
- Collect measurements of temperature, conductivity and pH using the Oakton probe
- Fill in data sheet (see Appendix I).
- Take a photo of the sump.

6. QA/QC Samples

- Collect one field duplicate by filling a second set of bottles with sump water at a given location, using the filtering and preservation procedures described in Table 1 and Step 5. This sample is identified by -98, e.g., SUMP-1230-98.
- Collect one field blank by filling an additional set of bottles with DI water using the filtering and preservation procedures described in Table 1 and Step 4. This sample is identified by -99, e.g., SUMP-1230-99.
- Collect QA/QC samples on a level with low traffic and/or adequate refuge.

7. Complete COC

- Complete COC as per example in Appendix II.

8. Ship Samples

- Ship samples to the analytical Laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure that the samples arrive at the laboratory <10°C.

Table 1: Sample Volume and Preservation Requirements

Bottle Volume and Type	Field Preservation	Field Filter	Refrigerate (4 °C)	Indicate on Bottle	Parameter(s) to be indicated on COC
500 mL plastic	None	No	Yes	Generals	pH, conductivity, TSS, turbidity, alkalinity, acidity, and anions
60 mL plastic	0.8 mL 1:4 HNO_3 (18%)	No	Yes	Total Metals	Total metals incl. Hg (BCMDG)
60 mL plastic	0.8 mL 1:4 HNO_3 (18%)	Yes	Yes	Dissolved Metals	Dissolved metals incl. Hg (BCMDG)
125 mL amber	1 mL 1:3 H_2SO_4	No	Yes	Nutrients	Phosphate, TOC, T-N, and ammonia
125 mL amber	1 mL 1:3 H_2SO_4	Yes	Yes	DOC and T-Diss-P	DOC and total dissolved P

Appendix I – Data Sheets

File location: J:\Environmental\03 Monitoring Programs\ML-ARD\Underground\Sumps\Sump-Field Parameters.xls

DATE		TIME		SAMPLER	
SUMP ID	FIELD MEASUREMENTS				
	pH	Temp	Conductivity	Dissolved O2	NOTES

Appendix II - COC

File location: J:\Environmental\02 Lab COCs, Results, Spreadsheets, etc\00 CoCs and Results\ALS\Templates\Template_COC_ALS_SUMPS.xls

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -
Page 1 of 1

Report To		**Report Format / Distribution**	**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	**R** ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report ☑ Yes ☐ No	**P** ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked	**E** ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	**E2** ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2 Alison.Shaw@lorax.ca	**Analysis Request**
Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Pretivm (Brucejack Project)	Email 1 or Fax invoices@pretivm.com	
Contact:	Accounts Payable (604-558-1784)	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:		Approver ID: / Cost Center:	
Job #:	Sumps	GL Account: / Routing Code:	
PO / AFE:	1024962	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:** Colleen Atherton

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, conductivity, alkalinity, acidity, TSS, turbidity	Anions-all (Br, Cl, F, NO_3, NO_2, SO_4)	nutrients (T-N, ammonia, and phosphate), TOC	MET-T-BCMDG-VA incl Hg	MET-D-BCMDG-VA incl Hg	DOC and T-diss.-P								Number of Containers
							P	P	F/P	F/P								
	SUMP-1140	9-Apr-18	13:40	water	R	R	R	R	R	R								5

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**	**SAMPLE CONDITION AS RECEIVED (lab use only)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	email 3: environmental@pretivm.com email 4: mholtby@pretivm.com email 5: svanzalingen@pretivm.com email 6: rmccall@pretivm.com	Frozen ☐ SIF Observations Yes ☐ No ☐
Are samples for human drinking water use? ☐ Yes ☑ No		Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐
		Cooling Initiated ☐
		INITIAL COOLER TEMPERATURES °C / FINAL COOLER TEMPERATURES °C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Robin McCall	[redacted]	
Health & Safety Manager / Designate	Rob Geddes		
Mine Manager / Designate	George Friesen		
JOHSC Co-chair or Member	Brittany Moore		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Initial Issue			2015/08/31
Update to PVG format		All	2018/06/27
Reduce number of sample locations		2-3	2019/09/11
Added roles and responsibilities		1	2020/10/06

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Appendix 8

Standard Operating Procedure:
Seep Inspection and Sample Collection

PRETIVM		PVG-ENV-SOP-022 Seep Monitoring	
Department: Environment	**Manager/Designate**: Robin McCall	**Revision Number**: 2	**Creation Date**: 2018-06-27 **Revision Date**: 2020/10/06

Objective

To describe the steps required for collection of quarterly water samples from the underground seeps as per the ML/ARD MP.

Scope

All activities related to the monitoring of underground seeps.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- Back: ceiling of the underground mine
- BCMDG: British Columbia Mine Design Guidelines
- DI water: De-Ionized water
- DO: Dissolved Oxygen
- DOC: Dissolved Organic Carbon
- COC: Chain of Custody
- Cross cut: drive off main level developed to access stopes.
- Loose: Rock on the ribs and back of the underground mine that may fall unexpectedly
- ML/ARD: Metal Leaching/ Acid Rock Drainage
- Muck: blasted rock
- PPE: Personal Protective Equipment incl. hearing protection, boots with meta-tarsal protection, coveralls, W-65 self-rescuer and miners belt
- QA/QC: Quality Assurance and Quality Control
- Rib: Vertical wall of the underground mine
- Shifter: underground supervisor
- Slimes: fine-grained sediment generated during mining activities
- TOC: Total Organic Carbon
- TSS: Total Suspended Solids
- VOK: Valley of Kings
- WZ: West Zone

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensure this procedure complies with H&S regulation.

The Area Manager or Designate is responsible for:

- Ensure this procedure is followed and sampling is completed on time.

The Worker is responsible for:

- Ensure this procedure is followed for all seep monitoring and sampling.

Preparation

Hazards

- Noise
- Air quality
- Unstable ground
- Loose
- Unstable slimes
- Heavy equipment interactions
- Working near hazardous chemicals
- Slips, trips, and falls

Tools

- pH probe
- 4 L plastic beaker
- Vinyl gloves
- 0.45 µm syringes filters and syringes
- Sample bottles as per Table 1
- Aluminum seep tags
- Hammer
- Flagging tape
- Seep maps
- DI water
- Water-proof markers
- Sample labels
- Data sheets
- Camera
- Cooler containing sample bottles and preservatives as per Table 1
- Blue flashing hard hat light
- Hand-held radio with underground channels

Requirements

- Trained and qualified to conduct water-quality sampling
- Underground orientation (visitor or full)

Job Step

1. Preparation

- Contact the Mine Captain and arrange access to truck (only if you are certified to drive underground) or transportation.
- Obtain the most recent seep location figures from the Geochemist.
- Review locations of known acidic seeps (Table 2).
- Prepare the seep sampling and reconnaissance plan.

2. Attend Underground Morning Meeting

- Obtain a copy of the production and development lineups or travel with someone knowledgeable about underground mining.
- Schedule the order of seep monitoring to minimize exposure to haul traffic e.g., if a scoop will be working on 1200 level in the morning, but not in the afternoon, schedule 1200 level monitoring for the afternoon.

  Note: the mining plan may change over the course of the day.
- **Do not travel by foot on levels where remote mucking is occurring without first contacting the remote scoop operator (identified by blue flashing light at level access).**

3. Seep Monitoring

- Review BJ-ENV-SOP-028 for general sample collection and handling procedures.
- Consult map of previous seep locations (Appendix I contains maps of seep locations as of October 2019, current seep maps can be found here: J:\Environmental\03 Monitoring Programs\ML-ARD\Underground\Seeps).
- **Be aware of ventilation conditions. Unused cross cuts with no vent tubing are not ventilated. Cross cuts with vent tubing choked off are not ventilated. Do not travel more than 10 m beyond the end of vent tubing in a cross cut.**
- **Main level drives with ventilation raises at the end are ventilated, even if no vent tubing is present.**
- **Monitor known seeps on all portions of accessible level (cross cuts may be inaccessible due to the presence of muck, lack of ventilation or a barricade).**
- **DO NOT cross barricades without authorization from the Shifter.**
- **Authorization to cross a barricade must be obtained each time**.
- When a seep is encountered, evaluate the seep to determine if it is possible to monitor.
  - If the presence of loose makes the area hazardous to monitor, scale the loose if possible, or alert the Shifter to the presence of hazardous conditions.
  - Seeps that flow across vent tubing should not be monitored.
  - Seeps with very low flow rate cannot be monitored.
  - Seeps within 10 m of an open stope will not be monitored.
- Place the 4 L plastic beaker underneath the seep and rinse three times with approximately 15 mL of seep water each time.
- Return the 4 L plastic beaker to the seep and collect enough seep water to rinse the end of the Hanna probe and conduct temperature, pH and conductivity measurements.
- If the pH is <6 and the conductivity is >200 µS/cm, discard the aliquot used for measuring field parameters, and collect 1 L of seep water for a complete sample for laboratory analysis (see Table 1).
- Label each sample with the seep number, e.g., SEEP-001, date and parameters of analysis as provided in Table 1.
- Filter and preserve the sample as indicated in Table 1.
- Fill in the data sheet (see Appendix II). For new seeps, record the seep location and sketch it on the map.
- Take photos of the seep.

4. QA/QC Samples

- Collect one field duplicate for every 10 samples by filling a second set of bottles with seep water at a given locations using the filtering and preservation procedure described in Table 1 and Step 3. This sample is identified by -98, e.g., SEEP-001-98.
- Collect one field blank for every 10 samples by filling an additional set of bottles with DI water at a monitoring station using the filtering and preservation procedure described in Table 1 and Step 3. This sample is identified by -99, e.g., SEEP-001-99.

- Collect QA/QC samples on a level with low traffic and/or adequate refuge.

5. Complete COC

- Complete COC as per example in Appendix III.

6. Ship Samples

- Ship samples to the analytical Laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure the samples arrive at the laboratory <10°C.

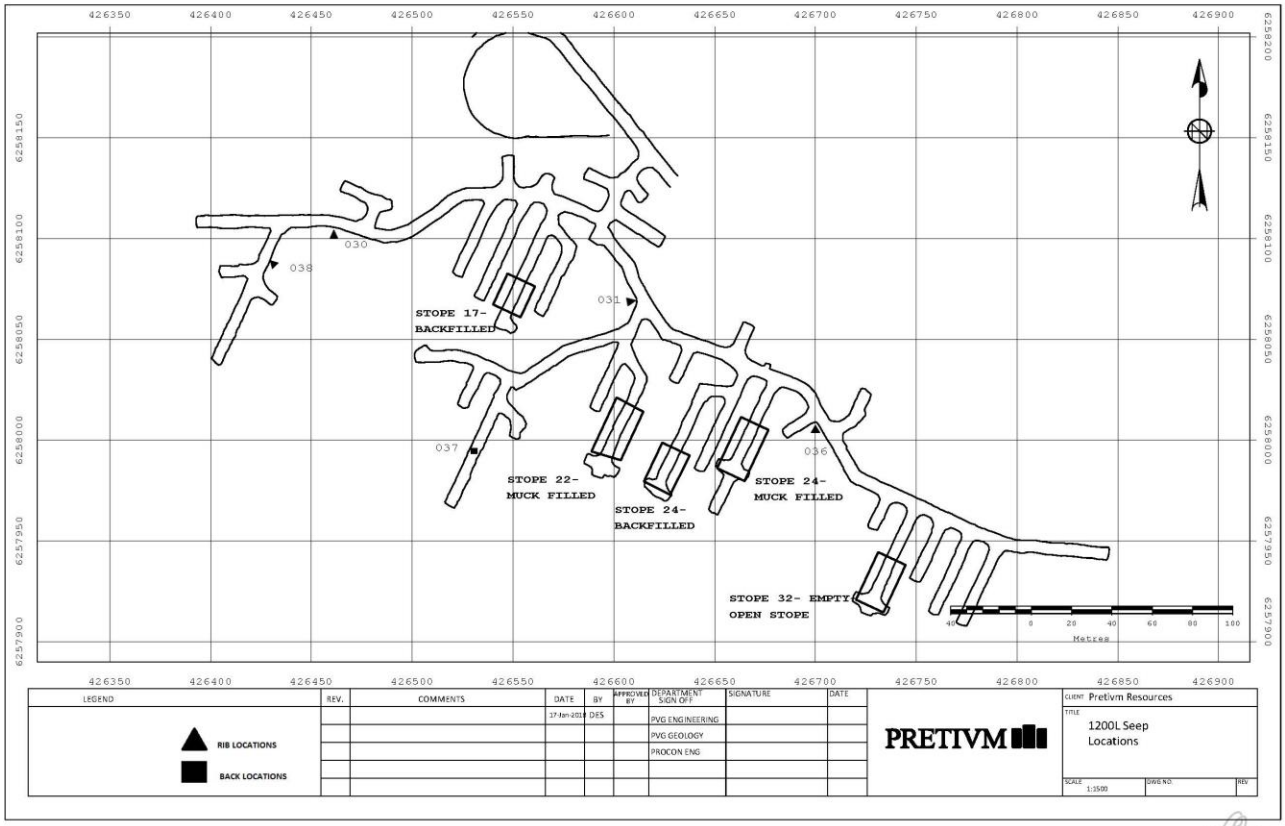
Table 1: Sample Volume and Preservation Requirements

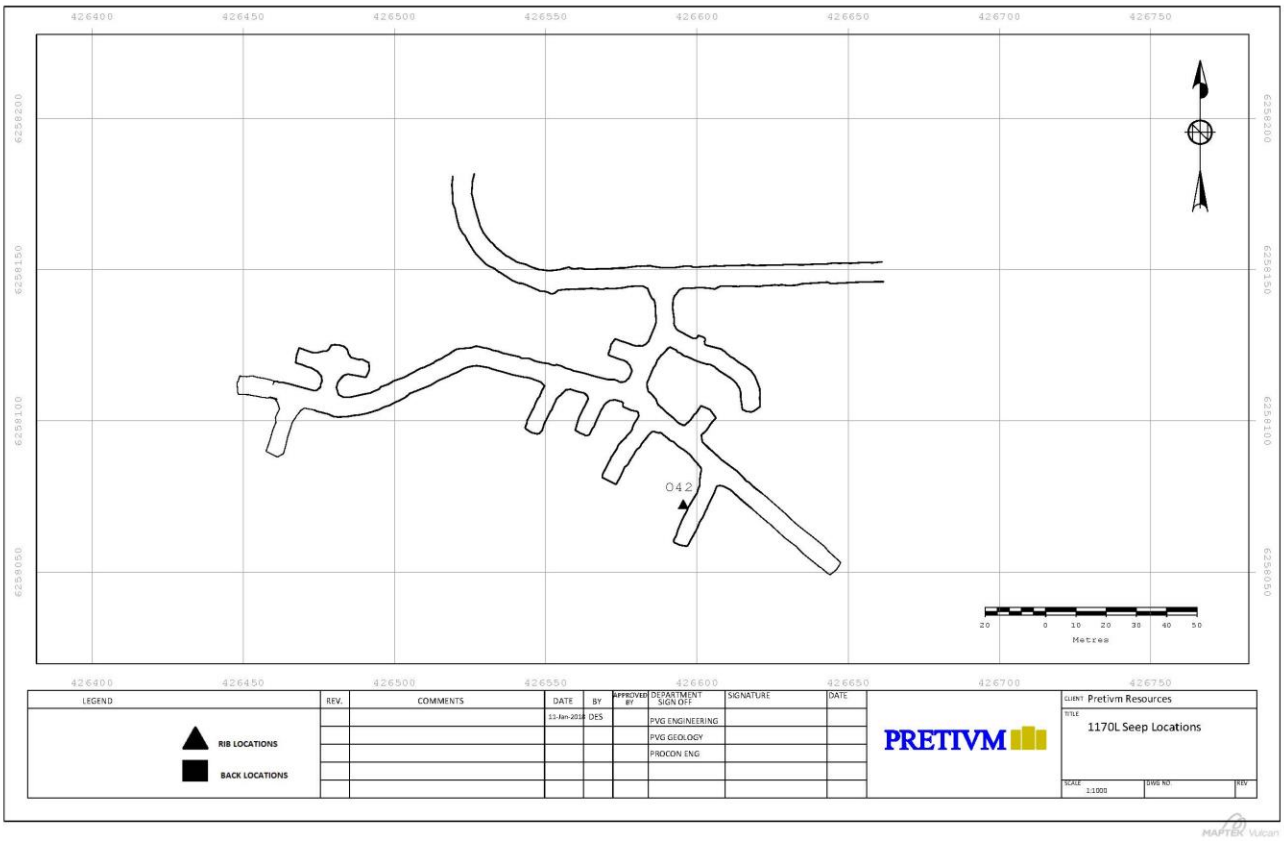
Bottle Volume and Type	Field Preservation	Field Filter	Refrigerate (4 °C)	Indicate on Bottle	Parameter(s) to be indicated on COC
500 mL plastic	None	No	Yes	Generals	pH, conductivity, TSS, turbidity, alkalinity, acidity, and anions
60 mL plastic	0.8 mL 1:4 HNO_3 (18%)	No	Yes	Total Metals	Total metals incl. Hg (BCMDG)
60 mL plastic	0.8 mL 1:4 HNO_3 (18%)	Yes	Yes	Dissolved Metals	Dissolved metals incl. Hg (BCMDG)
125 mL amber	1 mL 1:3 H_2SO_4	No	Yes	Nutrients	Phosphate, TOC, T-N, and ammonia
125 mL amber	1 mL 1:3 H_2SO_4	Yes	Yes	DOC and T-Diss-P	DOC and total dissolved P

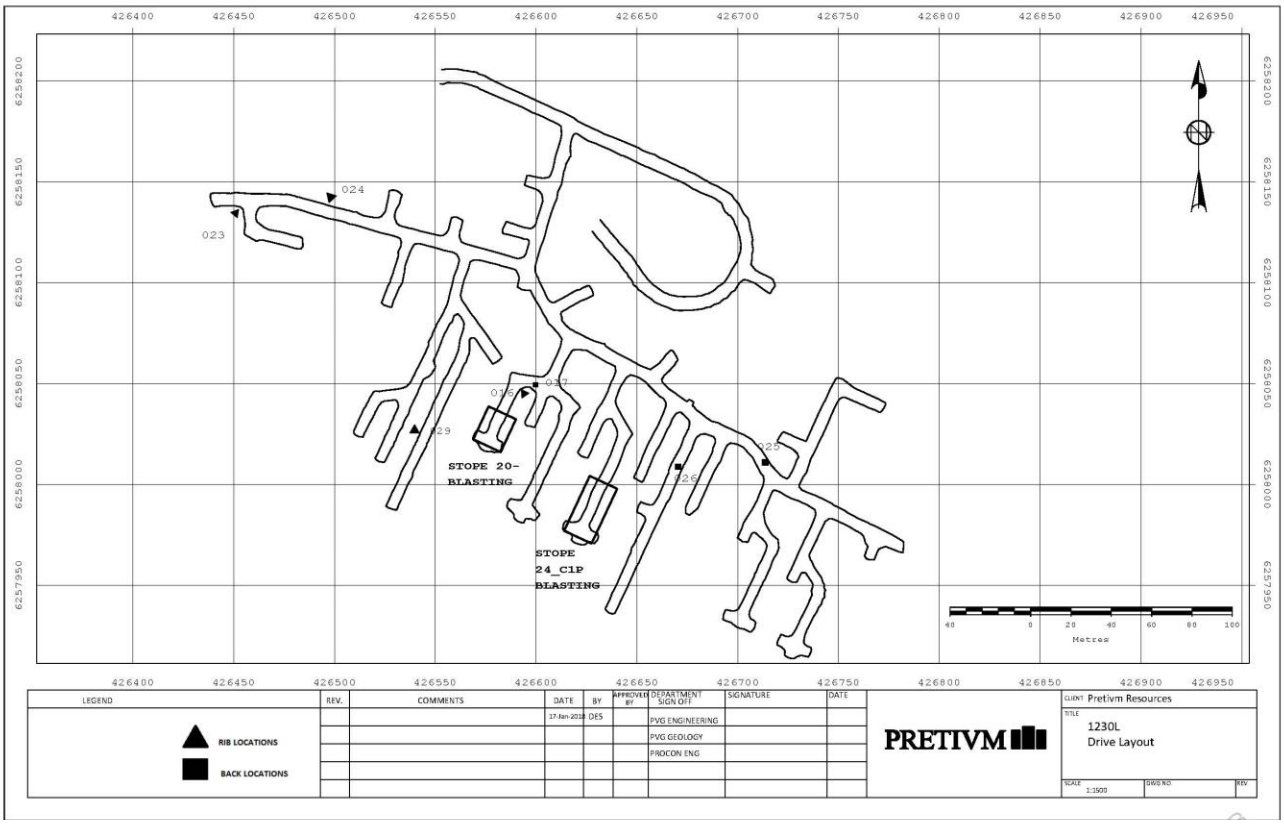
Table 2: Known Acidic Seep Locations

Seep No.	Level	Location	Description
Seep-007	1380-22	Borehole on back, located 7 m into XC	Decrease from original pH of 7.9 and increase in Fe oxide precipitation since first observation in 2016.
Seep-044	1350-25	Borehole on back, located 12 m into XC	Borehole was grouted between initial observation in 2018 and subsequent monitoring in 2019. pH of seep increased from 4.6 to 8.0 following grout application. BH drilled in 2011, maximum distance to breakthrough on 1410 is 80 m.
Seep-053	VOK Portal	Multiple boreholes on face	Located in cutout on west side of VOK portal near doors. Extensive Fe oxide precipitation generated from multiple flowing boreholes
Seep-054	1320-12	Fracture on rib, located ~140 m into XC	Two well developed areas of Fe oxide precipitation, sample collected from the smaller area with no interference from bolt.
Seep-055	1320-W	Borehole on back, located ~25 m from level access	Minimal Fe oxide precipitation. Slow flow observed during initial sample collection (~100 mL/min).
Seep-056	1410-E	Borehole on back, located at intersection with XC12	Moderate Fe oxide precipitation, moderate flow observed during initial sample collection.

Appendix I – Seep Location Maps



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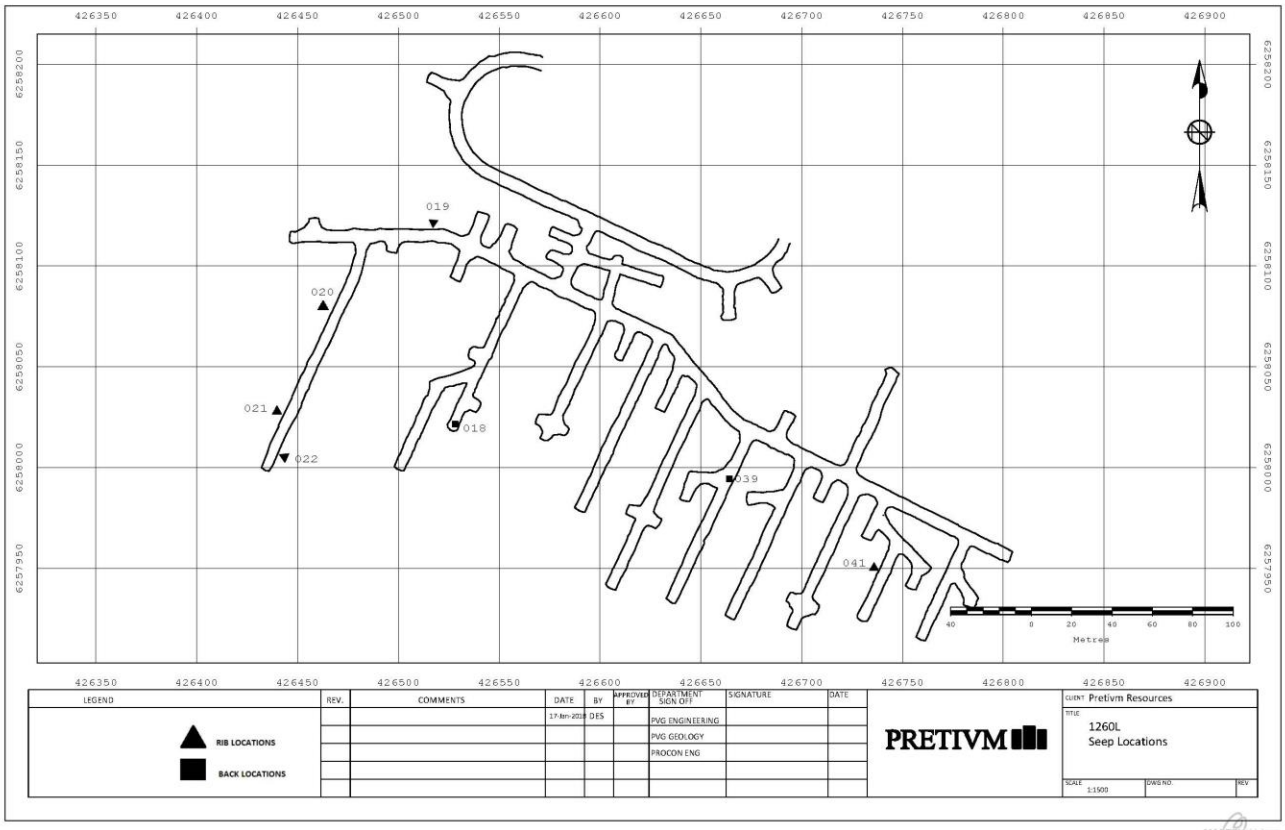
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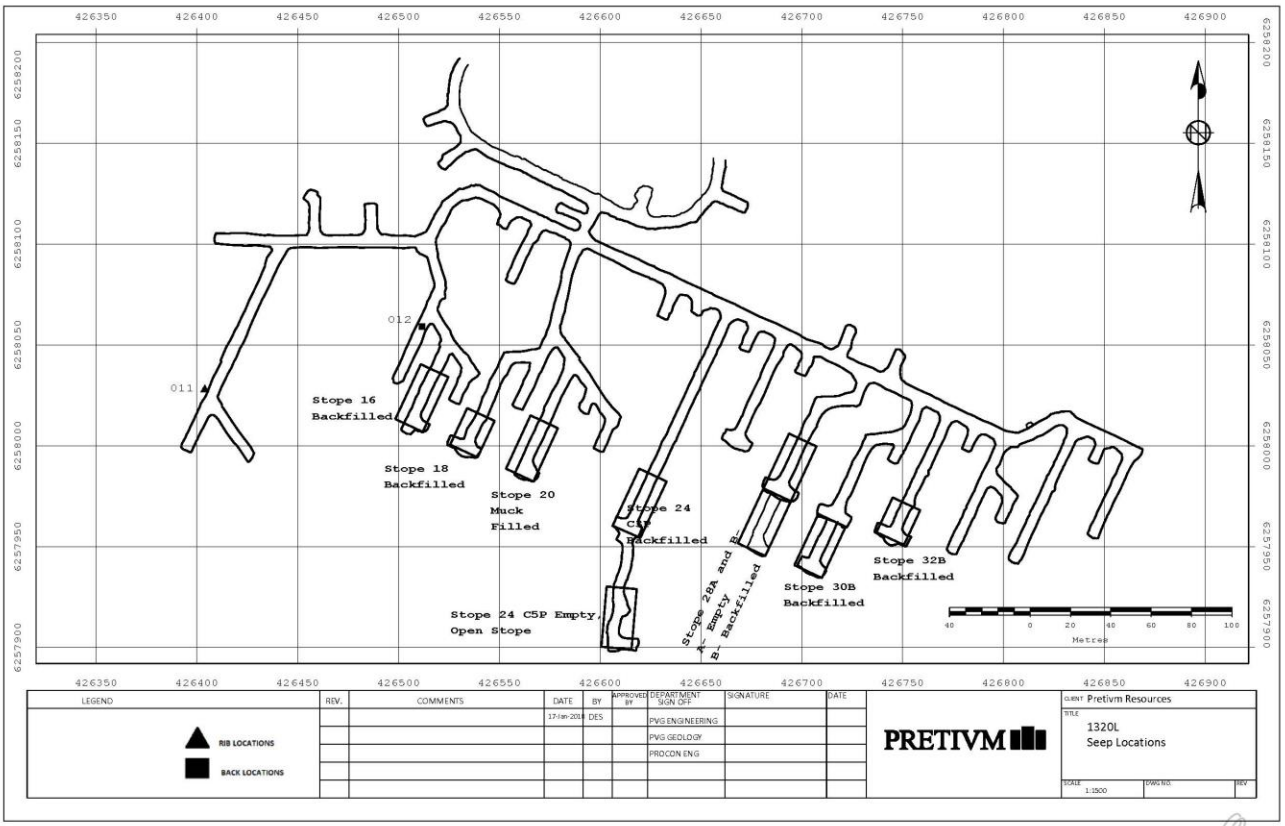
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Stope 28A and B
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B- Backfilled
Stope 30B
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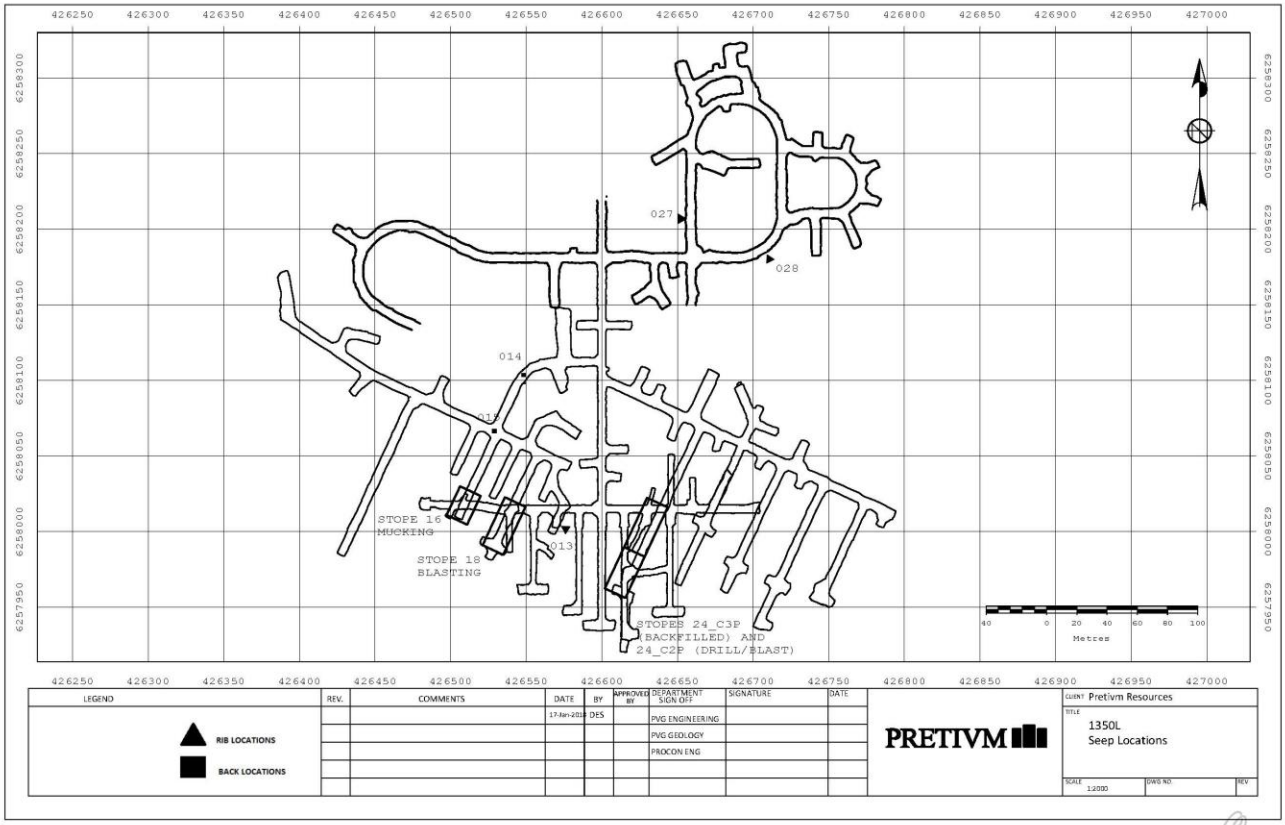
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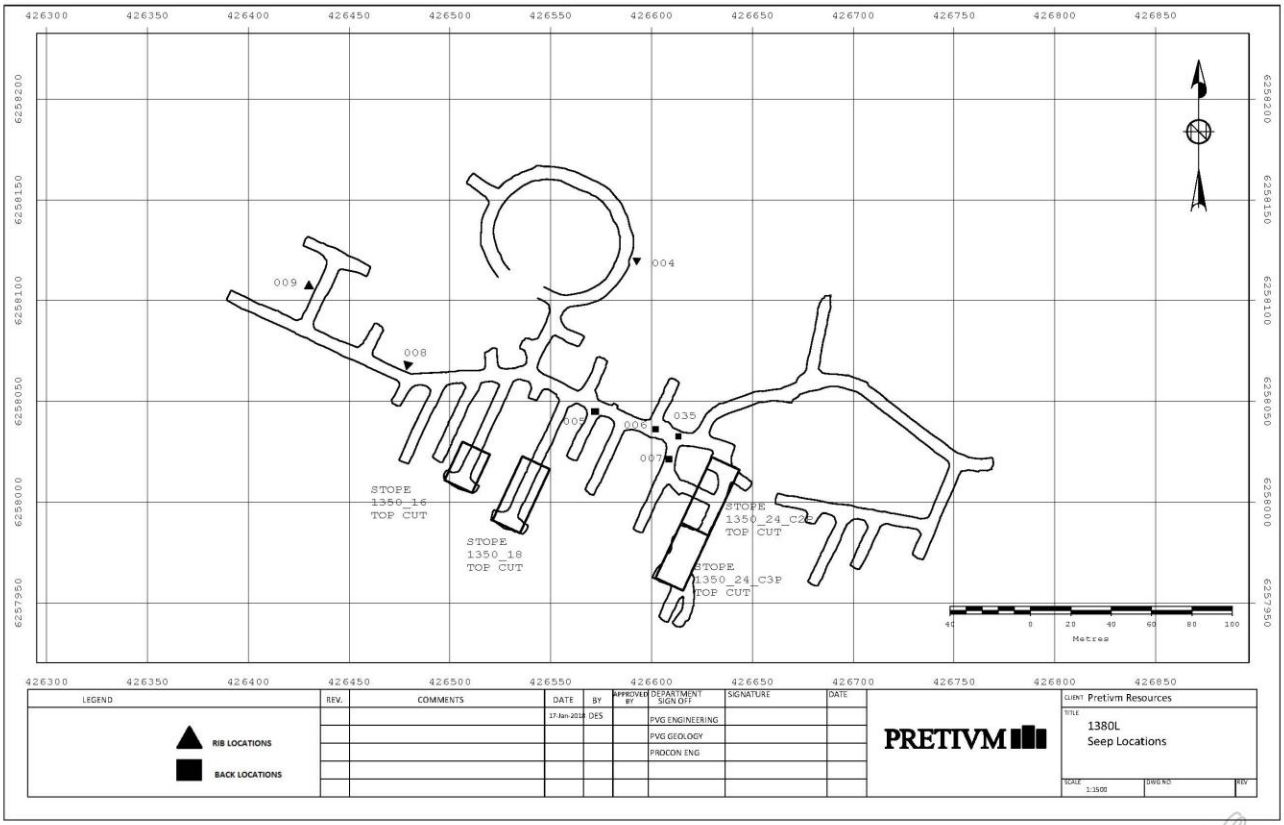
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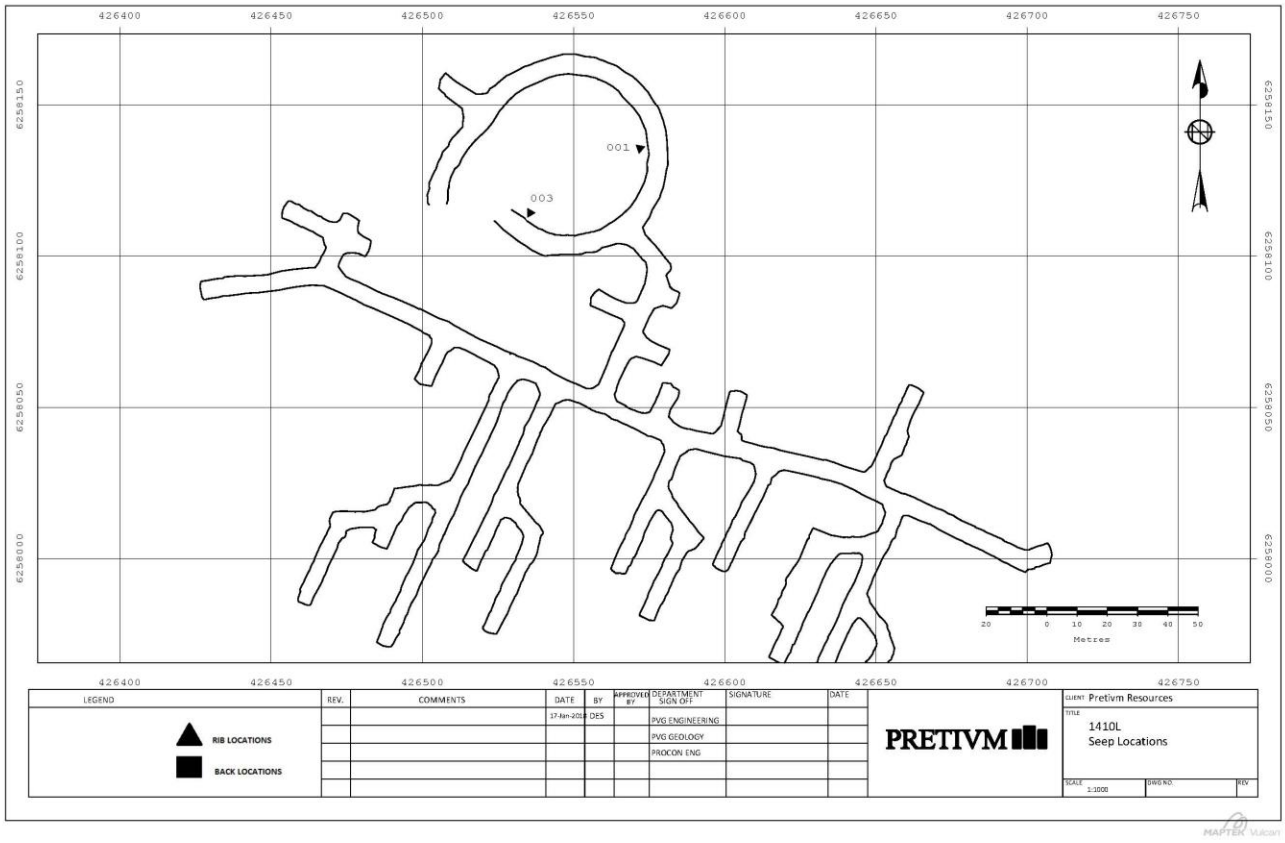
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PVG ENGINEERING
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PROCON ENG
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CLIENT Pretivm Resources
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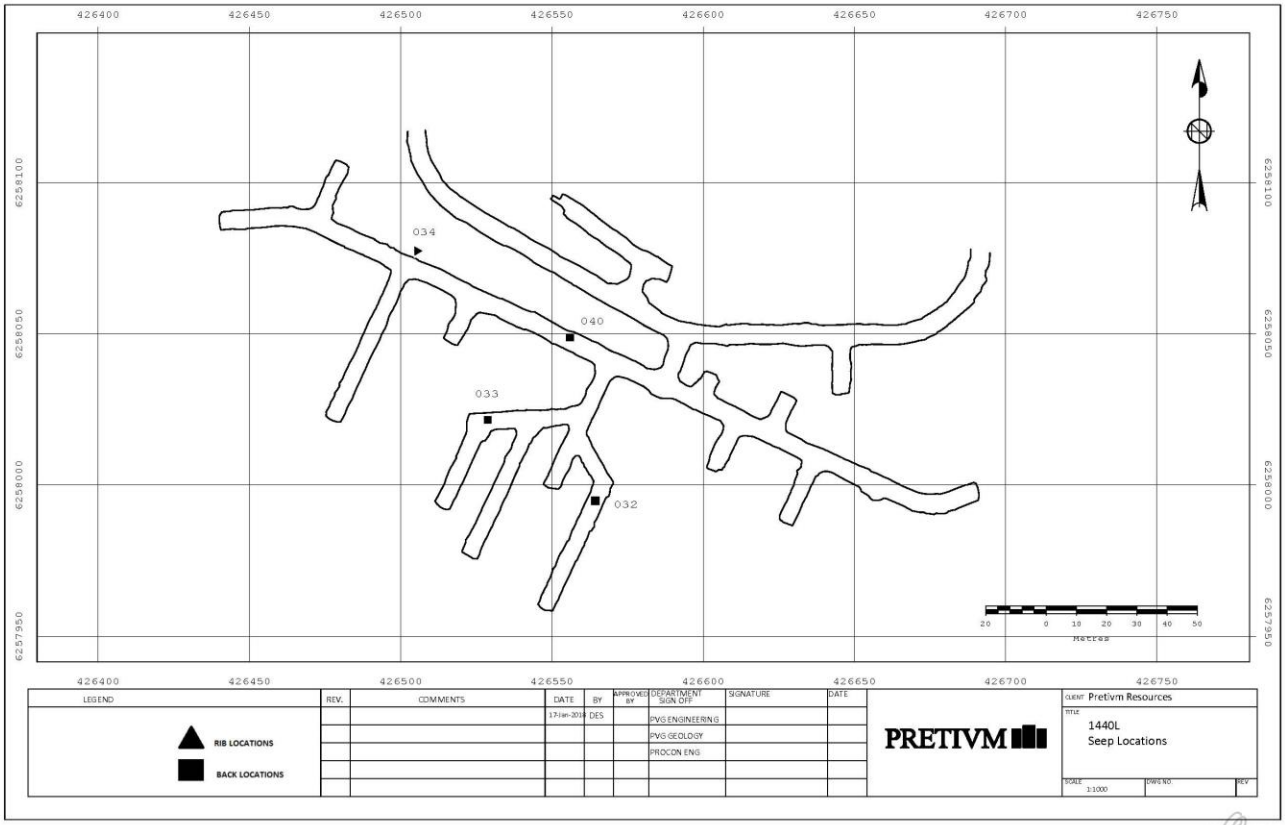
DWG NO.
REV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PVG GEOLOGY
PROCON ENG.
PRETIVM
CLIENT Pretivm Resources
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REV

Appendix II – Data Sheets

File location: J:\Environmental\03 Monitoring Programs\ML-ARD\Underground\Seeps\SEEP_MASTER.xls

DATE		SAMPLER		HANNA CAL?		Y/N	
TAG ID	STAINING	FLOW RATE	ORIGIN (BH/BACK/RIB)	NEW/OLD	pH	EC	NOTES

DATE		SAMPLER					
TAG ID	ZONE	LEVEL	XC	NORTHING	EASTING	ELEVATION	NOTES

Appendix III - COC

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\ALS\Templates\Template_COC_ALS_SEEPS.xls

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -

Page 1 of 1

Report To		**Report Format / Distribution**		**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format:	☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax	catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2	Alison.Shaw@lorax.ca	

Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**	
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
Company:	Pretivm (Brucejack Project)	Email 1 or Fax	invoices@pretivm.com
Contact:	Accounts Payable (604-558-1784)	Email 2	

Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	Sumps	GL Account:	Routing Code:
PO / AFE:	1025612	Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only)		**ALS Contact:**	**Dean Watt**	**Sampler:**	Colleen Atherton

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, conductivity, alkalinity, acidity, TSS, turbidity	Anions-all (Br, Cl, F, NO_2, NO_3, SO_4)	nutrients (T-N, ammonia, and phosphate), TOC	MET-T-BCMDG-VA incl Hg	MET-D-BCMDG-VA incl Hg	DOC and T-diss.-P	Number of Containers
					P		P	P	F/P	F/P	
	SEEP-001			water	R	R	R	R	R	R	5

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	email 3: environmental@pretivm.com email 4: mholtby@pretivm.com email 5: svanzalingen@pretivm.com email 6: rmccall@pretivm.com
Are samples for human drinking water use? ☐ Yes ☑ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐		SIF Observations	Yes ☐	No	☐
Ice packs	Yes ☐	No ☐	Custody seal intact	Yes ☐	No	☐
Cooling Initiated	☐					

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326e v09 Front 04-January-2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Robin McCall	[redacted]	
Health & Safety Manager / Designate	Rob Geddes		
Mine Manager / Designate	George Friesen		
JOHSC Co-chair or Member	Brittany Moore		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Update seep location maps, add table of known acidic seeps		Multiple	2019/09/11
Added roles and responsibilities		1	2020/10/06

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Appendix 9

Standard Operating Procedure:
Mine Wall Washing Water Quality Sampling

PRETIVM		PVG-ENV-SOP-038 Mine Wall Washing Water Quality Sampling	
Department: Environment	**Manager/Designate**: Robin McCall	**Revision Number**: 3	**Creation Date**: 2017/09/29 **Revision Date**: 2020/10/06

Objective

To provide guidance for collection of water quality samples and solid phase surface products from underground walls as well as bulk samples of muck from underground floors.

Scope

All activities related to the collection of sediment samples and water quality samples associated with mine wall washing stations. This includes sample collection protocols, collection of field measurements, quality assurance and quality control (QA/QC) requirements, shipping and handling details, completion and verification of chain of custody (COC) form and analytical parameters, communications with the analytical laboratories and documentation of field measurements and notes.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- BCMDG: British Columbia Mine Design Guideline (i.e. cost-effective low-level detection limits)
- DI water: De-ionized water
- DO: Dissolved Oxygen
- ML/ARD: Metal Leaching/ Acid Rock Drainage
- QA/QC: Quality Assurance and Quality Control
- QP: Qualified Professional
- PPE: Personal Protective Equipment
- TSS: Total Suspended Solids
- VOK: Valley of the Kings

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensure this procedure complies with H&S regulation.

The Area Manager or Designate is responsible for:

- Ensure this procedure is followed and compliance sampling is completed on time.

The Worker is responsible for:

- Ensure this procedure is followed for all mine wall station sampling.

Preparation

Hazards

- Slips and falls

- Working in areas where explosives are being utilized
- Noise
- Heavy equipment interactions
- Loose
- Poor air quality
- Working near hazardous chemicals

Tools

- PPE
- Powderless vinyl gloves
- Camera
- Hand lens
- Field book/ pencil
- Sample bags (small whirlpak and large poly)
- Sample tags
- Zip ties
- Measuring tape
- Rock hammer/ scraping tool
- Collection paper
- Grubbing tool
- Water sample bottles and preservative as per Table 1 (one set per site)
- 1000 mL plastic beaker
- Squeeze bottle with graduated volume
- pH/conductivity meter
- waterproof markers
- disposable syringes (one per site plus spares)
- disposable 0.45 µm disc filters (10 per site)
- 1 L of DI water (per site)
- Cooler with ice packs
- Water quality sample labels
- COC form

Requirements

- Trained and qualified to conduct sediment and water quality sampling
- Knowledge of wall washing monitoring program
- Underground driver training or chaperone
- Underground orientation (visitor or full)

Job Step

Monitoring of each wall washing station will occur annually.

1. Inspection and maintenance

- Wall washing station locations are shown in Appendix I.
- An example of a wall washing station is provided as Figure 1.
- Wall washing experiments will be conducted on an annual basis. It is recommended that each station be inspected occasionally between sampling events, and at a minimum two weeks before the scheduled sampling so that any necessary repairs can be completed well before the sampling event.

- Inspect the station for loose edging and broken seals against the rock.
- Repair any problems immediately to avoid losing wall wash water through broken seals.
- Record a note if any condensation is observed and if any water may have condensed and trickled out of the station between sampling events.
- Report any issues or concerns with the station set-up to the QP. Report all repairs and possible loss of sample to the QP.

2. Field preparation

- Review BJ-ENV-SOP-028 if necessary.
- In the lab, calibrate pH/ conductivity meter according to instructions included with the probe.
- Ensure graduated volumes are still visible on the squeeze bottle and collection container.
- Prepare water sample bottles by using the provided labels to label the bottles with Date, Sample ID (see Table 2) and parameters of analysis (see Table 1)
- Collect ice packs and water sample supplies and place in the cooler.
- Collect field supplies for solids sample collection.

3. Collection of floor sediments

- Put on gloves.
- Using the grubber, dig a small pit in the sediments accumulated on the floor below the wall washing station. Dig until bedrock is encountered and measure the depth of the muck.
- Record information about the muck in your field book such as depth to bedrock, visible differences, sample tag ID, any large cobbles removed from sample and photo number.
- Collect a 5 kg composite sample of the entire profile depth and place in a sample bag with a sample tag.

4. Collection of surface products

- Put on new vinyl gloves.
- Inspect the wall surface outside of the isolated rock surface for any surface alteration phases.
- Using a clean scraping tool, scrape the wall rock to remove surface products. A minimum of 10 g is required. Collect scrapings on a piece of paper held below the location being scraped. This sample will be limited therefore it is imperative that there is no loss of sample. Gently funnel the collected products into a small whirlpak bag.
- Add a sample ID tag to the bag and identify the sample location on the sample ID. Indicate the Sample ID, station and time of collection in your field book.
- Record any observations about the sample or section of wall from which the sample was removed (e.g., colour and size of surface phase, obvious concentrated sulphides on wall in proximity to sample, etc.).
- Photograph any visible oxidation products.
- Surface products may not be visible or may not be present in the early stages of mine development and wall exposure. If after five years of exposure no products are visible, the QP should be informed and a sample collection attempted.

5. Wall washing procedure and sample collection

- Two people are required for this task.
- Put on new vinyl gloves before collecting sample.
- Carefully remove the plastic sheet and place it somewhere clean and dry.
- Record any condensation that has accumulated or trickled out of the station.
- Using DI water and the squeeze bottle, rinse away any solid products that have accumulated on the lower trough.
- After cleaning the trough, prepare to rinse the wall surface with 500 mL of DI water. Place the 1000 mL beaker at the downstream end of the lower trough to catch rinse water. It is important to catch all rinse water in the collection container.

- With the squeeze bottle, carefully spray 500 mL over the entire isolated rock surface to rinse the area thoroughly.
    - Begin at the top and methodically move across the area in a uniform manner.
    - Ensure that the entire area is wetted with water.
    - Gently squeeze the water onto the surface to avoid water spray outside of the target area.
- Fill the collection container by holding the bottle below, or within, the drip without allowing the mouth of the container to come in contact with the plastic edging or the rib.
- Record the volume of water sprayed on the rock and the amount of water recovered in the collection container. Note any areas where water escaped the target area through fractures or damaged edging.
- Record the volume of particulate that settles on the bottom of the collection container.
- If insufficient rinsate is recovered to fill all sample bottles, fill the bottle for dissolved metals, and put a minimum of 100 mL in each of the other two bottles. Inform the QP if there is not enough rinsate to meet this requirement. The volume of DI water applied to the area may need to be revised.
- Put on a new pair of gloves.
    - Fill the water sample bottles in the order identified in Table 1.
    - Filter and preserve the sample as indicated in Table 1.
- If there is sufficient sample remaining in the collection container, measure the pH, temperature and conductivity with the pH/ conductivity probe.
- Take a photo of the wall washing station.
- Record any pertinent notes in your field book.
- Collect the QA/QC sample described in Section 6.
- Reattach the plastic sheet to the perimeter edging with the metal or plastic clasps, ensuring the plastic sheet does not touch the rock surface. The plastic cover prevents spray and groundwater infiltration from reaching the isolated rock surface and contaminating or rinsing the surface.

6. Description of QA/QC sample

- Prepare a field blank using DI water.
- Fill a set of three bottles with DI water during sampling of one of the wall washing stations. This sample should be collected by pouring DI water into the syringe and filtering and preserving the bottles in the same manner as described for the rinsate.
- Label these bottles as MW-#-99, where the # refers to the station location where the sample was collected, e.g., MW-VSF-1-99.

7. Shipping and analytical parameters

- All water quality samples are to be shipped via courier to an accredited laboratory (currently ALS Laboratories in Burnaby) immediately after collection for analysis of the parameters listed in Table 1. The address for the lab is provided in Appendix II.
- All floor sediment samples and surface product samples are to be shipped to an accredited laboratory (currently SGS Laboratories in Burnaby) immediately after collection. The address for the lab is provided in Appendix III.
- All floor sediment samples are to be analyzed for the parameters listed in Table 3, below.
- All surface product samples are to be analyzed using Rietveld Refined X-ray Diffraction.
- A completed COC form is to be shipped with all samples and an electronic version send via email to the accredited laboratory and any other appropriate parties (such as QP) communicating that the samples are in transit.

8. Data tracking and analysis

- Data will be compiled and evaluated by the Environmental Manager or Designate

Figure 1: Example of Wall Washing Station Covered by Plastic Sheeting

Table 1: Summary of Bottles, Preservation and Analytical Parameters for Water Quality Samples

Bottle and Volume	Field Preservation	Field Filter	Refrigerate (4°C)	Indicated on Bottle	Parameters
60 mL plastic	HNO_3	Yes	Yes	Dissolved Metals	Dissolved Metals (BCMDG)
125 mL amber glass	H_2SO_4	No	Yes	Nutrients	Total ammonia and total nitrogen
250 mL plastic	None	No	Yes	General Chemistry	pH, conductivity, alkalinity (bicarbonate, carbonate, hydroxide), acidity, anions (Cl, F, SO4, NO2-N and NO3-N)

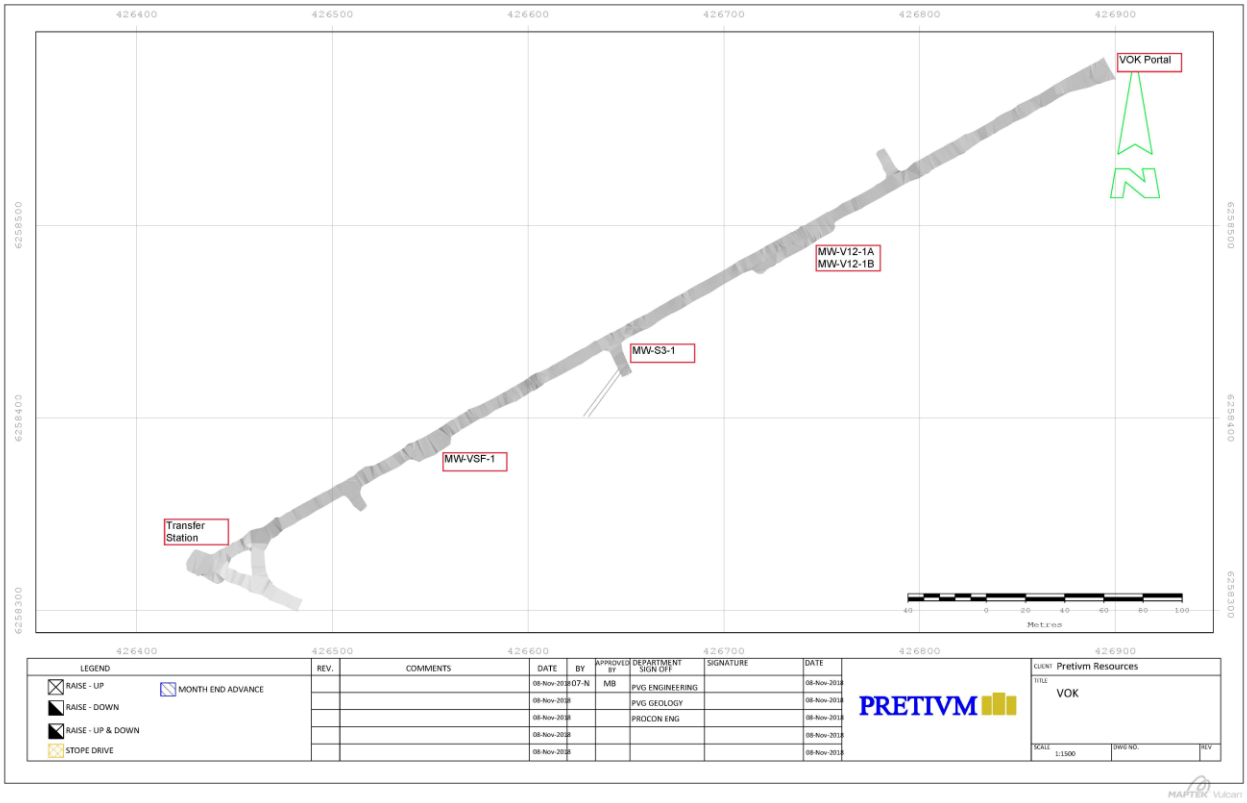
Table 2: Wall Washing Station IDs and Geologic Waste Rock Units

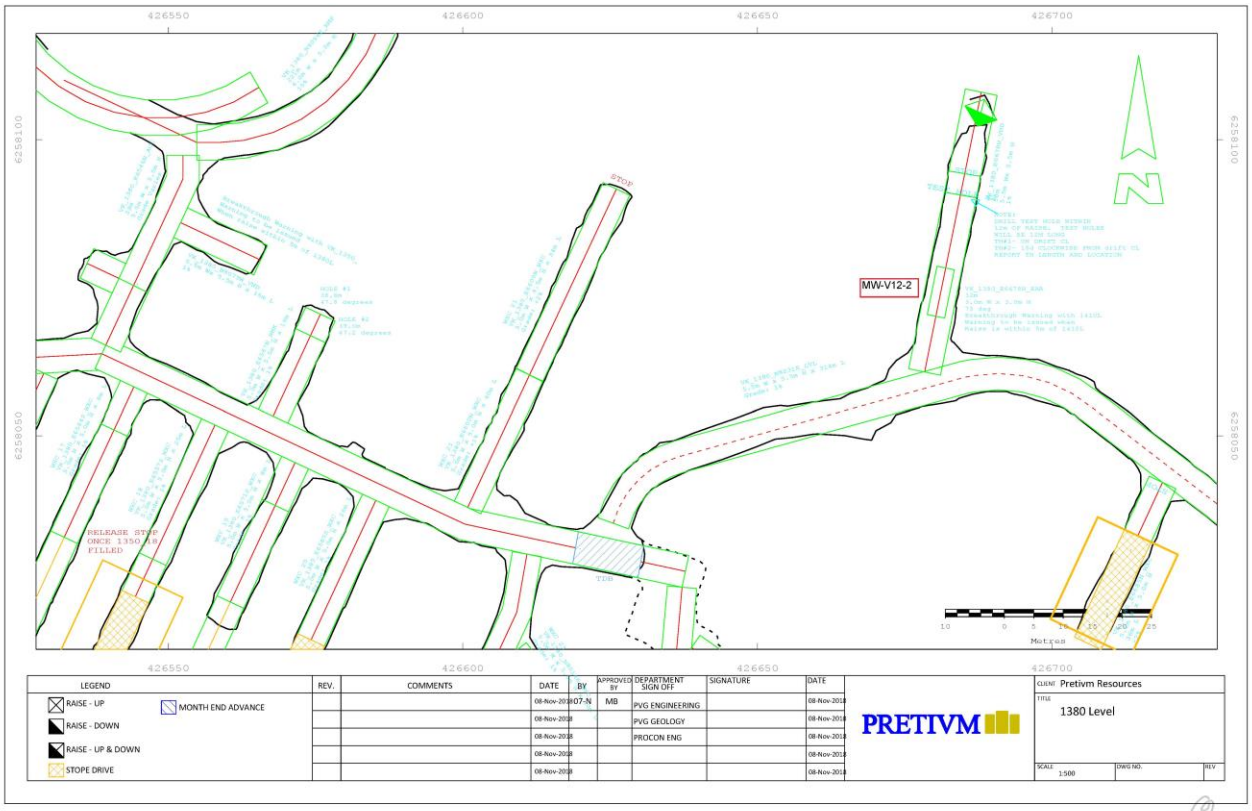
Underground Model Unit	No. to be Established	Location Description	Station ID
Fragmental (V12)	3	VOK Access Ramp Bypass 1	MW-V12-1A
		VOK Access Ramp Bypass 1	MW-V12-1B (destroyed)
		1380 VND E	MW-V12-2
Volcanic Sedimentary Facies (VSF)	2	VOK Access Ramp Bypass 2	MW-VSF-1
		1260 Escape Way	MW-VSF-2
Conglomerate (S3)	1	VOK Access Ramp Paste Cutout	MW-S3-1
Porphyry (Bridge P1)	1	TBD	MW-BP1-1

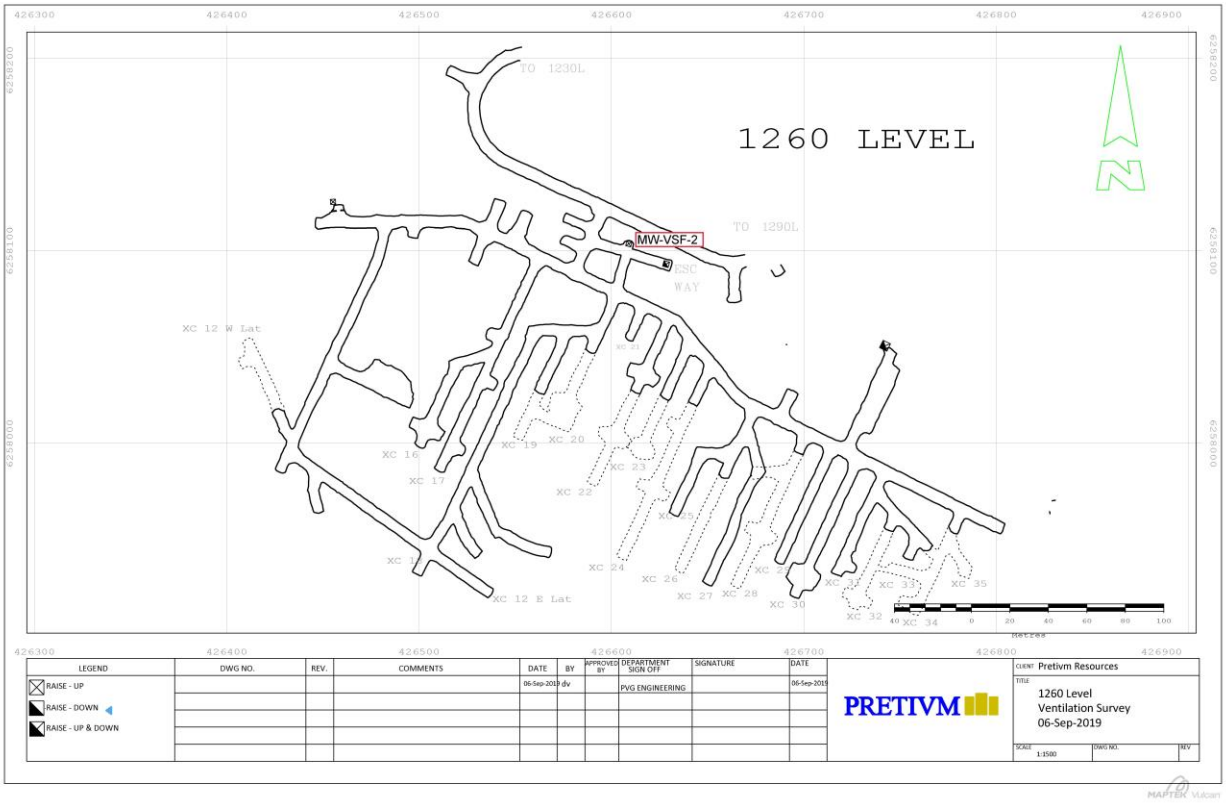
Table 3: Analytical Parameters for Floor Sediment Samples

ABA	Solid Phase Metals					Shake Flask Extraction			
Rinse pH	Ag	Cs	Lu	Sb	V	pH	Ag	Hg	Sb
Paste pH	Al	Cu	Mg	Se	W	Redox	Al	K	Se
TIC	As	Fe	Mn	Sn	Y	Conductivity	As	Li	Sn
T-C	Ba	Ga	Mo	Sr	Zn	Acidity (to pH 4.5)	Ba	Mg	Sr
T-S	Be	Ge	Na	Ta	Zr	Total Acidity (to pH 8.5	Be	Mn	Ti
$S(SO_4)$	Bi	Hf	Nb	Tb		Total Alkalinity	Bi	Mo	Tl
$S(S^{-2})$	Ca	Hg	Ni	Te		Chloride	Ca	Na	U
Insoluble S	Cd	In	P	Th		Fluoride	Cd	Ni	V
AP	Ce	K	Pb	Ti		Suphate	Co	P	Zn
Modified NP	Co	La	Rb	Tl		Nitrite-N	Cr	Pb	Zr
Fizz Test	Cr	Li	S	U		Nitrate-N	Cu	Rb	
						Ammonia-N			
						Total-N			
						Hardness as $CaCO_3$	Fe	S	

Appendix I – Sampling Locations



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XC 22
XC 23
XC 24
XC 26
XC 27
XC 28
XC 30
XC 32
XC 33
XC 34
XC 35
LEGEND
RAISE - UP
RAISE - DOWN
RAISE - UP & DOWN
DWG NO.
REV.
COMMENTS
DATE
BY
APPROVED BY
DEPARTMENT SIGN OFF
SIGNATURE
06-Sep-2019
dv
PVG ENGINEERING
PRETIVM
CLIENT Pretivm Resources
TITLE
1260 Level
Ventilation Survey
06-Sep-2019
SCALE 1:1500
DWG NO.
REV

Appendix II – ALS COC

File Location: J:\Environmental\02 Lab COCs, Results, Spreadsheets, etc\00 CoCs and Results\ALS\Templates\Template_COC_ALS_Wall Wash Stn

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -

Page 1 of 1

Report To		**Report Format / Distribution**		**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format:	☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax	catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2	Alison.Shaw@lorax.ca	**Analysis Request**
Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**		Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Pretivm (Brucejack Project)	Email 1 or Fax	invoices@pretivm.com	
Contact:	Accounts Payable (604-558-1784)	Email 2		
Project Information		**Oil and Gas Required Fields (client use)**		
ALS Quote #:		Approver ID:	Cost Center:	
Job #:	Mine Wall Washing Stn	GL Account:	Routing Code:	
PO / AFE:	1024962	Activity Code:		
LSD:		Location:		
ALS Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:**	

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	pH, conductivity, alkalinity (bicarb, carbonate, hydroxide), acidity	Anions (Cl, F, NO_2, NO_3, SO_4)	Total ammonia and total nitrogen	MET-D-BCMDG-VA incl Hg									Number of Containers
							P	F/P									
	MW-V12-1A			water	R	R	R	R									3
	etc.																

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**	**SAMPLE CONDITION AS RECEIVED (lab use only)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	email 3: environmental@pretivm.com email 4: mholtby@pretivm.com email 5: svanzalingen@pretivm.com email 6: rmccall@pretivm.com	Frozen ☐ SIF Observations Yes ☐ No ☐
Are samples for human drinking water use? ☐ Yes ☑ No		Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐
		Cooling Initiated ☐
		INITIAL COOLER TEMPERATURES °C / FINAL COOLER TEMPERATURES °C

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326e v09 Front 04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Appendix III – SGS COC

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\SGS\2018\COC\Wall Stations

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	2300-1055 Dunsmuir St, Four Bentall Centre, PO Box 49334 Vancouver, BC V7X 1L4	
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name:
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis													P.O. Number (if applicable)
	Paste pH	Rinse pH	Total Inorganic Carbon	Total Carbon	Total Sulphur	Sulphate-Sulphur	Sulphide-Sulphur	Modified NP	Metals on Solids by ICP-MS	Shake Flask Extraction	Reitveld Refined X-ray Diffraction			
Floor Sediment Sample IDs	x	x	x	x	x	x	x	x	x	x				
Surface Product Sample IDs											x			SFE Parameters: pH, redox, conductivity, acidity (to pH 4.5), total acidity (to pH 8.3), total alkalinity, anions (Cl, F, SO4, NO2-N, NO3-N, NH3-N, T-N), hardness (as CaCO3), dissolved metal suite.

CHAIN OF CUSTODY:

Relinquished by:	Time:	Date:	Received by:	Time:	Date:
Relinquished by:	Time:	Date:	Received by:	Time:	Date:

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Robin McCall	[redacted]	
Health & Safety Manager / Designate	Rob Geddes		
Mine Manager / Designate	George Friesen		
JOHSC Co-chair or Member	Brittany Moore		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Initial Issue			2017-09-29
Update to Pretivm SOP template, split SOP into Installation and Maintenance.		All	2018-10-23
Update station locations		3, 6, 9	2019-09-12
Added roles and responsibilities		1	2020/10/06

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Appendix 10

Standard Operating Procedure:
Mine Wall Station Installation

PRETIVM		BJ-ENV-SOP-039 Mine Wall Station Installation	
Owner: Colleen Atherton	Approver: Torence Sandhals	Revision Number: 1	Creation Date: Sept 29, 2017 Revision Date: Oct 20, 2018

Objective

To outline the procedure for installing mine wall washing stations.

Scope

Activities related to the installation of mine wall washing stations. For wall washing and sample collection for oxidation minerals and floor sediments, see BJ-ENV-SOP-038

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment

Definitions

- ML/ARD: Metal Leaching/ Acid Rock Drainage
- QP: Qualified Professional
- PPE: Personal Protective Equipment

Preparation

Hazards

- Slips and falls
- Working in areas where explosives are being utilized
- Noise
- Heavy equipment interactions
- Loose
- Poor air quality
- Hand injury

Tools

- PPE
- Powderless vinyl gloves
- Camera
- Hand lens
- Cutting device
- Field book/ pencil
- Measuring tape
- Rock hammer
- Rock drill and drill bits
- 4.5 m of 90°-bent, flexible vinyl stair nosing
- 3 tubes of pure silicon bathroom sealant (must be pure silicon) with applicator gun
- 1.2m by 1.2m piece of clear high-density polyethylene plastic sheeting (preferably 6 mm thickness to prevent tearing)
- 8 black metal alligator clasps often used for holding unbound reports
- Heavy duty scissors or tin snips

- Compass with clinometer
- Brushes
- Shop towels

Requirements

- Knowledge of wall washing monitoring program
- Underground driver training or chaperone
- Underground orientation (visitor or full)

Job Step

Note: The installation of a wall washing station occurs only once to establish the monitoring site. Currently, five stations have been constructed and an additional two stations are proposed for six different locations based on current exposures underground. As the mine develops, additional stations may need to be developed.

1. UNDERGROUND SURVEY

- In advance of developing the wall washing stations, review geologic mapping to identify prospective locations in low traffic areas for each model unit listed in Table 1.
- After identifying prospective locations, visit each area to determine if the location contains an appropriate 1m by 1m site for station installation.
- The following conditions should be considered when selecting a site:
  - Relatively flat surface of rock, preferably with no surface fractures;
  - In a section of the mine that:
    - has been exposed for at least three years,
    - is no longer being actively mined,
    - will not receive heavy traffic (i.e., not on an active haul route), and
    - will not receive paste backfill (at least until near end of operations); and
    - Away from obvious groundwater seeps or drainage routes;
  - Away from areas of shotcrete usage;
  - Away from infrastructure related oxidation/weathering (e.g., orange staining around bolts); however,
  - If available, select areas of visible oxidation/weathering.
- Underline the target area (1 x 1 m) at each site with spray paint and record the location description (i.e., zone, level, reference site) in your field book. Spray paint the station name on the rock above or below the station.
- Photograph the target exposure with the station name.

2. FIELD PREPARATION

- Collect field supplies for installation of wall washing station (see list above). Ensure proper amount of supplies based on number of stations to be established (Table 1).

3. INSTALLATION PROCEDURE

- Select a 1 x 1 m section of rock based on the conditions listed above for the Underground Survey. Figure 1 below is provided for reference.
- Brush slimes off the rib in the area the edging will be installed. Do not brush slimes off the area that will be rinsed with DI water following installation.
- With gloved hands, mark the intended perimeter of the station on the surface with a permanent marker. Due to imperfections in the rock surface, the actual area isolated may be less than one square meter.
- Holding the vinyl nosing against the rock surface, drill through the nosing and into the rock surface.

- Cut the plastic edging to the length required for each limb.
- Secure each limb to the rock surface using masonry screws or expanding rock bolts.

Note: the lowest (bottom) limb must slope downwards from horizontal so that all water caught on it will drain in one direction for collection (Figure 1).

- Seal each limb to the rock surface using pure silicon sealant.
    - Ensure silicon sealant fills all open spaces between the edging and the rock surface so that no water can pass underneath.
    - Ensure each limb overlaps so that no large gaps exist at any junction; seal any smaller gaps with silicon.
    - Ensure the upper limb(s) overhang lower limbs to divert wall runoff around the sides of the station so that the water will not flow over the isolated area.
- Measure the length and angle of each limb and record these details in your field book. Record any other notes about the station such as visible oxidation, location of fractures, sketch of the station, etc.
- Photograph the completed wash station.
- Proceed to wall cleaning. For the first sample collection use 1 L of DI water, but otherwise follow the procedure for sample collection outlined in BJ-ENV-SOP-038
- Otherwise,
    - Cut a clear plastic sheet to extend 2 cm over each limb.
    - attach the plastic sheet to the perimeter edging with the metal or plastic clasps, ensuring the plastic sheet does not touch the rock surface. The plastic cover prevents spray and groundwater infiltration from reaching the isolated rock surface and contaminating or rinsing the surface.

Figure 1: Example of Wall Washing Station (from Morin and Hutt, 2001)

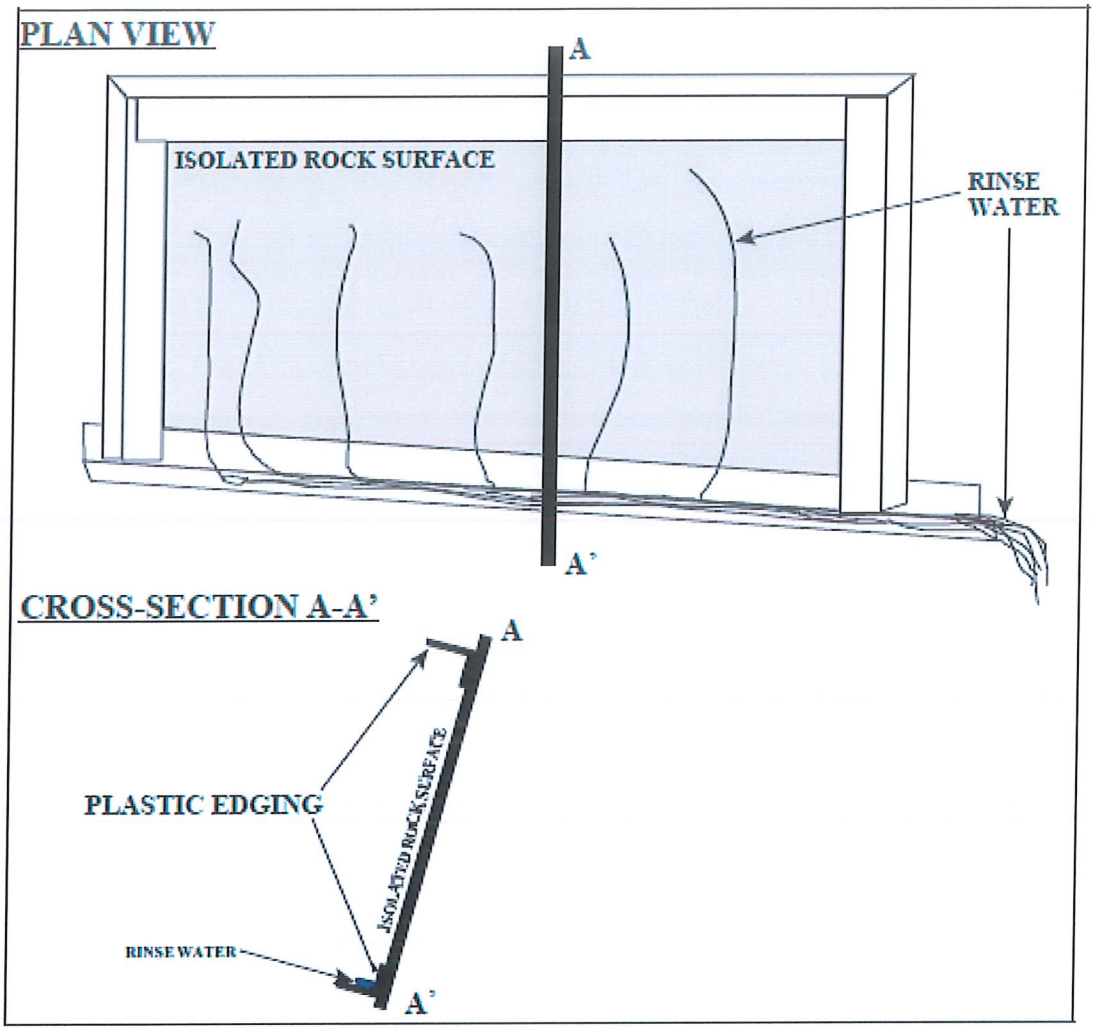


Table 1: Wall Washing Station IDs and Geologic Waste Rock Units

Underground Model Unit	No. to be Established	Location Description	Station ID	Status*
Fragmental (V12)	3	VOK Access Ramp Bypass 2	MW-V12-1A	Installed
		VOK Access Ramp Bypass 2	MW-V12-1B	Installed
		1380 VND E	MW-V12-2	Installed
Volcanic Sedimentary Facies (VSF)	2	VOK Access Ramp Paste Cutout	MW-VSF-1	Installed
		TBD	MW-VSF-2	Pending
Conglomerate (S3)	1	VOK Access Ramp Bypass 1	MW-S3-1	Installed
Porphyry (Bridge P1)	1	TBD	MW-BP1-1	Pending

* Status as of October 2018

References

Morin, K.A. and N.M. Hutt (1995). MINEWALL 2.0: A Technique for Predicting Water Chemistry in Open-Pit and Underground Mines. Paper presented at Sudbury '95, Conference on Mining and the Environment, Sudbury, Ontario, May 28 – June 1, 1995.

Morin, K.A. and N.M. Hutt (2001) Environmental Geochemistry of Minesite Drainage: Practical Theory and case studies, Digital Edition. Canadian Cataloguing in Publication Data, MDAG Publishing, Vancouver, British Columbia, Canada, 2001.

Morin, K.A. and N.M. Hutt (2004). The Minewall Approach for Estimating the Geochemical Effects of Mine Walls on Pit Lakes. Published by the Minesite Drainage Assessment Group (www.mdag.com). Presented at: Pit Lakes 2004; United States Environmental Protection Agency; Reno, Nevada; November 16-18, 2004.

MEND (1995). MINEWALL 2.0. Series of four reports (Literature Review, User's Guide, Application of MINEWALL to Three Minesites, and Programmer's Notes and Source Code) plus one diskette. Canadian Mine Environment Neutral Drainage (MEND) Reports 1.1

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2017-09-29	Initial Issue		
2018-10-23	Update to Pretivm SOP template, split SOP into Installation and Maintenance.		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Environment Superintendent or Designate			
Surface Operations Superintendent or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 11

Standard Operating Procedure:
WTP Influent/Effluent Water Quality Sampling

PRETIVM		PVG-ENV-SOP-035 Water Treatment Plant Sampling	
Department: Environment	**Manager/Designate**: Robin McCall	**Revision Number**: 2	**Creation Date**: 2018/11/15 **Revision Date**: 2020/10/06

Objective

To provide guidance for Pretivm personnel for collection of samples from the Water Treatment Plant (WTP) in conformance with Effluent Permit (PE-107835) requirements.

Scope

Activities related to collection of samples from the WTP influent, contact water influent, process water influent clarifier, freshwater and effluent

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- BCMDG: British Columbia Mine Design Guideline (i.e., cost-effective low-level detection limits)
- DI water: De-ionized water
- DO: Dissolved Oxygen
- DOC: Dissolved Organic Carbon
- EPH: Extractable Petroleum Hydrocarbons
- Field parameters: pH, specific conductivity, temperature, DO
- PE-107835: Environmental Management Act Effluent Permit
- TOC: Total Organic Carbon
- TDS: Total Dissolved Solids
- TSS: Total Suspended Solids
- VH: Volatile Hydrocarbons
- VOC: Volatile Organic Compounds
- WTP: Water Treatment Plant

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensure this procedure complies with H&S regulation.

The Area Manager or Designate is responsible for:

- Ensure this procedure is followed and compliance sampling is completed on time.

The Worker is responsible for:

- Ensure this procedure is followed for all WTP sampling.

Preparation

Hazards

- Noise
- Heavy equipment interactions

- Working near hazardous chemicals
- Slips, trips, and falls

Tools

- YSI ProPlus/DSS multi-meter
- Sample bottles and preservatives as per Table 1
- Disposable syringes
- Disposable 0.45 µm disc filters
- Vinyl gloves
- Water quality field data sheets
- Camera
- ~ 500 mL grab sampler (stored at WTP)

Requirements

- Trained and qualified to conduct water-quality sampling
- Mill orientation or guide

Job Step

Samples from the mine influent, contact water influent, process water influent, effluent and fire water will be collected twice per month.

1. **Field preparation**
   - Notify the WTP Operator 48 hours before collecting samples and request composite samplers be cleaned.
   - Calibrate multi-meter at lab.
   - Review BJ-ENV-SOP-028 Generic Water Sample Collection if necessary.
2. **Label sample bottles as per requirements and schedule in Appendix I.**
   Sample IDs are:
   - WTP-OUT-E302957
   - WTP-IN-Mine Water-E303052
   - WTP-IN-Process Water
   - WTP-IN-CWP-E303053
   - WTP-IN-CLARIFIER
   - Fire Water
3. **Enter Mill**
   - Report to control room and fill in sign in sheet located on clipboard outside of control room door. Contact WTP operator on shift and inform them that you are taking samples and request assistance if needed.
4. **At sample station, put on vinyl gloves**
   - Change gloves before every sample and when they become dirty or contaminated.
5. **Grab sample locations**
   - The clarifier overflow sample is taken as a grab sample using a long-handled sampler. This sample is taken from the top floor of the WTP from the walkway overlooking the underground clarifier. Rinse the grab sampler with DI water and wipe clean with a shop cloth. Rinse the grab sampler three times with clarifier overflow prior to sample collection.
   - The fire water sample is collected from the fresh/fire water pumps located beside the fresh/fire water tank in the southwest corner of the mill. There are three pumps and not all will be running simultaneously. Check the back of the motor casing to check the fan is running and select an active pump for sampling. Flush the valves for 30 seconds prior to sampling.

- Fill the general chemistry bottle.
- Agitating the general chemistry bottle after every aliquot is removed, use the general chemistry bottle to fill the nutrients bottle, followed by the total metals bottle.
- Filter an aliquot of sample from the general chemistry bottle into the dissolved metals bottle.
- Discard the sample remaining in the general chemistry bottle.
- Refill the general chemistry bottle with a fresh aliquot from the clarifier overflow.
- Preserve all bottles as indicated in Table 1.

6. Composite sample locations

- On top of the metal precipitation reactor (MPR) are the autosamplers for the process water and UG mine water influent. The CWP influent autosampler is located on the ground level along the eastern wall of the WTP. The final treated effluent autosampler is located on top of the final treated effluent tank. Access for these tanks are from the bottom floor of the mill.
- Composite samplers are maintained by the WTP Operator as per BJ-PRO-SOP-607.
- Samples are collected from the composite samplers maintained by the WTP.
- Water from the autosampler will be transferred to a 20 L bucket by the WTP Operator. This bucket will be left on the autosampler platform covered by a loose lid.
- Agitate the 20 L bucket prior to transferring an aliquot into each sample bottle.
- Collect sample using a new disposable syringe.
- Filter and preserve sample if required as per Table 1.

7. Collect QA/QC samples

- Collect one duplicate sample by collecting an additional bottle set for one of the sample locations. This sample will be identified by -98, e.g., WTP-OUT-98.
- Collect one field blank by filling an additional bottle set for one of the sample locations with DI water. Preserve the field blank as per the requirements in Table 1. This sample will be identified by -99, e.g., WTP-OUT-99.

8. Record field parameter measurements

- Using an aliquot of sample that will not be sent to the lab for analysis, measure the pH, specific conductivity, DO, turbidity, and temperature using the YSI ProDSS.
- In the case that the YSI ProDSS is unavailable, use the YSI ProPlus (or equivalent) to measure pH, conductivity, DO, and temperature. Collect an aliquot of sample that will not be sent to the lab for analysis. Upon return to the lab, measure the turbidity of the sample using a Lamotte 2020we turbidity meter.

9. Record site specific observations on the water quality form, such as:

- Station ID (i.e., WTP-OUT): consistent with each task being completed at the site (i.e., bottle labels, digital files, etc.).
- Samplers: the initials of all samplers present.
- Site conditions (e.g., plant shut down due to maintenance, composite sampler needs cleaning).
- Photo ref: the number of photos taken, if any, and photo file number on camera.
- Notes on any unusual occurrences, such as deviations from standard procedure, water colour or odour, algal growth, foreign substances (e.g., oil or surface film), etc.

10. Complete COC

- Complete COC as per example in Appendix I.

11. Ship samples

- Ship samples to the analytical Laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure that the samples arrive at the laboratory <10°C.

12. Data tracking and analysis

- Data will be compiled and evaluated by the Environmental Manager or designate.

- If exceedances of threshold limits as defined in the ML/ARD Management Plan occur, then the Mine Manager must be informed and actions outlined in the ML/ARD Management Plan must be taken.

Table 1: Summary of Bottles, Preservation, and Analytical Parameters for Samples

Bottle Volume and Type	Field Preservation	Field Filter	Refrigerate (4°C)	Indicate on Bottle	Parameter(s) to be indicated on COC	Locations	Frequency
500 mL plastic	None	No	Yes	General Chemistry	pH, conductivity, hardness, alkalinity, anions, Ortho P, TSS, TDS, and turbidity	All	2x per month
60 mL plastic	HNO_3	No	Yes	Total Metals	Total Metals (BCMDG)	All (except Fresh Water)	2x per month
60 mL plastic	HNO_3	Yes	Yes	Dissolved Metals	Dissolved Metals (BCMDG)	All (except Fresh Water)	2x per month
60 mL plastic	NaOH	Yes	Yes	D-Cr(VI)	Dissolved Cr(VI)	WTP-IN-Mine Water	When D-Cr >10 ug/L
40 mL glass	HCl	No	Yes	Total Hg	Total Hg	WTP-OUT	sQuarterly
40 mL glass	HCl	Yes	Yes	Dissolved Hg	Dissolved Hg	WTP-OUT	sQuarterly
125 mL amber	H_2SO_4	No	Yes	Nutrients	TOC, Total P, T-N and ammonia	All	2x per month
2x 100 mL amber	Sodium bisulphate	No	Yes	EPH	EPH	All (except Clarifier and Fresh Water)	2x per month

Appendix I: Chain of Custody

File location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\ALS\Templates\Template_COC_ALS_WTP

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # _____

Page 1 of 1

Report To				**Report Format / Distribution**				**Service Requested** (Rush for routine analysis subject to availability)
Company:	Pretivm Resources Inc.			☑ Standard	☐ Other			◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Max Holtby			☑ PDF	☑ Excel	☐ Digital	☐ Fax	○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street			Email 1:	environmental@pretivm.com			○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334			Email 2:	mholtby@pretivm.com			○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	(604)558-1784	Fax:	(604) 558-4784	Email 3:	rmccall@pretivm.com			**Analysis Request**
Invoice To	Same as Report ?	☑ Yes	☐ No	**Client / Project Information**				Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?		☑ Yes	☐ No	Job #:	Brucejack OWTP			
Company:				PO / AFE:	1025612			
Contact:				LSD:				
Address:	invoices@pretivm.com							
Phone:		Fax:		Quote #:				
Lab Work Order # (lab use only)				**ALS Contact:**	Dean Watt	**Sampler:**		

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Generals	TOC, Total P, ammonia, T-N	Total Metals	Dissolved Metals	Mecury (Total)	Mercury (Dissolved)	Dissolved Cr/VI	EPH	BTEX/F1/VPH	Arsenic speciation	NH4, T-N	NO3, NO2	Number of Containers
						P	P	F/P	P	F/P	F/P	P	P	F/P	P		
	WTP-IN-Process Water			Water	X	X	X	X				X	X				8
	WTP-IN-CWP-E303053			Water	X	X	X	X				X	X				8
	WTP-IN-Mine Water-E303052			Water	X	X	X	X				X	X				8
	WTP-OUT-E302957			Water	X	X	X	X				X	X				8
	WTP-Clarifier			Water	X	X	X	X									4
	Fire Water			Water											X	X	2
	TRAVELBLANK			Water	X	X	X										3

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

Please report in 5 days. Please CC report to slaliberte@pretivm.com. EMS Upload required. All dissolved metals filtered and preserved.
Dissolved Cr speciation is required on WTP-IN-Mine Water-E303052 samples if D-Cr > 10 ug/L.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
						°C				

NA-FM-0326d v06 Front / 22 May 2013

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Robin McCall	[redacted]	
Health & Safety Manager / Designate			
Mine Manager / Designate			
JOHSC Co-chair or Member			

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Initial Issue			2015-08
WTP sampling isolated, updated to PVG template		All	2018-10-24
Added freshwater sample, added responsibilities, minor additional updates		All	2020-10-06

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	[redacted]		
Health & Safety Manager / Designate			
Mine Manager / Designate			
JOHSC Co-chair or Member			

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Initial Issue			2015-08
WTP sampling isolated, updated to PVG template		All	2018-10-24
Added freshwater sample, added responsibilities, minor additional updates		All	2021-02-24

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Appendix 12

Standard Operating Procedure:
Tailings Supernatant and Solids Sampling

PRETIVM		PVG-ENV-SOP-007 Tailings Grab Sample Collection	
Department: Environment	**Manager/Designate**: Robin McCall	**Revision Number**: 3	**Creation Date**: 2017/11/15 **Revision Date**: 2020/10/06

Objective

To provide guidance for Environmental personnel regarding the collection of tailings slurry samples and the processing of tailings supernatant and solids.

Scope

All activities related to the collection and processing of tailings slurry solids and supernatant.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- Thickened tailings – Collected from the Tailings Thickener Underflow as it discharges into the Paste Stock Tank (PST) or the Tailings Disposal Surge Tank (TDST)
- ABA – Acid base accounting
- BCMDG – British Columbia Mine Design Guideline
- COD – Chemical Oxygen Demand
- DI water – De-ionized water
- DOC – Dissolved Organic Carbon
- HDPE – High-density polyethylene
- ML/ARD – Metal leaching and acid rock drainage
- QA/QC – Quality assurance and quality control
- PPE – Personal Protective Equipment, including hardhat, steel toed boots, hearing protection and safety glasses.
- PC – Potentiometric titration
- SFE – Shake flask extraction
- TDS – Total Dissolved Solids
- TOC – Total Organic Carbon
- TSS – Total Suspended Solids

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensure this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensure this procedure complies with H&S regulation.

The Area Manager or Designate is responsible for:

- Ensure this procedure is followed and sampling is completed on time.

The Worker is responsible for:

- Ensure this procedure is followed for all tailings sampling.

Preparation

Hazards

- Noise Level < 100 dB: normal hearing protection required
- Overreaching/heavy lifting
- Slips and falls
- Working near machinery
- Working near hazardous chemicals

Tools

- PPE
- For Steps 1-4 below:
  - 2-4 empty and clean 5 gallon HDPE buckets
  - 2 empty and clean 2 L wide-mouth HDPE bottles
  - Sharpie
  - SGS sample labels
  - Field data record sheets
- For Step 6 below:
  - Powderless nitrile gloves
  - Field data record sheets (same copy as for Steps 1-4)
  - Camera
  - pH/conductivity meter
  - Small (narrow) clean plastic cup (for field measurements)
  - Cooler for supernatant samples containing:
    - 3 disposable 60 mL Syringes and 30 disposable 0.45 µm disc filters
    - 3 empty 500 mL polyethylene bottles (general chemistry)
    - 6 empty 125 mL acid washed polyethylene bottles (metals)
    - 6 empty 125 mL amber glass bottles (nutrients/TOC/COD and DOC/T-dissolved-P)
    - 6 vials of preservative for total and dissolved metals (nitric acid for acid washed polyethylene bottles)
    - 6 vials of preservative for nutrients (1 mL 1:1 sulfuric acid for amber glass bottles)
    - DI water for rinsing and field blank collection
    - minimum of two large ice packs
  - ALS sample labels
- ALS COC form
- SGS COC form

Requirements

- Trained and qualified to conduct sediment and water-quality sampling
- Knowledge of tailings slurry solids and supernatant sampling program
- Mill Orientation or escort from Mill personnel

Job Step

1. Prepare sample containers.

- Label two 5 gallon buckets and one 2L HDPE bottle with “Thickened Tailings”.
  - Label 5 gallon buckets “1 of 2” and “2 of 2”.
- Label one 2L HDPE bottle with “Cemented Tailings”.

- During the first sampling event of the year, label a second set of containers as per the instructions above and as describe in Step 8 for the Thickened Tailings sample as a duplicate.

2. Thickened Tailings Sample

This sample will be collected from the inflow to the Tailings Disposal Surge Tank during discharge to lake or from the Paste Stock Tank during paste production.

This sample requires two 5 gallon buckets and one 2L HDPE bottle.

- Remove the lid of the 5 gallon buckets.
- Using the Marcy Cup sampler, fill both of the 5 gallon buckets by filling the Marcy Cup from the discharge of the thickened tailings underflow into the TDST or the Paste Stock Tank.
- Replace the lid of the 5 gallon buckets.
- Remove the lid of the 2L HDPE bottle.
- Using the same technique as above, fill the 2L HDPE bottle.
- Replace the lid of the 2L HDPE bottle.
- Record the time of collection and any issues (e.g., mill shut down).
- If mill shut down occurs, stop sampling and wait one hour before resuming sampling. However, in the event of an unanticipated mill shutdown the tailings thickener tank will contain slurry, in which case continue to take the sample from the inflow to TDST as long as the paste plant had not been running prior to the mill shutdown. Note any shutdowns on the data sheet.
- If paste shutdown occurs, wait until paste resumes before resuming sampling.

3. Collect sample of Cemented Tailings

This sample will be collected from the ports of the paste mixer overflow with assistance from the Paste Operator.

This sample requires one 2L HDPE bottle.

- Remove the lid of the 2L HDPE bottle.
- Fill the 2L HDPE bottle with paste.
- Replace the lid of the 2L HDPE bottle.

4. Tailings Settling

- Transfer sample containers to the tailings settling area by the TSDT.
- Remove lids of 5 gallon buckets, then set lids back on top of buckets.
- Do not move buckets for 48 hours.

5. Supernatant Field Preparation

- Calibrate pH/conductivity meter according to manufacturer's instructions.
- Collect frozen ice-packs from freezer.
- Collect and prepare field supplies for supernatant in cooler (see list above).
- Using the provided labels and black marker, label the bottles with the date, sample ID, and parameters of analysis as provided in Table 1 and return the labeled bottles to the cooler.

6. Supernatant Sample Processing

- Put on gloves. Replace gloves between samples and if suspected of having made contact with a dirty surface.
- Open the 5 gallon bucket to expose the thickened tailings supernatant.
- Decant supernatant from both buckets into a clean container using a clean syringe.
- Fill a pre-labelled 500 mL polyethylene bottle to capacity using a new 60 mL syringe.
- Fill a pre-labelled 60 mL acid washed polyethylene bottle to capacity for total metals using the same syringe, leaving only enough room for the preservative. Add the preservative (nitric acid), screw the lid on, and invert the bottle to mix.

- Fill a pre-labelled 120 mL amber glass bottle to capacity for nutrients, TOC and COD using the same syringe, leaving only enough room for the preservative. Add the preservative (sulfuric acid), screw the lid on, and invert bottle to mix.
- Using the same syringe and a disc filter, fill a pre-labelled 60 mL acid washed polyethylene bottle to capacity for dissolved metals as shown in Figure 2. Add the preservative (nitric acid), screw the lid on, and invert the bottle.
- Fill a pre-labelled 120 mL amber glass bottle for DOC and total-dissolved P using the same syringe and a new disc filter.
- Siphon supernatant using the same syringe and dispense in the small plastic cup. Use this sample for pH and conductivity measurements. Record the measurements on the field data sheets (Figure 1). Discard the sample.
- Collect the QA/QC samples for supernatant described in Step 8 during the first collection event of the year.
- Make notes regarding the sample and sample collection on the field data sheet (Figure 1).

7. Solids Sample Processing

- Solids are collected in 2 L HDPE containers.
- Do not pour off the supernatant as this may result in loss of fines.
- Place a completed SGS sample tag in each container.
- Use electrical tape or parafilm to secure the lids closed prior to shipment. If using parafilm, stretch a piece of parafilm across the opening of the container without breaking the parafilm. Screw the lid on tight.
- Communicate any issues with sample collection and shipping to the Environmental Manager and QP.

8. Description of QA/QC Samples

Supernatant QA/QC Samples:

- One field duplicate sample and one field blank sample are to be collected during the first supernatant sampling event of the year.
- A field duplicate is a second sample (a second set of five bottles) collected during sampling of the supernatant and is intended to monitor the variability in sub-sampling. This type of sample is obtained by filling a second set of bottles, from a separate aliquot of slurry, and filtering and preserving the samples in the same manner as described in Step 6 and in Table 1. A new 50 mL syringe and new disc filters must be used for the field duplicate. Label these bottles as Supernatant-##-98.
- A field blank is prepared using DI water, and is intended to monitor any contamination that may occur during sample collection, handling and transportation. This type of sample is obtained by filling a set of five bottles with DI water during sampling of the supernatant and filtering and preserving the metals and nutrient bottles in the same manner as described for the test samples in Step 6 and Table 1. A new 50 mL syringe and new disc filters must be used. Label these bottles as Supernatant-##-99.

Solids QA/QC Samples:

- A field duplicate is obtained by collecting a second sample of the tailings solids in the same manner as described in Step 2 or 3 during the first sampling event of the year. This type of sample is intended to assess heterogeneity of the tailings solids. The field duplicate is collected in a separate 2L bottle with a unique sample ID. Label this sample as Tailings-##-98. Specify which type of tailings the duplicate is.

Precautions During Sampling

- Under extenuating circumstances, when there is not sufficient supernatant to fill a complete set of bottles, use the following criteria.

- Ensure sufficient water to measure field parameters, in particular pH. The hold time for pH is 15 minutes; therefore, laboratory analysis of pH is always past the hold time.
- Fill each bottle according to the minimum volumes listed in the last column of Table 2 below. The bottles do not need to be filled completely under these circumstances.

Note that the minimum volumes provided do not allow for repeat analysis and should only be exercised if absolutely necessary. Record the details of the low supernatant volume in the field notes and collect additional slurry in subsequent sampling events.

Shipping and Analytical Parameters

Supernatant Samples:

- All samples are to be shipped via courier to an accredited laboratory (currently ALS Laboratories in Burnaby) immediately after collection for analysis of the parameters listed in the last column of Table 1. The address for the lab is provided on the Supernatant Sample COC in Appendix I.
- A completed COC form is to be shipped with the samples and an electronic version sent via e-mail to the accredited laboratory and any other appropriate parties (such as consulting QP) communicating that the samples are in transit. Email addresses are provided on the COC.
- Replace ice packs in cooler with frozen ice packs before shipping.

Solid Samples:

- All samples are to be shipped to an accredited laboratory (currently SGS Laboratories in Burnaby) for analysis. The address for the lab is provided on the COC in Appendix II. All tailings solids are to be analyzed for rinse pH, SFE, the full suite ABA analyses and solid phase element determination by aqua regia digestion. The full list of parameters to be measured are listed in Table 3 and on the COC.
- A completed COC form is to be shipped with the samples and an electronic version sent via e-mail to the accredited laboratory and any other appropriate parties (such as consulting QP) communicating that the samples are in transit. Email addresses are provided on the COC.

Data Tracking and Analysis

- Data will be compiled and evaluated by the Environmental Manager or designate. If exceedances of threshold limits or triggers as defined in the ML/ARD Management Plan occur, then the Mine Manager must be informed and actions outlined in the ML/ARD Management Plan must be taken.

Documents and Records

- Complete the COC, including the date and time of collection, name of sampler, sample IDs and analyses to be conducted.
- In the data sheet provided, record the date and time the tailings slurry is collected as well as the date and time the supernatant samples are collected. Complete the tailings sampling data sheet and record the field parameters.

Table 1 - Summary of Bottles, Preservation, and Analytical Parameters for Tailings Supernatant Samples

Bottle and Volume	Field Filter	Field Preservation	Refrigerate (4oC)	Indicate on Bottle	Parameter(s)*
500 mL plastic	No	none	Yes	General Chemistry	General Chemistry: pH, conductivity TSS, TDS, turbidity, alkalinity, acidity, anions (Br, Cl, F, SO_4, NO_2 and NO_3)
60 mL plastic	No	HNO_3	Yes	Total Metals	Total Metals (BCMDG)
120 mL amber glass	No	H_2SO_4	Yes	Nutrients, COD	Nutrients (phosphorus, nitrogen and ammonia), TOC and COD
60 mL plastic	Yes	HNO_3	Yes	Dissolved Metals	Dissolved Metals (BCMDG)
120 mL amber glass	Yes	H_2SO_4	Yes	DOC and T-dissolved-P	DOC and T-dissolved-P

Notes: * Parameters listed in bold must be indicated on the chain of custody for the analytical laboratory

BCMDG: Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, Th, Sn, Ti, U, V, Zn, Zr, Hg

Table 2 - Minimum bottle volumes required to complete analyses

Bottle Type	Parameters	MINIMUM Volumes	MINIMUM Bottle Volumes
General Chemistry	pH/EC/Acidity/Alkalinity	50 mL	290 mL
	Turbidity	30 mL	
	TDS	40 mL	
	TSS	150 mL	
	Anions (Br, Cl, F, NO_2, NO_3, SO_4)	10 mL	
Nutrients and TOC	Total phosphorus	25 mL	50 mL
	Total nitrogen	5 mL	
	Ammonia (NH_3)	5 mL	
	TOC	10 mL	
	COD	2 mL	
DOC and T-D-P	DOC	10 mL	35 mL
	Total dissolved phosphorus	25 mL	
Total metals	Total metals (BCMDG)	60 mL	60 mL
Dissolved metals	Dissolved metals (BCMDG)	60 mL	60 mL

Table 3 - Analytical Parameters

ABA	Solid Phase Metals					Shake Flask Extraction			
Paste pH	Ag	Cs	Mg	Se	Y	pH	Ag	Cu	Rb
TIC	Al	Cu	Mn	Sn	Yb	Redox	Al	Fe	S
$CaCO_3$	As	Fe	Mo	Sr	Zn	Conductivity	As	Hg	Sb
C(T)	B	Ga	Na	Ta	Zr	Acidity (to pH 4.5)	B	K	Se
S(T)	Ba	Ge	Nb	Tb		Total Acidity (to pH 8.3)	Ba	Li	Sn
$S(SO_4)$	Be	Hf	Ni	Te		Alkalinity	Be	Mg	Sr
$S(S^{-2})$	Bi	Hg	P	Th		Chloride	Bi	Mn	Ti
Insoluble S	Ca	In	Pb	Ti		Fluoride	Ca	Mo	Tl
AP	Cd	K	Rb	Tl		Sulphate	Cd	Na	U
Modified NP	Ce	La	S	U		Hardness $CaCO_3$	Cd	Ni	V
Fizz Test	Co	Li	Sb	V			Co	P	Zn
	Cr	Lu	Sc	W			Cr	Pb	Zr

Figure 1 – Field data collection sheet

SLURRY COLLECTION			
Date:		Name:	
Type:	T F C	Type:	T F C
Time:		Time:	
Vol (L):	20 40	Vol (L):	20 40
Notes:			

SUPERNATANT COLLECTION			
Date:		Name:	
Time:		Time:	
Vol:		Vol:	
pH:		pH:	
Cond: (uS/cm)		Cond: (uS/cm)	
Temp: °C		Temp: °C	
Notes:			

SOLIDS			
SGS ID		SGS ID	
Vol (L):	2 4 6	Vol:	2 4 6
Notes:			

Figure 1 – Photograph showing how syringe and disc filter are used to filter supernatant samples for dissolved parameters

Appendix I: ALS COC

File Location: J:\Environmental\02 Lab COCs, Results, Spreadsheets, etc\00 CoCs and Results\ALS\Templates\ Template_COC_ALS_supernatant.xls

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 17 -
Page ___ of ___

Report To		**Report Format / Distribution**	**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	**R** ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report ☑ Yes ☐ No	**P** ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked	**E** ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	**E2** ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2 Alison.Shaw@lorax.ca	**Analysis Request**
Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Ptrivm (Brucejack Project)	Email 1 or Fax invoices@pretivm.com	
Contact:	Accounts Payable (604-558-1784)	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:		Approver ID: / Cost Center:	
Job #:	Tailings Supernatant	GL Account: / Routing Code:	
PO / AFE:	1025612	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:**

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	LOR200-SUPERTANT-VA	General: pH, conductivity, TSS, TDS, turbidity, alkalinity (incl. bicarb, carb, hydroxide), acidity	General: anions (Br, Cl, F, NO2, NO3, SO4), ortho phosphorus	Nutrients: T-N, T-P, ammonia, TOC, COD	DOC and total-dissolved P	MET-T-BCMDG-VA (incl Hg)	MET-D-BCMDG-VA (incl Hg)	Arsenic Speciation							Number of Containers
								P	F/P	P	F/P								
	Tailings Supernatant THICKENED - E302910			water	R	R	R	R	R	R	R								5

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	Distribution email 3: mholtby@pretivm.com
Are samples for human drinking water use? ☐ Yes ☑ No	Distribution email 4: rmccall@pretivm.com
	Distribtution email 5: environmental@pretivm.com
	EMS Upload required

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐		SIF Observations	Yes ☐	No ☐	
Ice packs	Yes ☐	No ☐	Custody seal intact	Yes ☐	No ☐	
Cooling Initiated	☐					

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		

Released by:	**Date:**	**Time:**	INITIAL SHIPMENT RECEPTION (lab use only) Received by:	Date:	Time:	FINAL SHIPMENT RECEPTION (lab use only) Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0325ev09Front04January2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Appendix II: SGS COC

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	Centre, PO Box 49334 Vancouver, BC	Jan 5, 2020
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name: Sampler Phone: 778-724-4186 ext.
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis											P.O. Number (if applicable)
	SFE	Total Sulphur	Total Inorganic Carbon	Total Carbon	Modified NP	Sulphate-sulphur	Sulphide-sulphur	Metals on Solids by ICP-MS				1025603
T-Tails	x	x	x	x	x	x	x	x				
T-Tails-98	x	x	x	x	x	x	x	x				Special Instructions:
Paste	x	x	x	x	x	x	x	x				

CHAIN OF CUSTODY:

Relinquished by:	Time:		Date:		Received by:		Time:		Date:	
Relinquished by:	Time:		Date:		Received by:		Time:		Date:	

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Robin McCall	[redacted]	
Health & Safety Manager / Designate	Rob Geddes		
Mine Manager / Designate	George Friesen		
JOHSC Co-chair or Member	Brittany Moore		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Remove flotation tailings from sample requirements		multiple	2020/02/07
Add roles and responsibilities		1	2020/10/06

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Appendix 13

Standard Operating Procedure:
SAG Mill Sampling

PRETIVM		BJ-ENV-SOP-041 SAG Mill Sampling	
Owner: Colleen Atherton	Approver: Torence Sandhals, Jason Gabora	Revision Number:	Creation Date: Oct 22, 2018 Revision Date:

Objective

To measure the nitrogen load per tonne of ore to validate or revise the water quality model assumptions.

Scope

All activities related to sampling of SAG mill influent and effluent. This includes sample collection protocols, shipping and handling details, analytical procedures, quality assurance and quality control (QA/QC) requirements, parameters to be measured, communications with the analytical laboratories, the COC (chain of custody) and documenting the results.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- BCMDG: British Columbia Mine Design Guidelines
- COC: Chain of Custody
- COD: Chemical Oxygen Demand
- PPE: Personal Protective Equipment
- SAG: Semi-Autogenous Grinding
- TOC: Total Organic Carbon
- TSS: Total Suspended Solids

Preparation

Hazards

- Slips and falls
- Working near machinery
- Working near hazardous chemicals
- Noise
- Air Quality

Tools

- PPE
- Sample bottles and preservatives as per Table 1

Requirements

- Mill orientation or escort from Mill personnel
- Knowledge of SAG mill sampling program
- Trained and qualified to conduct water-quality sampling

Job Step

Collect SAG mill samples monthly in conjunction with Tailings and Supernatant samples (BJ-ENV-SOP 007).

1. **Field preparation**
    - 24 hours prior to sample collection, contact the Mill Operations Supervisor via email to request that SAG Mill Discharge and Process Water samples be collected.
    - Review BJ-ENV-SOP-028 Generic Water Sample Collection if required.
    - Label sample bottles and place in a cooler with ice packs.
        - SAG Mill Discharge:
            - 1 - 4L jug, unfiltered and unpreserved
        - Process Water:
            - 1 - 4L jug, unfiltered and unpreserved
            - 1 - 125 mL plastic, unfiltered and preserved with HNO3
    - Calibrate multi-meter.
2. **Enter Mill**
    - Contact control room operator to inform them that you have entered the mill building. Report to control room and fill in sign in sheet located on clipboard outside of control room door. Contact Grinding Operator on shift and inform them that you are taking samples and request assistance.
3. **Sample collection**
    - The Grinding Operator will collect a 20 L sample from each of the SAG mill discharge and the Process Water.
        - SAG Mill Discharge is collected by using a cutter to collect approximately 20 – 1 L aliquots into a 5 gallon bucket.
        - Process Water is collected by filling a 5 gallon bucket from a valve on the influent into the SAG Mill.
        - The sample will be collected in the morning on the day following notification to the Mill Operations Supervisor.
        - The Grinding Operator will wash and reuse the buckets for the subsequent sample.
    - Allow the sample to settle for 4-5 hours prior to subsampling.
    - Put on vinyl gloves prior to sampling.
    - Without agitating the sample, decant an aliquot from the 5 gallon bucket into the corresponding 4 L jug and 125 mL plastic bottle (Process Water only). Preserve the sample as indicated in Table 1.
4. **Data and records**
    - Complete Table 2 and send to the Geochemist and the Qualified Professional.
5. **Complete COC**
    - Complete COC as per example in Appendix 1
6. **Ship samples**
    - Ship samples to the analytical Laboratory (currently ALS Global in Burnaby, BC).
    - Use adequate ice packs to ensure that the samples arrive at the laboratory <10°C.
7. **Data tracking and analysis**
    - Data will be compiled and evaluated by the Environmental Manager or designate.

Table 1 – Summary of Analytical Parameters

Bottle Volume and Type	Field Preservation	Field Filter	Refrigerate (4°C)	Indicate on Bottle	Parameter(s) to be indicated on COC	Locations	Frequency
4 L plastic	None	No	Yes	General Chemistry	pH, conductivity, TSS, turbidity, total NH3-N, Br, Cl, F, NO3-N, NO2-N, T-N, T-P SO4, TOC, COD and dissolved metals excl. Hg	Both	monthly
60 mL plastic	HNO3	No	Yes	Total Metals	Total Metals excl. Hg (BCMDG)	Process Water	monthly

Table 2 – Field Data

SAG Mill Sample Location	Process Water	SAG Discharge
Date		
Sample Time		
Sub-Sample Time		
Process Water feed rate (at SAG Discharge sample time) (m3/h)		
Ore Feed Rate (at SAG Discharge sample time) (t/h)		

Appendix I – COC

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\ALS\2018\COC\Mill (Process Water & SAG)\ALS_COC_SAG Template.xlsx

ALS Environmental

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # _____

Page 1 of 1

Report To			
Company:	Pretivm Resources Inc.		
Contact:	Max Holtby		
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street		
	Vancouver, BC V7X 1L4 PO Box 49334		
Phone:	(604)558-1784	Fax:	(604) 558-4784
Invoice To	Same as Report ?	☑ Yes	☐ No
Hardcopy of Invoice with Report?		☑ Yes	☐ No
Company:			
Contact:			
Address:	invoices@pretivm.com		
Phone:		Fax:	

Report Format / Distribution			
☑ Standard	☐ Other		
☑ PDF	☑ Excel	☐ Digital	☐ Fax
Email 1:	environmental@pretivm.com		
Email 2:	mholtby@pretivm.com		
Email 3:	svanzalingen@pretivm.com		
Client / Project Information			
Job #:	Mill Process Water/SAG Feed		
PO / AFE:	1024947		
LSD:			
Quote #:			
ALS Contact:	Dean Watt	**Sampler:**	

Service Requested (Rush for routine analysis subject to availability)
◉ Regular (Standard Turnaround Times - Business Days)
○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Lab Work Order # (lab use only):

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	COD	Conductivity	pH	TSS	Turbidity	Total Ammonia	Anions (Br,Cl,F,NO2,NO3,SO4)	Total Nitrogen	TOC	Total Phosphorus	Total Metals (exclude Hg)	Dissolved Metals (exclude Hg)	Number of Containers
															P		
	SAG Mill Discharge			Water	X	X	X	X	X	X	X	X	X	X		X	1
	SAG Mill Process Water			Water	X	X	X	X	X	X	X	X	X	X	X	X	2

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

samples from buckets which had been taken at 5:45 am Process water and 5:52 am SAG Discharge the same day in order to allow settling time. Please CC report to rmccall@pretivm.com, slaliberte@pretivm.com, catherton@pretivm.com & patrick.mueller@lorax.ca. Centrifuge the sub samples and conduct all testing except total metals on the centrate. Test total metals on the sample cut

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature: °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

NA-FM-0326dv06Front / 22 May 2013

Revisions

DATE	CHANGES	SIGNATURE	PAGE #

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Environment Superintendent or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 14

Standard Operating Procedure:
Water Treatment Plant Sludge Sampling

PRETIVM		BJ-ENV-SOP-034 Water Treatment Plant Sludge Sampling	
Owner: Colleen Atherton	Approver: Torence Sandhals, Jason Gabora	Revision Number: 3	Creation Date: Aug 31, 2015 Revision Date: Oct. 23, 2018

Objective

To obtain samples of water treatment plant (WTP) sludge for static testing in accordance with the Metal Leaching – Acid Rock Drainage Management Plan.

Scope

This SOP applies to all employees who are sampling from the water treatment plant at the Brucejack Gold Mine.

Health, Safety & Reclamation Code of BC

- 1.11.1 - Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 - Personal Protective Equipment
- 2.13 - WHMIS

Definitions

- ABA: Acid Base Accounting.
- COC: Chain of Custody.
- HDPE: High Density Polyethylene.
- PPE: Personal Protective Equipment incl. hearing protection.
- TDST: Tailings Disposal Surge Tank.
- WTP: Water Treatment Plant.

Preparation

Hazards

- Noise.
- Working near hazardous chemicals.
- Working near machinery.
- Slips, trips and falls.
- Heavy lifting.

Tools

- PPE.
- Five empty and clean 20 L buckets (see note).
- Vinyl gloves.
- Notebook.
- Camera.
- SGS sample tags.

Note: in the first quarter of every year, fifteen 20 L buckets are required for duplicate samples.

Requirements

- Trained and qualified to conduct WTP sludge sampling.
- Mill orientation or guide.
- Knowledge of this SOP.

Job Step

WTP sludge samples will be collected once per quarter.

1. **Contact WTP Operator 24 hours before sample collection**
   - Request that wasted sludge be retained in the Sludge Centrifuge Feed Tank.
2. **Prepare sampling equipment**
   - Label the buckets "1 of 5", "2 of 5", etc.
   - In the first quarter of every year, prepare duplicate sampling equipment. In the first quarter a total of 15 buckets will be used. In all other quarters, five buckets will be used.
3. **Enter Mill**
   - Contact control room operator to inform them that you have entered the mill building. Report to control room and fill in sign in sheet located on clipboard outside of control room door. Contact WTP operator on shift and inform them that you are taking samples and request assistance if needed.
4. **Collect sludge from Sludge Centrifuge Feed Tank**
   - Fill all 20 L pails with WTP sludge.
   - Place lids on pails and transport to tailings supernatant prep area beside TDST.
   - Remove lids from pails and place lids on top to allow for minimal disturbance of sludge following settling.
   - Allow sludge to settle for 24 hours.
5. **Decant supernatant**
   - Pour off as much supernatant as possible without losing any fines.
   - Using a geopump, decant the remaining supernatant from the sludge. Be careful not to remove any sludge but remove as much of the supernatant as possible.
   - For details regarding geopump set up and operation, please see BJ-ENV-SOP-028.
   - **Ensure proper lifting techniques are being used, and two people when needed.**
6. **Consolidate sludge into one 20 L bucket**
7. **In the first quarter of every year, collect a field duplicate sample and a laboratory duplicate sample**
   - The laboratory duplicate will be composed of ten 20 L buckets. Label the HDPE buckets "1 of 10", "2 of 10", etc.
   - The field duplicate will be composed of five 20 L buckets. Label the HDPE bucket "1 of 5", "2 of 5", etc.
   - Decant all 15 buckets using the same techniques of decanting and consolidation in Step 5.
   - The sludge from the pails marked "laboratory duplicate" must not be mixed with sludge from the pails marked "field duplicate".
8. **Complete the SGS tags and place a tag in each consolidated bucket**
   - If collecting a duplicate sample, assign unique SGS numbers to the laboratory duplicate and the field duplicate.
   - Add DUP to the sample ID of the laboratory duplicate, e.g, B00######-DUP.
9. **Record field notes**
   - Date and time.
   - Name of samplers.
   - Sample IDs.
   - Observations.

10. Exit Mill

- Sign out at the control room and inform the control room operator that you have left the mill building.

11. Ship the samples to the laboratory

- Complete the COC as per the example provided in Appendix I.
- In addition to the typical shipping documents, complete an offsite removal form as per the example provided in Appendix II
- The current laboratory is SGS Laboratories in Burnaby, BC.

12. Data Tracking and Analysis

- Data will be compiled and evaluated by the Environmental Manager or designate.

Appendix I

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\SGS\2018\COC\WTP Sludge\COC_SGS_Sludge Template.xlsx

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	2300-1055 Dunsmuir St, Four Bentall Centre, PO Box 49334 Vancouver, BC V7X 1L4	
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name:
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis											P.O. Number (if applicable)
	Total Sulphur	Total Carbon	Total Inorganic Carbon	Modified NP	Sulphate-Sulphur	Sulphide-Sulphur	Metals on Solids by ICP-MS	Sequential Extraction				1025076
Sludge sample	x	x	x	x	x	x	x					
Duplicate (first quarter of every year)	x	x	x	x	x	x	x					Note: Samples labelled DUP represent laboratory duplicate samples which will need to be split in the laboratory
Sequential extraction (first quarter of every year)								x				

CHAIN OF CUSTODY:								
Relinquished by:	Time:		Date:		Received by:		Time:	Date:
Relinquished by:	Time:		Date:		Received by:		Time:	Date:

Appendix II

File Location: J:\Environmental\01 Administration\01 Purchasing Shipping\Shipping Documents\Forms for Shipping\Offsite Removal Form.xlsx

PRETIVM
Bruce Jack Project
Value Through Gold
Km 215, Hwy 37
British Columbia
(778) 724-4186

Offsite Removal Form

CONSIGNEE: SGS Canada Inc.
Address Suite F, 3260 Production Way
Burnaby BC V5A 4W4

ORIGINATOR: BRUCE JACK Environmental
Date 7/30/2018

QUANTITY (L)	DESCRIPTION OF ARTICLES	TDG Y/N	APPROX WEIGHT
60.00	WTP Sludge	N	

REASON FOR REMOVAL: LAB TESTING

Packed/ Inspected by:		SIGN	DATE
Employee		SIGN	DATE
Supervisor		SIGN	DATE
Mine Manager		SIGN	DATE

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2018-08-31	Initial Issue		
2017-03-03	Revised based on ML/ARD Management Plan Updates		
2018-10-23	Updated to Pretivm SOP template		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Environment Superintendent	[redacted]		
Assistant Environment Manager			
Mine Manager or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 15

Standard Operating Procedure:
Field Bin Sampling

PRETIVM		BJ-ENV-SOP-040 Field Bin Sampling	
Owner: Colleen Atherton	Approver: Torence Sandhals, Jason Gabora	Revision Number: 1	Creation Date: August 31, 2015 Revision Date: July 23, 2018

Objective

To provide guidance for maintenance and sampling of on-site field bins.

Scope

Field bins are used to mimic the natural weathering processes that act on mine waste material stored in surface impoundments and dumps in order to predict loadings from geologic materials. The sampling protocols described in this SOP are intended to ensure that field bin leachate samples and field data are collected in a consistent manner throughout the field bin monitoring program and that reliable, representative and scientifically credible water quality data is obtained.

All activities related to care and maintenance of the field kinetic tests and collection of leachate samples.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- BDMDG: British Columbia Mine Design Guideline (i.e., cost-effective low-level detection limits)
- DI water: De-ionized water
- COC: Chain of Custody

Preparation

Hazards

- Slips and falls
- Exposure to hazardous chemicals
- Pinch points
- Tight road ways & ATV/Truck use

Tools

- YSI meter
- 1 L Sample bottles
- Vinyl gloves
- Water quality field data sheets
- 1000 mL plastic beaker
- DI water
- Water-proof marker
- Sample labels
- Camera
- COC
- Radio

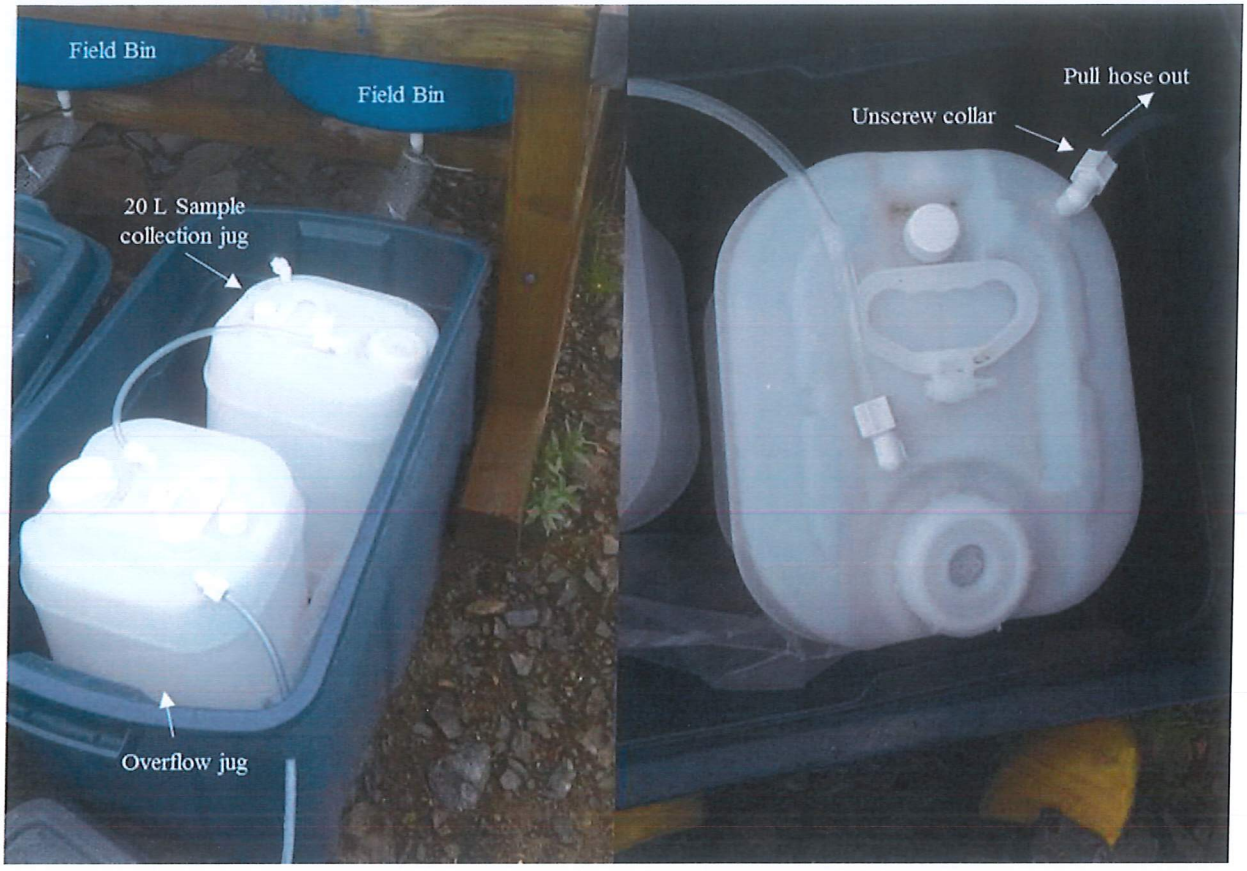
Requirements

- Trained and qualified to conduct water quality sampling
- If using ATV, ATV training and sign off

Care and Maintenance

1. **Commissioning**
   - Commissioning is to occur immediately after VOK becomes accessible following freshet and after risk of freezing has past, typically in June.
   - Attach tubing to the field bins and the sample collection jugs (Figure 1).
2. **Maintenance**
   - At the beginning of each sampling event, inspect tubing and connectors for cracks or damage.
   - A lack of water in one or more sample collection jugs may indicate a crack or damage to the tubing or connectors, clogging in the tubing or poor connections.
   - Water collected in the tote is an indication of a crack in the tubing or a poor connection.
   - Send photographs of damaged parts to Lorax and the Geochemist.
   - Dirty totes and/or collection jugs can be rinsed with DI water.
3. **Decommissioning**
   - Decommission field bins in late September or early October before freezing occurs.
   - Following collection of the final leachate sample, disconnect and remove water from tubing.
   - Collect the final leachate sample and return the empty jug to the tote.
   - Place tubing in a clean plastic bag, label the bag with the field bin number and place bag inside the tote.

Figure 1 – Configuration of sample collection jugs



Sampling

Samples are collected from the field bins whenever sufficient precipitation has been received for sample collection, typically monthly from June to October.

1. **Field Preparation**
   - Calibrate YSI meter
   - Collect and label field supplies and place in a cooler with ice packs.
     - For each field bin, label a 1 L polyethylene bottle with the date and field bin number.
   - Prepare one duplicate sample and one field blank sample for every sampling event.
2. **Leachate Collection**
   - Review BJ-ENV-SOP-028 for general sample collection and handling procedures.
   - Put on vinyl gloves. Replace gloves if they become contaminated and between each sample.
   - Remove lid of the leachate collection tote to reveal the sample collection jug (Figure 1).
   - Disconnect the tubing attached to the jug(s) in order remove the collection jug from the tote. This is accomplished by unscrewing the collar and pulling outward on the tubing (Figure 1).
   - Ensure you are wearing gloves. Once the tubing is disconnected, slowly pull the jug out of the buried tote, taking care not to pull the tubing out of the bottom of the bin.
   - Obtain a pre-labelled 1 L polyethylene bottle. Fill the bottle with leachate from the collection container by pouring the contents directly from the collection jug. If there is sufficient volume, fill the 1 L bottle to capacity. Screw the lid on and place the bottle in the cooler with the ice packs.
   - Fill the 2000 mL plastic beaker with water from the sample collection jug.

- Measure pH and conductivity of the leachate using the pH/conductivity meter.
- Fill in the Data Sheet (Appendix I)
  - Record time, temperature, pH and conductivity.
  - Using the beaker, record the total volume of leachate in the collection jug including the 1 L plastic bottle collected for laboratory analysis and the volume used to measure pH/conductivity.
  - Include any notes regarding the sample or sample collection.
- After measuring the volume, discard water from the sample collection jug.
- After emptying the sampling jug, reinstall it in the tote.
- Carefully place the jug back in the tote in the same position it was found originally, taking care not to pull the tubing out of the bottom of the field bin.
- Take the tubing and push it back into the elbow joint in the top of the sampling jug. It is important to make sure that the tubing is pushed all the way into the elbow joint to ensure a tight fit. Once the tubing is installed, pull the collar out to secure the tubing in the joint.
- Repeat the steps in Step 2 for each of the field bins.
- Collect the QA/QC samples described in Step 3.

3. QA/QC Samples

- Collect one field duplicate for every sampling event by filling a second 1 L polyethylene bottle with water from a collection jug that has sufficient volume. This sample is identified by -98, e.g., FB-01-98.
- Collect one field blank for every sampling event by opening a pre-filled 1 L polyethylene bottle containing DI water (provided by the analytical laboratory) during the collection of one of the leachate samples thereby exposing the contents to the same conditions as the leachate sample. This sample is identified by -99, e.g., FB-01-99.

4. Complete COC

- Complete COC as per example in Appendix II.
- All samples should be analyzed for the following parameters:
  - Anions-all, conductivity
  - pH, acidity, ortho – P
  - Alkalinity – PCT
  - TOC
  - Ammonia
  - Total Nitrogen
  - Dissolved Metals (BCMDG) + Hg
  - Hardness

5. Shipping and Analytical Parameters

- Ship samples to the analytical Laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure the samples arrive at the laboratory <10°C.

6. Data Tracking and Analysis

- Data will be compiled and evaluated by the Environmental Manager or designate.

Appendix I – Data Sheet

Field Bin Data-Sheet:

Date:
Sampler:
Water Temperature:

Sample	Time	pH	Temp (ºC)	Cond (uS/cm)	Total Volume in Collection Jug (L)
FB-1					
FB-2					
FB-x					
FB-#-DUP					
Blank-#					

Appendix II – COC

File location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\ALS\2018\COC\Field Bins/COC_ALS_Field Bins.xlsx

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 14 -
Page 1 of 1

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format:	☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report	☑ Yes ☐ No	P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution:	☑ EMAIL ☐ MAIL ☐ FAX	E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax	catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2	Alison.Shaw@lorax.ca	

Invoice To		Invoice Distribution	
	Same as Report To ☑ Yes ☐ No	Select Invoice Distribution:	☑ EMAIL ☐ MAIL ☐ FAX
	Copy of Invoice with Report ☑ Yes ☐ No	Email 1 or Fax	invoices@pretivm.com
Company:	Pretivm (Brucejack Project)	Email 2	
Contact:	Accounts Payable (604-558-1784)		

Project Information		Oil and Gas Required Fields (client use)	
ALS Quote #:		Approver ID:	Cost Center:
Job #:	Field Bins	GL Account:	Routing Code:
PO / AFE:	1024962	Activity Code:	
LSD:		Location:	

ALS Lab Work Order # (lab use only)		ALS Contact:	Dean Watt	Sampler:	

Analysis Request — Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Anions - all, conductivity	pH, acidity, ortho-P	Alkalinity - PCT	MET-D-BCMDG-VA incl Hg	Ammonia	Total Nitrogen	Hardness	TOC						Number of Containers
	FB-01	9-Apr-18	13:40	water	R	R	R	R	R	R	R	R						1

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	email 3: environmental@pretivm.com email 4: mholtby@pretivm.com email 5: svanzalingen@pretivm.com email 6: rmccall@pretivm.com
Are samples for human drinking water use? ☐ Yes ☑ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen	☐	SIF Observations	Yes ☐ No ☐
Ice packs	Yes ☐ No ☐	Custody seal intact	Yes ☐ No ☐
Cooling Initiated	☐		

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by:	Date:	Time:	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION — WHITE - LABORATORY COPY — YELLOW - CLIENT COPY — NA-FM-0326 v.09 Front / 04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
2015-08-31	Initial Issue		
2018-07-31	Update to Pretivm SOP template.		All

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Environment Superintendent or Designate			
Surface Operations Superintendent or Designate			
Health and Safety Manager or Designate			
JOHSC Co-chair or Member			

Appendix 9-1-12. Mine Emergency Response Plan

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Mine Emergency Response Plan

February 2022

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Mine Emergency Response Plan

Date: February 2022

Pretium Resources Inc.
Suite 2300, Four Bentall Centre
1055 Dunsmuir Street
PO Box 49334
Vancouver, BC, V7X 1L4
T: (604) 558-1784
F: (604) 558-4784

VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
1	May 15, 2015	J. Nicholson	First release of the plan
2	July 14, 2016	J. Nicholson	Review and edits, add Code 1
3	December 2018	J. Barbondy	Align with 2017 MEMPR Guidance (v1.4)
2021.0	February 2021	R. Geddes	Updated to align with current safety standards and practices
2022.0	February 2022	R. Geddes	Review and edits

COMMUNICATIONS AND CONTACT LISTS

Communications at Brucejack is available by VHF radio, satellite phones, and satellite Internet. Tables 1 to 3 provide internal and external contacts as well as other useful communications related references. Planning Managers will direct the maintenance team to maintain and monitor the communications system.

Table 1. Medical Emergency Contacts

Service	Party	Contact Number
Ambulance	BC Road and Air Ambulance	1-800-461-9911
	Back-up BC Ambulance	1-800-561-8011
	Terrace	1-250-638-1102
	Stewart Lora Lee Murray	1-250-636-2676
Hospitals	Stewart – Stewart General Hospital and Nurse On-duty	1-250-636-2221
	Terrace – Terrace Mills Memorial Hospital	1-250-635-2211

Table 2. Mine Camp Coordinates

	UTM NAD 83 Zone 9		WGS 84	
Locations	Easting	Northing	Latitude	Longitude
Brucejack Camp	427,080	6,258,695	N 56°28’01”	W 130°11’01”
Wildfire Camp	469,101	6,264,071	N 56°31’12”	W 129°30’8”
Bowser Aerodrome	44,367	6,250,234	N 56°23’35”	W 129°56’59”
Knipple Camp	43,795	6,251,226	N 56°24’44”	W 130°19’

Brucejack Camp is approximately 65 km by air north-northwest of the town of Stewart. It is 73 km via the Brucejack Access Road west from km 215 on Highway 37.

It is approximately 240 km by air from Terrace to Brucejack Camp, and about 370 km by road from Terrace to Brucejack Camp.

Table 3. General Emergency Contacts

Service	Party	Contact Number
Avalanche	MOTI – Stewart Avalanche Tech (if not in office call Burnaby)	1-250-636-2625
	Burnaby Dispatch Rapid Phone	1-604-660-9770
	MOTI – Avalanche Tech Stewart – Ryan Boyle	1-250-636-9055
	Last Frontier Heli-skiing - Bell II Lodge (Jan to April)	1-250-275-4770
	Northern Escape Heli-skiing	1-250-615-3154
	Canadian Avalanche Centre	1-250-837-2141
Ministry of Energy, Mines and Petroleum Resources (MEMPR)	Mines Inspector – Doug Flynn	1-250-847 7386
	Northwest Regional Office (Smithers)	1-250-847 7383
	Senior Inspector of Mines, Health and Safety – Jordan Whynot	1-250-876-6703
WorkSafeBC	Worker's Compensation Board (Vancouver)	1-604-561-3700
PEP	Provincial Emergency Program (24 hours)	1-800-663-3456
SAR	Stewart SAR – Erin Boyle	1-250-636-9055
	Stewart	1-250-636-2233
RCMP	Terrace	1-250-638-7400
Fire	Forest Fire Reporting	1-800-663-5555
Poison Control	B.C. Poison Control Centre (Vancouver)	1-800-567-8911
Environment	Enforcement & Environmental Emergencies (Victoria)	1-250-356-9302
	Environment Canada (Emergency Spill Reports)	1-604-666-6100
	Conservation Officer	1-800-663-9453
	Provincial Emergency Program – 24 hour (Spills)	1-800-663-3456
	Northwest Response Ltd. (Ray Hollenberg)	1-250-847-4556
	Transport Canada (TDG – Vancouver)	1-604-666-2955
Highways	Transport Emergency Centre (CANUTEC)	1-613-996-6666
Helicopters	Yellowhead Helicopters	1-250-963-9884
	Canadian Helicopters	1-250-635-2430
Other Companies	Soucie Construction	1-250-636-2389 office
	Seabridge Camp	403-387-2322
	Seabridge Camp Manager	403-387-2323

BRUCEJACK SITE EMERGENCY PHONE CONTACTS

The main Brucejack Phone Number is **778-724-4186**.

The primary means of communications on site is VHF Radio. There are three repeater channels allowing for long distance VHF communications and a number of shorter ranges "Talk Around" channels that require line of site with the receiving party (Table 4).

Table 4. Brucejack Radio Frequencies

Channel	Name	RX Frequency	TX Frequency	Tone
Ch 1	New Road **(NEW)**	166.080	166.080	
Ch 2	Repeater 1 **(Brucejack)**	162.735	167.715	71.9
Ch 3	Talk Around 1	162.735	162.735	
Ch 4	Repeater 2 **(Bowser)**	162.810	167.790	123.0
Ch 5	Talk Around 2	162.810	162.810	
Ch 6	Repeater 3 **(Wildfire)**	162.105	167.085	156.7
Ch 7	Talk Around 3	162.105	162.105	
Ch 8	Lad 1	154.100	154.100	
Ch 9	Lad 2	158.940	158.940	
Ch 10	Lad 3	154.325	154.325	
Ch 11	Lad 4	173.370	173.370	
Ch 12	VIH	166.470	166.470	

ACKNOWLEDGEMENTS, DISCLAIMER, AND SIGN-OFF

This Mine Emergency Response Plan (MERP) has been compiled for Pretium Resources Inc. (Pretium) from various public and private information sources, including the *Health, Safety and Reclamation Code for Mines in BC*, 2021, the *Handbook for Mineral and Coal Exploration in BC*, 2008/09 and the *Mine Emergency Response Plan Guidelines for the Mining Industry*, 2017, version 1.4.

This version of the Brucejack MERP is a revision of the 2021 version.

Any use of, or reliance on this Plan by any third party is at that party's sole risk.

Statutory authority:

	Mine Manager
	Health and Safety Manager

BRUCEJACK MINE

Mine Emergency Response Plan

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GLOSSARY AND ABBREVIATIONS

Avi-tech	Avalanche (or glacier) technician
BC	British Columbia
CO_2	Carbon dioxide
EOC	Emergency Operations Centre
EMP	Environmental Management Plan
ERC	Emergency Response Coordinator
ERCC	Mine Emergency Response Plan Coordinator
ERMT	Emergency Response Management Team
ERP	Emergency Response Plan
ERPC	Emergency Response Planning Committee
ERT	Mine rescue Emergency Response Team
HSE	Health, Safety and Environment
HSRC	*Health, Safety and Reclamation Code for Mines in BC* (2017)
IMT	Incident Management Team
ICS	Incident Command System
IMR	Incident Management Room
JOHSC	Joint Occupational Health and Safety Committee
OFA 3	Person with minimum Level 3 first aid qualifications
L	Litre(s)
m	Metre(s)
MEMPR	Ministry of Energy, Mines and Petroleum Resources
MEMLCI	Ministry of Energy, Mines and Low Carbon Innovation
MERP	Mine Emergency Response Plan
MHz	Megahertz
mm	Millimetre(s)
MST	Mountain Safety Technician

OHS	Occupational Health and Safety
PEP	Provincial Emergency Program
PPE	Personal protective equipment
Pretium	Pretium Resources Inc.
SAR	Search and Rescue
UG	Underground
VHF	Very high frequency

1 MINE EMERGENCY RESPONSE PLAN (MERP)

1.1 MERP OBJECTIVES

The goal of this Mine Emergency Response Plan (MERP) is to provide Pretium Resources Inc. (Pretium) employees, contractors and their employees with guidance to prepare and respond to an emergency situation in an organized and effective manner (formal structure). An organized response will contain and control the situation, and will mitigate consequences to people, property and the environment. The MERP outlines the response procedures and preventive measures that will achieve effective and timely management of an emergency.

This MERP is proposed to cover all the Brucejack Mine facilities and work areas, which include the access road, satellite camps (i.e., Knipple, Bowser and Wildfire camps), construction activities and in mine site production operations for the surface and underground areas.

The MERP, dependent on the nature of the emergency, can be activated when a project-related emergency and/or incident occurs anywhere on the mine.

This plan also outlines the responsibilities and duties of an Emergency Response Team (ERT) as required by Pretium in the event of an emergency at the mine.

The MERP is intended to meet the following objectives:

- Provide a pre-determined course of action during a mine site emergency situation;
- Provide a listing of the duties and responsibilities of personnel;
- Assist personnel in determining appropriate responses to emergency situations;
- Provide guidance to prevent and minimize personal injury during a mine-site emergency situation;
- Provide guidelines for initial first aid treatment of injured personnel;
- Provide guidance for initial emergency response to minimize damage to property, equipment and the environment;
- Enable communication and co-operation between corporate personnel, site personnel, mutual aid organizations, agency officials, and the community at large;
- Provide guidelines for ensuring the safety of site personnel, visitors, and community members;
- Provide guidance to reduce the magnitude of environmental impacts;
- Assist response personnel to determine and perform remedial actions quickly;
- Comply with legal requirements in response related matters in case of emergencies;
- Reduce recovery time and cost;
- Inspire confidence in response personnel;

- Ensure procedures comply with OHS and environmental requirements; and
- Safely restore operations to normal.

Anyone discovering a potential emergency should know the immediate steps to take and will follow the "decision flow chart" included in this plan (See Section 2.1). The MERP will provide guidance when the initial attempts to control a situation are not successful.

1.2 MERP POLICY DIRECTIVE

A Mine Emergency Response Plan is required by Part 3.7.1 of the *Health, Safety and Reclamation Code for Mines in BC*, 2017 (MEMPR 2017), and must be in general accordance with the *Mine Emergency Response Plan Guidelines for the Mining Industry*, 2017, version 1.4.

Pretium management is dedicated to providing a safe workplace for its employees and contractors. The goals of this MERP are, in order of priority, to protect the health and safety of workers and the public, protect the environment, avoid adverse social and economic effects, preserve heritage, as well as protect and minimize damage to company properties.

This MERP was developed to assist in protecting personnel and company facilities in the event of an emergency. An emergency is the unforeseen combination of circumstances, unusual occurrences or resulting state which may result in endangerment to lives or areas of the mine. This emergency may call for the immediate action from management and/or trained mine rescue, fire and first aid personnel.

Possible situations with the potential to create an emergency under some circumstances might include:

- avalanches;
- wildlife and human interaction;
- fire (electrical/mechanical);
- spills of fuel or hazardous substances;
- contact water pond and tailings line discharge;
- underground mine emergencies: ground failures, main fan ventilation failure, etc.;
- unexpected/unplanned explosions;
- aircraft/ground vehicle accidents;
- non-life- and life-threatening injury or fatality;
- flooding/snowstorm/blizzards/ice storms; and
- natural disaster.

In order to protect site personnel, Pretium will use specific evacuation procedures to remove all personnel from the source of danger and to account for all personnel on shift.

During the operation and closure phases of the Brucejack Mine, senior management will assign various responsibilities to specific personnel, and will provide overall supervision and monitoring.

Pretium will ensure that the MERP is current and maintained at all times. The Mine Manager will ensure that there is a budget is in place to address the requirements of the MERP, including related training. As per the annual budgets, funding is provided for emergency response team training, high level scenarios, incident management team tabletop and mock scenarios. Additional funds are also provided for emergency and auxiliary equipment used during the scenarios. The Mine Rescue Team will be compensated if a call out occurs after their working hours. Copies of the MERP will be posted in common locations for workers to review. Each worker will be required to become familiar with the details of the MERP, and the location of all emergency services at the time of the initial mine site familiarization training.

Pretium is strongly committed to having in place an efficient MERP resulting in an organized and effective response at containing and controlling the situation, as well as mitigating consequences to people, property and the environment. In meeting this commitment Pretium will:

- Provide training to all employees, contractors and their employees for their roles in all emergency plans;
- Ensure that ALL site personnel are familiar with and are able to call a CODE 1 for any type of emergency, BJ-OHS-SOP-002 - Code One Call Out & Response;
- Ensure all supervisors are responsible that their employees are aware of, and trained in, the proper emergency response procedures and that procedures and contact information are posted in all work areas. Supervisors are also responsible for ensuring that all employees follow safe work procedures and follow regulations to prevent emergencies from occurring, and that they are provided with the proper tools to do so, including PPE;
- Ensure all personnel (including Pretium employees, contractors and their employees) will participate in emergency response drills on a regular basis;
- Appoint a qualified person as a trainer for mine rescue members as per Part 3.7.9 or the HSRC;
- Procure the necessary mine rescue and emergency response equipment, and ensure adequate training in the use of this equipment is provided by the qualified person(s);
- Develop the required Emergency Response Teams as per Part 3.7.2 of the HSRC;
- Appoint a Mine Emergency Response Plan Coordinator and Planning Committee;
- Set up and continually improve the long-term goals of the plan;
- Establish a budget for the emergency response program, including hiring and training qualified personnel, to ensure the successful implementation of the MERP; and
- Support all other activities necessary to develop and implement an effective Emergency Response Plan.

All Pretium employees, contractors and their employees will need to be aware of the normal hazards associated with their work area. A sudden change from the norm may result in an unusual and dangerous situation. Being prepared for an emergency will mean quicker action and ensure proper manner of action in cases of individual injury, help for individuals or of a mine problem area.

All Pretium employees, contractors and their employees will be shown at the time of initial mine site familiarization:

- the emergency response and first-aid procedures and where are they posted;
- the procedure to summon the emergency response team in the event of any emergency by using the CODE 1 emergency procedures;
- the procedure to summon first aid;
- the procedure to follow in the event of a fire;
- the ability to access information for emergency facilities such as air ambulance, police, and hospital; and
- the location of their assembly area in case of an emergency; they will be given names of emergency personnel, their qualifications, and their contact information. This information will be posted at each individual working area and updated as necessary.

All Pretium employees, contractors and their employees will also receive the Brucejack Project Occupational Health and Safety Plan (OHSP) at the initial mine site orientation. After a general presentation of the company's Health and Safety Program, each worker will be required to complete a written sign-off and acknowledgement of understanding this material.

Emergency response drills will be undertaken for the following reasons:

- to validate the adequacy of the organizational infrastructure to effectively deal with emergencies;
- to test the initial communications sequences;
- to verify contact numbers are correct;
- to familiarize personnel with their duties and responsibilities;
- to evaluate the preparedness of each party involved in the Emergency Response Program;
- to identify and correct deficiencies in the Emergency Response Program;
- to verify the availability of support services;
- to exercise tactical site-specific responses; and
- to examine the interaction between the individuals, support groups, organizations, and agencies named in the Emergency Response Program, and to address identifiable shortfalls in the established lines of authority.

1.3 MERP LINKAGES TO OTHER ENVIRONMENTAL MANAGEMENT PLANS

Pretium is committed to providing safe and healthy working conditions, and protecting the health, safety and the environment as vital elements of the mine. This commitment is essential to achieving a successful long-term operation. Throughout the various mine phases, Pretium plans to conduct activities to minimize impacts on the environment.

The commitment to this objective will be achieved with the preparation and integration of Environmental Management Plans (EMPs) into mine operations. Each plan will provide methods, procedures, and actions to be utilized by Pretium personnel and/or its contractors to ensure that their activities comply with appropriate environmental legislation, mine commitments, and applicable environmental standards. This MERP is one of several plans that form part of the Brucejack Mine Environmental Management System (EMS).

Other Mine EMPs related to this MERP include:

- Occupational Health and Safety Manual (OHSM);
- Chemicals and Materials Storage and Handling Management Plan (CMSHMP);
- Fuel Management Plan (FMP);
- Spill Response Plan (SRP)
- Hydrocarbon Contaminated Soil Management Plan (HCSMP);
- Construction Environmental Management Plan (CEMP); and
- Waste Management Plan (IDWMP).

1.4 MERP Coordinator and Planning Committee

On the Brucejack Mine, the Mine Manager will appoint the Health and Safety Manager, or a designate, to act as the Mine Emergency Response Plan Coordinator (ERCC) for the site. The ERCC will have the full support of Pretium to successfully implement the MERP. Currently the ERCC is the Emergency Response Team Coordinator.

The Mine Manager will select members for a Mine Emergency Response Planning Committee (ERPC), and will integrate the ERPC, ERCC and the Joint Occupational Health and Safety Committee (JOHSC).

The ERPC will perform the following duties:

- Examine possible eventualities for each area of the mine, together with the possible measures of prevention and protection and resulting actions. The outcome of this pre-planning exercise will be reviewed periodically as conditions change over time. Initially, all areas and processes of the mine will be inspected to determine the risks associated with the work environment, including confined spaces, mine fires, explosions, rock-bursts, falls of ground, runs of muck, inrushes of water and avalanches.
- Review mitigation measures designed to prevent emergency events from occurring and reduce the adverse effects of such events. The review will assess the effectiveness of the mitigation and consider alternatives where necessary.
- Confirm the appropriateness of training and procedures, safe working practices, housekeeping programs, and first aid training to prevent a minor emergency escalating to a crisis or a disaster.
- Review the MERP annually to verify its effectiveness. As the Brucejack Mine develops, a re-assessment of emergencies and incidents will be undertaken. Findings from this periodic assessment will be used to update and revise procedures associated with the MERP.

Updates will be made based on corrective actions noted during tabletop and mock high-level exercises. Pretium Resources/Brucejack Mine has set the standard to run a minimum of three tabletop scenarios and one mock scenario per calendar year. The scenarios need involve the Brucejack Site Emergency Response Team and Incident Management Team, as well as the corporate office in Vancouver.

1.5 ERPC DUTIES AND RESPONSIBILITIES IN REGARD TO THE MERP

Regarding the MERP, specific members of the ERPC have various duties and responsibilities, as detailed below.

1.5.1 Mine Manager

The Mine Manager shall:

- ensure that personnel, equipment and resources are adequate to effectively deploy the MERP;
- ensure that a MERP has been developed and communicated to site staff and contractors;
- participate in the emergency response evaluation meeting after each emergency response; and
- interface and communicate with corporate senior management.

1.5.2 Health and Safety Manager

The Health and Safety Manger is a member of the ERPC, which develops, maintains and implements the MERP that is comprehensive and is regularly updated to meet the changing needs of mine activities.

The Health and Safety Manager shall:

- ensure that mine orientation and safety meetings include training for ERP roles and responsibilities;
- participate in post-incident evaluation meeting to review emergency response, MERP effectiveness and opportunities for improvement;
- work with the Mine Manager to identify and implement improvements to the MERP;
- coordinate annual fire drill and “man-down” drills to test and evaluate emergency preparedness; and
- update and post the MERP, telephone lists and plot plans (i.e., muster areas; location of emergency/medical equipment).

1.5.3 Operations Supervisors

The Operations Supervisors shall effectively communicate MERP roles and responsibilities to new employees.

1.5.4 Joint Occupational Health and Safety Committee (JOHSC)

The JOHSC committee is made up of worker and employer representatives consulting in a cooperative atmosphere to identify and resolve health and safety issues/concerns in support of the MERP.

The JOHSC shall:

- participate in the identification of dangers to safety and health in places of employment, and recommend means of controlling the hazards;
- obtain information from the employer and from additional sources regarding the identification of existing or potential dangers to safety and health;
- receive, consider, and where necessary, investigate complaints respecting safety and health of workers at this workplace, and where necessary, make recommendations to the employer;
- participate in workplace inspections; and
- participate in incident investigations.

1.6 PROJECT HAZARD IDENTIFICATION, PREVENTION AND PROTECTION

The Brucejack Mine has developed a Risk Assessment document that will continue to be used through mine operation and closure. The purpose of this document is to provide direction to personnel related to hazard identification and risk assessment. This is a multi-page Excel spreadsheet used to identify the steps, associated hazards, controls in place, and additional controls needed after the assessment has been completed. The additional controls are assigned to a specific worker and have a completion date. These processes will continue to be used to identify and evaluate both existing and potential hazards throughout the mine site. They will also assist in defining methods to control and/or eliminate the hazards identified.

As part of the Hazards Identification program, all Pretium employees, contractors and their employees shall assess their worksite and complete a Job Hazard Analysis form (available in supervisor's office). This assessment process must be completed prior to the start of all jobs, particularly new jobs to identify existing or potential hazards to workers and then to eliminate and/or control these hazards through the use of appropriate engineering or administrative controls, proper training or the use of personal protective equipment.

All company staff and contractors are required to take a proactive approach to managing and reporting hazards. When they observe a hazard, they shall take steps to manage that hazard directly (provided they are knowledgeable / trained to safely do so) – eliminate the hazard or get assistance from appropriate persons to do so whenever reasonably possible. Where hazards cannot be eliminated immediately, take necessary steps to warn others of the hazard. Report hazardous or potentially hazardous conditions and acts to a supervisor or your site contact if a contractor.

1.7 EMERGENCY RESPONSE PROGRAM (ERP) OUTLINE

As part of the MERP, the Brucejack Mine has proposed the Emergency Response Program (ERP) for the mine site, described in Section 2. The ERP details emergency response levels, emergency management team, planning and training, emergency response team structure, etc.

1.8 RELEVANT ENVIRONMENTAL ASSESSMENT CERTIFICATE CONDITIONS

On March 26, 2015, Pretium was granted an Environmental Assessment Certificate (#M15-01) which included a series of conditions. This MERP fulfills Condition #2, in relation to a Component Plan for mine emergency response planning, presented within Schedule B of the Certificate and copied below.

Condition 2

> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5. The Aboriginal Consultation Plan outlines the notification process if there is an emergency at the Brucejack Mine.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

1.9 FIRST RESPONDER CONSULTATION

The MERP will be provided to all mutual aid parties, British Columbia Ambulance Service, Stewart RCMP and Stuart Hospital. A map with helicopter landing zones will also be provided to Yellowhead Helicopters, BCA, Canadian Helicopters and Lakelse Helicopters.

2 EMERGENCY RESPONSE PROGRAM (ERP)

The Brucejack Mine has developed an Emergency Response Program (ERP) for the mine site. Details regarding certain aspects covered in the following sub-sections include:

- Emergency Response Levels: contains the emergency criteria, emergency level characteristics, reporting sequence and implementation summary;
- Emergency Response Management Team (ERMT): identifies who is on the Emergency Response Management Team(s) and identifies responsibilities and duties; and
- Planning and Training: documents pre-planning activities such as the development of the organization's emergency plans, education and training.

2.1 EMERGENCY CRISIS PROCESS

The Emergency Crisis Process assesses the consequence and severity level of an emergency (Figure 2.1-1). The Severity Table is provided in Appendix B.

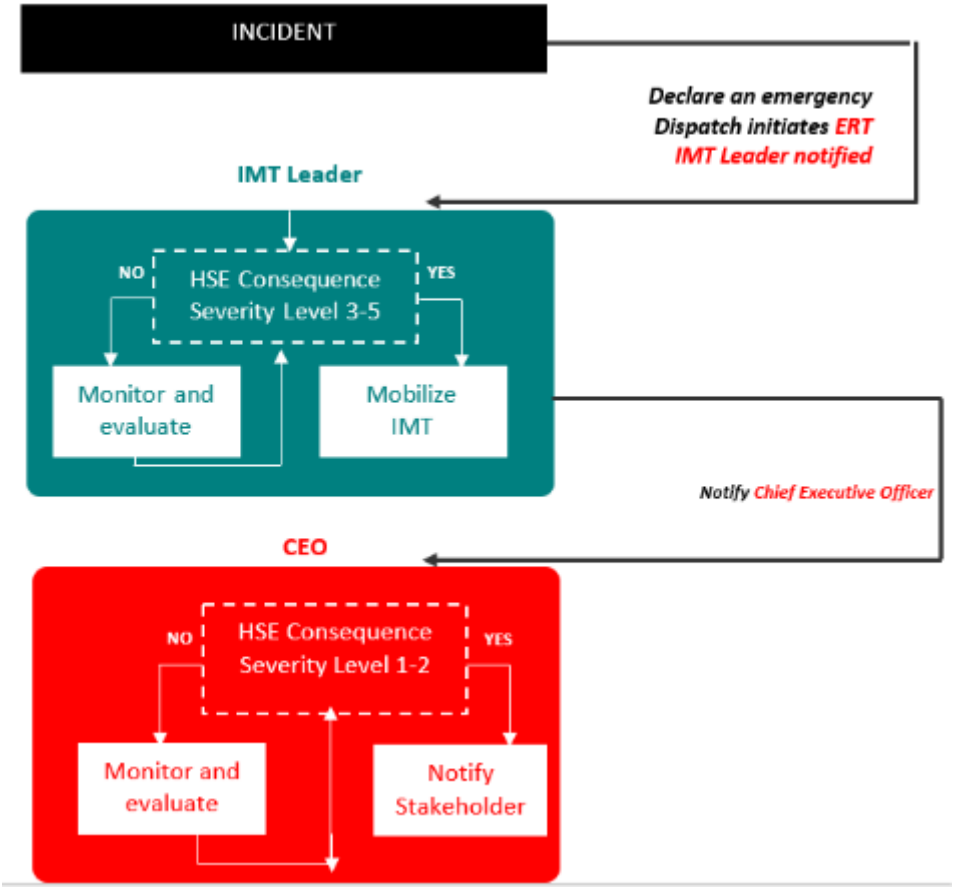


Figure 2.1-1. Emergency Crisis Process

2.2 EMERGENCY RESPONSE LEVELS

2.2.1 Introduction

The following emergency response level concept was originally conceived by Galore Creek Mining Corporation as part of their Emergency Response Plan v. 2.1 (GCMC ERP v. 2.1). This concept will be adopted in this MERP because it provides sound directions, procedures, and courses of action to follow in the event of a mine site emergency.

An emergency can be defined as any incident, or event that causes or creates the potential for a serious injury, loss of life, significant loss or damage to property, or environmental damage. Although emergencies by definition are unexpected events, the relative risk of some occurrences can be identified and preparations (policy and procedures) put in place for timely and effective response. Remember, this identification is the first step in ensuring adequate response.

Pretium incident reporting policy requires all levels of emergencies to be reported to the Health and Safety Manager (or designate). The urgency shall depend on the severity of the situation.

Emergency response criteria, definitions of Level 1, 2 and 3 emergencies and emergency level decision flow chart are discussed in the following sections of this MERP. It is anticipated that Pretium employees, contractors and their employees will be able to utilize this system, to aid in making appropriate decisions regarding the emergency response.

2.2.2 Emergency Response Criteria

The Risk Ranking Matrix presented in Figure 2.2-1 will be used by the Emergency Response Coordinator (ERC; or designate) to determine the level of emergency and deployment of emergency response personnel as follows:

- Activities with Low risk or acceptable risk level are denoted in **Green** in the Matrix
- If the Ranking Matrix indicates a low potential (**Blue**), the ERC (or designate) will initiate a Level 1 Alert.
- If the Ranking Matrix indicates medium potential (Yellow), the ERC (or designate) will initiate a Level 2 Alert and review the situation.
- If the Ranking Matrix indicates high potential (**Red**), the ERC (or designate) will initiate a full Level 3 Alert.

2.2.3 Emergency Level Characteristics

The Emergency Decision Flow Chart provides a summary of emergency level characteristics and processes for the Brucejack Mine (Figure 2.2-2). The flow chart will be utilized to assist management and employees in ensuring that a proper approach is taken in case of an emergency incident.

STEP 1 DETERMINE LIKELIHOOD

Likelihood (L)			
A	Almost Certain	Happens often	More than one event per month
B	Likely	Could easily happen	More than one event per year
C	Possible	Could happen and has occurred here or elsewhere	One (1) event per 1 to 10 years
D	Unlikely	Hasn't happened yet, but could	One (1) event per 10 to 100 years (within a single mine life)
E	Rare	Conceivable but only in extreme circumstances	Less than one (1) event per 100 years (life of Pretivm Resources Inc.)

STEP 2 DETERMINE CONSEQUENCES

Consequence/Severity (C)						
Rank	Consequence	People	Damage/Loss	Environment	Business	Reputation
1	Catastrophic	Fatality	Extreme Financial Loss (>US$1,000,000)	Irreparable Damage, very serious long term impairment of the eco-system	>48 Hours Production Delay	Major Damage to Reputation receiving national or international negative media OR production to cease as a result of statutory concerns
2	Major	Permanent and total disability	Major Financial Loss (US$500K – 1,000K)	Major Impact, serious medium term environmental impact effecting the whole eco-system	24 to 48 Hours Production Delay	Major Damage to reputation receiving province-wide negative media OR non-compliance with statutory requirements resulting in a major fine
3	Moderate	Loss Time Injury	Moderate Financial Loss (US$100K – 500K)	Minor Impact, moderate short term effects affecting part, but not affecting whole eco-system	12 to 24 Hours Production Delay	Moderate Damage to reputation localized to regional media OR non-compliance with statutory requirements resulting in minor fine
4	Minor	Disabling Injury	Minor Financial Loss (US$ 10K – 100K)	Minor Impact on biological or physical environment	6 to 12 Hours Production Delay	Minor Impact to reputation localized to communities OR technical divergence that may attract attention from statutory authorities
5	Low	First Aid/Medical Aid with no time lost or change of duties	Low Financial Loss (US$ <10K)	Limited Damage to minimal area of low significance or previously disturbed areas	<6 Hours Production Delay	No Impact on stakeholder or reputation

STEP 3 CALCULATE RISK

		Consequence / Severity (C)				
Likelihood (L)		1 Catastrophic	2 Major	3 Moderate	4 Minor	5 Low
A	Almost Certain	1 (Ex)	2 (Ex)	4 (Ex)	7 (H)	11 (H)
B	Likely	3 (Ex)	5 (Ex)	8 (H)	12 (H)	16 (M)
C	Possible	6 (H)	9 (H)	13 (H)	17 (M)	20 (M)
D	Unlikely	10 (H)	14 (M)	18 (M)	21 (L)	23 (L)
E	Rare	15 (M)	19 (M)	22 (L)	24 (L)	25 (L)

Consequence Severity Table												
SEVERITY LEVEL	Severity Rating	Financial		Operations						Compliance	Strategic	
		Liquid Cash	Project Budget Variance	Mine Shutdowns	Project Delays	Security	Health	Safety	Environment	Legal/Regulatory	Community Perception/Stakeholder Relations	Strategy
5	Catastrophic	>$40M	>20%	>15% impact on production volume	> 6 months	Security breach resulting in material theft and loss of significant assets	Multiple fatalities or serious disabling illness to multiple people.	Multiple Fatalities; or Permanent impairment to multiple people.	Extensive impact (>20 years) to land, biodiversity, ecosystem services, water resources or air	Fines and prosecutions relating to criminal breaches including jail terms and being the subject of a royal commission	Prolonged (>2months) international multi-NGO and media condemnation Extensive long-term social impacts and serious infringements of cultural heritage	Loss of significant business capability
4	Major	$30 -$ 40M	15 - 20%	7.5 – 15% impact on production volume	3 - 6 months		Single fatality or irreversible health effects or disabling illness.	Single fatality or Permanent impairment to > 30% of the body	Major impact (5-20 years) to land, biodiversity, ecosystem services, water resources or air	Major civil litigation including class actions	Major adverse international multi-NGO and media condemnation Major long-term social impacts and infringement of cultural heritage	Significant reduction in business capability
3	Serious	$20M - $30M	10 - 15%	2.5 – 7.5% impact on production volume	1 - 3 months	Security breach resulting in serious theft and/or loss of significant assets	Severe, reversible health effects of concern that would typically result in a lost time illness.	Permanent impairment, < 30% of the body to 1 or more Days lost due to injury/illness	Serious impact (1-5 years) to land, biodiversity, ecosystem services, water resources or air	Breach of regulations and lack of exploration title	Serious public or national media outcry, damaging NGO campaign Moderate medium-term social impacts	Temporary loss of service or business capability
2	Moderate	$10M - $20M	5 - 10%	0.5 – 2.5% impact on production volume	2 - 4 weeks	Security breach resulting in moderate theft and/or loss of low value assets	Reversible health effects of concern that would typically result in medical treatment.	Objective but reversible impairment Medical treatment for injury/illness	Moderate impact (<1 year) to land, biodiversity, ecosystem services, water resources or air	Minor legal issues, non-compliances and breaches of regulation	Non-material reputation damage Attention from regional media and local public attention and complaints Minor social impacts	Temporary delay in reaching objectives
1	Low / Minor	<$10M	<5%	< 0.5% impact on production volume	< 2 weeks	Security breach resulting in small theft	Reversible health effects of little concern, requiring first aid treatment at most.	Low-level short-term subjective symptoms or inconvenience. No medical treatment required	Minor disturbances and/or Low-level impact to land, biodiversity, ecosystem services, water resources or air	Low-level legal issues	Public concern restricted to local complaints Low-level interest from local media and/or regulator Low-level social impacts	No material impact on the achievement of business objectives

RISK MATRIX

LIKELIHOOD	Score	1	2	3	4	5
	Rating	Rare	Not Likely	Possible	Highly Likely	Expected
Chance of the potential consequence occurring considering the controls in place	Frequency	Greater than 100 year event	Every 10 to 100 years	Every 1 to 10 Years	Every 2 to 3 years	Almost Yearly

Risk Level	Actions Required
Critical	STOP - Manager approval required. Controls to reduce risk must be identified and implemented before performing work.
High	STOP - Superintendent approval required. Controls to reduce risk must be identified and implemented before performing work.
Moderate	STOP - Review and follow Work Instruction or complete Group JHA with team members and Team Leader.
Low	Worker conducts personal JHA prior to performing task and continually assesses risks.

Figure 2.2-1. Risk Ranking Matrix

Emergency levels are classified into three categories, based on different criteria described below. Generally, Level 1 emergencies can be controlled entirely by personnel within the immediate vicinity of the incident/accident. Notification will be made immediately with documentation to the safety department within 24 hours of the incident. As for Level 2 and 3 emergencies, they may force temporary suspension or shut down of operations indefinitely. These incidents must be reported immediately to the Mine Manager.

Level 1 – Potential Emergency (Containment Level)

- Can be controlled entirely by mine site personnel and operations;
- Located within the immediate vicinity of the incident/accident site;
- No danger outside of the mine site;
- Immediate control of the hazard/sources is possible;
- No threat to the public;
- Minimal environmental impact; and
- Little or no media interest.

Level 2 – Emergency (Notification Level)

- A section of the operation is temporarily shut down;
- Can be controlled by the personnel and equipment that are readily available at the mine;
- Potential exists for the emergency to extend beyond the mine site;
- Outside agencies (MEMPR, police, fire, etc.) must be alerted and kept informed of the situation;
- Imminent control of the emergency is probable;
- Some threats to the public exist;
- Moderate environmental impact; and
- Local/regional media interest is probable.

Level 3 – Major Emergency (Mobilization Level)

- Forces the indefinite shut down of operations;
- External emergency support services are required;
- Safe operating control has been lost;
- Actual or potential severe injuries or fatalities;
- Public safety jeopardized;
- Significant and ongoing environmental impact;
- Significant media interest;
- Immediate multi-agency involvement; and

- Assistance from outside parties required.

2.2.4 Emergency Level Decision Flow Chart

This flowchart, provided in Figure 2.2-2 is a simplified decision guide to assist management and particularly employees in taking appropriate actions in case of an emergency.

2.2.5 Emergency Response Plan Implementation Summary

Table 2.2-1 provides additional information for Pretium employees, contractors and their employees to ensure decisions are commensurate with the level of emergency.

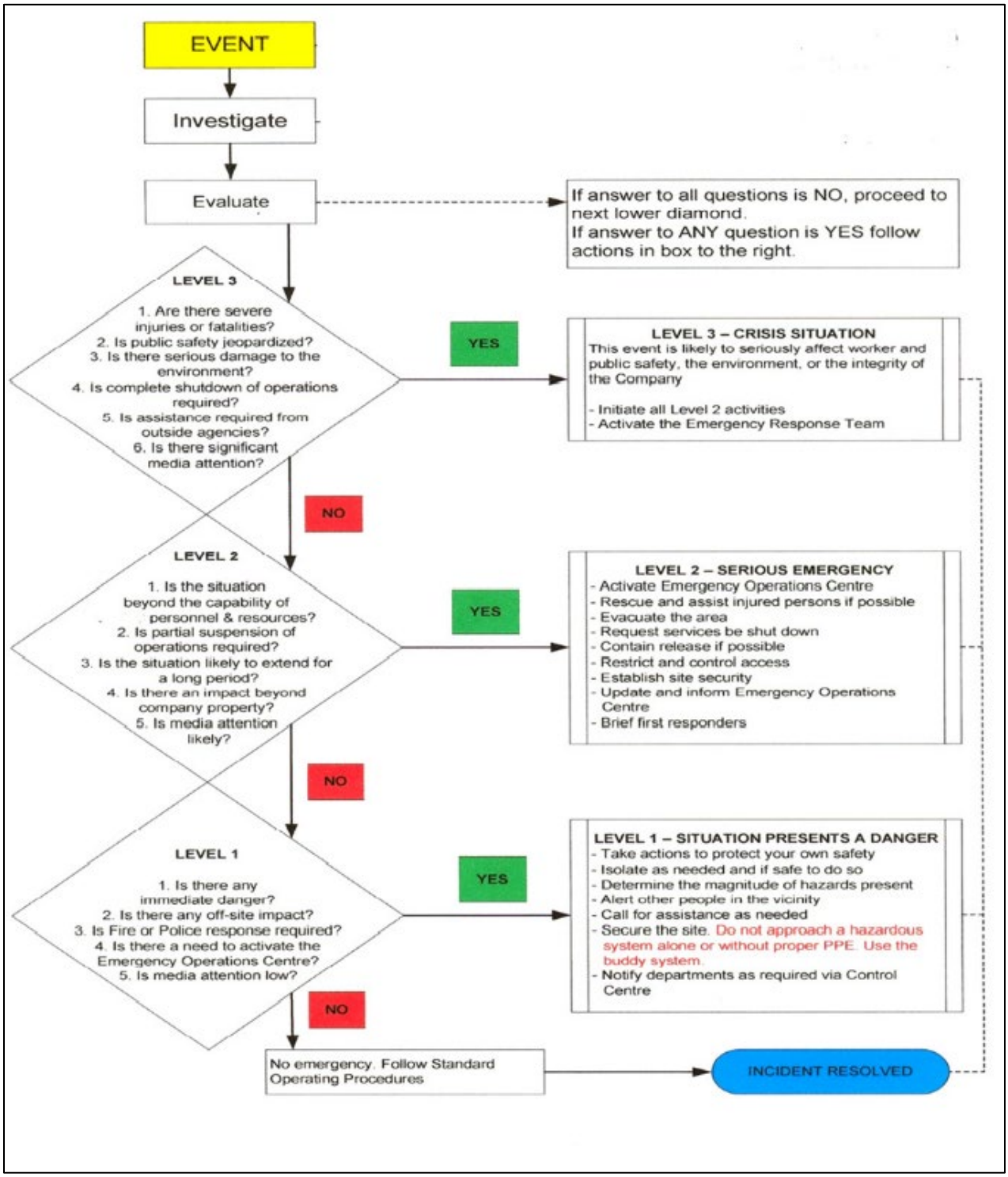


Figure 2.2-2. Emergency Decision Flow Chart (after GCMC Emergency Response Plan v. 2.1)

Table 2.2-1. Emergency Response Summary

Level	Criteria	Examples	Pretium Actions	Government Agency Actions
Level 1: ERT members to the initial response	• No danger outside of company property. • Immediate control of hazard/ source. • No immediate danger to public exists. • Minimal environmental impact. • Little or no media interest. • Situation handled entirely by company personnel.	• Potential for a small spill or small release of product confined to company property • Company/Contractor. Personnel minor injury or property damage. • Complaint telephone call received. • Trespassers on company property. • Spot fire/minor explosion	• Operational response made. • Reported as required internally. • Comply with appropriate government reporting after the fact. • Additional company personnel may be placed on standby status • Pretium initial response is undertaken as per the site specific ERP.	• No actions required. • Monitors response if advised.
Level 2 Mobilize IMT	• No immediate danger outside of company property, potential exists for emergency to extend beyond company property. • Outside services and Provincial Government agencies must be alerted • Imminent control of hazard is probable. • Some threat to workers or the public. • Moderate environmental impacts. • Local/regional media interest.	• Confirmed release with imminent control of the hazard probable. • Injuries/accidents involving workers. • Mischievous acts by trespassers threatening worker or public safety. • Fire/explosion that has a direct impact on worker/public safety.	• Pretium fully activates its ERP - internal resources mobilized - External resources mobilized. • Pretium mobilized and the emergency operations centre (EOC) may be on standby. • Lead agency notified (Smithers). • Public safety actions begin which could involve sheltering or evacuation. • External communications to media prepared and executed.	• Pretium has the capability to manage and control the incident using its own resources and expertise with limited assistance from local agencies and government authorities (MEMPR and WorkSafe BC, if necessary). • Lead agency notifies other agencies that may be affected. • Lead agency puts government EOC on standby. • Agencies with direct involvement may establish direct contact with Pretium. • Government agencies activate their
Level 3 Mutual aid mobilized to assist.	• Worker and/or public safety jeopardized. • Uncontrolled hazard. • Significant and ongoing environmental impacts. • Immediate multi-agency municipal and provincial government involvement. • Assistance from outside parties is required.	• Major accident impacting on workers or the public • Explosion with extensive damage to facilities • Mischievous acts which result in major damage • Major fire in a populated area and/or major wild fire	• Pretium emergency response is at maximum. • Pretium notifies lead agency • Pretium dispatches representative to Government EOC. • Pretium mobilizes corporate emergency response capabilities including Public Affairs, Legal, Executive, etc.	• Hospitals in Terrace and Stewart notified of potential trauma patients. • Government agencies with direct involvement dispatch staff to Pretium Operations. • Full activation of the Government Emergency Response Support Program to support Pretium.

2.3 EMERGENCY RESPONSE MANAGEMENT TEAM (ERMT)

Overall command to activate the Emergency Response Program shall be the responsibility of Pretium senior management at the incident site and/or the ERMT. Pretium personnel and contractor employees have the responsibility to implement the Brucejack Mine ERP.

Depending on the emergency level and the type of emergency, the Brucejack Mine - ERMT described below shall be formed to respond to an emergency.

In the event of an emergency at the mine, the chain of command structure provided in the Incident Command Emergency Management Organizational Chart will be enacted (Figure 2.3-1). The lead person for the chain of command will be the Emergency Response Coordinator (ERC), or alternatively the Mine Manager. This organization chart will expand or contract depending on the type and severity of the incident/emergency.

2.3.1 Emergency Operations Center (EOC)

The EOC will be established at the On-site Conference and Training Room following notification of an emergency. The site ERC (or designate) and facilitators of the site Mine Rescue Emergency Response Team (ERT) shall converge at this office. Requirements may include activities such as the allocation of on-site resources (personnel and equipment), setting up a communications center and external reporting of the incident/accident to government agencies, etc.

Should conditions dictate evacuation due to imminent danger; the EOC will be located at another defined location that is farthest from the imminent danger zone.

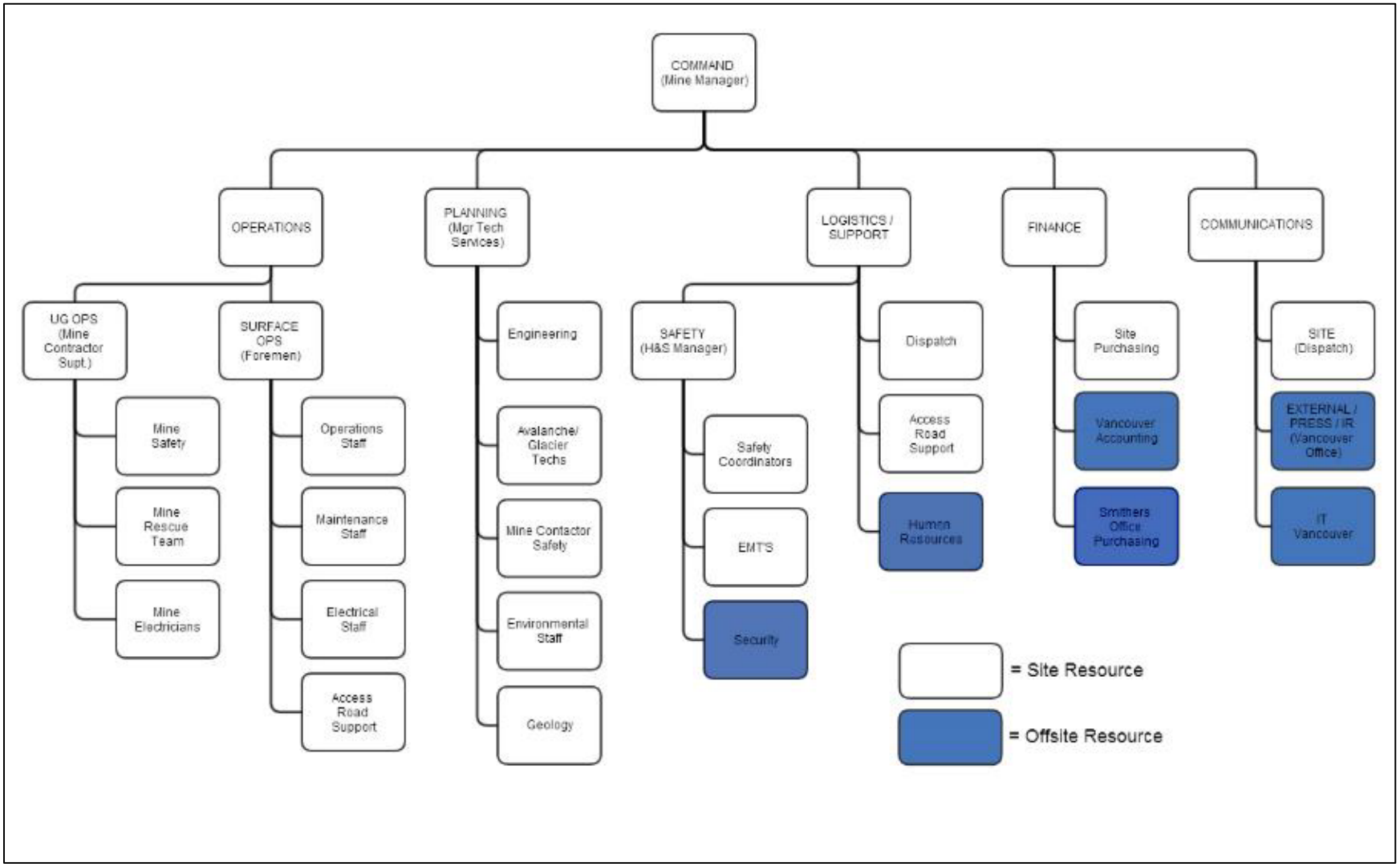


Figure 2.3-1. ICS Emergency Management Organizational Chart

Once established, EOC personnel will manage the emergency and undertake the following functions:

- Ensure that the Brucejack Mine ERP has been properly implemented;
- Monitor the health and safety of workers at the site;
- Monitor Security; and
- Provide appropriate technical information related to the incident.

2.3.2 Emergency Response Responsibilities and Duties

The following personnel involvement or requirements will depend solely on the Level emergency response (i.e. Level 1, 2, or 3).

All major emergencies require senior management personnel to form an ERMT. This team will direct emergency operations and assign tasks to individuals or groups. Responsibilities for each group are described in the following subsections. Note the list is not exhaustive and additional responsibilities may be identified commensurate with the type of incident.

2.3.2.1 Mine Rescue Emergency Response Team

The on-site surface and/or underground ERTs will consist of personnel trained as required of Part 3.7.7 of the *Health, Safety and Reclamation Code for Mines in BC*, 2017. They will be notified and requested as necessary.

2.3.2.2 First Responders – Level 1, 2, or 3 Emergency

- Take action to ensure their own safety;
- Alert other personnel in the immediate vicinity of the incident/accident;
- Determine the magnitude of hazards present, contact the Health and Safety Department and provide particulars of the emergency and request appropriate help;
- Perform duties as directed by the on-site supervisor (or designate). These initial duties may be as follows:
  - Providing assistance to injured personnel;
  - Assisting with procedures to control or minimize the effects of the emergency;
  - Determine if Personal Protective Equipment (PPE), safety equipment and supplies are adequate; and
  - Initiate an Event Log for the emergency.

No worker will approach a hazardous condition alone or without the proper PPE. First Responders will wait for the arrival of additional personnel and equipment.

2.3.2.3 Medic/Advanced First Aider – Level 1, 2, or 3 Emergency

When an injury requiring medical attention is reported, the Health and Safety Department will call the Medic/Advanced First Aider who will assess the degree of response required. All events shall be recorded in the Treatment Logbook. The Medic/Advanced First Aider shall:

- Take action to ensure your own safety;
- Alert other personnel in the immediate vicinity of the incident;
- Upon notification, the on-site supervisor (or designate) will meet with the Medic/Advanced First Aiders at the incident/accident scene (unless in radio contact). On-site supervisor (or designate) ensures that the Medic/Advanced First Aiders have the required supplies and that the area is secured and does not present any further danger to personnel; and
- The Medic/Advanced First Aiders will stabilize casualties and prepare for transportation. If transported, an Advanced First Aider will be required to attend.

2.3.2.4 Emergency Response Coordinator (ERC)

Upon hearing of and/or arrival at the scene of an emergency, the on-site Emergency Response Coordinator (or designate) will assume full command for the emergency response actions. Sometimes the ERC will work in conjunction with the on-site Mine Manager who will act as the representative of the company. In the event of an emergency the ERC will be responsible for:

- Determining the Level response of the emergency;
- Coordinating all emergency procedures through various levels of company personnel and delegate authority where appropriate;
- Making available the resources necessary to set up the ECO to deal effectively with the emergency including rehabilitation;
- Informing the Health and Safety Office of the emergency and have them remain on standby at the phones;
- Designating a person for traffic control who shall not allow any person to leave or enter the property via the glacier road or aircraft. The exception will be the following personnel who will be directed to the appropriate site locations:
    - Mine Rescue Emergency Response Personnel;
    - Emergency Response Team (ERT);
    - Mines Inspectors – BC Ministry of Energy, Mine, and Petroleum Resources; and
    - Other approved essential personnel.
- Conducting, in conjunction with the Health and Safety Office, all aspects of the investigations both at and away from the emergency scene, and report to the on-site Mine Manager; and
- Maintaining a log of occurrences.

Note the person designated for traffic control shall record the names and affiliations of any persons entering or leaving the property (after permission is given) and direct incoming workers to the mine dry to await instructions from the EMT.

2.3.2.5 Mine Manager

If the Emergency Response Coordinator is not immediately available, then upon hearing of and/or arrival at the scene of an emergency, the Mine Manager will assume full command for the emergency response actions until the ERC arrives at the EOC.

Otherwise in the event of an emergency the Mine Manager will be responsible for:

- Requesting assistance from agencies and others as required;
- Contacting local Mine's inspector as per the Mines Act requirements;
- Contacting R.C.M.P., Coroner, and senior management, as required;
- Activating the Mutual Aid Agreement; and
- Reviewing and making recommendations on emergency reports submitted by the ERC.

All public and press inquiries shall be directed to the Vancouver office.

2.3.2.6 Operations Superintendent

The Operations Superintendent (or designate) will ensure that Pretium employees, contractors and their employees are aware of their responsibilities under the plan. When notified of an occurrence, the Operations Superintendent will delegate authority to those on the scene, and relay pertinent information to those as required.

The Operations Superintendent will coordinate the efforts of response groups focusing on the following:

- **Evacuating the Mine:**
  - accounting for all employees and their locations;
  - evaluate the situation and estimate the number of personnel to handle the situation;
  - have mine rescue teams prepare and go on standby; and
  - in conjunction with the Mine Manager, arrange to have appropriate tasks assigned to all outside agencies and personnel on site as required.

- **If men are underground the Operations Superintendent will:**
  - devise a plan for rescue operations;
  - if fire, will devise a plan for control and extinguishment;
  - instruct / brief response group; and
  - send rescue teams underground.

- **As information from underground comes in, decide if additional rescue teams are required, change in rescue/procedures are required.**

- **If all men are accounted for and evacuated:**
  - locate the fire;
  - control and extinguishment of the fire;
  - ventilate the mine;
  - check the rest of the mine and assess damage;
  - determine causes and make reports; and
  - rehabilitation of damaged area.

- **In conjunction with the Mine Manager and ERC, will arrange to have appropriate tasks assigned to all outside agencies and on-site personnel as required.**

2.3.2.7 Mine Foreman or Shift Boss

The Mine Foreman or Shift Boss at the scene will assume command of the emergency until control is passed onto the Operations Superintendent. The Mine Foreman or Shift Boss will then work under the direction of the Operations Superintendent to implement rescue and rehab procedures. The Mine Foreman will take on the same responsibilities as the ones listed for the Operations Superintendent until the Superintendent arrives on the scene.

2.3.2.8 Security/Safety Manager

The Security/Safety Manager (or designate) will report directly to the Operations Superintendent and will be responsible for:

- Supervising all first aid, security and mine rescue operations;
- Ensuring all first aid, firefighting and mine rescue equipment is available to the accident scene;
- Coordinating call out of outside emergency agencies (Air Medivac, Ambulance) or other as required; and
- Coordinating investigation team, findings and reporting of emergency.

2.3.2.9 Maintenance Superintendent

Upon being notified of an emergency, the Maintenance Superintendent (or designate) will report to the EOC.

The Maintenance Superintendent will assist in mechanical/electrical matters relating to:

- mechanical/electrical problems and personnel;
- supply of compressed air;
- supply of tools and equipment that may be needed for the rescue operation;
- technical matters relating to power distribution and communication systems; and
- will ensure adequate water supply to the mine and servicing of pumping equipment underground.

2.3.2.10 Engineering Department

The Engineering Department will report to the Operations Superintendent and will provide up to date 1:250 and/or 1:3,000 scale plans showing:

- refuge stations;
- exit routes;
- fire-fighting equipment locations;
- an up to date ventilation plan showing directions and volumes of air flowing, fans and vent tubing extensions; and
- all vent doors being closed or open.

Upon the location of a fire, the Engineering Department designate along with the Operations Superintendent will assist in identifying locations of workers and equipment underground.

2.4 PLANNING AND TRAINING

2.4.1 Pre-incident Planning

2.4.1.1 Safety Precautions and Personnel Training

In preparation for implementation of this ERP, the Mine Manager shall verify the following measures are taken:

- Conduct safety meetings and orientation sessions with ERT Members to review the contents of the ERP;
- Ensure personnel on the mine site are familiar with their roles, duties, and safety responsibilities;
- Conduct ERP exercises four times per year to familiarize personnel with the correct emergency reporting and response procedures. On completion of each exercise, evaluate how efficiently the exercise was conducted, and address any areas of concern;
- ERT members respond in all mock scenarios as a training exercise. This is in addition to weekly planned training which is organized by the ERCC to cover all aspects of emergency response. Which includes specific focus on actual incidents in the mining industry;
- The Incident Management Team (IMT) planning manager and the rest of the IMT participate in all tabletop and mock scenarios where the focus is on incident management and business continuity planning;
- Ensure personnel are familiar with equipment they may be required to use; and
- Verify adequate safety equipment is available to meet the requirements in an emergency.

2.4.1.2 Mine Rescue Emergency Response Program Exercises

An emergency response exercise is a mechanism used to review the level of emergency preparedness within an organizational infrastructure and to evaluate the ability of the infrastructure to respond to potential emergencies that could arise (Table 2.4-1).

Table 2.4-1. Incident Management Team Training

Team	Induction (role specific)	Desktop Exercise	Mock Exercise (frequency/participants)
IMT	Within 2 months of joining (at a maximum)	Quarterly (four times a year)	Every 1-2 years

Prior to becoming an Incident Management Team Member, an individual must complete practical training with the ERT Coordinator. This will be achieved in one of two ways:

- One-on-One training: The new member and the ERT Coordinator will go through the IMT Room, IMT status boards, breakout room, communication systems, and general workflow of an IMT incident.
- Desktop Scenario: The new member will participate in an IMT desktop scenario, either as a primary, alternate, or observer. Every 1 to 2 years this will include all external offices to participate.

Once the member is trained, they become an Incident Management Team Member.

Objectives

Emergency Response Exercises are to be conducted for the following reasons:

- to validate the adequacy of the organizational infrastructure to effectively deal with emergencies;
- to test the initial communications sequences;
- to verify contact numbers are correct when required;
- to familiarize personnel with their duties and responsibilities;
- to evaluate the preparedness of each party involved in the ERP;
- to identify and correct deficiencies in the ERP;
- to verify the availability of support services;
- to exercise tactical site-specific responses; and
- to examine the interaction between the individuals, support groups, organizations, and agencies named in the ERP, and to address identifiable shortfalls in the established lines of authority.

Once scenarios are completed a debrief will be conducted to determine where changes need to be made. A record will be kept and followed up on until all items have been completed.

Scope

Emergency response exercises are held to review and evaluate existing ERPs. Normally a programmed scenario is developed to present a set of hypothetical emergency conditions, relevant to activities that fall under the scope of an existing ERP.

Emergency response exercise scenarios can be targeted to evaluate the initial response to potential emergency situations that may develop at both the site-specific level or at the senior management level.

Hypothetical criteria can be targeted to measure immediate tactical response or the extent of initial administrative support, depending upon how the scenario is devised.

Emergency response exercises may involve active communications from personnel within the organization, from government agencies, contract support services, and other parties involved in the ERP. Only those communication responses as described in the scenario will be activated.

A performance review meeting should be held immediately following the exercise. At the conclusion of the exercise a report will be generated to describe the outcomes for further analysis and to initiate remedial action and follow up.

2.4.2 Post-incident Review

2.4.2.1 Critical Incident Stress Debrief (CISD)

A critical incident stress debrief is a short (30 to 45 minute) non-judgmental session with all personnel involved in responding to a workplace incident. An incident is any workplace event like an accident, injury, or fatality that causes emotional or psychological trauma.

The critical incident Stress Debrief should occur no longer than 6 hours after the incident and should be carried out by professionals. The group will consist of personnel involved in the incident. Topics will vary but should include: what happened, what was learned, what was done well, as well as actions needing further improvement. The CISD should be a constructive experience for all those involved.

2.5 POSSIBLE FUTURE INCLUSIONS TO THE MERP

Further to the Emergency Response Process there are additional components, which are only outlined and/or not included in this initial MERP document. These additional MERP components should be developed by the Brucejack Mine operations management. They may include:

- **Detailed Emergency Response Team Structure:** Outlining the infrastructure of personnel that will be established to respond to an emergency and to provide further details on their assigned responsibilities.
- **Detailed Alerts and Warnings:** Documentation on how the organization will be alerted to an event or incident, and how the emergency communications sequence will be implemented for the Emergency Response Program.
- **Assessment and Notification:** Documentation of communications protocols within the organization and with outside agencies, including relationships with the media, before and after the event. Provisions for assessing and documenting the nature and severity of the

incident will also need to be developed. The MERP includes a family liaison, external affairs and human resource manager which is responsible for contacting and updating next of kin, managing press and social media.

- **Comprehensive Emergency Response Details:** Description of procedures needed to test the efficiency of the Emergency Response Program. This would document how members of the emergency management group would respond to emergencies within the context of the organization's EOC. Full comprehensive procedures combined with charts with tactical maps will need to be developed for both the alert and activation phases of the EOC.

3 EMERGENCY EVACUATIONS

3.1 OVERVIEW OF EVACUATION PROCEDURES

Structural fires may present the highest potential hazard at the Brucejack Mine. This is because of the flammable nature of the materials used in the construction of most buildings (camp, offices and administration complex).

The following functions listed below are essential in maintaining the integrity of the fire suppression systems and also providing adequate and effective response in the case of a fire.

Evacuation procedures will need to be further developed for the administration, processing and maintenance facilities. However, if there is an alarm or initiation of an evacuation order (administration facility, processing plant, etc.) or stench warning (underground), ensure you follow these procedures immediately:

- Evacuate the facilities, area of work or underground;
- Warn others of the emergency if you encounter them during your evacuation;
- Notify appropriate emergency services and your supervisor;
- All personnel will assemble in the designated (muster) areas and will remain there until ordered to move by the supervisor or the emergency services;
- If you did not evacuate to the designated area immediately you could be classified as missing, therefore immediately report to the supervisor in charge to get checked off the list;
- Some personnel may elect to use emergency equipment to control and/or extinguish flames, spills, etc. but at no time is any worker to remain in the facilities or underground if further exposure shall increase the risk hazard to the worker;
- No worker shall re-enter the workplace and/or return into the buildings after an evacuation until authorized by the Mine Manager and the emergency services; and
- Appoint a person to direct emergency vehicle(s) or personnel to the emergency site.

In the event of an emergency response, the responsibility for directing the response will be the ERC. The Supervisor(s) and Mine Rescue Emergency Response Team will assemble with the ERC at the EOC, who will then direct rescue and firefighting operations.

The response group will assess any reporting on anyone missing and/or details concerning the fire. The response group will then locate and rescue anyone not accounted for, and deal with the emergency response.

3.2 MEDICAL EMERGENCIES

In the event of an incident requiring first aid and/or evacuation, the Medic/Advance First Aider will attend immediately to the scene of the accident to provide first aid and to assess the requirement

for evacuation of the injured. The Medic/Advance First Aider, upon deciding to evacuate these person(s), will inform the ERC and Mine Manager who will then decide upon an appropriate course of evacuation for the injured.

Monthly fire suppression systems inspections will be essential to ensure their integrity. Scheduled maintenance and repairs will be undertaken in order to maintain the integrity of fire suppression systems.

Particular attention to housekeeping and observing the BC Fire Code will ensure that fire protection remains effective at all times. Combustibles shall not be stored inside buildings unless they are part of a work process. Flammable materials such as paints and aerosols shall be stored in approved and appropriate storage cabinets.

Fire drills and evacuation drills will be conducted periodically by management, and all persons shall co-operate during these drills.

3.3 General Mine Emergency Response Procedures – Surface Operations

Surface Operations include all surface activities such as the mill and maintenance operations, administration, camp, vehicle use, access roads, glacier travel routes, quarries, snow dump, etc.

In the event of a surface operations emergency, announce a Code One as per the Code One SOP.

3.3.1.1 Emergency Notification Plan, BJ-OHS-SOP-002 - Code One Call Out & Response

The person(s) discovering the emergency shall do the following.

If you have a radio, announce the "**Code 1**" three times on radio **Channel 2, Repeater 1** and stay on this channel until you receive confirmation that your notification was received by Dispatch. Make sure you pass on all details of the emergency, including:

- your name;
- nature of the emergency;
- location of the emergency;
- requirements for handling the emergency (i.e., first aid, rescue team, ambulance, firefighting);
- number of injured personnel; and
- description of the injuries.

When notification is received by Dispatch, they will instruct **"Radio silence – Code 1"** three times on **Channel 2, Repeater 1** as this channel is monitored at all times. All nonessential radio traffic and work activity will cease until further notice.

The onsite clinic personnel will be monitoring the repeater channels at all times.

If only a surface emergency, the Medic/Advanced First Aider assumes command and coordinates with Medical Aid and Air Operations. If it is a Code 1 then the ERCC assumes command and follows the ERP protocols.

3.3.2 Administration Facilities Emergency Evacuation

The procedure for evacuation from the facilities is clear. If some personnel elect to use emergency equipment to control and/or extinguish flames, spills, etc. they may do so until further exposure increases the risk hazard to that worker. If a risk hazard increase than all personnel will need to evacuate from the facilities immediately.

3.3.3 Camp Muster Areas

All emergencies will be coordinated through the senior on-site supervisor or designated person. All radio traffic will be cleared in the event of an emergency. All Camp mustering stations are clearly marked on-site.

3.3.4 Employee Responsibilities during All Emergencies

In an emergency, employees shall:

- ensure their own personal safety;
- assist others, alert others;
- check work area for others;
- close doors and windows;
- report to the muster station during an emergency or drill;
- bring appropriate PPE and clothing for the weather;
- report to their supervisor at the muster station; and
- remain in the muster area until directed by their supervisor.

3.3.5 Supervisor Responsibilities during All Emergency

All supervisors shall:

- Report to the muster station during an emergency or drill;
- Account for all employees under their direction;
- Provide a report to the ERC, if applicable regarding status of head count;
- Report all unaccounted employees including the last known whereabouts of the employee(s); and
- Instruct employees to remain at the muster station until the emergency is over.

3.4 MOBILE EQUIPMENT/VEHICLE ACCIDENTS

There is a potential for vehicle accidents involving multiple casualties on the Mine Access road.

In the event of these accidents it is highly likely to encounter multiple casualties because of the high volume of traffic on the road and the type of vehicles used (buses and multi-passenger vehicles).

In the event of an accident of this type the following procedures must be followed:

- Assess the accident scene for hazards, such as:
  - fire;
  - spills – hazardous cargo (chemicals or fuels);
  - equipment stability; and
  - electrical hazards from downed wires, etc.
- If you have a radio, announce the "**Code 1**" three times on radio **Channel 2, Repeater 1** and stay on this channel until you receive confirmation that your notification was received by Dispatch. Make sure you pass on all details of the Emergency:
  - your name;
  - nature of the emergency;
  - location of the emergency;
  - requirements for handling the emergency (i.e., first aid, rescue team, ambulance, firefighting);
  - number of injured personnel; and
  - description of the injuries.
- If it is not safe to approach the accident scene, stay clear, until appropriately trained mine rescue emergency response team arrives.

Figure 3.4-1 summarizes these procedures in flow chart format.

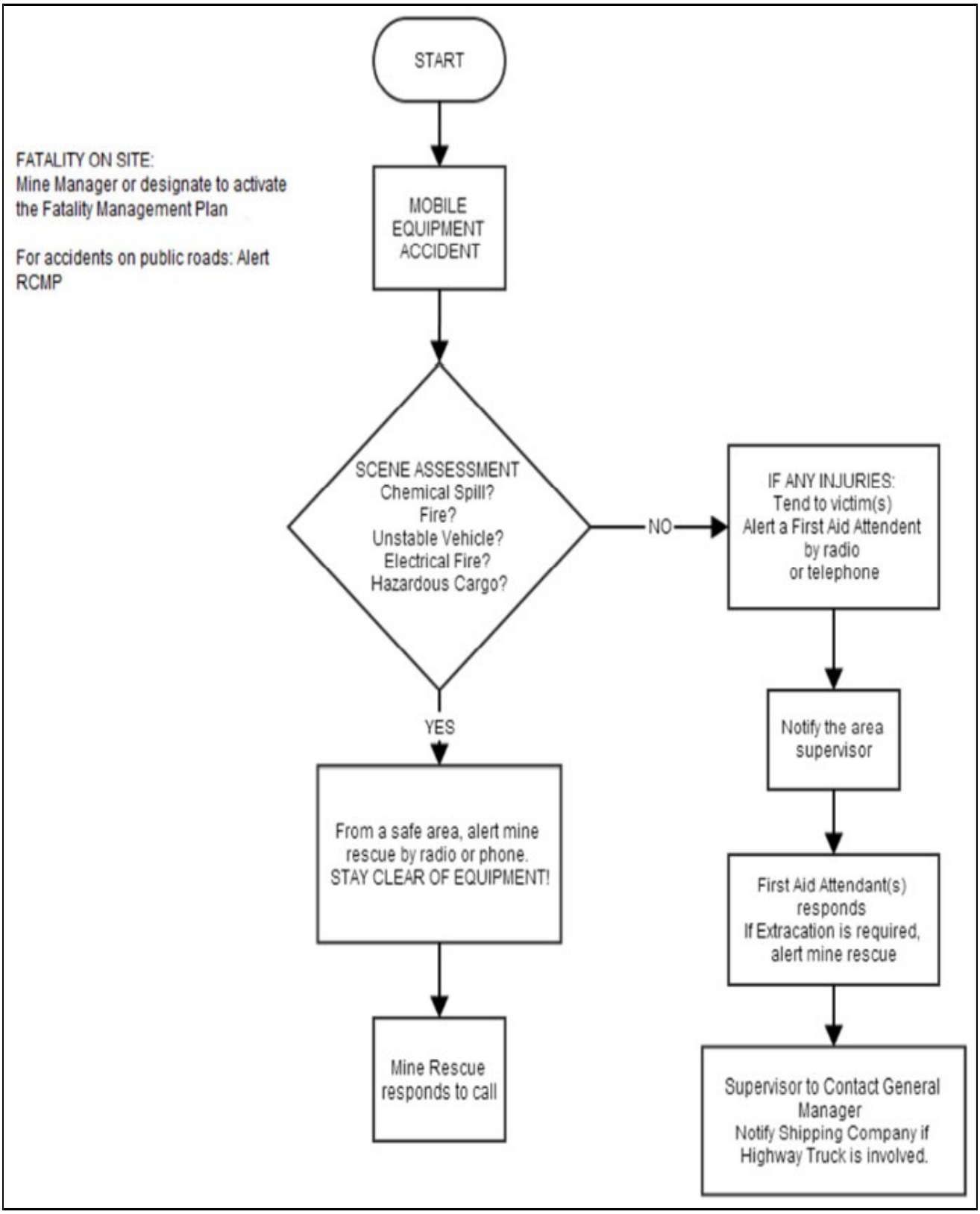


Figure 3.4-1. Mobile Equipment Accident Response Flow Chart

3.5 GENERAL MINE EMERGENCY RESPONSE PROCEDURES – UNDERGROUND OPERATIONS

The following ERP outlines the basic procedures to follow should any emergency occur in the underground operations at the Brucejack Mine. This section deals specifically with the underground; however, several of the other components of this plan are as relevant for the entire operation including fire and emergency procedures.

Some of the information in this section was sourced from the SOP "Underground Emergency Response Plan – Brucejack". Review the SOP for additional details.

Underground emergencies are those events that could cause an immediate threat to life. Types of underground emergencies could include the following but not limited to:

- injury to, or people requiring rescue;
- loss of life;
- unexpected/unplanned explosion;
- fire/heat/smoke;
- falls of ground;
- equipment electrical - failure/damage;
- loss of main ventilation; and
- any other situation that may jeopardize the safety of workers and/or the mine.

It is very important that all personnel be prepared. In order to accomplish this the following should be undertaken:

- Every employee should be trained and familiar with the MERP;
- Each employee must be familiar with the stench gas warning system, how it works and must understand what to do upon smelling it;
- All management personnel must be familiar with their roles in an emergency;
- Mine rescue personnel should be properly trained. Locations in where they can be reached shall be posted and their personnel in/out tags should be marked so they can be located easily;
- Refuge stations must be located where needed, maintained in good condition, well equipped, and with instructions for procedures to be followed posted in each station;
- Fire extinguishing equipment must be located where needed, must be ready for use and inspected regularly;
- The communication system underground must be kept in good condition;
- Ventilation doors if installed must be well located, kept in good repair and clearly marked "OPEN" or "CLOSED";

- Mine plans showing exit routes, refuge station locations must be posted; and
- All underground employees will receive basic training in the use of fire extinguishers and water hoses as well as survival mine rescue and first aid.

3.5.1 General Underground Emergency Response Procedure

3.5.1.1 Emergency Notification Plan, BJ-OHS-SOP-002 - Code One Call Out & Response

The person or persons discovering the emergency shall do the following:

- If you have a radio, or are at an underground phone (Femco), announce "**Code 1**" three times on your radio – UG All Dispatch **Channel 1** and stay on this channel until you receive confirmation that your notification was received by Dispatch. Note*: Underground Emergency – Code 1 will deploy UGIC if stench has been released.* Make sure you pass on all details of the Emergency:
  - your name;
  - nature of the emergency;
  - location of the emergency;
  - requirements for handling the emergency (i.e., first aid, rescue team, ambulance, firefighting);
  - number of injured personnel; and
  - description of the injuries.
- Remain on the radio or phone and wait for further directions.
- If you do not have a radio, go to the nearest Femco phone and announce the Code 1. Ensure supervisor has heard and will pass on to Dispatch.
- Warn all personnel in the area by releasing the stench gas in the ventilation system. Releasing the stench gas in compressed airlines requires approval from the Mine Manager.
- According to your skills and training, do what you can do to correct the situation with whatever you may have at hand to do so. Remember; do not jeopardize your own personal safety.
- When calling out ensure you give as complete information as possible to ensure correct and appropriate response.
- If there is any sign of fire or smoke put on your W65 self-rescuer, retreat to a refuge station or fresh air escape way and advise others in the area.
- If surface visibility is compromised due to whiteout snow conditions, the mine manager or designate shall organize for a guideline to be strung between the portal and truck shop.

3.5.2 Underground Fire Emergency Procedures

3.5.2.1 Discovery of Smoke Underground

If you encounter smoke anywhere in the underground mine workings:

- Assess the type of smoke you have encountered. Is this blasting smoke, diesel smoke or possible smoke from a fire? You will have to use your sense of smell and judgment to distinguish between the different types of smoke.
- If you suspect the smoke is from a fire, go to the nearest phone and call site dispatcher/ supervisor or the surface shops/offices and pass on all details of the emergency and have them call a **"Code 1"** three times on the UG Emergency **Channel 4**.
- Make sure you pass on all details of the emergency and ask for the stench gas to be injected:
  - provide your name and location of the emergency;
  - the precise location, nature of the fire and what is burning;
  - the size of the fire; and
  - your planned destination after the call.
- Put on your self-rescuer and proceed to the portal. If egress through the portal is not possible, proceed to the nearest refuge station or place of safety and await further instructions.
- Advise other workers that you encounter of the emergency.
- If your passage to the nearest refuge station or place of safety is blocked proceed to the nearest dead-end drift that has air and water available and seal yourself in using any available materials. Use your jacket, oiler jacket or shirt to make a tent over your head and the air header and crack open the airline and wait for help.
- **Do not panic and enter smoke** – trained rescue personnel will get you out.
- Occasionally beat on a pipe in a series of three (3) taps to indicate your location.
- If you reach the portal, proceed immediately to the tag board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine.
- Do not leave the truck shop area until authorized to do so by your supervisor.

3.5.2.2 Discovering Fire or Emergency

Persons discovering the fire or emergency shall:

- Immediately try to extinguish the fire with whatever means are available. Fire extinguishers are located at all refuge stations, shops, electrical sub-stations, storage areas, fuse and powder magazines and on all pieces of mobile equipment.
- If you cannot put the fire out quickly, try to warn everyone that you can and or get to a phone or radio and call your supervisor or the surface shops/offices and pass on all details of the emergency and have them call a **"Code 1"** three times on UG Emergency Channel 4. Make sure you pass on all details of the emergency and ask for the stench gas to be injected:

- your name and location of the emergency;
- the precise location, nature of the fire and what is burning;
- the size of the fire; and
- your planned destination after the call.

When the alarm is turned on, a stench gas warning will be introduced into the airline and ventilation system in the mine and all persons underground should proceed as follows:

- Put on your self-rescuer and proceed to the portal. If egress through the portal is not possible, proceed to the nearest refuge station or place of safety and await further instructions.
- Advise other workers that you encounter of the emergency.
- Upon reaching the portal, proceed immediately to the tab board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine. Remain at the pre-arranged safe designated place.
- Do not leave the truck shop area until authorized to do so by your supervisor.

3.5.2.3 Fire on Piece of Underground Equipment

If there is a fire on a piece of equipment in the underground mine workings:

- Stop the piece of equipment and shut down the engine.
- Turn off the master switch.
- Extinguish the fire using the handheld fire extinguisher from the piece of equipment first. If you are unsuccessful activate the fire suppression system from one of the two activation points located on most pieces of underground equipment.
- Do not expose yourself to smoke or gases.
- Even if you succeed in extinguishing the fire do not delay in announcing an emergency. Go to the nearest phone and call your supervisor or the surface shops/offices and pass on all details of the emergency and have them call "**Code 1**" three times on the **UG Emergency Channel 4.** Make sure you pass on all details of the emergency and ask for the stench gas to be injected:
  - your name and location of the emergency;
  - the precise location, nature of the fire and what is burning;
  - the size of the fire; and
  - your planned destination after the call.

When the alarm is turned on, a stench gas warning will be introduced into the airline and ventilation system in the mine and all persons underground should proceed as follows:

- Put on your self-rescuer and proceed to the portal. If egress through the portal is not possible, proceed to the nearest refuge station or place of safety and await further instructions.
- Advise other workers that you encounter of the emergency.

- Upon reaching the portal, proceed immediately to the tab board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine. Remain at the pre-arranged safe designated place.
- Do not leave the truck shop area until authorized to do so by your supervisor.

3.5.3 Emergency Activation System (Stench Gas)

3.5.3.1 Stench Gas Activation

Stench gas is normally injected for emergencies requiring mine evacuation or refuge such as fires. In the event of a stench gas deployment, all persons shall:

- Evacuate to a safe area where communication can be maintained unless immediately requested to assist.
- Evacuate to a designated assembly area for a head count or further instruction.
- Not leave the assembly areas or go back into the area until authorized.
- Not make any off-site phone calls with details of the emergency.
- If underground proceed to the portal. If egress is not possible, proceed to the refuge station and contact surface via the mine phones.

In order to release the stench gas underground follow BJ-OHS-SOP-004 Stench Gas Release.

3.5.3.2 Person Encountering Stench Gas

If you smell stench gas (ethyl mercaptan/rotten egg smell) anywhere in the mine:

- Stop working immediately and make sure others in the area are aware of the emergency.
- Shut down and secure any equipment you have been using. Make sure it is not parked blocking the roadway or access to emergency or electrical equipment.
- If egress to the portal is not possible (do not go past a refuge station), proceed to the refuge station.
- Travel quickly but calmly and do not run. Take any available tools with you. If there is any indication of the smell of smoke put on your W65 self-rescuer or Ocenco 6.5 EBA.
- Always stay on the fresh air side; never travel in air containing smoke.
- Do not change the ventilation system.
- Warn anyone you meet along the way of the emergency.
- Upon reaching the portal, proceed immediately to the tag board and tag yourself out. Then report immediately to your supervisor and notify him that you are out of the mine.
- Do not leave the tag board area until authorized to do so by your supervisor.

3.5.4 Loss of Ventilation

If ventilation is lost in the mine:

- In the event of an auxiliary fan failure:
  - leave the area;
  - shutdown all diesel-powered equipment;
  - notify your shift boss of the problem;
  - the shift boss will call an electrician to evaluate the problem;
  - once evaluated and fixed the ventilation will be turned on to flush out the affected area for 20 minutes prior to resuming work in the area; and
  - work will not resume in the heading until adequate ventilation can be established.
- In the event of a main fan failure:
  - shut down all diesel-powered equipment and notify shift boss;
  - small diesel-powered tractors or utility vehicles may be used to egress;
  - all personnel should proceed to the refuge station;
  - roll call will be completed from the tag board to ensure all personnel are accounted for;
  - work will not resume in the mine until adequate ventilation has been established; and
  - a gas tests as well as flow and velocity checks in all work areas will be completed prior to work resuming.
- If smoke or fire is encountered at any point refer to Section 3.5.2 of this MERP.

3.5.5 Refuge Station

3.5.5.1 Action Steps for Refuge Station Procedures

Step I – General Actions

1. A responsible person will take charge immediately (Does not have to be a supervisor).
2. Determine if there is compressed air coming in or not (airline).
3. Follow Step II or Step III, depending on compressed air.
4. Call in (phone/radio) and report all persons in refuge station. Double-check all names and those present. Make certain all present have been reported in.

Step II – When Compressed Air Is Available

1. Go in through the first door and close it behind you.
2. Purge contaminated air in the air lock with provided compressed air cylinders.
3. Open second door to enter chamber and close behind you.
4. Ensure compressed air is on.
5. Keep a check on pressure inside refuge station (must be positive). This can be determined by holding a string or piece of paper, etc. in exhaust pipe opening.
6. Conserve oxygen by keeping quiet and still.
7. Mix the air by having one-person walk around every fifteen (15) minutes or so.

8. Keep off the floor. The exhaled air containing CO_2 is heavier than normal air and settles to the floor.
9. Conserve cap lamps. One on per group is adequate.
10. Remain in station until you receive official instructions.
11. “NO SMOKING “at any time during Emergency Stench Warning.
12. Remain calm, follow Emergency refuge conduct procedures.
13. Ensure continuous gas monitoring to ensure air quality is sufficient.

Step III – If Compressed Air Is Not Available

***Note**: When compressed air (airline) is not available extra care must be exercised.*

1. Go in through the first door and close it behind you.
2. Purge contaminated air in the air lock with provided compressed air cylinders.
3. Open second door to enter chamber and close behind you.
4. Ensure the compressed air valve is closed.
5. Turn on oxygen and refuge chamber continuous gas monitor. This will continually measure the air quality in the chamber.
6. Ensure names of those in refuge station are phoned/radioed in and update information as necessary.
7. Frequently check sealed openings for possible leaks and maintain positive air pressure.
8. Conserve oxygen by keeping quiet and still.
9. Mix the air by having one-person walk around every fifteen (15) minutes or so.
10. Keep off the floor. The exhaled air containing CO_2 is heavier than normal air and settles to the floor.
11. Conserve cap lamp batteries – use only one cap lamp at a time.
12. Remain in the refuge station until you receive official instructions that it is safe to leave.
13. **NO SMOKING** at any time in the refuge station during the emergency.
14. Remain calm, you will eventually be rescued.

3.5.5.2 Duties of Person in Charge of Station

Duties of person in charge of station (a responsible person or as designated by Supervisor):

- Phone/radio mine office. If phone/radio is out of order, stay at your location until rescued.
- Report number and names of personnel in refuge station, injuries if any, location of fire if known, smoke conditions, ventilation, locations of other persons if known.
- Maintain discipline in the refuge station.
- Keep use of phone/radio to a minimum.

- Remain in refuge station until instructed otherwise.

3.5.5.3 Persons Entering Refuge Station

Duties of person entering a refuse station (a responsible person or as designated by Supervisor):

- Report your name and working place to person in charge.
- Follow any instructions by the person in charge.
- Sit down and remain calm and quiet.
- Do not smoke in the refuge station.
- Turn off your cap lamp to conserve the life of your battery. One lamp on per group is sufficient to illuminate the station.
- Save any food or liquid in case your rescue may be delayed.
- If you are alone in the refuge station, follow instructions given above or as posted in the refuge station.

REMEMBER: You are in no danger if you remain where you are. You will be advised via telephone/ radio by someone in authority or by the Mine Rescue Emergency Response Team when it is safe for you to leave and by what route you should travel to reach surface.

3.5.5.4 Refuge Station Locations

All refuge station locations must be constructed and equipped in accordance with Part 6.13.3 of the HSRC, 2017.

3.5.5.5 Refuge Station Required Emergency Supplies

The following items are to be stocked in each refuge station. No person may use or consume any of these supplies unless it is an emergency.

- first aid supplies and blankets;
- oxygen therapy unit;
- radio communications;
- phone (Femco or other);
- CO_2 scrubber;
- oxygen bottles;
- food rations;
- drinking water;
- portable toilet;
- sealant; and

- compressed air.

If inventory is taken from the refuge station, the safety department must be notified immediately so it may be restocked.

3.5.6 Employee Tally Procedures

In the event of an emergency a systematic check must be conducted to account for all persons underground at the time of the emergency. To achieve this, the following procedures must be followed.

1. Once an emergency has been established, the Shift Boss or designate will begin a roll call of all employees known to have gone underground. This firstly can be assessed by checking the tag board located in the main dry/shifters area. All employees going underground are required to place their personal ID tag on the board. All others such as visitors or contractors would be tagged accordingly. A back up check would be to do a mine lamp count and compare to tag count.
2. Should anyone be unaccounted for, the Shift Boss or designate would then determine their job description (miner, electrician, mechanic, etc.) and the last location where the person was working.
3. Once the Incident Command Group has been assembled a search and rescue plan shall be initiated.

4 GENERAL PROCEDURES TO FOLLOW FOR ACCIDENTS AND FIRST AID TREATMENTS

4.1 FIRST AID AND MEDICAL SERVICES

As per requirement of Part 3.6.1 of the *Health, Safety and Reclamation Code for Mines in BC*, 2017, Pretium Resources/ Brucejack Mine is providing and maintaining first aid supplies and services as required by WorkSafeBC. As part of the emergency response plan, Pretium Resources/ Brucejack Mine has mutual aid partnerships with Silvertip Mine and New Gold and will mutually provide resources and compensation as required.

The fully equipped first aid facility is located in a designated facility on the property. The facility and equipment are clearly identified and reserved for the treatment of injured personnel. The Medic/OFA 3 can be reached by radio at all times, On Channel 2, Repeater 1 in case of emergency, or if underground call on Channel 1.

All personnel working on site, including laborers and equipment operators are required to:

- have general knowledge of how to summon first aid help, and general knowledge of securing the scene and helping (as per the level they are trained at); and
- be authorized to call for transportation for injured workers and must be trained in the procedures.

The mine site should have a percentage of employees who have Level 1 and Transport first aid tickets while working on the mine site.

Any work site that requires specialized equipment for the rescue or transport of injured personnel is clearly identified. The equipment is properly stored to prevent damage or deterioration. Clear access to this equipment will be always maintained, and a regular inspection program has been established to check for deficiencies.

To complement the first aid services, Pretium has enacted the general procedures described in Section 4.2. All employees, contractors and their employees should follow these procedures in case of first aid treatments, accidents, and dangerous occurrences.

An Emergency Response Coordinator (or designate) will be in command during Code 1 emergencies.

To ensure that appropriate information is gathered during a site emergency or during a first aid response, checklists will need to be developed. An example form is provided in Section 9.

4.2 FIRST AID, MEDICAL AID AND TREATMENT PROCEDURES

4.2.1 First Aid Treatment Procedure

Any worker who sustains an injury or illness that is, or may be, work related shall report for treatment as soon as possible. The following three (3) situations below highlight, depending on the type of injury, what type of actions are required:

- If you suffer a minor injury that requires First Aid, the first three (3) action items are required.
- If you suffer a significant injury and are unable to continue work, and/or will not return to work the next day or for a period of time, all five (5) action items are required.
- If you suffer a significant injury and will not return to work the next day or for a period of time, all five (5) action items are required.

Action items to follow depending on the type of injury situation:

1. Report injury to First Aid Attendant.
2. Ensure you receive proper treatment.
3. Document in treatment record book.
4. Notify supervisor, who will initiate an investigation.
5. Complete required paperwork and forms.

If you encounter these typical first aid scenarios, be prepared and know how to treat them:

- bleeding from cuts and abrasions;
- slips and falls – injuries such strains, sprains and broken bones (fractures) or concussions;
- burns; and
- allergic reactions.

4.2.2 Procedures for Handling Medical Emergencies

The following assessment will be necessary during any medical emergency. Whether it is minor or life threatening, use the following simplified **Priority Action Approach:**

1. **Scene Assessment:** Mechanism of Injury? Hazards? Environment?

   First: Keep yourself safe

   Second: Observe for bleeding/deformities/eyes

   Third: Observe the skin/level of consciousness – moving/verbal

   Fourth: Spinal Precautions

   Fifth: **Airways** – With C-spine: Open/Clear – manually stabilize head

   Breathing – Rate and Quality

   Circulation – Radial/Carotid, skin – color, temperature and condition

   Sixth: Rapid Body Search (RBS) – Rapid/Through Life Threatening

Seventh: Warmth – Blankets/Reassurance/Support Injuries

2. **Transport Decision:** Load and Go (Hospital and/or Call for an ambulance)/Stay and Play (Administer First Aid).
3. **Communicate to Emergency Services:** Stewart or Terrace Hospital or call for help from other persons on-site.
4. **Secondary Assessment:** Vital, History, Head to Toe Evaluation.
5. **Definitive Treatment:** Ice, Dressings, Splitting, Wound Cleaning, etc.

Once relieved by the Medic/Advanced First Aider, continue to assist if required and pass on any information gathered during assessment of patient.

If the injury requires offsite medical aid, it will be the sole responsibility of the Medic/Advance First Aider on duty to do all Medical Aid Referrals, by making the decision to transport, the choice of methods and the decision to accompany the patient, if necessary. The direct supervisor is then solely responsible to arrange for the required transportation for the injured worker. If the transport is by helicopter than the Medic/Advanced First Aider will call the Site Dispatcher who will contact VIH Helicopters on radio Channel 2 or at the VIH Hanger in Stewart at 1-250-636-2498. Advise them if a litter stretcher is required. **THE LITTER STRETCHER IS REQUIRED FOR ALL SPINEBOARD SCENARIOS**.

If ambulance transportation is required from the Stewart Airport to the Stewart Health Centre or there is more than one injured person, contact BC Ambulance Services at 1-800-461-9911.

It is the responsibility of the Medic/Advance First Aider to complete the proper forms and submit them to WCB; as well to distribute a copy to the Mine Manager and if necessary, provide a copy for Pretium Resources Inc. head office. A record of every injury or illness that requires first aid treatment is kept in the Accident Record Book. Each record must be signed and dated by the person providing treatment. The First Aid statistics shall be reviewed monthly at a safety meeting to determine trends and recommend corrective action.

4.2.3 Procedures to Follow in Case of a Serious Accident or Fatality

The following basic procedures should be followed in the event of a serious (life-threatening) accident requiring first aid treatment or a fatality. It is imperative that you ensure there is no further danger to yourself and to the patient before starting treatment.

If you have a radio, call “Code 1” three times on UG Emergency Channel 4 and stay on this channel until you receive confirmation that your notification was received by Supervisor/Site Dispatcher/ Security/Safety Manager. If you are near a phone call extension 100 to dispatch and call a Code 1. ***Note:*** *Code 1 Emergency will deploy ERMT. Make sure you pass on all details of the Emergency*.

- Then follow the appropriate Emergency Evacuation Procedures that have been established for your area of operations;
- Ask Supervisor/Site Dispatcher/Security/Safety Manager to notify the Medic/Advanced First Aider (by radio) and indicate there is a medical emergency – **STAY CALM**;

- All work at the area of the accident, must cease, all equipment is to be shut off and made secure, except for those required to assist in the emergency; and
- ENSURE THAT THE ACCIDENT SCENE IS SAFE TO APPROACH – If not, report what you see.

If the scene is safe and you are able to approach the injured person, report and complete the Procedures for Handling Medical Emergencies as noted in Section 4.2.2.

REMEMBER: Call for help, stop or control bleeding, restore breathing, and avoid panic. Do no more than is necessary until help arrives.

Even if not in danger, **DO NOT MOVE** the injured patient but provide the best available first aid treatment that does not exceed your level of training. Provide comfort and warmth to the patient.

Ensure that, except for the purpose of saving a life or relieving human suffering, the scene of the accident or occurrence is not disturbed without appropriate approvals as required by Part 1.7.1 (2) of the HSRC, 2017.

If the injury is an obvious **fatality**, immediately contact the Mine Manager, who in turn will contact the appropriate authorities (RCMP and Chief Inspector of Mines). Every serious accident must be reported immediately to the Mine Manager, by the first aid attendant on duty after requesting an ambulance or helicopter. The Mine Manager will then contact MEMLCI, who will advise whether the Ministry will investigate the accident.

4.2.4 Procedures to Follow when Calling for a Provincial Ambulance

When instructed by the Medic/Advance First Aider or the Direct Supervisor, follow these steps:

1. Call AMBULANCE: Phone 1-800-561-8011 or 911;
2. When asked “For what place?” answer “Pretium – Brucejack Mine”;
3. As the mine does not have a municipal address, the dispatcher may not be familiar with the locations. If that is the case, pass along the following information that fits the 911 dispatch system:
   - First Name: Brucejack Camp
   - Last Name: Pretium Exploration Inc.
   - Street Number: Northern BC
   - Street Name: Near KM 215, Highway 37, Down 73 km Haul Road
   - City: Between Meziadin Junction and Bell 2
   - Other Information: LAT 56°27’57.64’N LON 130°11’11.32”W
     Elevation 1,440 m asl, 73 KM Haul Road Access off Hwy 37
4. State that “We have life threatening injuries and request vehicle or helicopter evacuation”;
5. There will be several questions the dispatcher will ask including:
   - “Your exact location?”
   - The Brucejack Camp co-ordinates are?”

     Latitude: 56 degrees 28 minutes 01 seconds

Longitude: 130 degrees 11 minutes 01 seconds

Map Coordinates: NAD 83 UTM: 9V East: 427080 North: 6258695

- What is the phone number you are calling from?
- What happened exactly?
- What are the injuries?
- Are you with the injured person now?
- How many people are hurt?
- How old is the patient?
- Is the patient conscious or unconscious?
- Is the patient on a spine board?
- Is the patient breathing?
- What is the weather at site?
- Is there an accessible area to safely land a helicopter?
- Is the patient accessible?
- How many daylight hours are left?

Triage is done based on the information you are able to provide. A road or air ambulance will be dispatched to the required location. If the ambulance crew from Stewart is required, they will come in a helicopter from Stewart. Flying conditions will be reviewed and Medevac will proceed at the discretion of the pilot in command.

The **one-way** flight lengths to Stewart:

- Direct: 60 km (approximately 20 minutes)
- Via the Granduc Valley and Knipple Glacier: 76 km (approximately 30 minutes).

Flight lengths to the Terrace airport:

- Direct: 245 km (approximately 80 minutes).

If you are calling for an air ambulance, then you must prepare a helicopter landing pad/area. This area must be clearly marked and cleared of debris that could become airborne when the helicopter approaches and damage the rotors in the machine. A guard must be posted in this area and all traffic in the vicinity stopped. The helicopter will be looking for this area and can be guided into the landing area.

4.2.5 Reporting of Illness or Injury

Every Pretium employee, contractor and contractor employee at the Brucejack Mine must report any work-related injury or illness to their immediate supervisor, immediately. It is the responsibility of the supervisor and/or Medic/Advanced First Aider to ensure that the ill or injured worker receives appropriate first aid or medical treatment immediately.

Failure to report any work-related injury or illness is grounds for discipline, up to and including dismissal.

Any non-work-related injury or illness that will result in a worker being absent from work, for any reason, must be reported to their immediate supervisor as soon as possible after the worker learns of his or her inability to work. All personnel (management, direct employees and contractor employees) with non-work-related injury or illness shall provide the immediate supervisor with any information they have as to the expected duration of the injury recovery or illness to allow for efficient manpower planning.

Prior to returning to work (from a work caused illness or injury or nonwork-related illness or injury) the person shall contact the immediate supervisor to confirm their return-to-work date.

5 SURFACE FIRE EMERGENCIES

Fires could be one of the most common incidents on the job. Therefore, it is important to have some general fire protection rules that must be adhered to by all Pretium employees and contractors.

5.1 GENERAL FIRE PROTECTION RULES

General protection rules include, but are not limited to the following:

- There will be no smoking on the job, other than those areas designated as “smoking areas.”
- Evacuation routes are to be posted at various locations throughout the mine site. Every person shall be familiar with the emergency escape routes and the evacuation procedures from their workplaces to the assigned assembly area.
- No person shall tamper with fire protection equipment or issue a false alarm.
- Discharged fire extinguishers and non-serviceable fire protection equipment shall be reported immediately to the supervisor on duty. Discharged and expired fire extinguishers shall be returned immediately to the Warehouse for a replacement, and the replacement shall be installed in its proper location.
- Any fire, and use of fire protection equipment regardless of severity, shall immediately be reported to management.
- Except for during an emergency, no work shall be performed on any fire protection system, including fire alarms and fire water supply, without the prior approval of the Mine Manager. In the case of emergency work being performed on fire protection system, the Mine Manager shall be immediately notified.
- Fire hazard areas shall be identified by warning signs, and no person shall smoke or use open flames in designated fire hazard areas.
- All persons shall be familiar with the location, and the use of the fire extinguishers, and know how to summon assistance.
- Fire extinguishers and fire suppression systems shall be inspected annually by an authorized person, and a written record of the inspection will be reported to management.
- Open flames, welding, and cutting and similar activities in certain locations shall not be permitted without following protocol as noted in the maintenance (welding) section.
- Flammable liquids shall be labeled, stored in a separate area, and transported and disposed of in an approved manner.
- When using gasoline-powered engines, do not refuel hot or running engines. After refueling, clean up all spills before starting.
- Never use gasoline or other flammable materials as a cleaner.
- When using propane for heating or other purposes in an enclosed area ensure that the gas supply is turned off at the cylinder, or the torch is removed from the area when the flame is extinguished.

5.2 PROCEDURES TO FOLLOW IN CASE OF A FIRE

If you encounter smoke and/or a fire, follow the rules listed below. A fire/explosion emergency response flowchart is provided in Figure 5.1-1.

- Attempt to extinguish the fire only if you can do so safely.
- If you encounter smoke, shout “FIRE” and sound an alarm or have someone do it and/or call on the mobile radio the situation.
- Evacuate the area and **call a Code 1 on Channel 2**, **repeater 1**.
- Immediately notify the supervisor on duty and/or Mine Manager.

If you are in a building and hear an alarm, the following procedures shall be followed:

- Leave the building immediately by the nearest fire exit, alerting people on the way.
- Close the doors behind you when exiting the building – REMAIN CALM.
- When exiting the building shout “FIRE” and knock on doors as you go out, but do not wait for an answer as the person may be off shift or working elsewhere.
- When you have reached the outside, move away from the building.
- Go to the designated assembly area.
- Wait for further instructions from either the supervisor on duty or the Mine Manager. If you are part of the emergency response team, at your discretion, attempt to control the fire with available fire equipment.
- DO NOT GO BACK INTO THE BUILDING FOR ANY REASON.

Record information about the fire; someone must keep notes on the situation, such as:

- Where was the fire?
- When was it discovered and by whom?
- Whom did you contact and when?
- What actions were taken to contain the fire?
- What is the extent of damage?
- Your name and telephone (contact) information.

5.3 PROCEDURES FOR USE OF FIRE EXTINGUISHERS

Attempt to extinguish a fire with an extinguisher only if the following conditions exist:

- There is a clear exit and the fire is small;
- The person using the fire extinguisher is familiar with its use; and
- The extinguisher is in working order.

When using a portable fire extinguisher:

- never place the fire between yourself and the exit;
- never turn your back on the fire;
- always keep your back to the exit; and
- remember PASS: Pull – Aim – Squeeze – Sweep.

A person shall not attempt to extinguish a fire if:

- the fire is quickly spreading beyond its point of origin; and
- the fire could block the exit, or the person is unsure how to use a fire extinguisher.

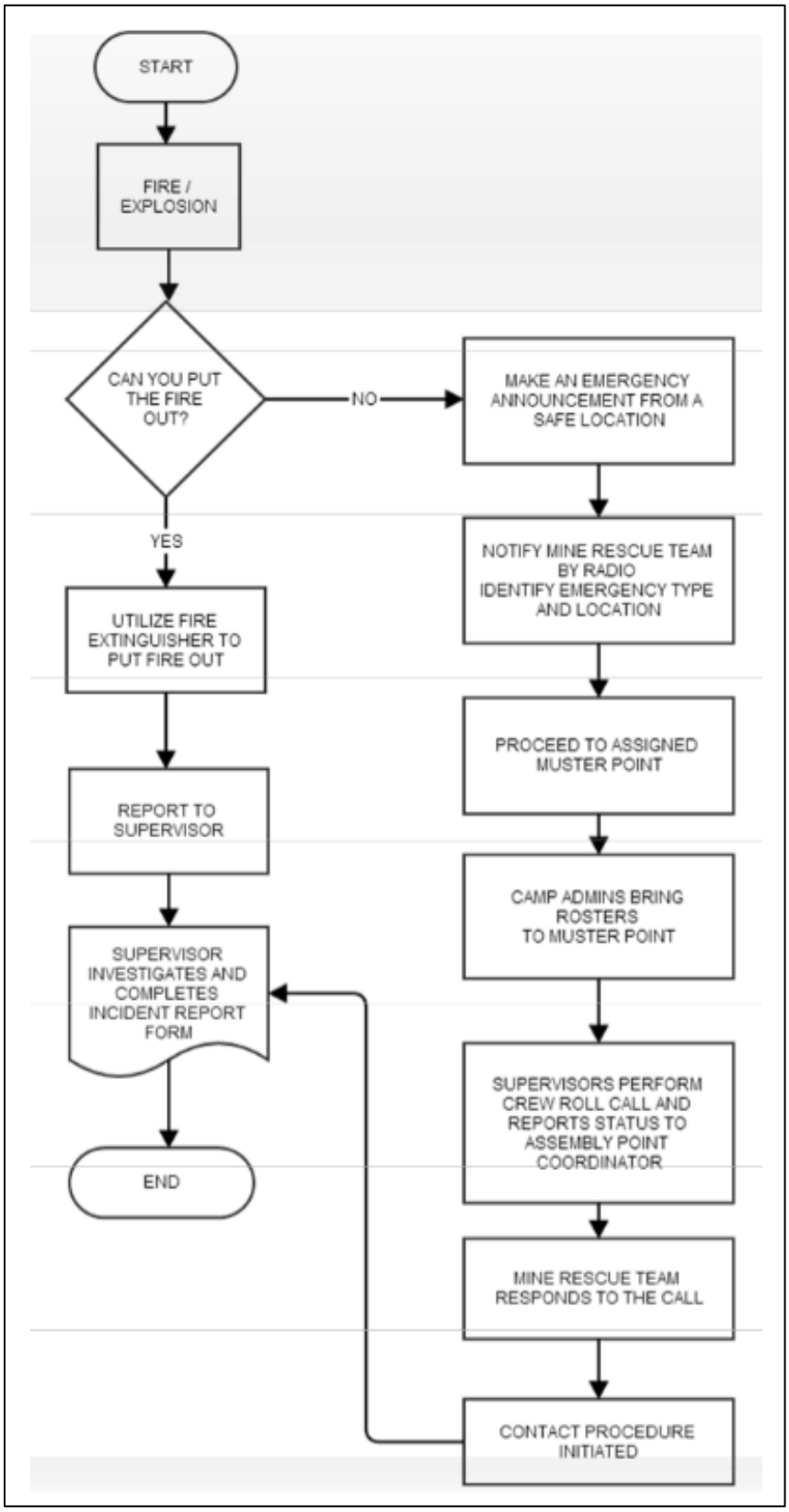


Figure 5.1-1. Fire/Explosion Emergency Response Flow Chart

6 AVALANCHE EMERGENCIES

6.1 INTRODUCTION

The Brucejack Mine operates in a high snowfall area with steep terrain subject to snow avalanches. At this time, some infrastructure facilities are located outside of known avalanche-prone areas, however personnel do work in avalanche-prone areas. During periods of (high) snow, advice on current (avalanche) risks must be obtained from an avalanche technician. As well all personnel must be equipped with appropriate safety gear and trained to use avalanche beacons.

At the mine, the Mine Rescue Emergency Response Team(s) will be trained in avalanche rescue techniques in case an avalanche affects facilities and personnel. Avalanche rescue will not be attempted unless the site is considered to be safe from further danger by Pretium's Mountain Safety personnel.

Pretium currently has an avalanche safety plan (ASP, Brucejack Mine Avalanche Safety Plan, updated March 2021) developed by Pretium's Mountain Safety Department. Some of the information in this section was obtained from the ASP, which will remain current for avalanche safety during mine operation and closure.

The ASP contains pertinent information on the following:

- Organization Structure and Personnel – Roles and Responsibility of Pretium and the Avalanche Contractor;
- Avalanche Training;
- Equipment and Infrastructure;
- Operational Procedures; and
- Search and Rescue, etc.

Pretium management, as part of the on-site training, will ensure that all employees, contractors and their employees have reviewed the ASP. Further, the ASP will be accessible on-site and available for future review.

6.2 GENERAL AVALANCHE SAFE OPERATIONAL PROCEDURES

All Pretium employees, contractors and their employees will be required to adhere to the General Avalanche Safe Operational Procedures. These procedures ensure work is conducted safely within avalanche areas and are effective at all hazard levels. General procedures include:

- attending scheduled avalanche safety training sessions;
- familiarizing themselves with avalanche hazard zones;
- familiarizing themselves with the location and use of rescue equipment;
- knowing how to properly use avalanche PPE, including the rescue transceiver;

- reading the Avalanche Hazard form every day, and adjusting work and PPE accordingly;
- following check-in, check-out procedures as per the Underground Incident Command Procedure;
- ensure that personal avalanche PPE is maintained and ready for use;
- reporting avalanche accidents or near misses immediately to Mountain Safety technicians, the Mine Manager, Health and Safety Manager and Operator Supervisor; and
- contacting Mountain Safety Technicians (MSTs) to update them of unusual weather or snow conditions.

6.3 AVALANCHE ACCIDENT/INCIDENT REPORTING AND REVIEW

All avalanche accidents, incidents or near misses will be immediately reported to MSTs, the Health and Safety Manager and the Mine Manager and Operator Supervisor. MSTs will complete the avalanche incident investigation reports and depending on the severity of the incident will be reported to the appropriate authorities as necessary (MEMPR, JHSC, WorkSafeBC, the CAA (Infoex) and Insurance agents if applicable). Standard WorkSafeBC protocols will be followed for accident investigation.

6.4 SEARCH AND RESCUE

In the event of an avalanche involvement, rescue must be initiated immediately. TIME IS OF THE ESSENCE. If people are buried in a vehicle, they may have several hours of available oxygen if they are not injured. If buried on foot, then they may only have 10 to 15 minutes, or less.

Rescuer safety is of paramount importance in an avalanche rescue. Under no circumstance should a rescue party enter an avalanche area unless it is certain that the area is safe. If in doubt, consult with MSTs.

There are three (3) separate documents that make up the overall Avalanche Emergency Response Plan for an avalanche accident/incident:

1. **Avalanche Rescue Card** – for those involved in or witnessing an avalanche.
2. **Site Rescue Leader (Commander)** (cheat sheet) – for the site rescue leader.
3. **Emergency/Incident Response Plan** – for base/office personnel.

6.4.1 Avalanche Rescue Card

Immediate Action for Vehicle or Worksite

IF YOU ARE BURIED IN A VEHICLE, DO THE FOLLOWING:

1. Shut off the engine and lights.
2. DO NOT smoke.
3. CALL a “Code 1” three times on the radio.
4. Make sure your avalanche beacon is on.

5. Turn on your four-way flashers.
6. Honk briefly 2 to 3 times/minute.
7. If you are completely buried, try pushing a probe out of the snow.
8. Stay calm and wait to be rescued.
9. DO NOT GET OUT OF VEHICLE, ANOTHER AVALANCHE COULD COME DOWN.
10. WAIT FOR INSTRUCTIONS FROM THE MOUNTAIN SAFETY TECHNICIANS.

If you witness an avalanche accident, follow these steps:

1. Note the last seen point and number of people caught in avalanche.
2. Ensure personal and/or group safety.
3. CALL “Code 1” three times on the radio and initiate the Incident Response Plan.
4. Reference the Site Rescue Leader (Commander) (Cheat Sheet).
5. WAIT FOR INSTRUCTIONS FROM MOUNTAIN SAFETY.

6.4.2 Site Rescue Leader (Commander) (Cheat Sheet)

Guidelines contained in the Site Rescue Leader Cheat Sheet are shown in Figure 6.4-1.

6.4.3 Avalanche Emergency Response Plan

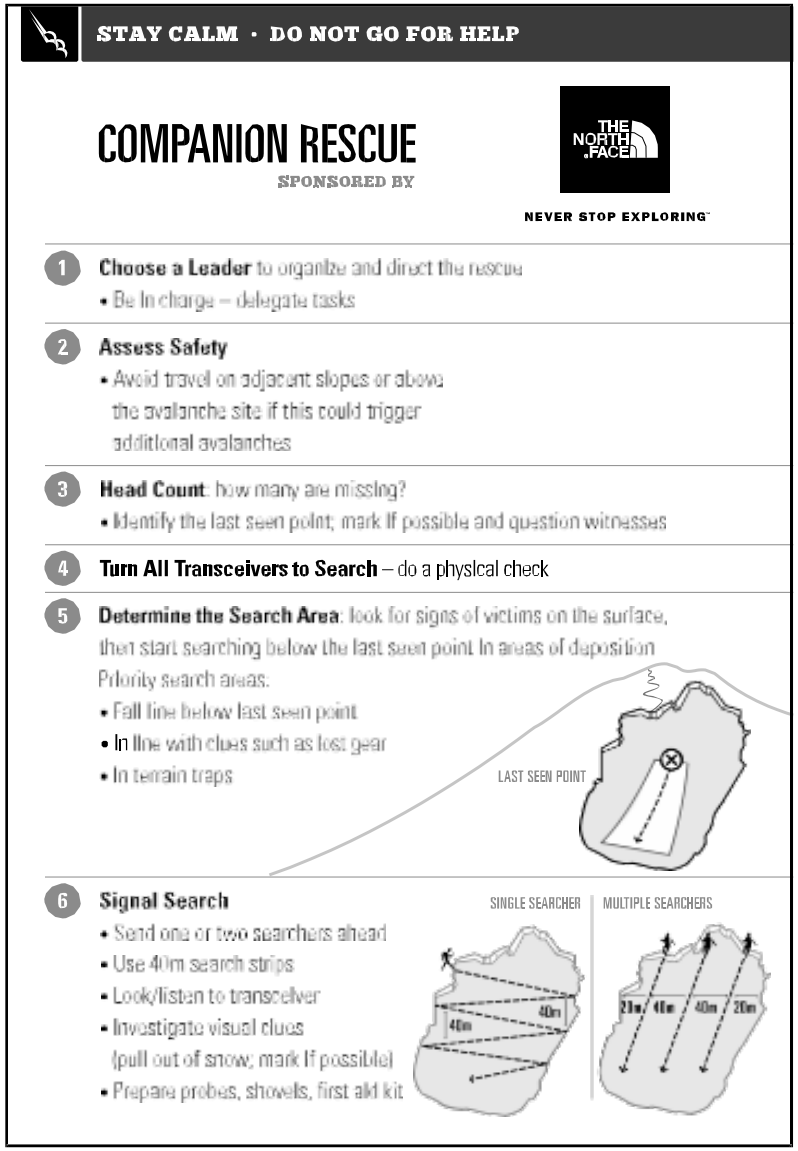
The Avalanche Emergency Response Plan has been developed for a Level 1, 2 or 3 incidents at the Brucejack Mine. The plan is based on the Incident Command System (ICS) structure. It is envisioned that on-site resources will complete the rescue in the first Operational Period (1 to 2 hours) dependent on size and location of incident.

In the event of a Code 1 avalanche being called, Emergency Response Teams (including Mountain Safety) will mobilize to the scene, the Fire Hall or be put on standby.

The Incident Management Team (IMT) will convene in the Incident Management Room (IMR) which is the boardroom in the Main Camp.

The IMT will define the Objectives, the Response Level and Strategies to be adopted as well as assigning resources to the rescue.

In the event of a large avalanche or an incident involving occupied buildings being damaged or destroyed, a Second Operational period would likely be required and the initial ICS structure expanded.



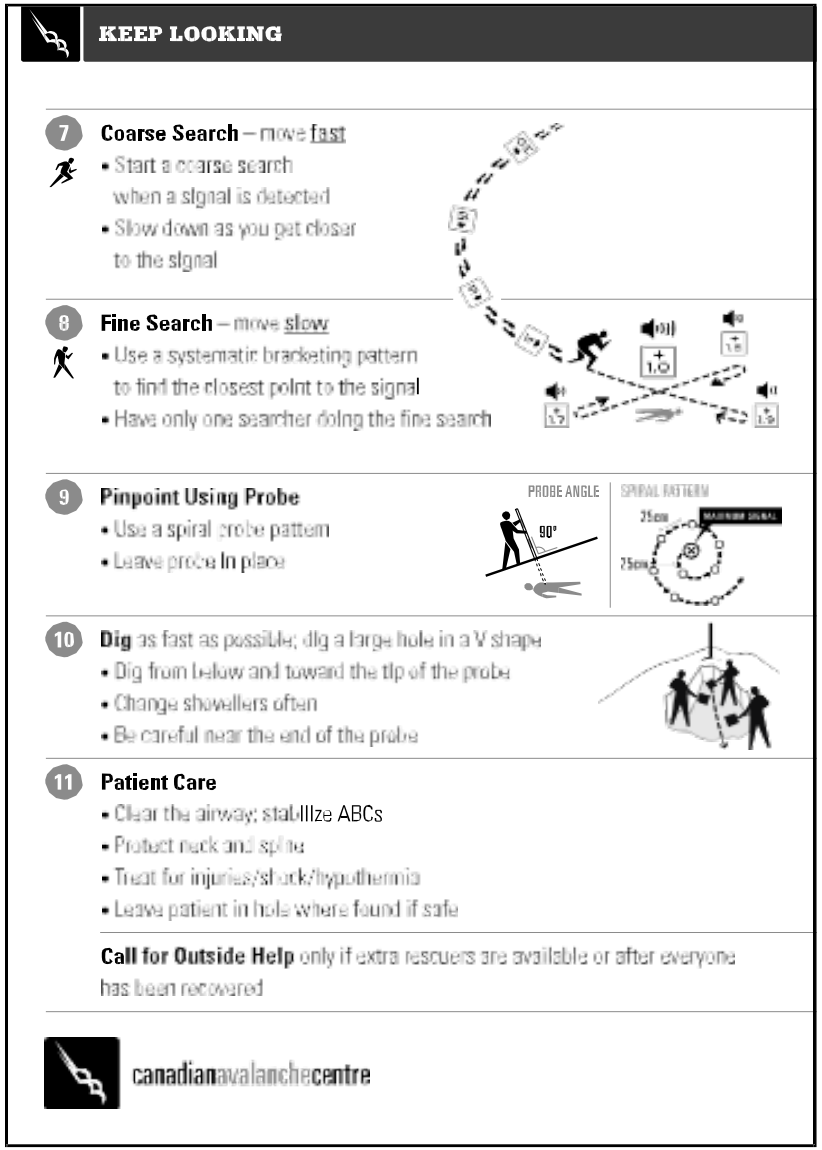


Figure 6.4-1. Site Rescue Leader Cheat Sheet

7 ON-SITE MINE RESCUE

7.1 MINE RESCUE EMERGENCY RESPONSE TRAINING

Pretium's underground contractor (Procon) has a fully developed underground MERP, that includes a fully trained mine rescue team equipped with all required emergency equipment, according to Part 3.7.1 of the HSRC, 2017. Pretium will continue to utilize the underground MERP and will develop and implement as well a surface MERP for the Brucejack Mine.

As per requirements of Parts 3.7.1 to 3.7.13 of the HSRC, 2017, the Brucejack Mine will have in place the appropriate mine rescue response capabilities. To this end several Pretium employees and contractors will be certified mine rescue personnel. They will meet the requirements of the Code and will have appropriate training.

The Mine Rescue Emergency Response Team will have qualified trainers, who will conduct classroom and field training/practice for not less than eight (8) hours in each three-month period of mine operations.

A training record/logbook is maintained on site. The surface/underground training programs will include both theory and practical training, in such things as:

- Mine Rescue Operations;
- Mine Gases – Recognition, Effects and Treatment;
- Oxygen Therapy;
- Gas-Detection Instruments;
- Fire Emergencies and Safe Firefighting Practices;
- Respiratory Protection Equipment Training;
- Mine Ventilation and Fire Suppression Underground;
- Emergency in Underground Mining Operations;
- Electrical Safety;
- Rescue Rigging;
- Rescue Operations, and
- Special Hazards of Winter Conditions.

7.2 UNDERGROUND MINE RESCUE EQUIPMENT INVENTORY

The Brucejack Mine will maintain the underground mine rescue equipment inventory shown in Table 7.2-1.

Table 7.2-1. Underground Mine Rescue Inventory

Description	Quantity	Part #
Dräger BG4's breathing apparatus	23	PSS BG4 PLUS
Ambulance – Miller Toyota	1	
BG4 oxygen bottles - spare (full)	34	B30230
BG4 filter mats (50)	3	4058167
BG4 ice molds	5	4056449
BG4 Tramix kit	1	R33777
BG4 dryer	1	R28305
Masterline Oxygen Booster Pump	1	
18 kg keg of Drägersorb	20	6737985
Filling stand for reusable canister	2	R33752
Dräger Tester RZ 7000	1	AG02690
Drager Quaestor 5000	1	
Airkem A-33 disinfectant	2	DIN 02035707
Klar-pilot anti fog	33	D40699
BC Level 3 first aid kit, soft case	1	EMFBC309
Basket stretcher	2	EMF34000
Spine board	2	EMF34100
Clam shell	1	
Set of spider straps	2	FOW770C
Adjustable hard collar	2	ABU000-281-000
Multipurpose splint	6	GEEM100
Gray utility blanket	14	SAFC125
50 ft canvas fire hose	4	ANG014909-1IF
200 ft Bag of 12 mm rescue rope	1	MSASRP504866SL200
100 ft Bag of 11 mm rescue rope	1	MSASRO544000100
30 m roll of 25 mm webbing	1	7901-RD
50 mm minding pulleys	4	610014
13 mm pulleys	4	610013
Scarab descender	2	NFPA128701
Full body harness	5	MLRRDT-TB/UBK
6 ft shock absorbing lanyard	5	DBI1240211C
Carabiners	25	NGSN263G
Mine rescue whistle	1	73-0646-0
8.5 x 11 clip board	2	97123
Scales	4	987-18-4

7.3 SURFACE MINE RESCUE EQUIPMENT INVENTORY

The Brucejack Mine maintains two sets of surface/crevasse rope rescue equipment. The first set is located in the Brucejack Mine Rescue Room (Table 7.3-1). The other set is located in the km 59 staging area shipping container (Table 7.3-2).

Table 7.3-1. Brucejack Surface/Crevasse Rescue Equipment Inventory-Brucejack Mine Rescue Room

Description	Quantity
70 L dry bag	1
60 m x 11 mm rope	1
Climbing harness (BD, large)	1
PSS 7000 SCBA	14
Petzl Bermuda Triangle evacuation sling	1
Camp helmet	1
Crampons	1
Petzl tikka headlamps	2
Picket	1
G3 steel probe (350 cm)	1
Edge protector	1
Ice screws	4
BD ascenders	2
ATC	1
MPD industrial device	1
Industrial pulley (1 single sheave, 1 double sheave)	1
Small pulley	1
Carabiners (non-locking)	4
Munter carabiners (locking)	2
Steel master link carabiner	1
SMC rigging plate	1
Locking carabiners	13
Yates sewn sling (yellow)	1
Bulk 1# tape sling material	2
7 mm prussic slings	4
8 mm prussic slings (long)	5
8 mm prussic slings (short/knotted or sewn)	4

Table 7.3-2. Knipple Staging Surface/Crevasse Rescue Equipment Inventory-KM 59 Staging

Description	Quantity
70 L dry bag	1
PSS 5000 SCBA	8
60 m x 11mm rope	1
Harness (medium)	1
Petzl Bermuda triangle evacuation sling	1
Camp helmet	1
Petzl Tikka headlamps	2
Picket	1
G3 steel probe (350cm)	1
Ice screws	4
BD ascenders	2
ATC	1
MPD industrial device	1
Industrial pulley (1 single sheave, 1 double sheave)	1
Small pulley	1
Carabiners (non-locking)	4
Munter carabiners (locking)	2
Steel master link carabiner	1
SMC rigging plate	1
Locking carabiners	12
Yates sewn sling (yellow)	1
Bulk 1# tape sling material	2
7 mm prussic slings	3
8 mm prussic slings (long)	5
8 mm prussic slings (short/knotted or sewn)	4

7.4 ACTIVATING THE MINE RESCUE MUTUAL AID PARTNERS

Pretium Brucejack Mine has a written agreement with mutual aid partners for on-site assistance, as needed. These partners are: New Gold based in Kamloops, BC, and Silvertip Mine located in northeast BC.

The decision to activate the mine rescue mutual aid partners shall be made in conjunction with the General Manager, the Mine Manager (or designate) and the Emergency Response Coordinator (ERC).

7.4.1 Standby Status

Once an emergency which has the potential need for mutual aid response is identified, Pretium's Mine Manager (or designate) or ERC will notify the mutual aid partner(s) to be prepared to respond.

Pretium's staff will begin evaluating transportation options and notifying Granmac Services and VIH Helicopters to standby and be ready to mobilize personnel, vehicles, and equipment.

Contact information for all mutual aid partners is included in the Emergency Contact List. The Mine Manager will notify the MEMLCI of this decision.

7.4.2 Activation Status

Once it is clear that additional assistance is required, the Mutual Aid Partners will be activated. At this time, Pretium staff will begin making transportation requirements. All mutual aid partners requested to help will start transporting personnel and equipment to site as directed by Pretium's staff.

The Mine Manager will notify the MEMLCI of this decision.

8 EARTHQUAKE RESPONSE

8.1 INTRODUCTION

The Brucejack Mine is located on the Pacific Rim and earthquakes of varying magnitudes are a possibility. An earthquake at site could affect:

- personnel safety;
- building structural integrity;
- fixed equipment integrity;
- waste dump stability;
- underground geotechnical conditions;
- avalanche slopes; and
- rock slope stability.

The following response protocols will be initiated in the event of a significant earthquake. For the purposes of this document a significant earthquake is an event during which buildings can be felt to sway or that will cause some noticeable damage.

8.2 INCIDENT MANAGEMENT

Depending on the severity of damage, the Mine Manager will decide if implementation of the Incident Command System is required.

8.3 PRIORITIES FOR RESPONSE

During or following an earthquake, the following actions will take priority:

- **Save Lives**: The preservation of life will be the top priority of managers and first responders and take precedence over any and all other considerations.
- **Diminish Suffering**: All possible efforts will be made to diminish suffering by providing basic human needs, including medical care, heated shelter, food, and water.
- **Protect Property:** All possible efforts will be made to protect Pretium and contractor property from further damage.
- **Protect the environment:** All possible efforts will be made to protect the environment from further damage. Protection of waterways will take priority.
- **Restore Basic Services: P**ower, heat, sanitation, and medical services will be restored as quickly as possible to enable the camp to function.

- **Restore Production:** Once the above items have been accomplished efforts to restore production will begin. Some production restoration items may be completed in parallel with the prior activities.

8.4 ROLES AND RESPONSIBILITIES

8.4.1 Brucejack Mine Site

In the event of an earthquake, the Mine Manager will be responsible for coordinating emergency medical response, environmental response, and facilities inspections. The various department heads will report to the Mine Manager.

8.4.2 Mine Manager

The Mine Manager will assign roles to the Incident Command system if necessary.

Once site conditions are assessed and response efforts are underway, the Mine Manager shall notify the senior management in the Vancouver and Smithers offices of the incident and any support required.

If damage or injuries fall under any immediately reportable category as defined by HSRC Section 1.7.1 and 1.7.3, the Mine Manager shall immediately report the incident to a BC MEMPR Inspector of Mines.

As soon as particle after the incident, the Mine Manager shall assign a qualified person to complete an incident report.

8.4.3 Access Road Manager

The Access Road Manager is responsible for coordinate response and doing inspections along the access road from km 0 to the base of the glacier. He is also responsible for coordinating response and inspections at Wildfire, Bowser, and Knipple Transfer Station camps.

8.4.3.1 Camp Inspections

Each Camp Manager shall be responsible for inspecting their camp's facilities in the event of a significant earthquake. All camp personnel shall report to their camp's muster location for roll call. Any personnel unaccounted for at the muster stations should be contracted on the radio. Searches will be completed for any personnel not accounted for during roll call.

The Camp Managers shall inspect or appoint a competent person to inspect the following items:

- **Propane tanks**: Propane supply valves should be shut off if it is safe to do so. They should not be turned on again until an inspection of the propane distribution system is completed.
- **Propane pipes**: The propane distribution pipes should be inspected for damage. If any rotten-egg smell from ethyl mercaptan in the propane is noted, the area should be evacuated and the propane supply isolated. Repairs to the propane piping shall be repaired and pressure tested by a qualified person prior to use.

- **Structural damage**: All buildings shall be inspected for damage to the structure or foundations. Damage should be documented so that repair planning can be implemented. The Mine Manager shall decide if damage is severe enough to require restrictions on building use.
- **Fuel stations**: All fuel storage areas shall be checked for damage. The inspection shall include the tanks, piping, and containment systems. If damage is noted to one or more tanks, efforts shall be made to immediately stop any leaks by plugging or transferring of fuel to another tank if possible. All spills shall be reported to the Environmental Manager. All spills over regulatory thresholds will be immediately reported to the Emergency Management BC.
- **Drinking Water Systems**: The drinking water system shall be inspected. Short term silting of the potable water system may be expected. If silting is sustained, bottled water should be used until confirmatory water analysis can be completed.

8.4.3.2 Road Conditions

The Access Road Manager shall inspect or appoint a qualified individual to do an inspection of the entire road. Areas of concern are:

- loose rock falling on the road;
- avalanches triggered by the earthquake;
- cracks in the road surface, particularly near the Bowser River and an elevated road surfaces; and
- cracks in any fill slopes above and below the road surface.

Any damage shall be reported to the Access Road Manager so that repairs can be planned. The Access Road Manager will determine if any road closures or restrictions are required.

8.4.3.3 Bridge Inspections

There are fifteen bridge along the access road between Hwy 37 and the Knipple Glacier. In the event of an earthquake, each of the bridges listed in Table 8.4-1 shall be inspected. The Access Road Manager shall inspect or appoint a competent person to perform a visual inspection of the bridge deck and footings prior to authorizing traffic over the bridges. If inspections show damage to the bridges, a qualified bridge engineer will be contacted to complete a formal inspection and make recommendations for repairs and any necessary load restrictions.

8.4.3.4 Airstrip Inspections

The Access Road Manager shall inspect or assign a competent person to inspect the airstrip. The runway and apron surfaces shall be inspected for any damage that would make it unsafe to land airplanes. The airstrip navigation lights and instrumentation shall also be checked for functionality.

If any airplanes are inbound at the time of an earthquake, the airstrip staff will attempt to divert the plane until an inspection of the runway surface can be completed.

Table 8.4-1. Access Road Bridges

Bridge	Road Kilometre	Notes
1	0.5	Bell Irving River
2	2.2	Wildfire Creek
3	4.3	
4	8.9	
5	12.6	
6	23.8	
7	30.6	
8	38	Scott Creek
9	40.3	
10	40.9	
11	46.9	
12	48.7	
13	49.7	
14	53.7	Knipple Causeway
15	53.9	Knipple Causeway

8.4.4 Emergency Response Staff

All paramedics, nurses, and OFA 3's shall call inform dispatch of their location and ability to respond to medical emergencies. All emergency response staff shall remain on standby until notified by dispatch that they may return to normal duties.

8.4.5 Dispatch

8.4.5.1 Roll Call

In the event of an emergency, the dispatcher shall report to the muster area with a copy of the current camp roster. The dispatcher shall confirm the presence of each individual by performing a roll call. Personnel unaccounted for at the muster station shall be contacted by radio. The mine tag board shall be checked to confirm which employees are underground. In the event that individuals are still not accounted for, the Mine Manager will be notified so that he may assign a person to perform a search.

8.4.5.2 Confirm Communications Systems Operational

The following communications procedures will take place following an earthquake:

- **Radio:** The Brucejack Mine Site dispatcher will verify radio functionality over all frequencies. If service is disrupted on a repeated channel, the Mine Manager will authorize helicopter mobilization so that the repeater(s) in question can be inspected.

- **Phone**: The IT department will verify phone system functionality. If service is disrupted, the satellite dish should be inspected for damage and alignment.
- **Internet**: The IT department will verify internet functionality. If service is disrupted, the satellite dish should be inspected for damage and alignment.

8.4.5.3 Notify Pretium Senior Management

At the Mine Manager's instruction or in the event the Mine Manager is unable, the Dispatcher shall attempt to contact Pretium's Senior Management Team in Smithers and Vancouver. Those contacts are listed in Appendix A-3.

8.4.6 Surface Foremen

In the event of a significant earthquake, the first duties for surface supervisors are as follows:

1. Recall all personnel and equipment from the Brucejack Lake waste rock dump site.
2. Conduct a roll call to confirm the location and wellbeing of their direct reports.
3. Check in with the dispatcher and Mine Manger.
4. Perform inspections of the following facilities:

- propane storage and distribution facilities;
- fuel storage and containment facilities;
- generators;
- waste rock dump;
- maintenance shops; and
- other active work areas.

8.4.7 Mine Superintendent

The Mine Superintendent is responsible for confirming the safety of all underground employees and the status of all underground workings and infrastructure. The Mine Superintendent will also coordinate any rescue or repair work required. The Mine Superintendent will report his findings and any updates to the Mine Manager. The Mine Superintendent will advise if Mine Rescue Teams should be placed on standby or if they can be assigned to assist with surface rescue needs.

8.4.8 Underground Shift Boss

In the event of an earthquake, the first priority for the Shift Boss is to account for the safety and whereabouts of his crews. Following that, he should report that status to the Mine Superintendent and standby for further instructions.

If a mine evacuation is warranted due to fire or other underground emergency, the Shift Boss will assign a person to guard the mine entrance against further entry. The Shift Boss will report to the mine tag in board to make sure all underground personnel are accounted for. Attempts shall be

made to contact any missing personnel by radio or by calling the mine refuge stations. If persons are still missing, the mine rescue team shall be assembled and prepared for an underground search. Once the mine has been evacuated no personnel shall enter the mine until authorized by the Mine Manager.

Once mine entry is authorized by the Mine Manager, all underground work areas shall be inspected for physical damage and adequacy of ventilation. The Shift Boss shall check and document gas readings in all headings prior to the Mine Manager authorizing re-entry.

In addition to active headings, the following infrastructure areas will be inspected for damage:

- Main fan;
- Mine heater and propane lines;
- Portal structures;
- Infrastructure areas;
- Refuge stations;
- Maintenance facilities;
- Crusher chamber;
- Fan Installations;
- Fuel storage bays;
- Substations;
- Conveyor declines;
- Explosives storage bays; and
- Active stope areas.

8.4.9 Mine Rescue Team

In the event of a significant earthquake, all members of the mine rescue team shall check in with the Mine Superintendent and standby for instructions.

8.4.10 Mill Manager

The Mill Manager shall inspect or appoint a competent person to inspect the mill facilities for damage to the process plant, paste backfill plant, mine water treatment plant, and tailings infrastructure.

8.4.11 Avalanche Technicians

In the event of a significant earthquake, the Mountain Safety Technicians (MSTs) should immediately call in to dispatch and report their availability to assist as needed.

The MSTs shall report current avalanche conditions to the Mine Manager and await his instructions in case inspections along the road are required. Depending on snow conditions, the MSTs may issue short-term closures or restrictions for certain sections of the mine, specially for Lake Shore Drive.

9 EMERGENCY CHECKLISTS AND REPORTING FORMS

As part of the revisions to this MERP, it is expected that Brucejack Mine management will develop and document critical information such as EOC location, EOC staffing and layout, building descriptions, personnel assets, transportation assets, communications assets, emergency equipment and supply assets, and medical staff and supplies. The revisions will also include current contact numbers, forms, site plans, and a controlled product inventory.

To ensure that appropriate information is gathered during a site emergency or during a first aid response, checklists will be developed for the Brucejack Mine. An example of an Incident reporting form is provided in Figure 9.1-1, the Brucejack evacuation map is provided in Figure 9.1-2, Figures 9.1-3 and 9.1-4 show the locations of primary and secondary muster stations for the main and upper camps, Figure 9.1-5 shows the layout of underground workings, and Figure 9.1-6 shows the underground evacuation.

In addition, Duty Cards are provided in the following sections:

- Section 10: Duty Cards for the Incident Management Team
- Section 11: Duty Cards for the Underground Incident Command Team Figure 9.1-1. Example Incident Reporting Form

Figure 9.1-1. Example Incident Reporting Form

This form needs to be completed before the end of the shift and sent directly to safety@Pretium.com					
Date:		Time:		Equipment Involved (if any):	
Supervisor:		Location (be specific):		Department/Contractor:	
Incident Category					NM - Near Miss High Potential
Injury/Illness		Property Damage		Other	
	FA – First Aid		PD – Property Damage		Loss of process
			FR – Fire		**DO** – Dangerous Occurrence

Occupation:		Task experience:	
Shift:	Day ☐ Night ☐	Regular schedule ☐	Overtime ☐

Description of the event: (What happened? How? What was the current task?)
IMMEDIATE CORRECTIVE ACTIONS TAKEN:
(Actions taken immediately to prevent re-occurrence, to make the scene safe for others)

Nature of material damage (if applicable):			
A. Was the workplace and/or equipment in good order?		Yes ☐	No ☐
B. Was the working method adequate (procedure respected)?		Yes ☐	No ☐
C. Was the employee trained to perform the task?		Yes ☐	No ☐
D. Did the employee wear the correct PPE to perform the task?		Yes ☐	No ☐
If you answered 'no' to any of the points A – D, explain the reason:			
For severity levels, refer to below chart of the incident report form			
Real severity:	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐	Potential severity:	1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
Is an A required?	Yes ☐ No ☐	(the supervisor is responsible for initiating the Analysis process)	

In order to determine the level of intervention, the following gravity codes have been established:

Classification of accidents/incidents:

Impact Category	Actual & Potential Impact Rating				
	1 – Low	**2 – Minor**	**3 – Moderate**	**4 – Major**	**5 Catastrophic**
Health and Safety	First Aid assessment only	First Aid Treatment	Lost Time Injury Restricted Work Medical Treatment	Serious injury, significant lost time > than two rotations	Permanent disability or fatality
Cost	> $50,000 > 1 hr. production delay	$50,000 - $250,000 1 - 4 hr. production delay	$250,000 - $1 Million 4 - 18 hr. production delay	$1 Million -$5 Million 18 hr. - 4 d production delay	> $5 Million > 4 d production delay

Incidents OR Potential of category 3, 4 or 5 must be incident analysis. Repeat incidents of category 2 or 1 that could have a higher severity level must also be investigated. The following table shows the times of investigation, analysis and report production.

Deadlines for the investigation, analysis, preparation and transmission of the investigation report:

Actual & Potential Impact Rating			
	4 or 5	**3**	**1&2**
Investigation	Immediately	Immediately	
Analysis and report production	Immediate verbal summary report max. 12h or less	Max. 72h	Potential is >3 completed 72h
Temporary corrective measure	Immediately	Immediately	Immediately
Permanent corrective action/preventative measure must be realized in:	3 days	5 days	5 Days

SPACE RESERVED FOR HEALTH & SAFETY DEPARTMENT					
		Nature of injury:			
		Nature of care:			
		Date:		Time:	
		Nurse:			
		Without injury		**With injury**	
		Material damage	☐	Reported:	☐
		Incident	☐	First aid:	☐
		Fire	☐	Medical aid:	☐
Front	Back			Restricted work:	☐
				Lost time:	☐

1. Must be submitted by end of shift

2. Supervisor must complete the D&A Post Incident Checklist.
3. If D&A test is recommended by supervisor, then Department Manager must approve test please consult with General Manager.
4. Complete an initial incident report and submit within Incident Severity Scale timeline.
5. Complete an incident analysis if the actual or potential impact is than 3, 4 and 5.
6. As per section 1.7.1, all dangerous occurrences listed in section 1.73 must be reported to the General Manager and JOHSC immediately.

Position	Print Name	Signature	Date
Worker			
Comments:			
JOHSC Rep.			
9.1 COMMENTS:			
Supervisor			
Comments:			
Safety Department			
9.2 COMMENTS:			
Departmental Manager			
Comments:			
If the Actual & Potential Impact Rating is a 3, 4 or 5 will require the following Signatures			

Position	Print Name	Signature	Date
Health & Safety Manager			
General Manager			

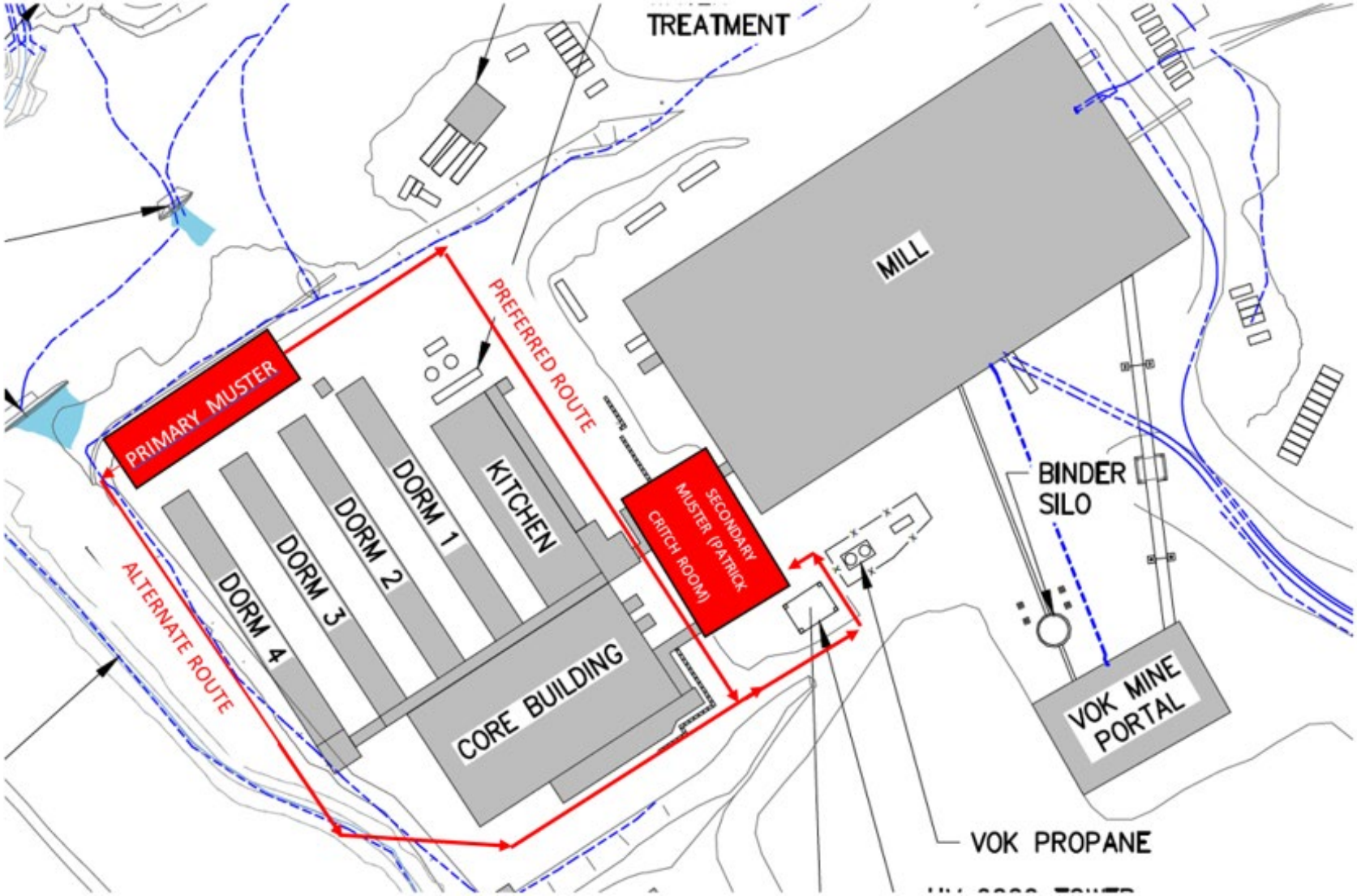


Figure 9.1-1. Brucejack Evacuation Map

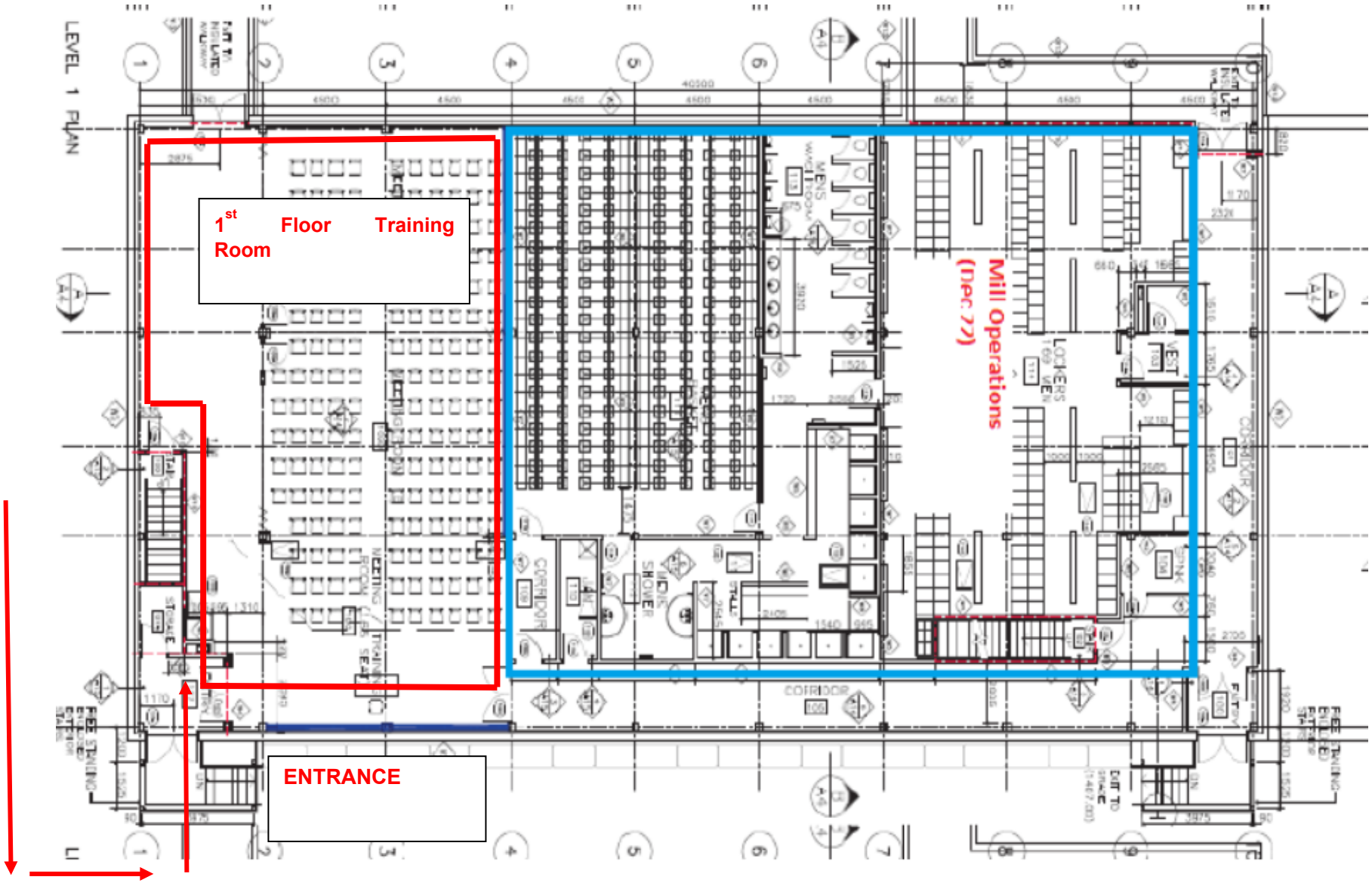


Figure 9.1-2. Secondary Muster Location. Mill Dry Floor Plan to get to Meeting Room – Secondary Muster Point – 1st floor meeting room

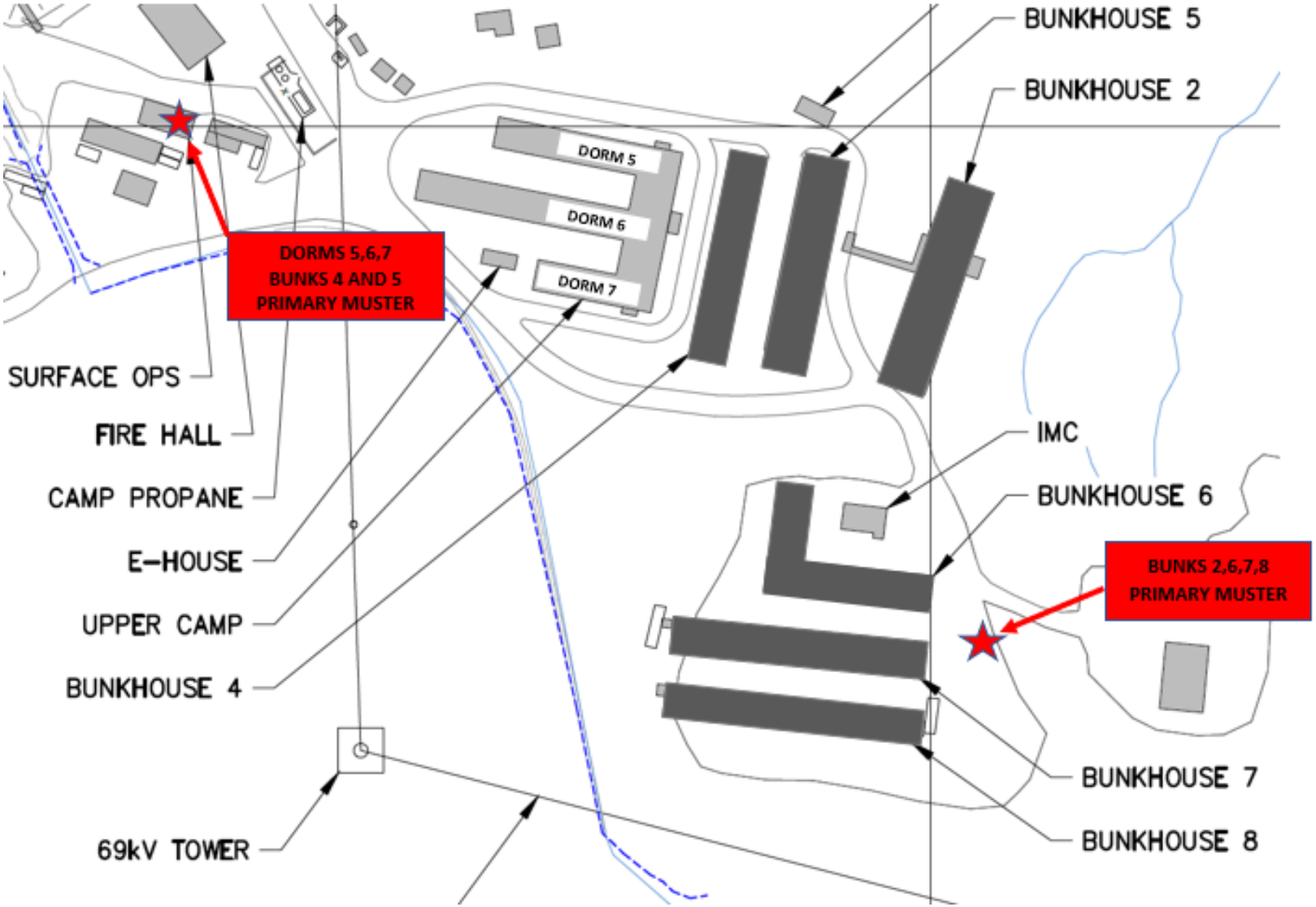


Figure 9.1-3 Primary Muster Station Upper Camp

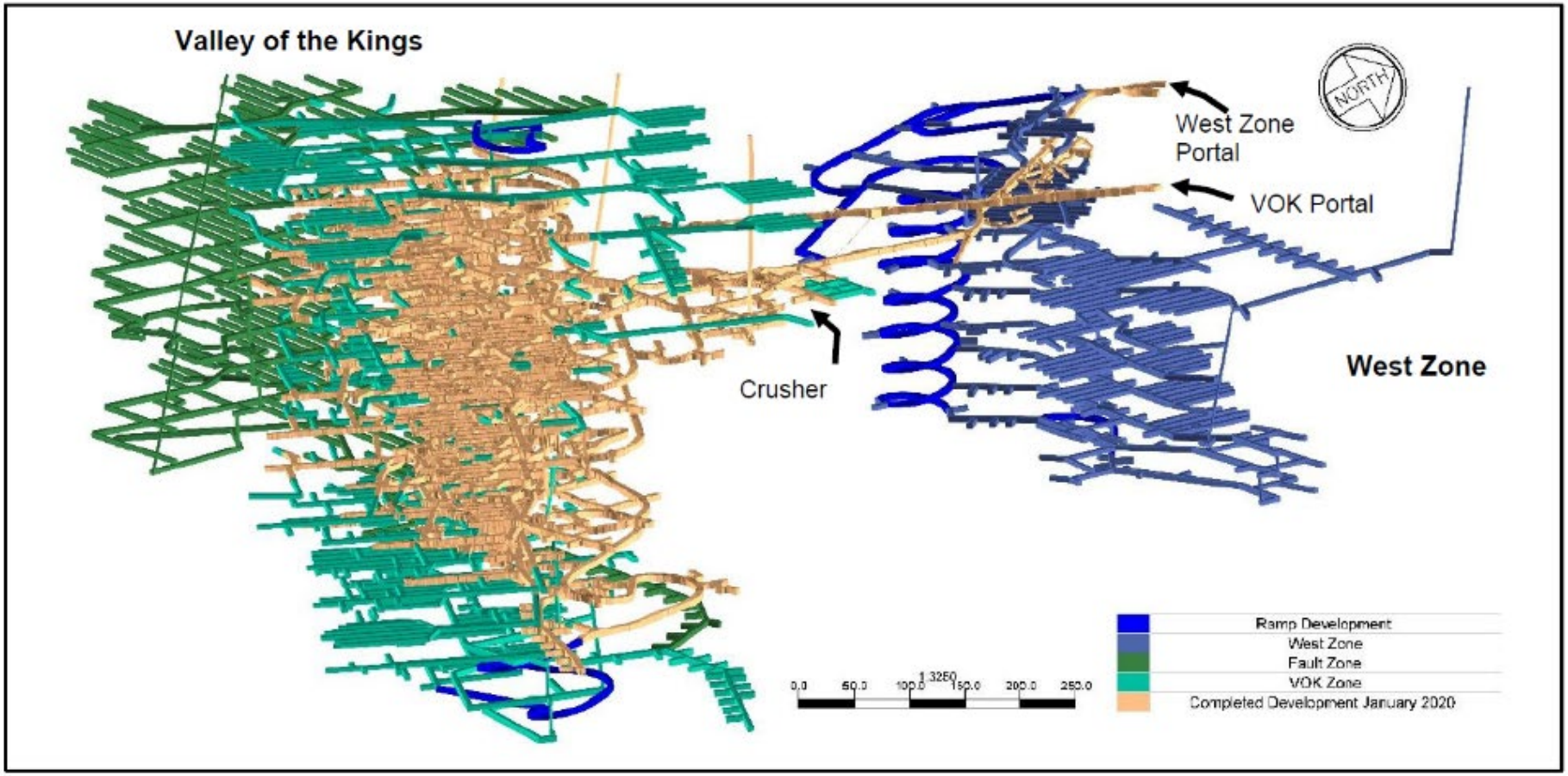


Figure 9.1-4. Layout of Underground

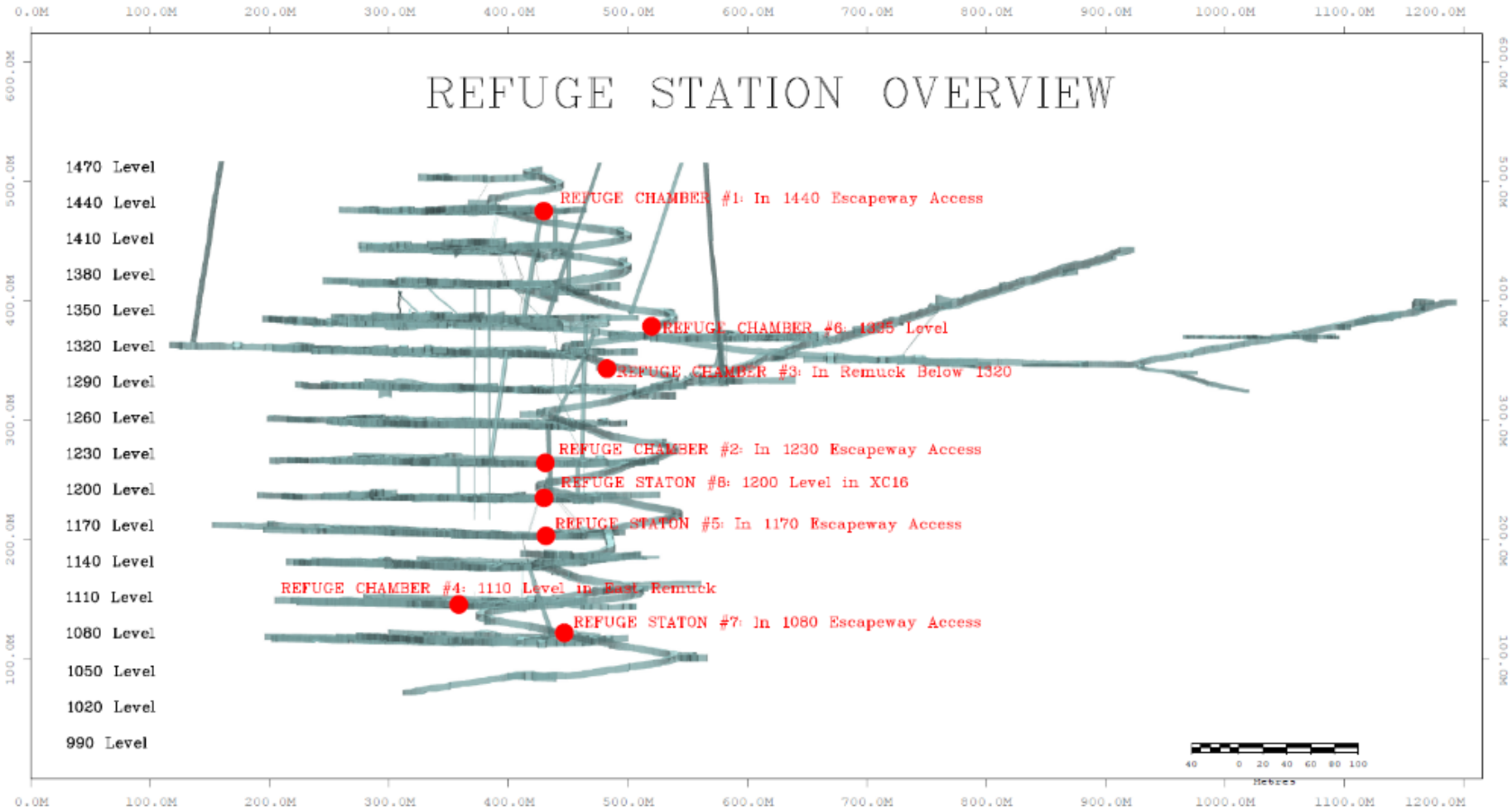


Figure 9.1-5. Underground Escapeway Plan

10 DUTY CARDS FOR THE INCIDENT MANAGEMENT TEAM

10.1 IMT LEADER

DUTY CARD 1 — IMT LEADER Reports to: Brucejack Mine President & CEO
Objective: The IMT Leader has overall responsibility for the management of the Incident Management Team (IMT). The IMT Leader leads and supervises the activities of IMT staff, develops objectives, approves plans and ensures that the response is carried out in a safe and legally sound manner. The IMT Leader interacts with appropriate government officials, the media, the community, and company management. The IMT Leader can delegate authority to IMT members to act on their behalf but retains the final responsibility for IMT response actions and decisions.
RESPONSIBILITIES
PRE-INCIDENT
☐ Ensure the operational readiness of the IMT; ☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Obtain a verbal briefing outlining the incident from the relevant manager and on-scene coordinator (if deployed); ☐ Start an individual log; ☐ Proceed to the IMR; ☐ Assess the level of the incident/issue using the Brucejack Mine Severity Table; ☐ Decide the level of IMT activation required to respond to the incident and activate the IMT if required via Dispatch ext 108; ☐ Authorize any additional resources or specialist advisors required; ☐ Obtain a current situation update on the incident; ☐ Confirm the IMT appointments required for the crisis; ☐ Conduct an initial team brief and detailed initial response priority to the IMT Managers; and, ☐ Ensure that relevant regulatory authorities are notified.
DURING INCIDENT
☐ Lead the IMT; ☐ Ensure the ERT are supported in their emergency response activities; ☐ Establish communications, exchange information and coordinate activities with other relevant response organisations (ERT, Emergency Services) and appropriate management personnel; ☐ Ensure that all necessary and required internal and external notifications have been made, ☐ Especially to government agencies and key stakeholders; ○ Doug Flynn Senior Inspector of mines (acting) - 1-250-847-7386 or 250-877-9747(cell) ○ Jacque Perron, President & CEO – 778-357-0809, 1-604-209-5456 cell ○ Patrick Godin, VP Operations & COO – 604-566-8784 ○ Sean Masse, General Manager – 250-202-2038 (140), 1 (604)754-9671 cell ☐ Manage the activities of the IMT and maintain overall control at the operational level. ☐ Ensure all IMT Group Managers are briefed and understand their individual and team responsibilities;

☐ Request additional specialist support if required; ☐ Regularly review the response by convening IMT update briefings at regular intervals; ☐ Oversee planning and set recovery and business resumption goals; ☐ Approve and authorise implementation of incident specific response and recovery plans; ☐ Monitor and control access to the IMR; ☐ Keep the President informed of the situation via regular situation reports; ☐ Remain aware of the communication strategy and be prepared to act as a media spokesperson; ☐ Authorise dissemination of press releases and statements to the public and media; ☐ Ensure active and on-going engagement with all relevant local stakeholders; ☐ Ensure all actions, decisions and events are accurately recorded and documented; ☐ Document all personal actions and decisions on an individual log; ☐ Decide when the crisis is over, inform IMT members; and, ☐ Communicate end of crisis response internally and externally.
POST-INCIDENT
☐ Oversee the conduct of an investigation; ☐ Review and approve the incident report; ☐ Allocate and supervise the implementation of the recovery plan; ☐ Chair the incident post-crisis review and ensure all lessons learned are recorded and implemented; ☐ Ensure all ERT and IMT members are debriefed and receive feedback; and, ☐ Debrief the IMT Deputy and IMT Group Managers and provide feedback;

10.2 DEPUTY IMT LEADER

DUTY CARD 2 — DEPUTY IMT LEADER Reports to: IMT Leader
Objective: The Deputy IMT Leader reports to the IMT Leader and is responsible for assisting the IMT Leader in managing the team's response to an incident. The Deputy IMT Leader assists in developing incident objectives, supervises the activities of the IMT Managers and manages set-up of the IMR. The Deputy IMT Leader conducts assessment meetings, oversees implementation of approved plans and ensures that safety of all responders is the highest priority. The Deputy IMT Leader assumes the responsibilities of the IMT Leader in their absence.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Confirm the arrival of all IMT members; ☐ Facilitate the initial team brief for the IMT Leader; ☐ Advise on the mobilisation of additional resources or specialist advisors required; ☐ Advise on the notification of the relevant Health Safety Environment Community (HSEC) related stakeholders; and, ☐ Draft relevant HSEC related reports for approval by the IMT Leader prior to releasing to external stakeholders.
DURING INCIDENT
☐ Understudy the IMT Leader; ☐ Ensure all IMT Control Group members are briefed and understand their individual responsibilities; ☐ Coordinate the activities of the IMT and manage work effort between groups as required; ☐ Facilitate regular IMT update briefings; ☐ Ensure regular situation reports are distributed to key stakeholders; ○ Doug Flynn Senior Inspector of mines (acting) - 1-250-847-7386 or 250-877-9747(cell) ○ Jacque Perron, President & CEO – 778-357-0809, 1-604-209-5456 cell ○ Patrick Godin, VP Operations & COO – 604-566-8784 ○ Sean Masse, General Manager – 250-202-2038 (140), 1 (604)754-9671 cell ☐ Assume the IMT Leader's role when he/she is unavailable; ☐ Supervise the activities of the IMT Group Managers, ensuring they act in a manner;

☐ Consistent with corporate policy and applicable government regulations and directives; ☐ Take the lead in the coordination, development and review of the response plan including: ☐ Coordinating of the plan and any sub-plans; ☐ Documenting response decisions; ☐ Consulting with specialist advisers and use of additional resources; ☐ Oversee the operation of the IMR, including status board updates and the flow of information; ☐ Keep the IMT Leader updated on the nature and status of the response operations; ☐ Check all correspondence drafted for release prior to approval by the IMT Leader; ☐ Remain aware of the communications strategy set by Brucejack Mine; ☐ Ensure regular liaison and reporting with Brucejack Mine employees; ☐ Ensure team rotations occur and back-up shifts are arranged for the ERT and IMT; ☐ Document all personal actions and decisions on an individual log; and, ☐ Ensure all ERT and IMT actions, decisions and events are recorded.
POST-INCIDENT
☐ Oversee post-crisis actions on behalf of the IMT Leader when required; ☐ Coordinate the incident post-crisis review; ☐ Debrief all Control Group members and provide them with feedback; and, ☐ Coordinate the development of the incident report.

10.3 IMT COORDINATOR

DUTY CARD 3 — IMT COORDINATOR Reports to: Deputy IMT Leader
Objective: The IMT Coordinator reports to the Deputy IMT Leader. This role is responsible for coordinating IMT preparation activities, overseeing the management of IMT information, and providing for the administrative requirements of the IMT.
RESPONSIBILITIES
PRE-INCIDENT
☐ Coordinate and attend all training activities organised for the IMT;
IMMEDIATE ACTIONS
☐ Proceed to the IMR; ☐ Start an individual log; ☐ Obtain a current situation update; ☐ Provide the IMT Leader with regular updates; ☐ Ensure the IMR is set-up as required; ☐ Ensure that the Log Keeper has commenced the IMT log; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Establish communications, exchange information and coordinate activities; ☐ Ensure the status boards are regularly updated by the Recorder; ☐ Assist the Log Keeper in maintaining a chronological log of events and make tape recordings as appropriate (pay special attention to times of significant activities and events); ☐ Ensure IMT members are present for briefs as required by the IMT Leader and Deputy; ☐ Ensure that any IMT member not able to attend a briefing session is updated with the relevant information; ☐ Manage the flow of hard copy information and retain copies for the permanent log; ☐ Provide administrative support to the IMT as required; ☐ Regularly collate the notes (logs) from other IMT groups into the IMT log; ☐ Collate all documentation for follow-up investigation, compensation, insurance and litigation purposes; ☐ Provide administrative, IT and catering support to the IMT; ☐ Monitor health, fatigue, morale and stress levels of the group and advise the Deputy as required; and, ☐ Document all personal actions and decisions on an individual log sheet.
POST-INCIDENT
☐ Participate in the post-crisis review; ☐ Contribute to the development of the incident report; ☐ Evaluate the effectiveness of the IMR during the response and implement any necessary changes to the room or associated procedures.

10.4 OPERATIONS MANAGER

DUTY CARD 4 — OPERATIONS MANAGER Reports to: IMT Leader
Objective: The Operations Manager reports to the IMT Leader and manages operations directly related to the IMT's field response. He/she activates, organises, assigns and directs all resources and activities in the field. He/she implements all operational plans to achieve the response objectives and protect people, the environment and property. He/she communicates frequently with the IMT Leader and Deputy IMT Leader to keep them updated on the progress of response operations.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT and the Operations Group.
IMMEDIATE ACTIONS
☐ Proceed to the IMR; ☐ Obtain all available information on the situation from the ERT, Dispatch, Underground Command Centre and/or Medical Clinic; ☐ Start an Individual log; ☐ Recommend to the IMT Leader the incident categorisation and the level of response required; ☐ Mobilise any additional resources or specialist advisors immediately required to assist with the crisis; ☐ Activate initial personnel required in the Operations Group; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Manage the activities of the Operations Group (including shift rosters); ☐ Ensure communications are maintained with the ERT; ☐ Ensure all Operations Group members are briefed and understand their individual and team responsibilities, and assess the need for additional specialist support; ☐ Attend IMT briefs and keep the IMT informed of progress on resolving the issue; ☐ Oversee and monitor the ERT response; ☐ Support the ERT; ☐ Ensure the Incident Dispatch and/or Medical Team are kept informed of the IMT response; ☐ Manage the development of the Response Plan; ☐ Manage the implementation of the Response Plan; ☐ Contribute to IMT situation reports; ☐ Allocate tasks to Operations Group members; ☐ Ensure that the Operations Group and the ERT are aware of and are following applicable Brucejack Mine policies and government agency directives; ☐ Document all personal actions, decisions and instructions on an individual log sheet; and ☐ Ensure all group actions, decisions, instructions and events are accurately recorded and documented in the IMT Log.
POST-INCIDENT

- Inform the ERT and Operations Group members when the crisis is over;
- Identify any group follow-on actions required and allocate responsibilities, resources and deadlines;
- Conduct Operations Group incident review and consolidate group feedback points;
- Attend the ERT debrief;
- Attend the post-crisis review;
- Debrief all Operations Group members and provide feedback; and,
- Contribute to the incident report.

10.5 RECORDER

DUTY CARD 5 — Recorder Reports to: Deputy IMT Leader
Objective: The Recorder reports to the Deputy IMT Leader and is responsible for updating the status boards, managing and equipping the Incident Management Room and providing for administrative requirements of the IMT.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; ☐ Ensure status boards, charts, maps and other tools/aids are readily available; ☐ Remain familiar with your responsibilities within the IMT; ☐ Confirm that there are sufficient quantities of consumables available for the IMT; and, ☐ Understand where the Incident Management Room equipment is stored and its use.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the Incident Management Room; ☐ Assist the IMT Coordinator in the set-up of the Incident Management Room; ☐ Start an Individual Log; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Record key incident information on the status boards; ☐ Manage the flow of hard copy information and retain copies for the permanent log; ☐ Assist the Log Keeper with the IMT Log as required; ☐ Alert other IMT members to major changes, issues and outstanding actions; ☐ Take digital photos of status boards before they are updated; ☐ Proactively monitor all communications and record pertinent points as they arise; and, ☐ Document all personal actions and decisions in an Individual Log.
POST-INCIDENT
☐ Assist with the collection and filing of all documentation from all groups; ☐ Ensure allocated post-crisis follow-up actions are completed; ☐ Participate in the IMT post-crisis review; ☐ Assist with refurbishing the IMR back to a ‘ready’ state; and, ☐ Assist the incident investigation as required.

10.6 LOG KEEPER

DUTY CARD 6 — Log Keeper Reports to: Deputy IMT Leader
Objective: The Log Keeper reports to the Deputy IMT Leader and is responsible for maintaining an accurate, up-to-date record of the decisions and actions of the IMT.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; ☐ Remain familiar with your responsibilities within the IMT; ☐ Understand where the Incident Management Room equipment is stored and its use; and, ☐ Assist the Recorder in maintaining the readiness of the Incident Management Room.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the Incident Management Room; ☐ Assist the IMT Coordinator in the set-up of the Incident Management Room; ☐ Start an individual log; ☐ Start the IMT log; and, ☐ Attend the IMT initial briefing.
DURING INCIDENT
☐ Assist the Recorder with updating the status boards; ☐ Request additional Log Keeper support as required; ☐ Maintain a chronological log of events and make tape recordings as appropriate (pay special attention to times of significant activities and events); ☐ Manage the flow of hard copy information and retain copies for the permanent log; ☐ Collect and retain a copy of all relevant IMT documents and incorporate into the incident log; ☐ Regularly collate the notes (logs) from other IMT groups into the IMT log; ☐ Remind the Deputy IMT Leader of outstanding issues or actions from the log; and, ☐ Proactively monitor all communications and record pertinent points as they arise.
POST-INCIDENT
☐ Assist with the collection and filing of all documentation from all groups; ☐ Ensure allocated post-crisis follow-up actions are completed; ☐ Participate in the IMT post-crisis review; ☐ Contribute to the development of the incident report; ☐ Assist with refurbishing the Incident Management Room back to a ‘ready’ state; and, ☐ Assist the incident investigation as required.

10.7 PLANNING MANAGER

DUTY CARD 7 — PLANNING MANAGER Reports to: IMT Leader
Objective: The Planning Manager reports to the Deputy IMT Leader and manages IMT related planning for the detailed recovery and resumption of normal operations. He/she oversees preparation of the Recovery Plan and assists in the development of other specialist plans, if required.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT and the Planning Group.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Attend the IMT initial briefing; ☐ Confirm the level of activation of the Planning Group in consultation with the IMT Leader; and, ☐ Mobilise any additional resources or specialist advisors required for the Planning Group.
DURING INCIDENT
☐ Manage the activities of the Planning Group; ☐ Ensure all Planning Group members are briefed and understand their individual and team Responsibilities; ☐ Ensure that the response plan and the recovery plan flow logically and are coordinated; ☐ Attend IMT briefs and keep the IMT informed of progress on the recovery plan; ☐ Manage the business continuity response including the implementation of workarounds; ☐ Lead the development of the business recovery plan and manage its implementation; ☐ Consult with specialist advisers (if required) for their input into the recovery plan (Maintenance, engineering, etc.); ☐ Contribute to the IMT Update Meetings; ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Ensure all group actions, decisions and events are accurately recorded and documented, and recorded in the IMT Log.
POST-INCIDENT
☐ Inform Planning Group members when the crisis is over; ☐ Identify any group follow-up actions required and allocate responsibilities and deadlines; ☐ Conduct Planning Group post-crisis review and record outcomes; ☐ Attend the incident post-crisis review; ☐ Debrief all Planning Group members and provide feedback; and, ☐ Contribute to the incident report.

10.8 SURFACE OPERATIONS SUPERVISOR

DUTY CARD 8 — SURFACE OPERATIONS SUPERVISOR Reports to: IMT Leader
Objective: The Surface operations supervisor reports to the IMT Leader and manages IMT related-support and service activities for the response. He/she is responsible for obtaining personnel, equipment, facilities and material needed to carry out response operations. He/she provides food, shelter, transportation, facilities, security, communications and other necessities for response personnel who are located both in the field and at the IMR. The Surface operations supervisor is to ensure that internal and external service needs are met.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT and the Logistics Group.
IMMEDIATE ACTIONS
☐ Respond to IMT activation ☐ Proceed to the IMR; ☐ Activate initial personnel required for Dispatch upon activation of the IMT ☐ Start an individual log ☐ Attend the IMT initial briefing ☐ Mobilize any additional resources or specialist advisors required for Dispatch; and, ☐ Conduct an initial group briefing.
DURING INCIDENT
☐ Manage the activities of Dispatch; ☐ Ensure Dispatch has been briefed and understand their individual and team responsibilities, and assess the need for additional specialist support; ☐ Identify the location and status of off-site equipment and personnel suitable to deal with the issue and coordinate their deployment as required; ☐ Liaise with the Operations Manager to provide transport and care/accommodation for employees and relatives if necessary. ☐ Ensure an overall inventory is maintained of all equipment, materials and supplies purchased, rented, borrowed or otherwise obtained; ☐ Inform the IMT Leader of logistical movements (include names and locations); ☐ Develop a resource plan in support of the response plan to: ○ Prioritize needs; ○ Identify alternative resources and supplies; ○ Coordinate delivery/deployment; ☐ Attend IMT briefings and keep the IMT informed on the actions of Dispatch; ☐ Contribute to the development of the response plan; ☐ Contribute to the development of the recovery plan;

☐ Contribute to the IMT situation reports; ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Ensure group actions, decisions and events are accurately documented, are recorded in the IMT Log.
POST-INCIDENT
☐ Inform Dispatch when the crisis is over; ☐ Identify any group follow-up actions required and allocate responsibilities and deadlines; ☐ Conduct Dispatch post-crisis review and record outcomes; ☐ Attend the incident post-crisis review; ☐ Debrief Dispatch and provide feedback; and, ☐ Contribute to the incident report.

10.9 HUMAN RESOURCES OFFICER

DUTY CARD 9 — HUMAN RESOURCES OFFICER Reports to: External IMT Coordinator
Objectives: The Human Resources Officer identifies and tracks all personnel involved in the incident. He/she coordinates and provides feedback to employees, ensures that consistent messages are conveyed to all concerned, and provides counselling services as required.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Participate in the initial group briefing.
DURING INCIDENT
☐ Work with Operations Group to establish the facts relating to casualties/numbers/severity of injuries/location etc.; ☐ Track casualties progress and inform the Family Liaison Officer; ☐ Ensure that Casualty Board is kept up to date; ☐ Verify any discrepancies relating to casualties; ☐ Provide advice to the IMT on ○ Employee relations; ○ Industrial relations; ○ Company HR Policy; ☐ Ensure that appropriate resources are available. Consider alerting all employers of personnel working at the site and/or within the asset/operation; ☐ Consider arrangements for handling / assisting employees, contractors, next-of-kin and public affected by the emergency; ☐ Ensure that appropriate systems are in place for managing Human Resource issues; ☐ Arrange grief counselling where needed for employees and families; ☐ Verify and maintain a record of location and status of persons involved in the incident; ☐ Verify details of fatalities, casualties, missing people and survivors; ☐ Arrange survivor reception and support for evacuees; ☐ Liaise with the Family Liaison Officer and External Affairs Officer to provide verified facts on the situation; ☐ Establish the Next-of-Kin room with the Family Liaison Officer; ☐ Work with External Affairs to draft internal messages and site notices; and, ☐ Document all personal actions and decisions on an individual log sheet.
POST-INCIDENT
☐ Complete any follow-up actions as directed; ☐ Contribute to the dispatch post-crisis review; and, ☐ Contribute to the incident report.

10.10 External Affairs Officer

DUTY CARD 10 — EXTERNAL AFFAIRS OFFICER Reports to: External IMT Coordinator
Objectives: The IMT External Affairs Officer reports to the External IMT Coordinator and manages IMT-related media and community issues for the response. He/she compiles and releases information on the incident and response efforts to the media and organises IMT press conferences and briefings. He/she works closely with the Family Liaison Officer to develop a community and stakeholder response strategy and arranges community outreach programs.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and,
IMMEDIATE ACTIONS
☐ Proceed to the IMR and set-up for operations; ☐ Start an individual log; ☐ Attend the IMT initial briefing; and, ☐ Advise the IMT Leader on potential community and media-related issues.
DURING INCIDENT
☐ In conjunction with the Investor Relations Spokesperson, determine the media strategy to be adopted for the incident and who will handle various aspects of the company's external affairs effort; ☐ Serve as the principal advisor to the IMT Leader regarding interactions with the media and advise him of any pressing media issues, concerns, or problems; ☐ Manage the Media Response Team (MRT); ☐ Establish a media briefing room onsite; ☐ Prepare and disseminate media holding statements, press releases and "fact sheets" for approval by the IMT Leader, as appropriate; ☐ Ensure proper and complete distribution of all approved press releases and fact sheets; ☐ Assist the IMT Leader in preparing for press conferences and interviews; ☐ Pass on all press releases as soon as possible to the IMT Leader; ☐ As appropriate, arrange and manage tours for the media, provided that they do not jeopardise personal safety or inhibit operations; ☐ Be available to respond to inquiries from the media; ☐ Monitor and maintain a record of media and internet coverage of the incident; and, ☐ Prior to demobilisation, ensure that all media, government relations and community issues and concerns have been resolved; Work with the Team Leader, Community Development to ☐ Identify community concerns and key issues; ☐ Identify community stakeholders and determine the best way to communicate with the community ☐ Develop a community management plan, if appropriate;

- Determine the optimum timing for and arrange and manage, community and "Town Hall" meetings;
- Determine whether additional community coordination personnel are needed, and if so, coordinate their activation and supervise their activities;
- Work closely and coordinate activities with the Family Liaison Officer;
- Assess the impact of the incident on the community, including:
- Duration;
- Health and safety issues;
- Impacts on housing and accommodations and the need for shelters;
- Disruptions to utilities and services such as electricity, water, heat, gas, transportation, sewage, etc.;
- Impacts on schools, hospitals, businesses and other institutions; and
- Other issues or causes for concern.
- Serve as the principal advisor to the IMT Leader regarding interactions with the community and advise him/her of concerning pressing issues or problems;
- Assist the IMT Leader or other IMT personnel in preparing for community meetings;
- Be the principal point of contact for the community;
- Attend IMT briefs and keep the IMT informed of community issues;
- Ensure the response plan and the recovery plan adequately considers community issues;
- Establish and maintain contact with relevant community groups;
- Assist the Services Coordinator with drafting internal messaging and site notices;
- Document all personal actions and decisions on an individual log sheet; and,
- Other duties as directed by the External IMT Coordinator.

POST-INCIDENT

- Complete any follow-up actions as directed;
- Contribute to the Dispatch post-crisis review;
- Attend the incident post-crisis review and ensure community issues are captured;
- Work with the Team Leader, Community Development to:
  - Ensure that all community-related concerns have been addressed and the best possible relations with the community are maintained;
  - Continue to monitor community attitudes concerning the incident and keep management advised of any which may have a substantial impact on the company or its operations;
  - Evaluate effectiveness of the community outreach program during the response and make appropriate modifications to IMT strategies and plans; and,
- Contribute to the incident report as required.

10.11 Family Liaison Officer

DUTY CARD 11 — FAMILY LIAISON OFFICER Reports to: External IMT Coordinator
Objectives: To provide support to the employee's family and friends during the incident. The Family Liaison Officer is to be the main point of contact for next-of-kin and friends and works closely with the Human Resources Officer and External Affairs Officer in gaining the latest information on the incident to be passed to the families.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT; and, ☐ Remain familiar with your responsibilities.
IMMEDIATE ACTIONS
☐ Respond to IMT activation; ☐ Proceed to the IMR; ☐ Start an individual log; ☐ Prepare for the initial briefing.
DURING INCIDENT
☐ If applicable, manage the Next-of-kin support Team ☐ Work with the IMT in communicating factual personnel information on the incident: ○ Pass on casualty/fatality list (including next-of-kin details); ○ Identify other stakeholders and ensure close liaison; ○ Provide liaison with Police and any incident investigation teams; ○ Determine the nature, tone and format of communication with employees and families; ○ Conduct post-incident debriefing as soon as possible; ○ Arrange transportation for families; ○ Plan accommodations; ○ Consider need for cash / clothing / communications with families etc.; and ☐ Establish call schedules as appropriate. ☐ Facilitate visits to hospitals by relatives, as requested by IMT; ☐ Provide support for families. Consider: ○ Transportation to hospital / point of arrival; ○ Childcare; ○ Accommodation; ○ Passport / Visa issues; ○ Financial Support; ○ Counselling support; ○ Reassurance, as appropriate. ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Other duties as directed by the External IMT Coordinator.
POST-INCIDENT
☐ Complete any follow-up actions as directed; ☐ Contribute to Dispatch post-crisis review; and ☐ Contribute to the incident report as required.

10.12 Dispatch and Aviation

DUTY CARD 12 — Dispatch/Aviation Reports to: IMT Leader
Objective: The Dispatch/Aviation reports to the IMT Leader and manages IMT related support and service activities for the response. He/she provides and coordinates radio communications and other necessities for ground/air transportation in the field and at the IMR. Dispatch/Aviation is to ensure that internal and external service needs are met.
RESPONSIBILITIES
PRE-INCIDENT
☐ Attend all training activities organised for the IMT ☐ Remain familiar with your responsibilities within the IMT.
IMMEDIATE ACTIONS
☐ Respond to IMT activation ☐ Activate initial personnel required for dispatch upon activation of the IMT ☐ Contact and assist in mobilizing additional resources or specialist advisors ☐ Start an individual log ☐ Attend the IMT initial briefing
DURING INCIDENT
☐ Identify the location and status of off-site equipment and personnel suitable to deal with the issue and coordinate their deployment as required; ☐ Liaise with the Operations Manager to provide transport and care/accommodation for employees and relatives if necessary. **Medivac will be arranged by Iridia Personnel with the assistance of Dispatch.** ☐ Inform the IMT Leader of logistical movements (include names and locations); ☐ Develop a resource plan in support of the response plan to: ○ Prioritise needs; ○ Identify alternative resources and supplies; ○ Coordinate delivery/deployment; ☐ Attend IMT briefings and keep the IMT informed on the actions of Dispatch/Aviation; ☐ Contribute to the development of the response plan; ☐ Contribute to the development of the recovery plan; ☐ Contribute to the IMT situation reports; ☐ Document all personal actions and decisions on an individual log sheet; and, ☐ Ensure group actions, decisions and events are accurately documented, and recorded in the IMT Log.
POST-INCIDENT
☐ Identify any group follow-on actions required and allocate responsibilities and deadlines; ☐ Attend the incident post-crisis review; ☐ Contribute to the incident report.

11 DUTY CARDS FOR THE UNDERGROUND INCIDENT COMMAND TEAM

11.1 INCIDENT COMMAND DUTY CARD

INCIDENT COMMANDER - **Checklist**		
☐	1)	In the event that there is an Underground CODE 1 **fire** emergency, it is critical that the Underground Emergency warning system is activated without delay, and that the accounting for personnel begins. These Three Actions must be taken FIRST before the Underground Incident Command Team musters: • Ensure the Main fan (WZ and VOK) Stench Gas has been released: • Only if required, have the electricians manually release the stench in the compressed airlines • Ensure Code One was called on all channels (Dispatch is responsible for this action); • Secure the UG tag-in board by placing a guard at the board. Non-fire emergencies require Code One call, and radio message to clear the ramp to the scene.
☐	2)	Ensure the Underground Incident Command Team positions are fulfilled: Operations Coordinator; Engineering Coordinator; Maintenance Coordinator; and Recorders. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444

☐	3)	Obtain a verbal briefing outlining the incident from the relevant Underground Team Captain and/or ERT Advisor (ext 444 Fire Hall).
☐	4)	Conduct an initial team brief and detail initial response priorities to the Underground Incident Command Team.
☐	5)	Start an individual log, document all personal actions and decisions. Ensure the Recorder has posted the status boards and is recording relevant information.
☐	6)	If the fire is in a heading with charged explosives (Operations Coordinator will confirm) and communicate this with the ERT Coordinator. The ERT Coordinator will instruct the ERT not to fight the fire.
☐	7)	In consultation with ERT Coordinator decide on a response plan for the Mine Rescue Team and whether or not to activate the Incident Management Team. Ventilation cannot be changed until the mine manager has approved changes and all personnel are accounted for. As well, everyone must be made aware of the ventilation change.
☐	8)	Determine staging areas for the extra people and traffic that are in the area effected by the code one.
☐	9)	Follow up and monitor assigned responsibilities.
☐	10)	Consult with ERT Coordinator and Mechanical Supervisor to determine if a mechanical inspection of any mobile equipment involved is required prior to calling the Code One over.
☐	11)	In consultation with the ERT Coordinator, decide when the incident is over. The ERT Coordinator will make arrangements for the “Code One Over” message to be relayed and broadcast. Dispatch will receive confirmation from the Incident Commander prior to broadcasting “Code one over”
☐	12)	Ensure all relevant information is entered in Incident Commander Log sheet.
☐	13)	At the conclusion of the incident, sign the Incident Commander log sheets.
Post Incident - **Checklist**		
☐	1)	Ensure the ERT Coordinator replenishes the Duty Card Packets.
☐	2)	Debrief the Underground Incident Command Team and provide feedback.
☐	3)	Confirm recommended changes to the Underground Incident Command Manual and other relevant documents have been completed (ERT Coordinator is responsible).

11.2 ERT COORDINATOR DUTY CARD

ERT Coordinator - Checklist		
☐	1)	Coordinate with Incident Commander and Underground Incident Command Team to plan the Mine Rescue Teams actions while underground. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	Brief Mine Rescue Team 1 on incident and plan of action. When Team 2 is travelling to Underground, Team 1 will get under air. Once Team 2 enters the Underground surface building, Team 1 can commence with their rescue operation.
☐	3)	Record all actions and orders given to Mine Rescue Team in your action log. Record the time Team 1 enters the underground in the ERT Coordinator Logbook (Approximately 1 bar for every 1-minute Underground with the BG4). Check in every 15mins and record all air supply levels of the team.
☐	4)	Maintain contact with Mine Rescue Team while underground and provide direction as required. Always follow the Mine Rescue Principals in order: Safety of the team; Safety of the trapped/injured; Protection of mine property; Rehabilitation of mine property.
☐	5)	Consult with Incident Commander and Mechanical Supervisor to determine if a mechanical inspection is required prior to calling the Code One over.
☐	6)	Check with Incident Command on areas underground where pre-loading of emulsion explosives are located. **NOTE: Under no circumstances will the Mine Rescue Team fight fires in a heading with charged explosives**
☐	7)	Contact Incident Command to relay 'The Code One is over' once the final Team is finished.
☐	8)	Replenish incident command cards
Post Incident- Checklist		
☐	1)	Debrief with ERT members at the Fire Hall.
☐	2)	Follow-up with Incident Commander and Engineering Coordinator on the Underground Incident Command Team debrief. Gather notes and action items.

11.3 ERT ADVISOR DUTY CARD

ERT Advisor - Checklist		
☐	1)	Gather cap lamps, tag-in cards, and W65's for incoming teams.
☐	2)	Report to Dispatch (108) or ADMIN CH 1 (ERT CHANNEL) when ERT arrives at the Fire Hall (both Team 1 and 2).
☐	3)	Brief Mine Rescue Team 1 on incident and plan of action. When Team 2 is travelling to Underground, Team 1 will get under air. Once Team 2 enters the Underground surface building, Team 1 can commence with their rescue operation.
☐	4)	Contact ERT Coordinator via Channel 1 (ERT Channel) <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
Post Incident- Checklist		
☐	1)	Debrief with ERT members at the Fire Hall.
☐	2)	Follow-up with Incident Commander and Engineering Coordinator on the Underground Incident Command Team debrief. Gather notes and action items.
☐	3)	Collect all information from rescue and make any necessary changes to procedure.

11.4 OPERATIONS COORDINATOR DUTY CARD

Operations Coordinator - Checklist		
☐	1)	Record all relevant information in the Operations Coordinator log sheet.

☐	2)	Oversee all immediate needs of the Incident Commander.
☐	3)	Assign the following responsibilities: Check-in Coordinator – Name: Mine Entrance Guards – Names: West Zone portal guard: VOK portal guard: Office Entrance Guard(security) – Name: Door guard: Transportation Coordinator (not required unless operation is extensive) Transportation Coordinator name:
☐	4)	Confirm with ERT Coordinator to ensure the Underground Mine Rescue Team has been notified and all necessary radio calls have been made.
☐	5)	If applicable, barricade or post guards at the incident area to prevent any unauthorized access and remove all non-essential personnel.
☐	6)	Brief and keep the Incident Commander informed. This communication must include any area that has the potential for explosives.
☐	7)	Monitor assigned responsibilities.
☐	8)	Sign the Operations Coordinator log sheet and return to Recorder when emergency is over.

Post Incident - Checklist		
☐	1)	Participate in the post crisis review
☐	2)	Evaluate the effectiveness of the Underground Incident Management Team during the response and implement any necessary changes to the room or associated procedures

11.5 Engineering Coordinator Duty Card

Engineering Coordinator - Checklist		
☐	1)	Set up personal workstation.

		Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	Enter all relevant information on the Engineering Coordinator log Sheet.
☐	3)	Assign a Ventilation Engineer and provide instructions and support throughout the incident.
☐	4)	Provide copy of current ventilation plans. Review plans showing mining areas, ventilation flows and controls, refuge stations, escape ways, explosives magazines, etc.
☐	5)	Provide technical assistance to the Incident Commander.
☐	6)	Ensure main surface fans are operating as required.
☐	7)	Follow up and monitor all assigned responsibilities.
☐	8)	Sign the Engineering Coordinator log sheet and return to the Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups. Pass the information onto the ERT Advisor.
☐	2)	Participate in the post-crisis debrief.
☐	3)	Ensure allocated post-crisis follow-up actions are completed.

11.6 MAINTENANCE COORDINATOR DUTY CARD

Maintenance Coordinator - Checklist		
☐	1)	Assign Mechanical Supervisor and Electrical Supervisor, if required: Name of Mechanical Supervisor:

		Name of Electrical Supervisor:
☐	2)	Confirm that Stench at the main fans has been released (by radio). Only if required, check to make sure the stench gas has been released in the compressed lines.
☐	3)	Report to Incident Commander that stench has been released.
☐	4)	Under the direction of the Incident Commander, identify and work to remedy any maintenance related issues.
☐	5)	Discuss with the ERT Coordinator the need to have a mechanic inspect equipment involved in the incident prior to calling the Code One over.
☐	6)	Record relevant information in the Maintenance Coordinator log sheet.
☐	7)	Sign the Maintenance Coordinator log sheet and return to Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Participate in the post crisis review
☐	2)	Evaluate the effectiveness of the Underground Incident Management Team during the response and implement any necessary changes to the room or associated procedures
☐	3)	Provide a list of what equipment is locked out and/or need repair.

11.7 RECORDER DUTY CARD #1

Recorder - Checklist		
☐	1)	Set up personal workstation and start recorder.
☐	2)	Record key incident information on the event log and/or the status boards (rolled up poster sheets located in the auxiliary room). This must include times.
☐	3)	Update the status boards and manage administrative functions.
☐	4)	Manage the flow of hard copy information and retain copies for the permanent log.
☐	5)	Assist the Incident Commander in record keeping.
☐	6)	Alert team members of major changes, issues and outstanding actions.
☐	7)	Take digital photos of status boards before they are updated.
☐	8)	Proactively monitor all communications and record pertinent points as they arise.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups.
☐	2)	Participate in the IMT post-crisis interview.
☐	3)	Assist with refurbishing the Incident Management Room back to a ready state.

11.8 RECORDER DUTY CARD #2

Recorder - Checklist		
☐	1)	Set up personal workstation.
☐	2)	Record key incident information on the event log. This must include times.
☐	3)	Assist Dispatch in all aspects.
☐	4)	Manage the flow of hard copy information and retain copies for the permanent log.
☐	5)	Record all pertinent information from radio and telephone communication
☐	6)	Alert team members of major changes, issues and outstanding actions.
☐	7)	Take digital photos of information received
☐	8)	Proactively monitor all communications and record pertinent points as they arise.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups.
☐	2)	Participate in the IMT post-crisis interview.
☐	3)	Assist with refurbishing the Incident Management Room back to a ready state.

11.9 DISPATCH DUTY CARD

Dispatch - Checklist		
☐	1)	If an underground emergency is called on any UG channel, immediately relay the message without delay to Senior Management as per site extensions. Ch2 days Event: _____ Location of Event: _____ Person Reporting Event: _____ Injuries: _____ <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	If it is a medical emergency, inform all personnel on all underground channels to clear all ramps to the incident scene.
☐	3)	Monitor channel “all dispatch” and record any information in the Dispatch logbook.
☐	4)	If calls are received from a refuge station to report people present tell the caller that someone will contact them shortly. If the caller has information regarding the emergency record on log sheet. Relay information to Operations Coordinator.
☐	5)	Relay relevant information received from the UG channels to the Operations Coordinator.
☐	6)	When requested, provide any information on the location of personnel or equipment to the Operations Coordinator.
☐	7)	Record relevant information on Dispatch log sheet.
Post Incident - Checklist		
☐	1)	Participate in the IMT post-crisis interview

11.10 Check-In Coordinator Duty Card

Check-In Coordinator - Checklist		
☐	1)	Start your Check in Coordinator log sheet. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	Designate the West Zone shop area and VOK Portal entrance as the muster area.
☐	3)	Assign one of the people mustering to direct, supervise & monitor personnel in the muster area. Instruct them to ensure all personnel remain in the muster area. Name: _____ Assign one Tag Board Check-In Assistant to oversee/guard the tag board. Instruct them not to let anyone remove a tag from the board until all workers are accounted for and the Check-In Coordinator has given approval. Tag board check in assistant: _____
☐	4)	Install the TAG BOARD “NO ENTRY” BARRICADES around the tag board to prevent persons from entering the TAG BOARD area.
☐	5)	Assign two Refuge Station Check-In Assistants. Designate each person specific refuge stations. Distribute refuge station records accordingly.
☐	6)	Delegate two Check-In Assistants to sit in the Shifter’s office to start call ins. Refuge Station Check-In Assistants #1: Refuge Station Check-In Assistants #2: Ensure the Check-In Assistants have their appropriate Refuge Station Check-In sheets (#1 and #2). The refuge stations are split up between Assistants to increase efficiency.
☐	7)	Monitor and direct the activities of the Check-In Assistants and UG Office muster area.
☐	8)	Provide a list of personnel accounted and unaccounted for and any Refuge Stations that were not contacted to the Operations Coordinator
☐	9)	Inform Operations Coordinator when all personnel are accounted for.
☐	10)	Release persons in the UG Offices muster area once the Code One is over.

☐	11)	Ensure all relevant information is entered in Check-In Coordinator log sheet, sign, then give to the recorder.
Post Incident - Checklist		
☐	1)	Participate in the IMT post-crisis interview

11.11 Check-In Assistant Duty Card

Check in Assistant - Checklist		
☐	1)	Use the REFUGE STATION RECORD sheets to phone all assigned refuge stations and record the name, employer/company name, refuge location, and condition of all personnel. Repeat the names to the refuge station attendant for verification. Ensure to include the refuge station attendant name. If a refuge station cannot be contacted by phone inform the Check-In Coordinator who will provide a radio. Attempt to contact the refuge station on radio channel 1, 2, and 3. Use a separate sheet for each refuge station and circle the refuge station location at the top of the sheet. <u>Required Phone Numbers:</u> Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) Mill Dry 3rd – 455 Tagboard – 675 1440 refuge - 405, 1335 refuge – 676, 1320 refuge - 413, 1230 refuge - 425, 1200 refuge-707, 1170 refuge - 457, 1110 refuge - 809, 1080 refuge - 810 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	2)	After all refuge stations have been contacted once, take the REFUGE STATION RECORD to the tag board and read the names one at a time to the Tag Board Check in Assistants. The Tag Board Check in Assistant will flip the tags as you read them. The Refuge Station Check in Assistant will mark an X in the column on the REFUGE STATION RECORD beside the person's name to indicate their tag has been flipped. Once all names have been read from the Refuge Station Check in Assistants list, compile a list of people not accounted for and notify the Check-In Coordinator.
☐	3)	Return to designated office and contact all the refuge stations again for any new arrivals. Repeat process at tag board of confirming names and flipping tags.
☐	4)	Provide a list of personnel unaccounted-for to the Check-In Coordinator.
☐	5)	Follow all directions from the Check in Coordinator.

☐	6)	Record all relevant information in the Refuge Station Check in Assistants Log sheet
☐	7)	Sign the Refuge Station Check in Assistant's Log sheet and return all paperwork to Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Attend the incident post-crisis review

11.12 Entrance Guard Duty Card

Entrance Guards - Checklist		
☐	1)	There are two locations that need to be guarded: West Zone Portal; VOK Portal; The Operations Coordinator will brief the two individuals with all pertinent information.
☐	2)	Obtain communications radio (Channel 2 RPT 1) and proceed to your designated location.
☐	3)	Record all relevant information in the Entrance Guard log sheet.
☐	4)	Position yourself, or vehicle: West Zone Portal - In a location that allows visual surveillance of the portal without being exposed to mine exhaust flow. VOK Portal - In a location that allows visual surveillance of the portal without being exposed to mine exhaust flow.
☐	5)	Stop anyone: West Zone Portal – Who attempts to enter the mine via the West Zone Portal. Contact Operations Coordinator to advise. VOK Portal – Who attempts to enter the mine via the VOK Portal. Contact Operations Coordinator to advise.
☐	6)	Identify anyone who exits the mine via the West Zone or VOK Portal. Contact the Operations Coordinator (Channel 2) to request transportation or first aid treatment of personnel exiting the mine.
☐	7)	Follow all directions from the Operations Coordinator.
☐	8)	Duties are not relieved until the Operations Coordinator instructs you to leave your post.
☐	9)	Sign the entrance guard log sheet and return to Underground Incident Command Team when emergency is over.

Appendix 9-1-13. Spill Response Plan

NEWCREST

PRETIUM RESOURCES INC.

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BRUCEJACK MINE

Spill Response Plan

March 2022

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Spill Response Plan

Date: March 2022

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BRUCEJACK MINE
Spill Response Plan

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VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
1	April 2015	Pretium Exploration Inc.	Original
2	February 2017	Pretium Exploration Inc.	Updated by Pretium
3	December 2018	Pretium Resources Inc.	Content update, version control table updated and cover page added
4	December 2018	Pretium Resources Inc.	Updated by Pretium
5	March 2020	Pretium Resources Inc.	Updated to reflect current regulations and practices
6	March 2021	Pretium Resources Inc.	Updated to reflect current regulations and practices
7	March 2022	Pretium Resources Inc.	Minor formatting edits. Removed Acknowledgements section. Modified Table 3.1-1 to incorporate changes from IAAC Information Request July 22, 2021. Updated contact information for IAAC and First Nations.

DISCLAIMER

Use of this Spill Response Plan is restricted to Pretium Resources Inc. (Pretium) staff and contractors who have participated in Spill Prevention and Response Training.

This plan should be viewed as a guide. Each spill is different and must be assessed individually. A response must be formulated to include unique strategies for safe containment, cleanup, disposal, and site restoration using best practicable technologies and methods. The strategies should be based on all available information, including the circumstances of the spill and information contained in this plan.

GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BJAR	Brucejack Access Road
CSA (Group)	Canadian Standards Association – Canadian authority on safety and performance standards and certification
EMBC	Emergency Management BC – the organization to which spills are reported in BC and which alerts agencies and assigns a case number
EMS	Environmental Management System
IAAC	Impact Assessment Agency of Canada
IMC	Incident Management Centre
IMT	Incident Management Team
KTA	Knipple Transfer Area
MECCS	BC Ministry Environment & Climate Change Strategy
MEMPR	BC Ministry of Energy, Mines and Petroleum Resources
MEMLCI	BC Ministry of Energy, Mines and Low Carbon Innovation
MERP	Mine Emergency Response Plan
Mine	Brucejack Mine
NLG	Nisga'a Lisims Government
PEP	Provincial Emergency Program – the predecessor to EMBC
PPE	Personal Protective Equipment – e.g., gloves, goggles, hard hat, etc.
Pretium	Pretium Resources Inc.
Regulated Person	A person or employee of a person who, while operating an industry, trade or business had possession, charge or control of a prescribed substance in prescribed quantities.
Responsible Person	A person who has possession, charge or control of a substance or thing when a spill of the substance or thing occurs or is at imminent risk of occurring.
SCBA	Self-contained Breathing Apparatus
SDS	Safety Data Sheet
TSKLH	Tsetsaut/ Skii km Lax Ha Nation
ULC	Underwriters Laboratories of Canada – an independent product safety testing, certification, and inspection organization
Universal Sorbent	Sorbent material that recovers water-soluble substances as well as oil products, usually grey, yellow or blue in colour

1. INTRODUCTION

1.1 PURPOSE

The purpose of this Spill Response Plan for the Brucejack Mine (the Mine) is to safeguard as far as possible against accidental spills of harmful substances that may negatively affect the environment. This will be achieved primarily by implementing spill prevention systems to avoid accidental releases to the environment, followed by responding timely and efficiently to a spill, thereby mitigating any negative effects.

This plan provides guidance to site personnel on how to respond to an accidental spill emergency and is a component of the environmental management system (EMS) for the mine and ancillary infrastructure. The information contained in this plan not only fulfils the basic requirements of Mines Act permitting, but also expands further to satisfy specific details related to the operation of the mine. The plan is reviewed every year.

This plan has been prepared to facilitate the prevention and safe and efficient cleanup of spills of the substances that may be present at the various Brucejack Mine facilities, including the Mine Site Area, along the Brucejack Access Road (BJAR), Knipple Transfer Area (KTA), Bowser Aerodrome, Brucejack transmission line and Wildfire Camp (Table 1.1-1).

Table 1.1-1. Substances in Use at the Brucejack Mine

Fuels/Oils	Dangerous Goods	Non-regulated Products	Gases
Diesel Gasoline	Ethylene Glycol Explosives (ANFO,Emulsion)	Actisand Borax	Acetylene Argon
Jet A	Hydrochloric acid	TerraFlow (mine backfill cement)	Propane Oxygen
Hydraulic	Litharge (lead oxide)	Propylene glycol	
Lube	Vanfroth 250 (frother)	Hydrated Lime	
Waste Oils	Nitric acid	Ferric Sulphate	
	Potassium Amyl Xanthate	Anionic Polymer (AN905)	
	Solvents ChemTreat CT788 Sodium Nitrate Perchloric Acid Hydrofluoric Acid Sulphuric acid	Flocculant (AN910) ChemTreat ML4428 Lithium Chloride	
	Sodium Sulphide		

Note: this list will be reviewed when the plan is updated as required

1.2 PERFORMANCE OBJECTIVES

The principal objectives of this Spill Response Plan are to:

- Provide emergency response information to mine management, response crews, and government agencies in the event of a spill;
- Comply with federal, provincial, and regional regulations pertaining to the preparation of contingency plans and spill reporting requirements;
- Promote the safe and effective recovery of spilled materials;
- Minimize the environmental impacts of spills to water, or land and ice; and
- Facilitate the management of wastes according to legislation.

This plan provides practical steps to safely assess an incident and to implement a response. Follow-up and corrective actions are also addressed so that these steps can be safely and efficiently conducted.

1.3 PLAN STRUCTURE

Relevant legislation and regulations are provided in subsection 1.4. Subsection 1.5 provides information on the Company and Emergency Operations.

Section 2 describes Spill Alerting and reporting, and Section 3 describes the Action Plan. Information on contacts (internal and external) is provided in Section 4. Finally, Section 5 describes Spill Response Roles and Responsibilities.

Additional information is provided in a series of appendices listed below.

- Appendix A provides the physical and chemical properties as well as emergency response measures for all substances expected to be in use have been compiled as Product Response Guides.
- Appendix B describes a current inventory of spill response kits.
- Appendix C describes the response strategies applied to the spill situations related to the chemicals and substances typically used at the Mine.
- Appendix D includes checklists for fuel and chemical storage and transfer operations. Regular inspections will help prevent spills and demonstrate due diligence. This appendix also provides the location and information of existing storage tanks.
- Appendix E outlines the spill response training that will be taken by Pretium employees and contractors. Training will enable them to respond safely and effectively to oil and chemical spill incidents.
- Appendix F contains Pretium's Standard Operating Procedure for Hydrocarbon Fuel Spill Response (BJ-ENV-SOP-025) including the Spill Reporting Information form.

Certain actions and responses supporting the implementation of the objectives of this Spill Response Plan overlap with other component management plans of the mine. Examples these plans are: the Mine Emergency Response Plan, the Chemicals and Materials Storage and Handling Plan and the Waste Management Plan. Spill prevention is also discussed in an appendix of the Chemicals and Materials Storage and Handling Plan.

1.4 RELEVANT LEGISLATION, REGULATIONS, AND ENVIRONMENTAL ASSESSMENT CERTIFICATE (EAC) CONDITIONS

1.4.1 Relevant Legislation and Regulations

This Spill Response Plan is a specific requirement of the BC Ministry of Energy, Mines and Low Carbon Innovation under the BC *Mines Act* and is also a requirement of the BC Ministry of Environment and Climate Change Strategy under the BC *Environmental Management Act* and regulations noted below. Applicable legislation and regulations include the following:

- BC Fire Code 2018;
- *Fire Services Act*
- *Fisheries Act*
- *Motor Vehicle Act*
- *Transportation of Dangerous Goods Act and Regulations*
- ULC/CSA standards
- *BC Water Act*
- *BC Water Sustainability Act*
- *BC Environmental Management Act:*
  - Petroleum Storage and Distribution Facilities Storm water Regulation
  - Hazardous Waste Regulation
  - Spill Reporting Regulation
  - Spill Preparedness, Response and Recovery Regulation
  - Spill Contingency Regulation
- Workplace Hazardous Materials Information System (WHMIS, 2015)
- BC *Mines Act*
- Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products (Canadian Council of Ministers of the Environment [CCME]), Document PN1326,2003
- BC Fuel Guidelines, 11th Edition January 2022
- BC Guidelines for Industry Emergency Response Plans updated July 2002

1.4.2 Relevant EAC Conditions

Pretium was granted an Environmental Assessment Certificate (EAC, #M15-01) on March 26, 2015 which includes a series of conditions. This Spill Response Plan contributes to fulfilling Condition 2 in relation to the component plans outlined in Appendix A of Schedule B of the EAC. Condition 2 of the EAC states that:

"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.

Component Plans, at minimum, must include the following information:

- *Purpose of Component Plan;*
- *Performance objectives;*
- *Effects mitigation measures;*
- *Monitoring programs;*
- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

1.5 COMPANY INFORMATION AND EMERGENCY OPERATIONS

1.5.1 Site Information

The Mine major components are:

- the Mine Site Area, the Brucejack Access Road linking the mine to Highway 37;
- the Bowser Aerodrome;
- the Knipple Transfer Area (KTA) bulk emulsion staging area;
- Bowser and Wildfire camps; and,
- the Brucejack transmission connecting to the Long Lake Hydro substation (Figure 1.4-1).

This plan has been developed to address potential spills at the major mine components during construction, operation, and closure.

1.5.1.1 Mine Site

The Brucejack Mine is situated in British Columbia at 56°28′20″N Latitude and 130°11′31″W Longitude. This is approximately 65 km north-northwest of Stewart by air. Road access is 60 km north from Meziadin Junction via Highway 37, then 73 km west via the Brucejack Access Road (BJAR, Figure 1.4- 1), including a 12 km section over the Knipple Glacier. The Mine Site Area is approximately 40 km upstream of the Canada/USA border and is located on provincial Crown land within the Regional District of Kitimat-Stikine

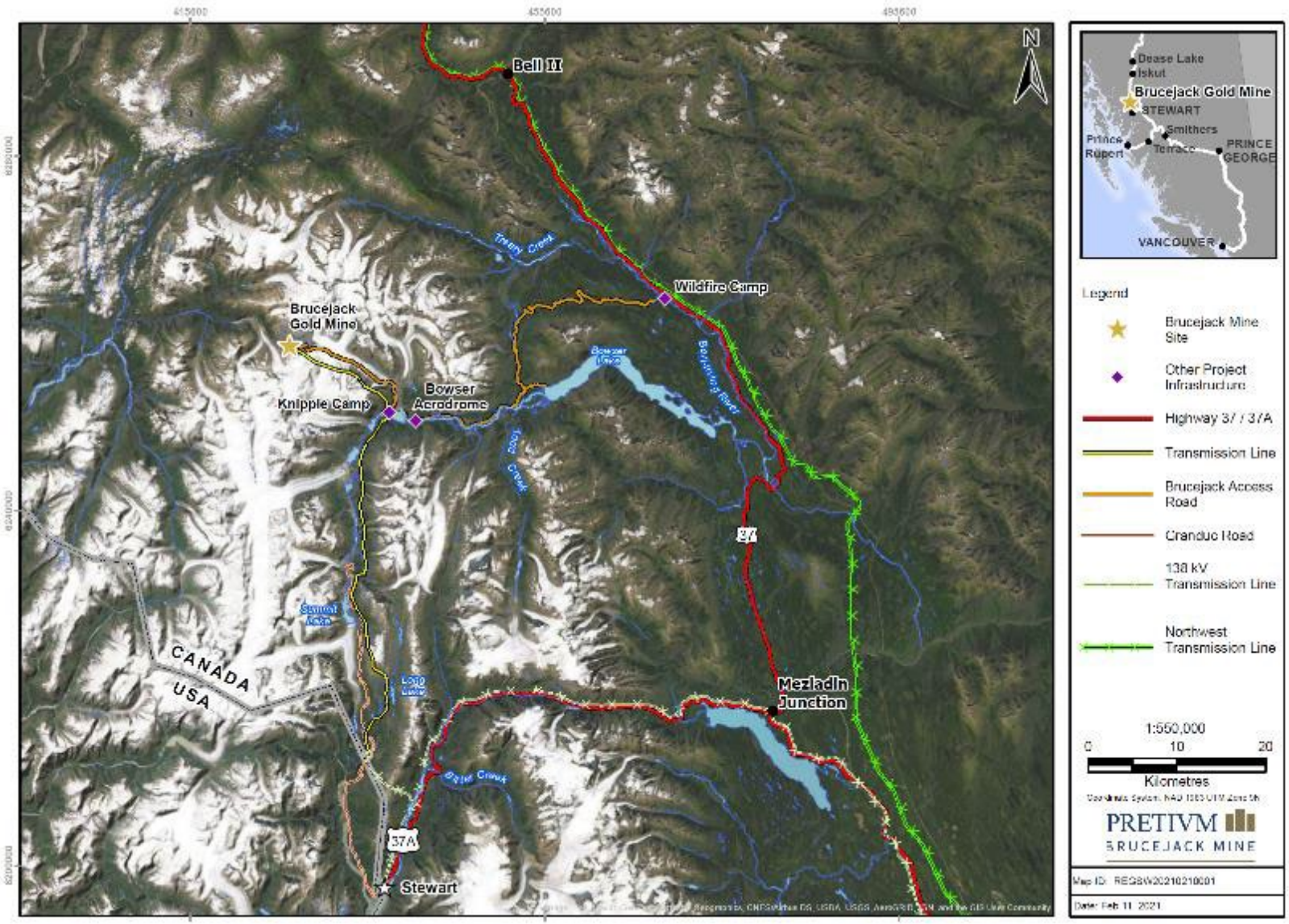

Figure 1.4-1. Project Location and Components

The Waste Rock and Tailings Storage Facility (WRTSF) catchment, where the Mine Site Area (underground mine, mill, subaqueous tailings and waste rock disposal, and NPAG quarry) is located, drains into Brucejack Creek. Brucejack Creek is a tributary to Sulphurets Creek, which drains into the Unuk River. The Unuk River is transboundary with Alaska.

1.5.1.2 Brucejack Access Road, Wildfire Camp, Bowser Aerodrome, Knipple Transfer Area and Bulk Emulsion Staging Area

The Brucejack Access Road extends 73.5 km west from Highway 37 to the Mine Site. A 30 person camp (Wildfire Camp) is located near km 1 of the access road (approximate Latitude 56°31'31"N Longitude 129°30'11"W). Wildfire Camp provides a base for road maintenance and transport.

The Bowser Aerodrome is located near km 50 of the Brucejack Access Road (approximate Latitude 56°23'44.161"N Longitude 129°56'28.266"W).

The Knipple Transfer Area was constructed near km 55 of the access road (approximate Latitude 56°24'1.886"N Longitude 130°0'19.052"W). This site is where product and materials will be transferred between highway transport vehicles to glacier crossing vehicles. The camp at this location serves road maintenance and transportation needs (particularly the interface between the lower all- weather road and the glacier transport route) during all phases of the mine.

A Bulk Emulsion Staging Area is located near km 48 of the Brucejack Access Road. This is a fenced and locked facility used for the transfer and short-term storage of bulk emulsion containers. Emulsion is delivered in 20,000 kg ISO steel containers for transportation to the Brucejack Mine Site. Any containers that cannot be immediately transported to the Mine Site are stored in the staging area. Outgoing empty emulsion containers can also be staged in this area.

1.5.1.3 Transmission Line

A 55 km long 138 kV transmission line was constructed from the existing Long Lake Hydro substation to the Brucejack Mine Site. Spills along the transmission line are considered unlikely as maintenance is helicopter based, other than at the control station about 1 km north of Long Lake Substation and the Brucejack Substation at Knipple Transfer Area.

1.5.2 Company Information

Pretium has corporate offices in Vancouver and Smithers that would be contacted in the case of a major spill on the Brucejack property:

Pretium Resources Inc. – Head Office
2300 – 1055 Dunsmuir Street
Vancouver, BC V7X 1L4
Tel. 604-558-1784

Pretium Resources Inc. – Smithers Office
2965 Tatlow Road
Smithers, BC V0J 2N5
Tel. 866-241-9772

A full list of contact numbers is provided in Section 4.

1.5.3 Spill Response Equipment

Spill response supplies and equipment are kept at Wildfire Camp, Knipple Transfer Area, the Brucejack Mine Site as well as strategic areas along the Access Road. Smaller kits are kept at any active work sites and all vehicles and equipment are required to have individual spill kits.

See Appendix B for detailed inventories of spill response equipment.

1.5.4 Incident Management Team (IMT)

In the event of a spill requiring an ongoing response an Incident Management Team (IMT) will be assigned and will meet at the designated *Incident Management Centre (IMC)*; the Mine Administration Office at the Brucejack Mine Site is the primary location. If needed, additional IMCs will be added at key locations along the Brucejack Access Road as follows:

- Knipple Transfer Area: Primary Location – Main Conference Room
- Wildfire Camp: Primary Location – Main Office

Functions of the IMT are summarized in Chapter 5 and further details are provided in the MERP.

1.5.5 Mustering/Assembly Areas

If an evacuation of an affected site is required, personnel must assemble upwind of the evacuated area to await further instructions. An employee tally will then be taken.

2. SPILL ALERTING AND REPORTING

There are two categories of spills, defined by set thresholds specified in Table 2.1-1:

- Non-reportable, refers to spills smaller than the set thresholds and are not reported to provincial regulatory bodies. These spills are only reported internally in the mine; and
- Reportable, refers to spill quantities greater than the set thresholds and are reported to provincial regulatory bodies

Regardless of their category, all spills must be cleaned up and reported either internally or to regulatory bodies. The Notification and Alerting Summary chart provided in Figure 2-1 highlights Pretium's reporting and alerting procedures, step 3 is only required for reportable quantities defined by table 2.2-1. These procedures are further addressed in this section.

Table 2.1-1. Thresholds for Reportable Spills

TDG Classification	Substance	Amount
1.5- Explosives	ANFO, emulsion	50 kg, or less if the substance poses a danger to public safety
3-Flammable liquids	Diesel, gasoline, hydraulic, lube, Jet A, solvents, waste oil, Vanfroth	100 L
4.2-Flammable solids	Potassium Amyl Xanthate	25 kg
8- Corrosives	Nitric acid, sulphuric acid, hydrochloric acid, perchloric acid, hydrofluoric acid, sodium Sulphide, ChemTreat CT788	5 kg or 5 L
2.1- Flammable gases	Propane and acetylene	10 kg
Leachable toxic waste	Coolant	25 L
6.1-Toxic substances	Litharge Lead Oxide, hydrofluoric acid	5 kg or 5 L
Not regulated	Borax, anionic polymer, flocculant, ferric sulphate, propylene glycol, methyl ether paint, hydrated lime, ChemTreat ML4428, lithium Chloride	200 kg or 200 L

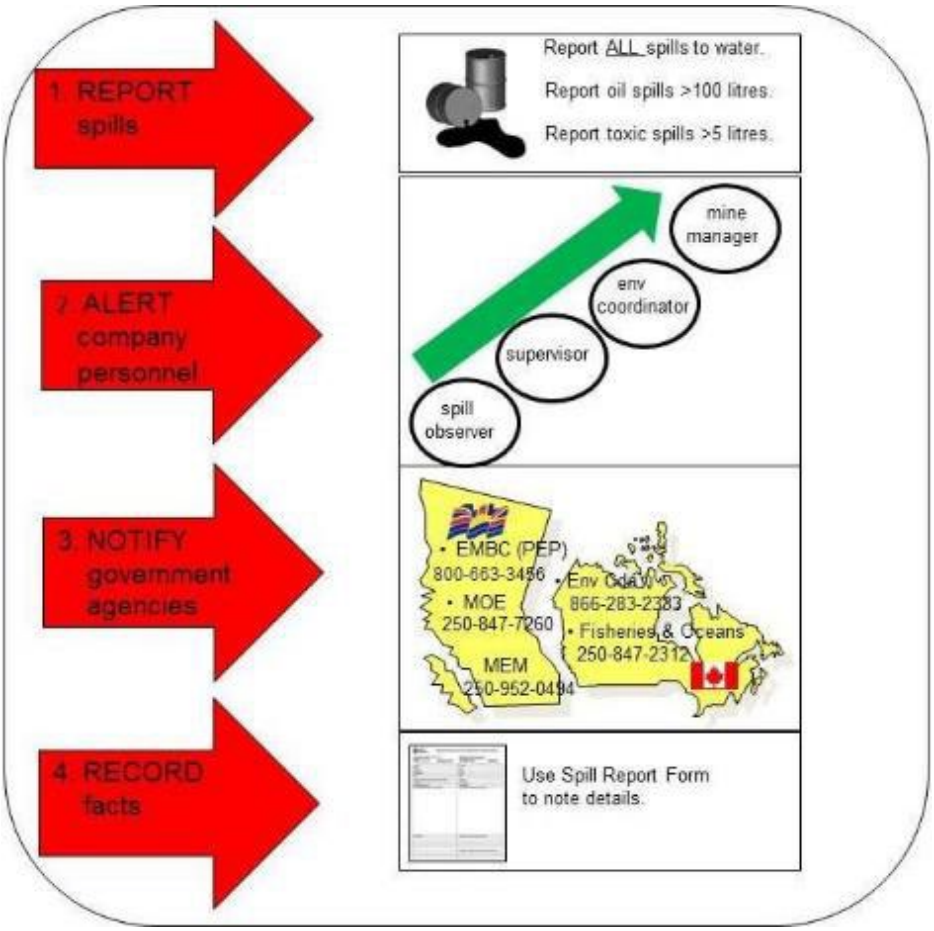

Figure 2.1-1. Notification and Alerting Summary

2.1 SPILL ALERTING

All spills occurring outside any fluid management system must be reported to:

- Supervisor
- Manager, Environment and Regulatory Affairs
- Health and Safety Manager
- Mine Manager
- General Manager

The general reporting structure for all spills is as follows:

- Environmental incident reports are submitted to the Environmental Superintendent (or Environmental Coordinator/designate) who reviews report before submitting to the Manager, Environmental and Regulatory Affairs and Mine Manager, with copies forwarded to the Health & Safety Manager and General Manager.

- Any spills exceeding the regulatory thresholds (Table 2.1-1) are reported to Emergency Management BC (EMBC) by the Environmental Manager or designate. As per Section 6 of BC's Spill Reporting Regulation, a written End-of-Spill Report is prepared and submitted to BC Ministry of Environment and Climate Change Strategy (MECCS) within 30 days following the emergency response completion date.
- Any spills with potential to cause adverse environmental effects are reported in writing to Impact Assessment Agency of Canada (IAAC) as per Condition 9.3.1 of Decision Statement Issued under Section 54 of the Canadian Environmental Assessment Act, 2012.
- Oil spills <100 litres, spills of dangerous goods <1 litre or any spills of substances below EMBC reporting thresholds must be cleaned up and require internal alerting or reporting only.
- First Nations with Traditional Territories located downstream of the Bowser River (Tsetsaut Skii km Lax Ha, Nisga'a Nation, Gitanyow First Nation, Tahltan Nation) must be notified if the spill enters water and is not contained and/or cleaned and may impact downstream aquatic environments. See Figure 2.1-2 for the potential spill flow pathways along the BJAR east of Brucejack Mine.
- For more detail on reporting structure, roles and responsibilities, refer to section 5.

2.1.1 Gas Release

In the event of a significant release of explosive or other dangerous gas, contact the Mine Manager as soon as possible. The Mine Manager will inform the regional Ministry of Energy Mines and Low Carbon Innovation (MEMCI) Health and Safety Inspector and the Pretium Health & Safety Manager as soon as possible, within 8 hours of a dangerous occurrence, and within one week will send a follow up written report to the MEMCI Health & Safety Inspector.

2.2 SPILL REPORTING

Substances spilled on land or ice in reportable quantities (refer to Table 2.1-1), and any quantity of substance spilled to water that might result in deleterious impacts must be reported to the **Emergency Management BC Program 24 hour Spill Report Hotline 1-800-663-3456** within 24 hours of the initial spill observation**.**

The Spill Report form (Appendix F) will be used to record the data that is required to be reported to EMBC.

It is not necessarily an offence to spill a substance. It is an offence NOT to report a reportable spill.

All spills, regardless of volume, must be recorded on the Spill Report form. Refer also to Section 3.1 for spills of dangerous goods.

GPS coordinates must be recorded for any reportable spill and should be recorded for any non-reportable spill. Wherever feasible, spill response actions will be photographed from initial control to the proper storage of waste materials.

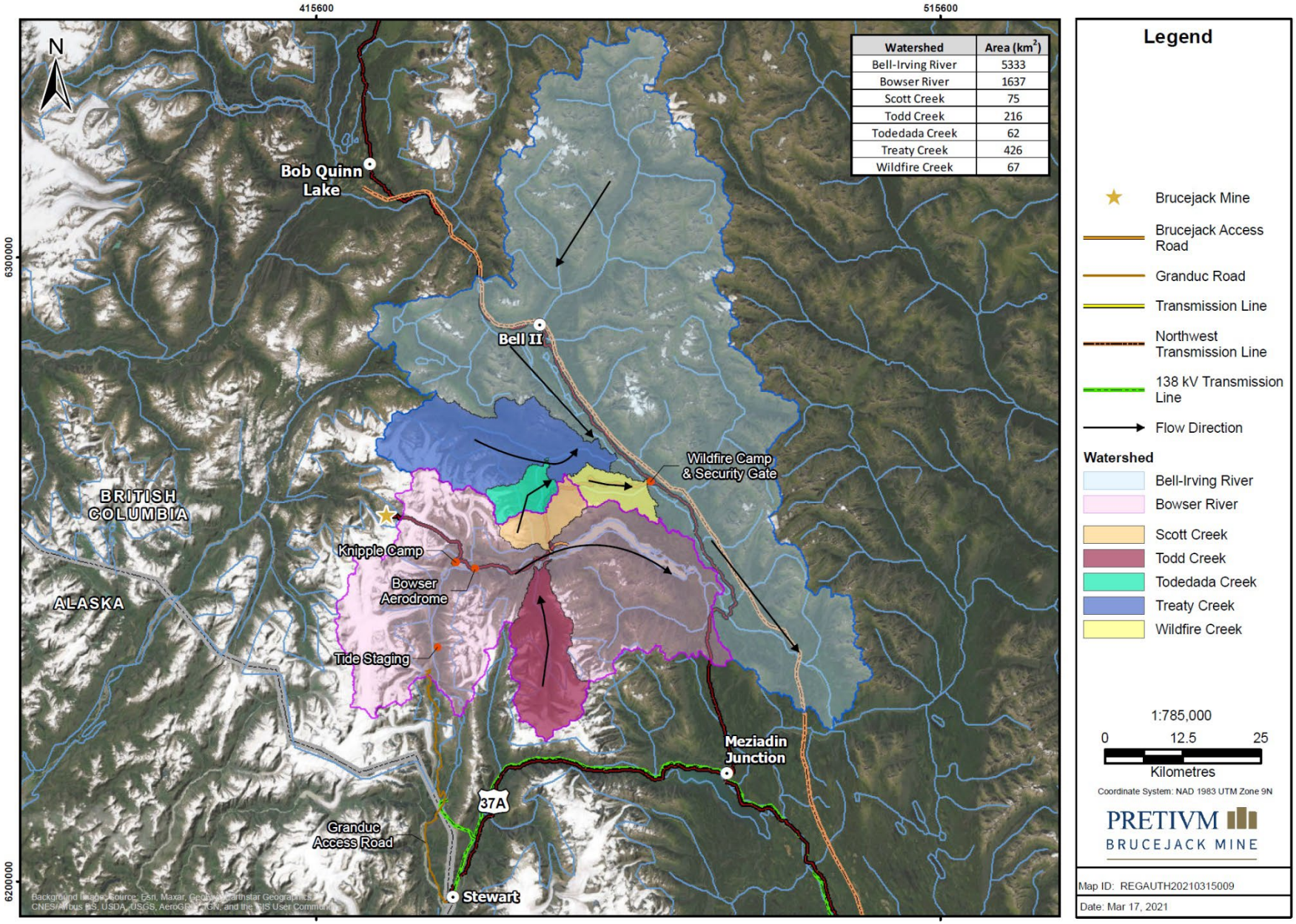

Figure 2.1-2. Potential Spill Flow Paths Along the Brucejack Access Road

3. ACTION PLAN

3.1 SEVERITY CLASSIFICATION

The response to a spill at the Mine depends on the severity of the incident and its potential impact. Three levels of emergency (Table 3.1-1) can be identified according to:

- the real or potential impacts of the incident;
- the need for outside support resources;
- who is contacted in an emergency; and
- the degree of public/media communication required.

Table 3.1-1 Severity Classification of Spill Incidents

Level 1: Minor	Level 2: Moderate	Level 3: Major
• Volume is less than the BC reportable threshold quantity (see Table 2.1-1). • No public concern or adverse environmental effects. • No release beyond the site. • Completely handled by on-site resources. • Of no interest to the media or the public.	• Volume is greater than the BC reportable threshold quantity (see Table 2.1-1). • No public concern but has potential to cause adverse environmental effects. • Spill is fully or substantially contained within site boundaries, but could possibly extend beyond Pretium property. • Control of incident is probable. • Possible local public or media interest.	• Volume is greater than the BC reportable threshold quantity (see Table 2.1-1). • Potential public concern and adverse environmental effects. • May be beyond local, on-site emergency response resources. Support of off-site personnel or other resources may be required. • May require multi-agency involvement. • High media and public interest.
Emergency Response Actions		
• Internally reportable.	• Notify EMBC. • Notify First Nations downstream of the Bowser River if spill enters water and is not contained and/or cleaned (Tsetsaut Skii km Lax Ha, Nisga'a Nation, Gitanyow First Nation, Tahltan Nation). • Notify IAAC if spill has the potential to cause adverse environmental effects. • Corporate management is notified and provides advice and support.	• Identified as "Emergency" by Pretium. • Maximum Pretium field and corporate response. • Pretium notifies and maintains ongoing communications with the EMBC, MEM*, IAAC and First Nations governments (see Level 2), and other government agencies as required.

** Notify the regional Health and Safety Inspector, MEMPR, who will notify the Chief Inspector if/as required.*

3.2 SPILL RESPONSE ACTIONS

Once the severity of the spill has been determined, personnel should follow the steps as summarized in Figure 3.1 and outlined in Table 3.2-1. Detailed information pertaining to different aspects related to response actions are provided in the following appendices:

- Appendix A: Response guides for specific products used in the mine, including the Water Treatment Plant;
- Appendix B: Spill Response Equipment;
- Appendix C: Spill response strategies
- Appendix D: Storage tanks and fuelling facilities; and
- Appendix F: Standard Operating Procedure (SOP) for hydrocarbon fuel spill response.

Figure 3.1. Spill Action Summary

Table 3.2-1. Spill Response Actions – Brucejack Mine

I. Respond Quickly
1. Identify the spilled material. 2. Ensure safety of yourself and others (evacuate if necessary). 3. Shut off ignition sources–no smoking. 4. Assess the severity of the spill. 5. Report to Supervisor OR Environmental Department – request assistance if required. 6. Attend to any injured personnel. 7. Keep unnecessary people out of the area. 8. Donn appropriate PPE – impervious clothing, goggles, gloves, respiratory protection. 9. Approach spill from upwind if safe to do so. 10. Stop product flow if possible: o Stop filling or transfer operations. o Turn off valves and/or plug leaks. 11. Contain spill as quickly as possible: o Berm, dike, and block entry to waterways and ditches. 12. Recover spill if safe to do so: o Use sorbents to remove petroleum products from surfaces and place contaminated material into marked containers for temporary storage. o Remove dangerous goods ONLY under supervision of qualified individual. o Transfer recovered materials to empty, labelled tank or container that can be sealed.
II. Respond Safely
1. Do not contain gasoline or solvents (vapours might ignite). 2. Allow gasoline to evaporate where safe to do so. 3. For spills of dangerous goods, consult Health & Safety Manager. 4. See Product Response Guides (Appendix A) for further information.
III. Obtain and Report Spill Details
See Spill Reporting Information form (Appendix F) for more details.

It is mandatory that all Pretium employees and contractors who handle the materials listed in this plan and who must respond to spills be trained in all aspects of spill response including health and safety, PPE, and spill control and cleanup. Only personnel trained in spill response for these materials are to implement these actions. Untrained personnel first on the scene are to report the spill, then close off the spill scene, establish a safe buffer zone and prevent access to anyone but trained personnel.

3.2.1 Disposal

Proper cleanup and disposal methods are prescribed by the Pretium Environmental Department together with the Health & Safety Manager who will ensure that all disposal options conform to BC MECCS requirements. Refer also to Safety Data Sheets (SDSs) for each specific product. SDSs will be updated when a product formulation changes and/or when a new product comes onto site.

SPENT SORBENTS MUST BE REMOVED IMMEDIATELY AFTER THEY ARE USED, BY PLACING IN SUITABLE SEALED AND LABELLED CONTAINERS, FOR PROPER OFF-SITE DISPOSAL. THEY MUST NOT BE LEFT ON THE GROUND.

The following list outlines disposal considerations for different materials.

- All contaminated materials resulting from a spill cleanup must be collected and stored in sealed, labelled containers (see Contacts – Terrapure).
- All contaminated materials must be shipped off site, unless otherwise approved, in waste manifested loads taken by a carrier with a list of emergency contacts and emergency measures clearly indicated.
- Biocells or other on-site means using nutrients, soil or other combinations thereof (i.e., landfarm) are not recommended for the disposal of contaminated soil from small spills. Larger spills may warrant the use of on-site disposal and would be considered at that time (regulatory approval required).
- Section 52 of the Hazardous Waste Regulations as outlined in the Environmental Management Act is also an option for seeking some exemptions (disposal and/or transport) of any/all waste resulting from an emergency/ spill incident.
- Oiled snow may be burned onsite in the incinerator which is permitted to burn waste oil if the ratio of oil to snow is acceptably high and the volume is recorded as per Waste Management Plan.
- Generally, oily sorbents resulting from ongoing operations must not be disposed of by burning in a drum or incinerator.
- Particulate sorbent used to treat spills, including Oil Gator, must be removed and NOT LEFT IN PLACE unless approved by the BC Ministry of Environment & Climate Change Strategy.
- Proper disposal methods may be prescribed by the Environmental Superintendent/ Coordinator if approval by BC MECCS needs to be obtained.

3.2.2 Northwest Fuels Limited Spill Contingency Plan

Spills resulting from Northwest Fuels Limited vehicles will be responded to according to the Northwest Fuels Limited Spill Contingency Plan provided in Appendix G.

4. CONTACTS

Internal emergency contact numbers and radio frequencies are listed in Tables 4.1-1 and 4.1-2.

4.1 INTERNAL EMERGENCY CONTACTS

Table 4.1-1. Phone Numbers – Brucejack Mine

Title/Dept.	Extension
Main Site Office	**778-724-4186**
Switchboard Admin/ Dispatch	**108**
Mine Manager	**127/165**
Mine Superintendent	**383/**
Health & Safety Manager	**392/167**
Environmental Manager/ Superintendent/ Coordinator	**504/ 211/ 103**
First Aid (Brucejack/ KTA/ Wildfire)	**111/ 422/ 222**
Vancouver Office	**604-558-1784**
Smithers Office	**250-847-2526**

Table 4.1-2. Radio Frequencies – Brucejack Mine

Channel	RX Frequency	TX Frequency	Tone	Name
Ch 1	166.080	166.080	n/a	New Road
Ch 2	162.735	167.715	71.9	Repeater 1 (Brucejack)
Ch 3	162.735	162.735	71.9	Talk Around 1
Ch 4	162.810	167.790	123.0	Repeater 2 (Bowser and Scott Creek)
Ch 5	162.810	162.810	123.0	Talk Around 2
Ch 6	162.105	167.085	156.7	Repeater 3 (Wildfire)
Ch 7	162.105	162.105	156.7	Talk Around 3
Ch 8	154.100	154.100	n/a	Lad 1
Ch 9	158.940	158.940	n/a	Lad 2
Ch 10	154.325	154.325	n/a	Lad 3
Ch 11	173.370	173.370	n/a	Lad 4
Ch 12	166.470	166.470	n/a	VIH

4.2 EXTERNAL CONTACTS

External emergency contact numbers are listed below (Tables 4.2-1 to 4.2-2).

To report a spill, contact Emergency Management BC (EMBC) 24-hrs 1-800-663-3456.

Table 4.2-1. External Emergency Contacts

Service	Organization	Contact Number
EMBC	Emergency Management BC (24 hours)	1-800-663-3456
Environment	Enforcement & Environmental Emergencies (Victoria)	1-250-356-9302
	Conservation Officer	1-800-663-9453
	National Environmental Emergency Centre (Gatineau QC)	1-866-283-2333
	Transport Canada (TDG – Vancouver)	1-604-666-2955
	IAAC – Pacific and Yukon Office	1-604-666-2431
Chemical spills	Transport Emergency Centre (CANUTEC)	1-613-996-6666
Ministry of Energy and Mines (MEM)	Mines Inspector – Doug Flynn	1-250-847 7386
	Northwest Regional Office (Smithers)	1-250-847 7383
	Chief Inspector of Mines (Victoria)	1-250-952-0491
First Nations		
	Tsetsaut Skii km Lax Ha	250-842-5651
	Nisga' a Lisims Government	250-633-3000
	Gitanyow First Nation	250-849-5222
	Tahltan Nation	250-771-3274
Avalanche	Worker's Compensation Board (Vancouver)	1-604-561-3700
	Burnaby Dispatch Rapid Phone	1-604-660-9770
	MOTI – Avalanche Tech Stewart – Ryan Boyle	1-250-636-9055
	Last Frontier Heli-skiing - Ripley Creek Office (Jan - April)	1-250-636-2620
	Last Frontier Heli-skiing - Bell II Lodge (Jan - April)	1-250-275-4770
	Northern Escape Heli-skiing	1-250-615-3154
	Canadian Avalanche Centre	1-250-837-2141
WCB	WorkSafeBC	1-888-621-7233
SAR	Stewart SAR – Erin Boyle	1-250-636-9055
RCMP	Stewart	1-250-636-2233
	Terrace	1-250-638-7400
Fire	Forest Fire Reporting	1-800-663-5555
Poison control	B.C. Poison Control Centre (Vancouver)	1-800-567-8911
Helicopter	Yellowhead Helicopters	1-250-963-9884
	Canadian Helicopters	1-250-635-2430
	Lakelse Helicopters (Terrace)	1-250-635-3245
Other Companies	Soucie Construction	1-250-636-2389
	NorthWest Response Ltd. (Ray Hollenberg)	1-250-847-4556
	Bandstra Transportation Systems Ltd.	1-250-847-6451
	Northwest Fuels – Diesel/Gas - Technical Advisor	1-250-635-2066

Table 4.2-2. Other External Contacts – Contractors & Suppliers

Contractors/ Suppliers	Location	Contact Number
Bulk Explosives Ltd. (BXL) 24 hrs	Calgary	Office 403-255-7776
Terra Pure (waste storage and disposal)	Prince George	Office 250-960-1404 250-960-1405
Canada Hazmat	Prince George	250-564-7263
Acklands Grainger	24-hr emergency no.	250-785-8162
West Coast Spill Response	Vancouver	1-888-548-3800
CEDA (large or hazmat spill cleanup)	Calgary	403-253-3233
Tervita Services Inc. (hazmat spill cleanup)	Terrace	250-765-5740
Quantum Murray Environmental Group (spill response/remediation)	Richmond	604-270-7388

5. SPILL REPONSE ROLES AND RESPONSIBILITIES

In the event of an emergency spill, an Incident Management Team (IMT) will be created. Functions of the IMT may include:

- Notification to internal and external personnel and agencies;
- Situation assessment and planning and evaluation of response actions;
- Coordination of mobilization for response equipment, personnel, and resources;
- Liaison with Response Coordinator;
- Documentation of events, decisions and activities; and
- Communication with First Nations governments including:
    - Tsetsaut/ Skii km Lax Ha
    - Nisga'a Lisims Government
    - Gitanyow First Nation
    - Tahltan Nation

The roles and responsibilities for Pretium personnel as well as contractors during a Level 2 or 3 spill response are described in the following sections. Pretium's organizational structure for spill response is provided in Figure 5.1-1.

5.1 PRETIUM PERSONNEL

Spill Observer/All Site Workers

- Assess the initial severity of spill.
- Report all spills to Immediate Supervisor as soon as possible.
- Determine the source of the spill and, if safe, stop or contain it where possible.
- Participate in spill response as member of cleanup crew.

Supervisor

- Starts measures to control the situation and/or minimize the danger.
- Erects barricades and evacuates unauthorized personnel.
- Establishes a limited number of controlled entry points to scene.
- Notifies additional personnel, including Environmental Superintendent/Coordinator, if required to assist with immediate response.
- Requests the services of the Emergency Response Team, if required.
- Identifies possible hazards in the area (fuel tanks, electrical, etc.).
- If required, evacuates employees to a safe area, have all names recorded and conduct tally to determine if anyone is missing.

- Restricts or stops further operations that may interfere with the response to a spill incident.
- Supports all aspects of the investigation and helps prepare reports that may be sent to government agencies, in conjunction with the Environmental Coordinator.

Environmental Superintendent/Coordinator

- Implements protective measures and containment procedures to minimize environmental damage.
- Establishes internal and external communications as required to maintain notification sequence.
- Oversees ongoing Environmental containment, cleanup and remediation activities.
- Determines and oversees requirements to monitor the spill site and adjacent areas for environmental impacts
- Liaises with other managers/supervisors as required.
- Complete the Spill Report Information form on cleanup efforts including possible follow- up rehabilitation, monitoring and sampling program.
- Ensure spill response materials are replaced following the incident.

Environmental Manager or Designate

- Reports spill to EMBC, as required.
- Reviews completed Spill Reporting Information form.
- Ensures any required follow up is implemented.
- Ensures the Spill Response Plan is current

Mine Manager or Designate

- The Mine Manager may or may not have to be called in to oversee spill response efforts.
- The Mine Manager or designate will be kept abreast of all spill response efforts being carried out.
- Is responsible for all inquiries from the public and where necessary re-direct these inquiries to the proper authorities.
- In the event of a sustained emergency situation, ensures communications.

President/CEO

- Liaises with media and concerned outside parties.
- Provides written approved information releases to media, etc.
- Oversees legal and financial matters.

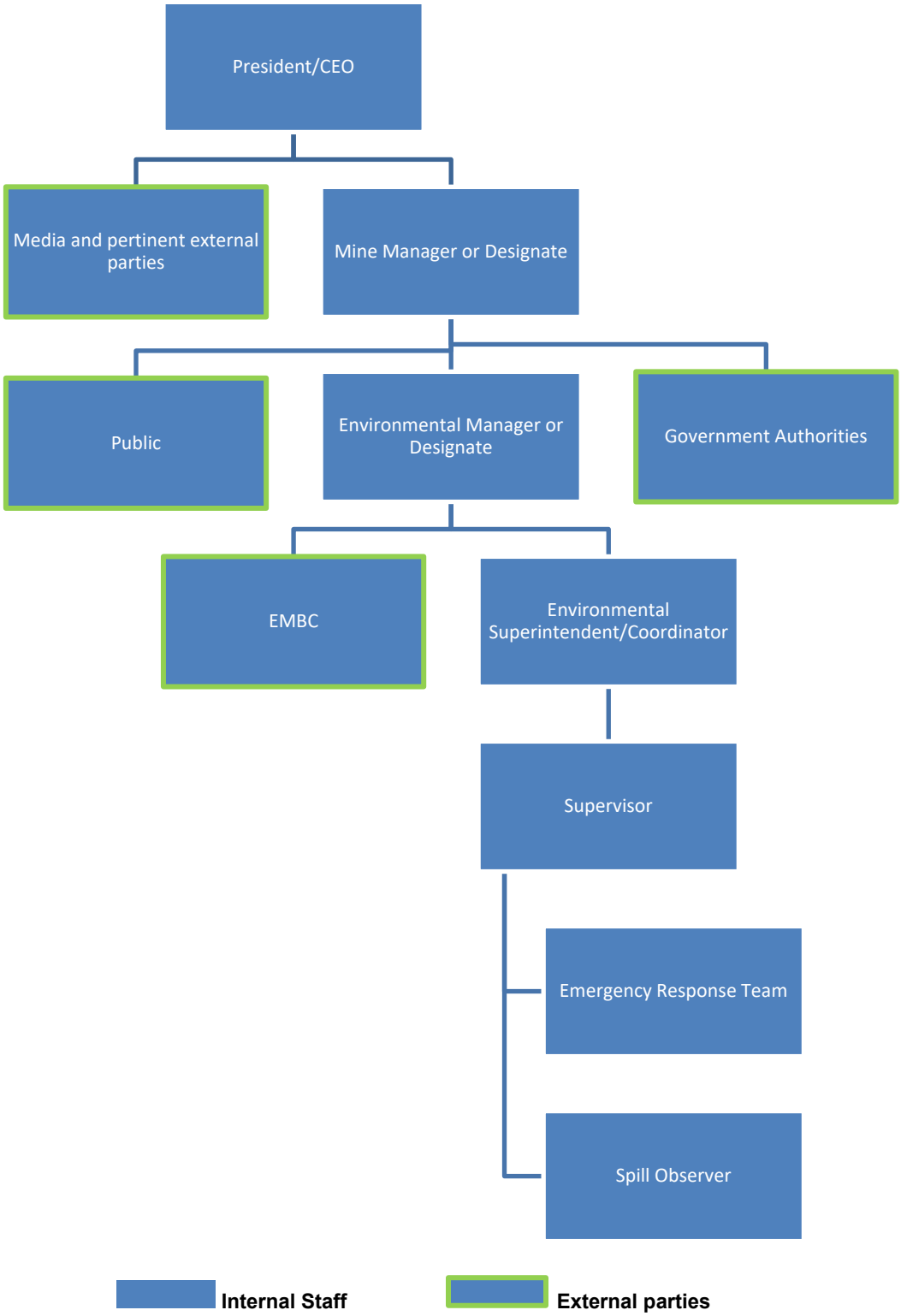

Figure 5.1-1. Pretium Senior Management Emergency Response Structure

5.2 CONTRACTORS

Several contractors operate in all areas of the Brucejack project performing a variety of tasks critical to the success of the Mine. While these contractors operate under Pretium's general direction and supervision, contractors remain as the responsible and regulated parties for any of their spills related to the Brucejack Project. Pretium Resources will assist and support in the response, cleanup and mitigation of all spills directly related to the Project.

APPENDIX A

Product Response Guides

BRUCEJACK MINE

Spill Response Plan

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PRODUCT RESPONSE GUIDES

For more detailed information on specific products, please refer to the Material Safety Data Sheets (MSDSs) provided by the supplier.

MSDSs MUST be updated every 3 YEARS or whenever a new product comes on site.

- ☐ Acetylene (UN1001)
- ☐ Actisand (Microsand)
- ☐ ANFO (Ammonium Nitrate)
- ☐ Antifreeze (Ethylene Glycol)
- ☐ Antiscalant (ChemTreat ML5105C)
- ☐ Argon (UN1006)
- ☐ Borax (Sodium Borate CAS 1303-96-4)
- ☐ ChemTreat CT788
- ☐ ChemTreat ML4428
- ☐ Diesel (UN 1202)
- ☐ Ferric Sulphate (LA14501)
- ☐ Flocculant (AN905)
- ☐ Flocculant (AN910)
- ☐ Frother (Polypropylene glycol methyl ether - VanFroth 250)
- ☐ Hydrated Lime
- ☐ Gasoline (UN 1203)
- ☐ Hydraulic Oil
- ☐ Hydrofluoric acid (UN 1790)
- ☐ Jet A-1 (UN 1863)
- ☐ Litharge (Lead Oxide UN 2291)
- ☐ Lithium Chloride

- Lube Oil
- MIBC (Methyl Isobutyl Carbinol)
- Nitric Acid (HNO_3 - UN 2031)
- PAX (POTASSIUM AMYL XANTHATE, UN3342)
- Perchloric Acid (UN1873)
- Propane (UN1075)
- Propylene Glycol
- SODIUM SULPHIDE
- Solvent (Naphtha Mineral Spirit & Petroleum Ether)
- Sulphuric Acid (H_2SO_4 UN 1830)

Terraflow (mine backfill binder)

PLEASE NOTE:

- The Emergency Response Team will be provided with Material Safety Data Sheets (MSDS) for ALL materials transported, stored and used on-site.
- MSDSs will be available in all strategic locations on-site and near to the hazardous and toxic substances storage, dispensing, and points of use.
- MSDSs will also be available in the Environmental Department office, Security/First Aid Office, Mine Manager's Office, warehouse, mill, maintenance department, First Aid Station and the Health & Safety Manager's Office.
- MSDSs will be maintained and updated as necessary by the Health & Safety Manager.

ACETYLENE (UN1001)

Physical and Chemical Properties			
Danger! Highly flammable gas that burns with explosive force.			
Storage	Various cylinders	**Flammability**	2.5% to 100%
Appearance	Colourless gas	**Flash Point**	-17.8°C
Odour	Garlic-like odour	**Freezing Point**	-82.2°C
Solubility	NA	**Boiling Point**	-75.2°C
Vapour Density	Lighter than air	**Specific Gravity**	Floats on water (0.91)

Safety Measures	
Warnings	☐ EXPLOSION is possible ☐ Vapours instantaneously form that are lighter than air. ☐ Vapours can travel to distant sources of ignition and flash back. ☐ Containers can contain acetone. ☐ Acetylene can accumulate static electricity charges. ☐ Eye contact causes irritation. ☐ Inhalation of vapours can cause dizziness, drowsiness, unconsciousness and death (from asphyxiation).
Personal Protection	☐ Wear impervious clothing, leather welding gloves, footwear, and safety goggles with side shields when appropriate to do so. ☐ Use of breathing protection such as positive pressureSCBA is recommended.
Precautions	☐ Monitor for explosive and oxygen-deficient atmosphere. ☐ Avoid contact with acids, chlorine, chlorine dioxide and hydrogen peroxide. ☐ Also avoid contact with copper. ☐ Eliminate ignition sources. ☐ Isolate spill or leak for 50 to 100 m. ☐ For large release, consider evacuation area of 800 m.

ACETYLENE (UN1001)

Response to Fires

Consider actions only if safety permits!

- ☐ Wear SCBA in confined spaces. Shut off fuel supply.
- ☐ Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- ☐ Use water fog or fine water spray to cool containers exposed to fire.
- ☐ **EXPLOSION is possible**!

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ ***Eliminate ignition sources!***
- ☐ ***Do not attempt to contain or remove spills!***
- ☐ ***Keep hands away from release point since severe frostbite can occur!***
- ☐ Knock down and disperse with water spray if safe to do so.

Storage, Transfer and Disposal

- ☐ It is not possible to collect released acetylene gas.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove and thoroughly air contaminated clothing.
- ☐ Discard saturated leather articles.
- ☐ Warm frostbite areas with warm (not hot) water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform Artificial Respiration if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ N/A.

ACTISAND (MICROSAND)

Typical Physical and Chemical Properties			
Avoid chronic exposure to Actisand dust.			
Storage	22.7 kg bags	**Flammability**	Not flammable
Appearance	(Off-) white granular solid	**Flash Point**	NA
Odour	Slight;	**Pour Point**	NA
Solubility	Insoluble	**Flammability**	Non-flammable
Viscosity	NA	**Toxicity**	TWA 0.025 mg/m^3
Vapour Density	NA	**Specific Gravity**	Greater than water

Safety Measures	
Warnings	Ensure adequate ventilation especially in confined areas. Dust contains crystalline silica that can damage lungs. Avoid chronic exposure to Actisand. Contact with eyes and skin may cause irritation. Repeated inhalation of dust may cause cancer.
Personal Protection	Wear impervious clothing, leather gloves, footwear, and goggles with side shields when appropriate to do so. Use of breathing protection such as filter respirator is recommended.
Precautions	Avoid prolonged exposure. Avoid contact with oxidizers (acids), chlorine. Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Actisand is not flammable and will not burn.
- Adjacent fires can be extinguished with CO_2, dry chemical, sand, earth, water spray or regular foam

ACTISAND (MICROSAND)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, do not flush into water.
- ☐ Block entry into waterways.
- ☐ Contain spill by diking with earth or other barrier, if necessary.
- ☐ Remove minor spills with shovels.
- ☐ Remove large spills with mechanical equipment.
- ☐ **On water**, Actisand sinks but does not mix.
- ☐ Contain spill by damming or diverting contaminated water.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials including acids.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal requirements.
- ☐ Actisand is a WHMIS regulated product. No known eco-toxic effects.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with plenty of fresh, warm water (not hot water) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to dust.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash skin thoroughly with soap and warm water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and not mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ Do NOT induce vomiting.
- ☐ If victim is conscious, give two glasses of water to rinse mouth out.

ANFO (AMMONIUM NITRATE)

Typical Physical and Chemical Properties			
Soluble, irritant, toxic non-flammable liquid			
Appearance	White pellets or granules Also colourless liquid	**Flash Point**	n/a
Odour	Slight	**Pour Point**	n/a
Solubility	completely soluble	**Flammability**	Decomposes explosively
Viscosity	n/a	**Toxicity**	n/a
Vapour Density	n/a	**Specific Gravity**	Sinks in water (1.35)

Safety Measures

Warnings

- Inhalation may cause dizziness, nausea, intestinal upset.
- Ingestion of large amounts may be harmful.
- Eye contact causes irritation, redness and tearing.
- Prolonged and repeated skin contact can cause irritation.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear, and goggles when appropriate to do so; PVC and Viton are suitable materials.

Precautions

- Prevent from contacting water.
- Dry material can decompose explosively when confined and exposed to high temperatures.
- Keep away from organic materials since these can lower decomposition temperature.

Response to Fires

Consider actions only if safety permits!

- Wear SCBA in confined areas.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (Note: Water or foam may cause frothing)
- Use water to cool containers exposed to fire.

ANFO (AMMONIUM NITRATE)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, do not flush into water.
- ☐ Block entry into waterways.
- ☐ Contain spill by diking with earth or other barrier.
- ☐ If liquid, remove minor spills with sorbent, large spills with pumps or vacuum equipment.
- ☐ Prills/granules can be shovelled or removed mechanically.
- ☐ **On water**, ammonium nitrate sinks and mixes with water; contain spill by isolating contaminated water through damming or diversion.
- ☐ Flushing with water can be tried, if spill area cannot be isolated.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- ☐ Segregate waste types.
- ☐ Place contaminated materials into marked containers.
- ☐ Consult Environmental Technician on final disposal.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash skin thoroughly with soap and water.
- ☐ Get medical attention.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ Induce vomiting immediately.
- ☐ If victim is conscious, give two glasses of water and stick finger down throat.
- ☐ Get prompt medical attention.

ANTIFREEZE (ETHYLENE GLYCOL)

Physical and Chemical Properties			
Soluble, irritant, toxic liquid			
Appearance	Clear colourless to green liquid	**Flash Point**	116°C
Odour	Slight; undetectable <25 ppm	**Pour Point**	-13°C
Solubility	Very soluble in all proportions	**Flammability**	3.2 to 15.3%
Viscosity	Not viscous (22 cSt)	**Toxicity**	TLV 50 ppm
Vapour Density	Will sink to ground levels	**Specific Gravity**	Same as water

Safety Measures

Warnings

- Vapours are heavier than air.
- Empty containers can, but are unlikely to, contain explosive vapours.
- Ingestion of very small quantities (several ml) can be lethal.
- Eye contact causes irritation.
- Skin contact can cause intoxication due to absorption.
- Inhalation of vapours can cause intoxication, headache, vomiting, and unconsciousness with convulsions.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear, and goggles when appropriate to do so; neoprene, nitrile and PVC are suitable protective materials.
- Use of breathing protection such as a cartridge respirator may be necessary but is unlikely.

Precautions

- Eliminate ignition sources.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (**Note:** Water or foam may cause frothing.)
- Use water to cool containers exposed to fire.

ANTIFREEZE (ETHYLENE GLYCOL)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, do not flush into water.
- ☐ Block entry into waterways.
- ☐ Contain spill by diking with earth or other barrier.
- ☐ Remove minor spills with Universal sorbent.
- ☐ Remove large spills with pumps or vacuum equipment.
- ☐ **On water**, ethylene glycol sinks and mixes.
- ☐ Contain spill by damming or diverting contaminated water.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash skin thoroughly with soap and water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ Induce vomiting immediately.
- ☐ If victim is conscious, give two glasses of water and stick finger down throat.

ANTISCALANT (CHEMTREAT ML5105C)

Physical and Chemical Properties			
Non-flammable liquid with low toxicity			
Storage	1000 L Totes	**Flammability**	No
Appearance	Clear liquid	**Flash Point**	None
Odour	Moderate	**Freezing Point**	-3 °C
Solubility	Soluble in water	**Boiling Point**	Not Available
Vapour Density	Not Available	**Specific Gravity**	1.17

Safety Measures

Warnings

- No significant health risks expected from normal exposure
- Do not freeze. If frozen, mechanical mixing is required

Personal Protection

- Safety glasses
- Butyl rubber or neoprene gloves. Wash or dispose of after use
- Respirator if misting occurs

Precautions

- Do not get in eyes, on skin or clothing
- Use with adequate ventilation

Response to Fires

Consider actions only if safety permits!

- Product is non-flammable
- Extinguish with media suitable for surrounding fire

ANTISCALANT (CHEMTREAT ML5105C)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Contain and recover liquid in closed container
- ☐ Flush spill area with water
- ☐ Avoid runoff to environment

Storage, Transfer and Disposal

- ☐ Store away from strong oxidizers
- ☐ Keep in closed container
- ☐ Dispose with appropriate waste facility

First Aid

Get prompt medical attention!

Eyes	☐ Rinse with water for several minutes
Skin	☐ Call poison centre if symptoms occur
Inhalation	☐ Call poison centre if symptoms occur
Ingestion	☐ Rinse mouth
	☐ Call poison centre if symptoms occur

ARGON (UN1006)

Physical and Chemical Properties			
Non- flammable gas that does not burn.			
Storage	Various cylinders	**Flammability**	Non-flammable
Appearance	Colourless gas	**Flash Point**	NA
Odour	Odourless	**Freezing Point**	-189.4°C
Solubility	NA	**Boiling Point**	-185.9°C
Vapour Density	1.38 (heavier than air)	**Specific Gravity**	Sinks in water (1.40)

Safety Measures

Warnings

- Argon is an asphyxiant. It can displace oxygen.
- Vapours instantaneously form that are heavier than air.
- Inhalation of vapours can cause dizziness, drowsiness, unconsciousness and death (from asphyxiation).
- No harm is expected from contact with eyes or skin.

Personal Protection

- Wear impervious clothing, leather welding gloves, footwear, and safety goggles with side shields when appropriate to do so.
- Use of breathing protection such as positive pressureSCBA is recommended.

Precautions

- Monitor for adequate oxygen levels.
- Argon is chemically inert. It does not react with chemicals.
- Isolate spill or leak for 50 to 100 m.

Response to Fires

Consider actions only if safety permits!

- Wear SCBA in confined spaces. Shut off fuel supply.
- Argon is not flammable
- Use water to cool containers exposed to fire.
- Rupture of cylinders can occur if these are exposed to heat.

ARGON (UN1006)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ***Do not attempt to contain or remove spills!***
- ***Keep hands away from release point since severe frostbite can occur!***
- Knock down and disperse with water spray if safe to do so.

Storage, Transfer and Disposal

- It is not possible to collect released argon gas.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- Flush with water.
- ☐ Seek medical attention if discomfort persists.
- ☐ Warm frostbite areas with warm (not hot) water.

Inhalation

- Move victim to fresh air.
- ☐ Perform Artificial Respiration if victim not breathing
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- NA

BORAX (SODIUM BORATE CAS 1303-96-4)

Typical Physical and Chemical Properties			
Non-flammable, stable solid with low water solubility			
Storage	25 kg bags	**Flammability**	Not flammable
Appearance	White granular solid	**Flash Point**	NA
Odour	Odourless	**Melting Point**	741°C
Solubility	Partially soluble	**Flammability**	Non-flammable
Viscosity	NA	**Toxicity**	TWA 0.3 mg/m^3
Vapour Density	NA	**Specific Gravity**	2.37 (sinks in water)

Safety Measures

Warnings

- Ensure adequate ventilation in confined areas.
- Contact with eyes and skin may cause irritation.
- Avoid chronic exposure to Borax.
- Repeated inhalation of dust may cause cancer.

Personal Protection

- Wear safety glasses with side shields, dust respirator, nitrile, PVC or other gloves, lab coat or equivalent clothing, regular work boots are OK for small releases.
- For large spills, full chemical suit and SCBA are recommended.

Precautions

- Avoid ingestion and prolonged exposure.
- Avoid contact with reducers, alkali, chemicals, metallic salts.
- Combines with moisture to form hydrate. Keep dry.

Response to Fires

Consider actions only if safety permits!

- Borax is not flammable and will not burn.
- Avoid confined spaces.
- Shut off fuel supply.
- Adjacent fires can be extinguished with CO_2, dry chemical, sand, earth, water spray or regular foam.

BORAX (SODIUM BORATE CAS 1303-96-4)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, do not flush into water.
- ☐ Block entry into waterways.
- ☐ Contain spill by diking with earth or other barrier, if necessary.
- ☐ Remove minor spills with shovels.
- ☐ Remove large spills with mechanical equipment.
- ☐ **On water**, Borax sinks but does not mix.
- ☐ Contain spill by damming or diverting contaminated water.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials including acids.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal requirements.
- ☐ Borax is not a WHMIS regulated product in Canada. No known eco-toxic effects.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to dust.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash skin thoroughly with soap and warm water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ Do NOT induce vomiting.
- ☐ If victim is conscious, give two glasses of water to rinse mouth out.

ChemTreatCT788

Typical Physical and Chemical Properties			
Danger! Causes severe skin burns and eye damage.			
Storage	Store at ambient temps	**Flammability**	N/D
Appearance	Liquid, colourless, clear	**Flash Point**	N/D
Odour	Odourless	**Freezing Point**	<-25°C
Solubility	Soluble	**Viscosity**	N/A
Vapour Density	N/D	**Specific Gravity**	1.424 @ 20°C

Safety Measures

Warnings

- Causes severe skin burns and eye damage.
- Causes serious eye damage.
- Harmful in contact with skin.
- Harmful if inhaled.
- Harmful if swallowed.
- Harmful to aquatic life.

Personal Protection

- Wear chemical splash goggles or safety glasses with full−face shield. Maintain eyewash fountain in work area.
- Maintain quick−drench facilities in work area. Wear butyl rubber or neoprene gloves. Wash them after each use and replace as necessary. If conditions warrant, wear protective clothing such as boots, aprons, and coveralls to prevent skin contact.
- If misting occurs, use NIOSH approved organic vapor/acid gas dual cartridge respirator with a dust/mist prefilter in accordance with 29 CFR 1910.134.

Precautions

- Wear protective gloves/clothing and eye/face protection.
- Do not breathe dust/fume/gas/mist/vapors/spray.
- Do not eat, drink or smoke when using this product.
- Wash hands thoroughly after handling.
- Use only outdoors or in a well−ventilated area.
- Avoid release into the environment.

Response to Fires

- Not flammable.
- Use extinguishing media suitable to surrounding fire.
- Use water spray to keep containers cool.

- If product is involved in a fire, wear full protective clothing including a positive- pressure, NIOSH approved, self-contained breathing apparatus.

Response to Spills

- Use appriate PPE
- Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.
- Contain and recover liquid when possible.
- Flush spill area with water spray.

First Aid

- Inhalation: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Immediately call a poison center or doctor/physician.
- Eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Immediately call a poison center or doctor/physician. Skin: Immediately remove/take off all contaminated clothing. Rinse skin with water/shower. Wash contaminated clothing before re−use. Immediately call a poison center or doctor/physician.
- Ingestion: DO NOT INDUCE VOMITING. Rinse mouth. Call a POISON CENTER or doctor/physician.

DIESEL (UN 1202)

Typical Physical and Chemical Properties			
Danger! Combustible liquid.			
Storage	Various tanks	**Flammability**	Combustible liquid
Appearance	Clear, pale yellow or red	**Flash Point**	38 to 55°C
Odour	Petroleum	**Freezing Point**	-50 to -6°C
Solubility	Insoluble	**Viscosity**	Not viscous
Vapour Density	Will sink to ground levels	**Specific Gravity**	Floats on water

Safety Measures

Warnings

- Vapours heavier than air form at high temperatures and may persist in depressions.
- Empty containers can contain explosive vapours.
- Toxic gases form upon combustion.
- Eye contact causes irritation.
- Diesel can accumulate static electricity charges.

Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.

Personal Protection

If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

Eliminate ignition sources.

- Electrically ground and bond containers when transferring diesel.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- Use water to cool containers exposed to fire.

DIESEL (UN 1202)

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into ditches or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.
- **On water**, use booms to contain and concentrate spill.
- Remove spill using sorbent, skimmer or vacuum truck.
- Protection booming can be considered for water intakes/marinas.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Electrically ground/bond containers and vehicles during transfer.
- Segregate waste types.
- Place contaminated materials into marked containers.
- Consult Environment Technician on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin

- Remove and launder contaminated clothing.
- Discard saturated leather articles.
- Wash skin thoroughly with soap and water.

Inhalation

- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion

- **Do not** induce vomiting.
- If victim is conscious, give milk or water to drink.
- If victim vomits, keep head below hips to prevent aspiration.

FERRIC SULPHATE(LA14501)

Typical Physical and Chemical Properties			
Danger! Creates acidic solutions; Harmful to skin, eyes, and respiratory system			
Storage	800 kg Bulk bag	**Flammability**	Low
Appearance	Light yellow powder	**Flash Point**	None
Odour	Slight	**Freezing Point**	Not available
Solubility	Soluble in water	**Viscosity**	Not available
pH	2-3 (1% solution)	**Specific Gravity**	3.097

Safety Measures

Warnings

- Irritating to skin and eyes; dust is irritating to mucous membranes
- Harmful if swallowed due to iron poisoning
- Creates acidic solution of 2-3 pH at low concentrations
- Reacts with strong bases, carbonates, and oxidizing materials
- Loses water in dry air and oxidizes on exposure to moisture, forming coating of extremely corrosive basic ferric sulphate

Personal Protection

- Chemical resistant gloves (nitrile or PVC)
- Suitable skin protection depending on exposure potential
- Safety goggles

Precautions

- Use process enclosure or exhaust ventilation to keep airborne levels low
- Ensure eyewash stations and safety showers are nearby

Response to Fires

Consider actions only if safety permits!

- Ferric Sulphate is not flammable
- Contact with sulphuric acid can produce heat and flammable hydrogen gas
- Extinguish with media suitable for surrounding fire

FERRIC SULPHATE(LA14501)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Ventilate spill area
- ☐ Isolate hazard area and put solids in appropriate sealed container

Storage, Transfer and Disposal

- ☐ Empty containers can contain hazardous residues
- ☐ Keep in sealed container and dispose with an approved waste management facility

First Aid

Get prompt medical attention!

Eyes
- ☐ Immediately flush eyes with large amount of water for at least 20 minutes
- ☐ Hold eyelids apart to flush entire surface

Skin
- ☐ Flush skin with large amount of water
- ☐ Seek medical attention if irritation persists
- ☐ Launder contaminated clothing

Inhalation
- ☐ Move to fresh air
- ☐ If not breathing, give artificial respiration
- ☐ Give oxygen if breathing is difficult

Ingestion
- ☐ Do not induce vomiting unless directed by a medical professional

FLOCCULANT (AN905)

Typical Physical and Chemical Properties			
Stable powder with low toxicity			
Storage	Plastic pails	**Flammability**	Low
Appearance	White Granular Solid	**Flash Point**	Not applicable
Odour	None	**Freezing Point**	Not applicable
Solubility	Completely in water	**Specific Gravity**	0.6-0.9 (dry powder)

Safety Measures

Warnings

- Makes surfaces extremely slippery when wet

Personal Protection

- Respirator not expected to be required unless airborne concentration exceeds 10 mg/m^3
- Nitrile or PVC gloves
- Safety glasses with side shields

Precautions

- Avoid contact with skin and eyes
- Avoid dust formation; do not breathe dust

Response to Fires

Consider actions only if safety permits!

- Extinguish fire with CO_2, dry chemical, or water
- Thermal decomposition may produce NOx and COx
- Wear self-contained breathing apparatus if these compounds are produced

FLOCCULANT (AN905)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Do not remove with water as it will create a slippery, gel-like compound
- ☐ Clean up dry powder with sweeping or vacuum
- ☐ Afterwards, flush traces with water
- ☐ If wet, remove with vacuum

Storage, Transfer and Disposal

- ☐ Keep in suitable and closed containers for disposal
- ☐ Can be landfilled or incinerated

First Aid

Get prompt medical attention!

Eyes
- ☐ Rinse thoroughly with plenty of water, including under the eyelids
- ☐ Get medical attention

Skin
- ☐ Wash with water and soap as a precaution
- ☐ Irritation not likely, but get medical attention if it persists

Inhalation
- ☐ Move to fresh air

Ingestion
- ☐ Rinse mouth with water
- ☐ Do not induce vomiting
- ☐ Get medical attention if symptoms occur

FLOCCULANT (AN910)

Typical Physical and Chemical Properties			
Stable powder with low toxicity			
Storage	Plastic pails	**Flammability**	Low
Appearance	White Granular Solid	**Flash Point**	Not applicable
Odour	None	**Freezing Point**	Not applicable
Solubility	Completely in water	**Specific Gravity**	0.6-0.9 (dry powder)

Safety Measures

Warnings

- Makes surfaces extremely slippery when wet

Personal Protection

- Wear respirator if dust is generated
- Nitrile or PVC gloves
- Safety glasses with side shields

Precautions

- Avoid contact with skin and eyes
- Avoid dust formation; do not breathe dust

Response to Fires

Consider actions only if safety permits!

- Extinguish fire with CO_2, dry chemical, or water
- Thermal decomposition may produce NOx and COx
- Wear self-contained breathing apparatus if these compounds are produced

FLOCCULANT (AN910)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Do not remove with water as it will create a slippery, gel-like compound
- ☐ Clean up dry powder with sweeping or vacuum
- ☐ Afterwards, flush traces with water
- ☐ If wet, remove with vacuum

Storage, Transfer and Disposal

- ☐ Keep in suitable and closed containers for disposal
- ☐ Can be landfilled or incinerated

First Aid

Get prompt medical attention!

Eyes
- ☐ Rinse thoroughly with plenty of water, including under the eyelids
- ☐ Get medical attention

Skin
- ☐ Wash with water and soap as a precaution
- ☐ Irritation not likely, but get medical attention if it persists

Inhalation
- ☐ Move to fresh air

Ingestion
- ☐ Rinse mouth with water
- ☐ Do not induce vomiting
- ☐ Get medical attention if symptoms occur

LITHIUM CHLORIDE

Typical Physical and Chemical Properties			
Laboratory chemical			
Storage	Keep in a dry, cool and well-ventilated place. Keep container tightly closed. Keep away from direct sunlight. Store under an inert atmosphere.	**Flammability**	No information available
Appearance	White solid	**Flash Point**	No information available
Odour	None	**Freezing Point**	No information provided
Solubility	No information available	**Specific Gravity**	2.060

Safety Measures	
Warnings	☐ Harmful if swallowed ☐ Causes serious eye irritation
Personal Protection	☐ Wear appropriate protective eyeglasses or chemical safety goggles ☐ Wear appropriate protective gloves and clothing to prevent skin exposure ☐ Wear a respirator if exposure limits exceeded or if irritation or other symptoms are experienced

Precautions

- Wash face, hands and any exposed skin thoroughly after handling
- Do not eat, drink or smoke when using this product
- Wear protective gloves/protective clothing/eye protection/face protection
- Do not breathe dust/fume/gas/mist/vapors/spray
- Use only outdoors or in a well-ventilated area

Response to Fires

Consider actions only if safety permits!

- Extinguish fire with water spray, carbon dioxide, dry chemical, chemical foam
- Thermal decomposition can lead to release of irritating gases and vapors
- Hazardous combustion products include hydrogen chloride gas and chlorine
  - Wear self-contained breathing apparatus if these compounds are produced

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Sweep up or vacuum up spillage and collect in suitable container for disposal
- ☐ Avoid dust formation

Storage, Transfer and Disposal

- ☐ Keep in a dry, cool and well-ventilated place.
- ☐ Keep container tightly closed.
- ☐ Keep away from direct sunlight.
- ☐ Store under an inert atmosphere.

First Aid

Get prompt medical attention!

Eyes ☐ Rinse thoroughly with plenty of water, also under the eyelids, for at least 15 minutes
☐ Get medical attention

Skin ☐ Wash off immediately with plenty of water for at least 15 minutes.

Inhalation ☐ Move to fresh air. If breathing is difficult, give oxygen. Get medical attention immediately if symptoms occur.

Ingestion ☐ Do not induce vomiting. Call a physician or Poison Control Center immediately

POLYPROPYLENE GLYCOL METHYL ETHER (VANFROTH 250)

Typical Physical and Chemical Properties			
Danger! Irritant to skin, eyes, and respiratory system.			
Storage	Large Tote	**Flammability**	Low
Appearance	Light Amber Liquid	**Flash Point**	>93C
Odour	Odourless	**Freezing Point**	Very Low
Solubility	Soluble in Water	**Viscosity**	Not Available
Vapour Density	Not Available	**Specific Gravity**	1.00

Safety Measures

Warnings

- Can cause respiratory irritation
- Can cause irritations of mucous membranes and eyes
- Chronic exposure may cause dizziness, nausea, and death

Personal Protection

- Use chemical safety goggles
- Wear impervious clothing, including gloves, to prevent skin contact
- Use respirator if fumes are generated

Precautions

- Ensure ventilation is adequate
- Avoid contact with skin and eyes

Response to Fires

Consider actions only if safety permits!

- May form explosive mixture with air
- Extinguish with water spray or dry chemical media

FROTHER (VANFROTH 250)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Absorb with inert dry material
- ☐ Put into metal salvage drum for disposal

Storage, Transfer and Disposal

- ☐ Keep in tightly closed container
- ☐ Store in cool, dry, well-ventilated area

First Aid

Get prompt medical attention!

Eyes	☐ Immediately flush eyes with water for 15 minutes
Skin	☐ Remove contaminated clothing
	☐ Wash skin with soap and water for 20 minutes
Inhalation	☐ Move to fresh air
	☐ Apply artificial respiration or oxygen if necessary
Ingestion	☐ Do not induce vomiting

HYDRATED LIME

Typical Physical and Chemical Properties			
Danger! Burns skin and eyes. Stable powder which makes highly basic solution			
Storage	Bulk Bags	**Flammability**	Non-Flammable
Appearance	Solid White Powder	**Flash Point**	Not Applicable
Odour	Odourless	**Freezing Point**	Not Applicable
Solubility	1.6 g/L in Water	**Viscosity**	Not Applicable
pH	12.44	**Specific Gravity**	0.4-0.7

Safety Measures

Warnings

- Strongly basic. Reacts violently and with high heat when mixed with acid

Personal Protection

- Use safety glasses or goggles. Do not wear contact lenses
- Use nitrile or PVC gloves to prevent skin contact
- Wear respirator if airborne dust is generated

Precautions

- Ensure eyewash stations and safety showers are nearby
- Avoid contact with skin and eyes
- Ensure ventilation is adequate to prevent dust generation

Response to Fires

Consider actions only if safety permits!

- Hydrated lime is not flammable, and is not considered an explosive hazard
- Extinguish with dry chemical media
- Do not use halogenated compounds to extinguish

HYDRATED LIME

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Use dry methods to collect spilled powder
- ☐ Avoid generating dust
- ☐ Collect in closed plastic or metal containers
- ☐ Wash residue with water or dilute vinegar

Storage, Transfer and Disposal

- ☐ Keep in closed containers
- ☐ Keep away from moisture and acidic compounds
- ☐ Not considered a hazardous waste in dry form

First Aid

Get prompt medical attention!

Eyes

- ☐ Causes severe irritation and permanent damage
- ☐ Flush eyes immediately with diphoterine (if available) and generous amounts of water for several minutes
- ☐ Pull back eyelid to wash out lime dust; do not rub eyes

Skin

- ☐ Can cause severe burning of skin
- ☐ Wash exposed area with diphoterine (if available) and generous amounts of water for several minutes

Inhalation

- ☐ Can cause severe irritation
- ☐ Move to fresh air
- ☐ Give artificial respiration if breathing stops

Ingestion

- ☐ Causes severe burning of gastrointestinal tract
- ☐ Do not induce vomiting

GASOLINE (UN 1203)

Typical Physical and Chemical Properties			
Danger! Highly flammable liquid – explosive vapours can form!			
Storage	Various tanks	**Flammability**	Flammable liquid
Appearance	Colourless liquid (can be dyed)	**Flash Point**	-40 to -50°C
Odour	Gasoline/petroleum	**Freezing Point**	-60°C
Solubility	Insoluble	**Viscosity**	Not viscous
Vapour Density	Will sink to ground levels	**Specific Gravity**	Floats on water

Safety Measures

Warnings

- Vapours instantaneously form that are heavier than air.
- Empty containers can contain explosive vapours.
- Vapours can travel to distant sources of ignition and flash back.
- Eye contact causes irritation.
- Gasoline can accumulate static electricity charges.
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable materials (**do not** use natural rubber, neoprene or PVC).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Monitor for explosive atmosphere.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Eliminate ignition sources.
- Electrically ground and bond containers when transferring fuel.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- Use water to cool containers exposed to fire.

GASOLINE (UN 1203)

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, block entry into waterways.
- ☐ Do not flush into ditches or drainage system.
- ☐ Contain spill by diking with earth or other barrier.
- ☐ Remove minor spills with sorbent.
- ☐ **On water**, do not attempt to contain or remove spills.
- ☐ Disperse with water spray.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, well-ventilated areas away from acids, fuels and solvents.
- ☐ Electrically ground containers and vehicles during transfer.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (not hot water) for 20 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove and launder contaminated clothing.
- ☐ Discard saturated leather articles.
- ☐ Wash skin thoroughly with soap and water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ **Do not** induce vomiting.
- ☐ If victim is conscious, give milk or water to drink.
- ☐ If victim vomits, keep head below hips to prevent aspiration.
- ☐ If victim vomits, keep head below hips to prevent aspiration

HYDRAULIC OIL

Typical Physical and Chemical Properties			
Combustible liquid that can generate toxic fumes in fire.			
Storage	20 L pails, 200 L drums	**Flammability**	Combustible liquid
Appearance	Straw-yellow liquid	**Flash Point**	215°C
Odour	Petroleum	**Pour Point**	-25°C
Solubility	Generally insoluble	**Viscosity**	Medium (265 cSt @ 15°C)
Vapour Density	Few vapours emitted	**Specific Gravity**	Floats on water (0.88)

Safety Measures	
Warnings	Vapours are heavier than air and may persist in depressions. Toxic gas can form in fire and at high temperatures. CO, CO_2 and dense smoke are produced upon combustion. Material can accumulate static charges. Oil mist or vapour from hot oil can cause irritation of the eyes, nose, throat and lungs.
Personal Protection	Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile, neoprene and Viton are suitable materials (**do not** use natural rubber or PVC). If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.
Precautions	Avoid excessive heat, which can cause formation of vapours. Avoid contact with acids, chlorine, ozone and peroxides. Eliminate ignition sources. Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Wear eye protection when responding to hydraulic oil fires.
- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (**Note:** Water or foam may cause frothing.)
- Use water to cool containers exposed to fire.

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into ditches or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.
- **On water**, use boom or other barrier to contain and concentrate spill.
- Remove spill using sorbent, pump or vacuum system.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Electrically ground containers and vehicles during transfer.
- Segregate waste types.
- Place contaminated materials into marked containers.
- Consult Environment Technician on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- Remove and launder contaminated clothing.
- ☐ Discard saturated leather articles.
- ☐ Wash skin thoroughly with soap and water.

Inhalation

- Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- **Do not** induce vomiting.
- ☐ If victim is conscious, give milk or water to drink.

Hydrofluoric acid

Physical and Chemical Properties			
Toxic liquid, corrosive			
Appearance	Colourless liquid	**Flash Point**	No data available
Odour	No data available	**Pour Point**	No data available
Solubility	No data available	**Flammability**	No data available
Viscosity	No data available	**Toxicity**	No data available
Relative Density	1.16 g/cm³ (20 °C)	**Specific Gravity**	No data available

5.3 Safety Measures

Warnings

- Fatal if in contact with skin, if swallowed, or if inhaled.
- Causes severe skin burns and eye damage.

Personal Protection

- Protective gloves, protective clothing, eye protection and face protection are required.
- Respiratory protection required if insufficient ventilation.

Precautions

- Rinse mouth if swallowed, do not induce vomiting.
- Rinse skin with plenty of water if in contact with skin.
- Move to fresh air if inhaled.
- Contact Poison Center or a doctor if exposed.
- Store with container tightly closed in a well-ventilated location.

5.4 Response to Fires

CONSIDER ACTIONS ONLY IF SAFETY PERMITS!

- The product itself does not burn, therefore respond to fires according to measures required by surroundings.
- Hydrogen fluoride may be liberated because of fire.
- Once the fire reaches explosives, do not fight the fire.
- Firefighters must wear appropriate personal protection including a self-contained breathing apparatus and chemical protective clothing.
- In case of fire, evacuate the area and do not inhale the combusted gases.
- Do not allow run-off from firefighting to enter drains or water courses.

5.5 Response to Spills

CONSIDER ACTIONS ONLY IF SAFETY PERMITS!

Accidental Release

- Ensure that there is adequate ventilation and do not breathe gas/vapor/spray.
- Use personal protective equipment and clear the spill immediately.
- Do not allow the spill to enter into drains or water and avoid discharge to the environment.
- Do not return the spilled material to the original container. Collect into a suitable closed container for disposal.

Safe Handling and Storage

- Store in a tightly closed contained in a well-ventilated area with a temperature of 15-25°C.
- Use an extractor hood when using in a laboratory.
- Adequate ventilation (exhaust ventilation) is required when uncovering the product.
- Protect from moisture.

5.6 First Aid

First aiders must ensure that they are adequately protected with the required personal protective equipment. Symptoms may develop several hours after exposure. Contact the Poison Center or a doctor immediately upon exposure.

Eyes

- Flush eyes with water immediately for 10-15 minutes.
- Remove contact lenses if present and continue rinsing.

Skin

- Immediate medical treatment required.
- Rinse with water thoroughly and remove all contaminated clothing.
- Wash off wit calcium gluconate solution.

Inhalation

- Move to fresh air immediately and rest.
- If breathing stops, do not perform mouth-to-mouth, administer artificial respiration (Ambu bag or ventilator).

Ingestion

Rinse mouth thoroughly with water followed by washing with calcium gluconate solution.

Jet A-1 (UN 1863)

Typical Physical/Chemical Properties			
Danger! Flammable liquid – explosive vapours can form!			
Storage	Various tanks	**Flammability**	Flammable liquid
Appearance	Clear, pale yellow or red	**Flash Point**	38°C
Odour	Petroleum	**Freezing Point**	-40°C
Solubility	Insoluble	**Viscosity**	Not viscous
Vapour Density	Will sink to ground levels	**Specific Gravity**	Floats on water

Safety Measures	
Warnings	Vapours heavier than air form at high temperatures and may persist in depressions. • Empty containers can contain explosive vapours. • Toxic gases form upon combustion. • Eye contact causes irritation. • Jet A-1 can accumulate static electricity charges when stored and transferred. • Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.
Personal Protection	Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable protective materials (**do not** use natural rubber, neoprene or PVC for prolonged periods). If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.
Precautions	Eliminate ignition sources. Electrically ground and bond containers when transferring Jet A. Avoid contact with acids, chlorine, ozone and peroxides. Restrict access and work upwind of spill.

Response to Fires
Consider actions only if safety permits!
Avoid confined spaces. Shut off fuel supply. Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. Use water to cool containers exposed to fire.

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, block entry into waterways.
- ☐ Do not flush into ditches or drainage system.
- ☐ Contain spill by diking with earth or other barrier.
- ☐ Remove minor spills with sorbent.
- ☐ **On water**, use boom or other barrier to contain and concentrate spill.
- ☐ Remove spill using sorbent, pump or vacuum system.

NOTE: Jet A evaporates at various rates depending on the spill and weather conditions. Do not assume complete evaporation will occur.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- ☐ Electrically ground/bond containers and vehicles during transfer.
- ☐ Segregate waste types.
- ☐ Place contaminated materials into marked containers.
- ☐ Consult Environment Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove and launder contaminated clothing.
- ☐ Discard saturated leather articles.
- ☐ Wash skin thoroughly with soap and water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ **Do not** induce vomiting.
- ☐ If victim is conscious, give milk or water to drink.
- ☐ If victim vomits, keep head below hips to prevent aspiration.

LITHARGE (LEAD OXIDE UN 2291)

Typical Physical and Chemical Properties			
Danger! Highly toxic, non-flammable solid that reacts with many chemicals.			
Storage	25 kg bags	**pH**	NA
Appearance	Orange powder/crystal	**Flash Point**	NA
Odour	Odourless	**Freezing Point**	886°C
Solubility	Insoluble	**Flammability**	Non-flammable
Viscosity	NA	**Toxicity (lead)**	TWA 0.05 mg/m^3
Vapour Density	NA	**Specific Gravity**	Sinks in water (9.4-10)

Safety Measures

Warnings

- Litharge can be fatal by ingestion, inhalation and skin adsorption.
- Contact with eyes and skin may cause irritation.
- Ingestion may cause lead poisoning: fatigue, abdominal pain, nausea, dizziness, joint pain, paralysis, convulsions, coma, and death.
- Damage may be caused to unborn fetus.
- ***Avoid repeated or prolonged exposure to Litharge!***

Personal Protection

- Wear impervious clothing, nitrile gloves, footwear, and goggles with side shields, SCBA and Level A suit when appropriate to do so.
- Use of skin and breathing protection is recommended.

Precautions

- Avoid contact with all sources of ignition, high temperatures.
- Avoid acids, chlorinated rubber, metals, hydrogen peroxide, ammonium nitrate ***Reaction with chemicals can be violent!***
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Litharge is not flammable and will not burn.
- Degradation products in a fire are toxic fumes of lead and lead oxide.
- Avoid confined spaces. Wear SCBA with full facepiece.
- Shut off fuel supply.
- Use water spray or fog to fully cool containers.

LITHARGE (LEAD OXIDE UN 2291)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, do not flush into water.
- ☐ Block entry into waterways.
- ☐ Contain spill by diking with earth or other barrier, if necessary.
- ☐ Remove minor spills with shovels.
- ☐ Remove large spills with mechanical equipment.
- ☐ **On water**, Litharge quickly sinks and does not mix.
- ☐ Contain spill by damming or diverting contaminated water.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from heat and incompatible materials including acids, hydrogen peroxide and metals.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal needs.
- ☐ Litharge is a TDG regulated product. Eco-toxic effects are possible.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to dust.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash skin thoroughly with soap and warm water for 15 minutes.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method or CPR and not mouth-to-mouth method if victim inhaled or ingested Litharge).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ Do NOT induce vomiting.
- ☐ If victim is conscious, give two glasses of water to rinse mouth out.
- ☐ Seek immediate medical attention.

LUBE OIL

Typical Physical and Chemical Properties			
Combustible liquid that can generate toxic fumes in fire.			
Storage	2o L pails, totes	**Flammability**	Combustible liquid
Appearance	Amber liquid	**Flash Point**	190 to 220°C
Odour	Petroleum	**Pour Point**	-37°C
Solubility	Generally insoluble	**Viscosity**	Medium (255 cSt @ 15°C)
Vapour Density	Few vapours emitted	**Specific Gravity**	Floats on water (0.89)

Safety Measures

Warnings

- Toxic gas can form in fire and at high temperatures.
- CO, CO_2 and dense smoke are produced upon combustion.
- Material can accumulate static charges.
- Hot oil vapours can irritate the eyes, nose, throat and lungs.

Personal Protection

- Wear chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable materials (**do not** use natural rubber, neoprene or PVC).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Avoid excessive heat, which can cause formation of vapours.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Eliminate ignition sources.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Wear eye protection when responding to lube oil fires.
- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (**Note:** Water or foam may cause frothing.)
- Use water to cool containers exposed to fire.

LUBE OIL

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, block entry into waterways.
- ☐ Do not flush into sewer or drainage system.
- ☐ Contain spill by diking with earth or other barrier.
- ☐ Remove minor spills with sorbent.
- ☐ **On water**, use boom or other barrier to contain and concentrate spill.
- ☐ Remove spill using sorbents pump or vacuum system.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- ☐ Electrically ground/bond containers and vehicles during transfer.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove and launder contaminated clothing.
- ☐ Discard saturated leather articles.
- ☐ Wash skin thoroughly with soap and water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ **Do not** induce vomiting.
- ☐ If victim is conscious, give milk or water to drink.
- ☐ If victim vomits, keep head below hips to prevent aspiration.

MIBC (METHYL ISOBUTYL CARBINOL)

Physical and Chemical Properties			
Toxic liquid that can react with acids.			
Storage	Tanks	**pH**	Not applicable
Appearance	Colourless liquid	**Flash Point**	41°C
Odour	Faint odour	**Boiling Point**	Decomposes
Solubility	Slightly soluble	**Exposure Limits**	Not available
Vapour Density	Not applicable	**Specific Gravity**	Floats on water (0.80)

Health and Safety

Warnings

- Inhalation may cause slight irritation of nose and throat.
- Prolonged skin contact may cause irritation and dermatitis.
- Eye contact may cause irritation.
- Avoid ingestion; MIBC is toxic.
- Static electricity discharge can occur when MIBC is transferred.

Personal Protection

- Wear goggles, gloves, boots.
- Wear SCBA where ventilation is not adequate.
- Plastic or rubber gloves are recommended.
- Ventilate at rate of ten changes/hr.

Precautions

- Avoid contact with strong oxidizing agents and acids.
- Ground and bond when transferring MIBC.

Response to Fires

Consider action only if safe!

- Wear SCBA.
- Products of combustion are CO_X, N_XO_X.
- Use dry chemical, foam, CO_2 to extinguish small fires.
- Use water to extinguish large fires.

MIBC (METHYL ISOBUTYL CARBINOL)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, prevent entry into water.
- ☐ Ventilate area.
- ☐ Wear PPE.
- ☐ Collect material into a waste container - avoid raising dust.
- ☐ Wash spill site after material pickup.
- ☐ Caution: water solutions are very slippery and may constitute a hazard.
- ☐ **On water**, MIBC partially mixes with water.
- ☐ Contain spill by damming or diverting contaminated water.

Storage, Transfer and Disposal

- ☐ Store in a cool, dry location away from fuels, acids.
- ☐ Consult Environmental Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for **15** minutes.
- ☐ Remove contact lenses if exposed to dust or liquid.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash exposed area with soap and water.

Inhalation

- ☐ Move victim to fresh air and keep warm and at rest.
- ☐ Perform AR if victim not breathing.
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ If victim is conscious, wash out mouth with water and dilute with two glasses of water.
- ☐ **Do not** induce vomiting.
- ☐ If victim vomits, keep head below hips to prevent aspiration.

NITRIC ACID (HNO_3 - UN 2031)

Physical and Chemical Properties			
Danger! Highly corrosive, toxic liquid that reacts with many chemical and metals.			
Storage	Glass vessels	**pH**	1 (68-70%)
Appearance	Colourless to slight brown	**Flash Point**	Not flammable
Odour	Acrid suffocating odour	**Boiling Point**	122°C
Solubility	Soluble in water.	**Freezing Point**	-42°C
Vapour Density	Heavier than air (2.5)	**Specific Gravity**	Sinks in water (1.42)

Health and Safety

Warnings

- **Highly corrosive** to all body tissues: skin, eyes, mucous membranes.
- Direct skin contact may cause deep painful burns, shock and collapse.
- **Highly toxic** and may be fatal if ingested.
- Inhalation may cause breathing difficulties, irritation and (@ 25 ppm) death.

Personal Protection

- Wear face shields, splash-proof safety goggles, rubber boots, heavy rubber gloves, rubber aprons/suits.
- Wear respirator with acid cartridge for pools, SCBA for mist, as required.
- Rubber, neoprene are recommended.

Precautions

- Avoid contact with water, most metals and oxidizers.
- Avoid alcohols, organic solvents, carbides, sulfides.
- Can generate explosive hydrogen gas in contact with metals.
- **Do not add water to concentrated acid**; heat, splattering occurs.

Response to Fires

Consider action only if safe!

- Generates NO_X in fire.
- Use dry chemical or CO_2 to extinguish small fires.
- Not flammable. Use appropriate media for adjacent larger fires.
- Water added to concentrated acid results in heat, violent spattering.

NITRIC ACID (HNO_3 - UN 2031)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

On Land

- ☐ Remove ignition sources. Ventilate area.
- ☐ **Inside buildings**: neutralize with soda ash or lime.
- ☐ Do not flush into ditches and drains.
- ☐ Call for help if significant quantity is spilled or people are affected.
- ☐ **Outside buildings**: contain spill by diking with sand or earth.
- ☐ Use only chemical-rated pump.
- ☐ Neutralize and remove minor spills with Universal sorbent.
- ☐ Rinse residuals with water and mild alkali.

On Water

- ☐ Will sink and mix completely with water.
- ☐ Contain spill: isolate contaminated water by damming or diversion.

Storage, Transfer and Disposal

- ☐ Store closed, sealed, labelled containers in cool, well-ventilated areas.
- ☐ Keep away from incompatible materials such as water, metals and fuels.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environmental Technician on transportation and disposal.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for at least 15 minutes.
- ☐ Remove contact lenses if exposed to vapours or liquid.

Skin

- ☐ Remove contaminated clothing.
- ☐ Flush with water for at least 15 minutes.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing. Do not use mouth-to mouth.
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ Administer large quantities of water, if victim is conscious.
- ☐ **Do not** induce vomiting.
- ☐ If victim vomits, keep head below hips to prevent aspiration.

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5.6.1.1 PAX (POTASSIUM AMYL XANTHATE, UN3342)

Physical and Chemical Properties			
Danger! Creates explosive vapours. Highly toxic.			
Storage		**Flammability**	Vapours/dusts may explode
Appearance	Solid Yellow	**Flash Point**	None
Odour	Not Available	**Freezing Point**	Not Available
Solubility	Soluble in Water	**Boiling Point**	Not Available
Vapour Density	Not Available	**Specific Gravity**	Not Available

Safety Measures	
Warnings	☐ Vapours or dusts may explode ☐ Solid PAX is stable when cool and dry, but decomposes slowly at room temperature
Personal Protection	☐ Impervious rubber or neoprene gloves ☐ Suitable impermeable clothing and footwear ☐ Chemical goggles ☐ Face shield if splashing could occur ☐ Respirator if exposure exceeds limits
Precautions	☐ Ensure eyewash and shower stations are close to the work area ☐ Avoid exposure to heat, acids, and oxidizing agents

Response to Fires

Consider actions only if safety permits!

- ☐ Product decomposes to flammable carbon disulphide, with flash point of -30C
- ☐ Extinguish with water, CO2, or dry chemical
- ☐ Firefighters should wear full protective clothing and SCBA
- ☐ In fire, produces potassium, sulphur, and carbon oxides

5.6.1.2 *PAX (POTASSIUM AMYL XANTHATE, UN3342)*

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ Prevent release to environment
- ☐ Pick up solids and put in sealed container
- ☐ Do not touch or walk through spilled material
- ☐ Flush small spills with water
- ☐ Collect large spills for disposal

Storage, Transfer and Disposal

- ☐ Keep containers grounded, well ventilated, and away from heat and flame
- ☐ Store under cool, dark, dry conditions
- ☐ Empty containers may contain hazardous residues
- ☐ Dispose with approved waste management facility

First Aid

Get prompt medical attention!

Eyes
- ☐ Immediately flush with water for at least 15 minutes

Skin
- ☐ Immediately flush with water for at least 15 minutes
- ☐ Remove contaminated clothing and launder before reuse

Inhalation
- ☐ Move to fresh air
- ☐ If not breathing, give artificial respiration

Ingestion
- ☐ Do NOT induce vomiting
- ☐ If vomiting occurs, keep head below hips to prevent aspiration of liquid into lungs

Perchloric acid

Physical and Chemical Properties			
Oxidizing liquid, Corrosive, Toxic liquid, Irritant			
Appearance	Colourless liquid	**Flash Point**	No data available
Odour	Odourless	**Pour Point**	No data available
Solubility	No data available	**Flammability**	No data available
Viscosity	No data available	**Toxicity**	No data available
Relative Density	1.67 g/cm³ (20 °C)	**Specific Gravity**	No data available

5.7 Safety Measures

Warnings

- Oxidizing liquid; may cause fires or explosions.
- Corrosive to metals.
- Toxic; harmful if swallowed; may damage organs.
- Corrosive; can cause skin burns and eye damage.

Personal Protection

- Protective gloves, protective clothing, eye protection and face protection are required.

Precautions

- Rinse mouth if swallowed, do not induce vomiting.
- Rinse skin with plenty of water if in contact with skin.
- Move to fresh air if inhaled.
- Contact Poison Center or a doctor if exposed.
- Store away from heat, hot surfaces, sparks, flames, other ignition sources, and combustible materials.
- In case of fire or major accidental release, evacuate immediately.

5.8 Response to Fires

CONSIDER ACTIONS ONLY IF SAFETY PERMITS!

- The product does not burn, but may intensify fire since it is an oxidizer.
- Once the fire reaches explosives, do not fight the fire.

- Firefighters must wear appropriate personal protection including a self-contained breathing apparatus and chemical protective clothing.
- In case of fire, evacuate the area and do not inhale the combusted gases (Hydrogen chloride).
- Do not allow run-off from firefighting to enter drains or water courses.

5.9 Response to Spills

CONSIDER ACTIONS ONLY IF SAFETY PERMITS!

Accidental Release

- Ensure that there is adequate ventilation and do not breathe gas/vapor/spray.
- Use personal protective equipment and clean the spill immediately.
- Do not allow the spill to enter into drains or water and avoid discharge to the environment.
- Do not return the spilled material to the original container. Collect into a suitable closed container for disposal.

Safe Handling and Storage

- Store in a tightly closed contained in a well-ventilated area with a temperature of 15-25°C.
- Use an extractor hood when using in a laboratory.
- Adequate ventilation (exhaust ventilation) is required when uncovering the product.

5.10 First Aid

First aiders must ensure that they are adequately protected with the required personal protective equipment. Symptoms may develop several hours after exposure. Contact the Poison Center or a doctor immediately upon exposure.

Eyes

- Flush eyes with water immediately for 10-15 minutes.
- Remove contact lenses if present and continue rinsing.

Skin

- Immediate medical treatment required.
- Rinse with water thoroughly and remove all contaminated clothing.

Inhalation

- Move to fresh air immediately and rest.
- If breathing stops, administer artificial respiration.

Ingestion

- Rinse mouth thoroughly with water.
- Do not induce vomiting.

Do not drink or eat.

PROPANE (UN1075)

Physical and Chemical Properties			
Danger! Extremely flammable gas that burns with explosive force.			
Storage	Various tanks and cylinders	**Flammability**	2.2% to 9.5%
Appearance	Colourless gas	**Flash Point**	-104°C
Odour	Natural gas odour	**Freezing Point**	-190°C
Solubility	Insoluble	**Boiling Point**	- 42°C
Vapour Density	Sinks to ground levels (1.52)	**Specific Gravity**	Floats on water (0.53)

Safety Measures	
Warnings	EXPLOSION is possible Vapours instantaneously form that are lighter than air. Vapours can travel to sources of ignition and flash back. Containers can contain acetone. Acetylene can accumulate static electricity charges. Eye contact causes irritation. Inhalation of vapours can cause dizziness, drowsiness, unconsciousness and death (from asphyxiation).
Personal Protection	Always wear impervious, chemical-resistant clothing, insulated gloves, footwear and goggles when appropriate to do so. Nitrile and Viton are suitable materials; cotton clothing is OK. If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate; otherwise wear positive pressure SCBA. Avoid frostbite burn to skin and eyes from contact with escaping gas.
Precautions	Monitor for explosive atmosphere. Avoid contact with acids, chlorine, chlorine dioxide and hydrogen peroxide. Eliminate ignition sources. Isolate spill or leak for 50 to 100 m. For large release, consider evacuation area of 800 m. For fire, isolate area and evacuate for 1600 m in all directions.

PROPANE (UN1075)

Response to Fires

Consider actions only if safety permits!

- ☐ Wear SCBA in confined spaces. Shut off fuel supply.
- ☐ Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- ☐ Use water fog or fine water spray to cool containers exposed to fire.
- ☐ **EXPLOSION is possible!**

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ☐ ***Eliminate ignition sources!***
- ☐ ***Do not attempt to contain or remove spills!***
- ☐ ***Keep hands away from release point since severe frostbite can occur!***
- ☐ Knock down and disperse with water spray if safe to do so.

Storage, Transfer and Disposal

- ☐ It is not possible to collect released propane gas.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove and thoroughly air contaminated clothing.
- ☐ Discard saturated leather articles.
- ☐ Warm frostbite areas with warm (not hot) water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform artificial respiration if victim not breathing.
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ NA

PROPYLENE GLYCOL

Typical Physical and Chemical Properties			
Storage	Keep in cool area	**Flammability**	2.6% To 12.5%
Appearance	Liquid [Oily Liquid]	**Flash Point**	188 C
Odour	N/A	**Freezing Point**	N/A
Solubility	In Hot/cold H2O, acetone	**Viscosity**	N/A
Vapour Density	2.62	**Specific Gravity**	1.036

Safety Measures	
Warnings	Absorbed through skin. Eye contact
	May cause damage to the following organs: central nervous system
	Hazardous in case of ingestion. Slightly hazardous in case of skin contact [irritant, permeator], or inhalation
	May affect genetic material (mutagenic). May cause adverse reproductive effects and birth defects (teratogenic) based on animal test data
Personal Protection	Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.
Precaution	Keep away from heat
	Keep away from sources of ignition
	Empty containers pose a fire risk, evaporate the residue under a fume hood
	Ground all equipment containing material
	Do not ingest
	Do not breathe gas/fumes/vapor/spray
	Wear PPE
	In case of insufficient ventilation, wear suitable respiratory equipment
	If ingested, seek medical advice immediately and show the container or the label
	Avoid contact with skin and eyes
	Keep away from incompatibles such as oxidizing agents, reducing agents, acids, alkalis, moisture

5.10.1.1 PROPYLENE GLYCOL

Response to Fires

Consider actions only if safety permits!

- Flammability of the Product: May be combustible at high temperature.
- Auto-Ignition Temperature: 371°C (699.8°F)
- Flash Points: CLOSED CUP: 99°C (210.2°F). OPEN CUP: 107°C (224.6°F) (Cleveland).
- Flammable Limits: LOWER: 2.6% UPPER: 12.5%
- Products of Combustion: These products are carbon oxides (CO, CO2).
- Fire Hazards in Presence of Various Substances: Slightly flammable to flammable in presence of heat.
- Explosion Hazards in Presence of Various Substances:
- Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.
- Fire Fighting Media and Instructions:
  - SMALL FIRE: Use DRY chemical powder.
  - LARGE FIRE: Use water spray, fog or foam. Do not use water jet.
  - Special Remarks on Fire Hazards: When heated to decomposition it emits acrid smoke and irritating fumes.
- Special Remarks on Explosion Hazards: Not available.

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- **Small Spill:** Dilute with water and mop up, or absorb with an inert dry material and place in an appropriate waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements
- **Large Spill:** Absorb with an inert material and put the spilled material in an appropriate waste disposal. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities

Storage, Transfer and Disposal

- Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 23°C (73.4°F).

5.10.1.2 PROPYLENE GLYCOL

First Aid	
	Get prompt medical attention!
Eyes	Check for and remove any contact lenses. Immediately flush eyes with running water for at least 15 minutes, keeping eyelids open. Cold water may be used. Get medical attention
Skin	In case of contact, immediately flush skin with plenty of water. Cover the irritated skin with an emollient. Remove contaminated clothing and shoes. Cold water may be used. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention
	Wash with a disinfectant soap and cover the contaminated skin with an anti-bacterial cream. Seek immediate medical attention.
Inhalation	If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Ingestion	Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. If large quantities of this material are swallowed, call a physician immediately. Loosen tight clothing such as a collar, tie, belt or waistband

SODIUM SULPHIDE (TO BE VERIFIED ONCE SUPPLIER CHOSEN)

Physical and Chemical Properties			
Yellow flakes, odourless or slight rotten egg smell			
Storage	Super sack	**Flammability**	NA
Appearance	Solid Flake	**Flash Point**	NA
Odour	None or rotten egg smell	**Freezing Point**	NA
Solubility	Soluble in water, 178 g/L	**Boiling Point**	NA
Vapour Density	NA	**Specific Gravity**	1.64

Safety Measures

Warnings

- Can generate toxic and deadly hydrogen sulphide gas if exposed to acids and in some cases water
- Ensure ambient H_2S detectors are kept in good working order
- Use a hydrogen sulphide gas detector when handling this product and when dealing with spills of any size
- Corrosive

Personal Protection

- Wear suitable respiratory equipment in case of poor ventilation
- Use certified respirators if exposed to concentrations above exposure limit
- Use chemical resistant gloves: PVC, Neoprene, Natural rubber
- Use goggles
- Use dust impervious protective suit, apron, boots

Precautions

- Keep away from flames and hot surfaces
- keep away from moisture
- Avoid carbon dioxide, acids, oxidizing agents and metals

Response to Fires

Consider actions only if safety permits!

- Use foam or powder
- Do not use water or carbon dioxide
- Not combustible, may produce hazardous decomposition products (sulphur oxides)**. Wear self-contained breathing apparatus.**

SODIUM SULPHIDE (TO BE VERIFIED ONCE SUPPLIER CHOSEN)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- ***Do not flush into surface water or sanitary sewer system***
- ***Isolate area***
- ***Wear self-contained breathing apparatus***
- ***Prevent further leakage if safe to do so ***
- ***Pick up solids manually with appropriate PPE***

Storage, Transfer and Disposal

- Use product only in closed system
- Ensure adequate ventilation
- Keep away from heat and incompatible materials
- Keep dry, avoid dust formation
- Package in original container, steel drum, or polyethylene container

First Aid

Get prompt medical attention!

Eyes

- Call physician immediately
- ☐ Rinse eyes with water and under eyelids for 15 minutes
- ☐ In case of difficulty of opening the lids, administer and analgesic eye wash (oxybupocaine)
- ☐ Take victim to hospital

Skin

- Take off contaminated clothing and shoes immediately
- ☐ Wash area with water
- ☐ Keep warm and in a quiet place
- ☐ Call physician
- ☐ Clean contaminated clothing before wearing

Inhalation

- Move to fresh air, provide oxygen or artificial respiration if needed

Ingestion

- Do NOT induce vomiting
- ☐ Rinse mouth with water if conscious

SOLVENT (NAPHTHA MINERAL SPIRIT & PETROLEUM ETHER)

Physical and Chemical Properties			
Use caution. Solvents are combustible liquids.			
Appearance	Clear liquid	**Flash Point**	Spirit: 41 to 138°C Ether: -49 to -18°C
Odour	Hydrocarbon/aromatic	**Pour Point**	Spirit: -69°C
Solubility	Insoluble @ 20°C	**Viscosity**	Similar to water
Vapour Density	Will sink to ground levels	**Specific Gravity**	Lighter than water

Safety Measures

Warnings

- Vapours are heavier than air. Ether vapours can be **extremely flammable** and **explosive** even in low concentrations.
- Empty solvent containers may contain explosive vapours.
- CO, CO_2 and unspecified compounds form upon combustion.
- Material may accumulate static electricity.
- Eye contact causes irritation.
- Inhaling vapours can cause respiratory irritation, headache, vomiting, unconsciousness with convulsions, and chemical pneumonitis.

Personal Protection

- Wear chemical-resistant clothing, gloves, footwear, and goggles when appropriate to do so; neoprene, nitrile and PVC are suitable protective materials.
- Cartridge respirator may be required.

Precautions

- Monitor for explosive atmosphere.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Eliminate ignition sources. Electrically ground/bond transfers.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- Use water to cool containers exposed to fire.

SOLVENT (NAPHTHA MINERAL SPIRIT & PETROLEUM ETHER)

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- ☐ **On land**, block entry into waterways.
- ☐ Do not flush into sewer or drainage system.
- ☐ Contain spill by diking with earth or other barrier.
- ☐ Remove minor spills with sorbent.
- ☐ **On water**, do not try to contain or remove petroleum ether spills.
- ☐ Use boom, barrier to contain and concentrate spills of mineral spirits.
- ☐ Remove mineral spills using sorbent, pump or vacuum system.

Storage, Transfer and Disposal

- ☐ Store closed labelled containers in cool, well-ventilated areas away from acids and fuels.
- ☐ Electrically ground/bond containers and vehicles during transfer.
- ☐ Segregate waste types and place in marked containers.
- ☐ Consult Environment Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- ☐ Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- ☐ Remove contact lenses, if exposed to vapours or liquid.

Skin

- ☐ Remove contaminated clothing.
- ☐ Wash skin thoroughly with soap and water.

Inhalation

- ☐ Move victim to fresh air.
- ☐ Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- ☐ **Do not** induce vomiting.
- ☐ If victim is conscious, give milk or water to drink.
- ☐ If victim vomits, keep head below hips to prevent aspiration.

SULPHURIC ACID (H_2SO_4 UN 1830)

Typical Physical/Chemical Properties			
Danger! Highly corrosive, toxic liquid that reacts with many chemical and metals.			
Storage	1000 tote	**pH**	0.3
Appearance	Colourless oily liquid	**Flash Point**	Not flammable/combustible
Odour	Acrid odour	**Boiling Point**	276 to 330°C
Solubility	Soluble in water.	**Freezing Point**	-11°C
Vapour Density	Heavier than air (3.4)	**Specific Gravity**	Sinks in water (1.67 to 1.84)

Safety Measures

Warnings

- Highly corrosive to all body tissues including skin, eyes, teeth, lungs.
- Direct skin contact may cause deep painful burns, shock and collapse.
- Highly toxic and may be fatal if ingested.
- Inhalation may cause breathing difficulties, irritation and death.
- Sulphuric acid is classified as a Group1 Carcinogen.

Personal Protection

- Wear face shields, splash-proof safety goggles, rubber boots, heavy rubber gloves, rubber aprons/suits.
- Wear respirator for pools, SCBA and Level A suit for mist, as required.
- Rubber, PVC gloves are recommended. Neoprene, nitrile are OK.

Precautions

- Avoid contact with organic materials, most metals and oxidizers.
- Avoid methanol, hydrogen peroxide, sulphides and sodium chlorate.
- Can generate explosive hydrogen gas in contact with metals.
- Do not add water to concentrated acid; heat, splattering occurs.

Response to Fires

Consider action only if safe!

- Generates SO_2 and SO_3 in fire.
- Use dry chemical or CO_2 to extinguish small fires.
- Use water spray or fog for larger fires.
- Water added to concentrated acid results in heat, violent spattering.

SULPHURIC ACID (H_2SO_4 UN 1830)

Response to Spills

Consider actions only if safety permits!

Containment and Removal

On Land

- Remove ignition sources. Ventilate area.
- **Inside buildings**: neutralize with soda ash or lime.
- Do not flush into ditches and drains. Eco-toxic effect can occur.
- Call for help if significant quantity is spilled or people are affected.
- **Outside buildings**: contain spill by diking with sand or earth.
- Use only chemical-rated pump.
- Neutralize and remove minor spills with Universal sorbent.
- Rinse residuals with water and mild alkali.

On Water

- Will sink and mix completely with water.
- Contain spill: isolate contaminated water by damming or diversion.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, well-ventilated areas.
- Keep away from incompatible materials such as water, metals and fuels.
- Segregate waste types and place in marked containers.
- Consult Environmental Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for at least 15 minutes.
- ☐ Remove contact lenses if exposed to vapours or liquid.

Skin

- Remove contaminated clothing.
- ☐ Flush with water for at least 15 minutes.

Inhalation

- Move victim to fresh air.
- ☐ Perform AR if victim not breathing. Do not use mouth-to mouth.
- ☐ Provide oxygen if victim is having difficulty breathing.

Ingestion

- Administer large quantities of water, if victim is conscious.
- ☐ **Do not** induce vomiting.
- ☐ If victim vomits, keep head below hips to prevent aspiration.

TERRAFLOW (MIXTURE OF CEMENT, LIMESTONE, CALCIUM OXIDE, GYPSUM, MAGNESIUM OXIDE & QUARTZ)

Typical Physical/Chemical Properties			
Danger! Serious eye damage, may cause cancer, causes damage to organs through prolonged or repeated exposure.			
Storage	Silo	**pH**	12 – 13 (in water)
Appearance	Gray or white powder	**Flash Point**	NA
Odour	None	**Boiling Point**	>1,000°C
Solubility	Soluble in water.	**Freezing Point**	NA
Vapour Density	NA	**Specific Gravity**	3 – 3.2

Safety Measures	
Warnings	May cause an allergic skin reaction. Causes serious eye damage. May cause respiratory irritation. May cause cancer. Causes damage to organs through prolonged or repeated exposure.
Personal Protection	
Precautions	Obtain special instructions before use. Do not handle until all safety precautions have been read and understood Do not breathe dust Wash hands, forearms, and exposed areas thoroughly after handling. Do not eat, drink or smoke when using this product. Use only outdoors or in a well ventilated area. Contaminated work clothing must not be allowed out of the workplace Individuals with lung disease (e.g. bronchitis, emphysema, COPD, pulmonary disease) can be aggravated by exposure.

Response to Fires

Consider action only if safe!

- Do not use a heavy water stream. Use of heavy stream may spread fire.

Response to Spills

Consider actions only if safety permits!

- Use HEPA vacuum or thoroughly wet with water to clean up dust.
- Place spilled material into a container. Avoid actions that cause the TerraFlow to become airborne.
- Scrape wet TerraFlow and place in container. Allow material to dry or solidify before disposal. Do not wash TerraFlow down sewage and drainage systems or into bodies of water (e.g. streams)
- Do not breathe dust. Do not get in eyes on skin, or on clothing.
- Use appropriate personal protection equipment (PPE).
- Equip cleanup crew with proper protection.
- Ventilate area.
- Prevent entry to sewers and public waters

First Aid

Get prompt medical attention!

Eyes Rinse eyes thoroughly with water for at least 60 minutes, including under lids, to remove all particles.

Skin Wash with cool water and a pH neutral soap or mild skin detergent.

Inhalation Move victim to fresh air.

Ingestion Do NOT induce vomiting. Drink plenty of water. Immediately call a POISON CENTER or doctor.

APPENDIX B

Spill Response Equipment

BRUCEJACK MINE

Spill Response Plan

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5.11 SPILL RESPONSE EQUIPMENT

INTRODUCTION

Bulk spill response supplies and equipment as well as mobile spill response trailers are kept at Wildfire Camp, Brucejack mine site and Knipple Transfer Area. Large scale spill supply caches are staged on the Brucejack Access Road at 30.5 km, 58.5 km and 72 km, and in the Pilsner Valley. Smaller kits will be kept at exploration drill sites and as well as at temporary worksites as needed.

These supplies and equipment are to be used only for their intended purpose. Under no circumstances will emergency supplies be used in non-emergency situations. Spill response equipment is located at all sites where fuels, oil and other materials are stored. They are maintained, inspected, and replenished to ensure that they are available for immediate use. **Note: Any equipment or materials used during a spill must be replaced as soon as possible following a spill.** A written regular review and inspection program will be developed and applied.

The Health & Safety Manager or their designate will inspect and maintain the emergency supplies. The inspection will be documented and records retained.

Resources available on the Brucejack Project to control, contain, and clean up spills include:

- haul trucks
- dozers
- front-end loaders
- motor graders
- Snowcats
- excavators
- small pumps
- hand-sized tools
- containment and cleanup supplies

Three types of spill kits are kept at Project facilities, all include personal protective equipment (PPE). More inclusive PPE with chemicals suits and Self-Contained Breathing Apparatus (SCBAs) is maintained at the Brucejack mine site - see last page this section.

Level "A" Spill Response Kit – Mobile Spill Response Trailer

Each camp is equipped with an identically stocked mobile spill response trailer which can be deployed at a moments notice to any road accessible spill on the project. These trailers are designed and stocked to be mobile command centers for spill response to be deployed day or night year round.

Level "A" Mobile Spill Response Trailer – 1 per Camp

Quantity	Item	
1	14′ Spill Response Trailer	
1	Pneumatic grooved drum oil skimmer	
1	210 L steel drum	
1	propane heater and spare bottles	
1	gas powered portable generator with jerry can	
1	set of LED work lights and stand	
2	PFDs	
2	sets of chest waders	
1	water rescue throw bag	
1	2″ gas powered pump with suction and 200′ of discharge hose	
2	headlamps	
1	Bear deterrent kit including bear spray and bear bangers	
1	15 minute eyewash station and Level 1 first aid kit	
8 bales	sorbent booms (4 per bale)	10' x 5"
1 length	PVC 6x6 River Boom	25′
10 bales	sorbent pads (100 pads to a bale)	
6 bales	sorbent socks (12 per bale)	3" x 4'
1	sorbent roll (150′ x 30″)	
12	stakes	3 ft
4	2″ x 4″ boards	16′
1	sledge hammer	6 lbs
1 set	tools (wire cutters, pliers, hammer, utility knife , nails)	
1	pipe for inverted weir	8' x 4"
1	Watergate® Barrier	
1	Roll of heavy duty oil spill disposal bags	
2	"No Smoking" signs	
1 roll	"Caution Do Not Enter" tape	
4	safety triangles	
2	poly tarps (18' x 20')	
2 jars	hand cleaner	
1 jar	Plug N′ Dike	
2	Rake	
4	round nose shovel	
200 feet	polypropylene rope	1/4"
1 box	Rags	

NOTE: SCBAs and chemical suits are also located at the mine site proper. Refer to next page.

Personal Protective Equipment - Mine Site

Item	Quantity/Size
Coveralls (Tyvek or Saranex)	12-XL, 12-XXL
Oil-resistant rubber boots	12 pairs
Chemical splash goggles with side shields- A/O (fit eyeglasses)	12 pairs
PVC, rubber, leather, and nitrile gloves	12 pairs
Dust respirators (NIOSH-approved)	12
Cartridge respirators (NIOSH-approved)	12
Cartridges for respirators (organic vapour, acid, base)	12
SCBA, positive pressure full face piece	6
Level A chemical suits (Hazmat)	6
Level B chemical suits (Hazmat)	6
Rain gear61XL, 2-XXL, 3XXXLHigh visibility vests	6
Fire proximity suit	6
Gas monitors/detectors	3
Personal flotation devices	6
Hearing protection	5 Packages
Sunblock	12-75 ml – SPF 60
Level B chemical suits (Hazmat)	6

Level “B” Spill Response Kit – Remote Spill Response Caches

Pretium has identified that fast access to key spill response resources is paramount to an effective response to large scale releases or releases to sensitive environments. To reduce the delay to spill response resources, Pretium has placed Remote Spill Response Caches along the BJAR at km 30.5, km 58.5, km 71.6 and in the Pilsner Valley. These serve as immediate stores of larger volumes of spill supplies and some larger spill response equipment that is otherwise available at each camp.

Level "B" Spill Response Kit – Remote Spill Response Caches

Quantity	Item	
1	Container to store all major response items , inventory list	
2 pairs	coveralls (Tyvek or Saranex)	1-XL, 1-XXL
10	sorbent socks	3" x 4'
24 bales	sorbent pads (12 oil only, 12 universal)	18" x 18" x 3/8"
1 Roll	Heavy duty spill disposal bags	
1 each	round nose shovel, flat nose shovel	
1 pair	chemical goggles - A/O (fit eyeglasses)	
2 pair	PVC gloves	
1	poly tarp	18' x 20'
1	Plywood culvert block	
1	Watergate	
10	Sandbags	
2	10′ long 2″x4″	
1	Plywood culvert block	30″x 30″
1	Watergate spill containment dam	21″ x 15′
2	“No Smoking” signs	
1 roll	“Caution Do not Enter” tape	
1	hand cleaner	
200 feet	Polypropylene rope	1/4"
1 box	Rags	
1 unit	Plug N′ Dike	
6	Hi-Vis delineators	45″ H

Level “C” Spill Response Kit – Mobile Equipment

Small caches of spill response materials are kept in a carrying case or other container on all pieces of equipment as well as light vehicles on site. They are clearly identified and readily accessible. Spills up to several tens of litres can be cleaned up. Refer to table: Level “C” Spill Response Kit.

Level "C" Spill Response Kit - Mobile Equipment

Quantity	Item	
1	Carrying bag or case, inventory list	
4	sorbent socks	3" x 4'
20	sorbent pads (10 Oil, 10 Universal)	18" x 18" x 3/8"
3	heavy duty oil spill disposal bags	
1	round nose shovel	
1 pair	chemical goggles - A/O (fit eyeglasses)	
1 pair	PVC gloves	
1	Spill containment berm	3′ x 3′
1 unit	Plug N′ Dike	

APPENDIX C

Spill Response Strategies

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SPILL RESPONSE STRATEGIES

INTRODUCTION

The equipment, strategies, and techniques that will be applied to control and clean up releases of fuels and other substances at the Brucejack Mine Project will depend on many factors. These include the circumstances of the incident, the type of substance(s) involved, the volume of the release, the nature of both the source and receiving environment, and the prevailing weather conditions. Basic spill response information is outlined that is applicable to the Brucejack mine site, Brucejack Access Road, Knipple Transfer Area, bulk emulsion staging area, Bowser Aerodrome, Tide Staging area, and Wildfire and Bowser camps.

SPILLS ON LAND

Safety permitting, spills on land should be prevented from entering watercourses such as ditches, creeks and streams, rivers, and lakes. This localizes the hazard and makes cleanup easier. For small spills, if safe to do so, use:

- loose sorbent
- sorbent pads and booms
- on land only, particulate, if available and safe to add, including Oil Gator
- non-combustible material (sand, earth)
- neutralizers with colour indicators for chemicals such as acids and alkalis

For larger spills, and if safe to do so, consider collection /removal by:

- trench or berm or both
- pumping or vacuum system, as available
- In-situ burning (away from facilities, vehicles, tanks, etc.) approved by BC MOE

Spills on land should be contained as close to the source as possible, if safety allows. Every effort should be made to ensure that a spill does not reach water, where its containment and recovery are much more difficult and the potential environmental impacts are much greater. Berms can be constructed from earth or sand bags, as available. The type and size of the containment method will depend on the following factors:

Size of Spill

Berms surrounding large oil spills which cover extensive areas will be difficult and time-consuming to build. For this reason, earth or snow berms may be more easily deployed than sand bags (see next section). It is also important to build the berm as close to the source as possible to minimize the spill's tendency to spread.

Terrain

Steep terrain can make work difficult, particularly with heavy equipment, while large flat areas will require longer barriers to contain the spill. Oil will also travel much faster on steep inclines while it will move more slowly and tend to pool on flat ground allowing more time for the construction of barriers.

Soil Type

Oil will soak into loose, coarse, or dry soils while packed or frozen soil can create a natural barrier. Frozen soil will also require relatively heavy machinery in order to build a trench or berm. Soft, wet soil ground can also impede vehicle and machinery access.

Presence of Ice and Snow (see also next section)

Oil can be soaked up by snow and pool on glacial or lake ice. Marking the boundaries of a spill will be necessary if snowfall is expected. Caution should be exercised **before** equipment is used on Knipple Glacier and other situations involving ice to contain or remove a spill. The ice thickness must support both people and equipment.

Proximity to Water

Precautions must be taken to ensure that an oil spill does not enter a waterway. If there is any possibility of contamination, a stream, river or lake should be protected with a berm.

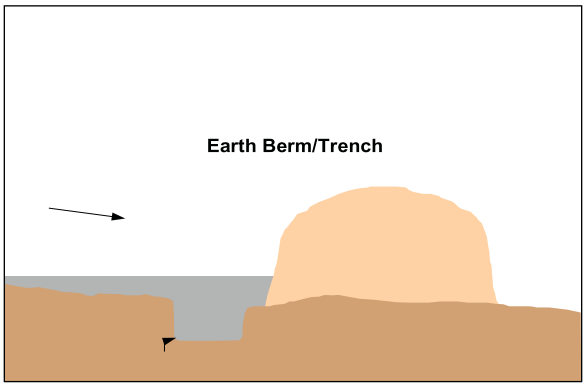
Weather

Weather plays an important role in spill response operations, particularly if the ground is frozen or if rainfall is heavy or prolonged. Since oil floats on water, any pooled water that collects in a trench or against a berm will effectively increase the volume of liquid needed to be contained. Water can also significantly increase the tendency of oil to spread thus hindering effective cleanup. During spring runoff, containment can be difficult.

Location

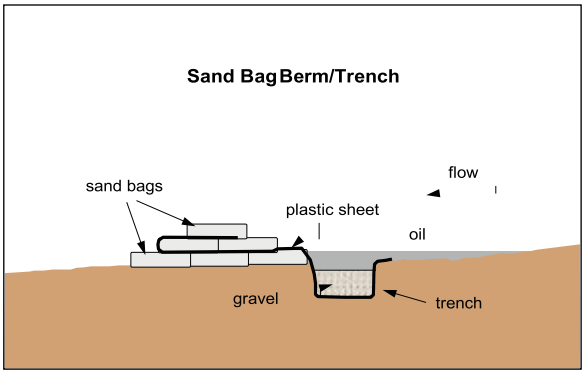
The location of a spill will play an important role in determining the most feasible type of containment barrier. Spills involving a fuel truck will generally occur in areas where there is good road access although a truck can leave the roadway along the Brucejack Access Road and release its cargo some distance away from a facility. Accessibility of both equipment and personnel could be hindered by difficult terrain or the dense tree growth at Pretium. Consideration must also be given to determining areas where a helicopter might initially land as well as one or more designated locations where equipment could be staged for later deployment at strategic locations.

Earth Berm/Trench



If possible, locate the berm or trench sufficiently downslope of the release point to complete its construction before the spill arrives. Dig the trench along a natural drainage contour. It should be approximately 0.5 m deep with a relatively flat bottom. The excavated material can then be combined with other available material to build a berm.

Sand Bag Berm/Trench



Sand bags can be used where available and if the earth is too hard or frozen and does not lend itself to excavation or compacting. A plastic liner can be used to seal the trench and bags and should be anchored with gravel or rocks and be woven between layers of bags.

SPILL RESPONSE IN ICE AND SNOW

Oil Behaviour

Snow will be present at the Brucejack Mine Project for more than half the year. Knipple Glacier has snow cover and ice year-round. The movement of oil on and into snow, including spreading, depends on:

1. type of snow (fresh or compacted, smooth or rough)
2. air temperature (the snow may be melting or dry)
3. gradient (sloped, steep or flat)
4. the type of oil (diesel, gasoline, hydraulic, or lube)

Ice will sometimes halt the downward movement of a spill. Expect cracks, however, to result in the possible migration of a release below the surface on Knipple Glacier. During summer weather, snow melt will result in contaminants either floating on water or, if soluble, entering water and moving down-gradient. Planning the response to a spill on Knipple Glacier may involve interception at the outflow of the glacier if lost to surface runoff.

Overall Strategies

Oil can remain relatively fresh, i.e., in an unweathered state, under snow and ice for several months

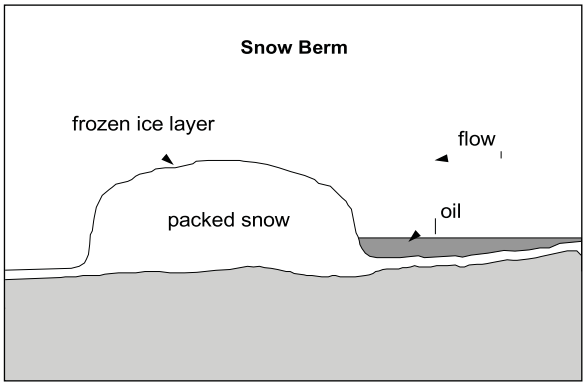
after a spill. Evaporation rates will still be very high when the oil is exposed to the atmosphere except in very low temperatures approaching its freezing point (-20 to -50°C). Oil can also move up and down small hills (several metres high) due to the capillary action of the snow. During snow melt, the Watergate® barrier (see picture on page C-6) may have application to halt fuel spills that follow a discrete pathway on Knipple Glacier. In frozen conditions, the following response strategies will be used:

Containment

- Oil spilled into snow will likely be contained by the snow. Snow is a good sorbent. The oil content may be very low (<1%) for low-viscosity oils, e.g., diesel, or if the oil has spread over a wide area. Oil content is higher for lube and hydraulic oils.
- Oil content is lowest on firm compacted snow surfaces in below-freezing temperatures and higher for fresh snow.
- Heavy oils can cause snow to melt but spread less than gasoline, which moves more quickly in snow and over a larger area. Light oils can spread upslope in snow through capillary action.
- Fresh snow that blows over oil tends to stick and migrate down into the oil, causing an increase in the volume of materials to be recovered.
- Snow falling onto oil tends to accumulate on the oil surface.
- Snow and ice can be used to create berms to keep spills from spreading.

Snow Berm

In the winter conditions common to the Brucejack Mine Project, snow may provide a quick and efficient berm construction material. The snow should be well packed and water should be sprayed to form an ice layer on the top and sides of the berm to make it impermeable to oil.



Removal Options

- Very light oils, e.g., gasoline, can evaporate during thaw periods.
- Manual removal (using shovels and rakes) is appropriate for small amounts of surface or subsurface oil or insoluble chemicals, but is less efficient as the amount of affected area and volume of contaminated snow increases.
- Pooled oil on the surface of a snow-covered area, or contaminant that has been collected in trenches or by containment berms, can be recovered by pumps.
- On flat surfaces, or where a mechanical arm can reach an oiled area, oil/snow can be scraped for removal and disposal. Include melting to separate the oil and snow, or burning.
- Surface oil can sometimes be removed by sorbents. Effectiveness decreases as the oiled area or volume of oiled snow increases.
- Pooled oil on snow or oil that has been contained by berms, can sometimes be removed by burning.

Typical Combinations of Response Methods

- Manual removal methods can be used such as hand tools, vacuums, and sorbents.
- Mechanical scraping is possible followed by manual removal of any oily residues.

RESPONSE TO SPILLS IN CREEKS AND RIVERS

Twenty-three bridges have been built along the access road between Highway 37 and the Bowser Camp, including 13 bridges between km 35 and 50. In most cases, should a spill occur at a bridge, containment efforts would need to be in close proximity to the bridge using sorbent booms. No- or low-velocity flowing water (< 0.25 m/s) would have to be present.

Responding to spills that escape source control into a river will be difficult at the Brucejack Mine Project, they might also require river bank cleanup. Various considerations will affect whether or not the removal of oil proceeds:

- On the Brucejack Mine Project, booming off creeks that lead into waterways should be a priority action where this is feasible to consider - 25 feet of boom should be sufficient for this purpose. Containment of a spill is feasible to achieve.
- In ditches and smaller waterways, the Watergate® barrier can be deployed to contain fuel spills. A tarp and 2x4 can also be applied (see also below).
- Conditions must be safe if a response is to be attempted. Monitors must be used to safeguard the health and safety of response personnel. An explosive, toxic atmosphere can develop in spills of volatile oils (e.g. gasoline) and some chemicals (e.g. hydrogen peroxide).
- Burning in-situ on water is prohibited by DFO on any in-land streams or water courses.
- If working in a stream and silt is created, set up a filter fence to reduce or eliminate silt.
- In current velocities of 0.5 to 1.0 m/s (1 to 2 knots), spill control in flowing cold water (off the Brucejack Access Road) will not only be difficult but also dangerous. A small fuel spill will dissipate quickly in turbulent water and not be amenable to cleanup.
- When required, specialists should determine whether ice, if present, will safely support the weight of equipment and personnel.
- Attempts to control moving oil should be considered only on slicks several millimetres or more thick using booms. Observers/planners and spill response specialists are required to position equipment on spills in rivers.

Note: Slicks thinner than 1 mm will likely dissipate, and usually cannot be efficiently removed in rivers using skimming or boom systems.

- Medium viscosity and heavy oils, as well as diesel, can persist in colder weather, possibly making it necessary to consider river bank protection/treatment.

- Spilled oil that becomes distributed in ice may be skimmed and burned if sufficiently thick (2 - 3 mm). Removal of thin slicks (less than 1 mm), oil droplets, globules and particles mixed with ice using any response option is impractical, unless melting results in concentrated slicks. Monitoring the spill may be the only practical response alternative.

Snow can be slippery on sloping surfaces, particularly if there is ice below the snow. Care should be taken to avoid slips, trips, and falls.

Slotting/Augering

In frozen rivers, angled slots about 1 m wide can be cut in the ice, where safety permits, to allow possible spill recovery. The oil will rise up into the slots where it will move toward the shore, concentrate, and be available for recovery using skimmers or pumps. At the Brucejack Mine Project, it is unlikely that this strategy will be applied as it might be in other situations. Nevertheless, the concept of making an opening in ice could be tried when safety and the feasibility of the operation warrant this approach.

CONTAINMENT IN SMALL WATERCOURSES

Containment methods are discussed in this section for diesel, hydraulic and lube oil (i.e. products that do not dissolve but float on water). Other products may mix with water and can only be contained by completely blocking flow. Gasoline can only be contained if safety permits and it has not evaporated. Often it is best left to evaporate.

Watergate®

A containment device was used by Pretium and contractor personnel during preliminary fuel spill training at the Brucejack Mine Project. The Watergate® barrier is a portable dam kept at the mine site that can be quickly deployed in a small waterway to halt the surface flow of spilled fuel. A weighted belt helps maintain the vertical position of the device and adjustable openings along the bottom allow the flow of water beneath the contained fuel. Its use on spills on Knipple Glacier is also possible.

Culvert Dams

Culverts under roadways can carry product away from the spill site causing contamination. Water running through a culvert or ditch adds to this problem.

To halt the flow of oil, completely blocking the culvert on the upstream side may be possible using various available materials or sorbents. Culverts in which water flow must be maintained can be partially blocked with plywood that holds back the surface oil but permits water to pass below.
The position of the plywood can be adjusted vertically to maintain the water at the desired level.

Tarp and Board

A tarp that is rolled on a simple 2x4 piece of lumber can also be tried to block the movement of oil as well as soluble contaminants in a ditch with low water flow. The tarp is unrolled from the 2x4 so that it contains flow in the ditch. The upstream end is weighted with rocks. Holes can be cut in the tarp to allow subsurface water flow if this is deemed to be needed. Surface contaminants can be directed to one side with the use of a second 2x4 and a spill response boom, if available to facilitate the removal of oils.

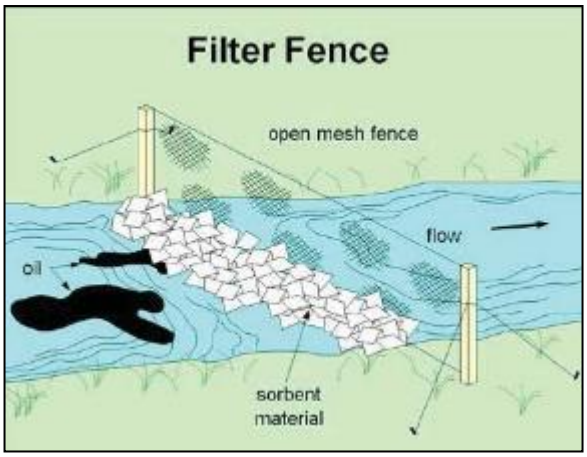
Other Containment Methods for Ditches and Streams

Dry ditches may be plugged with non-combustible material or sorbent. Use mechanical equipment, if required. For ditches containing water and streams, use these options:

Sorbent Boom

Sorbent boom is available in 3 m (10') lengths (4 to a bag) with a 13 - 25 cm (5 - 10") diameter and has fireman's hooks (carabineers) fitted toward each end to link lengths together. It can be used to contain spills in no-to low velocity waterways.

Filter Fence

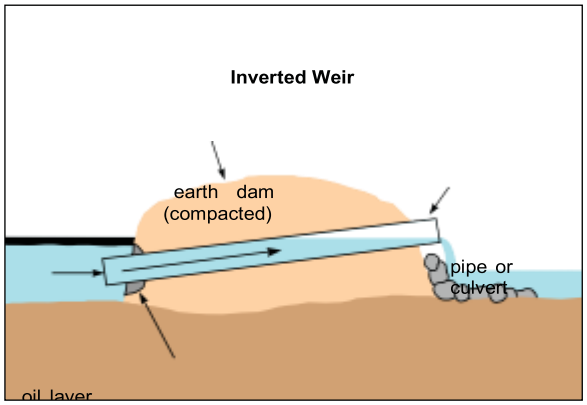


Wire mesh or netting, anchored by stakes as a back-stop for sorbent, can limit the spread of oil and oily debris.

A second mesh can be deployed slightly upstream of the first to act as a debris screen. The sorbent material is then placed between the two mesh screens.

To allow changing soiled or saturated sorbents, without escape of oil, additional fences can be constructed downstream of the second screen.

Siphon Dams (Inverted Weirs)



Siphon dams can be used to retain oil and allow the continuous flow of water in a ditch or stream. One or more pipes are placed at an angle through a soil or sandbag dam, with the upstream end of the pipe being close to the bottom of the ditch or stream and the downstream end at a level that permits water to drain away. If more than one pipe is used, these should be placed at slightly different angles.

NOTE: *Whenever the construction of a berm or siphon is considered for a spill response operation, the impacts of the disturbance must be weighed against the potential impacts of the uncontained spill. Care must be taken to minimize any harmful effects. Local Fish and Wildlife officers should be consulted in all cases prior to construction unless immediate action is necessary. Fisheries and Oceans Canada (DFO) should also be consulted if fish spawning streams are involved.*

Barriers can be constructed from earth or rocks, although if large rocks are used, plastic sheets or packed mud should be used to ensure that a complete seal is made. Choosing and positioning the pipe(s) is critical to effective operation of the weir. The pipe should be low enough at the inlet end to ensure that an increase of the slick thickness or substantial lowering of the water will not result in a loss of oil through the pipe. Larger pipes which allow greater volume (and slower) flows will minimize the tendency of oil to become entrained in the water at the inlet side. The outlet end of the pipe should be positioned to create a continuous, smooth flow. Underflow of oil (under the pipe) should also be prevented by ensuring that the pipe inlet is not located on loose gravel.

Ideally, a shallow angled pipe should run at a high flow rate without reducing the water level. Any other pipes should be angled to compensate for blockages in the primary pipe or increased water levels caused by rainfall. A simple weir holds back surface oil and allows water underflow. Relatively easy to install using plywood or a board, several can be quickly placed in a stream or ditch. Ensure the sides are cut well into the banks, otherwise the oil will escape around the ends. Sorbents can be used to plug any gaps. When planning containment, anticipate removal and other cleanup steps. **Monitor** and **remove barrier** when appropriate to do so.

Preventing spills of soluble chemicals from entering watercourses is a priority emergency measure.

Ensure safe operations.

ADDITIONAL GUIDANCE

BC has published guides that provide additional information on spill response.

Guide to Selecting Containment Techniques for Spills on Water*

Technique	Primary Use	Resources Required
Containment Boom	• best at location where spill enters water	• booms totaling 1.5 to 2 times slick diameter • recovery device such as a skimmer (if needed)
Sorbent Boom	• best across small ditches	• disposal containers or incinerator for used sorbents • chicken wire and supports to make "fence" • earth moving or digging equipment • operators, foreman, labourers
Earth Berm	• best across shallow ditches	• boom and recovery device such as a skimmer • may also require sandbags, liner material, sheets of metal or wood • a 10 X 4 X 2 m berm requires one hour to build

**from Aggregate Operators Best Management Practices Handbook for British Columbia*

Guide to Selecting Containment Techniques for Spills on Land*

Technique	Primary Use	Controlling Variables	Resources Required
Earth Dike	• best suited for spills on relatively flat areas	• sufficient earth may not be available, depending on location and season • crew of four can create dike at 5 m/hr	• earth-moving machine or digging equipment (e.g., bulldozer or backhoe) • sandbags, liner material, sand or gravel • labour
Sorbent Dike	• can provide temporary containment and cleanup • applicable in all seasons	• requires sufficient sorbent material • may become impractical for large spill volumes	• sorbent materials • temporary storage or a facility to burn used sorbents
Snow/Ice Dike	• best suited on relatively flat areas in winter	• requires sufficient snow or ice • only applicable when ice is >1 m thick • a crew of four with a bulldozer can create dike at 10 m/h	• earth moving machine • ice chain saws • equipment to spray water onto snow • labour
Land Trench	• best on relatively flat areas	• during the winter, frozen earth may be too difficult to excavate • in some areas, soil may be too thin to create trench • can create 30 m/h per machine in summer, half that in winter.	• earth digging equipment (backhoe or shovels) • operators, labourers, foreman • an oil recovery unit (pump)

** from Aggregate Operators Best Management Practices Handbook for British Columbia*

Guide to Selecting Cleanup Techniques for Spills on Land*

Technique	Controlling Variables	Environmental Effects	Resources Required
Excavation by Bulldozer	• heavy equipment site access • facility to receive excavated material • difficult in frozen soil	• removes 10 to 25 cm of surface material • can lead to erosion or surface instability • removes all shallow biota/vegetation • vegetation is slow to recover	• bulldozer, fuel and operator • work crew and foreman • method to handle or dispose of excavated material
Excavation by Front-end Loader	• heavy/light equipment site access • facility to receive excavated material • difficult in frozen soil	• as above, but excavation may be to depth of 50 cm • vegetation is slow to recover	• loader, fuel and operator • work crew and foreman • method to handle or dispose of excavated material
Excavation by Backhoe	• heavy/light equipment site access • facility to receive excavated material • difficult in frozen soil	• disturbs surface of soil • removes some organisms	• pressurized equipment • downslope containment and recovery facilities • water supply • work crew
High-pressure Flushing	• light equipment site access • water supply • not applicable in winter	• disturbs surface of soil • removes some organisms	• pressurized equipment • downslope containment and recovery facilities • water supply • work crew
Low-pressure Flushing	• light equipment site access • water supply • not applicable in winter	• as above but to a lesser degree	• as above
Steam Cleaning	• light equipment site access • water supply • not applicable in winter	• heat will damage surface vegetation and shallow organisms	• as above
Sand-blasting	• light equipment site access • adequate supply of sand • impractical for most sites	• adds material to the environment • potential recontamination, erosion or deeper penetration into soil • destroys surface vegetation and shallow organisms	• pressurized equipment • downslope containment and recovery facilities • supply of sand • work crew
Pumping	• nearby storage • heavy equipment access if vacuum truck is used	• surface disturbance if sump is excavated	• pump or vacuum truck and operator • storage facility

(continued)

Guide to Selecting Cleanup Techniques for Spills on Land* (completed)

Technique	Controlling Variables	Environmental Effects	Resources Required
Manual Removal	• labour intensive and time consuming • best suited for areas lightly contaminated or where equipment access is unavailable	• removes up to 5 cm of soil • some surface disturbance and removal of shallow organisms and vegetation • more rapid repopulation of organisms than other excavation techniques	• work crew with hand tools (rakes, shovels, wheelbarrows) • disposal facilities
Manual Scraping	• labour intensive and time consuming • best suited for man-made structures or contaminated rocks and boulders	• surface disturbance • removes, crushes surface vegetation and organisms	• work crew with hand tools • downslope containment facilities • disposal facilities
Sorbent Application	• adequate supply of sorbents	• relatively little damage except surface disturbance of foot traffic	• sorbents • work crew • disposal facility for used sorbents

** from Aggregate Operators Best Management Practices Handbook for British Columbia*

APPENDIX D

Brucejack Mine Storage Tanks and Fuelling

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STORAGE TANKS AND FUELLING FACILITIES

This Appendix summarizes the fuelling and storage facilities currently in place at the Brucejack Mine Project. This inventory will be updated as changes are made to existing facilities or new facilities are constructed. All company and contractor personnel must ensure that fuelling is conducted according to protocol to minimize the probability of accidents. Wastes must be stored in designated areas only.

A sample inspection checklist (see below) is to be applied weekly to ensure that all facilities meet Pretium standards.

Sample Inspection Checklist

Fuel Dispensing			
Inspection Item	**Y**	**N**	**Actions Required**
Garbage, other refuse, in area?			
Signs of new spillage?			
Tanks - signs of wear and tear, drips/leaks from nozzles, pipes, hoses, connections, etc.			
Nozzle containment used but not full?			
Hose off ground? In good condition?			
Legible signage - At least two content ID signs one hazardous materials placard and one attention required while fuelling sign			
Spill response kits fully stocked? 1 shovel, 1 bale 100 sorbent pads, 6 3"x48" sorbent socks, 1 bag 30 lb Oil Gator, PVC gloves, safety goggles, 1 Plug N' Dyke (or similar), 1 poly drum 55 gallon, 8 garbage bags			
Driver stays at nozzle while delivering fuel or fuelling equipment/vehicles?			
Spent sorbents removed?			
Lighting functions?			
Other observations			
Fuel Storage			
Inspection Area	**Y**	**N**	**Actions Required**
Area free of garbage?			
Signs of spillage/staining?			
Pumps, hoses, piping leaking?			
Signs of deterioration on hoses, connections nozzles?			
Spent sorbents picked up and removed?			
Water or oil level visible in containment under hoses, pumps, nozzles?			
Barrier protection intact and in place?			
Other Observations			

STORAGE TANKS AND FUELLING FACILITIES INVENTORY

Wildfire Main Diesel Dispensing Facility

Contents	diesel
Volume	16,000 litres/7,000 litres
Year Manufactured	1997
Type	double-walled/2 compartments ULC – S601
Collision Protection	4 cement lock blocks
Monitoring	no vacuum registers
Fire Extinguishers	1
Spill Kits	1 at tank
Hoses	retractable hose reel
Nozzles	auto-shutoff in holster with spill compartment
Labelling	placard and contents
Lighting	not explosion-proof (light bulb on cord)
Signage	No Smoking, Fueling Procedure, Spill Procedure
Security	fill box with secure lid, unlocked
Transfer Area	sediment, no concrete, no liner
Spills/Waterways	no drainage to water courses
Remote Shut-offs	no
Grounding	no

Comments

An electric pump on the tank top dispenses fuel via a nozzle on a hose reel. Filling is done directly from the top hatch.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Wildfire Gasoline Dispensing Facility

Contents	gasoline
Volume	4,630 litres
Year Manufactured	May 2011
Type	CAN/ULC – S601-07
Collision Protection	four concrete blocks
Monitoring	plug access at bottom
Fire Extinguishers	1
Spill Kits	1 kept at tank
Hoses	not retractable, no reel or hooks
Nozzles	auto-shutoff nozzle with drip containment
Labelling	placards and contents
Lighting	none at tank, remote in yard
Signage	No Smoking, Fueling Procedure, Spill Procedure
Security	fill box with secure lid
Transfer Area	sediment/gravel, no concrete, no liner
Spills/Waterways	no drainage to water courses
Remote Shut-offs	no
Grounding	yes

Comments

An electric pump on the tank top dispenses fuel via nozzle. Filling is done directly from the top hatch.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Wildfire Stationary Generator Fuel Tank and Dispensing Facility

Contents	diesel
Volume	4,530 litres
Year Manufactured	2011
Type	double-walled CAN/ULC-S601-07
Collision Protection	4 concrete blocks
Monitoring	plug access at bottom
Fire Extinguishers	1
Spill Kits	1 kept at tank
Hoses	hoses connect tank to generator
Nozzles	N/A
Labelling	placards and contents
Lighting	none at tank, remote in yard
Signage	No Smoking, Fueling Procedure, Spill Procedure
Security	fill box with secure lid
Transfer Area	sediment/gravel, no concrete, no liner
Spills/Waterways	no drainage to water courses
Remote Shut-offs	no
Grounding	yes

Comments

Tank supplies fuel to the main and backup diesel power generators at Wildfire Camp.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Knipple Transfer Area Fuel Storage and Dispensing Facility

Contents	diesel/gasoline
Volume	150,000/ 9,100 litres Diesel and 9,100 litres Gas
Year Manufactured	2016
Type	double-walled CAN/ULC-S601-07
Collision Protection	concrete blocks
Monitoring	plug access at bottom
Fire Extinguishers	2
Spill Kits	2 kept at tanks, multiple within 200m
Hoses	Arctic fuel hoses with break-away valves
Nozzles	Auto shutoff
Labelling	placards and contents
Lighting	Yes on at bulk transfer station, remote in yard
Signage	No Smoking, Fueling Procedure, Spill Procedure
Security	fill box with secure lid
Transfer Area	Lined and plumbed to oil water separator
Spills/Waterways	no drainage to water courses
Remote Shut-offs	yes
Grounding	yes

Comments

Smaller tanks supply mobile equipment and light vehicles while larger tank is temporary storage for transfer to Brucejack Mine Site.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

KM 58.5 Diesel Dispensing Facility

Contents	diesel
Volume	14,950 litres
Year Manufactured	2011
Type	double walled, CAN/ULC – S601-07
Collision Protection	4 concrete blocks
Monitoring	plug access at bottom
Fire Extinguishers	Yes
Spill Kits	1 kept at tank
Hoses	not retractable, no reel or hooks
Nozzles	auto-shutoff with nozzle containment
Labelling	placards and contents
Lighting	yes
Signage	No Smoking, Fueling Procedure, Spill Procedure
Security	fill box with secure lid
Transfer Area	sediment/gravel, no concrete, no liner
Spills/Waterways	N/A
Remote Shut-offs	no
Grounding	yes

Comments

Fueling station to serve glacier maintenance equipment. Adjacent to tank is a “Level B” Remote Spill Supply Cache.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Procon Diesel Dispensing Facility

Contents	diesel
Volume	25,000 litres
Year Manufactured	2012
Type	double-walled CAN/ULC-S601-07
Collision Protection	5 concrete lock blocks protect tank
Monitoring	Access cap for visual assessment
Fire Extinguishers	1
Spill Kits	2 at tank
Hoses	coiled on hooks
Nozzles	manual in holster with spill compartment
Labelling	placard only, no contents
Lighting	explosion-proof on adjacent building
Signage	no
Security	fill box/secure lid not used; pressure relief valve and bung hole used to fill tank
Transfer Area	sediment, no concrete, no liner
Spills/Waterways	no drainage to water courses
Remote Shut-offs	no
Grounding	no

Comments

A wooden shed houses a fuel pump driven by an electric motor that delivers fuel from ISO-containers to the tank via a hose system. Diesel from the tank is dispensed from a hose kept on a rack.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Pretium Diesel Dispensing Facility

Contents	diesel
Volume	45,000 litres
Year Manufactured	2016
Type	double-walled CAN/ULC-S601-07
Collision Protection	4 concrete lock blocks protect tanks
Monitoring	vacuum
Fire Extinguishers	1 in shed
Spill Kits	1 at tanks
Hoses	retractable fuel dispensing hose
Nozzles	manual in holster with spill compartment
Labelling	placard on each tank end, no contents
Lighting	explosion-proof on shed
Signage	no
Security	fuel accepted via pump/hose/piping system
Transfer Area	sediment, no concrete, no liner
Spills/Waterways	drainage is possible to water course
Remote Shut-offs	no
Grounding	no

Comments

A wooden shed houses a fuel pump contained in a plastic berm and driven by an electric motor that delivers fuel from cubes via a hose and pipe system to the three tanks. Valves can then be turned to use the pump to deliver fuel from the tanks to equipment and vehicles. Diesel from the tanks is dispensed from a retractable hose.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Pretium Gasoline Dispensing Cube Tank

Contents	Gasoline
Volume	3,000 litres
Year Manufactured	2012
Type	tank within a box UN 31A
Collision Protection	2 concrete lock blocks
Monitoring	visual assessment
Fire Extinguishers	1 in shed
Spill Kits	1
Hoses	hose placed on top of lube cube
Nozzles	auto-shut-off
Labelling	placards , contents noted on 4 sides
Lighting	Explosion-proof on shed
Signage	No
Security	pressure relief cap inside secured lid
Transfer Area	sediment, no concrete, no liner
Spills/Waterways	water course down-gradient from tank area
Remote Shut-offs	No
Grounding	No

Comments

The pump within the fuel cube and that delivers fuel to the adjacent diesel tanks is powered by electricity generated at the mine site.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Pretium Diesel Tanks for Generators

Contents	Diesel
Volume	4 @ 150,000 litres
Year Manufactured	2016
Type	double-walled CAN/ULC-S601-07
Collision Protection	2 concrete lock blocks protect pump, tanks
Monitoring	vacuum
Fire Extinguishers	1 mounted on shed
Spill Kits	1 at tanks
Hoses	retractable fuel dispensing hose
Nozzles	manual in holster with spill compartment
Labelling	4 placards on each tank, no contents
Lighting	explosion-proof on shed, light bulb inside shed
Signage	no
Security	fuel delivered via pump/hose/piping system
Transfer Area	sediment, no concrete, no liner
Spills/Waterways	drainage is possible to water course
Remote Shut-offs	no
Grounding	yes

Comments

A wooden shed houses a fuel pump contained in a plastic berm and driven by an electric motor that delivers fuel from cubes via a hose and pipe system to the two tanks. A piping system then delivers fuel to the generators.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Pretium Jet A-1 Fuel Tank

Contents	Jet A-1
Volume	31,000 litres
Year Manufactured	2018
Type	double-walled ULC-S601-14
Collision Protection	yes
Monitoring	
Fire Extinguishers	1
Spill Kits	yes
Hoses	hose reel
Nozzles	auto shut-off, stored in bunghole of drum
Labelling	placards , contents
Lighting	no
Signage	no
Security	open cam-lock connector on top of tank
Transfer Area	HDPE liner plumbed to Oil Water Separator
Spills/Waterways	water course is down-gradient from tank
Remote Shut-offs	no
Grounding	No, bonding wire is present

Comments

The pump for jet A-1 consists of a self-contained ISO-Container set on top of a lined pad plumbed to an oil-water separator.

STORAGE TANKS AND FUELING FACILITIES INVENTORY

Slip Tanks and Fuel Cubes – Wildfire, Bowser, Brucejack

Slip tanks are used at the Wildfire, Bowser, and Brucejack sites that vary in size from less than 450 L to greater than 450 litres. These are grounded and bonded when they accept and deliver fuels including diesel and gasoline. All tanks are labelled and placarded.

Pressure caps are secured and locked when not in use.

All slip tanks are properly secured to vehicles that transport them on site.

APPENDIX E

Spill Response Training Exercises

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SPILL RESPONSE TRAINING AND EXERCISES

INTRODUCTION TO TRAINING NEEDS

Pretium Resources Inc. (Pretium) and/or its contractors, as appropriate and needed, will continue to implement the following training-related needs:

- Design and implement a training program that certifies employees who handle fuels and chemicals to be capable of effectively dealing with the containment of fuel and chemical spills. All relevant Pretium employees and contractors involved with fuel and chemicals or other materials handling and transport for the Mine are to be trained in spill prevention and response.
- Review credentials of contractors and employees to ensure that they meet Pretium requirements before issuing a certificate authorizing them to dispense fuel or handle chemical reagents.
- Establish and maintain a register of persons who have successfully completed training and have been awarded certificates.
- Ensure that all persons attending site orientation are shown spill containment and treatment materials and where they are located. Managers and supervisors will also ensure that the proper procedures for transferring and handling fuel and chemicals from tanks, totes, and small containers and the proper use of fire extinguishers, are demonstrated during the site orientation, for those individuals whom it is applicable to.
- Ensure that any driver delivering propane, fuel, or chemicals to the site has had appropriate training and issue him/her a certificate following site orientation.

SCHEDULE OF TRAINING AND PRACTICE DRILLS

Pretium spill Prevention and response training will outline the following:

- Provide details of the training courses for personnel involved in preventing and responding to an emergency.
- Specify the amount, type and frequency of training for each member of the team.
- Note when training should be provided (i.e., new employee orientation, change of duties for existing employees, new equipment/materials, revised emergency procedures, when a practice drill is improved).
- Establish regular practice drills, mock exercises.

Training Program

Response personnel will be trained by a qualified instructor(s) in all aspects of their roles and responsibilities as well as spill prevention, cleanup, and the reporting procedures to be followed during a spill. A training course will include the following elements:

- Spill Response Plan
- Reporting Requirements
- Emergency Contacts
- Responsibilities of Personnel
- Sources and Causes of Spills
- Fate and Impacts of Spills
- Hazards, Risks and Prevention
- Health & Safety Aspects
- Containment Options
- Control and Cleanup Methods
- Storage and Disposal
- Post-Spill Activities
- Spill Response Exercise

Personnel working with hazardous materials will be required to take a spill response and prevention course that provides training on spill response. A mock emergency response exercise is to be conducted at least on an annual basis to ensure the availability and readiness of internal emergency response services. Any deficiencies or suggestions to improve the emergency procedures will be noted and incorporated into this plan. Level A and B chemical suits and SCBAs will be included.

Training may be held in conjunction with other companies, agencies, and organizations involved in emergency planning and response. Training will usually reflect countermeasures that can be applied in a relatively small operation. Cleanup Supervisors and crews will also receive training at industry or government training seminars, as appropriate and available. Both training and exercise records will be kept at the mine site Smithers and offices. Personnel attending the training program will receive a certificate indicating the date and type of training.

TRAINING COURSE OUTLINE

Title

Effective Oil and Chemical Spill Prevention & Response

Objectives

Upon completion of the course, attendees will be able to respond safely and effectively to oil spills, using equipment located at the Brucejack Mine Site, as well as additional equipment which might be required from other locations, such as skimmers, pumps and storage tanks.

Module 1 Spill Response Planning

- sources and causes of fuel and chemical spills
- physical and chemical properties fuels and chemical reagents
- fate and behaviour
- impacts on natural resources and property
- response priorities

Module 2 Prevention

- introduction
- site assessment
- upgrading existing facilities
- self-assessment procedures and checklist

Module 3 Administration

- reporting requirements and procedures
- regulations
- record keeping
- contingency plan/Spill Reporting Information form

Module 4 Health and Safety

- health risks and hazards
- spill response safety guidelines
- personal protection equipment
- site security

Module 5 Containment

- spills on land
- spills into small watercourses
- spills into water
- spills on ice and snow including glacier

Module 6 Neutralization/Recovery

- using neutralization methods on chemicals
- selecting recovery methods (manual and mechanical)
- skimmers
- sorbents
- controlling spills in creeks, streams, rivers, lakes

Module 7 Transfer

- application of pumps including chemical-rated units
- hoses and connections
- selection criteria
- main pump types
- vacuum systems

Module 8 Storage and Disposal

- overview
- separation of wastes/labelling
- selecting storage options
- waste reduction
- disposal options
- regulations

Module 9 Post-spill Activities

- cleanup options
- site remediation
- personnel decontamination
- equipment cleaning and maintenance
- debriefing and equipment review

Prerequisites

The course is intended for all company and contractor personnel who are involved in the transfer of fuel and chemicals and/or are part of the Spill Response Team. All attendees are expected to be familiar with the company's emergency response plans and any health and safety guidelines.

Duration

The course will take four to six hours to complete and include classroom and field sessions with spill countermeasures and personal protective equipment suitable for fuels and chemicals.

Training Supplier

Training will be provided by a qualified spill response training company.

Location

Training will be conducted at a site where classroom and fieldwork can be conducted.

Instructors Qualifications

The instructors chosen to conduct the training will be fully qualified in oil and chemical spill response and prevention methods.

INITIAL SPILL RESPONSE TRAINING

Initial spill response training was conducted at the Brucejack Project, and was based upon an audit of all the Bruecjack fuel facilities and site facilities viewed in June 2014. Subsequent third party training occurred in 2016, 2017 and 2018. The training consisted of the following components:

Spill Response Overview (90 minutes)

a. Overview of Assess
b. Legislative Requirements
c. Chemical Characteristics
d. Safety
e. Spill Response Scenarios (Water)
f. Spill Response Scenarios (Land, snow, and ice)

Practical Session - Spill Response *(90 minutes)*

g. Legislative Review & Fines
h. Chemical Characteristics
i. Safety
j. Assessments
k. Response Actions
l. Cleanup and Remediation
m. Disposal

1. Legal

Reportable pills

- Internally vs. Externally
- Spill Reporting Regulation – *Volume Based*
- Deleterious Products – *Product Based*

Due Diligence

A legal defense that you took reasonable measures to prevent the incident from occurring.

- Prevention
- Preparedness
- Risk Reduction
- Impact Reduction

2. Chemical Characteristics

- WHMIS
- MSDS
  - Flash Point: The temperature at which a product will emit sufficient vapours and could ignite.
  - Gasoline (-40°C)
  - Diesel (40°C)
  - Lube Oil (80°C)
- Rules of Thumb
  - *Evaporation*
  - *Dispersion*
  - *Dissolved*

3. Response Actions

Assessments

- Spill
  - Source
  - Product
  - Size/Volume
  - Cause/Effect
- Safety
  - Personal Protection
  - Fire/Explosive Risk
  - Site Security
  - Legal Obligations
- Environment
  - Water: Assessment

  - Land: Assessment
  - Air: Assessment
  - Environmental Sensitive Areas
  - Minimize Impact on the Environment

Initial Actions

- Stop the spill
  - Plug
  - Shut off valves/pumps
  - Shift or move tank
- Contain the spill
  - Culvert Blocks
  - Tarp Containment
  - Under Flow with PVC Pipes
  - Sandbag Diversion
  - Containment booms
  - Watergate®

Notification

- Notify Internal/ External
- Notify EMBC (formerly PEP)

Recover and Mop-up

- Recovery Equipment
- Sorbent Pads
- Sphagsorb (peat moss)
- Oil Gator (cotton seed)

Disposal

- Burner/Open Burn
- Treatment - Phytoremediation
- Bioremediation
- Waste Disposal Company

TRAINING AND AWARENESS FOR CHEMICAL REAGENTS

Pretium employees who may deal with hazardous materials will receive specific awareness training to maximize the safe management of these products. Employee training will consist of an

education program for all employees (including operators, emergency responders, and security personnel) who have access to or work in areas containing or processing hazardous materials:

- Pretium will oversee the design and supervision of the training programs to address the wide array of reagents and the specific hazard levels present at each specific facility.
- The training will include proper handling, equipment operation, and emergency procedures as well as the consequences of failing to follow the procedure.
- Pretium provides training for all new employees. Refresher programs are also provided, as needed, for current employees and contractors.

In general, the program includes:

a. The hazards created by the materials in use.
b. The proper operation or shutdown of the equipment under normal and emergency conditions. Critical procedures would be printed and posted for quick reference.
c. Proper material handling procedures (i.e., bonding/grounding, self-closing valves, safety bungs, spill cleanup, etc.).
d. Hazardous liquid piping system operation and shutdown including the location of all local and remote shutoff valves.
e. Proper hazardous material transfer and dispensing procedures.
f. The location, proper type and proper use of fire extinguishers, neutralizers and other materials for the hazard present.
g. Fixed extinguishing systems operation and function.

Additional procedures are addressed in training to deal with fires, spills, and other hazards:

- storage containers (types, features, means of closing, labeling, materials of construction)
- control of ignition sources and limiting storage of fuels and chemicals
- incompatible materials/segregation
- use and maintenance of engineering controls used in the workplace (such as ventilation)
- required personal protective equipment (PPE) for handling hazardous materials
- fire protection and prevention
- special circumstances (e.g., confined spaces, hot work) requiring added precautions and training
- other emergency procedures (medical, evacuation, etc.).

In addition to routine site orientation, employees and contractors will be guided through the Hazard Identification process which covers fire prevention and response, hot work, and chemical hazards.

APPENDIX F

BJ-ENV-SOP-025 Hydrocarbon Fuel Spill Response

BRUCEJACK MINE

Spill Response Plan

Objective

To provide a standard operating procedure for controlling and cleaning hydrocarbons (i.e., diesel, gasoline, hydraulic oil, Jet A-1, lube oil, and waste oil) spills at Pretivm facilities.

Scope

This SOP applies to all Pretivm employees and contractors working at Pretivm facilities who encounter hydrocarbon spills. Specific clean-up instructions are provided for various hydrocarbons in different media. A spill report template is provided in Appendix A. A simplified spill response flow chart is provided in Appendix B, and some examples of spill response techniques are presented in Appendix C. Spill supplies available in the yellow and red spill kits are presented in Appendix D.

Relevant Regulations

Applicable legislation and regulations include the following:

- BC Fire Code 2006; Office of Fire Commissioner Interpretation Bulletins
- Fire Services Act
- Fisheries Act
- Motor Vehicle Act
- Transportation of Dangerous Goods Act and Regulation
- ULC/CSA standards
- BC Water Act
- BC Environmental Management Act:
- Petroleum Storage and Distribution Facilities Storm Water Regulation
- Hazardous Waste Regulation
- Spill Reporting Regulation
- Workplace Hazardous Materials Information System (WHMIS)
- BC Mines Act
- Environmental Code of Practice for Aboveground and Underground Storage Tank Systems
- Containing Petroleum and Allied Petroleum Products (Canadian Council of Ministers of the Environment (CCME)), Document PN1326,2003
- BC Fuel Guidelines, 6th Edition February 2014, Northwest Response Ltd.
- BC Guidelines for Industry Emergency Response Plans updated July 2002

Definitions

Hydrocarbon – fuel substances including diesel, hydraulic oil, Jet A-1, lube oil, waste oil, and gasoline.

Preparation

Hazards by Hydrocarbon Type

Diesel

- Combustible liquid
- Vapours heavier than air form at high temperatures and may persist in depressions

- Empty containers can contain explosive vapours
- Toxic gases form upon combustion
- Eye contact causes irritation.
- Diesel can accumulate static electricity charges.
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.

Gasoline

- Flammable liquid
- Vapours instantaneously form that are heavier than air
- Empty containers can contain explosive vapours.
- Vapours can travel to distant sources of ignition and flash back
- Eye contact causes irritation
- Gasoline can accumulate static electricity charges
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness

Hydraulic Oil

- Flammable liquid
- Vapours are heavier than air and may persist in depressions
- Toxic gas can form in fire and at high temperatures
- CO, CO2 and dense smoke are produced upon combustion
- Material can accumulate static charges
- Oil mist or vapour from hot oil can cause irritation of the eyes, nose, throat and lungs

Jet A-1

- Flammable liquid
- Vapours heavier than air form at high temperatures and may persist in depressions
- Empty containers can contain explosive vapours
- Toxic gases form upon combustion
- Eye contact causes irritation
- Jet A-1 can accumulate static electricity charges when stored and transferred
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness

Lube Oil

- Flammable liquid
- Toxic gas can form in fire and at high temperatures
- CO, CO2 and dense smoke are produced upon combustion
- Material can accumulate static charges
- Hot oil vapours can irritate the eyes, nose, throat and lungs

Responsibilities

Mine Manager or Designate:

- Ensures this SOP is implemented and maintained.
- Ensures on-site personnel have up-to-date information regarding this SOP.

Departmental Manager / Supervisor:

- Ensures on-site personnel have up-to-date information regarding this SOP.

Health and Safety Manager/Coordinator:

- Monitors the implementation of this procedure.

Environmental Superintendent / Coordinator:

- Monitors the implementation of this procedure.

Personnel performing this task:

- Follow this SOP as outlined and directed by the appropriate departmental Supervisor.

Employees:

- Follow this SOP as outlined and directed by the appropriate departmental Supervisor.

Procedure

For all spills, use the appropriate spill supplies provided in the various spill kits located in vehicles and around site. Remember to place used spill materials in yellow Hazmat bags and dispose of the bags in blue Terrapure bins (if available).

DIESEL, HYDRAULIC OIL, JET A-1, LUBE OIL, WASTE OIL

- Begin spill response procedure ONLY IF SAFE to do so.
- Eliminate ignition sources (turn of vehicle engines and NO SMOKING).
- Stop spill source if safe to do so.
- Block entry of spills into waterways by building berm or trench.
- Wear PPE (impervious clothing, Nitrile or Viton gloves, footwear and goggles).
- Avoid contact with solvents and all other chemicals.
- Plan for and request additional cleanup assistance, if required.

Spill on Land

- Contain with earth berm, spill socks, or other barrier.
- DO NOT flush into any ditch or drainage system that leads to water.
- Mark off large spill perimeters with spray paint, flagging, or pylons.
- Remove minor spills with WHITE sorbent pads.
- Remove large spills with pumps or vacuum equipment.
- Excavate ALL contaminated materials with shovel or excavator and place contaminated materials in marked sealed containers (if available, clean up materials should be placed in blue Terrapure bins). Transfer and placement of large quantities of contaminated soil/gravel will be determined under the direction and permission of the Environmental Supervisor.

Spill on Lakes/Ponds

- Use sorbent boom or socks to contain spills, if possible (booms will not contain oil in fast flowing, turbulent water).
- On small spills, use WHITE sorbent pads to pick up contained oil.
- On larger spills, obtain and use pump or skimmer on contained slicks.

Spill on Rivers/ Streams

- Intercept moving slicks in backwater or quiet areas using sorbent booms, logs or other containment device, as available.
- Spills from fuel trucks should be contained as close to the source as possible especially along the access road to Bowser.
- Do not use sorbent booms/pads in fast currents and turbulent water.

Spill on Ice/Snow

- Block entry into waterways and contain with snow or other barrier.
- Trench or ditch to intercept or contain oil on snow, where possible.
- Mark off spill perimeter with spray paint, flagging, or pylons.
- Construct a dike with snow, either manually with shovels or with heavy equipment such as graders, dozers, and Snowcat, where available.
- Remove contaminated snow to designated area.

Storage/ Transfer

- Use a pump to transfer recovered fluid to a holding tank or drums.
- Store closed, labelled containers outside away from flammable items.
- Electrically ground containers and vehicles during transfer.
- Do not transfer petroleum products near waterways.

Disposal

- Segregate waste types.
- Place contaminated materials in marked sealed containers (if available, clean up materials should be placed in blue Terrapure bins). Transfer and placement of large quantities of contaminated soil/gravel will be determined under the direction and permission of the Environmental Supervisor.
- Consult Environmental Department on transportation and disposal needs.

Reporting

- Complete a Spill Report Form (Appendix A)
- Submit report to area Supervisor and Environmental Department

GASOLINE

- Begin spill response procedure ONLY IF SAFE to do so.
- Gasoline can form vapours that will ignite and explode!
- NO SMOKING – Eliminate ALL ignition sources.
- Stop spill source, if safe to do so.
- Wear PPE (impervious, chemical-resistant clothing, nitrile gloves, footwear, and goggles).
- Avoid contact with acids, hydrogen peroxide, and fuels.

- Static charge can build during transfer – ground and bond when transferring.
- Monitor for explosive atmosphere.

Spill on Land

- Block entry into waterways by diking with earth or other barrier(s).
- DO NOT flush into ditches or drains that lead to waterways.
- Do not contain spill if there is any chance of igniting vapours.
- Mark off larger spill perimeters with spray paint, flagging, or pylons.
- Remove minor spills with sorbent pads and rolls.
- On shop floors, apply particulate sorbents.

Spill on Lakes/Ponds

- Do not attempt to contain or remove spills.
- Sometimes distributing gasoline with water spray is the safest action.
- Sorbent booms could be deployed to deflect slicks from sensitive areas, if safe to do so.

Spill on Ice/Snow

- Block entry into waterways and contain with snow or other barrier.
- Trench or ditch to intercept or contain fuel on snow, where feasible.
- Mark off spill perimeter with spray paint, flagging, or pylons.
- Constructing a dike or dam out of snow, either manually with shovels or with heavy equipment such as graders and dozers where available.
- Remove contaminated snow to designated area and place contaminated materials in marked sealed containers (if available, clean up materials should be placed in blue Terrapure bins). Transfer and placement of large quantities of contaminated soil/gravel will be determined under the direction and permission of the Environmental Supervisor.

Storage/ Transfer

- Store closed, labelled containers in cool, well-ventilated areas away from fuels and acids. Add inert material (sand) to eliminate explosive atmosphere.
- Electrically ground containers and vehicles during transfer.
- Do not transfer petroleum products near waterways.

Disposal

- Segregate waste types, if necessary.
- Place contaminated materials in marked sealed containers (if available, clean up materials should be placed in blue Terrapure bins). Transfer and placement of large quantities of contaminated soil/gravel will be determined under the direction and permission of the Environmental Supervisor.
- Consult Environmental Department on transportation and disposal needs.

Reporting

- Complete a Spill Report Form (Appendix A).
- Submit report to area Supervisor and Environmental Department.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Manager of Environment and Regulatory Affairs	Robin McCall	[redacted]	
Environmental Superintendent	Torence Sandhals		
Health and Safety Manager/ Designate	Tom Cheveldave		
Mine Manager / Designate	George Friesen		
Access Road and Lower Camps Manager / Designate	Tim Bates		
JOHSC Co-chair or Member	Travis Beebe		

Appendix A – Spill Report Form

PRETIVM

BRUCEJACK PROJECT
SPILL REPORT FORM

SPILL REPORT #

1	DATE OF SPILL:	TIME OF SPILL (24 hr):
2	LOCATION OF SPILL (PROVIDE GPS COORDINATES IF NECESSARY):	SITE CONDITIONS (TEMPERATURE, WIND, GROUND PERMEABILITY ETC.):
3	SAFETY HAZARDS (FIRE, FUMES, EXPLOSIVE SUBSTANCE, ETC.):	
4	TYPE OF PRODUCT SPILLED: OIL ☐ GASOLINE ☐ DIESEL ☐ OTHER ☐ _____ QUANTITY RELEASED (IN LITRES):	
5	CAUSE OF THE SPILL (E.G., BROKEN HOSE, VEHICLE ACCIDENT):	
6	ACTIONS TAKEN TO DATE TO CONTAIN, RECOVER OR DISPOSE OF THE SPILLED PRODUCT AND CONTAMINATED MATERIALS:	
7	ENVIRONMENTAL RISK (WHAT IS THE DISTANCE TO NEAREST WATER BODY or SENSITIVE HABITAT):	
8	SAMPLES TAKEN:	
9	SUBSEQUENT ACTIONS REQUIRED TO CONTAIN, RECOVER OR DISPOSE OF THE SPILLED PRODUCT AND CONTAMINATED MATERIALS:	
10	RECOMMENDATIONS FOR IMPROVEMENTS/PREVENTATIVE MEASURES:	
11	COMPANY/CONTRACTOR INVOLVED:	FRONT LINE SUPERVISOR:

12	NAME OF PRETIVM ONSITE SUPERVISOR(S) AT THE TIME OF SPILL:	13	IS THE SPILL REPORTABLE AS PER TABLE 2.1-1 IN SPILL RESPONSE PLAN? YES ☐ NO ☐ IF YES, FILL OUT BOX 15. IF NO, STOP AFTER BOX 14.

14 INTERNAL REPORTING SEQUENCE:

FIRST OBSERVER:

_____

COMPANY

REPORTED TO:

_____

NAME COMPANY Date Time

REPORTED TO ENVIRONMENTAL DEPARTMENT:

_____

TO WHO BY WHOM Date Time

REPORTED TO PRETIVM MANAGEMENT (MGM OR ALTERNATE):

_____

TO WHO BY WHOM Date Time

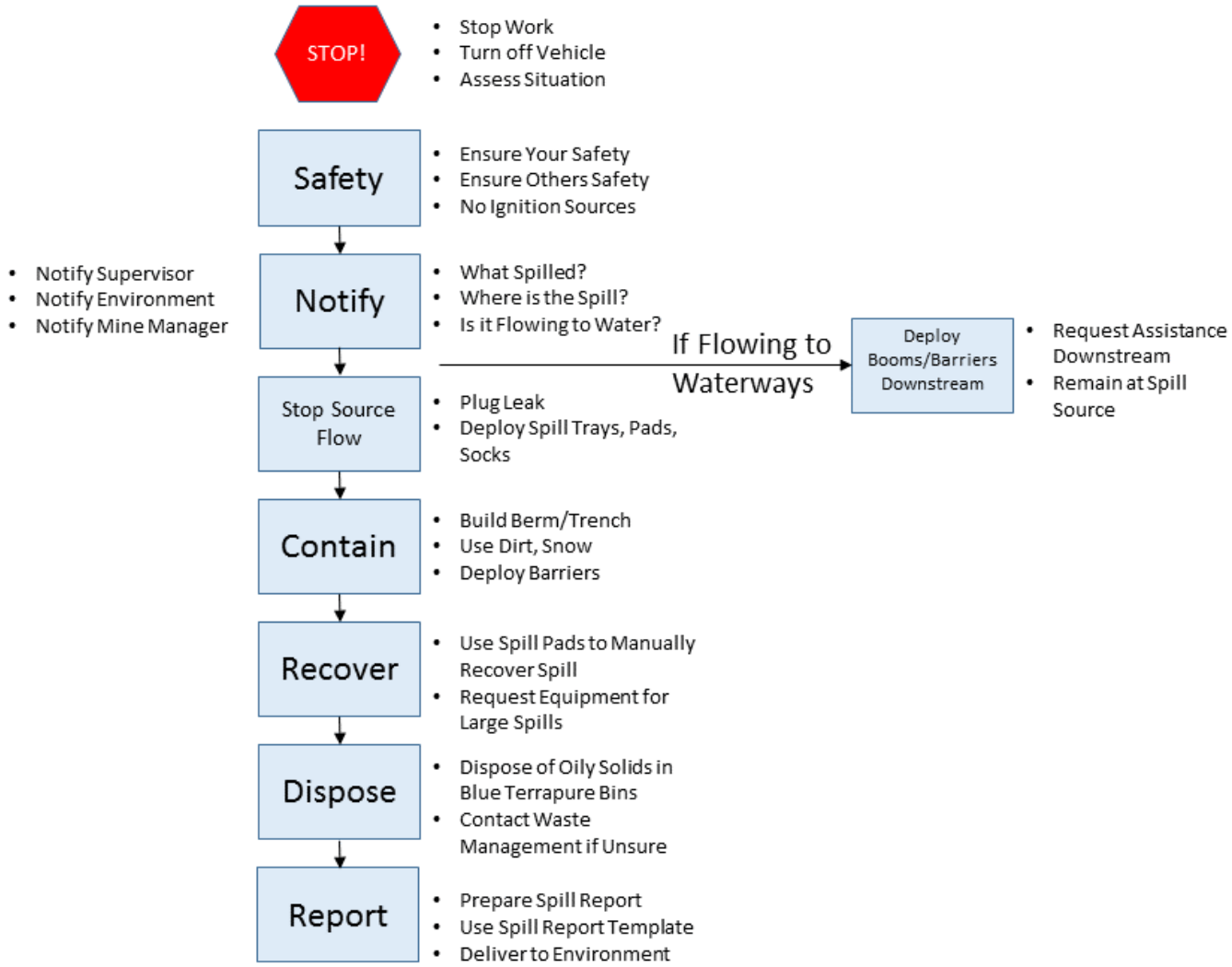
15 EXTERNAL REPORTING SEQUENCE:

REPORTED TO EMERGENCY MANAGEMENT BC PROGRAM 24-HOUR SPILL HOTLINE 1-800-663-3456:

_____

BY WHOM SPILL REPORT # TO WHO DATE/TIME

Appendix B – Spill Response Flow Chart

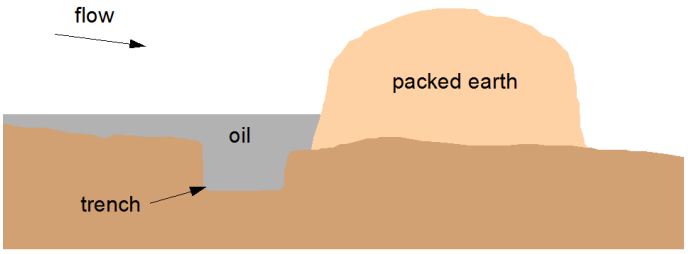


Appendix C – Spill Response Techniques

Response on Land

A trench should be dug downstream of the spill flow, following natural drainage channels, to catch the spill before it reaches a waterway. The material from the trench, along with other materials, can be used to construct an earth berm on the downslope of the trench.

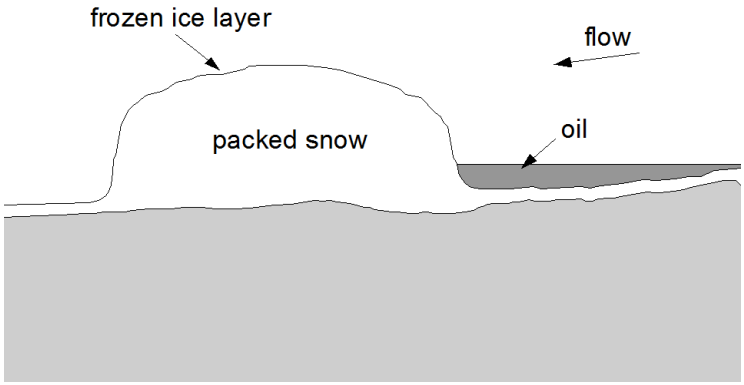
Earth Berm/Trench



Response in Ice and Snow

Snow provides a quick and efficient material to construct a berm. Snow should be piled in the direction of flow, compacted, and sprayed with water if possible, as ice will prevent further migration.

Snow Berm



Response in Creeks and Rivers

Linkable absorbent socks can be deployed across ditches or low flow creeks/streams where the spill enters the water. Additional linkable socks can be deployed downstream to ensure the spill is collected.

Containment booms are best deployed near the source of the spill, or where there is sufficient space and relatively low flow downstream. Hydrocarbons will collect upstream of the boom, where they can be collected with absorbent spill materials.

Appendix D – Spill Response Supplies

The following is a list of spill materials that are readily available at Pretivm facilities. Spill kits are stocked with absorbent materials (spill pads, socks, pillows) and Plug n'Dike.

Spill Material/Equipment		Description
Absorbent Materials		
White Absorbent Spill Pads		• Used to manually clean spilled hydrocarbons (diesel, hydraulic oil, gas) • Will not absorb water • Floats on water
Black/Grey Absorbent Spill Pads		• Used to manually clean water-based products and oils • All-purpose absorbent
Yellow Absorbent Spill Pads		• Used to manually clean spilled hazardous/chemical liquids • Absorbs acids, bases, and harsh chemicals
Absorbent Spill Socks		• Absorbent tubes used to prevent flowing spill material from migrating • Various sizes, and include white, black, and yellow variants, similar to spill pads (above) • Typically used on land
Linkable Absorbent Booms		• Absorbent booms that float on water, even when fully saturated • Linkable • Ideal for spills on calm water
Absorbent Pillows		• Absorbent pillows used to contain leaks and constant drips • Useful in tight spaces • Large absorption capacity
Containment		
Mini-Berms/Spill Trays		• Light berms to catch and contain leaks • Traps spills at the source
Barriers		

Inshore Containment Boom		• Lightweight boom to be deployed in sheltered waters • Prevents migration of spilled material • Deployed downstream of spill
Water-Gate Spill Barrier		• Inflatable dam to restrict water flow • Intercepts spilled material, reducing the recovery zone • Contains contaminant for clean-up
Miscellaneous		
Plug n'Dike		• Forms an immediate seal to control leaks and spills • Temporary repairs of drum/tank punctures

APPENDIX G

Northwest Fuels Limited Spill Contingency Plan

BRUCEJACK MINE

Spill Response Plan

Spill Contingency Plan

NORTHWEST FUELS LIMITED

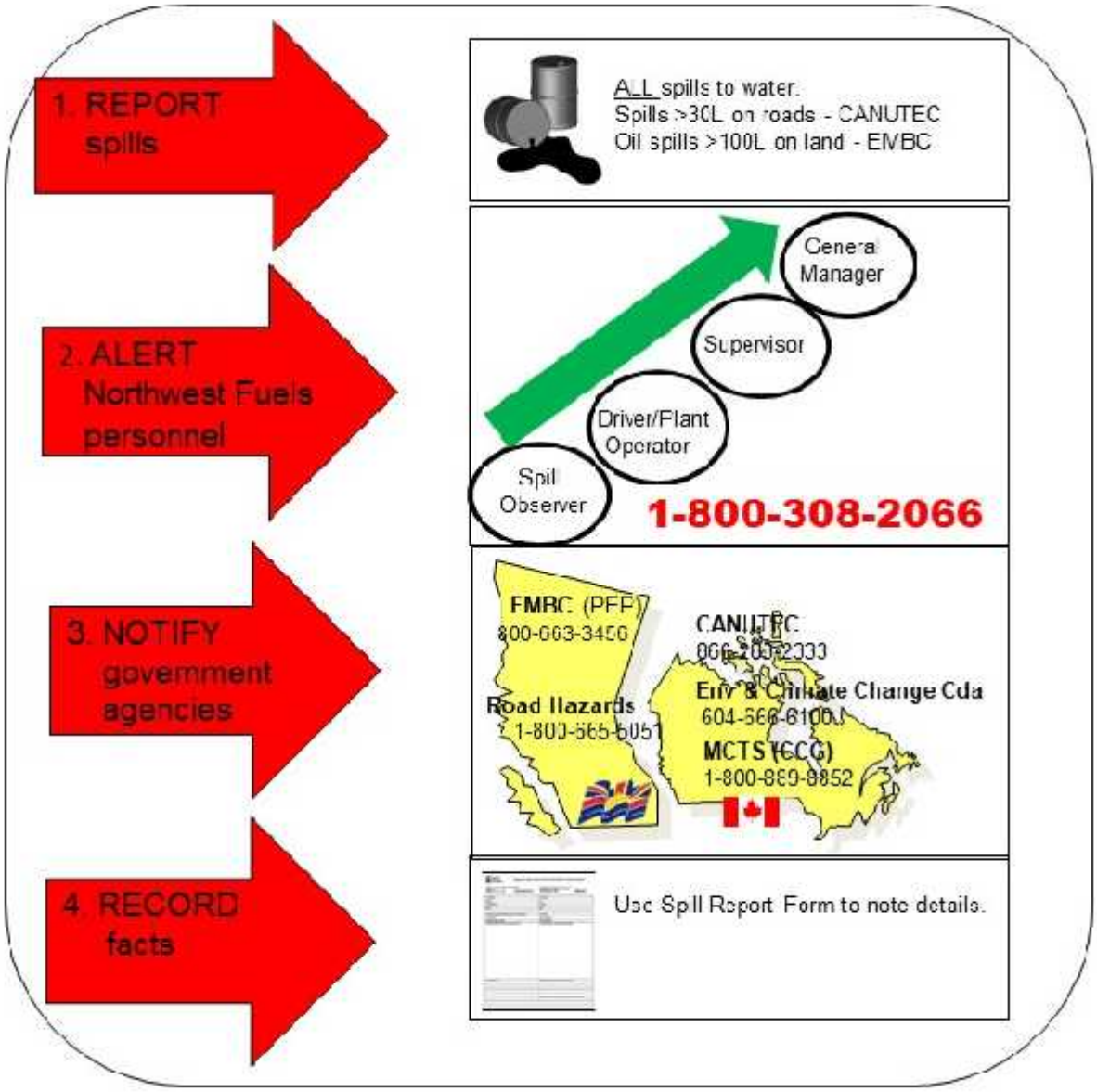
1 PREFACE

Response Action Chart

The Response Action Chart outlines the GENERAL STEPS to follow when a spill occurs. The actual actions taken will vary from situation to situation depending on the type and volume of substance released, the circumstances of the incident, and the nature of the receiving environment.

Alerting/Notification

ALL spills, regardless of size, must be reported to, and are recorded internally by, Northwest Fuels. Spills that threaten the environment, i.e., that are outside of containment and that require government notification are noted below. Refer also to Appendix A Contacts for phone numbers and to Section 12 Spill Response Procedures for more detailed countermeasures. NOTE: A spill to water includes a spill to pooled water or to a ditch leading to water.



Distribution

The following personnel must be familiar with this Spill Contingency Plan (SCP). Their ICS roles are indicated (see Glossary for acronyms). Printed hard copies are used for reference only. NOTE: Only the SCP on the Northwest Fuels website is considered to be fully up-to-date and current.

Location	Spill Role(s)	Primary/Alternate
Terrace	IC /ANY CHIEF	Ames, Doug
Terrace	IC /DC/LO/ERT	Ames, Angela
Terrace	IC/DC/SO/ OPS	Ainscow, Gary
Terrace	IC/DC/SO/ERT	Protzner, Bernie
Terrace	IC/DC/LO/ERT	Pruden, Dave
Terrace	IC/DC/OPS/ERT	Ames, Colby
Terrace	FO/ERT	Hernes, Erik
Terrace	IC/DC/SO/ ANY CHIEF	Bennett, Rob
Terrace	ERT/LO/IO	Ames, Avery
Terrace	ERT/LO/IO	Ames, Devynn
Terrace	DC/ERT	Leblond, Don
Terrace	DC/ERT	Obzera, Tim
Terrace	ERT MEMBER	Callieou, Pat
Terrace	ERT	Ippel, Alan
Terrace	ERT	Ruchotzke, Brad
Terrace	ERT	McGillivray, James
Terrace	ERT/IO/LO	Wafzig, Mike
Prince Rupert	IC/DC/IC CHIEF OPS	Gray, Mike
Prince Rupert	IC/DC/IC CHIEF OPS	Bergman, Peter
Prince Rupert	IC/LO/IO	Kovacs,Grace
Smithers	ERT/CHIEF OPS	Kuemper, Lorne
Smithers	IC/DC/OPS	Carroll,Shawna
Houston	ERT	Good, Deidre

Section 17 of the BC Spill Contingency Regulation requires that each truck transporting diesel, Jet A, and/or gasoline will be provided with sections of this plan that at a minimum indicate driver responsibilities relating to initial assessment, notification/reporting, and spill response. These are all included in detail in Section 12 Spill Response Procedures.

Declaration

Ministry of Environment and Climate Change Strategy

Declaration that the Spill Contingency Plan is true, accurate, and complete

As an authorized representative of the regulated person, I declare that a Spill Contingency Plan (SCP) has been prepared for the substance(s) for which the regulated person is defined as a regulated person under the *Environmental Management Act 2003*. I declare that the SCP is true, accurate, and complete and that Tables 1 and 2 below are complete and contain accurate information.

This declaration must be attached to the front of all copies of the SCP, including required sections in motor vehicles.

Regulated Person[1]:

Northwest Fuels Limited	Ainscow, Gary	General Manager
Legal company name	Surname, given name	Job title
		31-03-2019
	Signature	Date (day-month-year)

5138 Keith Avenue
Address
Terrace, BC

V8G 1K9

Designated contact[2]:

Northwest Fuels Limited	Ainscow, Gary	General Manager
Legal company name	Surname, given name	Job title
	gary@northwestfuels.ca	250-635-2066
	Email address	Phone number

5138 Keith Avenue
Address
Terrace, BC

V8G 1K9

[1] A director, officer, or partner, as appropriate, as outlined in section 3 (b) of the Spill Contingency Planning Regulation
[2] This is an individual who can be contacted directly regarding the SCP

April 2018 Page 1 of 2

Declaration (continued)

Ministry of Environment and Climate Change Strategy

Declaration that the Spill Contingency Plan is true, accurate, and complete

Table 1: Page numbers in the SCP where information that satisfies the requirements of the Spill Contingency Planning Regulation is available

Section of the SCPR	Page number(s) in SCP
Section 3 Contents of the SCP	12
Section 4 Hazard assessment	13 to 19
Section 5 Spill response planning map	20
Section 6 Equipment, personnel, and other resources	21 to 24
Section 7 Incident Command System	25 to 27
Section 8 Human health and safety	28-29
Section 9 Communication procedures	30 to 31
Section 10 Waste management	32
Section 11 Wildlife	32
Section 12 Spill response procedures	33 to 38
Section 13 Training	39

Note: multiple page numbers are required if content is located on more than one page of the SCP.

Table 2: List of substances that the SCP is capable of addressing

Common name	Classification	Volume in liters of the specified quantity (as defined in section 2 of the Spill Contingency Planning Regulation)
Diesel	CAN/CGSB-3.517-2015 Diesel fuel	50,000
Gasoline	CAN/CGSB-3.5-2016 Automotive gasoline	54,000
Jet A	[illegible]	50,000

Note: items are to be listed as they appear in the schedule section of the Spill Preparedness, Response and Recovery Regulation.

April 2018

Page 2 of 2

Log of Revisions

Section 9 of the Spill Preparedness Response and Recovery Regulation requires that changes to this spill plan be recorded with the date of the change and the reason for it. The plan is to be reviewed and revised annually as per the "Plan Review & Updating" section noted below.

Rev #	Date	Page Numbers and Reason for Revision	Initials

Plan Review & Updating

This plan will be reviewed and updated as deemed necessary by the Regulated Person as stipulated in **Section 15** of the Contingency Planning Regulation:

- Within one month of:
  - A significant change in the quantity or types of listed substances handled by the company that could increase the risk of a spill
  - A change in personnel that affects the Incident Command System
  - A significant change in equipment, personnel or outside help identified in this plan under the heading "Pre-Emergency Planning", subheading "Equipment, Personnel and Other Resources".
- At least annually with particular attention to:
  - Changes in contact information
  - New regulatory requirements (e.g. Federal: TDG; Provincial EMA)
  - New company processes
- Drill results and incident investigations that identify opportunities for improvement

Glossary

BC	British Columbia
DC	Deputy Commander
EMBC	Emergency Management BC (formerly Provincial Emergency Program – PEP)
ERT	Emergency Response Team (Northwest Fuels)
h	hour
IBC	Intermediate Bulk Container
IC	Incident Commander
ICS	Incident Command System
IO	Information Officer
km	kilometres
L	litres
LO	Logistics Officer
MCTS	Marine Communications & Traffic Services (Canadian Coast Guard)
MOE	BC Ministry of Environment and Climate Change Strategy
mm	millimetres
OHF	Oil Handling Facility: receives or dispenses 100 tonnes fuel annually over water
OPS	Operations Chief
PEP	Provincial Emergency Program
PPE	Personal Protection Equipment
SCP	Spill Contingency Plan
SCPR	Spill Contingency Planning Regulation
SDS	Safety Data Sheet
SO	Safety Officer
VHF	Very High Frequency (radio channel)
WCMRC	Western Canada Marine Response Corporation

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2.INTRODUCTION

Purpose & Scope

Purpose

The purpose of this Spill Contingency Plan is to:

1. Provide readily accessible emergency information to management, cleanup crews, and government agencies in the event of a spill;
2. Comply with our customers petroleum and hazardous waste management standards
3. Comply with federal, provincial, regional, and municipal regulations pertaining to the preparation of contingency plans and notification requirements
4. Promote safe and effective recovery of spilled materials
5. Minimize the environmental impacts of spills into water or land
6. Facilitate management of wastes according to environmental legislation

Scope

This plan addresses preparedness and procedures to mitigate the potential impacts as a result of releasing petroleum product or antifreeze to the ground or to an aquatic environment. Should such an event occur, the order of priorities when responding are:

1. Human safety (the general public as well as workers and emergency responders),
2. Infrastructure and property protection, and
3. Environmental protection (particularly the aquatic environment as that is the one most likely impacted by the products transported by Northwest Fuels)

Legislation

This plan is intended to ensure compliance with legislation regulating spill preparedness and response:

- Transportation of Dangerous Goods Regulations Canada
- BC Environmental Management Act and its Regulations
    - Spill Preparedness, Response and Recovery Regulation
    - Spill Reporting Regulation
    - Spill Contingency Planning Regulation

Substances

Because Northwest Fuels Limited transports diesel, gasoline, and Jet A by tanker truck in quantities greater than 10,000 litres the company is required to have a Spill Contingency Plan in accordance with the Spill Contingency Planning Regulation (SCPR) under the BC Environmental Management Act. Other substances that could be involved in a mishap are hydraulic fluid, lube oil and antifreeze that are stored in 200 litre drums and in 1,100 litre Intermediate Bulk Containers (IBCs)

Worst-Case Spill

Section 3 of the SCPR requires a worst-case scenario spill, i.e., the simulation of a spill of the maximum quantity that could be transported by a single motor vehicle, including trailers. Tanker trucks operated by Northwest Fuels have a capacity of 20,000 litres and may tow a 4-axle pup trailer with a capacity of 27,000 litres. A maximum capacity spill of the entire contents of gasoline would be 54,000 litres. The truck and pup tanks have individual compartments ranging in size from 1,400-to-12,000 litres with their capacities labeled at the top of each tank. Tank truck capacities are presented in Appendix D for the Northwest Fuels fleet of tank trucks including trailers.

A detailed spill scenario for a fuel truck incident with step--by-step- response procedures has been prepared for a higher probability event (see Appendix B).

Environmental Health & Safety Policy

Northwest Fuels Limited is committed to the protection of all its employees, customers and property. Accidental loss can be controlled through good management in combination with active employee involvement. Safety is the direct responsibility of all managers, supervisors, employees and contractors.

Northwest Fuels Limited is committed to reducing vehicle accidents and helping to ensure that all Northwest Fuels drivers and equipment are ready for all jobs they are assigned to. We hope to reduce maintenance costs and repairs of, and accidents involving, Northwest Fuels Limited vehicles.

To carry out this commitment **management** shall:

1. Provide a safe and healthy work environment which will meet or exceed industry standards and legislated requirements.
2. Eliminate or reduce any foreseeable hazards that could lead to injuries or property damage
3. Comply with safety and loss prevention requirements as they apply to the operation and maintenance of facilities and equipment.
4. Work with supervisors, employees, and drivers to resolve any safety concerns they may have.
5. Ensure that all drivers are qualified, trained, and certified.
6. Ensure that all employees are familiar with motor vehicle safety policies and procedures and accident/incident reporting requirements, and frequently check on their compliance.
7. Maintain all vehicles adequately for safe operation and ensure that only authorized personnel are allowed to operate vehicles.
8. Review each incidents/accident report to determine if the employee's actions were consistent with Northwest Fuels policies and procedures.
9. Ensure that unsafe vehicles are not driven until safety deficiencies have been corrected.
10. Determine what additional training or other positive action is required to deal with driver error.
11. Maintain complete records on fleet vehicle maintenance accidents.

To carry out this commitment **supervisors** and **employees** shall:

1. Perform their job to accepted standards in accordance with company policies, procedures and all legislated requirements.
2. Report any current or foreseeable hazards to management.
3. Report any incidents, accidents, or near-misses to management, regardless of how serious they may appear.

To carry out this commitment **employees driving** Northwest Fuels vehicles shall:

1. Operate trucks in a safe and responsible manner in compliance with the Northwest Fuels Limited *Driver Policy.*
2. Become familiar with and obey all motor vehicle safety policies and procedures, and provincial highway traffic rules and regulations.
3. Understand the "right to refuse unsafe work" legislated by WorkSafeBC OHS Regulation Section 3 and exercise this right when appropriate.
4. Do pre-trip and post-trip inspections and fill out "driver repair request form" when needed.
5. Report any current or foreseeable hazards to management whether on-site or during their delivery route.
6. Report all motor vehicle accidents/incidents immediately in accordance to the event reporting matrix.
7. Report immediate to supervisor any tickets or inspection reports given while operating a company vehicle.
8. Report immediately to management any suspension of driving privileges and cease to operate any fleet vehicle until his or her privileges are reinstated.

We pledge to continue improving our environmental, health and safety program and we trust that you will join us in our commitment to maintaining and operating a safe workplace and fleet of fuel trucks. Northwest Fuels Limited aims to not only meet current legislation and industry standards but strives to be a leader in our industry and adopt safety and loss prevention as a way of life.

3 CONTENTS OF THE SPILL CONTINGENCY PLAN

This Spill Contingency Plan contains Sections 4 to 13 as required by BC's Contingency Planning Regulation and as listed in the Declaration (see Preface). Information has been added to help guide responders.

1.Preface	Quick reference guide for responders: Response Action and Notification Charts Distribution List which includes ICS titles/roles Declaration by the Regulated Person Log of Revisions, Plan Review and Updating (Regulated Person) Glossary of terms used in the SCP Table of Contents
2.Introduction	Purpose & Scope Legislation regulating SCP preparation and spill response Substances of concern and worst-case spill Northwest Fuels Health, Safety & Environmental Policy
3.Contents of SCP	More detailed contents of SCP to facilitate finding information
4.Hazard Assessment	The risks of a worst-case spill along with impacts and mitigation measures
5.Spill Response Planning Map	Maps of the routes that Northwest Fuels tank trucks travel.
6.Equipment, Personnel & Other Resources	**C**ompany spill response trailer, equipment, responders.
7.Incident Command System	The primary roles in an ICS structure including IC and Officers.
8. Human Health & Safety	Specific toxicity and safety issues and mitigation for fuel spills.
9.Communication Procedures	Northwest communication protocols for spill response
10.Waste Management	External assistance Northwest will seek to comply with regulations
11.Wildlife	Brief indication of mitigation and external help Northwest will seek.
12.SPILL RESPONSE PROCEDURES	**Spill notification and reporting, 3 spill levels, initial response actions, Emergency Condition Report form**
13.Training	**O**utline of subjects covered that conform to MOE requirements
Appendix A Contacts	Emergency contacts for all areas Northwest transports fuel
Appendix B Response Tactics & Scenarios	Spill response tactics and detailed spill response scenarios
Appendix C Product Response Guides	Key data from SDSs for quick reference to help guide responders
Appendix D Tank Truck Capacities	Listing of volumes of tanks on Northwest Fuels tank trucks and trailers
Appendix E TDG Report	Report form for notifying Transport Canada of a spill

4 HAZARD ASSESSMENT

Hazards, Fate & Effects

Section 4 of the SCPR requires a hazard assessment and mitigation for all transported fuels. See also Section 8 Human Health & Safety. The hazards of diesel, gasoline, and jet fuel are similar with gasoline posing the highest risk of a fire or explosion. Appendix C Product Response Guides summarizes the properties, fire and spill response, and first aid measures for all substances that could be involved in a spill.

Hazardous Properties of Gasoline, Diesel and Jet A as per the Safety Data Sheets (SDSs):

- Gasoline: Highly flammable liquid and vapour (Average Flash Point -45°C)
- Diesel: Flammable liquid and vapour (Average Flash Point 40°C)
- Jet A: Flammable liquid and vapour (Flash Point 37.8°C)
- May be fatal if swallowed and enters airways causing pneumonia
- Causes skin irritation
- May cause drowsiness or dizziness
- Suspected of causing cancer
- Damages organs (eyes, blood) through prolonged or repeated exposure
- Considered toxic to aquatic life with long-term effects

Potential Hazards Associated with Fuel Spills

- *Fire* can start from spark, hot exhaust, static electricity and many other sources.
- *Explosions* can occur if the vapour/fuel mixtures reach critical levels.
- *Toxic g*asoline vapours can cause asphyxiation if sufficiently concentrated.
- Fuels are very *toxic* to most animals (both aquatic and terrestrial) when ingested or absorbed through the skin; plants in the spill area or along shores and banks of ditches may also be affected.

Other Substances

A release of lube oil and/or antifreeze (ethylene glycol) could pose toxicity concerns but not generally flammability hazards. Any release of either liquid would not be a component of a worst-case scenario but would require a response operation to contain and remove the spill as outlined in this SCP.

Fate & Behaviour of spills

The impacts of a worst-case spill are largely dictated by the nature of the receiving environment:

General Characteristics of Fuels When Spilled on Land:

- Fuels will usually *migrate* to a waterway, either on the surface or underground
- Soil *penetration* will depend on the permeability and moisture content of the soil (gravel, sand, clay, etc.). If the ground is sufficiently wet, the product will float on the water and soil penetration will be limited but surface migration will be more rapid. If the ground is dry, fuel will penetrate the ground more easily resulting in contaminated soil.

- Product that *seeps* into the ground may settle at the top of the water table and can reappear months later, some distance away, on the surface or in water well.
- Product release onto pavement or concrete will spread rapidly across the surface and *evaporate* quickly. Penetration into the concrete or pavement should be minimal if the spill is cleaned up quickly

General Characteristics of Fuels When Spilled on Water:

- Fuel will *spread* quickly across the surface of the water in a thin film or sheen.
- Fuel may *cover* a wide area, if uncontained.
- A fairly strong *odour* may be present even at non-toxic levels.
- Fuel will tend to *evaporate* fairly rapidly compared to thicker or more viscous oils.
- In a sheltered environment, evaporation of the product may be slow; evaporation and *wave action* are significant on small spills in a relatively high energy environment.
- Spilled fuel may form water-in-oil or oil-in-water *emulsions* or mousse.

Potential Impacts of Worst-Case Fuel Spill Scenario

On Human Health:

- A worst-case scenario would be a motor vehicle accident in a populated area on a hot day resulting in ignition and a large fire and possible explosion. In addition to the danger presented by the fire, workers and members of the public could be exposed to vapours at harmful concentrations from product evaporation, or more seriously, from product combustion.

On Infrastructure:

- A worst-case scenario for infrastructure would be similar where the motor vehicle accident and fire resulted in the destruction of a public structure or facility located adjacent to a roadway.

On the Environment:

- A worst-case scenario would likely be a motor vehicle accident resulting in the entire contents of a fuel truck being spilled into an aquatic resource such as a highly productive fish spawning or rearing area or marsh where endangered aquatic species might be present.

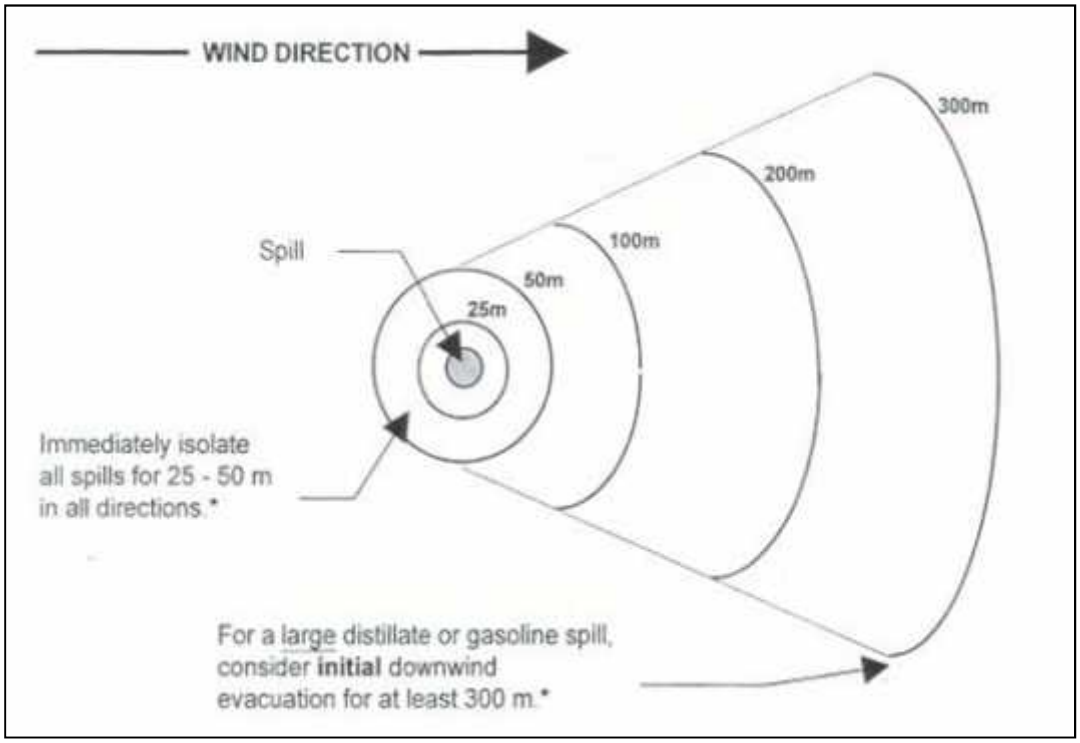
Mitigation

Evacuation

Should a large fuel spill occur, the immediate area around the spill site would be *isolated* and the downwind area temporarily *evacuated* until the level of risk is clearly and accurately assessed (i.e., type of product, size of spill, risk of fire/explosion). Unprotected emergency responders would not be allowed to enter the isolation zone.

NOTE: ***Evacuate*** means to move all people from the threatened area to a safer place.
Isolate means to keep everybody away from the area if they are not directly involved in response

The graphic on the following page shows the isolation and evacuation area for a large spill of gasoline, diesel or Jet A. The immediate evacuation zone will vary depending on the product spilled, migration of spill, prevailing wind speed, air temperature, and general weather conditions. The table that follows, shows the immediate isolation and initial evacuation distances for larger spills and also for fires involving large containers (tank trucks, storage tanks) for diesel, Jet A and gasoline (Source 1996 North American Emergency Response Guide (NAERG)).



Large Spill	Immediate Isolation Distances*	Initial Evacuation\Isolation Distances*
	25-50 m (all directions)	Consider initial evacuation for 300 m (downwind)
Large Container Fire	**25-50 m** (all Directions)	Isolate **800M** (all Directions) Consider initial evacuation for **800m** (all directions)

Safety Precautions

The following safety precautions would be taken by responders whenever approaching a spill site:

- ☐ **Never** rush in.
- ☐ **Verify the** type of product.
- ☐ **Assess** the risk of fire.
- ☐ **Confirm** wind direction.
- ☐ **Approach the** spill from an upwind direction.
- ☐ **Do not** walk or wade though spill material.
- ☐ **Use** appropriate personnel protective equipment.
- ☐ **Keep** unauthorized personnel away from the site.
- ☐ **Test** vapour levels regularly using available testing equipment.
- ☐ **Use** foam or fine water spray/water fog to suppress vapors if necessary.
- ☐ **Avoid** low-lying areas (e.g. ditches, culverts) and confined spaces since petroleum product vapors are usually heavier than air.

Risk Management – Spill Prevention

The prevention of incidents is a key part of Northwest Fuels risk management policy as outlined in its Fleet Safety Management Manual. The program addresses vehicle inspections, driver awareness, safety, and preventative maintenance and includes an annual road test and assessment of drivers as well as refresher training if deemed to be required. Northwest follows Petro-Canada's 1998 *Enhanced Marketer's Fleet Safety Manual "Full Circle" Fleet Safety Program.* This program covers all essentials for fleet safety from rules and regulations to the hiring of new drivers.

The Fleet Safety Manual is stored electronically and is modified to meet the needs of Northwest Fuels Ltd as these evolve:

Section 1 Leadership

1.1 Self-Assessment
1.2 Manual
1.3.1 Fleet Safety Policy
1.3.2 Fleet Safety Policy (Driver Sign-Off)
1.4.1 Safe Driving Procedures
1.4.2 Fatigue Management
1.4.3 Drug and Alcohol Policy
1.4.4 Working Alone
1.5 Driver Hiring
1.6 Recognition and Discipline Process

Section 2 Training

2.1.1 Training & Review Procedures
2.2.1 Refresher Training Frequency
2.2.2 Annual Road Tests
2.2.3 Provisions
2.2.4 Driver's Abstract
2.3.1 On-Site Refuelling

Section 3 Inspections

3.1.1 Pre-Trip Vehicle Inspections
3.1.2 Preventative Maintenance Inspections

Section 4 Emergency Preparedness

4.1.1 Emergency/Hazard Kits in Fleet Vehicles
4.1.2 Vehicle Emergency Response Plan
4.1.3 Emergency Contact List

Section 5 Event Reporting and Investigation

5.1.1 Event Management
5.1.2 Vehicle Investigation to Prevent Reoccurrence

Hazards of Spills Entering Water

Should there be a risk of a spill entering water, safety meetings are held to ensure personnel are aware of the specific risks involved and the means to mitigate these risks. Four forms itemize the procedures that are followed to minimize risks and the nature of the safety plan that results (source: WCMRC).

WCMRC Burrard Clean Operations/ Western Canada Marine Response Corporation

STOP and THINK!

Step 1 – Risk Assessment Step 2 – Tailgate Safety Meeting – Agenda Step 3 – Tailgate Safety Meeting - Record of Attendance

Customer:_____ Incident #: _____

Step 1 –Risk Assessment

Complete this risk assessment before the start of each shift (spill response) or when using the vessels (steady state). **Risks shall be reassessed any time conditions change.** Action plans to mitigate the hazards identified in the "Yes" column **MUST** be reviewed with all workers during the Tailgate Safety Meeting. Reference HS&LC Manual for "Critical Procedures".

Hazard	Yes	No	Suggested Control Measures
Hazardous materials			**Control measures are developed based on the Material Safety Data Sheet (MSDS)**
Inhalation: vapours, mists, fumes			Perform air monitoring and if required: mechanical ventilation, exclusion zones, respirators, SCBA.
Eye contact			Wear eye protection: safety face shield, safety goggles, safety glasses, eye wash stations.
Skin contact			Use chemically resistant: coveralls, gloves, special barrier cream. Clean exposed areas immediately.
Ingestion			Seek immediate medical attention.

Critical tasks

Is a Critical Procedure(s) to be reviewed prior to starting this job?
☐ Hot Work ☐ Confined Space Entry* ☐ Energy Lockout ☐ Crane Operations ☐ Working from a height
Procedures from HS&LC Manual must be followed

*** Confined space hazards: includes but not limited to barge/vessel tanks or holds, shoreline caves, under wharves or docks or logs, deep trenches.**

Weather hazards			
Tides, currents			Check tide charts and area currents, keep vessel crew and shoreline worker aware of changes.
Fog, ice, rain, snow, winds/waves			Maintain safe working distances, clear ice and snow from area of travel, wear appropriate PPE and/or clothing.
Darkness			Use portable lighting.
Hot or Cold weather			Stay hydrated (drink fluids), take rest breaks, warm-up breaks, use sunscreen, wear appropriate clothing.

Wind speed: knots	Wind direction:	Wave height: meters	Precipitation: ☐ Rain ☐ Snow
Air temperature: C	Current: knots	High tide at:	Low tide at:

General hazards			
Trips, slips and falls			Keep equipment, supplies, cords and/or air-lines out of the path of travel or secured; clean-up all oils, standing water, ice/snow or post warning sign; use handrails; secure ladders; maintain three-point contact when climbing or when on a vessel; take small, deliberate steps when walking in congested areas and along rugged shorelines.
Employee working alone			Communications **MUST** be done at four (4) hour intervals between worker and supervisor, and documented.
Working on or near water			PFDs **MUST** be worn at all times when working within 1m (3 feet) of the water unless protected by other means.
Person overboard			Be familiar with "overboard" procedures, location of life rings.
Abandon vessel			Be familiar with "abandon vessel" procedures, location and operation of survival suits and life rafts.
Repetitive motion injuries			Use different muscle groups and take rest breaks during repetitive tasks, vary tasks if possible.
Injuries from sharp material, needles, glass, etc.			Wear appropriate gloves, safety footwear. Make any cuts with blade facing away from the body. Store blades safely when not in use.
Pinch injuries			Watch mooring lines, don't get caught in the bight, avoid hand traps.
Lifting injuries			Use safe lifting techniques, **bend your knees, ask for help**; use mechanical lifting equipment when possible.
Fatigue			Work reasonably length shift, take breaks periodically.
Hearing damage			If you have to raise your voice to be heard, you need hearing protection.
Eye injuries			Wear eye protection; safety glasses or goggles/safety glasses and face shield.
Burns injuries			Maintain a safe working distance, wear gloves.
Miscellaneous injuries			Keep exit routes clear at all times; stack equipment and supplies in a place and manner where it will not cause injury; keep clear of tow-lines; beware of snap back from failed lines.

BCO103C Tailgate Safety Feb-09.doc Page 1 of 4

WCMRC

Burrard Clean Operations/
Western Canada Marine Response Corporation

STOP and THINK!

Step 1 – Risk Assessment Step 2 – Tailgate Safety Meeting – Agenda Step 3 – Tailgate Safety Meeting - Record of Attendance

Step 1 –Risk Assessment cont'd

Hazard	Yes	No	Suggested Control Measures
Vehicle hazards			
Trucks, heavy equipment, forklifts			Wear appropriate PPE; activate back up alarm; use a back up spotter; inspect equipment before use, use only trained operators.
Traffic congestion			Ensure site traffic and parking plans are in place.
Vacuum truck noise, hose failure or explosion			Wear appropriate PPE; operator(s) trained and experienced in petroleum handling; inspect equipment before use.
Other task specific hazards			
Aircraft hazards			
Working around helicopter landing areas			**Never** approach the helicopter unless signaled to do so by the pilot. **Always** maintain eye contact with the pilot as you approach. **Never** approach from the uphill side. **Never** wear loose clothing around a helicopter.
In flight hazards			**Never** speak to the pilot during takeoff or landing (unless it is an emergency). **Always** wear your seat belt. Wear warm clothing. Take extra food and drink along.
Working around fixed wing aircraft			**Never** approach the aircraft while engines are running. **Never** touch anything on the fuselage, wings or propellers – they may be hot and/or brittle. Stay behind the wings at all times.
Other task specific hazards			
Wildlife			
Injury, disease, potential of attack			Be aware of the dangers from bears, cougars, wolves, dogs, raccoons, moose, deer, otters, wild fowl, rats, snakes and insects. Keep bear spray and insect repellent on hand. Use a safety watch. Only trained personnel to handle wildlife. Safety watch in bear/cougar/wolf country may need to be armed and/or have the use of a purpose trained dog.

Personal Protective Equipment

- ☐ Hard Hat
- ☐ Safety Glasses
- ☐ Safety Goggles
- ☐ Hearing Protection
- ☐ Tyvec Coveralls
- ☐ Fire Resistant (NOMEX) Coveralls
- ☐ Rain Gear
- ☐ Fall Protection (harness)
- ☐ Personal Floatation Device
- ☐ Respiratory Protection (specify cartridge type)
- ☐ Hand Protection (specify type of gloves)
- ☐ Safety footwear

MSDS PPE complied with - Yes / No –please circle

Safety Equipment Required

- ☐ Atmosphere Tester
- ☐ Fire Extinguisher
- ☐ Life Raft
- ☐ Life Ring
- ☐ First Aid Kit
- ☐ Eye wash

Notes:

Risk assessment by: (print) _____ **Signature:** _____

Company name: _____ **Date:** _____

BCO103C Tailgate Safety Feb-09.doc Page 2 of 4

Burrard Clean Operations/
Western Canada Marine Response Corporation

STOP and THINK!

Step 1 – Risk Assessment Step 2 – Tailgate Safety Meeting – Agenda Step 3 – Tailgate Safety Meeting - Record of Attendance

Step 3 – Tailgate Safety Meeting - Record of Attendance

Signature on this record of attendance is confirmation that the Tailgate Safety Meeting has taken place, the risks and control measures identified on the risk assessment and any specific safety plans have been reviewed, are understood and will be complied with.
For time collection purposes use BCO302A-daily Worksheet-Time.

Please print first name, initial and last name clearly.

First Name	Init.	Last Name	Company/Vessel	Signature	Time

Meeting location:

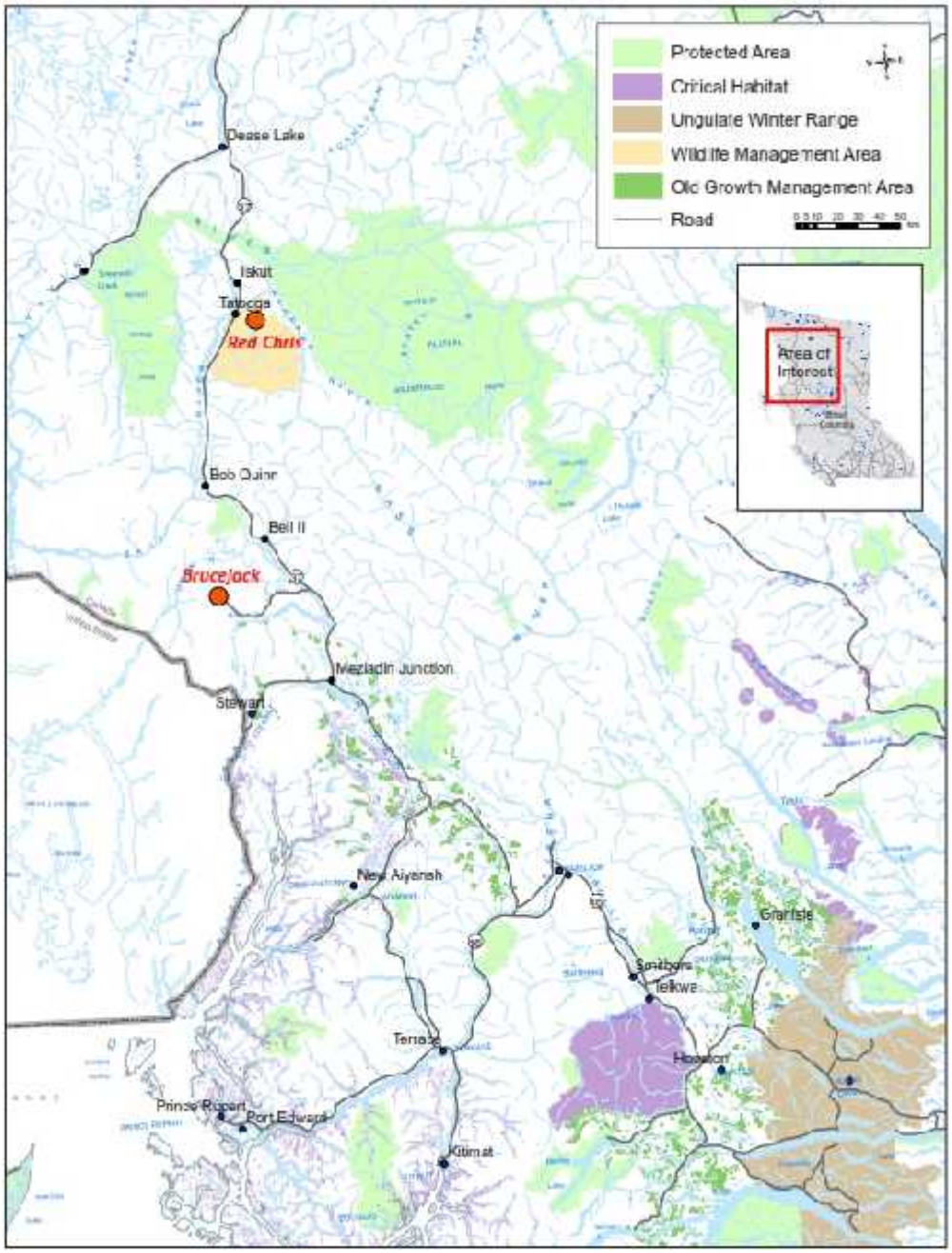
Meeting conducted by: (print) Signature:

Meeting Date:

BCO103C Tailgate Safety Feb-09.doc Page 4 of 4

5 SPILL RESPONSE PLANNING MAP

As required by Section 5 of the SCPR, roads on which the company regularly transports regulated substances (gasoline, diesel, and Jet A) are shown on the map below, typically Highways 16 and 37 from Prince Rupert to Burns Lake and south to Kitimat. Travel includes barge from Kitimat to Kemano. Fuels are taken north to Good Hope Lake including through Deas Lake, Iskut, Telegraph Creek, and Stewart. Fuels are delivered to two mining sites: Pretium's Brucejack and Imperial Metals Red Chris.



6 EQUIPMENT, PERSONNEL & OTHER RESOURCES

Section 6 of the SCPR requires identification of the resources to be used in responding to a worst-case spill scenario. Northwest Fuels fully stocked spill response trailer stationed in Terrace would be dispatched to the incident site. The trailer is inspected monthly using the itemized form below and verified by the Regulated Person.

The responders to a spill and other resources are subsequently indicated in this section.

Equipment

Northwest Fuels Spill Response Trailer Inventory		
Category	**Quantity**	**Item**
Sorbents	20 bales	Hydrophobic spill pads (100 pads/bale)
	4	Boom 5"X10'
	2	Boom 8"X10'
	1	Boom 8"X20'
	2	Snares (bags of 30 rope attached)
	2	Snares (bags of 30 no rope)
	4	Sorbent
Hoses & Fittings	2	2"X20' pressure fuel hose
	1	3"X3" Male Camlock
	1	2"Female X 1" Male Camlock
	1	2" X 2" Male Camlock
	1	2" X 2" Female Camlock
	1	3" Female X 2" Female Camlock
	1	4" Female X 2" Male Camlock
Power Tools	1	Coleman Generator 3700 Watt
	1	Air Compressor 8hp
	1	2" Trash Pump
	1	1/2" Air Drill
	1	Reciprocating Saw
Specialized Tools	1	20" Hatch Cone Device
	1	3.5" Hole Saw
	1	Vent Hookup
	4	48" Drain Stoppers
	4	Adjustable dome clamps
		Wood plugs

Hand Tools	2	6' Spade
	3	D handled Aluminum Shovels
	2	Garden Rakes
	1	Pick
	1	Pitch Fork
	1	2.5lb Axe
	1	Sledge Hammer
	1	24" Squeegee
	1	24" Broom
	2	Deck Brushes
Tools	1	Multi tool socket set
	1	Multi Air tool set
	1	14" Pipe Wrench
	1	Rubber mallet
	1	Wire Brush
	1	Ballpeen Hammer
	1	Flat File
	1	Hack Saw
	2	Hacksaw blades
	1	Allen key Set
	1	15" Crescent wrench
	1	Groove joint pliers
	1	8" Diagonal Pliers
	2	Funnels
	1	Box Drill bits
	1	Brass Hammer
PPE	4	Pairs Red Chemical gloves
	1	Box Nitrile Gloves size x-large
	1	Box Nitrile Gloves size large
	12	Safety Glasses
	4	Goggles
	6	Hi Viz Safety vest
	6	Hard Hats
	25	Tyvek Coverall size large
	25	Tyvek Coverall size x-large
	25	Tyvek Coverall size xx-large
	6	3-piece raingear size small (2), medium (2), large (2)
	6	3-piece raingear size X-large (2), XX-large (2), XXX-large (2)
	6	Steel toed rubber boots 2@size 10; 2@size 11; 2@size 12
	6	Full-face respirators
	6	half-face respirators

Safety	2	3-head gas monitors
	1	Megger ground monitor
	1	Basic First Aid Kit (10 man)
	1	Biomed Eyewash 7oz
	4	Flashlights
	2	Disposable Flashlights
	1	Foghorn
	1	20lb ABC Fire Extinguisher
	4	42"Delineator posts (safety cone)
	1	1000' roll "Danger" tape
Ropes & Chains	1	20' Chain with hooks
	1	Roll 335 ft 1/2" Polyrope
	1	100' 1/4 rope
	1	Roll 550' twine
	8	ratchet tiedown
Cleaners	1	bottle Superclean
	1	bottle bilge cleaner
	1	hand cleaner
	1 case	36"X50" Garbage bags
	1 Roll	6 mm Garbage bags XXL
Miscellaneous	1	7' X 14' Tandem axle covered trailer 7000 lb GVW
	1	Set of shelving 12' L 4' High
	2	rolls duct tape
	1	2 5/16" Trailer hitch
	1	roll tie wire
	3	various tarps
	1	box D batteries
	1	Tube Amazing Goop
	2	Galvanized Buckets
	2	Packages Zip Ties
	2	2 X 500 watt light with stands
	1	50' #12 extension cord
	4	3' Steel stakes
	12	3' stakes
	6	plastic tent pegs
	3	3' X 15' Plastic Fence
	1	10' X 10' Tent
	6	Resin Chairs
	1	4' x 4' x 4' "Fish Tote"

Northwest Fuels Equipment that Could be Transported to an Incident Site

- Megger meters to ensure the proper grounding of trucks prior to the transfer of fuel.
- Gas monitors to (1) measure the presence of flammable vapours in a damaged truck and to (2) measure concentrations of volatiles released at ground level to atmosphere
- Half- and full-face respirators for the protection of responders.
- Sorbents, hoses/connections, power/special/hand tools, other PPE, safety gear, ropes/chains, cleaners, and miscellaneous items as listed above.
- Spare fuel truck and pup trailer to accept fuel from the damaged truck
- Fuel transfer pump trailer to pump fuel from one truck or trailer to another
- Boom truck to stabilize the damaged fuel truck or trailer or to safely move debris or other items.
- Spill kits and fire extinguishers carried on company vehicles.
- Spill kit stored on the fuel truck.

Records of inspections and maintenance of the above required by section 6(1)(a) are kept separate from this plan and are available on request.

Personnel

In the event of a worst-case spill, in addition to the company deploying its response trailer to the accident site in a timely manner and members of its Emergency Response Team (ERT)., external resources will also be needed. A driver may be the only company person initially on-site but communications will be available by cellular phone, VHF radio, and/or satellite phone and an Incident Commander (IC) will be immediately dispatched to the site. Information, Liaison and Safety Officers will also be alerted to contribute to the response according to their role in an Incident Command System (ICS).

Company employees are trained in first aid as per the requirements of the BC Occupational Health and Safety Regulation. A lone driver is not required to be trained under that regulation so may or may not be trained. See also Section 13 Training.

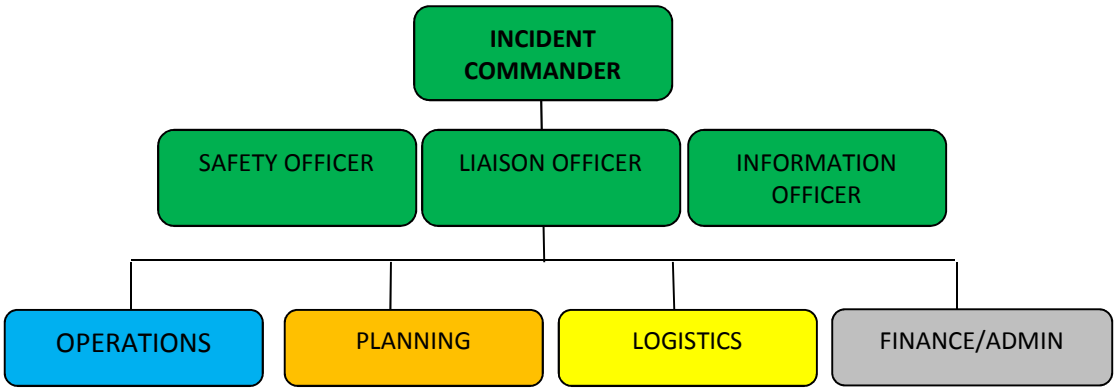
Outside Assistance

External inputs are key to dealing with worst-case scenarios. The following inputs would provide vital resources to control a large spill:

- 911 Emergency Responders (Fire, Ambulance, and Police)
- For initial response on some Level 2 spills and on Level 3 spills (see Section 12 Spill Response Procedures:
  - Ram Environmental Services (24-hour onsite spill response.)
  - Northwest Response Limited (24-hour onsite spill response.)
  - Western Canada Marine Response Corp (on-water response, not handled by Ram)
  - Terrapure Environmental (recycling and disposal)
- CANUTEC Technical Advice (Northwest Fuels registers annually with CANUTEC)
- WCMRC (Northwest Fuels is a member - 24-hour on-water spill response.)
- GHD Consultants (biological impacts)

7 INCIDENT COMMAND SYSTEM

SCPR section 7(2) requires the roles of Incident Commander, Information Officer, Liaison Officer and Safety Officer to be assigned with alternates by Northwest Fuels (see Distribution List and forms in this section) according to an Incident Command System (ICS). ICS is utilized by most response agencies and can be expanded from one person to as many persons required in a response. ICS roles in a spill response are briefly defined below.



COMMAND

- Sets objectives and priorities,
- Has overall responsibility at the incident or event

OPERATIONS

- Conducts tactical operations to carry out the plan
- Develops the tactical objectives, organization, and
- Directs all resources

PLANNING

- Develops the action plan to accomplish the response objectives
- Collects and evaluates information,
- Maintains resource status

LOGISTICS

- Provides support to meet incident needs,
- Provides resources and all other services needed to support the Incident

FINANCE/ADMINISTRATION

- Monitors costs related to incident
- Provides accounting, procurement, time recording, and cost analyses

SAFETY, INFORMATION AND LIAISON OFFICERS

- According to assigned roles, carry out functions relating to implementing a site safety plan, keeping media informed of the incident, and notifying and updating government agencies as the response to the incident progresses.

The assignment of ICS roles is guided through the use of ICS Form 201 Incident Briefing (see below).

ICS 201
Incident Briefing

Purpose. The Incident Briefing (ICS 201) provides the Incident Commander (and the Command and General Staffs) with basic information regarding the incident situation and the resources allocated to the incident. In addition to a briefing document, the ICS 201 also serves as an initial action worksheet. It serves as a permanent record of the initial response to the incident.

Preparation. The briefing form is prepared by the Incident Commander for presentation to the incoming Incident Commander along with a more detailed oral briefing.

Distribution. Ideally, the ICS 201 is duplicated and distributed before the initial briefing of the Command and General Staffs or other responders as appropriate. The "Map/Sketch" and "Current and Planned Actions, Strategies, and Tactics" sections (pages 1–2) of the briefing form are given to the Situation Unit, while the "Current Organization" and "Resource Summary" sections (pages 3–4) are given to the Resources Unit.

Notes:

- The ICS 201 can serve as part of the initial Incident Action Plan (IAP).
- If additional pages are needed for any form page, use a blank ICS 201 and repaginate as needed.

Block Number	Block Title	Instructions
1	**Incident Name**	Enter the name assigned to the incident.
2	**Incident Number**	Enter the number assigned to the incident.
3	**Date/Time Initiated** • Date, Time	Enter date initiated (month/day/year) and time initiated (using the 24-hour clock).
4	**Map/Sketch** (include sketch, showing the total area of operations, the incident site/area, impacted and threatened areas, overflight results, trajectories, impacted shorelines, or other graphics depicting situational status and resource assignment)	Show perimeter and other graphics depicting situational status, resource assignments, incident facilities, and other special information on a map/sketch or with attached maps. Utilize commonly accepted ICS map symbology. If specific geospatial reference points are needed about the incident's location or area outside the ICS organization at the incident, that information should be submitted on the Incident Status Summary (ICS 209). North should be at the top of page unless noted otherwise.
5	**Situation Summary and Health and Safety Briefing (**for briefings or transfer of command): Recognize potential incident Health and Safety Hazards and develop necessary measures (remove hazard, provide personal protective equipment, warn people of the hazard) to protect responders from those hazards.	Self-explanatory.
6	**Prepared by** • Name • Position/Title • Signature • Date/Time	Enter the name, ICS position/title, and signature of the person preparing the form. Enter date (month/day/year) and time prepared (24-hour clock).
7	**Current and Planned Objectives**	Enter the objectives used on the incident and note any specific problem areas.

ICS Form 201 Incident Briefing (continued)

Block Number	Block Title	Instructions
8	**Current and Planned Actions, Strategies, and Tactics** • Time • Actions	Enter the current and planned actions, strategies, and tactics and time they may or did occur to attain the objectives. If additional pages are needed, use a blank sheet or another ICS 201 (Page 2), and adjust page numbers accordingly.
9	**Current Organization** (fill in additional organization as appropriate) • Incident Commander(s) • Liaison Officer • Safety Officer • Public Information Officer • Planning Section Chief • Operations Section Chief • Finance/Administration Section Chief • Logistics Section Chief	• Enter on the organization chart the names of the individuals assigned to each position. • Modify the chart as necessary, and add any lines/spaces needed for Command Staff Assistants, Agency Representatives, and the organization of each of the General Staff Sections. • If Unified Command is being used, split the Incident Commander box. • Indicate agency for each of the Incident Commanders listed if Unified Command is being used.
10	**Resource Summary**	Enter the following information about the resources allocated to the incident. If additional pages are needed, use a blank sheet or another ICS 201 (Page 4), and adjust page numbers accordingly.
	• Resource	Enter the number and appropriate category, kind, or type of resource ordered.
	• Resource Identifier	Enter the relevant agency designator and/or resource designator (if any).
	• Date/Time Ordered	Enter the date (month/day/year) and time (24-hour clock) the resource was ordered.
	• ETA	Enter the estimated time of arrival (ETA) to the incident (use 24-hour clock).
	• Arrived	Enter an "X" or a checkmark upon arrival to the incident.
	• Notes (location/ assignment/status)	Enter notes such as the assigned location of the resource and/or the actual assignment and status.

8 HUMAN HEALTH & SAFETY

SCPR Section 8 requires procedures for protecting the health and safety of individuals involved in spill response actions and controlling access to and ensuring safety at locations where such actions are carried out as described below. Refer also to Section 4 Hazard Assessment and Appendix C Product Response Guides of this SCP for summaries of the health and safety concerns of diesel, gasoline, and Jet A.

Diesel and Jet A spills can generally be safely treated. **Gasoline spills require CAUTION!**

1. **Gasoline can be too volatile to attempt to clean up! Flushing the liquid and vapours with water might be required if an immediate fire and/or explosion could result.**
2. All transported fuels produce vapours that are heavier than air.

   Vapours can accumulate in low areas and pose a health hazard particularly on a calm, hot day. Responders must be prepared to move themselves or other persons out of the vapours if feeling dizzy or nauseous. The hazard area should be isolated and non-essential persons moved upwind at a safe distance (several hundred metres) if practical.
3. All fuels have increased carcinogenetic effects when they are burned. Inhaling combustion exhaust or smoke fumes should be avoided when possible.
4. All fuels can irritate the eyes and skin. Wearing goggles or wrap around safety glasses and/or a face shield and appropriate gloves are mandatory Personal Protection Equipment (PPE). Disposable coveralls and impermeable footwear are also recommended when responding to a spill.
5. The precautions and response procedures for spills of gasoline, diesel and Jet A are similar.

Precautions

- No smoking
- Remove ignition sources
- Ground/bond container and receiving equipment,
- Use non-sparking tools
- Avoid fumes (they are heavier than air).
- Deploy gas monitor to determine vapour levels
- Don respirators if a vapour hazard is determined to be present
- Extinguish with alcohol-resistant foam, CO2, Dry chemical
- Can cool with water mist

First Aid

- Call poison control immediately if swallowed. Do not induce vomiting or give milk or alcoholic beverage.
  - Vomiting can cause aspiration resulting in deadly pneumonia. If vomiting commences position the head low so that gravity help keep the liquid out of the lungs.
- If product gets in the eyes, flush with water for 15 minutes. Seek medical help if irritation persists.
- Remove person to fresh air if feeling unwell or dizzy after inhaling. Get medical advice if symptoms persist.
  - Give artificial respiration if not breathing

- Give oxygen if breathing is difficult
- Remove contaminated clothing and wash with soap and water if skin is exposed.

PPE

- Gloves: Nitrile, Viton, chlorinated polyethylene chlorosulfonated polyethylene, polyurethane.
- Boots: oil-resistant
- Eye protection: chemical safety goggles and/or full face shield.
- Respiratory Protection: cartridge respirator, organic vapour cartridge where ventilation is limited.
- Wear long sleeves, preferably coveralls

Waste Disposal

- Collect contaminated fire extinguishing/cleanup water
- Contain spillage then collect with sorbent booms and pads.
- Final cleanup with sand, diatomaceous earth, vermiculite, etc. Contact authorized disposal company.

Storage & Handling

- Keep containers tightly sealed and upright.
- Locate out of harm's way, well off roadway and away from any other traffic.
- Open drums carefully as they may be under pressure
- NOTE: Add additional inert material (e.g.., sand, dirt, silica or clay-based sorbent) and store gasoline-soaked materials, if present, in closed, sealed containers in cool ventilated area.

General Health & Hygiene

Fuels require good handling practices. For detailed information on health, safety, and hygiene for proper handling of fuels and related products, refer to the *Safety Data Sheets (SDS).*

Good Hygiene Practices

The following precautions are recommended when using petroleum products:

- **DO** wash and change work garments at least once a week for outer wear (i.e., uniform, coveralls).
- **DO** wear neoprene or PVC gloves or apply protective hand cream ("barrier cream") before starting work and after each periodic washing.
- **DO** cleanse hands and arms thoroughly with mild soap and warm water before eating and at the end of work shifts.
- **DO** get prompt treatment for any sign of skin irritation and all cuts and scratches.
- **DO NOT** wear clothing soaked with product, especially boots, shoes, belts, or watch bands.
- **DO NOT** use gasoline, kerosene, cleaning solvent and similar materials for the removal of oil or grease from the skin. Soap can be used and also baby oil is very effective.
- **AVOID** any ignition sources in the area of petroleum products. The hazard of fire, the greatest danger from fuels, is often overlooked but can result in serious bums or death.

Dermatitis and Petroleum Products

Normal skin has a protective layer of natural oils to retard moisture evaporation and to act as a chemical shield. Consequently, anything which tends to remove the natural oils from the skin may cause dermatitis. *Dermatitis (*inflammation of the skin) can be caused by use of solvent, gasoline or fuel oil. Lighter complexioned people tend to have the "driest" skin and therefore tend to be the most susceptible to developing skin problems from contact with fuel or solvent.

Skin areas subject to excess perspiration and clothing friction are the most sensitive to dermatitis: head, underarms, genitals, legs, and feet. Jewelry such as rings and watch bands can hold liquids against the skin for extended periods, leading to localized dermatitis. People who notice severe reddening, hardening, or cracking of the skin when working with solvents or fuels should seek medical advice.

Exposure to Vapours & Mists

Chronic or long term, exposure to fuel vapours should be minimized. Fuel vapours can cause headaches, nausea, dizziness or more serious medical problems if exposure is extensive or long-term.

Exposure to fuel or oil mist, or fine droplets is dangerous to the lungs, and must be avoided (by better ventilation, or by wearing breathing apparatus). Fuel or oil droplets in the lungs can cause a condition known as *"oil pneumonia",* which is serious. For this reason, it has been common practice in treating people who have swallowed fuel or solvent ~ to NOT cause them to vomit unless medically monitored. Without suitable medical precautions, a person vomiting may get fuel into the lungs.

Toxicity

Under normal handling conditions, gasoline, diesel and Jet A, have low toxicity to average healthy adults. Brief contact, or "one time exposure" to these products, is unlikely to cause lasting medical problems. However, exposure to these products can present significant hazards to susceptible groups such as children, pregnant women, and people suffering from certain chronic medical conditions. Such individuals should seek medical advice following exposure to petroleum products.

Increased health hazards (from skin contact, inhalation, or ingestion) due to specific components are possible: Some of these components have high toxicity or are suspected carcinogens.

- Gasoline (benzene);
- Jet fuels (may contain glycol-type anti-icing additive); and
- Diesel fuel (low level or polynuclear aromatic hydrocarbons).

Allergic Reactions

Many people handle or use petroleum fuels or solvents for years without experiencing health problems. Occasionally, however, an individual will suddenly become allergic or reactive to these substances. In such instances, medical evaluation is warranted.

Medical Treatment

Acute exposure: Seek immediate medical assistance (doctor, health clinic, or hospital emergency room) for significant exposure to petroleum products (especially for susceptible individuals).

Chronic exposure or chronic effects: Seek medical assistance from your doctor. Summary

Common sense, good safety practices, and good personal hygiene are the key factors in the safe use of petroleum fuels and solvents. Refer to product SDS for greater detail.

9 COMMUNICATON PROCEDURES

SCPR section 9 requires communications procedures for spill responders. Cellular phones would be the primary means of communication. Associated responsibilities are summarized below. Section 12 Spill Response Procedures details the alerting and notification protocols that Northwest Fuels would follow when mounting a response. Appendix A provides emergency contacts.

The Terrace Office will mobilize the NorthWest Fuels ERT 1-8000-308-2066

SPILL OBSERVER		
PRIORITY	***NOTIFY***	***ADDITIONAL INFORMATION***
1	**All personnel in the immediate working area**	Employees, Customers, Public
2	**Emergency Agencies (Fire, Police, Ambulance)**	Depending on the situation the responsibility can be left to the Person-In-Charge
3	**Person-In-Charge**	Usually the Plant Operator or Driver
PERSON-IN-CHARGE		
1	**Emergency Agencies (Fire, Police, Ambulance**	Fire Department very important for gasoline spills
2	**Northwest Fuels office**	Give all known details of incident.
3	**Emergency Response Team**	Contact all available trained Members
4	**Provincial Environmental Authority (as directed by Northwest Fuels ERT)**	Both PEP and AEP will normally notify other provincial government agencies and Environment Canada
5	**Other Contractors**	Contact as necessary.
6	**Neighbours**	All neighbours who could potentially be affected by the incident.
NORTHWEST FUELS EMERGENCY RESPONSE TEAM		
1	**Home Office Incident Management Team**	
2	**Regulatory Agencies** (Provincial Environmental Authority, DFO, Environment Canada, Canadian Coast Guard, WorksafeBC	Ensure Appropriate regulatory agencies have been notified.
3	**Local Government**	

10 WASTE MANAGEMENT

SCPR Section 10 requires the identification of waste management procedures for the waste resulting from any spill, including contaminated sorbents and equipment, recovered and contaminated fuel, contaminated water, contaminated soil, and contaminated debris.

A waste management plan that meets the BC Hazardous Waste Regulation will be developed in consultation with outside assistance, namely Ram Environmental and TerraPure Environmental. Should a spill enter a waterway, additional input would be obtained from Western Canada Marine Response Corporation.

Basic waste management practices would be followed by Northwest Fuels responders as part of the storage of spent materials that result from cleanup activities and their subsequent transportation:

- Segregation of oily liquids and solids from each other and from other wastes
- Clear labelling of collected wastes in closed, sealed storage containers
- Storage of wastes out of harm's way and protected from weather
- Inerting of any wastes containing gasoline using dirt, sand, particulate sorbent or other means.
- Proper manifesting and packaging of spent materials designated to be hazardous wastes prior to their transportation.
- Close consultation with MOE.

11 WILDLIFE

As required by SCPR section 11, impact on fish and aquatic wildlife will be minimized by:

- Containing the spill to prevent its entry into streams or drainage
- Recovering product from the surface of any standing water as soon as possible
- Cleaning up and properly disposing of contaminated materials as described above
- Applying well-founded biological principles to move fish and/or aquatic wildlife from contaminated areas in consultation with GHD Consultants.
- Focus Wildlife would be called to provide their expertise should the rehabilitation of affected birds, mammals, or other wildlife be required.

12 SPILL RESPONSE PROCEDURES

Notification & Reporting

Internal Notification

All spills regardless of size are to be reported by the Spill Observer immediately to the Person-In-Charge, usually the Plant Manager or Driver (**See Appendix A Contacts**). The Person-In-Charge is responsible for:

- Assessing the situation (size, severity, and circumstances of the spill)
- Determining the appropriate level of response (minor, moderate or major)
- Initiating the notification of appropriate internal and external contacts and resources.

If the Spill Observer cannot contact the Person-In-Charge, the Terrace Office is contacted immediately and will mobilize the NorthWest Fuels ERT 1-8000-308-2066

Depending on the assessment of the situation, the Person-In-Charge has the responsibility to call his or her direct supervisor, (Plant Operator, and Dispatcher). If unable to reach them, the Northwest Fuels Emergency Response Team (ERT)is called.

External Reporting

As soon as it is safely possible to do so, in consultation with Northwest Fuels Management, the Person-In-Charge or a designated ERT member will notify agencies that must be advised of the spill. Spills that are reportable to EMBC (formerly the Provincial Emergency Program – PEP) are releases that enter water and/or that threaten the environment, i.e., they have occurred outside of containment and they exceed reportable quantities:

EMBC (PEP) 1 800-663-3456
• 100 litres of petroleum products • 5 litres of toxins, e.g., antifreeze • ALL spills to water, i.e., direct into water or into pooled water or a ditch leading to water

Spills of ≥30 litres on a roadway that affect persons or infrastructure must be reported to CANUTEC:

CANUTEC 888-226-8832
Spill is 30 L or more and there is <u>one or more of the following criteria</u>: • Damage to a fuel tank of a truck or trailer has resulted in its integrity being compromised • Injury to one or more persons requiring medical treatment • Danger to the public (evacuation necessary) • Closure of a facility, railway or public road, or main waterway

It is Northwest Fuel policy to notify other agencies directly although EMBC and other organizations might indicate they intend to make these calls. See also Appendix A Contacts for specific areas.

• Transport Canada – actual or anticipated release of any quantity that could endanger public safety • Canadian Coast Guard – Marine Communications & Traffic Services – spills to water, at OHFs • Environment & Climate Change Canada – spills on First Nations land, Enforcement Officers • Worksafe BC – truck accident involving injury and/or spill

Categorizing Spills

Spills are categorized by Northwest Fuels as Tier or Level 1, 2 or 3 depending on the size, severity, and response to the spill and taking into account:

- the real or potential impacts of the incident
- the need for outside assistance
- who is contacted in an emergency
- the degree of public/media/agency communication required

Level 1 An incident that can be handled by on-site personnel. The spill is contained and removed. Contaminated waste is safely stored and proper disposal arranged.

Level 2 The scope of an incident is beyond what can be handled by on-site personnel. Assistance is required from off- site trained responders. There is no danger to the public.

Level 3: A major incident beyond the resources of Northwest Fuels. This would involve a major spill of fuel possibly complicated by fire, explosion or other threat to life, infrastructure or environment. It would include the "worst case scenario" where the entire contents of a pup and trailer (54,000 litres) are spilled. Assistance is required from local, regional, and/or provincial organizations. The media will be present and agencies might demand action.

The three tiers or levels of spills are summarized below in terms of the circumstances and actions required.

Classification of Spills		
Level 1: Minor	**Level 2: Moderate**	**Level 3: Major**
• Volume is small and contained on site (**ALL** spills must be reported to Northwest Fuels) • No risk to personnel, public, environment, or equipment • Volume is less than30 L (reportable to CANUTEC). • Handled by on-site resources. • Of no interest to the media or danger to the public.	• Volume exceeds CANUTEC reportable spill (30L). • No significant public danger or environmental impact, contained within site but possibly extends beyond site • Control of incident is probable • Possible local public or media interest and outside-assisted response • May exceed local, on-site emergency response resources	• Leaves roadway or site boundaries and/or remains on site with potential for: injury, fire, explosion, property damage, or impacts to environment or public safety • Volume exceeds EMBC reportable amount (100L). • Support of off-site personnel or other resources required. • Multi-agency response. • High media and public interest.

Emergency Response Actions		
• Limited amount of materials required for cleanup. • Spill Report Form is filled out	• Notify appropriate agencies • Northwest Fuels Terrace office is notified and provides advice and support • Lead agency may activate its own Emergency Ops Centre	• Identified as "Emergency" • Police are called out. • Maximum response. RAM, Environmental, NW Response might be called out. • Northwest Fuels notifies and communicates with lead and other agencies.

Emergency Condition Report

(initial □, update □, end-of-spill □, lessons learned □)

TIME:_____ □ AM □ PM

WHO is reporting the incident? NAME: _____
CONTACT #:_____

WHAT happened? (*Brief*):_____
_____
_____

WHEN did the incident occur? TIME:_____ □ AM □ PM DATE:_____

WHERE is the incident? Location:_____
*Additional Details:*_____

IS there anyone injured?: □ YES □ NO *Details*:_____
_____

HAVE you notified anyone else?: □ YES □ NO *Details*:_____

IS there help on the way?: □ YES □ NO *Details*:_____

HAS there been a spill?: □ YES □ NO *If YES, please ask the following if possible:*

IS the spill contained?: □ YES □ NO

- Estimated Volume Onboard? _____ L
- What Product is Onboard? □ DIESEL □ GASOLINE □ JET FUEL □ AV GAS □ OIL
- Where is it spilling from? □ TRUCK □ TRAILER > Unit #'s:_____

Is there a direct threat to people, a water source, or buildings? □ YES □ NO
Details:_____

WHAT additional help do they need? _____
_____

REQUIRED ACTIONS:

Contacted Supervisors □ YES □ NO WHO? _____ TIME: _____□ AM □ PM

Contacted Emergency Personnel □ YES □ NO WHO?_____ TIME: _____□ AM □ PM

Inacted Contingency Plan □ YES □ NO WHO?_____ _____ TIME: _____□ AM □ PM

INITIAL REPORT TAKEN BY:_____ DATE:_____

NWF REPORT #:_____

Initial Response Actions

The initial response actions are critical to the outcome of a tank truck accident including a spill. The Person-in Charge oversees an assessment of the situation and the safe, quick, and effective actions needed to be initially taken at the incident site:

INITIAL RESPONSE ACTIONS	
STEP	**ACTION**
ENSURE SAFETY	0 **STOP, THINK, AND ASSESS THE SITUATION. SAFETY FIRST ALWAYS** 0 **NEVER RUSH IN. WARN PUBLIC IN THE IMMEDIATE AREA.** 0 **SHUT OFF TANK TRUCK IGNITION AND ELIMINATE ALL AVOIDABLE SOURCES OF IGNITION. HAVE OTHER VEHICLES IN THE VICINITY TURN OFF ENGINES.** 0 **IMMEDIATELY ISOLATE THE SPILL AREA (25-50M FOR LARGER SPILLS).** 0 **TEND TO ANY SERIUOS INJURIES OR OBTAIN HELP FROM CAPABLE MOTORISTS.** 0 **USE APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT.** 0 **STAY UP WIND OF SPILL VAPOURS. STAY OUT OF LOW AREAS.** 0 **DO NOT TOUCH OR WALK THROUGH SPILLED PRODUCT.**
STOP PRODUCT FLOW	0 **ACT QUICKLY. ONLY ATTEMPT TO STOP THE PRODUCT FLOW IF IT IS SAFE TO DO SO.** 0 **ACTIVATE TANK TRUCK EMERGENCY STOP BUTTON.** 0 **IF TANK TRUCK IS PUNCTURED, ATTEMPT TO PLUG LEAK IF POSSIBLE TO DO SO SAFELY. USE NON-SPARKING MATERIALS CLOTH, WOOD PLUGNDIKE.** 0 **SET CONTAINERS UP RIGHT (DRUMS, PAILS).**
SECURE THE SPILL SITE	0 **KEEP THE PUBLIC AWAY FROM THE AREA. HAVE MOTORISTS INVOLVED IN THE ACCIDENT LEAVE THEIR CARS AND MOVE A SAFE DISTANCE AWAY FROM TANKER.** 0 **INITIALLY ISOLATE LARGER SPILLS FOR 25-50M IN ALL DIRECTIONS AND CONSIDER INITIAL DOWNWIND EVACUATION OF 300M FOR BOTH DISTILLATES AND GASOLINES.** 0 **OBTAIN THE HELP OF THE POLICE AND OTHER MOTORISTS TO SECURE THE AREA.** 0 **ENFORCE SAFETY PROCEDURES**
ASSESS THE SITUATION	0 **QUICKLY AND ACCURATELY GATHER SPILL DETAILS THAT NEED TO BE COMMUNICATED TO RESPONSE PERSONNEL AND AUTHORITIES.** 0 **RECORD INFORMATION ON THE REPORT** 0 **ADDITIONAL DATA SHOULD INCLUDE: EQUIPMENT INVOLVED, AFFECTED AREAS, SITUATION UNDER CONTROL OR ESCALATING.**
NOTIFICATION	0 **ENSURE THE POLICE; FIRE AND AMBULANCE HAVE BEEN NOTIFIED AS NECESSARY.** 0 **NORTHWEST FUELS EMERGENCY RESPONSE TEAM (ERT) 1-800-308-2066 DOUG 250-615-2110 GARY 250-631-7209 ANGELA 250-975-0246 THEY WILL USUALLY MAKE THE REST OF THE PHONE CALLS AS NEEDED BUT VERIFY WHO WILL BE DOING WHAT. MAKE UP A SHORTTERM ACTION PLAN WITH HELP FROM ERT** **NOTE: PROVIDE INFORMATION CLEARLY AND CONCISELY. VERIFY THAT INFORMATION HAS BEEN UNDERSTOOD. CONFIRM TIME AND MODE OF NEXT CALL.**

INITIAL RESPONSE ACTIONS (continued)	
STEP	**ACTION**
CONTAIN DIESEL SPILL **1202**	o ALWAYS THINK "WHAT IS GOING TO HAPPEN TO ME OR ANYONE ELSE IF THIS SPILL IGNITES? IF UNSURE THEN WAIT FOR HELP. o APPROACH SPILL FROM UPWIND. o PREVENT ENTRY INTO WATERWAYS, SEWERS OR CONFINED AREAS BY BLOCKING DRAINS, CULVERTS, DITCHES, AND OTHER ESCAPE POINTS. o CONTAIN SPILL WITH SORBENTS, EARTH, SAND OR OTHER NON-COMBUSTIBLE MATERIALS. o FOR PRODUCT ENTERING DRAINAGE DITCHES OR STORM DRAINS, DETERMINE THE POTENTIAL DESTINATION(S) OF FLOW.
CONTROL GASOLINE SPILL **1203**	GASOLINE IS VERY VOLITILE AND SHOULD ONLY BE CONTAINED IF SAFE TO DO SO, IF UNSURE THEN WAIT FOR FIRE DEPARTMENT o APPROACH SPILL FROM UPWIND DIRECTION AND AVOID LOW LYING AREAS. o PREVENT ENTRY INTO WATERWAYS, SEWERS OR CONFINED AREAS BY BLOCKING DRAINS, CULVERTS, DITCHES, AND OTHER ESCAPE POINTS. o CONTAIN SPILL WITH SORBENTS, EARTH, SAND OR OTHER NON-COMBUSTIBLE MATERIALS. o USE WATER FOG/MIST OR FOAM TO CONTROL OR DISPERSE GASOLINE VAPOURS. o FOR PRODUCT ENTERING DRAINAGE DITCHES OR STORM DRAINS, DETERMINE THE POTENTIAL DESTINATION(S) OF FLOW. NOTE: THE VAPOUR OF FLAMMABLE GAS IS USUALLY HEAVIER THAN AIR AND WILL SETTLE IN LOW PLACES AND PLACES SHELTERED FROM THE WIND.
RECOVERY A& CLEANUP	o FOR SMALL SPILL, USE SORBENTS TO RECOVER PRODUCT. o FOR LARGE QUANTITIES OF POOLED PRODUCT, PUMP TO APPROPRIATE STORAGE DEVICE. DO NOT USE VACUUM TRUCKS TO RECOVER SPILLED GASOLINE. o RECOVERED PRODUCT CAN BE STORED IN EMPTY DRUMS, TANK TRUCKS, PORT-A-TANKS, OR IN THE CASE OF DISTILLATES, VACUUM TRUCKS. o REMOVE CONTAMINATED SOIL.
WASTE DISPOSAL	o COLLECT USED SORBENTS USING CLEAN NON-SPARKING TOOLS. o PLACE WASTE MATERIALS IN LEAK PROOF SEALED CONTAINERS OR APPROPRIATE 6 MIL PLASTIC BAGS. o STORE WASTE CONTAINERS TEMPERORARILY IN A SECURE LOCATION. USED SORBENT MATERIAL REPRESENTS AN EXTREME FIRE HAZARD (PARTICULARLY GASOLINE SOAKED SORBENTS). USED SORBENTS SHOULD BE KEPT IN A WELL VENTILATED AREA AWAY FROM HEAT SOURCES, DIRECT SUNLIGHT, WET WEATHER, AND GENERAL PUBLIC. o CONSULT WITH THE TERRACE ERT TEAM AND THE APPROPRIATE PROVINCIAL AUTHORITY BEFORE REMOVING WASTE FROM THE SPILL SCENE.

Roles & Responsibilities

On-site Personnel

1. Assess the situation. If anyone is injured, an area must be evacuated, a public road must be closed or there is any danger to the public, elevate the spill response to Level 3.
2. Advise coworkers, if any, on site that there is a spill. Ask someone on site, or if no one is available, report to a Person-in-Charge.
3. Assess the safety of the situation and potential impacts.
4. If unsafe, evacuate the area and report the spill to a Person-in-Charge. This becomes a Level 3 spill, follow the actions in the chart for gasoline or diesel/Jest fuel
5. If the substance is gasoline, do not attempt to recover it. Evacuate the area, double check that all possible ignition sources have been removed and call for help or wait for it to evaporate if the quantity is small enough and it is safe to do so.
6. If, at any time, you feel that you may need outside help, make the call.
7. Access spill kit and PPE (gloves, eye and/or face protection, coveralls, boots).
8. Use PPE and spill equipment to control the spill in the following order of priority
   a. Stop the leak
   b. Contain the spilled product. If containment isn't possible redirect the flow away from areas of higher impact and/or to a location where the product can be contained.
   c. Recover as much of the product as possible and clean the area.
9. If at any time you or a co-worker feels unwell or dizzy, remove yourself from the immediate area (preferably upwind to higher ground)
10. As soon as the spill is contained, report the spill to the Person-in-Charge, if this has not already been done by a co-worker.
    a. Estimate the volume of the spill particularly if it exceeds 30- litres of fuel, <u>5 litres, if antifreeze) or if ANY amount into a stream or drainage ditch</u>.
    b. Advise of any actual or possible impacts on health, safety, property orenvironment.

Person-in-Charge

1. Ensure the spill has been properly cleaned up
2. Arrange for disposal of contaminated materials (Terrapure Environmental).
3. Confirm with responders that the Initial Actions were followed. Record comments.
4. Confirm that the product or products spilled were correctly identified
5. Estimate the volume of the product(s) spilled
6. Ensure the spill has been reported to the Terrace Office.
7. Provide any additional information required by the Terrace Office

Terrace Office Personnel

1. Organize Management Team and implement ICS: IC, Information, Liaison, and Safety Officers
2. Check to confirm product type and quantity
3. Review cleanup methods used.
4. Verify reporting to ensure all required information is submitted.
5. Arrange to have the incident investigated.

13 TRAINING

Drivers and Supervisors identified in this plan as an "Officer" or "Incident Commander" must be trained in their roles and responsibilities in an ICS structure. The pertinent information (as required by SCPR section 13) can be found in Section 12 Spill Response Procedures.

Additional training will be provided by having the same personnel participate in plan tests (drills) and in discussions of the learnings of those tests.

Testing of the Plan

As per **Section 15** (2) (a) of the SCPR, although a highway transporter is not required to test a worst-case scenario, tests of this spill contingency in every year over a 3 year period will include:

- At least one discussion-based test
- At least one operations-based test (e.g., application of spill trailer contents, fire extinguisher use, first aid response, air quality monitoring)

Individuals who would respond or implement this SCP would participate in the testing with results available to the Ministry of Environment and Climate Change Strategy as well as the opportunity of MOE to observe the testing if requested to do so. The plan sections to be tested are listed below:

(a) Section 12 (3) *[notification]*

(b) Section 12 (4) (c) *[mobilization, deployment and ongoing sufficiency]* as it relates to the mobilization and deployment of spill response equipment and spill response personnel;

(c) Section 12 (4) (c) as it relates to maintaining the ongoing sufficiency of equipment, personnel and other resources;

(d) Sections 7 *[incident command system]* and 12 (4) (d) *[incident command post]*;

(e) Section 12 (4) (e) *[source control]*;

(f) Section 12 (2) and (4) (b) *[initial and ongoing assessments]*;

(g) Section 12 (4) (f) *[stabilizing, containing, removing and cleaning up]*;

(h) Section 12 (4) (g) *[protection of aspects of environment, human health and infrastructure]*;

(i) Section 12 (1) (d) *[monitoring and documentation]*;

(j) Section 9 *[communication]*;

(k) Section 10 *[waste management]*.

APPENDIX A CONTACTS

APPENDIX B RESPONSE TACTICS & SCENARIO

APPENDIX C PRODUCT RESPONSE GUIDES

APPENDIX D TANK TRUCK CAPACITIES

APPENDIX E TDG REPORT FORM

APPENDIX A CONTACTS

PAGE	Area
A-2	Northwest Fuels Emergency Response Team
A-3	Prince Rupert
A-5	Terrace
A-7	Kitimat
A-9	Kitwanga Hazelton
A-11	Smithers
A-13	Houston
A-15	Stewart/Meziadian
A-17	Bobquinn / Dease Lake
A-19	Yukon
A-20	Alberta

NORTHWEST FUELS EMERGENCY RESPONSE TEAM (ERT)				
LOCATION	**NAME**	**OFFICE (250)**	**CELL (250)**	**HOME (250)**
Terrace	Ames, Doug	635-1160	615-2110	635-2882
Terrace	Ames, Rita	635-1160	615-8336	635-2882
Terrace	Ainscow, Gary	635-1160	631-7209	635-7279
Terrace	Bennett,Rob	635-2066	778-978-0704	
Terrace	Callieou, Pat	635-2066	631-2938	847-3454
Terrace	Davey, John	635-2066	615-2273	615-5566
Terrace	Hernes, Erik	635-1160	975-1633	638-1633
Terrace	Ippel, Alan	635-2066	641-9895	635-5656
Terrace	Kirkaldy, Dave	635-2066	631-2184	635-9505
Terrace	Leblond, Don	635-2066	615-7856	638-0055
Terrace	McGillivray, James	635-2066	615-2976	638-7696
Terrace	Obzera, Tim	635-2066	615-8007	638-8097
Terrace	Protzner, Bernie	635-1160	615-6011	635-6192
Terrace	Pruden, Dave	941-4444	615-8916	339-3166
Terrace	Ruchotzke, Brad	635-2066	615-8799	635-7745
Terrace	Van Genne, Mike	635-2066	641-4202	
Terrace	Wafzig, Mike	635-2066	631-7613	638-1275
Prince Rupert	Gray, Mike	624-4106	600-5348	624-5348
Prince Rupert	Bergman, Peter	624-4106	600-3143	
Prince Rupert	Kovacs, Grace	624-4106	778-645-0281	
Smithers	Kuemper, Lorne	847-2522	877-1131	847-5242
Smithers	Golem, Carol	847-2522	(519)860-0449	
Houston	Good, Deidre	845-2044	845-8999	845-3373

Depending on the situation, the Person-in-Charge has the responsibility to decide whether or not to call out the Terrace ERT:

TERRACE EMERGENCY RESPONSE TEAM (ERT)

1-800-308-2066

PRINCE RUPERT EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**911**	**911**
RCMP	**911 or (250) 624-2136**	**911**
AMBULANCE	**911 or 1-800-461-9911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Lands Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536	1-800-663-3456 (250)847-7259 (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Department Of Highways Road Hazard Reporting Marine Traffic - Canadian Coastguard Port of Prince Rupert	(604) 666-6100 (250) 845-7765 1-800-665-5051 (250) 627-3074 (250)627-2504	(604) 666-6100
LOCAL GOVERNMENT		
District office	(250) 624-6717	(250) 624-1037
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	1-888-769-3766 1-800-663-1173	
HOSPITALS		
Prince Rupert Regional Hospital	(250) 624-2171	

PRINCE RUPERT CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
Western Canada Marine Response Corp. (WCMRC) 24 Hour emergency Office Fax RAM Environmental Response Terrapure Kelowna Prince George	 1-855-294-9116 (250) 624-5666 (250) 624-5166 1-855-238-9350 1-800-999-9441 (250) 960-1404	 1-800-774-8466
SORBENTS		
Skeena Disposal M.J. Basso & Son	(250) 627-7202 (250) 624-1431	24 hrs 24 hrs
VACUUM TRUCKS		
Storey's Excavating Pro Vac Services	(250) 627-6844 (250) 635-1132	24 hrs 24 hrs
FOOD		
Crest Hotel Sub way Breakers Pub	(250) 624-6771 (250) 627-1561 (250) 624-5990	
TRUCKS		
Rupert Towing Ltd Skeena Disposal Edvan Construction	(250) 624-2722 (250) 627-7202 (250) 627-4744	(250) 624-3237 24 hrs 24 hrs
EXCAVATORS		
Edvan Construction	(250) 627-4744	24 hrs
TRUCK TOWING		
Rupert Towing	(250)624-2722	

TERRACE EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT Terrace	**911**	**911**
RCMP Terrace	**911**	**911**
AMBULANCE Terrace	**911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536	1-800-663-3456 (250)847-7259 (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Department Of Highways (MOT) Road Hazard Reporting	(604) 666-6100 (250) 638-1881 1-800-665-5051	(604) 666-6100
LOCAL GOVERNMENT		
District office	(250) 635-6311 (250)615-4021	(250) 638-4744
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	1-888-769-3766 1-800-663-1173	1-888-769-3766
HOSPITALS		
Mills Memorial Hospital	(250) 635-2211	

TERRACE CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
RAM Environmental Response	1-855-238-9350	
Terrapure		
Kelowna	1-800-999-9441	
Prince George	(250) 960-1404	1-800-774-8466
SORBENTS		
Western Equipment	(250) 635-6567	
J&L Excavating (Sand)	(250) 638-8713	(250) 638-8713
VACUUM TRUCKS		
Norco Septic Service (2006) Ltd.	(250) 635-5832	(250) 635-3893
Pro Vac Service	(250) 635-1132	(250) 635-1132
Spruce City Sanitary Services PG	(250)564-4666	
FOOD		
Polly's Café	(250) 638-1848	
Lucky Garden	(250) 638-8897	
Boston Pizza Terrace	(250) 635-3443	
Subway Terrace	(250) 635-1994	
TRUCKS & EXCAVATORS		
Bear Creek	(250) 635-3407	(250) 638-6806
J.L's Excavating (Sand)	(250) 638-8713	(250) 638-8713
Norco	(250)635-5832	(250)615-3893
TOOLS GENERATORS LIGHTS		
Westpoint Rentals	(250) 635-3038 (250) 635-8307	(250) 635-3545 H Richey or (250) 635-1163 D Richey
TRUCK TOWING		
Pronto Towing	(250) 635-3113	(250) 635-3113
Dingle Dan- Bruce Campbell	(250) 615-3706	
Noon Day Moon Towing	(250) 641-2484	250-615-1118

KITIMAT EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**911**	**911**
RCMP	**911**	**911**
AMBULANCE	**911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7259 1-888-967-5377 (250) 635-6536	1-800-663-3456 (604)273-7711
FEDERAL GOVERNMENT		
Canadian Coast Guard Environment & Climate Change Canada Department Of Highways Road Hazard Reporting Harbour Master Dave Fisher	(250)627-3074 (604) 666-6100 (250) 638-1881 1-800-665-5051 1(250)627-2504	 (604) 666-6100
LOCAL GOVERNMENT		
District office	(250) 632-8900	(250) 632-3173
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	1-888-769-3766 1-800-663-1173	1-888-769-3766
HOSPITALS		
Kitimat Hospital	(250) 632-2121	

KITIMAT CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
Western Canada Marine Response Corp. (WCMRC)		
24 hr emergency	1-855-294-9116	
Office	(604) 294-6001	
Fax	(604) 294-6003	
RAM Environmental Response	1-855-238-9350	
Terrapure Prince George	(250) 906-1404	1-800-774-8466
SORBENTS		
Sandhill	(250) 632-6155	
Kentron Construction	(250) 639-9141	
Daudette	(250) 632-4831	250-632-1033
VACUUM TRUCKS		
Norco	(250) 635-5832	(250) 635-5832
Pro Vac Service	(250) 635-1132	(250) 635-1132
Spruce City Sanitary Services PG	(250) 564-4666	
FOOD		
Subway	(250) 632-2991	
Chop Suey Kitchen	(250) 632-6666	
The Chalet Restaurant	(250) 632-2662	
TRUCKS & EXCAVATORS		
Daudet Creek	(250) 632-4831	250-632-1033
JHW Construction	(250) 632-9231	
Kentron Construction	(250) 639-9141	
Jose's Excavating (Al & Zo Mulder)	(250) 632-2938	
TOOLS GENERATORS LIGHTS		
Leavitt machinery	(250) 632-7833	
Westpoint Rentals	(250) 635-3038	(250) 635-3545
RG Auto	(250) 632-7722	(250) 632-2744
TRUCK TOWING		
See Terrace		
Pronto Towing	(250) 635-3113	(250) 635-3113

KITWANGA HAZELTON EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**(250) 842-5433**	**(250) 842-5433**
RCMP	**(250) 842-5244**	**911**
AMBULANCE	**1-800-461-9911**	**1-800-461-9911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536	1-800-663-3456 (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Department Of Highways Road Hazard Reporting	(604) 666-6100 (250) 847-9399 1-800-665-5051	(604) 666-6100
LOCAL GOVERNMENT		
Gitwangak Band Office	(250)849-5591	
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	1-888-769-3766 1-800-663-1173	
HOSPITALS		
Wrinch Memorial Hazelton Mills Memorial Hospital Terrace Bulkley Valley District Hospital (Smithers) Emergency Line	(250)842-5211 (250) 635-2211 (250) 847-2611 (250) 847-6212	

KITWANGA HAZELTON CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEAN UP & WASTE MANAGEMENT		
RAM Environmental Response	1-855-238-9350	
Terrapure		
Kelowna	1-800-999-9441	
Prince George	(250) 960-1404	1-800-774-8466
SORBENTS		
Rocky Mountain Environmental Ltd	1-888-677-4556	(604) 275-1346
JL Excavating Terrace	250-638-8713	24 hrs
Mattson Contracting	(250) 842-6059	24 hrs
VACUUM TRUCKS		
Norco Septic Service	(250) 635-5832	24 hrs
Pro-Vac Services	(250) 635-1132	24 hrs
Action Septic Service	(250) 847-3121	24 hrs
FOOD		
Petro Canada Service Station	(250) 849-5793	
TRUCKS		
Hobenshield Bros	(250) 849-5511	
Mattson Contracting	(250) 842-6059	24 hrs
EXCAVATORS		
Hobenshield Bros	(250) 849-5511	
Mattson Contracting	(250) 842-6059	24 hrs
TRUCK TOWING		
Pronto Towing	(250)635-3113	24 hrs
Aurora Truck Center	1-888-460-7600	
Noon Day Moon	(250) 641-2484	250-615-1118

SMITHERS EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT Emergency Non Emergency-	**911 (250)847-2015**	**911**
RCMP	**911**	**911**
AMBULANCE	**911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional Ministry of Transportation	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536 (250)847-7400	1-800-663-3456 Norm Fallows (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Billabong Road Hazard Reporting	(604) 666-6100 (250) 847-8737 1-800-665-5051	(604) 666-6100
LOCAL GOVERNMENT		
Town office Town of Smithers Works Yard(Wilf Takima)	(250) 847-1600 (250) 847-1647	(250) 847-1615
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies Telus Communications	1-888-769-3766 1-800-663-1173 611	1-888-769-3766 1-800-663-1173 611
HOSPITALS		
Bulkley Valley District Hospital Central Square Medical Clinic	(250) 847-2611 (250) 847-8761	

SMITHERS CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
RAM Environmental Response	1-855-238-9350	
Terrapure Prince George	(250) 960-1404	1-800-774-8466
SORBENTS		
Evergreen Industrial	(250) 847-4456	
D&M Industrial	(250) 845-3334	(250) 845-7364
Rocky Mountain Environmental Ltd	1-888-677-4556	(604) 275-1390
VACUUM TRUCKS		
Norco	(250) 635-5832	
Action Septic	(250) 847-3121	
Spruce City PG	(250) 564-4666	
FOOD		
A&W Restaurants	(250) 847-3700	
Subway	(250) 847-4771	
7-11 Stores	(250) 847-8086	
TRUCKS		
B & A Rentals	(250) 847-2037	
Pidherney Contracting	(250) 847-3397	(250) 847-0444
Ranch Trucking	(250) 847-2567	cell
Vihar	(250) 847-3024	(250) 847-2567
		(250) 847-6843
EXCAVATORS		
Pidherney Contracting	(250) 847-3397	(250) 847-0444
Ranch Trucking (Art Buchanan)	(250) 847-2567	cell
Vihar	(250) 847-3024	(250) 847-2567
C&C Excavating	(250) 877-1288	(250) 847-6843
Evelyn Mountain Contracting	(250) 846-5557	
TRUCK TOWING		
Aurora Truck Center	1-888-460-7600	
Tyler's Towing	(250) 847-2413	

HOUSTON EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**(250) 845-2250**	**(250) 845-2250**
RCMP	**(250) 845-2204**	**(250) 845-2204**
AMBULANCE	**911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536	1-800-663-3456 (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Department Of Highways (MOT) Road Hazard Reporting	(604) 666-6100 (250) 847-8737 1-800-665-5051	(604) 666-6100
LOCAL GOVERNMENT		
District office	(250) 845-2238	
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	(250) 845-7277 1-888-769-3766 1-800-663-1173	(250) 845-7277
HOSPITALS		
Houston Health Centre Houston Steelhead Clinic Lv Message Bulkley Valley District Hospital (Smithers) Emergency Line Burns Lake District Hospital	(250)845-2294 (250) 845-2521 (250) 847-2611 (250) 847-6212 (250) 692-2400	

HOUSTON CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
RAM Environmental Response	1-855-238-9350	
Terrapure		
Kelowna	1-800-999-9441	
Prince George	(250) 960-1404	1-800-774-8466
SORBENTS		
D & M Industrial	(250) 845-3334	(250) 845-7364
Rocky Mountain Environmental Ltd	1-888-677-4556	(604) 275-1390
VACUUM TRUCKS		
S-Quest Septic Service	(250) 846-9818	
Action Septic	(250) 847-3121	
Spuce City Sanitary Services	(250) 964-7485	
FOOD		
A&W Restaurants	(250) 845-7555	
Houston Food Market	(250) 845-2413	
7-11 Stores	(250) 845-7177	
TRUCKS		
Grouse Mountain Trucking	(250) 845-7220	
Morice River Sand & Gravel	(250) 845-7202	
Bodner Contracting	(250) 845-2498	(250) 845-7419
CELL	(250) 845-8498	
EXCAVATORS		
Bodnar Contracting	(250) 845-2498	(250) 845-7419
Gerry's Power Digging	(250) 845-2335	
Wilson Bros.	(250) 845-7702	
TRUCK TOWING		
Aurora Truck Center	1-888-460-7600	
Tyler's Towing	(250) 847-2413	

STEWART MEZIADIAN EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**911**	**911**
RCMP	**911**	**911**
AMBULANCE	**911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536	1-800-663-3456 (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Department Of Highways Billabong Road Hazard Reporting (MOT)	(604) 666-6100 (250) 636-2194 1-800-665-5051	(604) 666-6100
LOCAL GOVERNMENT		
District of Stewart	(250)636-2251	
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	1-888-769-3766 1-800-663-1173	
HOSPITALS		
Stewart Hospital Wrinch Memorial Hazelton Mills Memorial Hospital Terrace	(250)636-2221 (250)842-5211 (250) 635-2211	

STEWART MEZIADIAN CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
RAM Environmental Response	1-855-238-9350	
Terrapure Kelowna Prince George	 1-800-999-9441 (250) 960-1404	 1-800-774-8466
SORBENTS		
Granmac Services	(250)636-2307 (250)636-2402	(250)636-2456
Soucie Construction	(250)636-2389	24 hrs
VACUUM TRUCKS		
Norco Septic Service	(250) 635-5832	24 Hrs
Pro-Vac Services	(250) 635-1132	24 Hrs
Action Septic Service	(250) 847-3121	24 Hrs
FOOD		
Petro Canada Service Station	(250) 849-5793	
TRUCKS		
Soucie Construction Granmac Bar Kir Enterprises	(250)636-2389 (250)636-2307 (250) 849-5448	 24 Hrs
EXCAVATORS		
Soucie Construction	(250)636-2389	24 Hrs
TRUCK TOWING		
Pronto Towing Aurora Truck Center Tyler's Towing	(250)635-3113 1-888-460-7600 (250) 847-2413	24 Hrs

BOBQUINN/DEASE LAKE EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**(250)771-3134**	
RCMP	**(250)771-4111**	
AMBULANCE	**(250)771-3333**	
PROVINCIAL GOVERNMENT		
Emergency Management BC BC Ministry of Agriculture & Land Worksafe BC After Hours Accident Reporting Regional	1-800-663-3456 (250) 847-7260 1-888-967-5377 (250) 635-6536	1-800-663-3456 (604)273-7711
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Department Of Highways Billabong Road Hazard Reporting (MOT)	(604) 666-6100 (250) 771-3010 1-800-665-5051	(604) 666-6100 1-888-255-8055
LOCAL GOVERNMENT		
Chamber of Commerce	(250)771-3700	
PUBLIC UTILITES		
BC Hydro Emergency Line Natural Gas Emergencies	1-888-769-3766 1-800-663-1173	
HOSPITALS		
Stewart Hospital Dease Lake Hospital Mills Memorial Hospital Terrace	(250)636-2221 (250)771-4444 (250) 635-2211	

BOBQUINN/DEASE LAKE CONTRACTORS & SUPPLIERS		
CONTACT	**DAY**	**NIGHT**
SPILL CLEANUP & WASTE MANAGEMENT		
RAM Environmental Response	1-855-238-9350	
Terrapure Kelowna Prince George	 1-800-999-9441 (250) 960-1404	 1-800-774-8466
SORBENTS		
Dease Lake concrete	(250)771-3320	
Marion Bros	(250)771-3550	
Artic Excavating	(250) 771-3244	
VACUUM TRUCKS		
Norco Septic Service	(250) 635-5832	24 Hrs
Pro-Vac Services	(250) 635-1132	24 Hrs
Spruce City	(250) 564-4666	24 Hrs
FOOD		
Petro Canada Service Station	(250) 771-4381	
TRUCKS		
TNDC	(250)771-5454	
EXCAVATORS		
TNDC	(250)771-5454	
TRUCK TOWING		
Pronto Towing Aurora Truck Center	(250)635-3113 1-888-460-7600	24 Hrs

YUKON EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENTS	**(867) 668-2462**	**(867) 668-2462**
RCMP	**(867) 667-5555**	**(867) 667-5555**
AMBULANCE	**911**	**911**
PROVINCIAL GOVERNMENT		
Yukon Spill Report Yukon WCB Regional office	(867)667-7244 1-800-661-0443 (867)667-5645	
FEDERAL GOVERNMENT		
Environment & Climate Change Canada	(604) 666-6100	(604) 666-6100
LOCAL GOVERNMENT		
District office(Whitehorse)	(867) 456-3882	
PUBLIC UTILITES		
Department Of Highways Whitehorse weigh scale Yukon Power Emergency Line Natural Gas Emergencies	(867)-667-5196 (867)667-5729 (867)667-5196 1-800-663-1173	
HOSPITALS		
Houston Health Centre Houston Steelhead Clinic Lv Message Bulkley Valley District Hospital (Smithers) Emergency Line Burns Lake District Hospital	(250)845-2294 (250) 845-2521 (250) 847-2611 (250) 847-6212 (250) 692-2400	

ALBERTA EMERGENCY & GOVERNMENT AGENCIES		
CONTACT	**DAY**	**NIGHT**
FIRE DEPARTMENT	**911**	**911**
RCMP	**911**	**911**
AMBULANCE	**911**	**911**
PROVINCIAL GOVERNMENT		
Emergency Management Alberta Pollution Control spills over 200 litres	1-800-272-9600 1-800-222-6514	1-800-272-9600
FEDERAL GOVERNMENT		
Environment & Climate Change Canada Road Hazard Reporting	(780)951-8600 1-800-222-4357	
LOCAL GOVERNMENT		
Edmonton Edson Hinton Jasper	(780)442-5311 (780)723-3178 (780)865-6016 (780)852-6155	
CONTRACTORS		
RAM Environmental Response Western Canada Marine Response Corp. (WCMRC)	1-855-238-9350 (604)294-9116 1-855-294-9116	
HOSPITALS		
Edmonton Edson Hinton Jasper	(780) 735-4111 (780) 723-3331 (780) 865-3333 (780) 852-3344	

APPENDIX B RESPONSE TACTICS & SCENARIO

This section presents an overview of the tactics and countermeasures that may be applied to contain, recover, and clean up a land based spill. A detailed spill scenario involving a tank truck is also presented. For evacuation and isolation procedures refer to Section 4 Hazard Assessment.

The actual tactics used will depend on the unique circumstances of each incident (time of day, weather conditions, product(s) and the spill location). No two spills are the same.

Tactical Priorities

Once the safety of all personnel has been ensured, the source of the discharge secured, and initial notification activated, the overall tactical priorities should be:

- Identification of impacted or likely to be impacted areas
- Containment and recovery of spilled product
- Spill site cleanup

Development of an Incident Command Post (ICP) will be set up and members of the ERT will be notified and assembled as needed. Representatives of key government agencies will provide critical advice. The Incident Commander will decide what resources are needed and whether or not to bring in extra help from Ram Environmental and/or Norwest Response for land-based spills or WCMRC for water based spills (see Contacts). All of these organizations are on retainer by Northwest Fuels Limited and are ready to assist if needed.

The behaviour of diesel, gasoline, and Jet A determines the most appropriate and effective response tactics to be taken to contain and recover spilled product, to protect sensitive environmental resources, and to cleanup the spill site and other affected areas.

Response to a Spill to Land

Potential equipment for containing/cleaning up a spill on land

- Personal protective equipment (PPE);
- Sorbents;
- Sandbags
- Sand or earth; plastic/plywood sheeting, or neoprene mat
- Clean and empty drums
- Portable pump
- Vacuum truck
- Front end loader
- Heavy duty 6 mil plastic bags
- Non-sparking hand tools

General response steps for a land based spill

- **Carry out** initial response actions as outlined in Section 12 Response Actions
- **Identify all potential destinations of spilled product by anticipating the flow of spilled product.**
- Block drains, culverts, ditches and other escape points to prevent entry into waterways, sewers, basements, or confined areas.
- Attempt to prevent further spreading of product by building barriers to contain it. Use commercial sorbents, booms, earth, sand or other non-combustible materials. Storm drains can be blocked using prefabricated manhole covers (neoprene mats). Sandbags or earth on top of Sorbent pads, plywood, or plastic sheeting can also be used. (see Diagram 3.3)

Product which is contained in sumps, catch basins, oil/water separator, berms, or trenches should be pumped out as soon as possible using portable pumps and temporary storage containers such as drums, or by using a vacuum truck***. Do not use vacuum trucks for recovery of gasoline spills***. Catch basins and oil/water separator have limited oil retaining capacity and will eventually discharge oil to storm sewer systems. Consider closing inlet and/or outlet valves to/from separators. Small pools of standing product can be cleaned up using sorbents.

Waste materials (sorbents, contaminated earth) should be stored in a secure area such as the tank farm containment area or barrel storage area and should be disposed of according to BC regulations. Used sorbent materials are a fire hazard particularly gasoline soaked sorbents and should be kept in a well ventilated area away from heat sources, direct sunlight and wet weather. Contaminated earth may have to be removed for treatment.

3.4.1 Containment of Spills

For a spill of diesel, gasoline, or Jet A on concrete or asphalt, whenever possible, keep response operations on the uphill and upwind side of the spill area. Try to avoid working in areas where fuel has pooled and which would result in fuel flowing towards you. Spills on unpaved land can be encouraged to flow into open drainage ditches by flushing with a hose or can be contained by making temporary pits or dikes to hold the product. Spills that can be directed into open ditches are relatively easily blocked off with a barrier of straw, sorbent boom, logs, weirs, or other barrier that will hold back oil on the surface but allow water to pass through. Wire mesh or snow fences can be used for this purpose. Before a spill is directed into a temporary pit it should be lined with heavy gauge plastic to limit the soil contamination by the product. Water fog or mist should be used to control or disperse gasoline vapours.

Special Considerations for Gasoline Spills

Spills of gasoline are unlikely to result in long-term environment impacts but pose a maximum fire or explosion hazard. In any response to a gasoline spill, the risk of explosion or fire is the main concern. Immediate steps should be taken to stop all sources of spark or ignition. Fuel vapour is heavier than air and will form an invisible blanket which, in the absence of any wind, will spread out along the ground and settle in low areas. Open basement windows can provide access for the vapour to reach pilot light flames and ignite. In populated areas, depending on the size and location of the spill, it may be necessary to evacuate the adjacent properties,

request police assistance to cordon off the area to all traffic, and have the utility company cut the power to the affected area. Some fire departments are equipped with petroleum fire fighting foam which can be used to blanket the spill and reduce fire or explosion hazard.

Recovery Techniques

When a fuel spill is contained, various methods can be considered to recover it. Depending on the volume of the product, a vacuum truck may be used (**Do not use vacuum trucks for gasoline spills!**); hand trash pump, sorbents, straw or peat moss. Straw or peat moss should not be used if you are using any kind of pump as it could plug. Port-a-tanks or drums can be used to store recovered product. Port-a-tanks are better suited for this as they are commonly equipped with a bottom discharge valve to draw off water.

For a spill within a tank farm, it may be possible to use the tank farm sump pump with a few minor discharge piping changes that will allow the pumping of product to temporary storage. Portable explosion-proof pumps can also be used. Residual product can be flushed to the sump using water. Manual recovery is best suited for small spills and thin sheens, sorbent pads are well suited for this procedure. For a fast response, sorbent pads should be applied generously. Mechanical and manual recovery techniques are not mutually exclusive. An effective response can involve both techniques.

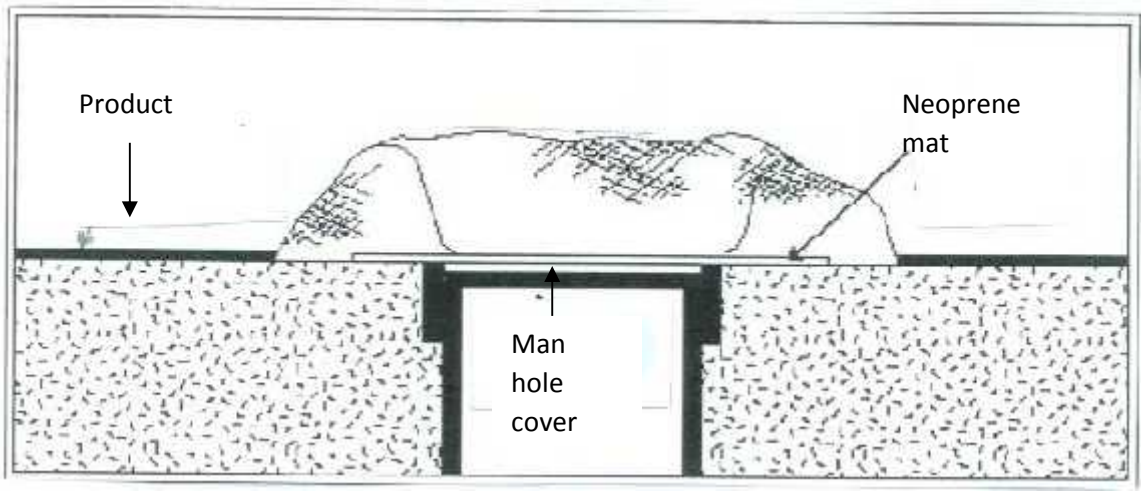
NOTE: Used sorbents are classified as hazardous waste under BC legislation and must be treated accordingly. The flammability of used sorbents must be taken into consideration when temporarily storing them. Keep sorbents away from other combustibles and in a well-ventilated area.

If the product has seeped into the ground, it should be recovered by digging an open trench or well to expose the water table, and using pads or skimmers to collect the product. Soil that has been contaminated may have to be removed to an approved site for disposal or treatment. Therefore, all efforts should be made to minimize size of the affected area and thus the volume of the contaminated soil.

General Containment Strategies For Land Spills

Blocking a Manhole or Storm Drain

The graphic below shows a simple method for blocking a manhole or storm drain to prevent product from entering a storm sewer system. Prefabricated neoprene mats, plastic sheets, or plywood sheets can be used along with sand or dirt for this purpose.



Scenario: Diesel Fuel Spill Resulting from a Road Accident

A tandem axle tank truck is involved in a single vehicle highway road accident in which the truck rolls over en route to a customer delivery location. Diesel fuel immediately begins to leak from a hole punctured in the shell of the overturned tank truck. No injuries to the driver or public are incurred.

Location	Rural Highway
Time and Date	1100 Hours, January
Weather	Light snow -6°C
Wind	Calm
Surrounding Activities	Few vehicles on highway due to weather conditions. On site managers at respective offices.

Hour 0 – 0.5 (1100 – 1130 Hours)	
Step	**Actions Taken**
Safety & Security	**The safety of the public, driver and responders is the highest priority.** The driver eliminates all sources of ignition nearby the tank truck by shutting off the trucks ignition and requesting drivers in the immediate area to shut off engines and to extinguish other ignition sources. All non emergency personnel are evacuated. They remain upwind of the spill area. Using pylons, the road is blocked to all vehicles other than emergency. The driver has one of the motorists at the incident scene notify the police and fire department of the incident. The driver ensures that all suitable personal safety precautions have been taken. He does not leave the accident scene unless injured or relieved.
Stop the discharge	The driver quickly determines that the punctured tank shell is too badly damaged to be plugged with a simple wedge, block of wood, or other available material.
Situation Assessment	The driver Conducts a brief but thorough assessment of the situation identifying: o Estimate quantity of spilled product. o Potential spread of the product. o Initial response actions taken so far. o Level and type of assistance required.

Hour 0 – 0.5 (1100 – 1130 Hours) cont.	
Step	**Actions Taken**
Notification & Reporting	The driver determines that the spill is substantial and at first opportunity (by radio, cellular phone, or third party) notifies the dispatcher at the office, thereby starting the predetermined notification process. The Dispatcher contacts the following: 1 Terrace ERT Team 2 EMBC (PEP). 3 All available ERT members who immediately deploy to the accident scene (e.g. other truck drivers and agency employees). 4 Emergency agencies to ensure they are on the way
Containment & Control	The released product is uncontained and migrating towards a drainage ditch. Using a snow shovel from the truck the driver attempts to build a dam by shovelling snow/dirt into the ditch. Sorbent pads are placed at the leading edge of the spill.

Hour 0.5 -2 (1130-1300 Hours)	
STEP	**Actions taken**
Safety & Security	The police and fire department assist in securing the area. A "Tailgate" Safety Meeting is held to go over what needs to be done and what safety procedures are to be followed.
Notification & Reporting	A Terrace ERT member contacts the provincial environment authority to confirm earlier notification by the dispatcher. A ow truck, Excavator, Dump Truck, Vacuum Truck and outside help from Ram Environmental are all called in to help.
Incident Management	The nearest On site Manager arrives at the accident site with spill supplies and conducts a situation assessment briefing with key staff and government agency representatives in attendance. The On site Manager takes over as Incident Commander. ERT members begin to show up from Terrace An ERT member walks along the drainage ditch to monitor product movement.
Containment & Control	It is estimated that a total of 2,000 litres was released from the overturned tank truck before flow of product was stopped. Sorbent boom is deployed downstream in the ditch. Minor trenching and build-up of the drainage ditch dam is required to help contain the spilled diesel in a small an area as possible.
Recovery & Cleanup	Sorbents are wrung out into barrels brought to the site by the SRT.

Hour 2-6 (1300-1700 Hours)	
STEP	**Actions taken**
Safety & Security	Appropriate safety procedures continue to be observed Response personnel only precipitate in operations they have been trained for. The security of the incident site continues to be handled by the police and fire department.
Incident Management	A basic Incident Command System is now in place with the on site manager as the Incident Commander and the Operations Chief. Planning, Logistics and Finance being taken care out of the Terrace office. The Incident Commander and Government Representatives discuss the various options for removing the remaining product from the overturned tank truck (i.e. cold tap, hatch cone device, piping modifications to truck) or right the truck without removing product. The Incident Commander and the Provincial Environmental Authority representative agree to issue a joint information release, following a request from a local newspaper reporter. A portable generator and emergency lighting is ordered from a local rental equipment business.
Recovery & Clean up	Clean pooled product in the drainage ditch is pumped directly to an empty tank truck. Using an explosion proof trash pump, the remaining product in the drainage ditch is pumped to empty drums. Following a decision to modify the truck piping, the product in the overturned tank truck is pumped to an empty agency tank truck.

Hour 6-12 (1700-2300 Hours)	
Step	**Actions Taken**
Safety & Security	Appropriate safety procedures continue to be observed. Emergency lighting is set up and operating. A Quantum Environmental Representatives shows up and takes over as Incident Commander for final cleanup.
Containment & Recovery	A temporary weir dam is constructed in the drainage ditch to help contain any remaining product that may seep to the surface over time.
	Pumping of clean pooled product in the drainage ditch is completed. Pumping out of overturned truck is completed.

Recovery & Clean up	The over turned tank truck is righted and towed back to the agency or other suitable, secure yard. Recovery and clean up operations continue until all spilled product and contaminated materials have been recovered. Remaining product is absorbed using Sorbent pads and granular Sorbent.
Waste Management	Drums containing diesel fuel from drainage ditch are taken to the agency and stored for pick up by Newalta. Solid wastes are packaged and also taken to the agency and stored for pick up by Newalta. Prior to preparing for disposal plan for recovered waste materials, the provincial environmental authority is consulted and agreement is reached for off site disposal of varies waste materials.
Business Resumption	The Terrace Incident Commander, Police Fire department, the provincial environmental authority, conducts a joint inspection of the spill area to determine that the spill is satisfactorily cleaned up prior to officially terminating response operations. Normal traffic patterns at the accident site are allowed to resume.

Hour 12+	
Step	**Actions Taken**
Monitoring & Cleanup	For an appropriate period of time following the incident, the drainage ditch is checked for oil showing up on the surface of storm water, at the weir dam. Depending on the location and level of soil contamination, BC MOE may require soil remediation activities at the accident site.
Formal Report	The ERT incident commander undertakes a full and through investigation of the incident and complete a formal incident reports.

APPENDIX C PRODUCT RESPONSE GUIDES

For more detailed information, refer to the Safety Data Sheets (SDSs) provided by the supplier.

SDSs MUST be updated every 3 YEARS or whenever a new product is used.

- Antifreeze
- Diesel
- Gasoline
- Hydraulic Fluid
- Jet A
- Lube Oil
- Sulphuric Acid (battery acid)

NOTE:

- The Emergency Response Team will be provided with Safety Data Sheets (SDS) for ALL transported fuels.
- SDSs will be available in all strategic locations including storage, dispensing, and points of use.
- SDSs will also be available in all regional offices of Northwest Fuels.
- SDSs will be maintained and updated as necessary by the Operations Manager.

Antifreeze (Ethylene Glycol)

Typical Physical and Chemical Properties			
Soluble, irritant, toxic liquid			
Appearance	Clear colourless to green liquid	**Flash Point**	116°C
Odour	Slight; undetectable <25 ppm	**Pour Point**	-13°C
Solubility	Very soluble in all proportions	**Flammability**	3.2 to 15.3%
Viscosity	Not viscous (22 cSt)	**Toxicity**	TLV 50 ppm
Vapour Density	Will sink to ground levels	**Specific Gravity**	Same as water

Safety Measures

Warnings

- Vapours are heavier than air.
- Empty containers can, but are unlikely to, contain explosive vapours.
- Ingestion of very small quantities (several ml) can be lethal.
- Eye contact causes irritation.
- Skin contact can cause intoxication due to absorption.
- Inhalation of vapours can cause intoxication, headache, vomiting, and unconsciousness with convulsions.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear, and goggles when appropriate to do so; neoprene, nitrile and PVC are suitable protective materials.
- Breathing protection, e.g., cartridge respirator may be necessary but is unlikely.

Precautions

- Eliminate ignition sources.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (**note:** Water or foam may cause frothing.)
- Use water to cool containers exposed to fire.

Response to Spills

Consider actions only if safety permits!

Containment and Removal

- **On land,** do not flush into water.
- Block entry into waterways.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with Universal sorbent.
- Remove large spills with pumps or vacuum equipment.

- **On water**, ethylene glycol sinks and mixes.
- Contain spill by damming or diverting contaminated water.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Segregate waste types and place in marked containers.
- Consult disposal company on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes
- Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin
- Remove contaminated clothing.
- Wash skin thoroughly with soap and water.

Inhalation
- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion
- **Induce vomiting immediately**.
- If victim is conscious, give two glasses of water and stick finger down throat.

Diesel (UN 1202)

Typical Physical and Chemical Properties			
***Danger! Combustible liquid*.**			
Storage	Various tanks	**Flammability**	Combustible liquid
Appearance	Clear, pale yellow or red	**Flash Point**	38 to 55°C
Odour	Petroleum	**Freezing Point**	-50 to -6°C
Solubility	Insoluble	**Viscosity**	Not viscous
Vapour Density	Will sink to ground levels	**Specific Gravity**	Floats on water

Safety Measures

Warnings

- Vapours heavier than air form at high temperatures and may persist in depressions.
- Empty containers can contain explosive vapours.
- Toxic gases form upon combustion.
- Eye contact causes irritation.
- Diesel can accumulate static electricity charges.
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable protective materials (**do not** use natural rubber, neoprene or PVC for prolonged periods).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Eliminate ignition sources.
- Electrically ground and bond containers when transferring diesel.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- Use water to cool containers exposed to fire.

Diesel (UN 1202)

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into ditches or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.

- **On water**, use booms to contain and concentrate spill.
- Remove spill using sorbent, skimmer or vacuum truck.
- Protection booming can be considered for water intakes/marinas.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Electrically ground/bond containers and vehicles during transfer.
- Segregate waste types.
- Place contaminated materials into marked containers.
- Consult disposal company on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes
- Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin
- Remove and launder contaminated clothing.
- Discard saturated leather articles.
- Wash skin thoroughly with soap and water.

Inhalation
- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion
- **Do not** induce vomiting.
- If victim is conscious, give milk or water to drink.
- If victim vomits, keep head below hips to prevent aspiration.

Gasoline (UN 1203)

Typical Physical and Chemical Properties			
Danger! Highly flammable liquid – explosive vapours can form!			
Storage	Various tanks	**Flammability**	Flammable liquid
Appearance	Colourless liquid (can be dyed)	**Flash Point**	-40 to -50°C
Odour	Gasoline/petroleum	**Freezing Point**	-60°C
Solubility	Insoluble	**Viscosity**	Not viscous
Vapour Density	Will sink to ground levels	**Specific Gravity**	Floats on water

Safety Measures

Warnings

- Vapours instantaneously form that are heavier than air.
- Empty containers can contain explosive vapours.
- Vapours can travel to distant sources of ignition and flash back.
- Eye contact causes irritation.
- Gasoline can accumulate static electricity charges.
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable materials (**do not** use natural rubber, neoprene or PVC).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Monitor for explosive atmosphere.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Eliminate ignition sources.
- Electrically ground and bond containers when transferring fuel.
- Restrict access and work upwind of spill.

Response to Fires

Consider action only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- Use water to cool containers exposed to fire.

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into ditches or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.

- **On water**, do not attempt to contain or remove spills.
- Disperse with water spray.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, well-ventilated areas away from acids, fuels and solvents.
- Electrically ground containers and vehicles during transfer.
- Segregate waste types and place in marked containers.
- Consult disposal company on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes
- Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin
- Remove and launder contaminated clothing.
- Discard saturated leather articles.
- Wash skin thoroughly with soap and water.

Inhalation
- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion
- **Do not** induce vomiting.
- If victim is conscious, give milk or water to drink.
- If victim vomits, keep head below hips to prevent aspiration.

Hydraulic Oil

Typical Physical and Chemical Properties			
Combustible liquid that can generate toxic fumes in fire.			
Storage	20 L pails, 200 L drums	**Flammability**	Combustible liquid
Appearance	Straw-yellow liquid	**Flash Point**	215°C
Odour	Petroleum	**Pour Point**	-25°C
Solubility	Generally insoluble	**Viscosity**	Medium (265 cSt @ 15°C)
Vapour Density	Few vapours emitted	**Specific Gravity**	Floats on water (0.88)

Safety Measures

Warnings

- Vapours are heavier than air and may persist in depressions.
- Toxic gas can form in fire and at high temperatures.
- CO, CO_2 and dense smoke are produced upon combustion.
- Material can accumulate static charges.
- Oil mist or vapour from hot oil can cause irritation of the eyes, nose, throat and lungs.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile, neoprene and Viton are suitable materials (**do not** use natural rubber or PVC).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Avoid excessive heat, which can cause formation of vapours.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Eliminate ignition sources.
- Restrict access and work upwind of spill.

Response to Fires

Consider action only if safety permits!

- Wear eye protection when responding to hydraulic oil fires.
- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (**note:** Water or foam may cause frothing.)
- Use water to cool containers exposed to fire.

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into ditches or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.

- **On water**, use boom or other barrier to contain and concentrate spill.
- Remove spill using sorbent, pump or vacuum system.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Electrically ground containers and vehicles during transfer.
- Segregate waste types.
- Place contaminated materials into marked containers.
- Consult disposal company on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with fresh, warm water (**not hot water**) for 20 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin

- Remove and launder contaminated clothing.
- Discard saturated leather articles.
- Wash skin thoroughly with soap and water.

Inhalation

- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion

- **Do not** induce vomiting.
- If victim is conscious, give milk or water to drink.
- If victim vomits, keep head below hips to prevent aspiration.

Jet A-1 (UN 1863)

Typical Physical and Chemical Properties			
Danger! Flammable liquid – explosive vapours can form!			
Storage	Various tanks	**Flammability**	Flammable liquid
Appearance	Clear, pale yellow or red	**Flash Point**	38°C
Odour	Petroleum	**Freezing Point**	-40°C
Solubility	Insoluble	**Viscosity**	Not viscous
Vapour Density	Will sink to ground levels	**Specific Gravity**	Floats on water

Safety Measures

Warnings

- Vapours heavier than air form at high temperatures and may persist in depressions.
- Empty containers can contain explosive vapours.
- Toxic gases form upon combustion.
- Eye contact causes irritation.
- Jet A-1 can accumulate static electricity charges when stored and transferred.
- Inhalation of vapours can cause irritation of the respiratory tract, headache, vomiting and unconsciousness.

Personal Protection

- Wear impervious, chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable protective materials (**do not** use natural rubber, neoprene or PVC for prolonged periods).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Eliminate ignition sources.
- Electrically ground and bond containers when transferring Jet A.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Restrict access and work upwind of spill.

Response to Fires

Consider actions only if safety permits!

- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog.
- Use water to cool containers exposed to fire.

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into ditches or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.

- **On water**, use boom or other barrier to contain and concentrate spill.
- Remove spill using sorbent, pump or vacuum system.

NOTE: Jet A evaporates at various rates depending on the spill and weather conditions. Do not assume complete evaporation will occur.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Electrically ground/bond containers and vehicles during transfer.
- Segregate waste types.
- Place contaminated materials into marked containers.
- Consult disposal company on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes
- Flush eyes immediately with fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin
- Remove and launder contaminated clothing.
- Discard saturated leather articles.
- Wash skin thoroughly with soap and water.

Inhalation
- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion
- **Do not** induce vomiting.
- If victim is conscious, give milk or water to drink.
- If victim vomits, keep head below hips to prevent aspiration.

Lube Oil

Typical Physical and Chemical Properties			
Combustible liquid that can generate toxic fumes in fire.			
Storage	2o L pails, totes	**Flammability**	Combustible liquid
Appearance	Amber liquid	**Flash Point**	190 to 220°C
Odour	Petroleum	**Pour Point**	-37°C
Solubility	Generally insoluble	**Viscosity**	Medium (255 cSt @ 15°C)
Vapour Density	Few vapours emitted	**Specific Gravity**	Floats on water (0.89)

Safety Measures

Warnings

- Toxic gas can form in fire and at high temperatures.
- CO, CO_2 and dense smoke are produced upon combustion.
- Material can accumulate static charges.
- Hot oil vapours can irritate the eyes, nose, throat and lungs.

Personal Protection

- Wear chemical-resistant clothing, gloves, footwear and goggles when appropriate to do so; nitrile and Viton are suitable materials (**do not** use natural rubber, neoprene or PVC).
- If appropriate, wear full-face organic vapour cartridge respirator where oxygen is adequate.

Precautions

- Avoid excessive heat, which can cause formation of vapours.
- Avoid contact with acids, chlorine, ozone and peroxides.
- Eliminate ignition sources.
- Restrict access and work upwind of spill.

Response to Fires

Consider action only if safety permits!

- Wear eye protection when responding to lube oil fires.
- Avoid confined spaces.
- Shut off fuel supply.
- Extinguish fire with CO_2, dry chemical, alcohol foam or water fog. (**Note:** Water or foam may cause frothing.)
- Use water to cool containers exposed to fire.

Response to Spills

Eliminate ignition sources! Consider actions only if safety permits!

Containment and Removal

- **On land**, block entry into waterways.
- Do not flush into sewer or drainage system.
- Contain spill by diking with earth or other barrier.
- Remove minor spills with sorbent.

- **On water**, use boom or other barrier to contain and concentrate spill.
- Remove spill using sorbents pump or vacuum system.
-

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, ventilated areas away from incompatible materials.
- Electrically ground/bond containers and vehicles during transfer.
- Segregate waste types and place in marked containers.
- Consult disposal company on transportation and disposal requirements.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with fresh, warm water (**not hot water**) for 15 minutes while holding the eyelids open.
- Remove contact lenses, if exposed to vapours or liquid.

Skin

- Remove and launder contaminated clothing.
- Discard saturated leather articles.
- Wash skin thoroughly with soap and water.

Inhalation

- Move victim to fresh air.
- Perform AR if victim not breathing (use Holger-Nielson method and **not** mouth-to-mouth method if victim inhaled or ingested the substance).
- Provide oxygen if victim is having difficulty breathing.

Ingestion

- **Do not** induce vomiting.
- If victim is conscious, give milk or water to drink.
- If victim vomits, keep head below hips to prevent aspiration.

Sulphuric Acid (Battery Acid UN 1830)

Typical Physical/Chemical Properties			
Danger! Highly corrosive, toxic liquid that reacts with many chemical and metals.			
Storage	Batteries	**pH**	0.3
Appearance	Colourless oily liquid	**Flash Point**	Not flammable/combustible
Odour	Acrid odour	**Boiling Point**	276 to 330°C
Solubility	Soluble in water.	**Freezing Point**	-11°C
Vapour Density	Heavier than air (3.4)	**Specific Gravity**	Sinks in water (1.67 to 1.84)

Health and Safety

Warnings

- **Highly corrosive** to all body tissues including skin, eyes, teeth, lungs.
- Direct skin contact may cause deep painful burns, shock and collapse.
- **Highly toxic** and may be fatal if ingested.
- Inhalation may cause breathing difficulties, irritation and death.
- Sulphuric acid is classified as a Group1 Carcinogen.

Personal Protection

- Wear face shields, splash-proof safety goggles, rubber boots, heavy rubber gloves, rubber aprons/suits.
- Wear respirator for pools, SCBA and Level A suit for mist, as required.
- Rubber, PVC gloves are recommended. Neoprene, nitrile are OK.

Precautions

- Avoid contact with organic materials, most metals and oxidizers.
- Avoid methanol, hydrogen peroxide, sulphides and sodium chlorate.
- Can generate explosive hydrogen gas in contact with metals.
- **Do not add water to concentrated acid**; heat, splattering occurs.

Response to Fires

Consider action only if safe!

- Generates SO_2 and SO_3 in fire.
- Use dry chemical or CO_2 to extinguish small fires.
- Use water spray or fog for larger fires
- Water added to concentrated acid results in heat, violent spattering.

Response to Spills

Consider actions only if safety permits!

On Land

Containment and Removal

- Remove ignition sources. Ventilate area.

- **Inside buildings**: neutralize with baking soda or colour-coded neutralizer.
- Do not flush into ditches and drains. Eco-toxic effect can occur.
- Call for help if significant quantity is spilled or people are affected.

- **Outside buildings**: contain spill by diking with sand or earth.
- Use only chemical-rated pump.
- Neutralize with baking soda or neutralizer with colour indicator.
- Remove minor spills with Universal sorbent.
- Rinse residuals with water deluge and mild alkali.

On Water

- Will sink and mix completely with water.
- Contain spill: isolate contaminated water by damming or diversion.

Storage, Transfer and Disposal

- Store closed, sealed, labelled containers in cool, well-ventilated areas.
- Keep away from incompatible materials such as water, metals and fuels.
- Segregate waste types and place in marked containers.
- Consult Environmental Technician on transportation and disposal needs.

First Aid

Get prompt medical attention!

Eyes

- Flush eyes immediately with plenty of fresh, warm water (**not hot water**) for at least 15 minutes.
- Remove contact lenses if exposed to vapours or liquid.

Skin

- Remove contaminated clothing.
- Flush with water for at least 15 minutes.

Inhalation

- Move victim to fresh air.
- Perform AR if victim not breathing. Do not use mouth-to mouth.
- Provide oxygen if victim is having difficulty breathing.

Ingestion

- Administer large quantities of water, if victim is conscious.
- **Do not** induce vomiting.
- If victim vomits, keep head below hips to prevent aspiration.

APPENDIX D TANK TRUCK CAPACITIES

Individua; tank capacities for the Northwest Fuels Ltd. Fleet are presented in this section for quick reference.

Unit #		Safe Fill	Diesel	Regular	
103					**Tractor**
302	**1**	15000	11000	12500	**Front of B-Train**
	2	7000	4000	5000	
	3	12000	10000	11000	
	Total	**34000**	**25000**	**28500**	
303	**1**	11000	10000	11000	**Rear of B-Train**
	2	17000	14000	16500	
	Total	**28000**	**24000**	**27500**	
103					**Tractor**
42A	**1**	17000	11200	13800	**Front of B-train**
	2	17000	13500	16000	
	Total	**34000**	**24700**	**29800**	
42B	**1**	11000	10000	10000	**Rear of B-train**
	2	17500	15000	17000	
	Total	**28500**	**25000**	**27000**	
501	**1**	2700	1400	2000	**Tandem Fuel Truck**
	2	3800	3700	3700	
	3	5700	5600	5600	
	4	5500	4600	5000	
	Total	**17700**	**15300**	**16300**	
1602	**1**	12400	12000	12000	

	2	11000		9000		11000	**Quad axle fuel trailer**
	3	10000		10000		10000	
	Total	**33400**		**31000**		**33000**	
601	**1**	3600		2200		3300	**Tridem Fuel truck**
	2	6700		6500		6700	
	3	6700		6500		6700	
	4	6700		4500		6500	
	Total	**23700**		**19700**		**23200**	
602	**1**	12000		11500		11800	**Quad axle fuel trailer**
	2	5000		3000		4000	
	3	5000		2500		4000	
	4	10500		10000		10000	
	Total	**32500**		**27000**		**29800**	
605							**Tractor**
35A	**1**	17000		11200		13800	**Front of B-Train**
	2	17000		13500		16000	
	Total	**34000**		**24700**		**29800**	
35B	**2**	11000		10000		10000	**Rear of B-Train**
	3	17500		15000		17000	
	Total	**28500**		**25000**		**27000**	
607	**1**	3600		2200		3300	**Tridem Fuel truck**
	2	6700		6500		6700	
	3	6700		6500		6700	
	4	6700		4500		6500	
	Total	**23700**		**19700**		**23200**	
202	**1**	12500		11500		11800	**Quad axle fuel trailer**

	2	5000		3000		4000	
	3	5000		2500		4000	
	4	10400		10000		10000	
	Total	**32900**		**27000**		**29800**	
609	**1**	5400		3800		5000	**Tandem Fuel Truck**
	2	5400		4800		5000	
	3	5400		4800		5200	
	4	2400		2200		2200	
	Total	**18600**		**15600**		**17400**	
611	**1**	3600		2500		3300	**Tridem Fuel truck**
	2	6700		6700		6700	
	3	6700		6600		6700	
	4	6700		4000		6500	
	Total	**23700**		**19800**		**23200**	
612	**1**	12000		11500		11800	**Quad axle fuel trailer**
	2	5000		3000		4000	
	3	5000		2500		4000	
	4	10500		10000		10000	
	Total	**32500**		**27000**		**29800**	
614	**1**	3600		2000		3300	**Tridem Fuel truck**
	2	6700		6500		6700	
	3	6700		6500		6700	
	4	6700		4500		6500	
	Total	**23700**		**19500**		**23200**	

615	**1**	12000	11500	11800	**Quad axle fuel trailer**
	2	5000	2600	4000	
	3	5000	2500	4000	
	4	10500	10000	10000	
	Total	**32500**	**26600**	**29800**	
616	**1**	3600	2300	3300	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6700	6700	
	4	6700	4300	6500	
	Total	**23700**	**20000**	**23200**	
617	**1**	12000	11000	11800	**Quad axle fuel trailer**
	2	5000	3000	4000	
	3	5000	2500	4000	
	4	10500	9800	10000	
	Total	**32500**	**26300**	**29800**	
618					**Tractor**
123	**1**	16000	10000	12500	**Front of B-Train**
	2	6000	5000	6000	
	3	11500	9500	10500	
	Total	**33500**	**24500**	**29000**	
124	**1**	11000	9500	10500	**Rear of B-Train**
	2	5500	5000	5000	
	3	11500	9500	10500	
	Total	**28000**	**24000**	**26000**	

619	**1**	3600	2300	3300	**Tridem Fuel truck**
	2	6700	6500	6700	
	3	6700	6500	6700	
	4	6700	4500	6500	
	Total	**23700**	**19800**	**23200**	
620	**1**	12000	11000	11800	**Quad axle fuel trailer**
	2	5000	3000	4000	
	3	5000	2500	4000	
	4	10500	9800	10000	
	Total	**32500**	**26300**	**29800**	
621	**1**	3600	2300	3300	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6700	6700	
	4	6700	4200	6500	
	Total	**23700**	**19900**	**23200**	
622	**1**	12000	11500	11800	**Quad axle fuel trailer**
	2	5000	3500	4000	
	3	5000	2500	4000	
	4	10500	9000	10000	
	Total	**32500**	**26500**	**29800**	
623	**1**	3600	1800	3000	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6700	6700	
	4	6700	4800	6700	
	Total	**23700**	**20000**	**23100**	

624	**1**	12000	11500	11800	**Quad axle fuel trailer**
	2	5000	3000	4000	
	3	5000	3000	4000	
	4	10500	9000	10000	
	Total	**32500**	**26500**	**29800**	
625	**1**	3600	2300	3000	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6600	6700	
	4	6700	4000	6700	
	Total	**23700**	**19600**	**23100**	
626	**1**	12000	11000	11800	**Quad axle fuel trailer**
	2	5000	2900	4000	
	3	5000	2900	4000	
	4	10500	9200	10000	
	Total	**32500**	**26000**	**29800**	
627	**1**	3600	2300	3000	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6600	6700	
	4	6700	4000	6000	
	Total	**23700**	**19600**	**22400**	
628	**1**	12500	11500	11800	**Quad axle fuel trailer**
	2	5000	3000	4000	
	3	5000	2500	4000	
	4	10400	9800	10000	
	Total	**32900**	**26800**	**29800**	

629					**Tractor**
137	**1**	16000	10000	12200	**Front of B-Train**
	2	6000	5500	5500	
	3	11500	9300	11500	
	Total	**33500**	**24800**	**29200**	
138	**4**	11000	9000	11000	**Rear of B-Train**
	5	5500	5000	5400	
	6	11500	9000	11500	
	Total	**28000**	**23000**	**27900**	
701	**1**	3600	2200	3200	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6700	6700	
	4	6700	4300	6300	
	Total	**23700**	**19900**	**22900**	
402	**1**	12500	11500	11800	**Quad axle fuel trailer**
	2	5000	3000	4000	
	3	5000	2500	4000	
	4	10400	10000	10000	
	Total	**32900**	**27000**	**29800**	
705	**1**	3600	2500	3200	**Tridem Fuel truck**
	2	6700	6500	6700	
	3	6700	6700	6700	
	4	6700	4000	6300	
	Total	**23700**	**19700**	**22900**	

706	**1**	12500	11000	11500	**Quad axle fuel trailer**
	2	5000	2900	4000	
	3	5000	2900	4000	
	4	10400	9200	10000	
	Total	**32900**	**26000**	**29500**	
707	**1**	3600	2200	3200	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6700	6700	
	4	6700	4400	6300	
	Total	**23700**	**20000**	**22900**	
708	**1**	12500	10500	11800	**Quad axle fuel trailer**
	2	5000	4000	4000	
	3	5000	3000	4000	
	4	10400	9000	10000	
	Total	**32900**	**26500**	**29800**	
709	**1**	3600	2300	3200	**Tridem Fuel truck**
	2	6700	6700	6700	
	3	6700	6700	6700	
	4	6700	4300	6300	
	Total	**23700**	**20000**	**22900**	
710	**1**	12000	11500	11800	**Quad axle fuel trailer**
	2	5000	2500	4000	
	3	5000	3000	4000	
	4	10500	10000	10000	
	Total	**32500**	**27000**	**29800**	

1801	**1**	3000	2800	2900	**Tandem Fuel Truck**
	2	3600	3400	3500	
	3	4000	1400	3000	
	4	4500	4400	4200	
	5	3000	2100	3000	
	Total	**18100**	**14100**	**16600**	
1202	**1**	13000	11000	13000	**Quad axle fuel trailer**
	2	5000	4400	5000	
	3	5000	5000	5000	
	4	10000	10000	10000	
	Total	**33000**	**30400**	**33000**	
???-1202	**1**	13000	10500	12000	
	2	5000	3100	3500	
	3	5000	3500	5000	
	4	10000	10000	10000	
	Total	**33000**	**27100**	**30500**	
901	**1**	2400	300	1500	**Tandem Fuel Truck**
	2	3600	3600	3600	
	3	5500	5500	5500	
	4	4500	4500	4500	
	5	2200	1000	2200	
	Total	**18200**	**14900**	**17300**	

APPENDIX E TDG REPORT FORM

Transport Canada / Transports Canada

TRANSPORTATION OF DANGEROUS GOODS
30-DAY FOLLOW-UP REPORT

PART I: REPORTING TIMELINE

1. Please provide applicable dates and check one box

Date of initial report to CANUTEC (yyyy-mm-dd): _____

30-Day Follow-up Report submission date (yyyy-mm-dd): _____

◯ 30-Day Follow-up Report

◯ Update or amendment to 30-Day Follow-up Report

• Date original 30-Day Follow-up Report submitted (yyyy-mm-dd): _____

FOR INTERNAL USE ONLY

Road, Rail or Marine Reports

◯ Release

◯ Anticipated Release

Air Report

◯ Dangerous Goods Accident or Incident

PART II: CONTACT INFORMATION

2. Information of the person completing this report

☐ Consignor ☐ Consignee ☐ Carrier/Aircraft Operator ☐ Other

First Name	Last Name	Title	
Telephone (999-999-9999)	Company Name		
Address		City	Province/Territory
Country	Postal Code (Z9Z 9Z9)	Email	

3. Information on the Consignor, Consignee and Carrier/Aircraft Operator

Consignor

First Name	Last Name	Title	
Telephone (999-999-9999)	Company Name		
Address		City	Province/Territory
Country	Postal Code (Z9Z 9Z9)	Email	

Consignee

First Name	Last Name	Title	
Telephone (999-999-9999)	Company Name		
Address		City	Province/Territory
Country	Postal Code (Z9Z 9Z9)	Email	

Carrier/Aircraft Operator

First Name	Last Name	Title	
Telephone (999-999-9999)	Company Name		
Address		City	Province/Territory
Country	Postal Code (Z9Z 9Z9)	Email	

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Canada

PART III: INCIDENT INFORMATION

4. Please indicate the date and time of the incident

Date (yyyy-mm-dd)	Time (24-hour system)

5. Geographic location of the incident

Address

City	Province/Territory	Postal Code (Z9Z 9Z9)	GPS Position

If the incident occured by rail, please indicate the milepost and subdivision	If the incident happened on First Nations Territory, please indicate the Territory name

Origin of consignment	Destination of consignment
◯ Same address as consignor ◯ Same address as consignee	◯ Same address as consignor ◯ Same address as consignee
◯ Other (please provide address):	◯ Other (please provide address):

6. Geographic Area (Check only one box)

◯ **Urban** Mixed use – residential, commercial
◯ **Suburban** Primary residential
◯ **Rural** Small towns, villages, agricultural lands
◯ **Wilderness/Remote** Little or no population

7. Mode of Transport (Check all applicable boxes)

☐ Road ☐ Rail ☐ Air ☐ Marine

8. If MARINE was checked on question 7, please indicate the position of the vessel and the next location at which the vessel will be at anchor or alongside a fixed facility

Position	Next location

9. Phase of Transport (Check only one box)

◯ **In-Transit** Consignment moving between origin and destination
◯ **Loading** Consignment is being packed or loaded into a means of transport at origin
◯ **Unloading** Consignment is being unpacked or unloaded from a means of transport at destination
◯ **Temporary Storage** Consignment is in short term storage pending transportation

10. Type of Incident (Check all applicable boxes)

☐ **Collision/Sideswipe** Moving vehicles striking an object, animal, or another vehicle
☐ **Derailment** Railcar leaving the rail tracks
☐ **Ran off road** Vehicle enters a soft shoulder, ditch or similar area
☐ **Overturn** Vehicle turning on its side or upside down
☐ **Loadshift** Shifting of the consignment within a vehicle
☐ **Dropped** Means of containment falling unexpectedly
☐ **Struck** Means of containment being struck by another object
☐ **Other (Please specify):** _____

11. Type of Release (Check all applicable boxes)

☐ **Spill** Quick, immediate discharge, emission or escape
☐ **Leak** Slow, sporadic or continuous discharge, emission or escape
☐ **Explosion** Violent sudden release of energy from means of containment producing a shock wave that may result in fragment projection and/or fire ball
☐ **Fire** Burning substances combined with oxygen to typically produce flame, heat and smoke
☐ **BLEVE** Boiling Liquid Expanding Vapour Explosion
☐ **Vapour** Dispersion in air of particles of a substance that is liquid or solid in its normal state
☐ **Venting** Controlled release of gas into the environment
☐ **Anticipated Release** Distressed means of containment that is not leaking, venting or otherwise releasing its contents

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12. Information on the Dangerous Goods

UN Number	Shipping Name	Primary Class	Subsidiary Class(es)	Packing Group or Category	Total Quantity in MOC Before the Release or Anticipated Release	Units *(kg, L, etc.)*	Estimated Quantity Released *(if applicable)*	Units *(kg, L, etc.)*

13. Means of Containment

Please provide a description of the means of containment involved in the incident by completing the appropriate forms from Annex E of the Guide (TP15294)

PART IV: CONSEQUENCES

14. Consequences of the incident (Check all applicable boxes)

NOTE: Refer to the Guide for more information on how to complete this section

☐ Human ☐ Property (e.g. product loss, facility, equipment) ☐ Environmental (e.g. contamination of waterway, ground, air)

15. Evacuation of people and buildings/Shelter in place

Was there an Evacuation as a result of the incident? ◯ Yes ◯ No

Was there Shelter in place as a result of the incident? ◯ Yes ◯ No

If **Yes**, please complete the following table

Evacuation of People and Buildings/Shelter in Place	**Private Residence** Includes houses and other buildings used as dwellings (e.g. Retirement homes)	**Public Buildings** Includes libraries, hospitals, churches, government buildings, etc.	**Workplace** Includes warehouse, facility, etc.	**Public (Outside) Areas** Includes parks, playgrounds, parking lots, etc.
Estimated number of **people evacuated**				
Estimated number of **people sheltered in place**				
Estimated number of **buildings evacuated**				

Size of Evacuation area (square meters)	Duration of Evacuation (hours)	Duration of Shelter in place (hours)

16. Injuries and/or deaths

Were there any injuries and/or deaths? ◯ Yes (please complete the following table) ◯ No

Minor injuries ◯ Yes ◯ No

Number of injured requiring immediate first aid treatment at the scene

Attributed to Dangerous Goods	Attributed to incident	**Total**

Moderate injuries ◯ Yes ◯ No

Number of injured requiring immediate emergency treatment in hospital and release shortly after

Attributed to Dangerous Goods	Attributed to incident	**Total**

Major injuries ◯ Yes ◯ No

Number of injured requiring immediate treatment with overnight hospitalization

Attributed to Dangerous Goods	Attributed to incident	**Total**

Deaths ◯ Yes ◯ No

Number of deaths

Attributed to Dangerous Goods	Attributed to incident	**Total**

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Canada

17. Please indicate an estimate of costs in Canadian dollars associated with the incident, as applicable

NOTE: Refer to the Guide for more information on how to fill this section

Material loss of dangerous goods	Damage incurred by the carrier	Property damage	Emergency response cost	Clean-up cost	**Total cost**

18. Infrastructure closure and duration (please use additional sheets for multiple closures)

Was there an infrastructure closure as a result of the incident? ◯ Yes ◯ No

If **Yes**, please complete the following table

Type	Duration of the closure (in hours)
☐ **Aerodrome** – Area of land, water or other supporting surface used either in whole or in part for arrival and departure, movement or servicing of aircraft includes any building, installations and equipment situated thereon or in connection therewith	
☐ **Air cargo facility** – Facility used to receive or transfer cargo carried or to be carried by an aircraft	
☐ **Facility** – Permanent or temporary building or a portion of a building or equipment used in loading or unloading of dangerous goods	
☐ **Railway** – Tracks used by trains	
☐ **Waterway** – Navigable body of water through which a ship or boat can move	
☐ **Roadway** – The strip of land over which motor vehicles circulate, such as dirt road, numbered provincial highway or multiple lane freeway	
☐ **Runway** – the strip of ground on a landing field that aircraft use for landing or takeoff	

19. Geographic location of closure

Address

City	Province/Territory	Postal Code (Z9Z 9Z9)	GPS Position

If the incident occured by rail, please indicate the milepost and subdivision	Name of facility, road, railway or waterway

20. ERAP Requirements

Was an ERAP required under Part 7 of the ***Transportation of Dangerous Goods Regulations***? ◯ Yes ◯ No

If **Yes**, please complete the following table

ERAP Reference Number	ERAP Holder

Address

City	Province/Territory	Postal Code (Z9Z 9Z9)	Telephone of ERAP Holder (999-999-9999)

Email

Level of Response (check all that apply)

☐ No response ☐ First responders on scene ☐ Phone call to ERAP holder ☐ Employee from ERAP holder ☐ Team from ERAP holder

☐ Other: _____

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PART V: INCIDENT DESCRIPTION

21. Please describe:

- The sequence of events that led to the incident
- The means of containment damage or failure, including the size/location of holes, cracks, etc.
- The actions taken at the time it was discovered
- What was done to mitigate the effects of the release
- Contributing factors (e.g. human error, mechanical, equipment, packaging, infrastructure, external, weather, etc.)
- The physical environment (e.g. residential, commercial, industrial, etc.)
- The road's appearance (e.g. flat, straight, inclined, curved, intersection, etc.)
- Timeline of event (e.g. how long it lasted, time of release or discovery, time of first responder arrival, etc.)
- Communications with first responders and with your organization

Photographs and diagrams should be submitted, as required, for clarification. Estimate the duration of the release, if possible. Please use additional sheets if necessary.

NOTE: Refer to the Guide for more information on how to complete this section

PART VI: INCIDENT DESCRIPTION – AIR ONLY

22. Please describe:

- Any serious jeopardy to persons on any aircraft or aircraft itself
- Any damages to property or environment
- The route by which the dangerous goods were to be or have been transported, including the name of any aerodromes along the route

Aircraft Operator	Air Cargo Facility

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INCIDENT BRIEFING (ICS 201)

1. Incident Name:	2. Incident Number:	3. Date/Time Initiated: Date: Time:

4. Map/Sketch (include sketch, showing the total area of operations, the incident site/area, impacted and threatened areas, overflight results, trajectories, impacted shorelines, or other graphics depicting situational status and resource assignment)**:**

5. Situation Summary and Health and Safety Briefing (for briefings or transfer of command)**:** Recognize potential incident Health and Safety Hazards and develop necessary measures (remove hazard, provide personal protective equipment, warn people of the hazard) to protect responders from those hazards.

6. Prepared by: Name: _____ Position/Title: _____ Signature: _____

 Date/Time: _____

INCIDENT BRIEFING (ICS 201)

1. Incident Name:	2. Incident Number:	3. Date/Time Initiated: Date: Time:

7. Current and Planned Objectives:

8. Current and Planned Actions, Strategies, and Tactics:

Time:	Actions:

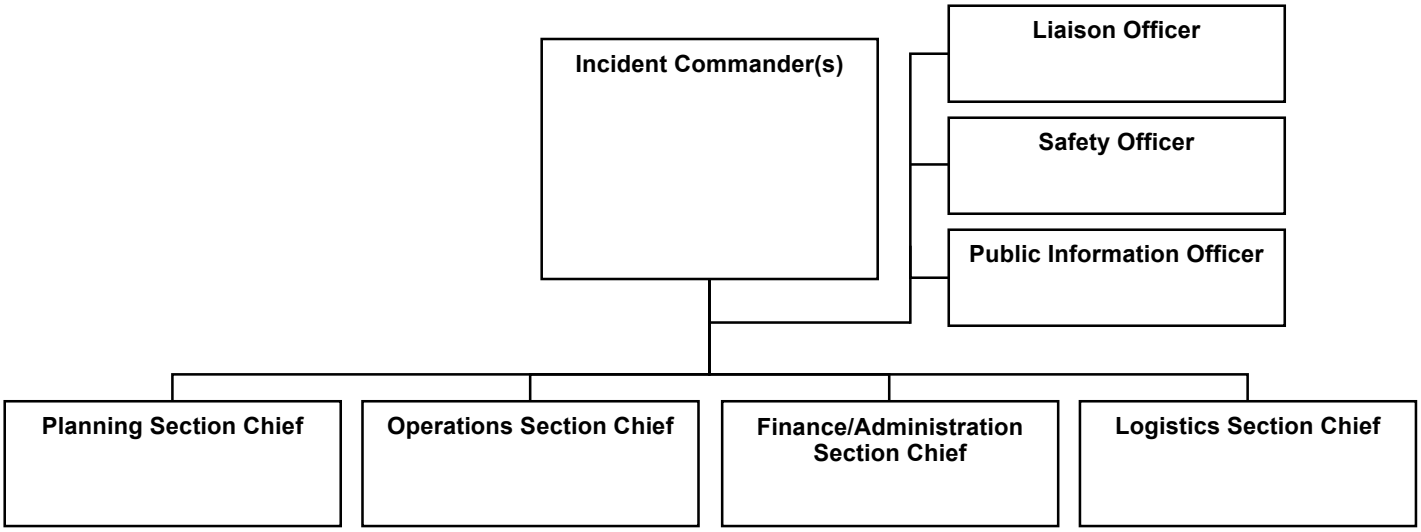
6. Prepared by: Name: _____ Position/Title: _____ Signature: _____

Date/Time: _____

INCIDENT BRIEFING (ICS 201)

1. Incident Name:	2. Incident Number:	3. Date/Time Initiated: Date: Time:

9. Current Organization (fill in additional organization as appropriate)**:**



6. Prepared by: Name: _____ Position/Title: _____ Signature: _____

Date/Time: _____

INCIDENT BRIEFING (ICS 201)

1. Incident Name:	2. Incident Number:	3. Date/Time Initiated: Date: Time:

10. Resource Summary:

Resource	Resource Identifier	Date/Time Ordered	ETA	Arrived	Notes (location/assignment/status)
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	
				☐	

6. Prepared by: Name: _____ Position/Title: _____ Signature: _____

Date/Time: _____

ICS 201
Incident Briefing

Purpose. The Incident Briefing (ICS 201) provides the Incident Commander (and the Command and General Staffs) with basic information regarding the incident situation and the resources allocated to the incident. In addition to a briefing document, the ICS 201 also serves as an initial action worksheet. It serves as a permanent record of the initial response to the incident.

Preparation. The briefing form is prepared by the Incident Commander for presentation to the incoming Incident Commander along with a more detailed oral briefing.

Distribution. Ideally, the ICS 201 is duplicated and distributed before the initial briefing of the Command and General Staffs or other responders as appropriate. The "Map/Sketch" and "Current and Planned Actions, Strategies, and Tactics" sections (pages 1–2) of the briefing form are given to the Situation Unit, while the "Current Organization" and "Resource Summary" sections (pages 3–4) are given to the Resources Unit.

Notes:

- The ICS 201 can serve as part of the initial Incident Action Plan (IAP).
- If additional pages are needed for any form page, use a blank ICS 201 and repaginate as needed.

Block Number	Block Title	Instructions
1	**Incident Name**	Enter the name assigned to the incident.
2	**Incident Number**	Enter the number assigned to the incident.
3	**Date/Time Initiated** • Date, Time	Enter date initiated (month/day/year) and time initiated (using the 24-hour clock).
4	**Map/Sketch** (include sketch, showing the total area of operations, the incident site/area, impacted and threatened areas, overflight results, trajectories, impacted shorelines, or other graphics depicting situational status and resource assignment)	Show perimeter and other graphics depicting situational status, resource assignments, incident facilities, and other special information on a map/sketch or with attached maps. Utilize commonly accepted ICS map symbology. If specific geospatial reference points are needed about the incident's location or area outside the ICS organization at the incident, that information should be submitted on the Incident Status Summary (ICS 209). North should be at the top of page unless noted otherwise.
5	**Situation Summary and Health and Safety Briefing (**for briefings or transfer of command): Recognize potential incident Health and Safety Hazards and develop necessary measures (remove hazard, provide personal protective equipment, warn people of the hazard) to protect responders from those hazards.	Self-explanatory.
6	**Prepared by** • Name • Position/Title • Signature • Date/Time	Enter the name, ICS position/title, and signature of the person preparing the form. Enter date (month/day/year) and time prepared (24-hour clock).
7	**Current and Planned Objectives**	Enter the objectives used on the incident and note any specific problem areas.

Block Number	Block Title	Instructions
8	**Current and Planned Actions, Strategies, and Tactics** • Time • Actions	Enter the current and planned actions, strategies, and tactics and time they may or did occur to attain the objectives. If additional pages are needed, use a blank sheet or another ICS 201 (Page 2), and adjust page numbers accordingly.
9	**Current Organization** (fill in additional organization as appropriate) • Incident Commander(s) • Liaison Officer • Safety Officer • Public Information Officer • Planning Section Chief • Operations Section Chief • Finance/Administration Section Chief • Logistics Section Chief	• Enter on the organization chart the names of the individuals assigned to each position. • Modify the chart as necessary, and add any lines/spaces needed for Command Staff Assistants, Agency Representatives, and the organization of each of the General Staff Sections. • If Unified Command is being used, split the Incident Commander box. • Indicate agency for each of the Incident Commanders listed if Unified Command is being used.
10	**Resource Summary**	Enter the following information about the resources allocated to the incident. If additional pages are needed, use a blank sheet or another ICS 201 (Page 4), and adjust page numbers accordingly.
	• Resource	Enter the number and appropriate category, kind, or type of resource ordered.
	• Resource Identifier	Enter the relevant agency designator and/or resource designator (if any).
	• Date/Time Ordered	Enter the date (month/day/year) and time (24-hour clock) the resource was ordered.
	• ETA	Enter the estimated time of arrival (ETA) to the incident (use 24-hour clock).
	• Arrived	Enter an “X” or a checkmark upon arrival to the incident.
	• Notes (location/ assignment/status)	Enter notes such as the assigned location of the resource and/or the actual assignment and status.

Northwest Fuels Limited

Environmental Response

Step 1 – Incident Type / product information **Step 2 – Risk Assessment** **Step 3 – Record of Attendance** **Step 4 - Debrief**

Date:_____**Customer:** _____ **Incident #:** _____

Step 1- Incident Specifics and Entry Objectives

Description: _____

Location: _____

Incident Type	***Site Entry Objectives***
Spill	Initial assessment
Gas Release	Account for personnel and/or rescue victims
Explosion	Source Control
Fire	Fire Suppression
Other_____	Spill Containment
Unknown	Spill Recovery and/or cleanup

Consult MSDS: If no MSDS call CANUTEC at 613-996-6666 or *666

Product Properties	***Product Hazards***
Name:	Flammable (Flash Point _____ C)
Estimated amount:	Explosive (LEL range _____ to _____%)
MSDS Available:	Corrosive (Corrodes_____)
Gas/ Liquid/ Solid	Reactive (reacts with _____)
Water Soluble?	Toxic (IDHL _____: TLV _____)

PPE Requirements	**Y/N**	**A**	**B**	**C**	**D**	***Equipment Requirements (* depends on situation)***
Responders						SCBA (Self Contained Breathing Apparatus) or Positive Pressure supplied air respirator with es SCBA
LEVEL A						Full Face or Half Mask with appropriate cartridges (specify)
LEVEL B						Escape mask*
LEVEL C						Encapsulating Suit (chemical protective with vapour barrier)
LEVEL D						Outer Gloves (chemically resistant)
Decon Team						Inner Gloves (chemically resistant)
LEVEL A						Boots (chemically resistant, steel toe and shank)
LEVEL B						Disposable Protective suit worn over entire ensemble
LEVEL C						Disposable outer boot covers, chemically resistant *
LEVEL D						Hard Hat
						Face Shield*
						Safety Glasses or chemical splash goggles
						Coveralls*
						Hearing Protection*
						PFD (Personal Flotation Device) within 1 meter of water
						Cold Weather Gear or Rain Gear*
						Fall Protection

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Environmental Response

Specific Gravity or Vapour Density	Carcinogenic

Step 2 –Risk Assessment

Complete this risk assessment before the start of each shift (spill response) or when using the vessels (day to day). **Risks shall be reassessed any time conditions change.** Action plans to mitigate the hazards identified in the "Yes" column **MUST** be reviewed with all workers during the Tailgate Safety Meeting. Refer to work Safe BC Standards for critical task procedures.

Hazard	Yes	No	Suggested Control Measures
Hazardous materials			**Control measures are developed based on the Material Safety Data Sheet (MSDS)**
Inhalation: vapours, mists, fumes			Perform air monitoring and if required: mechanical ventilation, exclusion zones, respirators, SCBA.
Eye contact			Wear eye protection: safety face shield, safety goggles, safety glasses, eye wash stations.
Skin contact:			Use chemically resistant: coveralls, gloves, special barrier cream. Clean exposed areas immediately.
Ingestion			Seek immediate medical attention.

Critical tasks

Is a Critical Procedure(s) to be reviewed prior to starting this job?
____ Hot Work ____ Confined Space Entry ____ Energy Lockout ____ Crane Operation ____ Working at Height ____ Fuel Transfer/Grounding & Bonding
Work Safe BC Procedures must be followed

*** Confined space hazards: includes but not limited to tanks, under wharves or docks or logs, deep trenches, fuel tanks, industrial containment**

Weather hazards

River/Creek currents			Check area currents, keep vessel crew and shoreline worker aware of changes.
Fog, ice, rain, snow, winds/waves			Maintain safe working distances, clear ice and snow from area of travel, wear appropriate PPE and/or clothing.
Darkness			Use portable lighting.
Hot or Cold weather			Stay hydrated (drink fluids), take rest breaks, warm-up breaks, use sunscreen, wear appropriate

Wind speed: Km/H	Wind direction:	Precipitation: Rain Snow
Air temperature:	Humidity Wind Chill	Forecast:

General hazards

Trips, slips and falls			Keep equipment, supplies, cords and/or air-lines out of the path of travel or secured; clean-up all oils, standing water, ice/snow or post warning sign; use handrails; secure ladders; maintain three-point contact when climbing or when on a vessel; take small, deliberate steps when walking in congested areas and along rugged shorelines.
Employee working alone			Communications **MUST** be done at four (4) hour intervals between worker and supervisor, and documented.
Working on or near water			PFDs **MUST** be worn at all times when working within 1m (3 feet) of the water unless protected by other means.
Person overboard			Be familiar with "overboard" procedures, location of life rings.
Repetitive motion injuries			Use different muscle groups and take rest breaks during repetitive tasks, vary tasks if possible.
Injuries from sharp material, needles, glass, etc.			Wear appropriate gloves, safety footwear. Make any cuts with blade facing away from the body. Store blades safely when not in use.
Pinch injuries			Watch mooring lines, don't get caught in the bight, avoid hand traps.
Lifting injuries			Use safe lifting techniques, **bend your knees, ask for help**; use mechanical lifting equipment when possible.
Fatigue			Work reasonably length shift, take breaks periodically.
Hearing damage			If you have to raise your voice to be heard, you need hearing protection.
Eye injuries			Wear eye protection; safety glasses or goggles/safety glasses and face shield.
Burn injuries			Maintain a safe working distance; wear gloves.
Working From a height			Safety Harness or barrier is necessary above 10 feet
Miscellaneous injuries			Keep exit routes clear at all times; stack equipment and supplies in a place and manner where it will not cause injury; keep clear of tow-lines; beware of snap back from failed lines.

Northwest Fuels Limited

Environmental Response

Step 2 –Risk Assessment cont'd

Hazard	Yes	No	Suggested Control Measures
Vehicle hazards			
Trucks, heavy equipment, forklifts			Wear appropriate PPE; activate back up alarm; use a backup spotter; inspect equipment before use, use only trained operators.
Traffic congestion			Ensure site traffic and parking plans are in place.
Vacuum truck noise, hose failure or explosion			Wear appropriate PPE; operator(s) trained and experienced in petroleum handling; inspect equipment before use.
Other task specific hazards			
Aircraft hazards			
Working around helicopter landing areas			**Never** approach the helicopter unless signaled to do so by the pilot. **Always** maintain eye contact with the pilot as you approach. **Never** approach from the uphill side. **Never** wear loose clothing around a helicopter.
In flight hazards			**Never** speak to the pilot during takeoff or landing (unless it is an emergency). **Always** wear your seat belt. Wear warm clothing. Take extra food and drink along.
Working around fixed wing aircraft			**Never** approach the aircraft while engines are running. **Never** touch anything on the fuselage, wings or propellers – they may be hot and/or brittle. Stay behind the wings at all times.
Other task specific hazards			
Wildlife			
Injury; disease, potential of attack			Be aware of the dangers from bears, cougars, wolves, dogs, raccoons, moose, deer, otters, wild fowl, rats, snakes and insects. Keep bear spray and insect repellent on hand. Use a safety watch. Only trained personnel to handle wildlife. Safety watch in bear/cougar/wolf country may needed.

Safety Equipment/ Personnel Requirements:

4 Gas Monitor	Fire Extinguisher	First Aid Kit/ attendant	Eyewash
Safety Watch	Traffic Control	Throw Rope or Ring	Other

Notes/ Other:

Risk assessment by: (print) _____ **Signature:** _____

Company name: _____ **Date:** _____

Northwest Fuels Limited

Environmental Response

Step 3 – Tailgate Safety Meeting - Agenda

☐ **Unsafe work**

Every worker has the authority and the responsibility to shut down unsafe work**.** Be watchful of changing, particularly deteriorating, conditions. Advise your supervisor of any unsafe work.

☐ **Site Health and Safety rules**

When working on someone else's site, please take note of and review any local health and safety rules that need to be followed (i.e. exits, assembling procedure, safety vests etc.). Attach a copy.

☐ **Safety Officer/contact method:** _____

☐ **First Aider/contact method:** _____

☐ **First aid kit location:** _____ ☐

Eye wash/emergency shower: _____

☐ **Decontamination process/location:** _____

☐ **Fire/explosion:** emergency signal will sound, assemble at _____

☐ **Incident reporting**: report incidents (including near misses) to your supervisor

☐ **Material Safety Data Sheets (MSDS):** reviewed with workers ☐

WCB Regulations

WCB Regulations and related materials including policies, guidelines and standards apply to all WCMRC/BCO work sites and

are available at the "WorkSafeBC" website. Any worker wishing computer system access and help with the process should contact their supervisor.

Specific Safety Plans (control measures to deal with the hazards identified in the preceding risk assessment)

STOP and THINK!

Northwest Fuels Limited

Environmental Response

Step 3 – Tailgate Safety Meeting - Record of Attendance

Signature on this record of attendance is confirmation that the Tailgate Safety Meeting has taken place, the risks and control measures identified on the risk assessment and any specific safety plans have been reviewed, are understood and will be complied with.

Please print first name, initial and last name clearly.

First Name	Init.	Last Name	Company/Vessel	Signature	Time

Meeting location: _____

Meeting Conducted by: (print)_____ Signature:_____

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Environmental Response

Meeting Date: _____

SKETCH :

Compass

Sketch NOT TO SCALE:

STOP and THINK!

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Environmental Response

Time	
H2S	
Benzene	
O2	
CO	
LEL	

Time	
H2S	
Benzene	
O2	
CO	
LEL	

Time	
H2S	
Benzene	
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Response Debrief (use extra paper as necessary)

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STOP and THINK!

Ram ER Response No:	
Date of Response:	
Team Leader:	

List or describe what you thought was successful or worked well in the response.

List or describe what you thought was NOT successful or did not work well in the response.

List your actions/recommendations for improvement for future responses.

List or describe what you thought was successful or observed working well in the whole event:

List or describe what you thought was NOT successful or observed working well in the whole event:

Any further comments or suggestions for improvement for future events:

SECTION 1. IDENTIFICATION

Product name	:	DIESEL FUEL
Synonyms	:	Seasonal Diesel, #1 Diesel, #2 Heating Oil, #1 Heating Oil, D50, Arctic Diesel, Farm Diesel, Marine Diesel, Low Sulphur Diesel, LSD, Ultra Low Sulphur Diesel, ULSD, Mining Diesel, Naval Distillate, Dyed Diesel, Marked Diesel, Coloured Diesel, Furnace special, Biodiesel blend, B1, B2, B5, Diesel Low Cloud (LC), Marine Gas Oil, Marine Gas Oil Dyed.
Product code	:	102907, 102762, 102763, 102755, 102302, 102744, 101801, 100678, 100677, 101802, 100107, 100668, 100658, 100911, 100663, 100652, 100460, 100065, 101796, 101793, 101795, 101792, 101794, 101791, 100768, 100643, 100642, 100103, 101798, 101800, 101797, 101788, 101789, 101787, 102531, 100734, 100733, 100640, 100997, 100995, 100732, 100731, 100994

Manufacturer or supplier's details

Petro-Canada
P.O. Box 2844, 150 - 6th Avenue South-West
Calgary Alberta T2P 3E3
Canada

Emergency telephone number

Suncor Energy: +1 403-296-3000;
Canutec Transportation: 1-888-226-8832 (toll-free) or 613-996-6666;
Poison Control Centre: Consult local telephone directory for emergency number(s).

Recommended use of the chemical and restrictions on use

Recommended use	:	Diesel fuels are distillate fuels suitable for use in high and medium speed internal combustion engines of the compression ignition type. Mining diesels, marine diesels, MDO and naval distillates may have a higher flash point requirement.
Prepared by	:	Product Safety: +1 905-804-4752

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Appearance	Bright oily liquid.
Colour	Clear to yellow (This product may be dyed red for taxation purposes)
Odour	Mild petroleum oil like.

GHS Classification

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Flammable liquids	:	Category 3
Acute toxicity (Inhalation)	:	Category 4
Skin irritation	:	Category 2
Carcinogenicity	:	Category 2
Specific target organ toxicity - single exposure	:	Category 3 (Central nervous system)
Specific target organ toxicity - repeated exposure	:	Category 2 (Liver, thymus, Bone)
Aspiration hazard	:	Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Flammable liquid and vapour.
May be fatal if swallowed and enters airways.
Causes skin irritation.
Harmful if inhaled.
May cause drowsiness or dizziness.
Suspected of causing cancer.
May cause damage to organs (Liver, thymus, Bone) through prolonged or repeated exposure.

Precautionary statements : **Prevention:**
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
Keep container tightly closed.
Ground and bond container and receiving equipment.
Use explosion-proof electrical/ ventilating/ lighting equipment.
Use non-sparking tools.
Take action to prevent static discharges.
Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
Wash skin thoroughly after handling.
Use only outdoors or in a well-ventilated area.
Wear protective gloves/ protective clothing/ eye protection/ face protection.
Response:
IF SWALLOWED: Immediately call a POISON CENTER/doctor.
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water.
IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER/doctor if you feel unwell.

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IF exposed or concerned: Get medical advice/ attention.
Do NOT induce vomiting.
If skin irritation occurs: Get medical advice/ attention.
Take off contaminated clothing and wash it before reuse.
In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
Storage:
Store in a well-ventilated place. Keep container tightly closed.
Store in a well-ventilated place. Keep cool.
Store locked up.
Disposal:
Dispose of contents/ container to an approved waste disposal plant.

Potential Health Effects

Primary Routes of Entry : Eye contact
Ingestion
Inhalation
Skin contact

Aggravated Medical Condition : None known.

Other hazards

None known.

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Mixture

Hazardous components

Chemical name	CAS-No.	Concentration
Kerosine (petroleum), hydrodesulfurized; Kerosine -unspecified	64742-81-0	70 - 100 %
Kerosine (petroleum); Straight run kerosine	8008-20-6	
Fuels, diesel; Gasoil -unspecified	68334-30-5	
Alkanes, C10-20-branched and linear	928771-01-1	0 - 30 %
Fatty acids, C16-18 and C18-unsatd., Me esters	67762-38-3	0 - 20 %

All concentrations are in percent by weight.

SECTION 4. FIRST AID MEASURES

If inhaled : Move to fresh air.
Artificial respiration and/or oxygen may be necessary.
Seek medical advice.

In case of skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash skin thoroughly with soap and water or use recognized skin cleanser.

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		Wash clothing before reuse. Seek medical advice.
In case of eye contact	:	Remove contact lenses. Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Obtain medical attention.
If swallowed	:	Rinse mouth with water. DO NOT induce vomiting unless directed to do so by a physician or poison control center. Never give anything by mouth to an unconscious person. Seek medical advice.
Most important symptoms and effects, both acute and delayed	:	Harmful if inhaled. Respiratory, skin and eye irritation; nausea; cancer.
Notes to physician	:	Treat symptomatically. For specialist advice physicians should contact the Poisons Information Service.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	Dry chemical Carbon dioxide (CO2) Water fog. Foam
Unsuitable extinguishing media	:	Do NOT use water jet.
Specific hazards during firefighting	:	Cool closed containers exposed to fire with water spray.
Hazardous combustion products	:	Carbon oxides (CO, CO2), nitrogen oxides (NOx), sulphur oxides (SOx), smoke and irritating vapours as products of incomplete combustion.
Further information	:	Prevent fire extinguishing water from contaminating surface water or the ground water system.
Special protective equipment for firefighters	:	Wear self-contained breathing apparatus for firefighting if necessary.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	For personal protection see section 8. Ensure adequate ventilation. Evacuate personnel to safe areas. Material can create slippery conditions.
Environmental precautions	:	If the product contaminates rivers and lakes or drains inform

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respective authorities.

Methods and materials for containment and cleaning up : Prevent further leakage or spillage if safe to do so.
Remove all sources of ignition.
Soak up with inert absorbent material.
Non-sparking tools should be used.
Ensure adequate ventilation.
Contact the proper local authorities.

SECTION 7. HANDLING AND STORAGE

Advice on safe handling : For personal protection see section 8.
Smoking, eating and drinking should be prohibited in the application area.
Use only with adequate ventilation.
In case of insufficient ventilation, wear suitable respiratory equipment.
Avoid spark promoters. Ground/bond container and equipment. These alone may be insufficient to remove static electricity.
Avoid contact with skin, eyes and clothing.
Do not ingest.
Keep away from heat and sources of ignition.
Keep container closed when not in use.

Conditions for safe storage : Store in original container.
Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Keep in a dry, cool and well-ventilated place.
Keep in properly labelled containers.
To maintain product quality, do not store in heat or direct sunlight.
Ensure the storage containers are grounded/bonded.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value type (Form of exposure)	Control parameters / Permissible concentration	Basis
Kerosine (petroleum), hydrodesulfurized; Kerosine - unspecified	64742-81-0	TWA	200 mg/m3 (As total hydrocarbon vapour)	ACGIH
		TWA	200 mg/m3 (total hydrocarbon vapor)	CA AB OEL
		TWA	525 mg/m3	CA ON OEL
		TWA	200 mg/m3 (As total hydrocarbon vapour)	ACGIH
		TWA	200 mg/m3 (total hydrocarbon	ACGIH

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			vapor)	
Kerosine (petroleum); Straight run kerosine	8008-20-6	TWA	200 mg/m3 (total hydrocarbon vapor)	CA BC OEL
		TWA	200 mg/m3 (total hydrocarbon vapor)	CA AB OEL
		TWA	200 mg/m3 (total hydrocarbon vapor)	ACGIH
Fuels, diesel; Gasoil - unspecified	68334-30-5	TWA	100 mg/m3 (total hydrocar-bons)	CA AB OEL
		TWA (Va-pour and inhalable aerosols)	100 mg/m3 (total hydrocar-bons)	CA BC OEL
		TWA (Inhal-able fraction and vapor)	100 mg/m3 (total hydrocar-bons)	ACGIH

Engineering measures : Adequate ventilation to ensure that Occupational Exposure Limits are not exceeded.
Use only in well-ventilated areas.
Ensure that eyewash station and safety shower are proximal to the work-station location.

Personal protective equipment

Respiratory protection : Concentration in air determines protection needed.
Use respiratory protection unless adequate local exhaust ventilation is provided or exposure assessment demonstrates that exposures are within recommended exposure guidelines. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Filter type : organic vapour cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air-purifying respirators is limited. Use a positive-pressure, air-supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstances where air-purifying respirators may not provide adequate protection.

Hand protection
Material : neoprene, nitrile, polyvinyl alcohol (PVA), Viton(R). Consult your PPE provider for breakthrough times and the specific glove that is best for you based on your use patterns. It should be realized that eventually any material regardless of their imperviousness, will get permeated by chemicals. Therefore, protective gloves should be regularly checked for wear and tear. At the first signs of hardening and cracks, they should be changed.

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Remarks	:	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Eye protection	:	Wear face-shield and protective suit for abnormal processing problems.
Skin and body protection	:	Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place.
Protective measures	:	Wash contaminated clothing before re-use.
Hygiene measures	:	Remove and wash contaminated clothing and gloves, including the inside, before re-use. Wash face, hands and any exposed skin thoroughly after handling.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Bright oily liquid.
Colour	:	Clear to yellow (This product may be dyed red for taxation purposes)
Odour	:	Mild petroleum oil like.
Odour Threshold	:	No data available
pH	:	No data available
Melting point	:	No data available
Boiling point/boiling range	:	150 - 371 °C (302 - 700 °F)
decomposition temperature		No data available
Flash point	:	> 40 °C (104 °F) Method: closed cup
Auto-Ignition Temperature	:	225 °C (437 °F)
Evaporation rate	:	No data available
Flammability	:	Flammable in presence of open flames, sparks and heat. Vapours are heavier than air and may travel considerable distance to sources of ignition and flash back. This product can accumulate static charge and ignite.
Upper explosion limit	:	6 %(V)
Lower explosion limit	:	0.7 %(V)
Vapour pressure	:	7.5 mmHg (20 °C / 68 °F)

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Relative vapour density	:	4.5
Relative density	:	0.8 - 0.88
Solubility(ies)		
Water solubility	:	insoluble
Partition coefficient: n-octanol/water	:	No data available
Viscosity		
Viscosity, kinematic	:	1.3 - 4.1 cSt (40 °C / 104 °F)

SECTION 10. STABILITY AND REACTIVITY

Reactivity	:	Stable at normal ambient temperature and pressure.
Chemical stability	:	Stable under normal conditions.
Possibility of hazardous reactions	:	Hazardous polymerisation does not occur.
Conditions to avoid	:	Extremes of temperature and direct sunlight.
Incompatible materials	:	Reactive with oxidising agents and acids.
Hazardous decomposition products	:	May release COx, NOx, SOx, smoke and irritating vapours when heated to decomposition.

SECTION 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure
Eye contact
Ingestion
Inhalation
Skin contact

Acute toxicity

Product:

Acute oral toxicity	:	Remarks: No data available
Acute inhalation toxicity	:	Acute toxicity estimate: 1.2 mg/l Exposure time: 4 h Test atmosphere: dust/mist Method: Calculation method
Acute dermal toxicity	:	Remarks: No data available

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Components:

Kerosine (petroleum), hydrodesulfurized; Kerosine -unspecified:

Acute oral toxicity	:	LD50 (Rat): > 5,000 mg/kg,
Acute inhalation toxicity	:	LC50 (Rat): > 5.2 mg/l Exposure time: 4 hrs Test atmosphere: dust/mist
Acute dermal toxicity	:	LD50 (Rabbit): > 2,000 mg/kg,

Kerosine (petroleum); Straight run kerosine:

Acute oral toxicity	:	LD50 (Rat): > 5,000 mg/kg,
Acute inhalation toxicity	:	LC50 (Rat): > 5 mg/l Exposure time: 4 h Test atmosphere: dust/mist
Acute dermal toxicity	:	LD50 (Rabbit): > 2,000 mg/kg,

Fuels, diesel; Gasoil -unspecified:

Acute oral toxicity	:	LD50 (Rat): 7,500 mg/kg,
Acute dermal toxicity	:	LD50 (Mouse): 24,500 mg/kg,

Skin corrosion/irritation

Product:

Remarks: Causes skin irritation.

Serious eye damage/eye irritation

Product:

Remarks: No data available

Respiratory or skin sensitisation

Product:

Remarks: Based on available data, the classification criteria are not met.

Germ cell mutagenicity

Product:

Genotoxicity in vitro	Remarks: No data available
Genotoxicity in vivo	Remarks: No data available

Carcinogenicity

Product:

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Carcinogenicity - Assessment	Suspected of causing cancer.

Reproductive toxicity

Product:

Effects on fertility	Remarks: Based on available data, the classification criteria are not met.

STOT - single exposure

Product:

Remarks: May cause drowsiness or dizziness.

STOT - repeated exposure

Product:

Remarks: May cause damage to organs through prolonged or repeated exposure.

No data available

Aspiration toxicity

Product:

May be fatal if swallowed and enters airways.

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Product:

Toxicity to fish	:	Remarks: No data available
Toxicity to daphnia and other aquatic invertebrates	:	Remarks: No data available
Toxicity to algae	:	Remarks: No data available
Toxicity to bacteria	:	Remarks: No data available

Persistence and degradability

Product:

Biodegradability	:	Remarks: No data available

Bioaccumulative potential

No data available

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Mobility in soil

No data available

Other adverse effects

No data available

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues	:	The product should not be allowed to enter drains, water courses or the soil. Offer surplus and non-recyclable solutions to a licensed disposal company. Waste must be classified and labelled prior to recycling or disposal. Send to a licensed waste management company. Dispose of as hazardous waste in compliance with local and national regulations. Dispose of product residue in accordance with the instructions of the person responsible for waste disposal.

SECTION 14. TRANSPORT INFORMATION

International Regulations

IATA-DGR

UN/ID No.	:	UN 1202
Proper shipping name	:	Diesel fuel
Class	:	3
Packing group	:	III
Labels	:	Class 3 - Flammable Liquid
Packing instruction (cargo aircraft)	:	366

IMDG-Code

UN number	:	UN 1202
Proper shipping name	:	DIESEL FUEL
Class	:	3
Packing group	:	III
Labels	:	3
EmS Code	:	F-E, S-E
Marine pollutant	:	no

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

National Regulations

TDG

UN number	:	UN 1202
Proper shipping name	:	DIESEL FUEL
Class	:	3
Packing group	:	III

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Labels	:	3
ERG Code	:	128
Marine pollutant	:	no

SECTION 15. REGULATORY INFORMATION

This product has been classified according to the hazard criteria of the Hazardous Products Regulations (HPR) and the SDS contains all of the information required by the HPR.

The components of this product are reported in the following inventories:

DSL	On the inventory, or in compliance with the inventory

SECTION 16. OTHER INFORMATION

For Copy of SDS	:	Internet: www.petro-canada.ca/msds Canada-wide: telephone: 1-800-668-0220; fax: 1-800-837-1228 For Product Safety Information: 1 905-804-4752
Prepared by	:	Product Safety: +1 905-804-4752
Revision Date	:	2018/12/19

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

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SECTION 1. IDENTIFICATION

Product name	:	GASOLINE - ETHANOL
Synonyms	:	SuperClean, SuperClean 94 (Montreal), GASOHOL, Regular, Mid-Grade, Plus, WinterGas, RegularClean, PlusClean, marked or dyed gasoline, Super Premium (94 RO), E-10, Ultra 94, Ethanol blended gasoline, P10
Product code	:	102823, 100494, 102797, 102795, 102803, 102802, 102801, 102799, 102793, 102792, 102751, 101836, 100505, 100503, 100482, 102073, 101828, 101825, 102071, 101827, 100481, 101826, 101824, 100479, 100480, 101832, 101831, 101835, 100504, 101829
Manufacturer or supplier's details		Petro-Canada P.O. Box 2844, 150 - 6th Avenue South-West Calgary Alberta T2P 3E3 Canada
Emergency telephone number		Suncor Energy: +1 403-296-3000; Canutec Transportation: 1-888-226-8832 (toll-free) or 613-996-6666; Poison Control Centre: Consult local telephone directory for emergency number(s).

Recommended use of the chemical and restrictions on use

Recommended use	:	Gasoline-Ethanol is used in spark ignition engines including motor vehicles, farm vehicles, inboard and outboard boat engines, small engines and recreational vehicles.
Prepared by	:	Product Safety: +1 905-804-4752

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Appearance	Clear liquid.
Colour	Clear to slightly yellow, undyed liquid. May be dyed for taxation purposes.
Odour	Gasoline

GHS Classification

Flammable liquids	:	Category 1
Skin irritation	:	Category 2
Eye irritation	:	Category 2A

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Germ cell mutagenicity	:	Category 1B
Carcinogenicity	:	Category 1A
Reproductive toxicity	:	Category 2
Specific target organ toxicity - single exposure	:	Category 3 (Central nervous system)
Specific target organ toxicity - repeated exposure	:	Category 1
Aspiration hazard	:	Category 1

GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Extremely flammable liquid and vapour.
May be fatal if swallowed and enters airways.
Causes skin irritation.
Causes serious eye irritation.
May cause drowsiness or dizziness.
May cause genetic defects.
May cause cancer.
Suspected of damaging fertility or the unborn child.
Causes damage to organs through prolonged or repeated exposure.

Precautionary statements : **Prevention:**
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
Keep container tightly closed.
Ground and bond container and receiving equipment.
Use explosion-proof electrical/ ventilating/ lighting equipment.
Use non-sparking tools.
Take action to prevent static discharges.
Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
Wash skin thoroughly after handling.
Do not eat, drink or smoke when using this product.
Use only outdoors or in a well-ventilated area.
Wear protective gloves/ protective clothing/ eye protection/ face protection.
Response:
IF SWALLOWED: Immediately call a POISON CENTER/doctor.
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water.

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IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER/doctor if you feel unwell.
IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
IF exposed or concerned: Get medical advice/ attention.
Do NOT induce vomiting.
If skin irritation occurs: Get medical advice/ attention.
If eye irritation persists: Get medical advice/ attention.
Take off contaminated clothing and wash it before reuse.
In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
Storage:
Store in a well-ventilated place. Keep container tightly closed.
Store in a well-ventilated place. Keep cool.
Store locked up.
Disposal:
Dispose of contents/ container to an approved waste disposal plant.

Potential Health Effects

Primary Routes of Entry	:	Eye contact Ingestion Inhalation Skin contact
Inhalation	:	Inhalation may cause central nervous system effects. May cause respiratory tract irritation.
Skin	:	Causes skin irritation.
Eyes	:	Causes eye irritation.
Ingestion	:	Ingestion of this material may cause irritation to the mouth, throat and gastro-intestinal tract. Aspiration hazard if swallowed - can enter lungs and cause damage.
Chronic Exposure	:	Chronic exposure to benzene may result in increased risk of leukemia and other blood disorders.
Aggravated Medical Condition	:	None known.

Other hazards

None known.

IARC	Group 1: Carcinogenic to humans	
	Benzene	71-43-2
ACGIH	Confirmed human carcinogen	
	Benzene	71-43-2

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Confirmed animal carcinogen with unknown relevance to humans	
Gasoline	86290-81-5
Ethanol	64-17-5

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Mixture

Hazardous components

Chemical name	CAS-No.	Concentration
gasoline	86290-81-5	70 - 97 %
toluene	108-88-3	0 - 20 %
ethanol	64-17-5	3 - 10 %
benzene	71-43-2	0 - 1.5 %

SECTION 4. FIRST AID MEASURES

If inhaled : Move to fresh air.
Artificial respiration and/or oxygen may be necessary.
Seek medical advice.

In case of skin contact : In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes.
Wash skin thoroughly with soap and water or use recognized skin cleanser.
Wash contaminated clothing before reuse.
Seek medical advice.

In case of eye contact : Remove contact lenses.
Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes.
Obtain medical attention.

If swallowed : Rinse mouth with water.
DO NOT induce vomiting unless directed to do so by a physician or poison control center.
Never give anything by mouth to an unconscious person.
Seek medical advice.

Most important symptoms and effects, both acute and delayed : Respiratory, skin and eye irritation; nausea; cancer.

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Protection of first-aiders	:	First Aid responders should pay attention to self-protection and use the recommended protective clothing It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	Dry chemical Carbon dioxide (CO2) Alcohol-resistant foam Water spray Water fog.
Unsuitable extinguishing media	:	Do NOT use water jet.
Specific hazards during fire-fighting	:	Cool closed containers exposed to fire with water spray.
Hazardous combustion products	:	Carbon oxides (CO, CO2), nitrogen oxides (NOx), polynuclear aromatic hydrocarbons, phenols, aldehydes, ketones, smoke and irritating vapours as products of incomplete combustion.
Further information	:	Prevent fire extinguishing water from contaminating surface water or the ground water system.
Special protective equipment for firefighters	:	Wear self-contained breathing apparatus and full protective wear. Wear a positive-pressure supplied-air respirator with full face-piece.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	For personal protection see section 8. Ensure adequate ventilation. Evacuate personnel to safe areas. Material can create slippery conditions.
Environmental precautions	:	Do not allow uncontrolled discharge of product into the environment.
Methods and materials for containment and cleaning up	:	Prevent further leakage or spillage if safe to do so. Remove all sources of ignition. Soak up with inert absorbent material. Non-sparking tools should be used. Ensure adequate ventilation. Contact the proper local authorities.

SECTION 7. HANDLING AND STORAGE

Advice on safe handling	:	For personal protection see section 8.

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Smoking, eating and drinking should be prohibited in the application area.
Do not ingest.
Avoid contact with skin, eyes and clothing.
Use only with adequate ventilation.
Keep away from heat and sources of ignition.
Keep container closed when not in use.
In case of insufficient ventilation, wear suitable respiratory equipment.
Avoid inhalation of vapour or mist.
Use explosion-proof equipment.
Ensure all equipment is electrically grounded before beginning transfer operations.

Conditions for safe storage : Store in original container.
Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Keep in a dry, cool and well-ventilated place.
Keep in properly labelled containers.
To maintain product quality, do not store in heat or direct sunlight.
Ensure the storage containers are grounded/bonded.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value type (Form of exposure)	Control parameters / Permissible concentration	Basis
gasoline	86290-81-5	TWA	300 ppm	CA AB OEL
		STEL	500 ppm	CA AB OEL
		TWA	300 ppm	CA BC OEL
		STEL	500 ppm	CA BC OEL
		TWA	300 ppm	ACGIH
		STEL	500 ppm	ACGIH
toluene	108-88-3	TWA	50 ppm 188 mg/m3	CA AB OEL
		TWA	20 ppm	CA BC OEL
		TWAEV	50 ppm 188 mg/m3	CA QC OEL
		TWA	20 ppm	ACGIH
ethanol	64-17-5	TWA	1,000 ppm 1,880 mg/m3	CA AB OEL
		STEL	1,000 ppm	CA BC OEL
		TWAEV	1,000 ppm 1,880 mg/m3	CA QC OEL
		STEL	1,000 ppm	ACGIH
benzene	71-43-2	TWA	0.5 ppm 1.6 mg/m3	CA AB OEL
		STEL	2.5 ppm 8 mg/m3	CA AB OEL
		TWA	0.5 ppm	CA BC OEL
		STEL	2.5 ppm	CA BC OEL

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		TWA	0.5 ppm	CA ON OEL
		STEL	2.5 ppm	CA ON OEL
		TWAEV	1 ppm 3 mg/m3	CA QC OEL
		STEV	5 ppm 15.5 mg/m3	CA QC OEL
		TWA	0.5 ppm	ACGIH
		STEL	2.5 ppm	ACGIH

Biological occupational exposure limits

Components	CAS-No.	Control parameters	Biological specimen	Sam-pling time	Permissible concentra-tion	Basis
Toluene	108-88-3	Toluene	In blood	Prior to last shift of work-week	0.02 mg/l	ACGIH BEI
		Toluene	Urine	End of shift (As soon as possible after exposure ceases)	0.03 mg/l	ACGIH BEI

Engineering measures : Use only in well-ventilated areas.
Adequate ventilation to ensure that Occupational Exposure Limits are not exceeded.
Use explosion-proof ventilation equipment.

Personal protective equipment

Respiratory protection : Use a properly fitted, air-purifying or air-fed respirator complying with an approved standard if a risk assessment indicates this is necessary.
Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Filter type : A NIOSH-approved air-purifying respirator with an organic vapour cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air-purifying respirators is limited. Use a positive-pressure, air-supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstances where air-purifying respirators may not provide adequate protection.

Hand protection
Material : polyvinyl alcohol (PVA), Viton(R). Consult your PPE provider for breakthrough times and the specific glove that is best for you based on your use patterns. It should be realized that eventually any material regardless of their imperviousness, will get permeated by chemicals. Therefore, protective gloves should be regularly checked for wear and tear. At the first

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signs of hardening and cracks, they should be changed.

Remarks	:	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Eye protection	:	Wear face-shield and protective suit for abnormal processing problems.
Skin and body protection	:	Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place.
Protective measures	:	Wash contaminated clothing before re-use.
Hygiene measures	:	Remove and wash contaminated clothing and gloves, including the inside, before re-use. Wash face, hands and any exposed skin thoroughly after handling.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Clear liquid.
Colour	:	Clear to slightly yellow, undyed liquid. May be dyed for taxation purposes.
Odour	:	Gasoline
Odour Threshold	:	No data available
pH	:	No data available
Pour point	:	No data available
Boiling point/boiling range	:	26 - 225 °C (79 - 437 °F)
Flash point	:	-43 °C (-45 °F) Method: Cleveland open cup
Auto-Ignition Temperature	:	No data available
Evaporation rate	:	No data available
Flammability	:	Extremely flammable in presence of open flames and sparks. May accumulate static electrical charge. Vapours are heavier than air and may travel considerable distance to sources of ignition and flash back.
Upper explosion limit	:	7.6 %(V)
Lower explosion limit	:	1.4 %(V)
Vapour pressure	:	307 - 802 mmHg (15 °C / 59 °F)

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Relative vapour density	:	3 Air = 1
Relative density	:	No data available
Density	:	0.7 - 0.78 kg/l (15 °C / 59 °F)
Solubility(ies)		
Water solubility	:	Hydrocarbon components slightly soluble in water., Ethanol is soluble in water.
Partition coefficient: n-octanol/water	:	No data available
Viscosity		
Viscosity, kinematic	:	0.6 cSt (40 °C / 104 °F)
Explosive properties	:	Do not cut, weld, heat, drill or pressurize empty container. Containers may explode in heat of fire. Runoff to sewer may create fire or explosion hazard.

SECTION 10. STABILITY AND REACTIVITY

Possibility of hazardous reactions	:	Hazardous polymerisation does not occur. Stable under normal conditions.
Conditions to avoid	:	Extremes of temperature and direct sunlight.
Incompatible materials	:	Reactive with oxidising agents, acids and interhalogens.
Hazardous decomposition products	:	May release COx, NOx, aldehydes, ketones, phenols, polynuclear aromatic hydrocarbons, smoke and irritating vapours when heated to decomposition.

SECTION 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure
Eye contact
Ingestion
Inhalation
Skin contact

Acute toxicity

Product:

Acute oral toxicity	:	Remarks: No data available
Acute inhalation toxicity	:	Remarks: No data available

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Acute dermal toxicity : Remarks: No data available

Components:

gasoline:

Acute oral toxicity : LD50 (Rat): 13,600 mg/kg,

Acute dermal toxicity : LD50 (Rabbit): > 3,750 mg/kg,

toluene:

Acute oral toxicity : LD50 (Rat): 5,580 mg/kg,

Acute inhalation toxicity : LC50 (Rat): 7585 ppm
Exposure time: 4 h
Test atmosphere: dust/mist

Acute dermal toxicity : LD50 (Rabbit): 12,125 mg/kg,

ethanol:

Acute oral toxicity : LD50 (Rat): 7,060 mg/kg,

Acute inhalation toxicity : LC50 (Rat): > 32380 ppm
Exposure time: 4 h
Test atmosphere: vapour

benzene:

Acute oral toxicity : LD50 (Rat): 2,990 mg/kg,

Acute inhalation toxicity : LC50 (Rat): 13700 ppm
Exposure time: 4 h
Test atmosphere: dust/mist

Acute dermal toxicity : LD50 (Rabbit): > 8,240 mg/kg,

Skin corrosion/irritation

Product:

Remarks: No data available

Serious eye damage/eye irritation

Product:

Remarks: No data available

Respiratory or skin sensitisation

No data available

Germ cell mutagenicity

No data available

Carcinogenicity

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No data available

Reproductive toxicity

No data available

STOT - single exposure

No data available

STOT - repeated exposure

No data available

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Product:

Toxicity to fish	:	Remarks: No data available
Toxicity to daphnia and other aquatic invertebrates	:	Remarks: No data available
Toxicity to algae	:	Remarks: No data available
Toxicity to bacteria	:	Remarks: No data available

Persistence and degradability

Product:

Biodegradability	:	Remarks: No data available

Bioaccumulative potential

No data available

Mobility in soil

No data available

Other adverse effects

No data available

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues	:	The product should not be allowed to enter drains, water courses or the soil. Offer surplus and non-recyclable solutions to a licensed disposal company. Waste must be classified and labelled prior to recycling or disposal. Send to a licensed waste management company.

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Dispose of as hazardous waste in compliance with local and national regulations.
Dispose of product residue in accordance with the instructions of the person responsible for waste disposal.

SECTION 14. TRANSPORT INFORMATION

International Regulations

IATA-DGR

UN/ID No.	:	UN 1203
Proper shipping name	:	Gasoline
Class	:	3
Packing group	:	II
Labels	:	Class 3 - Flammable Liquid
Packing instruction (cargo aircraft)	:	364

IMDG-Code

UN number	:	UN 1203
Proper shipping name	:	GASOLINE
Class	:	3
Packing group	:	II
Labels	:	3
EmS Code	:	F-E, S-E
Marine pollutant	:	no

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

National Regulations

TDG

UN number	:	UN 1203
Proper shipping name	:	GASOLINE
Class	:	3
Packing group	:	II
Labels	:	3
ERG Code	:	128
Marine pollutant	:	no

SECTION 15. REGULATORY INFORMATION

This product has been classified according to the hazard criteria of the Hazardous Products Regulations (HPR) and the SDS contains all of the information required by the HPR.

The components of this product are reported in the following inventories:

DSL On the inventory, or in compliance with the inventory

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SECTION 16. OTHER INFORMATION

For Copy of SDS	:	Internet: www.petro-canada.ca/msds Canada-wide: telephone: 1-800-668-0220; fax: 1-800-837-1228 For Product Safety Information: 1 905-804-4752
Prepared by	:	Product Safety: +1 905-804-4752
Revision Date	:	2018/10/23

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SECTION 1. IDENTIFICATION

Product name	:	JET A/A-1 AVIATION TURBINE FUEL
Synonyms	:	Jet A-1; Jet A-1-DI; Aviation Turbine Kerosene (ATK); JP-8; NATO F-34; Jet F-34; Aviation Turbine Fuel, Kerosene Type (CAN/CGSB 3.23 & CAN/CGSB 3.24)
Product code	:	101851, 100123
Manufacturer or supplier's details		Petro-Canada P.O. Box 2844, 150 - 6th Avenue South-West Calgary Alberta T2P 3E3 Canada
Emergency telephone number		Suncor Energy: +1 403-296-3000; Canutec Transportation: 1-888-226-8832 (toll-free) or 613-996-6666; Poison Control Centre: Consult local telephone directory for emergency number(s).

Recommended use of the chemical and restrictions on use

Recommended use	:	Used as aviation turbine fuel. May contain a fuel system icing inhibitor. In the arctic, Jet A-1 may also be used as diesel fuel (if it contains a lubricity additive) and heating oil.
Prepared by	:	Product Safety: +1 905-804-4752

SECTION 2. HAZARDS IDENTIFICATION

Emergency Overview

Appearance	Clear liquid.
Colour	Clear and colourless
Odour	Kerosene-like.

GHS Classification

Flammable liquids	:	Category 3
Skin irritation	:	Category 2
Reproductive toxicity	:	Category 2
Specific target organ toxicity - single exposure	:	Category 3 (Central nervous system)
Aspiration hazard	:	Category 1

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GHS label elements

Hazard pictograms :

Signal word : Danger

Hazard statements : Flammable liquid and vapour.
May be fatal if swallowed and enters airways.
Causes skin irritation.
May cause drowsiness or dizziness.
Suspected of damaging fertility or the unborn child.

Precautionary statements : **Prevention:**
Obtain special instructions before use.
Do not handle until all safety precautions have been read and understood.
Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.
Keep container tightly closed.
Ground and bond container and receiving equipment.
Use explosion-proof electrical/ ventilating/ lighting/ equipment.
Use non-sparking tools.
Take action to prevent static discharges.
Avoid breathing dust/ fume/ gas/ mist/ vapours/ spray.
Wash skin thoroughly after handling.
Use only outdoors or in a well-ventilated area.
Wear protective gloves/ protective clothing/ eye protection/ face protection.
Response:
IF SWALLOWED: Immediately call a POISON CENTER/doctor.
IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water.
IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER/doctor if you feel unwell.
IF exposed or concerned: Get medical advice/ attention.
Do NOT induce vomiting.
If skin irritation occurs: Get medical advice/ attention.
Take off contaminated clothing and wash it before reuse.
In case of fire: Use dry sand, dry chemical or alcohol-resistant foam to extinguish.
Storage:
Store in a well-ventilated place. Keep container tightly closed.
Store in a well-ventilated place. Keep cool.
Store locked up.
Disposal:
Dispose of contents/ container to an approved waste disposal plant.

Potential Health Effects

Primary Routes of Entry : Eye contact
Ingestion

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Inhalation
Skin contact

Inhalation : Inhalation may cause central nervous system effects. Symptoms and signs include headache, dizziness, fatigue, muscular weakness, drowsiness and in extreme cases, loss of consciousness.

Skin : May irritate skin.

Eyes : May irritate eyes.

Ingestion : Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhoea.
Aspiration hazard if swallowed - can enter lungs and cause damage.

Aggravated Medical Condition : None known.

Other hazards

None known.

IARC No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH Confirmed animal carcinogen with unknown relevance to humans

Kerosene 8008-20-6

SECTION 3. COMPOSITION/INFORMATION ON INGREDIENTS

Substance / Mixture : Mixture

Hazardous components

Chemical name	CAS-No.	Concentration
kerosine (petroleum)	8008-20-6	90 - 100 %
2-(2-methoxyethoxy)ethanol	111-77-3	0 - 0.2 %

SECTION 4. FIRST AID MEASURES

If inhaled : Move to fresh air.
Artificial respiration and/or oxygen may be necessary.
Seek medical advice.

In case of skin contact : In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing

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		and shoes. Wash skin thoroughly with soap and water or use recognized skin cleanser. Wash clothing before reuse. Seek medical advice.
In case of eye contact	:	Remove contact lenses. Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Obtain medical attention.
If swallowed	:	Rinse mouth with water. DO NOT induce vomiting unless directed to do so by a physician or poison control center. Never give anything by mouth to an unconscious person. Seek medical advice.
Most important symptoms and effects, both acute and delayed	:	First aider needs to protect himself.

SECTION 5. FIREFIGHTING MEASURES

Suitable extinguishing media	:	Dry chemical Carbon dioxide (CO2) Water fog. Foam
Unsuitable extinguishing media	:	Do NOT use water jet.
Specific hazards during firefighting	:	Cool closed containers exposed to fire with water spray.
Hazardous combustion products	:	Carbon oxides (CO, CO2), nitrogen oxides (NOx), sulphur oxides (SOx), smoke and irritating vapours as products of incomplete combustion.
Further information	:	Prevent fire extinguishing water from contaminating surface water or the ground water system.
Special protective equipment for firefighters	:	Wear self-contained breathing apparatus for firefighting if necessary.

SECTION 6. ACCIDENTAL RELEASE MEASURES

Personal precautions, protective equipment and emergency procedures	:	Use personal protective equipment. Ensure adequate ventilation. Evacuate personnel to safe areas. Material can create slippery conditions.
Environmental precautions	:	If the product contaminates rivers and lakes or drains inform respective authorities.

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Methods and materials for containment and cleaning up : Prevent further leakage or spillage if safe to do so.
Remove all sources of ignition.
Soak up with inert absorbent material.
Non-sparking tools should be used.
Ensure adequate ventilation.
Contact the proper local authorities.

SECTION 7. HANDLING AND STORAGE

Advice on safe handling : For personal protection see section 8.
Smoking, eating and drinking should be prohibited in the application area.
Use only with adequate ventilation.
In case of insufficient ventilation, wear suitable respiratory equipment.
Avoid spark promoters. Ground/bond container and equipment. These alone may be insufficient to remove static electricity.
Avoid contact with skin, eyes and clothing.
Do not ingest.
Keep away from heat and sources of ignition.
Keep container closed when not in use.

Conditions for safe storage : Store in original container.
Containers which are opened must be carefully resealed and kept upright to prevent leakage.
Keep in a dry, cool and well-ventilated place.
Keep in properly labelled containers.
To maintain product quality, do not store in heat or direct sunlight.

SECTION 8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value type (Form of exposure)	Control parameters / Permissible concentration	Basis
kerosine (petroleum)	8008-20-6	TWA	200 mg/m3 (total hydrocarbon vapor)	CA BC OEL
		TWA	200 mg/m3 (total hydrocarbon vapor)	CA AB OEL
		TWA	200 mg/m3 (total hydrocarbon vapor)	ACGIH

Engineering measures : Use only in well-ventilated areas.
Ensure that eyewash station and safety shower are proximal to the work-station location.

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Personal protective equipment

Respiratory protection	:	Use respiratory protection unless adequate local exhaust ventilation is provided or exposure assessment demonstrates that exposures are within recommended exposure guidelines. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.
Filter type	:	A NIOSH-approved air-purifying respirator with an organic vapour cartridge or canister may be permissible under certain circumstances where airborne concentrations are expected to exceed exposure limits. Protection provided by air-purifying respirators is limited. Use a positive-pressure, air-supplied respirator if there is any potential for uncontrolled release, exposure levels are unknown, or any other circumstances where air-purifying respirators may not provide adequate protection.
Hand protection		
Material	:	polyvinyl alcohol (PVA), Viton(R). Consult your PPE provider for breakthrough times and the specific glove that is best for you based on your use patterns. It should be realized that eventually any material regardless of their imperviousness, will get permeated by chemicals. Therefore, protective gloves should be regularly checked for wear and tear. At the first signs of hardening and cracks, they should be changed.
Remarks	:	Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Eye protection	:	Wear face-shield and protective suit for abnormal processing problems.
Skin and body protection	:	Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place.
Protective measures	:	Wash contaminated clothing before re-use.
Hygiene measures	:	Remove and wash contaminated clothing and gloves, including the inside, before re-use. Wash face, hands and any exposed skin thoroughly after handling.

SECTION 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	:	Clear liquid.
Colour	:	Clear and colourless
Odour	:	Kerosene-like.

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Odour Threshold	:	No data available
pH	:	No data available
Pour point	:	-51 °C (-60 °F)No data available
Boiling point/boiling range	:	140 - 300 °C (284 - 572 °F)
Flash point	:	> 38 °C (100 °F) Method: Tagliabue
Auto-Ignition Temperature	:	210 °C (410 °F)
Evaporation rate	:	No data available
Flammability	:	Flammable in presence of open flames, sparks and heat. Vapours are heavier than air and may travel considerable distance to sources of ignition and flash back. This product can accumulate static charge and ignite. May accumulate in confined spaces.
Upper explosion limit	:	5 %(V)
Lower explosion limit	:	0.7 %(V)
Vapour pressure	:	5.25 mmHg (20 °C / 68 °F)
Relative vapour density	:	4.5
Relative density	:	0.775 - 0.84 (15 °C / 59 °F)
Solubility(ies)		
Water solubility	:	No data available
Partition coefficient: n-octanol/water	:	No data available
Viscosity		
Viscosity, kinematic	:	1.0 - 1.9 cSt (40 °C / 104 °F)
Explosive properties	:	Do not pressurise, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Containers may explode in heat of fire.

SECTION 10. STABILITY AND REACTIVITY

Possibility of hazardous reactions	:	Hazardous polymerisation does not occur. Stable under normal conditions.
Conditions to avoid	:	Extremes of temperature and direct sunlight.

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Incompatible materials	:	Reactive with oxidising agents, acids and alkalis.
Hazardous decomposition products	:	May release COx, NOx, SOx, aldehydes, acids, ketones, smoke and irritating vapours when heated to decomposition.

SECTION 11. TOXICOLOGICAL INFORMATION

Information on likely routes of exposure
Eye contact
Ingestion
Inhalation
Skin contact

Acute toxicity

Product:

Acute oral toxicity	:	Remarks: No data available
Acute inhalation toxicity	:	Remarks: No data available
Acute dermal toxicity	:	Remarks: No data available

Components:

kerosine (petroleum):

Acute oral toxicity	:	LD50 (Rat): > 5,000 mg/kg,
Acute inhalation toxicity	:	LC50 (Rat): > 5 mg/l Exposure time: 4 h Test atmosphere: dust/mist
Acute dermal toxicity	:	LD50 (Rabbit): > 2,000 mg/kg,

Skin corrosion/irritation

Product:

Remarks: No data available

Serious eye damage/eye irritation

Product:

Remarks: No data available

Respiratory or skin sensitisation

No data available

Germ cell mutagenicity

No data available

Carcinogenicity

No data available

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Reproductive toxicity

No data available

STOT - single exposure

No data available

STOT - repeated exposure

No data available

SECTION 12. ECOLOGICAL INFORMATION

Ecotoxicity

Product:

Toxicity to fish	:	Remarks: No data available
Toxicity to daphnia and other aquatic invertebrates	:	Remarks: No data available
Toxicity to algae	:	Remarks: No data available
Toxicity to bacteria	:	Remarks: No data available

Persistence and degradability

Product:

Biodegradability	:	Remarks: No data available

Bioaccumulative potential

No data available

Mobility in soil

No data available

Other adverse effects

No data available

SECTION 13. DISPOSAL CONSIDERATIONS

Disposal methods

Waste from residues	:	The product should not be allowed to enter drains, water courses or the soil. Offer surplus and non-recyclable solutions to a licensed disposal company. Waste must be classified and labelled prior to recycling or disposal. Send to a licensed waste management company. Dispose of product residue in accordance with the instructions of the person responsible for waste disposal.

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Contaminated packaging	:	Do not re-use empty containers.

SECTION 14. TRANSPORT INFORMATION

International Regulations

IATA-DGR

UN/ID No.	:	UN 1863
Proper shipping name	:	Fuel, aviation, turbine engine
Class	:	3
Packing group	:	III
Labels	:	Class 3 - Flammable Liquid
Packing instruction (cargo aircraft)	:	366

IMDG-Code

UN number	:	UN 1863
Proper shipping name	:	FUEL, AVIATION, TURBINE ENGINE
Class	:	3
Packing group	:	III
Labels	:	3
EmS Code	:	F-E, S-E
Marine pollutant	:	no

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code

National Regulations

TDG

UN number	:	UN 1863
Proper shipping name	:	FUEL, AVIATION, TURBINE ENGINE
Class	:	3
Packing group	:	III
Labels	:	3
ERG Code	:	128
Marine pollutant	:	no

SECTION 15. REGULATORY INFORMATION

This product has been classified according to the hazard criteria of the Hazardous Products Regulations (HPR) and the SDS contains all of the information required by the HPR.

The components of this product are reported in the following inventories:

DSL	On the inventory, or in compliance with the inventory
TSCA	All chemical substances in this product are either listed on the TSCA Inventory or are in compliance with a TSCA Inventory exemption.
EINECS	On the inventory, or in compliance with the inventory

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SECTION 16. OTHER INFORMATION

For Copy of SDS	:	Internet: www.petro-canada.ca/msds Canada-wide: telephone: 1-800-668-0220; fax: 1-800-837-1228 For Product Safety Information: 1 905-804-4752
Prepared by	:	Product Safety: +1 905-804-4752
Revision Date	:	2018/06/07

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text.

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Appendix 9-1-14. Traffic and Access Management Plan

BRUCEJACK MINE

Traffic and Access Management Plan

January 2023

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Traffic and Access Management Plan

Date: January 2023

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
1	May 2015	Kevin Torpy, Sylvia Van Zalingen	MA/EMA Permits Application, Appendix 6-F
2	December 2018	Tim Bates, Sylvia Van Zalingen	EMP Update for EAO and Annual Report
3	January 2023	John Sheehan, Torence Sandhals	EMP Update for Annual Report and updated section 5.4 radio call out procedure

BRUCEJACK MINE

Traffic and Access Management Plan

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Appendix 1

Brucejack Access Road Standard Operating Procedures

ACRONYMS AND ABBREVIATIONS

The following acronyms and abbreviations are used throughout this Traffic and Access Management Plan (TAMP).

ANFO	Ammonium Nitrate Fuel Oil
ATV	All-Terrain Vehicle
BJAR	Brucejack Access Road
CEAA	Canadian Environmental Assessment Agency
EAC	Environmental Assessment Certificate (EAC #15-01)
EAO	BC Environmental Assessment Office
HSRC	Health, Safety and Reclamation Code for Mines in BC, 2022
Hwy	Highway
LHD	Load-Haul-Dump (Underground Loader)
Lakeshore Drive	BJAR km 71-73.3 (segment extending between the top of the Knipple Glacier (km 71) and the Mine Site (km 73.3)
Lower BJAR	BJAR km 0-59 (segment extending from Hwy 37 intersection (km 0) to the access onto the Knipple Glacier (km 59)
Mine Site	Core mine infrastructure area at the southwest end of Brucejack Lake
Mine Site Area	Mine infrastructure west of upper Knipple Glacier (km 71.6), including the NPAG Quarry, upper Brucejack Access Road, and the Mine Site
MFLNRORD	BC Ministry of Forests, Lands, Natural Resources Operations, and Rural Development
MHz	Megahertz
Mountain Safety	Avalanche Technician
NPAG	Non Potentially Acid Generating
PPE	Personal Protective Equipment
Pretium	Pretium Resources Inc.
ROPS	Rollover Protective Structure

ROW	Right-of-Way
TAMP	Traffic and Access Management Plan
UWR	Ungulate Winter Range
VHF	Very High Frequency
VOK	Valley of the Kings

1 INTRODUCTION

1.1 PURPOSE

The Brucejack Mine Traffic and Access Management Plan (TAMP) provides the management framework and directs implementation of the following:

- Access control and management for (1) the Brucejack Access Road (BJAR) between Highway 37 and the Mine Site, and (2) within the Mine Site;
- Road design and maintenance to maximize the safety of BJAR and Mine Site road users;
- Measures to minimize vehicle to vehicle and vehicle to pedestrian incidents on all roads;
- Measures to minimize potential adverse effects on the environment, including wildlife; and
- Measures to protect the security of Pretium Resources Inc. (Pretium) and contractor assets.

Restricting access to lands made accessible by the BJAR is particularly important, along with prohibiting hunting and/or fishing by persons accessing the road, since increased access can potentially expose wildlife to increased pressure from fishing, hunting, and trapping activities. Similarly, an increase in vehicular traffic along the BJAR resulting from uncontrolled access could elevate direct wildlife mortality and disruption of movement.

Road access to the Mine Site is via the 73 km long BJAR, which extends west from Hwy 37 (Figure 1.1-1). The first 59 km are via all-weather gravel surfaced access road, with a Security Gate located at km 1; the section from km 59 to 71 traverses the Knipple Glacier; and the remaining section to the Mine Site is via all-weather gravel surfaced access road (Figure 1.1-2).

1.2 ROAD OVERVIEW

The start of the BJAR is located near km 215 on Hwy 37, approximately 60 km north of Meziadin Junction (Figures 1.1-1 and 1.1-2). Road distances from population centres are shown in Table 1.2-1.

Table 1.2-1. Distances from Brucejack Access Road to Population Centres

City or Landmark	Highway Distance to Start of Access Road
Bell II	33 km
Meziadin Junction	60 km
Stewart	120 km
Gitlaxt'aamiks	202 km
Kitwanga	216 km
Dease Lake	272 km
Terrace	300 km
Smithers	326 km
Prince George	697 km
Vancouver	1,476 km

Figure 1.1-1. Brucejack and Access Road Location

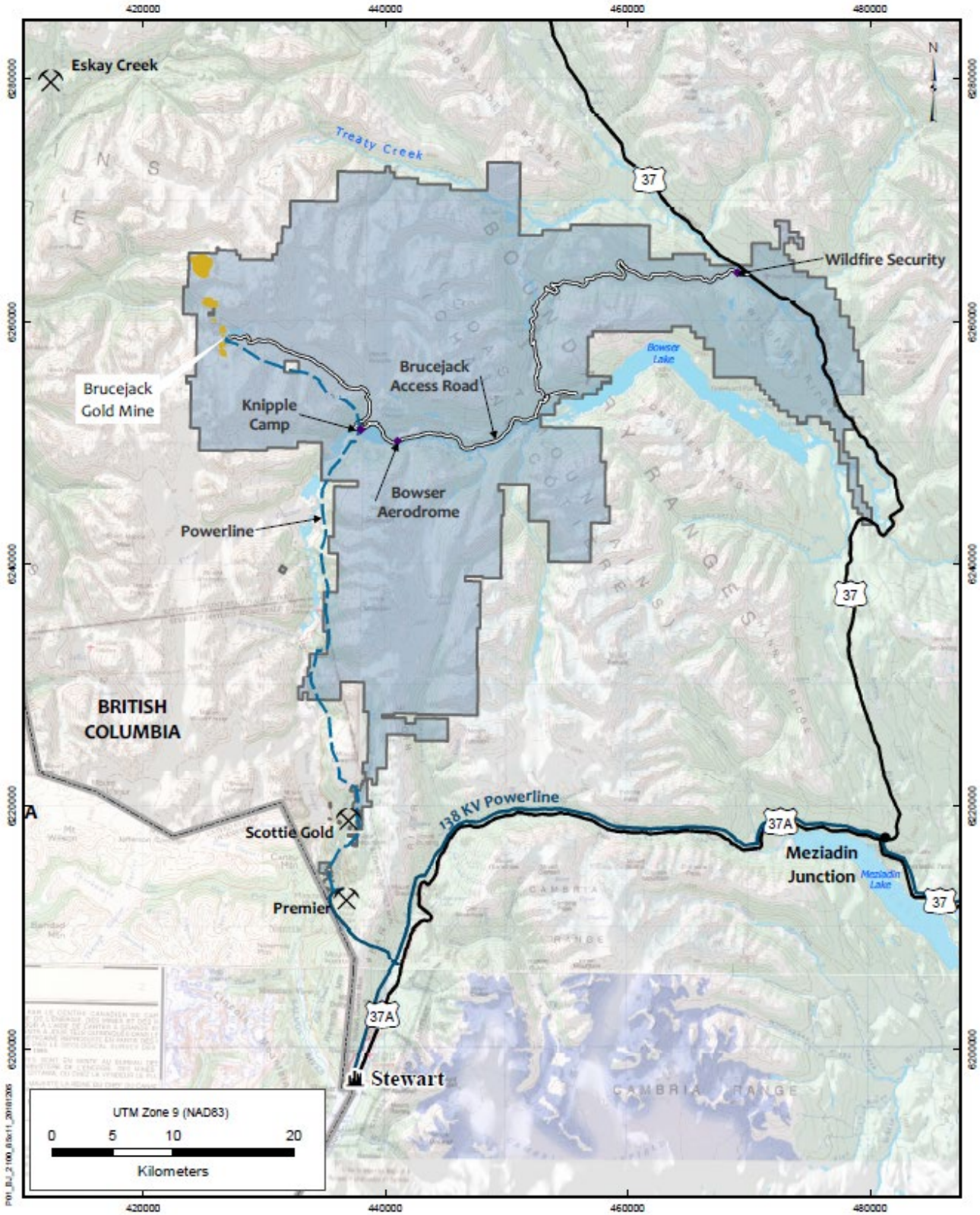
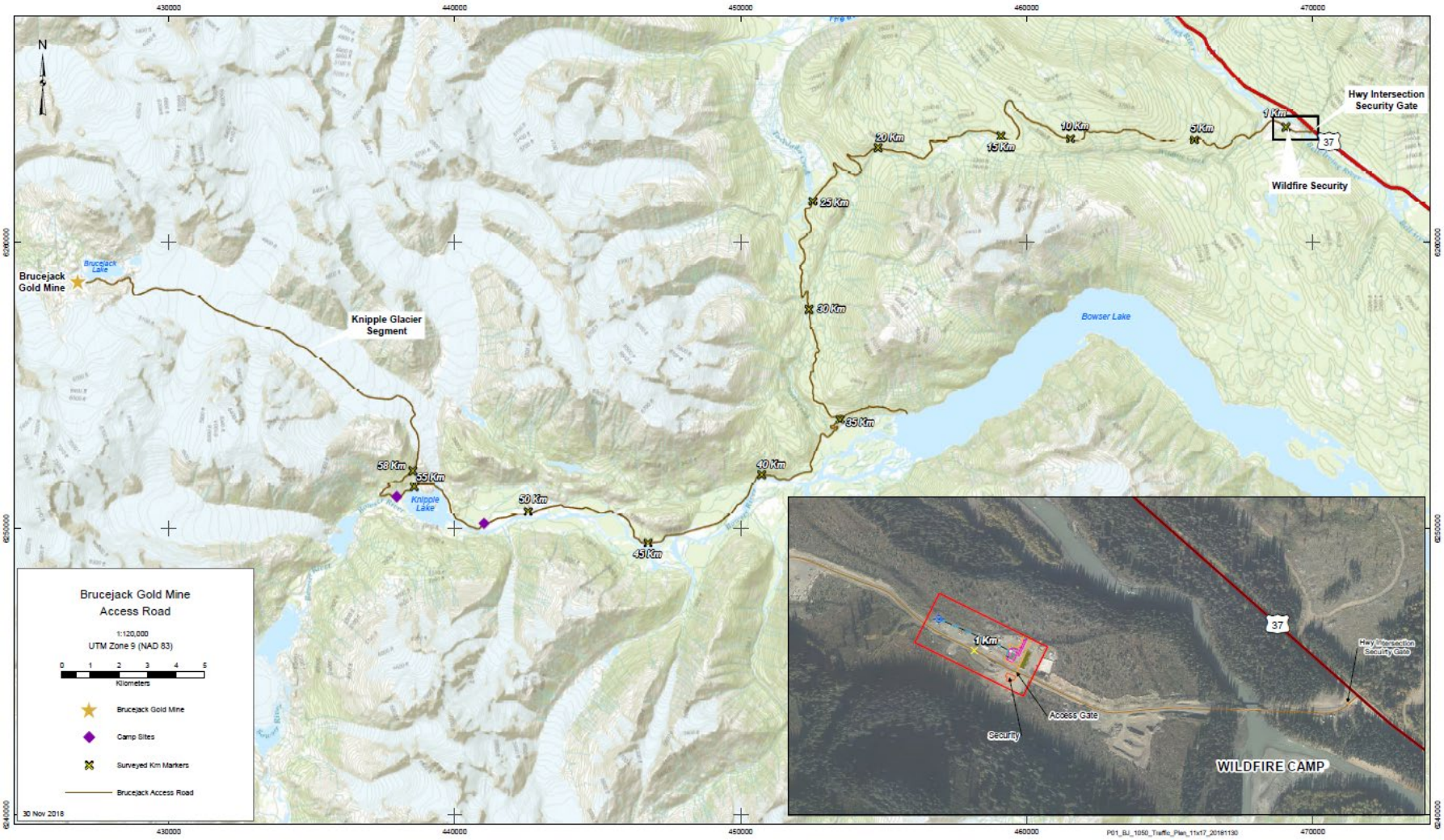


Figure 1.1-2. BJAR Overview



1.3 INSTRUCTIONS FOR TRAVELLING TO THE BRUCEJACK SITE

When travelling to the Brucejack Mine site from the south, use the following driving instructions (refer to BJAR Standard Operating Procedures (SOP; Appendix 1):

- From Smithers take Hwy 16 west to Kitwanga (115 km).
- From Terrace take Hwy 16 east to Kitwanga (95 km).
- At Kitwanga, turn north onto Hwy 37.
- Follow Hwy 37 north to Meziadin Junction (155 km). This is the last commercial fueling station and the last place to obtain fuel before reaching Wildfire Camp at km 1 of the BJAR.
- Turn right at Meziadin Junction (left goes to Stewart/Hyder) and proceed north. The turn off for the BJAR is on the left hand (west) side of the highway at km 215 (60 km north of Meziadin Junction). There is a large Pretium sign at the entrance, a gate, and a security booth.
- The Hwy 37 entry gate staff will ask your name and you will be required sign in. They will notify Wildfire Security to expect your arrival. Visitors without an appointment will be turned away.
- Drive from the Hwy 37 entry gate to the Wildfire Security gate at km 1.
- If it is your first time traveling on the BJAR, you will be required to receive a road orientation and review of the road travel procedures (Appendix 1) at Wildfire Security.
- All personnel must check in at Wildfire Security for contraband screening. If contraband is found, site access may be denied dependant on the findings. The security gate is open 06:30-18:30 year round; any variation from these time frames must be approved by the Mine Manager or Access Road Manager.
- All vehicles that travel on the BJAR <u>must</u> have all the BJAR SOP listed safety equipment, proper survival gear and a base radio with the required frequencies.
- All vehicles must call on the radio their kilometre marker while traveling on the road (refer to Section 2.7 for full call-out procedure).

1.4 GENERAL COMMUNICATIONS

Communications along the BJAR are currently by VHF radio, with work ongoing to enable conversion to digital communications. There are three repeated frequencies and numerous non-repeated frequencies, as well as a few new digital frequencies. For routine repeated or non-line-of-sight communications use the following channels:

- Channel 1, analog – BJAR from Hwy 37 at Wildfire Camp to km 58.5.
- Channel 2, Repeater 1, analog – BJAR from km 59 to 71 (Knipple Glacier road section), and call-out onto the glacier for the transition from Lakeshore Drive to the Mine Site at km 73.3.

- Ladd 2, analog – Km 71 to km 73, Lakeshore Drive and within the Mine Site for location and travel call-outs.
- Admin Channel 1, digital – Brucejack Underground Emergency.

Emergency call-out channels for accident response or other emergency assistance are as follows:

- Analog Channel 1 – BJAR km 0 – 58.5.
- Channel 2, Repeater 1 – Brucejack Mine Site and Knipple Glacier (km 59 to 71).
- Underground Channel 2, digital – Brucejack Mine, underground.
- Channel 6, Repeater 3 – BJAR km 1 – 36.5 (Wildfire Camp to Scott Creek) – this is a secondary emergency call-out if emergency assistance cannot be reached via Analog Channel 1. This channel will reach Dispatch/Logistics directly.
- Channel 4, Repeater 2 – BJAR km 36.5 – 58.5 (Scott Creek to bottom of Knipple Glacier) - this is a secondary emergency call-out if emergency assistance cannot be reached via Analog Channel 1. This channel will reach Dispatch/Logistics directly.

Local or line of site communications on the BJAR including kilometre callouts must be done using the Analog Channel 1, BJAR. Channel 1 is transmitted and received on the 166.08 MHz frequency. Note that the current site radio frequencies are licensed to others and used by Pretium with permission. Once a permanent communications system has been installed, new frequencies will be licensed to Pretium. The Traffic and Access Management Plan will be updated at that time.

1.5 TRAFFIC VOLUME MITIGATION

The use of a combination of chartered bus and airplanes mitigates traffic volume along the Lower BJAR and Hwy 37. To the extent feasible, all employees and contractors are required to use the charters for transferring personnel. Personal vehicles are NOT allowed past Wildfire Security gate and must be parked in designated parking areas with the keys left with Wildfire Security.

1.6 SECURITY AND ACCESS CONTROL

There are currently two security check points to control access to the Brucejack Project: (1) a check point immediately adjacent to the BJAR intersection with Hwy 37, and (2) a security gate and building at Wildfire Camp (Wildfire Security), located at km 1 of the BJAR. Temporary security check points are used at the Bowser airstrip on an as needed basis.

Persons authorized to use the BJAR include First Nations people conducting traditional use activities under authorization of their respective Nation's government, and mine personnel authorized by the Mine Manager (e.g., employees, contractors, suppliers). Visitors with an appointment are also allowed access to the road (e.g., consultants). Government inspectors are requested to undergo a security check, however inspectors from certain government agencies may be exempt from the security check requirement.

For safety reasons, First Nations people conducting traditional use activities authorized by their Nation's government are requested to park in designated areas.

Transportation via ATV, snowmobile, and motorcycle is prohibited on the BJAR unless required for work being done by Pretium or its contractors.

1.6.1 Highway 37 Security Gate

The security checkpoint at the Hwy 37 intersection consists of a security station and manually operated barrier gate. This checkpoint prevents unauthorized access to the west side of the Bell-Irving River via the BJAR km 0.4 bridge (i.e., prevents access to the west side of the Bell-Irving River for hunting, fishing and any other purposes). The gate is locked when the checkpoint is not staffed. A radio call box is installed outside the gate to communicate with Wildfire Security, who will return to the highway security gate during off-hours if/as necessary.

1.6.2 Wildfire Security

The second security facility is located at km 1 of the BJAR at the entrance to Wildfire Camp. This facility, Wildfire Security, consists of a security building, chain-link fence, and manually controlled gate. The main purposes of this facility is to screen all traffic for contraband and to further prevent unauthorized access to the BJAR beyond km 1.

Wildfire Security is the main check-in and check-out location for all vehicles travelling the BJAR. All of the traffic on the portion of the BJAR from the Hwy 37 intersection to Knipple Camp at km 56 is by conventional, rubber tired, highway legal vehicles. Operators travelling only this section of the road do not require any special glacier transport training.

Wildfire Security implements security screenings for all inbound and outbound personnel (except excluded government inspectors) and vehicles. Wildfire Security provides a road orientation to new BJAR operators, with instruction on safety and environmental requirements including radio channels; road speed limits; spill reporting procedures; taking care to prevent collisions with wildlife; wildlife attractant prevention requirements (no littering, waste disposal requirements); and wildlife interaction reporting procedures/requirements. They also notify operators of any road construction activity, or other hazards or recent wildlife sightings.

1.6.3 Bowser Airstrip Security Facility

A security checkpoint is occasionally operated at the Bowser Airstrip on an as needed basis. The purpose of this facility to check incoming and departing passengers for contraband. Orientations take place at Knipple Camp if required.

1.7 INCIDENT REPORTING

1.7.1 Vehicle Collisions and Medical Emergencies

All motor vehicle collisions on the BJAR, regardless of severity, and medical emergencies, must be reported immediately to the nearest Access Road Supervisor and Dispatch/Logistics. Call-out is directly to Dispatch/Logistics if a collision or medical emergency occurs between km 59 and the Mine Site, or within the Mine Site. Call-out is to 'Access Road Supervisor' if a collision or medical emergency occurs between km 0 and km 58.5. The responding Access Road Supervisor (nearest Access Road Supervisor, Access Road Superintendent or the Access Road Manager) will contact Dispatch/ Logistics as part of the response procedure.

This includes single vehicle collisions, multi-vehicle collisions, and collisions involving wildlife. In the event of a collision or medical emergency, Dispatch/Logistics notifies Brucejack Health and Safety personnel as well as both the Mine and Road Managers, who then organize the appropriate response and investigation.

The response must be prioritized according to the following hierarchy:

1. Human health and safety: The safety of personnel, both those involved in the incident as well as responders is first priority. Once a responder determines that they are not in danger themselves, all efforts are focused on any victims of the collision.
2. Environmental and wildlife safety: Once human life is secure, response efforts are focused on mitigating any further damage to the environment (e.g., by stopping, containing, and cleaning up any spills; addressing injured or deceased wildlife).
3. Recovery of physical assets: Once it is determined that the accident scene is no longer a threat to the environment, recovery of any involved equipment proceeds.

1.7.2 Wildlife/Vehicle Collisions

Any collisions between vehicles and wildlife are documented. The documentation includes information on the collision location, wildlife injuries or fatalities, and follow-up actions if/as appropriate. Employees and other vehicle operators are trained on reporting in the event of a collision with wildlife (Appendix 1). Information on any wildlife collisions on the BJAR is shared with relevant government agencies and the Brucejack Wildlife Advisory Committee (WAC). A Wildlife Collision Protocol specific to the BJAR has been developed (refer to Section 2.3) and is included in the Brucejack Wildlife Management Plan.

1.7.3 Incident Investigation

All motor vehicle near misses and accidents on the BJAR are investigated to determine the underlying cause. The locations and causes of both near misses and accidents are logged to track for trends which might suggest adaptive management is warranted.

A report is prepared for each investigation, and each accident investigation report provides recommendations in an effort to prevent future similar incidents. The recommendations consider mitigating risk to personnel, equipment, and wildlife.

Any locations along the BJAR identified as having a higher likelihood for vehicle collisions with wildlife will be managed adaptively.

1.7.4 Unauthorized Access and Hunting

Access to the BJAR is managed through controlled access security points to prevent its use for hunting and recreational activities. If unauthorized use, including hunting, is observed along the BJAR or anywhere within the Project area including the Brucejack Transmission Line, it will be reported immediately to Wildfire Security and the Brucejack Access Road Manager, who will provide the information to the Environmental Manager and the Environmental Superintendent (or designates). The Environmental Manager will in turn report any hunting activities involving the BJAR to provincial authorities.

Monitoring of hunting activity along the Brucejack Transmission Line Right-of-Way (ROW) is completed on an incidental basis. If hunting, or any use, of the Transmission Line ROW by non-project personnel is observed, it will be reported immediately to the Environmental Superintendent or designates. Trees were felled and left in place along segments of the Brucejack Transmission Line traversing forested terrain to prevent or minimize such unauthorized access. Steep mountainous terrain and difficult stream crossings provide further significant barriers to unauthorized access along the Brucejack Transmission Line.

1.8 RELEVANT ENVIRONMENTAL ASSESSMENT CONDITIONS

Condition 6.3 of the Decision Statement Issued under Section 54 of the *Canadian Environmental Assessment Act, 2012* to Pretium Resources Inc. for the Brucejack Project states that "the Proponent shall prohibit public access to the access road."

Schedule B, Condition 2 of Environmental Assessment Certificate (#M15-01), issued on March 26, 2015 to Pretium Resources Inc. for the Brucejack Project, requires a Component Plan for traffic and access management. The specific wording from Schedule B of the Certificate is provided below.

> *Condition 2*
>
> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*

- *Effects mitigation measures;*
- *Monitoring programs;*
- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the Nisga'a Lisims Government (NLG), Tahltan and Tsetsaut / Skii km Lax Ha Nation (TSKLH) on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

2 LOWER BRUCEJACK ACCESS ROAD TRAFFIC CONTROL

Although primarily focused on the gravel surfaced portion of the BJAR road between Hwy 37 (km 0) and the bottom of the Knipple Glacier (km 59; lower BJAR), the following also applies to the Lakeshore Drive section of the BJAR between the top of the Knipple Glacier (km 71) and the Mine Site (km 73.3) unless otherwise noted in Section 4.

2.1 ROAD DESIGN

2.1.1 Existing Road Design Parameters

The Lower BJAR (km 0 to 58.5) was originally designed and constructed to the following minimum criteria:

- L100 minimum design loading, with consideration of equivalent D9 track loading;
- 5.0 m road width, with 0.3 m wide by 0.8 m deep ditches between km 0 and 35;
- 30 m right-of-way width;
- 30 km/h design speed, 35 m minimum turning radius;
- Maximum 12% sustained grade, 18% pitches less than 150 m (with exceptions);
- Maximum 500 m turnout spacing, optimum 300 m spacing; and
- 7% maximum grade break per 15 m travel.

Many of the actual road design criteria exceed these minimum criteria. Some upgrades were made to the road during the mine Construction phase and the speed limit of the Lower BJAR was increased to 40 km/h, excluding Wildfire Camp and Security areas, bridge crossings, and Bowser Camp/ Aerodrome areas (km 50 to 52).

The design of the older 'Newhawk' road section from km 35 to 56 can accommodate significantly higher speeds (e.g., to 70 to 80 km/h), however speed limits are kept lower on a precautionary basis due to higher quality moose/ungulate and other wildlife habitat in this road section along the Bowser River (refer to additional details in Section 2.1.2). The focus is generally on moose, as moose are the wildlife species that are expected to be the most vulnerable to vehicle collisions along the BJAR, and are present in the Bowser River Valley.

2.1.2 Proposed Upgrades

Condition 2.08 of Special Use Permit (SUP) S25923 requires that the Lower BJAR be brought up to current forest road standards, and lists inspection/audit and other conditions to identify specific required improvements. Planned gradual improvements include ongoing culvert and bridge

replacements, minor realignments of sharper curves, reductions of steeper grades, and additional surfacing of some sections. Specifically, the work is currently expected to include:

- Replacement of culverts and bridges in accordance with recommendations from the Engineer of Record (EOR) for the BJAR, gradually bringing these to current MFLNRORD forest road standards;
- Variable depth surfacing (pit run gravel or 3" minus shot rock, which has been compacted, of 200 to 300 mm depth) and shaping;
- Upgrading to favourable grades of 12% (14% for pitches less than 150 m) and adverse grades of 8% (10% for pitches less than 100 m);
- Re-working of horizontal curves to a design radius of 65 m; a maximum 3% super-elevation (or crossfall) is prescribed (1/3 of an inch per foot or 3 cm/m);
- Safely addressing two-way traffic in all locations with sight distances below the Minimum Site Stopping Distance of 95 m (blind vertical and horizontal curves) – the road width will be widened to 10 m (double lane) to allow traffic to safely pass; and
- Posting additional signage in both directions of travel to identify road speed zones.

As the BJAR is gradually improved, the potentially allowable speed from a design and human safety perspective will increase in applicable road segments. Km 35 to 56 are already at a design standard that can accommodate significantly increased speeds.

Consistent with the Brucejack EAC/EIS Application (2014), Pretium will keep speed limits on the BJAR at or below 70 km/h as a precautionary measures to minimize the potential for collisions with wildlife. Evidence suggests that vehicle-moose collisions are less severe when speed limits are below 70 km/h compared to above 90 km/h (Lavsund and Sandergren 1991). The rate at which mortality decreases between 90 km/h and 70 km/h is approximately 80% (Seiler 2005).

Following are the maximum speeds currently planned for km 35 to 56 (excluding bridge crossings and the reduced speed zone for Bowser Camp area (km 50 to 52)):

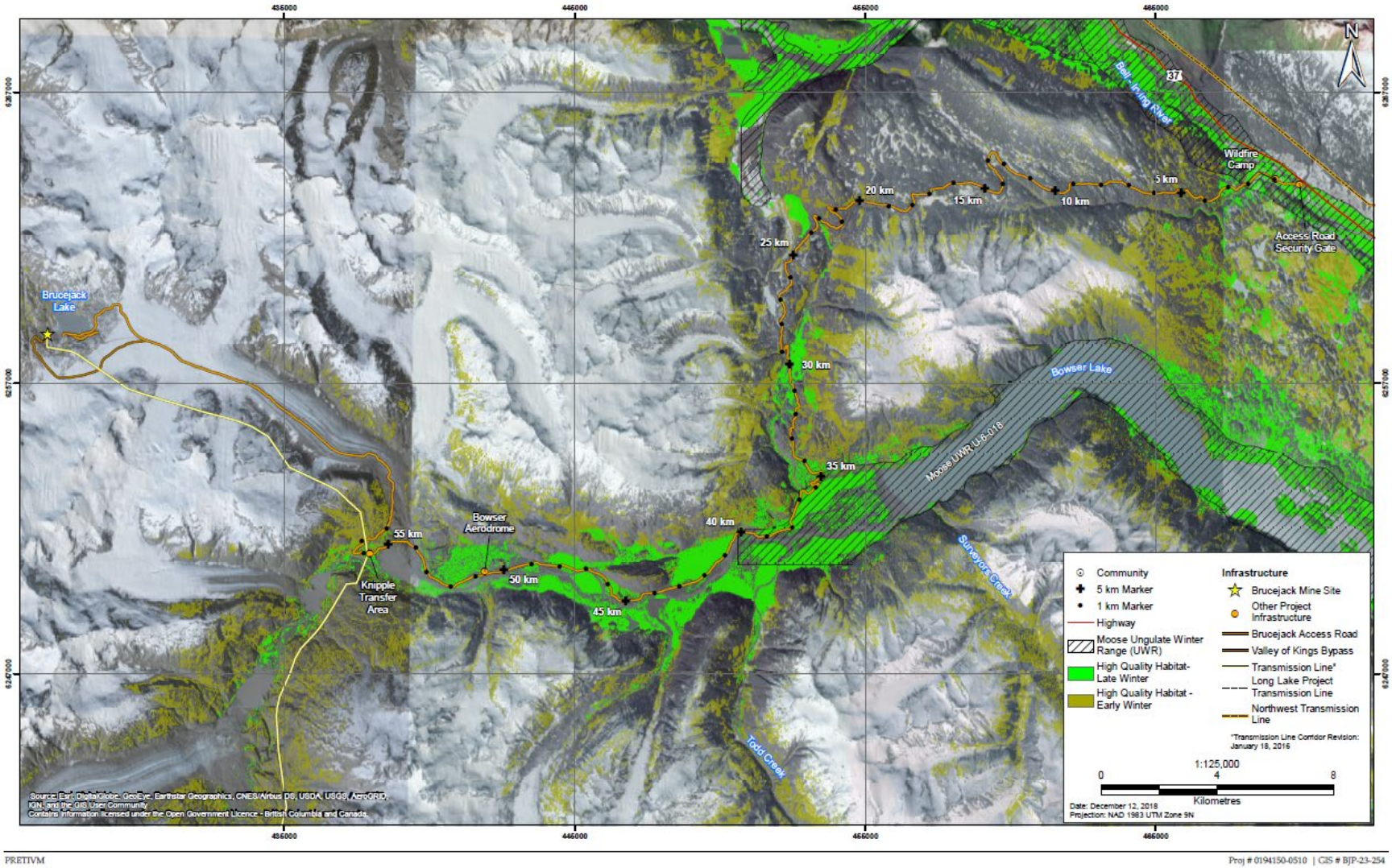
- Km 35 to 40 (adjacent and/or passes through Ungulate Winter Range [UWR]; Figure 2.1-1): maximum speed 50 km/h, year round;
- Km 40 to 56 (passes through high quality moose habitat; Figure 2.1-1): maximum speed 60 km/h during summer (snow free) driving conditions and maximum 50 km/h during winter (snow/ice) driving conditions.

During mine operations, the Lower BJAR is maintained throughout the year by road grooming equipment and snow plows. Regular patrols are conducted in potential avalanche areas and avalanche control measures are utilized.

2.2 GEOHAZARDS

Geohazards identified along the Lower BJAR include debris avalanches, debris floods, floods, and rockfall.

Figure 2.1-1. UWRs and High Quality Moose Habitat in Proximity to the BJAR



No landslide or fluvial geohazards were identified that exceeded a Moderate level of safety risk. For facilities, the only non-avalanche geohazard exceeding Moderate risk was flooding hazards along the BJAR where it runs parallel to the Bowser River (35-59 km), and at the Bowser airstrip.

Additional information on geohazard management including inspections and response is provided in the Brucejack Geohazards Management Plan.

2.2.1 Avalanches

2.2.1.1 Avalanche Zone at 44 km

Several portions of the Lower BJAR intersect avalanche paths. Conditions in each of these paths are monitored throughout the winter and mitigation measures are implemented as necessary.

The avalanche path having the most day-to-day impact on the BJAR is located near km 44 and is known locally as the "Slasher" zone. (Figure 2.2-1 and Plate 2.2-1) The active portion of this zone is just under 1 km long. The BJAR in this area is between the Slasher slope to the north and the Bowser River immediately to the south. Signs warning of the zone are located on either end of the slide paths. Vehicle operators are required to call out on the radio prior to entering and after leaving the zone during the avalanche season. Stopping in this zone is prohibited.

Six Gazex® Avalanche Release Systems have been installed within the Slasher zone to mitigate avalanche hazards in this area. Avalanche control by the use of a helicopter is used as needed to support mitigation of avalanche hazards on the Slasher slope.

2.2.1.2 Other Avalanche Zones

Other avalanche zones with potential to affect the Lower BJAR are listed in Table 2.2-1. Monitoring and hazard mitigation measures, including non-automated avalanche control methods, are used at each of these as needed. Details of mine and BJAR avalanche zones and controls are provided in the Avalanche Safety Plan; a summary is provided below.

Table 2.2-1. BJAR Avalanche Zone Locations

Access Road Km Marker	Local Avalanche Zone Name
2	Wildfire Hill
30	Butch Cassidy
31	Sundance Kid
44	Slasher
56	Fort Knox
58	Sluice Box
59	Crusher
60	DMZ

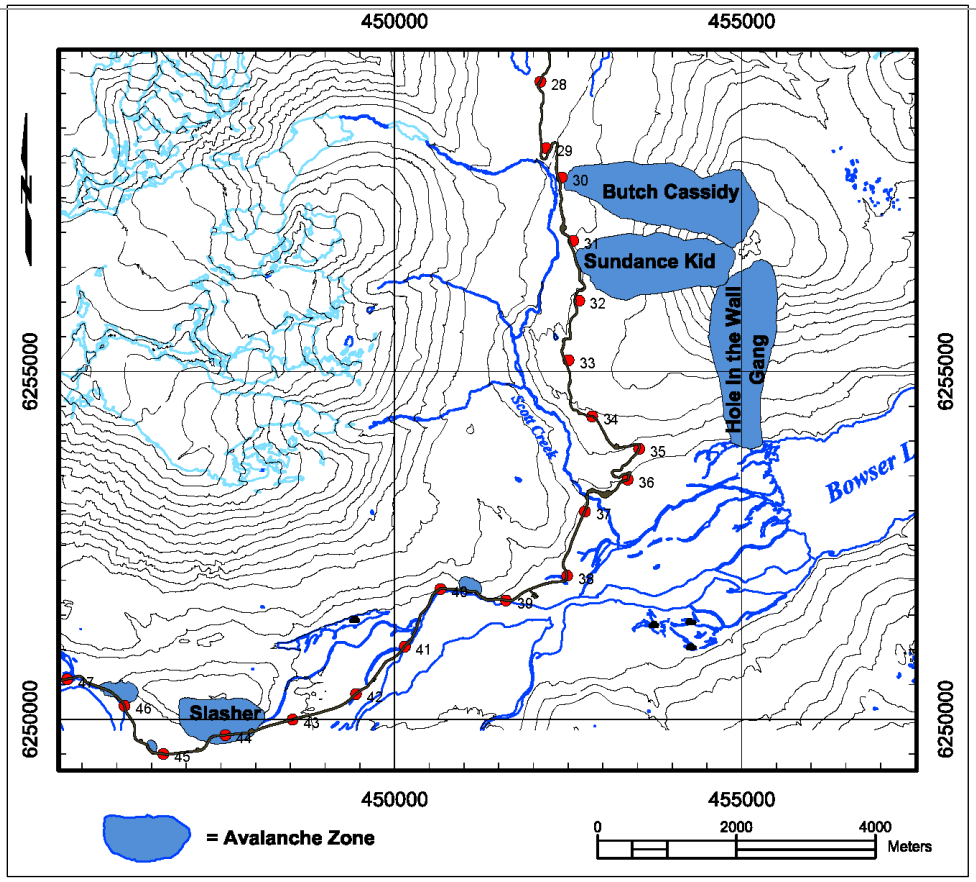


Figure 2.2-1. Road Avalanche Zones Km 30 to 44

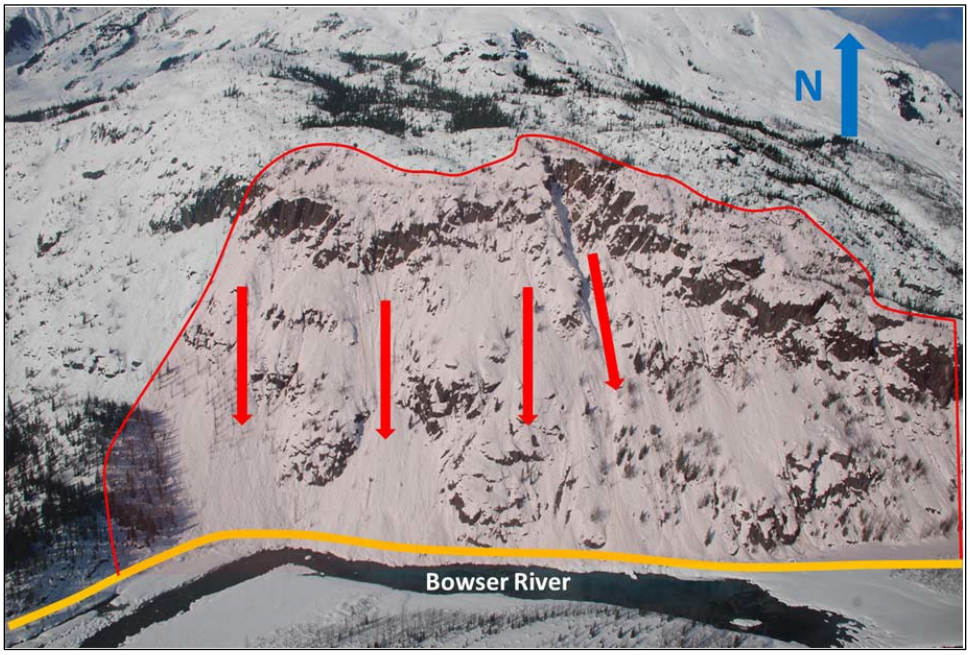


Plate 2.2-1. Slasher paths at km 44 outlined in red. BJAR in orange (Gould, 2014).

2.2.1.3 Avalanche Control

Avalanche control measures used throughout the site, or proposed, include:

- Hand charging;
- Gazex® Avalanche Release Systems;
- Wyssen Towers;
- ANFO prill bags, deployed both on the ground and via helicopter; and

Site avalanche technicians (Mountain Safety) report avalanche conditions to operations crews at the start of each shift and update throughout the day by radio as conditions change.

Unless requested by the Access Road Manager, general traffic travelling through and not working in avalanche areas are not required to carry companion rescue gear. Road maintenance equipment operators are required to wear avalanche transceivers. Rescue caches are situated at start and end of avalanche zones. Workers also receive avalanche rescue training.

Equipment operators must immediately report any avalanche activity to Mountain Safety making sure to note the location of the activity.

As above, Six Gazex® Avalanche Release Systems have been installed at the km 44 "Slasher" area. These systems consist of an exploder, located in in an avalanche start zone, connected by gas lines to a shelter, located on a ridgeline. The shelter houses oxygen and propane gas cylinders that release gases to the exploder through electronically controlled valves. The gases collect in the exploder and are ignited by a pressure actuated firing mechanism creating an explosion. The resulting pressure wave fractures the snow mantle, initiating an avalanche. The entire process is controlled remotely via a radio control system through a computer using sophisticated monitoring software (Lieberman, 2002).

The Gazex exploders are operated and maintained by the Mountain Safety department in conjunction with supporting onsite trades people. Access for maintenance and fueling is via helicopter as required.

Plate 2.2-5 shows a typical GAZEX® installation with the exploder shown in the foreground and the shelter in the background near the helicopter.

Plate 2.2-5. Typical GAZEX® installation.
(Photo courtesy of AvaTek Mountain Systems Inc.)

Additional details of avalanche control and safety measures are provided in the Avalanche Safety Plan.

2.2.2 Flooding

Moderate risk of flooding exists along the Lower BJAR where it runs parallel to the Bowser River between km 35 and 56.

River and tributary conditions are monitored during high water events and the road is closed if/as necessary.

2.3 WILDLIFE COLLISION PROTOCOL

The BJAR is maintained and managed to minimize or prevent wildlife attractants on and adjacent to the road, and to provide egress points during winter, however encounters with wildlife (e.g., moose) along the BJAR may still occur. The radio is used to alert other vehicle operators that there is wildlife in the area and to travel with caution.

If a large number of wildlife (e.g., moose) are present on or adjacent to the Lower BJAR, a temporary road closure may be initiated at the discretion of the Environmental Superintendent (or delegate) in consultation with the Access Road Manager and the Mine Manager.

Drivers are instructed to report encounters with wildlife along the BJAR (including observations or interactions) either directly to the Brucejack Environmental Department, or to Dispatch/Logistics,

who then forward these reports. The Brucejack Environmental Department maintains records of these reports via the wildlife log. Reporting and record keeping specific to collisions with wildlife follows the Wildlife Collision Protocol in the Brucejack Wildlife Management Plan:

- Any collisions between mine vehicles and wildlife are documented and include information on the location of the collisions;
- Wildlife species that are recorded include, but are not limited to, moose, mountain goat, grizzly and black bear, and deer;
- Personnel and drivers are instructed to report any wildlife-vehicle collision to Dispatch/Logistics or directly to Pretium Environmental Department staff; and
- Information on collisions with wildlife is included in the wildlife log, which is provided to the Brucejack Wildlife Advisory Committee (WAC) for review and feedback. If any mortality of Little Brown Myotis (*Myotis lucifugus*) or Northern Myotis (*Myotis septentrionalis*) resulting from vehicle collisions is reported, or if evidence of same is found through monitoring, this information is compiled as required by Condition 8.3 of the Decision Statement under Section 54 of the *Canadian Environmental Assessment Act*, *2012*, for the Brucejack Project.
- The Environmental Manager is responsible for training, providing a reporting system, and reporting collisions as appropriate to government officials.

These records will provide a basis for identifying locations of considerable risk for wildlife/vehicle collisions, and for developing mitigation strategies for such areas if/as appropriate.

2.4 SPEED LIMITS

BJAR speed limit signs are posted at appropriate intervals. Speed limits may be increased to 50 to 60 km/h for km 35 to 40 and km 40 to 56 (excluding bridges and km 50 to 52; refer to Sections 2.1.1 and 2.1.2), and for other sections once upgrades are complete. Lesser speed limits are posted as appropriate for:

- Steep grades;
- Bridges;
- Low visibility curves;
- Approaches through camps; and
- Construction zones.

In addition to speed limit signs, measures to control vehicle speed against appropriate design speed limits may also include installation of “speed bumps” or additional signage for areas where speed limit exceedances are observed on a reoccurring basis.

Vehicle speeds are monitored through unannounced radar speed spot checks via radar sign-equipped trailers.

2.5 MEASURES TO CONTROL TRAFFIC NOISE

Measures to control noise from traffic include:

- Maintaining vehicles regularly;
- Imposing speed limits; and
- Maintaining mufflers on vehicles.

Additional measures to control noise from traffic may include:

- Consideration of noise specifications when selecting equipment;
- Applying noise dampening measures where possible;
- Limiting the use of engine air brakes within 500 m of floodplains during May and October to protect moose;
- Restricting use of engine air brakes on floodplains in June and September to protect grizzly bear; and
- Restricting speed limits and engine air brake use along Bowser River floodplain before July 15 to protect mountain goat.

2.6 VEHICLE PRIORITY

The following is a hierarchy for determining vehicle priority and right-of-way. Vehicles with a lower priority must yield to vehicles of higher priority:

1. Emergency vehicles;
2. Vehicles carrying explosives;
3. Buses and passenger vans/shuttles;
4. Heavy trucks and road maintenance equipment; and
5. Light vehicles.

Loaded vehicles have priority over unloaded vehicles regardless of direction of travel. Loaded vehicles going down have priority over loaded vehicles coming up.

2.7 RADIO CALL OUT PROCEDURES

Each vehicle travelling the BJAR must have a VHF radio programmed with the routine and emergency radio frequencies used for the road. If travelling in a convoy, only the lead vehicle is required to call out as long the vehicles stay together.

At each kilometre marker, vehicles must indicate:

1. Number of vehicles travelling together;
2. Type of vehicle (pickup, semi, grader, etc.);
3. Kilometre marker; and
4. Direction of travel ("up" indicates travel towards Brucejack Mine Site and "down" indicates travel towards Hwy 37).

For instance, a three vehicle convoy of pickup trucks heading towards Hwy 37 would call out "three pickups, 36 km down."

When vehicles are converging towards each other, the vehicles with the lower right-of-way priority must find a location to pull over and yield to the higher priority vehicle. Once safely off of the road, the yielding vehicle must notify the oncoming traffic that they have pulled off safely and give their approximate location. Once the higher priority vehicle(s) has passed, the yielding vehicle is free to resume travel.

At times, it may be convenient for the higher priority vehicle to pull over first. In this case, that operator will notify oncoming traffic of his or her intent.

2.8 PASSING

Passing anywhere along the BJAR is prohibited in all areas unless the lead vehicle pulls over to a complete stop or there is ample passing room for two vehicles to pass and the lead vehicle signals the overtaking vehicle that it is safe to pass. This may be communicated by radio or by physically waving the operator past.

The same procedure must be followed when passing working road maintenance or construction equipment. When passing an excavator, vehicles must use caution to stay out of the machine's swing radius until positive communication is established with the operator. The machine operator will indicate that it is safe to pass by stopping all machine movement and placing the bucket on the ground.

3 KNIPPLE GLACIER TRAFFIC CONTROL

The Knipple Glacier portion of the BJAR extends between km 59 and 71.6(Figure 3-1). Travel on the glacier road has a unique set of hazards that require special equipment and additional training for those traversing the road. No one is allowed to travel across the Knipple Glacier unless the glacier orientation has been completed. Drivers must be escorted by a qualified person for their first trip across the Knipple Glacier.

3.1 ROUTE DELINEATION

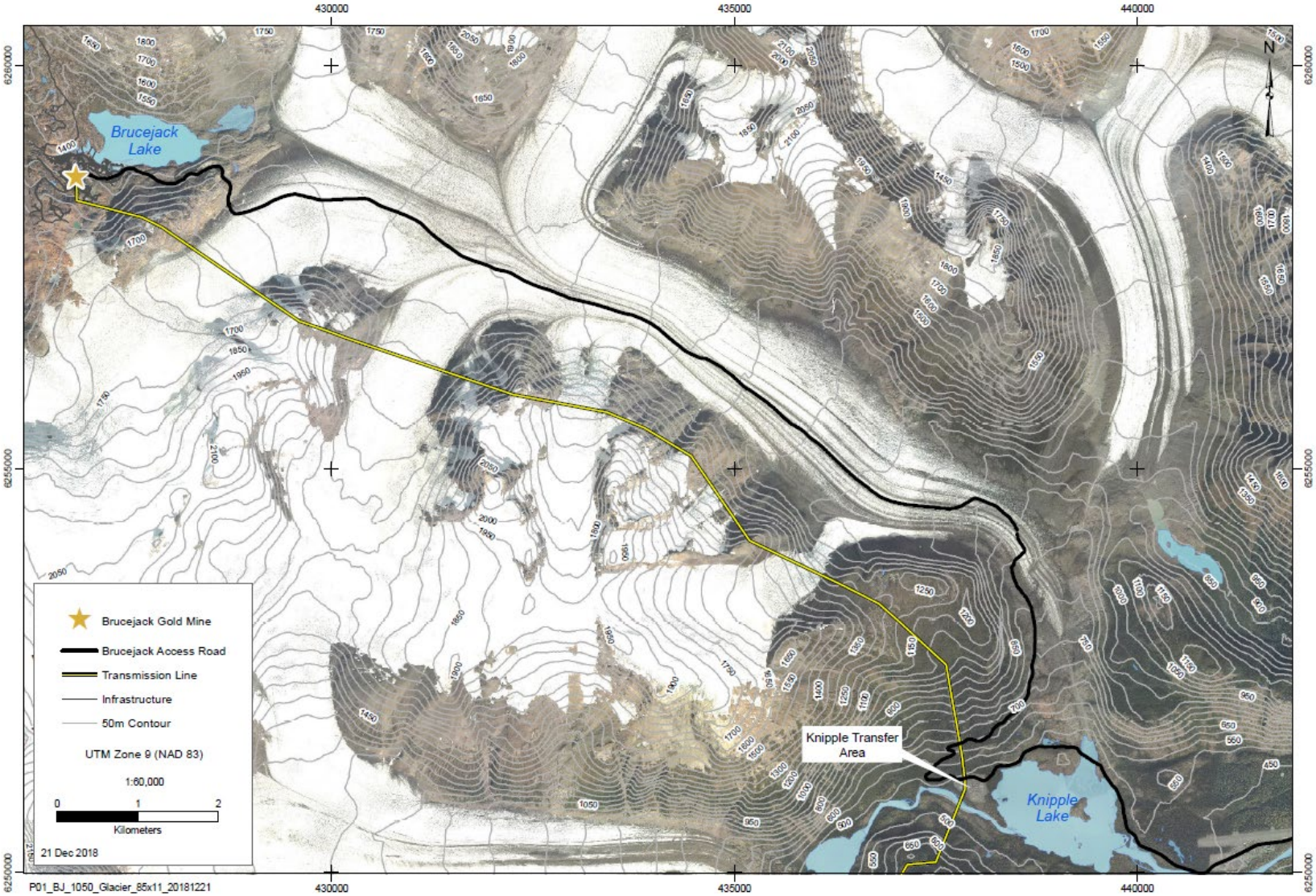
Bamboo markers are used on the VOK Bypass Route (winter emergency route when Lakeshore Drive is closed due to avalanche risk or control) to delineate the edge of the safe travel zone. High visibility reflective tape is placed on the markers to improve their visibility in low light conditions. The bamboo delineators are located on the side of the road for traffic incoming to the Brucejack Mine Site.

Local hazards and "Do Not Travel" areas are marked by various methods; including pylons, spray paint and bamboo arranged to form and "X"(Plate 3.1-1).

Plate 3.1-1. Bamboo "X" hazard identifier.

The route is moved from time to time in order to avoid hazards such as crevasses and moulins as the ice melts.

Figure 3-1. Knipple Glacier Portion of the BJAR



3.2 GLACIER HAZARDS

Some hazards unique to glacier travel include:

- Crevasses;
- Moulins or "Mill Holes";
- Slippery conditions;
- Flat light conditions; and
- Low visibility conditions.

3.2.1 Crevasses

As the spring snow melts, crevasses are exposed. Glacier safety and maintenance crews continuously work to keep crevasses on the roadway filled with ice. While the filled crevasses do not pose an entrapment hazard for equipment, driving over one while exceeding the speed limit can damage vehicles. The difference between the natural crevasses and the filled road route can be seen in Plate 3.2-1.

Plate 3.2-1. Crevasses along Knipple Glacier Route.

Procedures require that only trained and properly equipped personnel are allowed to exit their vehicles and walk on the glacier, as crevasses are large enough to entrap a person or cause injury.

Personnel or operators encountering a crevasse in need of filling must report it immediately to the Access Road Supervisor and Dispatch/Logistics.

3.2.2 Moulins

Moulins or "mill wells" are vertical or near vertical holes in the ice formed by moving water. Moulins can range in size from several centimetres (Plate 3.2-2) to tens of metres. They can extend to hundreds of metres in depth and may be full of water or dry.

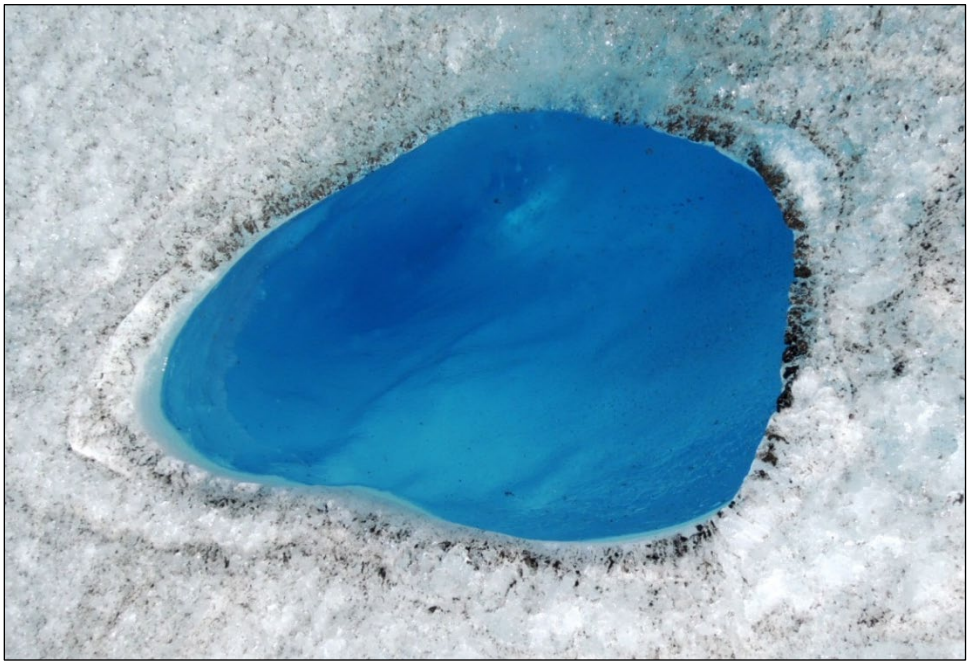


Plate 3.2-2. Water-filled moulin (8 to 12 inches across).

Moulins are the biggest danger to pedestrians, as they can cause injury ranging from a twisted ankle or entrapment and drowning.

Glacier safety and maintenance crews are always on the lookout for newly exposed moulins. When encountered, locations of moulins are marked with traffic cones and/or bamboo Xs.

Personnel encountering unmarked moulins must note the location and report it to the Access Road Supervisor and Dispatch/Logistics.

3.2.3 Slippery Conditions

Due to slippery condition created by the melting ice, rubber tired equipment must be equipped with tire chains.

All vehicle operators must refer to the BJAR SOP (Appendix 1).

All operators on the glacier ice (km 59 to 71) must know how to install and adjust their own tire chains. Contractors are expected to supply their own chains and receive approval for glacier travel prior to arrival. Approvals are limited to mobilization, demobilization, and essential travel only. For the most part, all contractors are be required to ride in Pretium provided shuttles.

Operators must be cautious of ice grooming equipment operating on the glacier and only overtake that equipment after positive communication has been established.

3.2.4 Flat Light

Flat light conditions occur when fog or blowing snow blends with the white background of the snow. This condition is very disorienting and can quickly cause an operator to leave the road surface.

The edges of the main portion of the Knipple Glacier section of the BJAR (km 59 to 71) are defined by berms left from snow removal and grading. Bamboo delineators are spaced closely along the VOK Bypass Route during the winter and offer some point of reference for the operator. Various tints of sunglasses are also useful in flat light conditions. Tinted safety glasses are provided to the operators.

If an operator encounters flat light conditions where they cannot see the road, berms, or delineators, they must stop all motion and wait for visibility to improve. If visibility does not improve within 15 minutes, the operator must call Dispatch/Logistics and notify them of the situation, making sure to transmit their approximate location. The operator must also communicate with other vehicles operating in the area so that they do not cause a collision with the stopped vehicle. The vehicle operator must not, under any circumstances, leave the safety of the vehicle in these conditions.

3.2.5 Whiteout Conditions

Whiteout conditions occur when blowing snow obscures all points of reference. Blowing snow usually occurs during storms, but can also occur due to windblown ground snow.

If an operator along the VOK Bypass Route encounters whiteout conditions where they cannot see the next bamboo delineator, they must stop all motion and wait for visibility to improve. If visibility does not improve within 15 minutes, the operator must call Dispatch/Logistics and notify them of the situation, making sure to transmit their approximate location. The operator must also communicate with other vehicles operating in the area so that they do not cause a collision with the stopped vehicle. The vehicle operator must not, under any circumstances, leave the safety of the vehicle in these conditions.

As whiteout conditions occur during the winter when snow berms are high, the likelihood of a vehicle getting lost on the glacier is minor. Vehicles wandering from the roadway would tend to get stuck in the deeper snow before completely leaving the roadway.

3.2.6 Bright Light Conditions

Bright sunlight reflected off of the snow causes photokeratitis or “snow blindness”. The reflected ultraviolet light essentially causes sun burning of the cornea. While not always immediately

noticeable, the condition can be severe. Equipment operators are required to wear UV protection sunglasses when operating on the glacier. This condition can even occur on overcast days, so operators must always be cautious about the condition.

Reflected UV light can also quickly cause sunburn to exposed skin. Operators are recommended to apply high SPF sunscreen over exposed skin.

3.3 SUMMER GLACIER OPERATIONS

3.3.1 Summer Glacier Hazards

The main hazards to vehicles on the Knipple Glacier in the summer are slippery conditions, crevasses, and moulins. Another hazard is at the bottom end of the glacier (km 60 and vicinity), where there is a steep uphill grade that can become slippery. All heavy loads must ensure that they contact Knipple operations before they make the glacier trip, as tow vehicles may be required to assist traverse of the steep grade from 59 km up the 60 km hill to 62 km marker.

3.4 WINTER GLACIER OPERATIONS

During the winter months, the glacier surface is kept clear using a combination of motor grader and snow blowers. Snow berms created by the snow blower are lowered and tapered using snow cats.

Glacier traffic includes:

- Conventional rubber tired vehicles with traction chains;
- Tracked haulage equipment;
- Tracked snow cats; and
- Snowmobiles.

3.4.1 Winter Hazards

Winter hazards include flat light, whiteout conditions, and bright light conditions. Conditions on the glacier are very dynamic, varying quickly over both time and elevation.

3.4.2 Valley of the Kings (VOK) Bypass Route

The VOK Bypass route (Figure 3-1) is a winter use only section of road that bypasses the Lakeshore Drive route to the Mine Site. This section of Knipple Glacier has larger crevasses than the rest of the glacier, so it must be deeply covered in snow prior to use. While longer, this section of road provides an alternate route during the management of avalanche hazards along Lakeshore Drive.

Operational procedures discussed for the main Knipple Glacier road also apply to the VOK Bypass, as relevant for tracked equipment.

3.5 SAFE VEHICLE TRAVEL

3.5.1 *Speed Limits*

The speed limit on the glacier is 40 km/h unless otherwise posted. Operators are expected to use good judgment and reduce speed as appropriate for the dynamic glacier conditions.

Certain sections of the glacier with steeper grades have signage requiring the use of the vehicles lowest gear and a brake check. All signed instructions must be followed.

3.5.2 *Glacier Radio Call Out Procedures*

All km call out procedures discussed previously in Section 2.7 apply on the Knipple Glacier road section. Additionally, drivers are required to call certain locations along the glacier section of the BJAR These locations include:

- The transition between the Lower BJAR and the glacier at km 59;
- Km 62 marker on the Knipple Glacier;
- The transition between the Knipple Glacier and Lakeshore Drive at km 71.6;
- The transition between Lake Shore Drive and the Mine Site road at km 73.3; and
- When leaving the Brucejack Mine Site to travel the VOK Bypass road.

3.5.3 *Hazard Monitoring*

Unlike other glaciers in the area, the Knipple Glacier is a frequently maintained glacier road surface and is generally free from large crevasses that present a hazard to equipment. Although the glacier does contain many crevasses that present hazards to ATVs or personnel on foot, seracs (ice cliffs) are not present along the immediate travel route.

As the surface of the glacier and exposure of hazards such as crevasses and moulins is dynamic, even day-to-day, Pretium maintains glacier safety staff, typically Mountain Safety, year round to advise on route alterations. Mountain Safety personnel monitor glacier road conditions for constantly changing hazards such as crevasses and moulins. Mountain Safety personnel also advise operating crews as to expected glacier conditions at the start of each shift, during the pre-shift safety meeting. Crews are updated by radio if conditions change during the shift.

Crevasse surveys are completed on an as needed basis and are used to plan route modifications.

3.5.4 *Glacier Road Maintenance*

3.5.4.1 Winter Glacier Road Maintenance

During the winter months, the Knipple Glacier Road is covered in many metres of snow. Prior to the winter of 2014/15, Pretium used ski resort-type snow cats to prepare the running surface for other tracked equipment. The snow cats are equipped with blades on the front to distribute the snow across

the road surface and break through snow drifts. A hydraulically powered tiller on the rear of the snow cat then mixes the new snow with previous layers, reduces chunks, and beats the air out of the snow. A plastic comb then compresses the snow into a ribbed or "corduroy" running surface. The end result is a snow surface that is dense enough for other tracked equipment to run on.

Beginning during the winter of 2014/15, the Knipple Glacier Road was maintained by snow blowing the road surface and grading down to near ice. This practice allowed for the use of conventional rubber tired vehicles to travel the glacier. Vehicles are required to utilize traction chains while on the glacier.

The berms created along the side of the road from snow blowing operations are pushed out and tapered with snow cats to control runoff during the spring.

Avalanche technicians monitor the glacier and assist operations with selecting a safe route.

As the winter progresses, the road is widened to accommodate multiple lane widths. Having multiple lanes allows one surface to be travelled on while the other is being groomed.

3.5.4.2 Summer Road Maintenance

As temperatures rise in the spring, the snow pack on the glacier turns to slush as it melts. This process starts at the lower elevations and works its way up the glacier as upper elevations warm.

As the snow becomes softer, it is important to clear the snow down to ice to provide a firm running surface. Snow clearing is completed using snow cats, excavators, motor graders, and snow blowers. As the snow is cleared from the road surface, ditches are established to shed water away from the road surface and into crevasses.

As temperatures warm, the dense blue glacier ice becomes very slippery. Motor graders are used to scarify the ice surface, providing additional traction for the mobile equipment. NPAG rock is placed on problematic sections of the glacier road.

Pretium has recorded vertical elevation drops of up to 15 m annually at the bottom of the glacier near km 60 of the BJAR. This causes the gradient between the gravel portion of the BJAR and the ice to increase every summer. This transition is extended using NPAG rock each year to maintain a safe gradient. Realignments of the access ramp onto the glacier are also expected to be necessary periodically, such as the realignment of the km 59 to 60 ramp during 2018.

Additional NPAG fill will be used to fill crevasses between ice ridges at the glacier margins. Pretium occasionally uses white geotextile fabric draped over the ice ridges to reflect sunlight, preserving the ridges as long as possible.

The transition to the gravel road at the top of the glacier near km 71 that leads to Lakeshore Drive is also exhibiting melt conditions, but to a lesser extent. NPAG rock is occasionally placed at this transition from the glacier to the gravel road.

As the surface of the glacier and exposure of hazards such as crevasses and moulins is dynamic, even day-to-day, Pretium maintains glacier safety staff, typically Mountain Safety, year round to advise on route alterations.

Mountain Safety also advise operating crews as to expected glacier conditions at the start of each shift, during the pre-shift safety meeting. Crews are updated by radio if conditions change during the shift.

4 LAKESHORE DRIVE TRAFFIC CONTROL

Lakeshore Drive is an approximately 2 km section of all-weather road between the top of the Knipple Glacier at km 71 and the Brucejack Mine Site at km 73.3. All drivers must call on the radio for each of the following km markers: 71.6, 72, 72.5 and 73. Drivers inbound to the Brucejack Mine must call "vehicle type X km up", and outbound drivers must call "vehicle type X km down". Lakeshore Drive is in a high risk avalanche area; during avalanche season no stopping is allowed anywhere along Lakeshore Drive.

4.1 GEOHAZARDS

Hazards along this section of road include avalanches and occasionally, falling rock.

4.1.1 Avalanches

Nearly all of Lakeshore Drive passes through avalanche zones. This road is actively monitored for avalanche conditions and the use of explosive control measures is frequent.

The active avalanche zone stretches from 71.6 to 74 km. The most active paths are between km 72.7 and km 73.

All of the avalanche control measure procedures discussed previously in this management plan also apply to the Lakeshore Drive zones.

4.1.2 Rock Falls

Sections of Lakeshore Drive are prone to loose rock falling on the roadway. Operators noticing fresh loose rock must notify Brucejack Mine Site Dispatch/Logistics. Dispatch/Logistics will notify mine management and the section of road will be inspected.

Additional information on geohazards is provided in the Brucejack Geohazards Management Plan.

4.2 WILDLIFE INTERACTIONS

Wildlife interactions along Lakeshore Drive are very rare, but operators are required to report any observations or interactions to Mine Site Dispatch/Logistics, or directly to the Environmental Department, noting the species and location.

5 MINE SITE ROADS TRAFFIC CONTROL

Mine Site roads consist of those roads between and around facilities at the Brucejack Mine Site, including:

- Phase 1 and Phase 2 Camp facilities;
- Mill pad and to the VOK Portal;
- Heavy Shop;
- Warehouse, Waste Transfer Facility, and Waste Rock Dump; and
- West Zone pad and Incinerator.

All vehicle traffic considerations discussed for the Lower BJAR and Lakeshore Drive also apply to the Mine Site roads.

5.1 DIRECTION OF TRAVEL

All traffic on the Mine Site is two way. The main traffic patterns are shown in Figure 5.1-1. The northwest side of the Mill is closed to traffic seasonally due to roof snow hazards. The road between the West Zone pad and Brucejack Creek is signed for heavy equipment access only.

5.2 SPEED LIMITS

The maximum Mine Site road speed limit is 20 km/h, with speed limits reduced to 10 km/h anywhere around buildings or high pedestrian traffic areas. Lower speed limits are posted in congested areas.

5.3 VEHICLE RIGHT OF WAY

The right-of-way hierarchy for the Mine Site roads is:

1. Emergency Vehicles;
2. Explosives;
3. Working construction equipment (graders, excavators, etc.);
4. Loaded haulage vehicles (freight or rock);
5. Empty haulage vehicles (freight or rock);
6. Other heavy equipment; and
7. Light vehicles, ATVs, and snowmobiles.

A lower priority vehicle must not overtake or pass a higher priority vehicle without first making positive contact with the operator and until after the higher priority vehicle has yielded way, typically by stopping all movement. Heavy equipment must not be overtaken until communication has been made with the operator and the operator has stopped all motion and grounded attachments.

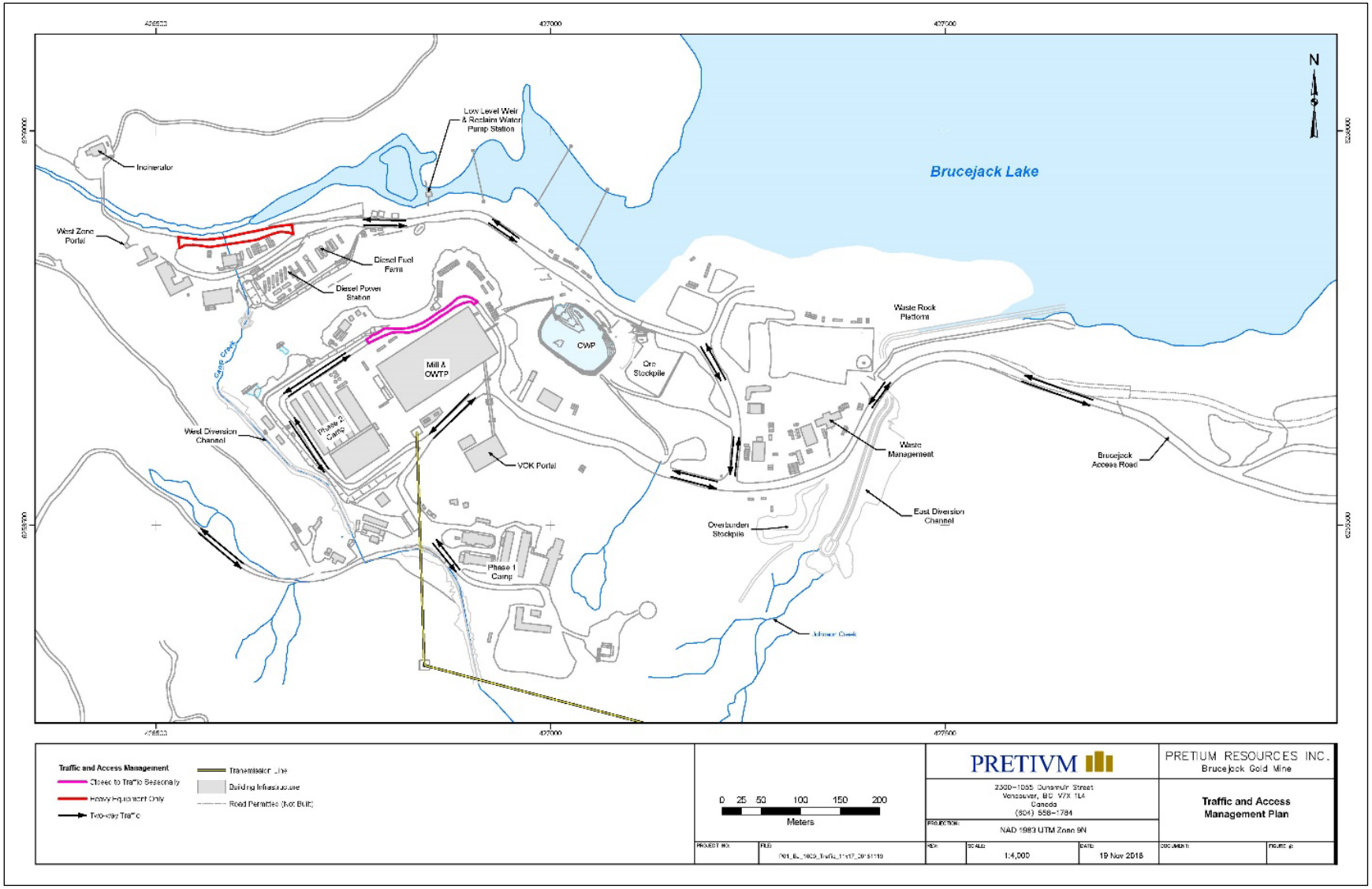


Figure 5.1-1. Brucejack Mine Site Traffic Patterns

5.4 RADIO CALLOUT PROCEDURE

Operators are also required to announce their departure or entrance from various Mine Site locations, including West Zone, Waste Rock Dump, (Phase 2) Camp Pad, Fire Hall, Mill Pad, Warehouse, Tailings Road, Bunk 6 (upper Phase 1 Camp), and Lakeshore Drive. This notification is not made to Dispatch/Logistics, but rather as a general notification. The operator must announce their starting point, destination, and type of vehicle.

5.5 WARNING SYSTEMS

Site mobile equipment is required to be equipped with backup alarms and strobes. Pickup trucks and vans must be equipped with strobes, backup alarms, and a buggy whip style antenna. ATVs and snowmobiles must be equipped with buggy whip style antenna.

Prior to moving a vehicle or piece of equipment equipped with an audible horn, the operator must indicate the intended movement by honking the horn as follows:

- One Honk – to go forward;
- Two honk – to go backward; and
- One long continuous honk – emergency.

Honk signals are not used around bunkhouses to avoid disturbing employees who are asleep.

5.6 PARKING

Equipment is required to be parked on designated, level surfaces out of the flow of traffic. Wherever possible, vehicles must be parked "back in." Operators are required to use appropriately sized wheel chocks when parking all rubber tired vehicles. Hydraulically driven self-propelled Genie or JLG boom type work platforms are not required to use wheel chocks when operating or parked. The use of wheel chocks on this type of equipment can cause tipping if run over.

Heavy equipment is required to be parked with buckets or blades grounded.

During the winter, operators are required to avoid parking under any roof line that is likely to shed snow. Operators are also required to consider predominant wind direction and avoid parking on the leeward side of a building to avoid the vehicle becoming drifted in. 'No Parking' signs are posted at various locations throughout the Mine Site and drivers are expected to adhere to all posted signage at all times.

6 UNDERGROUND TRAFFIC CONTROL

Traffic travelling underground is diesel or electrically powered only. No gasoline combustion powered engines are permitted to travel underground. All vehicles going underground must meet the following criteria:

- Diesel or electrically powered;
- Diesel engines must be CANMET certified; and
- All vehicles must have appropriate rollover protective structure (ROPS), braking, and fire suppression systems as required by the Health, Safety, and Reclamation Code for Mines in British Columbia (HSRC; BC Ministry of Energy and Mines 2017).

6.1 UNDERGROUND ROAD DESIGN

Development headings are designed with the following design criteria to provide a safe travel way.

- Travel ways have a minimum of 1 m of clearance on each side of the largest vehicle travelling the area;
- Main travel ways have a minimum centreline radius of 25 m;
- Main travel ways are not typically designed to exceed 15% gradient;
- Spiral ramps are avoided to the extent possible;
- Safety bays are provided at regular intervals to allow shelter for pedestrian traffic; and
- Signage is provided at major intersections and at appropriate intervals on levels showing direction to refuge stations and egress points.

6.2 ACCESS

Access to the underground mine is through the West Zone and VOK Portals. Traffic is two way throughout the mine except at designated locations such as the crusher dump pocket and infrastructure area. These areas have been provided with one way drive through loops.

6.3 ACCESS CONTROL

No unauthorized personnel are allowed underground and no person is allowed to operate a piece of equipment that they have not been trained on.

All personnel entering the mine must “tag in” at the mine operation office tag board. Upon exiting the mine, personnel must immediately proceed to the portal office and “tag out” so that mine supervision knows who is underground at all times.

6.4 PRE-SHIFT INSPECTION

All vehicle operators must complete a pre-shift inspection of their vehicle to ensure it is in safe, working order prior to operating it. The inspection shall be documented on a pre-shift card. Any deficiencies found during the inspection must be repaired prior to that vehicle's operation.

6.5 BRAKE TEST

Prior to entering the mine, the operator of the vehicle must perform tests on both the service and parking brakes.

To complete the brake test, the operator must:

1. Come to a complete stop;
2. Depress the service brake fully;
3. With the vehicle in first gear, step on the accelerator;
4. If the vehicle does not move, the service brake has passed;
5. Repeat steps 2 through 4 with the parking brake;
6. If both brakes pass, the operator is cleared to proceed; and
7. If either brake fails, the vehicle may not proceed. The operator must report the issue to the maintenance department. The vehicle will be tagged out until such time as the brakes are repaired.

6.6 VEHICLE PRIORITY

The following list is the priority hierarchy for mobile equipment underground:

1. Emergency response vehicles;
2. Explosives transport vehicles;
3. Loaded haul trucks and LHDs;
4. Empty haul trucks and LHDs;
5. Mine utility equipment such as scissor lifts, fuel/lube vehicles, graders, etc.;
6. Light vehicles such as tractors and small personnel carriers; and
7. Downhill traffic on the ramp always has priority over traffic going uphill.

6.7 FOOT TRAFFIC

Foot traffic is very common in the mine. All personnel must be equipped with mine lights and reflective clothing to increase their visibility. However, personnel must be aware that the heavy equipment operators have limited visibility. Foot traffic must always give mobile equipment a wide berth.

Do not approach operating equipment until you make positive contact with the operator. The operator will stop all machine movement and signal the pedestrian traffic that it is safe to approach. Always approach on the operators cab side of the equipment. At no time shall pedestrian traffic and heavy equipment pass/interact at the same time. Either the pedestrian will stop in a safe location and allow the equipment to pass, or equipment operators will stop and allow the pedestrian traffic to pass.

Whenever and wherever possible pedestrians will pass on the operator's side of the equipment for better visibility and safety. Personnel safety bays and other cut-outs will be provided at regular intervals to allow personnel on foot to get out of the traffic lane.

6.8 PARKING UNDERGROUND VEHICLES

Underground vehicles must be parked out of active travel ways, remucks, and stoping areas. If in doubt of an area's activity, the shift boss will be contacted prior to leaving a vehicle.

Wheel chocks will be used at all times when parking. When parking on a grade such as a ramp, the vehicle must be "ribbed" or parked against a wall and the wheel turned into the wall to prevent vehicle movement in the event of a brake failure; and the parking brake will be set. At no time will personnel walk downhill from an unattended vehicle that is not "ribbed" and chocked. Never rely on a parking brake alone.

At no time is anyone allowed to leave engines running on unattended vehicles. This is extremely unsafe and poses a fire hazard. When leaving the parked vehicle, the master switch must be turned off but the strobe left on. Personnel caught tampering with strobes will be disciplined up to and including loss of camp privileges. The master switch must be turned off on any unattended vehicle underground.

6.9 UNDERGROUND COMMUNICATIONS

The underground communication system currently consists of a leaky feeder line and receivers located through the mine. VHF radios are being used by underground personnel and equipment operators to communicate locations and allow for safe traffic movement. There is a dedicated underground mine emergency channel that will be used in the event of serious injury or fire. All persons working underground must be trained and well versed in calling an emergency on the radio system.

7 REFERENCES

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Appendix 1

Brucejack Access Road Standard Operating Procedures

Objective

To provide a clear and concise procedure to ensure safe travel for all vehicles travelling on the access road. All drivers will understand radio calling procedures, be qualified to drive their respective vehicle with skill and proficiency doing so in a safe, responsible manner.

Scope

This procedure applies to all access and service roads from Wildfire Camp-0 km to 59 km at Brucejack Site.

Health, Safety & Reclamation Code for Mines in British Columbia

- 6.8.3 Traffic control
- 4.9.4 Vehicle requirements
- 4.9.5 Vehicle requirements

Occupational Health & Safety (OHS) Regulation (WorkSafe BC)

- 26.14.3 Traffic control.
- 26.18 Landslides/Avalanches

Definitions

- SOP-safe operation procedure
- Bungee cords- Rubber straps

Roles and Responsibilities

The General Manager or Designate shall ensure:

- This SOP is implemented and maintained.
- On-site personnel have up-to-date information regarding this SOP.

The Health and Safety Manager or Designate shall ensure:

- The implementation of this procedure is monitored.

The Area Manager or Designate shall:

- Monitoring the implementation of this procedure.
- Review and revise when changes are needed.

The Worker are responsible for:

- Following and understanding this SOP when operating on the access road.

Preparation

Vehicle Checklist:

- Tire Chains
  - Use of tire chains are required during the winter months.
  - Bungee cords and tie straps are recommended to keep chains secure.
- Pre-operation inspection completed and documented in vehicle logbook
- Straps, tie-downs, chains, and cinches for securing loads.
- Strobe light
- Back up alarm
- Snow Brush when required
- Fire extinguisher
- BC Level 1 First aid Kit
- Spill Kit
- Two-way mobile radio with appropriate frequencies (see frequency list)
  - handheld portable radios not permitted for road travel
- 4 x 4 vehicles only
- 10 ply tires or Load Range "E" - Winter tread required for winter driving
- Spare tire
- Buggy whip with flag

Operator Checklist:

- PPE
  - Standard: Hard hat, safety glasses, hi-vis vest, steel-toed boots
  - Winter: Insulated Jacket, Insulated footwear, headwear, and gloves/mitts.

Right of Way Hierarchy is as follows:

1) Emergency Vehicles
2) Vehicles carrying explosives
3) Buses and Passenger Vans/Shuttles
4) Heavy Trucks or Equipment
5) Light Vehicles

(Right away is given not taken)

Job Step

- Drive within the speed limits and to the prevailing road conditions. Seasonally the road conditions can change
- Speed limit is 15 km/h near camps and bridges, 40 km/hr. on main routes except where posted, reduce speed were posted and gear down whenever descending or climbing hills
- Reduce speed when approaching work crews or working equipment
- The access road up to the glacier (60km) uses the Road Channel **Pretium (channel 1)**
- Call every km from Wildfire to Brucejack **UP** (example: type of vehicle km 1,2,3 'UP')
- Call every km from Brucejack to Wildfire **DOWN** (type of vehicle km 57, 56 'DOWN')
    - **Note: Failure to call KMs may result in forfeiture of driving privileges on Brucejack property**.
- Listen to your radio for voice traffic indicating other vehicle positions and for indications of changing road conditions
- Be aware that heavy loads may be traveling anywhere along the length of the road
- Ensure you have sufficient fuel for your journey.
- Do not stop in any of the posted avalanche or rockfall areas.
- In the event of a vehicle breakdown in an avalanche area
    - **Stay in your vehicle,** you are safer inside (keep all emergency flashers on)
    - On your radio call 'Brucejack dispatch" (Refer to channel table below) with your km location and that you are in an avalanche area,
    - Await instructions from Brucejack Dispatch
- Wheel chocks must be carried in or on the vehicle
- In the case of a medical emergency call Brucejack Dispatch.
- In the event of a spill, shut down engine, try to stop the leak, get assistance and assist in clean up

Tow Assist Parameters:

- A tow assist is required from 56km up if load weight exceeds 60,000lbs and/or is heavily tail loaded and is mandatory for heavy vehicles at 59km down.
- Tow Assist Loader will be used on the steep grades
- C500 trucks do not require to have tow assist unless driver has requested.
- Double towing is required for propane trucks, unstable, or any load deemed too heavy for a single tow at the discretion of the supervisor.

*Please refer to BJ-ACC-SOP-004 - Heavy Vehicle Towing Assist prior to any towing assists

Horn Signals

Activities on the mine site often involve high traffic within a small work area create a high potential for vehicle/pedestrian interactions. The following horn signals are mandatory for vehicle/equipment operators to clearly communicate to pedestrians and other operators in the area an intent to start or move a vehicle. We do not do this close to the bunks

- **1 Honk** - prior to moving forward
- **2 Honk –** prior to moving backward
- **1 Long Continuous Blast –** meant to draw attention to an imminent danger in the area. (Avalanche, runaway vehicle etc.)

Operator Responsibilities

- All operators require appropriate license/training and sign-off for the equipment they are operating.
- All operators must read the Pretium Standard Road Procedures and sign the appropriate form indicating they have read and understand all requirements before operating a vehicle or equipment on the Brucejack property.
- Avalanche Awareness – Operators required to or work in designated avalanche zones must complete the Avalanche Awareness/PPE course and will be issued an avalanche kit (see checklist) as part of their vehicle standard equipment if required.
- **Seat Belts are Mandatory.** Operators are responsible for ensuring that all passengers are always wearing seatbelts while in transit.
- Operators/Carriers are responsible for ensuring vehicles are equipped with a mobile radio with the appropriate channels and output. Handheld portable radios are not permitted for road travel.
- All operators are responsible for ensuring that their vehicle/equipment is in safe mechanical condition by performing a mandatory pre-trip inspection and logbook entry prior to operation. Mechanical problems encountered that pose a safety risk or risk of further mechanical damage must be immediately reported to Site Services Supervisor, Master Mechanic or designate and the vehicle must be tagged out of service until repair is complete.
- Operators/Carriers are responsible for following all relevant environmental regulations and policies that are in force at the mine site, including (but not limited to):
    - **a)** No Littering (i.e., must dispose of garbage at designated receptacles in each camp),
    - **b)** No Harassment of, feeding, or intentionally attracting wildlife,
    - **c)** Immediate response and reporting of any size spill to Pretivm Environmental Dept.
    - **d)** Reporting any direct wildlife related incidents to Dispatch and Pretivm Environmental Dept.

When parking light vehicles/Freight trucks the operator shall:

- Park in designated areas whenever possible. Leave keys in ignition, in case of an emergency.
- Spotter must be used when visibility is impaired in anyway.
- Park on level ground whenever possible with vehicle in a fundamentally stable position.
- Position 2-wheel chocks appropriately for the situation
- Park in a manner that allows for forward departure (drive through or reverse park)
- If required to park on a slope, turn wheel in a direction that will prevent runaway and apply park brake. Position wheel chocks.
- In winter conditions, avoid using parking brake to prevent brake from freezing on.

Hours for Road Travel

Effective September 18th, 2021 any traffic destined for Knipple or Brucejack will **NOT BE** allowed past the Wildfire Security screening area after 16:30 hrs. The Wildfire gate will be closed at 18:00. to all traffic, so it is recommended that those that cannot make the cut-off hours should stay at Meziadin Junction until the following morning. Summer hours are normally 06:30 to 19:30 for all traffic.

*****NOTE: Please check with Wildfire Camp or Wildfire Security for up-to-date times as things will change dependent of the hours of daylight and needs of the project. *****

Passing Mobile, Stationary Equipment, and Pedestrians

- Operators must establish radio or visual communication when approaching mobile, stationary equipment, and/or pedestrians working on or in proximity to the roadway. If radio communication cannot be established, ensure eye contact with the operator and a clear gesture to proceed.
- Do not proceed until the operator of the equipment has acknowledged your intent to pass and wheels, booms, lifts etc. have come to a complete stop.
- Never assume all members of the work crew are aware of your intent to pass. Proceed slowly and watch closely for workers approaching the roadway. If unsure of workers' intentions, Do Not Proceed.
- Proceed at 10 km/hr. through parking areas and watch for pedestrians.

Procedure for calling Kilometers's

Km	Road Channel	To Reach Brucejack Dispatch	Must Calls
0 - 37	Ch. 1/Pretium RoadChannel	Ch. 6/Repeater 3	- Call every Km - Km 2 to Km 3 - Anyone coming down & vice versa
55 - 60	Ch. 1/Pretium RoadChannel	Ch. 4/Repeater 2	- Must Call every Km - At Km 55 up - Is there anyone coming down from Knipple Camp - Leaving Knipple Camp going down is there anyone coming up from 55

RADIO FREQUENCIES

Brucejack Radio Frequencies				
	Name	RX Frequency	TX Frequency	Tone
Ch 1	New Road (NEW)	166.080	166.080	
Ch 2	Repeater 1 (Brucejack)	162.735	167.715	71.9
Ch 4	Repeater 2 (Bowser)	162.810	167.790	123.0
Ch 6	Repeater 3 (Wildfire)	162.105	167.085	156.7
Ch 9	Lad 2	158.940	158.940	

SOP References

BJ-ACC-SOP-004 - Heavy Vehicle Towing Assist

Appendix A

Recommended Vehicle Survival Kit should include the following:

- *Food that won't spoil, such as energy bars*
- *Blanket*
- *Extra clothing and shoes or boots*
- *First aid kit with seatbelt cutter*
- *Small shovel, scraper, and snowbrush*
- *Water – plastic bottles that won't break if the water freezes (replace them every six months)*
- *Candle in a deep can and matches*
- *Wind-up flashlight*
- *Whistle – in case you need to attract attention*
- *Roadmaps*

Road Hazard Rating

LOW	MODERATE	CONSIDERABLE

1. Receive orientation at Wildfire.
2. Check in at one of the camps or with Dispatch to obtain updated road status.
3. Use Pretium radio protocol for check-in/check-out for road transit
4. Ensure sufficient fuel before proceeding
5. Adjust speeds on glacier according to road status and conditions

Hazard level	Pickup	Heavy Traffic
LOW	40 km/hr.	40 km/hr. UP
MODERATE	25-35 km/hr.	20 km/hr.
HIGH	20-25 km/hr.	10-15 km/hr.

6. If there is a mechanical breakdown, or crevasse fall, call Dispatch. Turn the engine off, wait for help.
7. Check in at all posted MUST CALL signs
8. Call road crews on radio BEFORE attempting to pass heavy equipment (remain in vehicle)
10. Report any large holes or open crevasses to Dispatch (remain in vehicle)

HIGH

ROAD IS CLOSED ALL TRAFFIC IS PROHIBITED

Figure 1—V-Bar chain recommended

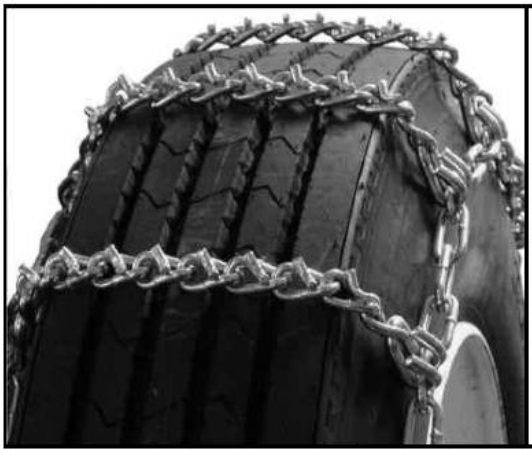

Figure 2—Triples recommended on drive wheels

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Access Road Superintendent/ Designate	Frank Forsythe	[redacted]	
JOHSC Co-chair or Member	Regan Kern		
Health & Safety Manager/ Designate	Michael Daley		
Departmental Manager	John Sheehan		
General Manager / Designate	Mike Gagnon		

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Formatting and updates	Travis Beebe	Throughout	03/02/22

SOP Review Sign Off	PRETIVM
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Completed copy to be forwarded to the Safety/Training Department

Appendix 9-1-15. Vegetation Management Plan

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Vegetation Management Plan

February 2023

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Vegetation Management Plan

Date: February 2023

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VERSION CONTROL

Revision #	Date Released	Amendment
1	May 2015	Original
1a	December 2018	Version control table updates and cover page added
2	February 2023	Document format updated to NCM Brucejack template.

ACKNOWLEDGEMENTS

This Vegetation Management Plan was prepared by ERM for Pretium Resources Inc. The report was written by Natasha Bush, B.Sc., P.Ag. The report was reviewed Ben Andrew, B.Sc., R.P.F., and Rolf Schmitt, M.Sc., P.Geo. Report was updated in December 2022 by Vaughan Blackman M.Sc., and reviewed by Torence Sandhals M.Sc., P.Ag.

BRUCEJACK MINE

Vegetation Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

CIS LRMP	Cassiar Iskut-Stikine Land and Resource Management Plan
m	Metre(s)
Pretium	Pretium Resources Inc.
Project	Brucejack Mine
SARA	*Species at Risk Act* (2002)
VMP	Vegetation Management Plan

1 PURPOSE

The Vegetation Management Plan (VMP) is designed to provide environmentally responsible, realistic, and operationally feasible guidance for ecosystem, soils, and vegetation management. The purpose of this VMP includes the following:

- avoid and minimize adverse effects to ecosystem functions;
- maintain plant and lichen biodiversity through avoidance and application of mitigation strategies; and
- monitor potential effects on wetland extent and function.

The measures provided in the following sections are based on the guiding principles outlined in the *Cassiar Iskut-Stikine Land and Resource Management Plan* (CIS LRMP; BC ILMB 2000) and the *Nass South Sustainable Resource Management Plan* (BC MFLNRO 2012).

2 PERFORMANCE OBJECTIVES

The VMP focuses on ecosystem-based management, which includes consideration of successional processes, such as disturbance type (e.g., fire, insects, avalanches), dispersal mechanisms (e.g., wind, water, animals), site history (e.g., flooding, erosion, fire), site competition (e.g., light, moisture), and germination conditions (e.g., site and climatic conditions). The broad performance objectives of the VMP are to:

- minimize soil loss and degradation (i.e., compaction, erosion, admixing) by adhering to the Surface Erosion Prevention and Sediment Control Management Plan;
- avoid the introduction and spread of invasive plants by adhering to the Invasive Plants Management Plan;
- minimize effects on rare plant and lichen populations through implementation of the Invasive Plants Management Plan;
- avoid and minimize detrimental effects to rare plants, lichens, or their habitat by adhering to guidance provided in the VMP;
- avoid and/or minimize direct harm to rare plant and lichen populations through alignment of footprint boundaries;
- avoid and minimize detrimental effects to wetland functions by adhering to guidance provided in the VMP;
- avoid and minimize loss of ecosystem functions related to Brucejack Mine (the Project) effects specifically due to clearing activities, dust deposition, fragmentation, edge effects, windthrow, and altered hydrology;
- minimize effects on rare plant and lichen populations through implementation of the Invasive Plants Management Plan; and
- identify and monitor effects to wetland extent and hydrological function along the Brucejack Access Road.

3 SCOPE

This plan provides measures for the ongoing management and monitoring of terrestrial and wetland ecosystems, and rare plants and lichens during the Construction, Operation, Closure, and Post-closure phases of the Project. The VMP applies to all Project components and activities that have the potential to result in effects to soils, ecosystems, and/or vegetation.

4 RELEVANT LEGISLATION, REGULATIONS, AND EAC CONDITIONS

4.1 RELEVANT LEGISLATION AND REGULATIONS

Legislation, guidelines, operational statements, and governing agencies applicable or of relevance to the management of vegetation, soils, and ecosystems are listed below. This section will be updated with any further relevant conditions cited in the Environmental Assessment Certificate or the *Mines Act* Permit.

- *Forest and Range Practices Act* (2002a), Forest Planning and Practices Regulation (BC Reg. 14/2004) Section 47-52. This act and regulation applies constraints to when, where, and how forest clearing is undertaken (for forest and range licensees) and applies protection to old forests (through establishment of old-growth management areas) and to riparian ecosystems (through Division 3, Riparian Areas, of the Forest Planning and Practices Regulation). The riparian reserve and management zones are consistent with those previously established under the *Forest Practices Code of British Columbia Act* (1996a; e.g., Riparian Management Area Guidebook).
- *Fisheries Act* (1985). This federal act protects fish and fish habitat across Canada; Subsection 35(1) prohibits "the release of a deleterious substance that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery."
- British Columbia (BC) *Mines Act* (1996). This act provides guidance on the operation and reclamation of existing and abandoned mines.
- *Weed Control Act* (1996c). This act regulates the management of noxious plants in BC. The *Weed Control Act* (1996c) requires all land occupiers to avoid establishment and dispersal of noxious weeds as defined by the Act.
- *Species at Risk Act* (SARA; 2002b). Federal legislation that aims to protect species at risk from becoming extinct. Certain species are also protected under SARA as part of wildlife habitat and in accordance with the Canadian Biodiversity Strategy. The Canadian Biodiversity Strategy provides federal legislation that supports the conservation of particular species and populations to ensure continuance of biological diversity over time (Federal-Provincial-Territorial Biodiversity Working Group 1995).
- The BC *Wildlife Act* (1996d) provides for conservation of specific ecosystems and ecosystem components as they provide habitat for species managed by the BC Ministry of Environment.

4.2 GUIDELINES AND PRACTICES

- CIS LRMP (BC ILMB 2000). Provides direction and management of endangered plants.
- BC Conservation Data Centre (BC MOE 2007). This provincial agency, part of the Environmental Protection and Sustainability Division in the BC Ministry of Environment, collects and disseminates information on the plants, animals, and ecosystems at risk in BC.
- *Windthrow Handbook for British Columbia Forests* (Stathers, Rollerson, and Mitchell 1994). This handbook provides guidance on windthrow management.
- *The Federal Policy on Wetland Conservation* (Environment Canada 1991). *The Federal Policy on Wetland Conservation* provides practical direction, support, and tools for environmental management of wetlands:

  > *The Federal Policy on Wetland Conservation complements the goals and objectives of the North American Waterfowl Management Plan, the Federal Water Policy, the Fisheries and Oceans Canada Policy for the Management of Fish, the International Ramsar Convention, the Wildlife Habitat Canada "Common Ground" Initiative, and the Wildlife Policy for Canada adopted by the Wildlife Ministers Council of Canada* (Environment Canada 1991).

- *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO 2014). This document provides guidance for riparian management in order to avoid and minimize effects to fish and fish habitat.
- *Towards an Environmental Mitigation and Offsetting Policy for British Columbia: A Discussion Paper* (BC MOE 2010). Provides a framework to consider when setting mitigation strategies for rare organisms and habitats.

4.3 RELEVANT EAC CONDITIONS

Pretium was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions. This management plan fulfills Condition #2, in relation to a Component Plan for vegetation management, presented within Schedule B of the Certificate and copied below.

> <u>Condition 2</u>
>
> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*

- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the Nisga'a Lisims Government (NLG), Tahltan and Tsetsaut / Skii km Lax Ha Nation (TSKLH) on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

An ecosystem-based approach to vegetation and soil management will be used to effectively avoid and minimize loss of ecosystem functions related to potential Project-related effects. Ecosystems are complex interactions of abiotic and biotic components that result in unique species composition, structure, and function. Minimizing effects to these ecological processes will reduce the likelihood of short- and long-term effects to terrestrial ecosystem functions and integrity.

Protection and management direction for rare plants and lichens is required for each species occurrence and must be specific to the requirements of that species. Often rare plant and lichen populations occur in clusters in unique habitats. Because these habitats are uncommon (e.g., cliffs, scree, seepages), protecting habitats where rare plants have been identified will often provide protection to other rare species not identified during surveys and is a good tool to reduce potential adverse Project effects on biodiversity.

5.1 MITIGATION MEASURES AND BEST MANAGEMENT PRACTICES

The effects of the Project on terrestrial ecosystem functions and integrity will be minimized through the actions listed below:

- minimize clearing dimensions during Construction (i.e., along the Brucejack Transmission Line and during upgrades to the Brucejack Access Road);
- coordinate clearing activities with other management and monitoring plans including the Air Quality Management Plan, the Aquatic Effects Monitoring Plan, the Wildlife Management Plan, and the Water Management Plan;
- minimize soil degradation (i.e., erosion) by adhering to the Surface Erosion Prevention and Sediment Control Management Plan and the Reclamation Plan. Specifically, soil will be salvaged during appropriate weather conditions to the extent feasible, transported to stockpiles in a timely manner, and erosion control measures will be implemented to minimize erosion;
- avoid, where feasible, removal of mature and old forests, which provide diverse ecological functions;
- minimize potential adverse environmental effects on alpine, parkland, and riparian habitats; wetlands/wetland complexes; and lake outlets;
- manage riparian areas according to the recommended management zone setbacks and work practices provided in the *Mines Act* (1996b) and *Forest and Range Practices Act* (2002a);
- limit changes to soil hydrology to the extent feasible through best management practices during Construction and Operations. For example, minimize redirection of surface and subsurface flows as much as feasible. Surface runoff will be redirected from hard surfaces (such as roads) to existing drainages (as much as feasible);
- restrict vehicles and machinery travel to designated road or exploration trail surfaces;

- avoid and/or reduce windthrow according to best management practices through retaining windfirm trees, feathering edges, topping/pruning of individual trees, and monitoring for windthrow along clearings and road edges in accordance with the guidance outlined in the *Windthrow Handbook for British Columbia Forests* (Stathers, Rollerson, and Mitchell 1994);
- adopt low-disturbance methods to clear vegetation within identified sensitive areas, such as alpine, parkland, and rare ecosystems and riparian areas, where clearing cannot be avoided;
- carry out dust suppression measures on roads to minimize fugitive dust;
- re-vegetate with native plant species and seeds;
- establish reporting procedures between general site personnel and environmental personnel to facilitate timely reporting of any incident or concern during each phase of the Project. Construction personnel will be instructed to communicate any concerns including erosion and sediment production, windthrow, invasive plants, and unauthorized access to restricted areas; and
- provide appropriate education and training for site personnel as appropriate, outlining how to minimize effects on ecosystems, soils, and vegetation, and why it matters.

Rare plants were assessed at the Project design stage. Impacts to rare plant and lichen populations will be further minimized through the following actions:

- optimizing alternatives to avoid rare plant and lichen populations, where feasible;
- applying adaptive Project design changes that avoid harm to rare plant and lichen populations, where feasible; and
- adherence to best management practices (described below).

The following best management practices will be applied to vegetation-clearing activities as appropriate to help avoid and reduce impacts to rare plants and lichens and their habitats:

- the known location of rare plants and lichens and their habitats will be considered in relation to planned Project activities;
- avoid use of herbicide sprays within 200 metres (m) of rare plant and lichen populations and limit such use to direct application rather than broadcast sprays;
- create no-work-zones (200 m) around known rare plant and lichen habitats, wherever feasible, to avoid direct disturbance and to minimize effects related to fugitive dust transport, weed invasion, vehicular activities, and accidental chemical spills;
- where avoidance is not feasible and development is required within a no-work-area around plant populations, erect temporary fencing or other barriers around the nearby rare plant and lichen populations to avoid further disturbance to the site;
- reduce the impact of fugitive dust on rare plant and lichen populations through adherence to established no-work-zones and dust control measures. Pre-existing roads where traffic is expected to increase will be managed for dust during the growing period (June through August). Water will be used for dust abatement with minimal use of chemicals; and
- minimize alteration and disturbance of light, temperature, surface, and subsurface hydrology that may affect rare plant or lichen populations.

6 ENVIRONMENTAL MONITORING

The purpose of the monitoring program is to evaluate and document if the VMP successfully achieves its performance objectives of avoiding and minimizing Project-related adverse effects to ecosystem extent and function and to rare plants and lichens. Monitoring will determine if performance objectives are being met and provide information to adapt management if objectives are not being met.

6.1 PERFORMANCE MONITORING

Monitoring will include consideration of successional processes, such as disturbance type, site history, site competition, and germination conditions. Consideration of successional processes will help distinguish natural effects from Project-related effects.

Site Environmental Monitors will assess the following:

- Clearing during Construction activities is being minimized.
- Success of re-vegetation efforts (appropriate timing and seed mix, percentage cover of live vegetation, presence of invasive plants, etc.).
- Assessment of the effectiveness of windthrow reduction measures, including number and species of wind-thrown trees and approximate area affected, and identify changes to windthrow mitigation measures if required.
- No rare plants have been found within the planned disturbance. If changes to the location of infrastructure result in intrusion into areas where rare plant communities were detected in the 2012 or 2013 field studies then monitoring will occur during the growing season (June through September). Monitoring will be performed by a qualified rare plant and lichen botanist, under the direction of the Project's Environmental Manager who will ultimately be responsible for the development, implementation, and monitoring of the VMP.
- Monitoring of wetlands to determine changes in extent and/or function. Monitoring will include measurements of surface and subsurface hydrology, wetland extent, and habitat function as described below.
    - Monitoring of subsurface water levels will be accomplished using push-in PVC standpipes and a combination of manual water-level measurements and water-level data loggers. At the three monitoring sites where the wetland is intersected by the Brucejack Access Road (BJ08, BJ12, WO62), standpipes will be placed on both sides of the road to determine the potential influence it may have on subsurface flow within the wetlands. Standpipes elevations will be surveyed on an annual basis in relation to local road survey control.
    - Monitoring of wetland extent will be achieved through a combination of field investigations as well as wetland mapping for the Construction, Operation, and Closure phases.

- General wildlife observations will be made during each environmental monitoring trip and incidentally by the environmental crew while conducting other management and/or monitoring duties in the area of the monitored wetlands.

6.2 WORK PLANNING AND SCHEDULE

Monitoring frequency will vary depending on the Project activity as well as the outcomes of previous year's monitoring (Table 6.2-1). The results of the site visits and mapping will determine if follow-up monitoring in the same or subsequent year is required to confirm that the objectives are being achieved and to determine if future monitoring is required.

Table 6.2-1. Vegetation Monitoring Schedule

Type of Monitoring Activity	Measurable Parameter	Frequency	Timing	Duration/ Phase
Vegetation clearing	Clearing dimension size in relation to planned activity	Variable	Between June and October	Ongoing as required; all phases
Re-vegetation	• Re-vegetation timing and seed mix • Percentage cover of live vegetation • Presence of invasive plants • Erosion	Variable	Between June and September	Ongoing as required; all phases
Windthrow	• Number and species of wind-thrown trees • Approximate area affected	Variable	Between April and June	Construction and Operation
Wetland extent and function	• Subsurface hydrology measurements • Wetland extent survey and mapping • Wildlife observation	Monitoring twice annually, and mapping during each Project phase to track changes over time	Between June and September	Construction and Operation

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance Reporting

Compliance reporting will be subject to Environmental Assessment Certificate and *Mines Act* permit conditions. Annual *Mines Act* (1996b) reporting of environmental monitoring in the Annual Reclamation Report will include a description of the following, as applicable:

- records of rare plants and lichen or invasive plants, monitoring undertaken where activities occur adjacent to identified sites, and reclamation activities will be summarized and available to report, with that year's completed data forms to be made available upon agency request; this information will be used as a means of tracking progress and determining future management activities;
- planning and ecosystem management activities that illustrate coordination with other management plans such as the Surface Erosion Prevention and Sediment Control Management Plan, the Aquatic Effects Monitoring Plan, and the Wildlife Management Plan;
- measures employed to reduce impacts to terrestrial ecosystems that depend on hydrological connectivity and flow (e.g., restoration of natural drainage following decommissioning of temporary access roads);
- evaluation and rationale of whether the environmental protection measures were carried out according to the planned management for the site;
- evaluation of the effectiveness of the environmental protection measure employed in achieving the stated objective(s); and
- proposed revisions to the VMP to address emerging negative trends, or to adjust monitoring programs, if required.

The Project's Environmental Manager will be responsible for the implementation and monitoring of the VMP and for ensuring that the Performance Objectives are achieved and reported.

Should periods of temporary closure or care and maintenance occur, some monitoring will continue. The periodicity of reporting for the Closure and Post-closure phases will be determined prior to commencement of Closure.

7.2 RECORD KEEPING/TRACKING

7.2.1 Monitoring Results

Pretium will maintain records of vegetation monitoring and results. This information will be collected using monitoring forms suitable for the Project. Data will be entered in a format and program that will allow for comparison between years. Monitoring data will be stored for the life of mine. Monitoring will be performed by a suitably qualified Environmental Monitor, under the direction of the Project's Environmental Manager, who will ultimately be responsible for the development, implementation, and monitoring.

7.2.2 Continuous Improvement, Follow-up, and Adaptive Management

Results from the vegetation monitoring programs will be reviewed to determine if any trends are evident and if objectives are being met. The need for any corrective actions to reduce negative effects to soils, vegetation, or ecosystems will be determined on a case-by-case basis. Indications of the need for corrective action or additional control measures may include monitoring data showing an increasing negative trend (e.g., considerable changes to wetland extent or function, sedimentation in fish bearing streams).

The monitoring data will also be used to provide feedback to modify any management and monitoring procedures incorporated at the site, as required. Measures described in the VMP apply to all Project components for the life of the Project, unless otherwise indicated. Components of the VMP may need to be revised over the life of the Project, based on regulatory changes and/or technological advances.

8 REFERENCES

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Appendix 9-1-16. Waste Management Plan

BRUCEJACK GOLD MINE

Waste Management Plan

December 2021

PRETIVM

BRUCEJACK GOLD MINE

Waste Management Plan

Date: December 2021

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VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
1	September 22, 2015	Leilah Tate	BC MOE Submission
2	December 30, 2016	Max Holtby	BC MOE Submission
3	December 2018	Pretium Resources Inc.	Updated content, version control table updated and cover page added
4	December 2021	Pretium Resources Inc.	Updated regulations, Section 5.2.4 and updated SOP list

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This second edition was updated by Leilah Tate (Sage Resource Consultants Ltd.) and reviewed by Pretivm Environmental Staff. The third edition has been updated and reviewed by Pretium Resources Inc.

BRUCEJACK GOLD MINE
Waste Management Plan

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GLOSSARY AND ABBREVIATIONS

BC	British Columbia
BC EMLI	British Columbia Ministry of Energy, Mines and Low Carbon Innovation
BMP	Best management practice
Code	Health, Safety and Reclamation Code for Mines in British Columbia (BC MEMPR 2021)
EAC	Environmental Assessment Certificate
EMA	*Environmental Management Act* (2003)
MPERG	Mining and Petroleum Environmental Research Group
PPE	Personal protective equipment
Pretivm	Pretium Resources Inc.
SOP	Standard Operating Procedure
WHMIS	Workplace Hazardous Materials Information System
WMP	Waste Management Plan

1 PURPOSE

The purpose of the Waste Management Plan (WMP) is to provide guidance for the proper handling, transport, and disposal of non-hazardous domestic and industrial solid waste and domestic sewage sludge generated from the Brucejack Gold Mine.

2 PERFORMANCE OBJECTIVES

The objectives of the WMP are to:

- provide practical measures for the handling and disposal of non-hazardous industrial and domestic solid waste and domestic sewage sludge to minimize any potential adverse effects to the environment, wildlife, or employees;
- identify appropriate best management practices (BMPs) for waste treatments, storage, and handling to deter wildlife and prevent wildlife attractants;
- identify site personnel orientation components; and
- identify responsibility for implementation and monitoring of this plan.

3 SCOPE

Under the British Columbia (BC) *Environmental Management Act* (EMA; 2003), "waste" includes air contaminants, litter, effluent, refuse, biomedical waste, hazardous waste, and any other substance prescribed by government enactment. This WMP addresses domestic and industrial materials generally considered kitchen and general camp refuse, as well as domestic sewage sludge and incinerator ash. Some litter/waste has commercial value when recycled or reused; recyclable materials are also identified in this WMP.

This plan does not address the management and storage of hazardous materials, transportation of dangerous goods, or chemical storage and handling; these are covered in the Chemicals and Materials Storage and Handling Plan. Nor does the WMP consider the management of mining waste generated from ore extraction and mineral processing; this is addressed in the Tailings and Waste Rock Subaqueous Deposition Management Plan.

The WMP applies to all aspects and facilities associated with the Brucejack Gold Mine, including the Brucejack Mine Site, Brucejack Access Road, Knipple Transfer Area, Bowser Aerodrome, Brucejack Transmission Line, and Wildfire camp. The plan is applicable to all phases of mine development, including Construction, Operations, and Closure, and is relevant to any employees and contractors handling, using, or transporting waste.

4 RELEVANT LEGISLATION, REGULATIONS, AND EAC CONDITIONS

4.1 RELEVANT LEGISLATION AND REGULATIONS

The management of waste in BC is regulated mainly under the EMA and its regulations (e.g., Hazardous Waste Regulation [BC Reg. 64/2021], Waste Discharge Regulation [BC Reg. 154/2019], Open Burning Smoke Control Regulation [BC Reg. 11/2021]). The EMA governs solid, liquid, and air waste discharges to the environment. Non-hazardous waste management conditions specified in the Environmental Assessment Certificate, *Mines Act* or *Environmental Management Act* Permits are, and will continue to be, incorporated into this plan as relevant.

For waste generation, handling, and disposal at mine sites, the *Health, Safety and Reclamation Code for Mines in British Columbia* (the Code; BC MEMPR 2021) applies as well. The Code specifies waste management requirements in the sections below:

- Section 6.30.1 addresses flammable waste and scrap from underground workings; all waste, including waste timber shall be removed from an underground mine on a regular basis and shall not be piled up nor permitted to decay in the mine; and
- Section 10.1.3 (3)(g) requires that the Mine Plan contain designs for material handling and waste disposal.

In addition, other federal and provincial regulations, guidelines, and statutes influence the handling, transport, and disposal of waste from the mine, through pollution prevention and environmental protection measures or hazardous waste management. Selected examples are summarized in Table 4.1-1.

Table 4.1-1. Regulatory Requirements – Selected Examples

Legislation and Regulations	Applicable Information
EMA (2003)	Prohibits the introduction of waste into the environment in a way that will cause pollution, except in accordance with a regulation, permit, approval, or code of practice issued under the Act
Hazardous Waste Regulation (BC Reg. 64/2021)	Addresses the proper handling and disposal of hazardous wastes, under the EMA
Waste Discharge Regulation (BC Reg. 154/2019)	"Prescribes" which industries and trades are regulated under the EMA
Open Burning Smoke Control Regulation (BC Reg. 11/2021)	Addresses open burning for vegetative matter waste disposal and lists prohibited materials to protect air quality
BC *Public Health Act* (2008)	Provides direction on the management of health hazards
BC *Forest and Range Practices Act* (2002)	Provides direction on the management of forest insects, disease, animals, or abiotic factors causing damage to a forest

(continued)

Table 4.1-1. Regulatory Requirements — Selected Examples (continued)

Legislation and Regulations	Applicable Information
Canada *Hazardous Products Act* (1985a)	Provides direction on the sale, importation, and advertising of hazardous products
Canada *Fisheries Act* (1985b)	Prohibits the release of a deleterious substance to fish habitat
BC *Mines Act* (1996a)	Provides guidance on the operations and reclamation of existing and abandoned mines
BC *Water Act* (1996b)	Provides guidance on wells and groundwater protection
The Code (BC EMLI 2021)	Provides direction regarding the protection of worker health and safety at mines and exploration sites
BC *Wildlife Act* (1996c)	Provides guidance on the disposal of animal remains
Canadian Environmental Protection Act, 1999 (1999)	Provides guidance on the preparation of pollution prevention plans
Controlled Products Regulation (SOR/88-66)	Defines regulations respecting controlled products, including provision of Material Safety Data Sheets
Transportation of Dangerous Goods Act (1992), Transportation of Dangerous Goods Regulations (SOR/2001-286)	Includes a substance classification system and specifies requirements for transportation of dangerous goods

4.2 Relevant Environmental Assessment Certificate Conditions

Pretivm was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015, that included a series of conditions. This management plan fulfills Condition #2, in relation to a Component Plan for waste management, presented within Schedule B of the Certificate and copied below.

<u>Condition 2</u>

> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
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> - *Purpose of Component Plan;*
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> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

5.1 APPROACH

The approach to the management of non-hazardous domestic and industrial solid waste and domestic sewage sludge at the mine is to practice effective and environmentally sound waste handling and disposal that will result in avoidance of wildlife interactions (e.g., creating wildlife attractants) and minimize potential environmental problems. The Brucejack Mine Site is compact and the storage capacity for waste materials intended for off-site disposal is extremely limited. The off-site shipping of bulky, non-hazardous combustible waste materials is generally cost prohibitive due to the remoteness of the site, although it will be necessary for solid wastes which are non-combustible and select recyclables. Accordingly, the WMP balances the need to minimize storage and handling of waste through burning and incineration of as much non-hazardous waste as possible, minimizing waste generation through inventory management, and reducing, reusing, and recycling materials to the extent possible.

All wastes referred to in this plan are pre-assessed against hazardous waste criteria under the *Hazardous Waste Regulation* (BC Reg. 64/2021) to properly characterize waste prior to storage and disposal.

Some waste products have a residual value as recyclable or alternate use materials which are typically processed through salvage recycling companies. These materials can be diverted from disposal through proper handling and sorting, and typically are either a salvageable commodity (e.g., used copper wire), recyclable material (e.g., beverage containers), or reusable materials (e.g., bulk chemical containers, electronics).

This plan is solely concerned with non-hazardous refuse, some of which is recyclable. Pretium's environmental staff work with warehousing and the service crew to assess the typical/ expected waste that will be generated on site, and identify feasible recyclables to ensure appropriate handing, temporary storage, and disposal procedures are followed. This is primarily based upon the combustibility and composition of a waste item and list of acceptable items for incineration or open burning.

To summarize, waste management practices at the mine include:

- incineration of non-hazardous combustibles (specific practices are discussed in the Air Quality Management Plan);
- open pit burning;
- efficient off-site transportation and disposal;
- reducing, reusing, and recycling (3 Rs) as feasible; and
- properly trained waste management technicians and incinerator operators.

5.1.1 *Types of Waste Generated*

This plan covers non-hazardous domestic and industrial waste generated throughout the life of the mine. The types of waste that are typically generated during mine Construction, Operations, Closure, and Post-closure are listed in Table 5.1-1 along with the disposal method. This list may evolve as the mine advances through the phases. If additional wastes are generated that are not considered here, Pretivm will identify appropriate disposal method(s). Anticipated quantities of materials to be incinerated are discussed in Section 5.2.4 On-site Waste Disposal.

Table 5.1-1. Waste Types and Disposal Method at the Brucejack Gold Mine

	Mine Phase				Disposal				
Waste Type	C	O	Cl	PC	On-site Incineration	Burn Pit	On-site Disposal	Off-site Facility[a]	Off-site Recycling
Aluminum cans	X	X	X	X					X
General refuse from camp (i.e., spent toiletries)	X	X	X	X	X				
Paper and cardboard	X	X	X	X	X				
Putrescible food waste, packaging, and plastics[b]	X	X	X	X	X				
Aerosol containers	X	X						X	
Used air filters	X	X	X		X				
Used oil filters	X	X	X						X
Oily rags (<3% oil by weight)[c]	X	X	X		X				
Used, empty plastic containers for bulk WTP chemicals[d]		X	X		X				X
Batteries	X	X	X						X
Wood – pallets, lumber	X	X	X		X	X			X
Concrete	X	X	X				X		
Conveyor belts (rubber/steel)		X	X		X			X	
Metal culverts	X	X	X					X	
First Aid waste (bandages, etc.)	X	X	X	X	X				
Fluorescent light ballasts	X	X	X					X	
Hose (air, water, hydraulic)	X	X	X		X				
Incinerator ash	X	X	X				X		
Plastic packaging	X	X	X	X	X				

(continued)

Table 5.1-1. Waste Types and Disposal Fate at the Brucejack Gold Mine (continued)

Waste Type	Mine Phase				Disposal				
	C	O	Cl	PC	On-site Incineration	Burn Pit	On-site Disposal	Off-site Facility	Off-site Recyclable
Plastic pipe	X	X	X		X				
Scrap metal (rebar, steel balls, vehicles, old parts)	X	X	X					X	X
Sewage sludge	X	X	X	X	X			X	
Tires	X	X	X		X			X	
Transformers	X	X	X					X	
Vent bags		X	X		X				
Wiring	X	X	X					X	X
Waste oil	X	X	X	X	X				
Insulation/fibreglass	X	X	X					X	
Mattresses	X	X	X	X				X	
Styrofoam	X	X	X	X	X				
Broken Appliances	X	X	X	X					X
Electronics	X	X	X	X					X

Notes:
C = Construction, O = Operations, Cl = Closure, PC = Post-closure.
[a] *Such as a landfill or other licenced facility.*
[b] *Polyvinylchloride (PVC) plastic will not be incinerated and will be landfilled. Combustion of plastics will be minimized through waste reduction and recycling programs where feasible.*
[c] *Oil contaminated rags containing less than 3% of oil by weight are permitted to be incinerated provided they do not exceed 0.2% of the total waste incinerated per year.*
[d] *Empty totes will be sent offsite for recycling or returned to supplier, spent chemical reagent bags will be incinerated or disposed of offsite depending on the type of chemical reagent and all other plastic chemical containers will be incinerated.*

Residual paint from latex-based paints is dried before disposal in a landfill. The cans from oil-based paints are properly sealed and stored in the waste handling facility before being shipped offsite. Biohazard containers are stationed at the first aid area, under the supervision of the first aid staff, to store bio waste (e.g., blood- and tissue-contaminated materials). Air filters are collected in bins in the mechanic shops before being disposed of in off-site landfills.

The following waste requires special consideration and are not to be burned / incinerated:

- hydrocarbon-contaminated soil;
- radioactive waste including smoke detectors;
- organic compounds containing chlorine including plastics, solvents and polyvinyl chloride piping;
- herbicides/pesticides (if used); items containing mercury, lead, or other heavy metals including paint, computer equipment, and fluorescent bulbs;

- batteries;
- explosives;
- pressurized cans, cylinders, or other containers that may explode when heated;
- synthetic fiber textiles;
- wood treated with pentachlorophenol, inorganic preservatives, lead paint or polychlorinated biphenyls-amended paint; and
- construction and demolition waste including roofing materials, electrical wire, and insulation.

5.2 MITIGATION MEASURES AND BEST MANAGEMENT PRACTICES

5.2.1 Waste Reduction

Reducing the amount of material that is consumed is an effective way of reducing the amount of waste that is generated and supports operations within a compact mine site footprint. Materials consumption are assessed by evaluating opportunities for possible reductions in material usage and generated waste volumes. Examples of waste reduction which may be applicable to the mine include:

- product review, selection, and substitution, e.g., recyclable/reusable and non-hazardous materials will be used instead of non-recyclable/non-reusable and hazardous materials;
- ordering chemicals or lubricants in bulk/returnable containers;
- keeping a workable minimum inventory to prevent expiration of products and resulting generation of waste;
- decreasing the amount of solid waste by reducing the use of disposable items (e.g., use of pump bottles in place of aerosol cans, where possible);
- requesting that suppliers provide less packaging materials on over-packaged products;
- preferential use of voice message devices, telephone, email, or verbal messaging; and
- printing and photocopying on both sides of paper.

5.2.2 Reuse and Recycling

A recycling program are incorporated for the mine to the extent possible given the remoteness of the site. Materials brought to the mine siteare used to the maximum extent feasible, and where applicable, reused on the site. Examples of potentially reusable materials include:

- scrap metal, conveyor belts, and lumber;
- chemical containers that can be returned to the supplier to be refilled; and
- waste oils, glycols, and solvents that can be reused for secondary applications (e.g., fueling the incinerator or waste oil burner for heat generation).

Used/waste oil generated during each Mine phase is collected and stored within specialized "Lube Pro" containers equipped with secondary containment. These units can be transferred safely to the incinerator or mechanic shop where an oil burner is located, for appropriate disposal. Recyclable materials which are not suitable for combustion are shipped off site to the nearest recycling facility. Examples of these products include:

- lead-acid and alkaline batteries;
- e-waste (e.g., computers, printers, scanners, etc.);
- ink cartridges;
- plastic petroleum pails;
- used/damaged vehicle/equipment parts;
- oil-based paints;
- empty drums; and
- beverage containers that are recyclable for cash.

Appropriate containers for storing the various waste types (e.g., batteries, ink cartridges, spent aerosols, e-waste, paper, appropriate plastics, etc.) are placed at relevant locations (e.g., within buildings) around the mine site. These materials are transported and staged at the waste handling facility before being shipped offsite to a suitable recycling facility. Combustible, non-reusable, and non-recyclable materials such as food-soiled packaging and non-reusable wood products are incinerated. The use of personal hot beverage containers and water bottles is prompted in an attempt to minimize the amount of disposable coffee cups and plastic water bottles used on-site.

5.2.3 Recovery

Recovery is the final level of waste minimization and involves extracting usable material or energy as a by-product for other uses. Opportunities for recovery are evaluated.

5.2.4 On-site Incineration (Burn Pits and Incinerators)

For the management of combustible wastes generated by the mine, Pretivm utilizes a combination of burn pits and two incinerators; one located at the Brucejack Mine Site and the other at Knipple Transfer Area. This is an effective and practical mode of waste disposal for combustible non-hazardous wastes which produce an ash by-product. The Brucejack Mine Site incinerator is an EcoWaste Solutions (EWS) ECO M2TN incinerator. The Knipple Transfer Area is equipped with a EWS CA100. The technology used by the CA100 is similar to that used by ECO M2TN, but with a smaller capacity. No sewage sludge will be incinerated in the EWS CA100.

The incinerators are used to dispose of all suitable combustible non-hazardous waste listed in Table 5.1-1 and in compliance with EMA air emissions permit conditions and BMPs. BMPS for the use of incineration and open pit burning are summarized below.

Incinerator feed includes potential wildlife attractants, such as food waste and food-related products and packaging. Kitchen, dining room, office, and accommodation waste, except for recyclable beverage containers, are incinerated in a timely manner to reduce the potential of attracting wildlife. Personnel are instructed and required to segregate wastes at the source, and monitoring will promote that materials are separated as close as possible to the source for designation as incinerator feed or off-site disposal/recycling. A maintenance program is in place for incinerator including regular vendor support.

Sewage sludge is generated from the Sewage Treatment Plant (STP) Filterboxx units (2 x C-75 units), consisting of a standard MBR wastewater treatment system. Sludge from the STP at the Brucejack Mine Site can also be incinerated. As per the Refuse Incinerator Management Plan, a prime rotary fan press is used to dewater the sewage sludge to a minimum of 25-30% solids content and a screw conveyor/feeder system is used to load 20 kg to 25 kg of the dewatered sewage sludge into reinforced combustible plastic bags. Each bag is sealed, then transported to the incinerator, weighed and loaded into the primary incinerator chamber at the appropriate time onto a layer of other solid camp waste. Each incinerator batch is comprised of no more than 20% dewatered sewage sludge. All of the solid waste materials are processed as a mixture.

Metal and glass remaining after incineration that was missed in pre-screening is separated from the incinerator ash for disposal, and the residual ash is then sent offsite to a certified landfill. By following the manufacturer's operating specifications for the incinerator, residual incinerator ash is inert and non-toxic. The incinerator operator has responsibility for efficient operation of the incinerator and a well-separated end-product.

Ash and residue from incineration and open burning is cooled and disposed of at the locations referenced in Waste Discharge Permit 107025. Ash is buried as soon as reasonably possible, weather permitting, to prevent it from becoming a wildlife attractant. Runoff will also be diverted away from any ash disposal site to prevent contact with the buried waste.

There are three active camps (Brucejack Mine Site, Knipple Transfer Area, and Wildfire). The Brucejack Mine Site Camp accommodates 650 people during Operations. Waste for the Knipple Transfer Area incinerator is mainly from Knipple Transfer Camp with less from Wildfire Camp. The maximum mass of refuse for incineration in the Knipple Transfer Area incinerator is 520 kg/day or 189,800 kg/year.

Pretivm's Waste Discharge permit covers the operation of both incinerators and Table 5.2-1 lists anticipated types and quantities of waste to be generated during Operations.

Table 5.2-1. Estimated Combustible Solid Waste Quantities for Incineration at Brucejack Mine Site Incinerator

Waste Category	Amount (kg/year)	Ash Content (% weight)
General domestic camp waste	400,000	5%
Waste food including associated packaging	120,000	15%

Waste Category	Amount (kg/year)	Ash Content (% weight)
Paper and cardboard boxes	60,000	6%
Wood/pallets	40,000	7%
HDPE pipes	680	1%
Air hose	200	1%
1-inch water hose	200	1%
Hydraulic hose	320	1%
1,200-mm vent bag	400	10%
Fuel filter	160	5%
Air filter	160	5%
Hydraulic oil return filter	60	5%
Brake hydraulic oil return filter	120	5%
AC filter	120	5%
Transmission oil filter	60	5%
Oil filters	160	5%
Oily rags	400	5%
Sewage sludge[a]	30,000	15%
Total[b]	**653,040**	

Notes:
This table is based on information provided to EWS. These estimates and calculated data were provided for reference and proposal purposes only. Use of this information has been granted permissions from EWS authorizing the specific use of this table in writing.
[a] *Sewage sludge is semi-solid.*
[b] *Maximum mass of refuse for Brucejack incinerator is 1800 kg/day or 657,000 kg/year.*

BMPs related to the effective operations of the incinerators are detailed in the Refuse Incinerator Management Plan, and include the following:

- train operators to be knowledgeable about critical steps in the incineration cycle, waste characterization, safety procedures, and equipment operations/maintenance;
- follow manufacturers' instructions for installation, maintenance, and operations;
- undertake routine inspections and scheduled maintenance;
- operate incinerator to design specifications to achieve complete combustion;
- discharge ash at least 1.2 m above the highest groundwater table and cover with a minimum of 0.2 m of soil;
- segregate waste prior to burning to ensure all recyclable and reusable waste is diverted and non-combustibles are removed;
- minimize storage duration of kitchen wastes to reduce wildlife attractant potential;
- keep waste as dry as possible;

- sort out high (e.g., oily rags), average (e.g., paper/cardboard) and low (e.g., wet food waste) heat value waste and mix wastes to achieve ideal burn composition, wherever feasible;
- mix wet food waste with dry waste to promote efficient burning;
- utilize appropriate personal protective equipment (PPE) for worker safety;
- segregate hazardous wastes and combustibles (e.g., aerosol cans) at source to prevent erroneous introduction into incinerator;
- safely handle and dispose of residues;
- track and record total amounts of waste incinerated, any problems, and overall performance and disposal method; and
- have fire suppression tools available in case of emergency.

Operations specifics are documented in the Refuse Incinerator Management Plan (Section 5.1 – Incinerator Operation) and the supporting operator manuals.

Burn pits for inert bulk materials (e.g., clean wood debris and large bulky packaging) are also be utilized. Waste Discharge Permit 107025 allows for a total of four burn pits at the Brucejack Mine Site (Upper Camp Creek, West Camp, West Zone and Km 72), and one each at Knipple Transfer Area, Bowser and Wildfire Camp. The locating of all burn pits took into consideration dominant wind direction in relation to accommodations. The following are the approved burn pit locations:

- burn pit at Brucejack Mine Site (Upper Camp Creek) – 56.4637N, 130.1859W;
- burn pit at Brucejack Mine Site (West Camp) – 56.4652N, 130.1902W;
- burn pit at Brucejack Mine Site (West Zone) – 56.4696N, 130.1941W;
- burn pit at Brucejack Mine Site (KM 72) – 56.4674N, 130.1631W;
- burn pit at Knipple Transfer Area – 56.4014N, 130.003W (438104.7 E, 6251184.4 N);
- burn pit at Bowser Laydown – 56.3924N, 129.9515W; and
- burn pit at Wildfire Camp – 56.5207N, 129.5131W.

Note that the burn pit at KM 72 is permitted to migrate within the NPAG quarry as required to avoid areas of active mining.

As per Waste Discharge Permit 107025 the source of waste for the burn pits may be dry, unpainted, untreated demolition and construction wood wastes; broken lumber and pallets; slabs; log ends and branches; brush; and miscellaneous, non-recyclable cardboard and paper products. However, waste will exclude nuisance-causing combustibles such as painted and treated wood, sawdust, mulch, wood chips, stumps, rubber, plastics, tars, insulations, etc. Cardboard packaging, and empty cardboard containers from explosives, may be burned. The paper sources may also include small quantities of office paper.

Open burning is managed as per the conditions outlined in Waste Discharge Permit 10702, the Brucejack Air Quality Management Plan and the Open Burning Smoke Control Regulation (BC Reg. 11/2021). BMPs related to open burning programs that will be practiced include the following:

- train operators to be knowledgeable about open burning practices, safety procedures and regulations;
- site burn pits at least 70 m from water bodies and ensure no habitations are downwind and that non-combustible surfaces are nearby (e.g., rock or quarry pits);
- monitor burn pits during aggressive burns for sparks and embers that may escape towards buildings or adjacent dry vegetation;
- segregate waste prior to burning to divert planned recyclable and/or reusable waste, and to remove non-combustibles (metal, aerosol cans, glass);
- conduct open burning for paper products, paperboard packing, untreated wood waste, and natural fiber textiles (e.g., cotton, wool) only;
- prohibit burning of kitchen waste in a burn pit;
- keep waste as dry as possible and do not burn during high winds;
- pile wastes so high temperatures can build and pre-heat unburned waste to minimize smoke production;
- mix wastes to achieve ideal burn composition;
- utilize appropriate PPE for worker safety;
- segregate hazardous wastes at the source so they are not burned;
- have fire suppression tools available in case of emergency;
- avoid low temperature, smoldering fires – mix as needed while using proper PPE; and
- avoid hot surfaces and utilize PPE to prevent burns and smoke inhalation.

5.2.5 Minimizing Wildlife Attractants

BMPs are used to minimize wildlife attractants and conflict. The overall goal of these practices is to minimize and avoid human/wildlife conflict. Practical steps will be followed that reduce the potential for wildlife to be attracted to and enter into conflict with people or camps. The BMPs also focus on steps to promote worker and wildlife safety to prevent negative outcomes for both groups as well as promote conservation of wildlife resources (Alberta Bear Smart 2014; MPERG 2008).

BMPs related to waste management and wildlife include the following:

- avoid creating wildlife attractant situations by storing odorous food supplies and wastes indoors or burn food and odorous waste immediately;
- store recyclable drink containers indoors;

- operate incinerator to obtain complete combustion of waste;
- fence waste storage areas as appropriate and surround incinerators with appropriate voltage electrified fencing to prevent animal intrusion;
- train applicable site employees in the proper handling and storage of wastes;
- utilize bear- and animal-proof containers as appropriate and schedule garbage pickups to avoid overnight storage of odorous wastes outdoors;
- conduct weekly visual inspections of waste facilities to help minimize possible bear/animal attractants;
- train personnel in bear awareness/safety training and rules for managing waste and minimizing attractants; and
- report wildlife sightings within camp to Environmental Department.

The incinerator and waste transfer facility at the Knipple Transfer Area is fenced with a chain linked electrified fence; the incinerator at the Brucejack Mine site will be fenced if it becomes necessary. The Wildfire Camp accommodations and kitchen are enclosed within electric bear fencing which is installed and uninstalled seasonally to allow effective snow removal during bear hibernation seasons.

5.2.6 Waste Handling Facilities

The Waste Handling Facilities function as temporary storage areas for waste until it is reused, disposed of on-site, or transferred to an off-site facility for recycling or disposal. The Waste Handling Facilities are designed to contain and prevent contamination of the environment. Where required, the Waste Handling Facilities are covered and fenced to prevent attraction of wildlife and to provide protection from weather. In general, the Waste Handling Facilities will consist of the following three parts:

1. **Reuse area**. Reuse areas will contain the items that can be reused on the site. Inert materials to be stored in this area include tires, scrap metals, and waste wood. These items will be placed in designated containers or areas within the reuse area of the waste collection area to allow personnel to search for materials to reuse. Once these containers or areas become full, the contents will be either disposed of in a designated on-site facility or removed from site as applicable to the waste.
2. **Hazardous waste area**. The hazardous waste areas will contain hazardous waste that is required to be shipped off site for appropriate disposal. Hazardous waste, including used glycol, acids, solvents, oil that are not used to fuel the incinerators, absorbent pads, hydraulic fluid, and any other hazardous chemicals, will be stored in a secondary containment area. Hazardous waste will not be permitted to accumulate to excessive volumes, but will be shipped off site to avoid crowding.
3. **Storage and Removal area**. This area will contain waste that will be sent to an off-site facility for disposal, as well as waste that is waiting incineration. Waste temporarily stored for removal will include domestic and industrial waste that is not hazardous or recyclable.

The Brucejack incinerator and is located at a distance from the other facilities to protect personnel from downwind emissions. Rather than transport all materials to this location a sorting facility will be established between the camp and quarry where materials suitable for off-site disposal can be transferred expeditiously. The Knipple Waste Handling Facility was constructed adjacent to the incinerator. The Wildfire Camp will have designated waste collection areas.

The segregated wastes in the waste collection areas are to be stored using accepted management practices including, but not limited to, the following:

- use of fire prevention systems adequately designed for the materials being stored;
- use of spill kits, protective equipment, and other necessary equipment to clean up and mitigate spills;
- only containers in good condition will be used to store items;
- containers and liner materials will be compatible with the waste being disposed;
- containers and drums will be labelled to identify the waste content and initial date of storage;
- containers will be stored on an elevated platform to detect leaks, if required;
- sufficient storage space between containers to allow for safe access and handling of containers; and
- incompatible wastes will not be stored in the same containers and will be stored at a safe distance from each other.

5.2.7 Transporting Waste

Certified transportation contractors are used for the transport of goods and materials to and from the site. Environmental Department staff will periodically inspect the transporters' performance and compliance with BC and federal transport regulations, contract requirements, and overall performance.

5.2.8 Off-site Disposal for Non-combustibles and Recyclable Waste

Non-combustible (and non-hazardous) solid wastes, which are suitable for recycling or must be disposed of in a permitted landfill, are trucked to the Kitimat-Stikine Regional District Meziadin landfill.

Waste for offsite disposal includes metal in the form of machine/mill parts, scrap or building supplies, aerosol containers, large quantities of conveyor belts or mixed rubber/steel products, metal culverts, light ballasts, fiberglass building insulation, large quantities of tires, transformers, wiring, and possibly solid concrete (if not possible to dispose of underground).

Some of the items above may be recyclable through salvage dealers in nearby communities. Additional recyclable waste will include drinking containers (aluminum, glass), wiring, batteries, and some forms of metal or plastic bulk containers for reagents.

5.2.9 Education and Training

The efficiency and overall effectiveness of on-site waste management practices is enhanced through proper education and training provided to all Pretivm employees and contractors working at the mine. Education is provided through site orientation/indoctrination of new employees and contractors, toolbox meetings, and Sunday safety presentations. The Pretivm Environmental Department, through education and monitoring, is working towards developing an environmentally conscious camp culture.

5.3 MINE PHASES

The mine includes activities at a number of sites across the various phases encompassing the Brucejack Mine Site, Brucejack Access Road, Knipple Transfer Area, Bowser Aerodrome, Brucejack Transmission Line, and Wildfire camp.

5.3.1 Construction Phase

The Construction phase took about 18 months. The existing sewage treatment plant located at the Brucejack Mine Site was expanded to accommodate the larger workforce during Construction. Bowser Camps, Knipple Transfer Camp and Wildfire Camp all have septic systems sized for the population in each camp.

The sludge from the Brucejack Mine Site sewage treatment system and the various septic systems was removed by a licensed company and hauled to the Regional District sewage lagoon at Meziadin.

5.3.2 Operations Phase

During the Operations phase, waste collection areas include the incinerators located at the Brucejack Mine Site and Knipple Transfer Area, waste collection and storage areas for recyclables, general and hazardous waste storage areas, and the sewage treatment plant. Waste collection areas have provisions to segregate waste according to disposal methods. The waste treatment areas and sewage effluent/sludge disposal systems have waste containment and runoff control structures as appropriate to prevent the escape of untreated liquid waste to surface or groundwater.

5.3.3 Closure Phase and Decommissioning

Activities during the Closure phase will be similar to the activities during the Construction phase, with the exception of the movement off site of a large component of the infrastructure. Additional equipment may be brought to the site to assist with decommissioning. It is expected that large volumes of waste and recyclable materials will be generated from the dismantling of buildings and process infrastructure.

Waste management during Closure will focus on identification of feasible salvage and recycling options to minimize the amount of solid waste materials and associated disposal costs. This typically involves an experienced salvage contractor who trucks components from the site to an off-site facility for commercial recycling. A range of materials will be dismantled and removed from the site for

disposal. The incinerator and burn pits will be operational at this time. Any equipment or materials with market value will be removed or sold for capital recovery.

Selected waste management facilities will be retained at the Brucejack Mine Site during closure, such as the incinerator and the sewage treatment plant, until no longer required, at which point they will be dismantled and removed from site.

5.4 STANDARD OPERATING PROCEDURES, POLICIES, ETC.

Pretivm has developed Standard Operating Procedures (SOPs) for the handling of waste materials. Current SOPs include:

- Burn Pit SOP;
- Incinerator Operation SOP
- Incinerator primary chamber clean out SOP
- Incinerator waste oil burning
- Terrapure Onsite Waste Management SOP; and
- Aerosol Can Proper Use and Disposal.

6 ENVIRONMENTAL MONITORING

6.1 PERFORMANCE MONITORING

The waste management practices outlined in the WMP have been implemented and are monitored. Waste handling and storage facilities at the Mine Site, such as waste collection containers, the Waste Transfer Facility, incinerators, burn pits, and sewage treatment plants, are monitored through periodic visual inspections and where applicable through sample analysis. Inspections may include a review of related documentation such as inventories, manifests, and logbooks. The frequency of inspections will be determined by the phase. During Operations, the inspection frequency is expected to be on a monthly basis.

Inspection findings are reported to the managers responsible for the inspected sites with copies provided to the Environmental Manager. All reports are reviewed internally by the managers and the Environmental Manager, or designate, in order to identify necessary improvements in waste management practices.

Additionally, the Environmental Manager may appoint an internal audit team, separate from the Environmental Monitor inspections, whose responsibility will be to:

- inspect facilities and waste collection areas for proper waste segregation and storage conditions;
- review the waste collection areas including any associated procedures, training, equipment, records, and employee awareness;
- make an action plan to correct deficiencies, improve procedures, maintain awareness and communication (with appropriate area supervisors, site personnel, transporters, and contractors), recognize positive or negative performance, and alert management when enforcement is necessary to ensure compliance; and
- recommend improvements to the mine's Waste Management Plan for continuous improvement of achieving the performance objectives.

Environmental monitoring of the various sites and facilities vary throughout the different mine phases and may be dependent upon the level of activity and volume of waste generation. Monitoring plans will be modified depending upon the number of employees, types of activities, expected waste streams refinement and employee adherence to the Waste Management Plan. A general approach to environmental monitoring is described below.

The frequency of monitoring at each waste-producing point source varies based upon the volume of waste generated, ease of handling, relative stability of waste for storage, storage conditions, and site access. Generally, sources which produce daily volumes of waste which must be disposed of immediately (e.g., kitchen waste, other liquid wastes) to minimize animal attractants and/or to maintain sanitary conditions, may be inspected as frequently as weekly to ensure waste handling is effective and timely. Waste which is low risk as an animal attractant, is stable outdoors, and has no

risk to the environment (e.g., clean wood waste, recyclable metals, reusable materials) may be inspected as infrequently as monthly to ensure that waste segregation and storage practices are appropriate. Monitoring inspection frequency will be increased if employees use low risk facilities to dispose of higher risk waste.

Waste accumulation and handling is be monitored by each department through their Manager or Superintendent. The key sites with potential for procedural non-compliance will be inspected on a regular basis defined by the level of the risk (weekly, monthly).

6.2 WORK PLANNING AND SCHEDULE

The volume of waste generated has declined as the mine progressed from Construction into Operations. For example, the initial period of Construction saw a larger workforce on site that generated larger amounts of construction waste, including wood waste, electrical and utility piping waste, insulation and large equipment packaging, and pallets. During Operations, a mixture of diverse but more predictable waste streams is generated, which can form the basis of continuous improvement in all facets of waste management and may result in less frequent monitoring and periodic internal audits. As a result, monitoring will change over time.

As part of their initial orientation, employees are made aware of the requirements and reasons surrounding the proper management of waste. The Environmental staff communicate the performance objectives and measures related to waste management to site personnel, and to the Engineering, Procurement, and to any Construction Management Contractor. Personnel requiring specific training in the management of waste will be identified by Pretivm and receive training prior to assuming any related responsibilities.

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance

Reporting is defined in the *Environmental Management Act* Permit and the *Mines Act* Permit.

As per Waste Discharge Permit 107025, the following data related to incineration will be reported on an annual basis:

- results of analyses of waste oil used for incineration;
- results of lab analyses of sewage sludge content;
- mass and percentage of sewage sludge per each batch of incineration; and
- summary of waste streams subject to incineration and open burning including annual quantification and waste storage methods.

This information is included as part of annual reporting outlined in the Air Quality Management Plan (Pretivm 2015), to be submitted on or before March 31 of each year for the previous year's operations. Copies of annual report will be sent to the Tsetsaut/Skii km Lax Ha, the Tahltan Central Council, and Nisga'a Lisims Government, as per the permit condition.

7.1.2 Internal Reporting

Routine internal reporting according to a schedule of monitoring/audit inspections is undertaken and highlights the effectiveness, challenges, and successes in managing waste. Key metrics are the volume and nature of waste generated on site, effectiveness of handling waste, environmental or wildlife problems associated with waste, and any applicable permit compliance results.

7.1.3 Incidents

Emergency or environmental incidents which occur as a result of wildlife encounters, incinerator upset conditions, or non-compliance with the WMP or permits will be documented and reported to the Environmental Superintendent and Mine Manager. An Incident Report Form will be completed and the follow-up for causes and solutions will be led by Environmental staff.

7.2 RECORD KEEPING AND TRACKING

7.2.1 Monitoring Results

Monitoring/inspection records are reviewed internally by the appropriate managers and Environmental staff, in order to identify necessary improvements in the monitoring system.

7.2.2 Audit Results

Findings from internal audits, related action items, and any additional follow-up measures are kept on record for the life of the mine.

7.2.3 Continuous Improvement, Follow Up, and Adaptive Management

Appropriately qualified personnel will be employed throughout the life of the mine to supervise, direct, monitor, and implement any adaptive management actions identified for waste management.

7.2.4 Incident Response Records

The Environmental staff are responsible for maintaining records of incidents and responses throughout the life of the mine.

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Appendix 9-1-17. Waste Rock and Tailings Storage Facility – OMS Manual

PRETIVM

Operations, Maintenance, and Surveillance Manual

–

Waste Rock and Tailings Storage Facility

Brucejack Mine - Version 08

Prepared for

Pretium Resources Inc.

PRETIVM
BRUCEJACK MINE
COURAGE TO CARE

Operation, Maintenance, and Surveillance Manual – Waste Rock and Tailings Storage Facility

June 2021

Reviews and updates of this document are a collaborative effort between Golder Associates Ltd. and Pretium Resources Inc.

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Mr. Cam MacKay-Stotesbury, Site Project Engineer, E.I.T.
Newcrest Mining Ltd.
2965 Tatlow Road
Smithers BC V0J 2N5

CONFIRMATION OF REVIEW OF THE OPERATION, MAINTENANCE, AND SURVEILLANCE MANUAL REVISION 8 FOR THE WASTE ROCK AND TAILINGS STORAGE FACILITY, BRUCEJACK MINE, BC

Dear Sir:

At the request of Newcrest Mining Ltd. (Newcrest), this letter confirms that the most current Operation, Maintenance, and Surveillance Manual, Revision 8D for the Waste Rock and Tailings Storage Facility (Pretium 2021) at Brucejack Mine, BC has been reviewed and supported by myself as the Engineer of Record.

I trust this meets your requirements at this time.

Yours very truly,

WSP Canada Inc.

Jeffrey Kwok, P.Eng.
Principal Geotechnical Engineer, Engineer of Record

JEK/jp/hp

https://golderassociates.sharepoint.com/sites/157185/project files/6 deliverables/3.0_issued/21507844-073-l-rev0-1000-letter to newcrest/21507844-073-l-rev0-1000-confirmation of wrtsf oms manual rev8 review 27oct_23.docx

REFERENCE

Pretium (Pretium Resources Inc.) 2021. Operations, Maintenance, and Surveillance Manual – Waste Rock and Tailings Storage Facility, Brucejack Mine – Version 8. June 2021.

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Appendix C: Water and Ice Emergency Response and Rescue Plan

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Appendix E: Tailings Deposition Infrastructure Issued for Construction Drawings

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1 Introduction

1.1 Background

The Brucejack Mine, wholly owned by Pretium Resources Inc. (Pretivm), is located approximately 65 km northwest of Stewart, British Columbia (BC) (Figure 1). Major authorizations for the mine include *Mines Act* Permit M-243, first issued to Pretivm on July 22, 2015, and Effluent Permit 107835, first issued on August 31, 2015. Both permits have been subsequently amended. Construction was initiated September 5, 2015, and commercial production began in July 2017.

Operation of the Brucejack Mine generates waste rock and tailings. Waste rock is primarily produced from underground mining. Most waste rock is potentially acid generating (PAG). All Brucejack Mine waste rock is assumed to be PAG and is managed as such, in accordance with the mine's authorizations. All waste rock is either deposited subaqueously within the Waste Rock and Tailings Storage Facility (WRTSF) or backfilled in the underground mine below the ultimate flooding elevation of the mine. Tailings are non-potentially acid generating (NPAG) and are either paste thickened and used for backfilling empty underground production stopes or deposited subaqueously in the WRTSF. Therefore, Pretivm has production flexibility to direct waste rock and tailings to either the WRTSF or the underground mine, depending on operational needs.

Sludge produced from the mine's Water Treatment Plant (WTP) is mixed with the tailings in the thickening tank. The resulting slurry, comprising approximately 1% to 2% of sludge, is then deposited in the WRTSF.

Effluent from the Sewage Treatment Plant (STP) is directed to the WTP discharge tank, where the effluents are combined and discharged through a single line to the WRTSF. The STP/WTP effluent discharge point is to the east of the waste rock dump (WRD) and approximately 75 m from the southern shore of the WRTSF. The maximum authorized rate of discharge from the WTP to Brucejack Lake is 10,000 m^3/day, while the maximum authorized rate of discharge from the STP to Brucejack Lake is 175 m^3/day.

1.2 Purpose and Objective of the OMS Manual

This Operations, Maintenance, and Surveillance (OMS) manual has been prepared to address requirements under the following authorizations, regulations, and legislation for subaqueous waste rock and tailings deposition within the Brucejack Mine WRTSF:

- *Mines Act* Permit M-243
- Effluent Permit 107835 (PE-107835)
- The Health, Safety, and Reclamation Code for Mines in British Columbia (MEMLI 2021)
- Requirements under the BC *Mines Act* and BC *Environmental Management Act*

These requirements pertain to a combination of environmental (primarily metal leaching / acid rock drainage [ML/ARD]), geotechnical, and health and safety aspects. Specific conditions under Permit M-243 applicable to WRTSF operations include geotechnical conditions listed under C.3(c) of this

permit, as well as ML/ARD-related conditions under D.3. This OMS manual also addresses one of the management plan requirements under Brucejack Mine Environmental Assessment Certificate (EAC) #M15-01 and follows requirements of the mine's Decision Statement Issued under Section 54 of the *Canadian Environmental Assessment Act, 2012*. The EAC and federal Decision Statement were both issued in 2015.

This OMS manual was also prepared in accordance with the Mining Association of Canada (MAC) guidelines for OMS manuals of tailings facilities (MAC 2021a). This rigorous framework is typically not required for waste rock deposition; however, in this case, waste rock deposition is a challenging operation where operational personnel safety is of paramount importance. In addition, since waste rock deposition occurs simultaneously with tailings deposition within the WRTSF, a combined OMS manual is appropriate.

This OMS manual is reviewed by the Engineer of Record (EOR) and approved by the manager prior to implementation in accordance with 10.5.2(2) of the Health, Safety and Reclamation Code for Mines in British Columbia (MEMLI 2021). The OMS manual is reviewed at least annually and is considered a live document. Engineer of Record review comments of the OMS manual specific to the WRTSF are provided under separate cover (e.g., the annual facility inspection report).

This OMS manual replaces the Tailings and Waste Rock Subaqueous Deposition Management Plan originally contained as Appendix 6-O of the Application for *Mines Act* and *Environmental Management Act* Permits for the Brucejack Mine (Pretivm 2015). This OMS manual provides the most current information and direction with respect to waste rock and tailings management at the Brucejack Mine and is the primary reference to be used with respect to these activities.

It is important to note that all waste rock and tailings are and will continue to be contained within the natural Brucejack Lake basin (i.e. the WRTSF), without the need for any external containment structure to retain the waste rock and tailings. There are no failure mechanisms that would result in breach or discharge of waste rock or tailings beyond the confines of the WRTSF, and therefore many of the MAC (2021) guidelines do not apply to this OMS manual.

This OMS manual provides the framework for the mine life-cycle subaqueous deposition of waste rock and tailings into the WRTSF, and defines and describes the following components of the operation:

- Roles, accountabilities, responsibilities, and levels of authority for positions associated with waste rock and tailings deposition
- Key elements of the Mine Site (core mine infrastructure area located at the southwest shore of the WRTSF) as it relates to the WRD and tailings deposition design
- Key components of the WRD and tailings design and expected life-cycle performance
- Procedures for waste rock and tailings deposition
- Regulatory and corporate policy compliance and obligation requirements associated with waste rock and tailings deposition

- Requirements for reporting the performance of the waste rock and tailings deposition progress
- Monitoring and surveillance requirements for the WRTSF, described as quantifiable performance objectives (QPOs), and emergency planning and response procedures

1.3 OMS Manual Updates

This OMS manual is the property of Pretivm, which has sole authority over the distribution of this document. Pretivm is the only party authorized to make revisions to the manual or to contract a third party to carry out revisions. Pretivm also assumes responsibility to inform all parties required to receive this OMS manual when updates have been made, and to undertake any necessary training to ensure individuals are familiar with the changes.

The OMS manual is reviewed at a minimum frequency of once per year as required, in accordance with mine authorizations, and updated as appropriate taking into consideration mine development changes that would affect the management of waste rock and tailings. Specific mine changes that would trigger an update to this manual include, but are not limited to:

- Substantial variation of observed WRD performance from predicted performance
- A recommendation by the EOR or any other qualified geotechnical professional that undertook an audit or safety review of the OMS Manual
- Changes in Pretivm's organizational structure and/or position responsibilities
- Changes in the status of the mine, such as temporary or permanent closure, and ultimately post-closure
- Regulatory and/or operational authorization changes including updated best practice guidelines for mine waste management

Notwithstanding the above, revisions are made proactively, as far as practicable, in advance of major mine changes that would affect the waste rock and tailings deposition plans. Revision of the OMS manual may also be required depending on results of WRTSF effluent monitoring required under the mine's authorizations, or monitoring required under the ML/ARD Management Plan (Lorax 2021) and other Environmental Management Plans (EMPs) (Pretivm 2015, 2016, 2017a, 2018, 2019, 2020a, 2021).

The following key supporting documents are considered integral to this OMS manual, and are attached as Appendices A through E, respectively:

- Appendix A: Responsible, Accountable, Support, Consulted, and Informed (RASCI) matrix
- Appendix B1: Standard Operating Procedure (SOP) for Waste Rock Deposition with Stacker/Bailing system
- Appendix B2: SOP for Waste Rock Deposition with Remote Dozer
- Appendix B3: SOP for Remote Dozing Operation
- Appendix B4: SOP for Waste Rock Dump PAG Material Replacement

- Appendix B5: SOP for Waste Rock Haulage
- Appendix C: Water and Ice Emergency Response and Rescue Plan
- Appendix D1: Daily Waste Rock Inspection Checklist
- Appendix D2: Weekly Waste Rock Deposition Audit Checklist
- Appendix E: Tailings Deposition Infrastructure Issued for Construction Drawings
- Appendix F: Waste Rock Dump Area Emergency Evacuation and Re-entry Plan Under Seismic Loading

These supporting documents are stand-alone documents intended to provide detailed guidance on specific elements of waste rock and tailings management; they are included as permanent appendices to the OMS manual for completeness. Should any changes to these plans be required, the OMS manual will require an update. Table 1-1 summarizes the revision history of this document.

Table 1-1: OMS manual – Revision history and record of change

Version	Prepared By	Primary Author(s)	Comments/Changes
Ver. 0; March 2016	SRK Consulting (Canada) Inc.	Stuart McPhee, EIT; Emma Helmers, EIT Reviewed by Maritz Rykaart, PhD, PEng	• Initial document. • Scope restricted to waste rock deposition, as tailings were not yet being produced.
Ver. 01; September 2016	SRK Consulting (Canada) Inc.	Stuart McPhee, EIT; Emma Helmers, EIT Reviewed by Maritz Rykaart, PhD, PEng	• Update waste rock deposition operations to include conveyor stacker. • Figures updated with new design and survey information.
Ver. 02; November 2016	SRK Consulting (Canada) Inc.	Stuart McPhee, EIT Reviewed by Maritz Rykaart, PhD, PEng	• Include preliminary information on the proposed tailings conveyance and deposition procedures and design. • Figures include the design and details of the tailings support cables.
Ver. 03; January 2017	SRK Consulting (Canada) Inc.	Stuart McPhee, EIT Reviewed by Maritz Rykaart, PhD, PEng	• Include responses to comments prepared by Ministry of Energy and Mines (MEM) reviewer Paul Hughes, PEng, that focus on QPOs; these are included in Table 6-3 of Section 6 of this report. • Include an update to the Organization Chart and Responsibilities Table to include key processing personnel.
Ver. 04; February 2017	SRK Consulting (Canada) Inc. with support from Lorax Environmental Services Ltd.	Stuart McPhee, EIT Alison Shaw, PhD Reviewed by: Maritz Rykaart, PhD, PEng	• Include additional responses to comments prepared by MEM reviewer Paul Hughes, PEng, that focus on QPOs included in Table 6-3 in Section 6. • Include details pertaining to co-deposition of WTP sludge with tailings. • Update to clarify ML/ARD management requirements of the permits.
Ver. 05; September 2017	SRK Consulting (Canada) Inc.	Stuart McPhee, PEng	• Updates to PAG Replacement Methodology. • Updates to Tailings Disposal including a new SOP on tailings deposition.
Ver. 06; October 2018	SRK Consulting (Canada) Inc.	Stuart McPhee, PEng Reviewed by: Maritz Rykaart, PhD, PEng	• Update information on production rate increase to 3800 tpd. Include operational flexibility to place waste rock into the WRTSF or underground to meet mine operational needs. • Updated design approach based on SRK (2018) WRD Design Report and Stability Analysis. • Updated Pretivm Organizational Chart. • Updated figures based on current WRD crest surveys. • Addition of new Appendix that details the WRD emergency evacuation plan triggered by a seismic event.

Version	Prepared By	Primary Author(s)	Comments/Changes
Ver. 07; March 2020	SRK Consulting (Canada) Inc. and Pretivm Resources Inc. With support from: Lorax Environmental Services Ltd	Stuart McPhee, PEng Reviewed by: Calvin Boese, MSc, PEng; and Sylvia Van Zalingen, MS, PAg.	• Update regulatory context. • Update Pretivm Organizational Chart. • Update figures based on current WRD crest surveys. • Update EOR transition from the late Maritz Rykaart to Calvin Boese.
Ver. 8; June 2021 (this document)	Pretium Resources with support from Golder and Associates.	Lyle Morgenthaler, PEng (Pretivm) Reviewed by: Greg Norton, MSc (Pretivm) and Jeffrey Kwok PEng (Golder) (Golder)	• . • Update Pretivm Organization Chart. • Add waste rock deposition procedure with remote controlled dozer. • Add QPO for the waste rock deposition with remote controlled dozer • Add RASCI table

2 Roles and Responsibilities

2.1 Organizational Structure

Pretivm's organizational structure as it relates to the operation, management, surveillance, and emergency preparedness and response of the WRD and tailings management is presented in Figure 2. This OMS manual version applies to the current organizational structure for an operating mine. If the organizational structure, positions, or responsibilities listed herein change, this document will be updated accordingly.

2.2 Position Responsibilities

Position responsibilities for the operation, management, surveillance, and emergency preparedness and response of the Brucejack Mine WRTSF and associated subaqueous mine waste (waste rock and tailings) deposition management are listed in Table 2-1. The positions are also presented in a Responsible, Accountable, Support, Consulted, and Informed (RASCI) matrix for site-specific tasks in Appendix A.

Table 2-1: Key positions and responsibilities associated with the administration of the WRTSF

Position	Organization	Responsibilities
Accountable Executive Officer, AEO	Pretivm	• Ensure appropriate and effective governance structure for the WRTSF. • Ensure appropriate and effective management system is in place that aligns with industry best practice. • Retain the services of qualified EOR. • Be aware of key outcomes of tailings facility risk assessments and how risks are being managed. • Report to Board on risks and performance of the waste and tailings management system.

Position	Organization	Responsibilities
General Manager	Pretivm	• Oversee overall operations implementation including waste rock and tailings deposition. • Budget control. • Overall on-site responsibility and oversight for all parties and activities. • Ensure implementation and maintenance of waste rock and tailings deposition SOPs and Emergency Response Plan (ERPs). • All site-wide responsibilities associated with the “Manger” per the HSR Code (MEMLI 2021)
WRTSF Responsible Person	Pretivm	• Overall on-site responsibility and oversight for all parties and activities. • Coordinate development of OMS with EOR and Department QPs; lead annual review and update. • Coordinate implementation of OMS; ensure Department QPs understand responsibilities per the OMS. • Accountable to ensure implementation and maintenance of waste rock and tailings deposition SOPs and ERPs. • Ensure the waste rock and tailings deposition area is operated in accordance with facility designs and mine permits. • Identify scope and budget required for waste rock and tailings management. • Manage the tailings facility including: o Establish and maintain relationship and ongoing communication with the EoR. o Ensure inspections are completed. o Implement an Independent Review process. o Coordinate and contribute to the development of life of mine (LOM) and annual deposition plans. o Report to the Mine Management, and AEO on performance of waste and tailings management. o Understand Code requirements and industry standards related to tailings management.
Tailings QP	Pretivm	• Oversee overall technical aspects and safety of the tailings production and distribution. • Direct and oversee the tailings production process and data records for tailings discharge rates and solids contents. • Ensure tailings-related surveillance is undertaken in accordance with design intent and performance objectives. • Ensure implementation and maintenance of tailings deposition SOPs and ERPs.
Waste Rock QP	Pretivm	• Provide technical and safety oversight. • Manage WRTSF geotechnical engineering activities on site. • Direct and oversee waste rock technical staff, including development of detailed work plans. • Communicate with EOR. • Prepare annual BC MEMLI reports. • Annually update SOPs in co-operation with the Health and Safety QP. • Provide site technical oversight of waste rock deposition SOP. • Ensure waste rock related surveillance is undertaken in accordance with design intent and performance objectives. • Maintain active database of waste rock settlement, survey, and volume tracking information. • Complete ongoing stability analysis and develop daily dump plan. • Ensure implementation and maintenance of waste rock deposition SOPs and ERPs.

Position	Organization	Responsibilities
		• Train waste rock deposition area operators, supervisors, and stakeholders in hazard recognition, deposition procedures, and reporting requirements. • Ensure EOR is up to date on all actions pertaining to the waste rock deposition area.
Environmental QP	Pretivm	• Overall responsibility and oversight for WRTSF environmental surveillance. • Lead Pretivm authorization/permitting processes related to the WRTSF operations. • Coordinate and compile annual report for BC MEMLI and BC Ministry of Environment and Climate Change Strategy. • Ensure implementation and maintenance of environmental SOPs and ERPs.
Health and Safety QP	Pretivm	• Monitor waste rock and tailings deposition SOPs and ensure safety compliance through audits every two weeks. • Develop, implement, and update SOPs and ERPs annually. • Ensure Emergency Response Team is trained to respond to WRTSF. • Maintain and test ERPs, or components of site-wide ERPs directly related to the WRTSF. • Ensure implementation and maintenance of waste rock and tailings deposition SOPs and ERPs.
Surface Operations QP	Pretivm	• Implement waste rock and tailings deposition SOP-related use of personal protective equipment (PPE). • Ensure implementation and maintenance of relevant waste rock and tailings deposition SOPs and ERPs. • Ensure the plans issued by Waste Rock QP and Tailings QP are executed safely and in a timely fashion.
Surface Maintenance QP		• Implement waste rock and tailings deposition SOP-related use of personal protective equipment (PPE). • Implement tailings distribution infrastructure surveillance. • Ensure tailings line preventative maintenance and corrective actions are performed as per schedule • Assist in repairs of tailings infrastructure as required in a timely fashion. • Ensure implementation and maintenance of relevant waste rock and tailings deposition SOPs and ERPs.
Engineer of Record (April 2021 to present) Jeffery Kwok P.Eng	Golder Associates Ltd.	• Design of waste rock and tailings deposition area (excluding deposition system, i.e., pipeline and pumping systems). • Evaluate design changes (technical). • Audit waste rock and tailings deposition progress. • Undertake annual geotechnical inspection of WRD.

Note: A “Qualified Person” (QP) means a person who, in the opinion of the manager, is:

(a) qualified because of the person’s knowledge, training and experience to design, organize, supervise and perform the duties for which the person is appointed,

(b) familiar with the provisions of this Act, the code, and the regulations that apply to the duties for which the person is appointed, and

(c) capable of identifying any potential or actual danger to health or safety in the workplace.

2.3 Competency and Training

The WRSTF Responsible Person must ensure that this OMS manual is kept current and that all personnel associated with waste rock and tailings management are familiar with its contents. Individuals who are assigned responsibilities for specific elements of the waste rock and tailings management, as defined in this OMS manual, have a duty to inform their immediate supervisors of any training requirements needed to fulfil those responsibilities as listed. Specific prerequisite competency and training associated with the responsibilities in Table 2-1 are listed in Table 2-2.

Table 2-2: Prerequisite competency and training for individuals responsible for WRTSF

Position	Core Competency and Training
WRTSF Responsible Person	Suitable level of experience as designated by Pretivm; a minimum of five years' experience around WRDs and tailings management.
Tailings QP	Extensive experience in industrial process management specifically in milling, dewatering, and tailings production.
Waste Rock QP	Professional Engineer registered in BC. Geotechnical engineer with at least five years' experience in mining and mine waste management, including tailings.
Environmental QP	Extensive experience in environmental incident responses and reporting, and in environmental monitoring and implementation of regulatory requirements, including environmental aspects of mine authorizations and the mine's Environmental Management Plans (EMPs). Thorough knowledge of site-specific and general permitting and other regulatory requirements; water quality requirements and required level of monitoring in BC; implementation.
Health and Safety QP	Extensive experience in mine health and safety planning and supervision and some experience with the operations of WRDs and tailings management.
Surface Operations QP	Five years' experience in managing operations projects and supervising personnel.
Surface Maintenance QP	Five years' experience in pipe maintenance, repairs, and wear surveillance
Engineer of Record	Professional Engineer registered in BC. Geotechnical engineer with at least 10 years' prior experience in mine waste management, including tailings.

2.4 Document Control

Pretivm is responsible for ensuring that all documents and records pertaining to waste rock and tailings management are current (with a history of changes and backups) and are available to individuals involved in waste rock and tailings management, as required. A document library with copies of, or electronic links to WRTSF documents and records will be maintained on the Brucejack J drive at a location accessible to employees with responsibilities associated with the WRTSF. A Microsoft Teams site will also be maintained as a central location for key documents and shared working files accessible to employees with responsibilities associated with the WRTSF.

3 Facility Description

This section summarizes physical site conditions relevant to this OMS manual and that provide the basis for design and operation of the WRTSF. Much of the information presented here is covered extensively in detailed baseline and background reports related to Brucejack Mine development and subsequent updates provided in the 2015 through 2019 annual reports for *Mines Act* Permit M-243, Effluent Permit 107835 and Air Permit 107025 (Pretivm 2015, 2016, 2017a, 2018, 2019, 2020a)

3.1 Location and Access

The Brucejack Mine is located in the headwaters of Brucejack Creek and consists of an approved underground mine and related production and ancillary infrastructure. The mine is located in northwestern BC approximately 65 km north-northwest of Stewart and 21 km south-southeast of the Eskay Creek Mine. The mine is located at approximately 1,370 m above sea level (masl) at Universal Transverse Mercator (UTM) 426,967E; 6,258,719N in Zone 9 on the North American (NAD) 83 grid (Figure 1)

Ground transportation to the site is by a 73 km long access road (Brucejack Access Road) west from approximately km 215 of Highway 37 North. Aerial access to site is by helicopter (usually from Stewart) or via fixed wing aircraft to the Bowser Aerodrome developed for the mine and located at km 50 of the Brucejack Access Road.

3.2 Site Terrain and Climate

The Brucejack Mine is situated in the BC coastal mountains, near the transition zone between the moderate coastal and interior continental climates. Mine Site infrastructure elevations are mainly between approximately 1,365 masl and 1,440 masl, with surrounding mountain peaks rising to 2,200 masl. Due to the elevation, the area has a subarctic climate and is dominated by non-vegetated or sparsely vegetated alpine ecosystems. Orographic effects by the mountainous topography and surrounding glaciers contribute to a high degree of spatial variability in air temperature and precipitation. Site-specific climatic data are limited, dating back primarily to 2009 (Pretivm 2015).

Mean daily winter and summer low temperatures at the VOK meteorological station west of the Mine Site range between 10°C and 4.4°C. Mean daily winter and summer high temperatures range between 4.7°C and 10°C. The absolute maximum daily temperature recorded at the VOK station was 24.6°C on July 30, 2018, and the absolute daily minimum was −30.4°C on February 2, 2019. The total annual adjusted precipitation recorded at the VOK station ranges from 1,252 to 2,019 mm, with monthly totals ranging from 19 to 400 mm. Precipitation is generally greater during the winter and fall. Approximately 60% of the annual precipitation falls as snow, accumulating between early October and mid-May.

Winds at the VOK meteorological station are predominantly from the east to east-southeast. Wind speeds above 6 m/s occur approximately 17% of the time during the year.

3.3 Regional Geology

The mine is located in the western Stikine terrane (Stikinia), the largest and westernmost terrane in the Intermontane Belt of the Canadian Cordillera. Stikinia is interpreted as an intra-oceanic island arc terrane formed between mid-Paleozoic to Middle Jurassic time. It was then strongly deformed during the Cretaceous accretion of the outboard insular belt terranes. The property is located on the eastern limb of the McTagg Anticlinorium, and as a result the rocks on the property are tilted and folded, generally younging progressively towards the east. The McTagg Anticlinorium is cut by a series of mid-Cretaceous thrusts and by a set of late-stage brittle faults, of probable Tertiary age, which includes the northerly trending Brucejack Fault.

Volcano-sedimentary rocks and related Early Jurassic plutons in the northwest part of Stikinia represent an exceptionally metal-rich tectonic assemblage in BC. This area includes volcanogenic massive sulfide deposits, alkaline porphyry copper-gold deposits, and transitional epithermal intrusion-related precious metal deposits like the Brucejack deposit. High-grade gold mineralization in the Valley of the Kings, the current focus of the mine, occurs in a series of west-northwest-trending sub-vertical corridors of structurally reoriented vein stockworks and breccias.

The Brucejack Fault separates two geological domains on the property: fine-grained and well-bedded siltstone and mudstone of the Triassic Stuhini Group are dominant west of the Brucejack Fault, and volcanic conglomerates and siltstones, hornblendes, and pyroclastic rocks of the Lower Jurassic Lower Hazelton Group outcrop to the east of the fault (Pretivm 2015).

3.4 Hydrological Conditions

Seasonal precipitation and snowmelt patterns lead to fluctuations in the elevation of the WRTSF water level. A lake elevation monitoring station was installed in July 2011 and collected data during the open water season until October 2018. The station was upgraded in October 2018 to include a telemetric satellite link and a freeze proof pressure transducer to record water levels year-round.

Water level elevations for the period of record between 2011 and 2019 ranged from 1,364.17 to 1,364.99 masl, with a mean elevation of 1,364.42 masl. Water level data may be affected by pressure build-up from ice, which typically occurs between late December and late April.

Median flows for the 2011 to 2019 period of record at the Brucejack gauging station (BJ 3.10) indicate a steady rise with the onset of freshet in late April to mid-May, followed by a decline until mid- to late September, when levels often rise again due to augmentation by episodic precipitation. After the fall, flows recede to base flow conditions by the end of November. Monitoring data for the period to 2015 are provided in the 2015 Application for *Mines Act* and *Environmental Management Act* Permits (Pretivm 2015). Monitoring data for the period 2015 through 2019 are available in the Annual Reports for *Mines Act* Permit M-243, Effluent Permit 107835 and Air Permit 107025 (Pretivm 2016, 2017a, 2018, 2019, 2020a).

3.5 Hydrogeological Conditions

Groundwater flow at and near the Mine Site was generally driven by topography prior to the commencement of underground mine dewatering, with groundwater discharging to Brucejack Creek

and Brucejack Lake. Continuous dewatering of the underground mine since August of 2012 has depressed the groundwater table in the vicinity of the mine and adjacent area. Strong downward vertical hydraulic gradients have developed at most monitoring well nests, driven by the underground mine dewatering. Groundwater levels are near ground surface along the shores of the WRTSF, and seasonally artesian along upper Brucejack Creek. Monitoring wells flanking the underground mine at higher elevations in the Valley of the Kings watershed indicate drawdown on the order of 100 m, although drawdown within the footprint of the underground mine workings is expected to be higher. Seasonal groundwater fluctuations range from less than 5 m to up to 55 m.

3.6 Water Quality

Deposition of waste rock and tailings in the WRTSF has the potential to change water quality downstream in Brucejack Creek. Flow is monitored continuously at the WRTSF outflow station (BJ 3.10), and during open water conditions in Brucejack Creek downstream of the outflow at station BJ 1.74. Surface water quality is monitored weekly at BJ 3.10 year-round, and monthly in Brucejack Creek at station BJ 2.62, which is located between monitoring sites BJ 3.10 and BJ 1.74.

Effluent Permit 107835 (amended December 14, 2018) specifies discharge limits at the WRTSF outflow (BJ 3.10). These limits are listed in Table 3-1 (Section 3.11.3).

3.7 Natural Hazards

3.7.1 Avalanche

The terrain and climate within the mine site area (mine development area within Pretivm's mining leases, west of upper Knipple Glacier) produce significant avalanche risks. A full-time team of avalanche technicians provides continuous year-round management of the risk of snow avalanches.

Avalanches are not expected to affect the WRTSF. Although one avalanche path identified in a study commissioned by Pretivm has the potential to reach the WRTSF, assessments indicate that the maximum size of an avalanche reaching the WRTSF from this area (along the south-central shore of the facility) will be Size 3 (less than 1,000 metric tonnes). Avalanche control combined with the construction of avalanche catchments and the installation of infrastructure impedes any avalanches from reaching the WRTSF.

3.7.2 Seismicity

The Brucejack property lies in the Saint Elias Region seismic zone, which is one of the most seismically active areas in Canada. The geometry of the boundary between the Pacific and North American plates is changing from transform to subduction, which results in rapid uplift rates of up to 30 mm/year and large earthquakes (NRC 2013). The 2010 National Building Code Seismic Hazard Calculation determined that Brucejack Lake is in an area with a peak ground acceleration value of 0.109 g, which corresponds to a probability of exceedance of 2% in 50 years or 1 in 2,475 years (NRC 2013).

3.8 WRTSF Bathymetry

Bathymetric surveys of Brucejack Lake prior to mine development indicated a shallow sloping shelf at the southeastern end of the lake. The lake bottom then dropped off quite steeply moving from the lakeshore towards the north. After the drop-off, the lake bottom generally sloped gently to the northeast. In the footprint of the present WRTSF waste rock and tailings deposition area, the lake reached a maximum depth of approximately 85 m. The pre-mine total volume of the lake was approximately 28.5 million cubic metres (Mm^3) (SRK 2015a).

Bathymetric surveys of the WRTSF are conducted at least annually per environmental surveillance program (see section 6.3).

3.9 WRTSF Foundation Conditions

No drilling has been conducted through the natural lake bed sediments lining the WRTSF; however, based on eight disturbed samples taken from the pre-development lake bottom, the in-situ sediments are characteristic of an alluvial depositional environment and are dominated by sand, silt, and clay particles. These sediments generally become finer moving away from the shorelines. The sandy silt material was found to have medium plasticity, while the clay material was found to have medium to high plasticity. Strength testing revealed a friction angle of 27° for the primarily fine-grained samples and a friction angle of 33° for the silty sand and sandy silt samples (BGC 2014).

A seismic refraction geophysical survey was completed in 2013 by Frontier Geosciences Inc. The survey interpreted the bedrock elevation from high compressional wave velocities over 4,000 m/s, in comparison to velocities through what was interpreted as sediments of under 1,500 m/s. Sediments range in thickness from 5 to 35 m within the footprint of the waste rock and tailings deposition area, with the thickest sediments occurring at the south end of the facility next to the shoreline (Frontier 2013).

Figure 4 shows the locations of samples taken from the bottom of Brucejack Lake before mine operations and the location of seismic refraction survey lines.

3.10 Waste Characteristics

3.10.1 Waste Rock

Physical Properties

The physical properties of the waste rock at the Brucejack Mine site vary according to the source of the material and the type of blasting employed. Limited geotechnical laboratory testing has been completed on the waste rock; its physical properties are therefore mostly deduced from observations. Waste rock is predominantly sourced from the underground mine operations.

Waste rock sourced from the underground mine is generally softer and finer than waste rock that is sourced from surface infrastructure, having particle sizes between 0.15 and 1.0 m. This is due in part that development of underground mine workings requires more closely spaced drilling, which creates finer waste rock. It is also due to orientation of the orebody being located in rock that has been highly altered with quartz-sericite-pyrite alteration; as a result, the rock breaks apart more

easily when blasted (Pretivm 2015). The underground waste rock generally has a higher moisture content than the waste rock previously produced from surface infrastructure during construction, as the majority of the mine is located below the water table (Pretivm 2015).

Waste rock previously sourced from the surface infrastructure works during the construction phase (mainly late 2015 through 2017) is harder, has a larger maximum particle size, is generally coarser, having a maximum particle size often greater than 1.0 m, and is drier than waste rock sourced underground. This is due to the larger spacing of previous surface blasting patterns compared to the underground pattern; also, the water table is likely deeper in the (former) surface infrastructure rock excavation locations than where it is being extracted from some areas (Pretivm 2015). The in situ and placed densities for all rock on site are assumed to be the same, at 2.78 t/m^3 and 2.06 t/m^3, respectively. Limited surface works are contemplated in the near future that would generate major waste rock volumes.

Geochemical Properties

As summarized in the 2015 Application for *Mines Act* and *Environmental Management Act* Permits (Pretivm 2015) and confirmed by subsequent monitoring in accordance with the requirements of Permit M-243 and the ML/ARD Management Plan, most of the Mine Site rock contains relatively high concentrations of sulfide minerals and variable but generally low proportions of acid-neutralizing carbonate minerals. A significant portion of the Mine Site rock is therefore classified as PAG. Waste rock is also classified as potentially posing metal-leaching concern, with elevated leachate concentrations of arsenic, cadmium, copper, lead, selenium, and zinc observed in humidity cell testing (Pretivm 2015).

Of the 160 surface development samples tested, 49% were characterized as PAG with enrichments (greater than 10x average continental crust) in silver, gold, manganese, antimony, and selenium (Pretivm 2016, 2017a). All surface waste rock excavated to develop the Mine Site infrastructure was placed subaqueously in the WRTSF. Saturated column tests indicate that subaqueous storage of surface waste rock will minimize any potential leaching and changes to WRTSF and Brucejack Creek water quality.

The three main units that comprise 83% of the waste rock coming from the underground mine (the Volcanic Sedimentary Facies, Fragmental, and Conglomerate units) contain between 76% and 85% PAG material. The data also show that many of the PAG samples with elevated sulfide content contain significant amounts of carbonate minerals (mostly calcite) that will neutralize acidity generated and prolong the onset of acid generation (Pretivm 2016). Humidity cell tests and field bin studies initiated to evaluate metal leaching behaviour indicate that cadmium, cobalt, copper, iron, lead, and zinc are parameters of potential concern (Pretivm 2015).

Confirmatory sampling programs have been developed to assess the geochemical characteristics of waste rock excavated from the Mine Site surface and the underground mine. The details of the sampling programs are outlined in the ML/ARD Management Plan, and the results are presented in the Annual Reclamation Reports (Pretivm 2016, 2017a, 2018, 2019, 2020a).

Volumes

Brucejack Mine operation generates waste rock and tailings. Depending on operational needs, Pretivm has production flexibility to either direct waste rock to the WRTSF for subaqueous deposition or to retain it in the underground mine, below the ultimate flooding elevation of the mine, as backfill. This operational flexibility allows Pretivm to deposit between 36% and 100% of all waste rock into the WRTSF. Based on the 2018 authorization to 3,800 tpd ore mining rate, this equates to approximate volumes of total deposited waste rock in the WRTSF between 1.9 Mt (0.92 Mm^3 at 2.06 t/m^3) and 5.3 Mt (2.6 Mm^3 at 2.06 t/m^3). However, Pretivm is currently seeking approval on a revised Mine Plan submitted July 2020, with associated volumes of total deposited waste rock in the WRTSF of between 2.1 Mt (1.03 Mm^3 at 2.06 t/m^3) and 5.9 Mt (2.85 Mm^3 at 2.06 t/m^3). Once approved within the M-243, these will be the new limits to work within.

3.10.2 Tailings

The Brucejack Mine is currently in operation and producing tailings. Mill commissioning, with limited tailings production, was initiated on May 16, 2017. Commercial production began in July 2017. Physical and geochemical properties of the tailings are summarized below.

Physical Properties

The particle size of Brucejack tailings inherently fluctuates; however, it has been measured to have a maximum particle size of approximately 0.3 mm, with about 65% fine particles passing a 0.074 mm sieve. The tailings have up to 40% clay content as measured during typical operations. Tailings are poorly graded, with a relatively small coefficient of uniformity, have little to no clay content, and are non-plastic. They can therefore be classified as poorly graded sand with silt or silty sand, depending on the fines content (Pretivm 2015).

Geochemical Properties

Ore samples tested in both humidity cells and subaqueous column tests did not generate acid drainage and are therefore classified as NPAG (Pretivm 2015). This is supported by confirmatory sampling results for tailings which yield neutralization potential ratios above the PAG/NPAG threshold value of 2 (Pretivm 2018, 2019).

Similar to Brucejack waste rock, the ore is found to have elevated concentrations of sulfate, arsenic, cadmium, copper, selenium, and silver (Pretivm 2015). Humidity cell and subaqueous column testing resulted in elevated concentrations of arsenic, antimony, molybdenum, and selenium in leachate solutions, meaning that the tailings are susceptible to neutral metal leaching.

Confirmatory sampling programs developed to assess the geochemical characteristics of both tailings and sludge are outlined in the ML/ARD Management Plan (Lorax 2020).

Volumes

The milling process at this mine produces two streams of tailings:

- Paste thickened tailings that are co-disposed underground with waste rock and cement binder as backfill
- Slurry tailings that are pumped and transported via pipeline and deposited in the WRTSF

Pretivm has production flexibility to direct tailings streams depending on operational needs. This operational flexibility allows Pretivm to deposit between 32% to 50% of tailings into the WRTSF over time. Based on the 2018 authorization to 3,800 tpd ore mining rate, this equates to between 5.5 Mt (3.46 Mm^3 at 1.59 t/m^3) and 8.7 Mt (5.47 Mm^3 at 1.59 t/m^3). However, Pretivm is currently seeking approval on a revised Mine Plan submitted July 2020, with associated volumes of total deposited tailings in the WRTSF of between 3.7 Mt (2.74 Mm^3 at 1.35 t/m^3) and 5.8 Mt (4.27 Mm^3 at 1.35 t/m^3). Once approved, these will be the new limits to work within.

3.11 Site Reference Data

3.11.1 Topographical Mapping and Grid System

The Brucejack Mine is situated approximately at Universal Transverse Mercator (UTM) 426,967E; 6,258,719N in Zone 9 on the North American (NAD) 83 grid. The site uses the NAD83 UTM coordinate system. LiDAR surveys, at precision greater than 1 m, were conducted in 2013, 2014, and 2019.

3.11.2 Datum and Benchmarks

Locations of permanent survey benchmarks and back sights are illustrated in Figure 3. The crest of the waste rock deposition area is regularly surveyed using portable survey monuments placed along the WRD crest as the crest advances; this allows tracking and observing settlement, aiding in planning and reporting.

The elevation of the WRTSF surface changes over the course of the year and is not used as a survey benchmark or reference. As described in Section 3.4, instead there is a water elevation gauge that records the change in surface elevation.

3.11.3 Monitoring and Regulatory Compliance Points

As described in Sections 3.4 and 3.6, flow rates and quality of surface water are monitored at the WRTSF outflow at station BJ 3.10, and downstream monitoring stations BJ 2.62 and BJ 1.74. Flow and water quality are also monitored at the influent and effluent locations of the mine WTP in accordance with PE-107835.

Monitoring site BJ 3.10 is the legal water quality compliance location for water discharge from the WRTSF (location at which legal discharge limits apply). Table 3-1 lists the PE-107835 discharge limits for this station. Condition 4.8 of PE-107835 also stipulates additional possible requirements if there are any exceedances of the BC Water Quality Guidelines for Freshwater Aquatic Life.

Table 3-1: Discharge Limits for Effluent Permit 107835 at Site BJ 3.10

Parameter	Maximum	Units
48 hr *Daphnia magna* single concentration toxicity test	50% survival in 100% concentration, minimum (see also PE-107835 Condition 4.3)	-
Algal Growth Inhibition Test (EPS 1/RM/25)	Less than 25% for 100% Lake Outlet Water (see also condition 4.3)	-
Total Suspended Solids	30 (maximum); 15 (monthly average)	mg/L
pH	6.5-8.5	-
Nitrite	240	µg/L as N
Nitrate	11.5	mg/L as N
Ammonia	4.0	mg/L as N
Total Antimony	28	µg/L
Total Arsenic	10	µg/L
Total Iron	1.7	mg/L
Total Silver	0.46	µg/L

Source: British Columbia Mine Effluent Permit PE-107835 – Brucejack Mine

3.12 Facility Components

3.12.1 Waste Rock Dump Working Surface

The deposition floor elevation is to be maintained a minimum of 0.3 to 1.0 m above the WRTSF surface water elevation, whereas the deposition crest elevation is to be maintained 1.5 to 2.0 m above the WRTSF surface water elevation. Due to natural seasonal fluctuations in water level, a constant water elevation of 1,364.5 masl was used in the design. Any variances must be reviewed on a case-by-case basis and approved by the EOR.

All waste rock placed at the surface must be submerged in the WRTSF to a minimum depth of 1 m within two years of placement, as required by *Mines Act* Permit M-243 Condition D.3(c). Therefore, the working surface of the waste rock deposition area initially consists of PAG waste rock. As initiated by Pretivm operations, this surface is excavated in sections to a depth of greater than 1 m below the water surface and ultimately replaced with either freshly excavated PAG waste rock, NPAG rock from the km 72 NPAG Quarry, or left ponded. Additional information is provided in Section 4.2.5.

All vehicles on the waste rock dump working surface are restricted to a maximum speed of 20 km/h for waste rock dump safety, including due to steep grades, limited visibility, and single-lane width areas in certain locations.

3.12.2 Tailings Discharge Pipelines

Thickened tailings are conveyed from the mill (process plant) to the WRTSF by pumping the slurry through either of two 8-inch (200 mm) internal diameter pipelines. Tailings disposal pumps draw the thickened tailings from a disposal surge tank to the disposal pipelines. Pipelines are partially buried, insulated, and heat traced from the process plant to the shoreline of the WRTSF.

The initial tailings discharge design consisted of two tailings pipelines: one (#1) positioned a short distance above the lake bed, and a second (#2) suspended from a cable extending between anchor points located on the south and north shores of the WRTSF. In October 2017, the section of the #1 tailings discharge pipeline within the ponded portion of the WRTSF was replaced with a second line suspended on a second cable support system to improve function, this line is no longer used and has been replaced by a line extending outward from the shoreline on the lakebed. The elevations of the suspended pipelines are adjustable such that their outfalls (discharge elevations) are less than the maximum of 7.5 m above the tailings bed as required by PE-107835. The original configuration was designed by AMEC-Foster Wheeler and illustrated in the selected design drawings referenced in Appendix E.

The vertical distance from the outfall elevations to the top of the deposited tailings is determined from the annual bathymetric surveys.

3.12.3 Reclaim Weir

The reclaim weir is a measuring system and a pump station for reclaiming water from the WRSTF back to the mill.

3.12.4 Turbidity curtains

There are four sediment curtains located in the WRTSF. The first curtain spans from the southwest corner of the WRD to the southeast corner of the waste dump and extends 30 m deep into the WRTSF, effectively confining the WRD. Three smaller curtains are located in parallel across the lake outlet, upstream of the low level weir (LLW). Condition 3.1 of PE-107835 specifies that waste rock and tailings disposal must not take place unless these three curtains, at a minimum, are in place. These curtains are assessed for damage annually and repaired/adjusted as required based on the annual assessment.

3.12.5 Water Rescue Equipment

Water rescue equipment and infrastructure are positioned for easy access within the working area to be used in the event of an emergency. Life rings are located immediately adjacent to the active working area on the crest of the deposition area. Life jackets and survival suits are located in an intermodal shipping container at the entrance to the active deposition area. Equipment operators and supervisors are also provided safety and equipment training for working near and around water.

3.13 Regulatory Requirements and Best Practice Guidelines

3.13.1 Regulatory

Planning and design of the WRTSF and this OMS manual and its associated supporting documents incorporate regulatory requirements of the Brucejack Mine's major authorizations, as well as Canadian federal and BC provincial regulatory requirements and guidelines relevant to this facility and its operations. These all prioritize worker safety and environmental protection, and include the following:

- Environmental Assessment Certificate #M15-01 and the BC *Environmental Assessment Act* (2018)
- Decision Statement Issued under Section 54 of the *Canadian Environmental Assessment Act, 2012*
- *Mines Act* Permit M-243 and related requirements under the:
  - BC *Mines Act* (1996)
  - Health, Safety and Reclamation Code for Mines in British Columbia (MEMLI 2021)
  - Ministry of Energy and Mines (2016). Health, Safety and Reclamation Code for Mines in British Columbia – Guidance Document. Version 1.0. Updated July 2016 (MEM 2016).
  - Part 10 of the Health, Safety and Reclamation Code for Mines in British Columbia, (MEMLI 2021)
- Effluent Permit 107835 and related requirements under the BC *Environmental Management Act* (2004)
- Metal and Diamond Mining Effluent Regulations SOR/2002-222 (last amended June 25, 2019), which are enabled under the Canadian federal *Fisheries Act* (R.S.C., 1985) (last amended August 28, 2019)

3.13.2 Best Practice Guidelines

- *Mined Rock and Overburden Piles, Investigation and Design Manual, Interim Guidelines* (British Columbia Mine Waste Rock Pile Research Committee 1991)
  - Note this guideline does not apply to subaqueous deposition; however, Pretivm adopted the guideline design values to provide a basis for defining acceptable safety factors to facilitate development of safe work procedures
- *Guidelines for Mine Waste Dump and Stockpile Design* (Hawley and Cunning 2017)
- *Global Industry Standard on Tailings Management* (Global Tailings Review 2020)
- *Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities* (MAC 2021a)
- A guide to the Management of Tailings Facility Version 3.2 (MAC2021b)
- *Tailings Management: Good Practice Guide* (ICMM 2021a)
- C*onformance Protocols: Global Industry Standard on Tailings Management* (ICMM 2021b)

3.14 Design Principles

3.14.1 Waste Rock Deposition

The current design report that governs waste rock deposition was prepared by SRK Consulting (Canada) Inc. (SRK 2018). The main considerations in the development of the waste rock deposition plan are as follows:

- *Mines Act* Permit M-243 requires that a 1 m water cover be maintained over the deposited waste rock.
- The maximum time that waste rock may be left exposed above water is two years from the date of placement on the WRD. Three approved methods are employed to manage exposed waste rock exposed for longer than two years. These options are summarized in detail in Section 4.2.5.
- Three methods are used to deposit waste rock subaqueously into the WRTSF:
  - Remote operated dozer push: a remote operated dozer (no operator on-board equipment) is used to directly push run-of-mine waste muck and/or the coarse size fraction from active screening.
  - Telestacker conveyance: a telescoping radial conveyor stacker (Telestacker) is used to deposit waste rock into the WRTSF. An active screening system separates materials that can pass through a mechanical an 8-inch (200 mm) screen. The coarse rock is defined as screened material that is greater than 8-inch (200 mm) and fine material is defined as everything measuring less than 8-inch (200 mm). The smaller size fraction is deposited with a Telestacker.
  - Excavator bailing: a hydraulic excavator is utilized to place the coarse size fraction from active screening and/or run-of-mine waste muck. This method is referred to later in this document and related SOPs as “bailing.”
- The deposition of waste rock leads to rapid undrained loading of the foundation sediments at the bottom of the WRTSF. Because characteristics of foundation sediment vary across the waste rock deposition area (Figure 4), the magnitude of settlement are not consistent fixed values, but require continuous experiential judgment as applied by the senior site geotechnical engineers with support from the EOR as necessary.
- The senior site geotechnical engineers preparing the dump management plans ensure that observational settlement data meets the QPO before additional waste rock is deposited.
- Deposition planning is completed daily; lake bed profile near the waste rock slope, real-time survey monitoring and observational data are required to determine if dump settlement meets QPOs, and periodic bathymetric survey for the subaqueous waste rock slope profile will help the deposition planning.
- Sediment curtains are used to help manage and mitigate concentrations of total suspended solids discharged from the WRTSF.

- As deposition occurs, surficial failures of the waste rock slope and outer foundations occur. The deposition plan is designed to allow these to occur safely. The monitoring plan is designed to monitor and project for the development of any larger failures that could affect the safety of those working on or around the dump.
- Once the working surface of the deposition area is developed and provided that the geochemistry requirements are met, certain areas of the deposition area may be used for storage and/or stockpiling, should monitoring data confirm that settlement has slowed and the area is stable.

3.14.2 Tailings Deposition

The current process control designs were prepared by AMEC Foster Wheeler (2016). The design principles for tailings deposition at Brucejack Mine are summarized as follows:

- Thickened tailings are deposited into the WRTSF. The thickened slurry has a solids content (by weight) of 55% to 65%. Control of the tailings slurry water content is maintained by the dewatering equipment in the process plant.
- Thickened tailings are conveyed from the mill and processing infrastructure by pumping the slurry through one or both of two 8-inch (200 mm) internal diameter pipelines to the WRTSF. Tailings disposal pumps draw the thickened tailings from the tailings disposal surge tank.
- During periods when tailings are not conveyed to the WRTSF, the tailings lines are flushed with water to clear the pipelines of solids and to prevent sanding.
- During periods when the ambient air temperature is below freezing, a continuous flow of process water is required in both pipelines to prevent potential freezing. Water can be introduced into the tailings pipelines through a single injection point inside the mill building.
- Both pipelines are buried and insulated from the process plant to the shore of the WRTSF. In addition, approximately 100 m of pipeline, between the mill and the water's edge, is heat traced in addition to being insulated.
- There are two tailings pipelines, each suspended from a cable support system. The elevation of the outfalls above the underlying tailings mass is determined a minimum of annually via bathymetric survey, with the outfalls then raised during the open water season as necessary to maintain proper function while meeting the 7.5 m elevation restriction under Condition 1.3.2 of PE-107835.
- The pipelines and associated outfalls can be raised within the WRTSF by increasing the tension on the cable systems. The suspended pipelines are raised by pulling and shortening the cables. The backup anchor cable is pulled using a piece of heavy equipment such as a tracked bulldozer or an excavator. The main cable will be pulled, shortened, and reconnected to the anchor. Shortening the cable by 6 m will raise the outlet of the tailings discharge by 11 m. After the main cable is shortened, the backup anchor cable can then be shortened.
- The pipeline suspension cable system is designed for the cable to be raised to its ultimate elevation while fully operational.

4 Operation

4.1 Deposition Planning

4.1.1 Life of Mine

All waste rock and tailings produced at the Brucejack Mine that are not used as backfill are to be placed subaqueously in the WRTSF. Deposition of waste rock is to occur from the WRD located on the southwestern shore of the WRTSF. Over the life of mine (LOM), the WRD will advance outwards from the shore across multiple deposition zones as described in Section 4.2. At Closure, the WRD will occupy a portion of the natural basin that forms the WRTSF, with all PAG material remaining submerged below the water surface of the WRTSF. Thickened tailings produced in the mill are to be distributed to the lake via pipeline and deposited at depth, near the centre of the WRTSF as described in Section 4.3. The outfall of the distribution lines will be progressively raised over time, such that a submerged mound of tailings will gradually fill the natural basin that forms the WRTSF from the bottom up. At Closure, tailings will occupy a substantive portion of the deeper portion of the WRTSF; the top of tailings mound will remain submerged below the water surface of the WRTSF by several tens of metres.

The current authorized limits for total waste and tailings deposition is to a maximum 5.3 Mt (2.6 Mm^3 at 2.06 t/m^3) of waste rock and 8.7 Mt (5.47 Mm^3 at 1.59 t/m^3) of tailings, and total combined maximum waste deposition of 10.8 Mt (i.e., waste rock and tailings)as described in *3800 tpd Amendment Application for Permits M-243 and PE-107835* (Pretivm 2017b). The revised limit for total waste deposition (i.e., waste rock and tailings) to the WRTSF based on the 2020 mine plan (submitted July 2020; Pretivm 2020b) will be 9.6 Mt.

Deposition is also indirectly limited by water quality at the outlet of the WRTSF that is to remain within effluent discharge limits for several water quality parameters. Compliance with discharge limits is achieved through source control of inputs to the WRTSF. Waste rock and tailings constitute the predominant source of constituent loadings for several parameters for which there is a discharge limit. As such, the deposition rate and total deposition of waste rock and tailings consider actual and future predicted water quality of the WRTSF. Limitations on deposition may be necessary beyond the specific volume limits to maintain effluent quality compliance at the point of discharge.

The schedule of planned waste rock and tailings deposition in the WRTSF is shown in Figure 4-1 for current LOM plan (Pretivm 2020b). Figure 4-2 illustrates the associated progressive development of the WRD and subaqueous tailings mound. It must be noted that additional authorization is required to increase total allowable LOM deposition to accord with 2020 Mine Plan (Pretivm 2020b).

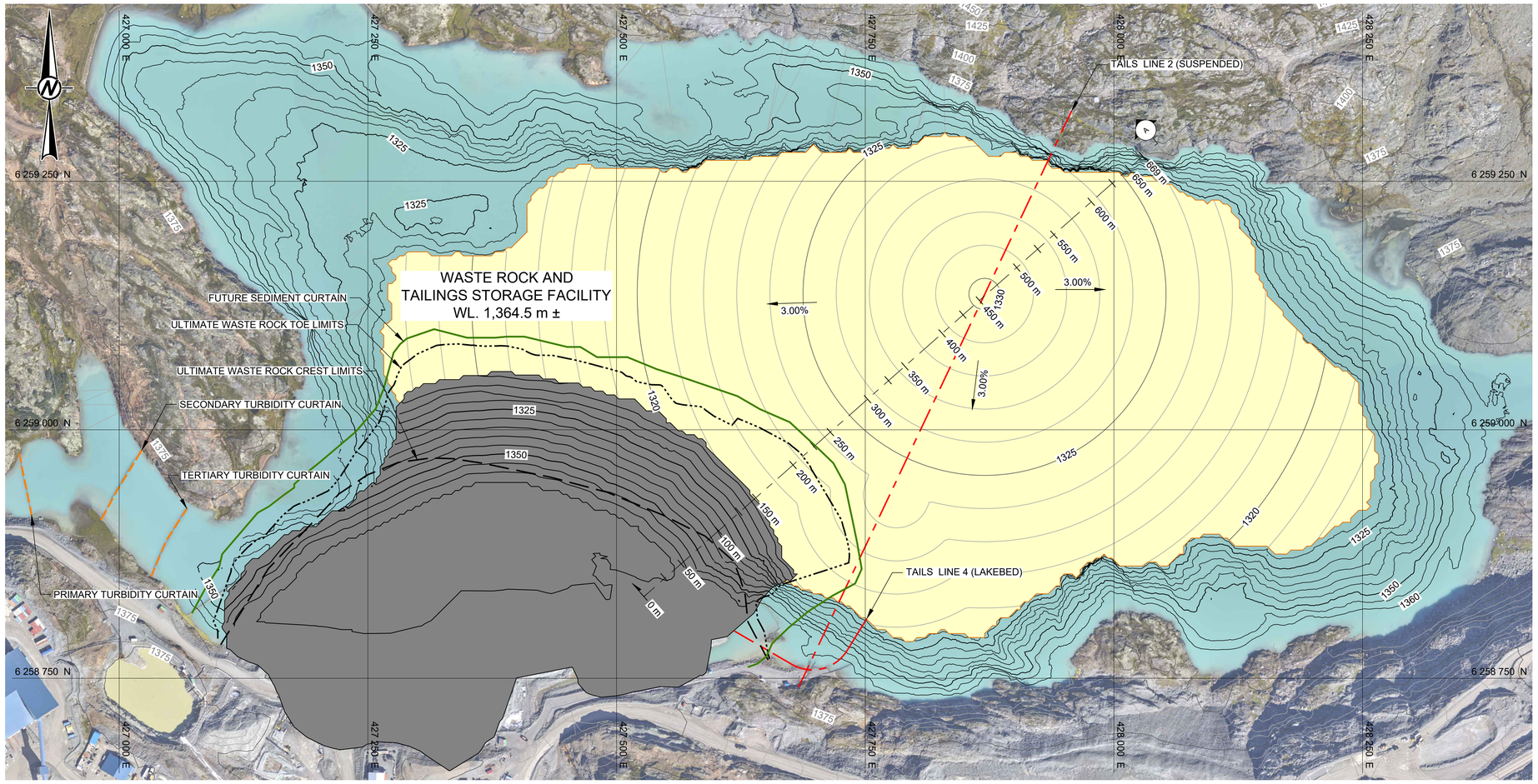
At a minimum, the LOM deposition plan is to be reviewed by the WRTSF RP and EoR each time the mine plan is updated to ensure accordance with total allowable deposition volumes, or to identify the need for changes to the deposition plan or authorized limits. Additional predictive water quality assessments may be required to understand potential implications to water quality compliance requirements as a result of an increase in total LOM deposition.

4.1.2 Annual

An annual deposition plan is to be prepared as part of the annual mine planning and budget process. The annual plan will provide a monthly schedule of waste rock and tailings deposition in the WRTSF based on:

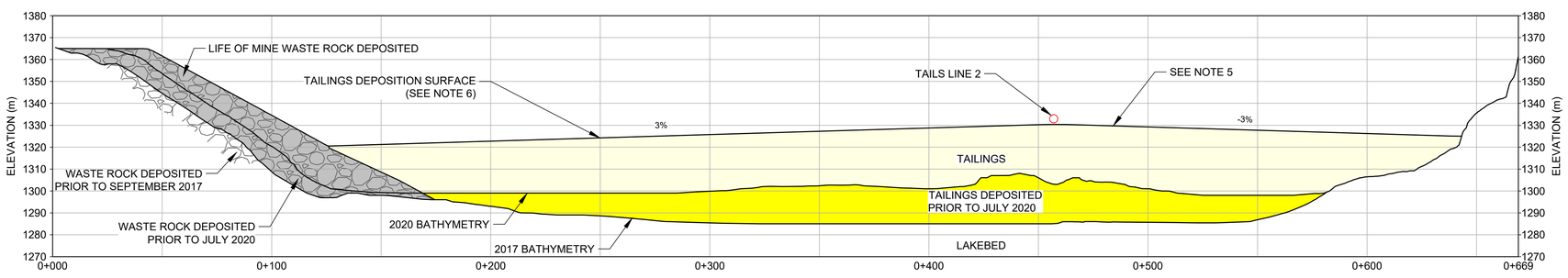
- Mine development and production schedules
- Known deposition limitations related to:
  - Geotechnical risks
  - Equipment efficiencies
  - Seasonal environmental considerations (e.g., water column turnover, ice on/off periods)
- Other objectives (e.g., depletion of surface stockpiles)

There must be a clear understanding of accordance between the annual and LOM deposition plans. Planning over shorter time periods (e.g., monthly, weekly, daily) is described as relevant in Sections 4.2 and 4.3.



WASTE ROCK AND TAILINGS STORAGE FACILITY PLAN

SCALE 1:2 500 m



SCALE 1:1 250 m (A) WASTE ROCK AND TAILINGS STORAGE FACILITY PROFILE

LEGEND

- 2019 EXISTING GROUND CONTOURS (SEE REFERENCE 1)
- 2020 BATHYMETRIC CONTOURS (SEE REFERENCE 2)
- APPROXIMATE 2019 SEDIMENT CURTAIN LOCATIONS
- APPROXIMATE FUTURE SEDIMENT CURTAIN LOCATION
- APPROXIMATE TAILINGS DISCHARGE LINE
- YEAR 15 TAILINGS DEPOSITION AREA
- WASTE ROCK DEPOSITION AREA
- ULTIMATE WASTE ROCK TOE LIMITS
- ULTIMATE WASTE ROCK CREST LIMITS

NOTES

1. ALL UNITS ARE IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES SHOWN IN UTM, NAD 83, ZONE 9. ELEVATIONS RELATIVE TO GEODETIC DATUM.
3. CONTOURS SHOWN AT 25 m MAJOR AND 5 m MINOR INTERVAL.
4. TAILINGS DEPOSITION AT END OF MINE LIFE, YEAR 15 (8.46 Mm^3 TAILINGS).
5. TOP OF TAILINGS CONE EXPECTED TO BE AT 6% GRADE OR LESS (TYPICALLY TAILINGS DEPOSITION ANGLE OF 3% EXPECTED) PER SRK (2015)
6. LOWER LIMIT OF TAILING DEPOSITION RUN-OUT ANGLES EXPECTED TO BE GREATER THAN 1% (TYPICALLY TAILINGS DEPOSITION ANGLE OF 3% EXPECTED) PER SRK (2015).

REFERENCES

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2. 2020 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 08 JULY 2020, RECEIVED: 16 MARCH 2021, FILE NAME: "ACAD-20-213 REV1_20200708 BruceJack Lake Bathymetric Survey Geo.dwg".
3. 2019 AERIAL PHOTO PROVIDED BY PRETIUM RESOURCES LTD., RECEIVED: 18 MARCH 2021, FILE NAME: "Brucejack_2019_Clip.tif"
4. SRK (SRK CONSULTING CANADA INC.) 2015. BRUCEJACK PROJECT - WASTE ROCK AND TAILINGS MANAGEMENT PLAN DESIGN REPORT - DRAFT. OCTOBER 2015

NOT FOR CONSTRUCTION

0 50 100
1:1,250 METRES

0 100 200
1:2,500 METRES

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DESIGNED	C. CARTWRIGHT
PREPARED	T. KLASSEN/A.DONG
REVIEWED	C. CARTWRIGHT
APPROVED	J.KWOK

PROJECT
BRUCEJACK GOLD MINE
TAILINGS DEPOSITION

TITLE
WASTE ROCK AND TAILINGS STORAGE FACILITY
LIFE OF MINE - YEAR 15 - PLAN AND PROFILE

PROJECT NO.	DOC.	REV.	FIGURE
20368347	013	0	4-1

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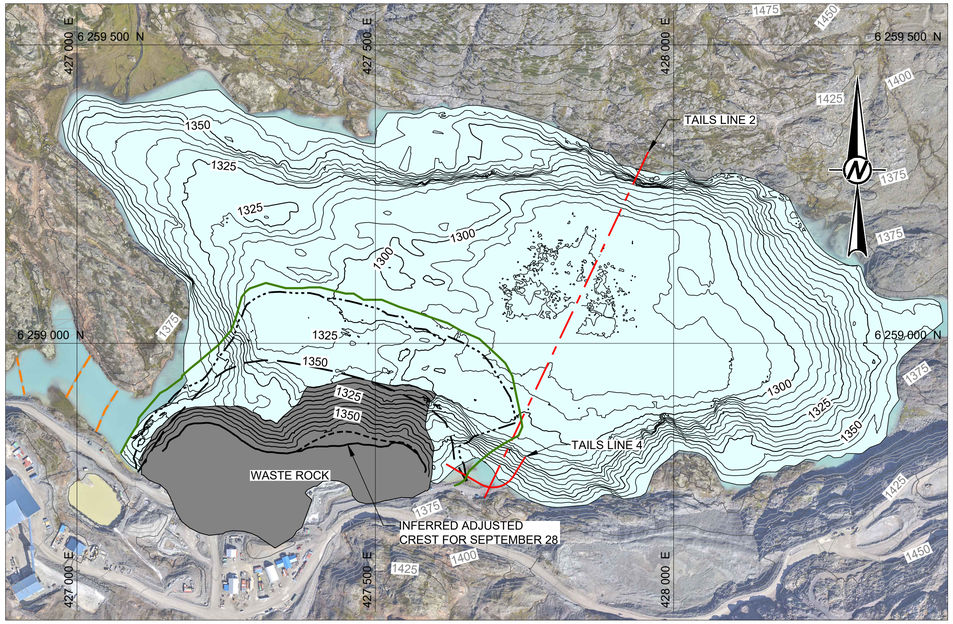
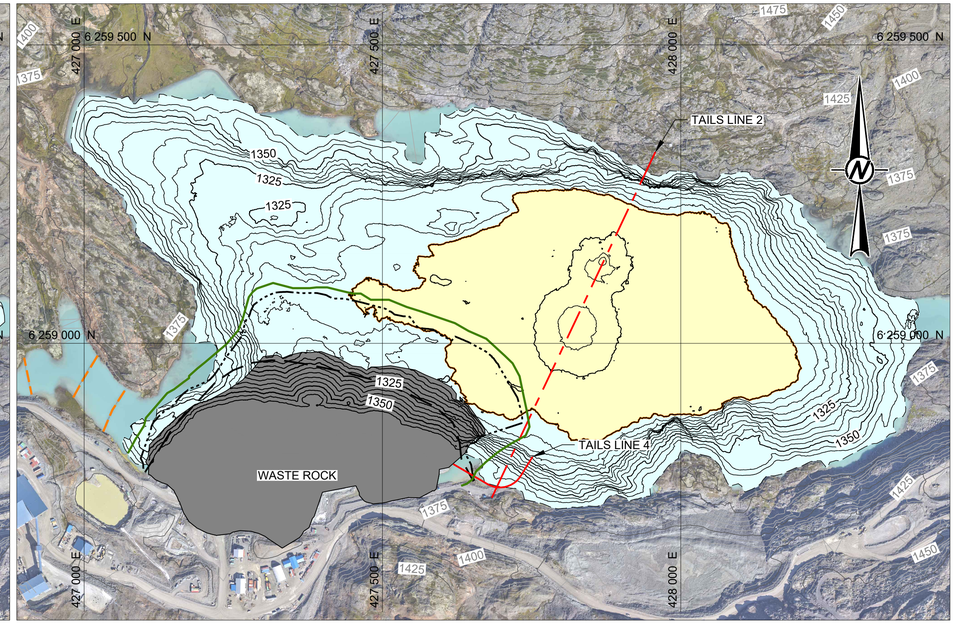


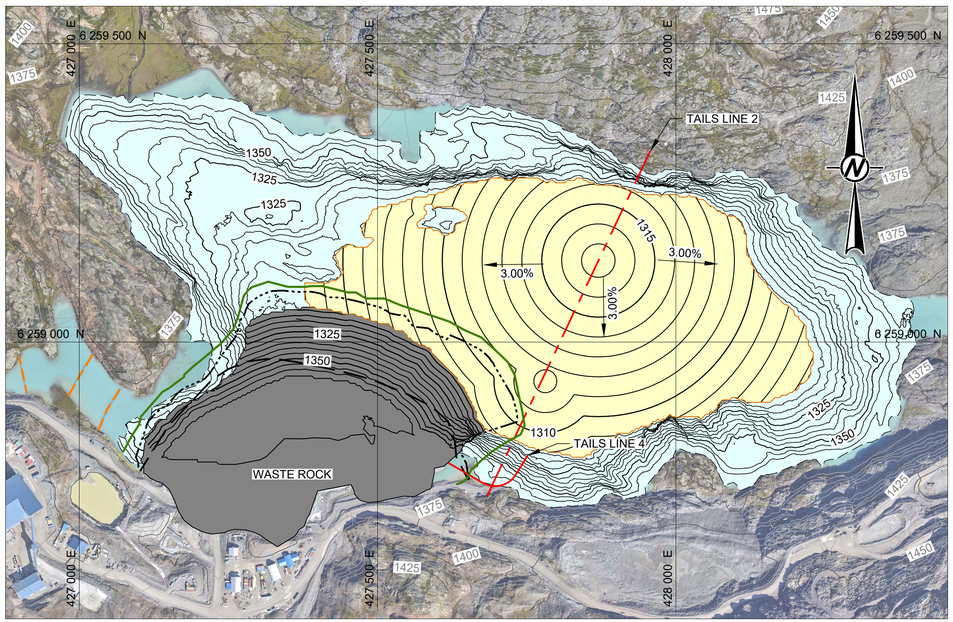
2017 (YEAR -1) (PRIOR TO TAILINGS DEPOSITION)

SCALE 1:5 000 m (1.12 Mm³ WASTE ROCK)



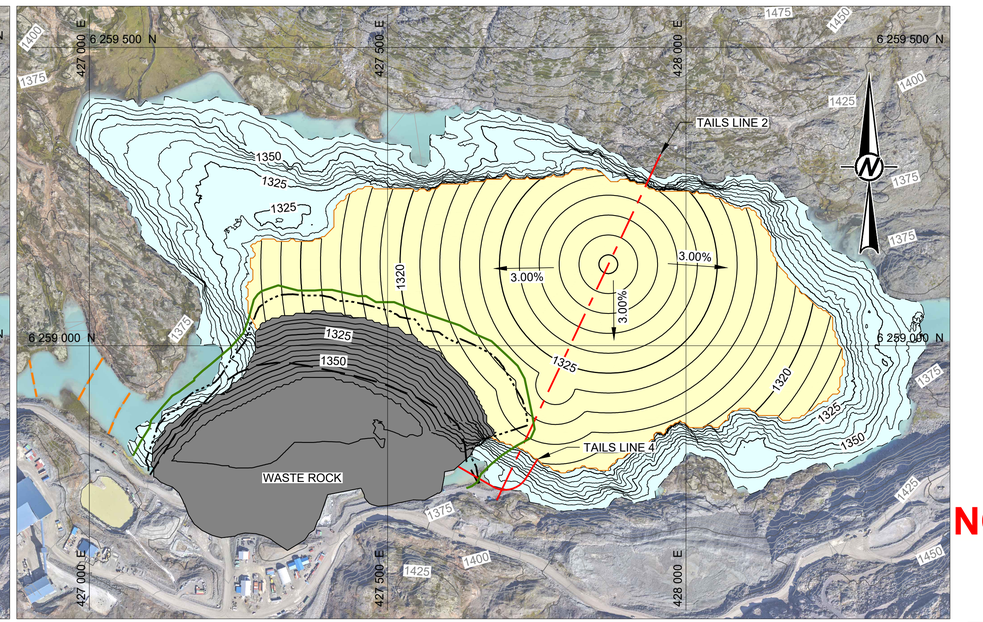
2020 (YEAR 3) EXISTING CONDITION (1.68 Mm³ TAILINGS)

SCALE 1:5 000 m (1.99 Mm³ WASTE ROCK)



2024 (YEAR 7) (4.75 Mm³ TAILINGS)

SCALE 1:5 000 m (3.00 Mm³ WASTE ROCK)



2032 (YEAR 15) LIFE OF MINE (8.46 Mm³ TAILINGS)

SCALE 1:5 000 m (3.03 Mm³ WASTE ROCK)

LEGEND

- 2019 EXISTING GROUND CONTOURS (SEE REFERENCE 1)
- 2020 BATHYMETRIC CONTOURS (SEE REFERENCE 2)
- APPROXIMATE 2019 SEDIMENT CURTAIN LOCATIONS
- APPROXIMATE FUTURE SEDIMENT CURTAIN LOCATION
- APPROXIMATE TAILINGS DISCHARGE LINE
- APPROXIMATE TAILINGS DEPOSITION AREA
- WASTE ROCK DEPOSITION AREA
- ULTIMATE WASTE ROCK TOE LIMITS
- ULTIMATE WASTE ROCK CREST LIMITS

NOTES

1. ALL UNITS ARE IN METRES UNLESS NOTED OTHERWISE.
2. COORDINATES SHOWN IN UTM, NAD 83, ZONE 9. ELEVATIONS RELATIVE TO GEODETIC DATUM.
3. CONTOURS SHOWN AT 25 m MAJOR AND 5 m MINOR INTERVAL.
4. TAILINGS DEPOSITION AT END OF MINE LIFE, YEAR 15 (8.46 Mm^3 TAILINGS).
5. TOP OF TAILINGS CONE EXPECTED TO BE AT 6% GRADE OR LESS (TYPICALLY TAILINGS DEPOSITION ANGLE OF 3% EXPECTED) PER SRK (2015).
6. LOWER LIMIT OF TAILING DEPOSITION RUN-OUT ANGLES EXPECTED TO BE GREATER THAN 1% (TYPICALLY TAILINGS DEPOSITION ANGLE OF 3% EXPECTED) PER SRK (2015).

REFERENCES

1. 2019 LIDAR SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 25 OCTOBER 2019, RECEIVED: 16 MARCH 2021, FILE NAME: "BJ_Lidar2019_Contour.shp".
2. 2020 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 08 JULY 2020, RECEIVED: 16 MARCH 2021, FILE NAME: "ACAD-20-213 REV1_20200708 BruceJack Lake Bathymetric Survey Geo.dwg".
3. 2019 AERIAL PHOTO PROVIDED BY PRETIUM RESOURCES LTD., RECEIVED: 18 MARCH 2021, FILE NAME: "Brucejack_2019_Clip.tif".
4. SRK (SRK CONSULTING CANADA INC.) 2015. BRUCEJACK PROJECT - WASTE ROCK AND TAILINGS MANAGEMENT PLAN DESIGN REPORT - DRAFT. OCTOBER 2015

NOT FOR CONSTRUCTION

0 200 400
1:5,000 METRES

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CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-06-15
DESIGNED	C. CARTWRIGHT
PREPARED	T. KLASSEN/A.DONG
REVIEWED	C. CARTWRIGHT
APPROVED	J.KWOK

PROJECT
BRUCEJACK GOLD MINE
TAILINGS DEPOSITION

TITLE
TAILINGS AND WASTE ROCK DEPOSITION SEQUENCE (YEAR -1 TO 15)

PROJECT NO.	DOC.	REV.	FIGURE
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4.2 Waste Rock Management

4.2.1 Waste Rock Volumes and Schedules

Pretivm has operational flexibility to backfill waste rock in the underground mine or dispose of it in the WRTSF. With this flexibility, the volumes and schedules of waste rock transported and disposed of in the WRTSF will fluctuate. Based on waste rock haulage data tracked by Pretivm's geotechnical engineers, an average of 1,150 m^3 per day is transported to the WRTSF. However, due to operational flexibility, the actual rate of waste rock transported to the WRTSF is observed to deviate from the average, producing a range of volumes between 0 m^3 per day and 2,000 m^3 per day.

4.2.2 Waste Rock Dump Planning

The waste rock deposition system consists of placing waste rock into the WRTSF. Nine approved deposition zones define the active areas of WRD where waste rock can be placed into the WRTSF (Figure 5). Planning and engineering efforts determine which of the zones will accept waste rock for deposition. The activity of the zones is decided by Pretivm's geotechnical engineers based on settlement and stability of the WRD.

WRD planning is a daily activity to be carried out by site staff as dictated in Table 2-1 of this OMS manual. The specific elements of this planning are summarized as follows:

- The OMS manual and accompanying SOPs provide the principles for deposition planning.
- Pretivm's geotechnical engineers collect and review settlement data all year and collect bathymetry survey data during ice free conditions to support daily deposition planning.
- Pretivm's geotechnical engineers prepare daily deposition plans that are communicated to supervisors. Daily plans include the zone(s) where active deposition is to occur and the duration of deposition.
- The daily deposition plan is discussed with supervisors and operations staff at the start of each shift. Any deviation from the plan must be approved by Pretivm's geotechnical engineers.
- The deposition plan is flexible to accommodate changing weather conditions. For example: When poor visibility affects the operator's ability to see potential hazards, the operator is to cease the work and notify the supervisor immediately and the deposition plan can be discussed and revised.

For waste rock deposition with the remotely controlled dozer, frequent localized bathymetric surveys along the face of the WRD are required to monitor the underwater waste rock slope profile.

4.2.3 Waste Rock Deposition Procedure – Remote Controlled Dozer

Waste rock deposition procedures are outlined in detail in Appendix B2 and B3. A summary of Pretivm's SOP is as follows:

Step 1: Waste rock transported by trucks from the underground portals arrives on the WRD area.

Step 2: Pre-shift preparations include daily planning, checking monitoring data, remote control station setup, and snow clearing and ice breaking in the winter.

Step 3: A remote controlled dozer advances the waste rock into the WRTSF while maintaining the berm profile.

Key to the waste rock deposition with remote controlled dozer method, the following processes are focused on the overall safety of the workers and the stability of the WRD:

- A berm that has a minimum height of 1 m must be maintained along the waste dump crest at all time.
- A 10 m restriction zone from the waste dump crest must be delineated and be adhered to.
  - Outside of the active dozing zone for the day, markers must be in place at all times to delineate the “no-entry” zone, which is to be a minimum of 10 m from the crest.
  - No conventionally operated equipment may enter the 10 m restriction zone.
  - Only personnel with approval from the remote dozer operator and the engineer are permitted within the 10 m restriction zone in an active dozing area. Only personnel with approval from the engineer are permitted within the 10 m restriction zone in inactive dozing areas. Those permitted must wear PPE that includes a floatation device and a harness with lifeline, and must be accompanied by a spotter located outside of the 10 m restriction zone.
  - Haul trucks must end dump waste rock outside of the 10 m restriction zone in an approved location detailed in the daily deposition plan.
  - At no time is a dozer to operate with its tracks parallel to the dump face inside the 10 m zone.
  - At no time is any equipment to be parked, or materials stored, within the 10 m zone.
- The waste rock surface must be maintained at a minimum elevation of 0.3 to 0.5 m above the water surface as the crest advances away from the shoreline.
- During winter subaqueous deposition, waste rock must not be placed directly onto ice. A piece of long-reach equipment (long-reach excavator or crane) is to be parked outside of the 10 m restriction zone to break ice in front of the waste dump crest where remote dozer is planned to deposit waste rock into lake. Any snow accumulation greater than 0.5 m in depth must be removed from the top surface of the WRD 30 m east and west of the deposition area prior to the placement of additional rock.
- As the waste dump crest advances, the muck berm along the crest must be maintained with its dimension.
- The waste rock dump front crest scan will be conducted as per Pretivm’s geotechnical engineers’ requirement to help determine the active remote dozing zone.
- As the crest advances, a Tiltmeter beam and slide movement monitor is installed to provide continuous settlement monitoring.

- Pretivm's geotechnical engineers determine the commencement of further crest advancement. Zones that have been identified as High Risk by Pretivm engineers or the EOR must follow additional measures outlined in Table 6-3 (Section 6.4).
- Localized bathymetric survey may be requested by Pretivm's geotechnical engineer to monitor the underwater waste rock slope profile.
- Where stockpiles of waste rock and snow must be constructed, a minimum of 40 m between stockpile and the crest of the dump must be maintained. Placement locations and material types must be discussed with the EOR.

4.2.4 Waste Rock Deposition Procedure – Stacker / Bailing System

Waste rock dumping procedures are outlined in detail in Appendix B1. A summary of the Pretivm's SOP is as follows:

Step 1: Waste rock transported by trucks from the underground portals arrives on the WRD area.

Step 2: A mechanical vibrating screen with conveyor separates the waste rock into two size fractions: greater than 8 inches (200 mm) and less than 8 inches (200 mm) passing through the screen.

Step 3: A hydraulic excavator places all the coarse rock larger than 8 inches (200 mm) and the conveyor transfers waste rock that is smaller than 8 inches (200 mm) to a telescoping stacker conveyor.

Step 4: A telescoping conveyor stacker (TeleStacker) advances the waste rock that is less than 8 inches (200 mm) in size into the WRTSF.

Key to both waste rock deposition methods, the following processes are focused on the overall safety of the workers and the stability of the WRD:

- A berm that has a minimum height of 1 m and a crest width of 3 m must be maintained along the perimeter of the waste rock deposition area at all times.
- A 10 m setback from the WRD crest must be adhered to for equipment and personnel working on the WRD. This distance is informed by stability assessments of the WRD.
    - Markers must be in place at all times to delineate the "no-dumping" zone, which is to be a minimum of 10 m from the active crest.
    - At no time is a bulldozer or excavator to operate with its tracks parallel to the dump face or wheels of the stacker be placed inside the 10 m zone.
    - At no time is a piece of equipment to be working individually within the 10 m zone; an additional operator or person to act as a spotter is needed while the work is performed.
    - At no time is any equipment to be parked, or materials stored, within the 10 m zone.

- Trucks must end dump waste rock along the designated 10 m crest offset zone. The dump operators may direct the location of individual loads along the 10 m crest offset zone and stockpile locations near the screening equipment. A bulldozer or excavator then advances the loads to the edge of the WRTSF.

– The waste rock surface must be maintained at a minimum elevation of 0.3 to 0.5 m above the water surface as the crest advances away from the shoreline.

– Pretivm's conveyor and screen shutdown-and-lock-out policy must be followed when shutting down the equipment for maintenance and repair. The loading operator must accompany the maintenance personnel during maintenance and remain a safe distance from their work.

– During operation and before starting up the conveyor, all guards, fences, and safety shielding must be attached and operational.

– During winter subaqueous deposition, waste rock must not be placed directly onto ice. An excavator must be used to break and remove ice, if necessary, along the deposition area. Any snow accumulation greater than 0.5 m in depth must be removed from the top surface of the waste rock 30 m east and west of the deposition area prior to the placement of additional rock.

– As the crest advances, a berm must be constructed along the crest. Settlement monuments must be placed atop these berms immediately after they are constructed. Baseline surveys of the settlement monuments are required immediately after the berms are completed.

– Pretivm's geotechnical engineers determine the frequency of additional surveys and make the final decisions regarding the re-entry of recently deposited zones and commencement of further crest advancement. Zones that have been identified as High Risk by Pretivm engineers in collaboration with the TSF QP and EOR must follow additional measures outlined in Table 63 (Section 6.4).

– Where stockpiles of waste rock and snow must be constructed, the setback distance from the stockpile to the crest of the dump must be a minimum of 40 m. Placement locations and material types must be discussed with the EOR.

4.2.5 Waste Rock Management Plan

Mines Act Permit M-243 Conditions D.3(c) (iv) and (v) require that all waste rock deposited in the WRTSF be covered with a minimum of 1 m water cover and limit temporary storage of waste rock on surface to a maximum of two years. Waste rock temporarily stored above the permanent flooding elevation and nearing the end of the allowable exposure period is managed following three possible methods:

– Replace waste rock that is approaching the exposure time of two years, to a minimum depth of 1 m below water surface, with NPAG quarried rock from the km 72 NPAG Quarry. The excavated material is then deposited subaqueously following the procedures described above. This method is suitable for dump surface where it is far from the dump crest where settlement is minimal.

- Replace PAG waste rock that is approaching an exposure time of two years, to a minimum depth of 1 m below water surface, with freshly excavated waste rock from mine development areas. This method is suitable for the dump surface which is not far from the dump crest where active settlement occurs that frequent waste rock placement is required to maintain the elevation of the dump surface above water elevation.
- Sub-excavate PAG waste rock that is approaching an exposure time of two years to a minimum depth of 1 m below water surface and retain a temporary pond in the excavated area. Note: this method is temporary and seasonal and will not be used during the winter when temperatures are below freezing.

Appendix B4 contains the Pretivm SOP for WRD PAG material replacement, which addresses these three methods. The WRD is managed using a combination of these methods to address operational needs while addressing permit requirements. All three methods entail excavation and removal of "old" PAG material to the same elevation; therefore, the same SOP can address all three options.

Sub-excavation Procedure

- Pretivm's geotechnical engineer must issue a daily plan for sub-excavation tasks at the start of shift and discuss the plan with crews at the morning toolbox meeting.
- The sub-excavation procedures must include the following items:
  - Locations and sequencing of sub-excavation and replacement activities
  - Locations where temporary ponded excavations will occur and expected duration
  - Locations where institutional controls and safety measures are to be constructed
- Daily plans must be provided to surveyors for surveying and demarcating sub-excavation area with survey stakes.
- Designated waste rock is removed by heavy equipment and deposited into the ponded portion of the WRTSF in adherance to the normal WRD SOP.
- The entire sub-excavation must be excavated to a minimum depth of 1 m below the water level (at or below 1,363.5 masl).
- The geotechnical engineer measures and marks out the prescribed depth on the excavator bucket or staff gauge and asks the operator to test the depth of the sub-cut in a number of locations and photo-document where the excavation has been properly cut to 1 m below the water table.
- The perimeter of the open excavation must be guarded with a minimum 1 m high safety berm. The safety setback distance is 3 m imposed by the safety berm and applies to all sub-excavation areas.
- Once the sub-excavation is complete, the operator must inform the supervisor, who must inform Pretivm's geotechnical engineer that the excavation is complete. Pretivm's geotechnical engineer documents the progress of replacement excavations.

Working Surface Backfill Procedures

- Pretivm's geotechnical engineer determines the material types (PAG or NPAG) that may be backfilled into the sub-excavations and where these materials will be deposited.
- To complete backfilling, the haul truck operators must dump (PAG or NPAG) material from a specified origin, and the bulldozer operator pushes the material to backfill the excavated area.
- Haul trucks must dump waste rock a minimum 5 m from perimeter safety berm (i.e., a minimum of 8 m from the crest of the excavation).
- The completion date and location for each backfilled sub-excavation is recorded in digital drawing records.

Temporary Ponded Area

- Temporary ponded areas that result from leaving an open sub-excavation are intended to only be used during snow- and ice-free months. Pretivm's geotechnical engineer must identify where ponded areas are located on the operational maps and how long they are intended to be exposed.

Safe Work Procedure

- Safe Work Procedures for the waste rock replacement and deposition plan share the common safe practices as defined for work on the WRD. In addition to the common safe practices, the following procedures are defined:
  - There is a 3 m exclusion "Do Not Pass" set back area around the perimeter of an open excavation.
  - There is a 1 m high safety berm around the perimeter of an open excavation, set back 3 m from the excavation edge.
  - No worker is to enter an excavation.
  - Any changes to the excavation and deposition plan are to be communicated immediately to all staff working on the dumpsite.

4.2.6 Waste Rock Dump Emergency Evacuation and Re-entry Plan under Seismic Loading

Seismic loading of the WRD foundation results in undrained foundation conditions, which result in an unstable WRD. Therefore, Pretivm will evacuate the WRD during any triggered earthquake events, and only re-enter the area after it has been deemed safe by the EOR and authorized by the WRTSF RP and Health & Safety. Included below is a summary of the WRD Emergency Evacuation Plan for evacuating the WRD when a significant seismic event occurs. This plan is detailed in Appendix F.

- **Trigger** – Based on the Modified Mercalli Scale of 1931, a seismic trigger event is a ranked on a Mercalli Scale of II (equivalent peak ground acceleration of 0.0017 *g* to 0.005 *g*). Ground motion of this scale is typically felt indoors by a few people at rest, especially on upper floors of multi-story buildings. Birds and animals are disturbed, and trees, structures, liquids, and bodies of water may sway. Delicately suspended hanging objects may swing.

- **Announcement** – Pretivm dispatch operators must immediately announce a “STOP WORK ON THE WASTE DUMP” on the radio to all personnel on the WRD on the dispatch “All Call” Channel
- **Evacuation** – All Pretivm personnel and contractors must immediately:
  - De-energize equipment (put bulldozer blades and excavator buckets down and shut down all motors).
  - Leave their equipment, taking with them their radio, their floatation devices, and specialized PPE (weather-appropriate clothing).
  - Retreat from their equipment in a direction perpendicular from the dump crest and water’s edge, preferably walking directly towards the WRD access road.

  The Site Operations Supervisor must immediately barricade all access roads to the WRD and put up signage to prevent all access.
- **Muster** – All people on the WRD at the time of the evacuation order must muster at the warehouse building.
- **Engineering Assessments and Stability Review** – Following an earthquake:
  - The EOR must be contacted immediately after an evacuation order has been placed on the WRD due to a seismic event.
  - Pretivm geotechnical engineers must complete visual inspections of the WRD and a detailed survey of the settlement monuments and settlement data.
  - Subsequent surveys on monuments must inform that the WRD meets stability QPOs outlined in the OMS manual before personnel are approved to enter the WRD. Agreement for a re-entry permission must be reached between the EOR, Mine Site geotechnical engineers, and the mine manager, who will authorize re-entry to the WRD.
- **Re-entry to Waste Rock Dump** – Mine Manager’s authority.

4.3 Tailings Deposition Management

4.3.1 Tailings Volumes and Schedules

Tailings deposition is not a fixed flow system where a unit rate flow of tailings will enter the WRTSF on an hourly basis. A portion of tailings generated in the refinement process is also placed back into the underground mine as paste backfill. When there is an excess of tailings being generated, that excess volume is conveyed to the WRTSF for subaqueous deposition. Sludge generated from the WTP, amounting to up to 2% of the tailings, is mixed with the mine tailings to be deposited in the WRTSF. During the co-disposal of WTP sludge, the sludge is mixed with tailings in the thickening tank prior to entering the tailings pipeline.

4.3.2 Tailings Deposition Operations

The following summarizes tailings deposition monitoring and maintenance:

- The mill team is responsible for tailings pipeline operations, including tracking the deposition elevations of the tailings and the discharge pipes and supervising adjustment of the tailings support cables. The support cable adjustments are implemented by the surface operations team.
- Pretivm's engineering team is responsible for maintaining the pipeline support cables monitors and prescribing adjustments to the support cables and maintenance needs on the pipeline system.
- The tailings pipelines are inspected daily by or under the supervision of mill maintenance supervisors, with observations recorded in the maintenance forms.
- Routine maintenance shutdowns are planned based on equipment needs.
- Adjustments to the elevation of each tailings pipeline discharge are made based on digital measurements of the relative difference in elevation between the tailings surface and the discharge pipe. Bathymetric surveys are completed to determine when the elevation of suspended tailings discharge pipeline requires adjustment. The elevation difference between the pipe and tailings is required to be maintained at no more than 7.5 m.
- Each tailings pipeline must be inspected for obvious signs of damage, especially around pipe welds and flanges. Any areas of the ground that show any discoloration or signs of previous leakage could indicate pipe leakage.
- A breather shack houses the pipelines' air vent valves before the pipelines enter the WRTSF. This shack must be inspected for signs of excessive venting that may cause minor tailings leakage, and the air vent valves must also be checked and maintained to prevent plugging. The tailings pipelines are insulated and heat-traced and must be inspected for damage and proper operation. Pretivm Electrical is to be contacted if the indicator lights are not active on the heat trace.
- A tailings pipeline suspension cable suspends each tailings line above the bottom of the WRTSF. These cables are under high tension and must not be approached. If there is debris, snow, or ice hanging on the suspension cable, contact site services to handle, as the removal of ice/snow may cause the cable to snap back.
- During winter, the tailings lines are likely to be covered in snow. Look for areas of depressions in the snow that may indicate enhanced melting around the pipes. The tailings are generally warm (~10°C) and if there is a leak, the snow in the area will melt and become discoloured (grey).

4.3.3 Tailings Deposition Procedures

Tailings deposition procedures are summarized as follows:

Pre-operation Inspection

- Within the mill: discharge piping of tailing discharge pumps 3126-PU-005/006 to the interior wall of the mill building, located near the southern bay door near the gold room.
- Exterior of mill: exposed discharge piping just east of the heavy-duty mechanic shop, downhill to the intersection of the west zone access road and lakeshore drive.
- As the inspection continues beyond the warehouse, notify dispatch on Repeater 1 channel as follows: “Hello Dispatch, this is ‘Operator’ and ‘Supervisor’ travelling onto lakeshore drive to inspect the tailings pipe. We should only require 15 minutes and will check-in when complete.” Then wait for dispatch to acknowledge your radio communication and continue driving along lakeshore drive about 100 m east of the warehouse. At this point, turn left along the road that runs parallel with the eastern diversion ditch of the lake. The tailings and water discharge piping will now be on the right-hand side of the road as you are facing east.
- Exterior of mill: lakeshore drive (east of the warehouse) along the east diversion ditch to the shoreline of the WRTSF.
- When you return from the inspection, contact dispatch on Repeater 1 channel and ensure dispatch acknowledges your communication.
- Once the tailings lines have undergone a pre-operation inspection, notification is to be sent to the control room operator that the tailings lines are good for use. At this point, the control room operator can begin tailings discharge (see procedure below) and the inspection team is to verify there are no leaks from the pipework on their return trip to the mill.
- An inspection log sheet must be filled out and filed in the metallurgy office for each inspection.

Running Inspection and Operation

A summary of the procedure for tailings inspection and operation of the tailings disposal system includes the following:

- Verify tailings line status as stated in the pre-operation inspection procedure above.
- Determine in which line the tailings are to be conveyed to the WRTSF.
- Have the tailings dewatering operator verify the position of valves at the tailings disposal pumps.
- The control room operator should now direct the thickened tailings from the underflow pumps to the tailings disposal. The operator will also control the agitator inside the tailings disposal tank once the liquid level is above the agitator blades.
- The field operator must visually verify the automated and manual valve positions prior to operating the disposal pump.

- During tailings disposal, the pumps must be monitored for abnormal noise, current draw, and other mechanical abnormalities. Pump failure or mechanical faults must be reported to the maintenance department immediately, and the standby pump should be operated (once the suction/discharge valves are checked for proper positioning).
- The density of the thickened tailings must be a minimum of 55% solids. The maximum density target is 65% solids. If the thickened tailings underflow solids are lower than this, the reason must be determined and rectified.

Shutdown Procedure

In the event that tailings disposal to the WRTSF is stopped, the tailings disposal tank must be drained as best possible through the tailings disposal pumps, the disposal tank should be flushed (with fresh water), and the tailings line needs to be flushed (with fresh water). Shutdown procedures are summarized as follows:

- Stop thickened tailings flow to the disposal tank by directing the thickened tailings to the paste plant.
- The tailings disposal pump will slow down as the level in the tank approaches the bottom. At this point, the tank is to be filled with fresh water to flush any remaining solids out of the tank. It is required that the tank be filled three times, with the agitator on, to ensure the majority of solids are flushed from the tank.
- Continue filling the tailings disposal tank with fresh water and continue operating the tailings disposal pumps. The approximate volume of the tailings disposal pipe is 42 m^3 (1.3 km long, 8-inch diameter). To ensure no solids remain in the pipe, five times this volume or 210 m^3 must be flushed through at full speed of the pump.
- The disposal pump must operate at the maximum speed allowable for the volume of fresh water supplied to the disposal tank. As the thickened tailings are displaced from the pipe with water, the tailings solids will have a tendency to settle faster in the clean water. Running the pump at maximum speed will force the remaining solids to be flushed out from the pipe.
- After the flush is complete, shut the suction valves of the pumps and open the pump suction drain valves, and using a hose, flush the suction piping of the pumps. The air vent hand valves located on the discharge of the pumps should be opened to allow the majority of flush water to drain by gravity to the WRTSF discharge. Allow thirty minutes drainage time. Ensure the suction drain valves and air vent valves are closed after this process to allow for restart without delays.
- When the tailings disposal piping is not in use from October to June, there is the possibility of freezing. To ensure there is no possibility of residual water freezing in the pipe, a water flush is to be conducted every 6 hours using fresh water. This can be accomplished by filling the disposal tank with fresh water while operating one of the disposal pumps. Each line must be flushed continuously for five minutes.

4.4 Water Management

The Brucejack mine site area is characterized by high annual snowfall and rainfall. In this humid climate, water management is an important component of the mine plan. Water management infrastructure at the mine site includes the following:

- Two fresh water (non-contact) diversion channels divert non-contact water around the core mine site surface infrastructure area. The Johnson Creek (East) Diversion Channel drains into the WRTSF, while the Camp Creek (West) Diversion Channel discharges to Brucejack Creek.
- Domestic wastewater from the camp is directed to the STP, located near the mill building, with the treated effluent discharged to the WRTSF.
- Contact water from the contact water management area (encompasses the mill and camp pads and additional core infrastructure areas) is directed to the Contact Water Pond (CWP) by way of collection weirs, ditches, sumps, pumps and HDPE pipes.
- Contact water in the CWP is pumped to the WTP, located in the mill building. The effluent from the WTP is either used as makeup water for the mill or piped to the WRTSF for discharge.
- Water from dewatering of the underground mine is pumped to the WTP for treatment. The priority use for this treated water is the mill process. When there is a surplus of treated water after fulfilling mill process requirements, the excess is discharged to the WRTSF.
- Process water is required for the thickened tailings slurry to Brucejack Lake, the underground paste backfill, and the concentrate slurry. This water is sourced from the WTP treated effluent, reclaim from the WRTSF, and ore moisture.
- Tailings are either directed to the paste backfill plant or sent to the WRTSF as thickened tailings for disposal at depth, but never concurrently.
- If there is insufficient makeup water for process from the CWP and/or underground dewatering, fresh water is reclaimed from the lake outlet at the LLW.
- Potable water is obtained from a groundwater well, with subsequent filtration and disinfection treatment before piping to end users at the Brucejack Camp and other facilities.

The final discharge point from Brucejack Lake for Metal and Diamond Mining Effluent Regulations and PE-107835 compliance conditions is monitoring site BJ 3.10, which is located at the LLW.

4.5 Documentation and Reporting

4.5.1 Internal Reporting

Daily progress reports for waste rock deposition and tailings discharge must be completed by a competent person under the supervision of the Tailings RP and WR RP and submitted to the following individuals:

– WRTSF RP

- Engineer of Record (EOR)
- Health and Safety Manager

In addition, site inspection reports, safety audit forms, and daily deposition plans must be maintained in the deposition planning and inspection binder. Appendix D1 of this OMS manual provides a copy of the Daily Waste Rock Inspection Checklist and Appendix D2 contains a copy of the Weekly Waste Rock Deposition Audit Checklist.

The volume and density of the tailings must be tracked every shift. Mill Operations monitors two totalizers: one is a volumetric totalizer for tailings flow from the thickener to the disposal tank; the second is a wet tonnes mass totalizer for this same flow. These totalizers must be recorded each shift and information transferred to the metallurgy technician. The metallurgy technician will send these data to the environmental department for record keeping and reporting.

4.5.2 Regulatory Reporting

An annual waste deposition progress report is submitted to the BC Ministry of Energy, Mines and Petroleum Resources in accordance with M-243 Condition C.3(c). The progress report is included as part of the *Mines Act* and *Environmental Management Act* permits annual report submitted by March 31 of each year for the prior calendar year. It summarizes the progress of the waste rock and tailings deposition, placed volumes, and the stability and settlement experienced during deposition.

An annual review of the WRTSF must be conducted by a Professional Engineer and a report submitted to the Chief Inspector until 2021, after which the reporting frequency is reduced to once every five years (M-243 Condition C.3(d)).

As per Condition 3.5 of PE-107835, the tailings outfalls and discharge lines must be inspected once per year by a QP or certified tradesperson to ensure they and all associated piping are in good working condition, there are no major leaks or bends, and that the height of the tailings discharge is not more than 7.5 m above the lake bottom (i.e., the top of the natural lake bottom or deposited tailings, whichever is higher). These inspections may include a combination of bathymetric surveys, camera inspections, visual inspections, digital sonar surveys, etc. An inspection report must be submitted each year in the annual report unless concerns are noted, in which case an inspection report and associated mitigation plan must be submitted to the director within 45 days after the inspection date.

5 Maintenance

5.1 Objective and Procedures

The objective of the waste rock and tailings deposition maintenance program is to ensure that the WRSTF complies with design and performance criteria. The maintenance procedures are event driven and directed by the WRTSF QP in consultation with the EOR and Responsible Persons, with co-operation and support from Pretivm's geotechnical engineers and maintenance teams.

5.1.1 Waste Rock

Events that could result in maintenance above and beyond the regular operating procedures of the waste deposition areas include:

- Excessive settlement of the dump pad requiring additional waste rock placement to achieve the long-term height above water required (0.3 to 0.5 m).
- Localized lower spot and/or ponding of the dump pad due to truck loads or downward blading from dozers that requires levelling
- Heavy snowfall events that require snow and ice removal from the dump pad (to prevent slippery surfaces for equipment and enable observations of surficial signs of instability) before carrying out the daily deposition plan
- Cracking or sloughing that extends into the WRD past the crest berm, where restricted work and modified deposition plan is to be applied to stabilize the area

Any actionable maintenance tasks performed on the WRD outside of normal construction and deposition activities will be documented in the daily progress reports. Furthermore, maintenance of mechanized equipment that is employed at the dumpsite must follow the manufacturer's specifications.

5.1.2 Tailings

Events that could result in maintenance above and beyond the regular operating procedures of the tailings deposition include:

- Interference between the tailings deposition elevations and the elevations of the discharge pipelines that may cause the discharge pipelines to be damaged or buried. Annual bathymetric surveys are performed and tailings heights are adjusted.
- Damage to the tailings pipelines (including heat tracing and insulation) or to the pipeline cable supports. The pipes on surface are inspected daily in the summer months when there is no snow cover for any issues and damage is rectified by the surface maintenance crews. Any damage should not exceed 10% of minimum wall thickness of the pipe required for the pipeline operating pressure.

- Corrosion or any event that weakens the tailings cable support structure and anchors. The cables above the water are visually inspected regularly. Upon identifying corrosion or significant reduction of metal cross-section, a plan will be developed to address the issue and then executed.
- Blockages of pipelines.
- Rupture or leakage of pipelines. The tailings disposal will be switched over to the secondary line. The ruptured section will be repaired and made ready for service.

5.1.3 Reclaim Weir

The reclaim weir is a measuring system and a pump station for reclaiming water from the WRSTF back to the mill.

- The building and civil facilities are visually inspected annually in the spring and minor repairs carried out prior to the beginning of the winter season.
- Pump inspection occurs on a two-week frequency for mechanical issues.
- Pump motors are greased on a monthly cycle.
- Flow meter checks are performed intermittently or on request and in conjunction with the environmental monitoring department. If there are repairs, a work order is required.

5.1.4 Turbidity Curtains

Events that could result in turbidity curtain maintenance above and beyond the regular operating procedures include:

- A tear in the curtain or separation of two sections that may result in sediment from waste rock dumping activities migrating downstream towards the LLW rather than settling to the bottom of the WRTSF.
- One or more of the curtain anchor lines breaking, potentially allowing excess sediment to pass underneath of the curtain.

To limit the potential of the above from occurring, preventative maintenance (e.g., confirm curtain position is correct, check that seems between adjacent panels are tight and anchors remain in place) is performed at least once annually during the summer months when the curtains are accessible. Critical spares (e.g., curtain replacement panels of various lengths, anchors, rope, buoys) are stored on site, ready for install if required and replaced as necessary.

5.2 Instrumentation

Maintenance of instrumentation is important to ensure the instrumentation is in good working order and provides reliable readings. All instrumentation needs to be clearly marked, identified, and protected using cement blocks or some other distinguishable feature to delineate it for heavy equipment operators. Drawings and installation record information includes location; refer to the WRD daily plan for instrumentation locations. Survey prisms are to be maintained to enable collection of the data, and repair and replacement is to be carried out when needed.

5.3 Event-Driven Maintenance

Potential event-driven maintenance items arising from pipeline leaks or breaks, earthquakes, and floods are listed below.

5.3.1 Pipeline Leaks or Breaks

- Inspect entire pipeline.
- Repair or replace affected components.
- Repair any collateral damage caused by a leak or break.
- Collect any released tailings and place in the WRTSF.
- Reclaim any disturbed areas.

5.3.2 Earthquake Occurrence

- Measure freeboard for compliance with design requirements.

5.3.3 Flood Event

- Measure freeboard for compliance with design requirements.
- Inspect WRD pad for erosion and repair if required.

5.4 Maintenance Schedule and Spare Parts

All electrical and mechanical components are to be inspected and maintained as per manufacturer's recommendations. A spare parts inventory is to be maintained as recommended by equipment manufacturers and as required by Pretivm. This inventory is not listed in the OMS manual, as it is beyond the scope of this document.

5.5 Documentation and Maintenace reports

Maintenance records of each component are to include the following:

- Up-to-date logs of in-service equipment and facilities
- Maintenance schedules
- Maintenance history
- Inspection logs
- Repair reports including cost
- Frequency, cause of problems, and planned mitigation
- Inventory of spares parts, materials, tools, and equipment
- Calibration records, if applicable
- Critical spare parts list, if applicable

6 Surveillance

6.1 Objectives

Surveillance information is gathered through visual inspections, safety audits, and survey data collection. Regular review of observational data allows operations personnel to evaluate trends and take appropriate actions. The objectives of the surveillance program are to:

- Regularly monitor for settlement and stability of the WRD. Tailings conveyance systems should be regularly inspected for leaks, damage, and overall operation of pumping systems.
- Promptly record and report observations.
- Regularly inspect work areas and interview operators and maintenance personnel to ensure that the operation and deposition plans are understood and followed correctly.

6.2 Surveillance Parameters and Procedures

6.2.1 Waste Rock

The WRD surveillance procedures are summarized in Table 6-1, and tailings surveillance procedures are summarized in Table 6-2. Waste rock deposition parameters include the following:

- Waste rock settlement
- Subaqueous waste rock slope monitoring through Bathymetric survey.
- Surface cracking on the WRD and the tailings pipelines
- Overloading or load concentration of waste rock on lakebed
- Sloughing and/or slope movement
- Changes in the material consistency
- Surface deflection from equipment
- Lake bed profile

6.2.2 Tailings

Tailings deposition surveillance parameters include the following:

- Tailings consistency (% solids) and discharge rates
- Damage to tailings conveyance pipelines and support cables
- Damage or signs of failure of the anchor points of the tailings support cable
- Subaqueous elevations of the deposited tailings cone and the tailings deposition pipeline

6.2.3 Environmental

Environmental surveillance parameters include the following:

- Interaction of the tailings cone to the discharge pipeline and the WRD
- Damage to any of the four turbidity curtains
- Water quality parameters at the BJ 3.10 monitoring site showing unusual increases or nearing permit limits
- Continuous in-situ monitoring of physical characteristics of the lake's water column with periodic sample collection to assess water quality at various depths
- Full bathymetric survey of the lake conducted at least once annually

6.2.4 Health and Safety

Health and safety surveillance parameters include the following:

- Training on SOPs and ERPs and tracking of personnel training
- Personal protective equipment availability and use
- Hazard recognition.

Table 6-1: Surveillance procedures for waste rock deposition area

Procedure Components	Frequency	Critical Observation
01: Stability Analysis and Inspection	• Start of every new deposition area • After WRD evacuation due to earthquake	• Determine anticipated settlement of new crest advance.. • Assess factor of safety and setback distance of new crest advance. • Coupled with settlement results, assess for deformation as a result of an earthquake .
02: Settlement Surveys	• Real time survey through Tiltmeters setting up one per zone. • Immediately after WRD evacuation due to an earthquake • Frequency afterwards based on the site geotechnical engineer's requirements	• Capture the baseline crest elevation for comparison with subsequent settlement surveying. • Conduct ongoing settlement surveying until necessary settlement has been achieved. • Confirm compliance with QPOs in Table 6-3 row 03.
03: Geotechnical Engineer & Surface Supervisor Inspections	• At the start of every shift • After each break • At least every 4 hours if no breaks have occurred • At the start of a new work area • After every blast near the WRD • After an evacuation of the WRD due to an earthquake	• Inspect for signs of instability such as: - Cracking - Settlement - Slope movement - Changes in material type and moisture content - Surface deflection from equipment. • Inspect for delineators that mark the dump zones and restricted areas, and for proximity of safety equipment. • Review localized settlement monitoring data. • Inspect for safety equipment and PPE worn by operators. • .
04: Equipment Operators Inspection	• At the start of each shift and continually during normal WRD operations	• Inspect for signs of instability on working surface and dump face. • Be aware of equipment position, locations of egress points, and visibility. • Be aware of location of delineator cones, overhead lighting, and settlement monuments.
05: Health and Safety Audits	• Every two weeks	• Assess availability and use of safety supplies and PPE. • Assess adherence to deposition plan and SOPs. • Develop suggestions to improve WRD conditions and safety.
06: Engineer of Record Audits	• As deemed by the EOR	• Assess the deposition planning, tracking, and documentation being carried out on site. • Determine if procedures are being followed and if WRD is being operated and is performing as designed.
07: Event (earthquake near site or unexpected large rainfall event) driven inspection	• Event driven	• Monitor deformation and settlements immediately after an earthquake. • Inspection by EOR, assess the stability of the WRD areas. Documentation of assessment to be conducted. • Assessment of the waste rock deposition area below water level (bathymetry) may be required.

Table 6-2: Surveillance procedures for tailings deposition

Procedure Components	Frequency	Critical Observation
01: Exposed Tailings Discharge Pipeline	• Daily • Prior to starting tailings pumps • After tailings pumps are shut down • Any time the flow is switched between pipes • After an earthquake	• Determine if there is damage to the exposed pipelines and if they are in working order. • Determine if there are signs of leaking, cracking, and ice/tailings blockages.
02: Tailings Cable Anchor System	• As directed by the engineer • After an earthquake	• Determine if there is damage, fatigue, and oxidation of the cable anchor bolts and loop ends. • Determine if there is damage and cracking of the concrete foundations.
03: Pipeline Discharge Elevation	• Biannually, or more frequently at the discretion of the mill manager	• Measure elevations of the tailings discharge pipelines in relation to the depth of deposited tailings.
04: Deposited Tailings Elevation	• Biannually at the same time as the pipeline elevation measurements, or more frequently at the discretion of the engineer	• Measure elevation of the subaqueous tailings deposition at the point of the outflow of the tailings pipelines. • As a secondary observation, measure the elevation of the tailings deposition cone that is forming in the peripheral areas.

Table 6-3: Environmental surveillance procedures

Procedure Components	Frequency	Critical Observation
01: Turbidity Curtain Inspections	• At the start of each shift	• Before commencing waste rock or tailings disposal, ensure all of the turbidity curtains are in place and there is no apparent damage
02: Environmental Compliance Sampling	• Weekly	• Collect surface water samples at BJ 3.10 monitoring site to ensure water quality parameters are below permit maximums.
03: Lake Water Column Sampling	• At least monthly when lake surface conditions permit safe access (typically July – Sept and Feb/Mar – Apr/May)	• Collect water samples at specific depths (just below surface to near bottom) to assess water quality
04: Monitoring of physical water characteristics	• Continuous	• Ensure CTDs located at the LLW and attached to the lake mooring stations are functioning such that conductivity, temperature, and turbidity are being recorded
05: Bathymetric Surveys	• At least annually	• Conduct a bathymetric survey of the lake to determine the elevation profile of the lake bed, tailings deposition area, and subaqueous waste rock slope

6.3 Quantifiable Performance Objectives

Quantifiable performance objectives (QPOs) associated with performance monitoring as described in the OMS manual are summarized in Table 6-3 for the waste rock deposition with remotely controlled dozer, the stacker / bailing system, and tailings deposition.

Table 6-4: Quantifiable performance objectives for monitoring the WRTSF

ID and Description	QPO	Methodology	Responsibility	Frequency	Mitigation Actions
General Objectives					
01: Environmental Water Quality	• Water quality discharge limits at sampling location BJ 3.10 in accordance with PE-107835 • Water quality discharge limits are listed in Table 3-1, Section 3.11.3 of this OMS manual	• In accordance with standard industry best practice test methods as stipulated in PE-107835.	• Environmental Superintendent and Environmental Coordinator under the guidance of the Environment QP.	• As specified in Table 31 in Section 3.3.4 of this OMS manual.	• The Manager, Environment and Regulatory Affairs or delegate will prioritize lake profiling (access dependent); visual inspections of the sediment curtains; and site BJ 3.10 water quality to determine the source of any exceedances.
02: Waste Rock Deposition Exposure	• Waste rock is to be deposited into the WRTSF below a minimum of 1.0 m of water cover (1,363.5 masl) within a 2-year (24-month) allowable exposure period.	• Excavate exposed waste rock to a minimum of 1.0 m below the WRTSF water level of 1,364 m. • This excavation results in a minimum of 1.0 m of water cover over waste rock. All excavations are to be guarded by a 1 m tall and 3 m wide safety berm that is set back 3 m from the excavation. • Where needed, a trafficking layer of NPAG waste rock is placed over the excavated PAG waste rock. • Elevations are confirmed by engineering staff and recorded in a digital database.	• Waste Rock QP	• Actions to complete QPO are ongoing and a component of operations work. • Due to weather constraints, the majority of the PAG waste rock excavation will occur in the summer months.	• The on-site geotechnical engineers with the support of the surface operations team will prioritize the location of PAG waste rock excavation and develop construction schedules and survey records.
03: Evacuation of the Waste Rock Dump due to an Earthquake	• An evacuation of all personnel working on the WRD is initiated simultaneously with an evacuation of the underground mine.	• Seismic sensors that are used to determine the threshold for underground mine evacuation are applied as the indicator for the WRD.	• On-site geotechnical engineers, WRTSF RP, and support from EOR as necessary.	• If an earthquake is experienced that triggers the underground seismic detection system that warrants an evacuation of the underground mine.	• Continue monitoring until the threshold values are recorded on the seismic sensors.
Waste Rock - Deposition with Remote Controlled Dozer					
04: Waste Rock Deposition Settlement Rate	• Observational method of surveying settlement monuments and tiltmeter to track settlement. Results must show that settlement rates are less than 0.03 m/day over two consecutive days.	• Foundation characteristics, depth of the lake, and height of the waste rock vary continuously, and therefore settlement rate and magnitude are variable. • Monument prism survey. • Tiltmeter installed along the dump crest with real time monitoring. <u>Zones that meet the QPO:</u> • Will be denoted with a green settlement condition colour signifying that settlement currently meets the QPO. <u>Zones that do not meet the QPO:</u> • Will be denoted with a red settlement condition colour signifying that settlement has not yet reached the QPO value. • Settlement graphs will be included in the daily report for all red conditions until the settlement QPO is met and two days following. <u>Zones denoted as "High Risk" by the geotechnical engineer delegated by Waste Rock QP or EOR:</u> • Are zones where daily settlement surveys have not been completed or zones that have been assessed by the geotechnical engineer to have safety recommendations other than settlement QPO. (e.g., stability assessments, work zone access, snow build up, poor visibility). Recommendations may be from site inspections, annual EOR inspections, or stability assessments, or based on visual observations.	• On-site geotechnical engineers with support from Waste Rock QP and EOR as necessary.	• Twice a day monument prism survey. • Real time tiltmeter data monitoring (every 10 minutes data collection). • Ongoing daily review of settlement survey results. • EOR formally reviews database biannually.	• Continue monitoring until the threshold values are reached.
05: Waste Rock Dumpsite Monitoring & Inspections	• Site inspections to visually assess the stability of active and inactive deposition zones. • Site inspections are required to be documented. • Inspections can also include the observations of the equipment operators and supervisors. • The restriction zone is defined as a 10 m buffer from the dump crest. This restriction zone is maintained and delineated to ensure no person-operated equipment may enter. • Individual personnel are authorized to enter the 10 m restriction zone by the	• Sloughing and slope movement (including from equipment traffic) are expected and considered normal but should, nonetheless, remain within the constraints identified in the design reports and the conditions set here: • Visual inspections focusing on surface cracks or other signs of instability on the dump crest and proximal, freshly deposited areas of dump floor. • Observed cracks which form within the safety berm or on the dump surface must result in the stoppage of work (including egress of workers and equipment from the area) until an assessment by the engineer is completed. • A change in deflection magnitude resulting from equipment traffic must be addressed by the EOR. • A notable increase in ground settlement recorded by tiltmeter(s). • Bathymetric surveys indicating a bulged profile of the subaqueous waste rock slope.	• On-site geotechnical engineers with support from EOR as necessary.	• • Visual assessment of WRD stability every 4 hours by supervisors and two times per day by geotechnical engineer for active remote dozing zones, or "High Risk" zones. • If there is no waste rock deposition for over 24 hours, the supervisor will inspect WRD once per shift, while the geotechnical engineer will inspect the WRD once per day. • EOR formally reviews database biannually.	• • Cracks forming in the crest berm are immediately communicated to the geotechnical engineer. They are photo-documented in the daily reports and visually assessed during regular inspections. • Cracks/slumps forming in the safety berm or in the dump pad surface result in an immediate work stoppage on the entire dumpsite. All signs of instability are immediately communicated to the geotechnical engineer and the EOR and recorded in the daily reports. • The tiltmeter reading will be used to alert stakeholder when ground settlement is over QPO threshold. The geotechnical engineer will be informed and action plan will be developed.

ID and Description	QPO	Methodology	Responsibility	Frequency	Mitigation Actions
	engineer under the circumstances that monitoring data and remote visual inspection or physical inspection from outside the 10 m restriction zone support doing so. The person should have PPE as defined in the SOP and must have another person stationed outside the 10 m restriction zone as a spotter. •				
06: Waste Rock Stability	• Geodetic surveys are required a minimum of two times per day on all settlement monuments. Surveying frequency and timing must include: • Initial survey immediately after the fresh berm is constructed to establish a baseline. • An initial check survey within 6 to 12 hours of the baseline survey. • Subsequent surveys at 12-hour intervals until the geotechnical engineer specifies otherwise. In areas of active remote dozer deposition, real-time monitoring tiltmeters are required, and their data must be available remotely, in real time. • Bathymetric survey is required at geotechnical engineer's request to monitor the underwater waste rock slope profile.	• • The geotechnical engineer reviews settlement results and applies experiential judgment to determine when settlement magnitudes reach acceptable bounds and it is safe to deposit more waste rock. • As necessary, the geotechnical engineer will conduct stability analysis and settlement analysis to confirm their experiential judgment. • EOR to review any numerical modelling and determine if a zone should be categized as "High Risk" and make site-specific recommendations to mitigate concerns. <u>Zones denoted as "High Risk" by the Geotechnical engineer delegated by WR QPor EOR:</u> • Are zones where daily settlement surveys have not been completed or zones that have been assessed by the geotechnical engineer to have safety recommendations other than settlement QPO (e.g., stability assessments, work zone access, snow build up, visibility). Recommendations may be from site inspections, annual EOR inspections, or stability assessments, or based on visual observations. • Bathymetric survey to the underwater WRD slope profile is one of the tools to assist the slope stability analysis when lake is not covered with ice.	On-site geotechnical engineers with support from Waste Rock QP and EOR as necessary.	• Ongoing daily review of settlement survey results. • Ongoing daily review of the tiltmeter monitoring data. • Ongoing daily review of waste rock stability through stability analysis and settlement analysis as necessary. • Visual assessment of WRD stability every 4 hours by supervisors. • Active remote dozer deposition zones & "High Risk" zones will be assessed via a conjunction of real-time monitoring instrumentation & drone inspection. • Bathymetric survey will be done at the geotechnical engineer's request. • EOR formally reviews database biannually.	• The geotechnical engineer and the Manager of Technical Services must be contacted if the survey frequency cannot be completed to determine an action plan. • The geotechnical engineer must track the date when the survey(s) were attempted and report on the daily reports when future surveys will be attempted. • EOR and the geotechnical engineer can assign sections of the dump as "High Risk" and develop site-specific recommendations to mitigate stability concerns where needed. These may include, but are not limited to, no work zones, additional site clean up and clearing before work, or capturing additional survey data on a higher frequency.
07: Rate of Waste Rock Deposition and Crest Advance	• Waste rock deposition rates into the WRTSF are dependent on need for waste rock as backfill in the underground mine. • During operations, the expected volume of waste rock delivered to the WRTSF from the underground mine ranges between 0 and 2,000 m^3/day. • The geotechnical engineer prescribes the deposition zones that have met the requirements for further deposition in the daily deposition plan. • The WRD crest advance per shift should be less than 3 m.	• The rate of waste rock deposition is related to the rate of crest advancement. • The rate of waste rock deposition is related to the subaqueous waste rock slope profile as determined by bathymetric survey.	• On-site geotechnical engineers and Waste Rock QP with support from EOR as necessary.	• Ongoing daily activity.	• The rate of waste rock deposition is determined by the rate of construction of the berm advancement and by the rate of settlements during construction: it cannot be a fixed value. • The active deposition zone will be determined based on the monitoring and survey data to allow enough settlement time.
Waste Rock - Deposition with Stacker / Bailing System					
08: Waste Rock Deposition Settlement Rate	Observational method of surveying settlement monuments to track settlement. Results must show that settlement rates are less than 0.03 m/day over two consecutive days (green settlement condition). Settlement ≥0.03 m/day over 2 days is classified as red settlement condition.	• Foundation characteristics, depth of the lake, and height of the waste rock vary continuously and therefore settlement rate and magnitude are variable. • Settlement times are therefore also variable and cannot be prescribed. • Monument prism survey. <u>Zones that meet the QPO:</u> • Will be denoted with a green settlement condition colour signifying that settlement currently meets the QPO. <u>Zones that do not meet the QPO:</u> • Will be denoted with a red settlement condition colour signifying that settlement has not yet reached the QPO value.	• On-site geotechnical engineers with support from Waste Rock QP and EOR as necessary.	• Ongoing daily review of settlement survey results. • EOR formally reviews database biannually.	• Continue monitoring until the threshold values are reached.

ID and Description	QPO	Methodology	Responsibility	Frequency	Mitigation Actions
		• Settlement graphs will be included in the daily report for all red conditions until the settlement QPO is met and two days following <u>Zones denoted as "High Risk" by the Geotechnical engineer or EOR:</u> • Are zones where daily settlement surveys have not been completed or zones that have been assessed by the geotechnical engineer to have safety recommendations other than settlement QPO (e.g., stability assessments, work zone access, snow build up, poor visibility). Recommendations may be from site inspections, annual EOR inspections, or stability assessments, or based on visual observations.			
09: Waste Rock Stability	Geodetic surveys are required a minimum of two times per day on all settlement monuments. Surveying frequency and timing must include: • Initial survey immediately after the dump crest advance is completed with a berm to establish a baseline. • An initial check survey within 6 to 12 hours of the baseline survey. • Subsequent surveys at 12-hour intervals until the geotechnical engineer specifies otherwise	• The geotechnical engineer reviews settlement results and applies experiential judgment to determine when settlement rates are acceptable and when it is safe to deposit more waste rock. • As necessary, the geotechnical engineer will conduct stability analyses and settlement analyses to confirm their experiential judgment. • EOR to review any numerical modelling and determine if a zone should be categized as "High Risk" and make site-specific recommendations to mitigate concerns. <u>Zones denoted as "High Risk" by the Geotechnical engineer or EOR:</u> • Are zones where daily settlement surveys have not been completed or zones that have been assessed by the geotechnical engineer to have safety recommendations other than settlement QPO (e.g., stability assessments, work zone access, snow build up, visibility). Recommendations may be from site inspections, annual EOR inspections, or stability assessments, or based on visual observations.	• On-site geotechnical engineers with support from Waste Rock QP and EOR as necessary.	• Ongoing daily review of settlement survey results. • Ongoing daily review of waste rock stability through stability analysis and settlement analysis as necessary. • Visual assessment of WRD stability every 4 hours. • EOR formally reviews database biannually.	• The geotechnical engineer and the Manager of Technical Services must be contacted if the survey frequency cannot be completed to determine an action plan. • The geotechnical engineer must track the date when the survey(s) were attempted and report on the daily reports when future surveys will be attempted. • EOR and the geotechnical engineer can assign sections of the dump as "High Risk" and develop site-specific recommendations to mitigate stability concerns where needed. These may include, but are not limited to, no work zones, additional site clean up and clearing before work, or capturing additional survey data on a higher frequency.
10: Waste Rock Deposition Inspections	• Site inspections to visually assess the stability of active and inactive deposition zones. • Site inspections are required to be documented. • Inspections can also include the observations of the equipment operators and supervisors.	Sloughing and slope movement (including from equipment traffic) are expected and considered normal but should, nonetheless, remain within the constraints identified in the design reports and the conditions set here: • Visual inspections focusing on surface cracks or other signs of instability within the safety berm area. • Cracks which form within the safety berm or on the dump surface must result in the stoppage of work (including egress of workers and equipment from the area) until an assessment by the engineer is completed. • A change in deflection magnitude resulting from equipment traffic must be addressed by the EOR.	• On-site geotechnical engineers with support from Waste Rock QP and EOR as necessary.	• Visual assessment of WRD stability every 4 hours. • EOR formally reviews database biannually.	• Cracks forming in the safety berm are immediately communicated to the geotechnical engineer. They are photo-documented in the daily reports and visually assessed during regular inspections. • Cracks/slumps forming in the safety berm or in the dump pad surface result in an immediate work stoppage on the entire dumpsite. All signs of instability are immediately communicated to the geotechnical engineer and the EOR and recorded in the daily reports.
11: Rate of Waste Rock Deposition and Crest Advance	• Waste rock deposition rates into the WRTSF are dependent on need for waste rock as backfill in the underground mine. • During operations, between 0 and 2,000 m^3/day is the expected range of waste rock that is delivered to the WRD from the underground mine. • The geotechnical engineer prescribes the deposition zones that have met the settlement rate requirements in the daily deposition plan.	• The rate of waste rock deposition is related to the rate of crest advancement during the deposition process. • The rate of crest advancement is operationally limited to the reach of the hydraulic excavators and conveyor systems that are used to bail waste rock over the safety berm and the settlement time discussed above. • Typically, the safety berms are 6 m wide and the current equipment has an approximate reach of 12 m. With the excavator situated behind the 6 m wide safety berm, the effective reach of waste rock placement is 6 m into the lake, and therefore the rate of waste rock crest advance is 6 m per settlement cycle.	• Waste Rock QP with support from EOR as necessary.	• Ongoing daily activity.	• Rate of waste rock deposition is determined by the rate of construction of the safety berms and by the rate of settlements during loading of the lake bottom sediments—it cannot be a fixed value. • To decrease the rate of waste rock deposition, decrease the capacity of the equipment used to construct the safety berm. • To increase the rate of waste rock deposition, increase the capacity of the equipment used to construct the safety berms. However, the rate of waste rock deposition will be limited to the availability of rock and the time required to meet the settlement requirements.
Tailings Discharge					
12: Tailings Discharge Solids Content	• Tailings discharged from the dewatering plant is required to have a solids content of 55% to 65% by weight (green condition).	• Solids content of the discharge will be analyzed continuously at the process waste infrastructure using automated controls. • Manual measurements may be required for system calibration.	• Mill process technicians and managers under the supervision of the Tailings QP.	• Daily when discharge to the WRTSF occurs.	At less than 55% solids by weight: • Polymer addition rate may be increased. • Speed of the thickener underflow pump may be decreased to slow the withdrawal rate to allow solids to thicken. At greater than 65% solids by weight: • Polymer addition rate may be reduced. • Process water may be added to dilute the tailings slurry.

ID and Description	QPO	Methodology	Responsibility	Frequency	Mitigation Actions
					• Speed of the thickener underflow pump may be increased.
13: Tailings Discharge Rates	• Tailings discharge rates are expected to vary between 960 m^3 and 1,180 m^3 per day based on operational needs. • There are no geotechnical stability concerns with the tailings discharge rate, as there is no association between rate and stability. • Discharge rates are expected to be monitored and reported.	• Tailings discharge rates will be measured at the process waste infrastructure using automated controls.	• Mill process technicians and managers under the supervision of t Tailings QP.	• Daily when discharge to the WRTSF occurs.	• Mill process technicians and managers must track and report the tailings discharge rates. The mill superintendent must be contacted if the rates do not follow the targeted values. • Assessments of the course of action are to be made by the Mill Superintendent at this time to mitigate any issues with the process or the discharge system.
14: Tailings Deposition – Subaqueous to the WRTSF	• The pipeline discharge must be no more than 7.5 m above the tailings cone and not more than the ultimate elevation of 1,325 masl.	• Tailings deposition on the lake bottom will be monitored by tracking the surface elevation of the deposited tailings and the elevation of the submerged discharge pipe. • During the surveying of the tailings surface elevation, data captured should include the tailings elevation directly beneath the pipe discharge and at multiple points radiating away that can be used to estimate the slope and height of the growing tailings cone.	• Mill process technicians and managers under the supervision of the Tailings QP.	• Under the direction of the Mill Superintendent with a biannual minimum frequency.	• The depth of the tailings discharge pipeline will be measured by a cable incrementally marked every 2 m and affixed to a float on the surface. The depth of the discharge pipe is measured from the float marker. • The depth of the deposited tailings surface is measured by a sonar depth sounder. • The depth of the tailings discharge pipeline is adjusted by pulling on the backup anchor's cable loop affixed to the shoreline using heavy equipment (i.e., loader or a tracked bulldozer).

7 Emergency Response Plan

The objective of the ERP for the waste rock and tailings deposition area is to ensure timely and appropriate response to emergency situations and compliance with applicable laws, industry standards, and legal codes of practice. Implementing the maintenance and surveillance programs described in Sections 5 and 6 will identify potential issues and help minimize the potential of an emergency event at WRTSF waste deposition areas.

7.1 Emergency Situations

Emergency situations result in damage and loss of equipment, injury or death of workers, and environmental spills; causes include but are not limited to the following:

- Failure of the WRD within or exceeding the 10 m zone from the dump crest
- Rapid settlement of the dump crest or WRD surface area or floor
- Earthquake causing damage to the tailings support cable and pipelines, and rapid settlements and displacements of the WRD surface
- Major storm event or avalanche that results in flooding of the WRD surface or damage to the tailings pipelines and cable support system

7.2 Response to an Emergency Situation

Pretivm has prepared a site-specific ERP for rescuing and recovering someone who has become submerged in the WRTSF. A copy of the ERP is provided in Appendix C. For other emergencies, the following steps should be taken:

- STOP WORK Call “Code 1, Code 1, Code 1”and call dispatch on Channel 2, Repeater 1. Briefly describe the nature of the emergency. Call co-workers on Ladd 1, Channel 8 to evacuate the WRD.
- If an earthquake is experienced, immediately evacuate the WRD. For other emergencies, establish communication with everyone in and around the emergency area to warn them of the risks.
- Gather in a safe area or designated muster point.
- Barricade the hazardous area to prevent other people from entering.
- The surface supervisor of the WRD is to perform a head count to account for everyone who was working in the emergency area.
- Gather and record information relating to the emergency.
- The WRTSF RP is to immediately contact appropriate on-site and off-site personnel including the EOR, based on the severity of the situation.
- The WRTSF RP is to complete a brief status report (to be kept on file) describing the nature of the emergency and recommendations for immediate action.

– Any follow-up action deemed necessary by the EOR is to be taken immediately and documented.

7.3 Emergency Contact Information

Table 7-1: Emergency contact information for key personnel

Pretivm Key Position Contact Information		
General Numbers	Brucejack Site	+1-778-724-4186
	Vancouver Office	+1-604-558-1784
WRTSF RP	Lyle Morgenthaler	+1-778-724-4186 ext. 125 (office direct) +1-236-982-1168 (mobile)
General Manager	Sean Masse	+1-778-724-4186 ext. 165 (office direct) +1-604-754-9671 (mobile)
Accountable Executive Officer	Greg Norton	+1-778-628-1846
Engineer of Record Contact Information: Golder Associates Ltd., member of WSP		
Engineer of Record (from April 2021)	Jeffrey E. Kwok (Ottawa)	1-613-592-9600 ext 3216 (office direct) 1-343-548-0153 (mobile)
Deputy Engineer or Record	Paul M. Bedell (Vancouver)	1-604-296-4391 (office direct) 1-604-836-3647
Ministry of Energy and Mines Contact Information: Smithers, BC		
Senior Inspector of Mines – Health and Safety	Doug Flynn	+1-250-847-7386

8 References

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[Frontier] Frontier Geosciences Inc. (2013). Report on Seismic Refraction, Bathymetric, and Sub-Bottom Acoustic Profiling Surveys, Brucejack Lake. Prepared for Pretium Resources Inc. Project No: FGI-1319. August 2013.

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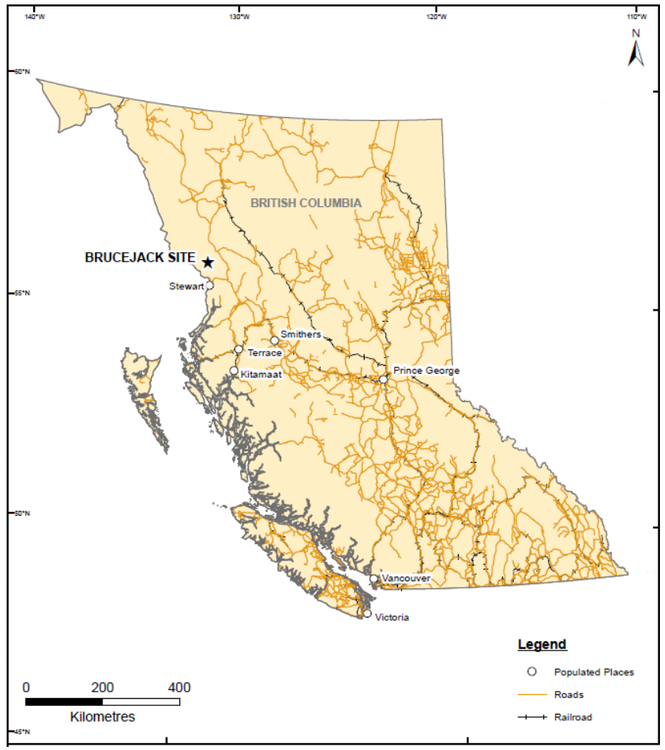
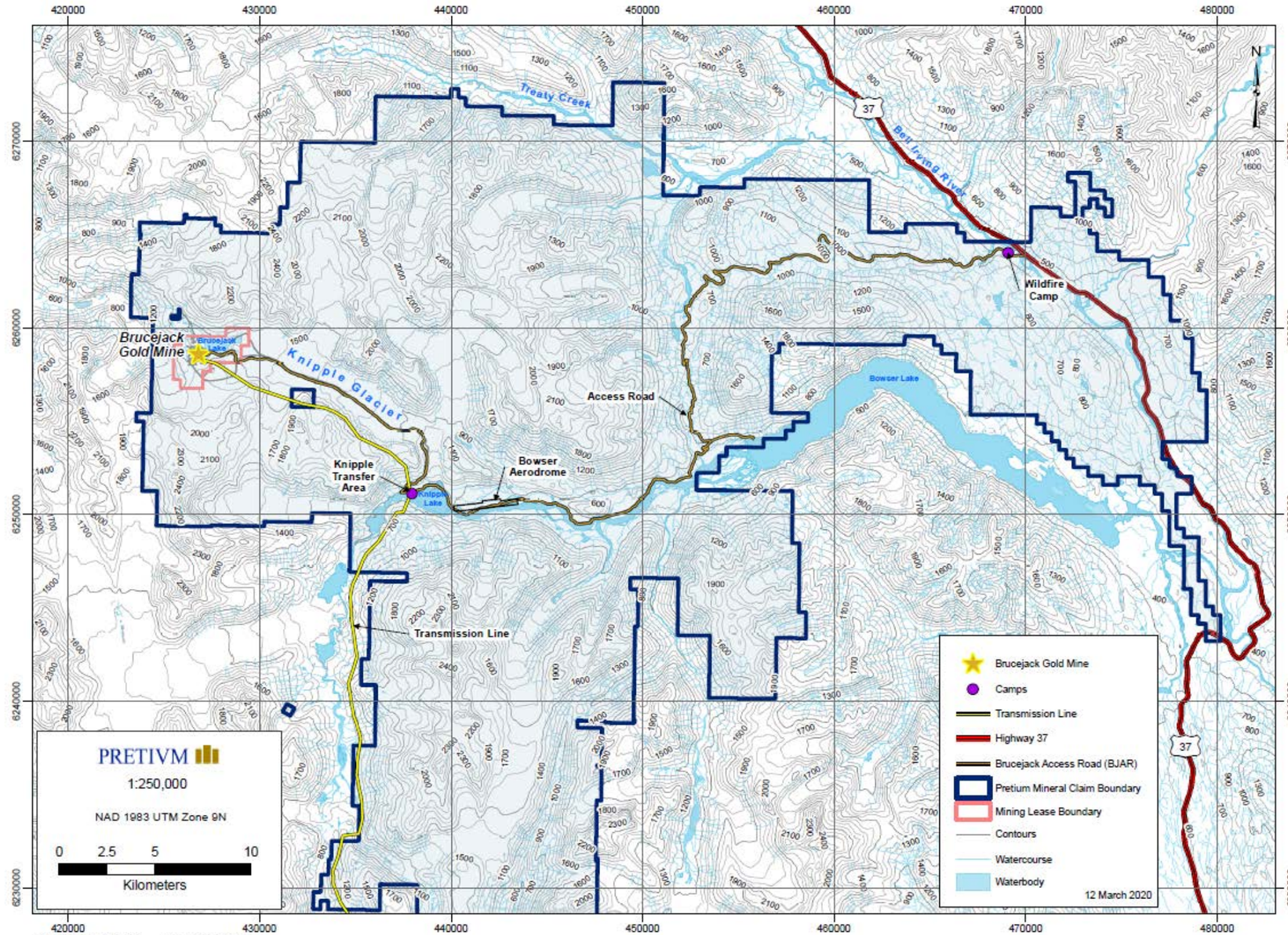
Figures

Figure 1: Brucejack Mine location map





srk consulting

PRETIVM

WRTSF – OMS Manual

Vicinity Map

Job No: 1CP026.001

Filename: Figure1_Location.pptx

Brucejack Gold Mine

Date: March 2020

Approved: SM

Figure: 1

Figure 2: Organizational structure for the WRTSF

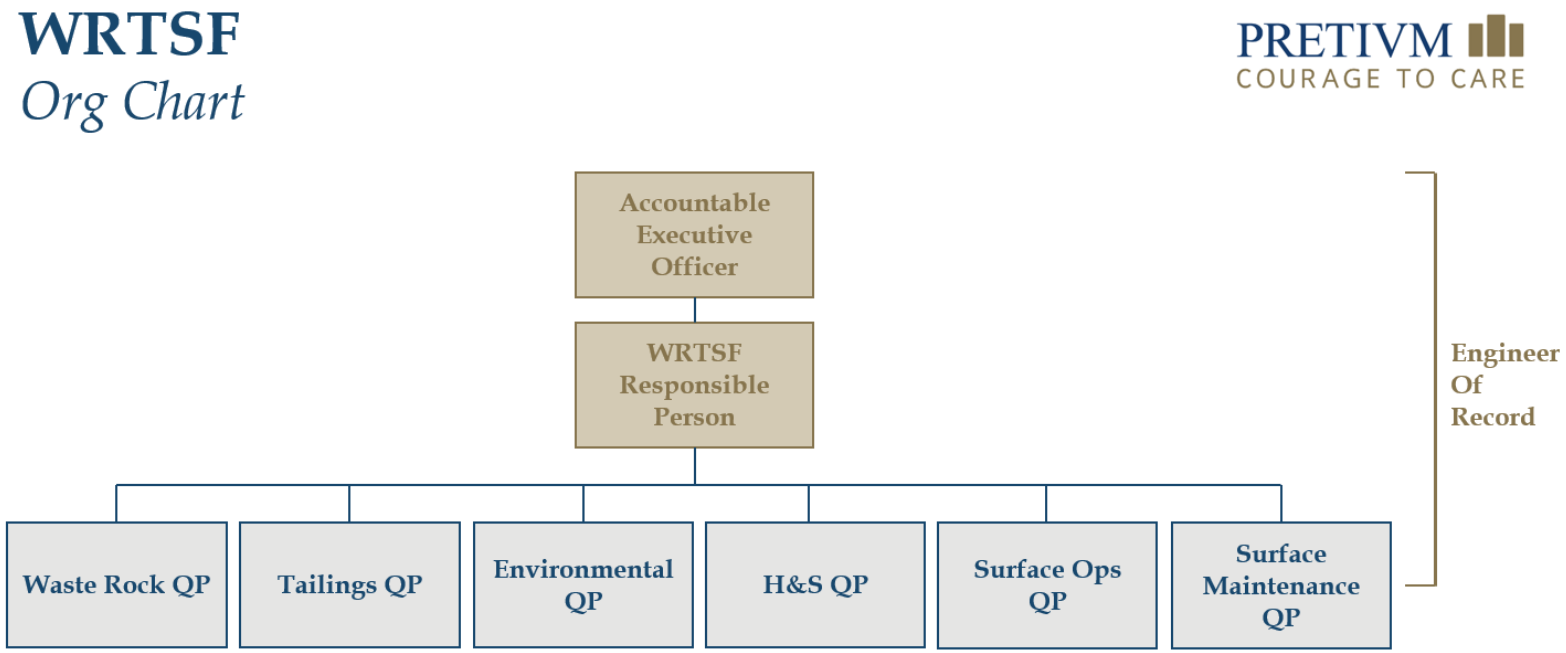
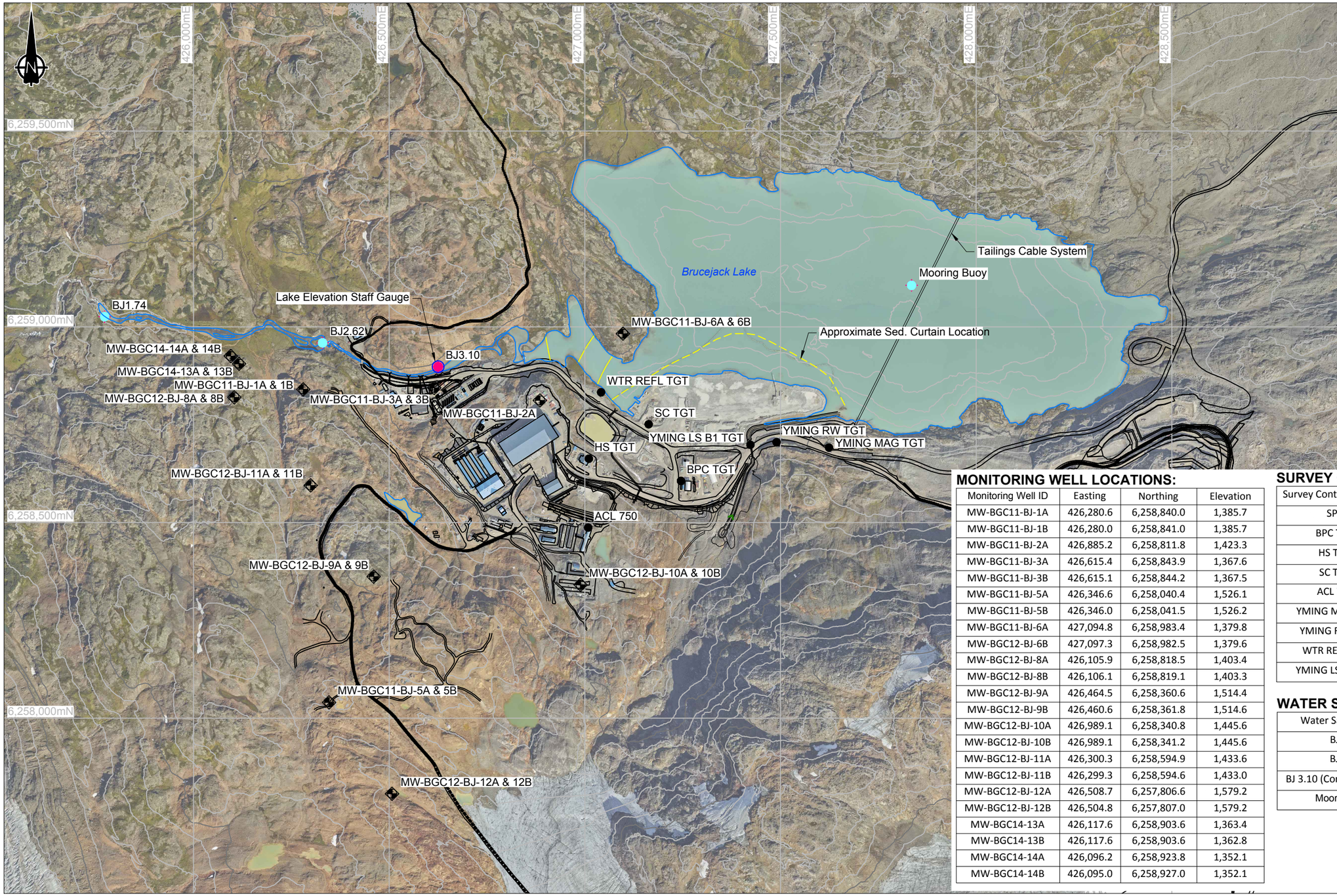


Figure 3: Site layout, survey control, and monitoring locations



LEGEND

- Compliance Point Location
- Groundwater Monitoring Well Location
- Lake Elevation Staff Gauge
- Routine Water Monitoring Location
- Survey Control Point

NOTES

1. Contours shown at 25.0m intervals.
2. Camp infrastructure received from AMEC Foster Wheeler.
3. Topography and orthophoto provided by Pretivm.
4. Monitoring well and monitoring point locations provided by Pretivm.
5. Survey control point locations provided by Allnorth Consultants Ltd.
6. Tailings cable system and pipeline design from AMEC Foster Wheeler drawings 177421-3410-DD10-PLS-0524, 177421-3410-DD10-PLS-0533,and 177421-3410-DD10-PLS-0534.

REFERENCE

NAD83 UTM Zone 9.
2019 Orthophoto and LiDAR provided by Pretivm Resources Inc.

MONITORING WELL LOCATIONS:

Monitoring Well ID	Easting	Northing	Elevation
MW-BGC11-BJ-1A	426,280.6	6,258,840.0	1,385.7
MW-BGC11-BJ-1B	426,280.0	6,258,841.0	1,385.7
MW-BGC11-BJ-2A	426,885.2	6,258,811.8	1,423.3
MW-BGC11-BJ-3A	426,615.4	6,258,843.9	1,367.6
MW-BGC11-BJ-3B	426,615.1	6,258,844.2	1,367.5
MW-BGC11-BJ-5A	426,346.6	6,258,040.4	1,526.1
MW-BGC11-BJ-5B	426,346.0	6,258,041.5	1,526.2
MW-BGC11-BJ-6A	427,094.8	6,258,983.4	1,379.8
MW-BGC12-BJ-6B	427,097.3	6,258,982.5	1,379.6
MW-BGC12-BJ-8A	426,105.9	6,258,818.5	1,403.4
MW-BGC12-BJ-8B	426,106.1	6,258,819.1	1,403.3
MW-BGC12-BJ-9A	426,464.5	6,258,360.6	1,514.4
MW-BGC12-BJ-9B	426,460.6	6,258,361.8	1,514.6
MW-BGC12-BJ-10A	426,989.1	6,258,340.8	1,445.6
MW-BGC12-BJ-10B	426,989.1	6,258,341.2	1,445.6
MW-BGC12-BJ-11A	426,300.3	6,258,594.9	1,433.6
MW-BGC12-BJ-11B	426,299.3	6,258,594.6	1,433.0
MW-BGC12-BJ-12A	426,508.7	6,257,806.6	1,579.2
MW-BGC12-BJ-12B	426,504.8	6,257,807.0	1,579.2
MW-BGC14-13A	426,117.6	6,258,903.6	1,363.4
MW-BGC14-13B	426,117.6	6,258,903.6	1,362.8
MW-BGC14-14A	426,096.2	6,258,923.8	1,352.1
MW-BGC14-14B	426,095.0	6,258,927.0	1,352.1

SURVEY CONTROL POINT LOCATIONS:

Survey Control Point ID	Easting	Northing	Elevation
SPK	427,171.5	6,258,752.8	1,365.3
BPC TGT	427,245.7	6,258,606.1	1,373.0
HS TGT	427,010.1	6,258,663.0	1,405.7
SC TGT	427,162.9	6,258,750.9	1,368.1
ACL 750	427,008.6	6,258,486.9	1,435.3
YMING MAG TGT	427,623.8	6,258,691.3	1,385.2
YMING RW TGT	427,489.8	6,258,705.1	1,373.3
WTR REFL TGT	427,041.4	6,258,832.6	1,373.9
YMING LS B1 TGT	427,423.2	6,258,698.3	1,369.9

WATER SAMPLING LOCATIONS:

Water Sampling Site	Easting	Northing
BJ 2.62	426,330	6,258,959
BJ 1.74	425,773	6,259,026
BJ 3.10 (Compliance Point)	426,625	6,258,897
Mooring Buoy	Floating, Location Varies	

0m 100 200 300 400

srk consulting

PRETIVM

SRK JOB NO.: 1CP026.001
FILE NAME: 1CP026.001 - Survey Control.dwg

BruceJack

OMS Manual

Site Layout, Survey Control, and Monitoring Locations

DATE: January 2020
APPROVED: --
FIGURE: 3

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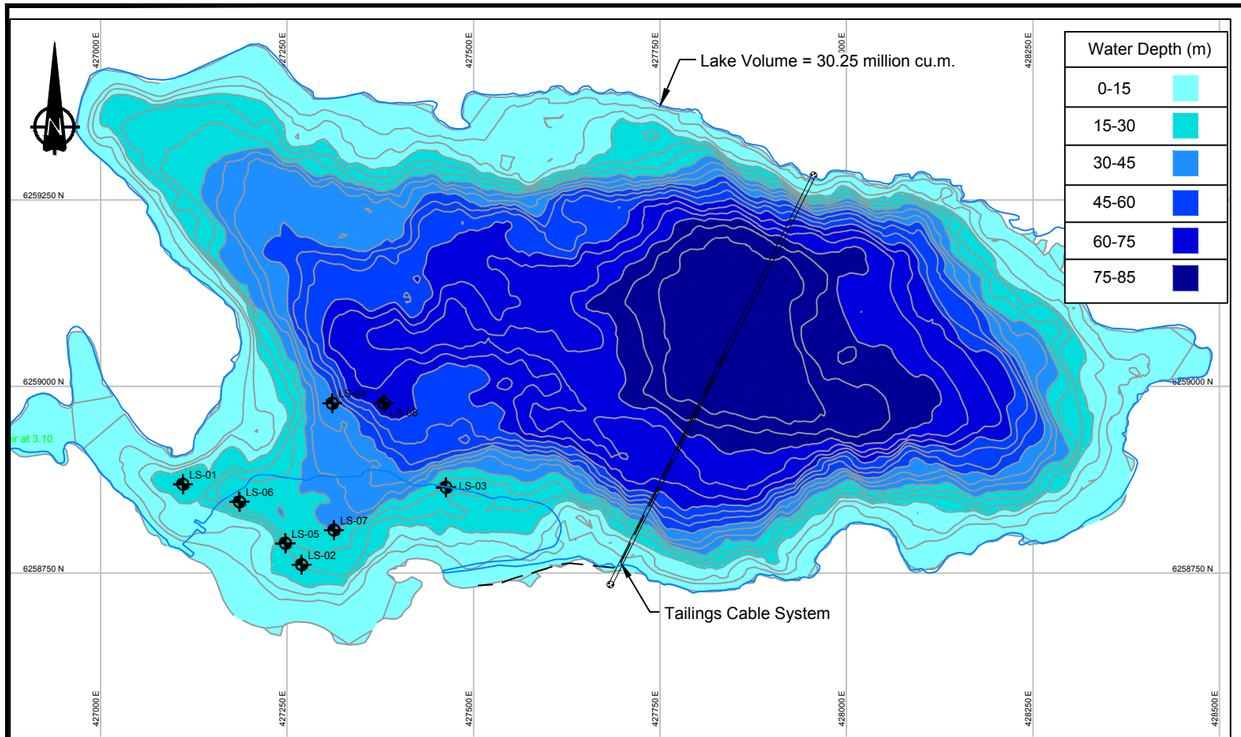
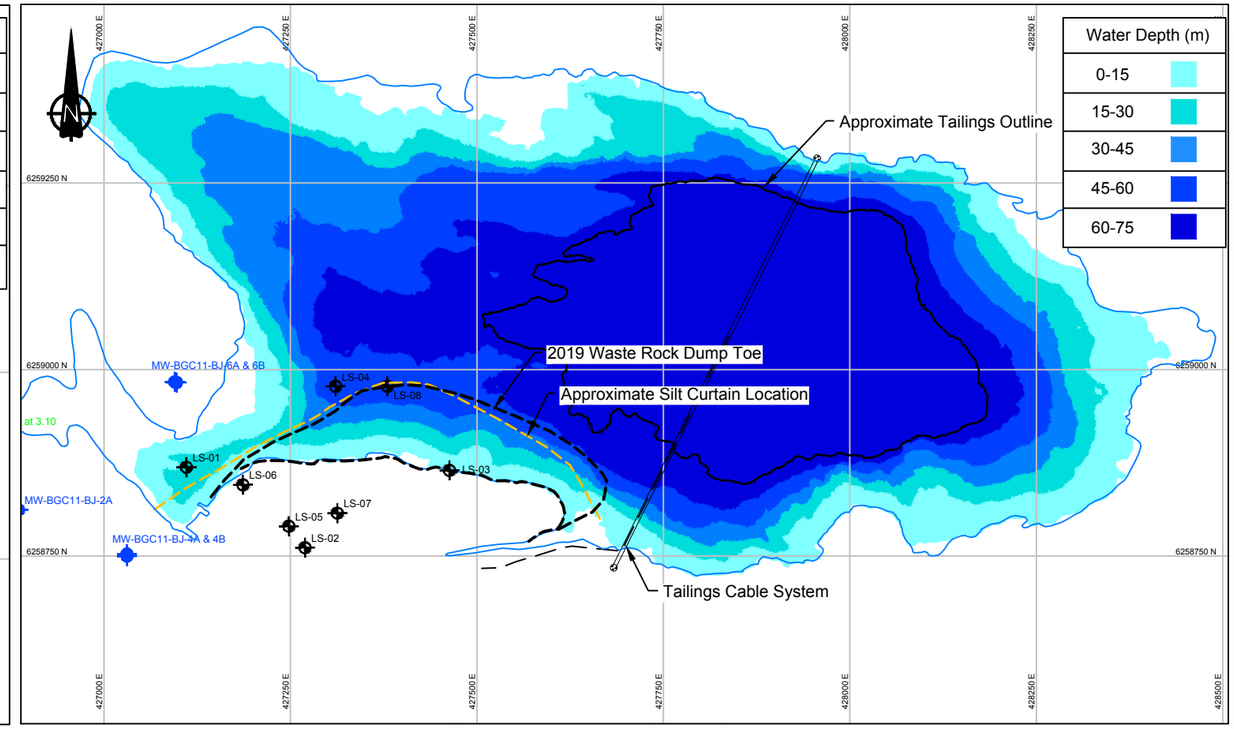
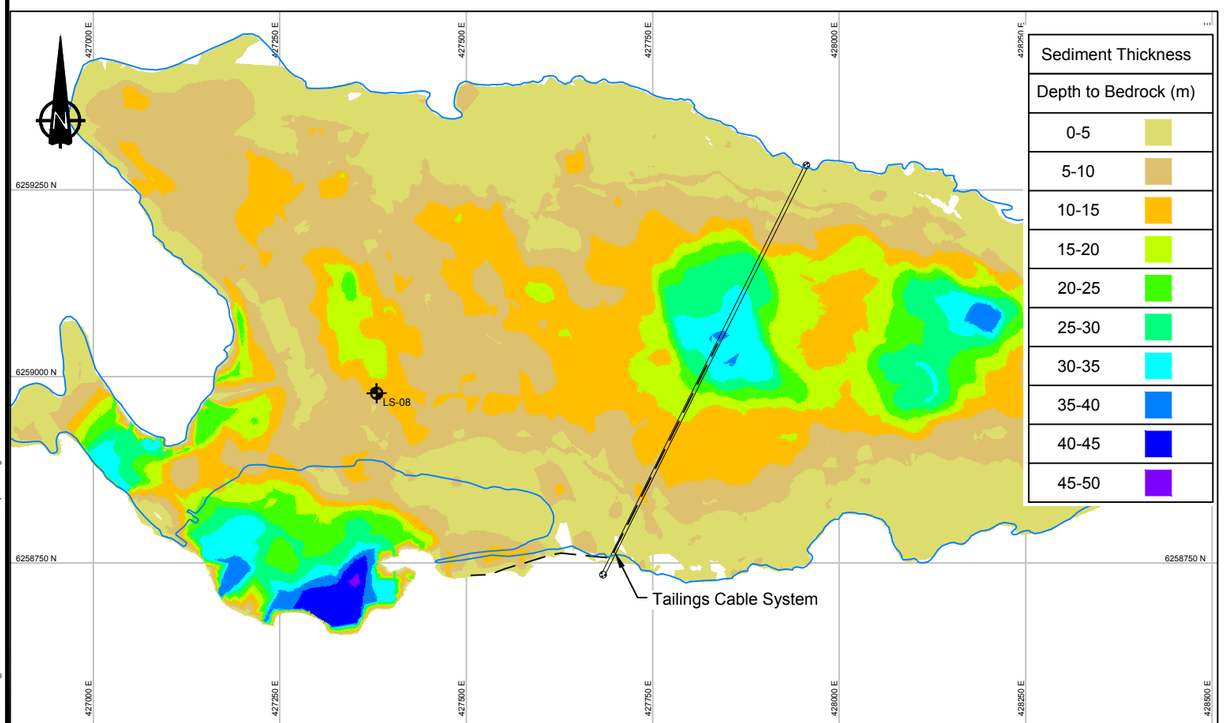
Figure 4: Brucejack Lake – Sediment isopach and lake bathymetry



Pre-mining: Brucejack Lake Water Depth Isopach



2019: Brucejack Lake Water Depth Isopach



Premining: Brucejack Lakebed Sediment Isopach

LEGEND

- Bathymetry Contour (5m)
- Turbidity Curtains
- Tailings Pipeline
- BGC (2014) Lakebed Sediment Sampling Locations

NOTES

1. Camp infrastructure received from AMEC Foster Wheeler.
2. Sediment isopach completed by digitizing bedrock contours presented in Frontier Geophysics (2013) 'Report on Bathymetric Survey, Brucejack Lake Bell II Area, B.C.'
3. Orthophoto provided by Pretivm.
4. Lakebed sampling locations presented in BGC Engineering Inc. (2014) 'Geotechnical Stability Assessment of Waste Rock Deposition in Brucejack Lake".
5. Tailings cable system and pipeline design from AMEC Foster Wheeler drawings 177421-3410-DD10-PLS-0524, 177421-3410-DD10-PLS-0533,and 177421-3410-DD10-PLS-0534.

REFERENCE

NAD83 UTM Zone 9.

srk consulting	PRETIVM	OMS Manual	
		Brucejack Lake Sediment Isopach and Lake Bathymetry	
SRK JOB NO.: 1CP025.000	Brucejack	DATE: January 2020	APPROVED: SM / FIGURE: 4
FILE NAME: 1CP026.001 - Isopachs.dwg			

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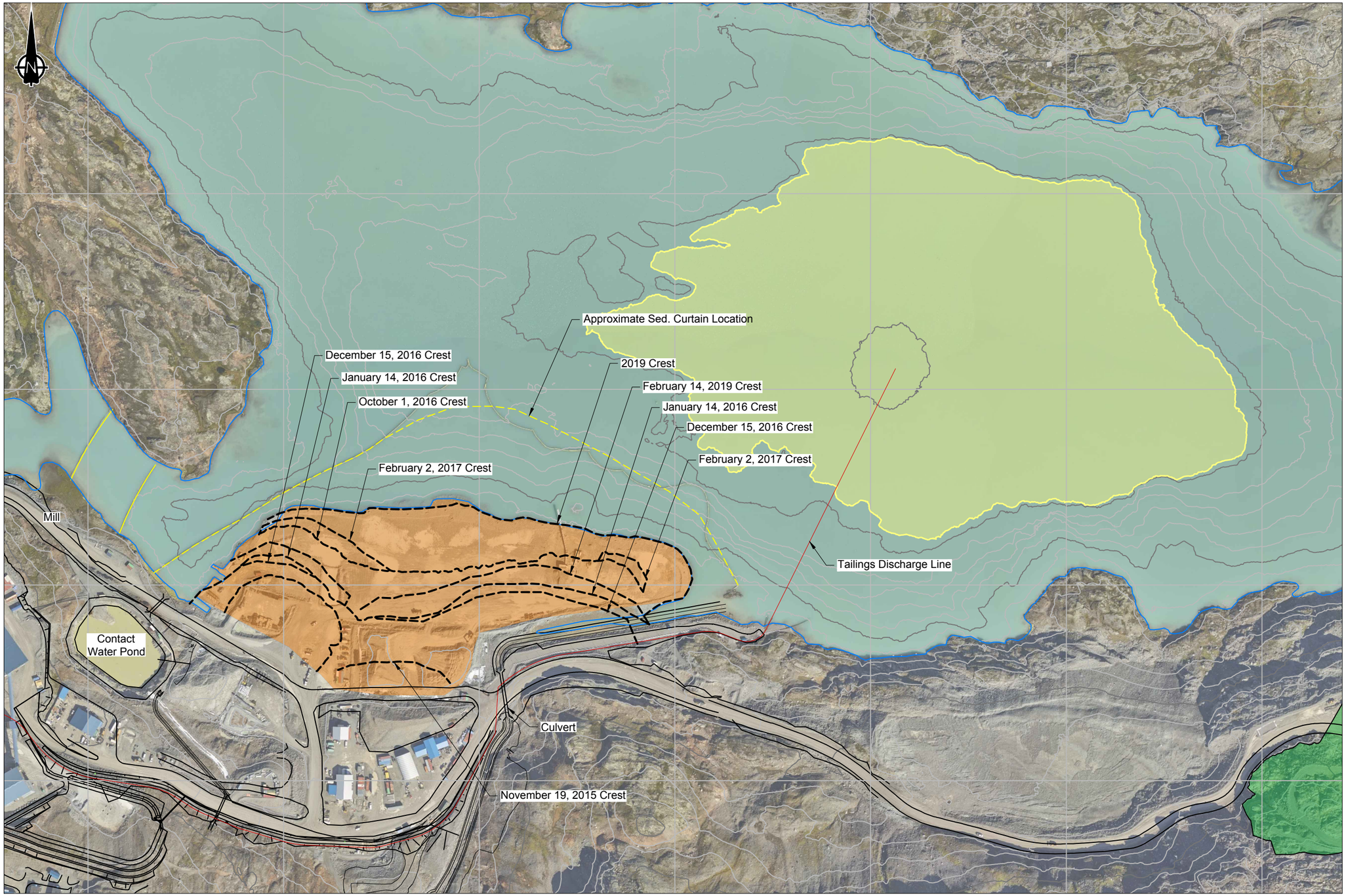
Figure 5: Survey control point locations and waste rock deposition history



LEGEND

- Waste Rock Dump Crest Survey
- Approximate 2019 Tailings Deposition Area
- Subaqueous Waste Rock Deposition Area

NOTES

1. Contours shown at 10.0m intervals.

REFERENCE

NAD83 UTM Zone 9.
2019 Orthophoto and LiDAR provided by Pretivm Resources Inc.

0m 40 80 120 160

srk consulting

PRETIVM

SRK JOB NO.: 1CP026.001

FILE NAME: 1CP026.001 - WR-History.dwg

BruceJack

OMS Manual

Waste Rock and Tailings Deposition History

DATE:	APPROVED:	FIGURE:
January 2020	--	5

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Appendix A:
Responsible, Accountable, Support, Consulted, and Informed (RASCI) matrix

RASCI Matrix: Waste Rock and Tailings Storage Facility (WRTSF), Brucejack Mine

Dated: 28 October 2023.

Rev.: C

RASCI Definitions:

- **A:** *Accountable*. The one ultimately answerable for the correct and thorough completion of the deliverable or task, the one who ensures the prerequisites of the task are met, and who delegates the work to those responsible. The accountable must sign off (approve) work that responsible provides. There must be only one accountable specified for each item.
- **R:** *Responsible*. Those doing the work to complete the item.
- **S:** *Support*. Resources allocated to responsible and who provide input to the work to complete the item.
- **C:** *Consulted*. Those whose opinions are sought, typically subject-matter experts, and with whom there is two-way communication.
- **I:** *Informed*. Those who are kept up to date on progress, often only on completion of the task or deliverable, and with whom there is just one-way communication.

WRTSF-SPECIFIC															
ITEMS			**Accountable Executive Officer (AEO)**	**WRTSF Responsible Person**	**Engineer of Record (EOR)**	**Deputy EOR**	**Independent Reviewer**	**Design Engineer**	**General Manager / Deputy General Manager**	**Tailings Qualified Person (QP)**	**Waste Rock QP**	**Environmental QP**	**Health and Safety QP**	**Surface Operations QP**	**Surface Maintenance QP**
Area	**No.**	**Description**	S.Vadnagra	C.MacKay-Stotesbury	J.E.Kwok	P.M.Bedell		(varies by scope)							
1—Governance	1-1	WRTSF development and implementation of systems required for responsible tailings management	A	R	S	S	C	n/a	S	S	S	S	S	S	S
	1-2	Verification of safe development of WRTSF	C	R	A	S	C	n/a	C	C	C	C	C	C	C
2—Design	2-1	Engineering Design (incl. report, drawings, technical specifications, design changes)	C	C	C	C (or I, depending on EOR availability)	C	A & R	I	C(depending on design scope)	C (depending on design scope)	C (depending on design scope)	C (depending on design scope)	C (depending on design scope)	C
	2-2	Review of designs with respect to safe	C	C	A & R	S	C	C	I	I	I	I	I	I	C

WRTSF-SPECIFIC															
ITEMS			Accountable Executive Officer (AEO)	WRTSF Responsible Person	Engineer of Record (EOR)	Deputy EOR	Independent Reviewer	Design Engineer	General Manager / Deputy General Manager	Tailings Qualified Person (QP)	Waste Rock QP	Environmental QP	Health and Safety QP	Surface Operations QP	Surface Maintenance QP
Area	No.	Description	S.Vadnagra	C.MacKay-Stotesbury	J.E.Kwok	P.M.Bedell		(varies by scope)							
		development of WRTSF													
3—Documentation	3-1	Annual WRTSF development report	C	A & R	R	S	C	n/a	S	S	S	S	S	S	I
	3-2	Bathymetry reports	C	A & R	S	C	I	n/a	S	I	I	R	S	S	I
	3-3	Deposition plan	C	A & R	S	C	I	n/a	C	R	R	I	I	I	I
	3-4	Deposition tracking & reforecasting	C	A & R	S	C	I	n/a	I	R	R	I	I	I	I
4—Operation	4-1	Tailings transport	C	A & R	S	C (or I, depending on EOR availability)	C	n/a	S	R	I	S	S	R	S
	4-2	Tailings deposition	C	A & R	C	C (or I, depending on EOR availability)	C	n/a	S	S	I	S	S	R	I
	4-3	Water management	C	A & R	S	C (or I, depending on EOR availability)	C	n/a	S	S	I	R	C	R	I
	4-4	Silt curtain relocation	C	C	C	C (or I, depending on EOR availability)	I	n/a	S	I	I	A	C	R	I
	4-5	Waste rock transport	I	C	C	C (or I, depending on EOR availability)	I	n/a	S	I	I	C	C	A & R	n/a
	4-6	Waste rock deposition	I	A	C	C (or I, depending on EOR availability)	I	n/a	S	I	R	C	C	S	n/a
	4-7	Reclaim Weir	C	A	C	C (or I, depending on EOR availability)	I	n/a	S	I	I	R	S	S	I

WRTSF-SPECIFIC															
ITEMS			Accountable Executive Officer (AEO)	WRTSF Responsible Person	Engineer of Record (EOR)	Deputy EOR	Independent Reviewer	Design Engineer	General Manager / Deputy General Manager	Tailings Qualified Person (QP)	Waste Rock QP	Environmental QP	Health and Safety QP	Surface Operations QP	Surface Maintenance QP
Area	No.	Description	S.Vadnagra	C.MacKay-Stotesbury	J.E.Kwok	P.M.Bedell		(varies by scope)							
5—Maintenance	5-1	Tailings transport	I	A	C	C (or I, depending on EOR availability)	C	n/a	S	R	I	C	C	C	R
	5-2	Silt curtain	n/a	I	C	C (or I, depending on EOR availability)	I	n/a	S	I	I	A	C	R	n/a
	5-3	Waste rock deposition	I	C	C	C (or I, depending on EOR availability)	C	n/a	S	I	A	C	C	R	n/a
	5-4	Water management	I	C	C	C (or I, depending on EOR availability)	C	n/a	S	I	I	A	C	R	n/a
	5-5	Reclaim Weir													
6—Surveillance	6-1	Site observations	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	I	R	R	I	I	S
	6-2	Daily inspections	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	R	R	R	R	I	S
	6-3	Weekly inspections	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	R	R	R	R	I	S
	6-4	Annual WRTSF inspections	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	R	R	I	C	I	n/a
	6-5	Instrumentation monitoring	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	C	R	R	C	I	I
	6-6	Data analysis	I	A	I	C (or I, depending	I	n/a	S	R	R	R	I	I	I

WRTSF-SPECIFIC															
ITEMS			Accountable Executive Officer (AEO)	WRTSF Responsible Person	Engineer of Record (EOR)	Deputy EOR	Independent Reviewer	Design Engineer	General Manager / Deputy General Manager	Tailings Qualified Person (QP)	Waste Rock QP	Environmental QP	Health and Safety QP	Surface Operations QP	Surface Maintenance QP
Area	No.	Description	S.Vadnagra	C.MacKay-Stotesbury	J.E.Kwok	P.M.Bedell		(varies by scope)							
						on EOR availability)									
	6-7	Analysis review	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	R	R	R	I	I	n/a
	6-8	Environmental monitoring	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	I	I	R	C	S	I
	6-9	Bathymetric surveys	I	A	I	C (or I, depending on EOR availability)	I	n/a	S	I	I	R	C	S	I

n/a = not applicable

Appendix B:
Standard Operating Procedures

Appendix B2:
Waste Rock Deposition with Remote Dozer

NEWCREST PRETIUM RESOURCES INC. A member of the Newcrest Group of companies		**BJ-ENG-SOP-011** **Waste Rock Disposal – Remote Dozer**	
Owner: Tech Services	**Approver**: Senior Geotechnical Engineer	**Revision Number**: 2.0	**Creation Date**: May 2021 **Revision Date**: October 2023

Objective

The objective of this procedure is to provide a safe and efficient process for the subaqueous disposal of Potentially Acid Generating (PAG) waste rock in the Brucejack Waste Rock and Tailings Storage Facility (WRTSF). The method of waste rock disposal detailed in this procedure is a remotely operated dozer push.

Scope

It has been determined that underwater disposal (subaqueous deposition) is, and will continue to be, the best management practice for the disposal of waste rock at the Brucejack Mine (the Mine) (i.e., for the waste rock that will not be used for underground backfill). As the Mine continues operation and production, waste rock mainly from the underground mine development is placed underwater within the WRTSF pond.

This procedure applies to all site personnel involved in subaqueous waste rock deposition at the Mine, including both Pretivm employees and independent contractors.

Health, Safety & Reclamation Code of BC

6.5.2(1)(2)(3) – Dump block

6.4.2 – Daily examination and report book

6.18.1 – Remote Control Operations

6.18.2 – Remote Control Operations

Definitions

PPE	Personal Protective Equipment.
Daily Deposition Plan	The Daily Dump Plan, or Deposition Plan, is a daily set of instructions which define the What, Where, and When of all tasks required over the next 24 hours at the waste rock dump, communicated via email, shared spreadsheet, and an annotated plan map attached to both.

Preparation

Hazards

Unplanned and/or uncontrolled activation of Dozer

Berm crest failure

Heavy equipment pedestrian interactions

High traffic area

Energized equipment

Stored energy

Unable to see settling materials

Slippery conditions

Sharp materials (rebar/fill fence)

Tools

- Remote Controlled Dozer
- Rock Truck
- Excavator
- Wheel Loader
- Personal Flotation Device
- Lock Out Locks and Tags
- Hand tools/power tools
- Long reach equipment for ice breaking (long arm excavator or crane that can park outside the 40 m restriction zone of the dump crest)
- GNSS instruments
- Tilt-beam instruments
- SlideMinder instruments
- Survey monument and prism

Requirements

- Operators, engineers, surveyors, and supervisors must review this SOP before commencing or participating in waste rock disposal with the remote-controlled dozer (RC Dozer).
- Operators, engineers, surveyors, and supervisors must review and understand the Waste Rock and Tailings Storage Facility Operations, Maintenance, and Surveillance manual (WRTSF OMS manual).
- Operators, engineers, surveyors, and supervisors must review and understand the Trigger Action Response Plan(s) (TARPs) appended to the WRTSF OMS.
- Operators and supervisors must review, be familiar with, and implement the associated SOP for remote dozer operation BJ-OPS-SOP-0020 Remote Dozer Operations before commencing waste rock disposal as described here.

Responsibilities

Mine Manager and Surface Operations Manager

The Mine Manager and Surface Operations Manager are responsible for:

- Ensuring this procedure is implemented and maintained.

Engineer

The Engineer is responsible for:

- Implementing this procedure.
- Developing a daily deposition plan, specific to remote dozer operation, and communicating this plan with all personnel working on the Waste Rock Dump.
- Maintaining and analyzing optical survey settlement data.
- Maintaining and analyzing GNSS settlement data.
- Maintaining and analyzing Tilt-Beam and/or SlideMinder data and observations when instruments are in-use.
- Assisting in operational management and supervision.
- Maintaining a waste rock dump geometry model.
- Training supervisors and other stakeholders in:
    - dump hazard recognition,
    - dumping procedures, and
    - reporting requirements.

Supervisors

Supervisors are responsible for:

- Implementing this procedure.
- Executing the daily deposition plan.
- Enforcing the use of dump site PPE.
- Training dump operators in hazard recognition and dumping procedures.
- Arranging for mentorship and coaching of newer operators by more experienced operators.
- Ensuring that dump safety features such as GNSS instruments, Tilt-Beams, berms, lighting, delineators, and barricades are constructed, installed, and maintained properly.
- Completing and recording dump inspections per the procedure. Completing inspections on active waste rock deposition areas.
- Ensuring that dump personnel understand their responsibilities, are trained, and are adhering to the procedures.

Health and Safety Manager

The Health and Safety Manager and their designate(s) are responsible for:

- Monitoring the implementation of this procedure.
- Maintaining training records.
- Maintaining emergency response and/or rescue SOPs and Management Plans.
- Performing bi-weekly audits of the dump site.

Dump Operations Personnel

Dump Operations Personnel are responsible for:

- Always adhering to this procedure.
- Safe remote operation of the dozer in conjunction with other equipment operated by conventional means.
- Performing visual dump inspections, equipment pre-shift inspections, and PPE inspections.
- Ensuring dumpsite PPE is always worn.
- Keeping all barricades and signage properly placed and maintained.
- Maintaining berm dimensions and profile as required.
- Stopping work, retreating to a safe area, and notifying supervisor(s), other personnel if conditions change.
- Immediately reporting any substandard dumpsite conditions to their supervisor.
- Asking for clarification from supervision if they have questions or concerns. Ensuring all snow and ice is removed from dump/ berms (Winter Months).
- Ensuring that ice immediately adjacent to the dump crest is cleared before waste rock deposition.

Personal Protective Equipment (PPE)

When settlement data and visual inspection indicate that the waste rock dump crest is stable, authorized personnel may enter the 40 m “remote only” exclusion zone on foot. Non-remote equipment is authorized to enter the 40 m exclusion zone only in specific, rare cases, as authorized by the Geotechnical Engineering team. In addition to standard PPE, any person within 40 m of the dump crest shall also use:

- A Personal Flotation Device (PFD), properly worn and buckled.
- A spotter with a radio standing outside the 40 m exclusion zone.

- Cold weather gear during winter.
- Personal lock (and tag(s)) for locking/tagging out any equipment with the potential for stored energy.

Monitoring and Inspections

Monitoring

GNSS settlement survey instruments are placed across the waste rock dump crest and report their positions hourly.

- Periodically, these instruments must be moved ahead to maintain proximity to the advancing dump crest. This work is authorized at the discretion of the Geotechnical team, following the performance objectives described in the WRTSF OMS TARP.
- If connectivity/network issues or power outages at the RC trailer compromise this system, troubleshooting and repair actions are initiated immediately.

Tilt-Beam system is to be placed across cracks or areas of concern observed on the waste rock dump crest or platform.

Bathymetric surveys are completed annually at a minimum; these surveys are interpreted to analyze the evolution of the underwater slope geometry.

Monitoring and Inspection Frequency

The Engineer must review the settlement monitoring data before issuing the daily plan. Periodic, ongoing review is also recommended.

The Engineer can request additional bathymetric surveys as required by waste rock deposition activities.

The dumpsite will be cleared of snow and ice and inspected prior to waste rock placement at the beginning of each shift.

The dump operators and supervisors shall complete an inspection of their active work areas prior to commencing or resuming work on the dump at the following intervals:

- At the start of every shift (day or night);
- After each break (i.e., coffee or lunch; day and nightshift); and
- Every time a new work area is started even if partway through the shift.

Except in rare cases where no geotechnical engineering personnel are on-site, an engineer must visit and inspect the dump every day that operations are occurring. Supervisors must visit and inspect the dump three times daily, including inactive work areas.

Inspection Procedure

When weather allows, a drone flight can be conducted to facilitate remote visual inspection. Otherwise, when inspecting the dump, the entire active area and 30 m to either side of that area will be inspected by foot from >40 m away from the dump crest and not from the cab of a vehicle.

Supervisors will inspect and monitor the active remote dozing areas of the dump, to be sure of the stability and finished work is satisfactory.

In cases where closer inspection is necessary, the geotechnical engineering team is authorized to enter the 40 m exclusion zone on foot, provided they adhere to the following conditions:

- Current settlement monitoring data indicates stability in the zones to be entered/inspected.
- Personnel entering the 40 m exclusion zone must wear the appropriate PPE (including Personal Floatation Device) and carry a functioning handheld radio.
- A spotter is nominated who will stay in a safe location with good visibility of the personnel entering the 40 m exclusion zone, and who will maintain visual and radio contact with the

inspection personnel until the inspection is complete and no personnel remain within the 40 m exclusion zone.

The person performing the physical inspection will pay particular attention to the dump floor and safety berm.

Signs of potential instability include:

Increased settlement rate (from GNSS, optical survey, and/or Tilt-Beam data).

Bulging waste rock slope profile (underwater) from bathymetric survey.

Cracking, or expanding crack aperture as measured by SlideMinder instrument(s).

Sloughing,

Changes in material type or moisture content, and

Surface deflection from equipment.

When signs of instability are observed, they will be noted, reported, and monitored. When these conditions are noted, all work will be stopped, and operators will retreat to a safe zone. The Mine Manager, Supervisor and Engineer will formulate a plan to work safely around the area, and/or to reduce the potential for more substantial slope failures.

For more information regarding indications of instability and standard response actions, please refer to the WRTSF Trigger Action Response Plan (TARP) table, found in the WRTSF Operations, Maintenance, and Surveillance manual (OMS manual).

Details of inspections recorded by supervisors will be filed for future reference.

Details of inspections recorded by engineers will be recorded and relevant observations reported in the Daily Dump Report.

Waste Rock Deposition Procedure

The Engineer will issue a daily dump plan, including the location and allowable volumes of deposition, in addition to any instructions related to atypical material specifications.

Plans for the daily deposition of materials will be communicated with the crews at the start of the shift. Any deviation from the plan must be approved by the Engineer.

During winter, it is critical to minimize or eliminate the incorporation of snow and ice into the waste rock slope:

Every effort must be made to clear accumulated snow from the dump floor and berm prior to commencing deposition activities:

- Snow found within the final dozer-length from the crest may not be recoverable; however, the rest of the exclusion zone can be cleared remotely by the RC dozer, with excavators and wheel loaders clearing the rest of the dump floor and stockpile as necessary.
- Depending on weather conditions, it’s possible that icebreaking is necessary to resume/sustain deposition.
    - Long-reach equipment (such as a long-reach excavator) can be employed to break ice from a safe distance.
    - Provided the ice thickness isn’t too great, the RC dozer can alternatively be used to break the ice by carefully advancing rock onto it. Additional operational experience is required to trial the effectiveness of this technique in different conditions, such as the presence of thicker, competent ice.

During operations, reflective markers or signage/delineators will be maintained to delineate the “40 m exclusion zone” distance from the dump crest.

Waste Rock Placement (Remote Dozer Operation)

As shown in Figure 1, the waste rock dump crest is divided into seven work zones (Zones 2, 3, 4, 5, 6, 7, and 8, respectively). These zones are demarcated in the field by signposts and signage, placed 40 m from the crest and periodically advanced to provide an accurate positioning aid for haul truck drivers to dump their loads.

The zones are approximately equal length. Their actual length is measured every time drone mapping is completed, and this measurement is used to calculate allowable daily deposition volumes per-zone:

A limit of 6.57 m3/m crest is prescribed for typical operations:

- On average, this cannot be exceeded; however, following deposition downtime or extended periods of reduced productivity, a “catch-up rate” can be applied for three days at a time to facilitate parity between average productivity and the deposition limit.

A limit of 9.00 m3/m crest is prescribed for 3-day catch-up periods:

- In cases where multiple catch-up periods are necessary, following two days of steady-state (6.57 m3/m) deposition during which settlement monitoring does not indicate accelerating trends or exceed the QPO, a second (or third, fourth, etc.) catch-up period can be initiated.

These limits can be modified based on physical, visual, and instrumentation observations: reduced deposition rates and/or barricading off portions of the dump crest have been shown to correct accelerating trends and QPO-exceeding settlement rates.

The remote dozer operator will aim to distribute the muck stockpiled in the active work zone throughout the crest length of that zone, working from one side to the other. When pushing muck, the dozer must maintain an orientation perpendicular to the dump crest.

A safety berm will always be maintained throughout this process: the dozer will push fresh muck into the existing safety berm, depositing the old safety berm into the WRTSF and replacing it with fresh muck.

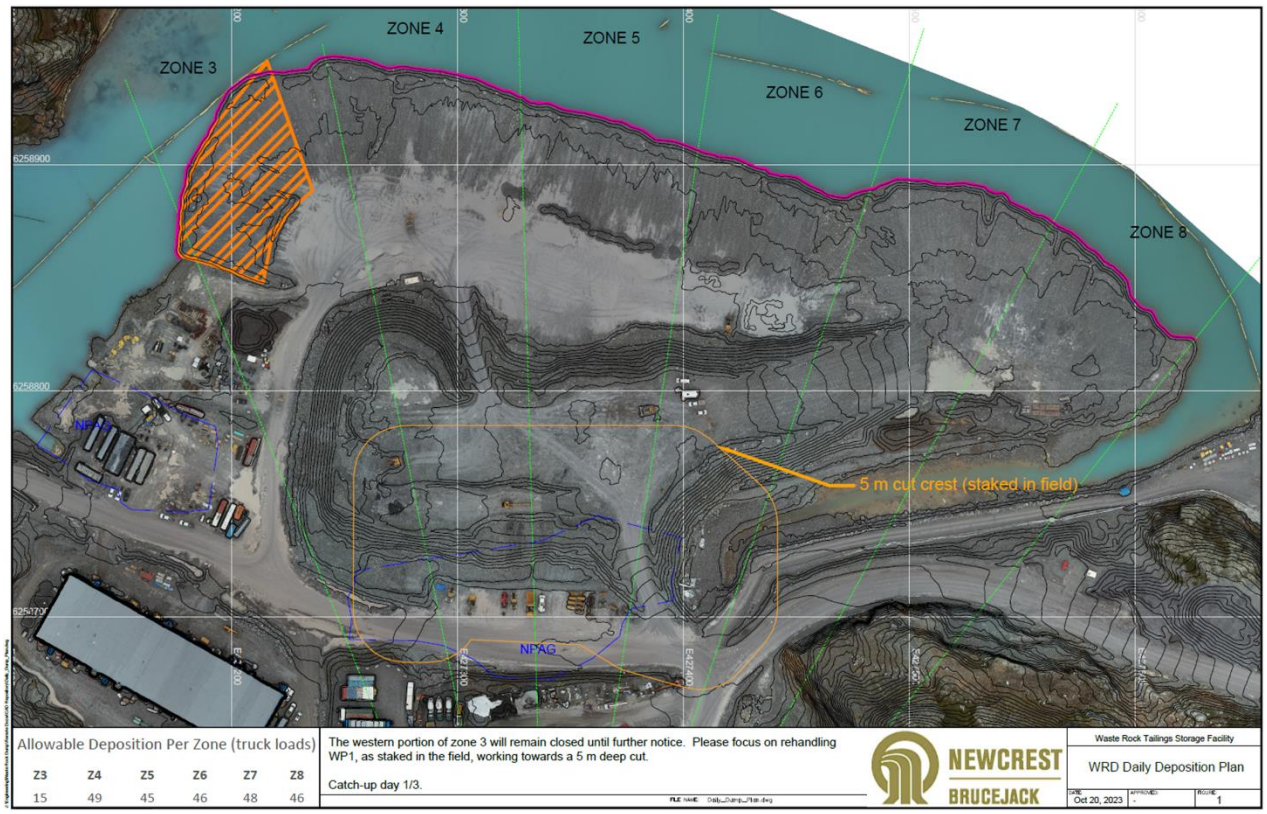


Figure 1: Example Daily Deposition Plan

Weather Conditions

Dumping operations shall be reassessed if the operator's visibility is impaired by weather conditions.

When visibility is reduced enough to affect the operator's ability to see potential hazards, the operator must cease work, retreat to a safe location, and notify their supervisor of the deteriorating conditions. The supervisor will decide if conditions require "Restricted Work" on the dump, or "Stop Work" on the dump.

Under "Restricted Work", no personnel or equipment will operate within 40 m of the dump crest. Truck dumping operations may continue outside the 40 m exclusion zone.

Under a "Stop Work" designation, no work will take place on the dump until conditions improve.

Work will not resume until visibility improves and a dump inspection completed.

References

Pretium Resources Inc., a member of the Newcrest Group of companies. (2023). Operations, Maintenance, and Surveillance Manual - Waste Rock and Tailings Storage Facility.

Pretium Resources Inc., a member of the Newcrest Group of companies. (2023). WRTSF Failure Management Plan.

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
WRTSF Responsible Person	Cam MacKay-Stotesbury	[redacted]	
Senior Geotechnical Engineer	Woo Shin		
Surface Operations Manager or Designate	Mike Blabey		
Health and Safety Manager or Designate	Wendy Willis		
JOHSC Co-chair or Member	Sienna Johnson		

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
October 2023	Procedure(s) updated to capture optimizations/improvements developed over 2.5 years of operational experience.		all

Appendix B3:
Remote Dozing Operation

NEWCREST BRUCEJACK		**BJM-OPS-SOP-0020** **Remote Dozer Operation**	
Department: **Surface Operations**	**Manager:** **John Sheehan**	**Revision Number:** **R1**	**Creation Date:** **August 28, 2021** **Revision Date:** **January 15, 2023**

Objective

This standard operating procedure (SOP) establishes the requirements for the safe operation of the remote-control dozing instrumentation on the Brucejack Waste Rock and Tailings Storage Facility (WRTSF) waste rock dump. This procedure was created to provide consistent and safe operating procedures for all employees and supervisors, and to comply with Brucejack's standards and relevant provincial mining regulations.

Scope

To provide a standard operating procedure for the safe operation of remote dozing of waste rock within the WRTSF. This SOP applies to all employees, including independent contractors working at the Brucejack Mine and designated sites.

Health, Safety & Reclamation Code for Mines in British Columbia

- 6.18.1, 6.18.2 remote control operations
- 6.19.1 Equipment operation
- 9.7.1 Terrain
- 10.5.6, 10.6.5 Major dumps

Definitions

- **Cat Command (Remote Dozer)** - Technology that allows an operator at a console to drive and operate remotely.
- **Cat Grade-** Technology that allows an operator to impute a daily grade plan into the dozer
- **Remote Operator-** A operator which operates a dozer from a mobile command center.
- **Remote Hot Zone-** The area defined as the controlled zone in which all Cat Command (remote dozing) activities are being carried out, and/or may impact surrounding waste disposal operations. This will be physically defined by the placement of the barricades.
- **Control room-** Mobile trailer which houses all the Cat Command controls and operators.
- **Remote all stop –** hand-held remote that is used to stop remote dozer activities in case of emergency.
- **WRTSF –** Waste rock tailings storage facility
- **WRD –** Waste rock dump
- **Avoidance Zone-** Digital fence on the Terrain Map system which will stop the RC dozer

- **Exclusion Zone –** There is an exclusion zone that is set by the geotechnical group that is an area of increased sloughing and is an indication of a potential slough. No one is to enter the exclusion zone unless approved by the Geotechnical group.

Roles and Responsibilities

The General Manager or Designate shall ensure that:

- A process is in place to develop, implement and use standard operating procedures (SOP)
- The resources, time, money, and technology available to support the safe operating procedures program.

The Health and Safety Manager or Designate shall ensure that:

- Provide advice and assistance in the development, implementation, and use of standard operating procedures (SOP)

The Area Manager or Designate shall ensure that:

- Ensure the implementation and use of standard operating procedures (SOP)
- Ensure that SOP is updated whenever there is a change to an existing process or equipment or an introduction of new processes or equipment
- Provide ongoing SOP training to all employees
- Inform all workers when a change occurs to the SOP
- Conduct the review of the standard operating procedures (SOP) within the required timeline specified in the document (3 years maximum) and make revisions as necessary due to changes in operating processes, industry best practices, or manufacturer recommendations

The Worker is responsible for:

- Adhering to the information supplied in this document
- Participating in the development and revision of standard operating procedures
- Annual standard operating procedure reviews

Preparation

Hazards

- Open water.
- Working near other heavy equipment/potential limited visibility.
- Any loss of communications from the remote dozer to the control room.
- Any interruptions to the remote dozer operator while operating the dozer.
- Any unexpected mechanical, electrical, or operational failure that impedes remote dozer activities in the hot zone that requires entry into the zone to retrieve or repair the remote dozer.
- Inadvertent entry to the Remote hot zone during remote dozer operations. which will be monitored by a camera.

Tools

- Spill Kit
- Remote All stops
- Light plant

Requirements

- WRD daily report
- Spotter required for manual retrieval within the exclusion zone
- Demarcation of the Exclusion zone
- Personal Protective Equipment (PPE) hard hat, safety glasses, hi vis vest, CSA certified boots and gloves
- In addition to standard PPE, operators working within 30m of the dump crest shall also use: Manually activated flotation vests
- Hard hats with chin straps must be worn while operating a dozer or excavator on the dump
- Cold weather gear during winter
- Seat belt DOES NOT HAVE TO BE WORN when working within the exclusion zone. But must be worn on other dump site work zones.
- Personal Lock (and Tags) for locking/tagging out potential energy equipment.
- In addition to standard PPE, personnel working within the exclusion zone must wear a flotation device.
- An **ALL STOP** is to be signed out if working within WRD RC dozer area.
- Test ALL STOP before use. To test press test and dozer will honk
- Operators shall have completed proper training and be deemed qualified by a trainer as per Brucejack's equipment training policy

Job Step

1. Only personnel trained and authorized in the use of a Remote Dozer shall be permitted to operate the Remote Dozer remotely. All other dozer operators may run the dozer manually for maintenance or transport only..
2. A safe location for the operator shall be provided in the Control room trailer within view of the dozer and work area.
3. Clean all camera lenses.
4. Conduct a manual pre-use inspection and servicing of the machine using the equipment logbook and FLHA.
5. Manually test all functions from the operator’s seat.
6. The work area **(Remote Hot Zone)** where any remote-controlled equipment is operating must have clearly marked signage. Signage shall state “Authorized personnel only".
7. The operator shall conduct a pre-inspection as per the operator's logbook. In addition, the operator shall test and inspect the remote dozer and remote operating unit consisting of the following
    a. Check antennas
    b. Check the condition of the transmitter
    c. Test for transmitter response
    d. Test the transmitter emergency stop button
    e. Test front and rear light functions
    f. Test throttle functions
    g. Test Blade and Ripper functions
    h. Test Park and service brake release functions
    i. Test steering function
    j. Test forward and reverse direction functions
    k. Test Shut Down

8. The manual controls in the cab must be locked out or gated to prevent accidental engagement during equipment movement.
9. Remote Dozer Operator and Rock truck operators will sign FLHAs and discuss Dump plan and hazards.
10. During waste rock dump crest inspections by engineers. Remote Dozer operation will Stop until inspection is complete. ALL STOP required within RC dozer area

NOTE: The operator will be located outside of the Remote Hot Zone to perform the above tests. If any of these tests are unsuccessful, immediately remove the Remote Dozer from service and Lockout. The supervisor and Heavy shop are to be notified immediately.
Once the above tests are complete operator will test the RC Dozer avoidance Zones. If Avoidance zone test fails, no remote work shall commence.

Control Room & Remote operator

11. The operator must be in the mobile control room trailer while remote dozing is active
12. No worker shall enter the remote dozer testing area without receiving permission from the remote dozer operator
13. Operator must follow a daily dump plan

End of shift

14. No maintenance work or servicing shall be performed on remote-controlled equipment unless the transmitter unit has been locked out.
15. Ensure the remote dozer tracks are cleaned and no muck or garbage is left in the dozer.
16. Post-operational inspection is to be completed and any deficiencies are to be reported immediately to the supervisor.

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	[redacted]		
Health & Safety Manager / Designate			
JOHSC Co-chair or Member			

APPROVER ROLE	NAME	SIGNATURE	DATE
Mine Manager / Designate			

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Exclusion Zone	[redacted]		

SOP Review Sign Off	
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Completed copy is to be forwarded to the Safety/Training Department

Appendix B4:
Waste Rock Dump PAG Material Replacement

NEWCREST BRUCEJACK		**BJM-OPS-SOP-1017** **NAG PAG Remove Replacement on Waste Rock Dump**	
Department **Surface Operations**	**Manager** **John Sheehan**	**Revision Number:**	**Creation Date:** **Feb 23, 2020**
			Revision Date: **Feb1, 2023**

Objective

As part of the requirements for the operations of the waste rock dump (WRD) at Brucejack Gold Mine, the potentially acid generating (PAG) rock used for the construction of the dump needs to be placed 1m below the Brucejack Lake water level. The removal of this material needs to be done in a safe and timely manner as the dump continues to be developed.

Scope

To provide a standard operating procedure for the safe and efficient removal of the potentially acid generating rock currently used to develop the waste rock dump. Once removed to 1m below Brucejack Lake level, the void is to be covered with non-acid generating (NAG) rock throughout the waste rock dump.

Health, Safety & Reclamation Code for Mines in British Columbia

- 4.17.1 - 4.17.15 Excavations.
- 10.1.15 Major Dumps
- 10.1.16 Metal Leeching and Acid Rock Drainage
- 10.5.5 – Permitting, Reclamation and Closure, Major Dumps.

Occupational Health & Safety (OHS) Regulation (WorkSafe BC)

- 16 Mobile Equipment

Definitions

- Acid generating – refers to the acidic water that is created when sulfide minerals are exposed to air and water and, through a natural chemical reaction, produce sulfuric acid and has the potential to introduce acidity and dissolved metals into water.
- PAG: Potentially Acid-Generating material.
- NAG: Non Acid-Generating material.
- PPE – personal protective equipment.

Roles and Responsibilities

The General Manager or Designate shall ensure that:

- A process is in place to develop, implement and use Standard Operating Procedures (SOP).
- The resources, time, money, and technology are available to support the Standard Operating Procedures program

The Health and Safety Manager or Designate shall ensure that:

- Provide advice and assistance in the development, implementation, and use of Standard Operating Procedures (SOP)

The Area Manager or Designate shall ensure that:

- Ensure the implementation and use of Standard Operating Procedures (SOP)
- Ensure that SOPs are updated whenever there is a change to an existing process or equipment, or an introduction of new processes or equipment;
- Provide ongoing SOP training to all employees.
- Inform all workers when a change occurs to SOP; and
- Conduct the review of the Standard Operating Procedures (SOP) within the required timeline specified inthe document (3 years maximum) and make revisions, as necessary, due to changes in Operating processes, industry best practices, manufacturer recommendations

The Supervisors are responsible for:

- Compliance to standard Operating Procedure guidelines for field work.
- Ensuring employees are properly trained on the equipment they have been designated to operate
- Providing the proper tools, equipment, information, support and guidance to the workers preforming the task.
- Verifying competency of the worker in the understanding of the Standard Operating Procedures

The Worker is responsible for:

- Comply with all Standard Operating Procedures (SOP)
- Participate in the development and revision of SOP
- Stop and refuse unsafe work

Preparation

Hazards

- Due to close quarters of the work visual and audible communications of equipment movement is essential. Establish positive communication prior to commencing any work.
- Excavation of the area to be removed is in the range of 1-2m deep. Berms (and delineators) will be in place to ensure no personnel wonder into the hole. Equipment operators are not to enter excavated area.

Requirements

- PPE: hard had safety, glasses, hi vis vests, CSA certified boots and gloves
- Personal Flotation Devices are to be worn inside 30m exclusion zone
- Equipment training and sign off

Tools

- Excavator.
- Dozer.
- Rock truck.
- Traffic delineators paint or stake markers to mark sub cut area

Job Step

1. Check to make sure the area to replace is outlined (paint or stakes) as per plan provided by Technical Services. If not, contact surveyors, supervisor or site engineer for clarification.
2. Check and mark depth of excavation as per following data (may need survey assistance to check on ultimate depth).
3. Place bucket flat at bottom of excavated area.
4. Apply mark on bucket or stick of excavator (spray paint / scribe mark) to ensure proper dig depth (repaint as necessary).
5. A photo of this setup should also be taken by the site engineer for record keeping.
6. Excavate area and PAG as per plan provided by Technical Services Engineer. Put PAG in truck and deliver to nearest active and/or available deposition zone. Please follow SOP - Waste Rock Disposal procedure for this part of the operation.
7. Preparing area may require use of a dozer's ripper claw to loosen up prior to excavating, as the ground may be very hard to penetrate with an excavator's bucket (even with a digging bucket).
8. Obtain permission from engineer prior to backfilling excavated area with NAG or PAG rock.
9. Push and level the NAG or PAG material using dozer into the recently excavated area. Ensure area is smoothed out after track-packing.
10. During excavation, a berm shall be maintained around the excavated area ¾ height of largest tire at all times when dig area is open. All four corners of the area should be delineated with cones, especially if left open w/o NAG or PAG backfilled.
11. Final survey pickup of the area shall be conducted after each area is backfilled with NAG or PAG and data provided to PVG Technical Services for documentation.

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	[redacted]		
Health & Safety Manager / Designate			
JOHSC Co-chair or Member			
APPROVER ROLE	**NAME**	**SIGNATURE**	**DATE**
Mine Manager / Designate			

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Equipment used for this task can have possibility of contact Changed to Due to close quarters of the work visual and audible communications of equipment movement is essential.	[redacted]		

SOP Review Sign Off	
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Appendix B5:
Waste Rock Haulage

NEWCREST BRUCEJACK		**BJM-OPS-SOP-1020** **Waste Rock Hauling**	
Department: Surface Operations	**Manager: John Sheehan**	**Revision Number:** **0**	**Creation Date:** **March 1 2018**
			Revision Date: **Nov 10, 2022**

Objective

To provide a standard operation for safe hauling of waste rock to the dumpsite.

Scope

This SOP applies to all employees including independent contractors, working at the Bruce Jack Project and designated sites.

Health, Safety & Reclamation Code for Mines in British Columbia

- HSRC1.9.1
- HSRC 2.2.1
- HSRC 6.10.1
- 16.34-16.43 OHS Regulations

Definitions

- PPE – Personal Protective Equipment
- Remote Dozer- Technology which allows an operator to operate dozer remotely from mobile command center.
- Remote Operator- An operator which operates a dozer from a mobile command center.
- Exclusion zones- Zones that are not to be entered
- FLHA- Field Level Hazard Assessment
- WRD – Waste Rock Dump

Roles and Responsibilities

The General Manager or Designate shall ensure that:

- A process is in place to develop, implement and use Standard Operating Procedures (SOP)
- The resources, time, money, and technology are available to support the Safe Operating Procedures Program.

The Health and Safety Manager or Designate shall ensure that:

- Provide advice and assistance in the development, implementation, and use of Standard Operating Procedures (SOP)

The Area Manager or Designate shall ensure that:

- Ensure the implementation and use of Standard Operating Procedures (SOP)
- Ensure that SOP are updated whenever there is a change to an existing process or equipment, or an introduction of new processes or equipment.
- Provide ongoing SOP training to all employees.
- Inform all workers when a change occurs to SOP; and
- Conduct the review of the Standard Operating Procedures (SOP) within the required timeline specified in the document (3 years maximum) and make revisions, as necessary, due to changes in Operating processes, industry best practices, manufacturer recommendations

The Worker are responsible for:

- Comply with all Standard Operating Procedures (SOP) and
- Participate in the development and revision of SOP
- All SOP are reviewed annually to maintain accurate and current directives.

Preparation

Hazards

- Light Vehicle interactions
- Steep Grades
- Extreme weather conditions
- Miscommunication
- Multiple radio channels
- Active work Area
- Mechanical failure
- Road conditions

Tools

- Pre-operational/ check lists
- Daily FLHA
- Spill Kits
- Radio
- Fire Extinguishers
- Chains in appropriate season
- PPE
- Training
- ALL STOP

Requirements

- Signed off on Remote Dozer SOP BJ-OPS-SOP-064
- Required training on haul truck.

Job Step

1. All operators must complete a thorough walk around and pre-operational check list prior to running any equipment on site to reduce the risk of mechanical failure on an active haul road.
2. Pre-operational/ post-operational check lists must be completed and handed in daily to ensure the safety of coworkers and the environment.
3. Operators are responsible for the operation and maintenance of equipment and follow all rules and policies. For operation of equipment on site.
4. Excavator/loader operators must complete radio check and sign FLHA with the haul trucks.
5. Excavator/Loader operators must maintain running surface surrounding muck bin to avoid side wall tire damage to underground/surface haul trucks.
6. Due to the steep grades and light vehicle interactions the operators loading any type of material into a haul truck for transport, must be diligent in their efforts to reduce spillage on an active haul road.
7. Any equipment on the west zone haul road or at VOK portal must have radio/visual confirmation with excavator/loader operator prior to passing the work zone.
8. Underground Haul trucks will be given the right of way due to separate underground channels and lack of visibility.
9. All underground/surface equipment must maintain a safe distance away from the excavator/ Loaders running surface/ swing zone prior to dumping or being loaded.
10. All operators must remain in the cab while being loaded, unless discussed with loader / excavator operator.
11. Loading significant oversized waste rock into a surface haul truck will require enough bedding waste rock to reduce the chance of damage to the equipment and load shift procurement.
12. All hauling of waste rock on surface will be subject to proper radio calls on the appropriate radio channels. Call at signage on the haul roads.
13. All haul truck operators must be compliant with the posted designated speeds throughout the Bruce Jack project. Under no circumstances will a haul truck exceed the speed of 30km/hour in any zone (Lakeshore Drive) throughout the Bruce Jack Project.
14. All haul truck operators / personnel must switch to radio channel to LAD 1 (Designated WRD channel) to announce entering and exiting WRD. Rock Truck drivers must radio check with RC dozer operator and Sign FLHA. Once clear of the WRD switch back to LAD 2
15. Rock truck drivers are required have an ALL STOP in their equipment and test prior to use.
16. Once haul truck operator has entered dump, remote dozer operator will instruct haul truck operator in which zone to start dumping waste.
17. In the event of extreme weather conditions or reduced visibility the haul truck operators are expected to reduce speeds to a maximum of 15km an hour and reduce efforts for hauling based on the "extreme weather conditions" hazard level.
18. No trucks shall enter the exclusion zone on the waste rock dump set by the Geotechnical team.
19. All operators are expected to complete a thorough post operational check list at the end of every shift as well as properly fill out and initial their FLHA end of shift check list

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	[redacted]		
Health & Safety Manager / Designate			
JOHSC Co-chair or Member			
APPROVER ROLE	**NAME**	**SIGNATURE**	**DATE**
Mine Manager / Designate			

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
4-Excavator/loader operators must complete radio check and sign FLHA with the haul trucks. Rock Truck drivers must check radio with RC dozer operator and Sign FLHA	[redacted]	3	Nov 10, 2022
14 - All haul truck operators / personnel must switch to radio channel to LAD 1 (Designated WRD channel) to announce entering and exiting WRD. Rock Truck drivers must radio check with RC dozer operator and Sign FLHA. Once clear of the WRD switch back to LAD 2		3	Nov 10, 2022
Rock truck drivers are required have an ALL STOP in their equipment and test prior to use.		3	Nov 10, 2022

SOP Review Sign Off	
SOP Title	
Supervisor/Facilitator Name	
Date	

I acknowledge a complete understanding of the SOP presented and by signing below, I agree to abide by the work instruction provided.

Completed copy to be forwarded to the Safety/Training Department

Appendix C:
Water and Ice Emergency Response and Rescue Plan

PRETIVM		BJ-OHS-SOP-034 Water / Ice Emergency Response & Rescue Plan	
Owner: Health & Safety	Approver: John Addy	Revision Number: 2	Creation Date: 13 Dec. 2015 Revision Date: 28 March 2020

Objective

The objective of this Operating Procedure is to provide a response plan to safely and effectively rescue a person that has entered Brucejack Lake or other lake/river on the Brucejack site.

Scope

This SOP applies to all employees, including independent contractors, working at the Brucejack Project and designated sites that potentially become submerged into Brucejack Lake or other lake/river on the Brucejack site.

Health, Safety & Reclamation Code of BC

- 3.2.2.1 – General Safety Rules

Definitions

- PPE – means Personal Protective Equipment for working around waterbodies such as floater suits, PFD's and other standard safety equipment.
- Workers – includes all Pretivm employees and contractors on site.

Responsibilities

Mine Manager or Designate is responsible for:
- Ensuring this SOP is implemented and maintained.

Health and Safety Manager is responsible for:
- Ensuring the implementation of this procedure is monitored;
- Conduct reviews and make amendments to the procedure as required; and,
- Ensuring on-site personnel have up-to-date information and appropriate training regarding this SOP.

ERT Coordinator is responsible for:
- Monitoring the implementation of this procedure; and,
- Maintain training records and certifications.

Surface Operations Supervisor is responsible for:
- Ensuring that all personnel who are involved in ice/water response/rescue understand this procedure; and,
- Ensuring that only trained and competent personnel are engaged in Ice/Water Rescue.

Dump Operation Personnel:
- Follow this SOP as outlined and directed by the content of this document; and,
- Ensure all Dump Operation Personnel are properly dressed, wear life vests, harness and or belt with a D-Ring.
- Be familiar with the safety seacan contents located at entrance of dump site.

Preparation

Hazards

- Personal Injury;
- Extreme cold, frostbite, hypothermia;
- Slippery conditions with personnel and vehicle interaction;
- Potential of additional dump failure;

- Potential of breaking through ice into open water;
- Rescue equipment out of reach or unavailable.

Work Preparation:

- During any outside rescue operation, it is imperative that all responders are properly
- dressed and protected from the outside elements.
- Ensure all rescue equipment is readily available and in in good working order.
- Rescue equipment is available at know location on the dump and includes safety rings,
- harness/ Belt with D-Ring, life vests, rescue rope.
- Conduct weekly inspections of the Safety Seacan located at the entrance of the waste dump

Job Steps

1. Upon an individual going through the ice into the water, initiate Code 1 protocol by calling Code 1 Code 1 Code 1 on Channel 2 Repeater 1.
2. Give dispatch the nature of the emergency, your name, and location.
3. Dispatch to call a Code 1 on all channels and contact the ERT Coordinator on channel 2 repeater 1.
4. ERT Coordinator to dispatch ambulance to arrange for pickup of site medic at clinic.
5. Before responding, ensure that the responders are properly dressed and protected from the outside elements.
6. Ensure that the responders are wearing a life vest and remains 10 m from the outside crest.
7. The responding person can toss a life ring and instruct the victim to grab it and insert their arm around the life ring. Pull the victim towards the shore.
8. Alternately, the rescuer can throw a rope bag to the victim and get them to grab the rope and pull them to shore.
9. If the victim is able, instruct them to get onto shore and walk away from the crest edge.
10. If the victim is not able to get onto shore or walk to safety, rescuers will be required to get ready to load for transport.
11. Should transportation from the crest edge / shore line be required (inside 10m from the crest) ensure that all responders are tied off, wearing rescue suits and that a basket stretcher is pre-rigged for transport.
12. As with all rescue operations, safety of the responders will be priority number 1. With that in mind, emphasis must be put on ensuring that the rescue is carried out quickly and efficiently and with the correct equipment.
13. The buddy system will be used to monitor rescuers for signs of exposure (frostbite, hypothermia etc.) and will take frequent warm-up breaks. The ability of all responders to function as a team and to be able to continue in rescue efforts started by other members will be imperative to the success of the rescue.
14. Outside resources may be contacted in the event that the situation is beyond our rescue capabilities or if this is deemed a recovery mission.

General Information

- Quick recognition and a quick response is vital to the survival of a person submerged in water. Providing the victim can stay above water, the average time for a person to go unconscious will be approximately 1 hour with a floatation device.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
November 20, 2015	Initial Issue		
November 29, 2015	Updated Procedural Detail		
March 28, 2020	Put into new SOP format and Updated		

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	Michael Pahkala	[redacted]	
ERT Coordinator	Tom Cheveldave		
Environmental Superintendent or Designate	Torence Sandhals		
Health and Safety Manager or Designate	John Addy		
Surface Operations Manager or Designate	Frank Forsythe		
JOHSC Co-chair or Member	Andre Moncion		

Appendix D:
Waste Deposition Inspection Checklist and Audit Forms

Appendix D1:
Daily Waste Rock Inspection Checklist

NEWCREST BRUCEJACK

Date: _____ *DS / NS*

WASTE ROCK TAILINGS STORAGE FACILITY INSPECTION CHECKLIST

Reason for Inspection

Start of shift ☐ Post Break ☐ New work area ☐

4 hour interval ☐ Other ☐ _____

Current weather conditions _____

Operation Status ☐ Normal ☐ Restricted ☐ Stop Work

Check all boxes that apply. Notify your supervisor of any deficiencies immediately. Do not proceed with dump operations until all deficiencies are corrected.

Time Description	AM	AM	PM	PM
Operator trained in dump procedures	☐	☐	☐	☐
Radio communications working	☐	☐	☐	☐
PPE inspected	☐	☐	☐	☐
Flotation Device	☐	☐	☐	☐
Exclusion zone Demarcated	☐	☐	☐	☐
Dump floor/surface +2% grade	☐	☐	☐	☐
No cracks/sink holes in dump	☐	☐	☐	☐
Equipment pre-shift completed	☐	☐	☐	☐
The deposition plan designed by the engineer is understood and followed	☐	☐	☐	☐

	AM	AM	PM	PM
Snow removed from work area	☐	☐	☐	☐
1 m berm in place at dump crest	☐	☐	☐	☐
Delineation at tilt beams	☐	☐	☐	☐
Barricades and signage at Entrance	☐	☐	☐	☐
Light plant inspected & operational	☐	☐	☐	☐
Visibility sufficient	☐	☐	☐	☐
Ice broken at push site (if applicable)	☐	☐	☐	☐
All Stops Tested (If applicable)	☐	☐	☐	☐
Engineer has signed off that sufficient preload of the active dump areas has occurred	☐	☐	☐	☐

Remote Dozer Run Time:				Muck To Stockpile:		
Zones Pushed:				3" to Portals:		
Muck to zone 3	Muck to zone 4	Muck to zone 5	Muck to zone 6	Muck to zone 7	Muck to zone 8	
WP1 to zone 3	WP1 to zone 4	WP1 to zone 5	WP1 to zone 7	WP1 to zone 7	WP1 to zone 8	
Soils to zone 3	Soils to zone 4	Soils to zone 5	Soils to zone 7	Soils to zone 7	Soils to zone 8	
Pushed zone 3	Pushed zone 4	Pushed zone 5	Pushed zone 6	Pushed zone 7	Pushed zone 8	Loads left on dump

Engineer Name (print): _____ Signature _____

Supervisor Name (print): _____ Signature _____

Appendix D2:
Weekly Waste Rock Deposition Audit Checklist

Date: **Time:**

Audit Team:

Supervisors Compliance Audit Checklist

Meets Expectation		Supervisor's Procedural Task
YES	NO	
		Have waste dump crest and remote dozer working/avoidance zone updated regularly? *Comments:*
		Have "Restricted 40 m zones" been properly marked? *Comments:*
		Has waste rock berm been placed along the crest of deposition areas properly? *Comments:*
		Do supervisors wear a floatation device during inspections when they are within 40 m from the crest? *Comments:*
		Has monitoring instruments (GNSS, Tilt-Beam, and/or SlideMinder) been placed properly and have the monitoring data been collected/recorded on a regular basis? *Comments:*
		Have settlement monuments been placed along the crest of advanced areas and have they been surveyed routinely? *Comments:*

		Have truck counts been provided to the Engineer for volume tracking? *Comments:*
		Have daily photos of the waste dump been taken? *Comments:*
		Have daily toolbox safety meetings been recorded that communicate the daily deposition plan to equipment operators? *Comments:*
		Is the current Emergency Response Procedure on file, available for reference, and understood by the relevant personnel? *Comments:*
		Have the relevant personnel been trained on the Emergency Response Procedures and do they have the necessary tools outlined in the Procedures to carry out a rescue? *Comments:*

Audit Comments

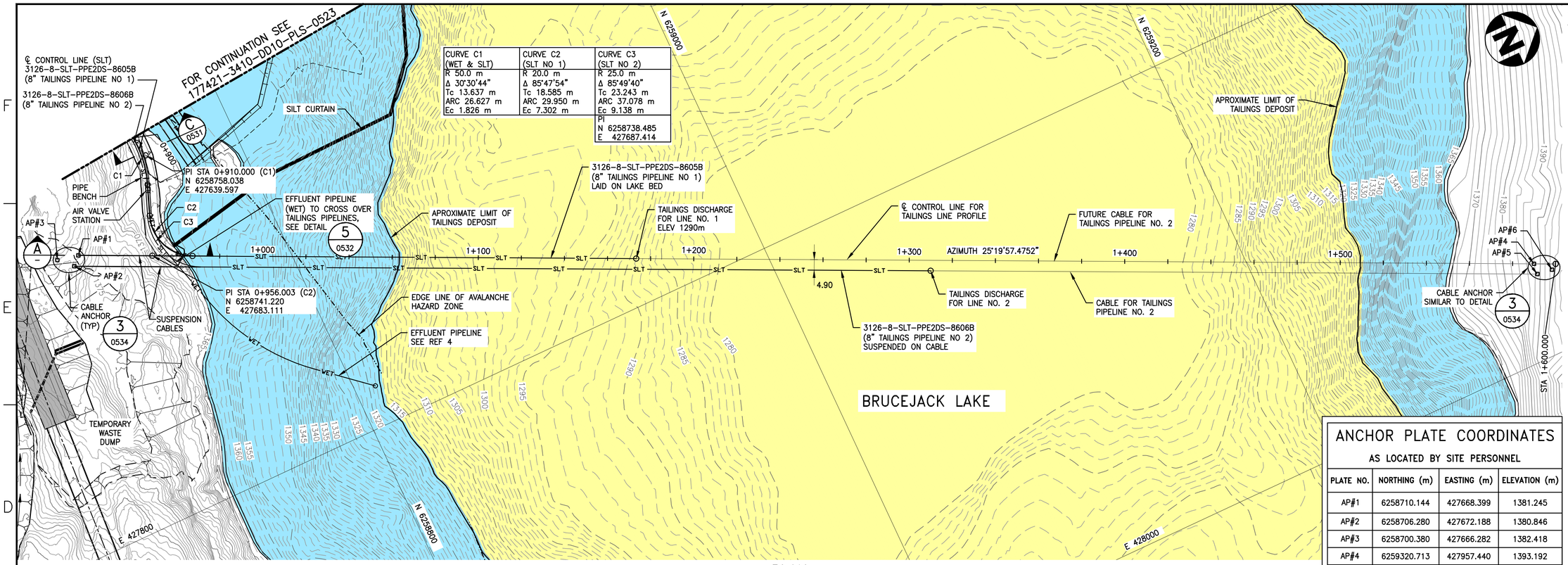
Meets Expectation		Supervisor's Daily Inspections
YES	NO	
		Has an inspection been completed for the active zones reported by remote dozer operator and/or surface operation supervisor? *Comments:*
		Have geotechnical inspections been completed on a routine basis: *Comments:*
		Have inspections included the following information to a satisfactory level? • Reported the time, active deposition areas, and weather conditions; • Work areas are delineated and dumping limit identified; • Noticeable signs of settlement, deflection, slope movement, changes in material type or moisture content on the waste rock deposition pad and crest areas; • Any areas experiencing consistent/frequent or notable erosion or tension cracking (including an accurate location of these areas); *Comments:*
		Has signage been located in the proper locations to avoid unnecessary traffic on dump site? *Comments:*
Audit Comments		

Equipment Operator's Compliance Audit Checklist

Meets Expectation		Operator's Procedural Tasks
YES	NO	
		Is type and origin of deposition material known by operator? *Comments:*
		Do operators follow specific deposition procedures: ice and snow removal, waste material mixing, setting times, and waste rock berm? *Comments:*
		Are haul truck drivers being directed where to dump and dumping from outside the 40 m dump marker? *Comments:*
		Do the operators understand the signs of geotechnical instabilities which include: consistent/frequent or notable erosion, sink hole, tension cracking, and surface deformations? *Comments:*
		Do operators actively monitor and inspect their workspace for signs of instability? Do they maintain a clean workspace so that signs of instability are more evident? *Comments:*
		Do operators understand and follow the mandatory track orientation while working on the dump? *Comments:*
		Do operators understand the difference between "Stop Work" and "Restricted Work"? *Comments:*
		Do operators perform pre-shift inspections and PPE inspections?

		Comments:
Meets Expectation		**Operator's Safety Equipment Audit**
YES	**NO**	
		Do operators working within 40 m of the dump crest have the following job specific PPE in addition to the standard PPE: • Manually activated floatation vests; • Hard hats with chin straps that must be worn while operating a dozer or excavator on the dump; and • Cold weather gear during winter *Comments:*
		Do operators complete a pre-work site hazard risk assessment during tailgate meetings? *Comments:*
Audit Comments		

Appendix E:
Tailings Deposition Infrastructure Issued For Construction Drawings



CURVE C1 (WET & SLT)	CURVE C2 (SLT NO 1)	CURVE C3 (SLT NO 2)
R 50.0 m	R 20.0 m	R 25.0 m
Δ 30°30'44"	Δ 85°47'54"	Δ 85°49'40"
Tc 13.637 m	Tc 18.585 m	Tc 23.243 m
ARC 26.627 m	ARC 29.950 m	ARC 37.078 m
Ec 1.826 m	Ec 7.302 m	Ec 9.138 m
		PI N 6258738.485 E 427687.414

PLAN
1:1000

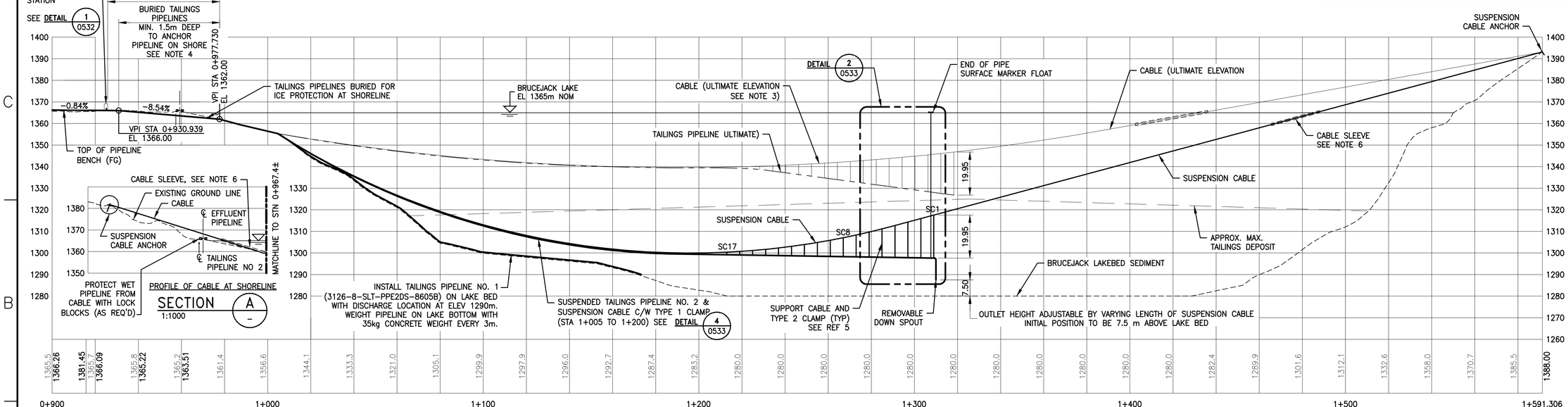
NOTES:

1. FOR GENERAL NOTES SEE REF 1.
2. SUSPENSION CABLE LENGTH AS SHOWN ON PROFILE = 665m EACH. ALLOW ADDITIONAL 120m PER PIPE FOR BACKUP CABLES AND FOR POTENTIAL ADJUSTMENT IN LOCATION OF CABLE ANCHORS.
3. THE SUSPENSION CABLE SYSTEM IS DESIGNED FOR THE LINE RAISED TO ITS ULTIMATE ELEVATION AND IS FLOWING FULL OF TAILINGS. WHEN FULL OF WATER, THE TENSION IS REDUCED TO APPROX. 110KN (25,000 LBF) AT THE ULTIMATE ELEVATION. ELEVATIONS HIGHER THAN THE ULTIMATE CABLE ELEVATION AS SHOWN ARE UNSAFE AS THE RESULTING TENSION CAN EASILY EXCEED CABLE BREAKING STRENGTH (47 TONNES/51.5 TONS).
4. ADD COMPACTED 75mm MINUS GRANULAR BERM ON TOP OF PIPE TRENCH TO ENSURE MIN. 1.5m OF COVERAGE OVER PIPELINES IN BURIED SECTION.
5. THE PIPE LINES SHALL BE FIELD INSULATED AND HEAT TRACED TO A MINIMUM DISTANCE OF 8m BEYOND THE SHORELINE AND A DEPTH OF EL 1362.00. THE INSULATION SHALL BE A WATERPROOF CLOSED CELL PLASTIC FOAM AND THE JACKET MATERIAL SHALL BE HDPE OF 1.14mm MINIMUM THICKNESS. ALTERNATELY, HALF ROUND HDPE SHELLS MAY BE FIELD-APPLIED AND WRAPPED IN PIPELINE TAPE COATING IN ACCORDANCE WITH AWWA C209. A DOUBLE LAYER OF TAPE SHALL BE USED WITHIN 8m ABOVE AND BELOW THE SHORELINE. OPEN ENDS OF PIPE INSULATION SHALL BE SEALED TO BE WATERPROOF.
6. ENCASE CABLE IN 2" OR 3" HDPE PIPE IN ZONE WHERE IT PASSES THROUGH WATER BETWEEN ELEVATIONS 1365 TO 1360. WHERE PRACTICAL (LIKELY SOUTH SHORE) PLACE MIN. 2m THICK LAYER OF SAND AND GRAVEL AROUND ENCASED CABLE C/W OUTER LAYER OF 10kg RIPRAP TO PROTECT FROM ICE ACTION.

ANCHOR PLATE COORDINATES

AS LOCATED BY SITE PERSONNEL

PLATE NO.	NORTHING (m)	EASTING (m)	ELEVATION (m)
AP#1	6258710.144	427668.399	1381.245
AP#2	6258706.280	427672.188	1380.846
AP#3	6258700.380	427666.282	1382.418
AP#4	6259320.713	427957.440	1393.192
AP#5	6259320.161	427962.411	1393.502
AP#6	6259327.123	427963.431	1396.251



TAILINGS PIPELINE PROFILE
(FOR WTP PIPELINE REFER TO REF 4)

0m 10 20 30 40 50
1:1000

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
0	30SEP16	ISSUED FOR CONSTRUCTION	PN	KC	VM	EY	SL	
B	19JAN16	ISSUED FOR APPROVAL	MT	AH	EW			
A	27NOV15	ISSUED FOR SQUAD CHECK	MT	EW	EW			

REF	NUMBER	TITLE
6	3410-DD10-PLS-0534	TAILINGS & WTP DISCHARGE PIPELINES, SECT'S & DET'S SHT 4
5	3410-DD10-PLS-0533	TAILINGS & WTP DISCHARGE PIPELINES, SECT'S & DET'S SHT 3
4	3230-DD10-PAP-0495	LAKESHORE PIPELINE CORRIDOR, SHEET 5
3	3410-DD10-PLS-0532	TAILINGS & WTP DISCHARGE PIPELINES, SECT'S & DET'S SHT 2
2	3410-DD10-PLS-0523	TAILINGS & WTP DISCHARGE PIPELINES, PLAN & PROFILE
1	3410-DD10-PLS-0520	TAILINGS & WTP DISCHARGE PIPELINES, OVERALL PLAN

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN AMEC AND ITS CLIENT: (I) THIS AMEC DOCUMENT CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) THIS DOCUMENT MAY ONLY BE USED BY THE CLIENT IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT HAS BEEN DELIVERED. ANY OTHER USE OR RELIANCE ON THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK AND RESPONSIBILITY.

STAMP/SEAL

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR	DEPARTMENT MGR	PROJECT MGR
	G. LI	S. LYNN

PRETIVM

amec foster wheeler

PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	MT	19NOV15
SCALE	PACKAGE CODE	DRN	MT	19NOV15
AS SHOWN		CHK	KC	30SEP16
		APP	VM	30SEP16

SUBJECT: CIVIL PLAN SECTION ELEVATION TAILINGS & WTP DISCHARGE PIPELINES PLAN & PROFILE, SHEET 4

AREA 3410 — TAILINGS

CLIENT DWG NO.

DRAWING NO. 177421-3410-DD10-PLS-0524 — REV 0

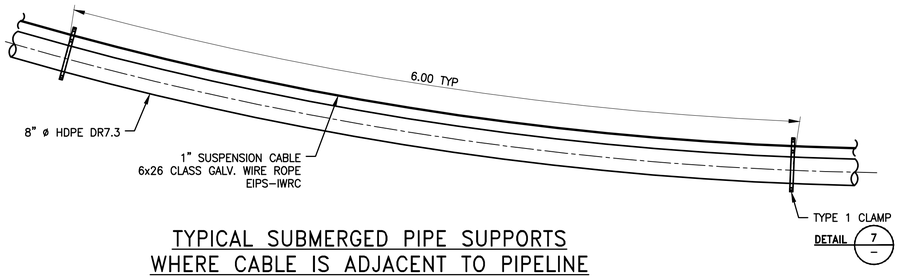
SAVED: 30-Sep-16 3:27 PM PLOTTED: 30-Sep-16 3:29 PM USER: BATCHPLOT, GI

DWG FILE: \\WAH-FS1\P00177421\CAD\CIV\177421-3410-DD10-PLS-0524.DWG

ISO A1-594x841

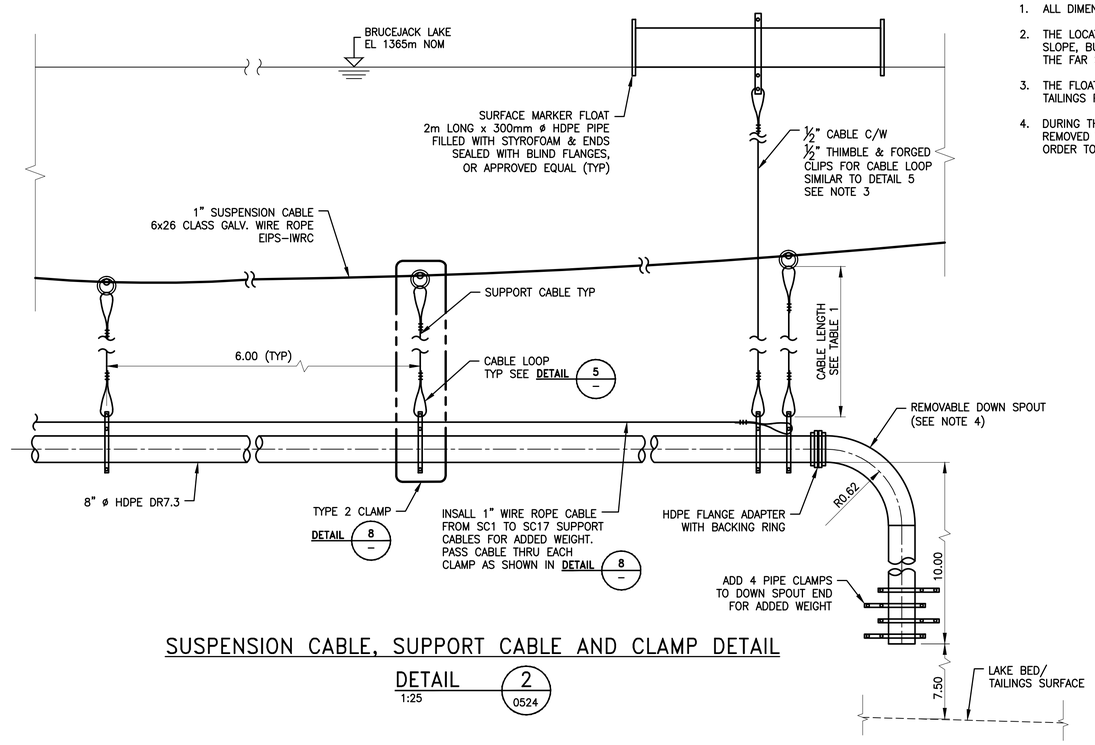
NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNO.
2. THE LOCATION OF THE CABLE ANCHOR CAN BE MOVED UP OR DOWN THE SLOPE, BUT MUST STAY IN ALIGNMENT WITH THE CABLE AND THE ANCHOR ON THE FAR SIDE.
3. THE FLOAT CABLE SHALL BE MARKED WITH TAGS INDICATING DISTANCE TO TAILINGS PIPELINE AT 2m INTERVALS STARTING 20m FROM TAILINGS PIPELINE.
4. DURING THE FINAL STAGES OF PIPE RAISING, THE DOWN SPOUT IS TO BE REMOVED TO LIMIT THE AMOUNT THAT THE CABLE NEEDS TO BE RAISED IN ORDER TO MEET DISCHARGE REQUIREMENT.



TYPICAL SUBMERGED PIPE SUPPORTS WHERE CABLE IS ADJACENT TO PIPELINE

DETAIL 4 / 0524
1:25



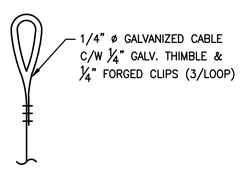
SUSPENSION CABLE, SUPPORT CABLE AND CLAMP DETAIL

DETAIL 2 / 0524
1:25

TABLE 1: CABLE LENGTH	
CABLE NO.	LENGTH (m)*
SC1	19.95
SC2	18.25
SC3	16.55
SC4	14.84
SC5	13.16
SC6	11.58
SC7	10.11
SC8	8.75
SC9	7.49
SC10	6.34
SC11	5.30
SC12	4.36
SC13	3.52
SC14	2.78
SC15	2.15
SC16	1.61
SC17	1.18

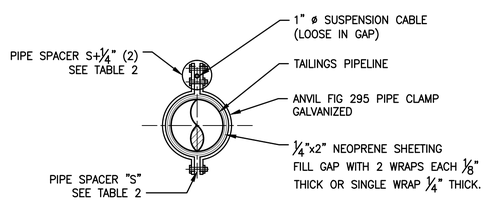
* LENGTH SHOWN IS DISTANCE BETWEEN CABLE AND PIPE AND DOES NOT INCLUDE ALLOWNACE FOR CABLE LOOPS.

TABLE 2: PIPE CLAMP DIMENSIONS		
PIPE DIA	RADIUS "R"	SPACER "S"
8"	4 9/16"	1 1/4"
12"	6 5/8"	1 7/16"



TYPICAL CABLE LOOP

DETAIL 5 / –
NTS

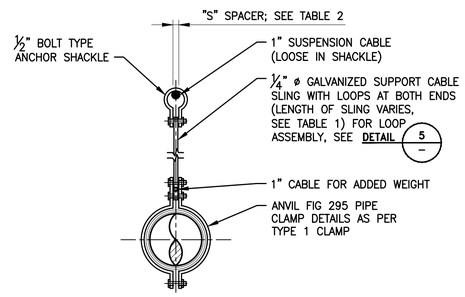


TYPE 1 CLAMP

CONNECTED DIRECTLY TO SUSPENSION CABLE

DETAIL 7 / –
NTS

TYPICAL OF 33 FOR EACH PIPELINE @ 6 m O/C
(FROM STA 1+005 ± TO 1+200)

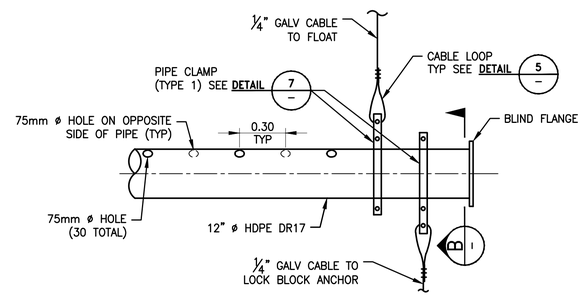


TYPE 2 CLAMP

TAILINGS PIPELINE SUPPORT CLAMP WITH CABLE

DETAIL 8 / –
NTS

TYPICAL OF 17 FOR EACH PIPELINE @ 6 m O/C
(FROM STA 1+213 TO END)



TREATED EFFLUENT WATER LINE

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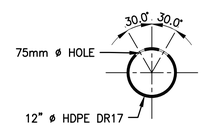

SECTION B / –
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0	30SEP16	ISSUED FOR CONSTRUCTION	PN	KC	VM	EY	SL	

REF	NUMBER	TITLE
3	3410–DD10–PLS–0534	TAILINGS & WTP DISCHARGE PIPELINES, SECT'S & DET'S SHT 4
2	3410–DD10–PLS–0524	TAILINGS & WTP DISCHARGE PIPELINES, PLAN & PROFILE
1	3230–DD10–PAP–0495	TAILINGS PIPLELINE CORRIDOR, SHEET 5

REFERENCES

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PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	VM	12JUL16
		DRN	PN	12JUL16
SCALE: AS SHOWN	PACKAGE CODE	CHK	KC	30SEP16
		APP	VM	30SEP16

SUBJECT: CIVIL
PLAN SECTION ELEVATION
TAILINGS & WTP DISCHARGE PIPELINES
SECTIONS & DETAILS, SHEET 3

AREA: 3410 TAILINGS

CLIENT DWG NO.

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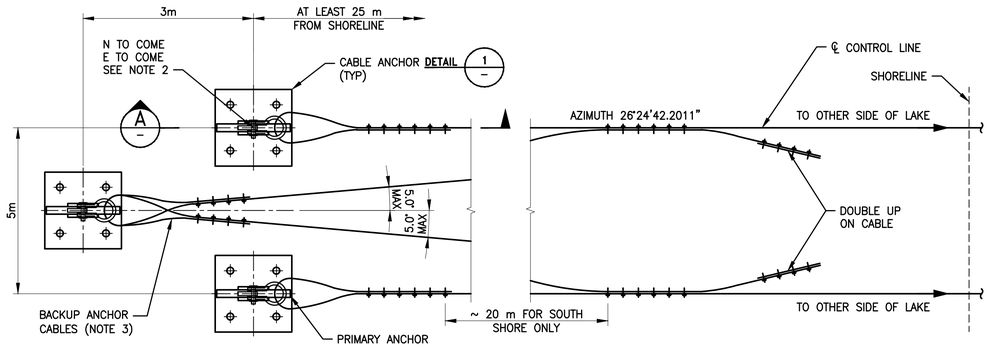

TAILINGS PIPELINE CABLE ANCHORING – PLAN

DETAIL 3 / 0524
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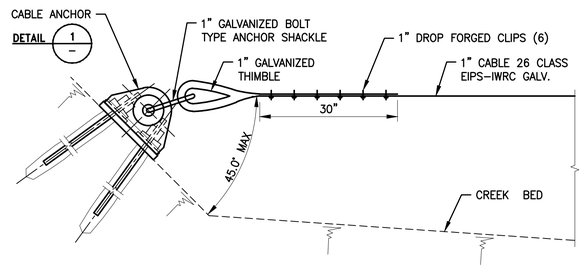
(SIMILAR DETAIL FOR NORTH SHORE)

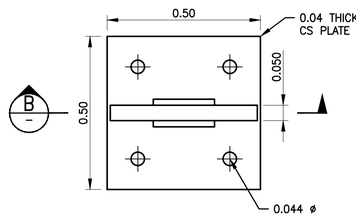


CABLE ANCHOR FOR TAILINGS PIPELINE FIXED LOOP CONNECTION (TYP)

SECTION A
NTS

NOTES:

1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNO.
2. THE LOCATION OF THE CABLE ANCHOR CAN BE MOVED UP OR DOWN THE SLOPE, BUT MUST STAY IN ALIGNMENT WITH THE CABLE AMD THE ANCHOR ON THE FAR SIDE. THE
3. THE BACKUP ANCHOR CABLE IS TO BE USED TO TAKE LOAD OFF OF MAIN CABLE WHEN TAILINGS DISCHARGE PIPE IS TO BE RAISED. PIPELINE TO BE RAISED ONLY WHEN EMPTY OF TAILINGS AND FULL OF WATER. THIS WILL MINIMIZE TENSION ON LINE WHEN WORKING ON IT. ONCE LOAD IS OFF MAIN CABLE, IT CAN BE UNCLIPPED AND SHORTENED TO RAISE THE PIPELINE TO THE DESIRED HEIGHT ABOVE THE DEPOSITED TAILINGS.
4. DURING THE FINAL STAGES OF PIPE RAISING, THE DOWN SPOUT IS TO BE REMOVED TO LIMIT THE AMOUNT THAT THE CABLE NEEDS TO BE RAISED IN ORDER TO MEET DISCHARGE REQUIREMENT.
5. THE SUSPENSION CABLE SYSTEM IS DESIGNED FOR A MAXIMUM TENSION OF 310KN (70000 LBF). THIS FORCE OCCURS WHEN THE LINE IS RAISED TO ITS FINAL LOCATION FOR THE LAST STAGE OF TAILINGS DEPOSITION AND IS FLOWING FULL OF TAILINGS. WHEN FULL OF WATER, THE TENSION IS ONLY 110KN (25,000 LBF) UNDER THE SAME CONDITIONS.
6. ANCHOR ROD DETAILS:
   - 32T (32 ø) DYWIDAG TEMPCORE THREADED BAR (500MPa YIELD STRENGTH) ROCK ANCHOR
   - USE 9" BEVELLED WASHER + ANCHOR PLATE
7. ANCHORAGE DEPTH INTO SOUND ROCK SHALL BE DETERMINED BY A QUALIFIED GEOTECHNICAL ENGINEER. ANCHOR DEPTH SHALL BE SUFFICIENT TO DEVELOP THE FULL YIELD STRENGTH OF THE ANCHOR IN TENSION INCLUDING THE EFFECTS OF GROUP ACTION. TESTING OF INSTALLED ROCK ANCHORS SHALL BE AT THE DISCRETION OF THE GEOTECHNICAL ENGINEER. MINIMUM ANCHORAGE DEPTH TO BE 3.0m.
8. ROCK ANCHORS SHALL BE PLACED IN 89ø HOLES IN ROCK WITH CENTRALIZERS AT 1 METER SPACING AND GROUTED IN PLACE. INSTALL GROUT TO MANUFACTURER'S RECOMMENDATIONS USING GROUT PUMP AND GROUT TUBES.
   - SIKAGROUT ARCTIC 100 WHERE AMBIENT SUBSTRATE TEMPERATURE IS BETWEEN –10°C AND +4°C.
   - MASTER BUILDERS MASTERFLOW 928 WHERE AMBIENT SUBSTRATE TEMPERATURE IS +7°C AND ABOVE.
   - REPORT TO THE ENGINEER FOR CASES WHERE THE AMBIENT SUBSTRATE TEMPERATURE FALLS BELOW –10°C.



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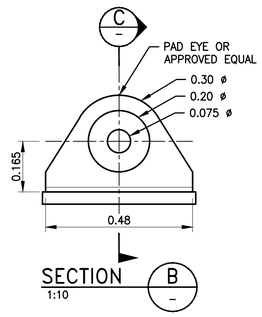

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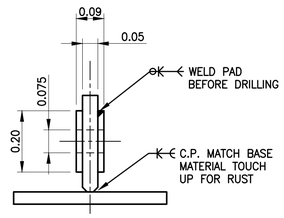

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CABLE ANCHOR DETAIL 1
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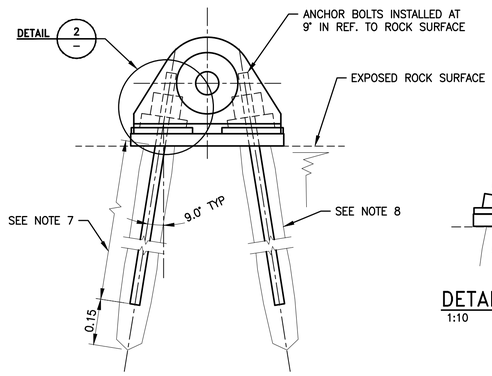

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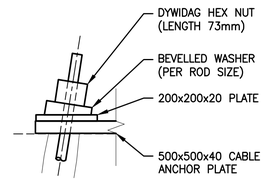

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4	0000–DD20–STD–0105	STANDARD, STRUCTURAL STEEL, GENERAL NOTES
3	3410–DD10–PLS–0533	TAILINGS & WTP DISCHARGE PIPELINES, SECT'S & DET'S SHT 3
2	3410–DD10–PLS–0524	TAILINGS & WTP DISCHARGE PIPELINES, PLAN & PROFILE
1	3230–DD10–PAP–0495	TAILINGS PIPELINE CORRIDOR, SHEET 5

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PROJECT: BRUCEJACK

PROJECT NO.: 177421

ACTIVITY NO.:

SCALE: AS SHOWN

PACKAGE CODE:

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CHK	EW	
APP	EW	

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SUBJECT: CIVIL
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TAILINGS & WTP DISCHARGE PIPELINES
SECTIONS & DETAILS, SHEET 4

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Newcrest Mining Ltd.—Brucejack Mine

Issue For Construction Design for Tailings Line A and Line B

Submitted to:

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

Mr. Mike Yakimchuk, P.Eng. Mill Manager

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Reference No. 21507844-062-R-Rev0-9000

24 August 2023

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1.0 INTRODUCTION

Newcrest Mining Ltd. (Newcrest; formerly Pretium Resources Ltd. [Pretium]) retained Golder Associates Ltd. (Golder), now WSP Canada Inc. (WSP), to produce an issued for construction (IFC) level design for tailings transport pipeline A (Line A) and tailings transport pipeline B (Line B) at Brucejack Mine. These two lines begin at the mill building and extend to the waste rock tailings storage facility (WRTSF) discharge location. Lines A and B are expected to be installed in the summer of 2023.

The Brucejack site is an active underground gold and silver mine located near Stewart, BC, Canada. The site is mountainous and has temperatures ranging from -30°C to 25°C.

1.1 Project Background

Tailings are either discharged to the WRTSF or thickened and transported for backfilling the excavated stopes in the underground mine. According to the Ministry of Environment and Climate Change Strategy Permit 107835, Section 1.3.2, the tailings outfall to the WRTSF, must never be positioned more than 7.5 metres (m) above the lake bottom (i.e., top of natural lake bottom or the deposited tailings), whichever is higher (MECCS 2018). Because the WRTSF is approximately 80 m deep, subaqueous tailings deposition is required. The previous pipeline system used either a series of cables spanning the WRTSF to support the pipeline, or a weighted pipeline system with a float at the discharge outfall located 7.5 m above the lake bottom or the tailings surface.

Newcrest experienced several reliability and safety concerns with the tailings transport system between its installation and July 2021. The existing cable-supported pipelines (Tails Lines 1 and 2) posed a safety risk to personnel due to the highly tensioned cables used. Tails Line 1 was plugged with tailings, then disconnected and abandoned. Tails Line 2 is also not in use. There are three of four operable perimeter discharge bottom pipelines (Tails Lines 3, 4 [inoperable], 5, and 6). Tails Line 3 was disconnected in the fall of 2017 after plumes were observed during line operation. Tails Line 3 was reconnected in 2018 but remains unused. Tails Line 4, installed in October 2020, operated until 9 July 2021 when Tails Line 4 was noticed to be floating on the surface of the WRTSF. Tailings delivery through Tails Line 4 was later shutdown, resulting in Tails Line 4 sinking to the bottom of the WRTSF and becoming plugged. Tails Line 4 was subsequently disconnected, while new Tails Lines 5 and 6 were installed for redundancy in September 2021 and functioning well to date. Figure 1 shows the current pipeline arrangement at shore.

Figure 1: Current Aerial Photo of Shore

1.2 Design Cycle and Update of Lines A and B

Prior to Tails Lines 5 and 6 design, a review of the tailings transport system (Tails Lines 1, 2, 3, and 4) and an options analysis was required to develop a pathway forward with a more reliable system. An options analysis for the tailings distribution system was completed by Golder in October 2021. Option E2 (fixed perimeter and central floating subaqueous pipeline discharge) was the preferred option (Golder 2021a). The feasibility design of the selected option was completed on 7 December 2021 (Golder 2021b). Three lines were included in this design (A, B, and FL1), which aligns with the deposition plan presented in Golder 2022b.

Collection of additional operating data was a key recommendation from the feasibility design report (Golder 2021b). The hydraulic design was based on a limited sample of data. Golder developed an Excel workbook for Pretium to collect additional data that would help validate the hydraulic design of the tailings pipelines at Brucejack.

On 8 April 2022, Golder Issued the IFC design for Tails Line A (Golder 2022a) at an average production rate of 4,600 tpd (tonnes per day).

The original project authorized production rate was 1,387,000 tonnes per year (average 3,800 tpd). Newcrest upgraded the system in the past and is currently operating at an average of 4,600 tpd. Newcrest is considering an increase in production to an average of 5,000 tpd at 92% utilization; therefore, the daily throughput of the mill is 5,434 tpd or 226.4 tonnes per hour (tph).

This IFC design report advances the design of Line A and Line B for an average production rate of 5,000 tpd, and a maximum volumetric production rate of 303 m^3/h of tailings to be transported to the WRTSF.

The addition of two subaqueous perimeter discharge pipelines (Line A and Line B) will provide added capacity and reliability to the existing system. The discharge location of Lines A and B are limited in movement as they will be weighted to the bottom of the WRTSF (see Drawing 2 for site plan in Appendix A).

The objective of this pipeline design is to allow for the acquisition of pipeline system materials for construction in the summer of 2023.

Note: This report is focused on the operation of the surface to subaqueous tailings perimeter discharge system of Lines A and B from pumps in the mill to the WRTSF. Paste production and transport is beyond WSP’s current scope.

2.0 CURRENT SURFACE TAILINGS DISTRIBUTION OPERATION

The current tailings distribution system at Brucejack Mine begins at the tailings disposal surge tank (TDST) (3126-TK-001) located within the mill. Two horizontal centrifugal pumps are installed in parallel to transport tailings slurry to the WRTSF. These two pumps (3126-PU-005 and 3126-PU-006) are High Head millMAX 6X4-21-HH (FLS 2018) with design duty points of 212 m^3/h at 55 m total dynamic head (TDH), and 117 m^3/h at 51 m TDH. Each pump is driven by a 150-horsepower (hp) motor (FLS 2018) with a variable speed drive. When throughput to the WRTSF is high, both pumps are used at the same time to deliver the required flow rate. When the flow rate to the WRTSF is reduced, only one pump is on duty and controlled by the slurry level in the TDST (3126-TK-001).

WSP identified a risk of low flow / sanding due to the uncontrolled volume of slurry coming into the TDST during paste backfill operations. Corrective actions included adding pump discharge pressure monitoring (implemented). Low flow over-ride to add dilution water to the TDST via HV-6857 was suggested during the feasibility design and is planned to be implemented. Implementation of the addition of dilution water to the tailings would ensure reliable transport of tailings to the deposition points.

Two 6-inch extra strong (XS) carbon steel (CS) pipelines are routed in parallel from the tailings disposal pumps (3126-PU-005 and 3126-PU-006) to the wall of the mill building. At the mill building wall, the pipeline specification changes from 6-inch XS CS to 6-inch dimension ratio (DR) 9 high-density polyethylene (HDPE). At chainage 0+705 m, a valve cross-over station was installed so that flow from one of the pipelines can be directed to the other line if needed. Before the valve cross-over station, both pipelines (Mill Lines 1 and 2) transition to 6-inch DR7.3 HDPE. After this transition, the two pipelines (Tails Lines 5 and 6) continue with the same pipe type to the discharge location. The valve shack is located at chainage 0+935 m on the shoreline of the WRTSF. Figure 2 presents a piping schematic diagram of the existing piping at the shore.

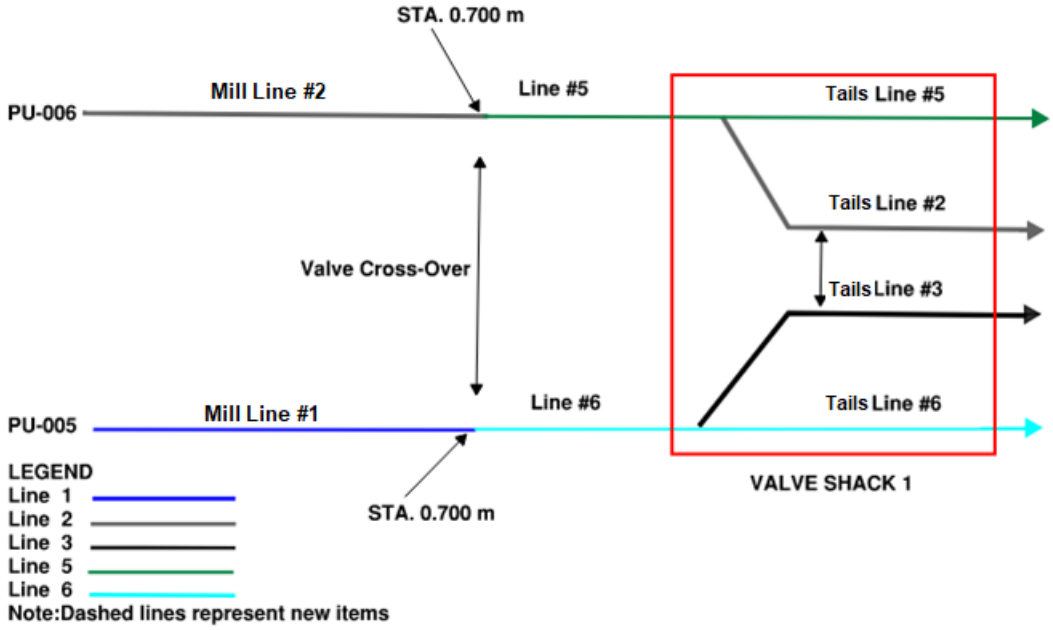


Figure 2: Pipeline Naming Diagram

Air/vacuum valves have been strategically positioned to allow more air to exhaust from the pipelines. Locating these valves closer to shore, where slack flow occurs more frequently, allows a larger volume of air to be exhausted. Newcrest has observed large volumes of air being exhausted out of the new air/vacuum valves that were installed in September. In the valve shack, one 8-inch HDPE DR7.3 pipeline ties into each of the 6-inch DR7.3 lines. One of the 8-inch lines is suspended (Tails Line 2) while the other 8-inch line runs along the bottom of the WRTSF (Tails Line 3). Figure 3 shows a site aerial view and approximate land pipeline routing.

Figure 3: Waste Rock Tailings Storage Facility

Pipelines are routed along the WRTSF bottom with concrete weights, attached to counteract the buoyancy of the HDPE pipe, as well as floats to prevent the pipeline from becoming buried.

The tailings discharge pipelines are mostly buried from the mill to the shore. Approximately 36.5 m (120 feet) of heat tracing and insulation is used, with 18.23 m extending into the WRTSF for each line. When the line is not transporting tailings and ambient temperatures are below freezing, a continuous flow of process water is introduced to the pipelines through an injection point at the mill to prevent lines from freezing. When not in use, tailings lines are flushed with water to clear the pipelines of solids.

The existing tailings pipelines at Brucejack lack the redundancy necessary for reliable operation. The main operational issues experienced with the original tailings transport system are pipeline plugging occurrences and non-functioning air valves.

Shoreline access is limited, with several pipelines routed closely together (Figure 4).

Figure 4: Waste Rock Tailings Storage Facility Access Area for Tails Lines 2, 3, 5, and 6 (30 August 2022)

Figure 5 shows existing valve shack 1.

Note: Eastview towards the snow dump (30 August 2022).

Figure 5: Valve Shack for Tails Lines 5 and 6

3.0 STUDY GENERAL CONSIDERATIONS

3.1 Scope and Battery Limits

The new perimeter discharge bottom tailings pipelines (Line A and Line B) are expected to be installed in 2023. These pipelines will tie-in near the tailings disposal pump area at the mill and will run to the WRTSF. At the shoreline, the pipelines will transition to subaqueous routing and run along the bottom of the WRTSF.

The scope of work includes:

- system design criteria
- review of Newcrest's prepared piping and instrumentation diagrams beginning outside the mill to pipeline discharge
- general arrangement drawings (key facilities outside the mill)
- plan and profile of pipeline
- piping tie-in drawing
- piping detail drawings
- steady-state hydraulic analysis
- sizing of pipeline weights and floats
- pipeline flushing water requirements
- material take-offs

This IFC design has been based on the design basis technical memorandum (WSP 2023a). Key design criteria can be found in Section 3.4.

3.2 Assumptions

The following assumptions form part of the Line A and B design:

- Laboratory test work provided by Newcrest is assumed to be accurate and representative.
- Operating data (including flow rate, pressure, and slurry density measurements) provided by Newcrest is representative and accurate.
- Friction losses were calculated using the Colebrook-White equation with a calibrated contingency percentage based on operating data (5% for 49% solids and 16% for 61% solids).
- Slurry transition velocity has a 10% safety factor.
- Slurry deposition velocity has a 10% safety factor.
- The flow rates have a 1.15 design factor.
- Current solids content operating range will remain the same in the future (i.e., 49% to 61% solids).
- Mill utilization is assumed to be 92%.

- Motor power use has a 15% safety factor.
- Pump hydraulic efficiency is based on the existing pump curve provided by the vendor.
- All HDPE pipe considered shall be resin type 4710.
- Absolute roughness of used HDPE (slurry operation) is 0.0000457 m and new HDPE is 0.00002 m.
- Absolute roughness of CS is 0.0000508 m.
- Absolute roughness of pipe rubber liner is 0.000305 m.
- Density of polyurethane foam is 30 kg/m^3 (1.87 pounds per cubic foot [lb/ft^3]).
- Weight of 8-inch DR9 pipe is 10.03 pounds per foot (lb/ft).
- Weight of 8-inch DR9 with 2-inch-thick insulation is 11.5 lb/ft.
- Density of slurry at 61% solids is 102.01 lb/ft^3.
- Weights spaced to counteract buoyancy of HDPE pipe when full of air.
- Weight of cable, pipe clamps, and other accessories have been taken into consideration.
- WRTSF water current is assumed to have no impact on weights required for Line A and Line B.
- Heat tracing and insulation for Line A and Line B per client request.
- Concrete post bases are to be used for the pipeline weights as per client request. Each weight is to be 34 kg (75 lbs) or 166 kg (366 lbs).
- Use pipe clamps rather than concrete collars for the pipeline weighting system at the client's request.
- Pond elevation (1,365 m) will not rise significantly during life of mine.
- Water depth at discharge of Line A is 32.3 m (1,332.7 m elevation) and Line B is 29.4 m (1,335.6 m elevation), based on the deposition plan (WSP 2023b).

3.3 Exclusions

The following were excluded from the study:

- evaluation of impact of change on the backfill plant operation (if any)
- site surveying
- permitting
- scope already covered in WSP's geotechnical design scope of work
- design or costing for access roads / pipeline corridors to WRTSF
- mooring analysis
- capital cost estimate and operating expenses

- new pumps and control equipment
- pipe supports
- isometric drawings
- all in-plant equipment
- water pipeline from WRTSF

3.4 Design Criteria

Table 1 and Table 2 present the key design criteria. The mine waste production is based on 5,000 tpd throughput.

Table 1: Properties and Throughput of Tailings Slurry Pipeline

Criteria	Unit	Planning Value	Comment/Reference
Tailings pH	-	8.7	mill team (Chong T., 12 May 2021)
Tailings gradation	-	**Size (µm)** / **Cumulative% Passing (by dry mass)** 310 / 95 250 / 90 162.4 / 80 110 / 70 80 / 60 42.5 / 50 20 / 40 9.0 / 30 4.2 / 20 2.2 / 10	May 2020 tails (RMS 2020)
Tailings solids specific gravity	-	2.65 to 2.75 (2.67)	Norton (2021), RMS (2020)
Solids content of tailings discharged to WRTSF	%	range: 49 to 61	Laliberte (2023)
Slurry density to TSF	kg/m^3	nominal: 1,453 design: 1,617	calculated nominal based on 49% solids, design based on 61% solids
Tailings slurry yield stress	Pa	~1.05 to 12.18	values taken from tab D Tank-50 and D Tank-60 for 49% to 61% solids slurry (Newcrest 2023a)
Tailings slurry dynamic viscosity	Pa.s	~0.016 to 0.103	May 2020 tails for 49% to 61% solids slurry (RMS 2020)
Planned average (nominal) daily ore production	tpd	5,000	5,000 tpd at 92% availability (Laliberte 2023)
Availability	%	92%	Laliberte (2023)
Daily throughput of the mill	tpd	5,434	Laliberte (2023)
Hourly through put of the mill	tph	226.4	Laliberte (2023)
Portion of tailings directed to WRTSF	%	52% to 100%	Laliberte (2023)

Table 1: Properties and Throughput of Tailings Slurry Pipeline

Criteria	Unit	Planning Value	Comment/Reference
Tailings dry tonnage to TSF	tph	109 to 214	214 tph nominal maximum (24% bypass, no paste), 109 tph nominal minimum (no bypass, 48% tailings to paste) (Laliberte 2023)
Minimum design slurry flow to TSF	m^3/h	108	no bypass, with paste at 61% solids (Laliberte 2023); no design factor will be added to this minimum
Maximum design slurry flow to TSF	m^3/h	303	24% bypass, no paste at 49% solids (Laliberte 2023), a 1.1x design factor will be added to this value for contingency

Pa.s = pascal-second; tpd = tonnes per day; tph = tonnes per hour; TSF = tailings storage facility; WRTSF = waste rock tailings storage facility; - = N/A.

Table 2: Pipeline Discharge Criteria

Criteria	Unit	Planning Value	Comment/Reference
Maximum pipeline discharge distance above tailings surface or WRTSF bottom[(a)]	m	7.5	MECCS Permit 107835
Tails Line A discharge location	m	N: 427730.45 E: 6258818.47 Elev:1329.49	WSP (2023b)
Tails Line B discharge location	m	N: 427833.56 E: 6258786.00 Elev: 1334.95	WSP (2023b)

(a) Pending on outcome of deposition model, this may change during design optimization. Further discussion with Newcrest permitting team during design development and amendment to the permit may be required.

Elev = elevation; N = north; E = east; MECCS = Ministry of Environment and Climate Change Strategy; WRTSF = waste rock tailings storage facility.

WSP (2023a) provides the detailed design basis and criteria.

4.0 LINES A AND B – TAILINGS TRANSPORT DESIGN

Two existing 150-hp tailings disposal pumps are installed currently in the mill. WSP understands that one new pump will be added to the existing pump arrangement to provide additional capacity and contingency for the tailings disposal system. Only up to two pumps are to be operated at any one time, and the third pump will serve as a standby.

Figure 6 provides an overview of the tailings disposal system.

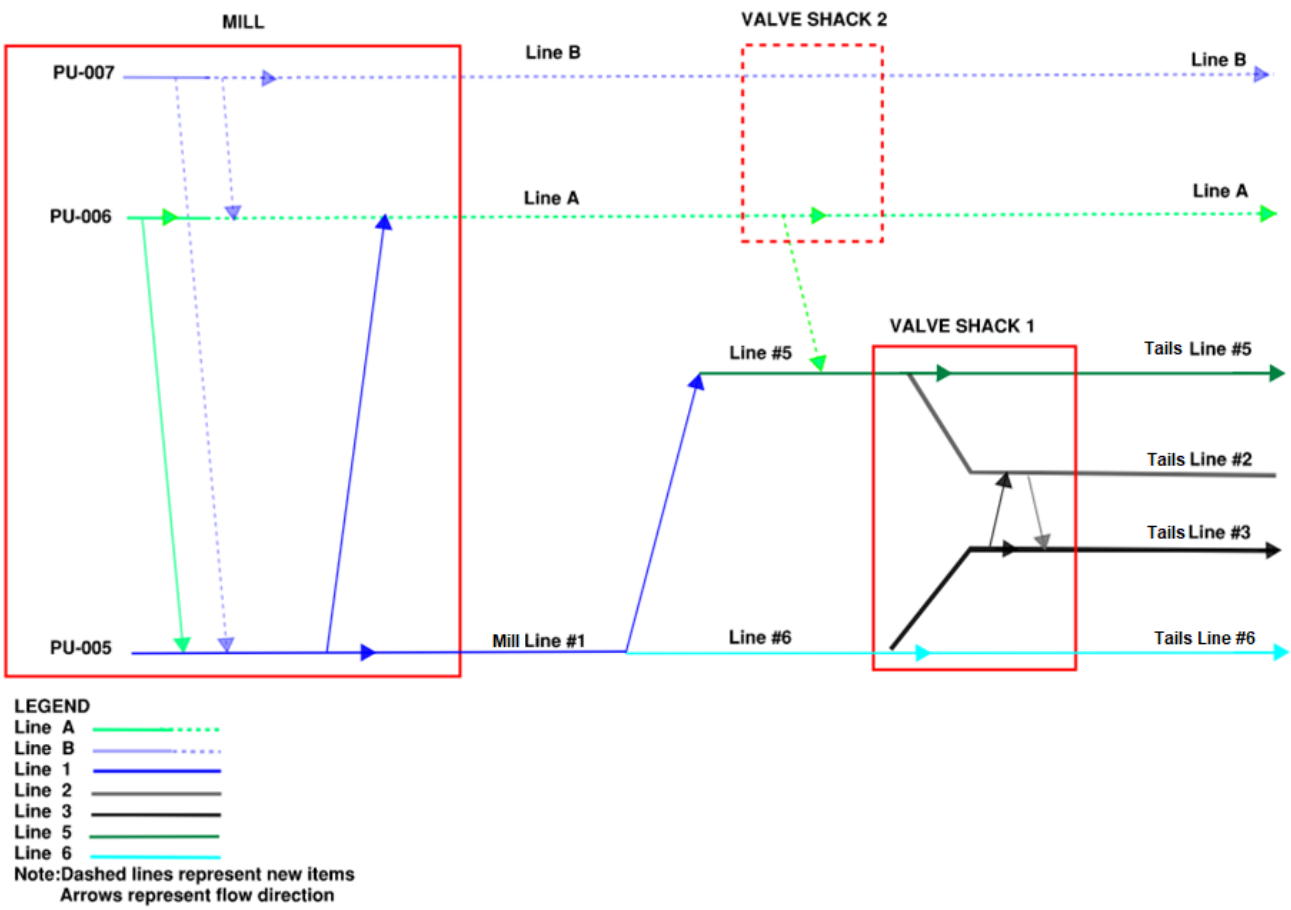


Figure 6:Tailings Pipeline Connection Schematic

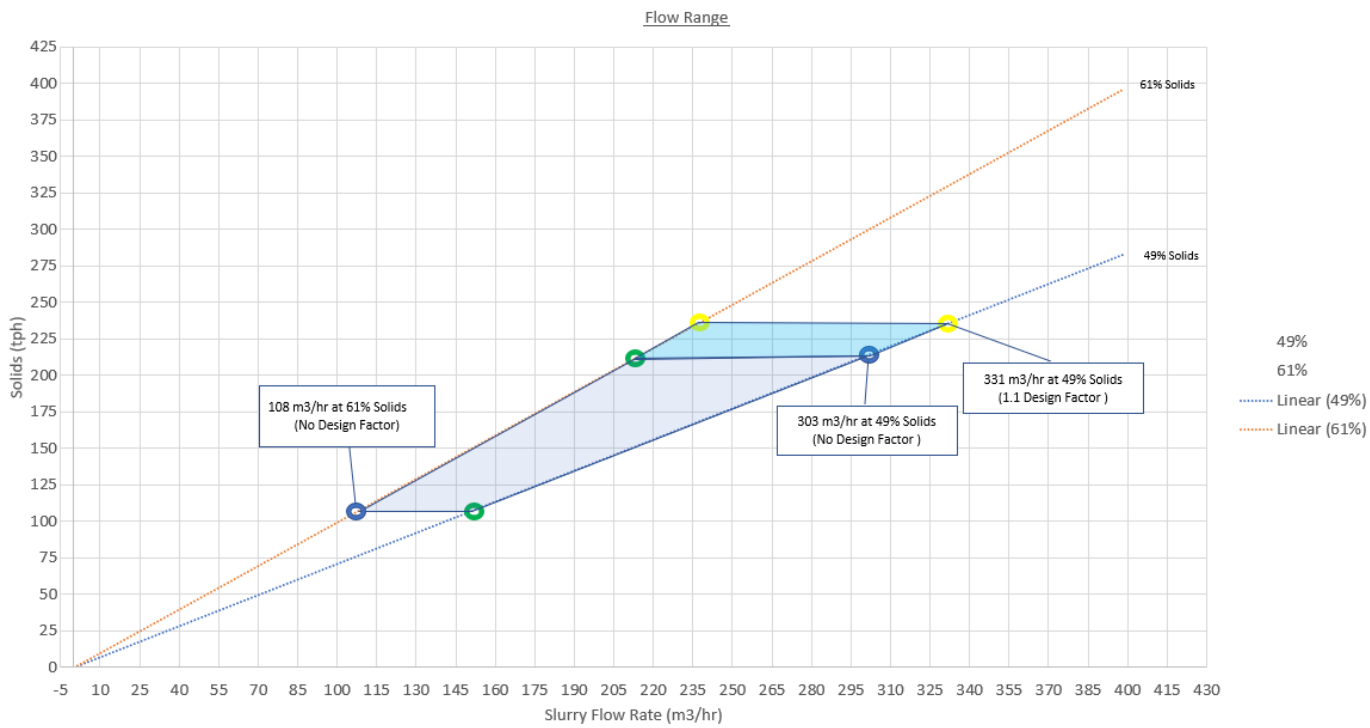
Mill Line 1 (potential discharge through Line 5, 6, 3, or A): entirely existing and the only change to this system is the addition of a tie-in from Line A to Line 5. This system is mainly fed by existing pump PU-005 with 150-hp motor and utilizes existing piping. PU-005 can also feed Line A through a by-pass in mill.

Line A (potential discharge through Line 5, 6, 3, or A): fed by existing pump PU-006 with 150-hp motor and utilizes existing 6-inch XS CS in-plant piping. All outside of plant piping and equipment is new per WSP design.

Line B (potential discharge through Line 5, 6, 3, A, B): fed by a new pump to provide flow to Line B; all components of Line B will be new equipment.

4.1 Flow Range Reporting to the Waste Rock Tailings Storage Facility

An average of 5,000 tpd of tailings is the planned production rate. Lines A and B are expected to operate between 49% and 61% solids by weight (Laliberte 2023). The volumetric flow range required in the design criteria is based on a plant utilization of 92% and a 1.1 design factor. The flow rate will range between 108 to 331 m^3/h (Figure 7).



tph = tonnes per hour; m^3/hr = cubic metres per hour.

Figure 7: Operating Flow Range to the Waste Rock Tailings Storage Facility

The tailings flow range represents the tailings to be transported to the WRTSF without dilution water addition. It is possible to reduce the variability in volumetric throughput by adding dilution water to the tailings when tailings production is low. WSP understands that Newcrest is planning to supply dilution water from the WRTSF for such purposes.

4.2 System Operating Data

An Excel workbook was developed by WSP for Newcrest to collect additional tailings disposal operating data. Additional data aids WSP in customizing pipeline design to Newcrest's specific tailings material.

Tests were run on Tails Lines 5 and 6, which were installed in September 2021. Each pipeline was tested at 0% (water only), 45%, 50%, and 63% solids, while varying the flow rate at each solids concentration. Pressure data were collected at specified hold times for each operating condition to allow the pipeline time to fill with the intended material and allow pressure readings to stabilize.

The completed worksheet was sent to WSP by Chloe Redies on 17 February 2023 (Newcrest 2023c). WSP understands that no low density (45% solids) operating data was collected due to the capacity of the TDST. Adding dilution water to the volume of slurry reporting to the TDST during the test would have caused the TDST to overflow. Raw data from the distributed control system was also provided for reference over various operating ranges (Newcrest 2023b).

4.3 Hydraulic Analysis

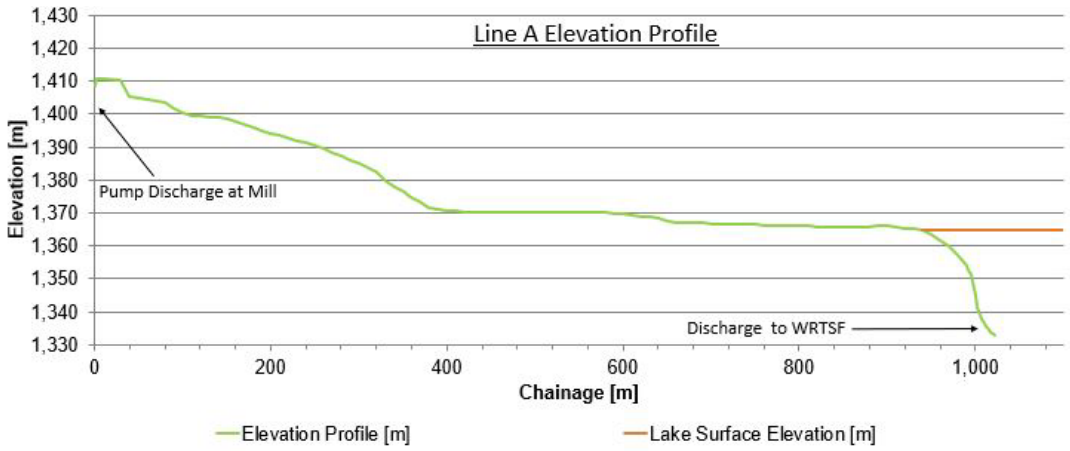
Table 3 provides Lines A and B start and discharge elevations.

Table 3: Pipeline Length and Elevation Parameters

Pipeline	Length (m)	Start Elevation (masl)	Discharge Elevation (masl)	Elevation Differential (m)	Discharge Depth from Water Surface 1,365 (m)
Line A	1023	1408.4	1332.7	-75.7	32.3
Line B	1091	1408.4	1335.6	-72.8	29.4

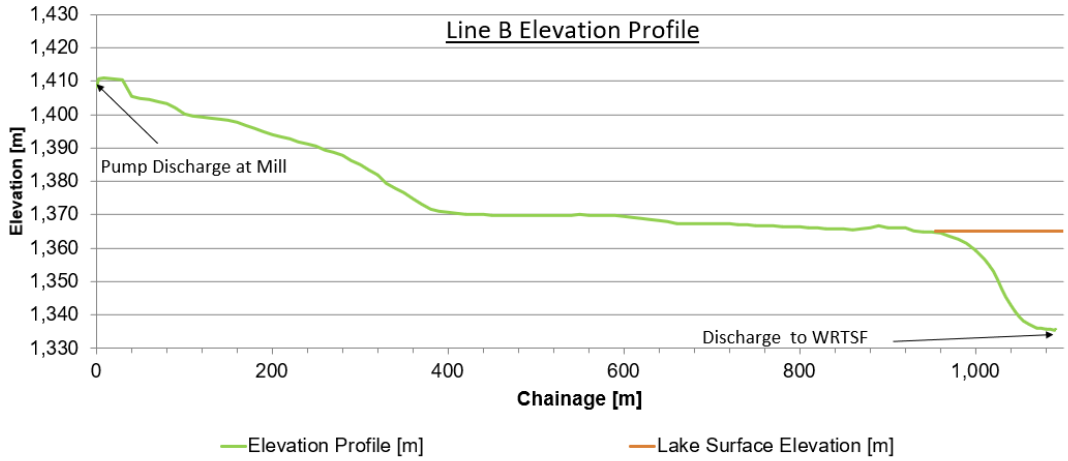
masl = metres above sea level.

Figure 8 and Figure 9 provide elevation profiles for Line A and Line B pipeline routes.



WRTSF = waste rock tailings storage facility.

Figure 8: Line A Elevation Profile



WRTSF = waste rock tailings storage facility.

Figure 9: Line B Elevation Profile

Due to the steep sloping drop-off as the pipeline enters the WRTSF, open channel flow will frequently occur at the shore. Air/vacuum valves were included in the design to mitigate vacuum formation and air constriction of the flow path.

Hydraulic analysis was carried out to determine the appropriate pipe specifications and pumping requirements to meet the design criteria. The existing tailings transport pumps were considered in this analysis.

4.3.1 Calibration of Hydraulic Model Based on Operating Data

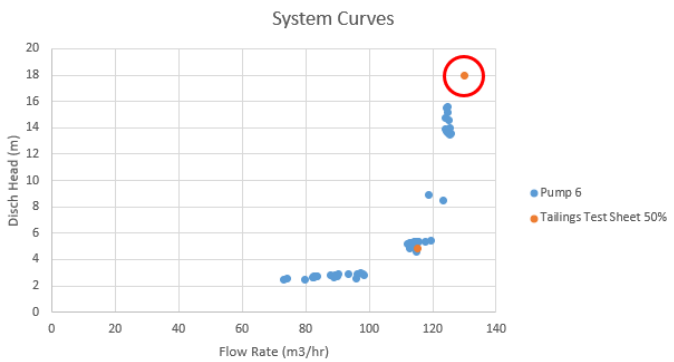
Slurry friction losses were calibrated using operating data (WSP 2023b,c) (Section 4.2). Head loss data were calibrated with the Colebrook-White equation for Newtonian fluid flow under each specific operating condition (percent of solids). The use of a calibrated Colebrook-White equation for specific flow conditions is appropriate for slurry flow in turbulent flow regime (design condition for the pipelines), based on WSP experience.

The purpose of calibrating the head loss equation is to determine the predicted head loss equation and apply this equation to the design of Lines A and B. Table 4 presents the results from the calibration analysis.

Table 4: Calibration Results

% Solids	Flow Rate from Data (m^3/h)	Pump Discharge Head from Data (m)	Calibration Factor on Colebrook
49%	130	17.92	+5%
61%	142	39.80	+16%

The calibration for the 49% solids head loss was based on the data point 130.1 m^3/h (17.92 m; circled in red in Figure 10). Calibration with this point resulted in a +5% calibration factor applied to the Colebrook equation to produce the same TDH as the operating data.

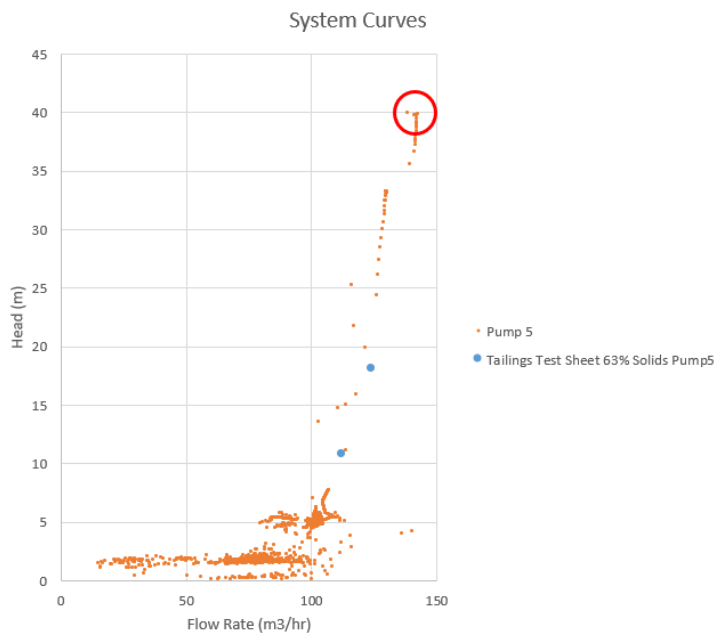


wt% = percent by weight; m^3/hr = cubic metres per hour.

Figure 10: Pump Discharge Head versus Flow Rate at 50 wt% to 55 wt% Solids

Figure 10 summarizes the operating data from the spreadsheet tailings test sheet.xlsx at 50% solids and spreadsheet tails correct data.xlsx from 50% to 55% solids.

Calibration for the 61% solids head loss was based on the data point 142.0 m^3/h (39.8 m; circled in red in Figure 11), which resulted in a +16% calibration factor applied to the Colebrook equation to produce the same TDH as the operating data.



wt% = percent by weight; m^3/hr = cubic metres per hour.

Figure 11: Pump Discharge Head versus Flow Rate at 60 wt% to 65 wt% Solids

Figure 11 summarizes the operating data from the spreadsheet tailings test sheet.xlsx at 63% solids and spread sheet tails correct data.xlsx from 60% to 65% solids.

The two points circled in red in Figure 10 and Figure 11 were selected for head loss calibration since they were collected at the high end of the flow range that was possible with the existing system and are closer to the desired operating points of the new lines.

For comparison, Table 5 shows the calculated unit head loss based on Colebrook with a 16% calibration factor and based on the WSP theory-based slurry model for each pipe specification for Line 6 calibration. By applying a 16% safety factor to the Colebrook equation, the resulting TDH matches the operating data of 39.8 m.

Table 5: Friction Loss Comparison at 61% Solids

Pipeline	% Solids	Flow Rate (m^3/h)	Unit Head Loss (m/km), Water (Colebrook+0%)	Unit Head Loss (m/km) Calibrated with Operating Data (Colebrook+16%)	Unit Head Loss (m/km), Theory-Based on Slurry Properties
6-inch XS	61	142	34.3	39.8	54.7
6-inch DR9	61	142	65.3	75.8	123
6-inch DR7.3	61	142	95.0	110	183
System TDH	61	142	28.3 m TDH	39.8 m TDH	93.7 m TDH

TDH = total dynamic head; XS = extra strong; DR = dimension ratio.

WSP selected to base the hydraulic analysis on operating data rather than the theoretical model based on slurry properties because the theoretical slurry head loss predictions far exceed the observed head losses reported on site.

The existing tailings disposal systems discharge pressure is set at an upper limit of 650 kilopascals (kPa); any pressure beyond that would blow out the existing packing (WSP understands that this is a gland water issue and can likely be fixed by using proper packing and water pressure). If operating the existing pumps above 650 kPa, an upgrade of the gland water system would be required.

The existing slurry pumps are each equipped with a 150-hp motor, which would limit the upper flow range of Lines 3 and A.

Table 6 and Table 7 present predicted TDH at 61% solids at various flow rates for Lines A and B, respectively.

Table 6: System Head (Total Dynamic Head) and Pressure Results for Line A

Pipeline A	% Solids	Flow Rate (m^3/h)	Line A, Slurry Head (m)	Lina A, Water Head (m) using HR[c]	Pressure (kPa)	Pressure (psi)	Assumed Pump Efficiency[a]	Power Draw[b] (hp)
Sizing for new pump	61	331	53.8	57.8	862	125	62.5%	196
Limited by 150-hp existing pump motor	61	313	43.7	47.0	701	102	62.5%	150
Limited by 650 kPa gland water pump packing	61	307	40.6	43.7	650	94	62.5%	137
Duty point	61	212	4.4	4.7	71	10	58.0%	11
Duty point	61	141	3.1	3.3	50	7	62.0%	4.8
Duty point	61	120	2.8	3.0	45	7	62.5%	3.65

a) Pump efficiencies are based on existing pump curve.

b) Power draw includes a 15% contingency.

c) Water head is consistently higher than slurry head as the density of water is less than the density of the slurry.

HR = head ratio; psi = pounds per square inch; kPa = kilopascal; hp = horsepower.

Table 7: System Head (Total Dynamic Head) and Pressure Results for Line B

Pipeline B	% Solids	Flow Rate (m^3/h)	Line B, Slurry Head (m)	Lina B, Water Head (m) using HR[c]	Pressure (kPa)	Pressure (psi)	Assumed Pump Efficiency[a]	Power Draw[b] (hp)
Sizing for new pump	61	331	55.5	59.7	890	129	62.5%	202
Limited by 150-hp existing pump motor	61	312	43.7	47.0	701	102	62.5%	150
Limited by 650 kPa gland water pump packing	61	307	40.6	43.7	650	94	62.5%	137
Duty point	61	276	24.7	26.0	396	57	61.0%	77
Duty point	61	141	2.7	2.9	43	6	62%	4

a) Pump efficiencies are based on existing pump curve.

b) Power draw includes a 15% contingency.

c) Water head is consistently higher than slurry head as the density of water is less than the density of the slurry.

HR = head ratio psi = pounds per square inch; kPa = kilopascal; hp = horsepower.

The maximum head that would occur within the design range is the pumping of 331 m^3/h of 61% solids slurry through one of the 8-inch pipelines. The pumping head estimate, at this point, is a slurry head of 56 m (890 kPa) with a power draw of 202 hp; assuming 62.5% pump efficiency. It would be the highest duty point required by the new pump; however, it is not recommended to pump the full flow through one line frequently as it could result in high wear. WSP recommends using this operating point to size the new pump for Line B so that the new pump does not become the bottleneck if design/operating conditions change in the future.

4.3.2 Pipe Selection and Expected Hydraulic Result

The design for Lines A and B is based on a model calibrated to the operating data.

Lines A and B would be used in combination with other operatable pipelines on site to deliver tailings from the mill to the WRTSF. Since the flow rate will vary widely (108 m^3/h to 331 m^3/h), operating pipelines will also vary depending on the flow rate delivered to the TDST.

The existing Tails Lines 5 and 6 are both 6-inch pipe diameter. Line 3 is mostly 6-inch pipe diameter with the discharge portion of the pipeline after valve shack 1 transitioning to 8-inch pipe diameter.

A pipe diameter of 8 inches was selected for the new sections of Lines A and Line B. This larger pipe diameter will provide operational flexibility in combination with the existing 6-inch pipelines.

WSP understands Newcrest would prefer the existing 6-inch XS CS in-plant piping for Line A. At the mill building exit, the pipeline would transition to 8-inch HDPE DR9 pipe and continue with this pipe type to the discharge point.

The new Line B would consist of 8-inch XS CS Grade B piping with a 0.375-inch rubber liner within the mill, then transition to 8-inch HDPE DR9 at the mill building exit and continue with this pipe specification to the discharge. Line B was specified as 8-inch to provide additional capacity with Tails Lines 5 and 6. Line A, Tails Line 5, and Tails Line 6 will have a consistent minimum flow rate to stay above deposition velocity. The deposition velocity of Line A is 1.61 m/s, and the deposition velocity of Line B is 1.64 m/s, set by the largest inner diameter section of the pipelines (8-inch DR9 and 8-inch XS CS with rubber liner for Lines A and B, respectively). Table 8 presents the deposition and transition velocities within each pipe type at various solids contents.

Table 8: Deposition and Transition Velocity

Solids	Pipe Type	Deposition (m/s)	Corresponding Flow (m^3/h)	Transition (m/s)	Corresponding Flow (m^3/h)
61%	8-inch XS CS with RL	1.63	141	2.84	245
	8-inch DR9	1.61	128	2.69	213
	6-inch XS CS	1.56	94	2.80	170
49%	8-inch XS CS with RL	1.64	141	0.77	66
	8-inch DR9	1.61	128	1.41	112
	6-inch XS CS	1.56	94	1.41	85

XS = extra strong; CS = carbon steel; DR = dimension ratio: RL = rubber liner.

The operating flow rate of Line A should not drop below 128 m^3/h, and the operating velocity of Line B should not drop below 141 m^3/h. If the flow rate of tailings reporting to the TDST drops below the deposition velocity of the operating line and a smaller diameter pipeline is not available, a low flow override via HV-6857 should activate the addition of dilution water to account for the difference. Implementation of this control would result in more reliable transport of tailings and reduce risks of plugging.

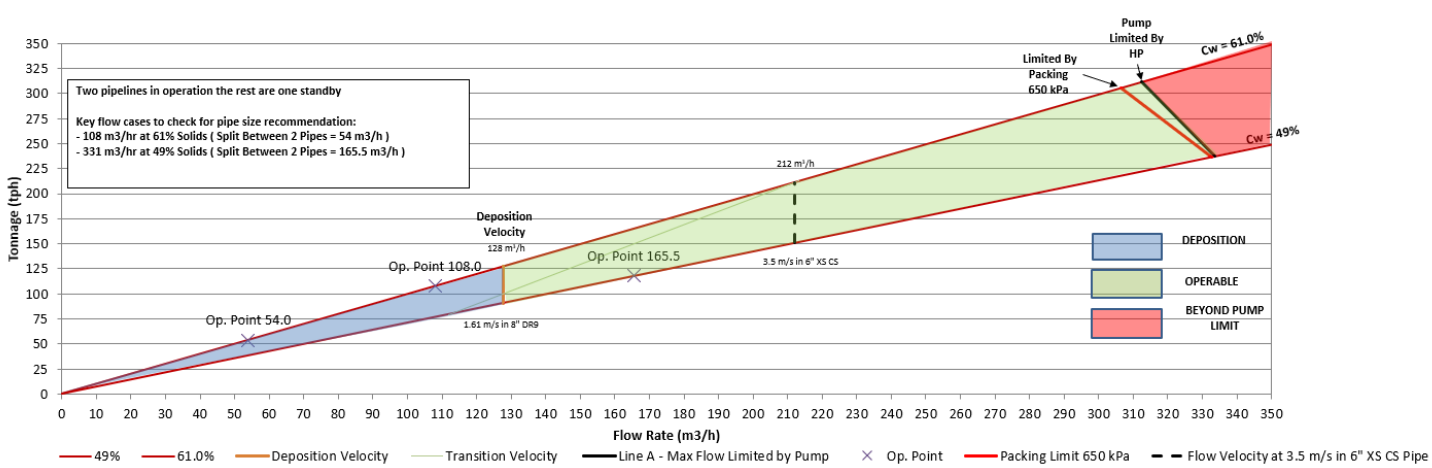
The transition velocity results show the relation between the solids content and the velocity required to maintain turbulent flow. The transition velocity increases at the higher solids content range.

When operating at higher solids contents, there is a risk of operating in laminar flow (below the transition velocity) and solids settling. Since the coarse fraction of material in Newcrest's tailings slurry is low, the fluid is likely operating in stable laminar flow. Stable laminar flow is an operating mode that could allow for some solids settling with the finer portion of the settled material being resuspended and dropped back to the bottom of the pipe over the length of the line. Since there is only a small fraction of coarse material remaining settled and dragged along the bottom of the pipe, it would not have a large impact on the head of the system in the short term. Sustained operation in this mode could result in solids accumulation and eventual blockage. WSP suggests operating at the upper range of the possible flow rates with frequent flushing to reduce the potential for solids accumulation in the pipeline. Discharge pressures should be monitored regularly. If flow is constant but discharge pressures are increasing, solids accumulation could be occurring. Mitigation of risks associated with operating below transition velocity is addressed in Section 4.3.3.

The expected hydraulic gradient was calibrated using the Colebrook-White equation assuming water fluid properties and a calibration factor of 16% for 61% solids, and calibration factor of 5% for 49% solids.

Figure 12 and Figure 13 show predicted operating range diagrams of Line A and Line B, respectively. The blue area represents operation below the deposition velocity where risk of solids accumulation at the bottom of the pipe is high. The red area was determined via hydraulic analysis, the pump curve, and the motor rating (existing pump curve in Appendix C). Operation in the red area represents operation exceeding the 150-hp capacity of the existing motors with a 15% safety factor on the motor power usage. The interface is slanted as more pumping power is required to pump a heavier specific gravity slurry than a lighter specific gravity slurry, resulting in higher flow rates being possible at lower solids contents.

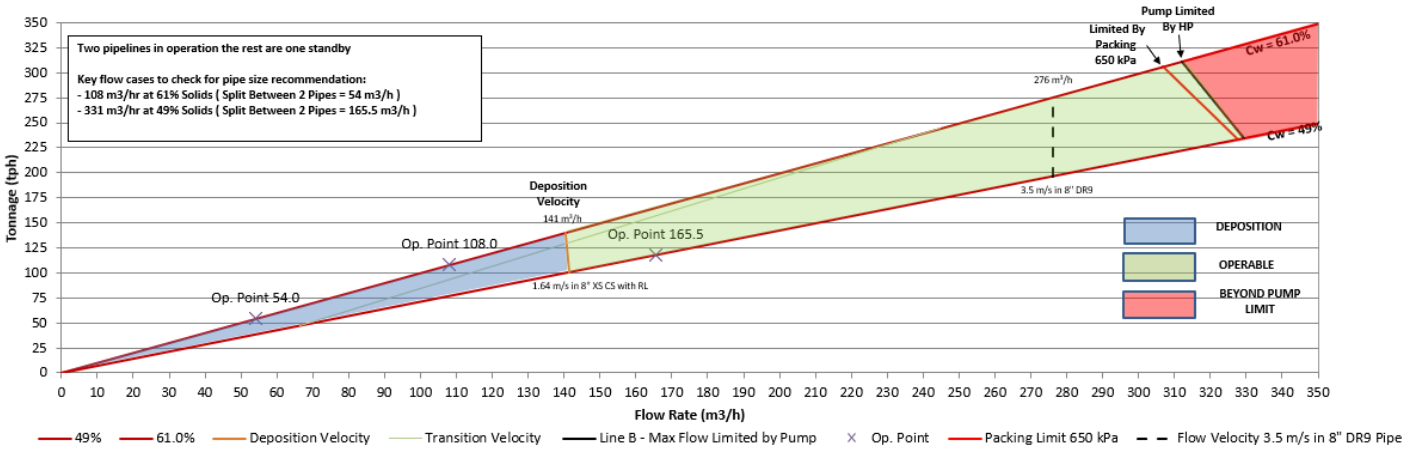
The vertical dashed line shows the flow rate that corresponds with a flow velocity of 3.5 m/s. Slurry pipelines operating above 3.5 m/s for a sustained period could experience increased wear and high energy consumption. It is not recommended to operate above 3.5 m/s for sustained periods. The maximum flow rates to stay below 3.5 m/s is 212 m^3/h in Line A and 276 m^3/h in Line B.



tph = tonnes per hour; XS = extra strong; CS = carbon steel; Cw = weight concentration; m^3/hr = cubic metres per hour; HP = horsepower; kPa = kilopascal; " = inch.

Figure 12: Operating Range Diagram of Line A

Line A is expected to be able to operate with a maximum flow rate of 312.5 m^3/h at 61% solids. Hydraulic analysis shows that the TDH of slurry to pump tailings at the maximum flow rate is 43.7 m, and one pump at the mill would draw 150 hp under such conditions. At the maximum flow rate, the operating velocity of this line is 3.94 to 5.16 m/s.

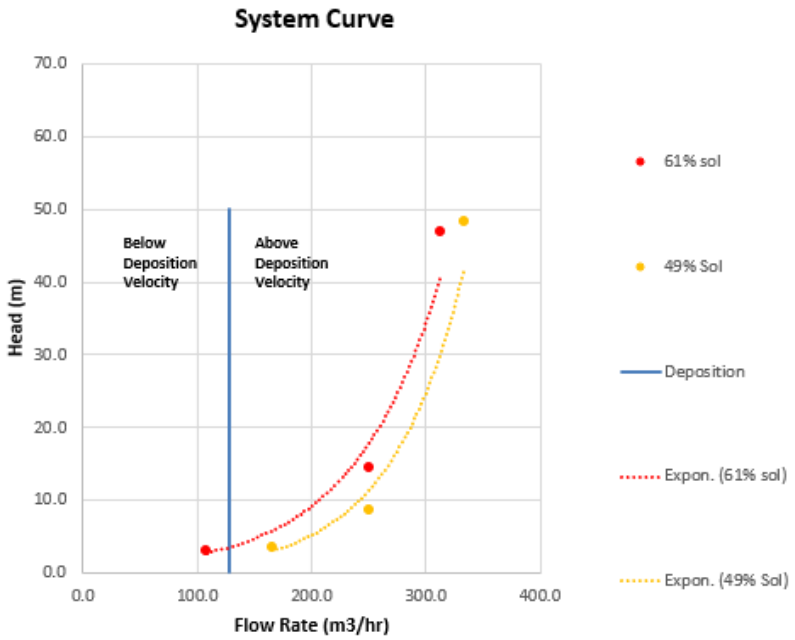


tph = tonnes per hour; XS = extra strong; CS = carbon steel; Cw = weight concentration; m^3/hr = cubic metres per hour; HP = horsepower; kPa = kilopascal; " = inch.

Figure 13: Operating Range Diagram of Line B

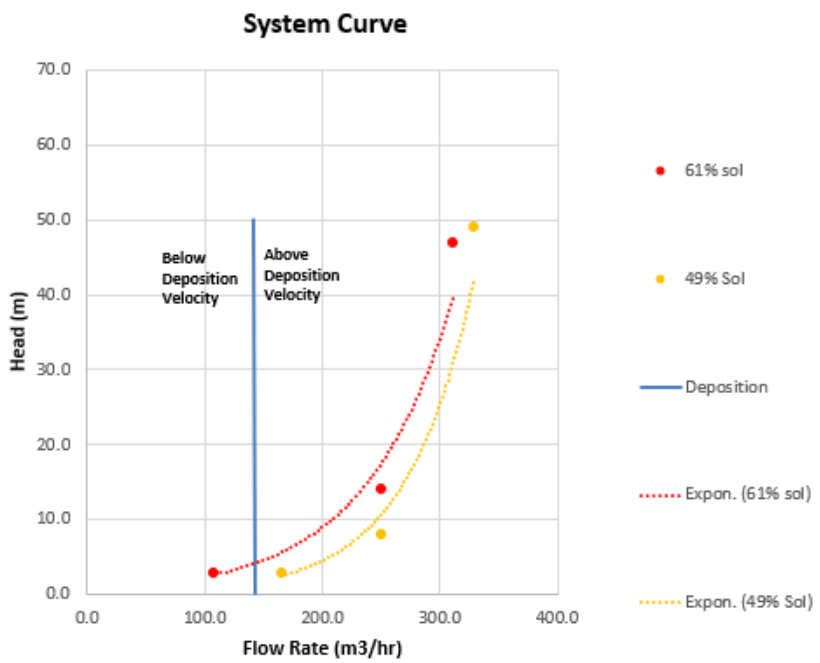
Line B is expected to operate with a maximum flow rate of 312.5 m^3/h at 61% solids. Hydraulic analysis shows that the TDH of slurry to pump tailings at the maximum flow rate is 43.7 m, and one pump at the mill would draw 150 hp under such conditions. At the maximum flow rate, the operating velocity of this line is 3.62 to 3.94 m/s.

Figure 14 and Figure 15 show the expected slurry pump discharge heads at the key operating interfaces shown in Figure 12 and Figure 13.



m^3/hr = cubic metres per hour; Sol = solids; ; Expon. =exponential.

Figure 14: Pump Discharge Head versus Flow Rate at Line A



m^3/hr = cubic metres per hour; Sol = solids; ; Expon. = exponential.

Figure 15: Pump Discharge Head versus Flow Rate at Line B

4.3.3 Operating Strategy

The operating strategy shown in Table 9 is preliminary and adjustable as the field performance of the system is observed after installation and commissioning. The constraints on the operation of this system are the minimum velocity, maximum velocity, and pumping capacity.

Lines A and B lower operating range is set by the deposition velocity. The deposition velocity of Line A is 1.61 m/s which corresponds to 128 m^3/h. Line B has a deposition velocity of 1.64 m/s, which corresponds to 141 m^3/h.

The upper operating range of Lines A and B is set by the 3.5 m/s recommended maximum operating velocity, which corresponds to 212 m^3/h in Line A and 276 m^3/h in Line B. The 3.5 m/s operating limit is set to control pipeline wear.

Table 9 shows the recommended operating strategy of the tailings pipeline system.

Table 9: Recommended Operating Strategy

Tailings Flow Rate (m^3/h)	Pipelines Operated
120 and below	use one 6-inch line (existing Line 1 and discharge through 3 or 5)
120 to 141	use one 8-inch line (Line A)
141 to 212	use one 8-inch line (Line A or Line B)
212 to 276	use one 8-inch line (Line B)
276 and above	use two 8-inch lines, or one 8-inch and one 6-inch line (flow in each line would be 138 m^3/h or greater if divided equally)

The recommended operating strategy is intended to serve as a guideline for system operation. Operation outside the above flow ranges may be acceptable for limited durations.

If the flow rate of tailings drops below the deposition velocity and it is not possible to switch to a smaller diameter pipe (or it is inconvenient to do so in the case where flow rates are regularly fluctuating), dilution water can be added or a more regular flushing procedure can be implemented.

The required flush velocity of Lines A and B must be a minimum of 1.64 m/s in the 8-inch XS CS portion of the pipe, with a required flush duration of 35 minutes which equates to a flow rate of 141 m^3/h and should be performed weekly.

If pressures begin to rise unexpectedly, it could be an indication of a partial blockage and a flush or addition of dilution water should be performed as soon as it is practical. After flushing, when it is known that there is a clean pipe free of blockage, the discharge pressure (on water) should be noted for future reference. This pressure could be used as a baseline. If there is not a similar pressure after flushing, this indicates there may still be settlements in the pipe and the flush velocity should be increased.

4.3.4 Configuration – Fixed Perimeter Discharge

Lines A and B are subaqueous perimeter discharge pipelines. Discharge locations of Lines A and B have limited mobility since they will not be able to be relocated once sunk (see Drawing 2 for site plan and pipeline and layout in Appendix A).

Line A is connected to PU-005 and Line B is connected to the new pump within the mill. From the pump tie-ins, the pipelines are expected to be routed along the wall on the southeast side of the mill building. At a point determined by Newcrest, the pipeline will be directed downward, under the floor of the mill, and continue underground to the WRTSF. The in-plant pipeline routing is beyond WSP's scope of work and will be defined by Newcrest. Line A will tie-in to Line 5 outside the mill building just before valve shack 1. Line B runs independently from the mill exit to the discharge.

Line A and B are weighted with concrete blocks to counteract the buoyant forces of the HDPE pipe, insulation, and air that could fill the pipe in the subaqueous section. The concrete blocks rest on the lakebed sediments and are attached to the pipe with cables and riser pipe clamps; weights would be installed at the end of the pipeline to allow flotation to 7.5 m above the natural lakebed or tailings surface. The length of each cable is unique to provide a gradually sloping profile minimizing any peaks or troughs where air or solids could accumulate (Drawings 3, 4, 5, and 6 for pipeline profiles and weight tables in Appendix A). See drawings 7 and 8 for weight details in Appendix A. Table 10 provides specific weight details and spacing.

Table 10: Weight Spacing

Line	Pipe Type	Insulated	Weights	Weight Type	Spacing Every	Chainage from shore (m)	Comments
A	8-inch HDPE DR9	yes	166 kg (366 lbs)	Pipe clamp with concrete block	1.4 m	0 - 18.2	-
	8-inch HDPE DR9	no	2 at 34 kg (75 lbs)	Pipe clamp with concrete block	1.4 m	19.6 - 109.2	-
	8-inch HDPE DR9	no	2 at 166 kg (366 lbs)	Pipe clamp with concrete block	N/A	110.6	additional two 366-lbs weights to counteract each float
B	8-inch HDPE DR9	yes	166 kg (366 lbs)	Pipe clamp with concrete block	1.4 m	0 – 18.2	-
	8-inch HDPE DR9	no	2 at 34 kg (75 lbs)	Pipe clamp with concrete block	1.4 m	19.6 – 155.4	-
	8-inch HDPE DR9	no	2 at 166 kg (366 lbs)	Pipe clamp with concrete block	18.5m	117.6;135.8;154.0	additional two 366-lbs weights to counteract each float

DR = dimension ratio; HDPE = high-density polyethylene; - = not applicable; lbs = pounds; kg = kilograms.

A neoprene sponge sheet should be wrapped around the pipeline before application of pipeline clamps to prevent the clamps from slipping. In addition, during installation of the pipeline clamps, it is recommended to tie a 0.5-inch diameter polypropylene rope to each of the clamps to prevent the weights from slipping during the installation.

One float composed of 6.5-foot long, 8-inch HDPE DR9 pipe with 3-inch thick insulation and capped ends is connected to the end of Line A to serve as an underwater pipe float. Three of the same specified floats are needed for the floating section of Line B to prevent the end of the pipeline from becoming submerged in settled tailings that could clog the pipe end (Table 11 for float specifications). An additional two 366-pound weights are required to counteract the buoyancy of each float; total of two 366-pound weights at the end of Line A. A total of six 366-pound weights along the end of Line B.

Table 11: Float Specification

Line	Pipe Type	Insulated	Float	Floating Length (m)	Spacing	Comments
A	8-inch HDPE DR9	no	one 6.5-ft long, 8-inch DR9 pipe with 3-inch thick insulation	18.5	one at end of pipe	an additional two 166 kg (366-lbs) weights to counteract each float
B	8-inch HDPE DR9	no	three 6.5-ft long, 8-inch DR9 pipe with 3-inch thick insulation	51.7	three along floating section of pipe spaced ~18.5 m apart	an additional two 166 kg (366-lbs) to counteract each float

DR = dimension ratio; HDPE = high-density polyethylene; lbs = pounds; kg = kilograms; ft = feet.

To prevent the pipe outlet from plugging, open features (e.g., holes in the pipe) are included to aid continued discharge in the event the end is plugged or grounded out (Appendix A; Figure 6 for holes detail). A length of 310 m of heat tracing and insulation is included and extending 18.23 m under the water per previous design. It is recommended the pipe is buried at the shoreline to prevent any damage from ice or other objects in the WRTSF.

A new valve shack (valve shack 2) is required at chainage 0+912 m to protect the air/vacuum valve of Line A and Line B from ice and snow. The exact location of valve shack 2 may require adjustment as shoreline access is currently congested (Drawings 9 and 10 for valve shack 2 detail in Appendix A). A small enclosure (valve shack 3) would also be required upstream of valve shack 1 to protect the Line A tie-in valving (Drawing 11 for Line A tie-in detail in Appendix A).

Figure 16 shows Newcrest's proposed valve shack location.

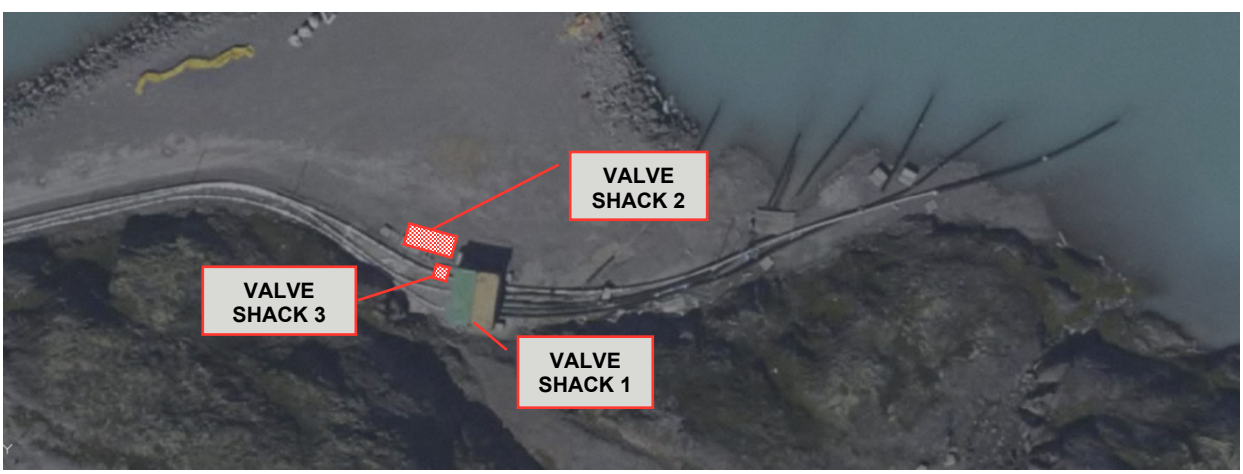


Figure 16: Valve Shack Location

Appendix B provides the detailed material take-off of all the equipment required for Lines A and B outside the mill building.

5.0 RECOMMENDATIONS FOR FUTURE WORK

The following are general recommendations:

- Site visit: WSP recommends having a site visit to validate and test the functionality of the upgraded and recently installed WSP-designed pipeline systems. This site visit will help ensure nothing has been overlooked. Also, this is part of WSP's due diligence and will allow for more accurate as-built documentation of Lines 5 and 6.
- Subaqueous pipeline installation: WSP recommends Newcrest, or pipeline installation contractor, contact WSP's marine installation experts for any questions or installation guidance required.
- Commissioning: Test the newly installed system to ensure it is performing as expected. Modification to the system may be needed to increase functionality and reliability.

6.0 CLOSURE

The reader is referred to the Study Limitations section, which precedes the text and forms an integral part of this report.

We trust the above meets your present requirements. If you have any questions or comments, please contact the undersigned.

Signature Page

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https://golderassociates.sharepoint.com/sites/157185/project files/6 deliverables/3.0_issued/21507844-062-r-rev0-9000-ifcdesign_tailingslinealineb/ss/21507844-062-r-rev0-9000-ifcdesign_tailingslinealineb 23aug_23_gd_mh.docx

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APPENDIX A

Drawings

2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

PROJECT LOCATION PLAN
NOT TO SCALE

DRAWING LIST

DRAWING No.	DRAWING TITLE	REVISION No.	PURPOSE OF ISSUE	DATE OF ISSUE
1	TITLE SHEET	0	ISSUED FOR CONSTRUCTION	2023-08-24
2	PIPELINE PLAN - TAILINGS PIPELINE A & PIPELINE B (4950 TPD)	0	ISSUED FOR CONSTRUCTION	2023-08-24
3	TAILINGS LINE A PROFILE - 2023 (4950 TPD)	0	ISSUED FOR CONSTRUCTION	2023-08-24
4	TAILINGS LINE B PROFILE - 2023 (4950 TPD)	0	ISSUED FOR CONSTRUCTION	2023-08-24
5	WEIGHT TABLES LINE A	0	ISSUED FOR CONSTRUCTION	2023-08-24
6	WEIGHT TABLES LINE B	0	ISSUED FOR CONSTRUCTION	2023-08-24
7	WEIGHT DETAILS	0	ISSUED FOR CONSTRUCTION	2023-08-24
8	INSULATED WEIGHT DETAILS	0	ISSUED FOR CONSTRUCTION	2023-08-24
9	VALVE SHACK ENCLOSURE - PLAN VIEW	0	ISSUED FOR CONSTRUCTION	2023-08-24
10	VALVE SHACK 2 ENCLOSURE- TAILINGS PIPELINE A AND B	0	ISSUED FOR CONSTRUCTION	2023-08-24
11	LINE A TO LINE 5 TIE-IN	0	ISSUED FOR CONSTRUCTION	2023-08-24

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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
TITLE SHEET

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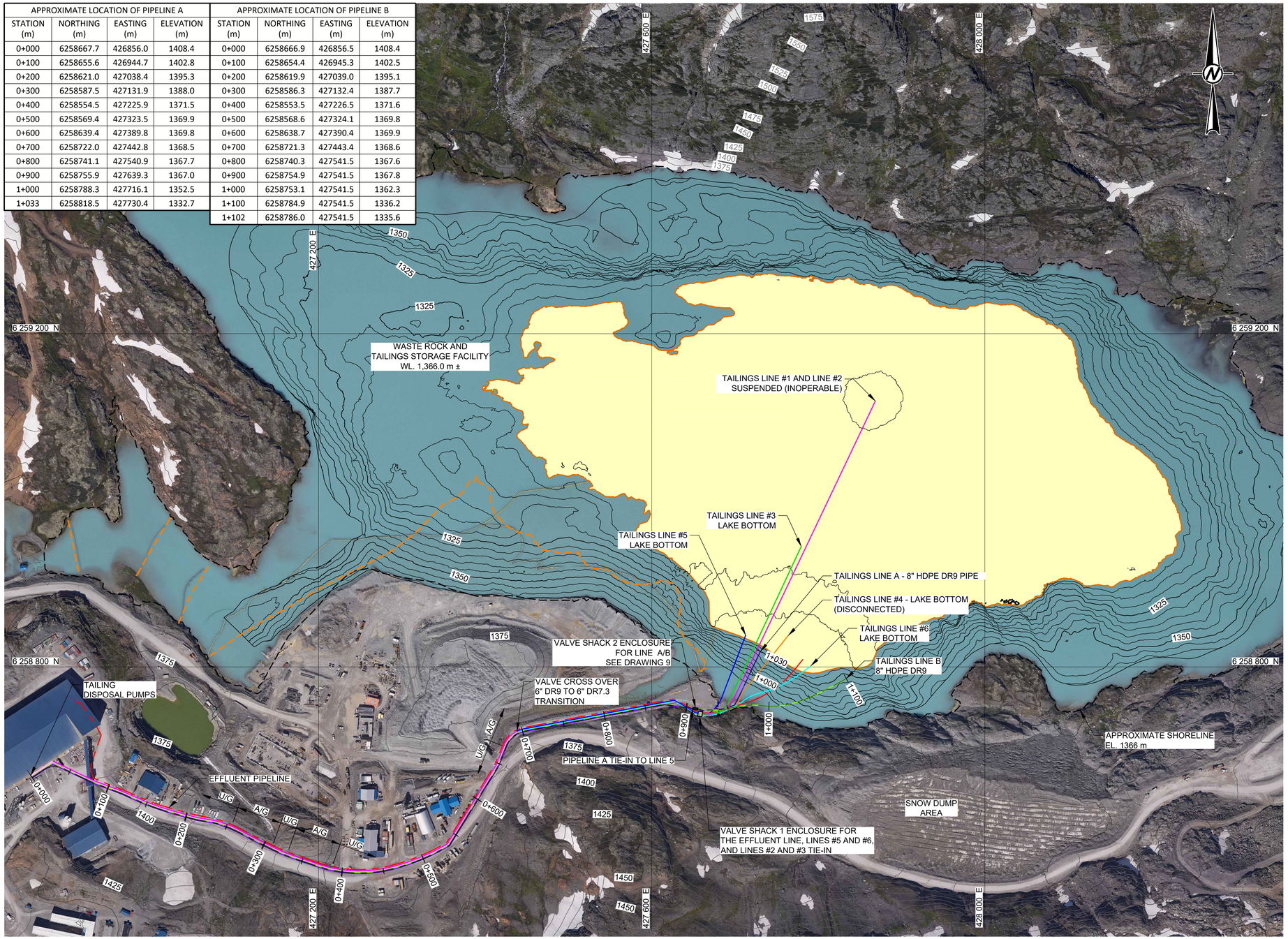
APPROXIMATE LOCATION OF PIPELINE A				APPROXIMATE LOCATION OF PIPELINE B			
STATION (m)	NORTHING (m)	EASTING (m)	ELEVATION (m)	STATION (m)	NORTHING (m)	EASTING (m)	ELEVATION (m)
0+000	6258667.7	426856.0	1408.4	0+000	6258666.9	426856.5	1408.4
0+100	6258655.6	426944.7	1402.8	0+100	6258654.4	426945.3	1402.5
0+200	6258621.0	427038.4	1395.3	0+200	6258619.9	427039.0	1395.1
0+300	6258587.5	427131.9	1388.0	0+300	6258586.3	427132.4	1387.7
0+400	6258554.5	427225.9	1371.5	0+400	6258553.5	427226.5	1371.6
0+500	6258569.4	427323.5	1369.9	0+500	6258568.6	427324.1	1369.8
0+600	6258639.4	427389.8	1369.8	0+600	6258638.7	427390.4	1369.9
0+700	6258722.0	427442.8	1368.5	0+700	6258721.3	427443.4	1368.6
0+800	6258741.1	427540.9	1367.7	0+800	6258740.3	427541.5	1367.6
0+900	6258755.9	427639.3	1367.0	0+900	6258754.9	427541.5	1367.8
1+000	6258788.3	427716.1	1352.5	1+000	6258753.1	427541.5	1362.3
1+033	6258818.5	427730.4	1332.7	1+100	6258784.9	427541.5	1336.2
				1+102	6258786.0	427541.5	1335.6



LEGEND

- 2022 EXISTING GROUND CONTOURS (SEE REFERENCE 1)
- 2022 BATHYMETRIC CONTOURS (SEE REFERENCE 2)
- 2022 WRTSF SHORELINE AT EL. 1366.0 m
- APPROXIMATE 2019 SEDIMENT CURTAIN LOCATIONS
- APPROXIMATE EFFLUENT TAILINGS LINE
- APPROXIMATE TAILINGS LINE #1 (SEE NOTE 11)
- APPROXIMATE TAILINGS LINE #2 (SEE NOTE 5)
- APPROXIMATE TAILINGS LINE #3 (SEE NOTE 6)
- APPROXIMATE TAILINGS LINE #4 (SEE NOTE 7)
- APPROXIMATE TAILINGS LINE #5 (SEE NOTE 9)
- APPROXIMATE TAILINGS LINE #6 (SEE NOTE 9)
- APPROXIMATE TAILINGS LINE A (SEE NOTE 10)
- APPROXIMATE TAILINGS LINE B (SEE NOTE 10)
- APPROXIMATE 2022 TAILINGS DEPOSITION AREA
- A/G U/G ABOVE GROUND / UNDERGROUND

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
2. COORDINATES SHOWN IN UTM, NAD 83, ZONE 9. ELEVATIONS RELATIVE TO GEODETIC DATUM.
3. EXISTING GROUND AND BATHYMETRY CONTOURS SHOWN AT 25 m MAJOR AND 5 m MINOR INTERVAL.
4. SEDIMENT CURTAIN SURROUNDING WASTE ROCK DUMP SHOULD BE EXPANDED IN 2022.
5. SUSPENDED TAILS LINE 2 IS INOPERABLE SINCE 22 AUGUST 2022. TAILS LINE 2 IS PLANNED TO BE DECOMMISSIONED AND REMOVED IN THE FUTURE.
6. TAILINGS LINE #3 IS OPERABLE BUT NOT USED DUE TO TOTAL SUSPENDED SOLID GENERATION FROM LAKE BOTTOM SEDIMENTS.
7. TAILINGS LINE #4 WAS PLUGGED JULY 2021, AND PARTIALLY REMOVED AS OF SEPTEMBER 2021.
8. ROUTES SHOWN FOR TAILS #1, 2, 3, 4 AND EFFLUENT PIPELINE ARE BASED OFF DRAWING PROVIDED BY PRETIUM. THESE LINES COULD HAVE POTENTIALLY SHIFTED OVER THE YEARS OF OPERATION. LOCATION OF THESE LINES SHOULD BE VERIFIED TO THE EXTENT POSSIBLE.
9. TAILINGS LINES # 5 AND # 6 WERE INSTALLED IN SEPTEMBER 2021 AND ARE ANCHORED TO THE LAKE BOTTOM.
10. TAILINGS LINES A AND B LOCATIONS ARE DESIGN, NOT INSTALLED.
11. TAILINGS LINE 1 IS DISCONNECTED AT SHORE.

REFERENCES

1. 2022 LIDAR SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 10 AUGUST 2022, RECEIVED: 17 OCTOBER 2022, FILE NAME: "Surface Drone Flight_dsm.tif".
2. 2022 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 22 JULY 2022, RECEIVED: 08 AUGUST 2022, FILE NAME: "20220722_adjusted_1.5x1.5 Brucejack Winghead Bathymetric Survey_median_UTMZ9_CGVD28.xyz".
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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
PIPELINE PLAN
TAILINGS PIPELINE A & PIPELINE B (4950 TPD)

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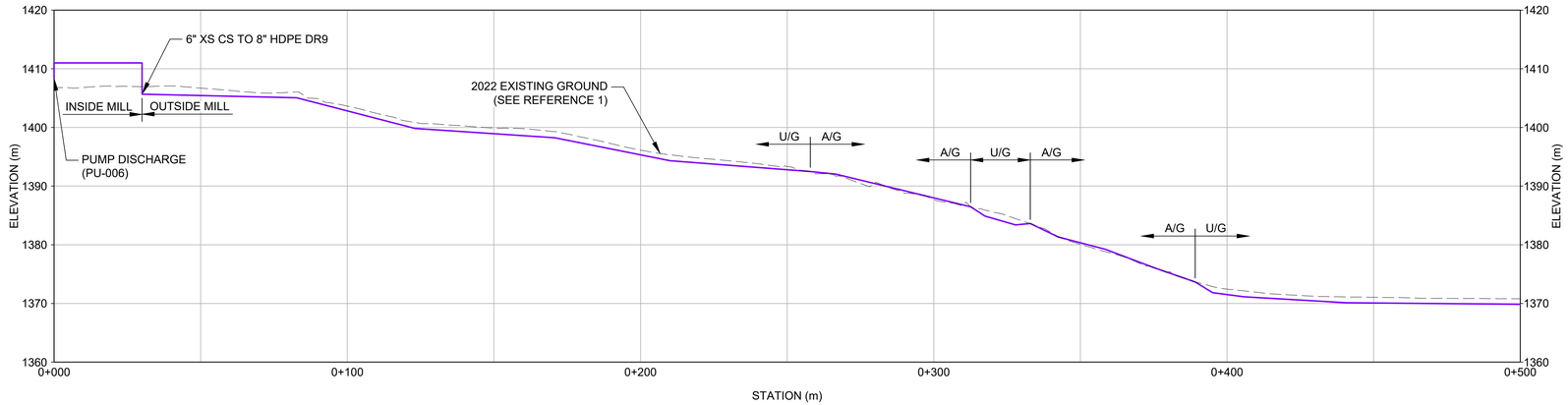

TAILINGS LINE A - PROFILE STA 0+000 TO 0+500

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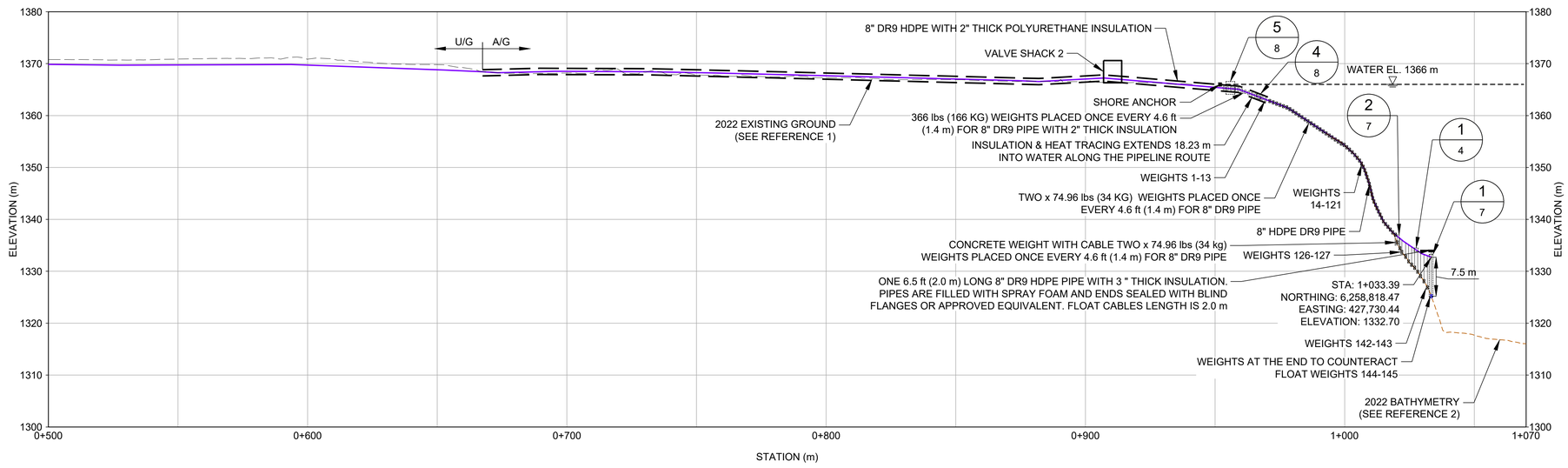

TAILINGS LINE A - PROFILE STA 0+500 TO 1+033

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:500

LEGEND

- 2022 EXISTING GROUND (SEE REFERENCE 1)
- POND SURFACE ELEVATION (SEE REFERENCE 1)
- 2022 BATHYMETRY (SEE REFERENCE 2)
- TAILINGS LINE A
- 8" DR9 HDPE PIPE WITH 2" THICK INSULATION AND HEAT TRACING
- A/G U/G — ABOVE GROUND / UNDERGROUND
- PIPE WEIGHT- 2 COUNT EACH 34 kg
- FLOAT WEIGHT - 2 COUNT EACH 166 kg
- PIPE FLOAT
- INSULATED PIPE WEIGHT - 1 COUNT EACH 166 kg

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
2. DRILLED PIPE INSTALLED AT END OF PIPE IN LAKE.
3. INSULATION AND HEAT TRACING BASED ON EXISTING PIPELINE DESIGN.
4. EACH FLOAT REQUIRES 2 WEIGHTS TO COUNTERACT BUOYANCY.

REFERENCES

1. 2022 LIDAR SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 10 AUGUST 2022, RECEIVED: 17 OCTOBER 2022, FILE NAME: "Surface Drone Flight_dsm.tif".
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0 20 40
1:500 METRES

0 50 100
1:1,000 METRES

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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
TAILINGS LINE A PROFILE - 2023 (4950 TPD)

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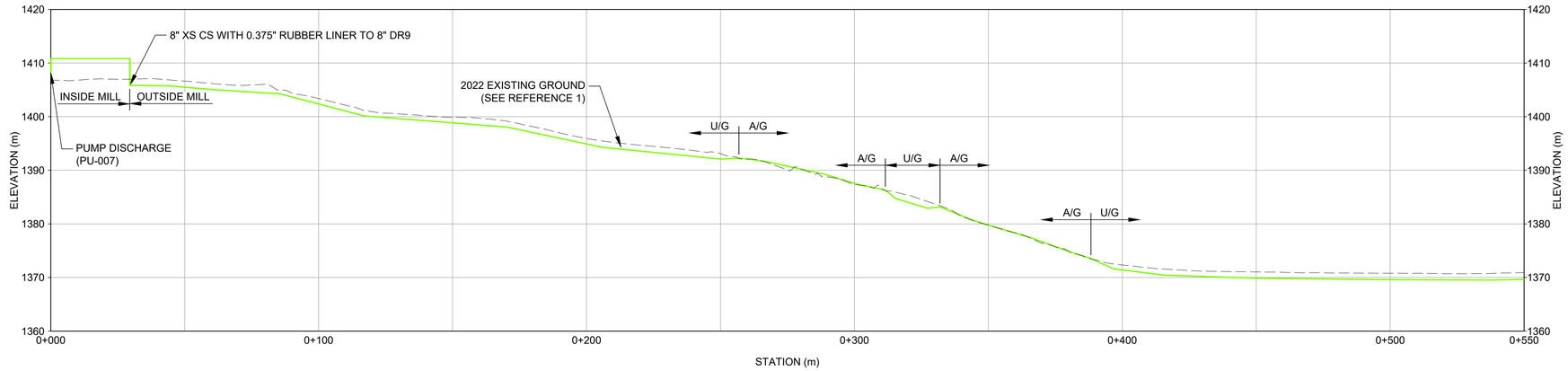

TAILINGS LINE B - PROFILE STA 0+000 TO 0+550

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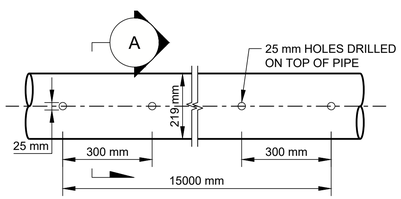
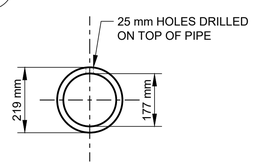
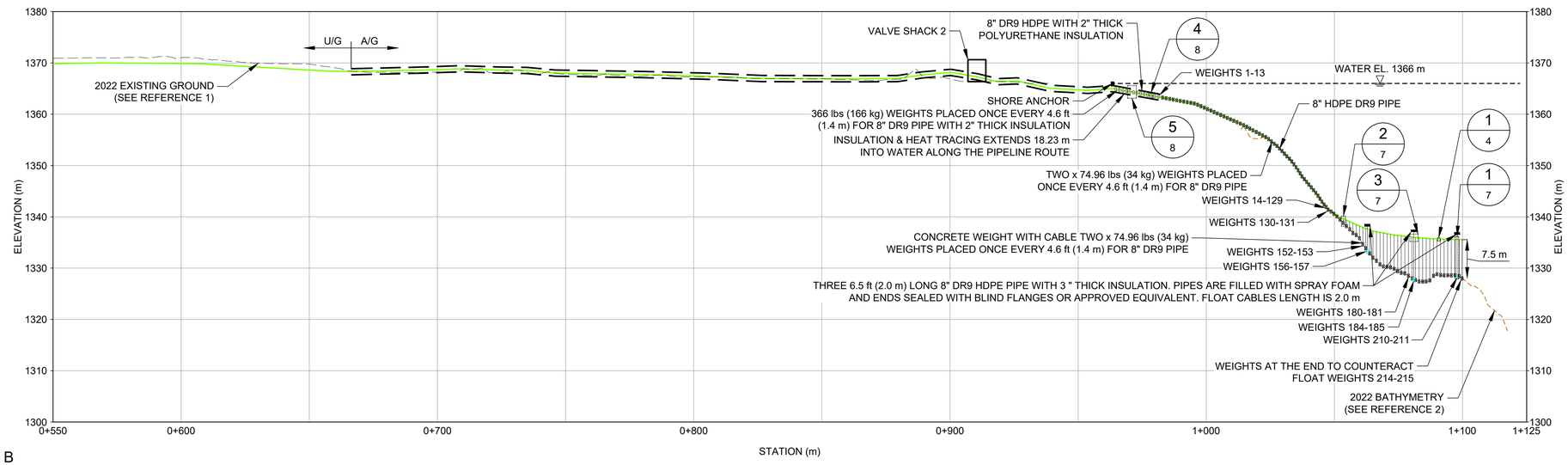


SCALE 1:10 m (1) DETAIL - TAILINGS LINE A & B DRILLED HDPE PIPE



SCALE 1:10 m (A) CROSS-SECTION - TAILINGS LINE A & B DRILLED HDPE PIPE



TAILINGS LINE B - PROFILE STA 0+550 TO 1+102

HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:500

LEGEND

- 2022 EXISTING GROUND (SEE REFERENCE 1)
- POND SURFACE ELEVATION (SEE REFERENCE 1)
- 2022 BATHYMETRY (SEE REFERENCE 2)
- TAILINGS LINE B
- 8" DR9 HDPE PIPE WITH 2" THICK INSULATION AND HEAT TRACING
- A/G | U/G — ABOVE GROUND / UNDERGROUND
- PIPE WEIGHT- 2 COUNT EACH 34 kg
- FLOAT WEIGHT - 2 COUNT EACH 166 kg
- PIPE FLOAT
- INSULATED PIPE WEIGHT - 1 COUNT EACH 166 kg

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
2. DRILLED PIPE INSTALLED AT END OF PIPE IN LAKE.
3. INSULATION AND HEAT TRACING BASED ON EXISTING PIPELINE DESIGN.
4. EACH FLOAT REQUIRES 2 WEIGHTS TO COUNTERACT BUOYANCY.

REFERENCES

1. 2022 LIDAR SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 10 AUGUST 2022, RECEIVED: 17 OCTOBER 2022, FILE NAME: "Surface Drone Flight_dsm.tif".
2. 2022 BATHYMETRY SURVEY PROVIDED BY PRETIUM RESOURCES LTD., SURVEYED: 22 JULY 2022, RECEIVED: 08 AUGUST 2022, FILE NAME: "20220722_adjusted_1.5x1.5 Brucejack Winghead Bathymetric Survey_median_UTMZ9_CGVD28.xyz".

0 0.5 1 — 1:10 METRES
0 20 40 — 1:500 METRES
0 50 100 — 1:1,000 METRES

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2023-08-24	ISSUED FOR CONSTRUCTION	EH	RM	MH	GD
A	2023-06-02	ISSUED FOR CLIENT REVIEW	EH	MR	-	-

SEAL

CLIENT
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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
TAILINGS LINE B PROFILE - 2023 (4950 TPD)

PROJECT NO.	DOC.	REV.		DRAWING
21507844	055	0	4 of 11	4

Path: \\golder.gds\complexdata\office\Vancouver\CAD-GIS\Client\Newcrest\Brucejack_Gold_Mine\99_PROJECTS\21507844\Doc 055\02_PRODUCTION\DWG\ | File Name: 21507844-055-03.dwg | Last Edited By: jrjmartin Date: 2023-08-24 Time:10:53:28 AM | Printed By: RJMartin Date: 2023-08-24 Time:11:31:04 PM
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm

NOTE

1. LENGTH SHOWN IS THE DISTANCE BETWEEN THE WEIGHT AND THE PIPE CLAMP AND DOES NOT INCLUDE AN ALLOWANCE FOR CABLE LOOPS.

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	1	1.4	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	2	2.8	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	3	4.2	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	4	5.6	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	5	7	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	6	8.4	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	7	9.8	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	8	11.2	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	9	12.6	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	10	14	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	11	15.4	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	12	16.8	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	13	18.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	14+15	19.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	16+17	21	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	18+19	22.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	20+21	23.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	22+23	25.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	24+25	26.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	26+27	28	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	28+29	29.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	30+31	30.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	32+33	32.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	34+35	33.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	36+37	35	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	38+39	36.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	40+41	37.8	0.5

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9	CONCRETE CABLES (2x34kg)	42+43	39.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	44+45	40.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	46+47	42	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	48+49	43.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	50+51	44.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	52+53	46.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	54+55	47.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	56+57	49	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	58+59	50.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	60+61	51.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	62+63	53.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	64+65	54.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	66+67	56	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	68+69	57.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	70+71	58.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	72+73	60.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	74+75	61.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	76+77	63	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	78+79	64.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	80+81	65.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	82+83	67.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	84+85	68.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	86+87	70	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	88+89	71.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	90+91	72.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	92+93	74.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	94+95	75.6	0.5

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9	CONCRETE CABLES (2x34kg)	96+97	77	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	98+99	78.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	100+101	79.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	102+103	81.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	104+105	82.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	106+107	84	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	108+109	85.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	110+111	86.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	112+113	88.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	114+115	89.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	116+117	91	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	118+119	92.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	120+121	93.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	122+123	95.2	0.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	124+125	96.6	1.6
8" HDPE DR9	CONCRETE CABLES (2x34kg)	126+127	98	2.0
8" HDPE DR9	CONCRETE CABLES (2x34kg)	128+129	99.4	2.4
8" HDPE DR9	CONCRETE CABLES (2x34kg)	130+131	100.8	2.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	132+133	102.2	3.1
8" HDPE DR9	CONCRETE CABLES (2x34kg)	134+135	103.6	3.3
8" HDPE DR9	CONCRETE CABLES (2x34kg)	136+137	105	3.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	138+139	106.4	4.2
8" HDPE DR9	CONCRETE CABLES (2x34kg)	140+141	107.8	4.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	142+143	109.2	5.8
8" HDPE DR9	**CONCRETE CABLES (2x166kg)**	**144+145**	**110.6**	**7.5**

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0	2023-08-24	ISSUED FOR CONSTRUCTION	EH	RM	MH	GD
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SEAL

CLIENT

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
WEIGHT TABLES LINE A

PROJECT NO.	DOC.	REV.		DRAWING
21507844	055	0	5 of 11	5

Path: \\golder.gds\complexdata\office\Vancouver\CAD-GIS\Client\Newcrest\Brucejack_Gold_Mine\99_PROJECTS\21507844\Doc 055\02_PRODUCTION\DWG\ | File Name: 21507844-055-05.dwg | Last Edited By: jrjmartin Date: 2023-08-24 Time:10:53:41 AM | Printed By: RJMartin Date: 2023-08-24 Time:2:09:52 PM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm
0

NOTE

1. LENGTH SHOWN IS THE DISTANCE BETWEEN THE WEIGHT AND THE PIPE CLAMP AND DOES NOT INCLUDE AN ALLOWANCE FOR CABLE LOOPS.

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	1	1.4	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	2	2.8	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	3	4.2	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	4	5.6	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	5	7	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	6	8.4	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	7	9.8	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	8	11.2	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	9	12.6	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	10	14	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	11	15.4	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	12	16.8	0.5
8" HDPE DR9 WITH 2" THICK INSULATION	CONCRETE CABLES (1x166kg)	13	18.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	14+15	19.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	16+17	21	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	18+19	22.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	20+21	23.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	22+23	25.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	24+25	26.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	26+27	28	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	28+29	29.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	30+31	30.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	32+33	32.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	34+35	33.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	36+37	35	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	38+39	36.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	40+41	37.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	42+43	39.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	44+45	40.6	0.5

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9	CONCRETE CABLES (2x34kg)	46+47	42	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	48+49	43.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	50+51	44.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	52+53	46.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	54+55	47.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	56+57	49	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	58+59	50.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	60+61	51.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	62+63	53.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	64+65	54.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	66+67	56	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	68+69	57.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	70+71	58.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	72+73	60.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	74+75	61.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	76+77	63	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	78+79	64.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	80+81	65.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	82+83	67.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	84+85	68.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	86+87	70	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	88+89	71.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	90+91	72.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	92+93	74.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	94+95	75.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	96+97	77	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	98+99	78.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	100+101	79.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	102+103	81.2	0.5

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9	CONCRETE CABLES (2x34kg)	104+105	82.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	106+107	84	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	108+109	85.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	110+111	86.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	112+113	88.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	114+115	89.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	116+117	91	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	118+119	92.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	120+121	93.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	122+123	95.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	124+125	96.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	126+127	98	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	128+129	99.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	130+131	100.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	132+133	102.2	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	134+135	103.6	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	136+137	105	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	138+139	106.4	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	140+141	107.8	0.5
8" HDPE DR9	CONCRETE CABLES (2x34kg)	142+143	109.2	0.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	144+145	110.6	1.2
8" HDPE DR9	CONCRETE CABLES (2x34kg)	146+147	112	1.6
8" HDPE DR9	CONCRETE CABLES (2x34kg)	148+149	113.4	1.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	150+151	114.8	2.1
8" HDPE DR9	CONCRETE CABLES (2x34kg)	152+153	116.2	3.0
8" HDPE DR9	CONCRETE CABLES (2x34kg)	154+155	117.6	3.6
8" HDPE DR9	**CONCRETE CABLES (2x166kg)**	**156+157**	**118.3**	**4.6**
8" HDPE DR9	CONCRETE CABLES (2x34kg)	158+159	119	4.3
8" HDPE DR9	CONCRETE CABLES (2x34kg)	160+161	120.4	4.9

PIPE TYPE	WEIGHT TYPE	WEIGHT NUMBER	DISTANCE FROM SHOREANCHOR (m)	APPROXIMATE LENGTH OF CABLE WITH WEIGHT (m)
8" HDPE DR9	CONCRETE CABLES (2x34kg)	162+163	121.8	5.4
8" HDPE DR9	CONCRETE CABLES (2x34kg)	164+165	123.2	5.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	166+167	124.6	6.2
8" HDPE DR9	CONCRETE CABLES (2x34kg)	168+169	126	6.1
8" HDPE DR9	CONCRETE CABLES (2x34kg)	170+171	127.4	6.1
8" HDPE DR9	CONCRETE CABLES (2x34kg)	172+173	128.8	6.3
8" HDPE DR9	CONCRETE CABLES (2x34kg)	174+175	130.2	6.6
8" HDPE DR9	CONCRETE CABLES (2x34kg)	176+177	131.6	6.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	178+179	133	6.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	180+181	134.4	7.3
8" HDPE DR9	CONCRETE CABLES (2x34kg)	182+183	135.8	7.7
8" HDPE DR9	**CONCRETE CABLES (2x166kg)**	**184+185**	**136.5**	**8.8**
8" HDPE DR9	CONCRETE CABLES (2x34kg)	186+187	137.2	8.0
8" HDPE DR9	CONCRETE CABLES (2x34kg)	188+189	138.6	8.2
8" HDPE DR9	CONCRETE CABLES (2x34kg)	190+191	140	8.2
8" HDPE DR9	CONCRETE CABLES (2x34kg)	192+193	141.4	8.1
8" HDPE DR9	CONCRETE CABLES (2x34kg)	194+195	142.8	7.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	196+197	144.2	6.9
8" HDPE DR9	CONCRETE CABLES (2x34kg)	198+199	145.6	6.6
8" HDPE DR9	CONCRETE CABLES (2x34kg)	200+201	147	6.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	202+203	148.4	6.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	204+205	149.8	6.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	206+207	151.2	6.7
8" HDPE DR9	CONCRETE CABLES (2x34kg)	208+209	152.6	6.7
8" HDPE DR9	**CONCRETE CABLES (2x166kg)**	**210+211**	**153.3**	**7.8**
8" HDPE DR9	CONCRETE CABLES (2x34kg)	212+213	154	7.3
8" HDPE DR9	CONCRETE CABLES (2x34kg)	214+215	155.4	7.5

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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
WEIGHT TABLES LINE B

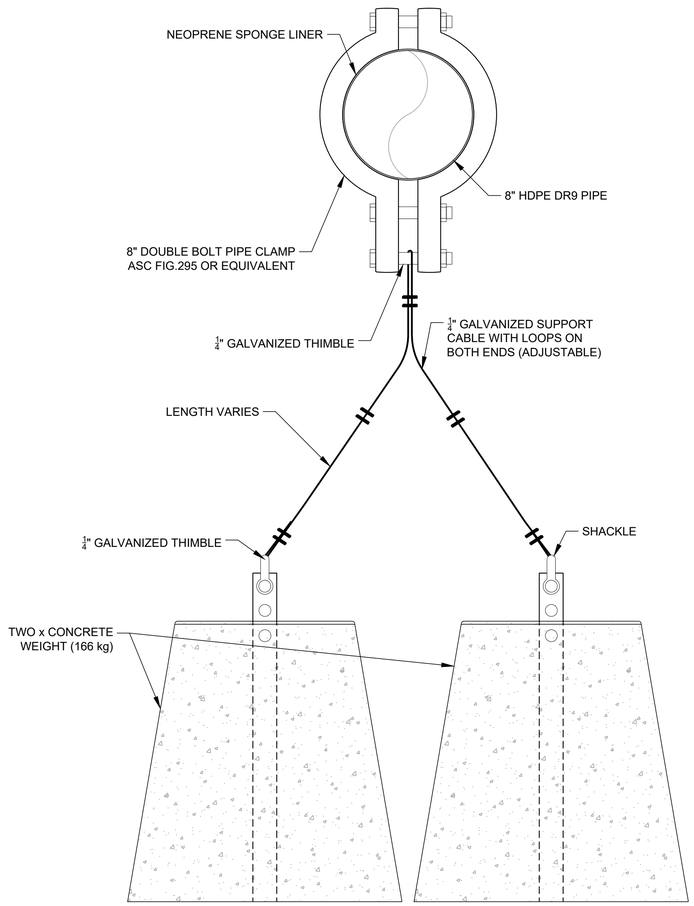
PROJECT NO.	DOC.	REV.		DRAWING
21507844	055	0	6 of 11	6

Path: \\golder.gds\complexdata\office\Vancouver\CAD-GIS\Client\Newcrest\Brucejack_Gold_Mine\99_PROJECTS\21507844\Doc 05\02_PRODUCTION\DWG\ | File Name: 21507844-055-05.dwg | Last Edited By: rjmartin Date: 2023-08-24 Time:10:21:44 AM | Printed By: RJMartin Date: 2023-08-24 Time:10:25:20 AM

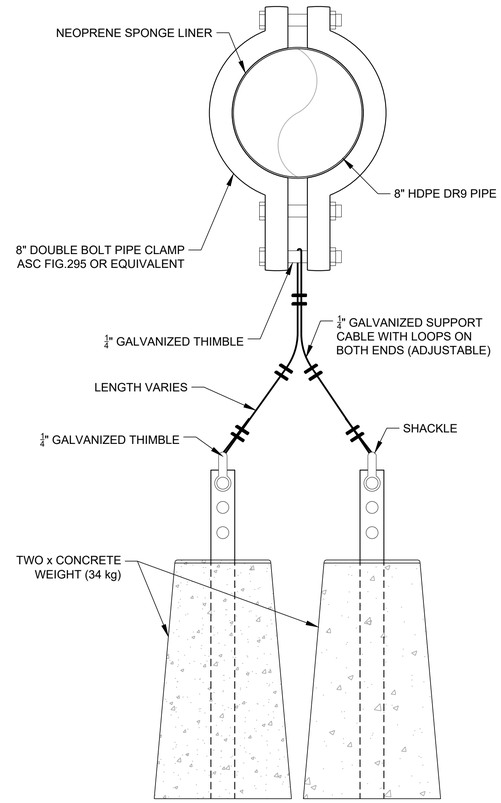
25 mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

NOTES

1. DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. DIMENSIONS OF PIPE CLAMP AND PARTS TO BE VERIFIED WITH SUPPLIER.



SCALE 1:5 m (1/4) SECTION - CONCRETE WEIGHT 2 x 166 kg



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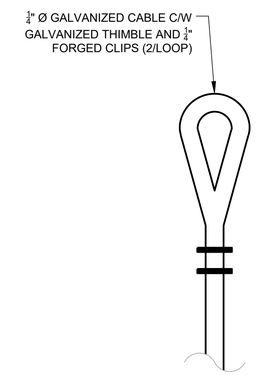
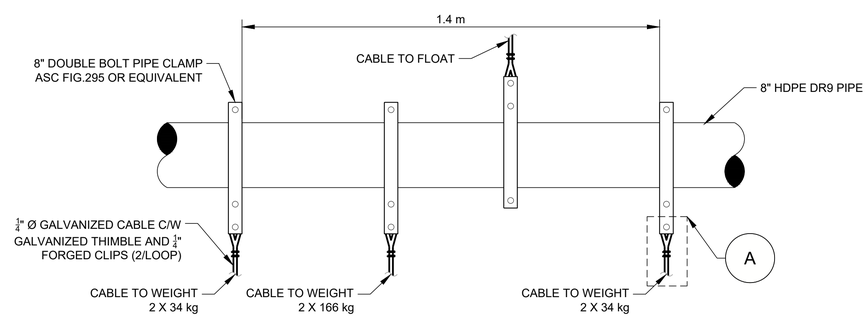


SCALE 1:2 m (A) DETAIL - TYPICAL CABLE LOOP



SCALE 1:10 m (3/4) DETAIL - PIPE AND WEIGHT CABLES FLOATED SECTION

NOT FOR CONSTRUCTION

DRAFT

0 0.1 0.2
1:2 METRES

0 0.2 0.4
1:5 METRES

0 0.5 1
1:10 METRES

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B	2023-08-16	ISSUED FOR CLIENT REVIEW	RM	EH	-	-
A	2023-07-02	ISSUED FOR CLIENT REVIEW	RM	EH	-	-

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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
WEIGHT DETAILS

PROJECT No.	DOC.	Rev.		DRAWING
21507844	055	0	7 of 11	7

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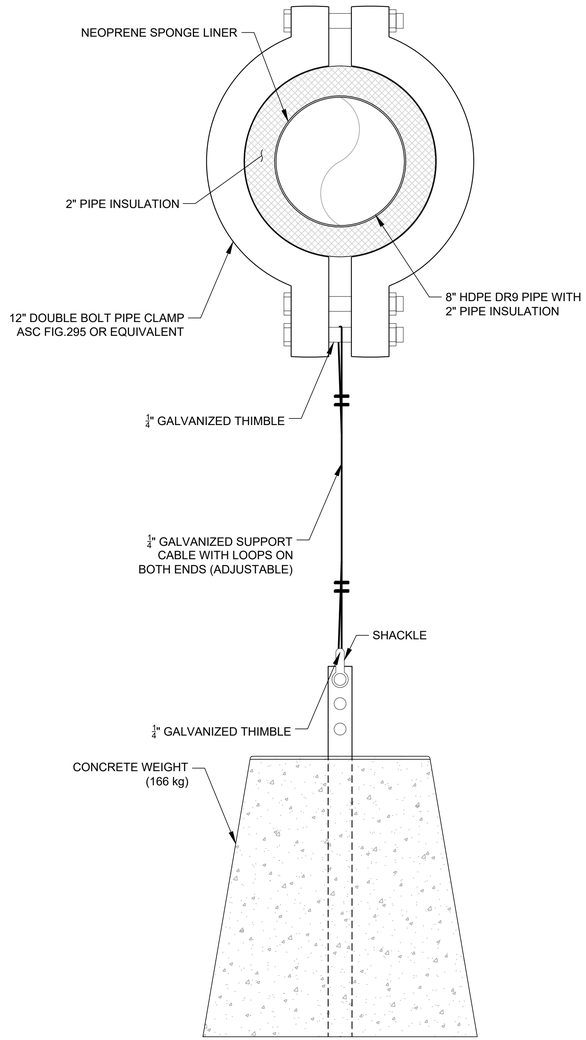
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
25 mm

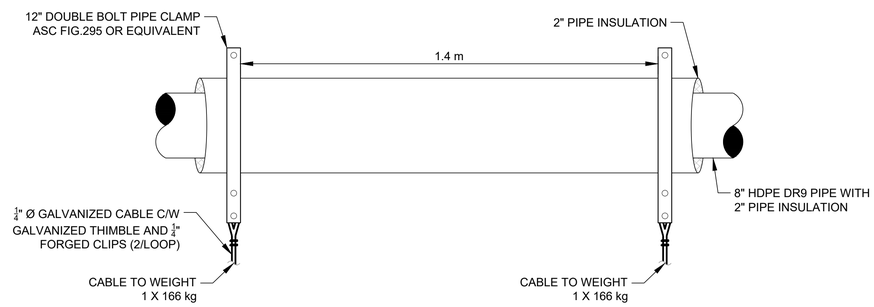
Xref R:\EDCAD\2015\1540290\REFERENCES\IMAGES\STAMPS 2018-08-01\STAMPS 2018-08-01.dwg

NOTES

1. DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. DIMENSIONS OF PIPE CLAMP AND PARTS TO BE VERIFIED WITH SUPPLIER.



SCALE 1:5 m 4/4 SECTION - CONCRETE WEIGHT 166 kg



SCALE 1:10 m 5/4 DETAIL - SUBAQUEOUS INSULATED PIPE AND WEIGHT DETAIL

NOT FOR CONSTRUCTION

DRAFT

0 0.2 0.4
1:5 METRES

0 0.5 1
1:10 METRES

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PROJECT

2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE

INSULATED WEIGHT DETAILS

PROJECT No.	DOC.	Rev.		DRAWING
21507844	055	0	8 of 11	8

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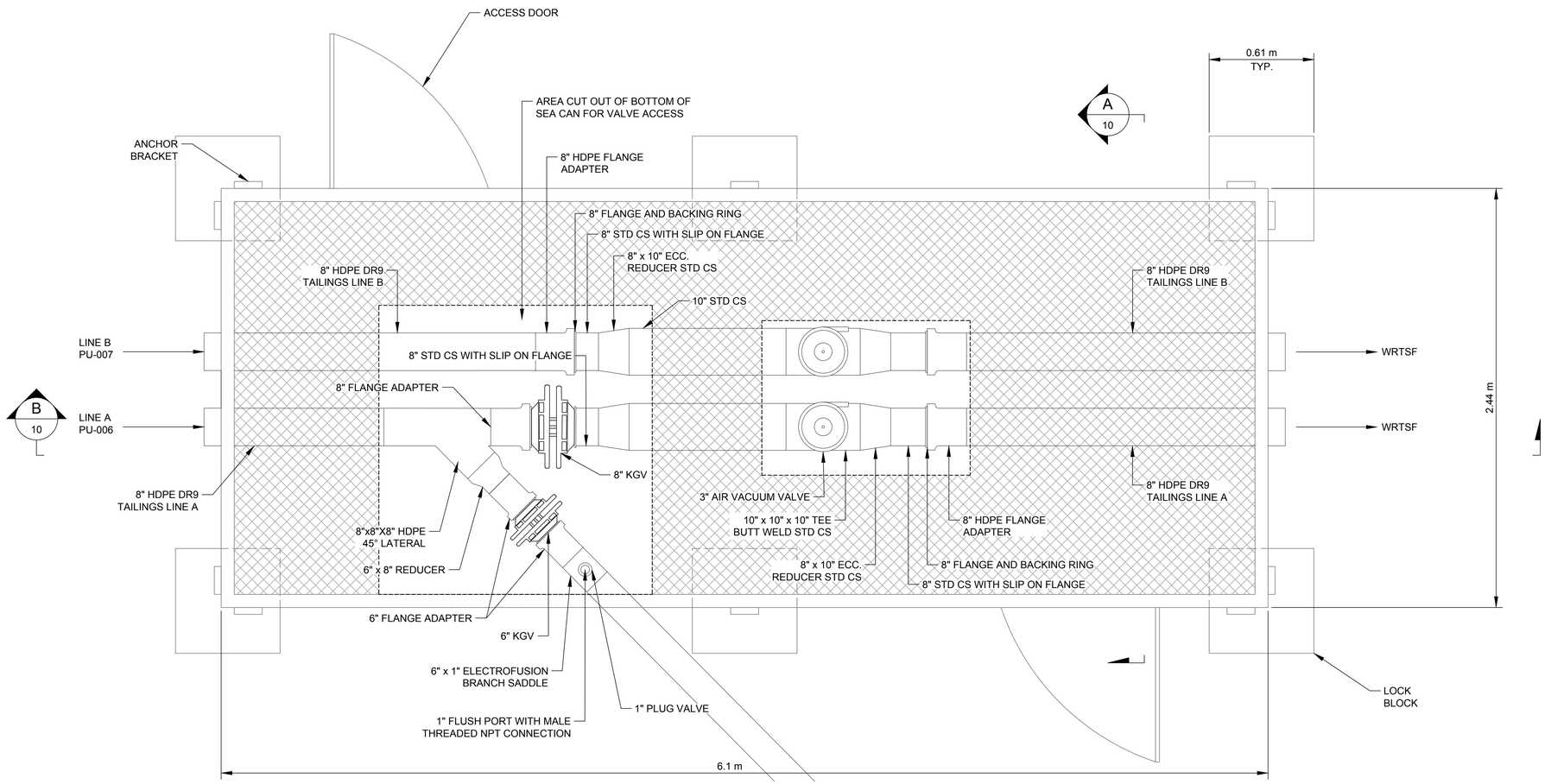
25 mm
0
Xref R:\EDCAD\2015\1540290\REFERENCES\IMAGES\STAMPS 2018-08-01\STAMPS 2018-08-01.dwg

LEGEND

TALKING/WALKING AREA

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
2. DOOR CAN BE POSITIONED TO CONNECT TO EXISTING VALVE SHACK 1 SEA CAN.
3. SEA CAN TO BE INSULATED.
4. ELECTRICAL ITEMS (LIGHTS, HEATER, ETC.) ARE NOT SHOWN IN THIS DRAWING AS THEY ARE NOT PART OF WSP'S SCOPE.
5. BASE OF SEA CAN TO BE LINED WITH 3/4' PLYWOOD SHEET.



VALVE SHACK 2 ENCLOSURE - PLAN VIEW

SCALE 1:15 m

0 0.5 1

1:15 METRES

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PROJECT

2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE

VALVE SHACK ENCLOSURE - PLAN VIEW

PROJECT NO.	DOC.	REV.	9 of 11	DRAWING
21507844	055	0		9

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25 mm

NOTES

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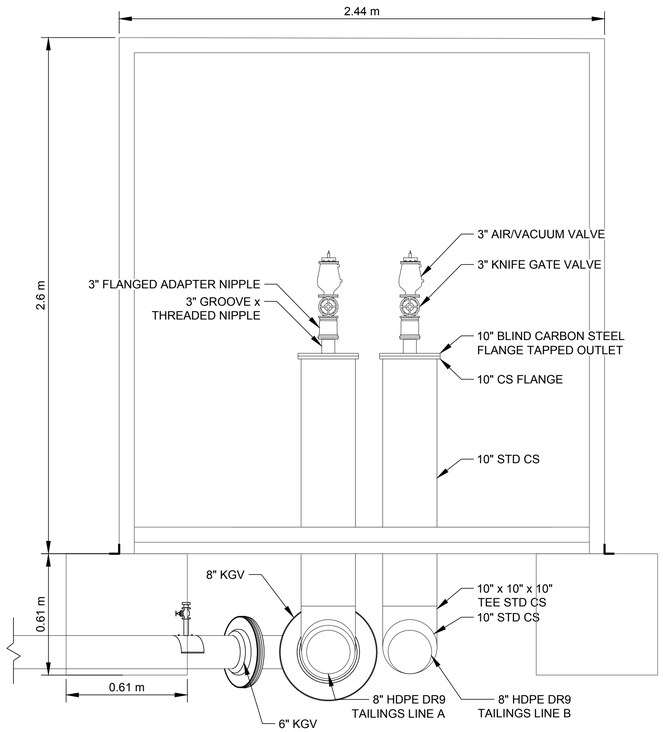
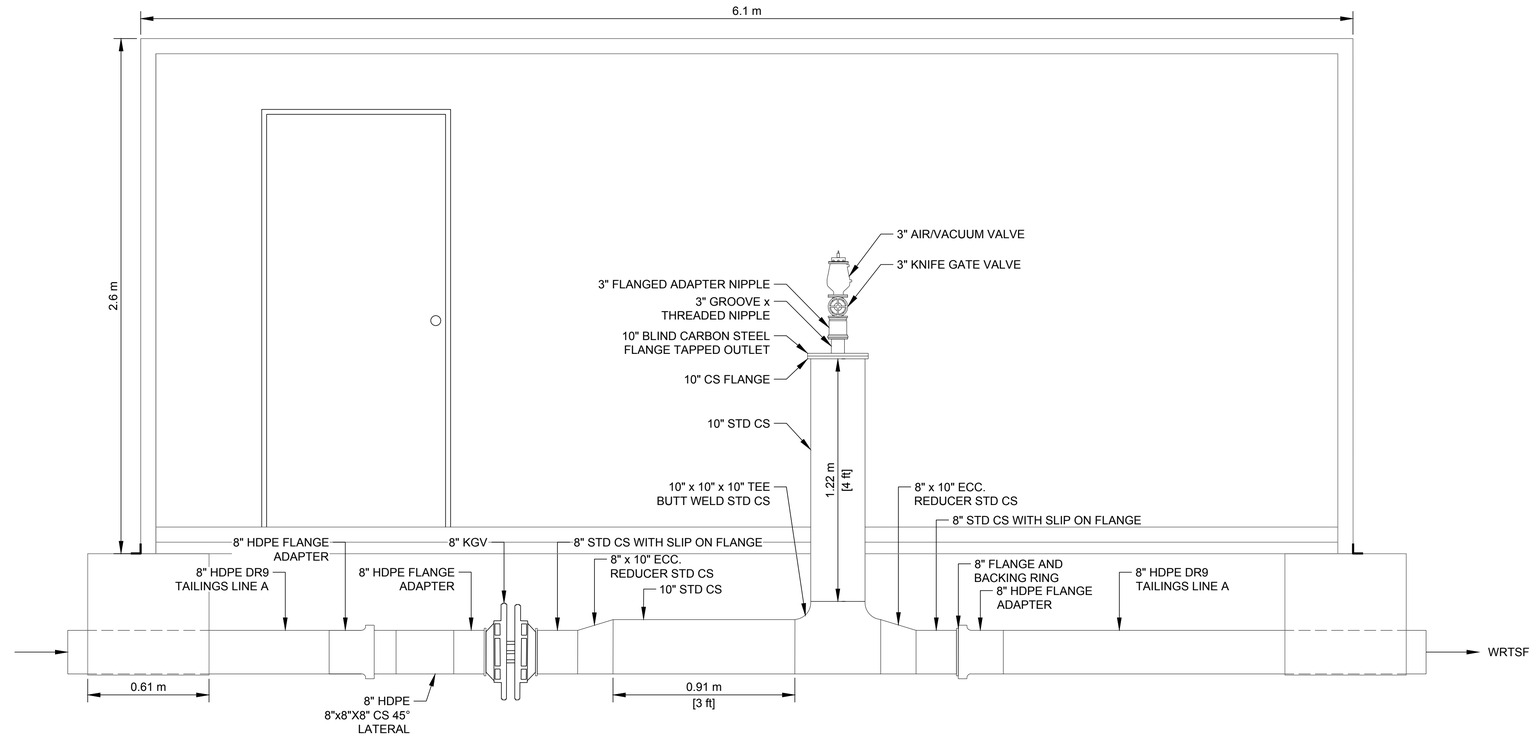


SCALE 1:15 m (A / 9 / 11) VALVE SHACK 2 ENCLOSURE - CROSS-SECTION



SCALE 1:15 m (B / 9 / 11) VALVE SHACK 2 ENCLOSURE - CROSS-SECTION

0 0.5 1
1:15 METRES

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PROJECT
2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE
VALVE SHACK 2 ENCLOSURE- TAILINGS PIPELINE A AND B

PROJECT NO.	DOC.	REV.	10 of 11	DRAWING
21507844	055	0		10

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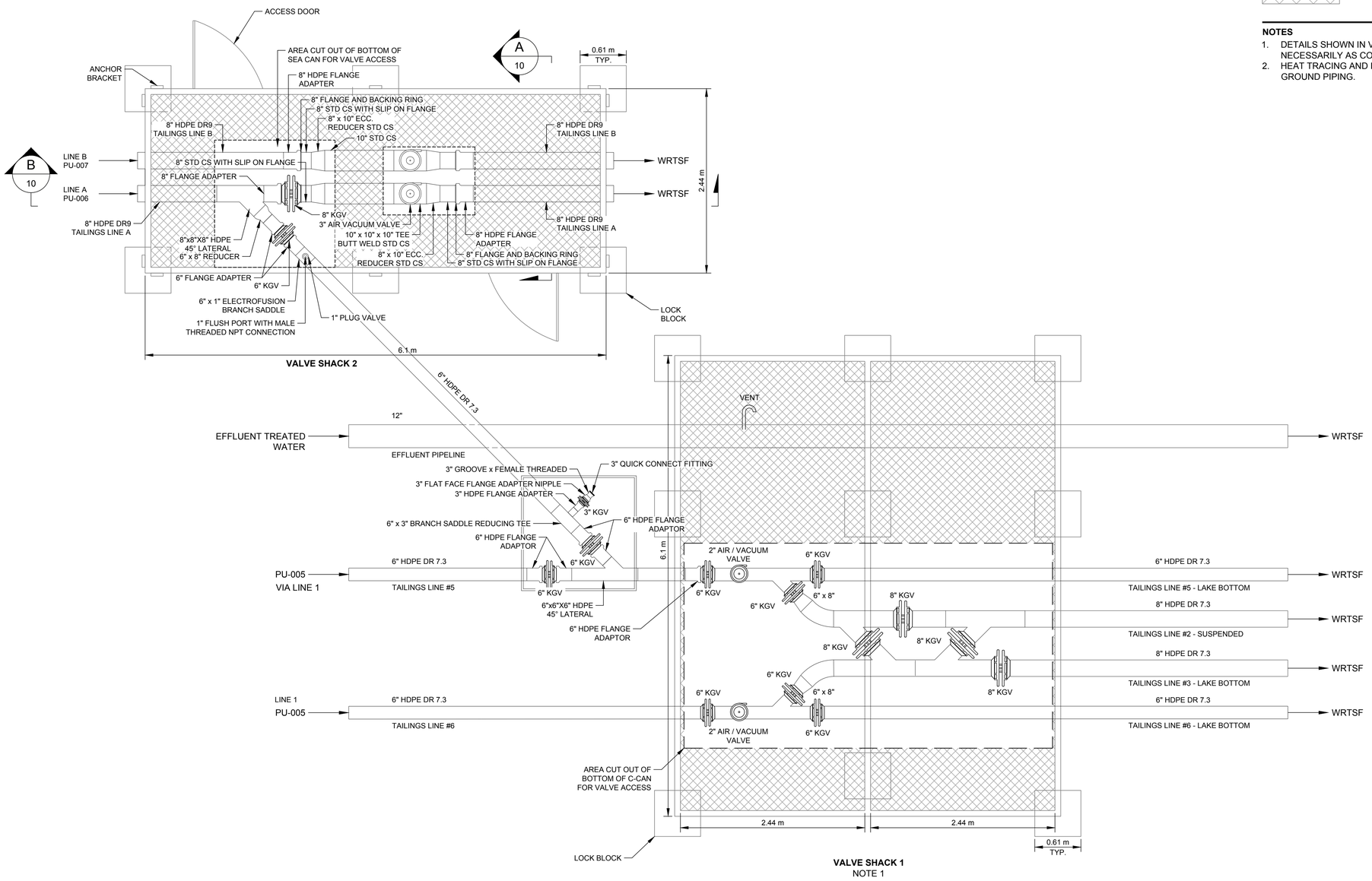
25 mm

LEGEND

WALKING AREA

NOTES

1. DETAILS SHOWN IN VENT SHACK 1 ARE AS PER DESIGN, AND ARE NOT NECESSARILY AS CONSTRUCTED.
2. HEAT TRACING AND INSULATION TO BE INCLUDED ON ALL OUTSIDE ABOVE GROUND PIPING.



LINE A to LINE 5 TIE-IN

SCALE 1:30 m

0 1 2
1:30 METRES

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PROJECT

2022 BRUCEJACK MINE WRTSF EOR SERVICES
TAILINGS PIPELINE A & PIPELINE B
MILL TO BRUCEJACK LAKE (WRTSF)

TITLE

LINE A TO LINE 5 TIE-IN

PROJECT NO.	DOC.	REV.		DRAWING
21507844	055	0	11 of 11	11

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25 mm
0

APPENDIX B

Material Take-Off

Piping Material Take-Off
Pretium
Brucejack : Line A&B Outside Mill - Preliminary MTO
Tailings Discharge System
Project No. 21507844

Area	Item	Description	Spec	Size (inch)	Quantity	Quantity (+10% SF if needed)	Unit	Comments
		Piping, Fittings and Valves						
	1	**Piping**						
Outside Mill	1.1	HDPE, PE4710 (SDR 9), Plain Ends	PE4710-DR9	8	1434	1578	m	Uninsulated pipe required for Line A&B
Outside Mill	1.2	HDPE, PE4710 (SDR 9), Plain Ends , 2" Thick Pre-insulated, with 2 heat channels	PE4710-DR9	8	620	682	m	Insulated pipe required for Line A&B
Valve Shack 2	1.3	Carbon Steel, Standard, ASTM A53 type B, butt weld, plain ends	CS XS GR. B	10	4	5	m	Line A&B for air vent in valve shack
Valve Shack 2	1.4	Carbon Steel, Standard, ASTM A53 type B, butt weld, plain ends	CS XS GR. B	8	2	3	m	Line A&B for air vent in valve shack
Outside Mill	1.5	HDPE, PE4710 (DR 7.3), plain ends, 2" Thick Pre-insulated, with 2 heat channels	PE4710 DR7.3	6	6	7	m	Line A tie-in to old Lines
Outside Mill	1.6	HDPE, PE 4710, 2" Thick Field joint insulation kits	PE4710 DR7.3	8	41	41	ea.	For Line A&B
Outside Mill	1.7	HDPE, PE 4710, 2" Thick Field joint insulation kits	PE4710 DR7.4	6	2	2	ea.	Line A tie-in to old Lines
	2	**Flanges**						
Valve Shack 2	2.1	High Density Polyethylene molded flange adapter - SDR9 c/w backing ring, ductile iron backup ring, bolt pattern conforming to ANSI Class 150, ANSI B16.5	Class 150	8	4	4	ea.	4 at vent shack, 2 for each line
Valve Shack 1, 2,3	2.2	High Density Polyethylene molded flange adapter - SDR9 c/w backing ring, ductile iron backup ring, bolt pattern conforming to ANSI Class 150, ANSI B16.5	Class 150	6	7	7	ea.	Line A lateral tie-in to old lines
Valve Shack 3	2.3	High Density Polyethylene molded flange adapter - SDR9 c/w backing ring, ductile iron backup ring, bolt pattern conforming to ANSI Class 150, ANSI B16.5	Class 150	3	2	2	ea.	For drain on Line A tie-in
Valve Shack 2	2.4	Slip on Flange, STD CS, bolt pattern conforming to ANSI Class 150, ANSI B16.5, ASTM A105	Class 150	8	4	4	ea.	2 for each air vent arrangement
Valve Shack 2	2.5	Blind Flange, Carbon Steel tapped 3" NPT outlet, ANSI Class 150, ASTM A105	Class 150	10	2	2	ea.	for 3 air valve connection at shack, one for each line
Valve Shack 2	2.6	Slip on Flange, STD CS, bolt pattern conforming to ANSI Class 150, ANSI B16.5, ASTM A105	Class 150	10	2	2	ea.	1 for each air vent arrangement
Valve Shack 2	2.7	3" Flat face flanged adapter nipple, Victaulic (No.45F)	Class 150	3	3	3	ea.	1 for each air vent arrangement, and one for drain on Line A tie-in
Valve Shack 2	2.8	3" Groove x male threaded nipple, Victaulic (N.40)	Class 150	3	2	2	ea.	for 3" air valve connection at shack, 1 for each line
	3	**Fittings**						
Valve Shack 2	3.1	Lateral Wye Molded, HDPE PE4710 (SDR 9), ends, 45 deg lateral	Class 150	8x8x8	1	1	ea.	Tie-in for line A to old pipelines, if procurement is difficult, switching to DR11 is allowed.
Valve Shack 3	3.2	Lateral Wye Molded, HDPE PE 4710 (SDR 7.3) 45 deg lateral	Class 150	6x6x6	1	1	ea.	Tie-in for line A to old pipelines, if procurement is difficult, DR9 will be a suitable substitution; DR 11 is allowed but will require two additional flange adaptor/backing ring assemblies
Valve Shack 3	3.3	Branch saddle reducing tee 6" x 3", HDPE PE 4710 (SDR 9)	Class 150	6 x 3	1	1	ea.	Tie-in to for Line A drain
Valve Shack 3	3.4	Adaptor Groove x female NPT threaded , ductile iron, (Victaulic No.80)	Class 150	3	1	1	ea.	Tie-in to for Line A drain
Valve Shack 3	3.5	Metal Cam-and-groove hose coupling for water, aluminum, threaded male NPT connection	Class 150	3	1	1	ea.	Tie-in to for Line A drain
Valve Shack 2	3.6	Electrofusion branch saddle 6" x 1", HDPE PE4710, Rated for 200-240 psi for water service or equivalent	Class 150	6 x 1	1	1	ea.	Tie-in to for Line A flush port
Valve Shack 2	3.7	Transition fitting, HDPE PE4710 to male NPT threaded metal	Class 150	1	1	1	ea.	Tie-in to for Line A flush port
Valve Shack 2	3.8	Spud with polymer seats, female NPSM X male NPT (Dixon Boss or equivalent) Stainless Steel	Class 150	1	1	1	ea.	Tie-in to for Line A flush port
Valve Shack 2	3.9	Concentric Reducer, HDPE PE4710 SDR9	Class 150	8x6	1	1	ea.	Tie-in for line A to old pipelines
Valve Shack 2	3.10	Eccentric Reducer, STD CS, ASTM A234, butt weld, plain ends	Class 150	10 x 8	4	4	ea.	Need 2 for each air vent
Valve Shack 2	3.11	Lateral Tee, STD CS, ASTM A234, butt weld, plain ends	Class 150	10 x 10 x 10	2	2	ea.	1 for each vent
	5	**Valves**						
Bypass	5.1	Knife gate, Ductile Iron Body, ASTM A536 or Cast Iron. Stainless steel gate and stem, EPDM Seal/seats, Rubber Lined , Open/Close(No Throttling) Lockout Required, Lug Style, Bottom Purging. Handwheel Operator, Class 150 Flanges, 250 psi rating of pipe	KGV	8	1	1	ea.	8" Valve for Line A bypass to old lines
Valve Shack 2, 3	5.2	Knife gate, Ductile Iron Body, ASTM A536 or Cast Iron. Stainless steel gate and stem, EPDM Seal/seats, Rubber Lined , Open/Close(No Throttling) Lockout Required, Lug Style, Bottom Purging. Handwheel Operator, Class 150 Flanges, 250 psi rating of pipe	KGV	6	3	3	ea.	6" Valve for Line A bypass to old lines
Valve Shack 2, 3	5.3	Knife gate, Ductile Iron Body, ASTM A536 or Cast Iron. Stainless steel gate and stem, EPDM Seal/seats, Rubber Lined ,Open/Close(No Throttling) Lockout Required, Lug Style, Bottom Purging. Handwheel Operator, Class 150 Flanges, 250 psi rating of pipe	KGV	3	3	3	ea.	3" Valves - In vent shack, and Line A tie-in
Valve Shack 2	5.4	Plug valve, female threaded NPT connection	PGV	1	1	1	ea.	Tie-in to for Line A flush port
Valve Shack 2	5.5	Air/ Vacuum Valve, Class 150 Flanges, 250 psi rating of pipe (EZ-VAC or similar), flanged connection	AV	3	2	2	ea.	3 " Air/ Vacuum valve - In vent shack Style and model number to be specified by Newcrest

Piping Material Take-Off
Pretium
Brucejack : Line A&B Outside Mill - Preliminary MTO
Tailings Discharge System
Project No. 21507844

Area	Item	Description	Spec	Size (inch)	Quantity	Quantity (+10% SF if needed)	Unit	Comments
	6	**Nuts, Bolts, Gaskets, and Couplings**						
Valve Shack 2	6.1	Studbolt, nut and washer, carbon steel hot dip galvanized package, standardized and tempered for 10" back-up ring, ASTM A193/194 (12 bolts)	Class 150	10	2	3	lot	For blind flange connection at vent shack
Valve Shack 2	6.2	Nitrile Gasket or approved equivalent, 1/8" thick, 150# Full Face	Class 150	10	2	3	ea.	For blind flange connection at vent shack
Valve Shack 2	6.3	Studbolt, nut and washer, carbon steel hot dip galvanized package, standardized and tempered for 8" back-up ring (SDR9, DI Backup-ring), ASTM A193/194 (8 bolts)	Class 150	8	5	6	lot	2 connections for each air valve arrangement, 1 for Line A tie-in to old line
Valve Shack 2	6.4	Nitrile Gasket or approved equivalent, 1/8" thick, 150# Full Face	Class 150	8	5	6	ea.	2 connections for each air valve arrangement, 1 for Line A tie-in to old line
Outside mill	6.5	Studbolt, nut and washer, carbon steel hot dip galvanized package, standardized and tempered for 6" back-up ring (SDR9, DI Backup-ring), ASTM A193/194 (8bolts)	Class 150	6	8	9	lot	4 for Line A tie-in to old line
Outside mill	6.6	Nitrile Gasket or approved equivalent, 1/8" thick, 150# Full Face	Class 150	6	8	9	ea.	4 for Line A tie-in to old line
Outside mill	6.7	Gasket and bolting kits 8" knife gate valve (item 5.1) with 8" DR9 flange with DI backing ring, 16 bolts	Class 150	8	1	2	lot	Stud bolts or hex bolts for both sides of valve
Valve Shack 2, 3	6.8	Gasket and bolting kits for 3" knife gate valve (item 5.3) , 8 bolts	Class 150	3	3	4	lot	Stud bolts or hex bolts for both sides of valve
Valve Shack 2	6.9	Victaulic Coupling (No. 07)	Class 150	3	3	4	lot	1 for each 3 " air valve connection at vent shack 2, and one for drain connection
	7	**Pipeline Weighting and Floatation**						
In lake	7.1	75 lbs (34 kg) concrete weight with tespar as per Wilson Concrete, rated for maximum load of 75 lbs or greater	-	400x160x230 mm	330	330	ea.	Two weights every 1.4 m on the uninsulated section of the pipe. 134 weights for line A and 196 weights for line B.
In lake	7.2	366 lbs (166 kg) concrete weight with telspar as per Wilson Concrete, rated for maximum load of 366 lbs or greater	-	470x300x460 mm	34	34	ea.	One weight every 1.4 m on the insulated section of the pipe plus weights to counteract the float. 13 (for insulated section)+ 2 (to counteract float) weights for line A and 13 (for non insulated section) + 6 (to counteract float) weights for line B.
In lake	7.3	Galvanized zinc plt 2 bolt riser pipe clamps (for 8" HDPE pipe) - fig 295H or equivalent, with bolts and nuts, rated for maximum load of 732 lbs or greater	-	8	169	186	m	For Line A&B - One clamp for each set (2 x 34 kg for the pipeline, and 2x166kg to counteract the float) of weights
In lake	7.4	Galvanized zinc plt 2 bolt riser pipe clamps (for 8" HDPE pipe with 2" insulation) - fig 295H or equivalent, with bolts and nuts, rated for maximum load of 732 lbs or greater		12	34	34	m	For Line A&B - One clamp for each weight on the insulated section of pipeline A & B
2 In lake	7.5	Wire rope cable (1/4") , 7x19 Galvanized aircraft cable reel, rated for maximum load of 732 lbs or greater	-	1/4	2377	2615	m	For Line A&B
In lake	7.6	Wire Rope Crosby clips (1/4")	-	1/4	1150	1265	ea.	4 for every 12" clamp, and 6 for every 8" clamp
In lake	7.7	Wire rope thimbles per (1/4")	-	1/4	575	633	ea.	2 for every 12" clamp and 3 for every 8" clamp
In lake	7.8	Shackle assemblies rated for maximum load of 732 lbs or greater, and compatible with 2.5" x 2.5" telspar and 0.5" pin hole	-	-	372	409	ea	1 for every 12" clamp and 2 for every 8" clamp to connect cables to telspar of concrete weight
In lake	7.9	Neoprene sponge padding, 3 mm thick, 250 mm minimum width of reel	-	0.003 m thick, 0.250 m width	602	662	m	to place between pipe and clamps
In lake	7.10	Rope, 0.5" thick Polypropylene	-	0.5 THK	290	319	m	to prevent clamps from slipping during installation for Line A and B
Float	7.11	High Density Polyethylene molded flange adapter - SDR9 c/w backing ring, ductile iron backup ring, bolt pattern conforming to ANSI Class 150, ANSI B16.5	PE4710-DR9	8	8	8	ea.	2 for each under water float
Float	7.12	8" blind flange HDPE DR9	PE4710-DR9	8	8	8	ea.	2 flanges for each under water float
Float	7.13	HDPE, PE4710 (SDR 9), Plain Ends , 3" Thick Pre-insulated	PE4710-DR9	8	8	8	m	6.5 ft length -1 for line A , and 3 for Line B
	8	**Enclosures**						
Valve Shack 2	8.1	Sea can, Heated Enclosure for Valves	-	6.1 m x 2.44 m x 2.59 m	1	1	ea.	Enclosure for valve shack 2 (8' x 20')
Valve Shack 2	8.2	Flat Top Concrete Square Blocks	-	24 x 24 x 24	6	6	ea.	To support sea can
At Shore	8.3	Regular Lock Blocks	-	30x30x60	4	4	ea.	For shore anchor (30"x30"x60")
Valve Shack 2	8.4	Ground Anchor Brackets, or equivalent	-	200 mm x 10 mm	10	10	ea.	To secure sea can on concrete blocks (200 mm x 10 mm or similar)
Valve Shack 2	8.5	3/4" Thick plywood sheets	-	6.1 m x 2.44 m	1	1	ea.	For floor of valve shack (3/4" thick)
Valve Shack 3	8.6	Treated base timber (4" x4")	-	4 x 4	1	1	lot	for valve shack 3
Valve Shack 3	8.7	Wood frame construction (2" x 4")	-	2 x 4	1	1	lot	for valve shack 3
Valve Shack 3	8.8	19 mm Exterior plywood cladding and roof	-	19 mm thick	1	1	lot	for valve shack 3
Valve Shack 3	8.9	50 mm thick Styrofoam insulation	-	50 mm thick	1	1	lot	for valve shack 3
Valve Shack 3	8.10	asphalt roll roofing	-	-	1	1	lot	for valve shack 3
Valve Shack 3	8.11	Minor hardware (hinges and screws)	-	-	1	1	lot	for valve shack 3

NOTES:
1. This MTO details items required for Line A&B that are outside the mill.
2. Items listed are best estimates at the time of issue of this MTO.
3. Metal plate reflectors should be added to pipeline to aid in bathymetric surveys.
4. Pipe supports have are not included in this scope of work.
5. Electrical items in valve shack have been excluded from this MTO (lighting, heater, fans), but should be considered by Newcrest.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA G. H. J. DICK # 18670 2023-08-24

Engineers & Geoscientists BC Permit #1000200

APPENDIX C

Pump Curve

Sheet :
Date: 5/30/2018
Proposal No.
By : Mike Shanahan

Pump Data Sheet

Customer :
Project Name :
Application :
Equipment / Tag No. :
Duty Point : 2

Pump Model: High Head millMAX 6X4-21-HH; 5 VANES
Reference No: PC150H547-21; Rev. 2 2/3/06

Application:

Flow:	212 M³/Hr	**Slurry Head:**	55 m
Slurry S.G.:	1.681	**Equivalent Water Head:**	55.6 m
Solid S.G.:	2.8	**Head Ratio:**	0.99
Liquid S.G.:	1	**Slurry Temperature:**	
Wt. % Solids:	63%	**Top Size:**	
Volumetric Concentration	38%	**Froth Factor:**	1
D50:			
NPSHa:			

Pump Data:

Suction Diameter:	152 mm	**Discharge Size:**	101 mm
Suction Velocity:	3.2 m/sec	**Discharge Velocity:**	7.3 m/sec
Impeller Size:	533 mm	**Maximum Sphere Size:**	45 mm
Discharge Position:		**Power Frame:**	
Seal Type:			

Motor Data:

Motor Power:	0.0 hp	**Enclosure:**	
Nominal Speed:		**Motor Frame Size:**	
Electrical Characteristics:			

Summary:

Pump Speed:	1084 RPM
Slurry Efficiency:	55.2%
Slurry Power:	129.2 hp
NPSH Required:	2.2 m
% BEP:	64.1%

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Sheet :
Date: 5/30/2018
Proposal No.
By : Mike Shanahan

Pump Data Sheet

Customer :
Project Name :
Application :
Equipment / Tag No. :
Duty Point : 1

Pump Model: High Head millMAX 6X4-21-HH; 5 VANES
Reference No: PC150H547-21; Rev. 2 2/3/06

Application:

Flow:	117 M³/Hr	**Slurry Head:**	51 m
Slurry S.G.:	1.681	**Equivalent Water Head:**	51.5 m
Solid S.G.:	2.8	**Head Ratio:**	0.99
Liquid S.G.:	1	**Slurry Temperature:**	
Wt. % Solids:	63%	**Top Size:**	
Volumetric Concentration	38%	**Froth Factor:**	1
D50:			
NPSHa:			

Pump Data:

Suction Diameter:	152 mm	**Discharge Size:**	101 mm
Suction Velocity:	1.8 m/sec	**Discharge Velocity:**	4 m/sec
Impeller Size:	533 mm	**Maximum Sphere Size:**	45 mm
Discharge Position:		**Power Frame:**	
Seal Type:			

Motor Data:

Motor Power:	0.0 hp	**Enclosure:**	
Nominal Speed:		**Motor Frame Size:**	
Electrical Characteristics:			

Summary:

Pump Speed:	1015 RPM
Slurry Efficiency:	40.1%
Slurry Power:	91.1 hp
NPSH Required:	1.5 m
% BEP:	37.5%

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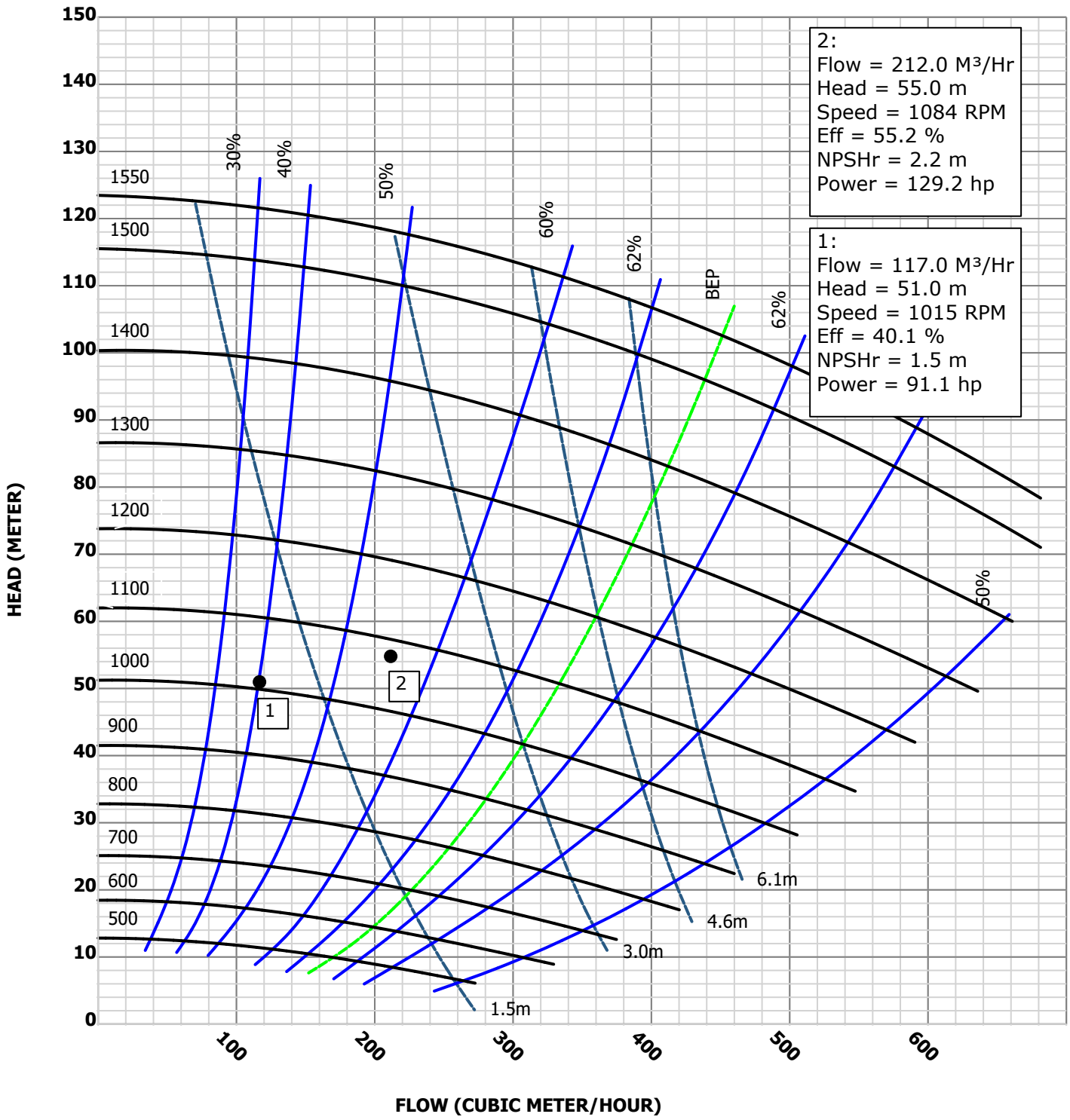
FLSmidth Krebs millMAX Pump	PERFORMANCE CURVE	
	PC150H547-21	Rev. 2 2/3/06

PUMP TYPE	APPLICATION	EQUIPMENT / TAG NO.
High Head millMAX		

PUMP SIZE	POWER FRAME	IMPELLER			
6 x 4		Dia. 21 in (533.4 mm)	5 VANE	Closed	1.75 in(45 mm) MAX. SOLIDS

* CURVE FOR CLEAR WATER PERFORMANCE: CORRECTIONS ARE TO BE MADE FOR SPECIFIC GRAVITY & VISCOSITY OF SLURRY. THE PUMP SPEED SHOULD BE CORRECTED FOR THE EFFECT OF SOLIDS IN THE SLURRY.



Note: Efficiency curves shown include a 0.98 efficiency ratio correction factor. No further efficiency ratio corrections are required for settling slurries.

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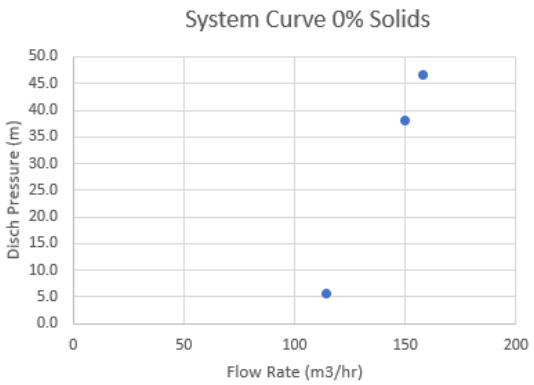
APPENDIX D

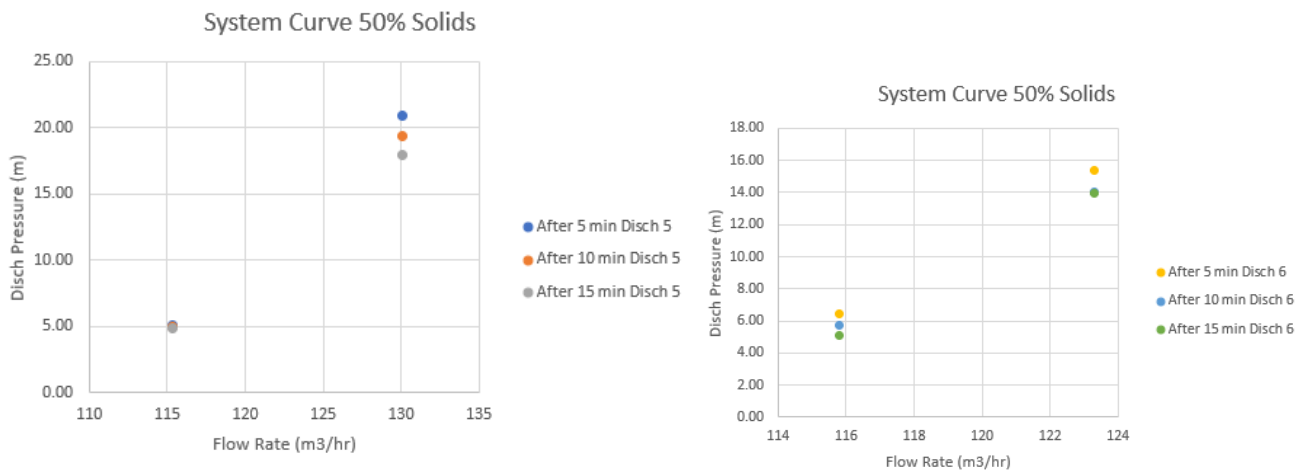
Operating Data

Figures D1, D2, and D3 present the graphed data points generated from operating data.



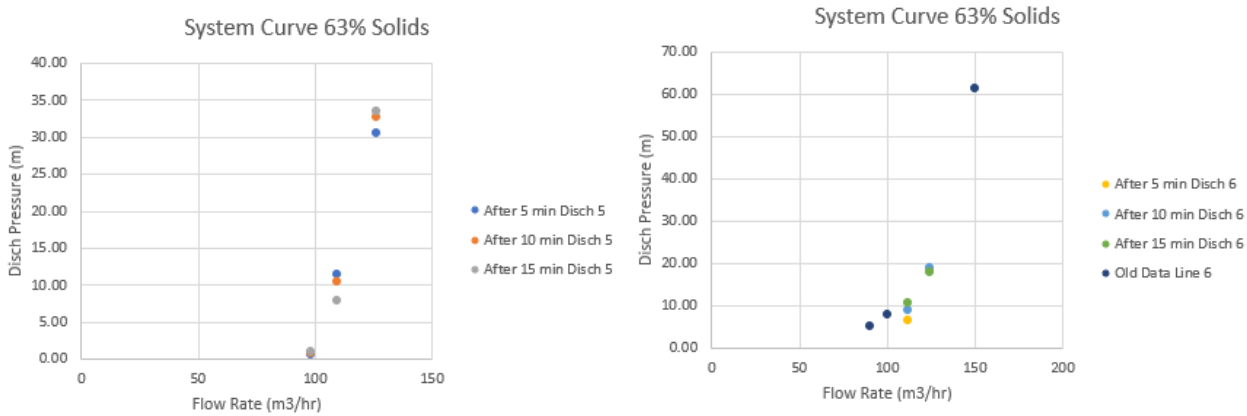
m^3/hr = cubic metres per hour.

Figure D1: Pump Discharge Pressure versus Flow Rate at 0% Solids for Line 6



m^3/hr = cubic metres per hour.

Figure D2: Pump Discharge Pressure versus Flow Rate at 50% Solids



m^3/hr = cubic metres per hour.

Figure D3: Pump Discharge Pressure versus Flow Rate at 63% Solids

wsp.com

Appendix F:

Waste Rock Dump Area Emergency Evacuation and Re-entry Plan under Seismic Loading

PRETIVM
BRUCEJACK PROJECT

WASTE ROCK DUMP EMERGENCY EVACUATION AND RE-ENTRY PLAN UNDER SEISMIC LOADING

Revision: 0
Issue Date: October 11, 2018

1 Introduction

This document summarizes emergency evacuation procedures for Pretivm Resources Staff and Sub-contractors that are working on the waste rock dump (WRD). These procedures are to be followed if a seismic event occurs that is substantial in size, that has the potential to cause WRD instability.

The waste rock dump requires an emergency evacuation plan in the event of an earthquake because seismic forces may decrease the stability of the waste rock dump and cause a failure and impose a safety risk to personnel.

2 Waste Rock Dump Emergency Evacuation Plan

- **Trigger** – Based on the Modified Mercalli Scale of 1931, a seismic trigger event is a ranked on a Mercalli Scale of II (equivalent PGA of 0.0017 g to 0.005 g). Ground motion under this scale is typically felt indoors by a few people at rest, especially on upper floors of multi-story buildings. Birds and animals are disturbed, and trees, structures, liquids, and bodies of water may sway. Delicately suspended hanging objects may swing.

- **Announcement** – Pretivm dispatch operators must immediately announce a "STOP WORK ON THE WASTE DUMP" on the radio to all workers on the WRD.

- **Evacuation** – All Pretivm personnel and contractors must immediately:
    - De-energize equipment (put dozer blades and excavator buckets down and shut down all motors).
    - Leave their equipment with their radio and their floatation devices and specialized PPE (Spare Air tanks and floatation jackets).
    - Retreat from their equipment in a direction perpendicular from the dump crest and water's edge, preferably walking directly towards the WRD access road.
    - Site safety personnel must immediately barricade all access roads to the WRD and put up signage to prevent all access.

- **Muster** – All people on the WRD at the time of the evacuation order must muster at the warehouse building.

- **Engineering and Stability Assessments** – Following an earthquake:
    - The EOR must be contacted immediately after an evacuation order has been placed on the WRD due to a seismic event.
    - Pretivm Minesite Geotechnical Engineers must complete visual inspections of the WRD and a detailed survey of the settlement monuments and settlement data.
    - Subsequent surveys on monuments must inform that the WRD meets stability QPOs outlined in the OMS manual before personnel are approved to enter WRD. Agreement for

a re-entry permission must be agreed upon between the EOR, Minesite Geotechnical Engineers and the Mine Manager who will authorize re-entry to the WRD.

- **Re-Entry to Waste Rock Dump –** Mine Manager's Authority.

3 References

Health, Safety and Reclamation Code for Mines in British Columbia, sec 6.5.2(1) (2) (3); 6.4.2

SRK Consulting (2018). Operation, Maintenance and Surveillance Manual: Brucejack Gold Mine Subaqueous Waste Rock and Tailings Deposition – Version 6 – October 2018. Prepared for Pretium Resources Inc., October 2018. Acknowledgement

The undersigned Pretivm employee or contractor employ acknowledges that he or she has:

1. Been provided with a copy of Pretivm's Waste Rock Dump Emergency Evacuation and Re-Entry Plan Under Seismic Loading, Revision Number 0, dated October 11, 2018.
2. Read the Waste Rock Dump Emergency Evacuation and Re-Entry Plan Under Seismic Loading in full and raised or discussed any questions regarding how the policy is applied in the event of non-conformance or noncompliance of company policy, safety rules, or applicable regulations.

Signature	**Date**
Name (Please Print)	**Employer**

Appendix 9-1-18. Water Management Plan – OMS Manual

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

OMS Manual – Water Management Plan

Brucejack Mine – Version 8

Prepared for

Pretium Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
1CP026.003
February 2023

OMS Manual – Water Management Plan

February 2023

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Project No: 1CP026.003

File Name: Brucejack_WaterMgmt_2023_OMS_1CP026-003_20230129.docx

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srk consulting

Record of Versions

Date	Revised Version	Changes	Changes by (names)
12/31/2017	001	Initial version.	
03/16/2018	002	Update to include all water management infrastructure.	H. Weatherly (BGC)
11/26/2018	003	Update to drawings and Pretium personnel.	H. Weatherly (BGC) R. McCall
12/15/2018	004	Update headers and footers to read “Water Management Plan”.	H. Weatherly (BGC)
3/31/2020	005	Change Water Management Engineer from BGC to SRK; include as-built drawings; update operational descriptions and remove pre-construction text that is no longer relevant; changes to reflect M-243 and PE-107835 amendments December 2018.	S. McPhee M. Herrera
2/11/2021	006	Update	M.Herrera
3/7/2022	007	Update	M.Herrera
2/15/2023	008	Update	M.Herrera

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Appendix B – 2018 CWP Construction Records Report

Appendix C – Permits

Appendix D – Flood Preparedness

Appendix E – Truck Shop Flow Estimates

Acronyms and Abbeviations

AEMP	Aquatic Effects Monitoring Plan
AEP	Annual Exceedance Probability
ARD	Acid Rock Drainage
BGC	BGC Engineering Inc.
BJAR	Brucejack Access Road
BMP	Best Management Practices
BOMs	Bill of Materials
Brucejack	Brucejack Mine
CWL	Conditional Water License
CWP	Contact Water Pond
DPS	Diesel Power Station
EAC	Environmental Assessment Certificate
EAO	Environmental Assessment Office
EEM	Environment Effects Monitoring
EMA	Environmental Management Act
EMP	Environmental Management Plans
EMS	Environmental Management System
HDPE	High-Density Polyethylene
HSRC	Health, Safety and Reclamation Code for Mines in BC
IDF	Inflow Design Flood
IFC	Issued for Construction
LLW	Low Level Weir
MAC	Mining Association of Canada
MDMER	Metal and Diamond Mining Effluent Regulations
MECCS	Ministry of Environment and Climate Change Strategy
MEMPR	Ministry of Energy, Mines and Petroleum Resources
MFLNRORD	Ministry of Forests, Lands and Natural Resource Operations and Rural Development
MH	Man Hole
ML/ARD	Metal Leaching/Acid Rock Drainage
NAD	North American Datum
NPAG	Non-Potentially Acid Generating
OMS	Operations, Maintenance, and Surveillance
PAG	Potentially Acid Generating
PEP	Provincial Emergency Program
PET	Potential Evapotranspiration
PM	Preventative Maintenance
Pretium	Pretium Resources Inc., a member of the Newcrest Group of companies (Pretium)
SOP	Standard Operating Procedures
SRK	SRK Consulting Inc.
STP	Sewage Treatment Plant
TSS	Total Suspended Solids
UTM	Unified Transverse Mercator
VE	Volume-Elevation
WMP	Water Management Plan
WQG	Water Quality Guidelines
WRTSF	Waste Rock Tailings Storage Facility
WTP	Operations Water Treatment Plant

1 Introduction

The Brucejack Mine (Brucejack) is located approximately 65 km north-northwest of Stewart, BC in the Sulphurets District of the Iskut River Region (Figure 1-1). The mine consists of an underground mine workings with associated surface infrastructure, including two non-contact water diversion channels, a contact water pond (CWP) and a contact water management system.

This version of the OMS Manual (v. 008) was updated by SRK Consulting (Canada) Inc. (SRK) with contributions from Pretium Resources Inc. (Pretium) and replaces the previous version (v.007) as well as previous versions of the Brucejack Water Management Plan. The OMS Manual serves as a reference document for the operation of all surface water management facilities within the Mine Site.

The Water Management Plan component of this OMS Manual is a requirement of Environmental Assessment (EA) Certificate #M15-01, Mines Act Permit M-243 and Effluent Permit 107835. This OMS Manual has been prepared in general accordance with the latest guidelines titled "Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities" prepared by the Mining Association of Canada (MAC 2021).

The primary objectives of this OMS Manual are to define and describe the following:

- Key components of the main Brucejack surface water management facilities;
- Roles and responsibilities of Pretium personnel assigned to these facilities;
- Procedures and processes for managing change;
- Procedures required to operate, monitor the performance of, and maintain the facilities to ensure that they function in accordance to design and meet regulatory and corporate policy obligations; and
- Requirements for analysis and documentation of the performance of the facilities.

The OMS Manual covers operations of main Mine Site surface water management infrastructure through the operations and closure phases at Brucejack. This infrastructure is shown in Figure 1-2 and includes:

- CWP and spillway;
- Contact water management system of ditches, sumps, pumps, weirs and pipelines;
- Non-contact diversion channels; and
- Low level weir (LLW) and reclaim system at the outflow of WRTSF.

This document has been prepared primarily for use by Brucejack Mine personnel who are responsible for the operation, maintenance and surveillance of the water management facilities. It contains information and instructions necessary to perform the above required activities.

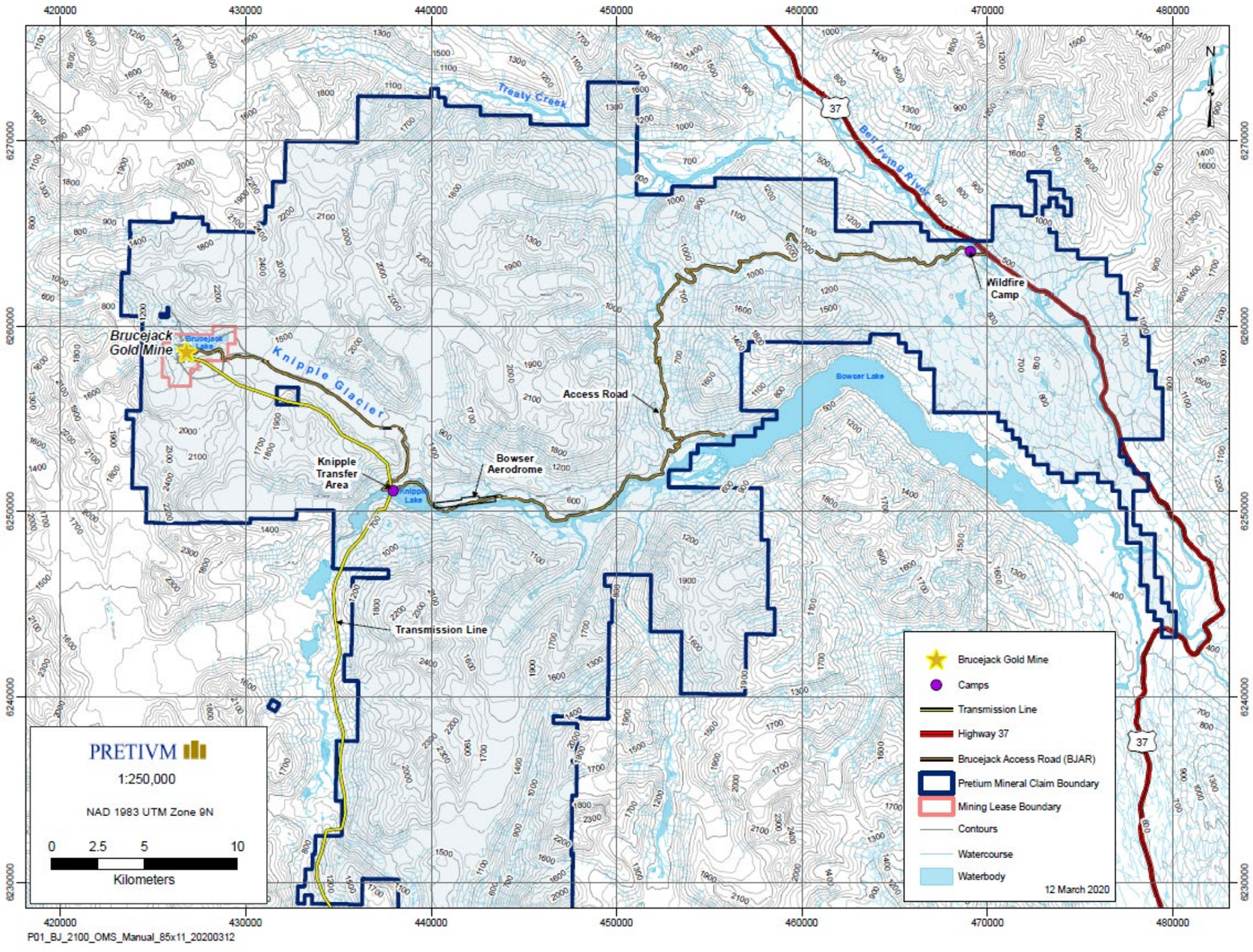
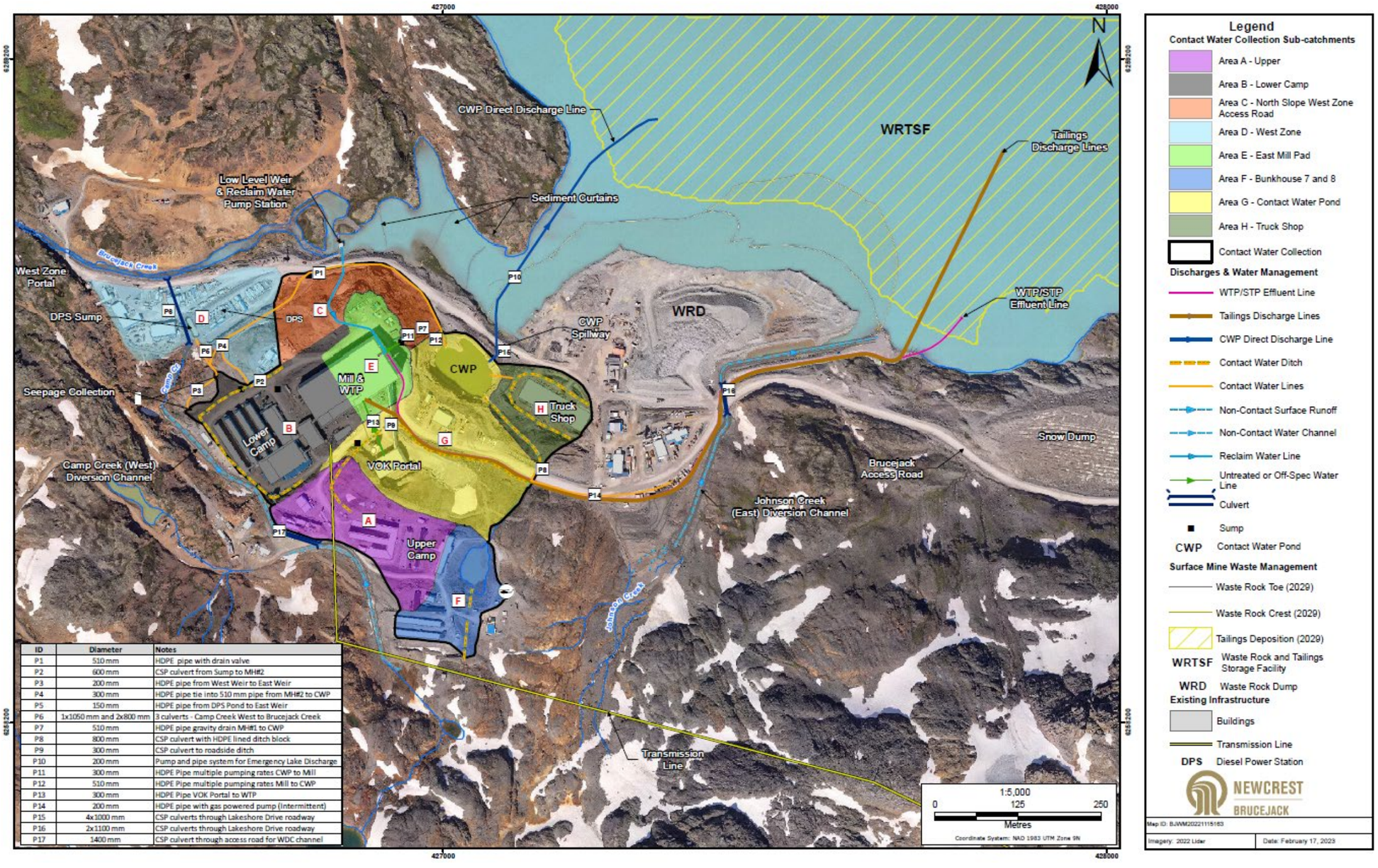


Figure 1-1: Brucejack Mine location.



ID	Diameter	Notes
P1	510 mm	HDPE pipe with drain valve
P2	600 mm	CSP culvert from Sump to MH#2
P3	200 mm	HDPE pipe from West Weir to East Weir
P4	300 mm	HDPE pipe tie into 510 mm pipe from MH#2 to CWP
P5	150 mm	HDPE pipe from DPS Pond to East Weir
P6	1x1050 mm and 2x800 mm	3 culverts - Camp Creek West to Brucejack Creek
P7	510 mm	HDPE pipe gravity drain MH#1 to CWP
P8	800 mm	CSP culvert with HDPE lined ditch block
P9	300 mm	CSP culvert to roadside ditch
P10	200 mm	Pump and pipe system for Emergency Lake Discharge
P11	300 mm	HDPE Pipe multiple pumping rates CWP to Mill
P12	510 mm	HDPE Pipe multiple pumping rates Mill to CWP
P13	300 mm	HDPE Pipe VOK Portal to WTP
P14	200 mm	HDPE pipe with gas powered pump (Intermittent)
P15	4x1000 mm	CSP culverts through Lakeshore Drive roadway
P16	2x1100 mm	CSP culverts through Lakeshore Drive roadway
P17	1400 mm	CSP culvert through access road for WDC channel

Figure 1-2: Brucejack Mine site general arrangement – Water Management Plan.

2 OMS Manual Preparation

2.1 OMS Manual Development and Maintenance Responsibilities

The OMS Manual is intended to be a living document which incorporates the surface water management infrastructure within the Mine Site and conforms to the MAC (2021) guidelines as well as BC's Health, Safety and Reclamation Code (HSRC) (2022). Ownership and stewardship of this document are provided by Pretium's Mill Manager, who assumes overall responsibility for development, maintenance and implementation of this OMS Manual, delegating tasks related to maintenance and implementation as appropriate.

2.2 OMS Manual Objectives and Contents Summary

This Manual serves as the primary reference document for the operation, maintenance and surveillance of the CWP and other surface water management infrastructure within the Mine Site. Use of this Manual will contribute to consistency of operation, and maintenance and surveillance of the water management facilities. Where appropriate, references to additional relevant documentation are included throughout the Manual.

Table 2-1 lists engineering and environmental reports and documents appended to the OMS Manual that are relevant to the regulatory requirements, design, operation, monitoring, surveillance and performance of the water management facilities.

Table 2-1: Appendices to OMS Manual.

Appendix		Contents
A	Construction Record Drawings and Specifications	Construction Record drawings and specifications for CWP, East/West Weir, Low Level Weir (LLW), Non-Contact Diversion Channels
B	CWP Construction Records Report	BGC Engineering Inc. 2018. Brucejack Gold Mine – Contact Water Pond Construction Records Report.
C	Permits	*Mines Act* Permit M-243 (November 14, 2022) Effluent Permit #107835 (July 16, 2022) Conditional Water Licence #C500684 (November 26, 2018)

2.3 OMS Manual Control and Update

Updates to the OMS Manual are made by Pretium with assistance and review by SRK. All updates will be reviewed by SRK as the CWP/Water Management Engineer for the Mine Site. The Manual is reviewed a minimum of once annually in accordance with Permit M-243 Condition C.4 (e) and updated as appropriate based on the review. Updates are distributed as part of the combined *Mines Act / Environmental Management Act* Permits Annual Report that is submitted to MEMPR, MECCS, Nisga'a Nation, Tahltan Central Government and Skii km Lax Ha Nation, and others, by March 31st of each year for the previous calendar year. Section 3.3 outlines how the manual is updated, in accordance with relevant regulations.

Revisions to the Manual are tracked in the Record of Versions table at the front of this report.

3 Roles, Responsibilities, and Authorities

3.1 Organization, Structure, Individual Responsibilities

The Mill Manager has the primary overall responsibility for ongoing review, updating and implementation of the OMS Manual, drawing upon assistance from and delegating to others as appropriate in this regard. The Environmental Manager (Principal, Environment) has the primary responsibility to confirm that the Manual is being reviewed a minimum of once annually, and for distribution of updated OMS Manual versions to the applicable stakeholders and authorities. Figure 3-1 provides an organization chart for Pretium and Table 3-1 presents a summary of key personnel involved in the stewardship of the water management facilities, including their roles and responsibilities. Table 3-2 presents external consultants involved in the OMS, including their roles and responsibilities.

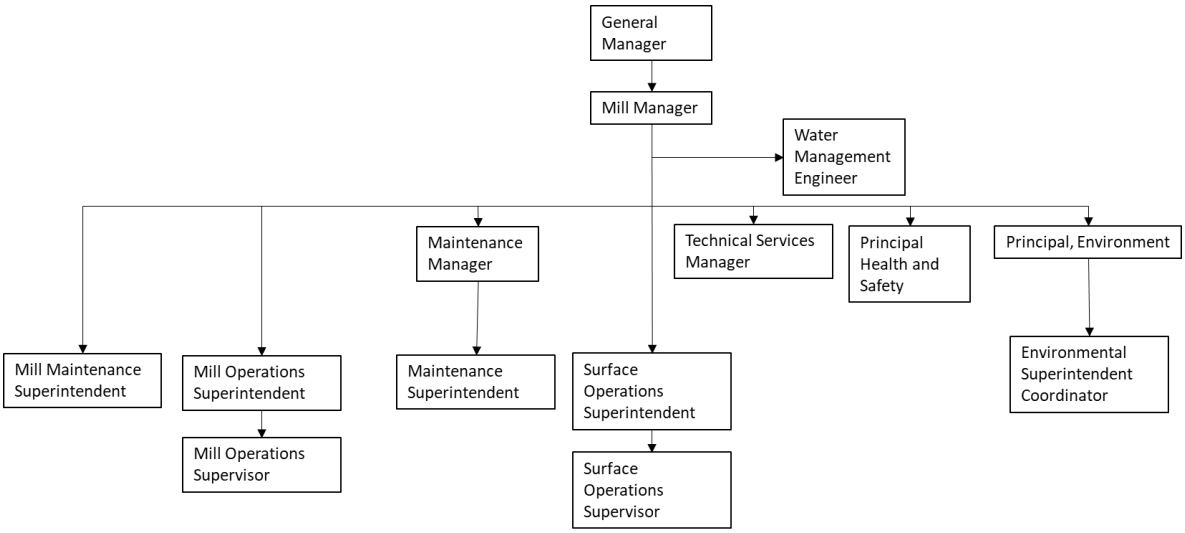


Figure 3-1: Brucejack organization chart for OMS Manual

Table 3-1: Pretium positions, roles and responsibilities for Mine Site Water Management Facilities OMS.

Position	Shift Schedule / Site Presence	Role	Responsibility	Authority
General Manager (GM)	Varies with a designate identified in their absence.	Corporate level operations oversight. Site-based oversight of water management stewardship.	Confirms that water management stewardship is in conformance with MAC guidelines, appropriate resources are in place to maintain conformance, and reports to the Vice President of Operations and Chief Executive Officer of Pretium on water management stewardship. Ensures that departments/groups involved in water management facilities stewardship are meeting assigned responsibilities. Confirms these personnel are interfacing as required, and that appropriate personnel/resources are in place to implement water management stewardship.	Overall operations authority. Direction of all senior site personnel and consultants. Allocation of personnel resources and budgets.
Mill Manager	2 weeks on, 2 weeks off with a designate in their absence.	Direction of water management facility operations, monitoring, and surveillance. Overall OMS responsibility.	Liaise with the Water Management Engineer over the CWP and any issues/anomalies with its monitored performance. Responsible for water level tracking in the CWP, including surveying of the operating pond. Ensure monitoring is carried out in accordance with approved protocols and frequency. Direct inspections of water management infrastructure for which the Mill Manager is directly responsible at appropriate frequencies, and report any unusual conditions/concerns to GM. The Mill Manager is directly responsible for the CWP and 'downstream' flows (piping from CWP to the mill and discharges from the mill/WTP), along with the reclaim water system. Owns and maintains the internal site water balance for the CWP and mill system related inputs/outputs. Review system water balance with Environmental Manager, Mill Maintenance and Mill Operations Superintendents. Ensure that flow data (pond volumes, reclaim water) are tracked, recorded, and provided to the Water Management Engineer to be incorporated into the site-wide water balance. Provide training to OMS Manual holders and operations personnel.	Liaise with the Engineer of Record over matters pertaining to operation of the water management facilities. Arrange for annual inspection of the water management facilities.
Principal, Environment	Full time, Brucejack	Lead and/or confirm the field implementation of environmental requirements related to water management and effluent discharge under all mine authorizations, including required site monitoring/sampling and implementation of required mitigations. Overall responsibility for review and leading updates to the EMS and applicable component plans.	Lead contact with MEMPR (excluding Health and Safety) MECCS, and MFLNRORD, and supporting contact with BC EAO and federal agencies related to regulatory requirements for water management, effluent discharge, and this OMS manual. Lead/coordinate technical consultant work, including work by the Water Management Engineer, ML/ARD, Water Quality, and Aquatic Biological Consultants. Responsible under major permits to lead annual reviews of this OMS manual as a component of the site EMS. Direct Environmental Superintendent/Coordinator in the implementation of site sampling, flow monitoring, and compliance monitoring programs, and in any compliance reporting. Lead ongoing confirmations, including via site personnel, that commitments under this OMS and permit/authorization requirements for water management and effluent discharge are implemented. This includes ensuring that applicable records are available for inspection upon request. Lead preparation and submission of provincial annual report and other submissions related to water management and effluent discharge pursuant to M-243 and PE-107835, including monthly reports.	Direct implementation of environmental and related compliance requirements pertaining to mine operations. Responsible and with the authority under Permit M-243 to implement remedial actions as may be necessary to ensure maintenance of environmental standards and permit requirements. Responsible under M-243 and PE-107835 to lead annual reviews of the EMS and ensure that annual reviews of component management plans (includes OMS) are completed, with plan updates as appropriate.
Principal, Health and Safety & Health and Safety Superintendents	2 weeks on, 2 weeks off, cross-shifting.	Site safety protocols, training, and monitoring.	Ensure that site safety protocols specific to water management facilities operations are established, enforced, and reviewed/improved as necessary.	Direction of safety requirements pertaining to mine operations.
Mill Operations Superintendent	2 weeks on, 2 weeks off, cross-shifting.	Oversight of operation and maintenance of tailings delivery and water reclaim systems.	Manage mill reclaim requirements. Report operational issues to Mill Manager, who in turn reports these to the General Manager as appropriate. Oversee and confirm that water management facilities are properly operated and maintained in accordance with SOPs. Advise CWP/Water Management Engineer, Mill Manager and Environmental Manager of any process changes with material effects on the water balance or process water quality or quantity. Confirm that CWP/Mill flow monitoring components of the water balance are being tracked, calibrated, and kept up to date and that required monitoring records are being kept for same. Review internal system water balance with Mill Manager and Environmental Superintendent/ Manager.	Direction of water management systems operation and maintenance.
Mill Maintenance Superintendent	2 weeks on, 2 weeks off, cross-shifting.	Responsible for the day to day maintenance of the CWP and other surface water management infrastructure.	Mill & Fixed Assets management & maintenance oversight. Oversee water management facilities under mill responsibility and confirm they are properly maintained in accordance with SOPs. Provision of personnel and resources necessary for the maintenance of the water pipeline distribution and reclaim/pumpback system consistent with the OMS Manual. Maintain records for maintenance and inspections pertinent to water management infrastructure and instrumentation.	Overall authority of Process Plant. Provision of personnel and resources/budgeting to support water management maintenance.

Position	Shift Schedule / Site Presence	Role	Responsibility	Authority
Mill Supervisors	2 weeks on, 2 weeks off, cross-shifting, variable day and night shifts.	Field operation of the water reclaim pumping/delivery systems.	Carry out the field operation of the CWP, other surface water management infrastructure 'downstream' of the CWP, the reclaim water system, and tailings discharge facilities, as defined by the Mill Operations Superintendent. Inspect water reclaim/pipelines no less frequently than once per shift. Fill out shift inspection reports and provide to Mill Operations Superintendent. Report any unusual conditions observed at surface water management infrastructure to Mill Operations Superintendent.	
Technical Services Manager / Chief Mining Engineer	2 weeks on, 2 weeks off, cross-shifting.	Site-based oversight. Direction of mine waste management planning and operations interfaces, and direction of mining engineering group.	Coordinate and manage mining engineering team with regards to any plans and/or actions pertinent to water management that may interface with mining activities.	Overall responsibility for mine planning, mine production, waste rock deposition, and stockpiles.
Maintenance Manager	2 weeks on, 2 weeks off with designate in his absence.	Oversight of mine site surface and underground maintenance, including electrical, excluding maintenance conducted by the Mill Department.	Coordinate and manage mine site maintenance team. The specific role of the Maintenance Department for this OMS is to support Surface Operations with maintenance of water management infrastructure 'upstream' (i.e. draining to) of the Contact Water Pond. This includes maintenance and related inspections of pumps, sumps/manholes, and pipelines.	Overall responsibility for surface and underground mine maintenance, excluding mill related maintenance.
Maintenance Superintendent	2 weeks on, 2 weeks off, cross-shifting.	Oversight of mine site surface and underground maintenance, including electrical, and excluding maintenance conducted by the Mill Department.	Supervise surface and underground maintenance personnel, excluding those for the mill. The specific role for this OMS is to direct and supervise maintenance of water management infrastructure 'upstream' of the Contact Water Pond.	Supervise implementation of maintenance work, excluding that conducted by the mill maintenance personnel.
Environmental Superintendent / Coordinator	2 weeks on, 2 weeks off, cross-shifting.	Site-based environmental compliance oversight.	Oversee water quality sampling and testing in accordance with approved protocols and following direction of technical consultants. Validate laboratory test results. Under the direction of the Environmental Manager, interpret environmental (facility water quality and flows) data in coordination with Mine and Mill Operation Superintendents and in consultation with the ML/ARD, Water Quality and Water Management Engineers. Oversee required monitoring of effluent discharges, and report non-compliance events or trends to the Environmental Manager, Mill Manager (if applicable to the discharge), the Mine Manager, and the General Manager. Confirm that CWP and site-wide water balance components are being tracked, calibrated, and kept up to date. Maintain on-site weather stations and plot/record/disseminate climate data.	Supervise site environmental personnel. Indicate water quality sampling locations, sample collection protocols and analytical parameters. Advise when CWP water quality is suitable for discharge or must be retained. Site lead responsible for confirming via monitoring/inspection that mining and milling activities comply with the requirements of the applicable authorizations and regulations governing the milling, tailings facilities.
Surface Operations Superintendent	2 weeks on, 2 weeks off, cross-shifting with the Surface Operations Supervisor.	Direction of mine fleet operators, and mine maintenance personnel.	Oversee maintenance of the non-contact diversion channels and water management facilities 'upstream' of the CWP, including contact water ditches, pipelines and related infrastructure draining to the CWP. In the event of an emergency or for operational support the Surface Operations Department can support the operations and maintenance of the CWP and other water management facilities. Snow management.	Responsible for operations of water management facilities draining to the CWP. Provide emergency and operational support for WP and other water management facilities.
Surface Operations Supervisor	2 weeks on, 2 weeks off, cross-shifting with the Surface Ops Superintendent.	Direction of mine fleet operators, and mine maintenance personnel.	Oversee maintenance of the non-contact diversion channels and water management facilities 'upstream' of the CWP, including contact water ditches, pipelines and related infrastructure draining to the CWP. In the event of an emergency or for operational support the Surface Operations Department can support the operations and maintenance of the CWP and other water management facilities. Snow management.	Responsible for operations of water management facilities draining to the CWP. Provide emergency and operational support for CWP and other water management facilities.

Table 3-2: External consultant's roles and responsibilities.

Position	Name and Contact Information	Role	Responsibility
CWP and Surface Water Management Engineer	SRK Consulting (Canada) Inc Technical Lead: Mauricio Herrera, PhD, PEng. Office: (604) 681-4196 Cell: (604) 764-1250 Email: mherrera@srk.com Technical Project Engineer: Stuart McPhee, PEng. Office: (604) 235-8549 Cell: (778) 879-4345 Email: smcphee@srk.com	External engineering support and inspection responsibilities for contact water management system design, monitoring, planning, and operations. OMS Manual oversight and review.	Liaise with appropriate Pretium personnel to remain well-informed and provide input to CWP operation. Review monitoring data, and report anomalies/concerns to Mill Operations Superintendent. Provide recommendations for revisions to monitoring requirements, as required. Provide input to OMS Manual and provide assistance in updates of the Manual as directed by Pretium. Review need for design modifications based on field conditions/monitoring data/Pretium suggestions and implement/document as appropriate. Contribute to closure planning. Provide assistance on surface water management.
ML/ARD Consultant	Lorax Environmental Services Ltd. Technical Lead: Alison Shaw, PhD, PGeo. Office: (604) 688-7173 (ext. 264) Email: alison.shaw@lorax.ca	Qualified Professional for ML/ARD Management Plan and geochemistry predictions, monitoring and assessment.	Provide ML/ARD consulting expertise as directed by the Environmental Manager
Water Quality Consultant	Lorax Environmental Services Ltd. Technical Lead: Alison Shaw, PhD, PGeo. Office: (604) 688-7173 (ext. 264) Email: alison.shaw@lorax.ca	Qualified Professionals for water quality/chemistry program.	Provide water quality/chemistry and water quality modeling consulting expertise and support as directed by the Environmental Manager.
Groundwater Consultant	Lorax Environmental Services Ltd. Technical Lead: Laura Findlater, PGeo. Office: (604) 688-7173 (ext. 230) Email: laura.findlater@lorax.ca	Qualified Professional for groundwater management.	Provide groundwater quality and quantity consulting expertise, including numerical groundwater modeling support, as directed by the Environmental Manager.
Hydro-Meteorological Consultant	Lorax Environmental Services Ltd. Technical Lead: Colin Fraser, PGeo. Office: (604)688-7173 (ext. 223) Email: colin.fraser@lorax.ca	Qualified Professional for hydro-meteorological modeling	Provide hydrological and meteorological consulting expertise, including site-wide water balance modeling support, as directed by the Environmental Manager.

3.2 Competency and Training

Training of personnel must be carried out to ensure the recommended minimum levels of knowledge set out in Table 3-3 are attained by personnel and positions involved in the operation, maintenance, and surveillance of the water management facilities. Training must consist of a review of this OMS Manual and/or a summary presentation.

Table 3-3: Knowledge and training requirements.

Position	Recommended Minimum Knowledge
General Manager	Review of the OMS Manual, with an understanding of the design, and operational requirements.
Mill Manager Mill Maintenance Superintendent Mill Operations Superintendent	Detailed understanding of the OMS Manual, with a complete understanding of the design, water balance, and operational requirements. Complete understanding of all related technical documents for design and operations. Detailed understanding of water management facilities surveillance (i.e. for CWP, reclaim water system, and infrastructure 'downstream' of the CWP) and visual indicators of unusual conditions. Detailed understanding of instrumentation surveillance, including monitoring requirements, action/threshold levels, and their significance.
Maintenance Manager Maintenance Superintendents	Understanding of the OMS Manual. Detailed understanding of the design, operational and maintenance requirements of water management infrastructure 'upstream' of the CWP. Detailed understanding of the visual surveillance and other inspection requirements for water management infrastructure 'upstream' of the CWP; this includes understanding of visual indicators of unusual conditions. Detailed understanding of applicable instrumentation surveillance, including monitoring requirements, action/threshold levels, and their significance.
Principal, Environment	Complete understanding of environmental compliance issues and monitoring requirements. Understanding of the OMS Manual, and the ongoing and future operational and water balance requirements. Knowledge of receiving environments adjacent to the Mine. Understanding of water management facilities, surveillance, and visual indicators of unusual conditions.
Mill Supervisors and Operators	Understanding of the OMS Manual. Detailed understanding of all operational elements within the facility and their operational and maintenance requirements, and for the CWP, reclaim water system, and infrastructure 'downstream' of the CWP. Detailed understanding of visual surveillance requirements.
Surface Operations Superintendent and Supervisor	Review of the OMS Manual, with an understanding of the design and operational requirements of infrastructure 'upstream' of the CWP. Understanding of all operational elements for water management and operational and maintenance requirements for infrastructure 'upstream' of the CWP. General knowledge of visual inspection requirements.

Position	Recommended Minimum Knowledge
Principal, Health and Safety	Review of the OMS Manual.
CWP/Water Management Engineer	Detailed understanding of the OMS Manual, and the water management facility design. Detailed and ongoing review of all monitoring and, inspections. Complete understanding of all related technical documents that support water management facility design and operation. Detailed understanding of operational and water balance management issues, and interfaces with design, operations, and planning.
ML/ARD Consultant	Understanding of design and interfaces with ML/ARD aspects.
Other external personnel (Designers and Contractors)	Varied levels of knowledge and understanding depending on involvement. The GM will determine levels of knowledge and instruct personnel.

3.3 Managing Change

3.3.1 Review and Update of the OMS Manual

Ownership and stewardship of this document is the responsibility of Pretium's Mill Manager. The Mill Manager ensures that the document is reviewed and updated on a regular basis and that the content is accurate. The Water Management Engineer is responsible to confirm that the OMS manual follows the guidelines published by MAC (2021) related to OMS Manuals for tailings and water management facilities.

The purpose of the OMS Manual is:

- To serve as the primary reference document for operational, maintenance and surveillance procedures for Pretium's Mine Site water management facilities.
- To adhere to established procedures over long periods of time, particularly during changes in operating and supervisory personnel.

This Manual will be reviewed on an annual basis, and updated if there are changes to any of the following:

- Changes to the organization, and/or shifting of roles and responsibilities between positions with regards to water management stewardship;
- Significant changes to any of the water management facilities (as approved);
- Significant variation of performance from design of the facilities;
- Addition of instrumentation, and/or adjustments to action/threshold levels established for instrumentation;

- Changes to operating procedures; and
- Regulatory changes/permit amendments.

3.3.2 Design and Operational Changes

Changes to the design and/or operations of the water management facilities may be necessary as a result of changes to the mine plan (resulting in an increase or decrease in required storage capacity in the CWP); in response to additional information acquired through site investigation; in response to changes in the performance of the water management facilities; or to take account of observed performance and lessons learned to improve the design.

Changes to OMS procedures may be necessary following design changes or changes in facility performance. Updates to the water management designs are undertaken under one or more of the following circumstances:

- Additional information is obtained through monitored (visual and instrumentation) performance which necessitate design changes; and/or
- Expansion of the CWP and construction of additional infrastructure.

Changes to design specifications and drawings are implemented via a system of approvals through the water management organization structure to ensure changes are consistent with operational needs, construction criteria, and design criteria. Ultimately any design change to the water management infrastructure requires authorization from the Mill Manager, in consultation with the General Manager and the Principal, Environment, and with technical support provided by the Water Management Engineer. Any design change also requires authorization under Permit M-243 and other mine authorizations as applicable, prior to implementation.

3.3.3 Succession/Planning Training

It is anticipated that the organizational chart for the mine will change over time. Succession training will be implemented to ensure continued operation of the water management facilities in the appropriate manner.

3.3.4 Regulatory Change

In the event of any regulatory change that impacts the design and/or operation of the water management facilities, it is the responsibility of the Principal, Environment to advise all Pretium staff identified in Table 3-1 and the Water Management Engineer of such change.

3.4 Documentation, Document Control and Reporting

Several documents are produced on a regular basis as part of operation of the water management facilities at Brucejack. Table 3-4 presents these documents in terms of their frequency of production, their purpose, filing requirements.

Table 3-4: Brucejack water management documentation – requirements.

Document	Purpose	Frequency of Issue	Issued By	Issued To	Distributed By	Filing Requirements
OMS Manual	To serve as the primary reference document for operational, maintenance and surveillance procedures for Pretium's Mine Site water management facilities. To adhere to established procedures over long periods of time, particularly during changes in operating and supervisory personnel.	Reviewed annually with updates issued if there are revisions	Pretium	Pretium, MEMPR, MECCS, SRK, external consultants (Table 3-2), and indigenous groups.	Pretium	Hard copies retained by Pretium and accessible by staff on-site. Digital copies are distributed externally.
Mines Act / EMA Permits Annual Report	Annual Report (due by March 31 of succeeding year).	Annually	Pretium	Various[1]	Pretium	Stored by Pretium.
Water Management Infrastructure Inspection	As per Section 2.6 of PE-107835: "All ponds, ditches, runoff or seepage collection, diversion works, flow monitoring weirs and gauges must be inspected at least twice per year, once in spring after freshet and once in fall before freeze-up. Records of inspections must be maintained, and any identified deficiencies in the work must be corrected immediately."	Twice a year	Pretium	Pretium	Pretium	Pretium retains files on-site.
Mill Operators Shift Inspection Report	Inspection form/checklist documenting CWP water levels and inspections (frequency season / facility dependent) contact water pipelines, water reclaim pipelines, and pumping operations (CWP).	Each shift (Day and Night)	Pretium (Mill Operators)	Pretium	Pretium	Pretium retains files on-site.
Daily Water Management Report	Seasonally when there is surface runoff, daily report of surface contact water management and related maintenance, including non-contact diversion channels, contact water ditches and pipelines 'upstream; of the CWP, East/West Weirs, and pumping operations.	Daily, day shift	Dewatering Coordinators	Pretium	Pretium	Pretium retains files.
Survey	Capture changes to CWP, new instrumentation, pond soundings, etc.	Ongoing, as required	Pretium	Pretium	Pretium	Files retained by Pretium. Incorporated into reporting summaries and updating site plans and as-built drawings for OMS Manual updates.

Notes:

[1]The annual report must be made available to MECCS, MEMPR, the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Council), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

4 Water Management Facility Description

4.1 Mine Description

Primary ore processing occurs in the mill building. Flotation tailings generated during processing are either deposited subaqueously in the WRTSF via a pipeline or thickened as a paste fill and used to backfill portions of the underground workings. Waste rock from underground mine development is also deposited subaqueously into the WRTSF or used as underground backfill.

Concentrate produced at the mine site is either refined into dore bars or hauled off-site by truck along the 74 km long access road that connects to Highway 37.

All runoff within the Mine Site contact water management system is collected in the CWP. The CWP is located near the southwest shore of the WRTSF (Figure 1-2). Contact water runoff is directed to the facility through a series of sump collection areas, ditches, pipes and pumps. From the CWP, contact water is pumped to the Operations Water Treatment Plant (WTP), located within the mill building. Treatment of collected surface contact water began part way through mine construction and will continue throughout the mine life. The CWP will be decommissioned during mine closure.

Construction of the mine started in September 2015, with production commencing in June 2017.

4.2 Site Conditions

4.2.1 Physical Setting

The Brucejack Mine is located within the Boundary Range of the Coast Mountain Physiographic Belt. The region is characterized by steep mountains and extensive glaciation. Elevations in the mine vicinity range from 400 meters above sea level (masl) at Bowser Lake to over 1,800 masl at the nearby highest peaks. The tree line is at approximately 1,200 masl elevation; therefore, the mine site (elevation ~1400 masl) is sparsely vegetated. Brucejack Creek has a watershed area of 6.6 km^2 at the outlet of the WRTSF (Figure 4-1). Approximately 6% of the watershed is covered in glaciers (mostly to the south of the camp site), while 9% is covered by the lake.

4.2.2 Climatic Setting

The climate at lower elevations in the mine vicinity is generally that of a temperate or northern coastal rainforest, with subarctic conditions at the high elevations where the Mine Site is located. In the winter (November to March), monthly mean air temperatures range from approximately -4°C to -20°C; and in the summer from 5°C to 20°C.

The hydrology of the mine site is characteristic of a snowmelt dominated regime supplemented by rainfall in the summer and early fall. The Mine Site experiences substantial precipitation with an estimated average annual precipitation of 2,200 mm. Most precipitation falls as snow from October to May.

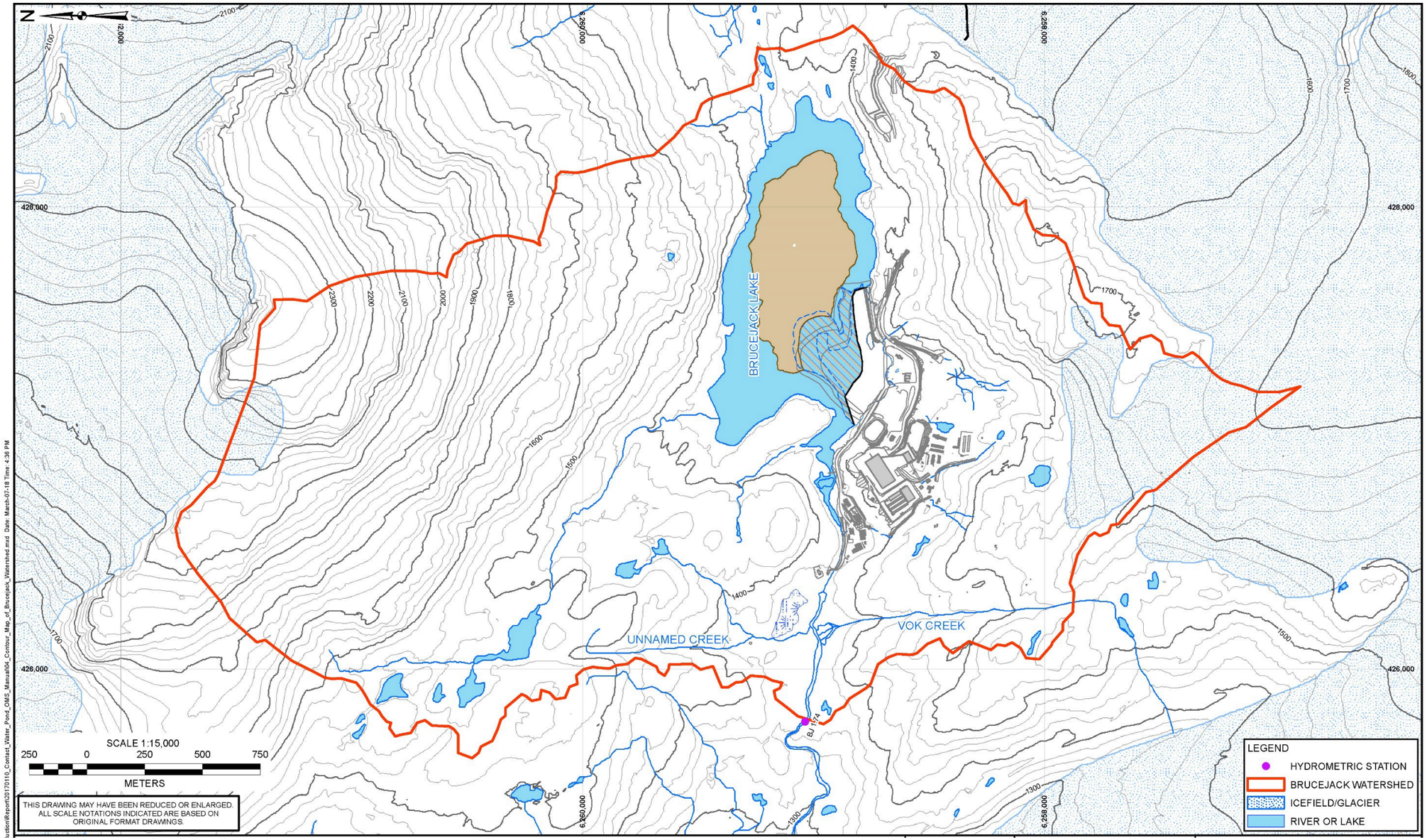


Figure 4-1: Brucejack Creek watershed at station BJ 1.74.

Rainfall amounts at Brucejack for durations of 24 hours to 10 days and return periods of 2 to 200 years are summarized in Table 4-1 (BGC 2014). Frequency results for wet and dry annual precipitation are summarized in Table 4-2 while shorter duration rainfall totals are summarized in Table 4-3.

Table 4-1: Rainfall estimates for various return periods and durations at the WRTSF.

Return Period (years)	24-hr Rainfall (mm)	2-day Rainfall (mm)	3-Day Rainfall (mm)	5-Day Rainfall (mm)	10-day Rainfall (mm)
2	82	102	122	154	195
5	117	141	159	196	246
10	139	161	183	221	276
25	167	189	212	249	312
50	187	210	233	268	336
100	206	230	253	286	360
200	226	249	273	302	382

Table 4-2: Annual precipitation estimates for various return periods.

Return Period (years)	Annual Precipitation (mm)	
	Dry	Wet
2	2200	2200
5	2001	2450
10	1860	2580
100	1420	2840

Table 4-3: Rainfall intensity-duration-frequency data estimates for the WRTSF.

Duration	Rainfall (mm)						
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr
5 min	2.7	4.3	5.1	6.2	7.0	7.8	8.8
10 min	4.0	5.4	6.2	7.3	8.1	8.9	9.8
15 min	4.7	6.0	7.0	8.1	8.9	9.7	10.7
30 min	6.5	7.8	8.8	10.0	10.8	11.7	12.7
1 hr	9.7	11.4	12.4	13.9	15.0	15.9	17.1
2 hr	15.8	18.9	21.1	23.7	25.8	27.7	30.0
6 hr	36	45	50	58	63	68	74
12 hr	59	74	84	96	105	114	125
24 hr	82	117	139	167	187	206	226

Estimated average monthly climate data for the Brucejack are summarized in Table 4-4. This table includes values for precipitation, temperature, PET and sublimation. Additional detailed information on the climatic and hydrologic setting of the Mine Site can be found in (BGC 2017b).

Table 4-4: Average monthly climate data.

Month	Average Temperature[1] (ºC)	Average Precipitation[2] (mm)	Average PET / Sublimation[3] (mm)
January	-7.1	269	2
February	-8.6	231	2
March	-5.9	196	2
April	-2.5	105	4
May	2.9	95	10
June	5.0	72	23
July	7.8	90	46
August	7.3	150	41
September	3.9	224	25
October	-1.6	267	8
November	-5.2	233	2
December	-8.3	267	2
Total/Mean	**-1**	**2,200**	**167**

Notes:

[1] Based on temperature data collected at the VOK meteorological station for 2014-2021 period.

[2] Using monthly precipitation distribution as observed at Unuk River Eskay Creek climate station (1989 to 2010).

[3] Estimated using climate data collected from the Brucejack meteorological station from 2010 to 2012 (BGC 2014).

4.2.3 Hydrologic Setting

Prior to start of Brucejack Mine construction in September 2015, WRTSF had an approximate volume of 30.4 Mm^3 and a maximum depth of 85 m. The watershed area at the outlet of the WRTSF has been estimated at 6.6 km^2, of which approximately 0.8 km^2 is covered by the water surface. Approximately 800 m downstream of the WRTSF outlet, streamflows have been monitored at hydrometric station BJ 1.74 since 2007. The drainage area at this station is approximately 8.5 km^2. Intervening tributaries between these two locations include Camp Creek (0.50 km^2), VOK Creek (0.45 km^2), and an Unnamed Creek (0.50 km^2) located north of Brucejack Creek and west of the WRTSF.

Groundwater flows from the historic West Zone mine adit previously discharged into Brucejack Creek immediately downstream of Camp Creek. However, the underground mine workings have been progressively dewatered since November 2011, initially to gain access to the historic West Zone workings and later to allow advanced exploration and subsequent active mining in the VOK Zone.

Between November 7, 2011 and February 4, 2012, underground dewatering with discharge from the West Zone adit occurred at an average rate of approximately 29 m^3/h (8 L/s). No dewatering occurred over the following six months. Dewatering resumed in September 2012 and has continued to date. Discharge from the underground dewatering continued via the West Zone adit

and ultimately to Brucejack Creek during the period from September 2012 until early 2016, when the construction phase WTP discharge was transitioned to the WRTSF. Two different water treatment plants were used during this period, with water piped out of the adit to the treatment plant, and post-treatment water discharged to Brucejack Creek. All underground mine water was pumped to the operations WTP located in the Mill beginning August 7, 2017, with this water then used in process and discharge of only the surplus.

The average dewatering rates were approximately 52 m^3/h (14.6 L/s) between September 2012 and October 2016; 41 m^3/h (11.4 L/s) from October 2016 to August 2017; and 61.8 m^3/h (17.2 L/s) from August 2017 through February 2020.

Streamflows have been monitored at the BJ 1.74[1] hydrometric station since mid-2007. Monthly average streamflow and unit runoff observed at this station is summarized in Table 4-5. Average annual runoff for the period of record is 2,207 mm – this record includes treated dewatering water pumped from underground. Streamflows are typically estimated for the November through May period due to the formation of ice on the creek and a deep snowpack, both of which hinder flow measurements.

4.2.4 Geology

The Brucejack Mine is located along the western margin of the Intermontaine Tectonic Belt and is underlain by Upper Triassic volcaniclastic and epiclastic sedimentary rocks of the Stuhini Group and Lower to Middle Jurassic volcanic, volcaniclastic, and sedimentary rocks of the Hazelton Group. The surficial materials in the local mine vicinity primarily consist of a veneer of well-graded glacial till over bedrock. However, thicker deposits of soils, including alluvium, have been encountered on the Mine Site.

Detailed information on the geology of the mine site can be found in the permitting documentation.

4.2.5 Geohazards

Avalanches are the primary geohazard within the Mine Site Area (infrastructure area west of the Knipple Glacier). Avalanche paths intersect the km 72 Non-Potentially Acid Generating (NPAG) Quarry located on the southeast side of the WRTSF, the gravel borrow area (currently undeveloped) east of the east end of the WRTSF, and parts of the Brucejack Access Road (BJAR) between the km 72 NPAG Quarry and the Mine Site. No geohazards have been identified that directly impact the CWP.

Detailed information on the geohazards within the Mine Site Area can be found in the 2015 *MA/EMA* Permits Application (Pretium 2015) and the Geohazards Management Plan (Pretium 2016).

[1] Prior to 2012, this station was referred to as BJL-H1 and was located at a slightly different site.

4.2.6 Geochemical Setting

Geochemical assessments indicate the majority of geological units on the mine site are classified as potentially acid generating (PAG) material.

Detailed geochemical characterization of the Brucejack site is provided in the 2015 *MA/EMA* Permits Application (Pretium 2015) and subsequent *MA/EMA* Annual Reports (Pretium 2016 to 2019). Management of PAG materials is governed by the applicable authorizations, particularly M-243 and PE-107835, and by the ML/ARD Management Plan, which is also reviewed annually and updated as appropriate based on review.

4.3 Site Reference Data

This section summarizes where reference data for the site can be found. These data include:

- Facility coordinate system and datum;
- Geotechnical site investigation data; and
- Baseline groundwater and surface water characteristics.

Table 4-5: Monitoring Site BJ 1.74 mean monthly discharge and Runoff from 2008 to 2021.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Discharge (m^3/s)	0.114	0.086	0.082	0.121	0.924	1.555	1.266	0.861	0.718	0.496	0.273	0.158
Runoff (mm)	36	25	26	37	291	474	399	271	219	156	83	50

Note:

2009 is a partial year

4.3.1 Facility Coordinate System and Datum

The Brucejack survey control uses the Universal Transverse Mercator (UTM) coordinate system, and is based on the Zone 9 North projection, using the North American Datum 1983 (NAD 1983).

4.3.2 Geotechnical Site Investigation Data

Site investigations have been completed in support of the design of the CWP. Details regarding the site investigations, including drill hole and test pit logs, geophysical surveys, and laboratory testing can be found in the following reports:

- BGC Engineering Inc. 2013. Brucejack Project Feasibility Study, 2011/2012 Site Investigation Report. July 12, 2013;
- BGC Engineering Inc. 2015a. Brucejack Project, 2014 Site Investigation Report. January 14, 2015; and

- BGC Engineering Inc. 2015b. Brucejack Project, Geotechnical Design of the Contact Water Pond. January 21, 2015.

4.3.3 Baseline Groundwater and Surface Water Quality

Detailed information on baseline groundwater sampling and surface water quality for the Brucejack Mine is provided in Chapter 2 of the Pretium Resources Inc. 2015 MA/EMA Permits Application (Pretium 2015).

4.4 Contact Water Pond Design

Design criteria and bases for the CWP are outlined in Table 4-6. Design criteria have been adopted for design of the CWP based on Pretium's *Mines Act* Permit M-243.

Table 4-6: Design criteria for the CWP.

Design Criteria	Description/Comments
CWP Storage Requirements	Store the runoff from the 24-hour duration, 200-year return period rainfall plus snowmelt event. The 24-hour 200-year rainfall has been estimated at 226 mm while snowmelt potential has been estimated at 43 mm. The CWP is to store a minimum of 50,000 m^3 without discharges through the spillway.
Operating Pond	During the surface runoff season (typically May to November),
IDF	1/200 annual exceedance probability (AEP).
Freeboard	Greater of no overtopping by 95% of the water caused by the most critical wind with a frequency of: • 1/1,000 years when the reservoir is at its maximum normal elevation; or • 1/10 years when the reservoir is at is maximum extreme level during the passage of the IDF.
Spillway Capacity	Pass the IDF.

The CWP was constructed without a liner, as it has been excavated entirely within bedrock. A hydrogeological assessment of the unlined facility is provided in BGC (2017c). Construction record drawings for the CWP are provided in Appendix A. A construction records report, including record drawings, is included in Appendix B.

4.5 Regulatory Requirements and Authorizations

The following legislation and regulations are pertinent to this OMS manual:

- BC *Mines Act* (1996a). Provides guidance and approvals for all activities on the Brucejack Mine Site, including exploration, development, production, closure, and reclamation;
- Health, Safety, and Reclamation Code for Mines in BC (HSRC 2022). Under the *Mines Act* (1996a), requires the operator to:
  - ensure that a tailings storage facility has a water balance and water management plan for the permitted life of mine that is prepared by a qualified person (section 10.1.12); and,

  - after commencement of operations, the water balance and water management plans under section 10.1.12 of this code shall be reconciled annually and updated as required (Section 10.4.1).

- BC *Environmental Management Act* (SBC 2003). Relevant to water management at Brucejack, regulates the discharge of liquid effluent into the environment;
- Metal and Diamond Mining Effluent Regulations (MDMER 2019). Environmental monitoring and surveillance programs of effluent discharges are requirements of the Metal and Diamond Mining Effluent Regulations (SOR/2002-222) pursuant to the *Fisheries Act*; and
- *BC Water Sustainability Act* (B.C. Reg. 36/2016). Brought into force February 29, 2016, this Act is the principal law for managing the diversion and use of water resources in BC.

The following is a list of the major authorizations for the Brucejack Mine relevant to this OMS:

- BC Environmental Assessment Certificate (EAC) #M15-01, issued in March 2015;
- Federal approval for the Brucejack Project under the *Canadian Environmental Assessment Act,* issued in July 2015;
- *Mines Act* Permit M-243, issued on July 22, 2015 and most recently amended November 14, 2022;
- *Environmental Management Act* (EMA) Effluent Permit 107835, issued on August 31, 2015 and most recently amended on July 16, 2022; and
- Conditional Water Licenses C132076 and C132077 also authorize the non-contact diversion channels [Camp Creek (West) Diversion and Johnson Creek (East) Diversion].

This OMS, including its Water Management Plan components, is a requirement of EAC #M15-01, *Mines Act* Permit M-243 and Effluent Permit 107835. Geotechnical, health and safety, geochemistry, reclamation and other environmental aspects of the Mine Site water management system are regulated under M-243. Discharges to the WRTSF, including those from the CWP, WTP, and mill (tailings), are regulated under PE-107835, along with the discharge from the WRTSF via the LLW. Permits M-243 and PE-107835 are provided in Appendix C.

Requirements of Permits M-243 and PE-107835 that are specific to the water management facilities are summarized in the following sub-sections.

4.5.1 CWP Authorized Discharge

Effluent Permit 107835 allows for the direct discharge from the CWP to WRTSF under the following conditions (see Appendix C):

- The maximum authorized rate of discharge from the CWP to WRTSF varies;
- Should the water quality concentrations of the WTP and CWP discharge to WRTSF exceed the values in Table 4-7 the permittee must immediately, upon receipt of analytical results, recirculate effluent through the CWP and WTP until treated water does not exceed; and

- The water quality concentrations of the WTP and CWP discharge to WRTSF must not exceed the values summarized in Table 4-7.

Table 4-7: CWP and WTP authorized discharge water quality concentrations.

Parameter	CWP Maximum[1)]	WTP Maximum[1)]	Units
Total Suspended Solids (TSS)	25[2)] 150 NTU [3)]	25	mg/L
pH	6.5 – 8.5	6.5 – 8.5	pH
Total Aluminum	0.3	0.3	µg/L
Total Arsenic	10	10	µg/L
Total Cadmium	0.25	0.25	µg/L
Total Cobalt	10	10	µg/L
Total Chromium	20	20	µg/L
Total Copper	10	10	µg/L
Total Iron	1.0	1.0	mg/L
Total Lead	5	5	µg/L
Total Manganese	22	22	mg/L
Total Silver	0.1	0.1	µg/L
Total Zinc	20	20	µg/L

Notes:

1) Concentration in any grab sample that triggers the recirculation of effluent through the CWP and WTP.

2) When available CWP storage capacity is between 10,000 and 50,000 m^3.

3) When available CWP storage capacity is less than 10,000 m^3.

4.5.2 Conditional Water License

Conditional Water License (CWL) (#500684) was issued on November 26, 2018 by the BC Ministry of Forests, Lands and Natural Resource Operations and Rural Development (MFLNRORD). This license replaces a prior CWL and allows for the extraction of water from the WRTSF at the LLW as follows:

- Maximum pumping rate = 70 m^3/h (20 L/s).
- The period of the year during which the water may be withdrawn is the whole year.
- The conditions of CWL #500684 are suitable for an average ore throughput rate of 3800 tpd.

4.5.3 Inspection and Maintenance of Water Management Works

As per Section 2.1 of PE-107835:

“The permittee must regularly inspect the Authorized Works and maintain them in good working order. If components of the Authorized Works have a manufacturer's recommended schedule, then those components must, at a minimum, be maintained in accordance with that schedule.

The permittee must maintain a record of inspections and maintenance of the Authorized Works, and make the record available to an office upon request.

In the event of an emergency or other condition which prevents normal operation of the Authorized Works or leads to an unauthorized discharge, the permittee must take remedial action immediately to restore the normal operation of the Authorized Works and to prevent any unauthorized discharges. The permittee must immediately report the emergency or other condition and the remedial action that has and will be taken to the EnvironmentalCompliance@gov.bc.ca email address or as otherwise instructed by the director.

The director may require the permittee to reduce or suspend operations until the Authorized Works have been restored, and/or corrective steps have been taken to prevent unauthorized discharges."

4.5.4 Surface Water and Groundwater Monitoring

Surface water and groundwater monitoring requirements are specified in Appendices A and B of Permit PE-107835 (Appendix C).

4.5.5 Water Management Facility Compliance Reporting

The Mill Manager and Environmental Superintendent are responsible for monitoring the water management facilities operations for compliance with permits. Reporting pertinent to the mine surface water management facilities and required by *Mines Act* Permit M-243 and Effluent Permit 107835 includes:

- Condition C.4.(e) of M-243 requires that Pretium implement an OMS Manual for the Contact Water Pond that is reviewed annually and updated, as needed, to reflect changes in status as the facility develops.
- Condition C.4.(f) of M-243 requires that Pretium have a Professional Engineer complete an annual inspection of all surface water ponds, ditches, and diversion channels that compose the water management facilities on the mine site. The annual inspection shall be documented and inspection reports shall be maintained onsite and provided to any inspector upon request.
- Condition D.1.(a & b) of M-243 requires that Pretium maintain and implement an Environmental Management System (EMS) consisting of Environmental Management Plans (EMPs) and Standard Operating Procedures (SOPs). The EMS must reference relevant policies and establish proactive procedures to provide direction of effective operational management and monitoring on-site. The EMS must be audited annually, revised as soon as often as required, and be made available to a Mines Inspector at the mine site at all times. Pretium must ensure that mine site employees and contractors are knowledgeable and accountable to act consistently with the requirements of the EMPs and SOPs that form the EMS. This OMS manual is one of the EMPs that comprise the EMS.

- Condition E.2 of M-243 requires that Pretium submit an Annual Reclamation Report Submitted in a form and containing the information required by the Chief Inspector.
- PE-107835 provides discharge limits and rate requirements for effluents discharged into and from the WRTSF (refer to Sections 4.5.1 and 4.5.2 above); authorizes and requires inspection of the various discharge works; contains monitoring and testing requirements for effluents and various sites in the aquatic receiving environment; contains reporting and related procedural requirements in the event of discharge limit exceedance; and specifies annual and other reporting requirements (see Appendix C).

5 Water Management Plan

5.1 Purpose

The purpose of the Water Management Plan (WMP) is to guide water management through operations and closure such that:

- Infrastructure is appropriately designed and maintained to safely convey and withstand predicted flows;
- Sufficient water is available for environmental mitigation purposes and to support consumptive uses of water for mining related purposes;
- Discharges to the aquatic receiving environment occur in a manner that meets environmental and regulatory requirements from both flow and quality perspectives; and
- Flood preparedness

The WMP is focused on mine infrastructure located within the upper Brucejack Creek (including the WRTSF) catchment and is integrated with a water balance model developed for the site. The catchment includes most of the Mine Site Area, defined as the mine infrastructure area west of Knipple Glacier.

The WMP incorporates principles of adaptive management by providing a framework for ongoing review and improvement of water management practices. The document is intended to be used in conjunction with other Environmental Management Plans (EMPs) pertinent to the protection of the aquatic receiving environment, including plans from the MA/EMA Permits Application (Pretium 2015), and subsequent EMP updates such as the ML/ARD Management Plan, Tailings and Waste Rock Subaqueous Deposition Management Plan, Reclamation and Closure Plan, and the Aquatic Effects Monitoring Plan (AEMP).

The WMP focuses primarily on water flows, although the Brucejack water management has been planned such that water flows and quality are fully integrated with facility design and operations. The specifics of water quality mitigation planning and management, including geochemistry aspects and erosion prevention and sediment control, are addressed in the management plans referenced in the previous paragraph.

5.2 Performance Objectives

The WMP portion of the OMS Manual provides guidance for achieving the following performance objectives:

- Managing water to ensure ongoing compliance from a flow perspective with regulatory commitments, guidelines, and objectives;
- Implementing water management measures in a timely and effective manner;
- Integrating water management activities with other management and monitoring programs;
- Intercepting and diverting non-contact water (freshwater) away from work and development areas;
- Minimizing runoff over areas of surficial disturbance where feasible;
- Preventing potential adverse effects on the downstream aquatic receiving environment from a flow perspective;
- Maintaining an adequate supply of water for mine operations; and
- Minimizing the use of freshwater through water recycling whenever possible.

Specific measures implemented to achieve performance objectives are summarized in Table 5-1. This table also lists other applicable management plans for each performance objective.

5.3 Scope

The Water Management Plan component of this OMS Manual is applicable to the following mine facilities and activities, throughout mine life:

- Underground mine water management and dewatering, with water from the underground mine pumped to the WTP;
- Diversion of non-contact (fresh) water around the Mine Site;
- Collection and management of contact water within the Mine Site, and directing it to the CWP for either treatment in the WTP or direct discharge if required conditions are met;
- Water requirements for the process plant, thickened tailings slurry and paste backfill;
- The weir at the outlet of the WRTSF, which is used to monitor discharge rate from the WRTSF; and
- Surface runoff at the 72 km NPAG (non-potentially acid-generating) quarry.

5.4 Operations Water Management

5.4.1 Overview

Water management at the Mine Site includes the following facilities:

- Two fresh water (non-contact) diversion channels divert water around the core Mine Site surface infrastructure area. The Johnson Creek (East) Diversion Channel drains into the WRTSF, while the Camp Creek (West) Diversion Channel drains to Brucejack Creek.
- Wastewater from the camp is directed to a sewage treatment plant (STP) located near the mill building, with the treated effluent discharged to the WRTSF.
- Contact water from the contact water management area (includes the mill and camp pads and additional core infrastructure areas) is directed to the Contact Water Pond (CWP) by way of collection weirs, ditches, sumps and HDPE pipes.
- Contact water in the CWP is pumped to the WTP, located in the mill building. The effluent from the WTP is either used as makeup water for the mill or piped to the WRTSF for discharge.
- Water from dewatering of the underground mine is pumped to the WTP for treatment. The priority use for this treated water is the mill. When there is a surplus of treated water after fulfilling mill requirements, the excess is discharged to the WRTSF.
- Process water is required for the thickened tailings slurry to the WRTSF, the underground paste backfill, and the concentrate slurry. This water is sourced from the WTP treated effluent, reclaim from the WRTSF at the LLW, and ore moisture.
- Tailings are either directed to the paste backfill plant or sent to the WRTSF as thickened tailings for disposal at depth, but never concurrently.
- If there is insufficient make-up water for process from the CWP and/or underground dewatering, fresh water is reclaimed from the lake outlet at the LLW.
- Potable water is obtained from a groundwater well, with subsequent filtration and disinfection treatment before piping to end users at the Brucejack Camp and other facilities.

Water management practices, structures, and systems for the operations phase are described in more detail below, with an emphasis on environmental protection measures incorporated into system operations.

Table 5-1: Water management performance objectives and corresponding management measures.

Mine Phase	Activity or System	Performance Objectives	Management Measure	Other Applicable Management Plans
Operations	Site drainage and ditch operations	Reduction, elimination, or mitigation of erosion and sediment yield interception and diversion of non-contact water. Collecting and treating contact water.	Water management and sediment control structures and facilities are regularly inspected and maintained. Non-contact (freshwater) diversion channels that have been constructed around the operations camp, plant site, and laydown area continue to discharge to Brucejack Creek and the WRTSF. Surface contact water captured by the contact water management system drains into the CWP, and is pumped to the WTP for treatment prior to use in the process plant or discharge to the WRTSF when water is not needed for process.	Reclamation and Closure Plan, AEMP.
	WTP and CWP	Collecting and treating contact water.	Mine water and plant site contact water is treated in the WTP. Excess treated water beyond process requirement is discharged to the WRTSF.	ML/ARD Management Plan.
	Process water supply system	Maintaining an adequate supply of water for mine operations.	Water requirements for the process plant are met with treated underground seepage water, recycling process water and reclaim water sourced from the WRTSF at the LLW.	ML/ARD Management Plan.
	Tailings disposal	Maintaining an adequate supply of water for mine operations.	Tailings are either diverted to the paste plant to be backfilled underground or discharged to the bottom of the WRTSF as thickened tailings.	Tailings and Waste Rock Subaqueous Deposition Management Plan.
	Potable water supply system	Maintaining an adequate supply of potable water for mine operations.	Potable water for Brucejack Camp and mill building is supplied from a groundwater well.	Potable Water Management Plan.
Closure and Post-closure	Site closure and reclamation	Ongoing compliance with regulatory commitments, guidelines, and objectives[1]	Water management/erosion and sediment control structures will be dismantled and sites will be reclaimed to a stable condition for Post-closure. Underground workings will be flooded.	AEMP, Closure and Reclamation, and ML/ARD Management Plan.

Notes:

[1] Performance objective is applicable to all activities throughout all phases of mine.

5.4.2 Non-Contact Water Diversion Channels

Non-contact water from areas up-gradient of the Mine Site is intercepted by two diversion channels: Johnson Creek Diversion (East Diversion) and Camp Creek Diversion (West Diversion) (Figure 5-1).

The construction of both diversion channels was one of the first tasks completed on site. The channels are lined with riprap underlain with geotextile as needed for erosion protection. Both channels were designed for the 200-year return period peak instantaneous flow (Q_{i200}). IFC drawings for the non-contact diversion channels are included in Appendix A.

Johnson Creek Diversion (East Diversion)

The Johnson Creek Diversion (East Diversion) intercepts Johnson Creek and directs the flow eastward around the Mine Site to the WRTSF (Figure 5-1). This channel was specified with a bottom width of 2.5 m, 2H:1V sideslopes, a minimum depth of 1 m, and minimum gradient of 0.5%. Class 50 riprap[2] was specified for erosion protection with a geotextile under the liner. The design flows were estimated at 5.0 m^3/s.

Camp Creek Diversion (West Diversion)

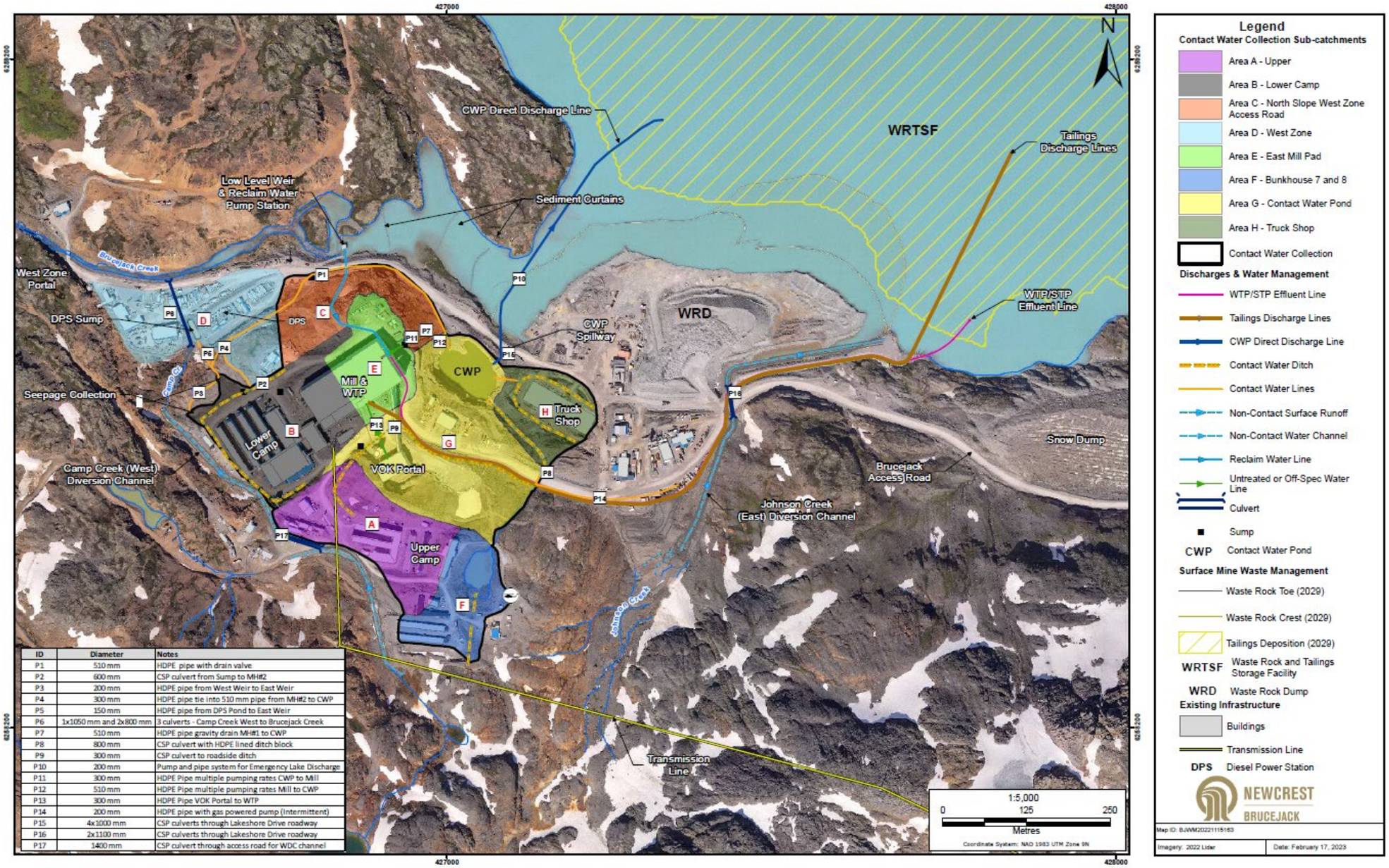
The Camp Creek Diversion (West Diversion) intercepts Camp Creek and direct flows around the western perimeter of most of the Mine Site to Brucejack Creek (Figure 5-1). Camp Creek is culverted through the West Zone Portal Pad. This channel was specified with a bottom width of 2.5 m, 2H:1V sideslopes, a minimum depth of 1 m, and minimum gradient of 0.5%. Class 50 riprap was specified for erosion protection with a geotextile under the liner. The design flow was estimated at 5.3 m^3/s.

5.4.3 Contact Water Management System

Contact water within the core infrastructure area of the Mine Site, where the main excavations of surface bedrock occurred during construction to create building pads, is directed to the CWP. A catchment area of approximately 15 ha currently reports to the CWP. These areas are delineated as Areas A, B, E, F and G as shown in Figure 5-1. Because these areas include excavations in PAG rock, runoff from these areas is directed to the CWP by way of collection ditches and sumps. Similar to the non-contact water diversions, the collection ditches and pipelines are designed to convey the Q_{i200}.

Areas C, D and H do not contain PAG rock excavations from mine construction (Figure 5-1). Area C is largely undisturbed and contains water collection and pumping infrastructure to allow water from its western portion to be directed to the contact water management system as needed for sediment control. Drainage from the Diesel Power Station (DPS) drains to a sump for this facility and from there is pumped to the CWP. The rest of Area D remains outside of the contact water collection system as per the original pre-mine designs, plans and assessments. Area H drains to the WRTSF although runoff from part of the area may be directed to the contact water system as needed.

[2] This class of riprap has an average diameter (D_{50}) of 350 mm with 85% greater than 100 mm and 15% greater than 500 mm.



ID	Diameter	Notes
P1	510 mm	HDPE pipe with drain valve
P2	600 mm	CSP culvert from Sump to MH#2
P3	200 mm	HDPE pipe from West Weir to East Weir
P4	300 mm	HDPE pipe tie into 510 mm pipe from MH#2 to CWP
P5	150 mm	HDPE pipe from DPS Pond to East Weir
P6	1x1050 mm and 2x800 mm	3 culverts - Camp Creek West to Brucejack Creek
P7	510 mm	HDPE pipe gravity drain MH#1 to CWP
P8	800 mm	CSP culvert with HDPE lined ditch block
P9	300 mm	CSP culvert to roadside ditch
P10	200 mm	Pump and pipe system for Emergency Lake Discharge
P11	300 mm	HDPE Pipe multiple pumping rates CWP to Mill
P12	510 mm	HDPE Pipe multiple pumping rates Mill to CWP
P13	300 mm	HDPE Pipe VOK Portal to WTP
P14	200 mm	HDPE pipe with gas powered pump (Intermittent)
P15	4x1000 mm	CSP culverts through Lakeshore Drive roadway
P16	2x1100 mm	CSP culverts through Lakeshore Drive roadway
P17	3400 mm	CSP culvert through access road for WDC channel

Figure 5-1: Mine water management plan with drainage areas.

Area A: Phase 1 Camp Area

A portion of surface runoff from Area A is diverted northeast toward the CWP. Runoff is collected on the inside ditch of an internal road that leads from the Mill Pad to the Phase 1 Camp buildings where water is collected in a sump located to the immediate west of the VOK mine portal; from here flows are conveyed via a culvert and ditch towards the CWP. The remainder of the Phase 1 Camp area drains north and onto the Phase 2 Camp Pad, where it is ultimately captured by the pipeline from the Camp Pad to the CWP (see description of Area B). Figure 5-1 illustrates the water management infrastructure for Area A.

Area B: Phase 2 Camp Pad and West Portion of Mill Pad

Surface Runoff:

Water collected by perimeter ditches on the Phase 2 Camp Pad reports to a drainage manhole (MH#2) at the northwest end of the pad. Runoff reporting to MH#2 is conveyed by a 20” (510 mm) diameter HDPE pipe to the CWP. This 20” pipe initially runs down toward Area C before running along a ditch on the inside of Lakeshore Drive (Figure 5-1). To prevent ice build-up in the line during the winter months, a valve is in the vicinity of the Area C sump to allow for the 20” pipe to be drained prior to the onset of winter.

A sump at the northeast corner of the pad also collects runoff from the area between the camp building and the mill. A 600 mm diameter culvert conveys runoff from the sump to a drainage manhole (MH#1).

Subsurface Runoff:

Two concrete weirs (East and West) were built downgradient of the pads where water is collected, and from here conveyed through a pipe towards the CWP. Location of east and west weirs are illustrated in Figure 5-1. Figure 5-2 shows a photograph of the west weir.

The weirs are founded on bedrock and are designed to contain the Q_{200} without overtopping. IFC drawings of the weirs are attached in Appendix A. Seepage and surface runoff collected in the West Weir are routed by gravity via an 8” (200 mm) HDPE pipeline that discharges into the East Weir. Runoff collected in the East Weir discharges to a 12” (300 mm) HDPE pipeline, which ties into the 20” line that runs from MH#2 to the CWP. In addition, flows from the DPS pond are pumped into the East Weir (Figure 5-1).

Figure 5-2: Overview of West Weir. SRK photograph of August 20, 2019.

Contact Water Ditches:

To minimize potential leakages on the camp and mill pad perimeter collection ditches, the permit-level WMP indicated that an HDPE geomembrane liner was to be placed under sections of the collection ditches founded either in high hydraulic conductivity (K) soil (i.e., soil with less than 20% of material passing No. 200 based on field classification) or fractured bedrock based on field observations. However, any seepage from these collection ditches is expected to report to the East Weir or the West Weir. As runoff and seepage collected in these areas is conveyed by gravity drainage or pumping to the CWP, the ditches have not been lined.

Area C: North Slope West Zone Access Road

Drainage from the northern portion of Area C is collected and directed to the CWP via a pumping system as needed to manage water along this section of Lakeshore Drive, including to prevent excessive wetting of the roadbed materials. A sump, east of the DPS Pad collects runoff from a gully located directly upslope, as well as ditch drainage to the east. Any runoff reporting to the sump is pumped to the CWP (Figure 5-1).

Area D: West Zone

The West Zone pad area includes the West Zone Portal and adjacent pad, the DPS Pad, and the DPS Sump (Figure 5-1). The Camp Creek (West) Diversion is culverted through this area with flows conveyed through three culverts (1 x 1050 mm and 2 x 800 mm). Surface runoff from this area reports to Brucejack Creek, with an approximate 1 m high armored berm providing separation between Brucejack Creek and mine infrastructure..

The Diesel Power Station (DPS) Pond is a lined facility that was constructed in 2016. Portions of the DPS Pad that contain diesel generators and fuel tanks are also lined. Runoff from lined areas

reports to an oil water separation system, prior to discharge to the DPS Sump. Runoff collecting in the DPS Sump overflows through a vertical standpipe to an adjacent sump, from where it is pumped to the East Weir for conveyance to the CWP (refer to pipeline label P5 in Figure 5-1).

Area E: East Portion of Mill Pad Area

Runoff from Area E includes the east half of the Mill Pad. Runoff within the mill footprint reports to a buried perimeter drainage system, which is tied into Manhole #1 (MH#1). Runoff reporting to MH#1 drains by gravity into the CWP via a 20” line.

Area F: Bunkhouse 6 Laydown

The Area F collection ditch and Area A/E/G collection ditch discharge to a common sump, before draining northwest to the CWP.

Area G: Contact Water Pond

Area G includes the footprint of the CWP, as well as upslope areas (Figure 5-1). Surface runoff from this area reports to the CWP, either directly as sheet runoff, or is through a ditch system. Contact water runoff from Zone A discharges into a ditch located on the upslope side of the access road. This ditch also intercepts contact water runoff from the mine portal area. In addition, surface contact runoff from Area F discharges into this ditch, upstream of the access road crossing.

The combined runoff is intercepted and conveyed across the access road through an 800 mm diameter CSP culvert. Downslope of the culvert, flows are conveyed in an HDPE-lined ditch in a northwest direction to the CWP.

The CWP spillway consists of a concrete control section, a channel excavated down to bedrock (with riprapped side slopes), and a culverted crossing (4 x 1,000 mm) of Lakeshore Drive.

Management of pond volumes can be divided into five categories: normal operating conditions, upset conditions in the WTP, pumped discharge (suitable water quality), pumped discharge (emergency conditions), and emergency discharge. Management practices for each operating condition are summarized in Table 5-2. Trigger levels for these various scenarios are discussed in Section 5.7.6.

Area H:

Area H includes the footprint of the Truck Shop (Figure 5-1). Surface runoff from this area reports to the CWP, either as runoff or through a perimeter ditch system. Water collected in the perimeter ditch is collected into a sump (on the west side) and then pumped into the CWP. Peak flow estimates and pump sizing analyses are presented in Appendix E.

Table 5-2: CWP operating conditions and management practices

CWP Operating Conditions	Management Practice
Normal Operating Condition	During normal operating conditions, water levels in the CWP fluctuate below 80% (water level at elevation 1374.8 masl, storing ~40,000 m^3) of the maximum storage capacity. The CWP has been designed to store 50,000 m^3 of contact water without discharge through the spillway. The CWP reclaim water system is operated as needed to manage the CWP. As-built drawings for the CWP reclaim system[3] are provided in Appendix B. A total of four submersible pumps are used to dewater the pond. Two large pumps, each with a capacity of 220 m^3/h, are connected to 6" hoses. Two smaller pumps, each with a capacity of 65 m^3/h, are connected to 4" hoses. Water is pumped from the CWP to the WTP in a 12" line that is heat traced and insulated. Any combination of these pumps can be operated to supply a range of flows to the WTP (or for emergency discharge to the WRTSF), depending upon the CWP pond level and WTP minimum flow requirements.
Upset Conditions in WTP	In the event of upset conditions or maintenance requirements that require temporary shutdown of the WTP, the CWP will be passively managed allowing pond volumes to increase up to 95% of the maximum storage capacity (water level at elevation 1376.1 masl, storing ~47,500 m^3).
Pumped Discharge (Suitable Water Quality)	CWP water quality must meet the discharge characteristics in PE-107835 Subsection 1.2.3 prior to direct discharge to the WRTSF. Direct discharge to the WRTSF may occur at any time that the CWP available storage capacity is between 10,000 and 50,000 m^3 provided that the water quality characteristics of Subsection 1.2.3 are met prior to discharge. This discharge would occur via the 8" (200 mm) direct discharge pipeline to the WRTSF.
Pumped Discharge (Emergency Conditions)	When pond levels reach the spillway invert, a controlled but unintended release of contact water will occur into the WRTSF. To minimize potential impacts to the water quality, it is preferable that any release of contact water occur at depth, rather than discharging to the surface as would occur from the spillway discharge. Therefore, when pond volumes reach 95% of the CWP storage capacity and dependent upon circumstances (e.g. if significant additional rainfall is forecast), direct discharge to the WRTSF via the 8" (200 mm) direct discharge pipeline may be initiated on an emergency basis. This pipeline can discharge up to 600 m^3/h with two pumps operating. This pipeline would operate as long as pond volumes remained above the 95% level. If the CWP water quality does not meet the discharge characteristics in PE-107835 Subsection 1.2.3 prior to this discharge occurring, non-compliance provisions of PE-107835 would take effect (PE-107835 Subsections 5.3 and 5.4, and reporting to MEMPR, the Tsetsaut/Skii km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), Nisga'a Nation, through Nisga'a Lisims Government, the Alaska Department of Natural Resources, and to federal agencies if applicable.)
Emergency Discharge	Emergency discharge will occur through the spillway when pond levels reach the spillway invert. This controlled release of water would report to the WRTSF. If the CWP water quality does not meet the discharge characteristics in PE-107835 prior to this discharge occurring, requirements outlined for Pumped Discharge, Emergency Conditions, would apply.

[3] Electric power is supplied to the mine site from a 69 kV transmission line. A 4.16 kV overhead distribution system is utilized to provide power to the major infrastructure around site and a 600 v feed for the CWP pumping system

The CWP is required to have a minimum storage capacity of 50,000 m^3, which is achieved at a maximum pond elevation of 1,376.5 m (i.e., the invert elevation of the spillway inlet). This elevation is the maximum operating and storage level of the CWP. Refer to CWP Record Drawings contained in Appendix B ("Contact Water Pond Construction Records Report" by BGC (2018), see Appendix A). Figure 5-3 illustrates the stage storage curve for the CWP.

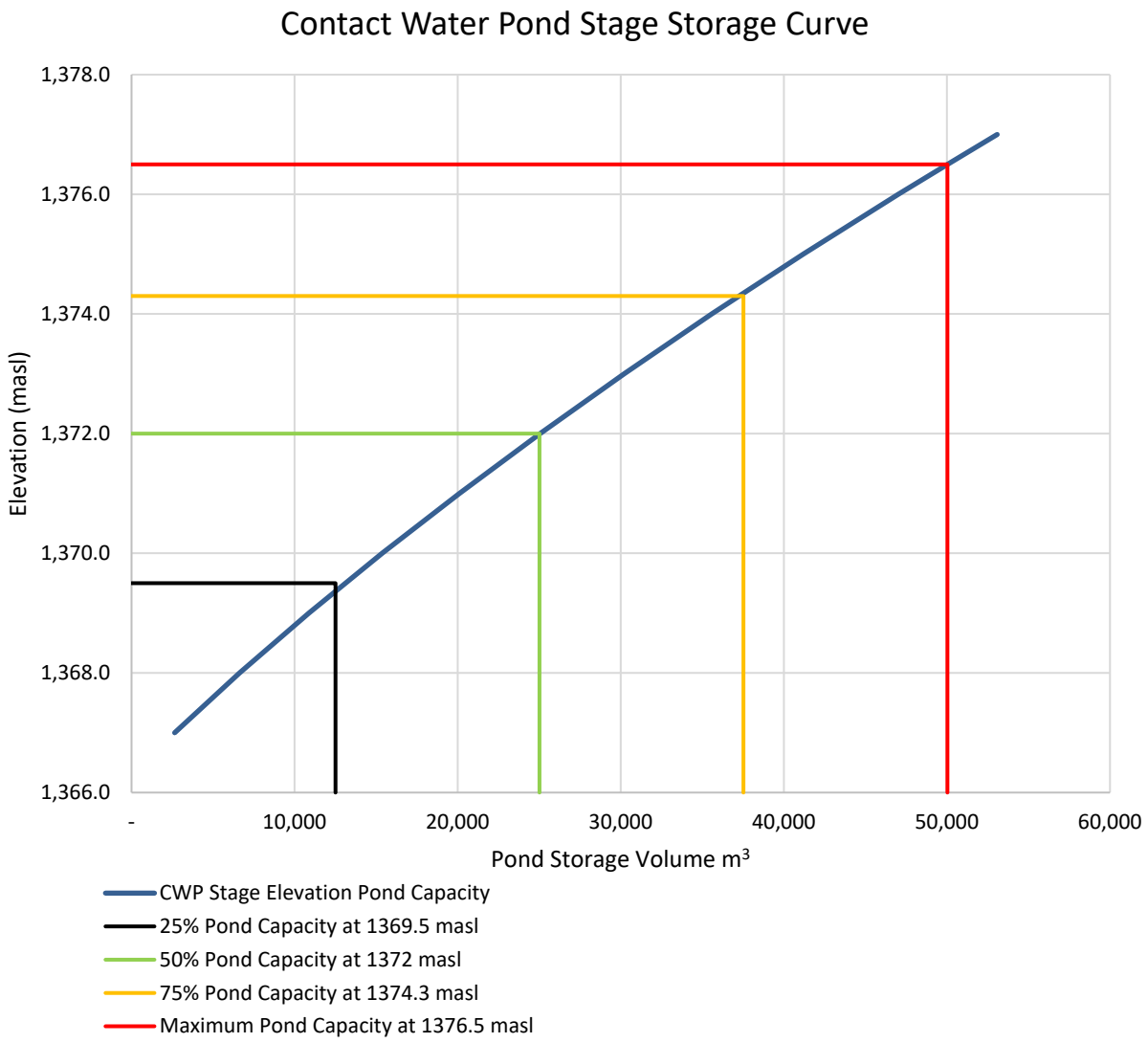


Figure 5-3: Storage capacity of the CWP

Environmental Protection

Regulatory requirements pertinent to the Mine Site water management system are described in Section 4.5. *Mines Act* Permit M-243 and Effluent Permit 107835 (both included in Appendix C for reference). Effluent Permit 107835 provides discharge limits for mine effluent (Section 1.0 of the permit); specific requirements for surface and groundwater flow and quality, and aquatic biological, sediment monitoring and toxicity testing requirements (refer to Section 4.0 and the related appendices in the Permit).

As discussed in Section 4.4, the CWP was constructed without a liner, as it has been excavated entirely within bedrock. The following monitoring is conducted to check for any seepage that could warrant geotechnical assessment:

- Quarterly monitoring of groundwater levels (including datalogger downloads of water level) and groundwater quality in BJ-GW16-5A/B, installed northwest of the CWP, and BJ-GW18-23A/B, installed northeast of the CWP, following the methodologies and parameters of the permitted (PE-107835 and M-243) groundwater monitoring network.
- Inspecting the area between the CWP and the WRTSF for evidence of seepage from the CWP once a year during the snow-free period for pond levels less than 30,000 m^3 capacity (elevation = 1373 masl), and once a month for higher pond levels, until it can be established that seepage breakout is not a concern for the normal operating range of the pond. If seepage breakout is observed to be a concern, this inspection will be augmented by mapping of any larger, persistent discontinuities that daylight in the northeast wall and if/when possible the floor of the CWP. Mapping of the northeast wall will be accomplished using photogrammetry when pond levels are low.
- Recording water levels in the CWP on at least a daily frequency.

Figure 5-4. View of CWP spillway concrete control section. SRK photograph of August 20, 2019.

5.4.4 Waste Rock Stockpiles

Waste rock from the underground mine is stockpiled temporarily at the WRD prior to sorting and subaqueous deposition. These temporary stockpiles are situated either on or slightly up-gradient of the WRTSF; in both cases rainfall and snowmelt infiltrates and eventually reports to the WRTSF.

5.4.5 Underground Mine

Dewatering of the underground mine will continue throughout mine operations. Water pumped from the underground mine workings is directed to the WTP, where it is treated prior to use in the process plant or discharge to the WRTSF. Modeling studies undertaken in 2015 predicted monthly average dewatering rates reaching a maximum of 5,300 m^3/d. Preliminary results from ongoing updates to both the numerical groundwater model and site wide water balance model indicate that the 2015 reported values are reasonably conservative and that underground dewatering rates are expected to stabilize in the last four years of mining.

5.4.6 Operations Water Treatment Plant

Water from the underground mine and contact water collected from the Mine Site contact water management area is treated by the WTP. Treated water is used in process, with the excess discharged to the WRTSF and to the CWP. The WTP has a maximum treatment capacity of approximately 417 m^3/h (10,000 m^3/day). Water pumped to the WTP is initially fed through a clarifier to remove most of the TSS. The clarified water is then sent to the primary treatment train and WTP sludge is discharged to the WRTSF with the tailings slurry within the proportion authorized by Permit M-243. Magnetic flow meters are used to track flow rates and associated volumes. Additional details of the WTP are provided in Section 7.1 of the 2015 *MA/EMA* Permits Application by Pretium (2015) and subsequent Annual *MA/EMA* reports (Pretium 2016 to 2019). The WTP will be used throughout the operations and closure phases until it is no longer required for water treatment.

The WTP requires a minimum feed of 175 m^3/h to operate at peak efficiency. Whenever this input rate is not met from the underground mine and process water, water from the CWP is recycled to the WTP to meet this minimum demand.

In the event of upset conditions or maintenance requiring temporary shutdown of the WTP, contact water from the underground mine can be temporarily diverted and stored in the CWP.

5.4.7 Process Water Supply System

Process water is required for:

- Mill processing;
- The thickened tailings slurry to the WRTSF;
- The underground paste backfill;

- The filtered and bagged concentrate; and
- Mine supply water for underground dust control and drilling.

The balance of the process water is supplied from the WTP, which treats water from the mine (underground water), CWP; and a portion of the CWP water. Process water is also sourced from ore moisture and a reclaim system installed at the low-level weir at the lake outlet.

5.4.8 Freshwater Supply System

Freshwater is held in a fresh/fire water storage tank. The tank is equipped with a suction pipe mounted at approximately 2/3 of tank height, which ensures that the tank always contains at least a two-hour supply of water for firefighting. Water is supplied to the freshwater tank from the LLW and WTP treated water. Freshwater from this tank is primarily used for:

- Fire water for emergency use;
- Gland water for the slurry pumps;
- Reagent make-up;
- Mine supply;
- Process water make-up;
- Mill process spray nozzles;
- Gravity concentrator fluidization water; and
- Gold Room Scrubber.

In addition to freshwater usage, the overflow supernatants of the tailings thickener is reused in the process circuit.

5.4.9 Tailings Disposal

Flotation tailings are either used in paste backfill in the underground workings or deposited in the WRTSF. The Brucejack Mine has a common thickener and filtration system for tailings dewatering prior to deposition in WRTSF and underground paste backfill. The thickened tailings deposited in WRTSF are pumped in a slurry consisting of a targeted 55 to 65% solids by weight, while the paste backfill has a slightly higher target percentage of solids (63 to 65%).

5.4.10 WRTSF Outlet Weir

The low level weir (LLW) is a weir is located across Brucejack Creek at the outlet of the WRTSF. Site location of the LLW is provided in Figure 5-1 and a photo of the location is included as Figure 5-5. The purpose of the LLW is to provide flow monitoring of the effluent stream from the WRTSF at a level of accuracy that meets regulatory requirements. The facility is also used as a platform to pump reclaim water to the mill.

Figure 5-5: View looking upstream to constructed low level weir. SRK photograph of August 20, 2019.

The LLW consists of a compound cross-section: concrete broad-crested structure with a low level opening to pass average annual flows and an overflow crest to pass peak flows (up to 200-year return period events). The LLW is enclosed in a concrete chamber founded on bedrock with a grating floor and heated superstructure above it. This configuration keeps the weir ice free during the winter period. This weir is illustrated in the conceptual design drawing in Figure 5-6 and Figure 5-7.

Water enters the upstream chamber through an underflow baffle, passes over the weir, and exits the downstream chamber through another underflow baffle. The reclaim water pumps are mounted on the floor above the upstream chamber. The water passes through the dividing wall into a secondary chamber through two openings, which are offset to either side of the pump intakes to minimize turbulence upstream of the weir. The weir and the flow monitoring instrumentation are located in the secondary chamber.

The underflow baffles at the inlet and outlet keep ice outside of the weir and promote flow mixing. The turbulence caused as water flows over the weir crest also creates flow mixing. This design is intended to ensure a proper reading for average TSS and other water quality parameters, which are monitored by sampling of water at the downstream end of the weir chamber.

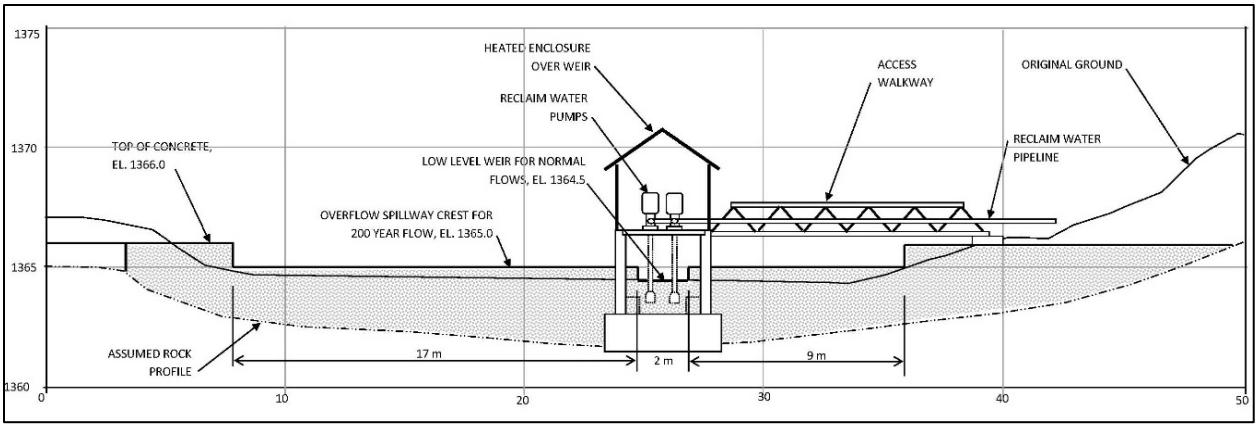


Figure 5-6: Low level weir profile looking upstream.

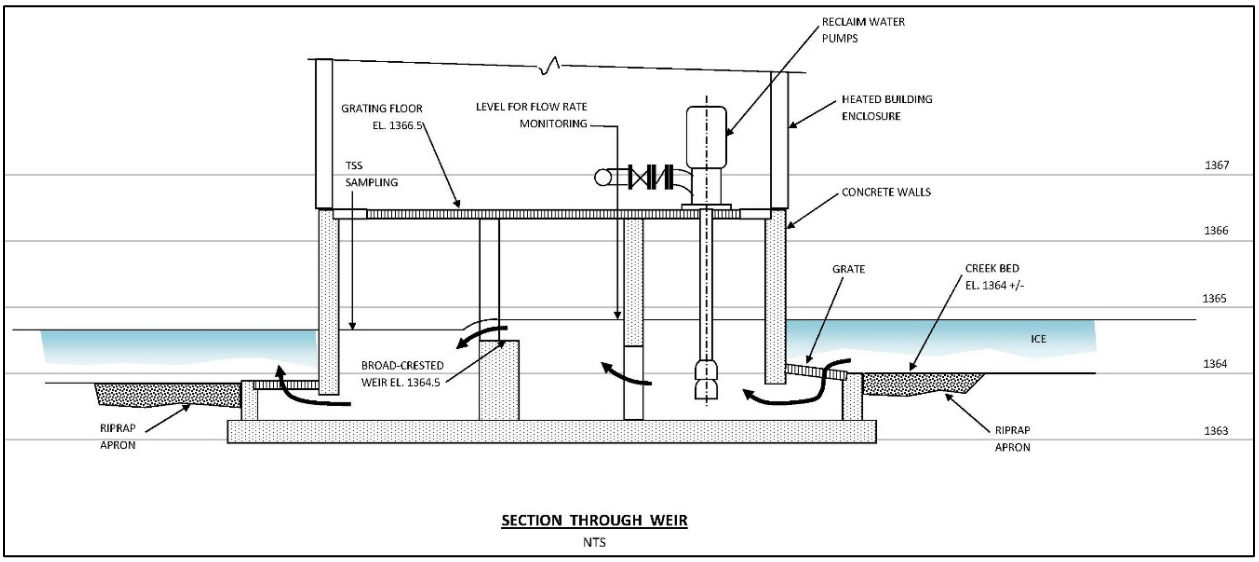


Figure 5-7: Section through low level weir.

Automated instrumentation is in operation to continuously measure water level, which is converted to a flow rate using an equation for a rectangular broad-crested weir (hydrometric station BJ 3.10). IFC drawings for the LLW are attached in Appendix A.

5.4.11 Pipelines and Pumps

Installed pipelines and pumps are summarized in Table 5-3.

Table 5-3: Summary of pipelines and pumps.

From	To	Pipeline Diameter (inches)	Pump Rate
West Weir	East Weir	8	gravity
East Weir	20” line	12	gravity
MH#2	CWP	20	gravity
DPS Sump	East Weir	8	60 m^3/h

From	To	Pipeline Diameter (inches)	Pump Rate
Area C sump	CWP	6” lay-flat hose	225 m^3/h
Area H Sump	HDPE-lined ditch/CWP	4” lay-flat hose	685 m^3/h
Underground	WTP	6” + 8”	6” only + single pump train: 150 m^3/h 8” only + single pump train: 180 m^3/h 6” and 8” + two pump trains: 385 m^3/h
LLW	Mill	6	80 m^3/h
CWP	Mill	12	2 x 65 m^3/h, 2 x 220 m^3/h
CWP	WRTSF	8	2 x 65 m^3/h, 2 x 220 m^3/h – close valve to Mill and open valve to 8” line to WRTSF
Mill/WTP	CWP	20	gravity
MH#1	CWP	20	gravity
Potable Well	Site	2	8 – 9 m^3/h

5.4.12 Closure and Post-Closure Water Management

Closure will involve the removal of all structures and equipment, closure of the portals, flooding of the underground mine workings, and site rehabilitation. The primary goal of water management activities during the closure and post-closure phases will be to minimize the long-term effects on the environment and return the site to as close to its pre-disturbance condition as possible.

Reclamation and closure activities that will occur during the Closure phase are described in the Reclamation and Closure Plan -MA/EMA Permits Application, Chapter 5 (Pretium 2015) and the subsequent annual reports by Pretium (2016 to 2021); this was updated in the 5 Year Mine Plan and Reclamation Program due July 31, 2020. The description that follows highlights reclamation and closure activities pertinent to water management as described in 2015.

When Mine Site Area roads are no longer required, they will be deactivated following the standards of the Health, Safety and Reclamation Code for Mines in BC These standards include, but are not limited to:

- Removal of the LLW, all culverts and bridges;
- Contouring potentially unstable road shoulders;
- Installing water bars (interceptor dikes);
- Ripping the road surface; and
- Revegetation.

At final closure, the two non-contact water diversion channels will remain in place.

The underground workings will be progressively backfilled with tailings (i.e., paste) and waste rock throughout mine operations and, once mining is completed, the remaining underground voids will be allowed to flood. The ventilation shafts and West Zone underground portal will be sealed with concrete plugs, and the new portals will be closed. Some seepage may occur from the West Zone Portal or adjacent rock face on a seasonal basis; any seepage flows from the West Zone Portal will be monitored in accordance with the monitoring plan.

The CWP will be decommissioned by backfilling and reclaiming it during the Closure phase.

5.5 Adaptive Management

Effective water management requires an integrated, adaptive approach. Water management activities emphasize best management practices (BMPs) to minimize disturbance to vegetation, soil, and natural drainages during operations. BMPs are discussed in the following sections. Measures that will apply throughout mine Operations and Closure incorporate adaptive management as part of the WMP.

5.5.1 General Approach

The general adaptive management approach for the WMP is describe below:

- Adaptive management is a process for continually improving management practices by learning from the outcomes of operational approaches (e.g., Holling 1978; Taylor et al. 1997). To be effectively implemented, it requires a prompt response to field observations of changing environmental conditions and limitations or deficiencies in existing water management structures.
- When properly implemented, adaptive management enables a cost and time-effective hierarchical response to potential water management issues. BMPs and a corresponding inspection, maintenance, and monitoring program constitute the basis of water management planning.
- The adaptive management approach promotes proactive measures, with the caveat that contingency plans and materials should be in place prior to the initiation of work so that additional measures can be quickly implemented if needed.
- Communication is essential in the implementation of adaptive management strategies of the WMP. Relevant site personnel are advised about the WMP's goals and purpose, and their responsibilities to implement the WMP successfully. Personnel are informed of changes in a timely manner. Appropriate training and field supervision are important elements of the WMP. It is important that personnel understand why water management measures are needed and how to implement them correctly.
- Adaptive management options that may be employed for the Mine Site include:
  - Increasing monitoring and sampling frequency;
  - Adding or relocating monitoring locations;

- Developing new contingency plans, operating procedures or analytical methods;
- Updating conceptual and numerical models developed for the site; and
- Adopting mitigation strategies.

5.5.2 Surface and Groundwater Adaptive Management Approach

If any issues, such as a non-compliance, are identified in any of the surface water or groundwater quantity or quality results through interpretation of instrumentation data and visual inspections of conditions on site, a review of the sampling frequency, parameters of interest, and sampling locations will be completed. A summary of adaptive management strategies for surface water infrastructure are presented in Table 5-4 . A summary of the main components of the groundwater monitoring program related to adaptive management are provided in Table 5-5. For sampling details and locations refer to PE-107835.

Table 5-4: Surface water adaptive management strategies.

Component	Objective	Management Approach
Non-Contact water diversion structures	Evaluate performance of infrastructure during freshet	Current winterization strategies and functioning during freshet is working well, however, if icing conditions worsen, additional ice control strategies will be implemented as appropriate, such as culvert steaming.
Contact Water Weirs	Evaluate seepage downstream of weirs	If monitoring of downstream seepage indicates an increase in flows, consideration will be given to for additional collection and pumping capacity

Table 5-5: Groundwater monitoring program components managed adaptively.

Component	Objective	Management Approach
Groundwater inflow pathways to the underground	Evaluate the accuracy of predicted groundwater inflow rates to the underground versus actual rates	Predicted inflow rates are considered conservative however rates will be monitored and additional management will be implemented as appropriate if rates are greater than predicted
Underground dewatering response	Evaluate the effects of underground dewatering on groundwater levels and hydraulic gradients	Monitoring results will be used to evaluate the effect of underground dewatering
Leakage rates from WRTSF and Brucejack Creek	Confirm and quantify leakage rates from WRTSF and Brucejack Creek	Leakage rates are assumed to be negligible however gradients from the lake to the underground will be monitored
Groundwater flow paths during operations	Evaluate changes in groundwater flow system and quality in	Monitoring results will be used to update conceptual and numerical models developed for the mine

Component	Objective	Management Approach
	response to mining activities	
Seepage from adit plugs at closure	Inspect adit plugs and if necessary, quantify seepage rates from the adit plugs that will be placed at the West Zone adit at closure and confirm that rates are negligible	Groundwater levels recovery in the underground will be monitored during closure and into post closure. If groundwater levels rise above adit plugs or seals, seepage around the plugs is possible. In this event, mine seals and caps will be inspected for seepage. Seepage rates are assumed to be negligible however contingency plans for monitoring the seepage rate and quality will be developed if seepage is observed. Results of the seepage monitoring will inform decision making as to the need for pressure grouting, or other repair, around plugs and seals is necessary. Failure of the plug would result in leakage to Brucejack Creek, requiring corrective mitigation measures.
Underground filling	Evaluate time to fill the underground workings at closure	Monitoring results will be used to update conceptual and numerical models developed for the mine
Groundwater flow paths at closure	Evaluate long-term predictions of groundwater elevations at closure	Conceptual and numerical models developed for the mine will be updated. New contingency plans will be developed if groundwater elevations do not trend as predicted.

5.5.3 Instrumentation

The adaptive management approach relies on the monitoring, analysis and interpretation of data collected by instrumentation installed on site to adapt to changing surface water and groundwater conditions. Data will be collected, processed and interpreted with the following considerations for application to the adaptive management program:

- Collecting data related to surface water quantity and groundwater quality and quantity according to the specified locations and frequency outlined in PE-107835;
- Processing and summarizing the data into an appropriate format;
- Reviewing instrumentation readings and comparing with baseline and predicted conditions;
- Identifying significant changes along with possible erratic readings or malfunctioning instrumentation;
- Ensuring that data is recorded and processed;
- Increasing the frequency of measurements if significant changes in the readings are observed or readings are significantly different from predicted conditions;
- Noting any malfunctioning, damaged or destroyed instruments and providing for maintenance where feasible and/or replacement where necessary; and,

- Informing the appropriate site personnel of readings that exceed threshold values and conditions and taking appropriate actions to manage changing conditions on site.

5.5.4 Seasonality

Seasonal climatic influences will be managed adaptively as outlined in Table 5-6.

Table 5-6: Seasonal climatic influences managed adaptively.

Season	Climate Considerations	Operating Considerations	Procedure
Winter (Nov – Mar)	• Runoff flows are negligible. • Lake, ditches, and channels freeze. • Freeze-thaw cycles impacts ground conditions. • Snow accumulation.	• Potential freezing and frost-heaving of discharge lines. • Impact of snow accumulation on access roads/ buildings/ geohazards.	• Inspections of water management structures. • Snow/ ice removal. • Review snow survey data from VOK station.
Spring (Apr – June)	• Breakup of ice at lake outlet. • Snowmelt contributes additional flows. • Freeze-thaw cycles contributing flows.	• Potential for ice jams and unsafe ice conditions. • High runoff/ erosion potential. • Large amount of surface runoff may cause erosion on the slopes of the landforms.	• Inspection of water management structures for potential impacts from increased runoff and seepage. • Monitoring of water levels and water quality at lake outlet. • Standby of emergency pumps if CWP water levels reach above a trigger (see Section 8.5).
Summer (July – Aug)	• Potential for single large precipitation event. • Large event results in increased runoff. • Potential for high wind speeds.	• High runoff/ erosion potential. • Increased infiltration rates may result in elevated groundwater levels or seepage rates.	• Inspection of water management structures for potential impacts from increased runoff and seepage. • Standby of emergency pumps if CWP water levels reach above a trigger.
Fall (Sept – Oct)	• Potential for single large precipitation event including rain-on-snow. • Large event results in increased runoff. • Freeze-thaw cycles. • Snow accumulation.	• High runoff/ erosion potential.	• Inspection of water management structures. • Standby of emergency pumps if CWP water levels reach above a trigger.

5.6 Water Management Facilities Maintenance

This section provides guidance and performance criteria for proper maintenance of water management facility components. Pretium has identified essential facility procedures and parameters to ensure that maintenance is conducted in accordance with applicable regulatory requirements and generally accepted operating practices. Maintenance activities required for the continued safe operation of the water management facilities include inspection, maintenance and repair of the following components:

- Contact water collection and delivery to the CWP (including contact water collection ditches, East/West Weir, culverts, sumps/manholes, pipelines and pumps)
- Non-contact water diversion channels
- LLW reclaim system
- CWP reclaim system to the WTP
- Underground pump system to the WTP
- Supply of maintenance tools
- CWP spillway and emergency line discharge
- Winterization

Maintenance records must be retained by the department performing the work. Timing of maintenance actions for unusual conditions should be based on specific recommendations from inspection/surveillance findings. Time frames for routine maintenance of pumping components should be based on manufacturer's recommendations when available.

5.6.1 Maintenance Parameters

Maintenance is performed on a regular basis for all the main factors that would reduce the quality, functionality and/or capacity of the water management facilities. Monitored parameters are completed daily and indicate if maintenance attention is required. Common parameters include, but not limited to:

- Pipeline wear and thickness;
- Pump temperature, the presence of cavitation;
- Excessive equipment sound emissions;
- Diversion channel and culvert capacity;
- Functionality of flow meters;
- Physical integrity and functionality of the CWP emergency spillway;
- Integrity of the CWP cut slopes; and

- Water flow rate.

5.6.2 Routine and Predictive Maintenance

Pretium has developed a preventive maintenance system that involves the Mill Maintenance/Operators, Surface Operations and Environment departments. Pretium operators are trained on the equipment and infrastructure within their workplace and can early identify odd situations or unusual equipment behavior. Their work scope includes checks to ensure optimal performance of the various systems in place. If something should require the maintenance department to take action, the operator will write a work order or request immediate attention, as needed.

CWP and Diversion Ditches

The following are examples of specific maintenance activities:

- Regularly check non-contact and contact water ditches and culverts for accumulation of debris or sediment, or any other form of blockage and remove if required;
- Visually inspect contact water ditches for cracking, bulging, slumping, and any other indications of slope movement;
- Remove accumulated sediment from the CWP pump sump; and
- Repair erosion gullies, local slumps or slides in the diversion ditches or spillway channel.

Water Delivery and Reclaim System

Regular maintenance of the water reclaim and delivery system will include:

- Checking the pump anchor system;
- Carry out maintenance as recommended by fitting and valve suppliers;
- Regularly inspect major wear components;
- Replace worn parts as recommended by manufacturers;
- Perform regular performance tests on the various pumps;
- Preventative maintenance of pumping systems; and
- Maintain system instrumentation.

5.6.3 Event-Driven Maintenance

Any unplanned maintenance events will be addressed in order of priority by Pretium staff. Incidents classified as an emergency will be assessed and dealt with in the appropriate manner depending on the situation. Such situations will involve impacts to personnel safety, the environment, or ensuring compliance with relevant permit requirements and may require drawing

resources from all areas of the mine and possibly outside personnel. All reasonable efforts will be made to mitigate the emergency condition as quickly and safely as possible.

Those unplanned events that are not considered an emergency will be documented and mitigated according to operating schedules and event priority.

5.6.4 Maintenance Documentation

Operation of the various water management facilities will be consistent with all the documentation used in the mill department. The correct management of the facilities, and associated equipment, requires detailed accounts of all pertinent information and any modifications thereto. The recording of maintenance documents enables Pretium to develop new strategies for optimal preservation of equipment and facilities and may include:

- Order requests;
- Log books;
- Audiovisual documentation;
- Frequency and cause of problems;
- Scheduled maintenance;
- Inspection reports;
- Equipment manuals;
- Spare list;
- Modification history; and
- Operations report.

5.6.5 Maintenance Reporting

The maintenance reporting at the Brucejack Mine is document-centered, and used for prevention, forecasting, tracking, and learning of any failure in the equipment or facilities. The final purpose of maintenance reporting is to improve equipment/ facility performance, minimize downtimes, and diminish maintenance expenses. These documents are used internally within the different departments and will be stored as digital copies.

The operators check sheets will record all operational and wear condition of relevant equipment. For instance, there is a project management program in the JD Edwards System (mine accounting system) for all mill equipment. This includes equipment for the water management facilities, as well as Bill of Materials (BOMs), which lists the location and availability of spare parts.

When the equipment or facility needs maintenance attention, a document designated as a "work order" will be made by the operator and delivered to the corresponding department. If any

equipment or facility needs urgent attention, the operator will follow the contingency protocols specified in the respective standard operation procedure document, requesting urgent attention, and thereafter record the event in the log book when the emergency is satisfactorily resolved.

5.6.6 Winterization

Seasonal climatic influences are managed adaptively, and proactive measures are exercised prior to winter to maintain the water management infrastructure systems around Brucejack mine site. Due to potential freezing and frost heaving of discharge lines, impact of snow accumulation on access roads, ditching, and buildings, the following preventative measures are performed by Mill Maintenance, Surface Operations, and Surface Maintenance accordingly.

Mill Maintenance

The mill water treatment plant operator (WTP) inspects the reclaim weir and contact water pond (CWP) once per 2-week shift in the winter time. The operator checks the CWP for cracks, deformation of the rock wall, depressions in the snow, and leaks in the piping. As part of the CWP and weir inspection, the mill verifies that the heat trace light is on within the reclaim pumphouse and inside the CWP valve sea can. Mill Maintenance is also responsible for regular Preventative Maintenance (PM) on the compressor building and ensuring the bubbler system in the CWP is operational prior to and during winter months, and this is also included on a CWP checklist. The bubbler system is a visual inspection to ensure that the system is functioning.

Surface Operations

Surface Operations have preseason meetings with the Environmental Department, De-watering Coordinator and Surface Maintenance to ensure that ditches are clear, all mechanical checks on pumps are completed, and lines are drained and properly stored. Surface operations is also responsible for removing the snow and ice from around critical areas, to gain access for inspection; such as pipelines, ditches, access roads and rooflines. During temperature fluctuations, ditches and pipes are monitored. Drill steel rods have been put in place to protect surface piping and ditching during winter months. Rock scaling with excavators is completed in areas where geo-hazards are present.

Surface Maintenance

Surface Maintenance are responsible for daily checks on the current electrical draw and heat trace on all piping. These are especially important in the fall of each year. Insulation damage is also checked when inspecting the heat trace. Surface Maintenance are also responsible to drain the 20” contact water line and other contact water pipes so they do not freeze before winter. Surface Maintenance are also responsible to steam the 20” pipeline and other pipelines before spring freshet to ensure they are functioning.

5.7 Water Management Facility Surveillance

5.7.1 Surveillance Objectives

Surveillance of the water management facilities is required to determine if the facilities are operating within expected parameters. Deviations from expected performance may require adjustments to operation, maintenance or design to facilitate ongoing safe and efficient operation of the facilities.

The conceptual procedure for surveillance is shown in Figure 5-8. Surveillance is undertaken by two primary methods – visual inspection and reading of instruments. Results of these qualitative and quantitative observations are compared to the expected performance of the facilities. If observations are within the expected range or performance, the results of the surveillance are simply recorded. If observations are outside the expected range, the results of the surveillance are recorded, and further evaluation is completed to determine if remedial action is necessary. If remedial action is needed it may range from a minor adjustment to operational procedures to initiation of emergency response, depending on the severity and nature of the deviation from expected performance. Authorization from the Mill Manager is required for any change to any operational procedure not covered in this Manual.

5.7.2 Surveillance Parameters

Signs of potential or actual hazards can be identified by a combination of visual inspection and instrumentation readings before hazards become significant. Using the CWP as an example, Pretium personnel can identify the need for maintenance if changes to the cut slopes, CWP berm and surrounding areas such as erosion, cracking, bulging, or seeps are observed. Additionally, changes in instrumentation readings (i.e., rapid rise in water levels) can also indicate potential hazards. Key qualitative and quantitative parameters for CWP surveillance are outlined below:

- pond levels
- reclaim pipeline flow
- crest stability (cracking, slumping, erosion, bulging, sinkholes)
- excessive seepage on downstream crest
- instability of bedrock cut slopes (slumping, sliding, etc.).

Several potential failure modes exist for the CWP and other water management facilities. These potential failure modes, along with alert triggers and observable visual and instrumentation indications of the failure mode, are presented in Table 5-7. Table 5-8 summarizes the expected behavior of the various CWP elements as well as behaviors that are indicative of potential failure mechanisms.

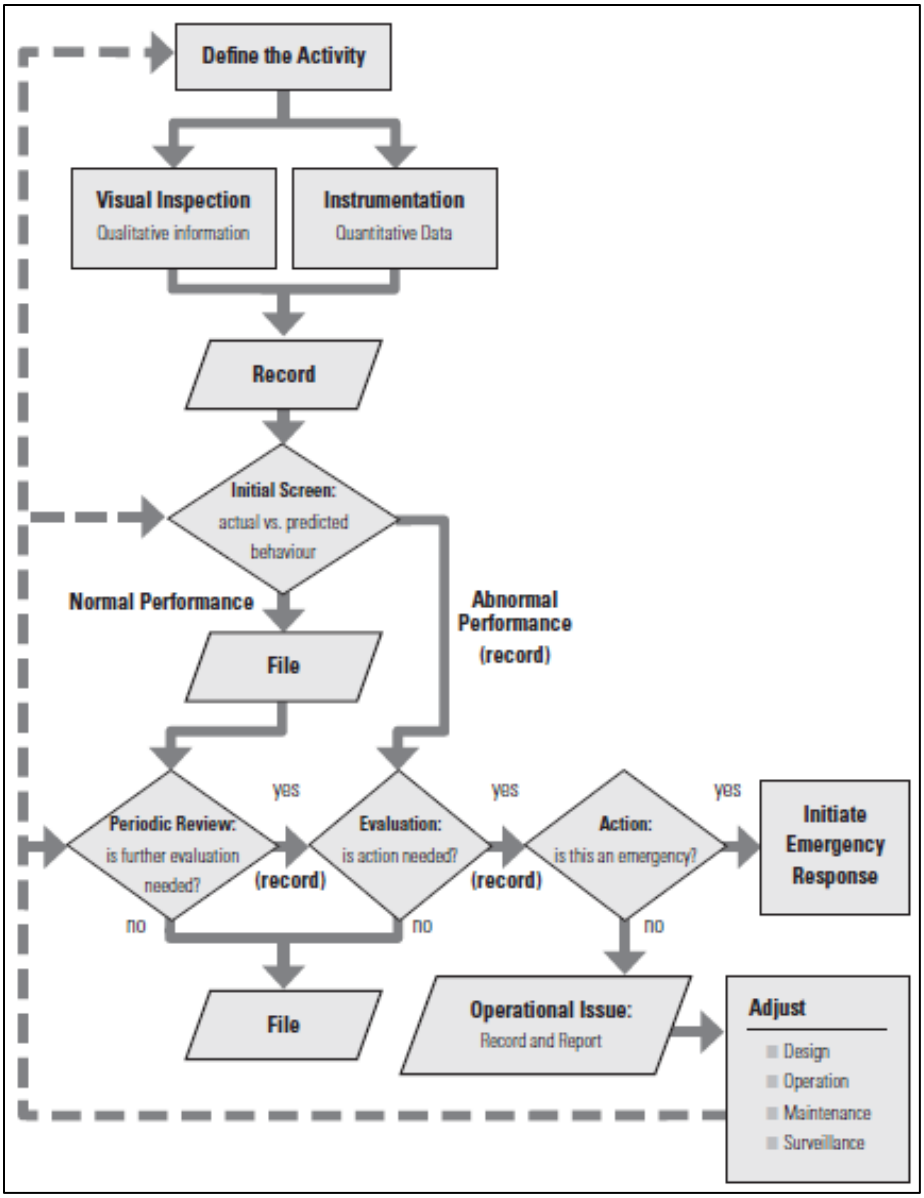


Figure 5-8: Conceptual surveillance procedure (MAC 2011).

Table 5-7: Potential failure modes, triggers and observable effects.

Failure Mode	Possible Causes (Triggers)	Visual Effects	Instrumentation Effects
CWP overtopping	Extreme precipitation, landslide generated wave, blockage of the spillway	Instability of cut slopes – slumping, sliding etc., breach of crest	Pond levels Reclaim pipeline flow
Channel Avulsion	Blocked culvert, mobilized riprap, reduced channel capacity	Ponded water at culvert inlet, debris accumulation, displaced riprap	n/a
CWP Cut Slope Failure	Adverse geological structures, changes to pore water pressure acting on the geological structures, earthquake induced	Dilation or sliding of blocks or slabs of rock defined by the geological structures	n/a
East or West Weir overtopping	Extreme precipitation, blockage of piping, blockage of storage basin	Water level of pond retained by the weir is within 0.5 m of the crest of the weir	n/a

Table 5-8: Visual observations – expected and unexpected behaviors.

Facility Element	Expected/Normal Behaviour	Unexpected Behaviour
CWP Berm crest	No changes to crest geometry	Cracking, slumping, erosion, bulging; sinkholes
CWP cut slopes (downstream and upstream)	No changes to slope geometry	Dilation of geological structures, cracking, slumping, bulging, erosion
Seepage from CWP	Minor seepage from geological structures.	Significantly fluctuating seepage rates, seepage appearing in new locations down gradient of CWP
East or West Weir	No change from geometry. Storage basin of the weirs is free of equipment and debris	Cracking, slumping, erosion. Degradation of concrete. Seepage through the weir. Water level of pond retained by the weir is within 0.5 m of the crest of the weir.
Inlet of Camp Creek Culverts under West Pad	Free flow into the culverts	Sediment and/or debris blockage
Inlet of Johnson Creek Culverts under Access Road	Free flow into the culverts	Sediment and/or debris blockage

5.7.3 Surveillance Procedures

Routine visual surveillance of the water management facilities is summarized in Table 5-9. The mine has also implemented an instrumentation and process control design that allows for continuous monitoring of CWP water levels and reclaim flows, as discussed in Section 5.7.4. These parameters are monitored at the mill control room.

Visual surveillance requirements after unusual events are outlined in Table 5-10.

5.7.4 Instrumentation

Flow instrumentation directly applicable to the CWP includes:

- Water levels in the CWP are monitored on a continuous basis (SCADA system with an alert system) by a level transmitter, which is strapped to one of the pump lines.
- Runoff collecting in the CWP will be pumped up to the WTP in one of four dedicated lines (2 x 4”, 2 x 6”). Each line is fitted with a magnetic flowmeter for continuous monitoring of flows.
- Non-spec effluent from the WTP will also be discharged to the CWP periodically. These flows are measured with a magnetic flowmeter in the plant site.
- As summarized in Table 5-3, an 8” pipeline allows for pumped CWP flows to be directly discharged to the WRTSF. This pipeline would be used if the CWP water quality met standards or an emergency discharge was required due to rising water levels. The 8” pipeline is tied into the four pumps that convey water to the WTP.
- Groundwater quality sampling is required on a quarterly basis from CWP well nest G..

5.7.5 Collation and Analysis of Data

Instrumentation readings are sent to Pretium’s Mill Operations Superintendent on a daily basis. The CWP/Water Management Engineer will review the instrumentation data on an annual basis (or more frequently if requested by Pretium), and, if applicable, provide recommendations to Pretium for additional actions.

Table 5-9: Routine visual surveillance.

Responsible Person	Activity	Frequency	Structure
Mill Operators	Visual inspection of mill-associated water management structures. Visual review of the CWP crest, cut slopes, and spillway. Check pumping system and pipelines from CWP to WTP and the direct lake discharge system. Focus on CWP and 'downstream'. Obtain maintenance support if/as needed.	Once per shift, with weather-related limitations during winter months	CWP, water management structures 'downstream' of CWP, and reclaim water system: • CWP • Pipelines from CWP to mill and WRTSF • Discharge pipelines from mill to WRTSF • LLW and reclaim system
Waste Management and De-Watering Coordinators	Inspection of non-contact water diversion channels and all aspects of the contact water management system 'upstream' of the CWP. Obtain maintenance support if/as needed.	Once per shift in non-frozen conditions, generally late April to late October. Major inspections pre- and post-freshet and pre-freeze-up in the fall	Surface contact water management facilities feeding into the CWP, and the non-contact water diversion channels: • Contact water ditches, pipelines, pumps, and manholes • East and West weirs • Manholes and sumps • Non-contact diversion channels
Environmental Scientists	Visual inspections of CWP crest, cut slopes, and spillway. Accompany Surface Ops in 3 times annual inspections of contact water management system upstream of CWP, and non-contact diversion channels, documenting findings. Accompany Mill Operators at least twice annually on CWP and pipeline/pumping inspections.	Major inspections pre- and post-freshet and pre-freeze-up in the fall. Checks/ observations of CWP and LLW each time water quality samples are collected at these locations	CWP, LLW coincidental with water quality sample collection
All Pretium employees working on/around the water management facilities	Visual inspections checking for any unusual conditions/conditions of concern as listed in Table 5-10. Includes instrumentation confirmation of observations.	As applicable	All water management facilities
CWP/Water Management Engineer - Technical Lead or Senior Engineer	Annual Inspection Report.	Annual Intermittent	CWP, all contact water management infrastructure and non-contact water diversion channels

Notes:
1) Requisite levels of training and familiarity with OMS Manual as outlined in Table 3-3
2) Refer Table 3-1, roles and responsibility matrix, outlining visual surveillance responsibilities listed above.

Table 5-10: Unusual event driven surveillance.

Unusual Event	Post-Event Inspection/Surveillance
Earthquakes	• Carry out a detailed walkover of all CWP structures, including crest, cut slopes and spillway, looking for signs of cracks, dilation, bulging, settlement and/or other deformations. • Look for and note any changes in seepage, particularly with respect to the rate of seepage flows along the cut slopes. • Read all groundwater wells adjacent to the CWP. • Inspect all pump stations, manholes and pipelines. • Inspect non-contact water diversions and contact water collection ditches, including culverts and the East Weir and West Weir. • Discuss findings with the Mill Manager and CWP/Water Management Engineer.
Rapid snowmelt and/or heavy rainstorms	• Inspect the (visible) slopes and the crest of the CWP looking for areas of concentrated runoff and erosion. • Examine cut slopes for indications of localized dilation/instability. • Inspect all pump stations, manholes and pipelines. • Inspect non-contact water diversions and contact water collection ditches, including culverts and the East Weir and West Weir. • Check the water levels in the CWP against the critical levels and keep checking these levels until the pond/reservoir inflows subside. • Discuss findings with Mill Manager and CWP/Water Management Engineer. • Check piezometric levels if instructed by CWP/Water Management Engineer.
Extreme snow pack	• Check the water levels in the CWP against the critical levels and keep checking these levels until the spring freshet is over. • Check the capacity of the diversion channels and collection ditches. Remove snow, if required. • Evaluate the situation in terms of possible snowmelt scenarios. Make predictions as to the expected storage capacity available in the CWP.
Deformation at berm crest, cut slope or toe area	• Record the current CWP level. • If deemed necessary, divert water from the CWP. • Contact the Mill Manager and CWP/Water Management Engineer.
Necessity to store more than typical amount of water in CWP (any reason)	• Record the current CWP level. • Contact the Mill Manager, Environmental Manager and CWP/Water Management Engineer.
Other events/observations.	• Notify Mill Maintenance and Mill Operations Superintendents as appropriate to the area/circumstance of the observation.

5.7.6 Trigger Levels – Management of CWP Inventory

During the non-winter months, the CWP inventory is primarily managed by pumping water up to the WTP from where it is either used in process or released to the environment. Various trigger levels for the CWP are summarized in Table 5-11 and the following bullets. A stage storage curve of the CWP is provided in Figure 5-3.

Table 5-11: Trigger levels for management of CWP water levels.

Water Elevation (m asl)	OWTP Operational	Water Quality	Action
< 1367.4 [1]	-	-	No pumping. Minimum water depth for pumping not achieved.
> 1367.4 [2]	✓	✓	Pump to the WTP
>1374.8 [3]	-	✓	Use of the 8” discharge line for deep lake disposal.
> 1376.1	-	✓	Emergency use of the 8” discharge line for deep lake disposal.

Notes:

[1] The reclaim pumps require a minimum water depth of 1.4 m to operate. Thus, the pumps will not operate when pond levels are below elevation 1367.4 masl.

[2] At pond levels in excess of 1367.4 masl, water will be reclaimed to the WTP for use in process or released to the environment (as per Permit 107835). The rate of reclaim will depend on process needs and climatic conditions. Water will not be reclaimed if the WTP is not operational.

[3] CWP levels can be drawn down via direct discharge (i.e., the 8-inch diameter pipeline) to a deep lake outfall in WRTSF subject to the following conditions:

- The most recent water quality results for the CWP meet all the limits specified in Section 1.2.3 of EMA Permit 107835.
- There has not been any diversion of untreated mine water to the CWP since the most recent CWP sample was taken.

If the above conditions are met, direct discharge could occur at any water level in excess of 1367.4 masl. Any direct discharge shall be coordinated with the Environmental and Mill departments.

Based on Effluent Permit 107835, Pretium can discharge water from the CWP to WRTSF provided water quality guidelines are met for the following two scenarios:

- When available CWP storage capacity is between 10,000 and 50,000 m^3 (Maximum TSS of 25 mg/L)
- When available CWP storage capacity is less than 10,000 m^3 (Maximum turbidity of 150NTU)
- When pond levels reach the spillway invert of 1376.5 m asl, a controlled but unintended release of contact water will occur into the WRTSF. To minimize potential impacts to the lake water quality, it is preferable that any release of contact water to the lake occur at depth, rather than discharging to the lake surface. Therefore, when pond volumes reach 95% of the CWP storage capacity (elevation = 1376.1 m asl) and additional rainfall is forecast, Pretium staff will start to operate both 8” pipelines with direct discharge to the lake

at depth. These pipelines would operate as long as pond volumes remained above the 95% level.

5.7.7 Periodic Inspection and Review by the Water Management Engineer

The frequency of inspections by the CWP/Water Management Engineer is as outlined in Table 5-9. Instrumentation monitoring data will be reviewed as it is provided by Pretium, and the CWP/Water Management Engineer will review the data on an annual basis (at minimum) and provide commentary and recommendations as required.

5.7.8 Documentation

Documentation is as discussed in the preceding sections. Hardcopy and electronic files are retained by Pretium on site and available to an inspector upon request.

5.7.9 Reporting

CWP instrumentation readings will be sent to Pretium's Mill Operations Superintendent on a daily basis.

The CWP/Water Management Engineer will issue a comprehensive annual review report that addresses any requirements for design changes, and/or changes to operation, maintenance, and surveillance that arise from the surveillance activities.

6 Emergency Preparedness and Response

There is no permanent population that is at risk from the CWP, and mine personnel are only temporarily in the spillway zone of the facility. Therefore, an ERP or EPP has not been prepared for the CWP.

6.1.1 Flood Preparedness

Hydraulic modeling of the West Zone pad drainage system area (SRK 2021) indicated that there is potential risk of flooding during the passage of the 200-year storm event. The modeling included the inflow from Camp Creek, the culverts that traverse the pad, and concurrent flows at Brucejack Creek. As a short-term flood mitigation measure it was recommended that an AquaDam was procured by Pretium and maintained nearby to be deployed when needed. To support the installation, an AquaDam SOP was developed (BJ-ENV-SOP-067 – AquaDam Deployment) to provide instructions related to deployment and installation around the West Zone Portal entrance with relatively short during high flow conditions.

7 Safety and Security

The Brucejack Mine is controlled under 24-hour security personnel that screen every person entering and leaving the site. The access road is gated near its intersection with Highway 37 and all persons who are not permanent employees require permission of the Mine Manager to proceed beyond the gate. All personnel working at the Brucejack Mine are also required to go through a health, safety and environmental orientation.

This report, OMS Manual – Water Management Plan, was prepared by

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10/25/23

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Principal Consultant

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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Appendix A – Issued for Construction Drawings

Crest of CWP to Lakeshore Rd

Spillway Top Of Crest (Cut approx 2m to SG trench in solid rock)

New Design Location (CP-07) due to outcropping to the East

AMEC Scaled position from Crest (Scaled off of drawing at 1.445m)

8.13m

Layout Location

2.88m

1.45m

0.42m

2.25m

2.25m

K CP 25

K CP 07

K CP 24

K CP 06

K CP 23

K CP 05

Original Design Loaction (CP-06)

Gabion Cages at Sump

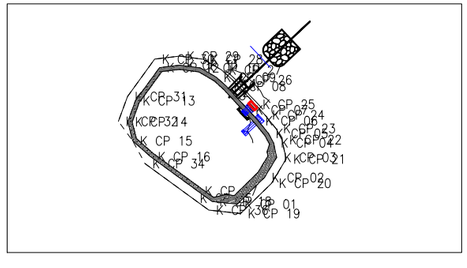
Outcropping of Rock

Note : Original Design too close to existing slope to build Pumphouse.

Note : AMEC Scaled distance from Crest (1.45m) too dangerous to layout and/or work in due to sloping crest, loose rock and snow.

Note : Layout offset distance (2.88m) allows for ample working space and still enough room for light duty vehicles to pass behind Pumphouse.

KEY MAP:



REFERENCE DRAWINGS		
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REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
-	-	-	-	-

CLIENT:

Allnorth

TITLE:

CWP Pumphouse - Design vs Proposed vs Layout

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PROJECT NO:	15TR0046	DSGN:	-	DATE:	-
DRAWING SIZE:	ANSI "B"	CHKD:	-	DATE:	-
SCALE:	AS NOTED	APVD:	-	DATE:	-

PROJECT:

Brucejack Minesite Construction

DWG NO: **161124-001**

REV: **0**

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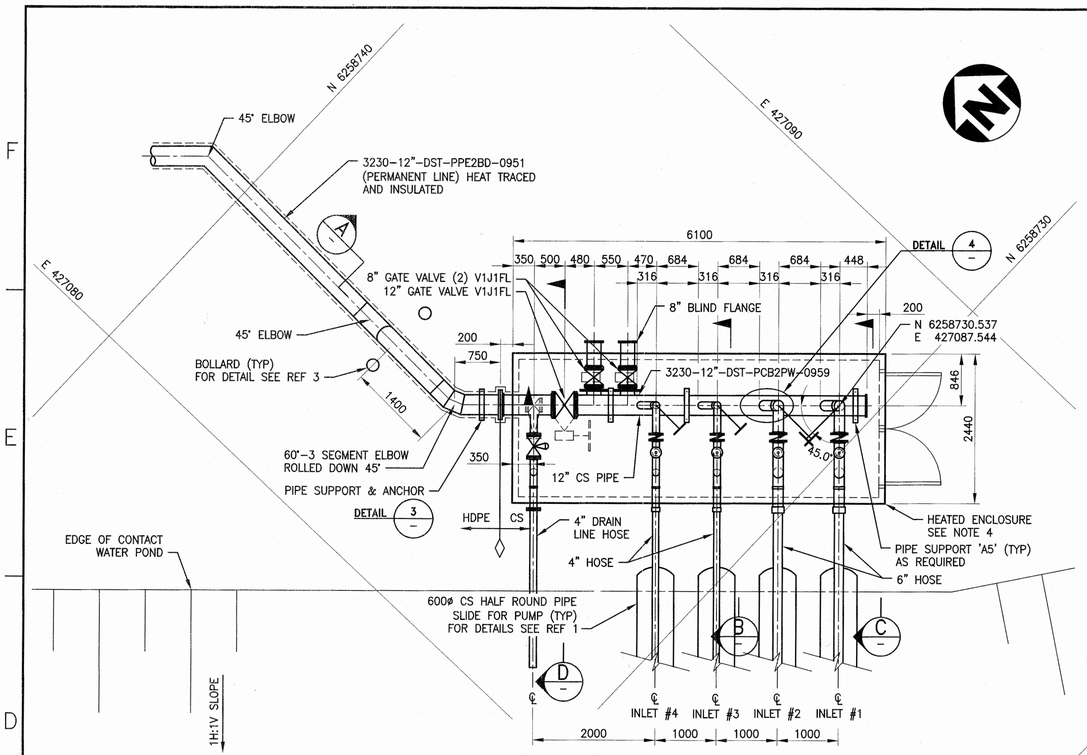

CWP PUMPED PIPING MANIFOLD

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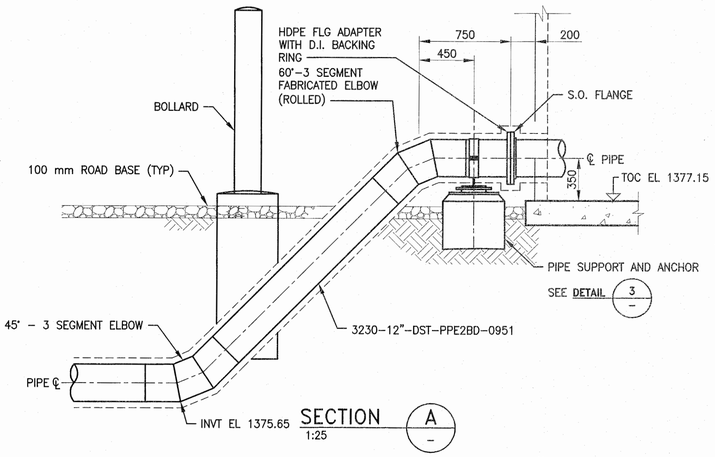

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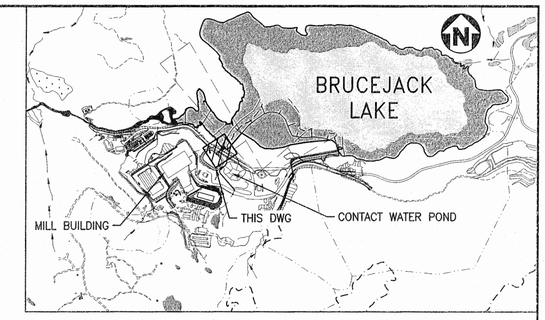
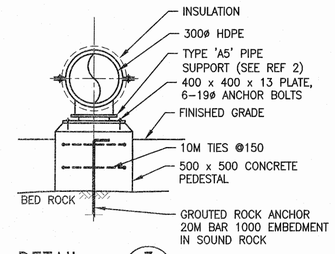


KEY PLAN



DETAIL 3

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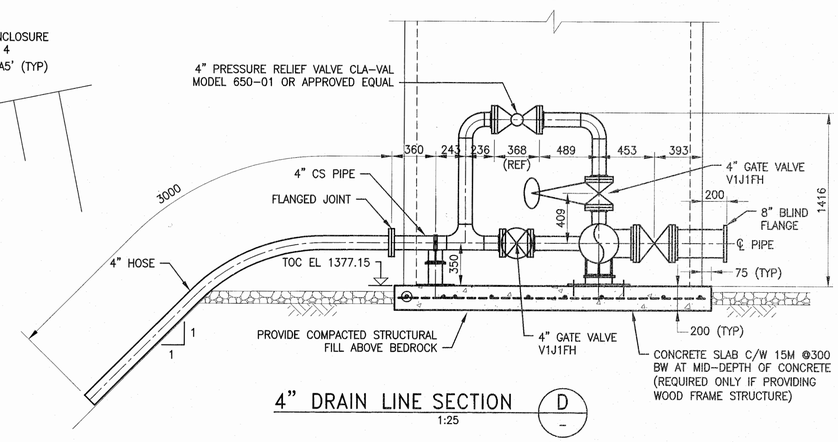
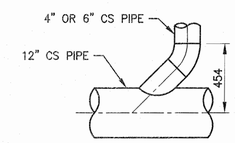
GENERAL REVISION 1



4" DRAIN LINE SECTION

D

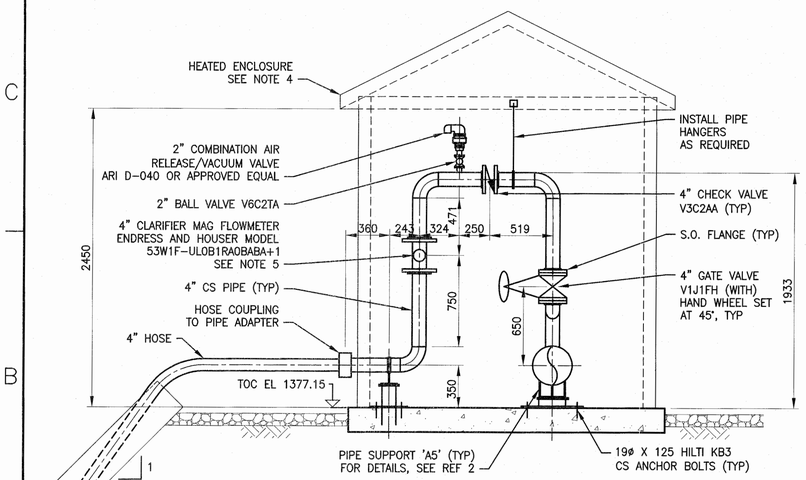
1:25



DETAIL 4

1:20 (SIDE VIEW)

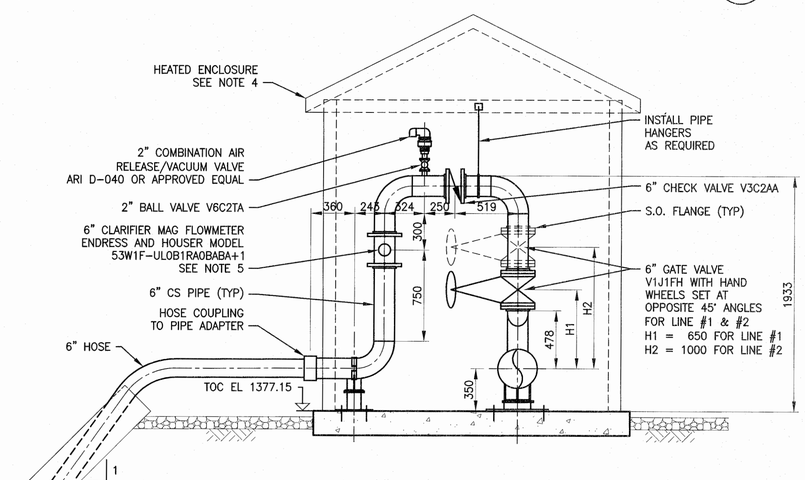
AS THE DESIGN OF THE CWP IS BEING REVISED BY THE OWNER, THE PLANS, SECTIONS AND DETAILS SHOWN ON DRAWINGS 177421-3230-DD10-GRD-0172 THRU 0179 SHALL BE USED AS APPLICABLE WITH FIELD MODIFICATIONS DONE AS NECESSARY TO WORK WITH THE REVISED CWP LAYOUT. ANY DEVIATIONS FROM THE DESIGNS SHOWN ON THESE DRAWINGS SHALL BE AGREED TO BY THE OWNER PRIOR TO PROCEEDING WITH CONSTRUCTION.



4" INTAKE LINES #3 & 4

SECTION B

1:25



6" INTAKE LINES #1 & 2

SECTION C

1:25

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL COORDINATES, CONTOURS AND SPOT ELEVATIONS ARE IN METRES AND REFER TO GEODETIC DATUM IN UTM NAD83, ZONE 9.
3. VALVE STATION PIPING TO BE WELDED CS CONSTRUCTION CONFORMING TO SPECIFICATIONS 177421-0000-DD10-SPC-0005 AND 177421-0000-DD10-SPC-0006. MATERIALS SHALL CONFORM TO PIPING DESIGN STANDARD PCB2PW.
4. VALVE ENCLOSURE MAY BE WOOD FRAME CONSTRUCTION OR SUPPLIED WITH PIPING AS A MODIFIED SEA CONTAINER. IF WOOD FRAME, CONSTRUCT WITH FOLLOWING MATERIALS:
   - 89x89 (4x4) TREATED TIMBER BASE PLATE
   - 38x89 (2x4) WOOD FRAME CONSTRUCTION (300 C/C FOR BEARING WALL)
   - 16mm EXTERIOR T&G PLYWOOD ROOF DECKING
   - 13mm EXTERIOR PLYWOOD WALL SHEATING
   - MINERAL WOOL BATT INSULATION INFILL
   - 6MIL POLY VAPOUR BARRIER
   - 13mm CEMENT BOARD WALLS & CEILING
   - INSULATED HOLLOW METAL DOOR (900x2150) WITH HOLLOW METAL FRAME PER SPECIFICATION 177421-0000-DD30-SPC-1004 C/W LEVER STYLE PASSAGE SET, WEATHER STRIPPING AND DOOR CLOSER
   - TYVEK WRAP
   - PRE-PAINTED GALVANIZED STEEL ROOF AND WALL CLADDING PER SPECIFICATION 177421-0000-DD30-SPC-1001
   - 38x286 (1.5x12) RAFTERS @ 300 C/C
5. CLARIFIER MAG FLOW METERS NEED TO BE INSTALLED IN VERTICAL PIPE RUN, WITH MINIMUM STRAIGHT RUN REQUIREMENTS AFTER FITTINGS OF 5 PIPE DIAMETERS UPSTREAM AND 2 PIPE DIAMETERS DOWNSTREAM.

0m 0.2 0.4 0.6 0.8 1 — 1:20
0m 0.25 0.5 0.75 1 1.25 — 1:25
0m 0.5 1 1.5 2 2.5 — 1:50

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
1	26SEP16	ISSUED FOR CONSTRUCTION	PA					
0	13JUL16	ISSUED FOR CONSTRUCTION	PN	PB	VRM	EY	SL	
C	28JUN16	ISSUED FOR QUOTATION	GP	EW	EW	EY		
B	05MAY16	ISSUED FOR APPROVAL	KW	EW	EW	EY	SL	
A	05MAY16	ISSUED FOR SQUAD CHECK	KW					

REF	NUMBER	TITLE
4	3230-DD10-GRD-0170	CONTACT WATER POND, PLAN
3	3230-DD10-PLS-0432	BURIED UTILITIES, DETAILS & SECTIONS, SHEET 2
2	0000-DE20-PSP-0002	PIPE SIPPORT DETAILS, SHEET 2
1	3230-DD10-GRD-0179	CONTACT WATER POND DETAILS, SHEEET 7

REFERENCES

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STAMP/SEAL

PROFESSIONAL ENGINEER — BRITISH COLUMBIA — 26 SEPT 2016

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR	DEPARTMENT MGR	PROJECT MGR
	G. LI	S. LYNN

PRETIVM

amec foster wheeler

PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	EW	19APR16
		DRN	KW	19APR16
SCALE	PACKAGE CODE	CHK	PB	15JUL16
AS NOTED		APP	VRM	15JUL16

SUBJECT: CIVIL PLAN SECTION ELEVATION CONTACT WATER POND DETAILS – SHEET 3

AREA 3230 — UTILITIES – WATER SYSTEMS

CLIENT DWG NO.

DRAWING NO. 177421-3230-DD10-GRD-0175 REV 1

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CAD FILE: \\WAN-FS1\P00177421\CAD\CIV\177421-3230-DD10-GRD-0175.DWG

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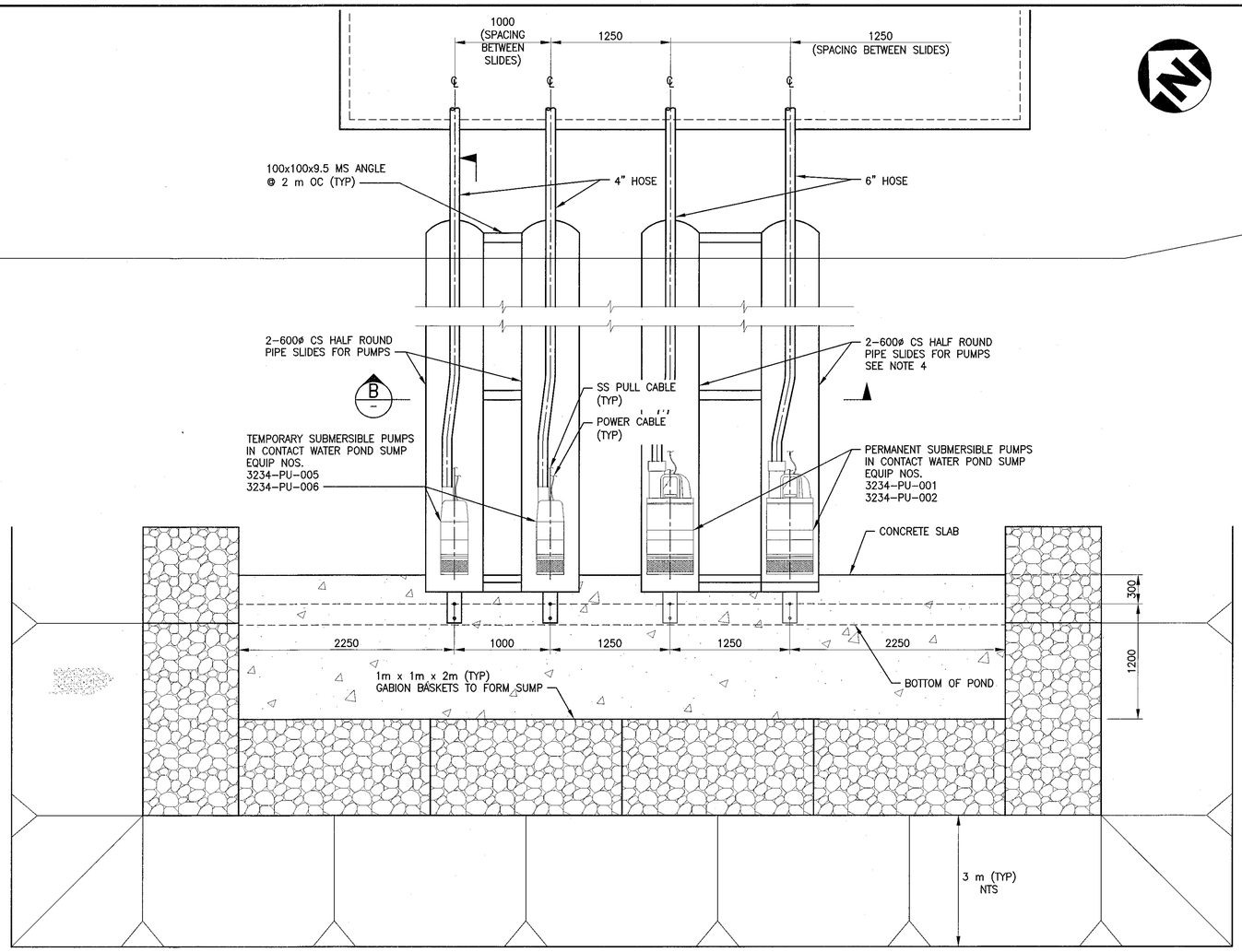
ISO A1-594x841



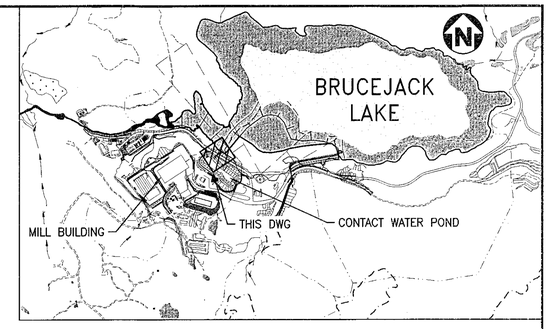
CONTACT WATER POND PUMPS AND SUMP

DETAIL 1 (0170) 1:30

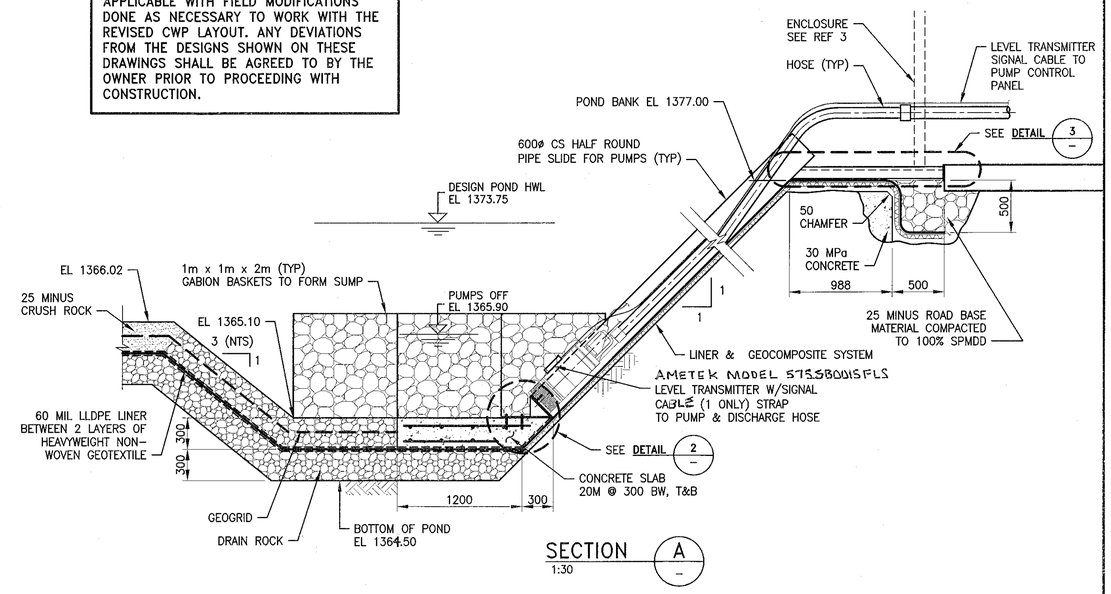
NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL ELEVATIONS ARE IN METRES AND REFER TO GEODETIC DATUM IN UTM NAD83, ZONE 9.
3. INSTALL THE SUMP AND PIPE SLIDES FOR PUMPS IN A LOCATION THAT SUITS PIPING ARRANGEMENT SHOWN ON REF 3.
4. PIPE SLIDES FABRICATED FROM STD WT CS PIPE TO BE GALVANIZED AFTER WELDING.

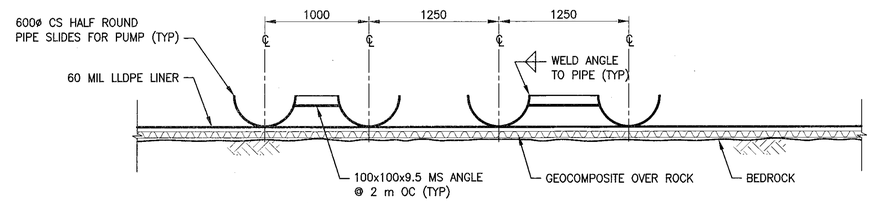
AS THE DESIGN OF THE CWP IS BEING REVISED BY THE OWNER, THE PLANS, SECTIONS AND DETAILS SHOWN ON DRAWINGS 177421-3230-DD10-GRD-0172 THRU 0179 SHALL BE USED AS APPLICABLE WITH FIELD MODIFICATIONS DONE AS NECESSARY TO WORK WITH THE REVISED CWP LAYOUT. ANY DEVIATIONS FROM THE DESIGNS SHOWN ON THESE DRAWINGS SHALL BE AGREED TO BY THE OWNER PRIOR TO PROCEEDING WITH CONSTRUCTION.



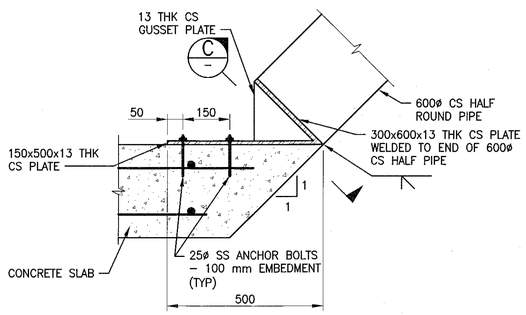
KEY PLAN



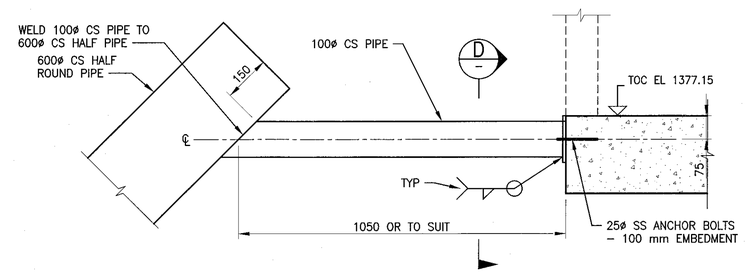
SECTION A 1:30



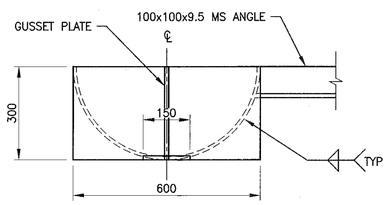
SECTION B 1:30



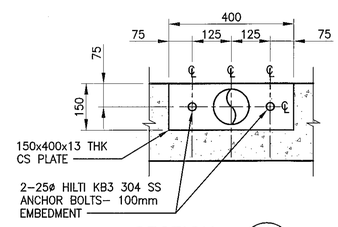
DETAIL 2 1:10



DETAIL 3 1:10



SECTION C 1:10



SECTION D 1:10

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
0	13JUL16	ISSUED FOR CONSTRUCTION	PN	PB				
C	28JUN16	ISSUED FOR QUOTATION	GP	EW	EW	EY		
B	05MAY16	ISSUED FOR APPROVAL	KW	EW	EW	EY	SL	
A	05MAY16	ISSUED FOR SQUAD CHECK	KW					

REF	NUMBER	TITLE
3	3230-DD10-GRD-0175	CONTACT WATER POND, DETAILS, SHEET 3
2	3230-DD10-GRD-0173	CONTACT WATER POND, DETAILS, SHEET 1
1	3230-DD10-GRD-0170	CONTACT WATER POND, PLAN

REFERENCES

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STAMP/SEAL

PROFESSIONAL ENGINEER — V. R. MADDALOZZO — BRITISH COLUMBIA — 15 JULY 2016

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PRETIVM

amec foster wheeler

PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	EW	28APR16
		DRN	PN	28APR16
SCALE	PACKAGE CODE	CHK	PB	15JUL16
AS NOTED		APP	VRM	15JUL16

SUBJECT: CIVIL GRADING DRAWING CONTACT WATER POND DETAILS – SHEET 7

AREA 3230 — UTILITIES – WATER SYSTEMS

CLIENT DWG NO.

DRAWING NO. 177421-3230-DD10-GRD-0179 REV 0

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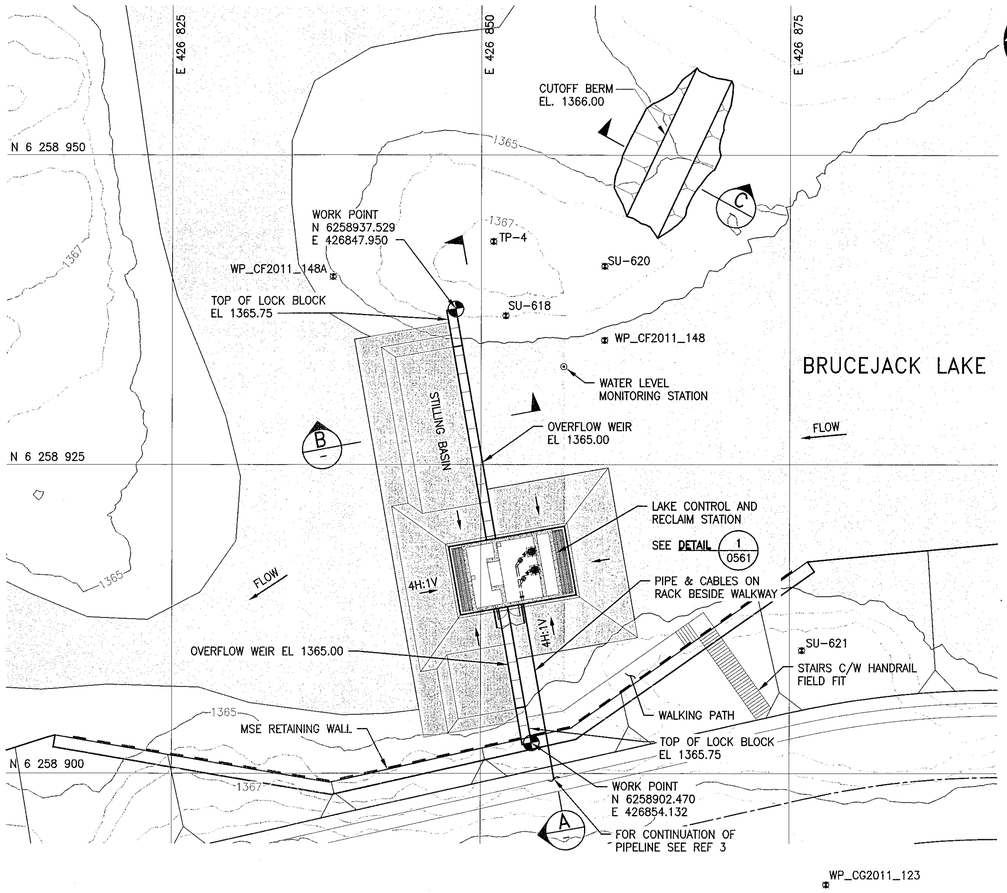

SITE PLAN
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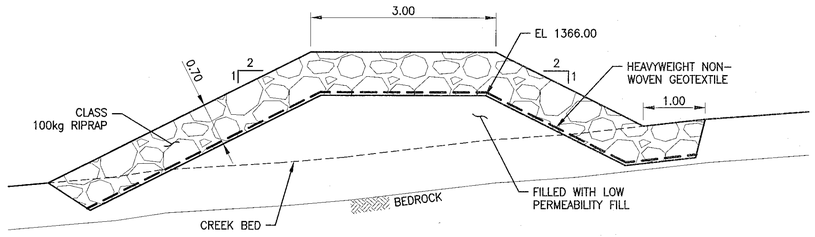

SECTION C
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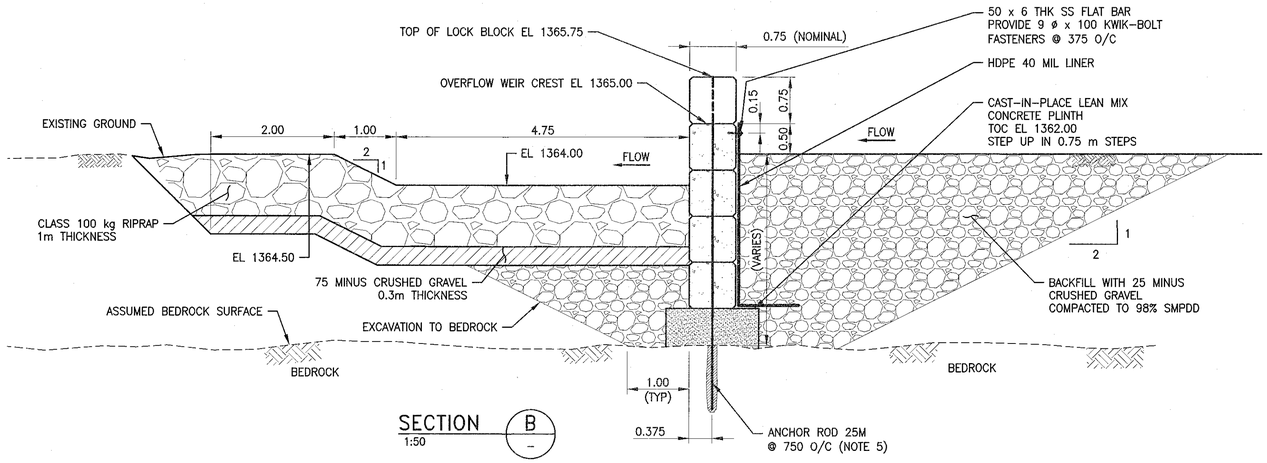
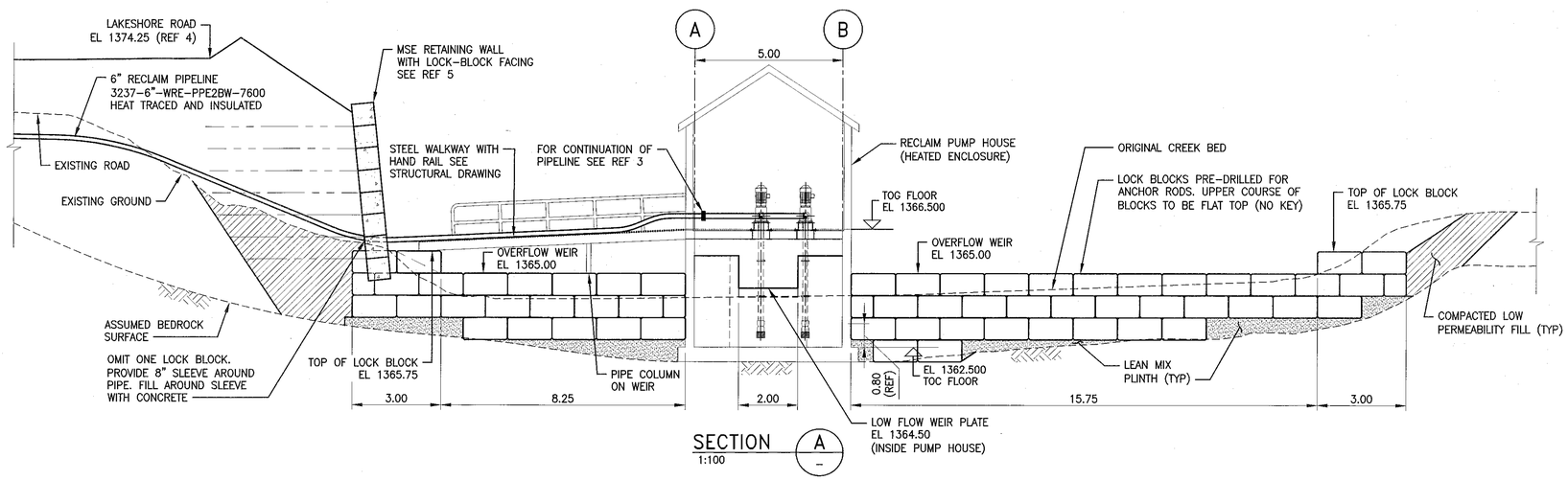


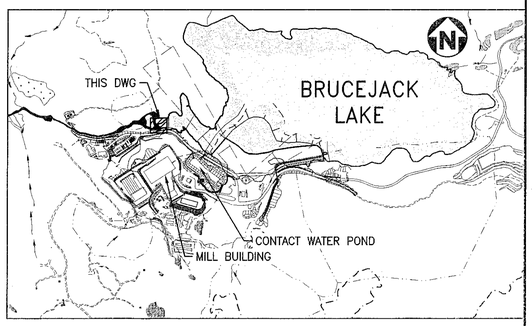
SECTION B
1:50

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
2. TOPOGRAPHIC DATA IS BASED ON LIDAR SURVEY PROVIDED BY ALLNORTH, DATED OCTOBER 24, 2014. CONTOUR INTERVAL IS 1 m.
3. GROUND PROFILE IS BASED ON LIDAR SURVEY THAT CAPTURED THE WATER SURFACE, NOT THE BOTTOM OF THE CHANNEL.
4. ALL COORDINATES, CONTOURS AND ELEVATIONS ARE IN METRES AND REFER TO GEODETIC DATUM IN UTM NAD83, ZONE 9.
5. ROCK ANCHOR INSTALLATION TO BE APPROVED BY GEOTECHNICAL ENGINEER.



SECTION A
1:100



KEY PLAN

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
0	20JUN16	ISSUED FOR CONSTRUCTION	PN	EW	EW	EY		
B	19APR16	ISSUED FOR APPROVAL						
A	06APR16	ISSUED FOR SQUAD CHECK						

REF	NUMBER	TITLE
5	3412-DD10-PLS-0562	LAKE CONTROL & RECLAIM STN, SECTIONS & DETAILS, SHT 2
4	1110-DD10-GRD-0252	ROAD, PLAN & PROFILE, SHEET 2
3	3410-DD10-PLS-0528	RECLAIM PIPELINE, PLAN & PROFILE, SHEET 1
2	3412-DD10-PLS-0570	LAKE CONTROL & RECLAIM STN, CONSTRUCTION DETAILS
1	3412-DD10-PLS-0561	LAKE CONTROL & RECLAIM STN, SECTIONS & DETAILS, SHT 1

REFERENCES

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STAMP/SEAL: PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 20 Jun 2016

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PRETIVM

amec foster wheeler

PROJECT: BRUCEJACK

PROJECT NO. 177421 | ACTIVITY NO. | SCALE: AS SHOWN | PACKAGE CODE

	BY	DDMMMYY
DES	EW	15MAR16
DRN	TC	15MAR16
CHK	PPB	20 Jun 16
APP		20 Jun 16

SUBJECT: CIVIL
PLAN SECTION ELEVATION
LAKE CONTROL & RECLAIM STATION
PLAN

AREA 3410 — TAILINGS

CLIENT DWG NO.

DRAWING NO. 177421-3412-DD10-PLS-0560 — REV 0

ISO A1-594x841

CAD FILE: \\VAN-FS1\PROJ\177421\CAD\CIV\177421-3412-DD10-PLS-0560.DWG

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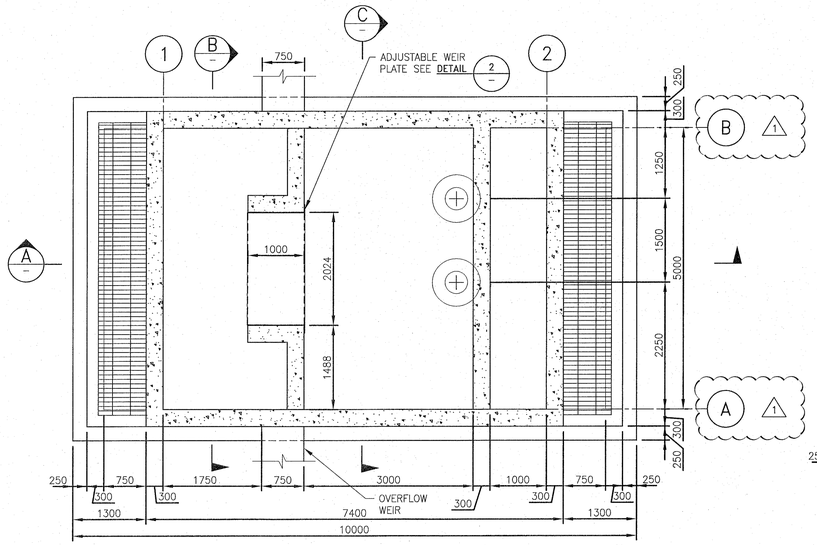

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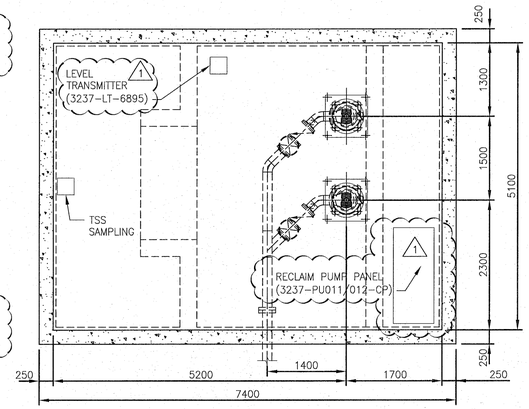
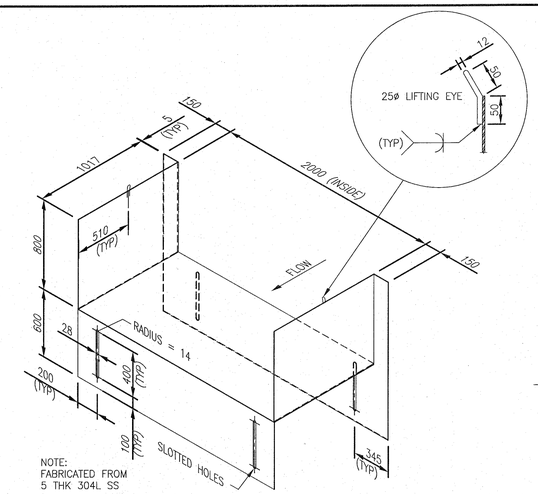
1:50



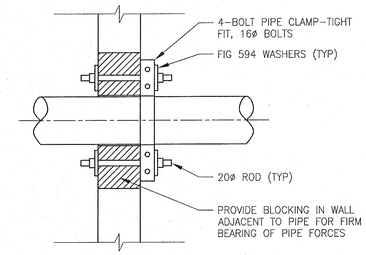
EL 1368.5m PLAN VIEW
1:50



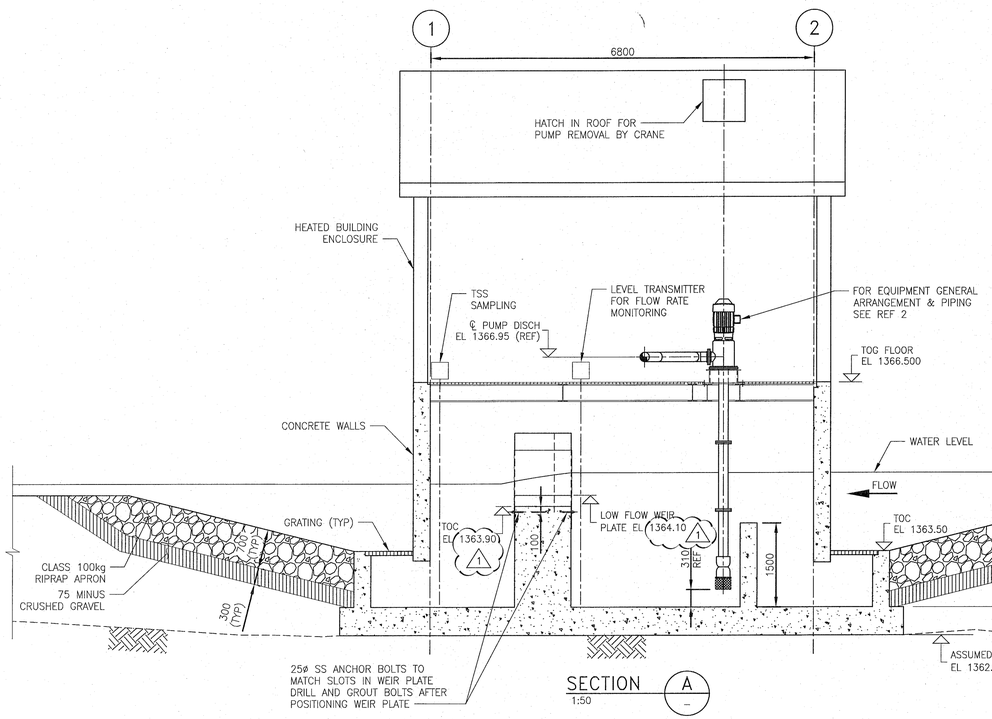
ADJUSTABLE WEIR PLATE DETAIL 2
1:25

NOTES:

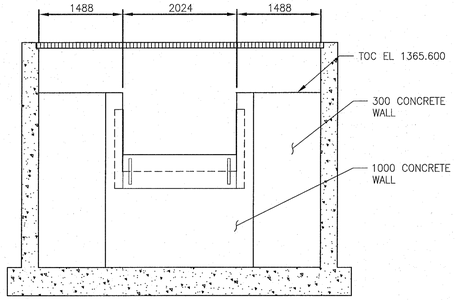
1. ALL ELEVATIONS ARE IN METRES AND REFER TO GEODETIC DATUM IN UTM NAD83, ZONE 9.
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
3. FOR STRUCTURAL DETAILS SEE REF 3.



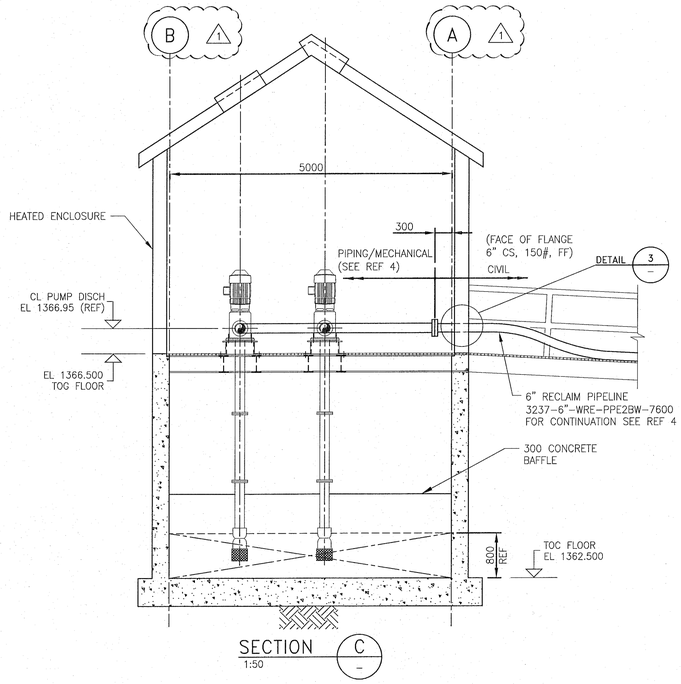
PLAN DETAIL 3
1:10



SECTION A
1:50



SECTION B
1:50



SECTION C
1:50

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
1	03MAR17	ISSUED FOR CONSTRUCTION	RL	PN	VRM	EY	SL	
0	20JUN16	ISSUED FOR CONSTRUCTION	GP	PB	EW	EY	SL	
B	19APR16	ISSUED FOR APPROVAL	PN	EW	EW	EY		
A	06APR16	ISSUED FOR SQUAD CHECK						

REF	NUMBER	TITLE
4	3410-DD10-PLS-0528	RECLAIM PIPELINE, PLAN & PROFILE, SHEET 1
3	3412-DD20-RCD-0101	RECLAIM PUMPHOUSE, PLAN AND SECTIONS
2	3237-DE10-GAD-0212	WATER PUMP STATION, PLANS AND SECTIONS
1	3412-DD10-PLS-0560	LAKE CONTROL & RECLAIM STATION PLAN

REFERENCES

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STAMP/SEAL

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — B. P. NAHAR # 34498 — 03/Mar/2017

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR	DEPARTMENT MGR	PROJECT MGR
	G. LI	S. LYNN

PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	EW	21JUN16
		DRN	JP	17APR15
SCALE	PACKAGE CODE	CHK	PB	21JUN16
AS SHOWN		APP	EW	21JUN16

PRETIVM

amec foster wheeler

SUBJECT: CIVIL — PLAN SECTION ELEVATION LAKE CONTROL & RECLAIM STN SECTIONS & DETAILS, SHT 1

AREA: 3410 — TAILINGS

CLIENT DWG NO.

DRAWING NO.: 177421-3412-DD10-PLS-0561 — REV: 1

CAD FILE: \\VAN-FS1\DQ\177421\CAD\CIV\177421-3412-DD10-PLS-0561.DWG

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ISO A1-594x841

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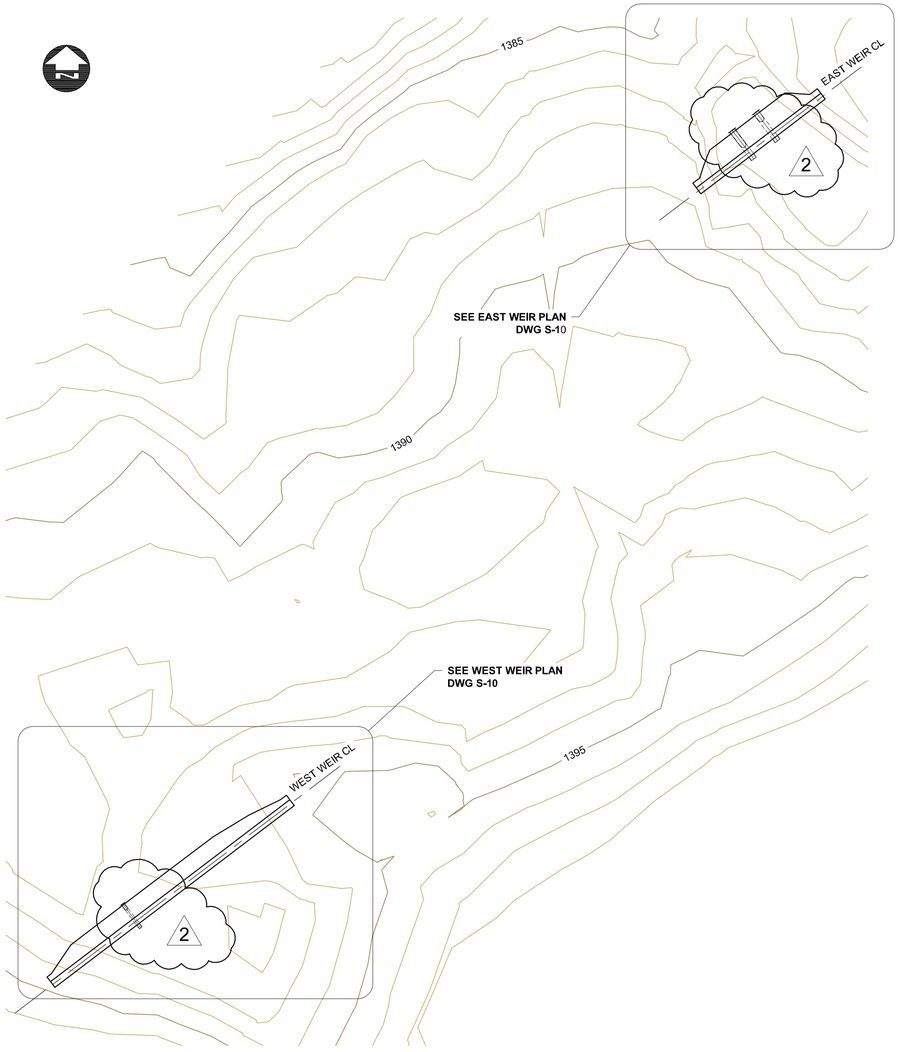

KEY PLAN
SCALE: 1:200

NOTES:

1.0 GENERAL

1.1 All elevations in m, all dimensions in mm.

1.2 Check all dimensions prior to commencing work. Notify Engineer of any conflicting or erroneous information.

1.3 Do not scale dimensions from the drawings.

2.0 DESIGN CRITERIA

2.1 Codes and Standards

(Do work in accordance with the current revision of the following standards except where specified otherwise.)

- British Columbia Building Code
- CSA A23.3 Design of Concrete Structures
- CSA S16 Limit States Design of Steel Structures
- Canadian Dam Association (2007), Technical Bulletin: Structural Considerations for Dam Safety

2.2 Design Loads

2.2.1 Ice loads: 150 kN/m @ 0.3m below water level

2.2.4 Seismic loads:

- Peak ground acceleration PGA = 0.08 g
- Normal importance factor Ie = 1.5
- Site classification Site class A (Assumed)
- Spectral parameters

Period, T	0.2s	0.5s	1.0s	2.0s
S(T)	0.16	0.07	0.05	0.03

2.2.5 Soil and Rock parameters:

- Foundation Condition: R3.5 porphyry, slightly weathered, slightly fractured rock
- Uniaxial Compressive Strength of the rock : 50 MPa
- Factored Bearing Resistance for foundation on rock : 1 MPa
- Rock/Grout Bond Stess for rock dowels : 1 MPa

	Unit Weight	Friction Angle
- Sediment	20 kN/m3	34°
- Rock	27 kN/m3	45°

2.2.6 Hydraulic parameters:

Peak instantaneous Design Flow: West Catchment Weir: 46 L/sec
East Catcment Weir: 127 L/sec

- Normal Operation Level: Static Head @ Inlet 1 m
- Emergency Operation level: Overtopping 0.3 m

3.0 CONCRETE

3.1 Materials

3.1.1 Concrete
-Cement: To CSA A3001 Type GU.
-Aggregates: To CSA A23.1
-Admixtures: CSA A23.3, ASTM C260, ASTM C494 and ASTM C1017. Calcium chloride admixtures not permitted.
-Exposure Class: CSA A23.1, F-1 (Exposed to freeze-thaw in a saturated condition but no chlorides)

3.1.2 Specified concrete cylinder strength at 28 days:
-Mix C30
-Compressive Strength f'c = 30 MPa

3.2 Do not add additional water to the concrete after batching and mixing in accordance with the mix design. The Engineer may reject any concrete to which additional water was added without further cause.

3.3 Do not place concrete without prior inspection and approval by the Engineer.

3.4 Location of construction joints shall be reviewed by the Engineer. Do not make construction joints within 2 m of the inlet pipe

3.5 Do not remove forms before the concrete achieves a cylinder strength of at least 70% of the specified compressive strength or twice the maximum stress present in the concrete after form removal.

3.6 Commence with curing of all surfaces immediately after stripping of forms.

3.7 Roughen all vertical and horizontal construction joints to minimum 5 mm amplitude by means of air/water jet blasting or bush-hamering to remove laitance and expose coarse aggregate. Simple roughening of freshly cast surface is not adequate.

4.0 REINFORCEMENT

4.1 Materials

4.1.1 Deformed bar reinforcement for structural concrete: CSA G30.18, Grade 400 W.

4.1.2 Minimum yield strengths for deformed reinforcement: fy = 400 MPa

4.2 Minimum Concrete Cover:
- 75 mm (Cast Against Rock)
- 60 mm (Contact with Water)
- 50 mm (Contact With Air or Soil)

4.3 Splices

All splice lengths not indicated explicitly on drawings are Type B, as defined by Clause 12.15.1 of CSA A23.3. Unless noted otherwise, minimum splice lengths are:

Bar (mm)	Top Bar (mm)	Other
10M	500	400
15M	700	550
20M	850	650
25M	1350	1050

Top bars have 300 mm or more of concrete cast below them.

5.0 EMBEDMENTS

5.1 Rock dowels: to CSA G30.18, grade 500W threaded bars w/ grout

5.2 Grout: Basalite Microsil Anchor Grout installed per manufacturer's recommendations or pre-approved alternate
fy (28 days) = 60 MPa (min)

5.3 Installation:

-After drilling, thoroughly clean borehole with a pressurized air/water lance.
-Introduce grout into the borehole first, using a tremie pipe to ensure grout fills the hole from the bottom up.
-Insert the rock dowel, with centralizers, into the grout-filled borehole, displacing the grout.
-Maintain dowel plumb, using wood wedges, for atleast 24 hours.

6.0 STRUCTURAL STEEL

6.1 Steel Pipe to ASTM A252 Grade 2 (GALV) fy = 240 MPa

6.2 Steel Flanges to AWWA Class B, Material to ASTM A105 (GALV)

6.3 Flange Bolts to ASTM A307 Grade B (GALV) 2

6.4 Welds

6.4.1 Welding: to CSA W59 E49XX unless noted otherwise.

6.4.2 Perform all welding using welders certified in accordance with the requirements of CSA W47.1.

6.4.3 Unless noted otherwise, welds are 6 mm continuous fillet welds.

7.0 FOUNDATION PREPARATION

7.1 Excavations shall be carried out to the lines and grades shown on the drawings or as directed by the Engineer.

7.2 Acceptable foundation shall be bedrock free of vegetation, organics, snow or ice and pockets, seams or layers of soft material.

7.3 All finished foundations shall be approved by the Owner's Engineer prior to placing concrete.

7.4 The Contractor shall take precautions to prevent disturbance of the foundation during excavation.

7.5 Bedrock surfaces may require slush grouting and/or dental concrete and shall be treated as follows:

- Remove loose or weathered rock
- Clean bedrock surface with air/water jets as appropriate
- Clean infill from cracks and joints to a depth of atleast twice the joint opening and backfill with slush grout
- Shape the bedrock surface with dental concrete as directed by the Engineer
- Dampen the bedrock surfaces before placing concrete

REVISION		DATE
2	STEEL SPOOL GEOMETRY UPDATED	19-09-2016
1	ISSUED FOR CONSTRUCTION	25-08-2016
0	ISSUED FOR CONSTRUCTION	23-08-2016

BRUCEJACK MINE
Subdrainage System - Weirs and Pipelines

TITLE:
GENERAL ARRANGEMENT
KEY PLAN AND NOTES

Gygax Engineering Associates Ltd.
103-1718 Commercial Drive
Vancouver, B.C., Canada V5N 4A3
Tel: (1 604) 254 3914 Fax: (1 604) 254 3928
E-mail: mail@gea.ca

FILE COPY SEALED
19 SEPT 16
A. GYGAX # 21344

SCALE: 1:200 (0 – 16 m)

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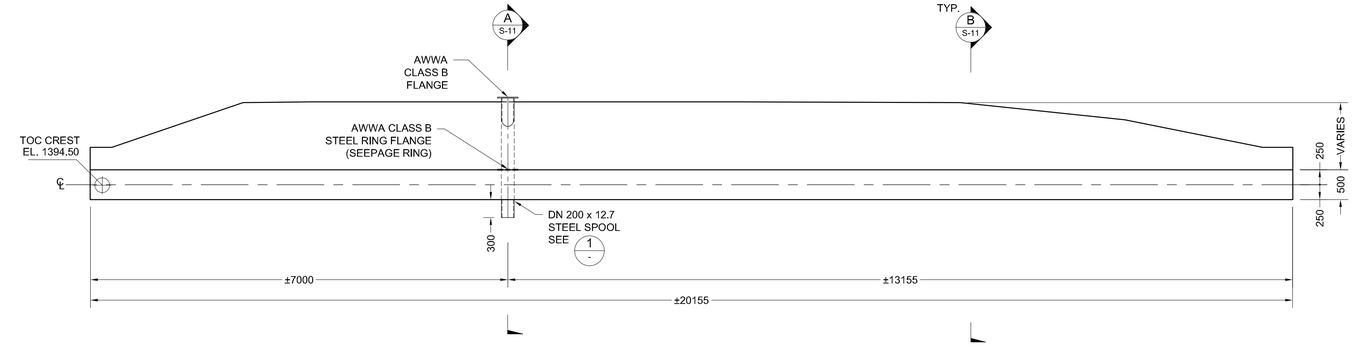
CHECKED:	A. GYGAX	DATE:	19 AUGUST 2016
APPROVED:	A. GYGAX	DATE:	23 AUGUST 2016

DRAWING NO: 16021.621- S-01 | 2



PLAN - WEST WEIR
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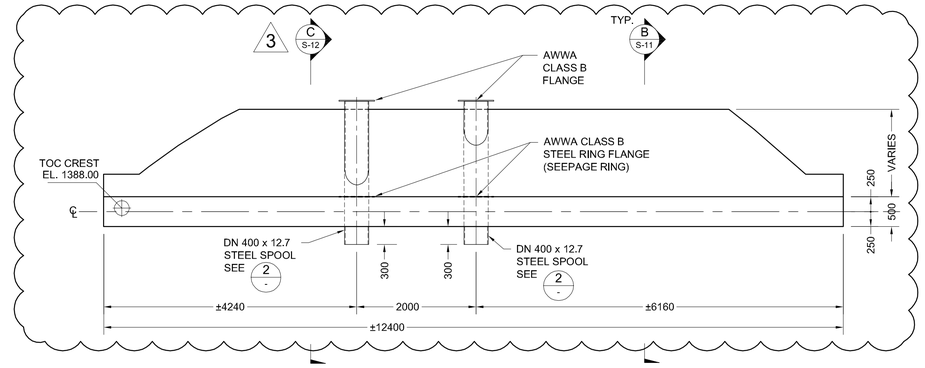

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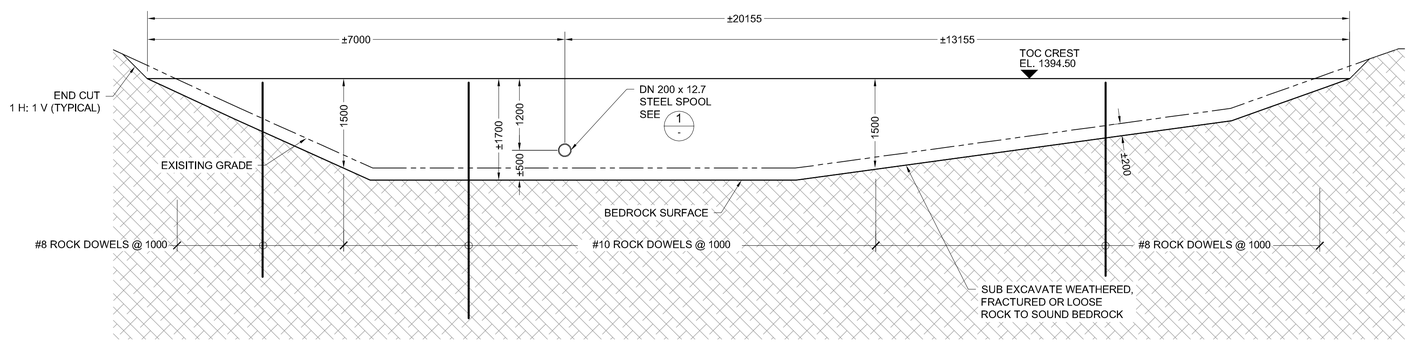

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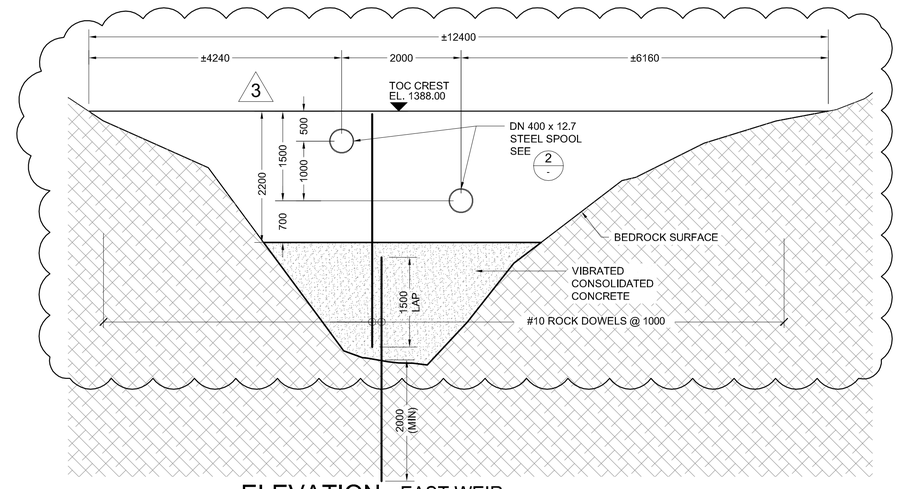

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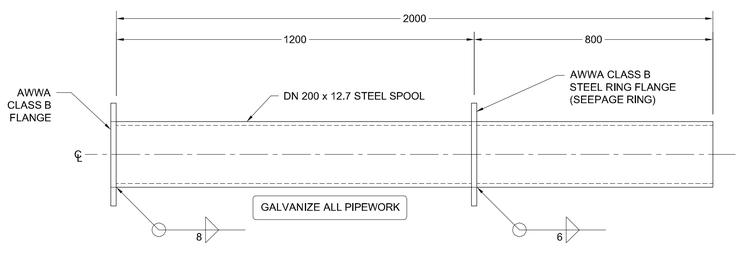

1/- 1/S-11 DETAIL - WEST WEIR STEEL SPOOL
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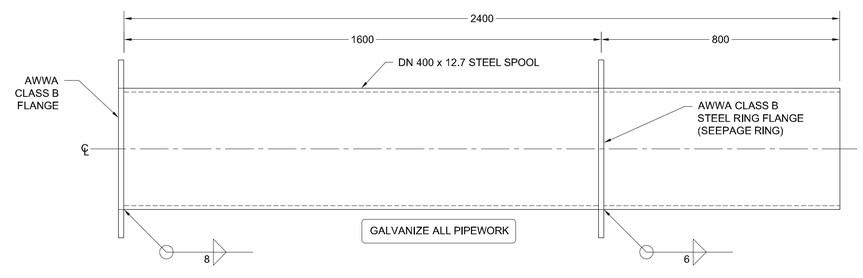

2/- 2/S-11 DETAIL - WEST WEIR STEEL SPOOL
SCALE: 1:10

GALVANIZE ALL PIPEWORK

NOTES:

1.1. REFER TO DWG S-01 FOR COMPLETE STRUCTURAL NOTES.

1.2. PIPE INTAKES SHALL BE MINIMUM 500 mm ABOVE APPROVED FOUNDATION.

REVISION		DATE
3	EAST WEIR GEOMETRY UPDATED	09-11-2016
2	STEEL SPOOL GEOMETRY UPDATED	19-09-2016
1	ISSUED FOR CONSTRUCTION	25-08-2016
0	ISSUED FOR CONSTRUCTION	23-08-2016

BRUCEJACK MINE

Subdrainage System - Weirs and Pipelines

TITLE:

STRUCTURE OUTLINE & REINFORCEMENT

PLANS AND ELEVATIONS

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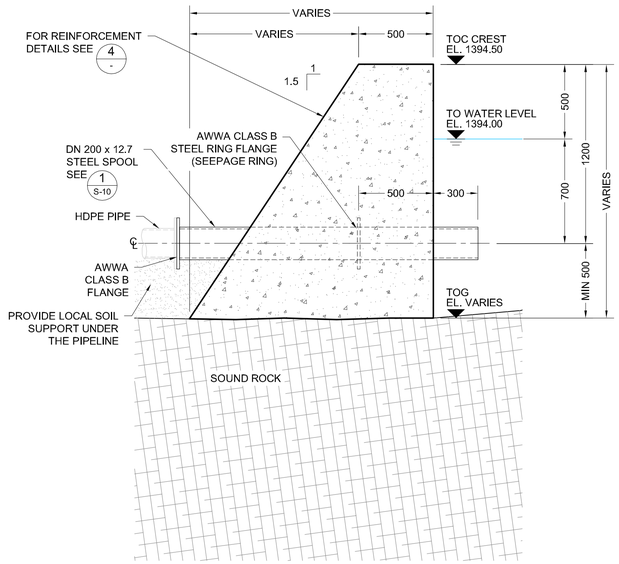
FILE COPY SEALED
09 NOV 16
A. GYGAX # 21344

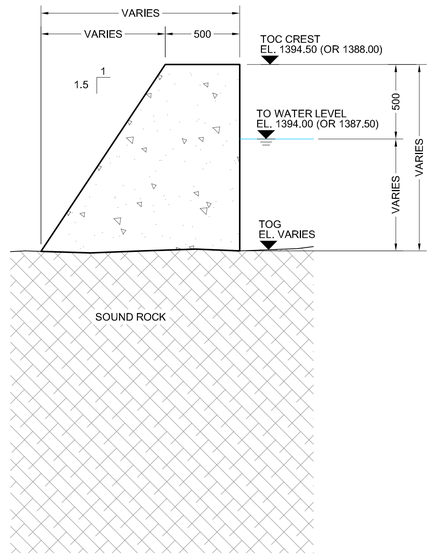
SCALE: 1:50 (0 – 4.0 m); 1:10 (0 – 800 mm)

DRAWN:	P. BHAT	DATE:	19 AUGUST 2016
CHECKED:	A. GYGAX	DATE:	19 AUGUST 2016
APPROVED:	A. GYGAX	DATE:	23 AUGUST 2016

DRAWING NO: 16021.621- S-10 | 3



A S-10 SECTION - WEST WEIR
SCALE: 1:20



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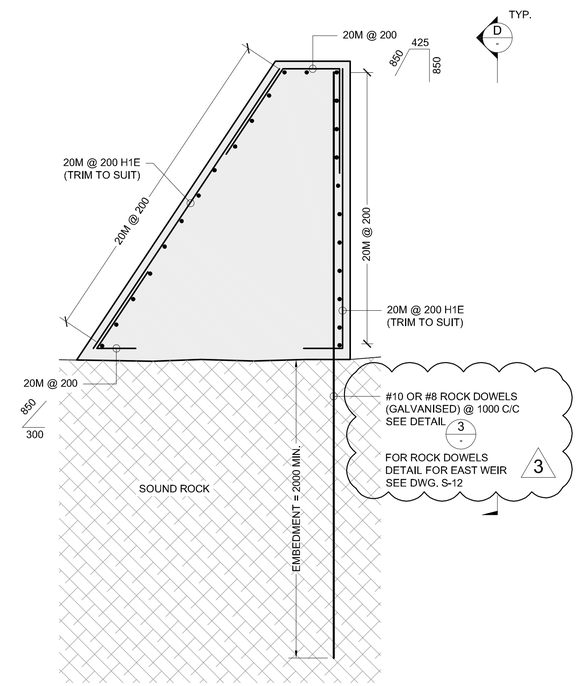

4 S-12 4 - DETAIL - REINFORCEMENT
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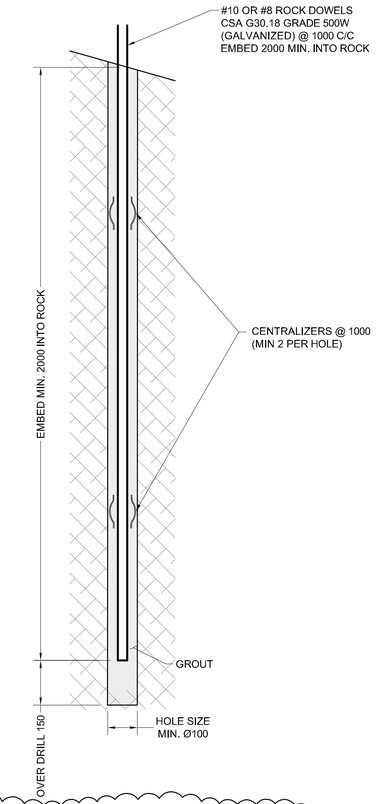

3 S-12 3 - DETAIL - ROCK DOWEL
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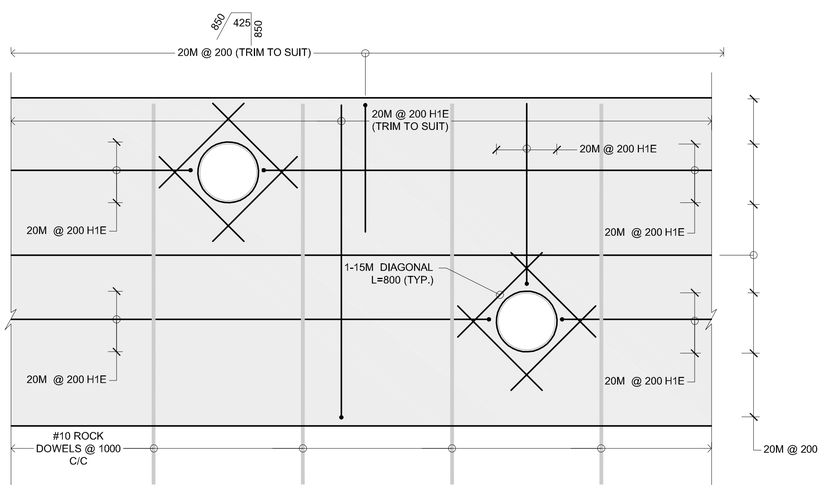

FOR WEST WEIR, SINGLE 200mm SPOOL OPENING ONLY

D - SECTION - TYPICAL OPENING
SCALE: 1:20 (EAST WEIR)

NOTES:

1.1. REFER TO DWG S-01 FOR COMPLETE STRUCTURAL NOTES.

1.2. PIPE INTAKES SHALL BE MINIMUM 500 mm ABOVE APPROVED FOUNDATION.

REVISION		DATE
3	EAST WEIR GEOMETRY UPDATED	09-11-2016
2	STEEL SPOOL GEOMETRY UPDATED	19-09-2016
1	ISSUED FOR CONSTRUCTION	25-08-2016
0	ISSUED FOR CONSTRUCTION	23-08-2016

BRUCEJACK MINE
Subdrainage System - Weirs and Pipelines

TITLE:
STRUCTURE OUTLINE & REINFORCEMENT
SECTIONS AND DETAILS

GEA Gygax Engineering Associates Ltd.
103-1718 Commercial Drive
Vancouver, B.C., Canada V5N 4A3
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E-mail: mail@gea.ca

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09 NOV 16
A. GYGAX # 21344

SCALE: 1:20 0 1.6 m; 1:10 0 800 mm

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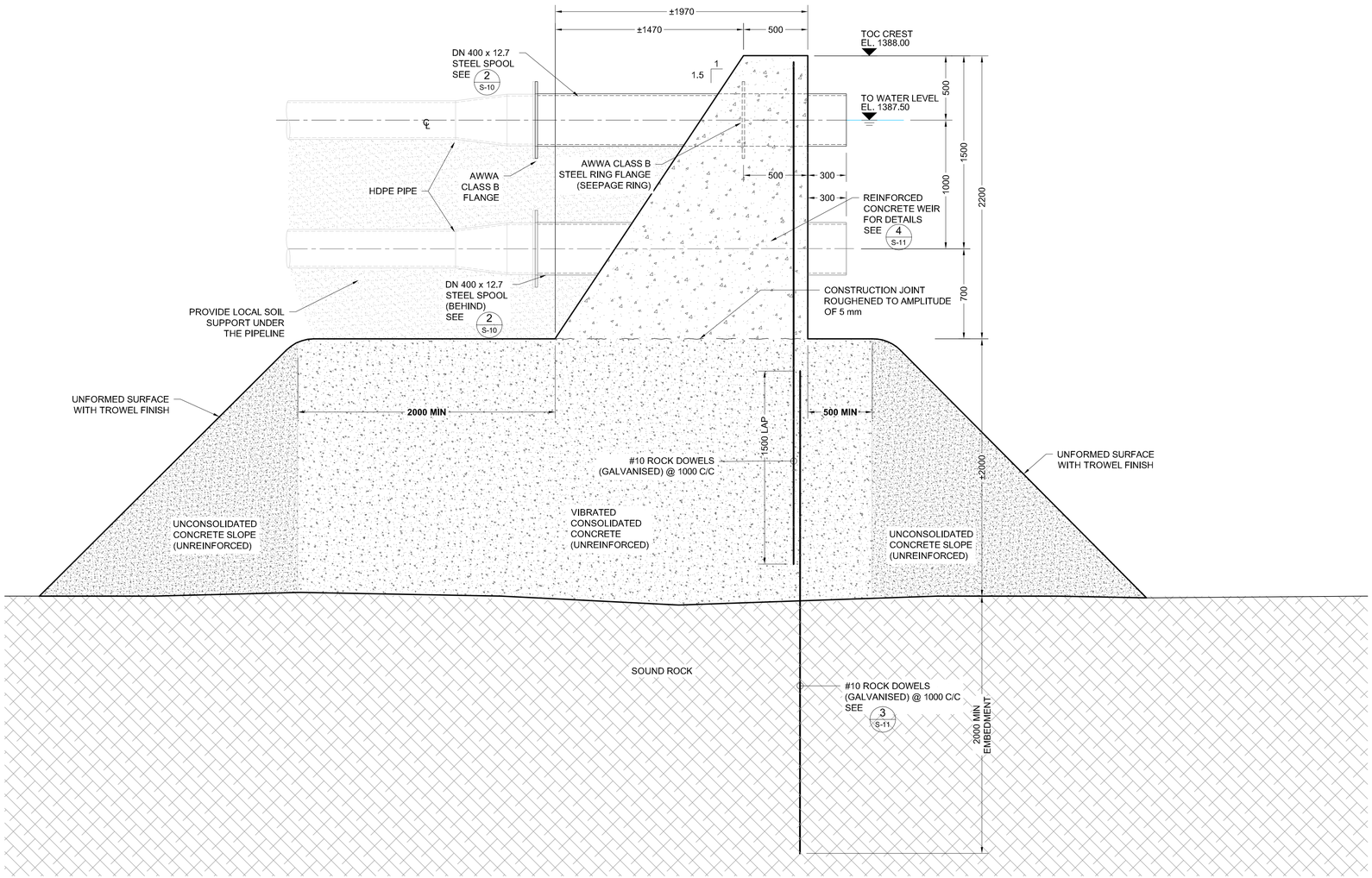
CHECKED:	A. GYGAX	DATE:	19 AUGUST 2016
APPROVED:	A.GYGAX	DATE:	23 AUGUST 2016

DRAWING NO: 16021.621- S-11 3



C S-10 SECTION
SCALE: 1:20

NOTES:

1.1. REFER TO DWG S-01 FOR COMPLETE STRUCTURAL NOTES.

1.2. PIPE INTAKES SHALL BE MINIMUM 500 mm ABOVE APPROVED FOUNDATION.

1.3. UNREINFORCED CONCRETE:

- MIX C30
- SPECIFIED CONCRETE COMPRESSIVE STRENGTH AT 28 DAYS f'c = 30 MPa
- CONCRETE PORTION BELOW THE EAST WEIR SHALL BE CONSOLIDATED (VIBRATED) CONCRETE.
- SLOPING CONCRETE PORTION SHALL BE UNCONSOLIDATED (NON-VIBRATED) CONCRETE WITH UNFORMED SURFACE AND TROWEL FINISH.
- INTERFACE BETWEEN STRUCTURAL CONCRETE AND UNREINFORCED CONCRETE SHALL BE ROUGHENED BY MEANS OF "GREEN-CUTTING".

REVISION		DATE
0	ISSUED FOR CONSTRUCTION	09-11-2016

BRUCEJACK MINE

Subdrainage System - Weirs and Pipelines

TITLE:

STRUCTURE OUTLINE

SECTION

Gygax Engineering Associates Ltd.
103-1718 Commercial Drive
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Tel: (1 604) 254 3914 Fax: (1 604) 254 3928
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A. GYGAX # 21344

SCALE: 1:20 (0 – 1.6 m)

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APPROVED:	A.GYGAX	DATE:	23 AUGUST 2016

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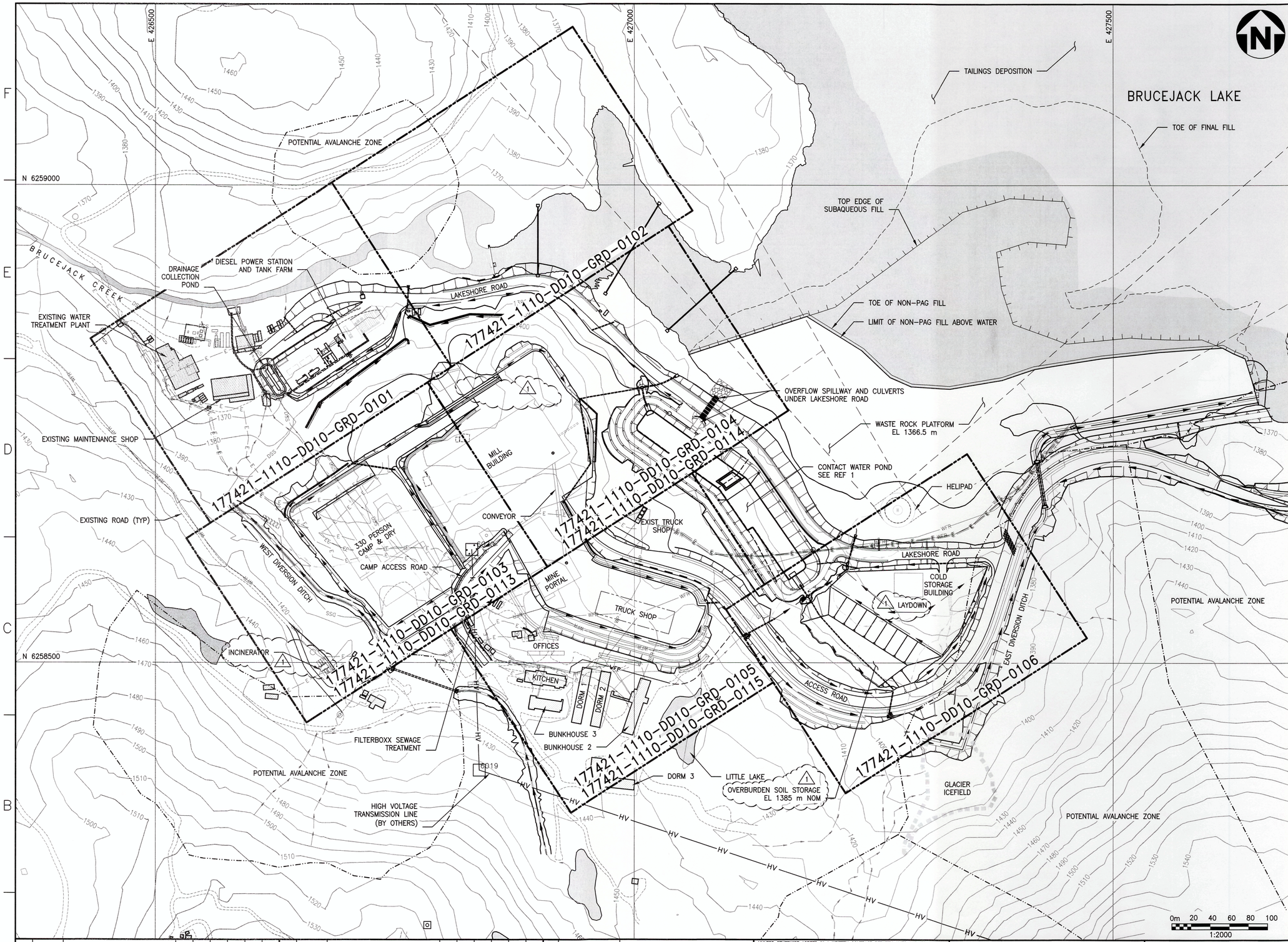

GENERAL NOTES FOR ROUGH GRADING DRAWINGS:

1. ALL EARTHWORKS, BLASTING, AND MATERIALS FOR ROUGH GRADING SHALL CONFORM TO THE FOLLOWING SPECIFICATIONS:

   ROCK EXCAVATION: 177421-0000-DD10-SPC-0001
   EXCAVATION FILL & COMPACTION: 177421-0000-DD10-SPC-0002
   EXPLOSIVES & BLASTING SAFETY: 177421-0000-DD10-SPC-0004

2. REMOVE OVERBURDEN AND RIPPABLE ROCK FROM SURFACES TO BE BLASTED, PLACE OVERBURDEN MATERIAL IN SEPARATE STOCKPILES IN A DESIGNATED AREA, IN ACCORDANCE WITH THE SPECIFICATIONS. HAUL RIPPABLE ROCK TO LAKE FOR DISPOSAL.

3. THIS IS A COMPACT AND CONGESTED SITE. EXERCISE EXTREME CAUTION, ESPECIALLY WHEN BLASTING IN THE AREAS ABOVE THE GENERATOR/FUEL TANK PAD, AND ADJACENT TO THE EXISTING CAMP, THE MECHANICS SHOP, THE NEW PERMANENT CAMP AND OTHER FACILITIES.

4. ALL ROCK ON THE SITE IS CONSIDERED PAG (POTENTIALLY ACID GENERATING) AND SHALL BE DISPOSED OF IN BRUCEJACK LAKE. PAG ROCK SHALL NOT BE USED AS FILL UNLESS THE CONTRACTOR IS SPECIFICALLY DIRECTED TO DO SO BY THE ENGINEER.

5. LAKE DISPOSAL OF PAG ROCK SHALL BE BY OTHERS. CONTRACTOR SHALL COORDINATE DUMPING OF WASTE ROCK WITH OTHERS PERFORMING DISPOSAL PROCEDURE.

6. ALL FILL MATERIALS SHALL BE PRODUCED FROM NON-PAG ROCK ORIGINATING FROM THE QUARRY.

7. BEFORE ANY FILL MATERIALS ARE PLACED ON OVERBURDEN SOIL, THE SURFACE SHALL BE STRIPPED OF INCOMPETENT OR EXCESSIVELY WET SOIL AND INSPECTED AND APPROVED BY THE ENGINEER.

8. LARGE EMBANKMENTS SHALL BE CONSTRUCTED OF RUN-OF-QUARRY ROCK FILL PLACED AND COMPACTED IN ACCORDANCE WITH SPECIFICATION 177421-0000-DD10-SPC-0002. EMBANKMENT FILL UNDER STRUCTURES AND FOUNDATIONS SHALL BE 300 MINUS CRUSHED ROCK FILL OVERLAIN BY A MINIMUM OF 1m of 75 MINUS STRUCTURAL FILL. (1)

9. FILL EMBANKMENTS LESS THAN 1m IN DEPTH SHALL BE CONSTRUCTED ENTIRELY OF 75mm MINUS ROAD SUBBASE MATERIAL.

10. THE MILL PAD AREAS SHALL BE FINISHED WITH A 150mm LAYER (HALF OF THE DESIGN THICKNESS) OF BASE COURSE MATERIAL BY CONTRACT # CB002. PLACEMENT OF THE REMAINING HALF OF THE BASE COURSE LAYER AND GRADING SHALL BE PERFORMED BY OTHERS AT THE END OF THE PROJECT.

11. ALL DIMENSIONS ARE IN METRES UNO. ALL COORDINATES, CONTOURS AND SPOT ELEVATIONS ARE IN METRES AND REFER TO GEODETIC DATUM IN UTM NAD83, ZONE 9. TO COMPUTE HORIZONTAL GROUND-LEVEL DISTANCES FROM UTM COORDINATES, DIVIDE UTM GRID DISTANCES BY THE AVERAGE COMBINED FACTOR OF 0.999444.

12. CONTRACTOR SHALL CONFIRM THAT IN WORKING AREAS ALL EXISTING UTILITIES/SERVICE PIPES AND LINES HAVE BEEN RELOCATED BY OTHERS BEFORE COMMENCING SITE WORKS.

13. FOR GEOTECHNICAL INFORMATION, SEE "UPDATED GEOTECHNICAL ANALYSIS AND DESIGN OF THE PLANT SITE FOUNDATION", BJ-2014-21, BGC ENGINEERING INC., JAN 14, 2015.

LEGEND:

EXISTING:

- MAJOR CONTOUR — 1420
- MINOR CONTOUR
- ROAD
- DITCH
- FRESH WATER — WFR
- ELECTRICAL CABLE — E
- SANITARY SEWER — DSS
- POTABLE WATER — WP
- LAKE

PROPOSED:

- ROUGH GRADE EL 1408.45
- DITCH/PIPE INVT EL 1390.25
- SWALE
- DITCH
- FIRE WATER LINE — WFP
- CUT/FILL SLOPE
- CULVERT
- EARTH BERM

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
1	14OCT15	ISSUED FOR CONSTRUCTION	GP	EW	EW	EY	SL	
0	28AUG15	ISSUED FOR CONSTRUCTION	JQ	HD	EW	EY	SL	
D	08JUL15	ISSUED FOR APPROVAL	JQ		EW	EY		
C	16JUN15	ISSUED FOR TENDER	JQ		EW	EY		
B	27FEB15	ISSUED FOR TENDER	JQ		EW	EY		
A	19FEB15	ISSUED FOR SQUAD CHECK						

REF	NUMBER	TITLE
1	3230-DD10-GRD-0170	CONTACT WATER POND, PLAN

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN AMEC AND ITS CLIENT: (I) THIS AMEC DOCUMENT CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) THIS DOCUMENT MAY ONLY BE USED BY THE CLIENT IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT HAS BEEN DELIVERED. ANY OTHER USE OR RELIANCE ON THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK AND RESPONSIBILITY.

STAMP/SEAL: PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 15 Oct 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR.	DEPARTMENT MGR.	PROJECT MGR.
	G. LI	S. LYNN

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	EW	20JAN15
		DRN	JQ	21JAN15
SCALE	PACKAGE CODE	CHK	HD	28AUG15
1:2000		APP	EW	28AUG15

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING ROUGH GRADING & DITCHING KEY PLAN

AREA 1110 — GENERAL DEVELOPMENT

CLIENT DWG. NO.

DRAWING NO. 177421-1110-DD10-GRD-0100 — REV. 1

ISO A1-594x841

SAVED: 14-Oct-15 11:58 AM PLOTTED: 14-Oct-15 1:11 PM USER: BATCHPLOT, GI

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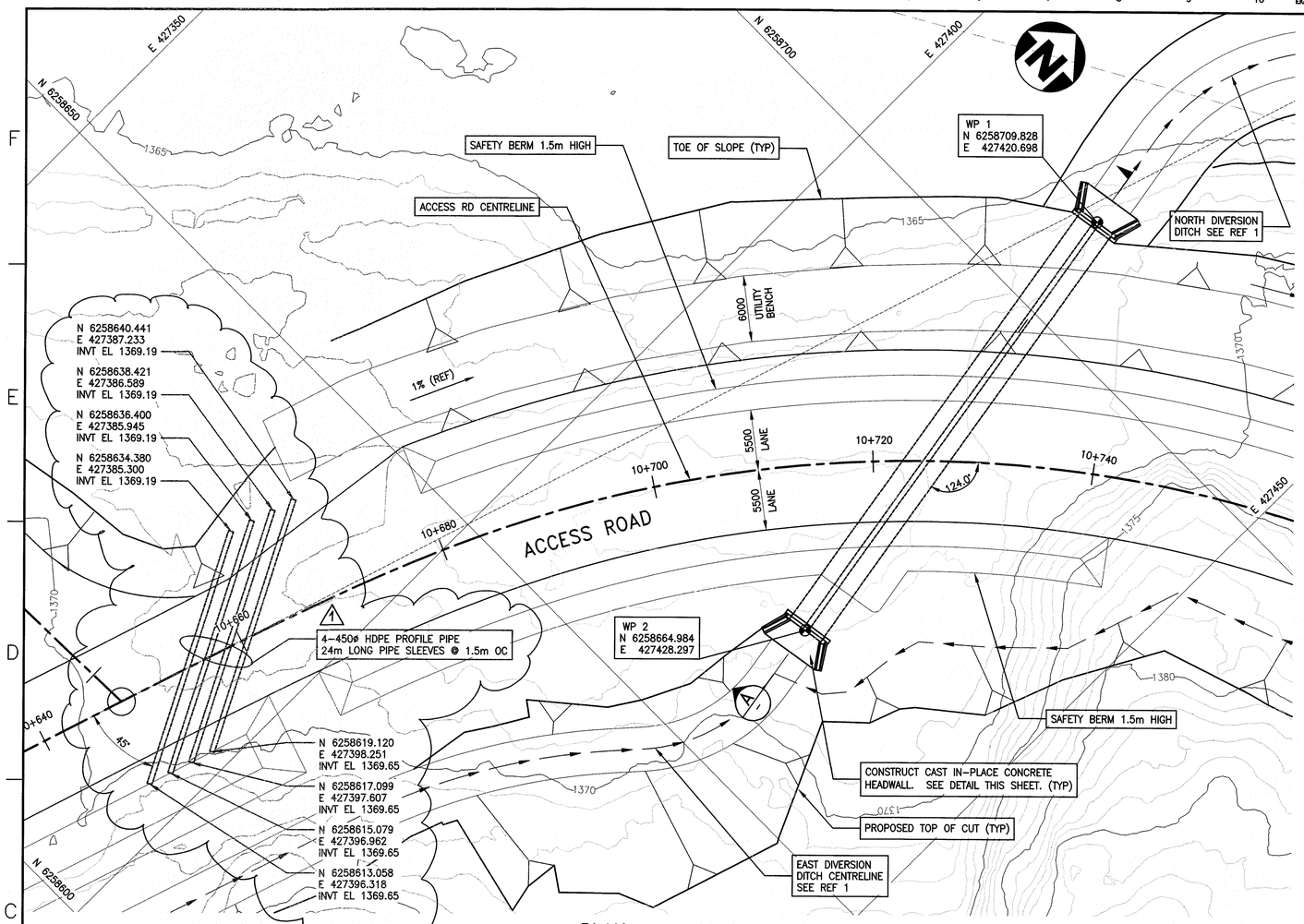

PLAN
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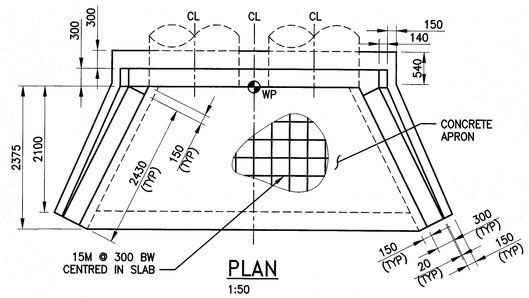

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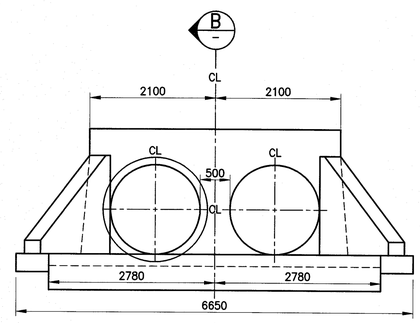

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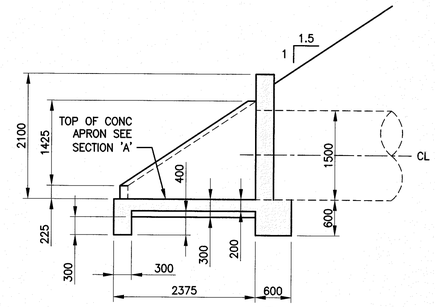
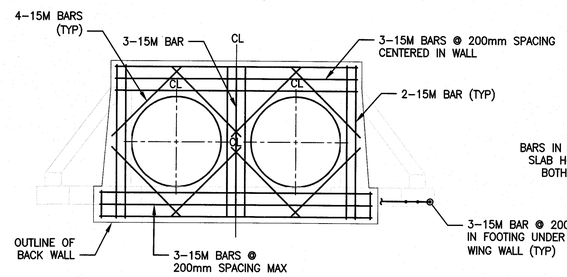
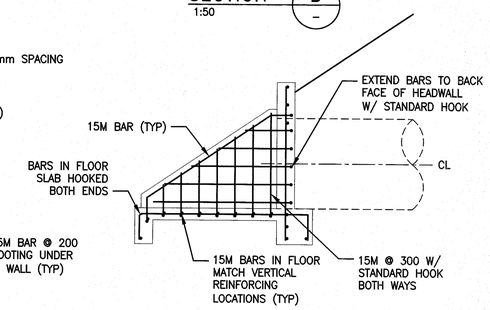


SECTION B
1:50

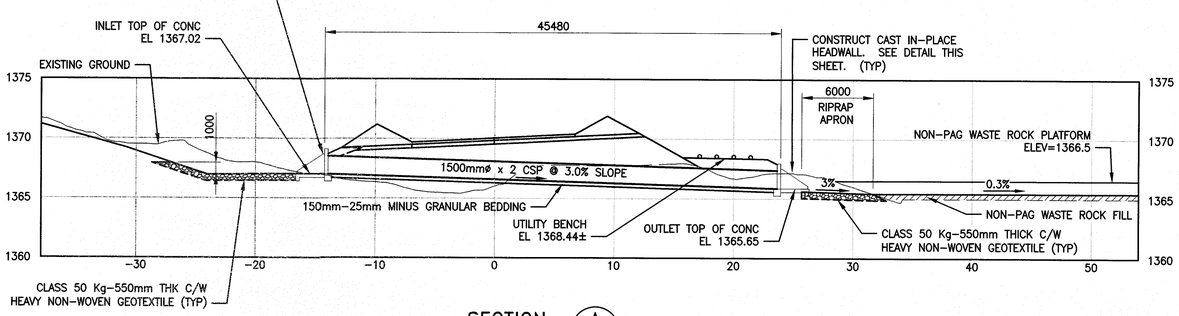




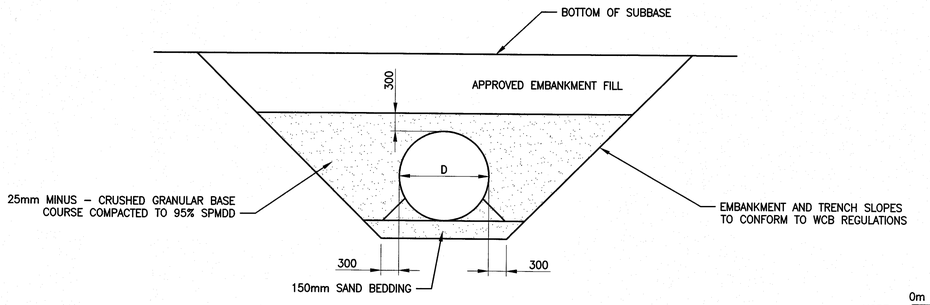
REINFORCING DETAILS
1:50

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES UNO.



SECTION A
1:250



TYPICAL CULVERT INSTALLATION IN EMBANKMENT
1:50

HORZ. 0m 2.5 5 7.5 10 12.5 — 1:250

HORZ. 0m 0.5 1 1.5 2 2.5 — 1:50

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
1	30SEP15	ISSUED FOR CONSTRUCTION	KW	EW	GH	EY	SL	
0	01SEP15	ISSUED FOR CONSTRUCTION	JQ	EW	EW	EY	SL	
C	17JUL15	ISSUED FOR APPROVAL	KW	EW	EW	EY		
B	12JUN15	ISSUED FOR TENDER	ARG	EW	EW	EY		
A	08JUN15	ISSUED FOR SQUAD CHECK	ARG	EW	EW	EY	SL	

REF	NUMBER	TITLE
5	1110-DD10-GRD-0254	ROADS, PLAN AND PROFILE
4	1110-DD10-GRD-0251	ROADS, PLAN AND PROFILE
3	1110-DD10-GRD-0233	GRADING DRAWING, DETAILS & SECTIONS
2	1110-DD10-GRD-0232	GRADING DRAWING, DETAILS & SECTIONS
1	1110-DD10-GRD-0262	DIVERSION DITCHES, PLAN & PROFILE

REFERENCES

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STAMP/SEAL

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 5 Oct 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR	DEPARTMENT MGR	PROJECT MGR
	G. LI	S. LYNN

PROJECT: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	ARG	31MAR15
SCALE	PACKAGE CODE	DRN	ARG	31MAR15
AS SHOWN		CHK	EW	02SEP15
		APP	EW	02SEP15

PRETIVM

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES CULVERT DETAILS - SHEET 1

amec foster wheeler

AREA 1110 — GENERAL DEVELOPMENT

CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0236 — REV 1

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0236.DWG

SAVED: 30-Sep-15 3:15 PM PLOTTED: 30-Sep-15 3:17 PM USER: BATCHPLOT, GI

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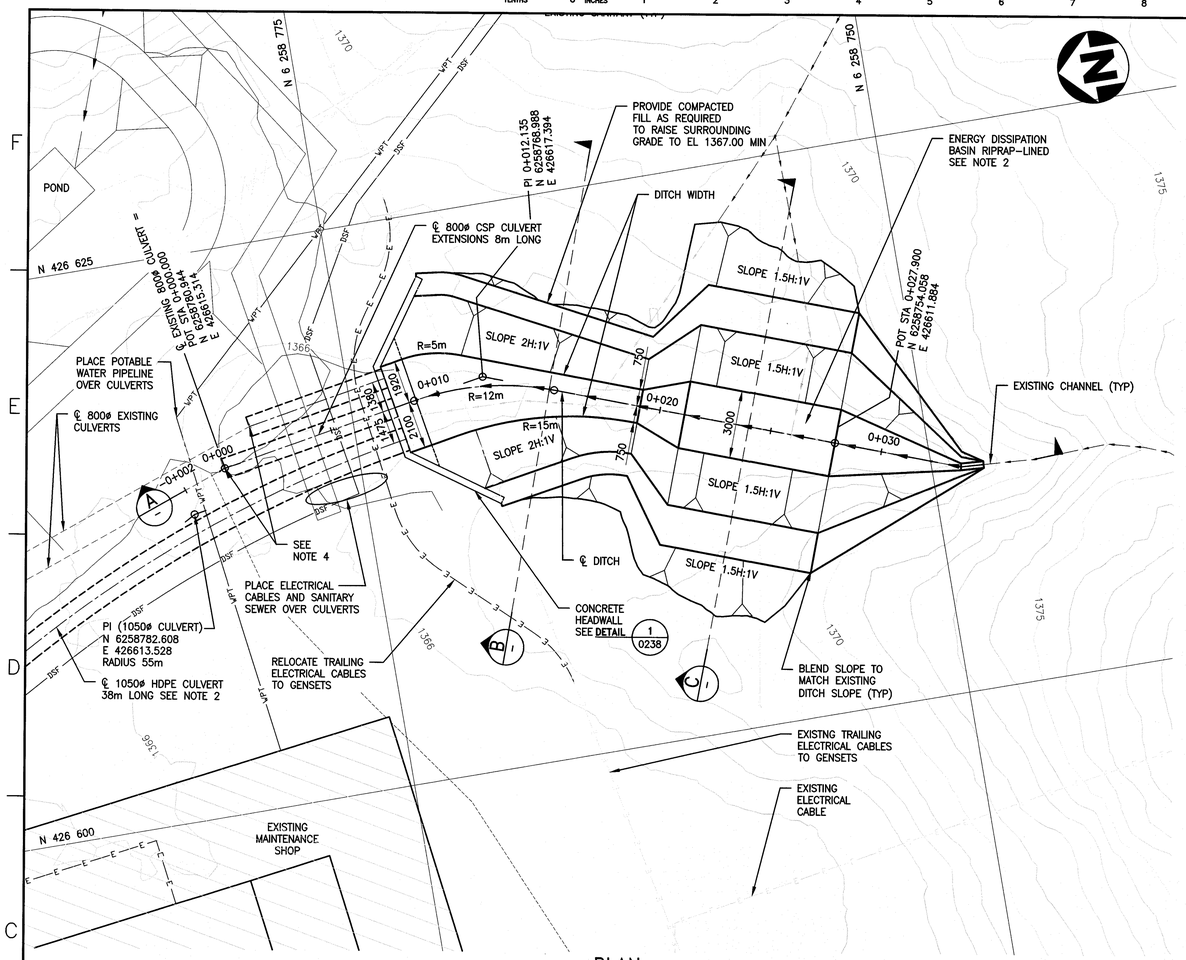
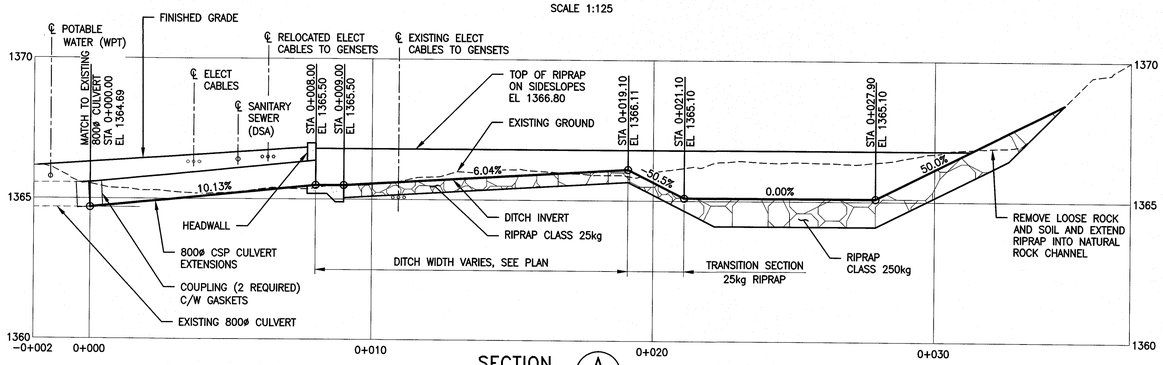
ISO A1-594x841



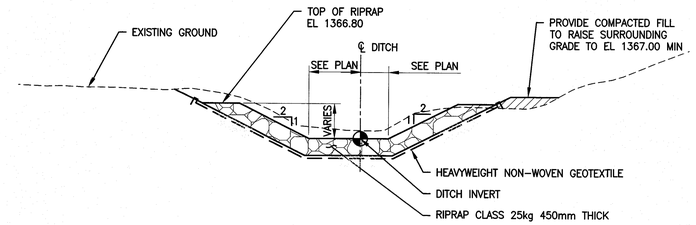
PLAN
SCALE 1:125



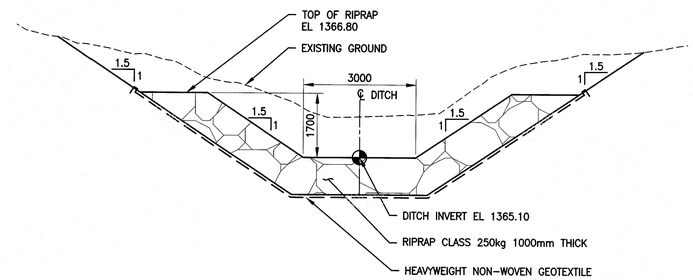
SECTION A
1:100

NOTES:

1. SEE GENERAL NOTES FOR ROUGH GRADING DRAWING IN 177421-1110-DD10-GRD-0100.
2. CONTRACT CB002 IS TO COMPLETE THE ENERGY DISSIPATION HEADWALL, CULVERT AND MANHOLE, PRIOR TO CONSTRUCTION OF THE DPS COLLECTION POND BY OTHERS.
3. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNO.
4. LOCATIONS OF TWO EXISTING 800ø CULVERT INLETS ARE APPROX AND MUST BE VERIFIED, IN ORDER TO DETERMINE THE LENGTHS FOR THE NEW CULVERT EXTENSIONS.



SECTION B
1:75



SECTION C
1:75

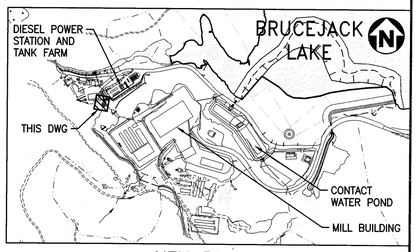
LEGEND:

EXISTING:

- 1350 MAJOR CONTOUR
- MINOR CONTOUR
- CREEK
- CREEK TO BE REMOVED
- ROAD
- CULVERT
- AVALANCHE ZONE
- SANITARY SEWER
- ELECTRICAL CABLES
- FRESH WATER
- BUILDING OUTLINE

PROPOSED:

- SLOPE SYMBOL
- BUILDING OUTLINE
- YFP YARD FIRE HYDRANT
- WFP WALL FIRE HYDRANT
- ROAD/PAD EDGE
- DITCH
- ELECTRICAL CABLE TRENCH
- E ELECTRICAL CABLES
- DSA SANITARY – GRAVITY
- DSF SANITARY – PUMPED
- MANHOLE
- WF FRESH WATER
- WFP FIRE WATER
- WPT POTABLE WATER
- WPR PROCESS WATER
- DST STORM
- WET TREATED EFFLUENT
- CULVERT



KEY PLAN

0m 1 2 3 4 — 1:75

0m 1 2 3 4 5 — 1:100

0m 1 2 3 4 5 6 — 1:125

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	29JAN16	ISSUED FOR CONSTRUCTION	GP	PN	EW	EY		
B	14DEC15	ISSUED FOR APPROVAL	GP	EW	EW	EY		
A	06NOV15	ISSUED FOR SQUAD CHECK	GP					

REF	NUMBER	TITLE
3	1110-DD10-GRD-0100	ROUGH GRADING & DITCHING, KEY PLAN
2	1110-DD10-GRD-0238	DIVERSION DITCHES, CULVERT DETAILS, SHEET 3
1	1110-DD10-GRD-0201	FINISHED GRADING PLAN, SHEET 1

REFERENCES

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STAMP/SEAL

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — A. HARO GARCIA # 42375 — 29 JAN 2016

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR. | DEPARTMENT MGR. (FOR) | PROJECT MGR.

PROJECT PHASE: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	EW	22OCT15
SCALE	PACKAGE CODE	DRN	GP	22OCT15
AS NOTED		CHK	PN	29JAN16
		APP		29JAN16

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES CULVERT DETAILS – SHEET 2

AREA 1110 — GENERAL DEVELOPMENT

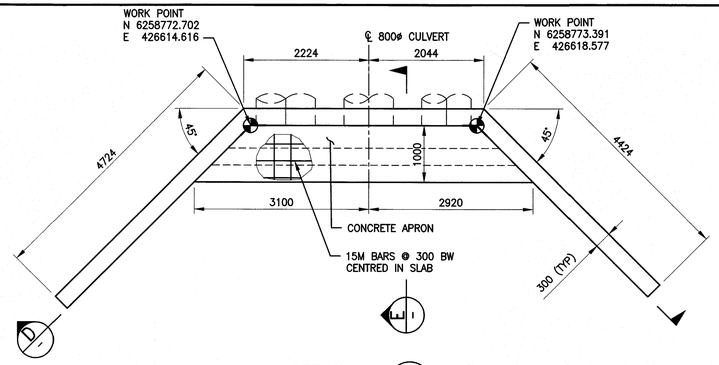
CLIENT DWG. NO.

DRAWING NO. 177421-1110-DD10-GRD-0237 — REV. 0

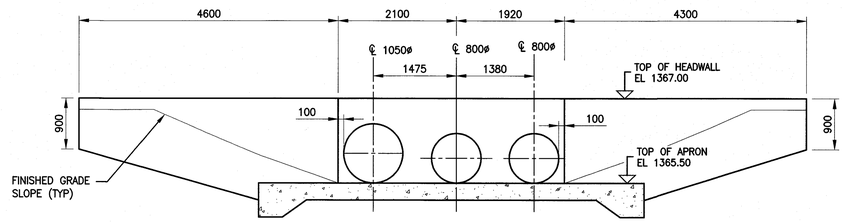
SAVED: 29-Jan-16 3:06 PM PLOTTED: 29-Jan-16 3:11 PM USER: BATCHPLOT, GI

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0237.DWG

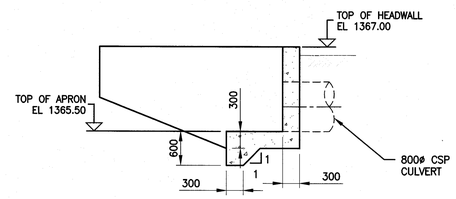
ISO A1-594-841



DETAIL 1 (0237)
1:50



SECTION D
1:50



SECTION E
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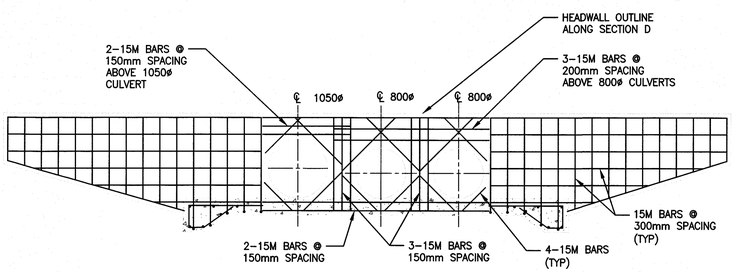

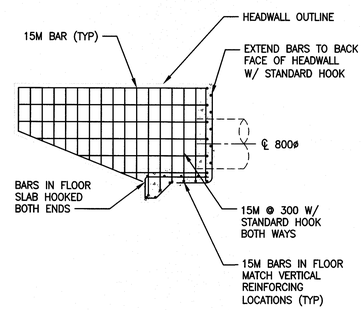

REINFORCING DETAILS
SCALE 1:50

NOTES:

1. SEE GENERAL NOTES FOR ROUGH GRADING DRAWINGS IN 177421-1110-DD10-GRD-0100.
2. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNO.

0m 0.5 1 1.5 2 2.5
1:50

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	29JAN16	ISSUED FOR CONSTRUCTION	GP	PN	EW	EY		
B	11DEC15	ISSUED FOR APPROVAL	GP	EW	EW	EY		
A	09NOV15	ISSUED FOR SQUAD CHECK	GP					

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP

REF	NUMBER	TITLE
1	1110-DD10-GRD-0237	DIVERSION DITCH, CULVERT DETAILS, SHEET 2

REFERENCES

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PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — A. HARO GARCIA # 42373 — 29 JAN 2016

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR. | FOR DEPARTMENT MGR. | PROJECT MGR.

PROJECT PHASE: BRUCEJACK

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	EW	03NOV15
		DRN	GP	03NOV15
SCALE: AS NOTED	PACKAGE CODE	CHK	PN	29JAN16
		APP		29 JAN 16

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES CULVERT DETAILS – SHEET 3

AREA: 1110 — GENERAL DEVELOPMENT

CLIENT DWG. NO.

DRAWING NO.: 177421-1110-DD10-GRD-0238 — REV.: 0

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0238.DWG

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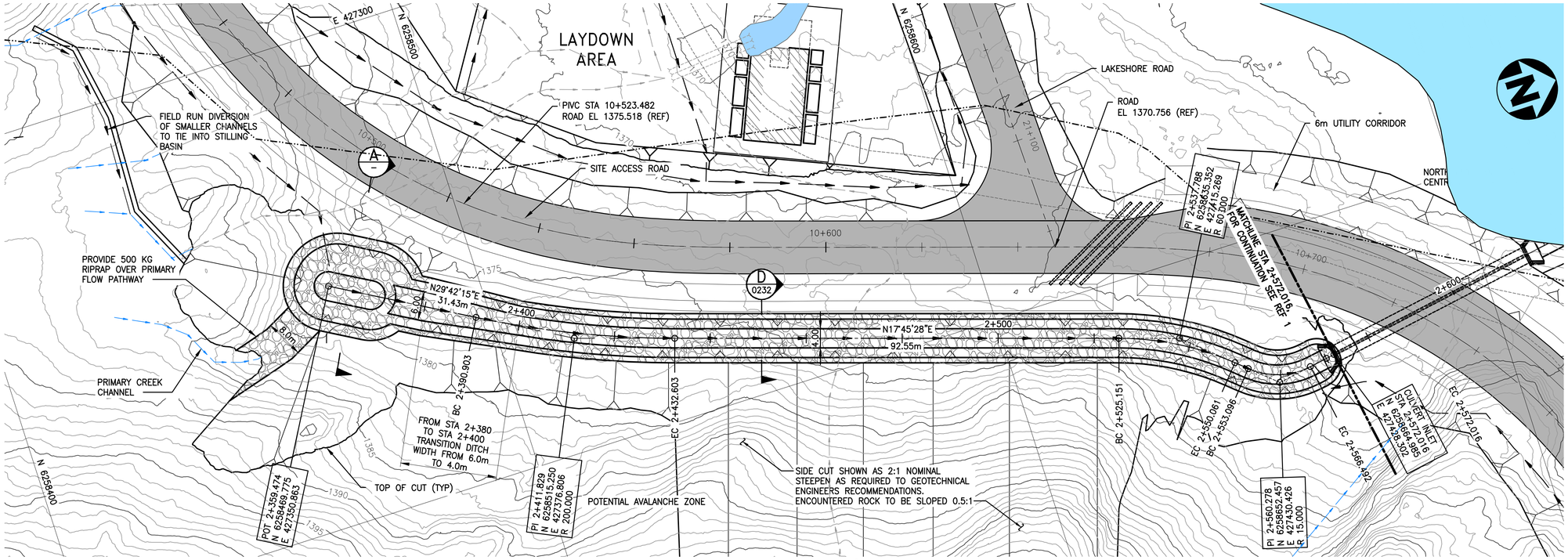
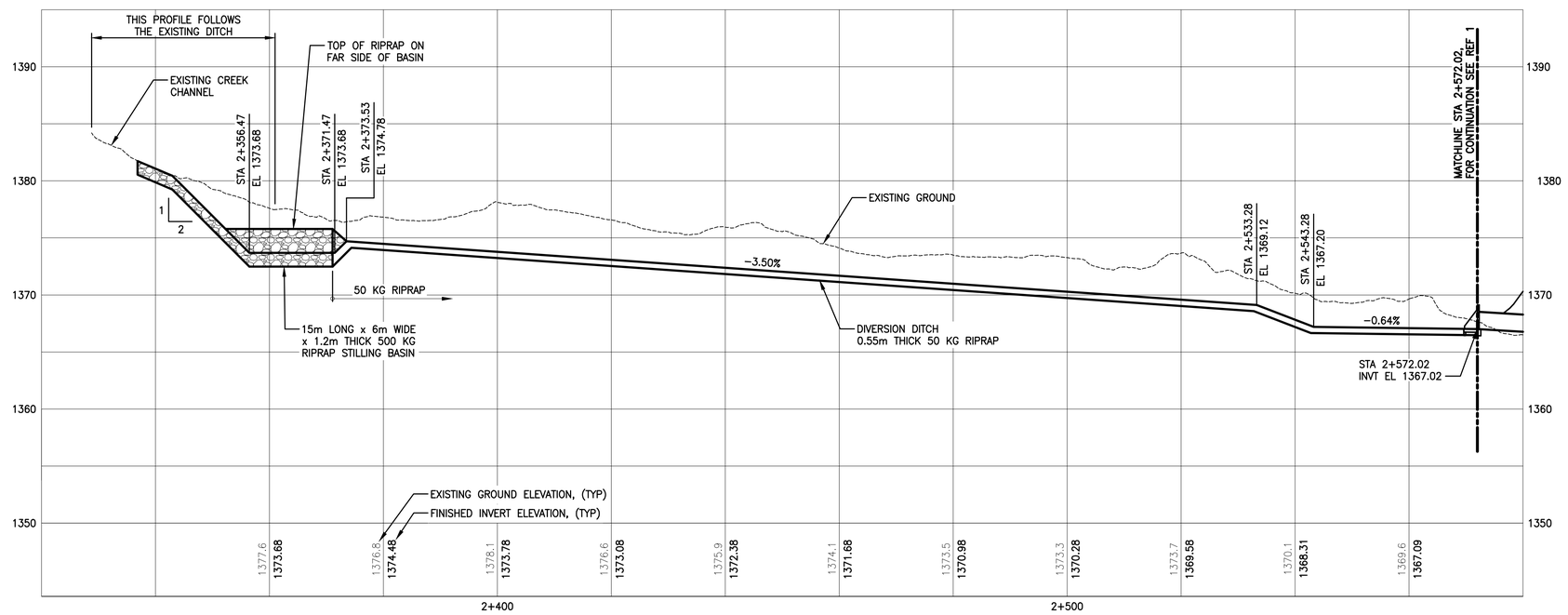
ISO A1-594x841



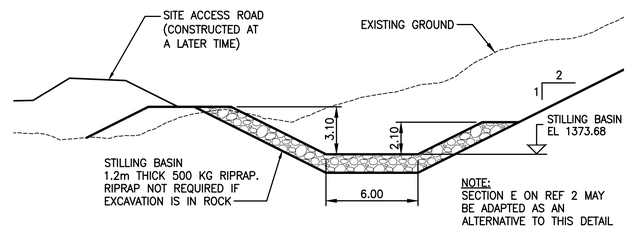
PLAN (ALTERNATE DESIGN)

SCALE 1:500



PROFILE (ALTERNATE DESIGN)

SCALE 1:500 HOR
1:250 VERT



SECTION A

1:200

NOTE:

THIS DRAWING PROVIDES AN ALTERNATIVE DESIGN FOR THE EAST DIVERSION DITCH TO THAT SHOWN ON DRAWING 177421-1110-DD10-GRD-0261.

0m 5 10 15 20 25
1:500

0m 2.5 5 7.5 10 12.5
1:250

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	04NOV15	ISSUED FOR INFORMATION	MT	EW	VM	EY	SL	

REF	NUMBER	TITLE
3	1110-DD10-GRD-0234	FINISHED GRADING, DETAILS & SECTIONS, SHEET 4
2	1110-DD10-GRD-0232	FINISHED GRADING, DETAILS & SECTIONS, SHEET 2
1	1110-DD10-GRD-0262	DIVERSION DITCHES, PLAN & PROFILE, SHEET 2

REFERENCES

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STAMP/SEAL

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	VM	15OCT15
		DRN	MT	15OCT15
SCALE	PACKAGE CODE	CHK	EW	
AS NOTED		APP	VM	

PRETIVM

amec foster wheeler

SUBJECT

CIVIL
GRADING DRAWING
EAST DIVERSION DITCH
PLAN & PROFILE

AREA 1110 — GENERAL DEVELOPMENT

CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0260 REV 0

SAVED: 04-Nov-15 11:16 AM PLOTTED: 06-Nov-15 3:04 PM USER: BATCHPLOT, GI

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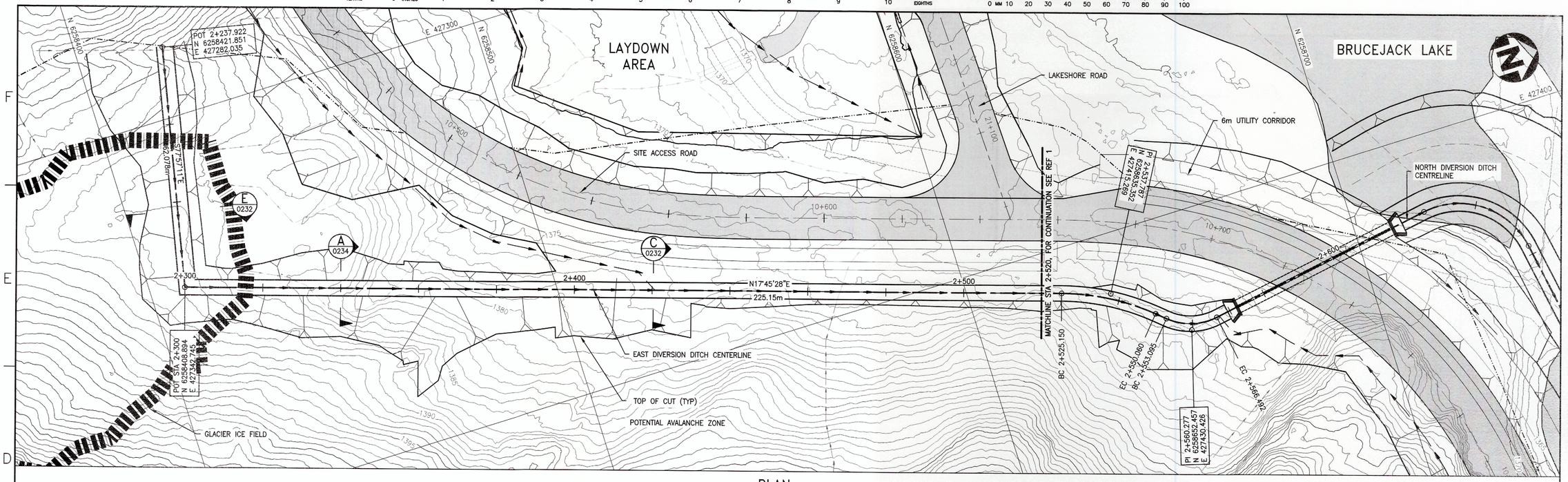
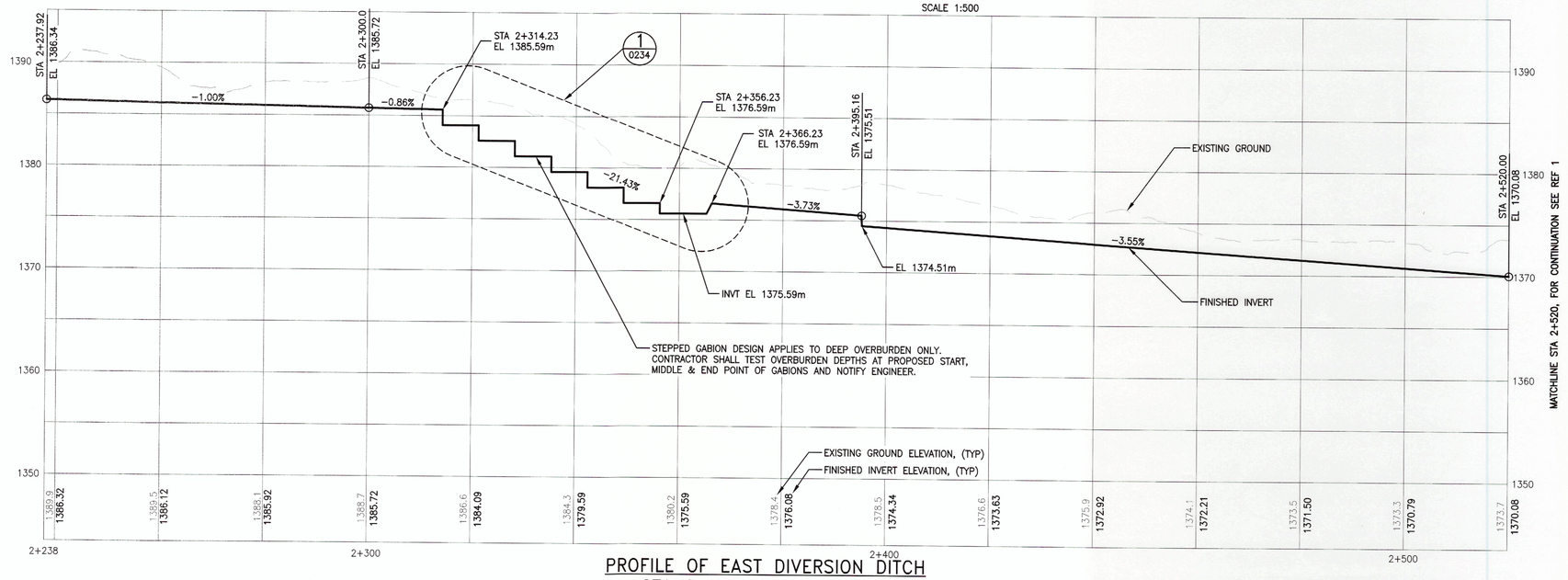
ISO A1-594x841



PLAN

SCALE 1:500



PROFILE OF EAST DIVERSION DITCH
STA 2+237.922 TO 2+520

SCALE 1:500 HOR
1:250 VERT

0m 5 10 15 20 25
1:500

0m 2.5 5 7.5 10 12.5
1:250

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	26AUG15	ISSUED FOR CONSTRUCTION	CP	HD	EW	EY	SL	
D	15JUN15	ISSUED FOR TENDER	KW	HD	EW	EY		
C	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
B	27FEB15	ISSUED FOR TENDER	ARG		EW	EY		
A	26FEB15	SQUAD CHECK & CLIENT REVIEW	ARG	EW	EY			

REF	NUMBER	TITLE
3	1110-DD10-GRD-0234	FINISHED GRADING, DETAILS & SECTIONS, SHEET 4
2	1110-DD10-GRD-0232	FINISHED GRADING, DETAILS & SECTIONS, SHEET 2
1	1110-DD10-GRD-0262	DIVERSION DITCHES, PLAN & PROFILE, SHEET 2

REFERENCES

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PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 2 Sep 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	ARG	03FEB15
SCALE	PACKAGE CODE	DRN	ARG	03FEB15
AS NOTED		CHK	HD	02Sep25
		APP	SL	2Sep15

PRETIVM

amec foster wheeler

SUBJECT
CIVIL
GRADING DRAWING
DIVERSION DITCHES
PLAN & PROFILE – SHEET 1

AREA 1110 — GENERAL DEVELOPMENT

CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0261 — REV 0

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CAD FILE: \\EDC01PROJECTS.AMEC.COM\SITES\V0017\7421\CAD\CIV\177421-1110-DD10-GRD-0261.DWG

ISO A1-594x841

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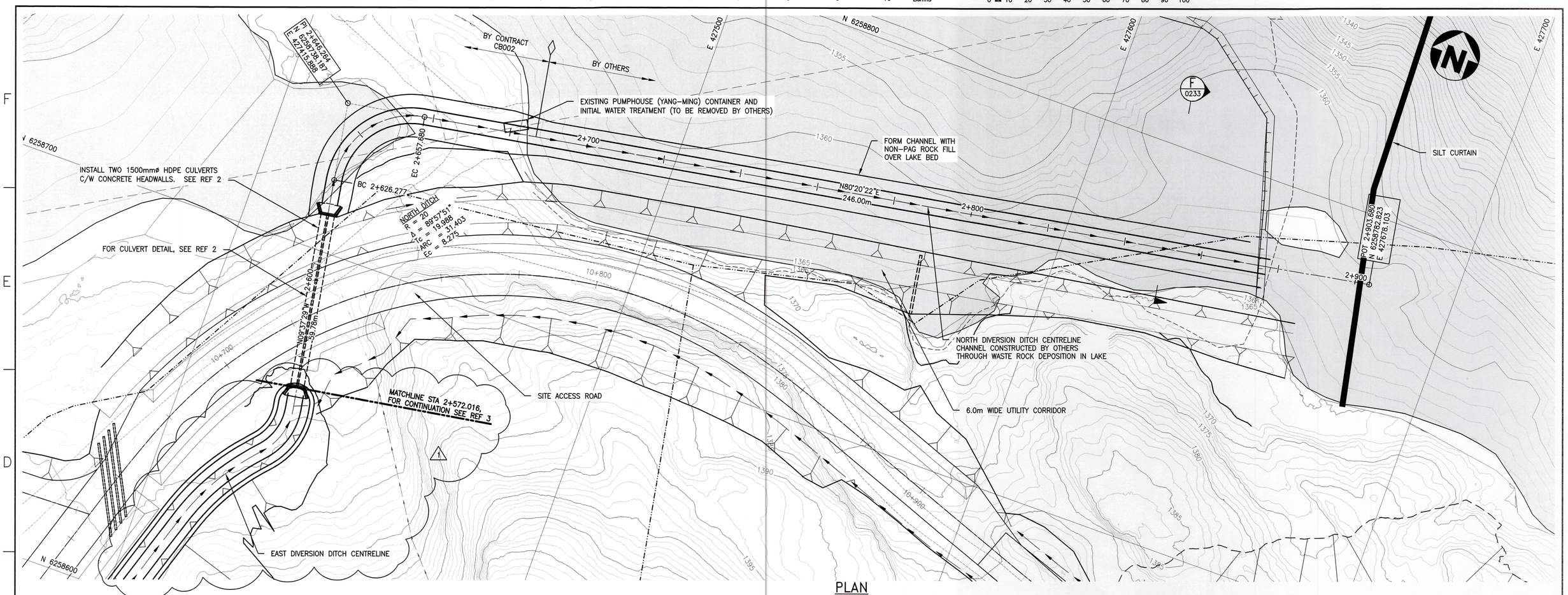
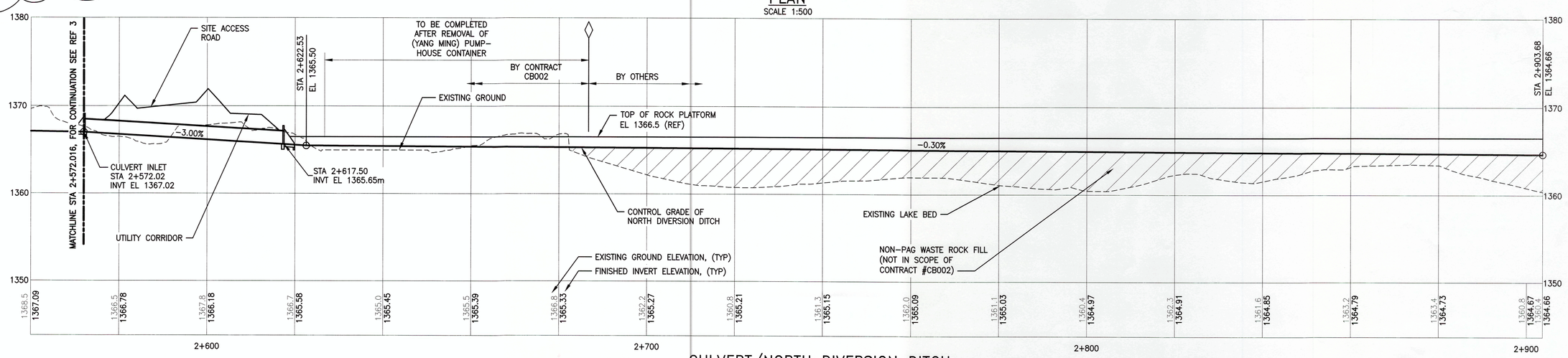


PLAN
SCALE 1:500



CULVERT/NORTH DIVERSION DITCH
STA 2+572.02 TO 2+903.68
SCALE 1:500 HOR
1:250 VERT

0m 5 10 15 20 25
1:500

0m 2.5 5 7.5 10 12.5
1:250

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	DL	EM	PM	CL
1	04NOV15	ISSUED FOR CONSTRUCTION	MT	EW				
0	01SEP15	ISSUED FOR CONSTRUCTION	GP	HD	EW	EY	SL	
D	15JUN15	ISSUED FOR TENDER	KW	HD	EW	EY		
C	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
B	27FEB15	ISSUED FOR TENDER	ARG		EW	EY		
A	26FEB15	SQUAD CHECK & CLIENT REVIEW	ARG	EW	EY			

REF	NUMBER	TITLE
4	1110-DD10-GRD-0233	FINISHED GRADING, DETAILS AND SECTIONS, SHEET 3
3	1110-DD10-GRD-0260	EAST DIVERSION DITCH, PLAN & PROFILE
2	1110-DD10-GRD-0236	DIVERSION DITCHES, CULVERT DETAILS, SHEET 1
1	1110-DD10-GRD-0232	FINISHED GRADING, DETAILS AND SECTIONS, SHEET 2

REFERENCES

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STAMP/SEAL
PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 5 NOV 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR	DEPARTMENT MGR	PROJECT MGR
	G. LI	S. LYNN

PROJECT

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
177421		DES	ARG	23FEB15
SCALE	PACKAGE CODE	DRN	ARG	23FEB15
AS NOTED		CHK	HD	02SEP15
		APP	EW	02SEP15

PRETIVM

amec foster wheeler

SUBJECT
CIVIL
GRADING DRAWING
DIVERSION DITCHES
PLAN & PROFILE – SHEET 2

AREA 1110 — GENERAL DEVELOPMENT

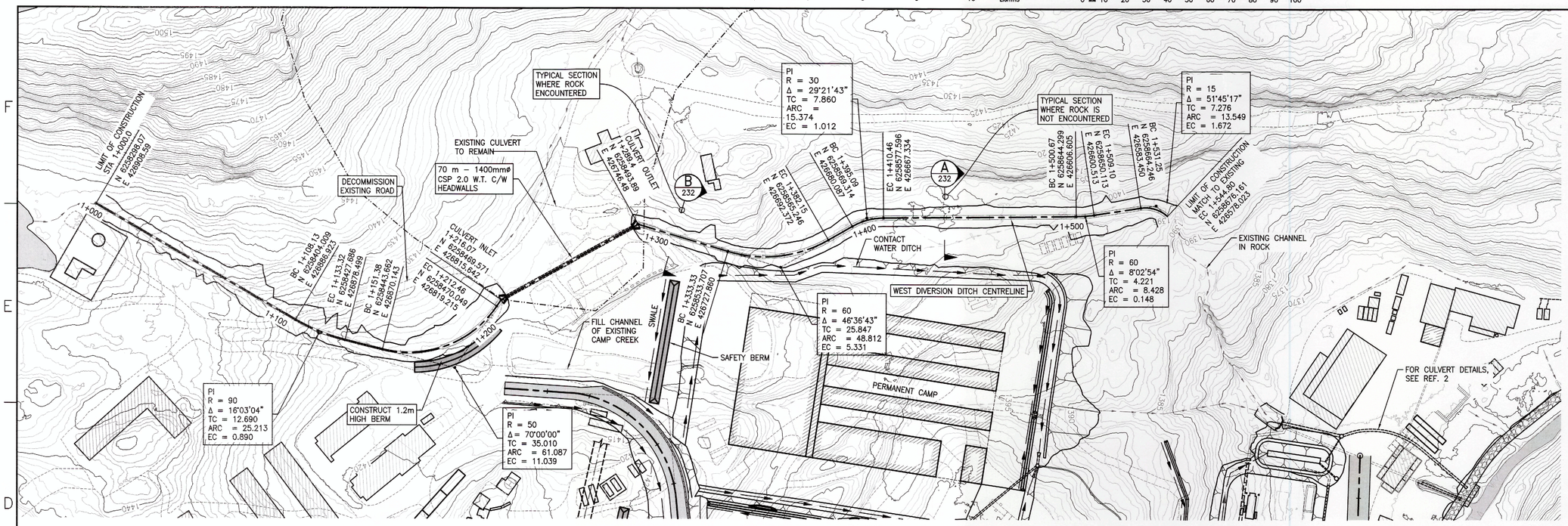
CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0262 — REV 1

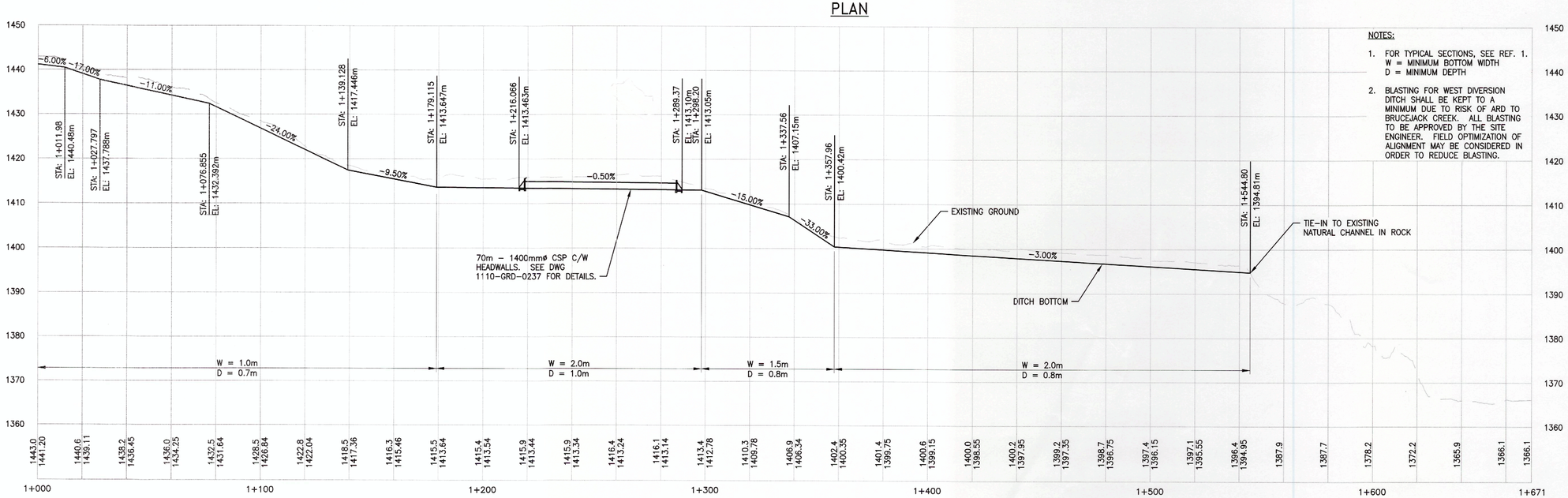
SAVED: 05-Nov-15 11:01 AM PLOTTED: 05-Nov-15 11:20 AM USER: TAM, MAN-YIP

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0262.DWG

ISO A1 594x841



PLAN



NOTES:

1. FOR TYPICAL SECTIONS, SEE REF. 1.
   W = MINIMUM BOTTOM WIDTH
   D = MINIMUM DEPTH
2. BLASTING FOR WEST DIVERSION DITCH SHALL BE KEPT TO A MINIMUM DUE TO RISK OF ARD TO BRUCEJACK CREEK. ALL BLASTING TO BE APPROVED BY THE SITE ENGINEER. FIELD OPTIMIZATION OF ALIGNMENT MAY BE CONSIDERED IN ORDER TO REDUCE BLASTING.

PROFILE OF WEST DIVERSION DITCH
STA 1+000 TO 1+544.80

1:1000 1:500

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	01SEP15	ISSUED FOR CONSTRUCTION	MT	HD	EW	EY	SL	
F	17JUL15	ISSUED FOR APPROVAL	ARG	EW	EW	EY	SL	
E	15JUN15	ISSUED FOR TENDER	ARG	EW	EW	EY		
D	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
C	20MAR15	REISSUED FOR TENDER	ARG		EW	EY		
B	27FEB15	ISSUED FOR TENDER	ARG		EW	EY		
A	26FEB15	SQUAD CHECK & CLIENT REVIEW	ARG	EW	EY			

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
2	1110-DD10-GRD-0101	ROUGH GRADING & DITCHING PLAN – SHEET 1						
1	1110-DD10-GRD-0232	FINISHED GRADING, DETAILS AND SECTIONS, SHEET 2						

REF	NUMBER	TITLE
	REFERENCES	

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN AMEC AND ITS CLIENT: (I) THIS AMEC DOCUMENT CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) THIS DOCUMENT MAY ONLY BE USED BY THE CLIENT IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT HAS BEEN DELIVERED. ANY OTHER USE OR RELIANCE ON THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK AND RESPONSIBILITY.

STAMP/SEAL: PROFESSIONAL ENGINEER, PROVINCE OF BRITISH COLUMBIA, H. E. WIENS, 2 Sep 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
		DES	ARG	23FEB15
		DRN	ARG	23FEB15
		CHK	HD	2SEP15
		APP		2 Sep 15

SCALE: AS SHOWN

PACKAGE CODE

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES PLAN & PROFILE – SHEET 3

AREA 1110 GENERAL DEVELOPMENT

CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0263 REV 0

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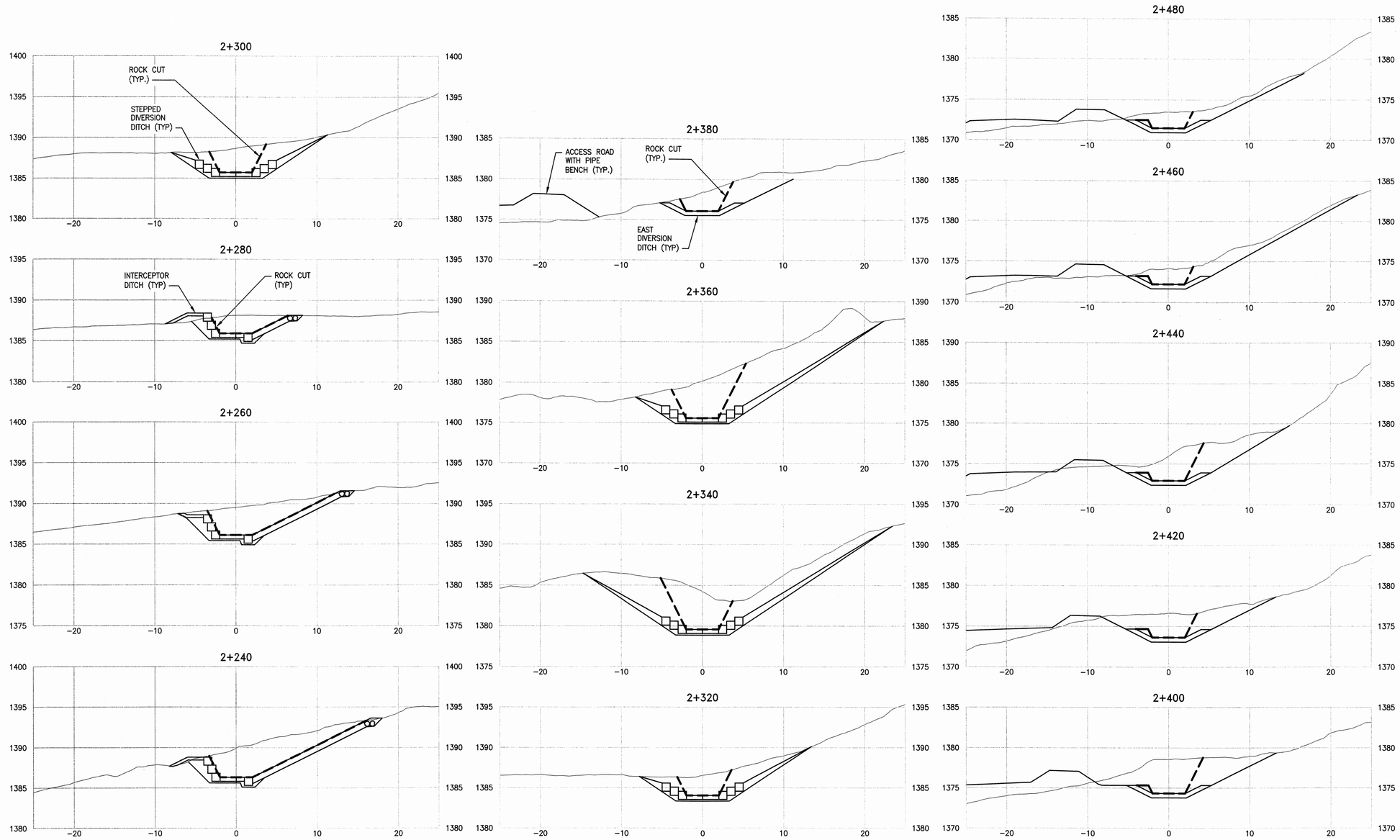
SAVED: 01-Sep-15 3:33 PM PLOTTED: 01-Sep-15 3:35 PM USER: TAM, MAN-YIP

CAD FILE: C:\USERS\MAN-YIP.TAM\CADTEMP\FILES\BRUCEJACK\CAD\CIVIL\177421-1110-DD10-GRD-0263.DWG

ISO A1-594x841



EAST DIVERSION DITCH

0m 2.5 5 7.5 10 12.5
1:250

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	17SEP15	ISSUED FOR CONSTRUCTION	MT	EW	EW	EY	SL	
D	12JUN15	ISSUED FOR TENDER	ARG	EW	EW	EY		
C	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
B	20MAR15	ISSUED FOR TENDER	ARG	EW	EW	EY		
A	17MAR15	ISSUED FOR SQUAD CHECK	ARG		EW	EY		

REF	NUMBER	TITLE
1	1110-DD10-GRD-0261	DIVERSION DITCHES, PLAN & PROFILE – SHEET 1

REFERENCES

UNLESS OTHERWISE AGREED IN A WRITTEN CONTRACT BETWEEN AMEC AND ITS CLIENT: (I) THIS AMEC DOCUMENT CONTAINS INFORMATION, DATA AND DESIGN THAT IS CONFIDENTIAL AND MAY NOT BE COPIED OR DISCLOSED; AND (II) THIS DOCUMENT MAY ONLY BE USED BY THE CLIENT IN THE CONTEXT AND FOR THE EXPRESS PURPOSE FOR WHICH IT HAS BEEN DELIVERED. ANY OTHER USE OR RELIANCE ON THIS DOCUMENT BY ANY THIRD PARTY IS AT THAT PARTY'S SOLE RISK AND RESPONSIBILITY.

STAMP/SEAL

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 17 Sep 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
		DES	ARG	30JAN15
		DRN	ARG	17MAR15
SCALE 1:250	PACKAGE CODE	CHK		17Sep15
		APP		17Sep15

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES SECTIONS – SHEET 1

AREA 1110 — GENERAL DEVELOPMENT

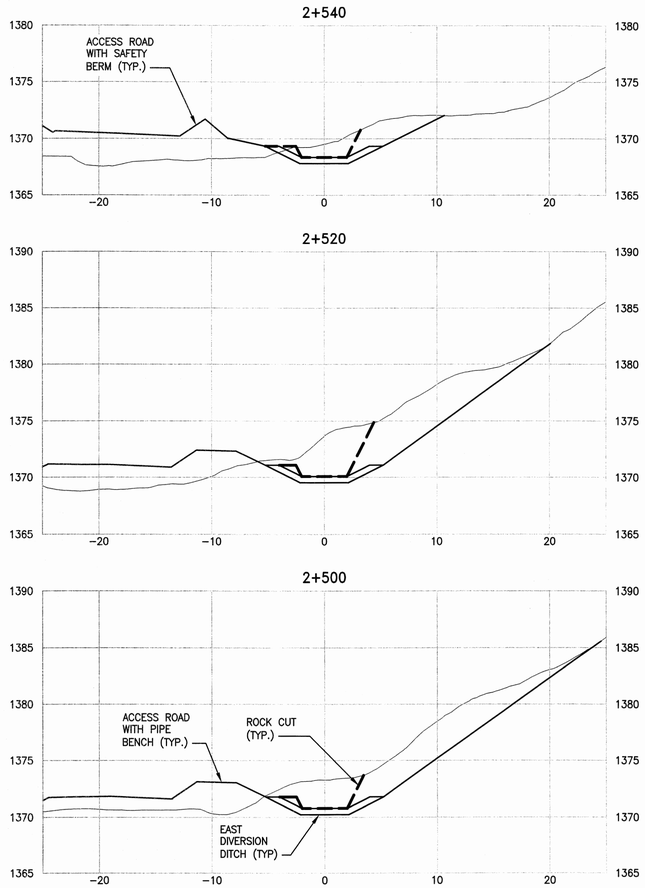
CLIENT DWG NO.

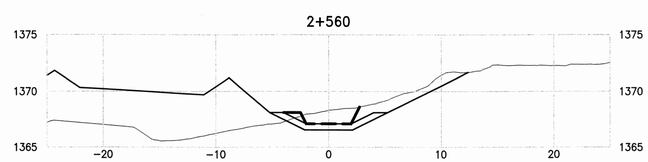
DRAWING NO. 177421-1110-DD10-GRD-0264 — REV 0

ISO A1-594x841

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0264.DWG

SAVED: 17-Sep-15 10:10 AM PLOTTED: 17-Sep-15 10:12 AM USER: TAM, MAN-YIP





EAST DIVERSION DITCH

0m 2.5 5 7.5 10 12.5
1:250

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	17SEP15	ISSUED FOR CONSTRUCTION	MTT	EW	EY	EY	SL	
D	12JUN15	ISSUED FOR TENDER	ARG	EW	EW	EY		
C	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
B	20MAR15	ISSUED FOR TENDER	ARG		EW	EY		
A	17MAR15	ISSUED FOR SQUAD CHECK	ARG		EW	EY		

REF	NUMBER	TITLE
2	1110-DD10-GRD-0262	DIVERSION DITCHES, PLAN & PROFILE – SHEET 2
1	1110-DD10-GRD-0261	DIVERSION DITCHES, PLAN & PROFILE – SHEET 1

REFERENCES

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STAMP/SEAL: PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 17 Sep 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
		DES	ARG	30JAN15
		DRN	ARG	17MAR15
		CHK		17Sep15
SCALE 1:250	PACKAGE CODE	APP		17Sep15

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES SECTIONS – SHEET 2

AREA 1110 — GENERAL DEVELOPMENT

CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0265 — REV 0

ISO A1-594x841

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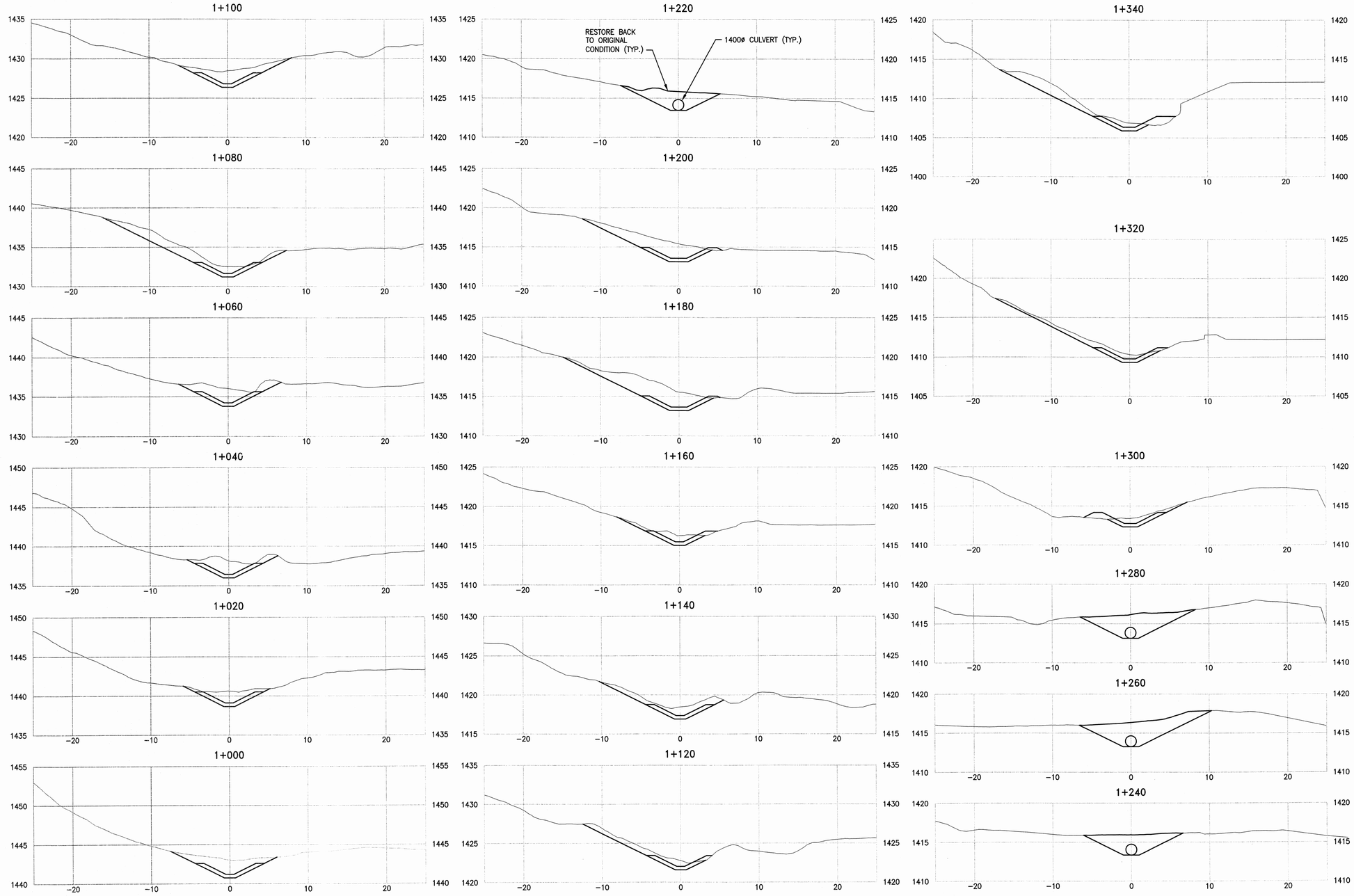

WEST DIVERSION DITCH

0m 2.5 5 7.5 10 12.5
1:250

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
0	17SEP15	ISSUED FOR CONSTRUCTION	MT	EW	EW	EY	SL	
E	17JUL15	ISSUED FOR APPROVAL	ARG	EW	EW	EY	SL	
D	12JUN15	ISSUED FOR TENDER	ARG	EW	EW	EY		
C	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
B	20MAR15	ISSUED FOR TENDER	ARG	EW	EW	EY		
A	17MAR15	ISSUED FOR SQUAD CHECK	ARG		EW	EY		

REF	NUMBER	TITLE
1	1110-DD10-GRD-0263	DIVERSION DITCH, PLAN & PROFILE SHEET 3

REFERENCES

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PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 17 Sep 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.
SCALE 1:250	PACKAGE CODE

	BY	DDMMMYY
DES	ARG	30JAN15
DRN	ARG	17MAR15
CHK		17 Sep 15
APP		17 Sep 15

PRETIVM

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES SECTIONS – SHEET 4

amec foster wheeler

AREA 1110 — GENERAL DEVELOPMENT

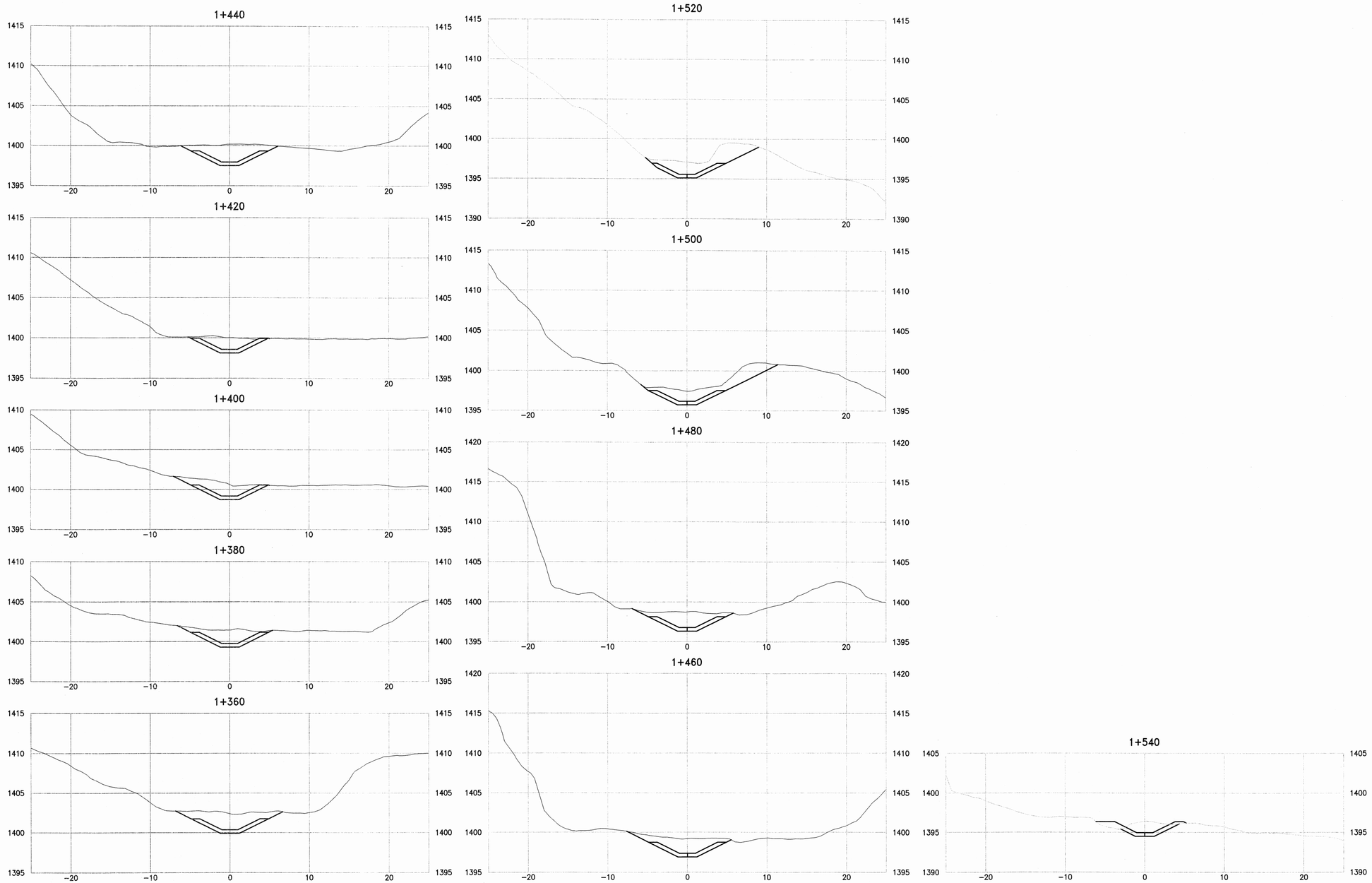
CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0267 — REV 0

SAVED: 17-Sep-15 10:30 AM PLOTTED: 17-Sep-15 10:33 AM USER: TAM, MAN-YIP

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0267.DWG

ISO A1-594x841



WEST DIVERSION DITCH

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1:250

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REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
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E	17JUL15	ISSUED FOR APPROVAL	ARG	EW	EW	EY	SL	
D	12JUN15	ISSUED FOR TENDER	ARG	EW	EW	EY		
C	30APR15	ISSUED FOR APPROVAL	JP	EW	EY			
B	20MAR15	ISSUED FOR TENDER	ARG	EW	EW	EY		
A	17MAR15	ISSUED FOR SQUAD CHECK	ARG		EW	EY		

REF	NUMBER	TITLE
1	1110-DD10-GRD-0263	DIVERSION DITCHES, PLAN & PROFILE – SHEET 3

REFERENCES

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STAMP/SEAL

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — H. E. WIENS — 17 Sep 2015

APPROVED FOR CONSTRUCTION

CLIENT PROJECT MGR | DEPARTMENT MGR | PROJECT MGR

PROJECT PHASE

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
		DES	ARG	30JAN15
		DRN	ARG	17MAR15
SCALE 1:250	PACKAGE CODE	CHK		17Sep15
		APP		17Sep15

PRETIVM

amec foster wheeler

SUBJECT: CIVIL GRADING DRAWING DIVERSION DITCHES SECTIONS – SHEET 5

AREA 1110 — GENERAL DEVELOPMENT

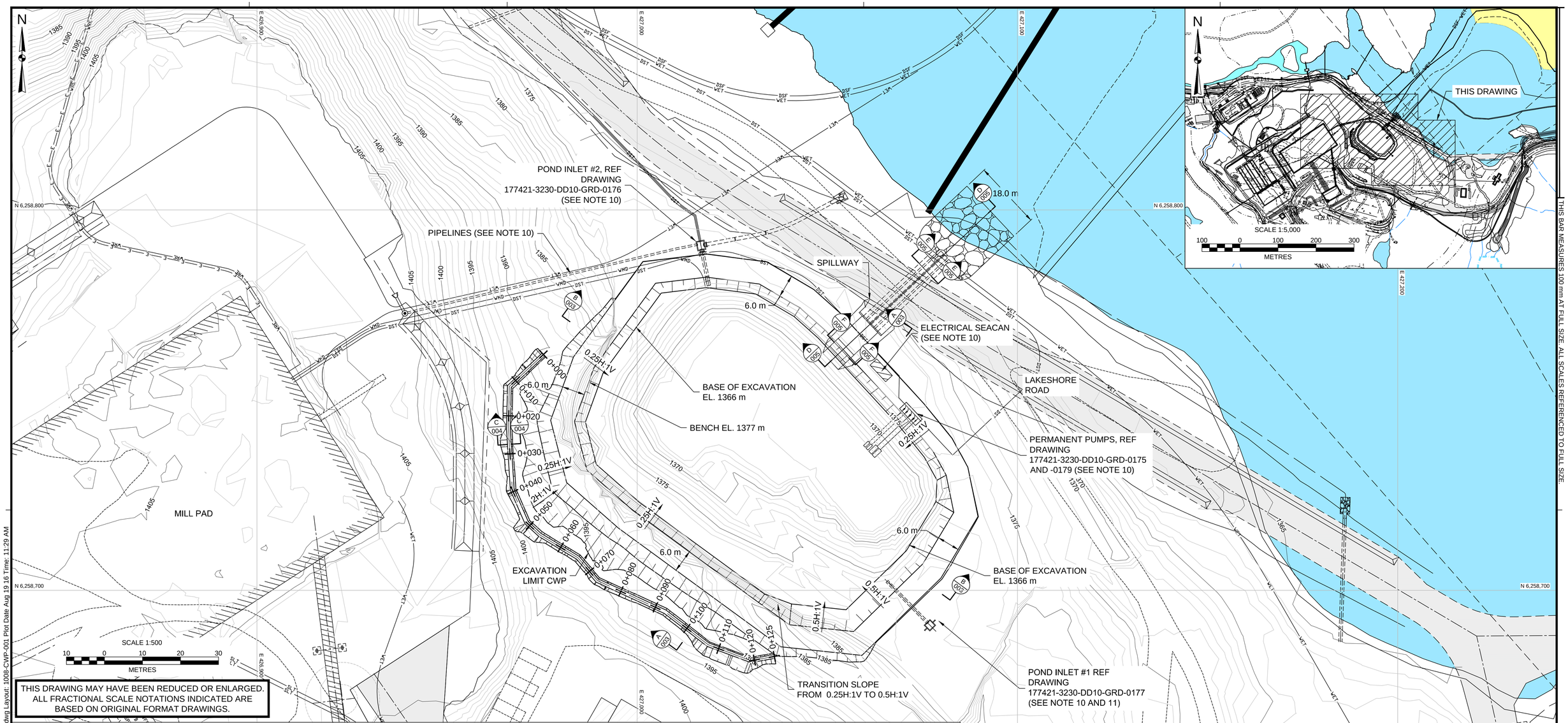
CLIENT DWG NO.

DRAWING NO. 177421-1110-DD10-GRD-0268 — REV 0

ISO A1-594x841

SAVED: 17-Sep-15 10:36 AM PLOTTED: 17-Sep-15 10:37 AM USER: TAM, MAN-YIP

CAD FILE: P:\CAD\CIV\177421-1110-DD10-GRD-0268.DWG



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NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER SHOULD UNCERTAINTIES ARISE WITH THE DRAWINGS, SCOPE, AND/OR TECHNICAL SPECIFICATIONS.
3. BASE TOPOGRAPHIC DATA BASED ON "CWP AND MILL PAD AS BUILT" PROVIDED BY ALLNORTH CONSULTANTS LTD., DATED JUNE 10, 2016. CONTOUR INTERVAL IS 1 m.
4. PROJECTION IS UTM NAD 83 ZONE 9N.
5. THE STORAGE CAPACITY OF THE COMPLETED CONTACT WATER POND TO EL 1375.5 m IS APPROXIMATELY 51,800 m³.
6. CONSTRUCTION OF THE CONTACT WATER POND REQUIRES AN EXCAVATION VOLUME OF APPROXIMATELY 42,100 m³.
7. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE DEVELOPED UTILIZING PRE-SHEAR BLASTING TECHNIQUES.
8. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE SCALED TO REMOVE ALL LOOSE MATERIAL.
9. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE REVIEWED BY THE GEOTECHNICAL ENGINEER. SLOPE SUPPORT, SUCH AS ROCK BOLTS AND MESH, MAY BE REQUIRED AS DETERMINED BY THE GEOTECHNICAL ENGINEER.
10. REFER TO AMEC FOSTER WHEELER DRAWINGS 177421-3230-DD10-GRD-0172 THROUGH -0179 FOR PLANS, CROSS SECTIONS, AND DETAILS. THE LAYOUT OF THE CONTACT WATER POND HAS BEEN REVISED SINCE THESE DRAWINGS WERE DEVELOPED. AS SUCH, DRAWINGS 177421-3230-DD10-GRD-0172 THROUGH -0179 SHALL BE USED AS APPLICABLE WITH FIELD MODIFICATIONS TO WORK WITH THE LAYOUT OF THE CONTACT WATER POND SHOWN ON DRAWING 1008-CWP-001. ANY DEVIATIONS FROM THE DESIGNS REQUIRED TO WORK WITH THE LAYOUT SHALL BE AGREED TO BY THE OWNER PRIOR TO PROCEEDING WITH CONSTRUCTION.
11. THE SITE WATER MANAGEMENT PLAN WILL NEED TO BE UPDATED TO DESIGN DITCHING TO AND FROM INLET #1. THE FINAL LOCATION OF INLET #1 TO BE DETERMINED BASED ON DESIGN OF DITCHING.
12. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

ISSUED FOR CONSTRUCTION

LEGEND
- CONTACT WATER POND
- EXISTING TOPOGRAPHY
- COLLECTION DITCH

REVISION INFORMATION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	16	07	26	COC	BMM	EC	DK	ISSUED FOR APPROVAL
B	16	08	08	LS	BMM	EC	BMM	ISSUED FOR APPROVAL
0	16	08	19	DK	BMM	EC	BMM	ISSUED FOR CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: COC	CHECK DRAWING: CJT
DESIGN BY: BMM	CHECK DESIGN: EC
LEAD ENGINEER: BMM	APPROVAL DATE: JULY 26, 2016
PROJECT MANAGER: DK	APPROVAL DATE: JULY 26, 2016

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK PROJECT

TITLE: CONTACT WATER POND GENERAL LAYOUT

SCALE:	DWG No.:	REV.:
1:500	1008-CWP-001	0

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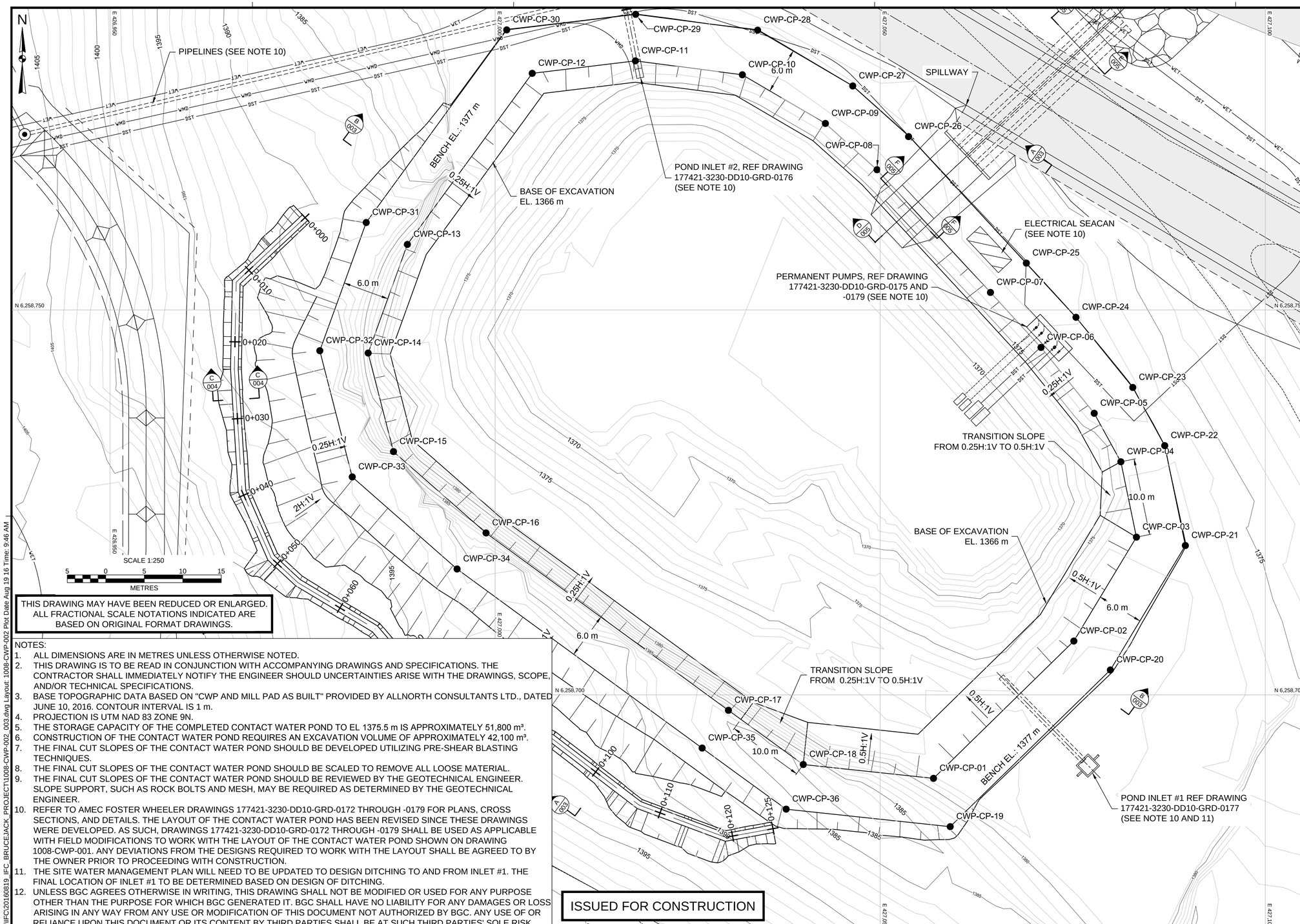

THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

CONSTRUCTION POINTS - CONTACT WATER POND			
NAME	EASTING (m)	NORTHING (m)	ELEVATION (m)
CWP-CP-01	427,056.9	6,258,689.2	1377.0
CWP-CP-02	427,075.1	6,258,707.0	1377.0
CWP-CP-03	427,083.3	6,258,720.5	1377.0
CWP-CP-04	427,081.2	6,258,730.3	1377.0
CWP-CP-05	427,077.8	6,258,736.6	1377.0
CWP-CP-06	427,070.9	6,258,745.1	1377.0
CWP-CP-07	427,064.3	6,258,752.3	1377.0
CWP-CP-08	427,049.6	6,258,768.2	1377.0
CWP-CP-09	427,042.9	6,258,774.2	1377.0
CWP-CP-10	427,032.1	6,258,780.5	1377.0
CWP-CP-11	427,018.2	6,258,782.3	1377.0
CWP-CP-12	427,004.8	6,258,780.7	1377.0
CWP-CP-13	426,988.6	6,258,758.5	1377.0
CWP-CP-14	426,983.5	6,258,744.4	1377.0
CWP-CP-15	426,986.8	6,258,731.6	1377.0
CWP-CP-16	426,998.8	6,258,721.0	1377.0
CWP-CP-17	427,030.3	6,258,698.0	1377.0
CWP-CP-18	427,040.0	6,258,691.0	1377.0
CWP-CP-19	427,059.1	6,258,682.9	1377.0
CWP-CP-20	427,079.9	6,258,703.2	1377.0
CWP-CP-21	427,089.6	6,258,719.4	1377.0
CWP-CP-22	427,086.9	6,258,732.4	1377.0
CWP-CP-23	427,082.8	6,258,739.9	1377.0
CWP-CP-24	427,075.4	6,258,749.0	1377.0
CWP-CP-25	427,069.0	6,258,756.1	1377.0
CWP-CP-26	427,053.7	6,258,772.5	1377.0
CWP-CP-27	427,046.4	6,258,779.1	1377.0
CWP-CP-28	427,034.1	6,258,786.3	1377.0
CWP-CP-29	427,018.2	6,258,788.4	1377.0
CWP-CP-30	427,001.5	6,258,786.4	1377.0
CWP-CP-31	426,983.3	6,258,761.3	1377.0
CWP-CP-32	426,977.2	6,258,744.7	1377.0
CWP-CP-33	426,981.5	6,258,728.3	1377.0
CWP-CP-34	426,995.1	6,258,716.3	1377.0
CWP-CP-35	427,026.9	6,258,693.1	1377.0
CWP-CP-36	427,037.8	6,258,685.2	1377.0

THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER SHOULD UNCERTAINTIES ARISE WITH THE DRAWINGS, SCOPE, AND/OR TECHNICAL SPECIFICATIONS.
3. BASE TOPOGRAPHIC DATA BASED ON "CWP AND MILL PAD AS BUILT" PROVIDED BY ALLNORTH CONSULTANTS LTD., DATED JUNE 10, 2016. CONTOUR INTERVAL IS 1 m.
4. PROJECTION IS UTM NAD 83 ZONE 9N.
5. THE STORAGE CAPACITY OF THE COMPLETED CONTACT WATER POND TO EL 1375.5 m IS APPROXIMATELY 51,800 m³.
6. CONSTRUCTION OF THE CONTACT WATER POND REQUIRES AN EXCAVATION VOLUME OF APPROXIMATELY 42,100 m³.
7. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE DEVELOPED UTILIZING PRE-SHEAR BLASTING TECHNIQUES.
8. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE SCALED TO REMOVE ALL LOOSE MATERIAL.
9. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE REVIEWED BY THE GEOTECHNICAL ENGINEER. SLOPE SUPPORT, SUCH AS ROCK BOLTS AND MESH, MAY BE REQUIRED AS DETERMINED BY THE GEOTECHNICAL ENGINEER.
10. REFER TO AMEC FOSTER WHEELER DRAWINGS 177421-3230-DD10-GRD-0172 THROUGH -0179 FOR PLANS, CROSS SECTIONS, AND DETAILS. THE LAYOUT OF THE CONTACT WATER POND HAS BEEN REVISED SINCE THESE DRAWINGS WERE DEVELOPED. AS SUCH, DRAWINGS 177421-3230-DD10-GRD-0172 THROUGH -0179 SHALL BE USED AS APPLICABLE WITH FIELD MODIFICATIONS TO WORK WITH THE LAYOUT OF THE CONTACT WATER POND SHOWN ON DRAWING 1008-CWP-001. ANY DEVIATIONS FROM THE DESIGNS REQUIRED TO WORK WITH THE LAYOUT SHALL BE AGREED TO BY THE OWNER PRIOR TO PROCEEDING WITH CONSTRUCTION.
11. THE SITE WATER MANAGEMENT PLAN WILL NEED TO BE UPDATED TO DESIGN DITCHING TO AND FROM INLET #1. THE FINAL LOCATION OF INLET #1 TO BE DETERMINED BASED ON DESIGN OF DITCHING.
12. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

ISSUED FOR CONSTRUCTION

REVISION INFORMATION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	16	07	26	COC	BMM	EC	DK	ISSUED FOR APPROVAL
B	16	08	08	LS	BMM	EC	BMM	ISSUED FOR APPROVAL
0	16	08	19	DK	BMM	EC	BMM	ISSUED FOR CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: COC	CHECK DRAWING: CJT
DESIGN BY: BMM	CHECK DESIGN: EC
LEAD ENGINEER: BMM	APPROVAL DATE: JULY 26, 2016
PROJECT MANAGER: DK	APPROVAL DATE: JULY 26, 2016

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK PROJECT

TITLE: CONTACT WATER POND EXCAVATION PLAN

SCALE:	DWG No.:	REV.:
1:250	1008-CWP-002	0

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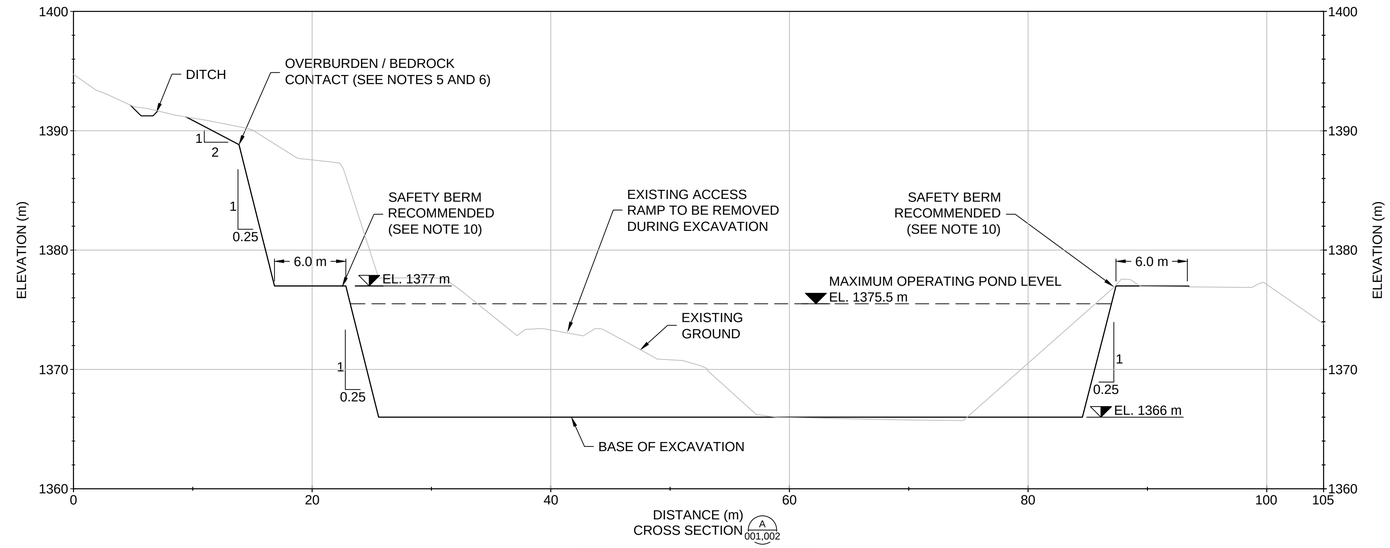
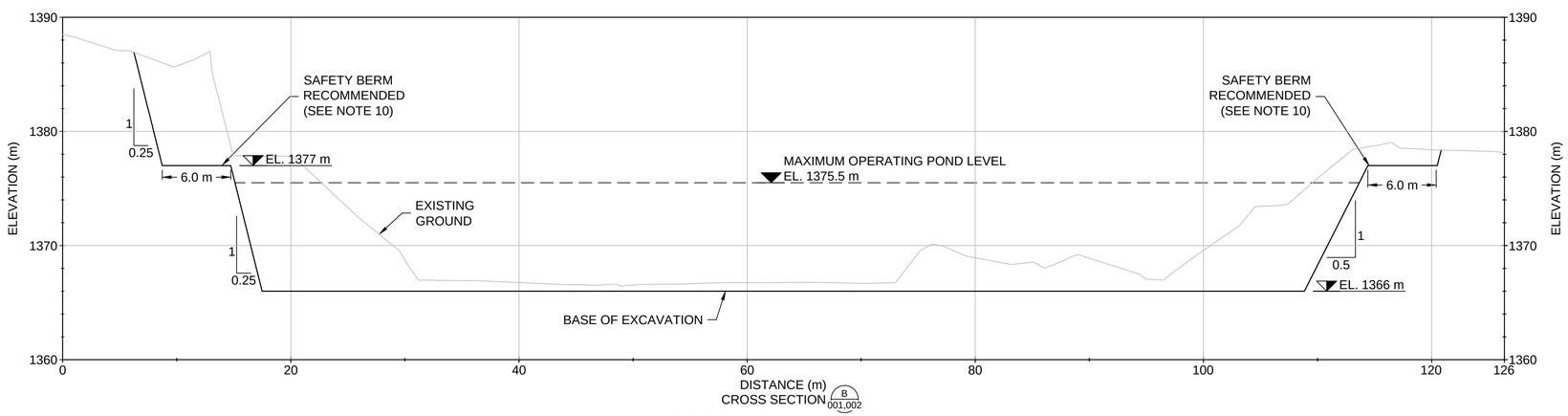


CROSS SECTION AT BEARING 036.2°



CROSS SECTION AT BEARING 126.2°

SCALE 1:250

5 0 5 10 15

METRES

THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER SHOULD UNCERTAINTIES ARISE WITH THE DRAWINGS, SCOPE, AND/OR TECHNICAL SPECIFICATIONS.
3. BASE TOPOGRAPHIC DATA BASED ON "CWP AND MILL PAD AS BUILT" PROVIDED BY ALLNORTH CONSULTANTS LTD., DATED JUNE 10, 2016. CONTOUR INTERVAL IS 1 m.
4. PROJECTION IS UTM NAD 83 ZONE 9N.
5. WHERE SOIL OVERBURDEN IS ENCOUNTERED, CUT SLOPES IN OVERBURDEN SHALL BE 2H:1V.
6. BEDROCK ELEVATIONS ARE INFERRED FROM MINIMAL SUBSURFACE DATA AND MAY VARY. THIS MAY RESULT IN MODIFICATIONS TO THE CUT SLOPES SHOWN.
7. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE DEVELOPED UTILIZING PRE-SHEAR BLASTING TECHNIQUES.
8. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE SCALED TO REMOVE ALL LOOSE MATERIAL.
9. THE FINAL CUT SLOPES OF THE CONTACT WATER POND SHOULD BE REVIEWED BY THE GEOTECHNICAL ENGINEER. SLOPE SUPPORT, SUCH AS ROCK BOLTS AND MESH, MAY BE REQUIRED AS DETERMINED BY THE GEOTECHNICAL ENGINEER.
10. RECOMMEND INSTALLING A SAFETY BERM THAT MEETS REGULATORY REQUIREMENTS NEAR THE CREST OF THE EL. 1377 m BENCH.
11. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

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REVISION INFORMATION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	16	07	26	COC	BMM	EC	DK	ISSUED FOR APPROVAL
B	16	08	08	LS	BMM	EC	BMM	ISSUED FOR APPROVAL
0	16	08	19	DK	BMM	EC	BMM	ISSUED FOR CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: COC	CHECK DRAWING: CJT
DESIGN BY: BMM	CHECK DESIGN: EC
LEAD ENGINEER: BMM	APPROVAL DATE: JULY 26, 2016
PROJECT MANAGER: DK	APPROVAL DATE: JULY 26, 2016

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

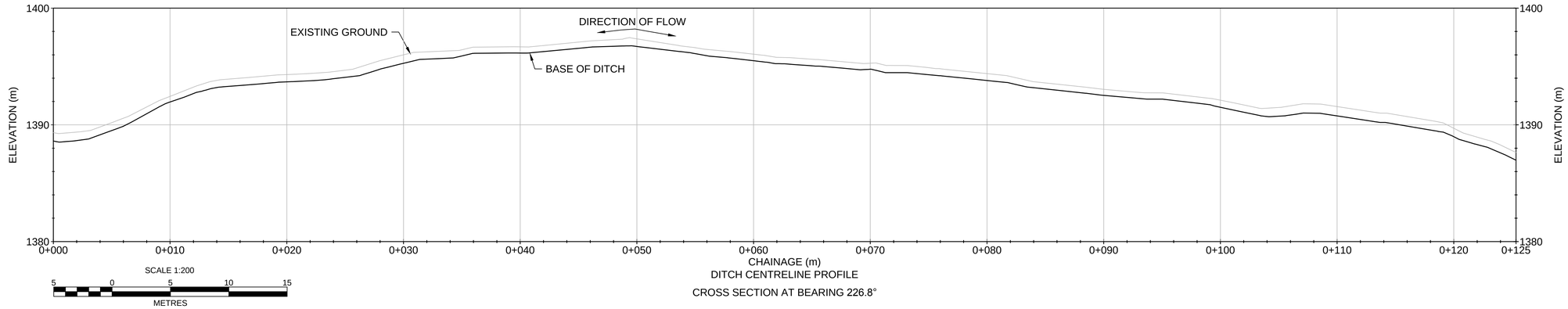
PROJECT: BRUCEJACK PROJECT

TITLE: CONTACT WATER POND CROSS SECTIONS

SCALE:	DWG No.:	REV.:
1:250	1008-CWP-003	0

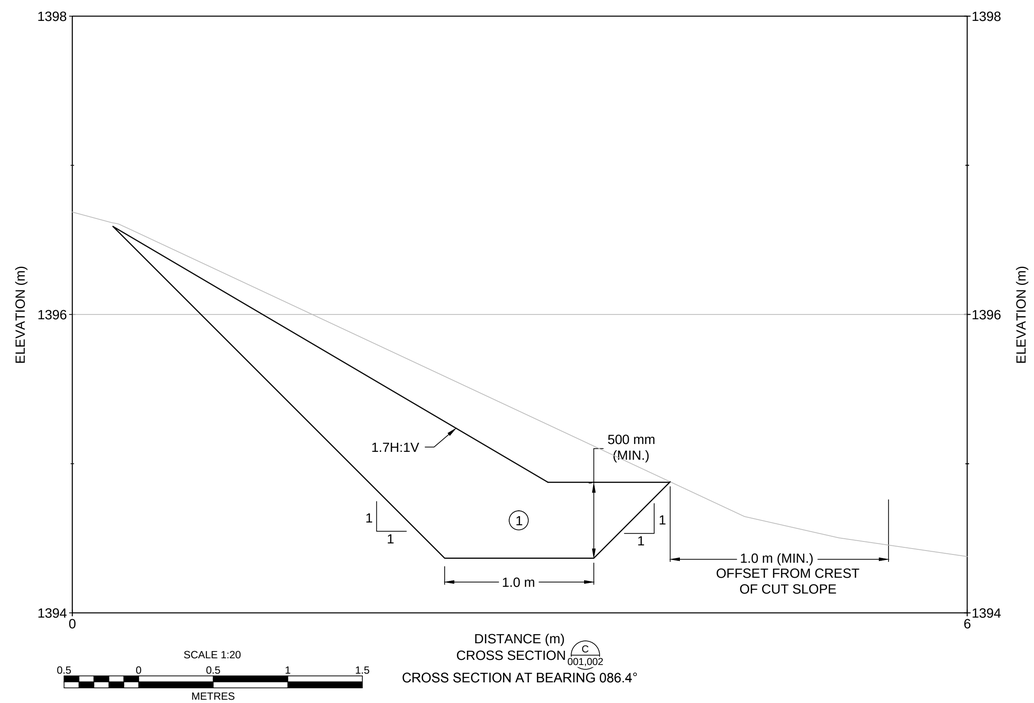
THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.

X:\Projects\1008\CAD\Production\IFC\20160819_IFC_BRUCEJACK_PROJECT\1008-CWP-002_003.dwg Layout: 1008-CWP-003 Plot Date Aug 19 16 Time: 9:45 AM



DITCH CENTRELINE PROFILE

CROSS SECTION AT BEARING 226.8°



CROSS SECTION C 001.002

CROSS SECTION AT BEARING 086.4°

THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER SHOULD UNCERTAINTIES ARISE WITH THE DRAWINGS, SCOPE, AND/OR TECHNICAL SPECIFICATIONS.
3. BASE TOPOGRAPHIC DATA BASED ON "CWP AND MILL PAD AS BUILT" PROVIDED BY ALLNORTH CONSULTANTS LTD., DATED JUNE 10, 2016. CONTOUR INTERVAL IS 1 m.
4. PROJECTION IS UTM NAD 83 ZONE 9N.
5. RIP RAP SHALL BE CLASS 10 kg AS PER THE PROJECT SPECIFICATIONS 177421-0000-DD10-SPC-0003 REV.0.
6. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

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LEGEND
(1) RIP RAP (SEE NOTE 5)

REVISION INFORMATION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	16	07	26	COC	BMM	EC	DK	ISSUED FOR APPROVAL
B	16	08	08	LS	BMM	EC	BMM	ISSUED FOR APPROVAL
0	16	08	19	DK	BMM	EC	BMM	ISSUED FOR CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: COC	CHECK DRAWING: CJT
DESIGN BY: BMM	CHECK DESIGN: EC
LEAD ENGINEER: BMM	APPROVAL DATE: JULY 26, 2016
PROJECT MANAGER: DK	APPROVAL DATE: JULY 26, 2016

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK PROJECT

TITLE: CONTACT WATER POND CROSS SECTIONS

SCALE:	DWG No.:	REV.:
AS SHOWN	1008-CWP-004	0

THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.

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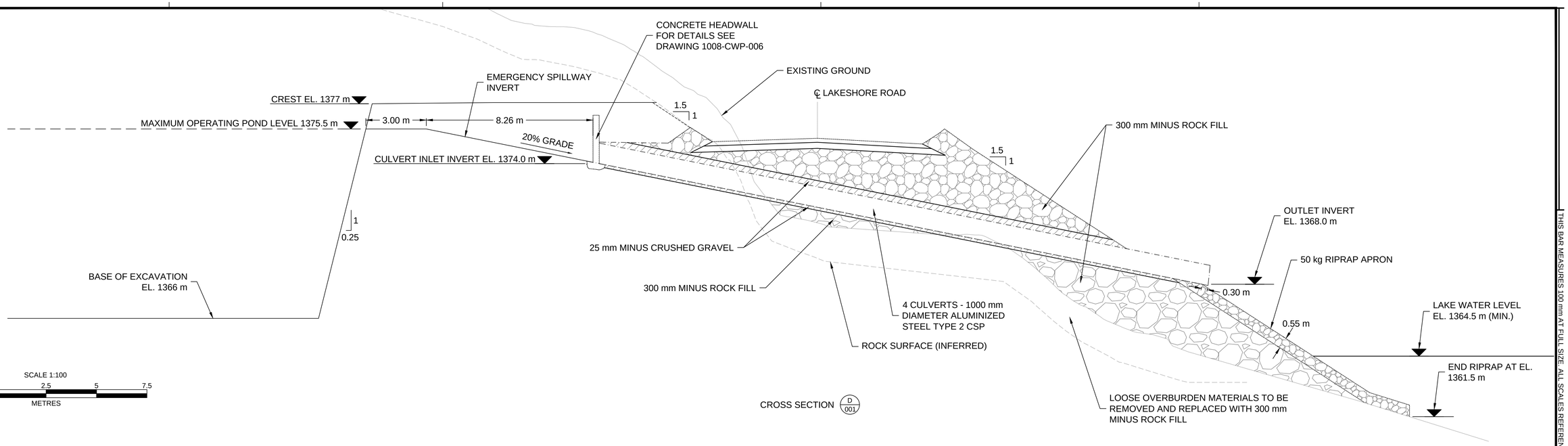
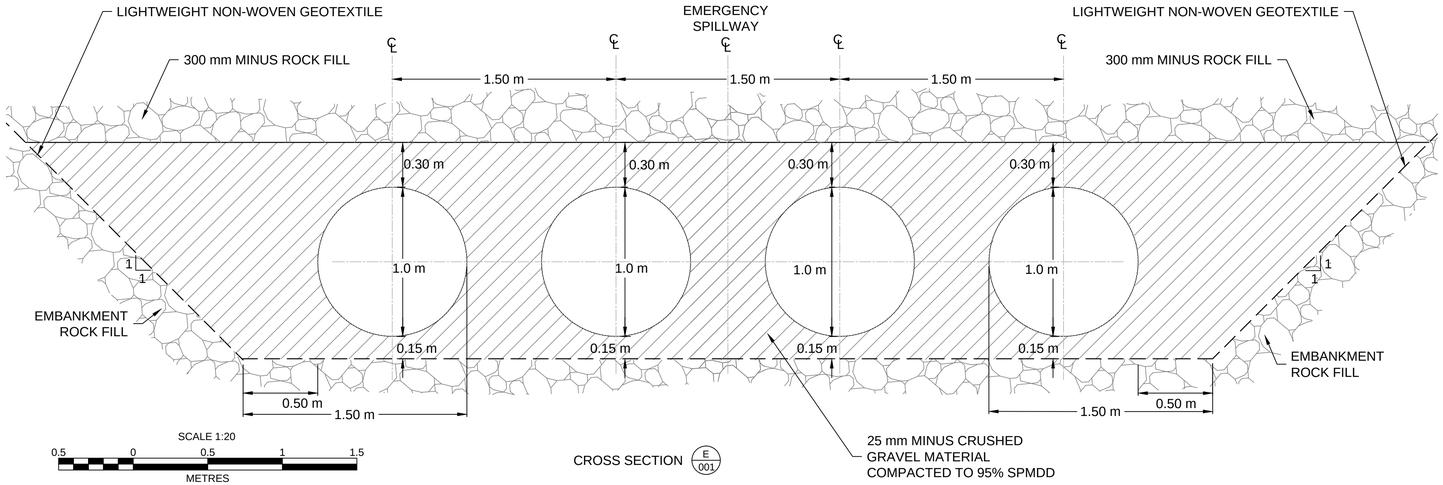


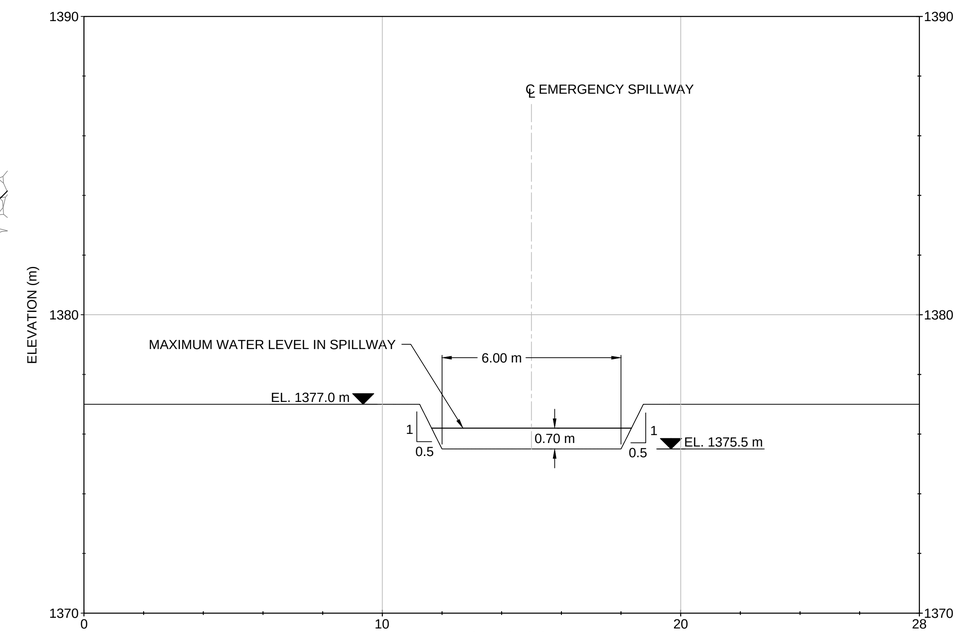
SCALE 1:100
2.5 0 2.5 5 7.5
METRES

CROSS SECTION D 001



SCALE 1:20
0.5 0 0.5 1 1.5
METRES

CROSS SECTION E 001



SCALE 1:100
2.5 0 2.5 5 7.5
METRES

CROSS SECTION F 001

THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED.
ALL SCALE NOTATIONS INDICATED ARE BASED ON
ORIGINAL FORMAT DRAWINGS.

NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER SHOULD UNCERTAINTIES ARISE WITH THE DRAWINGS, SCOPE, AND/OR TECHNICAL SPECIFICATIONS.
3. BASE TOPOGRAPHIC DATA BASED ON "CWP AND MILL PAD AS BUILT" PROVIDED BY ALLNORTH CONSULTANTS LTD., DATED JUNE 10, 2016. CONTOUR INTERVAL IS 1 m.
4. CULVERT DESIGN BASED ON AMEC FOSTER WHEELER DRAWING 177421-3230-DD10-GRD-172.
5. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

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REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
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0	16	08	19	DK	BMM	EC	BMM	ISSUED FOR CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: LS	CHECK DRAWING: CJT
DESIGN BY: BMM	CHECK DESIGN: EC
LEAD ENGINEER: BMM	APPROVAL DATE: AUGUST 8, 2016
PROJECT MANAGER: DK	APPROVAL DATE: AUGUST 8, 2016

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK PROJECT

TITLE: CONTACT WATER POND SPILLWAY DETAILS

SCALE:	DWG No.:	REV.:
AS SHOWN	1008-CWP-005	0

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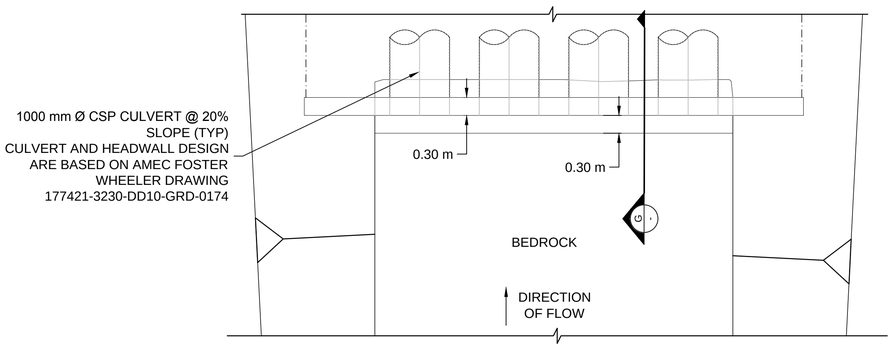
THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.



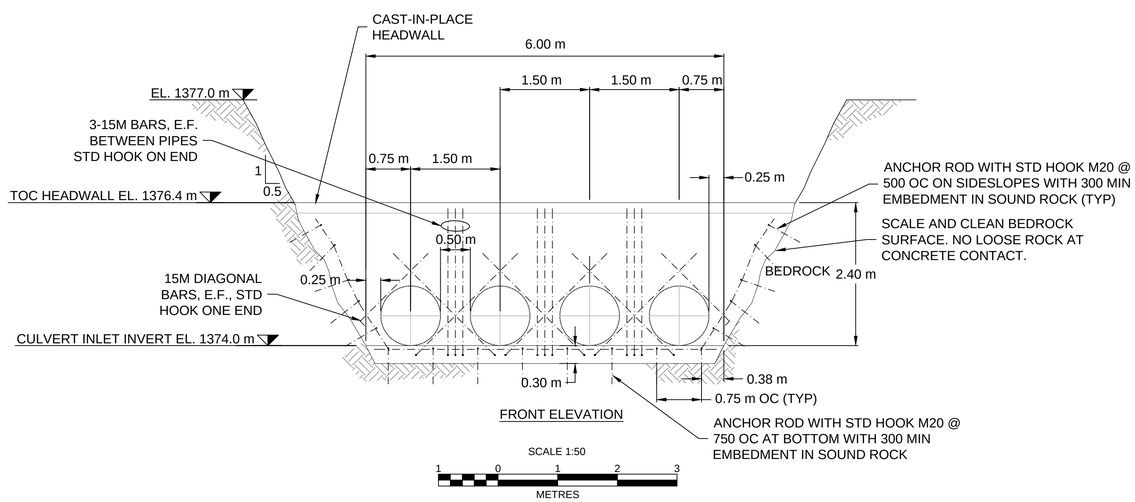
SPILLWAY CULVERT HEADWALL - PLAN

DETAIL 1/001

SCALE 1:50

1 0 1 2 3

METRES

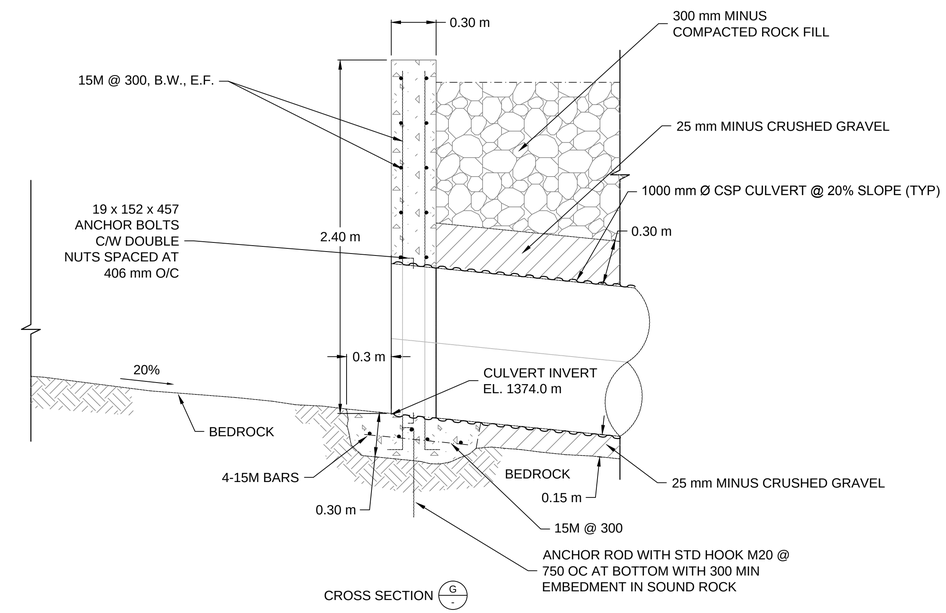


FRONT ELEVATION

SCALE 1:50

1 0 1 2 3

METRES



CROSS SECTION G

SCALE 1:20

0.5 0 0.5 1 1.5

METRES

THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING DRAWINGS AND SPECIFICATIONS. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER SHOULD UNCERTAINTIES ARISE WITH THE DRAWINGS, SCOPE, AND/OR TECHNICAL SPECIFICATIONS.
3. BASE TOPOGRAPHIC DATA BASED ON "CWP AND MILL PAD AS BUILT" PROVIDED BY ALLNORTH CONSULTANTS LTD., DATED JUNE 10, 2016. CONTOUR INTERVAL IS 1 m.
4. CULVERT AND HEADWALL DESIGN ARE BASED ON AMEC FOSTER WHEELER DRAWING 177421-3230-DD10-GRD-0174.
5. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

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A	16	08	08	LS	BMM	EC	BMM	ISSUED FOR APPROVAL									
0	16	08	19	DK	BMM	EC	BMM	ISSUED FOR CONSTRUCTION									

DRAWN BY: LS	CHECK DRAWING: CJT
DESIGN BY: BMM	CHECK DESIGN: EC
LEAD ENGINEER: BMM	APPROVAL DATE: AUGUST 8, 2016
PROJECT MANAGER: DK	APPROVAL DATE: AUGUST 8, 2016

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK PROJECT

TITLE: CONTACT WATER POND SPILLWAY DETAILS

SCALE:	DWG No.:	REV.:
AS SHOWN	1008-CWP-006	0

THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.

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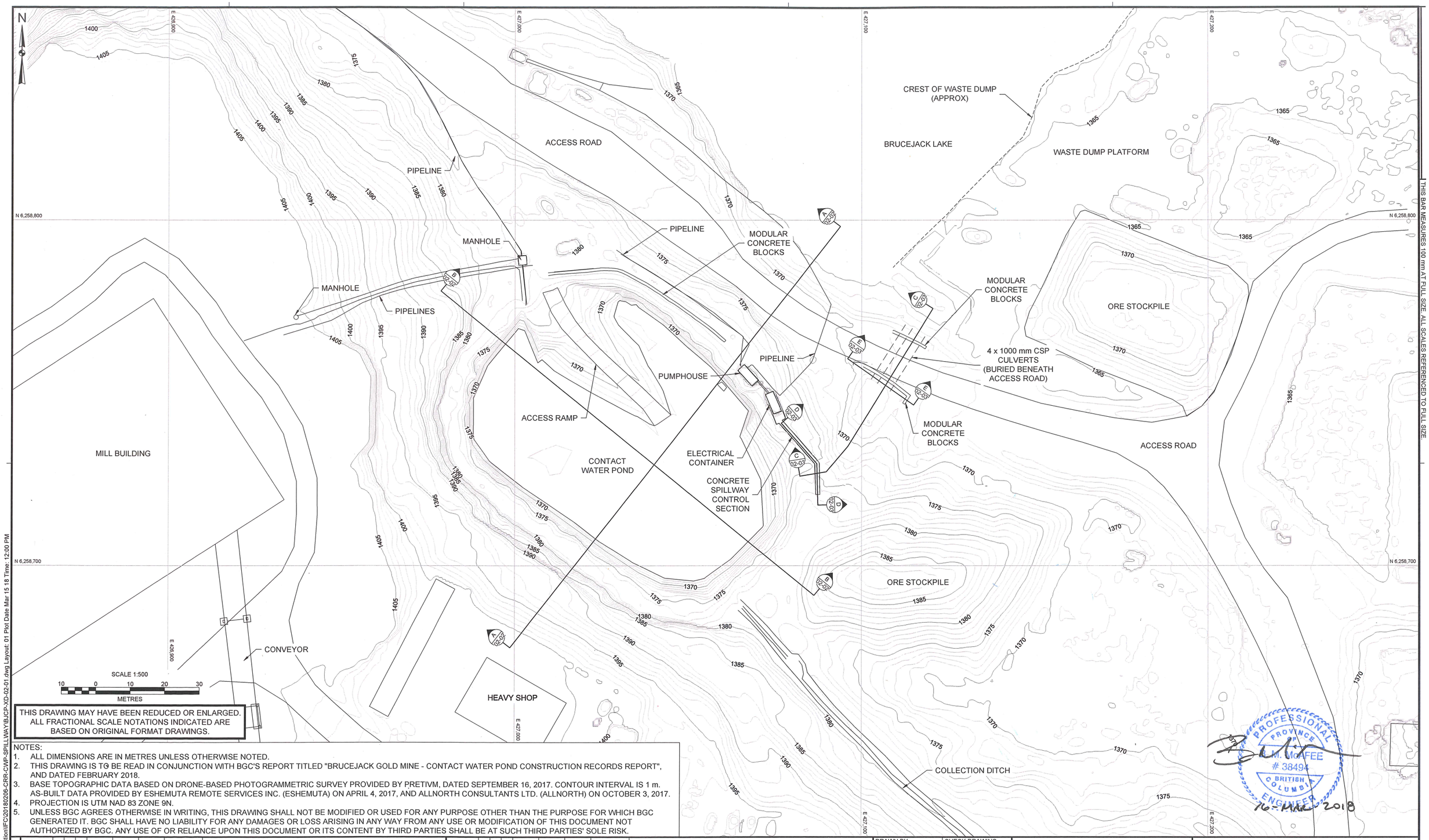
Appendix B – 2018 CWP Construction Records Report



THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "BRUCEJACK GOLD MINE - CONTACT WATER POND CONSTRUCTION RECORDS REPORT", AND DATED FEBRUARY 2018.
3. BASE TOPOGRAPHIC DATA BASED ON DRONE-BASED PHOTOGRAMMETRIC SURVEY PROVIDED BY PRETIVM, DATED SEPTEMBER 16, 2017. CONTOUR INTERVAL IS 1 m. AS-BUILT DATA PROVIDED BY ESHEMUTA REMOTE SERVICES INC. (ESHEMUTA) ON APRIL 4, 2017, AND ALLNORTH CONSULTANTS LTD. (ALLNORTH) ON OCTOBER 3, 2017.
4. PROJECTION IS UTM NAD 83 ZONE 9N.
5. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

REVISION INFORMATION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	18	03	16	CJT	BMM	MT	BMM	RECORD OF CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: CJT	CHECK DRAWING: LS
DESIGN BY: BMM	CHECK DESIGN: MT
LEAD ENGINEER: BMM	APPROVAL DATE: MARCH 16, 2018
PROJECT MANAGER: DK	APPROVAL DATE: MARCH 16, 2018

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

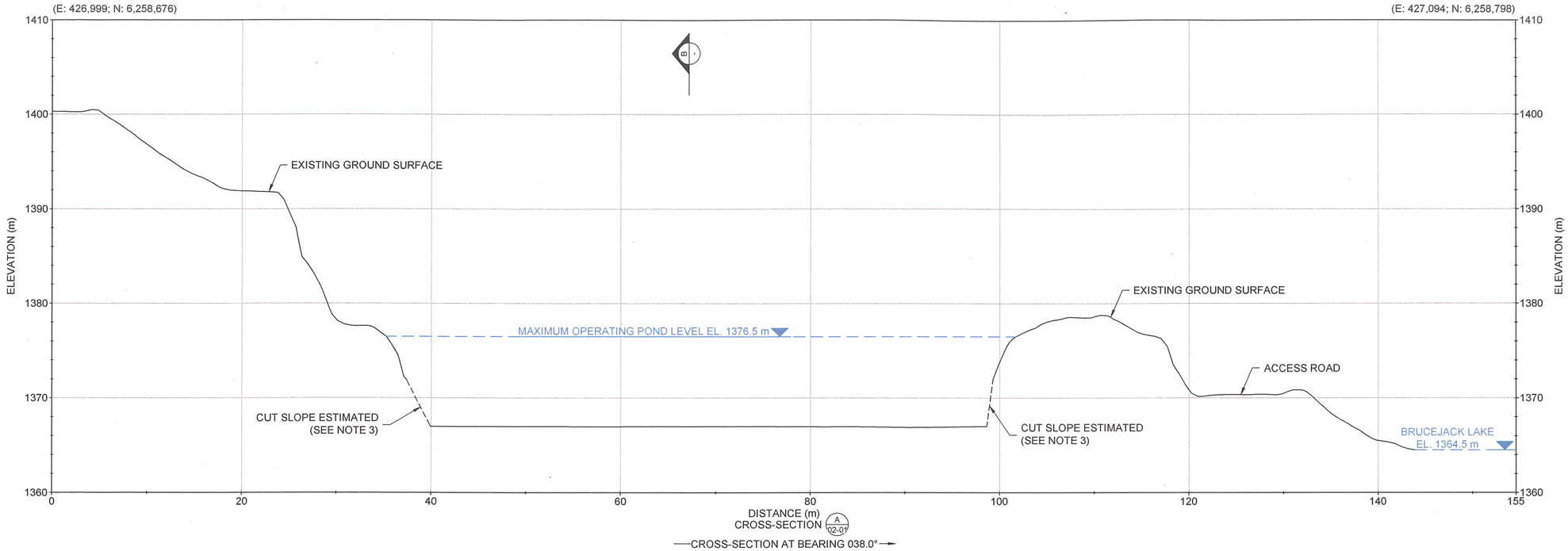
CLIENT: PRETIVM

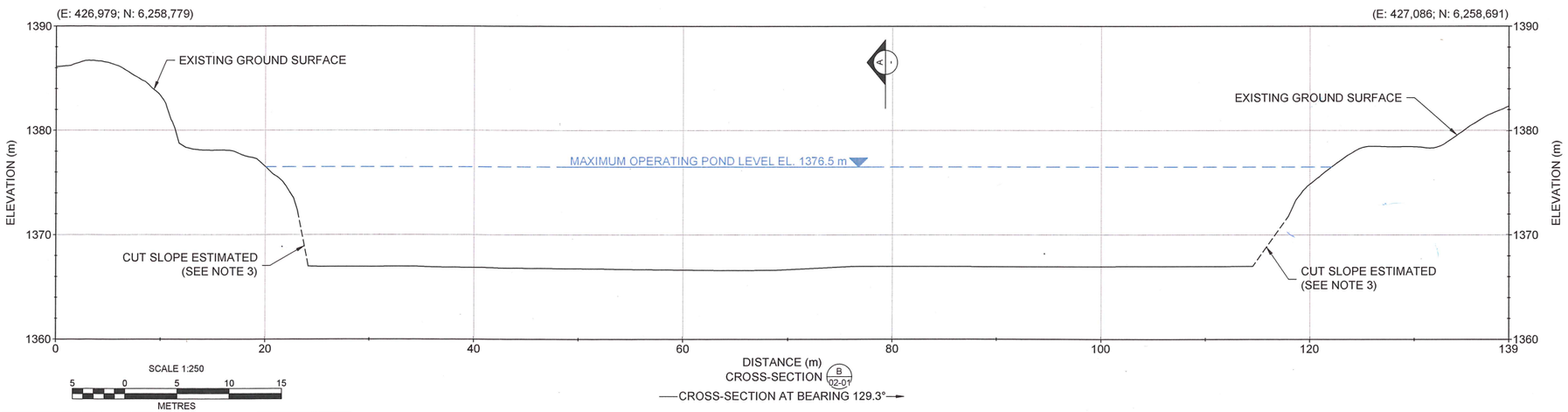
PROJECT: BRUCEJACK GOLD MINE

TITLE: CONTACT WATER POND GENERAL LAYOUT

SCALE:	DWG No.:	REV.:
1:500	BJCP-XD-02-01	A

X:\Projects\1008\CAD\Production\IFC\20180205-CRR-CWP-SPILLWAY\BJCP-XD-02-01.dwg Layout: 01 Plot Date Mar 15 18 Time: 12:00 PM





THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "BRUCEJACK GOLD MINE - CONTACT WATER POND CONSTRUCTION RECORDS REPORT", AND DATED FEBRUARY 2018.
3. CUT SLOPE ANGLES WITHIN THE CWP BASIN AT AND ABOVE EL. 1372 m ARE BASED ON A DRONE-BASED PHOTOGRAMMETRIC SURVEY PROVIDED BY PRETIVM, DATED SEPTEMBER 16, 2017. DUE TO THE PRESENCE OF WATER IN THE CWP BASIN AT THE TIME OF THE DRONE-BASED SURVEY, CUT SLOPE ANGLES WITHIN THE CWP BASIN BELOW EL. 1372 m WERE ESTIMATED BASED ON THE TOE OF THE CUT SLOPE SURVEYED BY ESHEMUTA ON APRIL 4, 2017.
4. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — B.M. MCAFEE # 38494 — 16 MAR 2018

REVISION INFORMATION																	
REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS	REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	18	03	16	CJT	BMM	MT	BMM	RECORD OF CONSTRUCTION									

DRAWN BY: CJT	CHECK DRAWING: LS
DESIGN BY: BMM	CHECK DESIGN: MT
LEAD ENGINEER: BMM	APPROVAL DATE: MARCH 16, 2018
PROJECT MANAGER: DK	APPROVAL DATE: MARCH 16, 2018

BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK GOLD MINE

TITLE: CONTACT WATER POND CROSS-SECTIONS

SCALE:	DWG No.:	REV.:
1:250	BJCP-XD-02-02	A

THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.

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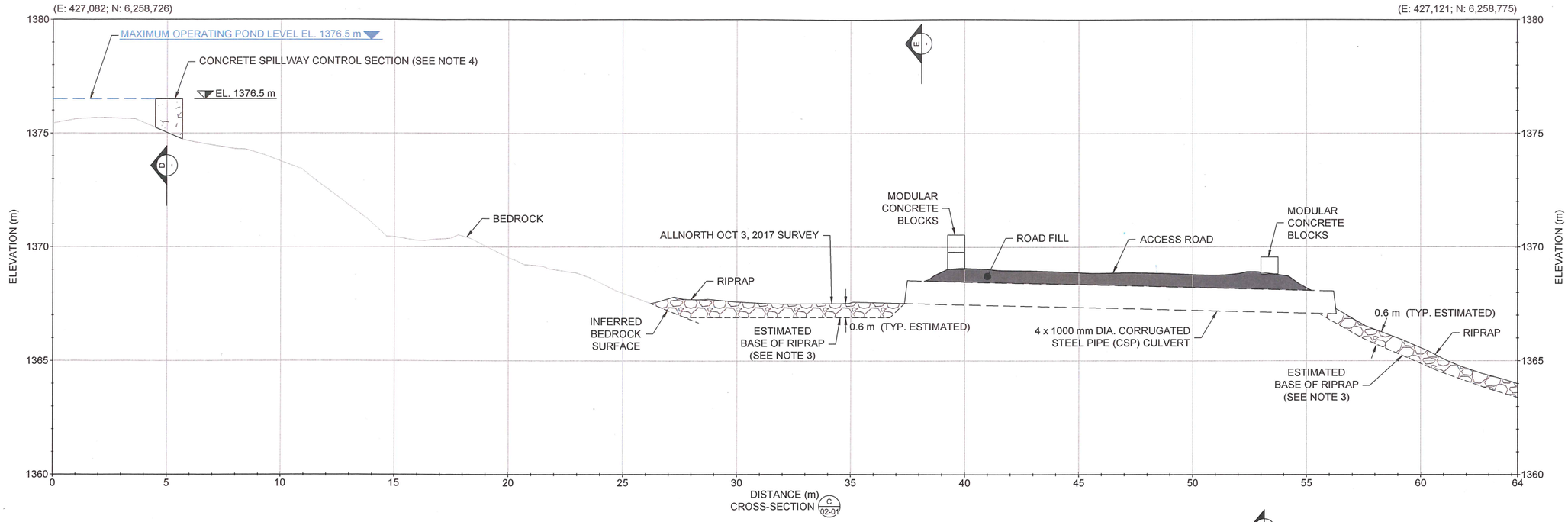

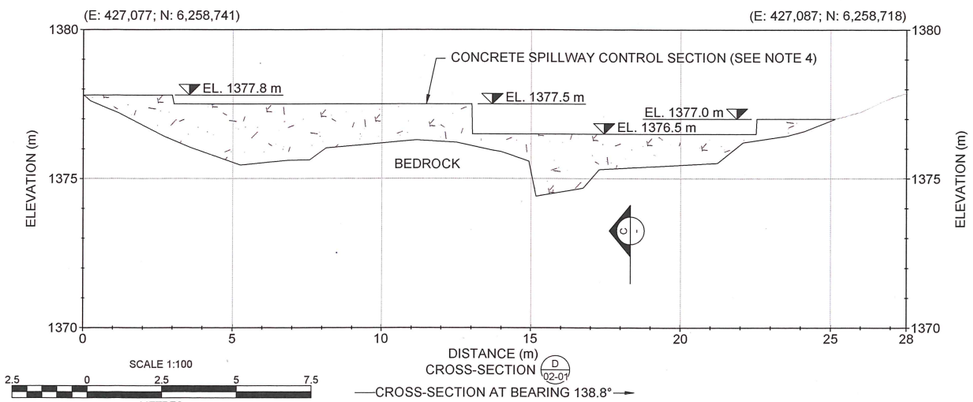

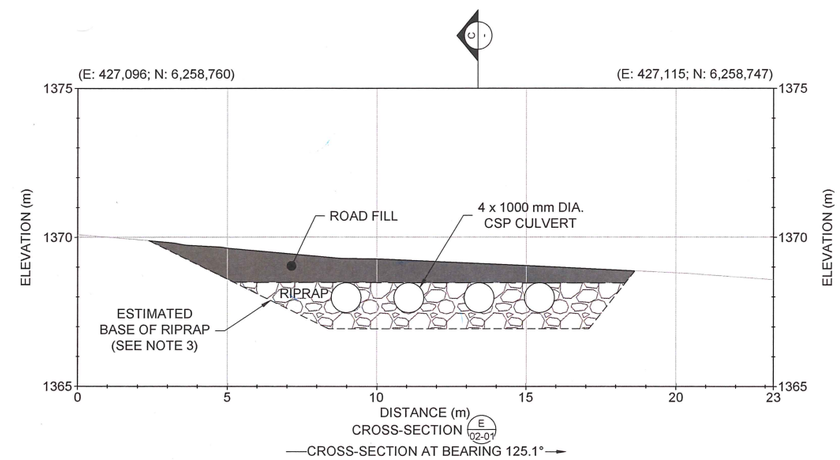

THIS DRAWING MAY HAVE BEEN REDUCED OR ENLARGED. ALL FRACTIONAL SCALE NOTATIONS INDICATED ARE BASED ON ORIGINAL FORMAT DRAWINGS.

NOTES:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH BGC'S REPORT TITLED "BRUCEJACK GOLD MINE - CONTACT WATER POND CONSTRUCTION RECORDS REPORT", AND DATED FEBRUARY 2018.
3. BASE OF RIPRAP ESTIMATED BASED ON VISUAL OBSERVATIONS BY BGC ON AUGUST 23, 2017.
4. IN MAY 2017, PRETIVM CONSTRUCTED THE CONCRETE CONTROL SECTION. ROCK ANCHORS WERE INSTALLED ALONG THE CENTRELINE OF THE CONTROL SECTION. ROCK ANCHORS WERE REPORTED BY PRETIVM TO BE 25M REINFORCEMENT BAR INSTALLED AT 1.0 m SPACING AND GROUTED IN PLACE. ROCK ANCHORS WERE EMBEDDED INTO BEDROCK TO A MAXIMUM DEPTH OF 1.0 m AND A MINIMUM DEPTH OF 0.3 m DEPENDING ON THE HEIGHT OF THE CONCRETE STRUCTURE ABOVE THE ANCHOR.
5. UNLESS BGC AGREES OTHERWISE IN WRITING, THIS DRAWING SHALL NOT BE MODIFIED OR USED FOR ANY PURPOSE OTHER THAN THE PURPOSE FOR WHICH BGC GENERATED IT. BGC SHALL HAVE NO LIABILITY FOR ANY DAMAGES OR LOSS ARISING IN ANY WAY FROM ANY USE OR MODIFICATION OF THIS DOCUMENT NOT AUTHORIZED BY BGC. ANY USE OF OR RELIANCE UPON THIS DOCUMENT OR ITS CONTENT BY THIRD PARTIES SHALL BE AT SUCH THIRD PARTIES' SOLE RISK.

PROFESSIONAL ENGINEER — PROVINCE OF BRITISH COLUMBIA — B. M. McAFEE # 38494 — 16-MAR-2018

REVISION INFORMATION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS
A	18	03	16	CJT	BMM	MT	BMM	RECORD OF CONSTRUCTION

REV. NO.	YY	MM	DD	DRAWN	DESIGN	CHECK	APPROVED	REVISION / ISSUED DESCRIPTIONS

DRAWN BY: CJT	CHECK DRAWING: LS
DESIGN BY: BMM	CHECK DESIGN: MT
LEAD ENGINEER: BMM	APPROVAL DATE: MARCH 16, 2018
PROJECT MANAGER: DK	APPROVAL DATE: MARCH 16, 2018

BGC ENGINEERING INC. AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIVM

PROJECT: BRUCEJACK GOLD MINE

TITLE: SPILLWAY CROSS-SECTIONS

SCALE:	DWG No.:	REV.:
1:100	BJCP-XD-02-03	A

THIS BAR MEASURES 100 mm AT FULL SIZE. ALL SCALES REFERENCED TO FULL SIZE.

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Appendix C – Permits

PROVINCE OF BRITISH COLUMBIA
MINISTRY OF ENERGY, MINES AND LOW CARBON INNOVATION

PERMIT

APPROVING MINE PLAN AND RECLAMATION PROGRAM

(Issued pursuant to section 10 of the *Mines Act* R.S.B.C. 1996, c. 293)

Permit: **M-243** Mine No: **0100270**

Issued to: **Pretium Resources Inc.**
Suite 2300, Four Bentall Centre
1055 Dunsmuir Street
PO Box 49334
Vancouver, BC
V7X 1L4

for work located at the:

Brucejack Mine

Issue Date	**Permit**
July 22, 2015	Approving Mine Plan and Reclamation Program

This permit supersedes and amends all previous versions of Permit M-243 issued pursuant to Part 10 of the Mines Act. All previously approved works systems are hereby transferred under this permit.

Amended at Victoria, British Columbia this 14th day of November in the year 2022.

J. Lowell Constable
Deputy Chief Permitting Officer
Major Mines Office

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PREAMBLE

The Mines Act Permit application, and applications for changes to approved works and conditions to Permit M-74, have been submitted to the Chief Permitting Officer, in accordance with Section 10(1) and/or 10(6) of the *Mines Act*, and Sections 10.1.2 and 10.1.18 of *the Health, Safety and Reclamation Code for Mines in British Columbia* (Code).

Where more than one version of information exists in the application, the most recent version must be considered the approved version unless otherwise stated or determined by the Chief Permitting Officer.

1. Approving Mine Plan and Reclamation Program (Issued July 22, 2015)

1.1 Application entitled "*Brucejack Gold Mine: Application for Mines Act and Environmental Management Act Permits*", dated May 2015.

1.2 Report entitled, "*Brucejack Gold Mine Project: Metal Leaching and Acid Rock Drainage Management Plan*", prepared by Pretium Resources Inc., dated June 30, 2015.

1.3 Memorandum entitled, "*Brucejack Project MA/EMA Permitting Phase – Responses to Information Requests from MEM & MOE – Groundwater Quality and Quantity Monitoring Plan*", prepared by BGC Engineering Inc., dated June 19, 2015.

1.4 Memorandum entitled, "*Brucejack Project MA/EMA Permitting Phase – Responses to Information Requests from MEM & MOE – Part 1 of 2*", prepared by BGC Engineering Inc., dated June 19, 2015.

1.5 Memorandum entitled, "*Brucejack Project MA/EMA Permitting Phase – Responses to Information Requests from MEM & MOE – Part 2 of 2*", prepared by BGC Engineering Inc., dated June 19, 2015.

1.6 Report entitled, "*Groundwater Monitoring and Sampling Protocol – Brucejack Mine; Revision 3*", prepared by Pretium Resources Inc., dated June 2015.

1.7 Letter entitled, "*Response to BC Ministry of Energy and Mines 'Information Requirements' and 'Clarifications' regarding underground geotechnical aspects of the Brucejack Project's Application for Mines Act and Environmental Management Act Permits*", prepared by BGC Engineering, dated June 18, 2015.

1.8 Report entitled, "*Brucejack Gold Mine Project - Invasive Plants Management Plan*", prepared by Pretium Resources Inc., dated July 2015.

1.9 Confidential Memorandum entitled, "*Brucejack Mine Project Mines Act Permit Application – Reclamation Cost Estimate*", prepared by ERM dated June 22, 2015.

1.10 Report entitled, "*Brucejack Gold Mine Project Wildlife Management Plan*", prepared by ERM dated July, 2015.

Application Received: March 12, 2015.
Gazette: BC Gazette June 4, 2015.
Referred: March 12, 2015.

Mine Review Committee Meetings: May 13, 2015; May 25, 2015.

2. Approving Groundwater Monitoring Plan (Issued August 26, 2015)

2.1 Report entitled "*Brucejack Gold Mine Project – Location, purpose, timing and monitoring schedule for monitoring wells to be installed to augment the Water Management Plan per Mines Act Permit M-243 Section D Part 4(c) – REV 1*", dated August 21, 2015.

Application Received: July 31, 2015.

3. Approving Updated Brucejack ML/ARD Management Plan (Issued September 9, 2015)

3.1 Report entitled "*Brucejack Gold Mine Project – Metal Leaching and Acid Rock Drainage Management Plan*", dated September 8, 2015.

Application Received: September 8, 2015.

4. Approving Temporary PAG Waste Rock Stockpile and Non-PAG Quarry (Issued March 17, 2016)

4.1 Application entitled "*Request for Authorization of Temporary Surface PAG Waste Rock Stockpile, Mines Act Permit M-243, Brucejack Mine*", dated October 18, 2015.
4.2 Application entitled "*Application for Modification of Km 72 NPAG Quarry, Permit M-243, Brucejack Mine*", dated November 3, 2015.

Application Received: November 3, 2015; November 16, 2015.
EAC M15-01 Amendment: March 10, 2016.

5. Approving Changes for Disturbance Area and Construction Water Treatment Plant (Issued August 4, 2016)

5.1 Application entitled "*Proposed Changes to Approved Disturbance Area, Mines Act Permit M-243, Brucejack Gold Mine – Amendment Application #2*", dated April 11, 2016.
5.2 Application entitled "*Application for Approval of Mine Water Treatment Plant Process Change for Nitrite Treatment*", dated April 25, 2016.
5.3 Report entitled "*Brucejack Gold Mine 2016 Freshet Water Management Plan*", dated March 2016.

Application Received: April 11, 2016.

6. Approving PAG Waste Rock Exposure Extension, Sludge Deposition with Tailings In Brucejack Lake and Chromium Management Plan (Issued April 3, 2017)

6.1 Report entitled "*Brucejack Mine: Proposed Extension for Waste Rock Storage on Surface*" dated November 10, 2016.
6.2 Report entitled "*Brucejack Gold Mine: Assessment of Long-Term Sludge Stability for In-Lake and Underground Deposition*" dated December 19, 2016.
6.3 Report entitled "*Chromium Management Plan*" dated February 23, 2017.
6.4 Report entitled "*Metal Leaching and Acid Rock Drainage Management Plan*" dated March, 2017.
6.5 Report entitled "*Operation, Maintenance and Surveillance Manual: Brucejack Gold Mine Subaqueous Waste Rock and Tailings Deposition; VERSION 04*" dated March, 2017.

Application Received: November, 2016; December, 2016 and September, 2016

7. Approving Mine Plan and Reclamation Program for Increased Production Rate and Waste Management (Issued December 14, 2018)

7.1 Application entitled "*3800 tpd Amendment Application for Permits M-243 and PE-107835*", prepared by Pretium Resources Inc., dated December 2017.
7.2 Report entitled "*Brucejack Gold Mine: Updated Subaqueous Waste Rock Dump Design*", prepared by SRK Consulting,dated October 2018.
7.3 Letter entitled "*Brucejack Gold Mine, Mine No. 0100270 MA Permit M-243 Section D.1 (d)*" dated March 8, 2018.

Application Received: April 13, 2018
Mine Development Review Committee Meetings: January 16, 2018; May 2, 2018; July 5, 2018

8. Approving West Zone Ramp, Additional Stope Development, and Underground Exploration (Issued December 18, 2020)

8.1 Application entitled "*Mines Act Permit M-243 Amendment Application: Permit Boundary Amendment*", prepared by ERM Worldwide Group Ltd., dated August 2020.

8.2 Report entitled "*OMS Manual - Water Management Plan*" prepard by SRK Consulting Inc., dated March 2020.

8.3 Report entitled "*Brucejack Gold Mine: 2020 Groundwater Model Review and Update*" prepared by Lorax Environmental, dated July 20, 2020.

8.4 Report entitled "*Brucejack Gold Mine Ground Control Management Plan – Version 7*", prepared by Pretium Resources Inc., dated October 2020.

8.5 Report entitled "*Production Ventilation Plan Brucejack Gold Mine*", prepared by Pretium Resources Inc., dated July 10, 2020.

Application Received: August 19, 2020

9. Approving Permitted Mine Area (PMA) Expansion for Future Access Road Realignment km 72 Ramp (Issued November 14, 2022)

9.1 Application entitled "*Permit M-243 Brucejack Mine – Amendment Application to Increase Permitted Mine Area for Future Brucejack Access Road km 72 Ramp Realignments*", prepared by Pretium Resources Inc., dated December 2, 2021.

9.2 Document entitled "*Geohazards Management Plan Revision 1*" prepared by Pretium Resources Inc., dated December 2016.

9.3 Report entitled "*Brucejack Access Road 72 km Glacier Ramp Design Basis*" prepared by Onsite Engineering Ltd., dated August 19, 2022.

Application Received: December 12, 2021

This permit contains the requirements of the Ministry of Energy, Mines and Low Carbon Innovation (EMLI). It also is compatible, to the extent possible, with the requirements of other provincial ministries. However, nothing in this permit limits the authority of other provincial ministries to set other conditions, or to act independently, under their respective permits and legislation.

The mine is located within the consultative territory of Tsetsaut /Skii-km Lax Ha and portions of the mine permitted area are located in the Nass Area as defined in the Nisga'a Final Agreement. Tsetsaut/ Skii-km Lax Ha, Nisga'a Lisims Government and Tahltan Central Government have been consulted with respect to this permit and have expressed their interests regarding potential concerns to their asserted or established rights.

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CONDITIONS

The Chief Permitting Officer hereby approves the Mine Plan and Reclamation Program as submitted in the applications, subject to compliance with the following conditions:

A. General

1. Compliance with *Mines Act* and Code

The Permittee must ensure all work is in compliance with all sections and parts of the *Mines Act* and the Health, Safety and Reclamation Code for Mines in B.C. (Code), and the owner, agent or manager (Permittee) must obey all orders issued by the Chief Inspector or their delegate.

2. Departure from Approval

The Permittee must notify the Chief Inspector of Mines (Chief Inspector) in writing of any intention to depart from the approved Application(s) and this *Mines Act* permit (M-243) to any substantial degree, and must not proceed to implement the proposed changes without the written authorization of the Chief Inspector.

3. Permit Approval

(a) Development, including surface disturbance and works, management buffers associated with 19 km of the Transmission Line extending southward from the Mine Site, and contingency buffers for mine infrastructure, encompassing approximately 659.3 ha (Figure 1a and Figure 1b), is authorized under this permit.

(b) Ore production rate must not exceed an average annual 1,387,000 tonnes on a calendar year basis.

4. Permit

This Permit is not transferable or assignable.

5. Maintenance of Mine

The Permittee must maintain mine facilities and infrastructure in a manner to meet design objectives and environmental protection and reclamation requirements.

6. Reports to be signed by a Qualified Professional

Unless otherwise specified in permit conditions, all reports required to be submitted under this permit the Permittee must ensure are reviewed and signed by a Qualified Professional with applicable experience and registered in the province of British Columbia.

7. Responsibility to Reclaim

Any outstanding reclamation associated with Reclamation Permit MX-1-842 that exists within the permitted mine area for the Brucejack Gold Mine defined in Figure 1a and Figure 1b is the responsibility of the Permittee under the terms and conditions of this permit.

8. First Nations Reporting Requirements

Unless otherwise requested, the Permittee must provide to the Tsetsaut/Skii-km Lax Ha, Nisga'a Lisims Government and Tahltan Central Council Government all material reports and plans relevant to this permit, including annual monitoring reports and material changes to the approved Reclamation and Closure Plan.

9. Compliance Status Report

The Permittee must track compliance status of all permit conditions, inspection orders or advisories in a form acceptable to the Chief Inspector. The Permittee must maintain a tracking table on site, and ensure it is revised when compliance changes or as required by the Chief Inspector. The Permittee must ensure that the tracking table is available at the mine site at all times and to a Mines Inspector upon request. An annual Compliance Status report must be submitted to the Chief Inspector by March 31st and must include a summary of outstanding non-compliance issues and an action plan, to the satisfaction of the Chief Inspector, for meeting compliance.

B. Health and Safety

1. Mine Emergency Response Plan (MERP)

(a) The Permittee must update the Mine Emergency Response Plan (MERP) The Permittee must keep the MERP up to date and file updates with the Chief Inspector, and make the updated MERP available at the mine site at all times.

(b) The Permittee must ensure that mine site employees and contractors are knowledgeable and accountable for fulfilling the actions of the MERP.

C. Geotechnical

1. General

(a) The Permittee must ensure that all geotechnical/designs, specifications, work plans, monitoring requirements and reports required to be prepared under section (C) are signed by a Professional Engineer and are submitted to the Chief Inspector.

(b) The Permittee must ensure that all geotechnical/designs, specifications, work plans, monitoring requirements and reports required to be prepared under section (C) are maintained on site and made available to any Inspector of Mines upon request.

(c) The Permittee must ensure all construction is completed under the supervision of a Professional Engineer and that sufficient field reviews have been conducted to ensure that all construction and facilities are built in conformance with the design, accepted engineering practices and the Code.

(d) The Permittee must ensure that recommendations by a Professional Engineer relating to health and safety, geotechnical stability or environmental protection are followed unless a suitable alternative course of action is approved in writing by a Professional Engineer.

(e) The Permittee must submit an Advice of Geotechnical Incident form to the Chief Inspector for any geotechnical incident that is classified as a dangerous occurrence or any other incident as described in the current EMLI Advice of Geotechnical Incident form.

2. Underground Mine

(a) The Permittee must maintain an up-to-date mine design that includes computer models, drawings, calculations, specifications, and written descriptions of:

(i) The geometry of all existing and proposed excavations,
(ii) The geologic, hydrogeologic and geotechnical conditions affecting the mine, and
(iii) Excavation design and ground support design that considers stress, structure and rockmass conditions.

(b) The mine design must be periodically, at a minimum of annually, updated to reflect site experience and the actual geological, hydrological and geotechnical conditions encountered.

(c) The Permittee must ensure the dimensions of all excavations and pillars are within nominal tolerances per the recommendation of a Professional Engineer.

(d) Ground Control Management Plan

The Permittee must implement the Ground Control Management Plan (GCMP). The GCMP must be reviewed annually by a Professional Engineer and updated as required. The Permittee must submit the updated GCMP to the Chief Inspector within 60 days of being issued, and it must include (but is not limited to) the following components:

(i) Ground control program roles, responsibilities, accountabilities, implementation, records and communications,
(ii) Design basis information and assumptions used to develop the mine design and the ground control program,
(iii) Geological model for the mine,
(iv) Hydrogeological model for the mine,
(v) Geotechnical (rock mechanics) model for the mine including stress, structure and rockmass,
(vi) Historical experience,
(vii) Mine design including mining methods, and excavation dimensions, pillar dimensions, stope sequencing, etc.; and criteria used in dimensioning of excavations and pillars,
(viii) Water control measures including specific precautions to be taken where bodies of water, water bearing structures, overburden, tailings etc., may inundate the mine workings,
(ix) Ground support systems and materials to be employed,
(x) Criteria used in selection, dimensioning, spacing and extent of ground support,
(xi) Standards and procedures to ensure worker safety including,
(xii) Minimum ground support standards to be employed at Mine,
(xiii) Blasting methods,
(xiv) Employee procedures and training,
(xv) Monitoring program to verify acceptable performance, detect early signs of instability, and confirm design basis information and assumptions,
(xvi) QA/QC program,
(xvii) Risk management, and
(xviii) Ground Control Management Plan reviews, audits, and scheduled update program.

(e) The Permittee must install ground support in new and rehabilitated excavations in accordance with the recommendations of a Professional Engineer.

(f) Mining-Backfill Standard Operating Procedure (SOP)

The Permittee must implement and maintain a Mining-Backfill Standard Operating Procedure (SOP). The Permittee must ensure the Mining Backfill SOP be reviewed annually by a Professional Engineer and updated as required. The Mining Backfill SOP must consider (but is not limited to) the following components:

(i) Barricade and berm design for anticipated loading conditions;
(ii) Procedures for determining suitable barricade location;
(iii) QA/QC procedures for constructed barricades;
(iv) Design rationale for minimum strength requirements for operating beside and underneath backfill at the design dimensions;
(v) Prescribed fill rates within stopes;
(vi) Paste line flushing procedures;
(vii) Procedures to ensure tight backfill has occurred,
(viii) Safe filling procedures that include safe worker setback distance from active paste pours, and
(ix) QA/QC backfill testing requirements.

(g) The Permittee must ensure that no placement of paste backfill into a mined void proceeds unless the fill retention barricades constructed for the placed paste backfill are inspected and approved by a Professional Engineer.

(h) Monitoring

(i) The Permittee must maintain a geotechnical model of the underground openings that record the stress conditions, structure and rock mass in all headings and stopes.

(ii) The Permittee must conduct performance testing on installed ground support to ensure performance is in accordance with design values. The Permittee must ensure quantifiable performance objectives provide triggers for when rehabilitation of ground support is required.

(i) The Permittee must maintain a Ground Control Log Book that must be available at any time at the mine site to any Mines Inspector and includes, but is not limited to, the following information:

(i) Records of damaged, loaded, or failed support;
(ii) Areas of ground support non-conformance to design;
(iii) Records of working ground such as cracks, noise, movement, or other signs of instability;
(iv) Records of uncontrolled falls of ground;

(v) Unusual or unexpected geological, hydrogeological and geotechnical conditions;

(vi) Identification of ground control concerns, coupled with a plan for mitigation/remediation and prioritization,

(vii) A record of the implementation of the mitigation/remediation to address the concern in C.2(i)(vi).

(j) The Permittee must monitor the strength of the paste backfill through laboratory or in-situ testing methods and ensure that no mining occur in areas below or adjacent to where low strength fill is encountered.

(k) The Permittee must ensure that the Ground Control Log Book is read and signed each day by the shift boss and the Mine Manager, or a mine engineer designated by the Mine Manager.

(l) The Permittee must ensure that in the event of mining induced seismicity, all mining must immediately cease until an observation, management and surveillance plan specific to mining in a mining induced seismically active area is submitted to the Chief Inspector and approved. The plan must provide measures to monitor micro seismicity and mitigate rock burst potential.

(m) Reporting

(i) The Permittee must ensure an annual review of the underground workings is undertaken by a Professional Engineer, and observations and recommendations made during the review are summarized in a report and submitted to the Chief Inspector by March 31 of the year following the inspection.

(ii) Starting in 2018, and every four years thereafter, or at the discretion of the Chief Inspector, the Permittee must ensure third party audits of the Ground Control Management Plan be conducted by a Professional Engineer and that they include a review of the instrumentation/monitoring program, QA/QC testing, stress management and pillar performance, and performance of installed ground support.

(iii) Starting in 2021, and every four years thereafter, or at the discretion of the Chief Inspector, the Permittee must ensure third party audits of the paste backfill operations be conducted by a Professional Engineer and that they include plant operations, paste reticulation system and paste placement procedures.

3. Subaqueous Waste Rock and Tailings Storage Facility (WRTSF)

(a) Operations

(i) The Permittee must implement the Subaqueous Waste Rock and Tailings Storage Facility Operation, Maintenance, and Surveillance Manual (OMS Manual; Document 6.5). The Permittee must ensure the OMS manual is reviewed annually and updated, as needed, to reflect changes in status as the facility develops.

(ii) The Permittee must ensure all employees and contractors involved in the operation of the WRTSF are trained in the implementation of the OMS Manual and that records of the training be maintained on site.

(iii) The Permittee must ensure that all subaqueous placement of tailings is to be performed under the guidance of a Professional Engineer.

(iv) The Permittee must assign a qualified person to monitor dumping and to provide a daily work schedule that shows the locations and quantities of waste rock to dump. No dumping of material must occur unless approved by the qualified person.

(v) The Permittee must ensure that no weak, cohesive materials or snow be dumped within the ultimate design limits of the subaqueous waste rock dump area, with the exception that high fines (cohesive) materials may be placed under the direction of the qualified person in areas approved by the Engineer of Record. The Permittee must ensure the locations, total volume and percentage (with respect to total placed) material of the high fines content is documented and included in the semi-annual and annual reports.

(vi) The Permittee must ensure any weak, cohesive materials or snow that is dumped outside the ultimate design limits of the WRTSF, be documented (locations and quantities) and included in the applicable semi-annual and annual reports.

(vii) The Permittee may, following standard operating procedures set in the OMS manual, and as outlined in Document 7.2, use a conveyor, excavator, or remotely operated vehicle to place waste rock into the ponded portion of the WRTSF.

(viii) The Permittee must develop an operational setback and delineation of high risk zone, including the following:

(a) The operational setback distance at the crest is defined with a Factor of Safety FoS > 1.1 for short term analysis of deep seated failures and areas with less than a FoS of 1.1 are identifiable as a high-risk zone;
(b) The zone must be clearly marked at all times;
(c) No personnel must work alone within this zone at any time;
(d) A clear, unobstructed escape route for equipment working within this zone must be maintained;
(e) Personal protective equipment, rescue equipment, communication equipment must be present at the location of work for all personnel working within the zone;
(f) At minimum a 10m operational setback distance must be maintained, and
(g) Prior to work occurring within the high risk zone, the area must be inspected and deemed safe by a Qualified Professional following all recommendations of the Engineer of Record

(ix) The Permittee must implement an earthquake monitoring system with an alarm to trigger evacuation of personnel from the dump in the event of an earthquake.

(b) Monitoring and Reporting

(i) The Permittee must monitor dump crest movement and implement a failure alert procedure on all active waste dumps and closed high consequence dumps.

(ii) The Permittee must install instrumentation to monitor the rate of settlement of the subaqueous waste rock dump. Reports of the settlement rates are to be made available to the Mine Inspector upon request.

(iii) The Permittee must install a water level gauge or other suitable pond level monitoring system to monitor Brucejack Lake water level.

(c) Annual Construction Progress Report

The Permittee must submit an annual construction progress report to the Chief Inspector by March 31 of that year, on the construction and monitoring of the WRTSF. The Permittee must ensure the report includes:

(i) A review of construction documentation,
(ii) Rock deposition advancement,
(iii) A discussion detailing any potential amendments to original design based on field observations,

(iv) Recommendations for the placement of material in all weather conditions, and
(v) Confirmation the report was reviewed by the Engineer of Record.

(d) Annual Review of WRTSF

(i) The Permittee must ensure that an annual review of the WRTSF is conducted by a Professional Engineer and a report submitted to the Chief Inspector until 2021.

(ii) Starting in 2022, and every five (5) years thereafter, the Permittee must ensure that a review of the WRTSF is conducted by a Professional Engineer and a report submitted to the Chief Inspector.

4. Surface Water Ponds, Ditches and Diversion

(a) The Permittee must not commence construction of surface water ponds and ditches that carry mine-influenced water or diversion channels until issued for construction (IFC) drawings, signed by a Professional Engineer, are submitted to the Chief Inspector. This condition does not apply to temporary diversion channels required to facilitate construction.

(b) The Permittee must ensure that water surface ponds, ditches and diversion channels are designed to convey the design flood without overtopping or side slope failure, and with adequate armour or lining to prevent significant erosion.

(c) Ponds must be designed with a minimum 0.5 m freeboard under the design flood. The design flood must be chosen with consideration of the consequence of failure, and duty life of the ponds, but must be no less than the 1:200 year peak flow event.

(d) The Permittee must submit an "As-Built" report to the Chief Inspector for all surface water ponds, ditches and diversion channels. The Permittee must ensure that the report certifies that each facility has been constructed in accordance with the design and the applicable guidelines.

(e) The Permittee must implement the Operations Maintenance and Surveillance Manual for the Contact Water Pond. The Permittee must ensure the OMS manual is reviewed annually and updated, as needed, to reflect changes in status as the facility develops.

(e) The Permittee must include all surface water ponds, ditches and diversion channels in an annual inspection by a Professional Engineer of water management facilities on the mine site. The annual inspections must be documented and inspection reports must be maintained onsite and provided to any inspector upon request.

5. Temporary Soil, Overburden, Rock, and Organic Material Stockpiles

The Permittee must ensure that the temporary soil, overburden, rock, and organic materials stockpiles are designed by a Professional Engineer and builtin accordance with the designs.

6. Borrow and Quarry Excavations

The Permittee must ensure that borrow and quarry excavations are designed by a Professional Engineer and developed in accordance with the designs.

7. Mine Site Roads

(a) The Permittee must ensure that all new mine roads are constructed in accordance with the designs and recommendations prepared by a Qualified Professional.

(b) The Permittee must ensure that all new roads with cut or fill slopes exceeding 6 m in height or located on terrain that can be classified as moderate (or higher) likelihood of initiating a landslide are designed by a Professional Engineer.

(c) The Permittee must ensure that all roads are reviewed at least every five years by a Qualified Professional. The Permittee must document the review and any recommendations and maintain a copy on site and provide it to an Inspector of Mines upon request.

(d) The Permittee must ensure that all roads are operated, maintained, and inspected in accordance with acceptable industry standards and guidelines.

8. Mine Site, Plant, Shop, and Other Infrastructure Foundations

(a) The Permittee must ensure that all building foundation designs address bearing capacity, potential settlement, and any necessary foundation preparation or treatment.

(b) The Permittee must ensure an inspection of the prepared excavation prior to the placement of permanent foundations is completed.

9. Geohazards Assessment

(a) The Permittee must develop and implement a Geohazards Management Plan. The Permittee must ensure that the plan is developed by a Qualified Professional. The Permittee must manage the geohazards associated with surface works in accordance with the plan. The plan must include mapping, an assessment of potential geohazards, and identification of risks prior to construction of the associated surface works.

(b) The Permittee must ensure a Qualified Professional conducts an annual review of the geohazard management practices being implemented by mine personnel at the mine site. The Permittee must provide the results of this inspection in an annual report to the Chief Inspector by March 31 of the year following the inspection.

D. Protection of Land and Watercourses

1. Environmental Management System

(a) The Permittee must maintain and implement an Environmental Management System (EMS) consisting of Environmental Management Plans (EMPs) and Standard Operating Procedures (SOPs). The EMS must reference relevant policies and establish proactive procedures to provide direction for effective operational management and monitoring on-site.

(b) The Permittee must audit the EMS annually, revise it as soon and as often as required, and make it available to a Mines Inspector at the mine site at all times. The findings of the annual audit of the EMS must be reported in the Annual Reclamation Report.

(c) The Permittee must ensure that mine site employees and contractors are knowledgeable and accountable to act consistently with the requirements of the EMPs and SOPs that form the EMS.

2. Environmental Manager

(a) The Permittee must ensure that an Environmental Manager is assigned.

(b) The Environmental Manager must have the authority to implement remedial actions as may be necessary to ensure maintenance of environmental standards and permit requirements. If suspension of construction or operations occurs due to environmental concerns, the Permittee or Environmental Manager must immediately notify the Chief Inspector.

3. Metal Leaching (ML) and Acid Rock Drainage (ARD)

(a) General

(i) The Permittee must ensure all materials with the potential to generate ML/ARD are placed in a manner that minimizes the production and release of metals and contaminants to levels that assure protection of environmental quality.

(ii) Unless otherwise approved, The Permittee must ensure all plans for the prediction, and if necessary, the prevention, mitigation and management of metal leaching and acid rock drainage are prepared in accordance with the *Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia* (1998).

(iii) The Permittee must ensure no changes are made to the criteria for ML/ARD definition, waste handling procedures, mitigation strategies, or materials monitoring program without the approval of the Chief Inspector.

(b) Definition of Potentially ARD Generating (PAG) and Metal Leaching (ML) Materials

All waste rock, quarry rock, borrow materials and tailings must be considered PAG if NP/AP is < 2, where AP is calculated from total sulphur and NP is calculated from total carbon.

(c) Mine Materials Handling and ML/ARD Mitigation

(i) The Permittee must ensure only non-PAG materials are used for construction purposes.

(ii) Prior to their use, the Permittee must ensure representative samples of quarry and borrow materials used for construction are tested and characterized in accordance with the ML/ARD Management Plan for their potential to generate ML/ARD.

(iii) The Permittee must ensure all waste rock generated from surface or underground development is backfilled in the underground workings, below the ultimate flood limit of the workings, or deposited in Brucejack Lake.

(iv) The Permittee must ensure all PAG waste rock deposited in Brucejack Lake is covered with a minimum 1 m water cover.

(v) The Permittee must ensure waste rock stored temporarily on surface, within the mine contact water collection system, for no longer than 2 years. Permanent disposal of waste rock on surface is not permitted.

(vi) The Permittee must ensure all tailings are either backfilled underground or deposited in Brucejack Lake.

(vii) The Permittee must ensure sludge generated from the Operations Water Treatment Plant is comingled with tailings and deposited in Brucejack Lake at a mixing ratio not to exceed 2% sludge by dry weight.

(viii) Underground co-disposal of Operations Water Treatment Plant sludge with cemented paste tailings is not permitted until such time as the Permittee can demonstrate the long term stability of these materials and an updated ML/ARD Management Plan and Subaqueous Waste Rock and Tailings Deposition OMS Manual is provided to the Chief Inspector for review and approval.

(ix) The placement of sludge from the Operations Water Treatment Plant in the underground workings is prohibited until such time the Permittee can demonstrate the long-term geochemical stability is demonstrated and an updated ML/ARD Management Plan and Subaqueous Waste Rock and Tailings Deposition OMS are provided to the Chief Inspector for review and approval.

(d) ML/ARD Operational Monitoring

(i) The ML/ARD Management Plan is approved and must be implemented. The Permittee must ensure no changes are made to the plan without the approval of the Chief Inspector.

(ii) The Permittee must ensure all personnel involved in waste rock and tailings generation and handling are trained and kept up to date on the content and implementation requirements of the ML/ARD Management Plan and the Subaqueous Waste Rock and Tailings Deposition OMS.

(iii) The Permittee must maintain an inventory of waste rock, quarry rock, borrow materials, exposed rock units in the underground workings, tailings products and water treatment plant sludge generated, including (as appropriate) information on source, composition, quantity of material, disposal location, elevation (meters), depth of water cover, and date of placement. This inventory must be kept on site and be made available to any Mines Inspector upon request.

(iv) Concurrent with mine development and operations, the Permittee must characterize excavated materials produced and mine surfaces exposed, including waste rock, quarry rock, borrow materials, exposed rock units in the underground, tailings products and generated water treatment plant sludge to determine ML/ARD generating potential, validate pre-mining predictions, guide material management decisions, confirm effectiveness of waste handling procedures, and determine the need for mitigation and contingency measures that ensure environmental protection.

(v) The Permittee must maintain a record of waste rock placed within the platform and active face areas of the waste rock dump. The record must include information on the type, amount and exposure time (in months) of waste rock prior to submergence in Brucejack Lake. The record must be kept on site and be made available to any Mines Inspector upon request. The record must be reported in the Annual Reclamation Report.

(e) Analytical Requirements

(i) The Permittee must present analytical QA/QC results in the Annual Reclamation Report.

(f) ML/ARD Reporting

The Permittee must report results of the ML/ARD analytical testwork (including raw data, sample descriptions, analytical QA/QC, and materials inventory) and underground geologic mapping in the Annual Reclamation Report. Any significant changes or trends must be discussed, and implications for materials handling must be identified.

4. Water Management and Monitoring

(a) Water Management

(i) The Permittee must obtain any necessary permits and licenses for water diversion and discharge.

(ii) The Permittee must ensure water from the underground workings is collected and directed to water treatment.

(iii) The Permittee must ensure that water from the Contact Water Pond is collected and either directed to water treatment or to Brucejack Lake through the direct discharge line, as per the Contact Water Pond OMS manual required as a condition of this permit.

(b) Groundwater

(i) The Permittee must ensure the Operation, Maintenance and Surveillance Manual: Mine Site Surface Water Management Facilities is kept up to date, reviewed annually, revised as soon and as often as required and is made available to an Inspector at the mine site at all times. Updated versions of the manual must be submitted to the Chief Inspector.

(ii) The Permittee must ensure updates to the post-closure groundwater elevation predictions be provided with each Five Year Mine Plan Update, commencing July 31, 2020. Any changes to predicted post-closure groundwater levels must be used to revise the ML/ARD Management Plan and the Water Management Plan, as required.

(c) Chromium Management Plan

(i) The Permittee must implement the Chromium Management Plan (Document 6.3).

(ii) The Permittee ensure the Chromium Management Plan is kept up to date, reviewed annually, revised as soon and as often as required and made available to an Inspector at the mine site at all times. The findings of any investigations undertaken and any significant changes to the plan must be reported in the Annual Reclamation Report.

(iii) The Permittee must ensure that mine site employees and contractors are knowledgeable and accountable to act consistently with the requirements of the Chromium Management Plan.

(d) Monitoring and Reporting

(i) The Permittee must monitor and track changes to mine site surface water and groundwater quality and quantity from the underground workings (including pumping rate of water into and out of the underground workings), groundwater monitoring wells, Contact Water Pond, and tailings supernatant. The Permittee must ensure the program is capable of providing early warning about the onset of ARD or an increase in contaminant loading and provide refined predictions regarding the post-closure groundwater elevation.

(ii) The Permittee must ensure detection limits are sufficient to compare to provincial water quality guidelines and permit requirements established by the British Columbia Ministry of Environment.

(iii) The Permittee must ensure an effective QA/QC program for mine site contact water is implemented.

(iv) The Permittee must ensure monitoring results of water quality and water quantity, including interpretation of the results, are kept up to date in a dedicated database available for review by a Mines Inspector and reported in the Annual Reclamation Report.

(v) The Permittee must ensure that the Annual Reclamation Report includes a table comparing relevant monitoring and testwork data to source term concentrations used in water quality predictions. The Permittee must ensure implications of the results for source term refinement, water quality mitigation and adaptive management is discussed in the report.

(e) Water Quality Predictions

During operations, the Permittee must track water quality and flow monitoring data to enable validation and refinement of water quality predictions based on site-specific monitoring information. The Permittee must ensure water quality model updates is provided in every 5 Year Mine Plan update thereafter, or more frequently as necessary to inform mine planning and mitigation design and engineering.

5. Closure Underground Water Quality Adaptive Management Plan

The Permittee must implement an appropriate monitoring program with water quality triggers and management actions that will be used to ensure the groundwater discharging from the underground workings during post-closure is protective of receiving environment water quality.

6. Water Treatment

(a) Operations

(i) The Permittee must ensure the Operations Water Treatment Plant Operations and Maintenance Manual (OWTP OMS) is kept up to date, reviewed annually, revised as soon and as often as required and be made available to an Inspector at the mine site at all times. The Permittee must submit updated versions of the OWTP OMS to the Chief Inspector.

(ii) The Permittee must ensure no substantive changes are made to the operations phase water treatment processes without the approval of the Chief Inspector.

(b) Monitoring and Reporting

(i) The Permittee must monitor, track and report in the Annual Reclamation Report on the performance of the Water Treatment Facility. The Permittee must report information on system performance, volume and quality of contact water influent and effluent of the water treatment system, volumes of reagents used, volumes and characteristics of waste generated, and information on any process changes.

(ii) The Permittee must ensure the Annual Reclamation Report includes a breakdown of all annual costs associated with operation of the Operations Water Treatment Facility, including labour, electricity, waste handling and storage and all delivered costs for diesel, reagents, etc.

7. Sediment and Erosion Control

(a) The Permittee must ensure that the Erosion and Sediment Control Management Plan is implemented. This plan must be reviewed at least annually and updated to reflect results of effectiveness monitoring and potential contingency requirements, changing site conditions, and site-specific freshet-related considerations. The Permittee must ensure substantive changes are provided to the Chief Inspector prior to implementation, and annual updates are reported in the Annual Reclamation Report.

(b) The Permittee must ensure that erosion and sediment control prescriptions, and associated effectiveness monitoring programs, are developed based on site-specific assessments of risk and consequence prior to construction of individual mine and water management components.

(c) The Permittee must ensure that unauthorized release of sediment-laden water released from the authorized water management system must be characterized and reported to the Chief Inspector, with recommendations for improvement to the water management system if required.

(d) The Permittee must initiate progressive reclamation where practicable to control erosion around the mine area.

8. Soil Salvage and Storage

(a) The Permittee must salvage and stockpile topsoil, overburden, and organic material to the greatest extent possible for use in reclamation.

(b) The Permittee must ensure a Qualified Professional monitor and direct sampling, soil salvage, stockpiling activities on-site.

(c) The Permittee must ensure an inventory of salvaged and stockpiled soil, including the locations, origins, and quantities of material, is documented and reported in the Annual Reclamation Report.

(d) The Permittee must protect stockpiles from erosion, degradation, and contamination using appropriate best management practices, and monitor them as appropriate to ensure effective controls are maintained. The Permittee must ensure stockpile protection activities and monitoring results are documented and reported in the Annual Reclamation Report.

(e) The Permittee must ensure soil stockpiles are located in areas that minimize handling requirements during site preparation and mine operations, provide adequate accessibility for reclamation activities, and optimize sediment control options.

(f) The Permittee must ensure soil stockpiles are clearly marked to ensure that they are protected during construction and mine operations.

(g) The Permittee must ensure stockpiled soil suitable for use in reclamation is not used as fill.

9. Vegetation Management

(a) The Permittee must ensure that the Vegetation Management Plan is implemented.

(b) The Permittee must limit disturbance to vegetation to those areas approved by this permit (Figure 1a and Figure 1b) and ensure that disturbance limits are clearly communicated and adhered to on-site. Where only minimal vegetation removal is proposed, the Permittee must ensure efforts are made to limit ground disturbance to minimize soil erosion and maximize the regeneration potential of the site.

(c) The Permittee must ensure that the Invasive Plants Management Plan, dated July 2015 is implemented.

(d) The Permittee must prevent the establishment of invasive plants on-site, manage and control weeds that do establish on the site, and take reasonable efforts to ensure that weeds do not move from the site to adjacent areas. The Permittee must ensure that seed used on-site is certified weed free and consider using non-toxic means for weed control.

(e) The Permittee must salvage and stockpile woody debris, including stumps, roots, limbs and rotting logs, that is generated during clearing and grubbing operations. The Permittee must keep an inventory of salvaged and stockpiled woody debris, including the locations, origins, and quantities of material, and report in the Annual Reclamation Report.

(f) The Permittee must avoid chipping or burning of woody debris suitable for use in reclamation.

10. Wildlife Protection

(a) The Permittee will implement the Wildlife Management Plan (REF 1.10), to prevent and mitigate impacts to wildlife, with the monitoring results provided in the Annual Reclamation Report.

(b) The Permittee must ensure that strategies, designed by a Qualified Professional with suitable experience, to prevent human-wildlife interactions are included in the Waste Management Plan and implemented.

(c) The Permittee must ensure that where exclusion fencing is installed that it is maintained in effective working order at all times that people are present on site.

(d) The Permittee must conduct monitoring and/or track incidental observations of bats in the underground throughout mine life. If bats are observed to be present the Permittee must:

(i) Develop, and submit to the Chief Inspector within 3 months of bat observations, an operational management plan to minimize risk to bats, particularly with respect to direct mortality and spread of white nose syndrome and

(ii) Conduct a bat survey and take all reasonable efforts to move bats out of the underground, prior to securing the underground openings.

(e) The Permittee must avoid wildlife sensitive periods and/or adhere to timing windows for construction activities. Where this is not practicable, the Permittee must adhere to mitigation measures outlined in the Wildlife Management Plan.

(f) Pursuant to Part 1.6.9 of the Code, the Mine Manager must incorporate in the mine safety program a no hunting and shooting policy, for the mine permit area (Figure 1a and Figure 1b).

(g) The Permittee must implement a policy of no fishing and hunting for all employees and contractors while on company business or while commuting to and from the mine on the Brucejack Access Road west of Highway 37.

11. Archaeological Resources

If archaeological materials or cultural features are encountered during construction or related activities, the Permittee must implement procedures as set out in the Heritage Management Plan.

12. Ongoing Reclamation Research

(a) The Permittee must by July 31, 2020, submit to the Chief Inspector a Reclamation Research Program that includes details for achieving the research requirements outlined in this permit with a schedule for implementation and description for how results will be utilized and reported.

(b) The Permittee must ensure a summary of all research being conducted under this section is provided in the Annual Reclamation Report and a detailed summary of results is provided in the Five Year Mine Plan and Reclamation Program updates.

(c) The Permittee must ensure research is conducted to explore opportunities for enhancement of both habitat and surface drainage control on the Mine Site, particularly with respect to design of the surface topography predicted to remain once infrastructure is decommissioned at closure. The scope of this research must include evaluation of options to optimize remaining concrete foundations.

(d) The Permittee must ensure research is conducted to evaluate opportunities for amending soil that is to be used for reclamation purposes to enhance the soil suitability, if necessary, based on soil analyses.

(e) The Permittee must ensure testwork is conducted to determine soil replacement depths and locations required to achieve the designed surface topography and end land use objectives.

(f) The Permittee must ensure research is conducted to determine the viability of revegetation with native plant species, including culturally important species.

(g) The Permittee must ensure research is conducted to assess decompaction methodologies to ensure that the severity of compaction that exists prior to commencing reclamation activities is effectively addressed in a manner intended to achieve end land use objectives and erosion control. The scope of this research must include mine access roads and mine site pads.

(h) The Permittee must develop a reclamation success monitoring program designed to evaluate the success of revegetation, landscape design, and erosion control that specifies sampling parameters and performance criteria.

(i) The Permittee must develop a monitoring program for evaluating metal uptake in exposed terrestrial and aquatic ecosystems, which specifies sampling requirements and performance criteria and targets areas where potential pathways for metal uptake via (e.g., dust, growth medium, or contact water). Where harmful levels are found, the Permittee must take any corrective action necessary to mitigate to ensure levels are safe for plant and animal life.

13. Subsidence Monitoring

The Permittee must develop a Subsidence Monitoring and Management Plan and submit it to the Chief Inspector as part of the 5 Year Mine Plan and Reclamation Program update. The plan must be designed to evaluate the effectiveness of subsidence controls, provide early warning of surface expression that may result in changes to terrestrial or aquatic values and include an adaptive management approach to ensure that appropriate mitigation and/or closure plans are developed as needed.

E. Reclamation and Closure Program

1. Reclamation Security

(a) The Permittee must maintain a total security for this permit of Thirty One Million Seven Hundred Thousand ($31,700,000.00) dollars. The security will be held by the Minister of Finance for the proper performance of the approved program and all the conditions of this permit in a manner satisfactory to the Chief Inspector.

(b) Notwithstanding the security posted as a condition of this Permit, the Permittee remains responsible for covering all closure and reclamation costs associated with reclamation and environmental protection.

2. Annual Reclamation Report

By March 31 of each year, starting in 2016, the Permittee must submit an Annual Reclamation Report in a form containing the information required by the Chief Inspector.

3. Land Use

The Permittee must reclaim the land with the intent of re-establishing average pre-mining capability to the following end land use objective: wildlife habitat, particularly matrix habitat for mountain goat, grizzly bear and hoary marmot on the mine site and high elevation sections of the Transmission Line, and moose and grizzly bear habitat at lower elevations of the Transmission Line. Achieving land capability objectives and habitat enhancement must guide the reclamation program.

4. Revegetation

(a) The Permittee must, where vegetation is a necessary component of fulfilling the approved end land use objective, ensure the land is revegetated to a self-sustaining state using appropriate and or native plant species including culturally important native species.

(b) The Permittee must ensure revegetation programs are designed to restore wildlife habitat where practicable.

(c) The Permittee must ensure revegetation practices are conducted to provide appropriate species and densities that are similar to naturally occurring ecosites at similar elevations, aspects, and climatic conditions.

(d) The Permittee must develop details of the proposed revegetation programs, including species and densities prescribed for specific areas, based on input from the reclamation research program required as a condition of this permit.

5. Growth Medium

(a) Where replacement of salvaged soil will occur, the Permittee must ensure surface preparation is done in a manner that controls erosion and achieves end land use objectives.

(b) The Permittee must monitor soil replacement to ensure the minimum depths are achieved and a confirmation sampling plan must be implemented to ensure quality of soil used for reclamation purposes will achieve end land use objectives. The Permittee must present the results in the Annual Reclamation Report.

(c) With the exception of areas where closure plans require compaction prior to placement of growth medium in order to reduce infiltration and contact water, the Permittee must ensure all areas are reclaimed and decompacted to the minimum depth required to adequately address the severity of compaction prior to placement of soil and or vegetation, in a manner intended to achieve end land use objectives and erosion control.

6. Contaminated Sites Assessment

The Permittee must develop and implement risk-based monitoring programs designed to ensure all potential sources of contamination have been addressed in order to satisfy reclamation success objectives and water quality requirements.

7. Erosion Control

The Permittee must ensure that long term erosion potential is minimized through landform configuration, appropriate surface preparation, development of maintenance-free vegetation covers, where applicable, and self-sustaining drainage control features and watercourses.

8. Surface Water Management Ponds and Channels

(a) The Permittee must ensure all surface water management ponds and water diversions are reclaimed to satisfy stability and erosion control requirements and the approved end land use once no longer required.

(b) At least 3 months prior to decommissioning water treatment facilities, the Permittee must develop and submit to the Chief Inspector for approval, a Closure Plan that addresses all non-contact and contact water management features that will no longer be required.

9. Transmission Line

At least 3 months prior to decommissioning the Transmission Line, the Permittee must develop and submit to the Chief Inspector for approval, a Reclamation and Closure Plan to satisfy the approved end land use objectives.

10. Borrows and Quarries

The Permittee must ensure borrow pits and quarries are reclaimed to satisfy stability and erosion control requirements and the approved end land use, once no longer required.

11. Mine Roads

(a) The Permittee must ensure all mine roads are reclaimed, in accordance with recommendations of a Qualified Professional, to satisfy the approved end land use objectives, including all reasonable effort to fully re-configure to conform to adjacent landscape where long-term stability is not compromised, unless permanent access is required.

(b) Individual mine roads may be exempted from the requirement for total reclamation pursuant to this permit if either:

(i) the Permittee can demonstrate that an agency of the Crown has explicitly accepted responsibility for the operation, maintenance and ultimate deactivation and abandonment of the road or

(ii) the Permittee can demonstrate that another private party has explicitly agreed to accept responsibility for the operation, maintenance and ultimate deactivation and abandonment of the road and has, in this regard, agreed to comply with all the terms and conditions, including bonding provisions, of this reclamation permit, and to comply with all other relevant provincial government (and federal government) regulatory requirements.

(c) The Permittee must ensure all access roads are effectively blocked to prevent inadvertent vehicular access to surface areas of the mine that may be dangerous.

12. Structures and Equipment

Prior to abandonment, the Permittee must, unless the Chief Inspector has made a ruling with respect to heritage project status or industrial use:

(a) Remove all machinery, equipment and building superstructures, unless the Permittee can demonstrate that another private party has explicitly agreed to accept responsibility for its operation and maintenance;

(b) Remove all synthetic sediment control structures, such as turbidity curtains, ditch liners, and soil covers not required after closure and where practical ,disposed of in the underground prior to flooding or buried in place where sufficient cover materials exist;

(c) Remove all concrete foundations, or covered with sufficient growth medium and re-vegetated, or otherwise reclaimed to fulfill approved end land use objectives based on input from the reclamation research program required as a condition of this permit; and

(d) Remove all scrap material and dispose of in an approved facility.

13. Temporary Shutdown

(a) If the mine ceases production, including for seasonal closure, within one month the Permittee must submit a Care and Maintenance Plan which describes, documents, and tracks key aspects of the ongoing mitigation, monitoring, and maintenance requirements for the care and maintenance of the site. The Permittee must ensure the manual documents the outstanding reclamation activities and closure requirements for the site, and develop a trigger action response plan that will be implemented to activate closure activities based on monitoring results and site conditions. This document must be a living document with updates submitted to the Chief Inspector whenever material changes occur.

14. Mine Plan and Reclamation Program Update

On or before July 31, 2020, and every 5 years thereafter, the Permittee must submit an updated Mine Plan and Reclamation Program, providing, but not limited to, the following:

(a) The current status of the mine plan and reclamation obligations;
(b) A compilation and interpretation of all monitoring including ML/ARD prediction, water quality and quantity, and post-closure groundwater elevation prediction updates;
(c) Closure and maintenance activities;
(d) Any changes to the reclamation program that affect long-term mitigation;

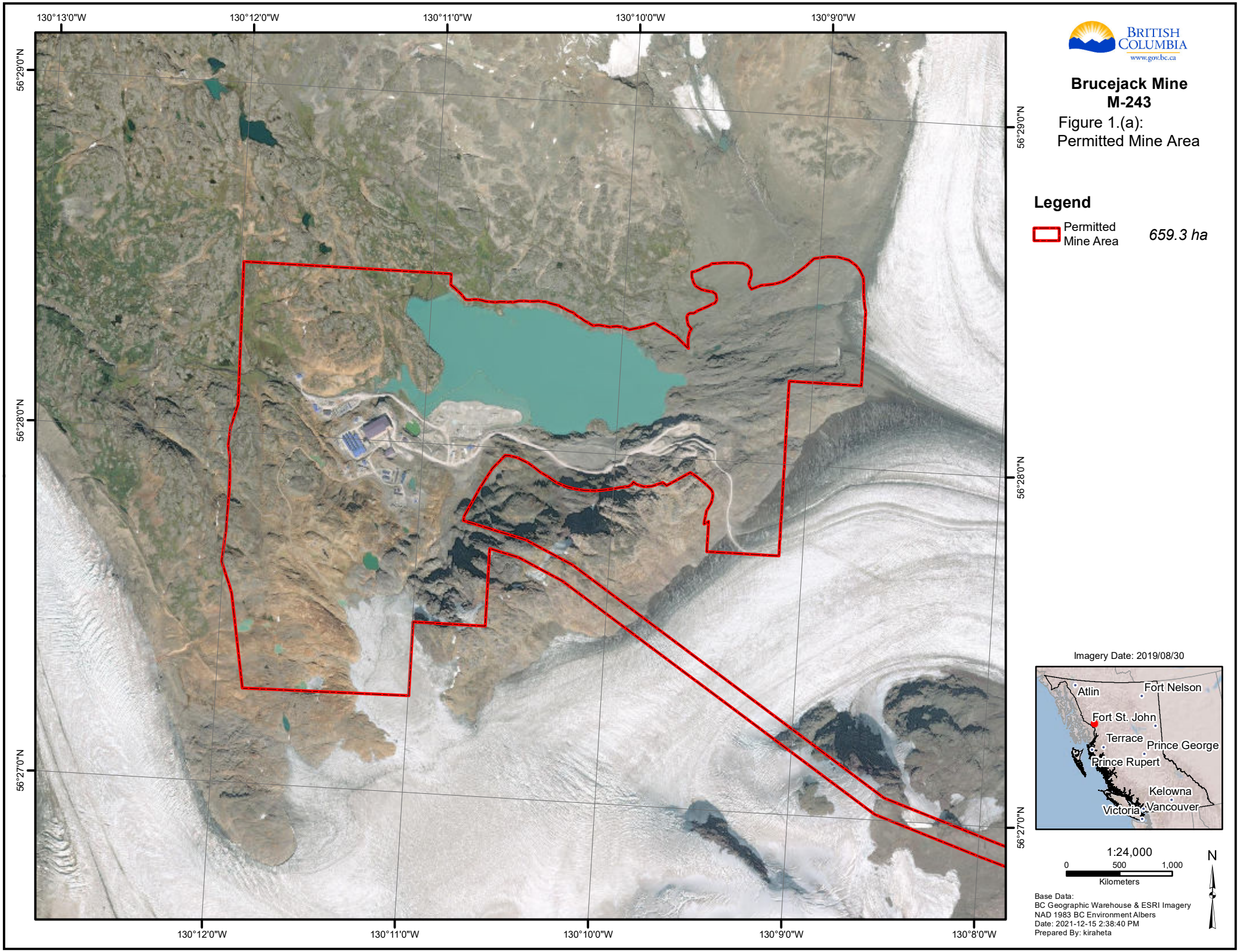
(e) Reclamation research program;
(f) Contingency plans;
(g) Schedule for completion of reclamation works and
(h) A breakdown of outstanding liabilities and associated costs.

15. Closure Plan

(a) Twelve months prior to final closure, the Permittee must submit a Closure Plan providing, but not limited to, the following:

(i) Closure objectives and criteria for each mine component;
(ii) Provide the current status of the mine plan and reclamation obligations;
(iii) A compilation and interpretation of all monitoring including ML/ARD prediction, water quality and quantity;
(iv) Closure and maintenance activities;
(v) Any changes to the reclamation program that affect long-term mitigation;
(vi) Reclamation research program;
(vii) Contingency plans;
(viii) Schedule for completion of reclamation works and
(ix) A breakdown of outstanding liabilities and associated costs.

(b) Concurrent with the final Closure Plan, the Permittee must submit a Closure Management Manual which describes and documents key aspects of the operational surveillance and monitoring requirements used to track important changes that could affect long-term mitigation performance, monitoring and maintenance requirements. This document must be a living document with updates submitted to the Chief Inspector, at least every five years while the permit remains active, and when material changes occur.



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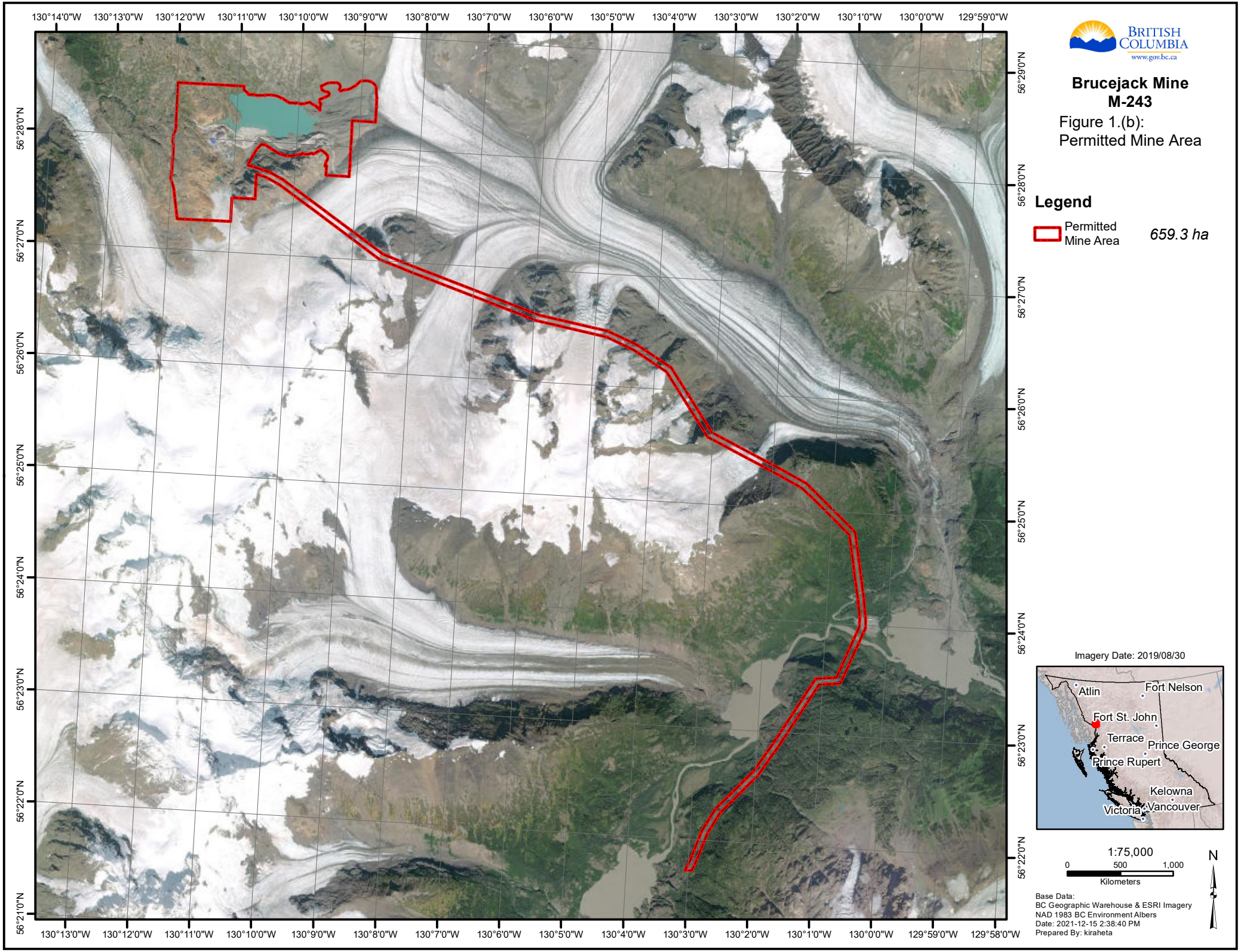

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June 16, 2022

Tracking Number: 412539
Authorization Number: 107835

REGISTERED MAIL

Pretium Resources Inc.
Suite 2300, Four Bentall Centre
PO BOX 49334 1055 Dunsmuir Street
Vancouver, BC V7X1L4

Dear Permittee:

Enclosed is Amended Permit 107835 issued under the provisions of the *Environmental Management Act*. Your attention is respectfully directed to the terms and conditions outlined in the permit. An annual fee will be determined according to the Permit Fees Regulation.

This permit does not authorize entry upon, crossing over, or use for any purpose of private or Crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority rests with the permittee. This permit is issued pursuant to the provisions of the *Environmental Management Act* to ensure compliance with Section 120(3) of that statute, which makes it an offence to discharge waste, from a prescribed industry or activity, without proper authorization. It is also the responsibility of the permittee to ensure that all activities conducted under this authorization are carried out with regard to the rights of third parties, and comply with other applicable legislation that may be in force.

This decision may be appealed to the Environmental Appeal Board in accordance with Part 8 of the *Environmental Management Act*. An appeal must be delivered within 30 days from the date that notice of this decision is given. For further information, please contact the Environmental Appeal Board at (250) 387-3464.

Administration of this permit will be carried out by staff from the Environmental Protection Division's Regional Operations Branch. Plans, data and reports pertinent to the permit are to be submitted by email or electronic transfer to the Director, designated Officer, or as further instructed.

Yours truly,

for Director, *Environmental Management Act*
Mining Authorizations - North Region

Enclosure

cc: Environment Canada

Environmental Protection Division

Ministry of Environment and Climate Change Strategy

Suite 325 - 1011 4th Avenue
Prince George BC V2L 3H9

Authorizations - North Region
Telephone: (250) 565-6135
Facsimile: (250) 565-6629

MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE STRATEGY

PERMIT

107835

Under the Provisions of the Environmental Management Act

Suite 2300, Four Bentall Centre
PO BOX 49334 1055 Dunsmuir Street
Vancouver, BC V7X1L4

Is authorized to discharge mine related contaminants and effluent to Brucejack Lake and Brucejack Creek, from the Brucejack Mine located approximately 60 km North of Stewart, British Columbia, subject to the requirements listed below.

Contravention of any of these requirements is a violation of the *Environmental Management Act* and may lead to prosecution.

This authorization supersedes and replaces all previous versions of Permit 107835 issued under Section 14 of the *Environmental Management Act*.

Where this authorization provides that the director may require an action to be carried out, the permittee must carry out the action in accordance with the requirements of the director.

1. AUTHORIZED DISCHARGES

1.1 Brucejack Lake Final Discharge Point

The permittee must manage the operations and authorized discharges in Sections 1.2, 1.3, 1.4, and 1.5, such that water quality at the outlet of Brucejack Lake (monitoring site BJ 3.10) does not exceed the maximum concentrations specified in Section 1.1.1. The site reference number and final point of compliance for this discharge is E298312.

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1.1.1 The characteristics of the Brucejack Lake Outlet (BJ3.10) water quality must not exceed the following:

Parameter	Maximum (1)	Units
48 hr Daphnia magna single concentration toxicity test	50% Survival in 100% Concentration, Minimum **(2)**	Not applicable
Algal Growth Inhibition Test (EPS 1/RM/25)	Growth Inhibition must be less than 25% for 100% Lake Outlet Water **(2)**	Not applicable
Total Suspended Solids	30 (maximum) 15 (monthly average)	mg/L mg/L
pH	6.5- 8.5	
Nitrite	240	µg/L as N
Nitrate	11.5	mg/L as N
Ammonia	4.0	mg/L as N
Total Antimony	28	µg/L
Total Arsenic	10	µg/L
Total Iron	1.7	mg/L
Total Silver	0.46	µg/L

(1) Maximum allowable concentration in any grab sample.
(2) Refer to Section 4.3.

1.1.2 The annual average authorized discharge rate from Brucejack Lake is 50,000 m^3/day. The average authorized discharge volume has been set to enable the calculation of discharge fees as required by the Permit and Approval Fees and Charges Regulation.

1.1.3 The discharge is authorized from Authorized Works, which are various discharge lines and outfalls from treatment works, collection works, ditches, oil/water separator, pipes, sumps, pumps, flow monitoring and water sampling devices, a low level weir, and Brucejack Lake.

1.1.4 The location of the facilities from which the discharge is authorized to originate and the point where the discharge is authorized to occur is Mining Lease 1038598. The Authorized Works and various points of discharge are as shown in attached Site Plan A.

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1.2 Water Treatment Plant and Contact Water Pond Effluent

This section applies to the discharge of effluent from the Water Treatment Plant (WTP) and the Contact Water Pond (CWP) to Brucejack Lake and/or for use as process water within the mill building. The site reference number for the WTP discharge is E302957. The site reference number for the CWP direct discharge is E306114.

1.2.1 The maximum authorized rate of discharge from the WTP to Brucejack Lake is 10,000 m^3/day.

1.2.2 The maximum authorized rate of discharge from the CWP to Brucejack Lake is indeterminate.

1.2.3 Subject to subsection 1.2.4, the characteristics of the WTP and CWP discharge to Brucejack Lake must not exceed the following:

Parameter	CWP Maximum (1)	WTP Maximum (1)	Units
Total Suspended Solids (TSS)	25 (2) 150 NTU (3)	25	mg/L
pH	6.5 – 8.5	6.5 – 8.5	pH
Total Aluminum	0.3	0.3	mg/L
Total Arsenic	10	10	µg/L
Total Cadmium	0.25	0.25	µg/L
Total Cobalt	10	10	µg/L
Total Chromium (see Section 3.4)	20	20	µg/L
Total Copper	10	10	µg/l
Total Iron	1.0	1.0	mg/L
Total Lead	5	5	µg/L
Total Manganese	22	22	mg/L
Total Silver	0.1	0.1	µg/L
Total Zinc	20	20	µg/L

(1) Concentration in any grab sample that triggers requirements in subsection 1.2.4
(2) When available CWP storage capacity is between 10,000 and 50,000 m^3
(3) When available CWP storage capacity is less than 10,000 m^3.

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1.2.4 Should the concentrations in Section 1.2.3 be exceeded for the WTP or CWP discharge to Brucejack Lake, the permittee must immediately upon receipt of analytical results recirculate effluent through the CWP and WTP until treated water quality does not exceed the discharge characteristics specified in Section 1.2.3.

1.2.5 **Water Treatment Plant Authorized Works**
The discharge is authorized from Authorized Works, which are Brucejack Lake, and the WTP that utilizes pH adjustment for metals precipitation using hydrated lime and, if necessary, sodium sulphide; coagulation using ferric sulphate; and flocculation using anionic polymer and microsand for removal of TSS; clarification using lamella plates and disc filter; sludge dewatering using centrifuge and cationic polymer; and pH neutralization using sulfuric acid and calcium hydroxide.

1.2.6 **Contact Water Pond Authorized Works**
The discharge is authorized from Authorized Works, which are Brucejack Lake and a CWP with a minimum storage capacity of 50,000 m^3. Related appurtenances include a permanent emergency spillway for events exceeding the design capacity as well as a drawdown pump and pipeline system to a deep lake outfall.

1.2.7 The location of the WTP and the deep lake discharge line are as shown on Site Plan B. The sources of the WTP influent are mine water, process water and the CWP.

1.2.8 The location of the CWP and the direct discharge line are as shown on Site Plan B. The sources of the CWP influent are various surface water collection works surrounding the mine site, Diesel Power Station (DPS) pond effluent, WTP effluent, as well as emergency storage of untreated Mine Water.

1.3 Thickened Tailings Slurry

This section applies to the discharge of Thickened Tailings Slurry via the tailings discharge lines to Brucejack Lake. The site reference number for this discharge is E302910.

1.3.1 The annual average authorized rate of discharge is 3,800 tonnes per day.

1.3.2 The tailings outfall must never be positioned more than 7.5 m above the lake bottom (i.e., the top of the natural lake bottom or deposited tailings, whichever is higher) unless approved by the director.

1.3.3 The discharge is authorized from Authorized Works, which are Brucejack Lake, tailings discharge lines to Brucejack Lake, and thickening processes and related appurtenances approximately located as shown on Site Plan B.

1.4 Water Treatment Plant Sludge

This section applies to co-deposition of the WTP Sludge with tailings via the tailings discharge lines to Brucejack Lake. The site reference number for this discharge is E302910.

1.4.1 The maximum rate of sludge deposition is indeterminate.

1.4.2 The mixing ratio of WTP Sludge to tailings must not exceed 2% sludge by dry weight.

1.4.3 The discharge is authorized from Authorized Works, which are Brucejack Lake, tailings discharge lines to Brucejack Lake, tailings thickening processes and related appurtenances approximately located as shown on Site Plan B.

1.5 Treated Domestic Wastewater

This section applies to the discharge of Treated Domestic Wastewater from the mine operations and camp infrastructure to Brucejack Lake. The site reference number for this discharge is E302911.

1.5.1 The maximum authorized rate of discharge is 175 m^3/day, 365 days/year.

1.5.2 The characteristics of the treated effluent must not exceed:

45 mg/L for Total Suspended Solids, and
45 mg/L for 5 day Biological Oxygen Demand.

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1.5.3 The discharge is authorized from Authorized Works, which are Brucejack Lake and three Filterboxx C75 treatment units, or an equivalent unit(s) approved by the director, and related appurtenances including a deep lake outfall.

1.5.4 The location of the Domestic Wastewater Treatment plant and the deep lake outfall discharge line are as shown on Site Plans A and B.

2. GENERAL CONDITIONS

2.1 Maintenance of Works and Emergency Procedures

The permittee must regularly inspect the Authorized Works and maintain them in good working order. If components of the Authorized Works have a manufacturer's recommended schedule, then those components must, at a minimum, be maintained in accordance with that schedule.

The permittee must maintain a record of inspections and maintenance of the Authorized Works, and make the record available to an officer upon request.

In the event of an emergency or other condition which prevents normal operation of the Authorized Works or leads to an unauthorized discharge, the permittee must take remedial action immediately to restore the normal operation of the Authorized Works and to prevent any unauthorized discharges. The permittee must immediately report the emergency or other condition and the remedial action that has and will be taken to the EnvironmentalCompliance@gov.bc.ca email address or as otherwise instructed by the director.

The director may require the permittee to reduce or suspend operations until the Authorized Works have been restored, and/or corrective steps have been taken to prevent unauthorized discharges.

2.2 Construction of Water Management and Pollution Control Works

The permittee must ensure the plans and specifications for the various phases of the WTP, the Domestic Wastewater Treatment Plant and other associated works authorized under Sections 1.2. 1.3, 1.4, and 1.5 are certified by a Qualified Professional and retained on site for inspection prior to the commencing any of the discharges from either sources. The permittee must cause the Qualified Professional to certify that the works have been constructed in accordance with such plans and specifications before discharge commences under this authorization, and a maximum of 45 days following completion of construction.

2.3 Controlled Bypasses

The permittee must not allow any discharge authorized by this authorization to bypass the Authorized Works, except with the prior written approval of the director.

2.4 Temporary Shutdown

In the event of a temporary shutdown in construction and mining activities at the site, the permittee must notify the director in writing and must ensure all permit conditions continue to be met.

2.5 Glossary

Capitalized terms referred to in this Authorization are defined in the attached Glossary. Other terms used in this Authorization have the same meaning as those defined in the Environmental Management Act and applicable regulations.

2.6 Licence to Publish Documents

Licence to Publish Documents a) Subject to paragraph b, the permittee authorizes the Province to publish on the Ministry of Environment and Climate Change Strategy website the entirety of any Regulatory Document. b) The Province will not publish any information that could not, if it were subject to a request under section 5 of the Freedom of Information and Protection of Privacy Act, be disclosed under that Act.

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3. OPERATIONAL REQUIREMENTS

3.1 Turbidity Curtains

Waste Rock and Tailings disposal must not proceed unless a minimum of three turbidity curtains are in place across the lake outlet approximately as shown on Site Plan B.

3.2 Source Control of Nitrite and Nitrogen

The permittee must maintain an up to date version of the Nitrogen Management Plan (NMP) on site for inspection by Environmental Protection staff.

The permittee must implement the most current version of the NMP. The NMP describes source control measures, monitoring, auditing and reporting activities that are undertaken to ensure nitrogen sources are controlled and minimized, and that the discharge standards in Section 1.1 are met.

The permittee must maintain records of the activities described in the NMP available for inspection at the request of Environmental Protection staff.

3.3 Closure Underground Water Quality Adaptive Management Plan

The permittee must develop a post closure management plan with the intent of limiting all impacts within Brucejack Creek to levels acceptable to the director.

The Plan must assess all available management options including but not limited to: directing mine pool water on closure to the CWP to allow for attenuation there, continuing to use the WTP and/or discharging the water where it would have minimal impact. In addition, the plan must include appropriate monitoring, water quality triggers, and management actions to maintain water quality throughout closure and post closure.

The Plan must include all available and updated hydrology, hydrogeology and geochemistry results and propose further work necessary to better define closure and post closure Water Quantity and Quality predictions.

An initial Plan submission is due by July 31, 2020. Subsequent updates with respect to ongoing findings and management options are required every five (5) years or as requested by the director. The final report must be submitted 2 years prior to closure for the approval of the director.

3.4 **Chromium Management Plan**

The permittee must maintain an up to date Chromium Management Plan (CMP) on site for inspection by Environmental Protection staff.

The permittee must implement the most current version of the CMP to manage, monitor and mitigate the release of hexavalent chromium from cement in the underground workings, and ensure that the BC Water Quality guidelines for Cr(III) and Cr(VI) are not exceeded at Brucejack Lake outlet (BJ 3.10).

The permittee shall implement the monitoring program and mitigations described in the most current version of the CMP if either of the following occurs:

1) dissolved Chromium levels prior to treatment in the WTP exceed the trigger level of 10 µg/L,

2) dissolved Chromium levels at BJ 3.10 exceed 1 µg/L.

3.5 **Outfall Inspection**

The permittee must cause the outfall(s) and discharge lines to be inspected once every year by a Qualified Professional or certified tradesperson to ensure they and all associated piping are in good working condition, there are no leaks, no major bends which would erode due to the flow of the tailings slurry, and the height of tailings discharge is in compliance with Section 1.1.3 of this permit. Inspections may include a combination of the following: bathymetric surveys, camera inspections, visual inspections, digital sonar surveys, etc. The permittee must submit an inspection report as part of each annual report unless concerns are noted. In the latter instances, the permittee must submit an inspection report accompanied by a mitigation plan to the director with 45 days after the inspection date.

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3.6 Water Treatment Plant Sludge

The permittee must implement the WTP sludge monitoring and management program outlined in the most current version of the Metal Leaching and Acid Rock Drainage (ML/ARD) Management Plan. Co-subaqueous deposition of WTP Sludge in Brucejack Lake with tailings is permitted as described in Condition 1.4. On-site sub-aerial storage of the WTP Sludge must not exceed twelve (12) months, unless approved by the director.

Disposal of the WTP Sludge does not require approval if it is disposed off-site at a licensed facility.

3.7 Reagents

The permittee must maintain records of reagents types, volumes and usage rates for various water treatment and ore concentration process.

When commissioning any specific process and or adding/changing reagent(s) the permittee must compile and submit documentation to the director 15 days prior to their usage.

3.8 Diesel Power Station (DPS) Oil/Water Separator

The permittee must develop and implement a preventative maintenance, monitoring and inspection program for the DPS separator system and DPS pond by January 31, 2019.

The permittee must maintain records of inspections, cleanouts, accidental discharges, and a site plan, available for inspection at the request of Environmental Protection staff.

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4. MONITORING REQUIREMENTS

Locations of all monitoring sites are depicted in Site Plans C and D. Appendices A and B specify the monitoring periods and frequencies, and monitoring parameters for the surface water and groundwater monitoring sites.

The groundwater monitoring frequencies will be as per Appendix B unless the permittee documents specific safety conditions present at a given well, or other condition such as lack of recovery, frozen or dry wells, that justify missing a specific sampling event. The director may approve revisions to the Groundwater Monitoring Program subject to the permittee submitting a review and recommendations by a Qualified Professional.

4.1 Benthic Invertebrates

The permittee must implement the benthic invertebrate program as specified in Appendix A using personnel or Qualified Professionals trained in the Environment Canada CABIN protocol.

The benthic invertebrate monitoring frequencies at BJ 2.62 and BJ 1.74 will be annually, as per Appendix A, for 3 years (i.e., 2019, 2020 and 2021) after which time the permittee may request a reduction of the monitoring frequency to once every 3 years.

4.2 Sediment Sampling

The permittee must implement the sediment program as specified in Appendix A using personnel or Qualified Professionals trained in the procedures.

The Program must analyze biologically relevant fine sediments less the 63 µm in size.

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4.3 Toxicity Sampling Requirements for the Outlet of Brucejack Lake (BJ 3.10)

As per Section 1.1, the discharge at the outlet of Brucejack Lake must not be acutely toxic to aquatic organisms or inhibit algal growth. The required test methods are:

1) Acute/ Lethal Toxicity - 48 hr Daphnia magna single concentration toxicity test (EPS 1/RM/14 2nd edition, December 2000), and
2) Growth Inhibition Test Using a Freshwater Alga (EPS 1/RM/25).

A lethal toxicity test failure is defined as undiluted effluent that results in >50% mortality of Daphnia magna in 48 hours.

A Growth Inhibition test failure is defined as whenever the growth inhibition in 100% lake outlet effluent is determined to be greater than 25%.

In the event of failures, the Ministry must be notified (as per section 5.3 "Non-compliance Notification) and the specific test must be immediately repeated. For Acute Toxicity, the follow-up test must use multiple concentrations to determine the 48 hr LC50 for Daphnia magna.

Test results must be validated and results must be reported as described in approved Environment Canada biological test methods as referred to above.

4.4 Long Term Trend Analysis Toxicity Sampling

A test for survival and growth using larvae of freshwater midges (*Chironomus dilutus*) (water only) (test method EPS1/RM/32) must be conducted on 100% lake outlet effluent. Results must be included in the Annual Report. Trends in survival and growth must be plotted, including all available data from previous tests. The summary must include a description of the results in the context of ecological effects in the receiving environment.

4.5 Aquatic Effects Monitoring Program (AEMP)

The permittee must implement the most current version of the AEMP, approved by the director.

The permittee must submit results of the AEMP, prepared by a Qualified Professional, to the director by March 31st of the year after the studies are conducted in accordance with Section 5.5. Based on the results of this monitoring program, the monitoring requirements may be extended or altered by the director.

Changes to the AEMP must be approved by the director in writing regardless of any language in the approved program indicating otherwise. Recommendations for changes to the monitoring program must be prepared by a Qualified Professional and submitted to the director.

4.6 Sampling and Analytical Procedures

The permittee must carry out sampling in accordance with the procedures described in the "British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment, and Biological Samples (2013 Edition)" or most recent edition, or by alternative procedures as authorized by the director.

A copy of the above manual is available on the Ministry web page at: https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-field-sampling-manual

The permittee must carry out analyses in accordance with procedures described in the "British Columbia Environmental Laboratory Manual (2015 Permittee Edition)", or the most recent edition, or by alternative procedures as authorized by the director.

A copy of the above manual is available on the Ministry web page at: https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/laboratory-standards-quality-assurance/bc-environmental-laboratory-manual

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4.7 Quality Assurance Quality Control (QA/QC)

The permittee must obtain from the analytical laboratory(ies) their precision, accuracy and blank data for each sample set submitted by the permittee and an evaluation of the data acceptability, based on criteria set by such laboratory.

The permittee must submit samples to analytical laboratory(ies) that meet the definition of a qualified laboratory under the Environmental Data Quality Assurance Regulation.

4.8 Exceedance of Guidelines at BJ 3.10

In the event that water quality parameters measured at BJ 3.10 exceed their respective "British Columbia Water Quality Guidelines" or discharge standards in Section 1.1, the director may require the following:

a) Additional sampling and monitoring;
b) Risk assessment that incorporates the loadings and concentrations considering biological sensitivity of the area;
c) Submission of an **Environmental Management Plan** in accordance with the following section for each parameter of concern; and
d) Submission of any other information the director considers necessary to assess environmental impact or to protect the environment.

An **Environmental Management Plan** must be to the satisfaction of the director and include but not be limited to:

a) Remedial and mitigation measures for the parameters(s) of concern;
b) An attainment schedule, whereby the permittee must specify actions and interim targets with associated timelines for reducing the amount of contaminants discharged into the environment, with the goal of attainment of water quality guidelines or other criteria as specified by the director;
c) Revised modelling predictions for the parameter of concern based on monitoring data and refinements to source term information; and,
d) Periodic review of the activities to date, and the implementation of future strategies as required by the director. The review will include but not be limited to performance and progress report on control and reduction programs and also provide an opportunity for adjustments to the monitoring program in light of new scientific knowledge and other related technical advances.

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5. REPORTING REQUIREMENTS

5.1 Spill Reporting

The permittee must immediately report all spills to the environment (as defined in the Spill Reporting Regulation) in accordance with the Spill Reporting Regulation. Notification must be via the Provincial Emergency Program at 1-800-663-3456.

5.2 Reporting of Monitoring Results

The permittee must submit field and laboratory monitoring results, including a summary of non-compliances and corrective actions taken, by email to the Ministry via the Routine Environmental Reporting Submission Mailbox (RERSM) at EnvironmentalReporting@gov.bc.ca within 30 days of the end of the month in which the monitoring occurred. The permittee must submit such data and information in a form that is tabulated, graphically represented and interpreted to the satisfaction of the director.

For guidelines on how to properly name the files and email subject lines or for more information visit the Ministry website:

https://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/data-and-report-submissions/routine-environmental-reporting-submission-mailbox

5.3 Non-Compliance Notification

The permittee must immediately notify the director or designate by email at EnvironmentalCompliance@gov.bc.ca, or as otherwise instructed by the director of any non-compliance with the requirements of this authorization by the permittee and take remedial action to remedy any effects of such non-compliance.

The permittee must provide the director with written confirmation of all such non-compliance events, including available test results within 24 hours of the original notification unless otherwise instructed by the director.

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Non-compliance notification must also be provided to the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

Exceedances of the WTP discharge characteristics specified in Section 1.2.3 are not non-compliance events. A non-compliance event would be not complying with requirements in Section 1.2.4, which are triggered in the event of discharge characteristics in Section 1.2.3 being exceeded.

5.4 Non-Compliance Reporting

If the permittee fails to comply with any of the requirements of this authorization, the permittee must, within 30 days of such non-compliance, submit to the director a written report that is satisfactory to the director and includes, but is not necessarily limited to, the following:

a) All relevant test results obtained by the permittee related to the non-compliance,
b) An explanation of the most probable cause(s) of the non-compliance, and
c) A description of remedial action planned and/or taken by the permittee to prevent similar non-compliance(s) in the future.

The permittee must submit all non-compliance reporting required to be submitted under this section by email to the Ministry's Compliance Reporting Submission Mailbox (CRSM) at EnvironmentalCompliance@gov.bc.ca or as otherwise instructed by the director. For guidelines on how to report a non-compliance or for more information visit the Ministry website:

http://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/data-and-report-submissions/non-compliance-reporting-mailbox

Non-compliance follow up reports must also be provided to the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

5.5 Annual Reporting

The permittee must submit to the director a comprehensive Annual Report by March 31st of each year, in a report format that follows directions of the "Technical Guidance 4 – Annual Reporting under the *Environmental Management Act* (2016)", or the most recent edition. The Annual Report must be submitted to the Ministry via the Routine Environmental Reporting Submission Mailbox (see Section 5.2). Copies of the annual report must also be made available to the Ministry of Energy, Mines, and Petroleum Resources.

The Annual Report must include but not be limited to:

1. an evaluation of the impacts of the discharge on the receiving environment, adequacy of monitoring and recommendations;
2. spills and other environmental incidents;
3. a comparison of monitoring data, including acute and chronic toxicity results, with Permit standards, BC Water Quality guidelines, and water quality modelling predictions;
4. results of long term toxicity sampling including plots of all data, trends in survival and growth, and a description of the results in the context of ecological effects in the receiving environment;
5. an interpretation (including graphs) of upward trending parameters monitored and/or predicted to potentially exceed BC Water Quality guidelines, or Permit standards;
6. results of water treatment operation and removal efficiency for all contaminants of potential concern;
7. a summary of all non-compliances submitted in an Annual Status Form, mitigation and continuous improvement efforts employed by the mine;
8. a summary of all surface water and groundwater quality, and hydrometric and groundwater levels for the previous year, including tables and graphs where appropriate to indicate trends in key water quality parameters, and including an assessment of relevant quality assurance data;
9. flow measurements and discharge rates data for all authorized discharges, estimates of the amount and type of chemical additions (flocculants and chemicals used in the WTP and mill for ore processing and tailings thickening process);

10. results and interpretations of receiving environment aquatic effects program monitoring, including: results and interpretations of acute and chronic toxicity testing, sediment and biological monitoring; analyses of key water quality trends; environmental effects; and assessment of the protectiveness of the discharge limits;
11. results of any additional hydrogeological investigation and assessment work and updates to the groundwater model for the site;
12. results and analyses of ongoing review of the site water quality predictions and source terms, water balance and water management at the site; and
13. results of ongoing ML/ARD chemistry studies.

The annual report must also be provided to the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), the Nisga'a Nation, through Nisga'a Lisims Government and the Alaska Department of Natural Resources.

5.6 Mine Data and Water Quality Modelling Review

Every five years during the operating life of the mine, or as required by the director in the event of significant changes with respect to monitoring results, production rates and or other factors, the permittee must conduct a review of the environmental monitoring required under this permit and reassess the predictive modelling with respect to the environmental impacts.

The permittee must ensure that the review be conducted by independent, third party Qualified Professionals. The permittee must cause the Qualified Professional to consider all the available data and any other information available to the permittee or Ministry of Environment staff. Each review will recommend what actions or permit amendments, if any, are advisable to limit impacts from the current or future activities at the mine site on the receiving environment and to ensure compliance with permit requirements.

The director shall consider these recommendations and may make amendments to the permit and/or the environmental monitoring plan that the director considers necessary for the protection of the environment.

A report summarizing the results of a five-year review must be submitted to the director and the Tsetsaut/Skii Km Lax Ha First Nation, the Tahltan Nation (as represented by the Tahltan Central Government), and the Nisga'a Nation,

through Nisga'a Lisims Government by July 31st of the year in which the review is required. The first five-year review report is due on July 31, 2020.

5.7 Electronic Submission of Data into EMS

The permittee must cause a private laboratory or certified third party to electronically submit all the water quality data collected under this permit into the Environmental Management System (EMS) database on their behalf. For instructions on the electronic submission process or for more information visit the Ministry website:

https://www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/monitoring/environmental-monitoring-system

6. GLOSSARY

Capitalized terms referred to in this authorization are defined in the attached Glossary. Other terms used in this authorization have the same meaning as those defined in the *Environmental Management Act* and applicable regulations.

6.1 "Authorized Works"

"Authorized Works" means Brucejack Lake, low level weir, contact water pond, emergency spillway, contact water pond direct discharge line and outfall, tailings discharge line and outfall, water treatment plant, domestic wastewater treatment plant, water treatment plant and domestic wastewater treatment plant effluent discharge line and outfall, collection works, ditches, pipelines, sumps, pumps, flow monitoring, water sampling, and related appurtenances at stated in Sections 1.1.3, 1.2.5, 1.2.6, 1.3.3, 1.4.3, and 1.5.3.

6.2 "Province"

"Province" means Her Majesty the Queen in right of British Columbia.

6.3 **"Regulatory Document"**

"Regulatory Document" means any document that the permittee is required to provide to the Director or the Province pursuant to:
(i) this Authorization;

(ii) any regulation made under the *Environmental Management Act* that regulates the facility described in this Authorization or the discharge of waste from that facility; or

(iii) any order issued under the *Environmental Management Act* directed against the permittee that is related to the facility described in this Authorization or the discharge of waste from that facility.

6.4 **"Qualified Professional"**

"Qualified Professional" means an applied scientist or technologist specializing in an applied science or technology applicable to the duty or function, including, if applicable and without limiting this, agrology, biology, chemistry, engineering, geology or hydrogeology and who:

(i) is registered with the appropriate professional organization, is acting under that organization's code of ethics and is subject to disciplinary action by that organization, and

(ii) through suitable education, experience, accreditation and/or knowledge, may be reasonably relied on to provide advice within their area of expertise.

All documents submitted to the Director by a Qualified Professional must be signed by the author(s).

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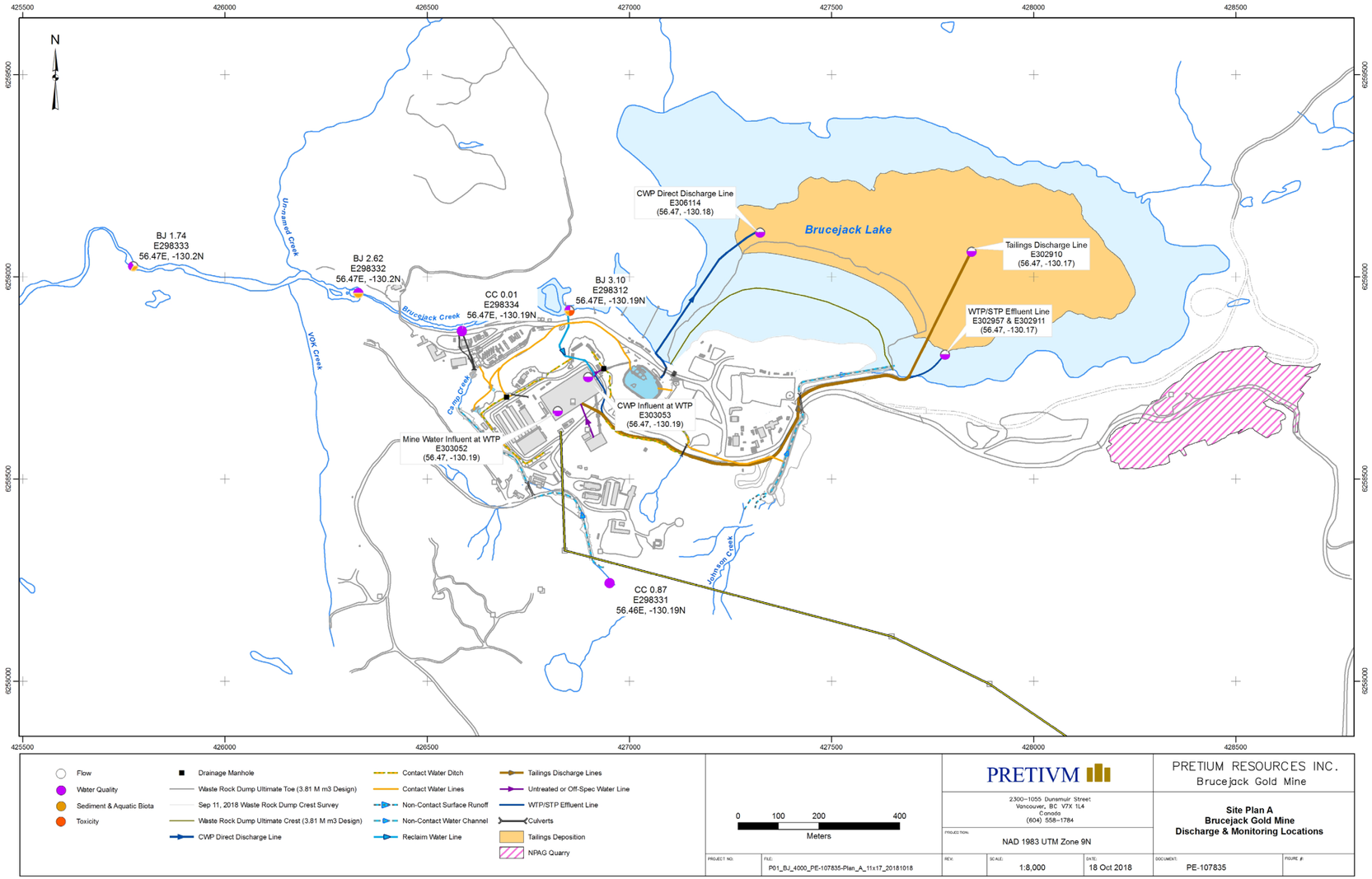
for Director, *Environmental Management Act*
Mining Authorizations



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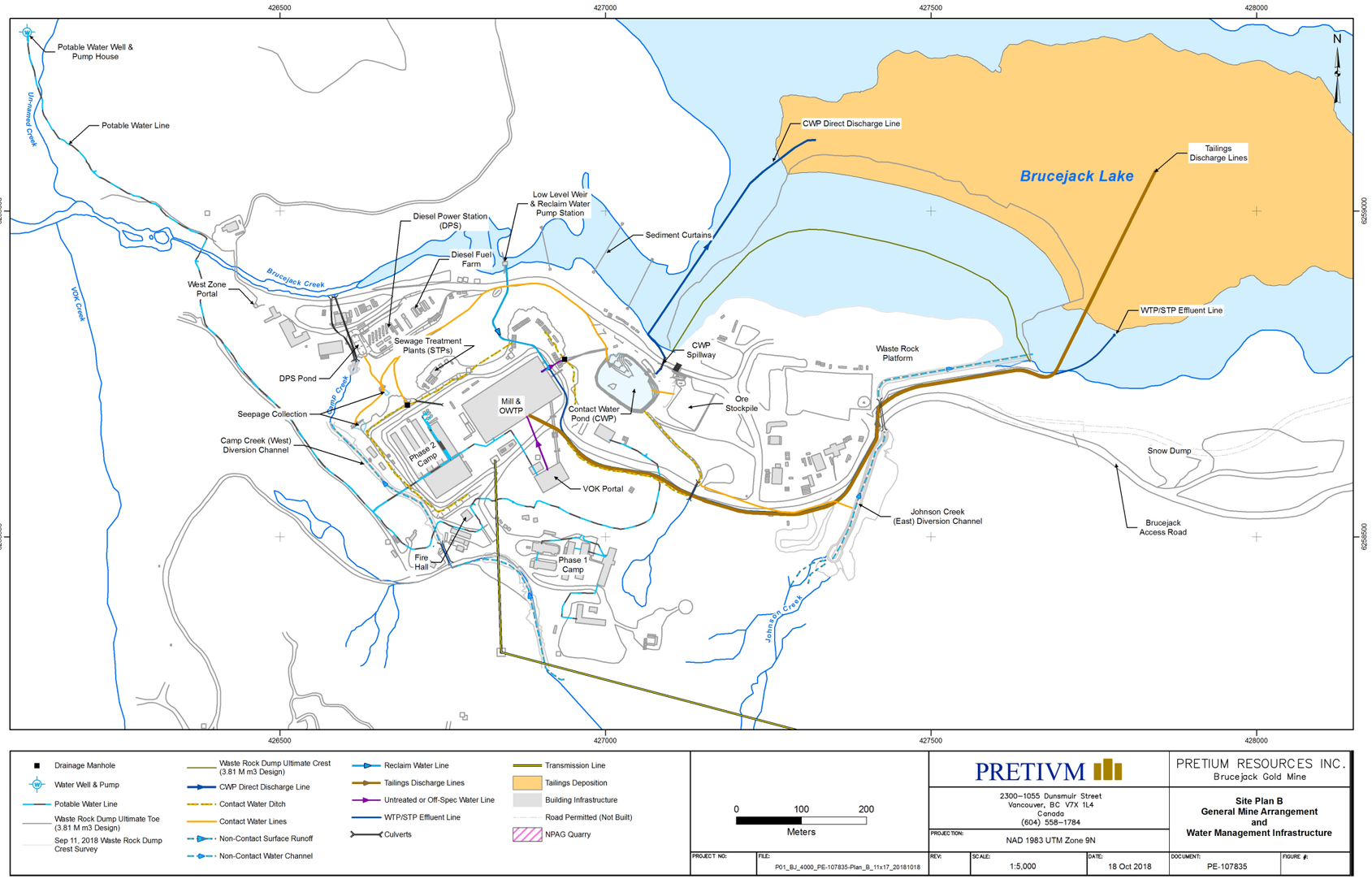

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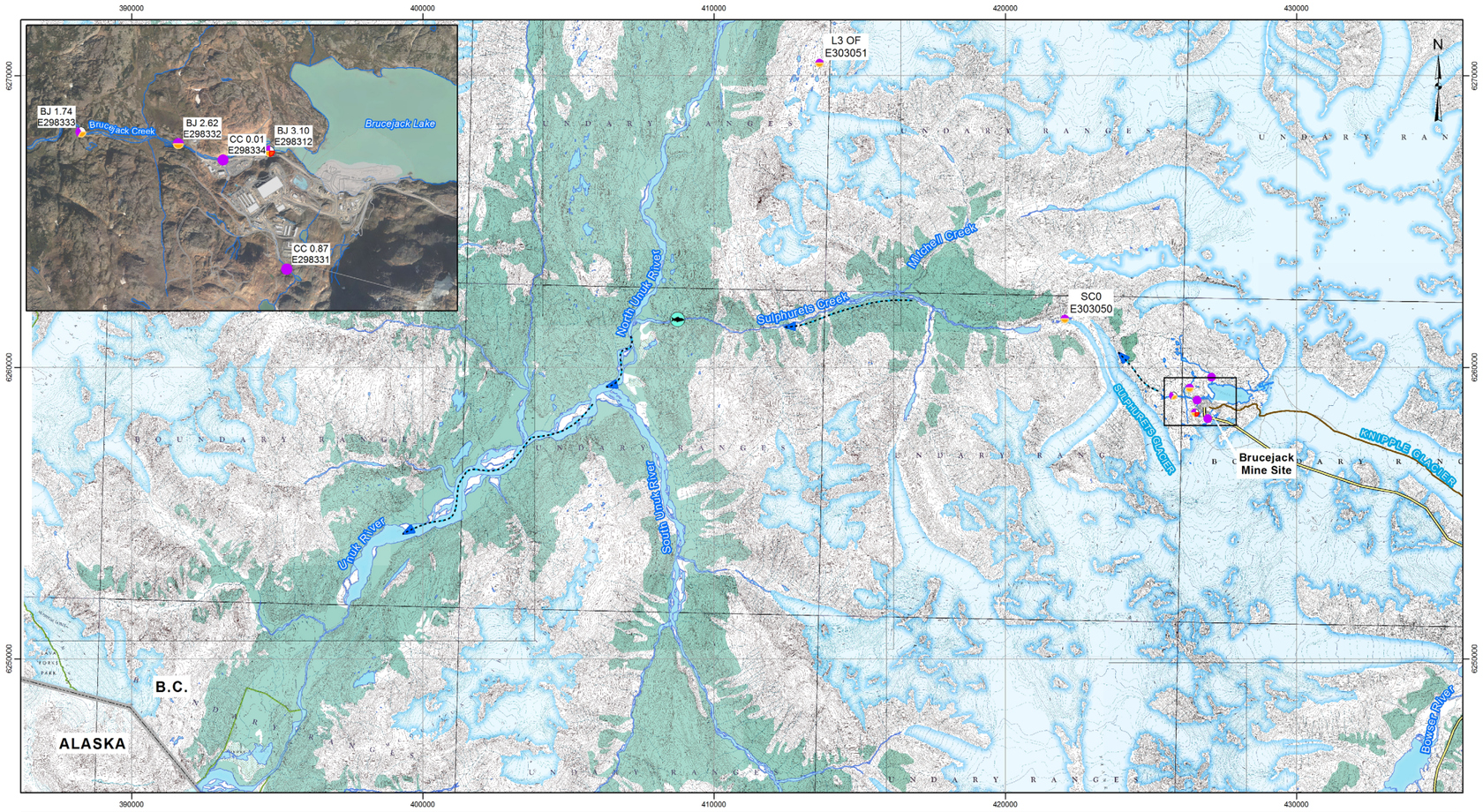

Flow
Water Quality
Sediment & Aquatic Biota
Toxicity
Fish Barrier
Transmission Line
Access Road
Building Infrastructure

0 1 2 4 6
Kilometers

PRETIVM

2300–1055 Dunsmuir Street
Vancouver, BC V7X 1L4
Canada
(604) 558–1784

PRETIUM RESOURCES INC.
Brucejack Gold Mine

Site Plan C
Surface Water Monitoring Sites

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_BJ_4000_PE-107835-Plan_C_11x17_20181018		1:120,000	18 Oct 2018	PE-107835	

PROJECTION: NAD 1983 UTM Zone 9N

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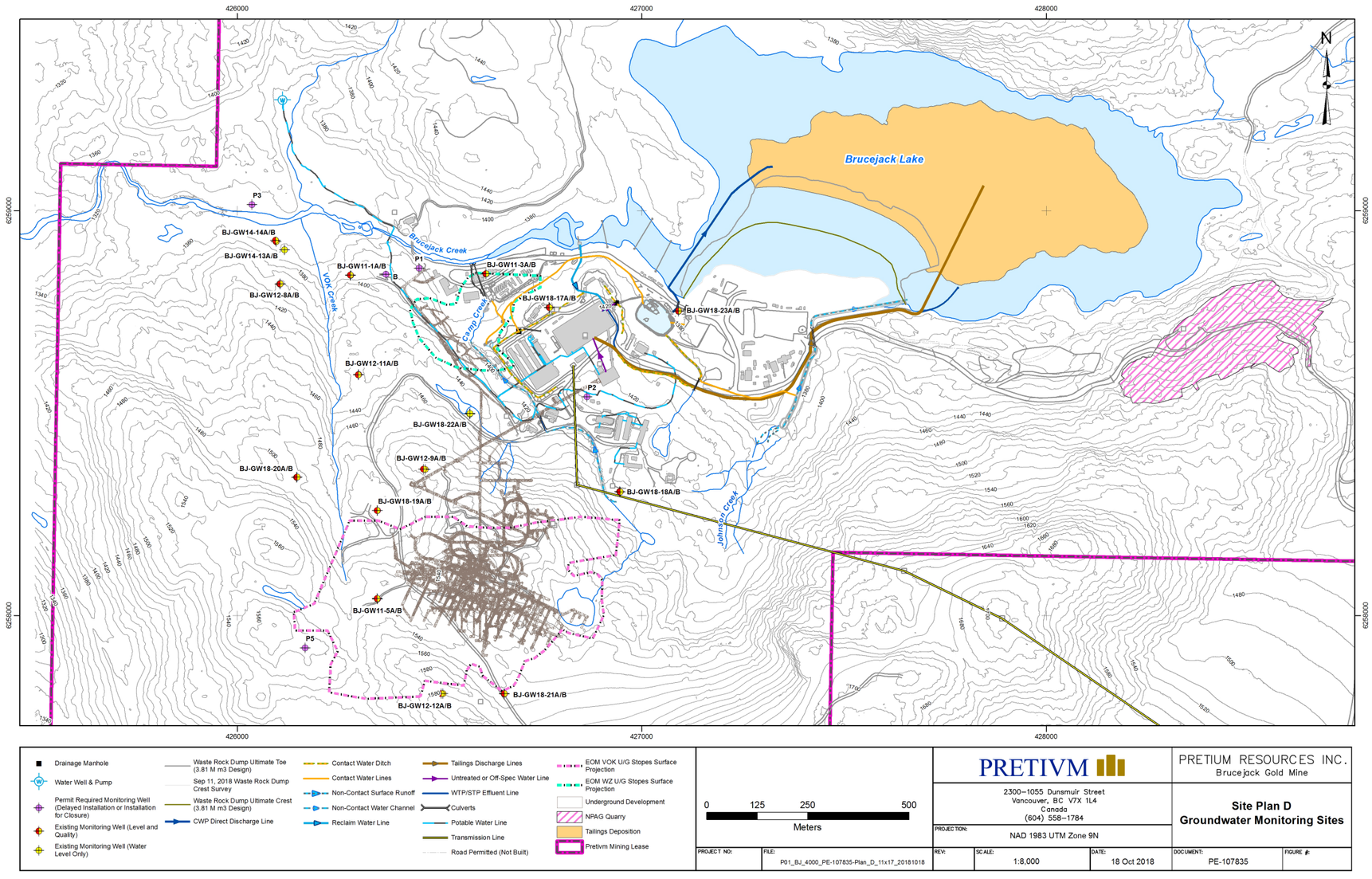

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Appendix A – Surface Water Quality Monitoring Requirements

Sample Site Name	Location	EMS ID	Field Turbidity[20] pH	Metals & General[1]	Flow Rate / Staff Gauge	5 in 30 days	Toxicity[21]	Sediment[15]	Periphyton[17]	Benthic Invertebrates[19]
BJ 3.10	Weir at Brucejack Lake Outlet	E298312	-	W[2]	C Q[8]	-	Q	A[16]	A[16]	A[16]
CC 0.87	Camp Crk US mine site	E298331	-	M	-	-	-	-	-	-
CC0.01	Camp Crk DS mine site at mouth	E298334	-	M	-	-	-	-	-	-
BJ 2.62	Brucejack Crk just US of VOK Crk	E298332	-	M[2]	-	-	-	A[16]	A[16]	A[16]
BJ 1.74	Brucejack Crk approx. 1.4km DS of lake outlet	E298333	-	M[3] Q	4/S[9]	-	-	3A[16]	A[16, 18]	A[16]
SC0	Sulphurets Crk approx. 8 km DS Mine Site, see Site Plan C	E303050	-	sQ	-	3A[14]	-	3A[16]	3A[16, 18]	3A[16]
L3 outflow	Reference Site approx. 20 Km to the NW, see Site Plan C	E303051	-	sQ	-	3A[14]	-	3A[16]	3A[16]	3A[16]
Mine water Influent at WTP	In plant prior to treatment	E303052	C	2/M	C	-	-	-	-	-
CWP influent at WTP	In plant prior to treatment	E303053	C	2/M[4]	C	-	-	-	-	-
WTP Effluent	After treatment prior to lake discharge	E302957	C	2/M	C	-	-	-	-	-
Tailings Supernatant	After thickening prior to outfall	E302910	-	M	D[10]	-	-	-	-	-
Treated Domestic Effluent	After treatment prior to outfall	E302911	-	Q[5]	D[10]	-	-	-	-	-
CWP direct discharge to lake	In Contact Water Pond or direct discharge line	E306114	2/D[6]	E[7]	D[11] 2/D[12] 2/W[13]	-	-	-	-	-

Notes: 3A = Once every 3 years, A = Annually, Q = Quarterly, M = Monthly, 2/M = two times per month, W = Weekly, 2/W = two times per week, D = Daily, C = Continuous monitoring, 2/D = two times per day, E = once per event, 4/S = four times per summer, sQ = Quarterly refers to shifting the Quarterly monitoring as follows: sQtr 1- Feb, Mar, & April, sQtr 2 - May, June & July, sQtr 3 - Aug, Sept & Oct, sQtr 4 - Nov, Dec & Jan

1. See details on Metals & General parameters on page 23
2. See additions specified under General parameters
3. May through October (sQ 2 & 3)
4. When discharging to the WTP
5. BOD and TSS only
6. Field turbidity only
7. Once for each direct discharge event
8. Continuous flow with manual checks quarterly
9. Manually at low flow and no recent precipitation
10. Cumulative flow per day
11. Daily volume of any diverted mine water
12. Direct discharge volume and 2 times daily staff gauge levels
13. May through October (sQ 2&3) 2 times weekly staff gauge levels
14. Freshet and Fall
15. Total Metals[1] and Total Organic Carbon
16. Fall low flow
17. Chlorophyll-a, Abundance and Taxonomy
18. Chlorophyll-a only
19. Abundance and Taxonomy
20. Field turbidity as NTU or "as mg/L TSS"
21. Per section 4.3 and 4.4

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Appendix B – Groundwater Monitoring Requirements

Well ID on Site Plan D	EMS ID	Easting (m)	Northing (m)	Depth (m)	Water Level	Metals & General*
BJ-GW11-1A	E303054	426281	6258840	103	C	sQ
BJ-GW11-1B	E314692	426280	6258841	39	C	sQ
BJ-GW11-3A	E303056	426615	6258844	94	C	sQ
BJ-GW11-3B	E314693	426615	6258844	9	C	sQ
BJ-GW11-5A	E303058	426347	6258040	103	C	sQ
BJ-GW11-5B	E314694	426346	6258042	51	C	sQ
BJ-GW12-8A	E303059	426106	6258819	92	C	sQ
BJ-GW12-8B	E314695	426106	6258819	51	C	sQ
BJ-GW12-9A	E303060	426465	6258361	80	C	sQ
BJ-GW12-9B	E314696	426461	6258362	50	C	sQ
BJ-GW12-11A	E303062	426300	6258595	30	C	sQ
BJ-GW12-11B	E314697	426299	6258595	54	C	sQ
BJ-GW12-12A	E303063	426509	6257807	100	C	sQ
BJ-GW12-12B	E314698	426505	6257807	53	C	sQ
BJ-GW14-13A	E303064	426118	6258904	101	C	-
BJ-GW14-13B	E314699	426118	6258904	75	C	-
BJ-GW14-14A	E303065	426096	6258924	35	C	sQ
BJ-GW14-14B	E314700	426095	6258927	5	C	sQ
BJ-GW18-17A	E303066	426771	6258761	148	C	sQ
BJ-GW18-17B	E314701	426772	6258760	75	C	sQ
BJ-GW18-18A	E303069	426946	6258306	101	C	sQ
BJ-GW18-18B	E314702	426947	6258306	65	C	sQ
BJ-GW18-19A	E303070	426347	6258259	197	C	sQ
BJ-GW18-19B	E314703	426346	6258259	159	C	sQ
BJ-GW18-20A	E303559	426147	6258341	167	C	B
BJ-GW18-20B	E314704	426148	6258342	118	C	B
BJ-GW18-21A	E303071	426661	6257806	205	C	B
BJ-GW18-21B	E314705	426660	6257807	159	C	B
BJ-GW18-22A	E303068	426575	6258498	379	C	-
BJ-GW18-22B	E314706	426576	6258499	87	C	-
BJ-GW18-23A	E314690	427091	6258751	29	C	sQ
BJ-GW18-23B	E314691	427091	6258752	11	C	sQ

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Well ID on Site Plan D	EMS ID	Easting (m)	Northing (m)	Installation Requirements
New well @ B	E303067	426368	6258843	Closure
New well @ P1	E303556	426450	6258858	Closure
New well @ P2	E303557	426865	6258540	Closure
New well @ P3	E303558	426037	6259015	Closure
New well @ P5	E303560	426168	6257920	2020

Notes:
B – Biannual: at Low Flow (Oct-Apr) and at High Flow (May-Sept)
C - Continuous
sQ - Quarterly refers to shifting the Quarterly monitoring as follows:
sQtr 1- Feb, Mar, & April; sQtr 2 - May, June & July;
sQtr 3 - Aug, Sept & Oct; sQtr 4 - Nov, Dec & Jan.
Closure - Submit installation plan 2 years prior to closure
2020 - Install timing to be assessed during 2020 Five Year Mine Plan update

Metals & General* - Appendices A & B

Metals refers to:

1. Low level ICP or equivalent analysis of Total and Dissolved Metals including: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Cadmium, Chromium, Cobalt, Copper, Iron, lead, Lithium, Manganese, Molybdenum, Nickel, Selenium, Silver, Strontium, Thallium, Tin, Uranium, Vanadium and Zinc; and
2. Mercury analysis which are to be included at the Brucejack Lake outlet (BJ 3.10), the WTP effluent, the tailings supernatant; Site BJ 2.62, SCO, BJ 1.74, on a sQuarterly basis. The mercury sampling frequency at Site L3 outflow must be during freshet and fall.

General Parameters are defined as:

1. Laboratory analysis: pH, Specific Conductivity, Hardness, Alkalinity, Sulphate, Chloride, Fluoride, Calcium, Magnesium, Sodium, Ammonia, Nitrate, Nitrite, Total & Ortho Phosphorous, Total Organic Carbon, Total Suspended & Total Dissolved Solids, and Turbidity;
2. Field measurements: Turbidity, pH, Conductivity and Temperature;
3. Dissolved Phosphorous and Dissolved Organic Carbon which are to be included as part of the General Parameters at Sites BJ 3.10 & BJ 2.62 at a frequency of 3x/ ice free period, and 1x mid-winter;
4. General groundwater monitoring does not need to include Total and Dissolved Organic Carbon;
5. Total Extractable Hydrocarbon analysis which is to be included at the CWP prior to direct discharge to Brucejack Lake and prior to treatment at the WTP; at a frequency of once for each event that DPS pond effluent is pumped to the CWP.

Date issued: August 31, 2015
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(most recent)

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for Director, *Environmental Management Act*
Mining Authorizations

Appendix D – Flood Preparedness

PRETIVM		BJ-ENV-SOP-067 AquaDam Deployment	
Owner: Environmental Department	Approver: Torence Sandhals / Jason Gabora	Revision Number:	Creation Date: May 1, 2021 Revision Date:

Objective

This document provides a step-by-step procedure for how to install a 3' x 150' AquaDam to prevent flooding of the West Zone Portal in case of a 1 in 200-year storm event.

Scope

This standard operating procedure (SOP) provides guidance on how to transport, deploy, monitor, deflate and re-roll the AquaDam. Personnel involved in any part of this process should read and understand this SOP.

Health, Safety & Reclamation Code for Mines in British Columbia

- 1.11.1 Training
- 1.8.2 to 1.8.5 Personal Protective Equipment
- 3.3.3 Drowning Hazard

Definitions

- **AquaDam:** a portable dam consisting of an outer tube made of heavy-duty polypropylene geotextile, and two inner tubes which are filled with water on site to cofferdam, contain, or divert the flow of water.
- **Personal Floatation Device (PFD):** a piece of equipment designated to assist the wearer to keep afloat in water. Unlike a lifejacket, the PFD will not keep the wearer's head out of the water.
- **SOP:** standard operating procedure

Roles and Responsibilities

The Mine Manager or Designate is responsible for:

- Ensuring this procedure is implemented and followed.

The Health and Safety Manager or Designate is responsible for:

- Ensuring this procedure complies with H&S regulations.

The Area Manager or Designate is responsible for:

- Ensuring all departments involved with the installation of the AquaDam are aware of this procedure and understand their responsibilities related to this procedure in the event of a 1 in 200-year flood.

The Worker is responsible for:

- Ensuring this procedure is followed.

Preparation

Hazards

- Slips, trips, and falls
- Working near water
- Extreme weather and/or temperatures
- Hidden / submerged hazards

- Floating debris
- Hypothermia
- Contact with contaminated water

Tools

- One 3' x 150' AquaDam
- Water source
- Two 2" or 3" trash pumps, capable of providing a total flow rate of at least 200gpm
- Two 2" or 3" x 20ft suction hoses
- Four 2" or 3" x 100ft discharge hoses
- Duct tape (1-2 rolls)
- AquaDam repair kit
- Utility knives (1 per person)
- Scissors (1 pair)
- Shovels (2)
- Wood boards – Approx. 2" x 6" (20)
- Sandbags (10)
- PFD (1 per person)
- Lifebuoy or throw rope (1)
- Standard PPE (high-vis vest, steel toed boots, CSA approved hard hat)

Requirements

- Understanding of this SOP
- ERT members who have Swift Water Rescue training and a valid First Aid certificate must be on standby in case of an emergency

Job Step

- **AquaDam installation requires 2-4 labourers.**

Preparing for WestZone Portal Closure

1. As soon as the decision is made to deploy the WestZone Portal AquaDam, the Environmental Superintendent or designate shall inform the Mine Captain that access / egress to the mine will be via the VOK Portal only.
2. The Mine Captain or designate will place signage ahead of the WestZone Portal doors underground, informing workers that access is restricted.
3. The Surface Operations Superintendent or designate shall inform Dispatch that flood protection works are commencing on surface near the WestZone Portal, and that traffic to the area should be restricted.
4. Dispatch will broadcast closure of the WestZone Portal on all radio channels, stating that surface traffic to the WestZone is restricted to persons helping implement flood mitigation measures only.

Transporting Equipment to the WestZone

5. Collect the AquaDam and associated installation equipment from the white sea-can near the incinerator.
    - The AquaDam will be stored rolled up like a carpet and can be transported in the back of an empty pick-up truck.
    - If the AquaDam is to be moved with heavy equipment, secure straps around the AquaDam and connect the straps to the heavy equipment for transportation.
    - Be very careful not to drag the AquaDam during transport.

- Pumps and hoses to fill the AquaDam will be stored in the white sea-can near the incinerator.

Laying out the AquaDam

- **This process assumes that the AquaDam will be installed on dry land prior to flood waters reaching the WestZone.**

1. Place the AquaDam at the starting point of the intended installation path such that the open end is at an elevation at least 3ft greater than the lowest point on the installation path.
   - It may be necessary to use sandbags to prop up the end of the AquaDam if the natural berm is not sufficiently elevated.
2. Unwrap the roll, using scissors to remove any shrink wrap and/or rope that may be securing the AquaDam. Be careful not to accidentally cut the AquaDam.
3. Visually survey the intended installation path, remove any obstructions, or sharp objects, and pad any immovable objects.
   - The installation path should avoid low points and cross-slopes if possible, ideally keeping to level high ground.
4. Unroll the AquaDam along the chosen path. (Figures 1 & 2).

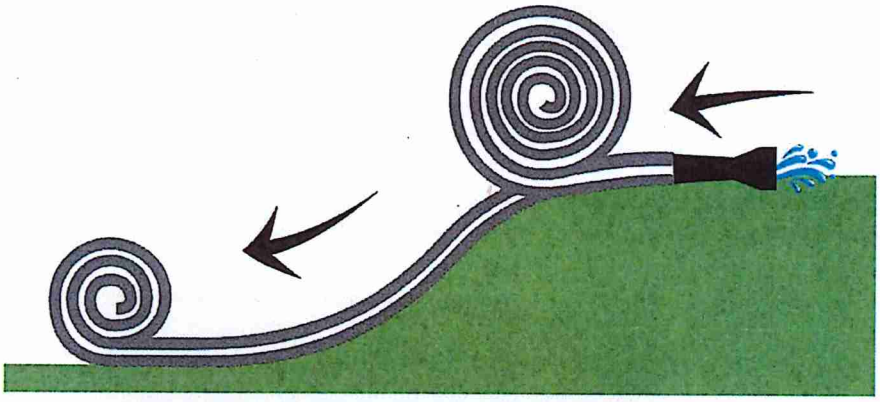


Figure 1: *Place the self-supporting (open) end of the AquaDam at a high point and unroll the AquaDam along the chosen path.*

Figure 2: *Unroll the AquaDam, avoiding low points and cross-slopes, if possible.*

- When turning the AquaDam, ensure there is a wrinkle pulled back from inside the turn to prevent kinking of the tube. (Figure 3)
- Try to create turns that are no more than 45° each. (Figure 4)

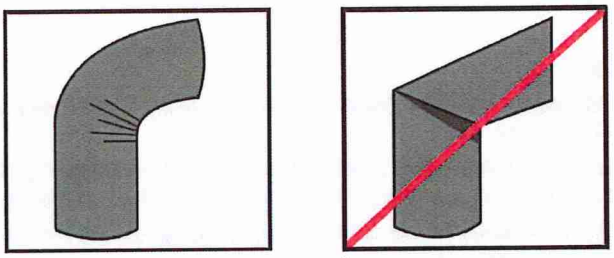


Figure 3: *Pull back a wrinkle when turning corners.*

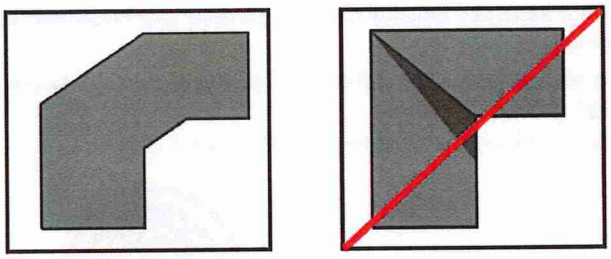


Figure 4: *If you need to turn a sharp corner, make two 45° turns rather than a single 90° turn.*

5. If installation along a cross-slope is unavoidable, install wooden boards, sandbags, or supersacks filled with dirt to brace the AquaDam against the slope. (Figure 5)

Figure 5: *Use wooden boards or sandbags to brace against cross-slopes.*

- **See Appendix A** for the ideal AquaDam installation path to prevent flooding of the WestZone Portal.

Filling the AquaDam

1. Attach the suction and discharge hoses to the pumps. Do not forget to attach a strainer to the suction hose.
2. Insert the discharge hoses 6-8 feet into the inner fill tubes.
   - If the ends of the discharge hoses have any sharp edges, wrap them with duct tape to prevent puncturing the inner tubes.
3. Gather up any loose tubing around the hoses and secure with duct tape, if necessary.
4. Insert the suction hose into a nearby water source and start pumping water into both inner tubes at the same time.

- It is important that the tubes be filled rapidly (minimum 100 gpm into each tube) and at the same rate.

5. While one person controls the pump(s), the other labourers will need to walk alongside the AquaDam as it fills, ensuring any air pockets are pushed out towards the fill tubes. The inner tubes may also need to be adjusted periodically to prevent kinking.
    - **It is important that each labourer carry a utility knife.** The knife can be used to cut the AquaDam and release the water in case of an emergency (such as a person becoming pinned to the ground if the AquaDam rolls).
6. Once the AquaDam is full, stop the pump(s), remove the discharge hoses, and wrap duct tape tightly around the fill tubes to restrict them to a manageable size. Fold the fill tubes back onto each other, and tape together in an upright position. (Figure 6)
    - **Note:** The AquaDam is full once it has reached a height of 3ft at the lowest point along the installation path (Figure 7). DO NOT overfill the AquaDam.
    - The AquaDam will have an inflated width of approximately 7ft.

Figure 6: *Fold the fill tubes back onto each other, and tape them together in an upright position.*

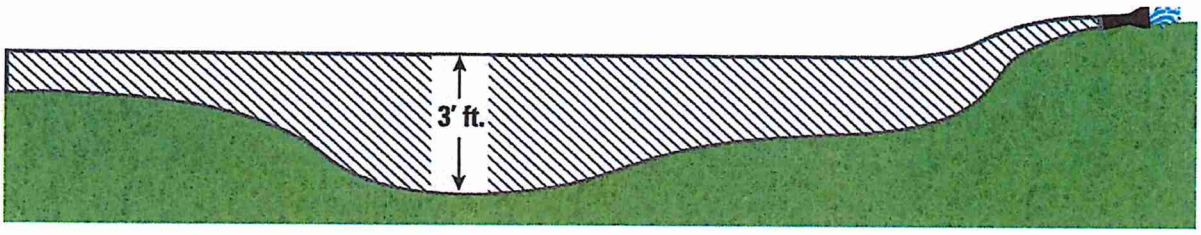


Figure 7: *The AquaDam is full once it has reached a height of 3ft at the lowest point along the path.*

Monitoring and Maintaining the Installed AquaDam

1. The installed AquaDam will need to be monitored regularly for leaks and rolling.
    - If you notice a leak in the AquaDam, patch it with repair tape.
    - If a leak occurs, you may need to add more water.
2. Monitor flood levels and place bracing (wooden boards or sandbags) behind the AquaDam in case of increased water levels. (Figure 8)
    - It is unlikely that this step will be required based on predicted flood levels at the WestZone Portal, but important to be aware of.

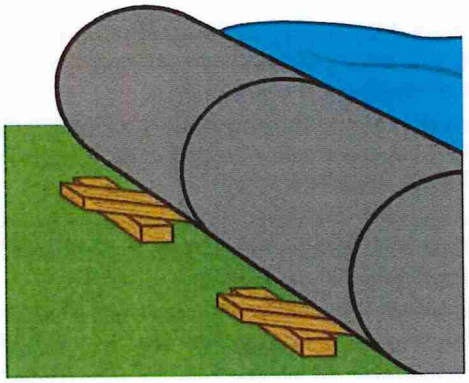
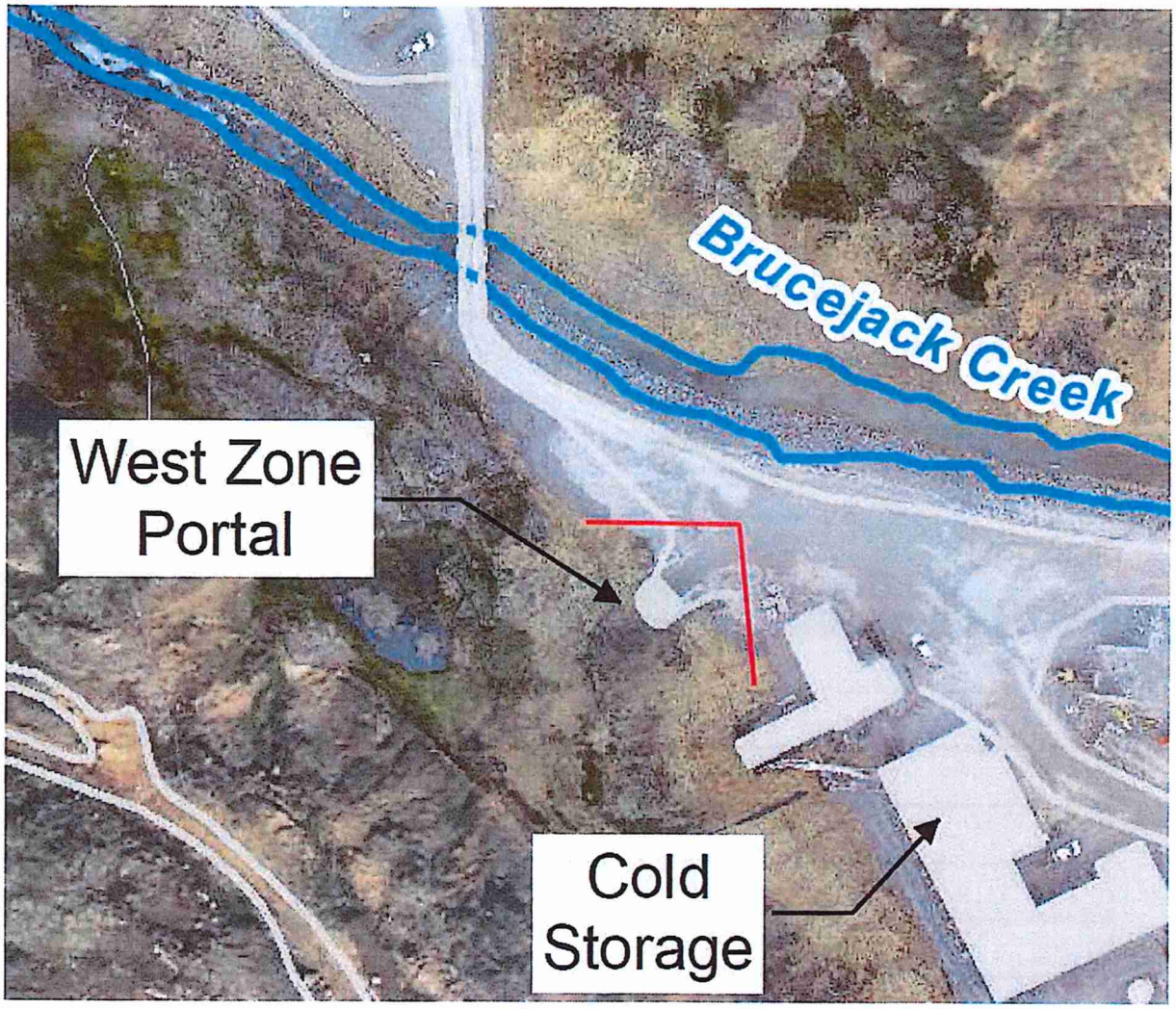


Figure 8: *Wooden boards or sandbags can be used if water levels approach the top of the AquaDam.*

Removing the AquaDam

1. Remove duct tape from the fill hoses and pump water out of the AquaDam.
2. After the AquaDam has been drained, place the wooden beam (which the AquaDam was originally wrapped around) at the closed end of the AquaDam.
3. Re-roll the AquaDam around the beam.
4. Tie off the rolled up AquaDam with rope and return it to storage.

Appendix A



= Approximate AquaDam installation path to prevent flooding of the WestZone Portal

Initial Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Department Manager / Designate	Robin McCall	[redacted]	[redacted]
Health & Safety Manager / Designate	[redacted]	[redacted]	[redacted]
Mine Manager / Designate	Travis Murphy	[redacted]	[redacted]
Surface Operations Supervisor / Designate	Jordan Bailey	[redacted]	[redacted]
JOHSC Co-chair or Member	Wendy Willis	[redacted]	[redacted]

Revisions

CHANGE DESCRIPTION	SIGNATURE	PAGE #	DATE
Initial issue	Brittany Moore	All	May 1, 2021

Annual Review Signature Record

REVIEWER ROLE	NAME	SIGNATURE	DATE

Appendix E – Truck Shop Flow Estimates

MEMORANDUM

To	Ali Farah, Rick Yokome
CC	Robin McCall, Sylvia Van Zalingen, Brett DeHay Turner
From	Xavier Pinto
Date	June 17, 2022
Subject	**Mean Annual Flow Estimates for Pump Sizing at New Heavy Shop**

Purpose

This memorandum provides mean annual flow (MAF) estimates for the drainage area of interest (DAI) where the new heavy shop building will be constructed (Figure 1). The estimates will be used as guidance for sizing of pumps located along drainage ditches surrounding the building. This guidance applies to the hydrology estimates only. Other engineering risks associated with the design of the pumps are outside the scope of this memorandum.

Methods

Synthetic Dataset

The drainage area of interest lacks hydrometric monitoring data; therefore, a synthetic daily discharge dataset was generated using available discharge data from the monitoring station BJ 3.10 located along Brucejack Creek, for the period 2010-2021.

The synthetic dataset for the drainage area of interest was scaled from available BJ 3.10 daily discharge data using the following equation:

$$Daily\ Discharge_{DAI\ (\frac{M3}{s})} = Daily\ DischargeDaily\ Discharge_{BJ\ 3.10} \times \frac{DA_{DAI}\ (km2)}{DA_{BJ\ 3.10}\ (km2)}$$

Where:

DA_{DAI} is the drainage area of interest (0.13 km^2)

$DA_{BJ\ 3.10}$ is the drainage area of Brucejack Creek at BJ 3.10 (6.7 km^2)

Climate Change Considerations

Uncertainties associated with precipitation increases caused by climate change were assessed. To account for possible future variations to the estimated MAF, safety factors were incorporated. These climate change factors were produced with the Design Value Explorer (DVE), a web-based interface from the Pacific Climate Impacts Consortium used to access historical climatic variables across Canada.

The DVE provides estimates for several climate change scenarios and the RCP8.5 scenario, which provides the most severe case, was selected.

Results

Annual statistics for the synthetic record for the drainage area of interest are shown in Figure 2. The estimated MAF (m^3/s) is 0.0084 m^3/s or 31 m^3/hr. To account for the effects of climate change the MAF estimates were adjusted by 9% resulting in a MAF of 0.0092 m^3/s or 33 m^3/hr (Table 1). The latter values are more conservative and are suggested to be used for the pump design.

Table 1. Mean Annual Flow Estimates for the Drainage Area of Interest

Parameter	m^3/s	m^3/hr
MAF Base Case	0.0084	31
MAF with Climate Change Scenario[1]	0.0092	33

[1] Assumes 2°C temperature and 9% precipitation increase, projected to 2059 by the climate scenario RCP8.5

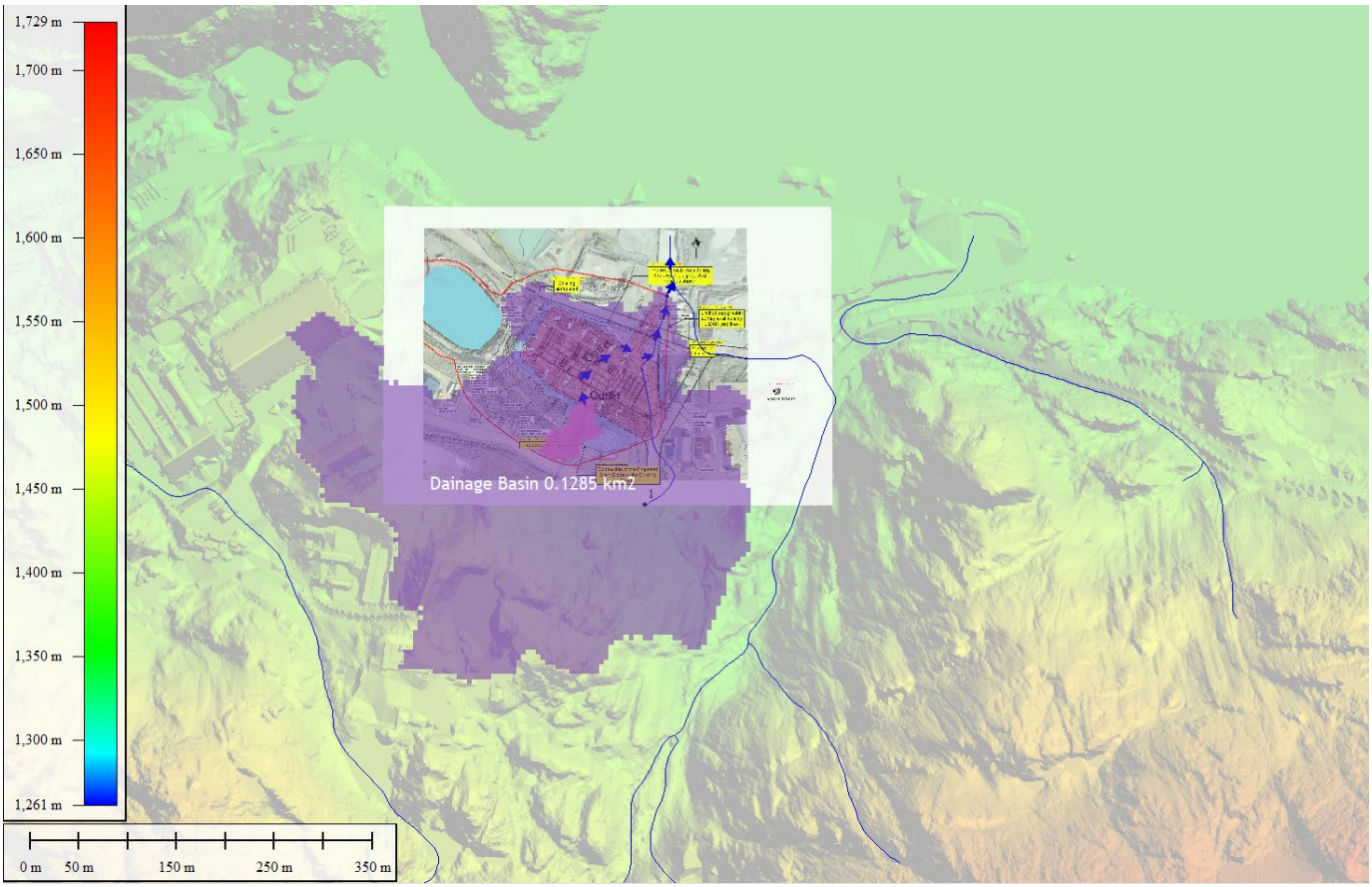


Figure 1. Drainage area of interest for the proposed Heavy Shop building

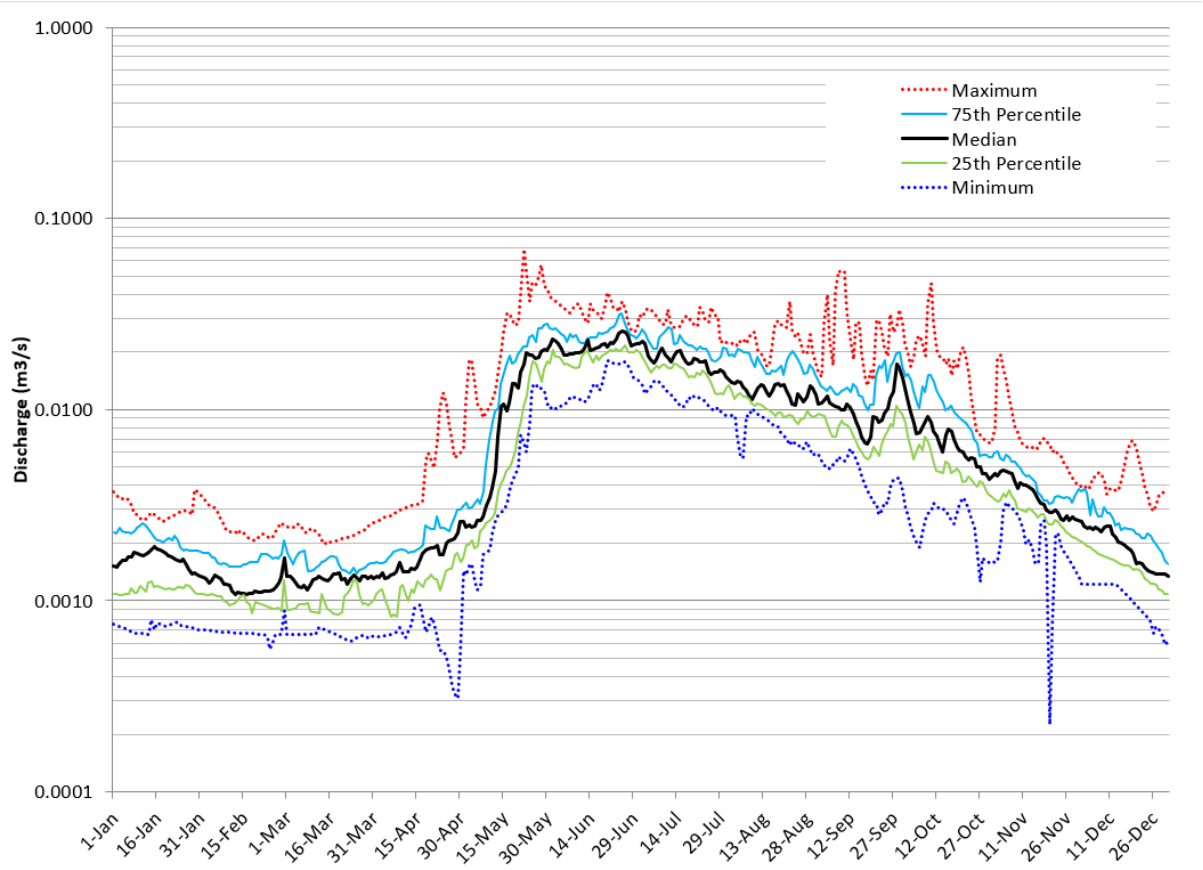


Figure 2. Annual discharge statistics for the drainage area of interest (Period 2010 -2021)

If you have further questions, please do not hesitate to contact me.

Xavier Pinto, M.Sc., P.Geo.

Senior Hydrologist

References

Pacific Climate Impacts Consortium (PCCIC). 2022. Design Value Explorer. https://services.pacificclimate.org/dev/dv-explorer/. Last Accessed: June 17, 2022.

memo

PRETIVM
BRUCEJACK MINE

To: Rick Yokome, Brett De-Hay Turner

From: Xavier Pinto

CC: Recipient names

Date: March 21, 2022

Re: Instantaneous Peakflow Event Estimation for Proposed Heavy Shop Diversion Works

---

Purpose

The purpose of this memo is to summarize the methods and the results for the estimated instantaneous peak flow for the delineated drainage basin around the new proposed heavy shop facility.

Methods

Instantaneous peakflow values for 1-in-100-year and 1-in-200-year return periods were calculated using the rational equation. This method was chosen because it is generally accepted for drainage areas smaller than 1 km^2.

The drainage basin was delineated in Global Mapper (v.23) using a Digital Elevation Model (DEM) generated with the latest LIDAR survey data (2019). The drainage basin was determined at 0.13 km^2 and is shown in Figure 1.

Peakflow Estimation

Instantaneous peakflow rates (m^3/s) for the 1-in-100-year and 1-in-200-year return periods were estimated using rainfall intensity values generated for the area of interest using the IDF-CC Tool v6.0. The tool provides rainfall intensity values for normal case and climate change scenarios. The climate change scenario used was the RCP 8.5 because this is the most severe scenario calculated by the tool and provided the most conservative results. Parameters used in the calculations of the peakflow estimates are provided in Table 1. Peakflow estimates are provided in Table 2.

Table 1 – Parameters used for peakflow estimation

Parameter	Value	Units
Drainage Area	0.13	km^2
Time of Concentration[a]	0.39	hr
Runoff Coefficient[b]	0.95	Dimensionless

[a]-Using Hathaway equation, assuming a roughness factor of 0.3 for rough bare soil; [b]-Value assumed from empirical tables (Coulson 1991) and uses a correction factor of 0.2 to account for a recurrence interval greater than 25 years and snowmelt.

Table 2. Instantaneous peakflow estimates

	Instantaneous Peakflow (m^3/s)	
Return Period	**Base Case**	**Climate Change Scenario**
1-in-100	0.82	0.99
1-in-200	1.05	1.29

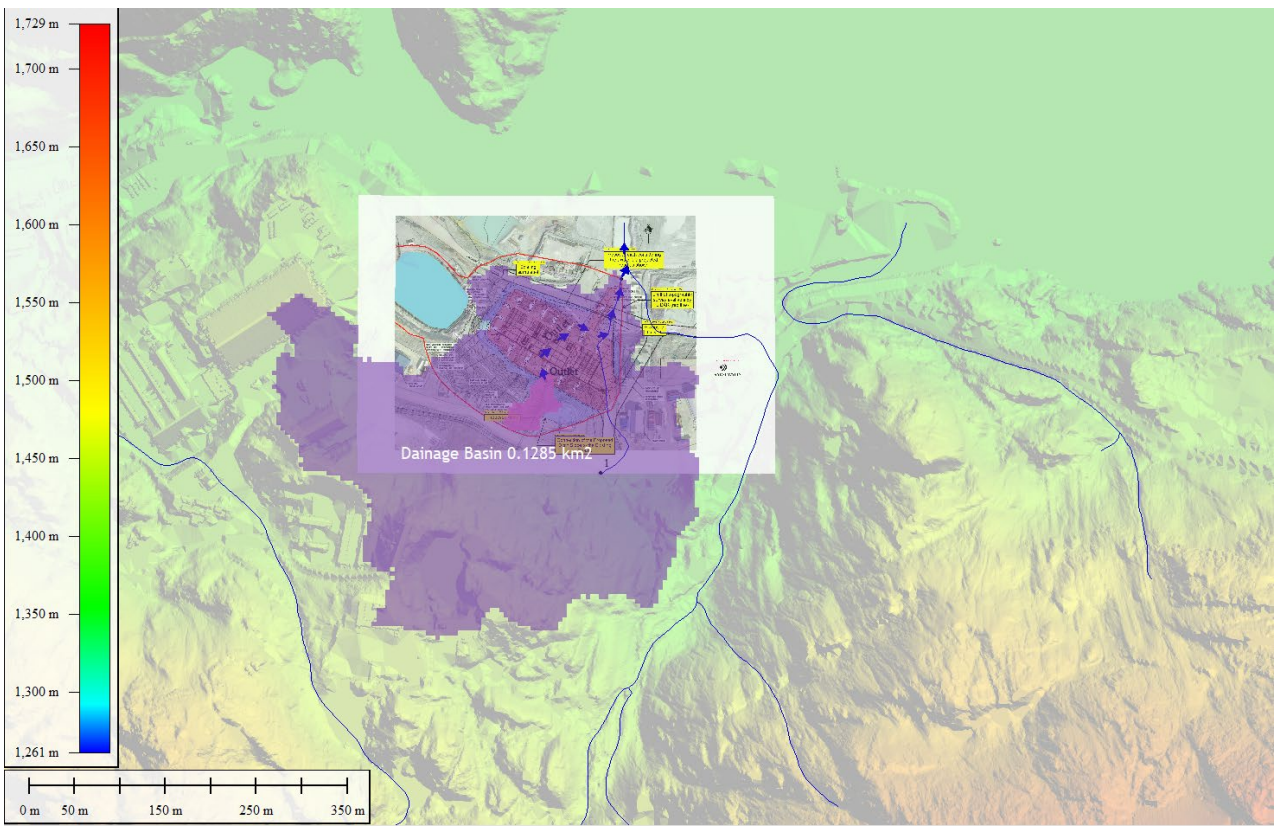


Figure 1 – Delineated Drainage Basin

The estimated instantaneous peakflow values should assist in the design of water diversion structures around the proposed heavy shop facilities.

If you have further questions, please do not hesitate to contact me.

Xavier. Pinto, M.Sc., P.Geo.

Senior Hydrologist

References

Coulson. C.H. 1991. Manual of Operational Hydrology in British Columbia. Ministry of Environment. Water Management Division. Hydrology Section.

Appendix 9-1-19. Wildlife Management Plan

BRUCEJACK MINE

NEWCREST
BRUCEJACK
PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

Wildlife Management Plan

February 2023

NEWCREST
BRUCEJACK

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Wildlife Management Plan

Version 4

Date: February 2023

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Detail
1	July 2015	Pretium Exploration Inc.	Original
2	December 2018	Pretium Resources Inc.	Updated in response to October 2018 EAO Inspection Report
3	June 2021	Pretium Resources Inc.	Updated to current Mine operations, updated Mountain Goat Management Plan following consultation process
4	February 2023	Pretium Resources Inc.	Clarifications to Section 5 (e.g., mitigation hierarchy for vegetation clearing, traffic and access management specifications, added waste disposal sites), edits to Table 5.1-1 to update sensitive periods for some species and added hibernacula for bats, required changes from EAC Amendment #8 for additional mineral lick, additional reference, mountain goat figures added (ungulate winter range and survey results for 2011-2021). Document format updated to NCM Brucejack template.

ACKNOWLEDGEMENTS

Version 1 of the Wildlife Management Plan was prepared by ERM for Pretium Resources Inc. (Pretivm) in 2015. The plan was written by Katie Kuker, M.Sc., and Jason Northcott, M.Sc., R.P.Bio., R.P.F. The plan was reviewed by Katie Kuker, M.Sc., Greg Sharam Ph.D., and Greg Norton, M.Sc.

Version 2 of the plan was updated in December 2018 by Shaun Freeman R.P.Bio. and reviewed by Katie Kuker, M.Sc. and Greg Norton, M.Sc.

Version 3 of the plan was updated in June 2021 by Robin McCall, R.P.Bio. (Pretivm) and reviewed by Greg Sharam Ph.D. (ERM).

Version 4 of the plan was updated in January 2023 by Xavier Pinto, M.Sc., P.Geo (Pretium) and Torence Sandhals M.Sc., P.Ag (Pretium) and reviewed by Greg Sharam Ph.D (ERM).

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BC	British Columbia
BC MF	British Columbia Ministry of Forests
BC MECCS	British Columbia Ministry of Environment & Climate Change Strategy
BC MEMLCI	British Columbia Ministry of Energy, Mines and Low Carbon Innovation
BC *Wildlife Act* (1996)	The main provincial law for protecting wildlife, endangered species, and wildlife habitat. The Act has several provisions for protecting, managing, and purchasing habitat areas as well as protecting endangered and threatened species. The Act is administered by the British Columbia Ministry of Environment and Climate Change Strategy
BJAR	Brucejack Access Road
BMP	Best Management Practice
EAC	Environmental Assessment Certificate
IWMS	Identified Wildlife Management Strategy: an initiative of the British Columbia Ministry of Environment and Climate Change Strategy in partnership with the British Columbia Ministry of Forests The IWMS provides direction, policy, procedures, and guidelines for managing Identified Wildlife. The goals of the Strategy are to minimize the effects of forest and range practices on Identified Wildlife situated on Crown land and to maintain their limiting habitats throughout their current ranges and, where appropriate, their historic ranges.
***Migratory Birds Convention Act* (1994)**	A federal government commitment established in 1917 to protect most migrating birds found in Canada. The Act fulfilled the terms of the Migratory Birds Convention of 1916 between Canada and the USA. The Canadian government has the authority to pass and enforce regulations to protect those species of migratory birds which are included in the Convention.
Mine	Brucejack Mine
NMMP	Nass Moose Management Program
Pretivm	Pretium Resources Inc.
ROW	right-of-way

Species at Risk Act (2002)	A Canadian federal statute which is designed to meet one of Canada's commitments under the International Convention on Biological Diversity. The goal of the Act is to protect endangered or threatened organisms and their habitats. It also manages species which are not yet threatened, but whose existence or habitat is in jeopardy.
SRMP	Sustainable Resource Management Plan
UWR	Ungulate Winter Range
VC	Valued Component
WHA	Wildlife Habitat Area: mapped areas that are necessary to meet the habitat requirements of an Identified Wildlife species under the Identified Wildlife Management Strategy. WHAs designate habitats in which activities are managed to minimize their effect on the Identified Wildlife for which the area was established.
WMP	Wildlife Management Plan

1 PURPOSE

The purpose of the Wildlife Management Plan (WMP) is to minimize potential effects on wildlife and wildlife habitat from mine-related activities at Brucejack Mine (the Mine) during the Construction, Operations (including potential temporary closure), Closure, and Post-closure phases, while considering operational requirements and the safety of mine personnel. The plan has taken into consideration the Cassiar Iskut-Stikine Land and Resource Management Plan (BC ILLR 2000), the Nass South Sustainable Resource Management Plan (SRMP; MFLNRO 2012), relevant provincial and federal legislated requirements for wildlife and wildlife habitat management, and current best management practices (BMPs).

The WMP targets the following wildlife included as Valued Components (VCs) in the Application for an Environmental Assessment Certificate (EAC) / Environmental Impact Statement:

- moose;
- mountain goat;
- grizzly bear and black bear;
- furbearers (wolverine, fisher, American marten);
- hoary marmot;
- bats;
- migratory birds (waterbirds and land birds);
- raptors; and
- western toad.

2 PERFORMANCE OBJECTIVES

The overall performance objectives of the WMP are to:

- minimize wildlife mortality as a direct or indirect consequence of the Mine; and
- avoid and/or minimize adverse effects on wildlife with special attention to their habitats, breeding activities, and feeding activities.

Specific actions related to achieving the objectives are to:

- review and meet legislation requirements regarding active or inactive bird nests (including raptors), mammal dens, and potential mortality of animals directly attributable to the Mine, particularly for species of conservation concern;
- minimize loss of high-quality habitat (Surface Erosion Prevention and Sediment Control Management Plan and Vegetation Management Plan);
- minimize disruption of wildlife movement;
- minimize disturbance of mountain goats within Ungulate Winter Range (UWR) during restricted periods;
- minimize disturbance to moose within winter habitat areas; and
- prevent disturbance within candidate grizzly bear Wildlife Habitat Areas (WHAs) during periods of greatest sensitivity: October 31 to April 30 (Section 5.1).

3 SCOPE

This WMP pertains to the VC's described in Section 1 and is applicable to Operations, Closure, and Post-closure phase activities at all mine facilities requiring site-specific mitigation and monitoring (Table 3.1-1).

Table 3.1-1. Mitigation and Monitoring during all remaining Phases of the Mine

Mine Phase	Site-specific Mitigation and Monitoring
Operations	Traffic, aircraft, access, and waste management plans, and personnel education and training
Closure	Traffic, aircraft, access, and waste management plans and personnel education and training
Post-closure	Access management

4 LEGISLATION, REGULATIONS, AND EAC CONDITIONS

4.1 LEGISLATION AND REGULATIONS

The following legislation applies to wildlife and wildlife habitat:

- British Columbia (BC) *Wildlife Act* (1996): Legal designation as Endangered or Threatened under the Act increases the penalties for harming a species, and also enables the protection of habitat in a Critical Wildlife Management Area. Moose, mountain goats, bears (black and grizzly), American marten, fisher, wolverine, bats, and western toads are protected legislatively by the provincial Act. The Act also protects some bird species, including raptors, active bird nests, and some inactive raptor nests.
- *Species at Risk Act* (SC 2002, c. 29): Federal legislation that aims to protect species at risk from becoming extinct. Certain species are also protected under the *Species at Risk Act* as part of wildlife habitat and in accordance with the Canadian Biodiversity Strategy.
- *Migratory Birds Convention Act* (1994): Federal protection of avian species that migrate between countries. It is the responsibility of Environment and Climate Change Canada to develop and implement policies and regulations for the protection of migratory birds, their eggs, and their nests.
- *Forest and Range Practices Act (2021)* (2004): Provides the legal authority to develop management measures and spatial areas for UWRs and WHAs. The Identified Wildlife Management Strategy (BC MWLAP 2004) of the *Forest and Range Practices Act* also provides management objectives and procedures for integrating fisher conservation with industrial development.
- BC *Environmental Assessment Act* (2002a, updated in 2018): The legal framework for the province's environmental assessment process for proposed major projects. The Act is supported by several regulations, including the Reviewable Projects Regulation (B.C. Reg. 243/2019), as well as a variety of policy, procedure, and technical guidelines. The environmental assessment guidelines in BC provide an outline of the best practices for the selection of wildlife VCs and the assessment of potential effects.

4.2 ENVIRONMENTAL ASSESSMENT CERTIFICATE CONDITIONS

Pretivm was granted an EAC (#M15-01) on March 26, 2015, that included conditions of certification. This management plan fulfills Condition #2, in relation to a Component Plan for wildlife management, Condition #14 and Condition #15 presented within Schedule B of the Certificate and copied below.

<u>Condition #2</u>

> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*

Component Plans, at minimum, must include the following information:

- *Purpose of Component Plan;*
- *Performance objectives;*
- *Effects mitigation measures;*
- *Monitoring programs;*
- *Monitoring schedules; and*
- *Reporting requirements.*

The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.

The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."

Condition #14

"The Holder must prepare a Wildlife Management Plan (WMP) that applies to the Mine Site and Ancillary Infrastructure in consultation with, and to the satisfaction of, FLNRO and MEM. The WMP must meet the Component Plan requirements set out in Condition 2. The WMP must include a Wildlife Collision Protocol (WCP). The Holder must implement the WCP."

Condition #15

"Before the start of Construction, the Holder must enter into a contribution agreement with the Province as represented by the Minister of Forests that will set out the terms of the Holder's participation in a program of activities that supports the recovery, conservation and management of the Nass moose population (NMMP). The Holder must abide by the terms of the Contribution Agreement.

The NMMP may include any measures that support the recovery, conservation, and management of moose population in the Nass Valley, and, without limitation, may include:

a) The development and implementation of population, habitat and access management measures that support the conservation and recovery of Nass moose;

b) Education and communication, inventory, monitoring, collection of harvest data, signage, and programs to increase knowledge of human interactions with moose; and

c) Administration of such activities.

The Contribution Agreement will require the Holder to contribute up to the following amounts to the province's costs of implementing the NMMP:

a) $7,500 payable as early as the date (the "Brucejack Access Road Start Date") of any physical alteration, including site preparation, to the Brucejack Access Road right of way made for the purpose of improving the Access Road; and

b) an amount ("Annual Contribution") consisting of $3,000, plus adjustments for inflation and Project Vehicle Wildlife Incidents referred to below, payable as early as on the first and every subsequent anniversary of the Access Road Start Date until FLNR determines that the Holder has commenced permanent closure and decommissioning of the Project.

Where the Province has not incurred expenses in implementing the NWWP and invoiced the Holder at the earliest payable date set out above, the Contribution Agreement will allow those amounts that have not been invoiced, together with interest accruing on them, to be carried over and invoiced later in addition to the Annual Contribution for a particular year.

The Annual Contribution will be adjusted by an inflation factor based on the increase in the British Columbia Consumer Price Index from the date of the issuance of the Environmental Assessment Certificate (EAC).

Five years after the first shipment of concentrate from the ore processing complex, and every five years after that date, the Annual Contribution will be adjusted by an amount determined by the province to reflect any increase or decrease in moose accidents caused by vehicles along the Brucejack Access Road ("Project Vehicle Wildlife Incidents"). However, in no circumstance shall the Annual Contribution be less than $3,000 plus any adjustment for inflation and BC Consumer Price Index as described above.

The Contribution Agreement may require the Holder to review, prepare, comment on, or otherwise participate in the preparation and presentation of draft plans, final plans, and reports regarding the NMMP."

5 MITIGATION AND BEST MANAGEMENT PRACTICES

This section identifies proposed mitigation measures to eliminate or reduce potential mine-related effects on wildlife. Environmental management concerning wildlife will take an adaptive approach. Management measures implemented are reviewed periodically and updated based upon initial outcomes, current best management practices (BMPs and methods, and the results of environmental monitoring.

Potential mine-related effects on wildlife could include:

- habitat loss and alteration;
- sensory disturbance;
- disruption of wildlife movement patterns;
- direct mortality;
- indirect mortality;
- attraction to the Mine due to attractants; and
- health effects due to chemical hazards.

Mitigation measures to address these potential effects are outlined in the following sections.

Maps were prepared, showing sensitive environmental features for wildlife, fish, vegetation, soils (risk of erosion), and archaeological sites. The maps include a summary of mitigation activities from relevant management plans. The completion of mitigation activities will be noted by the responsible persons qualified to identify wildlife features and summarized in the compliance reporting delivered to appropriate regulators and the Wildlife Advisory Committee.

5.1 VEGETATION CLEARING MANAGEMENT

Vegetation clearing activities that may disturb wildlife are avoided during sensitive periods (Table 5.1-1), where feasible. This includes modifications of design to avoid sensitive habitats and legislated UWRs or WHAs where feasible. If avoidance is not possible, pre-clearing surveys are conducted to identify features that must be avoided and protected with appropriate buffers. These surveys are described in more detail for each VC in Section 6.1.1 (Vegetation Clearing Monitoring).

Timing windows and pre-clearing surveys were designed to be site-appropriate, informed by the standard provincial guidelines, *A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (BC FLNRO 2014).

Table 5.1-1. Timing and Mitigation Activities for Vegetation Clearing

Valued Component	Sensitive Period	Habitat	Summary of Mitigation Measures	Legislation, Standards and Guidelines
Moose winter	January 1 to April 30	Late Winter High Quality and UWR	Applies to high-quality late winter habitat and provincial UWR. Avoid working in these areas during the sensitive period. If construction or critical works must occur during the sensitive later winter period, then pre-clearing ground surveys and construction monitoring will be conducted by an environmental monitor at least 300 m ahead of the activity. Include a mitigation strategy to minimize disturbance. If moose are observed within 100 m of clearing activities, work will be halted until moose are beyond 100 m.	Nass South SRMP (MFLNRO 2012). A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Moose calving	Late April to early June	All habitats	Surveys will be completed by an environmental monitor ahead of clearing, ground based surveys are preferred over aerial surveys which can result in unnecessary disturbance. If female moose with newborn calf is observed within 100 m of clearing activities, a break will be called until the moose move out of a 500 m range. Sightings will be reported to the environmental department.	Nass South SRMP (MFLNRO 2012). A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Mountain goat	November 1 to July 15	UWRs, Kidding period, known mineral licks and access trails	Avoid activities in, and within 500 m of, mountain goat UWRs and kidding habitat during the sensitive wintering and kidding periods from October 31 to July 15th and any known mineral licks and their access trail. If project critical work needs to occur in these areas, then conduct pre-clearing surveys and include a mitigation strategy to minimise disturbance. Maintain known and potential mineral licks in a natural state and verify ungulates have access to them during the season when they are used the most (April to October). If goats are observed within 500 m of UWR or kidding habitat, then pause work until goats have moved away. Avoid flying within 400 vertical meters and 2000 horizontal meters of all the mountain goat winter range areas. Track helicopter paths and document avoidance as well as an explanation or rationale as to why avoidance is not practicable. This monitoring data should	UWR U-6-002 Order, sections 9(2) and 12(1) of Government Actions Regulation (BC MOE 2008; BC Reg. 582/2004), unless an exemption is granted. Management Plan for Mountain Goat in BC (BC MOE 2010). Nass South SRMP (MFLNRO 2012). A Compendium of Wildlife Guidelines for Industrial Development Projects in the

Valued Component	Sensitive Period	Habitat	Summary of Mitigation Measures	Legislation, Standards and Guidelines
			be summarized and included in annual reporting and applied as an adaptive system to identify areas and instances of non-compliance and areas where mitigation may be required because compliance is not possible due to safety requirements.	North Area, British Columbia (BC FLNRO 2014)
Bears	October 31 to April 30	High Quality Denning Habitat	Avoid clearing in high-quality black bear denning habitat (e.g., riparian and old large old growth stands) and grizzly bear denning habitat (e.g., high elevation) during winter, whenever possible. Detailed level plans for road upgrades and maintenance will identify if high-quality habitat will be impacted by clearing activities. If work is planned in these areas during winter, then conduct pre-clearing surveys prior to snowfall or other mitigation may be required based on discussions with BC Ministry of Forests (BC MF). If active dens are detected, set a minimum of 60-m buffer (BC FLNRO 2014) where only limited work may occur (e.g., moving machinery through the area and conducting Project critical clearing or movement).	British Columbia Environmental Assessment Guidelines for Grizzly Bears and Black Bears (MacHutchon 2001). A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Hoary marmot	Annual	Colony Habitat	Conduct pre-construction surveys in previously identified marmot habitat if excavation activities are scheduled to occur. If marmots are identified within the excavation area, contact BC MF for direction on how to proceed.	
Furbearers (fisher, American marten, wolverine)	February 1 to September 30	Denning	Avoid clearing in high-quality denning habitat for furbearers during the winter. Detailed level plans for road upgrades and maintenance will identify if high-quality denning habitat will be impacted by clearing activities. If work must be conducted in these areas during winter, then conduct pre-clearing surveys for dens prior to snowfall or other mitigation may be required based on discussions with BC MF. If an active den is found, set a 50-m buffer where only unavoidable work may occur. Wolverines for example generally den in the subalpine in proximity to the treeline. The dens are constructed in boulders, under deadfall or in snow tunnels at higher elevations. This contrasts with fisher that rear their offspring during April to June in large, declining black cottonwood, trembling aspen, or balsam poplar trees. Marten have a similar home range as Fisher but prefer mature coniferous	A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (FLNRO 2014)

Valued Component	Sensitive Period	Habitat	Summary of Mitigation Measures	Legislation, Standards and Guidelines
			forests that provide the greatest winter cover. Old-growth trees and dead trees within these sites are often used for dens and resting.	
Furbearers (fisher, American marten, wolverine)	Annual	Maintain Connectivity	If clearing for right of ways (e.g., transmission line) occurs in suitable furbearer habitat, retain natural accumulations of coarse woody debris using machine-free zones or create piles of coarse woody debris using machinery. Manmade piles should generally be larger than 20 m³. Structural attributes, such as tall stumps should be left in place (or promoted in instances were clearing has removed screening vegetation) across openings to provide cover and connectivity at regular (< 500 m) intervals or less (100 m) in confirmed fisher habitat. Minimize the width of any clearing activity. In the case of wolverines, that have very large ranges, an all-encompassing, and more complex view is needed in terms of minimizing the impact to them.	
Bats	May 15 to September 30	High-quality Maternal Roosting Habitat	Avoid clearing during the spring and summer period in old growth forested habitat. If clearing needs to occur, conduct pre-clearing surveys in conjunction with bird surveys. If maternity roosts are identified, maintain a buffer of 50 to 125 m radius core around the roost. If the tree, or buffer, is in a Project-critical area the environmental staff will contact BC MF and determine a possible course of action for moving the bats out of the roost tree. To offset potential effects of removing bat roosts during vegetation clearing, bat boxes will be installed along the access road in areas of old growth forest where suitable roosting trees are removed with a goal to install approximately two roost boxes per hectare of cleared old growth and mature conifer forest.	A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Bats	October 1 to May 31	Hibernacula	The Project is not anticipated to interact with bat hibernacula but if discovered, bat hibernacula will not be disturbed or destroyed. Should a suspected hibernacula be identified, Project activities will be halted until a pre-disturbance survey can be completed by a qualified environmental profession to provide confirmation.	*Species at Risk Act* (2002) A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)

Valued Component	Sensitive Period	Habitat	Summary of Mitigation Measures	Legislation, Standards and Guidelines
			If an active bat hibernaculum is identified, a core area within a minimum 100-m radius of the hibernacula, and a special management zone within a 1-km radius of the core area, will be established (BC MOE 2016). If Project activities must occur within the buffer, the relevant regulating body (e.g., BC MF) will be consulted to develop additional mitigation strategies, if necessary.	
Migratory birds (waterbirds and landbirds	May 1 to July 31	Nesting Habitat (wetlands, rivers, forests)	Schedule vegetation clearing activities outside of the sensitive period where possible.	*Migratory Bird Convention Act* (1994) A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Migratory birds (waterbirds and landbirds	May 1 to July 31	Nesting Habitat (wetlands, rivers, forests)	If clearing must be completed during the breeding period, conduct pre-clearing surveys to identify active nests. Pre-clearing surveys will occur at least 100 m ahead of the activity and include the area to be cleared. If an active nest is found, the tree is protected under Section 34 of the *BC Wildlife Act* (1996). Establish a 50-m buffer where no work is conducted, with exceptions for critical project activities. Once the nest is inactive, vegetation clearing can occur.	*BC Wildlife Act* Section 34 (1996) A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Raptors	Varies for different raptor species, generally between mid-March and end of August	Nesting Habitat (forests and trees with stick nests)	Schedule vegetation clearing outside of raptor nesting timing in forested areas. If clearing is planned in these areas during the raptor nesting season, conduct pre-clearing surveys for nests in trees. If a nest is found, the tree is protected under Section 34 of the *BC Wildlife Act* (1996). Establish a 200 m to 500 m no disturbance buffer (depending on species as identified in BC FLNRO 2013) and a 100 m to 300 m forested buffer around active nests where no work is conducted, with exceptions for critical Project activities. Active nests will be monitored regularly until raptors and fledglings leave the nest	*BC Wildlife Act* Section 34 (1996): protects active raptor nests, and protects the nests of eagles, peregrine falcons, gyrfalcons and ospreys year-round. Guidelines for Raptor Conservation during Urban and Rural Land Development in British Columbia (MFLNRO 2013).

Valued Component	Sensitive Period	Habitat	Summary of Mitigation Measures	Legislation, Standards and Guidelines
			Any goshawk surveys will follow guidelines in the Nass South SRMP. Callback surveys are only required from February 15 to August 15. Once the nest is inactive, consult with BC MF on the possibility of removing or moving the nest if it is within the Project footprint.	A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)
Western toad	May through October	Breeding Ponds	Avoid construction activities in areas adjacent to potentially high-quality western toad breeding habitat from May through October. If this is not possible, conduct pre-clearing surveys and if breeding ponds are observed, establish a buffer zone of at least 30 m, or, if this is not possible, contact BC MF regarding alternative mitigation. If clearing does happen, level the ground, and fill any deep ruts left by machinery because the unintentional creation of ephemeral, shallow, pond-like habitats created by machinery, where large puddles or ruts hold water for prolonged periods of time attract breeding amphibians. When they breed in such, the eggs are exposed to predators and dry up over the season; these sites can be population sinks. Trenches and steep-sided holes with water in them can also attract western toads, which may become trapped	A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia (BC FLNRO 2014)

5.2 ROAD AND TRAFFIC MANAGEMENT

The Brucejack Access Road (BJAR) is managed to minimize the following potential effects:

- direct mortality from wildlife-vehicle interactions; and
- disruption of movement or mortality due to presence of BJAR, attraction to BJAR, or wildlife use of BJAR.

Management protocols for the BJAR are outlined below.

5.2.1 Traffic Management

Wildlife-vehicle interactions can be minimized by modifying driver behaviour. This includes adhering to speed limits, giving wildlife the right-of-way (ROW), and communicating wildlife sightings (described below and in Section 6.1.2). When travelling outside of daylight it is recognised that crepuscular hours (i.e., dawn and dusk) and night tend to be the periods of highest wildlife activity.

The following mitigation measures are being implemented:

- Speed limits are posted along the BJAR. Mine also adhere to open road speed limits for Highways 37 and 37A. Other types of road signs (e.g., wildlife ahead, toad crossing) will be maintained along the BJAR to alert drivers to speed limits and wildlife-sensitive areas. Speed limits are enforced by surface operations supervisors along the BJAR and can also be monitored by listening to the km marker calls. Radar speed signs are also used in areas where speeding is more likely to occur (e.g., KM 41-44 area).
- Drivers are informed that wildlife have the ROW along BJAR and the highway (included in orientation to all site employees and the Traffic and Access Management Plan).
- Tunnels will be maintained at pre-determined locations to allow safe passage under the road for western toads.
- Locations along the BJAR identified as having a higher likelihood for vehicle collisions with wildlife are being managed adaptively (e.g., signage, education, speed limits).

5.2.2 Wildlife Collision Protocol

- Collisions between Mine vehicles and wildlife are documented and include information on the location of the collisions. Mine personnel are instructed to report any wildlife-vehicle collision to Pretivm environmental staff.
- Records/reports include all wildlife sightings.
- Information on collisions is reported annually to the Wildlife Accident Reporting System maintained by the BC Ministry of Transportation and Infrastructure either through the BC Ministry of Forests, Lands and Natural Resources Operations or to the BC Ministry of Transportation and Infrastructure.
- The Principal, Environment is responsible for training, providing a reporting system, and reporting collisions to appropriate government officials.

5.2.3 Management to Minimize Wildlife Use of Roads

To minimize wildlife use of the BJAR, the following mitigation measures are being implemented:

- Use of road salts for winter road management has not been used along km 0 to 58 of the BJAR to reduce the potential of attracting ungulates to the road. Use of sand or stone chippings is the preferred approach to provide winter traction.
- Vegetation management is implemented to reduce site attractiveness to wildlife and, when appropriate, roadway edges are cleared to increase visibility of wildlife to drivers (e.g., a cleared buffer zone of appropriate size). Clearing will be site-specific to provide a balance between low vegetation and maintaining high-value and sensitive habitat. Vegetation maintenance activities (e.g., brush-cutting) is conducted as appropriate to reduce herbivore use of vegetation within corridor areas where concerns exist for wildlife-vehicle collisions and high-quality browse is present (e.g., willow, birch). These activities may be conducted on a different schedule if local conditions warrant, in the early summer months of June and July, to minimize attractiveness to herbivores such as moose (Rea et al. 2010). Pre-clearing surveys for bird nests are conducted during appropriate times of the year prior to brush cutting.
- To minimize potential wildlife-vehicle collisions along the lower (km 0 to 58) BJAR, the verge (i.e., the vegetated strip adjacent to the roadway) was seeded with a mix that has low or no clover content, which is less attractive forage to wildlife, especially to moose, mountain goats, and black bears. In locations where erosion control is the main objective of seeding, ground cover is the overriding factor in seed choices.
- Refuge areas are ploughed along the road during winter; gaps in snowbanks on roads are prepared to allow for egress of wildlife. Egress for moose is provided by creating gaps or 'push-outs' where feasible (i.e., as topography allows) on the outside of bends and/or corners and approximately every 0.5 km (one side/alternate) for extended straight sections of the BJAR (Heatherington et al. 1989).
- Ditches and culverts are designed and installed to minimize pooling of water. Free-draining roadside ditches help prevent pools that may form toad breeding areas.
- Carrion is removed from the BJAR to minimize attracting wildlife to the road, thereby reducing the risk of conflicts between vehicles and wildlife.
- Fugitive dust emissions generated by vehicles on BJAR and camp areas are managed through enforced speed limits, application of water as a dust suppressant, and the use of a Mg/Cl brine as a dust suppressant. Procedures are guided by the Air Quality Management Plan, Section 5.1.5.

5.3 ACCESS MANAGEMENT

The Brucejack Transmission Line is managed to minimize potential access to and along the transmission line ROW by all-terrain vehicles (ATVs) and snowmobiles. In areas where tree felling was required, the trees were left in place to act as barriers and discourage access. Additionally, the naturally steep terrain along the transmission route further deters access. Creation of points of entry to the transmission line ROW was minimized because the transmission line is constructed and maintained via helicopter. Therefore, no new roads were constructed to access the ROW during the Construction phase, nor will

there be an access trail constructed alongside the transmission line to support access and maintenance during the Operations phase.

The BJAR is managed to minimize the potential for indirect mortality to wildlife (e.g., hunting) through access management. To mitigate for the potential effects of increased access to the Mine and consequent increase in hunting of wildlife, the following mitigation measures were implemented:

- A security screening building at km 1 of the BJAR was installed to prohibit entry of non-authorized vehicles.
- Control access to the BJAR and the surrounding areas west of the Bell-Irving River by prohibiting access to recreational vehicles and deactivating all non-essential roads if long-term post-closure monitoring access is not required.
- Pretium No Hunting or Fishing Policy and Wildlife Attraction Zero Tolerance Policy prohibits the possession of personal firearms, other hunting weapons, and including fishing gear by personnel and contractors within the Mine area. Security checks are conducted for these items during the screening process and entry is denied if in possession.
- Deactivate all non-essential roads if long-term Post-closure monitoring access is not required.
- Limit use of personal vehicles to and at the Mine site as much as possible by transporting personnel via buses, aircraft, or designated company transport vehicles from communities or central collection sites at the start and end of each rotation.

5.4 AIRCRAFT MANAGEMENT

To minimize disturbance to sensitive wildlife species such as mountain goats, aerial support, including helicopter access, is directed along controlled routes or flight paths. Specific flight paths are followed unless weather or safety require pilots to fly within wildlife buffers. Locations of these flight paths and the reasons they must be used are communicated to workers involved in aviation support. Pilots are required to follow flight paths wherever feasible, and a member of the Environmental Dept. communicates and reviews with the pilots annually (or in orientation for new pilots) the location of environmentally sensitive areas.

The Province of BC provides guidance on helicopter activities in and near goat habitat in the *Management Plan for the Mountain Goat (Oreamnos americanus) in British Columbia* (BC MOE 2010). Mountain goat mitigation measures related to aircraft and helicopters from November 1 through July 15 include using helicopters that produce less punctuated noise (e.g., the 3-bladed Eurocopter A-star instead of 2-bladed Bell 206 Long Ranger), where possible.

There is a general set of helicopter “behaviours” which, if followed, can significantly reduce the potential for mountain ungulates to be disturbed by helicopters. Goats typically have little defence against predators, except fleeing to escape terrain and they likely perceive helicopters as a predation risk. Thus, it is important to understand and have the helicopter “behave” in a way that does not startle or trigger this predation response. General recommendations for pilots include:

- Avoid overflights of occupied goat habitat whenever possible (below suggested elevations of 500 m), including avoiding “flightseeing”.

- If flying a helicopter that produces a heavy “blade slap” noise, avoid inducing this noise when overflying or adjacent to occupied goat habitat.
- If a pilot is aware that goats are on the opposite side of a ridge or mountain, avoid surprising goats by flying low over the ridge and suddenly appearing above them.
- Avoid triggering a goat’s “chase response” by avoiding flying directly at goats. Helicopters flying tangentially to goats are perceived less as potential predators.
- Goats can become habituated to helicopters if the helicopters operate in a predictable and nonthreatening manner. Wherever possible, use the same routes and elevations to and from camps and drills and other destinations.
- Use topographic barriers to separate helicopters from mountain goats.
- Keep helicopters below mountain goats if feasible.
- Helicopters can drop off specialized work crews in goat habitat, but only when goats are not present within 500 m.

In the balance between operability and reducing disturbance to goats, for aircraft activities pilots are instructed to maintain the largest separation feasible from mountain goats. The ideal situation is >2 km. In some cases, it may not be possible to maintain >2 km separation with goats given that valleys may be less than 2 km wide, and seasonal low clouds may force helicopters into the bottom of valleys.

5.5 Building and Waste Management

Buildings are designed and maintained to exclude wildlife ingress wherever possible, such as:

- covering vents with mesh to prevent bats, birds, and furbearers (e.g., American marten) from entering;
- skirting buildings to deter wildlife from entering under buildings; and
- constructing additional structures (e.g., electric fencing) to exclude wildlife from areas that may be attractants to wildlife, such as waste management facilities and lower road camps.

Wildlife species, particularly grizzly bear and furbearers may be attracted to specific sites (e.g., kitchen, waste handling areas) if the waste products processed at these areas are not properly managed. Mitigation and monitoring to minimize attractants include the following measures:

- Incinerate kitchen wastes in a timely manner.
- Store recyclable wastes and chemicals in wildlife-proof containers / facilities.
- Store attractants and wastes (garbage, food waste) at permanent site infrastructure in bear-proof storage containers. Bear-proof containers are tightly secured when not in use.
- Conduct regular road and camp cleanups to remove hazardous substances, wires, or loose materials that could endanger wildlife, and arrange proper storage and disposal of hazardous wastes.

- Remove waste from collection sites regularly, incinerate in an approved incinerator or store in wildlife-proof areas and wildlife-proof buildings until incineration or transportation off site.
- Dispose of waste which cannot be incinerated at an approved disposal site such as the Regional District of Kitimat-Stikine Meziadin landfill for controlled and uncontrolled waste and Environmental 360 Solutions Ltd. in Prince George for hazardous waste.
- Prevent wildlife from entering incinerators and sewage treatment facilities, where possible, using appropriate wildlife exclusion techniques.
- Follow Chemical and Materials Storage and Handling Management Plan, Spill Response Management Plan and Waste Management Plan.

To help limit unnecessary wildlife attractants on site, a Wildlife Attractant Zero Tolerance Policy (Appendix B) has been developed and implemented at the Mine. The Policy requires that all personnel follow the specified rules on reducing wildlife attractants (e.g., no littering including disposal of cigarette butts on the ground and dumping coffee, keeping access to buildings and vehicles closed when not in use, placing food waste in appropriate designated receptacles, immediately cleaning up a spill, etc.) where failure to do so can result in disciplinary action, hence the use of “Zero Tolerance” in the title of the Policy.

Consideration for management of the mine ventilation and portal to exclude bats was evaluated; however, the high elevation of the site, cold environmental conditions during the growing season, and absence of bat observations or evidence of use of the adit after remaining open for 15 years suggests that it is unlikely to provide roosting habitat for bats. The adit will be sealed with doors to prevent access; no bat directed mitigation is deemed necessary for the portal and ventilation.

As per Section 6.1.6, Incidental Wildlife and Wildlife Incident Monitoring, observations of wildlife at or near Mine infrastructure are recorded and delivered to the Principal, Environment. If this monitoring program records observations of bears repeatedly in or near the camps, then a response plan will be prepared to limit bear access to the site, including all Mine camps (Brucejack, Wildfire, and the Knipple Transfer Area). In order of preference, this response plan may include (but is not limited to) the following options for management activities:

- Evaluate if waste management activities are successful, and update if necessary;
- Evaluate if building exclusion measures (e.g., skirting, electric fencing, etc.) are successful and update if necessary; and
- Conduct an audit of waste and attractant management (i.e., evaluate adherence to Wildlife Attractant Zero Tolerance Policy) and increase education and enforcement measures, if warranted.

If the observations of bears continue despite these measures, then additional measures may be required, as per the site audit. These measures may include additional fencing or measures to exclude bears from the kitchens, accommodations blocks, and other facilities that may attract bears at the Brucejack, Knipple and Wildfire Camps.

5.6 LIGHT MANAGEMENT

To avoid over-lighting, the level of illumination required for safe completion of tasks is minimized where possible. The potential effects of sensory disturbance on wildlife by exposure to light is mitigated through infrastructure design and by applying applicable measures as present in various guidelines such as *Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia; Migratory Birds Environmental Assessment Guideline* (BC MOE 2006).

Lighting at the Mine was designed to minimize potential effects on wildlife while ensuring safe operational conditions and included the following considerations:

- optimize the level of illumination required for the task to avoid over-lighting;
- use directed lighting rather than broad area lighting wherever possible;
- shield lighting and direct it downwards wherever possible; and
- switch on lighting only when it is necessary for safe mine site operation.

Lighting may be managed adaptively if observations suggest wildlife interactions with infrastructure are influenced by lights.

5.7 PERSONNEL EDUCATION AND TRAINING

An education program for personnel promotes stewardship and seeks to avoid human-wildlife conflicts. This program is supported by relevant Policies (e.g., No Hunting or Fishing Policy, Wildlife Attractant Zero Tolerance Policy), presentations at formal meetings (including the initial orientation), standard operating procedures, standard reporting forms, information sheets, posters, and signage. The education program places emphasis on:

- personnel awareness of wildlife-sensitive times of year;
- waste management/wildlife attractant protocols;
- not feeding or intentionally attracting wild animals;
- policies banning firearms, hunting, and fishing;
- bear awareness training;
- legal obligations and corporate commitments concerning working near mountain goats and UWRs and bird nests;
- responsibilities for pilots to use designated flight paths and maintain appropriate distances from wildlife and occupied wildlife habitat (e.g., UWR);
- operating protocols for the roads; and
- wildlife reporting and response procedures.

The effectiveness of the education program training is continually reviewed and amended as required.

6 ENVIRONMENTAL MONITORING

6.1 PERFORMANCE MONITORING

6.1.1 Vegetation Clearing Monitoring

If construction activities occur during sensitive timing windows for wildlife VCs (Table 5.1-1), a member of the Environmental Department, reporting to the Principal, Environment, will identify sensitive wildlife features and implement measures to avoid or minimize potential adverse effects to wildlife. For each wildlife VC, there are times when wildlife will be more sensitive to disturbance (e.g., breeding). Table 5.1-1 summarizes key sensitive periods for wildlife VCs applicable to the Mine, and highlights legislation or BMPs relevant to each VC. Any identified salt licks for wildlife are included as sensitive features. The identified salt lick for mountain goats on the north side of Knipple glacier is addressed in the Mountain Goat Management Plan.

6.1.2 Road and Traffic Monitoring

As per the Traffic and Access Management Plan, drivers are required to report wildlife collisions/mortalities along the BJAR and Highway 37. The location along the road and species is recorded and monthly mortalities are summarized to identify conflict “hot-spots,” which may then be used as part of adaptive management to further mitigate conflicts between road users and wildlife (e.g., through increased signage, further driver education, and enforcement of speed limits as mentioned in 5.2.1).

Any encounter with wildlife (including observations or interactions) is also required to be reported and records kept. The radio will be used to alert other operators when there is wildlife in the area and to travel with caution. These records provide a basis for identifying locations of higher risk for wildlife-vehicle collisions, and for developing appropriate mitigation strategies for those areas. If a large number of wildlife (e.g., moose or goats) are present on or adjacent to the road, a reduced speed limit or temporary road closure may be instigated at the discretion of the Principal, Environment in consultation with the Mine Manager.

Performance monitoring to reduce wildlife-vehicle interactions includes the following:

- A reporting system for wildlife-vehicle interactions and wildlife-road structure interactions (e.g., moose regularly observed on a particular segment of the road).
- The reporting system allows personnel to raise concerns anonymously or report observed non-compliance.
- Location, species, date, and type of wildlife-vehicle interactions are reviewed annually to identify any areas with higher frequencies of interactions.
- Personnel are trained on reporting procedures for wildlife observations and interactions through the personnel education and training program (Section 5.1.6).
- Completion of an incident report form if an incident is observed or occurs and follow up by Health and Safety working with the environmental staff, for the safety of mine personnel and

wildlife. Incidents are reviewed and mitigation measures adapted as necessary to help reduce the incidence of wildlife-vehicle interactions (e.g., through increased signage, further driver education, enforcement of speed limits).

- Wildlife fatalities will be removed from the BJAR to minimize attracting wildlife to the road, thereby reducing the risk of conflicts between vehicles and wildlife, and injured wildlife will be reported to Pretivm environmental staff for further investigation. The Principal, Environment reports these observations to regulatory authorities, as appropriate.

6.1.3 Access Monitoring

As described in Section 5.1.3, the BJAR is managed through controlled access points to prevent its use for hunting and recreational activities. If unauthorized use, including hunting, is observed along the access road or anywhere within the Mine area, it will be reported immediately to security. The Principal, Environment will in turn report hunting activities involving the access road to provincial authorities.

6.1.4 Monitoring via Aircraft

Pilots are asked to report incidental observations of large mammals (e.g., goats, moose, grizzly bears, wolf packs) as part of the incidental wildlife reporting program.

6.1.5 Building and Waste Management Monitoring

Environmental staff monitor Mine infrastructure and waste handling and management, as follows:

- Visual inspections of the outside of Mine infrastructure, including underground components, for observations of wildlife interacting with buildings or evidence of use (e.g., bird nesting materials in vents, scratching or chewing of building materials, bat activities and evidence of roosting, evidence of digging beneath buildings or skirting) and adaptively managed if necessary (e.g., improve building skirting, install bird spikes to deter bird nesting).
- In the event that wildlife is accessing Mine infrastructure where BMPs to prevent access have already been implemented, a response plan to limit access by the wildlife species will be developed. This could involve measures such as improvements to building skirting or installation of deterrents (e.g., bird spikes), depending on the species accessing the infrastructure.
- Visual inspections of waste handling and management practices at camps (e.g., kitchen and domestic wastes) and waste storage facilities (i.e., incinerator and burn pits) check for compliance with the Waste Management Plan.
- If wastes or other wildlife attractants are found to be misdirected or mismanaged, the wastes/attractants are moved to an appropriate secure location as soon as possible to limit attraction of wildlife.
- If wildlife is observed attempting to access or are successful in accessing waste storage facilities, alternative methods to secure wastes and wildlife attractants will be evaluated and applied as appropriate.

Personnel are encouraged to report incidental observations of issues related to camps or waste management. Incidental observations are reported and recorded continuously. Any incidents

where wildlife have been observed to interact directly with waste or observations of habituated wildlife (particularly bears and wolverine) are reported to Pretivm environment staff who may notify appropriate regulatory agencies and authorities, if required. These instances may be evaluated by Pretivm environment staff and corrective measures implemented in consultation with the Ministry of Environment, BC Conservation Officer Service, as appropriate. If wildlife is required to be trapped and relocated, BC Ministry of Forests, Lands and Natural Resources Operations are contacted for direction and the required permits.

Visual inspections of the transmission line are conducted annually to evaluate the condition of design features installed to reduce bird interactions. Inspectors are also on alert for evidence of bird mortality during inspection.

6.1.6 Incidental Wildlife and Wildlife Incident Monitoring

Wildlife observations by environment staff and other mine personnel are recorded in a general wildlife log. Objectives for keeping this log include:

- recording wildlife occurrence and activity in the Mine area;
- identifying unexpected conflicts or potential conflicts posed by existing Mine facilities to wildlife; and
- identifying needs for adaptive management if a new risk to wildlife, people, equipment, or infrastructure is identified.

Personnel are educated about the need to report observations of wildlife species interacting with Mine facilities to Pretivm environmental staff. Those wildlife observations are also reported to security or dispatch, or an observation is noted on a Field Level Hazard Assessment card, which has a section for reporting wildlife observations and incidents. All employees are trained on the use of Field Level Hazard Assessment cards in the initial orientation and when wildlife is observed, the following information is requested to be recorded, if possible:

- location, date, and time;
- type of interaction (e.g., attraction, nesting);
- species, number of animals;
- behaviour (e.g., feeding, resting);
- condition (e.g., limping, wounded, salivating); and
- any damage to or interaction with mine property.

Wildlife in poor condition, that may be diseased, or appear injured, is reported to Pretivm environmental staff for further investigation. The Principal, Environment reports these observations to regulatory authorities, as appropriate.

Where incidental sightings are clustered and result in hazards to wildlife and or people or property, possible causes will be investigated by a qualified environmental professional with a view to understanding the cause(s) for any attraction and to identify mitigation.

6.1.7 Mountain Goat and Avalanche Monitoring

Avalanche control is required in areas where avalanches may reach the BJAR and pose a safety concern to Mine personnel. Avalanche control may be required in mountain goat UWR and other areas that support mountain goats. Details on mountain goat monitoring, as it relates to avalanche control measures conducted at the Mine, are provided in the Mountain Goat Management Plan (Appendix C). Actions described in Appendix C for avalanche and goat management will also be applied to wolverine. Wolverine observations and incidents will be recorded during monitoring.

6.2 POPULATION MONITORING

Population monitoring is carried out for moose and mountain goat to detect potential effects of mine-related activities on these species.

Loss or alteration of moose, mountain goat, and grizzly bear habitat (including applicable UWRs and WHAs) will be modeled once during operation to compare total loss to the amount predicted in the EAC application / Environmental Impact Statement.

6.2.1 Moose Monitoring

To support the recovery, conservation, and management of the Nass moose population, Pretivm entered into a Contribution Agreement with the Province (BC MF) to participate in the Nass Moose Management Program (NMMP), as per Condition 15 of Environmental Assessment Certificate #M15-01 (see Section 4.2 of this plan). This Contribution Agreement requires a financial contribution to the NMMP and may require review, preparation, comments, or participation in drafts plans, final plans, and reports regarding the NMMP. Implementation of the financial contributions set out in the Contribution Agreement and participation in activities conducted as part of the NMMP are outside the scope of the WMP.

Pretivm also conducts periodic monitoring of the regional population of moose in a sub-set of the survey units surveyed during baseline studies for the Mine. Surveys occur every 5 years following provincial Resource Standards Information Committee standards, with the survey units determined in consultation with BC Ministry of Environment and Climate Change Strategy (BC MECCS). Moose surveys were completed in the late winter of 2018 and will be completed again in 2023. Reports are filed for internal monitoring purposes and submitted to indigenous groups for review and comment.

6.2.2 Mountain Goat Monitoring

Pretivm conducts periodic monitoring of the regional population of mountain goat in a sub-set of the survey units surveyed during baseline studies for the Mine. Surveys occur every 5 years following provincial Resource Standards Information Committee standards, with survey units determined in consultation with BC MECCS. The Mountain Goat Management Plan is provided in Appendix C.

6.3 WORK PLANNING AND SCHEDULE

Management measures are implemented to avoid, eliminate, or minimize adverse effects on wildlife and wildlife habitat throughout the remaining mine phases. Table 6.3-1 summarizes the Mine phases to which the various wildlife management measures are applicable. Table 6.3-2 summarizes the frequency of monitoring.

Table 6.3-1. Management Activities for Wildlife and Associated Mine Phases

Management Activity	Operations	Closure/Temp. Closure	Post-closure
Vegetation Clearing Management	X		
Road and Traffic Management	X	X	
Access Management	X	X	
Aircraft Management	X	X	X
Building and Waste Management	X	X	
Personnel Education and Training	X	X	X

Table 6.3-2. Performance Monitoring Activities for Wildlife and Associated Mine Phases

Monitoring Activity	Operations	Closure/Temp. Closure	Post-closure
Vegetation Clearing Monitoring[1]	X		
Road and Traffic Monitoring	X	X	
Access Monitoring	X	X	
Aircraft Monitoring	X	X	
Building and Waste Monitoring	X	X	
Incidental Wildlife and Wildlife Incident Monitoring	X	X	X
Avalanche Control Monitoring (Goats)	X	X	
Population Monitoring (Goat and Moose)	X		

[1] Vegetation clearing monitoring will only occur if construction/clearing activities take place during sensitive timing window for the various wildlife VCs, as described in Table 5.1-1.

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance Reporting

Compliance reporting is subject to Environmental Assessment Certificate and *Land Act* and *Mines Act* Permit conditions.

7.1.2 External / Internal Reporting

Internally, all personnel are to report wildlife observations made anywhere within the Mine area. Externally, Pretivm reports on WMP results annually summarizing, where pertinent, the monitoring methods and results, incidental observations, incidents, and adaptive mitigation measures.

7.1.3 Incident Reporting

Incident reporting includes vehicle collisions with wildlife, encounters with wildlife, aerial observations from pilots, and wildlife interactions with Mine infrastructure and waste handling systems. In addition, any mortality and/or encounters during vegetation clearing surveys, or other mortality events, are reported.

7.1.4 Monitoring Results

Pretivm maintains wildlife related records / data. Data is entered in a format and program that allows for comparison between years.

7.1.5 Continuous Improvement, Follow-up, and Adaptive Management

Mitigation measures are continuously improved by recording incidents involving wildlife and following up on these incidences and implementing adaptive management if current mitigation measures are ineffective. Some of these mitigation measures may include, reducing speed limits on certain sections of road where wildlife is frequently sighted, adapting our waste storage (animal proof bins, bins with hydraulic lids) if there are wildlife proximity concerns, changing our electric fence patterns around camp to deter bears, creating extra push ins to allow animals to exit roads, or education for workers.

7.1.6 Wildlife Advisory Committee

Pretivm chairs a Wildlife Advisory Committee to discuss the results of compliance and wildlife monitoring studies, and mitigation actions on the site on an annual basis. The committee comprises representatives from BC MECCS Tsetsaut/Ski km Lax Ha First Nation, Tahltan First Nations, Nisga'a Lisims Government, and Pretivm, with Pretivm to act as the chair of the committee. The membership and terms of reference for this committee were set at the first meeting. The timing of meetings follows submission of annual compliance and monitoring reports for review and discussion by the committee.

8 REFERENCES

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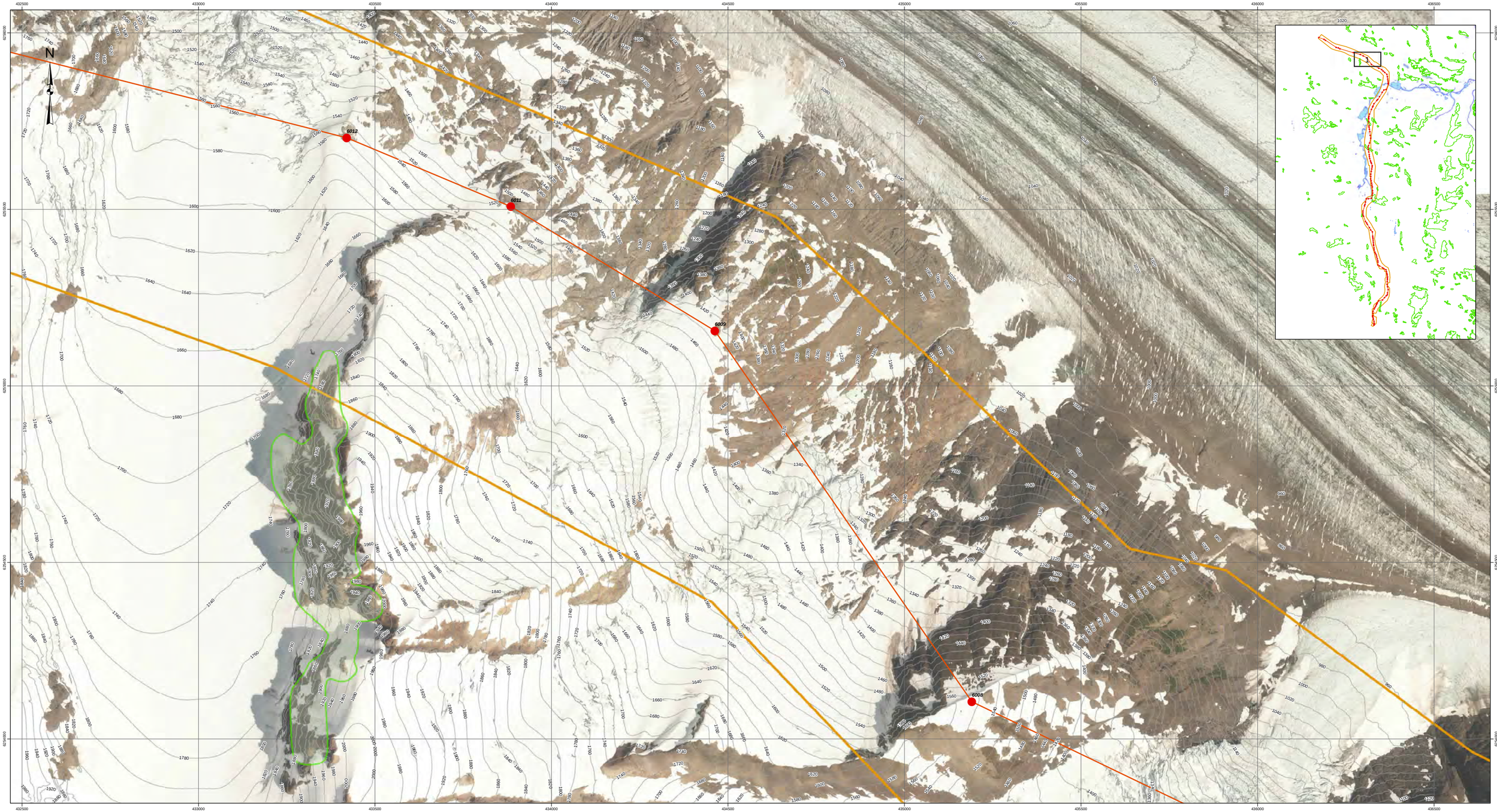
Appendix A

Figures



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

PRETIVM

1600–750 Granville St.
Vancouver, BC V6C 3P1
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(604) 558–1784

PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130		1:5,000	3 Feb 2015		1

PROJECTION: UTM Zone 9 (NAD 83)

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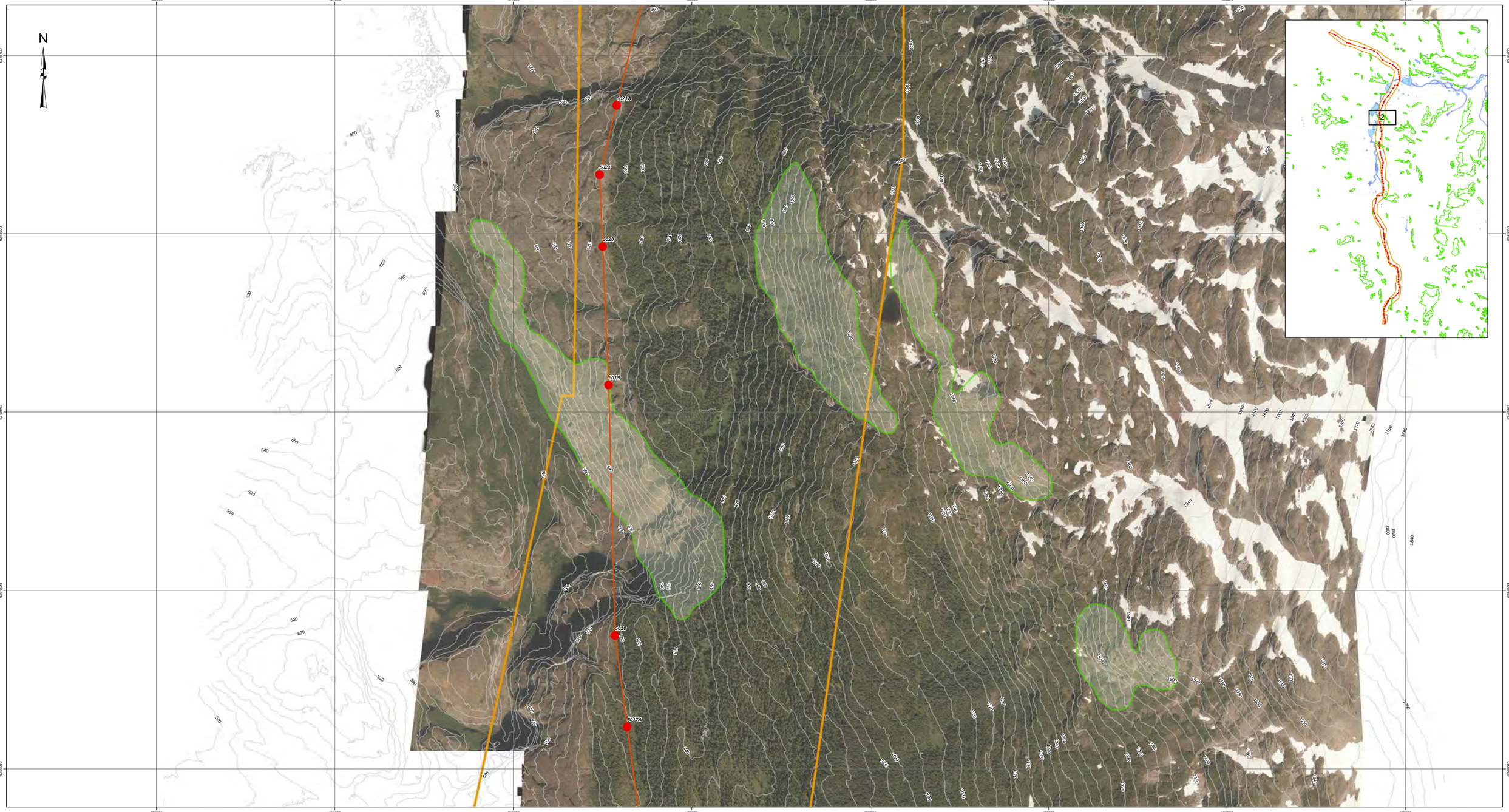

Legend

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- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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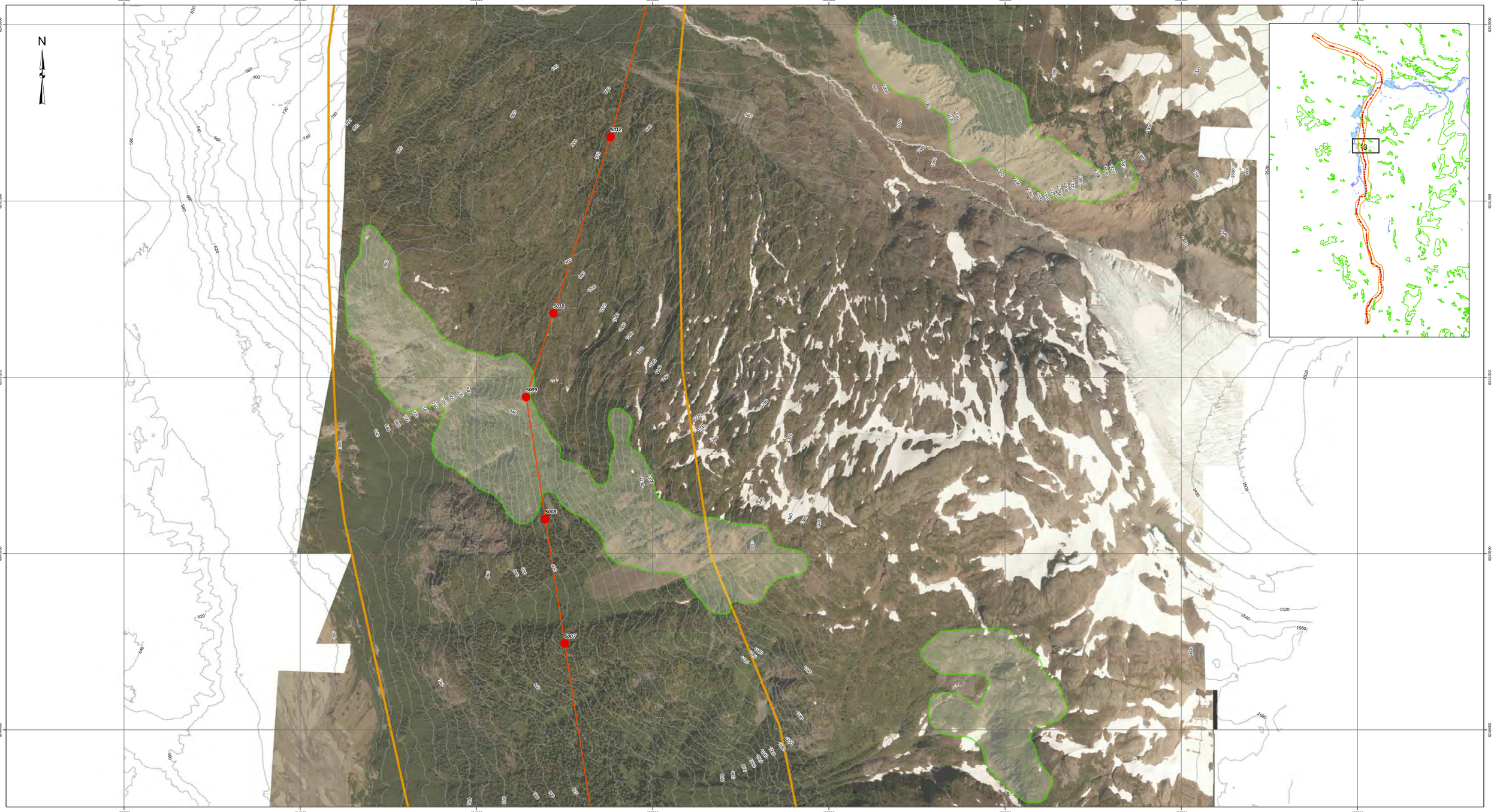
PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_2	UTM Zone 9 (NAD 83)		1:5,000	3 Feb 2015		2

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	TITLE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_3		1:5,000	3 Feb 2015		3

PROJECTION: UTM Zone 9 (NAD 83)

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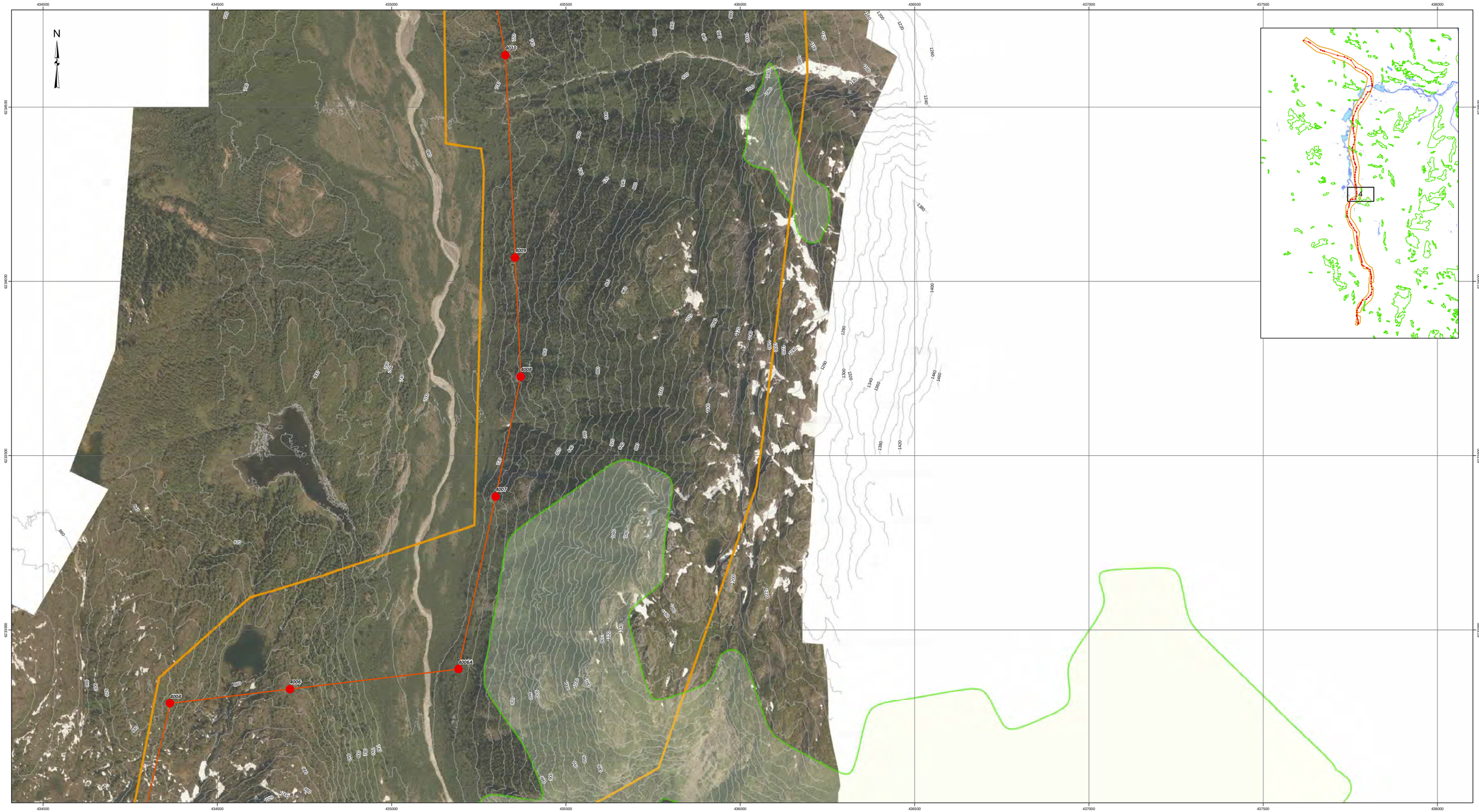

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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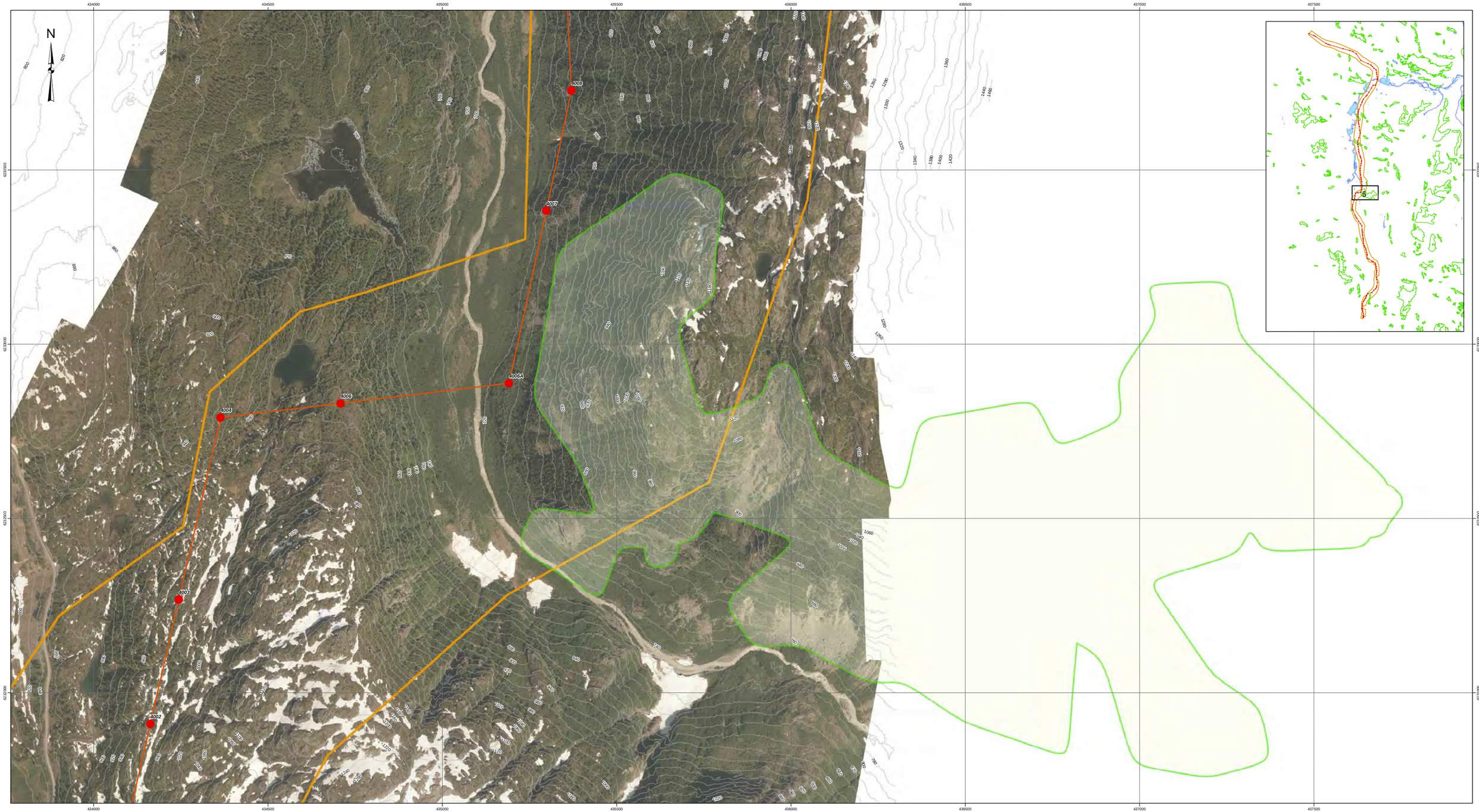
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_4		1:5,000	3 Feb 2015		4

PROJECTION: UTM Zone 9 (NAD 83)

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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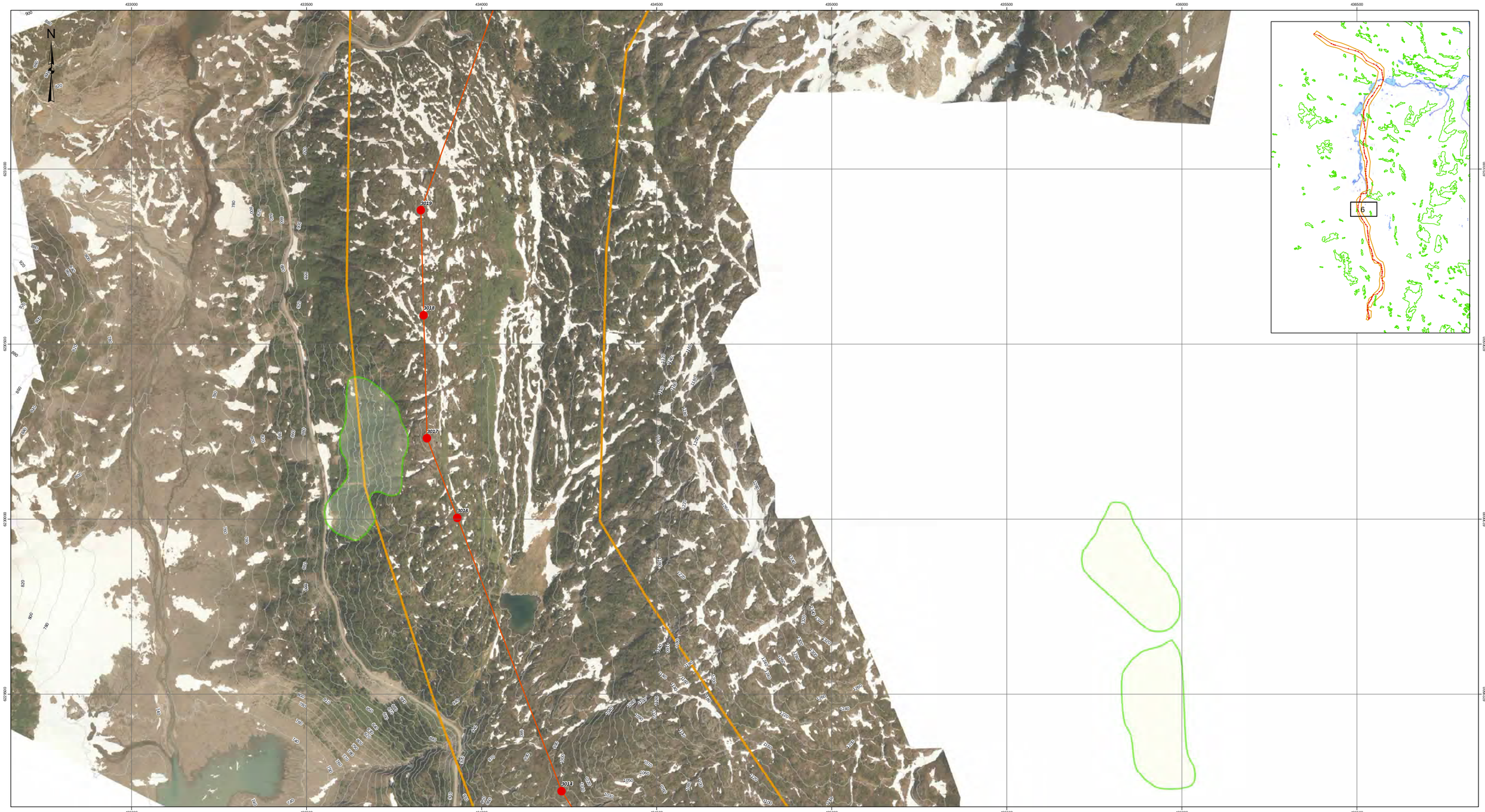
PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECTION:	PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	ISSUE #:
UTM Zone 9 (NAD 83)		Transmission_Line_Ungulate_22x34_20150130_5		1:5,000	3 Feb 2015		5

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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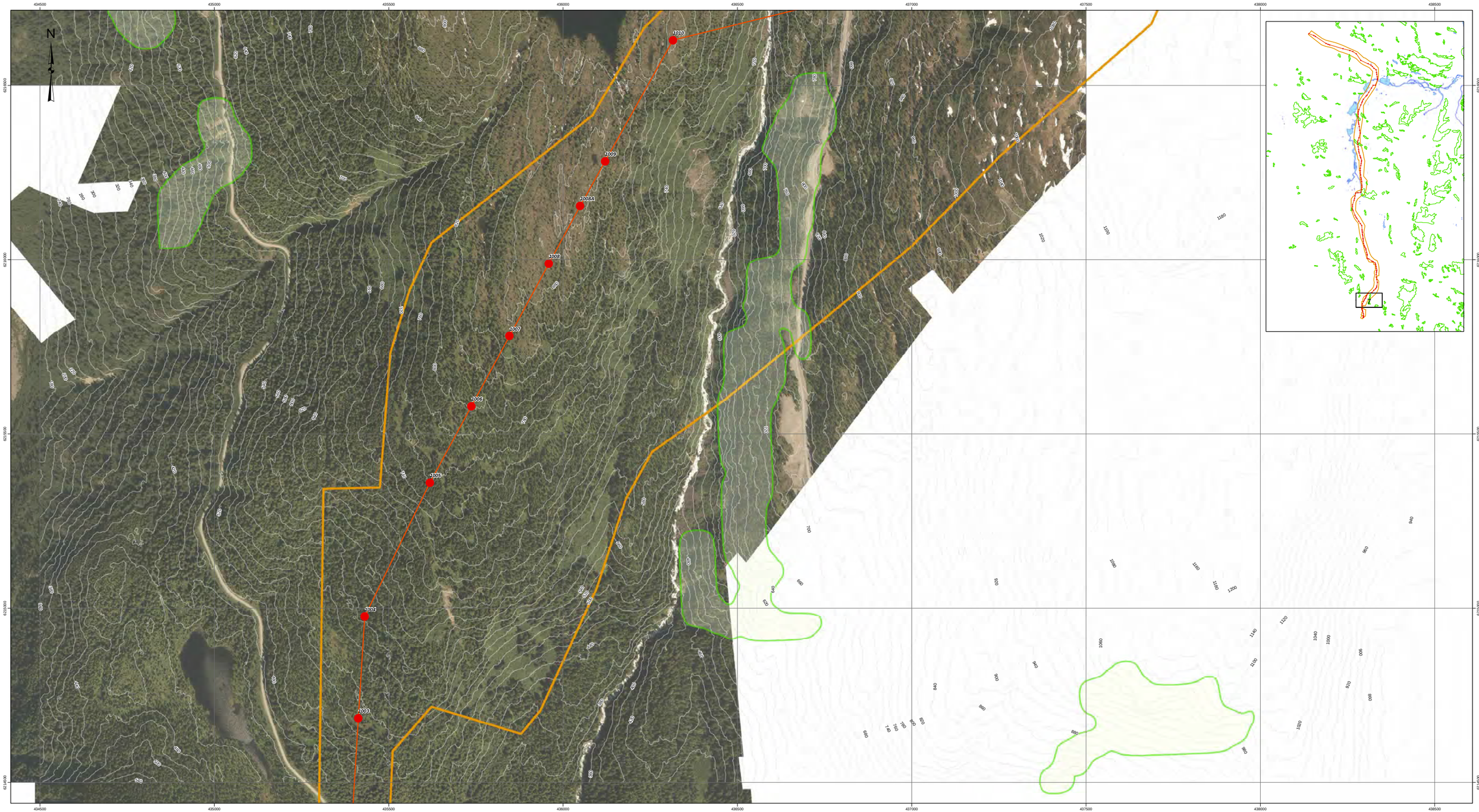
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECTION:	PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
UTM Zone 9 (NAD 83)		Transmission_Line_Ungulate_22x34_20150130_6		1:5,000	3 Feb 2015		6

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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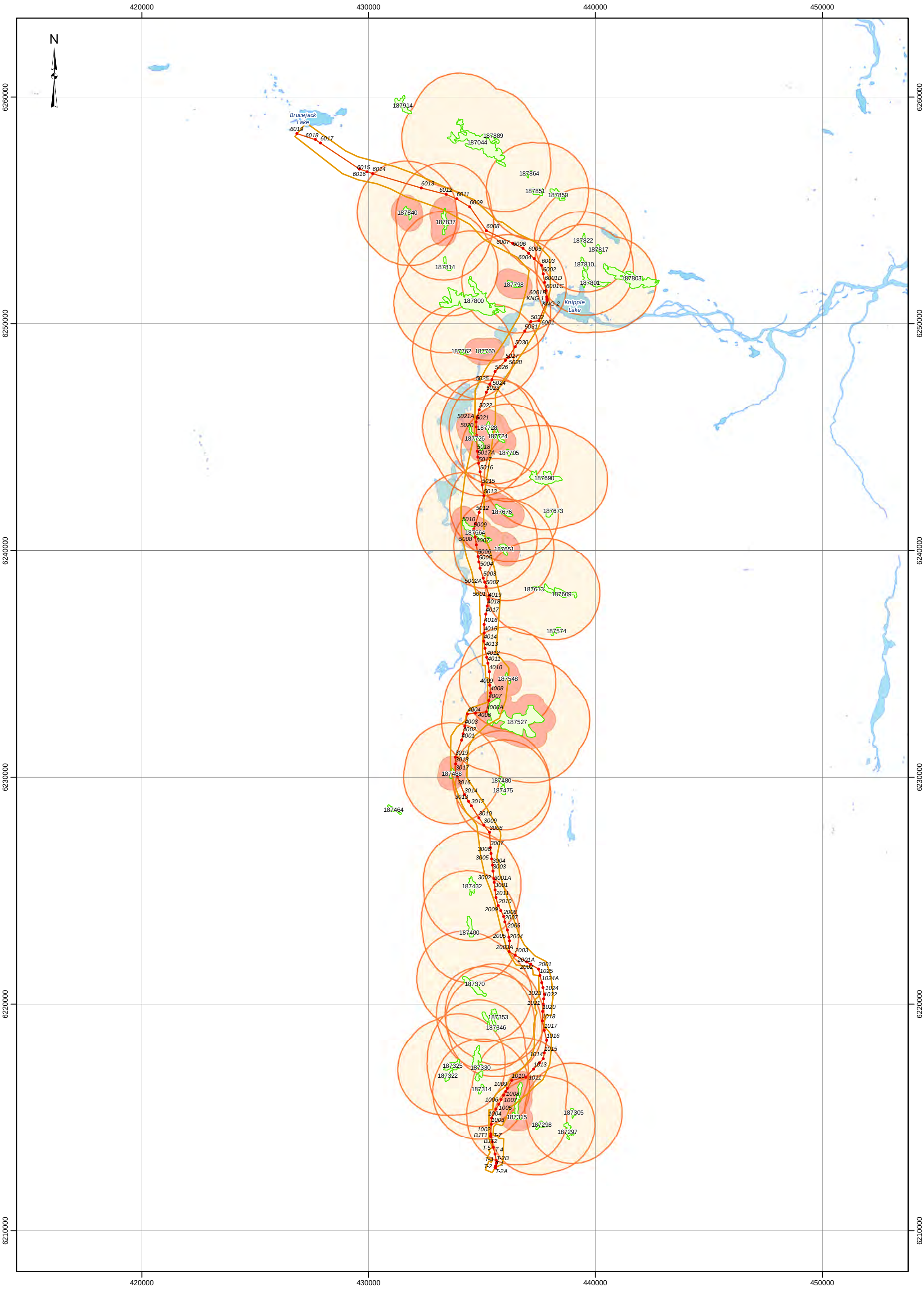
PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECTION: UTM Zone 9 (NAD 83)

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_7		1:5,000	3 Feb 2015		7

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Transmission Line Corridor (as of 9 Jan 2015)
- Mountain Goats Along Transmission Line
- 2 Km Buffer
- 500m Buffer

0 1 2 4 6 8
Kilometers

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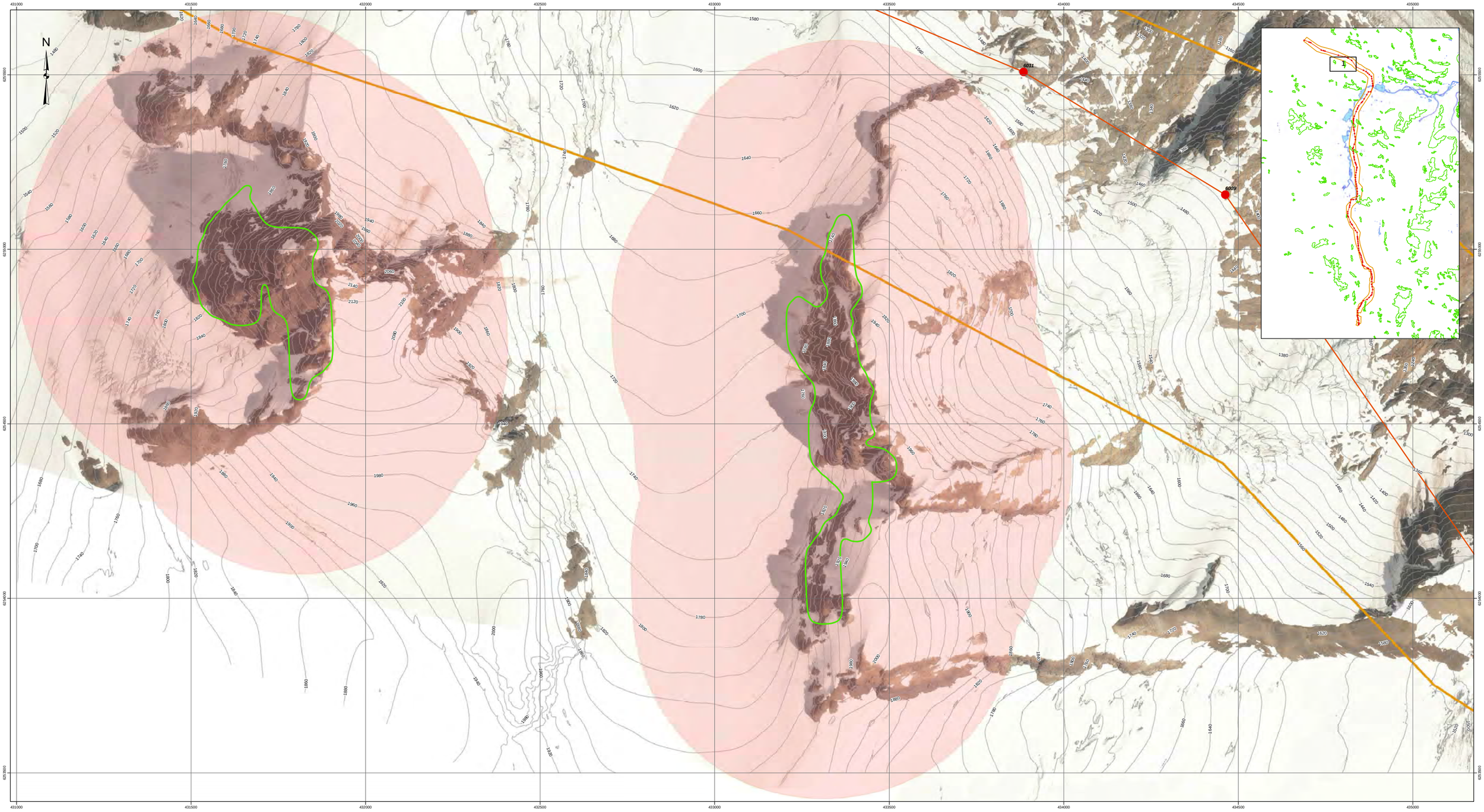
Mountain Goats Along Transmission Line

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_11x17_20150212_Overview		1:150,000	12 Feb 2015		

PROJECTION: UTM Zone 9 (NAD 83)



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundry Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_1_Buffer		1:5,000	10 Feb 2015		1

PROJECTION: UTM Zone 9 (NAD 83)

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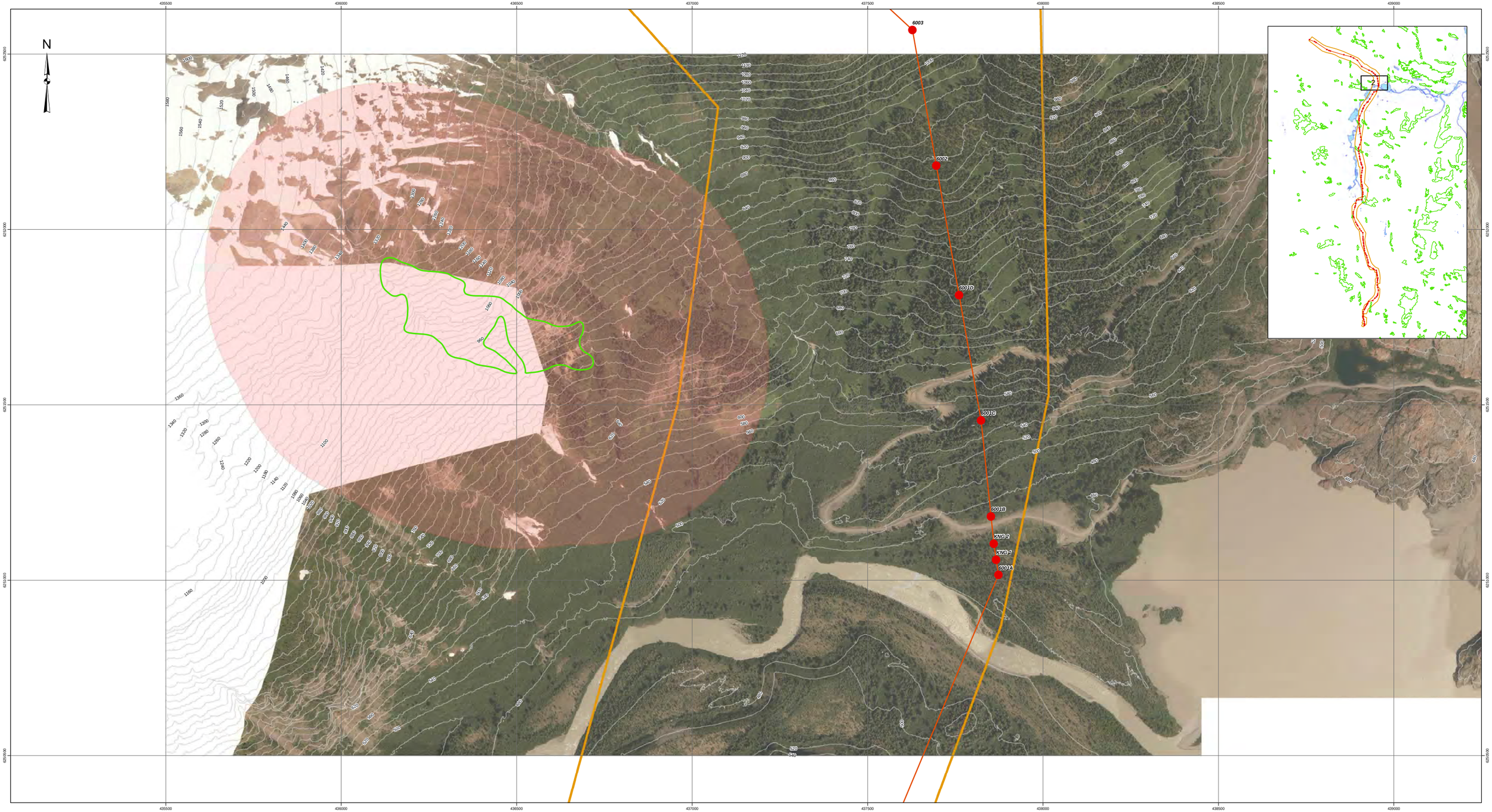

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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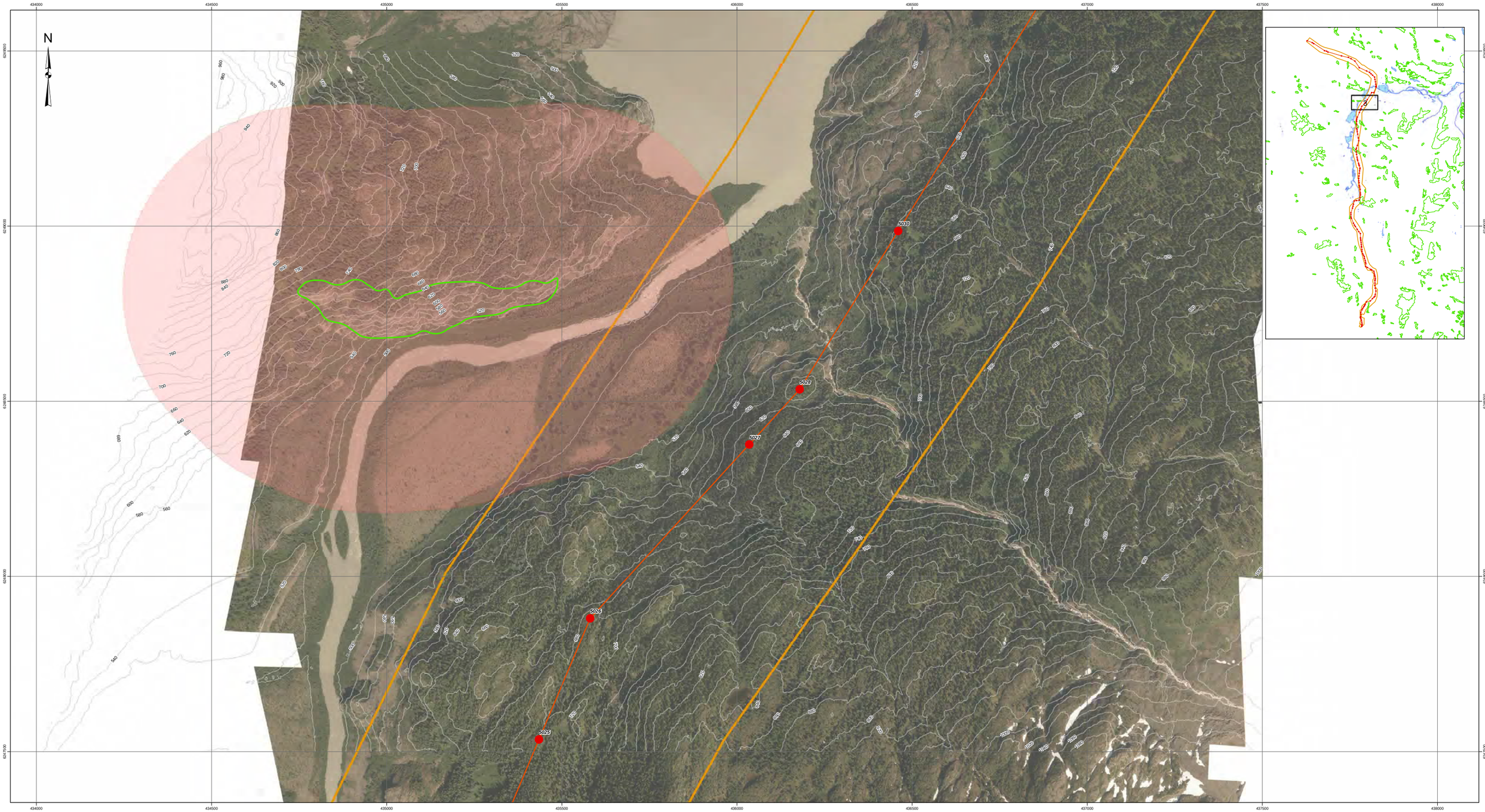
Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_2_Buffer	UTM Zone 9 (NAD 83)		1:5,000	11 Feb 2015		2

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	TITLE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_3_Buffer		1:5,000	11 Feb 2015		3

PROJECTION: UTM Zone 9 (NAD 83)

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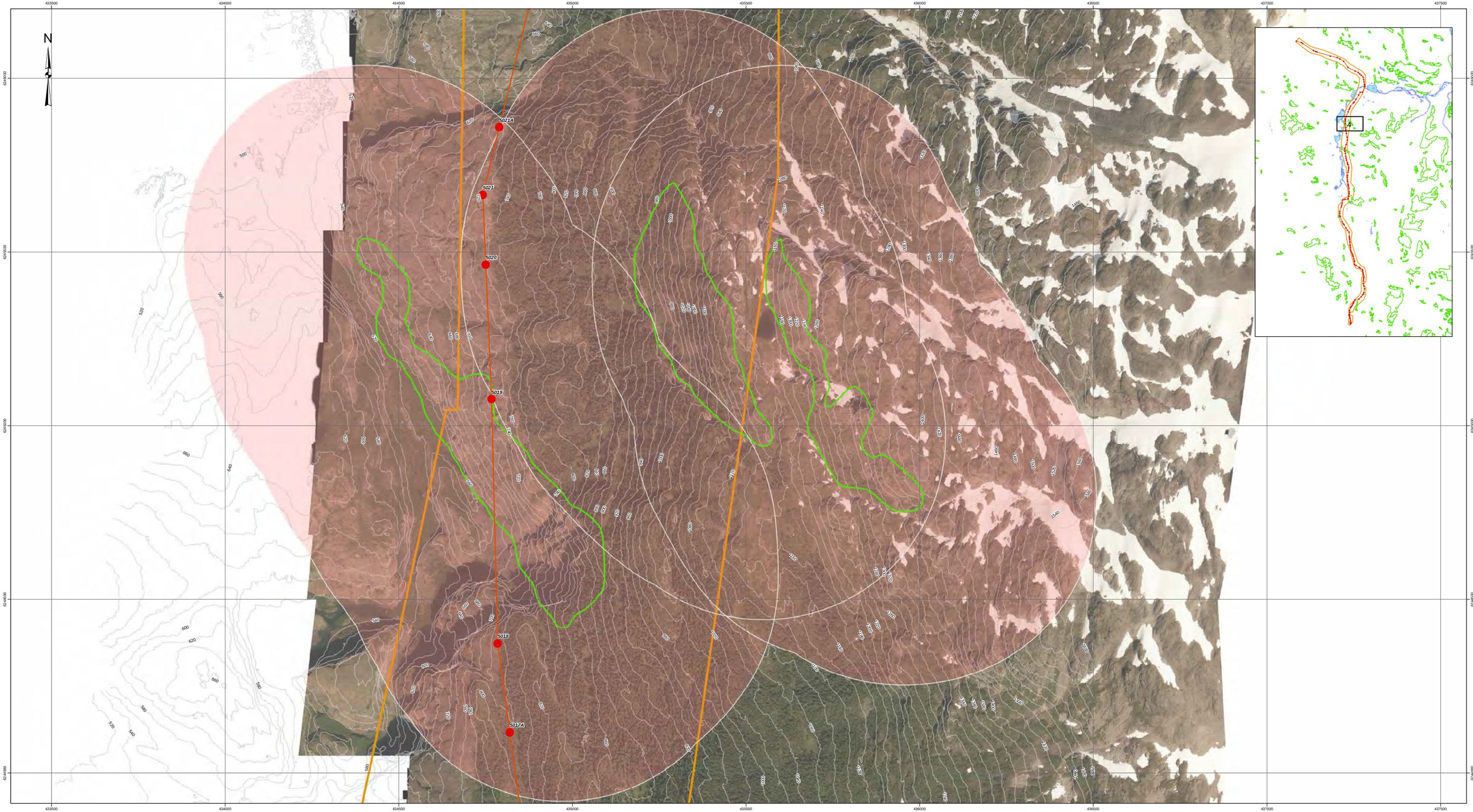

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV.	SCALE:	DATE:	DOCUMENT:	FIGURE #
	Transmission_Line_Ungulate_22x34_20150130_4_Buffer		1:5,000	11 Feb 2015		4

PROJECTION: UTM Zone 9 (NAD 83)

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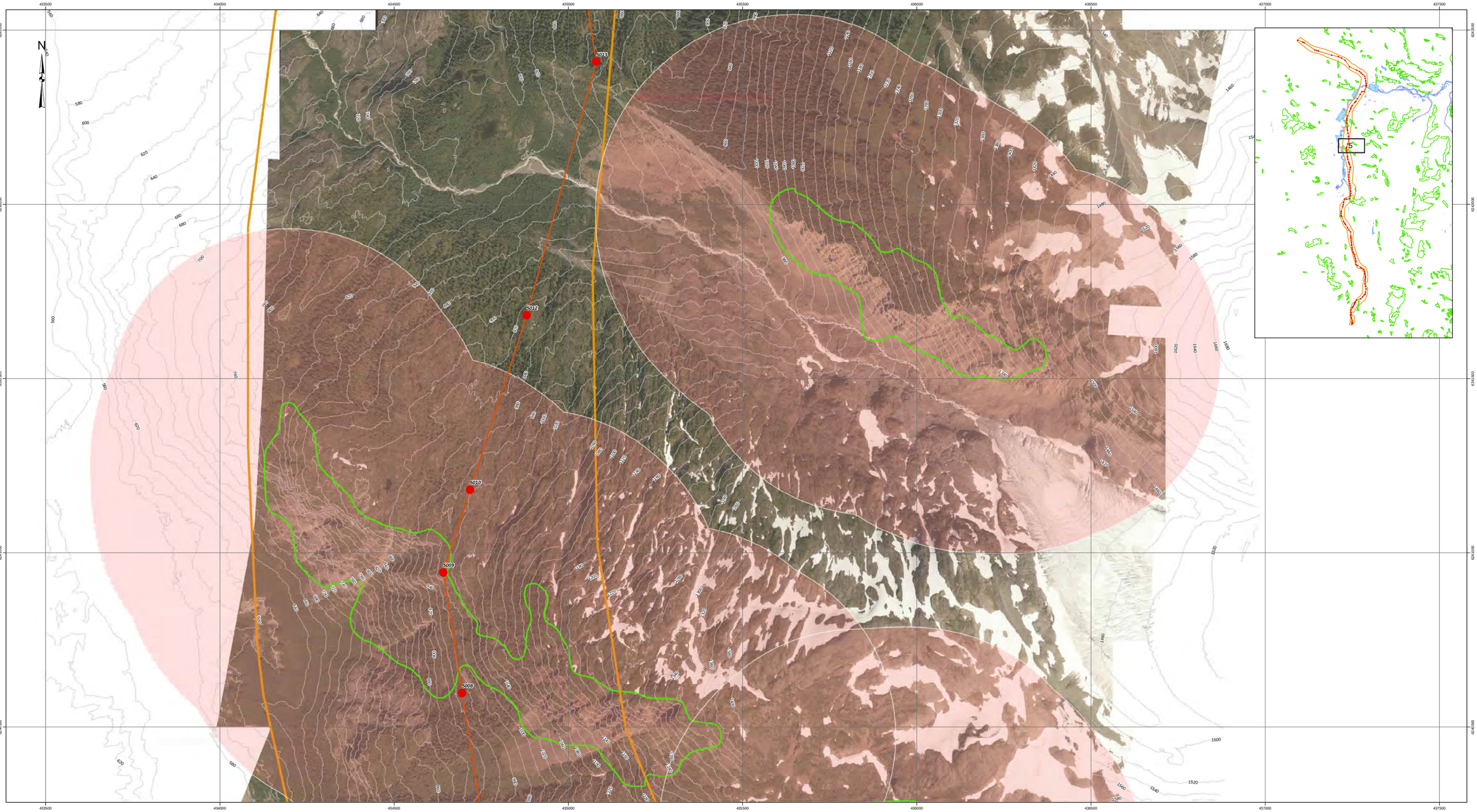

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_5_Buffer		1:5,000	11 Feb 2015		5

PROJECTION: UTM Zone 9 (NAD 83)

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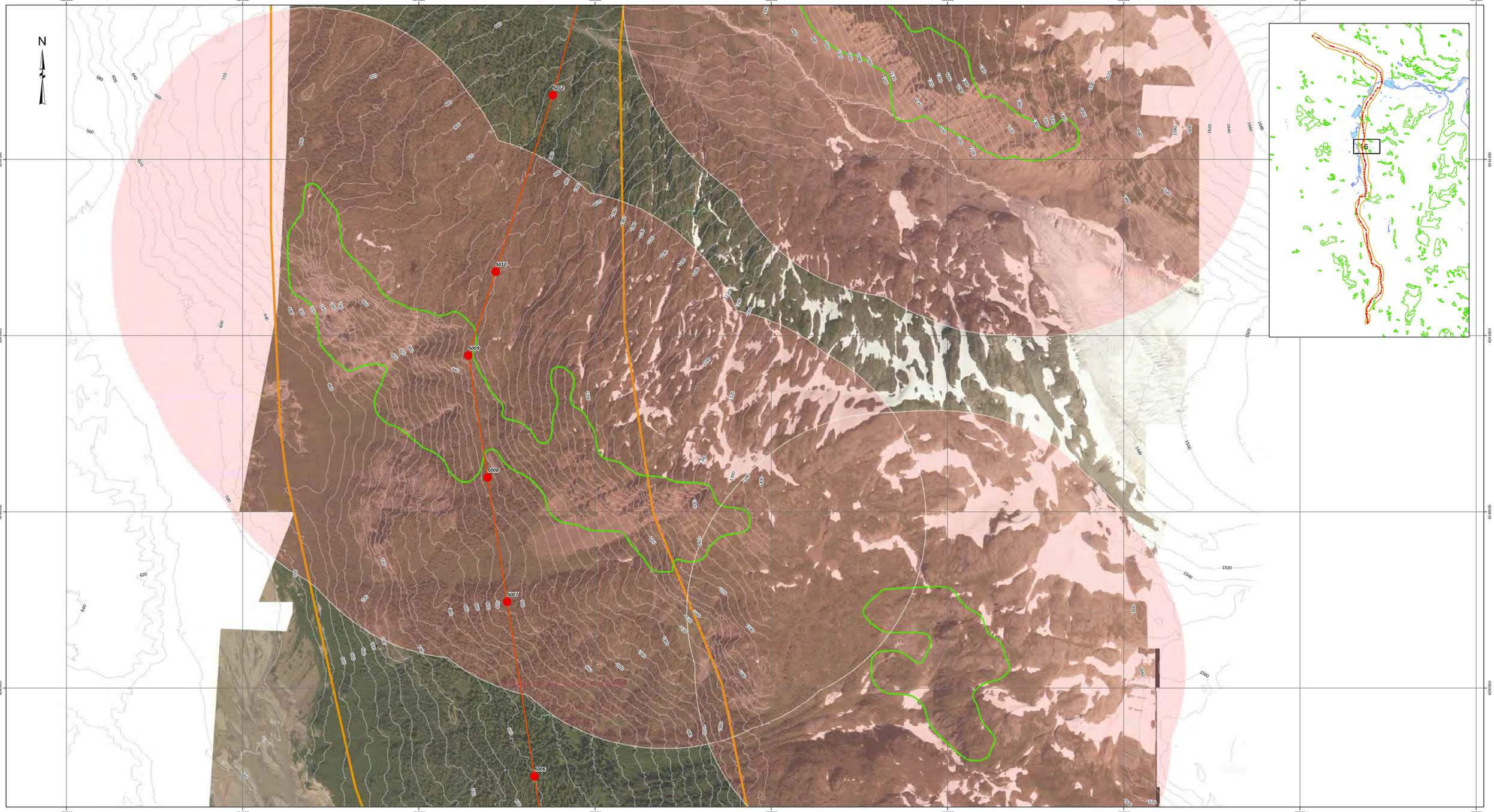

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_6_Buffer		1:5,000	11 Feb 2015		6

PROJECTION: UTM Zone 9 (NAD 83)

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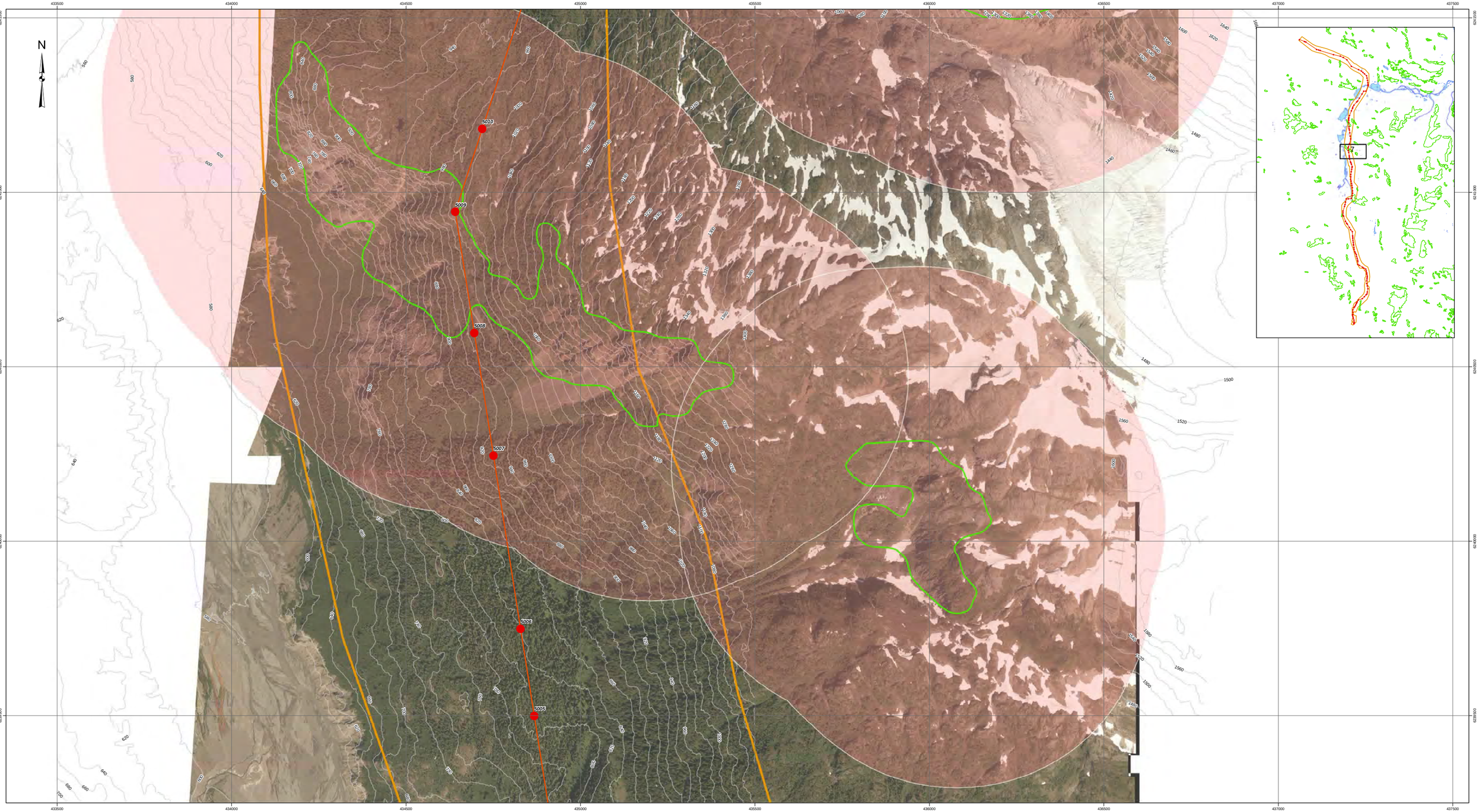

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_7_Buffer		1:5,000	11 Feb 2015		7

PROJECTION: UTM Zone 9 (NAD 83)

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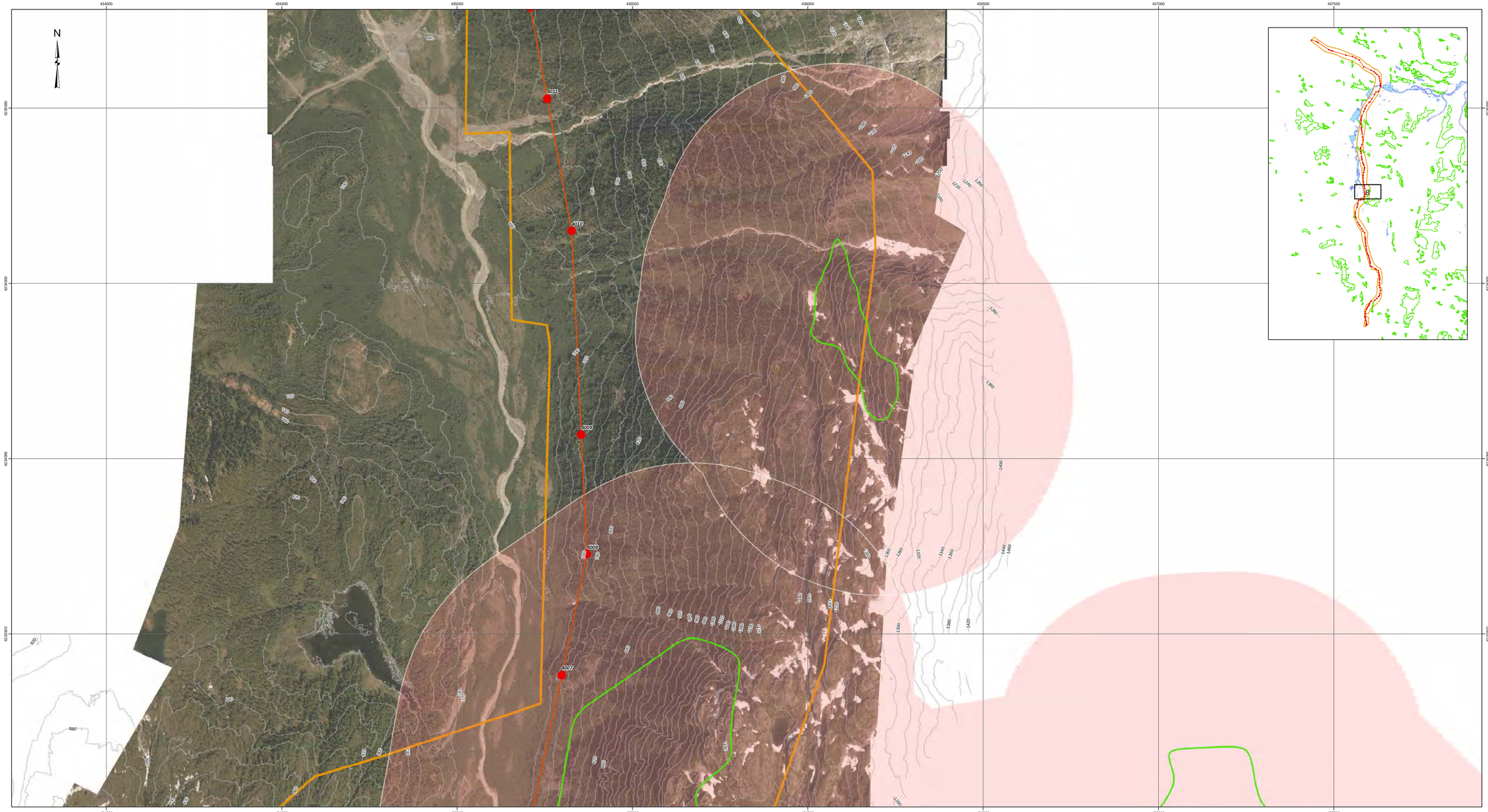

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PROJECTION: UTM Zone 9 (NAD 83)

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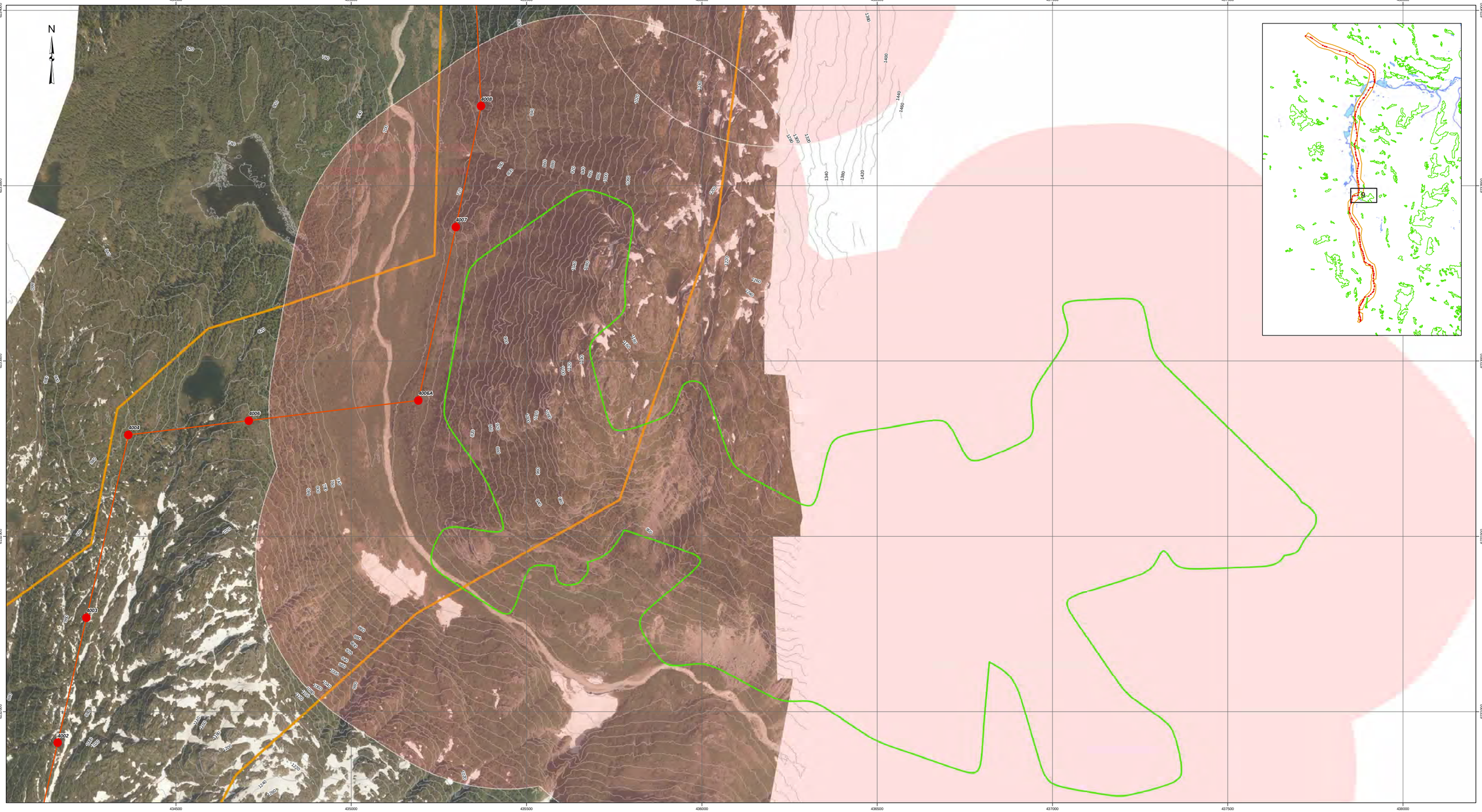
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_8_Buffer		1:5,000	3 Feb 2015		8

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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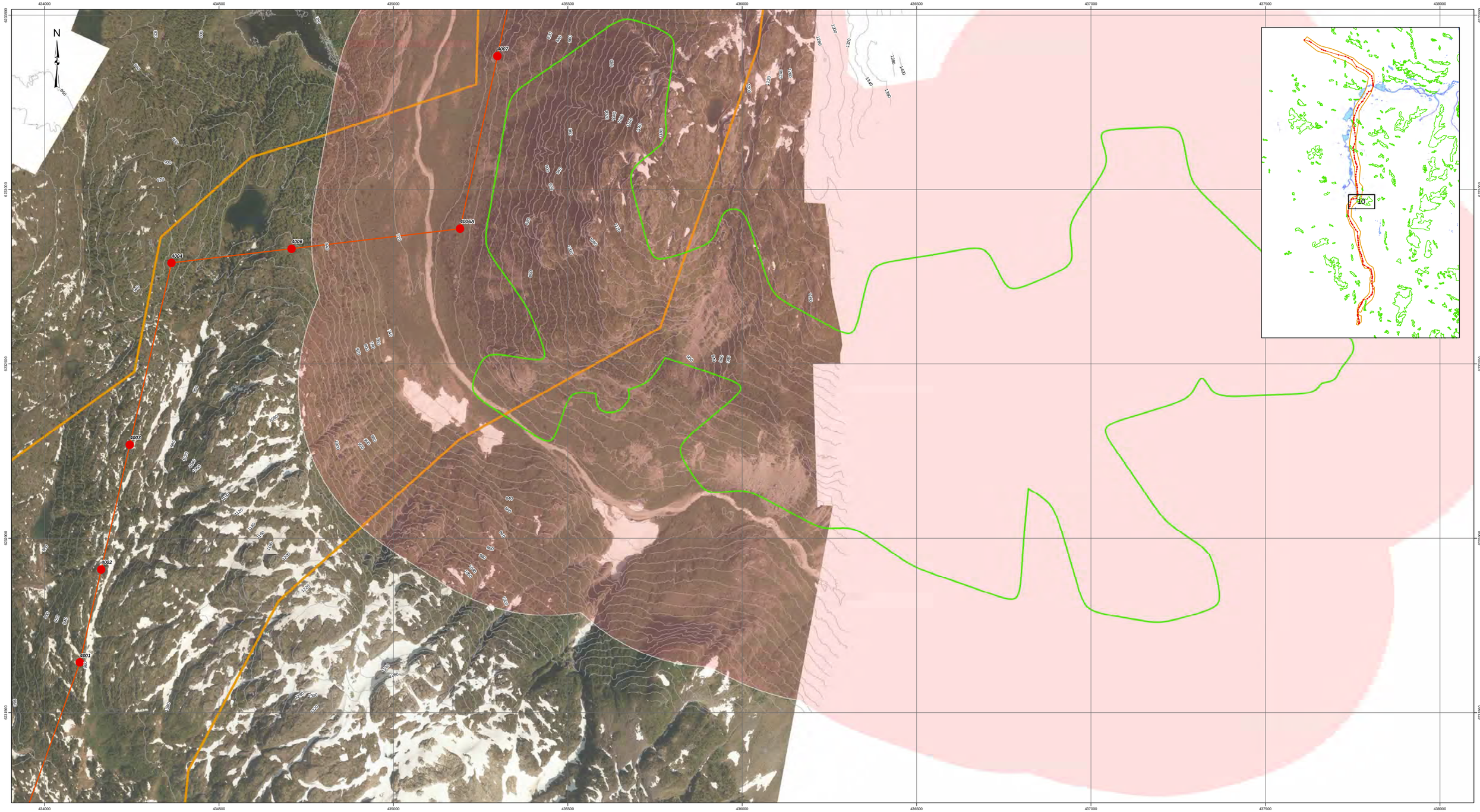
Mountain Goat Area Along Transmission Line

PROJECTION:	UTM Zone 9 (NAD 83)

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_9_Buffer		1:5,000	12 Feb 2015		9

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECTION:	PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
UTM Zone 9 (NAD 83)		Transmission_Line_Ungulate_22x34_20150130_10_Buffer		1:5,000	12 Feb 2015		10

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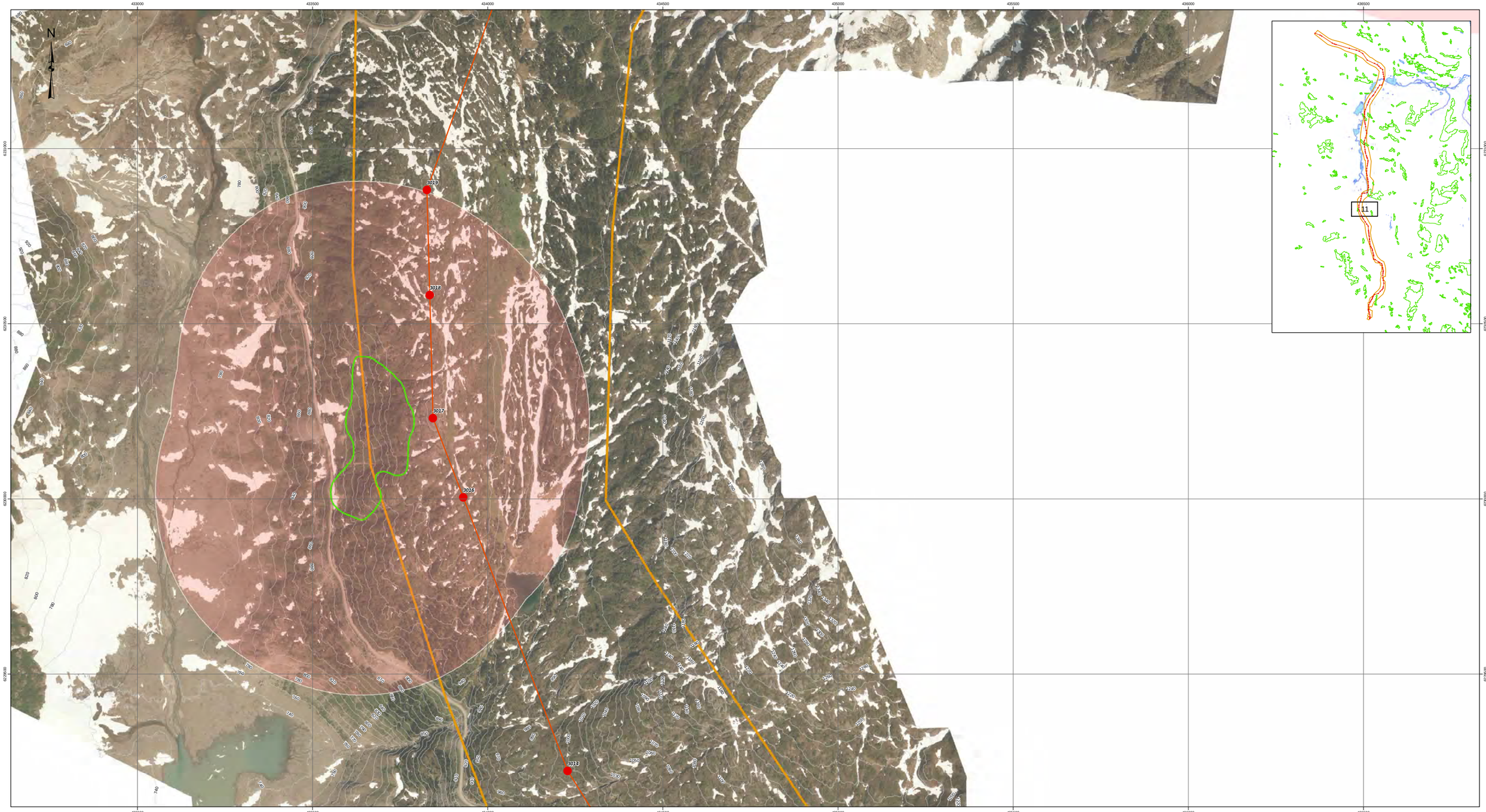

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_11_Buffer		1:5,000	12 Feb 2015		11

PROJECTION: UTM Zone 9 (NAD 83)

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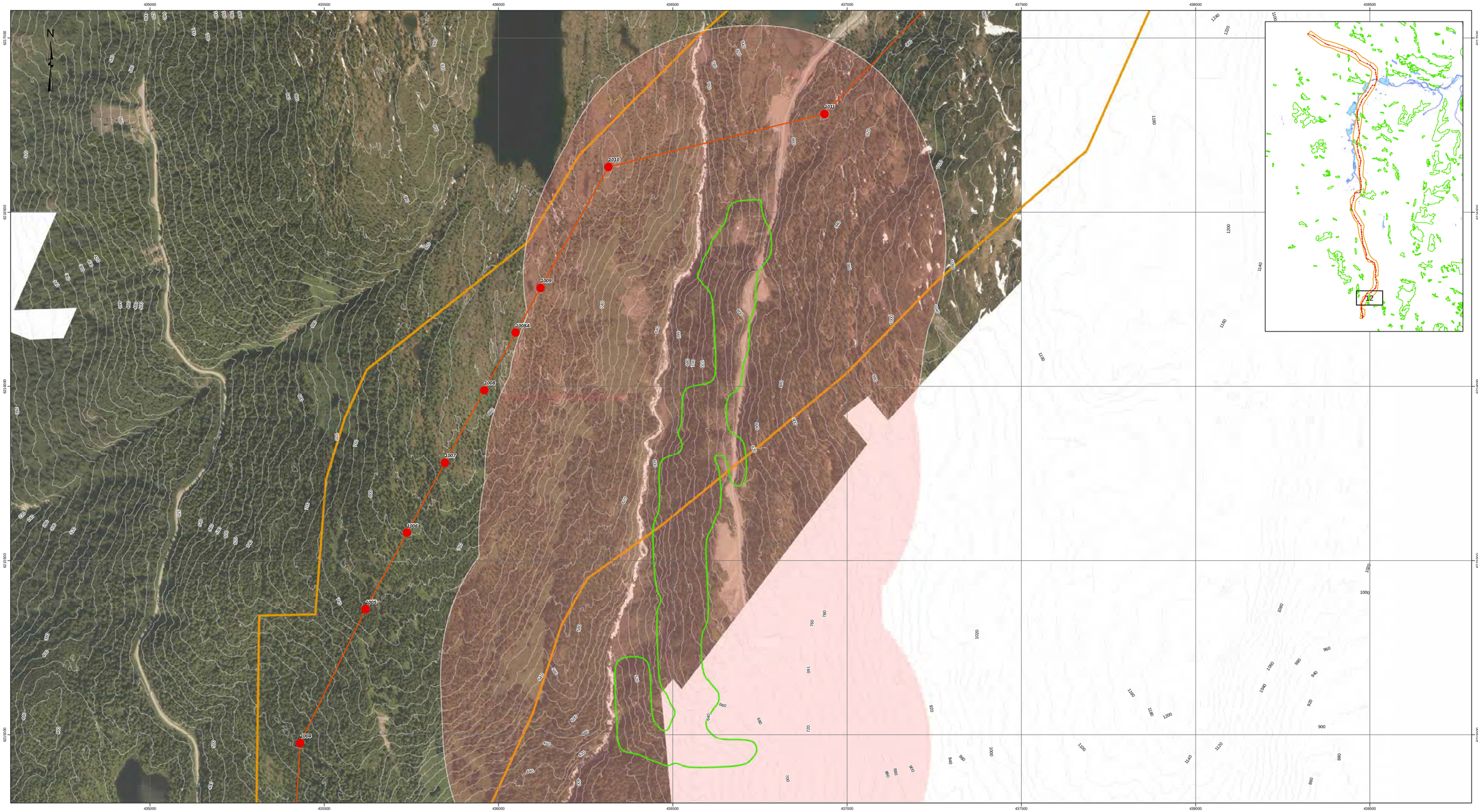

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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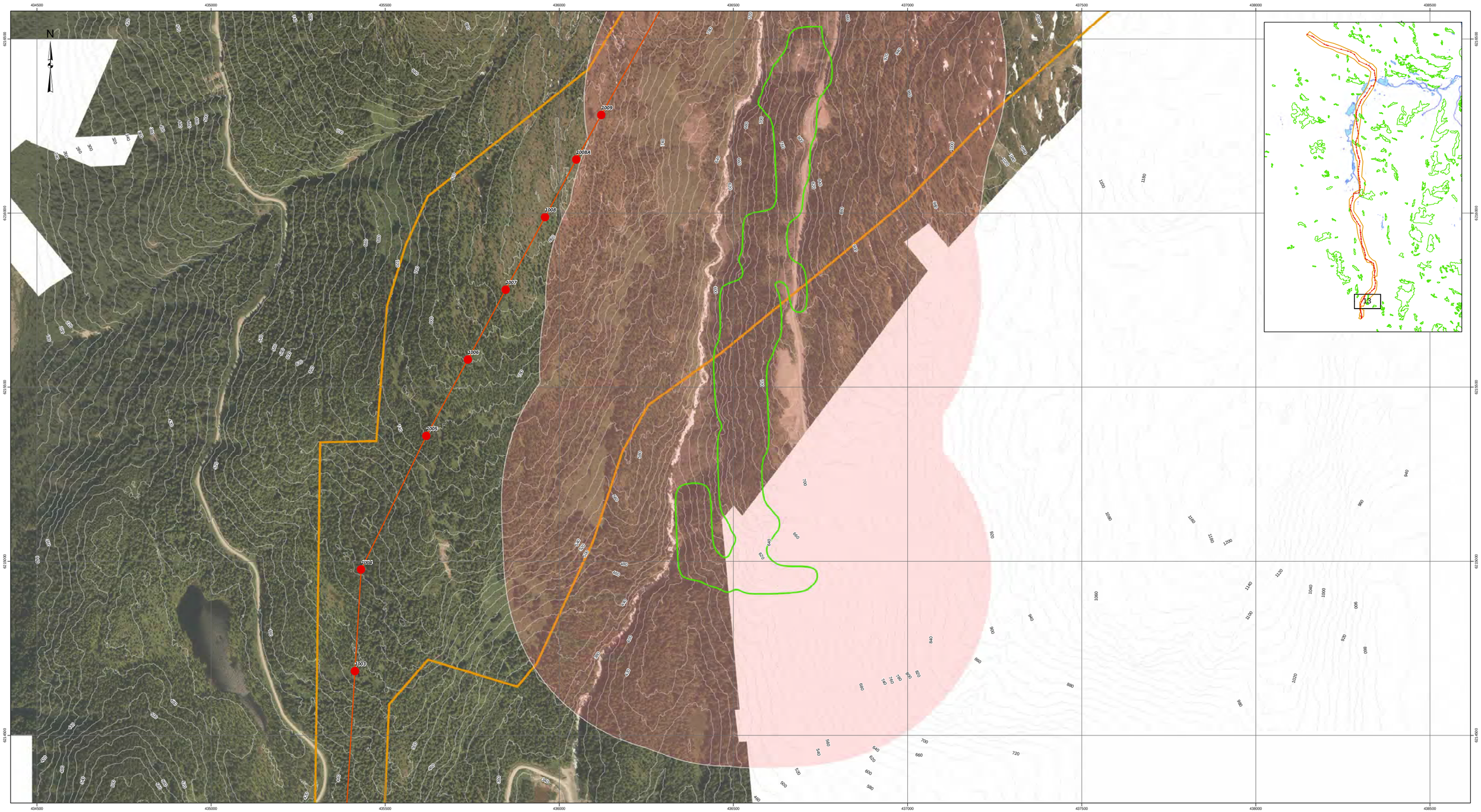
PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT PROJ: UTM Zone 9 (NAD 83)

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_12_Buffer		1:5,000	12 Feb 2015		12

This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150130_13_Buffer		1:5,000	12 Feb 2015		13

PROJECT REF: UTM Zone 9 (NAD 83)

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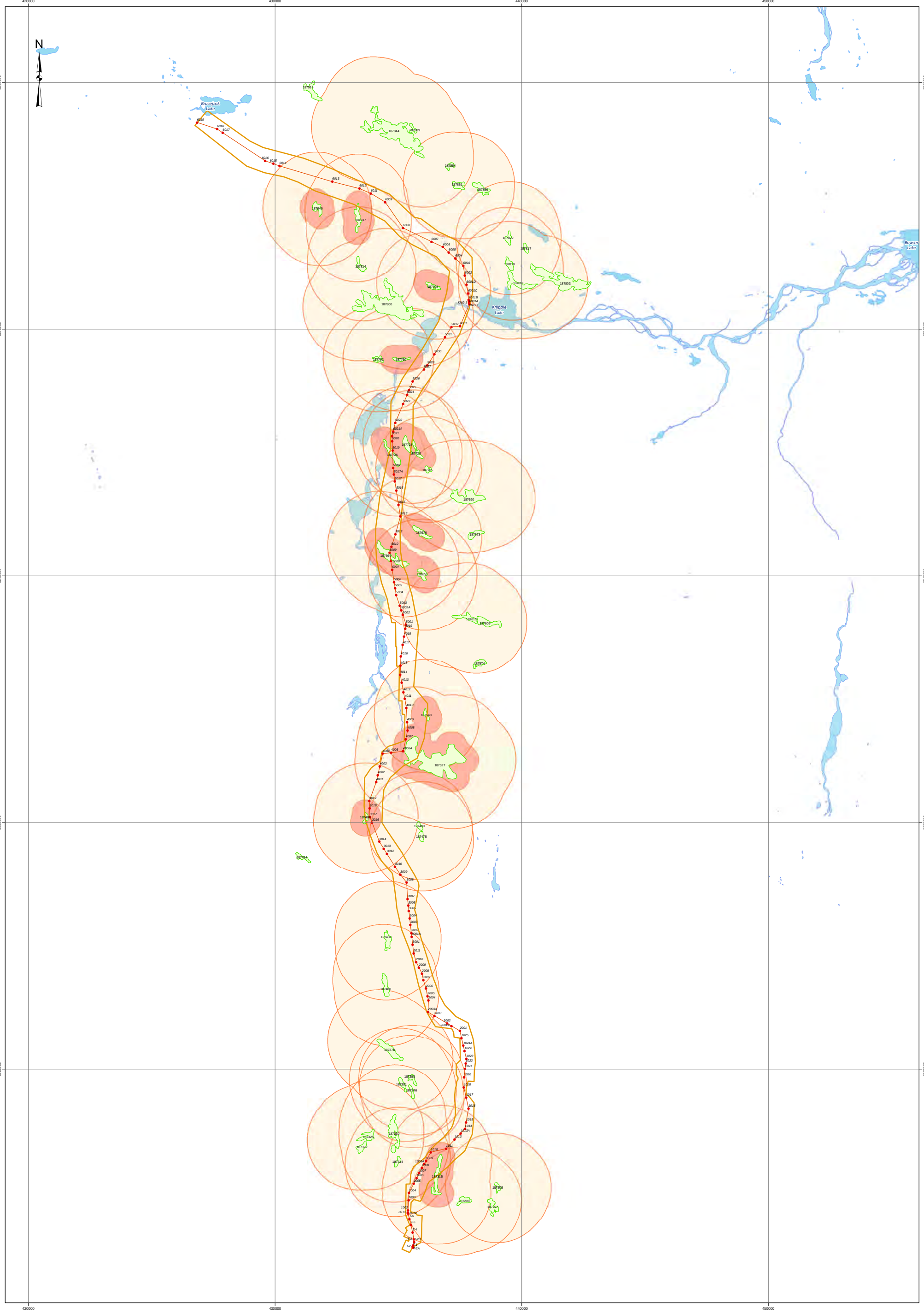

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Transmission Line Corridor (as of 9 Jan 2015)
- Mountain Goats Along Transmission Line
- 2 Km Buffer
- 500m Buffer

0 0.75 1.5 3 4.5 6
Kilometers

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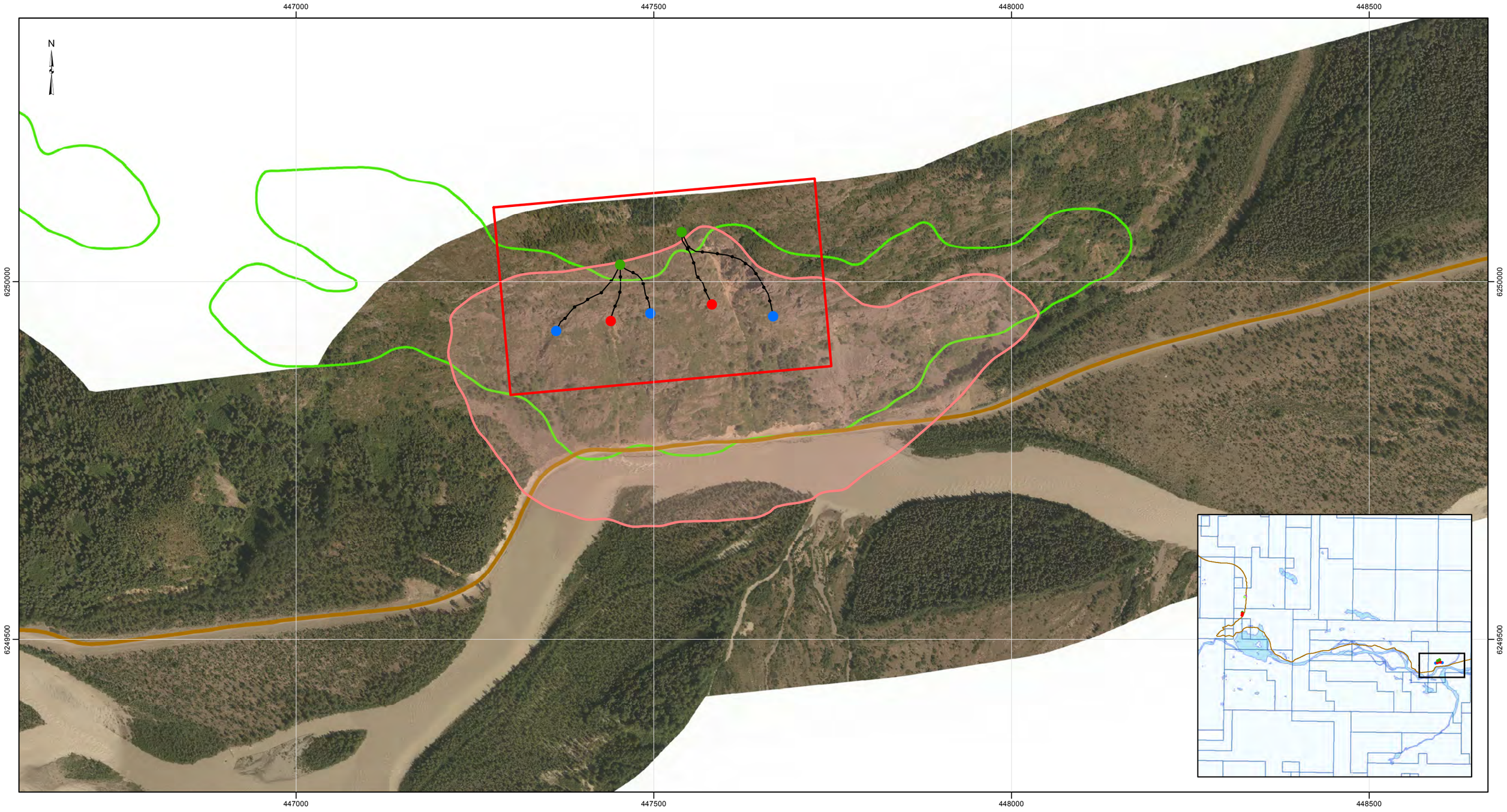
Mountain Goats Along Transmission Line

PROJECTION: UTM Zone 9 (NAD 83)

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Transmission_Line_Ungulate_22x34_20150212_Overview		1:70,000	12 Feb 2015		



Legend

- 0.8m³ Inertia Exploder
- 1.5m³ Inertia Exploder
- 3m³ Inertia Exploder
- Primary Control Shelter Location
- Alternate Control Shelter Location
- Propane Gas Pipelines
- Access Road
- Avalanche Area
- Ungulate Winter Range
- Avalanche Control LOO (Area: 11.9 Ha)

0 35 70 140 210 280
Meters

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	Avalanche_Control_11x17_1_LoO_20150413		1:5,000	13 Apr 2015		

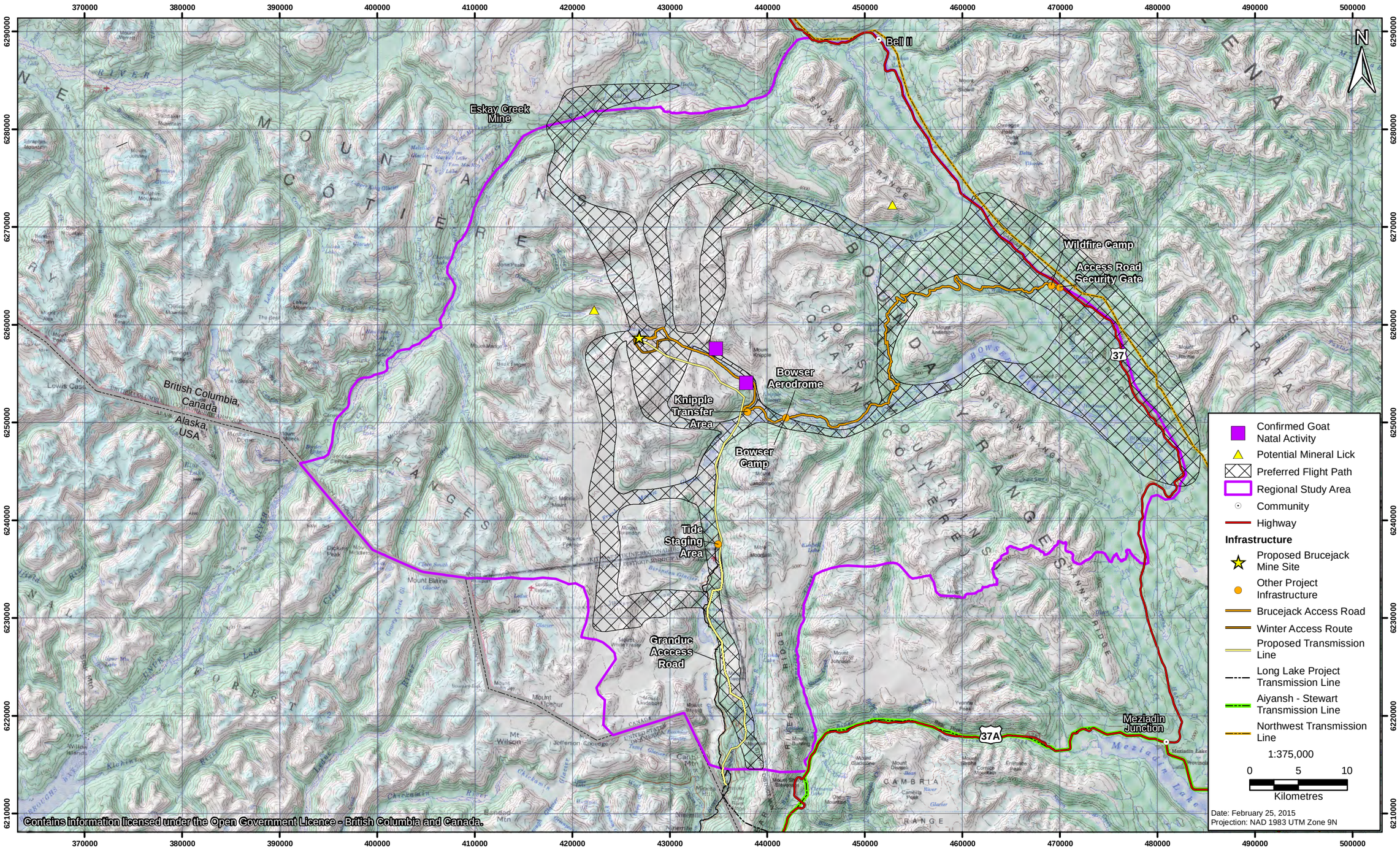
PRETIVM

1600–570 Granville St.
Vancouver, BC V6C 3P1
Canada
(604) 558–1784

PROJECTION: UTM Zone 9 (NAD 83)

PRETIUM EXPLORATION INC.
Brucejack Exploration Site

Licence of Occupation
Avalauncher Sites
(Km 44)
Site Specific Map


Bell II
Eskay Creek Mine
Wildfire Camp
Access Road Security Gate
Bowser Aerodrome
Knipple Transfer Area
Bowser Camp
Tide Staging Area
Granduc Acccess Road
Mezidin Junction
British Columbia, Canada
Alaska, USA
37
37A
N
Confirmed Goat Natal Activity
Potential Mineral Lick
Preferred Flight Path
Regional Study Area
Community
Highway
Infrastructure
Proposed Brucejack Mine Site
Other Project Infrastructure
Brucejack Access Road
Winter Access Route
Proposed Transmission Line
Long Lake Project Transmission Line
Aiyansh - Stewart Transmission Line
Northwest Transmission Line
1:375,000
0 5 10
Kilometres
Date: February 25, 2015
Projection: NAD 1983 UTM Zone 9N
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Appendix B

Wildlife Attractant Zero Tolerance Policy

WILDLIFE ATTRACTANT ZERO TOLERANCE POLICY

1. Purpose

The purpose of this Policy is to establish a zero-tolerance approach to improper disposal and allowing access to wildlife attractant infractions at the Brucejack mine site (i.e., including all camps, roads and associated infrastructure), and clarify what constitutes a wildlife attractant infraction.

2. Scope

This policy applies to all Newcrest employees as well as all contractors, suppliers, and visitors, working at or visiting Brucejack mine site and exploration sites.

3. Regulatory / Permit Requirements and Penalties

Newcrest has legally enforceable requirements under its Environmental Assessment (EA) Certificate (#M15-01) and Mines Act Permit (M-243) to implement its approved Wildlife Management and Waste Management Plans, including to prevent wildlife incidents involving attractants. The BC Wildlife Act also has provisions regarding wildlife attractants. Non-compliance can result in issuance of Warnings, Orders, Administrative Penalties (fines), or prosecution (listed in order of increasing enforcement magnitude). Fines issued under the Mines Act can be up to $500,000 per incident (per day). There is no maximum to the amount for a fine issued by BC Environmental Assessment Office Compliance and Enforcement. It is essential that the issue of wildlife attractants be fully addressed at the Brucejack mine site to prevent enforcement action beyond current Orders.

All personnel must adhere to proper waste handling procedures and other access prevention measures under the Waste Management Plan, to eliminate wildlife access to attractants. Internal disciplinary measures are needed as a tool to support full compliance.

4. Application

As per the Brucejack Disciplinary Policy, a Newcrest employee found to commit any "wildlife attractant infraction" will receive disciplinary action, up to and including termination, at the sole discretion of Brucejack mine site's General Manager, Mine Manager, Mine Superintendent or their designate (Newcrest Management). Any personnel working for a contractor, consultant, or supplier found to commit a "wildlife attractant infraction" while working, operating or visiting at Brucejack mine site, can have their site privileges revoked at the discretion of Newcrest Management.

5. Definitions

The following definitions apply to this Policy (adapted from the *BC Wildlife Act*):

"**wildlife attractant**" means food or food waste and their packaging, compost, or other waste or garbage that could attract dangerous wildlife, or, a carcass or part of a carcass of an animal, or fish, or other meat.

"**dangerous wildlife**" means a bear, cougar, coyote, wolf, fox, wolverine or pine marten, or any wildlife species deemed to be dangerous by Newcrest Management.

"**bear-resistant bin**" means a container of any size that is specifically designed to prevent access to a bear or other dangerous wildlife, as approved by the Brucejack Environmental Department.

"**food waste**" means any waste item that was previously used or associated with food or drink, including but not limited to, candy wrappers, cellophane or ziplock bags, food trays/boxes, drink boxes/cans, and fruit cores/peels.

6. Policy

Intentional or otherwise unintentional attracting of wildlife at Brucejack mine site such that the wildlife can access the attractant is considered an infraction, and is in direct violation of this Policy. Thus, a "wildlife attractant infraction" at Brucejack mine site includes, but not limited to, the following:

1) Intentionally feeding wildlife (e.g., feeding directly from hand to mouth, or knowingly leaving food or food waste outside accessible to the animal).
2) Baiting and/or beckoning wildlife using food or food waste to take a photo or to see the animal at closer range, even if the animal is not actually fed.
3) Disposing of coffee, juice or other fluid other than water outside of a fully enclosed building or in a designated bear-resistant bin.
4) Littering of food, food waste, or food packaging outside of a fully enclosed building or in a designated bear-resistant bin, where wildlife can access it.
5) Failing to place food or food waste in the appropriate receptacle (i.e., NOT in bins designated for metal, wire, heavy plastic, batteries, etc.), or failing to close the lid of the appropriate receptacle following waste placement.
6) Leaving food or food waste unattended within the room in all bunks and offices outside the main Brucejack Camp Complex. Food can be brought to the room or office but all remaining food and food waste, upon vacating that room for the work day, must be taken to the designated waste and recycling receptacles located at the entrance way to that bunk or office.

7) Failing to respond to, collect and properly dispose any spilled substance or item that can attract wildlife (e.g., coffee, juice, cigarette butt, chewing tobacco, antifreeze, hydrocarbon, coolant, etc.).
8) Failing to dispose of cigarette butts in a designated receptacle.
9) Leaving food, food waste, or food packaging in vehicles or equipment with one or more windows left open, or in an accessible location such as a pick-up truck box.
10) Leaving a door to a building ajar or open when not attended, including both personnel doors and bay doors on all buildings, or leaving a window open when not present in the room, thereby allowing access to wildlife. If ice build-up, a broken hinge or other obstruction is causing the door or window to remain ajar after repeated attempts to close it, rectify the issue immediately or contact Brucejack Maintenance for support, if required.
11) Leaving a fence gate open when not in active use for entering or exiting, including the electric fence gates at the Wildfire and Knipple Camps, and the Knipple Waste Facility gate.

7. References

1996. Wildlife Act, RSBC. C. 488.

2002a. Environmental Assessment Act, C. 43.

8. Document Control

Date last revised	May 16, 2022
Reviewer	Matt Salomons, HRBP
Changes	Changed all reference of Pretivm to Newcrest

9. Policy Approval

Name	Signature	Date
Sean Masse General Manager		
John Sheehan Surface Operations Manager		
Torence Sandhals Principal, Environment		

Appendix C

Mountain Goat Management Plan

BRUCEJACK MINE

Mountain Goat Management Plan

January 2023

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Mountain Goat Management Plan

Date: January 2023

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VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
1	April 2017	Pretivm	
2	June 2020	Pretivm	Address comments from Nisga'a Lisims Government; update to avalanche control measures (Wyssen Towers); update to helicopter management
3	January 2023	Pretium Resources Inc.	Updated title page and general updates throughout entire document.

BRUCJEACK MINE
Mountain Goat Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BC	British Columbia
BC ILMB	British Columbia Integrated Land Management Bureau
BC MOE	British Columbia Ministry of Environment
BC MFLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
BC *Wildlife Act* (1996)	The main provincial law for protecting wildlife, endangered species, and wildlife habitat. The Act has a number of provisions for protecting, managing, and purchasing habitat areas as well as protecting endangered and threatened species. The Act is administered by the Ministry of Environment.
BJAR	Brucejack Access Road
BMP	Best management practices
EA	Environmental assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
FRPA	*Forest Regulation and Protection Act* (2002)
GWM	General Wildlife Measure
LRMP	Land and Resource Management Plan
MGMP	Mountain Goat Management Plan
Pretium	Pretium Resources Inc.
RACS	Remote avalanche control system
RSA	Regional Study Area
SOP	Standard operating procedure
SU	Survey Unit
SRMP	Sustainable Resource Management Plan

UWR	Ungulate Winter Range
VC	Valued Component
WHA	Wildlife Habitat Area: mapped areas that are necessary to meet the habitat requirements of an Identified Wildlife species under the Identified Wildlife Management Strategy. WHAs designate habitats in which activities are managed to minimize their effect on the Identified Wildlife for which the area was established.
WAC	Wildlife Advisory Committee

1 PURPOSE

1.1 INTRODUCTION

This Mountain Goat Management Plan (MGMP) describes actions that are intended to mitigate potential effects on mountain goats during the Construction, Operations, Closure and Post-closure phases of the Brucejack Mine (the Mine), owned and operated by Pretium Resources Inc. (Pretium). It focuses on the management recommended for legislated Ungulate Winter Range (UWR), high quality summer habitat, unique areas (mineral licks; kidding areas), and areas of known persistent use within the wildlife Regional Study Area (RSA) particularly on the Mine footprint components and activities (Rescan 2013a). Unless otherwise indicated, measures described in the MGMP apply to all components for the life of the Mine. This plan is designed to be adaptive, effective, and achievable in both the short and long term, and will incorporate the activity details as they are developed with the Mine.

1.2 BACKGROUND INFORMATION

Mountain goat populations were surveyed in the RSA during the summers of 2010 and 2012, and the winters of 2011 and 2013, following provincial standards for aerial surveys standards (RIC 2002). These surveys reported 286 mountain goats in the RSA (Rescan 2013a). Furthermore, mountain goats were surveyed in 2017 following provincial standards for aerial survey standard during the summer and 298 goats were observed (ERM 2017). The mountain goat surveys in 2022 yielded detections of 325 goats in 84 groups from 12 survey unit (SU) areas (ERM 2023). Mountain goats were observed in all SUs including areas where no individuals were detected during the 2017 survey period (ERM 2023).

For winter habitat in the Brucejack area, aerial surveys indicate that, mountain goats prefer subalpine forest stands that provide a diverse range of arboreal and rooted plant forage adjacent to escape terrain. Tree and shrub cover on steep, rocky ledges offer thermal advantage during sunny weather (solar radiation) and during inclement stormy weather by providing cover from snow. Goats also prefer southerly aspects because snow accumulation tends to be lower and food can be found more readily (Wilson 2005). Natal and kidding habitats are generally smaller pockets of habitat located within and near winter ranges (Mountain Goat Management Team 2010, p. 11).

During summer, mountain goats move to higher elevations to exploit the newly emerged high-quality vegetation. Areas with abundant early seral stage vegetation (e.g., grasses and herbs) are preferred by mountain goats. Mountain goats also seek higher elevation habitat as it provides thermal relief during the warmest periods of summer. Mineral licks at various elevations receive annual use and are important for the local mountain goat population. They are used primarily during the summer to compensate for mineral deficiencies or imbalances in goats' diets (Ayotte, Parker, and Gillingham 2008).

The majority of goats recorded during baseline studies (Rescan 2013a) were observed in mid-elevation habitat generally below the treeline along the Bowser River and close to Bowser Lake in the winter, and in high-elevation habitat above the treeline near peaks associated with Sulphurets Creek, in the summer. These areas also have UWRs that were occupied by wintering goats in 2012. See maps in Appendix A.

The nearest occupied high quality mountain goat habitat to Mine infrastructure is beyond 3 km west of the Brucejack Mine Site on either side of Sulphurets Creek, well away from any mining activities. High quality mountain goat habitat was defined in the environmental assessment for the Mine as high, medium–high, and medium-rated habitat derived from habitat suitability modeling (Rescan 2013b). Baseline surveys indicated that the majority of goat observations occur in this high quality goat habitat (Rescan 2013a). Other areas of occupied high-quality mountain goat habitat within the Mine area include an area 1 km north of the Brucejack Access Road (BJAR) approximately mid-way between Knipple Lake and the Mine, and an area along the mountains north of Bowser Lake, beyond 3 km from the BJAR. Additionally, the nearest identified kidding habitat to Mine infrastructure is west of the Knipple Glacier, approximately 1 km away from the Knipple Glacier Access Road crossing. No mineral licks have been found near Mine infrastructure (see maps in Appendix A).

2 PERFORMANCE OBJECTIVES

The overall performance objectives of the MGMP are to:

- prevent disturbance and habitat loss to goats within designated and candidate UWR during the winter and within high-rated summer habitat during the kidding period;
- manage disturbance due to aircraft and helicopters through avoidance where possible and minimization where it cannot be avoided; and
- manage incidental mortality of mountain goats due to avalanche control procedures through pre-avalanche control surveys, herding of goats from avalanche paths, and delaying avalanche controls until goats clear the area.

This document provided direction for environmental managers mainly during the Construction phase of the Mine but also is applicable to the Operations, Closure and Post-closure phases. Mine-related activities of relevance to this MGMP include the construction of mining infrastructure, transmission line, camps and other early-stage facilities and activities associated with helicopter use, and avalanche control during all Mine phases.

3 SCOPE

The MGMP is applicable to Construction, Operations, Closure and Post-closure activities that require Mine-specific mitigation and monitoring. The MGMP provides the environmental personnel and construction crews with information that can be used to coordinate activities and avoid negative effects on mountain goats where possible and to mitigate effects where unavoidable. Site-specific mitigation and monitoring will be addressed through the following measures (Table 3-1):

1. Clearing Management for Mountain Goats (Section 5.1)
2. Aircraft and Helicopter Management for Mountain Goats (Section 5.2)
3. Avalanche Management for Mountain Goats (Section 5.3)

Table 3-1. Summary of Mitigation Measures Applicable to Mine Phases and Components

Mitigation Measure	Mine Phase	Mine Component
Clearing Management	Construction	Transmission Line
Aircraft and Helicopter Management	Construction; Operations	All Components
Avalanche Management	Construction; Operations; Closure	Mine Site, Access Road, Transmission Line

4 RELEVANT LEGISLATION, REGULATIONS, AND PERMITS

Mountain goats are protected legislatively by the provincial *Wildlife Act* (1996) and guidance for habitat management is provided by the provincial *Forest Regulation and Protection Act* (FRPA; 2002). Under the FRPA, areas that are important or critical to ungulates and sensitive wildlife may be designated as Ungulate Winter Ranges (UWRs) or Wildlife Habitat Areas (WHAs), and General Wildlife Measures (GWMs) may be used to manage forest and range practices for protection and conservation of the species (Mountain Goat Management Team 2010).

General Wildlife Measures established for UWRs and WHAs include regulations for primary forestry activity (defined under the Forest Planning and Practices Regulation to include tree clearing and access structure [road/trail] construction/maintenance), such as prohibiting road construction, timber harvesting or silviculture treatments within established buffers around UWR and/or WHA boundaries unless an exemption is provided. Schedule 1 - GWM order # U-6-002 identifies management measures and actions that can be carried out in the UWR in the Nass Timber Supply Area, Upper Portion of the Ningunsaw and Unuk watersheds within the Mine RSA.

The relevant best management practices that guided the development of this plan are summarized in the *Management Plan for the Mountain Goat in British Columbia* and *A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (Mountain Goat Management Team 2010; BC MFLNRO 2014). Procedures and protocols of the best management practices were incorporated in the clearing, aircraft and helicopter, and avalanche management actions for mountain goats in the following sections.

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

This section identifies the management and mitigation measures to facilitate protection of mountain goats as per the BC Mountain Goat Management team guidelines and GWM order #U-6-002 (Mountain Goat Management Team 2010). This includes consideration for clearing and pre-clearing surveys, and air-based activities. In addition, avalanche management is considered due to the potential of incidental mortality caused by avalanche control procedures.

5.1 CLEARING MANAGEMENT FOR MOUNTAIN GOATS

Most Construction Phase clearing for the Mine was completed between September 5 and November 1, 2015, within the timing window that is outside of periods identified as being sensitive for mountain goats. The southern-most section of the transmission line, as well as the preferred Bulk Emulsion Site are not within or in proximity to UWR habitat and were cleared in 2016 when it is snow-free. Clearing of the Knipple Transfer Area was also completed during autumn 2015, along with most of the clearing for the Bowser Aerodrome and camps, and locations where additional clearing was needed along the lower BJAR (km 0-58). Minor additional clearing for the Bowser Aerodrome and BJAR (mainly borrow locations) may be done later; however, these sites are not within or in proximity to UWR habitat. No clearing is needed at the Mine Site, as it is above treeline. Clearing management as described in the following section will therefore only be relevant in the unlikely event that additional clearing needs are identified for the Mine in the future.

Mitigation activities are determined by habitat type, season and the number of goats observed. If any winter clearing is planned in future, pre-clearing surveys will be conducted during winter when ground-based Mine activities are within 500 m of UWR habitat (Rescan 2013a, 2013b). If clearing is required within a UWR or within 500 m of UWR habitat during the sensitive period, an exemption permit application will be submitted by a Registered Professional Biologist. Work requiring helicopter or aircraft support will be conducted as described in Section 5.2, Aircraft and Helicopter Management.

All actions regarding mountain goat clearing management will be directed by qualified environmental personnel (either staff or consultant) with appropriate experience with ungulates in BC. The objective for surveys will be to conduct them as close to clearing as possible, with a maximum of 72 hours before clearing. The pre-clearing survey will survey for goats out to 2-3 km from the proposed clearing site, covering the area of mountainside defined by drainages unlikely to be crossed by goats. If a particular block of mountain side does not have goats, then the clearing teams are free to clear within 72 hours. If goats are found within 1.5 km of the clearing site: 1) a further pre-clearing survey will be conducted, 2) the site will be surveyed as the crews are being put out, or 3) the clearing schedule will be altered to clear that site later, following another pre-clearing survey. If the pre-clearing is conducted within 24 hours of clearing, and the area within 500 m of the clearing site is clear of goats, clearing can continue as planned. Vegetation clearing will be halted if goats are observed within 500 m of the clearing area during sensitive timing periods (i.e., winter – November 1 to June 14 for all goats, and

May 1 to July 15 for goats with kids) until animals are outside the recommended threshold distance of 500 m.

If goats with kids are observed, additional surveys will be conducted, and mitigation implemented. Note that kidding is assumed to occur at mid to high elevation generally up-slope during the winter or spring and goats are at high elevation during the summer or fall months. Table 5.1-1 summarizes the timing, habitat, triggers, and mitigation activities.

Table 5.1-1. Mitigation Activities for Mountain Goats during Vegetation Clearing

Timing	Habitat	Mitigation Activities
Winter (November 1 to April 30)	UWRs	The preferred option is to avoid activities within 500 m of UWR habitat during winter. If clearing is planned in these areas during winter, then conduct pre-clearing surveys and apply for an exemption permit. If goats are observed within a 500 m buffer of clearing, pause work until goats have moved outside of this buffer.
Summer (May 1 to July 15)	High-quality Summer Habitat – Kidding Areas	If goats with kids are observed between May 1 and July 15 within a 500 m buffer during clearing activities, pause work until goats have moved off. Avoid clearing activities within 2 km of confirmed natal/kidding areas. Pre-clearing surveys may also be conducted less than 72 hours prior to activity.
Spring/Fall (April to November	High-quality Summer Habitat – Mineral Licks	Avoid destruction of mineral licks. Minimize disturbance within 100 m of licks.
All Year	All Habitats	Vehicles accessing the Mine will be required to give the right of way to mountain goats observed on the road.

5.2 AIRCRAFT MANAGEMENT FOR MOUNTAIN GOATS

Mountain goats are potentially sensitive to noise and disturbance from development, particularly to helicopter disturbance, as well as other aircraft. Goats are vulnerable to disturbance during:

- winter (November 1 to April 30) in the low elevation forested areas that goats use during winter in designated UWRs; and
- kidding period (May 1 to July 15) in the high elevation alpine areas that goats use during kidding, summer, and fall.

The guidelines proposed by the province do not differentiate between types of helicopters. However, research and professional experience indicate that goats react at different distances to different types of aircraft. Goats typically react more strongly to larger, multi-rotor aircraft (e.g., Vertol, Chinook) that are louder than other helicopters, and larger helicopters with only two blades (e.g., Bell 205) that produce a distinct blade slap noise when descending (ERM unpublished data).

In contrast, goats typically react less strongly to smaller, multi-blade helicopters such as the Eurocopter A-star, which produces a "whine" rather than a blade slap sound. Choosing the appropriate helicopter should reduce the potential for disturbance to mountain goats at the site and allow the helicopters some small leeway in flying closer to goats if the circumstances require it (e.g., low ceiling).

During primary forest activities [i.e., clearing and access structure (road/trail) construction], mountain goat mitigation related to aircraft includes:

- As recommended by the province, maintaining 2 km horizontal setback from mountain goats where feasible and weather permitting. Also, maintaining 500 m vertical separation between helicopters and mountain goat habitat, weather permitting.
- Educating pilots as to the importance of avoiding and not flying towards mountain goats, particularly during important periods of the year such as kidding and winter.
- Disseminating established flight paths for camps and construction areas to all new pilots.

There is a general set of helicopter "behaviours" which, if followed, can significantly reduce the potential for mountain ungulates to be disturbed by helicopters. Goats typically have little defence against predators, except fleeing to escape terrain and they likely perceive helicopters as a predation risk. Thus, it is important to understand and have the helicopter "behave" in a way that does not startle or trigger this predation response.

General recommendations for pilots include:

- Avoid overflights of occupied goat habitat whenever possible (below suggested elevations of 500 m), including avoiding "flightseeing".
- If flying a helicopter that produces a heavy "blade slap" noise, avoid inducing this noise when overflying or adjacent to occupied goat habitat.
- If a pilot is aware that goats are on the opposite side of a ridge or mountain, avoid surprising goats by flying low over the ridge and suddenly appearing above them.
- Avoid triggering a goat's "chase response" by avoiding flying directly at goats. Helicopters flying tangentially to goats are perceived less as potential predators.
- Goats can become habituated to helicopters if the helicopters operate in a predictable and non-threatening manner. Wherever possible, use the same routes and elevations to and from camps and drills.
- Use topographic barriers to separate helicopters from mountain goats.
- Keep helicopters below mountain goats if feasible.
- Helicopters can drop off specialized work crews in goat habitat, but only when goats are not present within 500 m.

In the balance between operability and reducing disturbance to goats, for aircraft activities pilots are instructed to maintain the largest separation feasible from mountain goats. The ideal situation is

>2 km. In some cases, it may not be possible to maintain >2 km separation with goats given that certain valleys may be less than 2 km wide, and seasonal low clouds may force helicopters into the bottom of valleys. Pilots avoid flying within 500 m of goats, even if that means that certain valleys are unpassable on certain days with low cloud. Pilots minimize any flights in the range of 500-1,500 m, to those that are absolutely necessary. Pilots do not conduct crew "tours" near goats. There are allowances for different topographies given the fact that the average width of valleys in NW BC is 1.5-2.5 km wide. Flight paths that consider observed goat use and occupation of habitat within the RSA are provided in Appendix A. Air traffic is encouraged to use these paths to minimize disturbance during sensitive periods.

5.3 AVALANCHE MANAGEMENT FOR MOUNTAIN GOATS

5.3.1 Management Activities

Avalanche management is conducted in the winter during all Mine phases. Mountain goats occupy alpine areas with steep, rocky cliffs during the summer. During winter, mountain goats can occupy low elevation forested areas on southern slopes as well as habitat in or below areas prone to avalanches, including alpine areas above the BJAR, near Knipple Lake, and along the Knipple Glacier (Figure 5.3-1 and Appendix A). Avalanche management activities include management to avoid mortality or abandonment of habitats by mountain goats due to control induced avalanches.

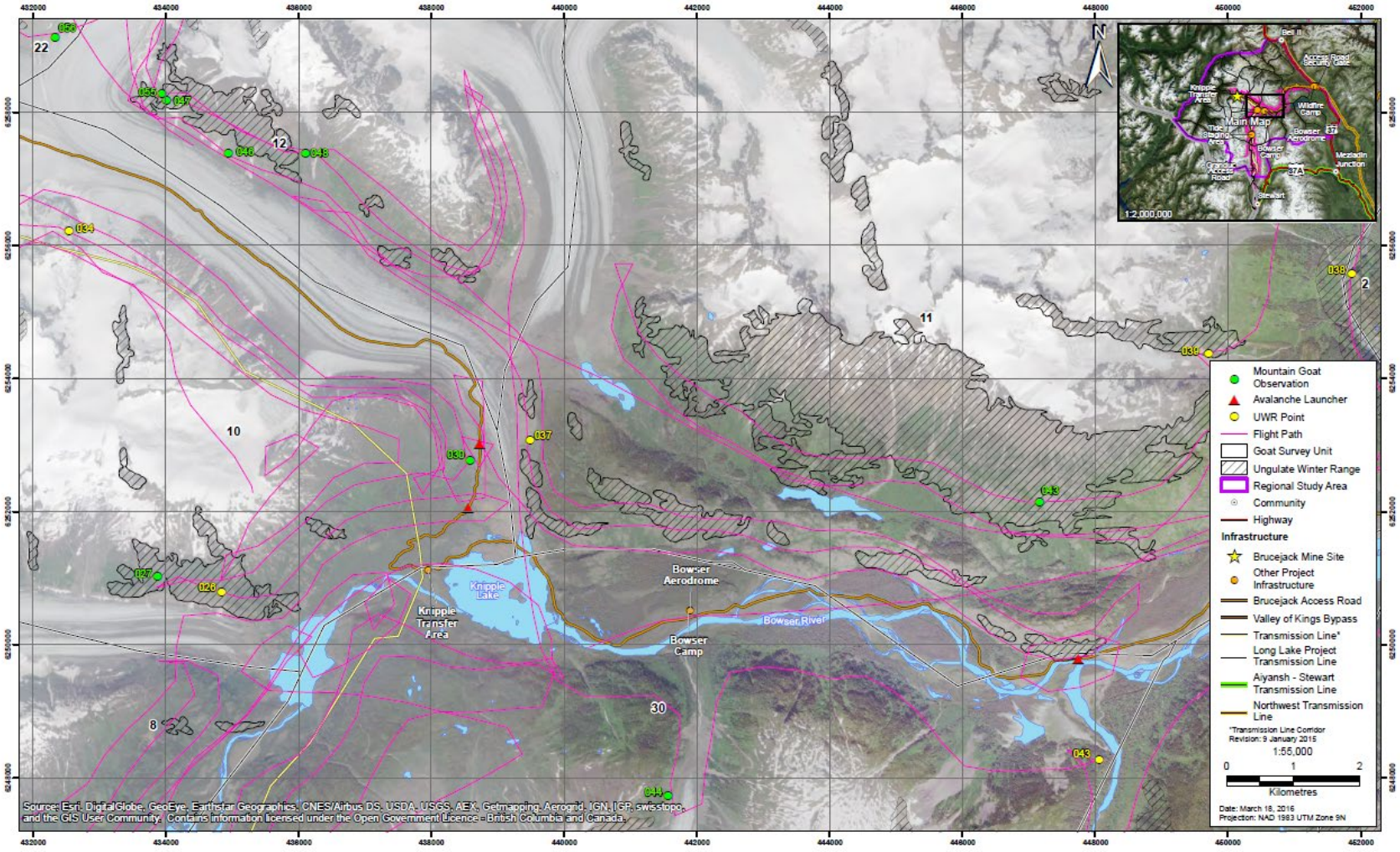
Avalanche management procedures typically use helicopter deployment of explosives (Pretium 2018a, 2018b). This procedure requires the avalanche area to be clear and visible prior to deployment. However, Remote Avalanche Control System (RACS) concussive devices that are built into the start zone of avalanche tracks can be deployed during or after snow events and at night.

Mitigation activities to limit risks to mountain goats are primarily based on conducting surveys for goats prior to initiating avalanche control and pausing control activities until goats have cleared avalanche paths. Mitigation activities depend on the choice of avalanche control. Three methods of avalanche control are currently used for the Mine; each has an associated survey protocol to ensure the site is clear of people or wildlife prior to detonation. These include:

1. Hand-based blasting is conducted predominantly at the base of the avalanche path using case charges which consist of a high explosive suspended on a bamboo pole tripod and remotely detonated. These are placed on or slightly above the BJAR. Ski-touring and throwing hand charges may also be employed up slope from the road: prior to conducting hand-based blasting the crew conducts visual confirmation the site is clear of people or wildlife along avalanche path and start zone. If goats are present, blasting will be delayed until they have left the area. Air horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins. If this is required, then a General Wildlife Permit application will be submitted to BC MFLNRORD.
2. Helicopter-based blasting is conducted at the top of avalanche paths and most often to be used in spring to clean up sites. It includes dropping of explosive charges out of the helicopter to

initiate and avalanche from above: prior to conducting helicopter-based blasting, there is a detailed sweep of the slope to determine where best to place targets ensuring a thorough survey of the path and surrounding area for hazards and goats. If the area and area immediately adjacent (within 100 m) to the avalanche path is clear, blasting will proceed. If not, goats will be herded away to a safe distance before blasting begins if possible. If terrain and snow conditions preclude herding goats away from the area, blasting will be delayed until goats clear the area.

Figure 5.3-1
Location of RACS Units



Over the past four winters during which helicopter-based blasting has been conducted for avalanche control at the Mine and along the BJAR, no mountain goats have been observed within or in proximity to the avalanche control sites at the time control was being conducted. Pre-blast visual inspections have been conducted as part of standard procedure to ensure that the areas are clear of both personnel and wildlife, including mountain goats.

3. In-place RACS concussive devices, of which Pretium uses two different systems, were installed at three of the most problematic sites along the BJAR. These devices may be operated remotely during any weather and are used to initiate avalanches at the top of the path. During clear weather, a ground-based survey of the avalanche track is conducted from a safe location using a spotting scope or similar device. Site-specific details are described in Section 6.1.3. If goats are observed and safety is not compromised, then blasting will occur once mountain goats move out of the avalanche area. Air horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins. If blasting is planned during obscured conditions with low lying cloud or fog, heavy snowfall or wind events, pre-blast surveys may not be feasible.

As some approaches to mountain goat deterrence may be novel, all avalanche management activities considered will be documented and summarized in an annual report. The results of avalanche mitigation activities will be used in an adaptive management approach to inform future actions. Documentation will include:

- Survey methods and results;
- Any mitigation required – deferring the avalanche control or use of air horns; and
- Results of avalanche control.

Details of the avalanche control methodology were included in the Licence of Occupation applications submitted by Pretium to BC MFLNRORD, which were subsequently approved.

5.3.2 Risk to Mountain Goats from Avalanche Control Measures

This section evaluates the risk to mountain goats resulting from avalanche control measures at a site level using field data on the locations of proposed avalanche control measures, goat habitat, and goat occupancy collected during 2015. There are several avalanche zones identified along the BJAR and near the mine site. Avalanche control measures in all areas follow the mitigation and adaptive management approach described in Section 5.3.1.

Within each of the zones there are areas that are managed for avalanches; these include areas along the BJAR at 2 km, 30 km, 44 km, 56 km, 58 km, 59 km, and the area around the Brucejack Camp. While the event frequency and size of avalanches vary, of the areas requiring most consistent avalanche control, the areas at the Brucejack Camp, 56 km, and 2 km are not identified as key goat winter habitat, and goats were not observed at any of these locations during inventory (Rescan 2011). Slopes above

the BJAR at 30 km are near a UWR, however goats were not identified in this area during inventory. The UWR is at the top of the avalanche zone, and control measures are only expected to be associated with the lower slope above the road. Consequently, goats are not expected to occupy this area when avalanche control is required.

Risk to goats from avalanche control at the Brucejack Mine Site, 56 km, 30 km, and 2 km is considered very low. Directed monitoring for goats is not proposed for these sites beyond the scanning protocol that currently occurs for avalanche control using helicopter-based or hand-based blasting described in section 5.3.1. If, for exceptional circumstances, goats are observed within avalanche tracks planned for blasting, avalanche control will be halted until the goats have cleared the area. If required, noise will be used to herd goats out of the danger area as described in Section 5.3.1. The response of goats to noise will be documented (Section 5.3.1).

Avalanche control at 44 km and 58 km is the most likely to provide a risk to mountain goat. The 59 km site has also been assessed for risk to mountain goat. All three methods of control may potentially be used at these sites, however, the ground-based RACS represent the avalanche control of greatest consequence to goats in size of area, potential goat occupancy, and frequency of use. The RACS are remotely fired with a charge of compressed oxygen and propane, Gasex®, or 4 kg explosive charge dropped from Wyssen Towers to initiate an avalanche. The RACS used to manage avalanche hazards will be installed at three key locations along the Brucejack Access Road. The Gazex® is permanently fixed at the top of the avalanche paths at 44 km, while Wyssen Towers are installed at the top of avalanche paths at 58 km and 59 km (Figure 5.3-1). A monitoring plan has been identified for use with RACS avalanche control in these areas and it can be extended to include all methods of avalanche control at these problematic sites.

To evaluate the potential risk to mountain goats at these three sites from the installation of the RACS and other avalanche control systems, a field survey was carried out in May 2015 (June 17, 2015, Wildlife Trip Report). The survey was conducted, in part, to evaluate the likelihood that goats would occupy the areas slated for avalanche control. The risk to goats was evaluated based on the results of this survey combined with the information available from habitat suitability mapping, spatial distribution of habitat, and the anticipated goat use. Locations at 44 km and 58 km were identified as potentially supporting use, while goat winter use at km 59 is not anticipated. The risk to mountain goats from avalanche control at these three sites was qualitatively evaluated based on professional judgement of habitat suitability and potential occupancy during the winter. The habitat value, and therefore likelihood of habitat uses and risk to goats, was referenced to a local benchmark; the UWR unit on the north side of Bowser Lake which supports substantial goat numbers (12 observed in the winter 2011 survey at this location). This UWR is located at Anderson Mountain approximately 5 km away from the 10 km marker on the Brucejack Access Road, along Wildfire Creek, and is not expected to be disturbed by Mine-related activities.

The Gazex® RACS unit at 44 km is at the edge of a large UWR complex that has potential to support several goats. This avalanche control site is at the lower, south, and eastern edge of the complex, and while goats may occupy the site during winter, there is habitat of higher quality and greater connectivity north of the site. Within the UWR, goats were observed in May 2015 (waypoint 043,

Figure 5.3-1) up slope on the mountain within the UWR. Goats were observed in a favourable area of green vegetation near the large UWR polygon during the May 2015 reconnaissance. The 2011 winter ungulate surveys (Rescan 2011), did not detect goats in this area, but identified a total of 14 goats to the north and west of the 44 km UWR polygon unit. The RACS unit will affect a large area downslope from the UWR polygon unit (Plate 5.3-1). Considering the isolation of this unit at the periphery of a larger more suitable complex, the probability of it being occupied by goats during avalanche control is low and with monitoring, risk to goats is predicted as Low as well. The 44 km avalanche control area was checked for presence of mountain goats and other wildlife as part of standard pre-blast procedures during blasting that occurred over the past four winters; no mountain goats were observed within the blast areas.

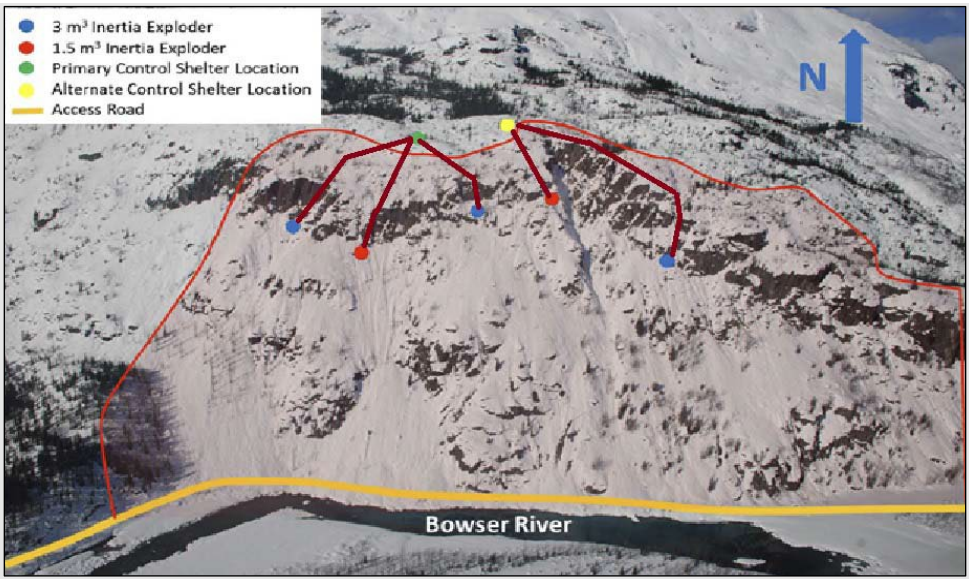
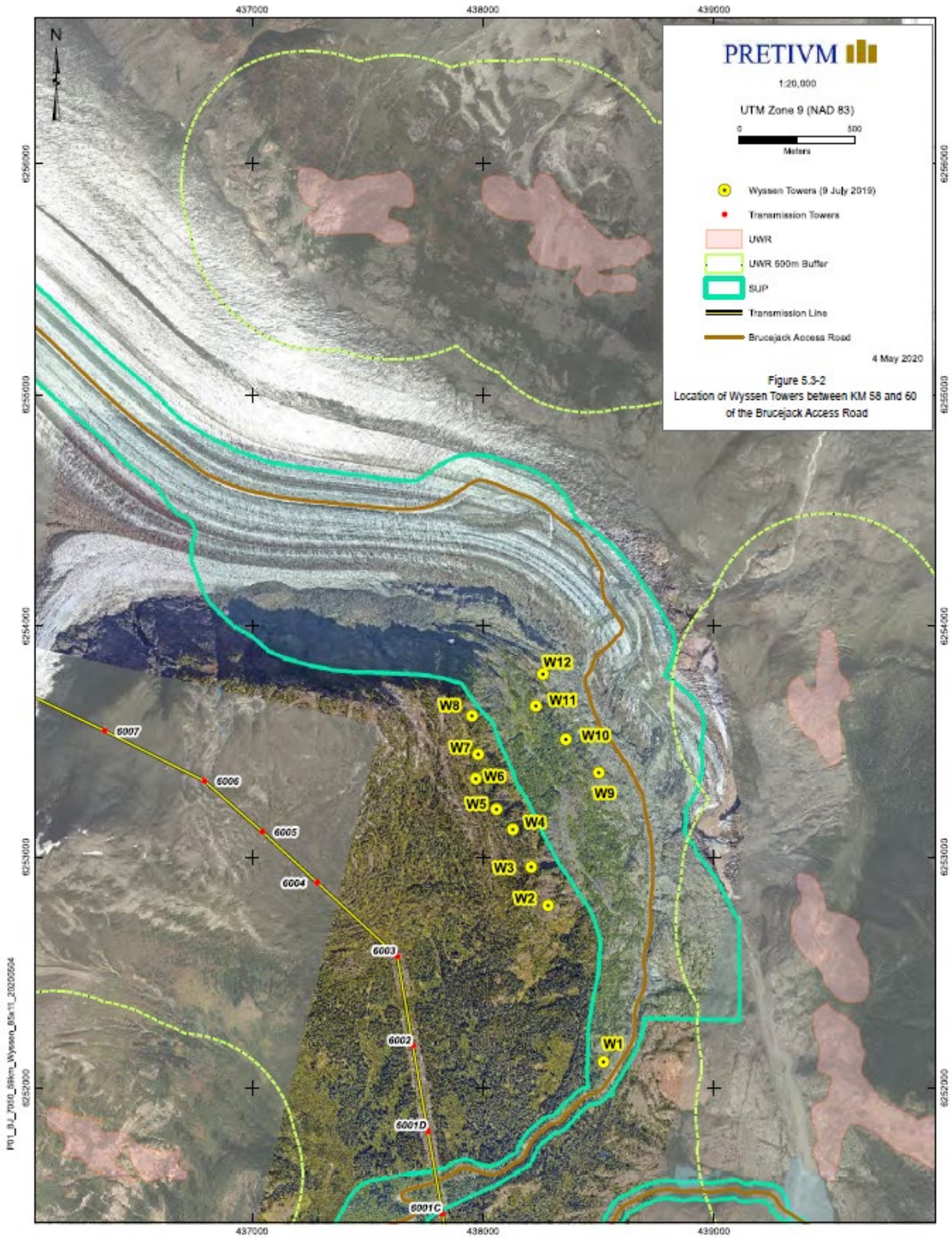


Plate 5.3-1. Location of RACS unit exploders at 44 km site.

The first Wyssen RACS site is comprised of one tower located at 58 km at the southern end of the Knipple Glacier portion of the BJAR. One mountain goat was observed at this location during the May 2015 reconnaissance, and goats with kids had been recorded near this site in 2011 prior to July 1 as recorded in the July 14, 2011, Vegetation and Wildlife Critical Review trip report. No goats were observed during winter 2011 survey near this location (Rescan 2011) and the survey unit associated with the site only had one goat observed during the winter 2011 surveys. The habitat was assessed as high-quality winter habitat as it supports vegetation including conifer cover and shrubs adjacent to escape terrain. The area potentially affected by the RACS is at the lower elevation of the suitable habitat, where escape terrain is becoming fragmented, and connectivity to more contiguous habitat is reduced in winter (Figure 5.3-2). Considering the location at the edge of habitat and no documented winter use, it has a low probability of being occupied by goats during avalanche control, and risk to goats is predicted as Low with monitoring. As with the 44 km area, km 58 was also checked for mountain goat presence prior to blasting over the past four winters and no goats were observed within the avalanche zone.

The second Wyssen RACS site is comprised of 11 towers located between 59 and 60 km and was assessed as low-quality winter habitat for goats. This site is in area recently exposed as the Knipple Glacier receded and has virtually no vegetation cover that would provide winter forage to goats. Its value as escape terrain is also marginal as it is small and surrounded by more gently rolling topography (Figure 5.3-2), and only a small, low elevation area will be impacted by the RACS. No goats were observed near this site during the 2011 winter inventory (Rescan 2011) and only one goat was observed in survey unit (SU) 10. The probability of this site being used during winter by goats is very low and risk to goats is predicted as Very Low. No goats have been observed at this location during previous avalanche blasting activities.

Figure 5.3-2. Location of Wyssen Towers between Km 58 and 60 of the Brucejack Access Road



6 ENVIRONMENTAL MONITORING

6.1 PERFORMANCE MONITORING

6.1.1 Clearing Monitoring

Any additional pre-clearing surveys will be completed by consultants or environmental staff (preferably Registered Professional Biologists) with appropriate experience and/or training with mountain goats in BC. As described in Section 5.1 however, almost all planned clearing has been completed to date and any further clearing required in sensitive areas will occur between September 5 and November 1, outside of the sensitive periods for mountain goats.

Monitoring frequency may be triggered during vegetation clearing but not during normal operations thereafter. Monitoring will occur for clearing activities that will occur in winter (November 1 until April 30) within 500 m the mountain goat UWR. The objective for surveys will be to conduct them as close to clearing as possible, with a maximum of 72 hours before clearing. The pre-clearing survey will survey for goats out to 2-3 km from the proposed clearing site, covering the area of mountainside defined by drainages unlikely to be crossed by goats. If a particular block of mountain side does not have goats, then the clearing teams are free to clear within 72 hours. If goats are found within 1.5 km of the clearing site, then: 1) a further pre-clearing survey will be conducted, 2) the site will be surveyed as the crews are being put out, or 3) the clearing schedule will be altered to clear that site later, following another pre-clearing survey. If the pre-clearing is conducted within 24 hours of clearing, and the area within 500 m of the clearing site is clear of goats, then clearing can continue as planned.

Ground surveys may be used to supplement helicopter-based surveys if topography requires, and weather and work safety allows it. Flight scheduling for monitoring will be conducted by a Registered Professional Biologist with appropriate experience and/or training with mountain goats in BC.

6.1.2 Aircraft Monitoring

Pilots are asked to report incidental observations of goats as part of the incidental wildlife reporting program as discussed in the Wildlife Monitoring Plan (Pretium 2023). Employees who feel that pilots have flown too close to goats are encouraged to report this to Brucejack Logistics or environmental staff.

6.1.3 Avalanche Monitoring

Monitoring during avalanche control activities is conducted to minimize potential mountain goat mortality during avalanche control measures.

Avalanche control monitoring information collected include:

- Location;

- Date;
- Time;
- Personnel;
- Methods and results of pre-control surveys;
- Mitigation actions including;
  - all wildlife herding actions and other mitigative measures,
  - wildlife response,
  - subsequent rationale for decision regarding blasting (including decision not to trigger an avalanche);
- Any blasting activity undertaken; and
- Notes on results.

As listed above, the monitoring measures include visual surveys before avalanche control is initiated to the extent feasible, mitigation efforts and their effects, decision making, and avalanche control results. The avalanche control results include post-control surveys to evaluate if any goat mortality has occurred. The RACS units located at 44 km, 58 km and 59 km along the BJAR have been predicted as having a Low (44 km and 58 km) or Very Low (59 km) risk to goats. Surveys conducted in May 2015 identified varied risks at each location considering connectivity of habitat, habitat quality and spatial distribution of habitat and goats.

The site at 44 km includes a large area of slope that tails out over the BJAR and into the Bowser River. This control is initiated by six Gazex® RACS exploders. The initiation zone is in the low elevation portion of a UWR polygon that has been identified as potentially used by goats. When feasible – i.e., when avalanche control is to be conducted during clear weather conditions – spotting for mountain goats (and moose at the tail out) will be conducted from the ground with a spotting scope (or similar device) prior to detonation of exploders. Spotting will be conducted from 44.4 km. The observer will be in communication by radio and give the all clear when there are no goats within 100 m of the "Slasher" avalanche path

The site at 58 km includes a relatively short run and small area at the bottom of the slope that can be initiated by a Wyssen Tower RACS exploder. The site is expected to have a Low risk to goats and can be observed on the ground by a monitor with a spotting scope prior to detonation. Spotting for 58 km will be done from the causeway across the Bowser River, as there is no safe location with good visibility closer to the 58 km site. The observer will be in communication by radio and give the all clear when no goats are observed in openings within 500 m from the blast location.

The sites between 59 and 60 km include a large area of slope that tails out over the BJAR at several locations and is managed by 11 Wyssen Tower RACS exploders. The area is predicted to have a Very Low risk to goats as such no monitoring is proposed.

Monitoring for mortalities will occur as a check by environmental staff in the spring, with mortality evidenced by signs of goats or as signs of scavenging by predators or birds. Monitoring will be implemented if evidence of goat use is identified through the course of development.

6.2 WORK PLANNING AND SCHEDULE

The mitigation and management measures for mountain goats that will be implemented to eliminate or minimize adverse effects will occur throughout the various Mine phases.

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance Reporting

Compliance reporting will be subject to EA Certificate conditions, and *Mines Act* permit conditions.

Compliance reporting for a wildlife permit used to herd mountain goats away from avalanche paths, if needed, will be reported separately to BC MFLNRORD as detailed in the permit.

The results of monitoring and mitigation are reported to the Wildlife Advisory Committee (WAC).

7.1.2 External/Internal Reporting

All personnel are encouraged to report wildlife observations made anywhere within the Mine. Information collected during monitoring activities, including incidental observations, is summarized in the daily wildlife monitoring log.

7.1.3 Incident Reporting

Incident reporting includes observations of mountain goats during pre-clearing surveys, mountain goat encounters with aircraft/helicopters not following appropriate mitigation measures, and wildlife interactions with avalanche mitigation actions. In addition, any mortality and/or encounters during vegetation clearing surveys, or other mortality events, are reported.

7.2 RECORD KEEPING/TRACKING

7.2.1 Monitoring Results

Information collected during monitoring activities includes the effort that the monitor has put into surveying (start and end times), as well as documenting information on goat observations including time of observation, physical condition, age, sex (if possible) and number of goats. Notes on behaviour and response to the activity will also be recorded, as will observations of other sensitive wildlife incidentally observed.

7.2.2 Continuous Improvement, Follow up, and Adaptive Management

Mitigation measures will continuously be improved by recording incidents involving mountain goats and following up on these incidences and implementing adaptive management when or if current mitigation measures are ineffective.

8 REFERENCES

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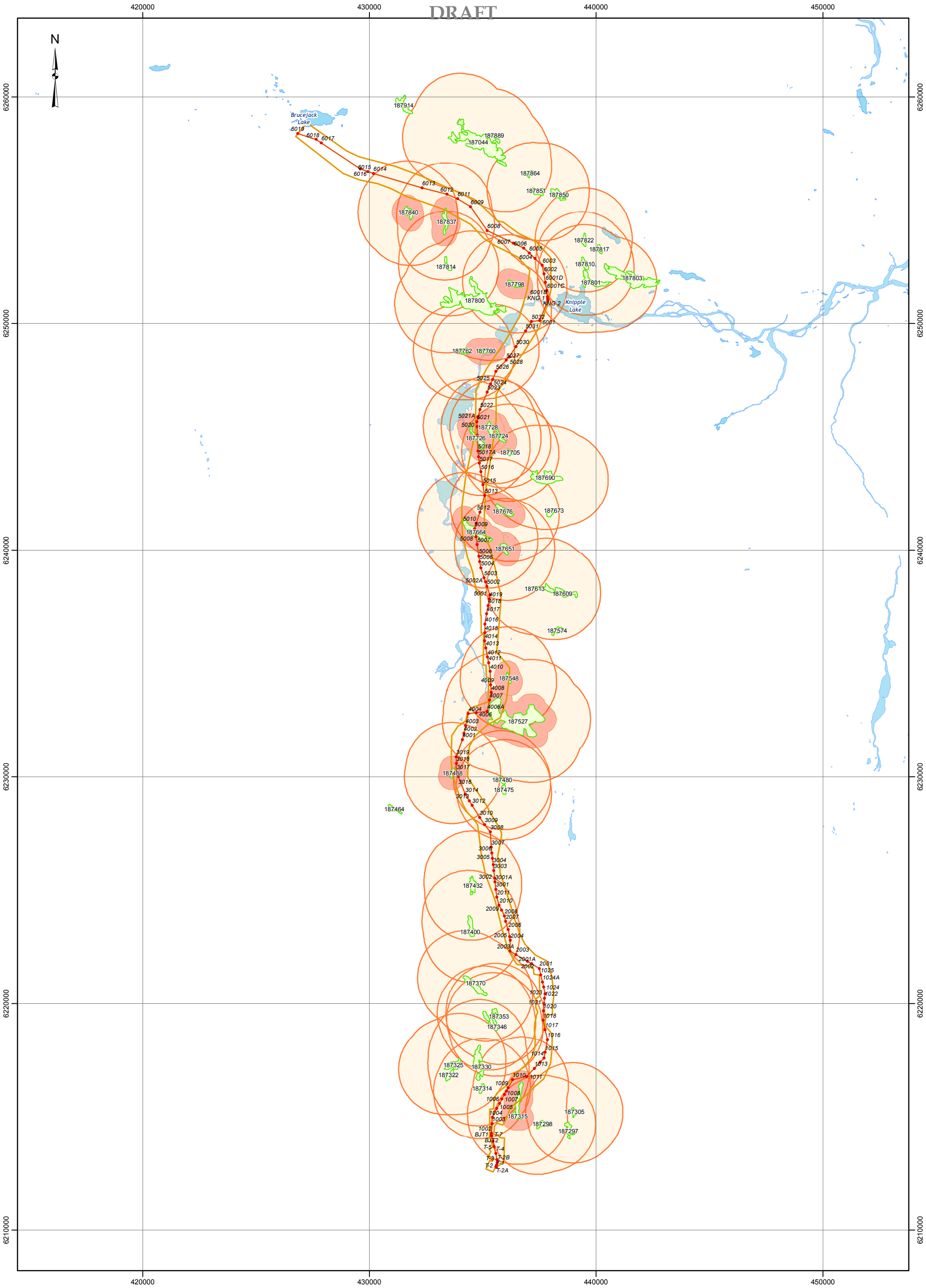
Appendix A

Figures and Maps

DRAFT



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Transmission Line Corridor (as of 9 Jan 2015)
- Mountain Goats Along Transmission Line
- 2 Km Buffer
- 500m Buffer

0 1 2 4 6 8
Kilometers

PRETIVM

PRETIUM RESOURCES INC.
Brucejack Project

1600–570 Granville St.
Vancouver, BC V6C 3P1
Canada
(604) 558–1784

Mountain Goats Along Transmission Line

PROJECTION: UTM Zone 9 (NAD 83)

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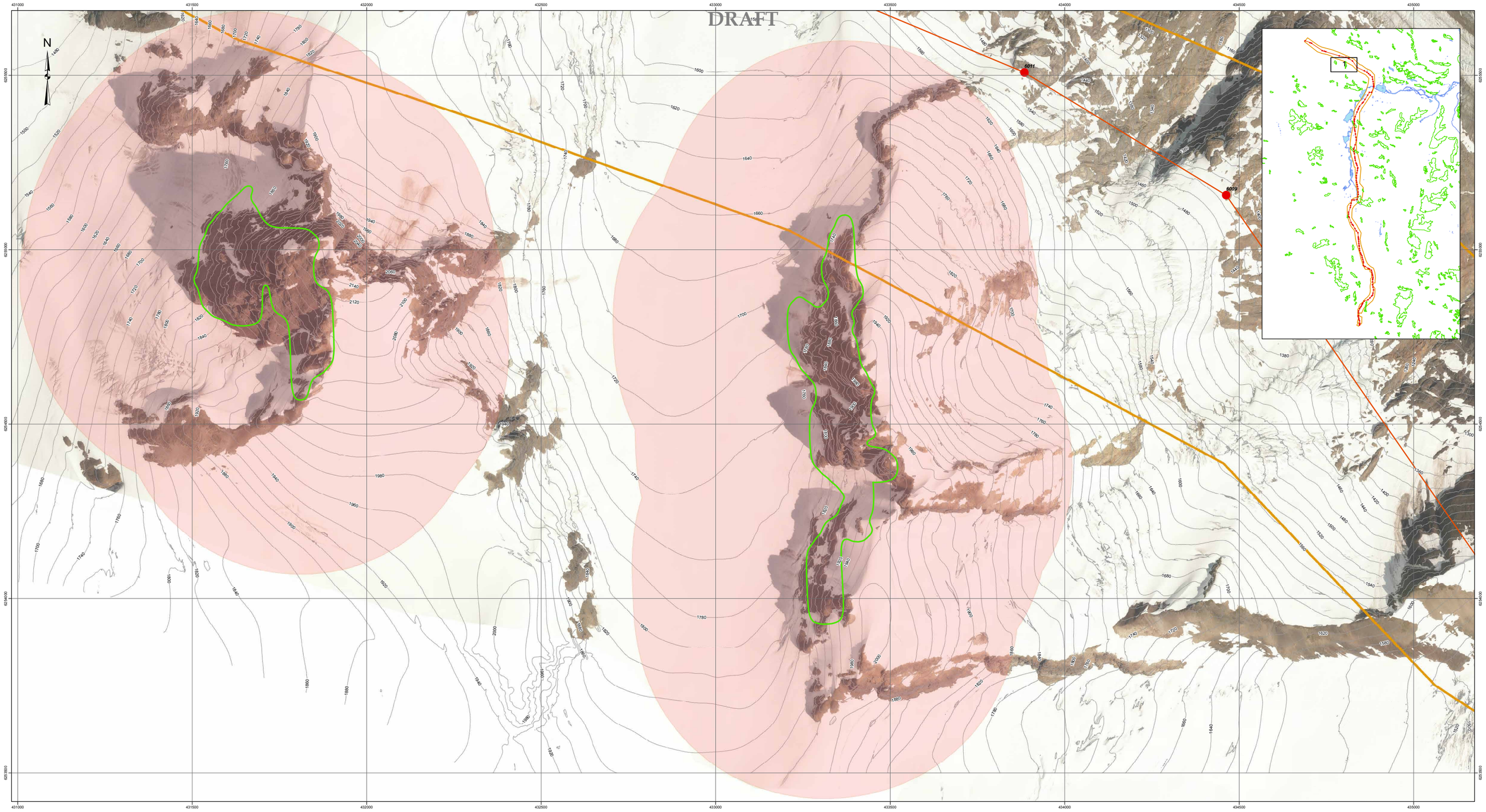

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundry Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Vancouver, BC V6C 3P1
Canada
(604) 558–1784

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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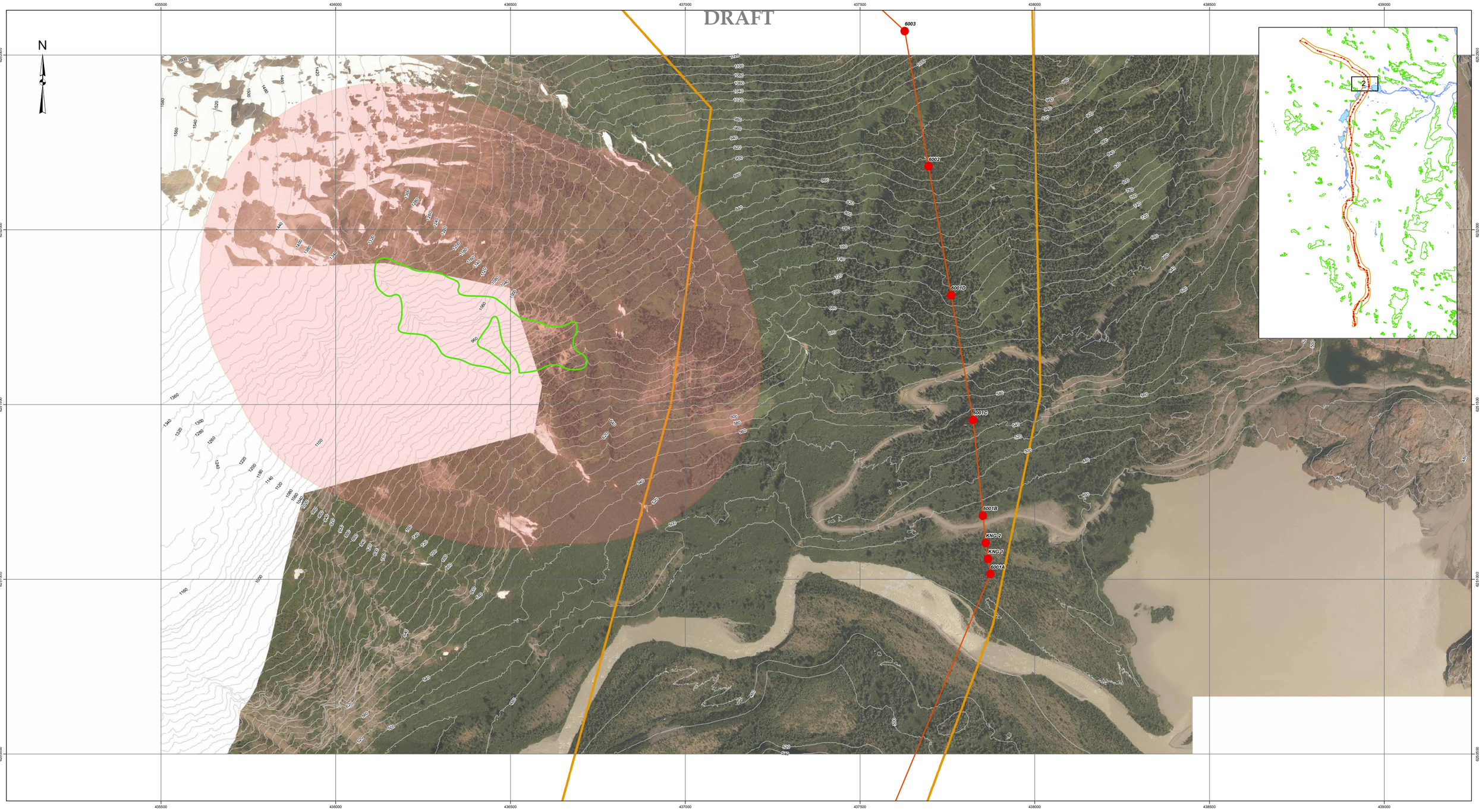

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Vancouver, BC V6C 3P1
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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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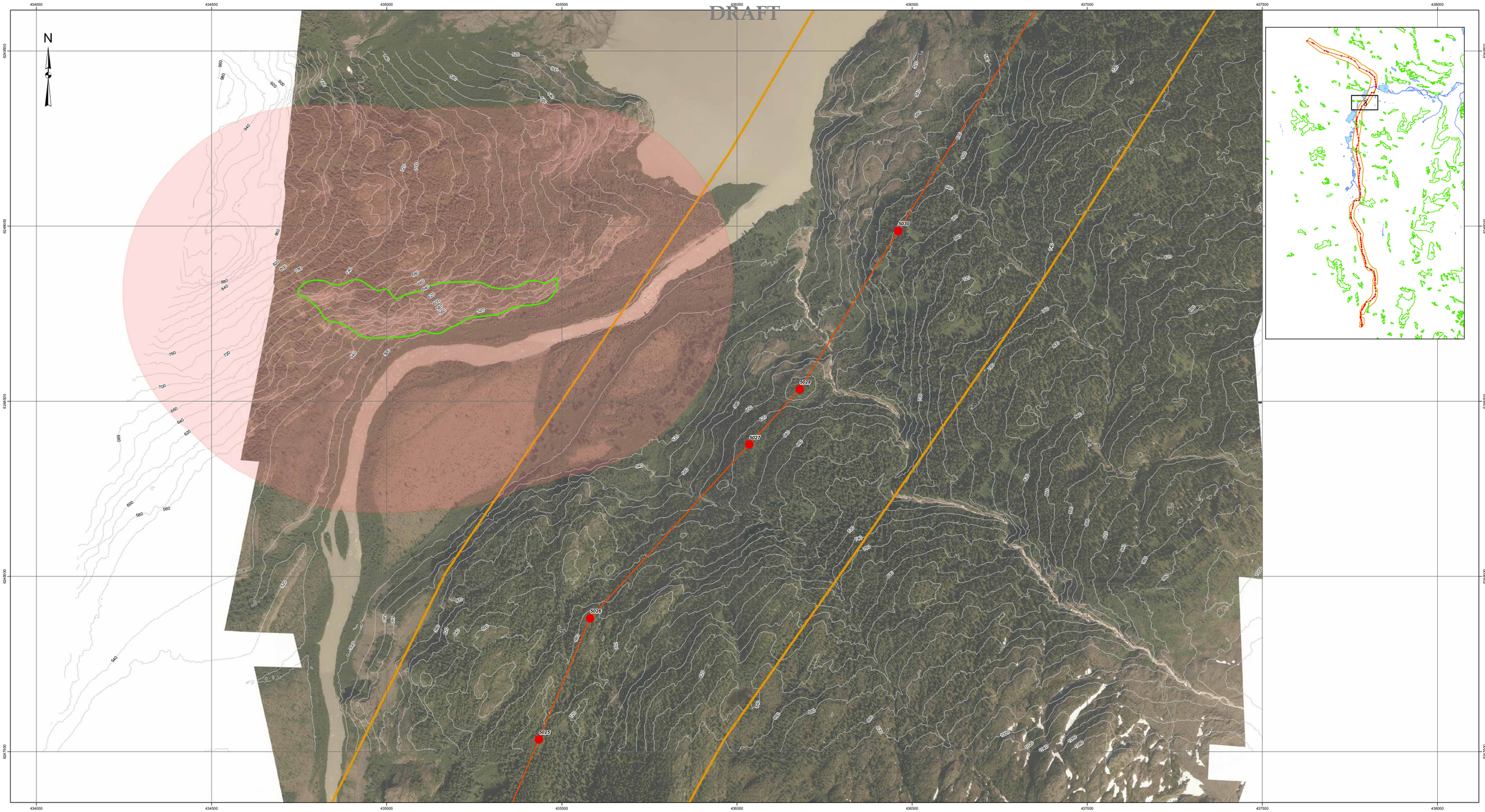

Legend

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0 75 150 300 450 600
Meters

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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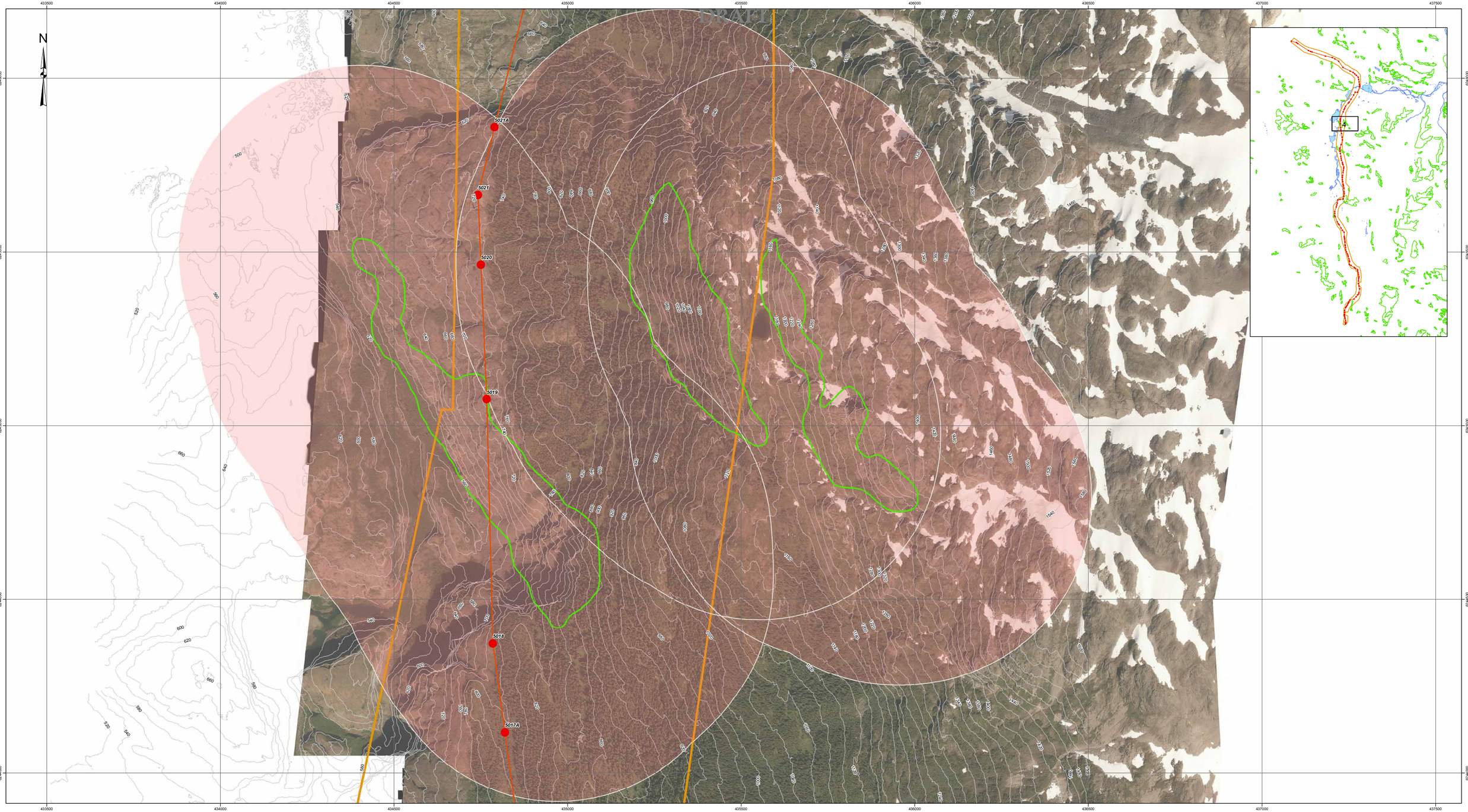

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with 500m Buffer

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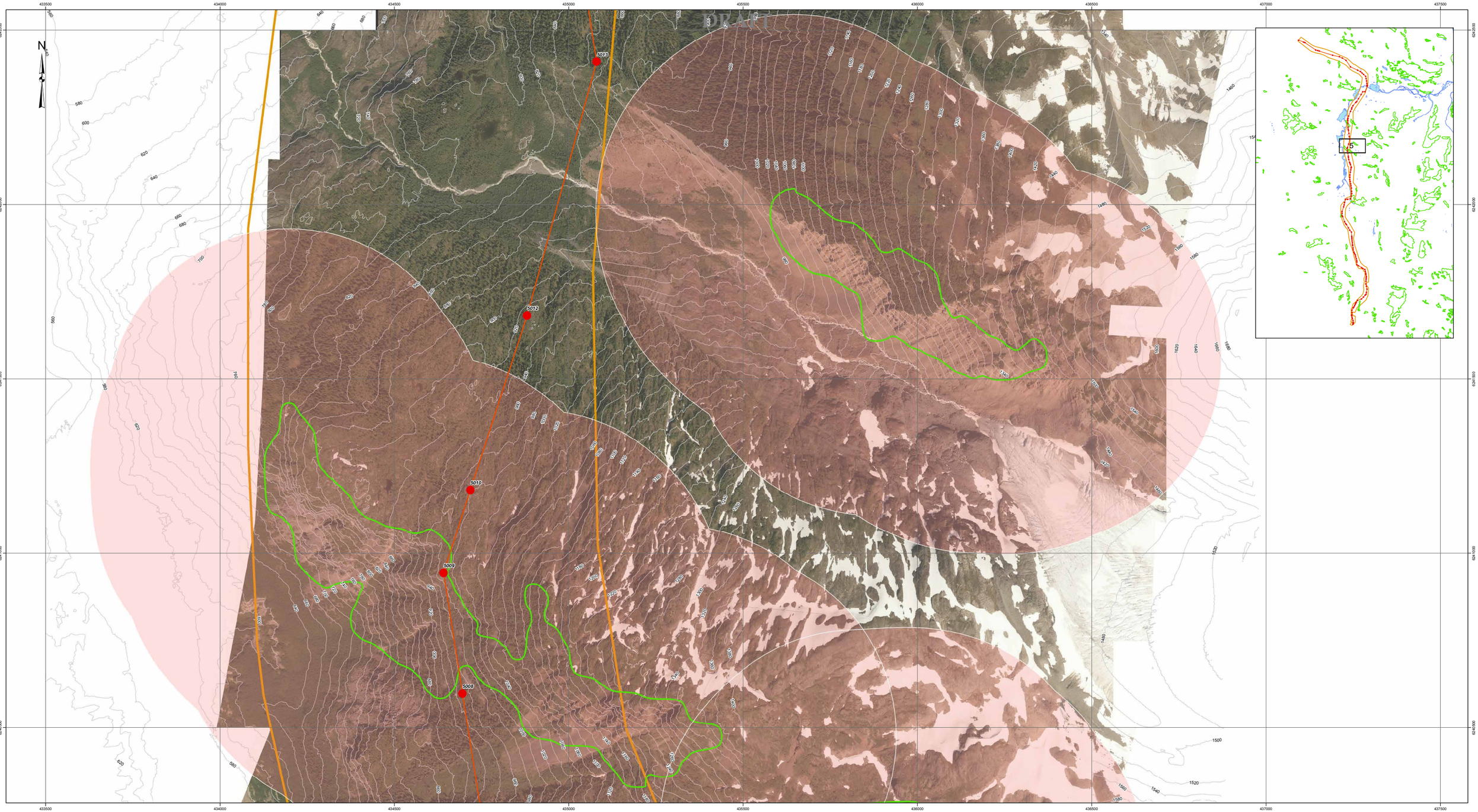

Legend

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- Transmission Line Corridor (as of 9 Jan 2015)

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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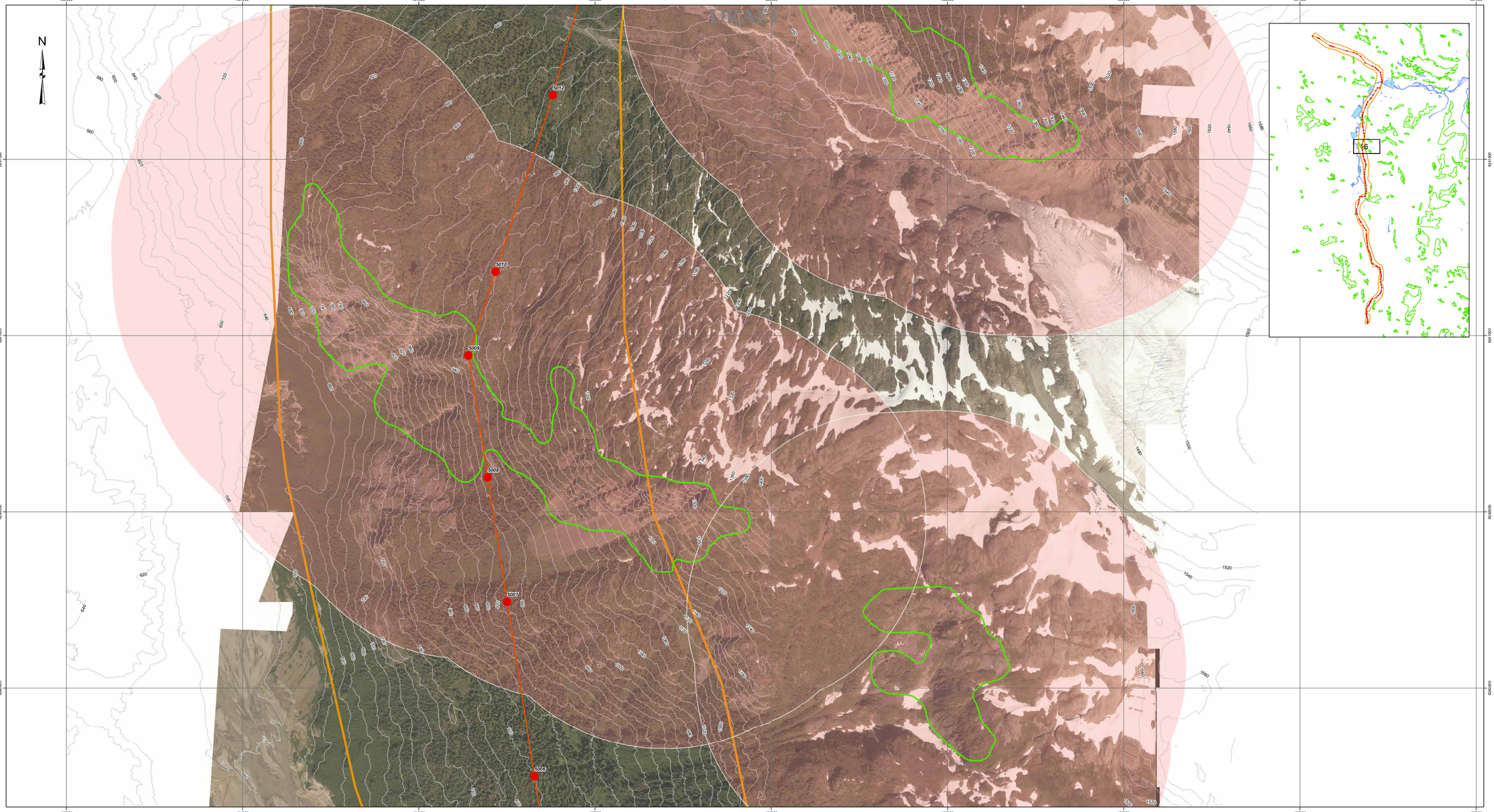

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Brucejack Project

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with 500m Buffer

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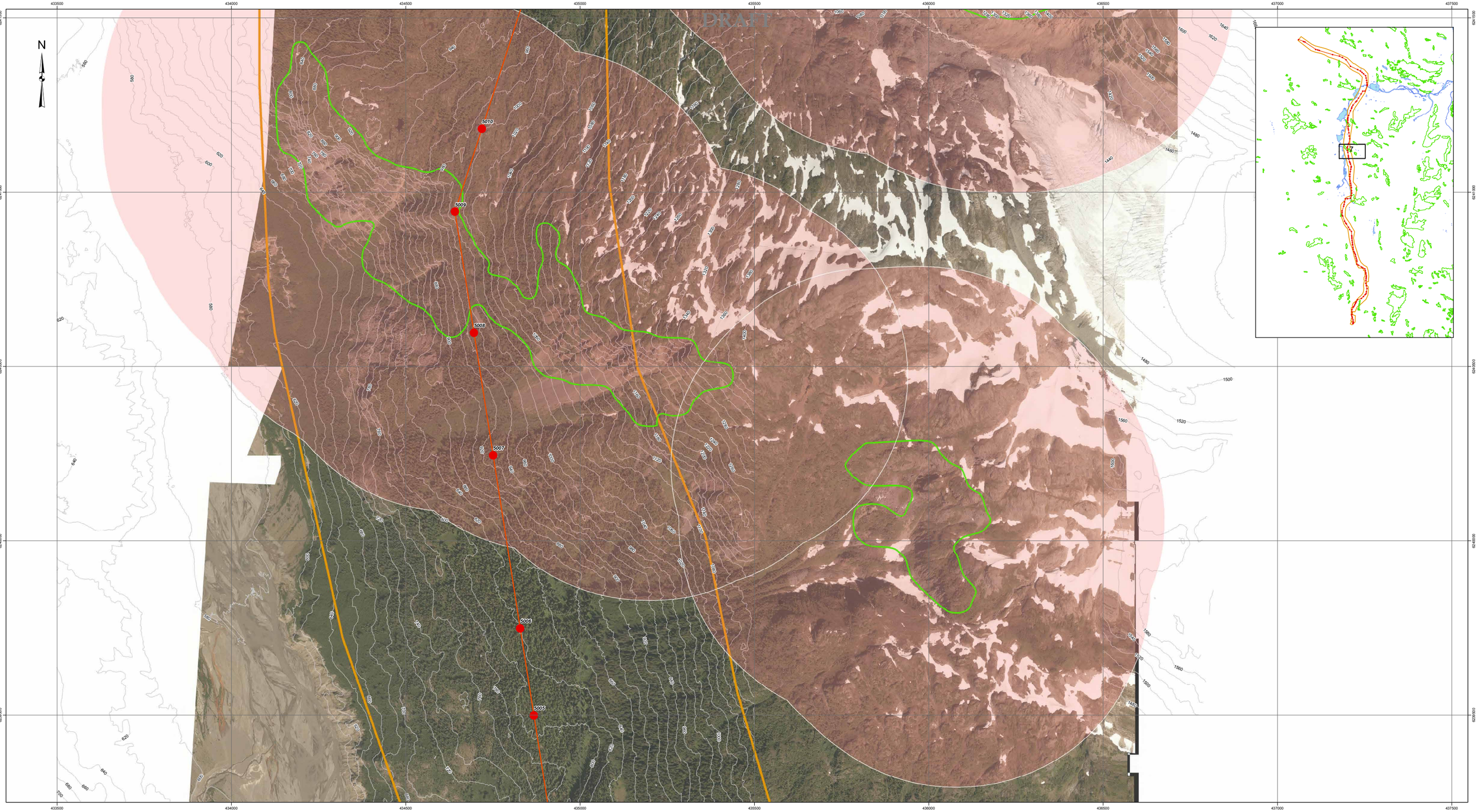

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

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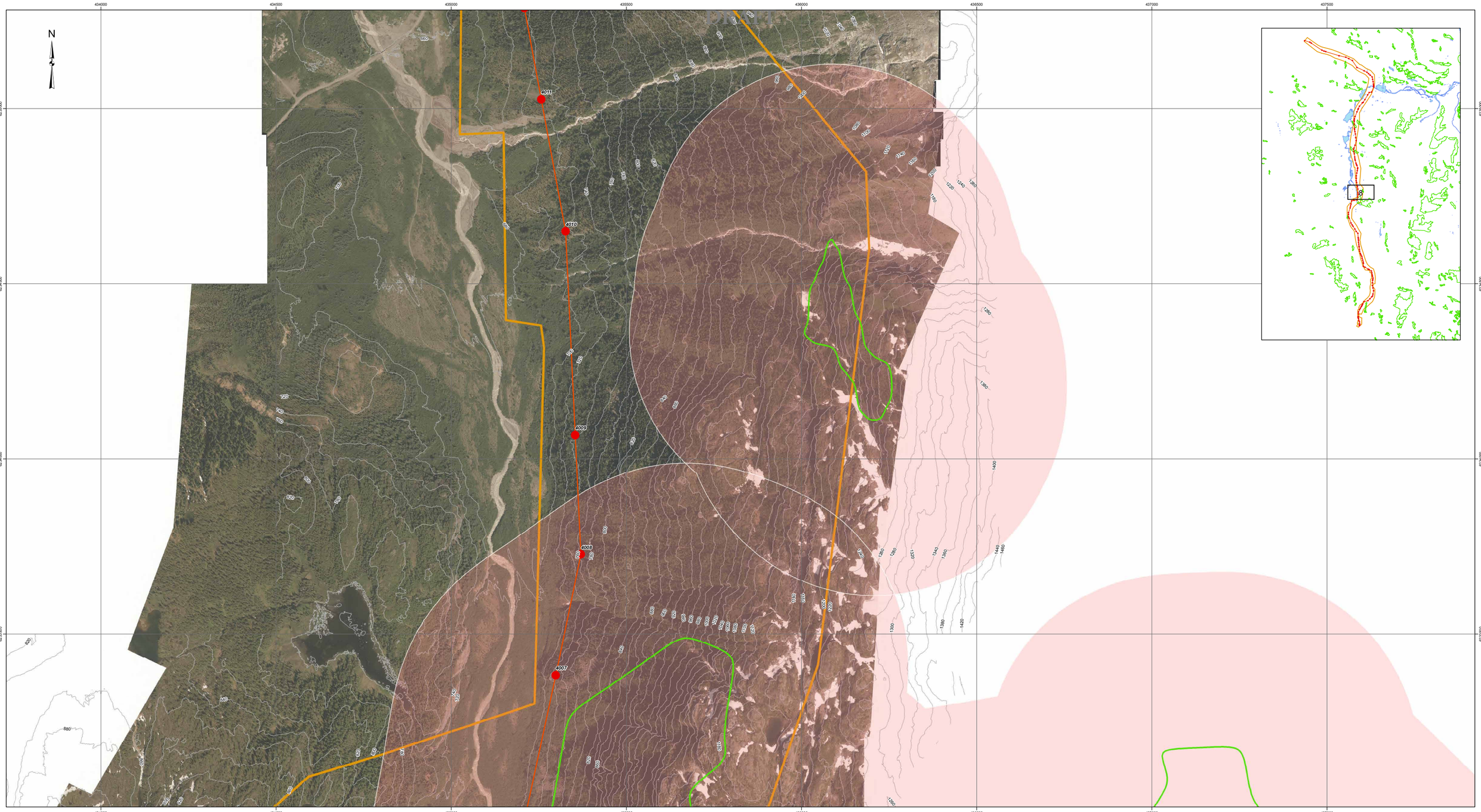

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- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Canada
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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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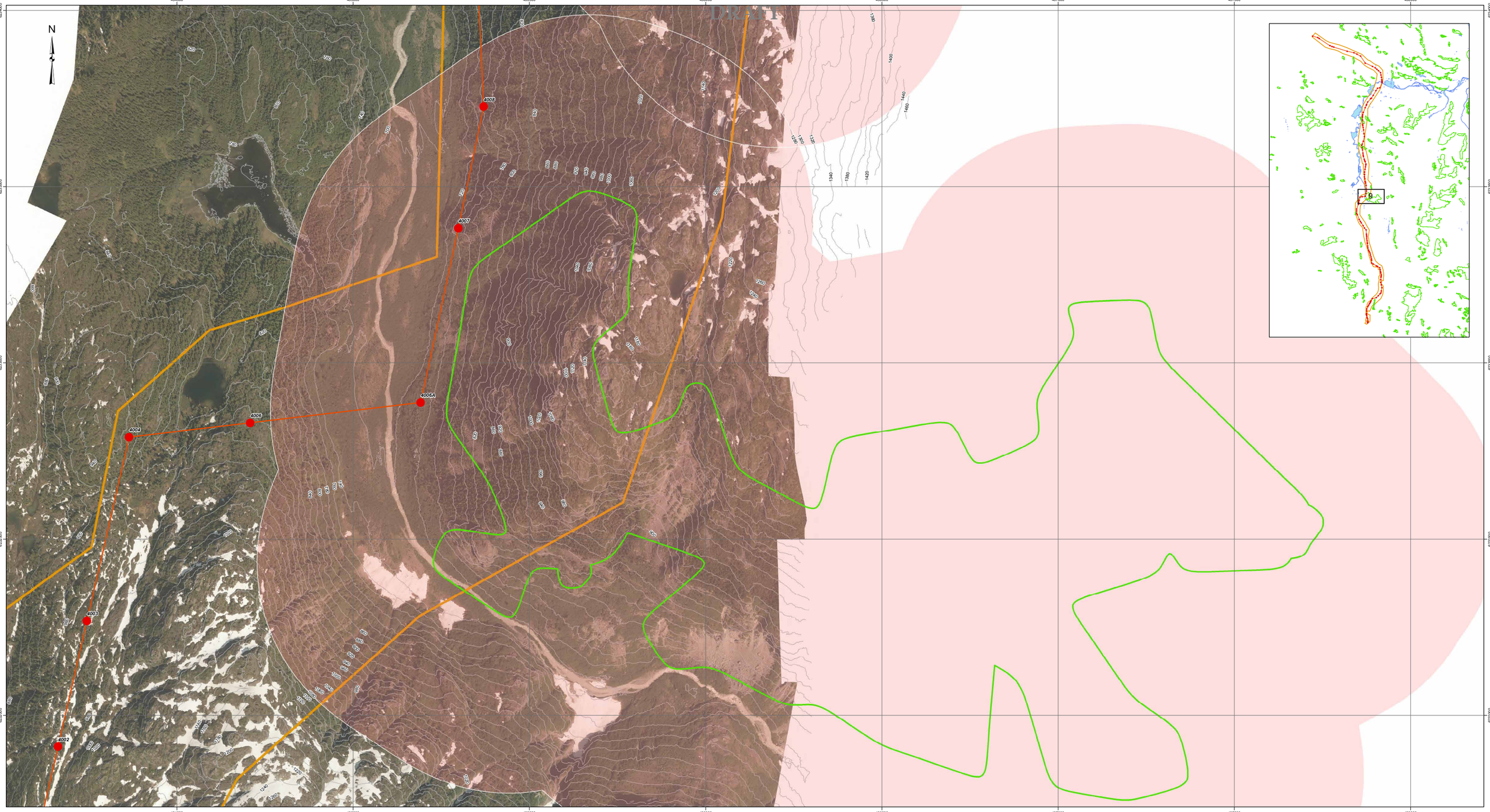
This drawing may have been reduced or enlarged. All scale notations indicated are based on original format drawings. Some text will not be legible. Please contact ERM or Pretivm for the digital copies.



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
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Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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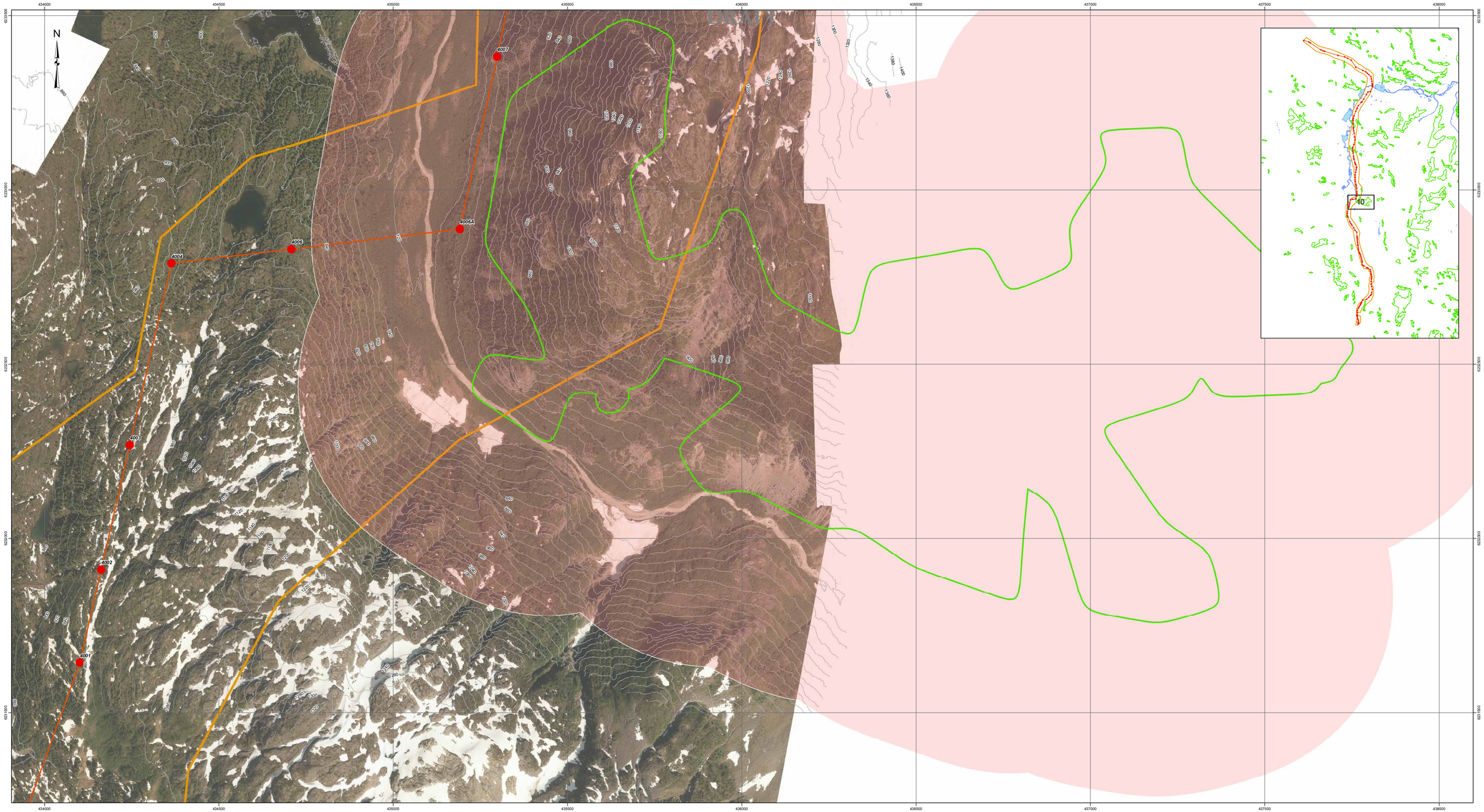

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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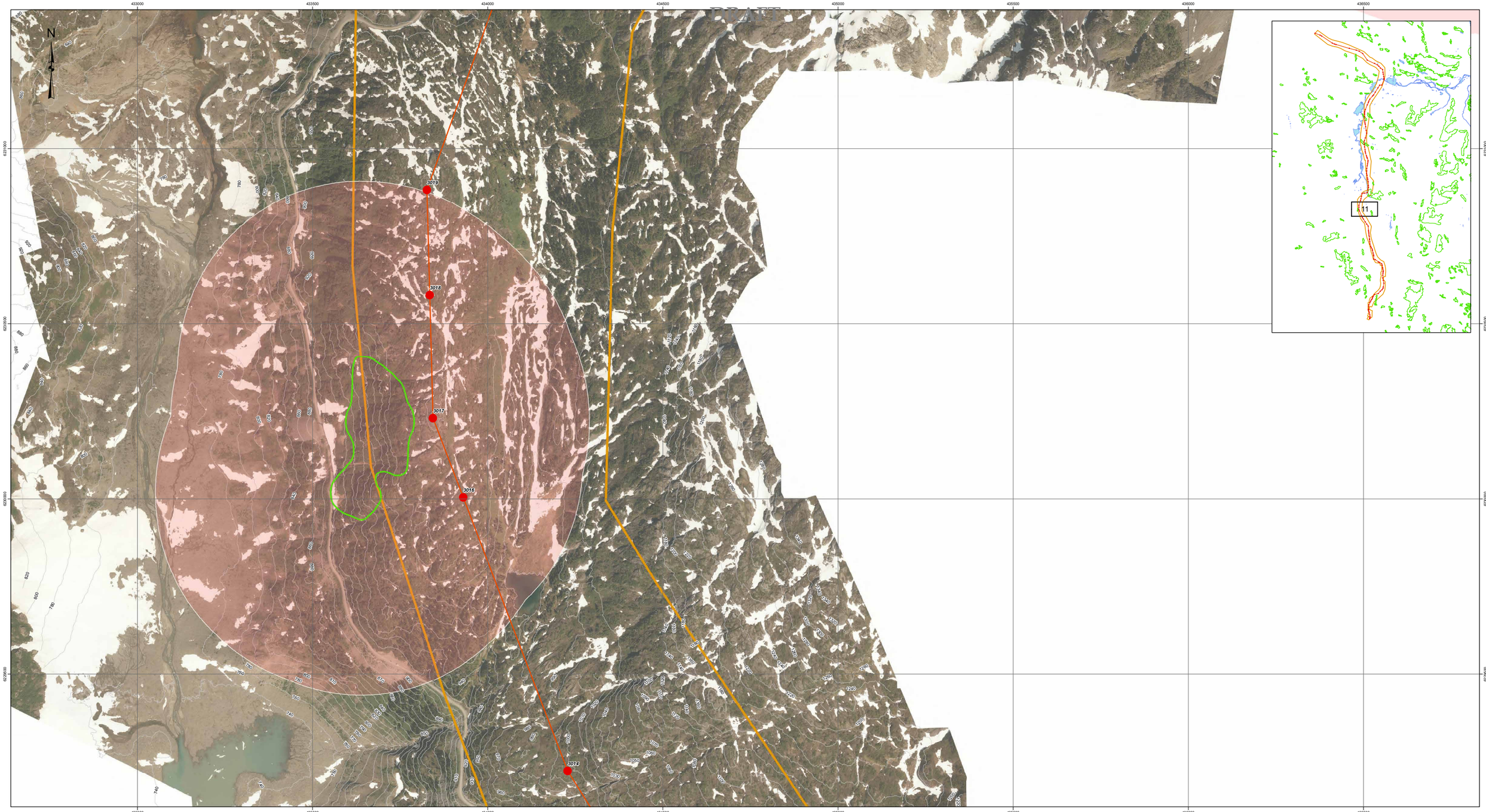

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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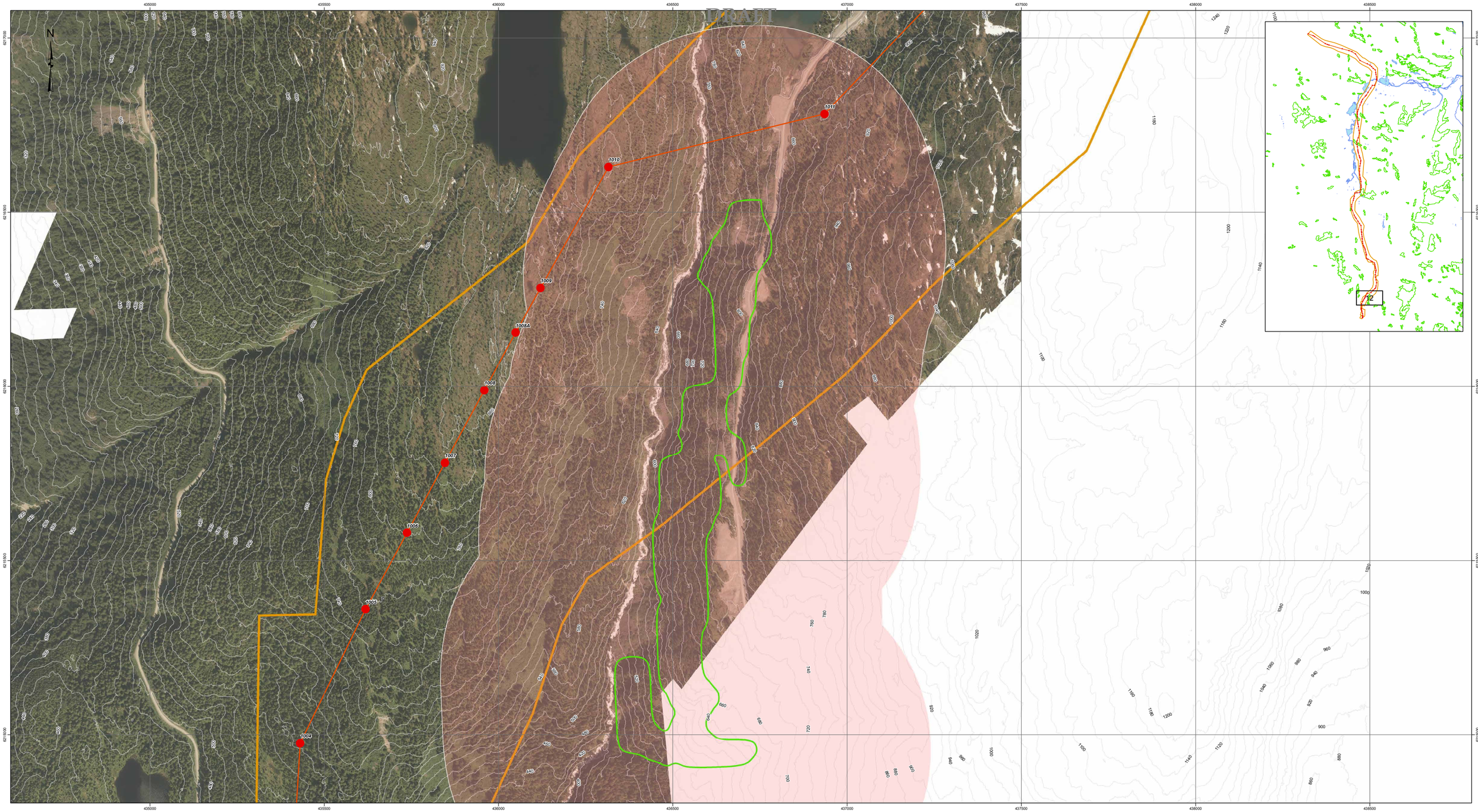

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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PROJECTION: UTM Zone 9 (NAD 83)

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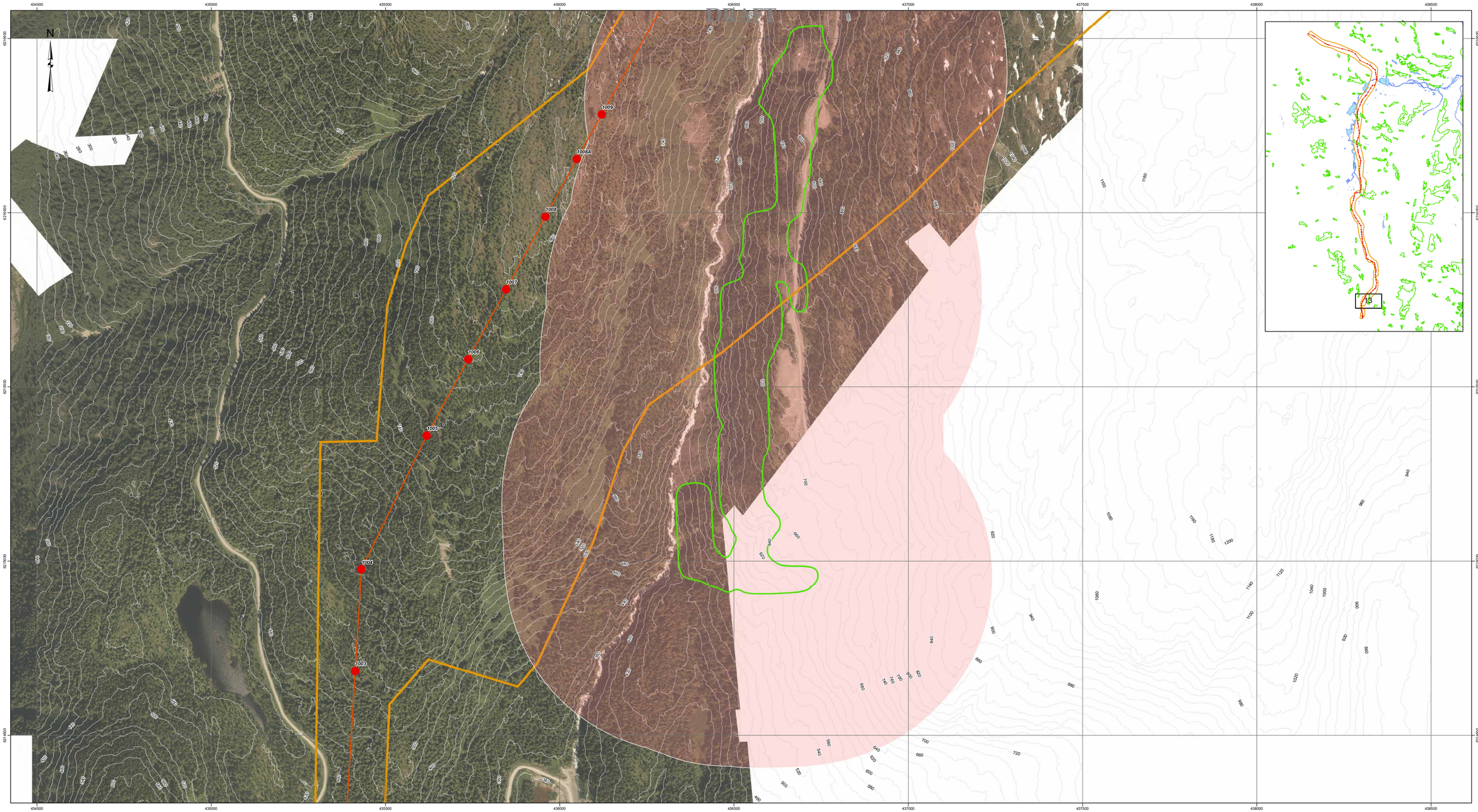

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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DRAFT

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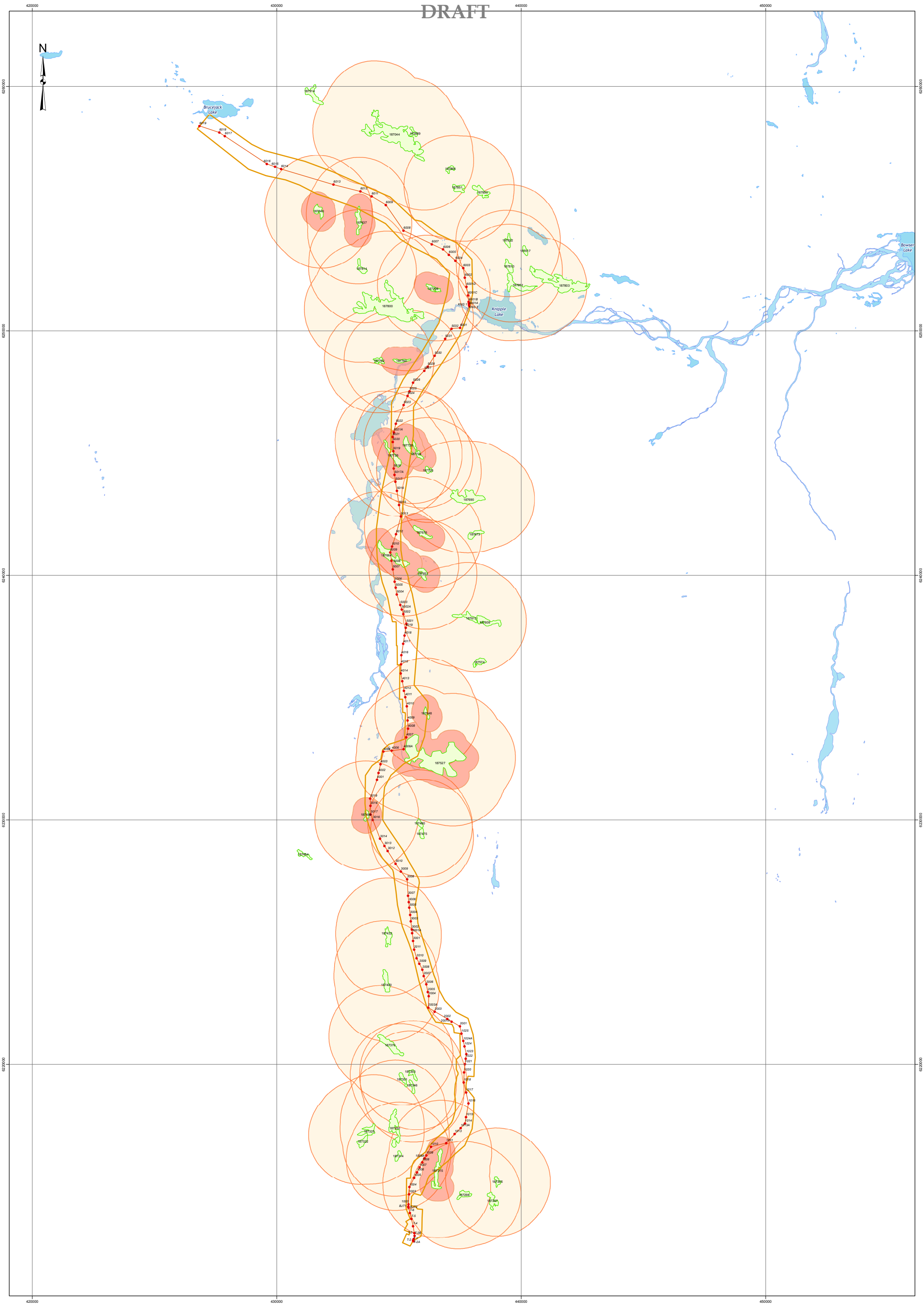

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Transmission Line Corridor (as of 9 Jan 2015)
- Mountain Goats Along Transmission Line
- 2 Km Buffer
- 500m Buffer

0 0.75 1.5 3 4.5 6
Kilometers

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goats Along Transmission Line

PROJECTION: UTM Zone 9 (NAD 83)

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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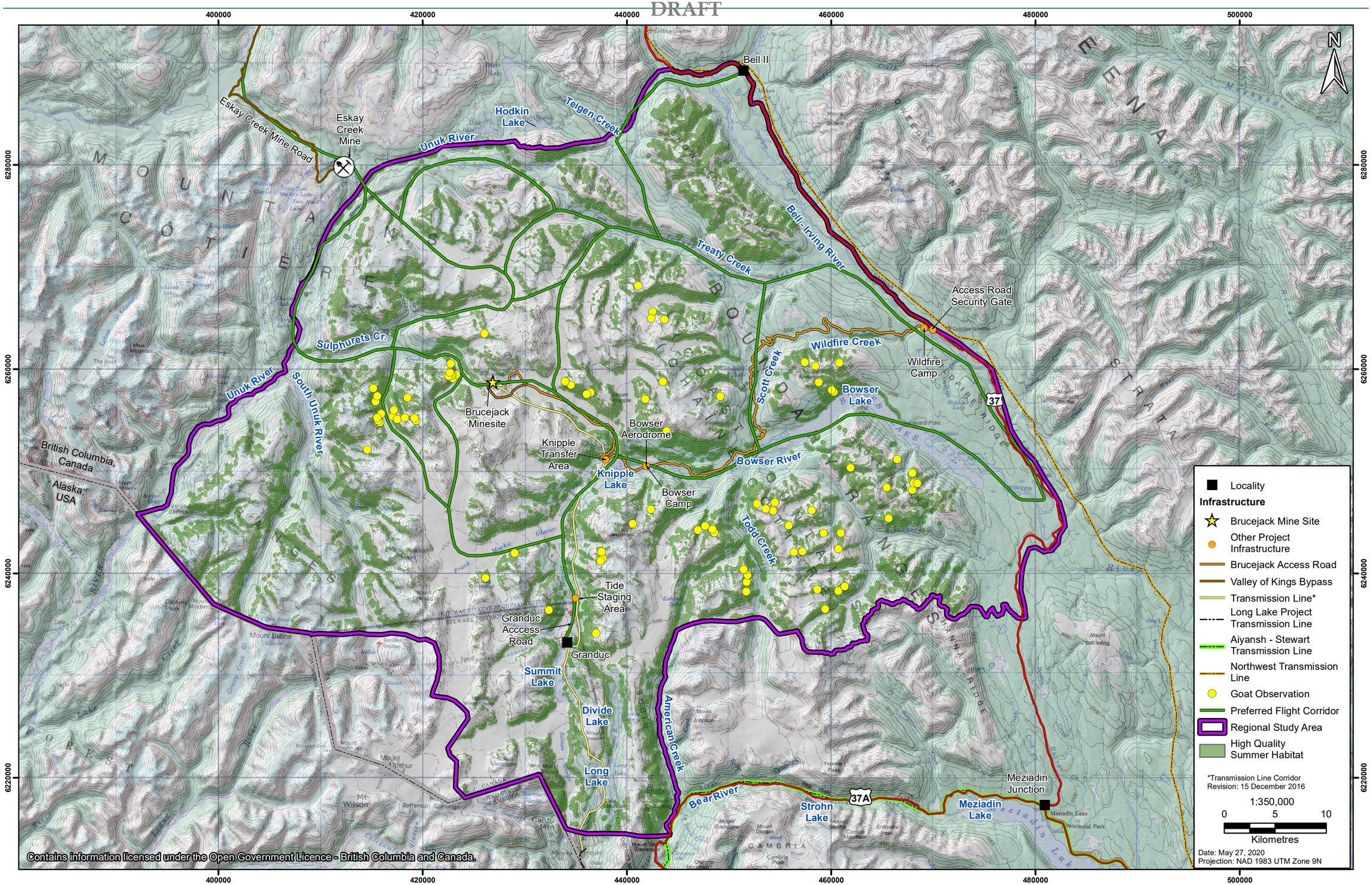
DRAFT



Helicopters and Mountain Goats at Brucejack

Appendix 9-1-20. Soils Management Plan

PRETIVM

BRUCEJACK GOLD MINE

Soils Management Plan

Date: December 2018

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VERSION CONTROL

Version #	Date Released	Approved By	Amendment/Details
1	May 2015	Pretium Exploration Inc.	Submitted as part of Chapter 5 Reclamation Planning and Effective Mine Closure, MAEMA Permit Application
2	December 2018	Pretium Resource Inc.	Content extracted from Ch.5 and presented as a standalone Soil Management Plan

BRUCEJACK GOLD MINE
Soils Management Plan

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GLOSSARY AND ABBREVIATIONS

BC	British Columbia
BC MEM	British Columbia Ministry of Energy and Mines
BC MEMPR	British Columbia Ministry of Energy, Mines and Petroleum Resources
BC MECCS	British Columbia Ministry of Environment & Climate Change Strategy
BEC	Biogeoclimatic Ecosystem Classification
Code, the	Health, Safety and Reclamation Code for Mines in British Columbia (BC MEMPR 2008)
EAC	Environmental Assessment Certificate
EMP	Environmental Management Plan
km	Kilometre(s)
m	Metre(s)
Mine	Brucejack Gold Mine (including all mine components)
Mine Site	Brucejack Mine Camp Site
NLG	Nisga'a Lisims Government
NPAG	Not potentially acid generating
Pretivm	Pretium Resource Inc.
TSKLH	Tsetsaut/Skii Km Lax Ha

1 PURPOSE, SCOPE, AND PERFORMANCE OBJECTIVES

The purpose of the Soils Management Plan for the Brucejack Gold Mine is to outline soil and growth media salvage, stockpiling, and replacement approaches for the Mine Site Area only, under auspices of the *Mines Act* Permit M-243.

Following is a discussion of soil and overburden resources, as well as the soil salvage and management considerations for the Mine Site Area and the 19 km northernmost section of the Brucejack Transmission Line.

The scope of this Soils Management Plan includes only the area specified under the *Mines Act* Permit M-243: the Mine Site Area (i.e., Brucejack Mine Site, Lakeshore Drive Realignment, Lakeshore Drive, Valley of the Kings Bypass Road, NPAG Quarry Borrow Sources, and northern 19 km of Transmission Line extending from Pretivm's Mineral Claim #1026976 to the northern terminus of the line). All other areas (i.e., Knipple Transfer Area, Bowser Aerodrome, Bowser Camp, Wildfire Camp, southern 38 km of the Brucejack Transmission Line, explosive storage areas, communications towers, avalanche control systems, and meteorological stations) are covered under the Ancillary Infrastructure Decommissioning and Reclamation Plan.

2 RELEVANT LEGISLATION, REGULATIONS, AND EAC CONDITIONS

2.1 RELEVANT LEGISLATION AND REGULATIONS

This Plan follows the structure outlined by the British Columbia (BC) Ministry of Energy, Mines and Petroleum Resources (BC MEMPR) in its draft application guide for *Mines Act* and *Environmental Management Act* Permits (BC MEM 2013), and addresses the content requirements provided by both the BC MEM and BC Ministry of Environment & Climate Change Strategy (BC MECCS). As well, soils management will follow the Health, Safety and Reclamation Code for Mines in British Columbia (2017).

2.2 RELEVANT EAC CONDITIONS

Pretivm was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that included a series of conditions associated with the Certificate. This management plan is in support of Condition #2, in relation to a Reclamation and Closure Plan and Component Plan for Ancillary Infrastructure Decommissioning and Reclamation, presented within Schedule B of the Certificate and copied below.

> *Condition 2*
>
> *"The Holder must prepare the Construction, Operations, Closure and Post-Closure Component Plans identified in Appendix A in consultation with, and to the satisfaction of, RRAs.*
>
> *Component Plans, at minimum, must include the following information:*
>
> - *Purpose of Component Plan;*
> - *Performance objectives;*
> - *Effects mitigation measures;*
> - *Monitoring programs;*
> - *Monitoring schedules; and*
> - *Reporting requirements.*
>
> *The Holder must consult with the NLG, Tahltan and TSKLH on the content and implementation of Component Plans in accordance with the ACP set out in Condition 5.*
>
> *The Holder must implement Component Plans according to timelines set by RRAs. This can be no later than the commencement of Construction."*

2.3 Relevant Permit Conditions

The *Mines Act* Permit M-243 and associated Management Plans require that conditions in the *Mines Act* Permit M-243 be followed for soil salvage and storage as well as sediment and erosion control. Following mine closure the Reclamation Plan for the site requires landforms be appropriately prepared for long term maintenance-free configuration and have self-sustaining drainage control features and watercourses that do not allow soils to be remobilized into aquatic resources. Soils salvaged and stored are to be used for reclamation purposes where appropriate. At closure the Mine Site is to meet land use objectives of the permit, i.e. the landscape is to be returned to a matrix habitat that does not hamper movement of wildlife.

3 SOILS MANAGEMENT STRATEGY

This section describes the soil and growth media salvage, stockpiling, and replacement approaches for the Brucejack Mine Site Area and the Northern 19 km of the Transmission Line. Soils or growth media suitable for use in reclamation will be salvaged from Mine surface development areas, where feasible. The land capability of reclaimed areas will be affected by soil handling including salvage, storage, and spreading at reclamation, as well as site preparation for reclamation.

3.1 BRUCEJACK MINE SITE AREA

3.1.1 Soil Assessment

The Brucejack Mine Site Area is located in the high elevation, very cold Coastal Mountain-heather Alpine (undifferentiated; CMAun) Biogeoclimatic Ecosystem Classification (BEC) subzone. The surface disturbance (infrastructure footprints) area has been estimated at about 22 ha for the Brucejack Mine Site with a buffer and interdisturbance areas at the Mine Site estimated at 23.5 ha for a total of 45.5 ha. The greater Mine Site Area has been estimated at 62 ha and includes:

- Brucejack Mine Site;
- Lakeshore Drive realignment to the gravel borrow sources;
- existing Lakeshore Drive;
- existing Valley of the Kings bypass road (to glacier);
- NPAG Quarry; and
- gravel borrow sources.

Within this Mine Site Area, vehicle travel is kept to the main roads and pathways, and is discouraged outside of these areas. Vegetation is sparse, generally covering less than 20% of the Brucejack Mine Site and with little to no cover at the other facilities within the Mine Site Area. This sparseness is due to the occurrence of extensive bedrock, as well as the limited extent and poor quality of growth media, many of which do not meet the definition of soils and/or have elevated metals concentrations. Soils and growth media are poorly developed as a result of limited weathering of parent materials, and/or of poor quality due to the site's location primarily on a gossan (mineralized, oxidized rock on surface; Plate 3.1-1). There has also been historical disturbance of growth media within the Mine Site due to advanced mineral exploration activities.

Where soils are present, they are generally rated as poor due to the high coarse fragment content, lack of soil development, or shallowness over bedrock. Most material proposed for salvage at the Mine Site is unconsolidated overburden (subsoils), as the very limited soil that may have been present in some areas has been disturbed. The overburden comprises recently deposited/exposed morainal and residual (materials developed in-place) materials. Small areas of Fair to Good rated soil material may be present between rock outcrops in some areas. However, based on Canadian Council of Ministers

of the Environment guidelines, soil analysis indicates that the soils at the Mine Site have metal exceedances, including arsenic. Therefore, the soils at the Mine Site are considered to be generally unsuitable for use in reclamation.

Plate 3.1-1. Brucejack Mine Site located on a gossan.

3.1.2 Soil Salvage

The Mine Site Area is predominantly hummocky with rock outcrops and patchy, shallow, soil development in residual/colluvial and morainal materials, along with extensive disturbed areas (Figures 3.1-1 and 3.1-2; Polygons: 605, 609, 610, and 636). The Mine Site Area also contains a small area of near level sediments of fluvio-lacustrine and moraine fill (Polygon 608) near Brucejack Lake. However, polygon 608 is an area that was used for a waste rock and mineralized material storage facility until 1999 and remnants of that material remain, generally below the water table. As above, the plan is to not salvage unconsolidated overburden within the Mine Site area for reclamation purposes. Nonetheless, overburden has been excavated and stored, primarily from polygon 609. Limited chemical analyses conducted before construction began indicated the material is often PAG and is not be suitable for reclamation purposes (Lorax 2016; Appendix A). Further chemical analysis will be carried out and if the material is suitable for reclamation purposes, it will be excavated at Closure and used on-site for reclamation. Otherwise, this material will remain in place at Closure.

Rock outcrops dominate the NPAG Quarry site and along the Lakeshore Drive realignment. Cobbles and gravel also extend to surface at the gravel borrow sources. No growth media salvage is feasible at these sites.

Figure 3.1-1
Brucejack Mine Site Terrain Mapping Polygons

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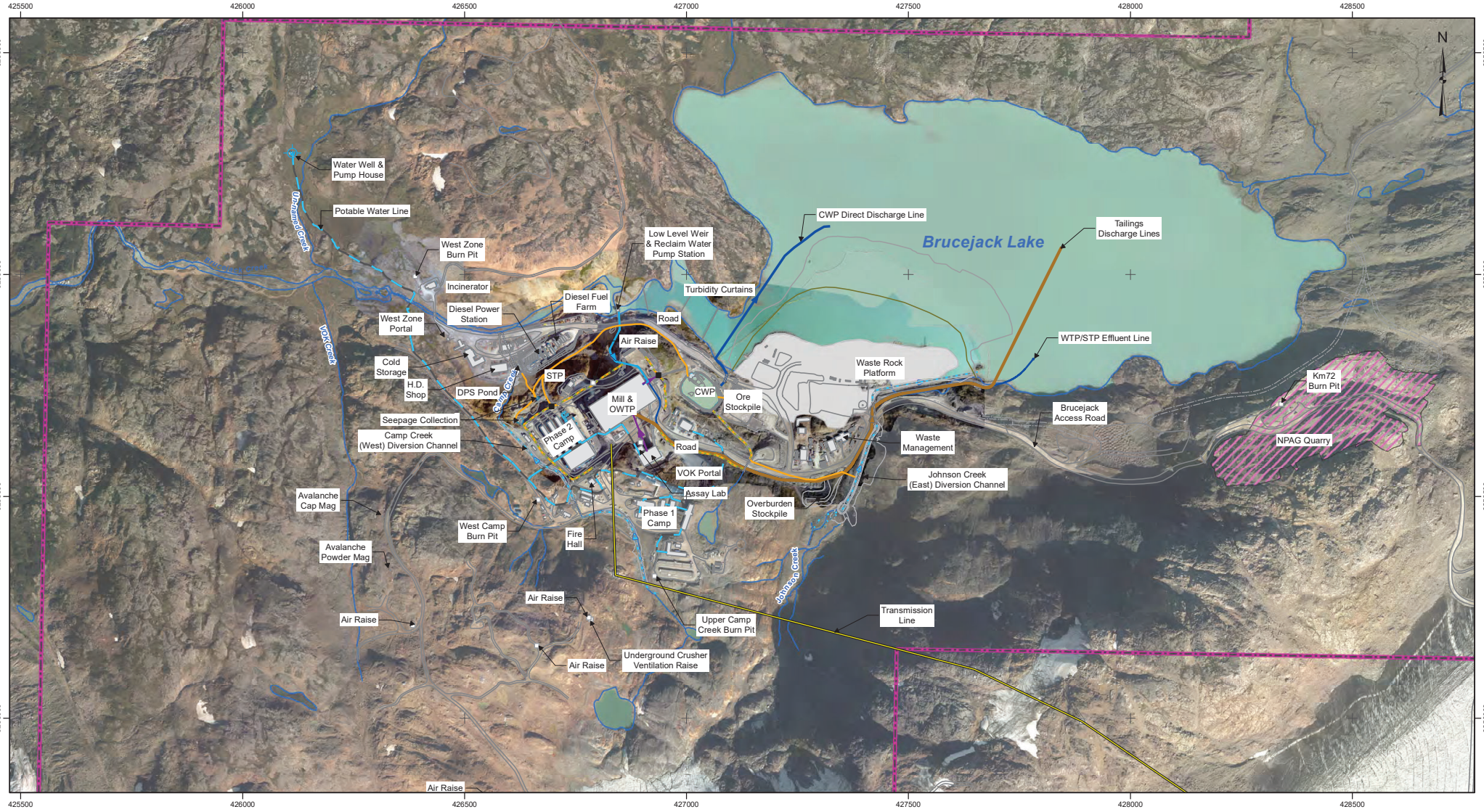

Drainage Manhole
Water Well & Pump
Potable Water Line
Transmission Line
Road Permitted (Not Built)
Building Infrastructure
Waste Rock Dump Ultimate Toe (3.81 M m3 Design)
Sep 11, 2018 Waste Rock Dump Crest Survey
Waste Rock Dump Ultimate Crest (3.81 M m3 Design)
CWP Direct Discharge Line
Contact Water Ditch
Contact Water Lines
Non-Contact Surface Runoff
Non-Contact Water Channel
Relcaim Water Line
Tailings Discharge Lines
Untreated or Off-Spec Water Line
WTP/STP Effluent Line
Culverts
Pretivm Mining Lease

0 100 200 400
Meters

PRETIVM

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PRETIUM RESOURCES INC.
Brucejack Gold Mine

Mine Site General Arrangement

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
	P01_BJ_1000_GA_11x17_20181120		1:8,000	20 Nov 2018		

PROJECTION: NAD 1983 UTM Zone 9N

3.2 TRANSMISSION LINE (NORTHERN 19 KM)

The Brucejack Transmission Line follows bedrock-dominated terrain. Towers and lines were installed by helicopter. Little surficial material was disturbed due to the small size of the tower footprints and use of helicopter support.

Any soils that were disturbed during construction will be seeded with a native seed mixture such as:

- alpine bluegrass (*Poa alpine*);
- spike trisetum (*Trisetum spicatum*); and
- blue wildrye (*Elymus glaucus*).

This seeding will provide a vegetative cover in the disturbed areas and reduce the potential for erosion.

4 REFERENCES

2003. *Environmental Management Act*, SBC. C. 53.

BC MEM. 2013. *Application Guide for Technical Information Required for a* Mines Act *Permit and an* Environmental Management Act *Permit* (draft August). Prepared by the British Columbia Ministry of Energy and Mines: Victoria, BC.

BC MEMPR. 2017. *Health, Safety and Reclamation Code for Mines in British Columbia*. Prepared by the British Columbia Ministry of Energy, Mines and Petroleum Resources, Mining and Minerals Division: Victoria, BC.

BC MEMPR. 2018. *Permit M-243 Approving Mine Plan and Reclamation Program, Brucejack Gold Mine.* Issued by the British Columbia Ministry of Energy, Mines and Petroleum Resources.

Lorax. 2016. *Characterization of Overburden at the Brucejack Mine Site*. Prepared for Pretium Resources Inc. by Lorax Environmental: Vancouver, BC.

Appendix A

Lorax Environmental Memo (February 18, 2016):
Characterization of Overburden at the Brucejack Mine Site

MEMORANDUM

To:	**Sylvia Van Zalingen, Max Holtby, Robin McCall (Pretivm)**	**Date: February 18, 2016**
From:	**Alison Shaw, Stephanie Simpson (Lorax)**	**Project #: A384-1**
Subject:	**Characterization of Overburden at the Brucejack Mine Site**	

A significant volume of overburden material (estimated at up to 60,000 m^3) will be excavated by the end of Construction and relocated within the Brucejack Mine Site in order to develop site infrastructure. Pretivm Resources Inc. (Pretivm) requested that Lorax Environmental Services Ltd. (Lorax) develop a sampling program to assess the geochemical characteristics of overburden and its suitability for use in reclamation, in accordance with requirements of *Mines Act* Permit M-243. Relevant conditions outlined in *Mines Act* Permit M-243 that pertain to management of overburden material include the following:

Section D(9)(a):

> *The Permittee shall salvage and stockpile topsoil, overburden and organic material, to the extent practical, for use in reclamation.*

Section D(3):

> *All materials with the potential to generate ML/ ARD shall be placed in a manner that minimizes the production and release of metals and contaminants to levels that assure protection of environmental quality.*

This memorandum provides an overview of the overburden at the Brucejack Mine Site; a description of the assessment methods employed for the 2015 characterization program; and a discussion of the static test results in the context of the regulatory requirements outlined above. The findings presented herein indicate that the overburden at the Mine Site is not suitable for reclamation purposes due to the low nutrient and organic matter contents; the elevated metal concentrations; and the potentially acid generating (PAG) characteristics of the material.

1. Overburden at the Brucejack Mine Site

1.1 Site Description

The Brucejack Mine Site is located predominantly on bedrock outcropping with pockets of sparse alpine vegetation covering less than 20% of the area (Photo 1-1). Located above the tree line in the Coastal Mountain-heather Alpine Biogeoclimatic Ecosystem Classification zone, the mine site has an elevation of approximately 1400 m above sea level and is surrounded by glaciers and ice fields to the west, south, and east. The mean annual temperature in this region

ranges from 0 ºC to 4 ºC. Snow, névé, and firn persist late into the year resulting in a short frost free period (Pretivm, 2015).

Vegetation development is limited by the availability and poor quality of growth media, and due to excessive snow pack, strong winds, and low temperatures in this region. When present, the distribution of Alpine Group species (*e.g*. small shrubs, lichen, mosses) is limited by growth media depth, drainage, and microclimate.

Photo 1-1: An aerial view of the Brucejack Mine Site and Brucejack Lake from the east.

The Canadian System of Soil Classification (1998) defines soi1 as:

> *'naturally occurring, unconsolidated minera1 or organic material at least 10 cm thick that occurs at the earth's surface and is capable of supporting plant growth. In this definition "naturally occurring" includes disturbance of the surface by activities of man such as cultivation and logging but not displaced materials such as grave1 dumps and mine spoils.'*

The baseline (pre-development) soils and reclamation assessment of the Brucejack Mine Site characterized the surficial materials (potential growth media) as poorly developed as a result of limited weathering of parent materials and disturbance related to mineral exploration activities (Pretivm, 2015). Most material originally proposed for salvage at the Mine Site is unconsolidated overburden (subsoils), comprised of recently exposed morainal and residual (developed in-place) materials. Where present, soils were generally rated as Poor due to the high coarse fragment content, or shallowness over bedrock (Pretivm, 2015). Baseline and reclamation assessments also noted that the Mine Site is located within a gossan, with mineralization to surface.

1.2 Previous Characterization Programs

Baseline studies were carried out to assess the characteristics of the Brucejack Gold Mine Project terrain and soils. Fifty soil samples were collected from 34 inspection sites within three defined sub-areas of the local study area (LSA): Brucejack Access Road, Brucejack Mine Site, and Brucejack Transmission Line (Pretivm, 2014). Soil inspections were carried out in the field and a range of parameters, including pH, carbon (C) content, texture, $CaCO_3$ equivalence, metal concentrations and cation exchange capacity (CEC), were analyzed to provide information on ecologically important characteristics relative to reclamation suitability and soil management. The results of this analysis indicated that soils at the Mine Site were generally considered to be unsuitable for use in reclamation due to the poor quality, low nutrient contents and elevated metal concentrations (As and Ni in particular). The detailed results for this study are presented in the 2012 Terrestrial Ecosystem Baseline Studies (Appendix 16-A in Pretivm, 2014).

A separate baseline study, carried out by BGC in August 2013, was completed to evaluate the ML/ARD characteristics of the Mine Site overburden. The study included 14 overburden samples from the surface layer around the Mine Site which were submitted for ABA and solid phase element determination by aqua regia digestion. Results from this program indicated that all 14 samples were PAG, and five samples had paste pH values < 6 (4.9 to 5.9).

Additional geochemical sampling was carried out at the Mine Site in July 2015, whereby 10 overburden samples were collected from two small pits in the vicinity of the proposed Contact Water Pond (CWP). The pits were developed through approximately 4 m of overburden, but were not developed to bedrock. In one of the pits, geotextile fabric was encountered, indicating that this area had previously been disturbed from the period of time in the mid to late 1980s when Newhawk Gold Mines Ltd. was undertaking mineral exploration at the site. All 10 samples were indicated to be PAG.

The extent of overburden at the Mine Site has been estimated from stratigraphy data collected during a drilling program carried out by BGC Engineering (BGC) between 2012 and 2014. The BGC program was comprised of forty boreholes and included a description of the overburden

material and the measured thicknesses. This data, along with a map showing borehole locations, is provided in Appendix A. This information was used to estimate the amount overburden that would be removed from the mine Site during construction and to provide guidance for recommended sample locations for the 2015 overburden program.

2. Assessment Methods for 2015 Mine Site Overburden Program

2.1 Rationale for Sample Frequency

As described above, pre-development site investigations suggested that excavation of up to 60,000 m^3 of overburden would be necessary within the Brucejack Mine Site during Construction. Given that the overburden material is weathered from predominantly PAG rock and that the existing overburden samples at the site are indicated to be PAG, a sampling frequency consistent with that recommended by the British Columbia Ministry of Energy and Mines (MEM) for preliminary assessment of rock (*i.e.,* 8 samples per < 100,000 metric tonnes) was applied to characterize the Mine Site overburden. Using the MEM standard, 60,000 m^3 equates to 108,000 metric tonnes (assuming a density of 1.8 g/cm^3) and a minimum of 16 sample locations.

To achieve the target sampling frequency, the Mine Site was divided into 16 quadrants with recommendations that at least one test pit be developed in each quadrant and two samples be collected from each location; one sample from the upper horizon (generally the upper 30 cm) and a second sample from the lower horizon. Quadrants superimposed entirely over Brucejack Lake or outside of the Mine Site boundary were omitted and additional sampling completed in the vicinity of the portal pad where the nature of the material was unknown.

A total of 28 overburden samples were collected from 17 test pits around the Mine Site in September 2015. Figure 2-1 shows the location of test pits for the 2015 sampling programs and surface sites for the 2013 program. A description of each overburden sample collected to date from the Brucejack Mine Site is provided in Appendix B.

2.2 Collection Methods

Test pits were developed either with the aid of an excavator or by hand using a large shovel. Sites accessible by an excavator had a trench cut down to the bedrock to expose the complete overburden profile in cross section. The depth from the surface of the overburden to bedrock was noted and the vertical profile documented. Once the profile had been documented, a 2 kg composite sample from the entire upper 30 cm was collected using a hand shovel and a second 2 kg composite sample was collected from the entire horizon below 30 cm to bedrock.

At each of the test pits developed for the 2015 sampling programs, the thickness of the overburden and depth to bedrock was recorded. Samples were only collected from locations

that had sufficient thickness of overburden, determined as 30 cm for the purpose of this evaluation. Sites that had less than 30 cm overburden were documented, but no sample was collected.

2.3 Quality Assurance and Quality Control

The quality assurance and quality control (QA/QC) program for the Brucejack Mine Site overburden assessment included one field duplicate sample per 10 samples collected to assess variability in PAG potential and soil content of the overburden over short distances. A total of four field duplicate samples were collected in 2015. The duplicate sample was achieved by collecting a second 2 kg composite sample in the same manner and from the exact same location as the original test sample.

Results for field duplicate samples are generally consistent with the original test sample, with the majority of parameters having a % difference ((test sample – duplicate) / duplicate * 100) of < 30. The largest variations are observed for insoluble S concentrations for the test and field duplicate samples. Of note is the variation in C content and NP for the duplicate of B00208469 (upper 30 cm at Site 3) and the variation in S content and AP for the duplicate of B00208479 (upper 30 cm at Site 14), indicating variation in NP and AP over short distances in overburden at the Mine Site. The QA/QC results are presented in Appendix C.

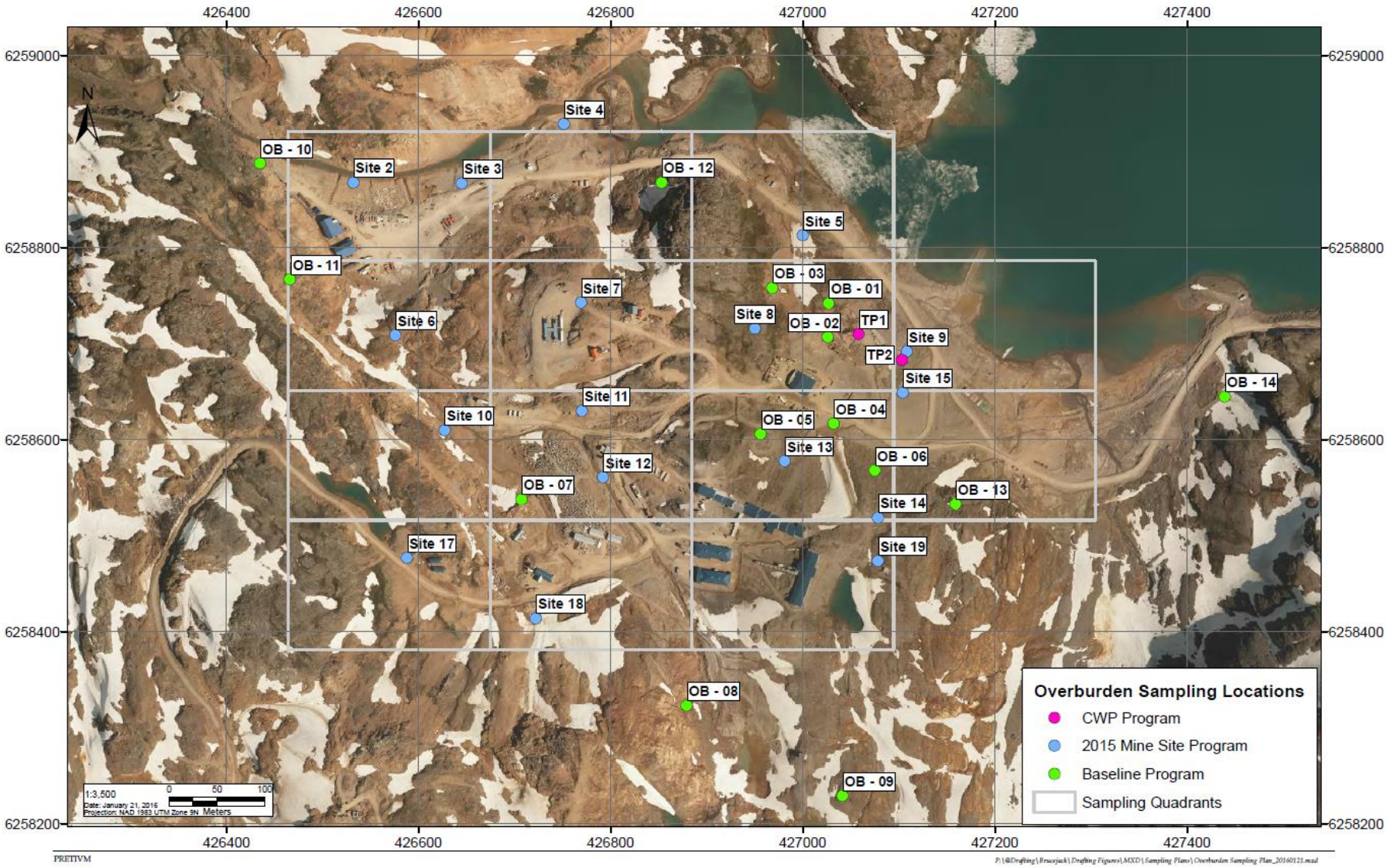

Figure 2-1: Map showing overburden sample locations at the Brucejack Mine Site.

2.4 Analytical Methods

2.4.1 Sample Preparation

All samples collected in 2015 were submitted to SGS Canada Inc. (SGS) in Burnaby BC for processing and analyses. The overburden samples were thoroughly homogenized then riffle split into two portions. One split from each sample was used for particle size analysis (PSA) and the other split for geochemical static testing. From the split reserved for static testing, 250 g of the "as received" material was split out from each sample for shake flask extraction (SFE) experiments and another 200 g was split out and pulverized to 80% passing of the 270 mesh (53 µm) for acid base accounting (ABA) and solid phase element determination. The remaining pulverized sample was used for organic matter (OM) and nutrient determination.

2.4.2 Particle Size Analysis

The 2015 overburden samples were submitted for PSA, including wet and dry sieve and fine fraction separation using the Malvern Mastersizer 2000.

2.4.3 Acid Base Accouting

All overburden samples were submitted to SGS for the full suite of ABA, including paste pH, sulphur (S) species and total and inorganic carbon (C). ABA compares the acid production (AP) and neutralization potential (NP) of a sample to provide an overall theoretical acid generation potential for the sample (*i.e.*, net potential ratio). The net potential ratio (NPR) is the ratio of AP to NP for a given sample. All waste rock, quarry rock, borrow materials, and tailings for the Brucejack Project are considered PAG if NP/AP is < 2.

2.4.4 Solid Phase Element Content

All overburden samples were submitted to SGS for solid phase element determination by aqua regia digestion. Total metals were conducted by digesting 0.500 g of sample in 5 mL of 3:1 HCl/HNO_3 (aqua regia) at 95ºC for 1.5 hours. The extract is then diluted to 25.0 mL and analyzed for metals by inductively coupled plasma mass spectrometry (ICP-MS). Solid-phase metals data are used to identify which metals are enriched in waste materials and could potentially leach from the test material.

2.4.5 Water Soluble Parameters

Shake flask extraction (SFE) experiments were conducted on the overburden samples to evaluate the water soluble parameters. Representative samples, comprising the full range of particle sizes, were subjected to 24-hour Nanopure water leach extraction tests at a 3:1 liquid to solid ratio.

2.4.6 Organic Matter and Nutrients

Pulverized sub-samples from the 2015 overburden program were sent to SGS Agri-Food Laboratories in Guelph, ON for quantitative soils analyses, including OM content and nutrient concentrations. The analyses included determination of:

- Al, B, Ca, Cu, Fe, K, Mg, Mn, P and Zn by Mehlich III method;
- OM by the modified Walkley Black digestion;
- Total phosphorus by the Olson method; and
- Total nitrogen by the Dumas method (Leco Nitrogen analyzer).

The Mehlich III method uses a NH_4NO_3, NH_4F and EDTA-H_4 extracting solution with inductively coupled plasma optical emission spectrometry (ICP-OES) finish. The Mehlich III method overestimates the amount of P available for plant uptake since it is a more aggressive extraction method carried out under lower pH conditions; therefore, P was also determined by the Olson method, which uses a 1N sodium bicarbonate ($NaHCO_3$) extracting solution and colourimetric finish to provide a more realistic estimation of the available P in the overburden samples.

Organic matter content was determined using a modified Walkley Black titration method with colourimetric finish. The method is based on the oxidation of OM by potassium dichromate ($K_2Cr_2O_7$) sulfuric acid mixture followed by back titration of the excessive dichromate by ferrous ammonium sulfate ($Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$). The method is modified by extensively heating the sample during oxidation to ensure complete digestion.

Nitrogen was quantified using a LECO Nitrogen analyzer whereby a sample of known mass is combusted at a high temperature (about 900°C) in the presence of oxygen.

3. Results

3.1 Grain Size Analysis

For the purpose of this characterization, soil describes particles <2 mm in diameter, which are responsible for the majority of water and nutrient holding capacity (Sheoran *et al.*, 2010). Conversely, particles >2 mm in diameter are classified as gravel, and are not optimal for plant growth because the larger pore space of coarse grained material cannot hold enough water or nutrients to sustain growth. Table 3-1 presents the particle size distribution of overburden samples collected during the 2015 sampling program. Figure 3-1 presents the soil fraction for Mine Site overburden samples according to depth. The laboratory reports for particle size distribution (PSD) analyses by sieving and laser diffraction techniques are presented in Appendix D.

The PSD results from sieve analyses (Appendix D-1) indicate that 19 out of the 28 samples analysed are dominated by soil-sized particles. Of these samples, 14 represent samples from the upper 30 cm of the overburden. Both the upper 30 cm and lower overburden samples at sites 3, 4, 9, 11, 12 and 15 have > 50% soil-sized particles, whereas this is only the case for the upper 30 cm samples at sites 2, 6, 8, 10, 13, 14 and 19. It is noteworthy that sites 2, 6, 8 and 19 have < 35 cm thickness of overburden overlying bedrock. Therefore, the PSD data indicates that soil-sized particles represent the majority of particles over the entire overburden profiles at sites 2, 3, 4 (along Brucejack Creek), 6, 8, 11, 12, 15 and 19.

The Malvern Mastersizer 2000 employs laser diffraction techniques which allows for differentiation between sand, silt and clay fractions. Results from the analyses are presented in Appendix D-2 and indicate that the majority of soil fractions can be classified as loamy sand or sandy loam, and to a smaller degree, sand. Of the soil fraction, sand comprises 52-98% of the samples and silt + clay comprises 2-48% of the samples (Table 3-1). The percentage of clay was less than 10% in all samples, inferring generally low cation exchange capacity and low capacity for nutrient retention. Available water storage capacity, based on texture classifications, suggest values ranging from 83-125 mm water/m soil, allowing for moderate to low available water to plants and good drainage (BCMAFF, 2002).

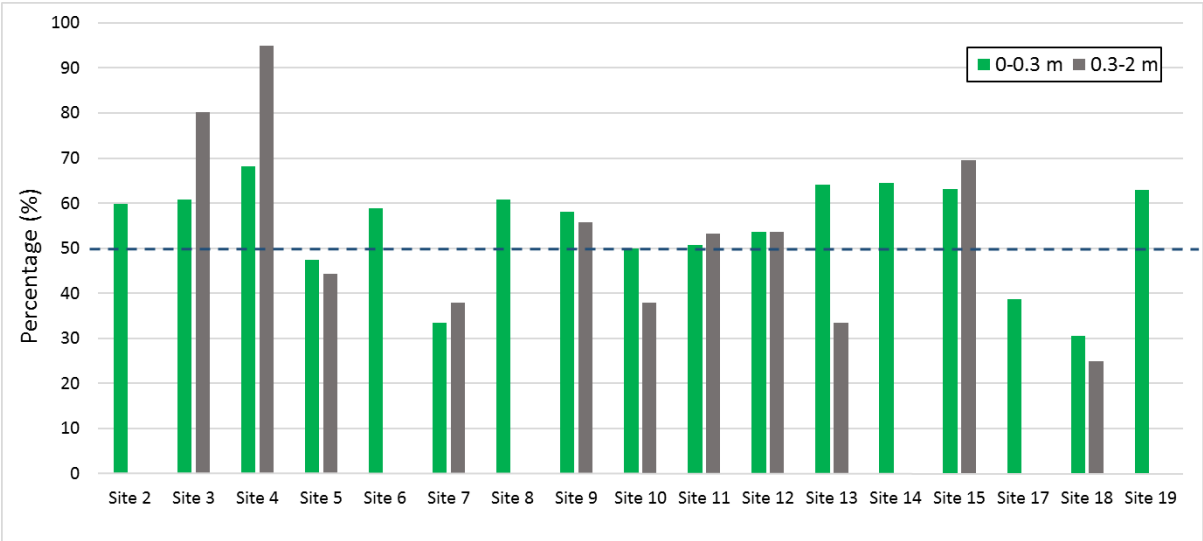

Figure 3-1: Soil percentage (%) in Mine Site overburden samples according to depth with the 50% level highlighted for reference.

Table 3-1:
Particle Size Distribution for Overburden Samples

Sample ID	Location	From (m)	To (m)	Soil Percentage (< 2mm) of PSD (%)	% Sand (2000-50 µm) of soil fraction	% Silt (50-2 µm) of soil fraction	% Clay (<2 µm) of soil fraction	Texture classification	*AWSC (mm water / m soil)
B00208481	Site 2	0	0.33	**60**	58	36	5	Sandy loam	125
B00208469	Site 3	0	0.3	**61**	79	18	3	Loamy sand	100
B00208471		0.3	2.15	**80**	64	31	4	Sandy loam	125
B00208467	Site 4	0	0.3	**68**	66	29	5	Sandy loam	125
B00208468		0.3	0.65	**95**	64	32	4	Sandy loam	125
B00208472	Site 5	0	0.3	47	67	29	4	Sandy loam	125
B00208473		0.3	1.7	44	65	31	3	Sandy loam	125
B00208477	Site 6	0	0.34	**59**	80	17	3	Loamy sand	100
B00208451	Site 7	0	0.3	33	82	15	2	Loamy sand	100
B00208452		0.3	0.74	38	79	19	2	Loamy sand	100
B00208478	Site 8	0	0.35	**61**	62	33	5	Sandy loam	125
B00208459	Site 9	0	0.3	**58**	62	31	7	Sandy loam	125
B00208461		0.3	2.38	**56**	68	27	5	Sandy loam	125
B00208475	Site 10	0	0.3	**50**	63	31	6	Sandy loam	125
B00208476		0.3	0.4	38	58	35	7	Sandy loam	125
B00208453	Site 11	0	0.3	**51**	76	20	4	Loamy sand	100
B00208454		0.3	1.04	**53**	84	14	2	Loamy sand	100
B00208455	Site 12	0	0.3	**54**	77	19	4	Loamy sand	100
B00208456		0.3	1.47	**54**	78	18	4	Loamy sand	100
B00208465	Site 13	0	0.3	**64**	66	28	6	Sandy loam	125
B00208466		0.3	1.15	33	88	10	2	Sand	83
B00208479	Site 14	0	0.33	**65**	67	28	5	Sandy loam	125
B00208457	Site 15	0	0.3	**63**	64	33	4	Sandy loam	125
B00208458		0.3	2.3	**69**	66	28	6	Sandy loam	125
B00208464	Site 17	0	0.37	39	76	20	4	Loamy sand	100
B00208462	Site 18	0	0.3	31	79	18	4	Loamy sand	100
B00208463		0.3	1.45	25	98	2	0	Sand	83
B00208474	Site 19	0	0.35	**63**	52	42	6	Sandy loam	125

Notes: *AWSC: Available Water Storage Capacity (BCMAFF, 2002; Water Conservation Factsheet); bold values represent samples with >50% soil percentage (< 2 mm) of PSD; samples were not collected at Site 1 and Site 16 due to extensive 'infill' at these locations (*i.e.*, no overburden present).

3.2 Acid-Base Accounting

Acid base accounting results for the overburden samples are provided in Table 3-2. For the overburden samples, AP was determined from sulphide S and NP from total inorganic C (TIC) to avoid overestimating AP and available NP. As outlined in *Mines Act* Permit M-243, an NPR < 2 indicates that a sample is PAG and must be placed in a manner that minimizes the production and release of metals and contaminants to levels that assure protection of environmental quality.

Total S content in the overburden samples ranges from below the detection limit (0.01%) to 3.44%, with sulphide S comprising the major portion of the total S content. The insoluble S content is likely in non-acid generating organic mineral phases. Neutralization potential derived from TIC is low, ranging from below detection (0.01%) to 1.6% (median of 0.12%).

Of the 52 overburden samples, 47 are PAG (NPR < 2). However, two of the five NPAG samples (OB-03 and OB-07 in Table 3-2) have paste pH < 5.5, indicating that the samples are slightly acidic.

Table 3-2:
Acid-Base Accounting Results for Overburden Samples

Sample ID	Reference Location	Depth		Paste pH	Total S	Sulphide S	Insol. S	AP	Total C	TIC	CaNP	NPR	ARD Designation
		From (m)	To (m)		%	%	%	kg $CaCO_3$/t	%	%	kg $CaCO_3$/t	CaNP/AP	
Baseline Program													
OB - 01	*NA*	surface		8.1	0.54	0.49	0.04	15.3	*ND*	0.28	23.3	1.52	*PAG*
OB - 02	*NA*	surface		8.0	1.72	1.58	0.12	49.4	*ND*	*<0.01*	*<0.8*	0.02	*PAG*
OB - 03	*NA*	surface		*5.4*	0.10	0.01	0.02	0.3	*ND*	*<0.01*	*<0.8*	2.56	*NPAG*
OB - 04	*NA*	surface		*5.9*	0.31	0.23	0.03	7.2	*ND*	0.04	3.3	0.46	*PAG*
OB - 05	*NA*	surface		7.6	1.44	1.26	0.16	39.4	*ND*	0.34	28.3	0.72	*PAG*
OB - 06	*NA*	surface		*4.2*	0.19	0.08	0.03	2.5	*ND*	*<0.01*	*<0.8*	0.32	*PAG*
OB - 07	*NA*	surface		*4.4*	0.21	*<0.01*	0.04	*<0.3*	*ND*	*<0.01*	*<0.8*	2.67	*NPAG*
OB - 08	*NA*	surface		*5.5*	0.12	0.07	0.05	2.2	*ND*	*<0.01*	*<0.8*	0.37	*PAG*
OB - 09	*NA*	surface		7.4	1.14	1.08	0.04	33.8	*ND*	*<0.01*	*<0.8*	0.02	*PAG*
OB - 10	*NA*	surface		7.7	0.40	0.35	0.03	10.9	*ND*	*<0.01*	*<0.8*	0.07	*PAG*
OB - 11	*NA*	surface		9.1	3.33	3.09	0.23	96.6	*ND*	1.56	130.0	1.35	*PAG*
OB - 12	*NA*	surface		9.1	3.44	3.37	0.07	105.3	*ND*	0.75	62.5	0.59	*PAG*
OB - 13	*NA*	surface		6.1	0.15	0.08	0.04	2.5	*ND*	*<0.01*	*<0.8*	0.32	*PAG*
OB - 14	*NA*	surface		*5.2*	0.15	0.04	0.03	1.3	*ND*	*<0.01*	*<0.8*	0.64	*PAG*
CWP Overburden Program													
B00208001	CWP, TP1	0	2	8.0	0.76	0.72	0.026	22.5	0.40	0.32	26.7	1.19	*PAG*
B00208002		0	2	8.7	0.69	0.66	0.014	20.6	0.28	0.23	19.2	0.93	*PAG*
B00208003		2	2.25	7.6	0.47	0.43	0.034	13.4	0.35	0.25	20.8	1.55	*PAG*
B00208004		2	2.25	7.8	0.51	0.48	*<0.01*	15.0	0.32	0.17	14.2	0.94	*PAG*
B00208005		2.25	3.75	8.1	0.84	0.74	0.081	23.1	0.53	0.52	43.3	1.87	*PAG*
B00208006		2.25	3.75	8.0	1.44	1.36	0.05	42.5	0.31	0.3	25.0	0.59	*PAG*
B00208007	CWP, TP2	0	2	8.0	0.93	0.87	0.038	27.2	0.34	0.29	24.2	0.89	*PAG*
B00208008		0	2	8.1	0.72	0.68	0.022	21.3	0.23	0.21	17.5	0.82	*PAG*
B00208009		2	4	8.1	0.69	0.64	0.026	20.0	0.33	0.3	25.0	1.25	*PAG*
B00208010		2	4	8.0	0.78	0.72	0.041	22.5	0.16	0.14	11.7	0.52	*PAG*

Sample ID	Reference Location	Depth		Paste pH	Total S	Sulphide S	Insol. S	AP	Total C	TIC	CaNP	NPR	ARD Designation
		From (m)	To (m)		%	%	%	kg $CaCO_3$/t	%	%	kg $CaCO_3$/t	CaNP/AP	
2015 Mine Site Overburden Program													
B00208481	Site 2	0	0.33	6.7	0.71	0.59	0.091	18.4	0.21	0.12	10.0	0.54	*PAG*
B00208469	Site 3	0	0.3	7.1	0.83	0.04	0.09	21.9	0.21	0.08	6.7	0.30	*PAG*
B00208471		0.3	2.15	6.7	0.17	0.02	0.03	3.8	0.11	*<0.01*	*<0.8*	0.21	*PAG*
B00208467	Site 4	0	0.3	*5.5*	0.16	0.05	0.03	2.5	0.41	*<0.01*	*<0.8*	0.32	*PAG*
B00208468		0.3	0.65	6.7	0.06	0.01	0.05	*<0.3*	0.30	*<0.01*	*<0.8*	2.67	*NPAG*
B00208472	Site 5	0	0.3	7.0	0.10	0.02	0.02	1.9	0.15	*<0.01*	*<0.8*	0.43	*PAG*
B00208473		0.3	1.7	7.7	0.25	*<0.01*	0.03	6.9	0.47	0.24	20.0	2.91	*NPAG*
B00208477	Site 6	0	0.34	*5.7*	0.07	0.03	0.018	0.9	0.16	*<0.01*	*<0.8*	0.85	*PAG*
B00208451	Site7	0	0.3	*5.3*	0.19	0.03	0.02	4.4	0.21	0.01	0.8	0.19	*PAG*
B00208452		0.3	0.74	6.1	0.61	0.04	0.05	16.3	0.46	0.04	3.3	0.21	*PAG*
B00208478	Site 8	0	0.35	6.1	0.08	0.05	0.032	1.6	1.10	0.02	1.7	1.07	*PAG*
B00208459	Site 9	0	0.3	8.4	0.76	0.01	*<0.01*	23.4	0.58	0.53	44.2	1.88	*PAG*
B00208461		0.3	2.38	8.3	1.46	0.01	0.07	43.1	0.38	0.35	29.2	0.68	*PAG*
B00208475	Site 10	0	0.3	*5.5*	0.24	0.12	*<0.01*	3.8	0.16	0.02	1.7	0.44	*PAG*
B00208476		0.3	0.4	*5.4*	0.22	0.07	*<0.01*	2.2	0.16	*<0.01*	*<0.8*	0.37	*PAG*
B00208453	Site 11	0	0.3	7.9	0.24	0.04	*<0.01*	5.9	0.31	0.25	20.8	3.51	*NPAG*
B00208454		0.3	1.04	6.8	0.24	0.04	0.02	5.6	0.09	0.03	2.5	0.44	*PAG*
B00208455	Site 12	0	0.3	7.5	0.87	0.07	0.02	24.4	0.28	0.19	15.8	0.65	*PAG*
B00208456		0.3	1.47	7.2	0.83	0.05	0.05	22.5	0.15	0.12	10.0	0.44	*PAG*
B00208465	Site 13	0	0.3	8.2	0.66	*<0.01*	0.04	19.4	0.60	0.45	37.5	1.94	*PAG*
B00208466		0.3	1.15	8.4	0.62	0.01	0.04	17.8	0.26	0.22	18.3	1.03	*PAG*
B00208479	Site 14	0	0.33	7.9	0.52	0.48	0.028	15.0	0.40	0.12	10.0	0.67	*PAG*
B00208457	Site 15	0	0.3	8.2	1.24	0.01	0.08	35.9	0.74	0.63	52.5	1.46	*PAG*
B00208458		0.3	2.3	8.2	0.80	0.01	0.03	23.8	0.32	0.28	23.3	0.98	*PAG*
B00208464	Site 17	0	0.37	*5.9*	0.11	0.03	0.03	1.6	0.11	*<0.01*	*<0.8*	0.51	*PAG*
B00208462	Site 18	0	0.3	*5.5*	0.34	0.07	0.03	7.5	0.03	*<0.01*	*<0.8*	0.11	*PAG*
B00208463		0.3	1.45	*5.4*	0.12	0.06	*<0.01*	1.9	0.04	*<0.01*	*<0.8*	0.43	*PAG*
B00208474	Site 19	0	0.35	8.4	0.85	0.74	0.108	23.1	0.30	0.25	20.8	0.90	*PAG*

Notes: AP (acid potential) is calculated from sulphide S and NP (neutralization potential) calculated from total inorganic carbon (TIC). NPR (net potential ratio) is the ratio of NP over AP.

3.3 Solid Phase Elements

Solid-phase metals data are used to identify which metals are enriched in materials. This information can be used in combination with ABA to establish the geochemical properties of a material. Table 3-3 presents select metal abundances obtained from aqua-regia digestion of the overburden samples. The degree of enrichment of an element over crustal abundance can be used as a general indicator of the metals that could be of potential concern (Price, 2009). However, solid-phase metal concentrations well above crustal abundance do not conclusively indicate that the metal will be leached at a high rate from the material. Rather, the rate of metal leaching is related to the metal's mineralogical association and the aqueous geochemistry of the infiltrating waters. The full set of solid phase element results is provided in Appendix E.

An indicator of significant solid-phase enrichment is assigned arbitrarily herein to be values greater than or equal to three times the crustal abundance. These values are indicated as shaded cells (light grey) in Table 3-3. Values indicated to be greater than or equal to ten times the crustal abundance are shaded in dark grey.

Table 3-3 indicates that silver (Ag), arsenic (As), mercury (Hg), sulphur (S), antimony (Sb), selenium (Se), and thallium (Tl) are present in elevated concentrations in overburden samples. Additionally, cadmium (Cd), copper (Cu), molybdenum (Mo) and lead (Pb) are elevated in some samples.

Also presented in Table 3-3 are the Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health for industrial limits (CCME, 2007). Values that exceed the CCME guideline are indicated in bold italics in the table. Arsenic concentrations for all overburden samples are above the CCME guideline of 12 ppm As, with concentrations ranging from 21 ppm to 446 ppm As (median of 50.5 ppm As). One sample at Site 12 also has elevated Cu concentrations of 1790 ppm, exceeding the CCME guideline of 91 ppm Cu. With the exception of one Sb value and one Se value in surface samples collected during the 2013 program, all other parameters are below the CCME soil quality guideline.

Table 3-3:
Solid Phase Element Results for Overburden Samples

CCME		*40*	*12*	*22*	*91*	*50*	*40*	*600*		*20*	*2.9*	*1*	*360*
ACA		*0.08*	*1.8*	*0.15*	*60.0*	*0.09*	*1.50*	*12.5*	*0.035*	*0.20*	*0.05*	*0.001*	*70.0*
Sample ID	**Reference Location**	**Ag**	**As**	**Cd**	**Cu**	**Hg**	**Mo**	**Pb**	**S**	**Sb**	**Se**	**Tl**	**Zn**
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
Baseline Program													
OB - 01	*NA*	0.60	33.0	0.12	44.1	0.38	1.65	9.0	0.14	2.11	2	0.10	70.0
OB - 02	*NA*	0.05	21.0	0.24	22.2	0.16	2.41	12.2	0.16	3.10	3	0.11	32.0
OB - 03	*NA*	1.13	58.0	0.25	34.0	0.26	2.20	12.9	0.06	1.29	*<1*	0.22	145
OB - 04	*NA*	2.26	61.0	0.27	16.3	0.22	1.82	25.6	0.84	2.64	1	0.12	63.0
OB - 05	*NA*	15.1	42.0	0.24	30.1	0.17	0.90	48.7	0.6	7.18	*<1*	0.07	75.0
OB - 06	*NA*	3.79	59.0	0.36	27.8	0.31	1.25	17.3	1.94	2.40	*<1*	0.10	91.0
OB - 07	*NA*	7.50	42.0	0.09	14.9	0.09	2.31	43.7	0.08	7.15	5	0.17	15.0
OB - 08	*NA*	2.88	50.0	0.07	12.2	0.64	0.95	12.7	0.36	2.02	*<1*	0.09	59.0
OB - 09	*NA*	3.27	65.0	0.26	19.0	0.33	1.24	14.4	1.47	1.42	*<1*	0.10	89.0
OB - 10	*NA*	8.83	220.0	0.34	21.5	0.01	4.31	114	0.15	15.2	1	0.43	73.0
OB - 11	*NA*	25.6	180.0	0.07	38.9	0.09	4.11	153	0.19	30.3	1	0.24	23.0
OB - 12	*NA*	0.48	42.0	0.09	22.3	0.09	1.20	10.3	0.1	1.48	*<1*	0.11	69.0
OB - 13	*NA*	8.84	71.0	0.54	31.6	0.64	2.29	15.1	1.19	3.80	*<1*	0.21	140
OB - 14	*NA*	1.01	63.0	0.11	16.7	0.50	1.67	14.8	0.43	1.73	*<1*	0.18	63.0
CWP Overburden Program													
B00208001	CWP, TP1	0.91	32.0	0.17	36.0	0.18	2.98	10.8	0.77	2.11	*<1*	0.08	82.0
B00208002		0.91	30.0	0.24	26.6	0.21	2.83	10.7	0.67	1.48	*<1*	0.08	94.0
B00208003		1.71	40.0	0.17	24.6	0.18	2.87	11.4	0.45	1.64	*<1*	0.07	82.0
B00208004		1.25	32.0	0.16	19.0	0.11	2.95	11.3	0.51	1.25	*<1*	0.07	85.0
B00208005		1.04	36.0	0.25	27.8	0.19	3.12	11.3	0.85	1.34	*<1*	0.08	93.0
B00208006		1.23	49.0	0.21	26.2	0.25	2.79	12.4	1.46	1.47	*<1*	0.10	86.0
B00208007	CWP, TP2	1.95	33.0	0.37	24.4	0.27	3.18	12.7	0.9	1.68	*<1*	0.09	103
B00208008		0.91	79.0	0.23	20.6	0.39	3.04	10.6	0.72	1.50	*<1*	0.11	91.0
B00208009		3.66	51.0	0.32	21.5	0.43	3.41	13.0	0.69	1.42	*<1*	0.11	113.0
B00208010		1.03	58.0	0.23	18.3	0.37	3.12	12.9	0.8	1.46	*<1*	0.10	86.0
2015 Mine Site Overburden Program													
B00208481	Site 2	11.80	100.0	0.50	20.9	0.10	12.3	61.0	0.7	5.83	2	0.26	85.0
B00208469	Site 3	8.83	92.0	0.66	33.0	0.22	4.58	36.1	0.93	7.22	1	0.25	113
B00208471		1.67	80.0	0.32	17.5	0.23	3.35	16.1	0.18	2.62	*<1*	0.14	92.0
B00208467	Site 4	3.73	78.0	0.21	21.8	0.38	5.75	38.8	0.16	4.30	2	0.40	68.0
B00208468		1.30	72.0	0.10	27.4	0.28	3.94	19.5	0.03	2.91	2	0.16	70.0
B00208472	Site 5	0.50	135.0	0.28	58.5	0.33	3.92	12.5	0.1	3.42	*<1*	0.22	116
B00208473		0.63	132.0	0.25	51.7	0.26	3.40	12.8	0.29	3.34	*<1*	0.16	101
B00208477	Site 6	1.68	53.0	0.08	16.2	0.10	3.11	14.4	0.07	3.02	*<1*	0.14	62.0
B00208451	Site7	0.24	25.0	0.12	16.5	0.09	3.07	9.6	0.18	2.13	2	0.12	93.0
B00208452		0.46	39.0	0.21	19.9	0.17	3.41	13.5	0.62	2.34	2	0.13	88.0
B00208478	Site 8	0.61	50.0	0.22	12.3	0.17	2.44	12.2	0.07	3.05	*<1*	0.13	99.0
B00208459	Site 9	1.31	40.0	0.27	15.8	0.26	3.33	10.8	0.8	1.49	*<1*	0.10	86.0
B00208461		2.82	50.0	0.22	18.7	0.31	4.03	15.0	1.46	2.13	*<1*	0.12	77.0
B00208475	Site 10	8.52	77.0	0.20	32.2	0.15	3.28	48.7	0.25	7.59	2	0.28	74.0
B00208476		14.2	90.0	0.16	37.7	0.10	4.17	47.2	0.23	9.57	2	0.30	77.0
B00208453	Site 11	1.32	41.0	0.16	12.3	0.11	3.77	14.6	0.24	2.70	*<1*	0.14	40.0
B00208454		1.91	58.0	0.16	15.1	0.22	3.33	15.7	0.24	3.16	*<1*	0.13	73.0
B00208455	Site 12	4.65	120.0	0.19	1790	0.26	5.80	27.7	0.87	5.22	1	0.29	63.0
B00208456		3.30	46.0	0.22	20.4	0.20	3.94	17.0	0.8	2.61	*<1*	0.10	69.0
B00208465	Site 13	0.88	30.0	0.26	15.5	0.17	3.27	10.6	0.73	1.60	*<1*	0.07	78.0
B00208466		0.66	38.0	0.26	21.2	0.15	3.01	11.1	0.67	1.54	*<1*	0.10	83.0
B00208479	Site 14	1.05	49.0	0.24	13.7	0.28	3.73	11.6	0.86	1.44	*<1*	0.11	85.0
B00208457	Site 15	1.45	44.0	0.28	28.8	0.24	3.31	16.8	1.19	1.89	*<1*	0.11	110
B00208458		1.79	47.0	0.64	19.2	0.79	3.63	16.0	0.82	1.79	*<1*	0.11	223
B00208464	Site 17	1.41	79.0	0.12	37.0	0.05	2.69	36.3	0.11	2.55	2	0.26	73.0
B00208462	Site 18	6.80	137.0	0.14	18.4	0.37	9.74	34.8	0.36	5.39	1	0.21	55.0
B00208463		3.59	446.0	0.11	31.0	1.07	2.98	37.0	0.13	13.4	*<1*	0.46	59.0
B00208474	Site 19	1.26	50.0	0.24	42.4	0.19	2.97	13.1	0.53	3.23	*<1*	0.10	90.0

Notes: 1. Italicized values in blue font indicate values measured below the detection limit;
2. ACA = average continental crust abundance values according to Price (1997); light shaded values are higher than 3x's the ACA and dark shaded values are higher than 10x's the ACA.
3. CCME = Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health, Industrial limits (CCME, 2007); bold italic values are higher than the CCME guideline.

3.4 Water Soluble Extraction

Shake flask extraction tests provide a preliminary measure of the water-soluble constituents of a sample. The SFE results of select parameters for overburden samples collected at the Brucejack Mine Site are presented with Metal Mining Effluent Regulations (MMER) Maximum Authorized Monthly Mean Concentration (MMM) values (MMER, 2015) and BC Ministry of Environment (BCMOE) Water Quality Guidelines for the Protection of Aquatic Life for reference (Table 3-4). The full set of SFE results is provided in Appendix F.

The SFE leachate compositions from all overburden samples are below the MMER MMM values for water soluble species. However, sulphate and dissolved Ag, Al, As, Cd, Co, Cu, Mn, Se, Tl and Zn exceed the long-term (30-day) and/or short-term (maximum) BCMOE water quality guidelines in at least one overburden sample. Cadmium, in particular, is elevated in leachate from many of the overburden samples.

The CCME interim remediation criteria for soil recommends a pH range of 6 to 8 (CCME, 1991). In general, most plants prefer to grow in moderate rather than extreme pH environments, as soil nutrients are most available at a circumneutral pH; however, vegetation can be sustained in soil pH values ranging from 4 (very strongly acidic soils) to 10 (very strongly alkali soils) (BCMAFF, 2001). The SFE tests for the Brucejack overburden samples produced pH values ranging from 5.1 to 8.0 (median of 7.4), within the range of typical soil pH and consistent with recommended remediation criteria (CCME, 1991). The slightly lower pH values measured during SFE experiments compared to paste pH values from ABA analyses is likely due to the higher water to rock ratio used for the SFEs (3:1 versus 2:1).

Table 3-4:
Shake Flask Extraction Results for Overburden Samples

MMER	*MMM*	*NP*	*NP*	*NP*	*NP*	*NP*	*0.5*	*NP*	*NP*	*0.5*	*NP*	*0.5*	*NP*	*0.5*
BCMOE WQG	*Long-term*	*6.5-8.5*	*NP*	*128.0*	*0.00005*	*0.050*	*NP*	*0.00016*	*0.004*	*0.002*	*0.73*	*0.001*	*NP*	*0.008*
	Short-term	*NP*	*NP*	*NP*	*0.0001*	*0.100*	*0.005*	*0.00008*	*0.11*	*0.0046*	*0.85*	*0.002*	*0.0003*	*0.033*
Parameter	**Reference Location**	**pH**	**T-Alk**	**SO_4**	**D-Ag**	**D-Al**	**D-As**	**D-Cd**	**D-Co**	**D-Cu**	**D-Mn**	**D-Se**	**D-Tl**	**D-Zn**
Units			mg $CaCO^3$/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
B00208481	Site 2	6.5	2.78	66.0	0.000006	0.029	0.0018	***0.0030***	***0.019***	***0.0074***	***4.31***	0.00074	0.00015	***0.20***
B00208469	Site 3	7.4	17.4	***182***	0.000008	0.005	0.0006	0.000087	0.00013	0.0013	0.31	0.00043	0.000062	0.001
B00208471		7.1	3.25	52.0	***0.000095***	0.003	0.0017	***0.00034***	0.0024	0.00077	***2.97***	0.00051	0.000048	0.004
B00208467	Site 4	6.1	1.04	45.0	***0.000074***	0.015	0.0071	***0.00050***	***0.0048***	0.0020	***1.73***	***0.0010***	0.000417	0.006
B00208468		7.5	3.70	26.0	0.000006	0.021	0.0006	0.000007	0.000032	0.00072	0.037	***0.0011***	0.000046	*<0.001*
B00208472	Site 5	7.5	6.29	16.0	0.000002	0.014	0.0004	0.000005	0.000005	0.00068	0.0015	0.00035	0.000011	*<0.001*
B00208473		7.9	37.9	12.0	0.000002	0.022	0.0006	0.000003	0.000016	0.0011	0.0046	0.00022	0.000011	*<0.001*
B00208477	Site 6	5.3	0.96	4.0	*<0.000002*	0.033	0.0002	0.000058	0.00043	0.0017	0.17	0.00006	0.000041	0.007
B00208451	Site7	5.7	0.69	26.0	0.000032	***0.091***	*<0.0002*	***0.00021***	0.00068	0.0011	0.72	0.00039	0.000073	***0.012***
B00208452		6.0	1.08	37.0	0.000010	***0.073***	0.0003	***0.00017***	0.00079	0.0012	0.72	0.00053	0.000054	0.004
B00208478	Site 8	6.3	2.58	5.0	0.000017	***0.19***	0.0008	0.000027	0.00017	0.0015	0.11	0.00018	0.000013	0.002
B00208459	Site 9	7.9	44.0	21.0	0.000006	0.015	0.0006	*<0.000003*	0.000004	0.00053	0.00071	0.00016	0.000010	*<0.001*
B00208461		7.8	41.7	24.0	0.000002	0.010	0.0003	0.000005	*<0.000004*	0.00048	0.00055	0.00018	0.000010	*<0.001*
B00208475	Site 10	5.8	1.50	9.0	0.000004	***0.067***	0.0002	***0.00023***	0.0012	***0.0035***	0.26	0.00014	0.000090	***0.021***
B00208476		5.1	2.78	15.0	0.000010	***0.11***	*<0.0002*	***0.00052***	0.0016	***0.0058***	0.39	0.00016	0.00015	***0.067***
B00208453	Site 11	8.0	49.1	38.0	0.000002	0.033	0.0011	0.000005	0.000021	0.0010	0.019	0.00046	0.000021	*<0.001*
B00208454		7.2	4.09	50.0	0.000003	0.004	0.0003	0.00010	0.000076	0.00077	0.21	0.00022	0.000037	0.002
B00208455	Site 12	7.5	25.3	***175***	*<0.000002*	0.006	0.0006	0.000012	0.000059	***0.0023***	0.078	0.00040	0.000074	*<0.001*
B00208456		7.8	58.0	***145***	0.000003	0.006	0.0004	0.000022	0.00017	0.00071	0.53	0.00055	0.000035	*<0.001*
B00208465	Site 13	7.7	56.1	4.0	0.000006	0.035	0.0007	0.000009	0.000029	0.0016	0.016	0.00009	0.000008	*<0.001*
B00208466		7.8	38.2	4.0	0.000003	0.021	*<0.0002*	0.000003	0.000007	0.00053	0.00005	0.00014	0.000006	*<0.001*
B00208479	Site 14	7.6	37.6	6.0	0.000004	0.021	0.0005	0.000005	0.000012	0.0014	0.00057	0.00015	0.000009	*<0.001*
B00208457	Site 15	7.9	48.1	35.0	0.000002	0.022	0.0007	0.000008	0.000009	0.0014	0.0018	0.00016	0.000014	*<0.001*
B00208458		7.9	44.3	41.0	0.000002	0.011	0.0005	*<0.000003*	0.000004	0.00050	0.00028	0.00019	0.000008	*<0.001*
B00208464	Site 17	6.8	1.72	9.0	0.000003	0.028	*<0.0002*	0.000086	0.00055	0.0013	0.19	0.00013	0.000048	0.007
B00208462	Site 18	6.6	1.95	14.0	0.000004	0.039	*<0.0002*	0.00012	0.0024	***0.0032***	0.32	0.00007	0.000070	***0.013***
B00208463		6.9	1.96	15.0	0.000014	0.023	*<0.0002*	***0.00022***	0.00038	***0.0023***	0.31	0.00004	0.000097	***0.014***
B00208474	Site 19	7.5	29.2	17.0	0.000003	0.038	0.0006	0.000009	0.000021	0.0013	0.0023	0.00017	0.000007	*<0.001*

Notes:
1. italicized values in blue font indicate values measured below the detection limit;
2. BC WQG = British Columbia water quality guidelines for the protection of aquatic life (BC MOE, 2006 and BC MOE, 2015); guidelines for Al, Cd and Fe are for dissolved species, all other guidelines are for total, shaded values are higher than the maximum value and bold italic values are higher than the 30-day criteria; NP = none proposed; NA = not applicable.
3. MMER MMM = Metal Mining Effluent Regulations, Maximum Authorized Monthly Mean Concentration (MMER, 2015).
4. Hardness dependent guidelines (Ag, Cd, Cu, Pb, Ni and Zn) were calculated based on the waster hardness in Brucejack Lake of 28 mg $CaCO_3$/L.

3.5 Organic Matter and Nutrients

Organic matter (OM) describes the fraction of soil that contains plant or animal tissues in various stages of decomposition (Cornell University, 2008). OM contributes to soil productivity in several ways, including (1) enhancing aggregate formation and stability, resulting in increased water-holding capacity; (2) increasing soil CEC and long-term nutrient supply; and (3) facilitating nutrient cycling through enhanced soil microbial activity. OM is also a major source of C, N, and available P and K in unfertilized soils (Sheoran *et al.*, 2010). In mineral soils, an OM content greater than 3%, which is equivalent to approximately 2% total organic C (TOC), generally indicates good fertility. Productive agricultural soils have been found to have OM content of between 3 and 6% (Cornell University, 2008).

Table 3-5 presents the results for OM and nutrients in the Mine Site overburden samples. The results indicate that overburden at the Mine Site contain OM ranging from 0.2 to 1.8%. With the exception of one sample (B00208478), all samples contain < 0.75% OM. Concentrations of OM are consistent with TOC values calculated from ABA data. Analysis of overburden samples for OM and nutrients were not limited to the soil fraction (< 2 mm), as is typical of most soil studies. As such, concentrations may be diluted by the gravel fraction of the overburden samples. However, even if all of the measured OM was assumed to be within the soil fraction of the overburden samples, only sample B00208478 would contain sufficient OM (3.0%) to be considered fertile.

Phosphorus (P) concentrations in all samples were low according to target indices for mineral soil (0-15 cm) in BC (BC Ministry of Agriculture, 2010). Concentrations were < 40 ppm, indicating that crops growing on such soil media would respond beneficially to additional P. Soil potassium (K) ranged from 214-448 ppm, constituting optimal (133-333 ppm) to high and excess (>334 ppm) K concentrations. Boron (B) is an essential micronutrient, but the concentration range between deficiency and toxicity to plants is relatively narrow. Background concentrations of 1 ppm are required for normal plant growth; however, at concentrations of 3 ppm, as observed in the overburden samples (mean B = 3.x), toxicity may occur for sensitive plants (Sylvis Environmental, 2008).

Nitrogen (N) concentrations in the Brucejack overburden samples range from 0.06 to 0.23% N. However, total N analysis measures N in all organic and inorganic forms and, therefore, is not necessarily representative of bio-available N (Horneck *et al.*, 2011). Approximately one to four percent of the total N is generally considered bio-available during a growing season, converting from organic N to inorganic N via microbial activity. Furthermore, N in soil is very water soluble and can be easily leached during a heavy precipitation event. Nitrogen is often the limiting nutrient (*i.e.*, nutrient in relatively short supply which is exhausted first and thus limits cellular growth) and soils which are intended to support vegetation are generally fertilized according to the nutrient needs of the target plant for growth.

Table 3-5:
Soil Analyses Results for Overburden Samples

Sample	Location	Depth		OM	B	Ca	K	Mg	P		N
		From (m)	To (m)								
			Unit	*%*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*
			Method	*WB*[1]	*Mehlich*[2]	*Mehlich*[2]	*Mehlich*[2]	*Mehlich*[2]	*Mehlich*[2]	*Na Bicarb*[3]	*Dumas*[4]
B00208481	Site 2	0	0.33	0.4	4.07	2669	387	74.0	9.0	19.3	0.06
B00208469	Site 3	0	0.3	0.7	3.07	2579	310	100	13.0	10.7	0.10
B00208471		0.3	2.15	0.4	3.70	658	296	117	0.0	14.4	0.07
B00208467	Site 4	0	0.3	0.7	3.43	503	285	92.0	17.0	16.5	0.23
B00208468		0.3	0.65	0.7	2.46	520	222	73.0	31.0	28.6	0.07
B00208472	Site 5	0	0.3	0.2	2.16	783	230	69.0	12.0	13.9	0.12
B00208473		0.3	1.7	0.4	2.10	4154	214	119	5.0	8.82	0.09
B00208477	Site 6	0	0.34	0.2	2.70	160	284	98.0	30.0	34.1	0.11
B00208451	Site7	0	0.3	0.2	2.96	396	282	115	26.0	23.5	0.11
B00208452		0.3	0.74	0.7	2.19	1230	259	95.0	20.0	18.8	0.11
B00208478	Site 8	0	0.35	1.8	2.07	482	244	80.0	9.0	8.91	0.10
B00208459	Site 9	0	0.3	0.7	2.85	4530	248	122	0.0	3.49	0.08
B00208461		0.3	2.38	0.9	2.85	4354	255	104	0.0	3.69	0.08
B00208475	Site 10	0	0.3	0.2	3.17	418	354	69.0	14.0	29.4	0.10
B00208476		0.3	0.4	0.2	3.60	208	384	55.0	19.0	28.3	0.07
B00208453	Site 11	0	0.3	0.2	2.74	4442	427	77.0	12.0	14.6	0.07
B00208454		0.3	1.04	0.2	2.98	1182	286	88.0	9.0	15.9	0.10
B00208455	Site 12	0	0.3	0.7	3.01	4255	327	100	8.0	13.4	0.09
B00208456		0.3	1.47	0.4	3.40	3752	261	119	1.0	10.4	0.09
B00208465	Site 13	0	0.3	0.7	2.51	4567	226	114	0.0	4.35	0.09
B00208466		0.3	1.15	0.7	2.43	3709	235	132	0.0	3.49	0.07
B00208479	Site 14	0	0.33	0.7	2.49	4342	261	128	0.0	3.11	0.07
B00208457	Site 15	0	0.3	0.7	3.00	4521	240	104	0.0	3.32	0.10
B00208458		0.3	2.3	0.7	3.10	4484	232	120	0.0	3.16	0.08
B00208464	Site 17	0	0.37	0.2	3.13	299	448	96.0	21.0	23.4	0.08
B00208462	Site 18	0	0.3	0.2	4.47	282	386	115	14.0	12.6	0.10
B00208463		0.3	1.45	0.2	3.63	230	342	67.0	17.0	22.3	0.08
B00208474	Site 19	0	0.35	0.4	2.23	3563	248	110	0.0	5.67	0.16

Notes: 1. Modified Walkley Black Digestion, Analysis by Colourmetry; 2. Mehlich III method: Extracted using Mehlich III extracting solution, Analysis by ICP OES (Mehlich, 1984); 3. Olsen method: Extracted using 1N Sodium Bicarbonate, Analysis by Colourmetry (Olsen *et al.*, 1954); 4. Dumas method by LECO Nitrogen analyzer.

Results of the OM and nutrient study indicate that the overburden at the Mine Site is deficient with respect to OM (and TOC), P and N, and contains excess K and B, potentially to toxic levels for sensitive plant species. Although amendment with chemical fertilization is possible to bolster the deficient nutrients, there is limited potential for long-term fertility due to slow OM buildup at this elevation and climate.

4. Discussion

The results presented herein are consistent with baseline and previous characterization studies carried out on overburden material at the Brucejack Mine Site. The main findings of the 2015 characterization program are outlined below:

- PSD analysis of overburden samples shows that the majority of particles fall within the soil size fraction and have a texture that indicates sufficient capacity for drainage and physical stability, but the data also suggests limited capacity for nutrient and water retention given the moderate to low proportion of clay and silt.
- ABA results indicate that overburden from the Brucejack Mine Site is predominantly PAG due to the generally low NP measured in test samples (median NP = 10 kg $CaCO_3$/t) coupled with variable AP (up to 10.5 kg $CaCO_3$/t).
- SFE analyses shows that sulphate and Ag, Al, As, Co, Cu, Mn, Se, Tl and Zn exceed the BCMOE water quality guidelines in at least one overburden sample; however, Cd is elevated in leachate from many of the overburden samples. Arsenic, in particular, is elevated in all overburden samples, with concentrations ranging from 21 ppm to 446 ppm As (median of 50.5 ppm As) and exceeding the CCME Industrial Limits Soil Quality Guidelines for the Protection of Environmental and Human Health of 12 ppm As.
- OM and nutrient contents of overburden samples are generally low, thereby considered to be limiting for plant growth. While nutrient deficiencies can be amended with chemical fertilization, there is limited potential for long-term fertility due to slow OM buildup at this elevation and climate.

Overall, the results of the overburden characterization program indicate that the material is not suitable for use in reclamation. It is recommended that once the overburden material is removed, that it be disposed of in a manner that will minimize ARD. It is understood that the final disposal location would require careful consideration to the following: the geotechnical stability of the proposed dumping location, the impact on TSS levels in Brucejack Lake, and any associated water quality issues.

5. Closing

We appreciate the opportunity to contribute to the ongoing development of the Brucejack Mine. Please contact Stephanie Simpson or Alison Shaw if you have any questions regarding the content of this memorandum.

Best regards,

Lorax Environmental Services Ltd.

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APPENDIX A: FIELD DATA SUMMARY

PRETIVM

Appendix A: Results of the 2012-2014 BGC Borehole Program

Facility	Test Hole ID BGC (Pretium)		Completion Date	Coordinates		Ground Elev	Test Hole Depth	Overburden Thickness (m)				Bedrock		
				East	North	masl	m	Fill	Alluvial	Glacio-lacustrine	Glacial Till	Depth	Approx Elevation	Geologic Unit
Mill Building	DH-BGC12-27	(SU-383)	8-Jun-12	426,846	6,258,671	1,414.1	30.2	-	-	-	0	0	1,414.1	P2
	DH-BGC12-28	(SU-385)	9-Jun-12	426,910	6,258,774	1,421.0	30.5	-	-	-	0.5	0.5	1,420.5	P2
	DH-BGC12-29	(SU-389)	11-Jun-12	426,904	6,258,737	1,415.2	30.5	-	-	-	0	0	1,415.2	P2
		(SU-622)	11-Oct-13	426,807	6,258,674	1,406.5	30.3	-	-	-	0.4	0.4	1,406.1	P2
		(SU-623)	11-Oct-13	426,844	6,258,690	1,409.0	31	-	-	-	0.7	0.7	1,408.3	P2
		(SU-624)	12-Oct-13	426,883	6,258,706	1,413.5	36.3	-	-	-	0.4	0.4	1,413.1	P1
		(SU-625)	12-Oct-13	426,915	6,258,695	1,410.5	35.8	-	-	-	0.7	0.7	1,409.8	S3
		(SU-626)	13-Oct-13	426,836	6,258,712	1,410.0	35	-	-	-	0.3	0.3	1,409.7	P2
	DH-BGC14-03	(SU-635)	10-Aug-14	426,873	6,258,703	1,409.9	40.8	-	-	-	0.4	0.4	1,409.5	P2
300 Camp and Miner's Dry	TP-BGC14-08		26-Jul-14	426,761	6,258,628	1,402.8	3	2.5	-	-	0	2.5	1,400.3	-
	TP-BGC14-11		26-Jul-14	426,685	6,258,690	1,393.4	0.8	-	-	-	0.3	0.3	1,393.1	-
	TP-BGC14-12		26-Jul-14	426,714	6,258,653	1,395.7	0.8	-	-	-	0.6	0.6	1,395.1	-
	TP-BGC14-13		26-Jul-14	426,747	6,258,671	1,399.7	0.5	-	-	-	0.2	0.2	1,399.5	-
	TP-BGC14-14		26-Jul-14	426,698	6,258,609	1,401.3	2.2	1.2	-	-	0.5	1.7	1,399.6	-
	DH-BGC14-01	(SU-633)	7-Aug-14	426,730	6,258,656	1,398.8	30.9		-	-	1.3	1.3	1,397.5	P2
	DH-BGC14-02	(SU-634)	9-Aug-14	426,683	6,258,673	1,396.2	35.6	-	-	-	0.8	0.8	1,395.4	P2
Substation	TP-BGC12-11		13-Aug-12	426,804	6,258,531	1,413.2	1.4	-	-	-	1.4	1.4	1,409.9	-
	TP-BGC12-12		13-Aug-12	426,758	6,258,558	1,412.1	1	-	-	-	1	1	1,411.1	-
	TP-BGC12-13		13-Aug-12	426,791	6,258,566	1,409.5	3	-	-	-	3	3	1,406.5	-
	TP-BGC14-09		26-Jul-14	426,796	6,258,567	1,410.9	3.1	0.5	-	-	1.9	2.4	1,408.5	-
	TP-BGC14-10		26-Jul-14	426,772	6,258,559	1,410.4	0.6	-	-	-	0.5	0.5	1,409.9	-
	DH-BGC14-04	(SU-636)	11-Aug-14	426,799	6,258,561	1,410.3	35.1	-	-	-	3.6	3.6	1,406.7	V12
Truck Shop	TP-BGC12-20		15-Aug-12	426,980	6,258,579	1,410.8	1	-	-	-	1	1	1,409.8	-
	TP-BGC12-21		16-Aug-12	426,959	6,258,601	1,417.3	3.3	-	-	-	3.3	3.3	1,412.4	-
	TP-BGC14-06		25-Jul-14	427,017	6,258,549	1,408.1	3.6	-	-	-	3.4	3.4	1,404.7	-
	TP-BGC14-07		25-Jul-14	427,043	6,258,560	1,408.7	4.6	-	-	-	4.5	4.5	1,404.2	-
	DH-BGC12-32	(SU-586)	30-Sep-12	426,981	6,258,578	1,410.8	50	-	-	-	2.1	2.1	1,408.7	S3
	DH-BGC14-06	(SU-638)	13-Aug-14	427,019	6,258,575	1,400.6	30.3	-	-	-	6.3	6.3	1,394.3	V12/S
98 Man Camp	TP-BGC14-15		26-Jul-14	426,977	6,258,494	1,427.0	4	-	-	-	>4	-	-	-
	TP-BGC14-16		26-Jul-14	426,948	6,258,435	1,425.8	3.6	-	-	-	>3.6	-	-	-
	DH-BGC14-05	(SU-637)	12-Aug-14	426,958	6,258,453	1,425.4	30.7	-	-	-	5.8	5.8	1,419.6	S4
Maintenance Shop	TP-BGC14-18		26-Jul-14	426,580	6,258,837	1,365.9	3.3	1.2	>2.1	-	-	-	-	-
	TP-BGC14-31		5-Aug-14	426,564	6,258,768	1,365.7	3	0.7	>2.3	-	-	-	-	-
	TP-BGC14-32		5-Aug-14	426,559	6,258,801	1,365.6	3	0.6	>2.4	-	-	-	-	-
	DH-BGC14-07	(SU-639)	14-Aug-12	426,580	6,258,826	1,367.8	20.1	2.6	6.3	3.7	2.6	15.2	1,353.7	P2
Pre-production Ore/WR Transfer Storage	TP-BGC12-16		13-Aug-12	427,348	6,258,584	1,371.4	2.3	-	2.3	-	-	2.3	1,365.9	-
	TP-BGC12-17		13-Aug-12	427,298	6,258,553	1,370.5	2.5	-	2.5	-	-	2.5	1,366.1	-
	TP-BGC12-18		13-Aug-12	427,254	6,258,550	1,370.3	1.5	-	1.5	-	-	1.5	1,368.8	-
	TP-BGC14-35		1-Sep-14	427,267	6,258,591	1,367.6	5	0.3	>4.7	-	-	-	-	-
	TP-BGC14-36		1-Sep-14	427,346	6,258,623	1,367.6	5	-	5	-	-	5	1,362.6	-

PRETIVM

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APPENDIX B: SUMMARY OF OVERBURDEN SAMPLES FROM THE BRUCEJACK MINE SITE

PRETIVM

Appendix B. Summary of Overburden Samples from the Brucejack Mine Site

Sample ID	Coordinates		Reference Location	Depth		Depth to Bedrock	Underlying Lithology	Sample Date	Munsell Soil Colour	Sample Description
	Easting	Northing		From (m)	To (m)					
Baseline Program										
OB - 01	427027	6258742	OB - 01	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Clayey Sand
OB - 02	427026	6258707	OB - 02	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Sand with Gravel
OB - 03	426968	6258758	OB - 03	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Clayey Sand
OB - 04	427032	6258617	OB - 04	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Sand with Clay
OB - 05	426956	6258606	OB - 05	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Clayey Sand
OB - 06	427075	6258568	OB - 06	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Clayey Sand
OB - 07	426707	6258538	OB - 07	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Regolith [friable rock chips and soil]
OB - 08	426879	6258323	OB - 08	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Clayey sand with some gravel
OB - 09	427041	6258229	OB - 09	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Immature clayey sand with gravel [till]
OB - 10	426435	6258888	OB - 10	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Gravelly sand with trace clay [slope detritus]
OB - 11	426466	6258767	OB - 11	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Organic rich regolith [clayey sand with friable rock chips]
OB - 12	426853	6258868	OB - 12	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Sandy gravel, trace clay [soil]
OB - 13	427159	6258533	OB - 13	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Clayey sand with some gravel
OB - 14	427439	6258645	OB - 14	*ND*	*ND*	*ND*	*ND*	Aug-13	*ND*	Gravel and cobbles, trace clay
Contact Water Pond Overburden Program										
B00208001	427058	6258708	CWP, TP1	0	2	> 3.75	*ND*	Jul-15	*ND*	30% cobble boulder subrounded clasts with minimal fine grained sand and abundant coarse clay.
B00208002	427058	6258709		0	2			Jul-15	*ND*	30% cobble boulder subrounded clasts with minimal fine grained sand and abundant coarse clay.
B00208003	427058	6258710		2	2.25			Jul-15	*ND*	horizon of oxidized and orange stained cobbles and gravel material with coarse clay. Filter cloth at ~ 2m
B00208004	427058	6258711		2	2.25			Jul-15	*ND*	horizon of oxidized and orange stained cobbles and gravel material with coarse clay. Filter cloth at ~ 2m
B00208005	427058	6258712		2.25	3.75			Jul-15	*ND*	gravel horizon with 30-50% >5cm cobbles and fine sand matrix, minimal clay.
B00208006	427058	6258713		2.25	3.75			Jul-15	*ND*	gravel horizon with 30-50% >5cm cobbles and fine sand matrix, minimal clay.
B00208007	427102	6258682	CWP, TP2	0	2	> 4.0	*ND*	Jul-15	*ND*	fine grained gravel with medium sand laminations throughout. Clasts were cobble boulder (5-50cm) in size and matrix was coarse clay to fine sand.
B00208008	427103	6258683		0	2			Jul-15	*ND*	fine grained gravel with medium sand laminations throughout. Clasts were cobble boulder (5-50cm) in size and matrix was coarse clay to fine sand.
B00208009	427104	6258684		2	4			Jul-15	*ND*	fine grained gravel with medium sand laminations throughout. Clasts were cobble boulder (5-50cm) in size and matrix was coarse clay to fine sand.
B00208010	427105	6258685		2	4			Jul-15	*ND*	fine grained gravel with medium sand laminations throughout. Clasts were cobble boulder (5-50cm) in size and matrix was coarse clay to fine sand.
2015 Mine Site Overburden Program										
B00208481	426532	6258868	Site 2	0	0.33	0.33	TSD	Sep-15	10yr 5/6	25% subangular rocks between 0.5-7cm across, surrounded by a matrix of loamy sand
B00208469	426645	6258867	Site 3	0	0.3	> 2.15	V12	Sep-15	7.5yr 6/2	Fine to medium grained sandy loam with subangular clasts up to 4cm across. Fine moss with <1cm long fibres in upper 10cm
B00208471	426645	6258867		0.3	2.15			Sep-15	7.5yr 6/2 (0.3-0.7m); interbedded 5yr 6/8 & 4/1 (0.7-1.2m); 7.5yr 5/2 (1.2-1.6m); 5yr 4/1 (1.6-2.15m)	Sandy loam with decreasing frequency of rock clasts down to 0.7m. Dark grey clay between 0.7-1.2m and 1.6-2.15m. Interbedded rusty layers of silty clay loam up to 8cm thick in upper clay layer. Coarse grained sand grading gradually to fine grained sand between 1.2-1.6m
B00208467	426751	6258929	Site 4	0	0.3	0.65	V12	Sep-15	7.5yr 5/0 (0-0.1m); 10yr 6/8 (0.1-0.22m); 7.5yr 4/2 (0.22-0.3m)	Grey clay with subangular clasts to 10cm, dry medium-coarse grained sand between 10-22cm followed by dark brown loam to 0.3m. Loam layer hosts ~2-3% roots up to 3mm thick
B00208468	426751	6258929		0.3	0.65			Sep-15	7.5yr 6/0 (0.3-0.41m); 7.5yr 4/4 (0.41-0.65m)	Grey clay to 41cm similar in composition to the upper 10cm, followed by dark red silt loam
B00208472	427000	6258813	Site 5	0	0.3	1.7	VSF	Sep-15	10yr 3/3	Sandy clay loam with angular, platy rock fragments up to 30cm wide. Most frags between 0.5-3cm.
B00208473	427000	6258813		0.3	1.7			Sep-15	10yr 3/3	Sandy clay loam with angular, platy rock fragments up to 30cm wide. Most frags between 0.5-3cm. Fine mossy fibres up to 1cm long seen occasionally
B00208477	426576	6258709	Site 6	0	0.34	0.34	TSD	Sep-15	7.5yr 6/4 (0-0.11m); 5yr 4/3 (0.11-0.19m); 5yr 5/3 (0.19-0.34m)	Medium grained loamy sand with pebbles and cobbles ranging from angular to rounded. Colour changes with depth but texture does not.
B00208451	426769	6258743	Site 7	0	0.3	0.74	V12	Sep-15	5yr 4/4	Uniform colour and silty loam texture. Platy weathered clasts of latite from 0.1-10cm wide. Less than 5% of clasts are beige, remainder are red-brown
B00208452	426769	6258743		0.3	0.74			Sep-15	5yr 4/4	Uniform colour and silty loam texture. Platy weathered clasts of latite from 0.1-10cm wide. Less than 5% of clasts are beige, remainder are red-brown
B00208478	426950	6258716	Site 8	0	0.35	0.35	VSF	Sep-15	10yr 4/3	Light grey-green moss covering moist silt loam. Subangular to subrounded cobbles up to 10cm wide.
B00208459	427108	6258692	Site 9	0	0.3	> 11.0	VSF	Sep-15	7.5yr 4/6	Clay loam with ~10% subangular rocks up to 15cm wide, uniform colour
B00208461	427108	6258692		0.3	2.38			Sep-15	7.5yr 4/4	Clay loam with ~20% subangular to subrounded rocks from 0.02-1.2m across (large boulder removed while digging test pit
B00208475	426627	6258610	Site 10	0	0.3	0.4	TSD	Sep-15	5yr 4/6	Fine clay with ~30-40% subangular clasts between 1-4cm across.
B00208476	426627	6258610		0.3	0.4			Sep-15	5yr 4/6	Fine clay with ~30-40% subangular clasts between 1-4cm across.
B00208453	426770	6258630	Site 11	0	0.3	1.04	V12	Sep-15	5yr 5/3	Fine grained loamy sand. Infrequent weathered rock fragments
B00208454	426770	6258630		0.3	1.04			Sep-15	5yr 4/4 (0.3-0.54m); 5yr 4/6 (0.54-1.04m)	Fine grained loam, grading to clay loam and back between 0.6-0.85m. Subangular rock fragments under 3cm are <10%.
B00208455	426792	6258561	Site 12	0	0.3	>1.47	V12	Sep-15	5yr 3/4	Fine grained loam with 20-30% subrounded to rounded cobbles up to 15cm across
B00208456	426792	6258561		0.3	1.47			Sep-15	5yr 3/4 (0.3-0.4m); 10yr 4/3 (0.4-1.0m); 10yr 3/2 (1.0-1.47m)	Fine to medium grained sand to loamy sand to 1m, subangular to rounded clasts ranging from 0.5-5cm wide. Below 1m is fine grained clay with cobbles up to 15cm wide
B00208465	426981	6258578	Site 13	0	0.3	1.15	VSF	Sep-15	5yr 4/3	Sandy loam with roots up to 3mm wide and 15cm long. Subrounded to rounded cobbles frequently seen.
B00208466	426981	6258578		0.3	1.15			Sep-15	5yr 4/3 (0.3-0.45m); 10yr 3/4 (0.45-1.15m)	Sandy loam with <1% roots up to 1mm wide. Rock fragments becoming more angular and generally below 10cm across
B00208479	427078	6258519	Site 14	0	0.33	0.33	VSF	Sep-15	10yr 5/3 (0-0.15m; 10yr 3/2 (0.15-0.33m)	Fine clay loam with <10% subangular to subrounded pebbles up to 3cm wide. Infrequent organics- moss fragments seen down to 0.2m depth
B00208457	427104	6258649	Site 15	0	0.3	> 11.0	VSF	Sep-15	5yr 4/4	Fine grained sandy loam with subangular to rounded rocks ranging from 1-30cm wide
B00208458	427104	6258649		0.3	2.3			Sep-15	5yr 4/4 (0.3-1.65m); 7.5yr 4/6 (1.65-2.3m)	Fine grained sandy loam to 1.65m, silty clay loam from 1.65-2.3m. Subrounded to subangular V12 and Vsf cobbles up to 50cm across
B00208464	426588	6258477	Site 17	0	0.37	0.37	VSF	Sep-15	5yr 4/4	Loamy sand with subangular platy Vsf fragments comprising 50% of the overburden. Fragments range from 0.5-10cm long
B00208462	426722	6258414	Site 18	0	0.3	1.45	VSF	Sep-15	7.5yr 5/4	Coarse grained sandy loam with 30% subrounded gravel and cobbles
B00208463	426722	6258414		0.3	1.45			Sep-15	7.5yr 5/4	Medium to coarse grained sandy loam with gravel and cobble frequency decreasing with depth
B00208474	427078	6258474	Site 19	0	0.35	0.35	V12	Sep-15	5yr 4/3	Silty clay with occasional moss fragments to 0.25m. Moisture seeping at bottom of pit

Notes: ND: No Data
bgs: below ground surface, the depths are approximate based on field photos provided by BGC
V12: Intermediate fragmental volcanics
VSF: Volcanic Sedimentary Facies
TSD: Pebbly volcanic litharenite to sandy pebble or cobble conglomerate (similar to the VSF).

APPENDIX C: QAQC RESULTS

APPENDIX C-1. QAQC RESULTS FOR ACID BASE ACCOUNTING

APPENDIX C-2. QAQC RESULTS FOR SOLID PHASE ELEMENT ANALYSES

APPENDIX C-3. QAQC RESULTS FOR ORGANIC MATTER AND NUTRIENT ANALYSES

PRETIVM

Appendix C-1. QAQC Results for Acid Base Accounting

Parameter	Unit	B00208010	B00208011 DUP of B00208010	*% Difference*	B00208459	B00208460 DUP of B00208459	*% Difference*	B00208469	B00208470 DUP of B00208469	*% Difference*	B00208479	B00208480 DUP of B00208479	*% Difference*
Paste pH		8.0	8.1		8.4	8.3		7.1	7.3		8.4	8.4	
Total S	%	0.78	0.74	***6.1***	0.76	1.03	***-25.8***	0.83	0.49	***69.3***	0.85	1.02	***-16.9***
Sulphide S	%	0.72	0.70	***2.9***	0.01	0.01	***0.0***	0.04	0.04	***0.0***	0.74	0.90	***-17.8***
Sulphate S	%	0.02	0.02	***0.0***	0.75	0.98	***-23.5***	0.70	0.41	***70.7***	*<0.01*	*<0.01*	***0.0***
Insoluble S	%	0.04	0.02	***156.3***	*<0.01*	0.04	***-75.0***	0.09	0.04	***125.6***	0.11	0.12	***-10.0***
AP	kg $CaCO_3$/t	22.5	21.9	***2.9***	23.4	30.6	***-23.5***	21.9	12.8	***70.7***	23.1	28.1	***-17.8***
Total C	%	0.16	0.23	***-28.4***	0.58	0.33	***74.5***	0.21	0.20	***4.9***	0.30	0.36	***-15.1***
TIC	%	0.14	0.20	***-30.0***	0.53	0.29	***82.8***	0.08	0.08	***0.0***	0.25	0.29	***-13.8***
CaNP	kg $CaCO_3$/t	11.7	16.7	***-30.0***	44.2	24.2	***82.8***	6.7	6.7	***0.0***	20.8	24.2	***-13.8***
Mod. NP	kg $CaCO_3$/t	15.0	17.4	***-13.8***	46.4	26.2	***77.1***	8.4	8.0	***5.0***	24.0	24.5	***-2.0***
Net Mod. NP	kg $CaCO_3$/t	-7.5	-4.5	***67.6***	23.0	-4.4	***-618.9***	-13.5	-4.8	***180.0***	0.9	-3.6	***-124.1***
Fizz Test		Slight	Slight		None	None		None	None		None	None	
NPR	CaNP/AP	0.007	0.010	***-30.4***	0.025	0.011	***128.0***	0.010	0.016	***-38.5***	0.013	0.013	***3.3***

Notes: 1. Italicized values in blue font indicte values measured below the detection limit
2. Values shaded in blue indicate a % difference greater than 30%

Appendix C-2. QAQC Results for Solid Phase Element Analyses

Parameter	Unit	B00208010	B00208011 DUP of B00208010	% Difference	B00208459	B00208460 DUP of B00208459	% Difference	B00208469	B00208470 DUP of B00208469	% Difference	B00208479	B00208480 DUP of B00208479	% Difference
Ag	ppm	1.03	1.42	-27.5	1.31	1.1	19.1	8.83	8.16	8.2	1.05	1.32	-20.5
Al	%	1.37	1.39	-1.4	1.28	1.4	-8.6	0.96	1.1	-12.7	1.4	1.25	12.0
As	ppm	58	57	1.8	40	55	-27.3	92	93	-1.1	49	54	-9.3
B	ppm	30	30	0.0	20	20	0.0	<10	<10	0.0	<10	<10	0.0
Ba	ppm	346	377	-8.2	384	306	25.5	229	291	-21.3	331	274	20.8
Be	ppm	0.3	0.3	0.0	0.4	0.4	0.0	0.3	0.4	-25.0	0.4	0.4	0.0
Bi	ppm	0.09	0.07	28.6	0.09	0.08	12.5	0.18	0.16	12.5	0.08	0.07	14.3
Ca	%	0.75	0.97	-22.7	2.17	1.36	59.6	0.54	0.53	1.9	1.2	1.31	-8.4
Cd	ppm	0.23	0.23	0.0	0.27	0.33	-18.2	0.66	0.71	-7.0	0.24	0.24	0.0
Ce	ppm	16.8	16.5	1.8	16.8	16.8	0.0	19.8	20	-1.0	17.9	16	11.9
Co	ppm	11.1	10.9	1.8	9.1	10.4	-12.5	9.5	9	5.6	10.7	9.9	8.1
Cr	ppm	44	49	-10.2	59	59	0.0	75	88	-14.8	54	55	-1.8
Cs	ppm	1.37	1.41	-2.8	1.48	1.6	-7.5	2.23	2.33	-4.3	1.41	1.36	3.7
Cu	ppm	18.3	20	-8.5	15.8	16	-1.3	33	24.5	34.7	13.7	14.9	-8.1
Fe	%	4.39	4.38	0.2	4.3	4.8	-10.4	3.26	3.32	-1.8	4.58	4.67	-1.9
Ga	ppm	3	3.1	-3.2	3.2	3.6	-11.1	2.5	2.9	-13.8	3.7	3.3	12.1
Ge	ppm	<0.1	<0.1	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0	<0.1	<0.1	0.0
Hf	ppm	0.08	0.09	-11.1	0.1	0.09	11.1	<0.05	<0.05	0.0	0.09	0.08	12.5
Hg	ppm	0.37	0.34	8.8	0.26	0.38	-31.6	0.22	0.23	-4.3	0.28	0.36	-22.2
In	ppm	<0.02	<0.02	0.0	<0.02	<0.02	0.0	<0.02	<0.02	0.0	<0.02	<0.02	0.0
K	%	0.11	0.12	-8.3	0.14	0.15	-6.7	0.19	0.25	-24.0	0.14	0.13	7.7
La	ppm	8.9	8.8	1.1	8.3	8.1	2.5	9.3	9.3	0.0	8.7	7.8	11.5
Li	ppm	22	22	0.0	22	24	-8.3	12	13	-7.7	24	22	9.1
Lu	ppm	0.09	0.1	-10.0	0.1	0.1	0.0	0.07	0.07	0.0	0.11	0.1	10.0
Mg	%	0.62	0.61	1.6	0.58	0.62	-6.5	0.4	0.39	2.6	0.61	0.52	17.3
Mn	ppm	1240	1310	-5.3	1380	1300	6.2	829	975	-15.0	1320	1220	8.2
Mo	ppm	3.12	3.15	-1.0	3.33	3.63	-8.3	4.58	5.14	-10.9	3.73	4.23	-11.8
Na	%	0.03	0.03	0.0	0.03	0.03	0.0	0.02	0.02	0.0	0.03	0.02	50.0
Nb	ppm	0.09	0.1	-10.0	0.09	0.1	-10.0	0.41	0.4	2.5	0.08	0.07	14.3
Ni	ppm	4	5.1	-21.6	6.4	5.3	20.8	5.9	6.2	-4.8	6	5.5	9.1
P	%	0.122	0.125	-2.4	0.105	0.121	-13.2	0.102	0.098	4.1	0.133	0.129	3.1
Pb	ppm	12.9	13.2	-2.3	10.8	12.6	-14.3	36.1	38.9	-7.2	11.6	11.8	-1.7
Rb	ppm	3.9	4.1	-4.9	5.1	5.4	-5.6	8.3	10	-17.0	4.6	4.6	0.0
S	%	0.8	0.74	8.1	0.8	1.03	-22.3	0.93	0.55	69.1	0.86	1.02	-15.7
Sb	ppm	1.46	1.7	-14.1	1.49	1.82	-18.1	7.22	5.32	35.7	1.44	1.55	-7.1
Sc	ppm	2.6	2.8	-7.1	2.7	2.9	-6.9	2.5	2.7	-7.4	2.9	2.7	7.4
Se	ppm	<1	<1	0.0	<1	<1	0.0	1	1	0.0	<1	<1	0.0
Sn	ppm	1.8	0.4	350.0	0.7	0.7	0.0	0.4	0.4	0.0	<0.3	<0.3	0.0
Sr	ppm	29.4	30.6	-3.9	59.7	43.1	38.5	34.6	34.7	-0.3	31.9	34.8	-8.3
Ta	ppm	<0.05	<0.05	0.0	<0.05	<0.05	0.0	<0.05	<0.05	0.0	<0.05	<0.05	0.0
Tb	ppm	0.3	0.3	0.0	0.31	0.32	-3.1	0.25	0.25	0.0	0.33	0.31	6.5
Te	ppm	<0.05	<0.05	0.0	<0.05	<0.05	0.0	0.08	0.07	14.3	<0.05	<0.05	0.0
Th	ppm	2	2	0.0	1.8	1.9	-5.3	2	2	0.0	1.8	1.8	0.0
Ti	%	0.02	0.02	0.0	0.02	0.01	100.0	0.02	0.02	0.0	0.02	0.01	100.0
Tl	ppm	0.1	0.11	-9.1	0.1	0.13	-23.1	0.25	0.28	-10.7	0.11	0.11	0.0
U	ppm	0.68	0.67	1.5	0.59	0.63	-6.3	0.74	0.74	0.0	0.55	0.59	-6.8
V	ppm	36	38	-5.3	37	38	-2.6	26	29	-10.3	38	34	11.8
W	ppm	<0.1	<0.1	0.0	0.1	0.1	0.0	0.4	0.4	0.0	0.1	0.1	0.0
Y	ppm	7.37	7.64	-3.5	8.92	8.29	7.6	5.35	5.35	0.0	8.65	7.91	9.4
Yb	ppm	0.7	0.7	0.0	0.7	0.6	16.7	0.5	0.5	0.0	0.7	0.7	0.0
Zn	ppm	86	95	-9.5	86	102	-15.7	113	119	-5.0	85	89	-4.5
Zr	ppm	3.9	4	-2.5	4.2	4.1	2.4	3.1	3	3.3	4.2	4	5.0

Notes: 1. Italicized values in blue font indicte values measured below the detection limit
2. Values shaded in blue indicate a % difference greater than 30%

Appendix C-3. QAQC Results for Organic Matter and Nutrient Analyses

Parameter	Unit	B00208459	B00208460	*% Difference*	B00208469	B00208470	*% Difference*	B00208479	B00208480	*% Difference*
			DUP of B00208459			DUP of B00208469			DUP of B00208479	
OM	%	0.7	0.7	***0.0***	0.7	0.7	***0.0***	0.7	0.7	***0.0***
Al	ppm	471.1	590.9	***-20.3***	703.5	855.7	***-17.8***	653	443.3	***47.3***
B	ppm	2.85	2.98	***-4.4***	3.07	3.04	***1.0***	2.49	2.27	***9.7***
Ca	ppm	4530	4598	***-1.5***	2579	2698	***-4.4***	4342	3880	***11.9***
Cu	ppm	2.1	1.7	***23.5***	2.9	2.2	***31.8***	1.7	1.7	***0.0***
Fe	ppm	622.1	643.5	***-3.3***	688.1	697.5	***-1.3***	602.8	549.5	***9.7***
K	ppm	248	245	***1.2***	310	429	***-27.7***	261	207	***26.1***
Mg	ppm	122	131	***-6.9***	100	115	***-13.0***	128	96	***33.3***
Mn	ppm	392.5	409.6	***-4.2***	342.3	393	***-12.9***	433.2	358.2	***20.9***
Zn	ppm	11.4	12	***-5.0***	9.9	10.3	***-3.9***	11.1	10	***11.0***
P	ppm	0	0	***0.0***	13	6	***116.7***	0	0	***0.0***
P	ppm	3.49	2.85	***22.5***	10.67	12.24	***-12.8***	3.11	2.72	***14.3***
N	ppm	0.08	0.05	***60.0***	0.1	0.07	***42.9***	0.07	0.1	***-30.0***

Note that values shaded in blue indicate a % difference greater than 30%

APPENDIX D: PSD RESULTS

APPENDIX D-1: SIEVE PSD DATA

APPENDIX D-2: MALVERN MASTERSIZER PSD DATA

PRETIVM

Date
Oct. 02, 2015

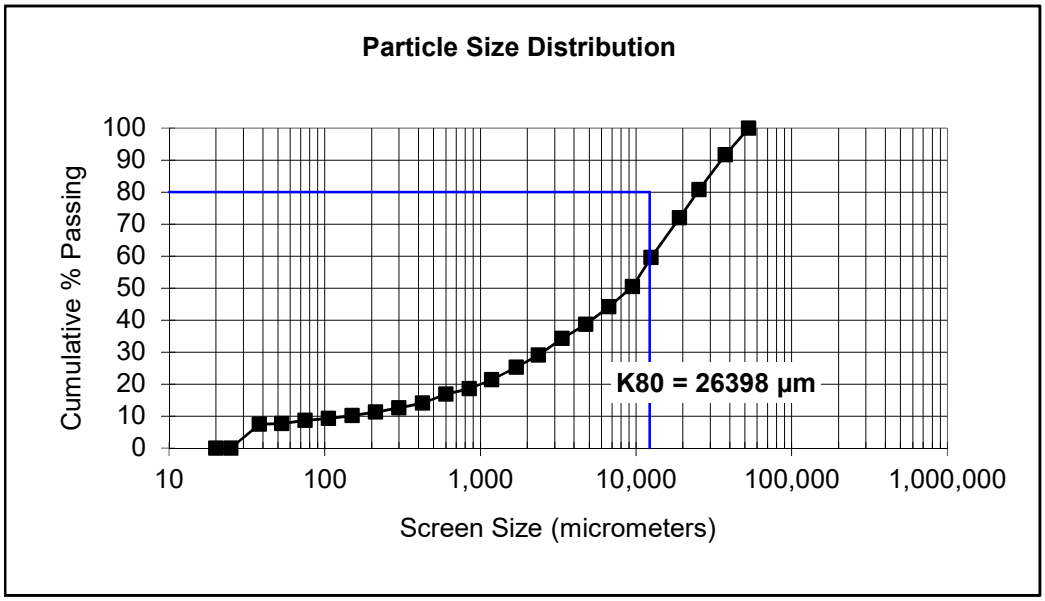
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208462**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
2.12"	53,000	0.0	0.0	0.0	100.0
1 1/2"	37,500	0.0	0.0	0.0	100.0
1"	25,400	115.1	21.9	21.9	78.1
3/4"	19,000	32.0	6.1	28.0	72.0
1/2"	12,500	78.6	15.0	43.0	57.0
3/8"	9,500	26.0	5.0	48.0	52.0
3	6,700	29.0	5.5	53.5	46.5
4	4,750	30.2	5.8	59.3	40.7
6	3,350	27.3	5.2	64.5	35.5
8	2,360	26.0	5.0	69.4	30.6
10	1,700	23.2	4.4	73.8	26.2
14	1,180	25.5	4.9	78.7	21.3
20	850	18.1	3.4	82.1	17.9
28	600	17.7	3.4	85.5	14.5
35	425	12.4	2.4	87.9	12.1
48	300	7.7	1.5	89.3	10.7
65	212	9.7	1.8	91.2	8.8
100	150	4.7	0.9	92.1	7.9
150	106	3.1	0.6	92.7	7.3
200	75	2.2	0.4	93.1	6.9
270	53	1.8	0.3	93.4	6.6
400	38	1.2	0.2	93.7	6.3
500	25	1.3	0.2	93.9	6.1
635	20	0.5	0.1	94.0	6.0
Pan	-20	31.4	6.0	100.0	0.0
Total	**-**	**524.7**	100.0	**-**	**-**
K80	**26,398**				



Date
Oct. 02, 2015

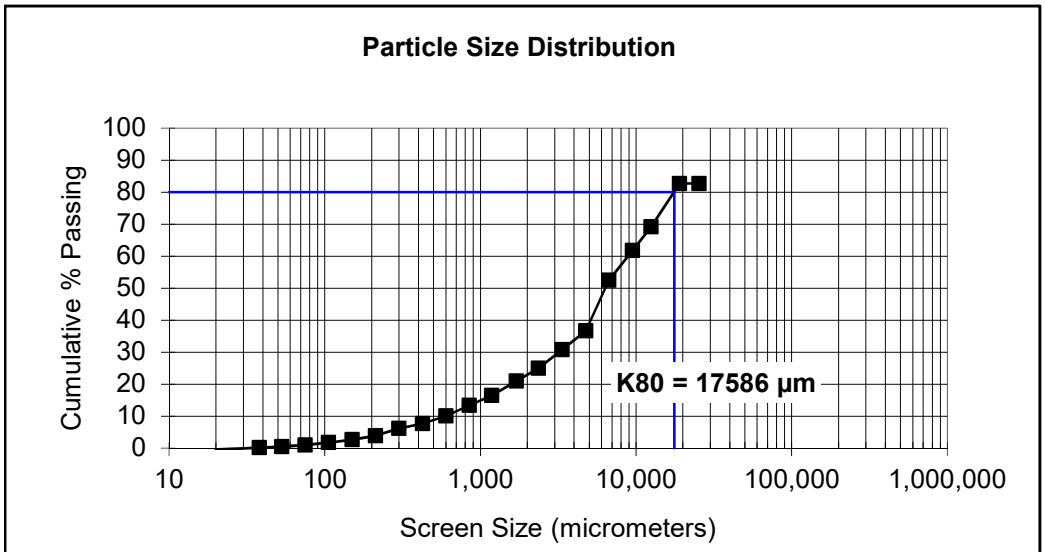
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208463**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	83.1	17.3	17.3	82.7
3/4"	19,000	0.0	0.0	17.3	82.7
1/2"	12,500	65.0	13.5	30.9	69.1
3/8"	9,500	35.2	7.3	38.2	61.8
3	6,700	44.9	9.4	47.5	52.5
4	4,750	75.9	15.8	63.4	36.6
6	3,350	28.2	5.9	69.2	30.8
8	2,360	27.8	5.8	75.0	25.0
10	1,700	19.2	4.0	79.0	21.0
14	1,180	21.6	4.5	83.5	16.5
20	850	15.2	3.2	86.7	13.3
28	600	15.8	3.3	90.0	10.0
35	425	11.6	2.4	92.4	7.6
48	300	7.2	1.5	93.9	6.1
65	212	11.0	2.3	96.2	3.8
100	150	5.8	1.2	97.4	2.6
150	106	4.2	0.9	98.3	1.7
200	75	3.6	0.8	99.0	1.0
270	53	2.5	0.5	99.5	0.5
400	38	1.3	0.3	99.8	0.2
500	25	2.2	0.5	100.3	-0.3
635	20	0.6	0.1	100.4	-0.4
Pan	-20	-1.9	-0.4	100.0	0.0
Total	**-**	**480.0**	100.0	**-**	**-**
K80	**17,586**				



Date
Oct. 02, 2015

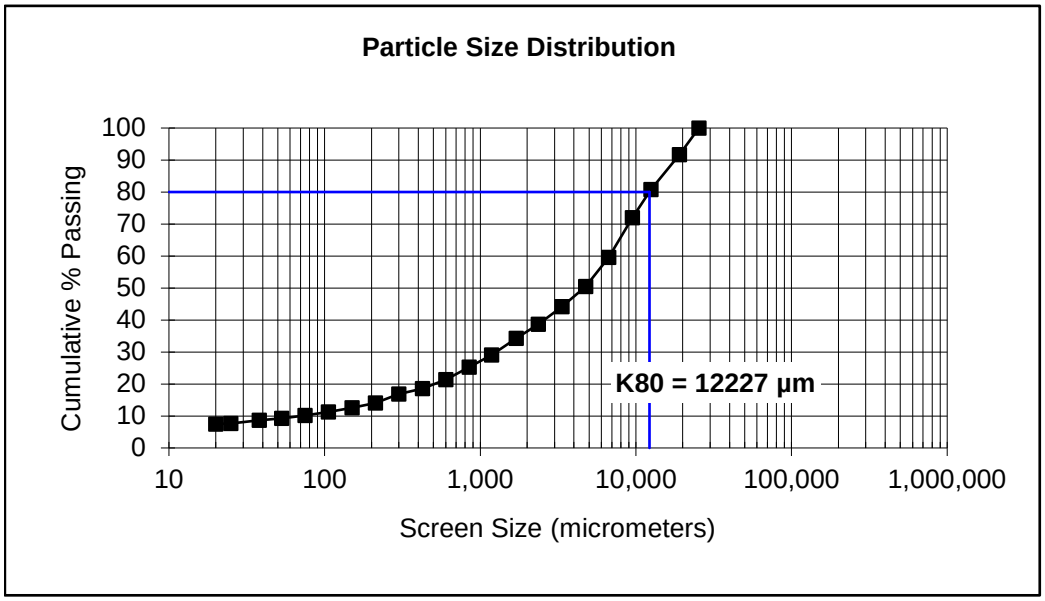
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208464**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	58.5	8.4	8.4	91.6
1/2"	12,500	76.3	10.9	19.3	80.7
3/8"	9,500	61.3	8.8	28.0	72.0
3	6,700	87.2	12.5	40.5	59.5
4	4,750	63.4	9.1	49.5	50.5
6	3,350	43.9	6.3	55.8	44.2
8	2,360	38.7	5.5	61.3	38.7
10	1,700	30.8	4.4	65.7	34.3
14	1,180	36.5	5.2	70.9	29.1
20	850	26.3	3.8	74.7	25.3
28	600	27.7	4.0	78.7	21.3
35	425	19.6	2.8	81.5	18.5
48	300	12.1	1.7	83.2	16.8
65	212	19.0	2.7	85.9	14.1
100	150	11.1	1.6	87.5	12.5
150	106	8.9	1.3	88.8	11.2
200	75	7.8	1.1	89.9	10.1
270	53	6.3	0.9	90.8	9.2
400	38	4.3	0.6	91.4	8.6
500	25	6.9	1.0	92.4	7.6
635	20	1.0	0.1	92.5	7.5
Pan	-20	52.4	7.5	100.0	0.0
Total	**-**	**700.0**	100.0	**-**	**-**
K80	**12,227**				



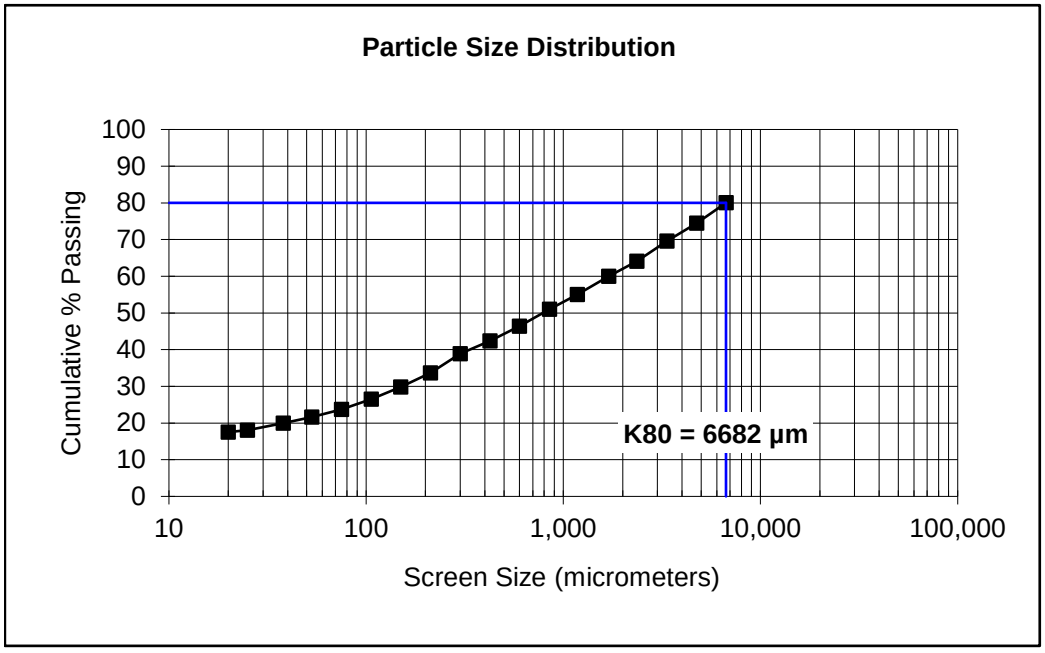
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208465**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
3	6,700	89.8	20.0	20.0	80.0
4	4,750	25.1	5.6	25.5	74.5
6	3,350	22.1	4.9	30.4	69.6
8	2,360	24.5	5.4	35.9	64.1
10	1,700	18.5	4.1	40.0	60.0
14	1,180	22.5	5.0	45.0	55.0
20	850	17.8	4.0	49.0	51.0
28	600	21.1	4.7	53.6	46.4
35	425	18.1	4.0	57.7	42.3
48	300	15.5	3.4	61.1	38.9
65	212	23.5	5.2	66.3	33.7
100	150	17.4	3.9	70.2	29.8
150	106	14.9	3.3	73.5	26.5
200	75	12.6	2.8	76.3	23.7
270	53	9.4	2.1	78.4	21.6
400	38	7.4	1.6	80.0	20.0
500	25	8.8	2.0	82.0	18.0
635	20	2.1	0.5	82.5	17.5
Pan	-20	78.9	17.5	100.0	0.0
Total	**-**	**450.0**	100.0	**-**	**-**
K80	**6,682**				



Date
Oct. 02, 2015

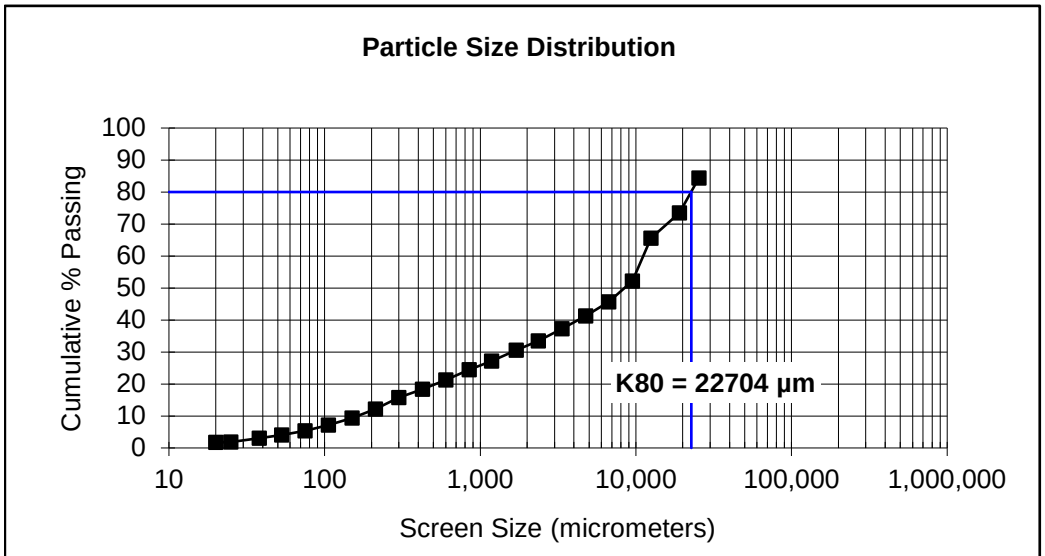
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B0208466**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	101.3	15.6	15.6	84.4
3/4"	19,000	71.2	11.0	26.5	73.5
1/2"	12,500	51.1	7.9	34.4	65.6
3/8"	9,500	87.3	13.4	47.8	52.2
3	6,700	42.0	6.5	54.3	45.7
4	4,750	28.7	4.4	58.7	41.3
6	3,350	25.9	4.0	62.7	37.3
8	2,360	25.1	3.9	66.6	33.4
10	1,700	18.7	2.9	69.4	30.6
14	1,180	22.1	3.4	72.8	27.2
20	850	17.6	2.7	75.5	24.5
28	600	21.0	3.2	78.8	21.2
35	425	18.8	2.9	81.7	18.3
48	300	16.5	2.5	84.2	15.8
65	212	23.9	3.7	87.9	12.1
100	150	17.9	2.8	90.6	9.4
150	106	14.5	2.2	92.9	7.1
200	75	11.7	1.8	94.7	5.3
270	53	8.6	1.3	96.0	4.0
400	38	6.2	1.0	96.9	3.1
500	25	7.7	1.2	98.1	1.9
635	20	1.1	0.2	98.3	1.7
Pan	-20	11.1	1.7	100.0	0.0
Total	**-**	**650.0**	100.0	**-**	**-**
K80	**22,704**				



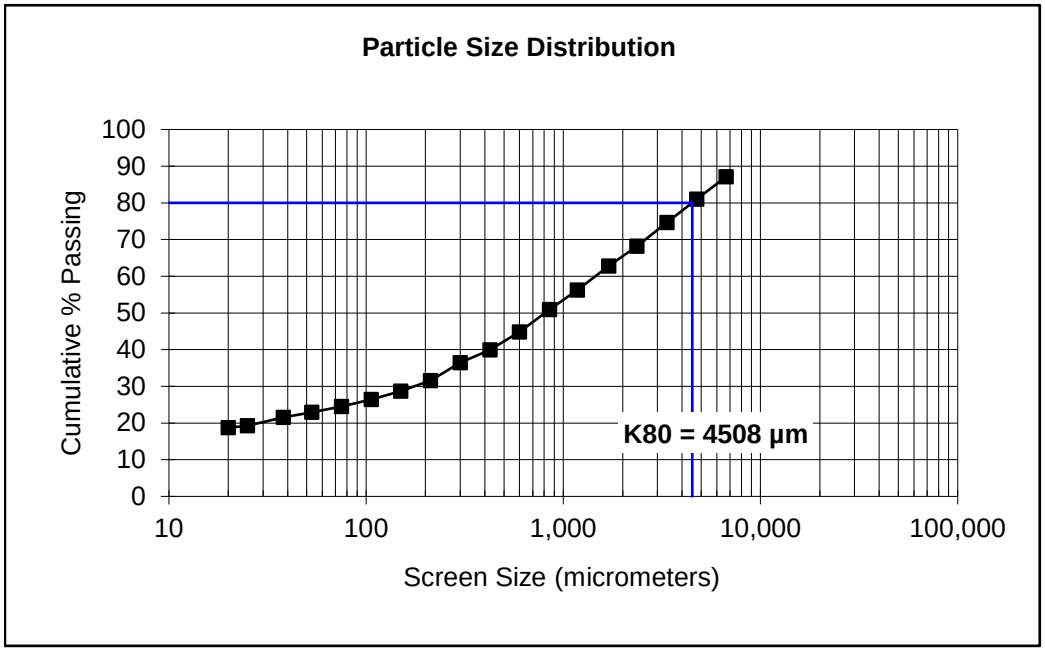
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208467**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
3	6,700	64.3	12.9	12.9	87.1
4	4,750	30.8	6.2	19.0	81.0
6	3,350	31.6	6.3	25.3	74.7
8	2,360	32.3	6.5	31.8	68.2
10	1,700	26.9	5.4	37.2	62.8
14	1,180	33.1	6.6	43.8	56.2
20	850	26.2	5.2	49.0	51.0
28	600	30.6	6.1	55.2	44.8
35	425	24.5	4.9	60.1	39.9
48	300	17.3	3.5	63.5	36.5
65	212	24.5	4.9	68.4	31.6
100	150	14.5	2.9	71.3	28.7
150	106	11.3	2.3	73.6	26.4
200	75	9.6	1.9	75.5	24.5
270	53	7.9	1.6	77.1	22.9
400	38	7.1	1.4	78.5	21.5
500	25	11.2	2.2	80.7	19.3
635	20	2.8	0.6	81.3	18.7
Pan	-20	93.5	18.7	100.0	0.0
Total	**-**	**500.0**	100.0	**-**	**-**
K80	**4,508**				



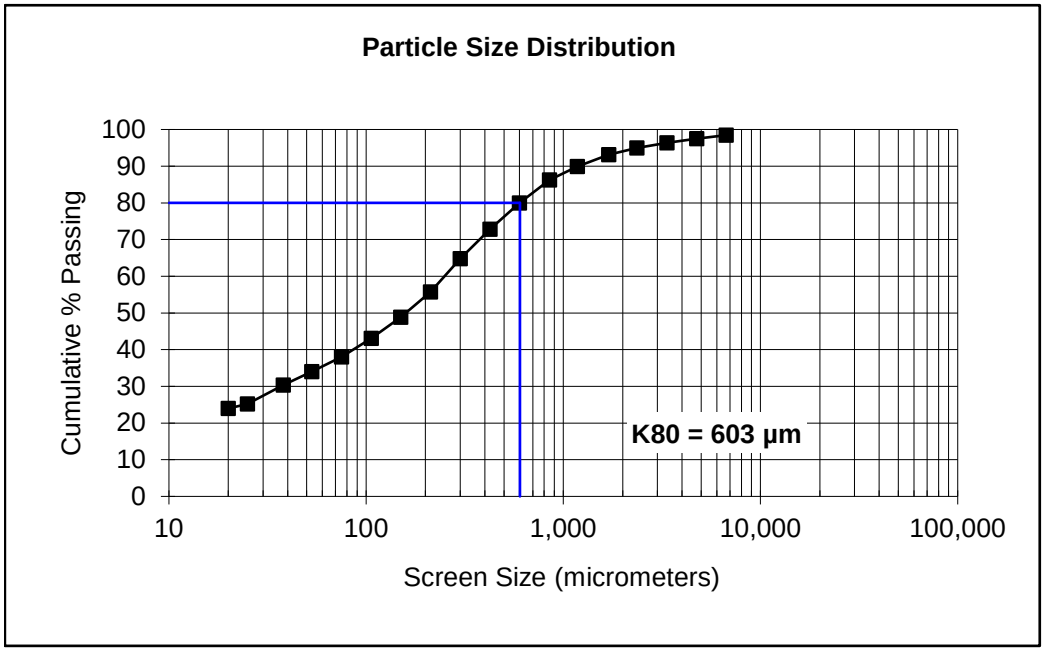
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208468**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
3	6,700	8.5	1.5	1.5	98.5
4	4,750	5.5	1.0	2.5	97.5
6	3,350	6.1	1.1	3.7	96.3
8	2,360	7.6	1.4	5.0	95.0
10	1,700	10.0	1.8	6.9	93.1
14	1,180	17.8	3.2	10.1	89.9
20	850	20.4	3.7	13.8	86.2
28	600	34.5	6.3	20.1	79.9
35	425	39.1	7.1	27.2	72.8
48	300	44.3	8.1	35.2	64.8
65	212	49.6	9.0	44.3	55.7
100	150	38.1	6.9	51.2	48.8
150	106	31.5	5.7	56.9	43.1
200	75	27.7	5.0	61.9	38.1
270	53	22.5	4.1	66.0	34.0
400	38	20.0	3.6	69.7	30.3
500	25	28.4	5.2	74.8	25.2
635	20	6.6	1.2	76.0	24.0
Pan	-20	131.8	24.0	100.0	0.0
Total	**-**	**550.0**	100.0	**-**	**-**
K80	**603**				



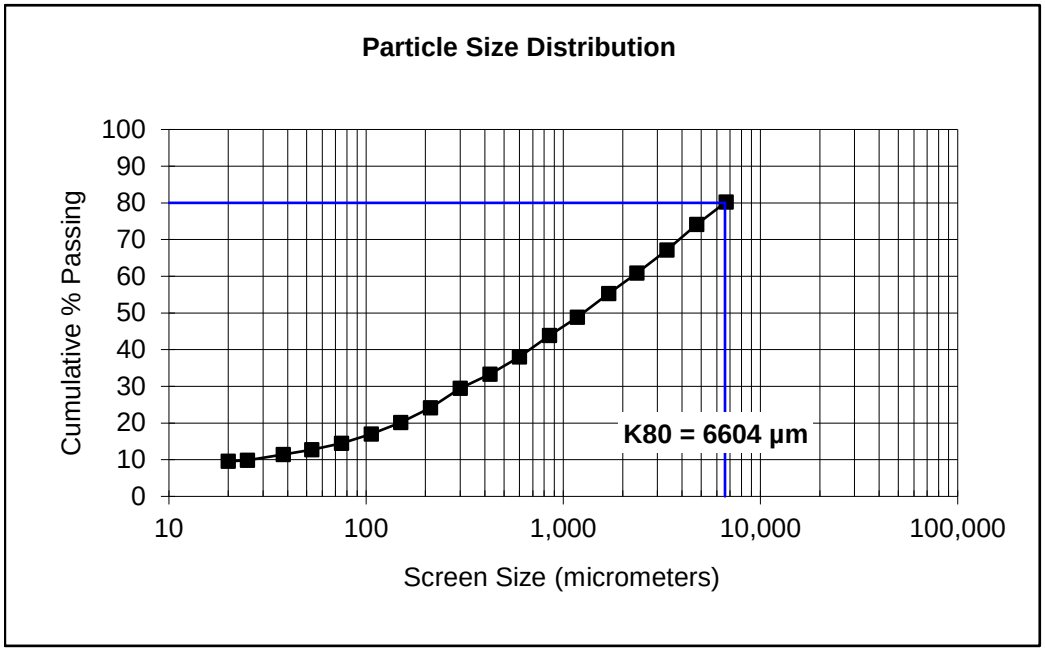
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208469**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
3	6,700	118.4	19.7	19.7	80.3
4	4,750	36.8	6.1	25.9	74.1
6	3,350	41.7	7.0	32.8	67.2
8	2,360	38.0	6.3	39.2	60.9
10	1,700	33.2	5.5	44.7	55.3
14	1,180	38.7	6.5	51.1	48.9
20	850	30.2	5.0	56.2	43.8
28	600	34.7	5.8	62.0	38.1
35	425	28.3	4.7	66.7	33.3
48	300	23.2	3.9	70.5	29.5
65	212	32.0	5.3	75.9	24.1
100	150	23.9	4.0	79.9	20.2
150	106	19.0	3.2	83.0	17.0
200	75	15.0	2.5	85.5	14.5
270	53	10.7	1.8	87.3	12.7
400	38	7.5	1.3	88.6	11.5
500	25	9.4	1.6	90.1	9.9
635	20	2.0	0.3	90.5	9.6
Pan	-20	57.3	9.6	100.0	0.0
Total	**-**	**600.0**	100.0	**-**	**-**
K80	**6,604**				



Date
Oct. 02, 2015

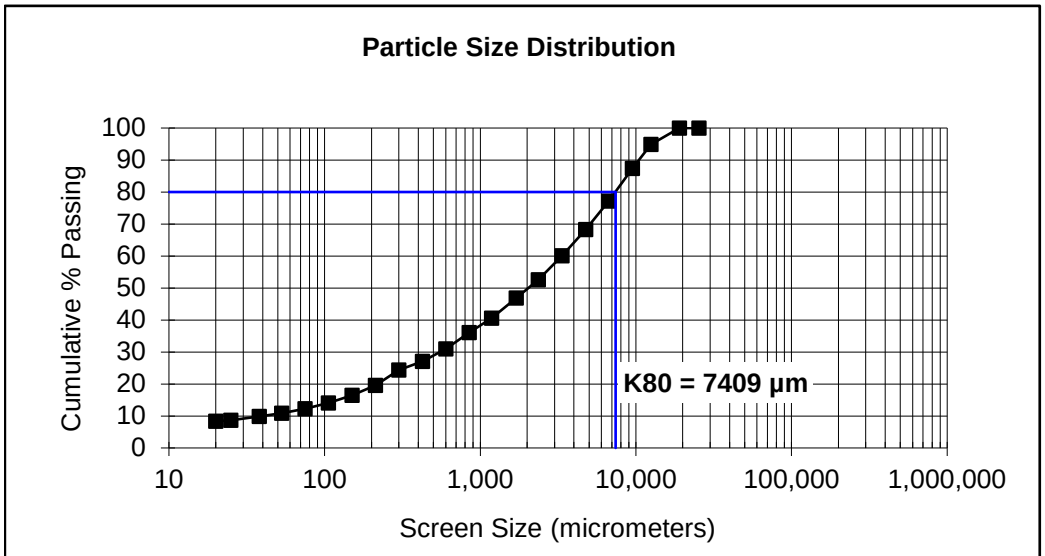
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208470**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	15.5	5.2	5.2	94.8
3/8"	9,500	22.4	7.5	12.6	87.4
3	6,700	30.5	10.2	22.8	77.2
4	4,750	26.7	8.9	31.7	68.3
6	3,350	24.6	8.2	39.9	60.1
8	2,360	22.5	7.5	47.4	52.6
10	1,700	17.3	5.8	53.2	46.8
14	1,180	18.9	6.3	59.5	40.5
20	850	13.5	4.5	64.0	36.0
28	600	15.1	5.0	69.0	31.0
35	425	11.9	4.0	73.0	27.0
48	300	8.0	2.7	75.6	24.4
65	212	14.5	4.8	80.5	19.5
100	150	9.2	3.1	83.5	16.5
150	106	7.1	2.4	85.9	14.1
200	75	5.6	1.9	87.8	12.2
270	53	4.1	1.4	89.1	10.9
400	38	2.9	1.0	90.1	9.9
500	25	3.7	1.2	91.3	8.7
635	20	0.9	0.3	91.6	8.4
Pan	-20	25.1	8.4	100.0	0.0
Total	**-**	**300.0**	100.0	**-**	**-**
K80	**7,409**				



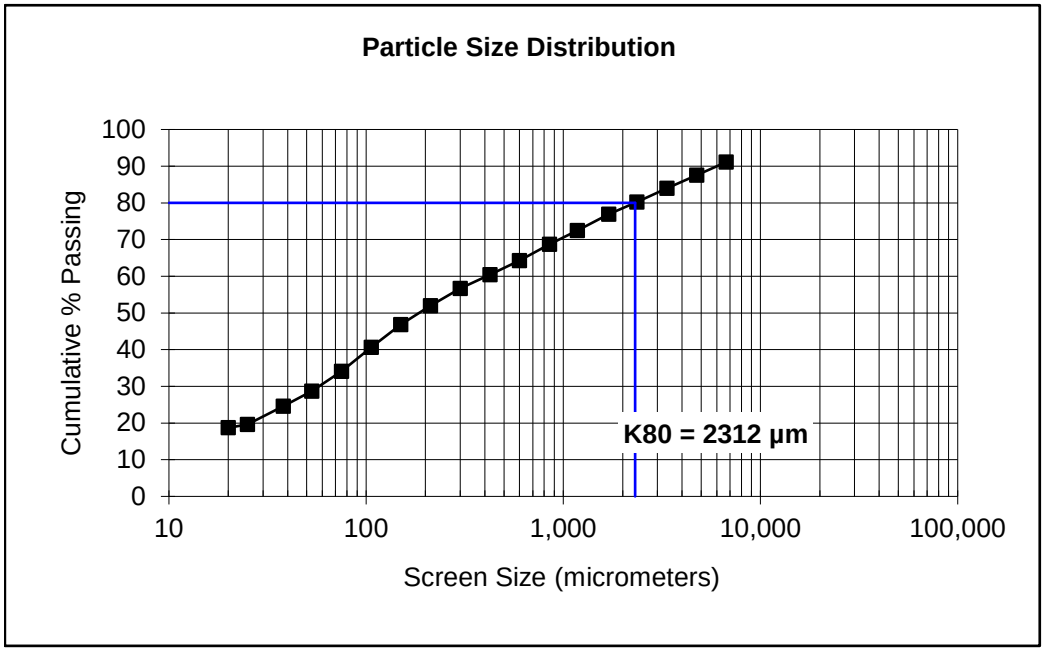
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208471**

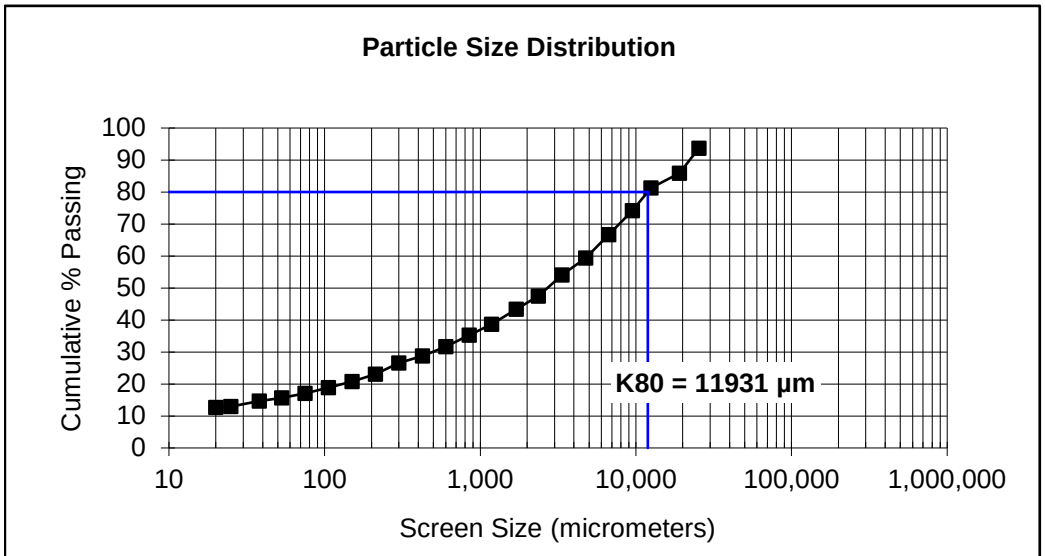
Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
3	6,700	88.9	8.9	8.9	91.1
4	4,750	35.2	3.5	12.4	87.6
6	3,350	35.8	3.6	16.0	84.0
8	2,360	38.0	3.8	19.8	80.2
10	1,700	33.2	3.3	23.1	76.9
14	1,180	44.5	4.5	27.6	72.4
20	850	36.9	3.7	31.3	68.8
28	600	45.2	4.5	35.8	64.2
35	425	38.4	3.8	39.6	60.4
48	300	37.5	3.8	43.4	56.6
65	212	46.5	4.7	48.0	52.0
100	150	52.0	5.2	53.2	46.8
150	106	61.5	6.2	59.4	40.6
200	75	65.7	6.6	65.9	34.1
270	53	53.6	5.4	71.3	28.7
400	38	41.0	4.1	75.4	24.6
500	25	49.6	5.0	80.4	19.7
635	20	9.5	1.0	81.3	18.7
Pan	-20	187.0	18.7	100.0	0.0
Total	**-**	**1000.0**	100.0	**-**	**-**
K80	**2,312**				



Date	SGS Minerals Services	Project No.
Oct. 02, 2015	**Size Distribution Analysis**	**1187**

Sample: Test No.: **B00208472**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	31.5	6.3	6.3	93.7
3/4"	19,000	39.4	7.9	14.2	85.8
1/2"	12,500	22.9	4.6	18.8	81.2
3/8"	9,500	35.2	7.0	25.8	74.2
3	6,700	37.7	7.5	33.3	66.7
4	4,750	36.6	7.3	40.7	59.3
6	3,350	26.6	5.3	46.0	54.0
8	2,360	32.8	6.6	52.5	47.5
10	1,700	20.6	4.1	56.7	43.3
14	1,180	23.4	4.7	61.3	38.7
20	850	16.8	3.4	64.7	35.3
28	600	18.1	3.6	68.3	31.7
35	425	14.6	2.9	71.2	28.8
48	300	11.1	2.2	73.5	26.5
65	212	17.5	3.5	77.0	23.0
100	150	11.4	2.3	79.2	20.8
150	106	9.6	1.9	81.2	18.8
200	75	8.8	1.8	82.9	17.1
270	53	7.1	1.4	84.3	15.7
400	38	4.8	1.0	85.3	14.7
500	25	8.8	1.8	87.1	12.9
635	20	1.3	0.3	87.3	12.7
Pan	-20	63.4	12.7	100.0	0.0
Total	**-**	**500.0**	100.0	**-**	**-**
K80	**11,931**				



Date
Oct. 02, 2015

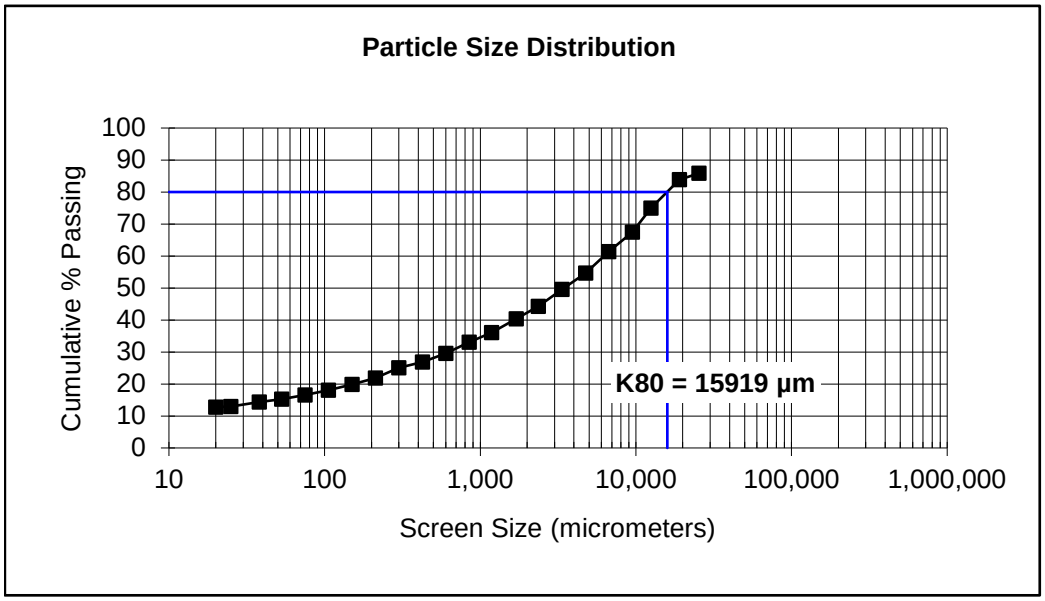
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208473**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	99.2	14.2	14.2	85.8
3/4"	19,000	13.4	1.9	16.1	83.9
1/2"	12,500	62.8	9.0	25.1	74.9
3/8"	9,500	52.6	7.5	32.6	67.4
3	6,700	42.4	6.1	38.6	61.4
4	4,750	46.9	6.7	45.3	54.7
6	3,350	35.5	5.1	50.4	49.6
8	2,360	37.5	5.4	55.8	44.2
10	1,700	27.0	3.9	59.6	40.4
14	1,180	30.6	4.4	64.0	36.0
20	850	20.7	3.0	66.9	33.1
28	600	24.2	3.5	70.4	29.6
35	425	19.1	2.7	73.1	26.9
48	300	12.7	1.8	74.9	25.1
65	212	22.1	3.2	78.1	21.9
100	150	14.6	2.1	80.2	19.8
150	106	12.1	1.7	81.9	18.1
200	75	10.9	1.6	83.5	16.5
270	53	8.8	1.3	84.7	15.3
400	38	6.4	0.9	85.6	14.4
500	25	9.6	1.4	87.0	13.0
635	20	1.5	0.2	87.2	12.8
Pan	-20	89.4	12.8	100.0	0.0
Total	**-**	**700.0**	100.0	**-**	**-**
K80	**15,919**				



Date
Oct. 6, 2015

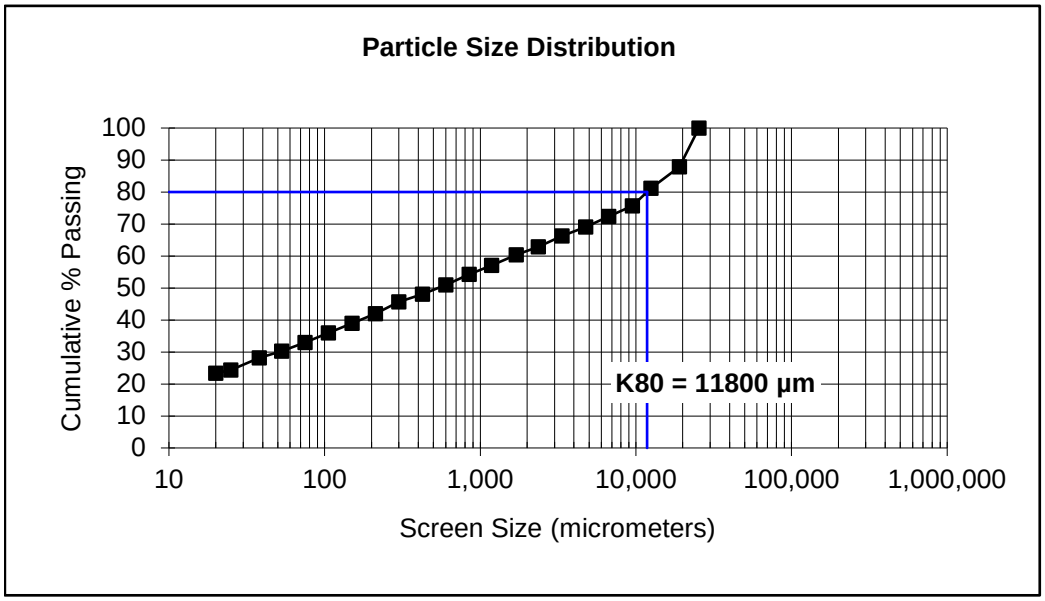
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208474**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	60.7	12.1	12.1	87.9
1/2"	12,500	33.3	6.7	18.8	81.2
3/8"	9,500	27.8	5.6	24.4	75.6
3	6,700	16.3	3.3	27.6	72.4
4	4,750	16.4	3.3	30.9	69.1
6	3,350	14.4	2.9	33.8	66.2
8	2,360	16.8	3.4	37.1	62.9
10	1,700	12.7	2.5	39.7	60.3
14	1,180	16.5	3.3	43.0	57.0
20	850	13.8	2.8	45.7	54.3
28	600	16.5	3.3	49.0	51.0
35	425	14.4	2.9	51.9	48.1
48	300	12.2	2.4	54.4	45.6
65	212	18.4	3.7	58.0	42.0
100	150	15.2	3.0	61.1	38.9
150	106	14.6	2.9	64.0	36.0
200	75	15.0	3.0	67.0	33.0
270	53	13.9	2.8	69.8	30.2
400	38	10.1	2.0	71.8	28.2
500	25	19.3	3.9	75.7	24.3
635	20	4.7	0.9	76.6	23.4
Pan	-20	117.0	23.4	100.0	0.0
Total	**-**	**500.0**	100.0	**-**	**-**
K80	**11,800**				



Date
Oct. 6, 2015

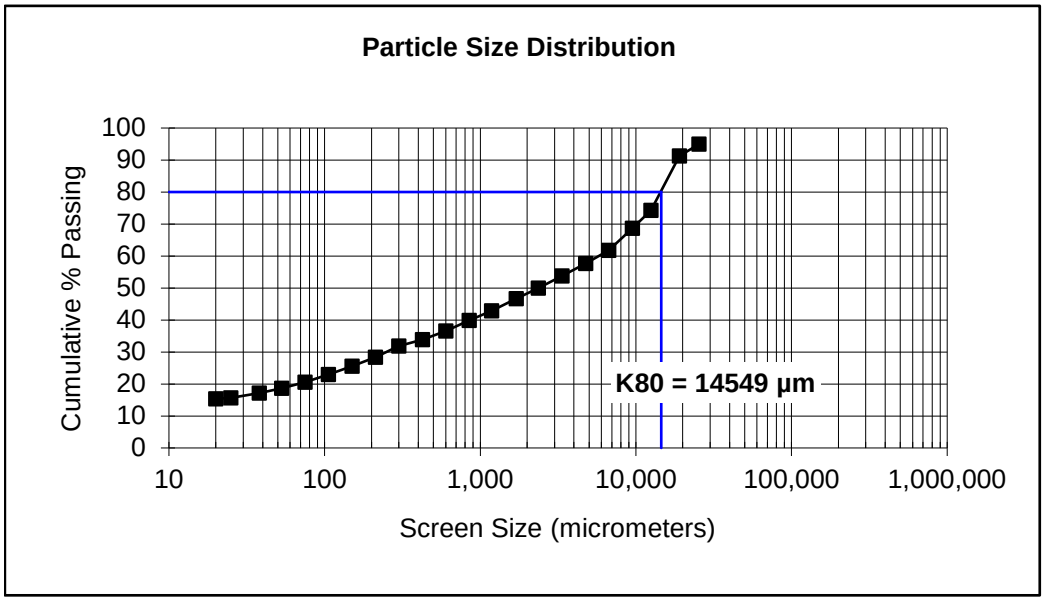
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208475**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	30.4	5.1	5.1	94.9
3/4"	19,000	22.1	3.7	8.8	91.3
1/2"	12,500	102.1	17.0	25.8	74.2
3/8"	9,500	33.3	5.6	31.3	68.7
3	6,700	41.4	6.9	38.2	61.8
4	4,750	24.8	4.1	42.4	57.7
6	3,350	23.3	3.9	46.2	53.8
8	2,360	23.0	3.8	50.1	49.9
10	1,700	19.4	3.2	53.3	46.7
14	1,180	23.1	3.9	57.2	42.9
20	850	17.8	3.0	60.1	39.9
28	600	19.8	3.3	63.4	36.6
35	425	16.1	2.7	66.1	33.9
48	300	12.0	2.0	68.1	31.9
65	212	21.3	3.6	71.7	28.4
100	150	16.8	2.8	74.5	25.6
150	106	15.6	2.6	77.1	23.0
200	75	14.5	2.4	79.5	20.5
270	53	11.2	1.9	81.3	18.7
400	38	8.9	1.5	82.8	17.2
500	25	8.9	1.5	84.3	15.7
635	20	2.0	0.3	84.6	15.4
Pan	-20	92.2	15.4	100.0	0.0
Total	**-**	**600.0**	100.0	**-**	**-**
K80	**14,549**				



Date
Oct. 6, 2015

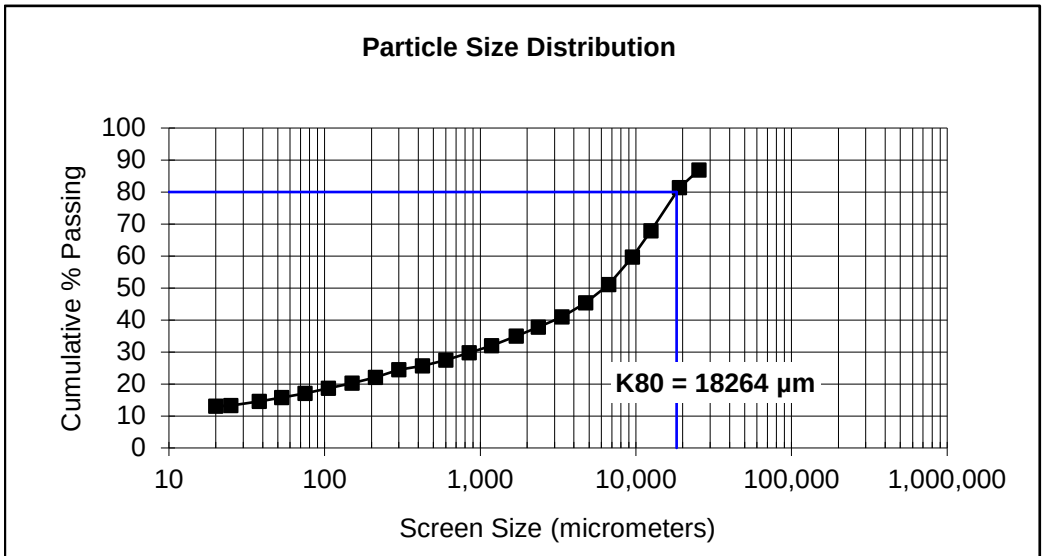
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208476**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	59.1	13.1	13.1	86.9
3/4"	19,000	24.7	5.5	18.6	81.4
1/2"	12,500	60.6	13.5	32.1	67.9
3/8"	9,500	37.2	8.3	40.4	59.6
3	6,700	38.7	8.6	49.0	51.0
4	4,750	25.6	5.7	54.6	45.4
6	3,350	20.0	4.4	59.1	40.9
8	2,360	14.0	3.1	62.2	37.8
10	1,700	12.6	2.8	65.0	35.0
14	1,180	13.7	3.0	68.0	32.0
20	850	9.7	2.2	70.2	29.8
28	600	10.5	2.3	72.5	27.5
35	425	8.1	1.8	74.3	25.7
48	300	5.4	1.2	75.5	24.5
65	212	11.0	2.4	78.0	22.0
100	150	7.9	1.8	79.7	20.3
150	106	7.2	1.6	81.3	18.7
200	75	7.3	1.6	83.0	17.0
270	53	5.9	1.3	84.3	15.7
400	38	5.1	1.1	85.4	14.6
500	25	5.9	1.3	86.7	13.3
635	20	1.2	0.3	87.0	13.0
Pan	-20	58.6	13.0	100.0	0.0
Total	**-**	**450.0**	100.0	**-**	**-**
K80	**18,264**				



Date
Oct. 6, 2015

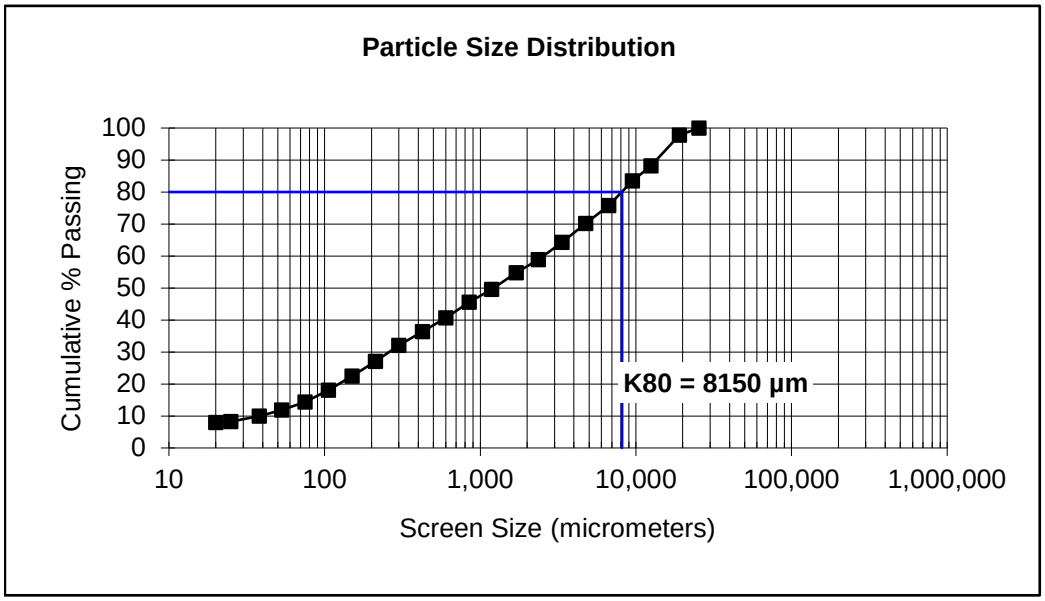
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208477**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	16.9	2.3	2.3	97.7
1/2"	12,500	71.6	9.5	11.8	88.2
3/8"	9,500	35.3	4.7	16.5	83.5
3	6,700	58.1	7.7	24.3	75.7
4	4,750	41.6	5.5	29.8	70.2
6	3,350	44.3	5.9	35.7	64.3
8	2,360	40.6	5.4	41.1	58.9
10	1,700	30.9	4.1	45.2	54.8
14	1,180	38.7	5.2	50.4	49.6
20	850	30.4	4.1	54.5	45.5
28	600	36.4	4.9	59.3	40.7
35	425	32.4	4.3	63.6	36.4
48	300	32.1	4.3	67.9	32.1
65	212	37.7	5.0	72.9	27.1
100	150	34.9	4.7	77.6	22.4
150	106	32.4	4.3	81.9	18.1
200	75	28.2	3.8	85.7	14.3
270	53	18.9	2.5	88.2	11.8
400	38	14.2	1.9	90.1	9.9
500	25	12.8	1.7	91.8	8.2
635	20	2.0	0.3	92.1	7.9
Pan	-20	59.6	7.9	100.0	0.0
Total	**-**	**750.0**	100.0	**-**	**-**
K80	**8,150**				



Date
Oct. 6, 2015

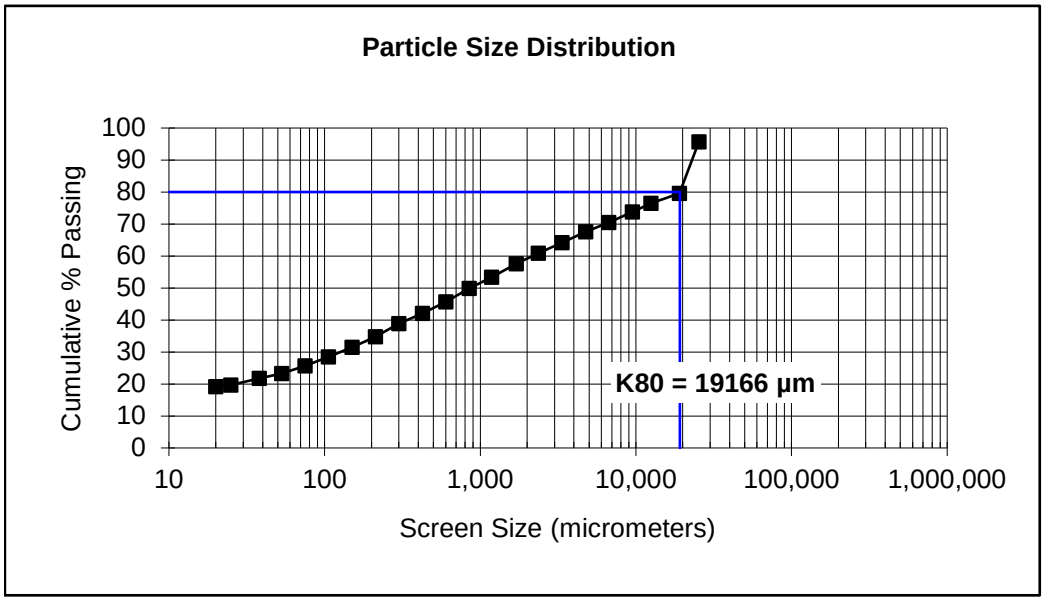
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208478**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	30.0	4.3	4.3	95.7
3/4"	19,000	113.1	16.2	20.4	79.6
1/2"	12,500	21.7	3.1	23.5	76.5
3/8"	9,500	19.1	2.7	26.3	73.7
3	6,700	22.8	3.3	29.5	70.5
4	4,750	20.6	2.9	32.5	67.5
6	3,350	23.3	3.3	35.8	64.2
8	2,360	23.5	3.4	39.2	60.8
10	1,700	22.9	3.3	42.4	57.6
14	1,180	29.4	4.2	46.6	53.4
20	850	24.5	3.5	50.1	49.9
28	600	29.5	4.2	54.3	45.7
35	425	25.4	3.6	58.0	42.0
48	300	22.0	3.1	61.1	38.9
65	212	28.9	4.1	65.2	34.8
100	150	23.4	3.3	68.6	31.4
150	106	20.8	3.0	71.6	28.4
200	75	19.8	2.8	74.4	25.6
270	53	16.6	2.4	76.8	23.2
400	38	10.6	1.5	78.3	21.7
500	25	14.3	2.0	80.3	19.7
635	20	3.7	0.5	80.8	19.2
Pan	-20	134.1	19.2	100.0	0.0
Total	**-**	**700.0**	100.0	**-**	**-**
K80	**19,166**				



Date
Oct. 6, 2015

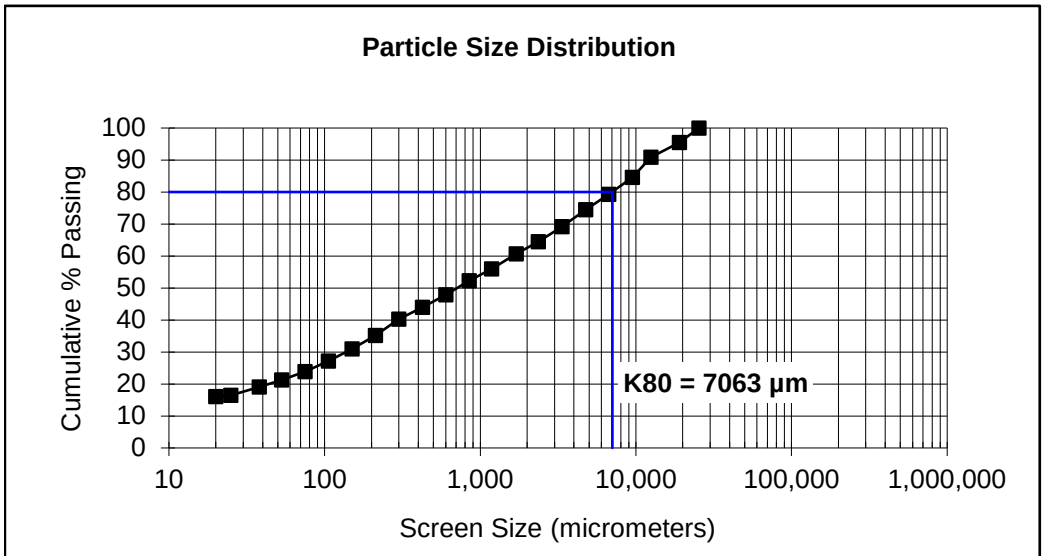
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208479**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	22.4	4.5	4.5	95.5
1/2"	12,500	23.4	4.7	9.2	90.8
3/8"	9,500	31.6	6.3	15.5	84.5
3	6,700	26.5	5.3	20.8	79.2
4	4,750	24.0	4.8	25.6	74.4
6	3,350	26.5	5.3	30.9	69.1
8	2,360	23.1	4.6	35.5	64.5
10	1,700	19.3	3.9	39.4	60.6
14	1,180	23.4	4.7	44.0	56.0
20	850	18.4	3.7	47.7	52.3
28	600	22.2	4.4	52.2	47.8
35	425	19.6	3.9	56.1	43.9
48	300	18.2	3.6	59.7	40.3
65	212	25.5	5.1	64.8	35.2
100	150	21.3	4.3	69.1	30.9
150	106	18.7	3.7	72.8	27.2
200	75	16.8	3.4	76.2	23.8
270	53	12.9	2.6	78.8	21.2
400	38	11.0	2.2	81.0	19.0
500	25	12.7	2.5	83.5	16.5
635	20	2.0	0.4	83.9	16.1
Pan	-20	80.5	16.1	100.0	0.0
Total	**-**	**500.0**	100.0	**-**	**-**
K80	**7,063**				



Date
Oct. 08, 2015

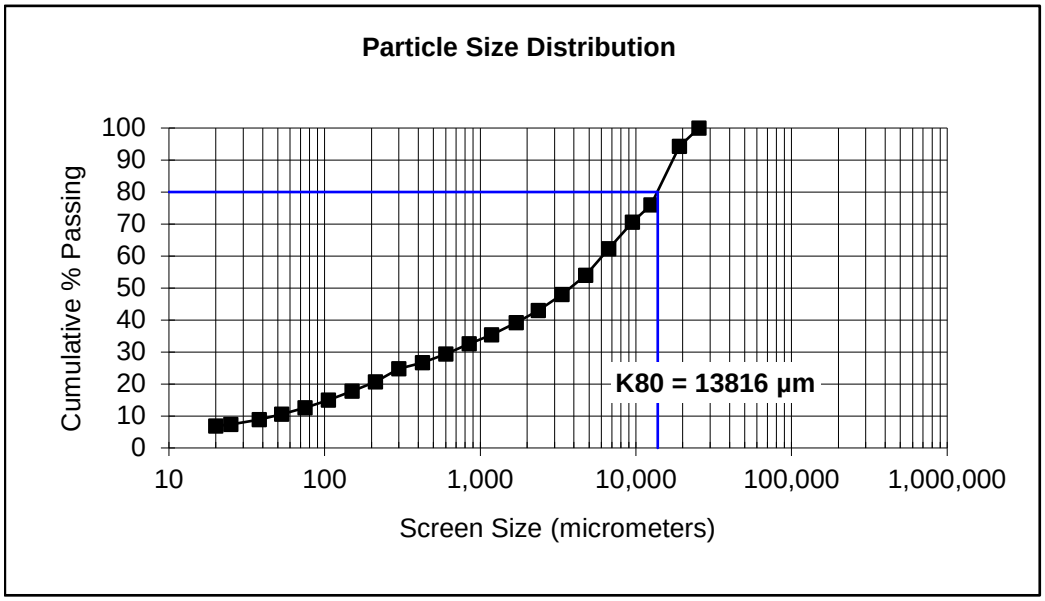
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208480**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	21.4	5.7	5.7	94.3
1/2"	12,500	68.7	18.3	24.0	76.0
3/8"	9,500	20.1	5.4	29.4	70.6
3	6,700	31.4	8.4	37.8	62.2
4	4,750	31.2	8.3	46.1	53.9
6	3,350	22.5	6.0	52.1	47.9
8	2,360	18.6	5.0	57.0	43.0
10	1,700	14.4	3.8	60.9	39.1
14	1,180	14.0	3.7	64.6	35.4
20	850	10.6	2.8	67.4	32.6
28	600	11.9	3.2	70.6	29.4
35	425	10.3	2.7	73.4	26.6
48	300	7.2	1.9	75.3	24.7
65	212	15.1	4.0	79.3	20.7
100	150	11.2	3.0	82.3	17.7
150	106	10.2	2.7	85.0	15.0
200	75	9.3	2.5	87.5	12.5
270	53	7.3	1.9	89.4	10.6
400	38	6.3	1.7	91.1	8.9
500	25	5.7	1.5	92.6	7.4
635	20	1.8	0.5	93.1	6.9
Pan	-20	25.8	6.9	100.0	0.0
Total	**-**	**375.0**	100.0	**-**	**-**
K80	**13,816**				



Date
Oct. 08, 2015

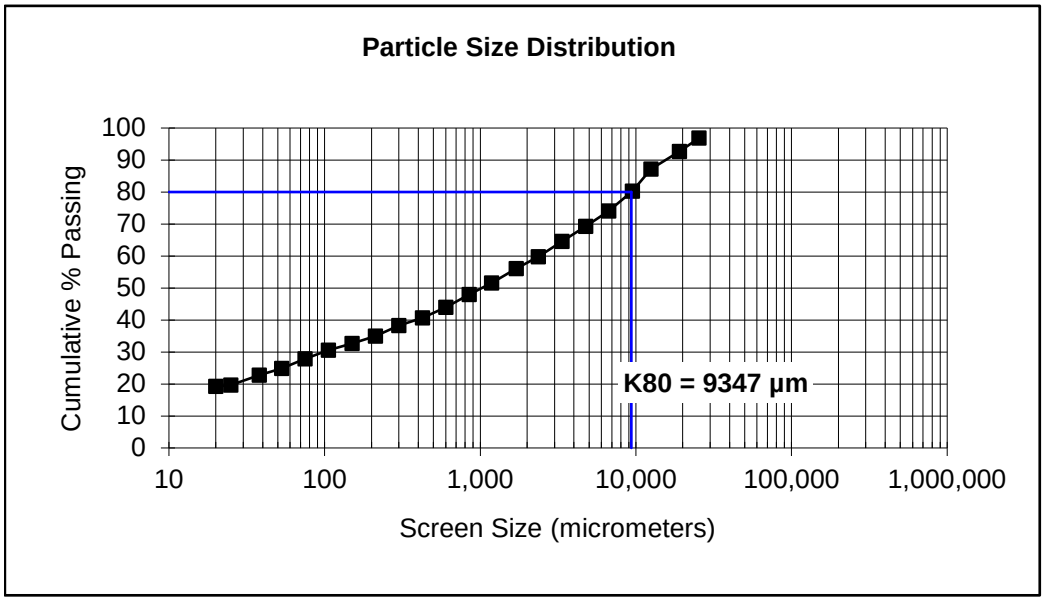
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208481**

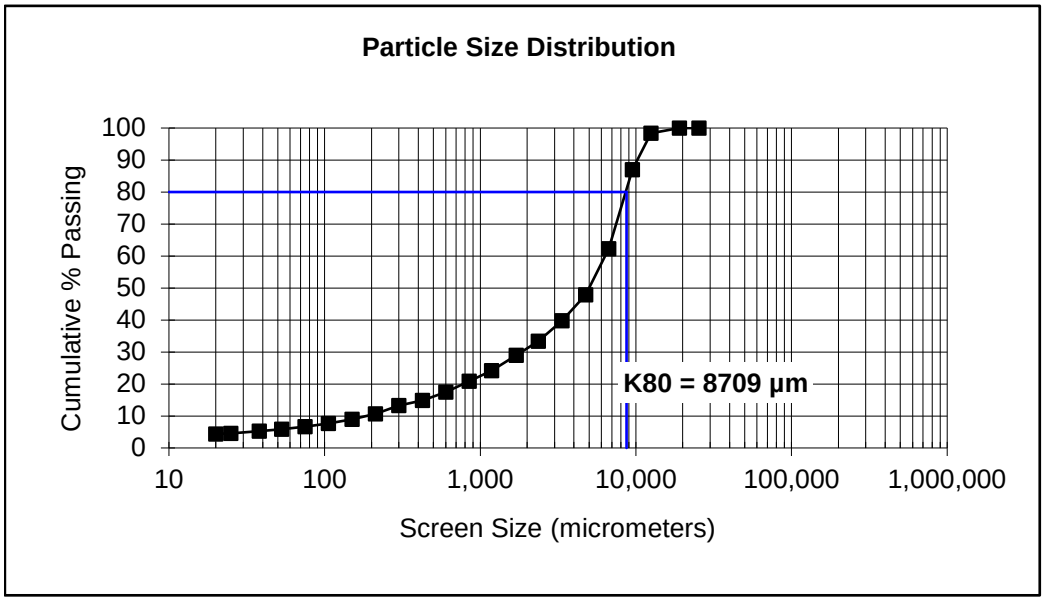
Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	31.6	3.2	3.2	96.8
3/4"	19,000	41.9	4.2	7.4	92.7
1/2"	12,500	55.0	5.5	12.9	87.2
3/8"	9,500	68.5	6.9	19.7	80.3
3	6,700	62.0	6.2	25.9	74.1
4	4,750	47.9	4.8	30.7	69.3
6	3,350	47.8	4.8	35.5	64.5
8	2,360	48.1	4.8	40.3	59.7
10	1,700	36.6	3.7	43.9	56.1
14	1,180	45.4	4.5	48.5	51.5
20	850	35.8	3.6	52.1	47.9
28	600	40.2	4.0	56.1	43.9
35	425	32.3	3.2	59.3	40.7
48	300	24.8	2.5	61.8	38.2
65	212	32.9	3.3	65.1	34.9
100	150	22.4	2.2	67.3	32.7
150	106	21.1	2.1	69.4	30.6
200	75	27.3	2.7	72.2	27.8
270	53	29.6	3.0	75.1	24.9
400	38	21.4	2.1	77.3	22.7
500	25	30.5	3.1	80.3	19.7
635	20	4.7	0.5	80.8	19.2
Pan	-20	192.2	19.2	100.0	0.0
Total	**-**	**1000.0**	100.0	**-**	**-**
K80	**9,347**				



Date	SGS Minerals Services	Project No.
Oct. 08, 2015	**Size Distribution Analysis**	**1187**

Sample: Test No.: **B00208451**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	11.3	1.6	1.6	98.4
3/8"	9,500	78.7	11.4	13.0	87.0
3	6,700	170.7	24.7	37.8	62.2
4	4,750	98.9	14.3	52.1	47.9
6	3,350	56.3	8.2	60.3	39.7
8	2,360	44.0	6.4	66.7	33.3
10	1,700	30.0	4.3	71.0	29.0
14	1,180	33.1	4.8	75.8	24.2
20	850	22.9	3.3	79.1	20.9
28	600	23.9	3.5	82.6	17.4
35	425	17.6	2.6	85.1	14.9
48	300	11.0	1.6	86.7	13.3
65	212	18.4	2.7	89.4	10.6
100	150	11.5	1.7	91.1	8.9
150	106	8.9	1.3	92.3	7.7
200	75	7.2	1.0	93.4	6.6
270	53	5.3	0.8	94.2	5.8
400	38	4.2	0.6	94.8	5.2
500	25	4.7	0.7	95.4	4.6
635	20	1.1	0.2	95.6	4.4
Pan	-20	30.3	4.4	100.0	0.0
Total	**-**	**690.0**	100.0	**-**	**-**
K80	**8,709**				



Date
Oct. 08, 2015

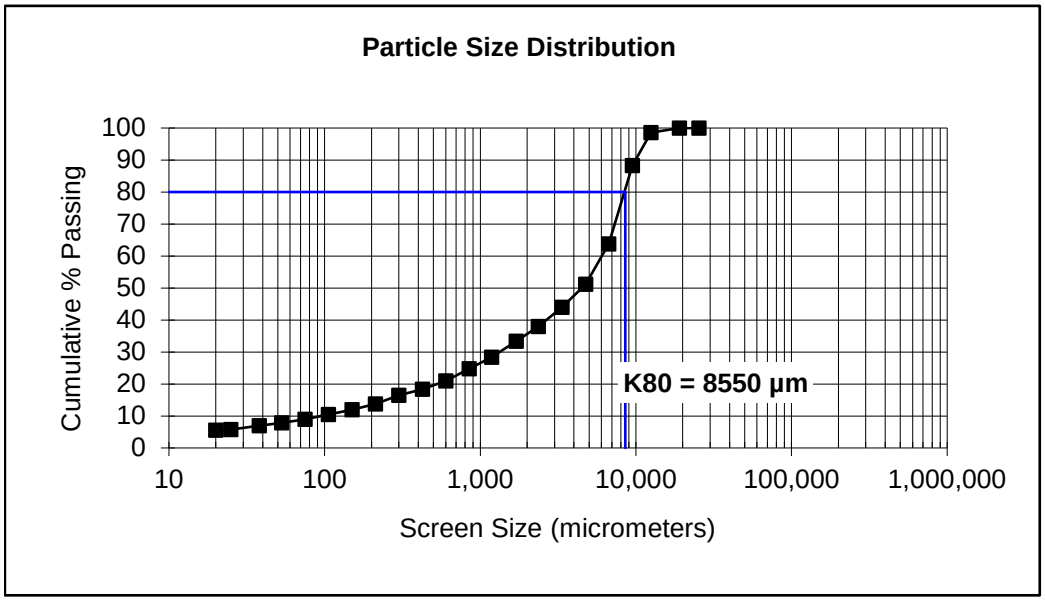
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208452**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	6.7	1.4	1.4	98.6
3/8"	9,500	48.5	10.3	11.7	88.3
3	6,700	115.2	24.5	36.3	63.7
4	4,750	59.2	12.6	48.9	51.1
6	3,350	33.8	7.2	56.0	44.0
8	2,360	28.3	6.0	62.1	37.9
10	1,700	21.5	4.6	66.6	33.4
14	1,180	23.4	5.0	71.6	28.4
20	850	16.9	3.6	75.2	24.8
28	600	17.8	3.8	79.0	21.0
35	425	12.6	2.7	81.7	18.3
48	300	8.6	1.8	83.5	16.5
65	212	12.7	2.7	86.2	13.8
100	150	8.7	1.9	88.1	11.9
150	106	7.2	1.5	89.6	10.4
200	75	6.7	1.4	91.0	9.0
270	53	5.1	1.1	92.1	7.9
400	38	4.2	0.9	93.0	7.0
500	25	5.8	1.2	94.2	5.8
635	20	0.9	0.2	94.4	5.6
Pan	-20	26.2	5.6	100.0	0.0
Total	**-**	**470.0**	100.0	**-**	**-**
K80	**8,550**				



Date
Oct. 13, 2015

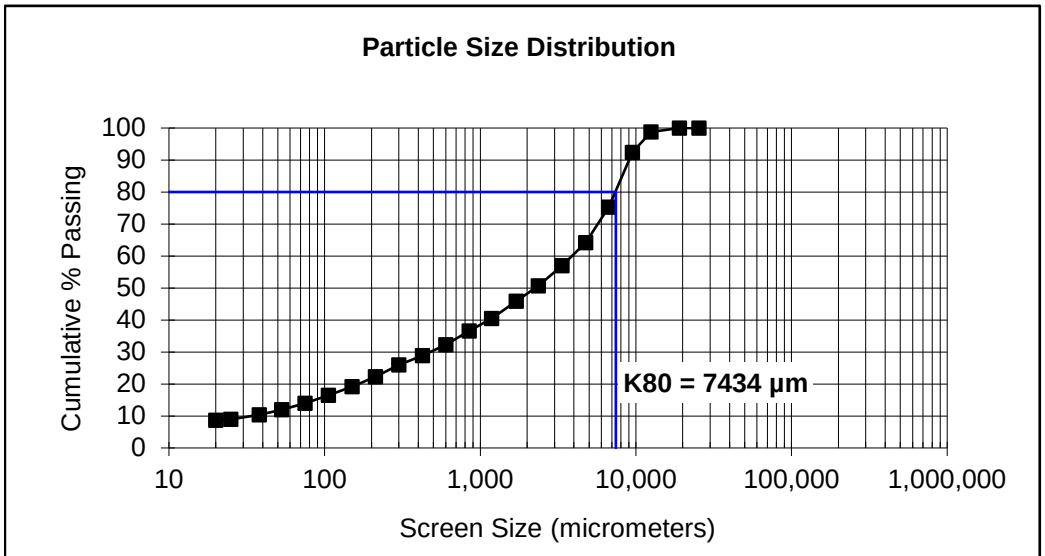
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208453**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	6.6	1.2	1.2	98.8
3/8"	9,500	35.3	6.4	7.6	92.4
3	6,700	94.2	17.1	24.7	75.3
4	4,750	61.1	11.1	35.8	64.2
6	3,350	39.4	7.2	43.0	57.0
8	2,360	34.9	6.3	49.3	50.7
10	1,700	26.6	4.8	54.2	45.8
14	1,180	29.7	5.4	59.6	40.4
20	850	21.4	3.9	63.5	36.5
28	600	23.7	4.3	67.8	32.2
35	425	18.5	3.4	71.1	28.9
48	300	15.8	2.9	74.0	26.0
65	212	20.7	3.8	77.8	22.2
100	150	16.8	3.1	80.8	19.2
150	106	15.2	2.8	83.6	16.4
200	75	13.8	2.5	86.1	13.9
270	53	10.6	1.9	88.0	12.0
400	38	8.7	1.6	89.6	10.4
500	25	8.2	1.5	91.1	8.9
635	20	1.2	0.2	91.3	8.7
Pan	-20	47.8	8.7	100.0	0.0
Total	**-**	**550.2**	100.0	**-**	**-**
K80	**7,434**				



Date
Oct. 13, 2015

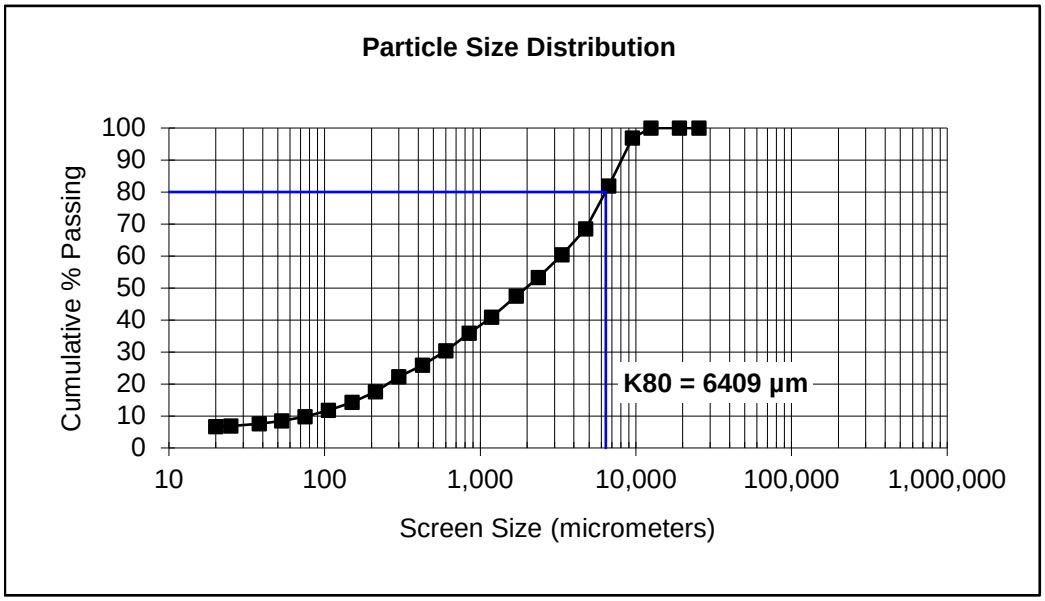
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208454**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	0.0	0.0	0.0	100.0
3/8"	9,500	25.0	3.1	3.1	96.9
3	6,700	120.1	15.0	18.1	81.9
4	4,750	106.8	13.4	31.5	68.5
6	3,350	65.3	8.2	39.7	60.4
8	2,360	57.0	7.1	46.8	53.2
10	1,700	46.1	5.8	52.5	47.5
14	1,180	53.2	6.7	59.2	40.8
20	850	39.8	5.0	64.2	35.8
28	600	43.8	5.5	69.6	30.4
35	425	35.8	4.5	74.1	25.9
48	300	28.7	3.6	77.7	22.3
65	212	38.0	4.8	82.5	17.6
100	150	26.2	3.3	85.7	14.3
150	106	20.2	2.5	88.3	11.8
200	75	15.9	2.0	90.2	9.8
270	53	10.2	1.3	91.5	8.5
400	38	7.3	0.9	92.4	7.6
500	25	6.1	0.8	93.2	6.8
635	20	1.1	0.1	93.3	6.7
Pan	-20	53.4	6.7	100.0	0.0
Total	**-**	**800.0**	100.0	**-**	**-**
K80	**6,409**				



Date
Oct. 13, 2015

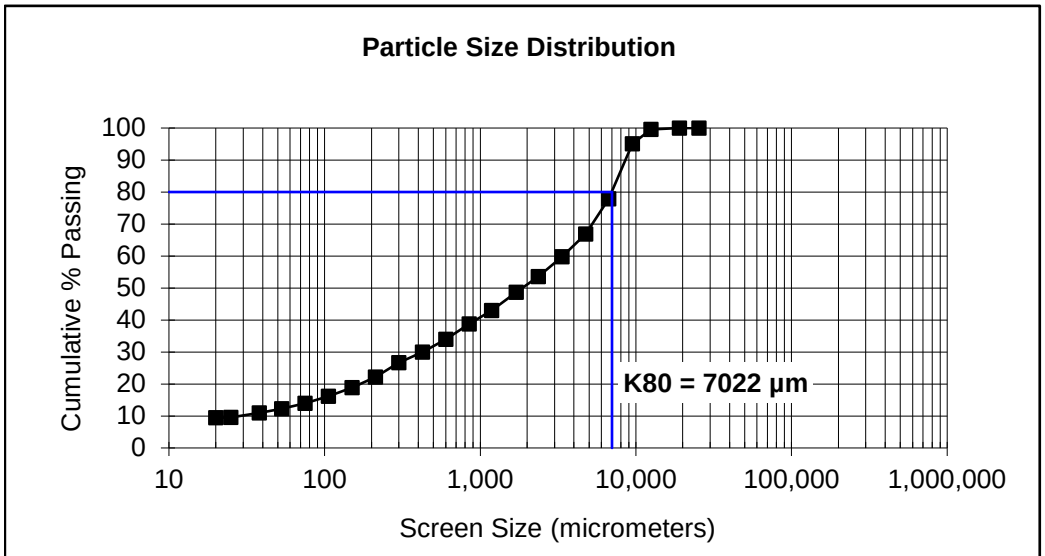
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208455**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	4.1	0.5	0.5	99.5
3/8"	9,500	40.5	4.5	5.0	95.0
3	6,700	154.4	17.2	22.1	77.9
4	4,750	99.0	11.0	33.1	66.9
6	3,350	64.5	7.2	40.3	59.7
8	2,360	55.4	6.2	46.4	53.6
10	1,700	44.5	4.9	51.4	48.6
14	1,180	50.6	5.6	57.0	43.0
20	850	38.0	4.2	61.2	38.8
28	600	43.3	4.8	66.0	34.0
35	425	36.0	4.0	70.0	30.0
48	300	30.0	3.3	73.4	26.6
65	212	39.9	4.4	77.8	22.2
100	150	29.8	3.3	81.1	18.9
150	106	24.3	2.7	83.8	16.2
200	75	20.4	2.3	86.1	13.9
270	53	14.9	1.7	87.7	12.3
400	38	12.0	1.3	89.1	10.9
500	25	12.2	1.4	90.4	9.6
635	20	1.3	0.1	90.6	9.4
Pan	-20	84.9	9.4	100.0	0.0
Total	**-**	**900.0**	100.0	**-**	**-**
K80	**7,022**				



Date
Oct. 13, 2015

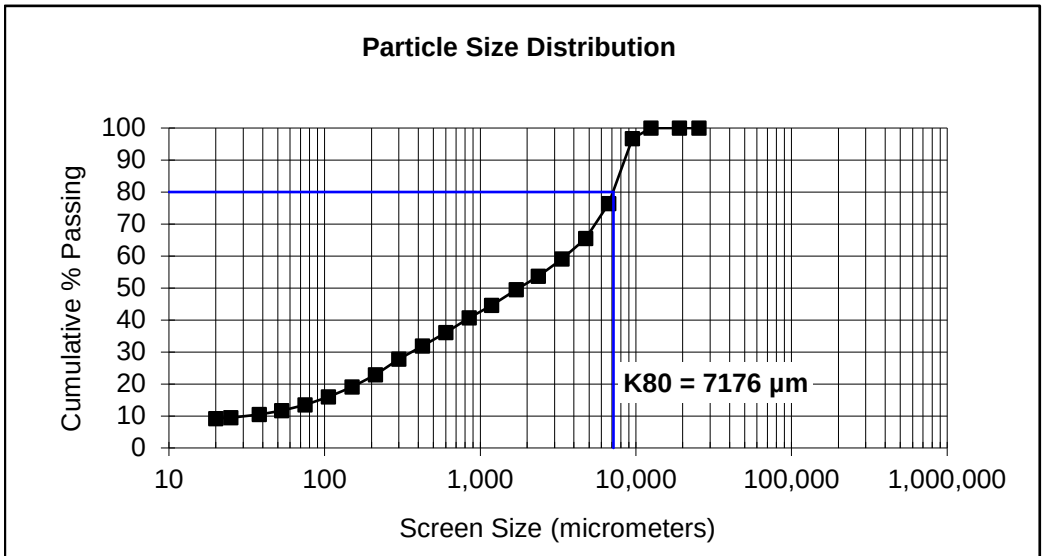
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208456**

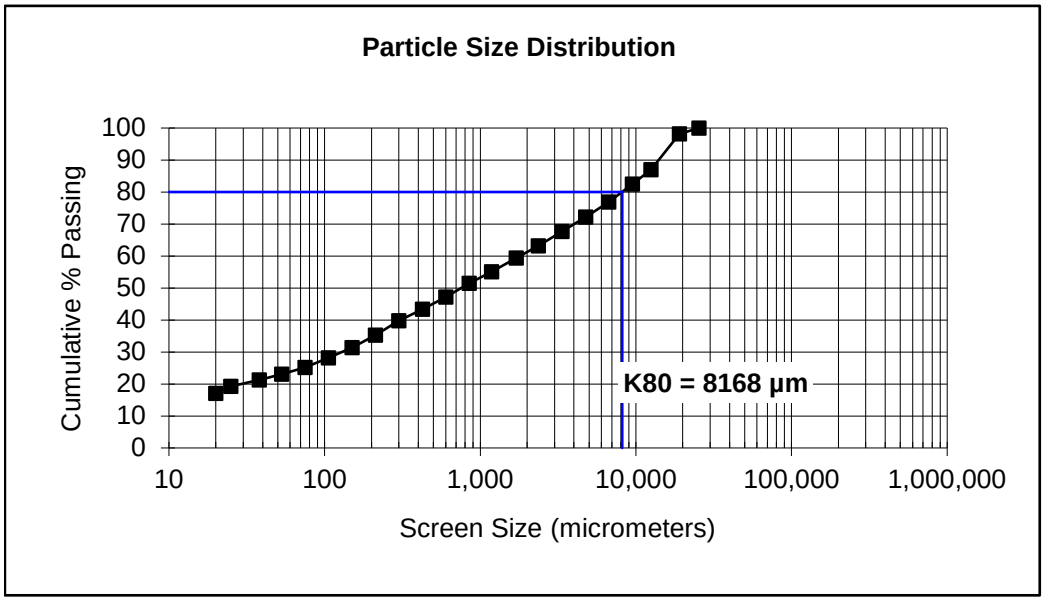
Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	0.0	0.0	0.0	100.0
3/8"	9,500	29.5	3.3	3.3	96.7
3	6,700	183.2	20.4	23.6	76.4
4	4,750	97.9	10.9	34.5	65.5
6	3,350	58.1	6.5	41.0	59.0
8	2,360	48.5	5.4	46.4	53.6
10	1,700	37.2	4.1	50.5	49.5
14	1,180	44.7	5.0	55.5	44.5
20	850	34.7	3.9	59.3	40.7
28	600	41.7	4.6	63.9	36.1
35	425	37.9	4.2	68.2	31.8
48	300	36.5	4.1	72.2	27.8
65	212	44.1	4.9	77.1	22.9
100	150	34.4	3.8	80.9	19.1
150	106	27.9	3.1	84.0	16.0
200	75	22.9	2.5	86.6	13.4
270	53	15.5	1.7	88.3	11.7
400	38	11.5	1.3	89.6	10.4
500	25	9.1	1.0	90.6	9.4
635	20	2.0	0.2	90.8	9.2
Pan	-20	82.7	9.2	100.0	0.0
Total	**-**	**900.0**	100.0	**-**	**-**
K80	**7,176**				



Date	SGS Minerals Services	Project No.
Oct. 14, 2015	**Size Distribution Analysis**	**1187**

Sample: Test No.: **B00208457**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	11.9	1.8	1.8	98.2
1/2"	12,500	72.8	11.2	13.0	87.0
3/8"	9,500	29.1	4.5	17.5	82.5
3	6,700	36.7	5.6	23.2	76.8
4	4,750	30.3	4.7	27.8	72.2
6	3,350	29.6	4.6	32.4	67.6
8	2,360	29.1	4.5	36.8	63.2
10	1,700	24.4	3.8	40.6	59.4
14	1,180	28.5	4.4	45.0	55.0
20	850	23.1	3.6	48.5	51.5
28	600	27.8	4.3	52.8	47.2
35	425	24.7	3.8	56.6	43.4
48	300	23.6	3.6	60.2	39.8
65	212	29.3	4.5	64.8	35.2
100	150	25.0	3.8	68.6	31.4
150	106	21.4	3.3	71.9	28.1
200	75	18.9	2.9	74.8	25.2
270	53	14.0	2.2	77.0	23.0
400	38	11.9	1.8	78.8	21.2
500	25	12.9	2.0	80.8	19.2
635	20	14.1	2.2	82.9	17.1
Pan	-20	110.9	17.1	100.0	0.0
Total	**-**	**650.0**	100.0	**-**	**-**
K80	**8,168**				



Date

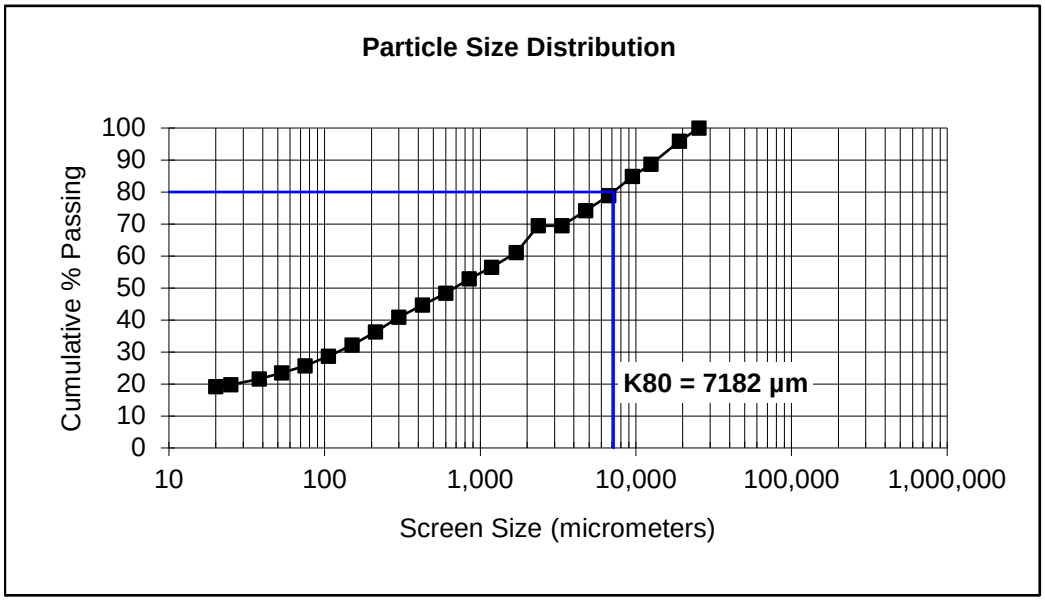
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208458**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	29.1	4.2	4.2	95.8
1/2"	12,500	50.4	7.2	11.4	88.6
3/8"	9,500	26.7	3.8	15.2	84.8
3	6,700	41.9	6.0	21.2	78.8
4	4,750	33.0	4.7	25.9	74.1
6	3,350	32.6	4.7	30.5	69.5
8	2,360	0.0	0.0	30.5	69.5
10	1,700	58.9	8.4	38.9	61.1
14	1,180	32.1	4.6	43.5	56.5
20	850	25.6	3.7	47.2	52.8
28	600	30.9	4.4	51.6	48.4
35	425	26.4	3.8	55.4	44.6
48	300	26.3	3.8	59.1	40.9
65	212	32.6	4.7	63.8	36.2
100	150	28.3	4.0	67.8	32.2
150	106	24.4	3.5	71.3	28.7
200	75	21.2	3.0	74.3	25.7
270	53	15.7	2.2	76.6	23.4
400	38	13.2	1.9	78.5	21.5
500	25	12.2	1.7	80.2	19.8
635	20	4.2	0.6	80.8	19.2
Pan	-20	134.3	19.2	100.0	0.0
Total	**-**	**700.0**	100.0	**-**	**-**
K80	**7,182**				



Date
Oct. 14, 2015

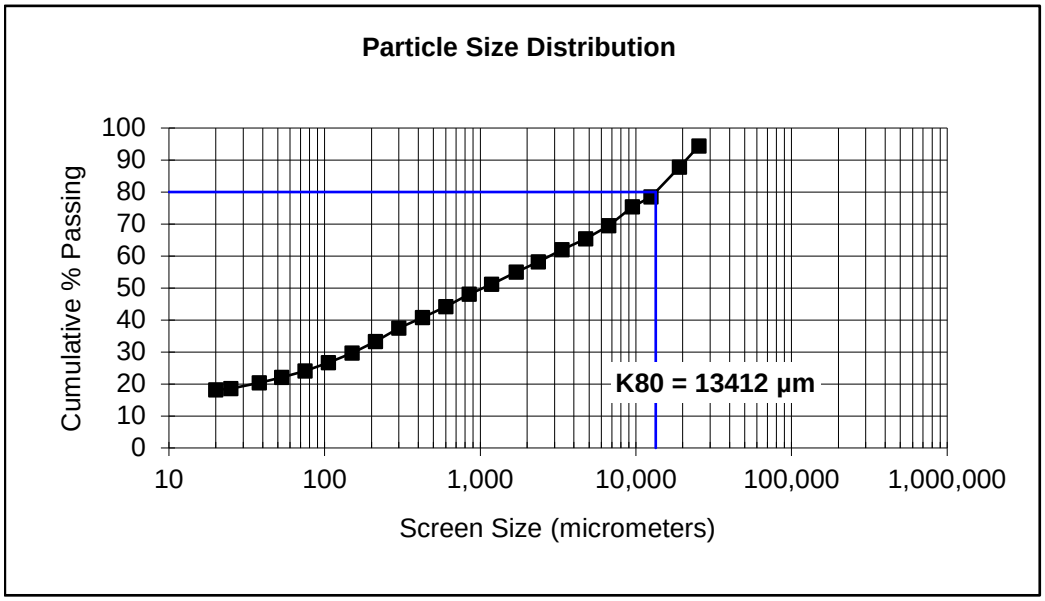
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208459**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	41.9	5.6	5.6	94.4
3/4"	19,000	49.5	6.6	12.2	87.8
1/2"	12,500	69.8	9.3	21.5	78.5
3/8"	9,500	23.8	3.2	24.7	75.3
3	6,700	43.7	5.8	30.5	69.5
4	4,750	31.0	4.1	34.6	65.4
6	3,350	25.5	3.4	38.0	62.0
8	2,360	28.8	3.8	41.9	58.1
10	1,700	24.1	3.2	45.1	54.9
14	1,180	28.5	3.8	48.9	51.1
20	850	23.3	3.1	52.0	48.0
28	600	28.6	3.8	55.8	44.2
35	425	25.8	3.4	59.2	40.8
48	300	24.4	3.3	62.5	37.5
65	212	32.1	4.3	66.8	33.2
100	150	26.4	3.5	70.3	29.7
150	106	22.7	3.0	73.3	26.7
200	75	19.9	2.7	76.0	24.0
270	53	14.9	2.0	78.0	22.0
400	38	12.7	1.7	79.7	20.3
500	25	13.1	1.7	81.4	18.6
635	20	3.3	0.4	81.8	18.2
Pan	-20	136.2	18.2	100.0	0.0
Total	**-**	**750.0**	100.0	**-**	**-**
K80	**13,412**				



Date
Oct. 16, 2015

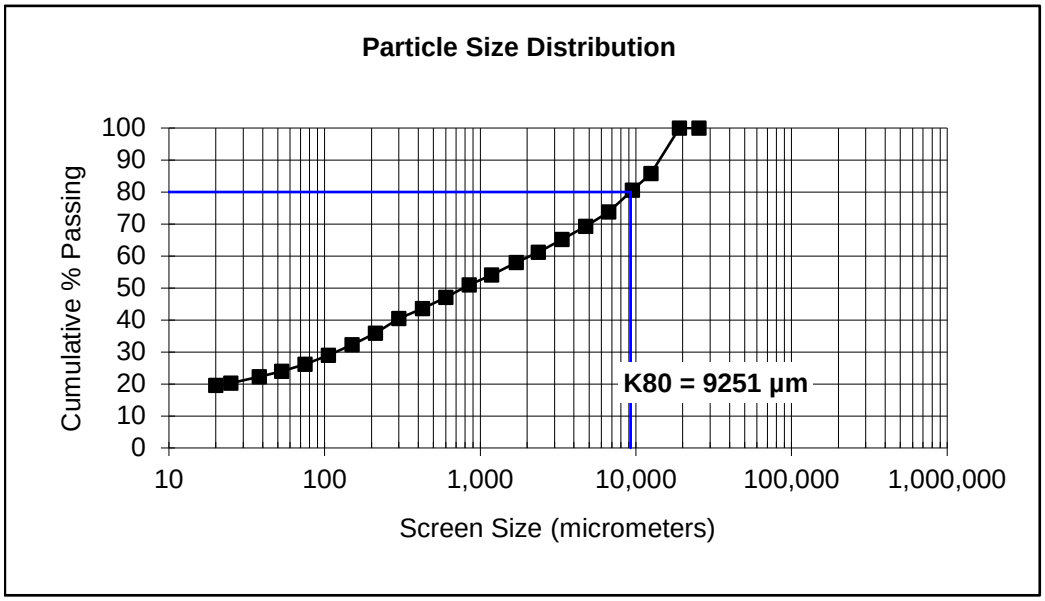
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208460**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	0.0	0.0	0.0	100.0
3/4"	19,000	0.0	0.0	0.0	100.0
1/2"	12,500	71.0	14.2	14.2	85.8
3/8"	9,500	26.3	5.3	19.5	80.5
3	6,700	34.1	6.8	26.3	73.7
4	4,750	22.3	4.5	30.7	69.3
6	3,350	20.7	4.1	34.9	65.1
8	2,360	19.8	4.0	38.8	61.2
10	1,700	15.9	3.2	42.0	58.0
14	1,180	19.6	3.9	45.9	54.1
20	850	15.5	3.1	49.0	51.0
28	600	19.5	3.9	52.9	47.1
35	425	17.3	3.5	56.4	43.6
48	300	15.9	3.2	59.6	40.4
65	212	22.6	4.5	64.1	35.9
100	150	18.4	3.7	67.8	32.2
150	106	16.1	3.2	71.0	29.0
200	75	14.3	2.9	73.9	26.1
270	53	10.8	2.2	76.0	24.0
400	38	8.6	1.7	77.7	22.3
500	25	10.0	2.0	79.7	20.3
635	20	3.3	0.7	80.4	19.6
Pan	-20	98.0	19.6	100.0	0.0
Total	**-**	**500.0**	100.0	**-**	**-**
K80	**9,251**				



Date
Oct. 16, 2015

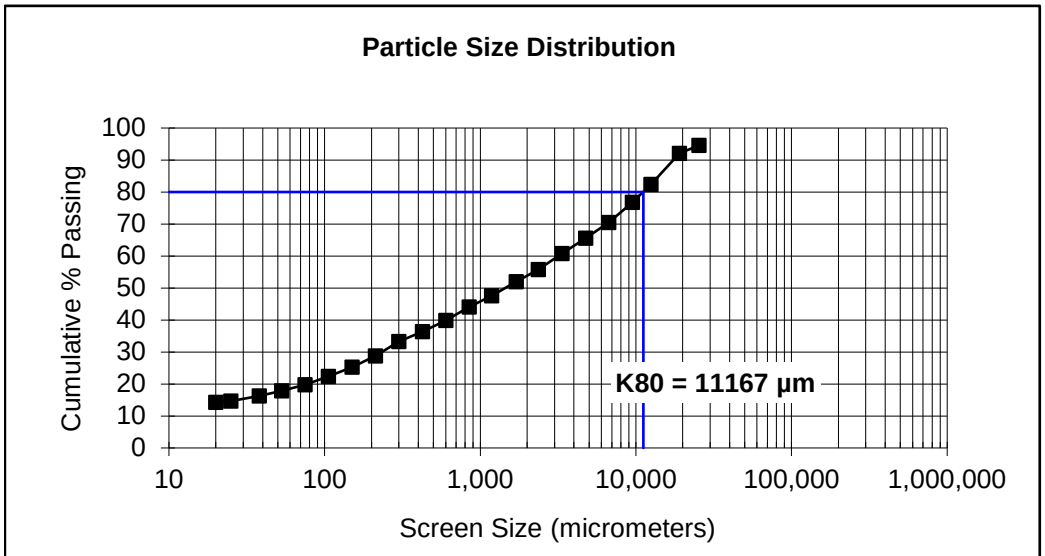
SGS Minerals Services
Size Distribution Analysis

Project No.
1187

Sample:

Test No.: **B00208461**

Size		Weight	% Retained		% Passing
Mesh	µm	grams	Individual	Cumulative	Cumulative
1"	25,400	51.6	5.4	5.4	94.6
3/4"	19,000	24.0	2.5	8.0	92.0
1/2"	12,500	92.3	9.7	17.7	82.3
3/8"	9,500	52.7	5.5	23.2	76.8
3	6,700	59.8	6.3	29.5	70.5
4	4,750	47.1	5.0	34.5	65.5
6	3,350	45.1	4.7	39.2	60.8
8	2,360	47.5	5.0	44.2	55.8
10	1,700	36.2	3.8	48.0	52.0
14	1,180	42.2	4.4	52.5	47.5
20	850	33.4	3.5	56.0	44.0
28	600	39.0	4.1	60.1	39.9
35	425	34.0	3.6	63.7	36.3
48	300	29.5	3.1	66.8	33.2
65	212	42.2	4.4	71.2	28.8
100	150	33.1	3.5	74.7	25.3
150	106	28.2	3.0	77.7	22.3
200	75	24.6	2.6	80.3	19.7
270	53	18.1	1.9	82.2	17.8
400	38	15.3	1.6	83.8	16.2
500	25	15.1	1.6	85.4	14.6
635	20	3.5	0.4	85.7	14.3
Pan	-20	135.5	14.3	100.0	0.0
Total	**-**	**950.0**	100.0	**-**	**-**
K80	**11,167**				



MALVERN INSTRUMENTS

MASTERSIZER 2000

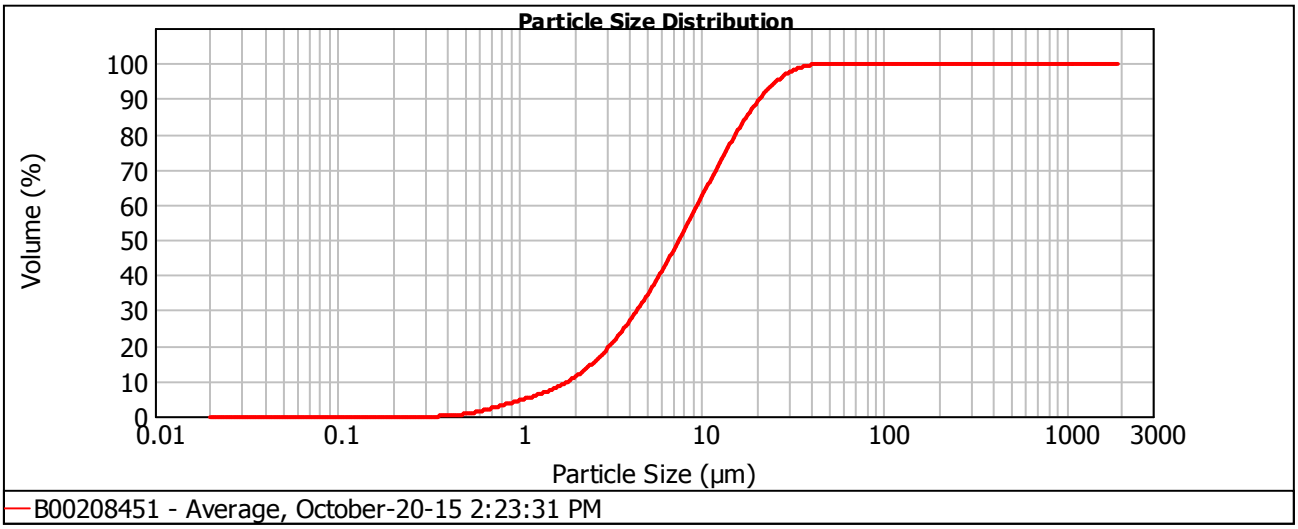
Result Analysis Report

Sample Name: B00208451 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 26.78 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.306 %	**Result Emulation:** Off

Concentration: 0.0185 %Vol	**Span :** 2.521	**Uniformity:** 0.785	**Result units:** Volume
Specific Surface Area: 1.48 m²/g	**Surface Weighted Mean D[3,2]:** 4.047 um	**Vol. Weighted Mean D[4,3]:** 9.732 um	

d(0.1): 1.866 um d(0.5): 7.518 um d (0.8) : 15.383 um d(0.9): 20.819 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.00	11.482	5.78	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.15	13.183	5.47	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.39	15.136	5.01	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.72	17.378	4.39	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.11	19.953	3.67	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.54	22.909	2.87	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	2.99	26.303	2.09	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.44	30.200	1.36	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	3.88	34.674	0.78	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.11	3.802	4.30	39.811	0.35	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.32	4.365	4.70	45.709	0.09	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.52	5.012	5.07	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.67	5.754	5.39	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.77	6.607	5.66	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.84	7.586	5.86	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	0.88	8.710	5.96	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	0.92	10.000	5.94	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

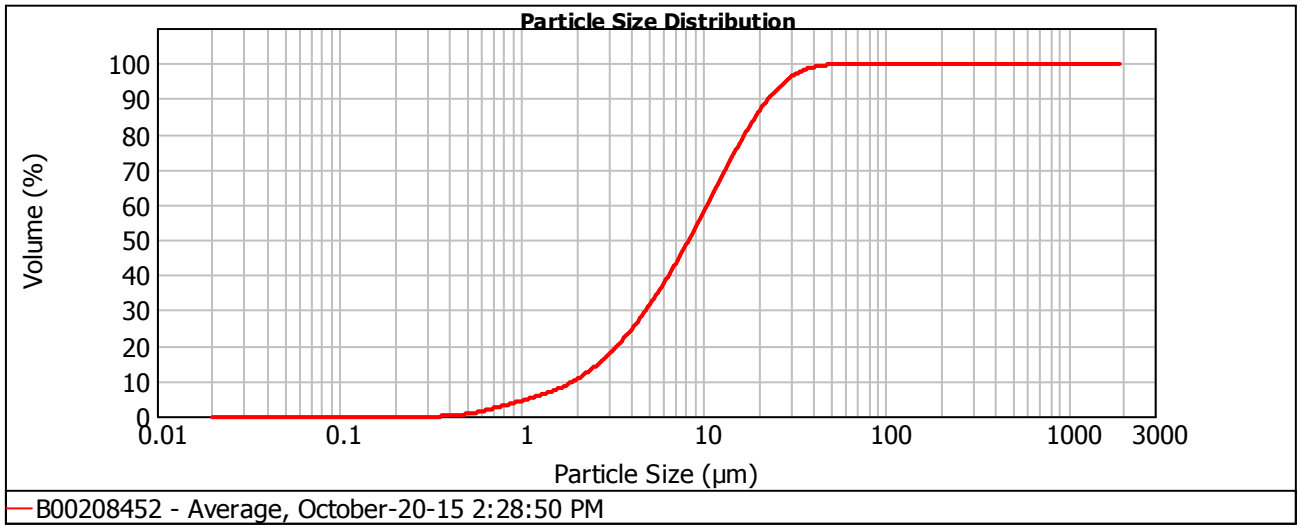
Result Analysis Report

Sample Name: B00208452 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 21.34 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.289 %	**Result Emulation:** Off

Concentration: 0.0151 %Vol	**Span :** 2.500	**Uniformity:** 0.801	**Result units:** Volume
Specific Surface Area: 1.41 m²/g	**Surface Weighted Mean D[3,2]:** 4.247 um	**Vol. Weighted Mean D[4,3]:** 10.786 um	

d(0.1): 1.945 um d(0.5): 8.278 um d (0.8) : 16.798 um d(0.9): 22.637 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	0.94	11.482	6.00	120.226	0.02	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.06	13.183	5.81	138.038	0.02	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.26	15.136	5.43	158.489	0.02	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.54	17.378	4.87	181.970	0.02	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	1.89	19.953	4.16	208.930	0.01	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.27	22.909	3.34	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	2.67	26.303	2.50	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.08	30.200	1.71	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	3.48	34.674	1.05	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.12	3.802	3.89	39.811	0.55	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.33	4.365	4.29	45.709	0.23	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.51	5.012	4.67	52.481	0.09	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.66	5.754	5.05	60.256	0.04	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.76	6.607	5.39	69.183	0.02	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.82	7.586	5.69	79.433	0.01	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	0.85	8.710	5.91	91.201	0.01	954.993	0.00	10000.000	
0.091	0.00	0.955	0.88	10.000	6.02	104.713	0.02	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

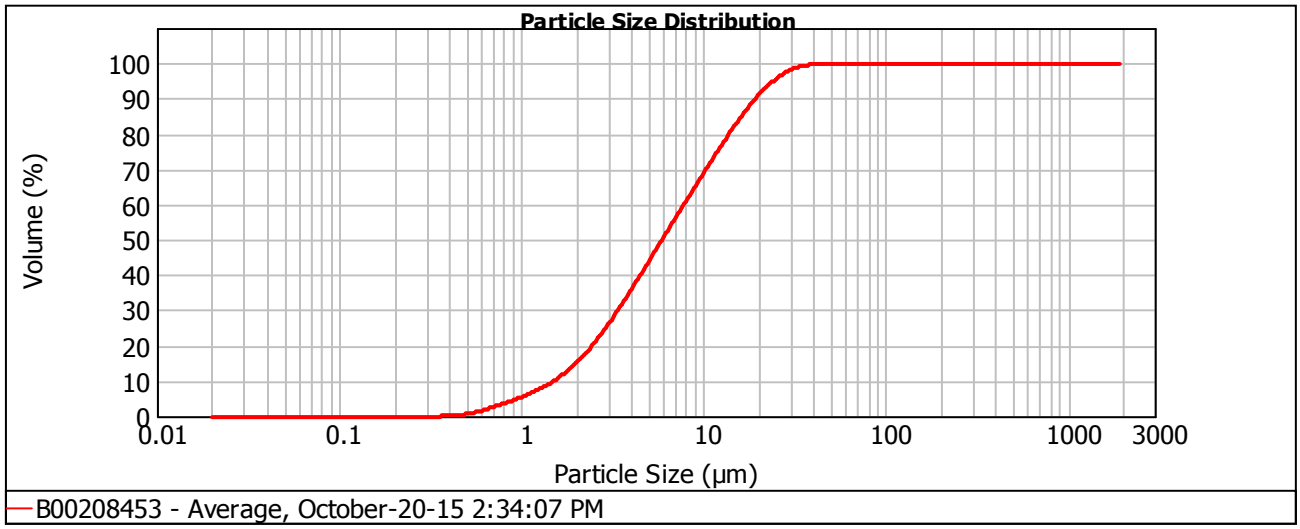
Result Analysis Report

Sample Name: B00208453 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 17.32 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.588 %	**Result Emulation:** Off

Concentration: 0.0094 %Vol	**Span :** 2.992	**Uniformity:** 0.923	**Result units:** Volume
Specific Surface Area: 1.76 m²/g	**Surface Weighted Mean D[3,2]:** 3.404 um	**Vol. Weighted Mean D[4,3]:** 8.444 um	

d(0.1): 1.505 um d(0.5): 5.905 um d (0.8) : 13.754 um d(0.9): 19.172 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.44	11.482	4.74	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.70	13.183	4.53	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.07	15.136	4.19	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.55	17.378	3.71	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.08	19.953	3.09	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.62	22.909	2.39	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.09	26.303	1.68	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.48	30.200	1.04	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.75	34.674	0.55	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.12	3.802	4.92	39.811	0.21	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.35	4.365	5.01	45.709	0.03	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.58	5.012	5.04	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.79	5.754	5.03	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.95	6.607	5.00	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.07	7.586	4.97	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.17	8.710	4.93	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.28	10.000	4.86	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

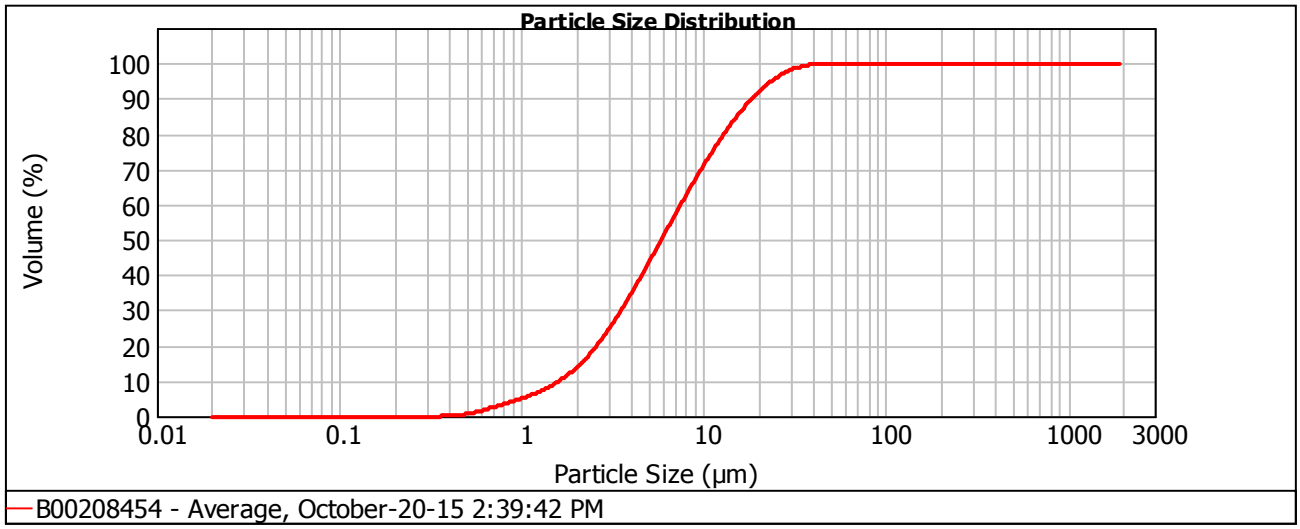
Result Analysis Report

Sample Name: B00208454 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 15.60 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.494 %	**Result Emulation:** Off

Concentration: 0.0086 %Vol	**Span :** 2.864	**Uniformity:** 0.88	**Result units:** Volume
Specific Surface Area: 1.72 m²/g	**Surface Weighted Mean D[3,2]:** 3.489 um	**Vol. Weighted Mean D[4,3]:** 8.225 um	

d(0.1): 1.615 um **d(0.5):** 5.844 um **d (0.8) :** 12.910 um **d(0.9):** 18.355 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.26	11.482	4.59	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.50	13.183	4.21	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.87	15.136	3.77	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.35	17.378	3.26	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.91	19.953	2.69	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.50	22.909	2.09	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.08	26.303	1.51	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.59	30.200	0.98	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.01	34.674	0.55	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.13	3.802	5.33	39.811	0.23	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.36	4.365	5.55	45.709	0.05	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.58	5.012	5.65	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.75	5.754	5.65	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.87	6.607	5.57	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.96	7.586	5.41	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.02	8.710	5.19	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.11	10.000	4.91	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

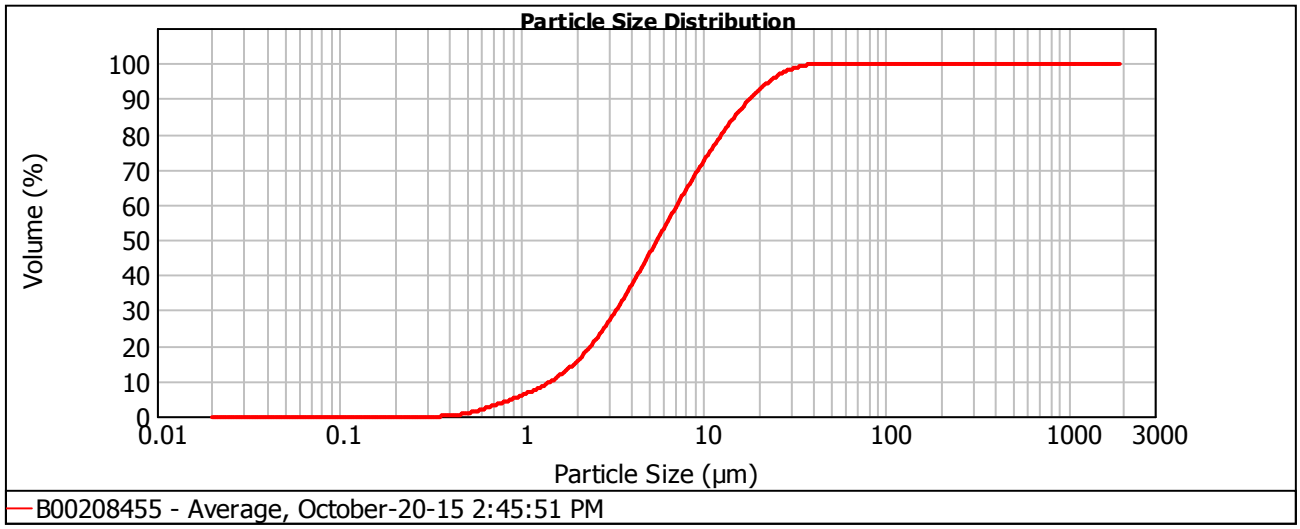
Result Analysis Report

Sample Name: B00208455 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 15.90 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.620 %	**Result Emulation:** Off

Concentration: 0.0083 %Vol	**Span :** 2.969	**Uniformity:** 0.909	**Result units:** Volume
Specific Surface Area: 1.83 m²/g	**Surface Weighted Mean D[3,2]:** 3.272 um	**Vol. Weighted Mean D[4,3]:** 7.942 um	

d(0.1): 1.463 um d(0.5): 5.561 um d (0.8) : 12.561 um d(0.9): 17.975 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.44	11.482	4.41	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.69	13.183	4.05	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.06	15.136	3.63	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.53	17.378	3.14	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.08	19.953	2.60	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.66	22.909	2.01	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.20	26.303	1.44	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.67	30.200	0.92	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.04	34.674	0.50	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.18	3.802	5.31	39.811	0.19	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.43	4.365	5.46	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.66	5.012	5.52	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.85	5.754	5.48	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.00	6.607	5.37	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.10	7.586	5.20	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.19	8.710	4.98	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.29	10.000	4.71	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

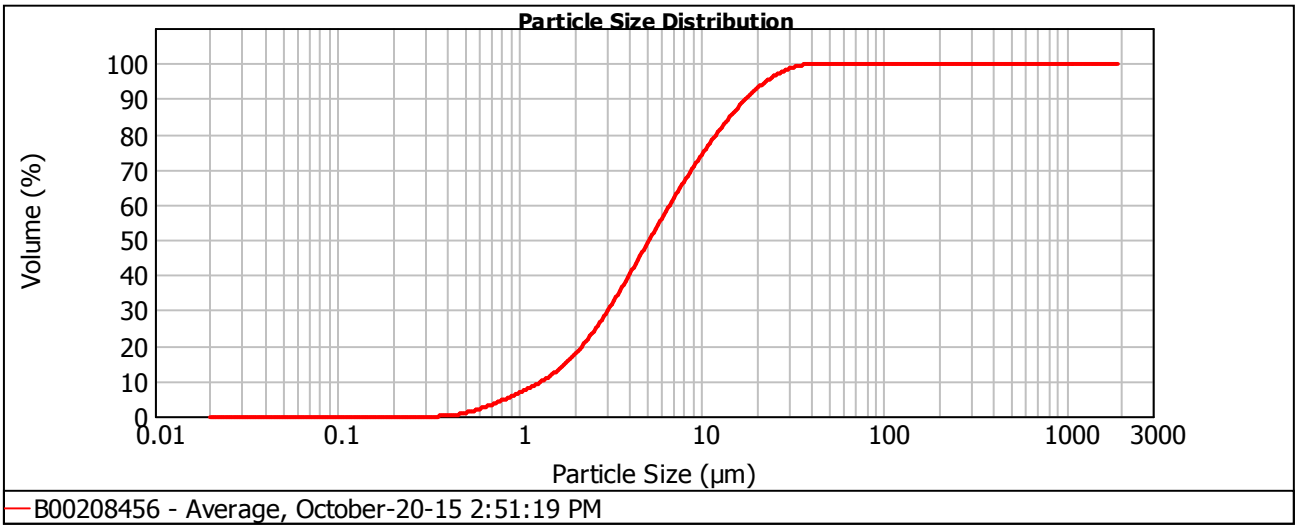
Result Analysis Report

Sample Name: B00208456 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 12.99 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.735 %	**Result Emulation:** Off

Concentration: 0.0063 %Vol	**Span :** 3.143	**Uniformity:** 0.955	**Result units:** Volume
Specific Surface Area: 1.96 m²/g	**Surface Weighted Mean D[3,2]:** 3.065 um	**Vol. Weighted Mean D[4,3]:** 7.603 um	

d(0.1): 1.336 um d(0.5): 5.161 um d (0.8) : 12.071 um d(0.9): 17.557 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.64	11.482	4.10	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.92	13.183	3.78	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.30	15.136	3.41	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.80	17.378	2.97	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.36	19.953	2.47	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.93	22.909	1.92	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.45	26.303	1.38	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.88	30.200	0.87	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.19	34.674	0.46	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.22	3.802	5.37	39.811	0.16	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.48	4.365	5.43	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.73	5.012	5.39	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.95	5.754	5.27	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.12	6.607	5.09	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.24	7.586	4.87	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.35	8.710	4.63	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.47	10.000	4.37	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

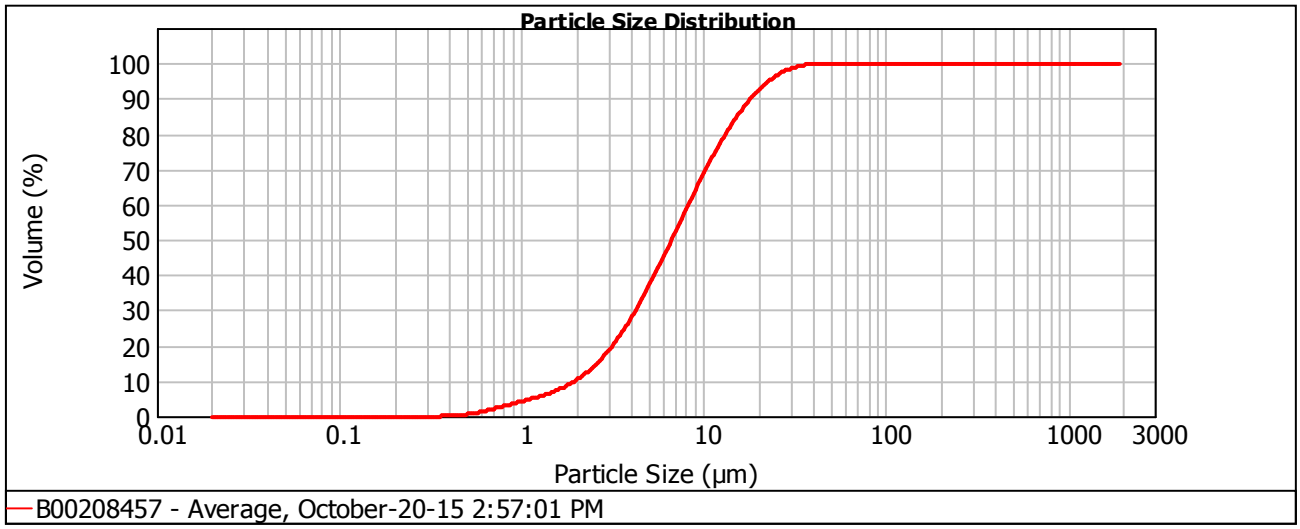
Result Analysis Report

Sample Name: B00208457 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 12.93 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.449 %	**Result Emulation:** Off

Concentration: 0.0080 %Vol	**Span :** 2.411	**Uniformity:** 0.744	**Result units:** Volume
Specific Surface Area: 1.51 m²/g	**Surface Weighted Mean D[3,2]:** 3.986 um	**Vol. Weighted Mean D[4,3]:** 8.606 um	

d(0.1): 1.969 um **d(0.5):** 6.662 um **d (0.8) :** 13.158 um **d(0.9):** 18.033 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	0.91	11.482	5.37	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.04	13.183	4.79	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.27	15.136	4.15	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.62	17.378	3.45	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.08	19.953	2.73	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.63	22.909	2.03	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.26	26.303	1.38	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.92	30.200	0.85	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.00	3.311	4.59	34.674	0.41	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.08	3.802	5.21	39.811	0.15	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.28	4.365	5.75	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.48	5.012	6.17	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.63	5.754	6.44	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.74	6.607	6.54	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.80	7.586	6.47	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	0.83	8.710	6.23	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	0.85	10.000	5.86	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

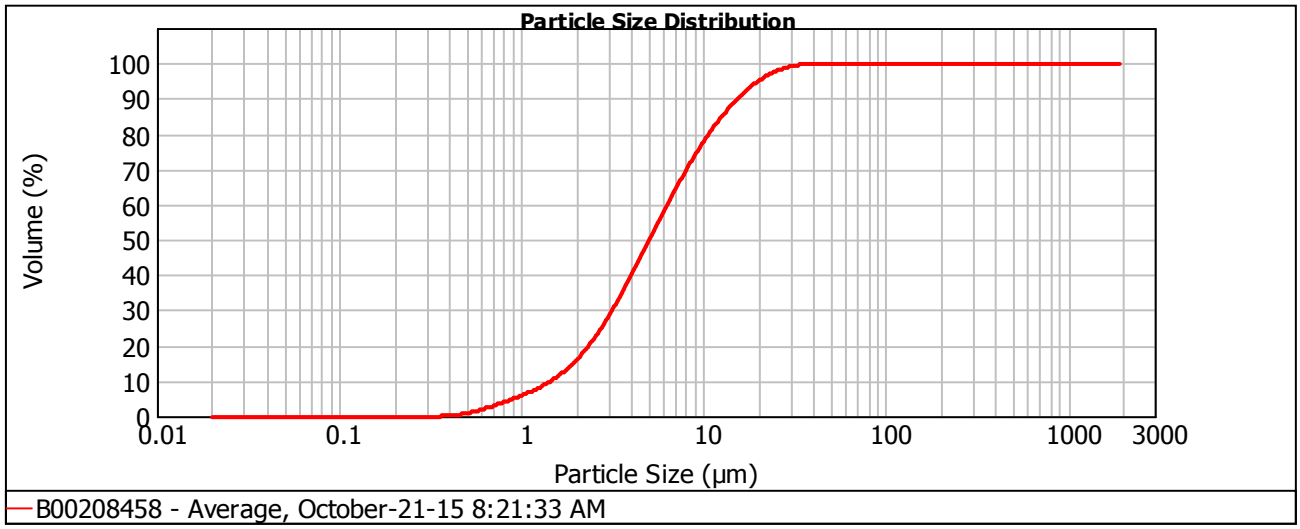
Result Analysis Report

Sample Name: B00208458 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 24.32 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.562 %	**Result Emulation:** Off

Concentration: 0.0127 %Vol	**Span :** 2.758	**Uniformity:** 0.846	**Result units:** Volume
Specific Surface Area: 1.91 m²/g	**Surface Weighted Mean D[3,2]:** 3.137 um	**Vol. Weighted Mean D[4,3]:** 6.989 um	

d(0.1): 1.452 um d(0.5): 5.028 um d (0.8) : 10.643 um d(0.9): 15.317 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.48	11.482	3.93	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.75	13.183	3.42	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.16	15.136	2.91	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.70	17.378	2.38	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.34	19.953	1.87	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	4.01	22.909	1.36	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.66	26.303	0.91	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	5.23	30.200	0.53	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.68	34.674	0.24	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.18	3.802	5.99	39.811	0.07	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.43	4.365	6.14	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.65	5.012	6.13	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.84	5.754	5.98	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.99	6.607	5.71	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.10	7.586	5.34	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.19	8.710	4.91	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.30	10.000	4.43	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

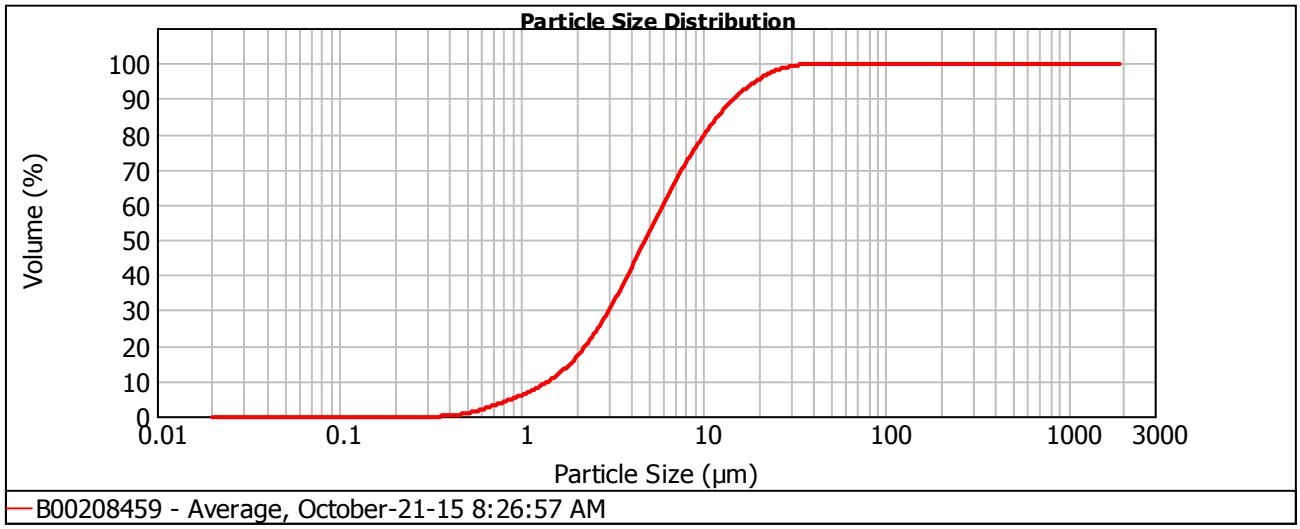
Result Analysis Report

Sample Name: B00208459 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 15.21 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.726 %	**Result Emulation:** Off

Concentration: 0.0073 %Vol	**Span :** 2.775	**Uniformity:** 0.855	**Result units:** Volume
Specific Surface Area: 1.97 m²/g	**Surface Weighted Mean D[3,2]:** 3.046 um	**Vol. Weighted Mean D[4,3]:** 6.697 um	

d(0.1): 1.414 um d(0.5): 4.777 um d (0.8) : 10.082 um d(0.9): 14.670 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.56	11.482	3.64	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.87	13.183	3.13	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.31	15.136	2.64	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.89	17.378	2.16	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.57	19.953	1.69	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	4.27	22.909	1.24	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.93	26.303	0.83	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	5.50	30.200	0.49	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.93	34.674	0.22	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.17	3.802	6.19	39.811	0.06	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.42	4.365	6.27	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.66	5.012	6.19	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.86	5.754	5.95	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.02	6.607	5.60	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.14	7.586	5.16	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.24	8.710	4.67	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.37	10.000	4.15	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

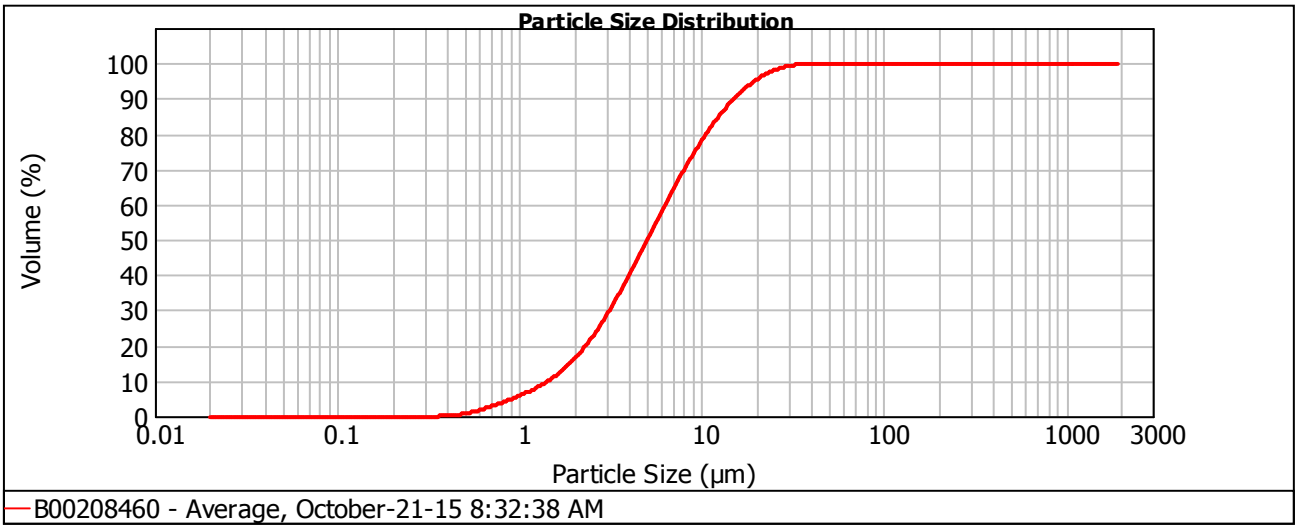
Result Analysis Report

Sample Name: B00208460 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 9.16 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.786 %	**Result Emulation:** Off

Concentration: 0.0044 %Vol	**Span :** 2.715	**Uniformity:** 0.835	**Result units:** Volume
Specific Surface Area: 1.92 m²/g	**Surface Weighted Mean D[3,2]:** 3.132 um	**Vol. Weighted Mean D[4,3]:** 6.901 um	

d(0.1): 1.441 um d(0.5): 5.012 um d (0.8) : 10.554 um d(0.9): 15.047 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.52	11.482	3.99	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.81	13.183	3.45	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.22	15.136	2.90	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.76	17.378	2.35	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.39	19.953	1.80	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	4.04	22.909	1.29	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.67	26.303	0.83	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	5.21	30.200	0.47	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.64	34.674	0.18	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.15	3.802	5.94	39.811	0.04	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.40	4.365	6.09	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.64	5.012	6.10	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.84	5.754	5.97	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.00	6.607	5.74	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.12	7.586	5.40	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.22	8.710	4.98	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.34	10.000	4.50	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

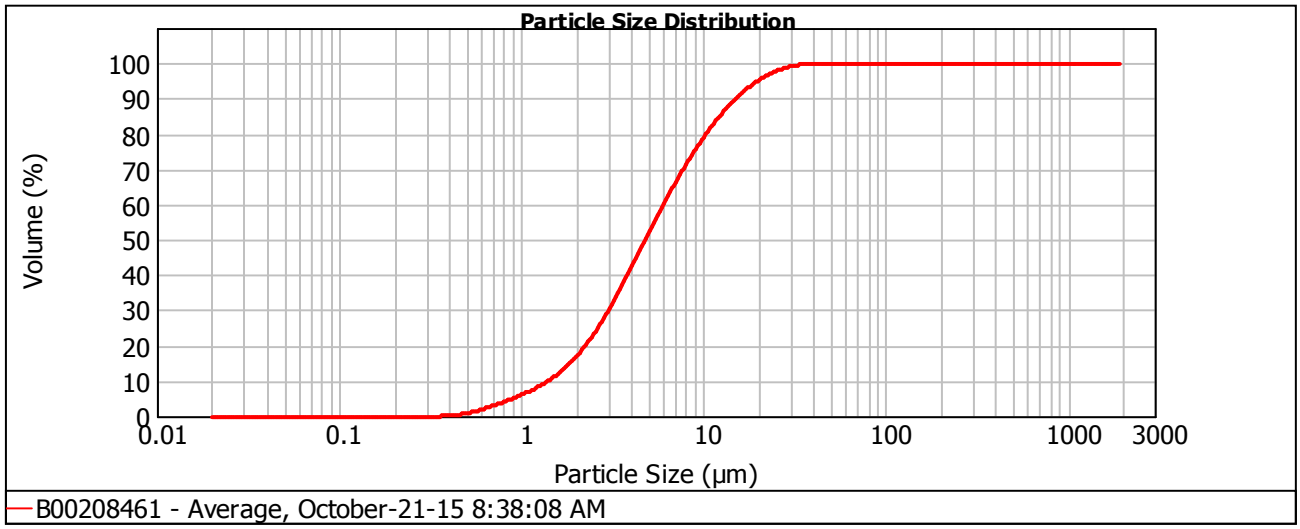
Result Analysis Report

Sample Name: B00208461 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type:	**Measured by:** Shengmei_Yang2	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 17.27 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.696 %	**Result Emulation:** Off

Concentration: 0.0084 %Vol	**Span :** 2.842	**Uniformity:** 0.871	**Result units:** Volume
Specific Surface Area: 1.97 m²/g	**Surface Weighted Mean D[3,2]:** 3.039 um	**Vol. Weighted Mean D[4,3]:** 6.774 um	

d(0.1): 1.404 um d(0.5): 4.785 um d (0.8) : 10.279 um d(0.9): 15.001 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.57	11.482	3.69	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.88	13.183	3.22	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.33	15.136	2.75	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.91	17.378	2.27	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.58	19.953	1.79	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	4.28	22.909	1.31	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.93	26.303	0.88	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	5.47	30.200	0.52	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.87	34.674	0.23	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.18	3.802	6.10	39.811	0.06	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.43	4.365	6.16	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.67	5.012	6.06	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.87	5.754	5.83	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.03	6.607	5.49	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.15	7.586	5.07	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.25	8.710	4.62	91.201	0.00	954.993	0.00	10000.000	
0.091	0.00	0.955	1.38	10.000	4.15	104.713	0.00	1096.478	0.00		
0.105		1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208462 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
14.03 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.657 %

Result Emulation:
Off

Concentration:
0.0069 %Vol

Span :
2.973

Uniformity:
0.908

Result units:
Volume

Specific Surface Area:
1.95 m²/g

Surface Weighted Mean D[3,2]:
3.083 um

Vol. Weighted Mean D[4,3]:
7.430 um

d(0.1): 1.369 um **d(0.5):** 5.169 um **d (0.8) :** 11.376 um **d(0.9):** 16.735 um

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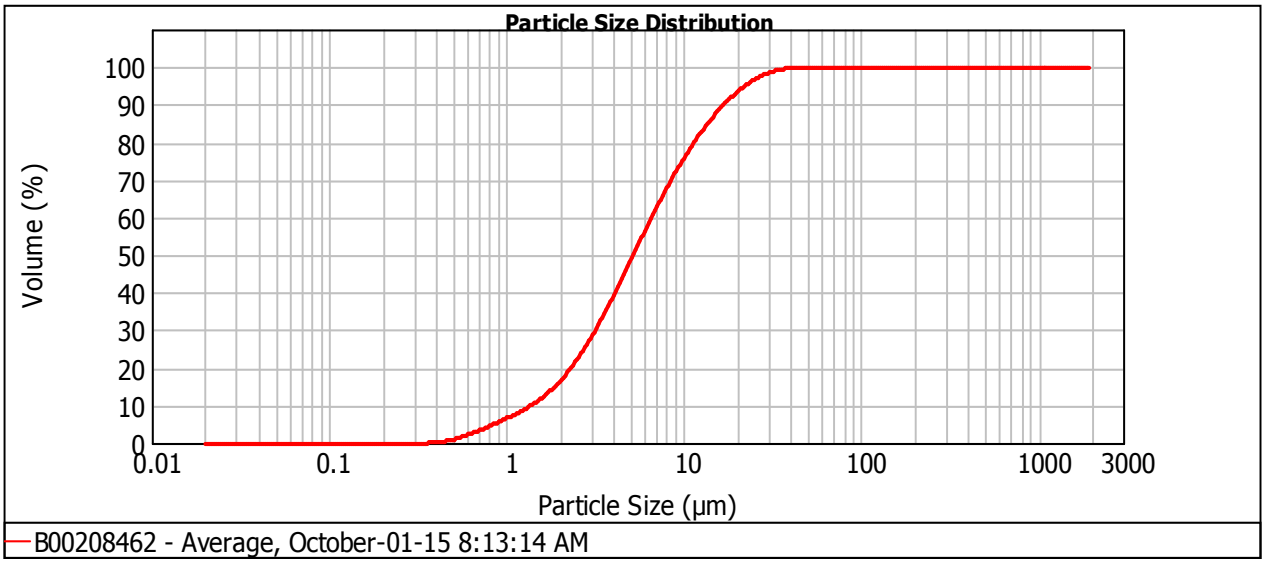

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.51	11.482	3.94	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.74	13.183	3.50	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.10	15.136	3.07	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.59	17.378	2.62	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.17	19.953	2.16	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.79	22.909	1.69	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.40	26.303	1.23	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.94	30.200	0.81	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.39	34.674	0.46	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.26	3.802	5.71	39.811	0.19	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.52	4.365	5.88	45.709	0.04	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.76	5.012	5.90	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.96	5.754	5.78	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.11	6.607	5.54	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.21	7.586	5.20	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.28	8.710	4.81	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.37	10.000	4.38	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208463 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
16.98 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.707 %

Result Emulation:
Off

Concentration:
0.0083 %Vol

Span :
2.873

Uniformity:
0.882

Result units:
Volume

Specific Surface Area:
2.01 m²/g

Surface Weighted Mean D[3,2]:
2.978 um

Vol. Weighted Mean D[4,3]:
7.025 um

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d(0.1): 1.306 um **d(0.5):** 4.976 um **d (0.8) :** 10.718 um **d(0.9):** 15.603 um

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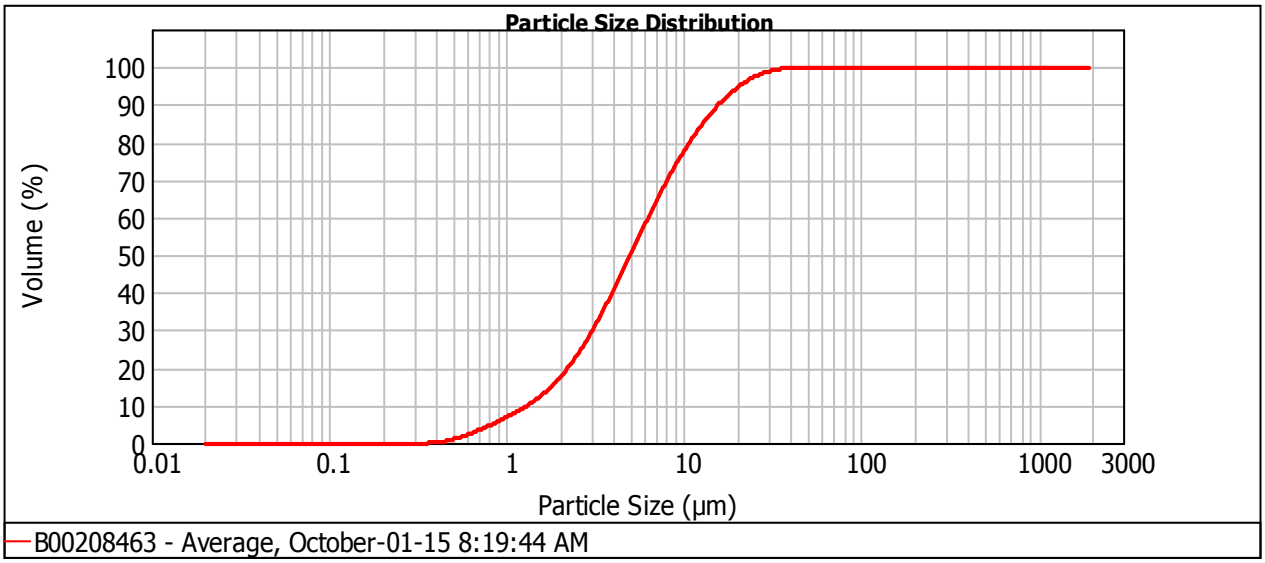

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.63	11.482	3.86	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.88	13.183	3.36	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.24	15.136	2.87	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.73	17.378	2.38	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.30	19.953	1.90	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.91	22.909	1.44	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.50	26.303	1.00	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	5.03	30.200	0.63	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.47	34.674	0.32	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.27	3.802	5.77	39.811	0.13	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.54	4.365	5.94	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.79	5.012	5.96	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	1.00	5.754	5.84	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.17	6.607	5.59	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.28	7.586	5.24	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.38	8.710	4.82	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.48	10.000	4.34	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208464 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
12.87 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.586 %

Result Emulation:
Off

Concentration:
0.0067 %Vol

Span :
3.078

Uniformity:
0.953

Result units:
Volume

Specific Surface Area:
1.87 m²/g

Surface Weighted Mean D[3,2]:
3.201 um

Vol. Weighted Mean D[4,3]:
8.867 um

d(0.1): 1.310 um **d(0.5):** 6.193 um **d (0.8) :** 14.537 um **d(0.9):** 20.374 um

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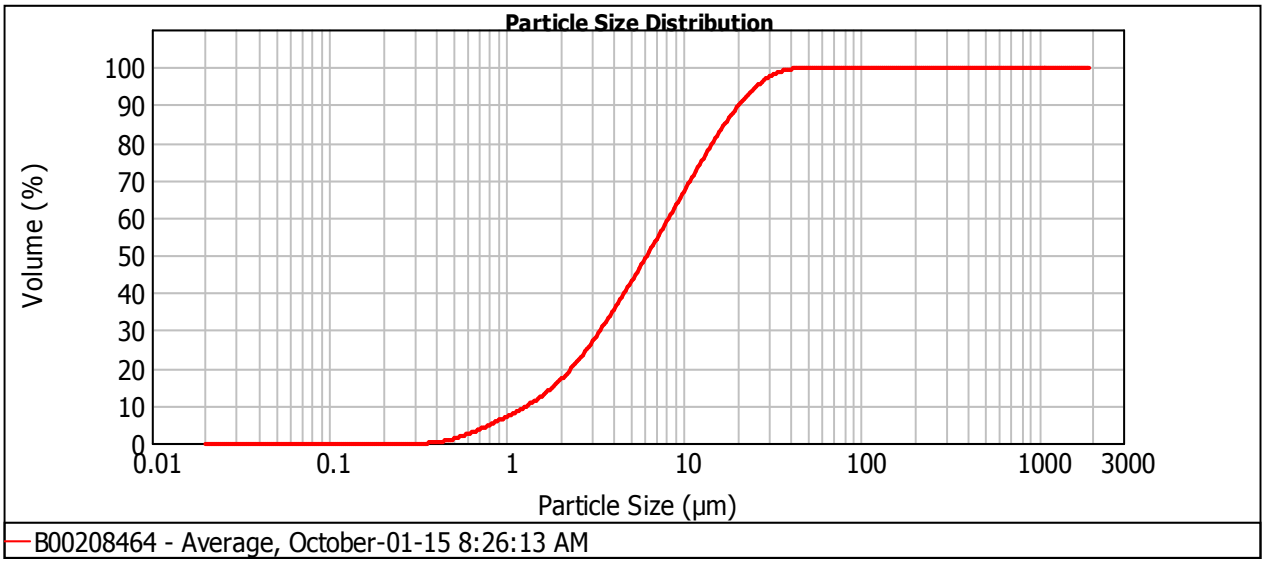

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.54	11.482	4.80	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.73	13.183	4.60	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.03	15.136	4.29	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.41	17.378	3.85	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.84	19.953	3.30	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.27	22.909	2.65	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.65	26.303	1.98	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.98	30.200	1.33	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.24	34.674	0.79	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.28	3.802	4.45	39.811	0.37	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.57	4.365	4.60	45.709	0.11	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.83	5.012	4.72	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	1.05	5.754	4.81	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.19	6.607	4.88	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.29	7.586	4.93	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.35	8.710	4.94	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.42	10.000	4.90	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208465 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
15.19 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.556 %

Result Emulation:
Off

Concentration:
0.0078 %Vol

Span :
3.008

Uniformity:
0.92

Result units:
Volume

Specific Surface Area:
1.95 m²/g

Surface Weighted Mean D[3,2]:
3.071 um

Vol. Weighted Mean D[4,3]:
8.161 um

d(0.1): 1.253 um d(0.5): 5.765 um d (0.8) : 13.136 um d(0.9): 18.594 um

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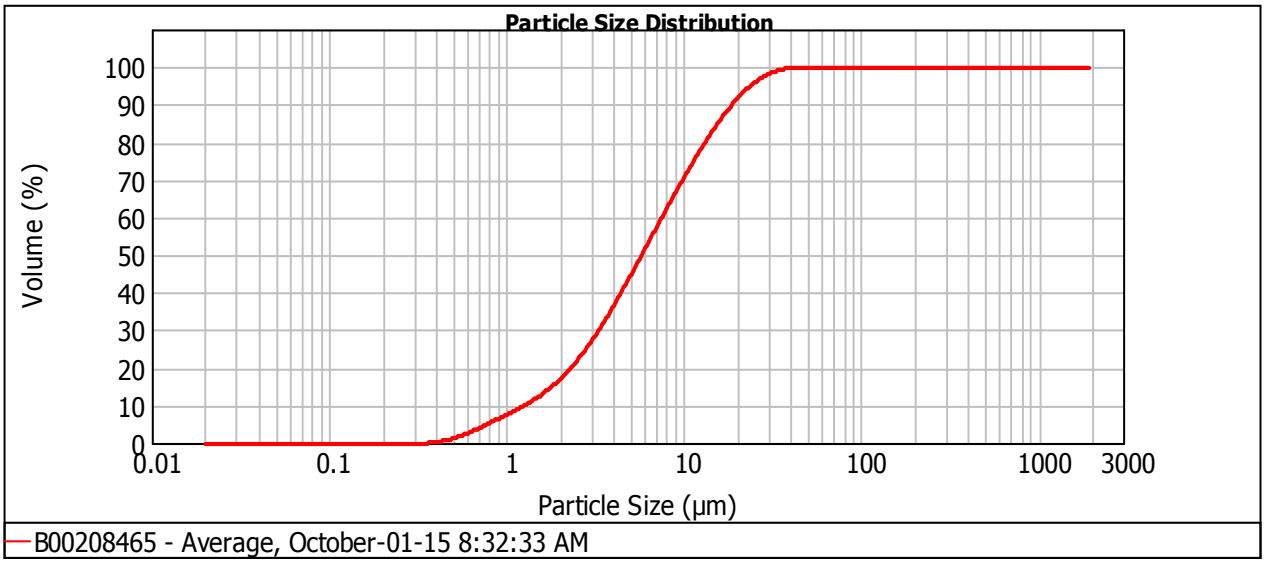


Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.52	11.482	4.60	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.69	13.183	4.28	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.96	15.136	3.88	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.33	17.378	3.39	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.79	19.953	2.82	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.28	22.909	2.19	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.77	26.303	1.57	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.21	30.200	1.00	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.60	34.674	0.54	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.34	3.802	4.90	39.811	0.21	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.64	4.365	5.11	45.709	0.01	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.91	5.012	5.24	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	1.13	5.754	5.29	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.28	6.607	5.26	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.36	7.586	5.17	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.40	8.710	5.03	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.44	10.000	4.84	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

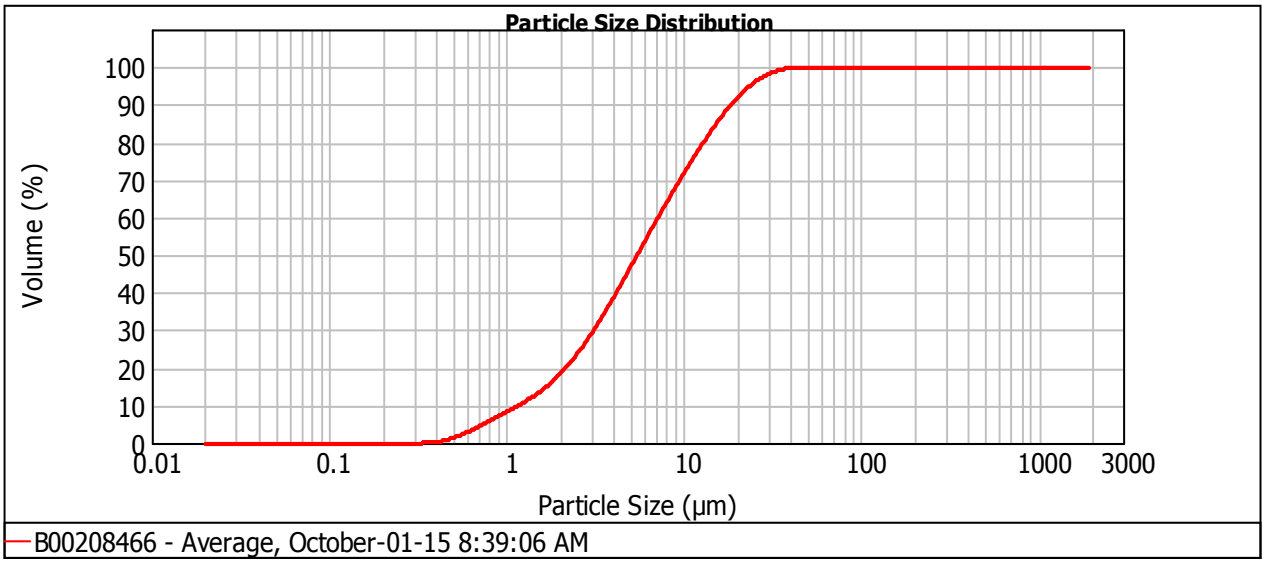
Result Analysis Report

Sample Name: B00208466 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 12.64 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.653 %	**Result Emulation:** Off

Concentration: 0.0061 %Vol	**Span :** 3.165	**Uniformity:** 0.964	**Result units:** Volume
Specific Surface Area: 2.06 m²/g	**Surface Weighted Mean D[3,2]:** 2.918 um	**Vol. Weighted Mean D[4,3]:** 7.920 um	

d(0.1): 1.169 um d(0.5): 5.438 um d (0.8) : 12.849 um d(0.9): 18.383 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.65	11.482	4.36	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.83	13.183	4.08	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.12	15.136	3.73	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.53	17.378	3.29	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.00	19.953	2.75	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.50	22.909	2.15	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.97	26.303	1.54	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.39	30.200	0.97	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.03	3.311	4.71	34.674	0.51	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.39	3.802	4.94	39.811	0.18	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.71	4.365	5.08	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.99	5.012	5.12	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	1.23	5.754	5.10	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.38	6.607	5.02	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.46	7.586	4.90	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.51	8.710	4.75	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.56	10.000	4.57	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

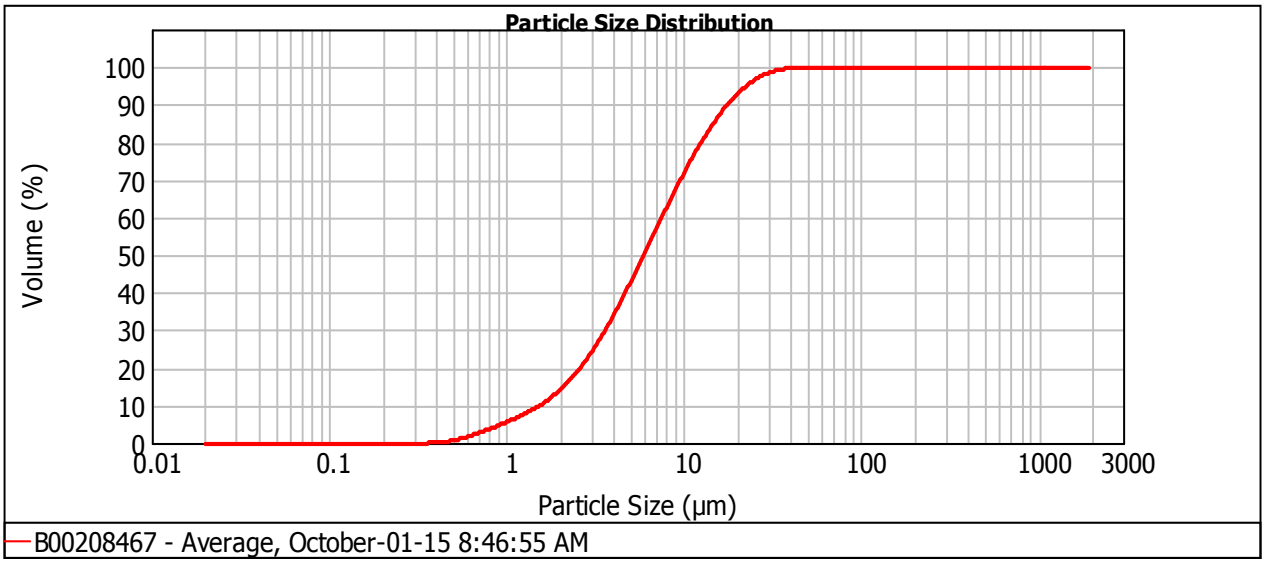
Result Analysis Report

Sample Name: B00208467 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 14.00 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.542 %	**Result Emulation:** Off

Concentration: 0.0076 %Vol	**Span :** 2.699	**Uniformity:** 0.833	**Result units:** Volume
Specific Surface Area: 1.75 m²/g	**Surface Weighted Mean D[3,2]:** 3.421 um	**Vol. Weighted Mean D[4,3]:** 8.042 um	

d(0.1): 1.540 um d(0.5): 5.924 um d (0.8) : 12.467 um d(0.9): 17.530 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.31	11.482	4.75	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.51	13.183	4.24	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.80	15.136	3.68	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.21	17.378	3.08	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.69	19.953	2.47	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.23	22.909	1.86	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.79	26.303	1.31	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.33	30.200	0.82	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.82	34.674	0.45	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.14	3.802	5.25	39.811	0.18	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.40	4.365	5.59	45.709	0.04	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.64	5.012	5.82	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.83	5.754	5.93	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.98	6.607	5.92	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.07	7.586	5.79	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.13	8.710	5.54	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.20	10.000	5.18	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208468 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
15.84 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.325 %

Result Emulation:
Off

Concentration:
0.0109 %Vol

Span :
2.375

Uniformity:
0.74

Result units:
Volume

Specific Surface Area:
1.41 m²/g

Surface Weighted Mean D[3,2]:
4.253 um

Vol. Weighted Mean D[4,3]:
10.469 um

d(0.1): 1.936 um **d(0.5):** 8.433 um **d (0.8) :** 16.646 um **d(0.9):** 21.966 um

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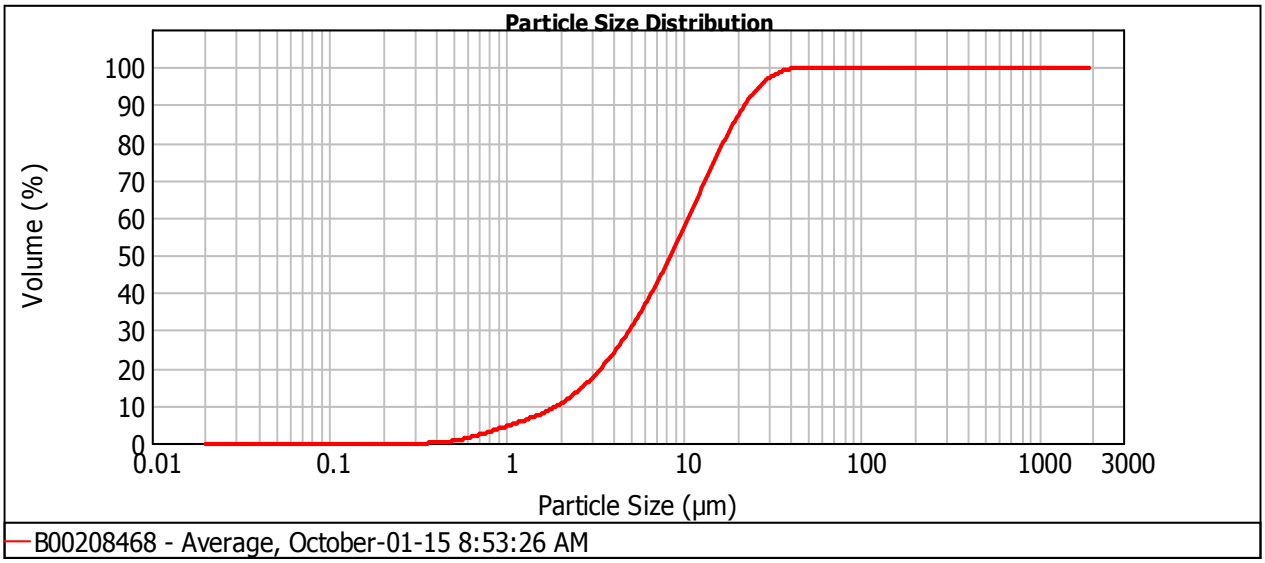


Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	0.95	11.482	6.26	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.06	13.183	6.11	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.24	15.136	5.74	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.49	17.378	5.14	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	1.81	19.953	4.35	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.16	22.909	3.43	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	2.55	26.303	2.47	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	2.95	30.200	1.59	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	3.35	34.674	0.87	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.11	3.802	3.77	39.811	0.35	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.33	4.365	4.19	45.709	0.06	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.52	5.012	4.60	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.68	5.754	5.02	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.79	6.607	5.41	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.85	7.586	5.76	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	0.88	8.710	6.04	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	0.90	10.000	6.22	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

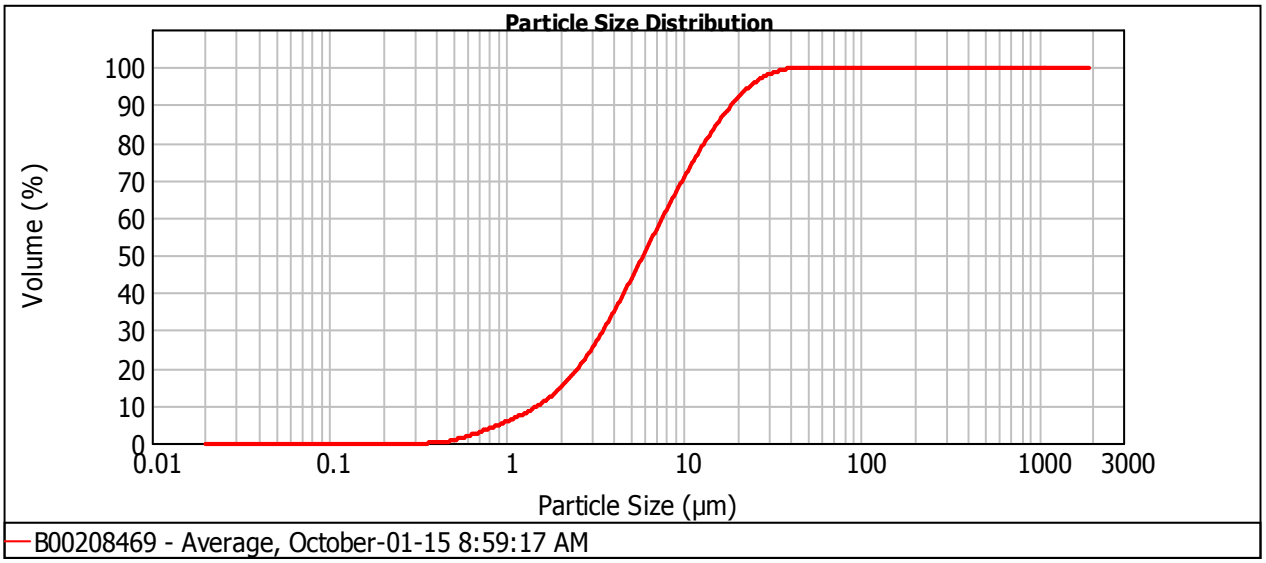
Result Analysis Report

Sample Name: B00208469 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 13.10 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.514 %	**Result Emulation:** Off

Concentration: 0.0070 %Vol	**Span :** 2.888	**Uniformity:** 0.885	**Result units:** Volume
Specific Surface Area: 1.77 m²/g	**Surface Weighted Mean D[3,2]:** 3.381 um	**Vol. Weighted Mean D[4,3]:** 8.274 um	

d(0.1): 1.507 um d(0.5): 5.898 um d (0.8) : 13.058 um d(0.9): 18.537 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.35	11.482	4.64	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.56	13.183	4.26	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.88	15.136	3.82	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.31	17.378	3.31	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.82	19.953	2.75	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.36	22.909	2.14	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.89	26.303	1.55	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.39	30.200	1.01	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.81	34.674	0.57	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.17	3.802	5.15	39.811	0.24	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.42	4.365	5.39	45.709	0.05	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.66	5.012	5.53	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.85	5.754	5.58	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.99	6.607	5.53	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.08	7.586	5.40	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.15	8.710	5.21	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.22	10.000	4.95	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

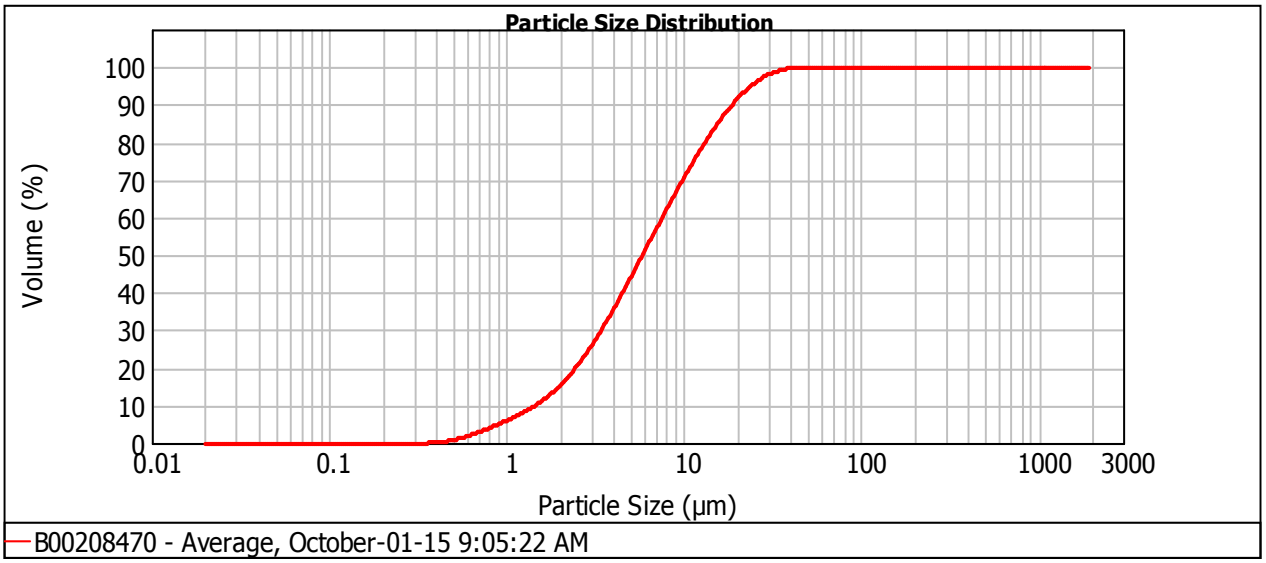
Result Analysis Report

Sample Name: B00208470 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 12.39 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.542 %	**Result Emulation:** Off

Concentration: 0.0065 %Vol	**Span :** 2.953	**Uniformity:** 0.906	**Result units:** Volume
Specific Surface Area: 1.81 m²/g	**Surface Weighted Mean D[3,2]:** 3.316 um	**Vol. Weighted Mean D[4,3]:** 8.264 um	

d(0.1): 1.456 um d(0.5): 5.828 um d (0.8) : 13.138 um d(0.9): 18.666 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.42	11.482	4.60	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.64	13.183	4.25	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.97	15.136	3.84	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.41	17.378	3.35	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.91	19.953	2.79	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.44	22.909	2.18	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.95	26.303	1.58	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.40	30.200	1.03	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.78	34.674	0.58	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.18	3.802	5.08	39.811	0.24	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.44	4.365	5.28	45.709	0.05	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.69	5.012	5.39	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.88	5.754	5.42	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.03	6.607	5.37	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.13	7.586	5.26	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.20	8.710	5.09	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.29	10.000	4.87	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

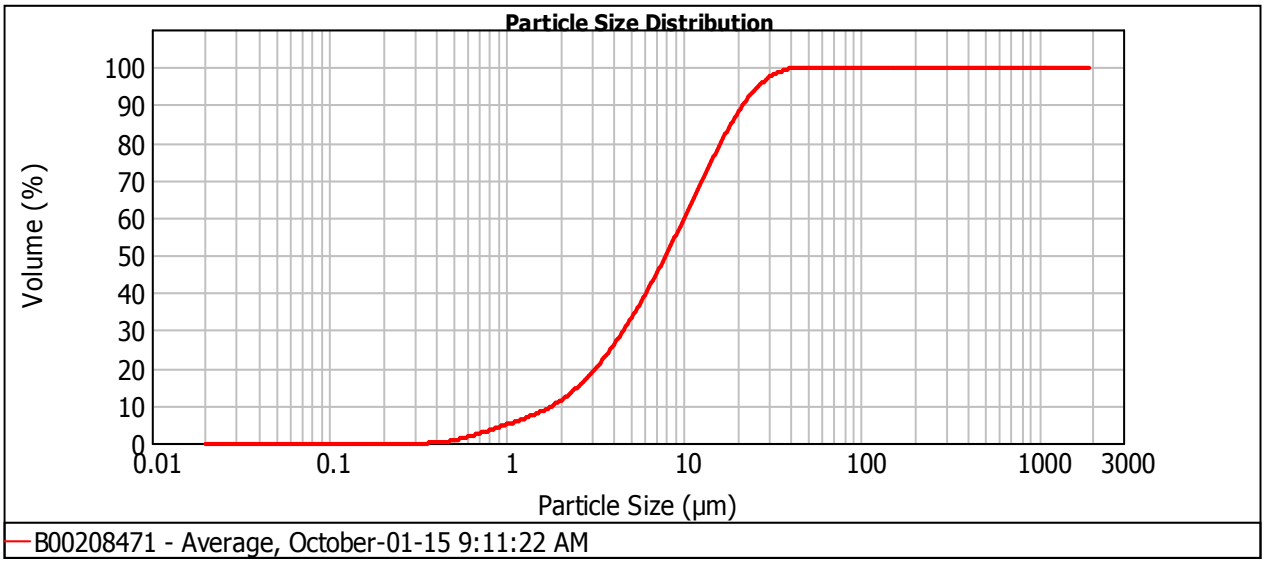
Result Analysis Report

Sample Name: B00208471 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 14.28 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.316 %	**Result Emulation:** Off

Concentration: 0.0092 %Vol	**Span :** 2.491	**Uniformity:** 0.774	**Result units:** Volume
Specific Surface Area: 1.5 m²/g	**Surface Weighted Mean D[3,2]:** 4.011 um	**Vol. Weighted Mean D[4,3]:** 10.073 um	

d(0.1): 1.817 um d(0.5): 7.908 um d (0.8) : 16.147 um d(0.9): 21.516 um



Size (µm)	Volume In %
0.010	0.00
0.011	0.00
0.013	0.00
0.015	0.00
0.017	0.00
0.020	0.00
0.023	0.00
0.026	0.00
0.030	0.00
0.035	0.00
0.040	0.00
0.046	0.00
0.052	0.00
0.060	0.00
0.069	0.00
0.079	0.00
0.091	0.00
0.105	0.00

Size (µm)	Volume In %
0.105	0.00
0.120	0.00
0.138	0.00
0.158	0.00
0.182	0.00
0.209	0.00
0.240	0.00
0.275	0.00
0.316	0.01
0.363	0.16
0.417	0.39
0.479	0.60
0.550	0.75
0.631	0.86
0.724	0.91
0.832	0.93
0.955	0.95
1.096	

Size (µm)	Volume In %
1.096	1.00
1.259	1.11
1.445	1.31
1.660	1.60
1.905	1.95
2.188	2.36
2.512	2.79
2.884	3.22
3.311	3.65
3.802	4.05
4.365	4.43
5.012	4.78
5.754	5.11
6.607	5.39
7.586	5.64
8.710	5.83
10.000	5.93
11.482	

Size (µm)	Volume In %
11.482	5.93
13.183	5.76
15.136	5.41
17.378	4.84
19.953	4.10
22.909	3.23
26.303	2.33
30.200	1.50
34.674	0.82
39.811	0.32
45.709	0.04
52.481	0.00
60.256	0.00
69.183	0.00
79.433	0.00
91.201	0.00
104.713	0.00
120.226	

Size (µm)	Volume In %
120.226	0.00
138.038	0.00
158.489	0.00
181.970	0.00
208.930	0.00
239.883	0.00
275.423	0.00
316.228	0.00
363.078	0.00
416.869	0.00
478.630	0.00
549.541	0.00
630.957	0.00
724.436	0.00
831.764	0.00
954.993	0.00
1096.478	0.00
1258.925	

Size (µm)	Volume In %
1258.925	0.00
1445.440	0.00
1659.587	0.00
1905.461	0.00
2187.762	0.00
2511.886	0.00
2884.032	0.00
3311.311	0.00
3801.894	0.00
4365.158	0.00
5011.872	0.00
5754.399	0.00
6606.934	0.00
7585.776	0.00
8709.636	0.00
10000.000	

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208472 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
13.59 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.450 %

Result Emulation:
Off

Concentration:
0.0077 %Vol

Span :
2.757

Uniformity:
0.853

Result units:
Volume

Specific Surface Area:
1.68 m²/g

Surface Weighted Mean D[3,2]:
3.573 um

Vol. Weighted Mean D[4,3]:
8.565 um

d(0.1): 1.638 um **d(0.5):** 6.251 um **d (0.8) :** 13.511 um **d(0.9):** 18.872 um

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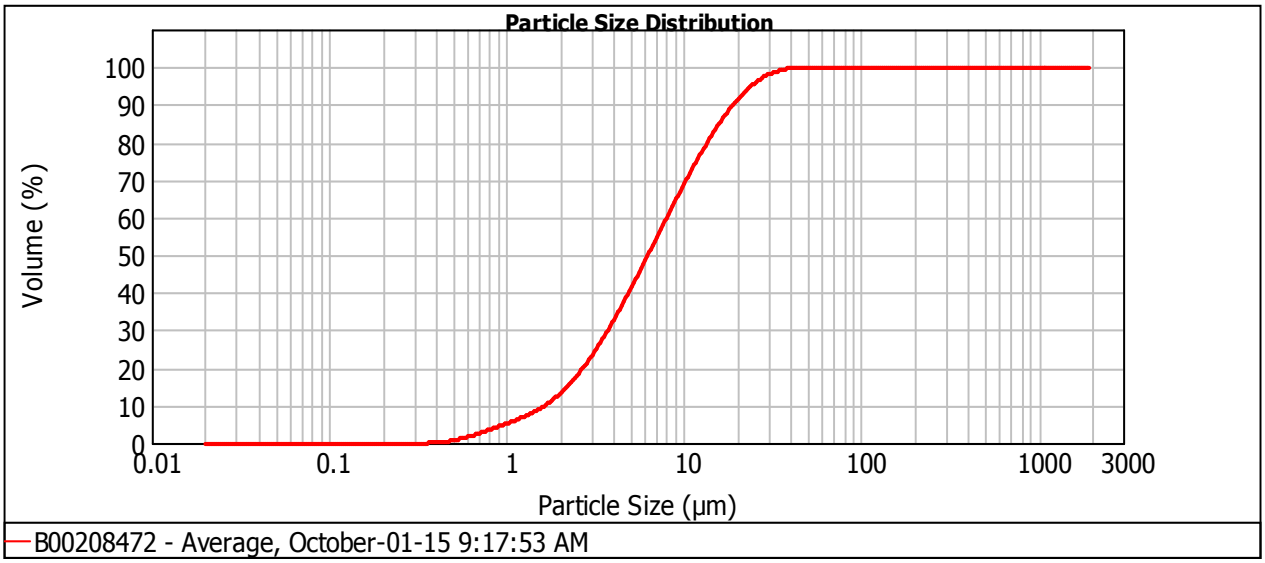

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.20	11.482	4.95	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.40	13.183	4.57	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.72	15.136	4.10	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.14	17.378	3.53	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.65	19.953	2.90	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.19	22.909	2.24	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.73	26.303	1.60	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.23	30.200	1.03	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.67	34.674	0.58	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.15	3.802	5.03	39.811	0.24	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.39	4.365	5.31	45.709	0.05	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.60	5.012	5.51	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.77	5.754	5.62	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.89	6.607	5.64	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.96	7.586	5.59	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.02	8.710	5.46	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.08	10.000	5.25	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208473 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
12.68 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.379 %

Result Emulation:
Off

Concentration:
0.0078 %Vol

Span :
2.569

Uniformity:
0.795

Result units:
Volume

Specific Surface Area:
1.51 m²/g

Surface Weighted Mean D[3,2]:
3.962 um

Vol. Weighted Mean D[4,3]:
9.200 um

d(0.1): 1.876 um **d(0.5):** 6.972 um **d (0.8) :** 14.451 um **d(0.9):** 19.791 um

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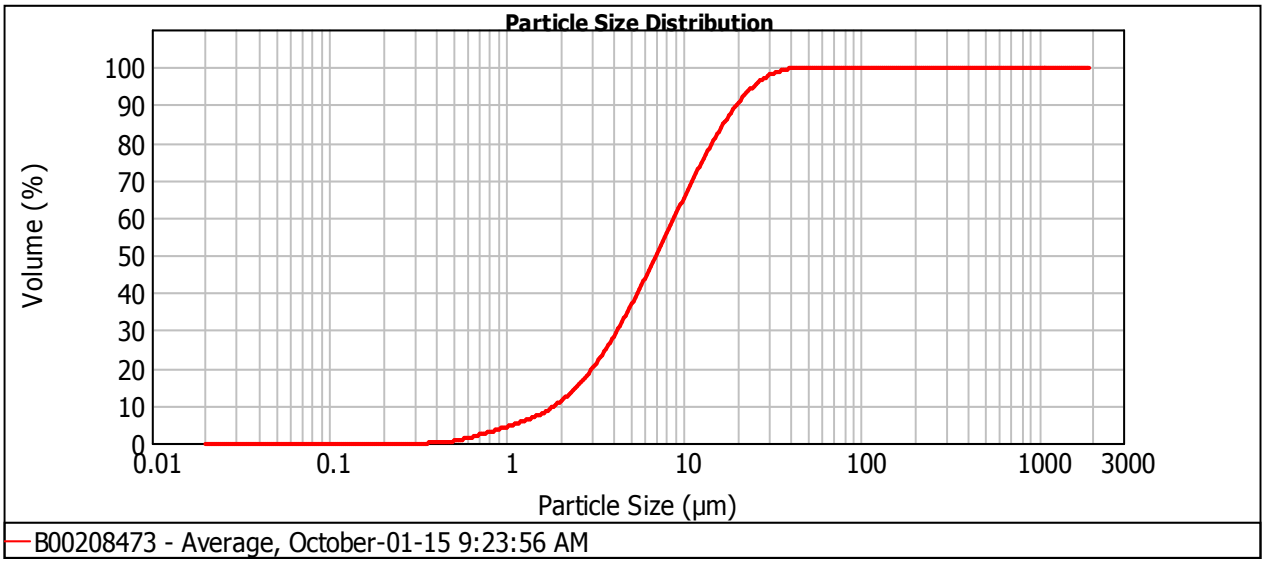

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	0.98	11.482	5.46	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.15	13.183	5.08	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.41	15.136	4.59	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.77	17.378	3.98	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.23	19.953	3.28	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.74	22.909	2.54	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.27	26.303	1.82	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.80	30.200	1.17	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.31	34.674	0.65	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.10	3.802	4.77	39.811	0.27	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.31	4.365	5.17	45.709	0.05	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.51	5.012	5.49	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.65	5.754	5.73	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.76	6.607	5.87	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.82	7.586	5.92	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	0.86	8.710	5.87	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	0.90	10.000	5.72	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208474 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
18.53 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.345 %

Result Emulation:
Off

Concentration:
0.0115 %Vol

Span :
2.554

Uniformity:
0.791

Result units:
Volume

Specific Surface Area:
1.58 m²/g

Surface Weighted Mean D[3,2]:
3.808 um

Vol. Weighted Mean D[4,3]:
9.193 um

d(0.1): 1.735 um **d(0.5):** 7.066 um **d (0.8) :** 14.631 um **d(0.9):** 19.782 um

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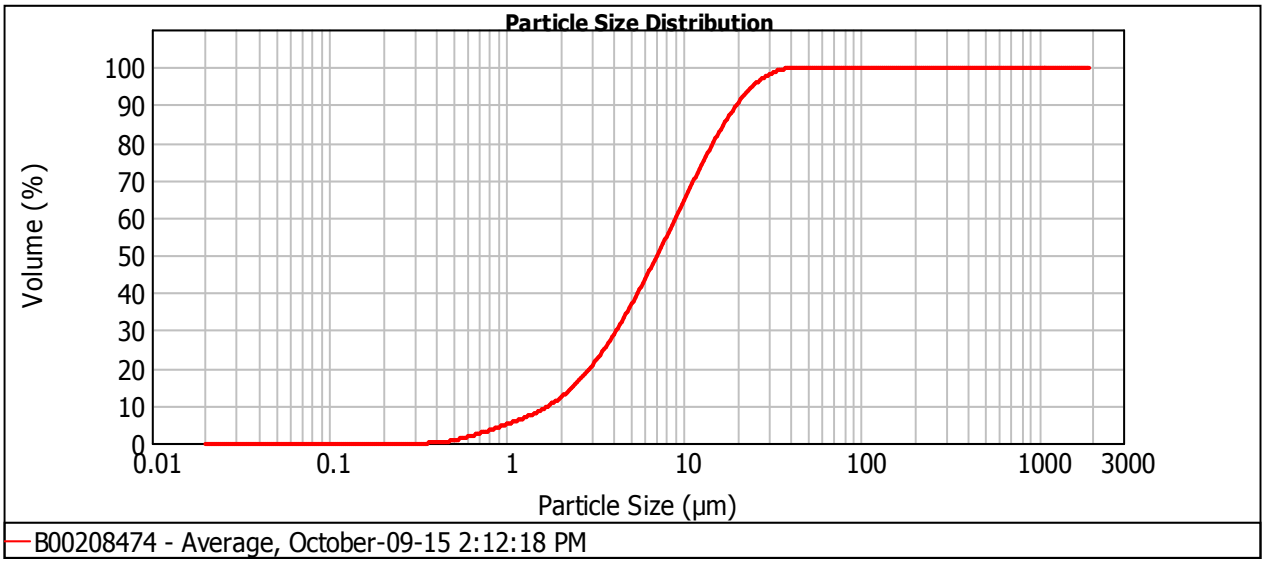

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.09	11.482	5.61	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.24	13.183	5.28	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.48	15.136	4.81	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.81	17.378	4.17	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.23	19.953	3.43	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.70	22.909	2.62	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.18	26.303	1.83	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.66	30.200	1.12	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.11	34.674	0.58	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.15	3.802	4.53	39.811	0.20	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.38	4.365	4.90	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.59	5.012	5.22	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.75	5.754	5.48	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.87	6.607	5.68	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.93	7.586	5.80	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	0.97	8.710	5.85	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.01	10.000	5.79	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208475 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
13.43 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.643 %

Result Emulation:
Off

Concentration:
0.0068 %Vol

Span :
2.973

Uniformity:
0.909

Result units:
Volume

Specific Surface Area:
1.88 m²/g

Surface Weighted Mean D[3,2]:
3.190 um

Vol. Weighted Mean D[4,3]:
7.814 um

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d(0.1): 1.409 um **d(0.5):** 5.475 um **d (0.8) :** 12.287 um **d(0.9):** 17.686 um

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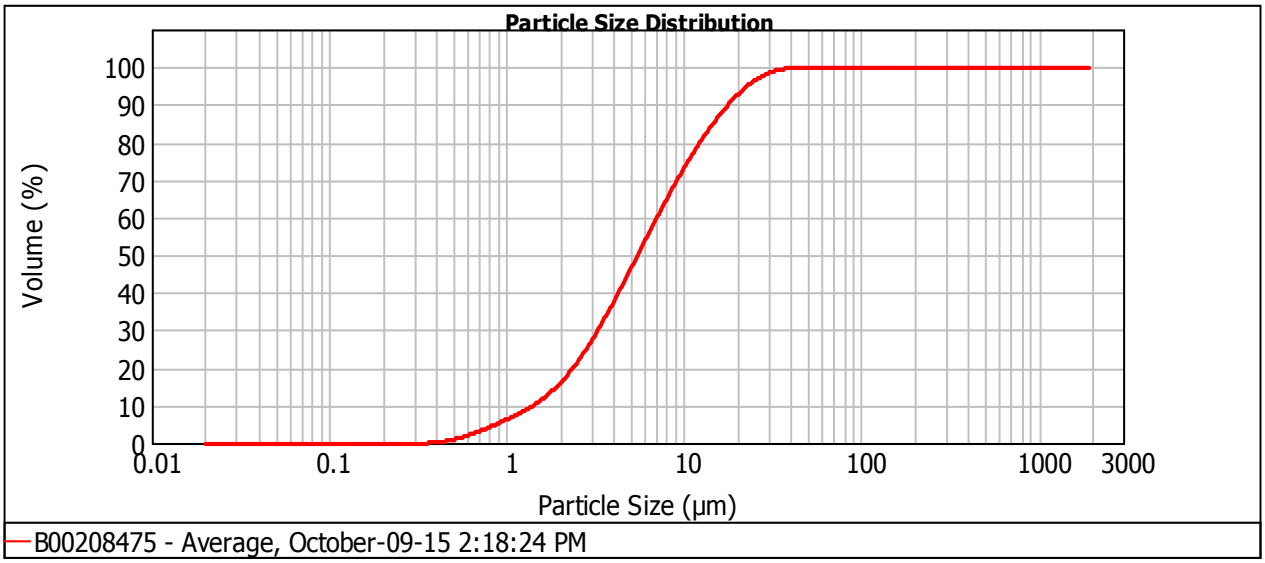


Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.48	11.482	4.32	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.71	13.183	3.93	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.06	15.136	3.50	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.52	17.378	3.02	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.06	19.953	2.49	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.63	22.909	1.94	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.18	26.303	1.39	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.67	30.200	0.89	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.07	34.674	0.49	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.24	3.802	5.36	39.811	0.19	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.48	4.365	5.53	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.72	5.012	5.59	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.91	5.754	5.55	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.06	6.607	5.42	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.16	7.586	5.22	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.24	8.710	4.96	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.33	10.000	4.66	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

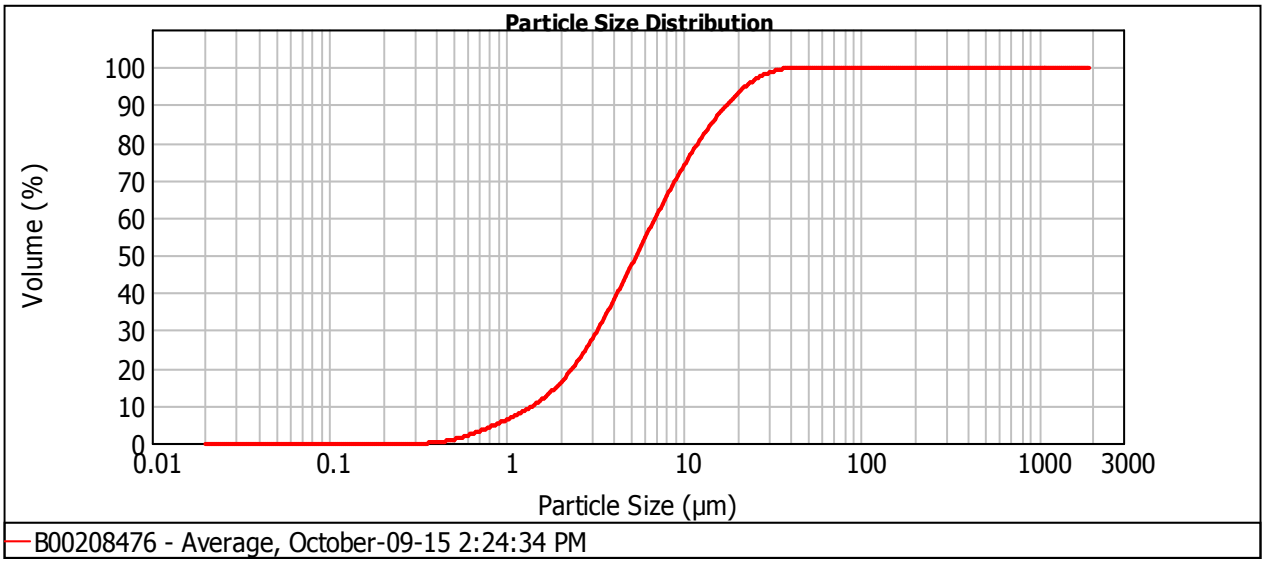
Result Analysis Report

Sample Name: B00208476 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 15.41 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.623 %	**Result Emulation:** Off

Concentration: 0.0079 %Vol	**Span :** 2.955	**Uniformity:** 0.903	**Result units:** Volume
Specific Surface Area: 1.89 m²/g	**Surface Weighted Mean D[3,2]:** 3.179 um	**Vol. Weighted Mean D[4,3]:** 7.691 um	

d(0.1): 1.413 um d(0.5): 5.396 um d (0.8) : 12.035 um d(0.9): 17.357 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.48	11.482	4.25	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.72	13.183	3.85	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	2.08	15.136	3.41	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.55	17.378	2.93	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	3.10	19.953	2.40	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.69	22.909	1.86	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.25	26.303	1.32	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.75	30.200	0.84	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.16	34.674	0.46	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.23	3.802	5.46	39.811	0.17	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.48	4.365	5.63	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.71	5.012	5.68	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.90	5.754	5.62	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.05	6.607	5.46	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.16	7.586	5.23	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.24	8.710	4.94	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.33	10.000	4.61	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208477 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
11.91 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.569 %

Result Emulation:
Off

Concentration:
0.0062 %Vol

Span :
2.969

Uniformity:
0.905

Result units:
Volume

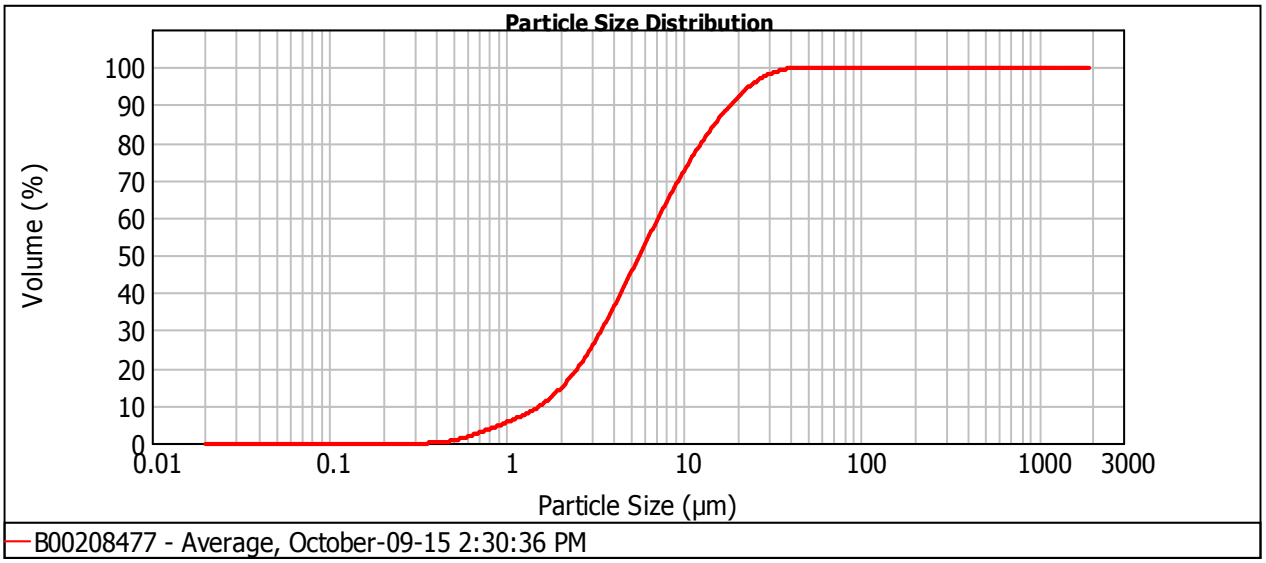
Specific Surface Area:
1.78 m²/g

Surface Weighted Mean D[3,2]:
3.370 um

Vol. Weighted Mean D[4,3]:
8.047 um

d(0.1): 1.548 um **d(0.5):** 5.610 um **d (0.8) :** 12.570 um **d(0.9):** 18.205 um

---



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.31	11.482	4.30	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.55	13.183	3.93	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.91	15.136	3.54	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.39	17.378	3.09	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.97	19.953	2.60	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.58	22.909	2.06	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	4.19	26.303	1.51	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.74	30.200	0.99	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	5.19	34.674	0.56	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.15	3.802	5.52	39.811	0.24	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.40	4.365	5.71	45.709	0.04	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.63	5.012	5.76	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.81	5.754	5.69	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.94	6.607	5.52	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.03	7.586	5.27	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.10	8.710	4.97	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.18	10.000	4.64	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208478 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
14.13 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.411 %

Result Emulation:
Off

Concentration:
0.0085 %Vol

Span :
2.720

Uniformity:
0.85

Result units:
Volume

Specific Surface Area:
1.57 m²/g

Surface Weighted Mean D[3,2]:
3.825 um

Vol. Weighted Mean D[4,3]:
9.644 um

d(0.1): 1.693 um **d(0.5):** 7.155 um **d (0.8) :** 15.408 um **d(0.9):** 21.151 um

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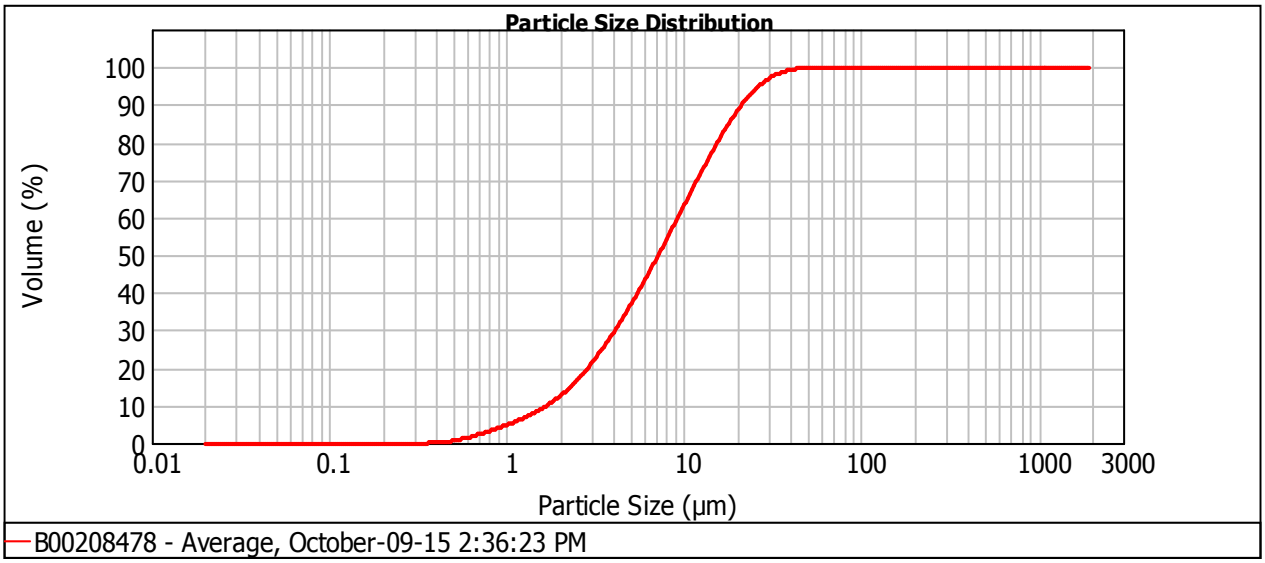

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.18	11.482	5.40	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.36	13.183	5.16	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.62	15.136	4.78	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.97	17.378	4.25	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.38	19.953	3.60	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.81	22.909	2.87	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.24	26.303	2.13	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.65	30.200	1.44	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.03	34.674	0.87	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.10	3.802	4.37	39.811	0.44	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.33	4.365	4.67	45.709	0.17	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.55	5.012	4.93	52.481	0.06	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.72	5.754	5.15	60.256	0.02	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.85	6.607	5.33	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	0.94	7.586	5.46	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.01	8.710	5.53	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.08	10.000	5.52	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208479 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
10.62 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.550 %

Result Emulation:
Off

Concentration:
0.0058 %Vol

Span :
2.812

Uniformity:
0.867

Result units:
Volume

Specific Surface Area:
1.77 m²/g

Surface Weighted Mean D[3,2]:
3.395 um

Vol. Weighted Mean D[4,3]:
8.940 um

d(0.1): 1.434 um **d(0.5):** 6.583 um **d (0.8) :** 14.544 um **d(0.9):** 19.945 um

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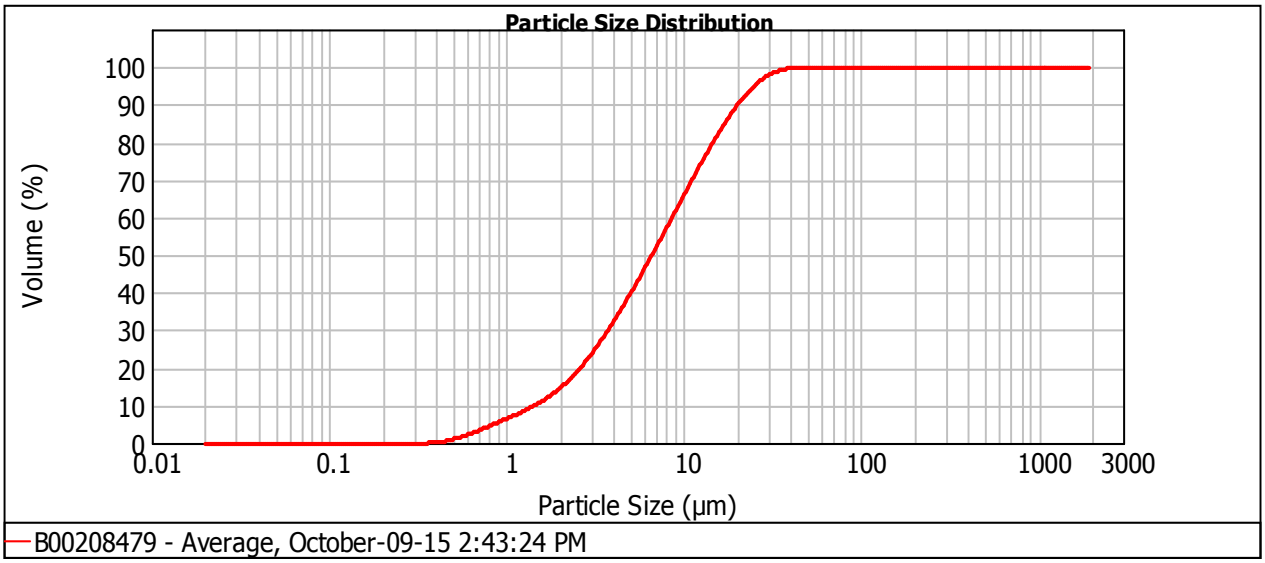


Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.31	11.482	5.16	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.46	13.183	4.93	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.70	15.136	4.57	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.05	17.378	4.05	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.47	19.953	3.40	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.93	22.909	2.66	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.39	26.303	1.90	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.83	30.200	1.19	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.21	34.674	0.62	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.26	3.802	4.53	39.811	0.21	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.54	4.365	4.79	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.78	5.012	4.99	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.98	5.754	5.14	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.11	6.607	5.25	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.18	7.586	5.31	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.21	8.710	5.32	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.25	10.000	5.28	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

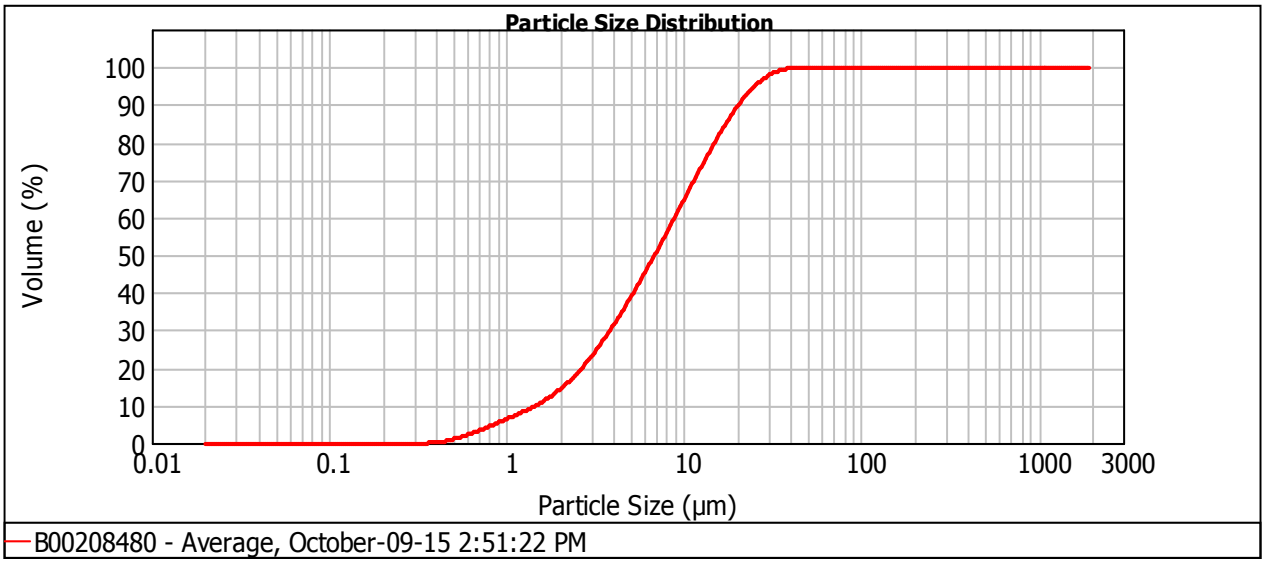
Result Analysis Report

Sample Name: B00208480 - Average	**SOP Name:** ARD-1452	**Measured:** 12000
Sample Source & type: 1187	**Measured by:** Kristelle_Sarinas	**Analysed:** Enhanced
Sample bulk lot ref:	**Result Source:** Averaged	

Particle Name: Default	**Accessory Name:** Hydro 2000G (A)	**Analysis model:** General purpose	**Sensitivity:** Enhanced
Particle RI: 1.520	**Absorption:** 0.1	**Size range:** 0.020 to 2000.000 um	**Obscuration:** 10.86 %
Dispersant Name: Water	**Dispersant RI:** 1.330	**Weighted Residual:** 1.525 %	**Result Emulation:** Off

Concentration: 0.0061 %Vol	**Span :** 2.753	**Uniformity:** 0.85	**Result units:** Volume
Specific Surface Area: 1.74 m²/g	**Surface Weighted Mean D[3,2]:** 3.458 um	**Vol. Weighted Mean D[4,3]:** 9.130 um	

d(0.1): 1.460 um d(0.5): 6.815 um d (0.8) : 14.864 um d(0.9): 20.223 um



Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.28	11.482	5.32	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.42	13.183	5.11	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.65	15.136	4.75	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	1.98	17.378	4.22	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.38	19.953	3.55	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	2.83	22.909	2.77	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.27	26.303	1.97	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	3.69	30.200	1.23	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.08	34.674	0.64	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.26	3.802	4.40	39.811	0.22	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.53	4.365	4.68	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.77	5.012	4.90	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.97	5.754	5.09	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	1.09	6.607	5.23	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.16	7.586	5.34	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.19	8.710	5.41	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.22	10.000	5.41	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

MALVERN INSTRUMENTS

MASTERSIZER 2000

Result Analysis Report

Sample Name:
B00208481 - Average

SOP Name:
ARD-1452

Measured:
12000

Sample Source & type:
1187

Measured by:
Kristelle_Sarinas

Analysed:
Enhanced

Sample bulk lot ref:

Result Source:
Averaged

Particle Name:
Default

Accessory Name:
Hydro 2000G (A)

Analysis model:
General purpose

Sensitivity:
Enhanced

Particle RI:
1.520

Absorption:
0.1

Size range:
0.020 to 2000.000 um

Obscuration:
17.89 %

Dispersant Name:
Water

Dispersant RI:
1.330

Weighted Residual:
1.489 %

Result Emulation:
Off

Concentration:
0.0103 %Vol

Span :
2.649

Uniformity:
0.816

Result units:
Volume

Specific Surface Area:
1.69 m²/g

Surface Weighted Mean D[3,2]:
3.546 um

Vol. Weighted Mean D[4,3]:
8.328 um

d(0.1): 1.616 um **d(0.5):** 6.218 um **d (0.8) :** 13.001 um **d(0.9):** 18.090 um

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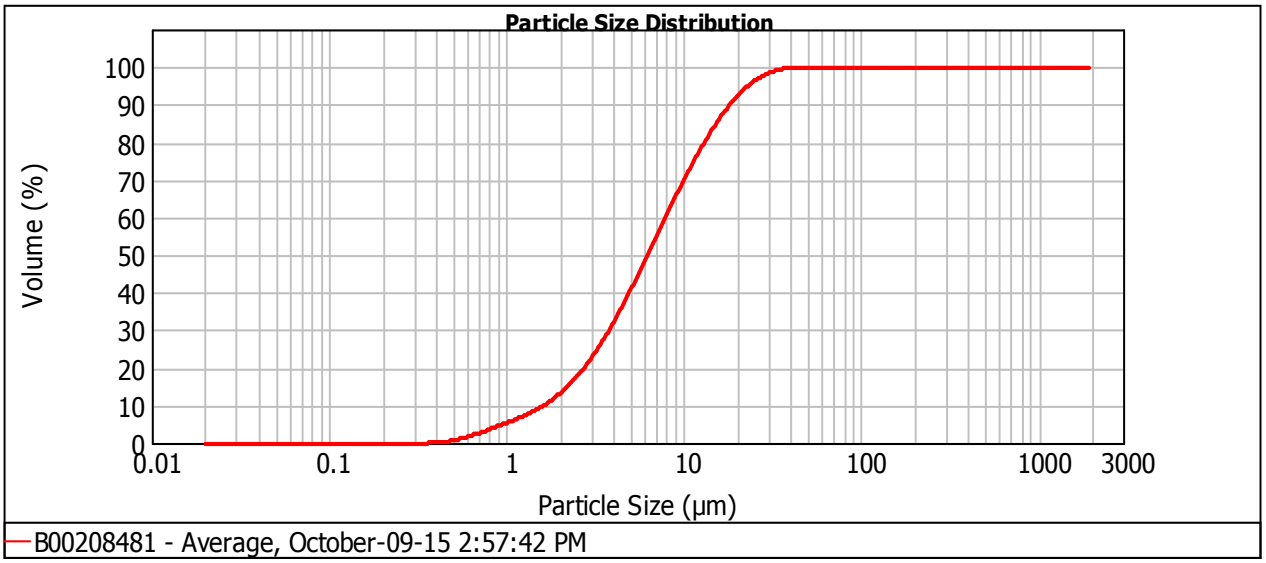

Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %	Size (µm)	Volume In %
0.010	0.00	0.105	0.00	1.096	1.21	11.482	4.98	120.226	0.00	1258.925	0.00
0.011	0.00	0.120	0.00	1.259	1.37	13.183	4.51	138.038	0.00	1445.440	0.00
0.013	0.00	0.138	0.00	1.445	1.64	15.136	3.97	158.489	0.00	1659.587	0.00
0.015	0.00	0.158	0.00	1.660	2.02	17.378	3.36	181.970	0.00	1905.461	0.00
0.017	0.00	0.182	0.00	1.905	2.49	19.953	2.71	208.930	0.00	2187.762	0.00
0.020	0.00	0.209	0.00	2.188	3.02	22.909	2.04	239.883	0.00	2511.886	0.00
0.023	0.00	0.240	0.00	2.512	3.59	26.303	1.42	275.423	0.00	2884.032	0.00
0.026	0.00	0.275	0.00	2.884	4.14	30.200	0.88	316.228	0.00	3311.311	0.00
0.030	0.00	0.316	0.01	3.311	4.67	34.674	0.46	363.078	0.00	3801.894	0.00
0.035	0.00	0.363	0.14	3.802	5.13	39.811	0.17	416.869	0.00	4365.158	0.00
0.040	0.00	0.417	0.39	4.365	5.51	45.709	0.00	478.630	0.00	5011.872	0.00
0.046	0.00	0.479	0.63	5.012	5.78	52.481	0.00	549.541	0.00	5754.399	0.00
0.052	0.00	0.550	0.81	5.754	5.93	60.256	0.00	630.957	0.00	6606.934	0.00
0.060	0.00	0.631	0.94	6.607	5.96	69.183	0.00	724.436	0.00	7585.776	0.00
0.069	0.00	0.724	1.02	7.586	5.87	79.433	0.00	831.764	0.00	8709.636	0.00
0.079	0.00	0.832	1.07	8.710	5.67	91.201	0.00	954.993	0.00	10000.000	0.00
0.091	0.00	0.955	1.12	10.000	5.37	104.713	0.00	1096.478	0.00		
0.105	0.00	1.096		11.482		120.226		1258.925			

Operator notes:

APPENDIX E: SOLID PHASE ELEMENT RESULTS FOR OVERBURDEN SAMPLES FROM BRUCEJACK MINE SITE

PRETIVM

Appendix E. Solid Phase Element Results for Overburden Samples from Brucejack Mine Site

ACA		*0.075*	*8.23*	*1.8*	*10*	*425*	*3*	*0.17*	*4.15*	*0.15*	*66.5*	*25*	*102*	*ND*	*60*	*5.63*	*19*	*1.5*	*3*	*0.085*	*ND*	*2.085*	*ND*	*20*	*ND*	*2.33*	*950*
Sample ID	**Reference Location**	**Ag**	**Al**	**As**	**B**	**Ba**	**Be**	**Bi**	**Ca**	**Cd**	**Ce**	**Co**	**Cr**	**Cs**	**Cu**	**Fe**	**Ga**	**Ge**	**Hf**	**Hg**	**In**	**K**	**La**	**Li**	**Lu**	**Mg**	**Mn**
		ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	%	ppm
LOD		*0.01*	*0.01*	*1*	*10*	*5*	*0.1*	*0.02*	*0.01*	*0.01*	*0.05*	*0.1*	*1*	*0.05*	*0.5*	*0.01*	*0.1*	*0.1*	*0.05*	*0.01*	*0.02*	*0.01*	*0.1*	*1*	*0.01*	*0.01*	*2*
OB - 01	*NA*	0.6	0.94	33	30	84	0.8	0.04	0.06	0.12	53.2	12.5	33	2.01	44.1	4.07	2.5	*<0.1*	0.07	0.38	*<0.02*	0.13	16.3	9	0.19	0.19	1400
OB - 02	*NA*	0.05	0.94	21	20	94	0.3	0.56	0.39	0.24	25	11.4	19	6.65	22.2	4.48	2.1	*<0.1*	<0.05	0.16	*<0.02*	0.11	10.9	10	0.1	0.37	2210
OB - 03	*NA*	1.13	1.59	58	30	92	0.7	0.18	0.18	0.25	41.5	11.3	36	3.53	34	4.04	7.6	*<0.1*	0.19	0.26	0.05	0.12	15.4	22	0.21	0.59	1850
OB - 04	*NA*	2.26	0.92	61	30	262	0.3	0.28	0.62	0.27	14.7	6.7	46	2.2	16.3	4.11	2.2	*<0.1*	*<0.05*	0.22	*<0.02*	0.13	7.7	15	0.07	0.43	739
OB - 05	*NA*	15.1	1.22	42	20	294	0.3	0.07	1.25	0.24	16.6	9.3	37	1.38	30.1	4.29	3.3	*<0.1*	0.08	0.17	*<0.02*	0.12	8.3	19	0.11	0.61	1200
OB - 06	*NA*	3.79	1.16	59	30	188	0.3	0.08	1.47	0.36	14.6	11.7	33	1.66	27.8	4.41	2.8	*<0.1*	0.07	0.31	*<0.02*	0.12	7.4	21	0.1	0.61	1330
OB - 07	*NA*	7.5	0.28	42	40	119	*<0.1*	0.32	0.01	0.09	19.8	0.6	20	1.4	14.9	2.53	0.7	*<0.1*	*<0.05*	0.09	*<0.02*	0.16	11	1	0.02	0.03	38
OB - 08	*NA*	2.88	1.14	50	30	425	0.2	0.15	0.26	0.07	12.4	6	32	1.24	12.2	3.96	3	*<0.1*	0.07	0.64	*<0.02*	0.1	5.8	15	0.06	0.54	399
OB - 09	*NA*	3.27	1.25	65	20	203	0.3	0.06	1.36	0.26	15.7	10.3	30	2.16	19	3.93	2.9	*<0.1*	*<0.05*	0.33	*<0.02*	0.11	8	23	0.09	0.56	1030
OB - 10	*NA*	8.83	0.26	220	30	75	0.2	0.11	0.07	0.34	19.9	6.7	22	2.38	21.5	2.69	0.6	*<0.1*	*<0.05*	0.01	*<0.02*	0.16	10	*<1*	0.03	0.01	722
OB - 11	*NA*	25.6	0.35	180	30	137	0.1	0.46	0.03	0.07	23.8	2	26	1.91	38.9	6.09	2.3	*<0.1*	0.11	0.09	0.02	0.21	14.3	2	0.01	0.08	50
OB - 12	*NA*	0.48	1.31	42	30	226	0.3	0.1	0.19	0.09	16.7	10.8	45	1.13	22.3	3.59	3.7	*<0.1*	0.07	0.09	0.02	0.12	8.7	22	0.05	0.74	740
OB - 13	*NA*	8.84	1.15	71	20	156	0.4	0.08	0.58	0.54	14.8	12.4	32	2.57	31.6	4.38	2.9	*<0.1*	0.08	0.64	0.02	0.12	7.6	21	0.12	0.68	1910
OB - 14	*NA*	1.01	1.1	63	30	359	0.3	0.04	0.71	0.11	19.9	9.9	56	1.38	16.7	3.76	2.8	*<0.1*	0.11	0.5	*<0.02*	0.12	11	19	0.11	0.56	1020
B00208001	CWP, TP1	0.91	1.29	32	30	299	0.3	0.08	1.33	0.17	16	9.8	54	1.49	36	3.82	2.9	*<0.1*	0.08	0.18	*<0.02*	0.12	8.7	21	0.09	0.64	1150
B00208002		0.91	1.39	30	40	303	0.3	0.09	1.02	0.24	18.9	10.3	50	1.38	26.6	3.94	3.2	*<0.1*	0.09	0.21	0.02	0.13	10.6	22	0.09	0.68	1190
B00208003		1.71	1.36	40	40	298	0.3	0.07	1.09	0.17	18.3	10.4	49	1.28	24.6	4.18	3.1	*<0.1*	*<0.05*	0.18	*<0.02*	0.12	9.8	21	0.11	0.66	1220
B00208004		1.25	1.3	32	40	513	0.3	0.05	0.89	0.16	22.7	9.6	60	1.58	19	3.97	2.9	*<0.1*	*<0.05*	0.11	*<0.02*	0.13	12.7	21	0.1	0.6	957
B00208005		1.04	1.38	36	40	289	0.3	0.09	1.99	0.25	18	9.9	51	1.39	27.8	3.91	3.1	*<0.1*	0.08	0.19	*<0.02*	0.12	9.7	22	0.1	0.62	1500
B00208006		1.23	1.35	49	30	284	0.3	0.06	1.26	0.21	15.9	11.6	47	1.39	26.2	4.5	3	*<0.1*	0.08	0.25	*<0.02*	0.12	8.8	23	0.1	0.63	1390
B00208007	CWP, TP2	1.95	1.31	33	40	356	0.3	0.08	1.18	0.37	17.6	11.3	49	1.37	24.4	3.89	3.2	*<0.1*	0.09	0.27	*<0.02*	0.12	9.4	20	0.1	0.62	1290
B00208008		0.91	1.34	79	40	301	0.2	0.08	0.96	0.23	15.1	10.2	49	1.36	20.6	4.07	3	*<0.1*	0.07	0.39	*<0.02*	0.12	8.2	22	0.09	0.6	1210
B00208009		3.66	1.44	51	30	358	0.3	0.1	1.27	0.32	16.7	10.8	49	1.35	21.5	4.42	3.3	*<0.1*	0.09	0.43	0.02	0.12	9	23	0.1	0.66	1380
B00208010		1.03	1.37	58	30	346	0.3	0.09	0.75	0.23	16.8	11.1	44	1.37	18.3	4.39	3	*<0.1*	0.08	0.37	*<0.02*	0.11	8.9	22	0.09	0.62	1240
B00208481	Site 2	11.8	0.61	100	*<10*	185	0.3	0.24	0.51	0.5	17.2	5.6	60	2.16	20.9	3.79	1.9	*<0.1*	0.06	0.1	*<0.02*	0.22	8.7	8	0.06	0.19	496
B00208469	Site 3	8.83	0.96	92	*<10*	229	0.3	0.18	0.54	0.66	19.8	9.5	75	2.23	33	3.26	2.5	*<0.1*	*<0.05*	0.22	*<0.02*	0.19	9.3	12	0.07	0.4	829
B00208471		1.67	1.32	80	*<10*	298	0.4	0.13	0.34	0.32	24.1	10.4	52	1.84	17.5	4.47	3.6	*<0.1*	0.09	0.23	*<0.02*	0.14	11.2	19	0.1	0.53	877
B00208467	Site 4	3.73	1.12	78	*<10*	215	0.4	0.17	0.17	0.21	27.2	7.5	61	3.44	21.8	4.2	3.6	*<0.1*	*<0.05*	0.38	*<0.02*	0.17	12.8	14	0.07	0.41	382
B00208468		1.3	1.34	72	*<10*	118	0.5	0.24	0.17	0.1	27.4	8.7	64	2.29	27.4	4.44	4.6	*<0.1*	0.12	0.28	0.03	0.14	11.3	16	0.11	0.48	482
B00208472	Site 5	0.5	0.89	135	*<10*	116	0.6	0.1	0.21	0.28	22.8	13.7	65	3.42	58.5	3.65	2.3	*<0.1*	*<0.05*	0.33	0.02	0.16	10.8	14	0.1	0.39	2520
B00208473		0.63	1.45	132	*<10*	160	0.5	0.09	1.07	0.25	23.6	14	60	3.11	51.7	4.24	4	*<0.1*	*<0.05*	0.26	0.02	0.16	11.3	28	0.1	0.88	1770
B00208477	Site 6	1.68	1.15	53	*<10*	128	0.3	0.11	0.1	0.08	20.5	8.5	51	2.67	16.2	5.18	3.3	*<0.1*	*<0.05*	0.1	*<0.02*	0.16	9.7	18	0.05	0.52	943
B00208451	Site7	0.24	1.09	25	20	200	0.3	0.3	0.09	0.12	16.1	6	36	4.62	16.5	4.12	2.9	*<0.1*	*<0.05*	0.09	*<0.02*	0.13	8	24	0.06	0.65	1110
B00208452		0.46	1.28	39	20	184	0.4	0.31	0.27	0.21	20.6	8.3	39	4.66	19.9	4.77	3.6	*<0.1*	*<0.05*	0.17	0.03	0.15	9.4	25	0.08	0.69	1280
B00208478	Site 8	0.61	1.68	50	10	272	0.5	0.23	0.28	0.22	24.4	9.7	54	1.93	12.3	4.33	4.2	*<0.1*	*<0.05*	0.17	*<0.02*	0.16	12.2	27	0.07	0.69	1560
B00208459	Site 9	1.31	1.28	40	20	384	0.4	0.09	2.17	0.27	16.8	9.1	59	1.48	15.8	4.3	3.2	*<0.1*	0.1	0.26	*<0.02*	0.14	8.3	22	0.1	0.58	1380
B00208461		2.82	1.17	50	20	225	0.3	0.09	1.52	0.22	13.5	9.4	60	1.39	18.7	4.48	2.8	*<0.1*	0.08	0.31	*<0.02*	0.15	6.5	20	0.09	0.48	1200
B00208475	Site 10	8.52	0.78	77	*<10*	268	0.4	0.18	0.13	0.2	21.9	6.7	54	2.6	32.2	4.81	2.4	*<0.1*	*<0.05*	0.15	0.02	0.23	11.1	9	0.06	0.23	577
B00208476		14.2	0.63	90	*<10*	281	0.3	0.2	0.08	0.16	24.3	5.8	66	2.21	37.7	4.79	1.9	*<0.1*	*<0.05*	0.1	0.02	0.27	12.7	6	0.04	0.16	493
B00208453	Site 11	1.32	0.72	41	20	567	0.4	0.2	1.19	0.16	19.3	4	68	2.44	12.3	2.6	2	*<0.1*	0.12	0.11	*<0.02*	0.24	10	9	0.08	0.24	851
B00208454		1.91	1.02	58	20	461	0.3	0.3	0.28	0.16	18.5	8.5	57	2.94	15.1	4.59	2.8	*<0.1*	*<0.05*	0.22	*<0.02*	0.15	9.9	16	0.08	0.42	922
B00208455	Site 12	4.65	0.92	120	20	430	0.3	0.21	0.88	0.19	14.2	6.8	66	1.87	1790	3.93	2.4	*<0.1*	*<0.05*	0.26	*<0.02*	0.19	7.2	14	0.06	0.38	819
B00208456		3.3	1.07	46	20	431	0.3	0.11	1.06	0.22	13.7	9	77	1.3	20.4	3.74	2.9	*<0.1*	0.14	0.2	*<0.02*	0.14	6.7	16	0.09	0.4	779
B00208465	Site 13	0.88	1.38	30	*<10*	301	0.3	0.08	1.83	0.26	19.8	9.3	62	1.49	15.5	3.94	3.7	*<0.1*	0.11	0.17	*<0.02*	0.13	9.2	21	0.11	0.59	1460
B00208466		0.66	1.5	38	*<10*	505	0.3	0.07	1.06	0.26	21.2	11.3	54	1.4	21.2	4.28	4.4	*<0.1*	0.15	0.15	*<0.02*	0.17	10	22	0.11	0.64	1230
B00208479	Site 14	1.05	1.4	49	*<10*	331	0.4	0.08	1.2	0.24	17.9	10.7	54	1.41	13.7	4.58	3.7	*<0.1*	0.09	0.28	*<0.02*	0.14	8.7	24	0.11	0.61	1320
B00208457	Site 15	1.45	1.09	44	20	264	0.4	0.08	2.47	0.28	14.2	9	55	1.57	28.8	4.01	2.8	*<0.1*	0.09	0.24	*<0.02*	0.14	7	20	0.1	0.52	1850
B00208458		1.79	1.48	47	20	360	0.4	0.08	1.34	0.64	17.1	10.5	54	1.42	19.2	4.84	3.8	*<0.1*	0.09	0.79	0.04	0.14	8.3	26	0.1	0.66	1480
B00208464	Site 17	1.41	0.71	79	*<10*	131	0.2	0.58	0.06	0.12	22.1	6.4	45	3.03	37	3.78	1.9	*<0.1*	*<0.05*	0.05	*<0.02*	0.26	10.7	8	0.04	0.35	650
B00208462	Site 18	6.8	1.01	137	*<10*	1340	0.2	0.18	0.14	0.14	16.6	5.8	80	1.96	18.4	2.94	2.6	*<0.1*	0.09	0.37	*<0.02*	0.2	8	11	0.05	0.35	368
B00208463		3.59	0.69	446	*<10*	543	0.2	0.12	0.06	0.11	20	5.6	46	4.95	31	3.15	1.7	*<0.1*	0.06	1.07	*<0.02*	0.22	10.2	6	0.06	0.17	396
B00208474	Site 19	1.26	1.34	50	*<10*	329	0.6	0.13	0.71	0.24	22.1	11.1	47	2.4	42.4	4.35	3.7	*<0.1*	0.06	0.19	0.02	0.15	10.8	25	0.11	0.65	1480

Notes: 1. italicized values in blue font indicate values measured below the detection limit;
2. ACA = average continental crust abundance values according to Price (1997); highlighted values are higher than three times the ACA.

Appendix E. Solid Phase Element Results for Overburden Samples from Brucejack Mine Site

Sample ID	Reference Location	Mo	Na	Nb	Ni	P	Pb	Rb	S	Sb	Sc	Se	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	U	V	W	Y	Yb	Zn	Zr
ACA		*1.5*	*2.36*	*20*	*84*	*0.105*	*12.5*	*90*	*0.035*	*0.2*	*ND*	*0.05*	*2.3*	*375*	*ND*	*ND*	*ND*	*1.2*	*0.565*	*0.001*	*2.7*	*120*	*1.25*	*33*	*3.2*	*70*	*165*
		ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
LOD		*0.05*	*0.01*	*0.05*	*0.5*	*0.005*	*0.2*	*0.2*	*0.01*	*0.05*	*0.1*	*1*	*0.3*	*0.5*	*0.05*	*0.02*	*0.05*	*0.1*	*0.01*	*0.02*	*0.05*	*1*	*0.1*	*0.05*	*0.1*	*1*	*0.5*
OB - 01	*NA*	1.65	0.02	3.36	7.9	0.099	9	5.2	0.14	2.11	1.7	2	0.7	4	*<0.05*	0.52	0.51	2	*<0.01*	0.1	1.23	11	0.1	7.56	1.5	70	9.6
OB - 02	*NA*	2.41	0.02	*<0.05*	12.6	0.1	12.2	5.7	0.16	3.1	3.7	3	*<0.3*	12.6	*<0.05*	0.33	0.21	1.9	*<0.01*	0.11	0.23	15	*<0.1*	6.45	0.7	32	1.4
OB - 03	*NA*	2.2	0.04	9.15	24.7	0.143	12.9	6.2	0.06	1.29	3.1	*<1*	2	10.9	*<0.05*	0.64	0.12	2.7	0.04	0.22	1.15	27	0.3	13	1.4	145	23.6
OB - 04	*NA*	1.82	0.02	0.16	3.1	0.124	25.6	5.3	0.84	2.64	2.1	1	*<0.3*	21.5	*<0.05*	0.23	0.18	1.7	*<0.01*	0.12	0.39	22	*<0.1*	5.38	0.5	63	3.6
OB - 05	*NA*	0.9	0.03	0.14	2.9	0.131	48.7	4.3	0.6	7.18	2.9	*<1*	*<0.3*	39	*<0.05*	0.3	*<0.05*	2	0.02	0.07	0.68	40	0.1	8.18	0.7	75	4.7
OB - 06	*NA*	1.25	0.02	0.13	5.7	0.134	17.3	4.5	1.94	2.4	2.6	*<1*	*<0.3*	43.3	*<0.05*	0.3	*<0.05*	1.6	*<0.01*	0.1	0.48	25	0.1	8.14	0.7	91	5.4
OB - 07	*NA*	2.31	0.01	0.12	0.5	0.092	43.7	6.6	0.08	7.15	0.9	5	*<0.3*	3.5	*<0.05*	0.11	0.26	2.1	*<0.01*	0.17	0.26	10	0.2	1.34	0.1	15	2.3
OB - 08	*NA*	0.95	0.03	0.23	2	0.114	12.7	4.1	0.36	2.02	2.3	*<1*	*<0.3*	18.1	*<0.05*	0.18	0.05	1.7	0.02	0.09	0.54	31	0.1	3.73	0.4	59	4.2
OB - 09	*NA*	1.24	0.02	*<0.05*	3.4	0.127	14.4	4.3	1.47	1.42	2.3	*<1*	*<0.3*	35.6	*<0.05*	0.31	*<0.05*	1.7	*<0.01*	0.1	0.47	20	*<0.1*	7.57	0.6	89	3.7
OB - 10	*NA*	4.31	*<0*	0.1	2.2	0.106	114	7.6	0.15	15.2	0.9	1	*<0.3*	6.5	*<0.05*	0.16	0.52	1.4	*<0.01*	0.43	0.97	5	1	2.34	0.2	73	0.6
OB - 11	*NA*	4.11	0.01	1.33	1.8	0.209	153	11.3	0.19	30.3	1.6	1	*<0.3*	10.8	*<0.05*	0.14	0.73	1.5	0.01	0.24	0.15	23	0.2	1.24	*<0.1*	23	0.9
OB - 12	*NA*	1.2	0.02	1.05	13.3	0.087	10.3	5.8	0.1	1.48	2.8	*<1*	*<0.3*	21.5	*<0.05*	0.22	0.06	1.7	0.04	0.11	0.57	35	0.1	4.59	0.4	69	3
OB - 13	*NA*	2.29	0.02	0.16	5.9	0.115	15.1	6.1	1.19	3.8	3.2	*<1*	*<0.3*	20.3	*<0.05*	0.34	*<0.05*	1.5	*<0.01*	0.21	0.63	23	*<0.1*	8.19	0.7	140	3.9
OB - 14	*NA*	1.67	0.02	0.15	3.3	0.119	14.8	5.3	0.43	1.73	2.4	*<1*	*<0.3*	23.8	*<0.05*	0.31	*<0.05*	2.5	*<0.01*	0.18	0.7	22	0.1	7.12	0.6	63	4.7
B00208001	CWP, TP1	2.98	0.02	0.19	5.7	0.118	10.8	4.2	0.77	2.11	2.7	*<1*	0.4	36.4	*<0.05*	0.28	*<0.05*	1.9	0.02	0.08	0.58	34	0.1	7.06	0.6	82	3.9
B00208002		2.83	0.03	0.15	5.6	0.123	10.7	4.4	0.67	1.48	2.9	*<1*	0.4	33.2	*<0.05*	0.31	*<0.05*	2.1	0.02	0.08	0.61	38	*<0.1*	7.38	0.7	94	4.3
B00208003		2.87	0.04	0.26	4.1	0.135	11.4	4.1	0.45	1.64	3	*<1*	0.4	35.8	*<0.05*	0.33	*<0.05*	2	0.04	0.07	0.66	38	*<0.1*	8.13	0.8	82	4.1
B00208004		2.95	0.04	0.29	5.2	0.132	11.3	4.3	0.51	1.25	2.8	*<1*	0.4	39.6	*<0.05*	0.33	*<0.05*	2.1	0.03	0.07	0.65	38	*<0.1*	7.46	0.7	85	4.1
B00208005		3.12	0.03	0.08	4	0.114	11.3	4.2	0.85	1.34	3	*<1*	0.3	49.4	*<0.05*	0.33	*<0.05*	1.9	0.02	0.08	0.53	32	*<0.1*	8.49	0.7	93	3.9
B00208006		2.79	0.02	0.07	4	0.126	12.4	4.3	1.46	1.47	2.8	*<1*	*<0.3*	42.3	*<0.05*	0.29	*<0.05*	1.9	0.01	0.1	0.62	31	*<0.1*	7.36	0.7	86	4.3
B00208007	CWP, TP2	3.18	0.03	0.13	7.2	0.12	12.7	4.7	0.9	1.68	2.8	*<1*	0.3	38	*<0.05*	0.3	*<0.05*	2.1	0.02	0.09	0.66	34	*<0.1*	7.41	0.7	103	4
B00208008		3.04	0.03	0.09	4.1	0.121	10.6	3.9	0.72	1.5	2.5	*<1*	0.3	31.3	*<0.05*	0.28	*<0.05*	1.9	0.01	0.11	0.66	36	*<0.1*	6.73	0.6	91	3.8
B00208009		3.41	0.03	0.11	4.8	0.114	13	4	0.69	1.42	3	*<1*	0.4	41.8	*<0.05*	0.3	*<0.05*	1.9	0.02	0.11	0.72	40	*<0.1*	7.48	0.7	113	4.1
B00208010		3.12	0.03	0.09	4	0.122	12.9	3.9	0.8	1.46	2.6	*<1*	1.8	29.4	*<0.05*	0.3	*<0.05*	2	0.02	0.1	0.68	36	*<0.1*	7.37	0.7	86	3.9
B00208481	Site 2	12.3	0.01	0.26	3.8	0.122	61	10.5	0.7	5.83	1.7	2	*<0.3*	33.7	*<0.05*	0.2	0.17	2.1	*<0.01*	0.26	0.51	17	0.5	4.29	0.4	85	5
B00208469	Site 3	4.58	0.02	0.41	5.9	0.102	36.1	8.3	0.93	7.22	2.5	1	0.4	34.6	*<0.05*	0.25	0.08	2	0.02	0.25	0.74	26	0.4	5.35	0.5	113	3.1
B00208471		3.35	0.02	0.48	4.7	0.145	16.1	5.6	0.18	2.62	3.1	*<1*	*<0.3*	23.1	*<0.05*	0.35	0.06	2.3	0.03	0.14	0.83	39	0.3	7.81	0.7	92	5.4
B00208467	Site 4	5.75	0.02	2.21	9.3	0.111	38.8	7.9	0.16	4.3	3.1	2	0.6	20.8	*<0.05*	0.29	0.26	2	0.03	0.4	0.98	33	0.2	5.32	0.5	68	3.1
B00208468		3.94	0.02	2.51	10.5	0.118	19.5	7.4	0.03	2.91	4.2	2	0.8	29.1	*<0.05*	0.35	0.25	2.7	0.08	0.16	1.07	54	0.3	5.51	0.8	70	13.5
B00208472	Site 5	3.92	0.02	0.27	48.3	0.097	12.5	6.5	0.1	3.42	3.1	*<1*	*<0.3*	11.8	*<0.05*	0.32	0.05	1.6	*<0.01*	0.22	0.4	18	0.1	6.78	0.6	116	1.6
B00208473		3.4	0.02	0.37	36.6	0.11	12.8	6.3	0.29	3.34	3.4	*<1*	*<0.3*	39.8	*<0.05*	0.33	*<0.05*	1.7	0.01	0.16	0.49	31	0.1	7.62	0.7	101	1.9
B00208477	Site 6	3.11	0.02	0.5	3.2	0.123	14.4	7	0.07	3.02	2.8	*<1*	*<0.3*	8.4	*<0.05*	0.22	0.1	2.1	0.02	0.14	0.79	39	0.2	3.67	0.4	62	1.5
B00208451	Site7	3.07	0.02	0.13	2.4	0.125	9.6	5.3	0.18	2.13	2.2	2	0.6	11.2	*<0.05*	0.19	0.19	1.3	*<0.01*	0.12	0.21	18	0.1	4.38	0.4	93	1.1
B00208452		3.41	0.03	1.33	5.3	0.129	13.5	6	0.62	2.34	2.3	2	0.8	14.8	*<0.05*	0.28	0.18	1.1	*<0.01*	0.13	0.53	22	0.1	6.04	0.6	88	1.4
B00208478	Site 8	2.44	0.02	0.96	14.4	0.106	12.2	7.2	0.07	3.05	2.7	*<1*	*<0.3*	23	*<0.05*	0.28	0.09	1.1	0.04	0.13	0.57	40	0.2	6.33	0.5	99	1.4
B00208459	Site 9	3.33	0.03	0.09	6.4	0.105	10.8	5.1	0.8	1.49	2.7	*<1*	0.7	59.7	*<0.05*	0.31	*<0.05*	1.8	0.02	0.1	0.59	37	0.1	8.92	0.7	86	4.2
B00208461		4.03	0.02	*<0.05*	4.6	0.119	15	5.3	1.46	2.13	2.5	*<1*	0.6	40.9	*<0.05*	0.26	*<0.05*	1.6	*<0.01*	0.12	0.5	28	*<0.1*	6.87	0.6	77	3.5
B00208475	Site 10	3.28	0.02	0.59	4.3	0.147	48.7	10.3	0.25	7.59	3.2	2	*<0.3*	24.2	*<0.05*	0.22	0.13	2.2	0.01	0.28	0.69	23	0.3	4.1	0.4	74	3.1
B00208476		4.17	0.01	0.38	4	0.15	47.2	11.7	0.23	9.57	3.7	2	*<0.3*	19.1	*<0.05*	0.2	0.18	2.1	*<0.01*	0.3	0.62	18	0.3	3.37	0.3	77	2.8
B00208453	Site 11	3.77	0.02	0.68	3.8	0.108	14.6	8.9	0.24	2.7	1.8	*<1*	0.7	64.5	*<0.05*	0.25	0.1	1.8	0.05	0.14	0.84	20	0.3	6.67	0.5	40	5
B00208454		3.33	0.02	0.17	3.6	0.122	15.7	6.4	0.24	3.16	2.3	*<1*	0.7	21.2	*<0.05*	0.28	0.14	1.8	0.01	0.13	0.6	32	0.1	5.97	0.5	73	3.7
B00208455	Site 12	5.8	0.02	0.2	4.3	0.104	27.7	7.4	0.87	5.22	2.2	1	0.6	39.5	*<0.05*	0.2	0.06	1.8	0.01	0.29	0.5	24	1.1	4.97	0.4	63	3.6
B00208456		3.94	0.02	0.29	4.8	0.185	17	5.2	0.8	2.61	3.1	*<1*	0.6	70.6	*<0.05*	0.27	*<0.05*	1.5	0.06	0.1	0.64	29	0.2	7.14	0.6	69	5.8
B00208465	Site 13	3.27	0.03	0.24	4.8	0.108	10.6	4.6	0.73	1.6	3.1	*<1*	*<0.3*	37.8	*<0.05*	0.34	*<0.05*	1.9	0.02	0.07	0.6	35	0.2	8.83	0.7	78	4
B00208466		3.01	0.03	0.2	5.6	0.114	11.1	6.2	0.67	1.54	4.4	*<1*	0.4	37	*<0.05*	0.35	*<0.05*	2	0.05	0.1	0.62	46	0.2	8.54	0.7	83	4.7
B00208479	Site 14	3.73	0.03	0.08	6	0.133	11.6	4.6	0.86	1.44	2.9	*<1*	*<0.3*	31.9	*<0.05*	0.33	*<0.05*	1.8	0.02	0.11	0.55	38	0.1	8.65	0.7	85	4.2
B00208457	Site 15	3.31	0.03	0.1	6.4	0.109	16.8	5.4	1.19	1.89	2.6	*<1*	0.7	63.4	*<0.05*	0.29	*<0.05*	1.5	0.01	0.11	0.54	27	0.1	8.16	0.6	110	4.1
B00208458		3.63	0.03	0.09	4.9	0.135	16	5.1	0.82	1.79	2.8	*<1*	0.7	40	*<0.05*	0.3	*<0.05*	1.9	0.02	0.11	0.61	40	0.1	8.21	0.7	223	4.6
B00208464	Site 17	2.69	*<0*	0.19	9.8	0.108	36.3	10.9	0.11	2.55	2.3	2	*<0.3*	3.2	*<0.05*	0.15	0.07	1.4	*<0.01*	0.26	0.27	17	0.6	2.37	0.3	73	1.7
B00208462	Site 18	9.74	0.02	0.12	4.3	0.075	34.8	8.2	0.36	5.39	2.3	1	*<0.3*	32.5	*<0.05*	0.18	*<0.05*	1.9	0.01	0.21	0.64	24	0.2	3.3	0.3	55	3.4
B00208463		2.98	0.01	0.13	2.8	0.087	37	9.7	0.13	13.4	2	*<1*	*<0.3*	15	*<0.05*	0.18	0.19	2.1	*<0.01*	0.46	0.97	15	4.3	3.61	0.4	59	3.1
B00208474	Site 19	2.97	0.02	0.77	8.8	0.139	13.1	6	0.53	3.23	2.9	*<1*	*<0.3*	26.1	*<0.05*	0.36	0.08	1.9	0.01	0.1	0.71	28	0.2	8.5	0.8	90	7.2

Notes: 1. italicized values in blue font indicate values measured below the detection limit;
2. ACA = continental crust abundance values according to Price (1997); highlighted values are higher than three times the ACA.

APPENDIX F: SHAKE FLASK EXTRACTION RESULTS FOR OVERBURDEN SAMPLES FROM MINE SITE

PRETIVM

Appendix F. Shake Flask Extraction Results for Overburden Samples from Mine Site

Parameter	Reference Location	Volume Nanopure Water	Sample Weight	pH	Redox	Conductivity	Acidity (to pH 4.5)	Total Acidity (to pH 8.3)	Alkalinity	Chloride	Fluoride	Sulphate	Hardness
Units		*mL*	*g*		*mV*	*uS/cm*	*mg $CaCO_3$/L*	*mg $CaCO_3$/L*	*mg CaCO3/L*	*mg/L*	*mg/L*	*mg/L*	*mg $CaCO_3$/L*
B00208481	Site 2	750	250	6.5	458	170	#N/A	5.0	2.8	*<1*	*<0.06*	66	53.9
B00208469	Site 3	750	250	7.4	463	427	#N/A	2.3	17.4	*<1*	0.08	***182***	208
B00208471		750	250	7.1	432	135	#N/A	2.3	3.3	2	*<0.06*	52	49.9
B00208467	Site 4	750	250	6.1	560	117	#N/A	2.6	1.0	*<1*	*<0.06*	45	41.7
B00208468		750	250	7.5	444	82	#N/A	2.0	3.7	*<1*	0.11	26	31.9
B00208472	Site 5	750	250	7.5	427	55	#N/A	2.0	6.3	*<1*	*<0.06*	16	22.3
B00208473		750	250	7.9	428	109	#N/A	1.7	37.9	*<1*	0.06	12	49.5
B00208477	Site 6	750	250	5.3	599	16	#N/A	2.3	1.0	*<1*	*<0.06*	4	2.95
B00208451	Site7	750	250	5.7	509	78	#N/A	2.3	0.7	*<1*	0.06	26	25.4
B00208452		750	250	6.0	491	109	#N/A	2.2	1.1	*<1*	*<0.06*	37	41.3
B00208478	Site 8	750	250	6.3	518	9	#N/A	2.2	2.6	*<1*	*<0.06*	5	3.07
B00208459	Site 9	750	250	7.9	423	141	#N/A	2.5	44.0	*<1*	0.10	21	63.3
B00208461		750	250	7.8	464	139	#N/A	1.6	41.7	*<1*	*<0.06*	24	61.5
B00208475	Site 10	750	250	5.8	516	33	#N/A	2.6	1.5	*<1*	*<0.06*	9	6.97
B00208476		750	250	5.1	569	50	#N/A	2.8	2.8	*<1*	*<0.06*	15	11.4
B00208453	Site 11	750	250	8.0	430	185	#N/A	2.5	49.1	*<1*	0.16	38	82.6
B00208454		750	250	7.2	435	135	#N/A	2.4	4.1	*<1*	*<0.06*	50	51.5
B00208455	Site 12	750	250	7.5	432	436	#N/A	2.6	25.3	*<1*	0.09	***175***	198
B00208456		750	250	7.8	406	437	#N/A	2.9	58.0	*<1*	0.12	***145***	199
B00208465	Site 13	750	250	7.7	412	120	#N/A	3.0	56.1	*<1*	*<0.06*	4	57.5
B00208466		750	250	7.8	422	83	#N/A	2.5	38.2	*<1*	*<0.06*	4	39.7
B00208479	Site 14	750	250	7.6	457	81	#N/A	1.8	37.6	*<1*	*<0.06*	6	39.0
B00208457	Site 15	750	250	7.9	397	178	#N/A	2.5	48.1	*<1*	0.06	35	80.0
B00208458		750	250	7.9	425	182	#N/A	2.1	44.3	*<1*	0.07	41	80.6
B00208464	Site 17	750	250	6.8	466	33	#N/A	3.9	1.7	*<1*	*<0.06*	9	8.5
B00208462	Site 18	750	250	6.6	477	50	#N/A	3.2	2.0	*<1*	*<0.06*	14	15.2
B00208463		750	250	6.9	466	50	#N/A	4.0	2.0	*<1*	*<0.06*	15	16.7
B00208474	Site 19	750	250	7.5	474	105	#N/A	1.7	29.2	*<1*	0.10	17	48.2

Appendix F. Shake Flask Extraction Results for Overburden Samples from Mine Site

Parameter	Reference Location	Volume Nanopure Water	Dissolved Metals												
			Ag	Al	As	B	Ba	Be	Bi	Ca	Cd	Co	Cr	Cu	Fe
Units		*mL*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
B00208481	Site 2	750	0.000006	0.029	0.0018	0.0079	0.0524	0.000078	*<0.000007*	20.3	0.003024	0.0192	*<0.00003*	0.00743	0.011
B00208469	Site 3	750	0.000008	0.0054	0.0006	0.0127	0.0331	*<0.000007*	*<0.000007*	80.9	0.000087	0.000130	*<0.00003*	0.00131	*<0.007*
B00208471		750	0.000095	0.0025	0.0017	0.0128	0.0346	*<0.000007*	*<0.000007*	18.7	0.000343	0.00236	*<0.00003*	0.00077	*<0.007*
B00208467	Site 4	750	0.000074	0.0153	0.0071	0.0117	0.0714	0.000027	*<0.000007*	15.8	0.000496	0.00475	*<0.00003*	0.00198	*<0.007*
B00208468		750	0.000006	0.0211	0.0006	0.0115	0.00999	*<0.000007*	*<0.000007*	12.2	0.000007	0.000032	*<0.00003*	0.00072	0.021
B00208472	Site 5	750	0.000002	0.0135	0.0004	0.0133	0.0108	*<0.000007*	*<0.000007*	8.48	0.000005	0.000005	0.00003	0.00068	*<0.007*
B00208473		750	0.000002	0.0220	0.0006	0.0089	0.0192	*<0.000007*	*<0.000007*	19.1	0.000003	0.000016	*<0.00003*	0.00105	0.010
B00208477	Site 6	750	*<0.000002*	0.0325	0.0002	0.0111	0.0321	0.000019	*<0.000007*	1.06	0.000058	0.000425	*<0.00003*	0.00168	*<0.007*
B00208451	Site7	750	0.000032	0.0909	*<0.0002*	0.0095	0.0675	0.000037	*<0.000007*	9.63	0.000207	0.000680	*<0.00003*	0.00112	0.060
B00208452		750	0.000010	0.0732	0.0003	0.0090	0.0522	0.000022	*<0.000007*	15.7	0.000174	0.000787	0.00004	0.00124	0.029
B00208478	Site 8	750	0.000017	0.187	0.0008	0.0077	0.0368	0.000009	*<0.000007*	1.04	0.000027	0.000170	0.00018	0.00147	0.104
B00208459	Site 9	750	0.000006	0.0151	0.0006	0.0142	0.0209	*<0.000007*	*<0.000007*	24.2	*<0.000003*	0.000004	0.00004	0.00053	*<0.007*
B00208461		750	0.000002	0.0098	0.0003	0.0058	0.0121	*<0.000007*	*<0.000007*	24.0	0.000005	*<0.000004*	*<0.00003*	0.00048	*<0.007*
B00208475	Site 10	750	0.000004	0.0665	0.0002	0.0083	0.0713	0.000037	*<0.000007*	2.57	0.000230	0.00123	*<0.00003*	0.00354	*<0.007*
B00208476		750	0.000010	0.111	*<0.0002*	0.0083	0.0491	0.000048	*<0.000007*	4.18	0.000519	0.00157	*<0.00003*	0.00583	*<0.007*
B00208453	Site 11	750	0.000002	0.0331	0.0011	0.0127	0.0650	*<0.000007*	*<0.000007*	32.5	0.000005	0.000021	0.00004	0.00101	*<0.007*
B00208454		750	0.000003	0.0037	0.0003	0.0106	0.0305	*<0.000007*	*<0.000007*	19.8	0.000103	0.000076	*<0.00003*	0.00077	*<0.007*
B00208455	Site 12	750	*<0.000002*	0.0063	0.0006	0.0161	0.0275	*<0.000007*	*<0.000007*	78.0	0.000012	0.000059	0.00004	0.00230	*<0.007*
B00208456		750	0.000003	0.0055	0.0004	0.0103	0.0251	*<0.000007*	*<0.000007*	77.4	0.000022	0.000174	*<0.00003*	0.00071	*<0.007*
B00208465	Site 13	750	0.000006	0.0346	0.0007	0.0101	0.0475	*<0.000007*	*<0.000007*	22.5	0.000009	0.000029	*<0.00003*	0.00156	0.014
B00208466		750	0.000003	0.0214	*<0.0002*	0.0082	0.0247	*<0.000007*	*<0.000007*	15.6	0.000003	0.000007	*<0.00003*	0.00053	*<0.007*
B00208479	Site 14	750	0.000004	0.0207	0.0005	0.0055	0.0321	*<0.000007*	*<0.000007*	15.2	0.000005	0.000012	0.00008	0.00135	0.010
B00208457	Site 15	750	0.000002	0.0215	0.0007	0.0768	0.0350	*<0.000007*	*<0.000007*	31.1	0.000008	0.000009	0.00009	0.00144	0.010
B00208458		750	0.000002	0.0111	0.0005	0.0247	0.0131	*<0.000007*	*<0.000007*	31.6	*<0.000003*	0.000004	0.00008	0.00050	*<0.007*
B00208464	Site 17	750	0.000003	0.0279	*<0.0002*	0.0117	0.0479	0.000010	*<0.000007*	3.02	0.000086	0.000551	*<0.00003*	0.00134	*<0.007*
B00208462	Site 18	750	0.000004	0.0389	*<0.0002*	0.0164	0.0706	0.000028	*<0.000007*	4.73	0.000120	0.00243	*<0.00003*	0.00323	*<0.007*
B00208463		750	0.000014	0.0232	*<0.0002*	0.0117	0.0356	0.000019	*<0.000007*	5.40	0.000216	0.000380	*<0.00003*	0.00225	*<0.007*
B00208474	Site 19	750	0.000003	0.0378	0.0006	0.0049	0.0233	*<0.000007*	*<0.000007*	18.4	0.000009	0.000021	*<0.00003*	0.00133	0.017

Appendix F. Shake Flask Extraction Results for Overburden Samples from Mine Site

Parameter	Reference Location	Volume Nanopure Water	Dissolved Metals													
			Hg	K	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Se	Si
Units		*mL*	*ug/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
B00208481	Site 2	750	*<0.01*	2.18	0.00840	0.768	4.31	0.00108	0.44	0.0106	0.003	0.00160	22.4	0.0003	0.00074	2.32
B00208469	Site 3	750	*<0.01*	1.71	0.000427	1.39	0.309	0.00049	0.87	0.0004	0.065	0.00212	64.0	0.0021	0.00043	0.88
B00208471		750	0.01	0.656	0.00304	0.758	2.97	0.00013	1.30	0.0013	0.069	0.00011	19.3	0.0005	0.00051	2.92
B00208467	Site 4	750	0.10	1.16	0.000893	0.534	1.73	0.00014	0.83	0.0027	0.058	0.00265	15.2	0.0003	0.00104	3.22
B00208468		750	*<0.01*	0.406	0.000135	0.328	0.0366	0.00021	0.87	0.0002	0.062	0.00146	9.8	0.0004	0.00114	1.68
B00208472	Site 5	750	*<0.01*	0.371	0.000309	0.271	0.00149	0.00009	0.54	0.0005	0.063	0.00002	5.7	0.0002	0.00035	0.83
B00208473		750	*<0.01*	0.596	0.000168	0.409	0.00458	0.00045	0.53	0.0004	0.064	0.00005	5.1	0.0004	0.00022	0.63
B00208477	Site 6	750	*<0.01*	0.345	0.000682	0.073	0.167	0.00003	0.30	0.0004	0.007	0.00057	1.4	*<0.0002*	0.00006	0.48
B00208451	Site7	750	*<0.01*	0.897	0.00140	0.322	0.715	0.00150	0.50	0.0011	0.136	0.00022	9.0	*<0.0002*	0.00039	0.80
B00208452		750	*<0.01*	0.889	0.000916	0.488	0.717	0.00109	0.44	0.0009	0.139	0.00021	14.0	*<0.0002*	0.00053	1.06
B00208478	Site 8	750	*<0.01*	0.176	0.000074	0.113	0.105	0.00002	0.54	0.0006	0.014	0.00027	0.5	*<0.0002*	0.00018	0.94
B00208459	Site 9	750	*<0.01*	0.843	0.00157	0.730	0.00071	0.00593	0.55	*<0.0001*	*<0.003*	0.00002	8.6	0.0010	0.00016	0.80
B00208461		750	*<0.01*	0.489	0.000902	0.379	0.00055	0.00642	0.48	*<0.0001*	*<0.003*	0.00006	8.7	0.0008	0.00018	0.54
B00208475	Site 10	750	*<0.01*	0.912	0.00130	0.137	0.258	0.00016	0.54	0.0011	0.008	0.00007	3.6	*<0.0002*	0.00014	0.96
B00208476		750	*<0.01*	1.16	0.00240	0.233	0.390	0.00006	0.72	0.0024	0.008	0.00013	5.4	*<0.0002*	0.00016	1.10
B00208453	Site 11	750	*<0.01*	2.05	0.000334	0.318	0.0187	0.00266	0.79	*<0.0001*	0.022	*<0.00001*	14.6	0.0013	0.00046	0.91
B00208454		750	*<0.01*	0.972	0.00104	0.508	0.211	0.00092	0.73	0.0005	*<0.003*	0.00013	17.9	*<0.0002*	0.00022	0.80
B00208455	Site 12	750	*<0.01*	1.84	0.00101	0.777	0.0780	0.00103	0.52	0.0002	*<0.003*	*<0.00001*	63.6	0.0010	0.00040	0.74
B00208456		750	*<0.01*	1.16	0.00156	1.47	0.527	0.00062	1.36	0.0001	0.004	*<0.00001*	54.0	0.0004	0.00055	0.71
B00208465	Site 13	750	*<0.01*	0.645	0.000593	0.296	0.0155	0.00119	0.37	0.0003	0.070	0.00002	1.7	0.0005	0.00009	1.04
B00208466		750	*<0.01*	0.451	0.000795	0.207	0.00005	0.00160	0.42	0.0002	0.058	0.00001	1.4	0.0005	0.00014	0.89
B00208479	Site 14	750	*<0.01*	0.426	0.000717	0.246	0.00057	0.00232	0.50	*<0.0001*	0.005	0.00123	1.7	0.0006	0.00015	0.80
B00208457	Site 15	750	*<0.01*	0.673	0.000953	0.555	0.00181	0.00365	0.70	*<0.0001*	*<0.003*	0.00007	13.4	0.0013	0.00016	1.11
B00208458		750	*<0.01*	0.544	0.00135	0.404	0.00028	0.00357	0.56	*<0.0001*	*<0.003*	*<0.00001*	15.4	0.0008	0.00019	0.66
B00208464	Site 17	750	*<0.01*	0.914	0.000606	0.241	0.185	0.00041	0.27	0.0016	0.078	0.00006	3.6	*<0.0002*	0.00013	0.84
B00208462	Site 18	750	*<0.01*	0.793	0.00191	0.819	0.315	0.00233	0.36	0.0010	0.063	0.00010	5.8	*<0.0002*	0.00007	0.80
B00208463		750	0.04	0.778	0.00223	0.776	0.307	0.00075	0.39	0.0011	0.068	0.00007	6.0	*<0.0002*	0.00004	0.72
B00208474	Site 19	750	*<0.01*	0.596	0.000379	0.519	0.00225	0.00107	0.51	*<0.0001*	*<0.003*	*<0.00001*	6.9	0.0007	0.00017	1.49

Appendix F. Shake Flask Extraction Results for Overburden Samples from Mine Site

Parameter	Reference Location	Volume Nanopure Water	Dissolved Metals								Ion Balance			
			Sn	Sr	Ti	Tl	U	V	Zn	Zr	Major Anions	Major Cations	Difference	Balance (%)
Units		*mL*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*meq/L*	*meq/L*	*meq/L*	*%*
B00208481	Site 2	750	0.00004	0.148	*<0.00005*	0.000150	0.000015	0.00003	0.199	*<0.002*	1.43	1.32	0.11	4.2%
B00208469	Site 3	750	0.00002	0.311	*<0.00005*	0.000062	0.000011	0.00003	0.001	*<0.002*	4.15	4.25	-0.10	-1.2%
B00208471		750	0.00001	0.127	*<0.00005*	0.000048	0.000003	0.00003	0.004	*<0.002*	1.21	1.18	0.03	1.1%
B00208467	Site 4	750	*<0.00001*	0.179	*<0.00005*	0.000417	0.000009	0.00003	0.006	*<0.002*	0.96	0.97	-0.01	-0.4%
B00208468		750	0.00004	0.130	0.00168	0.000046	0.000003	0.00017	*<0.001*	*<0.002*	0.63	0.69	-0.07	-5.1%
B00208472	Site 5	750	0.00004	0.0268	0.00008	0.000011	0.000003	0.00005	*<0.001*	*<0.002*	0.47	0.48	-0.02	-2.0%
B00208473		750	0.00003	0.0520	0.00014	0.000011	0.000012	0.00006	*<0.001*	*<0.002*	1.02	1.03	-0.01	-0.6%
B00208477	Site 6	750	0.00001	0.00408	*<0.00005*	0.000041	0.000006	0.00004	0.007	*<0.002*	0.10	0.09	0.01	6.3%
B00208451	Site7	750	0.00003	0.0222	0.00006	0.000073	0.000010	0.00004	0.012	*<0.002*	0.57	0.59	-0.02	-1.7%
B00208452		750	0.00009	0.0299	0.00031	0.000054	0.000028	0.00005	0.004	*<0.002*	0.81	0.90	-0.09	-5.5%
B00208478	Site 8	750	0.00002	0.00398	0.00264	0.000013	0.000037	0.00023	0.002	*<0.002*	0.16	0.12	0.04	13.0%
B00208459	Site 9	750	*<0.00001*	0.0830	0.00018	0.000010	0.000090	0.00005	*<0.001*	*<0.002*	1.32	1.32	0.00	0.1%
B00208461		750	0.00006	0.0566	*<0.00005*	0.000010	0.000045	0.00004	*<0.001*	*<0.002*	1.33	1.26	0.07	2.7%
B00208475	Site 10	750	*<0.00001*	0.0129	*<0.00005*	0.000090	0.000010	0.00003	0.021	*<0.002*	0.22	0.20	0.01	3.1%
B00208476		750	*<0.00001*	0.0225	0.00007	0.000151	0.000021	0.00003	0.067	*<0.002*	0.37	0.32	0.05	7.5%
B00208453	Site 11	750	0.00001	0.0999	0.00019	0.000021	0.000062	0.00005	*<0.001*	*<0.002*	1.78	1.74	0.04	1.1%
B00208454		750	0.00004	0.0517	*<0.00005*	0.000037	0.000005	0.00004	0.002	*<0.002*	1.12	1.10	0.02	1.1%
B00208455	Site 12	750	0.00003	0.145	0.00005	0.000074	0.000016	0.00005	*<0.001*	*<0.002*	4.16	4.04	0.12	1.5%
B00208456		750	*<0.00001*	0.180	*<0.00005*	0.000035	0.000058	0.00004	*<0.001*	*<0.002*	4.19	4.10	0.09	1.1%
B00208465	Site 13	750	0.00004	0.0474	0.00032	0.000008	0.000063	0.00008	*<0.001*	*<0.002*	1.21	1.19	0.02	0.9%
B00208466		750	0.00013	0.0398	*<0.00005*	0.000006	0.000022	0.00005	*<0.001*	*<0.002*	0.85	0.83	0.02	1.5%
B00208479	Site 14	750	0.00006	0.0399	0.00014	0.000009	0.000031	0.00005	*<0.001*	*<0.002*	0.88	0.82	0.06	3.6%
B00208457	Site 15	750	*<0.00001*	0.0802	0.00019	0.000014	0.000082	0.00008	*<0.001*	*<0.002*	1.69	1.67	0.02	0.7%
B00208458		750	*<0.00001*	0.0718	*<0.00005*	0.000008	0.000054	0.00005	*<0.001*	*<0.002*	1.74	1.66	0.09	2.5%
B00208464	Site 17	750	0.00003	0.0085	*<0.00005*	0.000048	0.000002	0.00002	0.007	*<0.002*	0.23	0.22	0.01	2.1%
B00208462	Site 18	750	0.00003	0.0285	*<0.00005*	0.000070	0.000014	0.00003	0.013	*<0.002*	0.34	0.36	-0.03	-3.6%
B00208463		750	0.00004	0.0377	*<0.00005*	0.000097	0.000008	0.00001	0.014	*<0.002*	0.36	0.39	-0.03	-4.1%
B00208474	Site 19	750	*<0.00001*	0.0590	0.00021	0.000007	0.000013	0.00008	*<0.001*	*<0.002*	0.94	1.00	-0.06	-3.1%

Appendix 9-2. Additional Management Plans Per Other Provincial Authorizations and Requirements

Appendix 9-2-1. Chromium Management Plan

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Chromium Management Plan

Date: February 14, 2023

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VERSION CONTROL

Revision #	Date Released	Amendment
0		
1	September 14, 2016	Incorporation of new kinetic test results and Cr monitoring plans
2	February 23, 2017	Revised based on MEM/MOE comments
3	March 13, 2019	3800 tpd amendment
4	February 14, 2023	Cover page update and general updates to entire document.

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BRUCEJACK MINE
Chromium Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Cr	Chromium
CMP	Chromium Management Plan
Cr (III)	Trivalent chromium
Cr (VI)	Hexavalent chromium
CWP	Contact Water Pond
D-Cr	Dissolved chromium
FWAL	Freshwater Aquatic Life
T-Cr	Total chromium
SOP	Standard Operating Procedure
WTP	Water Treatment Plant

1 PURPOSE

The purpose of this Chromium Management Plan (CMP) is to provide guidance for Pretium Resources Inc. (Pretium) on how to avoid, minimize and otherwise mitigate the release of hexavalent chromium [Cr(VI)] to the receiving environment. Hexavalent Cr is expected to leach from paste backfill cement and to a lesser degree from shotcrete used during mining operations. This plan aims to: 1) document the potential risk to the environment; 2) describe the monitoring plan for ensuring that the environmental risks are minimized; and 3) outline a plan for identifying and implementing mitigation.

2 SCOPE

The CMP is intended to provide guidance for managing the release of hexavalent Cr from cement in the Brucejack Mine underground workings. It is focused on the generation and placement of cemented paste tailings as backfill in underground workings during the Operation phase of the Brucejack Mine. The proposed mitigation and monitoring for managing the release of hexavalent Cr is also applicable to the generation and use of shotcrete and grout in underground workings.

This Plan is intended to meet regulatory requirements related to Cr at the Brucejack Mine. Effluent Permit 107835 (PE-107835) issued under the provisions of the *Environmental Management Act* for the Brucejack Mine requires that British Columbia Freshwater Aquatic Life water quality guidelines be met at the outlet of Brucejack WRTSF (i.e., 9 µg/L for total trivalent Cr [Cr(III)] and 1 µg/L for total hexavalent Cr [Cr(IV)]). The permit stipulates that actions as outlined in this plan are required if any of the following occurs: 1) dissolved Cr (D-Cr) in water treatment plant (WTP) influent exceeds 10 µg/L, 2) total Cr (T-Cr) in WTP effluent exceeds 20 µg/L, or 3) D-Cr at Brucejack WRTSF outlet (BJ 3.10) exceeds 1 µg/L.

3 INTRODUCTION

In recent years, the release of hexavalent Cr from cement has been identified as a potential environmental concern (e.g., Tarik and Yanful, 2013). However, the potential risks associated with hexavalent Cr are not widely recognized in the context of cemented paste backfill, which is otherwise regarded as a best practice option for tailings disposal. There is little published information on the risks associated with Cr release from cemented paste backfill at mine sites, and best management practices are not yet widely disseminated. Consequently, Pretium has determined that the release of hexavalent Cr warrants careful evaluation and an adaptive management strategy, to incorporate relevant information as it becomes available, and to develop appropriate management practices for the Brucejack Mine.

Underground mine operations at the Brucejack Mine will result in the leaching of Cr from cement contained within paste backfill. Depending on the cement fabrication process, cement can contain up to 30 ppm of hexavalent Cr, which is the water-soluble form of Cr under circum-neutral pH conditions (Kronos ecochem, 2011). Additional leaching of hexavalent Cr may also occur in localized areas within the underground mine as a result of extensive use of shotcrete and/or grout.

While the WTP is expected to remove trivalent Cr, which will also be present, the WTP will not be effective at removing hexavalent Cr. Consequently, without some other form of mitigation, it is possible

that hexavalent Cr, originating from cement, could pass through the WTP, into Brucejack WRTSF, and ultimately into Brucejack Creek.

Significant work has been carried out by Pretium and its consultants to evaluate the potential risks associated with cement-derived Cr(VI) at the Brucejack Mine site. This work has included the following:

- Initiation of static and kinetic testwork on cement and paste materials to identify the source(s) and speciation of Cr;
- Assessment of the expected water treatment plant removal efficiency for various species of Cr;
- Research on Cr leaching behaviour and associated best management practices; and
- Assessment of potential environmental effects

The following sections summarize Cr sources and mitigation options, the results of experimental programs developed, the monitoring programs initiated and adaptive management measures that will be implemented to limit the concentration of hexavalent Cr in mine water. A preliminary framework for implementation of the Plan is also provided. This Plan will be routinely updated as relevant information becomes available and management practices are refined.

4 CHROMIUM SOURCES AND CONTROLS

4.1 OVERVIEW

Cement will be introduced into the underground workings at the Brucejack Mine in cemented paste backfill, shotcrete and grout. It is estimated that up to 50% of ore process tailings will be mixed into cemented paste, which will be deposited in mined-out underground workings. A total of up to 8.7 million tonnes of cemented paste backfill will be generated through life of mine. The paste backfill is expected to include approximately 3.9% cement, although some high-strength paste with cement content of 10%, and low strength paste with 2% cement, will also be generated. Shotcrete and grout are also used in the underground workings to stabilize the workings, and to plug drill holes to minimize the volume of groundwater entering the workings.

Cr is present in the raw materials used to make cement (e.g., fuels, refractory brick, grinding media), and may also be introduced in the manufacturing process from other materials including gypsum, pozzolans, ground granulated blast furnace slag, mineral components, cement kiln dust and set regulators (Hills & Johansen, 2007). Much of the Cr in these materials typically occurs as Cr(III), which is stable with low solubility and low reactivity (Hills & Johansen, 2007). While cemented paste backfill is generally an effective method for the stabilization of heavy metals including Cr (Wilk, 1997), some Cr(III) is typically oxidized to Cr(VI) in the cement kiln and the finish mill. Cr(VI) is unstable, and water soluble. Consequently, Cr(VI) is leached when cement is hydrated.

Based on discussions with potential cement suppliers, the commercial cement available in British Columbia typically contains 25-50 parts per million (ppm) Cr. Lafarge Canada, a supplier of cement for the Brucejack Project, has indicated that the typical Cr content in their cement is approximately 25

ppm, and that this originates from raw materials (Dalkie, M. Pers. Comm., 2015). No additional Cr is added in Lafarge's cement manufacturing process.

4.2 CHROMIUM AT BRUCEJACK MINE

4.2.1 Chromium in Mine Water

Predicted Cr concentrations of Brucejack mine water throughout the Operations phase have been estimated based on the results of humidity cell (HC) tests on paste backfill materials. Initial results from HC37, as described in Section 4.6.4.2 of the MA & EMA Permits Application, resulted in water quality predictions in the receiving environment that exceed the BC FWAL Cr(VI) guideline of 1 µg/L.

Paste samples used in the initial humidity cell tests (HC37) were prepared by Rheological Consulting Services Pty Ltd. (RCS) of Melbourne, Australia, for the purpose of evaluating the suitability of Brucejack tailings for generation of paste backfill. The cement used in the paste sample was Australian general purpose (GP) cement. The cement comprised 4 wt% (dry basis) of the tailings sample (RCS, 2013). The Cr content of the cement was not reported; however, Cr concentrations were determined for raw paste (i.e., tailings) (303 ppm Cr) and a cemented paste backfill sample (250 ppm Cr).

Humidity cell testing was undertaken using a crushed, composite sample of cemented paste backfill. The composite sample was found to have an inferred cement content of approximately 6% (by comparing the Ca content of uncemented and cemented paste, determined from aqua regia and Sobek NP analysis). The test involved placement of a crushed 1 kg sample of the cemented paste backfill sample in a short cylinder, rinsing of the sample with 0.5 L of water once a week, and analysis of the leachate for anions and metals. The results indicated that soluble Cr is readily leached out of the cemented paste backfill materials. The concentrations predicted in the underground workings and the receiving environment as presented in the 2015 MA & EMA Permits Application are based on these results, but scaled for grain size, permeability and temperature to take into account laboratory and experimental conditions. The concentration of Cr leached from cemented paste is anticipated to be mainly the water-soluble Cr(VI) species. The actual concentration of Cr(VI) in leachate from this humidity cell tests was not measured, but for the purpose of modeling it was assumed that all of the Cr released was in the hexavalent form.

Subsequent humidity cell test work was initiated in 2015 to further assess the anticipated Cr(VI) loads released to mine water. The 2015 experiments were carried out on Brucejack tailings generated from metallurgical tests on the 2012-2013 Bulk Sample and cement from a local supplier (Lafarge Canada). The results (presented in Section 5.1) confirm that soluble Cr(VI) is expected to leach from paste backfill; however, the estimated amount of Cr(VI) released to mine water is significantly lower than originally anticipated.

4.2.2 Chromium in the Brucejack Receiving Environment

The water quality model developed for Brucejack Mine generates predictions for T-Cr and D-Cr, based on a site-specific water balance model and geochemical source terms (refer to Sections 7.1.3 and 4.6 of the Permit Application). Water quality predictions are generated for two key receiving environment locations: BJ 3.10, located near the outlet of Brucejack WRTSF; and BJ 2.62, located in

Brucejack Creek, approximately 700 m downstream of the WRTSF outlet. Effluent is currently regulated at BJ 3.10 under PE- 107835. The water quality predictions were most recently updated for Pretium's 3800 tpd Amendment Application for Permits M-243 and PE-107835 (approved on December 14th, 2018).

Updated Base Case and Upper Case T-Cr predictions at BJ 3.10 are presented in Figure 4-1, as compared to the BC FWAL guideline for hexavalent Cr. Base Case is considered to represent the expected case while Upper Case incorporates conservative geochemical source terms. The updated predictions incorporate revisions to the site water balance and the results of 2015 kinetic test data (Section 5.1) with appropriate scaling factors accounting for temperature, grain size and contact water applied. No mitigation has been applied to the predictions presented.

Based on these results, Cr concentrations are expected to remain below the hexavalent Cr guideline of 1 µg/L throughout mine life (maximum Base Case T-Cr = 0.6 µg/L). However, if an Upper Case scenario was realized, then mitigation measures could be implemented to reduce Cr(VI) concentrations if it became necessary. Cr concentrations are expected to decrease rapidly during the Closure phase once paste backfill placement has ceased. The potential mitigation options and the results of follow-up test work are summarized in the sections below.

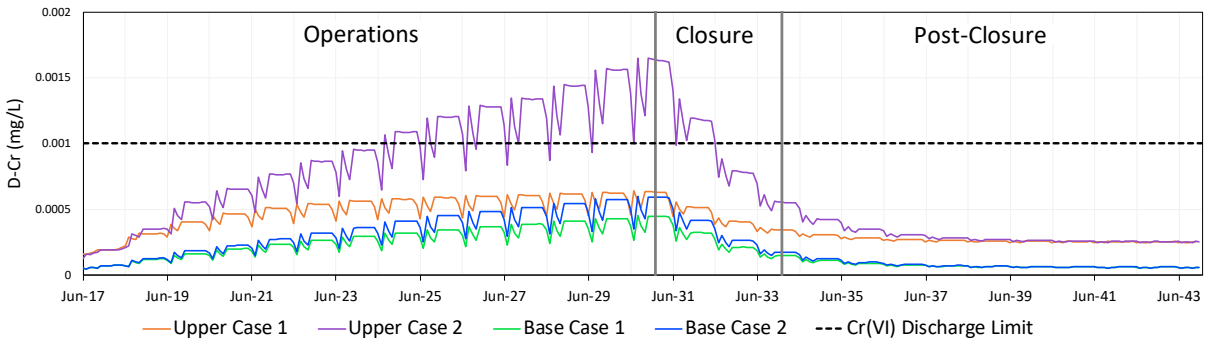

Figure 4-1: Upper Case and Base Case dissolved Cr concentration predictions at BJ 3.10 (Brucejack WRTSF outlet) through Operations, Closure and Post-Closure mine phases for mine plan Scenarios 1 and 2 (Scenario 1 assumes that all waste rock is placed in Brucejack WRTSF; Scenario 2 assumes that ~40% is placed in Brucejack WRTSF with the remainder placed as backfill in the underground mine). Results are compared to the BC FWAL maximum guideline for Cr(VI) (1 µg/L).

4.3 MITIGATION OPTIONS

Controlling potential contaminants at the source is best practice. Mitigation of Cr(VI) can be achieved through refinement of source control measures or through various treatment options. Source control measures could include minimizing the amount of paste or shotcrete that comes into contact with mine water; whereas treatment options would involve the addition of a reducing agent (e.g., ferrous sulphate) to convert any soluble Cr(VI) to Cr(III) (Qin et. al, 2005; Hills and Johansen, 2007; Kronos ecochem, 2011; Chang, 2001). Four potential treatment options have been identified for Brucejack Mine:

(i) A reducing agent (such as ferrous sulphate) can be added in the cement manufacturing process;

(ii) A reducing agent can be added in the process of making cemented paste backfill;

(iii) A reducing agent can be added to mine water underground; or

(iv) Alternatively, a treatment train can be added to the WTP to reduce Cr(VI) to Cr(III).

Experience from other jurisdictions indicates that the addition of a reducing agent such as ferrous sulphate is an effective method for reducing Cr(VI) to Cr(III), such that the Cr(VI) concentration is reduced by more than an order of magnitude, which will be protective of the receiving environment.

Based on conversations with cement suppliers, it is not currently feasible to purchase a ferrous sulphate-amended cement product that could be used for cemented paste backfill production (option (i) identified above); however, a ferrous sulphate-amended shotcrete product is available. Experimental test programs were therefore developed to assess the amended shotcrete product, and the efficacy of ferrous sulphate addition to both the tailings-cement mixture (mitigation option (ii)) and mine water directly (option (iii)). In the event that these mitigation options were not effective, option (iv) would be considered.

5 EXPERIMENTAL TEST PROGRAMS

The sections below describe the experimental programs developed to evaluate the efficacy of the mitigation strategies identified in Section 4.3: the addition of ferrous sulphate to cemented paste backfill to prevent leaching of soluble Cr(VI), and the addition of ferrous sulphate to mine water should elevated Cr(VI) concentrations be encountered. The results of test work carried out on ferrous sulphate-amended shotcrete are also summarized in the final section.

5.1 TAILINGS AND PASTE BACKFILL CEMENT TESTS

As per conditions outlined in prior versions of *Mines Act* Permit M-243, Pretium developed a geochemical program to evaluate the leaching potential of hexavalent Cr from cemented paste backfill, which included the initiation of a series of humidity cell test experiments. These experiments were initiated in 2015 and used tailings materials generated from metallurgical test work carried out on ore extracted during the 2012-2013 Bulk Sample Program and cement from Lafarge Canada (in representative proportions). These materials were well characterized in terms of their total Cr and hexavalent contents.

The main goals of the 2015 experiments were:

1. To confirm the 2013 humidity cell test results, along with the associated water quality predictions, using more representative materials (Lafarge cement and tailings generated from more recent metallurgical tests);

2. To determine the speciation of Cr leached from the cemented paste; and

3. To evaluate whether the addition of ferrous sulphate to the paste backfill results in a reduction in the amount of hexavalent Cr leached.

Thickened tailings, derived from metallurgical tests carried out on ore extracted during the 2012-2013 Bulk Sample Program, were used for the development of the 2015 kinetic test program, whereas the tailings used in the 2013 kinetic test program were generated from an earlier series of metallurgical tests. The tailings used in the 2015 program are considered to be more representative of the tailings that will be generated during Operations. Another notable difference between the material used in the initial kinetic programs, is the cement. The 2013 program used Australian General Purpose (GP) cement, whereas the 2015 program used 'Portlandite L10' from Lafarge Canada.

The cement and tailings materials were characterized in terms of Cr speciation and concentrations, the results of which are presented in the following section. A summary of the different humidity cell tests that were initiated is provided in Table 5-1. The program consisted of seven humidity cells, including a tailings control test (T5) composed of tailings as received from the 2012-2013 Bulk Sample Program. The other six humidity cells were comprised of paste tailings with 3.9% cement (by mass), which represents the anticipated typical composition of paste backfill at the Brucejack Mine. T12 (and duplicate T15) represented the unmitigated cemented paste backfill case, whereas the other tests had variable amounts of ferrous sulphate ($FeSO_4 \cdot 7H_2O$) added. Specifically, T13 (and duplicate T16) included an amount of ferrous sulphate representing 0.2% of cement, 2 times the requisite amount based on stoichiometry and the measured Cr content of the cement (67 ppm Cr). T14 (and duplicate T17) included an amount of ferrous sulphate representing 1% of the cement, 10 times the stoichiometrically-determined amount. In this manner, the effect of ferrous sulphate on reducing Cr leaching could be assessed for different dosages.

Table 5-1: Summary of 2015 Tailings Kinetic Tests used to Evaluate Cr Leaching and Mitigation Options

Kinetic Test ID	Test Description	Sample Description			
		Portlandite L10 (Ca(OH)) (% by mass)	Ferrous Sulphate ($FeSO_4 \cdot 7H_2O$)	Particle Size	Dry Wt. (kg)
T5	tailings only	-	-	as received	1
T12	paste with 3.9% cement	3.9%	-	-1/4"	0.8
T13	cemented paste + 0.2% ferrous sulphate	3.9%	0.2% of cement Cr content (2× excess)	-1/4"	0.8
T14	cemented paste + 1% ferrous sulphate	3.9%	1% of cement Cr content (10× excess)	-1/4"	0.8
T15	duplicate of T12				
T16	duplicate of T13				
T17	duplicate of T14				

Ferrous sulphate granules were ground to a powder and mixed with the dry cement prior to mixing the cement with the tailings. Proportions of cement and iron sulphate added to the test samples were derived assuming a tailings solids content of 65% (by mass). The cemented paste samples were

spread on individual silicon baking sheets and cured for 28 days before being crushed to -1/4" and placed in the humidity cells.

The humidity cells were constructed and operated according to the MEND procedure described by Price (2009). Each test consisted of an acrylic cylinder measuring 21 cm in diameter by 10.5 cm in height and fitted with an acrylic perforated disk and nylon mesh. The humidity cells were closed at the surface and fitted with one standard port near the top of the cylinder. The tests were operated at room temperature (20-22°C) and the contents subjected to weekly cycles of three days of humid air followed by three days of dry air before being stirred and flushed with 500 mL of distilled water. The weekly leachates were collected and analysed for pH, conductivity, alkalinity, hardness, sulphate, dissolved metals and dissolved hexavalent Cr.

The full set of static test results for the 2015 thickened tailings samples (T-Tails-1) and the Lafarge cement is presented in Appendix 4.6-1 of the Pretium Brucejack 2015 Mines Act and EMA Permits Annual Report. A summary of the Cr concentrations for the 2015 kinetic test materials and the original 2013 kinetic test materials is presented in Table 5-2. Of particular note, are the lower Cr concentrations of the tailings (11 ppm) and cemented tailings (67 ppm) used in the 2015 program compared to the materials used in the original tests (303 ppm). As previously mentioned, the tailings used in the 2015 program are derived from the 2012-2013 Bulk Sample Program and are considered more representative of the tailings that will be produced during Operations at the Brucejack Mine, while the material used in the 2013 test was from a preliminary metallurgical test. Solid phase element determination of the Lafarge Portlandite L10 cement which will be sourced for the production of cemented paste backfill indicates that the cement comprises 57 to 67 ppm Cr, with 86% indicated to be in the hexavalent form (Table 5-2; Appendix 4.6-1-8 of the 2015 Annual Report).

Table 5-2: Chromium Concentrations in Tailings, Cement and Kinetic Test Sub-samples

Test Description	Kinetic Test ID	T-Cr	Cr(VI)
		ppm	ppm
2015 Tailings Program			
tailings only	T5	11	ND
Lafarge Portlandite L10 cement	NA	67	ND
Lafarge Portlandite L10 cement	NA	57	49
paste with 3.9% cement	T12 (T15)	54	ND
cemented paste + 0.2% ferrous sulphate	T13 (T16)	62	ND
cemented paste + 1% ferrous sulphate	T14 (T17)	78	ND
2013 Tailings Program			
raw paste (tailings only)	T4	303	ND
Australian general purpose (GP) cement	NA	ND	ND
paste with 4% GP cement	HC37	250	ND

Notes: NA = not applicable; ND = no data

The lower Cr concentrations of the 2015 program materials are reflected in the leachate results from the new cemented paste kinetic tests (Figure 5-1). Dissolved Cr concentrations in leachate generated from duplicate crushed samples (T12 and T15) are significantly lower than the original humidity cell

test (HC37), which was assessed using the same analytical approach. The initial flush of Cr in the 2015 testwork is lower by a factor of nearly two and decreases by two orders of magnitude over the tested time period. Chromium speciation analysis of the leachate indicates that essentially all of the Cr is present in the hexavalent form (Figure 5-2).

Evaluation of the cemented paste backfill tests dosed with ferrous sulphate indicates that the addition of ferrous sulphate at the higher dose (an amount representing 1% of the cement by mass or an estimated Fe(II) to Cr(VI) ratio of 30) resulted in a reduction of hexavalent Cr by two orders of magnitude during the initial weeks of kinetic testwork (Figure 5-2). The reduction in Cr(VI) is consistent with the low initial pH of these columns (~3 to 4) (lower plot in Figure 5-2). The influence of pH on the oxidation and reduction reactions of Cr is a complex process; however, in general, high pH values enhance the oxidative power (and solubility of Cr(VI)) while low pH values enhance reduction reactions (and the solubility of Cr(III)) (Dhal et al., 2013). As such, under acidic conditions, Cr exists in the trivalent state as soluble $Cr(OH)^{2+}$ (Erdem et al., 2011). This explains why the T-Cr concentrations are similar between all paste backfill tests, with the only significant differences being the relative abundances of Cr(III) and Cr(VI). As discussed, trivalent Cr is not a concern as it will be treated by the WTP.

The kinetic tests composed of cemented paste backfill with a lower dose of ferrous sulphate (i.e., 0.2% of the cement by mass or an estimated Fe(II) to Cr(VI) ratio of 6) did not show Cr(VI) reduction, indicating that insufficient reductant was added (Figure 5-2). Should this mitigation option be implemented, it will be critical to ensure that sufficient ferrous sulphate is added to the cemented paste backfill mixture.

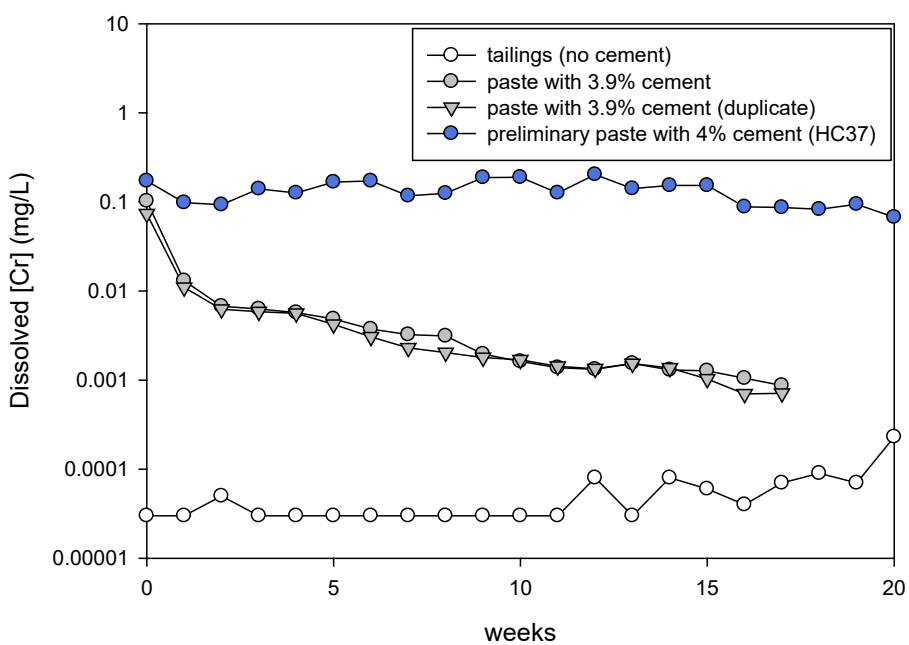

Figure 5-1: Dissolved Cr concentrations in leachate from cemented paste of the 2015 kinetic test program compared to Cr concentrations in leachate from cemented paste of the 2013 tailings kinetic program (HC37).

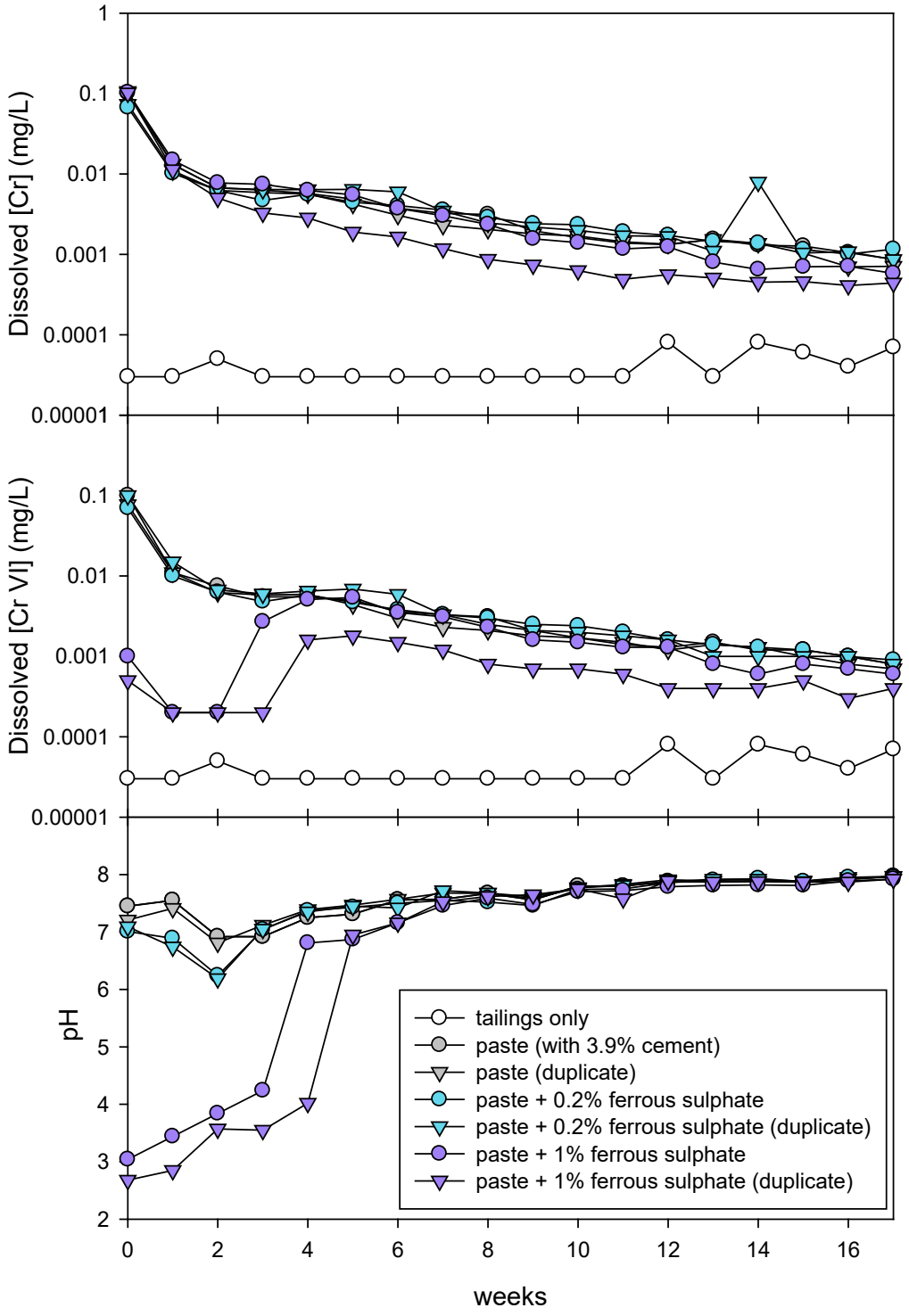

Figure 5-2: Kinetic test time series showing changes in dissolved Cr, hexavalent Cr and leachate pH for tailings, paste and ferrous sulphate-amended paste samples from the 2015 tailings program humidity cells.

5.2 UNDERGROUND MINE WATER

A series of experiments were developed to assess whether direct treatment of mine water with ferrous sulphate ($FeSO_4$) is an effective mitigation option for hexavalent Cr in underground mine water. This mitigation could be implemented as necessary to individual areas within the underground mine where elevated Cr concentrations are encountered (e.g., individual sumps). The experimental approach and the full set of results are described in a separate report (Lorax, 2019). A summary of the results relevant to Cr management are presented below.

The experiments were carried out using underground mine water spiked with variable amounts of hexavalent Cr, yielding Cr(VI) concentrations ranging from 300 to 1600 µg/L. These concentrations are considered to represent an upper estimate of concentrations that could be encountered in mine water following paste backfill placement. Ferrous sulphate (as $Fe(SO_4)\cdot 7H_2O$) was added to the spiked mine water samples and the resulting hexavalent Cr concentrations were assessed using spectrophotometric methods. All experiments were carried out at 4ºC, but pH and total suspended solids (TSS) conditions were varied to assess whether these variables would limit Cr reduction rates.

The results of the experimental program indicate that Cr(VI) is effectively reduced within less than 30 minutes through the addition of ferrous sulphate when the ratio of Fe(II) to Cr(VI) is at least 8 (Figure 5-3). Effective reduction (98% to 100% reduction) was observed at all TSS concentrations and pH conditions. Therefore, if elevated Cr(VI) concentrations are observed within specific areas of the underground mine, direct treatment with ferrous sulphate is expected to be an effective mitigation strategy. A figure showing the concentration of $Fe(SO_4)\cdot 7H_2O$ required to reduce Cr(VI) to Cr(III) for a given Cr(VI) concentration and Fe(II) to Cr(VI) ratio is provided for reference should this be implemented at site. Based on the experimental program results, the rate of Cr(VI) reduction is rapid and thus any Cr(VI) in mine water should be reduced before reaching the WTP where the Cr(III) generated will be removed.

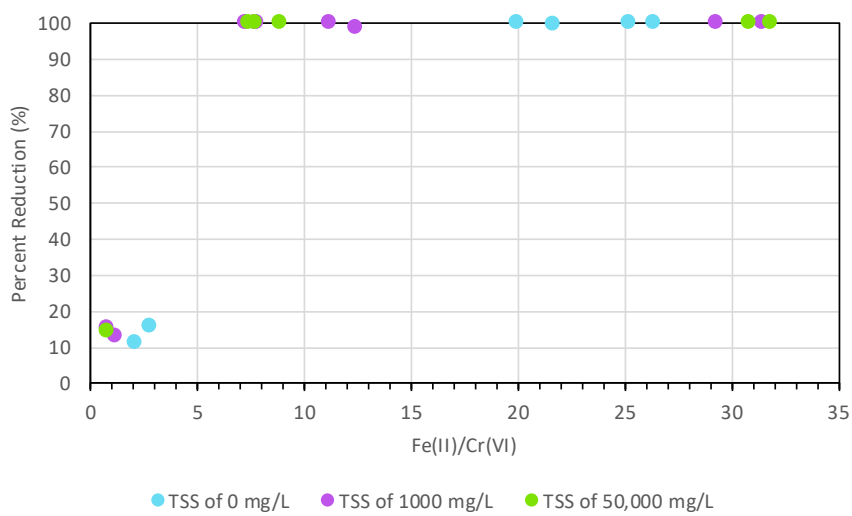

Figure 5-3: Percent reduction of hexavalent Cr over variable Fe(II) to Cr(VI) ratios for samples having variable total suspended solids (TSS) concentrations.

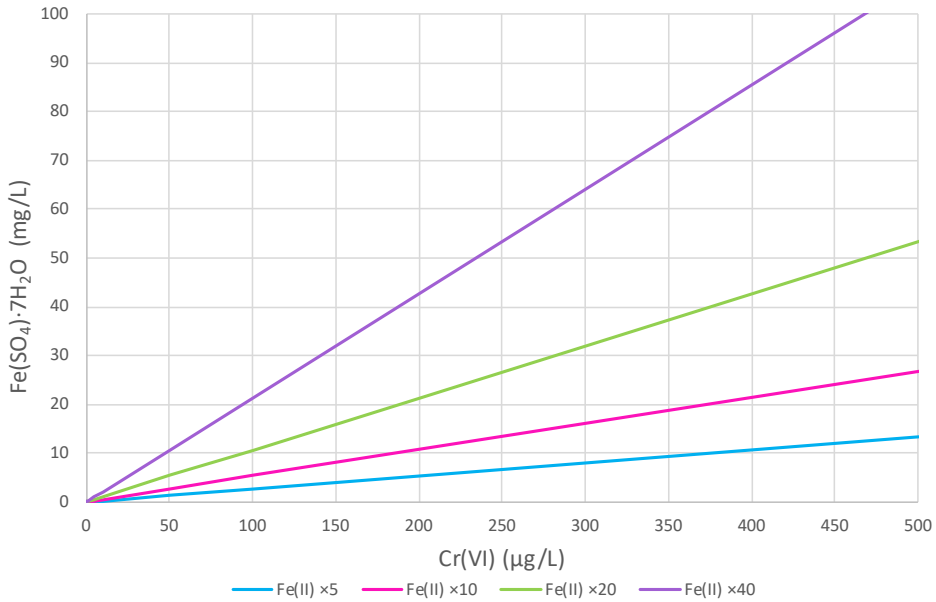

Figure 5-4: Concentration of ferrous sulphate heptahydrate required for reduction of Cr(VI) at specified Cr(VI) concentrations and Fe(II) to Cr(VI) ratios (expressed as an excess of Fe(II)). The experiments carried out indicate that effective reduction is achieved when the concentration of Fe(II) is at least 8× that of Cr(VI).

5.3 SHOTCRETE

Shotcrete is used at the Brucejack Mine for structural reinforcement of underground mine headings to prevent tunnel failure and to help ensure the safety of underground workers, and for construction of fences to retain cemented paste within excavated stopes. Shotcrete used in the underground is a mixture of Portland cement, aggregate, accelerant and water; therefore, water-soluble hexavalent Cr (approximately 2 mg/kg) is introduced to the shotcrete mixture from the Portland cement. A study of the release and mitigation of hexavalent Cr from shotcrete application at the Brucejack Mine indicates that ferrous sulphate will be effective in reducing the release of water-soluble hexavalent Cr to mine water. A brief overview of the study is summarized below. Additional details are described in Appendix 4.5-5 of the 2015 Annual Report.

Lab experiments indicated shotcrete cured for 24 hours released approximately 0.03 mg/kg hexavalent Cr, a reduction of more than 98% compared to the maximum amount available in the uncured product. The lab study evaluated the effect of ferrous sulphate added to the dry shotcrete mixture prior to the addition of water. Ferrous sulphate converts hexavalent Cr to Cr (III) hydroxide, which is not water soluble in the elevated pH conditions of the wet shotcrete mixture, thereby preventing Cr release to the liquid phase. Shotcrete mixtures were amended with 0.2% and 0.5% (of the cement by mass) ferrous sulphate, resulting in loading reductions of the maximum water-soluble hexavalent Cr to 0.7 mg/kg and 0.6 mg/kg, respectively (reductions of approximately 65% to 70% compared to the non-amended shotcrete product). For cured shotcrete amended with ferrous

sulphate, the hexavalent Cr release was 0.01 mg/kg and 0.02 mg/kg, also lower than the release rate for the non-amended shotcrete (approximately 35% to 65% reduction).

Following this testwork, Pretium refined shotcrete application methods and began using a ferrous sulphate-amended shotcrete product (starting on March 1, 2016). The amount of ferrous sulphate added constitutes approximately 0.2% of the cement and has proven to be effective at reducing concentrations of hexavalent Cr in mine water. Pretium has also implemented best practices for source control to minimize the amount of uncured shotcrete that comes into contact with mine water.

6 MONITORING

6.1 OVERVIEW

The placement of cemented paste backfill into mined-out stopes began in August 2017. The backfill placement process and the associated monitoring was undertaken in a controlled manner to minimize any potential environmental risks associated with hexavalent Cr. The overall aims of the monitoring program are to assess Cr behaviour and ensure that Cr associated with the various mine components can be managed appropriately. The program consists of routine measurements for the following components:

- Paste backfill cement: to ensure that Cr contents in the cement provided by the supplier are within the anticipated range (25-50 ppm). An SOP for cement sampling procedures is provided in Appendix 6-1 of this document.

- Tailings solids: to assess the variability of Cr contents in tailings and ensure that concentrations are within the range expected based on prior static test results. An SOP for tailings solids sampling procedures is provided in Appendix 11 of the ML/ARD Management Plan.

- Paste backfill solids: to assess the variability of Cr contents in cemented paste backfill and ensure that the concentrations are within the expected range. Sampling procedures are outlined in Appendix 11 of the ML/ARD Management Plan.

- Seepage from backfilled stopes: to evaluate soluble Cr loads associated with backfilled stopes and verify water quality model assumptions. Sampling protocols are outlined in Appendix 6-2 of this document.

- Sump water: to assess changes in Cr in underground mine water as paste backfilling proceeds. A general SOP for sump water sampling is provided in Appendix 6 of the ML/ARD Management Plan, with Cr specific instructions provided in Appendix 6-2 of this document.

- WTP influent: to evaluate Cr inputs to the water treatment plant and ensure that D-Cr is below the WTP influent management trigger value of 10 µg/L. An SOP for WTP sampling is provided in Appendix 10 of the ML/ARD Management Plan, with Cr specific instructions provided in Appendix 6-2 of this document.

- WTP effluent: to assess Cr discharged to Brucejack WRTSF from the water treatment plant and ensure that T-Cr is below the WTP effluent trigger specified in Permit 107835 (20 µg/L). Sampling protocols are outlined in Appendix 10 of the ML/ARD Management Plan and Appendix 6-2 of this document.

- Brucejack WRTSF at BJ 3.10: to ensure that Cr is meeting BC Freshwater Aquatic Life guidelines (T-Cr < 9 µg/L and Cr(VI) < 1 µg/L). Sampling protocols are outlined in the Water Quality Sampling for Compliance Site BJ 3.10 SOP.

The ongoing Cr monitoring program, including the sampling frequencies and parameters measured for the various mine components, is summarized in Table 6-1.

Table 6-1: Overview of the Brucejack Mine Chromium Monitoring Program

Mine Component	Monitoring Frequency	Parameters Measured		
		T-Cr	D-Cr	Cr(VI)
Paste backfill cement	Quarterly	√	-	-
Tailings solids	Quarterly	√	-	-
Paste backfill solids	Quarterly	√	-	-
Seepage from paste backfilled stopes	Two stopes per year with a minimum of 5 samples collected at each stope[1]	√	√	√
Seeps and sump water	Quarterly	√	√	-
WTP influent	Twice per month	√	√	Only if D-Cr is > 10 µg/L
WTP effluent	Twice per month	√	√	Only if T-Cr is > 20 µg/L
Brucejack WRTSF at BJ 3.10	Weekly	√	√	Only if D-Cr is > 1 µg/L

Notes: 1 – until such time as data validate source term assumptions or a data set sufficient to define updated source terms has been acquired.

6.2 MONITORING RESULTS

The full set of monitoring results for Cr along with other parameters are presented on an annual basis in the Brucejack Mine annual reports. The sections below provide a summary of monitoring results for cement binder, tailings solids, paste backfill solids, seepage from backfilled stopes, seeps and sumps, WTP influent and effluent, and Brucejack WRTSF at BJ 3.10.

6.2.1 Cement

Of the 23 samples that have been analysed since the paste backfilling operation was initiated, only 1 sample was above the expected range (25-50 ppm) with a value of 61 ppm. The total Cr content of cement binder samples analysed ranged from 15-61 ppm, with a median value of 23 ppm.

6.2.2 Tailings Solids

Samples of thickened tailings are collected from the underflow of the thickening tank and are representative of tailings used to generate cemented paste backfill and of tailings discharged to Brucejack WRTSF. The Cr content of the 29 representative samples collected since the mill was commissioned ranged from 8-42 ppm with a median value of 29 ppm.

6.2.3 Paste Backfill Solids

Solid phase element analysis has been conducted on 23 samples of cemented paste collected since paste backfilling was initiated. The Cr content of the cemented paste ranged from 9-31 ppm with a median value of 18 ppm. The results of tailings solids and paste backfill solids sampling indicates that the Cr content of the cement binder has not significantly affected the Cr content of the cemented paste.

6.2.4 Seepage from Backfilled Stopes

Seepage from backfilled stopes was monitored approximately weekly during the paste backfill phase in period (August to November 2017). Following the initial phase in period, seepage has been monitored a minimum of monthly to the end of 2018. Typically, stopes where backfilling operations were in progress or had recently been completed were selected for monitoring; however, a time series was conducted on stope 1320-18 to investigate the rate at which Cr concentrations decreased following completion of backfilling operations.

Immediately after backfilling, upwards of 75% of Cr in seepage from backfilled stopes is present in the dissolved form (Figure 6-1). The proportion of dissolved Cr decreases rapidly following completion of backfilling operations: one month after backfilling was completed in stope 1320-18, 27% of Cr was present in the dissolved form. The majority of dissolved Cr in seepage from backfilled stopes is present as Cr(VI); however, the speciation of Cr in low concentration samples cannot be assessed due to laboratory detection limits. The limit of detection for dissolved Cr is 0.1 µg/L whereas the limit of detection for dissolved Cr(VI) is 1 µg/L.

Total Cr concentrations in seepage ranged from 0.42-632 µg/L with a median of 22 µg/L, dissolved Cr concentrations ranged from 0.1-131 µg/L with a median of 13.3 µg/L and dissolved Cr(VI) concentrations ranged from 0.5-135 µg/L with a median of 11.7 µg/L. Concentrations of dissolved Cr(VI) decreased below the limit of detection in seepage from stope 1320-18 within 34 days of backfill completion (Figure 6-2).

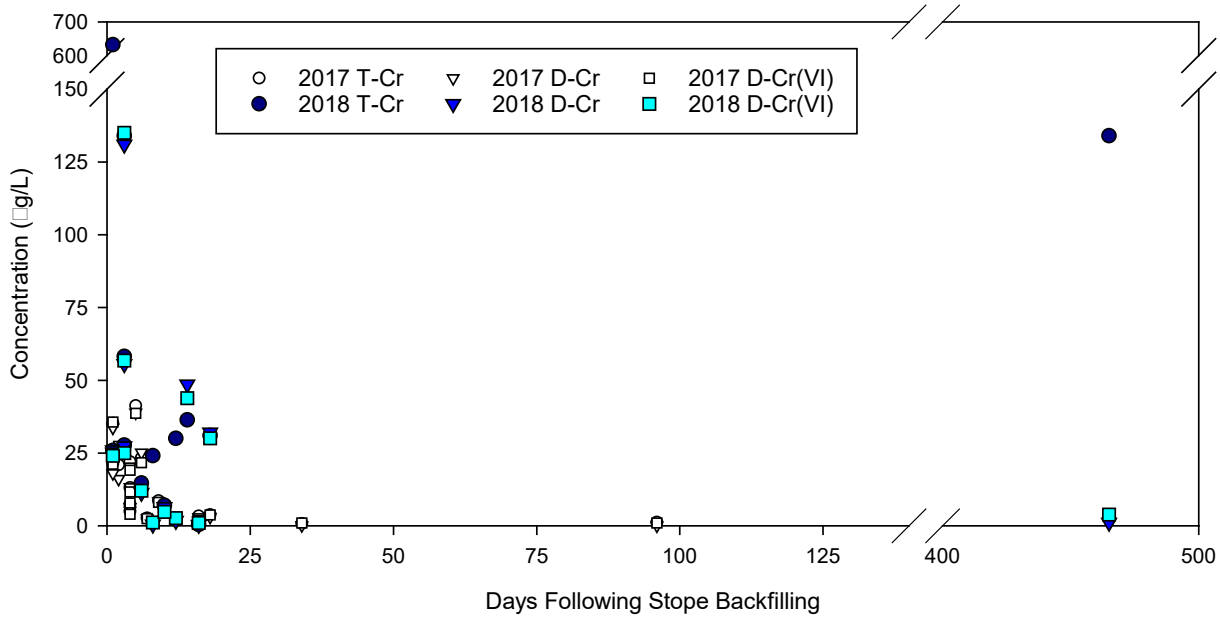

Figure 6-1: Cr monitoring results for seepage from backfilled stopes.

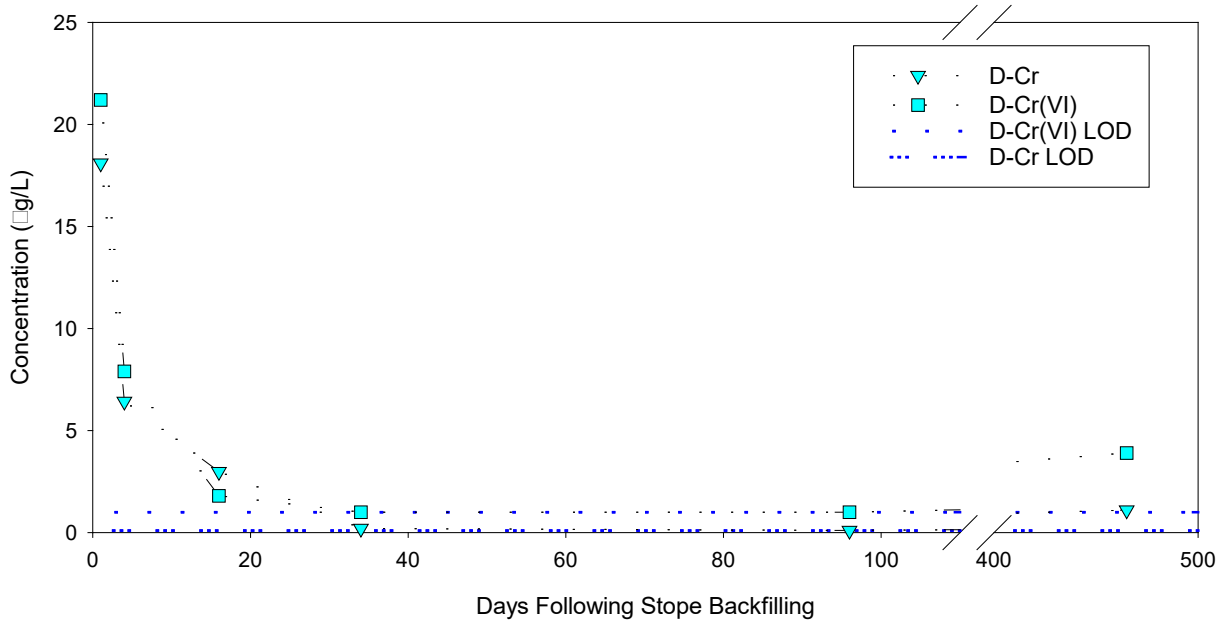

Figure 6-2: Cr monitoring results for seepage from Stope 1320-18.

6.2.5 Seeps and Sumps

Monitoring of underground mine sumps and seeps is conducted quarterly. Seeps with low pH (<6) and elevated conductivity (>200 µS/cm) are sampled when they are encountered whereas sumps are sampled quarterly. One seep sample has been collected since paste backfill placement commenced.

The total Cr and dissolved Cr concentrations in the seep sample were below the limit of detection (LOD).

Samples have been collected from the ten active sumps during five sampling events since paste backfill placement commenced. The slimes content of the sumps is typically high and the total Cr concentrations correspondingly elevated. The median total Cr concentration in sumps was 39 µg/L and concentrations ranged from 0.44-329 µg /L. Dissolved Cr concentrations in sump water are much lower with a median value of 0.47 µg /L and a range of 0.1-26 µg /L. Of the 47 sump samples collected since initiation of paste backfill operations, dissolved Cr concentrations were below the LOD in 18 samples and one sample had dissolved Cr concentrations greater than the WTP influent trigger of 10 µg/L.

6.2.6 WTP Monitoring

WTP influent and effluent water quality is analysed twice a month for various parameters including T-Cr and D-Cr. Monitoring results spanning the time period since paste placement began (August 2017 through September 2018) are presented in Figure 6-3. The WTP influent D-Cr concentrations during this time period ranged from 0.1 to 5.3 µg/L, well below the WTP influent trigger value of 10 µg/L. Dissolved and total Cr concentrations in WTP effluent ranged from 0.1 to 2.4 µg/L, also well below the WTP Effluent trigger level of 20 µg/L. The observation of lower D-Cr in WTP effluent, as compared to influent suggests that a portion of the D-Cr is in the Cr(III) form and treated by the WTP.

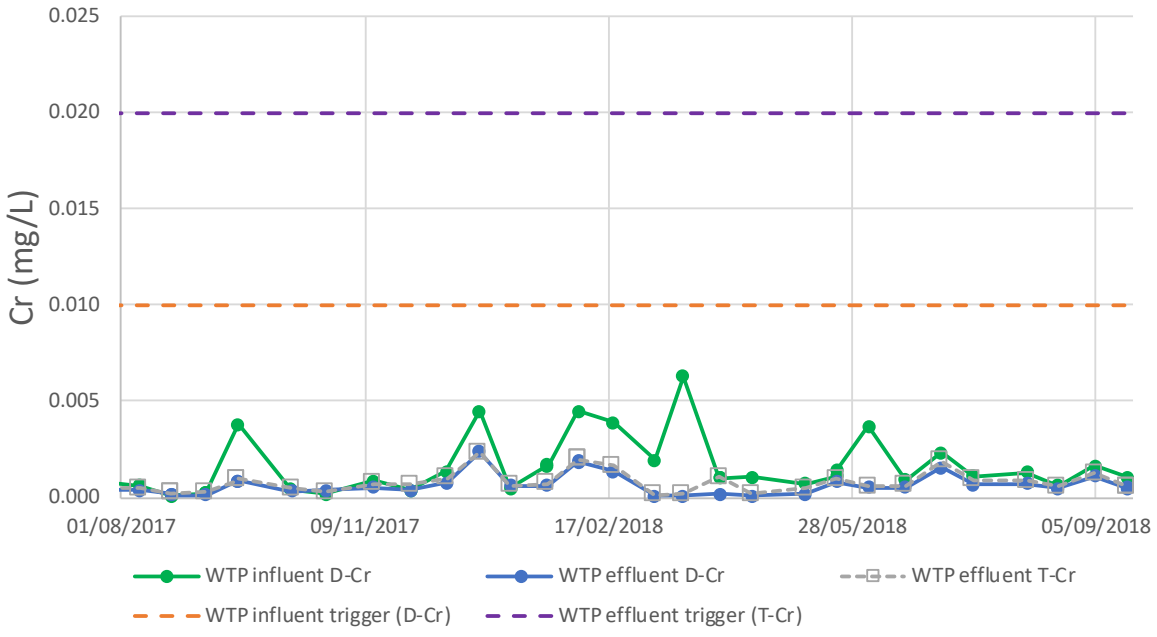

Figure 6-3: Cr concentrations in WTP influent (D-Cr) and effluent (D-Cr and T-Cr) as compared to Cr management trigger levels. Paste backfilling of mined-out stopes began in August 2017.

6.2.7 Brucejack WRTSF at BJ 3.10

Brucejack WRTSF water quality at BJ 3.10 is measured on a weekly basis for the full suite of parameters including T-Cr and D-Cr. BJ 3.10 water quality must meet BC Freshwater Aquatic Life (FWAL) guidelines for Cr(III) (9 µg/L) and Cr(VI) (1 µg/L). Monitoring data for D-Cr, as compared to water quality predictions are presented in Figure 6-4. The monitoring results show that samples are well below the Cr(VI) BC FWAL guideline, with most samples having D-Cr concentrations at the detection limit (0.1 µg/L) and maximum D-Cr values of up to 0.16 µg/L.

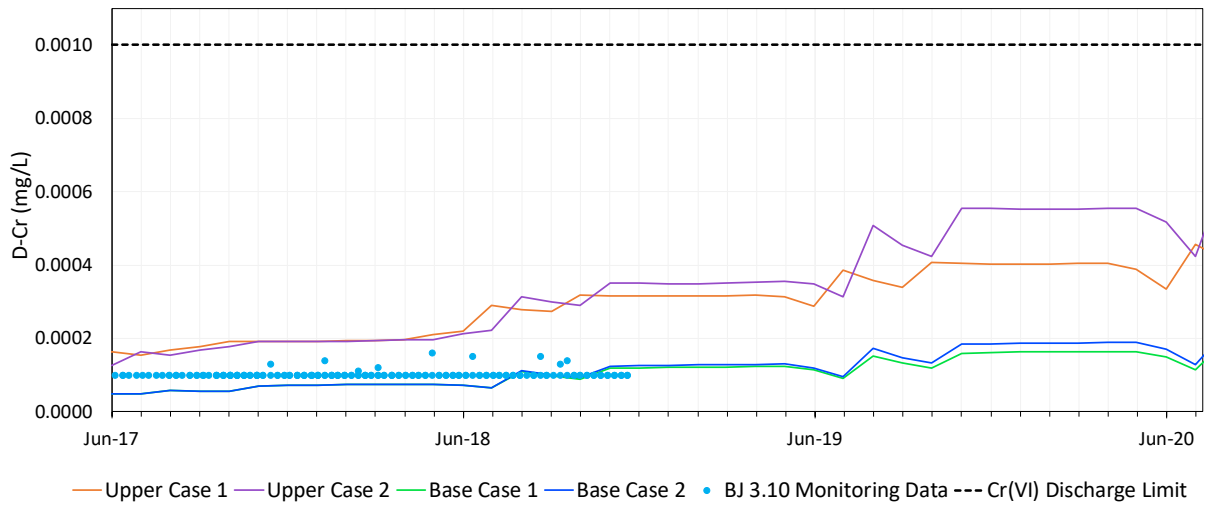

Figure 6-4: Dissolved Cr concentrations in Brucejack WRTSF at monitoring station BJ 3.10, as compared to modelled Upper Case and Base Case water quality predictions and the BC FWAL maximum guideline for Cr(VI) (1 µg/L). Note that most samples have concentrations equal to the analytical detection level for dissolved Cr (0.1 µg/L).

7 ADAPTIVE CHROMIUM MANAGEMENT

7.1 OVERVIEW

Management of Cr at Brucejack Mine is achieved through an adaptive approach which includes the following key elements:

- Research and experimental test programs to better understand the risk associated with Cr(VI) at Brucejack Mine;
- Cr-specific monitoring programs for the various mine components (Table 6-1; Section 6);
- Cr management triggers and response plans for WTP influent, WTP effluent, and Brucejack WRTSF water quality at BJ 3.10;
- Investigations when monitoring data shows Cr concentrations above management trigger level or the anticipated range;

- Identification and implementation of mitigation measures as necessary;
- Delineation of the roles and responsibilities of Pretium staff; and
- Annual Review of the CMP.

The details of the experimental and monitoring programs are outlined in Section 5 and Section 6, respectively. The other key elements of Cr management at Brucejack Mine are described in the sections below.

7.2 CHROMIUM MANAGEMENT TRIGGERS

Chromium is monitored and managed at various locations at Brucejack Mine as described in Section 6. Chromium management triggers have been specified for WTP influent, WTP effluent and Brucejack WRTSF water at BJ 3.10. The trigger levels and actions required following a trigger exceedance for each of these monitored components are outlined below.

7.2.1 WTP Influent

The Cr trigger level for WTP influent is specified for D-Cr and is 10 µg/L. In the event of a trigger level incident where D-Cr levels in WTP influent exceed 10 µg/L, Pretium will follow the steps outlined in the Cr Trigger Response Plan Flow Chart for WTP influent (Figure 7-1). The first step will be to determine the speciation of Cr and verify the initial result through the collection of additional samples. If the concentration of Cr (VI) in the follow up sample is greater than 10 µg/L, then the next step in the process will be to initiate an investigation to identify the cause of the exceedance (Section 7.3). Following the investigation, appropriate mitigation measures (Section 7.4) will be identified and implemented, as necessary. The efficacy of the mitigation selected will be determined based on follow up monitoring results.

The details of any WTP influent Cr trigger incident and the ensuing investigation, mitigation and follow up monitoring results will be reported in the Annual Reclamation Report.

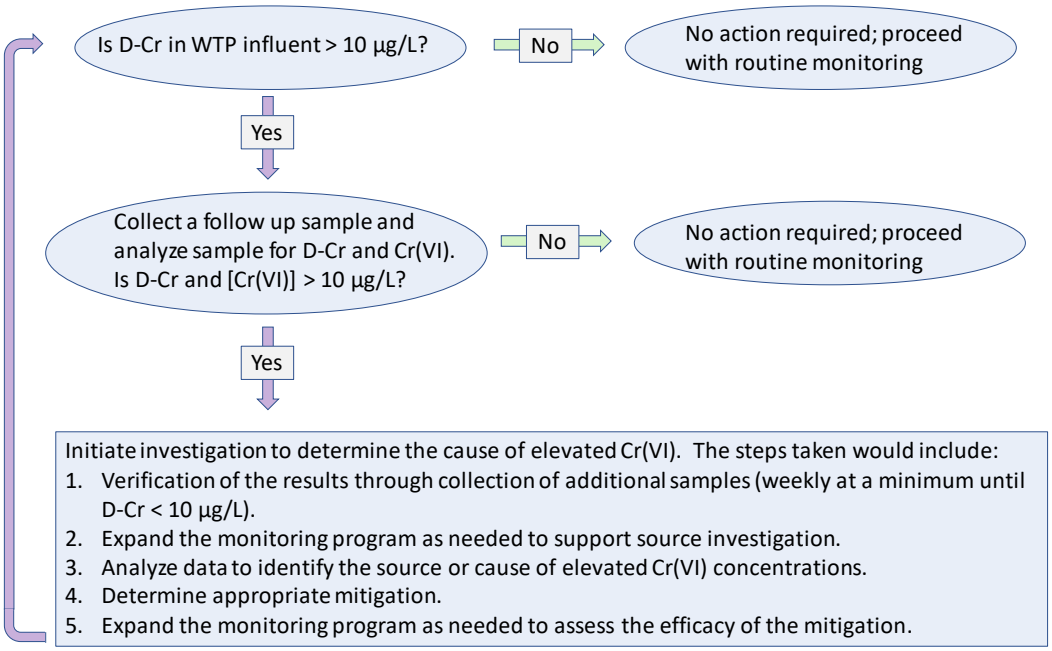

Figure 7-1: Cr Trigger Response Plan Flow Chart for WTP Influent

7.2.2 WTP Effluent

The Cr trigger level for WTP effluent is specified for T-Cr and is 20 µg/L. In the event of a trigger level incident where T-Cr levels in WTP effluent exceed 20 µg/L, Pretium will follow the steps outlined in the Cr Trigger Response Plan Flow Chart for WTP effluent (Figure 7-2). The first step will be to recirculate WTP effluent to the contact water pond (CWP), as per Condition 1.2.4 in PE 107835 and to collect a follow up sample to verify the initial result and to determine the speciation of Cr. If the concentration of T-Cr in the follow up sample is less than 20 µg/L, then WTP effluent recirculation to the CWP can be discontinued and regular monitoring protocols can be resumed. If the concentration of T-Cr in the follow up sample is greater than 20 µg/L, then the next step in the process will be to initiate an investigation to identify the cause of the exceedance (Section 7.3). Following the investigation, appropriate mitigation measures will be identified and implemented, as necessary. The efficacy of the mitigation selected will be determined based on follow up monitoring results.

The details of any WTP effluent Cr trigger incident including the duration of the recirculation to the CWP along with the ensuing investigation, mitigation and follow up monitoring results will be reported in the Annual Reclamation Report.

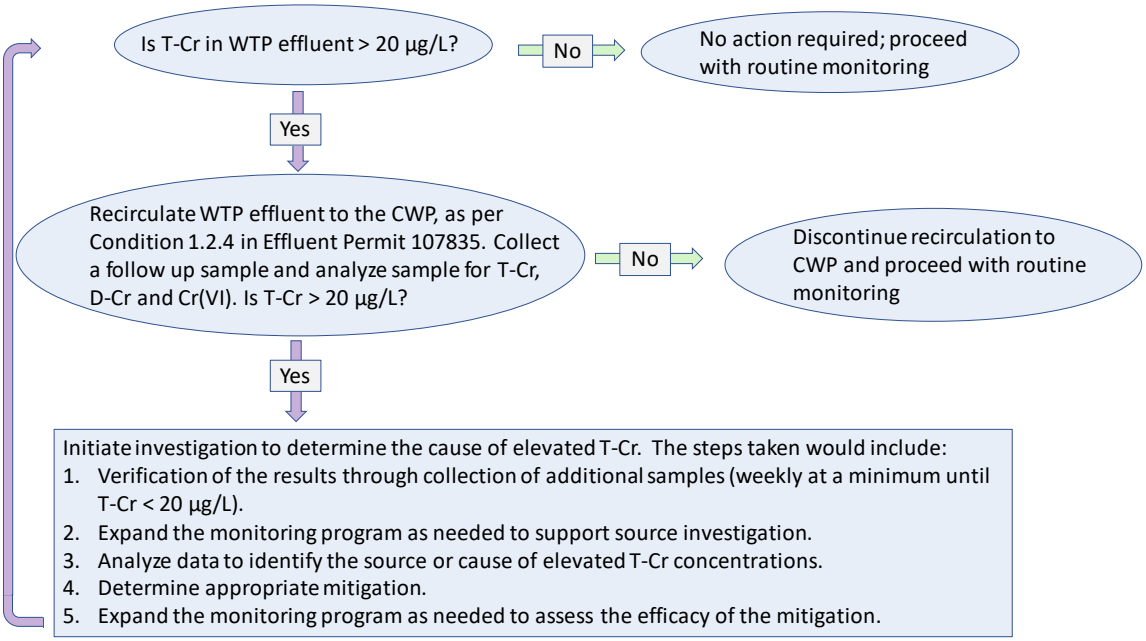

Figure 7-2: Cr Trigger Response Flow Chart for WTP Effluent

7.2.3 Brucejack WRTSF at BJ 3.10

Brucejack WRTSF water quality as measured at BJ 3.10 is required to meet BC FWAL guidelines for total trivalent Cr [Cr(III)] (9 µg/L) and total hexavalent Cr [Cr(IV)] (1 µg/L). Hexavalent Cr is soluble and thus the BJ 3.10 Cr trigger is specified for D-Cr and equal to 1 µg/L. In the event of a trigger level incident where D-Cr at BJ 3.10 exceeds 1 µg/L, Pretium will follow the steps outlined in the Cr Trigger Response Plan Flow Chart for WTP effluent (Figure 7-3). The first step will be to determine the speciation of Cr and verify the initial result through the collection of an additional sample. If the concentration of Cr (VI) in the follow up sample is greater than 1 µg/L, then the exceedance will be reported to the B.C. Ministry of Environment, in accordance with the requirements of PE-107835. The next step in the process will be to initiate an investigation to identify the cause of the exceedance (Section 7.3). Following the investigation, appropriate mitigation measures will be identified and implemented, as necessary. The efficacy of the mitigation selected will be determined based on follow up monitoring results.

The details of any WTP influent Cr trigger incident and the ensuing investigation, mitigation and follow up monitoring results will be reported in the Annual Reclamation Report.

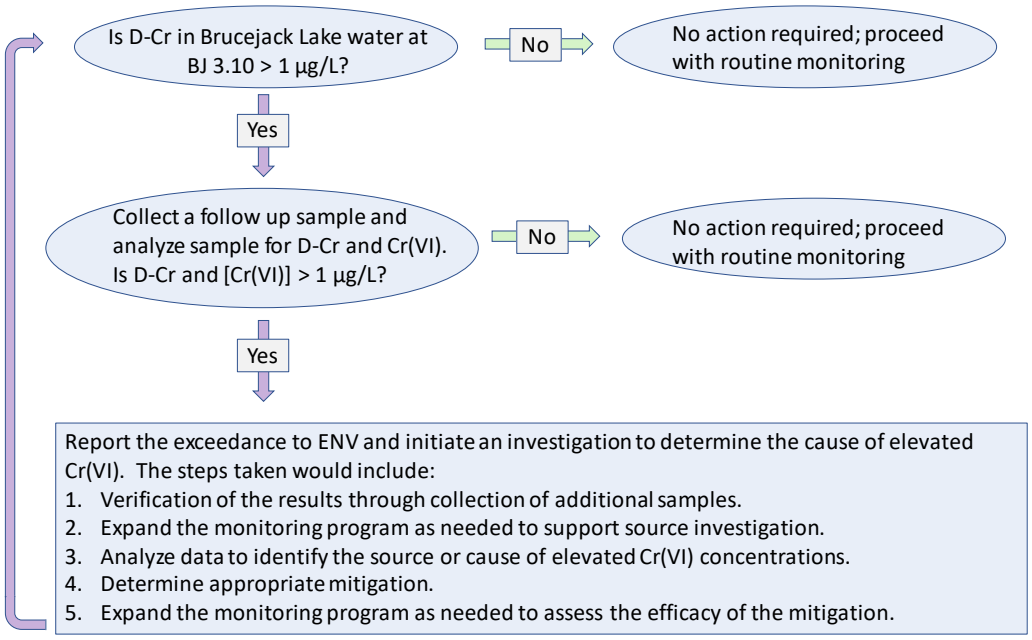

Figure 7-3: Cr Trigger Response Flow Chart for Brucejack WRTSF at BJ 3.10

7.3 INVESTIGATION

In the event that monitoring results indicate Cr concentrations for a particular mine component that are higher than the anticipated range or a specified trigger level (Section 7.2), an investigation will be carried out. The investigation will be undertaken to identify the root cause of elevated Cr. The investigation may include, but will not necessarily be limited to, the following:

1. Verification of results through collection of additional samples to be analyzed for T-Cr, D-Cr and Cr(VI) where applicable.
2. Determining the potential cause(s) in consultation with mine personnel or cement suppliers, including consideration of whether elevated Cr may have resulted from routine operations or from any unusual or extraordinary circumstances.
3. A visual inspection of the underground mine to determine whether there is significant seepage from backfilled stopes, or if there are any other likely causes of elevated Cr concentrations in the underground mine (these may include extensive use of shotcrete, or intensive grouting of drillholes, for example).
4. Expansion of the monitoring program to identify the source of elevated Cr. This could include collection of mine water samples in the vicinity of recently backfilled stopes and/or other areas where cement has been used. Samples will be sent to an external accredited laboratory for analysis, with the intention that the results will allow Pretium to confirm the degree to which Cr concentrations are elevated, as well as the location at which Cr was introduced into mine water.
5. An assessment of the severity (maximum Cr concentration), temporal and geographic extent of the occurrence, and likelihood of recurrence.
6. Recommendations for immediate source control and mitigation.

The results of the investigation will be documented and described in the Annual Reclamation Report. Documentation of the incident may include, but will not necessarily be limited to, the following information:

- A description of the incident;
- A summary of the source control measures that were implemented;
- A description of the investigation that was undertaken;
- An assessment of the root cause; and
- Recommended action.

7.4 MITIGATION

In the case where elevated Cr concentrations are encountered, corrective action may be implemented to minimize the effect on the receiving environment, in both the short-term, and throughout the Operations phase. Mitigation will be determined based on the outcome of the investigation. The following sections describe potential source control measures and treatment options.

7.4.1 Source Control

Options for source control may include, but are not limited to:

- Water management strategies (e.g., storage, diversion, dilution) to minimize Cr concentrations in mine water discharge;
- Modifying backfill placement methods or otherwise preventing or minimizing the release of leachate from backfilled stopes.
- Minimizing seepage from backfilled stopes by plugging any leaks identified;
- Amending mine water with ferrous sulphate (refer to Figure 5-4) in target areas to reduce the Cr concentration, prior to pumping the mine water to the WTP.

Corrective actions will be implemented promptly and reviewed for effectiveness. The Environmental Manager is responsible for ensuring that corrective actions are implemented, and reviewed, until an incident is deemed to be resolved.

7.4.2 Treatment

If the results of the investigation indicate that elevated Cr is likely to be a recurring problem, or if the problem persists for unforeseen reasons, it may be necessary to mitigate through implementation of treatment measure on an ongoing basis. The decision to implement treatment will be made based on a review of the available data by the Environmental Manager and Chief Mining Engineer/Manager of Technical Services.

Treatment measures may include, but are not necessarily limited to, the following:

1. Adding ferrous sulphate into the cemented paste backfill mixture.
2. Modification of the WTP treatment process to reduce the concentration of Cr(VI).

Pretium's preferred treatment option, should it be required, is the addition of ferrous sulphate to the paste backfill within the paste plant prior to placement underground (option 1). The results of testwork presented in Section 5.1 indicate that a dosage of 1% (of the cement by mass) is effective at reducing the amount of leachable hexavalent Cr.

The current design for paste backfill generation includes a paste mixer where the cement binder is combined with the thickened tailings received from the mill. The requisite amount of ferrous sulphate would be introduced to the paste mixer with the cement. The homogenized paste mixture would then be pumped to the various stopes to be backfilled. Hydrostatic bulkheads will be placed at the base of the stopes to contain the paste backfill and minimize seepage.

While treatment to reduce Cr(VI) within the WTP (option 2) is feasible, it will be necessary to design the treatment process, evaluate the proposed treatment process through bench tests or other suitable means, incorporate the modifications into the WTP and fully commission the updated WTP. This work will only be initiated should other mitigation options prove insufficient or ineffective in limiting the concentration of Cr(VI) in WTP effluent.

7.5 Roles and Responsibilities

Effective Cr management will require coordinated action by members of the mine engineering and environmental teams. Key tasks include: (i) selecting and implementing mitigation and adaptive management measures, as necessary (ii) transporting and handling ferrous sulphate in accordance with applicable health, safety and environmental requirements; (iii) incorporating the ferrous sulphate into the paste backfill (should this become necessary) or mine water in the appropriate amount so as to mitigate Cr(VI) leaching; and (iv) monitoring, to ensure that the CMP is effective.

General roles and responsibilities are outlined below, recognizing that some refinement and further delineation may ultimately be required as the CMP is fully implemented. The successful implementation of the CMP will require oversight by the Chief Mine Engineer/Manager of Technical Services and Environmental Manager, and may ultimately require action by the Mill Manager.

Key responsibilities for each are outlined as follows:

1. The Mill Manager will be responsible for incorporating ferrous sulphate in the preparation of paste backfill, should this be necessary;
2. The Chief Mine Engineer/Manager of Technical Services will be responsible for placement of paste backfill in accordance with this Plan;
3. The Mill Manager will be responsible, should it become necessary, to incorporate a treatment process for reducing Cr(VI) concentrations in mine water; and
4. The Environmental Manager will be responsible for monitoring and implementation of mitigation measures, as necessary, so as to ensure that treated mine water complies with regulatory requirements prior to discharge to the receiving environment.

These Managers will be responsible to ensure the development and implementation of standard procedures for the various aspects of Cr management for which they are responsible. More specifically, standard procedures would be adopted for:

- Transportation, storage and handling of ferrous sulphate, at the Mine Site, and within the facilities in which it is used.
- Operational procedures for dosing and mixing of ferrous sulphate within the paste plant.
- Operational procedures for paste placement in the underground workings, so as to avoid and minimize the release of leachate.
- Operational procedures for monitoring within the underground workings and the WTP, as appropriate.

It is understood that the managers to whom responsibilities are assigned may delegate certain responsibilities and actions to other personnel and/or contractors, and that specific roles and responsibilities will be further defined in due course.

7.6 ANNUAL REVIEW

The implementation and effectiveness of the CMP, including the results of the monitoring program and any exceedance of the trigger threshold, will be evaluated through ongoing and annual review of monitoring results. The annual review will be led by the geochemistry Qualified Professional.

8 CONCLUSIONS

Monitoring will be undertaken in accordance with this plan to verify water quality predictions, which indicate that while hexavalent Cr is expected to be leached from cemented paste backfill, concentrations are not expected to exceed BC FWAL guidelines in the receiving environment.

In the event that Cr concentrations exceed any of the trigger threshold levels as specified in Section 7.2, an investigation will be undertaken to identify the cause and suitable remedies. Mitigation may include localized efforts to prevent leachate from being released from backfilled stopes or the addition of ferrous sulphate to mine water and/or the paste backfill mixture within the paste plant. Mitigation through ferrous sulphate amendment of mine water or paste backfill is expected to reduce the concentration of hexavalent Cr in mine contact water to levels that are protective of the receiving environment. Should these mitigation strategies prove ineffective for any reason, Cr(VI) treatment will be incorporated into the existing water treatment plant process.

The effectiveness of this CMP will be periodically evaluated by the geochemistry Qualified Professional and the plan adapted to include detailed operational procedures, as necessary.

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APPENDIX 6-1 SOP: WATER QUALITY SAMPLE COLLECTION FOR DETERMINATION OF CHROMIUM CONCENTRATIONS AND SPECIATION

PRETIVM		BJ-ENV-SOP-011 Underground Chromium Sample Collection	
Owner: Colleen Atherton	**Approver**: Robin McCall/ Torence Sandhals/ Jason Gabora	**Revision Number**: 3	**Creation Date**09/14/2018
			Revision Date: Feb 4, 2019

Objective

To provide guidance for Pretivm personnel for collection of underground water quality samples in support of the Chromium Management Plan (CMP).

Scope

Activities related to collection of Cr speciation samples during monitoring of paste backfill. Samples will be collected in the underground workings adjacent to recently backfilled stopes. Two stopes are to be monitored each year until such time as data validate source term assumptions or a data set sufficient to define updated source terms has been acquired. Six samples will typically be collected from each stope following completion of backfill placement. Samples will be collected roughly on Day 1, Day 3, Day 7, Day 14, Day 28 and Day 180.

The sample volumes, bottle types and preservation methods described in this SOP are also applicable to Cr speciation samples collected from WTP influent, WTP effluent and BJ 3.10 as required following exceedance of the triggers identified in the CMP.

Health, Safety & Reclamation Code of BC

- 1.11.1 - Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 - Personal Protective Equipment
- 2.13 - WHMIS

Definitions

- BCMDG: British Columbia Mine Design Guideline (i.e., cost-effective low-level detection limits)
- CMP: Chromium Management Plan
- DI water: De-ionized water
- DO:Dissolved oxygen
- Field parameters: DO, pH, and conductivity
- ML/ARD: Metal leaching and acid rock drainage
- Muck: blasted underground rock
- Paste Fence: plug constructed to retain cemented paste within the stope
- PPE: Personal Protective Equipment which includes hardhat with reflective stripes, steel toed boots with metatarsal protection, safety glasses, W65 self-rescuer, cap lamp, belt, and nitrile gloves.
- QA/QC: Quality assurance and quality control
- TSS: Total suspended solids

Preparation

Hazards

- Slips and falls.
- Air quality.
- Unstable ground.
- Noise.
- Working near machinery.
- Working with hazardous chemicals.

Tools

- PPE
  - Underground hi-vis coveralls
  - Hart hat
  - Blue blinking light attached to back of hard hat
  - Miners light
  - W 65 self-rescuer
  - Miners belt
  - Clear safety glasses
  - Underground steel toe boots
  - Respirator
- pH/conductivity/DO probe.
- Nitrile gloves.
- Field notebook and pencil.
- Sample labels.
- Camera.
- Cooler containing
  - Disposable syringes and disposable 0.45 µm disc filters.
  - Bottles described in Table 1.
  - Preservatives described in Table 1.
- QA/QC supplies as required
  - Full additional bottle and preservative set as described in Table 1 for field blank.
  - Additional D-Cr (VI) and D-Metals bottles and preservative for duplicate.
  - 1 L of DI water for field blank.

Requirements

- Trained and qualified to conduct water-quality sampling.
- Knowledge of CMP and monitoring program.
- Underground orientation.

Job Step

1. Contact Mine Captain

- Contact Mine Captain to identify an appropriate stope and to arrange transportation.
- A stope with no accumulation of water between the paste fence and the muck pile prior to paste placement should be selected, if possible. Ideally, the sample will be composed entirely of paste bleed water, with no sources external to the stope.

2. Prepare sampling equipment

- Organize and label bottles with the stope ID, e.g., 1320-28. Some stopes will have an alpha-numeric ID, e.g., 1320-28A.
- Calibrate probe for field parameters.
- Review sample collection methods in BJ-ENV-SOP-028 “General Water Sampling” if required.

3. Collect samples

- Samples should be collected as close to the paste fence as possible. Safety considerations may restrict access to the outside of the safety barricade (composed of muck).
- The sample should be collected from running water if possible, but may be collected from standing water if necessary, e.g., from water collected behind the muck barricade.
- Put on nitrile gloves. Replace gloves if they become contaminated and between each sample.

- Fill and preserve bottles as specified in Table 1. Use a new syringe and disc filter for each sample.
- **Collect QA/QC samples during the first sampling event for each stope.**
- Collect measurements of field parameters on a separate aliquot of sample.
- Record observations in your field notes, such as:
  - Date and time.
  - Field parameters.
  - Location of sample collection, e.g., at paste fence, in front of muck barricade, behind muck barricade.
  - Whether the sample was collected from standing or running water.
  - Approximate flow rate.
  - Water clarity and odor.
  - Photographs.

Table 1: Summary of Bottles, Preservation, and Analytical Parameters for Samples

Bottle and Volume	**Field Preservation**	**Field Filter**	**Refrigerate (4°C)**	**Indicate on Bottle**	**Parameter(s) to be indicated on COC**
500 mL plastic	None	No	Yes	General Chemistry	General Chemistry: **pH, TSS, and anions**
60 mL plastic	HNO3	No	Yes	T-Cr	Total chromium
60 mL plastic	HNO3	Yes	Yes	Dissolved Metals	MET-D-BCMDG-VA*
60 mL plastic	NaOH	Yes	Yes	D-Cr(VI)	Dissolved hexavalent Cr*
125 mL amber	H2SO4	No	Yes	Total Nutrients	Ammonia and T-N

Notes: Parameters listed in **bold** must be indicated on the COC for the analytical laboratory.

*Duplicate sample to be collected during first sampling event.

4. QA/QC Samples

- Collect one duplicate using the filtering and preservation procedure described in Table 1 and Step 3. This sample is identified by -98, e.g., 1320-28-98.
- Collect duplicates only for parameters identified in Table 1.
- Collect one blank by filling an additional set of bottles with DI water using the filtering and preservation procedure described in Table 1 and Step 3. This sample is identified by -99, e.g., 1320-28-99.

5. Complete COC

- Complete COC as per example in Appendix 1.

6. Ship samples

- Ship samples to the analytical Laboratory (currently ALS Global in Burnaby, BC).
- Use adequate ice packs to ensure the samples arrive at the laboratory <10°C.

Appendix I

ALS Environmental
www.alsglobal.com

Chain of Custody (COC) / Analytical Request Form

Canada Toll Free: 1 800 668 9878

Affix ALS barcode label here
(lab use only)

COC Number: 17 -

Page 1 of 1

Report To		**Report Format / Distribution**	**Select Service Level Below** (Rush Turnaround Time (TAT) is not available for all tests)
Company:	Pretium Resources Inc.	Select Report Format: ☑ PDF ☑ EXCEL ☑ EDD (DIGITAL)	**R** ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Max Holtby	Quality Control (QC) Report with Report ☑ Yes ☐ No	**P** ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	Suite 2300, Four Bentall Centre, 1055 Dunsmuir Street	☐ Criteria on Report - provide details below if box checked	**E** ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
	Vancouver, BC V7X 1L4 PO Box 49334	Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	**E2** ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	(604)558-1784	Email 1 or Fax catherton@pretivm.com	Specify Date Required for E2,E or P:
		Email 2 Alison.Shaw@lorax.ca	**Analysis Request**
Invoice To	Same as Report To ☑ Yes ☐ No	**Invoice Distribution**	Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below
	Copy of Invoice with Report ☑ Yes ☐ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	Pretivm (Brucejack Project)	Email 1 or Fax invoices@pretivm.com	
Contact:	Accounts Payable (604-558-1784)	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:		Approver ID: / Cost Center:	
Job #:		GL Account: / Routing Code:	
PO / AFE:	1025612	Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:** Dean Watt	**Sampler:**

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	TSS, pH, anions (SO4, NO3, NO2, Br, Cl, F)	Total Cr	Dissolved metals (MET-D-BCMDG-VA)	Dissolved Cr(VI)	ammonia and T-N								Number of Containers
					P	F/P	F/P	F/P	P								
	e.g. 1380-18				R	R	R	R	R								5

Drinking Water (DW) Samples[1] (client use)	**Special Instructions / Specify Criteria to add on report (client Use)**	**SAMPLE CONDITION AS RECEIVED (lab use only)**
Are samples taken from a Regulated DW System? ☐ Yes ☑ No	Distribution email 3: environmental@pretivm.com Distribution email 4: svanzalingen@pretivm.com Distribution email 5: mholtby@pretivm.com	Frozen ☐ SIF Observations Yes ☐ No ☐ Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐ Cooling Initiated ☐
Are samples for human drinking water use? ☐ Yes ☑ No	Please analyze within 5 days as per Pretivm agreement	INITIAL COOLER TEMPERATURES °C / FINAL COOLER TEMPERATURES °C

SHIPMENT RELEASE (client use)	INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
	Received by:	Date:	Time:	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION WHITE - LABORATORY COPY YELLOW - CLIENT COPY NA-FM-0326ev09Front/04January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a **Regulated Drinking Water (DW) System**, please submit using an **Authorized DW COC form**.

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
Sep 14, 2016	Initial Issue		
Nov 22, 2018	Update to PVG template, update bottle sizes and preservation techniques.		
Feb 4, 2019	Update sample frequency.		

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Assistant Environment Manager	[redacted]		
Environment Superintendent			
Mine Captain			
Health and Safety Manager / Designate			
JOHSC Co-chair or Member			

APPENDIX 6-2 SOP: PASTE BACKFILL CEMENT SAMPLE COLLECTION FOR DETERMINATION OF CHROMIUM CONCENTRATIONS

PRETIVM		BJ-ENV-SOP-042 Cement Binder Sampling	
Owner: Colleen Atherton	**Approver**: Torence Sandhals	**Revision Number**: 3	**Creation Date**: Feb 23, 2017 **Revision Date**: Jan 24, 2019

Objective

To provide guidance for Pretivm personnel for collection of cement binder (Terraflow 90) samples in support of the Chromium Management Plan (CMP).

Scope

All activities related to collection of cement binder samples.

Health, Safety & Reclamation Code of BC

- 1.11.1 Training
- 1.8.2, 1.8.3, 1.8.4, 1.8.5 Personal Protective Equipment
- 2.13 WHMIS

Definitions

- CMP: Chromium Management Plan
- COC: Chain of Custody
- PPE: Personal Protective Equipment which includes hardhat with reflective stripes, steel toed boots, safety glasses, hearing protection and nitrile or vinyl gloves and respirator.
- QA/QC: Quality assurance and quality control

Preparation

Hazards

- Slips and falls
- Working near heavy machinery
- Noise
- Pinch points
- Contact with alkaline material
- Faulty PPE

Tools

- PPE
  - Hi-vis vest
  - Hard hat
  - Steel toed boots
  - Safety glasses
  - Hearing protection
  - Nitrile or vinyl gloves.
- Field notebook, pen and markers
- Sample bags and sample tags
- COC, offsite removal form

Requirements

- Trained and qualified to conduct cement sampling
- Knowledge of CMP and monitoring program

Job Step

1. **Field Preparation**
   - Ensure appropriate number of sample bags and sample tags are available to collect cement binder samples
   - The Environmental Scientist will prepare a sample bag by filling out the SGS sample tag and placing it in the sample bag.
   - The Environmental Scientist will deliver the sample bag to the Operator in charge of filling the isotainers from the silo at Knipple Camp.
2. **Sampling**
   - The Operator will obtain a sample of cement binder by accessing the top hatch using the stairway and platform.
   - The Operator will place at least 500 g of cement binder in the bag provided by the Environmental Scientist
   - When instructed by the Environmental Scientist, the Operator will obtain a 1500 g aliquot which will be separated into two QA/QC samples by the Environmental Scientist (one QA/QC sample for every 10 samples).
   - The Environmental Scientist will retrieve the sample bag from the Operator.
3. **Description of QA/QC Samples**
   - Duplicate samples must be collected for every 10 samples for QA/QC purposes.
   - This is achieved by collecting a 1500g sample, instead of the typical 500 g sample.
   - The Environmental Scientist will take a 500g sub-sample from the 1500 g sample after it is collected by the Operator and will place the sub-sample in a separate sample bag with a unique sample tag number.
   - After sub-sampling, the remaining 1000 g will be the laboratory duplicate. The sample tag must have DUP added to the tag number e.g., B00000001-DUP. This sample will be split by the lab technician and analyzed for T-Cr.
4. **Record Field Notes**
   - Date and time.
   - Name of samplers.
   - Sample IDs.
   - Observations.
5. **Shipping and Analytical Parameters**
   - Complete the COC as per the example provided in Appendix I.
   - All samples are to be shipped via courier to an accredited laboratory (currently SGS Laboratories in Burnaby, B.C.) for total chromium (T-Cr) analysis.
   - In addition to the COC, complete an Offsite Removal Form as shown in Appendix II.

Appendix I – COC

File Location: J:\Environmental\02 Lab COCs, Results, Speadsheets, etc\00 CoCs and Results\SGS\2018\COC\Terraflow Cement Binder\COC_SGS_Cement_Template.xlsx

Chain of Custody

SGS Canada Inc.	Project	Brucejack Mine	Date Submitted:
Suite F, 3260 Production Way	Address	Centre, PO Box 49334 Vancouver, BC	Feb 14, 2018
Burnaby, B.C.	Phone	866-214-9772	
V5A 4W4	Fax		
604-638-2359 Ext. 27141	Email	Alison.Shaw@lorax.ca; Mholtby@pretivm.com; svanzalingen@pretivm.com; rmccall@pretivm.com; catherton@pretivm.com	Sampler Name: Sampler Phone: 778-724-4186 ext.
Attention: Carolyn Jones	Contact	Colleen Atherton	
Email: Carolyn.Jones@sgs.com			

Sample List	Analysis	P.O. Number (if applicable)
	Total Chromium	1025076
Cement Binder - SGS - B00207355	x	
		Special Instructions: Process samples designated as duplicates, then split the sample such that T-Cr is analysed on both

CHAIN OF CUSTODY:								
Relinquished by:	Time:		Date:		Received by:		Time:		Date:	
Relinquished by:	Time:		Date:		Received by:		Time:		Date:	

Appendix II – Offsite Removal Form

File Location: J:\Environmental\01 Administration\01 Purchasing Shipping\Shipping Documents\Forms for Shipping\Offsite Removal Form.xlsx

PRETIVM
Bruce Jack Project
Value Through Gold
Km 215, Hwy 37
British Columbia
(778) 724-4186

Offsite Removal Form

CONSIGNEE:
Address

ORIGINATOR:
Date 8/9/2016

QUANTITY	DESCRIPTION OF ARTICLES	TDG Y/N	APPROX WEIGHT

REASON FOR REMOVAL:

Packed/ Inspected by:		SIGN	DATE
		SIGN	DATE
Supervisor		SIGN	DATE
Mine Manager		SIGN	DATE

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
Feb 23, 2017	Initial Issue		
Aug 18, 2017	The addition of SFE analyses to assess soluble loads		
Jan 24, 2019	Update to PVG template, SFE removed from requested analyses.		

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Environment Superintendent/ Environment Coordinator	[redacted]		
Health and Safety Manager / Designate			
JOHSC Co-chair or Member			

Appendix 9-2-2. Closure Underground Water Quality Adaptive Management Plan

BRUCEJACK GOLD MINE

PRETIVM

Closure Underground Water Quality Adaptive Management Plan

July 2020

PRETIVM

BRUCEJACK GOLD MINE

Closure Underground Water Quality Adaptive Management Plan

Date: 2020-07-29

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VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
0	July 2020	Pretivm	Initial issue

AUTHORSHIP

This Adaptive Management Plan for the Underground Mine Water Quality at Closure was prepared for Pretium Resources Inc. (Pretivm) by Lorax Environmental Services Ltd. (Lorax). The Management Plan was written by Alison Shaw, Ph.D., P.Geo. and Laura Findlater, B.Sc., P.Geo. Input from Pretivm senior management was provided by Greg Norton and Sylvia Van Zalingen.

BRUCEJACK GOLD MINE PROJECT

Closure Underground Water Quality Adaptive Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AMP	Adaptive Management Plan
BC	British Columbia
FWAL	Freshwater Aquatic Life
LOM	Life of Mine
PAG	Potentially Acid Generating
POPC	Parameter of Potential Concern
ML/ARD	Metal Leaching / Acid Rock Drainage
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant

1 INTRODUCTION

1.1 PURPOSE

The purpose of this Adaptive Management Plan (AMP) is to outline adaptive management for water quality that develops in the underground workings (the 'mine pool') during the Closure phase of Brucejack Gold Mine when the mine will be flooded. Waste rock and paste backfill placed in the mine over operations, as well as the mine wall exposures, are expected to release chemical loads to the mine pool as they are submerged. Estimates of these loads and the associated peaks in concentrations have been incorporated into the site wide water quality model (Lorax 2020b). This AMP provides details with respect to the current plan for managing the predicted water quality at Closure, additional management strategies that could be implemented as required, and monitoring programs developed to refine understanding of potential water quality at Closure and the groundwater flow system.

1.2 PERFORMANCE OBJECTIVES

The performance objectives will be evaluated based on the underground mine water quality both during Operations (to revise predictions for mine pool water quality) and during the Closure phase when management strategies outlined in this plan will be implemented.

The main goal of this plan is to achieve water quality of the mine pool, once flooded, that will not lead to exceedances of relevant water quality guidelines or approved discharge limits in the receiving environment (Brucejack Creek) and no longer requires active treatment.

1.3 SCOPE

The scope of this plan covers monitoring plans throughout Operations and Closure mine phases relevant to water quality of the underground mine, as well as a description of contingency options that could be implemented during reflooding of the mine.

1.4 RELEVANT LEGISLATION AND REGULATIONS

This plan has been prepared as required by *Mines Act* Permit M-243 Condition D.5 and in accordance with the information requirements outlined in Section 3.3 of *Environmental Management Act* Effluent Permit 107835 (PE-107835). The water quality, water balance and groundwater models informing this plan have been revised to include the most up-to-date geochemistry, hydrology and hydrogeology data (Lorax 2020 a,b,c).

During the Operations phase, the waste rock and tailing storage facility (WRTSF) receives all mine-affected inputs, and thus monitoring station BJ 3.10 at the outlet to the WRTSF is the mine's final compliance location where discharge limits specified in Section 1.1.1 of PE-107835 apply. However, during the Post-closure phase, once the mine is flooded, the majority of groundwater flow paths from the underground mine discharge to the upper reaches of Brucejack Creek between the WRTSF outlet

and BJ 2.62. It is expected that BJ 2.62 will become the regulated final discharge point at Closure. The current PE-107835 BJ 3.10 discharge limits and applicable BC FWAL water quality guidelines for Brucejack Gold Mine are presented in Table 1-1.

Table 1-1. PE-107835 Discharge Limits and Applicable BC FWAL Guidelines

Parameter	Units	BC FWAL Guidelines		Effluent Discharge Limit
		Long-term	Short-term	
Ammonia	mg-N/L	NA	NA	4.0
Nitrite	mg-N/L	NA	NA	0.24
Nitrate	mg-N/L	NA	NA	11.5
Chloride	mg/L	150	600	NP
Fluoride	mg/L	NP	0.82	NP
Sulfate	mg/L	128	NP	NP
Aluminum-D	mg/L	0.050	0.10	NP
Antimony-T	mg/L	NA	NP	0.028
Arsenic-T	mg/L	NP	NA	0.01
Boron-T	mg/L	1.2	NP	NP
Barium-T	mg/L	1.0	NP	NP
Beryllium-T	mg/L	0.00013	NP	NP
Cadmium-D	mg/L	0.000083	0.00016	NP
Chromium-T	mg/L	0.0010	NP	NP
Cobalt-T	mg/L	0.0040	0.11	NP
Copper-D	mg/L	0.00030	0.0017	NP
Iron-D	mg/L	NP	0.35	NP
Iron-T	mg/L	NP	NA	1.7
Lead-T	mg/L	0.0039	0.016	NP
Mercury-T	mg/L	0.000020	NP	NP
Manganese	mg/L	0.73	0.85	NP
Molybdenum-T	mg/L	1.0	2.0	NP
Nickel-T	mg/L	0.25	NP	NP
Phosphorus-T	mg/L	NP	NP	NP
Selenium-T	mg/L	0.0020	NP	NP
Silver-T	mg/L	NA	NA	0.00046
Thallium	mg/L	0.00080	NP	NP
Uranium-T	mg/L	0.0085	NP	NP
Zinc-T	mg/L	0.0075	0.033	NP

Notes: BC FWAL = BC water quality guidelines for protection of freshwater aquatic life. Hardness dependent guidelines calculated using the baseline median hardness of 28 mg/L as $CaCO_3$. Ammonia guidelines calculated using a pH of 8.0 and temperature of 15°C.
Copper guidelines calculated using the BC biotic ligand model. Inputs to the model were the 2019 annual averages measured at BJ 3.10 of pH 7.9, DOC 0.5 mg/L, Alkalinity 52 mg/L, Ca 24 mg/L, Mg 1.2 mg/L, Na 22 mg/L, K 7.7 mg/L, SO_4 46.5 mg/L, and Cl 1.6 mg/L. A summer temperature of 10 °C was used. The default of 10% of DOC present as humic acid was used. Chromium guideline is for Cr(VI). NP=none proposed. NA=not applicable because the WQG is superseded by the discharge limit.

2 ADAPTIVE MANAGEMENT FOR MINE POOL AT CLOSURE

2.1 OVERVIEW

Brucejack Gold Mine operations will continue through to the end of 2032, with closure of the mine and its ancillary facilities scheduled to commence in January 2033 and continue over a total period of approximately three years, as described in the 2020 Mine Plan and Reclamation Program Update (Pretivm, 2020c). Flooding of the mine is planned to start in January 2033 with water in the mine predicted to flood to an ultimate level of approximately 1400 masl (varying seasonally between 1394 and 1410 masl) (Lorax 2020a).

The groundwater model developed for the site (Lorax 2020a) predicts that natural groundwater infiltration would flood the mine within approximately 2.5 years. However, once the water level reaches 1360 masl, after approximately 21 months, contact water from the underground mine is predicted to begin reporting to Brucejack Creek via subsurface pathways. It will be necessary to manage water quality in the underground mine pool throughout mine flooding and potentially beyond, to achieve regulatory compliance in the receiving environment (Section 1.4). The adaptive management strategies available to Pretium Resources Inc. (Pretivm) and which are described in this plan, include water treatment, control of the flooding rate and control of the discharge from the mine pool.

Underground mine water quality is managed during Operations through mine dewatering and water treatment. Groundwater is pumped from the underground mine to the process plant and ultimately to the mine's water treatment plant (WTP) for treatment prior to discharge to the waste rock and tailings storage facility (WRTSF). The quality of underground mine water is expected to degrade during Operations due to the presence of potentially acid generating (PAG) mine wall exposures, waste rock and ore. As mining proceeds and PAG rock is exposed, the sulfides present in the rocks will oxidize over time, thereby generating acidity and potential metal leaching acid rock drainage (ML/ARD) issues. This acidity will initially be neutralized by carbonate minerals present in the rocks, but eventually the drainage is expected to acidify and metal concentrations in the mine are predicted to increase. The increase in metal concentrations in the underground mine will be managed through the WTP throughout Operations and into the Closure phase. The parameters treated by the WTP, along with the measured and modelled removal efficiencies are presented in Table 2-1.

The recommended long-term strategy for managing PAG rocks and the associated drainage is placement under permanent water cover such that oxidation reactions are essentially shut off (Price and Errington 1998). Flooding of the mine will ultimately result in effective management of ML/ARD since most of the mine wall exposures and all of the backfilled waste rock will be placed below the final water table elevation. However, as the mine is flooding, oxidation products that have built up on mine walls and backfilled waste surfaces will be flushed into the mine pool, resulting in elevated concentrations of several parameters of potential concern (POPCs). While most of the identified POPCs can be treated by the WTP, some cannot (i.e., nitrite, nitrate, Cr and Se). Managing the peaks in POPC concentrations and overall mine pool water quality during flooding will require an adaptive management approach.

Table 2-1. Measured and Modelled Water Treatment Removal Efficiencies for Parameters Treated by the Water Treatment Plant

Parameter	Units	% Removal Measured	% Removal Modelled
Ag	mg/L	0%	0%
Al	mg/L	98%	90%
As	mg/L	93%	90%
Cd	mg/L	32%	25%
Cu	mg/L	62%	50%
Mo	mg/L	27%	25%
Pb	mg/L	83%	75%
P	mg/L	82%	75%
Sb	mg/L	54%	50%
Se	mg/L	30%	25%
U	mg/L	65%	50%
V	mg/L	83%	75%
Zn	mg/L	32%	25%

Note: the %removal measured and %removal modelled are based on values presented in the 2020 Water Quality Model Review and Update (Lorax 2020a)

The options for management of the mine pool water quality during Closure include the following:

- Acceleration of the flooding rate by pumping WRTSF water into the underground mine. This would serve to both (i) dilute mine water concentrations, and (ii) reduce the exposure time of PAG rock, thereby limiting the time period over which oxidation products can be generated.

- Treatment of mine pool water with recirculation of the effluent to the underground mine at depth. This strategy would reduce the concentrations of treated parameters (Table 2-1).

- Treatment of mine pool water with discharge of WTP effluent to the WRTSF. This strategy would (i) minimize the potential for concentrations of untreated parameters to build up in the mine pool, (ii) afford additional dilution and buffering of loads within the WRTSF, and (iii) reduce the flooding rate, thereby reducing the monthly loads directed to the WTP.

A conceptual illustration of these potential management strategies is presented in Figure 2-1. The following section describes the proposed Base Case adaptive management strategy for managing water quality at Closure, along with adaptive management strategies that could be implemented should they be required.

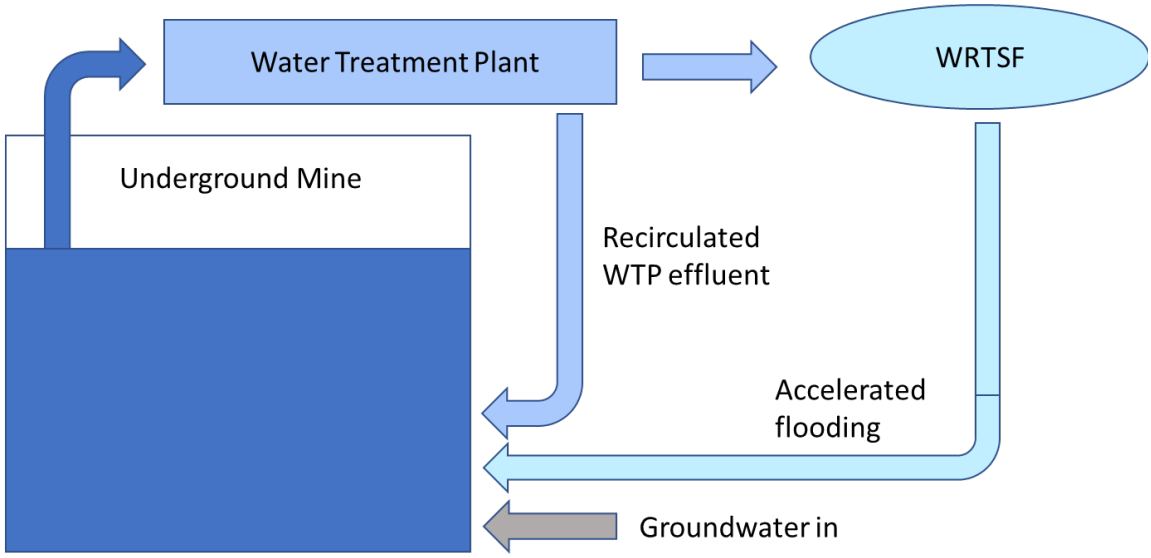

Figure 2-1. Conceptual illustration of options for underground mine flooding and treatment at Closure.

2.2 BASE CASE MANAGEMENT STRATEGY

The Base Case Closure plan for managing water quality at Closure employs both accelerated flooding and water treatment strategies as described in Pretivm 2020c. The plan includes accelerated flooding of the underground mine by pumping or siphoning water from the WRTSF at the BJ 3.10 weir to the underground mine for a total of 7 months, at which point the mine pool reaches its final flooding elevation of approximately 1400 masl. The water would be pumped at a rate of 70 m^3/hr for a 4 month period, from January 2033 through to the end of April 2033. This rate represents the withdrawal rate specified in the mine's current water license. Starting in May 2033, water would be pumped to the underground mine at a higher rate, equivalent to 20% of the MMD (mean monthly discharge) at BJ 3.10 for an additional 3 months. This withdrawal rate is sufficiently low to minimize alteration to the flow regime of Brucejack Creek. No adverse effects on aquatic biota are anticipated due to the flows being within the normal high range of the creek.

In order to mitigate water quality through this accelerated flooding scenario, the water would be treated through the WTP at a rate of 10,000 m^3/day and recirculated to the underground mine. Water would be withdrawn using submersible pumps and returned to the mine pool at various locations. Water would be treated for a total of 15 months, covering the entire flooding period and an additional 8 months. This duration of treatment amounts to treatment of 4.5 Mm^3 of water, the equivalent of a volume 2.4 times the mine void.

The water quality results presented in the 2020 Water Quality Model Review and Update (Lorax 2020b) indicate that under this Base Case management scenario, water quality will be mitigated with no significant impacts to the receiving environment anticipated. Through the course of mining, as additional monitoring data is acquired (details are outlined in Section 2.4.1), the water quality

predictions and water management plans will be refined. This Base Case management strategy will be reviewed and updated, as necessary.

2.3 CONTINGENCY MANAGEMENT STRATEGIES

As flooding commences, various monitoring programs will be initiated (as described in Section 2.4.2), the results of which will inform decisions regarding whether contingency adaptive management strategies will need to be employed. Potential contingency management strategies in the event that water quality is substantively worse than expected include:

- deceleration of flooding rate;
- directing treated water to the WRTSF rather than recirculating to the underground; and
- extending the duration of active water treatment.

The following sections outline the potential contingency management strategies and conditions that would lead to their implementation.

2.3.1 Deceleration of Flooding rate

A contingency option to slow the filling rate would be implemented if the flushing loads released to the mine pool resulted in higher than anticipated concentrations of POPCs which could not be managed through the Base Case treatment and recirculation strategy described above. The water quality predictions for the mine pool chemistry at closure indicate that water treatment will be required in all cases; however, the duration of treatment will depend on the efficiency of treatment and recirculation. A reduced flooding rate would allow for a greater number of mine void volumes to be treated through the WTP (in the case of recirculation) before the mine pool water reached the threshold elevation of 1360 masl at which point contact water is anticipated to start flowing towards Brucejack Creek. Deceleration of the flooding rate could be achieved through various means including:

- Reducing the rate at which BJ 3.10 weir flows are pumped into the underground mine;
- Shutting down the BJ 3.10 weir pumps and allowing the mine to passively flood; and
- Directing the treated underground mine water to the WRTSF.

Decelerating the rate of flooding would allow for more intensive treatment of mine pool water and additional time for monitoring, but would also extend the exposure time of backfilled waste rock and mine walls, thereby exacerbating the effects of ML/ARD. Under this scenario, the treated water could be recycled to the underground mine or discharged to the WRTSF. The situation favouring discharge to the WRTSF is outlined in Section 2.3.2.

2.3.2 *Directing Treated Water to the WRTSF*

Another contingency option if the flushing loads released to the mine pool resulted in higher than anticipated concentrations of POPCs which could not be managed through the Base Case treatment and recirculation strategy described above would be directing treated mine water (or a portion thereof) to the WRTSF rather than recirculating it to the underground. This measure would result in several potential benefits to overall water quality including:

- Reducing the potential for concentrations of untreated parameters to build up in the mine pool as a consequence of recirculation.
- Afford additional dilution for mine pool loads and buffering of loads within the WRTSF. Predicted peak concentrations occur during the low flow months when groundwater discharge in Brucejack Creek experiences less dilution from surface runoff. These peaks could potentially be mitigated by directing the discharge into a larger reservoir (i.e., the WRTSF).
- Reduce the flooding rate, thereby reducing the monthly loads directed to the WTP (as described in Section 2.3.1).

The decision to direct WTP discharge to the WRTSF will be dictated by water quality of the mine pool and an assessment of the potential for parameter concentrations to go above specified water quality guidelines or discharge limits. The seasonal implications and the untreated parameter concentrations will determine whether WTP discharge (or a portion thereof) is directed to the WRTSF.

2.3.3 *Extending the Duration of Treatment*

Currently, based on modeling predictions, the Base Case Closure underground water quality management strategy entails a total treatment duration of 15 months to achieve mine pool water quality suitable for discharge either via subsurface pathways to Brucejack Creek or to the WRTSF. This treatment duration could be extended if necessary, to achieve suitable mine pool water quality. It is likely that treatment would be required throughout reflooding, or at least until the threshold elevation of 1360 masl when subsurface seepage would begin to follow towards Brucejack Creek. The benefit of treating water above this level for an extended time frame will be assessed through the monitoring programs developed for Closure (Section 2.4.2).

There is uncertainty in how long elevated concentrations could persist in the mine pool; current water quality modelling (Lorax 2020b) indicates that metal concentrations in Brucejack Creek will reach long term Post-closure levels within 3 to 5 years. Extending the duration of mine pool water treatment will minimize the time over which these levels are reached by reducing the flushing loads. The decision to extend active water treatment beyond 15 months will be based on water quality trends in the underground mine pool and Brucejack Creek during the Closure period.

2.4 MONITORING

2.4.1 Operations Monitoring

Monitoring data collected over the course of mine operations will be used to update the water quality predictions for closure and refine water quality management strategies. These data will be also be used to develop appropriate management triggers in due course. The sections below highlight the relevant monitoring programs that have been developed for Operations.

2.4.1.1 Underground Mine Water

Underground mine water data are routinely monitored and will continue to be monitored throughout Operations. These data are reviewed on a regular basis to verify water quality model predictions and ensure that water quality is being managed appropriately. Underground mine water data are critical for gaining insight into the anticipated mine pool water quality at Closure. Underground mine water sampling programs include the following:

- In-situ pH and conductivity measurements of underground seeps on a quarterly basis, with low pH samples analysed for the full suite of water quality parameters (pH, TSS, nutrients, anions and metals), as outlined in the ML/ARD Management Plan (Pretivm 2020b).
- Quarterly sampling of water from underground mine sumps, as outlined in Appendix 7 of the ML/ARD Management Plan.
- Sampling of drainage from backfilled stopes on a minimum of 2 stopes per year to assess soluble Cr loads released to mine water, as described in the Chromium Management Plan (Pretivm 2019).
- Monitoring of bulk underground water twice a month, as outlined in the ML/ARD Management Plan. These samples are used to verify the water quality model source terms and assumptions regarding the rate of onset of ML/ARD.
- Mine wall washing water quality samples carried out at lithology-specific stations on an annual basis. These data are used to evaluate flushing loads, as outlined in the ML/ARD Management Plan.

2.4.1.2 Underground Mine Rock, Paste Backfill and Precipitates

Ongoing characterization of rocks, paste backfill and mineral precipitates in the underground mine will provide critical information for refining Closure water quality predictions. These data will be used to determine estimates of flushing loads released upon submergence of backfilled paste, waste rock and wall rock during the Closure phase (*i.e.*, dissolution of soluble oxidation products). The relevant monitoring programs are described below:

- Confirmatory sampling of waste rock material will continue to be carried out throughout the Operations phase as described in the ML/ARD Management Plan; at least one composite sample for every 25,000 m^3.

- Confirmatory sampling of paste backfill samples will continue to be carried out on a quarterly basis to assess Cr concentrations, as outlined in the Chromium Management Plan.
- Kinetic test Programs have been developed and are being implemented for waste rock and paste backfill under both saturated and unsaturated conditions, as described in the 2020 ML/ARD Review and Update (Pretivm 2020b).
- Characterization of mineral precipitates in the underground workings will continue to be conducted, as part of the wall washing program described in the ML/ARD Management Plan.

2.4.1.3 Water Treatment Plant

The WTP influent and effluent data through the Operations phase will provide a good indication of how effective treatment will be in reducing loadings associated with underground mine water at Closure. The observed treatment efficiencies (Table 2-1) and overall WTP performance will be reviewed on a regular basis to ensure that the proposed management strategies are appropriate. WTP performance is currently assessed on an annual basis and presented in the annual reports. Ongoing WTP monitoring includes:

- WTP influent and WTP effluent samples collected twice a month and analyzed for the full suite of water quality parameters.
- WTP influent and effluent flows monitored continuously. As mine development proceeds, dewatering rates will increase. It will be critical to evaluate whether the WTP performance changes when treating at higher flow rates.

2.4.1.4 Groundwater

Groundwater monitoring comprises both groundwater quantity and groundwater quality monitoring. Both aspects of groundwater monitoring are ongoing and will continue through Operations. Groundwater quantity and groundwater quality monitoring are described in the Groundwater Monitoring and Sampling Protocol (Pretivm 2020a).

Continuous groundwater level measurements, in addition to underground flow rates, will be used to validate and/or update the groundwater model, which is used to predict the following:

- Inflows to the underground mine during future Operations;
- Flooding rates into the underground mine void at Closure;
- Time to flood the mine and the ultimate flooded elevation in the mine at Closure;
- The timing, volumetric flux and spatial distribution of contact water draining from the underground towards surface water receptors at Closure; and,
- Changes in baseflow at surface water receptors during Operations and Closure.

Continuous water level monitoring is achieved through dedicated water level loggers programmed to record water level pressure and temperature at 6 hour intervals. The datalogger records are cross-

referenced to manual water level elevations recorded at the time of sampling, typically two to four times per annum.

Groundwater quality sampling is specified on a quarterly or biannual basis as specified in PE-107835. The scope of groundwater quality monitoring may be modified on account of wells becoming dry through Operations. Groundwater quality monitoring is comprised of the following:

- In-line measurements of field parameters including temperature, pH, electrical conductivity, dissolved oxygen, oxidation-reduction potential and turbidity;
- Laboratory analysis of total and dissolved metals, physical parameters, anions, nutrients and sulphide.

The monitoring program will be used to determine changes in groundwater quality arising from the depression of water levels through operations. This may result in changes to the groundwater redox environment and concentrations of redox-sensitive parameters. This information will be used to confirm conceptualization of mine pool evolution at closure.

2.4.2 Closure Monitoring

Once flooding of the underground mine is initiated, it will be critical to ensure that the mine pool is responding as anticipated both in terms of flooding rate and water quality. Management triggers will be identified through the monitoring plans described above as additional data is collected. These triggers will identify water quality threshold limits and be evaluated on an ongoing basis. The sections below outline monitoring programs that will be carried out during Closure. It is likely that many of these programs will continue for some time into Post-closure.

2.4.2.1 Underground Mine Water

Monitoring of the underground mine water will continue during the Closure phase once flooding has commenced. Monitoring plans will include the following:

- Collection of monthly sump water quality samples from the accessible sump network.
- Installation of water level and conductivity loggers at different depths in the underground workings at closure via one or more air raises to measure water level rebound and electrical conductivity as a surrogate for mine pool water quality.
- Collection of monthly water quality samples from different depths in the mine pool via discrete sampling from one or more air raises.

2.4.2.2 Water Treatment Plant

The WTP influent and effluent data will continue to be monitored through the Closure phase to assess treatment efficacy and response to maximized WTP treatment flow rates (10,000 m^3/day). The WTP performance will assessed on an ongoing basis to determine whether adaptive management strategies will be required. The WTP monitoring will include:

- WTP influent and WTP effluent samples will continue to be collected twice a month and analyzed for the full suite of water quality parameters.
- WTP influent and effluent flows will continue to be monitored continuously.

2.4.2.3 Groundwater

Groundwater quantity and quality monitoring will continue into Closure. The monitoring program will include five additional monitoring wells slated for installation before or during Closure per PE-107835. Data collection from all monitoring wells slated for Closure monitoring includes the following:

- Continuous water level measurements via dedicated water level loggers programmed to record groundwater temperature and pressure;
- In-line measurements of field parameters including temperature, pH, electrical conductivity, dissolved oxygen, oxidation-reduction potential and turbidity;
- Laboratory analysis of total and dissolved metals, physical parameters, anions, nutrients and sulphide.

Continued water level monitoring through closure will be used to validate and/or update the groundwater model, facilitating prediction of the location and volumetric flux of contact water migrating from the underground to Brucejack Creek. The database of groundwater quality amassed though baseline, Operations and Closure will serve as an important benchmark for evaluating whether Closure groundwater quality is influenced by the flooded mine workings, thereby confirming contact water flow paths. Characterization of evolving groundwater redox conditions as the mine refloods will inform conceptualization of geochemical loadings to Brucejack Creek.

3 CONTINUOUS IMPROVEMENT, FOLLOW UP AND ADAPTIVE MANAGEMENT

The monitoring programs developed to evaluate closure water quality of the underground mine are currently part of existing management plans including:

- ML/ARD Management Plan (Pretivm 2020a)
- Chromium Management Plan (Pretivm 2019)
- Groundwater Monitoring and Sampling Protocol (Pretivm 2020a)
- Nitrogen Management Plan (Pretivm 2020d)

Field results collected through these existing plans are and will continue to be recorded when taken with external lab test results transferred electronically into a database.

Triggers and other performance indicators, corrective actions, and mine plans will be reviewed to identify potential operational improvements. Management strategies will be assessed and updated using evidence-based approaches, as necessary.

Mine pool information will be reviewed and incorporated into reports, as needed. These include at minimum:

1. Annual Reclamation Report required under Mines Act Permit M-243 for Construction and Operations; and
2. The updated Mine Plan and Reclamation Program for the mine, which must be submitted every five years to the Chief Inspector of Mines pursuant to *Mines Act* permit M-243. The Mine Plan and Reclamation Program update summarizes environmental data collected over the previous five years and documents validation of and any updates to the groundwater, water balance and water quality models.
3. The Closure Plan which must be submitted 12 months prior to final Closure pursuant to *Mines Act* permit M-243.

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Appendix 9-2-3. Geohazards Management Plan

Brucejack Mine

Geohazard Management Plan Update

Prepared by BGC Engineering Inc. for:

Newcrest Mining Limited

October 24, 2023

Project 1696001

Pioneering responsible solutions to complex earth science challenges

October 24, 2023 Project 1696001

Newcrest Mining Limited
2965 Tatlow Road
Smither, BC V0J 2N5

Attention: Cam Mackay-Stotesbury, EIT

Geohazard Management Plan Update

Please find the report attached. We appreciate the opportunity to collaborate with you on this challenging and interesting project.

Should you have any questions, please do not hesitate to contact the undersigned.

Yours sincerely,

BGC Engineering Inc.
per:

Marc-André Brideau, Ph.D., P.Geo.
Senior Engineering Geologist

TABLE OF REVISIONS

Date	Revision	Remarks
February 6, 2023	DRAFT	Draft issued for comments
October 24, 2023	R0	Issued for Use

CREDITS AND ACKNOWLEDGEMENTS

BGC would like to acknowledge the following contributors to this report:

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GLOSSARY

Term	Definition
Geohazard	Landslide, fluvial, glacial, or snow avalanche process with the potential to result in some type of undesirable outcome. For example, this could include a debris flow hazard area intersecting the footprint of a facility. The term geohazard refers to the specific nature of the process (type, frequency, magnitude), but not the consequences of a geohazard event. In this document, the term “geohazard” is used exclusively to describe naturally-occurring landslide, fluvial, and glacial hazards at the minesite. Snow avalanche hazards are not discussed in this plan.
Geohazard Event	Actual or potential occurrence of a geohazard resulting in an undesirable outcome. For example, this could include debris flow damage to a facility resulting in a one day loss of function. The term geohazard event refers to the specific nature of the consequences, but not their severity in terms of economic, environmental, safety, or reputation loss, or the likelihood this will occur.
Geohazard Risk	Likelihood of a geohazard event occurring and resulting in a particular severity of consequence, defined in terms of economic, environmental, safety, or reputation loss. For example, this could include the likelihood of debris flow damage to a facility resulting in $1M of economic loss.
Unsafe Situation	Situation of elevated geohazard risk. This would include site conditions indicating elevated likelihood of a geohazard event with the potential for consequences to workers or facilities (e.g., high rainfall while working in a stream susceptible to debris flows). Potentially unsafe situations not related to geohazards are not discussed in this report.

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1.0 INTRODUCTION

The objective of the Geohazards Management Plan (GMP) is to make a safer workplace by providing workers with the tools to identify geohazards with the potential to cause damage and/or create unsafe working conditions. The GMP includes protocols designed to mitigate the potential adverse effects of geohazards.

Newcrest Mining Ltd. (Newcrest) retained BGC Engineering Inc. (BGC) to review and update the existing Geohazard Management Plan for the Brucejack Mine in northwest British Columbia, Canada. The Brucejack Gold Mine Project Geohazards Management Plan was finalized for Pretium Resources Inc. in 2014 and updated in 2016 following an annual geohazard inspection review (Pretium Resources Inc., November 26, 2014; Pretium Resources Inc., December 2016). The Pretium Resources Inc. GMP (December 2016) outlines the plan that was in place when Newcrest acquired the mine in March 2022.

This document provides an updated GMP for the geohazards identified by the terrain stability mapping completed for this updated plan (Drawings 01 to 05). Appendix A introduces landslide hazards in the context of the Brucejack project and provide on-site personnel with tools to:

1. Understand the factors affecting slope stability and triggering mechanisms leading to slope failure; and,
2. Recognize the main types of landslides, their characteristics, early warning signs and potential consequences.

Appendix B provides a summary of the updates made to the Pretium Resources Inc. (December 2016) version of the GMP. Appendix C provides a review of the use and performance of the existing GMP (Pretium Resources Inc., December 2016) as well as a review of geohazard events reported on site and weather data trends observed since 2014.

Based on previous work (BGC, July 31, 2015) and updated terrain mapping completed for this GMP update, the main geohazards at the Brucejack Minesite are landslides and snow avalanches. Considerations for ice fall and flooding are also discussed in the GMP update as they have been identified in the terrain mapping. The language and examples in the GMP update focus on landslides but the geohazard management strategies outlined in Section 5.0 (day to day actions, response protocol and periodic inspection) are applicable to landslides, ice fall, and flooding hazards. A management plan for snow avalanche hazards was provided by Alpine Avalanche Solutions (November 2014) and is not updated by this report.

2.0 PERFORMANCE OBJECTIVES AND SCOPE

The study area covered by this GMP is outlined in Drawings 01 to 05. This includes the existing road and building infrastructure present in the CAD drawing file, provided by Newcrest, “PVG 3300-DD30-SKT-0002.dwg” dated September 2, 2020. Drawings 01 to 05 show locations of geohazards in relation to these facilities, based on terrain mapping completed by BGC for this GMP update (Appendix B).

This GMP scope pertains to geohazards management for day-to-day operations. The performance objectives of this GMP and corresponding protocols provided by this GMP are for:

- Recognizing geohazard occurrence and unsafe situations
- Responding to geohazard event occurrence
- Minimizing worker exposure to geohazards
- Reporting and recording geohazard event occurrence.

The following is not considered by this GMP:

- Geohazards other than naturally-occurring landslide, glacial, and hydrotechnical processes
- Stability of anthropogenically modified terrain
- Infrastructure outside of the study area, including Bowser airstrip, Knipple Camp, Wildfire Camp, the transmission line, and the glacier access road
- Engineering design of any structural measures associated with facility design.

3.0 COMPLIANCE OBLIGATIONS, GUIDANCE, AND BEST MANAGEMENT PRACTICES

3.1 Relevant Legislation, Regulations, Permits and Environmental Assessment Conditions

- BC Mines Act (RSBC, 1996) regulates all mines during the exploration, construction, production, closure, reclamation, and abandonment phases.
- Health, Safety and Reclamation Code for Mines in British Columbia (the Code; BC Ministry of Energy, Mines, and Low Carbon Innovation [EMLI], 2022a), which is empowered under the Mines Act (RSBC, 1996). The purpose of the code is to:
    - Protect employees and all other persons from undue risks to their health and safety arising out of or in connection with activities at mines.
    - Safeguard the public from risks arising out of or in connection with activities at mines.
    - Protect and reclaim the land and watercourses affected by mining.
    - Monitor the extraction of mineral and coal resources and ensure maximum extraction with a minimum of environmental disturbance, taking into account sound engineering practice and prevailing economic conditions.
- British Columbia Guidelines for Reportable Incidents for Mines (EMLI, 2022b) is a supplement to the Code to assist with compliance of reportable incidents
- Permit M-243 is the Mines Act Permit for the Brucejack Gold Mine. Conditions specific geohazards assessment are contained in Section C.10 of the permit. The Geohazards Management Plan is also one of the management plans required and approved under M-243.

3.2 Guidance and Best Management Practices

Guidance and best management practice relevant to the GMP include:

- Guidelines for Legislated Landslide Assessments. Engineers and Geoscientists BC (EGBC, 2022)
- Mapping and Assessing Terrain Stability Guidebook (Ministry of Forests [MOF] and Ministry of Environment [MOE],1999)
- Terrain Classification System for British Columbia, Version 2 (Howes, & Kenk, 1997)
- Specifications and Guidelines for Terrain Mapping in British Columbia. (Resources Inventory Committee, 1996)
- Risk Management – Canadian Technical Guidelines and Best Practices Related to Landslides (VanDine, 2012).

4.0 DESCRIPTION OF GEOHAZARDS

This section provides overview description of geohazards within the project area. Appendix A introduces landslide hazards in the context of the Brucejack Mine to provide on-site personnel with tools to:

1. Understand the factors affecting slope stability and triggering mechanisms leading to slope failure; and,
2. Recognize the main types of landslides, their characteristics, early warning signs and potential consequences.

Protocols for date to-day actions and response to geohazard occurrences are provided in Section 5.0.

4.1 Summary of Geohazards

BGC identified landslide, glacial, and hydrotechnical geohazards in the mine site area of this GMP based on 2022 data sources provided by Newcrest (Appendix B). These geohazards are identified in terrain stability maps (Drawings 01 to 05) and include rockfall, debris flood, debris flow, debris avalanche, ice fall and flood hazards. These terrain maps form the basis for identifying potential naturally occurring hazards in relation to works sites. Risk posed to work sites by identified geohazards has not been assessed for this GMP update. Nonetheless, BGC considers all geohazards identified in Drawings 01 to 05 to be credible hazards.

The geohazards identified in the terrain stability maps include both geohazards that directly impact mine infrastructure (i.e., terrain polygons showing existing geohazard landforms that intersect mine infrastructure) and those distal to infrastructure with potential to reach mine infrastructure (i.e., where mine infrastructure is in the impact/runout zone of geohazards but away from the source). The potential impact areas of large scale distal geohazards are generally difficult to confine. Large scale hazards, such as ice falls, are generally less likely to occur in comparison to small scale hazards, such as rockfalls, however their potential effects are more severe.

5.0 GEOHAZARD PROTOCOLS

The GMP protocols are divided into three components:

1. Day to day actions.
2. Geohazard event responses.
3. Periodic inspections.

Day to day actions include:

- Watching for and communicating changes in the landscape and seeking expert review if unsure of the geohazard type observed, or its potential consequence
- Monitoring and forecasting weather conditions to define work and travel protocols with respect to weather conditions
- Recording precipitation and weather conditions for later correlation with geohazard events.

Geohazard events are defined as geohazard occurrences with the potential to result in an unsafe situation. Response includes:

- Actions when first recognizing and entering the area of a geohazard event
- Safe work procedures for working around geohazards
- Reporting, escalation levels and protocols: who to inform, and when.

Periodic review includes:

- Civil-geotechnical inspection of Newcrest facilities
- Procedures for geohazard risk review
- Adjustment of site protocols as appropriate.

5.1 Day to Day Actions

Day to day actions that Newcrest Operations Personnel (personnel) can undertake to minimize their exposure to geohazards include:

- Identifying landscape changes indicating geohazard occurrence or unsafe situations (Section 5.1.1)
- Determining the weather advisory level (Section 5.1.2)
- Following weather advisory work protocols (Section 5.1.3)
- Following appropriate geohazard event communication and response protocols (Section 5.2).

5.1.1 Identifying Landscape Changes

Visually identifying landscape changes that could indicate an increase in hazard is an important part of anticipating events that could result in injury (fatality) and/or damage to equipment. It forms part of the general site safety culture and encouraging site operations and construction teams to report landscape changes is important as they repeatedly see the same areas and can note subtle changes. An example of recognizing and reporting landscape changes can be notifying the shift supervisors of changing conditions, such as high water levels or the presence

of rocks on a road. Other example of landscape or facility condition changes that could be indicators of increased landslide hazard risk to facilities or workers include:

- Any changes in surface water drainage paths (e.g., stream avulsion) or landscape changes with the potential to lead to drainage path changes (e.g., landslides entering streams). Facilities are constructed to manage the surface drainage where it was encountered during construction and geohazard management approaches included avoidance (e.g., placing transmission poles away from creeks), and protection (e.g., construction of rip rap channels for cross drainage). If drainage paths crossing roads or transmission line change their path (avulse), facilities could be vulnerable to damage.
- Increasing frequency of small landslides may indicate an increased likelihood for larger and potentially more damaging events.
- Cut or natural slope failures, fill slope failures, or soil/gully erosion that could lead to undermining of facilities or increased vulnerability of facilities to up slope landslide hazards (e.g., structure foundations: pole, guys, and anchors).
- Slack or over-tensioned guy wires or conductors, or tilting or rotation or translation of transmission poles which could be associated with slope movement or soil creep or snow creep.
- New access road developments up slope of facilities as these can alter surface and groundwater flow patterns, potentially increasing the landslide susceptibility. Road fills on steep slopes may also create increased debris avalanche and debris flow potential.
- Changes in the landscape could alter surface and groundwater flow patterns, potentially increasing the susceptibility of terrain to landslides. In coordination with contractors, personnel will document changes to the landscape upslope and downslope of Newcrest facilities.

5.1.2 Weather Advisory Level

Weather conditions are an important trigger for many geohazards. To account for this, Newcrest has implemented protocols based on weather forecasts. Newcrest operates a climate station adjacent to the BJL-H1 hydrometric station (Lat 56 deg 28’ N, 130 deg 12’ W; elevation 1,360 m above sea level), near Brucejack Lake. Site avalanche technicians use meteorological data from site weather stations, contracted weather services, and Environment Canada to provide daily weather forecasts. These forecasts along with field observations are used to evaluate geohazard potential. The forecasts are disseminated by email each morning and discussed with crews during pre-shift safety meetings.

Based on experience estimating rainfall thresholds for other locations in British Columbia (Jakob & Weatherly 2003; Jakob et al., 2006; Jakob & Lambert, 2009), BGC currently recommends the use of 24-hour and 4-week antecedent rainfall values to derive a rainfall-initiated landslide hazard value. This process accounts for storm event rainfall (24-hour timeframe) and the accumulated rainfall of the previous several weeks (4-week antecedent accumulated rainfall). Table 5-1 provides a weather advisory matrix based on forecasted storm precipitation and 4-week antecedent precipitation. Additional factors exist that also influence

geohazard occurrence (freeze thaw cycles, temperature behaviour, freezing level, wind speed and short-term rainfall intensities). However, a more sophisticated advisory system may not be warranted for day-to-day operations given the limited data available for actual geohazard events and their timing in the local area. The weather advisory matrix should be read as follows:

1. Obtain the recorded rainfall in millimetres over the previous 4 weeks (4-week antecedent rainfall), and assign the appropriate category on the vertical axis.
2. Obtain the forecasted storm rainfall for the next storm cycle for rainfall events exceeding at least 6 hours of continuous rain above 1 mm/hr, and assign the appropriate category on the horizontal axis.
3. Follow the horizontal and vertical results into the middle of the matrix to obtain the advisory level.
4. During changing weather (precipitation) conditions, the advisory level should be frequently updated (e.g., several times per day).

The threshold values in the advisory should be reviewed and updated as more data on actual site precipitation versus geohazard site conditions or landslide events accumulate. Day to day operations will continue to maintain digital climate records so that they are available for correlation to geohazard events. Correlation of climate data and geohazard events can be used to refine hydro-climatic thresholds for Weather Advisory Levels.

Table 5-1 Weather advisory matrix.

4-wk Antecedent Rainfall (mm)	Storm Precipitation (mm) <25	25-50	50-75	75-100	>100
<150	L	M	M	H	VH
150-200	M	M	H	VH	VH
>200	M	H	VH	VH	VH

Notes:

1. If temperature at work site < 0°C lower rating by two categories unless already Low.
2. If temperature at work site >5°C and snow is on the ground (e.g., it is raining on the snowpack) raise rating by one category unless already Very High.

5.1.3 Weather Advisory Protocols

Table 5-2 presents weather advisory work protocols for areas subject to geohazards. On site identification of unsafe situations with respect to geohazards (see Section 5.1.1) should override the work protocols listed in this matrix.

Table 5-2 Weather advisory work protocols for areas subject to geohazards.

Weather Advisory Level	Hazard Zone Protocols			
	Road Traffic	**Vehicle Stoppage**	**Operational Works**	**Return to Work Guidance**
Low	No restrictions	No restrictions	Monitor for geohazards during repair or construction	N/A
Moderate	No restrictions	No non-essential vehicle stoppage	Consider delaying non-essential repair or construction work until weather conditions improve. Be prepared to suspend work if local weather conditions worsen.	Once the weather advisory returns to “low”
High	Advise road traffic of increased road hazard condition	No non-essential vehicle stoppage	Delay non-essential repair or construction work until weather conditions improve. Be prepared to suspend essential repairs if local weather conditions worsen. Evacuate workers from remote sites (e.g., sites inaccessible by road).	When safe, following the storm event, have Newcrest operations personnel complete a site inspection to identify any geohazard events. If a geohazard event is identified refer to Section 5.2 for geohazard response protocols.
Very High	Restrict road traffic to essential vehicle traffic only	No vehicle stoppage	Essential repairs only. Follow access and hazard/review monitoring protocols for sites with active geohazards.	When safe, following the storm event, have a qualified professional(s) supported by Newcrest operations personnel complete a geohazard review of Newcrest facilities. If a geohazard event is identified refer to Section 5.2 for geohazard response protocols.

5.2 Geohazard Response Protocol

Geohazard response refers to the sequence of actions following the occurrence of a geohazard event, or identification by workers of an unsafe situation with respect to geohazards. These actions include assessing the effect of the event on safety and operations, and determining how to safely access the area to restore normal operation, while not exposing personnel to intolerable risk.

5.2.1 Training

Response to a geohazard event or identified unsafe situation will be completed by personnel trained in:

- The non-geohazard related hazards of the facilities (e.g., power lines)
- Recognition of geohazard types with an understanding of their characteristics
- Risk evaluation protocols.

5.2.2 General Response Protocol

Evaluation of risk to personnel is required before investigating a geohazard event or situation, and/or repairing damage caused by a geohazard event.

Every geohazard event or situation response will be unique and requires its own evaluation and action plan. When personnel are in doubt about the appropriate response to a geohazard event or situation, the affected site area will first be closed off to all traffic and personnel. The Shift Supervisor will be contacted immediately (ideally with overview photos in an email and information to fill a Natural Hazard Incident Report form provided in Appendix D), any affected facilities will be prepared for shut-down, and a qualified registered engineer or geoscientist will be called in to support the hazard evaluation and response.

The general response protocol is:

1. Confirm no personnel were affected by the event. Account for all personnel.
2. Restrict entry within the affected area until the likelihood of further events is assessed. For events having an immediate effect on operations, inform the Mine Manager.
3. Assess the type, severity, and effects of the event. Assess the likelihood of further events that could affect safety at the site, with consideration of forecast weather and indicators of instability for the geohazard type. Limit access to essential personnel. Follow the best practices approach and assessment procedures summarized below when making assessments. If uncertain, obtain specialist advice.
4. Maintain communications and provide status updates to the Shift Supervisor and Mine Manager. If the situation warrants, inform any affected neighbouring operators or government officials with the potential to be affected by the event.
5. Describe site access and evacuation plan for any repair work. Consider elements such as a spotter, escape route, and weather monitoring.

6. When the site conditions are such that the risk to personnel is considered tolerable with the implementation of the proposed site access and evacuation plan, carry out clean up and repair work.
7. Collect photographs and document site observations within a natural hazard event report as soon as safely possible and practical. Use the Natural Hazard Incident Report form provided in Appendix D. In addition, the EMLI “Advice of Geotechnical Incident” form (Appendix D) will be completed by the Mine Manager and submitted to EMLI if applicable.

5.2.3 Geohazard Approach and Assessment Procedures

A geohazard event is more likely during or shortly after peak trigger conditions such as heavy rainfall, snowmelt, or a combination of both, and will generally occur in steeper terrain. It is often not clear if another event is possible, necessitating a high level of caution when approaching and assessing an event. The guidelines below will help minimize the exposure to personnel making an initial event assessment.

When responding to a geohazard event the following objectives should be met before close approach to the event:

1. Review the weather conditions and Weather Advisory Level and determine if precipitation intensity is increasing or decreasing. Avoid approaching the site until the rainfall threshold (Table 5-1) is moderate or lower.
2. Identify the type of geohazard (e.g., debris flow, rockfall, etc.) and its characteristics. When in doubt, workers should request the support of a qualified registered geoscientist or engineer.
3. Assess the limits of the area affected by the geohazard as much as possible without entering the affected area, so a safe zone can be established.
4. Establish a spotter well outside of the affected area with the ability to communicate with all personnel approaching the hazard area. The spotter must be able to visually appraise the event initiation area, and warn others if another event occurs. The spotter will be equipped with communication devices such as a very high frequency (VHF) radio or air horn, and warning system protocols established, in order to contact personnel in the hazard area. The spotter will sound a warning on the radio or sound one long blast of the air horn to notify personnel to evacuate the area immediately.
5. Assess the current activity of the geohazard. This should be done in stages, first visually and audibly (by sound) over a period of about 2 hours before entering the hazard area. Do not enter the area if there are any signs of ongoing activity (e.g., active landsliding or flooding).

Once steps one through five are complete, closer approach can be made for further assessment of the likelihood of additional events or movement. Most geohazards move down slope from an initiation point, so personnel should avoid the travel or runout zone of the geohazard when making further assessments. Head scarp areas should be approached from the side or above, not by climbing up the geohazard travel path. At all times ensure that a designated safe zone can be reached in two steps (i.e., two steps to safety). This stage of assessment should attempt

to identify additional imminent geohazards at or near the head scarp or source area, and establish more quantitative measurement of potential further movement (i.e., monitoring).

No individual will be permitted within the limits of the geohazard area until (at a minimum):

- A safety watch (spotter) has been established
- The trigger conditions for the event are no longer present (e.g., the rain has stopped and sufficient time has passed for the slope to drain)
- The limits of the geohazard (e.g., landslide) have been defined
- Ground movement within the affected area has stopped.

Under good light and working conditions this assessment may take a minimum of two hours to complete. If in any doubt about the adequacy of any of the requirements above, keep the area closed to personnel, and obtain specialist assistance.

5.2.4 Assessment Escalation

The Mine or Road Manager will determine escalation requirements for the response to and management of geohazard events. This could vary from no immediate action, to immediate specialist review. This decision will require judgment, based on factors such as:

- Weather conditions and Weather Advisory Level
- Type, size, and activity of the geohazard
- Potential for unsafe situations
- Potential or existing facility damage.

If in doubt, the Mine or Road Manager should retain a specialist to review the situation and support decision making.

5.3 Periodic Civil-Geotechnical Inspection of Facilities

On an annual basis, or following an exceptional weather event (e.g., 75% percent of a design weather event or following “Very High” weather advisory issuance), have a qualified professional(s) supported by Newcrest operations personnel complete a geohazard review of Newcrest facilities. Annual lidar change detection and/or satellite interferometric synthetic aperture radar (InSAR) are technologies that may be included as part of periodic civil-geotechnical inspections as they can record changes that took place over large areas, away from the main infrastructure, or that are too subtle to be observed visually.

Inspection Program Goals:

- Inspect for changes in site conditions that may increase the risk to facilities from geohazards and note areas of vulnerability for repair planning
- Increase understanding of local geohazard types and how they behave and could affect facilities
- Review and update geohazard areas described in Drawings 01 to 05
- Over time and based on site experience with weather events and geohazard initiation, review and update weather advisory level criterion described above.

Recommended Inspection Scope:

- Review of previous annual civil-geotechnical inspection reports.
- Office review of any specific areas of concern identified by operations and maintenance staff including, but not necessarily restricted to reported geohazard events. Reviews can include geohazard event documentation including photos or videos to assist in the evaluation of changing site conditions.
- Review of recorded mitigation measures applied to prevent or in response to geohazard events (i.e., scaling, ditch clearing, related construction activities, etc.). This includes follow up actions completed in response to prior geohazard review inspections, even if no follow up action was performed.
- Office review of on-site weather data, and evaluation of climatic events with respect to reported geohazard events and the effectiveness of established Weather Advisory Level criterion.
- Identify locations of changes in the landscape including: new developments such as access roads, borrow pits, forest cover changes, rights-of-way clearing and modifications or repairs to road networks, bridges, or culverts.
- Review and update baseline hazard mapping presented in Drawings 01 to 05 of the GMP.
- Low-level and high-level overflight inspections (helicopter or drone as appropriate) of the Newcrest facilities.
- Ground inspection of any specific areas of concerns noted by personnel or from helicopter flight inspections.
- Documentation of review with recommendations.

6.0 REPORTING AND RECORDING

6.1 Event and Mitigation Reporting

Operations personnel are encouraged to document geohazard events within the project corridor as soon as possible after they are observed. Areas of increased frequency of small landslides or rockfalls may indicate an increased likelihood for larger and potentially more damaging events. To standardize reporting, a Natural Hazard Incident Report Form is included in this document (Appendix D). The completed forms will be e-mailed to the Mine and Road Manager. Response to a geohazard event could vary from no immediate action recommended to immediate specialist review. When appropriate, the EMLI “Advice of Geotechnical Incident” form (Appendix D) will be completed by the Mine Manager and submitted to EMLI if applicable.

Mitigative measures taken (i.e., scaling, ditch clearing, related construction activities, etc.) in response to or in prevention of geohazard events should be documented and considered during annual geohazard inspections.

6.2 Record Keeping

Digital files of the event reports and photographs will be maintained on site and at Newcrest’s head office. Digital files will have a specific directory (e.g., Geohazard Events), and each event will have a separate sub-folder clearly labeled with the date, facility, location, and type of event. All associated event documentation will be stored in this folder with appropriate sub folders as necessary (e.g., Event Report, Photographs, Follow up Reports, etc.).

Digital files of event reports will have a consistent file name that allows them to be sorted chronologically, and that clearly identifies the event date, facility, location, and event type (e.g., 20230131 - Brucejack Access Road Km X – Debris Flood).

7.0 ADAPTIVE MANAGEMENT

The GMP is a “living” document that will evolve over time in response to monitoring results and changing site conditions and regulatory requirements. The GMP will be reviewed periodically to assess the effectiveness of mitigation and management measures (examples provided in Section 5.3) and whether plan objectives are being met.

8.0 CLOSURE

We trust the above satisfies your requirements. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

BGC Engineering Inc.
per:

PROFESSIONAL
PROVINCE OF
Dr. M. BRIDEAU
42325
BRITISH COLUMBIA
GEOSCIENTIST

24 Oct 2023

Marc-André Brideau, Ph.D., P.Geo.
Senior Engineering Geologist

Reviewed by:

Kris Holm, M.Sc., P.Geo.
Principal Geoscientist

EGBC Permit to Practice, BGC Engineering Inc. 1000944

MAB/KH/mjp/syt

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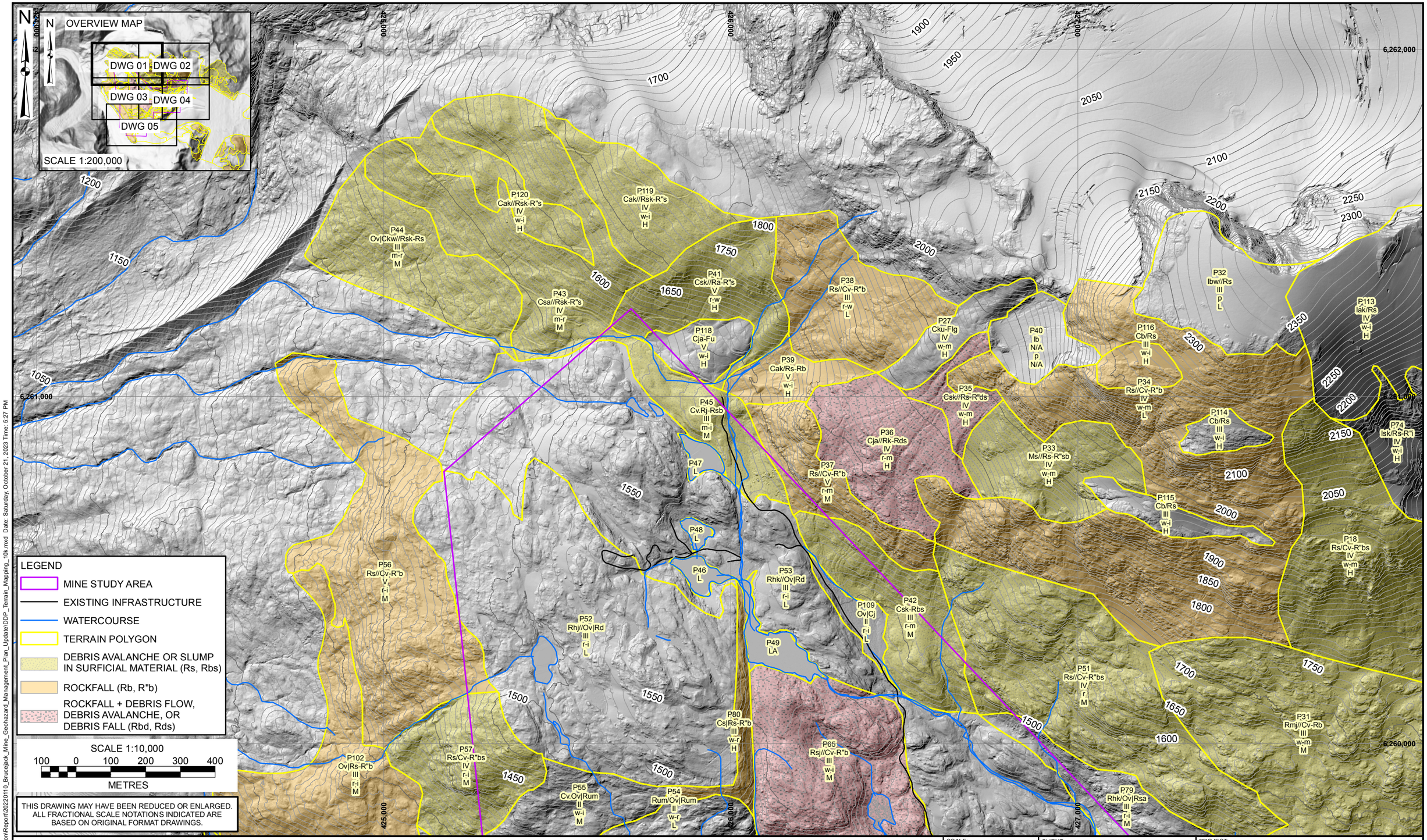
DRAWINGS



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APPROVED:	MAB

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PROJECT: BRUCEJACK MINE GEOHAZARD MANAGEMENT PLAN – UPDATE

TITLE: TERRAIN MAPPING NORTHWEST

PROJECT No.: 1696001

DWG No: 01

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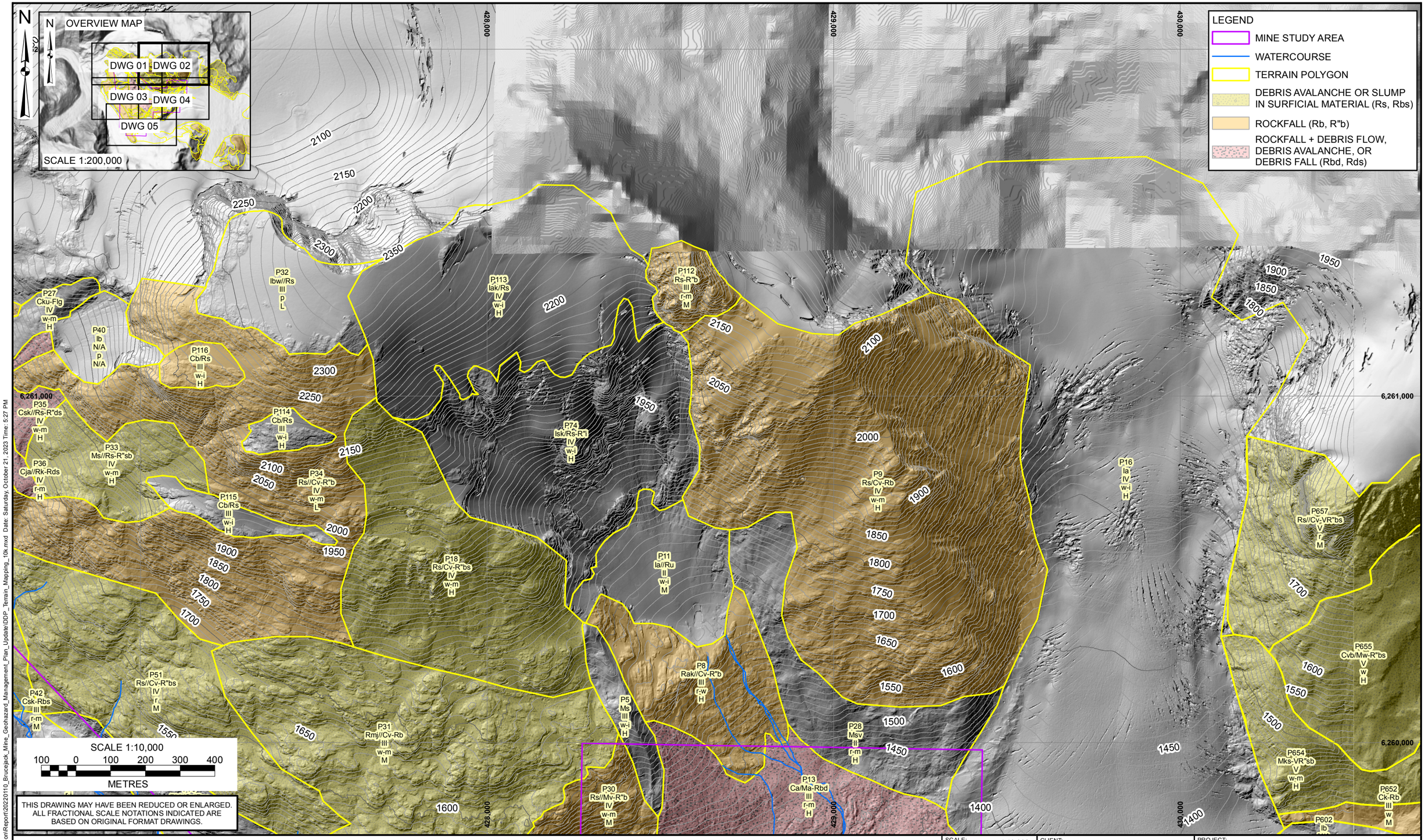

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TITLE: TERRAIN MAPPING NORTHEAST

PROJECT No.: 1696001

DWG No: 02

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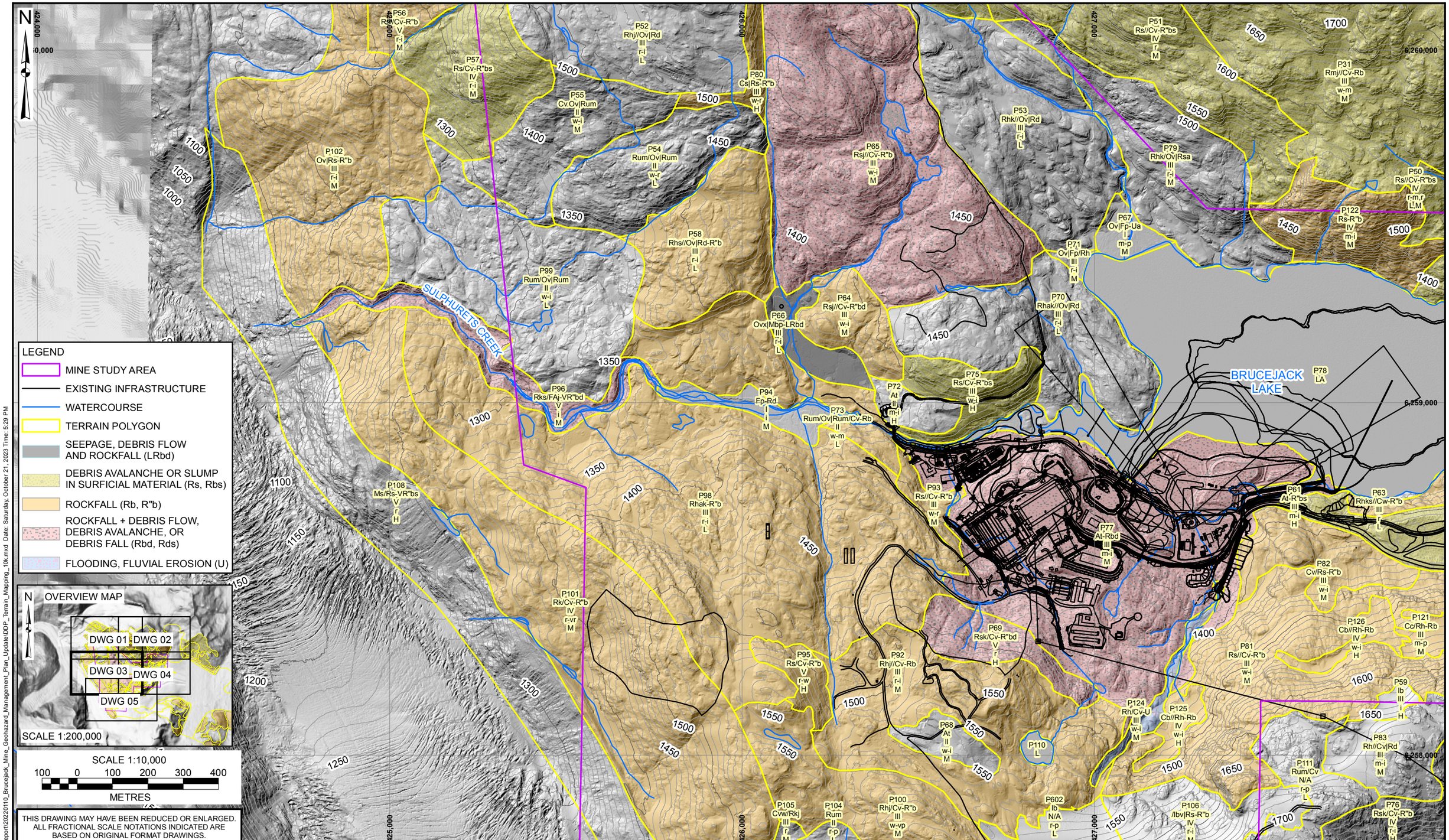

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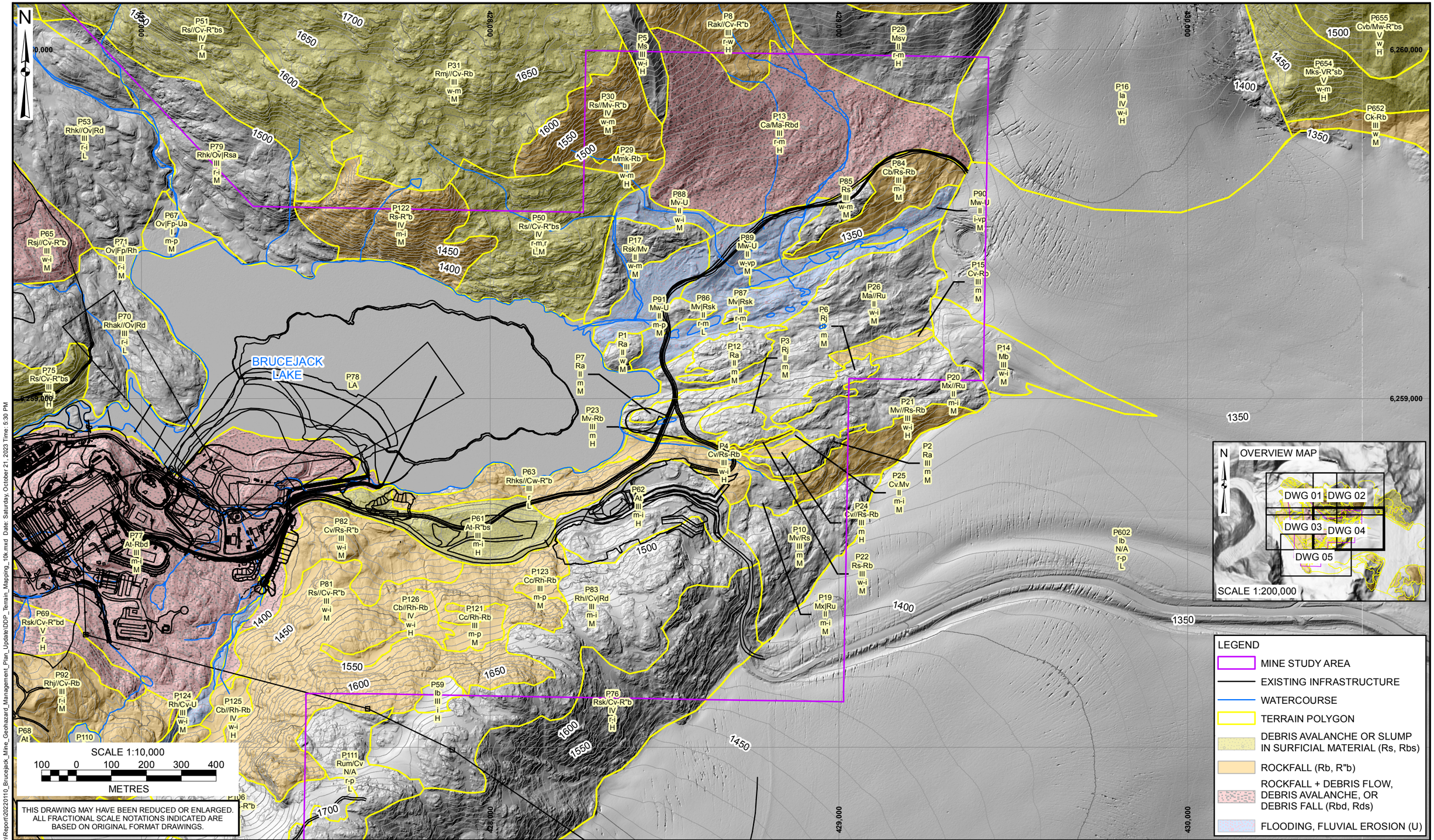

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TITLE: TERRAIN MAPPING CENTRAL EAST

PROJECT No.: 1696001

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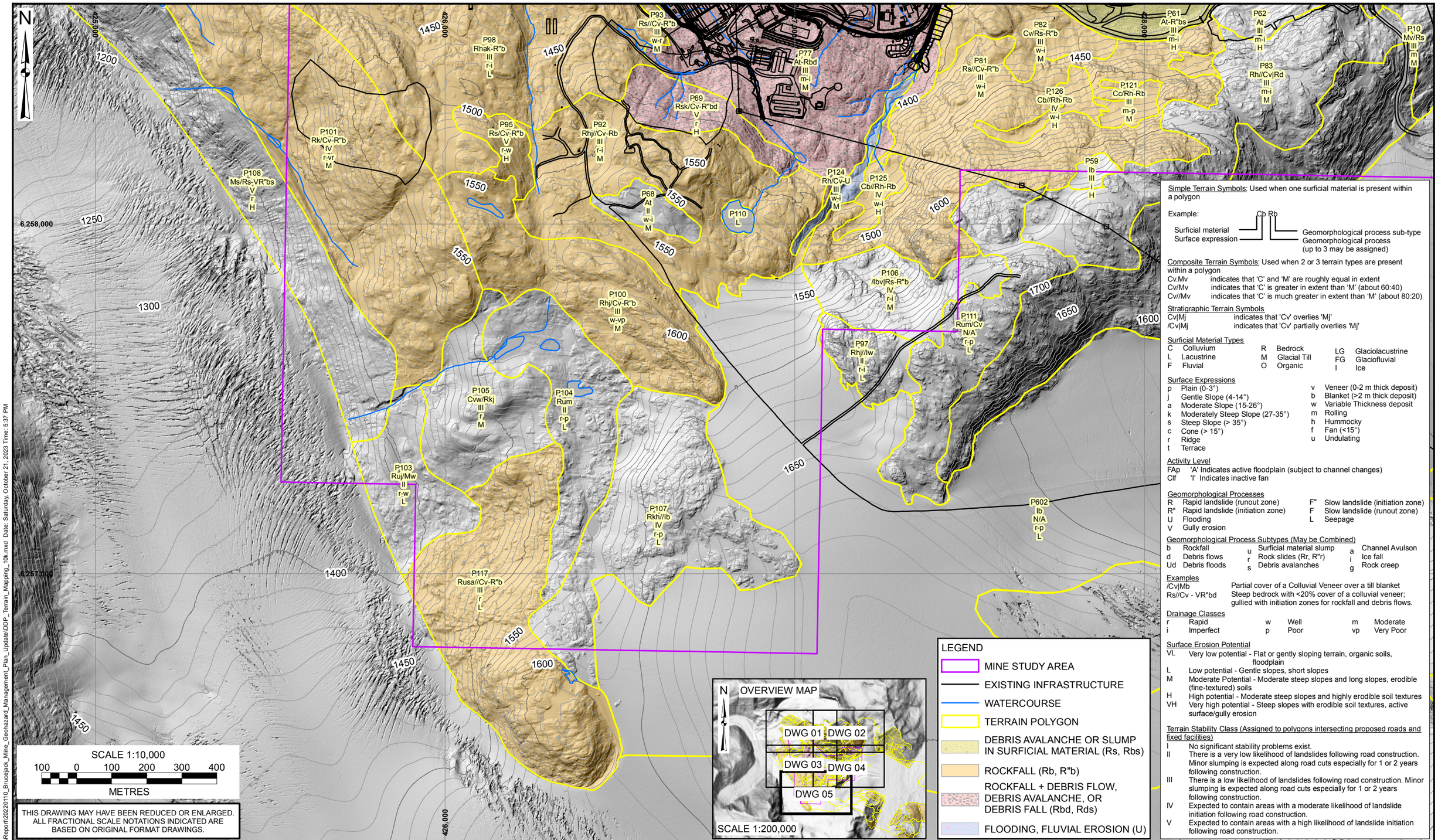

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LEGEND

- MINE STUDY AREA
- EXISTING INFRASTRUCTURE
- WATERCOURSE
- TERRAIN POLYGON
- DEBRIS AVALANCHE OR SLUMP IN SURFICIAL MATERIAL (Rs, Rbs)
- ROCKFALL (Rb, R"b)
- ROCKFALL + DEBRIS FLOW, DEBRIS AVALANCHE, OR DEBRIS FALL (Rbd, Rds)
- FLOODING, FLUVIAL EROSION (U)

Simple Terrain Symbols: Used when one surficial material is present within a polygon

Example: Cb Rb

Surficial material — Geomorphological process sub-type
Surface expression — Geomorphological process (up to 3 may be assigned)

Composite Terrain Symbols: Used when 2 or 3 terrain types are present within a polygon

Cv.Mv	indicates that 'C' and 'M' are roughly equal in extent
Cv/Mv	indicates that 'C' is greater in extent than 'M' (about 60:40)
Cv//Mv	indicates that 'C' is much greater in extent than 'M' (about 80:20)

Stratigraphic Terrain Symbols

Cv|Mj	indicates that 'Cv' overlies 'Mj'
/Cv|Mj	indicates that 'Cv' partially overlies 'Mj'

Surficial Material Types

C	Colluvium	R	Bedrock	LG	Glaciolacustrine
L	Lacustrine	M	Glacial Till	FG	Glaciofluvial
F	Fluvial	O	Organic	I	Ice

Surface Expressions

p	Plain (0-3°)	v	Veneer (0-2 m thick deposit)
j	Gentle Slope (4-14°)	b	Blanket (>2 m thick deposit)
a	Moderate Slope (15-26°)	w	Variable Thickness deposit
k	Moderately Steep Slope (27-35°)	m	Rolling
s	Steep Slope (> 35°)	h	Hummocky
c	Cone (> 15°)	f	Fan (<15°)
r	Ridge	u	Undulating
t	Terrace		

Activity Level

FAp	'A' Indicates active floodplain (subject to channel changes)
Clf	'I' Indicates inactive fan

Geomorphological Processes

R	Rapid landslide (runout zone)	F"	Slow landslide (initiation zone)
R"	Rapid landslide (initiation zone)	F	Slow landslide (runout zone)
U	Flooding	L	Seepage
V	Gully erosion		

Geomorphological Process Subtypes (May be Combined)

b	Rockfall	u	Surficial material slump	a	Channel Avulson
d	Debris flows	r	Rock slides (Rr, R"r)	i	Ice fall
Ud	Debris floods	s	Debris avalanches	g	Rock creep

Examples

/Cv|Mb	Partial cover of a Colluvial Veneer over a till blanket
Rs//Cv - VR"bd	Steep bedrock with <20% cover of a colluvial veneer; gullied with initiation zones for rockfall and debris flows.

Drainage Classes

r	Rapid	w	Well	m	Moderate
i	Imperfect	p	Poor	vp	Very Poor

Surface Erosion Potential

VL	Very low potential - Flat or gently sloping terrain, organic soils, floodplain
L	Low potential - Gentle slopes, short slopes
M	Moderate Potential - Moderate steep slopes and long slopes, erodible (fine-textured) soils
H	High potential - Moderate steep slopes and highly erodible soil textures
VH	Very high potential - Steep slopes with erodible soil textures, active surface/gully erosion

Terrain Stability Class (Assigned to polygons intersecting proposed roads and fixed facilities)

I	No significant stability problems exist.
II	There is a very low likelihood of landslides following road construction. Minor slumping is expected along road cuts especially for 1 or 2 years following construction.
III	There is a low likelihood of landslides following road construction. Minor slumping is expected along road cuts especially for 1 or 2 years following construction.
IV	Expected to contain areas with a moderate likelihood of landslide initiation following road construction.
V	Expected to contain areas with a high likelihood of landslide initiation following road construction.

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PROJECT: BRUCEJACK MINE GEOHAZARD MANAGEMENT PLAN – UPDATE

TITLE: TERRAIN MAPPING SOUTH

PROJECT No.: 1696001

DWG No: 05

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APPENDIX A
LANDSLIDE HAZARD CHARACTERISTICS

A-1 INTRODUCTION

This appendix introduces landslide hazards in the context of the Brucejack Minesite. The objective is to provide on-site personnel with tools to: 1) understand the factors affecting slope stability and triggering mechanisms leading to slope failure; and, 2) recognize the main types of landslides, their characteristics, early warning signs and potential consequences.

A-2 LANDSLIDE TERMINOLOGY

Landslides are defined as “the movement of a mass of rock, debris or earth down a slope” (Cruden 1991) and as “a physical system that develops in time through several stages” (Hungr et al., 2014). There are a number of other phrases/terms that are used interchangeably with the term “landslide” including mass movement, slope failure, and slope instability.

Landslide names are generated by determining an initiating material type for the landslide and a type of landslide movement. Common descriptors of landslide types are outlined below and summarized in Table A-1, with landslides relevant to the Brucejack Minesite in bold font. Landslides are further described by their rate of movement summarized in Table A-2.

Material type terms:

- Rock – pre-failure intact bedrock
- Soil – including clay, mud, silt, sand, gravel, boulders, debris and peat.

Movement type terms:

- Fall
- Topple
- Slide
- Spread
- Flow
- Slope deformation.

Table A-1 Landslide type classification (after Hungr et al., 2014).

Type of Movement	Rock	Soil
Fall	**1. Rock fall***	*2. Boulder/debris/silt* fall*
Topple	3. Rock block topple*	*5. Gravel/sand/silt* topple*
	4. Rock flexural topple	
Slide	6. Rock rotational slide	***11. Clay/silt* rotational slide (surficial material slump)**
	7. Rock planar slide*	*12. Clay/silt* planar slide
	8. Rock wedge slide*	*13. Gravel/sand/debris* slide*
	9. Rock compound slide	*14. Clay/silt* compound slide
	10. Rock irregular slide*	
Spread	15. Rock slope spread	*16. Sand/silt* liquefaction spread*
		17. Sensitive clay spread*
Flow	18. Rock avalanche*	*19. Sand/silt/debris* dry flow
		20. Sand/silt/debris flowslide*
		21. Sensitive clay flow slide*
		22. Debris flow*
		23. Mud flow*
		24. Debris flood*
		25. Debris avalanche*
		26. Earthflow*
		27. Peat flow
Slope Deformation	28. Mountain slope deformation	30. Soil slope deformation
	29. Rock slope deformation	31. Soil creep
		32. Solifluction

Notes:

1. For material types in italics, use one only.
2. *Denotes movement types that usually reach extremely rapid velocities as defined by Hungr et al. (2014). The other landslide types are most often (but not always) extremely slow to very rapid.

Table A-2 Landslide velocity classification (after Hungr et al., 2014).

Description	Velocity (mm/s)	Typical Velocity
Extremely Rapid	$5X10^{3}$	5 m/s
Very Rapid	$5X10^{1}$	3 m/min
Rapid	$5X10^{-1}$	1.8 m/hr
Moderate	$5X10^{-3}$	13 m/month
Slow	$5X10^{-5}$	1.6 m/year
Very Slow	$5X10^{-7}$	16 mm/year
Extremely Slow	-	-

A-3 FACTORS AFFECTING SLOPE STABILITY

Slope failures are the result of gravitational forces acting on a mass which result in slow creep, free fall, sliding along a failure surface, or flow as a slurry, with stability and behavior of the failure dependent on different variables, including:

- Site topography and downslope materials
- Bedrock stratigraphy
- Material properties (including material structure and strength)
- Groundwater conditions
- Vegetation type and cover
- Anthropogenic modifications
- Seismic activity.

Two forces affecting the stability of slopes include: 1) Gravitational forces (shear stress) that causes the slope to move (force pulling it down); 2) Resisting forces (shear strength) that stabilize the slope and prevent movement (force holding it up). When gravitational forces exceed the resisting forces, a slope instability occurs. A simplified diagram of the forces affecting slope stability is shown in Figure A-1.

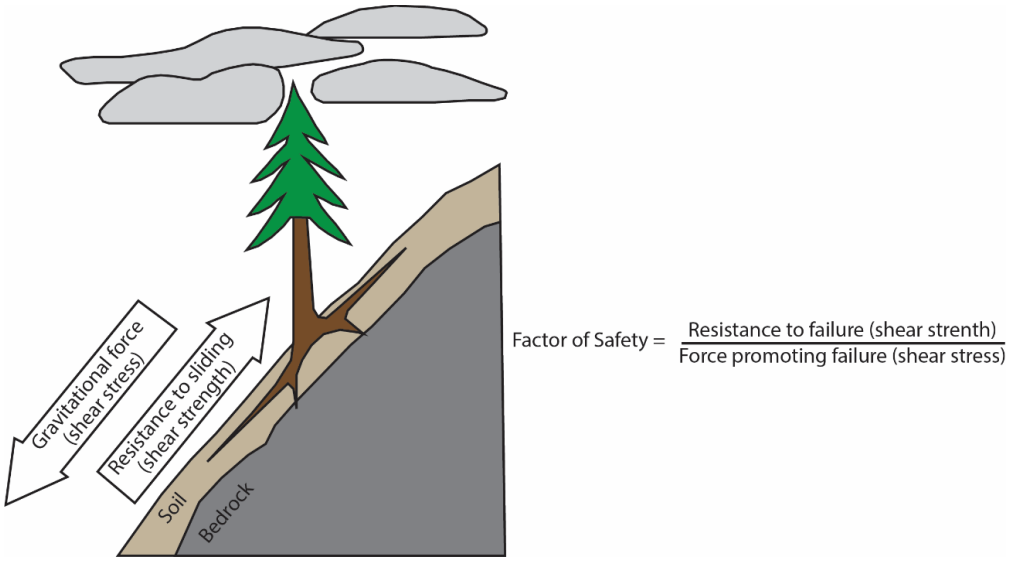

Figure A-1 Diagram of simplified forces acting on a slope (modified from BCMOF, 1994).

Slopes can be sensitive to modifying factors which change the shear stress and or shear strength over time and therefore affect the likelihood that slope instability can be triggered. Some changes in material and mass properties are gradual effects occurring over time whereas some changes are almost immediate such as those from climatic events.

Decrease in Shear Strength

Several different processes can lead to reduction in the shear strength of slope materials. The processes most relevant to the Brucejack Minesite include:

1. *Development of a high or perched water table* (increased soil pore water pressure). Increased soil pore water pressure reduces shear strength in soil, between soil or rock surfaces, and in joints (cracks) in rock. If subsurface groundwater flows are less than infiltrating rates for extended periods of time, a perched or high groundwater table will form within overburden soils. Rising groundwater levels and the effects of adverse seepage can commonly develop during periods of intense rainfall, rapid snowmelt, or prolonged high precipitation. Increases in groundwater levels can also be caused by leaking pipes or penstocks, and drainage redirection associated with road networks that concentrate surface water flows. All types of soils can be affected by the development of high water tables, with the length of time required for pore pressures to change dependent upon the permeability of soil.
2. *Removal of vegetation cover.* Tree cover influences the amount and intensity of rainfall reaching the ground surface as well as the amount of water stored in the ground. Root systems of trees and other vegetation also increase the strength of overburden soil by roots providing long-fiber binders within the overburden soil. When tree cover is removed (as a result of timber harvesting, forest fires, or wind throw) there can be a corresponding change in the soil water retention and runoff, and a decrease in soil shear strength as roots decay.

3. *Weathering.* Weathering is a common process that alters rock to soil over time and affects particles in soil as well as bedrock. Weathering involves various physical, chemical, and biological processes.
4. *Cyclic loading.* Under the influence of cyclic loads, such as those caused by earthquake shaking, bonds between soil particles may be broken and pore pressures may increase. Loose sands can liquefy under cyclic loading, lose virtually all strength, and flow like a liquid.

Increase in Shear Stress

Even if the strength of the soil /rock mass does not change, slopes can fail if the loads on them change, resulting in increased shear stresses within the soil. Mechanisms through which shear stresses can increase include:

1. *Overloading of slope.* If the ground at the top of the slope is loaded, the shear stress will increase. Common occurrences that provide surcharge loading of the ground are the placement of fill and construction of buildings supported on shallow foundations.
2. *Water pressure in cracks at the top of the slope.* If tension cracks at the top of a slope are filled with water (or partially filled), the water pressure in the cracks loads the soil within the slope.
3. *Water freezing in cracks.* The expansion of water as it freezes within cracks imposes an outward lateral stress within the slope. Freeze-thaw actions can act to jack apart existing fractures in rock.
4. *Increase in soil weight due to increased water content.* Infiltration and seepage into the soil within a slope can increase the soil water content thereby increasing its weight.
5. *Removal of support.* Excavations or erosion that make a slope steeper or higher will increase the shear stresses in the slope and reduce stability.
6. *Earthquake shaking.* Earthquakes subject slopes to horizontal and vertical accelerations that result in cyclic variations in stresses within the slope increasing stress beyond the static condition for brief periods.

A-4 TRIGGERING MECHANISMS

Landslides can have several causes (factors) that may reduce the stability of a slope and lead to failure in a progressive fashion (progressive failure). These include geological, morphological, physical, and human causes as outlined in Table A-3. However, the final impetus leading to slope failure may not be a gradual degradation of the landslide failure surface (progressive failure) but instead some external stimuli ‘triggering’ a slope failure. Examples of external stimuli, or triggering mechanisms, include intense rainfall, earthquake shaking, or human slope modification that results in failure by rapidly changing either shear stresses, or shear strength. Note that some triggering mechanisms can also be considered as causative factors in some cases. For example, an earthquake may not trigger a landslide, but weaken slope material, making the slope more susceptible to failure over time.

Table A-3 Factors that may reduce the stability of a slope (after Cruden and Varnes, 1996).

1. Geological causes	a. Weak materials b. Weathered materials c. Jointed or fissured materials d. Adversely orientated discontinuity (bedding, rock joints, etc.) e. Contrast in permeability
2. Morphological causes	a. Glacial debuttressing b. Fluvial erosion of slope toe c. Subterranean erosion (solution, piping) d. Landslide deposition loading of slope or its crest e. Vegetation removal (forest fire, disease, wind storm, drought)
3. Physical causes	a. Intense rainfall* b. Rapid snowmelt* c. Prolonged exceptional precipitation* d. Earthquake* e. Freeze–and-thaw actions / weathering* f. Change in groundwater level*
4. Human causes	a. Excavation of slope or its toe* b. Loading of slope or its crest c. Deforestation d. Irrigation or water leakage from utilities* e. Surface water re-direction* f. Artificial vibration*

In many cases landslides occur as progressive failures absent of a triggering mechanism. For this reason, an awareness of geohazard processes is essential if causative factors that may lead to landslide events exist. In several other cases however, a triggering mechanism can be attributed to the landslide event. Therefore, common triggering mechanisms are described below.

Intense or Prolonged Rainfall

Storms that produce intense rainfall for periods as short as several hours or have a moderate intensity lasting several days are known to act as triggers for landslides. The rapid infiltration of rainfall causing soil saturation and a temporary rise in pore-water pressures reduces available shear strength, triggering failure. Alternatively, prolonged precipitation with moderate intensity can also result in soil saturation and temporary rise in pore-water pressures.

Intense rainfall or prolonged moderate precipitation can occur at any time in northeastern BC, however, the most consistent period of intense or prolonged rainfall events occurs over the fall season.

Rapid Snowmelt

Rapid melting of a snowpack caused by a sudden warming spells or by rain falling on snow can have the same effect as intense precipitation. Snowmelt, leading to high surface and subsurface water flows, generally occurs during the spring and early summer seasons. Rain on snow events occur when a warm Pacific frontal storm system dramatically raises the freezing level combined with high precipitation. This causes rapid snowmelt to add to already high precipitation. These events usually occur between late fall and early spring.

Freezing-Thawing

The expansion of water as it freezes in rock joints or fissures can promote rock wedging and reduce rock joint strength. Freezing of surface water on slopes can also block drainage paths (seepage outlets) resulting in a build-up of water pressure in the slope which can result in reduced shear strengths. The active freeze-thaw cycle is most prevalent in the spring season and the fall season when daily temperatures rise above and fall below 0°C allowing hydrostatic pore pressures to develop within a rock fractures and then similarly allowing ice to form and expand within fractures.

Earlier Landslide Events

For some situations a smaller landslide event can act to change ground conditions and make a second landslide event more likely. For example, landsliding could result in the removal of slope support, such as in the case of an over steepened head scarp following a rock fall event. The accumulation of landslide debris along a slope or within a confined channel can also act as a surcharge load or disrupt slope drainage contributing to continued slope instability.

Earthquake Shaking

Strong ground shaking during earthquakes has triggered landslides in many different topographic and geologic settings. Rock falls, debris avalanches, and rock avalanches from steep slopes involving relative thin or shallow disaggregated soils or rock are the most common failure types. Earth and debris slides on gentler slopes are also very abundant during earthquakes.

A-5 LANDSLIDE TYPES

A-5.1 Rock Falls, Rock Slides and Rock Avalanches

Rock fall is a fragment of rock or boulder that detaches from a steep slope by sliding or toppling (Figure A-2). The rock or boulder may free-fall and break upon impact, or may begin rolling or bouncing down steeper slopes before arresting on flatter terrain. Rock falls are usually of limited volume (i.e., less than 10,000 m3).

Rock avalanches are extremely rapid, flow-like motion of disintegration of the rock mass that initiated as large rock slides or rock falls.

Characteristics of rock falls, rock slides and rock avalanches include:

- Abrupt and extremely rapid landslide events (velocities of rock avalanches have been noted to be in excess of 200 km/hour)
- Their runout path is influenced by topography, which can deflect their trajectory
- With increasing rock mass involved in a failure, movement changes from falling and bounding to a more flowing movement; this transition from rock fall to rockslide to rock avalanche is fluid and it is sometime difficult to distinguish
- Failures can run out past the toe of steep slopes. The run out distance depends on the fall height and the volume involved. Rock avalanches greater than about 1 Mm3 in volume can have a high mobility and long run-out distances.

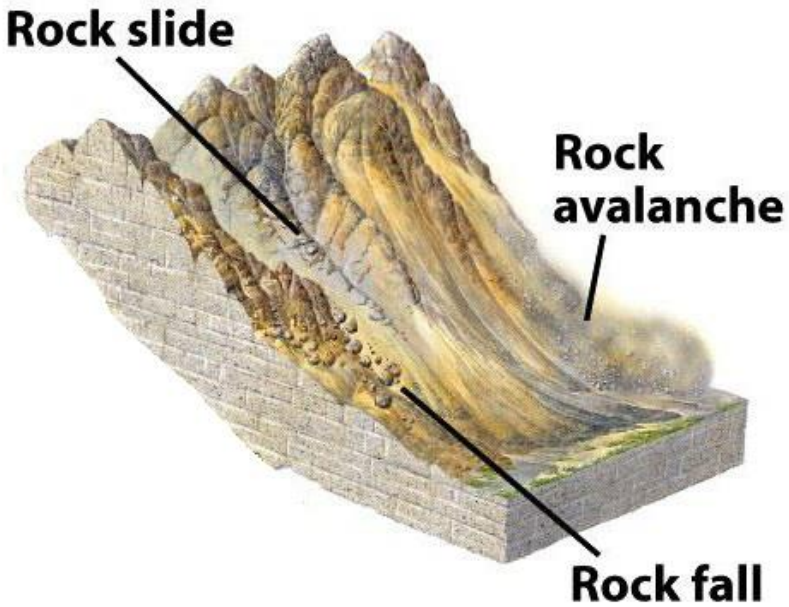

Figure A-2 Rock fall, rock slide, and rock avalanche schematic (from Louisiana State University website).

Rock Fall, Rock Slide and Rock Avalanche Event Causes

Causal factors:

- Steep and sub-vertical rock slopes as source zones
- Bedrock discontinuities such as fractures, joints, fault and bedding planes that intersect with the slope configuration to form block geometries that can slide down and out of the slope or topple out of the slope
- Erosion at the base of slopes from rising rivers and streams or from human related disturbances such as undercutting
- Likelihood is strongly influenced by mechanical weathering (tree roots or ice formation prying rock).

Trigger conditions:

- Rainfall or snowmelt events increasing water pressure in fissures

- Freeze-thaw cycles causing mechanical weathering of the rock mass
- Seismic events.

Early Warning Signs

Indicators of imminent rock fall can include terrain with overhanging rock or rock with open joints (fissures) or blocks that are separating from the surrounding rock. Fresh rock fall evidence includes recent rock fall impact marks, rock fragments in ditches, fresh rock faces at the source area, and torn soil layers at the slope crest.

Larger rock avalanches often show signs of instability before failure including:

- Slope deformation and slope cracks
- Vegetation disturbance
- Slow measurable movements
- Repeated small rockslides and rock falls.

Consequences

Structures and access roads within the run-out path of a rock fall or rock slide can also be severely impacted by the momentum of the blocks or debris. Structures and access roads within the run out path of a rock avalanche will be destroyed and buried by the mass of debris.

Possible safety concerns include direct impact from rock fall, rock slide or rock avalanche, or running into blocks and debris while travelling on an access road affected by an event.

Secondary effects may generate consequences away from location of large rock slide and rock avalanche events. For example, the debris of large rock slides and rock avalanches may temporarily dam a stream, which may cause flooding upstream of the dam, or outbreak floods downstream if the dam breaches. Large rock slides and rock avalanches impacting a lake may generate displacement waves.

A-5.2 Debris Avalanches

Debris avalanche is an open-slope slide formed when an unstable slope collapses and the resulting fragmented debris rapidly moves down the slope (Figure A-3). Debris avalanches initiate as debris slides and occur on open slopes without confinement of an established channel.

Characteristics of debris avalanches include:

- Very rapid to extremely rapid shallow landslides with event velocities that range from 3 m/min to in excess of 80 km/hour
- Generally, originate from steep hillslopes or from within shallow hillslope depressions (hollow) where groundwater is concentrated
- Fragmented debris travels downslope, in some instances extending over 1 km downslope from the source zone
- Landslide dimensions range from head scarps spanning only a few meters in width to head scarps with widths greater than hundreds of meters.

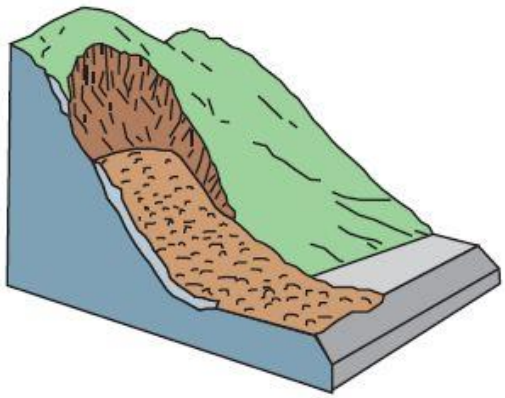

Figure A-3 Debris avalanche schematic (Highland and Bobrowsky, 2008).

Debris Avalanche Event Causes

Causal factors:

- Steep slopes
- Weak surficial material (overburden) over higher strength lower permeability material such as bedrock or glacial till
- The occurrence of debris avalanches can be intensified on slopes or in gullies that have been denuded of vegetation due to forest fires or timber harvesting.

Trigger conditions:

- Intense rainfall, prolonged intense rainfall, rapid snowmelt, or rain on snow events
- Surface water concentration associated with poorly constructed or poorly maintained access roads
- Seismic events.

Early Warning Signs

If a debris avalanche event is triggered, the resulting slide could form rapidly with little warning. Early warning for the event can be any signs of land movement such as tension cracks, smaller landslides or progressively tilting trees. Small changes can indicate an increased immediate threat of a slide. Sounds that might indicate moving debris include trees cracking or boulders knocking together; a trickle of flowing or falling mud or debris may precede a larger landslide.

Consequences

Structures and access roads on the slide can be severely damaged or destroyed. Structures within the run-out path can also be severely impacted by the momentum of the mass of material. If a debris avalanche or debris slide deposits material within a confined creek channel, a debris flow or sediment laden creek flood can be initiated.

Possible safety concerns include direct impact from landslide debris or running into debris while travelling on an access road affected by an event.

A-5.3 Debris Flows

Debris flow is a very rapid to extremely rapid surging flow of saturated debris in a steep channel (Figure A-4). Debris flows exhibit strong entrainment of material and water from the flow path (Hungr et. al., 2014). Debris flows are sometimes informally called “mudslides”. Debris flows are part of a spectrum of channel processes that range in order of increasing sediment concentrations from clear water floods to debris floods to debris flows (Figure A-5). Debris flows are typically triggered by side slope landslides or progressive bulking with erodible sediment. Dilution of a debris flow through partial sediment deposition on lower gradients channels and tributary injection of water can lead to a transition towards debris floods and eventually floods.

Characteristics of debris flows include:

- Very rapid to extremely rapid flow movements with event velocities ranging from 3 m/min up to 80 km/hour. The velocity of flows depends upon channel gradient, water content, material mobility, and evolution of the movement.
- Initiation within steep confined channels during high runoff periods (rainfall or snowmelt) being triggered by high stream flow mobilizing in-stream material and eroding and entraining additional channel material as the debris mass flows down the channel.
- Coarser material collecting at the front and sides of the flow. It is common to see boulders “floating” and tumbling at the front of the debris flow.
- Super-elevation of the flow around bends causing debris to deposit at a higher elevation on the outside of the bend.
- Creation of debris levees (raised ridges) at the margins of the flow.
- Deposition of material where the slope gradient flattens. This commonly occurs where channels transition to a colluvial fan or cone.
- Transport and deposition in “surges” or “lobes”. It is common for subsequent surges to divert out of the channel (avulse) when they come up against channel blockage caused by deposition of the preceding surge.
- More fluid discharge with finer sediment in later surges of a flow. This later stage often cuts down through previous deposited lobes, further re-mobilizing sediment.

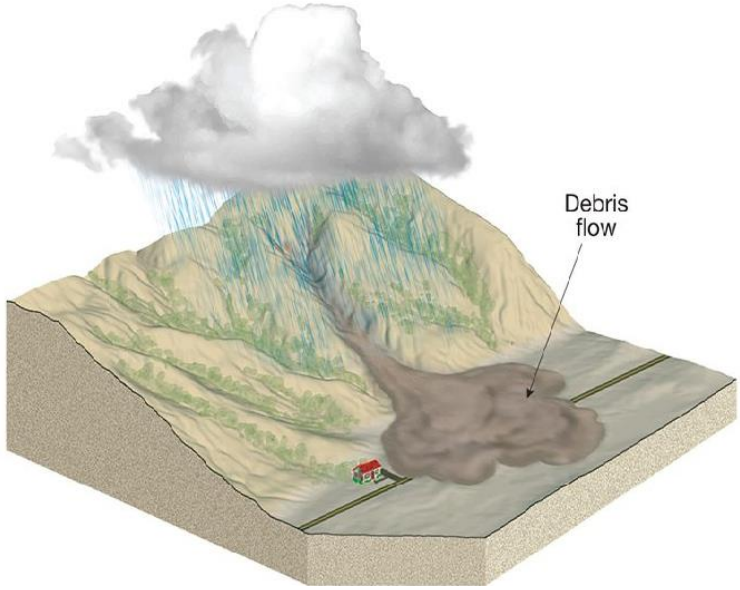

Figure A-4 Debris flow schematic (https://domino.dei.unipd.it/features/debris-flows/).

Debris Flow Event Causes

Causal factors:

- Steep channel gradients (typically greater than 10° to 15°)
- Source of sediment – either in channel bedload or channel sidewalls or from other landslides that deposit in the channel
- Changes to the hillside surface and groundwater flow patterns caused by loss of tree cover from forest fires or timber harvesting, or from roads and trails that collect and direct surface water drainage.

Trigger conditions:

- Intense surface-water flow due to heavy or prolonged precipitation or rapid snowmelt that saturates, erodes, and mobilizes loose soil or rock on steep slopes
- During high stream flow, the initiation of smaller debris slides from gully channel side walls that then imped creek flow leading to a super-saturated plug of debris mobilizing into a debris flow in the channel.

Early Warning Signs

At a stream level observation point, an early warning sign of the potential for an imminent debris flow event is the rapid increase of sediment content and sediment pulses through the stream channel; the sediment content increase and sediment pulses may be the remnants of smaller debris flows upstream of the observation point indicating that triggering conditions for larger debris flows are imminent.

Consequences

Debris flows may be life-threatening as they can be extremely rapid and may occur without any warning. The erosive potential of the debris laden sediment flows is such that it can entrain

large boulder and rapidly transport them downstream. Debris flows can move objects as large as houses or can fill structures with a rapid accumulation of sediment and organic matter. Structures, including bridges and culverts, may be overwhelmed and destroyed by the momentum of the mass of material. Subsequent erosion from creek flow that has changed its path after the event can erode and undermine structures.

At the break of slopes, where channels become unconfined, flows can easily avulse and deposit silt and debris on a fan feature with high impact forces. In some instances, where a flow enters another river or stream, debris floods can be generated that further impact bridge structures located downstream. Debris flows can affect the quality of water by depositing large amounts of silt and debris.

Safety concerns include direct impact from landslide debris, running into debris while travelling on an access road affected by an event, or road washout limiting road passage.

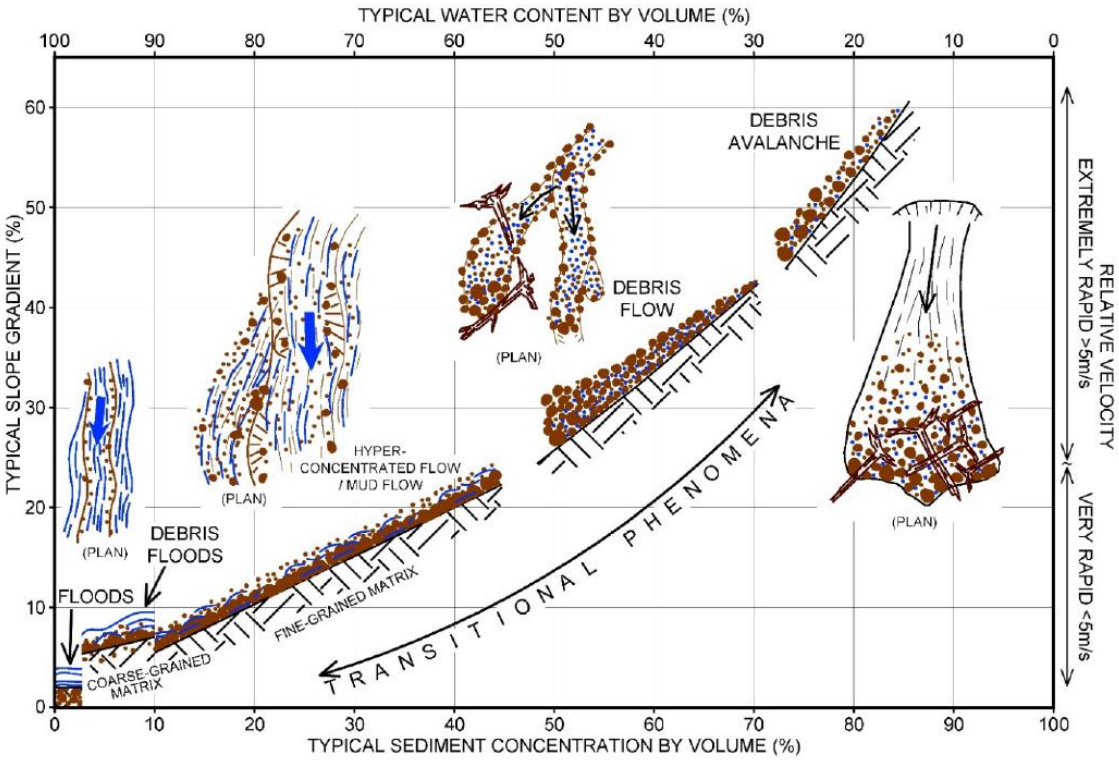

Figure A-5 Hydrogeomorphic process classification by sediment concentration, slope velocity, and planform appearance.

APPENDIX B
SUMMARY OF GEOHAZARD MANAGEMENT PLAN UPDATES

B-1 INTRODUCTION

For convenience and record keeping, this appendix provides a summary of the updates to the GMP from the 2016 version (Pretium Resources Inc., 2016). It also includes details on the terrain mapping methodology. Terrain mapping over the minesite area was updated using 2022 lidar digital elevation model and orthophotos as part of the current scope.

B-2 SUMMARY OF GEOHAZARD MANAGEMENT PLAN UPDATES

In general, the 2016 GMP was updated by removing references to infrastructure supporting construction activities that are no longer in use (e.g., Bowser Camp).

Section 3.1 pertaining to the relevant legislation, regulations, permits and EA conditions was updated to reference the up-to-date versions of the relevant documents. It includes the recently published guidance by the BC Ministry of Mines, Energy and Low Carbon Initiatives on reportable incidents.

Section 3.2 on landslide guidance documents and best management practices was added to provide additional framework for the GMP.

Section 4.0 was updated to address the geohazards identified in the update terrain stability maps.

Section 5.3 was updated to acknowledge the increased use of drones to do inspections. It also identifies that lidar change detection and satellite InSAR can contribute to periodic civil-geotechnical inspections.

Section 6.1 was expanded to also include mitigation reporting. This is to better capture the efforts to manage geohazards at the Brucejack Minesite.

Section 7.0 Adaptive Management was added to further emphasize that the GMP should be updated as needed to incorporate up-to-date information regarding geohazard rating, activity and infrastructure layout.

Appendix A – Landslide Hazard Characteristics was included in the GMP to provide on site personnel with reference material to allow them to understand the contributing and triggering factors of slope instabilities and to recognize the main types of landslides, characteristics, and potential consequences.

Appendix C – Preceding Geohazard Management Plan Performance and Recommendations was included in the GMP synthesize past annual reviews and meteorological data which was then used to support recommendations in the implementation of this updated GMP.

Appendix D – Geohazard Reporting Forms Updated and was included in the GMP to present the new simplified event geohazard reporting form for internal purposes and it also includes a copy of the latest “Reportable Incident” form for the BC Ministry of Mines, Energy and Low Carbon Initiatives.

B-3 ADDITIONAL DETAILS ON TERRAIN MAPPING METHODOLOGY

BGC previously completed terrain stability mapping for the Brucejack Mine project area in 2014 with revisions made in 2015 (BGC, June 5, 2014; BGC, July 31, 2015). Updates to this terrain stability mapping were made in 2023 for the study area outlined in the main body of this report based on updated data provided to BGC by Newcrest. A summary of the data sources used to complete these updates and a summary of the methods used are presented in this Appendix.

B-3.1 Data Sources

The data sources used to update terrain mapping and identify credible geohazards in study area include:

- A mine site layout (.dwg file) dated September 2, 2022 and provided by Newcrest on November 8, 2022
- Lidar-based digital elevation data and ortho imagery (August 8, 2022) covering the mine facilities and area surrounding Brucejack Lake was provided by Newcrest on November 8, 2022
- Terrain stability mapping generated by BGC in 2014 and updated in 2015 (BGC, July 31, 2015).

B-3.2 Terrain Stability Mapping Methods

Criteria that were used to map these characteristics are described below. Mapping methods were based on guidelines described by the Resource Inventory Committee (1996), using the terrain classification of Howes & Kenk (1997).

Symbols describing material types and drainage classes were added to all terrain polygons. All polygons intersecting the proposed general arrangement of roads and fixed facilities were also assigned terrain stability classes. Material types and stability classes are shown on Drawings 01 to 05.

B-3.3 Mapping Reliability

The minimum size of terrain polygons that can be mapped at 1:20,000 scale terrain mapping is about 2 ha. Thus, local variations in terrain conditions over areas of 2-3 ha, or over distances of less than about 150 m, may not be identified. As a result, within any polygon, variations in slope steepness, material characteristics and soil moisture should be expected. Consequently, small features may not be reflected in the assessment. Terrain stability ratings reflect average conditions in the polygon. Facilities that intersect only a small part of a terrain polygon may have slope stability conditions that are different from the average rating.

B-3.4 Surficial Materials

In general, surficial materials can be considered to be of relatively young geological age. Other terms that are often used for surficial material are Quaternary sediments, unconsolidated materials, earth, and soil. Surficial materials are classified according to their mode of formation.

Specific processes of erosion, transportation, deposition, mass wasting and weathering produce materials that have specific sets of physical characteristics (Howes & Kenk, 1997). Typical descriptions of each material mapped within the Brucejack Minesite area, with their mapping codes, are given in the following sections.

Glaciofluvial (FG)

Glaciofluvial material is typically composed of coarse sands and gravels, deposited during the immediate post-glacial and earlier interglacial periods. It is commonly located in terraces above present river level.

Fluvial (F, FAp)

Fluvial material is deposited by the current river either in floodplains or low terraces and is typically composed of sand and gravel. Areas mapped as active floodplains (FAp) have little vegetation and are regularly flooded.

Colluvium (C)

Colluvium is material that has weathered and eroded from bedrock or other deposits and has been moved downslope by gravity. It is common as a thin veneer (< 1 m thick) on rocky slopes and as thicker deposits at the base of slopes which have experienced slumping or land sliding. The texture of colluvium reflects its source - where derived from bedrock, colluvium will typically be silt to gravel sized with some boulders and highly disturbed bedrock.

Till (M)

Till is material that has been deposited by glacial ice. Typically, it is a highly consolidated deposit consisting of poorly sorted, usually matrix-supported subangular or subrounded clasts in a clayey sandy-silt matrix. It is common as thick blankets or thin veneers throughout the study area.

Organic (O)

Organic material is sediment that is composed largely of partially decomposed vegetative matter. It is common on floodplains of along major streams.

Bedrock (R)

Bedrock material is solid consolidated rock. Applies to bedrock outcrops and rock covered by up to 10 cm of unconsolidated organic materials.

Ice (I)

Ice material is considered ice and snow involved in active glacier movement. Applies to all glaciers and associated permanent snowfields.

B-3.5 Drainage Classes

Drainage classes rate the potential for water to drain from a given polygon in relation to water supply (Table B-1). These drainage classes provide information that can influence road construction and design of drainage and erosion control structures. Drainage classes were assigned to all polygons but are not shown on the drawings.

Table B-1 Example materials and locations for each drainage class (RIC 1996).

Drainage Class	Description	Example Materials and Locations
Rapid (r)	Water is removed rapidly in relation to supply	Exposed rock
Well (w)	Water is removed from the soil readily but not rapidly	Sand and coarser grained sediments, typically on upper slopes
Moderate (m)	Water is removed from the soil somewhat slowly in relation to supply	Sand and coarser grained sediments, typically on mid-lower slopes
Imperfect (i)	Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season	Coarser to finer grained sediments on lowermost slopes, gully bottoms, and in moist areas of floodplains
Poor (p) Very Poor (vp)	Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen	Bogs in bedrock depressions, marshy or wet areas of floodplains

B-3.6 Terrain Stability Interpretations

Terrain stability refers to the potential for landslide initiation within the polygon following disturbance by road construction or removal of forest cover. Terrain stability ratings range from Class I (stable) to Class V (unstable), as shown in Table B-2 and were added to all terrain polygons intersecting proposed facilities. The classes are based primarily on slope steepness, surficial material type, and geomorphological processes occurring within the polygon (e.g., gully erosion or existing landslides) as shown in Table B-3. For example, a slope morphology that includes irregular, near-surface bedrock would typically be rated as more stable than a similar slope with a smooth profile, because bedrock irregularities tend to stabilize soil against failure. Polygons with existing landslides in bedrock or surficial material are automatically assigned Class V ratings. Existing landslides are included in the assessment of terrain stability.

As terrain stability ratings consider terrain disturbance in the stability class, they are not directly equivalent to estimates of hazard likelihood. They are primarily used to identify areas requiring more detailed stability assessment prior to logging, road construction, or other construction. Terrain Stability Field Assessments (TSFA's) are usually carried out prior to forest clearing or road construction on terrain mapped as terrain stability classes IV and V and should also be referenced where existing.

Table B-2 Terrain stability rating for road construction.

Terrain Stability Class	Interpretation
I	No significant stability problems exist.
II	There is a very low likelihood of landslides following road construction. Minor slumping is expected along road cuts, especially for 1 or 2 years following construction.
III	There is a low likelihood of landslide initiation following road construction. Minor slumping is expected along road cuts, especially for 1 or 2 years following construction.
IV	Expected to contain areas with a moderate likelihood of landslide initiation following road construction.
V	Expected to contain areas with a high likelihood of landslide initiation following road construction.

Table B-3 Criteria used to assign terrain stability classes (modified from Ryder, 2002).

		SLOPE CLASS					
		Plain (p) 0-5% (0-3°)	Gentle Slope (j) 6-27% (3-15°)	Moderate (a) 28-49% (15-26°)	Moderately Steep (k) 50-60% (26-30°)	Moderately Steep (k) 61-70% (31-35°)	Steep (s) >70% (>35°)
TERRAIN STABILITY CLASS	I	Any material, plain or gently undulating topography					
	II		Moderately steep rock slopes				
			Fans and gentle slopes of any material				
	III		Irregular rock slopes with till or colluvial veneers				
				Moderate glaciofluvial slopes			
				Till or colluvial veneers or blankets, glaciofluvial scarps			
					Course textured talus, competent rock		
				Glaciolacustrine or Glaciomarine blankets or slopes			
	IV				Glaciolacustrine or glaciomarine blankets or slopes		
					Gullied till or colluvial blankets		
						Fine textured till or colluvial veneers or blankets. Till, colluvial, glaciolacustrine, glaciomarine slopes	

APPENDIX C
REVIEW OF PRECEDING GEOHAZARD MANAGEMENT PLAN PERFORMANCE AND RECOMMENDATIONS

C-1 INTRODUCTION

BGC reviewed the performance of the existing Brucejack GMP (Pretium Resources Inc., December 2016) which included a review of reported geohazard events at the site, the weather advisory levels and overall performance of the existing GMP. This Appendix summarizes this review and provides recommendations.

C-2 REVIEW OF GEOHAZARD REPORTING

C-2.1 Summary of Past Events

BGC understands Pretium Resources Inc. performed annual inspections and reports of geohazard events that occurred each year from 2016 through 2020 inclusive as required by the existing GMP. These inspections involved field observations and monitoring data (where applicable) across several geohazard areas on the mine site. BGC is aware of the following recorded geohazard events:

- Ten locations of access road flooding identified on Oct 10, 2015 (BGC, March 8, 2017). Occurred during/on day with weather advisory levels of “high or very high”
- One rock fall in 2016 along transmission line (BGC, March 8, 2017)
- One rock fall on access road (km 43, “Slasher”) March 5, 2015 (BGC, March 8, 2017), impacted vehicle.

Pretium Resources Inc.’s annual inspection reports for 2017, 2018, 2019 and 2020 did not report any geohazards events and BGC has no record of a 2021 inspection report or reports of events identified outside of annual inspections (Pretium Resources Inc., January 29, 2018; Pretium Resources Inc., November 12, 2018; SRK Consulting (Canada) Inc., March 20, 2020; SRK Consulting (Canada) Inc., March 12, 2021). BGC notes that no geohazard events have been reported in the mine study area covered by this updated GMP. BGC assumes based on experience in similar and nearby terrain that smaller scale geohazard events or events of small consequence likely occurred but have not all been recorded for the mine site and related infrastructure.

Approximately 8 kilometres from Brucejack Mine in July 2021 a rock avalanche occurred on Canoe Glacier. This event is thought to have been triggered by an extreme heat event (Menounos et al., 2021) and demonstrates the potential magnitude of geohazard events possible in the Brucejack Area. Geohazard event reporting will be of critical importance to the continued operations of Brucejack Mine going forward. Event records improves preparedness for future events and allows safety protocols to be updated to evolving site conditions.

C-2.2 Geohazard Reporting Recommendations

BGC has modified the existing reporting guidance and associated forms to increase ease of use and reporting. BGC recommends Newcrest consider the implementation of a mobile geohazard reporting application in the future for mine operation personnel. A mobile application would make geohazard reporting more accessible in the field, where and when geohazards are first

identified. BGC also anticipates the use of a mobile application would increase geohazard data collection across the mine site. A mobile reporting application could be integrated with BGC's Cambio online data management solution used by other Newcrest operations.

C-3 REVIEW OF SUGGESTED WEATHER ADVISORTY LEVELS

The following section is a review of the weather advisory levels implemented by the existing Brucejack GMP and corresponding meteorological data collected near Brucejack since it's issuance.

C-3.1 Meteorological Data

Rainfall events can be an important trigger for geohazard processes. The existing GMP characterizes base case mine weather advisory levels per the matrix outlined in Table C-1. Four-week antecedent rainfall and "storm" precipitation values define the weather advisory levels. A "storm" precipitation is defined as events where more than 1 mm of precipitation falls per hour for at least six consecutive hours, per the existing GMP. A summary of four-week antecedent precipitation data and base case weather advisory levels issued by the storm events recorded at the weather station BJ VOK near the mine site is presented in Figure C-1 for the timeframe spanning December 2, 2014 to November 17, 2022. A summary of the noted storm events, their duration and corresponding weather advisory levels is presented in Table C-2.

Table C-1 Weather advisory level matrix based on the observed 4-week antecedent precipitation and the forecasted storm precipitation.

		Storm Precipitation (mm)				
		< 25	**25-50**	**50-75**	**75-100**	**>100**
4-week Antecedent (mm)	<150	**L**	**M**	**M**	**H**	**VH**
	150-200	**M**	**M**	**H**	**VH**	**VH**
	>200	**M**	**H**	**VH**	**VH**	**VH**

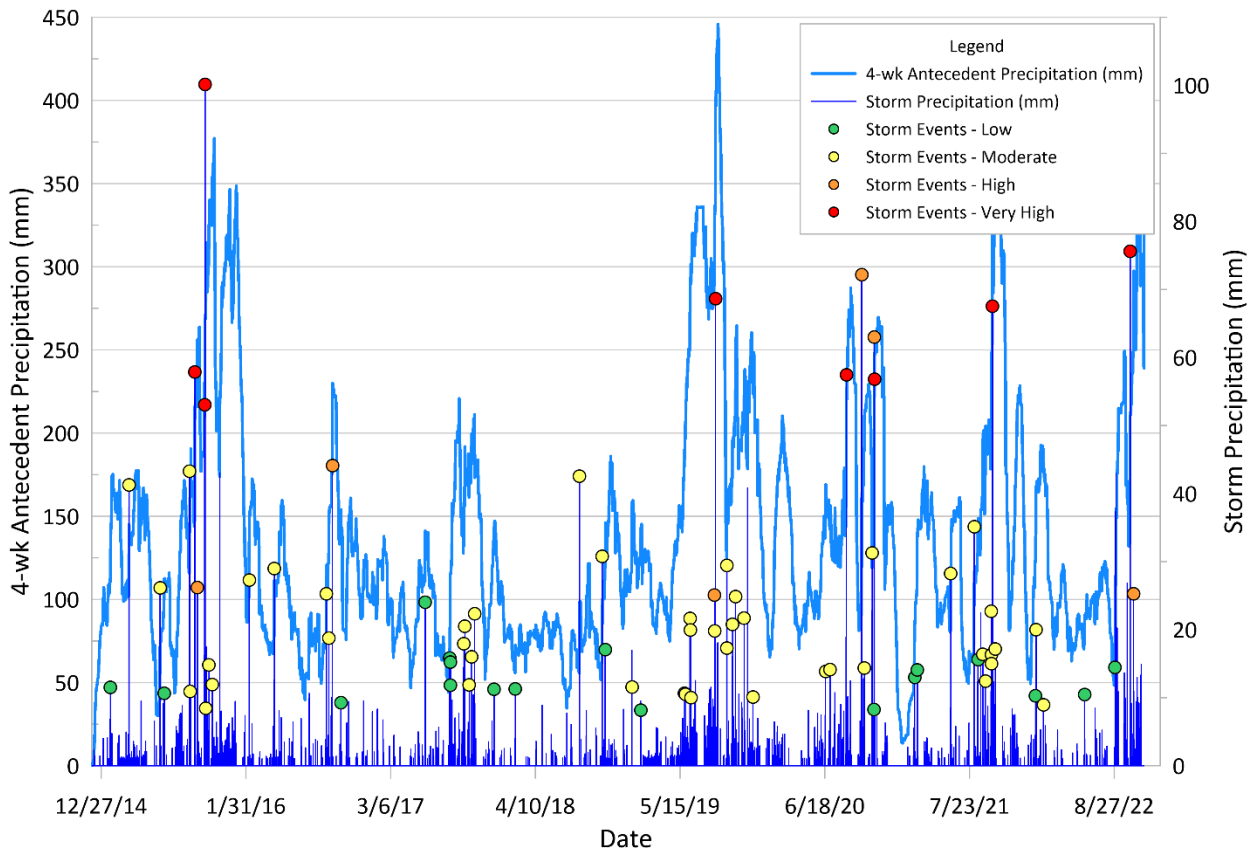

Figure C-1 Precipitation time-series and storm events near Brucejack Mine with associated base case weather advisory level.

Table C-2 Summary of storm events near Brucejack Mine and their base case weather advisory level.

	Weather Advisory Level				Total
	Low	Moderate	High	Very High	
Number of Storm Events	18	55	6	8	87
Avg. Duration (hours)	7.1	8.8	12.0	20.0	9.7

Precipitation has a complex relationship with geohazard processes, with other meteorological factors such as snow level and temperature affecting the likelihood that rainfall storms will trigger geohazard events. These factors are applied to adjust the base case weather advisory level associated with the storm events outlined in Table 5-1. The following conditions are outlined in the Geohazard Management Plan (Pretium Resources Inc., December 2016) to account for the influence of these additional meteorological factors:

1. If temperatures are ≤ 0°C, lower the risk level by two unless already Low.

2. If temperatures are greater than 5°C and there is snow on the ground, raise the risk level by one unless already Very High.

A summary of the noted storm events, their duration and corresponding adjusted weather advisory levels is presented in Table 5-1 for the timeframe spanning December 2, 2014 to November 17, 2022.

Table C-3 Adjusted weather advisory level summary for storm events between 2014 and 2022 near Brucejack Mine.

	Weather Advisory Level				Total
	Low	Moderate	High	Very High	
Adjusted Number of Storm Events	38	28	13	8	87

Contrasted in Table C-2 and Table C-3, the storm hazard modifying conditions outlined have significant impact on the ranking of rainfall events. There was a storm event on October 10, 2015 ranked Very High (base case) and High (adjusted) resulted in ten areas of flooding along the access road (BGC, March 8, 2017). No other annual monitoring reports consulted by BGC (Pretium Resources Inc., January 29, 2018; November 12, 2018; SRK Consulting (Canada) Inc., March 20, 2020; March 12, 2021) mentioned records of geohazard events in areas outside the mine site. Improved record-keeping and reporting of geohazard events along access roads will improve the connection between rainfall thresholds and geohazard events.

C-3.2 Weather Advisory Level Recommendations

Based on the guidance provided by the 2016 GMP, storm event “Very High” weather level advisories have been issued eight times over approximately seven years, from the timeframe spanning December 2, 2014 to November 17, 2022. Limited record of geohazard events in the mentioned timeframe prevents further calibration or assessment of the advisory levels accuracy and performance. Given this limited availability of calibration events and the reasonable distribution of weather advisory levels summarized in Table C-1 for the storms identified in the studied timeframe, BGC recommends maintaining the current GMP weather level advisory guidelines in the updated 2023 GMP prepared for Newcrest.

C-4 RECOMMENDATIONS

BGC recommends the following based on review of the existing GMP and its performance:

- Newcrest facilities inspections should be performed by Newcrest personnel following “High” weather advisory level storm events to assess potential geohazard occurrences
- Newcrest facilities inspections should be performed by qualified professional(s) following “Very High” weather advisory level storm events to assess potential geohazard occurrences or increased geohazard level

- Mitigative measures taken (e.g., scaling, ditch clearing, bolting) in response to or in prevention of geohazard events should be documented and made available for review during annual geohazard inspections. This includes follow up actions completed in response to prior geohazard review inspections, even if no follow up action was performed.

These recommendations have been applied to the updated GMP (main body of this report).

BGC recommends the following for future works at the Newcrest Brucejack facilities:

- Expand the area covered by the GMP to encompass all Brucejack facilities including but not limited to access roads and transmission lines
- Reconciling Stantec (October 31, 2014) and BGC (July 31, 2015) terrain mapping and geohazard assessment information generated for the site transmission lines
- Further study to quantify the geohazard risk posed to existing infrastructure, mine operations and workers safety within the study area by the identified hazards.

APPENDIX D
GEOHAZARD EVENT REPORTING FORMS

Ministry of Energy and Mines

ADVICE OF GEOTECHNICAL INCIDENT

PART A: To be completed by mine management to document geotechnical incidents.

APPLICABILITY OF THIS FORM

This form applies to any geotechnical incident classified as a dangerous occurrence or to any geotechnical incident that requires changes to an existing standard operating procedure or the creation of a site-specific safe work plan. In addition, any multi-bench pit slope failure, spoil failure resulting in full loss of the crest berm, or dam embankment instability (regardless of size) is to be documented on this form. This form is not intended for single bench failures fully captured by catchment berms or for "sliver" failures on spoils not resulting in a dangerous occurrence.

GENERAL INFORMATION

Name of Mine: _____ Permit Number: _____

Mining Company: _____ Location: _____

Manager: _____ Appropriate Contact: _____

Phone: _____ Phone: _____

Part of Mine Involved/Affected: _____

Date of Event: _____ Probable Time: _____

Summary of Incident: _____

_____

_____

Type of slope: ❑ Pit Wall ❑ Waste Rock Spoil ❑ Dam Embankment ❑ U/G Rockfall ❑ Other

DETAILS OF EVENT

Potential triggers (weather, mining activity, etc.): _____

Volume or Mass Involved / Type of Material: _____/_____

Description of Incident (include likely failure mechanism, run-out distance, slope height, and pre/post failure slope angle):

_____

_____

Damage or Consequences: _____

_____

Immediate (Short-term) Actions Taken by Mine: _____

_____

ADVICE OF GEOTECHNICAL INCIDENT OR UNUSUAL OCCURRENCE

PART B: To be completed by mine management to document follow-up actions.

Date / Time of Incident (if Part B not submitted at same time as Part A): _____/_____

Follow-up actions by in-house geotechnical personnel: _____

_____

Has this incident been discussed with / reviewed by a geotechnical consultant?_____

Follow-up actions recommended by geotechnical consultant (if applicable): _____

_____

Any required changes to standard operating procedures? _____

Any site-specific safe work plan(s) required?_____

Report from mine (including plans and section) or other attachments?

1.) _____

2.) _____

3.) _____

Items to be forwarded at a future date / expected date of submission?

1.) _____/_____

2.) _____/_____

3.) _____/_____

Additional Comments: _____

_____

_____

_____

_____

_____

_____

_____

BGC Engineering Inc.

Brucejack Mine
Geohazard Event Reporting Form

Newcrest Mining Ltd.

Facility/Structure Impacted

Name: _____

Location: _____

GPS

Northing: _____

Easting: _____

Elevation: _____

Details

Date: _____

Est. time of incident: _____

Observed by: _____

Reported by: _____

Weather

Snow on ground?
Yes ☐ No ☐

Past 24-hour temperature:
< 0°C ☐ 0 - 5°C ☐ > 5°C ☐

Past 24-hour rainfall:
Heavy ☐ Light ☐ None ☐

Brucejack Weather Advisory Level:
Low ☐ Moderate ☐ High ☐
Very High ☐ Unknown ☐

Fall/Slide

Rock

Runout:
Asset reached ☐
Asset not reached ☐

Ice

Runout:
Asset reached ☐
Asset not reached ☐

Volume Class:
Single small block ☐
Single large block ☐
Multiple small blocks ☐
Multiple large blocks ☐

Earth/Debris Landslide

Runout:
Asset reached ☐
Asset not reached ☐

Material:
Rocks ☐ Sand/silt/clay ☐
Gravel ☐ Trees/vegetation ☐

Volume Class:
Moved by hand ☐
<1 truck ☐
1 truck ☐
Several trucks ☐

Washout/Erosion

Erosion:
Upslope ☐
Downslope ☐
Through asset ☐

Elements present:
Unobstructed culvert ☐
Obstructed culvert ☐
Damaged culvert ☐

Stream condition:
Seasonal flow ☐
Year-round flow ☐

Source Area

Cut slope ☐ Embankment ☐
Natural slope ☐ Gully/creek ☐

Position from asset:
Distance: _____ m
Above ☐
Below ☐

Consequence

None ☐
Event progression could threaten asset(s) ☐
Asset obstructed, not damaged ☐
Asset damaged ☐
Safety consequence ☐

Severity

	Major	Minor
Event progression could threaten asset(s)	☐	☐
Asset obstructed, not damaged	☐	☐
Asset damaged	☐	☐
Safety consequence	☐	☐

Repair time

None ☐
< 1 day ☐
< 1 week ☐
> 1 week ☐

Repair effort

None ☐
General labourer ☐
Onsite equipment ☐
Offsite equipment ☐

Notes + Photos:

Appendix 9-2-4. Ground Control Management Plan

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Ground Control Management Plan – Version 9

Date: February 2023

Pretium Resources Inc.
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VERSION CONTROL

Revision #	Date Released	Approved By	Brief Description	Amendment By
1.01	July 2014	Brucejack Technical Services		BGC Engineering Inc.
2	August 2015	Brucejack Technical Services		BGC Engineering Inc.
3	November 2016	Brucejack Technical Services		BGC Engineering Inc.
4	December 2017	Brucejack Technical Services	Changing ground support 6m Cable bolts to 16′ connectables for Stope top-cut support	Brucejack Geotechnical Team
5	August 2018	Brucejack Technical Services	Face screen and lower screen height	Brucejack Geotechnical Team
6	January 2019	Brucejack Technical Services	2019 Review	BGC Engineering Inc.
7	October 2020	Brucejack Technical Services	2020 Review and update	Brucejack Geotechnical Team
8	January 2022	Brucejack Technical Services	2021 Review and update	Brucejack Geotechnical Team
9	February 2023	Brucejack Technical Services	2022 Review and update	Brucejack Geotechnical Team

PREVIOUS EDITIONS

The first three editions of the Brucejack Mine Ground Control Management Plan (GCMP) (i.e. through 2016) were prepared by BGC Engineering Inc. The 2018 edition of the GCMP reflects updates and other revisions by Brucejack Gold Mine Senior Geotechnical Engineers (Dr. Woo Shin, P.Eng. and Allan Chan, P.Eng.). The 2019 edition of the GCMP was prepared by BGC Engineering Inc. The 2020 edition of the GCMP reflects updates and other revisions by Brucejack Gold Mine Senior Geotechnical Engineers (Dr. Woo Shin, P.Eng. and Dr. Baoyao Tang, P.Eng.) and was reviewed by SRK Consultants Inc. The 2021 edition of the GCMP reflects updates and other revisions by Brucejack Gold Mine Senior Geotechnical Engineers (Dr. Woo Shin, P.Eng. and Dr. Baoyao Tang, P.Eng.). The 2022 edition of the GCMP reflects updates and other revisions by Brucejack Mine Senior Geotechnical Engineer (Dr. Woo Shin, P.Eng.).

BRUCEJACK MINE

Ground Control Management Plan

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1 INTRODUCTION

The Brucejack Ground Control Management Plan (GCMP) is the authoritative record of data, information, and systems used to manage ground control matters at the Brucejack Mine.

Key objectives of the GCMP are as follows:

- Reduce and / or mitigate the risks of uncontrolled ground failure; and
- Contribute to the development and maintenance of a safe and productive mining environment.

These objectives are achieved through:

- Clear definitions of Ground Control roles and responsibilities for key individuals;
- On-going assessment of the mine's geotechnical conditions, and evaluation of ground control risks;
- Design and implementation of ground control management systems;
- Development of Standard Work Procedures (SWP) that address ground control issues;
- Communication of ground control matters and potential hazards within the workforce;
- Ground monitoring systems;
- Ground support testing;
- Internal and external auditing; and
- GCMP review, and scheduled updating.

The Brucejack GCMP consists of four sections:

- Section 1. Roles and Accountabilities;
- Section 2. Ground Control Management at Brucejack;
- Section 3. Implementation of the GCMP; and
- Section 4. Verification of the GCMP.

An archive of drawings, data, and information relating to the GCMP is attached to this document, including the following:

- **Drawings:**
  - Drawing 01. Location Map;
  - Drawing 02. Developed Prospects and Past Producers Near Brucejack Project, Plan Map;

- Drawing 03. Interpreted Groundwater Elevation Map;
- Drawing 04. Laboratory Intact Rock Strength Testing Results;
- Drawing 05. Hoek-Brown Strength Curves for Geotechnical Units; and
- Drawing 06. Structural Geology Plan Map.

- **Appendices**
  - Appendix A. Drill Hole Summary Logs;
  - Appendix B. Drill Hole and Underground Mapping Stereonets;
  - Appendix C. Laboratory Testing Results;
  - Appendix D. Point Load Testing;
  - Appendix E. Rock Mass Characterization;
  - Appendix F. Brucejack Fault Zone Summary;
  - Appendix G. Mine Domain Stereonets;
  - Appendix H. 2019 Geotechnical Data Review
  - Appendix I. Stope Stability and Support Assessment & Stope Design Review;
  - Appendix J. Stope Dilution Assessment;
  - Appendix K. Site Inspection Reports;
  - Appendix L. Minimum Ground Support Standards; and
  - Appendix M. Full-Width Undercut Support.
  - Appendix N. Geotechnical Assessment of Secondary Stopes
  - Appendix O. Ground Support System- Development into/beside Paste Backfill
- **Supporting Information**
  - I. Brucejack Ground Support Product Specifications and Installation Guidelines;
  - II. Current Mining Contractor Safety and Ground Control Documentation; and
  - III. Pretium Resources Inc. (Pretium) Safety and Ground Control Documentation.

The Brucejack Mine GCMP has been updated in 2020 by Brucejack Mine Technical Services Department Senior Geotechnical Engineers (Dr. Woo Shin and Dr. Baoyao Tang), in 2019 by BGC Engineering Inc. (BGC), and in 2017 and 2018 by Brucejack Mine Technical Services Department Senior Geotechnical Engineers (Dr. Woo Shin and Allan Chan). BGC authored previous editions. The GCMP is reviewed annually and updated as appropriate by Professional Engineer(s) in accordance with Mines Act Permit M-243 Conditions C.2(d).

2 GROUND CONTROL ROLES AND RESPONSIBILITIES

Roles and Responsibilities for ground control at the Brucejack Mine are outlined in Table 2-1.

Table 2-1 Ground Control Roles and Responsibilities at Brucejack

Title	Responsibility
Mine Manager	• Fulfill regulatory, Code, and mine permit requirements for ground control matters; • Confirm ground control is adequately considered in design and operation of the mine; • Appoint task-trained / qualified persons with ground control knowledge and experience; • Support implementation and on-going review of the GCMP; • Provide adequate resources to fulfill the requirements of the GCMP; • Support subordinates and review progress on ground control responsibilities; and • Support development and implementation of Safe Work Procedures (SOPs).
Mine Operations Superintendent	• Support subordinates in ground control responsibilities; • Confirm development and implementation of SOPs; • Provide support to shift supervisors and technical services in resolving ground control issues; and • Investigate and address GCMP and SOP deficiencies.
Mining Contractor Mine Superintendent	• Appoint task-trained / qualified persons with ground control knowledge and experience; • Provide and document adequate task and ground control training to mine personnel; • Support subordinates in ground control responsibilities; • Confirm suitable equipment, tools, and materials are supplied and maintained; • Confirm development and implementation of SOPs; • Provide support to shift supervisors and technical services in resolving ground control issues; and
Mining Contractor Shift Supervisor	• Confirm that work sites and travel ways are maintained to safe and acceptable standards; • Confirm suitable equipment, tools, and materials are supplied and maintained; • Inspect, monitor, and communicate on ground conditions in work areas; • Confirm SOPs and ground control procedures are understood and followed by mine personnel; and • Ensure mine contractor personnel are task trained and competent in their duties.
Pretium Chief Mine Engineer	• Confirm implementation of the GCMP; • Provide resources to support and update the GCMP; • Confirm geotechnical and ground control aspects are considered in design, planning, execution; and • Investigate and address GCMP and SOP deficiencies.
Pretium Senior	• Collect and analyze data to determine geotechnical inputs for mine planning and

Title	Responsibility
Geotechnical Engineer **Pretim Senior Geotechnical Engineer**	design. Interpret and communicate findings and recommendations; • Develop and maintain a ground condition model, based on the geological and geotechnical setting and the underground mining environment; • Determine ground control design criteria to support mine planning; • Provide ground support / reinforcement designs based on the ground condition model; • Conduct, record, and archive regular ground assessments of work areas; • Monitor, record, interpret, and communicate on excavation surveillance data; • Inspect and document ground falls, zones of potential geotechnical concern; • Conduct ground control training; • Conduct, document, and archive ground control audits, reviews, and quality assurance programs; and • Regularly review and update the GCMP.
Mine Geologist	• Collect geology and geotechnical data to determine inputs for mine planning and design. Analyze, interpret, and communicate findings and recommendations; • Provide geology support and input to the Underground Manager, Mining Engineers, and Mine planners; • Complete field investigation tasks (mapping, drilling, logging) to support ground control management; and • Develop, maintain, and update the mine geology model.
Pretium / Mining Contractor Safety Coordinators	• Conduct regular safety inspections of work places; • Develop, approve, and review SOPs and conduct compliance audits; • Investigate and report on safety incidents; and • Help supervision ensure mine personnel are appropriately trained and competent to safely carry out proscribed tasks.
Miners, Operators, Underground Personnel	• Comply with SOPs; • Inspect and monitor ground conditions. If unsafe, withdraw and barricade area, and notify the Shift Supervisor; • Undertake 'Ground Awareness' training; • Undertake task specific training; • Understand and implement ground support standards; and • Communicate on ground control issues.

3 GROUND CONTROL MANAGEMENT FOR MINE DESIGN AND PLANNING

Ground Control Management is integral to mining at Brucejack and will be considered over the life of the mine, during the design, planning, development, and operational stages. Ground control management will be approached in a systematic manner, and take into account the following factors:

- **Geological and Geotechnical Factors:**
  - Distribution of rock types;
  - Distribution, orientation, and condition of regional and local geologic structures;
  - Ore zone location and grade;
  - Geotechnical conditions of the rock mass;
  - Rock strength parameters (uniaxial compressive strength, cohesion and friction angle, etc.);
  - In-situ stress conditions and anticipated changes arising from mining;
  - Groundwater conditions; and
  - Ground response to mining determined from monitoring and surveillance.
- **Mining Factors:**
  - Excavation dimensions;
  - Mining method and sequencing;
  - Backfill type and strength;
  - Required use of excavation;
  - Required service life of zone or excavation; and
  - Ground support requirements, equipment, and constraints.

This section presents a summary of the existing project geology and geotechnical datasets, and provides a description of ground control analysis and design tasks and systems used to support mine design and planning activities. An objective of the discussion presented in this section is to provide a template for incorporating geology, geotechnical, and ground control data and information into the mine plan on an ongoing basis.

Current mine plans and designs at Brucejack are based in part on results of site investigations and geotechnical assessments completed by BGC and Brucejack Technical Services (BTS) personnel. The assessments included rock mass characterization tasks, structural geology interpretations, excavation and pillar stability analyses, and ground support designs and audits.

Geotechnical site investigations completed to support the current designs included: geological and geotechnical drilling and logging, oriented drill core measurements, borehole televiewer surveys,

laboratory testing of rock core and discontinuity samples, and installation of borehole instrumentation to measure groundwater pressures. Geotechnical mapping of the underground workings was also completed to provide structural geology and rock mechanics information. Additionally, the geotechnical performance of excavations within the mine are regularly inspected and verified by Pretim, the mining contractor, and BGC.

A comprehensive presentation of the data and information summarized in this section is presented in BGC's May 2013 "Underground Rock Mechanics Assessment" (BGC, 2013a), completed in support of the Brucejack Project's Feasibility Study. For reference purposes, select Appendices and Drawings from that document are attached to this GCMP (Appendices A, C to K, Drawings 1 - 6). Since BGC's 2013 study, a number of location specific assessments and inspections have been completed (BGC, 2013b; BGC, 2014a; BGC, 2015a; BGC, 2016b, 2016c; BGC, 2017b, 2017c; BGC, 2018b). Summary reports for those inspections and assessments, including the geotechnical data, are provided in the Appendices.

3.1 GEOLOGY AND GEOTECHNICAL DATABASE

This section summarizes geology and geotechnical data sources and information used to support the development of the GCMP.

3.1.1 Drill Holes

Data from approximately 6,000 drill holes advanced between 2010 and 2022 are included in the mine database. In total, the dataset includes over 890,000 m of geological and geotechnical core logging information from NQ, HQ, and PQ diameter core, collected throughout the Brucejack Mine area by Pretium and their predecessors.

Fourteen holes (~6,000 m) were drilled specifically for geotechnical purposes and logged by or under the direct supervision of BGC.

3.1.2 Geotechnical Core Logging

Geotechnical core logging completed for the Brucejack Mine can be divided into seven phases:

1. Data collected by Silver Standard during the 2010 exploration drilling programs;
2. Data collected by Pretium during the 2011 exploration drilling program;
3. Data collected by Pretium during the 2012 exploration drilling program with training from BGC to facilitate the collection of additional geotechnical data during logging; and
4. Data collected by or under the direct supervision of BGC during the 2010 and 2012 geotechnical drilling programs.
5. Data collected by or under the direct supervision of BGC during the 2014 and 2015 geotechnical drilling programs.
6. Data collected by Pretium between the 2016 and 2022 exploration drilling program.

7. Data collected by Newcrest between the March 2022 and August 2022 exploration drilling program

Data from the 2012 thru 2015 drilling programs collected by BGC and data from the 2016 to 2022 drilling program collected by Pretium, and data from the March 2022 to August 2022 drilling program collected by Newcrest represent the most complete geotechnical drill hole dataset available for the Mine. Parameters and observations logged by BGC per core interval include:

- Total grade (ISRM, 1978);
- Average core recovery;
- Rock quality designation (RQD) (Deere and Deere, 1988);
- Longest stick;
- Number of discontinuities;
- Number of discontinuity sets;
- Strength grade (ISRM, 1978);
- Weathering joint condition (Bieniawski, 1976); and
- Point load testing.

These data, combined with detailed discontinuity logs, and underground mapping data and observations, provide the basis for the rock mass characterizations completed by BGC and BTS. Summary geotechnical drill hole logs are provided in Appendix A. Data from the 2014/2015 underground inspections are provided in Appendices K.

3.1.3 Televiewer Surveys and Oriented Core

Data collected from acoustic and optical borehole televiewer surveys are the main source of sub-surface discontinuity orientation information for the Brucejack Mine. Eight of the ten geotechnical drill holes completed in 2010 and 2012 were surveyed and interpreted. During the 2012 drilling program, six holes were also oriented using the ACT II core orientation system to provide an independent check on the televiewer survey results. In 2014 and 2015, an additional four holes were drilled, geotechnically logged, and oriented (ACT II), for the purpose of assessing ground conditions near the Underground Crusher Chamber. The results of the ACT II orientation method were consistent with the televiewer results. The discontinuities measured during the televiewer surveys and oriented core drilling were compiled into structural domain stereonets, and are provided in Appendix G. An update of the VOK structural domains was completed in 2018 (BGC, 2018b) and 2019 (BGC, 2019a), and the updated stereonets are provided in Appendix I-1 and Appendix H.

Since 2020, 66 drill holes have been oriented using the ACT III core orientation system. The oriented core data is generally not used to model fault structure because orienting core in zones of broken core is problematic. The fault are modelled in a number of steps as follows. The initial step involves modelling zones of low RQD as volumes that represent damage zones associated with the faults.

Midplanes surfaces are then extracted from the damage zone volumes to represent the fault surfaces that offset lithologies and mineralization domains. The fault surfaces are then extruded from 0.25 to 0.75m for use in the RMR model. Updated 2022 RMR model can be found,

J:\Geo Engineer Share\RMR Model\RMR_Dec2022\rmr_simulation_Dec2022_sub_block_tri.bmf

3.1.4 Laboratory Testing

Laboratory testing of rock core samples and discontinuity surfaces from geotechnical drill holes was conducted in during all drilling programs. Tests completed include uniaxial compressive strength (UCS), Brazilian tensile strength (BTS), triaxial compressive strength, and small scale direct shear (DS).

Testing of fault gouge and soil-like materials recovered from the geotechnical drill holes included grain size analysis, hydrometer tests and Atterberg limits. In addition to samples collected from geotechnical drill holes, tests were completed on PQ-sized exploration drill holes stored at Pretium's core warehouse in Stewart, BC, to increase the number of test results for each lithology. Laboratory reports are provided in Appendix C.

3.1.5 Structural Geology Review

BGC referenced work completed by Earth Resource Surveys Inc. (ERSi) at the adjacent KSM property for regional structural geology interpretations. Lineations were mapped from color and black and white aerial photographs, LiDAR digital elevation model (DEM) data, and color orthophotographs. Ground-truthing of the lineament mapping study was completed by ERSi in September 2009 and August 2010. The results of this mapping have been used to develop an understanding of the regional structural fabric and to assist in the selection of design discontinuity sets.

3.1.6 Structural Mapping

The underground geotechnical designs at Brucejack are in part based on geotechnical mapping completed in 2012 by BGC in the de-watered underground workings previously mined by Newhawk Gold Mines Ltd. Where accessible, geological structures were mapped and their influence on excavation stability was evaluated. Over 1,000 structural measurements were collected from the portal, ramp, exploration drift and 1350 level. Information on the orientation, infilling, roughness, and persistence of the discontinuities was collected. Additional surface outcrop mapping and structural interpretations by Pretium were made available to BGC and were incorporated into the geotechnical database.

Since Brucejack commenced development in 2015, additional geologic and geotechnical data has been collected during mapping by the geologists and geotechnical engineers during the development cycle (Figure 3.1). The new data is used to regularly update the existing geotechnical database. A review of the geotechnical data (rock mass and geologic structure) collected since 2012 was completed by BGC in early 2019, and the results are summarized in Appendix H.

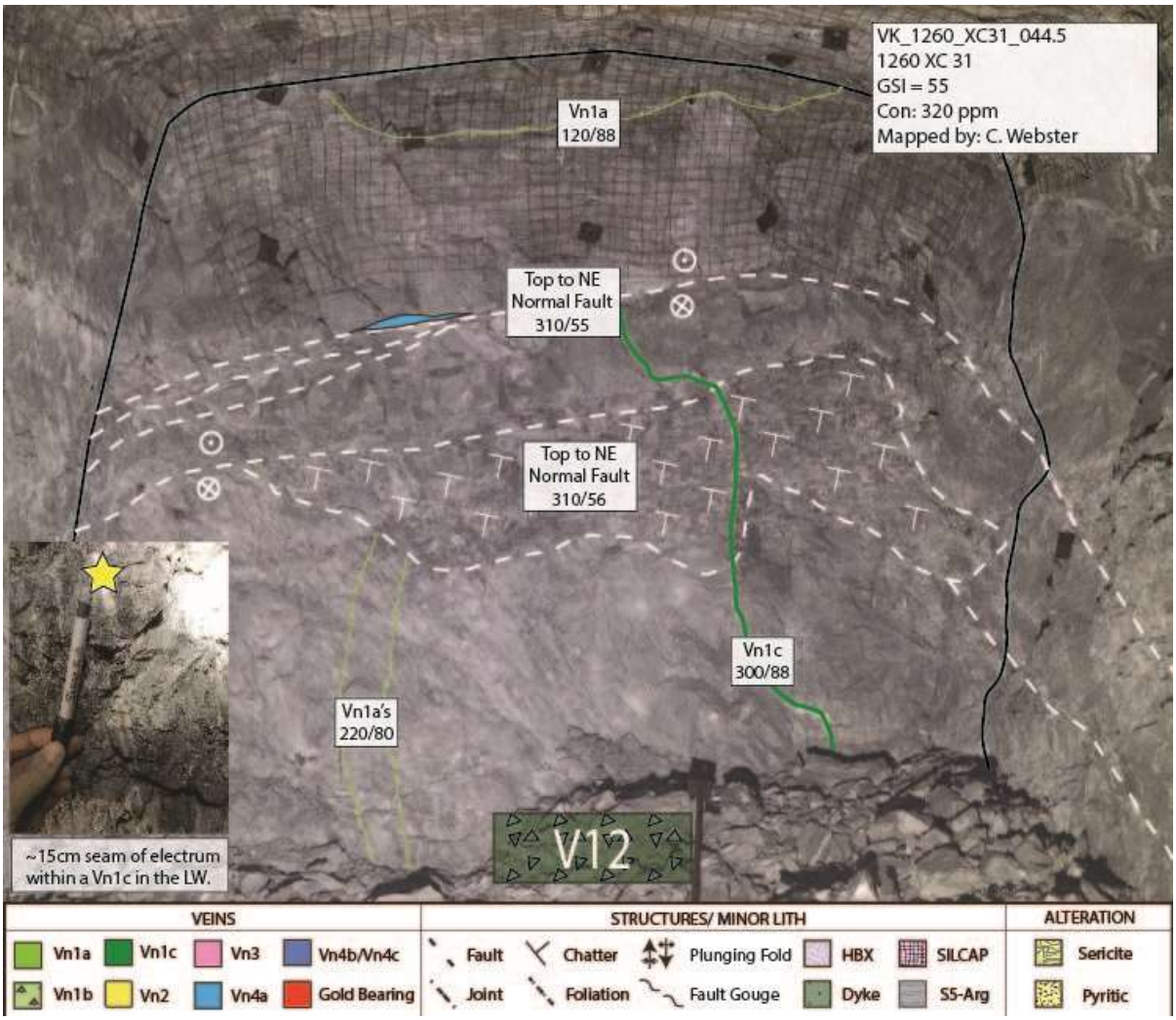

Table 3-1 Example of Geological and Geotechnical Mappings

3.1.7 Geotechnical Inspections

In January 2013, April 2014, April 2015, and May 2016, BGC completed annual geotechnical inspections of the Brucejack underground workings, with BTS completing regular underground inspections throughout mine development work since 2017. Geotechnical conditions throughout the mine were assessed on these occasions and ground control procedures and support practices were reviewed. The summary report for 2019 has been attached to the GCMP in Appendix K.

3.1.8 Other Relevant Data

Three dimensional (3D) geological models of the main lithologies and geological units have been interpreted by Pretium within the West Zone (WZ) and Valley of the Kings Zone (VOK). These interpretations have been used a basis for mine planning and design tasks. The 3D models are subject to ongoing review and updating from Pretium's geology department.

The Brucejack Fault Zone surface had been interpreted by previous owner Silver Standard for a 2010 PEA. BGC reviewed the drill hole intercepts from all drilling (geotechnical and exploration) to refine the interpretation of the Brucejack Fault Zone with respect to orientation, rock mass characteristics, and true thickness of the fault zone. Additional underground mapping and drilling by BTS during development work has further defined the location and character of the Brucejack Fault. Interpretations of this fault are discussed below. Geological maps and reports for the area were sourced from the B.C. Geological Survey (BCGS), Geological Survey of Canada (GSC), MinFile, and historic reports from previous owners (Newhawk, Silver Standard).

3.2 GEOLOGY AND GEOTECHNICAL MODELS

A full discussion of the Brucejack Property geology is presented in several regulatory submissions (43-101 Technical Reports) and company reports on file with Pretium. For context, a summary is provided below.

3.2.1 Geological Setting

The Brucejack Property is underlain by Upper Triassic volcaniclastic and epiclastic sedimentary rocks of the Stuhini Group and Lower to Middle Jurassic volcanic, volcaniclastic, and sedimentary rocks of the Hazelton Group. Unuk River Member andesites of the Hazelton Group are the most important host rocks to the gold and silver bearing quartz veins.

Multiple zones of alteration have been noted in the Mine area. Alteration assemblages vary with proximity to deformation events, but sericitic alteration is pervasive throughout. Carbonate, chlorite, and silica alteration are also common.

The Brucejack Mine area has been divided into structural domains separated by location and major faults and folds, as shown in Drawing 06. Within each domain, design discontinuity sets have been interpreted for both the ore zone and wall rock, from borehole televiewer surveys, oriented core measurements, underground mapping, outcrop mapping, and regional structural interpretations. Sources of data are indicated in Drawing 06. Summary stereonets for each domain are provided in Appendix G, H, and I.

Observations from outcrop and underground mapping demonstrate that localized variations in joint set orientations and intensity occur due to folding and faulting. These local variations may not be observed in statistically significant quantities in downhole data due to infrequency of measurements. In each structural domain, the design sets constitute approximately 40% to 45% of the total poles measured. The remaining "random" discontinuities do not cluster into dip or dip direction patterns and are unlikely to represent site scale structural fabric; however they demonstrate wide structural variability across the site. Since discreet discontinuities are present in practically all orientations it can be reasonably assumed that adversely oriented structures may be present around all excavations.

3.2.2 Major Faults and Regional Structure

The Brucejack Mine area includes major faults mapped by various sources. Reports available through MINFILE were reviewed and associated maps were digitized to compile site and regional scale fault traces around the Mine site. Data from those sources were supplemented by a review of

the structural geology of the region completed by ESRi (2010) for the adjacent KSM property, and with ongoing mapping by Pretium's geology department. Major faults and lineaments identified to date are summarized in Table 3.2.

Table 3-2 Major Geologic Structure in the Brucejack Mine Area

Scale	Structure	Strike (*)	Dip (*)	Orientation Source
Regional	Treaty Creek Lineament	291 or 111	-	ERSi, 2010
	Upper Treaty Glacier Lineament	310 or 130	-	ERSi, 2010
	Brucejack Fault Lineament	355	-	ERSi, 2010
		176	60-90	Newhawk, 1990
		356	60	Margolis, 1993
Site	Lancaster Fault	330	74	BGC Mapping, 2012
		023	80-85	Newhawk, 1990
	Sutcliffe Fault	036	86	Newhawk, 1990
		038	73	BGC Mapping, 2012
	Jaz Fault	204	40	BGC Mapping, 2012
		191	-	Newhawk, 1990
	Zorzi Fault	212	74	BGC Mapping, 2012
		200	-	Newhawk, 1990
	Babics Fault	141	83	BGC Mapping, 2012
		125	-	Newhawk, 1990
		122	75	Roach, 1991
	Rainy Fault	220-240	30-10	Pretium
	Ryne Fault	246	71	BGC Mapping, 2012
		213	-	Newhawk, 1990
	Maddux Fault	059	69	BGC Mapping, 2012 – 1350 Level Ore Drive
		048	73	BGC Mapping, 2012 – Ramp-Exploration Drift Intersection
		020	72	Roach, 1991
		020	-	Newhawk, 1990
	Not My Fault	312	-	Newhawk, 1990
	Kovacic Fault	124	-	Newhawk, 1990
	SW Fault	151	-	Newhawk, 1990
	Brucejack Fault	340	60-90	Newhawk, 1990, SSR NI 43-101
	Wobbegone Fault	237	-	Newhawk, 1990
	Grace Shear Zone	321	-	Newhawk, 1990

	Upper Thrust Fault	136	28	Pretium, 2015
	VOK Main Thrust Fault	100	33	Pretium, 2015

3.2.3 In-situ Stress

In-situ stress conditions, and related mining-induced changes to these conditions, may have a significant influence on excavation stability. However, due to the lack of consistency in the available data, it is not possible to estimate the orientation of the major horizontal principal stress direction at Brucejack. With regards to magnitude of principal stresses, it is considered appropriate to assume that horizontal stresses are higher than vertical in the near-surface region, particularly in mountainous regions such as the Brucejack Mine (McKinnon et al., 2002).

The following additional assumptions, which follow common practice in defining in-situ stresses (McKinnon et al., 2002), have been made:

- The principal axes of the in-situ stress field are horizontal and vertical.
- The orientations of the principal stresses in the horizontal plane do not vary with depth.
- The magnitude of the principal stresses vary linearly with depth below surface.

BGC and Pretium are cognisant of the importance of evolving ground stress conditions and their impact on the safety and productivity of mining activities at Brucejack.

A ground stress surveillance program is included as a component of the GCMP to better predict, monitor, and document in-situ and induced ground stress. Although significant stress-induced rockmass instability is not anticipated at current mining depths, the mountainous topography and large faults at Brucejack result in lower confidence estimates of in-situ stress and the potential for variation in in-situ stresses throughout the mine plan.

As mining proceeds and the extraction ratio increases, there is the potential for stress-induced rockmass instability to occur as the result of lower confidence in the in-situ stresses and convergence of stress in pillars due to mining. The early development of a ground stress surveillance program will facilitate the documentation of baseline data to support back-analysis and expeditious modification of the mine plan should stress-induced rockmass instability occur during the mine life. Potential risks arising from unknown or incorrectly quantified in-situ stress conditions include:

- under-estimating stress magnitudes, resulting in potentially hazardous mining conditions;
- poor stope performance and productivity;
- damage to permanent infrastructure;
- errors predicting and responding to 'over-stressed' and 'de-stressed' zones, ground deformation;
- errors determining causes and effective responses to ground failures;

- errors estimating stope and pillar dimensions; and
- errors determining the optimal mining sequence.

To mitigate these risks for the Brucejack Mine a number of elements have been incorporated into the mine designs and GCMP to account for the uncertainty. For example, conservative stress estimates and industry-tested empirical and analytical geotechnical techniques that inherently account for the uncertainty were used to determine 'allowable' stoping geometries and related mining layouts. These were supplemented by knowledgeable engineering judgement guided by significant operational experience with similar mining methods in similar ground conditions. In addition, a preliminary 3D Boundary Element Model was developed to broadly conceptualize the evolution of ground stress conditions throughout the mining cycle and identify potential locations of concern.

Most importantly, an observational 'mine and monitor' risk management system will be employed at Brucejack, as part of the GCMP. Details of this are presented in Section 4.4. If field observations and performance data indicate the development of un-anticipated / anomalous / elevated stress conditions, or growing uncertainties with respect to Pretium's understanding of evolving stress conditions, an in-situ stress measurement program should be re-considered at that time. Combined with an observational approach based on rock mass and ground support reactions, stress measurement data could be used to help refine and calibrate 2D and / or 3D numerical models to help guide mine planning decisions.

Brucejack mine on-site geotechnical team installed stress-meters for collecting stress measurement data in 2021 and 2022, and 3-dimwnsional stress back analysis was conducted in 2022 to evaluate the effect of stress distribution following the stope development procedure. Total 6 stress-meters were installed to three different stopes, VK_1050_14N-ELAT7_15L, VK_1200_30-WLAT12_28L, and VK_1140_24_16T. The instruments installed near the center point planned stope walls get the maximum stress release and concentration caused by developing underground openings. Stress monitoring data from two stopes in 1050 level and 1200 level were successfully collected but the monitoring data from 1140 level was not collected because of delayed stope development and changed actual stope location.

Map3D 3-dimensional boundary element stress analysis tool was used for the back analysis on the stress changes near VK_1050_14N-ELAT7_15L stope following stope development sequences. Figure 2 shows the stress distribution of major stress contour around stope. There are small stress concentration zones (red contour) at the back and bottom corner, but possible stress induced failure zone could not be observed from most of the stope wall areas.

Stress changes monitoring following stope development were shown in Figure 3.1 and stress analysis results were compared with stress-meter readings in Table 3.3. Stress measurement data and technical summary of the back analysis can be found,

Stress-meter reading:

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Technical summary of stress distribution back analysis:

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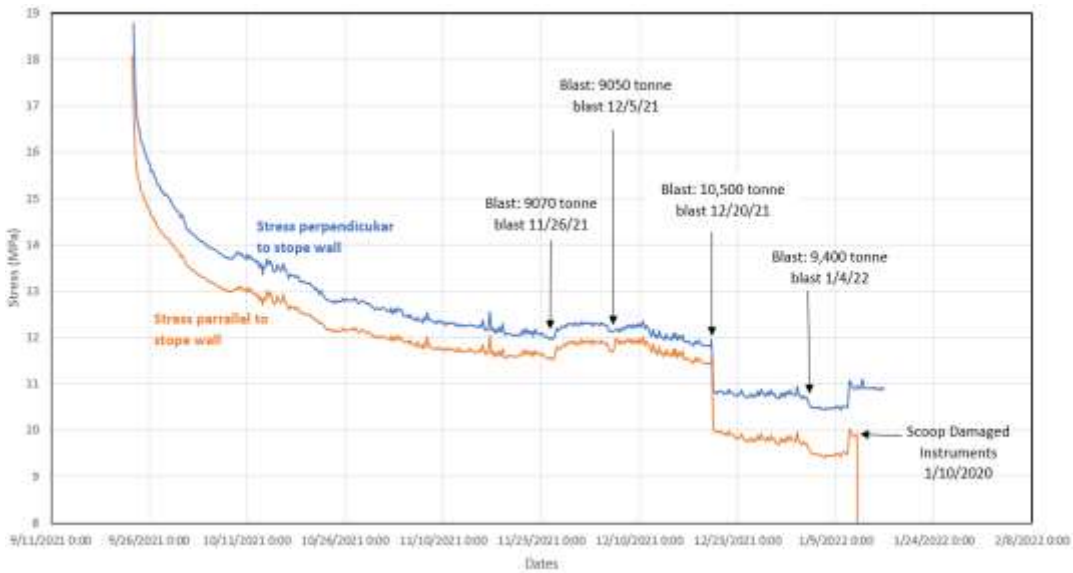
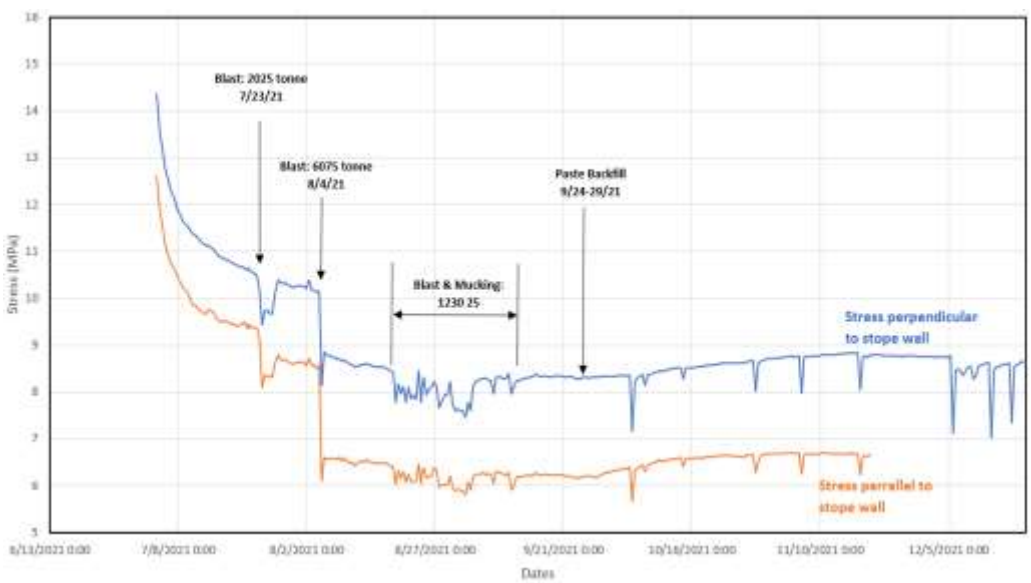


(a) Stress monitoring from the wall of VK_1050_14N-ELAT7_15L Stope (Elev. 1065m)



(b) Stress monitoring from the wall of VK_1200_30-WLAT12_28L Stope (Elev. 1215m)

Figure 3.1 Stress change monitoring before/after stope developments

Table 3-3 Summary of stress distributions from monitoring and analysis

Stope Name		VK_1050_N14-ELAT7_15L		VK_1200_30-WLAT12_28L	
Direction of Stress to Stope Wall		Perpendicular	Parallel	Perpendicular	Parallel
Estimated in-situ Stress (MPa)		13.5		9.5	
Stress-	Initial Reading (MPa)	12.2	11.7	10.2	8.8

Meter	Stress after Stope (MPa)	10.5	9.5	8.3	6.2
Stress	Initial Reading (MPa)	13.0	10.0	-	-
Analysis	Stress after Stope (MPa)	1.1	7.0	-	-

3.2.4 Rock Mass Characterization and Geotechnical Units

The rock mass classification presented in this section is a summary of work completed as part of the Feasibility Study for Brucejack (2015), and forms the basis for the geotechnical underground designs.

Since Brucejack commenced development in 2015, additional geologic and geotechnical data has been collected during underground resource drilling, and from regular mapping by BTS geologists and geotechnical engineers. This new data is used to regularly update the existing geotechnical database. A review of the geotechnical data (rock mass and geologic structure) collected since 2012 was completed by BGC in early 2019, and the results are summarized in Appendix H, and shows that the new data are generally consistent with the historical rock mass classification data at Brucejack.

The rock mass at Brucejack has been divided into several "geotechnical units" based on the properties of the rock and the character of the discontinuities. The properties of each geotechnical unit are estimated with consideration of:

- Lithology and alteration grade;
- Intact rock properties, including intact strength, specific gravity, Hoek-Brown material constant (mi), Young's Modulus (Ei), and Poisson's ratio (v);
- Block size versus discontinuity density, or "blockiness";
- Condition of the discontinuities separating blocks of intact rock; and
- Fault-disturbed zones.

Geotechnical units identified in the West Zone (WZ) of the mine, in order of increasing competence, are as follows:

- The Fault Zone ("WZ FZ") unit comprises fault-disturbed rock identified by Pretium ("FZ" lithology), and less competent rock and faulting identified on BGC geotechnical drill hole logs (Appendix A). This unit is strong with fair rock quality designation (RQD) values and close to moderate discontinuity spacing.
- The Weathered Rock Zone ("WZ WRZ") unit comprises weathered near-surface rock as indicated on geotechnical and exploration drill hole logs (Appendix A). It is medium strong with good RQD values and moderate discontinuity spacing. It extends to a depth of between 10 to 50 m below surface.

- The Fresh Rock ("WZ FR") unit comprises all remaining rock mass, which is very strong with excellent RQD values and wide discontinuity spacing.

Geotechnical units identified in the Valley of the Kings (VOK) zone, in order of increasing competence, are as follows:

- The Fault Zone ("VOK FZ") unit comprises rock identified as fault-disturbed rock by Pretium ("FZ" lithology), and less competent rock and faulting identified on BGC geotechnical drill hole logs (Appendix A). This unit includes the Brucejack Fault Zone. It is strong with good RQD values and close discontinuity spacing.
- The Weathered Rock Zone ("VOK WRZ") unit comprises overburden material identified by Pretium and weathered near-surface rock indicated on geotechnical and exploration drill hole logs (Appendix A). This unit is medium strong with good RQD values and close discontinuity spacing. It extends to a depth of between 10 to 50 m below surface.
- Rock mass Domain 1 ("VOK D1") includes the Volcanosedimentary facies (argillite portion) ("ARG") geologic unit and is very strong with good RQD values and moderate discontinuity spacing.
- Rock mass Domain 2 ("VOK D2") includes the Bridge Zone Porphyry ("BZP1"), the Office Porphyry ("OFP1"), and Silicified Rock ("Silcap") geologic units, which are strong with excellent RQD values, and moderate discontinuity spacing.
- Rock mass Domain 3 ("VOK D3") includes the Volcaniclastics ("CONG"), Volcanosedimentary facies (sandstone-conglomerate portion) ("VSF"), S3-Trans ("Trans"), and ANDX ("V12") units, which are strong with excellent RQD values and wide discontinuity spacing.

A summary of intact rock properties for each geotechnical unit is presented in Table 3.3. A summary of rock mass classification data for each geotechnical unit is presented in Table 3.4. Supporting rock mass characterization data and information is contained in Appendix E.

The rock mass strength of each geotechnical unit has been estimated from the intact rock strength, blockiness, and discontinuity conditions.

Following industry practice, a rock mass rating (RMR) has been estimated for each unit. The RMR (Bieniawski, 1976) applies a score to each basic rock mass parameter and sums the scores for a total rating. This rating may be used with the design UCS, estimated *mi*, and assumed rock mass disturbance value to define the empirical Hoek-Brown failure envelope for each unit. These failure envelopes define the rock mass strength. The results for each geotechnical unit are shown in Table 3.5.

A RMR Vulcan block model is under development for the future ground stability assessment.

Table 3-4 Intact Rock Properties

Unit	UCS – Lab (MPa)	Average Is50 (MPa)	K	UCS - Design1 (MPa)	Brazilian Tensile Strength (MPa)	Hoek-Brown Material Constant, mi	Unit Weight (kN/m³)	Young's Modulus (GPa)	Poisson's Ratio
VOK FZ	N/A	N/A	N/A	89	N/A	12	26.3	30.0	0.20
VOK WRZ	N/A	N/A	11	50	N/A	17	28.6	3.8	0.18
VOK D1	N/A	N/A	N/A	116	N/A	17	27.2	30.5	0.20
VOK D2	107	7.3	15	95	9.4	19	27.1	30.8	0.11
VOK D3	77	6.0	13	73	5.0	26	27.3	30.0	0.14
WZ FZ	N/A	N/A	20	77	N/A	12	26.3	30.0	0.20
WZ WRZ	14	1.3	11	37	0.7	17	28.6	3.8	0.18
WZ FR	126	7.0	18	116	5.7	21	27.3	35.0	0.17

Notes:
1. Design UCS values have been estimated from the median Is50 values using laboratory-derived K values if available.
2. Unit weights are based on average results of specific gravity testing if available.
3. Hoek-Brown material constants have been derived based on a review of laboratory testing results.
4. Young's Modulus and Poisson's ratio have been estimated based on laboratory testing results if available.

Based on the data available, the WZ FR unit is estimated to have the highest rock mass strength while the WRZ and FZ units in both the VOK and WZ are estimated to have the lowest.

Table 3-5 Rock Mass Classification Summary

Geotechnical Unit	Length Observed (m)	Case[1]	RQD (%)	Fracture Intercept (m)	Blockiness Index Rating	Intact Strength: Logged Strength Grade	Intact Strength: Is_{50} (MPa)	Intact Strength: No. PLTs	Intact Strength: UCS[2] (MPa)	Intact Strength: Description	Intact Strength: Rating[2]	Joint Condition ('76)	RMR'76: Rating[3]	RMR'76: Description	Rock Mass Quality Q'
Brucejack FZ	523	Lower Range	39	0.103	16	3	0.3	26	6	Weak	4	12	**42**	Fair	2
		Median	**62**	**0.163**	**23**	**4**	**3.5**		**69**	**Strong**	**7**	**16**	**56**	**Fair**	**4**
		Upper Range	78	0.305	29	5	6.5		128	Very Strong	12	16	67	Good	10
West Zone FZ (including Brucejack FZ)	89	Lower Range	33	0.147	18	3.5	2.0	13	39	Medium Strong	5	12	45	Fair	1
		Median	**64**	**0.244**	**24**	**4**	**3.9**		**77**	**Strong**	**7**	**16**	**57**	**Fair**	**6**
		Upper Range	96	0.510	37	4.5	7.0		138	Very Strong	9	16	72	Good	13
West Zone WRZ	43	Lower Range	58	0.170	20	3	1.7	14	18	Weak	4	12	46	Fair	4
		Median	**82**	**0.310**	**31**	**3.5**	**3.5**		**37**	**Medium Strong**	**5**	**16**	**62**	**Good**	**9**
		Upper Range	93	0.388	34	4	5.0		53	Strong	7	20	71	Good	23
West Zone FR	8230	Lower Range	87	0.500	33	4	4.7	350	84	Strong	7	16	66	Good	20
		Median	**97**	**1.027**	**43**	**5**	**6.5**		**116**	**Very Strong**	**12**	**20**	**85**	**Very Good**	**59**
		Upper Range	100	3.000	49	6	9.0		161	Very Strong	14	25	98	Very Good	211
VOK FZ (including Brucejack FZ)	422	Lower Range	54	0.119	20	3	2.6	75	51	Strong	4	12	46	Fair	2
		Median	**78**	**0.225**	**27**	**4**	**4.5**		**89**	**Strong**	**7**	**16**	**60**	**Good**	**6**
		Upper Range	93	0.412	34	4	6.5		128	Very Strong	7	16	67	Good	18
VOK WRZ	656	Lower Range	69	0.204	26	3	2.9	30	31	Medium Strong	4	12	52	Fair	4
		Median	**87**	**0.430**	**34**	**4**	**4.7**		**50**	**Medium Strong**	**7**	**12**	**63**	**Good**	**13**
		Upper Range	96	1.010	41	4	5.8		61	Strong	7	20	78	Good	37
VOK D1 (ARG)	191	Lower Range	63	0.169	25	4	N/A	0	75	Strong	7	12	54	Fair	3
		Median	**87**	**0.339**	**34**	**5**	**N/A**		**116**	**Very Strong**	**12**	**16**	**72**	**Good**	**9**
		Upper Range	96	1.017	43	5	N/A		116	Very Strong	12	16	81	Very Good	53
VOK D2 (P1, RHY)	15817	Lower Range	72	0.289	28	4	5.3	206	77	Strong	7	16	61	Good	7
		Median	**91**	**0.533**	**37**	**4**	**6.5**		**95**	**Strong**	**7**	**16**	**70**	**Good**	**23**
		Upper Range	98	1.470	43	5	8.2		120	Very Strong	12	20	85	Very Good	74
VOK D3 (JR, TRS, ANDX)	47264	Lower Range	89	0.507	37	4	4.1	546	52	Strong	7	16	70	Good	18
		Median	**96**	**1.017**	**43**	**5**	**5.7**		**73**	**Strong**	**12**	**20**	**85**	**Very Good**	**52**
		Upper Range	99	2.990	49	5	7.3		93	Strong	12	25	96	Very Good	146

Notes:

1. Lower, median and upper values correspond to 25%, 50%, 75% cumulative fraction, respectively (Appendix E).

2. UCS has been estimated from point load index tests where available. VOK D1 strength is estimated from logged strength grade.

3. Groundwater rating of 10 has been assumed for the calculation of RMR'76.

Table 3-6 Rock Mass Strength and Deformation Modules

Unit	UCS (MPa)	GSI[2]	Unit Weight[3] (kN/m³)	m_i	m_b	S	E_{rm} (GPa)
VOK FZ	89	60	26.3	12	1.110	0.0023	5.13
VOK WRZ	50	63	28.6	17	1.879	0.0037	0.77
VOK D1	116	72	27.2	17	3.211	0.0144	9.76
VOK D2	95	70	27.1	19	3.186	0.0106	9.02
VOK D3	73	85	27.3	26	10.647	0.103	14.37
WZ FZ	77	57	26.3	12	0.928	0.0015	4.27
WZ WRZ	37	62	28.6	17	1.771	0.0032	0.73
WZ FR	116	85	27.3	21	8.599	0.103	16.77

Notes:
1. The Hoek-Brown failure criteria have been estimated assuming a disturbance factor ('D') of 0.8 for all units.
2. GSI is calculated from median rock mass parameters for each unit, where GSI = RMR '76.
3. Unit weights are based on average results of specific gravity testing when possible.
4. The Hoek-Brown curves have been derived using a sigma3 max. for a tunnel depth of 650 m.

The rock mass deformation modulus for each geotechnical unit has been estimated from the Young's modulus laboratory testing results of the intact rock, rock mass characterization, and assumed disturbance value (0.8) using the empirical methods of Hoek and Diederichs (2006). Higher deformation moduli result in less deformation of the rock mass when stress is applied.

3.2.5 Brucejack Fault

The Brucejack Fault lineament is currently one of three known major / regional structure that intersects the mining footprint (Drawing 06). By the end of 2019 and early 2020, the mine developments intersected the fault on two levels: 1080 L West side access drift and the 1320L Fault zone development heading. The Brucejack Fault is a northerly striking anastomosing fault zone located along the western margin of the study area and extends north to the Iskut River Fault. In places the lineament appears to be several sub-vertical to moderately (greater than 60°) dipping fault strands braided together. The zone has normal faulting with variable displacement estimated at 500 to 800 m (ERSi, 2010).

Pretium are currently developing an authoritative structural geology model for the Mine area. Prior to this, BGC reviewed drill hole data and core photographs in relation to the Brucejack Fault to characterize the properties of the Fault and review its proximity to the mine workings. BGC's work focused on identifying the orientation, thickness, and rock mass characteristics of the Fault.

The Brucejack Fault is comprised of a core of highly fractured rock with a zone of less fractured, fault-disturbed rock mass on either side. The width of the fault zone varies with depth and along strike from approximately 5 to 40 m. It is considered to be continuous along strike, and appears to dip slightly to the east above the 1,325 m elevation, and dip slightly west below the 1,325 m

elevation. For design purposes, the median RQD, Joint Condition, and point load index Is50 value (ISRM 1981) are 62%, 16, and 3.5 MPa, respectively, compared to the "excellent" median RQD value (91%) and median Is50 value of 6.5 MPa in the surrounding undisturbed VOK D2 rock mass.

The Fault zone rock mass also has a slightly higher degree of weathering / alteration intensity than undisturbed rock; however, both the Brucejack Fault Zone and undisturbed D2 rock mass have comparable median strength grades (R4) and median joint condition values (16).

The Brucejack Fault truncates several local-scale faults at the western extent of the Brucejack deposit, and thus has been interpreted as post-dating site-scale deformation events. Orientations parallel to the inferred Brucejack Fault lineament were commonly observed in downhole structural measurements across the property. All interpreted structural domains include sets oriented along the Brucejack Fault Zone with dips ranging from 56˚ to vertical.

Detailed descriptions and photographs of the Brucejack Fault can be found in Appendix F.

Based on the current mine plan, stopes and related development in the WZ are unlikely to intercept the Brucejack Fault. A pillar of greater than 100 m is inferred to exist between the WZ resource and the Brucejack Fault. This pillar thickness is considered sufficient to isolate the Brucejack Fault from significant mining related effects.

However, based on the current VOK zone mine plan the Brucejack Fault passes through the VOK footprint. At all planned working elevations, the resource blocks are continuous across the fault with the inference that stopes will be required proximal to, and likely within, the fault zone. Section 3.4.11 below discusses options for mining through the fault.

3.2.6 Rainy Fault

The Rainy Fault is a shallowly dipping structure that intersects the mine working in the main access drive between the WZ and VOK zones. The fault has a true thickness varying from 0.5 to 15 m, but generally between 0.5 m and 2 m thick.

Within 30 m of the crusher location, its orientation is approximately 35° dipping towards 230° based on the structural geology model provided by Pretium. Drilling and underground mapping work done as part of a recent study generally supports this interpretation, although the local orientation of the structure varies. Drilling and mapping intercepts suggest that splays are present.

The rock mass within the fault zone is generally very blocky with very poor to poor RQD (< 50%) and discontinuity spacing less than 0.20 m, but varies from relatively unbroken rock to compact silty/clayey gouge zones up to 1.5 m thick. Often the fault zone is comprised of multiple gouge zones separated by more competent zones of very blocky rock mass. Seepage conditions within the zone vary significantly, from dry to dripping.

3.2.7 *Hydrogeology*

Conceptualization of the groundwater flow system at the Brucejack site was required to provide estimates of groundwater inflow to the existing and future underground mine workings. These inflow estimates were used to size dewatering equipment and as input to the process water balance. The results of site investigations and hydrogeologic testing, ongoing groundwater level measurements, adit water treatment plant outflow measurements (approximately equal to adit inflow rates), and numerical modelling were used to better understand the groundwater flow system.

Site investigations were completed between 2010 and 2012 to evaluate the hydrogeologic conditions (e.g., hydraulic parameters of the bedrock, hydrostratigraphic units, and hydraulic gradients) in the vicinity of the underground workings, and included hydraulic response testing (e.g., packer testing, slug testing) and the installation of groundwater monitoring wells and vibrating wire piezometers. Data collected during site investigations are supplemented by ongoing monitoring of groundwater elevations and collection of water quality samples, and by data collected during adit dewatering activities at the site. The available data have been synthesized in a conceptual hydrogeologic model and represented in numerical groundwater flow models for quantitative analyses. The parameters and results of the calibrated numerical model are well constrained by the measured adit inflows which reflect the bulk hydraulic properties of the rock mass in the vicinity of the underground workings.

Details regarding the investigations and data used to develop the conceptual and numerical hydrogeologic models are summarized in BGC (2014b). Details of the numerical modelling approach and results are summarized in BGC (2015b, 2015c). Annual groundwater monitoring (BGC, 2016a; 2017a; 2018a) supports the assumption that the rockmass is dewatered by ongoing mine dewatering activities.

The hydrostratigraphy of the site is composed of a thin, discontinuous layer of glacial till or colluvium underlain by bedrock. Thicker overburden deposits are confined to local sections of the valley bottom and are not present in the vicinity of the underground mine.

The geometric mean of bedrock hydraulic conductivity estimates for test zones not interpreted to intersect faulted rock is 1.3×10^{-7} m/s, while the geometric mean of hydraulic conductivity estimates for test zones interpreted to intersect faulted rock is 3.8×10^{-7} m/s. Based on these data sets, it appears that the increased fracture frequency and rock mass alteration associated with fault zones may increase hydraulic conductivities by up to a factor of three in comparison to hydraulic conductivities of unfaulted rock. Site-wide, a general trend of decreasing bedrock hydraulic conductivity with depth is observed, although "point" scale hydraulic conductivity estimates from packer testing and single well response (slug) testing varies by 2 to 3 orders of magnitude at any given depth.

Surface topography has a pervasive influence on the groundwater flow system at the site. The elevation within the immediate Mine area ranges from approximately 1,350 m at the outlet of Brucejack Lake to over 2,000 m at the highest peaks. Measured groundwater elevations suggest that the water table is a subdued replica of topography, with depths to groundwater typically greater in

the uplands relative to the valley bottoms. Groundwater enters the flow system from an infiltration of precipitation and snowmelt, with lesser components supplied by surface water infiltration in lakes. Groundwater discharge zones are generally restricted to lakes, creeks, gullies, and breaks in slope.

3.3 BRUCEJACK MINE PLAN

The Brucejack Mine Plan supports the extraction of 3,800 t/d of ore through a combination of transverse Long Hole Open Stoping (LHOS) and longitudinal LHOS. Paste backfill is integral to the mine plan to maximize both orebody recovery and mining productivity. Modern trackless mobile equipment will be employed in the majority of mining activities.

The mine has two decline accesses – a decline from the VOK portal in close proximity to the concentrator is dedicated to conveying crushed ore directly to the concentrator via a ~650 m long conveyor. The West Zone portal is used to access a second decline, which is used for main access and egress. Figure 3.1 illustrates the decline configurations. The VOK ramp can be used as a waste haulage ramp when the West Zone ramp is shutdown or there are a large number of trucks hauling waste from the underground.

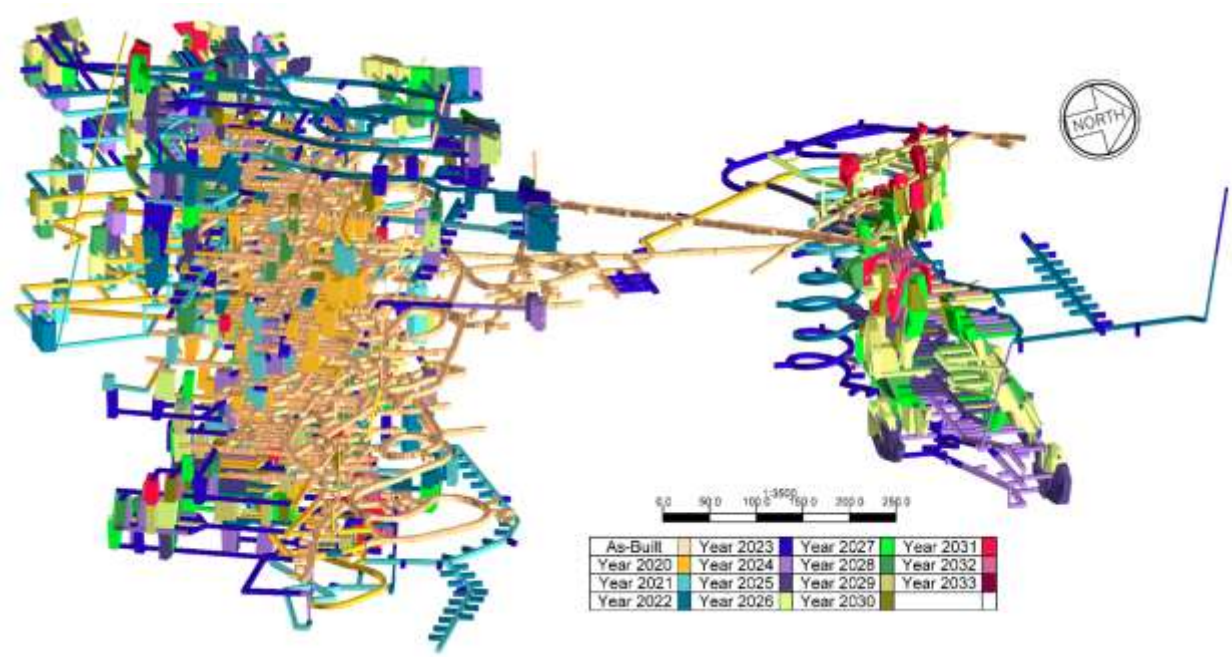


Figure 3-2 Perspective 3D view of Mine Plan (as of April 2020).

A fleet of LHDs and trucks is used for material loading and transport from the various underground working areas, through an internal ramp system that connects all levels to the centrally located crusher.

Permanent fans provide ventilation by forcing air down the declines, through the internal ramps, and exhausting to surface via dedicated raises that connect the various working levels to surface in each zone. The primary fans will be located at each of the main surface portals. Auxiliary fans are used for ventilating each level. An electric mine air heating system is used to take advantage of low electricity prices, with a propane system used to augment the electric system.

Ongoing development, to sustain ore production, will average approximately 850 m/mo. in the next five years, and then decrease to approximately 155 m/mo. in later years of the mine life.

Major underground infrastructure includes the underground crusher, conveyor system, ventilation raises, fans, heating system, pumping stations, electrical substations, a fuelling facility, explosives magazines, refuges, mine communications and other ancillary installations.

3.3.1 Access and Ramp Infrastructure

The VOK Portal decline join the main surface portal to the crusher tip and workshop area on the 1,330 Level. A main cross-over drive on the 1,330 Level joins the main decline to the two independent ramps servicing the VOK Zone and West Zone. Figure 3.1 illustrates the general development arrangement.

The internal ramps will connect all levels of the mine. The existing West Zone portal is used for underground access, and a second West Zone portal has been developed as a ventilation portal. The VOK ramp serves as the conveyor ramp and secondary access/egress point.

The southern ramp (VOK ramp) services the VOK and Galena Hill zones, and the northern ramp (West Zone ramp) services the West Zone, were both designed in a race-track configuration for safety, haulage efficiency, and to minimize wear on mobile equipment.

The use of an independent ramp for each zone–as opposed to a single ramp servicing both zones–was selected in the interest of access and capital efficiency, given that the West Zone ramp will not be required until mid-way through the mine life. For ease of entry and exit, ramps were designed with a 30 m turning radius and a 15% gradient, levelling out in proximity to a level access intersection. Passing bays were incorporated where required.

3.3.2 Level Development

Sublevels are accessed from the ramps on a 30 m vertical interval that is defined by the planned stoping heights. Footwall and hanging wall drives are set back a minimum of 22.5 m pillar thickness (i.e., 25 m from the centreline of the drift to the stope wall), whereas ramp development will be set back a minimum 50 m from the centreline of the ramp to the stope wall. This arrangement promotes long-term geotechnical stability and provides adequate space for the placement of a fresh air raise and other ancillary services between the ramp and level development, as required.

Sublevels generally terminate at a ventilation raise at one or both ends, permitting the exhaust of contaminated air from activity on the level. Figure 3.2 illustrates the VOK Zone sublevel arrangement in long section.

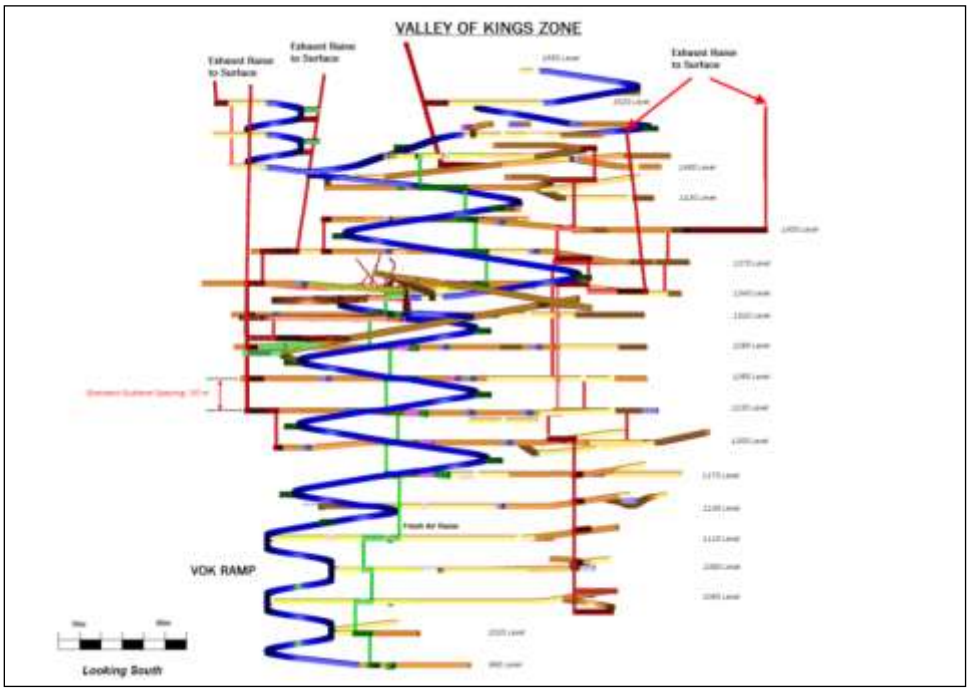


Figure 3-3 VOK Zone Sublevel Arrangement – Long Section

Level development follows the general strike of the various lenses, providing access to the mineralized zones in a manner that promotes transverse mining wherever possible and also add flexibility to mine longitudinally. Level development is generally in the hanging wall, with hanging wall drives typically including excavations for sumps, refuges, transformers, remucks, paste fill line, and raise accesses.

Stope access crosscuts will be on 15 m spacings, with the exception of those levels where sill extraction or near-surface weathered ore will be recovered in smaller units that are designed on 10 m spacings. Figure 3.3 illustrates typical level development requirements.

3.3.3 Excavation Dimensions

Table 3.6 provides excavation dimensions for standard development at Brucejack. All of these excavations are considered permanent mine excavations. A permanent excavation is any excavation with a life span greater than 6 months.

Table 3-7 Standard Excavation Dimensions

Parameter	Lateral							Vertical	
	Main Ramp	Access Drive	Cross Cut	Re-muck	Sump	Convyr. Ramp	VND	Esc. Raise	Vent. Raise
Width (m)	5.5	5.5	5.0	5.5	5.5	6.0	5.5	3.0	3.0
Height (m)	6.0	5.5	4.5	6.0	5.5	6.0	5.5	3.0	3.0

Arch (m)	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0	0.0
Max. Grad. (%)	15	5	15	15	15	15	2	-	-

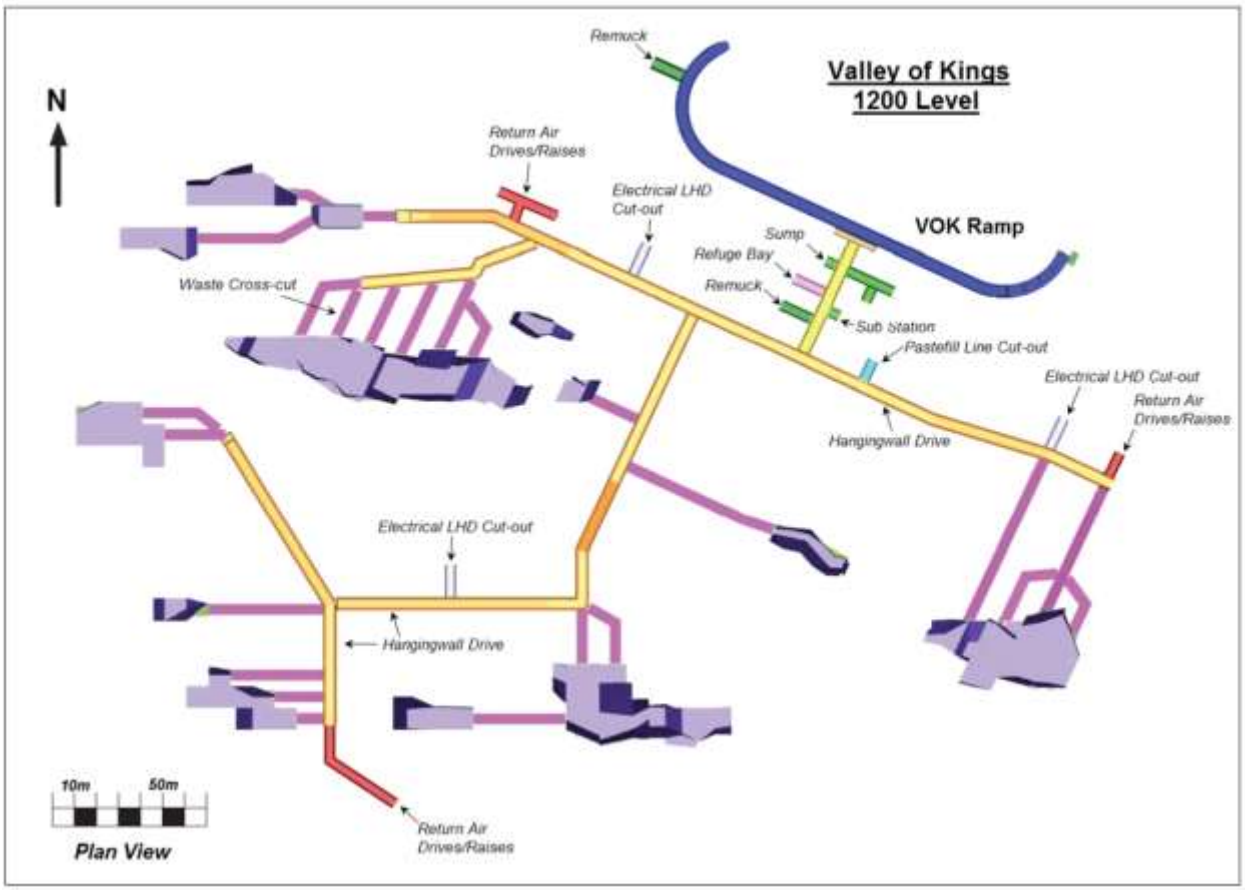


Figure 3-4 Typical Level Plan – 1,200 Level in the VOK Zone

3.3.4 Stope Cycle

The primary mining method will be transverse Long Hole Open Stope (LHOS) based on a standard primary/secondary sequence. No permanent pillars are currently planned, and maximum ore extraction will be targeted. Mining of the sills will expose the cemented backfill of the stopes in the block immediately above. They will be relatively more problematic to mine due to the effects of increasing ground stress and the overhead fill, with lower recovery, higher dilution, and higher costs anticipated.

The hanging wall drives will be completed, and a through ventilation circuit will be established before mining begins between any two levels.

A cross-cut will be driven from the hanging wall drive, through the centre of the stope, to the far ore contact on the undercut and overcut levels. The undercut level will have already been developed if stoping has progressed beyond the block starting level.

Cross-cuts on both levels will be cable-bolted (or equivalent) from the central access to pre-support the roof prior to full-width slashing of the entire stope footprint. Slashing to the adjacent stope boundaries will expose paste fill walls in the case of secondary stope extraction.

Full width slashing in primary stopes will permit parallel production hole drilling across the entire width of the stope, and will reduce the potential for ore in stope corners to fail to break to design due to inadequate free face or poor explosives distribution. Ore recovery will be higher than a fan drilling alternative (in the absence of full-width slashing). Given the significant value of Brucejack ore, high recovery was an overriding criterion in the design. Mining of secondary stopes with sidewalls of paste will be limited to 5 m wide overcuts with fan drilling or development of a cross-drift to allow for parallel drilling.

Once the stope footprint is slashed out, a 750 mm pilot hole will be drilled in the slot raise location. Production drilling will follow in the raise and slot area, followed by the production rings as drilling progresses towards the near ore contact.

The raise and slot are generally opened in five firings or less. Production blasting and mucking will proceed cyclically until the stope is depleted and all ore has been mucked out. Transverse LHOS is a non-entry method, with remote mucking of blasted ore required once the drawpoint brow is open to the extent where the operator may be exposed to uncontrolled sloughing from the stope cavity.

The empty stope will be remotely surveyed with cavity monitoring equipment. A barricade will be constructed in the drawpoint and the stope backfilled to just below the floor elevation of the top level. Crushed aggregate or ROM waste may be spread over the fill surface to reduce backfill dilution and increase trafficability of mucking equipment for the next lift of the stope.

The mining of sills and other areas, where top access is not available, will proceed in a similar manner; however, raise development and production drilling will be performed via up hole drilling from the bottom level.

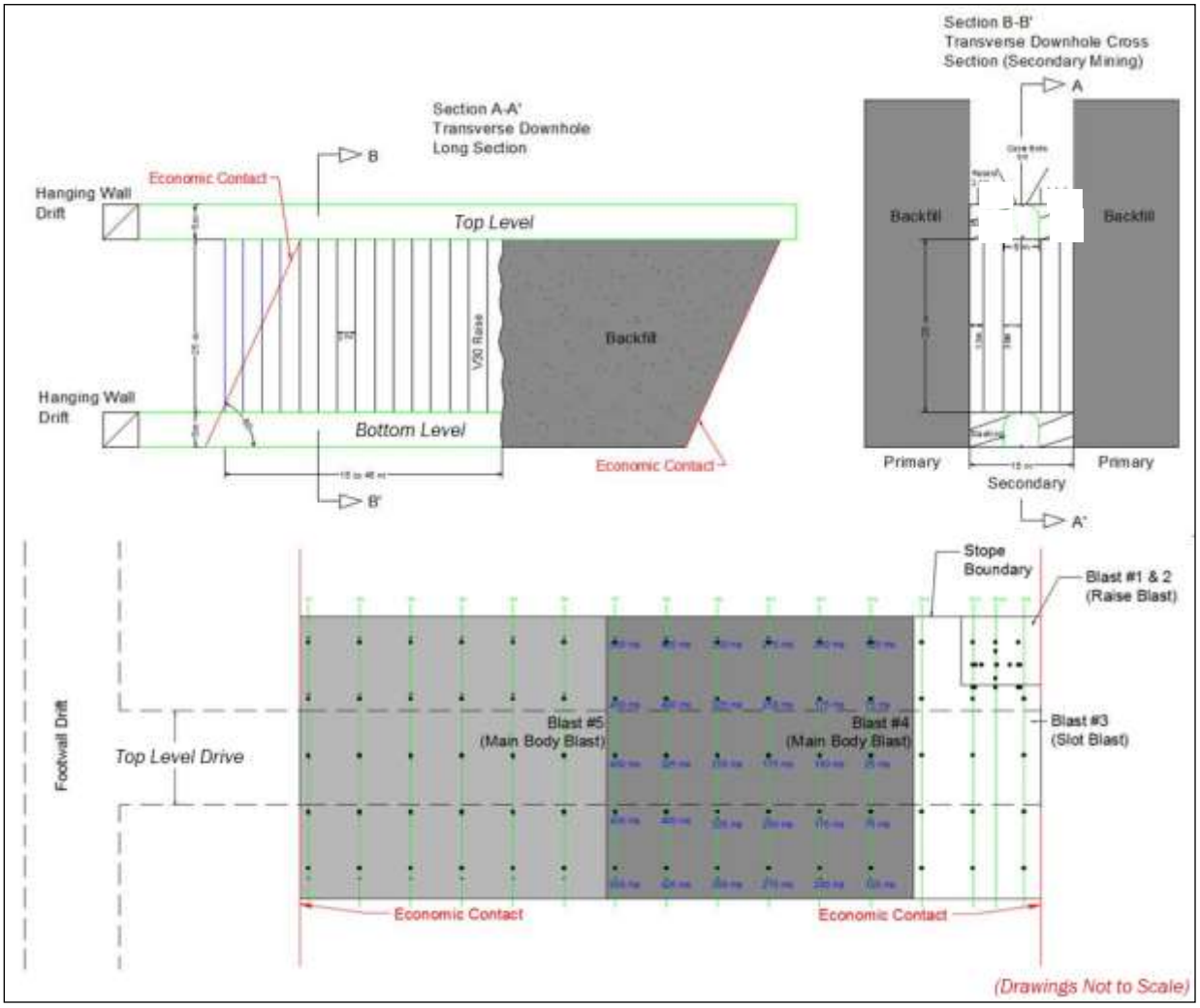


Figure 3-5 Typical LHOS Design.

Note that mining of secondary stopes with sidewalls of paste will be limited to 5 m wide overcuts with fan drilling or development of a cross-drift to allow for parallel drilling.

Longitudinal LHOS will also be employed at the mine, although significantly less ore tonnage will be recovered by this method in comparison to transverse LHOS. The longitudinal method will be used in thinner areas of the orebody, where the thickness of mineralization is less than 15 m, to avoid excessive access development in waste. In contrast to transverse LHOS, mining will progress along the strike of the orebody to a common access point.

The overcut and undercut will be slashed to the footwall and hanging wall contacts. In all other respects, the stope cycle will be similar to transverse LHOS.

3.3.5 Stope Sequence

The mining sequence in any lens of a given mining block begins with the extraction of the primary stopes on the first (lowest) level. Wherever possible, the first primary stope will be located near the middle of the lens to develop a pattern of stope extraction that moves outwards to the extremities of the lens while progressing upwards towards the top. As confirmed by 3D numerical modeling, this generally promotes a favourable redistribution of ground stress, although many smaller lenses in the Brucejack orebody are either irregular in shape or of insufficient dimensions to properly develop this sequence.

When the adjacent primary stopes from the level above have been filled and cured, secondary stoping will commence. Figure 3.5 illustrates typical sequencing for the more massive lenses at Brucejack.

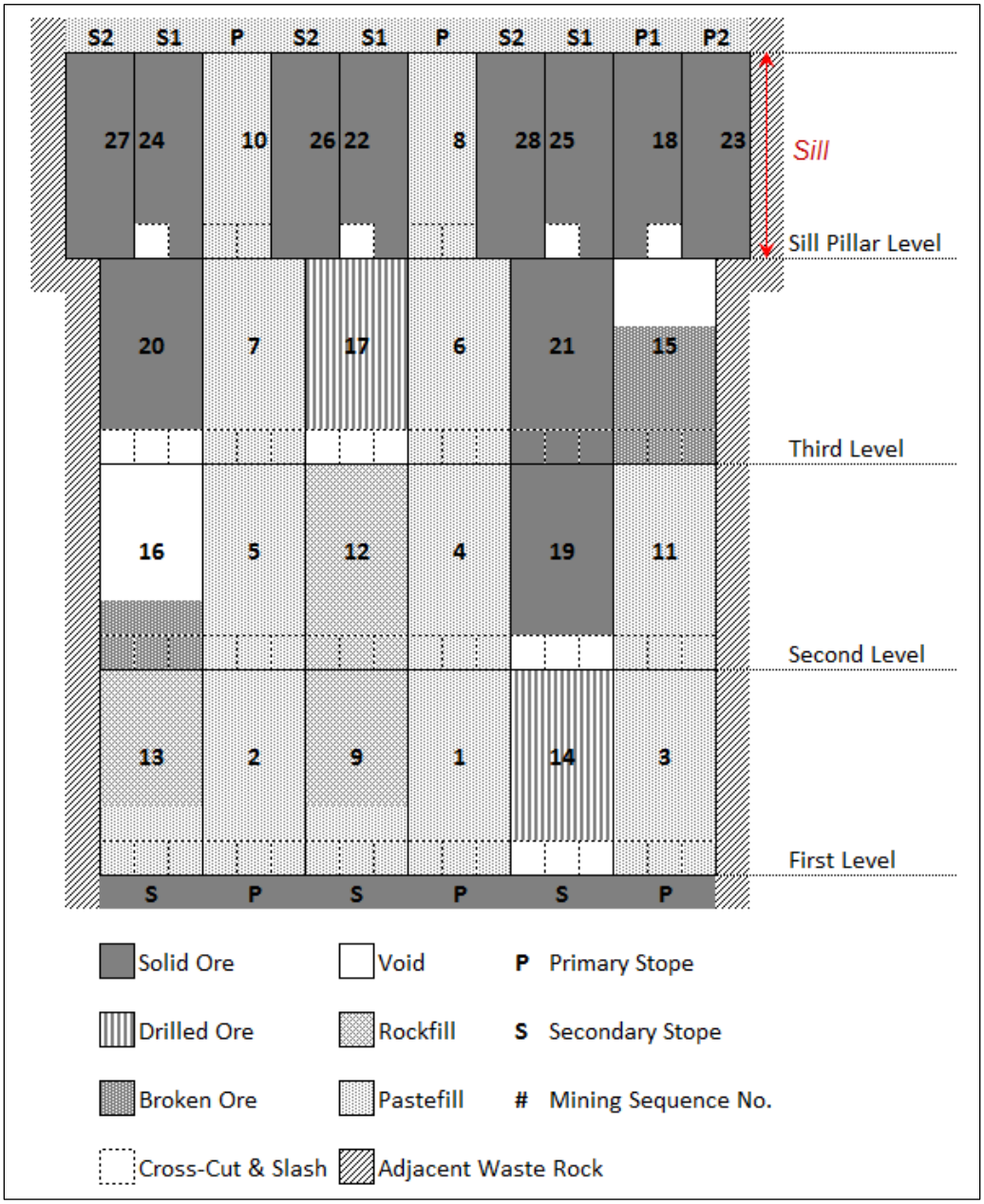


Figure 3-6 Example of Primary / Secondary LHOS Sequence

3.3.6 Backfilling

The primary means of backfilling will be paste fill, generated from unclassified mill tailings mixed with adequate cementitious binder to meet the strength requirements of re-exposure. Regular strength paste fill is commonly required where there will be re-exposure of vertical stope walls. The

design rationale and procedures for backfilling at Brucejack are documented in the Brucejack Backfill Management Plan.

Stopes that will not be re-exposed by adjacent mining may be backfilled with unconsolidated waste and/or by paste fill with sufficient binder to remove any risk of future liquefaction (low-strength paste fill).

High-strength paste fill will be required in the lower portion of all primary and secondary stopes that will be undercut by sill extraction from below. Table 3.7 tabulates the total projected paste fill volumes over the LOM by strength requirement and by binder dosage.

Table 3-8 LOM Paste fill Requirements

Paste Type	LOM Quantity (m^3)	28-day Strength (kPa)	Binder Dosage (%)	Density Dry Paste (t/m^3)	Mass Dry Paste (t)	Binder Required (t)
High-strength Paste	298,985	1,100	11/9.8	1.11	331,873	35,191
Regular Paste	1,408,585	350/250	6.4/5.5	1.11	1,563,529	96,460
Low-strength Paste	2,376,736	100	4.3	1.11	2,638,177	109,354
Total	**4,084,306**	**-**	**-**	**-**	**4,533,580**	**241,004**

The mine plan assumes that high-strength paste fill is a requirement in the lower portion of all primary and secondary stopes on the sill level, and regular strength paste fill will remain as a requirement for primary stopes where re-exposure of vertical stope walls will occur during secondary stope development. Only secondary stopes that will not be re-exposed by adjacent mining will be backfilled with unconsolidated waste rock (Figure 3.6). This requires around 15% of developed stope backfill with high strength paste with high percentage of cemented binder. Percentage of normal strength paste, and low strength paste backfill is 45% and 10% respectively. This plan can maximize total 30% of stopes to be filled with waste rock.

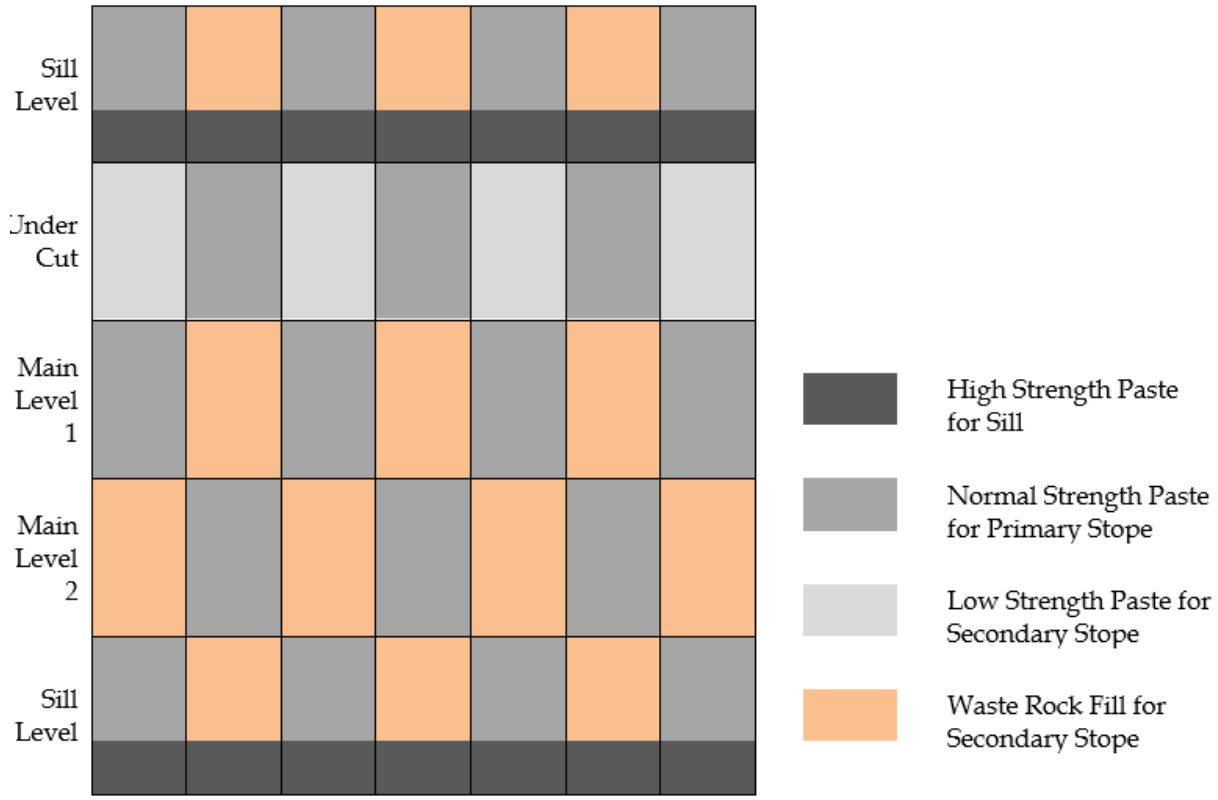


Figure 3-7 Schematic of Backfill Plan

3.4 UNDERGROUND ROCK MECHANICS ASSESSMENT

3.4.1 Methodology

BGC's underground rock mechanics assessment methodology is based on industry standard techniques. BGC has:

- Estimated achievable stope spans and associated ground support requirements based on empirical stope stability design charts;
- Analyzed potential kinematic failure modes resulting from major geological discontinuities or persistent rock mass fabrics, and developed associated ground support requirements; and
- Assessed pillar stability conditions using estimates of pillar strength and induced stresses, using analytical and numerical design tools.

3.4.2 Primary and Secondary Stope Designs

BGC has developed recommendations for unsupported and supported hydraulic radii and ground support to assist with the development of stoping design criteria. The empirical "Stability Graph" method (Hutchinson and Diederichs, 1996, and Nickson et al., 1992, after Potvin, 1988) was used to

estimate acceptable mining dimensions for the stope backs and hanging walls. Geotechnical and representative stope geometry parameters are combined to determine a "Stability Number" (N'), defined by:

$$N' = Q' \; x \; A \; x \; B \; x \; C$$

Where:

- Q' is a rock mass classification parameter;
- A is a measure of the ratio of intact rock strength to applied stress;
- B is a measure of the relative orientation of dominant structure with respect to the excavation surface; and
- C is a measure of the influence of gravity on the stability of the face being considered.

The Q classification system is frequently simplified to include only factors dependent on the rock mass, ignoring environmental considerations such as water and active stresses. The resulting rating will give the same assessment for the same rock conditions at different depths and hydro-geological states. Q' is the modified Q classification value with Jw and SRF set to 1. Modern design approaches account for the influence of stress in the design steps and it would be incorrect to assess these factors twice by including them in the rock mass classification.

$$Q' = \frac{RQD}{Jn} \times \frac{Jr}{Ja}$$

Parameter A is estimated for each face of the stope using the Stewart and Forsyth method, which estimates the maximum induced tangential stress acting at the centre of the stope face from an assumed stress regime (Stewart and Forsyth, 1995). As virgin stress has not been measured and World Stress Map data is unavailable in the region, stress conditions have been estimated empirically for the method using an assumed vertical stress given by the following equation, k = 2, and the ratio of opening dimensions being considered.

$$\sigma_v = unit\ weight\ x\ depth$$

Parameter B is dependent on the discontinuities most likely to cause instability. These discontinuities will intersect the stope face at shallow oblique angles. Due to structural variability in all structural domains it has been conservatively assumed that all excavations could have geologic structures that are sub-parallel to stope walls. Therefore, parameter B has been assumed to be 0.2 for all cases.

Parameter C is calculated using the orientation of the critical discontinuity set used to determine parameter B. However in cases where the discontinuity could contribute to both sliding and gravity fall, a conservative minimum value of C = 2 was used.

During the FS (BGC, 2013a) in an effort to simplify the results of the Stability Graph Method, so as to be useful to mine planners, conservative and base case Q' values of 10 and 40 respectively were

used to calculate the resultant hydraulic radii (Appendix I). Statistical observations of mapping data and the 110,000-plus m of core indicated that regardless of lithology, alteration, geological domain, or geotechnical unit, less than 20% of the data mapped or logged has Q' values less than 10. Similarly, over 50% of the rock has a Q' value of 40 or greater. These classes, and the resulting stope design recommendations, were intended to demonstrate the potential variability in rock mass quality and resultant achievable stope spans at Brucejack.

In 2019, BGC completed a review of geotechnical data collected at Brucejack since the FS (BGC, 2019a), and although the median values of the new data suggest the FS ranges are still valid (with 50% of the rock mass having Q' >10), the medians are close to the threshold value, and the upper range (i.e. higher quality rock) may be less common than initially assumed during previous assessments.

The resulting stability graph is used to match the calculated stability number (N') to maximum recommended unsupported and supported hydraulic radii. Stability charts have also been produced for stopes in weathered rock. Although stope dips of 78° were assumed for the stability analyses, most of the planned stopes at Brucejack are near vertical, and the hanging wall and foot walls are not clearly defined.

Based on the most recent work by BGC (2019a), for mine planning purposes, the conservative case hydraulic radii presented in Appendix I can be used as "base case" design values. BGC continues to recommend that Brucejack review stope designs on a case-by-case / package-by-package basis, particularly if optimized, larger, and less conservative stope dimensions (i.e. greater than "median" designs) are proposed to be implemented in the mine plan. Stope dilution estimates are provided in Appendix J.

Current designs are for nominal rock mass, absent of large-scale or controlling geologic structure. Wide 'Stable' spans intersected by geologic structure or poorer quality rock required enhanced / deep patterned support consisting of minimum 4.88 m long coupled Super Swellex or cement grouted cable bolts (0.7" diameter, bulbed, dual strand ~ 30-35 ton capacity/strand, nominally >50 t / hole installed capacity). If geologic structure is present (as observed in some of current secondary stopes) dead weight analysis of the rock wedge / block is required to confirm adequate bolt capacity.

3.4.3 Stope Ground Support

If mine planners elect to use "supported" case hydraulic radii, then the stopes must be supported with cable bolts or their equivalent. Empirical design charts (Hutchinson and Diederichs, 1996) were used to determine the minimum cable bolt lengths and spacings required for stability, and to minimize ravelling and dilution. Charts for stopes excavated in fresh rock are provided in Appendix I and I-1, respectively, and assume an equivalent square cable bolt pattern.

Given that no hanging wall development is planned, a modified cable bolt pattern will be required, whereby the cable bolts are installed from the footwall side of the topsill and bottomsill into the

hanging wall. This will result in a point anchor support approach to hanging wall support, and the cable bolts will be installed in a fan pattern to divide the hanging wall into smaller unsupported stable spans. As discussed by Nickson (1992), this type of support simulates a series of reinforced beams along the hanging wall.

Previous experience suggests that approximately 5 cable bolts per ring, with rings spaced every 1.5 - 2.5 m can be used for bolt density estimates. Cable bolt lengths will be designed and installed to exceed 25% of maximum unsupported span; for example, a hanging wall with an exposed face of 35 m between topsill and bottomsill would require a minimum cable bolt length of 9 m. The success of point anchor support is heavily dependent on block size, and designs will be calibrated with site specific data from observations of stope dilution when available.

For added versatility during mining operations, a study was conducted on the use of connectable Super Swellex (PM24C at 4.8m / 16' length) for stope span stability to achieve similar design objectives equivalent to cable bolts. Moreover, given the shorter-term nature of stopes, the Super Swellex was considered a good, practical option for this application. The details of this study, which was completed by BGC, are in Appendix M.

3.4.4 3D Stress Analysis

A number of preliminary 2D and 3D stress analyses models have been completed to date by BGC and the on-site geotechnical engineering team for the mine; these are considered suitable for studying the evolution of mining-induced stresses, but are not considered suitably calibrated to estimate precise magnitudes of stress, strain, or infer the relative degrees of rock mass damage resulting from failing / yielding rock (i.e., micro-cracking, spalling, on-going plastic deformation, and, in the extreme case, rock- bursting).

The model results can be reviewed with the goal of highlighting areas where stress is concentrating, where stress shadows (loss of confinement, or relaxation) are occurring, and where standoff distances or pillar thicknesses are not sufficient to isolate a critical openings from significant mining-induced stress changes.

The models limited capacity arises from the current level of knowledge (or lack thereof) regarding the 'final' mining sequence, in-situ stress conditions, local and intermediate-scale structural features and geotechnical 'zoning', etc. All of these can significantly constrain the extent to which the model can be used to accurately predict local and global rock mass behaviour during mine life.

3.4.5 Stand-off Distances

Minimum stand-off distances between excavations of 10 m, 25 m, and 50 m are recommended for the raises, ramps, and underground crusher, respectively. The recommended stope stand-off distance from all hanging wall drives is 25 m from the centreline of the drift to the stope wall.

3.4.6 Rib Pillars

The illustrations in Figure 3.7 are provided for context:

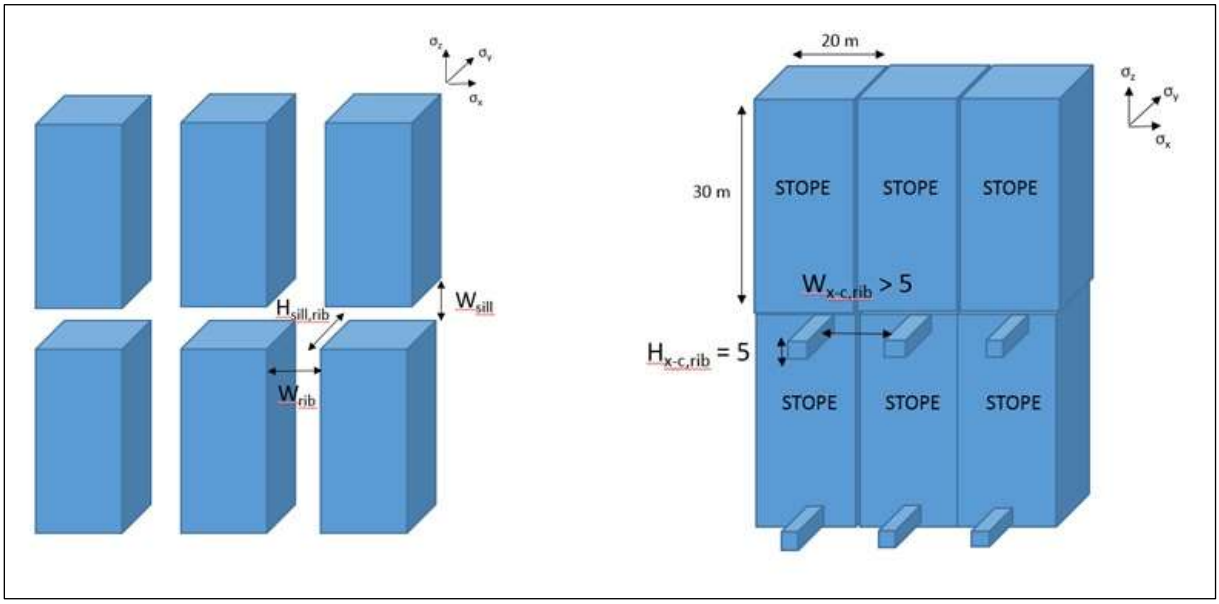


Figure 3-8 Pillar Schematics

The rib pillars between cross-cuts were designed to be in waste and therefore will not be recovered, but are considered temporary based on the short-term lifespan required for access to a given stope. The minimum recommended pillar width to height ratio for cross-cut rib pillars for the "base case" design is 1.1:1.0, and 3.3:1.0 for the "conservative case" design. If cross-cuts are developed within the weathered zone, the recommended rib pillar width to height ratios are 1.7:1. The rib pillars between the open stoping blocks are intended to give temporary support to the mining block until the primary stopes are backfilled and the pillar can be recovered in the form of a secondary stope. Using the pillar stability graph method developed by Hudyma (1988) and tributary loading theory, the minimum recommended secondary stope span (rib pillar thickness) to primary stope span for the "base case" stope design is 1:1 for sublevel intervals of 30 m.

Analysis of the "conservative / low strength case" indicates that higher pillar load to UCS ratios may develop in the pillar cores, resulting in an increased potential for progressive pillar damage, such as pillar cracking and or surface spalling, as Load to UCS ratios approach and exceed 0.5.

If such a case arises, a number of mitigation measures could be used to remedy potential rib pillar deterioration, including increased localized reinforcement of the pillars with bolts, screen, straps and / or shotcrete (where accessible), or alternatively, a change in the local excavation geometry and /or mining sequence.

3.4.7 Sill Pillars

The current design sill pillar thickness is 30 m. The numerical modelling analysis shows some relaxation in larger stope hanging walls, and stress concentrations in sill pillars within areas of the mine with denser stoping. The model shows that the bottom-up sequence concentrates stress in both

VOK Zone sill pillars. Yielding is likely to occur prior to recovering the entire sill pillar, and therefore achievable sill pillar recovery may be less than 100%. The West Zone sill pillar is interpreted to be stable except for stress concentration in the sill pillar abutments. Stress concentration in pillar abutments is common in mines using centre-out sequencing, and does not necessarily indicate stability problems prior to full extraction of the sill pillar.

3.4.8 Crown Pillar

To maximize crown pillar recovery, the minimum recommended crown pillar thickness for the West Zone and VOK Zone is 15 m, with a maximum recommended stope span of 10 m for all stopes immediately below the crown pillar. As the recommended maximum span is narrower than the transverse width of the mineralized zones, transverse stopes immediately below the crown must be tight-filled as much as practicable to reduce the potential for crown pillar collapse. The crown pillar will be supported with 6.0 m long single strand bulbed cable bolts on 2.5 m spacing.

3.4.9 Ground Support

Minimum ground support standards are shown in Appendix L. Ground support analyses for permanent "man-entry" and temporary "production" headings were conducted in each structural domain. Ground support designs were then refined based on operational considerations such as standardization of ground support. All mesh is assumed to be 100 mm x 100 mm x 4.0 mm (8 gauge) wire. The 0.7" cable bolts specified are assumed to have a minimum breaking strength of 339 kN, and the #7 resin-grouted rebar specified are assumed to have a minimum yield strength of 155KN and the breaking strength of 232KN. Double layers of mesh are used to strap pillars to avoid ground support installed by the jack leg. Example shotcrete designs are provided in the Supporting Information package.

Minimum ground support standards are summarised in Table 3.8. These support standards are provided for the average rock mass as Brucejack, with a RMR value ranging from 40 to 100. Ground support for other rock mass qualities in standard development headings are provided in the next section. All other openings (intersections, infrastructure, portals, raises, etc.) should be considered on a case-by-case basis.

Table 3-9 Brucejack Ground Support Recommendations for Average Rock Mass Quality (40<RMR <100)

Opening Type	Cross Section (w x h, m)		Ground Support Type	Length (m)	Spacing (m)	Mesh Estimate (%)	Additional Notes
Main access decline, ramps, and other haulage routes	5.5 x 6.0 (VOK ramp) 6 x 6 (conveyor ramp)	Back	Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	100	Welded wire mesh will be installed in the back & extended to within 1.5m-3.0m of sill elevation down the walls, lagging min. 1 round behind only. All active faces to be screened 1.2m down from the back.
		Walls	Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	70	
Level development	5.5 x 5.5	Back	Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	100	Welded wire mesh will be installed in the back & extended to within 1.5m-3.0m of sill elevation down the walls, lagging min. 1 round behind only. All active faces to be screened 1.2m down from back.
		Walls	Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	70	
Sumps	5.5 x 5.5 – 7.0	Back	Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	100	Welded wire mesh will be installed in the back and 1.0 m down the walls
		Walls	Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	20	
Historic development (if rehab. required)	3 x 3	Back	Fully-grouted #7 Resin grouted rebar	1.2	1.2 x 1.2	100	To be installed only if rehab. is required. Welded wire mesh will be installed in the back &extended w/in 1.5m of sill.
		Walls	Fully-grouted #7 Resin grouted rebar	1.2	1.2 x 1.2	20	
Intersections	Includes 6 x 5, 5 x 5, three-way, four-way, and herringbone layouts	Back	Pre-support: Fully-grouted #7 Resin grouted rebar	2.4	1.8 x 1.8	100	Welded wire mesh will be installed on the back and down to within 1.5m-3.0m of sill on each wall for all intersections with an effective span greater than 6 m. Double wrap each pillar with an additional screen.
		Back	Long support: Single strand 0.7" bulbed cable bolts, 1.0 m bulb spacing or 16′ connectable Swellex	6.0	2.5 x 2.5		
		Walls	Fully-grouted #7 Resin grouted rebar	2.1	1.8 x 1.8	70	
Cross-Cut Drives	5 x 4.5	Back	SS39 Split-Set	2.1	1.2 x 1.2	100	Welded wire mesh will be installed in the back & extend within 1.5m-3m of the sill elevation down the walls.
		Walls	SS39 Split-Set	2.1	1.2 x 1.2	70	
Full-width undercuts	5 x 5 pilot	Back	Pre-support: SS39 Split-Set	2.1	1.2 x 1.2	100	All support must be installed prior to slashing.
		Back	Long support: Single strand 0.7" bulbed cable bolts, 1.0 m bulb spacing or 16′ connectable Swellex	6.0	2.5 x 2.5		
	15 m wide full undercut (post-slash)	Back	SS39 Split-Set	2.1	1.2 x 1.2	100	
		Back	Long support: Single strand 0.7" bulbed cable bolts, 1.0 m bulb spacing or 16′ connectable Swellex as required	6.0	2.5 x 2.5		
		Walls	SS39 Split-Set	2.1	1.2 x 1.2	20	
Raises	3 x 3 m cross-section	All	Fully-grouted #7 Resin grouted rebar	1.2	0.8 x 0.8	50	Staggered spacing. Reduced support may be feasible if man-access is not permitted.[6]

Notes:

1. Wall bolts and screen must extend down to within 1.5 m of sill (floor), with wall screen lagging <u>no more than 3 round behind current face in all cases</u> during development.

2. Screen to be extended 1 screen width down from the back at all active headings for further loose retention at the face.

3. Surface support should be installed when excavation intersects relatively poorer ground, faults, more persistent joints or narrower joint spacing, soft joint walls, groundwater seepage points, or "dead" sounding difficult to scale material.

4. Use mesh estimate percentage for shotcrete cost estimating if shotcrete is preferred surface support.

5. Mesh and shotcrete will only be used in the exhaust raises if ground conditions require it, as there are no manways in these raises. The Fresh Air/Escapeway raises will be bolted and screened.

Table 3-10 Brucejack Ground Support Recommendations for Below Average Rock Mass Quality (RMR <40) [1, 2]

Rock Mass Class	Opening Type	Cross Section (w x h, m)		Ground Support Type	Length (m)	Spacing (m)	Mesh Estimate (%)	Additional Notes [3]
(RMR < 40) ("very poor" to "poor")	Main access decline, ramps, and other haulage routes	5.5 x 6 (VOK ramp) 6 x 6 (conveyor ramp)	Back	Fully-grouted #7 Resin grouted rebar Long support: Single strand 0.7" bulbed cable bolts, 1.0 m bulb spacing as required	2.4	1.2 x 1.2	100	Welded wire mesh with 50 mm of shotcrete across the back and walls to within 1.5 m of floor. All active faces to be screened 1.2m down face from back.
			Walls	Fully-grouted #7 Resin grouted rebar	2.4	1.2 x 1.2	100	
	Level development	5.5 x 5.5 5.0 x 4.5	Back	Fully-grouted #7 Resin grouted rebar Long support: Single strand 0.7" bulbed cable bolts, 1.0 m bulb spacing as required	2.4	1.2 x 1.2	100	Welded wire mesh with 50 mm of shotcrete across the back and walls to within 1.5 m of floor. All active faces to be screened 1.2m down face from back.
			Walls	Fully-grouted #7 Resin grouted rebar	2.4	1.2 x 1.2	100	

Notes:

1. *Ground support for excavations not reflected in the table should be reviewed on a case-by-case basis.*
2. *Alternative ground support materials might be required to deal with gouge and muddy ground where resin rebar is not suitable.*
3. *It may be advantageous to apply the shotcrete prior to mesh and rebar installation when exposed ground is to be soft, laminated, or highly fractured.*
4. *Extra ground support might be required based on the exposed ground conditions as per geotechnical engineer's judgement.*

Historic excavations will be recommissioned during the development of the mine. A historic excavation will be visually inspected by the Chief Mine Engineer or designate prior to first-entry by any personnel. The rock mass and existing ground support will be visually assessed for degradation, and, if it is determined that rehabilitation is required, rehabilitation will be carried out prior to recommissioning the excavation. If a historic excavation is rehabilitated, the ground support installed will meet the standards summarized in Table 3.8. Sample ground support installation procedures and specifications are included in Supporting Information Package I and II.

3.4.9.1 Ground Support for Variable Rock Mass Qualities in Standard Development Headings

As discussed above, the ground support summarized in Table 3.8 were designed for the average rock mass quality at Brucejack, which is RMR values 40 to 100. Ground support recommendations for standard development areas where RMR are less than 40 are provided in Table 3.9 and Trigger Action Response Plan (TARP) for standard drifts and intersection developments in different ground conditions are summarized in Table 3.10. All other excavations should be considered on a case-by-case basis.

3.4.10 Full-width Undercuts

The mine planners plan full-width undercutting of select primary stopes. Ground support recommendations are provided in Table 3.8 with recommendations for full-width undercuts provided in Appendix M. Primary stopes should be tight-filled as best as possible.

3.4.11 Intersection Pillar Noses

The pillar noses in intersection area need to be supported by proper bolting and screen depends on ground condition to minimize intersection zone. Minimum support with wire mesh screen pinned by 2.1m long split sets down to 1.5m from sill of pillar in fair to good condition of ground. The pillar nose in poor condition with sub-vertical discontinuities required coverage of double layers screen down to 1.5m with split sets from sill. Additional 50 mm of shotcrete are also required for the intersection pillars in possible progressive sloughing condition of ground.

3.4.12 Ground Support for Mining through Mine-Scale Fault Zones

All developments through large (mine-scale) fault zones will require support with fully grouted #7 resin grouted rebar bolts or swellex bolts on a 1.2 m square pattern. Full coverage (sill to sill) of welded wire mesh and 50 mm of shotcrete is also recommended. Stopes will be excavated in isolation and backfilled prior to any other production openings within the fault zone. The rock mass within the fault zone is not competent enough to form adequate rib or sill pillar strength between stopes. In each case, stopes will be constrained to either the host or fault disturbed rock. Excavations bridging the boundary will have unplanned dilution along the contact. The preliminary recommendation for maximum supported back hydraulic radii is 2.5 (10 m by 10 m), and maximum unsupported hanging wall hydraulic radii is 3.75 (10 m by 30 m), for stopes within the fault zone. Cable bolt support consisting of 6 m single or double strand bulbed cable bolts on a 2.5 m square spacing in the back is recommended.

3.4.13 Ground Support for Mining through/beside Paste Backfill

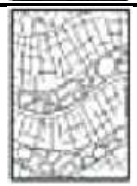
When drift develops through paste backfill, the drift should be excavated with arched back with straight wall height around 4m before the curve starts. Development will be advanced in 2.0m round length. 50 mm thick of shotcrete will be applied after mucking. Giving a 6-hour shotcrete curing time before bolting and screening is to start. 2.1 m long split sets are to be installed on a 1.0 m square pattern with screen coverage from sill to sill. Then advance for another round. When apply shotcrete to the newly exposed paste backfill, the previously installed bolt and screen for the last round should be covered with the 50 mm thick of shotcrete also. Details of the development sequence and support patterns are shown in the Appendix O.

When developing besides paste backfill, the development sequence and ground support requirements are shown in Appendix O. All drifts developing beside paste and have exposed paste wall will require additional support with 2.1 m long split sets on a 1.2 m square pattern and full coverage of welded wire mesh for the paste exposure as a primary support standard. 50 mm thick of shotcrete before or after primary support may also be required as per on-site geotechnical engineer's discretion. All developments also have paste exposure at the back more than 1.0 m wide, the drift need to be considered as a mining through paste and will require following support standard for mining through paste backfill.

3.4.14 Surface Raise Locations

The raise locations were chosen to avoid fault-disturbed rock and minimize intersection of weathered rock. The recommended pillar thickness between a raise and nearby development or production openings, including the decline access ramp.

Table 3-11 Brucejack Ground Support Trigger Action Response Plan (TARP)

Ground Condition		Risk	Opening Type	Dim (mxm)	Rock Bolt			Wire Mesh	Additional Support
					Type	L (m)	S (mxm)		
Fair to Good (40<RMR<100)		Low	Main Ramp	5.5 x 6.0	Rebar	2.4	1.8 x 1.8	Up to 3.0m From Sill	
		Low	Level Drift	5.5 x 5.5	Rebar	2.4	1.8 x 1.8	Up to 3.0m From Sill	
		Low	Waste Drift	5.0 x 5.0	Rebar	2.4	1.8 x 1.8	Up to 3.0m From Sill	
		Low	Ore Drift	5.0 x 5.0	Split Set	2.1	1.8 x 1.8	Up to 3.0m From Sill	
		Med	Int. A	7.0 – 10.0	Rebar	2.4	1.8 x 1.8	Up to 3.0m From Sill	6.0m Cable bolts
		High	Int. B	10.0 – 15.0	Rebar	2.4	1.8 x 1.8	Up to 3.0m From Sill	6.0m Cable bolts
Extremely Poor to Poor (RMR<40)		Med	Main Ramp	5.5 x 6.0	Rebar	2.4	1.2 x 1.2	Up to 1.5m From Sill	6.0m cable bolts as Req. Shotcrete as Req.
		Med	Level Drift	5.5 x 5.5	Rebar	2.4	1.2 x 1.2	Up to 1.5m From Sill	6.0m cable bolts as Req. Shotcrete as Req.
		Med	Waste Drift	5.0 x 5.0	Rebar	2.4	1.2 x 1.2	Up to 1.5m From Sill	6.0m cable bolts as Req. Shotcrete as Req.
		Med	Ore Drift	5.0 x 5.0	Split Set	2.1	1.2 x 1.2	Up to 1.5m From Sill	4.9m Connectables as Req. Shotcrete as Req.
		High	Int. A	7.0 – 10.0	Rebar	2.4	1.2 x 1.2	Up to 1.5m From Sill	12.0m Cable bolts Shotcrete
		Critical	Int. B	D > 10.0	***Possible intersection with D > 10m in poor ground need to be relocated or develop with separate ground support plan***				

3.4.15 Underground Infrastructure Bearing Capacity and Anchorage

Three (3) methods were used to evaluate preliminary ultimate and allowable bearing capacities for underground infrastructure at Brucejack. These include:

- US Army Corps of Engineers (USACE) / Peck Hanson Thornburn Method for Bearing Capacity in Jointed Rock Masses (1994);
- Widjojo and Kulhawy's (2004) Bearing Capacity Method for Strip Footings on Jointed Rock Masses; and
- Finite Element Modeling (RS3 Rocscience, 2016).

For all methods, a factor of safety of 3 has been applied to the 'Ultimate Bearing Capacity' (q_{ult}) to determine the "Allowable Bearing Capacity" (q_{allow}):

$$q_{allow} = q_{ult}/3$$

For the analyses the following assumptions were made:

- foundation footings are located on the surface of the bedrock (i.e., not buried); and
- foundations are not affected by groundwater conditions.

The results varied somewhat depending on the method used; they have been reviewed and evaluated to determine 'reasonable' values of q_{ult} and q_{allow}. These 'preliminary' values are presented in Table 3.10, and are considered valid for static, transient, and dynamic conditions. The values are to be confirmed upon final excavation of the rock mass at the specified infrastructure locations.

Table 3-12 Ultimate and Allowable Bearing Capacity (Preliminary)

Ultimate Bearing Capacity q_{ult}	Allowable Bearing Capacity q_{allow}
2.0 MPa / 290 psi	0.67 MPa / 97 psi

Table 3-13 Ground Support Recommendations for Mine Infrastructure

Area	Dimension (w x h x l) (m)	Design Factor of Safety	Lifespan	Support
Cap Magazine	5.5 x 5.5 x 10.0	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2" plain shotcrete.
Crusher Chamber – Lower level (Bin)	11.5 x 16.5 x 21.4	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2″ plain shotcrete. Double-strand 0.7″ bulbed cable bolts: Walls: 5.0 m length, 2.5 m square spacing, 1.0 m bulb spacing Back: 5.0 m length, 2.5 m square spacing, 1.0 m bulb spacing Confining surface support (e.g., steel or heavy gauge mesh straps) recommended for all noses and benches within the excavation.
Crusher Chamber – Coarse Ore Bin (between Grizzly and Bin)	7.5 x 21.5 x 6.0	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2″ plain shotcrete. Double-strand 0.7″ bulbed cable bolts: Walls: 5.0 m length, 2.5 m square spacing, 1.0 m bulb spacing Confining surface support (e.g., steel or heavy gauge mesh straps) recommended for all noses and benches within the excavation.
Crusher Chamber – Upper level (Grizzly station)	11.6 x 8.0 x 15.0	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2″ plain shotcrete Double-strand 0.7″ bulbed cable bolts: Walls: 5.0 m length, 2.5 m square spacing, 1.0 m bulb spacing Back: 5.0 m length, 2.5 m square spacing, 1.0 m bulb spacing Confining surface support (e.g., steel or heavy gauge mesh straps) recommended for all noses and benches within the excavation.
Fuel and Lube Station	6.0 x 5.5	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2" plain shotcrete.

(continued)

Area	Dimension (w x h x l) (m)	Design Factor of Safety	Lifespan	Support
Service Bay, Maintenance Bay, and Tire Bay	6.0 x 5.5	2	LOM	#7 fully grouted resin rebar: 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2" plain shotcrete.
Powder Magazine	5.5 x 5.5 x 10	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2" plain shotcrete.
Refuge Station and Offices	5.5 x 5.5 x 25	2	LOM	#7 fully grouted resin rebar: 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2" plain shotcrete.
Warehouse	6.0 x 5.5	2	LOM	#7 fully grouted resin rebar; 2.4 m length; 1.8 m square spacing. Welded wire mesh, 100% coverage on back and walls, coated with minimum 2" plain shotcrete.

Rock Anchors

Rock anchor loads are determined by evaluating safety factor requirements for specific structures and equipment, operating under a wide-range of potential operating conditions. Anchors may be designed for a variety of stability considerations including foundation uplift, overturning and / or sliding. The anchor concepts presented in the discussion below require further review once final designs are determined for Brucejack.

Anchor depth depends largely upon the condition and quality of the rock mass into which the anchors are to be installed, and the desired anchor pattern (i.e., a single anchor, a single row of anchors, or multiple rows of anchors) (refer to Figure 3.8). The 'anchor depth' is defined as the anchor length necessary to develop the anchor force required for stability.

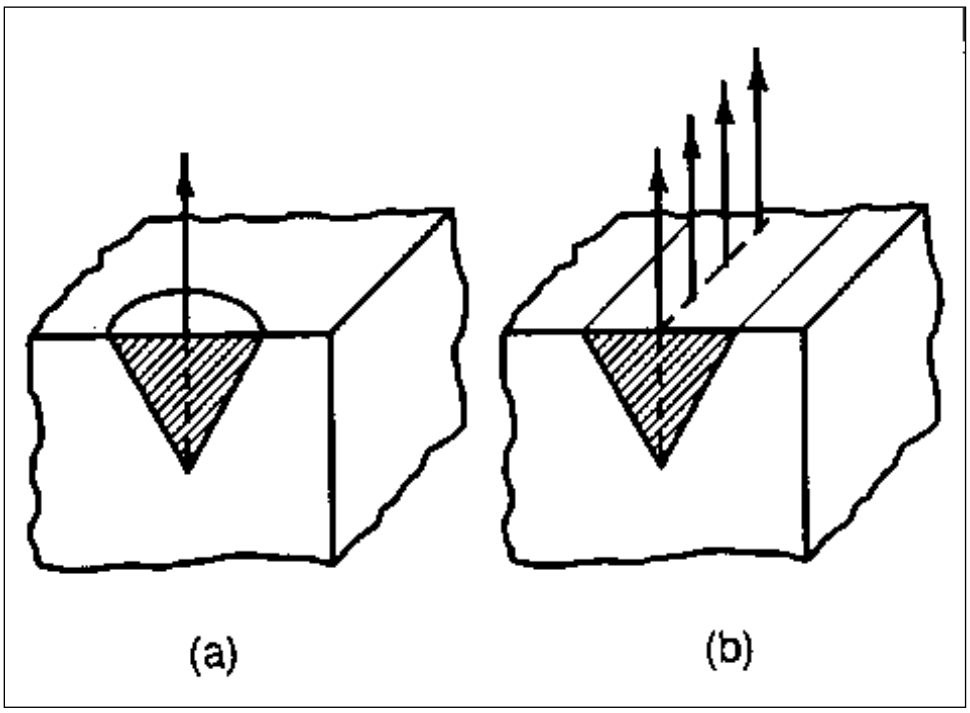


Figure 3-9 Anchor Depth for Single Anchor vs. Row of Anchors

Per Littlejohn and Bruce (1977), in fractured rock the strength of the rock mass subjected to a tensile force (the anchor force) cannot typically be relied upon to provide the necessary pullout / uplift resistance. For this reason, only the weight of the affected rock is usually considered in design. Based on this assumption, the anchor depth is computed as follows:

$$D = \sqrt[3]{\frac{3 * F * P}{\gamma * \pi}}$$

Where:

- D = required depth of anchorage;
- F = appropriate factor of safety;

- P = anchor force required for stability;
- g = unit mass of rock.

Note that it is assumed that the in-situ stresses are zero.

Similarly, for a single row of anchors in fractured rock typically only the weight of the affected wedge of rock is relied upon to provide the necessary resistance. For a single row of anchors, spaced 's' units apart, in fractured rock, the anchorage depth is computed as follows:

$$D = \sqrt{\frac{F * P}{\gamma * s}}$$

For multiple rows of anchors, with rows spaced 'L' units apart, again, only the weight of the affected rock mass resists the anchor force. The following equation can be used to determine the anchorage depth:

$$D = \frac{F * P}{\gamma * L * s}$$

Bond Strength

The design of grouted anchorages must insure against failure between the anchor and the grout, as well as between the grout and the rock. Experience and numerous pull-out tests have shown that the bond developed between the anchor and the grout is typically twice that developed between the grout and the rock. Therefore, primary emphasis in design and analysis is placed upon the grout/rock interface.

Values of ultimate bond strength are normally determined from shear strength data, or field pull-out tests. In the absence of such tests, the ultimate bond stress is often taken as 1/10 of the uniaxial compressive strength of the rock or grout (whichever is less) (Littlejohn 1977) up to a maximum value of 4.2 MPa (i.e., 600 psi). This results in ultimate bond stresses of 4.0 MPa and 2.0 MPa respectively. The working bond stress is exactly half of the ultimate bond stress if a safety factor of 2 is applied. The anchor load P is related to the fixed anchor design by the following:

$$P = \pi d L \tau$$

Where:

- P = Anchor Load;
- d = Effective anchor diameter (including annulus);
- L = Fixed anchor length; and
- τ = Working bond stress.

Under most conditions adequate bond strength is developed within the first 1.0 m of embedded length such that the anchor capacity becomes the weakest element in the anchorage system.

Preliminary anchor depths for floor anchors were determined for Brucejack using the above noted industry standard techniques. Table 3.12 and Table 3.13 present a summary of anchor depths for a variety of uplift loads and anchor patterns, for Safety Factors of 1.5 and 2.0 respectively.

Table 3-14 Anchor Depths for a Variety of Loads, Anchor Patterns, and FOSs (1.5)

Uplift Load (t)	Single Anchor Depth (m)[1]	Single Row Anchor Spacing (m)	Single Row of Anchors Depth (m)[1]	Perpendicular Spacing (m)	Multiple Anchor Depth (m)[1,2]
5	1.38	0.75	1.92	0.75	-
5	1.38	1.75	1.26	1.75	0.91
10	1.74	0.75	2.72	0.75	-
10	1.74	1.75	1.78	1.75	1.81
20	2.20	0.75	3.85	0.75	-
20	2.20	1.75	2.52	1.75	3.63
30	2.52	0.75	4.71	0.75	-
30	2.52	1.75	3.09	1.75	5.44
40	2.77	0.75	5.44	0.75	-
40	2.77	1.75	3.56	1.75	7.26

Notes:
1. Anchor depth calculations assume a Safety Factor of 1.5.
2. Multiple anchors generally require > ~ 1 m spacing for reasonable anchor depths.

Table 3-15Anchor Depths for a Variety of Loads, Anchor Patterns, and FOSs (2.0)

Uplift Load (t)	Single Anchor Depth (m)[1]	Single Row Anchor Spacing (m)	Single Row of Anchors Depth (m)[1]	Perpendicular Spacing (m)	Multiple Anchor Depth (m)[1,2]
5	1.52	0.75	2.22	0.75	-
5	1.52	1.75	1.45	1.75	1.21
10	1.92	0.75	3.14	0.75	-
10	1.92	1.75	2.06	1.75	2.42
20	2.42	0.75	4.44	0.75	-
20	2.42	1.75	2.91	1.75	4.84
30	2.77	0.75	5.44	0.75	-
30	2.77	1.75	3.56	1.75	7.26
40	3.05	0.75	6.29	0.75	-
40	3.05	1.75	4.11	1.75	9.67

Notes:
1. Anchor depth calculations assume a Safety Factor of 2.0.
2. Multiple anchors generally require > ~ 1 m spacing for reasonable anchor depths.

Based on a review of preliminary designs and geotechnical data, the following anchor arrangement and capacities are recommended for 'Side Wall Platform Supports' at Brucejack:

- 2 x 1.8 m long #7 Dywidag rock bolts (galv.) per support 'point', with bolts spaced ~ 30 cm apart, resulting in ~ 2 x 200 KN min tensile yield, and, ~ 2 x 115 KN shearing resistance, per 'point'.

Similarly, the following anchor arrangement and capacities are recommended for 'Roof Crane Supports' at Brucejack:

- 2 x 1.8 m long #7 Dywidag rock bolts (galv.) per mount point, spaced on 3 m centres along the length of both the LHS and RHS crane rails (i.e., each mount point for the crane rails consists of a group of 2 x #7 Dywidag bolts, providing 2 x 200 KN min tensile yield per 'mount point'.

A high-strength micro-fine cement grout or equivalent anchor resin is recommended as a bonding agent. The BTS group will determine an appropriate product. Anchor installation guidelines including the manufacturer's recommended drill hole diameter are attached to this document.

The preliminary anchorage depths noted above should be confirmed pending final designs and once loading conditions are known.

Installation / Quality Control

Proper installation of the rock anchors is required to achieve adequate performance characteristics. Installation recommendations, and bolt (and resin) technical specifications from relevant product manufacturers have been attached to this document. In addition to these, a trigger-response table for installation specific to Brucejack is provided (Table 3.14). It is recommended that anchors and accessories used in 'permanent' installations be galvanized to protect against corrosion.

Table 3-16 Rock Anchor Support Installation - Trigger / Response

Trigger Condition	Response
Normal drilling conditions	Proceed with installation per recommended guidelines
Soft / weak ground encountered, hole completed to depth	Proceed with installation per recommended guidelines, confirm acceptable installation, record and report location to Shift Supervisor / Geotechnical Engineer
Soft / weak ground encountered, unable to advance hole to depth	If possible, relocate hole collar within available area. If not possible, record and report location to Shift Supervisor / Geotechnical Engineer
Excessive cracking / separation of shotcrete during drilling, installation	Contact shift supervisor
Change of ground condition in same location over time	Contact shift supervisor / Geotechnical Engineer
Excessive water inflows from hole	Contact shift supervisor / Geotechnical Engineer
Fines / Mud / Water in hole prevents resin from setting, bolts rotate but do not set	Contact shift supervisor / Geotechnical Engineer, expect to use a secondary grouting method

4 IMPLEMENTING THE GROUND CONTROL MANAGEMENT PLAN

This section describes the procedures and systems for training, communication, analysis, interpretation and records management regarding ground control matters at Brucejack.

4.1 GROUND CONTROL TRAINING

Relevant ground control training shall be provided to all mine personnel, commensurate with the work to be undertaken and the responsibilities associated with a particular role. Ground Control training is conducted through a number of forums including:

- Underground Induction. The underground induction is presented by the Mining Contractor's Training and Safety Department. The induction contains basic information on working in an underground environment.
- Ground Awareness Training. All underground employees will receive Ground Awareness Training. For current employees this training shall be retaken every year. This training aims to equip underground personnel with the ability to identify geotechnical hazards and the skills to react appropriately. Includes Rock Scaling Examinations and Sign-offs.
- Operator Training. The operators will be required to be skilled and competent in the use of underground equipment. The mining contractor's Training and Safety Department shall ensure that a comprehensive training and assessment program is implemented, with completion records maintained in an accessible format.
- Safe Work Procedures (SWP's). Safe Work Procedures are currently being developed jointly by Pretim and the mining contractor for regular / recurrent tasks underground. The Mine Manager will authorize all SWP's before implementation, and along with other Key Individuals, supervise their implementation and review / update.
- Geotechnical Hazard Information Sessions. When new or unique geotechnical hazards are encountered in the mine the Geotechnical Engineer will present information on the hazard to the workforce. This can be done at the same time as the Shift Change Meeting, or a suitable alternative. Content from the information sessions will be noted in a 'Geotechnical Hazards Register' to ensure a record exists for the specific Ground Control issue.

4.2 GROUND CONTROL COMMUNICATION

It is the responsibility of all mine workers to communicate ground control matters to the appropriate person. These communications take various forms, including meetings, ground control information sessions, job hazard assessments, notice boards, mine plans, and memorandums.

4.2.1 Meetings

4.2.1.1 Daily Site Safety Meeting

The purpose of the meeting is to inform all mine site personnel of safety related items specific to work activities planned for the day. If Ground Control Management issues are likely to impact any, or all, of these tasks, the Daily Safety Meeting is an appropriate venue for any worker to initiate discussions regarding concerns, risks, mitigation strategies, etc.

4.2.1.2 Daily Shift Change Meeting

The purpose of the meeting is to plan and schedule tasks for the upcoming shift. The daily task list is based on work scheduled in the weekly planning meeting, as well as other daily items. During the handover between shifts, the Shift Supervisor of the outgoing shift provides information on the current workplace ground conditions, including any geotechnical hazards. Allocation of ground control tasks to mine personnel and operators will be made by the oncoming Shift Supervisor at this meeting.

The Geologist/Geotechnical Engineer must attend the meeting if information on ground control needs to be communicated to miners and operators.

4.2.1.3 Daily Production Meeting

The purpose of this meeting is to review daily development targets and potential production delays. The Geologist/Geotechnical Engineer can use this meeting to highlight issues with ground control that may impact production activities. During this meeting any reported hazards shall be discussed and responsibility assigned to the appropriate departments.

4.2.1.4 Weekly Planning Meeting

The purpose of the weekly planning meeting is to plan and coordinate the work efforts of all departments for the upcoming week. The geologist/geotechnical engineer attends this meeting and provides information on the expected ground conditions, ground support requirements, diamond drilling, quality assurance and quality control, etc. From this meeting a weekly plan is formulated for Ground Control Management.

4.2.2 Ground Control Information Sessions

The geotechnical engineer will develop and direct information sessions discussing geotechnical hazards at Brucejack Mine, and arrange for such sessions to be given on a regular basis to all underground personnel. The talks will focus on specific Ground Control Management items and related geotechnical issues.

4.2.3 Job Hazard Assessments

Ground Control issues and risks will be considered and evaluated as part of all Job Hazard Assessments (JHAs). A JHA Template is included in the supporting information attached to the

GCMP. Specific plans and actions aimed at reducing and / or mitigating risks will be outlined in detail in the JHA. The geotechnical engineer shall contribute relevant guidance and facilitate ground control discussions during Job Hazard Assessment sessions for unique work tasks.

4.2.4 Ground Control Notice Board

A Ground Control Notice Board will be maintained in the Shift Change Room. This space will be used to present information on Ground Control issues such as changes to support standards and details of actions carried out to address and mitigate geotechnical hazards.

A copy of the Ground Control Management Plan and current IFC Mine Plans shall be kept in this area for any mine personnel to access and review.

4.2.5 Official Development Drawing (Mine Plans)

Official Development Drawings are issued by Pretium to the mining contractor for construction / execution. The plans are signed off by the Mine Planning Engineer, Senior/Chief Mine Geologist, the Geotechnical Engineer, the Senior /Chief Engineer /the mining contractor's Superintendent and the Mine Captain/Superintendent.

No development will occur without an IFC Mine Plan for a particular heading or stope, nor without an assessment of the ground conditions and anticipated support requirements. The plan will show any unique geotechnical conditions that may be encountered as well as any 'geotechnical holds' that have been identified. The 'geotechnical holds' will also be stored and maintained electronically in an accessible format by the Geotechnical Engineer.

Where a 'geotechnical hold' is issued, the Geotechnical Engineer will coordinate with Pretium technical services and operations groups, and the mining contractor, to determine how development is to proceed. A written instruction will be issued ('Variation of Ground Support' Form), and attached to the relevant IFC Mine Plan.

4.2.6 Variation of Ground Support Form

No development shall proceed with ground support different from the standards indicated in the current GCMP, unless a 'Variation to Ground Support' form has been completed by the Geotechnical Engineer and signed by the underground Mine Manager. The form will be attached to the relevant IFC mine plan. This applies to situations where less ground support is deemed appropriate, or when customized and / or enhanced ground support is required based on the triggers or conditions described above.

4.2.7 Rehabilitation Memorandums

Rehabilitation Memorandums shall be issued for areas where, upon inspection, ground support does not achieve the established standards, or where ground conditions dictate that additional

support is required. This may occur due to equipment damage, mining induced damage, poor mining practices, or exposure of unanticipated ground conditions during development.

An example of a typical rehabilitation memorandum and related information is Geotechnical Inspection Memo (GIM) issued based on daily inspection by on-site geotechnical engineers and examples of the GIM can be found,

> *J:\Engineering\Geotechnical\Geotechnical Log Book\2023\02 - Fev\11\GIM20230211-VK_1500 Sump Long Support Plan - Final Version.pptx*

4.2.8 Reporting Ground Control Hazards

4.2.8.1 Mine Personnel and Operators

Mine personnel and Operators immediately report any geotechnical hazards to their Supervisors. They also record geotechnical hazards on their 'Field level Hazard Assessment' cards that get filled in daily, prior to commencing any task. These cards prompt the worker to check the excavation and ground conditions prior to work. An example of the card is presented in Supporting Information Package II.

If geotechnical hazards are encountered that prevent the Operator from working safely the Shift Boss should be contacted. The Shift Boss must record the geotechnical hazard in his or her log book. The Shift Boss must report the hazard to the Superintendent and the Geotechnical Engineer. A description of all reported geotechnical hazards is kept in the Geotechnical Log Book in the Shift Boss' office, and digitally on the Geotechnical drive on the computer network. The Register will include information on the actions taken to rectify the hazard and the feedback given to the Shift Boss and Operator.

4.2.8.2 Other Underground Personnel

Other personnel underground are expected to report geotechnical hazards directly to their supervisors or to the Geotechnical Engineer. These shall also be entered into the ' Geology / Geotechnical Log Book.

4.3 STANDARD OPERATING PROCEDURES (SOPS)

Developing, implementing, and auditing ground control SOPs is a core responsibility of Key Individuals under the GCMP.

The Mining Contractor is primarily responsible for the development of SOP's. Pretium are also currently developing a number of supplemental SOP's to address tasks and conditions unique to the Brucejack Mine. Relevant SOP's are to be incorporated into the GCMP as they are developed.

4.4 OBSERVING AND ASSESSING GROUND BEHAVIOUR

4.4.1 Rock Mass Quality

The quality of the rock mass within the mine is expected to range from predominantly 'good to fair' quality rock. The locations of 'poor to very poor' rock are typically associated with fault disturbed zones. For the purpose of choosing appropriate support for the expected rock mass conditions, the

rock mass quality has therefore been divided into 'good to fair' and 'poor to very poor' quality rock. This classification is not related to the empirical schemes proposed in the previous sections, but is a simplified method that allows mine personnel to quickly assess the ground quality based on visual observations. In cases where drill hole data is available and the quality of the rock can be pre-determined, locations of 'fair to poor' ground will be indicated on IFC Mine Plans. Definitions of 'Fair to Poor' and 'Good to Fair' ground are given in Table 4.1.

Table 4-1 Definition of Poor and Good Ground

Poor to Very Poor Ground (has ANY of these characteristics)	Good to Fair Ground (has ALL of these characteristics)
Excessive barring / scaling down is or was required, or ground is drummy and cannot be scaled	Minimal scaling required
Significant blast damage to the rock mass	Minimal overbreak from blasting
Significant stress related damage (bagging of mesh in the back, buckling, corner crushing, wall slabbing, etc.) is evident	No stress fracturing (no bagging of mesh in the back or buckling or corner crushing or wall slabbing, etc.).
Fault zones, with weak infill minerals present	Absence of low friction minerals on joints
Potential exists for formation of unstable blocks in walls or backs	No recent history of rock falls in the same drive
Ground with a history of water ingress or bolt corrosion	No visible faults, joints or cracks with potential for forming wedges
Excessive unraveling	Unraveling behavior is not excessive
Ground support problems	No history of bolt corrosion

4.4.2 Investigating Rock or Support Failures

All rock and ground support failures are to be fully investigated by the Geotechnical Engineer. As a minimum, a Preliminary Incident Report shall be completed, and entered into the Geotechnical Hazard Register. For more significant failures the Geotechnical Engineer will complete a back-analysis to determine the causes. A register of all rock and support failures will be maintained by the Geotechnical Engineer. This data will be considered when changes to the Ground Support Standards are proposed.

4.4.3 Monitoring

Where fair to poor ground conditions are encountered the Geotechnical Engineer shall determine if convergence monitoring, or other monitoring, is required. This is particularly the case for life-of-mine excavations, mine egress excavations, and larger span excavations.

Convergence monitoring is to be carried out regularly in conjunction with visual inspections of the areas. Convergence monitoring will be carried out by the Survey Department under the direction of the Geotechnical Engineer. A guideline for the frequency of inspections is presented in Table 4.2 below.

Table 4-2 Guidelines for Frequency of Convergence Monitoring

Days between Readings	Description of Areas being Monitored
1	Convergence points for the first month after installation
	Critical areas (areas around failures or new areas near development headings)
2	Convergence points for the second month after installation
4	Convergence points for the third month after installation or until long term trends are determined
7	Convergence points up to 6 months after installation to confirm long term trends
30	Long term data collection/monitoring

Responses in ground support such as cracked shotcrete or deformed bolt plates will be noted. In conjunction with this inspection, the geological structures in the area shall be reviewed. Rehabilitation will be required if deemed necessary by the Geotechnical Engineer.

An observational 'mine and monitor' risk management system will be employed at Brucejack, as part of the GCMP. Similar to the current state of practice for monitoring in underground mines in North America, Brucejack's planned ground monitoring system includes, progressively:

- Visual geotechnical inspections of mine workings;
- Tape extensometer stations;
- Survey prisms tied into the mine coordinate system;
- Vibrating wire and / or manual crackmeters;
- Multi-point borehole extensometers (MPBX) in pillars and walls;
- Borehole stressmeters; and
- Microseismic systems, as appropriate.

The various hardware systems noted above shall be augmented with an appropriate suite of software to provide near real-time visualization, displacement calculations, monitoring, and warnings for the geotechnical and operations staff of the mine. Of particular significance will be the excavations near and within the Brucejack Fault Zone, the underground crusher chamber, and crown, rib, and sill pillars.

Initially, regular visual geotechnical inspections of all mine workings shall be completed by Pretium and their contractors, and deformation monitoring of critical stope walls, pillars, and infrastructure excavations such as shops, service bays, crusher chambers, primary developments, main access ramps, ventilation infrastructure etc., shall be initiated as mining progresses. This monitoring is required to:

- Maintain safe operational practices for personnel and equipment;
- Provide warning of rock mass instability; and
- Provide geotechnical information for designs to assist in making subsequent modifications, should they be required, to achieve the desired rock mass performance.

If field observations and performance data indicate the development of un-anticipated / anomalous / elevated stress conditions, or growing uncertainties with respect to Pretium's understanding of evolving stress conditions, monitoring programs and related instrumentation will be progressively upgraded until the necessary levels of surveillance are achieved and maintained.

4.4.4 Overbreak and Blast Damage

Overbreak is to be measured by the survey department and reported on regularly. To minimize overbreak or blast damage the Superintendent and Shift Supervisor will instruct Operators on changes to the type and amount of explosives depending on changes in ground conditions and observed excavation performance. Changes in ground conditions and excavation performance are recorded during geological and geotechnical mapping by the Geology Department.

4.4.5 Historical Experience

The observations and assessments of ground behaviour and ground support reactions are used to evaluate the adequacy of the ground control management program at Brucejack. The evaluations may result in site-specific modifications for a specific working area, or a broader update to the mine design or standard ground support designs.

4.5 RECORDS MANAGEMENT

4.5.1 Geotechnical Hazards

Geotechnical Hazards shall be recorded in the Shift Boss's Log on the day the hazard is identified. The Geotechnical Engineer will also maintain a 'Geotechnical Hazard Register' in the Geotechnical Office. This Register will include a description of the geotechnical hazard, actions taken to rectify the hazard, the reporting person and confirmation that feedback on the problem was given to the reporting person.

4.5.2 Geotechnical Log Book

The Geotechnical Log Book is kept in the Mine Operations. It is a record of any inspections made of excavations and headings in mine. Any significant geotechnical milestones in an excavation's development must also be recorded in this log.

4.5.3 Mapping Data

Digital copies of all geological and geotechnical mapping are to be stored and maintained in an accessible format by the Geologist and the Geotechnical Engineer.

4.5.4 Photographic Records

Photographic records of all geological and geotechnical content are to be stored and maintained in an accessible format by the Geologist and the Geotechnical Engineer.

4.5.5 Underground Geotechnical Monitoring Data

Geotechnical monitoring data will be collected from numerous systems underground at Brucejack. These systems are described in the next chapter. All geological and geotechnical monitoring data are to be stored and maintained in an accessible format by the Geologist and the Geotechnical Engineer.

5 VERIFICATION OF THE GROUND CONTROL MANAGEMENT PLAN

This section provides a discussion of procedures and actions used to verify implementation of the GCMP. Areas discussed include Excavation Performance Assessments, Ground Support Installation QA/QC, and GCMP Review.

5.1 EXCAVATION PERFORMANCE ASSESSMENTS

5.1.1 Active Headings and Stope Inspections

During the pre-production development cycle, all active headings will be inspected by the Geotechnical Engineer at least once every three months (i.e., quarterly). When production commences, all active headings, current and in-development stopes, and related workings (drawpoints, level access drifts, cross-cuts, etc.) will be inspected and assessed by the Geotechnical Engineer on a regular basis.

Additionally, Geologists and / or Technicians who conduct ongoing geological mapping of active headings will carry out basic geotechnical inspections during the course of their work.

All underground workers shall be familiar with quality control requirements for ground support installation and performance, so that issues and concerns related to these can be identify, communicated, and resolved.

In addition to visual inspections, instrumentation such as closure stations, extensometers, stress cells, and smart cables may be installed in critical infrastructure to monitor excavation performance. These monitoring systems, used to verify successful implementation of the GCMP, are currently in development and will be described in detail in future updates to the GCMP.

5.1.2 Main Travelways and Escapeways

The Geotechnical Engineer will be required to carry out a formal inspection of main travelways and escapeways on a yearly basis. An entry must be made in the Shift Boss's Log book of this inspection. A record of this inspection must also be kept in the Geotechnical Log Book noting the time and date of the inspection, any problem areas, and actions taken to rectify them.

5.1.3 All other Excavations

A minimum requirement is that all open excavations are inspected by the Geotechnical Engineer on a yearly basis. A record of the inspection will be required to be kept in the Geotechnical drive on the computer network.

5.2 GEOTECHNICAL RISK ASSESSMENT

Broadly speaking, a risk assessment is the combined effort of: identifying and analyzing potential events that may negatively impact individuals, assets, and/or the environment; and making judgments "on the tolerability of the risk on the basis of a risk analysis" while considering influencing factors

5.2.1 Geotechnical Hazard Recognition

The recognition of geotechnical hazards before they present as ground failure is important. Integrated with mine design, ground support design, underground inspection, and ground movement monitoring when needed, ground hazard recognition involves identifying a potential hazard before it becomes an event. Through the inspection and monitoring of the existing underground openings, with analysis of the numerical modelling software and empirical method, potential hazards can be recognized in some circumstances.

5.2.2 Risk Matrix

A risk matrix is used to rate risks according to their Likelihood and Consequence. The Table 5.1 below is the risk matrix to classify identified Geotechnical hazards in terms of risk.

Table 5-1 Risk Assessment Matrix and Risk Score Legend

Impact \ Likelihood	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost Certain (5)
Catastrophic (5)	Medium Risk	Medium Risk	High Risk	Critical Risk	Critical Risk
Major (4)	Low Risk	Medium Risk	High Risk	High Risk	Critical Risk
Moderate (3)	Low Risk	Medium Risk	Medium Risk	High Risk	High Risk
Minor (2)	Low Risk	Low Risk	Medium Risk	Medium Risk	Medium Risk
Insignificant (1)	Low Risk	Low Risk	Low Risk	Medium Risk	Medium Risk

Risk Score	Risk Level Category	Description
1 to 4	Low Risk	Manage by routine procedures and operations; should not require much attention but should be reviewed at least every 12 months.
5 to 10	Medium Risk	Managed by specific monitoring or response procedures; should be monitored and reviewed every 6 months.
11 to 18	High Risk	Requires escalation to VP; should be constantly monitored and reviewed every 3 months.
19 to 25	Critical Risk	Requires escalation to Board of committee responsible for risk management oversight; should be constantly monitored and reviewed monthly.

The risk matrix is designed to work in conjunction with the Geotechnical Log. The Log is designed to identify the risk, classify the risk and describer actions too minimize the risk.

5.2.3 Risk Assessment Process

Geotechnical risk assessment must be conducted by the Mine Manager or designate. Geotechnical risk assessments will be carried out for identified geotechnical hazards as frequently as required to assess the current nature of the risk. For example, if the likelihood or the consequences were to increase, the risk must be re-assessed.

Mine Manager or designate must implement all controls specified in the risk assessment.

5.2.4 Hazard Communication

Hazards must be communicated to all personnel working within the mine by appropriate means such as verbal briefings and notices on safety boards. Further, if required to or directed to by Mine Inspectors communication must be an open dialogue.

5.2.5 Hazard Prevention

The prevention of hazards is the best engineering control that can be used. Through systematic approach including geotechnical design, and verification; potential hazards can be realized and prevented. The preventive measures (controls) required vary according to the likelihood and consequence of the failure.

5.2.6 Hazard Mitigation

Hazard mitigation involves reducing the consequence of a potential failure. If a hazard can not be eliminated, operational and engineering controls must be put into place to reduce the consequence or likelihood.

Figure 5-1 Hierarchy of Controls

Elimination – The hazard can be mined out or removed from the mine site

Substitution – Modifications to be the mine design and the change of operational procedures

Isolation – The barrier off of an area to restrict access, using a variety of methods such as rope off, screen fencing, etc.

Engineering controls – Altered mine design to improve stability, such as layout, dimension, ground excavation and support plan, and increased ground inspection and monitoring.

Adminstrative – Communication of Geotechncial hazards, geotehcncial reporting and Job Hazard Analysis (JHA) for one such example.

5.2.7 Risk Register – Site Geotechnical Log

A Geotechnical Risk Register must be always kept on site. This risk register is incorporated into the Site Geotechnical Log for simplicity and efficiency. The Site Geotechnical Log will be built up over time and have a closeout process.

The closeout process illustrates that action has been taken to reduce the risk classification level.

5.3 MONITORING QUALITY ASSURANCE AND QUALITY CONTROL OF GROUND SUPPORT

Quality assurance and quality control of ground support is to be carried out through ground support installation inspections, pull testing, shotcrete batch plant inspections, shotcrete panel, core, or beam testing (ASTM C1550/ASTM C1140), and long-term monitoring.

5.3.1 Rock Bolt Installation QA/QC

5.3.1.1 Visual Inspection

Visual inspection of installed ground support will provide for the assessment of several items as listed in Table 5.2.

Table 5-2 Visual Ground Support Assessment Parameters

Parameter	Specification
Bolt position	The bolt will be installed within 200 mm of the design bolt spacing and ring spacing.
Length of bolt tail	No more than 100 mm of bolt will extend from the collar of the hole
Orientation of bolt	The bolt must be oriented to be as near as perpendicular to the surface of the excavation as possible. Bolts that are dumped forward or backwards due to poor positioning of the jumbo will be subject to replacement.
Torque nut	The torque nut will be broken to ensure the resin has set correctly
Encapsulation	Visual inspection of the collar of the bolt will be made to assess the encapsulation of the bolt. The aim is to achieve 100% encapsulation

5.3.1.2 Quality of Work

The quality of ground support installation work shall be inspected by the Shift Boss during each shift. If bolt(s) do not meet acceptable installation standards, new bolt(s) shall be installed within 250 mm of the original bolt(s).

Operators will note any bolts that do not install correctly and report this to the Shift Boss at the end of bolting the heading.

The Geologist/Geotechnical Engineer shall also visually inspect the adequacy of bolting near the heading during mapping of each new round. Any non-conformances must be reported to the Shift Boss and to the Geotechnical Engineer, Geologist or Mining Engineer.

Technical specifications and installation instructions for ground support products currently in use at Brucejack are included in Supporting Information Package I.

5.3.1.3 Pull Testing

Routine pull testing will be implemented at Brucejack with a requirement that a minimum of 0.5% of the new rock bolts installed in the current year demonstrate a pull test capacity indicating 75% of the bolt's yield strength. Additional testing of ground support in historic excavations will be carried out. For all rock bolts in a recommissioned historic excavation, selected bolts will be tested at the discretion of the geotechnical engineer to confirm the supporting efficiency. If a systemic problem, such as excessive corrosion throughout the historic excavations, is detected, a rehabilitation program will be initiated.

Testing will be conducted on rock bolts installed along the sidewalls and backs of all excavations.

In addition, some bolt pull tests will be conducted to failure. If a bolt fails to reach 75% of the yield strength, additional pull tests shall be carried out on surrounding bolts. Additional pull testing will aim to test 10% of bolts located in the five rings before and five rings after the failed bolt.

A summary of Pretium's Bolt Testing Procedures and Example Test Results are included in Supporting Information Package III.

5.3.2 Shotcrete QA/QC

In the event that shotcrete is used at Brucejack to support or remediate "Fair to Poor" ground, or for other Ground Control applications, the following QA / QC procedures will be implemented to verify adequate installation.

5.3.2.1 Batch Plant

Several quantities require monitoring during the batching stage of shotcrete production. Monitoring of these quantities is the responsibility of the Shotcrete Operator. These include:

1. The quality of the ingredients (moisture content, aggregate grading curves, etc.);
2. Cement quality;
3. Equipment calibration;
4. Shotcrete mix quality tests (temperature, unit mass, air content, maximum values of boiled absorption/maximum volume of permeable voids); and
5. Shotcrete slump testing (to be carried out once batching is complete).

5.3.2.2 During Installation

Several quantities shall be monitored during and directly after the spraying of the shotcrete. Monitoring of these quantities is the responsibility of the Shift Boss and Operators. These include:

1. Operational performance. During spraying of the shotcrete the Operator will note the ability of shotcrete to adhere to the excavation surface. Other problems such as balling of fibres (if used) or poor mix quality shall be noted by the Operator / Nozzleman. If the shotcrete mix is not suitable for spraying then the batch is to be rejected. A record of the amount of additives used during spraying, total cubic metres sprayed, and operating times shall be kept by the Nozzleman.
2. Performance during bolting. If the shotcrete breaks out during bolt installation then the Operator will stop the bolt installation. Bolting must not recommence for a 30-minute duration, to give the shotcrete further time to cure. If the shotcrete continues to break out then the Geotechnical Engineer shall be notified.
3. Thickness Checks shall be performed at regular intervals to ensure that the applied coverage meets design specifications.

5.3.2.3 Long Term Shotcrete Performance

The long-term performance of shotcrete can usually be monitored effectively with standardized, regular visual inspections. Shotcrete damage and cracking detected in areas of operational significance are to be monitored regularly. Changes in conditions must be documented and changes in crack length and aperture measured and recorded.

Other testing for long term shotcrete performance includes testing of mechanical properties. Testing of shotcrete will be carried out to determine:

1. Unconfined Compressive Strength (UCS). UCS samples shall be taken once for each heading where sprayed shotcrete by coring through shotcrete panels, or similar. Tests to determine representative UCS values at 1 day, 7 day, and 28 days shall be completed.
2. Toughness or Energy Absorption. Round Determinate Panel (RDP) tests shall be carried out as determined by BTS, depending on the type of shotcrete used (e.g., normal vs. fibrecrete) and the intended service conditions. Energy absorbed by test panels shall be equal to or greater than 360 j.

A project-specific Shotcrete QA /QC program will be developed for Brucejack in the event that significant quantities or regular use of shotcrete is required.

5.3.3 Grouting and Grout Testing

A high strength cement grout of consistent quality is required to ensure there is adequate bond between the rock bolt or cable bolt and the rock mass. The water to cement ratio to be used will depend on the type of cable bolt being installed and the grouting methods. The ratio shall be between 0.35(grout tube method) and 0.4 (breather tube method).

Uniaxial Compressive Strength and water cement ratio testing will be conducted on grout cylinders and grout bottles randomly collected during an underground grouting cycle. A minimum UCS of 30 MPa should be achieved after 28 days of curing and water cement ratio should be not more than 0.45. These tests will be performed on cable bolts installation on a random basis. However, the frequency of testing will be increased if grout strength does not meet the criteria.

5.4 REVIEWING AND UPDATING THE GROUND CONTROL MANAGEMENT PLAN

5.4.1 Annual Review of the GCMP

The GCMP is considered a "live" document that is regularly updated as ground control management approaches are changed and as knowledge of the rock mass behavior is developed.

The GCMP is reviewed annually and updated as determined by a Professional Engineer in accordance with *Mines Act* Permit M-243 Condition C.2(d). Any deficiencies identified in the annual review are addressed and included in the applicable update of the GCMP.

5.4.2 GCMP Audit

Starting in 2018, and every four years thereafter, or at the discretion of the Chief Inspector, the GCMP is audited by a third-party in accordance with *Mines Act* Permit M-243 Condition C.2(m)(ii).

5.4.3 Certification

This document was prepared, reviewed, and approved by the undersigned.

Prepared:

Woo Shin, Ph.D., P.Eng.
Senior Geotechnical Engineer, Brucejack Mine

Reviewed:

Dinesh Devathasan, P.Eng.
Chief Mine Engineer, Brucejack Mine

Approved:

Travis Murphy, P.Geo.
Technical Services Manager & Mine Manager, Brucejack Mine

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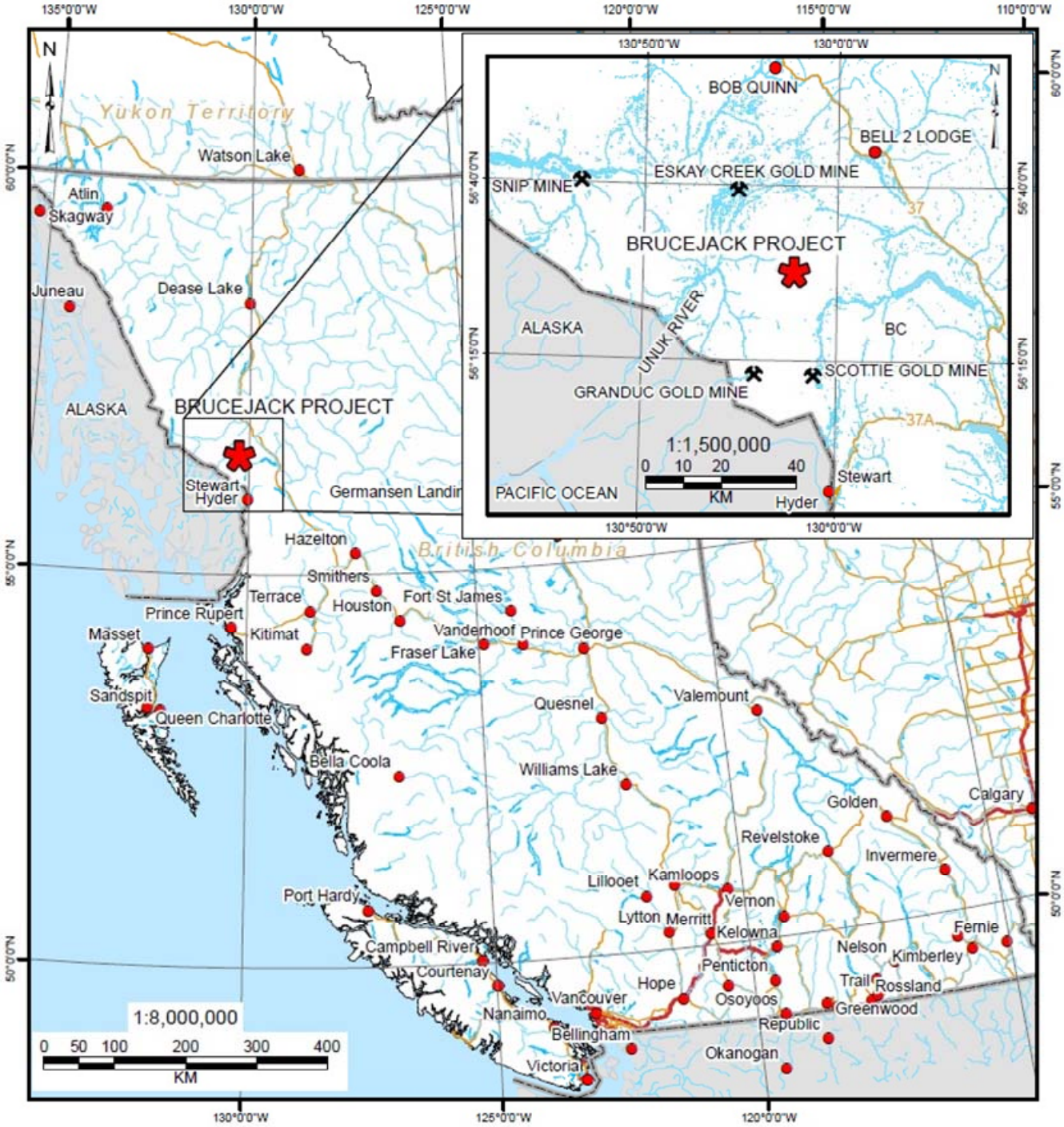
Drawings

Drawing 01

Location Map



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PROJECT: BRUCEJACK PROJECT - GCMP

TITLE: LOCATION MAP

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.:	DWG No.:	REV.:
1008020-02	01	A

DWG. TO BE READ WITH REPORT TITLED "BRUCEJACK PROJECT GROUND CONTROL MANAGEMENT PLAN" DATED AUGUST 2015

\\BGC-HV-FILE2\Data\BGC\Projects\1008 Pretium\010 EA 2013\006 Geotechnical\06 Underground GCMP\Reports\GCMP\2015 Version - Rev 1\GCMP Drawings3\supporting files\Drawing 01 - Location Map.grf

Drawing 02

Developed Prospects and Past Producers Near Brucejack Project, Plan Map

NOTES:
1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2. THIS DRAWING MUST BE READ IN CONJUNCTION WITH THE REPORT TITLED "BRUCEJACK PROJECT GROUND CONTROL MANAGEMENT PLAN," AND DATED AUGUST 2015.
3. BASE TOPOGRAPHIC DATA BASED ON CONTOURS FROM CANADIAN DIGITAL ELEVATION DATASET 250K, DATED APRIL 2012. CONTOUR INTERVAL IS 100 m.
4. BASEMAP ORTHOPHOTO FROM ESRI ONLINE WORLD IMAGERY.
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PROJECT: BRUCEJACK PROJECT – GCMP

TITLE: DEVELOPED PROSPECTS AND PAST PRODUCERS NEAR BRUCEJACK PROJECT

PROJECT No.: 1008020-02

DWG No: 02

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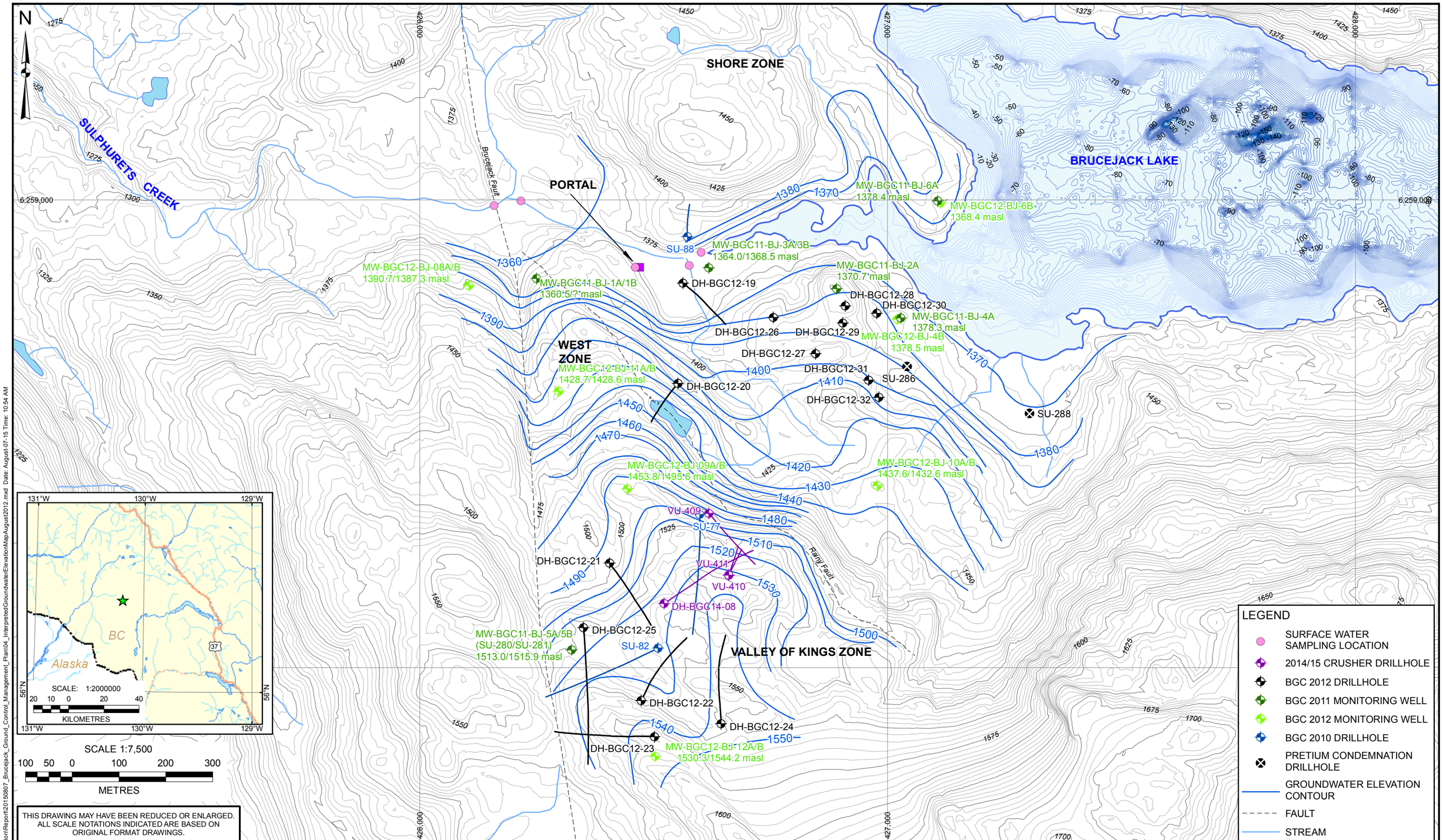
Drawing 03

Interpreted Groundwater Elevation Map



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3. BASE TOPOGRAPHIC DATA BASED ON CONTOURS PROVIDED BY AEROGEOMETRICS, DATED FEBRUARY 2011. CONTOUR INTERVAL IS 5 m.
4. PROJECTION IS NAD 1983 UTM ZONE 9N.
5. GROUNDWATER LEVELS MEASURED AUG 14, 2012.
6. ALL HYDROLOGY DATA PROVIDED BY CANVEC, JUNE 2010.
7. BATHYMETRY DATA FOR BRUCEJACK LAKE SUPPLIED BY RESCAN, FEB 2011.
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PROJECT: BRUCEJACK PROJECT – GCMP

TITLE: INTERPRETED GROUNDWATER ELEVATION MAP - AUGUST 2012

PROJECT No.: 1008007

DWG No: 03

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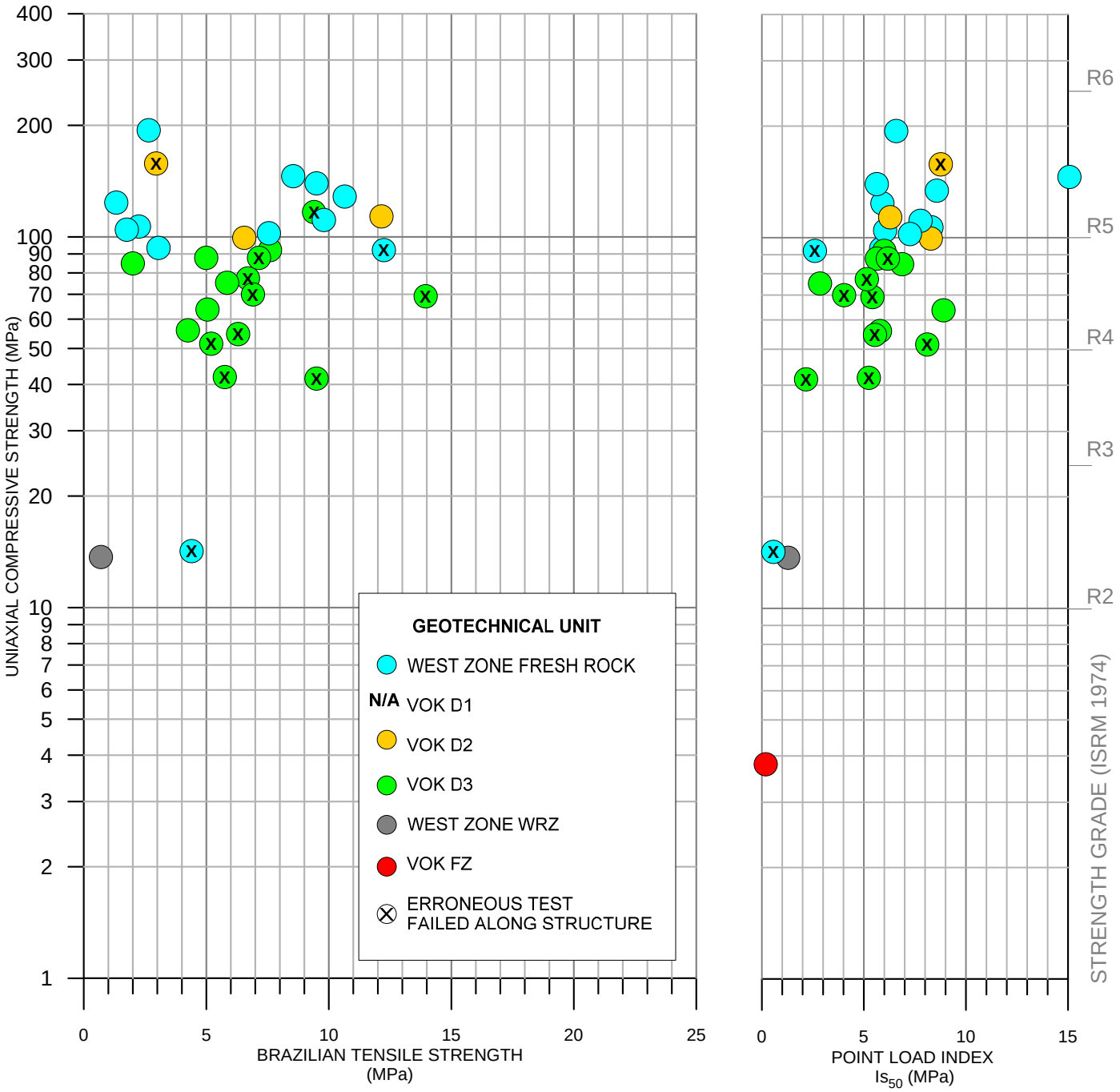
Drawing 04

Laboratory Intact Rock Strength Testing Results



NOTES:
1. LABORATORY TEST REPORTS PROVIDED IN APPENDIX C.
2. WHERE POSSIBLE, TWO BRAZILIAN TENSILE STRENGTH TESTS HAVE BEEN COMPLETED AND AVERAGED FROM OFF-CUTS OF EACH UNIAXIAL COMPRESSIVE STRENGTH SAMPLE.
3. PLOTTED Is_{50} VALUES ARE THE AVERAGE OF TWO TO FOUR POINT LOAD TESTS COMPLETED ADJACENT TO EACH UCS SAMPLE.

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PROJECT: BRUCEJACK PROJECT - GCMP

TITLE: LABORATORY INTACT ROCK STRENGTH TESTING RESULTS

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PRETIUM RESOURCES INC.	1008020-02	04	

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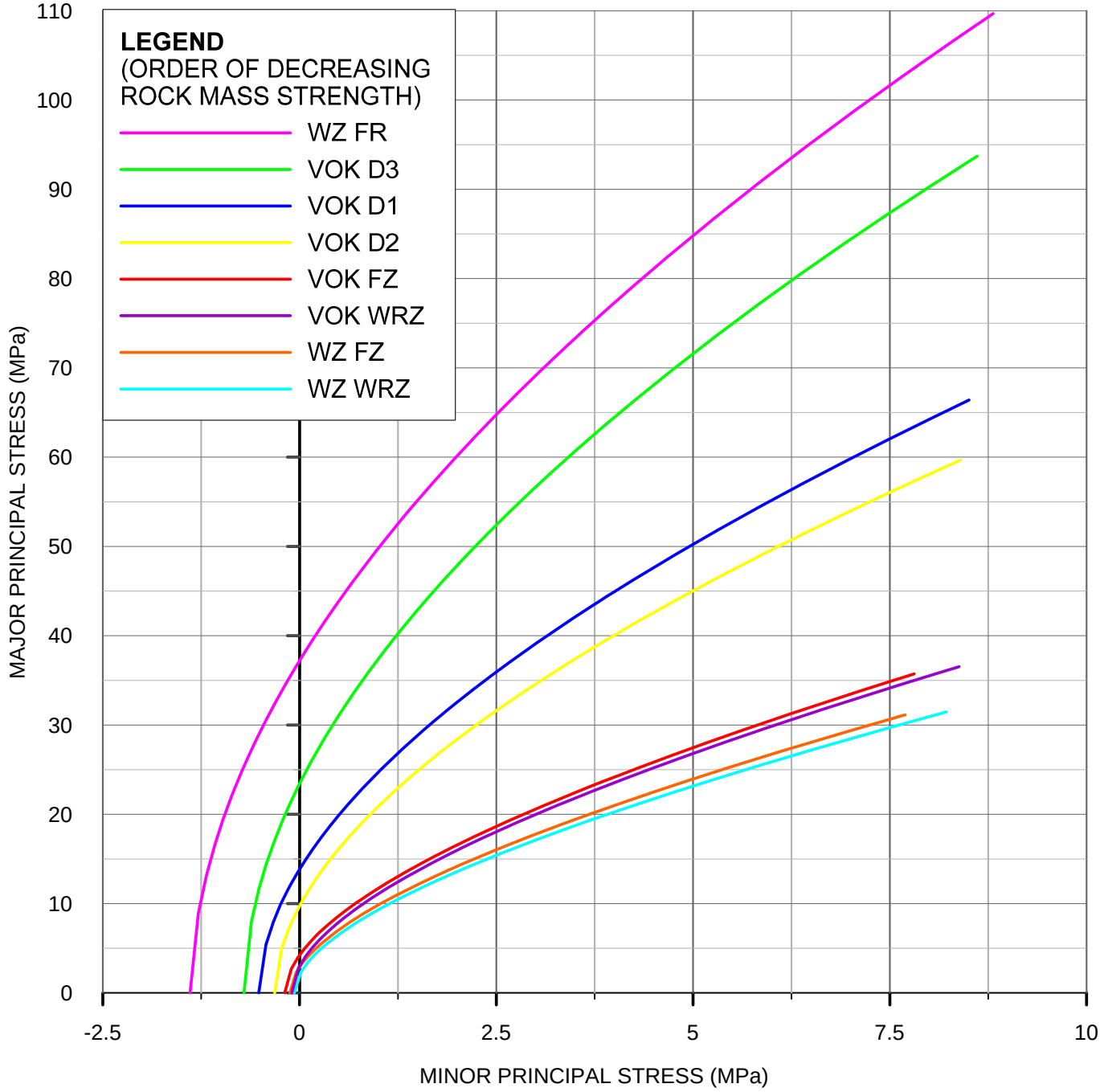
Drawing 05

Hoek-Brown Strength Curves for Geotechnical Units



NOTES:
1. A DISTURBANCE FACTOR OF 0.8 WAS ASSUMED FOR ANALYSES.
2. DATA SOURCES INCLUDE GEOTECHNICAL CORE LOGGING, LABORATORY TESTING, AND LITERATURE.
3. A CONFINING STRESS EQUIVALENT TO A TUNNEL AT 650 m DEPTH WAS ASSUMED FOR THE FAILURE ENVELOPE RANGE.

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PROJECT: BRUCEJACK PROJECT - GCMP

TITLE: HOEK-BROWN STRENGTH CURVES FOR GEOTECHNICAL UNITS

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.:	DWG No.:	REV.:
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N:\BGC\Projects\1008 Pretium\007 Feasibility\002 ug - Office\01 Rockmass and Structure\Rockmass\Strength Curves

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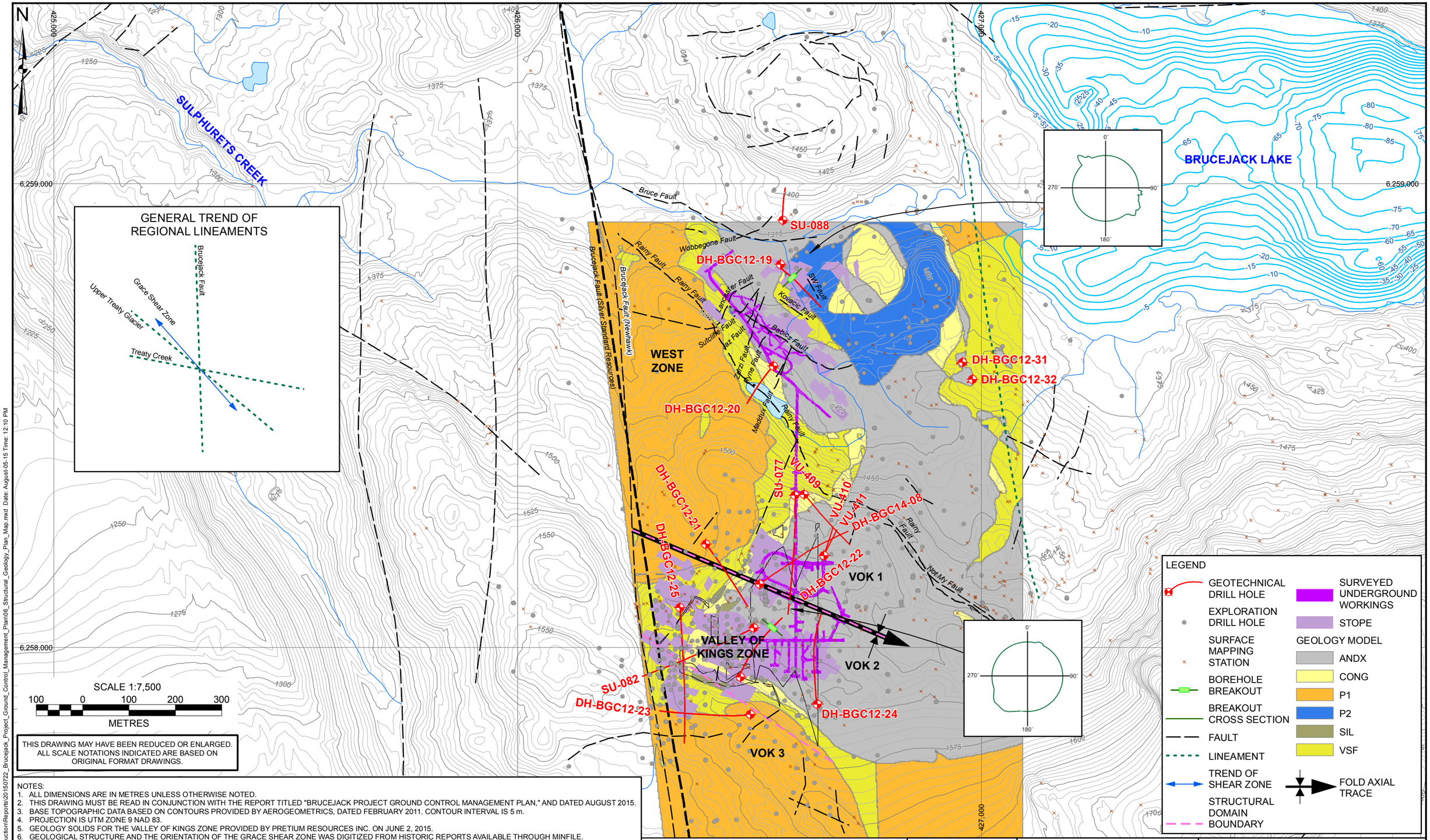
Drawing 06

Structural Geology Plan Map



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3. BASE TOPOGRAPHIC DATA BASED ON CONTOURS PROVIDED BY AEROGEOMETRICS, DATED FEBRUARY 2011. CONTOUR INTERVAL IS 5 m.
4. PROJECTION IS UTM ZONE 9 NAD 83.
5. GEOLOGY SOLIDS FOR THE VALLEY OF KINGS ZONE PROVIDED BY PRETIUM RESOURCES INC. ON JUNE 2, 2015.
6. GEOLOGICAL STRUCTURE AND THE ORIENTATION OF THE GRACE SHEAR ZONE WAS DIGITIZED FROM HISTORIC REPORTS AVAILABLE THROUGH MINFILE.
7. SURVEYS OF THE AS BUILT UNDERGROUND WORKINGS WERE PROVIDED BY PRETIUM RESOURCES INC. ON JUNE 22, 2015.
8. REGIONAL LINEAMENTS ARE INTERPRETED FROM A STRUCTURAL GEOLOGY REVIEW BY EARTH RESOURCE SURVEYS INC. FOR AN ADJACENT PROPERTY.
9. SYNCLINE AXIAL TRACE PROVIDED BY PRETIUM RESOURCES INC. ON THEIR MAY 1, 2012 "BRUCEJACK HIGH-GRADE TECHNICAL SESSION" PRESENTATION.
10. BRUCEJACK FAULT SURFACE TRACES PROVIDED BY SILVER STANDARD RESOURCES INC. ON MAY 21, 2010 AND DIGITIZED FROM HISTORIC NEWHAWK GOLD MINES LTD. MAPS.
11. BATHYMETRY OF BRUCEJACK LAKE RECEIVED FROM RESCAN FEBRUARY 2013.
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PROJECT: BRUCEJACK PROJECT – GCMP

TITLE: STRUCTURAL GEOLOGY PLAN MAP

PROJECT No.: 1008020-02

DWG No: 06

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Appendices

Appendix A

Drill Hole Summary Logs

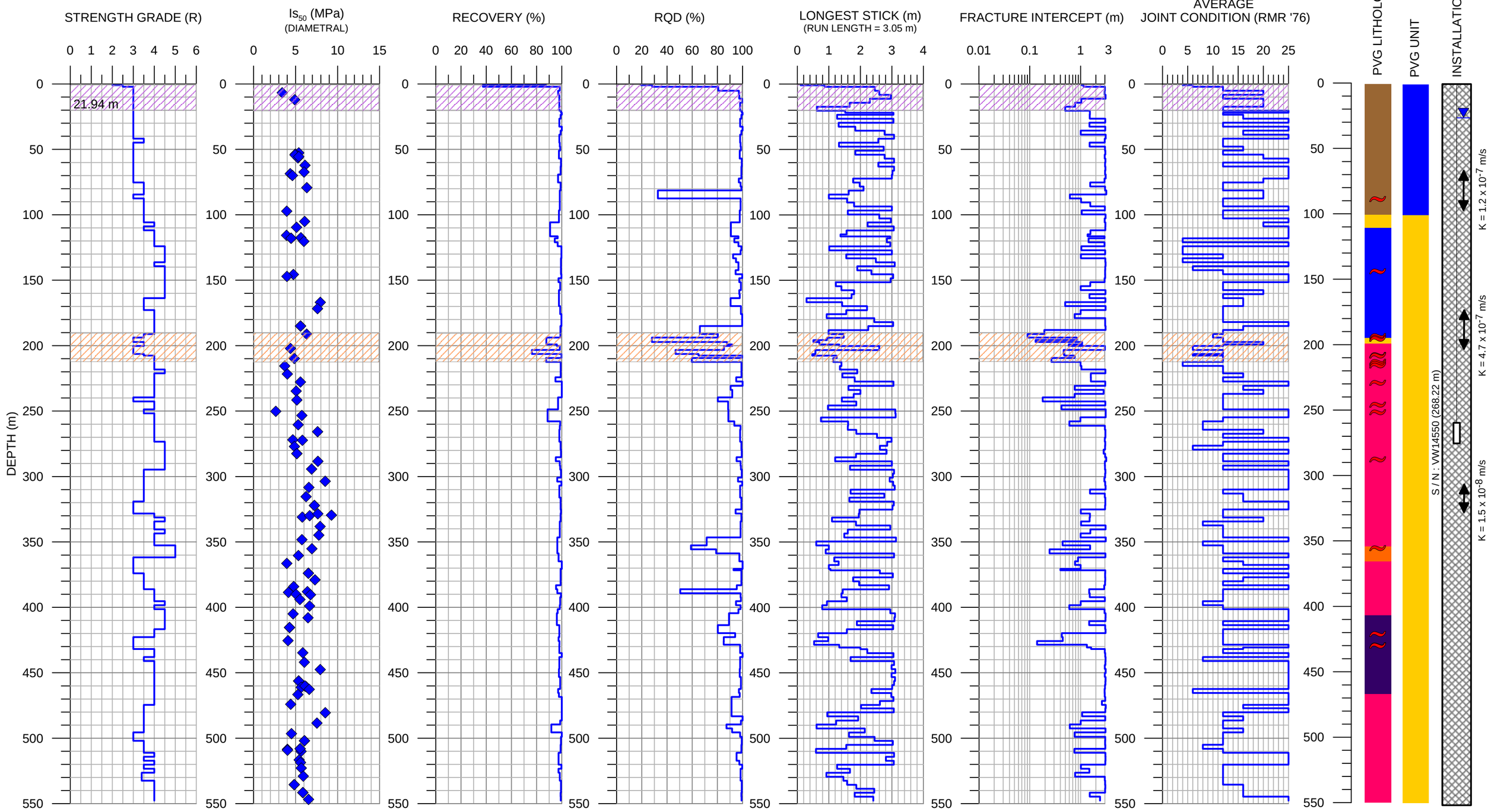
Table 10. Brucejack Project Site Investigation Downhole Plots Unit and Lithology Key

Code	Unit Description
ARG	Argillite
JR	Jurassic conglomerate
P1	Porphyry
RHY	Rhyolite
TRS	Triassic Sediments
ANDX	Andesite

Code	Lithology Description
P1	Plagioclase-hornblende porphyritic rocks (feldspar phyric to porphyritic, lesser hornblende phenocrysts)
P2	Potassium feldsapr-hornblende-plagioclase porphyritic volcanic rocks
P3	Plagioclase porphyritic rocks
V1	Rhyolite (quartz-rich (> 15% quartz by vol) or siliceous volcanic rock)
V2	Felsic volcanic rocks (Rhyolite, Ryodacite, Dacite; silica content > 63%
V4	Intermediate volcanic rocks (Andesite, Latite; Silica content 57-63%)
V5	Trachyte (andesitic; mainly flows/sills with K-feldspar phenocrysts)
V6	Mafic dykes; cross cutting, basaltic-andesite
V8	Mafic volcanic rocks (basaltic-andesite, basalt; silica content 45-57%)
V12	Calcareous intermediate volcanic
I2	Felsic intrusive rocks
I4	Intermediate intrusive rocks
I8	Mafic intrusive rocks
M7	Metamorphosed intermediate to mafic rocks
S2	Oligomictic conglomerate
S3	Polylithic conglomerate (coarser clasts, angular to sub-angular, poorly sorted)
S4	Sandstone/arenite (fine- to coarse-grained); greywacke; carbonate rocks (limestone)
S5	Mudstone/siltstones/pelites (including calcareous); cherts and jasperites
H1	quartz vein (identified as lithology when > 100 cm)
H2	quartz-carbonate vein (massive white to white quartz and pink or white calcite, yellow sericite, ivory ankerite veining, carbonate comprised at least 5% of vein)
H3	quartz-silicate vein (quartz-tourmaline; often occurring as hard, dark-grey veinlets)
H4	quartz-sulphide vein
H6	Hydrothermal replacement (quartz veining is greater than 50% and any clasts present have been largely replaced by silica)
H7	Hydrothermal breccias (quartz veining is greater than 25%)
H8	Intensely silicified breccia zone (possible rhyolite); associated with WZ and VOK
H15	Hydrothermally altered rock
FZ	Fault Zone
NC	no core/chips
NR	not recorded
OVB	overburden

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

SU-077 DOWNHOLE DATA



LITHOLOGY: P1, V2, V8, I4, S3, H1, H4, H8, NC, P2, V4, V12, I8, S4, H2, H6, H15, OVB, P3, V6, I2, S2, S5, H3, H7, FZ, FAULT

UNIT: ARG, RHY, JR, TRS, P1, ANDX

INSTALLATION: GROUT, OPEN HOLE, PLUG, STATIC WATER LEVEL, PACKER INTERVAL, BRUCEJACK FAULT ZONE, WEATHERED ROCK ZONE, FAULT ZONE

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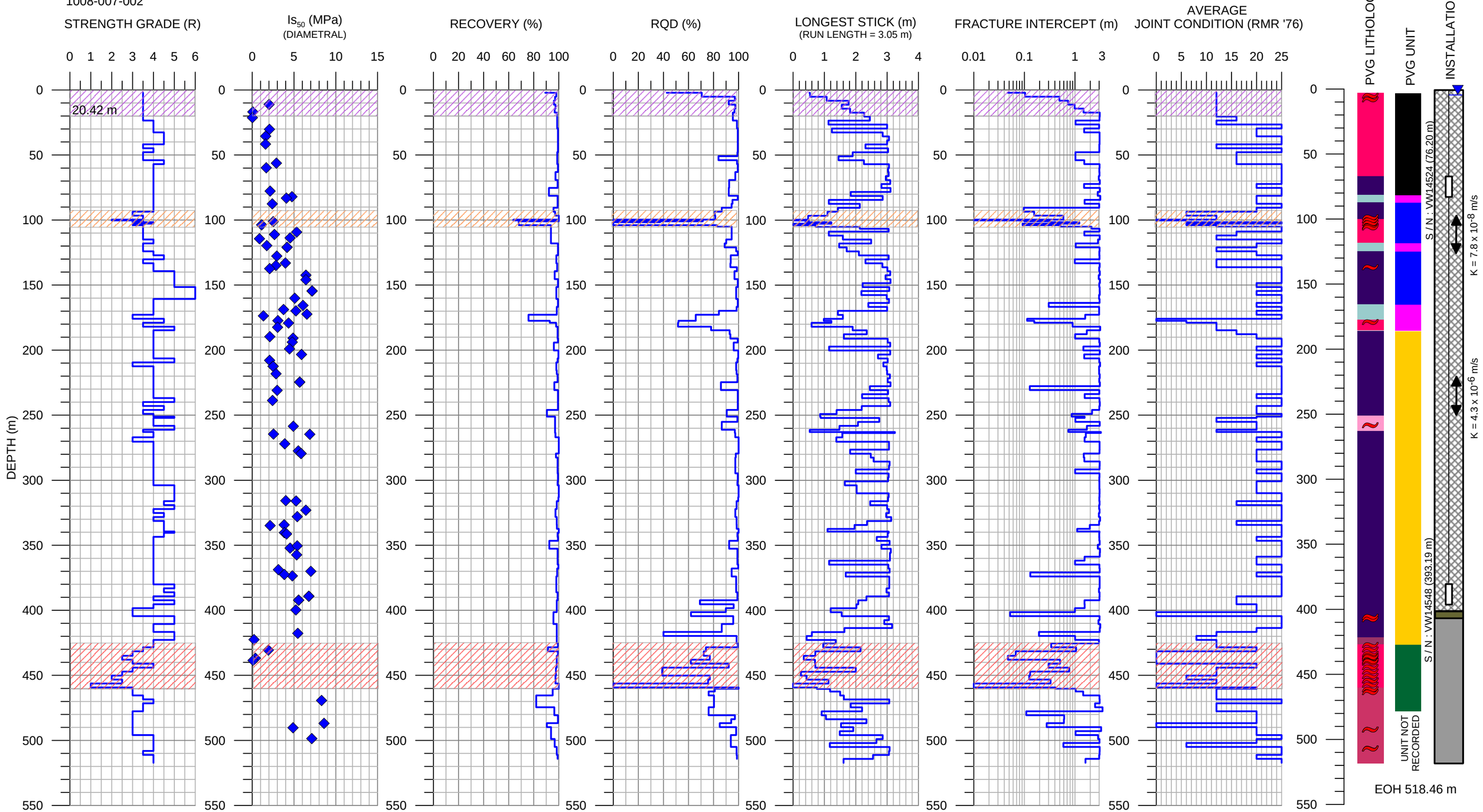
BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

SU-082 DOWNHOLE DATA



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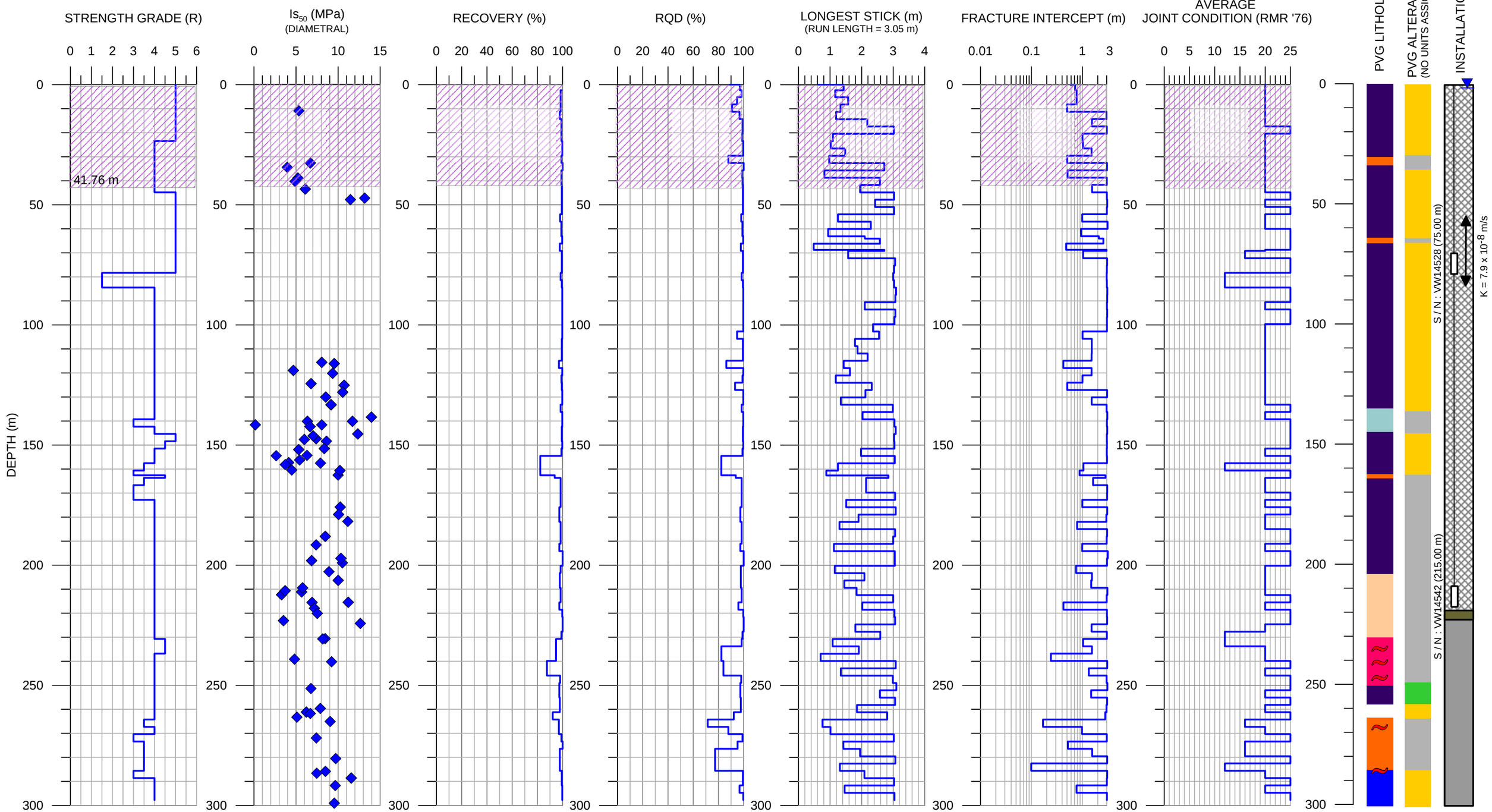
BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

SU-088 DOWNHOLE DATA



LITHOLOGY: P1, V2, V8, I4, S3, H1, H4, H8, NC, P2, V4, V12, I8, S4, H2, H6, H15, OVB, P3, V6, I2, S2, S5, H3, H7, FZ, FAULT

ALTERATION: CHLORITIC, SERICITIC, SILICEOUS, CHLORITIC - SERICITIC

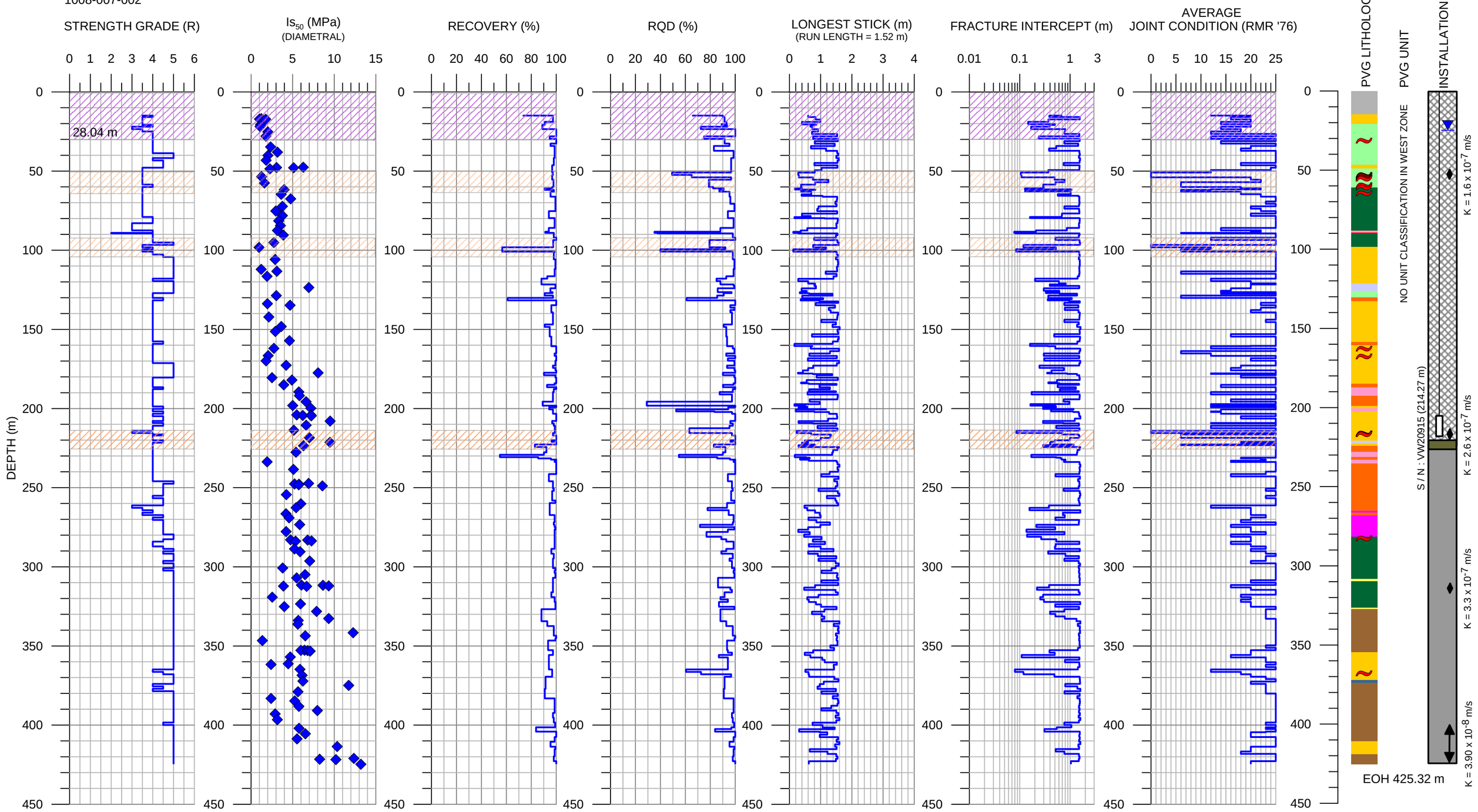
INSTALLATION: GROUT, OPEN HOLE, PLUG, STATIC WATER LEVEL, PACKER INTERVAL

BRUCEJACK FAULT ZONE, WEATHERED ROCK ZONE, FAULT ZONE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

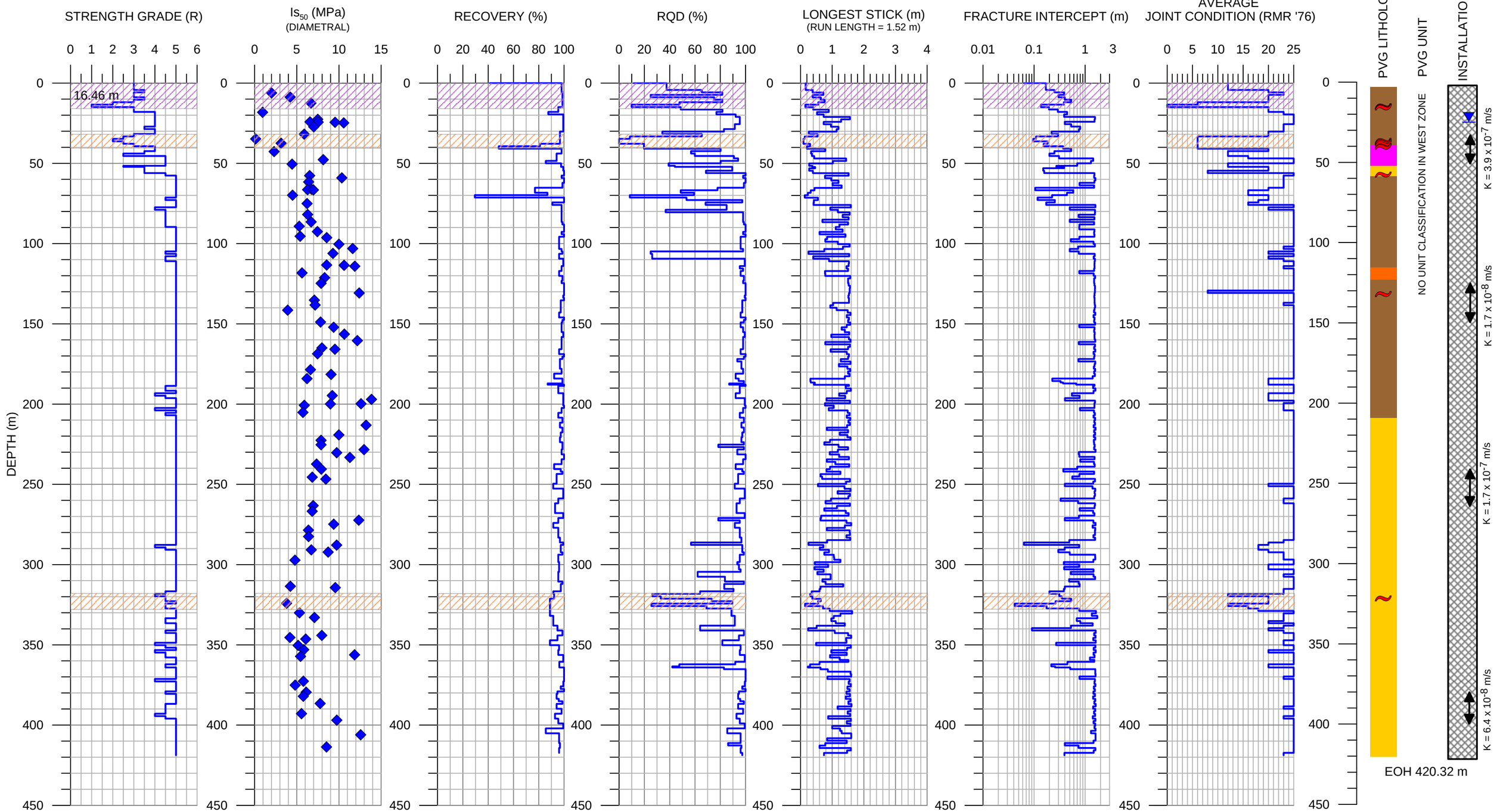
DH-BGC12-19 DOWNHOLE DATA



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

DH-BGC12-20 DOWNHOLE DATA



LITHOLOGY: P1, V2, V8, I4, S3, H1, H4, H8, NC, P2, V4, V12, I8, S4, H2, H6, H15, OVB, P3, V6, I2, S2, S5, H3, H7, FZ, FAULT

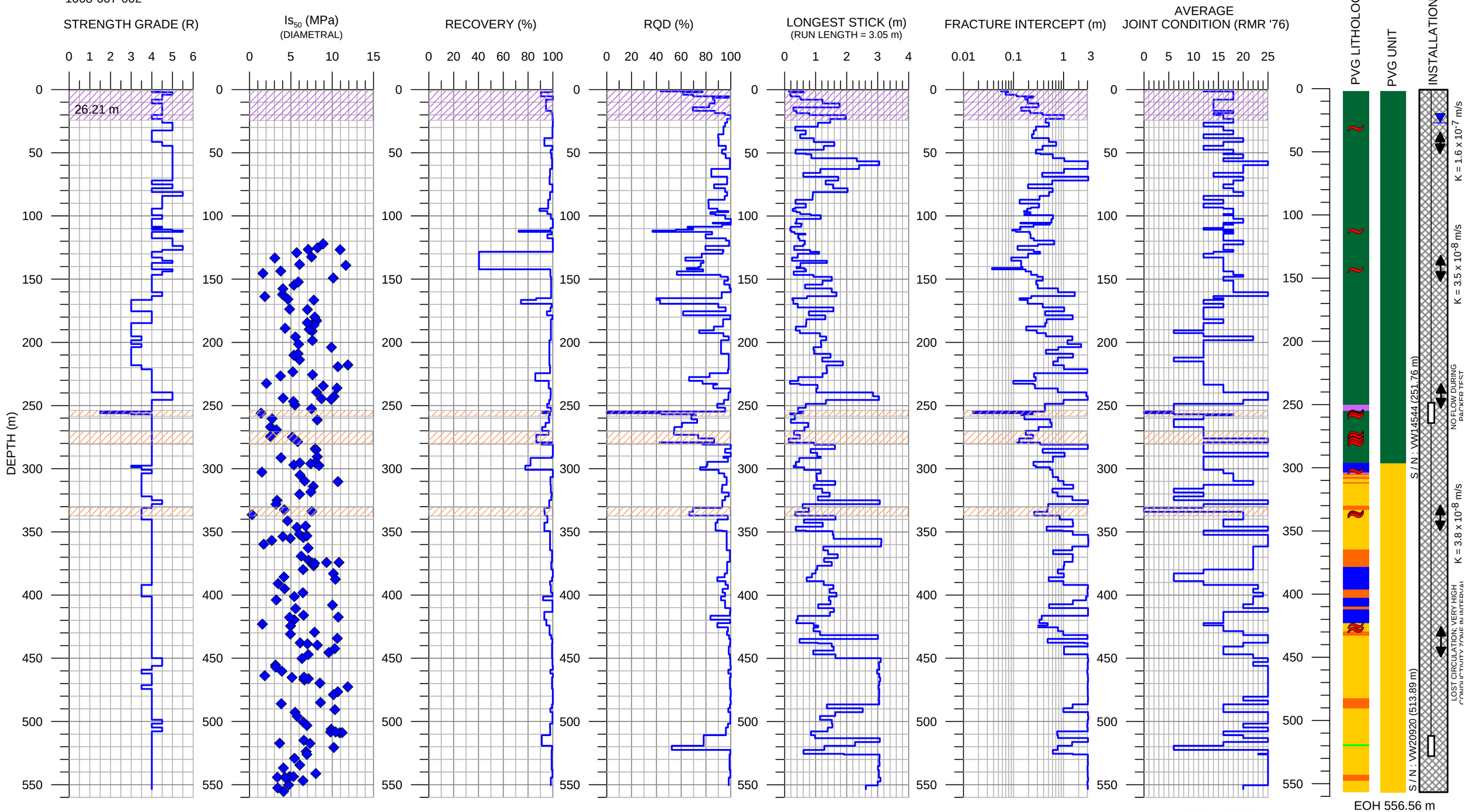
UNIT: ARG, RHY, JR, TRS, P1, ANDX

INSTALLATION: GROUT, OPEN HOLE, PLUG, STATIC WATER LEVEL, PACKER INTERVAL, BRUCEJACK FAULT ZONE, WEATHERED ROCK ZONE, FAULT ZONE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

DH-BGC12-21 DOWNHOLE DATA



LITHOLOGY: P1, P2, P3, V2, V4, V6, V8, V12, I2, I4, I8, S2, S3, S4, S5, H1, H2, H3, H4, H6, H7, H8, H15, FZ, NC, OVB, FAULT

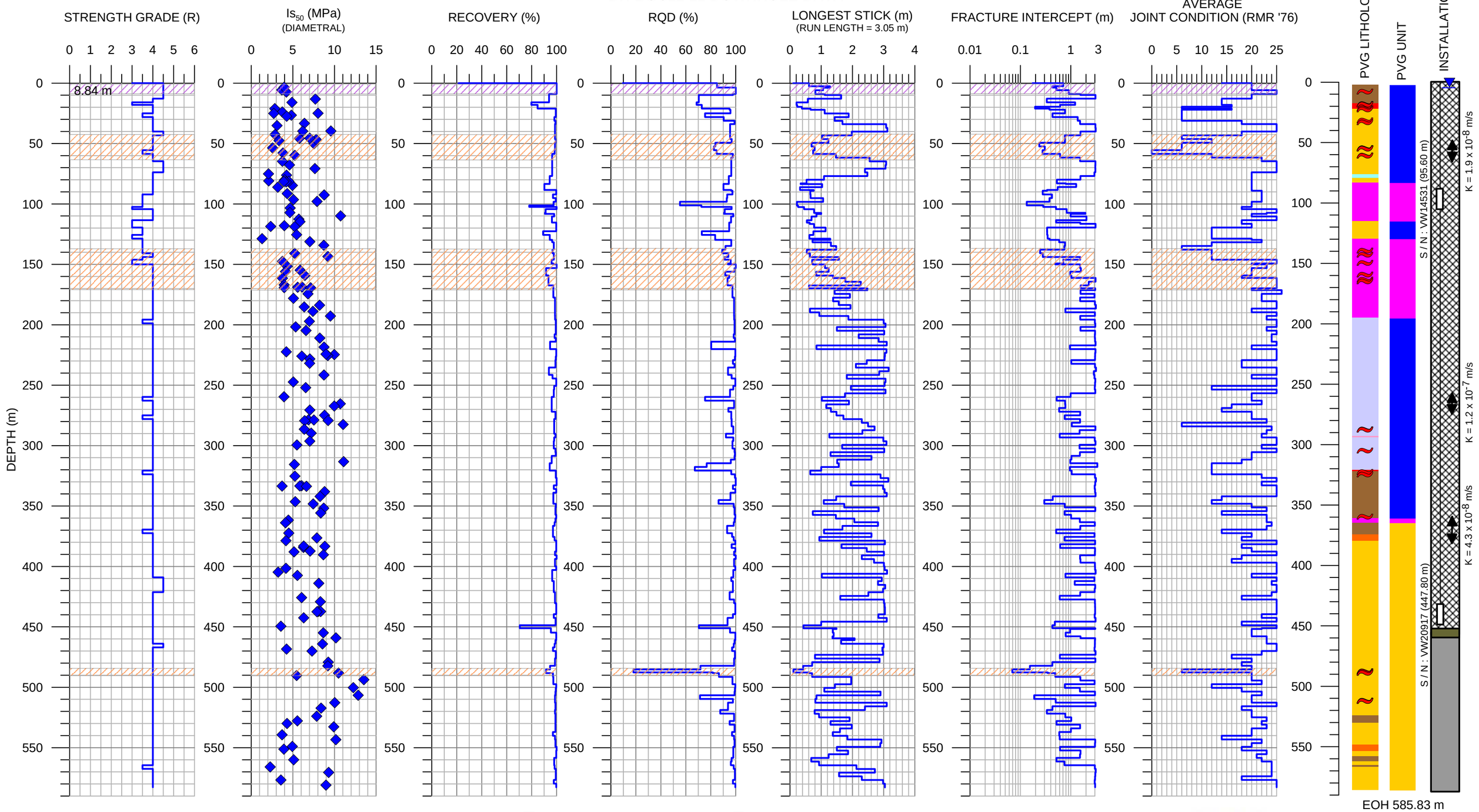
UNIT: ARG, JR, P1, RHY, TRS, ANDX

INSTALLATION: GROUT, OPEN HOLE, PLUG, STATIC WATER LEVEL, PACKER INTERVAL, BRUCEJACK FAULT ZONE, WEATHERED ROCK ZONE, FAULT ZONE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

DH-BGC12-22 DOWNHOLE DATA



LITHOLOGY: P1, V2, V8, I4, S3, H1, H4, H8, NC, P2, V4, V12, I8, S4, H2, H6, H15, OVB, P3, V6, I2, S2, S5, H3, H7, FZ, FAULT

UNIT: ARG, RHY, JR, TRS, P1, ANDX

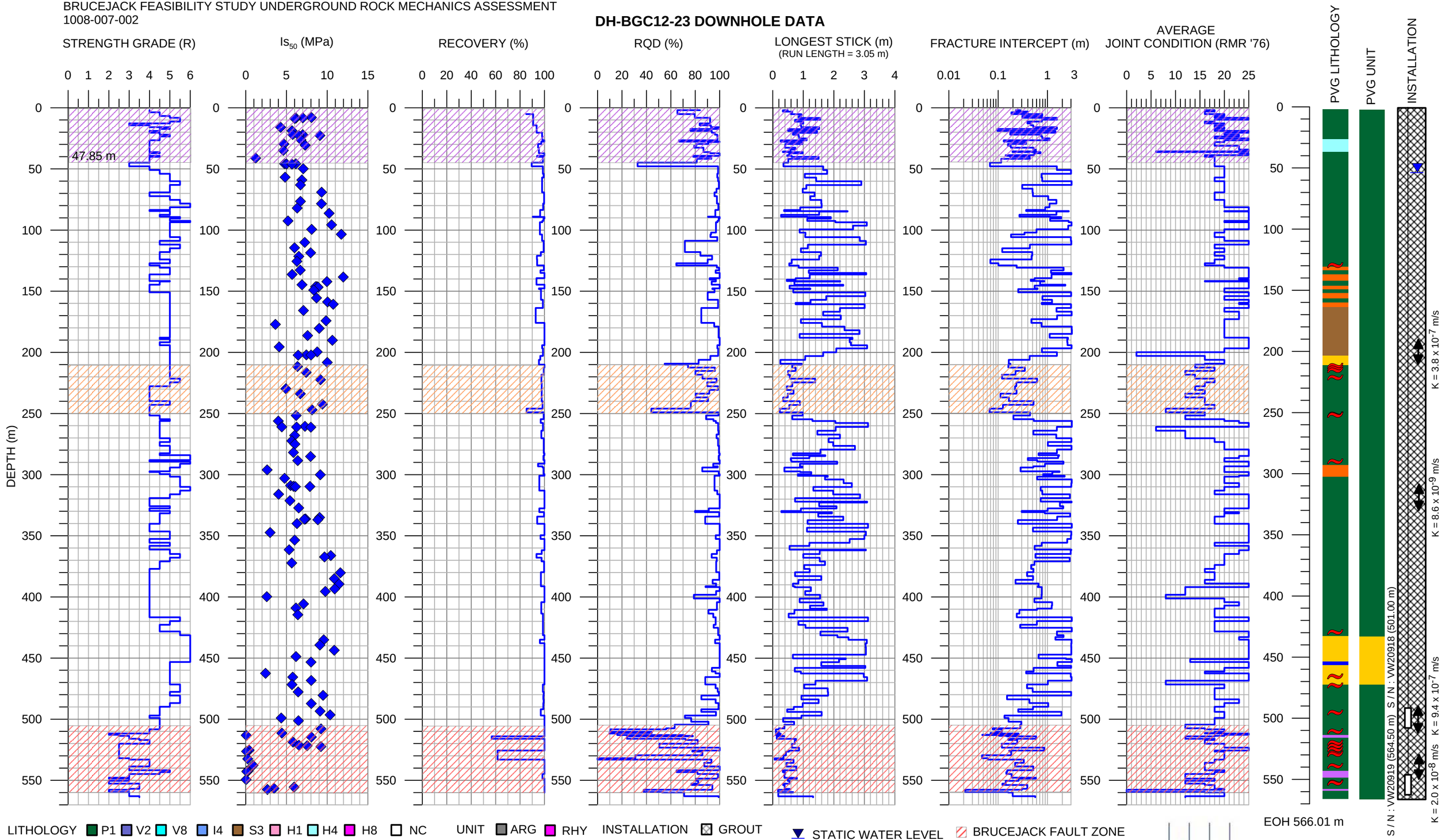
INSTALLATION: GROUT, OPEN HOLE, PLUG, STATIC WATER LEVEL, PACKER INTERVAL

BRUCEJACK FAULT ZONE
WEATHERED ROCK ZONE
FAULT ZONE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

DH-BGC12-23 DOWNHOLE DATA



BGC ENGINEERING INC.
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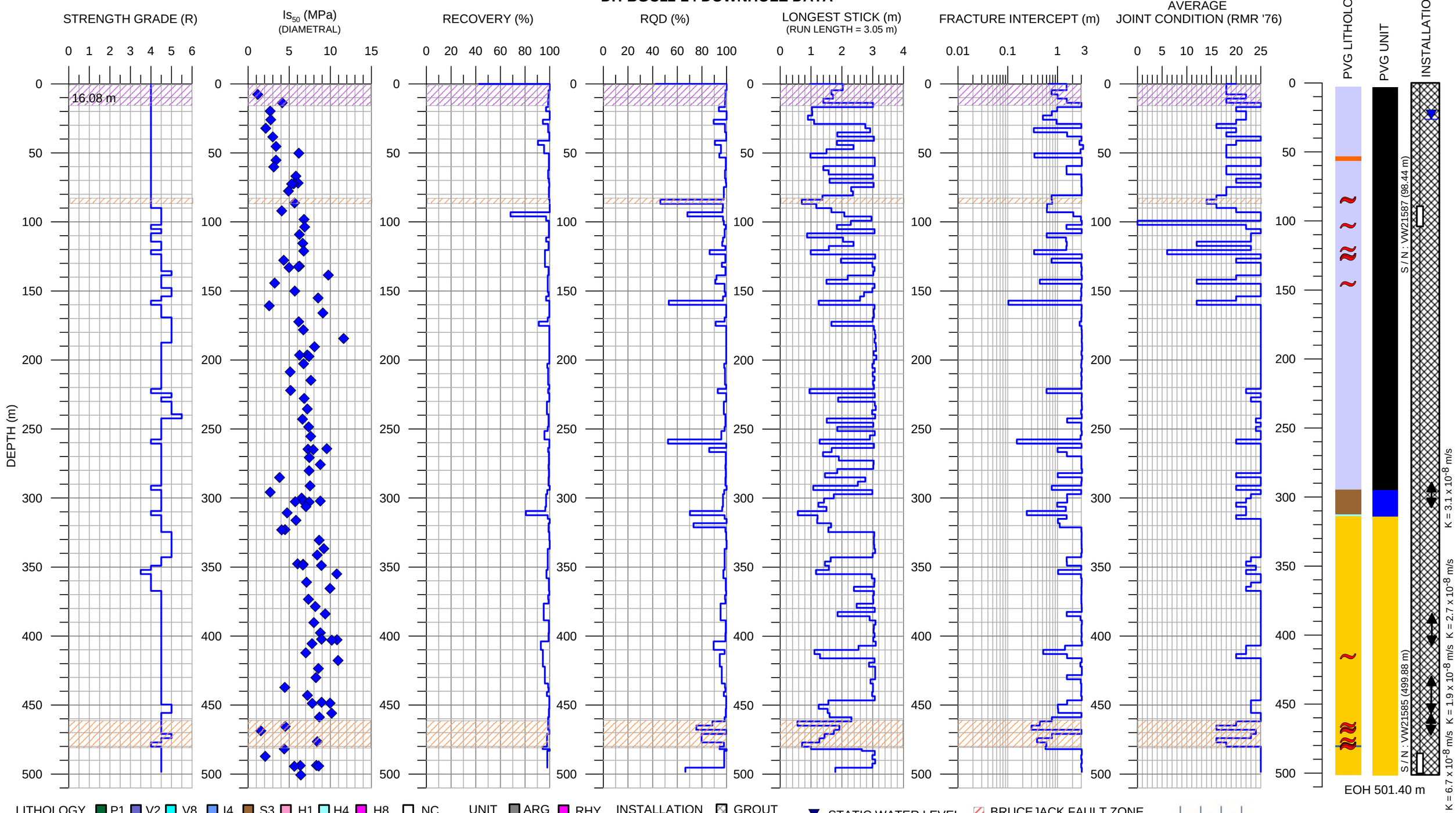
BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

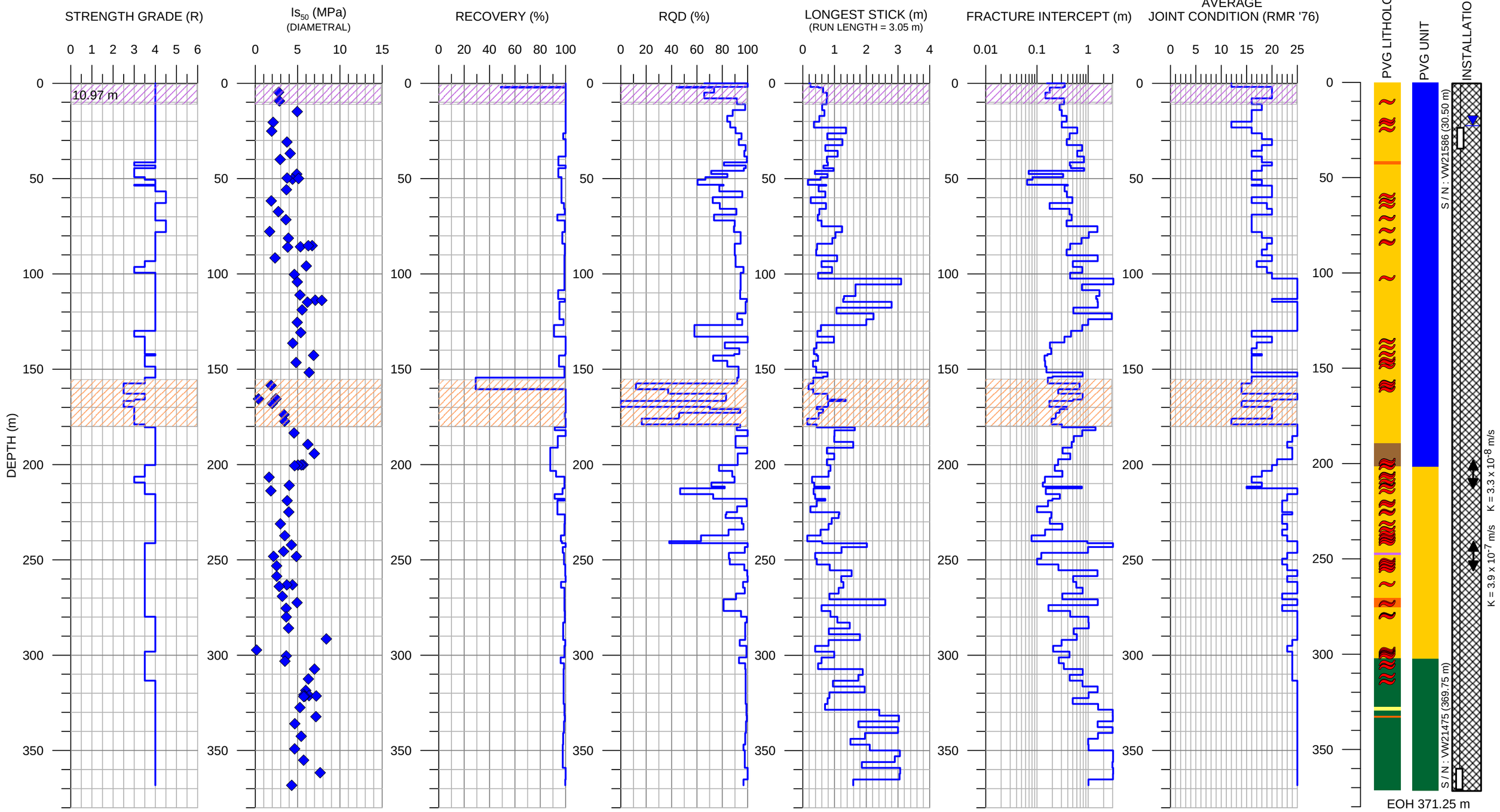
DH-BGC12-24 DOWNHOLE DATA



BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

BRUCEJACK FEASIBILITY STUDY UNDERGROUND ROCK MECHANICS ASSESSMENT
1008-007-002

DH-BGC12-25 DOWNHOLE DATA



LITHOLOGY: P1, V2, V8, I4, S3, H1, H4, H8, NC, P2, V4, V12, I8, S4, H2, H6, H15, OVB, P3, V6, I2, S2, S5, H3, H7, FZ, FAULT

UNIT: ARG, RHY, JR, TRS, P1, ANDX

INSTALLATION: GROUT, OPEN HOLE, PLUG, STATIC WATER LEVEL, PACKER INTERVAL

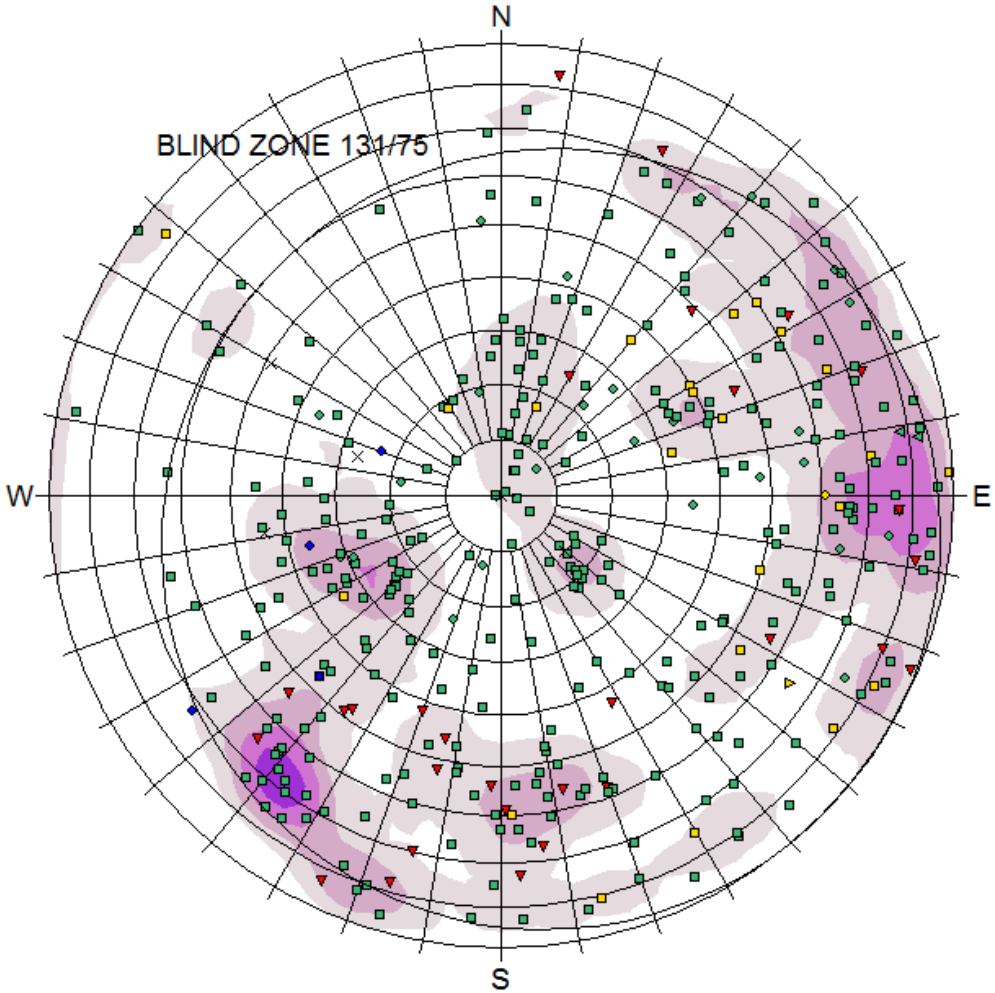
BRUCEJACK FAULT ZONE, WEATHERED ROCK ZONE, FAULT ZONE

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Appendix B

Drill Hole and Underground Mapping Stereonets

BRUCEJACK FEASIBILITY STUDY



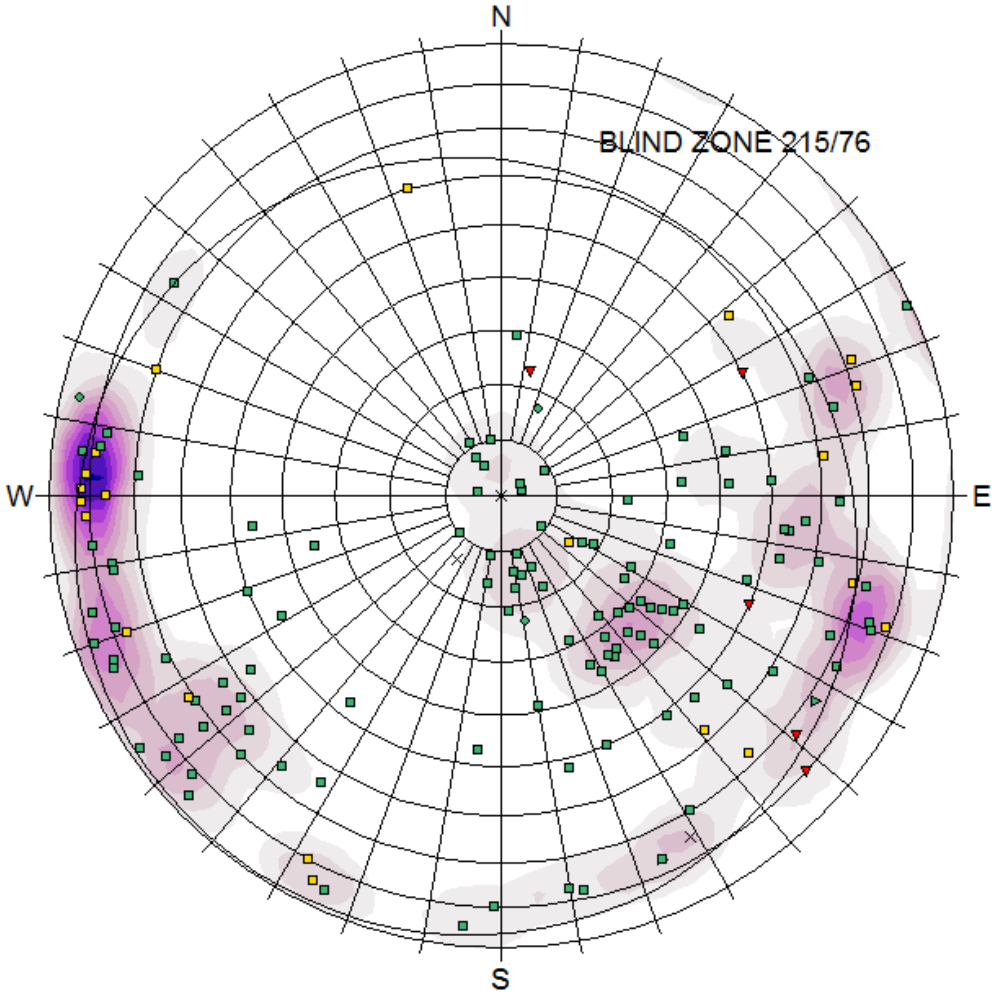
TYPE

- C [3]
- F [29]
- J [272]
- J-B [2]
- J-V [25]
- S [24]
- S-O [1]
- S-V [1]
- V [4]

Equal Area
Lower Hemisphere
361 Poles
361 Entries

DH-BGC12-19 - TELEVIEWER

BRUCEJACK FEASIBILITY STUDY



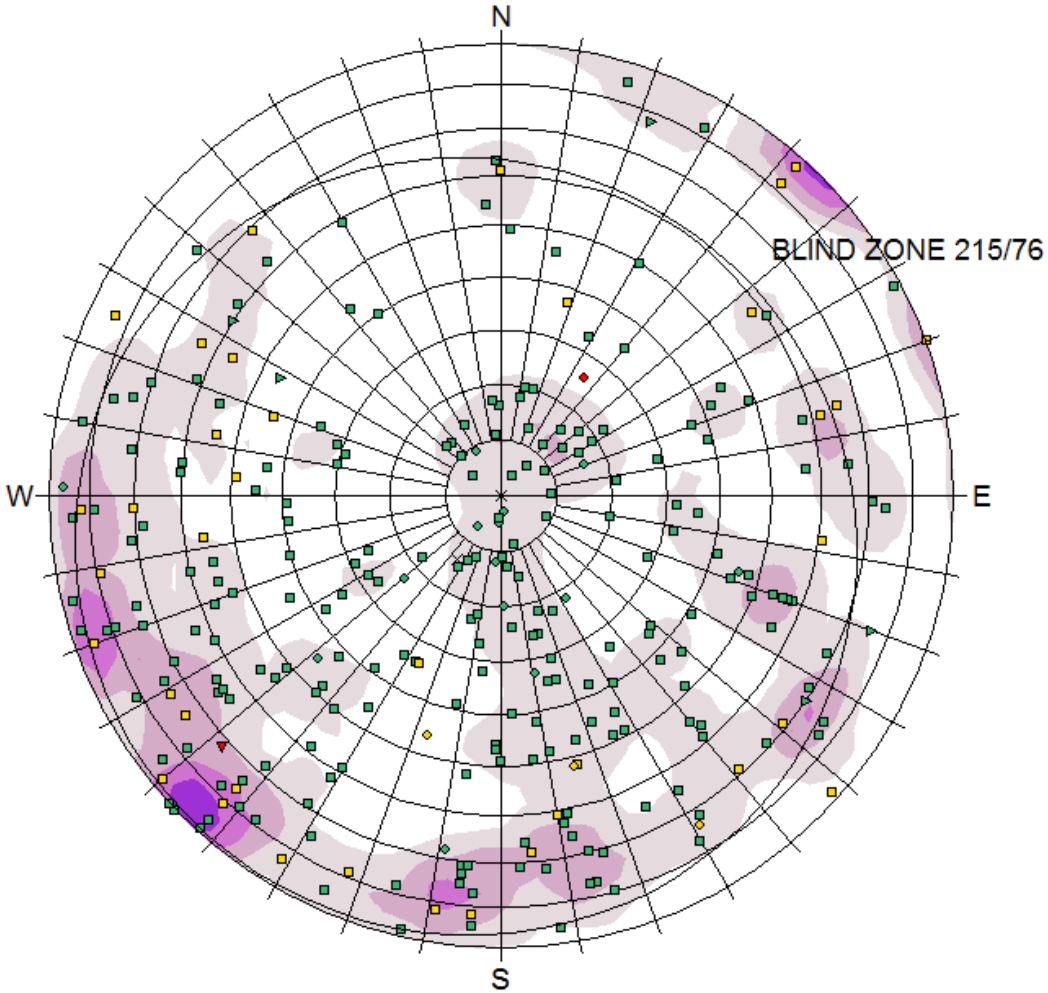
TYPE

- C [1]
- F [5]
- J [114]
- J-O [2]
- J-V [3]
- S [22]

Equal Area
Lower Hemisphere
147 Poles
147 Entries

DH-BGC12-20 - TELEVIEWER

BRUCEJACK FEASIBILITY STUDY



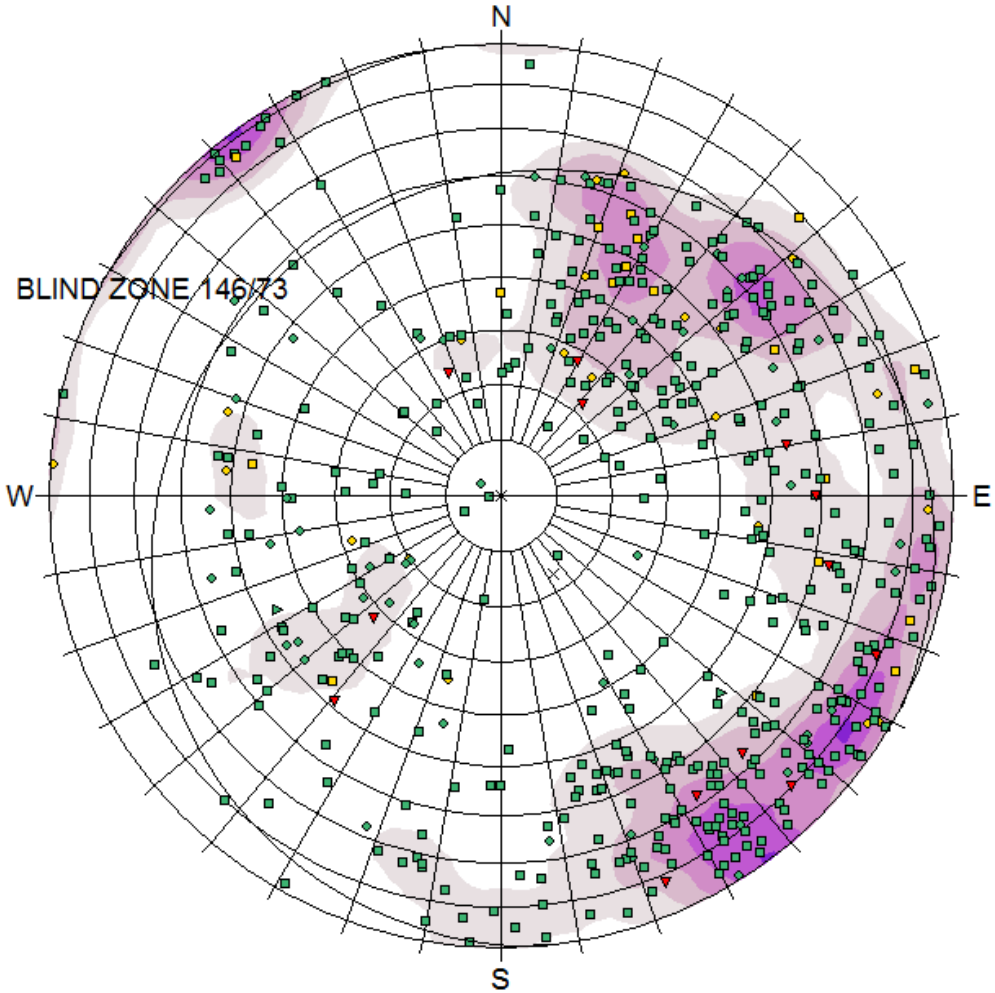
TYPE

- F [1]
- FV [1]
- J [224]
- JO [5]
- JV [15]
- S [37]
- SV [3]

Equal Area
Lower Hemisphere
286 Poles
286 Entries

DH-BGC12-20 - ACT II

BRUCEJACK FEASIBILITY STUDY



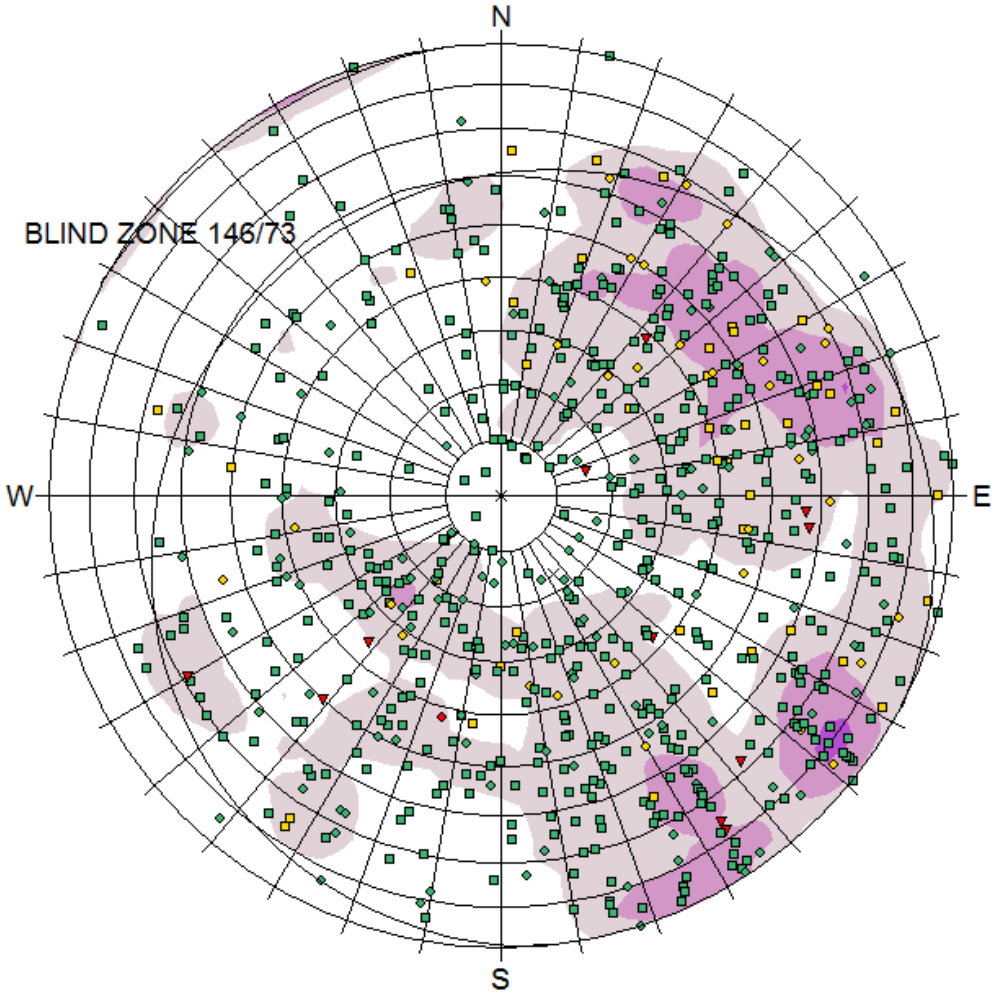
TYPE

- F [13]
- J [399]
- J-O [3]
- J-V [56]
- S [18]
- S-V [22]

Equal Area
Lower Hemisphere
511 Poles
511 Entries

DH-BGC12-21 - TELEVIEWER

BRUCEJACK FEASIBILITY STUDY



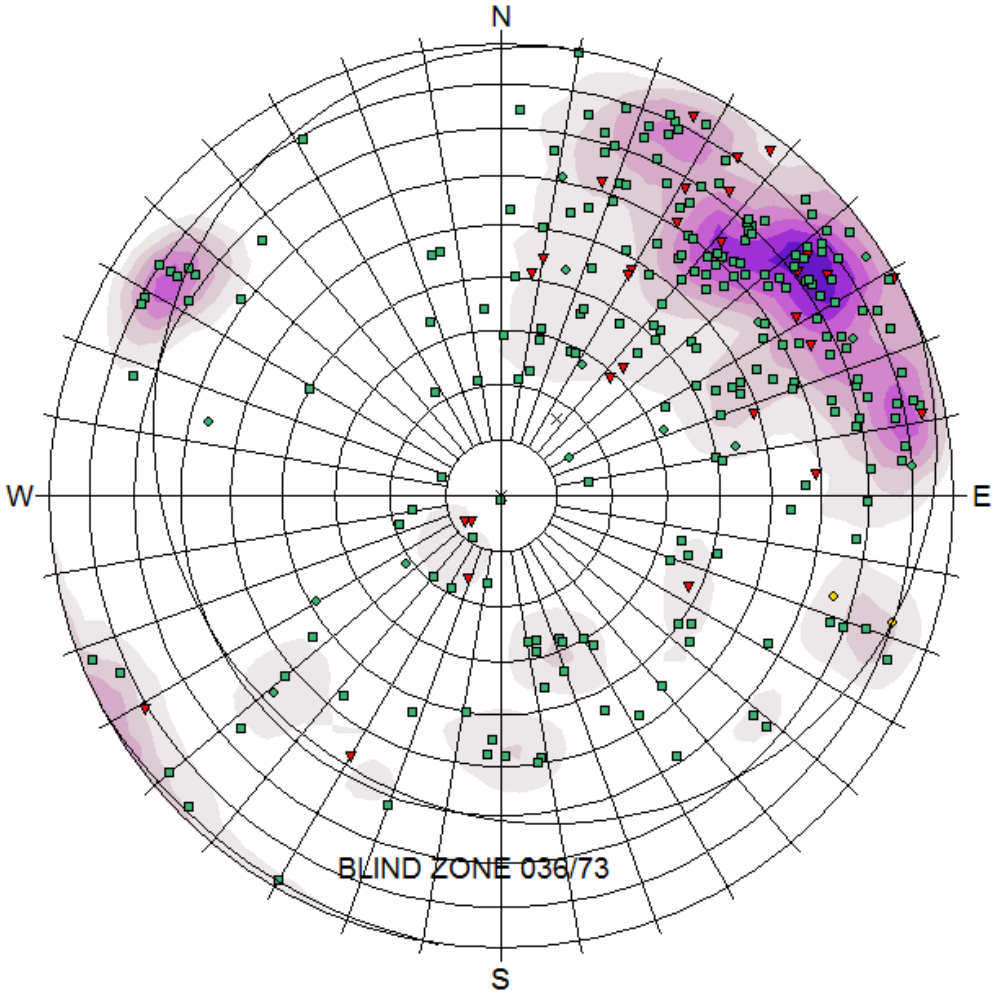
TYPE

- F [11]
- FV [1]
- J [466]
- JV [121]
- S [46]
- SV [31]

Equal Area
Lower Hemisphere
676 Poles
676 Entries

DH-BGC12-21 - ACT II

BRUCEJACK FEASIBILITY STUDY



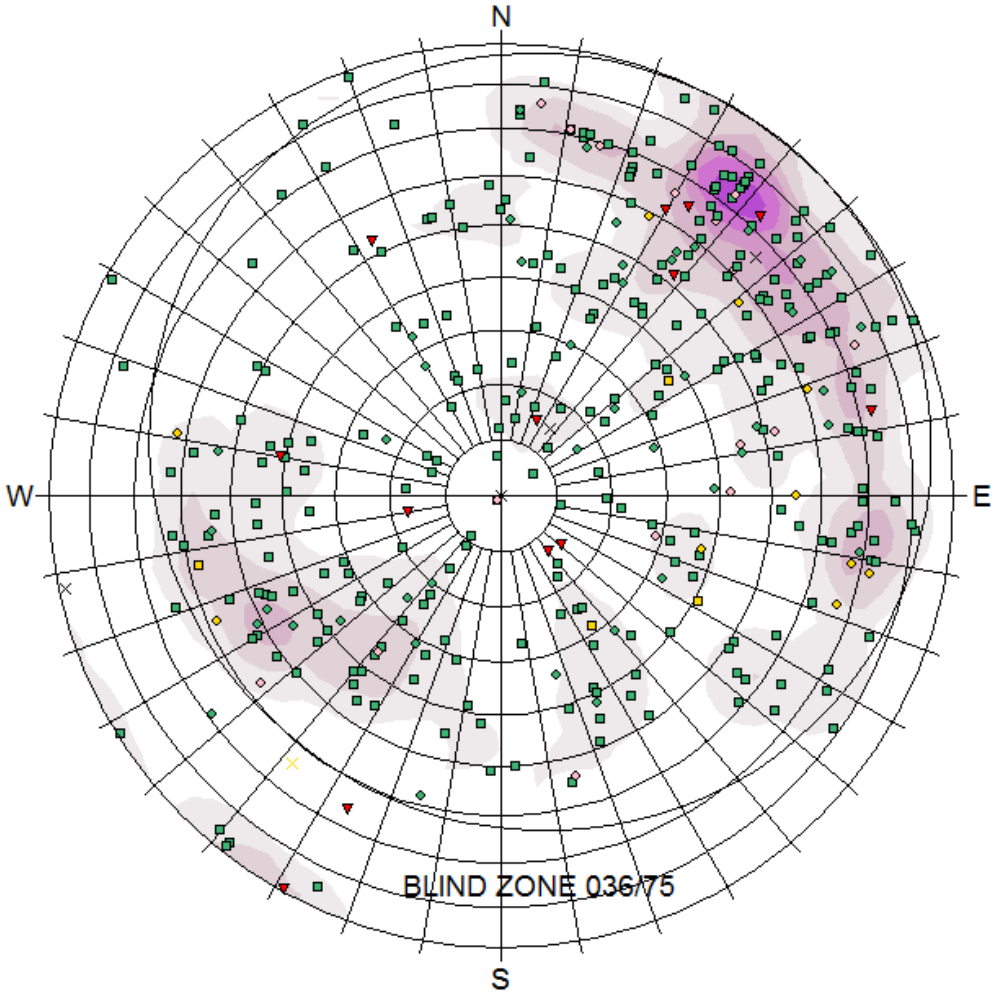
TYPE

- F [30]
- J [217]
- J-V [14]
- S-V [2]

Equal Area
Lower Hemisphere
263 Poles
263 Entries

DH-BGC12-22 - TELEVIEWER

BRUCEJACK FEASIBILITY STUDY



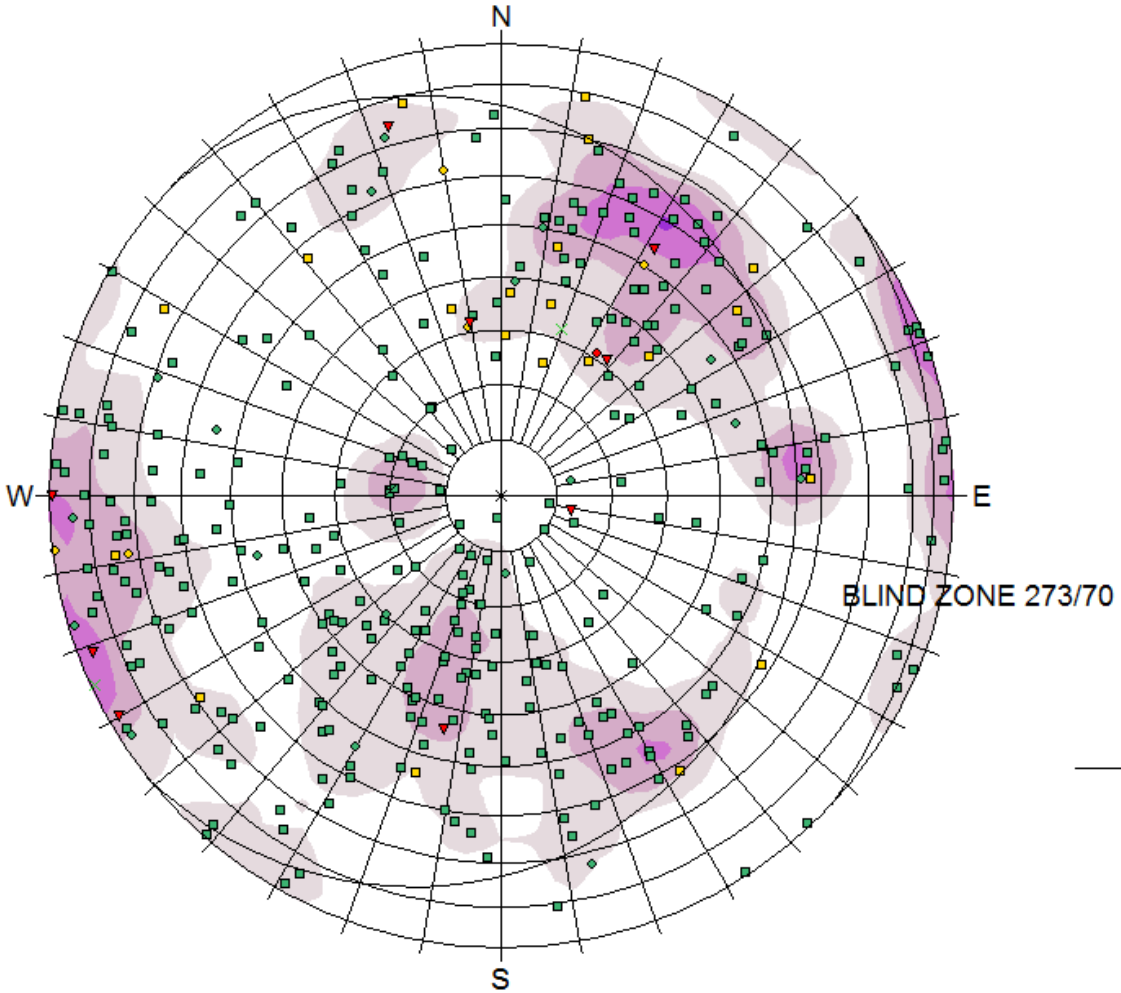
TYPE

- C [2]
- F [14]
- J [284]
- JV [46]
- S [4]
- SC [1]
- SV [10]
- V [17]

Equal Area
Lower Hemisphere
378 Poles
378 Entries

DH-BGC12-22 - ACT II

BRUCEJACK FEASIBILITY STUDY



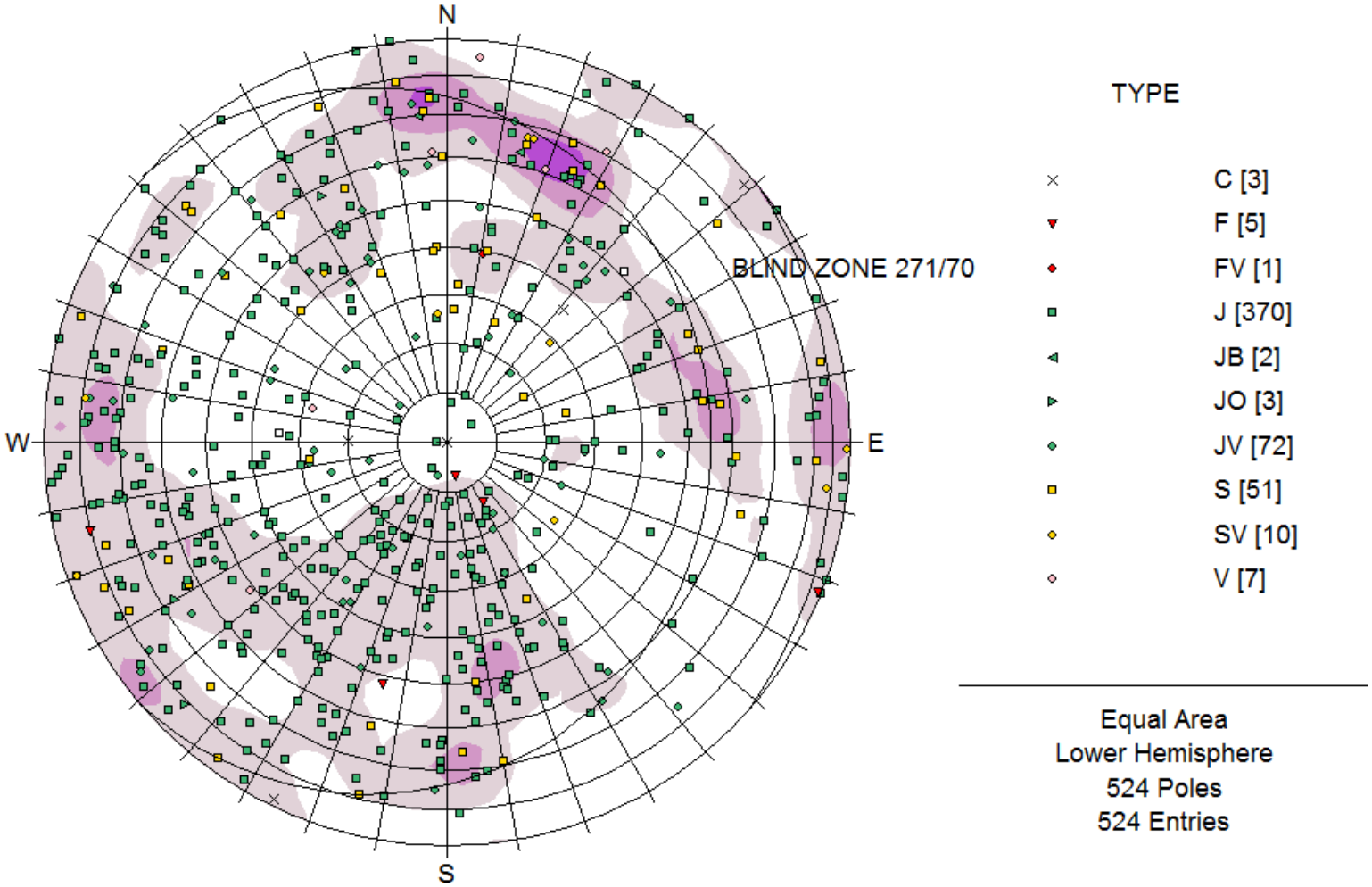
TYPE

- F [9]
- F-V [1]
- J [301]
- J-C [2]
- J-V [18]
- S [22]
- S-V [5]

Equal Area
Lower Hemisphere
358 Poles
358 Entries

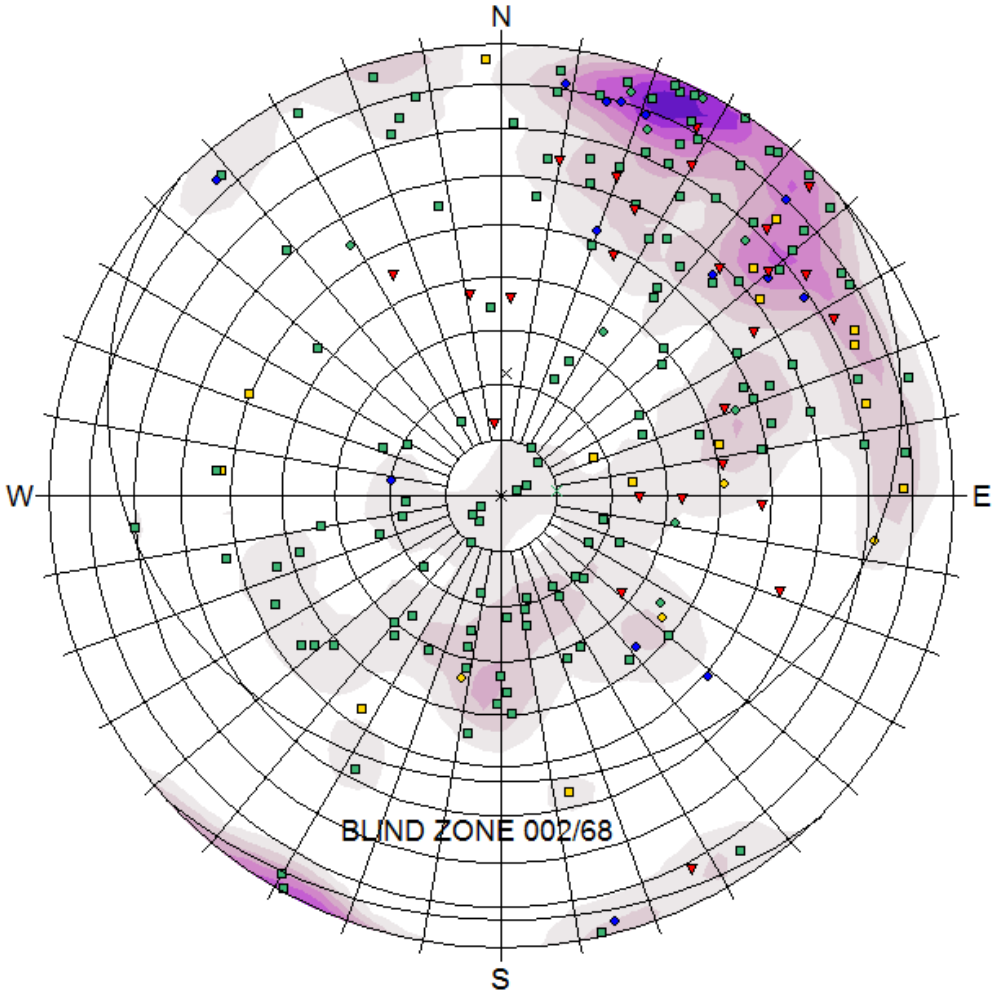
DH-BGC12-23 - TELEVIEWER

BRUCEJACK FEASIBILITY STUDY



DH-BGC12-23 - ACT II

BRUCEJACK FEASIBILITY STUDY



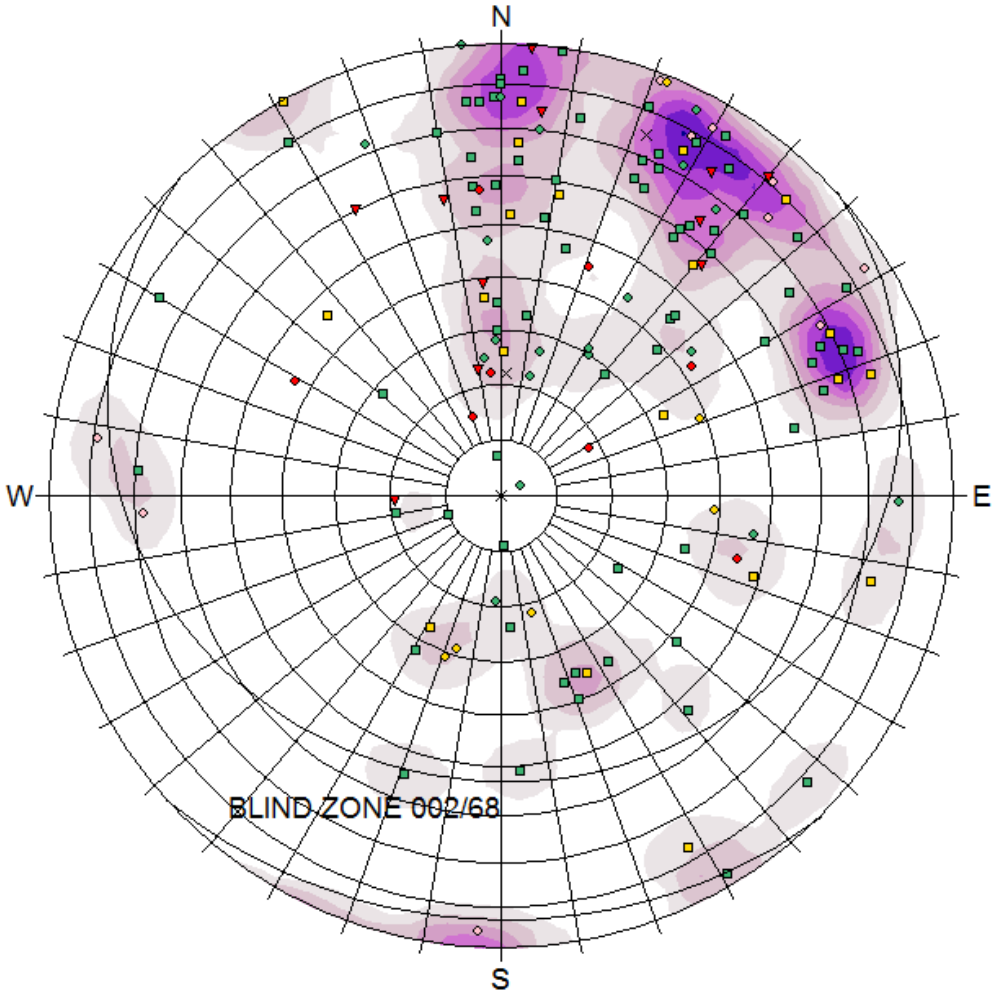
TYPE

- F [25]
- J [131]
- J-C [1]
- J-V [9]
- S [15]
- S-V [4]
- V [14]

Equal Area
Lower Hemisphere
199 Poles
199 Entries

DH-BGC12-24 - TELEVIEWER

BRUCEJACK FEASIBILITY STUDY



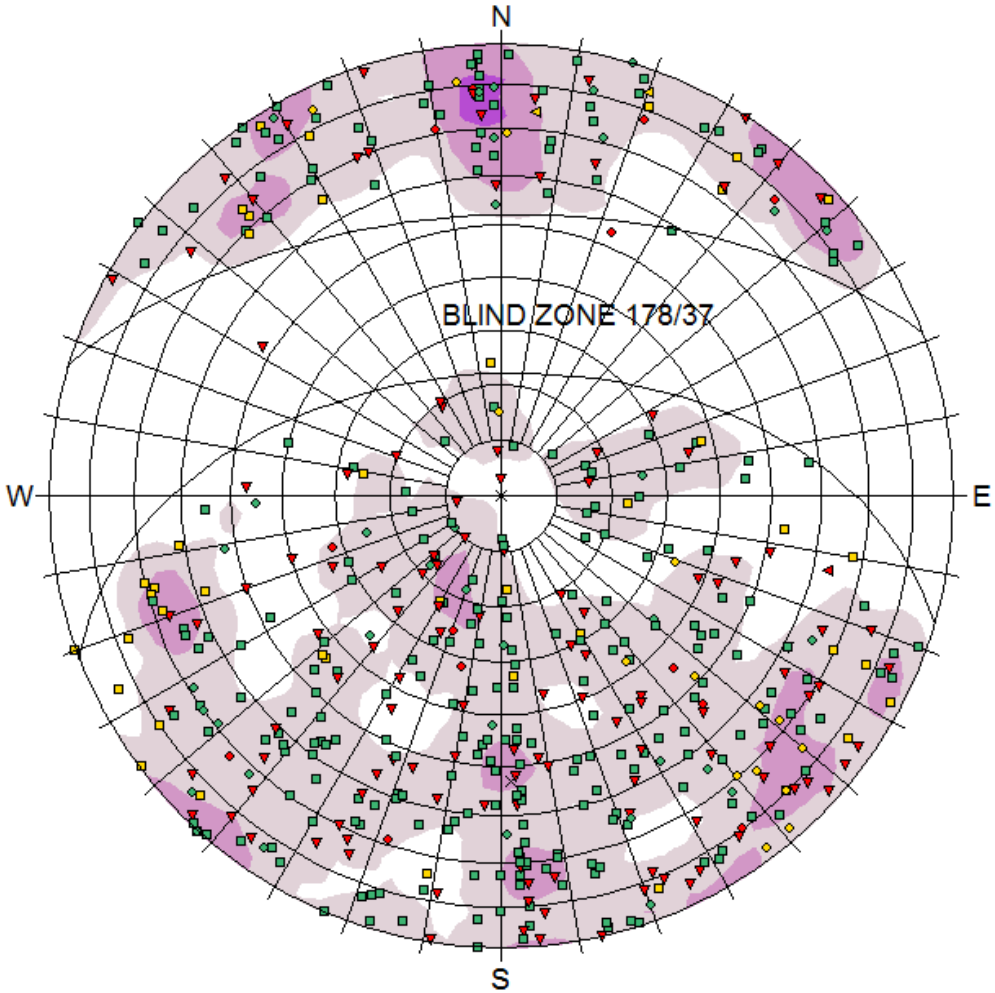
TYPE

- C [1]
- F [13]
- FV [8]
- J [73]
- JV [20]
- S [21]
- SV [6]
- V [10]

Equal Area
Lower Hemisphere
152 Poles
152 Entries

DH-BGC12-24 - ACT II

BRUCEJACK FEASIBILITY STUDY



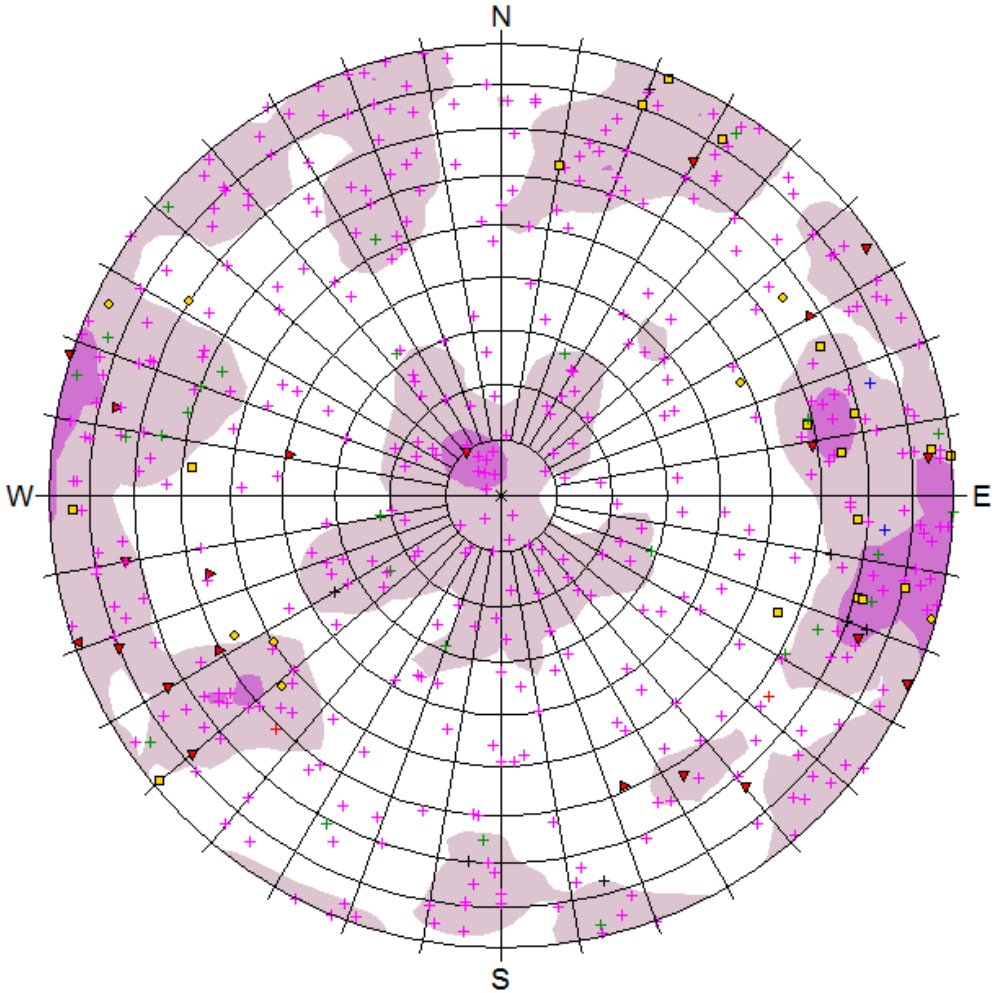
TYPE

- F [130]
- FO [1]
- FV [13]
- J [275]
- JV [35]
- S [40]
- SO [3]
- SV [15]

Equal Area
Lower Hemisphere
512 Poles
512 Entries

DH-BGC12-25 - ACT II

BRUCEJACK UG MAPPING



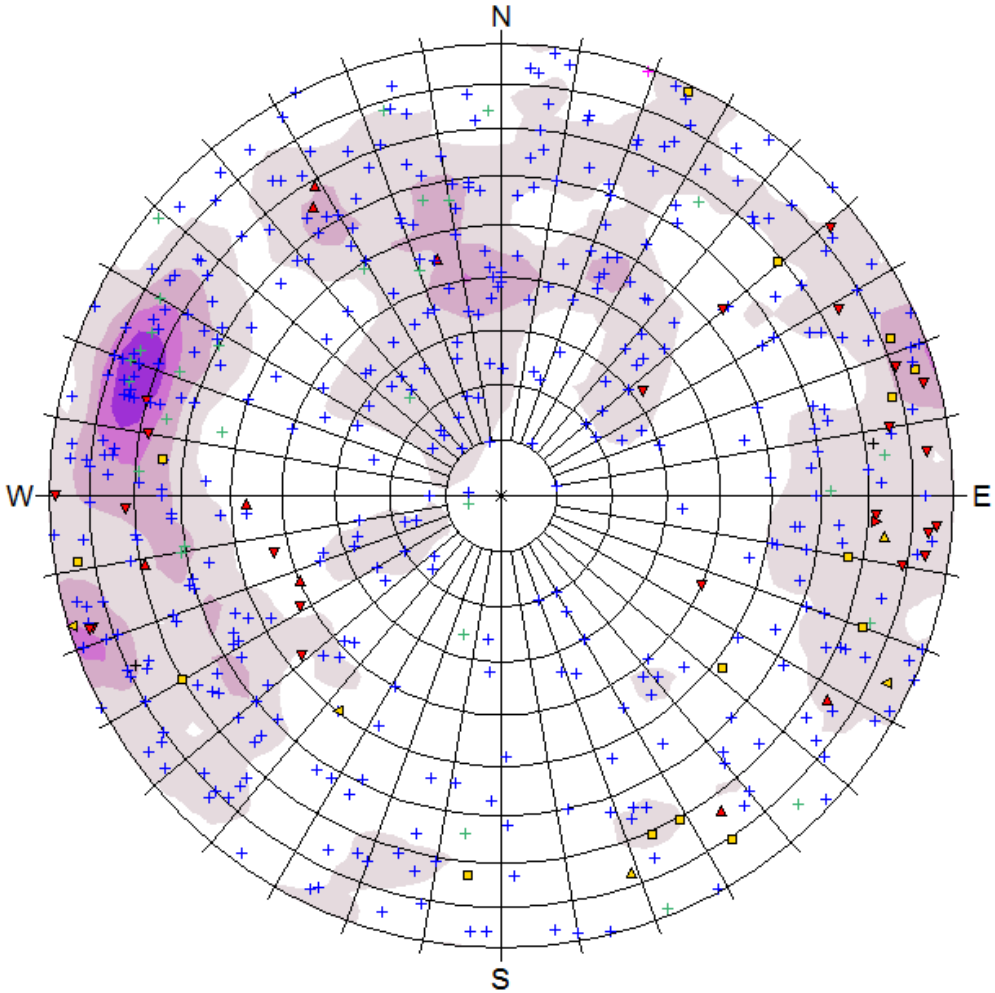
RAMP + PORTAL + NUB + EXPLORATION DRIFT

DISCON

- C [2]
- F [14]
- F-C [1]
- F-V [6]
- J [399]
- J-C [2]
- J-V [27]
- S [18]
- S-V [8]
- [no data] [7]

Equal Area
Lower Hemisphere
484 Poles
484 Entries

BRUCEJACK UG MAPPING



1350 LEVEL

DISCON

- F [23]
- F-V [8]
- FB [1]
- J [413]
- J-C [1]
- J-V [29]
- S [15]
- S-J [3]
- S-V [2]
- [no data] [2]

Equal Area
Lower Hemisphere
497 Poles
497 Entries

Appendix C

Laboratory Testing Results

Summary Results of Sample Failure Tests (Brucejack Project #1008-007-01-03)

Sample (depth)	Bulk Density (g/cm^3)	Unconfined Compressive Strength S_C, (MPa)	Sigma 1 (MPa)	Sigma 3 (MPa)	Young's Modulus E, (GPa)	Poisson's Ratio (m)	Brazilian Indirect Tensile Strength (and range) S_T, (MPa)
DH20-01 (14.94-15.05) *	---	---	---	---	---	---	---
DH20-02 (24.49-24.66)	2.75	133.9	---	---	28.680	0.10	
DH20-04 (98.52-98.72) **	---	---	---	---	---	---	---
DH20-05 (113.76-113.99)	2.77	---	129.6	5	41.093	---	
DH20-09 (199.34-199.66)	2.77	106.6	---	---	21.404	0.23	2.4 (1.3-3.2)
DH20-10 (241.30-241.61) **	---	---	---	---	---	---	---
DH20-13 (345.64-345.90)	2.78	93.4	---	---	27.644	0.10	3.1 (2.6-3.5)
DH19-01 (16.52-16.80)	2.92	13.7	---	---	3.841	0.18	0.7 (0.4-1.0)
DH19-06 (215.80-215.85) *	---	---	---	---	---	---	---
DH19-07 (247.39-247.50)	2.72	123.7	---	---	25.090	0.10	1.4 (0.75-1.9)
DH19-08 (267.66-267.90) **	---	---	---	---	---	---	---
DH19-09 (283.17-283.40)	2.80	104.6	---	---	23.149	0.10	1.8 (1.1-2.4)
DH19-10 (287.30-287.48) **	---	---	---	---	---	---	---
DH19-11 (311.78-312.00)	2.74	---	201.8	20	39.110	---	---
DH19-12 (353.00-353.24)	2.72	193.9	---	---	26.229	0.10	2.6 (2.3-3.0)
DH19-13 (368.19-368.43) **	---	---	---	---	---	---	---
DH21-02 (125.69-125.96)	2.74	157.8 (pf)	---	---	29.662	0.09	3.0 (2.6-3.3)
DH21-03 (225.47-225.68) **	---	---	---	---	---	---	---
DH21-05 (260.39-260.59) **	---	---	---	---	---	---	---
DH21-06 (295.63-295.94)	2.80	---	144.8	10	36.807	---	---
DH21-11 (416.75-416.98)	2.77	84.8	---	---	28.985	0.10	2.0 (1.9-2.1)

(*) – grain size analysis, or other, tests requested but not able to be performed by this laboratory
(**) – direct shear test data listed in following tables
(f) – indicates failure along pre-existing foliation surfaces
(pf) – indicates failure partially along pre-existing foliation surfaces

Summary Results of Direct Shear Failure Tests

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH20-04 (98.52-98.72)	.31	.15
	.62	.32
	.93	.46
Residual Strength Data	1.24	.70
	1.55	.87
Cohesion = 0 kPa	1.86	1.02
Internal Friction Angle = 30.1º	2.17	1.18
	2.48	1.38
$r^2 = 0.998$	2.79	1.56
	3.10	1.79

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH20-10 (241.30-241.61)	.37	.30
	.74	.52
	1.11	.64
Residual Strength Data	1.48	.79
	1.85	.97
Cohesion = 105 kPa	2.22	1.14
Internal Friction Angle = 25.8º	2.59	1.29
	2.96	1.55
$r^2 = 0.995$	3.33	1.75

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH19-08 (267.66-267.90)	.27	.13
	.53	.27
	.80	.39
Residual Strength Data	1.06	.49
	1.33	.59
Cohesion = 13 kPa	1.59	.71
Internal Friction Angle = 23.9º	1.86	.78
	2.12	.91
$r^2 = 0.991$	2.39	1.10
	2.65	1.24

Summary Results of Direct Shear Failure Tests

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH19-10 (287.30-287.48)	.37	.46
	.74	.59
	1.11	.79
Residual Strength Data	1.48	.99
	1.85	1.19
Cohesion = 193 kPa	2.22	1.40
Internal Friction Angle = 28.8º	2.59	1.58
	2.96	1.78
$r^2 = 0.996$	3.33	2.01

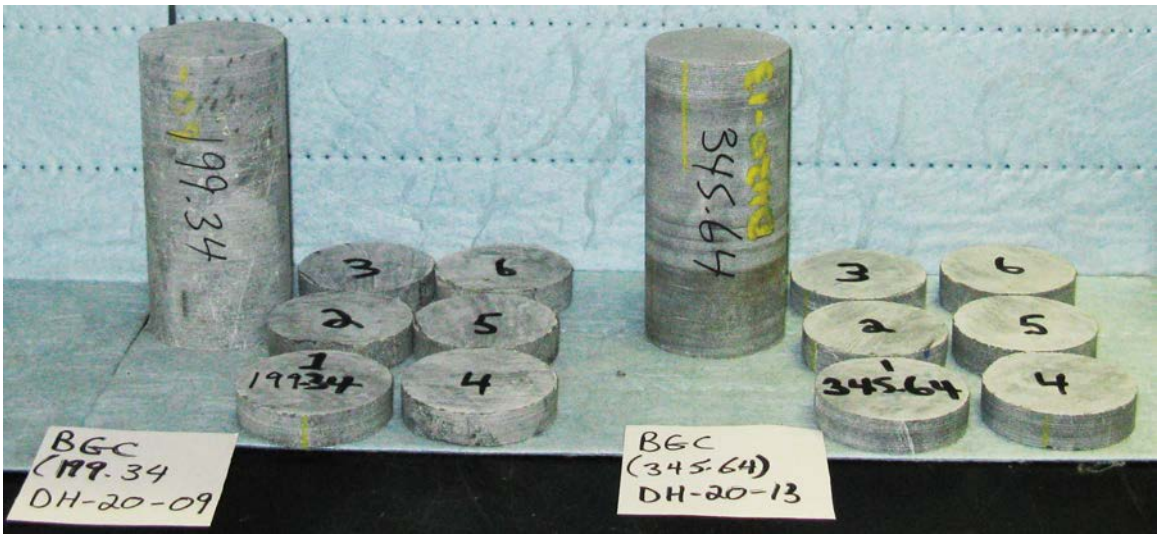
Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH19-13 (368.19-368.43)	.33	.53
	.65	.69
	.98	.82
Residual Strength Data	1.20	.93
	1.63	1.09
Cohesion = 391 kPa	1.95	1.25
Internal Friction Angle = 23.9º	2.28	1.40
	2.60	1.60
$r^2 = 0.997$	2.93	1.69
	3.25	1.80

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH21-03 (225.47-225.68)	.34	.21
	.68	.42
	1.02	.59
Residual Strength Data	1.36	.76
	1.70	.92
Cohesion = 53 kPa	2.04	1.09
Internal Friction Angle = 27.3º	2.38	1.29
	2.72	1.46
$r^2 = 0.999$	3.06	1.61
	3.40	1.82

Summary Results of Direct Shear Failure Tests

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH21-05 (260.39-260.59)	.33	.20
	.65	.40
	.98	.53
Residual Strength Data	1.30	.69
	1.63	.85
Cohesion = 48 kPa	1.95	1.00
Internal Friction Angle = 26.2º	2.28	1.13
	2.60	1.30
$r^2 = 0.997$	2.93	1.53
	3.25	1.66

Pre-Test UCS, Triaxial Confined and Brazilian Tensile Sample Test Photographs
(for all except direct shear test specimens)

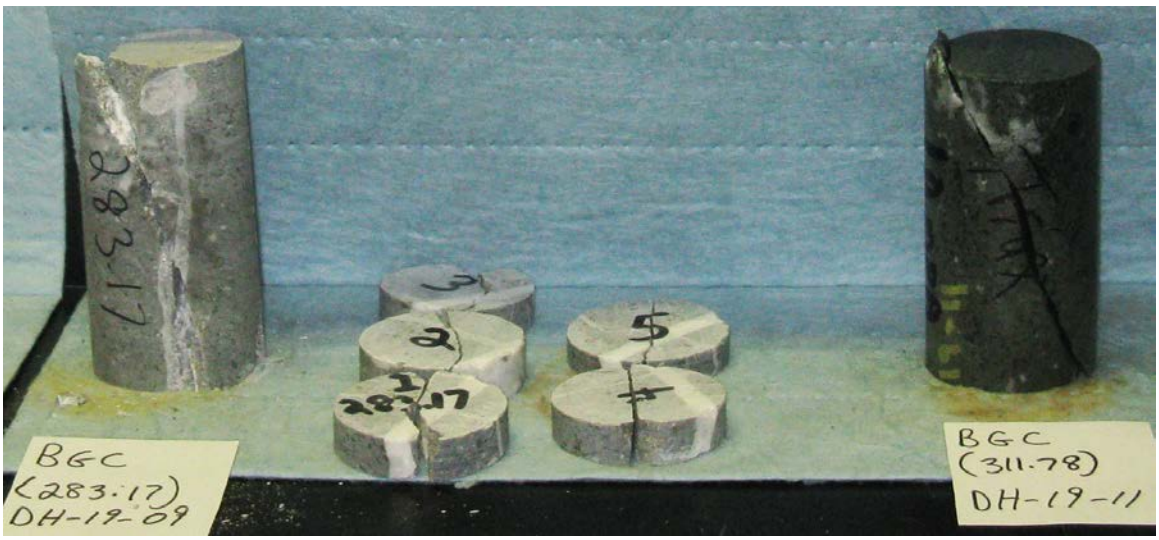


283.17
3
2
1
283.17
5
4
BGC
(283.17)
DH-19-09
311.78
BGC
(311.78)
DH-19-11

353.00
3
2
353.00
1
5
4
BGC
(353.00)
DH-19-12
125.69
3
2
125.69
1
BGC
(125.69)
DH-21-02

295.63
295.94
06
BGC
(295.63)
DH-21-06
416.75
3
2
1
416.75
BGC
(416.75)
DH-21-11

Post-Test UCS, Triaxial Confined and Brazilian Tensile Test Sample Photographs


BGC
(283.17)
DH-19-09
BGC
(311.78)
DH-19-11

BGC
(353.00)
DH-19-12
BGC
(125.69)
DH-21-02

BGC
(295.63)
DH-21-06
BGC
(416.75)
DH-21-11

Post-Test Direct Shear Sample Photographs

DH20-04 (98.52-98.72)

DH20-10 (241.30-241.61)

DH19-08 (267.66-267.90)

DH19-10 (287.30-287.48)

DH19-13 (368.19-368.43)

DH21-03 (225.47-225.68)

DH21-05 (260.39-260.59)

Summary Results of Set #2 Sample Failure Tests (Brucejack Project #1008-007-01-03)

Sample (depth)	Bulk Density (g/cm^3)	Unconfined Compressive Strength S_C, (MPa)	Sigma 1 (MPa)	Sigma 3 (MPa)	Young's Modulus E, (GPa)	Poisson's Ratio (m)	Brazilian Indirect Tensile Strength (and range) S_T, (MPa)
DH-BGC12-22 (46.20)	2.80	92.2			29.764	0.10	7.4 (6.2-9.0)
DH-BGC12-22 (332.84)	2.82	---	140.4	10	27.049	---	---
DH-BGC12-22 (436.85)	2.80	51.5 (pf)			21.228	0.11	5.0 (3.4-7.0)
DH-BGC12-23 (146.40)	2.77	99.5			30.245	0.10	7.0 (4.6-8.5)
DH-BGC12-23 (336.57)	2.80	---	127.2	20	28.914	---	---
DH-BGC12-23 (542.53)	2.68	3.8			0.731	0.25	---
DH-BGC12-24 (72.07)	2.81	87.8			27.209	0.16	5.0 (4.2-5.8)
DH-BGC12-24 (132.57)	2.88	56.0			21.575	0.17	4.2 (3.4-5.1)
DH-BGC12-24 (302.35)	2.86	---	99.5	5	26.578	---	---
DH-BGC12-24 (448.26)	2.78	63.7			23.361	0.11	5.1 (4.8-5.3)
DH-BGC12-25 (85.25)	2.82	54.7 (pf)			22.989	---	6.2 (3.6-9.0)
DH-BGC12-25 (320.85)	2.77	113.6			31.362	0.11	12.0 (11.0-13.3)

(pf) – indicates failure partially along pre-existing foliation surfaces

Summary Results of Direct Shear Failure Tests (July, 2012)

Borehole, Sample and Depth	Normal Stress (MPa)	Shear Stress (MPa)
DH-BGC12-22 (DH22-11) (206.18-206.53)	0.27	0.38
	0.53	0.54
	0.80	0.70
Residual Strength Data	1.06	0.86
	1.33	1.27
Cohesion = 74 kPa	1.59	1.49
Internal Friction Angle = 41.0º	1.86	1.80
	2.12	1.89
$r^2 = 0.986$	2.39	2.11

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH-BGC12-22 (DH22-17) (324.43-324.70)	0.45	0.38
	0.90	0.57
	1.35	0.72
Residual Strength Data	1.80	0.88
	2.25	1.01
Cohesion = 190 kPa	2.70	1.32
Internal Friction Angle = 21.7º	3.15	1.45
$r^2 = 0.988$		

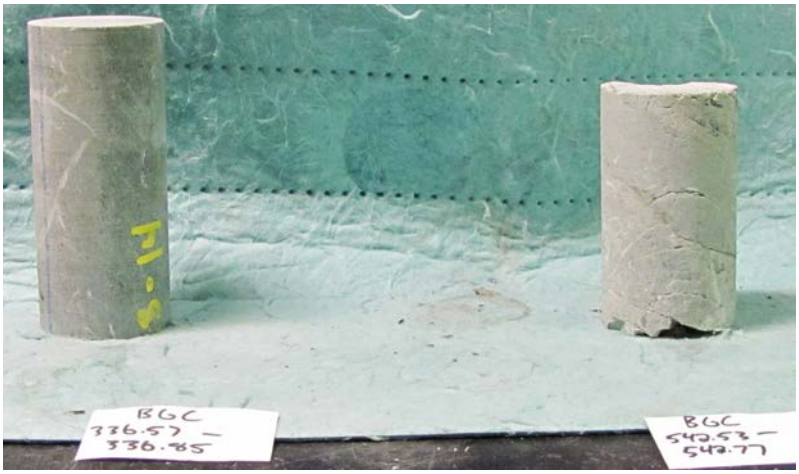
Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH-BGC12-23 (DH23-17) (520.77-521.04)	0.68	1.02
	1.02	1.12
	1.36	1.33
Residual Strength Data	1.70	1.54
	2.04	1.82
Cohesion = 521 kPa	2.38	1.96
Internal Friction Angle = 31.9º	2.72	2.24
	3.06	2.45
$r^2 = 0.993$		

Summary Results of Direct Shear Failure Tests (July, 2012)

Borehole, Sample and Depth	Normal Stress (MPa)	Shear Stress (MPa)
DH-BGC12-24 (DH24-06) (257.71-257.92)	0.36	0.29
	0.72	0.44
	1.08	0.59
Residual Strength Data	1.44	0.74
	1.80	0.90
Cohesion = 181 kPa	2.16	0.90
Internal Friction Angle = 20.2º	2.52	1.10
	2.88	1.25
r^2 = 0.986		

Sample	Normal Stress (MPa)	Shear Stress (MPa)
DH-BGC12-25 (DH25-13) (345.24-345.54)	0.31	0.70
	0.62	0.90
	0.93	1.05
Residual Strength Data	1.24	1.37
	1.55	1.60
Cohesion = 449 kPa	1.86	1.73
Internal Friction Angle = 35.8º	2.17	2.05
r^2 = 0.991		

Pre-Test UCS, Triaxial Confined and Brazilian Tensile Sample Test Photographs

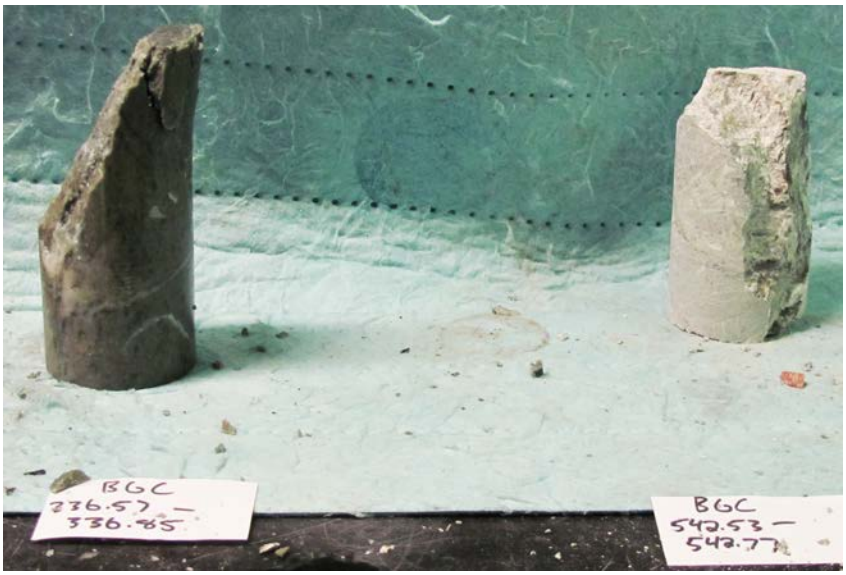


BGC
72.07 —
72.32
BGC
132.53 —
132.83

BGC
302.35 —
302.59
BGC
448.26 —
448.48

BGC
85.25 —
85.55
BGC
320.85 —
321.14

Post-Test UCS, Triaxial Confined and Brazilian Tensile Test Sample Photographs



BGC
72.07 –
72.32
BGC
132.53 –
132.83

BGC
302.35 –
302.59
BGC
448.26 –
448.48

BGC
85.25 –
85.55
BGC
320.85 –
321.14

Post-Test Direct Shear Test Sample Photographs

DH22-11 (206.18-206.53)

DH22-17 (324.43-324.70)

DH23-17 (520.77-521.04)

DH24-06 (257.71-257.92)

DH25-13 (345.24-345.54)

Appendix D

Point Load Testing

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-19	16.2	DIAMETRAL	140	61	∠ TO FABRIC	3.1	INVALID	0.79	0.86
DH-BGC12-19	15.97	DIAMETRAL	190	61	∠ TO FABRIC	4.1	INVALID	1.04	1.14
DH-BGC12-19	16.9	DIAMETRAL	200	61	∠ TO FABRIC	4.46	VALID	1.14	1.24
DH-BGC12-19	17.17	DIAMETRAL	100	61	∠ TO FABRIC	3.64	VALID	0.93	1.01
DH-BGC12-19	17.27	DIAMETRAL	110	61	∠ TO FABRIC	6.32	VALID	1.61	1.76
DH-BGC12-19	20.7	DIAMETRAL	170	61	∠ TO FABRIC	4.12	VALID	1.05	1.15
DH-BGC12-19	21.88	DIAMETRAL	145	61	NA	3.9	VALID	0.99	1.09
DH-BGC12-19	25.23	DIAMETRAL	180	61	NA	7.24	VALID	1.84	2.02
DH-BGC12-19	27.96	DIAMETRAL	180	61	∠ TO FABRIC	6.42	VALID	1.64	1.79
DH-BGC12-19	32.67	DIAMETRAL	120	61	∠ TO FABRIC	5.7	INVALID	1.45	1.59
DH-BGC12-19	34.74	DIAMETRAL	150	61	∠ TO FABRIC	8.44	VALID	2.15	2.35
DH-BGC12-19	38.09	DIAMETRAL	180	61	∠ TO FABRIC	11.4	VALID	2.90	3.18
DH-BGC12-19	40.16	DIAMETRAL	140	61	∠ TO FABRIC	7.28	VALID	1.85	2.03
DH-BGC12-19	43.18	DIAMETRAL	190	61	∠ TO FABRIC	6.52	VALID	1.66	1.82
DH-BGC12-19	47.14	DIAMETRAL	90	61	∠ TO FABRIC	13.08	INVALID	3.33	3.64
DH-BGC12-19	47.6	DIAMETRAL	200	61	∠ TO FABRIC	22.52	VALID	5.74	6.27
DH-BGC12-19	47.79	DIAMETRAL	135	61	∠ TO FABRIC	11	VALID	2.80	3.06
DH-BGC12-19	47.92	DIAMETRAL	140	61	∠ TO FABRIC	18.36	VALID	4.68	5.12
DH-BGC12-19	48.65	DIAMETRAL	145	61	∠ TO FABRIC	8.14	VALID	2.07	2.27
DH-BGC12-19	52.18	DIAMETRAL	195	61	∠ TO FABRIC	11.24	INVALID	2.86	3.13
DH-BGC12-19	53.57	DIAMETRAL	150	65	∠ TO FABRIC	4.54	VALID	1.16	1.26
DH-BGC12-19	57.56	DIAMETRAL	140	61	∠ TO FABRIC	5.78	VALID	1.47	1.61
DH-BGC12-19	61.74	DIAMETRAL	165	61	NA	14.3	VALID	3.64	3.98
DH-BGC12-19	64.7	DIAMETRAL	130	61	NA	13.02	VALID	3.32	3.63
DH-BGC12-19	67.57	DIAMETRAL	180	61	NA	17.08	VALID	4.35	4.76
DH-BGC12-19	69.11	DIAMETRAL	90	61	NA	2.84	INVALID	0.72	0.79
DH-BGC12-19	72.32	DIAMETRAL	140	61	NA	13.52	VALID	3.44	3.77
DH-BGC12-19	75.21	DIAMETRAL	90	61	NA	10.68	VALID	2.72	2.98
DH-BGC12-19	78.19	DIAMETRAL	175	61	NA	13.54	VALID	3.45	3.77
DH-BGC12-19	81.44	DIAMETRAL	120	61	NA	11.92	VALID	3.04	3.32
DH-BGC12-19	84.51	DIAMETRAL	140	61	NA	12.66	VALID	3.23	3.53
DH-BGC12-19	87.56	DIAMETRAL	150	61	NA	11.38	VALID	2.90	3.17
DH-BGC12-19	90.47	DIAMETRAL	115	61	NA	13.92	VALID	3.55	3.88
DH-BGC12-19	95.2	DIAMETRAL	175	61	∠ TO FABRIC	9.82	VALID	2.50	2.74
DH-BGC12-19	98.24	DIAMETRAL	195	61	∠ TO FABRIC	3.44	VALID	0.88	0.96
DH-BGC12-19	101.14	DIAMETRAL	120	61	∠ TO FABRIC	0.46	INVALID	0.12	0.13
DH-BGC12-19	105.86	DIAMETRAL	160	61	∠ TO FABRIC	10.4	VALID	2.65	2.90

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-19	107.19	DIAMETRAL	205	61	∠ TO FABRIC	7.38	INVALID	1.88	2.06
DH-BGC12-19	112.11	DIAMETRAL	120	61	NA	4.36	VALID	1.11	1.21
DH-BGC12-19	113.33	DIAMETRAL	120	61	∠ TO FABRIC	11.14	VALID	2.84	3.10
DH-BGC12-19	116.5	DIAMETRAL	130	61	∠ TO FABRIC	6.9	VALID	1.76	1.92
DH-BGC12-19	119.34	DIAMETRAL	110	61	∠ TO FABRIC	6.82	INVALID	1.74	1.90
DH-BGC12-19	123.57	DIAMETRAL	135	61	NA	24.94	VALID	6.35	6.95
DH-BGC12-19	128.72	DIAMETRAL	170	61	NA	10.92	VALID	2.78	3.04
DH-BGC12-19	133.83	DIAMETRAL	155	61	∠ TO FABRIC	7.06	VALID	1.80	1.97
DH-BGC12-19	134.8	DIAMETRAL	160	61	∠ TO FABRIC	16.82	VALID	4.29	4.69
DH-BGC12-19	137.2	DIAMETRAL	170	61	∠ TO FABRIC	11.44	INVALID	2.91	3.19
DH-BGC12-19	142.19	DIAMETRAL	120	61	∠ TO FABRIC	7.66	VALID	1.95	2.13
DH-BGC12-19	143.95	DIAMETRAL	120	61	∠ TO FABRIC	4.84	INVALID	1.23	1.35
DH-BGC12-19	148.2	DIAMETRAL	190	61	∠ TO FABRIC	13.06	VALID	3.33	3.64
DH-BGC12-19	151.36	DIAMETRAL	120	61	∠ TO FABRIC	10.5	VALID	2.68	2.93
DH-BGC12-19	154.19	DIAMETRAL	130	61	∠ TO FABRIC	6.16	INVALID	1.57	1.72
DH-BGC12-19	157.17	DIAMETRAL	200	61	NA	16.56	VALID	4.22	4.61
DH-BGC12-19	162.02	DIAMETRAL	110	61	NA	9.84	VALID	2.51	2.74
DH-BGC12-19	163.11	DIAMETRAL	210	61	NA	9.56	INVALID	2.44	2.66
DH-BGC12-19	166.63	DIAMETRAL	200	61	NA	7.4	VALID	1.89	2.06
DH-BGC12-19	169.9	DIAMETRAL	150	61	∠ TO FABRIC	6.5	VALID	1.66	1.81
DH-BGC12-19	172.72	DIAMETRAL	180	61	∠ TO FABRIC	15.14	VALID	3.86	4.22
DH-BGC12-19	177.49	DIAMETRAL	190	61	NA	28.94	VALID	7.37	8.06
DH-BGC12-19	180.56	DIAMETRAL	220	61	NA	9.06	VALID	2.31	2.52
DH-BGC12-19	182.03	DIAMETRAL	115	61	NA	17.64	VALID	4.49	4.91
DH-BGC12-19	185.06	DIAMETRAL	100	61	NA	14.12	VALID	3.60	3.93
DH-BGC12-19	189.54	DIAMETRAL	110	61	NA	20.6	VALID	5.25	5.74
DH-BGC12-19	191.89	DIAMETRAL	100	61	NA	20.86	VALID	5.31	5.81
DH-BGC12-19	195.74	DIAMETRAL	110	61	NA	23.76	VALID	6.05	6.62
DH-BGC12-19	198.1	DIAMETRAL	150	61	NA	18	VALID	4.59	5.02
DH-BGC12-19	200.11	DIAMETRAL	275	61	NA	8.96	INVALID	2.28	2.50
DH-BGC12-19	199.72	DIAMETRAL	145	61	∠ TO FABRIC	8.5	INVALID	2.17	2.37
DH-BGC12-19	199.86	DIAMETRAL	190	61	∠ TO FABRIC	25.8	VALID	6.57	7.19
DH-BGC12-19	203.35	DIAMETRAL	105	61	∠ TO FABRIC	6.94	INVALID	1.77	1.93
DH-BGC12-19	204.04	DIAMETRAL	145	61	∠ TO FABRIC	19.7	VALID	5.02	5.49
DH-BGC12-19	204.23	DIAMETRAL	200	61	∠ TO FABRIC	25.88	VALID	6.59	7.21
DH-BGC12-19	204.4	DIAMETRAL	140	61	∠ TO FABRIC	22.3	VALID	5.68	6.21
DH-BGC12-19	204.54	DIAMETRAL	130	61	∠ TO FABRIC	18.18	INVALID	4.63	5.07

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-19	204.66	DIAMETRAL	135	61	∠ TO FABRIC	26	VALID	6.62	7.24
DH-BGC12-19	207.96	DIAMETRAL	170	61	∠ TO FABRIC	34.12	VALID	8.69	9.51
DH-BGC12-19	210.6	DIAMETRAL	190	61	∠ TO FABRIC	23.78	VALID	6.06	6.63
DH-BGC12-19	213.74	DIAMETRAL	110	61	∠ TO FABRIC	18.46	VALID	4.70	5.14
DH-BGC12-19	218.48	DIAMETRAL	135	61	∠ TO FABRIC	25.2	VALID	6.42	7.02
DH-BGC12-19	221.37	DIAMETRAL	116	61	NA	34.06	VALID	8.68	9.49
DH-BGC12-19	223.54	DIAMETRAL	150	61	NA	22.64	VALID	5.77	6.31
DH-BGC12-19	227.64	DIAMETRAL	105	61	NA	19.4	VALID	4.94	5.41
DH-BGC12-19	233.72	DIAMETRAL	110	61	NA	6.94	VALID	1.77	1.93
DH-BGC12-19	238.48	DIAMETRAL	185	61	NA	18.32	VALID	4.67	5.10
DH-BGC12-19	239.32	DIAMETRAL	115	61	NA	0.22	INVALID	0.06	0.06
DH-BGC12-19	247.35	DIAMETRAL	70	61	NA	24.84	VALID	6.33	6.92
DH-BGC12-19	247.67	DIAMETRAL	190	61	NA	18.78	VALID	4.78	5.23
DH-BGC12-19	247.85	DIAMETRAL	110	61	NA	20.66	VALID	5.26	5.76
DH-BGC12-19	248.18	DIAMETRAL	195	61	NA	20.58	VALID	5.24	5.73
DH-BGC12-19	283.1	DIAMETRAL	135	61	NA	24.42	VALID	6.22	6.80
DH-BGC12-19	282.95	DIAMETRAL	150	61	NA	17.04	VALID	4.34	4.75
DH-BGC12-19	283.49	DIAMETRAL	165	61	NA	10.52	INVALID	2.68	2.93
DH-BGC12-19	283.66	DIAMETRAL	150	61	NA	26.1	VALID	6.65	7.27
DH-BGC12-19	283.8	DIAMETRAL	160	61	NA	19.2	VALID	4.89	5.35
DH-BGC12-19	248.9	DIAMETRAL	140	61	∠ TO FABRIC	30.78	VALID	7.84	8.58
DH-BGC12-19	254.41	DIAMETRAL	110	61	NA	15.22	VALID	3.88	4.24
DH-BGC12-19	260.2	DIAMETRAL	165	61	NA	21.52	VALID	5.48	6.00
DH-BGC12-19	262.68	DIAMETRAL	120	61	NA	19.46	VALID	4.96	5.42
DH-BGC12-19	266.5	DIAMETRAL	130	61	NA	15.06	VALID	3.84	4.20
DH-BGC12-19	269.1	DIAMETRAL	90	61	NA	16.4	VALID	4.18	4.57
DH-BGC12-19	273.34	DIAMETRAL	125	61	NA	20.98	VALID	5.35	5.85
DH-BGC12-19	277.75	DIAMETRAL	125	61	NA	15.12	VALID	3.85	4.21
DH-BGC12-19	288.74	DIAMETRAL	135	61	∠ TO FABRIC	18.76	VALID	4.78	5.23
DH-BGC12-19	290.45	DIAMETRAL	145	61	∠ TO FABRIC	21.16	VALID	5.39	5.90
DH-BGC12-19	294.5	DIAMETRAL	115	61	∠ TO FABRIC	13.66	INVALID	3.48	3.81
DH-BGC12-19	296.38	DIAMETRAL	190	61	∠ TO FABRIC	25.32	VALID	6.45	7.05
DH-BGC12-19	300.79	DIAMETRAL	95	61	∠ TO FABRIC	13.66	VALID	3.48	3.81
DH-BGC12-19	304.97	DIAMETRAL	115	61	∠ TO FABRIC	23.3	VALID	5.94	6.49
DH-BGC12-19	307	DIAMETRAL	110	61	∠ TO FABRIC	19.68	VALID	5.01	5.48
DH-BGC12-19	311.58	DIAMETRAL	120	61	∠ TO FABRIC	21.72	VALID	5.53	6.05
DH-BGC12-19	311.71	DIAMETRAL	130	61	∠ TO FABRIC	31.06	VALID	7.91	8.65

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-19	312.07	DIAMETRAL	115	61	∠ TO FABRIC	33.5	VALID	8.53	9.33
DH-BGC12-19	312.2	DIAMETRAL	130	61	∠ TO FABRIC	13.98	VALID	3.56	3.90
DH-BGC12-19	312.34	DIAMETRAL	125	61	∠ TO FABRIC	23.98	VALID	6.11	6.68
DH-BGC12-19	315.28	DIAMETRAL	175	61	∠ TO FABRIC	15.92	INVALID	4.06	4.44
DH-BGC12-19	319.21	DIAMETRAL	150	61	∠ TO FABRIC	9.14	VALID	2.33	2.55
DH-BGC12-19	323.46	DIAMETRAL	130	61	∠ TO FABRIC	21.34	VALID	5.44	5.95
DH-BGC12-19	325.16	DIAMETRAL	115	61	∠ TO FABRIC	14.34	VALID	3.65	4.00
DH-BGC12-19	328.19	DIAMETRAL	165	61	∠ TO FABRIC	28.26	VALID	7.20	7.87
DH-BGC12-19	332.72	DIAMETRAL	105	61	∠ TO FABRIC	33.5	VALID	8.53	9.33
DH-BGC12-19	333.87	DIAMETRAL	130	61	∠ TO FABRIC	20.38	VALID	5.19	5.68
DH-BGC12-19	336.26	DIAMETRAL	175	61	NA	20.2	VALID	5.15	5.63
DH-BGC12-19	341.66	DIAMETRAL	135	61	NA	44.04	VALID	11.22	12.27
DH-BGC12-19	343.6	DIAMETRAL	160	61	NA	23.4	VALID	5.96	6.52
DH-BGC12-19	346.62	DIAMETRAL	110	61	NA	4.9	VALID	1.25	1.37
DH-BGC12-19	352.71	DIAMETRAL	100	61	NA	23.08	VALID	5.88	6.43
DH-BGC12-19	352.83	DIAMETRAL	155	61	∠ TO FABRIC	21.52	VALID	5.48	6.00
DH-BGC12-19	352.96	DIAMETRAL	100	61	∠ TO FABRIC	24.42	VALID	6.22	6.80
DH-BGC12-19	353.3	DIAMETRAL	115	61	∠ TO FABRIC	25.52	VALID	6.50	7.11
DH-BGC12-19	356.96	DIAMETRAL	170	61	∠ TO FABRIC	16.92	VALID	4.31	4.71
DH-BGC12-19	361.23	DIAMETRAL	115	61	∠ TO FABRIC	16.04	VALID	4.09	4.47
DH-BGC12-19	361.72	DIAMETRAL	145	61	∠ TO FABRIC	8.64	VALID	2.20	2.41
DH-BGC12-19	364.79	DIAMETRAL	120	61	∠ TO FABRIC	21.12	VALID	5.38	5.88
DH-BGC12-19	368.57	DIAMETRAL	130	61	∠ TO FABRIC	22.02	VALID	5.61	6.14
DH-BGC12-19	372.22	DIAMETRAL	120	61	∠ TO FABRIC	22.36	VALID	5.70	6.23
DH-BGC12-19	374.94	DIAMETRAL	120	61	∠ TO FABRIC	42.12	VALID	10.73	11.74
DH-BGC12-19	378.98	DIAMETRAL	130	61	∠ TO FABRIC	20.26	VALID	5.16	5.64
DH-BGC12-19	383.19	DIAMETRAL	100	61	∠ TO FABRIC	8.64	VALID	2.20	2.41
DH-BGC12-19	384.74	DIAMETRAL	155	61	∠ TO FABRIC	18.84	VALID	4.80	5.25
DH-BGC12-19	388.22	DIAMETRAL	130	61	∠ TO FABRIC	20.64	VALID	5.26	5.75
DH-BGC12-19	390.83	DIAMETRAL	150	61	∠ TO FABRIC	28.6	VALID	7.29	7.97
DH-BGC12-19	392.93	DIAMETRAL	120	61	NA	10.38	VALID	2.64	2.89
DH-BGC12-19	396.59	DIAMETRAL	220	61	NA	11.34	VALID	2.89	3.16
DH-BGC12-19	402.02	DIAMETRAL	165	61	∠ TO FABRIC	20.7	VALID	5.27	5.77
DH-BGC12-19	405.52	DIAMETRAL	155	61	∠ TO FABRIC	23.44	VALID	5.97	6.53
DH-BGC12-19	408.71	DIAMETRAL	190	61	∠ TO FABRIC	19.84	VALID	5.05	5.53
DH-BGC12-19	410.48	DIAMETRAL	130	61	∠ TO FABRIC	20.16	INVALID	5.14	5.62
DH-BGC12-19	413.55	DIAMETRAL	130	61	∠ TO FABRIC	37.16	VALID	9.47	10.35

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-19	417.86	DIAMETRAL	180	61	∠ TO FABRIC	0.2	INVALID	0.05	0.06
DH-BGC12-19	419.77	DIAMETRAL	120	61	∠ TO FABRIC	26.02	INVALID	6.63	7.25
DH-BGC12-19	421.05	DIAMETRAL	100	61	∠ TO FABRIC	44.38	VALID	11.31	12.37
DH-BGC12-19	421.57	DIAMETRAL	115	61	NA	29.6	VALID	7.54	8.25
DH-BGC12-19	421.68	DIAMETRAL	110	61	∠ TO FABRIC	11.4	INVALID	2.90	3.18
DH-BGC12-19	421.8	DIAMETRAL	150	61	NA	36.62	VALID	9.33	10.20
DH-BGC12-19	422.05	DIAMETRAL	90	61	NA	24.68	INVALID	6.29	6.88
DH-BGC12-19	424.76	DIAMETRAL	125	61	∠ TO FABRIC	47.38	VALID	12.07	13.20
DH-BGC12-20	5.72	DIAMETRAL	150	61	∠ TO FABRIC	8.88	INVALID	2.26	2.47
DH-BGC12-20	6.17	DIAMETRAL	150	61	∠ TO FABRIC	7.22	VALID	1.84	2.01
DH-BGC12-20	8.77	DIAMETRAL	160	61	∠ TO FABRIC	15.18	VALID	3.87	4.23
DH-BGC12-20	12.49	DIAMETRAL	200	61	∠ TO FABRIC	24.02	VALID	6.12	6.69
DH-BGC12-20	16.66	DIAMETRAL	220	61	∠ TO FABRIC	0.42	INVALID	0.11	0.12
DH-BGC12-20	18.21	DIAMETRAL	160	61	∠ TO FABRIC	3.42	VALID	0.87	0.95
DH-BGC12-20	22.61	DIAMETRAL	100	61	∠ TO FABRIC	26.9	VALID	6.85	7.49
DH-BGC12-20	24.23	DIAMETRAL	115	61	NA	23.6	VALID	6.01	6.58
DH-BGC12-20	24.35	DIAMETRAL	110	61	NA	27.04	VALID	6.89	7.53
DH-BGC12-20	24.46	DIAMETRAL	90	61	NA	34.26	VALID	8.73	9.55
DH-BGC12-20	24.82	DIAMETRAL	140	61	NA	37.92	VALID	9.66	10.57
DH-BGC12-20	27.24	DIAMETRAL	110	61	NA	25.2	VALID	6.42	7.02
DH-BGC12-20	31.87	DIAMETRAL	160	61	∠ TO FABRIC	21.12	VALID	5.38	5.88
DH-BGC12-20	34.82	DIAMETRAL	120	61	∠ TO FABRIC	0.46	VALID	0.12	0.13
DH-BGC12-20	37.46	DIAMETRAL	165	61	∠ TO FABRIC	11.28	VALID	2.87	3.14
DH-BGC12-20	42.68	DIAMETRAL	185	61	∠ TO FABRIC	8.3	VALID	2.11	2.31
DH-BGC12-20	47.76	DIAMETRAL	100	61	∠ TO FABRIC	29.24	VALID	7.45	8.15
DH-BGC12-20	50.51	DIAMETRAL	105	61	∠ TO FABRIC	15.96	VALID	4.07	4.45
DH-BGC12-20	52.87	DIAMETRAL	170	61	∠ TO FABRIC	12.6	INVALID	3.21	3.51
DH-BGC12-20	57.67	DIAMETRAL	120	61	∠ TO FABRIC	23.42	VALID	5.97	6.53
DH-BGC12-20	59.1	DIAMETRAL	130	61	∠ TO FABRIC	37.14	VALID	9.46	10.35
DH-BGC12-20	61.6	DIAMETRAL	140	61	∠ TO FABRIC	23	VALID	5.86	6.41
DH-BGC12-20	65.29	DIAMETRAL	110	61	∠ TO FABRIC	16.68	INVALID	4.25	4.65
DH-BGC12-20	65.55	DIAMETRAL	215	61	∠ TO FABRIC	21.2	INVALID	5.40	5.91
DH-BGC12-20	66.05	DIAMETRAL	155	61	∠ TO FABRIC	18.3	INVALID	4.66	5.10
DH-BGC12-20	66.16	DIAMETRAL	150	61	∠ TO FABRIC	24.24	VALID	6.18	6.75
DH-BGC12-20	66.45	DIAMETRAL	185	61	∠ TO FABRIC	22.56	VALID	5.75	6.29
DH-BGC12-20	353.06	DIAMETRAL	140	61	NA	20.94	VALID	5.33	5.83
DH-BGC12-20	357.23	DIAMETRAL	150	61	NA	19.54	VALID	4.98	5.44

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-20	356.25	DIAMETRAL	140	61	NA	42.56	VALID	10.84	11.86
DH-BGC12-20	368.18	DIAMETRAL	180	61	NA	19.32	INVALID	4.92	5.38
DH-BGC12-20	369.2	DIAMETRAL	200	61	NA	22.82	INVALID	5.81	6.36
DH-BGC12-20	372.67	DIAMETRAL	130	61	NA	20.78	VALID	5.29	5.79
DH-BGC12-20	375.11	DIAMETRAL	155	61	NA	17.28	VALID	4.40	4.81
DH-BGC12-20	377.47	DIAMETRAL	175	61	NA	14.3	INVALID	3.64	3.98
DH-BGC12-20	379.55	DIAMETRAL	165	61	NA	21.94	VALID	5.59	6.11
DH-BGC12-20	382.07	DIAMETRAL	200	61	NA	20.74	VALID	5.28	5.78
DH-BGC12-20	386.57	DIAMETRAL	160	61	NA	27.9	VALID	7.11	7.77
DH-BGC12-20	389.84	DIAMETRAL	150	61	NA	17.24	INVALID	4.39	4.80
DH-BGC12-20	392.89	DIAMETRAL	140	61	NA	19.98	VALID	5.09	5.57
DH-BGC12-20	396.97	DIAMETRAL	130	61	NA	34.98	VALID	8.91	9.75
DH-BGC12-20	403.56	DIAMETRAL	190	61	NA	26.48	INVALID	6.75	7.38
DH-BGC12-20	406.04	DIAMETRAL	170	61	NA	45.14	VALID	11.50	12.58
DH-BGC12-20	411.97	DIAMETRAL	140	61	NA	8.84	INVALID	2.25	2.46
DH-BGC12-20	413.67	DIAMETRAL	125	61	NA	30.6	VALID	7.80	8.53
DH-BGC12-20	66.59	DIAMETRAL	135	61	∠ TO FABRIC	25.04	VALID	6.38	6.98
DH-BGC12-20	69.88	DIAMETRAL	160	61	∠ TO FABRIC	16.16	VALID	4.12	4.50
DH-BGC12-20	75.08	DIAMETRAL	150	61	∠ TO FABRIC	22.34	VALID	5.69	6.22
DH-BGC12-20	79.19	DIAMETRAL	210	61	∠ TO FABRIC	17.82	INVALID	4.54	4.96
DH-BGC12-20	81.9	DIAMETRAL	150	61	∠ TO FABRIC	22.6	VALID	5.76	6.30
DH-BGC12-20	86.5	DIAMETRAL	130	61	∠ TO FABRIC	24.06	VALID	6.13	6.70
DH-BGC12-20	89.24	DIAMETRAL	120	61	∠ TO FABRIC	19	VALID	4.84	5.29
DH-BGC12-20	92.56	DIAMETRAL	175	61	∠ TO FABRIC	26.74	VALID	6.81	7.45
DH-BGC12-20	95.46	DIAMETRAL	185	61	∠ TO FABRIC	19.4	VALID	4.94	5.41
DH-BGC12-20	96.3	DIAMETRAL	160	61	∠ TO FABRIC	30.7	VALID	7.82	8.55
DH-BGC12-20	100.42	DIAMETRAL	250	61	∠ TO FABRIC	35.88	VALID	9.14	10.00
DH-BGC12-20	103.1	DIAMETRAL	240	61	∠ TO FABRIC	41.76	VALID	10.64	11.64
DH-BGC12-20	106.17	DIAMETRAL	160	61	∠ TO FABRIC	33.36	VALID	8.50	9.29
DH-BGC12-20	103.32	DIAMETRAL	195	61	NA	18.88	INVALID	4.81	5.26
DH-BGC12-20	113.36	DIAMETRAL	190	61	∠ TO FABRIC	30.68	VALID	7.82	8.55
DH-BGC12-20	113.56	DIAMETRAL	165	61	∠ TO FABRIC	38.08	VALID	9.70	10.61
DH-BGC12-20	113.69	DIAMETRAL	140	61	∠ TO FABRIC	18.26	INVALID	4.65	5.09
DH-BGC12-20	114.14	DIAMETRAL	220	61	∠ TO FABRIC	42.64	VALID	10.86	11.88
DH-BGC12-20	116.94	DIAMETRAL	120	61	∠ TO FABRIC	19.48	INVALID	4.96	5.43
DH-BGC12-20	118.29	DIAMETRAL	100	61	∠ TO FABRIC	20.18	VALID	5.14	5.62
DH-BGC12-20	121.3	DIAMETRAL	155	61	∠ TO FABRIC	29.8	VALID	7.59	8.30

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-20	124.75	DIAMETRAL	170	61	∠ TO FABRIC	28.34	VALID	7.22	7.90
DH-BGC12-20	127.8	DIAMETRAL	170	61	∠ TO FABRIC	37.32	INVALID	9.51	10.40
DH-BGC12-20	130.83	DIAMETRAL	145	61	∠ TO FABRIC	44.52	VALID	11.34	12.40
DH-BGC12-20	135.27	DIAMETRAL	100	61	∠ TO FABRIC	25.44	VALID	6.48	7.09
DH-BGC12-20	138.33	DIAMETRAL	110	61	∠ TO FABRIC	25.78	VALID	6.57	7.18
DH-BGC12-20	141.51	DIAMETRAL	155	61	∠ TO FABRIC	14.08	VALID	3.59	3.92
DH-BGC12-20	146	DIAMETRAL	135	61	∠ TO FABRIC	26.56	INVALID	6.77	7.40
DH-BGC12-20	148.89	DIAMETRAL	155	61	∠ TO FABRIC	28.06	VALID	7.15	7.82
DH-BGC12-20	152.16	DIAMETRAL	130	61	∠ TO FABRIC	33.64	VALID	8.57	9.37
DH-BGC12-20	156.44	DIAMETRAL	145	61	∠ TO FABRIC	38.2	VALID	9.73	10.64
DH-BGC12-20	160.49	DIAMETRAL	120	61	∠ TO FABRIC	43.72	VALID	11.14	12.18
DH-BGC12-20	161.59	DIAMETRAL	190	61	∠ TO FABRIC	10.92	INVALID	2.78	3.04
DH-BGC12-20	165.02	DIAMETRAL	205	61	∠ TO FABRIC	28.64	VALID	7.30	7.98
DH-BGC12-20	165.26	DIAMETRAL	240	61	∠ TO FABRIC	19.36	INVALID	4.93	5.39
DH-BGC12-20	165.64	DIAMETRAL	180	61	∠ TO FABRIC	20.84	INVALID	5.31	5.81
DH-BGC12-20	165.89	DIAMETRAL	130	61	∠ TO FABRIC	34.18	VALID	8.71	9.52
DH-BGC12-20	164.86	DIAMETRAL	135	61	∠ TO FABRIC	20.72	INVALID	5.28	5.77
DH-BGC12-20	168.7	DIAMETRAL	170	61	∠ TO FABRIC	26.8	VALID	6.83	7.47
DH-BGC12-20	170.3	DIAMETRAL	140	61	∠ TO FABRIC	18.26	INVALID	4.65	5.09
DH-BGC12-20	173.52	DIAMETRAL	155	61	NA	16.7	INVALID	4.25	4.65
DH-BGC12-20	178.56	DIAMETRAL	160	61	∠ TO FABRIC	23.78	VALID	6.06	6.63
DH-BGC12-20	181.51	DIAMETRAL	150	61	∠ TO FABRIC	32.54	VALID	8.29	9.07
DH-BGC12-20	184.17	DIAMETRAL	160	61	∠ TO FABRIC	22.3	VALID	5.68	6.21
DH-BGC12-20	186.24	DIAMETRAL	160	61	∠ TO FABRIC	20.4	INVALID	5.20	5.68
DH-BGC12-20	190.12	DIAMETRAL	180	61	NA	19.44	INVALID	4.95	5.42
DH-BGC12-20	194.7	DIAMETRAL	130	61	∠ TO FABRIC	33.06	VALID	8.42	9.21
DH-BGC12-20	197.08	DIAMETRAL	180	61	∠ TO FABRIC	49.74	VALID	12.67	13.86
DH-BGC12-20	199.05	DIAMETRAL	195	61	∠ TO FABRIC	20.62	INVALID	5.25	5.75
DH-BGC12-20	199.2	DIAMETRAL	110	61	∠ TO FABRIC	20.62	INVALID	5.25	5.75
DH-BGC12-20	199.29	DIAMETRAL	100	61	∠ TO FABRIC	15.92	INVALID	4.06	4.44
DH-BGC12-20	199.79	DIAMETRAL	240	61	∠ TO FABRIC	45.3	VALID	11.54	12.62
DH-BGC12-20	199.96	DIAMETRAL	125	61	∠ TO FABRIC	32.26	VALID	8.22	8.99
DH-BGC12-20	200.8	DIAMETRAL	125	61	∠ TO FABRIC	21.14	VALID	5.39	5.89
DH-BGC12-20	203.86	DIAMETRAL	110	61	∠ TO FABRIC	28.16	INVALID	7.17	7.85
DH-BGC12-20	205.2	DIAMETRAL	115	61	∠ TO FABRIC	20.58	VALID	5.24	5.73
DH-BGC12-20	210.07	DIAMETRAL	130	61	∠ TO FABRIC	20.26	INVALID	5.16	5.64
DH-BGC12-20	213.18	DIAMETRAL	225	61	∠ TO FABRIC	47.44	VALID	12.09	13.22

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-20	214.73	DIAMETRAL	150	61	∠ TO FABRIC	18.92	INVALID	4.82	5.27
DH-BGC12-20	219.23	DIAMETRAL	165	61	∠ TO FABRIC	35.84	VALID	9.13	9.99
DH-BGC12-20	222.61	DIAMETRAL	150	61	∠ TO FABRIC	28.3	VALID	7.21	7.88
DH-BGC12-20	225.34	DIAMETRAL	160	61	∠ TO FABRIC	28.3	VALID	7.21	7.88
DH-BGC12-20	228.38	DIAMETRAL	165	61	∠ TO FABRIC	46.58	VALID	11.87	12.98
DH-BGC12-20	230.33	DIAMETRAL	160	61	∠ TO FABRIC	34.96	VALID	8.91	9.74
DH-BGC12-20	233.29	DIAMETRAL	195	61	∠ TO FABRIC	40.56	VALID	10.33	11.30
DH-BGC12-20	237.42	DIAMETRAL	175	61	∠ TO FABRIC	26.38	VALID	6.72	7.35
DH-BGC12-20	240.54	DIAMETRAL	110	61	∠ TO FABRIC	28.38	VALID	7.23	7.91
DH-BGC12-20	240.81	DIAMETRAL	150	61	∠ TO FABRIC	21.94	INVALID	5.59	6.11
DH-BGC12-20	245.54	DIAMETRAL	190	61	∠ TO FABRIC	24.54	VALID	6.25	6.84
DH-BGC12-20	246.34	DIAMETRAL	205	61	∠ TO FABRIC	19.78	INVALID	5.04	5.51
DH-BGC12-20	246.64	DIAMETRAL	115	61	∠ TO FABRIC	20.76	INVALID	5.29	5.78
DH-BGC12-20	246.76	DIAMETRAL	100	61	∠ TO FABRIC	30.3	VALID	7.72	8.44
DH-BGC12-20	246.84	DIAMETRAL	70	61	∠ TO FABRIC	17.72	INVALID	4.51	4.94
DH-BGC12-20	250.71	DIAMETRAL	230	61	∠ TO FABRIC	11.7	INVALID	2.98	3.26
DH-BGC12-20	253.54	DIAMETRAL	195	61	∠ TO FABRIC	8.76	INVALID	2.23	2.44
DH-BGC12-20	247.18	DIAMETRAL	105	61	∠ TO FABRIC	21.16	INVALID	5.39	5.90
DH-BGC12-20	260.24	DIAMETRAL	110	61	∠ TO FABRIC	16.3	INVALID	4.15	4.54
DH-BGC12-20	263.29	DIAMETRAL	130	61	∠ TO FABRIC	24.92	VALID	6.35	6.94
DH-BGC12-20	266.8	DIAMETRAL	150	61	∠ TO FABRIC	24.52	VALID	6.25	6.83
DH-BGC12-20	270.9	DIAMETRAL	110	61	∠ TO FABRIC	14.3	INVALID	3.64	3.98
DH-BGC12-20	272.36	DIAMETRAL	150	61	∠ TO FABRIC	44.34	VALID	11.30	12.35
DH-BGC12-20	274.84	DIAMETRAL	105	61	∠ TO FABRIC	33.66	VALID	8.58	9.38
DH-BGC12-20	278.56	DIAMETRAL	140	61	∠ TO FABRIC	22.9	VALID	5.83	6.38
DH-BGC12-20	282.53	DIAMETRAL	100	61	∠ TO FABRIC	22.98	VALID	5.85	6.40
DH-BGC12-20	234.66	DIAMETRAL	125	61	∠ TO FABRIC	18.8	INVALID	4.79	5.24
DH-BGC12-20	287.88	DIAMETRAL	130	61	∠ TO FABRIC	34.92	VALID	8.90	9.73
DH-BGC12-20	290.86	DIAMETRAL	150	61	∠ TO FABRIC	24.12	VALID	6.15	6.72
DH-BGC12-20	292.23	DIAMETRAL	130	61	∠ TO FABRIC	31.32	VALID	7.98	8.73
DH-BGC12-20	297.24	DIAMETRAL	240	61	NA	17.18	VALID	4.38	4.79
DH-BGC12-20	299.61	DIAMETRAL	185	61	NA	18.28	INVALID	4.66	5.09
DH-BGC12-20	305.91	DIAMETRAL	145	61	NA		INVALID		
DH-BGC12-20	313.51	DIAMETRAL	130	61	NA	15.24	VALID	3.88	4.25
DH-BGC12-20	314.35	DIAMETRAL	220	61	NA	34.36	VALID	8.75	9.57
DH-BGC12-20	318.18	DIAMETRAL	180	61	NA	15.18	INVALID	3.87	4.23
DH-BGC12-20	324.11	DIAMETRAL	220	61	NA	13.62	VALID	3.47	3.79

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-20	328.33	DIAMETRAL	250	61	NA	11.48	INVALID	2.92	3.20
DH-BGC12-20	330.06	DIAMETRAL	180	61	NA	19.12	VALID	4.87	5.33
DH-BGC12-20	333	DIAMETRAL	150	61	NA	25.48	VALID	6.49	7.10
DH-BGC12-20	336.22	DIAMETRAL	200	61	NA	12.52	INVALID	3.19	3.49
DH-BGC12-20	339.34	DIAMETRAL	210	61	NA	17.8	INVALID	4.53	4.96
DH-BGC12-20	344.12	DIAMETRAL	240	61	NA	28.6	VALID	7.29	7.97
DH-BGC12-20	345.45	DIAMETRAL	180	61	NA	15.04	VALID	3.83	4.19
DH-BGC12-20	346.43	DIAMETRAL	180	61	NA	21.76	VALID	5.54	6.06
DH-BGC12-20	350.38	DIAMETRAL	170	61	NA	18.52	VALID	4.72	5.16
DH-BGC12-21	148.22	DIAMETRAL	155	61	NA	6.92	INVALID	1.76	1.93
DH-BGC12-21	214.63	DIAMETRAL	200	61	NA	12.84	INVALID	3.27	3.58
DH-BGC12-21	182.57	DIAMETRAL	220	61	NA	29	VALID	7.39	8.08
DH-BGC12-21	223.36	DIAMETRAL	165	61	// TO FABRIC	18.8	VALID	4.79	5.24
DH-BGC12-21	149.16	DIAMETRAL	130	61	NA	36.36	VALID	9.26	10.13
DH-BGC12-21	213.84	DIAMETRAL	230	61	NA	21.7	VALID	5.53	6.05
DH-BGC12-21	145.46	DIAMETRAL	240	61	// TO FABRIC	5.8	VALID	1.48	1.62
DH-BGC12-21	141.67	DIAMETRAL	220	61	NA	18.82	INVALID	4.79	5.24
DH-BGC12-21	142.67	DIAMETRAL	180	61	NA	24	INVALID	6.11	6.69
DH-BGC12-21	143.68	DIAMETRAL	200	61	NA	13.56	VALID	3.45	3.78
DH-BGC12-21	183.08	DIAMETRAL	160	61	NA	28.32	VALID	7.46	8.10
DH-BGC12-21	139.12	DIAMETRAL	262	61	NA	41.8	VALID	10.65	11.65
DH-BGC12-21	138.4	DIAMETRAL	135	61	NA	21.74	VALID	5.54	6.06
DH-BGC12-21	133.31	DIAMETRAL	163	61	NA	10.98	VALID	2.80	3.06
DH-BGC12-21	132.43	DIAMETRAL	150	61	NA	26.96	VALID	6.87	7.51
DH-BGC12-21	129.14	DIAMETRAL	182	61	NA	20.46	VALID	5.21	5.70
DH-BGC12-21	125.2	DIAMETRAL	200	61	NA	29.56	VALID	7.53	8.24
DH-BGC12-21	122.06	DIAMETRAL	108	61	NA	31.96	VALID	8.14	8.90
DH-BGC12-21	125.27	DIAMETRAL	122	61	NA	17.88	INVALID	4.56	4.98
DH-BGC12-21	124.51	DIAMETRAL	211	61	NA	25.3	INVALID	6.45	7.05
DH-BGC12-21	124.75	DIAMETRAL	145	61	NA	21.58	INVALID	5.50	6.01
DH-BGC12-21	126.41	DIAMETRAL	149	61	NA	27.7	INVALID	7.06	7.72
DH-BGC12-21	126.57	DIAMETRAL	142	61	NA	25.49	VALID	6.49	7.10
DH-BGC12-21	126.71	DIAMETRAL	161	61	NA	39.34	VALID	10.02	10.96
DH-BGC12-21	180.03	DIAMETRAL	116	61	NA	28.34	VALID	7.22	7.90
DH-BGC12-21	174.09	DIAMETRAL	115	61	NA	24.5	VALID	6.45	7.00
DH-BGC12-21	173.78	DIAMETRAL	75	61	NA	16.98	VALID	4.47	4.85
DH-BGC12-21	166.66	DIAMETRAL	122	61	NA	27.2	VALID	7.16	7.78

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-21	163.77	DIAMETRAL	281	61	NA	6.64	VALID	1.69	1.85
DH-BGC12-21	165.91	DIAMETRAL	189	61	NA	16.68	VALID	4.25	4.65
DH-BGC12-21	161.02	DIAMETRAL	134	61	NA	22.54	INVALID	5.74	6.28
DH-BGC12-21	162.13	DIAMETRAL	220	61	NA	14.34	VALID	3.65	4.00
DH-BGC12-21	225.68	DIAMETRAL	152	61	NA	26.68	VALID	7.03	7.63
DH-BGC12-21	157.67	DIAMETRAL	263	61	NA	14.48	VALID	3.69	4.03
DH-BGC12-21	154.82	DIAMETRAL	169	61	NA	19.26	VALID	4.91	5.37
DH-BGC12-21	152.3	DIAMETRAL	109	61	NA	21.14	VALID	5.39	5.89
DH-BGC12-21	210.2	DIAMETRAL	178	61	NA	18.78	VALID	4.95	5.37
DH-BGC12-21	208.96	DIAMETRAL	172	61	NA	21.08	VALID	5.37	5.87
DH-BGC12-21	203.95	DIAMETRAL	308	61	NA	35.56	VALID	9.06	9.91
DH-BGC12-21	201.5	DIAMETRAL	203	61	NA	20.78	VALID	5.47	5.94
DH-BGC12-21	198.52	DIAMETRAL	308	61	NA	26.64	VALID	7.02	7.62
DH-BGC12-21	195.77	DIAMETRAL	172	61	NA	19.42	VALID	5.11	5.55
DH-BGC12-21	191.2	DIAMETRAL	110	61	NA	26.48	VALID	6.97	7.57
DH-BGC12-21	188.93	DIAMETRAL	222	61	NA	15.46	VALID	3.94	4.31
DH-BGC12-21	189.78	DIAMETRAL	113	61	NA	25.28	VALID	6.66	7.23
DH-BGC12-21	187.5	DIAMETRAL	224	61	NA	23.6	INVALID	6.01	6.58
DH-BGC12-21	186.35	DIAMETRAL	165	61	NA	28	VALID	7.13	7.80
DH-BGC12-21	183.94	DIAMETRAL	184	61	NA	27.42	INVALID	6.99	7.64
DH-BGC12-21	183.98	DIAMETRAL	160	61	NA	28.04	INVALID	7.38	8.02
DH-BGC12-21	184.54	DIAMETRAL	150	61	NA	24.44	VALID	6.44	6.99
DH-BGC12-21	219.32	DIAMETRAL	221	61	NA	37.38	VALID	9.84	10.69
DH-BGC12-21	261.45	DIAMETRAL	83	61	NA	29.42	VALID	7.50	8.20
DH-BGC12-21	266.95	DIAMETRAL	104	61	NA	9.1	VALID	2.32	2.54
DH-BGC12-21	269.25	DIAMETRAL	233	61	// TO FABRIC	11.66	VALID	2.97	3.25
DH-BGC12-21	274.48	DIAMETRAL	203	61	NA	9.1	VALID	2.32	2.54
DH-BGC12-21	275.09	DIAMETRAL	187	61	∠ TO FABRIC	18.58	VALID	4.73	5.18
DH-BGC12-21	278.55	DIAMETRAL	200	61	NA	20.9	VALID	5.32	5.82
DH-BGC12-21	284.17	DIAMETRAL	181	61	NA	28.54	VALID	7.27	7.95
DH-BGC12-21	285.15	DIAMETRAL	211	61	NA	28.88	VALID	7.36	8.05
DH-BGC12-21	290.61	DIAMETRAL	108	61	NA	28.68	VALID	7.55	8.20
DH-BGC12-21	291.38	DIAMETRAL	152	61	// TO FABRIC	13.66	VALID	3.48	3.81
DH-BGC12-21	295.43	DIAMETRAL	164	61	NA	21.82	VALID	5.56	6.08
DH-BGC12-21	295.16	DIAMETRAL	165	61	∠ TO FABRIC	28.48	VALID	7.26	7.94
DH-BGC12-21	297.5	DIAMETRAL	213	61	∠ TO FABRIC	30.18	VALID	7.69	8.41
DH-BGC12-21	302.75	DIAMETRAL	101	61	// TO FABRIC	5.38	VALID	1.37	1.50

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-21	305.08	DIAMETRAL	161	61	NA	21.92	VALID	5.58	6.11
DH-BGC12-21	309.77	DIAMETRAL	220	61	NA	23.94	VALID	6.10	6.67
DH-BGC12-21	310.26	DIAMETRAL	123	61	NA	38.38	VALID	9.78	10.69
DH-BGC12-21	314	DIAMETRAL	223	61	NA	27.68	VALID	7.05	7.71
DH-BGC12-21	318.44	DIAMETRAL	292	61	NA	26.64	VALID	6.79	7.42
DH-BGC12-21	320.2	DIAMETRAL	220	61	NA	21.74	VALID	5.54	6.06
DH-BGC12-21	325.04	DIAMETRAL	252	61	NA	11.94	VALID	3.04	3.33
DH-BGC12-21	297.03	DIAMETRAL	255	61	NA	19.24	VALID	4.90	5.36
DH-BGC12-21	296.03	DIAMETRAL	122	61	NA	26.58	VALID	6.77	7.41
DH-BGC12-21	332.59	DIAMETRAL	104	61	NA	15.14	VALID	3.86	4.22
DH-BGC12-21	328.09	DIAMETRAL	230	61	NA	11.5	VALID	2.93	3.20
DH-BGC12-21	333.8	DIAMETRAL	228	61	NA	27.06	VALID	6.89	7.54
DH-BGC12-21	336.4	DIAMETRAL	129	61	// TO FABRIC	1.12	VALID	0.29	0.31
DH-BGC12-21	341.31	DIAMETRAL	104	61	// TO FABRIC	16.5	VALID	4.20	4.60
DH-BGC12-21	345.41	DIAMETRAL	189	61	∠ TO FABRIC	24.34	VALID	6.20	6.78
DH-BGC12-21	346.43	DIAMETRAL	267	61	∠ TO FABRIC	20.62	VALID	5.25	5.75
DH-BGC12-21	351.83	DIAMETRAL	324	61	∠ TO FABRIC	21.64	VALID	5.51	6.03
DH-BGC12-21	354.46	DIAMETRAL	147	61	// TO FABRIC	23.32	VALID	5.94	6.50
DH-BGC12-21	353.7	DIAMETRAL	96	61	// TO FABRIC	14.48	VALID	3.69	4.03
DH-BGC12-21	353.1	DIAMETRAL	195	61	∠ TO FABRIC	24.9	VALID	6.34	6.94
DH-BGC12-21	355.18	DIAMETRAL	189	61	NA	17.7	VALID	4.51	4.93
DH-BGC12-21	356.79	DIAMETRAL	199	61	NA	9.66	VALID	2.46	2.69
DH-BGC12-21	359.79	DIAMETRAL	227	61	NA	6.16	VALID	1.57	1.72
DH-BGC12-21	362.78	DIAMETRAL	100	61	NA	25.46	VALID	6.49	7.09
DH-BGC12-21	368.13	DIAMETRAL	222	61	NA	23.68	INVALID	6.03	6.60
DH-BGC12-21	369.22	DIAMETRAL	183	61	// TO FABRIC	22.48	VALID	5.73	6.26
DH-BGC12-21	372.48	DIAMETRAL	214	61	NA	25.64	VALID	6.53	7.14
DH-BGC12-21	376.81	DIAMETRAL	178	61	NA	27.84	VALID	7.09	7.76
DH-BGC12-21	379.83	DIAMETRAL	100	61	NA	23.28	VALID	5.93	6.49
DH-BGC12-21	383.03	DIAMETRAL	294	61	NA	36.44	VALID	9.28	10.15
DH-BGC12-21	374.7	DIAMETRAL	158	61	NA	27.26	VALID	6.95	7.60
DH-BGC12-21	374.8	DIAMETRAL	131	61	NA	28.28	VALID	7.20	7.88
DH-BGC12-21	374.26	DIAMETRAL	200	61	NA	33.44	VALID	8.52	9.32
DH-BGC12-21	374.2	DIAMETRAL	115	61	NA	38.84	VALID	9.90	10.82
DH-BGC12-21	386.51	DIAMETRAL	202	61	NA	26.38	INVALID	6.72	7.35
DH-BGC12-21	387.26	DIAMETRAL	173	61	NA	33.12	INVALID	8.44	9.23
DH-BGC12-21	385.66	DIAMETRAL	223	61	NA	14.98	VALID	3.82	4.17

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DH-BGC12-21	387.5	DIAMETRAL	122	61	NA	37.28	VALID	9.50	10.39
DH-BGC12-21	390.95	DIAMETRAL	160	61	NA	12.4	VALID	3.16	3.45
DH-BGC12-21	395.09	DIAMETRAL	132	61	NA	31.32	INVALID	7.98	8.73
DH-BGC12-21	394.99	DIAMETRAL	204	61	NA	15.22	VALID	3.88	4.24
DH-BGC12-21	398.17	DIAMETRAL	199	61	NA	23.18	VALID	5.91	6.46
DH-BGC12-21	401.21	DIAMETRAL	148	61	NA	19.46	VALID	4.96	5.42
DH-BGC12-21	403.95	DIAMETRAL	210	61	NA	29.42	INVALID	7.50	8.20
DH-BGC12-21	403.89	DIAMETRAL	210	61	NA	11.62	VALID	2.96	3.24
DH-BGC12-21	407.91	DIAMETRAL	136	61	∠ TO FABRIC	36.02	VALID	9.18	10.04
DH-BGC12-21	410.71	DIAMETRAL	120	61	NA	20	VALID	5.10	5.57
DH-BGC12-21	415.97	DIAMETRAL	133	61	NA	23.46	VALID	5.98	6.54
DH-BGC12-21	419.64	DIAMETRAL	105	61	∠ TO FABRIC	30.52	INVALID	7.78	8.50
DH-BGC12-21	419.54	DIAMETRAL	228	61	// TO FABRIC	19.38	VALID	4.94	5.40
DH-BGC12-21	423	DIAMETRAL	160	61	∠ TO FABRIC	5.6	VALID	1.43	1.56
DH-BGC12-21	424.44	DIAMETRAL	134	61	NA	17.82	VALID	4.54	4.96
DH-BGC12-21	427.1	DIAMETRAL	157	61	∠ TO FABRIC	24.38	INVALID	6.21	6.79
DH-BGC12-21	429.41	DIAMETRAL	242	61	NA	28.24	VALID	7.19	7.87
DH-BGC12-21	430.91	DIAMETRAL	203	61	NA	17.76	VALID	4.52	4.95
DH-BGC12-21	416.68	DIAMETRAL	96	61	∠ TO FABRIC	30.26	INVALID	7.71	8.43
DH-BGC12-21	417.51	DIAMETRAL	300	61	∠ TO FABRIC	28.18	INVALID	7.18	7.85
DH-BGC12-21	417.4	DIAMETRAL	212	61	∠ TO FABRIC	38.5	VALID	9.81	10.73
DH-BGC12-21	417.2	DIAMETRAL	229	61	∠ TO FABRIC	24.68	INVALID	6.29	6.88
DH-BGC12-21	417.72	DIAMETRAL	233	61	∠ TO FABRIC	17.38	VALID	4.43	4.84
DH-BGC12-21	434.2	DIAMETRAL	233	61	NA	25.3	INVALID	6.45	7.05
DH-BGC12-21	434.27	DIAMETRAL	144	61	NA	38.08	VALID	9.70	10.61
DH-BGC12-21	437.85	DIAMETRAL	173	61	NA	21.98	VALID	5.60	6.12
DH-BGC12-21	438.58	DIAMETRAL	111	61	∠ TO FABRIC	25.16	VALID	6.41	7.01
DH-BGC12-21	442.35	DIAMETRAL	184	61	∠ TO FABRIC	37.02	VALID	9.43	10.31
DH-BGC12-21	439.62	DIAMETRAL	200	61	∠ TO FABRIC	29.46	VALID	7.51	8.21
DH-BGC12-21	445.16	DIAMETRAL	131	61	∠ TO FABRIC	27.6	INVALID	7.03	7.69
DH-BGC12-21	445.45	DIAMETRAL	164	61	NA	34.42	VALID	8.77	9.59
DH-BGC12-21	446.91	DIAMETRAL	150	61	NA	30.26	INVALID	7.71	8.43
DH-BGC12-21	447.33	DIAMETRAL	229	61	NA	30.52	INVALID	7.78	8.50
DH-BGC12-21	447.5	DIAMETRAL	139	61	NA	30.94	INVALID	7.88	8.62
DH-BGC12-21	451.02	DIAMETRAL	121	61	NA	25.96	INVALID	6.61	7.23
DH-BGC12-21	450.69	DIAMETRAL	170	61	NA	25.9	INVALID	6.60	7.22
DH-BGC12-21	447.05	DIAMETRAL	130	61	// TO FABRIC	25.5	VALID	6.50	7.10

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-21	455.41	DIAMETRAL	147	61	NA	11.28	VALID	2.87	3.14
DH-BGC12-21	457.01	DIAMETRAL	151	61	// TO FABRIC	11.34	VALID	2.89	3.16
DH-BGC12-21	460.22	DIAMETRAL	182	61	// TO FABRIC	14.04	VALID	3.58	3.91
DH-BGC12-21	463.68	DIAMETRAL	306	61	NA	32.22	INVALID	8.21	8.98
DH-BGC12-21	463.77	DIAMETRAL	306	61	NA	6.6	VALID	1.68	1.84
DH-BGC12-21	466.69	DIAMETRAL	282	61	∠ TO FABRIC	23.58	VALID	6.01	6.57
DH-BGC12-21	469.59	DIAMETRAL	270	61	NA	29.54	INVALID	7.53	8.23
DH-BGC12-21	469.65	DIAMETRAL	172	61	NA	30.58	VALID	7.79	8.52
DH-BGC12-21	472.62	DIAMETRAL	212	61	∠ TO FABRIC	42.64	VALID	10.86	11.88
DH-BGC12-21	477.4	DIAMETRAL	294	61	∠ TO FABRIC	29.72	INVALID	7.57	8.28
DH-BGC12-21	467.18	DIAMETRAL	223	61	∠ TO FABRIC	23.88	VALID	6.08	6.65
DH-BGC12-21	478.59	DIAMETRAL	155	61	NA	19.08	INVALID	4.86	5.32
DH-BGC12-21	476.5	DIAMETRAL	210	61	NA	38.32	VALID	9.76	10.68
DH-BGC12-21	478.78	DIAMETRAL	171	61	NA	36.44	VALID	9.28	10.15
DH-BGC12-21	450.42	DIAMETRAL	158	61	NA	20.38	INVALID	5.19	5.68
DH-BGC12-21	450.22	DIAMETRAL	136	61	NA	22.78	VALID	5.80	6.35
DH-BGC12-21	466.17	DIAMETRAL	304	61	∠ TO FABRIC	25.56	VALID	6.51	7.12
DH-BGC12-21	466.29	DIAMETRAL	215	61	∠ TO FABRIC	30.7	INVALID	7.82	8.55
DH-BGC12-21	465.66	DIAMETRAL	222	61	∠ TO FABRIC	29.34	INVALID	7.47	8.17
DH-BGC12-21	465.4	DIAMETRAL	249	61	∠ TO FABRIC	29.18	INVALID	7.43	8.13
DH-BGC12-21	465.21	DIAMETRAL	210	61	// TO FABRIC	18.44	VALID	4.70	5.14
DH-BGC12-21	464.96	DIAMETRAL	315	61	∠ TO FABRIC	23.64	VALID	6.02	6.59
DH-BGC12-21	485.04	DIAMETRAL	180	61	NA	30.84	VALID	7.86	8.59
DH-BGC12-21	485.99	DIAMETRAL	319	61	NA	13.78	VALID	3.51	3.84
DH-BGC12-21	490.69	DIAMETRAL	130	61	NA	37.06	VALID	9.44	10.33
DH-BGC12-21	492.76	DIAMETRAL	280	61	NA	19.78	VALID	5.04	5.51
DH-BGC12-21	495.99	DIAMETRAL	270	61	NA	20.72	VALID	5.28	5.77
DH-BGC12-21	500.49	DIAMETRAL	134	61	NA	23.34	VALID	5.95	6.50
DH-BGC12-21	506.13	DIAMETRAL	151	61	NA	35.48	VALID	9.04	9.89
DH-BGC12-21	503.15	DIAMETRAL	199	61	NA	24.92	VALID	6.35	6.94
DH-BGC12-21	508.99	DIAMETRAL	320	61	NA	39.16	VALID	9.98	10.91
DH-BGC12-21	508.85	DIAMETRAL	223	61	NA	40.22	VALID	10.25	11.21
DH-BGC12-21	508.3	DIAMETRAL	353	61	NA	35.18	VALID	8.96	9.80
DH-BGC12-21	508.37	DIAMETRAL	230	61	NA	37.4	VALID	9.53	10.42
DH-BGC12-21	514.97	DIAMETRAL	380	61	NA	23.6	VALID	6.01	6.58
DH-BGC12-21	517.28	DIAMETRAL	308	61	NA	13.1	VALID	3.34	3.65
DH-BGC12-21	517.38	DIAMETRAL	210	61	NA	26.28	VALID	6.70	7.32

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DH-BGC12-21	520.6	DIAMETRAL	251	61	NA	36.6	VALID	9.32	10.20
DH-BGC12-21	523.86	DIAMETRAL	187	61	NA	24.58	VALID	6.26	6.85
DH-BGC12-21	526.23	DIAMETRAL	183	61	NA	30.96	INVALID	7.89	8.63
DH-BGC12-21	526.18	DIAMETRAL	183	61	NA	34.02	INVALID	8.67	9.48
DH-BGC12-21	526.12	DIAMETRAL	183	61	NA	24.9	VALID	6.34	6.94
DH-BGC12-21	529.19	DIAMETRAL	125	61	NA	19.52	VALID	4.97	5.44
DH-BGC12-21	556.32	DIAMETRAL	165	61	NA	25.3	INVALID	6.45	7.05
DH-BGC12-21	555.79	DIAMETRAL	233	61	NA	32.9	INVALID	8.38	9.17
DH-BGC12-21	555.35	DIAMETRAL	198	61	NA	14.78	VALID	3.77	4.12
DH-BGC12-21	552.61	DIAMETRAL	302	61	NA	12.26	VALID	3.12	3.42
DH-BGC12-21	550.26	DIAMETRAL	227	61	NA	16.98	VALID	4.33	4.73
DH-BGC12-21	546.86	DIAMETRAL	227	61	NA	23.24	VALID	5.92	6.48
DH-BGC12-21	544.19	DIAMETRAL	240	61	NA	12.08	VALID	3.08	3.37
DH-BGC12-21	541.25	DIAMETRAL	230	61	NA	28.76	VALID	7.33	8.01
DH-BGC12-21	536.81	DIAMETRAL	161	61	NA	14.72	VALID	3.75	4.10
DH-BGC12-21	534.47	DIAMETRAL	234	61	NA	21.84	VALID	5.56	6.09
DH-BGC12-21	543.6	DIAMETRAL	230	61	NA	17.44	VALID	4.44	4.86
DH-BGC12-21	543.67	DIAMETRAL	165	61	NA	19.08	VALID	4.86	5.32
DH-BGC12-21	544.31	DIAMETRAL	101	61	NA	15.42	VALID	3.93	4.30
DH-BGC12-21	217.89	DIAMETRAL	115	61	NA	41.64	VALID	10.97	11.90
DH-BGC12-21	232.49	DIAMETRAL	100	61	NA	7.34	VALID	1.87	2.05
DH-BGC12-21	234.52	DIAMETRAL	170	61	NA	32.02	VALID	8.16	8.92
DH-BGC12-21	236.2	DIAMETRAL	129	61	NA	37.98	VALID	9.68	10.58
DH-BGC12-21	239.44	DIAMETRAL	139	61	NA	28.38	VALID	7.47	8.11
DH-BGC12-21	242.81	DIAMETRAL	99	61	NA	36.72	VALID	9.36	10.23
DH-BGC12-21	245.79	DIAMETRAL	260	61	∠ TO FABRIC	32.82	INVALID	8.36	9.14
DH-BGC12-21	249.61	DIAMETRAL	200	61	// TO FABRIC	19.72	VALID	5.02	5.49
DH-BGC12-21	226.68	DIAMETRAL	155	61	// TO FABRIC	13.44	VALID	3.42	3.74
DH-BGC12-21	252.63	DIAMETRAL	330	61	NA	26.92	VALID	6.86	7.50
DH-BGC12-21	260.46	DIAMETRAL	112	61	NA	9.8	VALID	2.50	2.73
DH-BGC12-21	256.06	DIAMETRAL	130	61	// TO FABRIC	5.02	VALID	1.28	1.40
DH-BGC12-21	244.64	DIAMETRAL	251	61	∠ TO FABRIC	31.28	VALID	7.97	8.72
DH-BGC12-21	244.24	DIAMETRAL	204	61	// TO FABRIC	14.58	VALID	3.71	4.06
DH-BGC12-21	245.16	DIAMETRAL	148	61	∠ TO FABRIC	35.46	VALID	9.03	9.88
DH-BGC12-21	244	DIAMETRAL	170	61	∠ TO FABRIC	25.38	INVALID	6.47	7.07
DH-BGC12-21	246.8	DIAMETRAL	111	61	// TO FABRIC	19.06	VALID	4.86	5.31
DH-BGC12-21	261.76	DIAMETRAL	124	61	NA	24.4	INVALID	6.22	6.80

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-21	262.24	DIAMETRAL	176	61	NA	27.24	INVALID	6.94	7.59
DH-BGC12-22	70.9	DIAMETRAL	192	61	∠ TO FABRIC	27.7	INVALID	7.06	7.72
DH-BGC12-22	70.67	DIAMETRAL	234	61	∠ TO FABRIC	29.82	INVALID	7.60	8.31
DH-BGC12-22	70.72	DIAMETRAL	234	61	∠ TO FABRIC	27.46	VALID	7.00	7.65
DH-BGC12-22	73.94	DIAMETRAL	179	61	NA	24.86	INVALID	6.33	6.93
DH-BGC12-22	75.09	DIAMETRAL	184	61	// TO FABRIC	7.46	VALID	1.90	2.08
DH-BGC12-22	76.24	DIAMETRAL	298	61	NA	33.5	INVALID	8.53	9.33
DH-BGC12-22	76.17	DIAMETRAL	298	61	NA	15.24	VALID	3.88	4.25
DH-BGC12-22	80.03	DIAMETRAL	229	61	// TO FABRIC	14.42	VALID	3.67	4.02
DH-BGC12-22	84.64	DIAMETRAL	250	61	NA	17.76	VALID	4.52	4.95
DH-BGC12-22	86.17	DIAMETRAL	320	61	NA	11.46	VALID	2.92	3.19
DH-BGC12-22	46.64	DIAMETRAL	244	61	∠ TO FABRIC	28.02	VALID	7.14	7.81
DH-BGC12-22	45.57	DIAMETRAL	326	61	∠ TO FABRIC	25.26	VALID	6.44	7.04
DH-BGC12-22	81.29	DIAMETRAL	134	61	// TO FABRIC	16.22	VALID	4.13	4.52
DH-BGC12-22	81.8	DIAMETRAL	291	61	// TO FABRIC	15.06	VALID	3.84	4.20
DH-BGC12-22	81.64	DIAMETRAL	210	61	∠ TO FABRIC	16.5	INVALID	4.20	4.60
DH-BGC12-22	81.39	DIAMETRAL	172	61	∠ TO FABRIC	14.04	VALID	3.58	3.91
DH-BGC12-22	91.45	DIAMETRAL	168	61	NA	15.52	VALID	3.95	4.32
DH-BGC12-22	92.56	DIAMETRAL	200	61	NA	31.48	VALID	8.02	8.77
DH-BGC12-22	96.38	DIAMETRAL	178	61	NA	18.22	VALID	4.64	5.08
DH-BGC12-22	97.91	DIAMETRAL	232	61	NA	28.38	VALID	7.23	7.91
DH-BGC12-22	103.34	DIAMETRAL	122	61	NA	16.8	VALID	4.28	4.68
DH-BGC12-22	107.16	DIAMETRAL	149	61	NA	16.68	VALID	4.25	4.65
DH-BGC12-22	109.93	DIAMETRAL	301	61	NA	32.9	INVALID	8.38	9.17
DH-BGC12-22	109.89	DIAMETRAL	158	61	NA	38.54	VALID	9.82	10.74
DH-BGC12-22	112.54	DIAMETRAL	254	61	NA	20.54	VALID	5.23	5.72
DH-BGC12-22	114.63	DIAMETRAL	123	61	NA	21.03	VALID	5.36	5.86
DH-BGC12-22	118.04	DIAMETRAL	150	61	∠ TO FABRIC	6.44	INVALID	1.64	1.79
DH-BGC12-22	118	DIAMETRAL	80	61	∠ TO FABRIC	14.28	VALID	3.64	3.98
DH-BGC12-22	118.08	DIAMETRAL	75	61	∠ TO FABRIC	5.8	INVALID	1.48	1.62
DH-BGC12-22	118.2	DIAMETRAL	145	61	∠ TO FABRIC	5	INVALID	1.27	1.39
DH-BGC12-22	118.15	DIAMETRAL	100	61	∠ TO FABRIC	3.88	INVALID	0.99	1.08
DH-BGC12-22	118.35	DIAMETRAL	135	61	∠ TO FABRIC	4.1	INVALID	1.04	1.14
DH-BGC12-22	118.49	DIAMETRAL	100	61	∠ TO FABRIC	4.9	INVALID	1.25	1.37
DH-BGC12-22	118.6	DIAMETRAL	95	61	∠ TO FABRIC	8.42	VALID	2.15	2.35
DH-BGC12-22	118.79	DIAMETRAL	185	61	∠ TO FABRIC	18.8	VALID	4.79	5.24
DH-BGC12-22	121.42	DIAMETRAL	120	61	// TO FABRIC	5.62	INVALID	1.43	1.57

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-22	125.47	DIAMETRAL	190	61	∠ TO FABRIC	19.58	VALID	4.99	5.46
DH-BGC12-22	128.75	DIAMETRAL	195	61	∠ TO FABRIC	4.68	VALID	1.19	1.30
DH-BGC12-22	131.17	DIAMETRAL	130	61	∠ TO FABRIC	25.28	VALID	6.44	7.04
DH-BGC12-22	134.22	DIAMETRAL	145	61	∠ TO FABRIC	31.32	VALID	7.98	8.73
DH-BGC12-22	140.88	DIAMETRAL	95	61	∠ TO FABRIC	18.8	VALID	4.79	5.24
DH-BGC12-22	143.48	DIAMETRAL	150	61	∠ TO FABRIC	33.08	VALID	8.43	9.22
DH-BGC12-22	147.45	DIAMETRAL	190	61	∠ TO FABRIC	13.48	VALID	3.43	3.76
DH-BGC12-22	151.57	DIAMETRAL	120	61	∠ TO FABRIC	15.5	VALID	3.95	4.32
DH-BGC12-22	154.76	DIAMETRAL	110	61	∠ TO FABRIC	21.1	VALID	5.38	5.88
DH-BGC12-22	155.97	DIAMETRAL	185	61	∠ TO FABRIC	14.78	VALID	3.77	4.12
DH-BGC12-22	159.16	DIAMETRAL	120	61	∠ TO FABRIC	23.14	VALID	5.90	6.45
DH-BGC12-22	161.48	DIAMETRAL	150	61	∠ TO FABRIC	13.46	VALID	3.43	3.75
DH-BGC12-22	166.98	DIAMETRAL	140	61	∠ TO FABRIC	14.2	VALID	3.62	3.96
DH-BGC12-22	168.72	DIAMETRAL	95	61	NA	21.96	VALID	5.59	6.12
DH-BGC12-22	168.9	DIAMETRAL	120	61	∠ TO FABRIC	20.02	VALID	5.10	5.58
DH-BGC12-22	169.23	DIAMETRAL	170	61	NA	14.24	VALID	3.63	3.97
DH-BGC12-22	169.44	DIAMETRAL	150	61	NA	25.64	VALID	6.53	7.14
DH-BGC12-22	303.05	DIAMETRAL	140	61	∠ TO FABRIC	11.2	INVALID	2.85	3.12
DH-BGC12-22	305.49	DIAMETRAL	135	61	∠ TO FABRIC	20.08	INVALID	5.12	5.59
DH-BGC12-22	310.23	DIAMETRAL	150	61	∠ TO FABRIC	16.7	INVALID	4.25	4.65
DH-BGC12-22	313.28	DIAMETRAL	120	61	∠ TO FABRIC	39.87	VALID	10.16	11.11
DH-BGC12-22	315.57	DIAMETRAL	160	61	∠ TO FABRIC	18.62	VALID	4.74	5.19
DH-BGC12-22	318.3	DIAMETRAL	150	61	∠ TO FABRIC	11.72	INVALID	2.99	3.27
DH-BGC12-22	325.27	DIAMETRAL	130	61	∠ TO FABRIC	18.86	VALID	4.80	5.25
DH-BGC12-22	332.65	DIAMETRAL	110	61	∠ TO FABRIC	2.34	INVALID	0.60	0.65
DH-BGC12-22	333.23	DIAMETRAL	110	61	∠ TO FABRIC	21.74	VALID	5.54	6.06
DH-BGC12-22	333.36	DIAMETRAL	185	61	∠ TO FABRIC	20.96	VALID	5.34	5.84
DH-BGC12-22	333.54	DIAMETRAL	160	61	∠ TO FABRIC	13.3	VALID	3.39	3.71
DH-BGC12-22	333.7	DIAMETRAL	150	61	∠ TO FABRIC	23.8	VALID	6.06	6.63
DH-BGC12-22	335.81	DIAMETRAL	150	61	∠ TO FABRIC	16.18	INVALID	4.12	4.51
DH-BGC12-22	338.85	DIAMETRAL	170	61	∠ TO FABRIC	19	INVALID	4.84	5.29
DH-BGC12-22	338.14	DIAMETRAL	135	61	∠ TO FABRIC	31.64	VALID	8.06	8.82
DH-BGC12-22	342.08	DIAMETRAL	170	61	∠ TO FABRIC	29.7	VALID	7.57	8.27
DH-BGC12-22	346.42	DIAMETRAL	185	61	∠ TO FABRIC	18.98	VALID	4.84	5.29
DH-BGC12-22	348.27	DIAMETRAL	140	61	∠ TO FABRIC	26.72	VALID	6.81	7.44
DH-BGC12-22	351.74	DIAMETRAL	115	61	NA	31.28	VALID	7.97	8.72
DH-BGC12-22	355.74	DIAMETRAL	220	61	∠ TO FABRIC	30	VALID	7.64	8.36

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-22	357.95	DIAMETRAL	120	61	∠ TO FABRIC	10.1	INVALID	2.57	2.81
DH-BGC12-22	361.66	DIAMETRAL	110	61	∠ TO FABRIC	16.04	VALID	4.09	4.47
DH-BGC12-22	363.84	DIAMETRAL	80	61	NA	14.78	VALID	3.77	4.12
DH-BGC12-22	368.87	DIAMETRAL	170	61	NA	12.12	INVALID	3.09	3.38
DH-BGC12-22	372.4	DIAMETRAL	140	61	NA	16.2	VALID	4.13	4.51
DH-BGC12-22	376.38	DIAMETRAL	150	61	NA	28.3	VALID	7.21	7.88
DH-BGC12-22	378.66	DIAMETRAL	180	61	NA	14.96	VALID	3.81	4.17
DH-BGC12-22	381.13	DIAMETRAL	110	61	∠ TO FABRIC	15.8	INVALID	4.03	4.40
DH-BGC12-22	384.25	DIAMETRAL	160	61	∠ TO FABRIC	22.54	VALID	5.74	6.28
DH-BGC12-22	387.29	DIAMETRAL	90	61	∠ TO FABRIC	25.38	VALID	6.47	7.07
DH-BGC12-22	387.98	DIAMETRAL	115	61	∠ TO FABRIC	18.46	VALID	4.70	5.14
DH-BGC12-22	383.1	DIAMETRAL	110	61	∠ TO FABRIC	22.62	VALID	5.76	6.30
DH-BGC12-22	383.36	DIAMETRAL	160	61	∠ TO FABRIC	31.72	VALID	8.08	8.84
DH-BGC12-22	390.33	DIAMETRAL	130	61	∠ TO FABRIC	31.12	VALID	7.93	8.67
DH-BGC12-22	395.31	DIAMETRAL	170	61	∠ TO FABRIC	13.74	INVALID	3.50	3.83
DH-BGC12-22	394.84	DIAMETRAL	160	61	∠ TO FABRIC	12.32	INVALID	3.14	3.43
DH-BGC12-22	398.3	DIAMETRAL	110	61	∠ TO FABRIC	15.64	INVALID	3.98	4.36
DH-BGC12-22	401.52	DIAMETRAL	115	61	∠ TO FABRIC	14.98	VALID	3.82	4.17
DH-BGC12-22	404.74	DIAMETRAL	175	61	∠ TO FABRIC	11.62	VALID	2.96	3.24
DH-BGC12-22	407.45	DIAMETRAL	130	61	∠ TO FABRIC	19.92	VALID	5.08	5.55
DH-BGC12-22	408.94	DIAMETRAL	120	61	∠ TO FABRIC	12.3	INVALID	3.13	3.43
DH-BGC12-22	413.96	DIAMETRAL	235	61	∠ TO FABRIC	29.14	VALID	7.42	8.12
DH-BGC12-22	416.22	DIAMETRAL	130	61	∠ TO FABRIC	24.5	INVALID	6.24	6.83
DH-BGC12-22	419.38	DIAMETRAL	115	61	∠ TO FABRIC	26.66	INVALID	6.79	7.43
DH-BGC12-22	429.2	DIAMETRAL	145	61	∠ TO FABRIC	29.84	VALID	7.60	8.31
DH-BGC12-22	425.85	DIAMETRAL	140	61	∠ TO FABRIC	21.74	VALID	5.54	6.06
DH-BGC12-22	436.53	DIAMETRAL	125	61	∠ TO FABRIC	10.58	INVALID	2.70	2.95
DH-BGC12-22	436.65	DIAMETRAL	115	61	∠ TO FABRIC	15.58	INVALID	3.97	4.34
DH-BGC12-22	436.77	DIAMETRAL	135	61	∠ TO FABRIC	10.82	INVALID	2.76	3.01
DH-BGC12-22	437.17	DIAMETRAL	100	61	∠ TO FABRIC	28.96	VALID	7.38	8.07
DH-BGC12-22	437.32	DIAMETRAL	190	61	∠ TO FABRIC	29.94	VALID	7.63	8.34
DH-BGC12-22	437.5	DIAMETRAL	135	61	∠ TO FABRIC	28.36	VALID	7.23	7.90
DH-BGC12-22	7.37	DIAMETRAL	318	61	NA	15.16	VALID	3.86	4.22
DH-BGC12-22	5.65	DIAMETRAL	291	61	NA	13.22	VALID	3.37	3.68
DH-BGC12-22	3.37	DIAMETRAL	182	61	NA	14.2	VALID	3.62	3.96
DH-BGC12-22	13.17	DIAMETRAL	275	61	NA	27.64	VALID	7.04	7.70
DH-BGC12-22	15.01	DIAMETRAL	145	61	∠ TO FABRIC	24.24	INVALID	6.18	6.75

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-22	15.94	DIAMETRAL	163	61	// TO FABRIC	17.58	VALID	4.48	4.90
DH-BGC12-22	21.12	DIAMETRAL	135	61	NA	10.16	VALID	2.59	2.83
DH-BGC12-22	26.54	DIAMETRAL	250	61	NA	17.32	VALID	4.41	4.83
DH-BGC12-22	80.89	DIAMETRAL	115	61	// TO FABRIC	7.54	VALID	1.92	2.10
DH-BGC12-22	53.63	DIAMETRAL	141	61	// TO FABRIC	9.2	VALID	2.34	2.56
DH-BGC12-22	50.7	DIAMETRAL	300	61	∠ TO FABRIC	26.84	INVALID	6.84	7.48
DH-BGC12-22	50.16	DIAMETRAL	410	61	∠ TO FABRIC	27.08	VALID	6.90	7.55
DH-BGC12-22	57.8	DIAMETRAL	135	61	// TO FABRIC	13.7	VALID	3.49	3.82
DH-BGC12-22	59.79	DIAMETRAL	170	61	∠ TO FABRIC	18.82	VALID	4.79	5.24
DH-BGC12-22	23.88	DIAMETRAL	285	61	NA	13.42	VALID	3.42	3.74
DH-BGC12-22	25.05	DIAMETRAL	202	61	NA	9.72	VALID	2.48	2.71
DH-BGC12-22	39.63	DIAMETRAL	226	61	∠ TO FABRIC	34.34	VALID	8.75	9.57
DH-BGC12-22	33.26	DIAMETRAL	199	61	NA	22.94	VALID	5.84	6.39
DH-BGC12-22	35.28	DIAMETRAL	155	61	NA	23.12	INVALID	5.89	6.44
DH-BGC12-22	35.16	DIAMETRAL	280	61	NA	11.14	VALID	2.84	3.10
DH-BGC12-22	40.11	DIAMETRAL	240	61	NA	29.18	INVALID	7.43	8.13
DH-BGC12-22	39.71	DIAMETRAL	200	61	NA	22.2	VALID	5.66	6.19
DH-BGC12-22	42.49	DIAMETRAL	101	61	// TO FABRIC	10.26	VALID	2.61	2.86
DH-BGC12-22	45.72	DIAMETRAL	165	61	∠ TO FABRIC	20.78	VALID	5.29	5.79
DH-BGC12-22	47.58	DIAMETRAL	243	61	// TO FABRIC	11.98	VALID	3.05	3.34
DH-BGC12-22	26.15	DIAMETRAL	208	61	NA	22.82	INVALID	5.81	6.36
DH-BGC12-22	24.9	DIAMETRAL	212	61	NA	28.8	VALID	7.34	8.02
DH-BGC12-22	27.37	DIAMETRAL	310	61	// TO FABRIC	15.3	VALID	3.90	4.26
DH-BGC12-22	64.73	DIAMETRAL	189	61	∠ TO FABRIC	25.84	INVALID	6.58	7.20
DH-BGC12-22	64.67	DIAMETRAL	120	61	// TO FABRIC	13.46	VALID	3.43	3.75
DH-BGC12-22	67.72	DIAMETRAL	113	61	// TO FABRIC	16.5	VALID	4.20	4.60
DH-BGC12-22	289.7	DIAMETRAL	150	61	NA	25.86	VALID	6.59	7.21
DH-BGC12-22	295.2	DIAMETRAL	220	61	NA	18.24	INVALID	4.65	5.08
DH-BGC12-22	296.33	DIAMETRAL	150	61	NA	25.24	VALID	6.43	7.03
DH-BGC12-22	299.45	DIAMETRAL	170	61	∠ TO FABRIC	19.72	VALID	5.02	5.49
DH-BGC12-22	581.03	DIAMETRAL	100	61	∠ TO FABRIC	32.22	VALID	8.21	8.98
DH-BGC12-22	174.42	DIAMETRAL	135	61	∠ TO FABRIC	24.48	VALID	6.24	6.82
DH-BGC12-22	176.91	DIAMETRAL	160	61	∠ TO FABRIC	18.72	INVALID	4.77	5.22
DH-BGC12-22	178.08	DIAMETRAL	165	61	∠ TO FABRIC	18.22	VALID	4.64	5.08
DH-BGC12-22	183.79	DIAMETRAL	145	61	∠ TO FABRIC	29.48	VALID	7.51	8.21
DH-BGC12-22	185.2	DIAMETRAL	230	61	∠ TO FABRIC	22.84	VALID	5.82	6.36
DH-BGC12-22	188.91	DIAMETRAL	250	61	∠ TO FABRIC	26.6	VALID	6.78	7.41

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-22	192.74	DIAMETRAL	220	61	∠ TO FABRIC	34.16	VALID	8.70	9.52
DH-BGC12-22	197.13	DIAMETRAL	130	61	∠ TO FABRIC	25.1	VALID	6.39	6.99
DH-BGC12-22	201.72	DIAMETRAL	120	61	∠ TO FABRIC	19.16	VALID	4.88	5.34
DH-BGC12-22	204.74	DIAMETRAL	190	61	∠ TO FABRIC	23.62	VALID	6.02	6.58
DH-BGC12-22	209.71	DIAMETRAL	130	61	∠ TO FABRIC	9.48	INVALID	2.42	2.64
DH-BGC12-22	211.04	DIAMETRAL	190	61	∠ TO FABRIC	29.58	VALID	7.54	8.24
DH-BGC12-22	215.42	DIAMETRAL	120	61	∠ TO FABRIC	29.36	INVALID	7.48	8.18
DH-BGC12-22	218.45	DIAMETRAL	170	61	∠ TO FABRIC	31.4	VALID	8.00	8.75
DH-BGC12-22	222.38	DIAMETRAL	150	61	∠ TO FABRIC	15.14	VALID	3.86	4.22
DH-BGC12-22	224.64	DIAMETRAL	170	61	∠ TO FABRIC	35.82	VALID	9.13	9.98
DH-BGC12-22	225.49	DIAMETRAL	160	61	∠ TO FABRIC	33.02	VALID	8.41	9.20
DH-BGC12-22	225.65	DIAMETRAL	145	61	∠ TO FABRIC	19.7	INVALID	5.02	5.49
DH-BGC12-22	225.82	DIAMETRAL	210	61	∠ TO FABRIC	20.98	INVALID	5.35	5.85
DH-BGC12-22	225.98	DIAMETRAL	130	61	∠ TO FABRIC	21.82	VALID	5.56	6.08
DH-BGC12-22	224.32	DIAMETRAL	120	61	∠ TO FABRIC	32.22	VALID	8.21	8.98
DH-BGC12-22	228.27	DIAMETRAL	140	61	∠ TO FABRIC	25.3	VALID	6.45	7.05
DH-BGC12-22	231.84	DIAMETRAL	150	61	∠ TO FABRIC	25.2	VALID	6.42	7.02
DH-BGC12-22	235.34	DIAMETRAL	150	61	∠ TO FABRIC	25.6	INVALID	6.52	7.13
DH-BGC12-22	237.68	DIAMETRAL	230	61	∠ TO FABRIC	24.38	INVALID	6.21	6.79
DH-BGC12-22	241.47	DIAMETRAL	140	61	∠ TO FABRIC	22.66	INVALID	5.77	6.31
DH-BGC12-22	243	DIAMETRAL	180	61	∠ TO FABRIC	21.4	INVALID	5.45	5.96
DH-BGC12-22	241.59	DIAMETRAL	120	61	∠ TO FABRIC	31.38	VALID	7.99	8.74
DH-BGC12-22	247.34	DIAMETRAL	100	61	∠ TO FABRIC	18.16	VALID	4.63	5.06
DH-BGC12-22	252.04	DIAMETRAL	150	61	∠ TO FABRIC	23.5	VALID	5.99	6.55
DH-BGC12-22	255.34	DIAMETRAL	170	61	∠ TO FABRIC	2.78	INVALID	0.71	0.77
DH-BGC12-22	259.59	DIAMETRAL	190	61	NA	14.14	VALID	3.60	3.94
DH-BGC12-22	260.82	DIAMETRAL	200	61	NA	18.68	INVALID	4.76	5.20
DH-BGC12-22	265.33	DIAMETRAL	150	61	∠ TO FABRIC	38.42	VALID	9.79	10.70
DH-BGC12-22	267.28	DIAMETRAL	120	61	NA	35.82	VALID	9.13	9.98
DH-BGC12-22	270.6	DIAMETRAL	140	61	NA	25.28	VALID	6.44	7.04
DH-BGC12-22	274.87	DIAMETRAL	120	61	NA	31.62	VALID	8.06	8.81
DH-BGC12-22	278.69	DIAMETRAL	130	61	NA	24.68	VALID	6.29	6.88
DH-BGC12-22	278.84	DIAMETRAL	140	61	NA	27.02	VALID	6.88	7.53
DH-BGC12-22	279.24	DIAMETRAL	130	61	NA	33.16	VALID	8.45	9.24
DH-BGC12-22	279.38	DIAMETRAL	110	61	NA	23.04	VALID	5.87	6.42
DH-BGC12-22	282.47	DIAMETRAL	180	61	NA	39.62	VALID	10.09	11.04
DH-BGC12-22	286.44	DIAMETRAL	165	61	NA	22.88	VALID	5.83	6.37

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-22	473.12	DIAMETRAL	125	61	∠ TO FABRIC	19.1	INVALID	4.87	5.32
DH-BGC12-22	459.15	DIAMETRAL	120	61	∠ TO FABRIC	36.53	VALID	9.31	10.18
DH-BGC12-22	463.04	DIAMETRAL	140	61	∠ TO FABRIC	22.4	INVALID	5.71	6.24
DH-BGC12-22	464.18	DIAMETRAL	160	61	∠ TO FABRIC	30.72	VALID	7.83	8.56
DH-BGC12-22	479.24	DIAMETRAL	160	61	∠ TO FABRIC	33.22	VALID	8.46	9.26
DH-BGC12-22	482.29	DIAMETRAL	180	61	∠ TO FABRIC	33.04	VALID	8.42	9.21
DH-BGC12-22	484.8	DIAMETRAL	140	61	∠ TO FABRIC	16.3	INVALID	4.15	4.54
DH-BGC12-22	488.24	DIAMETRAL	100	61	NA	37.64	VALID	9.59	10.49
DH-BGC12-22	490.28	DIAMETRAL	110	61	∠ TO FABRIC	19.6	VALID	4.99	5.46
DH-BGC12-22	493.74	DIAMETRAL	130	61	∠ TO FABRIC	48.56	VALID	12.37	13.53
DH-BGC12-22	497.34	DIAMETRAL	135	61	∠ TO FABRIC	23.18	INVALID	5.91	6.46
DH-BGC12-22	500.32	DIAMETRAL	150	61	∠ TO FABRIC	44.02	VALID	11.21	12.26
DH-BGC12-22	503.66	DIAMETRAL	140	61	∠ TO FABRIC	17.28	INVALID	4.40	4.81
DH-BGC12-22	508.09	DIAMETRAL	100	61	∠ TO FABRIC	17.56	INVALID	4.47	4.89
DH-BGC12-22	506.64	DIAMETRAL	130	61	∠ TO FABRIC	46.14	VALID	11.76	12.86
DH-BGC12-22	511.72	DIAMETRAL	125	61	∠ TO FABRIC	2.4	INVALID	0.61	0.67
DH-BGC12-22	512.77	DIAMETRAL	170	61	∠ TO FABRIC	36	VALID	9.17	10.03
DH-BGC12-22	517.25	DIAMETRAL	135	61	∠ TO FABRIC	30.12	VALID	7.67	8.39
DH-BGC12-22	518.33	DIAMETRAL	95	61	∠ TO FABRIC	10.92	INVALID	2.78	3.04
DH-BGC12-22	523.97	DIAMETRAL	210	61	∠ TO FABRIC	28.24	VALID	7.19	7.87
DH-BGC12-22	527.85	DIAMETRAL	120	61	NA	19.92	VALID	5.08	5.55
DH-BGC12-22	529.98	DIAMETRAL	95	61	NA	15.44	VALID	3.93	4.30
DH-BGC12-22	532.75	DIAMETRAL	155	61	∠ TO FABRIC	35.6	VALID	9.07	9.92
DH-BGC12-22	536.27	DIAMETRAL	150	61	∠ TO FABRIC	18.14	INVALID	4.62	5.05
DH-BGC12-22	539.33	DIAMETRAL	140	61	∠ TO FABRIC	13.32	VALID	3.39	3.71
DH-BGC12-22	543.36	DIAMETRAL	180	61	∠ TO FABRIC	36.48	VALID	9.29	10.16
DH-BGC12-22	545.84	DIAMETRAL	135	61	∠ TO FABRIC	24.44	INVALID	6.23	6.81
DH-BGC12-22	549	DIAMETRAL	150	61	NA	17.74	VALID	4.52	4.94
DH-BGC12-22	551.24	DIAMETRAL	250	61	NA	14.08	VALID	3.59	3.92
DH-BGC12-22	554.71	DIAMETRAL	170	61	∠ TO FABRIC	12	INVALID	3.06	3.34
DH-BGC12-22	560.03	DIAMETRAL	200	61	∠ TO FABRIC	18.32	VALID	4.67	5.10
DH-BGC12-22	565.94	DIAMETRAL	130	61	NA	8.2	VALID	2.09	2.28
DH-BGC12-22	570.51	DIAMETRAL	140	61	∠ TO FABRIC	33.38	VALID	8.50	9.30
DH-BGC12-22	576.77	DIAMETRAL	170	61	∠ TO FABRIC	12.8	VALID	3.26	3.57
DH-BGC12-22	437.76	DIAMETRAL	120	61	∠ TO FABRIC	30.16	INVALID	7.68	8.40
DH-BGC12-22	442.51	DIAMETRAL	120	61	∠ TO FABRIC	22.62	VALID	5.76	6.30
DH-BGC12-22	448.46	DIAMETRAL	120	61	∠ TO FABRIC	11.56	INVALID	2.95	3.22

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-22	449.5	DIAMETRAL	125	61	∠ TO FABRIC	12.8	VALID	3.26	3.57
DH-BGC12-22	453.92	DIAMETRAL	125	61	∠ TO FABRIC	16.8	INVALID	4.28	4.68
DH-BGC12-22	454.5	DIAMETRAL	130	61	∠ TO FABRIC	12.4	INVALID	3.16	3.45
DH-BGC12-22	454.94	DIAMETRAL	140	61	∠ TO FABRIC	31.08	VALID	7.92	8.66
DH-BGC12-22	468.39	DIAMETRAL	150	61	∠ TO FABRIC	15.22	VALID	3.88	4.24
DH-BGC12-22	470.08	DIAMETRAL	140	61	∠ TO FABRIC	26.2	VALID	6.67	7.30
DH-BGC12-23	78.47	DIAMETRAL	210	61	NA	33.38	VALID	8.50	9.30
DH-BGC12-23	82.05	DIAMETRAL	120	61	NA	22.68	VALID	5.78	6.32
DH-BGC12-23	83.23	DIAMETRAL	170	61	NA	13.64	INVALID	3.48	3.80
DH-BGC12-23	86.29	DIAMETRAL	170	61	NA	36.76	VALID	9.37	10.24
DH-BGC12-23	91.27	DIAMETRAL	100	61	NA	15.14	INVALID	3.86	4.22
DH-BGC12-23	7.87	DIAMETRAL	130	61	∠ TO FABRIC	17.6	INVALID	4.48	4.90
DH-BGC12-23	8.01	DIAMETRAL	155	61	∠ TO FABRIC	28.96	VALID	7.38	8.07
DH-BGC12-23	8.3	DIAMETRAL	125	61	∠ TO FABRIC	25.16	VALID	6.41	7.01
DH-BGC12-23	8.46	DIAMETRAL	175	61	∠ TO FABRIC	22.12	VALID	5.64	6.16
DH-BGC12-23	8.76	DIAMETRAL	280	61	∠ TO FABRIC	21.59	VALID	5.50	6.02
DH-BGC12-23	12.88	DIAMETRAL	140	61	NA	9.54	INVALID	2.43	2.66
DH-BGC12-23	16	DIAMETRAL	150	61	NA	15.4	VALID	3.92	4.29
DH-BGC12-23	18.81	DIAMETRAL	160	61	NA	20.4	VALID	5.20	5.68
DH-BGC12-23	21.86	DIAMETRAL	160	61	NA	20.66	VALID	5.26	5.76
DH-BGC12-23	22.02	DIAMETRAL	125	61	NA	25.12	VALID	6.40	7.00
DH-BGC12-23	22.57	DIAMETRAL	110	61	NA	23.38	VALID	5.96	6.51
DH-BGC12-23	22.7	DIAMETRAL	140	61	NA	32.7	VALID	8.33	9.11
DH-BGC12-23	26.24	DIAMETRAL	190	61	NA	24.34	VALID	6.20	6.78
DH-BGC12-23	29.69	DIAMETRAL	200	61	NA	16.82	VALID	4.29	4.69
DH-BGC12-23	30.67	DIAMETRAL	135	61	NA	26.2	VALID	6.67	7.30
DH-BGC12-23	34.88	DIAMETRAL	130	61	NA	16.58	VALID	4.22	4.62
DH-BGC12-23	36.42	DIAMETRAL	100	61	NA	2.58	INVALID	0.66	0.72
DH-BGC12-23	41.66	DIAMETRAL	165	61	NA	14.68	INVALID	3.74	4.09
DH-BGC12-23	41.2	DIAMETRAL	155	61	NA	4.36	VALID	1.11	1.21
DH-BGC12-23	45.32	DIAMETRAL	110	61	NA	16.76	INVALID	4.27	4.67
DH-BGC12-23	45.2	DIAMETRAL	120	61	NA	18.76	INVALID	4.78	5.23
DH-BGC12-23	45.76	DIAMETRAL	220	61	NA	17.1	VALID	4.36	4.76
DH-BGC12-23	45.8	DIAMETRAL	130	61	NA	22.08	VALID	5.63	6.15
DH-BGC12-23	45.97	DIAMETRAL	130	61	NA	17.98	VALID	4.58	5.01
DH-BGC12-23	46.12	DIAMETRAL	150	61	NA	20.4	VALID	5.20	5.68
DH-BGC12-23	49.85	DIAMETRAL	210	61	NA	25.36	VALID	6.46	7.07

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-23	53.08	DIAMETRAL	120	61	NA	9.88	INVALID	2.52	2.75
DH-BGC12-23	56.77	DIAMETRAL	130	61	NA	17.34	VALID	4.42	4.83
DH-BGC12-23	59.08	DIAMETRAL	160	61	NA	24.74	VALID	6.30	6.89
DH-BGC12-23	63.18	DIAMETRAL	160	61	NA	24.14	VALID	6.15	6.73
DH-BGC12-23	64.29	DIAMETRAL	180	61	NA	15.96	INVALID	4.07	4.45
DH-BGC12-23	69.11	DIAMETRAL	120	61	NA	33.46	VALID	8.52	9.32
DH-BGC12-23	72.35	DIAMETRAL	210	61	NA	14.3	INVALID	3.64	3.98
DH-BGC12-23	76.56	DIAMETRAL	160	61	NA	24.14	VALID	6.15	6.73
DH-BGC12-23	92.52	DIAMETRAL	180	61	NA	18.64	VALID	4.75	5.19
DH-BGC12-23	95.75	DIAMETRAL	150	61	NA	37.84	VALID	9.64	10.54
DH-BGC12-23	99.44	DIAMETRAL	140	61	NA	29.08	VALID	7.41	8.10
DH-BGC12-23	103.47	DIAMETRAL	170	61	NA	42.12	VALID	10.73	11.74
DH-BGC12-23	105.69	DIAMETRAL	155	61	NA	14.2	INVALID	3.62	3.96
DH-BGC12-23	110.1	DIAMETRAL	110	61	NA	26.03	VALID	6.63	7.25
DH-BGC12-23	114.36	DIAMETRAL	160	61	NA	24.74	INVALID	6.30	6.89
DH-BGC12-23	114.52	DIAMETRAL	155	61	NA	21.5	VALID	5.48	5.99
DH-BGC12-23	118.58	DIAMETRAL	115	61	NA	28.6	VALID	7.29	7.97
DH-BGC12-23	121.51	DIAMETRAL	115	61	NA	23.4	VALID	5.96	6.52
DH-BGC12-23	125.59	DIAMETRAL	200	61	NA	22.56	VALID	5.75	6.29
DH-BGC12-23	128.84	DIAMETRAL	150	61	NA	12.07	INVALID	3.08	3.36
DH-BGC12-23	132.77	DIAMETRAL	160	61	NA	24.04	VALID	6.12	6.70
DH-BGC12-23	136.3	DIAMETRAL	95	61	NA	20.46	VALID	5.21	5.70
DH-BGC12-23	138.46	DIAMETRAL	110	61	NA	43	VALID	10.96	11.98
DH-BGC12-23	142.15	DIAMETRAL	165	61	NA	35.8	VALID	9.12	9.97
DH-BGC12-23	144.72	DIAMETRAL	155	61	NA	24.8	VALID	6.32	6.91
DH-BGC12-23	146.26	DIAMETRAL	120	61	NA	31.36	VALID	7.99	8.74
DH-BGC12-23	146.35	DIAMETRAL	80	61	NA	30.78	VALID	7.84	8.58
DH-BGC12-23	146.73	DIAMETRAL	100	61	NA	31.92	VALID	8.13	8.89
DH-BGC12-23	149.15	DIAMETRAL	100	61	NA	29.98	VALID	7.64	8.35
DH-BGC12-23	155.51	DIAMETRAL	130	61	NA	31.2	VALID	7.95	8.69
DH-BGC12-23	158.79	DIAMETRAL	110	61	NA	36.08	VALID	9.19	10.05
DH-BGC12-23	160.72	DIAMETRAL	165	61	NA	38.56	VALID	9.82	10.74
DH-BGC12-23	165.83	DIAMETRAL	135	61	NA	25.46	VALID	6.49	7.09
DH-BGC12-23	169.84	DIAMETRAL	140	61	NA	26.68	INVALID	6.80	7.43
DH-BGC12-23	174.16	DIAMETRAL	160	61	NA	35.4	VALID	9.02	9.86
DH-BGC12-23	177.14	DIAMETRAL	165	61	NA	13.08	VALID	3.33	3.64
DH-BGC12-23	180.4	DIAMETRAL	120	61	NA	32.4	VALID	8.25	9.03

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-23	182.42	DIAMETRAL	140	61	NA	33.82	INVALID	8.62	9.42
DH-BGC12-23	186.29	DIAMETRAL	120	61	NA	27.26	VALID	6.95	7.60
DH-BGC12-23	190.14	DIAMETRAL	100	61	NA	38.2	VALID	9.73	10.64
DH-BGC12-23	193.24	DIAMETRAL	135	61	NA	12.9	INVALID	3.29	3.59
DH-BGC12-23	195.58	DIAMETRAL	165	61	NA	14.74	VALID	3.76	4.11
DH-BGC12-23	199.82	DIAMETRAL	100	61	NA	18.58	INVALID	4.73	5.18
DH-BGC12-23	199.68	DIAMETRAL	190	61	NA	31.5	VALID	8.03	8.78
DH-BGC12-23	202.06	DIAMETRAL	150	61	NA	26.74	VALID	6.81	7.45
DH-BGC12-23	202.2	DIAMETRAL	160	61	NA	28.76	VALID	7.33	8.01
DH-BGC12-23	202.35	DIAMETRAL	135	61	NA	23.1	VALID	5.89	6.44
DH-BGC12-23	202.74	DIAMETRAL	130	61	NA	17.38	INVALID	4.43	4.84
DH-BGC12-23	204.67	DIAMETRAL	110	61	NA	21.94	INVALID	5.59	6.11
DH-BGC12-23	208.26	DIAMETRAL	140	61	NA	35.94	VALID	9.16	10.01
DH-BGC12-23	211.58	DIAMETRAL	130	61	⊥ TO FABRIC	22.82	VALID	5.81	6.36
DH-BGC12-23	215.94	DIAMETRAL	140	61	⊥ TO FABRIC	24.68	INVALID	6.29	6.88
DH-BGC12-23	216.42	DIAMETRAL	130	61	⊥ TO FABRIC	26.62	VALID	6.78	7.42
DH-BGC12-23	222.42	DIAMETRAL	185	61	NA	32.96	VALID	8.40	9.18
DH-BGC12-23	224.6	DIAMETRAL	185	61	NA	15.04	INVALID	3.83	4.19
DH-BGC12-23	226.44	DIAMETRAL	155	61	NA	19.22	INVALID	4.90	5.36
DH-BGC12-23	229.77	DIAMETRAL	180	61	NA	17.68	VALID	4.50	4.93
DH-BGC12-23	233.91	DIAMETRAL	200	61	NA	24.08	VALID	6.13	6.71
DH-BGC12-23	236.91	DIAMETRAL	180	61	NA	7.64	INVALID	1.95	2.13
DH-BGC12-23	240.8	DIAMETRAL	160	61	NA	13.92	INVALID	3.55	3.88
DH-BGC12-23	242.41	DIAMETRAL	190	61	NA	33.76	VALID	8.60	9.41
DH-BGC12-23	247.04	DIAMETRAL	175	61	NA	29.26	VALID	7.45	8.15
DH-BGC12-23	251.69	DIAMETRAL	140	61	NA	22.24	VALID	5.67	6.20
DH-BGC12-23	256.15	DIAMETRAL	110	61	NA	14.36	VALID	3.66	4.00
DH-BGC12-23	260.52	DIAMETRAL	110	61	NA	26.12	VALID	6.65	7.28
DH-BGC12-23	260.97	DIAMETRAL	110	61	NA	15.9	VALID	4.05	4.43
DH-BGC12-23	261.1	DIAMETRAL	140	61	NA	22.42	VALID	5.71	6.25
DH-BGC12-23	261.24	DIAMETRAL	120	61	NA	28.7	VALID	7.31	8.00
DH-BGC12-23	265.72	DIAMETRAL	170	61	NA	9.68	INVALID	2.47	2.70
DH-BGC12-23	267.93	DIAMETRAL	115	61	NA	21.56	VALID	5.49	6.01
DH-BGC12-23	272.39	DIAMETRAL	115	61	NA	20.32	VALID	5.18	5.66
DH-BGC12-23	275.05	DIAMETRAL	200	61	NA	21.66	VALID	5.52	6.03
DH-BGC12-23	277.7	DIAMETRAL	130	61	NA	24.28	INVALID	6.19	6.76
DH-BGC12-23	281.87	DIAMETRAL	220	61	NA	21.04	VALID	5.36	5.86

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-23	285.17	DIAMETRAL	160	61	NA	28.58	VALID	7.28	7.96
DH-BGC12-23	288.55	DIAMETRAL	140	61	NA	22.92	VALID	5.84	6.39
DH-BGC12-23	293.5	DIAMETRAL	130	61	NA	18.92	INVALID	4.82	5.27
DH-BGC12-23	296.14	DIAMETRAL	120	61	NA	9.44	VALID	2.41	2.63
DH-BGC12-23	300.14	DIAMETRAL	210	61	NA	32.88	VALID	8.38	9.16
DH-BGC12-23	303.05	DIAMETRAL	155	61	NA	17.12	VALID	4.36	4.77
DH-BGC12-23	308.36	DIAMETRAL	180	61	NA	16.8	INVALID	4.28	4.68
DH-BGC12-23	308.88	DIAMETRAL	125	61	NA	19.78	VALID	5.04	5.51
DH-BGC12-23	309.16	DIAMETRAL	200	61	NA	10	INVALID	2.55	2.79
DH-BGC12-23	309.36	DIAMETRAL	150	61	NA	17.02	INVALID	4.34	4.74
DH-BGC12-23	309.54	DIAMETRAL	200	61	NA	21.06	VALID	5.37	5.87
DH-BGC12-23	309.75	DIAMETRAL	220	61	NA	28.3	VALID	7.21	7.88
DH-BGC12-23	309.85	DIAMETRAL	120	61	NA	21.9	VALID	5.58	6.10
DH-BGC12-23	311.43	DIAMETRAL	140	61	NA	19.46	INVALID	4.96	5.42
DH-BGC12-23	316.01	DIAMETRAL	130	61	NA	14.48	VALID	3.69	4.03
DH-BGC12-23	319.33	DIAMETRAL	180	61	NA	10.6	INVALID	2.70	2.95
DH-BGC12-23	321.31	DIAMETRAL	150	61	NA	19.5	VALID	4.97	5.43
DH-BGC12-23	325.23	DIAMETRAL	210	61	NA	18.56	INVALID	4.73	5.17
DH-BGC12-23	327.26	DIAMETRAL	215	61	NA	23.36	VALID	5.95	6.51
DH-BGC12-23	331.72	DIAMETRAL	190	61	NA	16.06	INVALID	4.09	4.47
DH-BGC12-23	335	DIAMETRAL	200	61	NA	32.56	VALID	8.30	9.07
DH-BGC12-23	336.26	DIAMETRAL	250	61	NA	26.36	VALID	6.72	7.34
DH-BGC12-23	336.47	DIAMETRAL	160	61	NA	25.86	VALID	6.59	7.21
DH-BGC12-23	336.92	DIAMETRAL	125	61	NA	31.78	VALID	8.10	8.85
DH-BGC12-23	337.06	DIAMETRAL	170	61	NA	18.54	INVALID	4.72	5.17
DH-BGC12-23	340.03	DIAMETRAL	95	61	NA	22.6	VALID	5.76	6.30
DH-BGC12-23	347.35	DIAMETRAL	140	61	NA	10.76	VALID	2.74	3.00
DH-BGC12-23	350.53	DIAMETRAL	120	61	NA	20.7	INVALID	5.27	5.77
DH-BGC12-23	353.53	DIAMETRAL	140	61	NA	21.56	VALID	5.49	6.01
DH-BGC12-23	356.55	DIAMETRAL	180	61	NA	9.03	INVALID	2.30	2.52
DH-BGC12-23	358.73	DIAMETRAL	155	61	NA	11.04	INVALID	2.81	3.08
DH-BGC12-23	361.16	DIAMETRAL	180	61	NA	17.5	INVALID	4.46	4.88
DH-BGC12-23	361.45	DIAMETRAL	160	61	NA	19.14	VALID	4.88	5.33
DH-BGC12-23	366.22	DIAMETRAL	200	61	NA	37.5	VALID	9.55	10.45
DH-BGC12-23	367.31	DIAMETRAL	170	61	NA	34.74	VALID	8.85	9.68
DH-BGC12-23	372.24	DIAMETRAL	160	61	NA	20.28	VALID	5.17	5.65
DH-BGC12-23	376.27	DIAMETRAL	180	61	NA	15.14	INVALID	3.86	4.22

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-23	376.46	DIAMETRAL	165	61	NA	22.64	INVALID	5.77	6.31
DH-BGC12-23	380.25	DIAMETRAL	160	61	NA	41.72	VALID	10.63	11.62
DH-BGC12-23	383.5	DIAMETRAL	260	61	NA	16.74	INVALID	4.26	4.66
DH-BGC12-23	385.07	DIAMETRAL	200	61	NA	39.06	VALID	9.95	10.88
DH-BGC12-23	389.45	DIAMETRAL	200	61	NA	41.14	VALID	10.48	11.46
DH-BGC12-23	393.43	DIAMETRAL	150	61	NA	39.22	VALID	9.99	10.93
DH-BGC12-23	395.51	DIAMETRAL	140	61	NA	35.1	VALID	8.94	9.78
DH-BGC12-23	399.81	DIAMETRAL	175	61	NA	9.28	VALID	2.36	2.59
DH-BGC12-23	405.72	DIAMETRAL	110	61	NA	25.48	VALID	6.49	7.10
DH-BGC12-23	409.09	DIAMETRAL	130	61	NA	22.14	VALID	5.64	6.17
DH-BGC12-23	414.58	DIAMETRAL	140	61	NA	22.98	VALID	5.85	6.40
DH-BGC12-23	435.08	DIAMETRAL	190	61	NA	34.38	VALID	8.76	9.58
DH-BGC12-23	437.53	DIAMETRAL	150	61	NA	24.88	INVALID	6.34	6.93
DH-BGC12-23	439.53	DIAMETRAL	180	61	NA	27.32	INVALID	6.96	7.61
DH-BGC12-23	439.36	DIAMETRAL	115	61	NA	32.68	VALID	8.33	9.11
DH-BGC12-23	443.62	DIAMETRAL	175	61	NA	39.02	VALID	9.94	10.87
DH-BGC12-23	448.82	DIAMETRAL	190	61	NA	22.14	VALID	5.64	6.17
DH-BGC12-23	453.28	DIAMETRAL	145	61	NA	28.78	VALID	7.33	8.02
DH-BGC12-23	458.57	DIAMETRAL	120	61	NA	25.38	INVALID	6.47	7.07
DH-BGC12-23	460.92	DIAMETRAL	140	61	NA	18.08	INVALID	4.61	5.04
DH-BGC12-23	462.48	DIAMETRAL	160	61	NA	8.74	VALID	2.23	2.44
DH-BGC12-23	465.2	DIAMETRAL	130	61	NA	8.32	INVALID	2.12	2.32
DH-BGC12-23	465.59	DIAMETRAL	210	61	NA	20.72	VALID	5.28	5.77
DH-BGC12-23	468.35	DIAMETRAL	140	61	NA	28.86	VALID	7.35	8.04
DH-BGC12-23	471.74	DIAMETRAL	140	61	NA	20.38	VALID	5.19	5.68
DH-BGC12-23	474.76	DIAMETRAL	185	61	NA	26.3	INVALID	6.70	7.33
DH-BGC12-23	477.56	DIAMETRAL	140	61	NA	20.3	INVALID	5.17	5.66
DH-BGC12-23	477.72	DIAMETRAL	185	61	NA	23.1	VALID	5.89	6.44
DH-BGC12-23	480.5	DIAMETRAL	180	61	NA	34.08	VALID	8.68	9.50
DH-BGC12-23	483.8	DIAMETRAL	145	61	NA	15.44	INVALID	3.93	4.30
DH-BGC12-23	487.22	DIAMETRAL	170	61	NA	28.9	VALID	7.36	8.05
DH-BGC12-23	489.93	DIAMETRAL	240	61	NA	18.44	INVALID	4.70	5.14
DH-BGC12-23	493.45	DIAMETRAL	140	61	NA	32.78	VALID	8.35	9.13
DH-BGC12-23	496.47	DIAMETRAL	180	61	NA	37.2	VALID	9.48	10.36
DH-BGC12-23	499.02	DIAMETRAL	110	61	NA	15.64	VALID	3.98	4.36
DH-BGC12-23	501.26	DIAMETRAL	130	61	NA	23.24	VALID	5.92	6.48
DH-BGC12-23	506.75	DIAMETRAL	160	61	NA	11.38	INVALID	2.90	3.17

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-23	507.91	DIAMETRAL	160	61	NA	33.18	VALID	8.45	9.24
DH-BGC12-23	511.35	DIAMETRAL	190	61	NA	15.94	VALID	4.06	4.44
DH-BGC12-23	513.14	DIAMETRAL	85	61	NA	0.22	VALID	0.06	0.06
DH-BGC12-23	514.6	DIAMETRAL	130	61	NA	28.92	VALID	7.37	8.06
DH-BGC12-23	518.73	DIAMETRAL	165	61	NA	20.88	VALID	5.32	5.82
DH-BGC12-23	521.27	DIAMETRAL	210	61	NA	23.46	VALID	5.98	6.54
DH-BGC12-23	521.7	DIAMETRAL	120	61	NA	27.08	VALID	6.90	7.55
DH-BGC12-23	522.4	DIAMETRAL	80	61	NA	33.12	VALID	8.44	9.23
DH-BGC12-23	525.34	DIAMETRAL	180	61	NA	1.5	VALID	0.38	0.42
DH-BGC12-23	526.34	DIAMETRAL	200	61	NA	0.38	VALID	0.10	0.11
DH-BGC12-23	532.47	DIAMETRAL	125	61	NA	0.88	VALID	0.22	0.25
DH-BGC12-23	537.73	DIAMETRAL	150	61	NA	3.22	VALID	0.82	0.90
DH-BGC12-23	542.37	DIAMETRAL	90	61	NA	0.64	VALID	0.16	0.18
DH-BGC12-23	542.48	DIAMETRAL	95	61	NA	0.98	VALID	0.25	0.27
DH-BGC12-23	542.83	DIAMETRAL	120	61	NA	0.46	VALID	0.12	0.13
DH-BGC12-23	549.44	DIAMETRAL	130	61	NA	0.16	VALID	0.04	0.04
DH-BGC12-23	555.55	DIAMETRAL	120	61	NA	21.32	VALID	5.43	5.94
DH-BGC12-23	556.54	DIAMETRAL	130	61	NA	12.48	VALID	3.18	3.48
DH-BGC12-23	557.47	DIAMETRAL	130	61	NA	9.56	VALID	2.44	2.66
DH-BGC12-24	412.2	DIAMETRAL	130	61	∠ TO FABRIC	25.18	VALID	6.42	7.02
DH-BGC12-24	7.7	DIAMETRAL	160	61	∠ TO FABRIC	4.2	VALID	1.07	1.17
DH-BGC12-24	13.66	DIAMETRAL	75	61	∠ TO FABRIC	14.92	VALID	3.80	4.16
DH-BGC12-24	19.76	DIAMETRAL	110	61	∠ TO FABRIC	9.62	VALID	2.45	2.68
DH-BGC12-24	26.01	DIAMETRAL	190	61	∠ TO FABRIC	9.88	VALID	2.52	2.75
DH-BGC12-24	32.15	DIAMETRAL	130	61	∠ TO FABRIC	7.7	VALID	1.96	2.15
DH-BGC12-24	38.28	DIAMETRAL	145	61	∠ TO FABRIC	3.46	INVALID	0.88	0.96
DH-BGC12-24	38.43	DIAMETRAL	160	61	∠ TO FABRIC	10.78	VALID	2.75	3.00
DH-BGC12-24	45.33	DIAMETRAL	150	61	∠ TO FABRIC	12.2	VALID	3.11	3.40
DH-BGC12-24	50.21	DIAMETRAL	140	61	∠ TO FABRIC	22.16	VALID	5.65	6.17
DH-BGC12-24	55.28	DIAMETRAL	260	61	∠ TO FABRIC	12.2	VALID	3.11	3.40
DH-BGC12-24	60.16	DIAMETRAL	130	61	∠ TO FABRIC	11.18	VALID	2.85	3.11
DH-BGC12-24	66.84	DIAMETRAL	135	61	NA	20.86	VALID	5.31	5.81
DH-BGC12-24	71.88	DIAMETRAL	180	61	NA	21.82	VALID	5.56	6.08
DH-BGC12-24	72.04	DIAMETRAL	100	61	∠ TO FABRIC	17.48	INVALID	4.45	4.87
DH-BGC12-24	72.39	DIAMETRAL	115	61	∠ TO FABRIC	19.9	VALID	5.07	5.54
DH-BGC12-24	72.51	DIAMETRAL	110	61	∠ TO FABRIC	19	VALID	4.84	5.29
DH-BGC12-24	77.63	DIAMETRAL	170	61	∠ TO FABRIC	17.64	VALID	4.49	4.91

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-24	82.02	DIAMETRAL	170	61	NA	14.34	INVALID	3.65	4.00
DH-BGC12-24	86.26	DIAMETRAL	135	61	NA	20.28	VALID	5.17	5.65
DH-BGC12-24	92	DIAMETRAL	170	61	NA	14.7	VALID	3.75	4.10
DH-BGC12-24	98.21	DIAMETRAL	110	61	NA	24.42	VALID	6.22	6.80
DH-BGC12-24	103.66	DIAMETRAL	120	61	NA	24.7	VALID	6.29	6.88
DH-BGC12-24	108.27	DIAMETRAL	135	61	NA	11.64	INVALID	2.97	3.24
DH-BGC12-24	109.1	DIAMETRAL	150	61	NA	22.4	VALID	5.71	6.24
DH-BGC12-24	115.52	DIAMETRAL	210	61	NA	23.86	VALID	6.08	6.65
DH-BGC12-24	120.95	DIAMETRAL	140	61	NA	14.4	INVALID	3.67	4.01
DH-BGC12-24	121.11	DIAMETRAL	140	61	NA	24.3	VALID	6.19	6.77
DH-BGC12-24	127.78	DIAMETRAL	220	61	NA	15.56	VALID	3.96	4.34
DH-BGC12-24	132.3	DIAMETRAL	140	61	∠ TO FABRIC	17.9	INVALID	4.56	4.99
DH-BGC12-24	132.17	DIAMETRAL	130	61	∠ TO FABRIC	17.98	INVALID	4.58	5.01
DH-BGC12-24	132.06	DIAMETRAL	95	61	∠ TO FABRIC	22.45	VALID	5.72	6.25
DH-BGC12-24	132.45	DIAMETRAL	145	61	∠ TO FABRIC	21.94	VALID	5.59	6.11
DH-BGC12-24	132.91	DIAMETRAL	120	61	∠ TO FABRIC	17.48	INVALID	4.45	4.87
DH-BGC12-24	133.05	DIAMETRAL	180	61	∠ TO FABRIC	17.88	VALID	4.56	4.98
DH-BGC12-24	138.43	DIAMETRAL	100	61	∠ TO FABRIC	24.56	INVALID	6.26	6.84
DH-BGC12-24	138.55	DIAMETRAL	100	61	∠ TO FABRIC	35.02	VALID	8.92	9.76
DH-BGC12-24	144.33	DIAMETRAL	145	61	∠ TO FABRIC	11.61	VALID	2.96	3.23
DH-BGC12-24	149.97	DIAMETRAL	140	61	∠ TO FABRIC	19.72	INVALID	5.02	5.49
DH-BGC12-24	150.1	DIAMETRAL	120	61	∠ TO FABRIC	20.38	VALID	5.19	5.68
DH-BGC12-24	155.13	DIAMETRAL	190	61	∠ TO FABRIC	30.58	VALID	7.79	8.52
DH-BGC12-24	160.72	DIAMETRAL	165	61	∠ TO FABRIC	9.22	VALID	2.35	2.57
DH-BGC12-24	166	DIAMETRAL	210	61	∠ TO FABRIC	32.66	VALID	8.32	9.10
DH-BGC12-24	172.11	DIAMETRAL	135	61	∠ TO FABRIC	22.74	INVALID	5.79	6.34
DH-BGC12-24	172.29	DIAMETRAL	130	61	∠ TO FABRIC	22.12	VALID	5.64	6.16
DH-BGC12-24	178.23	DIAMETRAL	135	61	∠ TO FABRIC	24.12	VALID	6.15	6.72
DH-BGC12-24	184.49	DIAMETRAL	145	61	∠ TO FABRIC	41.72	VALID	10.63	11.62
DH-BGC12-24	190.41	DIAMETRAL	160	61	∠ TO FABRIC	29	VALID	7.39	8.08
DH-BGC12-24	196.36	DIAMETRAL	140	61	∠ TO FABRIC	25.82	VALID	6.58	7.19
DH-BGC12-24	196.5	DIAMETRAL	200	61	∠ TO FABRIC	22.48	VALID	5.73	6.26
DH-BGC12-24	196.98	DIAMETRAL	170	61	∠ TO FABRIC	20.04	INVALID	5.11	5.58
DH-BGC12-24	197.42	DIAMETRAL	220	61	∠ TO FABRIC	26.6	VALID	6.78	7.41
DH-BGC12-24	202.76	DIAMETRAL	185	61	∠ TO FABRIC	24.24	VALID	6.18	6.75
DH-BGC12-24	208.65	DIAMETRAL	200	61	∠ TO FABRIC	18.36	VALID	4.68	5.12
DH-BGC12-24	214.77	DIAMETRAL	215	61	∠ TO FABRIC	27.4	VALID	6.98	7.63

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-24	219.98	DIAMETRAL	160	61	∠ TO FABRIC	22.4	INVALID	5.71	6.24
DH-BGC12-24	222.1	DIAMETRAL	120	61	∠ TO FABRIC	18.56	VALID	4.73	5.17
DH-BGC12-24	227.87	DIAMETRAL	120	61	∠ TO FABRIC	24.48	VALID	6.24	6.82
DH-BGC12-24	233.11	DIAMETRAL	120	61	∠ TO FABRIC	12.86	INVALID	3.28	3.58
DH-BGC12-24	235.67	DIAMETRAL	135	61	∠ TO FABRIC	21.42	INVALID	5.46	5.97
DH-BGC12-24	235.54	DIAMETRAL	110	61	∠ TO FABRIC	25.86	VALID	6.59	7.21
DH-BGC12-24	242.93	DIAMETRAL	100	61	∠ TO FABRIC	23.76	VALID	6.05	6.62
DH-BGC12-24	248.51	DIAMETRAL	185	61	∠ TO FABRIC	26.44	VALID	6.74	7.37
DH-BGC12-24	255.37	DIAMETRAL	160	61	∠ TO FABRIC	27.34	VALID	6.97	7.62
DH-BGC12-24	260.7	DIAMETRAL	185	61	∠ TO FABRIC	19.32	INVALID	4.92	5.38
DH-BGC12-24	264.17	DIAMETRAL	135	61	∠ TO FABRIC	9.7	INVALID	2.47	2.70
DH-BGC12-24	264.3	DIAMETRAL	120	61	∠ TO FABRIC	34.34	VALID	8.75	9.57
DH-BGC12-24	264.67	DIAMETRAL	135	61	∠ TO FABRIC	26.14	VALID	6.66	7.28
DH-BGC12-24	264.81	DIAMETRAL	130	61	∠ TO FABRIC	15.8	INVALID	4.03	4.40
DH-BGC12-24	264.95	DIAMETRAL	200	61	∠ TO FABRIC	28.42	VALID	7.24	7.92
DH-BGC12-24	270.69	DIAMETRAL	180	61	∠ TO FABRIC	26.72	VALID	6.81	7.44
DH-BGC12-24	275.74	DIAMETRAL	180	61	∠ TO FABRIC	31.54	VALID	8.04	8.79
DH-BGC12-24	280.09	DIAMETRAL	175	61	∠ TO FABRIC	25.86	INVALID	6.59	7.21
DH-BGC12-24	280.27	DIAMETRAL	180	61	∠ TO FABRIC	26.64	VALID	6.79	7.42
DH-BGC12-24	285.92	DIAMETRAL	135	61	∠ TO FABRIC	15.86	INVALID	4.04	4.42
DH-BGC12-24	285.15	DIAMETRAL	130	61	∠ TO FABRIC	13.74	VALID	3.50	3.83
DH-BGC12-24	291.2	DIAMETRAL	210	61	∠ TO FABRIC	27.06	VALID	6.89	7.54
DH-BGC12-24	295.08	DIAMETRAL	190	61	∠ TO FABRIC	24.24	INVALID	6.18	6.75
DH-BGC12-24	295.76	DIAMETRAL	140	61	∠ TO FABRIC	9.66	VALID	2.46	2.69
DH-BGC12-24	300.09	DIAMETRAL	170	61	∠ TO FABRIC	23.38	VALID	5.96	6.51
DH-BGC12-24	302.2	DIAMETRAL	100	61	∠ TO FABRIC	31.54	VALID	8.04	8.79
DH-BGC12-24	302.31	DIAMETRAL	95	61	∠ TO FABRIC	24.08	VALID	6.13	6.71
DH-BGC12-24	302.66	DIAMETRAL	110	61	∠ TO FABRIC	20.58	VALID	5.24	5.73
DH-BGC12-24	302.95	DIAMETRAL	180	61	∠ TO FABRIC	26.66	VALID	6.79	7.43
DH-BGC12-24	306.22	DIAMETRAL	190	61	∠ TO FABRIC	25.26	VALID	6.44	7.04
DH-BGC12-24	310.76	DIAMETRAL	180	61	∠ TO FABRIC	17.02	VALID	4.34	4.74
DH-BGC12-24	316.17	DIAMETRAL	160	61	∠ TO FABRIC	20.9	VALID	5.32	5.82
DH-BGC12-24	320.2	DIAMETRAL	140	61	∠ TO FABRIC	14.38	INVALID	3.66	4.01
DH-BGC12-24	322.92	DIAMETRAL	110	61	∠ TO FABRIC	16.14	VALID	4.11	4.50
DH-BGC12-24	323.07	DIAMETRAL	180	61	∠ TO FABRIC	14.66	VALID	3.73	4.08
DH-BGC12-24	330.6	DIAMETRAL	190	61	∠ TO FABRIC	31.02	VALID	7.90	8.64
DH-BGC12-24	334.17	DIAMETRAL	130	61	∠ TO FABRIC	19.3	INVALID	4.92	5.38

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-24	336.67	DIAMETRAL	160	61	∠ TO FABRIC	33.08	VALID	8.43	9.22
DH-BGC12-24	341.31	DIAMETRAL	155	61	∠ TO FABRIC	30.2	VALID	7.69	8.41
DH-BGC12-24	347.68	DIAMETRAL	130	61	∠ TO FABRIC	21.6	VALID	5.50	6.02
DH-BGC12-24	348	DIAMETRAL	210	61	∠ TO FABRIC	24.02	VALID	6.12	6.69
DH-BGC12-24	348.58	DIAMETRAL	185	61	∠ TO FABRIC	23.92	VALID	6.09	6.66
DH-BGC12-24	348.74	DIAMETRAL	170	61	∠ TO FABRIC	22.1	INVALID	5.63	6.16
DH-BGC12-24	348.91	DIAMETRAL	180	61	∠ TO FABRIC	32.02	VALID	8.16	8.92
DH-BGC12-24	355.02	DIAMETRAL	150	61	∠ TO FABRIC	38.7	VALID	9.86	10.78
DH-BGC12-24	361	DIAMETRAL	200	61	∠ TO FABRIC	25.5	VALID	6.50	7.10
DH-BGC12-24	365.54	DIAMETRAL	160	61	∠ TO FABRIC	35.76	VALID	9.11	9.96
DH-BGC12-24	373.37	DIAMETRAL	160	61	∠ TO FABRIC	26.34	VALID	6.71	7.34
DH-BGC12-24	378.6	DIAMETRAL	150	61	∠ TO FABRIC	29.36	VALID	7.48	8.18
DH-BGC12-24	385.48	DIAMETRAL	175	61	∠ TO FABRIC	15.18	INVALID	3.87	4.23
DH-BGC12-24	437.19	DIAMETRAL	90	61	∠ TO FABRIC	16.02	VALID	4.08	4.46
DH-BGC12-24	442.2	DIAMETRAL	110	61	∠ TO FABRIC	14.4	INVALID	3.67	4.01
DH-BGC12-24	442.97	DIAMETRAL	170	61	∠ TO FABRIC	25.92	VALID	6.60	7.22
DH-BGC12-24	448	DIAMETRAL	130	61	∠ TO FABRIC	32.08	VALID	8.17	8.94
DH-BGC12-24	448.18	DIAMETRAL	155	61	∠ TO FABRIC	25.02	INVALID	6.37	6.97
DH-BGC12-24	448.54	DIAMETRAL	90	61	∠ TO FABRIC	25.32	INVALID	6.45	7.05
DH-BGC12-24	448.64	DIAMETRAL	130	61	∠ TO FABRIC	35.8	VALID	9.12	9.97
DH-BGC12-24	448.78	DIAMETRAL	120	61	∠ TO FABRIC	28	VALID	7.13	7.80
DH-BGC12-24	448.9	DIAMETRAL	140	61	∠ TO FABRIC	12.58	INVALID	3.21	3.51
DH-BGC12-24	455.92	DIAMETRAL	155	61	∠ TO FABRIC	36.5	VALID	9.30	10.17
DH-BGC12-24	458.79	DIAMETRAL	170	61	∠ TO FABRIC	31.16	VALID	7.94	8.68
DH-BGC12-24	465.48	DIAMETRAL	145	61	∠ TO FABRIC	16.22	VALID	4.13	4.52
DH-BGC12-24	468.67	DIAMETRAL	90	61	∠ TO FABRIC	5.56	VALID	1.42	1.55
DH-BGC12-24	476.52	DIAMETRAL	185	61	∠ TO FABRIC	30.22	VALID	7.70	8.42
DH-BGC12-24	481.76	DIAMETRAL	190	61	∠ TO FABRIC	15.78	VALID	4.02	4.40
DH-BGC12-24	488.6	DIAMETRAL	150	61	∠ TO FABRIC	21.76	INVALID	5.54	6.06
DH-BGC12-24	487.13	DIAMETRAL	185	61	∠ TO FABRIC	7.48	VALID	1.91	2.08
DH-BGC12-24	493.71	DIAMETRAL	115	61	∠ TO FABRIC	29.84	VALID	7.60	8.31
DH-BGC12-24	493.82	DIAMETRAL	90	61	∠ TO FABRIC	22.8	VALID	5.81	6.35
DH-BGC12-24	494.15	DIAMETRAL	140	61	∠ TO FABRIC	30.82	VALID	7.85	8.59
DH-BGC12-24	494.34	DIAMETRAL	215	61	∠ TO FABRIC	20.18	VALID	5.14	5.62
DH-BGC12-24	494.49	DIAMETRAL	120	61	∠ TO FABRIC	23.02	INVALID	5.86	6.41
DH-BGC12-24	500.11	DIAMETRAL	150	61	∠ TO FABRIC	20.78	INVALID	5.29	5.79
DH-BGC12-24	500.7	DIAMETRAL	160	61	∠ TO FABRIC	23	VALID	5.86	6.41

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-24	383.94	DIAMETRAL	110	61	∠ TO FABRIC	33.66	VALID	8.58	9.38
DH-BGC12-24	390.27	DIAMETRAL	145	61	∠ TO FABRIC	28.72	VALID	7.32	8.00
DH-BGC12-24	395.97	DIAMETRAL	230	61	∠ TO FABRIC	13.54	INVALID	3.45	3.77
DH-BGC12-24	397.68	DIAMETRAL	120	61	∠ TO FABRIC	31.56	VALID	8.04	8.79
DH-BGC12-24	402.14	DIAMETRAL	160	61	∠ TO FABRIC	25.74	INVALID	6.56	7.17
DH-BGC12-24	402.3	DIAMETRAL	135	61	∠ TO FABRIC	32.06	VALID	8.17	8.93
DH-BGC12-24	402.7	DIAMETRAL	115	61	∠ TO FABRIC	38.84	VALID	9.90	10.82
DH-BGC12-24	402.81	DIAMETRAL	120	61	∠ TO FABRIC	17.08	INVALID	4.35	4.76
DH-BGC12-24	402.99	DIAMETRAL	150	61	∠ TO FABRIC	36.54	VALID	9.31	10.18
DH-BGC12-24	405.51	DIAMETRAL	140	61	∠ TO FABRIC	27.92	VALID	7.11	7.78
DH-BGC12-24	417.7	DIAMETRAL	150	61	∠ TO FABRIC	39.28	VALID	10.01	10.94
DH-BGC12-24	423.56	DIAMETRAL	130	61	∠ TO FABRIC	30.7	VALID	7.82	8.55
DH-BGC12-24	429.98	DIAMETRAL	150	61	∠ TO FABRIC	18.48	INVALID	4.71	5.15
DH-BGC12-24	430.14	DIAMETRAL	180	61	∠ TO FABRIC	29.6	VALID	7.54	8.25
DH-BGC12-25	332.25	DIAMETRAL	140	61	NA	25.72	VALID	6.55	7.17
DH-BGC12-25	335.98	DIAMETRAL	160	61	NA	16.78	VALID	4.28	4.68
DH-BGC12-25	342.52	DIAMETRAL	155	61	NA	19.48	VALID	4.96	5.43
DH-BGC12-25	349.14	DIAMETRAL	120	61	NA	16.7	VALID	4.25	4.65
DH-BGC12-25	355.1	DIAMETRAL	230	61	NA	20.52	VALID	5.23	5.72
DH-BGC12-25	361.64	DIAMETRAL	185	61	NA	27.52	VALID	7.01	7.67
DH-BGC12-25	368.27	DIAMETRAL	120	61	NA	15.44	VALID	3.93	4.30
DH-BGC12-25	177.23	DIAMETRAL	170	61	∠ TO FABRIC	12.44	VALID	3.17	3.47
DH-BGC12-25	183.46	DIAMETRAL	135	61	∠ TO FABRIC	16.44	VALID	4.19	4.58
DH-BGC12-25	189.42	DIAMETRAL	170	61	NA	22.3	VALID	5.68	6.21
DH-BGC12-25	194.27	DIAMETRAL	200	61	∠ TO FABRIC	25.02	VALID	6.37	6.97
DH-BGC12-25	200.13	DIAMETRAL	230	61	∠ TO FABRIC	20.28	VALID	5.17	5.65
DH-BGC12-25	200.18	DIAMETRAL	100	61	∠ TO FABRIC	19.52	VALID	4.97	5.44
DH-BGC12-25	200.27	DIAMETRAL	100	61	∠ TO FABRIC	18.12	VALID	4.62	5.05
DH-BGC12-25	200.61	DIAMETRAL	170	61	∠ TO FABRIC	16.7	VALID	4.25	4.65
DH-BGC12-25	206.85	DIAMETRAL	200	61	∠ TO FABRIC	9.12	INVALID	2.32	2.54
DH-BGC12-25	206.65	DIAMETRAL	160	61	∠ TO FABRIC	5.84	VALID	1.49	1.63
DH-BGC12-25	210.91	DIAMETRAL	200	61	∠ TO FABRIC	14.4	VALID	3.67	4.01
DH-BGC12-25	213.77	DIAMETRAL	120	61	∠ TO FABRIC	6.62	VALID	1.69	1.84
DH-BGC12-25	218.97	DIAMETRAL	230	61	∠ TO FABRIC	13.52	VALID	3.44	3.77
DH-BGC12-25	225	DIAMETRAL	155	61	∠ TO FABRIC	13.34	INVALID	3.40	3.72
DH-BGC12-25	224.9	DIAMETRAL	100	61	∠ TO FABRIC	14.22	VALID	3.62	3.96
DH-BGC12-25	230.6	DIAMETRAL	175	61	∠ TO FABRIC	7	INVALID	1.78	1.95

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-25	231.1	DIAMETRAL	115	61	∠ TO FABRIC	10.64	VALID	2.71	2.96
DH-BGC12-25	235.2	DIAMETRAL	145	61	∠ TO FABRIC	10.52	INVALID	2.68	2.93
DH-BGC12-25	237.5	DIAMETRAL	200	61	∠ TO FABRIC	2.62	INVALID	0.67	0.73
DH-BGC12-25	237.33	DIAMETRAL	160	61	∠ TO FABRIC	12.5	VALID	3.18	3.48
DH-BGC12-25	242.14	DIAMETRAL	180	61	∠ TO FABRIC	15.36	VALID	3.91	4.28
DH-BGC12-25	245.57	DIAMETRAL	120	61	∠ TO FABRIC	11.98	VALID	3.05	3.34
DH-BGC12-25	248.18	DIAMETRAL	160	61	NA	7.76	VALID	1.98	2.16
DH-BGC12-25	248.23	DIAMETRAL	100	61	NA	17.44	VALID	4.44	4.86
DH-BGC12-25	253.14	DIAMETRAL	160	61	∠ TO FABRIC	9.06	VALID	2.31	2.52
DH-BGC12-25	258.57	DIAMETRAL	200	61	∠ TO FABRIC	9.08	VALID	2.31	2.53
DH-BGC12-25	263.09	DIAMETRAL	215	61	∠ TO FABRIC	15.78	VALID	4.02	4.40
DH-BGC12-25	263.15	DIAMETRAL	90	61	∠ TO FABRIC	13.36	VALID	3.40	3.72
DH-BGC12-25	263.81	DIAMETRAL	135	61	∠ TO FABRIC	8.58	INVALID	2.19	2.39
DH-BGC12-25	263.96	DIAMETRAL	200	61	∠ TO FABRIC	10.16	VALID	2.59	2.83
DH-BGC12-25	269.1	DIAMETRAL	160	61	∠ TO FABRIC	11.48	VALID	2.92	3.20
DH-BGC12-25	272.44	DIAMETRAL	200	61	NA	17.74	VALID	4.52	4.94
DH-BGC12-25	275.42	DIAMETRAL	170	61	NA	13.1	VALID	3.34	3.65
DH-BGC12-25	279.67	DIAMETRAL	170	61	∠ TO FABRIC	8.44	INVALID	2.15	2.35
DH-BGC12-25	279.97	DIAMETRAL	220	61	∠ TO FABRIC	13.14	VALID	3.35	3.66
DH-BGC12-25	285.8	DIAMETRAL	180	61	∠ TO FABRIC	14.12	VALID	3.60	3.93
DH-BGC12-25	291.47	DIAMETRAL	260	61	∠ TO FABRIC	30.16	VALID	7.68	8.40
DH-BGC12-25	297.31	DIAMETRAL	160	61	∠ TO FABRIC	0.54	VALID	0.14	0.15
DH-BGC12-25	300.37	DIAMETRAL	150	61	∠ TO FABRIC	13.14	VALID	3.35	3.66
DH-BGC12-25	303.14	DIAMETRAL	160	61	∠ TO FABRIC	12.56	VALID	3.20	3.50
DH-BGC12-25	307.31	DIAMETRAL	165	61	∠ TO FABRIC	25.14	VALID	6.40	7.00
DH-BGC12-25	312.51	DIAMETRAL	235	61	NA	22.52	VALID	5.74	6.27
DH-BGC12-25	318.51	DIAMETRAL	165	61	NA	21.42	VALID	5.46	5.97
DH-BGC12-25	320.63	DIAMETRAL	165	61	NA	11.1	INVALID	2.83	3.09
DH-BGC12-25	320.79	DIAMETRAL	120	61	NA	20.62	VALID	5.25	5.75
DH-BGC12-25	321.23	DIAMETRAL	180	61	NA	22.82	VALID	5.81	6.36
DH-BGC12-25	321.42	DIAMETRAL	180	61	NA	25.86	VALID	6.59	7.21
DH-BGC12-25	321.56	DIAMETRAL	135	61	NA	21.02	VALID	5.36	5.86
DH-BGC12-25	321.71	DIAMETRAL	130	61	NA	20.58	VALID	5.24	5.73
DH-BGC12-25	327.45	DIAMETRAL	155	61	NA	18.94	VALID	4.83	5.28
DH-BGC12-25	4.64	DIAMETRAL	125	61	∠ TO FABRIC	9.9	VALID	2.52	2.76
DH-BGC12-25	9.29	DIAMETRAL	115	61	∠ TO FABRIC	10.26	VALID	2.61	2.86
DH-BGC12-25	15.45	DIAMETRAL	180	61	∠ TO FABRIC	9.46	INVALID	2.41	2.64

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-25	14.87	DIAMETRAL	165	61	∠ TO FABRIC	17.8	VALID	4.53	4.96
DH-BGC12-25	20.5	DIAMETRAL	120	61	∠ TO FABRIC	7.58	VALID	1.93	2.11
DH-BGC12-25	25.08	DIAMETRAL	240	61	∠ TO FABRIC	6.96	VALID	1.77	1.94
DH-BGC12-25	30.8	DIAMETRAL	150	61	∠ TO FABRIC	13.44	VALID	3.42	3.74
DH-BGC12-25	36.8	DIAMETRAL	185	61	∠ TO FABRIC	14.82	VALID	3.78	4.13
DH-BGC12-25	39.96	DIAMETRAL	135	61	∠ TO FABRIC	10.54	VALID	2.69	2.94
DH-BGC12-25	47.65	DIAMETRAL	190	61	∠ TO FABRIC	17.6	VALID	4.48	4.90
DH-BGC12-25	50.05	DIAMETRAL	110	61	∠ TO FABRIC	12.14	INVALID	3.09	3.38
DH-BGC12-25	50.28	DIAMETRAL	150	61	∠ TO FABRIC	15.82	VALID	4.03	4.41
DH-BGC12-25	50.62	DIAMETRAL	90	61	∠ TO FABRIC	3.6	INVALID	0.92	1.00
DH-BGC12-25	49.93	DIAMETRAL	130	61	∠ TO FABRIC	18.38	VALID	4.68	5.12
DH-BGC12-25	49.72	DIAMETRAL	110	61	∠ TO FABRIC	13.5	VALID	3.44	3.76
DH-BGC12-25	55.82	DIAMETRAL	130	61	∠ TO FABRIC	13.22	VALID	3.37	3.68
DH-BGC12-25	61.7	DIAMETRAL	130	61	∠ TO FABRIC	6.78	VALID	1.73	1.89
DH-BGC12-25	67.32	DIAMETRAL	175	61	∠ TO FABRIC	9.78	VALID	2.49	2.72
DH-BGC12-25	71.55	DIAMETRAL	140	61	∠ TO FABRIC	13	VALID	3.31	3.62
DH-BGC12-25	76.21	DIAMETRAL	170	61	∠ TO FABRIC	12.4	INVALID	3.16	3.45
DH-BGC12-25	76.36	DIAMETRAL	100	61	∠ TO FABRIC	11.2	INVALID	2.85	3.12
DH-BGC12-25	77.77	DIAMETRAL	105	61	∠ TO FABRIC	6.1	VALID	1.55	1.70
DH-BGC12-25	81.25	DIAMETRAL	135	61	∠ TO FABRIC	14.04	VALID	3.58	3.91
DH-BGC12-25	85.16	DIAMETRAL	190	61	∠ TO FABRIC	24.12	VALID	6.15	6.72
DH-BGC12-25	85.76	DIAMETRAL	145	61	∠ TO FABRIC	19.16	VALID	4.88	5.34
DH-BGC12-25	85.92	DIAMETRAL	200	61	∠ TO FABRIC	13.75	VALID	3.50	3.83
DH-BGC12-25	85.22	DIAMETRAL	90	61	∠ TO FABRIC	22.5	VALID	5.73	6.27
DH-BGC12-25	91.63	DIAMETRAL	150	61	∠ TO FABRIC	8.38	VALID	2.13	2.33
DH-BGC12-25	95.86	DIAMETRAL	130	61	∠ TO FABRIC	21.62	VALID	5.51	6.02
DH-BGC12-25	100.3	DIAMETRAL	220	61	∠ TO FABRIC	16.56	VALID	4.22	4.61
DH-BGC12-25	104.2	DIAMETRAL	130	61	∠ TO FABRIC	17.82	VALID	4.54	4.96
DH-BGC12-25	111.04	DIAMETRAL	135	61	∠ TO FABRIC	18.96	VALID	4.83	5.28
DH-BGC12-25	113.68	DIAMETRAL	165	61	∠ TO FABRIC	14	INVALID	3.57	3.90
DH-BGC12-25	113.78	DIAMETRAL	110	61	∠ TO FABRIC	25.44	VALID	6.48	7.09
DH-BGC12-25	113.88	DIAMETRAL	190	61	∠ TO FABRIC	28.22	VALID	7.19	7.86
DH-BGC12-25	114.26	DIAMETRAL	105	61	∠ TO FABRIC	16	INVALID	4.08	4.46
DH-BGC12-25	114.8	DIAMETRAL	120	61	∠ TO FABRIC	22.15	VALID	5.64	6.17
DH-BGC12-25	118.84	DIAMETRAL	145	61	∠ TO FABRIC	19.88	VALID	5.06	5.54
DH-BGC12-25	125.27	DIAMETRAL	105	61	∠ TO FABRIC	17.38	INVALID	4.43	4.84
DH-BGC12-25	125.43	DIAMETRAL	210	61	∠ TO FABRIC	17.8	VALID	4.53	4.96

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-25	130.77	DIAMETRAL	165	61	∠ TO FABRIC	19.3	VALID	4.92	5.38
DH-BGC12-25	136.35	DIAMETRAL	165	61	∠ TO FABRIC	15.9	VALID	4.05	4.43
DH-BGC12-25	142.72	DIAMETRAL	150	61	∠ TO FABRIC	24.74	VALID	6.30	6.89
DH-BGC12-25	146.47	DIAMETRAL	170	61	∠ TO FABRIC	17.3	VALID	4.41	4.82
DH-BGC12-25	151.72	DIAMETRAL	190	61	∠ TO FABRIC	22.86	VALID	5.82	6.37
DH-BGC12-25	158.52	DIAMETRAL	160	61	∠ TO FABRIC	6.72	VALID	1.71	1.87
DH-BGC12-25	165.55	DIAMETRAL	220	61	∠ TO FABRIC	1.38	VALID	0.35	0.38
DH-BGC12-25	165.45	DIAMETRAL	135	61	∠ TO FABRIC	8.84	VALID	2.25	2.46
DH-BGC12-25	167.95	DIAMETRAL	215	61	∠ TO FABRIC	7.16	VALID	1.82	1.99
DH-BGC12-25	173.8	DIAMETRAL	140	61	∠ TO FABRIC	12.14	VALID	3.09	3.38
DH-BGC12-25	177.4	DIAMETRAL	150	61	∠ TO FABRIC	8.02	INVALID	2.04	2.23
DH-BGC12-26	5.95	DIAMETRAL	100	61	∠ TO FABRIC	3.96	INVALID	1.01	1.10
DH-BGC12-26	6.05	DIAMETRAL	110	61	∠ TO FABRIC	12.72	VALID	3.24	3.54
DH-BGC12-26	5.76	DIAMETRAL	160	61	∠ TO FABRIC	7.78	VALID	1.98	2.17
DH-BGC12-26	6.48	DIAMETRAL	150	61	∠ TO FABRIC	6.34	VALID	1.62	1.77
DH-BGC12-26	6.63	DIAMETRAL	130	61	∠ TO FABRIC	5.84	INVALID	1.49	1.63
DH-BGC12-26	6.8	DIAMETRAL	175	61	∠ TO FABRIC	6.78	VALID	1.73	1.89
DH-BGC12-26	9.23	DIAMETRAL	170	61	∠ TO FABRIC	6.8	VALID	1.73	1.89
DH-BGC12-26	11.65	DIAMETRAL	160	61	∠ TO FABRIC	7.42	VALID	1.89	2.07
DH-BGC12-26	15.8	DIAMETRAL	140	61	∠ TO FABRIC	16.04	VALID	4.09	4.47
DH-BGC12-26	15.93	DIAMETRAL	140	61	∠ TO FABRIC	4.1	INVALID	1.04	1.14
DH-BGC12-26	16.38	DIAMETRAL	190	61	∠ TO FABRIC	13.7	VALID	3.49	3.82
DH-BGC12-26	16.68	DIAMETRAL	190	61	∠ TO FABRIC	15.58	VALID	3.97	4.34
DH-BGC12-26	18.7	DIAMETRAL	175	61	∠ TO FABRIC	13.96	VALID	3.56	3.89
DH-BGC12-26	21.45	DIAMETRAL	200	61	∠ TO FABRIC	13.4	INVALID	3.41	3.73
DH-BGC12-26	21.64	DIAMETRAL	190	61	∠ TO FABRIC	12.96	INVALID	3.30	3.61
DH-BGC12-26	21.8	DIAMETRAL	180	61	∠ TO FABRIC	6.62	VALID	1.69	1.84
DH-BGC12-26	22.94	DIAMETRAL	240	61	∠ TO FABRIC	13.74	VALID	3.50	3.83
DH-BGC12-26	26.21	DIAMETRAL	170	61	∠ TO FABRIC	12.52	INVALID	3.19	3.49
DH-BGC12-26	26.4	DIAMETRAL	240	61	∠ TO FABRIC	14.42	VALID	3.67	4.02
DH-BGC12-26	29.87	DIAMETRAL	200	61	∠ TO FABRIC	15.56	VALID	3.96	4.34
DH-BGC12-27	26.86	DIAMETRAL	250	61	∠ TO FABRIC	19.14	VALID	4.88	5.33
DH-BGC12-27	27.23	DIAMETRAL	180	61	∠ TO FABRIC	28.76	VALID	7.33	8.01
DH-BGC12-27	30.12	DIAMETRAL	250	61	∠ TO FABRIC	15.7	INVALID	4.00	4.37
DH-BGC12-27	2.81	DIAMETRAL	135	61	∠ TO FABRIC	25.36	VALID	6.46	7.07
DH-BGC12-27	4.08	DIAMETRAL	180	61	∠ TO FABRIC	13.38	INVALID	3.41	3.73
DH-BGC12-27	4.6	DIAMETRAL	200	61	∠ TO FABRIC	29.26	VALID	7.45	8.15

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-27	4.75	DIAMETRAL	190	61	∠ TO FABRIC	26.64	VALID	6.79	7.42
DH-BGC12-27	3.93	DIAMETRAL	120	61	∠ TO FABRIC	22.18	VALID	5.65	6.18
DH-BGC12-27	8.61	DIAMETRAL	155	61	∠ TO FABRIC	23.28	VALID	5.93	6.49
DH-BGC12-27	8.43	DIAMETRAL	240	61	∠ TO FABRIC	27.42	VALID	6.99	7.64
DH-BGC12-27	11.39	DIAMETRAL	120	61	∠ TO FABRIC	25.72	VALID	6.55	7.17
DH-BGC12-27	14.45	DIAMETRAL	250	61	∠ TO FABRIC	32.17	VALID	8.20	8.96
DH-BGC12-27	18.08	DIAMETRAL	220	61	∠ TO FABRIC	18.76	INVALID	4.78	5.23
DH-BGC12-27	18.63	DIAMETRAL	240	61	∠ TO FABRIC	32.76	VALID	8.35	9.13
DH-BGC12-27	20.42	DIAMETRAL	180	61	∠ TO FABRIC	20.78	INVALID	5.29	5.79
DH-BGC12-27	20.13	DIAMETRAL	190	61	∠ TO FABRIC	26.7	VALID	6.80	7.44
DH-BGC12-27	24.3	DIAMETRAL	210	61	∠ TO FABRIC	2.1	VALID	0.54	0.59
DH-BGC12-28	4.77	DIAMETRAL	190	61	∠ TO FABRIC	23.06	VALID	5.88	6.42
DH-BGC12-28	7.79	DIAMETRAL	165	61	∠ TO FABRIC	30.58	VALID	7.79	8.52
DH-BGC12-28	9.8	DIAMETRAL	160	61	∠ TO FABRIC	16.98	INVALID	4.33	4.73
DH-BGC12-28	9.98	DIAMETRAL	175	61	∠ TO FABRIC	24.54	VALID	6.25	6.84
DH-BGC12-28	10.12	DIAMETRAL	95	61	∠ TO FABRIC	17.74	INVALID	4.52	4.94
DH-BGC12-28	9.58	DIAMETRAL	165	61	∠ TO FABRIC	22.62	VALID	5.76	6.30
DH-BGC12-28	10.72	DIAMETRAL	95	61	∠ TO FABRIC	20.76	VALID	5.29	5.78
DH-BGC12-28	13.87	DIAMETRAL	140	61	∠ TO FABRIC	25.22	INVALID	6.43	7.03
DH-BGC12-28	14.49	DIAMETRAL	130	61	∠ TO FABRIC	17.44	VALID	4.44	4.86
DH-BGC12-28	18.18	DIAMETRAL	150	61	∠ TO FABRIC	2.92	INVALID	0.74	0.81
DH-BGC12-28	18.54	DIAMETRAL	135	61	∠ TO FABRIC	5.8	VALID	1.48	1.62
DH-BGC12-28	16.49	DIAMETRAL	200	61	∠ TO FABRIC	19.14	VALID	4.88	5.33
DH-BGC12-28	20.12	DIAMETRAL	230	61	∠ TO FABRIC	2.88	VALID	0.73	0.80
DH-BGC12-28	21.48	DIAMETRAL	190	61	∠ TO FABRIC	7.22	INVALID	1.84	2.01
DH-BGC12-28	22.3	DIAMETRAL	175	61	∠ TO FABRIC	10.6	VALID	2.70	2.95
DH-BGC12-28	24.79	DIAMETRAL	200	61	∠ TO FABRIC	9.78	VALID	2.49	2.72
DH-BGC12-28	28.59	DIAMETRAL	140	61	∠ TO FABRIC	30.16	VALID	7.68	8.40
DH-BGC12-28	30.15	DIAMETRAL	180	61	∠ TO FABRIC	14.9	VALID	3.80	4.15
DH-BGC12-29	3.1	DIAMETRAL	200	61	∠ TO FABRIC	33.14	VALID	8.44	9.23
DH-BGC12-29	5.24	DIAMETRAL	120	61	∠ TO FABRIC	24.68	INVALID	6.29	6.88
DH-BGC12-29	5.37	DIAMETRAL	125	61	∠ TO FABRIC	30.44	VALID	7.76	8.48
DH-BGC12-29	5.85	DIAMETRAL	180	61	∠ TO FABRIC	31.1	VALID	7.92	8.67
DH-BGC12-29	5.97	DIAMETRAL	90	61	∠ TO FABRIC	16.78	INVALID	4.28	4.68
DH-BGC12-29	5.03	DIAMETRAL	190	61	∠ TO FABRIC	27.74	VALID	7.07	7.73
DH-BGC12-29	6.88	DIAMETRAL	160	61	∠ TO FABRIC	32.28	VALID	8.22	8.99
DH-BGC12-29	7.16	DIAMETRAL	165	61	∠ TO FABRIC	23.78	INVALID	6.06	6.63

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
DH-BGC12-29	7.65	DIAMETRAL	190	61	∠ TO FABRIC	20.06	INVALID	5.11	5.59
DH-BGC12-29	7.8	DIAMETRAL	165	61	∠ TO FABRIC	30.64	VALID	7.81	8.54
DH-BGC12-29	7.98	DIAMETRAL	180	61	∠ TO FABRIC	29.86	VALID	7.61	8.32
DH-BGC12-29	10.15	DIAMETRAL	255	61	NA	18.9	INVALID	4.82	5.27
DH-BGC12-29	10.98	DIAMETRAL	125	61	NA	31.44	VALID	8.01	8.76
DH-BGC12-29	14.86	DIAMETRAL	230	61	NA	27.96	VALID	7.12	7.79
DH-BGC12-29	18.52	DIAMETRAL	195	61	NA	28.62	VALID	7.29	7.97
DH-BGC12-29	22.11	DIAMETRAL	160	61	NA	24.02	INVALID	6.12	6.69
DH-BGC12-29	21.96	DIAMETRAL	140	61	NA	18.38	VALID	4.68	5.12
DH-BGC12-29	24.47	DIAMETRAL	155	61	NA	17.52	INVALID	4.46	4.88
DH-BGC12-29	24.62	DIAMETRAL	150	61	NA	19.96	VALID	5.09	5.56
DH-BGC12-29	28.29	DIAMETRAL	135	61	NA	27.64	VALID	7.04	7.70
DH-BGC12-30	3.18	DIAMETRAL	130	61	∠ TO FABRIC	15.06	VALID	3.84	4.20
DH-BGC12-30	4.97	DIAMETRAL	180	61	∠ TO FABRIC	29.52	VALID	7.52	8.22
DH-BGC12-30	5.16	DIAMETRAL	180	61	∠ TO FABRIC	20.94	VALID	5.33	5.83
DH-BGC12-30	5.66	DIAMETRAL	190	61	∠ TO FABRIC	26.36	VALID	6.72	7.34
DH-BGC12-30	7.52	DIAMETRAL	190	61	∠ TO FABRIC	18.54	VALID	4.72	5.17
DH-BGC12-30	10.17	DIAMETRAL	175	61	∠ TO FABRIC	18.48	VALID	4.71	5.15
DH-BGC12-30	10.22	DIAMETRAL	120	61	∠ TO FABRIC	10.1	INVALID	2.57	2.81
DH-BGC12-30	10.68	DIAMETRAL	185	61	∠ TO FABRIC	19.3	VALID	4.92	5.38
DH-BGC12-30	10.91	DIAMETRAL	120	61	∠ TO FABRIC	21.44	VALID	5.46	5.97
DH-BGC12-30	11.04	DIAMETRAL	120	61	∠ TO FABRIC	23.26	VALID	5.93	6.48
DH-BGC12-30	13.2	DIAMETRAL	220	61	∠ TO FABRIC	20.76	VALID	5.29	5.78
DH-BGC12-30	14.88	DIAMETRAL	135	61	∠ TO FABRIC	19.92	VALID	5.08	5.55
DH-BGC12-30	15.03	DIAMETRAL	140	61	∠ TO FABRIC	17.8	VALID	4.53	4.96
DH-BGC12-30	15.4	DIAMETRAL	135	61	∠ TO FABRIC	13.44	VALID	3.42	3.74
DH-BGC12-30	15.54	DIAMETRAL	135	61	∠ TO FABRIC	13.26	VALID	3.38	3.69
DH-BGC12-30	18.51	DIAMETRAL	150	61	∠ TO FABRIC	5.8	VALID	1.48	1.62
DH-BGC12-30	17.95	DIAMETRAL	160	61	∠ TO FABRIC	2.8	VALID	0.71	0.78
DH-BGC12-30	18.1	DIAMETRAL	140	61	∠ TO FABRIC	7.14	VALID	1.82	1.99
DH-BGC12-30	18.63	DIAMETRAL	120	61	∠ TO FABRIC	9.5	VALID	2.42	2.65
DH-BGC12-30	20.09	DIAMETRAL	140	61	∠ TO FABRIC	6.56	VALID	1.67	1.83
DH-BGC12-30	22.06	DIAMETRAL	185	61	∠ TO FABRIC	19.02	VALID	4.85	5.30
DH-BGC12-30	26.98	DIAMETRAL	120	61	∠ TO FABRIC	9.7	INVALID	2.47	2.70
DH-BGC12-30	26.84	DIAMETRAL	140	61	∠ TO FABRIC	18.16	VALID	4.63	5.06
DH-BGC12-30	31.55	DIAMETRAL	160	61	∠ TO FABRIC	21.86	VALID	5.57	6.09
SU-077	6.72	DIAMETRAL	330	61	∠ TO FABRIC	12.26	VALID	3.12	3.42

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-077	12.09	DIAMETRAL	220	61	∠ TO FABRIC	17.6	VALID	4.48	4.90
SU-077	19.13	DIAMETRAL	230	61	∠ TO FABRIC	9.68	INVALID	2.47	2.70
SU-077	27.76	DIAMETRAL	170	61	∠ TO FABRIC	9.84	INVALID	2.51	2.74
SU-077	29.29	DIAMETRAL	285	61	∠ TO FABRIC	8	INVALID	2.04	2.23
SU-077	35.93	DIAMETRAL	230	61	∠ TO FABRIC	14.32	INVALID	3.65	3.99
SU-077	41.76	DIAMETRAL	320	61	∠ TO FABRIC		INVALID	0.00	0.00
SU-077	43.25	DIAMETRAL	180	61	∠ TO FABRIC	12.32	INVALID	3.14	3.43
SU-077	44.81	DIAMETRAL	160	61	∠ TO FABRIC		INVALID	0.00	0.00
SU-077	47.72	DIAMETRAL	155	61	∠ TO FABRIC	16.74	INVALID	4.26	4.66
SU-077	52.36	DIAMETRAL	240	61	∠ TO FABRIC	10.64	INVALID	2.71	2.96
SU-077	52.69	DIAMETRAL	170	61	∠ TO FABRIC	19.32	VALID	4.92	5.38
SU-077	53.67	DIAMETRAL	162	61	∠ TO FABRIC	17.86	VALID	4.55	4.98
SU-077	54.26	DIAMETRAL	195	61	∠ TO FABRIC	17.7	VALID	4.51	4.93
SU-077	55.54	DIAMETRAL	180	61	∠ TO FABRIC	19.34	VALID	4.93	5.39
SU-077	56.5	DIAMETRAL	235	61	∠ TO FABRIC	18.98	VALID	4.84	5.29
SU-077	62.19	DIAMETRAL	170	61	∠ TO FABRIC	22	VALID	5.60	6.13
SU-077	67.37	DIAMETRAL	250	61	∠ TO FABRIC	21.56	VALID	5.49	6.01
SU-077	68.61	DIAMETRAL	230	61	∠ TO FABRIC	15.68	VALID	3.99	4.37
SU-077	69.7	DIAMETRAL	255	61	NA	8.5	INVALID	2.17	2.37
SU-077	69.96	DIAMETRAL	240	61	∠ TO FABRIC	16.6	VALID	4.23	4.63
SU-077	70.6	DIAMETRAL	215	61	∠ TO FABRIC	8.46	INVALID	2.16	2.36
SU-077	79.27	DIAMETRAL	275	61	∠ TO FABRIC	22.74	VALID	5.79	6.34
SU-077	87.38	DIAMETRAL	140	61	∠ TO FABRIC	16.6	INVALID	4.23	4.63
SU-077	94.59	DIAMETRAL	155	61	∠ TO FABRIC		INVALID	0.00	0.00
SU-077	94.82	DIAMETRAL	200	61	∠ TO FABRIC	9.94	INVALID	2.53	2.77
SU-077	97.26	DIAMETRAL	280	61	∠ TO FABRIC	14.18	VALID	3.61	3.95
SU-077	105.08	DIAMETRAL	195	61	NA	21.84	VALID	5.56	6.09
SU-077	109.6	DIAMETRAL	140	61	NA	18.36	VALID	4.68	5.12
SU-077	115.69	DIAMETRAL	230	61	NA	14.08	VALID	3.59	3.92
SU-077	115.91	DIAMETRAL	240	61	NA	12.72	INVALID	3.24	3.54
SU-077	116.5	DIAMETRAL	200	61	NA	12.76	INVALID	3.25	3.56
SU-077	117.55	DIAMETRAL	300	61	NA	20.24	VALID	5.16	5.64
SU-077	117.96	DIAMETRAL	156	61	NA	16.02	VALID	4.08	4.46
SU-077	120.35	DIAMETRAL	300	61	∠ TO FABRIC	21.52	VALID	5.48	6.00
SU-077	125.86	DIAMETRAL	270	61	∠ TO FABRIC	15.72	INVALID	4.00	4.38
SU-077	126.12	DIAMETRAL	265	61	∠ TO FABRIC	12.5	INVALID	3.18	3.48
SU-077	129.34	DIAMETRAL	152	61	∠ TO FABRIC		INVALID	0.00	0.00

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-077	130.24	DIAMETRAL	190	61	∠ TO FABRIC		INVALID	0.00	0.00
SU-077	132.51	DIAMETRAL	170	61	∠ TO FABRIC	17.68	INVALID	4.50	4.93
SU-077	136.56	DIAMETRAL	220	61	∠ TO FABRIC	13.86	INVALID	3.53	3.86
SU-077	145.6	DIAMETRAL	150	61	∠ TO FABRIC	17.02	VALID	4.34	4.74
SU-077	146.07	DIAMETRAL	275	61	∠ TO FABRIC	10.04	INVALID	2.56	2.80
SU-077	147.08	DIAMETRAL	140	61	∠ TO FABRIC	14.26	VALID	3.63	3.97
SU-077	147.35	DIAMETRAL	200	61	∠ TO FABRIC		INVALID	0.00	0.00
SU-077	148.43	DIAMETRAL	160	61	∠ TO FABRIC	16.6	INVALID	4.23	4.63
SU-077	152.17	DIAMETRAL	260	61	∠ TO FABRIC	18.96	INVALID	4.83	5.28
SU-077	159.52	DIAMETRAL	270	61	∠ TO FABRIC	15.2	INVALID	3.87	4.24
SU-077	166.94	DIAMETRAL	250	61	∠ TO FABRIC	28.52	VALID	7.27	7.95
SU-077	171.76	DIAMETRAL	205	61	∠ TO FABRIC	27.32	VALID	6.96	7.61
SU-077	178.57	DIAMETRAL	210	61	∠ TO FABRIC	13.72	INVALID	3.50	3.82
SU-077	185.01	DIAMETRAL	280	61	NA	20.08	VALID	5.12	5.59
SU-077	191.21	DIAMETRAL	180	61	NA	22.68	VALID	5.78	6.32
SU-077	227.8	DIAMETRAL	205	61	∠ TO FABRIC	20.02	VALID	5.10	5.58
SU-077	234.74	DIAMETRAL	165	61	NA	18.2	VALID	4.64	5.07
SU-077	241.6	DIAMETRAL	360	61	∠ TO FABRIC	18.5	VALID	4.71	5.15
SU-077	242.62	DIAMETRAL	220	61	∠ TO FABRIC	7.4	INVALID	1.89	2.06
SU-077	242.9	DIAMETRAL	240	61	∠ TO FABRIC		INVALID	0.00	0.00
SU-077	250.21	DIAMETRAL	280	61	∠ TO FABRIC	9.5	VALID	2.42	2.65
SU-077	251.45	DIAMETRAL	240	61	NA	12.22	INVALID	3.11	3.40
SU-077	253.35	DIAMETRAL	285	61	∠ TO FABRIC	20.64	VALID	5.26	5.75
SU-077	260.5	DIAMETRAL	320	61	∠ TO FABRIC	19.08	VALID	4.86	5.32
SU-077	265.8	DIAMETRAL	200	61	NA	27.36	VALID	6.97	7.62
SU-077	272	DIAMETRAL	190	61	∠ TO FABRIC	16.76	VALID	4.27	4.67
SU-077	272.32	DIAMETRAL	150	61	∠ TO FABRIC	20.86	VALID	5.31	5.81
SU-077	273.51	DIAMETRAL	170	61	∠ TO FABRIC	14.52	INVALID	3.70	4.05
SU-077	273.68	DIAMETRAL	245	61	∠ TO FABRIC	16.98	INVALID	4.33	4.73
SU-077	273.9	DIAMETRAL	155	61	∠ TO FABRIC	12.72	INVALID	3.24	3.54
SU-077	274.8	DIAMETRAL	195	61	∠ TO FABRIC	13.34	INVALID	3.40	3.72
SU-077	277.09	DIAMETRAL	150	61	∠ TO FABRIC	17.46	VALID	4.45	4.86
SU-077	277.24	DIAMETRAL	260	61	∠ TO FABRIC	5.56	INVALID	1.42	1.55
SU-077	282.55	DIAMETRAL	265	61	NA	18.5	VALID	4.71	5.15
SU-077	288	DIAMETRAL	180	61	NA	19.86	INVALID	5.06	5.53
SU-077	288.45	DIAMETRAL	200	61	NA	27.48	VALID	7.00	7.66
SU-077	294.15	DIAMETRAL	170	61	NA	16.52	INVALID	4.21	4.60

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-077	294.32	DIAMETRAL	255	61	NA	24.82	VALID	6.32	6.92
SU-077	300.75	DIAMETRAL	150	61	NA		INVALID	0.00	0.00
SU-077	301.69	DIAMETRAL	230	61	NA	21.07	INVALID	5.37	5.87
SU-077	303.67	DIAMETRAL	220	61	NA	30.6	VALID	7.80	8.53
SU-077	308.39	DIAMETRAL	255	61	NA	23.62	VALID	6.02	6.58
SU-077	315.45	DIAMETRAL	240	61	NA	22.44	VALID	5.72	6.25
SU-077	322.17	DIAMETRAL	320	61	NA	25.98	VALID	6.62	7.24
SU-077	324.2	DIAMETRAL	145	61	⊥ TO FABRIC	19.38	INVALID	4.94	5.40
SU-077	328.53	DIAMETRAL	220	61	NA	27.46	VALID	7.00	7.65
SU-077	328.83	DIAMETRAL	200	61	NA		INVALID	0.00	0.00
SU-077	329.57	DIAMETRAL	175	61	NA	33.28	VALID	8.48	9.27
SU-077	330	DIAMETRAL	230	61	NA	23.98	VALID	6.11	6.68
SU-077	331.05	DIAMETRAL	185	61	NA	20.82	VALID	5.30	5.80
SU-077	338.22	DIAMETRAL	270	61	∠ TO FABRIC	28.42	VALID	7.24	7.92
SU-077	340.08	DIAMETRAL	210	61	∠ TO FABRIC	9.72	INVALID	2.48	2.71
SU-077	344.87	DIAMETRAL	250	61	NA	27.88	VALID	7.10	7.77
SU-077	348.29	DIAMETRAL	200	61	NA	20.66	VALID	5.26	5.76
SU-077	355.23	DIAMETRAL	235	61	∠ TO FABRIC	24.94	VALID	6.35	6.95
SU-077	360.45	DIAMETRAL	205	61	NA	19.16	VALID	4.88	5.34
SU-077	366.49	DIAMETRAL	220	61	∠ TO FABRIC	14.2	VALID	3.62	3.96
SU-077	373.98	DIAMETRAL	185	61	∠ TO FABRIC	23.44	VALID	5.97	6.53
SU-077	379	DIAMETRAL	230	61	∠ TO FABRIC	26.24	VALID	6.69	7.31
SU-077	382.29	DIAMETRAL	190	61	∠ TO FABRIC	8.86	INVALID	2.26	2.47
SU-077	384.2	DIAMETRAL	210	61	∠ TO FABRIC	17.14	VALID	4.37	4.78
SU-077	388.05	DIAMETRAL	260	61	∠ TO FABRIC	23	VALID	5.86	6.41
SU-077	388.6	DIAMETRAL	340	61	∠ TO FABRIC	14.92	VALID	3.80	4.16
SU-077	389.23	DIAMETRAL	280	61	∠ TO FABRIC	13.62	INVALID	3.47	3.79
SU-077	390.09	DIAMETRAL	150	61	∠ TO FABRIC	18.14	VALID	4.62	5.05
SU-077	390.29	DIAMETRAL	155	61	∠ TO FABRIC	17.82	INVALID	4.54	4.96
SU-077	390.42	DIAMETRAL	245	61	∠ TO FABRIC	24.32	VALID	6.20	6.78
SU-077	394.01	DIAMETRAL	165	61	NA	19.8	VALID	5.04	5.52
SU-077	399.02	DIAMETRAL	235	61	NA	23.94	VALID	6.10	6.67
SU-077	405.03	DIAMETRAL	250	61	∠ TO FABRIC	16.9	VALID	4.31	4.71
SU-077	408	DIAMETRAL	165	61	∠ TO FABRIC	23.28	VALID	5.93	6.49
SU-077	415.45	DIAMETRAL	195	61	∠ TO FABRIC	15.36	VALID	3.91	4.28
SU-077	418.59	DIAMETRAL	210	61	∠ TO FABRIC	25.62	INVALID	6.53	7.14
SU-077	425.5	DIAMETRAL	215	61	∠ TO FABRIC	14.72	VALID	3.75	4.10

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-077	434.75	DIAMETRAL	195	61	∠ TO FABRIC	21.04	VALID	5.36	5.86
SU-077	442	DIAMETRAL	310	61	∠ TO FABRIC	21.7	VALID	5.53	6.05
SU-077	447.62	DIAMETRAL	330	61	NA	28.5	VALID	7.26	7.94
SU-077	456.29	DIAMETRAL	190	61	∠ TO FABRIC	19.26	VALID	4.91	5.37
SU-077	460.12	DIAMETRAL	270	61	NA	21.96	VALID	5.59	6.12
SU-077	460.71	DIAMETRAL	230	61	NA	22.46	VALID	5.72	6.26
SU-077	461.15	DIAMETRAL	180	61	NA	20.4	VALID	5.20	5.68
SU-077	462.74	DIAMETRAL	305	61	NA	23.78	VALID	6.06	6.63
SU-077	466.7	DIAMETRAL	300	61	NA	18.94	VALID	4.83	5.28
SU-077	474.15	DIAMETRAL	215	61	NA	15.88	VALID	4.05	4.42
SU-077	480.6	DIAMETRAL	230	61	NA	30.62	VALID	7.80	8.53
SU-077	488.5	DIAMETRAL	240	61	NA	27.08	VALID	6.90	7.55
SU-077	489.26	DIAMETRAL	175	61	∠ TO FABRIC	19.18	INVALID	4.89	5.34
SU-077	496.59	DIAMETRAL	200	61	∠ TO FABRIC	16.18	VALID	4.12	4.51
SU-077	502.01	DIAMETRAL	260	61	NA	21.72	VALID	5.53	6.05
SU-077	508.1	DIAMETRAL	240	61	∠ TO FABRIC	19.92	VALID	5.08	5.55
SU-077	508.55	DIAMETRAL	220	61	∠ TO FABRIC	14.47	VALID	3.69	4.03
SU-077	509.25	DIAMETRAL	240	61	∠ TO FABRIC	14.48	VALID	3.69	4.03
SU-077	510.12	DIAMETRAL	275	61	∠ TO FABRIC	20.28	VALID	5.17	5.65
SU-077	516.66	DIAMETRAL	320	61	∠ TO FABRIC	19.48	VALID	4.96	5.43
SU-077	518.65	DIAMETRAL	270	61	∠ TO FABRIC	20.06	VALID	5.11	5.59
SU-077	522.85	DIAMETRAL	320	61	NA	20.38	VALID	5.19	5.68
SU-077	529.05	DIAMETRAL	270	61	NA	21.24	VALID	5.41	5.92
SU-077	535.53	DIAMETRAL	280	61	NA	17.36	VALID	4.42	4.84
SU-077	541.47	DIAMETRAL	165	61	NA	17.82	INVALID	4.54	4.96
SU-077	541.63	DIAMETRAL	290	61	NA	21.06	VALID	5.37	5.87
SU-077	546.85	DIAMETRAL	355	61	NA	23.48	VALID	5.98	6.54
SU-077	191.72	DIAMETRAL	165	61	NA	4.9	INVALID	1.25	1.37
SU-077	195.24	DIAMETRAL	290	61	∠ TO FABRIC	14.74	INVALID	3.76	4.11
SU-077	196.54	DIAMETRAL	255	61	∠ TO FABRIC	17.28	INVALID	4.40	4.81
SU-077	202.18	DIAMETRAL	290	61	∠ TO FABRIC	15.76	VALID	4.02	4.39
SU-077	209.83	DIAMETRAL	265	61	∠ TO FABRIC	17.4	VALID	4.43	4.85
SU-077	210.27	DIAMETRAL	210	61	∠ TO FABRIC	16.3	INVALID	4.15	4.54
SU-077	215.58	DIAMETRAL	250	61	∠ TO FABRIC	13.32	VALID	3.39	3.71
SU-077	220.39	DIAMETRAL	300	61	∠ TO FABRIC	18.64	INVALID	4.75	5.19
SU-077	221.72	DIAMETRAL	280	61	∠ TO FABRIC	14.42	VALID	3.67	4.02
SU-082	5.17	DIAMETRAL	150	61	∠ TO FABRIC	1.58	INVALID	0.40	0.44

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-082	5.32	DIAMETRAL	160	60	∠ TO FABRIC	0.1	INVALID	0.03	0.03
SU-082	11.17	DIAMETRAL	110	61	∠ TO FABRIC	7.26	VALID	1.85	2.02
SU-082	16.89	DIAMETRAL	110	60	∠ TO FABRIC	0.26	VALID	0.07	0.07
SU-082	21.29	DIAMETRAL	90	61	∠ TO FABRIC	0.08	VALID	0.02	0.02
SU-082	29.66	DIAMETRAL	801	60	NA	5.8	INVALID	1.53	1.66
SU-082	30.29	DIAMETRAL	110	60	NA	7.22	VALID	1.90	2.06
SU-082	34.73	DIAMETRAL	125	60	NA	7.78	INVALID	2.05	2.22
SU-082	35.57	DIAMETRAL	90	61	∠ TO FABRIC	5.78	VALID	1.47	1.61
SU-082	41.64	DIAMETRAL	120	61	∠ TO FABRIC	5.72	VALID	1.46	1.59
SU-082	47.74	DIAMETRAL	110	61	NA	12.02	INVALID	3.06	3.35
SU-082	47.85	DIAMETRAL	80	60	∠ TO FABRIC	7.8	INVALID	2.05	2.23
SU-082	53.72	DIAMETRAL	120	61	∠ TO FABRIC	4.78	INVALID	1.22	1.33
SU-082	56.3	DIAMETRAL	160	61	∠ TO FABRIC	10.4	VALID	2.65	2.90
SU-082	59.85	DIAMETRAL	110	61	∠ TO FABRIC	6.04	VALID	1.54	1.68
SU-082	66.2	DIAMETRAL	70	61	∠ TO FABRIC	13.5	INVALID	3.44	3.76
SU-082	69.03	DIAMETRAL	85	61	∠ TO FABRIC	13.5	INVALID	3.44	3.76
SU-082	72.57	DIAMETRAL	125	60	NA	5.26	INVALID	1.39	1.50
SU-082	75.16	DIAMETRAL	110	61	∠ TO FABRIC	7.14	INVALID	1.82	1.99
SU-082	77.8	DIAMETRAL	100	61	∠ TO FABRIC	7.72	VALID	1.97	2.15
SU-082	82.1	DIAMETRAL	90	61	∠ TO FABRIC	17.08	VALID	4.35	4.76
SU-082	83.15	DIAMETRAL	160	61	∠ TO FABRIC	14.68	VALID	3.74	4.09
SU-082	87.55	DIAMETRAL	85	60	∠ TO FABRIC	8.4	VALID	2.21	2.40
SU-082	88.91	DIAMETRAL	80	61	∠ TO FABRIC	6.6	INVALID	1.68	1.84
SU-082	93	DIAMETRAL	90	61	NA	12.62	INVALID	3.22	3.52
SU-082	101.19	DIAMETRAL	120	61	∠ TO FABRIC	9.06	VALID	2.31	2.52
SU-082	103.72	DIAMETRAL	110	61	∠ TO FABRIC	4.06	VALID	1.03	1.13
SU-082	108.05	DIAMETRAL	85	61	∠ TO FABRIC	13.8	INVALID	3.52	3.84
SU-082	109.27	DIAMETRAL	125	61	∠ TO FABRIC	19.12	VALID	4.87	5.33
SU-082	111.14	DIAMETRAL	105	61	∠ TO FABRIC	9.56	VALID	2.44	2.66
SU-082	89.03	DIAMETRAL	120	61	∠ TO FABRIC	6.16	INVALID	1.57	1.72
SU-082	170.21	DIAMETRAL	70	61	∠ TO FABRIC	33.9	INVALID	8.64	9.45
SU-082	171.74	DIAMETRAL	70	61	∠ TO FABRIC	3.26	INVALID	0.83	0.91
SU-082	172.37	DIAMETRAL	170	61	∠ TO FABRIC	23.48	VALID	5.98	6.54
SU-082	169.87	DIAMETRAL	90	61	NA	18.8	VALID	4.79	5.24
SU-082	168.83	DIAMETRAL	170	61	∠ TO FABRIC	13.48	VALID	3.43	3.76
SU-082	165.69	DIAMETRAL	90	61	NA	21.84	VALID	5.56	6.09
SU-082	159.9	DIAMETRAL	150	61	∠ TO FABRIC	6.34	INVALID	1.62	1.77

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-082	160.09	DIAMETRAL	80	61	∠ TO FABRIC	18.26	VALID	4.65	5.09
SU-082	158.05	DIAMETRAL	80	61	∠ TO FABRIC	7.54	INVALID	1.92	2.10
SU-082	159	DIAMETRAL	95	61	∠ TO FABRIC	19.24	INVALID	4.90	5.36
SU-082	154.53	DIAMETRAL	150	61	∠ TO FABRIC	25.72	VALID	6.55	7.17
SU-082	145.9	DIAMETRAL	135	61	∠ TO FABRIC	23.06	VALID	5.88	6.42
SU-082	142.39	DIAMETRAL	110	61	NA	23.06	VALID	5.88	6.42
SU-082	137.37	DIAMETRAL	140	61	NA	7.5	VALID	1.91	2.09
SU-082	133.2	DIAMETRAL	95	61	∠ TO FABRIC	12.04	INVALID	3.07	3.35
SU-082	133.06	DIAMETRAL	115	61	∠ TO FABRIC	14.28	VALID	3.64	3.98
SU-082	134.96	DIAMETRAL	90	61	NA	10.16	VALID	2.59	2.83
SU-082	127.33	DIAMETRAL	70	61	∠ TO FABRIC	10.66	INVALID	2.72	2.97
SU-082	127.71	DIAMETRAL	90	61	∠ TO FABRIC	10.54	VALID	2.69	2.94
SU-082	124.87	DIAMETRAL	110	61	∠ TO FABRIC	4.1	INVALID	1.04	1.14
SU-082	126.74	DIAMETRAL	70	60	∠ TO FABRIC	6	INVALID	1.58	1.72
SU-082	126.64	DIAMETRAL	70	61	∠ TO FABRIC	7.12	INVALID	1.81	1.98
SU-082	121	DIAMETRAL	80	61	NA	14.98	VALID	3.82	4.17
SU-082	119.67	DIAMETRAL	75	59	NA	5.96	VALID	1.62	1.75
SU-082	114.37	DIAMETRAL	85	61	∠ TO FABRIC	3.12	VALID	0.79	0.87
SU-082	113.77	DIAMETRAL	95	61	∠ TO FABRIC	16.3	VALID	4.15	4.54
SU-082	201.24	DIAMETRAL	135	61	∠ TO FABRIC	4.48	INVALID	1.14	1.25
SU-082	203.36	DIAMETRAL	145	61	∠ TO FABRIC	21.2	VALID	5.40	5.91
SU-082	197.91	DIAMETRAL	70	61	∠ TO FABRIC	13.58	INVALID	3.46	3.78
SU-082	199.09	DIAMETRAL	80	61	NA	16.02	VALID	4.08	4.46
SU-082	197.69	DIAMETRAL	95	62	∠ TO FABRIC	13.2	INVALID	3.26	3.59
SU-082	192.64	DIAMETRAL	75	61	∠ TO FABRIC	17.76	INVALID	4.52	4.95
SU-082	193.61	DIAMETRAL	100	61	∠ TO FABRIC	19.42	INVALID	4.95	5.41
SU-082	193.9	DIAMETRAL	90	61	∠ TO FABRIC	17.2	VALID	4.38	4.79
SU-082	189.66	DIAMETRAL	130	61	∠ TO FABRIC	7.58	VALID	1.93	2.11
SU-082	196.77	DIAMETRAL	140	61	∠ TO FABRIC	12.08	INVALID	3.08	3.37
SU-082	190.83	DIAMETRAL	80	61	∠ TO FABRIC	17.54	VALID	4.47	4.89
SU-082	185.82	DIAMETRAL	140	60	NA	19.48	INVALID	5.13	5.57
SU-082	188.62	DIAMETRAL	120	61	∠ TO FABRIC	9.84	INVALID	2.51	2.74
SU-082	182.45	DIAMETRAL	110	61	NA	10.92	VALID	2.78	3.04
SU-082	179.2	DIAMETRAL	90	61	NA	15.62	VALID	3.98	4.35
SU-082	177.35	DIAMETRAL	70	61	NA	11.02	VALID	2.81	3.07
SU-082	173.66	DIAMETRAL	145	62	NA	4.94	VALID	1.22	1.34
SU-082	228.58	DIAMETRAL	110	61	NA	13.38	INVALID	3.41	3.73

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-082	224.64	DIAMETRAL	135	61	NA	20.42	VALID	5.20	5.69
SU-082	221.11	DIAMETRAL	105	62	NA	19.88	INVALID	4.90	5.40
SU-082	222.3	DIAMETRAL	105	61	NA	13.16	INVALID	3.35	3.67
SU-082	223.14	DIAMETRAL	80	60	NA	8.54	INVALID	2.25	2.44
SU-082	218.22	DIAMETRAL	105	61	NA	10.22	VALID	2.60	2.85
SU-082	212.45	DIAMETRAL	140	61	NA	9	VALID	2.29	2.51
SU-082	207.88	DIAMETRAL	70	61	∠ TO FABRIC	7.48	VALID	1.91	2.08
SU-082	299.12	DIAMETRAL	120	61	NA	23.3	INVALID	5.94	6.49
SU-082	299	DIAMETRAL	115	61	NA	28.3	INVALID	7.21	7.88
SU-082	290.49	DIAMETRAL	130	61	NA	15.12	INVALID	3.85	4.21
SU-082	287.22	DIAMETRAL	115	61	NA	23.52	INVALID	5.99	6.55
SU-082	286.86	DIAMETRAL	105	61	NA	25.02	INVALID	6.37	6.97
SU-082	277.51	DIAMETRAL	165	60	∠ TO FABRIC	19.32	VALID	5.09	5.52
SU-082	271.18	DIAMETRAL	70	61	∠ TO FABRIC	4.96	INVALID	1.26	1.38
SU-082	272.06	DIAMETRAL	70	61	∠ TO FABRIC	13.98	VALID	3.56	3.90
SU-082	264.7	DIAMETRAL	150	61	∠ TO FABRIC	24.74	VALID	6.30	6.89
SU-082	264.55	DIAMETRAL	85	61	∠ TO FABRIC	9.14	VALID	2.33	2.55
SU-082	258.54	DIAMETRAL	120	61	∠ TO FABRIC	17.66	VALID	4.50	4.92
SU-082	251.33	DIAMETRAL	130	61	∠ TO FABRIC	7.4	INVALID	1.89	2.06
SU-082	243.58	DIAMETRAL	100	61	NA	9.42	INVALID	2.40	2.62
SU-082	238.7	DIAMETRAL	90	61	∠ TO FABRIC	8.74	VALID	2.23	2.44
SU-082	230.95	DIAMETRAL	90	61	∠ TO FABRIC	10.7	VALID	2.73	2.98
SU-082	278.52	DIAMETRAL	130	61	∠ TO FABRIC	19.7	INVALID	5.02	5.49
SU-082	279.5	DIAMETRAL	240	61	∠ TO FABRIC	20.98	VALID	5.35	5.85
SU-082	334.31	DIAMETRAL	70	61	∠ TO FABRIC	13.72	VALID	3.50	3.82
SU-082	331.05	DIAMETRAL	185	61	∠ TO FABRIC	16.02	INVALID	4.08	4.46
SU-082	328.04	DIAMETRAL	150	62	NA	19.86	VALID	4.90	5.40
SU-082	322.02	DIAMETRAL	155	61	∠ TO FABRIC	22.06	INVALID	5.62	6.15
SU-082	323.08	DIAMETRAL	90	61	∠ TO FABRIC	23.04	VALID	5.87	6.42
SU-082	321.58	DIAMETRAL	90	61	∠ TO FABRIC	10.26	INVALID	2.61	2.86
SU-082	316	DIAMETRAL	105	61	∠ TO FABRIC	18.84	VALID	4.80	5.25
SU-082	315.77	DIAMETRAL	115	61	∠ TO FABRIC	14.42	VALID	3.67	4.02
SU-082	312.8	DIAMETRAL	80	61	∠ TO FABRIC	11.56	INVALID	2.95	3.22
SU-082	303.56	DIAMETRAL	140	61	∠ TO FABRIC	18.42	INVALID	4.69	5.13
SU-082	368.84	DIAMETRAL	185	61	∠ TO FABRIC	11.26	VALID	2.87	3.14
SU-082	364.07	DIAMETRAL	180	61	∠ TO FABRIC	20.5	INVALID	5.22	5.71
SU-082	360.63	DIAMETRAL	165	61	∠ TO FABRIC	22.06	INVALID	5.62	6.15

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-082	357.4	DIAMETRAL	155	61	∠ TO FABRIC	19.1	VALID	4.87	5.32
SU-082	355.7	DIAMETRAL	145	61	∠ TO FABRIC	12.96	INVALID	3.30	3.61
SU-082	350.49	DIAMETRAL	95	61	∠ TO FABRIC	19.34	VALID	4.93	5.39
SU-082	346.56	DIAMETRAL	165	61	∠ TO FABRIC	7.8	INVALID	1.99	2.17
SU-082	343.7	DIAMETRAL	120	61	∠ TO FABRIC	10.74	INVALID	2.74	2.99
SU-082	341.34	DIAMETRAL	130	61	∠ TO FABRIC	14.78	VALID	3.77	4.12
SU-082	340.33	DIAMETRAL	125	61	∠ TO FABRIC	13.82	VALID	3.52	3.85
SU-082	400.08	DIAMETRAL	210	61	∠ TO FABRIC	21.04	INVALID	5.36	5.86
SU-082	399.74	DIAMETRAL	120	61	∠ TO FABRIC	18.76	VALID	4.78	5.23
SU-082	392.28	DIAMETRAL	185	61	∠ TO FABRIC	19.94	VALID	5.08	5.56
SU-082	389.22	DIAMETRAL	125	61	∠ TO FABRIC	24.32	VALID	6.20	6.78
SU-082	386.9	DIAMETRAL	155	61	∠ TO FABRIC	9.6	INVALID	2.45	2.67
SU-082	382.53	DIAMETRAL	210	61	∠ TO FABRIC	13.14	INVALID	3.35	3.66
SU-082	379.13	DIAMETRAL	145	61	∠ TO FABRIC	9.4	INVALID	2.39	2.62
SU-082	376.75	DIAMETRAL	170	61	∠ TO FABRIC	9.86	INVALID	2.51	2.75
SU-082	372.46	DIAMETRAL	235	61	NA	13.8	VALID	3.52	3.84
SU-082	373.57	DIAMETRAL	210	61	∠ TO FABRIC	17.24	VALID	4.39	4.80
SU-082	372	DIAMETRAL	440	61	∠ TO FABRIC	6.1	INVALID	1.55	1.70
SU-082	375.32	DIAMETRAL	200	61	∠ TO FABRIC	8.94	INVALID	2.28	2.49
SU-082	370.07	DIAMETRAL	160	61	∠ TO FABRIC	25.2	VALID	6.42	7.02
SU-082	407.52	DIAMETRAL	160	61	∠ TO FABRIC	17.18	INVALID	4.38	4.79
SU-082	334.92	DIAMETRAL	100	61	∠ TO FABRIC	7.7	VALID	1.96	2.15
SU-082	339.95	DIAMETRAL	70	61	∠ TO FABRIC	8.64	INVALID	2.20	2.41
SU-082	341.47	DIAMETRAL	70	61	∠ TO FABRIC	14.22	INVALID	3.62	3.96
SU-082	343.51	DIAMETRAL	160	61	∠ TO FABRIC	8.32	INVALID	2.12	2.32
SU-082	349.7	DIAMETRAL	80	61	NA	11.44	INVALID	2.91	3.19
SU-082	353	DIAMETRAL	140	61	∠ TO FABRIC	16.66	INVALID	4.24	4.64
SU-082	352.19	DIAMETRAL	70	61	∠ TO FABRIC	16.28	VALID	4.15	4.54
SU-082	359.52	DIAMETRAL	140	61	∠ TO FABRIC	25.9	INVALID	6.60	7.22
SU-082	359.68	DIAMETRAL	120	61	∠ TO FABRIC	12.86	INVALID	3.28	3.58
SU-082	364.26	DIAMETRAL	90	61	∠ TO FABRIC	7.84	INVALID	2.00	2.18
SU-082	422.54	DIAMETRAL	260	61	∠ TO FABRIC	0.78	VALID	0.20	0.22
SU-082	438.58	DIAMETRAL	120	61	∠ TO FABRIC	0.36	VALID	0.09	0.10
SU-082	436.86	DIAMETRAL	120	61	∠ TO FABRIC	1.36	VALID	0.35	0.38
SU-082	430.64	DIAMETRAL	150	61	∠ TO FABRIC	6.94	VALID	1.77	1.93
SU-082	429.14	DIAMETRAL	160	61	∠ TO FABRIC	1.12	INVALID	0.29	0.31
SU-082	429.5	DIAMETRAL	200	61	∠ TO FABRIC	10.52	INVALID	2.68	2.93

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-082	425	DIAMETRAL	160	61	NA	13.02	INVALID	3.32	3.63
SU-082	424.23	DIAMETRAL	260	61	NA	30.42	INVALID	7.75	8.48
SU-082	425.16	DIAMETRAL	240	61	NA	23.3	INVALID	5.94	6.49
SU-082	453.39	DIAMETRAL	200	61	NA	0.62	INVALID	0.16	0.17
SU-082	422.76	DIAMETRAL	190	61	NA	37.28	INVALID	9.50	10.39
SU-082	423.79	DIAMETRAL	130	61	NA	32.64	INVALID	8.32	9.09
SU-082	421.17	DIAMETRAL	110	61	⊥ TO FABRIC	19.18	INVALID	4.89	5.34
SU-082	420.92	DIAMETRAL	210	61	∠ TO FABRIC	20.42	INVALID	5.20	5.69
SU-082	417.74	DIAMETRAL	240	61	∠ TO FABRIC	19.6	VALID	4.99	5.46
SU-082	414.42	DIAMETRAL	190	61	∠ TO FABRIC	11.46	INVALID	2.92	3.19
SU-082	412.03	DIAMETRAL	190	61	∠ TO FABRIC	18.1	INVALID	4.61	5.04
SU-082	452.53	DIAMETRAL	170	61	∠ TO FABRIC	1.96	INVALID	0.50	0.55
SU-082	449.4	DIAMETRAL	270	61	∠ TO FABRIC	1.22	INVALID	0.31	0.34
SU-082	447.33	DIAMETRAL	140	61	∠ TO FABRIC	1.34	INVALID	0.34	0.37
SU-082	446.3	DIAMETRAL	150	61	∠ TO FABRIC	15	INVALID	3.82	4.18
SU-082	445.85	DIAMETRAL	260	61	∠ TO FABRIC	8.9	INVALID	2.27	2.48
SU-082	498.65	DIAMETRAL	210	61	∠ TO FABRIC	25.62	VALID	6.53	7.14
SU-082	495.15	DIAMETRAL	150	61	⊥ TO FABRIC	34.66	INVALID	8.83	9.66
SU-082	494.5	DIAMETRAL	260	61	⊥ TO FABRIC	4.8	INVALID	1.22	1.34
SU-082	490.34	DIAMETRAL	210	61	⊥ TO FABRIC	17.52	VALID	4.46	4.88
SU-082	487.34	DIAMETRAL	230	61	NA	23.92	INVALID	6.09	6.66
SU-082	488.77	DIAMETRAL	200	61	⊥ TO FABRIC	16.6	INVALID	4.23	4.63
SU-082	486.95	DIAMETRAL	270	61	NA	30.86	VALID	7.86	8.60
SU-082	485.7	DIAMETRAL	190	61	∠ TO FABRIC	29.52	INVALID	7.52	8.22
SU-082	484.16	DIAMETRAL	150	61	NA	31.22	INVALID	7.95	8.70
SU-082	480.03	DIAMETRAL	270	61	NA	8.5	INVALID	2.17	2.37
SU-082	481.46	DIAMETRAL	180	61	NA	8.76	INVALID	2.23	2.44
SU-082	478.87	DIAMETRAL	230	61	∠ TO FABRIC	6.64	INVALID	1.69	1.85
SU-082	477.11	DIAMETRAL	260	61	∠ TO FABRIC	22.7	INVALID	5.78	6.32
SU-082	478.6	DIAMETRAL	150	61	NA	22.3	INVALID	5.68	6.21
SU-082	474.86	DIAMETRAL	180	61	NA	46.76	INVALID	11.91	13.03
SU-082	474.67	DIAMETRAL	150	61	NA	18.5	INVALID	4.71	5.15
SU-082	471.54	DIAMETRAL	180	61	∠ TO FABRIC	8.2	INVALID	2.09	2.28
SU-082	473.14	DIAMETRAL	200	61	NA	16.36	INVALID	4.17	4.56
SU-082	469.39	DIAMETRAL	210	61	NA	29.8	VALID	7.59	8.30
SU-082	465.43	DIAMETRAL	250	61	∠ TO FABRIC	9.36	INVALID	2.38	2.61
SU-082	467.01	DIAMETRAL	300	61	∠ TO FABRIC	14.1	INVALID	3.59	3.93

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-082	464.38	DIAMETRAL	190	61	∠ TO FABRIC	9.42	INVALID	2.40	2.62
SU-082	463.47	DIAMETRAL	230	61	NA	4.1	INVALID	1.04	1.14
SU-082	462.14	DIAMETRAL	260	61	NA	3.96	INVALID	1.01	1.10
SU-082	501.45	DIAMETRAL	160	61	NA	27.26	INVALID	6.95	7.60
SU-082	499.84	DIAMETRAL	210	61	NA	29.46	INVALID	7.51	8.21
SU-082	503.04	DIAMETRAL	150	61	NA	14.7	INVALID	3.75	4.10
SU-082	503.25	DIAMETRAL	120	61	NA	14	INVALID	3.57	3.90
SU-082	508.17	DIAMETRAL	120	61	NA	13.94	INVALID	3.55	3.88
SU-082	508.65	DIAMETRAL	140	61	NA	18.68	INVALID	4.76	5.20
SU-082	509.98	DIAMETRAL	230	61	NA	20.8	INVALID	5.30	5.80
SU-082	511.26	DIAMETRAL	230	61	NA	11.78	INVALID	3.00	3.28
SU-082	513.24	DIAMETRAL	250	61	NA	16.18	INVALID	4.12	4.51
SU-082	514.13	DIAMETRAL	165	61	NA	13.98	INVALID	3.56	3.90
SU-082	517.09	DIAMETRAL	130	61	NA	14.1	INVALID	3.59	3.93
SU-088	2.15	DIAMETRAL	130	61	NA	14.1	INVALID	3.59	3.93
SU-088	2.35	DIAMETRAL	200	61	NA	10.78	INVALID	2.75	3.00
SU-088	3.53	DIAMETRAL	185	61	NA	6.12	INVALID	1.56	1.71
SU-088	4.45	DIAMETRAL	230	61	NA	8.24	INVALID	2.10	2.30
SU-088	5.33	DIAMETRAL	190	61	NA	10.7	INVALID	2.73	2.98
SU-088	7.18	DIAMETRAL	110	61	NA	8.72	INVALID	2.22	2.43
SU-088	7.7	DIAMETRAL	210	61	NA	11.44	INVALID	2.91	3.19
SU-088	10.94	DIAMETRAL	180	61	NA	19.16	VALID	4.88	5.34
SU-088	11.14	DIAMETRAL	140	61	NA	21.28	INVALID	5.42	5.93
SU-088	12.52	DIAMETRAL	150	61	NA	9.44	INVALID	2.41	2.63
SU-088	12.67	DIAMETRAL	130	61	NA	6.4	INVALID	1.63	1.78
SU-088	15.37	DIAMETRAL	310	61	NA	15.22	INVALID	3.88	4.24
SU-088	15.68	DIAMETRAL	120	61	NA	15.12	INVALID	3.85	4.21
SU-088	17.37	DIAMETRAL	135	61	NA	13.36	INVALID	3.40	3.72
SU-088	21.79	DIAMETRAL	210	61	NA	14.96	INVALID	3.81	4.17
SU-088	23.47	DIAMETRAL	200	61	NA	17.09	INVALID	4.35	4.76
SU-088	25.76	DIAMETRAL	170	61	NA	21.06	INVALID	5.37	5.87
SU-088	27.11	DIAMETRAL	220	61	NA	12.26	INVALID	3.12	3.42
SU-088	28.62	DIAMETRAL	280	61	NA	15.96	INVALID	4.07	4.45
SU-088	29.12	DIAMETRAL	220	61	∠ TO FABRIC	16.62	INVALID	4.23	4.63
SU-088	29.35	DIAMETRAL	230	61	NA	15.04	INVALID	3.83	4.19
SU-088	32.61	DIAMETRAL	150	61	NA	24.08	VALID	6.13	6.71
SU-088	34.38	DIAMETRAL	210	61	NA	14.2	VALID	3.62	3.96

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	36.29	DIAMETRAL	130	61	NA	16.67	INVALID	4.25	4.64
SU-088	36.43	DIAMETRAL	160	61	NA	21.92	INVALID	5.58	6.11
SU-088	37.5	DIAMETRAL	200	61	NA	13.92	INVALID	3.55	3.88
SU-088	37.7	DIAMETRAL	210	61	NA	11.08	INVALID	2.82	3.09
SU-088	38.17	DIAMETRAL	200	61	NA	17.56	INVALID	4.47	4.89
SU-088	38.82	DIAMETRAL	130	61	NA	18.76	VALID	4.78	5.23
SU-088	38.96	DIAMETRAL	230	61	NA	20.74	INVALID	5.28	5.78
SU-088	39.2	DIAMETRAL	150	61	NA	24.94	INVALID	6.35	6.95
SU-088	39.37	DIAMETRAL	180	61	NA		INVALID	0.00	0.00
SU-088	39.57	DIAMETRAL	160	61	NA	20.16	INVALID	5.14	5.62
SU-088	39.73	DIAMETRAL	200	61	NA	20.78	INVALID	5.29	5.79
SU-088	40.27	DIAMETRAL	120	61	NA	17.54	VALID	4.47	4.89
SU-088	40.39	DIAMETRAL	160	61	NA	11.7	INVALID	2.98	3.26
SU-088	40.65	DIAMETRAL	150	61	NA	18.82	INVALID	4.79	5.24
SU-088	40.79	DIAMETRAL	190	61	NA	16.1	INVALID	4.10	4.49
SU-088	43.45	DIAMETRAL	225	61	∠ TO FABRIC	21.88	VALID	5.57	6.10
SU-088	43.45	DIAMETRAL	225	61	∠ TO FABRIC	21.88	VALID	5.57	6.10
SU-088	44.34	DIAMETRAL	120	61	∠ TO FABRIC	21.88	INVALID	5.57	6.10
SU-088	44.34	DIAMETRAL	120	61	∠ TO FABRIC	21.88	INVALID	5.57	6.10
SU-088	44.81	DIAMETRAL	190	61	∠ TO FABRIC	21.88	INVALID	5.57	6.10
SU-088	44.81	DIAMETRAL	190	61	∠ TO FABRIC	21.88	INVALID	5.57	6.10
SU-088	45.2	DIAMETRAL	125	61	NA	11.88	INVALID	3.03	3.31
SU-088	45.2	DIAMETRAL	125	61	NA	11.88	INVALID	3.03	3.31
SU-088	45.31	DIAMETRAL	245	61	NA	17.44	INVALID	4.44	4.86
SU-088	47.24	IRREGULAR LUMP	110	33	NA	21.98	VALID	15.03	13.16
SU-088	47.24	IRREGULAR LUMP	110	33	NA	21.98	VALID	15.03	13.16
SU-088	47.26	DIAMETRAL	170	61	NA	25.14	INVALID	6.40	7.00
SU-088	47.26	DIAMETRAL	170	61	NA	25.14	INVALID	6.40	7.00
SU-088	47.85	IRREGULAR LUMP	135	36	NA	21.92	VALID	12.59	11.47
SU-088	47.85	IRREGULAR LUMP	135	36	NA	21.92	VALID	12.59	11.47
SU-088	48.04	DIAMETRAL	165	61	∠ TO FABRIC	18.16	INVALID	4.63	5.06
SU-088	48.04	DIAMETRAL	165	61	∠ TO FABRIC	18.165	INVALID	4.63	5.06
SU-088	48.5	IRREGULAR LUMP	100	36	NA	19.04	VALID	10.94	9.96
SU-088	48.5	IRREGULAR LUMP	100	36	NA	19.04	INVALID	10.94	9.96
SU-088	49.35	DIAMETRAL	155	61	NA	23.67	INVALID	6.03	6.59
SU-088	49.5	DIAMETRAL	230	61	NA	18.78	INVALID	4.78	5.23
SU-088	49.72	DIAMETRAL	155	61	NA	14.32	INVALID	3.65	3.99

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	50.75	DIAMETRAL	150	61	NA	12.88	INVALID	3.28	3.59
SU-088	50.9	IRREGULAR LUMP	100	30	NA	13.58	VALID	11.23	9.43
SU-088	50.9	IRREGULAR LUMP	100	30	NA	13.58	VALID	11.23	9.43
SU-088	51.76	IRREGULAR LUMP	100	37	NA	17.86	VALID	9.71	8.96
SU-088	51.76	IRREGULAR LUMP	100	37	NA	17.86	VALID	9.71	8.96
SU-088	52.57	DIAMETRAL	175	61	NA		INVALID	0.00	0.00
SU-088	53.52	DIAMETRAL	175	61	NA	11.6	INVALID	2.96	3.23
SU-088	55.95	DIAMETRAL	170	61	NA	16.64	INVALID	4.24	4.64
SU-088	56.36	IRREGULAR LUMP	110	37	NA	26.22	VALID	14.26	13.15
SU-088	56.36	IRREGULAR LUMP	110	37	NA	26.22	VALID	14.26	13.15
SU-088	56.5	IRREGULAR LUMP	120	37	NA	17.42	INVALID	9.47	8.74
SU-088	56.56	IRREGULAR LUMP	120	37	NA	17.42	INVALID	9.47	8.74
SU-088	57	DIAMETRAL	155	61	NA	22	INVALID	5.60	6.13
SU-088	57.92	DIAMETRAL	120	61	NA	18.6	INVALID	4.74	5.18
SU-088	58.26	IRREGULAR LUMP	100	37	NA	33.88	VALID	18.43	16.99
SU-088	58.96	IRREGULAR LUMP	100	37	NA	33.88	VALID	18.43	16.99
SU-088	59.51	IRREGULAR LUMP	86	35	NA	20.92	INVALID	12.72	11.43
SU-088	59.51	IRREGULAR LUMP	86	35	NA	20.92	INVALID	12.72	11.43
SU-088	60.04	DIAMETRAL	120	61	NA	19.84	INVALID	5.05	5.53
SU-088	60.9	IRREGULAR LUMP	140	34	NA	17.9	INVALID	11.53	10.23
SU-088	60.9	IRREGULAR LUMP	140	34	NA	17.9	INVALID	11.53	10.23
SU-088	61.04	DIAMETRAL	130	61	NA	22.28	INVALID	5.68	6.21
SU-088	61.13	IRREGULAR LUMP	140	35	NA	23.52	VALID	14.30	12.86
SU-088	61.13	IRREGULAR LUMP	140	35	NA	23.52	VALID	14.30	12.86
SU-088	61.55	DIAMETRAL	125	61	NA	15.34	INVALID	3.91	4.27
SU-088	62.16	DIAMETRAL	180	61	NA	12.39	INVALID	3.16	3.45
SU-088	63.05	DIAMETRAL	130	61	NA	18.58	INVALID	4.73	5.18
SU-088	63.39	DIAMETRAL	165	61	NA	23.64	INVALID	6.02	6.59
SU-088	63.51	IRREGULAR LUMP	110	30	NA	22.9	VALID	18.94	15.90
SU-088	63.51	IRREGULAR LUMP	110	30	NA	22.9	VALID	18.94	15.90
SU-088	64.17	DIAMETRAL	200	61	NA	17.94	INVALID	4.57	5.00
SU-088	65	DIAMETRAL	130	61	NA	17.94	INVALID	4.57	5.00
SU-088	65.94	IRREGULAR LUMP	100	32	NA	13.96	VALID	10.15	8.77
SU-088	65.94	IRREGULAR LUMP	100	32	NA	13.96	VALID	10.15	8.77
SU-088	66.04	IRREGULAR LUMP	100		NA		INVALID		
SU-088	66.04	IRREGULAR LUMP	100		NA		INVALID		
SU-088	66.48	DIAMETRAL	140	61	NA	17.94	INVALID	4.57	5.00

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	67.21	DIAMETRAL	190	61	NA	18.52	INVALID	4.72	5.16
SU-088	68.15	IRREGULAR LUMP	95	30	NA	23.8	VALID	19.69	16.52
SU-088	68.15	IRREGULAR LUMP	95	30	NA	23.8	VALID	19.69	16.52
SU-088	68.25	IRREGULAR LUMP	100	31	NA	23.78	VALID	18.42	15.69
SU-088	68.25	IRREGULAR LUMP	100	31	NA	23.78	VALID	18.42	15.69
SU-088	69.05	DIAMETRAL	140	61	NA	16.98	INVALID	4.33	4.73
SU-088	70.1	IRREGULAR LUMP	110	36	NA	21.26	VALID	12.21	11.12
SU-088	70.1	IRREGULAR LUMP	110	36	NA	21.26	VALID	12.21	11.12
SU-088	71.16	DIAMETRAL	140	61	NA	20.28	VALID	5.17	5.65
SU-088	71.6	IRREGULAR LUMP	110	38	NA	21.78	VALID	11.23	10.48
SU-088	71.6	IRREGULAR LUMP	110	38	NA	21.78	VALID	11.23	10.48
SU-088	72.24	DIAMETRAL	120	61	NA	19.22	VALID	4.90	5.36
SU-088	72.7	DIAMETRAL	130	61	NA	11.64	INVALID	2.97	3.24
SU-088	72.83	DIAMETRAL	210	61	NA	21.6	INVALID	5.50	6.02
SU-088	73.04	DIAMETRAL	145	61	NA	18.5	INVALID	4.71	5.15
SU-088	73.18	DIAMETRAL	125	61	NA	14.34	INVALID	3.65	4.00
SU-088	73.81	DIAMETRAL	160	61	NA	19.82	INVALID	5.05	5.52
SU-088	74.48	DIAMETRAL	175	61	NA	31.04	INVALID	7.91	8.65
SU-088	75.04	DIAMETRAL	180	61	NA	29.12	INVALID	7.42	8.11
SU-088	75.28	DIAMETRAL	160	61	NA	29.68	INVALID	7.56	8.27
SU-088	75.42	DIAMETRAL	160	61	NA	24.2	INVALID	6.17	6.74
SU-088	75.64	IRREGULAR LUMP	90	38	NA		INVALID		
SU-088	75.64	IRREGULAR LUMP	90	38	NA		INVALID	0.00	0.00
SU-088	76.37	DIAMETRAL	180	61	NA	21.28	VALID	5.42	5.93
SU-088	76.54	IRREGULAR LUMP	100	34	NA	22.14	INVALID	14.26	12.66
SU-088	78.33	DIAMETRAL	235	61	NA	25.34	VALID	6.46	7.06
SU-088	78.33	DIAMETRAL	235	61	NA	25.34	VALID	6.46	7.06
SU-088	79.6	IRREGULAR LUMP	85	45	NA	24.76	INVALID	9.10	9.17
SU-088	81.12	DIAMETRAL	190	61	NA	20.16	VALID	5.14	5.62
SU-088	81.12	DIAMETRAL	190	61	NA	20.16	VALID	5.14	5.62
SU-088	81.38	IRREGULAR LUMP	90	30	NA	13.26	INVALID	10.97	9.20
SU-088	82.63	IRREGULAR LUMP	95	34	NA	27.8	VALID	17.91	15.89
SU-088	84.1	DIAMETRAL	160	61	NA	18.6	INVALID	4.74	5.18
SU-088	84.1	DIAMETRAL	160	61	NA	18.6	INVALID	4.74	5.18
SU-088	84.43	IRREGULAR LUMP	110	42	NA	17.8	INVALID	7.51	7.33
SU-088	84.43	IRREGULAR LUMP	110	42	NA	17.8	INVALID	7.51	7.33
SU-088	85.5	DIAMETRAL	190	61	NA	24.08	INVALID	6.13	6.71

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	85.5	DIAMETRAL	190	61	NA	24.08	INVALID	6.13	6.71
SU-088	85.78	DIAMETRAL	160	61	NA	14.7	INVALID	3.75	4.10
SU-088	85.78	DIAMETRAL	160	61	NA	14.7	INVALID	3.75	4.10
SU-088	87.17	DIAMETRAL	180	61	NA	23.6	INVALID	6.01	6.58
SU-088	87.17	DIAMETRAL	180	61	NA	23.6	INVALID	6.01	6.58
SU-088	87.48	IRREGULAR LUMP	95	30	NA	14.24	VALID	11.78	9.88
SU-088	87.48	IRREGULAR LUMP	95	30	NA	14.24	VALID	11.78	9.88
SU-088	89.14	DIAMETRAL	180	61	NA	13.02	INVALID	3.32	3.63
SU-088	89.14	DIAMETRAL	180	61	NA	13.02	INVALID	3.32	3.63
SU-088	89.45	DIAMETRAL	130	61	NA	25.32	INVALID	6.45	7.05
SU-088	90.32	IRREGULAR LUMP	95	39	NA	14.78	VALID	7.24	6.83
SU-088	90.52	IRREGULAR LUMP	95	39	NA	14.78	VALID	7.24	6.83
SU-088	90.79	DIAMETRAL	210	61	NA	16.62	INVALID	4.23	4.63
SU-088	90.79	DIAMETRAL	210	61	NA	16.62	INVALID	4.23	4.63
SU-088	91.56	DIAMETRAL	150	61	NA	31.94	INVALID	8.14	8.90
SU-088	91.56	DIAMETRAL	150	61	NA	31.94	INVALID	8.14	8.90
SU-088	93.57	DIAMETRAL	230	61	NA	27.52	INVALID	7.01	7.67
SU-088	93.57	IRREGULAR LUMP	105	41	NA	26.14	VALID	11.58	11.18
SU-088	93.57	DIAMETRAL	230	61	NA	27.52	INVALID	7.01	7.67
SU-088	93.57	IRREGULAR LUMP	105	41	NA	26.14	VALID	11.58	11.18
SU-088	94.07	DIAMETRAL	190	61	NA	9.74	INVALID	2.48	2.71
SU-088	94.07	DIAMETRAL	190	61	NA	9.74	INVALID	2.48	2.71
SU-088	96.07	DIAMETRAL	150	61	NA	28.24	INVALID	7.19	7.87
SU-088	96.07	DIAMETRAL	150	61	NA	28.24	INVALID	7.19	7.87
SU-088	96.27	IRREGULAR LUMP	70	34	NA	14.2	VALID	9.15	8.12
SU-088	96.62	DIAMETRAL	175	61	NA	19.52	INVALID	4.97	5.44
SU-088	96.62	DIAMETRAL	175	61	NA	19.52	INVALID	4.97	5.44
SU-088	97.23	IRREGULAR LUMP	60	61	NA	13.62	INVALID	2.73	3.15
SU-088	97.23	IRREGULAR LUMP	60	61	NA	13.62	INVALID	2.73	3.15
SU-088	99.45	DIAMETRAL	130	61	NA	25.32	INVALID	6.45	7.05
SU-088	99.56	DIAMETRAL	135	61	NA	25.32	INVALID	6.45	7.05
SU-088	99.56	DIAMETRAL	135	61	NA	25.32	INVALID	6.45	7.05
SU-088	100.15	IRREGULAR LUMP	90	30	NA	20.1	VALID	16.63	13.95
SU-088	100.47	IRREGULAR LUMP	65	61	NA	25.32	VALID	5.07	5.85
SU-088	100.47	IRREGULAR LUMP	65	61	NA	25.32	INVALID	5.07	5.85
SU-088	101.71	DIAMETRAL	125	61	NA	20.47	INVALID	5.22	5.70
SU-088	101.71	DIAMETRAL	125	61	NA	20.47	INVALID	5.22	5.70

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	101.86	IRREGULAR LUMP	90	30	NA	22.52	VALID	18.63	15.63
SU-088	102.6	DIAMETRAL	130	61	NA	29.36	INVALID	7.48	8.18
SU-088	102.6	DIAMETRAL	130	61	NA	29.36	INVALID	7.48	8.18
SU-088	103.96	IRREGULAR LUMP	55	61	NA	15.2	INVALID	3.04	3.51
SU-088	103.96	IRREGULAR LUMP	55	61	NA	15.2	INVALID	3.04	3.51
SU-088	105.58	DIAMETRAL	125	61	NA	5.8	INVALID	1.48	1.62
SU-088	105.58	DIAMETRAL	125	61	NA	5.8	INVALID	1.48	1.62
SU-088	105.7	DIAMETRAL	75	61	NA	5.82	INVALID	1.48	1.62
SU-088	105.7	IRREGULAR LUMP	75	61	NA	5.82	INVALID	1.16	1.34
SU-088	105.94	IRREGULAR LUMP	70	35	NA	11.64	INVALID	7.07	6.36
SU-088	106.15	IRREGULAR LUMP	90	31	NA	15.52	INVALID	12.02	10.24
SU-088	107.36	DIAMETRAL	130	61	NA	26.58	INVALID	6.77	7.41
SU-088	107.36	DIAMETRAL	130	61	NA	26.58	INVALID	6.77	7.41
SU-088	108.76	IRREGULAR LUMP	90	34	NA	21.14	VALID	13.62	12.09
SU-088	110.92	IRREGULAR LUMP	85	61	NA	18.86	INVALID	3.77	4.36
SU-088	110.93	DIAMETRAL	85	61	NA	18.86	INVALID	4.80	5.25
SU-088	111.03	DIAMETRAL	120	61	NA	26.2	INVALID	6.67	7.30
SU-088	111.03	DIAMETRAL	120	61	NA	26.2	INVALID	6.67	7.30
SU-088	111.74	DIAMETRAL	120	61	∠ TO FABRIC	24.44	INVALID	6.23	6.81
SU-088	111.74	DIAMETRAL	120	61	∠ TO FABRIC	24.44	INVALID	6.23	6.81
SU-088	113.52	DIAMETRAL	160	61	∠ TO FABRIC	10.68	INVALID	2.72	2.98
SU-088	113.52	DIAMETRAL	160	37	∠ TO FABRIC	10.68	INVALID	7.40	6.46
SU-088	114.27	DIAMETRAL	170	61	NA	24.72	INVALID	6.30	6.89
SU-088	114.27	DIAMETRAL	170	61	NA	27.72	INVALID	7.06	7.72
SU-088	115.6	DIAMETRAL	150	61	NA	28.94	VALID	7.37	8.06
SU-088	115.6	DIAMETRAL	150	61	NA	28.94	VALID	7.37	8.06
SU-088	116.11	IRREGULAR LUMP	105	31	NA	14.46	VALID	11.20	9.54
SU-088	116.11	IRREGULAR LUMP	105	31	NA	14.46	VALID	11.20	9.54
SU-088	118.95	DIAMETRAL	140	61	NA	16.84	VALID	4.29	4.69
SU-088	118.95	DIAMETRAL	140	61	NA	16.84	VALID	4.29	4.69
SU-088	120.19	IRREGULAR LUMP	115	37	NA	18.66	VALID	10.15	9.36
SU-088	120.19	IRREGULAR LUMP	115	37	NA	18.66	VALID	10.15	9.36
SU-088	123.12	DIAMETRAL	240	61	NA	10.44	INVALID	2.66	2.91
SU-088	123.12	DIAMETRAL	240	61	NA	10.44	INVALID	2.66	2.91
SU-088	123.89	DIAMETRAL	270	61	NA	14.76	INVALID	3.76	4.11
SU-088	123.89	DIAMETRAL	270	61	NA	14.76	INVALID	3.76	4.11
SU-088	124.05	DIAMETRAL	260	61	NA	19.88	INVALID	5.06	5.54

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	124.05	DIAMETRAL	260	61	NA	19.88	INVALID	5.06	5.54
SU-088	124.45	IRREGULAR LUMP	90	35	NA	12.42	VALID	7.55	6.79
SU-088	124.45	IRREGULAR LUMP	90	35	NA	12.42	VALID	7.55	6.79
SU-088	125.14	IRREGULAR LUMP	100	35	NA	19.62	VALID	11.93	10.72
SU-088	125.14	IRREGULAR LUMP	100	35	NA	19.62	VALID	11.93	10.72
SU-088	125.45	DIAMETRAL	270	61	NA	38.84	INVALID	9.90	10.82
SU-088	125.45	DIAMETRAL	270	61	NA	38.84	INVALID	9.90	10.82
SU-088	126.84	DIAMETRAL	220	61	NA	15.68	INVALID	3.99	4.37
SU-088	126.84	DIAMETRAL	220	61	NA	15.68	INVALID	3.99	4.37
SU-088	128.01	IRREGULAR LUMP	100	37	NA	21.04	VALID	11.44	10.55
SU-088	128.01	IRREGULAR LUMP	100	37	NA	21.04	VALID	11.44	10.55
SU-088	130.04	DIAMETRAL	120	61	NA	30.62	VALID	7.80	8.53
SU-088	130.04	DIAMETRAL	120	61	NA	30.62	VALID	7.80	8.53
SU-088	130.95	DIAMETRAL	140	61	NA	19.16	INVALID	4.88	5.34
SU-088	130.95	DIAMETRAL	140	61	NA	19.16	INVALID	4.88	5.34
SU-088	133.2	IRREGULAR LUMP	85	35	NA	16.78	VALID	10.20	9.17
SU-088	133.3	IRREGULAR LUMP	85	35	NA	16.78	VALID	10.20	9.17
SU-088	133.53	DIAMETRAL	205	61	NA	26.22	INVALID	6.68	7.31
SU-088	133.53	DIAMETRAL	205	61	NA	26.22	INVALID	6.68	7.31
SU-088	133.85	DIAMETRAL	150	61	NA	19.36	INVALID	4.93	5.39
SU-088	133.85	DIAMETRAL	150	61	NA	19.36	INVALID	4.93	5.39
SU-088	134.1	IRREGULAR LUMP	155	32	NA	19.08	INVALID	13.87	11.98
SU-088	134.1	IRREGULAR LUMP	155	32	NA	19.08	INVALID	13.87	11.98
SU-088	135.3	DIAMETRAL	135	61	NA	24.16	INVALID	6.16	6.73
SU-088	135.3	DIAMETRAL	135	61	NA	24.16	INVALID	6.16	6.73
SU-088	138.4	IRREGULAR LUMP	100	29	NA	19.1	VALID	16.91	13.97
SU-088	138.4	IRREGULAR LUMP	100	29	NA	19.1	VALID	16.91	13.97
SU-088	140.14	IRREGULAR LUMP	100	33	NA	19.56	VALID	13.37	11.71
SU-088	140.14	IRREGULAR LUMP	100	33	NA	19.56	VALID	13.37	11.71
SU-088	140.15	DIAMETRAL	190	61	NA	22.82	VALID	5.81	6.36
SU-088	140.15	DIAMETRAL	190	61	NA	22.82	VALID	5.81	6.36
SU-088	141.62	IRREGULAR LUMP	100	33	NA	0.282608696	VALID	0.19	0.17
SU-088	141.62	IRREGULAR LUMP	100	33	NA	13.46	VALID	9.20	8.06
SU-088	142.34	DIAMETRAL	155	61	NA	23.94	VALID	6.10	6.67
SU-088	142.34	DIAMETRAL	15	61	NA	23.94	VALID	6.10	6.67
SU-088	145.39	IRREGULAR LUMP	110	35	NA	22.58	VALID	13.72	12.34
SU-088	146.2	DIAMETRAL	140	61	NA	25.24	VALID	6.43	7.03

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	146.2	DIAMETRAL	140	61	NA	25.24	VALID	6.43	7.03
SU-088	147.39	DIAMETRAL	200	61	NA	26.52	VALID	6.76	7.39
SU-088	147.39	DIAMETRAL	200	61	NA	26.52	VALID	6.76	7.39
SU-088	147.7	DIAMETRAL	150	61	NA	21.5	VALID	5.48	5.99
SU-088	147.7	DIAMETRAL	150	61	NA	21.5	VALID	5.48	5.99
SU-088	148.44	IRREGULAR LUMP	95	39	NA	18.66	VALID	9.13	8.62
SU-088	151.48	IRREGULAR LUMP	105	33	∠ TO FABRIC	13.96	VALID	9.54	8.36
SU-088	151.92	DIAMETRAL	150	61	NA	19.1	VALID	4.87	5.32
SU-088	151.92	DIAMETRAL	150	61	NA	19.1	VALID	4.87	5.32
SU-088	153.47	IRREGULAR LUMP	185	38	NA	21.82	INVALID	11.25	10.50
SU-088	154.32	DIAMETRAL	115	61	NA	22.64	VALID	5.77	6.31
SU-088	154.32	DIAMETRAL	115	61	NA	22.64	INVALID	5.77	6.31
SU-088	154.46	IRREGULAR LUMP	75	67	NA	13.26	VALID	2.20	2.65
SU-088	154.46	IRREGULAR LUMP	75	67	NA	13.26	INVALID	2.20	2.65
SU-088	156.12	IRREGULAR LUMP	120	27	NA		INVALID	0.00	0.00
SU-088	156.24	DIAMETRAL	225	61	∠ TO FABRIC	19.48	VALID	4.96	5.43
SU-088	156.24	DIAMETRAL	225	61	∠ TO FABRIC	19.48	INVALID	4.96	5.43
SU-088	157.32	DIAMETRAL	140	61	∠ TO FABRIC	14.86	VALID	3.79	4.14
SU-088	157.32	DIAMETRAL	140	61	∠ TO FABRIC	14.86	INVALID	3.79	4.14
SU-088	157.54	IRREGULAR LUMP	110	38	NA	16.44	VALID	8.48	7.91
SU-088	158.17	IRREGULAR LUMP	65	49	NA	11.48	VALID	3.56	3.72
SU-088	158.17	IRREGULAR LUMP	65	49	NA	11.48	INVALID	3.56	3.72
SU-088	160.41	DIAMETRAL	120	61	∠ TO FABRIC	16.14	VALID	4.11	4.50
SU-088	160.41	DIAMETRAL	120	61	∠ TO FABRIC	16.14	INVALID	4.11	4.50
SU-088	160.63	IRREGULAR LUMP	95	38	NA	21.24	VALID	10.95	10.22
SU-088	161.95	IRREGULAR LUMP	110	39	NA	7.36	INVALID	3.60	3.40
SU-088	162.36	DIAMETRAL	160	61	NA		INVALID	0.00	0.00
SU-088	162.36	DIAMETRAL	160	61	NA		INVALID	0.00	0.00
SU-088	162.55	IRREGULAR LUMP	100	40	NA	22.52	VALID	10.48	10.01
SU-088	162.65	IRREGULAR LUMP	110	37	NA	11.74	INVALID	6.39	5.89
SU-088	166.09	IRREGULAR LUMP	100	34	NA	11.74	INVALID	7.56	6.71
SU-088	166.72	IRREGULAR LUMP	105	30	NA	15.22	INVALID	12.59	10.56
SU-088	169.28	IRREGULAR LUMP	85	40	NA	17.54	INVALID	8.16	7.79
SU-088	175.01	IRREGULAR LUMP	90	36	NA	23.4	INVALID	13.44	12.24
SU-088	175.87	IRREGULAR LUMP	90	35	NA	18.76	VALID	11.40	10.25
SU-088	178.92	IRREGULAR LUMP	95	34	NA	17.6	VALID	11.34	10.06
SU-088	181.48	DIAMETRAL	135	61	NA	13.12	INVALID	3.34	3.66

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	181.48	DIAMETRAL	135	61	NA	13.12	INVALID	3.34	3.66
SU-088	181.81	IRREGULAR LUMP	95	33	NA	18.64	VALID	12.74	11.16
SU-088	188.06	IRREGULAR LUMP	110	33	NA	14.16	VALID	9.68	8.48
SU-088	188.36	IRREGULAR LUMP	105	40	NA	19.66	INVALID	9.15	8.74
SU-088	191.57	IRREGULAR LUMP	80	37	NA	14.74	VALID	8.02	7.39
SU-088	197.08	DIAMETRAL	130	61	NA	17.1	INVALID	4.36	4.76
SU-088	197.08	DIAMETRAL	130	61	NA	17.1	INVALID	4.36	4.76
SU-088	197.21	IRREGULAR LUMP	95	33	NA	17.28	VALID	11.81	10.35
SU-088	198.14	DIAMETRAL	170	61	NA	24.6	VALID	6.27	6.85
SU-088	198.14	DIAMETRAL	170	61	NA	24.6	VALID	6.27	6.85
SU-088	199.05	IRREGULAR LUMP	90	33	NA	17.56	VALID	12.01	10.51
SU-088	202.75	IRREGULAR LUMP	80	33	NA	14.9	VALID	10.19	8.92
SU-088	204.62	DIAMETRAL	170	61	NA	11.7	INVALID	2.98	3.26
SU-088	204.62	DIAMETRAL	170	61	NA	11.7	INVALID	2.98	3.26
SU-088	204.81	DIAMETRAL	160	61	NA	18.86	INVALID		
SU-088	204.81	DIAMETRAL	160	61	NA	18.86	INVALID	4.80	5.25
SU-088	206.35	IRREGULAR LUMP	85	31	NA	15.18	VALID	11.76	10.01
SU-088	208.84	IRREGULAR LUMP	80	38	NA	13.26	INVALID	6.84	6.38
SU-088	209.48	DIAMETRAL	180	61	NA	20.78	VALID	5.29	5.79
SU-088	209.48	DIAMETRAL	180	61	NA	20.78	VALID	5.29	5.79
SU-088	210.67	DIAMETRAL	165	61	NA	13.3	VALID	3.39	3.71
SU-088	210.67	DIAMETRAL	165	61	NA	13.3	VALID	3.39	3.71
SU-088	211.18	DIAMETRAL	170	61	NA	20.34	VALID	5.18	5.67
SU-088	211.18	DIAMETRAL	170	61	NA	20.34	VALID	5.18	5.67
SU-088	212.33	DIAMETRAL	120	61	NA	11.8	VALID	3.01	3.29
SU-088	212.33	DIAMETRAL	120	61	NA	11.8	VALID	3.01	3.29
SU-088	213.31	IRREGULAR LUMP	115	40	NA	11.54	INVALID	5.37	5.13
SU-088	215.49	IRREGULAR LUMP	95	31	NA	17	VALID	13.17	11.22
SU-088	215.54	DIAMETRAL	150	61	NA	24.82	VALID	6.32	6.92
SU-088	215.54	DIAMETRAL	150	61	NA	24.82	VALID	6.32	6.92
SU-088	217.96	IRREGULAR LUMP	100	31	NA	10.9	VALID	8.45	7.19
SU-088	220.08	DIAMETRAL	190	61	NA	27.02	VALID	6.88	7.53
SU-088	220.08	DIAMETRAL	190	61	NA	27.02	VALID	6.88	7.53
SU-088	223.14	DIAMETRAL	115	61	NA	12.62	VALID	3.22	3.52
SU-088	223.14	DIAMETRAL	115	61	NA	12.62	VALID	3.22	3.52
SU-088	224.26	IRREGULAR LUMP	90	33	NA	21.12	VALID	14.44	12.65
SU-088	230.6	DIAMETRAL	130	61	NA	30.38	VALID	7.74	8.46

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	230.73	DIAMETRAL	140	61	NA	29.34	VALID	7.47	8.17
SU-088	239.19	DIAMETRAL	145	61	NA	17.32	VALID	4.41	4.83
SU-088	239.99	DIAMETRAL	170	61	∠ TO FABRIC	13	INVALID	3.31	3.62
SU-088	240.25	DIAMETRAL	180	61	∠ TO FABRIC	33.12	VALID	8.44	9.23
SU-088	241.24	DIAMETRAL	120	61	∠ TO FABRIC	5.12	INVALID	1.30	1.43
SU-088	243.38	DIAMETRAL	130	61	∠ TO FABRIC	25.38	INVALID	6.47	7.07
SU-088	243.51	DIAMETRAL	125	61	∠ TO FABRIC	24.34	INVALID	6.20	6.78
SU-088	245.35	DIAMETRAL	200	61	∠ TO FABRIC	24.02	INVALID	6.12	6.69
SU-088	251.35	DIAMETRAL	125	61	NA	24.34	VALID	6.20	6.78
SU-088	252.07	DIAMETRAL	165	61	NA	27.04	INVALID	6.89	7.53
SU-088	252.49	DIAMETRAL	160	61	NA	12.62	INVALID	3.22	3.52
SU-088	254.41	DIAMETRAL	120	61	NA	12.62	INVALID	3.22	3.52
SU-088	254.98	DIAMETRAL	135	61	NA	11.78	INVALID	3.00	3.28
SU-088	255.27	DIAMETRAL	170	61	NA	5.92	INVALID	1.51	1.65
SU-088	259.35	DIAMETRAL	165	61	NA	5.02	INVALID	1.28	1.40
SU-088	259.68	IRREGULAR LUMP	90	34	NA	13.8	VALID	8.89	7.89
SU-088	260.51	DIAMETRAL	165	61	NA	9.74	INVALID	2.48	2.71
SU-088	261.21	DIAMETRAL	120	61	NA	13.94	INVALID	3.55	3.88
SU-088	261.21	IRREGULAR LUMP	80	35	NA	11.4	VALID	6.93	6.23
SU-088	261.78	DIAMETRAL	130	61	∠ TO FABRIC	24.08	VALID	6.13	6.71
SU-088	263.29	DIAMETRAL	180	61	NA	18.34	VALID	4.67	5.11
SU-088	265.09	DIAMETRAL	120	61	NA	12.6	INVALID	3.21	3.51
SU-088	265.11	IRREGULAR LUMP	70	33	NA	15.14	VALID	10.35	9.07
SU-088	268.89	IRREGULAR LUMP	90	30	∠ TO FABRIC	10.94	INVALID	9.05	7.59
SU-088	268.99	DIAMETRAL	170	61	∠ TO FABRIC	8.64	INVALID	2.20	2.41
SU-088	269.92	DIAMETRAL	200	61	NA	19.46	INVALID		
SU-088	271.96	DIAMETRAL	140	61	NA	26.62	VALID	6.78	7.42
SU-088	272.17	IRREGULAR LUMP	90	31	∠ TO FABRIC	10.96	INVALID	8.49	7.23
SU-088	272.87	IRREGULAR LUMP	80	30	∠ TO FABRIC	11.94	INVALID	9.88	8.29
SU-088	277.12	DIAMETRAL	140	61	NA	10.58	INVALID	2.70	2.95
SU-088	278.58	DIAMETRAL	180	61	NA	13.62	INVALID	3.47	3.79
SU-088	280.53	DIAMETRAL	160	61	NA	23.8	INVALID	6.06	6.63
SU-088	280.56	IRREGULAR LUMP	10	40	∠ TO FABRIC	21.88	VALID	10.18	9.72
SU-088	284.88	DIAMETRAL	155	61	NA	15.9	INVALID	4.05	4.43
SU-088	284.95	IRREGULAR LUMP	80	32	NA	13.14	INVALID	9.55	8.25
SU-088	285.87	IRREGULAR LUMP	80	31	NA	12.88	VALID	9.98	8.50
SU-088	286.65	DIAMETRAL	145	61	∠ TO FABRIC	26.78	VALID	6.82	7.46

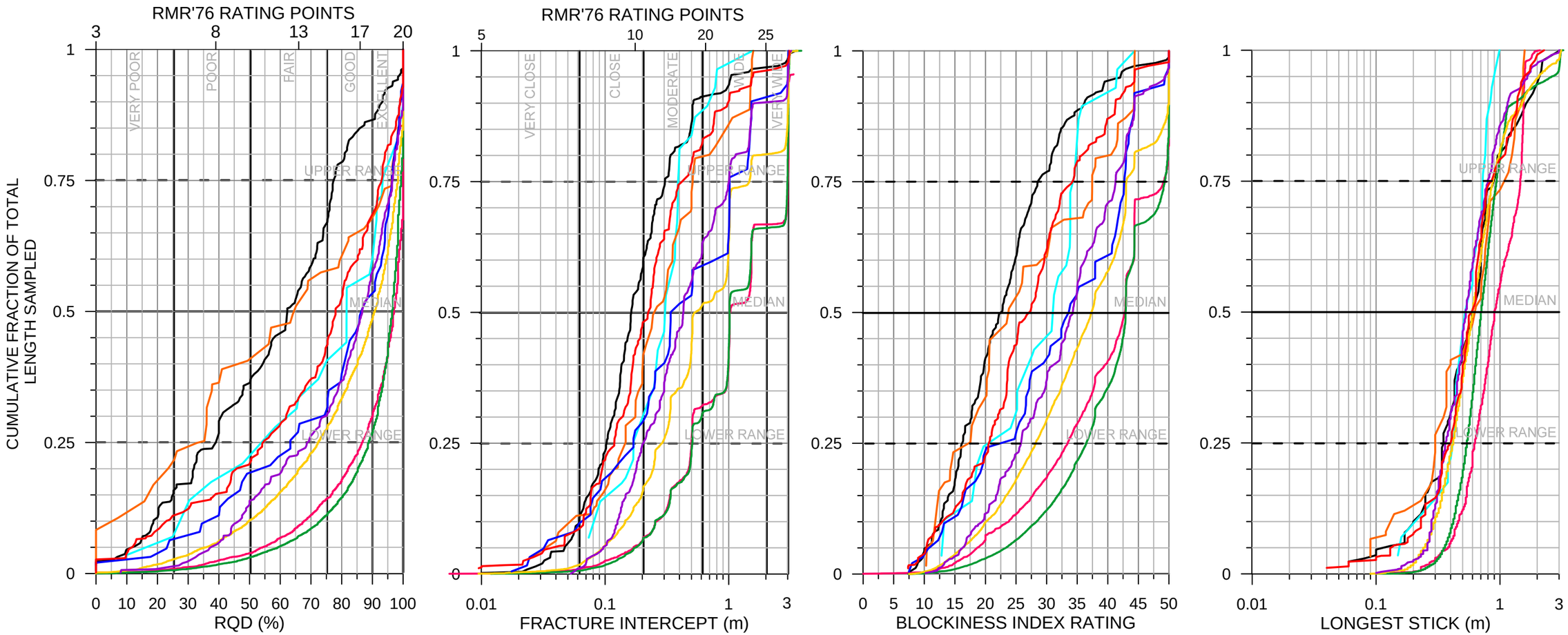
Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-088	288.64	DIAMETRAL	145	61	NA	17.08	INVALID	4.35	4.76
SU-088	288.64	IRREGULAR LUMP	100	40	NA	26.04	VALID	12.12	11.57
SU-088	290.6	DIAMETRAL	150	61	NA	13.12	INVALID	3.34	3.66
SU-088	291.62	DIAMETRAL	125	61	∠ TO FABRIC	23.9	INVALID	6.09	6.66
SU-088	291.76	IRREGULAR LUMP	80	31	NA	14.66	VALID	11.36	9.67
SU-088	292.13	DIAMETRAL	140	61	∠ TO FABRIC	23.58	INVALID	6.01	6.57
SU-088	293.98	DIAMETRAL	135	61	∠ TO FABRIC	32.6	INVALID	8.31	9.08
SU-088	295.42	DIAMETRAL	175	61	NA	19.06	INVALID	4.86	5.31
SU-088	296.89	IRREGULAR LUMP	80	34	NA	13.14	INVALID	8.46	7.51
SU-088	296.9	DIAMETRAL	120	61	∠ TO FABRIC	15.38	INVALID	3.92	4.29
SU-088	297.02	DIAMETRAL	140	61	∠ TO FABRIC	19.14	INVALID	4.88	5.33
SU-088	297.79	DIAMETRAL	175	61	∠ TO FABRIC	19.44	INVALID	4.95	5.42
SU-088	297.79	IRREGULAR LUMP	80	30	NA	9.69	INVALID	8.02	6.73
SU-088	299.12	IRREGULAR LUMP	90	30	NA	13.76	VALID	11.38	9.55
SU-088	300	DIAMETRAL	160	61	NA	26.14	INVALID	6.66	7.28
SU-088	300.69	DIAMETRAL	150	61	NA	16.02	INVALID	4.08	4.46
SU-088	300.7	IRREGULAR LUMP	110	30	NA	18.46	INVALID	15.27	12.81
SU-098	11.73	DIAMETRAL	150	85	NA	24.34	VALID	3.19	4.06
SU-098	17	DIAMETRAL	135	85	NA	23.12	VALID	3.03	3.85
SU-098	44.55	DIAMETRAL	165	85	NA	6.08	VALID	0.80	1.01
SU-098	51.22	DIAMETRAL	181	85	NA	17	VALID	2.23	2.83
SU-098	60	DIAMETRAL	163	85	NA	4.74	VALID	0.62	0.79
SU-098	69.66	DIAMETRAL	120	85	NA	8.6	VALID	1.13	1.43
SU-098	80	DIAMETRAL	120	85	NA	3.16	VALID	0.41	0.53
SU-098	96.84	DIAMETRAL	140	85	NA	11.72	VALID	1.54	1.95
SU-098	103.17	DIAMETRAL	140	85	NA	2.28	VALID	0.30	0.38
SU-098	114	AXIAL	85	75	NA	1.72	VALID	0.20	0.26
SU-098	128.5	DIAMETRAL	120	85	NA	2.82	VALID	0.37	0.47
SU-098	134.76	AXIAL	85	55	NA	10.24	VALID	1.63	1.98
SU-098	148.3	DIAMETRAL	185	85	NA	19.24	VALID	2.52	3.21
SU-098	154	DIAMETRAL	125	85	NA	17.98	VALID	2.36	3.00
SU-098	194.1	DIAMETRAL	204	85	NA	24.98	VALID	3.28	4.16
SU-098	197	DIAMETRAL	180	85	NA	35	VALID	4.59	5.83
SU-098	197.18	DIAMETRAL	158	85	NA	15.62	VALID	2.05	2.60
SU-098	213	DIAMETRAL	100	85	NA	23.76	VALID	3.12	3.96
SU-098	232.43	DIAMETRAL	180	85	NA	17.26	VALID	2.26	2.88
SU-098	240.67	DIAMETRAL	220	85	NA	35	VALID	4.59	5.83

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-098	248	DIAMETRAL	185	85	NA	40	VALID	5.25	6.66
SU-098	256.5	DIAMETRAL	100	85	NA	25.08	VALID	3.29	4.18
SU-098	259.8	DIAMETRAL	235	85	NA	36	VALID	4.72	6.00
SU-098	260.85	DIAMETRAL	100	85	NA	30	VALID	3.94	5.00
SU-098	260.95	DIAMETRAL	140	85	NA	33.62	VALID	4.41	5.60
SU-098	261.95	DIAMETRAL	100	85	NA	31.68	VALID	4.16	5.28
SU-098	272	DIAMETRAL	100	85	NA	37	VALID	4.85	6.16
SU-103	89.2	DIAMETRAL	110	85	NA	7.16	VALID	0.94	1.19
SU-103	94.11	DIAMETRAL	150	85	NA	15.86	VALID	2.08	2.64
SU-103	99.57	DIAMETRAL	165	85	NA	23.74	VALID	3.11	3.96
SU-103	106.67	DIAMETRAL	110	85	NA	10.84	VALID	1.42	1.81
SU-103	110.3	DIAMETRAL	200	85	NA	2.3	VALID	0.30	0.38
SU-103	112	DIAMETRAL	164	85	NA	4.48	VALID	0.59	0.75
SU-103	114.7	DIAMETRAL	185	85	NA	12.18	VALID	1.60	2.03
SU-103	117	DIAMETRAL	180	85	NA	21.28	VALID	2.79	3.55
SU-103	126	DIAMETRAL	130	85	NA	10.2	VALID	1.34	1.70
SU-251	18.17	DIAMETRAL	205	85	NA	26.28	VALID	3.45	4.38
SU-251	15.57	DIAMETRAL	250	85	NA	26.04	VALID	3.42	4.34
SU-251	31.6	DIAMETRAL	125	85	NA	42.06	VALID	5.52	7.01
SU-251	27.65	DIAMETRAL	150	85	NA	21.34	VALID	2.80	3.56
SU-251	32.8	DIAMETRAL	200	85	NA	19.82	VALID	2.60	3.30
SU-251	45.2	DIAMETRAL	194	85	NA	25.38	VALID	3.33	4.23
SU-251	44.59	DIAMETRAL	122	85	NA	33.02	VALID	4.33	5.50
SU-251	49.9	DIAMETRAL	101	85	NA	24.64	VALID	3.23	4.11
SU-251	56.6	DIAMETRAL	87	85	NA	32.54	VALID	4.27	5.42
SU-251	53.4	DIAMETRAL	141	85	NA	30.56	VALID	4.01	5.09
SU-251	60.04	DIAMETRAL	115	85	NA	39.78	VALID	5.22	6.63
SU-251	65.14	DIAMETRAL	138	85	NA	27.92	VALID	3.66	4.65
SU-251	99.6	DIAMETRAL	193	85	NA	43		5.64	7.16
SU-251	85.15	AXIAL	85	30	NA	18.84	VALID	5.50	5.83
SU-251	8.22	DIAMETRAL	235	85	NA	31.58	VALID	4.14	5.26
SU-251	2.33	DIAMETRAL	204	85	NA	20.98	VALID	2.75	3.50
SU-258	3.1	DIAMETRAL	150	85	NA	11.22	VALID	1.47	1.87
SU-258	8	DIAMETRAL	195	85	NA	11.94	VALID	1.57	1.99
SU-258	15.56	AXIAL	85	80	NA	20.92	VALID	2.29	3.03
SU-258	15.56	AXIAL	85	75	NA	30.04	VALID	3.51	4.57
SU-258	19.88	DIAMETRAL	110	85	NA	12.58	VALID	1.65	2.10

Hole ID	Sample Depth (m)	Test Type	Sample Length (mm)	Sample Width (mm)	Load Direction	Gauge Reading (MPa)	Test Quality	Is (MPa)	Is_{50} (MPa)
SU-258	29.7	DIAMETRAL	105	85	NA	10.32	VALID	1.35	1.72
SU-258	37.67	DIAMETRAL	93	85	NA	20.96	VALID	2.75	3.49
SU-258	38.5	DIAMETRAL	135	85	NA	9.68	VALID	1.27	1.61
SU-258	40.5	DIAMETRAL	100	85	NA	8.42	VALID	1.10	1.40

Appendix E

Rock Mass Characterization



GEOTECHNICAL UNITS AND LENGTH OBSERVED

- BRUCEJACK FZ (523 m)
- VOK FZ (422 m)
- WEST ZONE FZ (89 m)
- WEST ZONE WRZ (43 m)
- VOK WRZ (656 m)
- VOK D1 (191 m)
- VOK D2 (15817 m)
- VOK D3 (47264 m)
- WEST ZONE FRESH ROCK (8230 m)

NOTES:
1. QUALITATIVE DESCRIPTIONS ARE SHOWN FOR RQD (DEERE AND DEERE, 1989) AND FRACTURE INTERCEPT (ISRM, 1981).
2. BLOCKINESS INDEX IS THE SUM OF RMR '76 RATING POINTS FOR RQD AND FRACTURE INTERCEPT.
3. DATA SOURCES INCLUDE GEOTECHNICAL SITE INVESTIGATION AND EXPLORATION DRILLING PROGRAMS FROM 2010 TO 2012.
4. VOK FZ AND WEST ZONE FZ INCLUDE BRUCEJACK FZ DATA.

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AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENT

TITLE: DISTRIBUTION OF RQD, FRACTURE INTERCEPT, BLOCKINESS INDEX AND LONGEST STICK BY GEOTECHNICAL UNIT

PROJECT No.:	DWG No.:	REV.:
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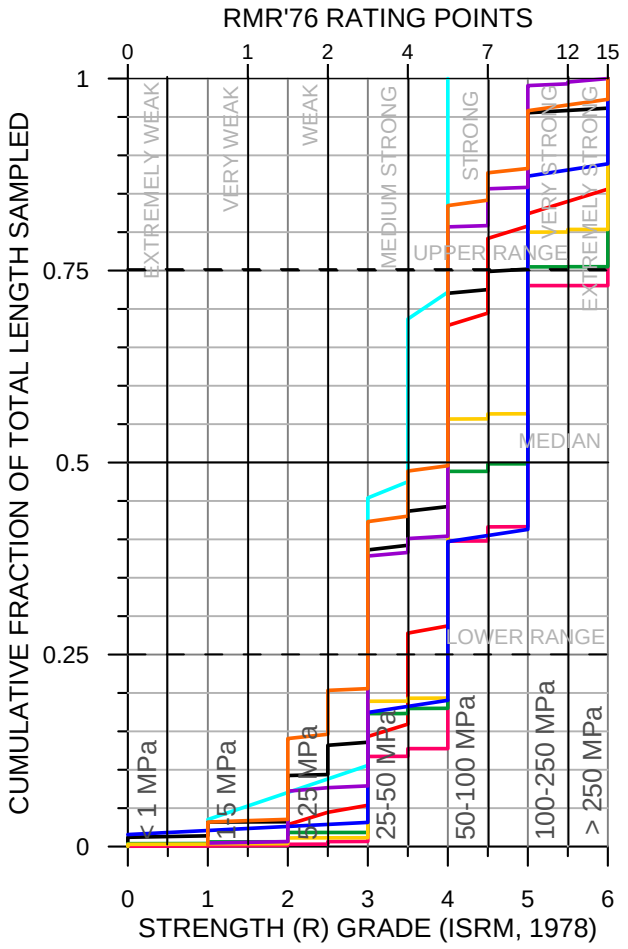

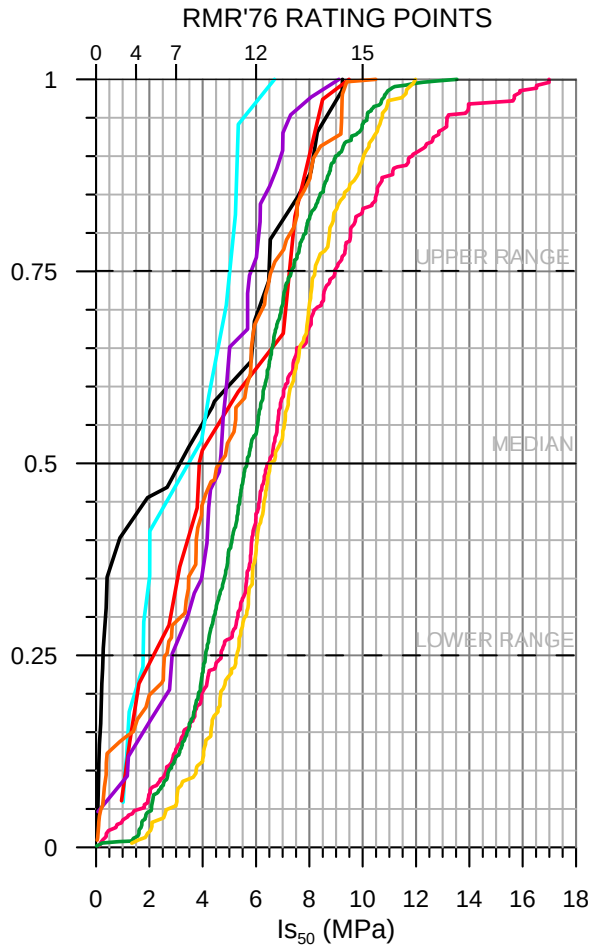

GEOTECHNICAL UNITS AND LENGTH OBSERVED

- BRUCEJACK FZ (523 m)
- VOK FZ (422 m)
- WEST ZONE FZ (89 m)
- VOK WRZ (656 m)
- WEST ZONE WRZ (43 m)
- VOK D1 (191 m)
- VOK D2 (15817 m)
- VOK D3 (47264 m)
- WEST ZONE FRESH ROCK (8230 m)

DRAFT

NOTES:
1. QUALITATIVE DESCRIPTIONS ARE SHOWN FOR STRENGTH GRADE (ISRM, 1978).
2. DATA SOURCES INCLUDE GEOTECHNICAL SITE INVESTIGATION AND EXPLORATION DRILLING PROGRAMS FROM 2010 TO 2012.
3. VOK FZ AND WEST ZONE FZ INCLUDE BRUCEJACK FZ DATA.

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AN APPLIED EARTH SCIENCES COMPANY

PROJECT: BRUCEJACK FEASIBILITY STUDY UNDERGROUND

TITLE: DISTRIBUTION OF INTACT ROCK STRENGTH ESTIMATES FROM STRENGTH GRADE AND Is_{50}

CLIENT:	PROJECT No.:	DWG No.:	REV.:
PRETIUM RESOURCES INC.	1008-007-002	F-02	

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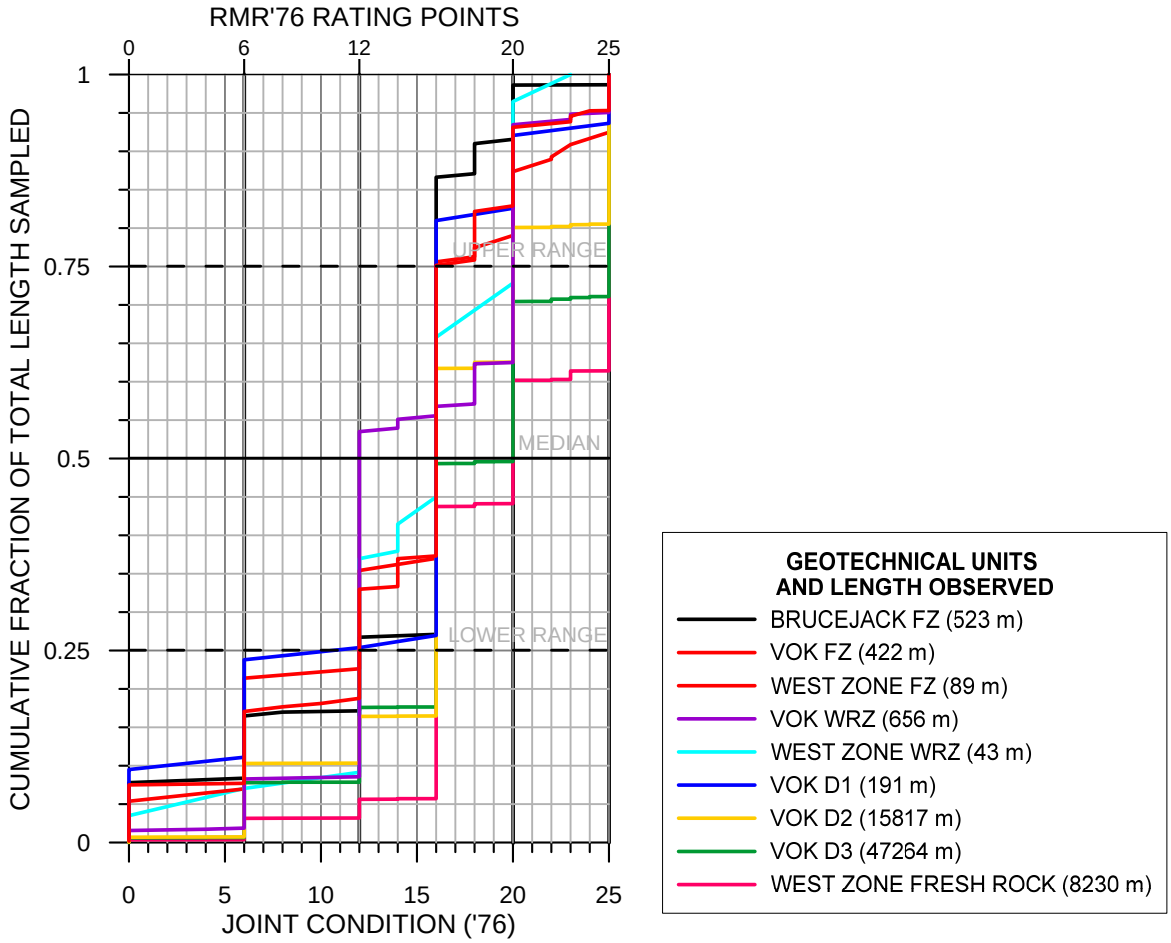

JC '76 RATING	CONDITION OF DISCONTINUITY	ADDITIONAL NOTES [BGC, 2010]
25	VERY ROUGH SURFACE; NOT CONTINUOUS; NO SEPERATION; UNWEATHERED (HARD) WALLS	INCLUDES INTERVALS WITH NO DISCONTINUITIES, 16≤ JRC
20	SLIGHTLY ROUGH SURFACES, SEPARATION <1 mm; SLIGHTLY WEATHERED (HARD, ≥R3) WALLS	> R3 WALL ROCK; INTERLOCKING DISCONTINUITIES WITH 8 < JRC < 14
12	SLIGHTLY ROUGH SURFACES; SEPARATION <1 mm; HIGHLY WEATHERED (SOFT, <R3) WALLS	< R3 WALL ROCK AND SLIGHTLY ROUGH OR > R3 WALL ROCK; PLANAR/SMOOTH SURFACES WITH NO INFILL
6	SLICKENSIDED SURFACES OR GOUGE <5 mm THICK OR SEPERATION 1 TO 5 mm; CONTINUOUS	VEINS ≤ R1 OR MOHS # ≤ 3 INCLUDED AS INFILLING
0	SOFT GOUGE >5 mm OR SEPERATION >5 mm; CONTINUOUS	VEINS ≤ R1 OR MOHS # ≤ 3 INCLUDED AS INFILLING

NOTES:
1. DATA SOURCES INCLUDE GEOTECHNICAL SITE INVESTIGATION AND EXPLORATION DRILLING PROGRAMS FROM 2010 TO 2012.
2. WEST FZ AND VOK FZ INCLUDE BRUCEJACK FZ DATA.

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENT

TITLE: DISTRIBUTION OF JOINT CONDITION ('76)
BY GEOTECHNICAL UNIT

CLIENT:	PROJECT No.:	DWG No.:	REV.:
PRETIUM RESOURCES INC.	1008-007-002	F-03	

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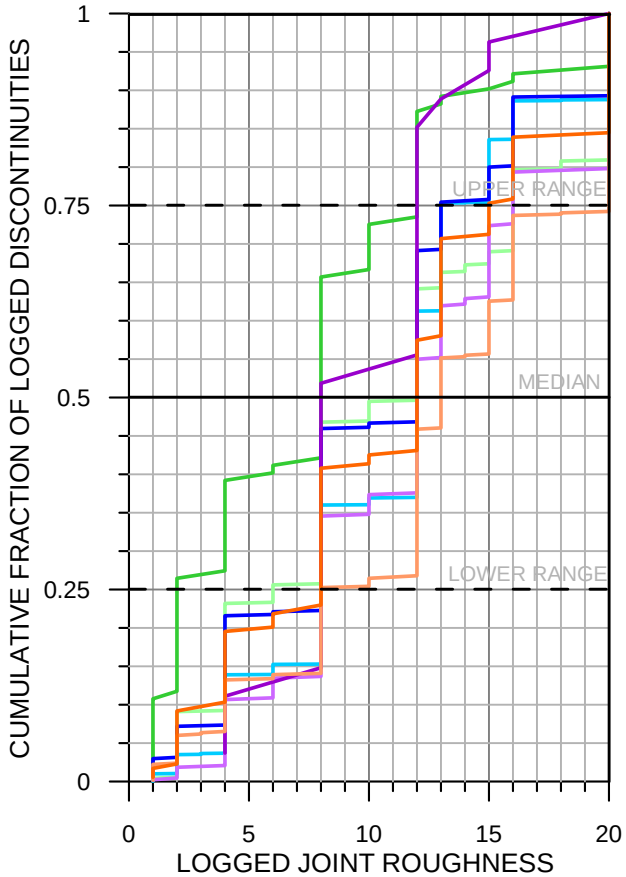

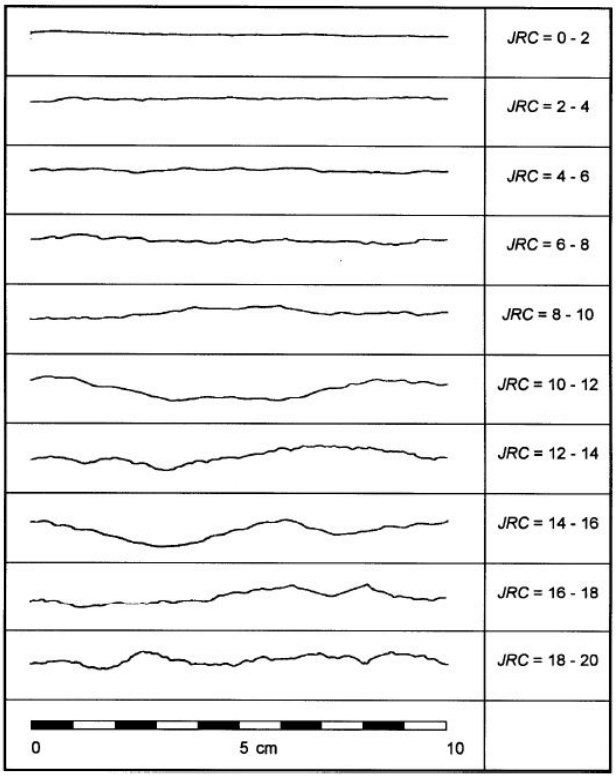

JOINT ROUGHNESS PROFILES (BARTON & CHOUBEY, 1977)

CUMULATIVE DISTRIBUTION OF JOINT ROUGHNESS

DISCONTINUITY		UNIT	25%	50%	75%	NUMBER OF DISCONTINUITIES
JOINT		WZ FR	6	12	16	703
FAULT/SHEAR			2	8	12	102
JOINT		VOK FR	8	12	13	2597
FAULT/SHEAR			8	12	13	570
JOINT		WRZ	8	12	16	431
FAULT/SHEAR			8	8	12	27
JOINT		FZ	8	13	20	582
FAULT/SHEAR			8	12	15	174

NOTES:
1. DATA SOURCES INCLUDE CORE OBSERVATIONS FROM 2010 AND 2012 GEOTECHNICAL SITE INVESTIGATIONS.
2. JOINT ROUGHNESS ESTIMATED IN FIELD USING BGC CORE TOOL BASED ON 10 cm JOINT ROUGHNESS PROFILES FROM BARTON AND CHOUBEY (1977).

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AN APPLIED EARTH SCIENCES COMPANY

PROJECT: BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENT

TITLE: DISTRIBUTION OF JOINT ROUGHNESS

CLIENT:	PROJECT No.:	DWG No.:	REV.:
PRETIUM RESOURCES INC.	1008-007-002	F-04	

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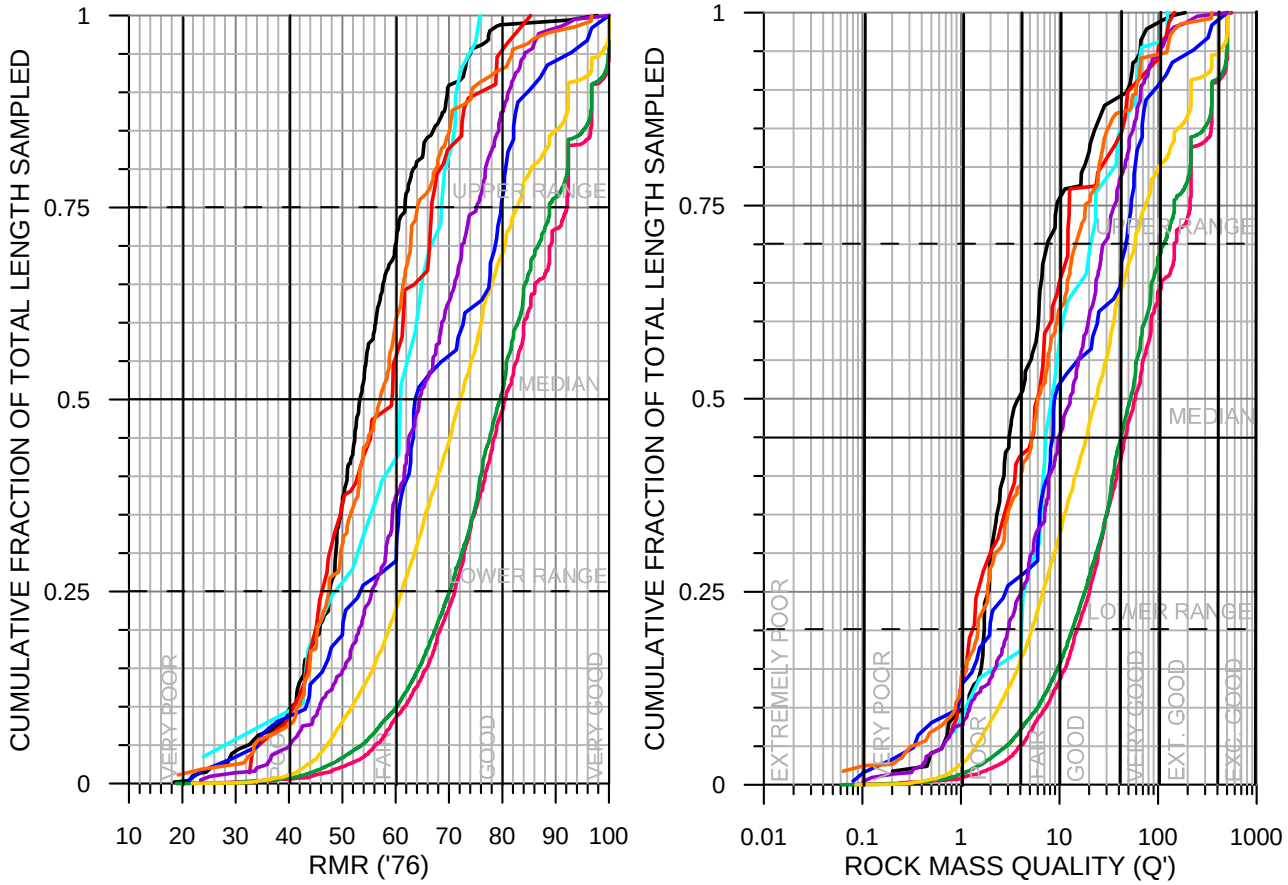

GEOTECHNICAL UNITS AND LENGTH OBSERVED (m)

- BRUCEJACK FZ (523 m)
- WEST ZONE FZ (89 m)
- VOK FZ (422 m)
- WEST ZONE WRZ (43 m)
- VOK WRZ (656 m)
- VOK D1 (191 m)
- VOK D2 (15817 m)
- VOK D3 (47264 m)
- WEST ZONE FRESH ROCK (8230 m)

DRAFT

NOTES:
1. DATA SOURCES INCLUDE GEOTECHNICAL SITE INVESTIGATION AND EXPLORATION DRILLING PROGRAMS FROM 2010 TO 2012.
2. ROCK MASS RATING (RMR) IS DERIVED FROM STRENGTH RATING, RQD RATING, FRACTURE INTERCEPT RATING, JOINT CONDITION, AND GROUND WATER RATING (BIENIAWSKI, 1976).
3. VOK FZ AND WEST ZONE FZ INCLUDE BRUCEJACK FZ DATA.

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AN APPLIED EARTH SCIENCES COMPANY

PROJECT: BRUCEJACK FEASIBILITY STUDY UNDERGROUND

TITLE: DISTRIBUTION OF RMR ('76) AND Q' VALUES BY GEOTECHNICAL UNIT

CLIENT:	PROJECT No.:	DWG No.:	REV.:
PRETIUM RESOURCES INC.	1008-007-002	F-05	

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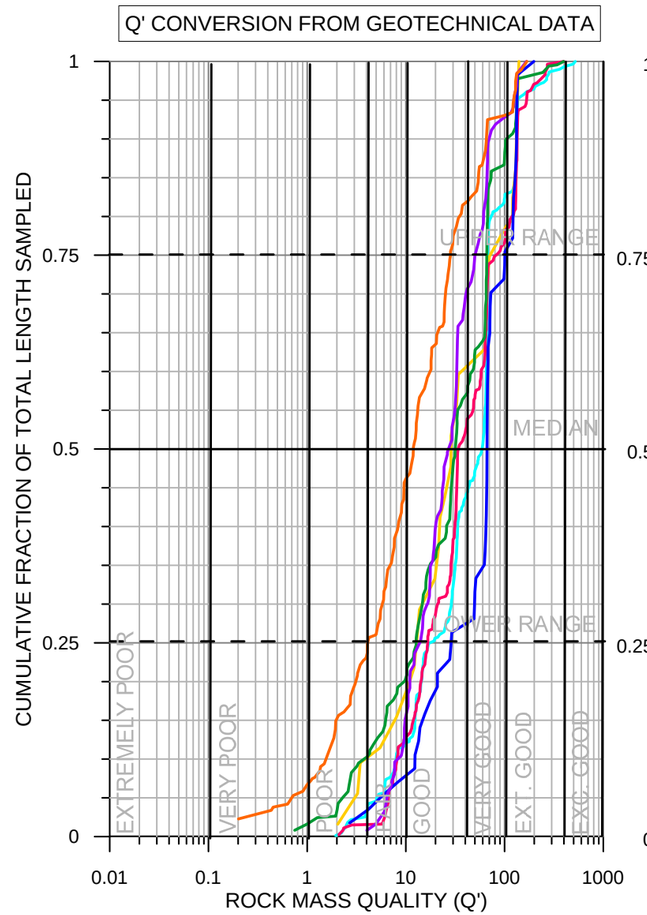

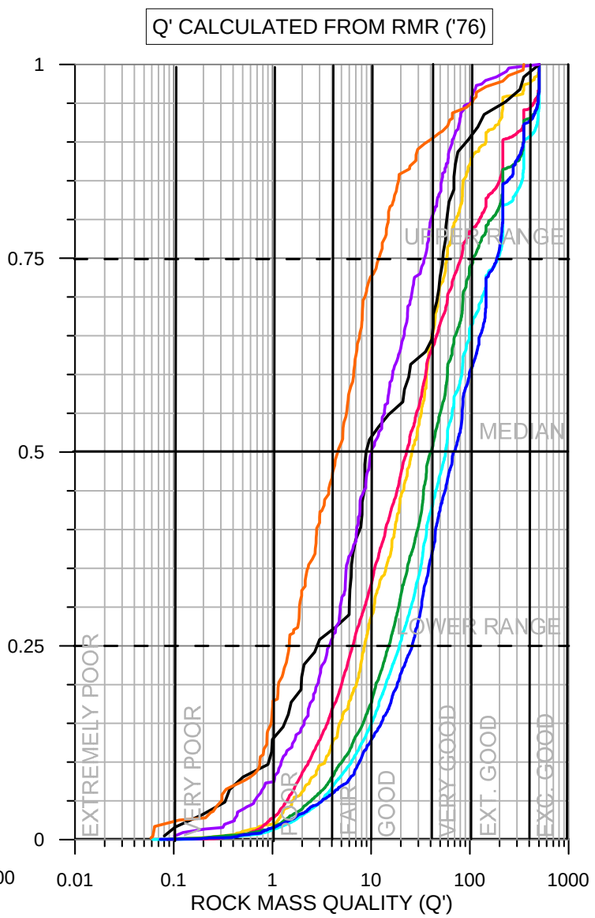

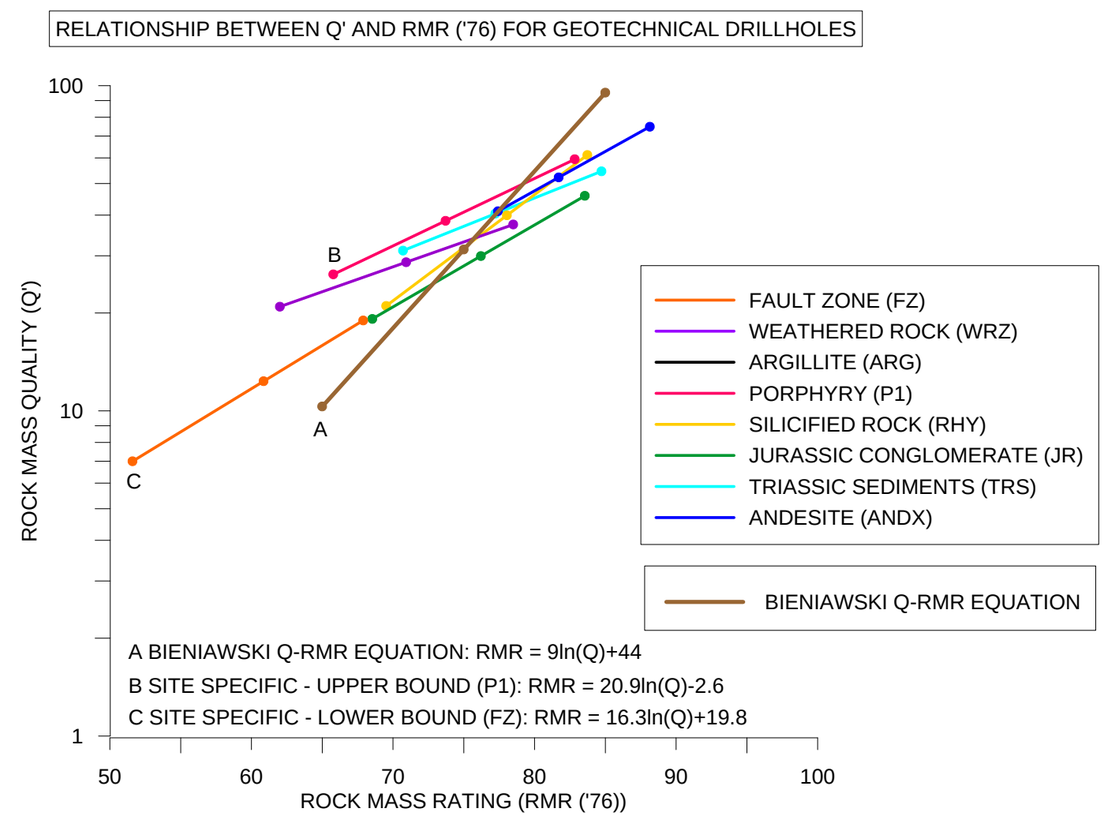

MEDIAN Q' VALUES				
PRETIUM UNIT	LENGTH OBSERVED ALL DRILLHOLES (m)	Q' CALCULATED FROM RMR	LENGTH OBSERVED GEOTECHNICAL DRILLHOHLES	Q' DERIVED FROM GEOTECHNICAL DATA
ANDX	7654	123	174	70
TRS	27713	125	893	63
JR	12074	101	374	51
RHY	2010	56	77	54
P1	13827	79	608	62
ARG	189	47	0	No data
WRZ	663	27	190	38
FZ	424	19	275	25

NOTES:
1. ROCK MASS RATING (RMR) IS DERIVED FROM STRENGTH RATING, RQD RATING, FRACTURE INTERCEPT RATING, JOINT CONDITION, AND GROUND WATER RATING (BIENIAWSKI, 1976).
2. ROCK MASS QUALITY (Q') IS DERIVED FROM RQD, NUMBER OF JOINT SETS,JOINT ROUGHNESS, AND JOINT ALTERATION.
3. Q' VALUES FOR GEOTECHNICAL DRILL HOLES DERIVED FROM FIRST PRINCIPLES BASED ON RAW DATA COLLECTED BY BGC DURING 2010 AND 2012.
4. Q' VALUES FOR EXPLORATION DRILL HOLE DATA FROM 2010 TO 2012 ARE CALCULATED FROM RMR ('76) USING THE FORMULA: Q = e^((RMR - 44)/9)
5. POINTS PLOTTED ON Q'-RMR CONVERSION GRAPH ARE Q' VALUES FOR 25TH PERCENTILE, MEDIAN, AND 75TH PERCENTILE RMR VALUES.

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BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

CLIENT: PRETIUM RESOURCES INC.

PROJECT: BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENT

TITLE: DISTRIBUTION OF RMR ('76) AND Q' VALUES BY GEOTECHNICAL UNIT

PROJECT No.: 1008-007-002
DWG No.: F-06
REV.:

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Appendix F

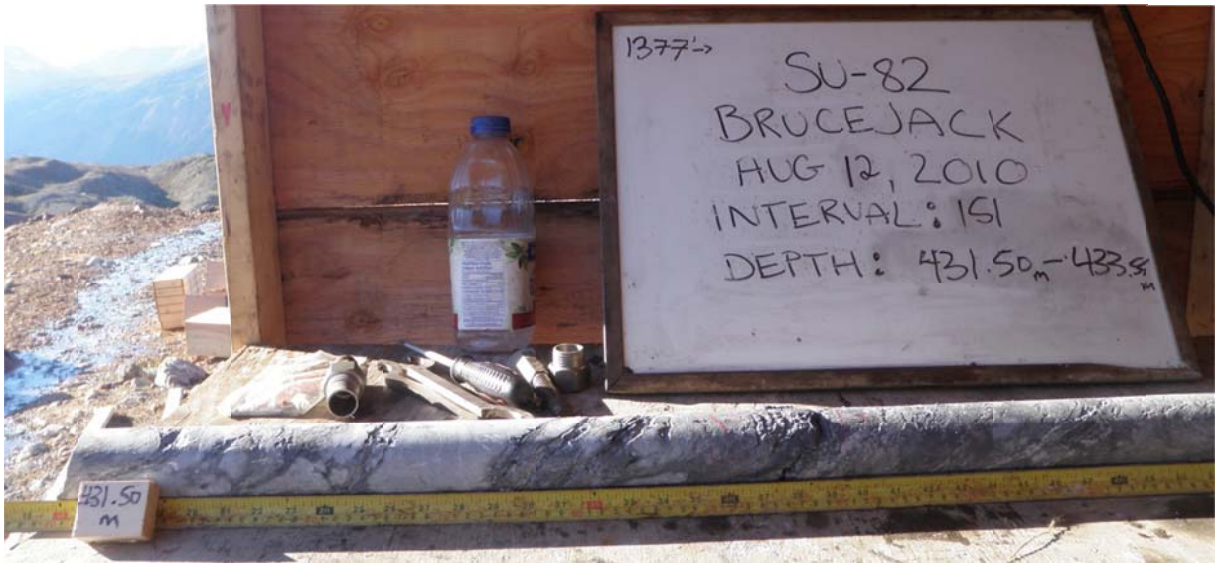
Brucejack Fault Zone Summary

Drill hole DH-BGC12-23 (SU-318) intercepts the fault-disturbed zone from 500 m to 564 m depth, and the central fault zone from 507 m to 562 m (1104 to 1053 m elevation) (Photograph G-1 and G-2). Sericite-chlorite alteration is noted throughout the Fault Zone with a uniform intensity of 4 ("moderate") on Pretium's alteration intensity rating scale.

Photograph G-1. Core Box Photos for DH-BGC12-23 Showing Transition from Decreasing RQD Values Beginning at 500 m Depth into Fault Zone at Approximately 507 m. Bottom Three Core Boxes are Illustrative of Typical Fault Zone Core.

Photograph G-2. Core Box Photos Showing Fault-disturbed Zone and Transition into Less Fractured Rock Below Fault Zone in DH-BGC12-23 (SU-318).

Drill hole SU-082 intercepts the fault-disturbed zone between 420 m and 482 m depth and the central fault zone between 435.19 m and 463.1 m (1178 m to 1124 m elevation). Photograph G-3 shows an example of a faulted intercept. The Fault Zone in SU-082 has sericite alteration throughout with a uniform intensity of 5 ("moderate to strong") on Pretium's alteration intensity rating scale.



Photograph G-3. First 'Worst Case' Fault Discontinuity (2 mm Fault Gouge Infill) Encountered in SU-082 at 431.96 m Depth.

In DH-BGC12-23, the Fault Zone consists of intervals of competent rock with a slightly higher number of discontinuities relative to undisturbed rock mass interspersed with lengths of broken rock (RQD <30%) and a few lengths of fault gouge and decomposed rock between 10 to 150 mm thick. A 'worst case' length of fault-disturbed rock from 512.70 m to 513.85 m depth (RQD 40%) is shown in Photograph G-4.

Photograph G-4. Example of 'Worst Case' Fault-Disturbed Rock in DH-BGC12-23 (SU-318).

The more competent sections comprise 10 to 70 cm lengths of unbroken rock in which discontinuities are mainly joints with 0.5 to 5 mm aperture with no infill, calcite infill, or 1 to 2 mm of broken rock infill. A slightly altered three metre interval in DH-BGC12-23 (544.83 m to 547.58 m) exhibiting iron staining retains RQD, joint condition, and strength grade values within the characteristic range of the D2 geotechnical unit.

Point load testing in the upper portion of the Brucejack Fault Zone (from 507 to 524 m depth) in DH-BGC12-23 yielded Is_{50} values ranging from approximately 4.5 MPa to 10 MPa, which are comparable to those recorded in the 30 m interval above the fault zone. Point load test results from the lower portion of the fault zone (525 to 550 m), yield much lower values (0.1 to 0.9 MPa), then recover to 2.5 to 6 MPa at the bottom of the fault zone. No point load tests were performed below 557.5 m depth in DH-BGC12-23.

The Fault Zone is similar in SU-082, although the lengths of broken rock are absent and the discontinuities with fault gouge are from 10 to 640 mm thick. There is a length of healed fault-disturbed rock from 454 m to 457 m depth (Photograph G-7). Point load tests above the fault-disturbed zone (from 400 to 420 m depth) yielded Is_{50} values of approximately 5 MPa. Is_{50} values in the fault-disturbed zone from 420 m to 435 m dropped to 0.1 to 1.9 MPa in the fault zone, recovering to 4.8 to 8.5 MPa directly below the fault zone.

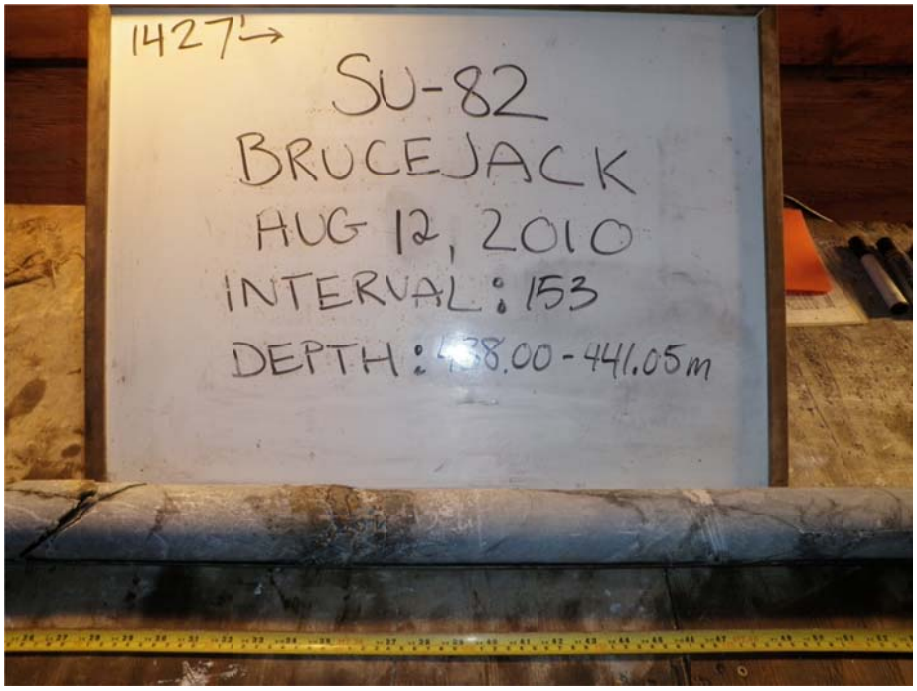
All discontinuities identified as faults with fault gouge infill, or any infill type greater than 5 mm thick are shown in SU-082 and DH-BGC12-23 downhole plots (Appendix A). 'Worst case' discontinuities in both drill holes are summarized in Table G-1 and examples of these are shown in Photograph G-5 through G-7. These photographs show short lengths of fault disturbance within mostly undisturbed rock, which is typical of the Brucejack Fault Zone.

Table G-1. Upper and Lower Boundaries of the Brucejack Fault Zone Picked from Drill Hole Data

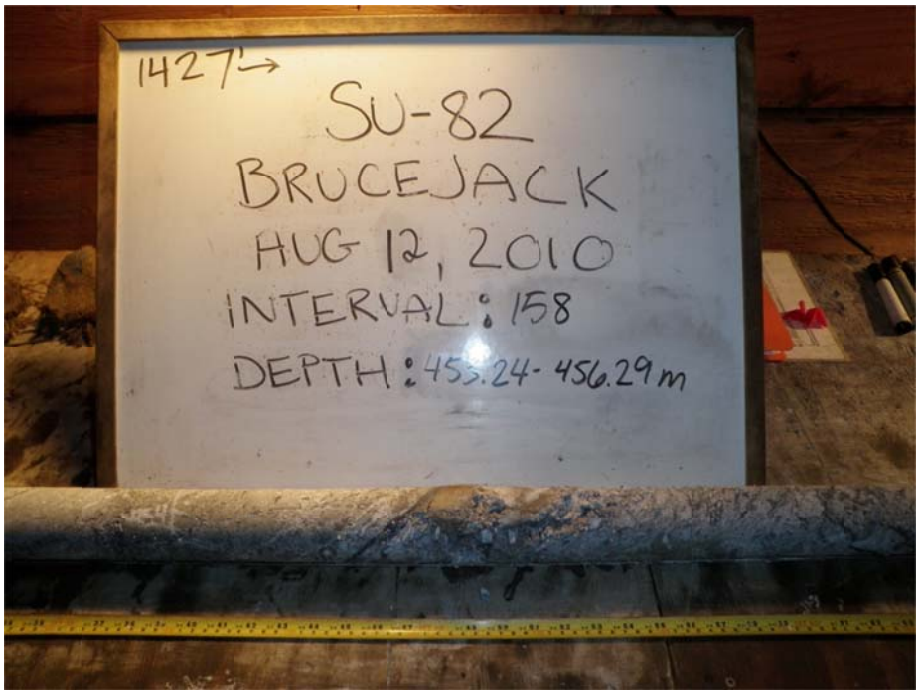
Hole ID	Fault-disturbed zone upper boundary (m)	Fault-disturbed zone lower boundary (m)	Fault zone upper boundary (m)	Fault zone lower boundary (m)
DH-BGC12-23	500	564	507	562
SU-082	419.71	483.72	431.96	463.1
SU-157	87.48	130.15	96.63	124.05
SU-161	209.41	255.11	227.7	239.88
SU-216	215.49	239.88	218.54	227.69
SU-223	398.37	434.95	404.47	413.61
SU-040	128.73	142.34		
SU-043	477	486.16		
SU-152	354.18	375.54	360.28	369.42
SU-193	136	184	157	184
SU-200	291.08	303.28	296.26	298.7
SU-208	391.67	430.68	391.67	430.68
SU-232	79.86	109.73	92.05	98.15
SU-250	440.74	455.98	449.88	452.93

Hole ID	Fault-disturbed zone upper boundary (m)	Fault-disturbed zone lower boundary (m)	Fault zone upper boundary (m)	Fault zone lower boundary (m)
SU-263	416.66	436.79	422.76	428.85
SU-251	75.29	99.67	78.33	79.24
SU-268	196.29	208.48	196.29	208.48

Photograph G-5. 'Worst Case' Fault Discontinuity at 510.06 m in DH-BGC12-23 (100 mm Fault Gouge, Crushed Rock, and Broken Rock Infill) in Relatively Undisturbed Length of Core.



Photograph G-6. 'Worst Case' Fault Discontinuity in SU-082 at 438.85 m (40 mm Fault Gouge Infill) in Relatively Undisturbed Length of Core.

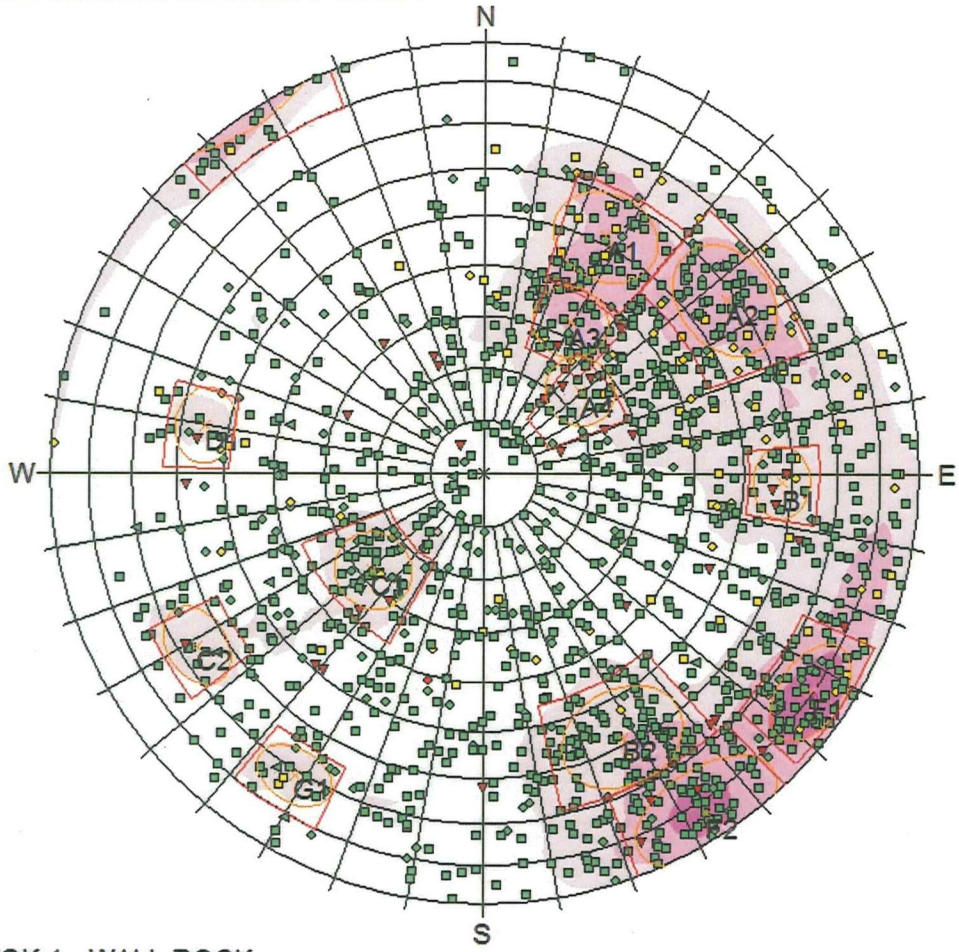


Photograph G-7. 'Worst Case' Fault Discontinuity at 454.17 m (160 mm Fault Gouge Infill) Within Section of Fault-Disturbed Core Between 454 and 457 m Depth in Drill Hole SU-082.

Appendix G

Mine Domain Stereonets

BRUCEJACK FEASIBILITY STUDY



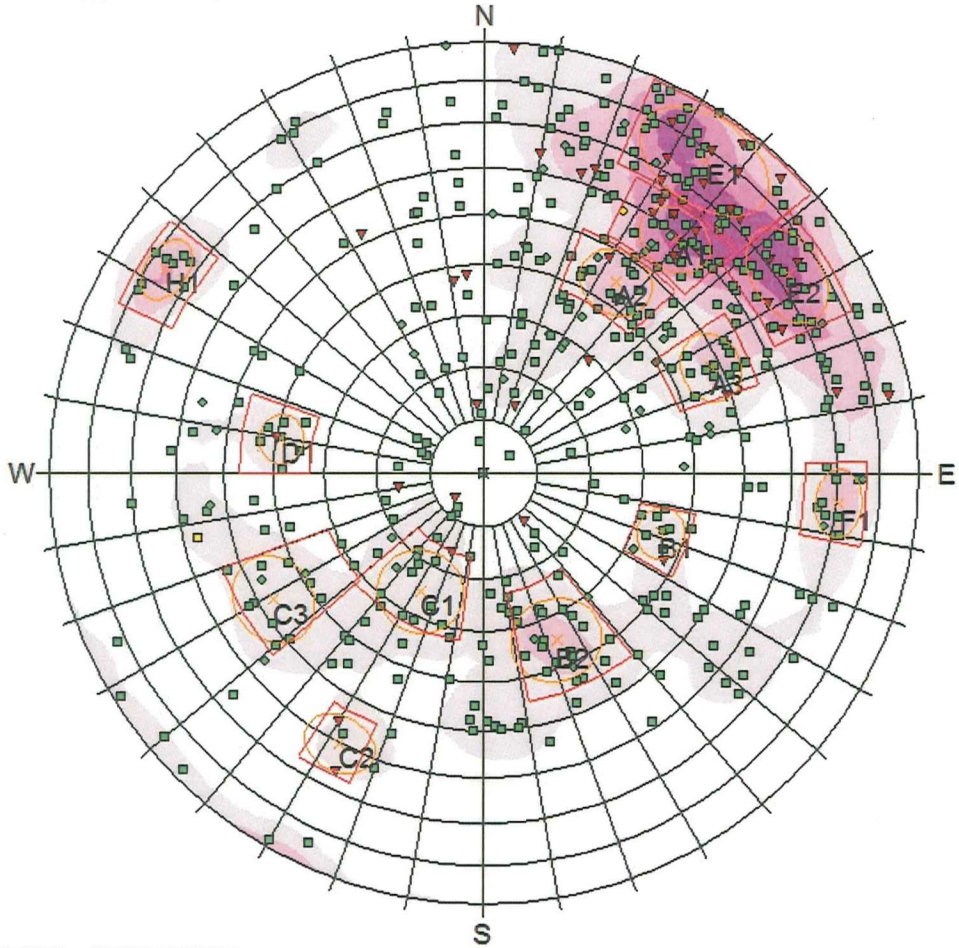
TYPE

- F [38]
- FV [1]
- J [1006]
- JO [13]
- JV [188]
- S [64]
- SV [53]
- V [2]

Equal Area
Lower Hemisphere
1365 Poles
1365 Entries

VOK 1 - WALL ROCK

BRUCEJACK FEASIBILITY STUDY



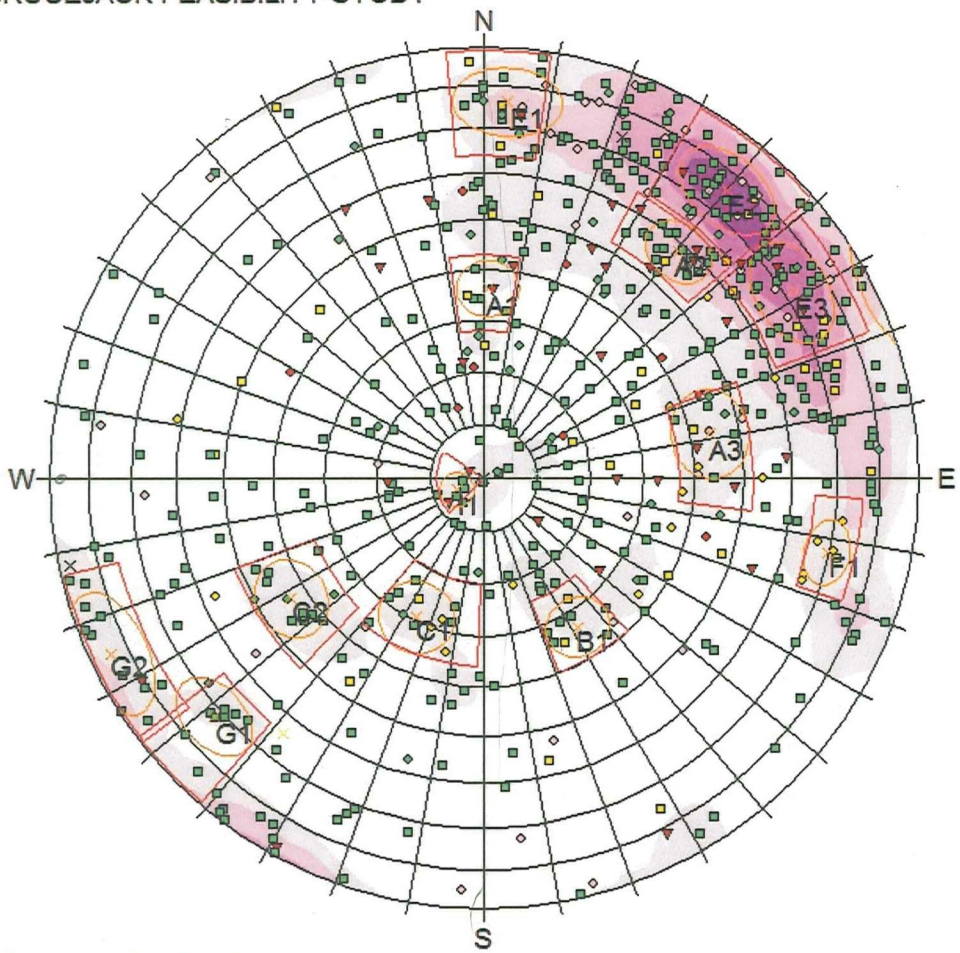
TYPE

- F [44]
- J [394]
- JV [45]
- S [1]
- SV [1]

Equal Area
Lower Hemisphere
485 Poles
485 Entries

VOK 2 - ORE ZONE

BRUCEJACK FEASIBILITY STUDY



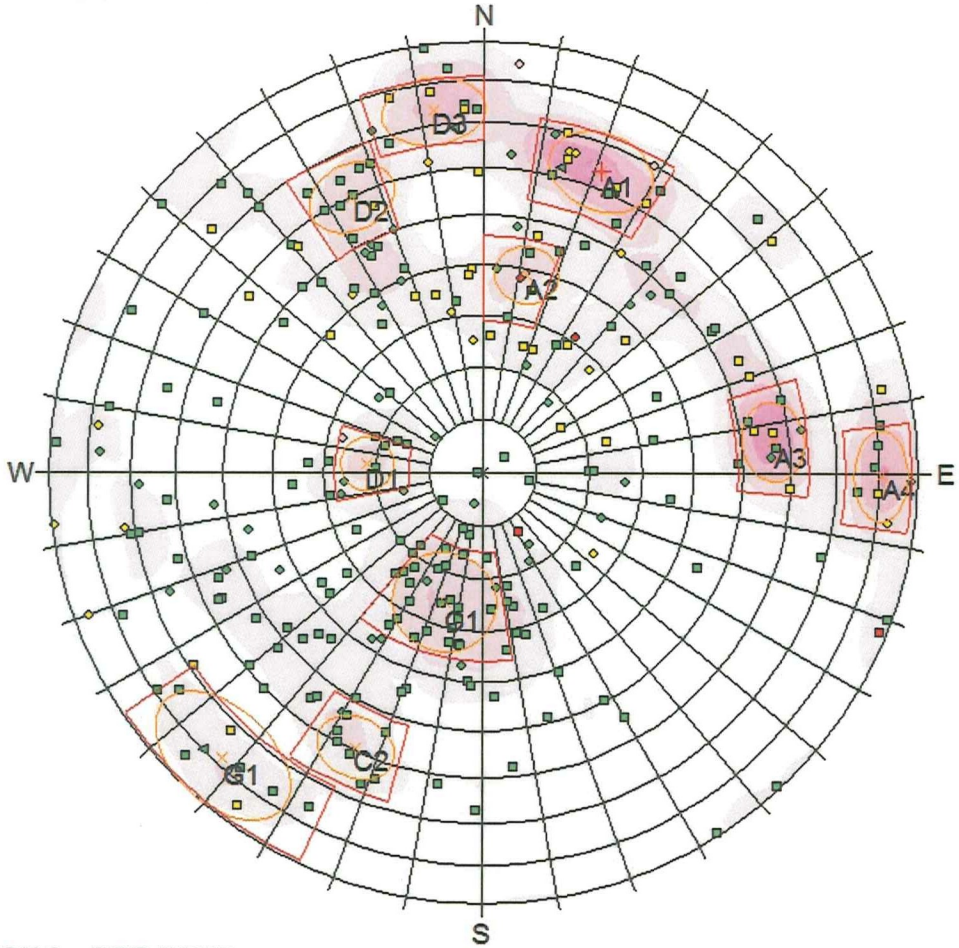
TYPE

×	C [3]
▼	F [39]
◆	FV [8]
■	J [390]
×	JC [1]
◆	JV [44]
■	S [39]
×	SC [1]
◆	SV [21]
◆	V [43]

Equal Area
Lower Hemisphere
589 Poles
589 Entries

VOK 2 - WALL ROCK

BRUCEJACK FEASIBILITY STUDY



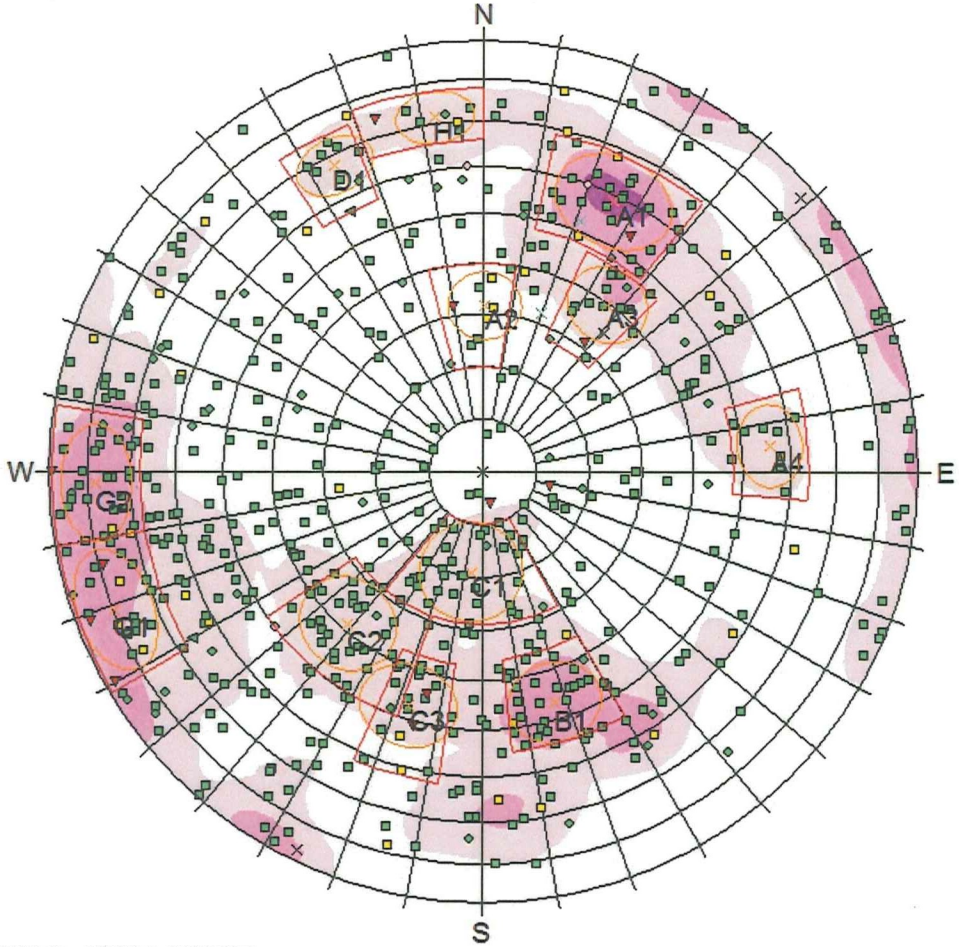
TYPE

- F [2]
- FV [2]
- J [173]
- JO [3]
- JV [40]
- S [37]
- SV [15]
- V [4]

Equal Area
Lower Hemisphere
276 Poles
276 Entries

VOK 3 - ORE ZONE

BRUCEJACK FEASIBILITY STUDY



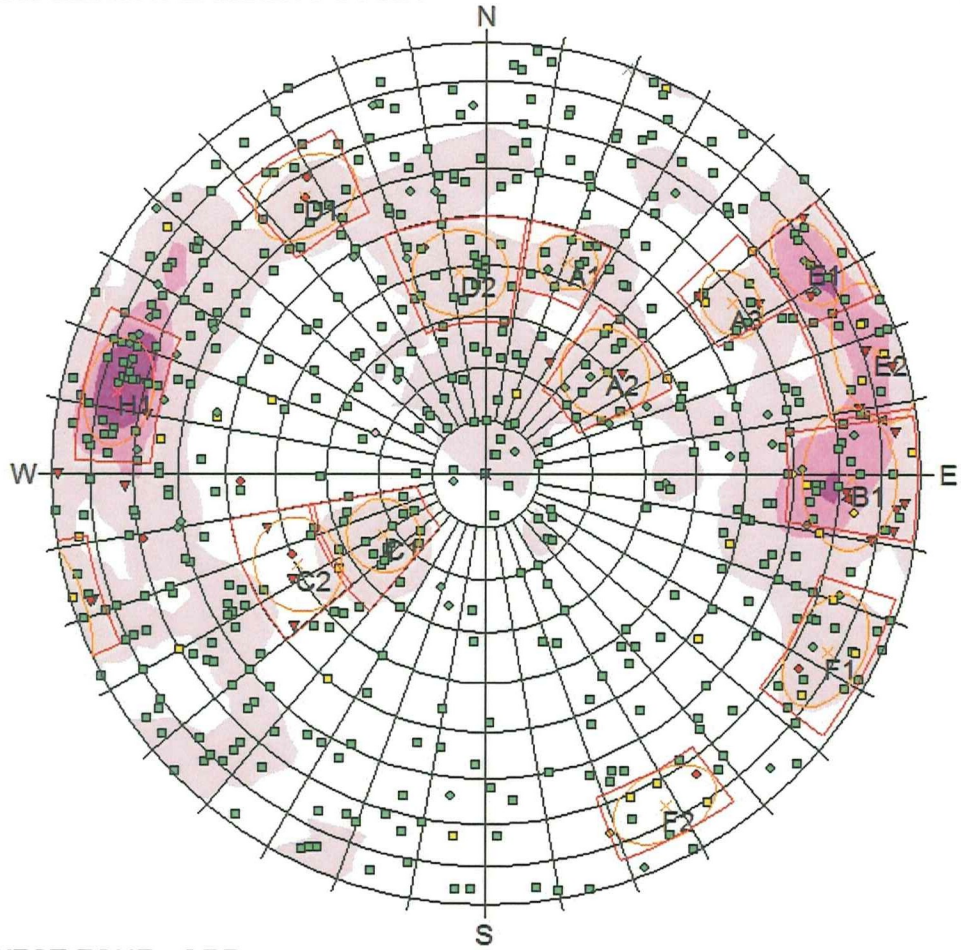
TYPE

×	C [3]
▼	F [12]
■	J [500]
×	JC [3]
◄	JO [2]
◆	JV [50]
□	S [36]
◇	V [3]

Equal Area
Lower Hemisphere
609 Poles
609 Entries

VOK 3 - WALL ROCK

BRUCEJACK FEASIBILITY STUDY



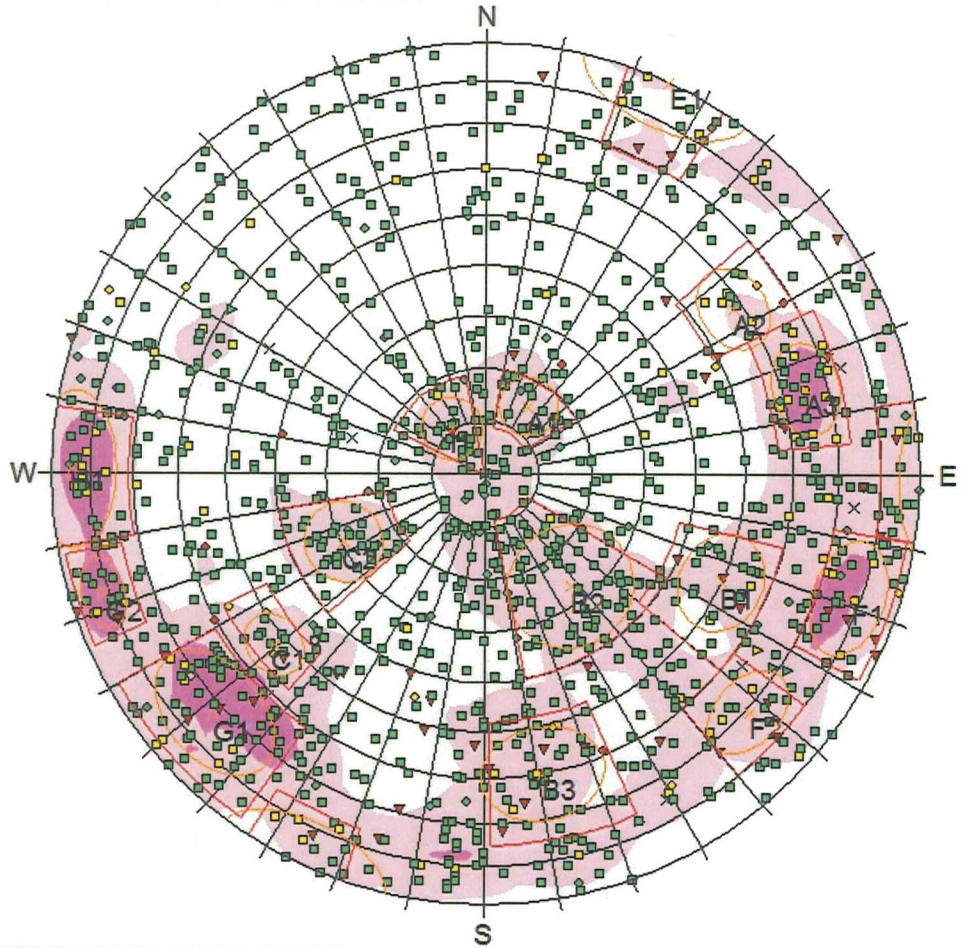
TYPE

▼	F [24]
◀	FB [1]
◆	FV [8]
■	J [490]
◀	JB [2]
×	JC [1]
◆	JV [47]
□	S [30]
◇	SV [3]
◇	V [1]

Equal Area
Lower Hemisphere
607 Poles
607 Entries

WEST ZONE - ORE

BRUCEJACK FEASIBILITY STUDY



TYPE

×	C [8]
▼	F [49]
◆	FV [7]
■	J [940]
▶	JO [7]
◆	JV [53]
■	S [89]
▶	SO [1]
◆	SV [11]
◆	V [3]

Equal Area
Lower Hemisphere
1168 Poles
1168 Entries

WEST ZONE - WALL ROCK

Appendix H

2019 Geotechnical Data Review

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Project Memorandum

To:	**Brucejack Gold Mine**		
Attention:	**Woo Shin, Allan Chan, Sylvia Van Zalingen**		
From:	**Catherine Schmid**	**Date:**	**March 6, 2019**
Subject:	**Review of Underground Geotechnical Units and Structural Domains for 2019 NI 43-101 Update**		
Project No.:	**1008033**		

1.0 INTRODUCTION AND SCOPE OF WORK

BGC Engineering Inc. (BGC) was requested by Pretium Resources Inc. (Pretivm) to provide technical input and serve as a 'Qualified Professional' for an ongoing update to the National Instrument (NI) 43-101-compliant Technical Report (the "NI 43-101") on its Brucejack Gold Mine (Brucejack). The NI 43-101 update will reflect a recently approved Mine Permit amendment allowing an increase in the production rate from an average of 2,700 tpd (tonnes per day) to 3,800 tpd.

The Scope of Work items detailed below are based on email and telephone communications between BGC and Pretivm on January 7, 14, and 30, 2019:

- BGC compiled all available geotechnical data collected since the project's Feasibility Study (FS) in 2013 (BGC, May 17, 2013), consisting of core logging data from exploration/infill drilling programs, geotechnical drilling programs, and hydrogeological programs, as well as underground mapping completed by others since 2013.
- The current mine geology model was reviewed by BGC to identify changes to anticipated geologic conditions, and to correlate geotechnical units and lithologies developed during the FS to the current geologic model lithologies. Some efficiency has been achieved by relying on data already compiled for a stope design update completed by BGC 2018 (BGC, 2018).
- New hydrogeological data was reviewed by BGC to re-estimate the hydrogeological conditions within the proposed mine workings, for comparison to the design assumptions of the FS.

This memo addresses updates relevant to the NI 43-101 regarding the geotechnical units and geologic structural domains previously defined for the project.

NI 43-101 report sections related to underground geotechnics will be provided by BGC under separate cover, pending issuance of the draft document by Pretivm, to consist of:

- 16.5 (Mining Methods – Geotechnical)
- 26.4.1 (Recommendations – Mining Methods – Geotechnical)
- 27.9 (References – Mining Geotechnical)

Per Pretivm's instructions, the current scope of work does not include revisions of rock mechanic designs (i.e., analysis for ground support, stope dimensions, crown pillar, etc.).

2.0 REVIEW AND COMPILATION OF AVAILABLE DATA

Pretivm provided the following data to BGC:

- Drilling program geotechnical core logging data up to February 2019 (XLS format). This dataset included all drilling programs in the Brucejack database up to drill holes SU-563, VU-920, and VUG-068.
- Underground mapping data (CSV format) compiled from Pretivm's Vulcan database in 2017 and 2018. A database export of structures logged in drill holes was also provided, however very few of the geological structures were oriented, therefore this data has not been reviewed as part of the current scope of work.
- 2017 structural geology model update (DXF format).
- 2019 geological model update (DXF format).

All of the above were developed by Pretivm and are assumed by BGC to be accurate and representative of conditions at Brucejack. Intervals with incomplete data were removed from the compilation.

The mine plan referenced in this document was provided by Pretivm on June 28, 2018 as a DXF file titled "Brucejack 2015 feasibility stopes". The structural domains referenced in this document are defined in BGC (May 17, 2013); the geographic boundaries for those domains are also provided in that report.

2.1. Review and Update of Geotechnical Units

This section presents the updated geotechnical units, including updated naming convention for the lithologies within each geotechnical unit, and updated cumulative frequency curves for the rock mass classification values (Q' (NGI, 2015), RMR (Bieniawski, 1976)) within each geotechnical unit. Due to limited additional drilling in the West Zone since the FS, only the VOK geotechnical units have been updated as part of the current scope of work.

The geotechnical units defined for the 2013 underground FS assessments were:

- West Zone:
  - WZ FZ: fault-disturbed rock
  - WZ WRZ: weathered near-surface rock
  - WZ FR: fresh rock
- VOK:
  - VOK FZ: fault-disturbed rock
  - VOK WRZ: weathered near-surface rock
  - VOK D1: ARG lithology
  - VOK D2: P1 and RHY lithology
  - VOK D3: JR, TRS, and ANDX lithology.

The 2019 geological model consists of the following units, as defined by Pretivm (pers. comm.):

- P1 Office Porphyry (OFP1): hornblende and(or) feldspar phyric latite to trachyandesite flows and subordinate fragmental rocks.
  - Correlates to the "P1" lithology used during the FS assessments.

- P1 Bridge Zone Porphyry (BZP1): hornblende feldspar phyric latite to trachyandesite flows and subordinate fragmental rocks.
    - Correlates to the “P1” lithology used during the FS assessments.
- VSF (Volcanosedimentary facies): This sequence consists of intercalated polylithic conglomerates, immature conglomerates, gritstones, sandstones, mottled submarine sandstones, through greywackes to argillites. Lateral facies variations abound. Contains common carbonate concretions (may be pyrite-, chlorite-, calcite-replaced). VSF represents the sandstone-conglomerate portion of this facies.
    - Correlates to the “TRS” lithology used during the FS assessments.
- ARG (Volcanosedimentary facies): This sequence consists of intercalated polylithic conglomerates, immature conglomerates, gritstones, sandstones, mottled submarine sandstones, through greywackes to argillites. Lateral facies variations abound. Contains common carbonate concretions (may be pyrite-, chlorite-, calcite-replaced). ARG represents the argillite portion of this facies.
    - Correlates to the “ARG” lithology used during the FS assessments.
- Volcaniclastics (CONG): immature angular to subrounded polylithic conglomerate horizon.
    - Correlates to the “JR” lithology used during the FS assessments.
- S3-Trans (Trans): Transitional unit between the CONG and the V12. Contains both blocks, bombs, and clasts.
    - This is a new unit since the FS assessments. It is a subgroup of the “JR” lithology used during the FS assessments.
- ANDX (V12): Latite fragmental unit which is heralded by a sandy reworked epiclastic base, then variably by different pyroclastic units – lapilli tuffs, crystal-lithic tuffs, crystal tuffs, agglomerates, and units with large bombs.
    - Correlates to the “ANDX” lithology used during the FS assessments.
- Silcap: Intense silica alteration along permeable horizons, typically lithology contacts and in the CONG.
    - Correlates to the “RHY” lithology used during the FS assessments.

In summary, the lithologies in the 2019 Brucejack geological model are generally consistent with the lithologies used during the FS assessments, although some of the lithology names have been revised. The most significant update to the model is the delineation of the S3-Trans lithology from the JR lithology.

Based on the updated Pretivm geological model presented above, the updated lithologies within the VOK geotechnical units are:

- VOK:
    - VOK FZ: fault-disturbed rock
    - VOK WRZ: weathered near-surface rock
    - VOK D1: ARG lithology
    - VOK D2: P1 Bridge Zone Porphyry, P1 Office Porphyry, and Silcap lithology
    - VOK D3: Volcaniclastics (CONG), VSF, S3-Trans, and ANDX lithology.

Cumulative frequency curves for the updated VOK geotechnical units are provided in Appendix A.

As shown in Figure A-1, the updated VOK D1 curve is consistent with the original FS distribution, with no significant difference noted between the RMR'76 and Q' ratings between the two datasets. The updated VOK D2 curve is also relatively consistent with the FS VOK D2 curve, with slightly lower rock mass quality in the new dataset compared to the FS dataset, with a downgrade of approximately 4 RMR'76 points, and a similar relative decrease for the Q' ratings. Importantly, overall, the data plots in the same rock mass quality classes as the FS (i.e. the median value for VOK D2 is "Good" (Bieniawski, 1976; NGI, 2015)). VOK D3 shows the most significant variation from the FS dataset, with a downgrade of approximately 10 RMR'76 points and one Q' class (i.e. downgraded from "Very Good" to "Good" (Bieniawski, 1976; NGI, 2015)). The contributing factor(s) to the decrease in observed VOK D3 rock mass quality were not assessed as part of the current scope of work, however both local rockmass quality variation (i.e. poorer rock mass quality in the areas drilled more recently compared to those drilled during the FS) and granularity within the geotechnical logging data (i.e. faults or poor rock mass quality not identified as separate small intervals, and instead logged as part of a larger (and subsequently weaker) interval) are potential factors.

2.2. Review of Structural Domains

Pretivm's Vulcan compilation of 2017 and 2018 underground structural geology mapping data was used to generate stereonets for defined structural domains VOK 1 and VOK 2 (Appendix B). No geologic structures were mapped in VOK 3, and only 52 structures were mapped in the West Zone, therefore these domains are not considered in the current update. The mapping data were assigned to "ore zone" and "wall rock" groupings by filtering structures inside and outside the proposed stopes, respectively. The structure type within the new dataset consists primarily of 'faults'.

Updated stereonets were checked for consistency with the FS structural domain stereonets, and are summarized below:

- VOK 1 Wall Rock – This domain generally shows consistency with the FS design stereonet, except for the SE striking sets, which were observed to be moderately (30 to 60°) dipping in the FS data and appear to be steeply (65 to 85°) dipping in the most recent mapping data (with the moderately dipping set apparent in the FS data not present). This may be due to spatial variation in the orientation of the set, with the 2017 and 2018 data predominantly from the upper levels of the mine, and the FS data from drill holes located throughout the mining footprint; or it may be a new set. Because both the moderately dipping and steeply dipping NE striking sets were observed in this domain in 2017 (BGC, 2018), and the steeply dipping set is present in other domains, it's considered more likely that this steeply dipping set is an additional set not previously identified in the FS assessments. The northwest striking shallowly dipping (20 to 35°) set identified in the FS assessments is weak to absent in the most recent data.

- VOK 1 Ore Zone – The number of poles within the most recent mapping data for the VOK 1 Ore Zone domain is small (two poles), and therefore statistically not significant enough for a comparison to the historical data.
- VOK 2 Wall Rock – The VOK 2 Wall Rock domain is consistent with the FS design stereonet. A moderately (40 to 50°) dipping SE striking set is present in the most recent mapping data and was not as strongly developed in the FS data but is weakly developed relative to the subvertical SW striking set, which is the dominant set in this domain.
- VOK 2 Ore Zone – The VOK 2 Ore Zone domain is generally consistent with the FS design stereonet, except for a lack of moderately-dipping structures in the most recent data. These moderately dipping structures were identified in the FS assessments as weak sets relative to the dominant steeply-dipping to subvertical southeast striking set, which continues to be the dominant set as shown in Appendix B. This dominant set also appears to overturn occasionally in the most recent data.

2.3. Review of Major Structures Model

The 2017 three-dimensional major structures (fault) model developed by Pretivm includes the Brucejack Fault, the Rainy Fault, the VOK Main Fault, and the Upper Thrust Fault. At the time of the FS (BGC, May 17, 2013), only the Brucejack Fault had been modelled in three-dimensions, hence it was the only major structure considered during assessment of the potential influence of large-scale structure on the proposed FS mine plan.

The three additions to the major structures model since the FS appear to be part of a package of gently dipping south-southwest striking structures, as there is a periodicity to the Rainy Fault, VOK Main Fault, and Upper Thrust Fault. A geotechnical summary of the structures and the potential for them to affect excavation stability is presented below:

- The Rainy Fault is a gently dipping (10 to 30 deg.) south-southwest striking (220 to 240 deg.) fault (Figure 1). It was studied in detail as part of the geotechnical assessment for the underground crusher (BGC, November 6, 2015). The fault has a thickness ranging between 0.5 – 15 meters (average thickness: 2 m), with the thickness appearing to increase with depth. The rock mass within the fault zone is generally very blocky with very poor to poor RQD (< 50%) and discontinuity spacing less than 0.20 m but varies from relatively unbroken rock to compact silty/clayey gouge zones up to 1.5 m thick. Often the fault zone is comprised of multiple gouge zones separated by more competent zones of very blocky rock mass. Seepage conditions within the zone vary significantly, from dry to dripping. The Rainy Fault intersects several levels of the mine, including the VOK main access ramp, 1340 to 1310 elevations of the north ventilation raise, and stoping areas between 1205 to 1355 elevation. It has been intersected by mine development to date, and although seepage is strong and rock mass quality decreases within the fault zone, Pretivm has successfully mined through the fault zone using increased ground support. The seepage is reported by Pretivm to decrease over time to an essentially dry condition.

Figure 1. Visible exposure of the Rainy Fault near DH-BGC15-02 drill station. Red line indicates hangingwall of fault.

- The VOK Main Fault intersects the upper levels of the mine within the stoping areas between the 1415 and 1475 levels. This fault strikes perpendicular to the stope hangingwalls in this area and has the potential to cause structural instability in the stope hangingwalls and backs. This fault was intercepted during the FS drilling program by drill hole DH-BGC12-23 at between approximately 210 to 250 m along hole and resulted in locally reduced RQD (between 40 to 80%) and fracture spacing (between 0.06 to 0.50 m) compared to the fresh (unfaulted) rock. It has been intersected by mine development to date on the 1470 and 1440 elevations.
- The Upper Thrust Fault is highest in the stratigraphic sequence of the three known faults in this package and intersects a small number of planned stopes between the 1450 and 1520 Levels at the southwest corner of the mine. It has not been intersected by mine development to date. It strikes subparallel to a development drift on the 1480 level and has the potential to cause structural instability and resulting increased ground support requirements during development through that area. DH-BGC12-23 also intercepted this fault, and although a small fault structure was logged, it did not cause a significant reduction in rock mass quality.

2.4. Review of Hydrogeological Data

Hydrogeological conditions, including bedrock hydraulic conductivity estimates, hydraulic conductivity variation with depth, and groundwater elevations at Brucejack were summarized in the FS assessments (BGC, May 17, 2013). Since then, BGC has completed a groundwater monitoring well installation in 2018 (BGC, February 21, 2019), as well as annual groundwater monitoring reports for 2015, 2016, and 2017 (BGC, March 30, 2016; March 27, 2017; March 19, 2018). New data was collected, and groundwater quantity assessments were completed as part of those studies, using hydraulic head data from monitoring wells and monthly average underground mine dewatering rates. The rock mechanics assessments used to support the mine

design and planning generally assume that the rockmass is dewatered by ongoing mine dewatering activities. This assumption remains valid based on the new information.

Anecdotally, stopes and development within the Brucejack Fault and other major structures may encounter more groundwater inflow than the average mine inflows quantified to date (BGC, February 21, 2019), based on groundwater inflow reported by Pretivm during drilling of several exploration drill holes that intersected the Brucejack Fault. However, existing hydrogeological data (packer testing and hydraulic head measurements) do not confidently identify the Brucejack Fault as a groundwater flow path or flow barrier. While ongoing mine dewatering activities may be able to dewater this structure, additional hydrogeological characterization of the major structures including the Brucejack Fault, and subsequent update of the existing numerical groundwater flow model, would increase operational confidence in managing inflow from major structures.

3.0 COMPARISON TO FEASIBILITY STUDY DESIGN ASSUMPTIONS

This section summarizes the comparison of the most recent geotechnical and structural data to the data used for the FS rock mechanics assessments.

The geotechnical units used for the FS assessments had slightly higher assumed median rock mass quality when compared to the most recent data collected at Brucejack, although overall the median rock mass quality for all three VOK geotechnical units remains “Good” (Bieniawski, 1976; NGI, 2015). This moderate reduction in apparent rock mass quality has the potential to be most significant for stope stability, where maximum achievable stope dimension is strongly correlated to rock mass quality. The updated stope designs presented in BGC (2018) assumed two rock mass classes at Brucejack – Q’ of 10 to 50, and Q’ of 3 to 10. These classes, and the resulting stope design recommendations, were intended to demonstrate the potential variability in rock mass quality and resultant achievable stope spans at Brucejack. Although the median values of the new data suggest these ranges are still valid (with 50% of the rock mass having Q’ >10), the medians are close to the threshold value, and the upper range (i.e., higher quality rock) may be less common than initially assumed during previous assessments. BGC continues to recommend that Brucejack review stope designs on a case-by-case / package-by-package basis, particularly if optimized, larger, and less conservative stope dimensions (i.e. greater than “median” designs) are proposed to be implemented in the mine plan.

The structural domains used for the FS assessments are generally consistent with the most recent data collected by Pretivm. The most significant change is the appearance of a moderately-dipping set in VOK 2 Wall Rock domain, which has the potential to form wedges with other moderately-dipping structures and result in structural instability, particularly if the structures are persistent and closely spaced. Despite this new set, the FS ground support designs (BGC, 2013) and updated stope designs (BGC, 2018) are considered by BGC to be suitable for the “base-case designs” at Brucejack because there appears to be a low concentration of adversely oriented conjugate sets with which this set could form wedges. However, due to adverse orientation of the discontinuity sets in the Brucejack rock mass, there will remain residual risk for rock fall and stope dilution. The risk increases where the discontinuities are persistent and closely spaced, and as stope

dimensions increase. The existing geotechnical database is insufficient to predict where more persistent and/or closely spaced discontinuities may occur, therefore thorough and regular geotechnical inspections and cavity monitor surveys throughout the development and production continue to be recommended.

There are three newly-identified major structures (fault zones) identified within the mining footprint, in addition to the Brucejack Fault. These new structures were not considered in the rock mechanics assessments for the FS mine design. The mine design (i.e., excavation dimensions, ground support designs, and sequencing) should be reviewed on a case-by-case basis in all areas where these major structures are within 20 m of the proposed excavations, with consideration to the interpreted rock mass quality, geologic structure, groundwater conditions, stress, and mine sequence local to the area of interest.

4.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of Brucejack Gold Mine. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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Yours sincerely,

BGC ENGINEERING INC.
per:

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33195
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Mar 6/2019

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Senior Mining Rock Mechanics Engineer

HP/CJS/JRT/dk/sjk

Attachment(s): Appendix A – Cumulative Frequency Plots
Appendix B – Structural Domain Stereonets

REFERENCES

BGC Engineering Inc. (2013, May 17). *Brucejack Project Feasibility Study Underground Rock Mechanics Assessment* [Report]. Issued to Pretium Resources Inc.

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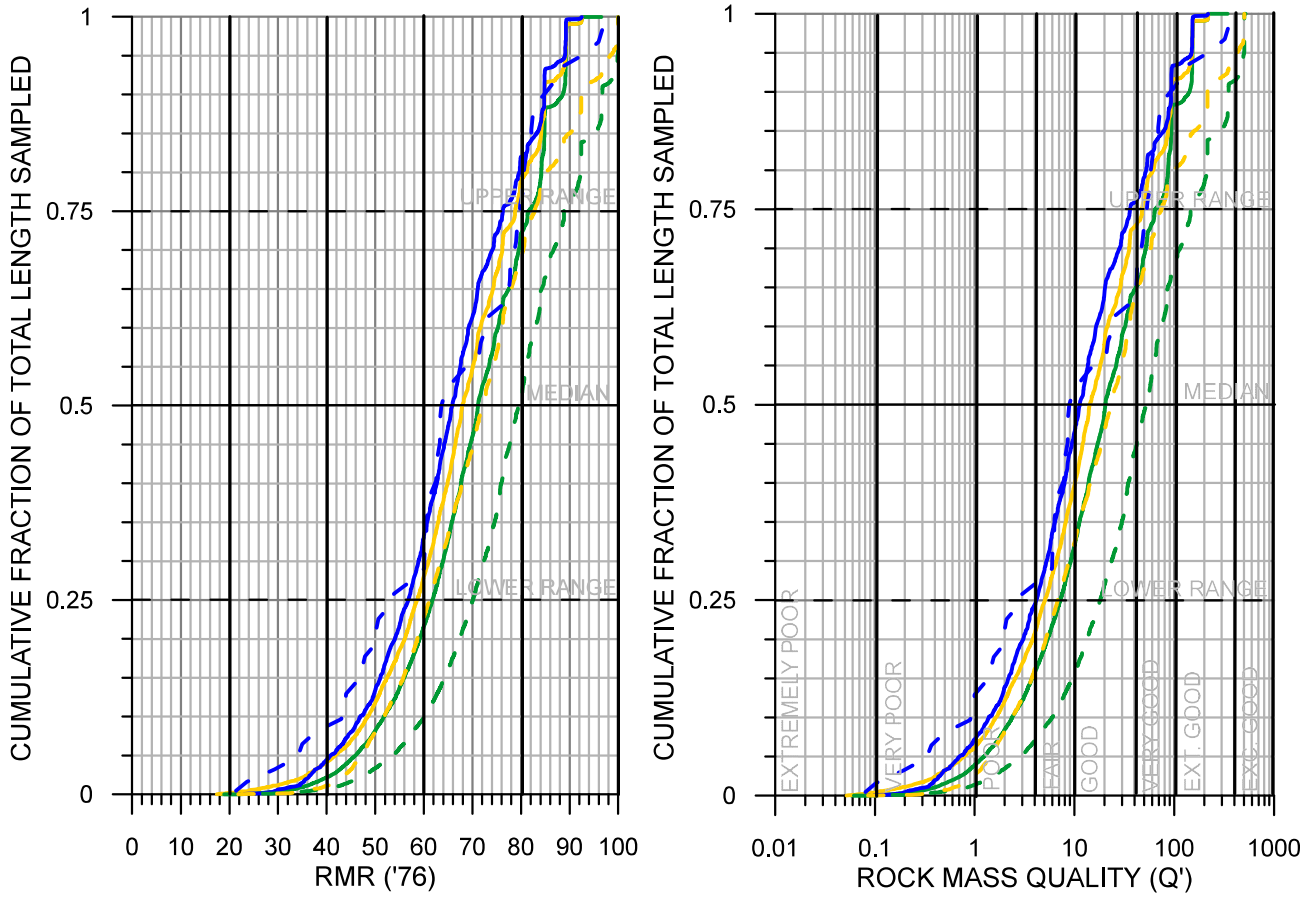
APPENDIX A
CUMULATIVE FREQUENCY PLOTS



GEOTECHNICAL UNITS

- VOK D1 (new data)
- VOK D2 (new data)
- VOK D3 (new data)
- VOK D1 - FS
- VOK D2 - FS
- VOK D3 - FS

NOTES:

1. NEW DATA SOURCES INCLUDE GEOTECHNICAL DATA COLLECTED UP TO FEBRUARY 2019. FS DATA SOURCES INCLUDE GEOTECHNICAL SITE INVESTIGATION AND EXPLORATION DRILLING PROGRAMS FROM 2010 TO 2012.
2. ROCK MASS RATING (RMR'76) IS DERIVED FROM STRENGTH RATING, RQD RATING, FRACTURE INTERCEPT RATING, JOINT CONDITION, AND GROUND WATER RATING (BIENIAWSKI, 1976).
3. WHERE Q' VALUES COULD NOT BE DERIVED BASED ON FIRST PRINCIPLE, VALUES ARE CALCULATED USING Q' = e^((RMR - 44)/9).

AS A MUTUAL PROTECTION TO OUR CLIENT, THE PUBLIC, AND OURSELVES, ALL REPORTS AND DRAWINGS ARE SUBMITTED FOR THE CONFIDENTIAL INFORMATION OF OUR CLIENT FOR A SPECIFIC PROJECT. AUTHORIZATION FOR ANY USE AND/OR PUBLICATION OF THIS REPORT OR ANY DATA, STATEMENTS, CONCLUSIONS OR ABSTRACTS FROM OR REGARDING OUR REPORTS AND DRAWINGS, THROUGH ANY FORM OF PRINT OR ELECTRONIC MEDIA, INCLUDING WITHOUT LIMITATION, POSTING OR REPRODUCTION OF SAME ON ANY WEBSITE, IS RESERVED PENDING BGC'S WRITTEN APPROVAL. IF THIS REPORT IS ISSUED IN AN ELECTRONIC FORMAT, AN ORIGINAL PAPER COPY IS ON FILE AT BGC ENGINEERING INC., AND THAT COPY IS THE PRIMARY REFERENCE WITH PRECEDENCE OVER ANY ELECTRONIC COPY OF THE DOCUMENT, OR ANY EXTRACTS FROM OUR DOCUMENTS PUBLISHED BY OTHERS.

SCALE:	AS SHOWN	DESIGNED:	
DATE:	MARCH 2019	CHECKED:	
DRAWN:	CJS	APPROVED:	JRT

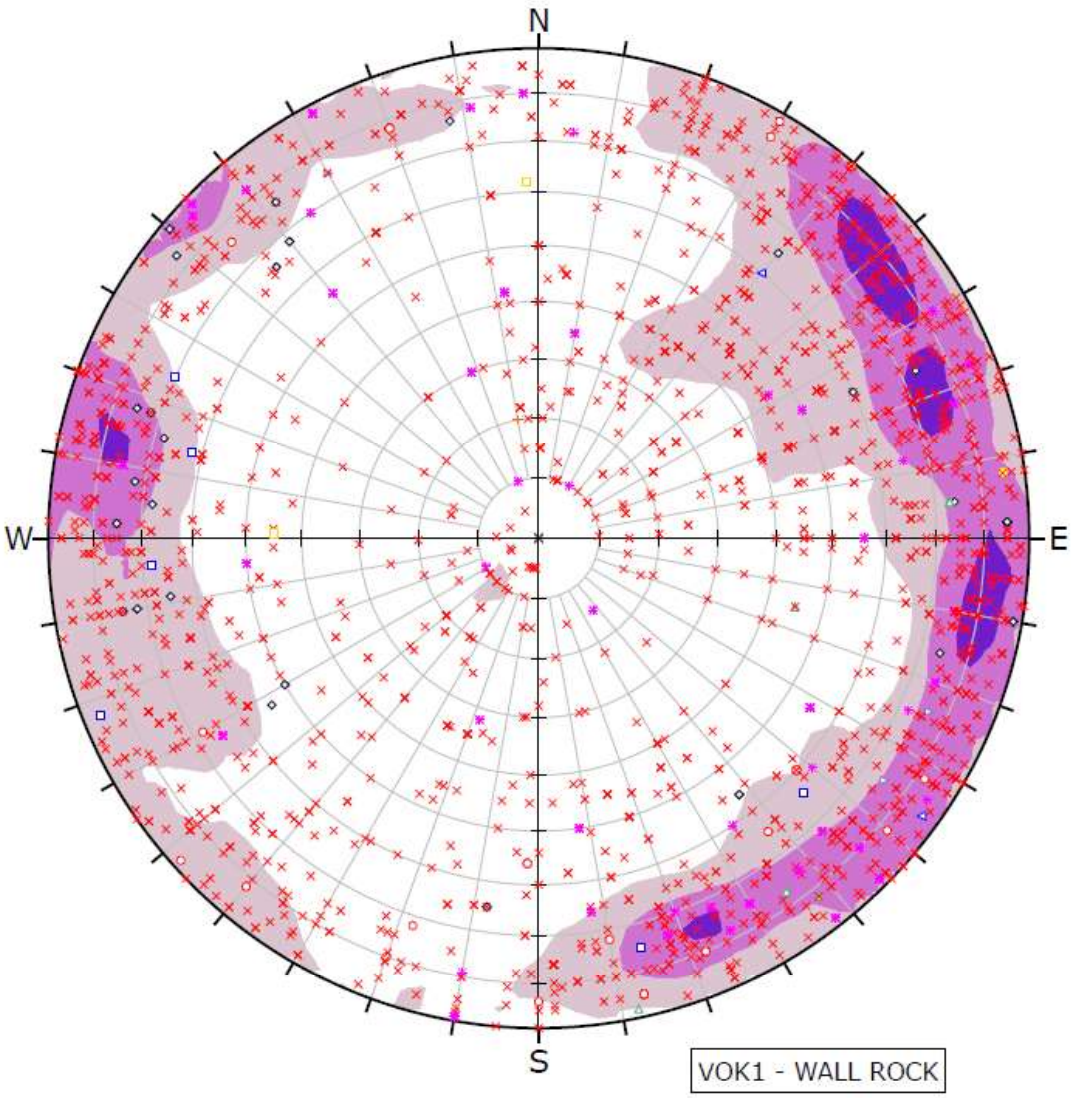
BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

PROJECT:
BRUCEJACK GOLD MINE - REVIEW OF UNDERGROUND GEOTECHNICAL UNITS AND STRUCTURAL DOMAINS FOR 2019 NI 43-101 UPDATE

TITLE:
DISTRIBUTION OF RMR ('76) and Q' BY GEOTECHNICAL UNIT

CLIENT:	PROJECT No.:	DWG No.:	REV.:
PRETIUM RESOURCES INC.	1008-033	A-1	

APPENDIX B
STRUCTURAL DOMAIN STEREONETS



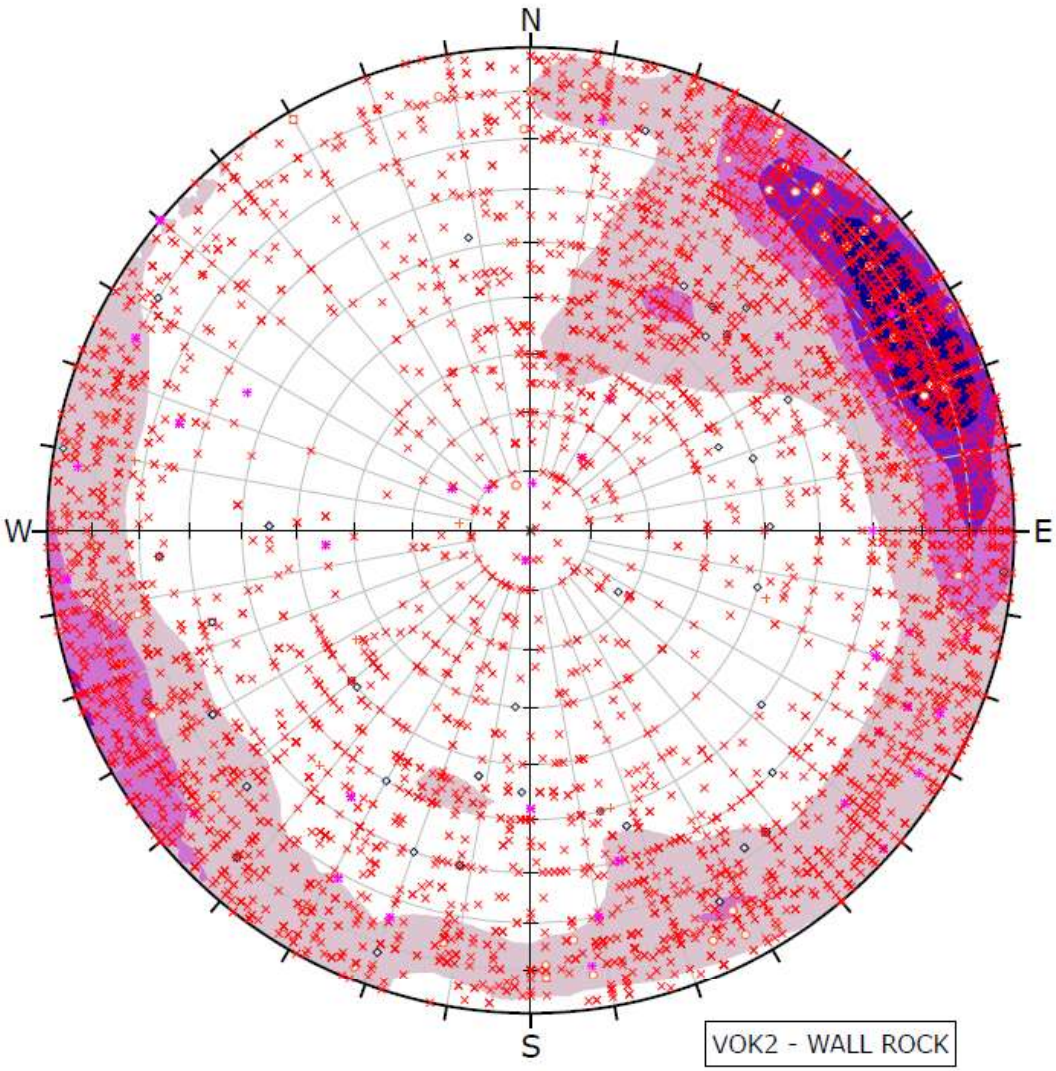
Symbol	STRUCTURE	Quantity
◇	Bedding	99
□	Contact	6
△	FZG	9
+	FZG/Shear_Plane	1
×	Fault	1764
□	Fold_Hinge	5
◁	Fold_Limb	4
○	Foliation	69
▷	Foliation/Cleavage	3
*	Joint	192
	Others	3

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 <

Contour Data	Pole Vectors
Maximum Density	3.44%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	2155 (2155 Entries)
Hemisphere	Lower
Projection	Equal Area

Figure 1 Equal area lower hemisphere stereonet – VOK1 Wall Rock



Symbol	STRUCTURE	Quantity
◇	Bedding	75
×	FAULT	1
+	FZG	27
+	FZG/Shear_Plane	16
×	Faault	1
×	Fault	4588
○	Foliation	54
○	Foliation/Cleavage	28
*	Joint	71
×	fault	6
	Others	43

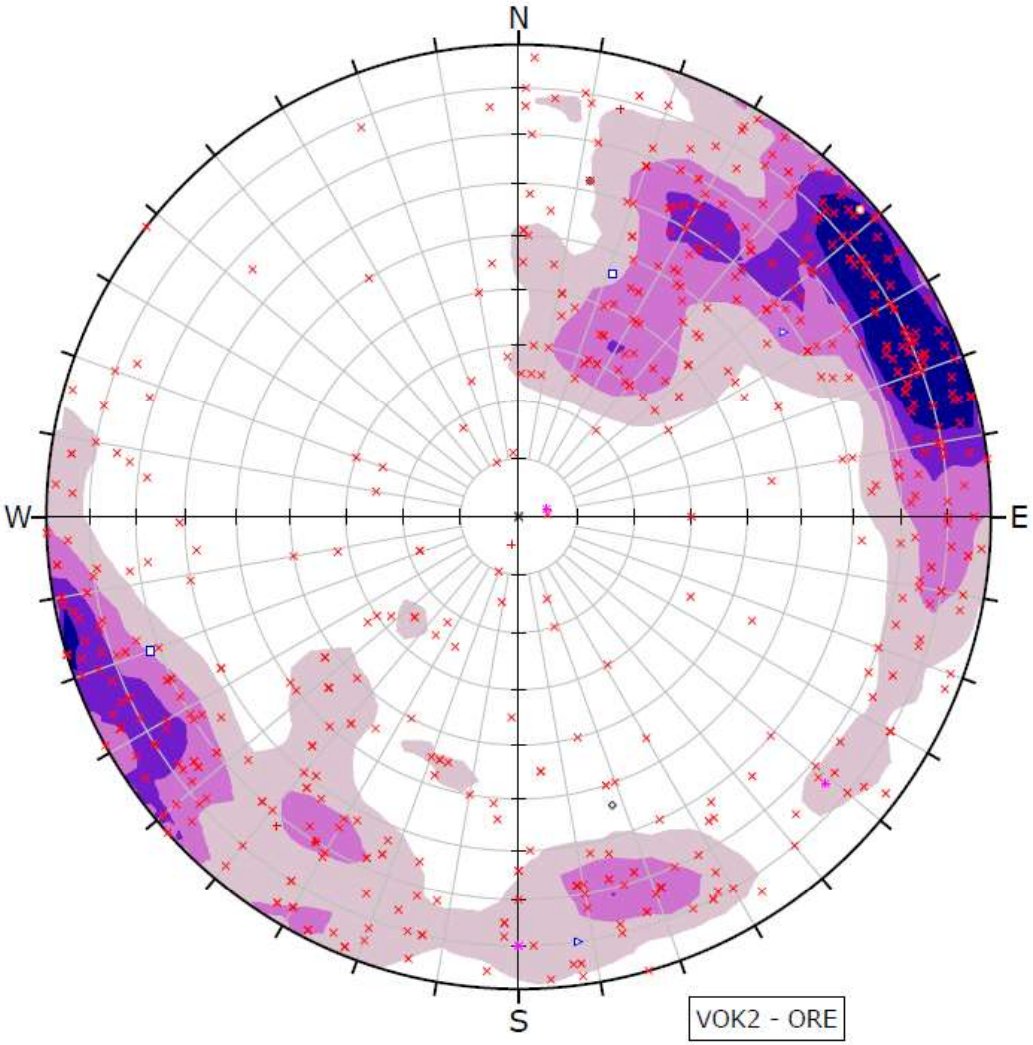
Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 <

Contour Data	Pole Vectors
Maximum Density	5.82%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	4910 (4910 Entries)
Hemisphere	Lower
Projection	Equal Area

Too many entries for grid intersections

Figure 2 Equal area lower hemisphere stereonet – VOK2 Wall Rock



Symbol	STRUCTURE	Quantity
◇	Bedding	2
□	Contact	2
+	FZG/Shear_Plane	5
×	Fault	569
○	Foliation	1
▷	Foliation/Cleavage	2
✱	Joint	4
×	fault	1
	Others	3

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 <

Contour Data	Pole Vectors
Maximum Density	6.95%
Contour Distribution	Fisher
Counting Circle Size	1.0%

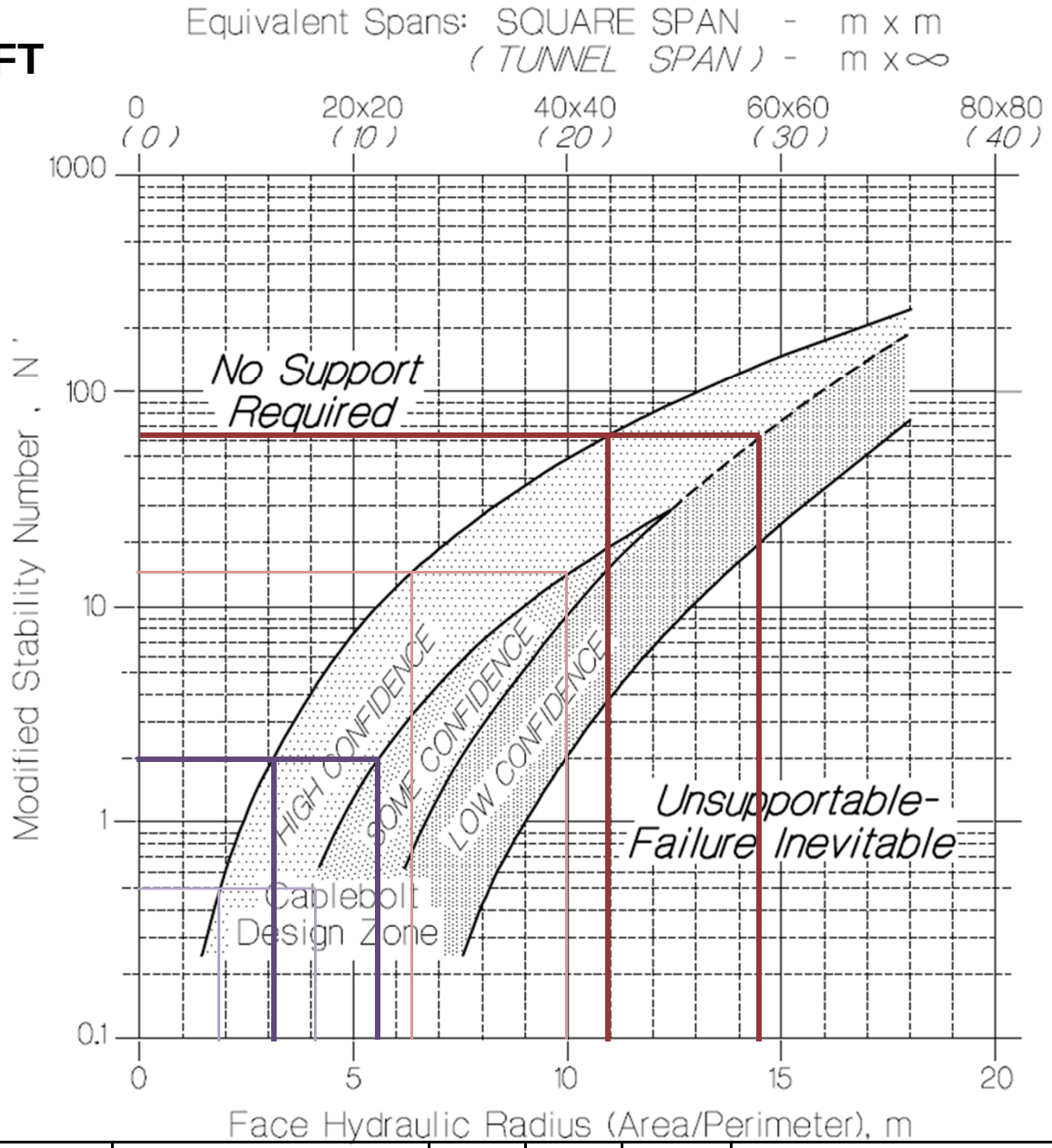
Plot Mode	Pole Vectors
Vector Count	589 (589 Entries)
Hemisphere	Lower
Projection	Equal Area

Figure 3 Equal area lower hemisphere stereonet – VOK2 Ore

Appendix I

Stope Stability and Support Assessment & Stope Design Review

DRAFT



MATHEW'S METHOD PARAMETERS	Q'		A	B	C	N'	
	CONSERVATIVE	BASE				CONSERVATIVE	BASE
BACK	10	40	0.12	0.2	2	0.5	2.0
HANGINGWALL	10	40	1.00	0.2	8	16.0	64.0

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 400 m, 78°, AND 30 m x 30 m x 13 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.
2. THIS CHART DOES NOT APPLY TO WEATHERED OR FAULTED ROCK. STOPES IN WEATHERED OR FAULTED ROCK SHOULD BE ASSESSED ON A CASE-BY-CASE BASIS.

HYDRAULIC RADIUS	UNSUPPORTED		SUPPORTED	
	LOW	HIGH	LOW	HIGH
BACK	1.9	3.1	4.1	5.6
HANGINGWALL	6.2	11	10	14.5

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
STOPE DESIGNS USING THE STABILITY GRAPH METHOD

CLIENT: PRETIUM RESOURCES INC.

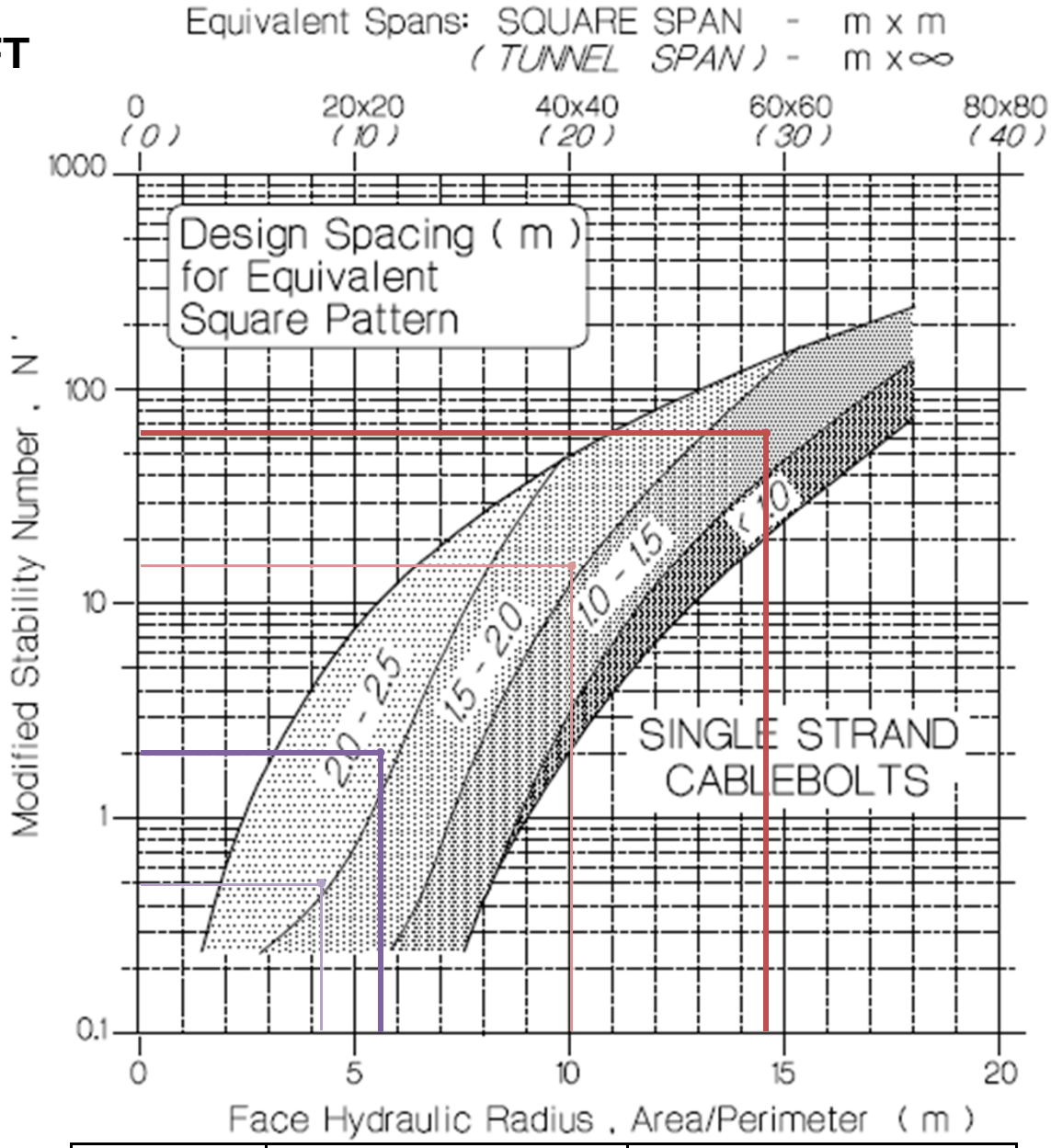
PROJECT No.: 1008-007-002

FIGURE No.: I-01

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\06 STOPES - STABILITY GRAPH METHOD\STABILITY CHARTS

TO BE READ WITH REPORT TITLED "BRUCEJACK PROJECT FEASIBILITY STUDY – UNDERGROUND ROCK MECHANICS ASSESSMENT" DATED APRIL 2013

DRAFT



CABLEBOLT SPACING	CONSERVATIVE CASE			BASE CASE		
	N'	HR	BOLT SPACING (m)	N'	HR	BOLT SPACING (m)
BACK	0.5	4.1	2.0 m – 2.5 m	2.0	5.6	2.0 m – 2.5 m
HANGINGWALL	16.0	10.0	1.5 m - 2.0 m	64.0	14.5	1.0 m x 1.5 m

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 400 m, 78°, AND 30 m x 30 m x 13 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.
2. SPECIFIED CABLEBOLT SPACING IS FOR A SQUARE PATTERN.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
STOPE CABLEBOLT SPACING

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-02

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\06 STOPES - STABILITY GRAPH METHOD\STABILITY CHARTS

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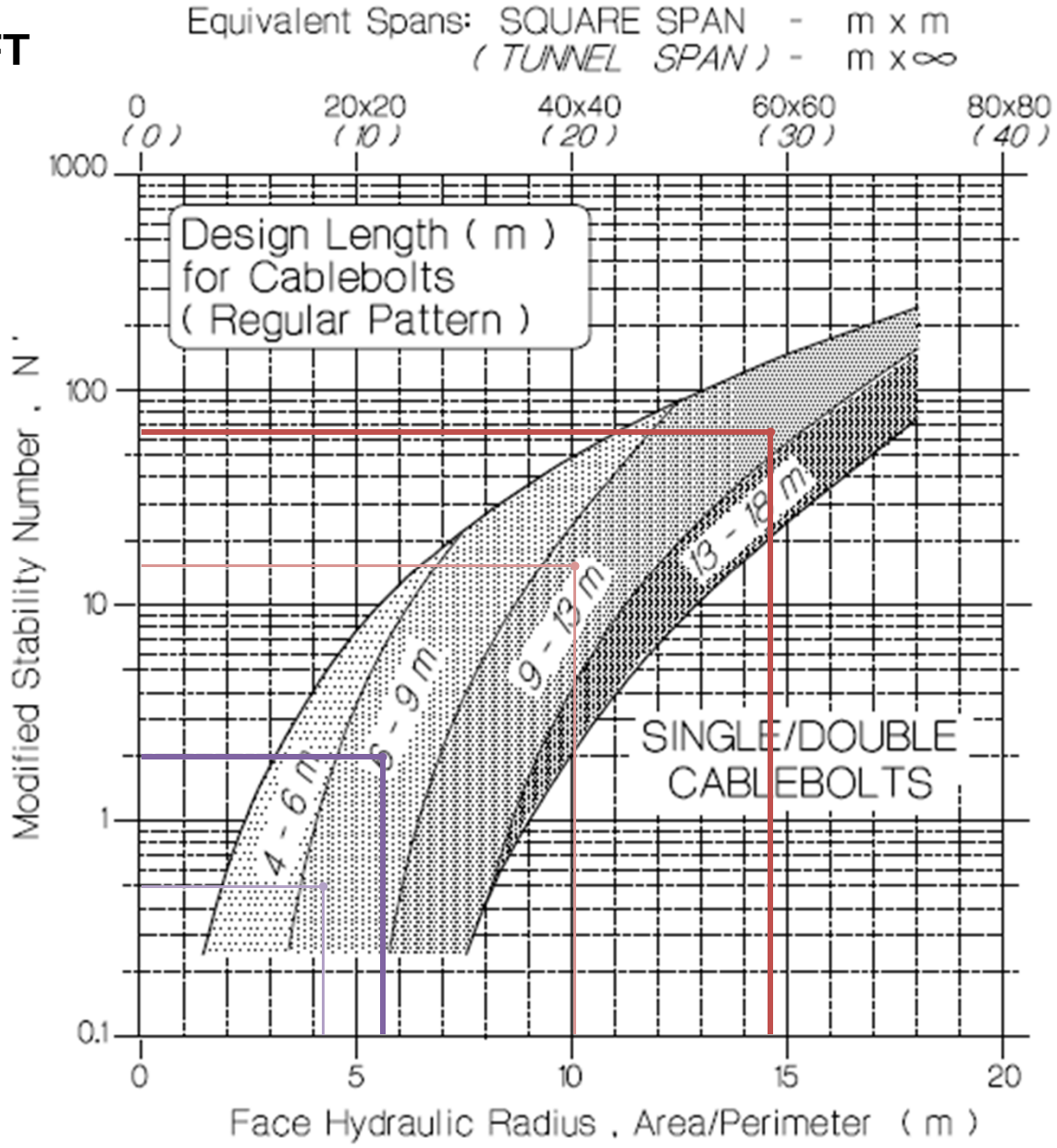

CABLEBOLT LENGTH	CONSERVATIVE CASE			BASE CASE		
	N'	HR	BOLT LENGTH (m)	N'	HR	BOLT LENGTH (m)
BACK	0.5	4.1	6.0 m – 9.0 m	2.0	5.6	6.0 m – 9.0 m
HANGINGWALL	16.0	10.0	9.0 m – 13.0 m	64.0	14.5	9.0 m – 13.0 m

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 400 m, 78°, AND 30 m x 30 m x 13 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.
2. THIS CHART DOES NOT APPLY TO WEATHERED OR FAULTED ROCK. STOPES IN WEATHERED OR FAULTED ROCK SHOULD BE ASSESSED ON A CASE-BY-CASE BASIS.

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AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
STOPE CABLEBOLT LENGTH

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-03

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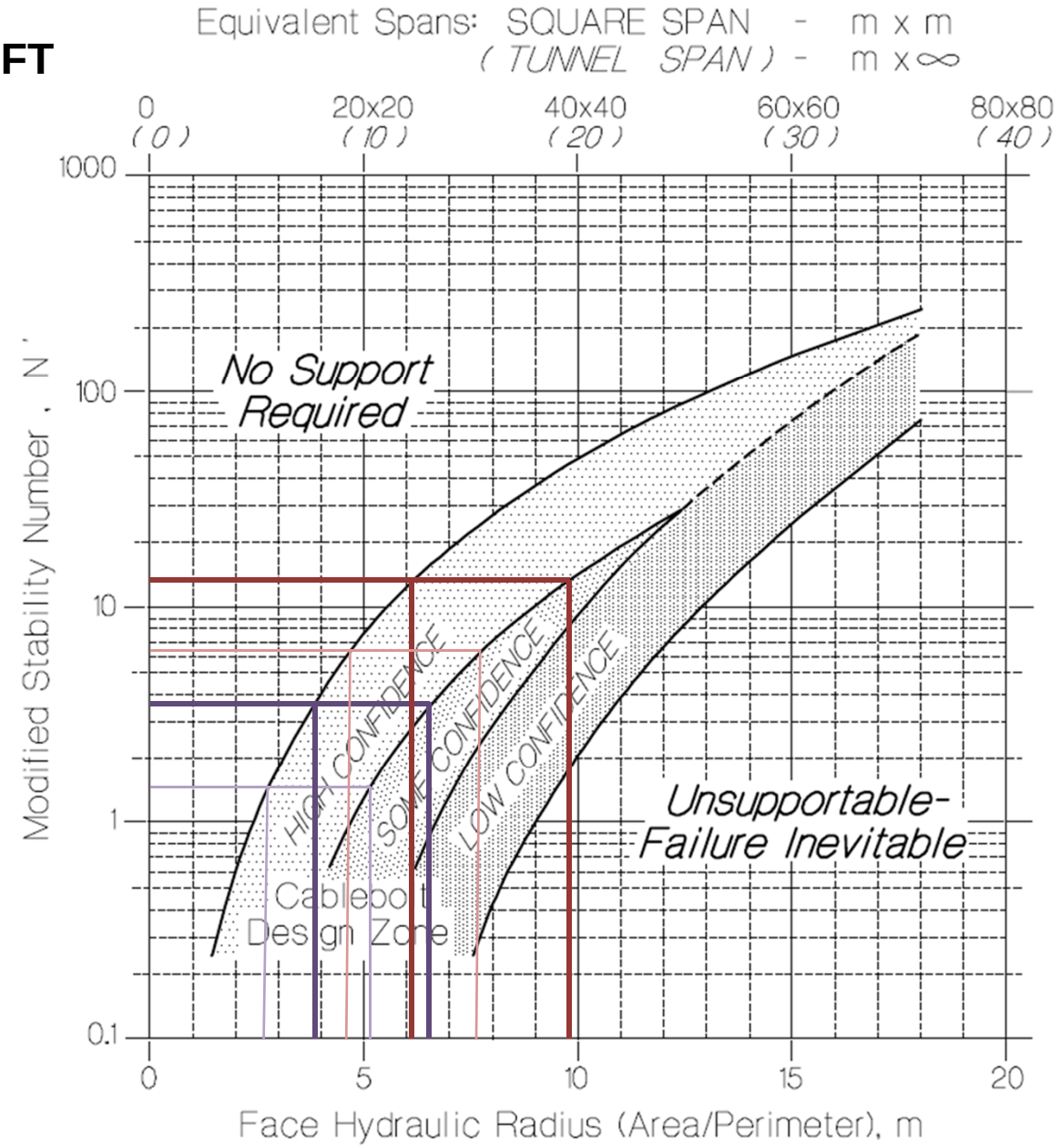

MATHEW'S METHOD PARAMETERS	Q'		A	B	C	N'	
	CONSERVATIVE	BASE				CONSERVATIVE	BASE
BACK	4	9	1.00	0.2	2	1.6	3.6
HANGINGWALL	4	9	1.00	0.2	8	6.4	14.4

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 30 m, 68°, AND 30 m x 30 m x 12 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.

HYDRAULIC RADIUS	UNSUPPORTED		SUPPORTED	
	LOW	HIGH	LOW	HIGH
BACK	2.7	3.9	5.1	6.5
HANGINGWALL	4.6	6.1	7.6	9.9

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REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
WEST ZONE WEATHERED ROCK STOPE DESIGNS USING THE STABILITY GRAPH METHOD

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-07

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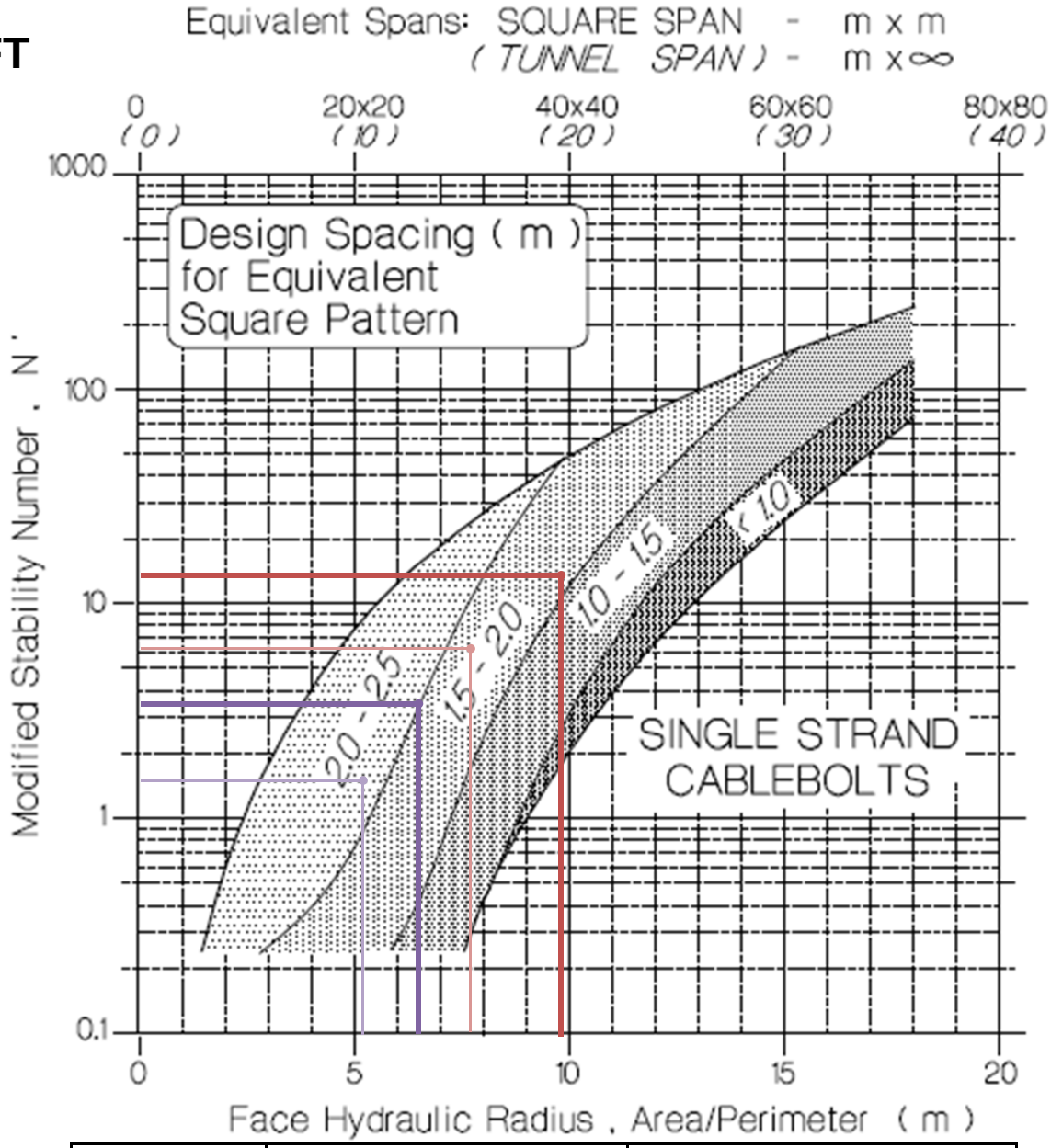

CABLEBOLT SPACING	CONSERVATIVE CASE			BASE CASE		
	N'	HR	BOLT SPACING (m)	N'	HR	BOLT SPACING (m)
BACK	1.6	5.1	2.0 m – 2.5 m	3.6	6.5	2.0 m – 2.5 m
HANGINGWALL	6.4	7.6	1.5 m – 2.0 m	14.4	9.9	1.5 m – 2.0 m

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 30 m, 68°, AND 30 m x 30 m x 12 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.
2. SPECIFIED CABLEBOLT SPACING IS FOR A SQUARE PATTERN.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
WEST ZONE WEATHERED ROCK STOPE CABLEBOLT SPACING

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-08

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\06 STOPES - STABILITY GRAPH METHOD\STABILITY CHARTS

TO BE READ WITH REPORT TITLED "BRUCEJACK PROJECT FEASIBILITY STUDY – UNDERGROUND ROCK MECHANICS ASSESSMENT" DATED APRIL 2013

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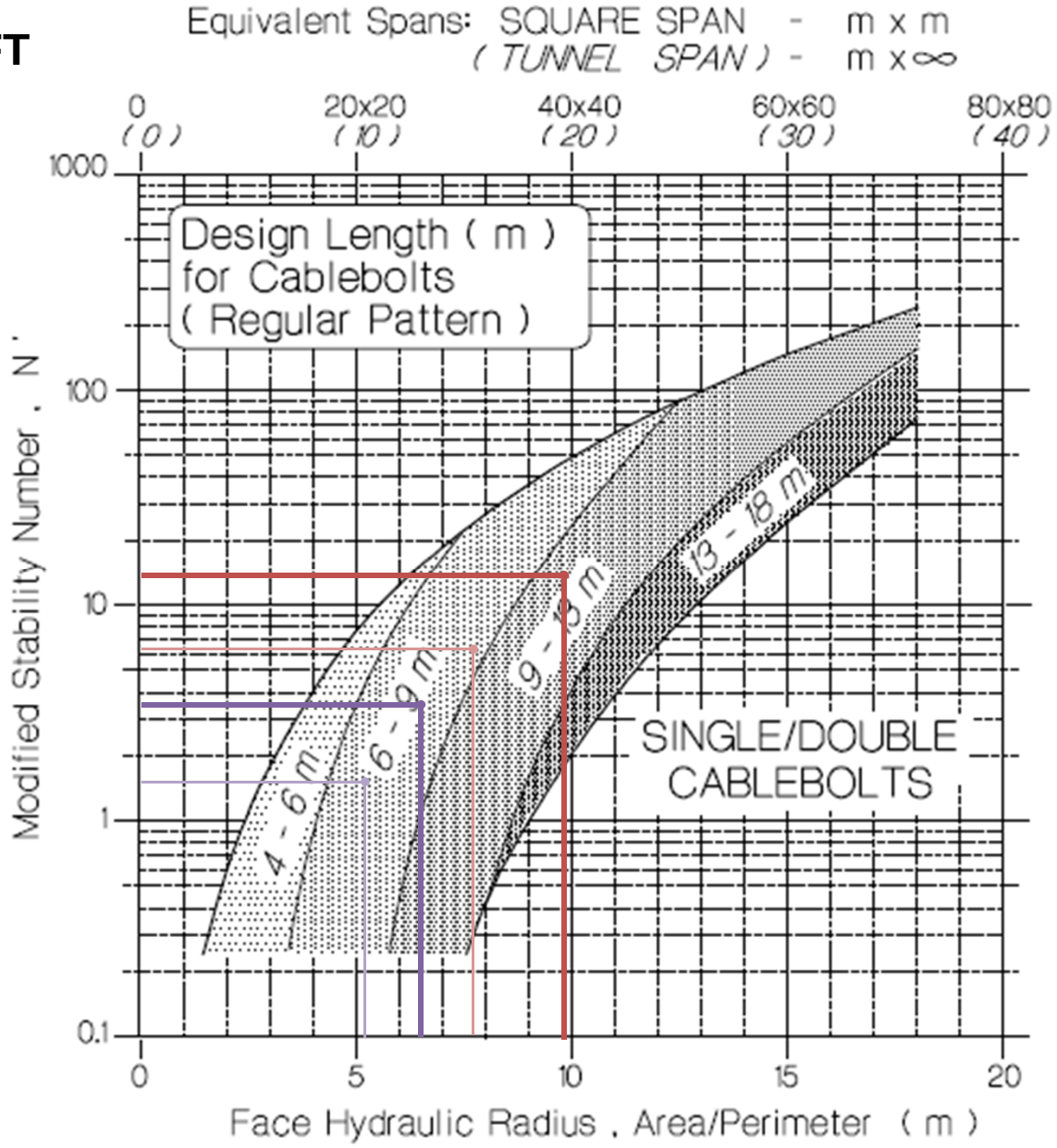

CABLEBOLT LENGTH	CONSERVATIVE CASE			BASE CASE		
	N'	HR	BOLT LENGTH (m)	N'	HR	BOLT LENGTH (m)
BACK	1.6	5.1	6.0 m – 9.0 m	3.6	6.5	6.0 m – 9.0 m
HANGINGWALL	6.4	7.6	6.0 m – 9.0 m	14.4	9.9	9.0 m – 13.0 m

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 30 m, 68°, AND 30 m x 30 m x 12 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
WEST ZONE WEATHERED ROCK STOPE CABLEBOLT LENGTH

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-09

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\06 STOPES - STABILITY GRAPH METHOD\STABILITY CHARTS

TO BE READ WITH REPORT TITLED "BRUCEJACK PROJECT FEASIBILITY STUDY – UNDERGROUND ROCK MECHANICS ASSESSMENT" DATED APRIL 2013

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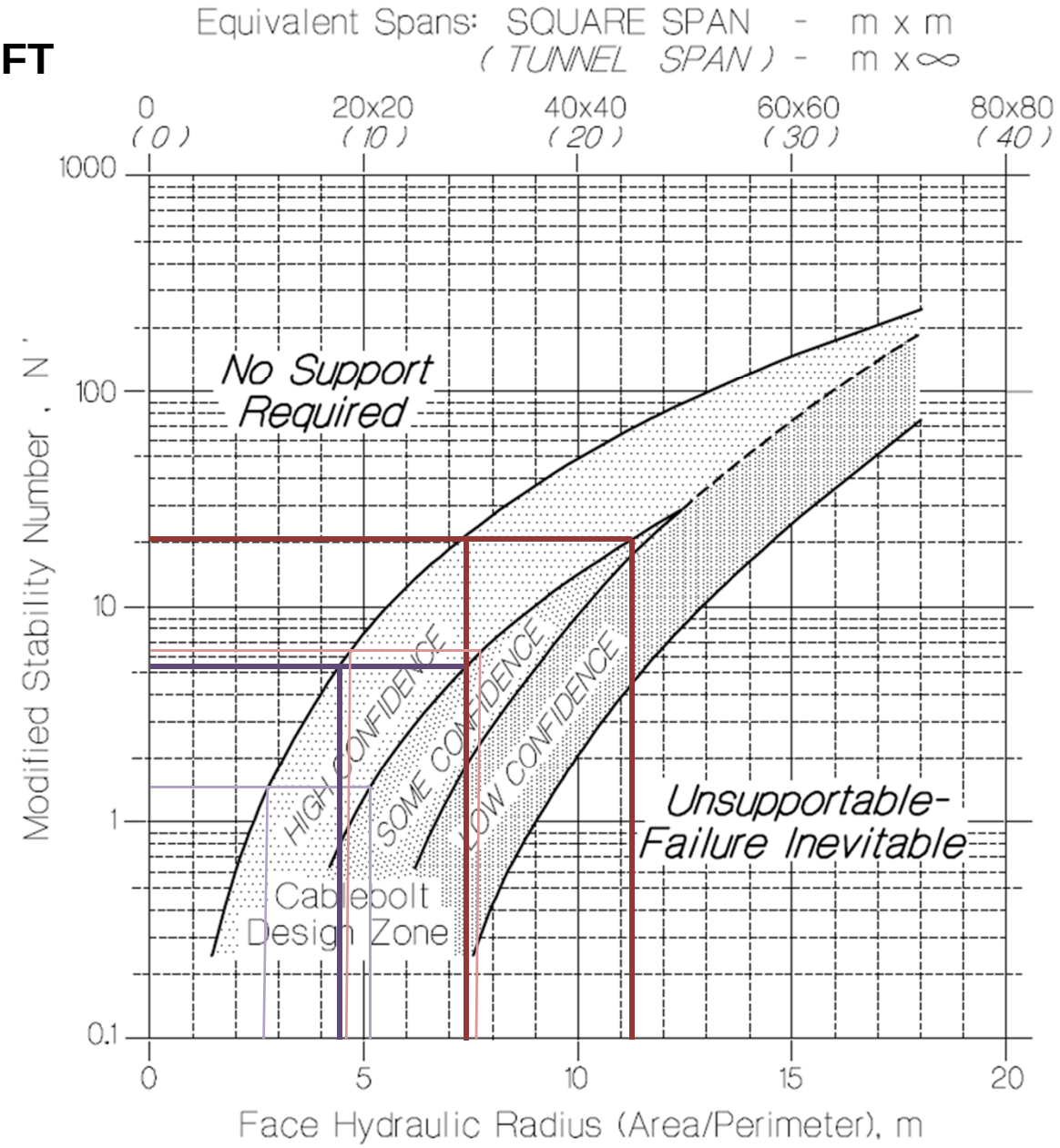

MATHEW'S METHOD PARAMETERS	Q'		A	B	C	N'	
	CONSERVATIVE	BASE				CONSERVATIVE	BASE
BACK	4	13	1.00	0.2	2	1.6	5.2
HANGINGWALL	4	13	1.00	0.2	8	6.4	20.8

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 30 m, 78°, AND 30 m x 30 m x 25 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.

HYDRAULIC RADIUS	UNSUPPORTED		SUPPORTED	
	LOW	HIGH	LOW	HIGH
BACK	2.7	4.4	5.1	7.4
HANGINGWALL	4.5	7.4	7.6	11.2

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
VALLEY OF KINGS WEATHERED ROCK STOPE DESIGNS
USING THE STABILITY GRAPH METHOD

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-10

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TO BE READ WITH REPORT TITLED "BRUCEJACK PROJECT FEASIBILITY STUDY – UNDERGROUND ROCK MECHANICS ASSESSMENT" DATED APRIL 2013

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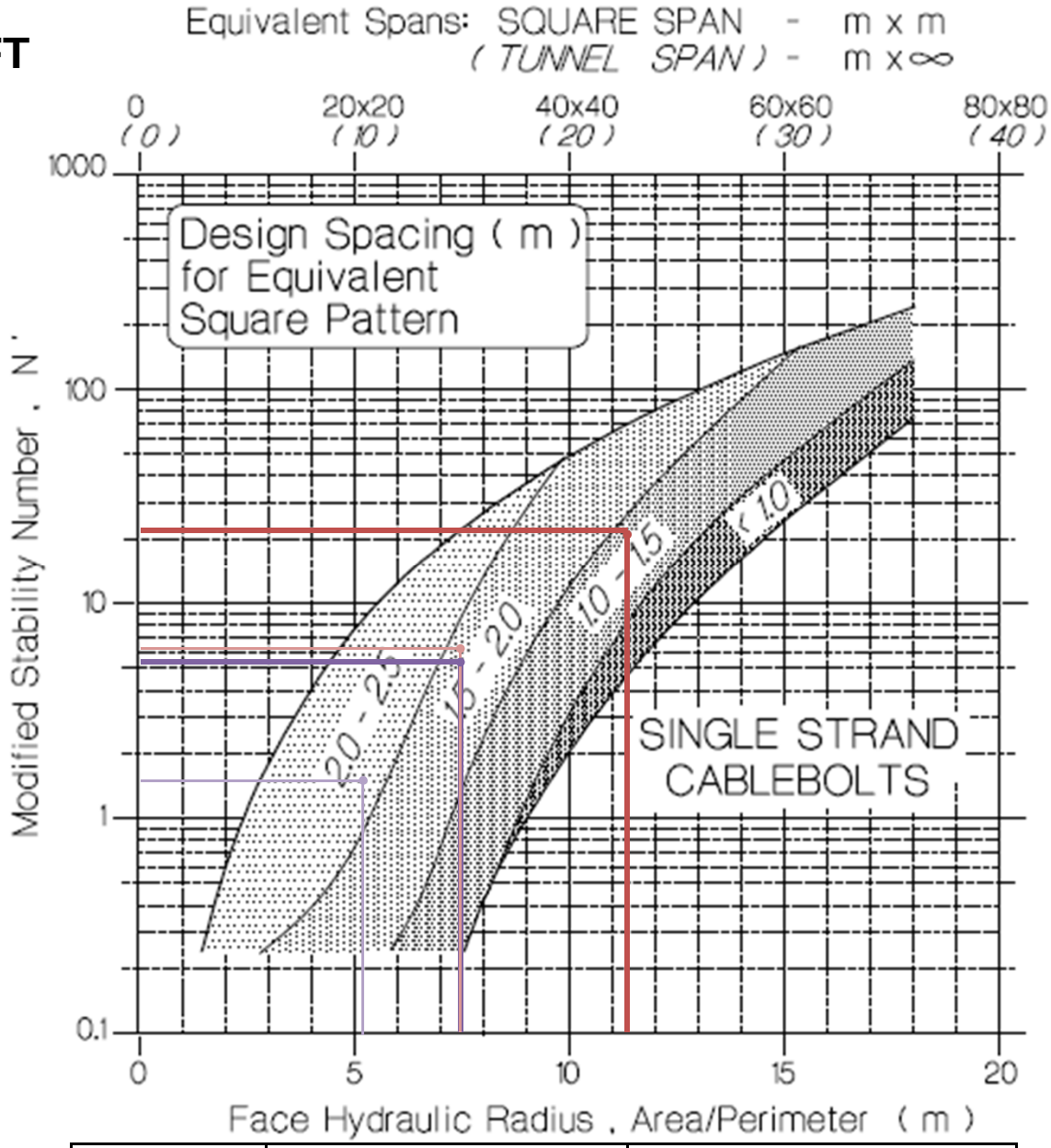


CABLEBOLT SPACING	CONSERVATIVE CASE			BASE CASE		
	N'	HR	BOLT SPACING (m)	N'	HR	BOLT SPACING (m)
BACK	1.6	5.1	2.0 m – 2.5 m	5.2	7.4	1.5 m – 2.0 m
HANGINGWALL	6.4	7.4	1.5 m – 2.0 m	20.8	11.2	1.0 m – 1.5 m

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 30 m, 78°, AND 30 m x 30 m x 25 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.
2. SPECIFIED CABLEBOLT SPACING IS FOR A SQUARE PATTERN.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
VALLEY OF KINGS WEATHERED ROCK STOPE CABLEBOLT SPACING

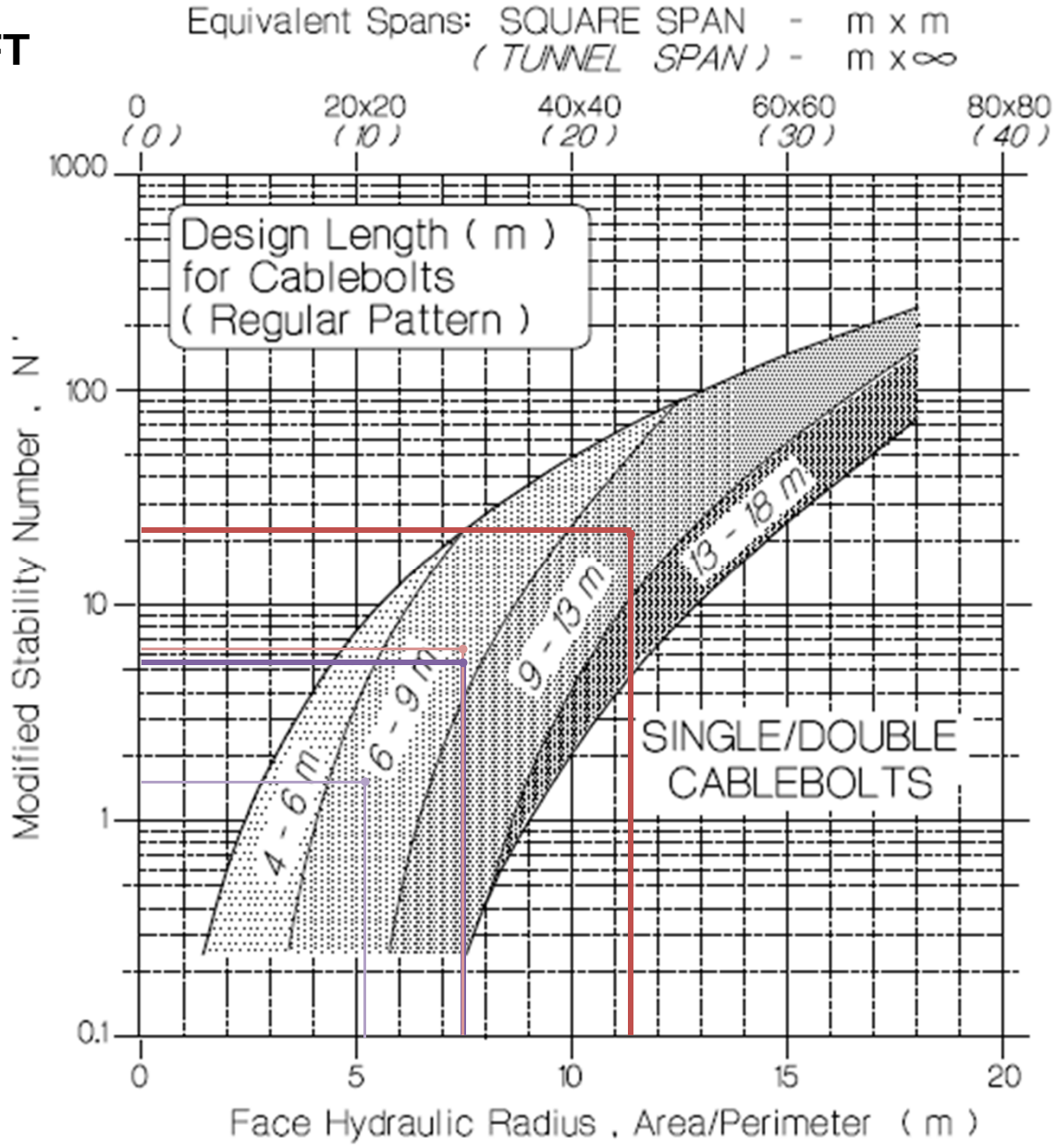
CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-11

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\06 STOPES - STABILITY GRAPH METHOD\STABILITY CHARTS

DRAFT



CABLEBOLT LENGTH	CONSERVATIVE CASE			BASE CASE		
	N'	HR	BOLT LENGTH (m)	N'	HR	BOLT LENGTH (m)
BACK	1.6	5.1	6.0 m – 9.0 m	5.2	7.4	6.0 m – 9.0 m
HANGINGWALL	6.4	7.4	6.0 m – 9.0 m	20.8	11.2	9.0 m – 13.0 m

NOTES:

1. STOPE DEPTH, INCLINATION, AND DIMENSIONS OF 30 m, 78°, AND 30 m x 30 m x 25 m RESPECTIVELY WERE ASSUMED FOR DESIGN AND MEASURED FROM A REPRESENTATIVE STOPE IN THE PEA MINE PLAN PROVIDED BY AMC ON MARCH 18, 2012.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENTS

FIGURE TITLE:
VALLEY OF KINGS WEATHERED ROCK STOPE CABLEBOLT LENGTH

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: I-12

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\06 STOPES - STABILITY GRAPH METHOD\STABILITY CHARTS

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY
Suite 500 - 980 Howe Street
Vancouver, BC Canada V6Z 0C8
Telephone (604) 684-5900
Fax (604) 684-5909

January 30, 2018
Project No.: 1008027

Mr. Lyle Morgenthaler, P.Eng.
Brucejack Project
Pretium Resources Inc.
Suite 2300, Four Bentall Centre, 1055 Dunsmuir St.
Vancouver, B.C. V7X 1L4

Dear Lyle,

Re: Brucejack Project - Review and Update of Stope Designs – FINAL

Pretium Resources Inc. (Pretium) requested that BGC Engineering Inc. (BGC) review and update the mining geotechnics and stopes designs included in the Brucejack Project's (Brucejack) Feasibility Study (FS) (BGC, 2013). The current work is carried out per Pretium PO 1024802.

The scope of work for the mining geotechnics and stope designs update includes:

- A review of Pretium's current geotechnical model, mine-scale fault model, and underground drilling and mapping data collected since 2013.
- A review and update of the FS geotechnical units and structural domains.
- A review and update of the FS stope stability assessments, using empirical methods and preliminary numerical modelling.
- Determination of ground support recommendations for enlarged stopes.
- A summary memo including updated stope designs and related geotechnical guidance.

BGC did not complete a site visit as part of the work; geotechnical conditions and related design inputs used in the following analyses require field confirmation.

1.0 SUMMARY OF FS GEOTECHNICS AND STOPE DESIGNS

For the FS, BGC developed design recommendations for stope backs and walls using the empirical "Stability Graph" method (Hutchinson and Diederichs, 1996, and Nickson, 1992, after Potvin et al., 1988).

Geotechnical and stope geometry parameters are combined to determine a "Stability Number" (N'), defined by:

$$N' = Q' \times A \times B \times C$$

Where:

Q' is a rock mass classification parameter

A is a measure of the ratio of intact rock strength to applied stress

B is a measure of the relative orientation of dominant structure with respect to the excavation surface

C is a measure of the influence of gravity on the stability of the face being considered.

Conservative and base case Q' values of 10 and 40 respectively were used in combination with conservative A, B, and C inputs to calculate permissible stoping dimensions (hydraulic radii).

Statistical observations of the Brucejack dataset indicated that regardless of lithology, alteration, geological domain, or geotechnical unit, less than 20% of mapped or logged data had a Q' value less than 10, and greater than 50% of the rock had a Q' value of 40 or more.

Stability Graph inputs used in the FS are summarized in Table 1, below. The resulting FS stope designs are summarized in Table 2.

Table 1. Stability Graph Assumptions For FS Stope Designs

Parameter	Value in FS	FS Design Assumption
Q' (base case)	40 (all fresh rock)	Median
Q' (conservative case)	10 (all fresh rock)	Lower quartile
A	0.12 (back) 1.0 (walls)	Assume induced stresses concentrate above & adjacent to backs; Walls are generally destressed.
B	0.2 (back, walls)	Conservative assumption based on structural variability in all domains
C	2 (backs) 8 (walls)	Defined based on critical discontinuity set assuming horizontal structure in back and vertical structure in walls.

Table 2. FS Stope Design Summary

Stope Face	N' (conservative)	N' (base case)	Unsupported Hydraulic Radius (conservative)	Unsupported Hydraulic Radius (base case)
Back	0.5	2.0	1.9	3.1
Hangingwall	16.0	64.0	6.2	11.0

Pretium mine planners used these criteria to determine mining shapes for the FS, primarily resulting in transverse stopes 30 m high, 15 m wide (parallel to mineralization strike), and 20 m deep (ore width).

2.0 REVIEW AND UPDATE OF STOPE DESIGNS

This section summarizes recent data and related revisions to the geotechnical units and structural domains, revised stability graph inputs, and resulting updated empirical stope designs. Preliminary numerical modelling was completed to further investigate and confirm the results of the empirical assessment, and those results are also summarized below.

2.1. New Data

Pretium provided the following data for the design updates, which became available after the FS stope designs were completed:

- 2016 underground exploration drilling program core logging data (drill hole collars VU-409 to VU-752) (XLS format)
- 2017 geological model update (DXF format)
- 2017 structural model update (DXF format)
- All available underground mapping data (DXF and CSV format)
- Multi-point borehole extensometer (MPBX) readings from 1350-16, 1350-20, and 1350-28 (XLS format)
- October 2017 mine as-built (DXF format)
- 2017 mine development plan (DXF format)

All of the above data were developed by Pretium. Pretium also verbally reported to BGC that all five stopes developed to date (all within the upper mining levels) had been performing adequately.

2.2. Revised Geotechnical Units and Structural Domains

Geotechnical core logging data from the 2016 underground drilling program was converted by BGC into Q' values using the industry-standard equation:

$$Q' = e^{(RMR_{76}-44)/9}$$

Per the FS, lithology was used as a basis to sort this data into geotechnical units (VOK-D1, -D2, -D3, -FZ). Updated cumulative frequency graphs including the FS and 2016 data are presented in Appendix A. Faulted rock is not included in the current assessment, as stope designs within large fault zones require detailed assessment on a case-by-case basis.

From analyses of this data, Geotechnical Unit 1 and Geotechnical Unit 2 have been updated from the FS, as follows:

- Geotechnical Unit 1: 10 < Q' < 50 ("average" rock mass)
- Geotechnical Unit 2: 3 < Q' < 10 ("poor" rock mass)

Recent geologic mapping data provided by Pretium has been used to update design stereonets for structural domains VOK 1 and VOK 2. No geologic structures were mapped in VOK 3. The design discontinuity sets were ranked according to pole concentrations and association with major structures to define the critical discontinuity sets for design. Updated design stereonets for VOK 1 and VOK 2 are presented in Appendix A. Design stereonets for VOK 3 and the WZ, where no new data was collected, are available in the FS report (BGC, 2013).

2.3. Stope Design Update

The revised geotechnical units and structural domains were used to update the inputs to the Stability Graph method, as summarized in Table 3. The resulting permissible stope designs, presented as unsupported and supported cases for a given rock mass quality range, allow Pretium flexibility in their stope designs relative to rock mass quality and operational considerations such as ore geometry and ease of support (cable bolt) installation. Based on a review of the mine plan provided by Pretium, it has been assumed that the base-case stope orientation is a transverse stope orientation with a hangingwall orientation of approximately 140/80 (dip direction/dip).

Table 3. Stability Graph Assumptions For Current Work

Parameter	Value	Design Assumption
Q’	10 – 50	Geotechnical Unit 1
Q’	3 - 10	Geotechnical Unit 2
A	0.1 (back) 1.0 (walls)	Assume induced stress concentrates in back and that the walls are destressed.
B	0.3 (walls) 0.6 (back)	Based on weighted average structural variability in all domains
C	2 (backs) 4 (walls)	Defined based on critical discontinuity set assuming horizontal structure in back and adversely oriented sliding structure in walls.

The resulting Stability Graphs and stope dimension design tables for Domain 1 and Domain 2 are presented in Appendix B. The FS designs were derived based on lower quartile rock mass quality assumptions. The design recommendations presented in this report assume median rock mass quality, and that the more common geologic structures associated with large-scale faults and shears are more likely to cause stope instability. The updated designs suggest:

- Unsupported stope heights of up to 60 m may be achievable, dependent on rock mass quality as shown in Appendix B, and on the presence of persistent and closely spaced adversely-oriented discontinuities. The risk of rock fall and stope dilution increases as stope height increases. Therefore, at 60 m stope heights, Pretium should anticipate a requirement for cable-bolting of the hangingwalls and end walls to mitigate structurally-

controlled failures, where accessible and practical (i.e. on 30 m sublevels, for instance). Paste stability at these dimensions has not been assessed for this study.

  - According to feedback from Pretium, stope heights exceeding 30 m may not be practicable due to existing mine development.

- Achievable stope widths and lengths will be largely governed by the stability of the stope backs. The design cases presented in Appendix B indicate unsupported stope widths or lengths of 20 m may be achievable, with increased lengths in one dimension achievable with a reduction in the other.
  - According to feedback from Pretium, stope widths must be a factor of 15 m (i.e. 15 m or 30 m) due to existing mine development. Therefore, an increase in stope width may not be practicable. It has therefore been assumed the stope length will be increased preferentially over stope width. If stope width is 15 m, stope lengths of 40 to 45 m may be achievable in the upper range of Geotechnical Unit 1 (i.e. rock approaching a Q' value of 50).
- Ground support requirements will depend on the stope dimensions and rock mass quality in the production areas. For ground support costing purposes, for a 'base case' stope 30 m x 15 m x 40 m (height x width x length), it can be reasonably assumed that approximately 10% of exposed walls and backs will likely require a minimum cablebolt density of ~0.25 bolts/m^2 in the hangingwall, and ~0.30 bolts/m^2 in the back. This estimate is based on the cumulative frequency charts provided in Appendix A, and will vary based on rock mass conditions in individual stopes.

Modifications to the FS designs outlined in this report provide additional flexibility in the stope designs, despite minimal observed change in the rock mass and geologic structure dataset; BGC notes that the improvements largely result from a reduction in the degree of conservatism necessarily applied to the designs at the time of the FS. Pretium should consider the above designs preliminary until the currently deployed 'mine and monitor' approach confirms the soundness of the designs. Recommendations to mitigate the increased risk are discussed in Section 3.

2.4. Preliminary Numerical Modelling Results

The results of the stope stability assessment were used to inform preliminary numerical modelling, with the objective of understanding the potential implications of the larger stope dimensions on overall mine stability (i.e. sill and rib pillar stability, effects on stability of nearby development, etc.). The reliability of the numerical models is limited due to a limited understanding of the in-situ stress conditions, and a limited amount of calibration data. However, they do support the empirical analyses for stope lengths up to 40 m, and do not indicate significant loss of ground control at stope lengths of 45 m. A summary of the model inputs, geometry, and results are presented in Appendix C, and include some runs to investigate the effect of lower rock quality and deeper stress conditions (400 m) on rock mass stability.

3.0 CONCLUSIONS AND RECOMMENDATIONS

BGC's analysis indicates that Brucejack's 'base case' stope design dimensions could be moderately increased from those reported in the FS report (BGC, 2013). However, the following items were noted by BGC:

- Due to adverse orientation of the discontinuity sets in the Brucejack rock mass, there will remain residual risk for rock fall and stope dilution. The risk increases where the discontinuities are persistent and closely spaced, and as stope dimensions increase. The existing geotechnical database is insufficient to predict where more persistent and/or closely spaced discontinuities may occur, therefore thorough geotechnical inspections and cavity monitor surveys throughout the development and production continue to be recommended.
- A revised "base case" stope design of 30 m height x 15 m width x 40 to 45 m length is supported by empirical analyses and preliminary numerical modelling, for rock in the upper range of Geotechnical Unit 1 (i.e. rock approaching a Q' value of 50) in dry conditions under moderate stress. BGC recommends that Pretium consider using this revised "base case" on a case by case basis with consideration to the interpreted rock mass quality, geologic structure, groundwater conditions, stress, and mine sequence local to the stope of interest.
- Where poorer quality rock masses and/or persistent structure(s) are encountered, customized support designs which address local conditions are required.
- Increasing the stope heights may affect not only the rock mass stability but the adjacent paste backfill stability. The stability of the paste backfill has not been assessed as part of the current study.
- Underground mining personnel will need to assess and confirm that rock mass conditions closely match the assumed conditions. Should different or atypical conditions be encountered, the designs supplied herein may not be appropriate or valid.
- The designs are valid for fresh rock only, and should not be used for stope design in weathered (near-surface) or faulted rock.
- Pretium should consider the above designs preliminary until the currently deployed mine and monitor approach confirms the robustness of the designs.

4.0 CLOSURE

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Yours sincerely,

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per:

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BRITISH COLUMBIA
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Attachment(s): Appendices

REFERENCES

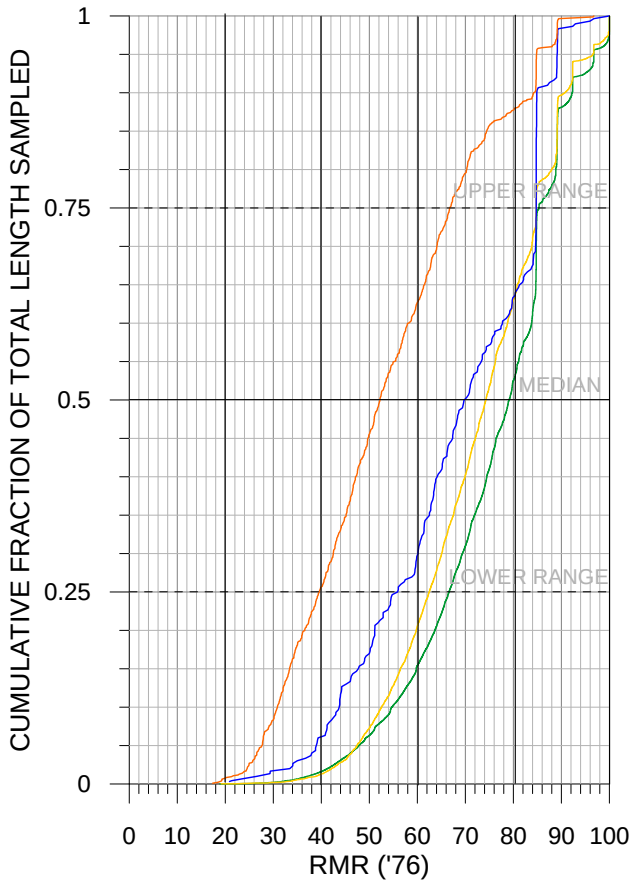
BGC Engineering Inc. 2013. Brucejack Project Feasibility Study – Underground Rock Mechanics Assessments – FINAL. Report to Pretium Resources Inc., dated May 17, 2013.

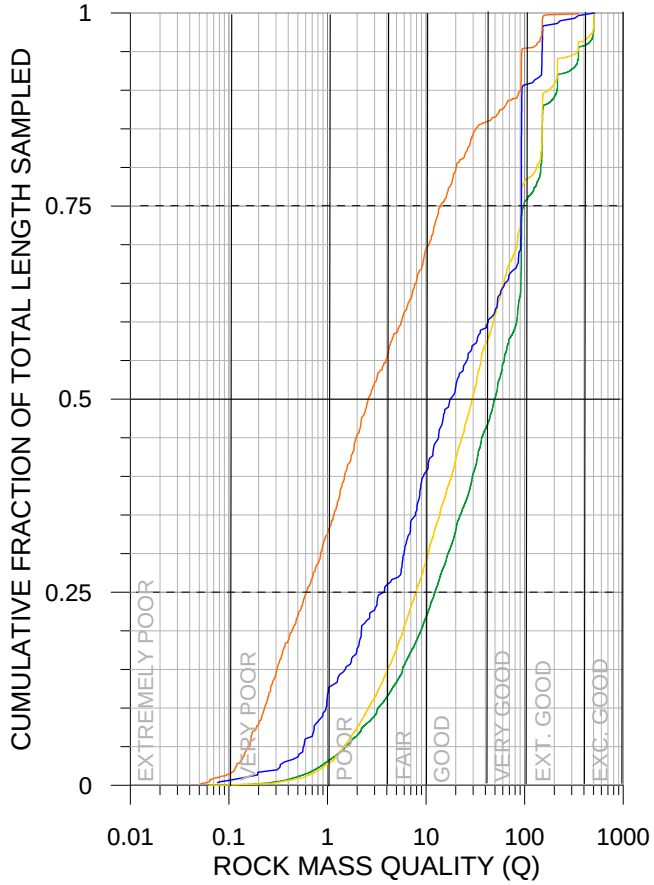
Hutchinson, D.J., and M. Diederichs. 1996. Cablebolting in Underground Mines. BiTech Publishers Ltd.

Nickson, S.D. 1992. Cable Support Guidelines for Underground Hard Rock Mine Operations. Master of Applied Science Thesis for McGill University Faculty of Graduate Studies. University of British Columbia. December 1992.

Potvin, Y, Hudyma, M., and H.D.S. Miller. 1988. The Stability Graph Method for Open Stope Design. Presented at the 90th CIM AGM, Edmonton, Alberta, May 1988.

APPENDIX A
ROCK MASS AND GEOLOGIC STRUCTURE SUMMARY





GEOTECHNICAL UNITS

- VOK FZ
- VOK D1
- VOK D2
- VOK D3

NOTES:

1. 2016 DATA SOURCES INCLUDE UNDERGROUND GEOTECHNICAL DRILL DATA COLLECTED BETWEEN 2015 - 2016. FS DATA SOURCE INCLUDE GEOTECHNICAL SITE INVESTIGATION AND EXPLORATION DRILLING PROGRAMS FROM 2010 TO 2012.
2. ROCK MASS RATING (RMR) IS DERIVED FROM STRENGTH RATING, RQD RATING, FRACTURE INTERCEPT RATING, JOINT CONDITION, AND GROUND WATER RATING (BIENIAWSKI, 1976).
3. Q' VALUES ARE CALCULATED FROM RMR ('76) USING THE FORMULA WHEN Q' VALUES COULD NOT BE DERIVED BASED ON FIRST PRINCIPLE: Q = e^((RMR - 44)/9).

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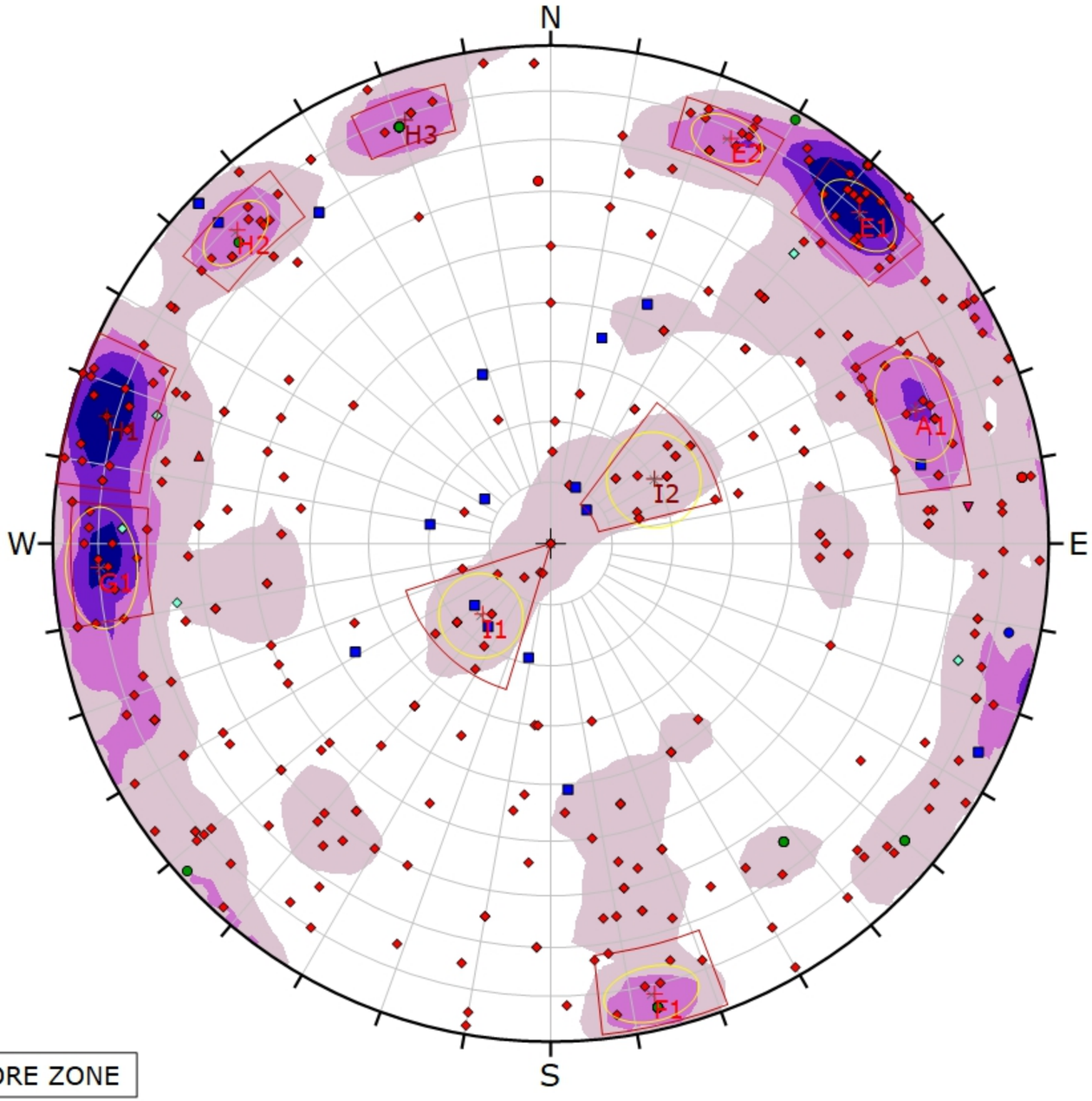
AN APPLIED EARTH SCIENCES COMPANY

PROJECT: BRUCEJACK 2017 STOPE OPTIMIZATION

TITLE: DISTRIBUTION OF RMR ('76) and Q BY GEOTECHNICAL UNIT

CLIENT:	PROJECT No.:	DWG No.:	REV.:
PRETIUM RESOURCES INC.	1008-027		



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▼	FG	2
●	FO	4
■	J	21
●	JV	1
●	O	36

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	2.00 - 3.00
	3.00 - 4.00
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Contour Distribution	Fisher
Counting Circle Size	1.0%

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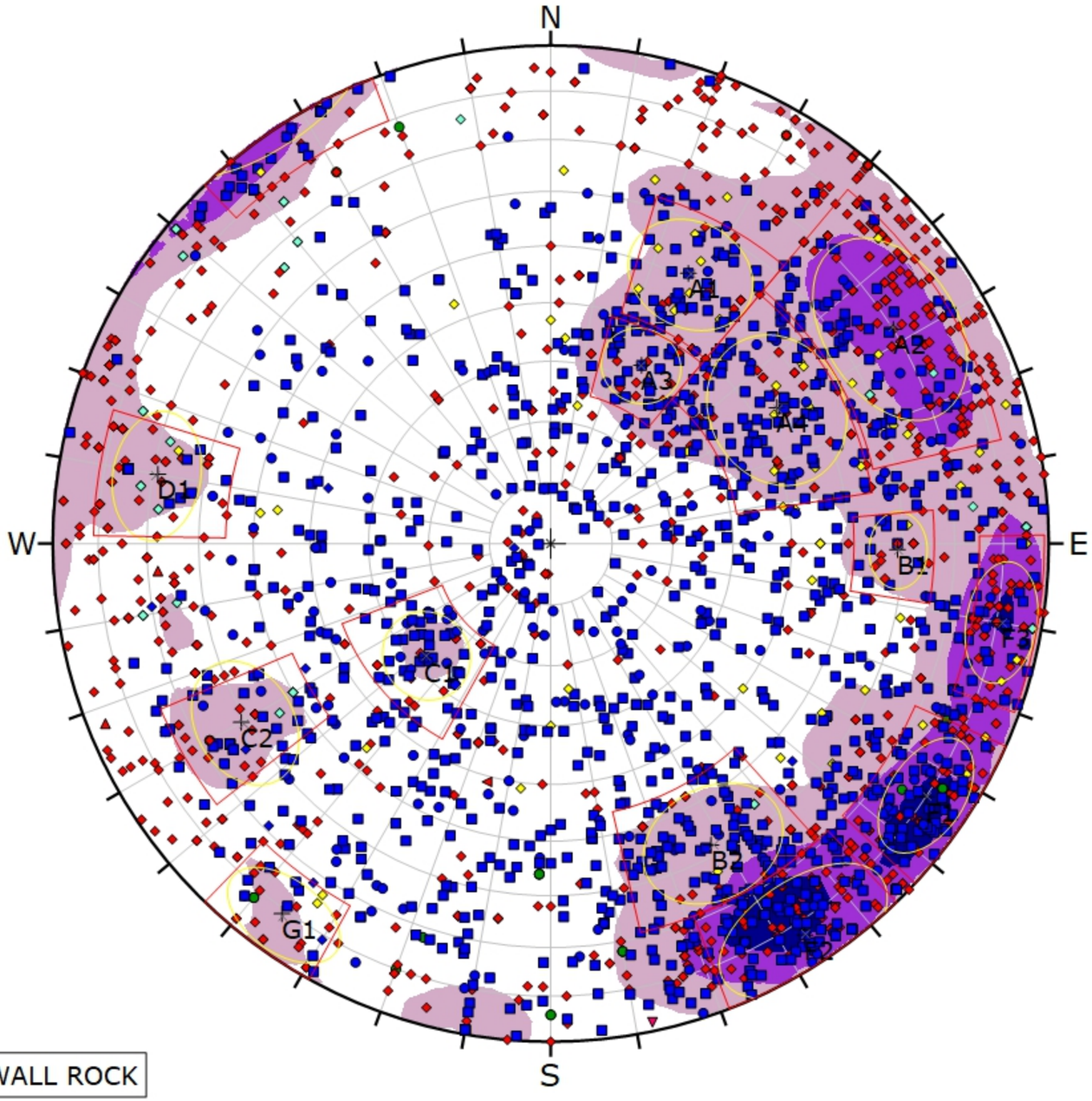
Hemisphere	Lower
Projection	Equal Area

VOK 1 - ORE ZONE



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●	JV	187
●	O	26
◇	S	64
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Maximum Density	3.53%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

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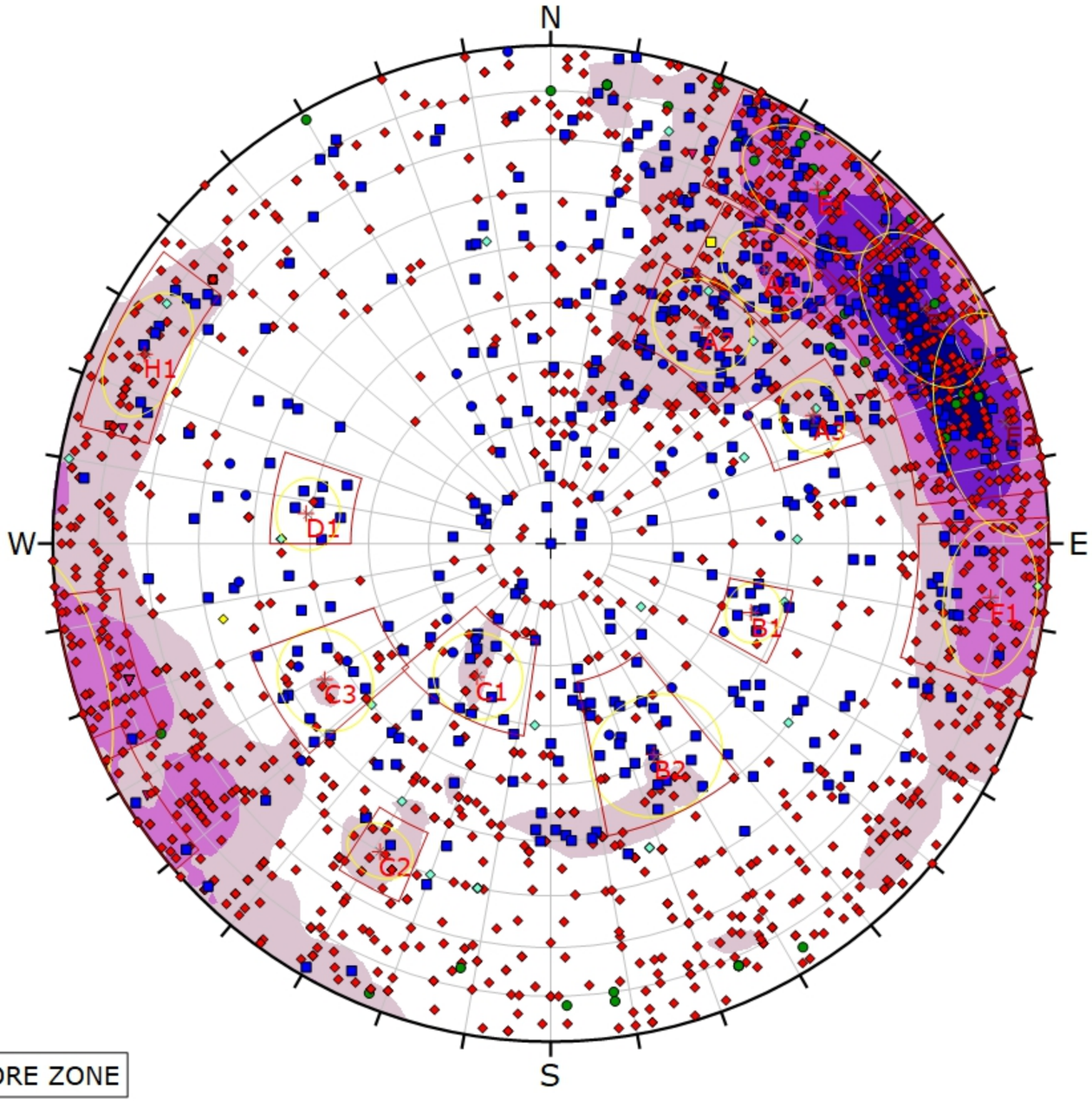
Terzaghi Weighting	Minimum Bias Angle 15°
Hemisphere	Lower
Projection	Equal Area

VOK 1 - WALL ROCK



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■	J	409
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●	O	44
◇	S	1
□	SV	1

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	2.00 - 3.00
	3.00 - 4.00
	4.00 <

Maximum Density	4.92%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
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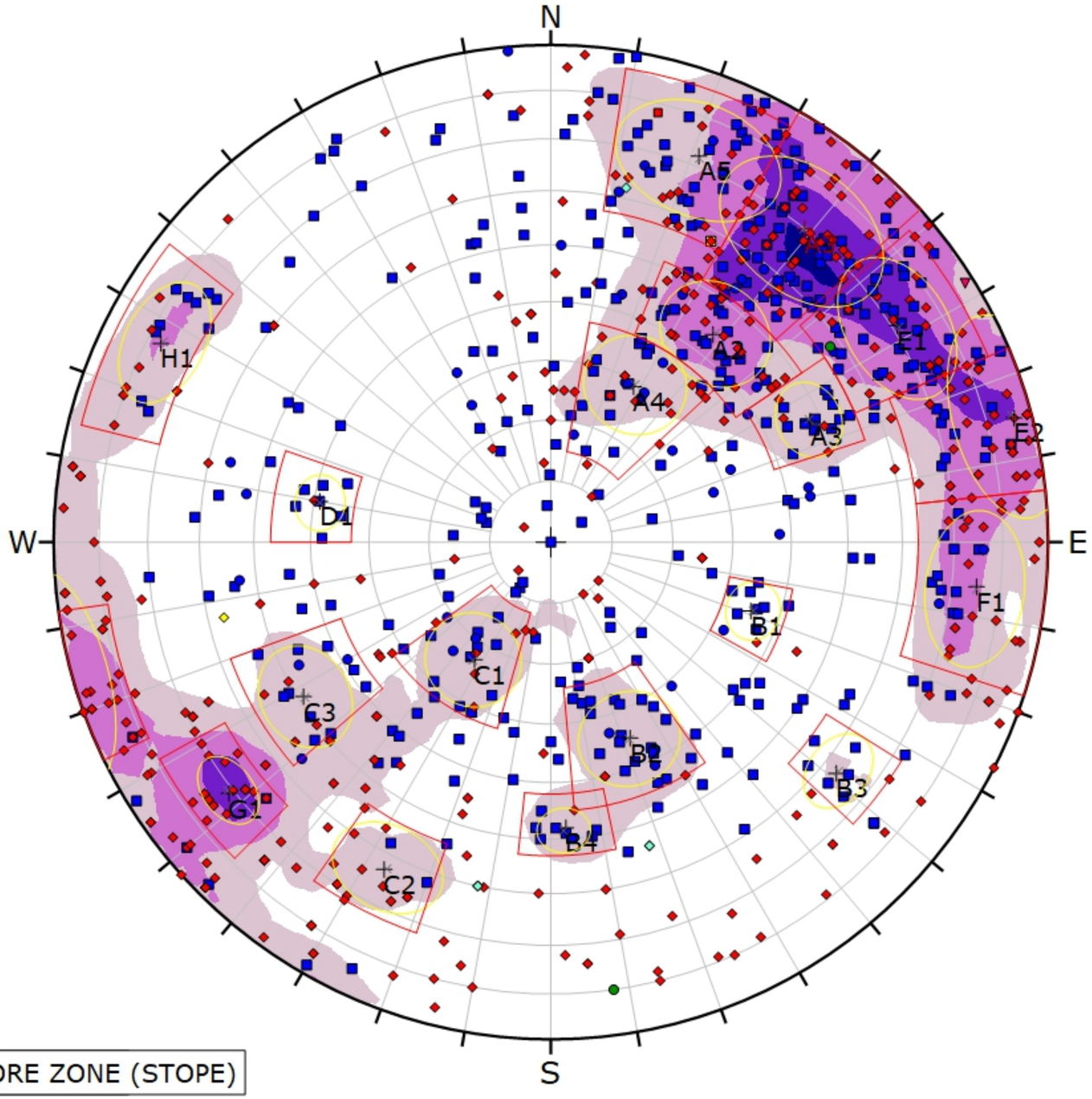
Terzaghi Weighting	Minimum Bias Angle 15°
Hemisphere	Lower
Projection	Equal Area

VOK 2 - ORE ZONE



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■	J	397
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Contour Distribution	Fisher
Counting Circle Size	1.0%

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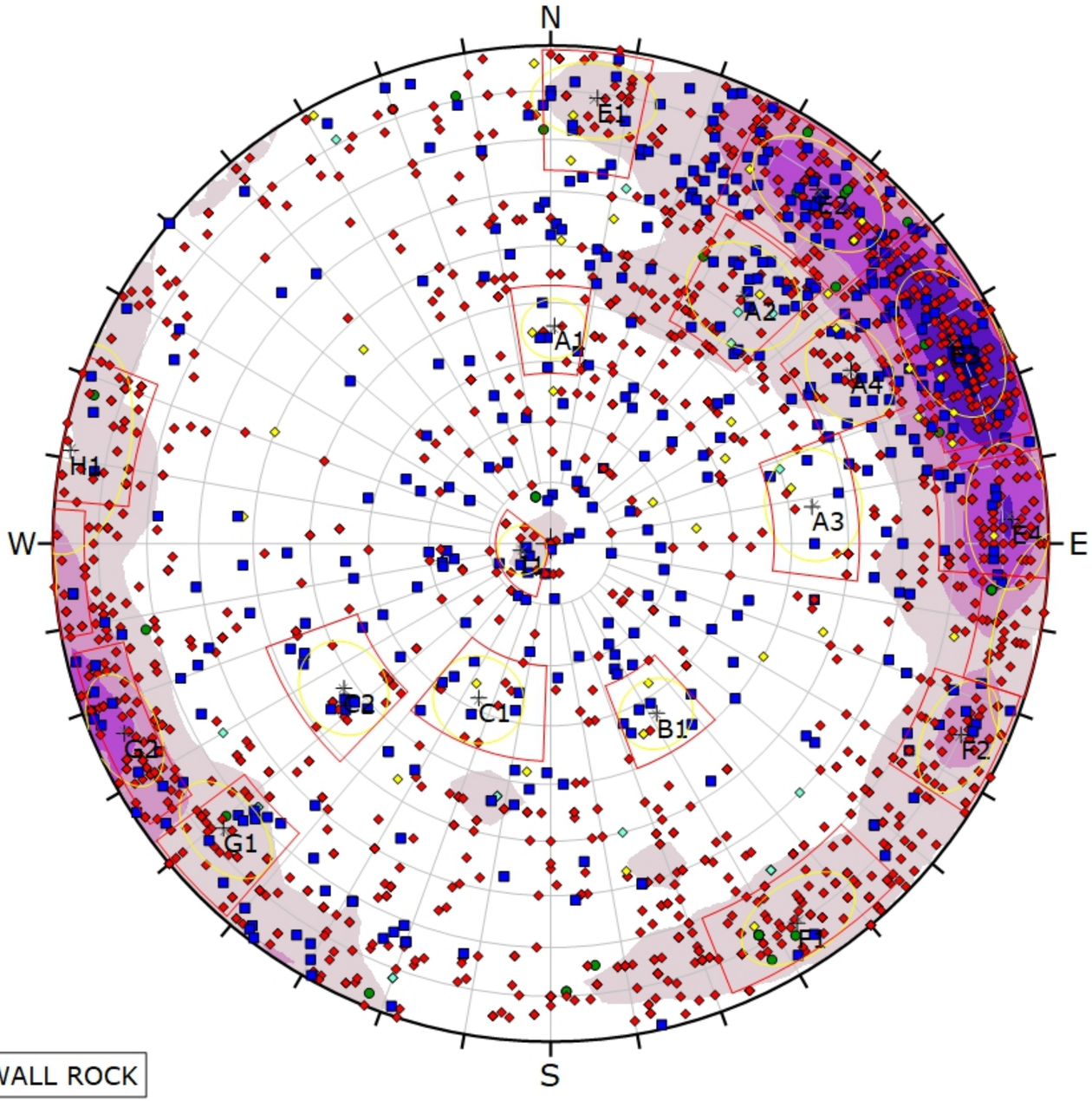
Projection	Equal Area

VOK 2 - ORE ZONE (STOPE)



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	3.00 - 4.00
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Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

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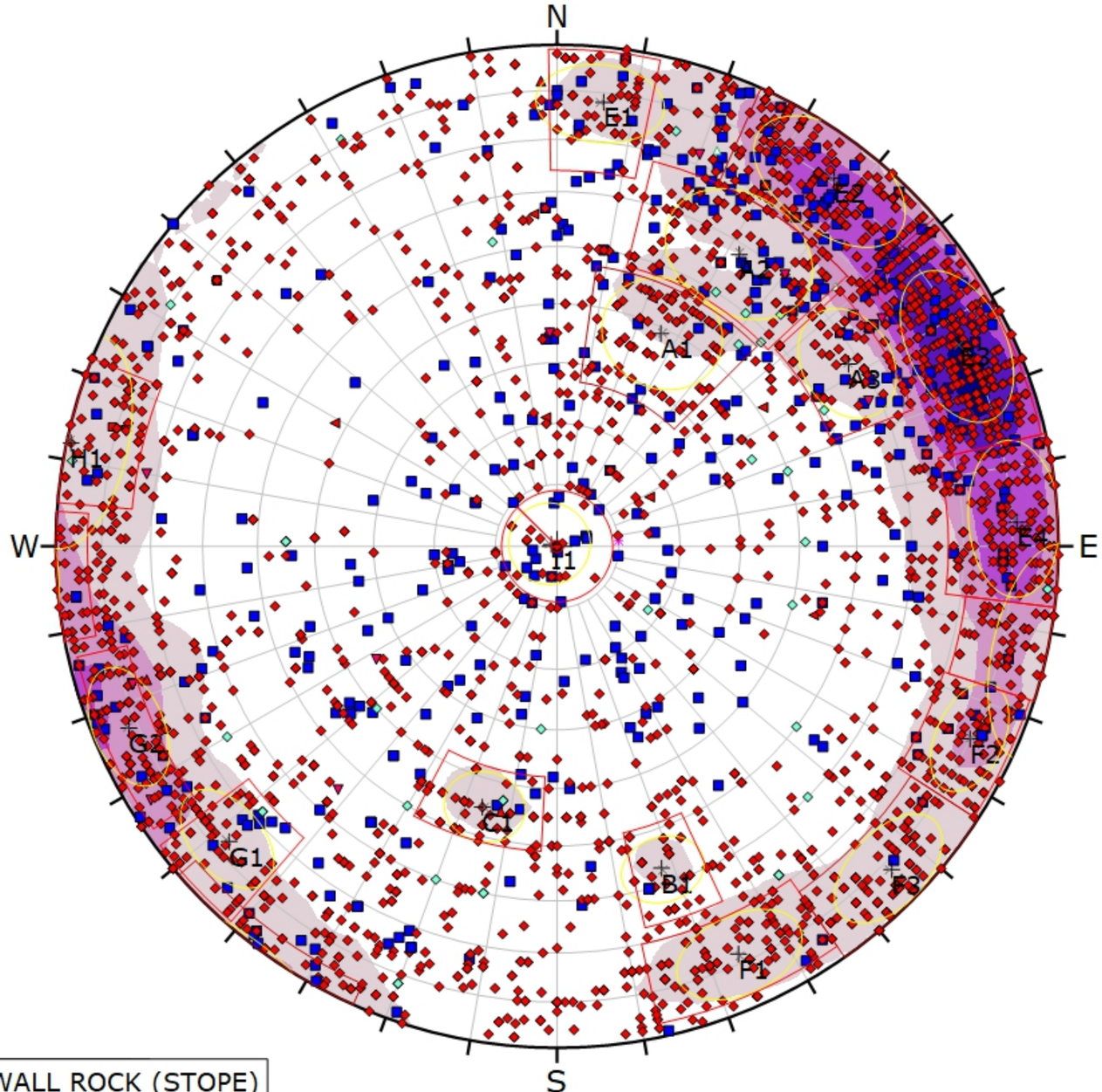
Hemisphere	Lower
Projection	Equal Area

VOK 2 - WALL ROCK



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◀	FV	8
■	J	447
✳	JC	1
	Others	234

Color	Density Concentrations
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Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	3802 (3802 Entries)
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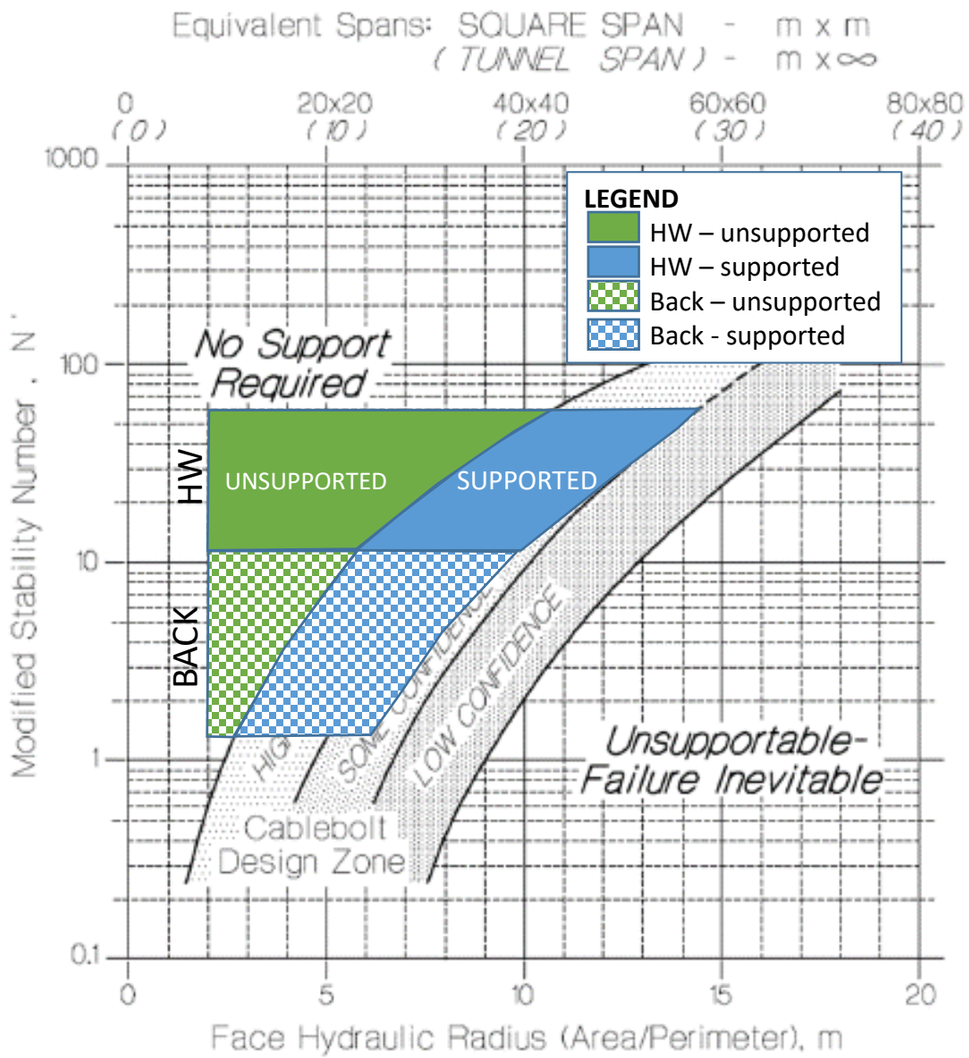
Hemisphere	Lower
Projection	Equal Area

VOK 2 - WALL ROCK (STOPE)

APPENDIX B
STOPE DESIGN CHARTS



Hydraulic Radius	Unsupported Q'=10	Unsupported Q'=50	Supported Q'=10	Supported Q'=50
BACK	2.5	5.9	6.0	9.8
HW	5.9	10.5	10.0	14.0

- Unsupported design for rock mass in lower end of design range.
- Unsupported design for rock mass in upper end of design range.
- Supported design for rock mass in lower end of design range.
- Supported design for rock mass in upper end of design range.

BACK — W (metre) / L (metre)

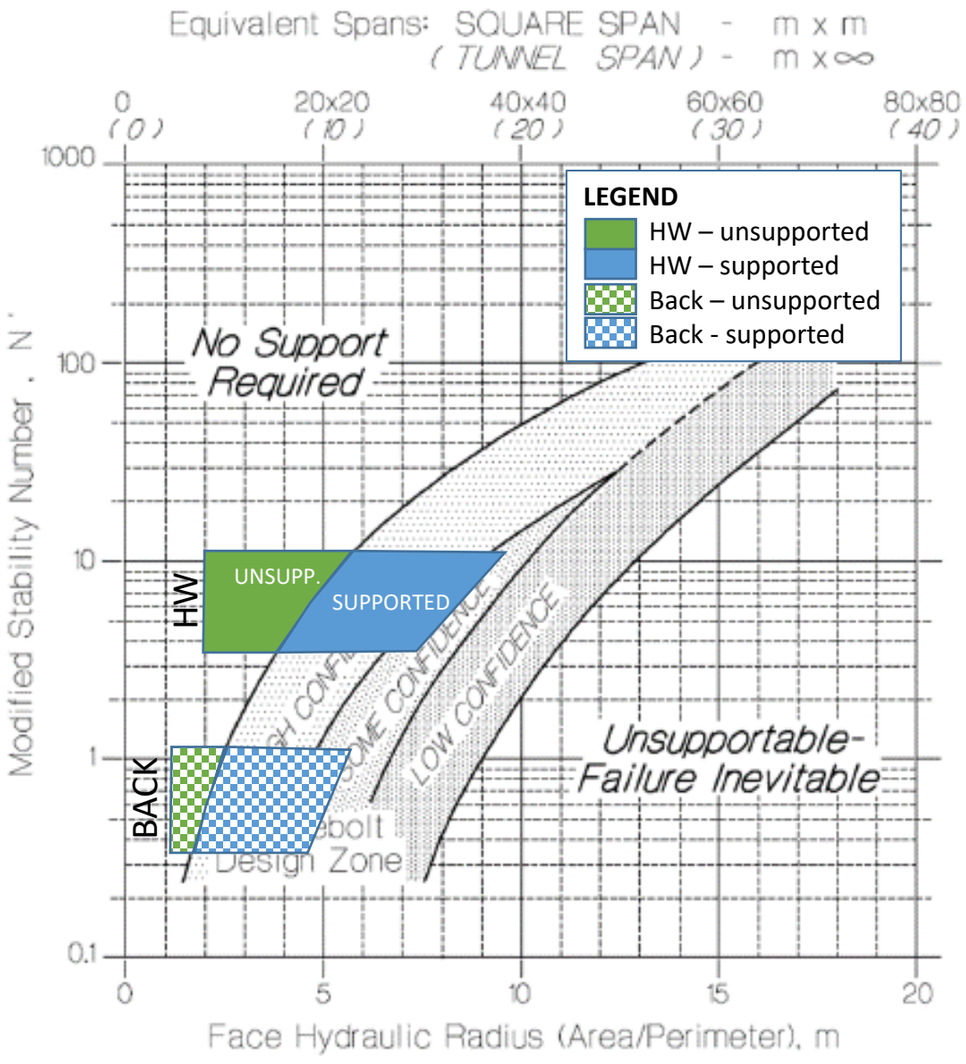
HYD RAD	10	15	20	25	30	35	40	45	50	55	60
5	1.7	1.9	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.3
10	2.5	3.0	3.3	3.6	3.8	3.9	4.0	4.1	4.2	4.2	4.3
15	3.0	3.8	4.3	4.7	5.0	5.3	5.5	5.6	5.8	5.9	6.0
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0

HW — W (metre) / H (metre)

HYD RAD	10	15	20	25	30	35	40	45	50	55	60
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0
75	4.4	6.3	7.9	9.4	10.7	11.9	13.0	14.1	15.0	15.9	16.7
80	4.4	6.3	8.0	9.5	10.9	12.2	13.3	14.4	15.4	16.3	17.1

Notes:
1. Stope designs presented for Geotechnical Unit 1 (10 < Q' < 50) and assumed conditions as presented in the accompanying letter report.

Figure 1 **Geotechnical Stope Designs for Geotechnical Unit 1**



Hydraulic Radius	Unsupported Q'=3	Unsupported Q'=10	Supported Q'=3	Supported Q'=10
BACK	1.6	2.5	4.5	6.0
HW	3.8	5.9	7.3	10.0

- Unsupported design for rock mass in lower end of design range.
- Unsupported design for rock mass in upper end of design range.
- Supported design for rock mass in lower end of design range.
- Supported design for rock mass in upper end of design range.

BACK

L (metre) \ W (metre)	10	15	20	25	30	35	40	45	50	55	60
5	1.7	1.9	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.3
10	2.5	3.0	3.3	3.6	3.8	3.9	4.0	4.1	4.2	4.2	4.3
15	3.0	3.8	4.3	4.7	5.0	5.3	5.5	5.6	5.8	5.9	6.0
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0

HW

H (metre) \ W (metre)	10	15	20	25	30	35	40	45	50	55	60
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0
75	4.4	6.3	7.9	9.4	10.7	11.9	13.0	14.1	15.0	15.9	16.7
80	4.4	6.3	8.0	9.5	10.9	12.2	13.3	14.4	15.4	16.3	17.1

Notes:

1. Stope designs presented for Geotechnical Unit 2 (3 < Q' < 10) and assumed conditions as presented in the accompanying letter report.

Figure 2 Geotechnical Stope Designs for Geotechnical Unit 2

APPENDIX C
PRELIMINARY NUMERICAL MODELLING

Appendix C : BJ U/G 3D Stress Analysis
(Rocscience RS3 v2.0)
January 2018

Geotechnical Model

(this data used as input for RS3 stress analysis modeling to assess stability impacts resulting from range of anticipated conditions)

Table 3.2-3. Intact Rock Properties

Unit	UCS - Lab (MPa)	Average Is50 (MPa)	K	UCS - Design1 (MPa)	Brazilian Tensile Strength (MPa)	Hoek-Brown Material Constant, mi	Unit Weight (kN/m³)	Young's Modulus (GPa)	Poisson's Ratio
VOK FZ	N/A	N/A	N/A	89	N/A	12	26.3	30.0	0.20
VOK WRZ	N/A	N/A	11	50	N/A	17	28.6	3.8	0.18
VOK D1	N/A	N/A	N/A	116	N/A	17	27.2	30.5	0.20
VOK D2	107	7.3	15	95	9.4	19	27.1	30.8	0.11
VOK D3	77	6.0	13	73	5.0	26	27.3	30.0	0.14
WZ FZ	N/A	N/A	20	77	N/A	12	26.3	30.0	0.20
WZ WRZ	14	1.3	11	37	0.7	17	28.6	3.8	0.18
WZ FR	126	7.0	18	116	5.7	21	27.3	35.0	0.17

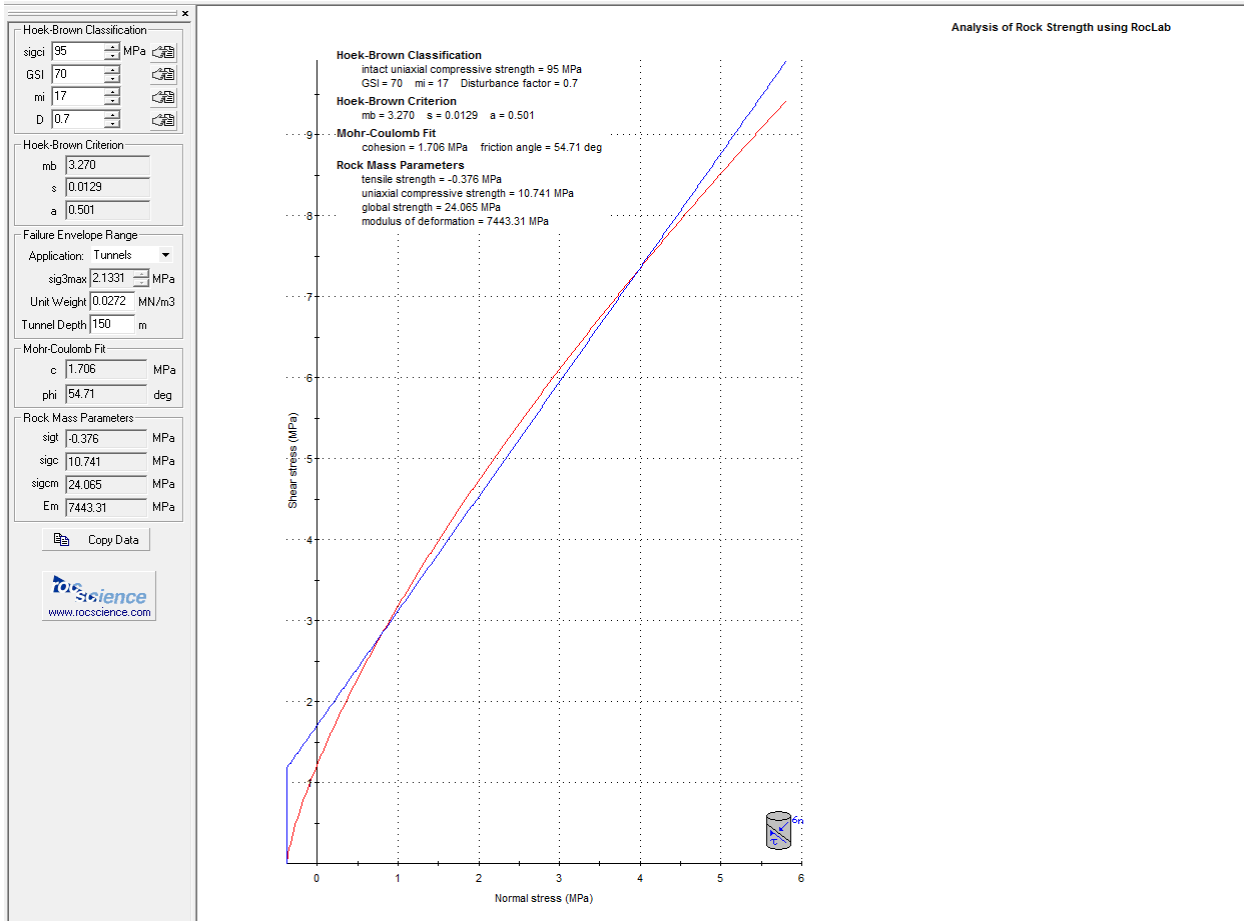
Notes:
1. Design UCS values have been estimated from the median Is50 values using laboratory-derived K values if available
2. Unit weights are based on average results of specific gravity testing if available
3. Hoek-Brown material constants have been derived based on a review of laboratory testing results
4. Young's Modulus and Poisson's ratio have been estimated based on laboratory testing results if available

Table 3.2-5. Rock Mass Strength and Deformation Modules

Unit	UCS (MPa)	GSI[2]	Unit Weight[3] (kN/m³)	m_i	m_b	S	E_{rm} (GPa)
VOK FZ	89	60	26.3	12	1.110	0.0023	5.13
VOK WRZ	50	63	28.6	17	1.879	0.0037	0.77
VOK D1	116	72	27.2	17	3.211	0.0144	9.76
VOK D2	95	70	27.1	19	3.186	0.0106	9.02
VOK D3	73	85	27.3	26	10.647	0.103	14.37
WZ FZ	77	57	26.3	12	0.928	0.0015	4.27
WZ WRZ	37	62	28.6	17	1.771	0.0032	0.73
WZ FR	116	85	27.3	21	8.599	0.103	16.77

Notes:
1. The Hoek-Brown failure criteria have been estimated assuming a disturbance factor ('D') of 0.8 for all units.
2. GSI is calculated from median rock mass parameters for each unit, where GSI = RMR '76.
3. Unit weights are based on average results of specific gravity testing when possible.
4. The Hoek-Brown curves have been derived using a sigma3 max. for a tunnel depth of 650 m.

VOK D1 / D2 / D3 Rock Strength Envelope



Example Inputs for RS3 Stress Analysis

RS^3 Analysis Information

Project Settings

Document Name: BJ 1460-1370 Stope Complex
Project Title: BJ Stope Complex 1460-1370L

Units

Units:	Metric, stress as MPa
Time Units:	Seconds
Permeability Units:	Meters/second
Coordinate:	Cartesian x,y,z

Boreholes

Stage Information

Number of Stages: 12

#	Name
1	Stage 1
2	Stage 2
3	Stage 3
4	Stage 4
5	Stage 5
6	Stage 6
7	Stage 7
8	Stage 8
9	Stage 9
10	Stage 10
11	Stage 11
12	Stage 12

Stress Analysis

Maximum Number of Iterations:	1000
Tolerance:	0.01
Load Steps:	Automatic
Convergence Type:	Absolute Force & Energy
Accelerate Initial Stiffness:	Yes
Min. Alpha:	0.1
Max. Alpha:	10

General	
Name:	VOK D1/D2/D3
Color:	
Initial Element Loading:	Field Stress & Body Force
Unit Weight (MN/m3):	0.0272
Material Behavior:	Drained
Strength	
Failure Criterion:	Hoek-Brown
Material Type:	Plastic
Dilation Parameter:	0
Residual mb Parameter:	1
Residual s Parameter:	0.003
Intact Compressive Strength (MPa):	95
Peak mb Parameter:	3.2
Peak s Parameter:	0.0125
Stiffness	
Type:	Linear Isotropic
Young's Modulus (MPa):	30000
Poisson's Ratio:	0.13
Using Unloading Condition:	No
Hydraulics	
Default Water Condition	
Type:	NONE
Name:	Dry
Value:	-1
Color:	
Model:	Simple
Soil Type:	General

General	
Name:	Backfill
Color:	
Initial Element Loading:	Body Force Only
Unit Weight (MN/m3):	0.02
Material Behavior:	Drained
Strength	
Failure Criterion:	Mohr Coulomb
Material Type:	Elastic
Peak Tensile Strength (MPa):	0.25
Peak Friction Angle (Degrees):	35
Peak Cohesion (MPa):	0.5
Unsaturated Shear Strength - Phi B:	0
Unsaturated Shear Strength - Air Entry (MPa):	0
Stiffness	
Type:	Linear Isotropic
Young's Modulus (MPa):	2500
Poisson's Ratio:	0.3
Using Unloading Condition:	No
Hydraulics	
Default Water Condition	
Type:	NONE
Name:	Dry
Value:	-1
Color:	
Model:	Simple
Soil Type:	General

Solver Options

Analysis Type:	Uncoupled
Solver Type:	Automatic

Groundwater Settings

Method:	Phreatic Surfaces
Pore Fluid Unit Weight:	0.00981 MN/m3

Shear Strength Reduction

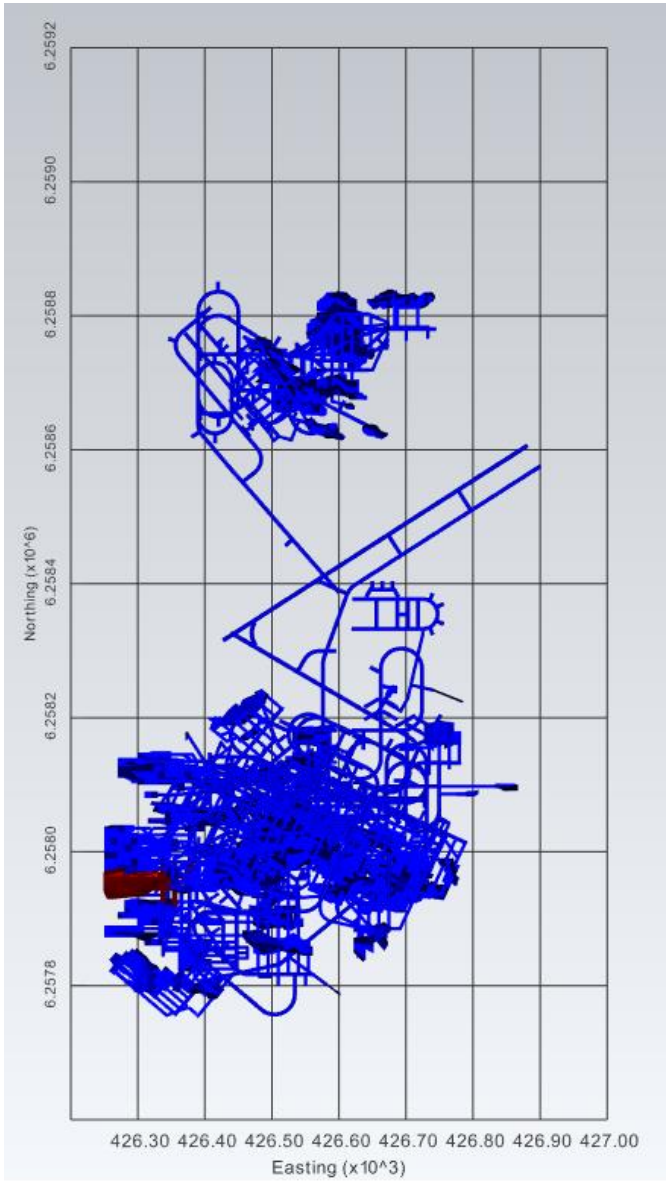
Determine Strength Reduction Factor: No

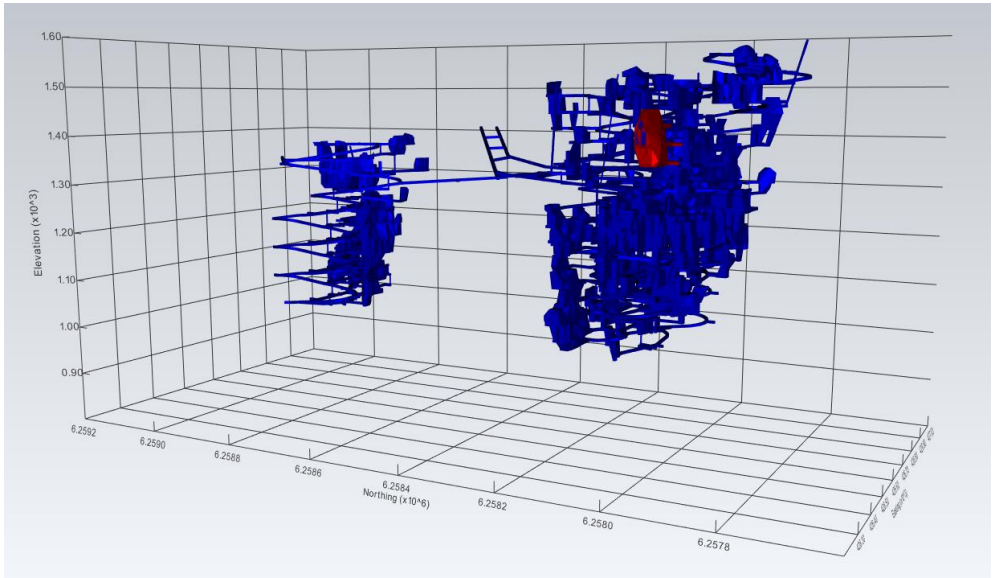
Mesh Setup

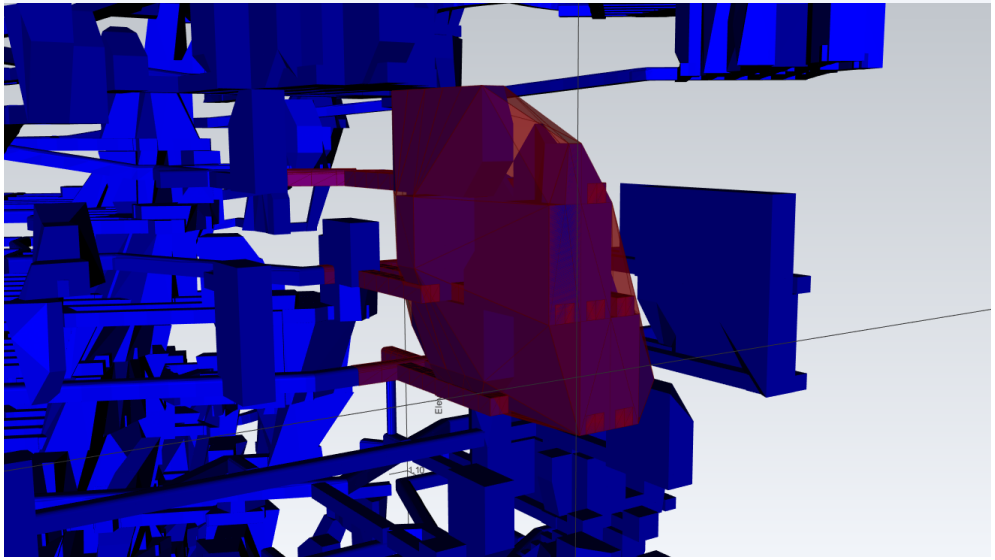
Element Type:	4-Noded Tetrahedra
Mesh Gradation:	Graded

The following slides are representative examples of typical RS3 analysis results. These were used to help develop designs, confirm / modify engineering judgement, and inform conclusions and outcomes of the underground assessment.)

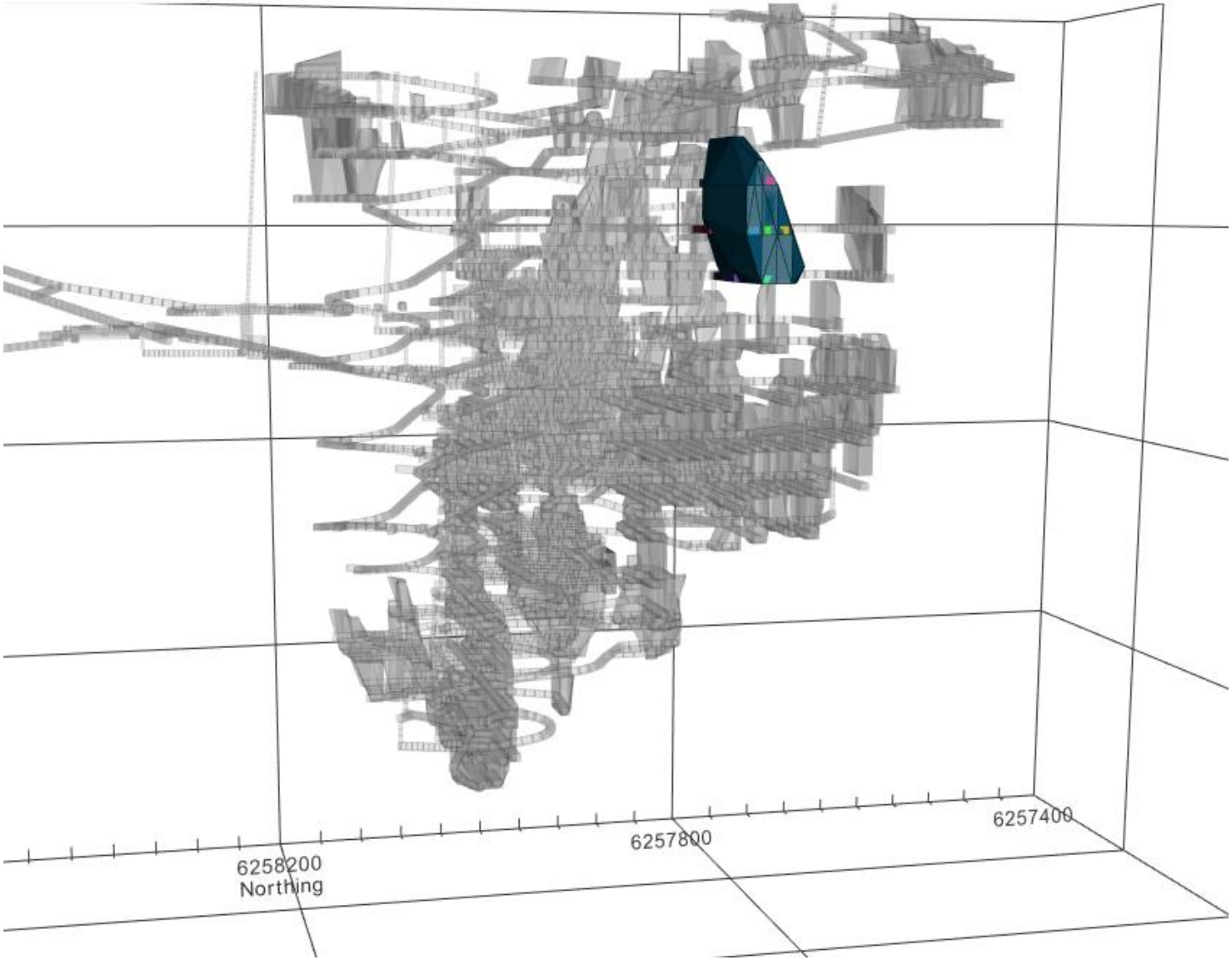
A number of scenarios run with varying sequences, stages, material inputs and boundary conditions, using ranges of values determined from review of geotechnical model.



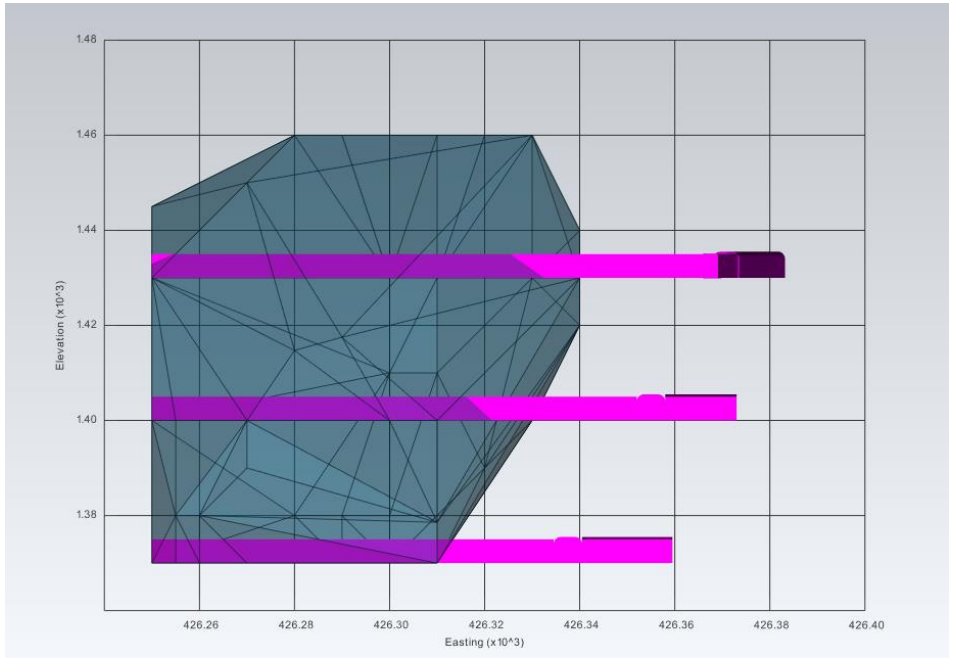


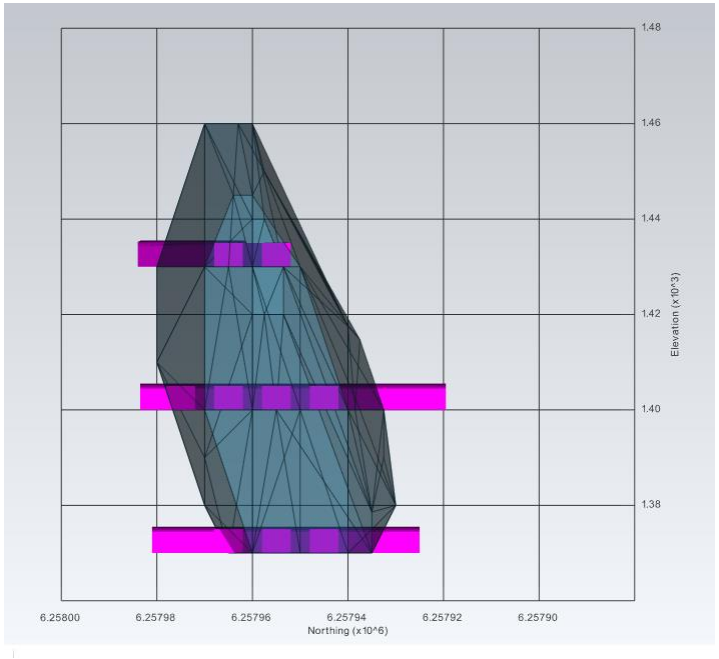


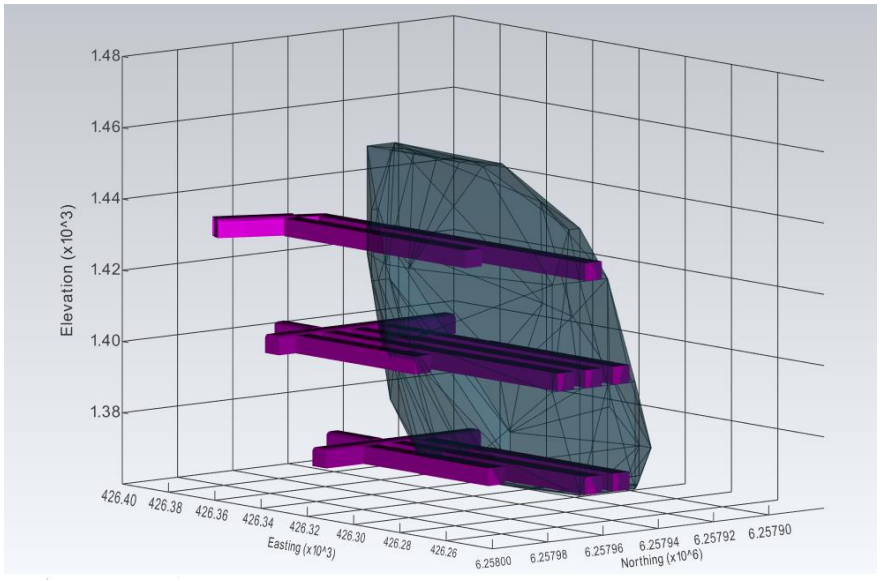
1460-1370L Stope Zone



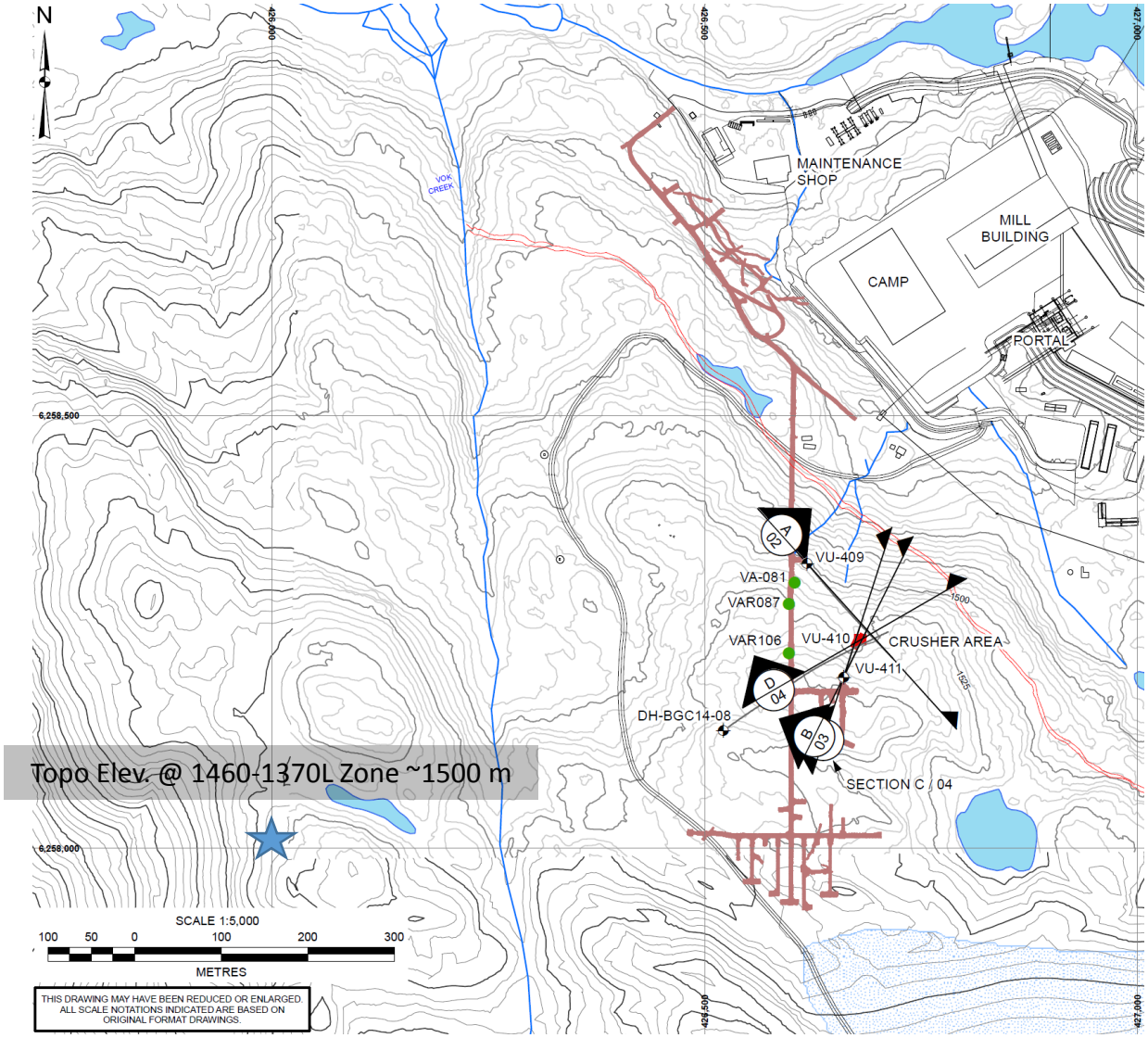
1460-1370L Stope Zone



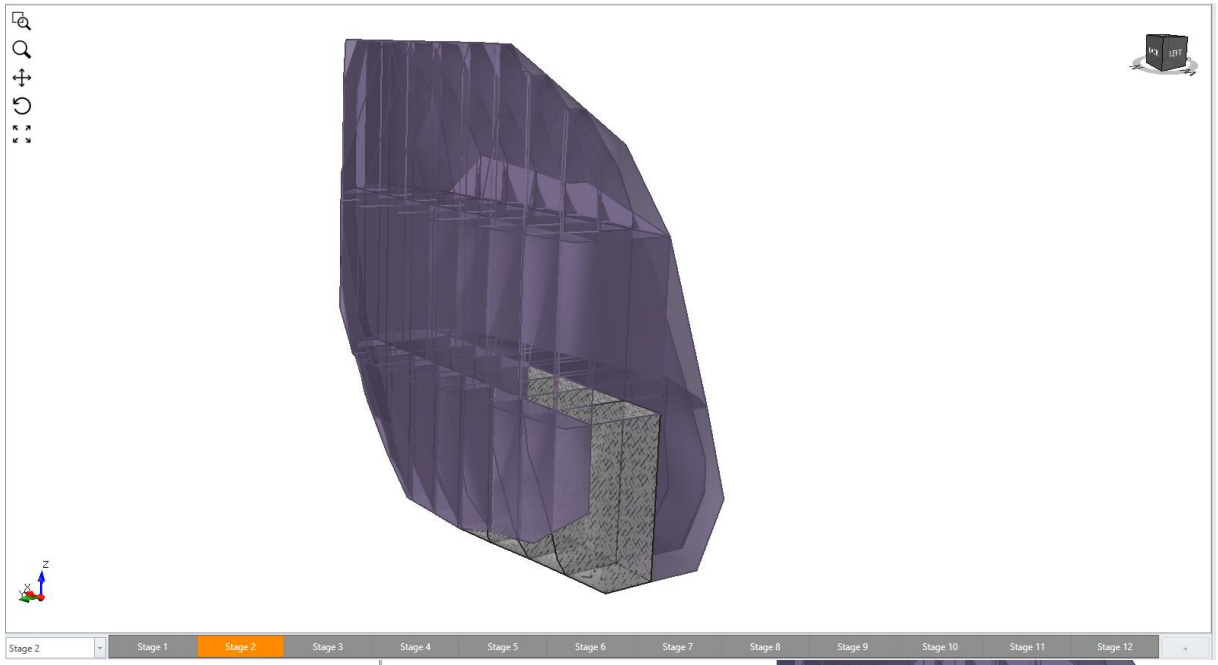


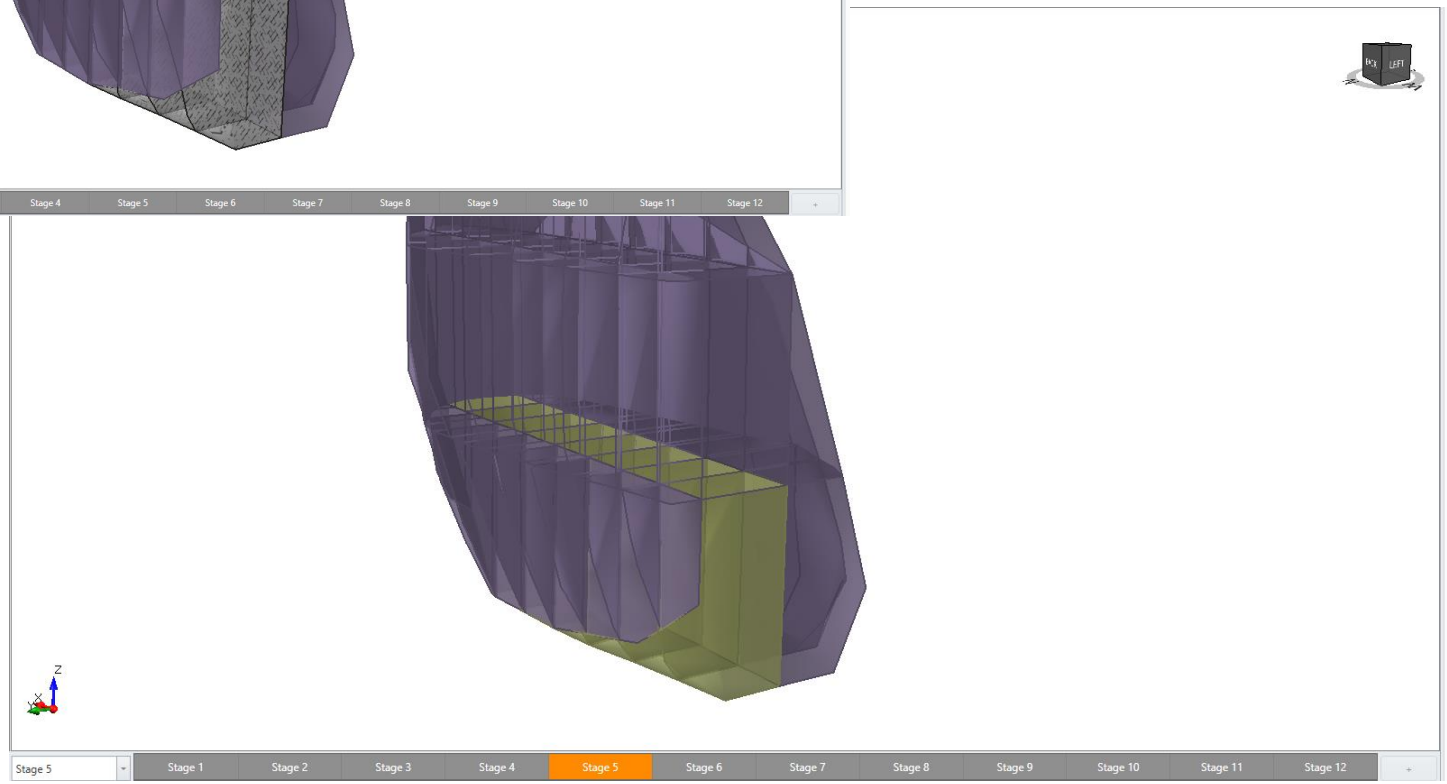


1460-1370L Stope Zone



Topo Elev. @ 1460-1370L Zone ~1500 m





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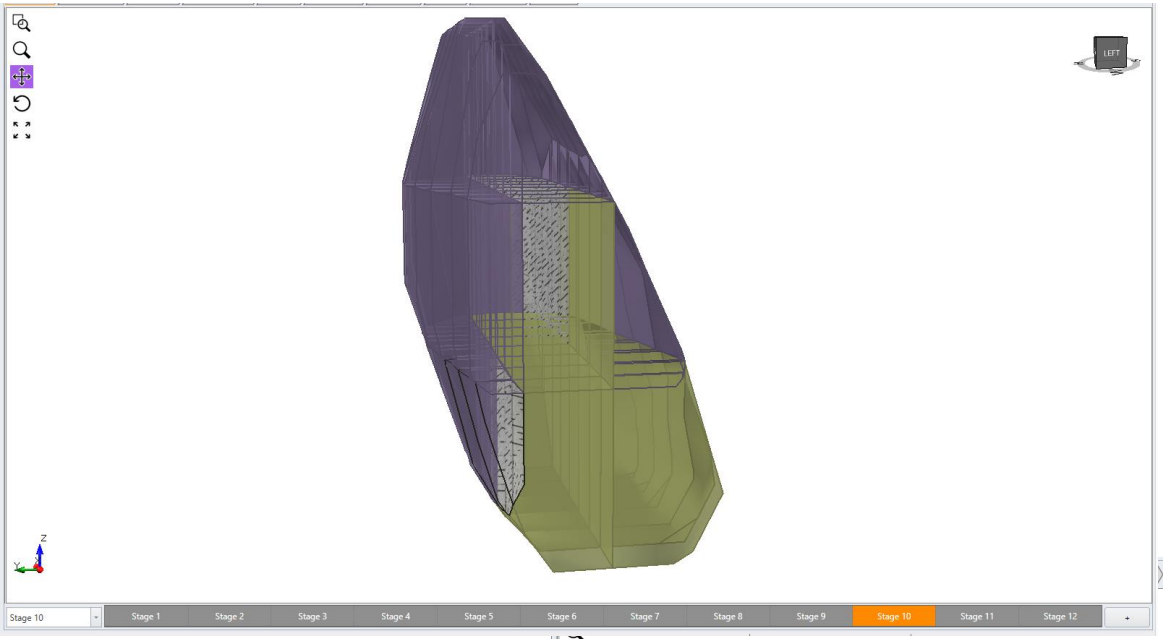
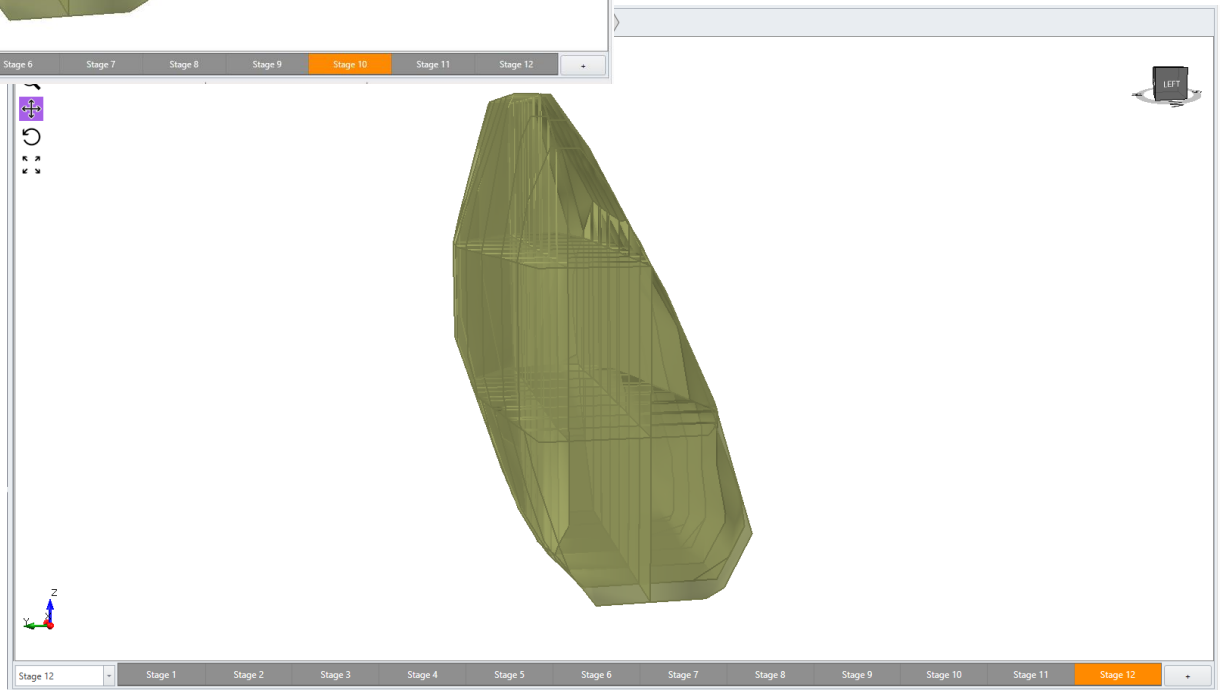
Stope Review & Optimization

Sequence Examples Stages 2 & 5

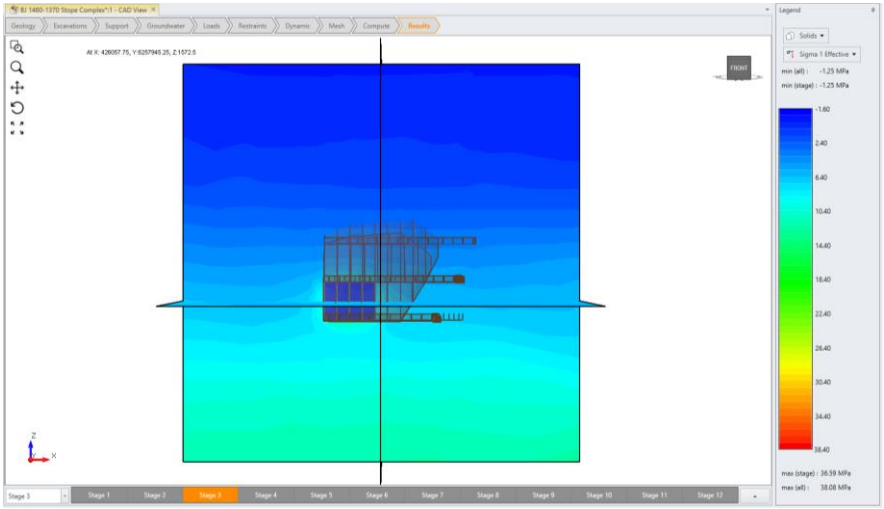




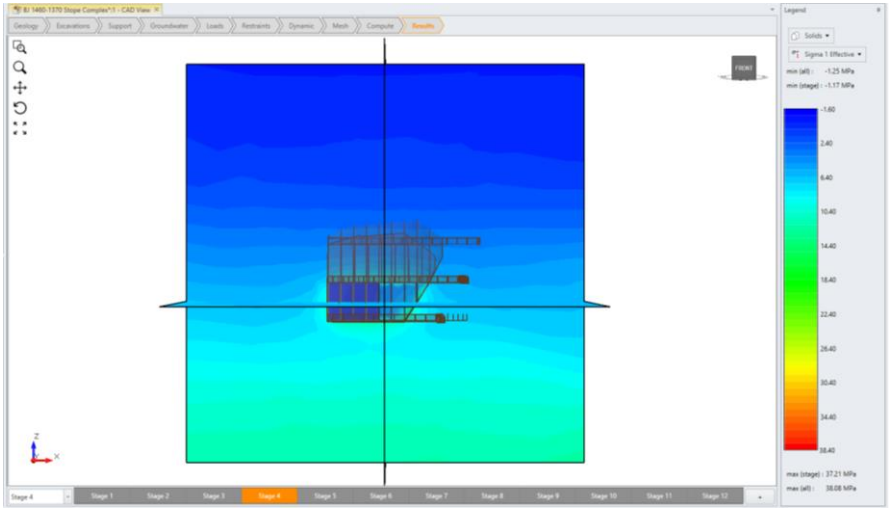
Brucejack Underground
Stope Review & Optimization

Sequence Examples Stages 10 & 12

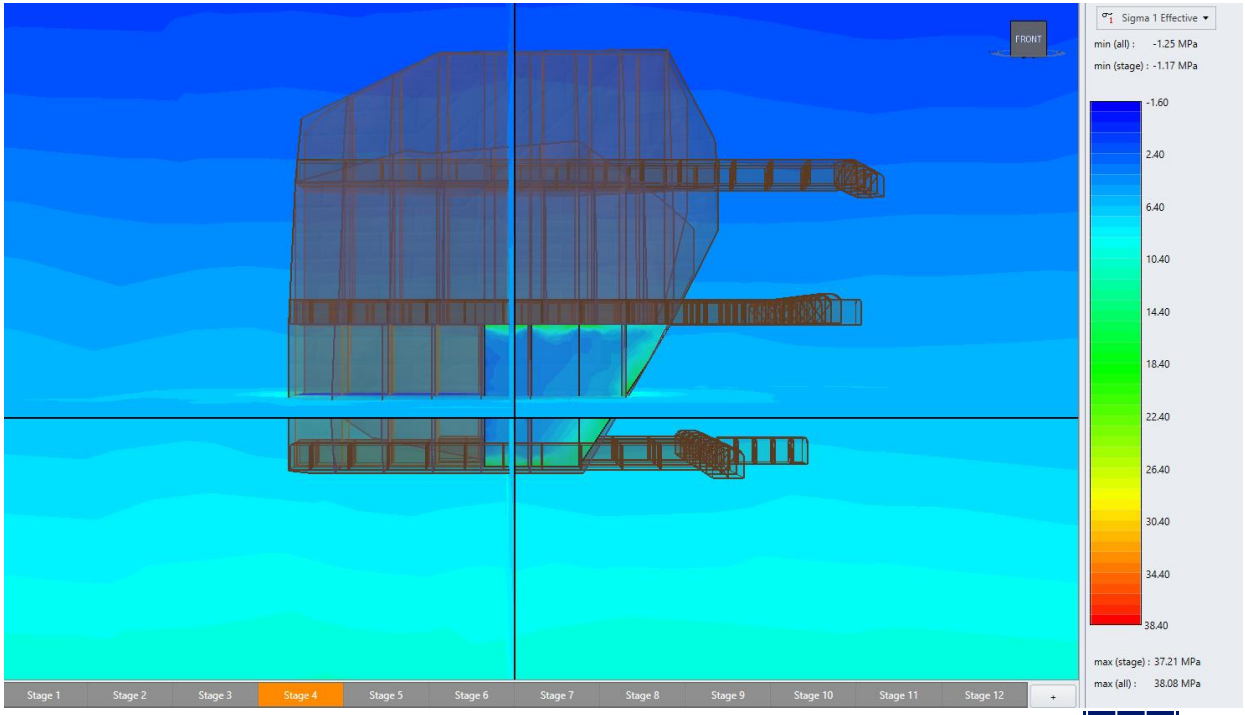
BGC PRETIVM



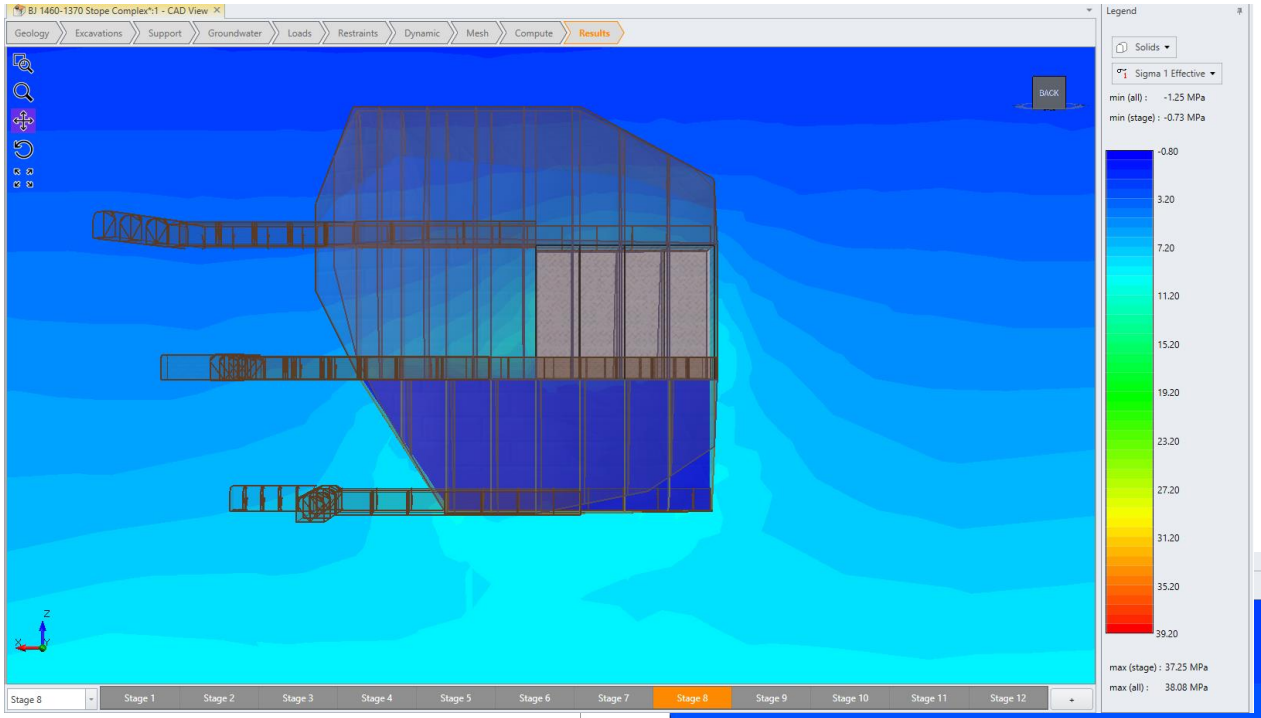
Global Sig1 @ Stg. 3



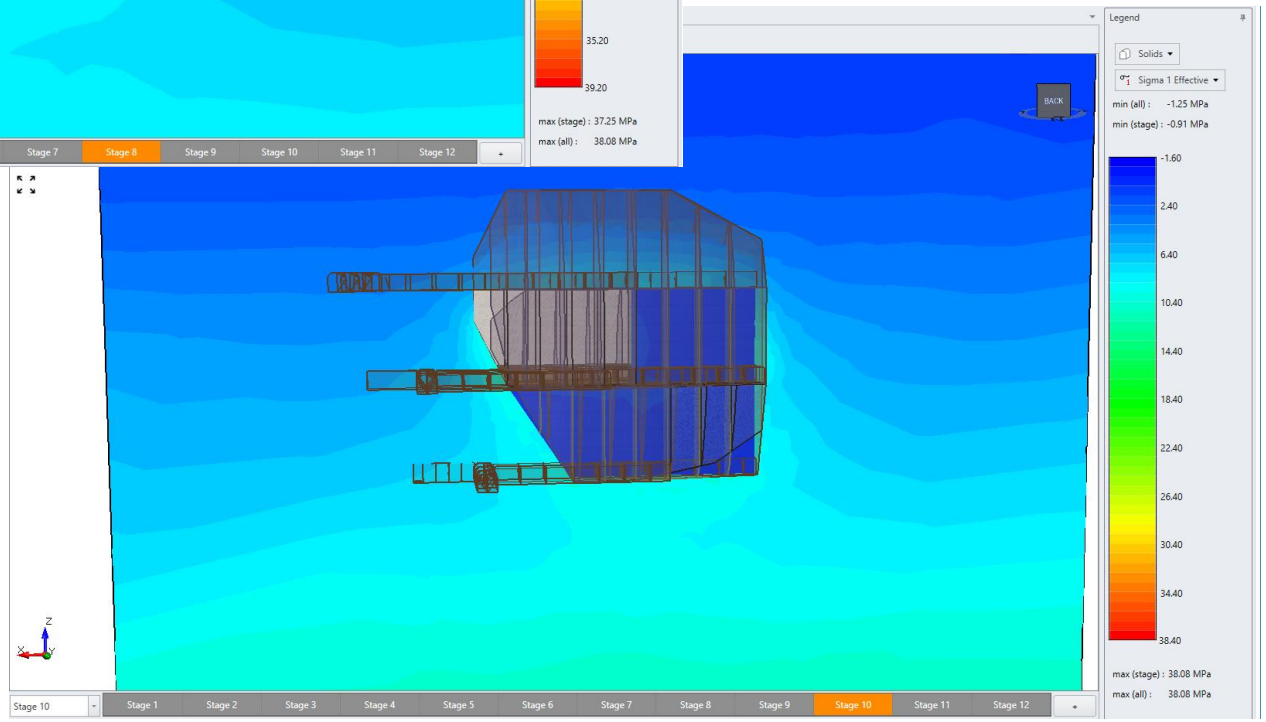
Global Sig1 @ Stg. 4



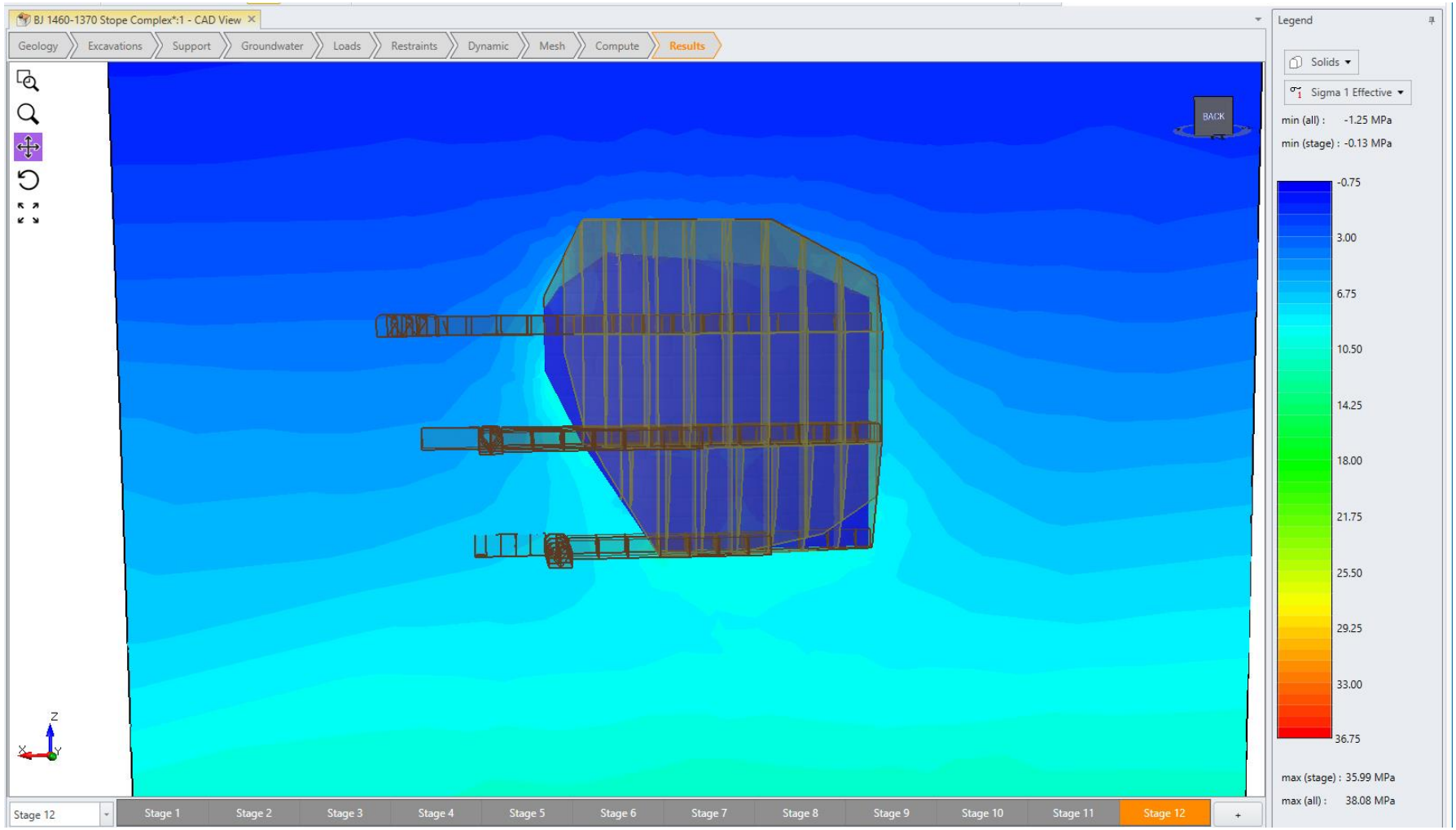
Global Sig1 @ Stg. 4 (zoomed w/ ext. str. contour)



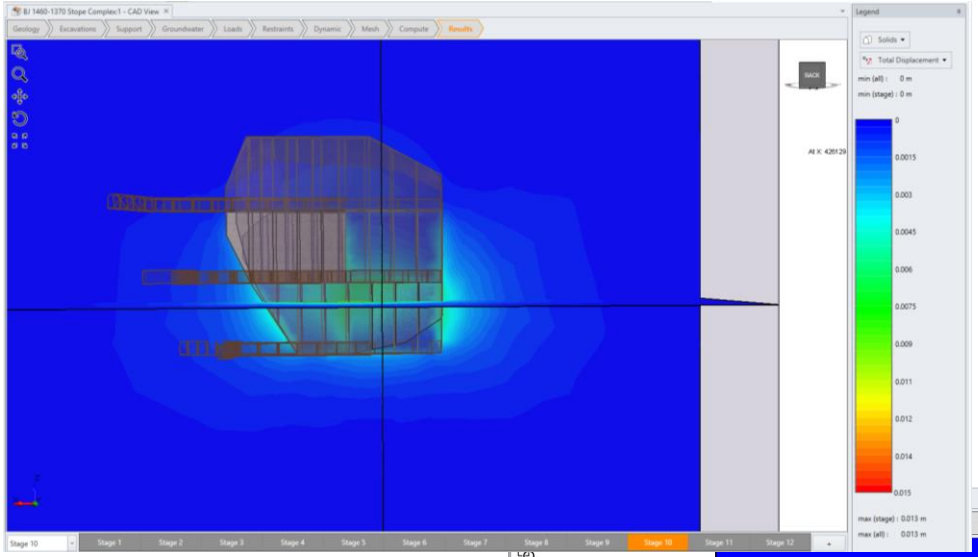
Global Sig1 @ Stg. 8

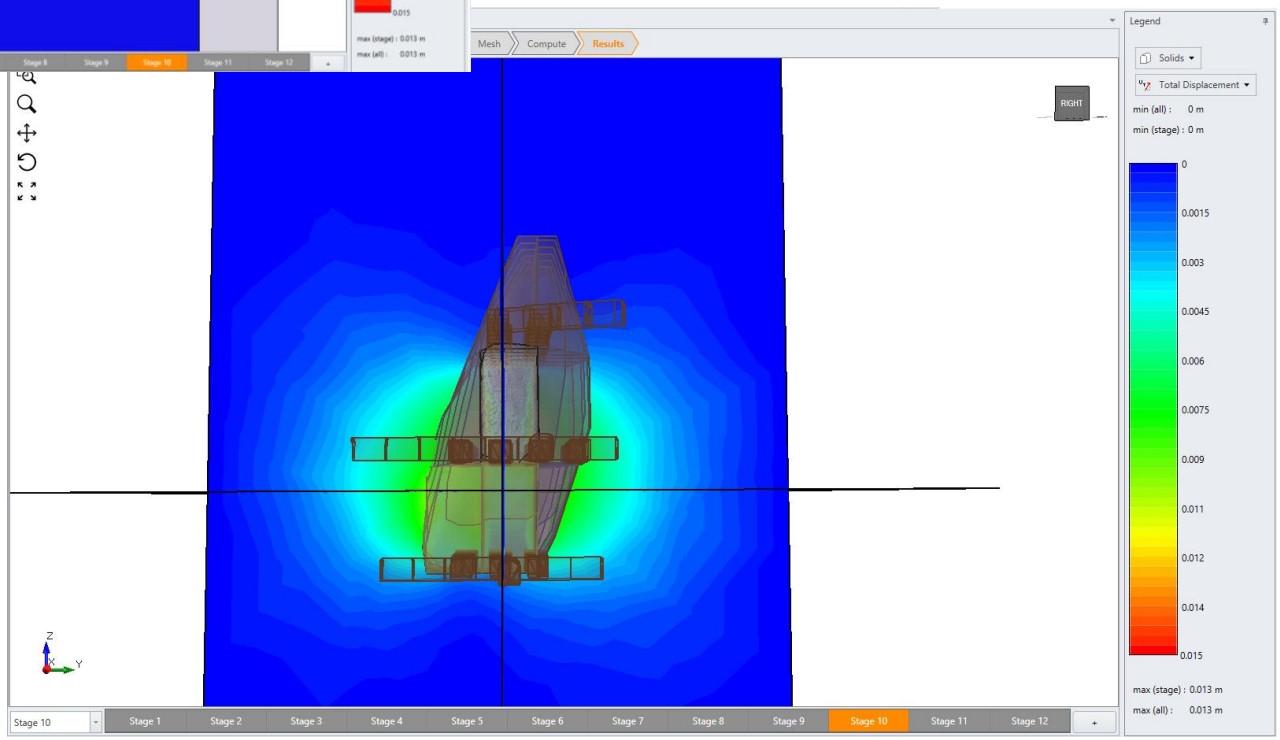


Global Sig1 @ Stg. 10

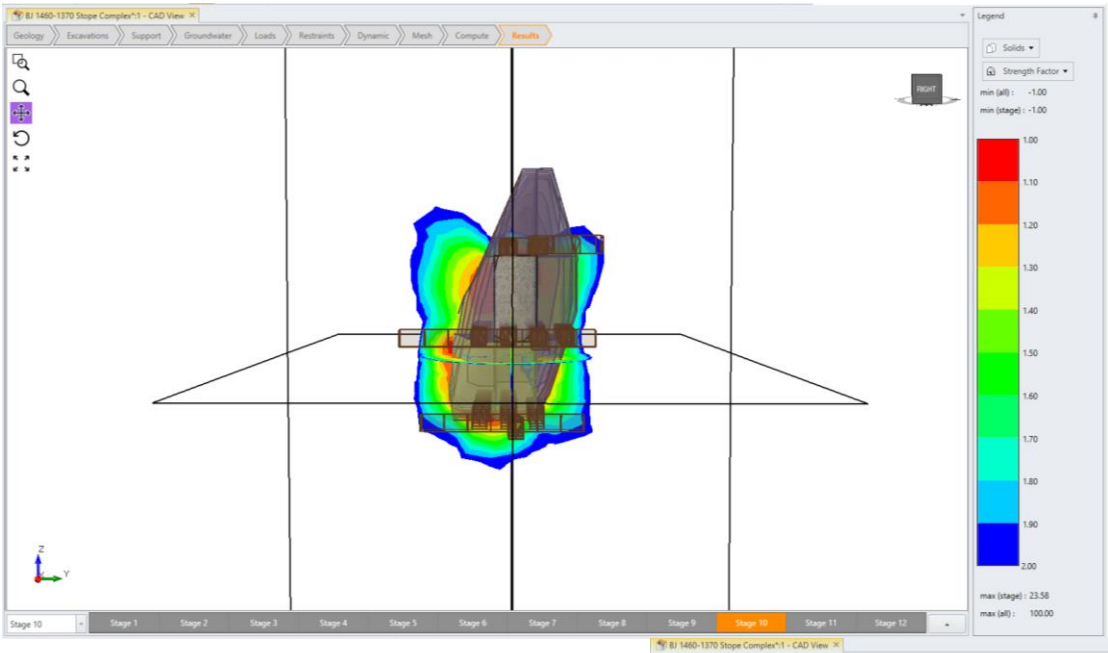


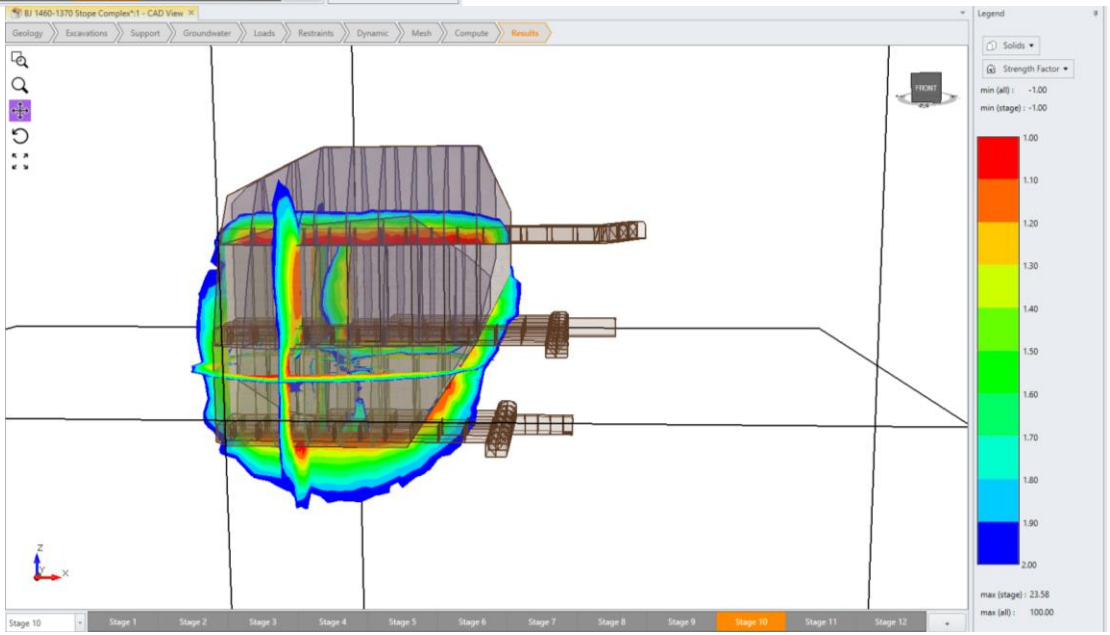
Global Sig1 @ Stg. 12





Total Displ. @ Stg. 10





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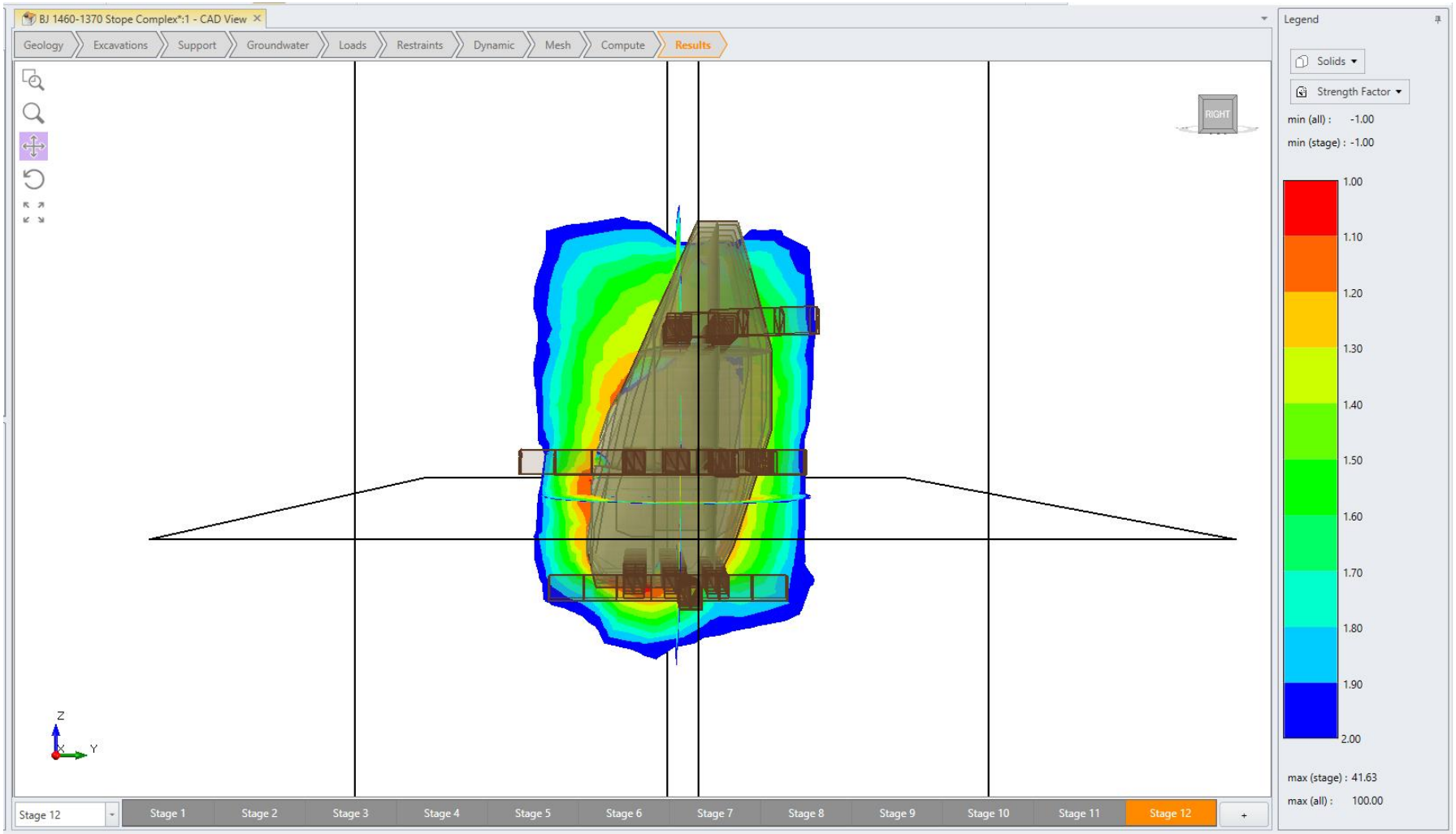
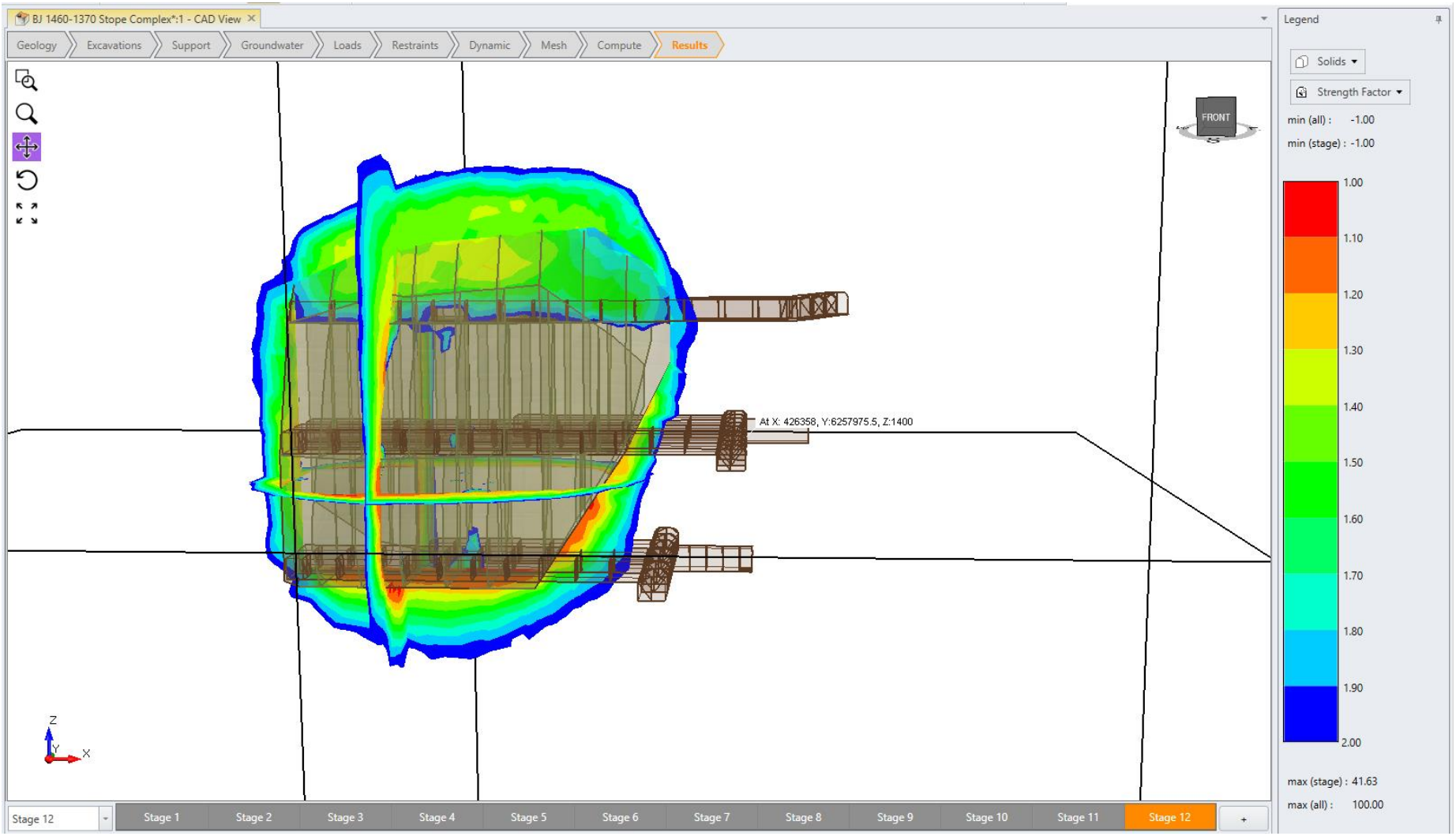
Base Case Model
Strength Factor @ Stg. 10



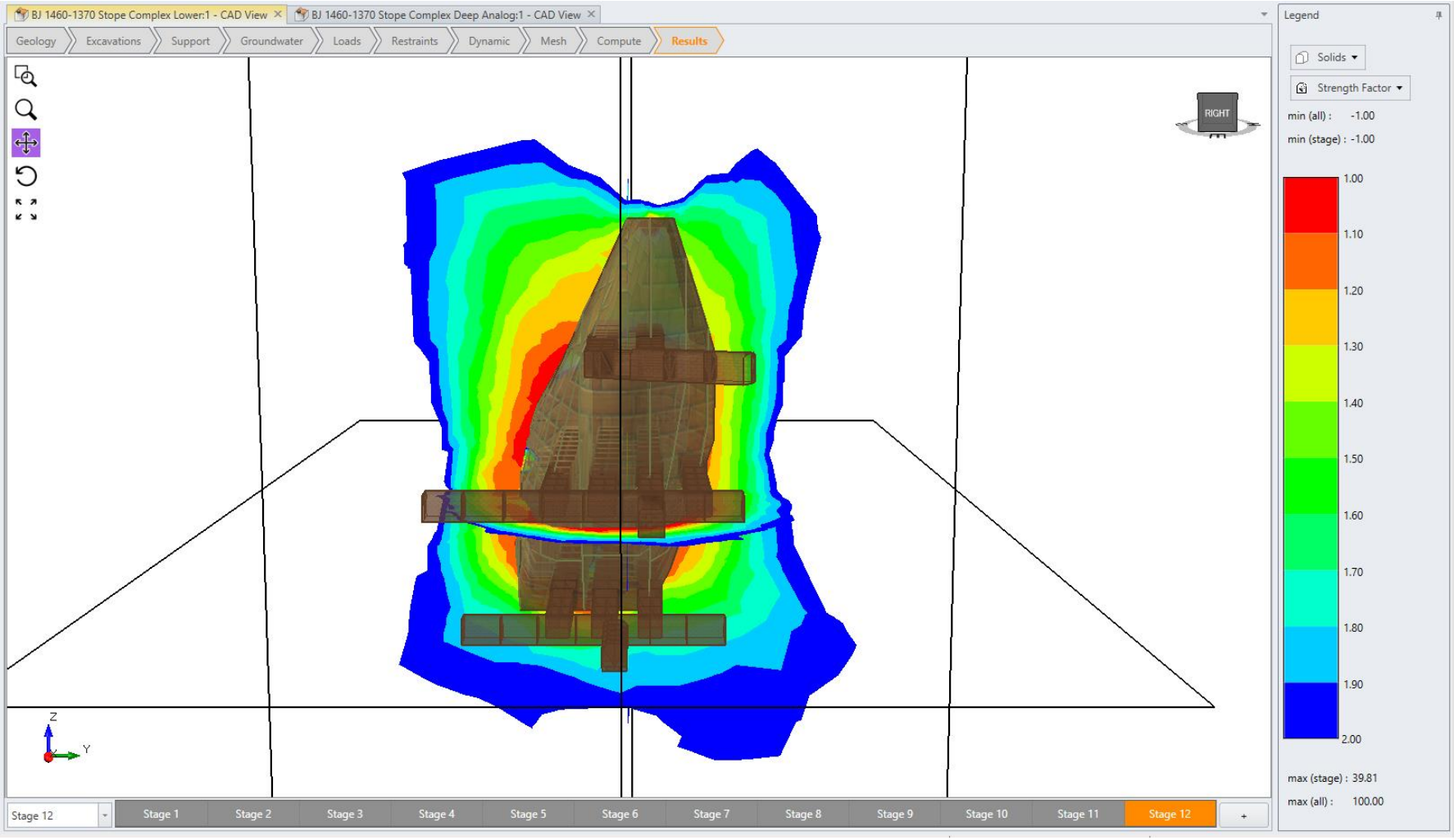
Brucejack Underground
Stope Review & Optimization

Base Case Model
Strength Factor @ Stg. 10

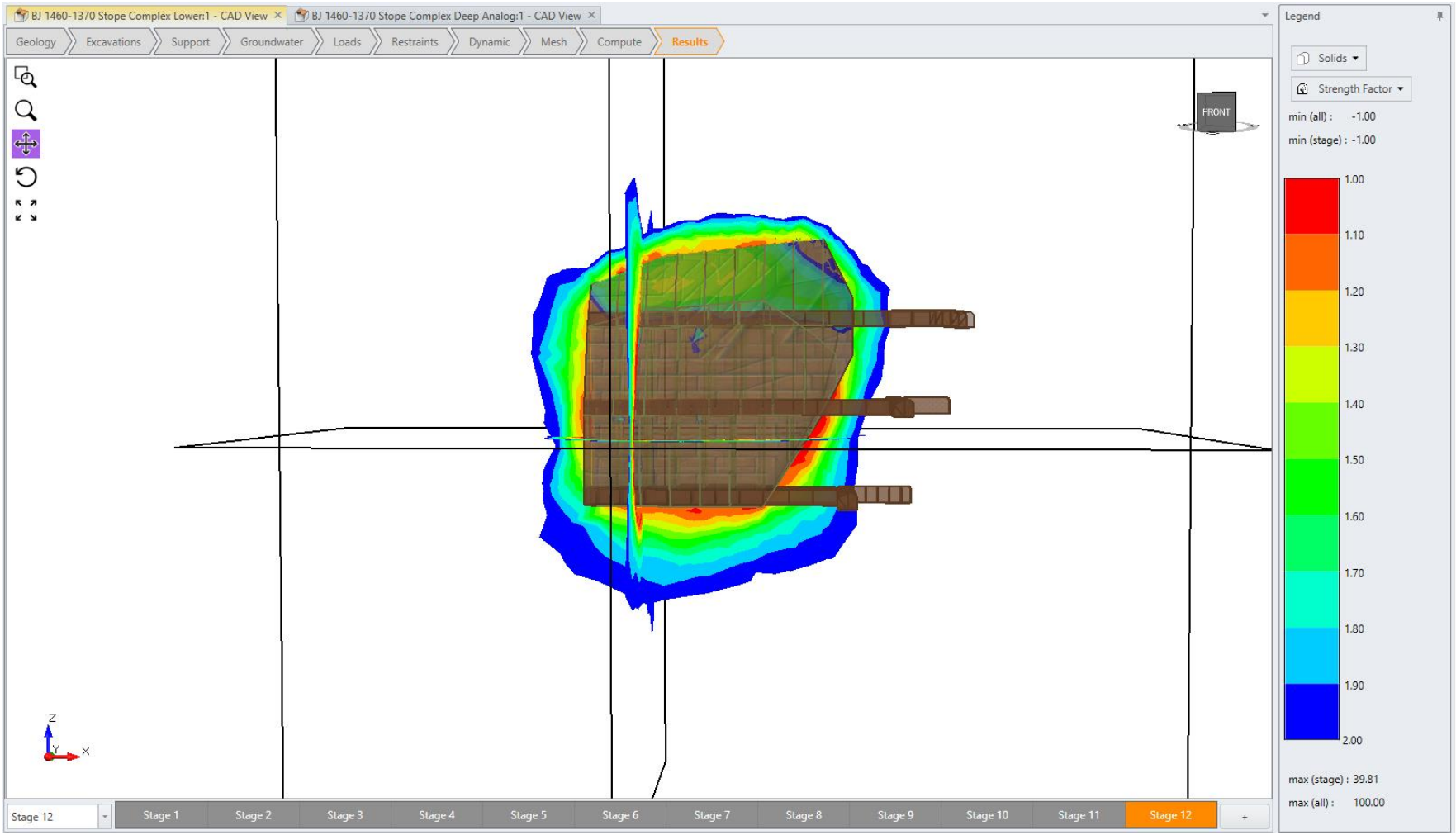


Brucejack Underground
Stope Review & Optimization

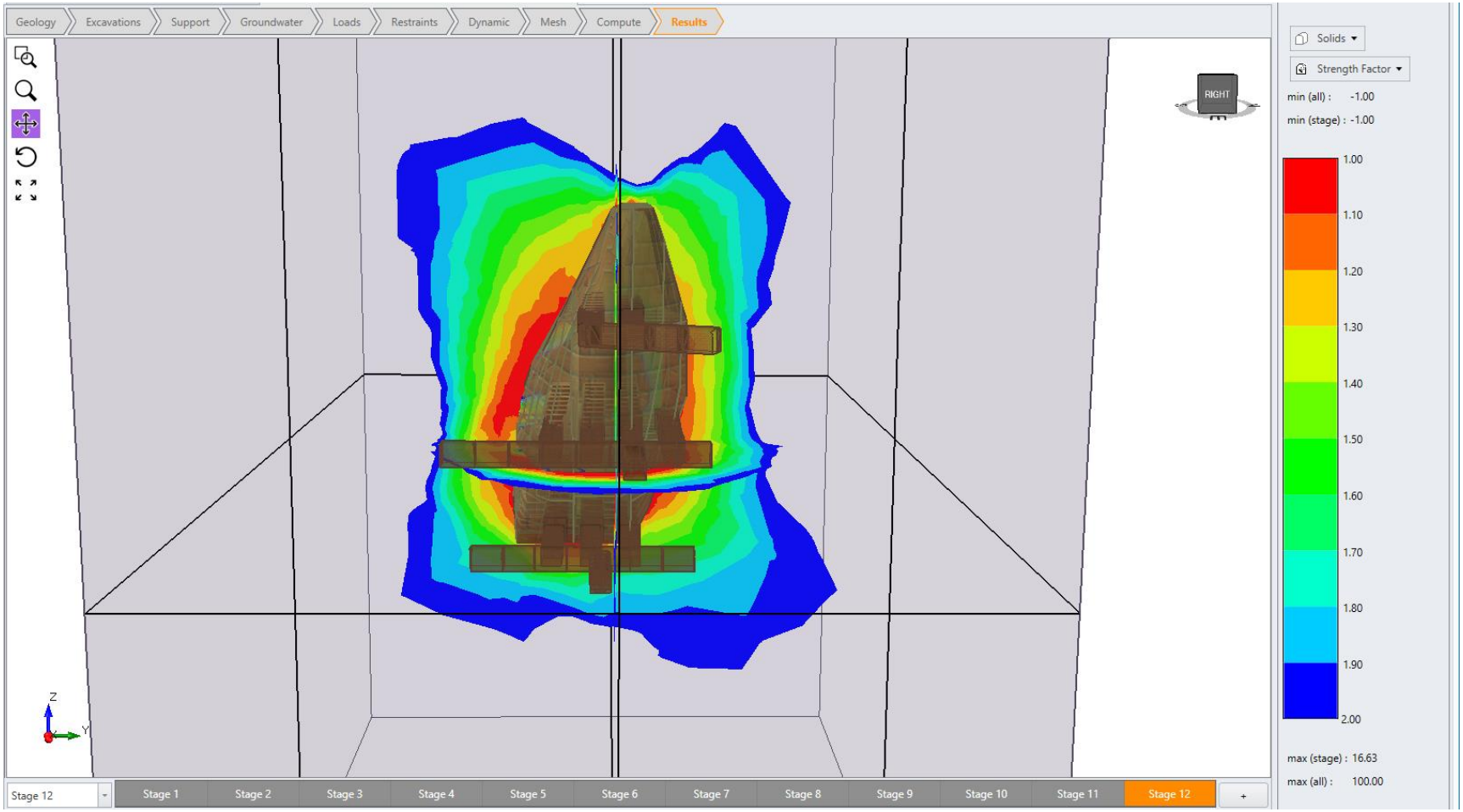
Base Case Model
Strength Factor @ Stg. 12



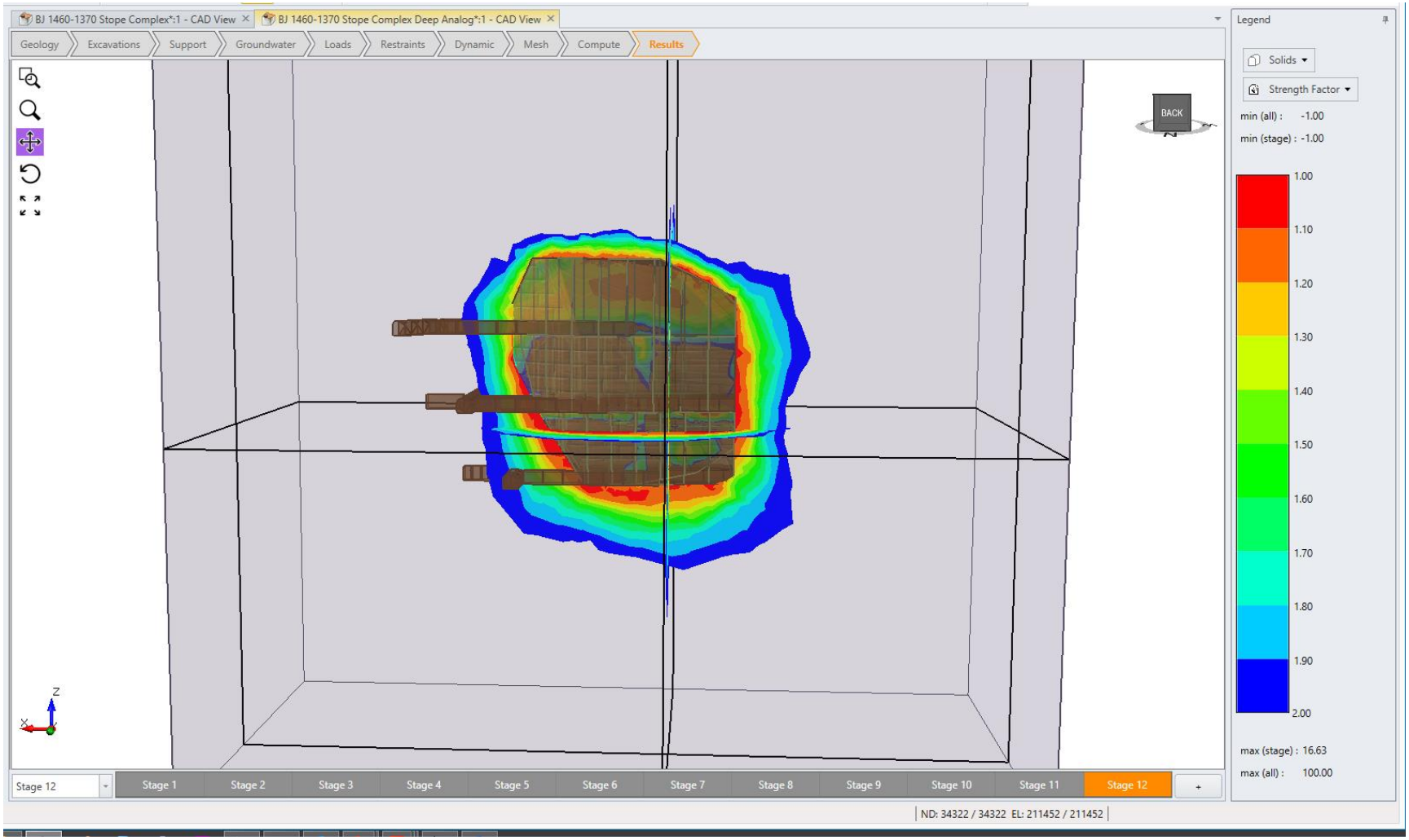
Lower Strength Model
Strength Factor @ Stg. 12



Lower Strength Model
Strength Factor @ Stg. 12

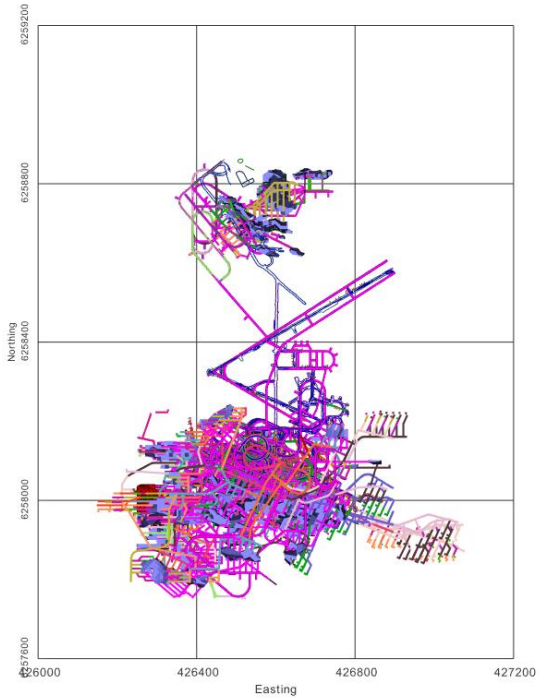


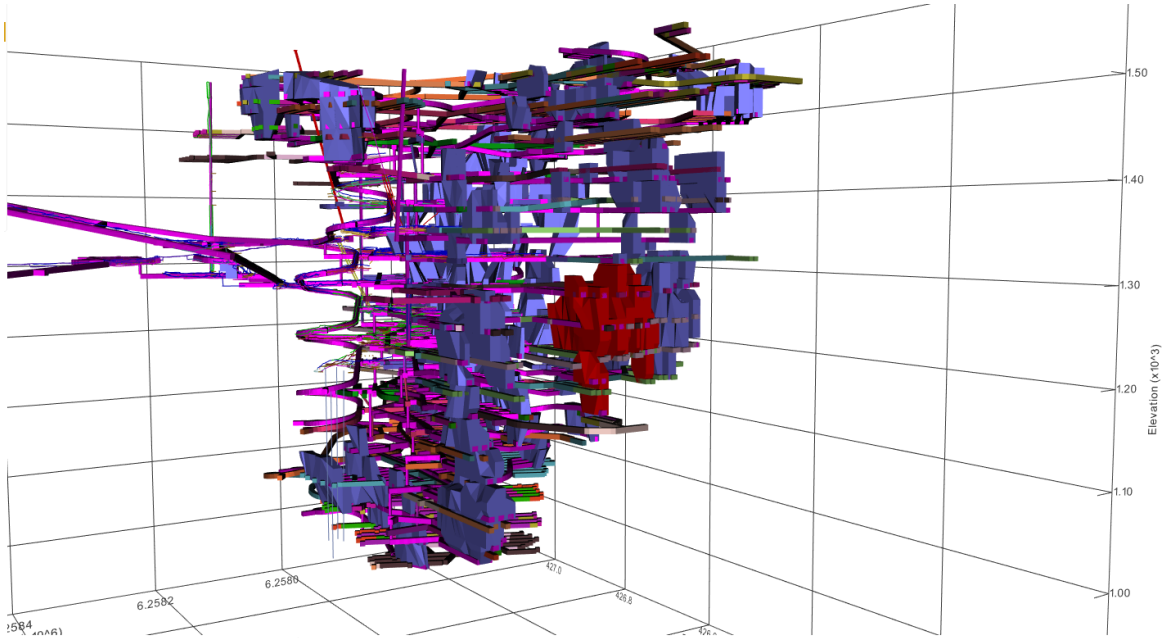
Analog Model 400 m Deeper–
Strength Factor @ Stg. 12

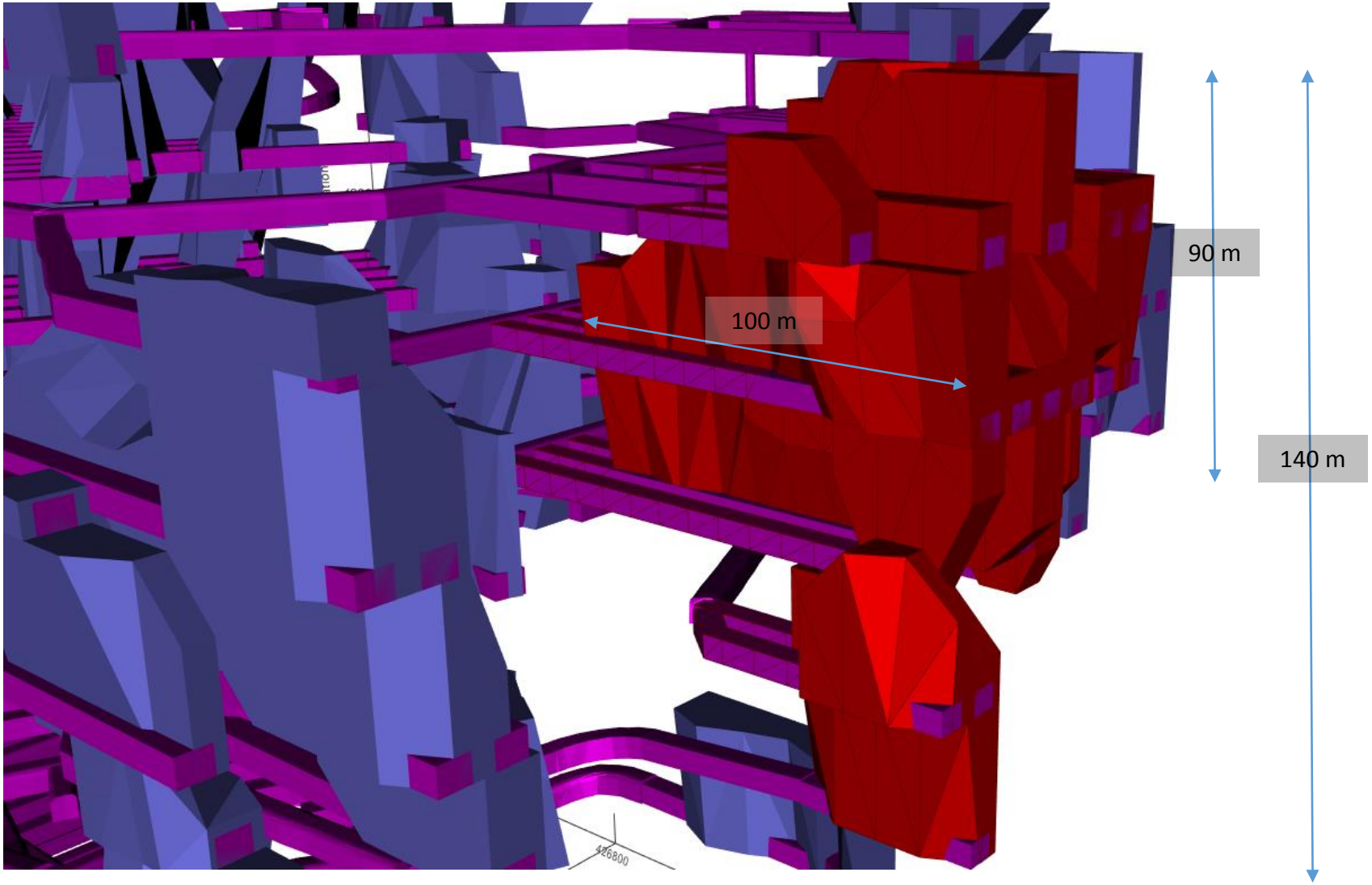


Analog Model 400 m Deeper–
Strength Factor @ Stg. 12

Example of Additional RS3 Stress Analysis Model Location





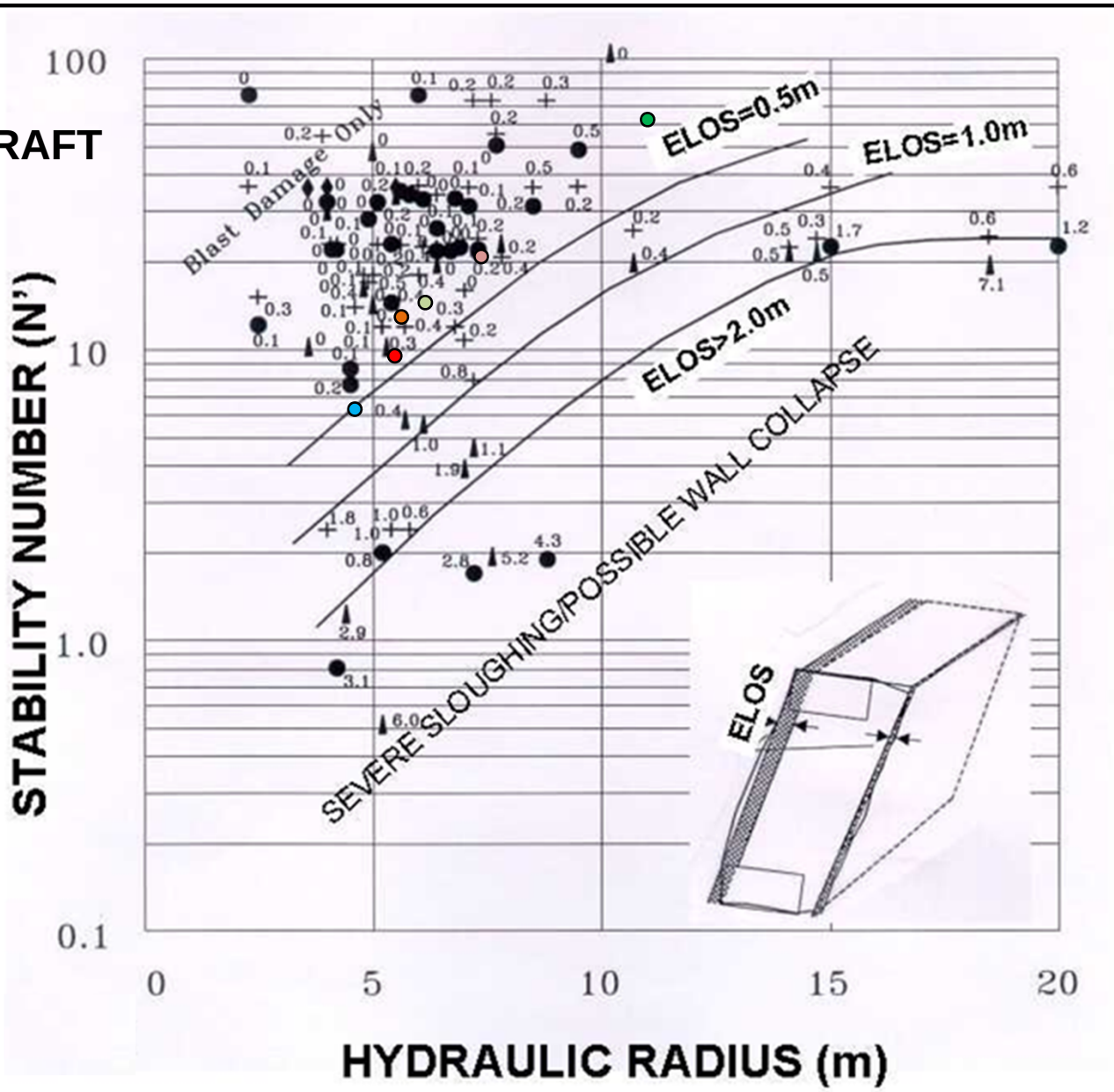


Example of Additional RS3 Stress Analysis Model Location

Appendix J

Stope Dilution Assessments

DRAFT



UNSUPPORTED HANGINGWALL	CASE	N'	HYDRAULIC RADIUS (m)
FRESH ROCK	CONSERVATIIVE	16	6.2
	BASE	64	11.0
FAULTED ROCK	CONSERVATIIVE	6.4	4.5
	BASE	9.6	5.5
WEST ZONE WEATHERED ROCK	CONSERVATIIVE	6.4	4.6
	BASE	14.4	6.1
VOK WEATHERED ROCK	CONSERVATIIVE	6.4	4.5
	BASE	20.8	7.4

NOTES:
1. ELOS determination follows methodology proposed by Clark, 1995.

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

REPORT TITLE:
BRUCEJACK PROJECT FEASIBILITY STUDY
UNDERGROUND ROCK MECHANICS ASSESSMENT

FIGURE TITLE:
EQUIVALENT LINEAR OVERBREAK SLOUGH ESTIMATES FOR AN UNSUPPORTED HANGINGWALL

CLIENT: PRETIUM RESOURCES INC.

PROJECT No.: 1008-007-002

FIGURE No.: J-01

N:\BGC\PROJECTS\1008 PRETIUM\007 FEASIBILITY\002 UG - OFFICE\02 DESIGN TASKS\11 OVERBREAK

TO BE READ WITH REPORT TITLED "BRUCEJACK PROJECT FEASIBILITY STUDY – UNDERGROUND ROCK MECHANICS ASSESSMENT" DATED APRIL 2013

Appendix K

Brucejack Mine 2019 Annual Review of the Underground Workings

SRK Consulting (Canada) Inc.
2200–1066 West Hastings Street
Vancouver, BC V6E 3X2

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F: +1.604.687.5532
vancouver@srk.com
www.srk.com

March 9, 2020
Project No: 1CP026.001

Lyle Morgenthaler, P.Eng.
Chief Mining Engineer
Brucejack Gold Mine
Pretium Resources Inc.
2300 – 1055 Dunsmuir Street
Vancouver, BC, V7X 1L4
Canada

Dear Mr. Morgenthaler,

Re: Brucejack Gold Mine 2019 Annual Review of the Underground Workings

This letter has been prepared by SRK Consulting (Canada) Inc. (SRK) at Pretium Resources Inc.'s (Pretivm's) request to address the requirement under Permit M-243 Condition C.2(m)(i) for an annual review of the underground workings by a Professional Engineer. The letter is to satisfy the 2019 reporting requirements of that condition, for submission to the Chief Inspector of Mines.

Pretivm retained SRK Consulting (Canada) Inc. (SRK) in February 2019 to conduct the work required for the annual review. Work conducted by SRK in support of this 2019 annual review included:

1. Review of existing underground mine design and related ground control documentation, including the updated minimum ground support standards approved in January 2020; the Ground Control Management Plan (GCMP) and its included Standard Operating Procedures (SOPs), structural geology models, rock mass data and historical design reports prepared by BGC Engineering and others.
2. Site based underground workings review, which was initiated Tuesday September 24th, 2019 with a site visit by Tim Coleman, PEng, BEng (Hons) ACSM MSc DIC and Bruce Murphy, PEng, MSc., and concluded with a follow-up site visit by SRK's consultant, Alida Hartzenberg, M.Sc., February 15th to 20th 2020.

The February 2020 detailed site visit included attendance at planning, safety and daily production meetings to gain a better understanding of the mining operations. Discussions were held with various personnel involved with underground mine planning and implementation, including those from the Technical Services (including Geotechnical), Geological, and Mining departments and personnel with the underground mining Contractor (Procon). These discussions were targeted at gaining an understanding

of the interaction between the different disciplines and their integration in the operations. The underground visits were predominantly led by Brucejack's Senior Geotechnical Engineers and Junior Geotechnical Engineers, accompanied by other technical personnel.

SRK has completed its 2019 review of the underground workings and procedures and in general practices were considered to be good. SRK has provided feedback to Brucejack Gold Mine's technical and engineering teams with some suggested areas of improvement, as follows:

- Formal reporting and follow-ups of requests should be completed to ensure close-outs;
- Update and sign off on the secondary support recommendations and communicate these to relevant teams;
- Ensure all intersections are supported by means of long support, as per the minimum ground support standard;
- Where different lengths of the same ground support type are used across the mine, a means of identifying the difference in length after installation should be implemented;
- Consideration should be given to modifying the ground support in the overcut to reduce the likelihood of instabilities, typically observed as overbreak/damage in stope shoulders, resulting from mining of primary stopes, which have the potential to adversely impact the safe extraction of secondary stopes;
- Ensure quality assurance and quality control of all support products used at the mine is being undertaken and documented;
- Review and update the monitoring and instrumentation procedures;
- Reconciliation of Stope Performance; and
- Minimum ground control designs are recommended for the major structures and associated alteration. This would not preclude the current approach of site-specific assessment but sets guidelines to ensure consistency of approach to the implementation of ground support at the mine.

Sincerely,
SRK Consulting (Canada) Inc.

Tim Coleman, PEng, BEng (Hons) ACSM MSc DIC
Principal Consultant, Mining Rock Mechanics

Alida Hartzenberg, MSc
Consultant, Mining Rock Mechanics

Disclaimer—SRK Consulting (Canada) Inc. has prepared this document for Pretium Resources Inc.. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

Appendix L

Minimum Ground Support Standards

Table 1 Minimum Primary Ground Support– Drift

Rock mass Condition	Dimension (m x m)	Ground Support Type	Length (m)	Spacing (m x m)	Additional comment
Level development (access drift, level drift, remuck and refuge station drive)					
Good to Fair (RMR_{76} > 40)	5.5w x 5.5h	**#7 fully grouted rebar** plus #8 welded wire screen to cover the back and walls with not more than 2.5m from sill.	2.4	1.8 x 1.8	
Poor to very poor (RMR_{76} < 40)			2.4	1.2 x 1.2	Special instruction might be required from geotechnical engineer. Screen is to bring down to 1.5m from sill.
Main ramp (decline, incline and other hauling routs)					
Good to Fair (RMR_{76} > 40)	6.0w x 5.5h	**#7 fully grouted rebar** plus #8 welded wire screen to cover the back and walls with not more than 1.5m from sill.	2.4	1.8 x 1.8	
Poor to very poor (RMR_{76} < 40)			2.4	1.2 x 1.2	Special instruction might be required from geotechnical engineer
Cross cut (waste cross cut)					
Good to Fair (RMR_{76} > 40)	5.0w x 5.0h	**#7 fully grouted rebar** plus #8 welded wire screen to cover the back and walls with not more than 3.0m from sill.	2.4	1.8 x 1.8	
Poor to very poor (RMR_{76} < 40)			2.4	1.2 x 1.2	Special instruction might be required from geotechnical engineer. Screen is to bring down to 1.5m from sill.
Cross cut (Ore cross cut)					
Good to Fair (RMR_{76} > 40)	5.0w x 5.0h	**2.1m Splitset** plus #8 welded wire screen to cover the back and walls with not more than 3.0m from sill.	2.1	1.2 x 1.2	
Poor to very poor			2.1	1.2 x 1.2	Special instruction might be required from geotechnical engineer. Screen is to bring down to 1.5m from sill.
Develop through paste backfill					
11% binder paste backfill	5.2w x 5.3h	2.1m long splitset plus #8 welded wire screen plus two 50mm thick layers of shotcrete (total thick of 100 mm): one before bolt & screen and another after bolt & screen.	2.1	1.0 x 1.0	Development sequence: 1). 2m excavation; 2). 50 mm thick of shotcrete will be applied right after excavation; 3). 6 hours shotcrete curing; bolt and screen; excavation for next round; 4). apply 50mm thick shotcrete to the current round exposed paste and to second layer to the previous round to cover the bolt and screen. Repeat the steps until paste development completion.

Note: 0.9m long splitset will be used to tight the screen to the rock surface whenever required.

Table 2 Secondary Ground Support - Drift

Rock mass Condition	Dimension (m x m)	Ground Support Type	Length (m)	Spacing (m x m)	Additional comment
Top cut of ore stope (Primary stope)					
Good to Fair (RMR_{76} > 40)	5.0~15.0w x 5.0h	single strand cable bolts	6	2.5 x 2.5	
Poor to very poor (RMR_{76} < 40)		single strand cable bolts	6	2.0 x 2.0	Special instruction might be required from geotechnical engineer
Top cut of ore stope (Secondary stope)					
Good to Fair (RMR_{76} > 40)	5.0w x 5.0h	double strands cable bolts	12.5	1.5 x 1.5	Toes fan out
Poor to very poor (RMR_{76} < 40)		double strands cable bolts	12.5	1.5 x 1.5	Special instruction might be required from geotechnical engineer
Bottom cut of ore stope (full width expansion for mucking only)					
Good to Fair (RMR_{76} > 40)	5.0w x 5.0h	Connectable Super Swellex	4.88	2.5 x 2.5	Three Superswellex per ring in the back to be installed before slash. No long support for the slashed area.
Poor to very poor (RMR_{76} < 40)		Connectable Super Swellex	4.88	2.0 x 2.0	Three Superswellex per ring to be installed before slash. Special instruction might also be required from geotechnical engineer.

Bottom cut of ore stope (full width expansion for drilling)					
Good to Fair (RMR_{76} > 40)	15.0w x 5.0h	Connectable Super Swellex	4.88	2.5 x 2.5	Three Superswellex per ring to be installed at vertical before slash . Slashed area will have the rest of the Superswellex installed into the pattern.
Poor to very poor (RMR_{76} < 40)		Connectable Super Swellex	4.88	2.0 x 2.0	Special instruction might be required from geotechnical engineer

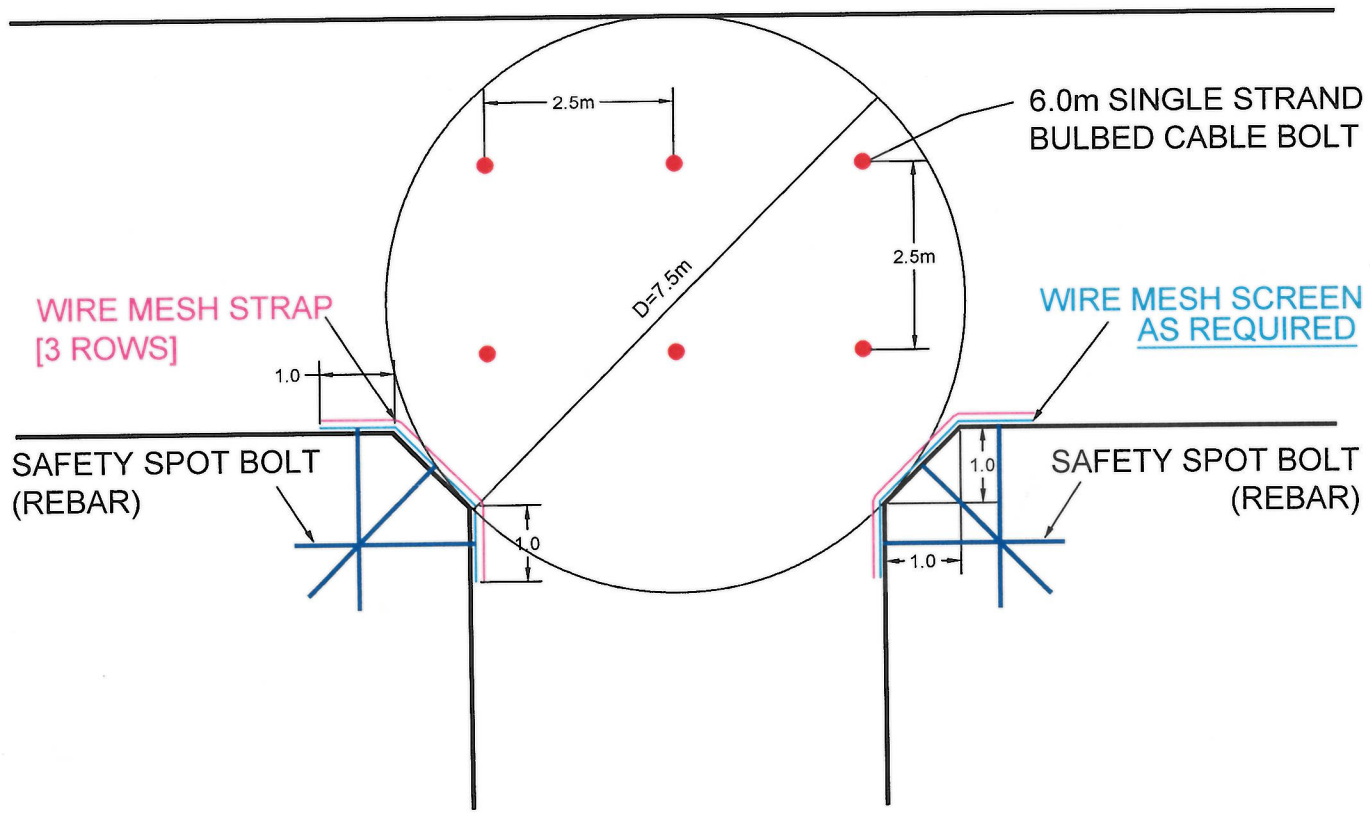
Table 3 Secondary Ground Support guideline for Oversized Intersections

Rock mass Condition	Dimension (D, m)	Ground Support Type	Length (m)	Spacing (m x m)	Additional comment
Small scale, 3-way intersection					
Good to Fair (RMR_{76} > 40)	7~10	6 or more single strand bulbed cable bolt	6	2.5 x 2.5	
Poor to very poor (RMR_{76} < 40)		9 or more single strand bulbed cable bolt	6	2.0 x 2.0	Special instruction might be required from geotechnical engineer
Large scale, 4-way intersection					
Good to Fair (RMR_{76} > 40)	>10	9 or more single strand bulbed cable bolt	6	2.5 x 2.5	
Poor to very poor (RMR_{76} < 40)		12 or more single strand bulbed cable bolt	6	2.0 x 2.0	Special instruction might be required from geotechnical engineer
Intersection in temporary drift					
Good to Fair (RMR_{76} > 40)	7~9	6 or more connectable Superswellex	2.4	2.5 x 2.5	
Poor to very poor (RMR_{76} < 40)		9 or more connectable Superswellex	2.4	2.0 x 2.0	Special instruction might be required from geotechnical engineer

INTERSECTION DEVELOPMENT - 7.0m< D <10.0m

RAMP & LEVEL [RMR : > 40]

PATTERN ID: **PI - T1**



SUPPORT ELEMENTS

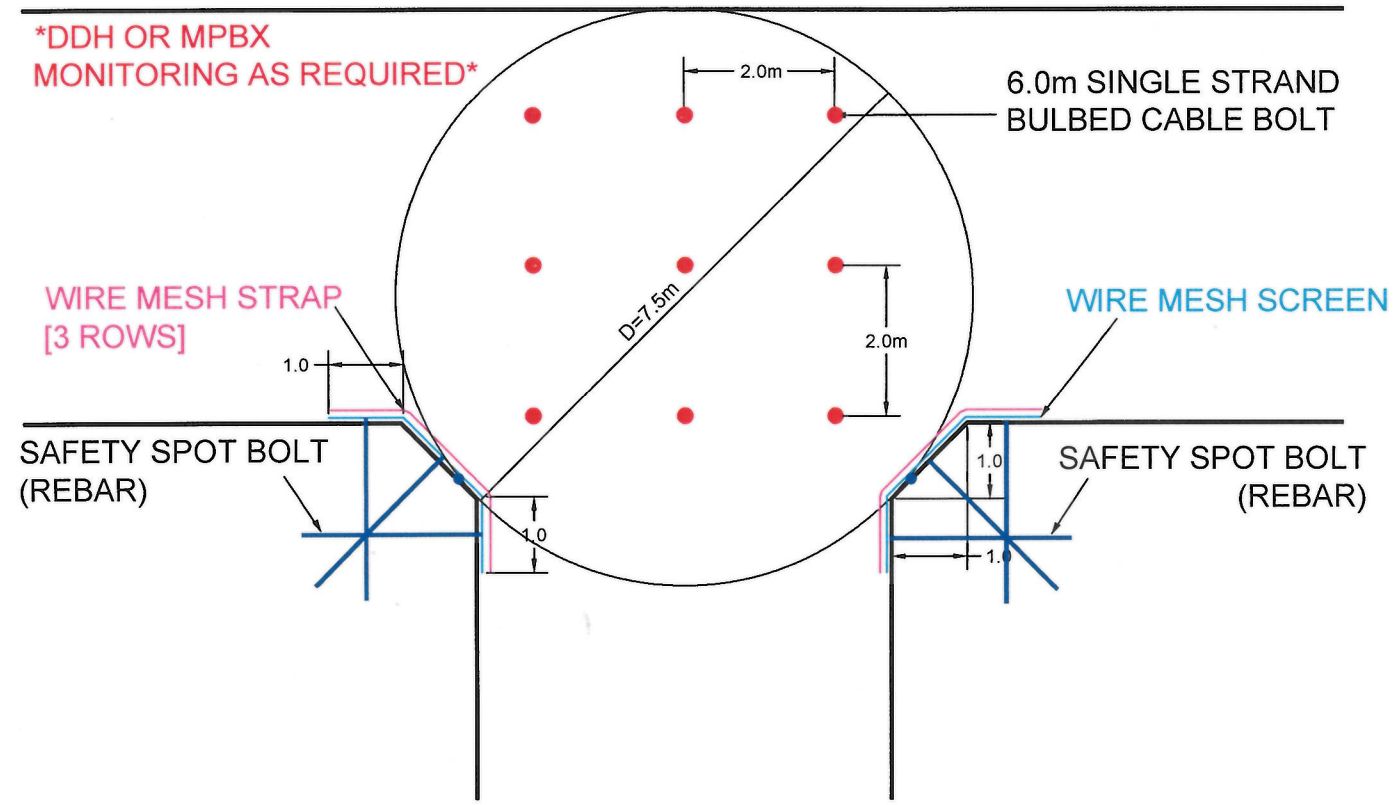
SUPPORT TYPE	LENGTH	PATTERN
SINGLE STRAND CABLE BOLT	6.0m	2.5m X 2.5m
WIRE MESH STRAPS	-	3 ROWS
WIRE MESH SCREEN	-	**AS REQUIRED**

NOTE:
1. Number of Cable Bolts will be installed depending on the true dimension of the intersection. B.T.
2. This instruction shows Secondary support patterns ONLY.
3. PI-T2 and PI-T4: Cable bolts sequence as per geotechnical group recommendations.

RAMP & LEVEL [RMR : < 40]

WHEN RMR < 40, SPECIAL INSTRUCTIONS MAY BE ISSUED

PATTERN ID: **PI - T2**



SUPPORT ELEMENTS

SUPPORT TYPE	LENGTH	PATTERN
SINGLE STRAND CABLE BOLT	6.0m	2.0m X 2.0m
WIRE MESH STRAPS	-	3 ROWS
WIRE MESH SCREEN	-	1.5m FROM SILL

NOTE:
1. Number of Cable Bolts will be installed depending on the true dimension of the intersection. B.T.
2. This instruction shows Secondary support patterns ONLY.
3. PI-T2 and PI-T4: Cable bolts sequence as per geotechnical group recommendations.

REVISION

No.	DATE	DESCRIPTION
002	DECEMBER 2019	UPDATE SUPPORT PATTERN WITH REGARDS TO ROCK MASS CLASSIFICATION
001	JULY 2018	UPDATED WALL & FACE SCREEN REQUIREMENTS
0	APRIL 2017	ISSUED FOR CONSTRUCTION

APPROVAL

MINE MANAGER		Jan 14, 2020
CHIEF MINING ENG.		Feb 6 2020
MINE SUPERINTENDENT		Jan 14, 2020
MINE CAPTAIN		Jan 14, 2020
SR. GEOTECHNICAL ENG.		Jan 14, 2020
PROCON SUPERINTENDENT		Jan 16 2020
SR. PROCON ENG.		Jan 15, 20

PRETIVM BRUCEJACK PROJECT

DATE:	191215
SCALE:	NTS
DRAWN BY:	IH / YZ
CHECKED BY:	BT

PRETIUM RESOURCES INC.

BRUCEJACK GOLD MINE

OVERSIZE INTERSECTION
SECONDARY SUPPORT
7.0m<D<10.0m

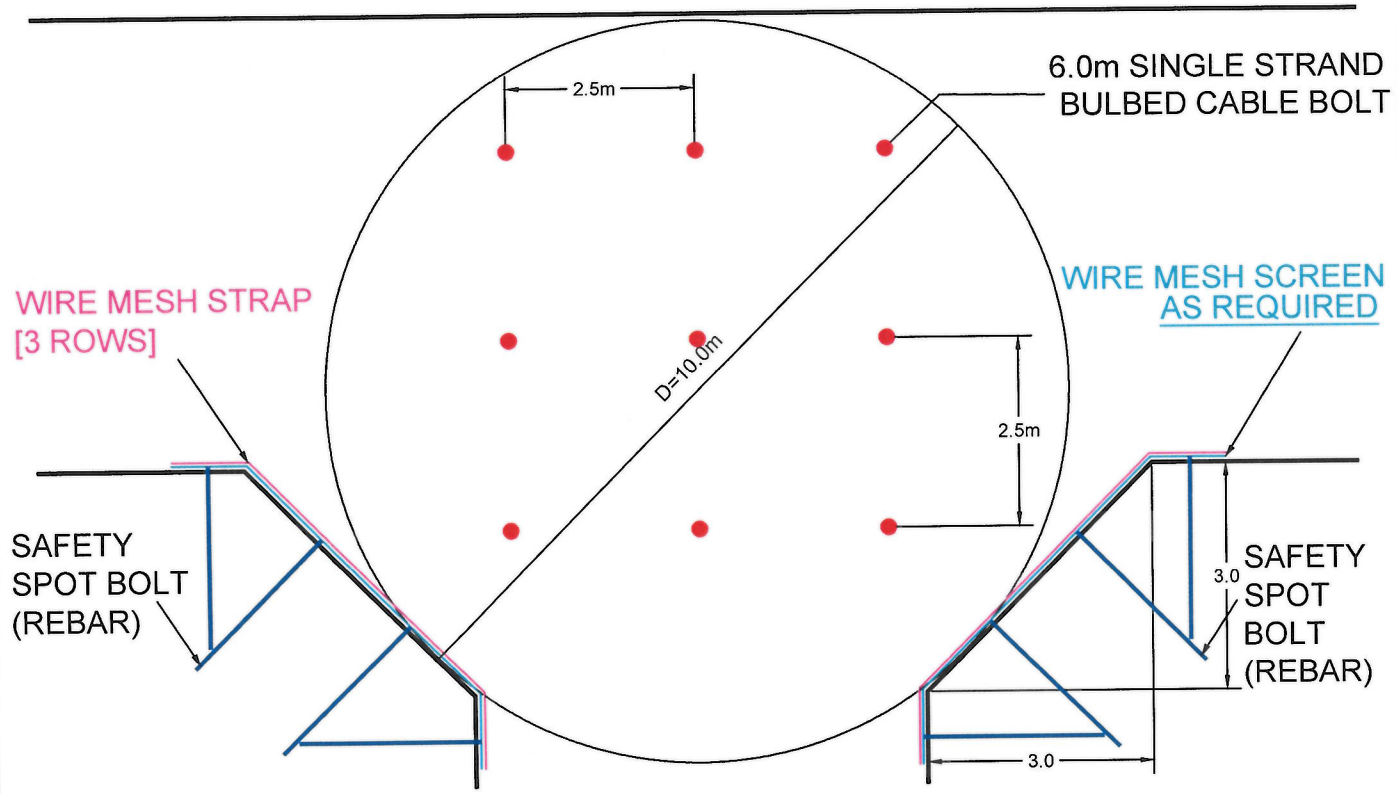
DWG. No.: 191215_PRETIVM_GROUND_SUPPORT_R2

REV: 002

INTERSECTION DEVELOPMENT - 10.0 m<D < 15.0m

RAMP & LEVEL [RMR : > 40]

PATTERN ID: **PI - T3**



SUPPORT ELEMENTS

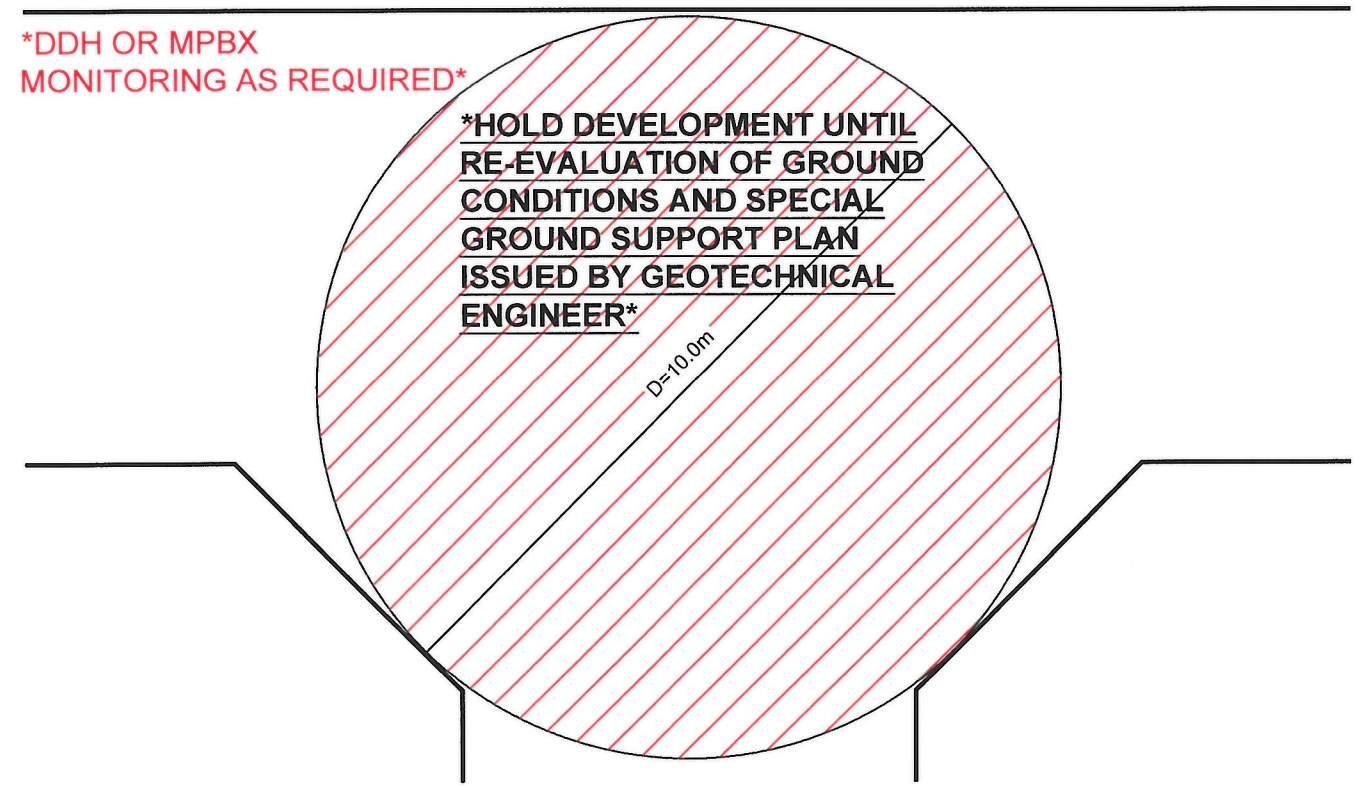
SUPPORT TYPE	LENGTH	PATTERN
SINGLE STRAND CABLE BOLT	6.0m	2.5m X 2.5m
WIRE MESH STRAPS	-	3 ROWS
WIRE MESH SCREEN	-	**AS REQUIRED**

NOTE:
1. Number of Cable Bolts will be installed depending on the true dimension of the intersection.
2. This instruction shows secondary support patterns ONLY. B.J.
3. PI-T2 and PI-T4: Cable bolts sequence as per geotechnical group recommendations.

RAMP & LEVEL [RMR : < 40]

WHEN RMR < 40, SPECIAL INSTRUCTIONS MAY BE ISSUED

PATTERN ID: **PI - T4**



SUPPORT ELEMENTS

SUPPORT TYPE	LENGTH	PATTERN
SINGLE STRAND CABLE BOLT	-	HOLD
WIRE MESH STRAPS	-	HOLD
WIRE MESH SCREEN	-	HOLD

NOTE:
1. Number of Cable Bolts will be installed depending on the true dimension of the intersection.
2. This instruction shows secondary support patterns ONLY. B.J.
3. PI-T2 and PI-T4: Cable bolts sequence as per geotechnical group recommendations.

REVISION

No.	DATE	DESCRIPTION
002	DECEMBER 2019	UPDATE SUPPORT PATTERN WITH REGARDS TO ROCK MASS CLASSIFICATION
001	JULY 2018	UPDATED WALL & FACE SCREEN REQUIREMENTS
0	APRIL 2017	ISSUED FOR CONSTRUCTION

APPROVAL

MINE MANAGER		Jan 14, 2020
CHIEF MINING ENG.		Feb 6 2020
MINE SUPERINTENDENT		Jan 14, 2020
MINE CAPTAIN		Jan 14, 2020
SR. GEOTECHNICAL ENG.		Jan 14, 2020
PROCON SUPERINTENDENT		Jan 16 2020
SR. PROCON ENG.		Jan 15, 20

PRETIVM BRUCEJACK PROJECT

DATE:	191215
SCALE:	NTS
DRAWN BY:	IH / YZ
CHECKED BY:	BT

PRETIUM RESOURCES INC.

BRUCEJACK GOLD MINE

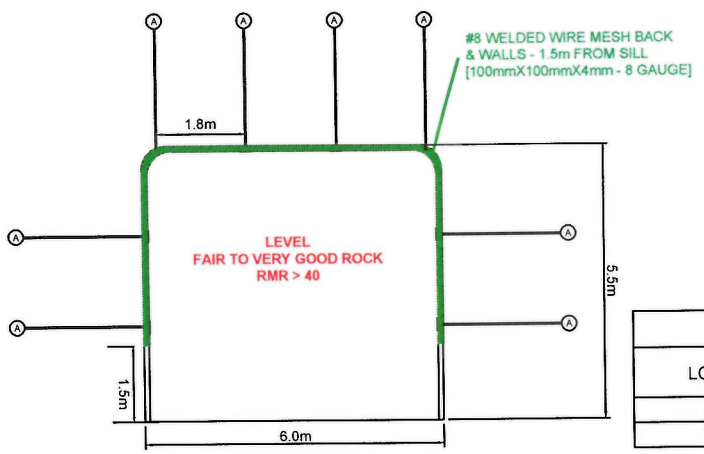
OVERSIZE INTERSECTION SECONDARY SUPPORT 10.0m<D<15.0m

DWG. No.: 191215_PRETIVM_GROUND_SUPPORT_R2

REV: 002

TYPE - RAMP I (PATTERN ID: R-T1)
(6.0mW X 5.5mH)

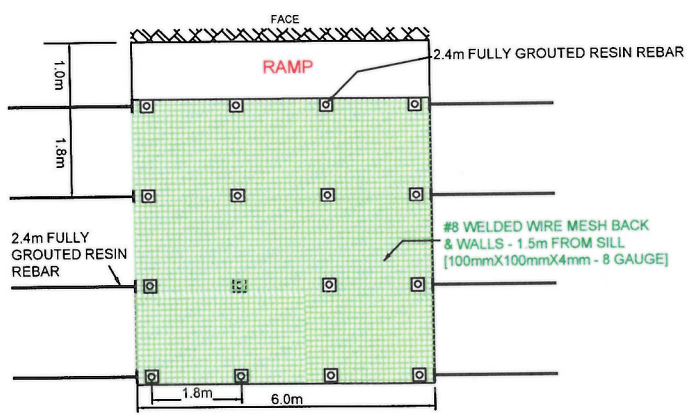
SECTION



SUPPORT BOLT TABLE		
No.	TYPE	LENGTH (m)
A	FULLY GROUTED #7 REBAR	2.4
B	SS39 SPLIT SET	2.1
C	SINGLE STRAND CABLE BOLT	6.0
D	SUPER SWELLEX EXT. BOLT	4.8

SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	A	2.4m	1.8m X 1.8m	-	-	AS NOTED
Walls	A	2.4m	1.8m X 1.8m	-	-	AS NOTED

PLAN

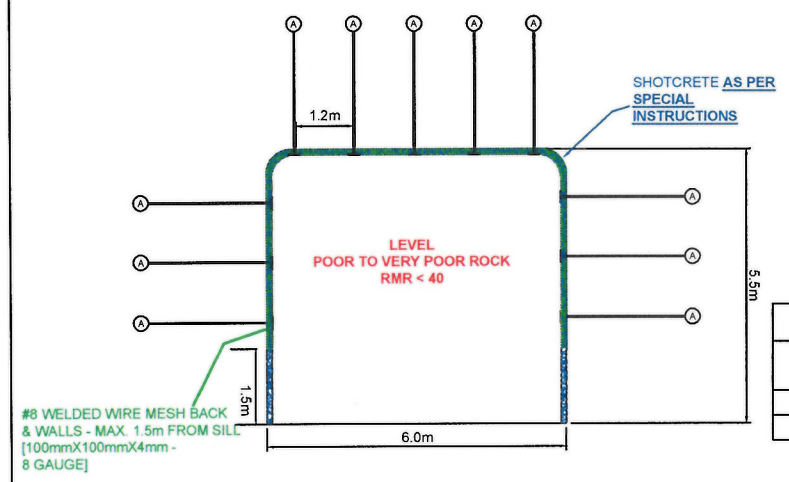


NOTES
1. NO PERSON IS TO WORK UNDER UNSUPPORTED GROUND.
2. ALL ROCKBOLTS ARE TO BE INSTALLED AT 90+-10 DEGREES TO THE PLANNED PROFILE.
3. ANY FAULTY ROCKBOLTS MUST HAVE A REPLACEMENT BOLT INSTALLED BESIDE IT.
4. LAST ROW OF BOLTS MUST BE NO FURTHER THAN 1.0M FROM THE FACE.WALL SCREEN CAN BE LAGGED FOR 3 ROUNDS BUT NO MORE THAN 5 ROUNDS.
5. ALL ACTIVE FACES TO BE SCREENED 2.1M DOWN FROM BACK (1 SCREEN WIDTH).
6. ALL BOLTS TO BE PLATED BEFORE FIRING THE NEXT FACE.
7. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
8. SPOT BOLT VISIBLE WEDGES AND SLABS AS REQUIRED
9. ALL SUPPORT MUST BE INSTALLED PRIOR TO SLASH

TYPE - RAMP II (PATTERN ID: R-T2)
(6.0mW X 5.5mH)

WHEN RMR < 40, SPECIAL INSTRUCTIONS MAY BE ISSUED

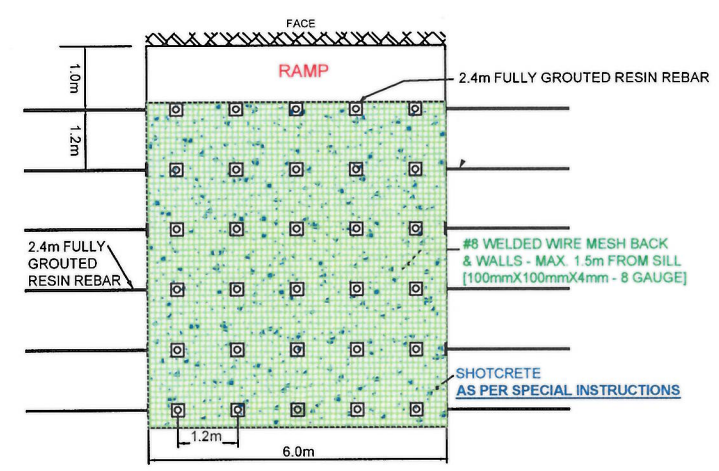
SECTION



SUPPORT BOLT TABLE		
No.	TYPE	LENGTH (m)
A	FULLY GROUTED #7 REBAR	2.4
B	SS39 SPLIT SET	2.1
C	SINGLE STRAND CABLE BOLT	6.0
D	SUPER SWELLEX EXT. BOLT	4.8

SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	A	2.4m	1.2m X 1.2m	-	AS NOTED	AS NOTED
Walls	A	2.4m	1.2m X 1.2m	-	AS NOTED	AS NOTED

PLAN



NOTES
1. NO PERSON IS TO WORK UNDER UNSUPPORTED GROUND.
2. ALL ROCKBOLTS ARE TO BE INSTALLED AT 90+-10 DEGREES TO THE PLANNED PROFILE.
3. ANY FAULTY ROCKBOLTS MUST HAVE A REPLACEMENT BOLT INSTALLED BESIDE IT.
4. LAST ROW OF BOLTS MUST BE NO FURTHER THAN 1.0M FROM THE FACE.WALL SCREEN CAN BE LAGGED FOR 3 ROUNDS BUT NO MORE THAN 5 ROUNDS.
5. ALL ACTIVE FACES TO BE SCREENED 2.1M DOWN FROM BACK (1 SCREEN WIDTH).
6. ALL BOLTS TO BE PLATED BEFORE FIRING THE NEXT FACE.
7. ALL SHEETS OF MESH ARE TO OVERLAP BY 3 SQUARES, WITH THE BOLT IN THE MIDDLE (2ND ROW) OF THE OVERLAP.
8. SPOT BOLT VISIBLE WEDGES AND SLABS AS REQUIRED
9. ALL SUPPORT MUST BE INSTALLED PRIOR TO SLASH

REVISION		
002	DECEMBER 2019	UPDATE SUPPORT PATTERN WITH REGARDS TO ROCK MASS CLASSIFICATION
001	JULY 2018	UPDATED WALL & FACE SCREEN REQUIREMENTS
0	APRIL 2017	ISSUED FOR CONSTRUCTION
No.	DATE	DESCRIPTION

APPROVAL		
MINE MANAGER		Jan 14, 2020
CHIEF MINING ENG.		Feb 6 2020
MINE SUPERINTENDENT		Jan 14, 2020
MINE CAPTAIN		Jan 14-2020
SR. GEOTECHNICAL ENG.		Jan. 14, 2020
PROCON SUPERINTENDENT		Jan 16 2020
SR. PROCON ENG.		Jan 15, 20

PRETIVM BRUCEJACK PROJECT

DATE:	191215
SCALE:	NTS
DRAWN BY:	IH / YZ
CHECKED BY:	BT

PRETIUM RESOURCES INC.

BRUCEJACK GOLD MINE

MINIMUM GROUND SUPPORT
RAMP DEVELOPMENT
PRIMARY SUPPORT

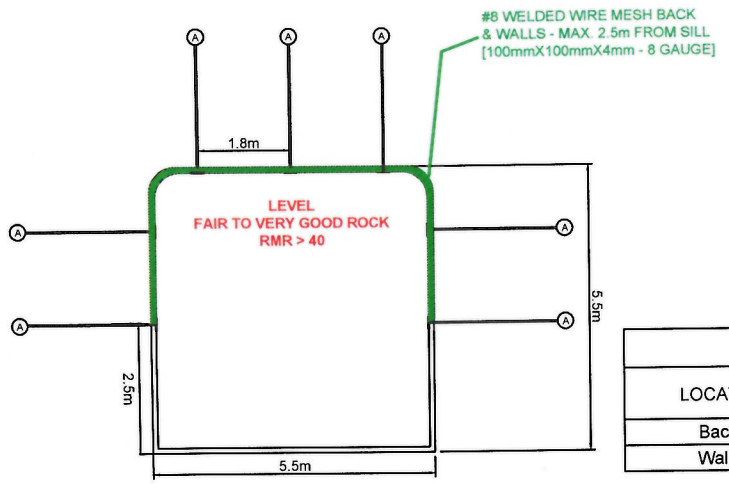
DWG. No.: 191215_PRETIVM_GROUND_SUPPORT_R2

REV: 002

TYPE - LEVEL I (PATTERN ID: L - T1)

(5.5m X 5.5m)

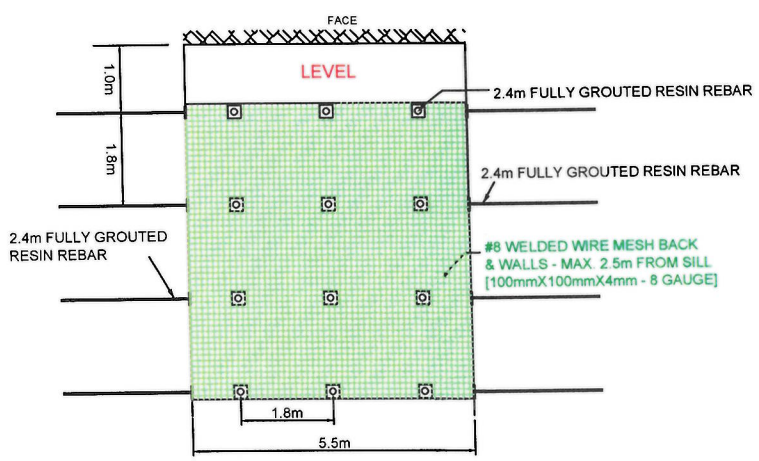
SECTION



SUPPORT BOLT TABLE		
No.	TYPE	LENGTH (m)
A	FULLY GROUTED #7 REBAR	2.4
B	SS39 SPLIT SET	2.1
C	SINGLE STRAND CABLE BOLT	6.0
D	SUPER SWELLEX EXT. BOLT	4.8

SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	A	2.4m	1.8m X 1.8m	-	-	AS NOTED
Walls	A	2.4m	1.8m X 1.8m	-	-	AS NOTED

PLAN



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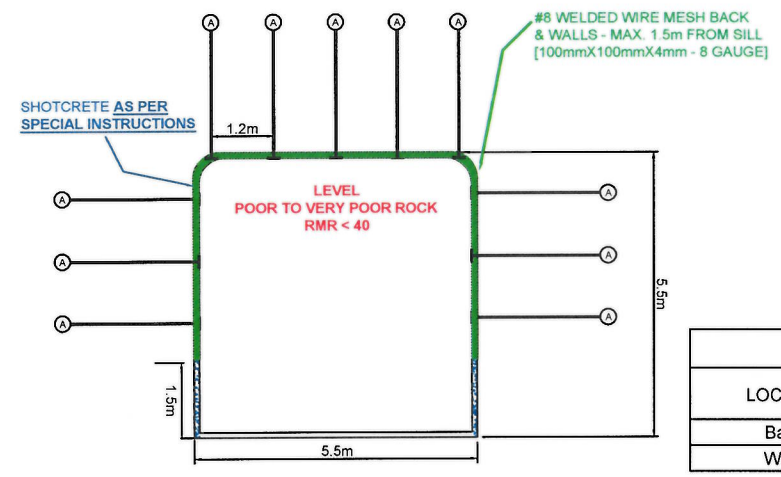
8. SPOT BOLT VISIBLE WEDGES AND SLABS AS REQUIRED
9. ALL SUPPORT MUST BE INSTALLED PRIOR TO SLASH

TYPE - LEVEL II (PATTERN ID: L - T2)

(5.5m X 5.5m)

WHEN RMR < 40, SPECIAL INSTRUCTIONS MAY BE ISSUED

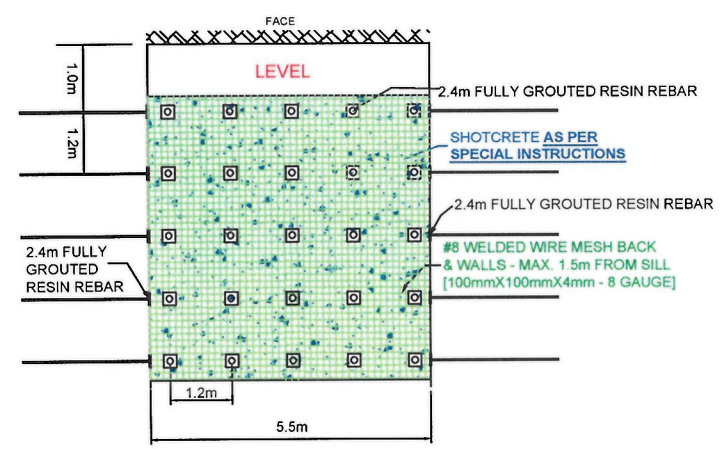
SECTION



SUPPORT BOLT TABLE		
No.	TYPE	LENGTH (m)
A	FULLY GROUTED #7 REBAR	2.4
B	SS39 SPLIT SET	2.1
C	SINGLE STRAND CABLE BOLT	6.0
D	SUPER SWELLEX EXT. BOLT	4.8

SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	A	2.4m	1.2m X 1.2m	-	AS NOTED	AS NOTED
Walls	A	2.4m	1.2m X 1.2m	-	AS NOTED	AS NOTED

PLAN



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REVISION			
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001	JULY 2018	UPDATED WALL & FACE SCREEN REQUIREMENTS	
0	APRIL 2017	ISSUED FOR CONSTRUCTION	
No.	DATE	DESCRIPTION	

APPROVAL		
MINE MANAGER		Jan 14, 2020
CHIEF MINING ENG.		Feb 6 2020
MINE SUPERINTENDENT		Jan 14, 2020
MINE CAPTAIN		Jan 14-2020
SR. GEOTECHNICAL ENG.		Jan 14, 2020
PROCON SUPERINTENDENT	Wayne Peter	Jan 16 2020
SR. PROCON ENG.		Jan 15, 20

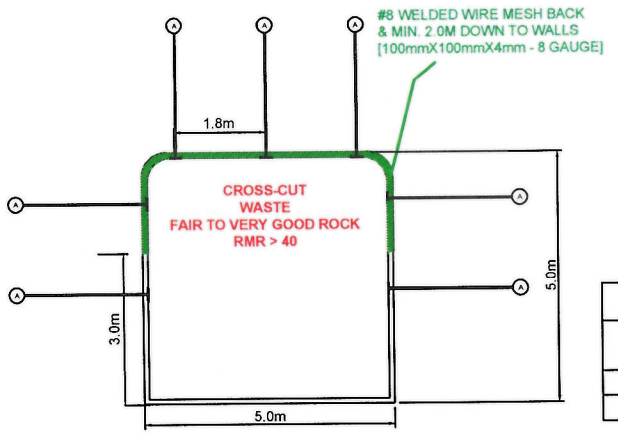
PRETIVM BRUCEJACK PROJECT

DATE:	191215	PRETIUM RESOURCES INC.
SCALE:	NTS	BRUCEJACK GOLD MINE
DRAWN BY:	IH / YZ	MINIMUM GROUND SUPPORT LEVEL DEVELOPMENT PRIMARY SUPPORT
CHECKED BY:	BT	DWG. No.: 191215_PRETIVM_GROUND_SUPPORT_R2 — REV: 002

WASTE CROSS-CUT I (PATTERN ID: WXC-T1)

(5.0m X 5.0m)

SECTION



SUPPORT BOLT TABLE		
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A	FULLY GROUTED #7 REBAR	2.4
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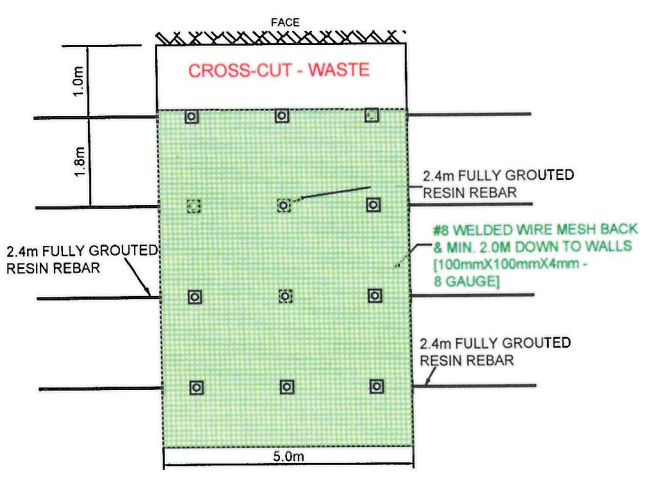
C	SINGLE STRAND CABLE BOLT	6.0
D	SUPER SWELLEX EXT. BOLT	4.8

SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	A	2.4m	1.8m X 1.8m	-	-	AS NOTED
Walls	A	2.4m	1.8m X 1.8m	-	-	AS NOTED

PLAN



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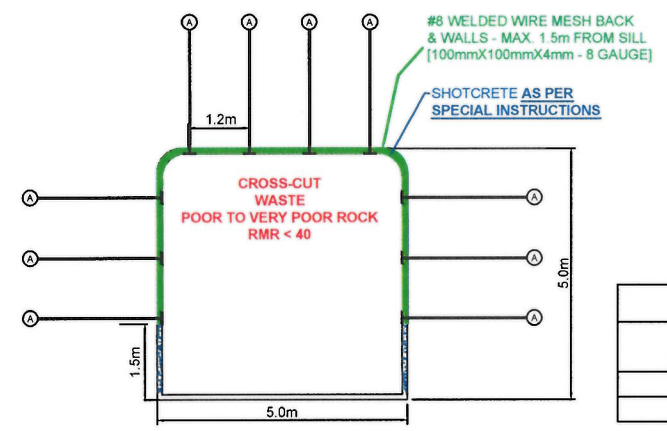
WASTE CROSS-CUT II (PATTERN ID: WXC-T2)

(5.0m X 5.0m)

WHEN RMR < 40, SPECIAL INSTRUCTIONS MAY BE ISSUED

SECTION



SUPPORT BOLT TABLE		
No.	TYPE	LENGTH (m)
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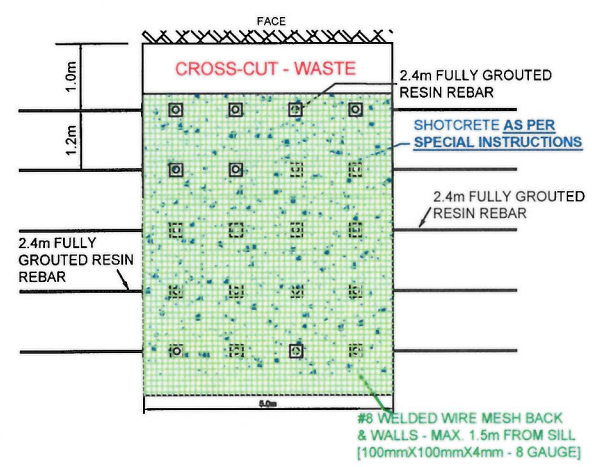
SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	A	2.4m	1.2m X 1.2m	-	AS NOTED	AS NOTED
Walls	A	2.4m	1.2m X 1.2m	-	AS NOTED	AS NOTED

PLAN



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PRETIVM BRUCEJACK PROJECT

DATE:	191215
SCALE:	NTS
DRAWN BY:	IH / YZ
CHECKED BY:	BT

PRETIUM RESOURCES INC.

BRUCEJACK GOLD MINE

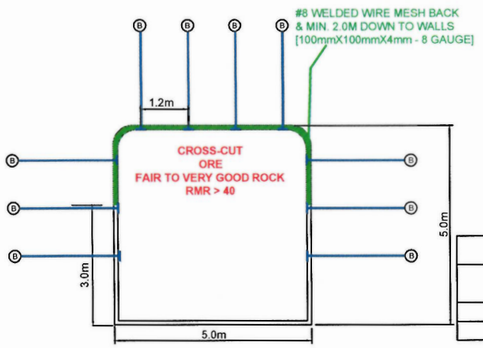
MINIMUM GROUND SUPPORT
CROSS-CUT WASTE DEVELOPMENT
PRIMARY SUPPORT

DWG. No.: 191215_PRETIVM_GROUND_SUPPORT_R2

REV: 002

ORE CROSS-CUT I (PATTERN ID: OXC - T1)
(5.0m X 5.0m)

SECTION



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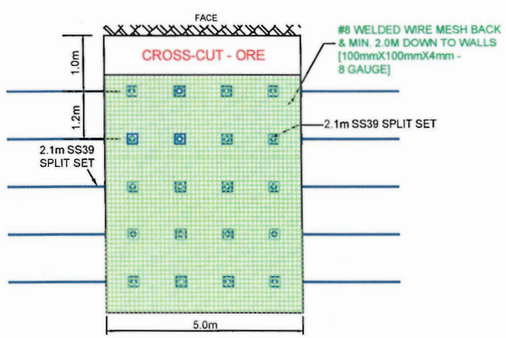
SUPPORT ELEMENTS						
LOCATION	ROCKBOLT			SHOTCRETE		#8 W.W. MESH
	No.	LENGTH	PATTERN	SIZE	THICKNESS	
Back	B	2.1m	1.2m X 1.2m	-	-	AS NOTED
Walls	B	2.1m	1.2m X 1.2m	-	-	

PLAN



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ORE CROSS-CUT II (PATTERN ID: OXC - T2)
(5.0m X 5.0m)

WHEN RMR < 40, SPECIAL INSTRUCTIONS MAY BE ISSUED

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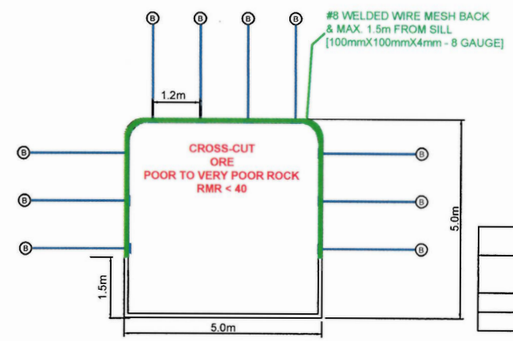

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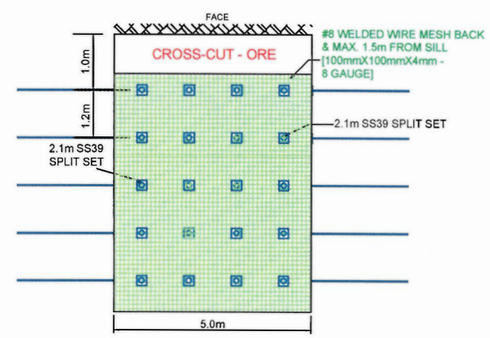
PLAN



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SR. PROCON ENG.		Jan 15, 20

PRETIVM BRUCEJACK PROJECT

DATE:	191215
SCALE:	NTS
DRAWN BY:	IH / YZ
CHECKED BY:	BT

PRETIUM RESOURCES INC.

BRUCEJACK GOLD MINE

MINIMUM GROUND SUPPORT
CROSS-CUT ORE DEVELOPMENT
PRIMARY SUPPORT

DWG. No.: 191215_PRETIVM_GROUND_SUPPORT_R2

REV: 002

Appendix M

Full-Width Undercut Support

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

234 St. Paul Street, Kamloops, BC Canada V2C 6G4
Telephone (250) 374-8600 Fax (250) 374-8606

Project Memorandum

To:	**Pretium Resources Inc.**	**Doc. No.:**	**BJ-2017-55**
Attention:	**Woo Shin, Allan Chan, George Zazzi**	**cc:**	**Roland Tosney**
From:	**Cathy Schmid**	**Date:**	**September 22, 2017**
Subject:	**Brucejack Project – Full Width Undercuts Ground Support Design Review – DRAFT**		
Project No.:	**1008026**		

1.0 BACKGROUND AND SCOPE

Pretium Resources Inc. (Pretium) requested (via email on September 11, 2017 and September 13, 2017) that BGC Engineering Inc. (BGC) review and update the ground support standard for 15 m wide full width undercuts for the Brucejack Project underground mine (Brucejack). The scope of work for this request includes:

1. Review of the existing ground support design for the 15 m wide full width undercuts (Split-set, 2.4 m length, 1.8 x 1.8 m spacing in the back and walls; Bulbed single cables, 6 m length, 2.5 x 2.5 m spacing in the back; 25% shotcrete coverage (back)) to assess the feasibility of achieving the design objectives using 4.88 m (16') connectable Super Swellex (PM24C) instead of the single cables.
2. Update the existing analyses (BGC 2013; BGC 2017) assuming no change to the geotechnical properties for the rock mass and geologic structure used in those analyses.
3. Summarize all analysis work in a brief memo. The memo will be issued in draft to Pretium for review, and then issued in final upon receipt of edits from Pretium.

The objective of this assessment is to confirm if Pretium can replace single strand cable bolts (i.e., the long support) for the full width undercuts with 4.88 m (16') connectable Super Swellex (PM24C) for the "average" and "poor" rock mass conditions. This scope does not include update of the ground support standard drawings or Ground Control Management Plan (GCMP), or site visits to confirm the suitability of the designs. This memorandum summarizes the current work defined under numbers 1 and 2 above, and the resulting updated ground support designs.

The revised designs supersede the designs presented in the current GCMP (2016) and a recent ground support desktop review of the ore drifts and cable bolt ground support standards (BGC 2017), and should be incorporated into the 2017 GCMP version when it is updated by Pretium before the end of the current year.

2.0 DESIGN METHODOLOGY AND CURRENT STANDARD GROUND SUPPORT

2.1. Current Standard Ground Support Designs in Ore Drifts

The full width undercuts are developed as part of stope development work. They are developed as a pilot drift that is then slashed out to full 15 m width as the bottom sill of the stope (Figure 1). The stope is drilled, blasted, and mucked, and then backfilled.

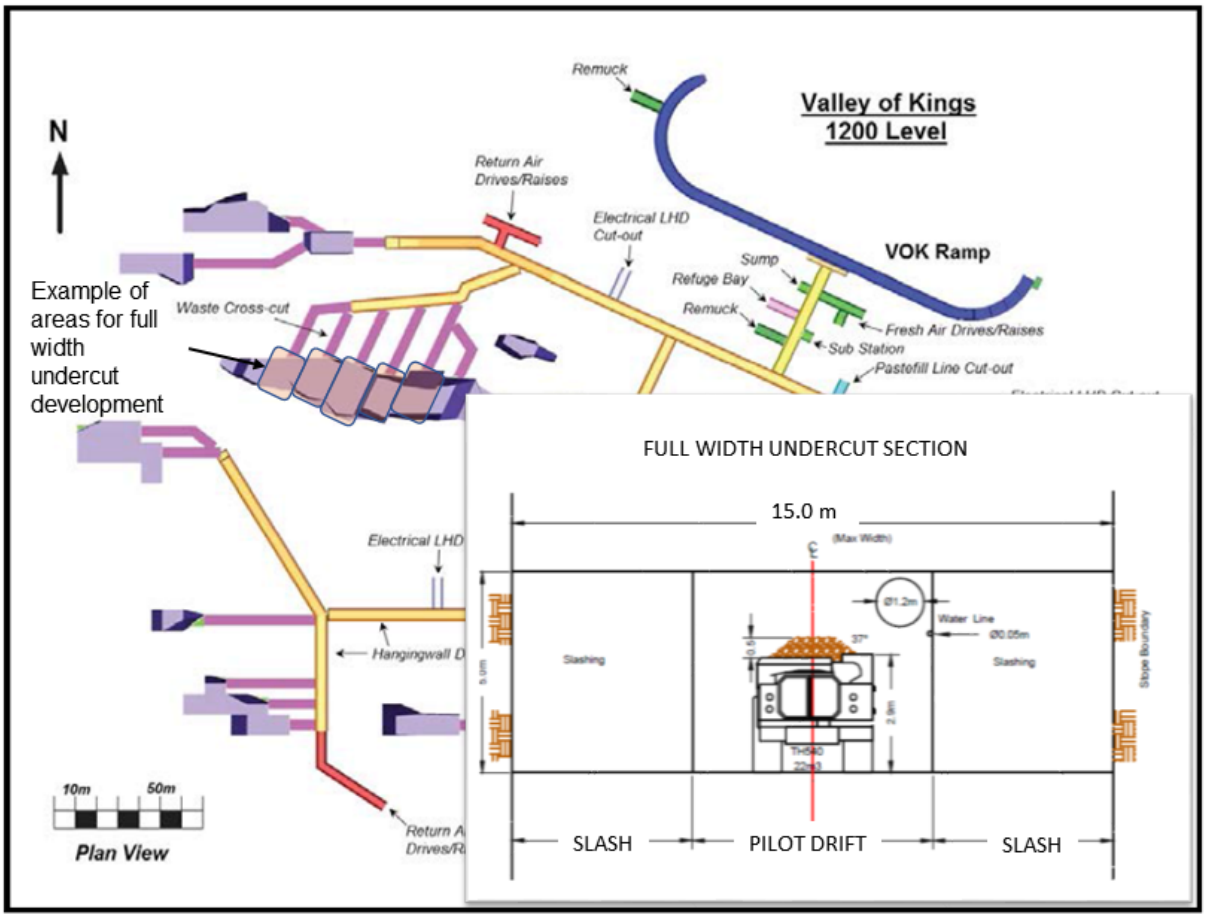

Figure 1. Schematic plan and cross-section view of full width undercut development (base images from Pretium (2014))

The full width undercut ground support designs currently used at Brucejack are:

- "Average" rock mass (10 < Q' < 40) (GSI 70 – 85)
  - SS39 Split Sets, 2.4 m (8') length, 1.8 m spacing
  - Single strand cable bolts, 6 m length, 2.5 m spacing
  - #9 welded wire mesh on the back and 1.0 m down the walls
- "Poor" rock mass rock mass (0.1 < Q' < 10) (GSI 50 – 70)
  - SS39 Split Sets, 2.4 m (8') length, 1.8 m spacing
  - Single strand cable bolts, 6 m length, 2.5 m spacing

- #9 welded wire mesh on the back and down the walls to 1.5 m from the sill

As specified by Pretium, the bolt spacing for the Super Swellex can be adjusted as required to attain the design FOS, but it is not feasible for Brucejack to adjust the bolt length for the Super Swellex due to supply chain limitations.

2.2. Design Methodology

Overall excavation stability was assessed using Grimstad's (2007) empirical design chart for each rock mass condition (average and poor, as defined above).

Kinematic stability analyses were conducted using wedge stability analysis software Unwedge© (Rocscience 2017) to develop minimum ground support recommendations for the full width undercuts in each structural domain (BGC 2013). Discontinuity design sets in each structural domain were defined by considering orientation frequency and sampling method, similarity to major structure, and prominent structure type within each set. Discontinuity strength properties for each structural domain are described in BGC (2013). In-situ stresses were not considered; this adds a degree of conservatism to the analyses, as clamping forces are ignored. Joint set persistence was assumed to be 2.5 m, and fault set persistence was assumed to be 7 m, based on the average observed persistence of discontinuity sets during BGC's 2016 annual underground inspection (BGC, 2016). BGC notes that longer persistence values can significantly impact the results of the Unwedge analyses; if such conditions are observed underground, the current analyses should be reconsidered.

All possible combinations of discontinuity sets were analyzed to assess the adequacy of prescribed ground support to prevent wedge failure. Analyses were run for a range of drift orientations (180° to 270°) to assess stability conditions for proposed access and stoping arrangements.

All mesh is assumed to be 100 mm x 100 mm x 4.0 mm (8 gauge) wire. The Super Swellex (PM24C) and plate are assumed to have a minimum breaking strength of 240 kN and 180 kN, respectively, with an assumed bond strength of 170 kN/m. The standard SS39 Split Set Stabilizer rock bolts are assumed to have a minimum breaking strength of 105 kN. Shotcrete and/or mesh is not considered as a stabilizing component in the factor of safety calculations, but is assumed to be installed as per Pretium (2016) to retain the integrity of the rock mass at the drift boundary.

The full width undercuts are assumed to be "temporary" headings with a design Factor of Safety (FOS) of 1.2. It was assumed that wedges less than 1.0 m^3 (2.7 tons) will be adequately retained by surface support (shotcrete or galvanized welded wire mesh).

3.0 ANALYSIS RESULTS AND SUPPORT RECOMMENDATIONS

Appendix A presents a summary of the overall rock mass stability using Grimstad's (2007) empirical design chart. At the given full width span of 15 m, and assuming an excavation support ratio (ESR) for temporary mine openings, the PM24C long support is predicted to achieve the

design intent with respect to overall rock mass stability of the undercuts in both “good” and “poor” rock mass conditions.

To assess kinematic stability using Unwedge© (Rocscience 2017), the following assumptions were made:

- Joint friction angle is 35°
- Joint cohesion is 0 MPa
- Joint persistence is 2.5 m
- Fault friction angle is 30°
- Fault cohesion is 0 MPa
- Fault persistence is 7 m
- The mean set orientation for the design discontinuity sets in each domain was assumed as defined in BGC (2013)
- The long support design in a drawing (“Brucejack Ground Support Types R1(2017)”) provided by Pretium showed only the pilot drift, with the cable bolts in the shoulder angled outwards at approximately 45°. The original design intent for the full width undercuts (BGC 2013) was for effective full-width cable bolt support. Both geometries were analyzed.

Example Unwedge analyses and the associated inputs are shown in Appendix B. For the assumptions defined above, 4.88 m long connectable Super Swellex (PM24C) installed on 2.4 m spacing are a suitable replacement for the 6 m long single strand bulbed cables. For ore drifts, the full-width condition represents the ‘worst-case’ geometry. Unwedge© analyses of these conditions with the prescribed support indicate a low likelihood of failure, with all wedge geometries that have FOS values lower than the design threshold of 1.2 predicted to have volumes that should be adequately retained by the near surface support (welded wire mesh).

In summary, the revised ground support for the 15 m full width undercuts (15 m width by 5 m height) is:

- 2.4 m long SS39 split sets on 1.8 m spacing in the back and walls
    - Bolts in adjacent rows should be offset by a distance equal to half the row spacing.
- 4.88 m long connectable Super Swellex (PM24C) on 2.4 m spacing in the back
    - Bolts in adjacent rows should be offset by a distance equal to half the row spacing.
    - Three Super Swellex per row (one mid-span (vertical), and one angled into each shoulder of the pilot drift).
- Welded wire mesh or shotcrete in the back and walls to retain the integrity of the rock mass at the drift boundary.

The results of the kinematic stability analysis, which include a limited amount of sensitivity analysis on discontinuity properties, indicate that the adequacy of the ground support is heavily sensitive to the persistence of the joints and faults in the full width undercuts. Specific recommendations on how to manage residual risk for rock fall are provided in the next section.

4.0 CONCLUSIONS AND RECOMMENDATIONS

BGC's analysis indicates the 16' (4.88 m) connectable Super Swellex (PM24C) will generally achieve the design objectives for long support in the full width undercuts. However, the following items were noted by BGC:

- Due to adverse orientation of some of the discontinuity sets in the Brucejack rock mass, there will remain some residual risk for rock fall in the full width undercuts despite the installation of the ground support summarized in this memo. The risk for that rock fall increases where the discontinuities are persistent (greater than half of the cross-cut span) and closely spaced (less than half of the cross-cut span). The existing geotechnical database is insufficient to predict where these more persistent and/or closely spaced discontinuities may occur, therefore thorough geotechnical inspections and routine scaling of the workings throughout the development cycle should be carried out to help mitigate the residual risk.
- When poorer quality rock masses and/or persistent structure(s) are encountered, customized support designs which address local conditions are required. Additional support may include simple modifications such as reducing the spacing on the Super Swellex, or more complex solutions targeting specific zones or features.
- Underground mining personnel will need to assess if underground rock mass conditions closely match the assumed conditions. Should different or atypical conditions be encountered, then the design supplied herein may not be appropriate or valid. BGC should be consulted if different or atypical conditions (rock mass, groundwater, stress regime, blast fragmentation, etc.) are encountered to determine if alternative support requirements are required.
- Mucking level brows of full width undercuts should be regularly inspected by qualified geotechnical staff and mining supervisors for signs of rock mass damage, raveling, and failure within the back and ribs.
- All support (short and long) should be installed in timely manner (ideally "in-cycle") and subject to a rigorous QA/ QC program.
- Rehabilitation of damaged zones of rock within full width undercuts should be carried out as soon as practical.

It is recommended that all standard ground support designs be reviewed and updated annually, as additional operational experience, structural data, stress regime data, and excavation performance data becomes available.

5.0 CLOSURE

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Yours sincerely,

BGC ENGINEERING INC.
per:

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J. Roland Tosney, M.Sc., P.Eng.
Senior Mining Rock Mechanics Engineer

CJS/JRT/vc/ht

Attachments: Appendix A
Appendix B

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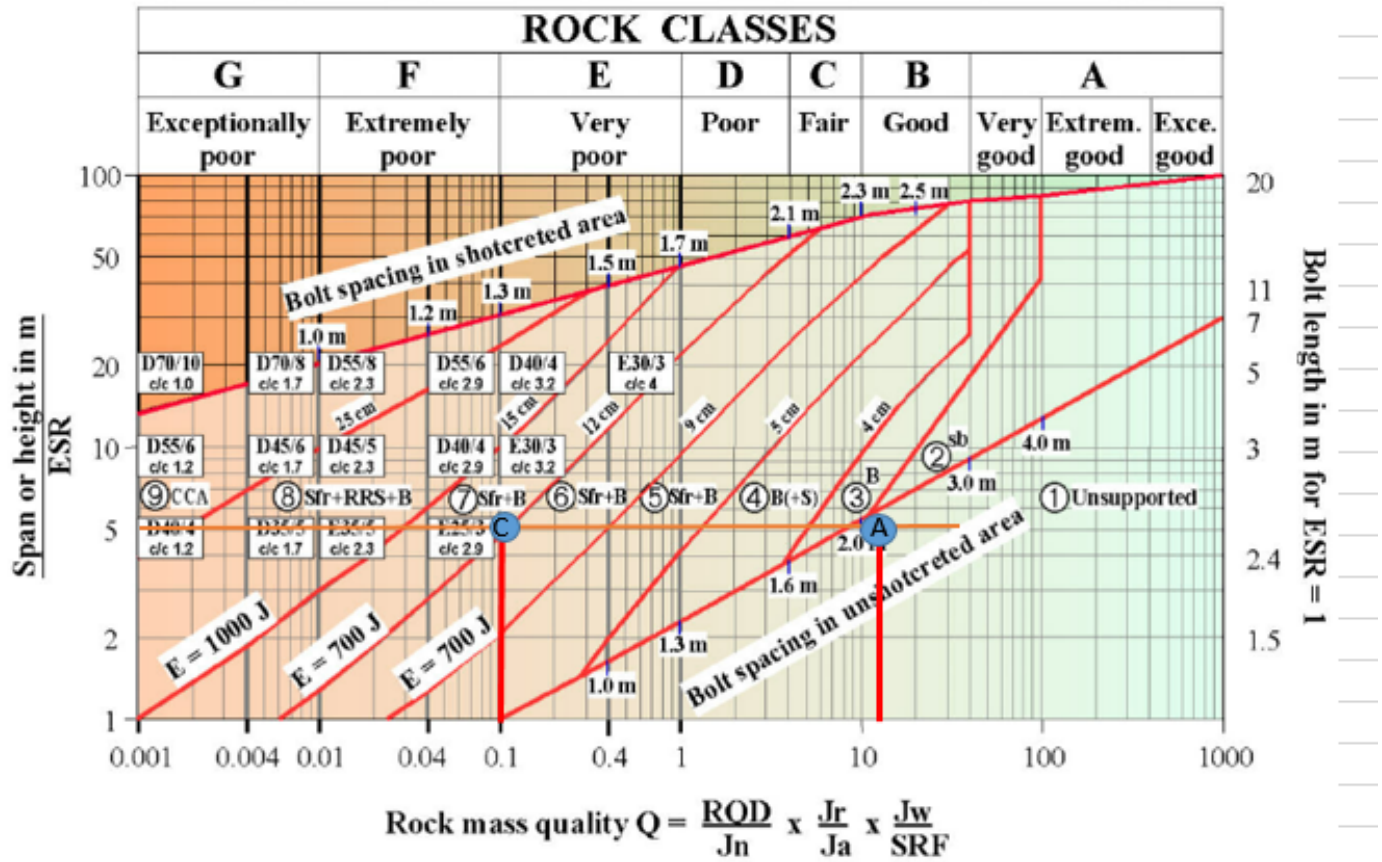
APPENDIX A
GROUND SUPPORT DESIGN CHART



REINFORCEMENT CATEGORIES

1) Unsupported
2) Spot bolting, **sb**
3) Systematic bolting, **B**
4) Systematic bolting, (and unreinforced shotcrete, 4-10 cm), **B(+S)**
5) Fibre reinforced shotcrete and bolting, 5-9 cm, **Sfr+B**
6) Fibre reinforced shotcrete and bolting, 9-12 cm, **Sfr+B**
7) Fibre reinforced shotcrete and bolting, 12-15 cm, **Sfr+B**
8) Fibre reinforced shotcrete > 15 cm + reinforced ribs of shotcrete and bolting, **Sfr+RRS+B**
9) Cast concrete lining, **CCA**

E) Energy absorbtion in fibre reinforced shotcrete at 25 mm bending during plate testing

D45/6 c/c 1.7 = RRS with 6 reinforcement bars in double layer in 45 cm thick ribs with centre to centre (c/c) spacing 1.7 m. Each box corresponds to Q-values on the left hand side of the box. (See text for explanation)

Figure A1 Ground support for rock mass stability in full width undercuts. Point A = "Good" rock mass, Point C = "Poor" rock mass at Brucejack.

APPENDIX B
TYPICAL UNWEDGE© ANALYSIS

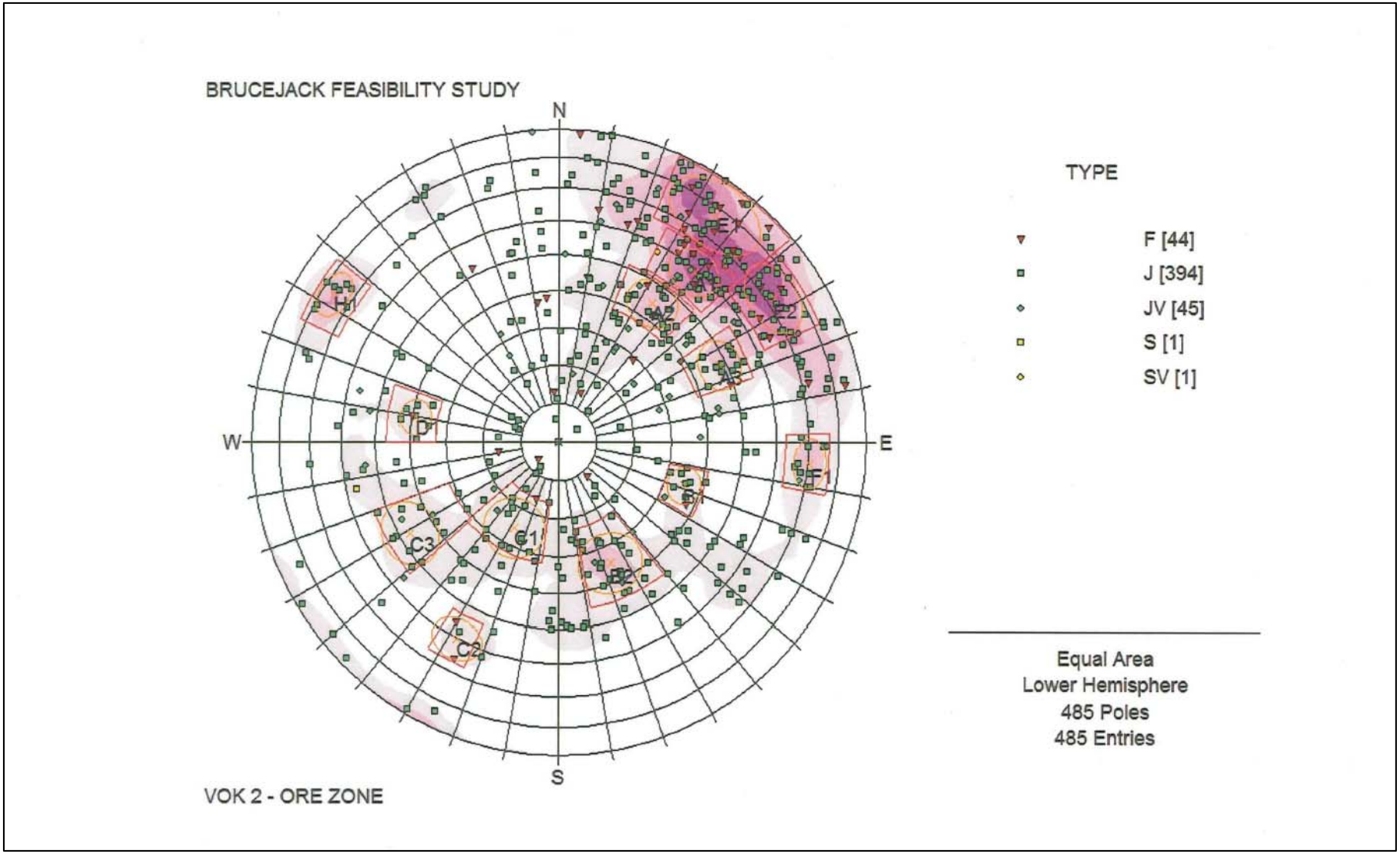


Figure 1 Design Stereonet (VOK 2 – ore domain)

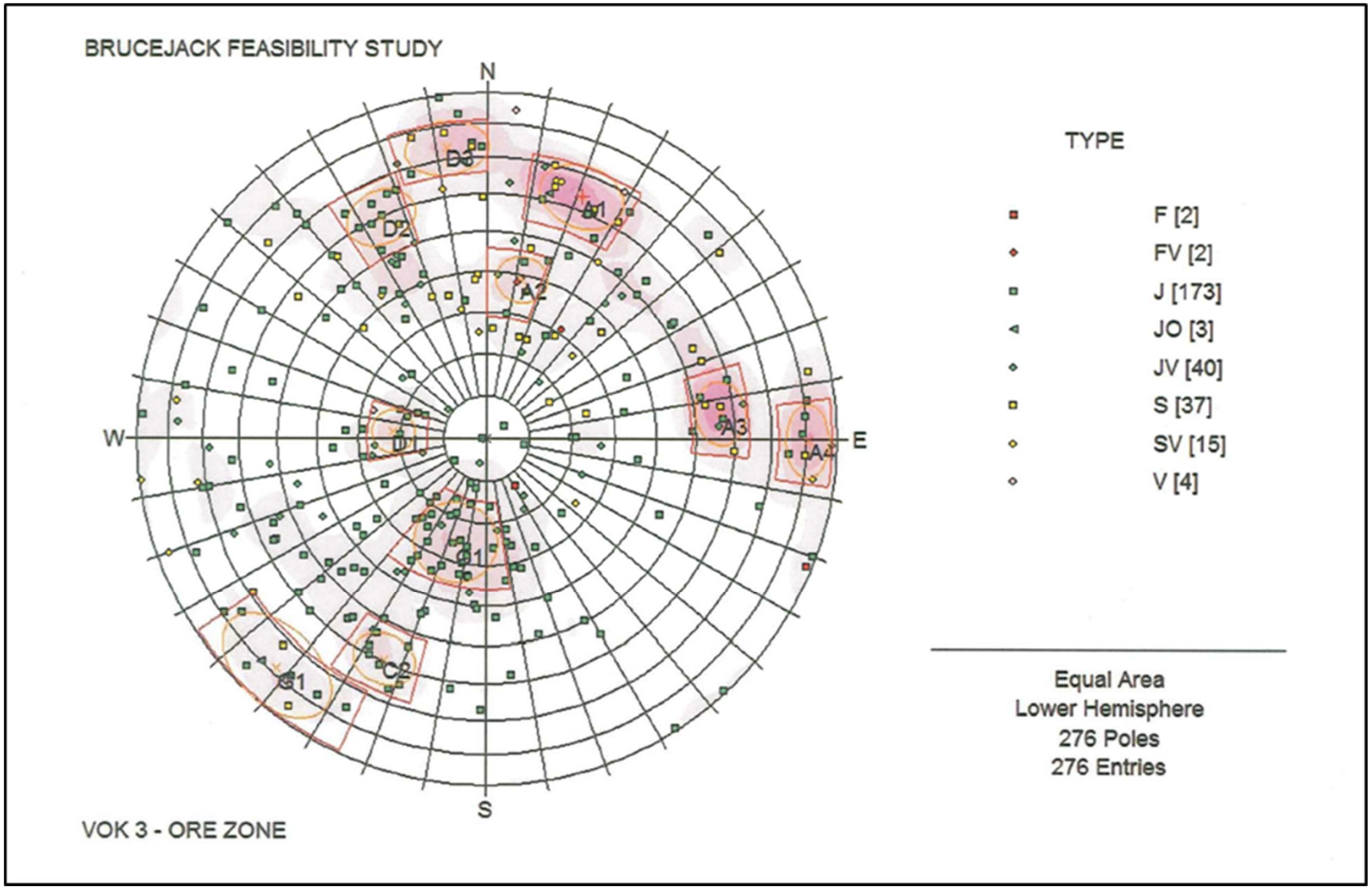


Figure 2 Design Stereonet (VOK 3 – ore domain)

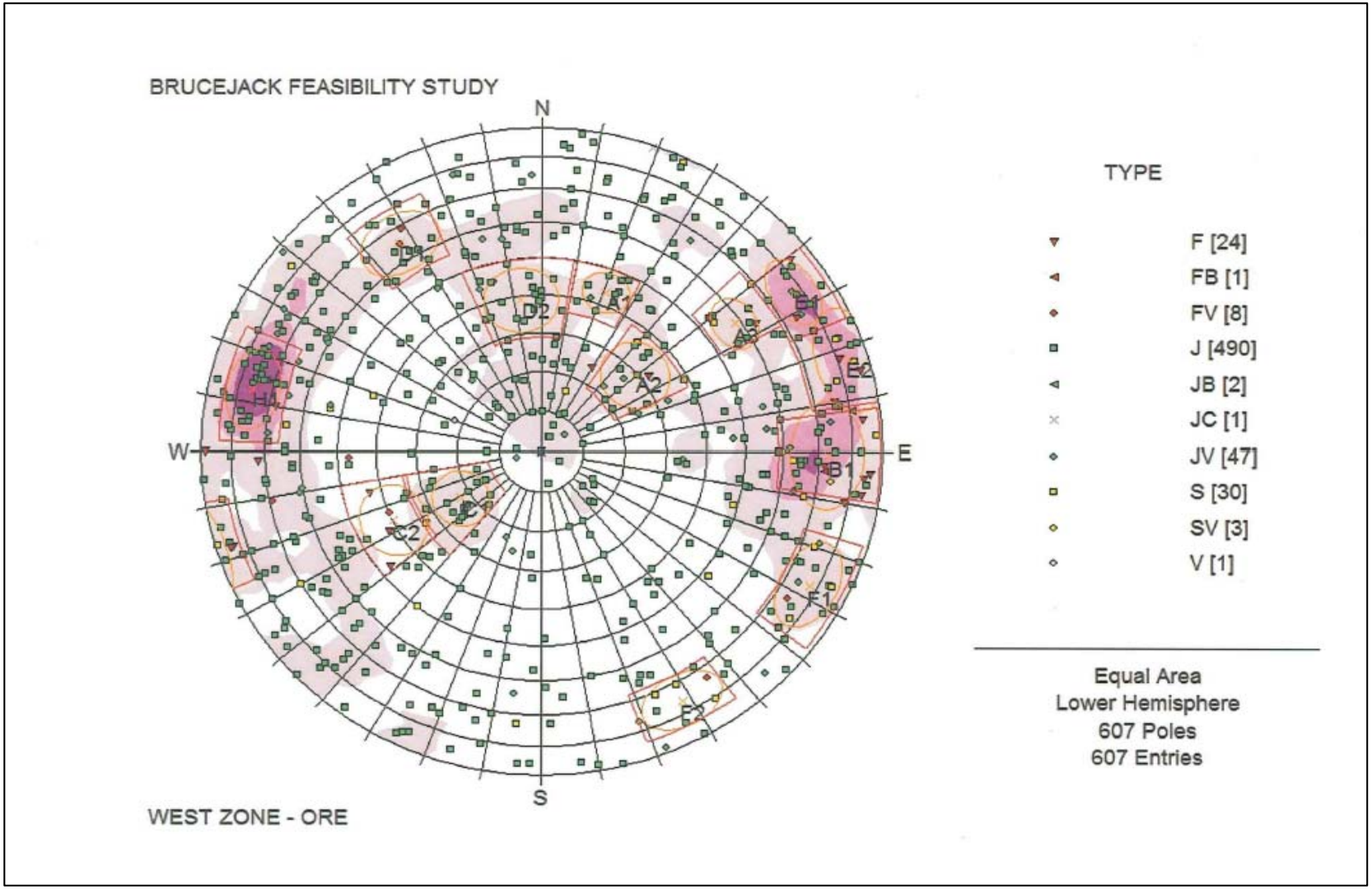


Figure 3 Design Stereonet (West Zone – ore domain)

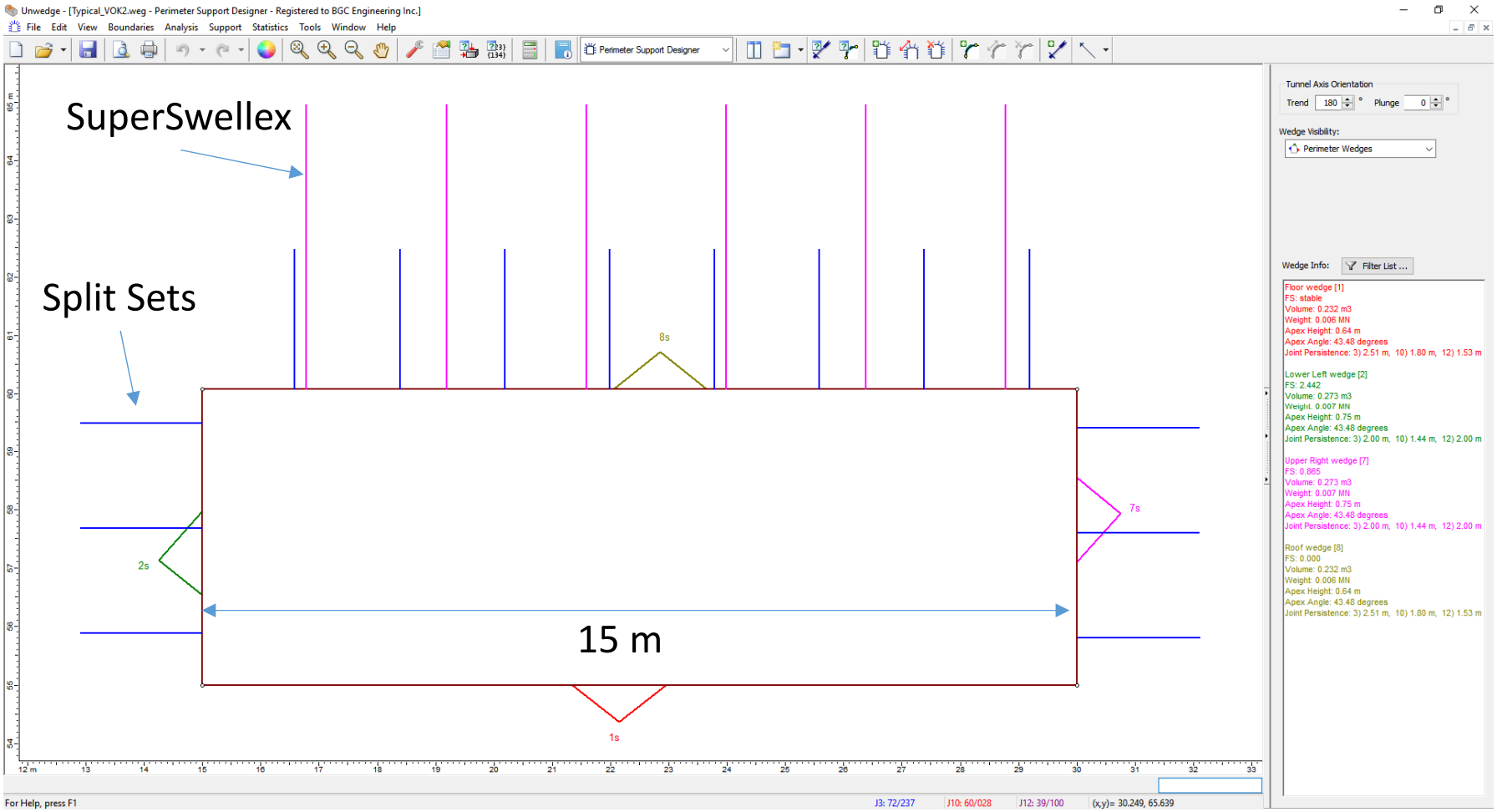


Figure B4 Example of geometry for full width undercut support – long support extending across the full width of the excavation.

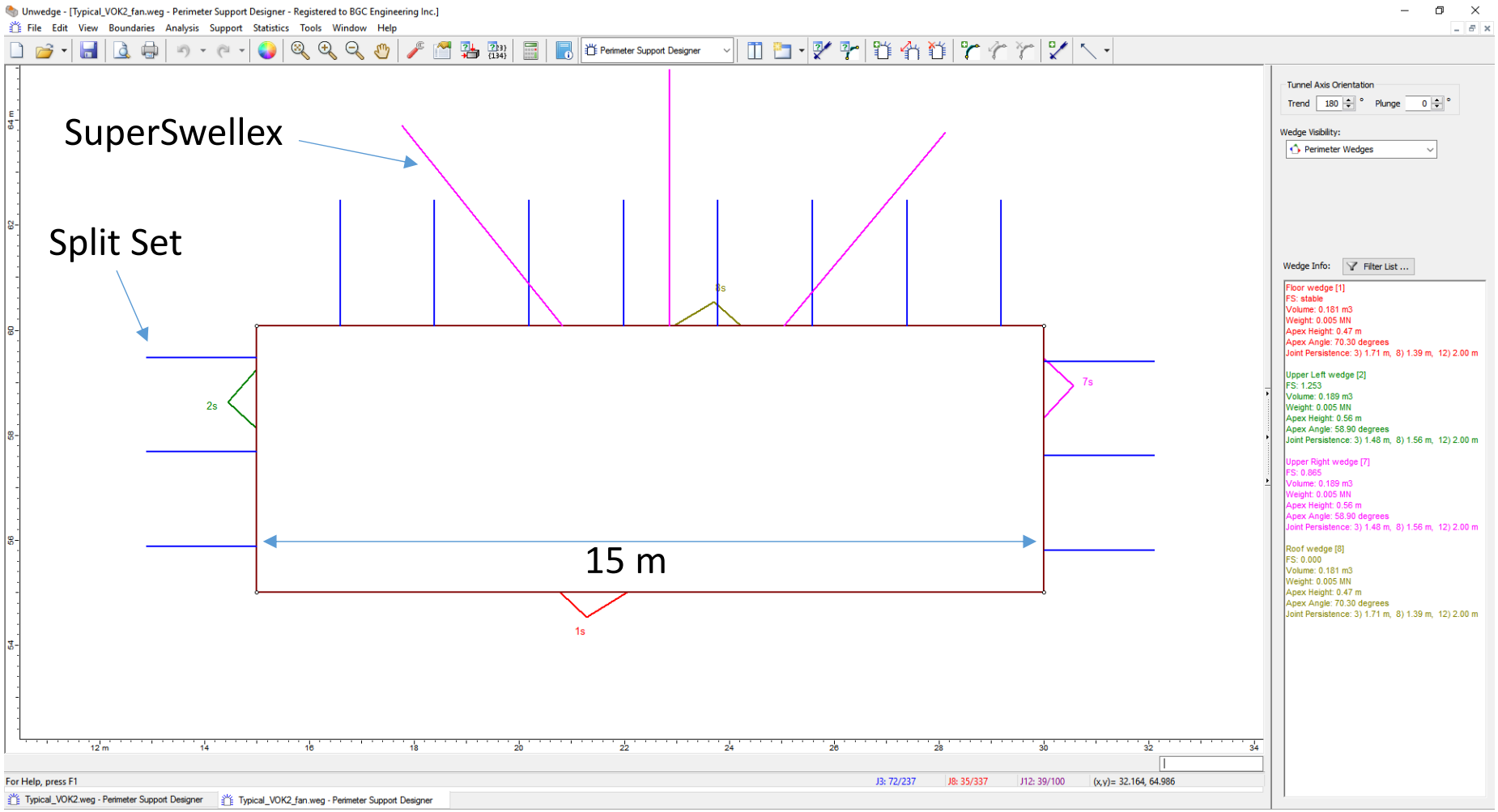


Figure B5 Example of geometry for full width undercut support – long support angled out through the shoulders of the pilot drift.

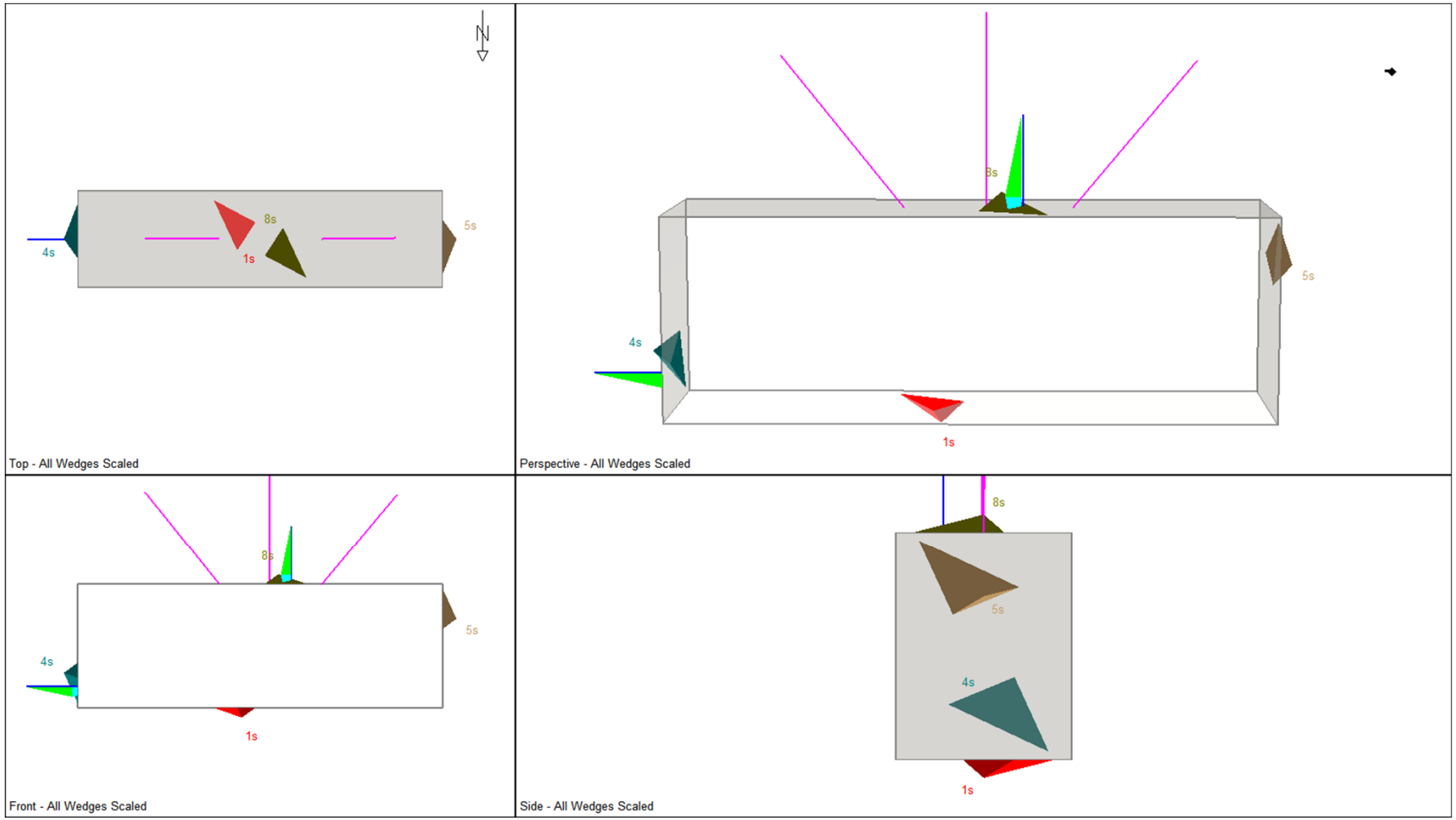


Figure 6 **Example of Unwedge analysis showing ground support taking load in back and walls of excavation.**

Appendix N

Geotechnical Assessment of Secondary Stopes

BGC ENGINEERING INC.
AN APPLIED EARTH SCIENCES COMPANY

Brucejack Project
Geotechnical Assessment of Secondary Stopes
Project Number: 1008030

DRAFT

Introduction

BGC Engineering Inc. (BGC) visited Pretium Resources Inc. (Pretium) Brucejack Gold Mine (Brucejack) in support of an ongoing Ground Control Management Plan (GCMP) audit and review under Pretium PO 1025470 (BGC, October 26, 2018).

The site visit for the GCMP audit occurred on December 1 and December 2, 2018

A ground fall of approximately 2,500 m^3 had recently occurred during extraction of secondary stope #17 on the 1350 Level. No injuries or equipment damage resulted from the ground fall.

During the site visit, Pretium requested that BGC complete a geotechnical assessment of Brucejack's proposed secondary stope extraction mine plan and associated ground support designs to minimize the potential for ground falls during secondary stope extraction.

Scope of Work

The scope of work for the assessment summarized in the following slides is:

- Review the proposed mine plan for secondary stope extraction, and assess the potential for ground falls to occur during secondary stope extraction.
- Complete a preliminary geotechnical analysis of the 1350-17 ground fall to identify the probable cause(s).
- Provide recommendations to reduce the potential for ground falls to occur during secondary stope extraction.

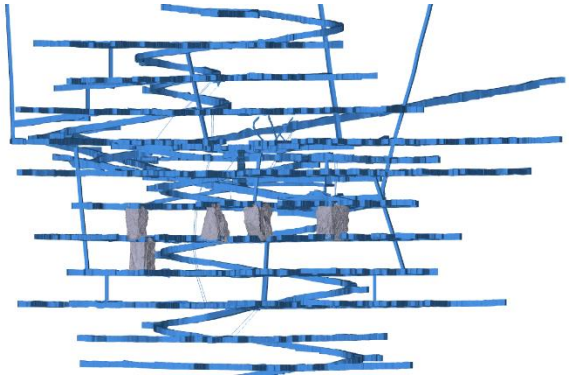
Terms of Reference

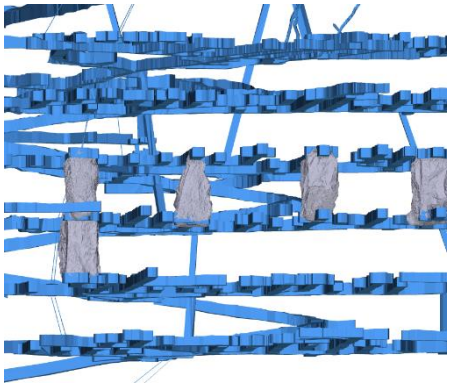
BGC and Pretium Mine Technical services (MTS) staff have established the following terms of reference for the current SOW:

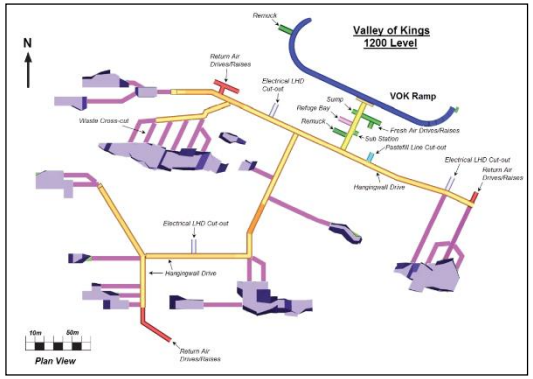
- Recovery of ore should be maximized due to the high value of Brucejack ore.
- Level development within the mine is established at 30 m level spacing and 15 m cross-cuts, therefore neither reduction of stope heights nor reduction of stope strike length is currently feasible
- Ground support costs are a relatively small component of the overall mining costs at Brucejack.
- Non-worker entry mucking techniques are standard practice , and continue to be recommended by BGC following all stope production blasts.

Mining at Brucejack

- The mining method at Brucejack is long-hole (blast-hole) open stoping, with the majority of stopes planned in a transverse orientation.
- Stope heights are 30 m (sill to sill), and cross-cuts are spaced on 15 m centers (i.e. transverse stope strike length is 15 m).
- Stope widths are designed at 15 m. Sill levels are spaced at 120 m (i.e. 1440 L, 1320 L, 1200 L).
- Stopes are excavated in a primary-secondary sequence from the bottom-up within an individual stoping block between sill levels.
- The mining sequence in any lens of a given mining block begins with the extraction of the primary stopes on the first (lowest) level. Wherever possible, the first primary stope will be located near the middle of the lens to develop a pattern of stope extraction that moves outwards to the extremities of the lens while progressing upwards towards the top. As confirmed by 3D numerical modeling (discussed below), this generally promotes a favourable redistribution of ground stress, although many smaller lenses in the Brucejack orebody are either irregular in shape or of insufficient dimensions to properly develop this sequence.







Ground Control Management is required over the life of the mine, during the design, planning, development, and operational stages. Ground control management should be **(and is currently)** approached in a systematic manner, and takes into account the following factors:

Geological and Geotechnical Factors:

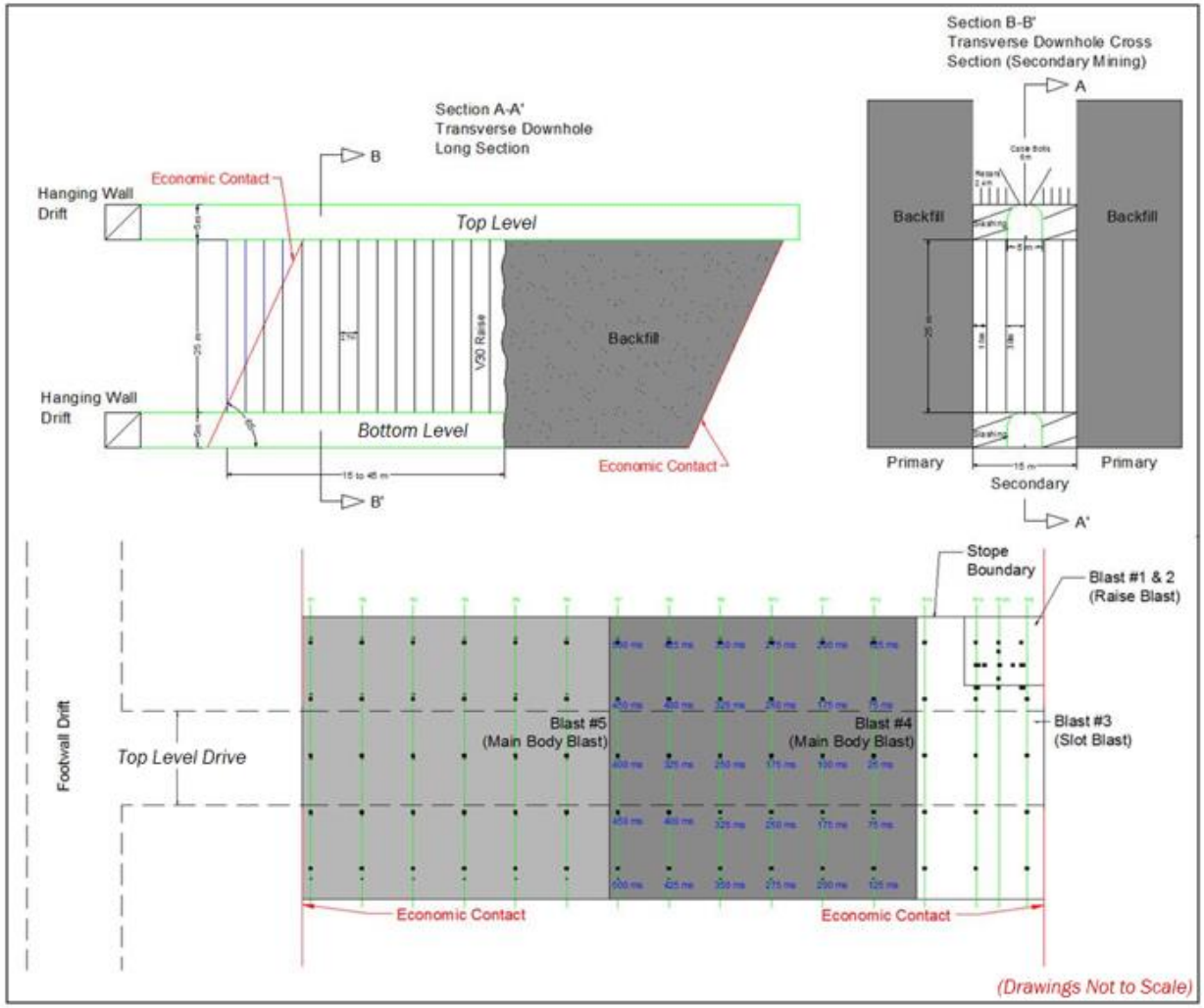
- Distribution of rock types;
- Distribution, orientation, and condition of regional and local geologic structures;
- Ore zone location and grade;
- Geotechnical conditions of the rock mass;
- Rock strength parameters (uniaxial compressive strength, cohesion and friction angle, etc.);
- In-situ stress conditions and anticipated changes arising from mining;
- Groundwater conditions; and
- Ground response to mining determined from monitoring and surveillance.

Mining Factors:

- Excavation dimensions;
- Mining method and sequencing;
- Required use of excavation;
- Required service life of zone or excavation; and
- Ground support requirements, equipment, and constraints.

Stope Extraction Plan

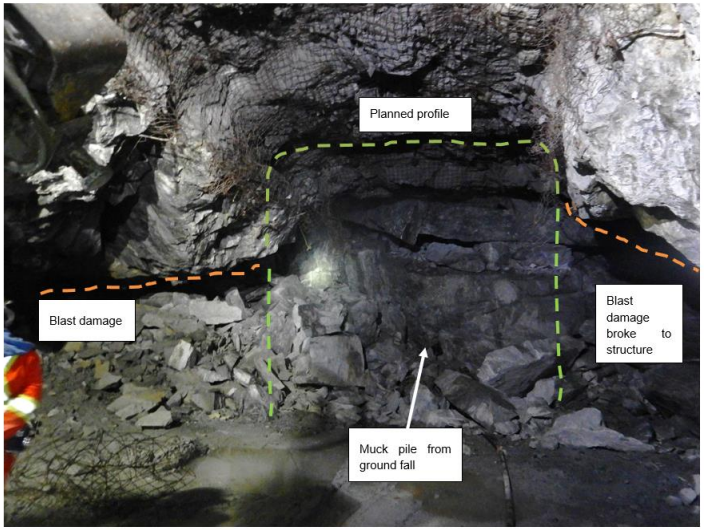
- For Primary stopes to date partial and full-width overcut and undercuts have typically been establishing starting with a 5 m pilot drift, initially supported using 2.4 m long SS39 split sets on 1.8 m spacing and 4.88 m long connectable Super Swellex (PM24C) installed as a fan of three bolts into the back of the pilot drift.
- The pilot drift is then slashed out to the full 15 m stope width, to allow parallel production hole drilling across the entire width of the stope thereby increasing drilling precision and helping to maximize recovery. The full-width is excavated in 2.5 m wide slashes, with one 4.88 m long connectable Super Swellex (PM24C) installed in the back of each slash (a total of ~four additional Super Swellex are installed in the back during the full-width slashing).
- A 750 mm pilot hole is drilled in the slot raise location.
- Production drilling occurs in the raise and slot area, followed by production rings as drilling progresses to the ore contact.
- The stope is then blasted and mucked, with remote mucking required by Pretium once the drawpoint brow is open to the extent that the operator may be exposed to uncontrolled sloughing from the stope cavity. This continues to be the recommended practice.
- Once empty, the stope is remotely surveyed with cavity monitoring equipment (CMS). This is an important step for to reconciliation tasks and adjacent stope planning and requires completion in a timely manner.
- A paste backfill barricade (either shotcrete arch or muckpile) is constructed, and the stope is backfilled with fresh paste distributed directly from the paste plant on surface.
- **Secondary stopes are now regularly being scheduled for development and production**, with Pretium MTS seeking to optimize mining actives with specific reference to, and integration of, local conditions and mining conventions (i.e. geology & geotechnical controls, available mining equipment , standard development dimensions, scheduled production requirements, stope access plans, ventilation requirements, paste distribution system, risk tolerance etc.)

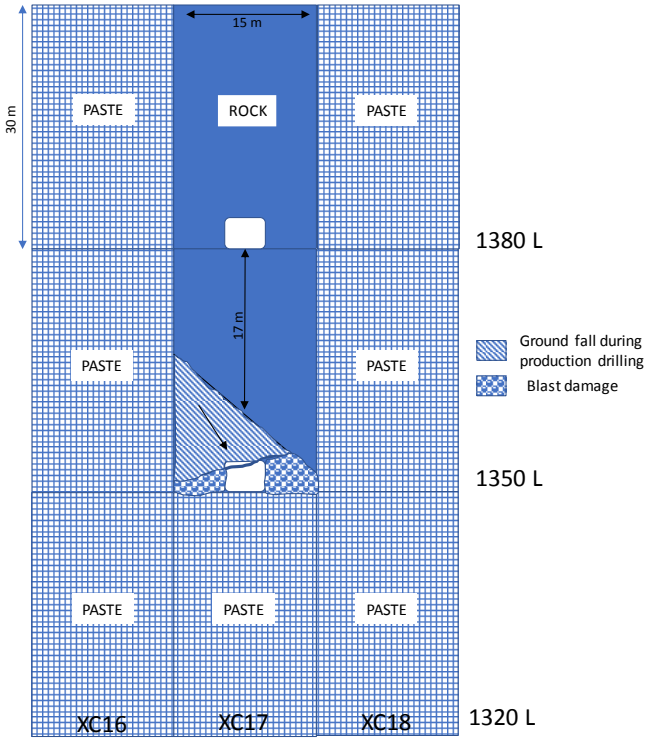

Section A-A'
Transverse Downhole
Long Section
Economic Contact
Hanging Wall
Drift
Top Level
Backfill
V30 Raise
Hanging Wall
Drift
Bottom Level
Economic Contact
B
B'
Section B-B'
Transverse Downhole Cross
Section (Secondary Mining)
A
Backfill
Backfill
Primary
Primary
Secondary
A'
Stope
Boundary
Blast #1 & 2
(Raise Blast)
Footwall Drift
Top Level Drive
Blast #5
(Main Body Blast)
Blast #4
(Main Body Blast)
Blast #3
(Slot Blast)
Economic Contact
Economic Contact
(Drawings Not to Scale)

1350 to 1320-17 Stope Instability

- During recent extraction in November 2018 of the 1350 to 1320-17 stope, blast damage occurred in the walls and back of the 1350-17 cross-cut.
- The damaged zones were scaled and supported with 6 m long cable bolts on 2.5 m by 2.5 m spacing.
- When production drilling commenced from the top cut for the 1380 to 1350-17 stope, a ground fall occurred in the 1380 to 1350-17 stope.
- Drilling crews reported losing water down the production holes, and hitting a slip in one at approximately 17 m depth.
- This slip is inferred to be a large geologic structure possibly related to the moderately dipping structure visible in the right wall of the 1350-17 cross-cut A schematic of the ground fall is shown below.
- Total mass of the failed volume of rock has been roughly estimated @ 2600 tons

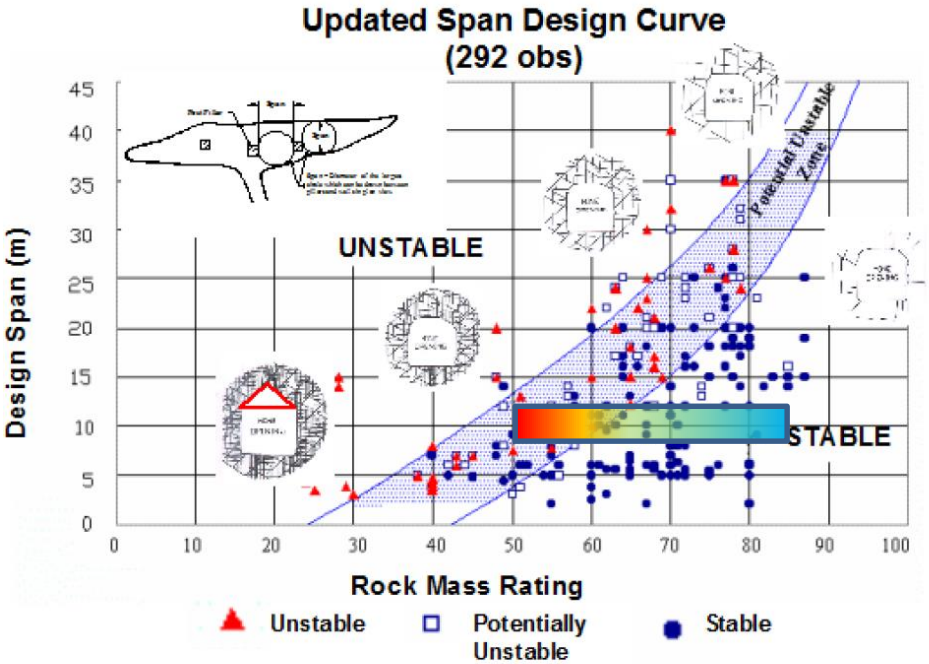
View from 1350-17 cross-cut, showing blast damaged zone and ground fall





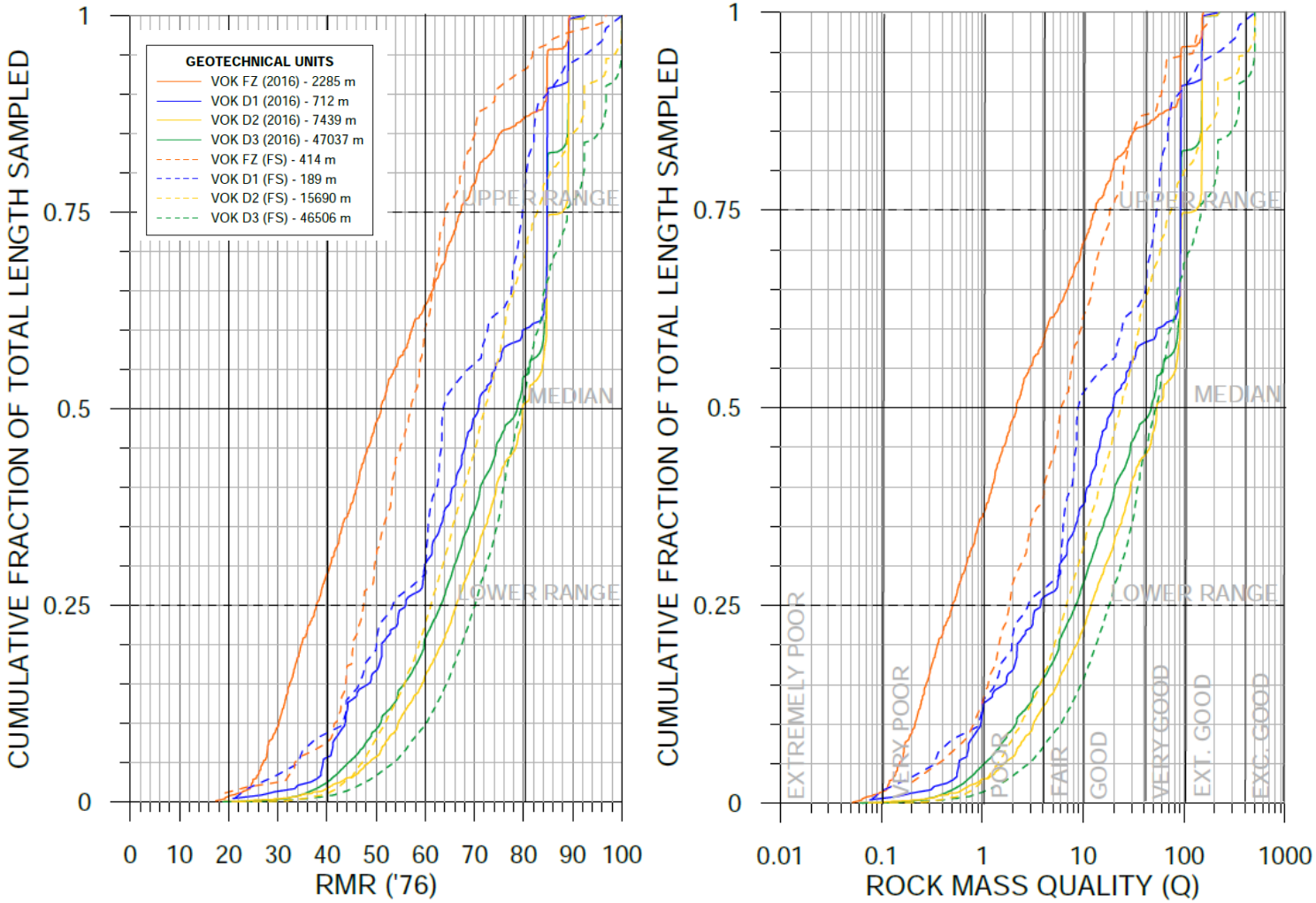
Geotechnical Model

- Typical Rock Mass Classification values range from ~60-80 RMR / GSI, Q' = 2-20+, generally classified as "Good Rock"
- MTS geology and geotechnical engineering staff regularly visit the active faces during development of the cross-cuts, undercuts, and top cuts.
- This task is an important component for informing mine planning for adjacent stopes, and should be completed in a timely manner.
- **Current experience at Brucejack indicates largely structurally driven rock instability vs. stress driven instability . Stress impacts are likely to become a larger contributor to instability as mining depths increase.**
- **Custom support design using a combination of enhanced near surface support and deep fully grouted support are likely to be required where persistent geologic structure , poorer quality rock or fault zones are encountered.**



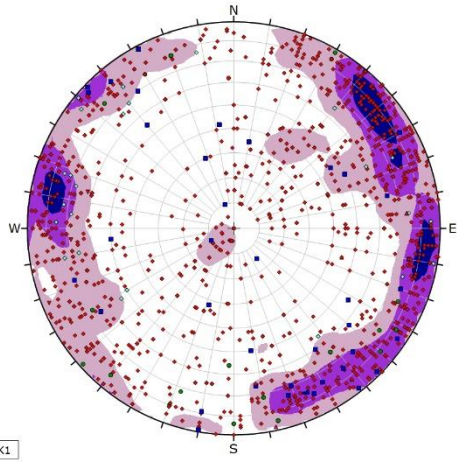
Critical span curve for mine entry methods employing local support only
Span design chart assumes rock abutments

Geotechnical Model RMR & Q



Project:	Subject:
Brucejack Project – Geotechnical Assessment of Secondary Stopes Project Number: 1008030	RMR76 and Q Cumulative Frequency Histograms
	Date: 1/19/2019 Page 9

BJ Structural Model



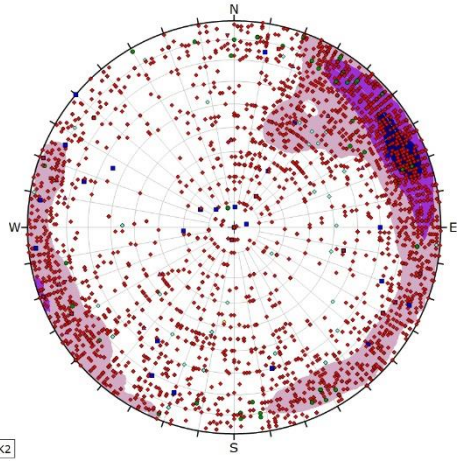
VOK1

Symbol	TYPE_SYMBOL	Quantity
◇	B	99
◆	F	1369
▲	FC	3
▼	FG	8
●	FO	4
■	J	166
●	O	62

Color	Density Concentrations
	0.00% - 1.00%
	1.00% - 2.00%
	2.00% - 3.00%
	3.00% - 4.00%

Maximum Density	3.63%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	1711 (1711 Entries)
Hemisphere	Lower
Projection	Equal Area



VOK2

Symbol	TYPE_SYMBOL	Quantity
◇	B	72
×	BX	2
◆	F	3367
▲	FC	3
▼	FG	28
■	FS	7
■	J	60
●	O	87
◇	S	1

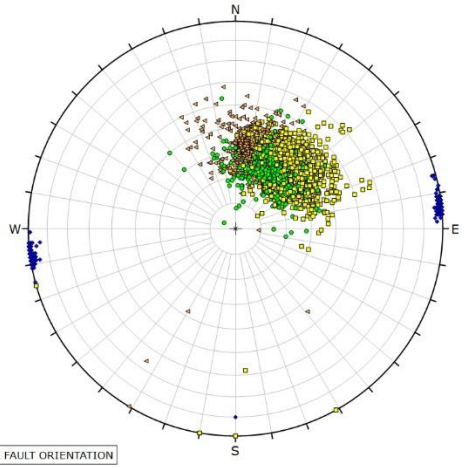
Color	Density Concentrations
	0.00% - 1.40%
	1.40% - 2.80%
	2.80% - 4.20%
	4.20% - 5.60%

Maximum Density	5.63%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	3627 (3627 Entries)
Hemisphere	Lower
Projection	Equal Area

To assess kinematic stability using Unwedge© (Rocscience 2017), the following assumptions were made:

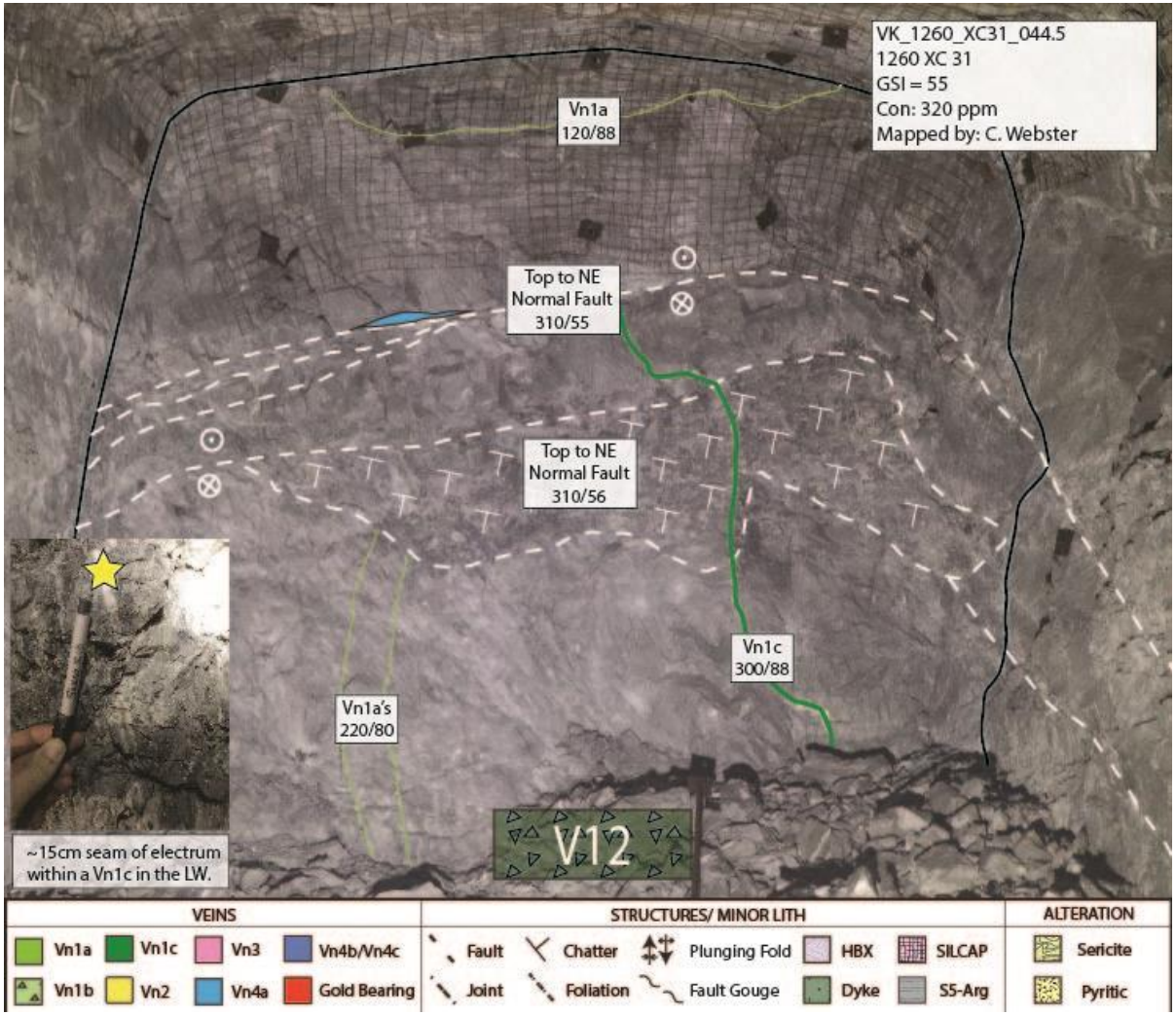
- Joint friction angle is 35°
- Joint cohesion is 0 MPa
- Joint persistence is 2.5 m
- Fault friction angle is 30°
- Fault cohesion is 0 MPa
- Fault persistence is 7 m
- **Current experience at Brucejack indicates largely structurally driven rock instability vs. stress driven instability . Stress impacts are likely to become a larger contributor to instability as mining depths increase.**
- The mean set orientation for the design discontinuity sets in each domain was assumed as defined in BGC (2013)



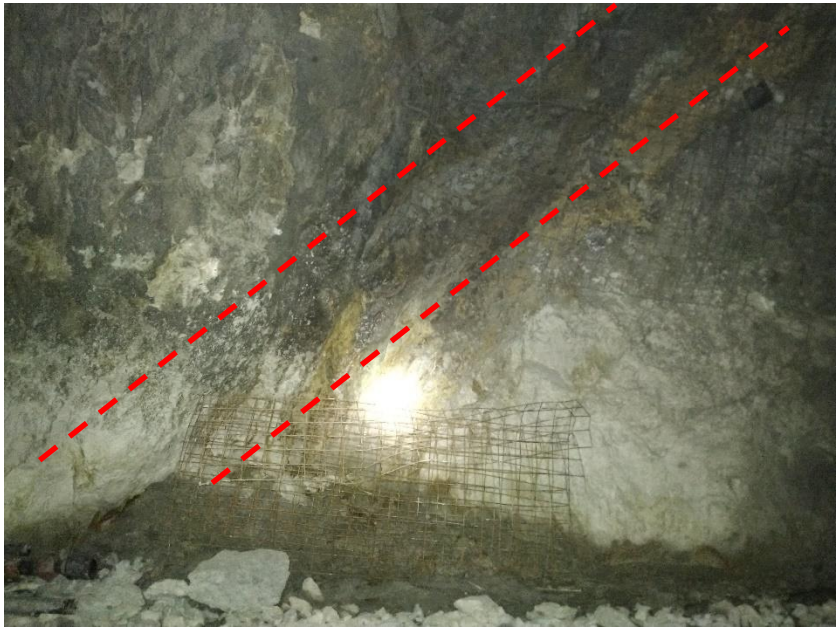
MAJOR FAULT ORIENTATION

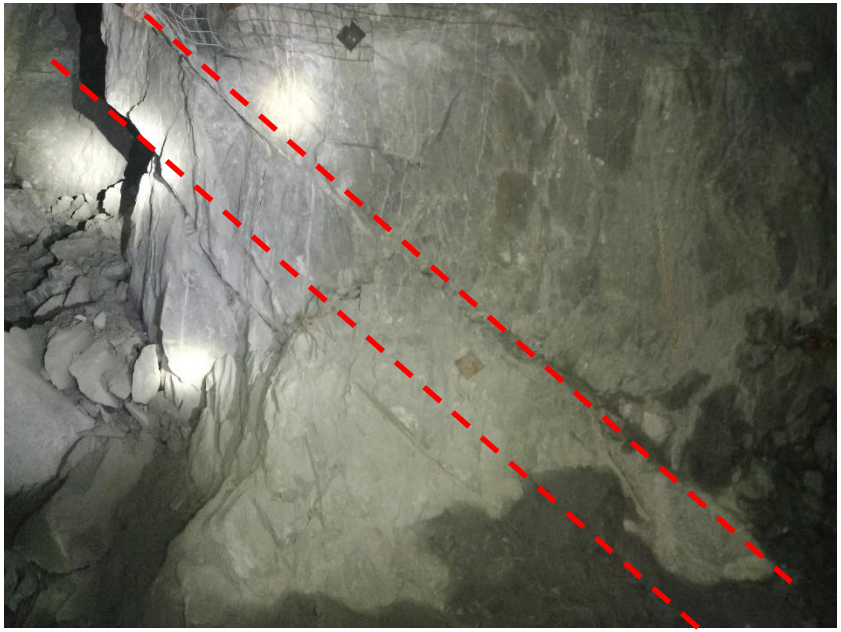
Symbol	FAULT	Quantity
◆	Brucelack	504
□	Rainy	3779
●	Upper	1887
◁	VOK	830

Plot Mode	Pole Vectors
Vector Count	7000 (7000 Entries)
Hemisphere	Lower
Projection	Equal Area
E02: Too many entries for grid intersections	



Project:	Subject:
Brucejack Project – Geotechnical Assessment of Secondary Stopes Project Number: 1008030	Example Cross Cut Face Map
	Date: 1/19/2019 Page 11





Permissible Stoping Dimensions

BGC has developed design recommendations for stope backs and walls using the empirical "Stability Graph" method (Hutchinson and Diederichs, 1996, and Nickson, 1992, after Potvin et al., 1988) . Geotechnical and stope geometry parameters are combined to determine a "Stability Number" (N'), defined by:

N' = Q' x A x B x C

Where:

- Q' is a rock mass classification parameter
- A is a measure of the ratio of intact rock strength to applied stress
- B is a measure of the relative orientation of dominant structure with respect to the excavation surface
- C is a measure of the influence of gravity on the stability of the face being considered.

Cconservative and base case Q' values of 10 and 40 respectively were used in combination with conservative A, B, and C inputs to calculate permissible stoping dimensions (hydraulic radii).

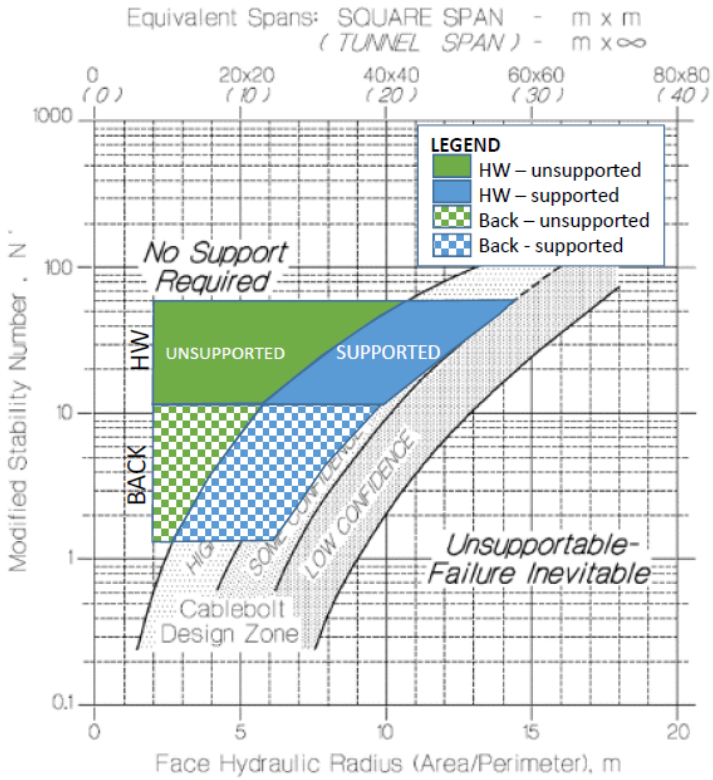
Statistical observations of the Brucejack dataset indicated that regardless of lithology, alteration, geological domain, or geotechnical unit, less than 20% of mapped or logged data had a Q' value less than 10, and greater than 50% of the rock had a Q' value of 40 or more.

Stability Analysis Inputs

Parameter	Value	Design Assumption
Q'	10 – 50	Domain 1
Q'	3 - 10	Domain 2
A	0.1 (back) 1.0 (walls)	Assume induced stress concentrates in back and that the walls are destressed.
B	0.3 (walls) 0.6 (back)	Based on weighted average structural variability in all domains
C	2 (backs) 4 (walls)	Defined based on critical discontinuity set assuming horizontal structure in back and adversely oriented sliding structure in walls.

Results from the stability method analysis include :

- Unsupported stope heights of up to 60 m may be achievable. However, as stope heights increase, so will the likelihood for large structurally controlled failures. At 60 m stope heights, Pretium should anticipate a requirement for cable-bolting of the hangingwalls and end walls, where accessible and practical (i.e. on 30m sublevels, for instance) . Paste stability at these dimensions has not been assessed for this study.
- Achievable stope widths and lengths will be largely governed by the stability of the stope backs. The design cases presented below indicate unsupported stope widths or lengths of 20 m may be achievable, with increased lengths in one dimension achievable with a reduction in the other.



Hydraulic Radius	Unsupported Q'=10	Unsupported Q'=50	Supported Q'=10	Supported Q'=50
BACK	2.5	5.9	6.0	9.8
HW	5.9	10.5	10.0	14.0

- Unsupported design for rock mass in lower end of design range.
- Unsupported design for rock mass in upper end of design range.
- Supported design for rock mass in lower end of design range.
- Supported design for rock mass in upper end of design range.

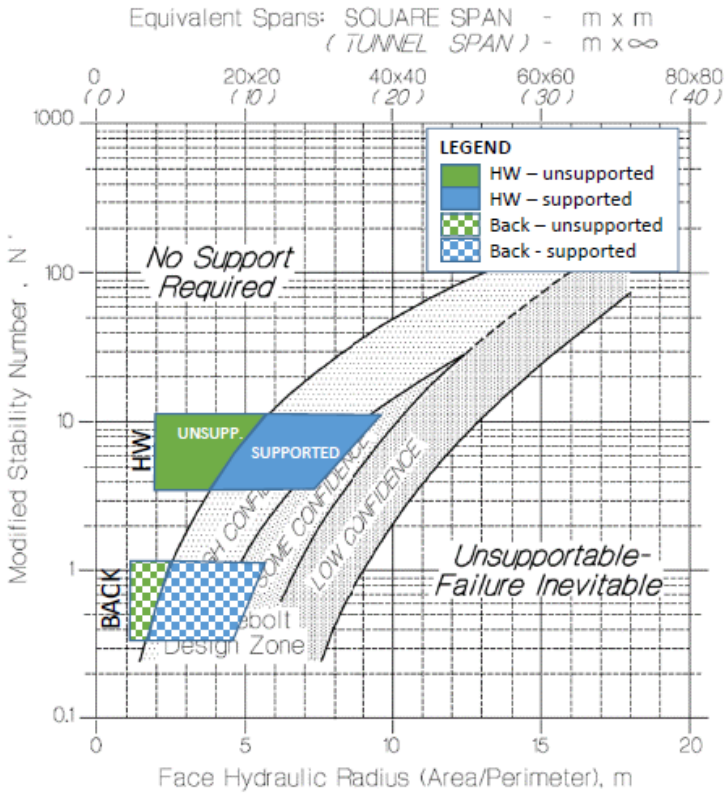
BACK — W (metre)

L (metre) \ HYD RAD	10	15	20	25	30	35	40	45	50	55	60
5	1.7	1.9	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.3
10	2.5	3.0	3.3	3.6	3.8	3.9	4.0	4.1	4.2	4.2	4.3
15	3.0	3.8	4.3	4.7	5.0	5.3	5.5	5.6	5.8	5.9	6.0
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0

HW — W (metre)

H (metre) \ HYD RAD	10	15	20	25	30	35	40	45	50	55	60
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0
75	4.4	6.3	7.9	9.4	10.7	11.9	13.0	14.1	15.0	15.9	16.7
80	4.4	6.3	8.0	9.5	10.9	12.2	13.3	14.4	15.4	16.3	17.1

Notes:
1. Stope designs presented for Geotechnical Unit 1 (10 < Q' < 50) and assumed conditions as presented in the accompanying letter report.



Hydraulic Radius	Unsupported Q'=3	Unsupported Q'=10	Supported Q'=3	Supported Q'=10
BACK	1.6	2.5	4.5	6.0
HW	3.8	5.9	7.3	10.0

- Unsupported design for rock mass in lower end of design range.
- Unsupported design for rock mass in upper end of design range.
- Supported design for rock mass in lower end of design range.
- Supported design for rock mass in upper end of design range.

BACK — W (metre)

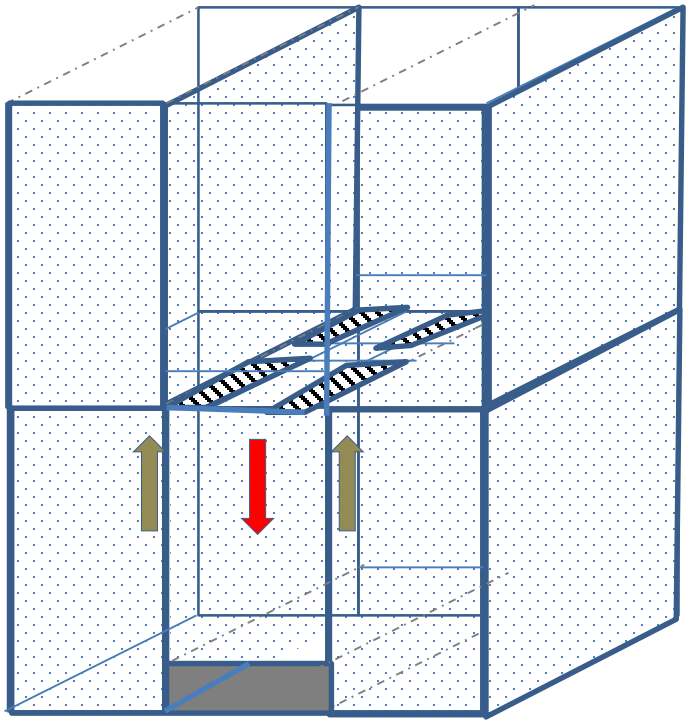
L (metre) \ HYD RAD	10	15	20	25	30	35	40	45	50	55	60
5	1.7	1.9	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.3	2.3
10	2.5	3.0	3.3	3.6	3.8	3.9	4.0	4.1	4.2	4.2	4.3
15	3.0	3.8	4.3	4.7	5.0	5.3	5.5	5.6	5.8	5.9	6.0
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0

HW — W (metre)

H (metre) \ HYD RAD	10	15	20	25	30	35	40	45	50	55	60
20	3.3	4.3	5.0	5.6	6.0	6.4	6.7	6.9	7.1	7.3	7.5
25	3.6	4.7	5.6	6.3	6.8	7.3	7.7	8.0	8.3	8.6	8.8
30	3.8	5.0	6.0	6.8	7.5	8.1	8.6	9.0	9.4	9.7	10.0
35	3.9	5.3	6.4	7.3	8.1	8.8	9.3	9.8	10.3	10.7	11.1
40	4.0	5.5	6.7	7.7	8.6	9.3	10.0	10.6	11.1	11.6	12.0
45	4.1	5.6	6.9	8.0	9.0	9.8	10.6	11.3	11.8	12.4	12.9
50	4.2	5.8	7.1	8.3	9.4	10.3	11.1	11.8	12.5	13.1	13.6
55	4.2	5.9	7.3	8.6	9.7	10.7	11.6	12.4	13.1	13.8	14.3
60	4.3	6.0	7.5	8.8	10.0	11.1	12.0	12.9	13.6	14.3	15.0
75	4.4	6.3	7.9	9.4	10.7	11.9	13.0	14.1	15.0	15.9	16.7
80	4.4	6.3	8.0	9.5	10.9	12.2	13.3	14.4	15.4	16.3	17.1

Notes:

1. Stope designs presented for Geotechnical Unit 2 (3 < Q' < 10) and assumed conditions as presented in the accompanying letter report.



X 4 Provides Tensile Strength for Pendant Pillar

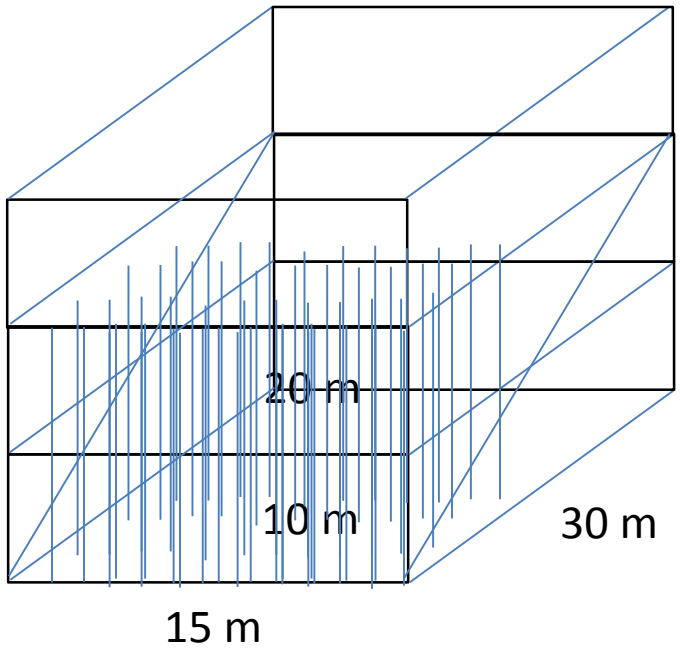
The current stope extraction plan at Brucejack results in secondary stopes with sidewalls of paste, a fully exposed footwall (via slot), and a fully exposed sill (via the full width undercut). When the topcut is slashed to full width, the stope is therefore mostly supported by the shear strength of the rock to rock contact at the hangingwall, with a nominal amount of support provided by the shear strength of the paste in the sidewalls.

Deadweight calc's for the entire secondary stope block mass have been completed to determine required tensile strength to maintain pillar stability (in the absence of large structure)

- Block is ~ 20,000 t (200 MN) for 15 m Strike (15w x 15l x 30h x 2800kg/m3)
- 4m x 5m x 5m = 100m^2 x (2.5 - 5.0 MPa) Rock Tensile strength = 250 - 500 MN available
- Block is ~ 40,000 t (400MN) for 30 m Strike (15w x30l x 30h x 2800kg/m3)
- 4 x 12.5l x 5w = 250m^2 x (2.5 - 5.0 MPA) tensile strength = 625 - 1250 MN available

(Note: Paste side friction and FW Rock Contact not included)

Cable Reinforcement of Deadweight Block



20 m High Block is ~ 12,600 tons for 15 m Strike
(15w x 15l x 20h x 2800kg/m3)

10 m High Block is ~ 6,300 tons for 15 m Strike
(15w x15l x 10h x 2800kg/m3)

Equal to ~ 28 tons / m2 for 10 m High cut
Equal to ~ 56 tons / m2 for 20 m High cut

1m x 1m pattern is ~ 196 Cables in a 15 x 15 cut

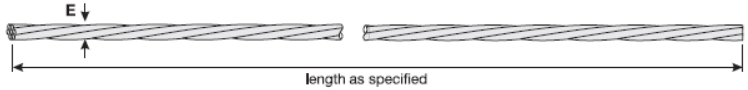
Double Strand Bulbed Cables ~ 50 – 60 t / hole
~200 x 50-60t = 10,000 to 12,000 tons available

- Wide 'Stable' spans intersected by geologic structure or poorer quality rock required enhanced / deep patterned support consisting of minimum 6m long coupled Super Swellex or cement grouted cable bolts (0.7" dia, bulbed, dual strand ~ 30-35 ton capacity/strand, nominally >50 t / hole installed capacity)

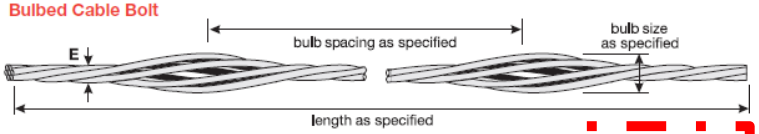
- Current designs are for nominal rock mass, absent of large scale or controlling geotechnical structure

- If structure is present (as observed in some of current secondary stopes) dead weight analysis of rock wedge / block is required to confirm adequate bolt capacity

Plain Cable Bolt



Bulbed Cable Bolt



Dimensions

	0.5" Cable Bolt	0.6" Cable Bolt	0.7" Cable Bolt
E Strand Diameter	0.500" $^{+0.026"}_{-0.006"}$ 12.70 mm $^{+0.66\ mm}_{-0.15\ mm}$	0.600" $^{+0.026"}_{-0.006"}$ 15.24 mm $^{+0.66\ mm}_{-0.15\ mm}$	0.700" $^{+0.026"}_{-0.006"}$ 17.78 mm $^{+0.66\ mm}_{-0.15\ mm}$

Physical Properties

	0.5" Cable Bolt	0.6" Cable Bolt	0.7" Cable Bolt
Product	uncoated 7 wire low relaxation strand		
Grade	270 K - 270,000 psi (1860 MPa) ultimate strength		
Breaking strength, min.	41,300 lbs (183.7 kN)	58,600 lbs (260.7 kN)	76,200 lbs (339 kN)
1% extension under load, min.	37,170 lbs (165.3 kN)	52,740 lbs (234.6 kN)	68,600 lbs (305.1 kN)
Elongation in 24 inch (610 mm)	3.5% minimum		
Relaxation after 1000 hrs	maximum 2.5% with initial load = 70% breaking strength maximum 3.5% with initial load = 80% breaking strength		
Specification	ASTM A416, CSA G279-75, CSA G279-M1985		

Construction Details

	0.5" Cable Bolt	0.6" Cable Bolt	0.7" Cable Bolt
Construction	1 center wire & 6 outer wires		
Steel area	nom. 0.153 in^2 (98.7 mm^2)	nom. 0.217 in^2 (140 mm^2)	nom. 0.304 in^2 (196 mm^2)
Standing pitch	12-16 x diameter		
Weight per 1000 ft	520 lbs	740 lbs	1110 lbs
Weight per 1000 m	775 kg	1102 kg	1654 kg
Difference in wire size (center - outer)	min. 0.003" (0.076 mm)	min. 0.004" (0.102 mm)	min. 0.005" (0.127 mm)

Galvanized cable bolts available on request

DYWIDAG-SYSTEMS INTERNATIONAL

Geotechnical Considerations

- Structure - **Current experience at Brucejack indicates largely structurally driven rock instability vs. stress driven instability .**
- Stress – Rock Stress conditions are currently assessed using visual observations only. Consider upgrading stress monitoring program to include a network of MPBXs and Stress Cells. Stress impacts are likely to become a larger contributor to instability as mining depths increase.
- Rock Mass – Time Rock Mass Classification and geologic assessment tasks are import to the stope planning and execution process . Rock mass conditions require continuous evaluation with related adjustments made to ground support systems

Operational Considerations

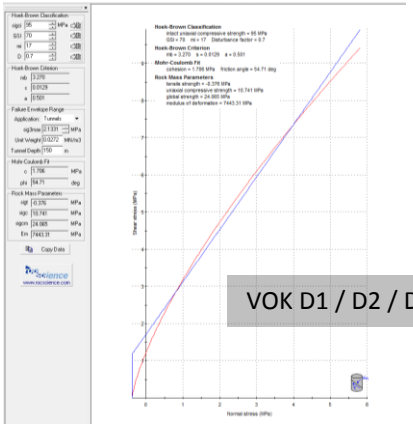
- Revisit Secondary Stope Blast Designs , particularly adjacent to paste walls.
- Install appropriate , custom ground support specific to local conditions in a timely manner, as soon as possible following excavation.
- Drill production holes parallel to paste walls where possible
- Consider a primary / secondary/ tertiary stoping sequence where 'key stopes' (those stopes connecting two or more paste filled stopes on either side, are mined low grade material and when practical towards the end of mine life.
- Where possible consider alternate stope access geometries (i.e. rear-access) and paste distribution geometries to optimize local conditions

The following slides are representative examples of typical RS3 analysis results. These were used to help develop designs, confirm / modify engineering judgement, and inform conclusions and outcomes of the underground assessment.)

A number of scenarios run with varying sequences, stages, material inputs and boundary conditions, using ranges of values determined from review of geotechnical model.

Geotechnical Model

(this data used as input for RS3 stress analysis modeling to assess stability impacts resulting from range of anticipated conditions)



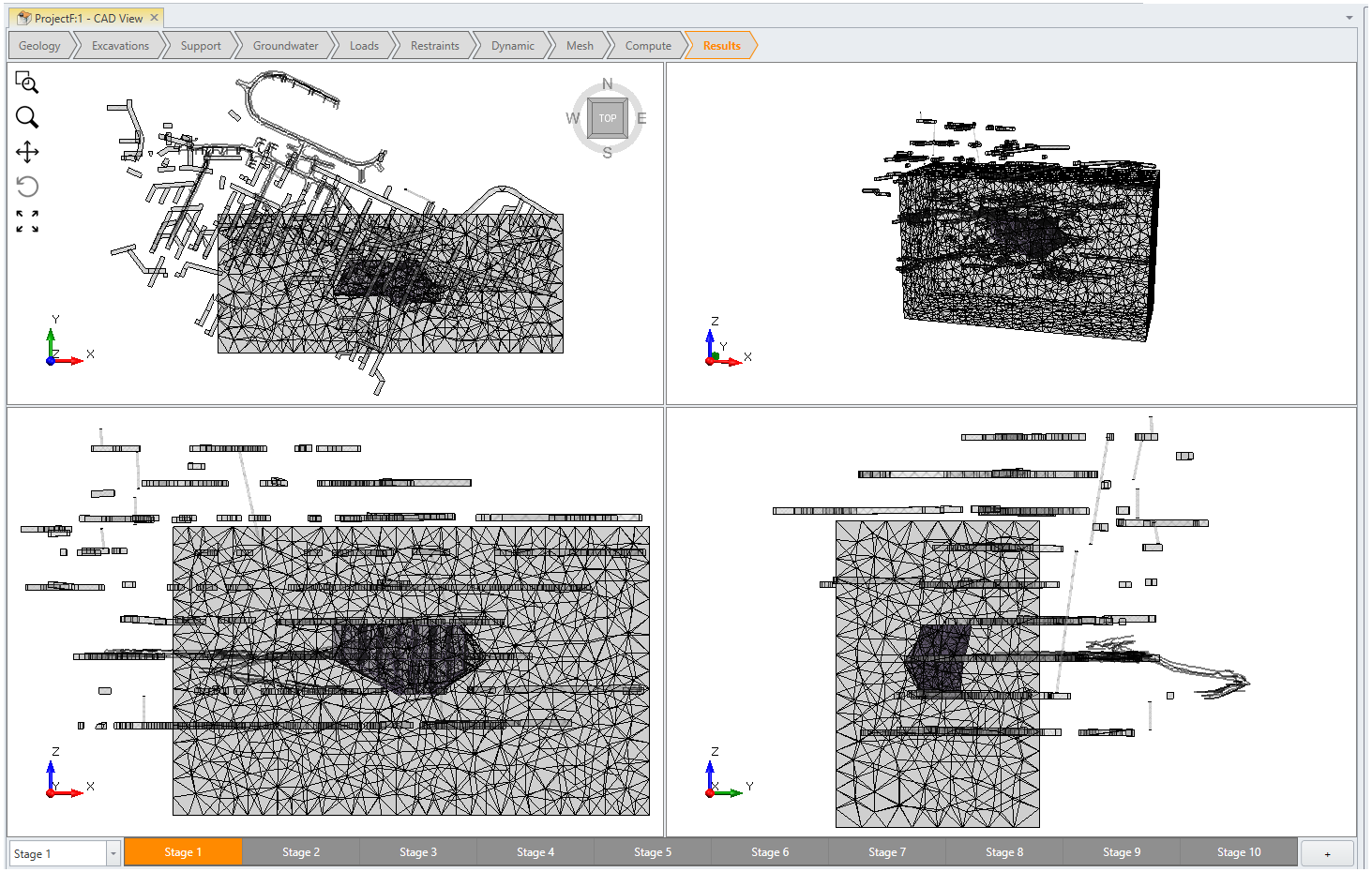
VOK D1 / D2 / D3 Rock Strength Envelope

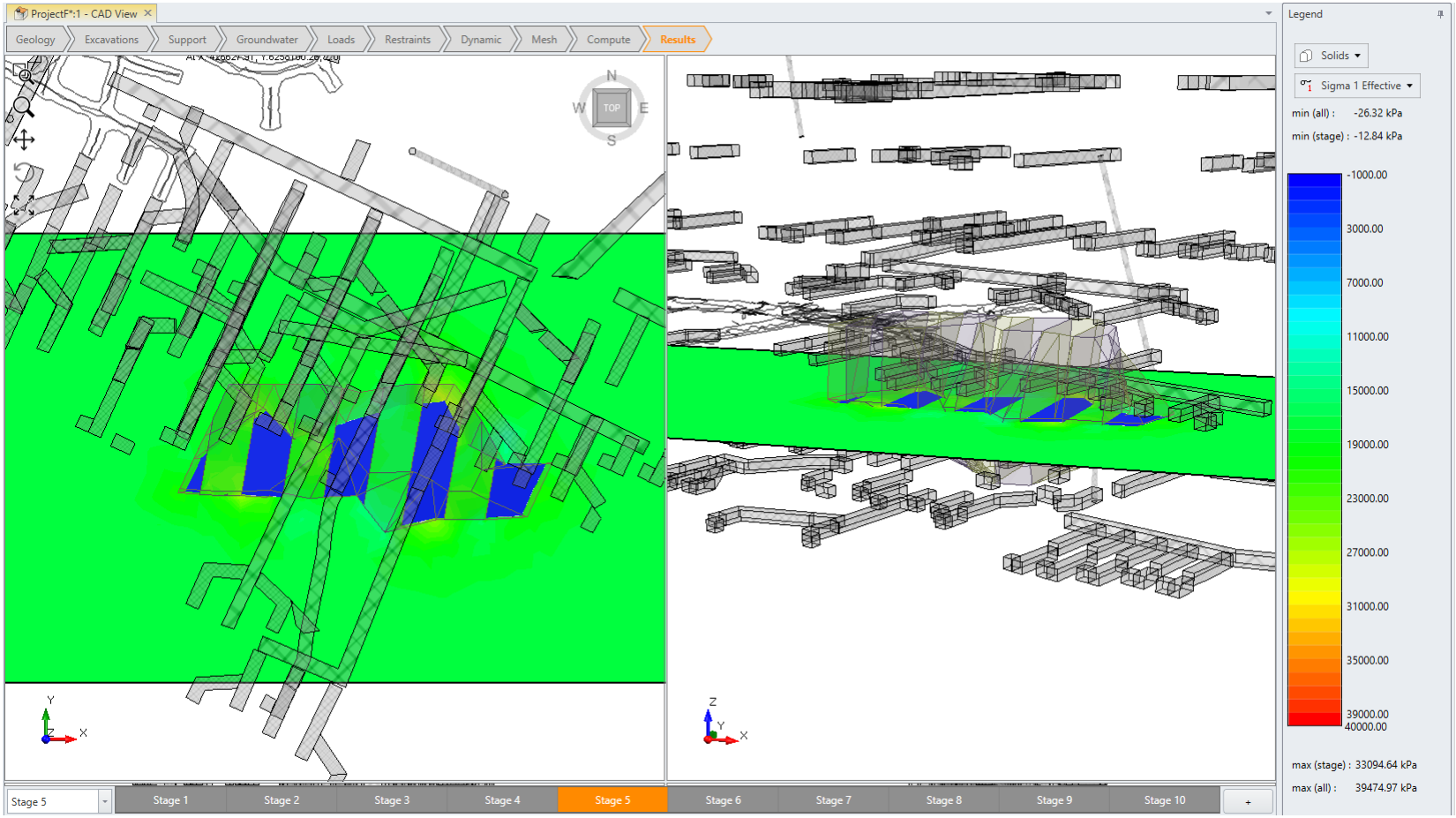
Unit	UCS – Lab (MPa)	Average Is50 (MPa)	K	UCS – Design1 (MPa)	Brazilian Tensile Strength (MPa)	Hoek-Brown Material Constant, mi	Unit Weight (kN/m³)	Young's Modulus (GPa)	Poisson's Ratio
VOK FZ	N/A	N/A	N/A	89	N/A	12	26.3	30.0	0.20
VOK WRZ	N/A	N/A	11	50	N/A	17	28.6	3.8	0.18
VOK D1	N/A	N/A	N/A	116	N/A	17	27.2	30.5	0.20
VOK D2	107	7.3	15	95	9.4	19	27.1	30.8	0.11
VOK D3	77	6.0	13	73	5.0	26	27.3	30.0	0.14
WZ FZ	N/A	N/A	20	77	N/A	12	26.3	30.0	0.20
WZ WRZ	14	1.3	11	37	0.7	17	28.6	3.8	0.18
WZ FR	126	7.0	18	116	5.7	21	27.3	35.0	0.17

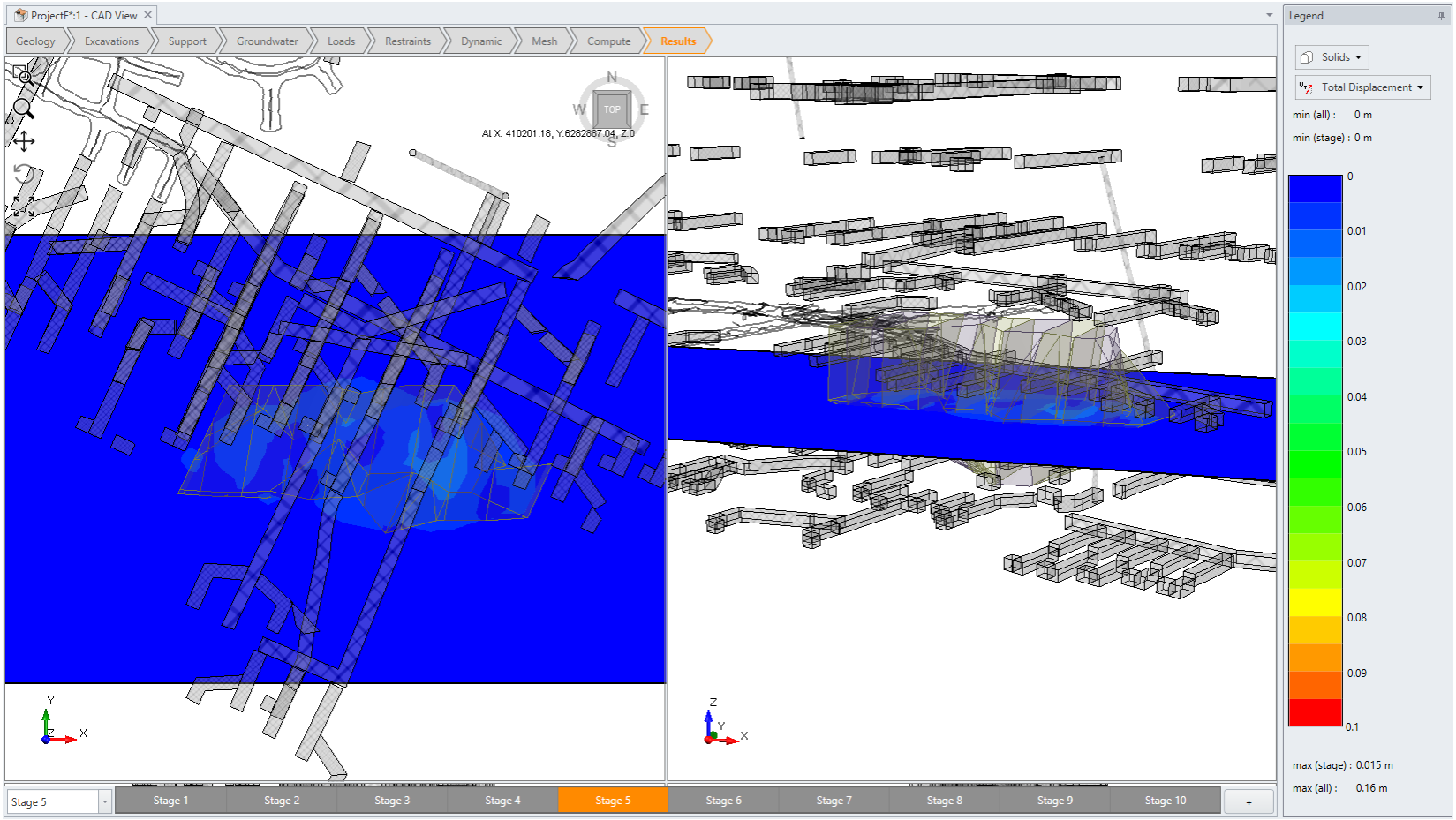
Notes:
1. Design UCS values have been estimated from the median Is50 values using laboratory-derived K values if available
2. Unit weights are based on average results of specific gravity testing if available
3. Hoek-Brown material constants have been derived based on a review of laboratory testing results
4. Young's Modulus and Poisson's ratio have been estimated based on laboratory testing results if available

Unit	UCS (MPa)	GSI[2]	Unit Weight[3] (kN/m³)	m_i	m_b	S	E_{rm} (GPa)
VOK FZ	89	60	26.3	12	1.110	0.0023	5.13
VOK WRZ	50	63	28.6	17	1.879	0.0037	0.77
VOK D1	116	72	27.2	17	3.211	0.0144	9.76
VOK D2	95	70	27.1	19	3.186	0.0106	9.02
VOK D3	73	85	27.3	26	10.647	0.103	14.37
WZ FZ	77	57	26.3	12	0.928	0.0015	4.27
WZ WRZ	37	62	28.6	17	1.771	0.0032	0.73
WZ FR	116	85	27.3	21	8.599	0.103	16.77

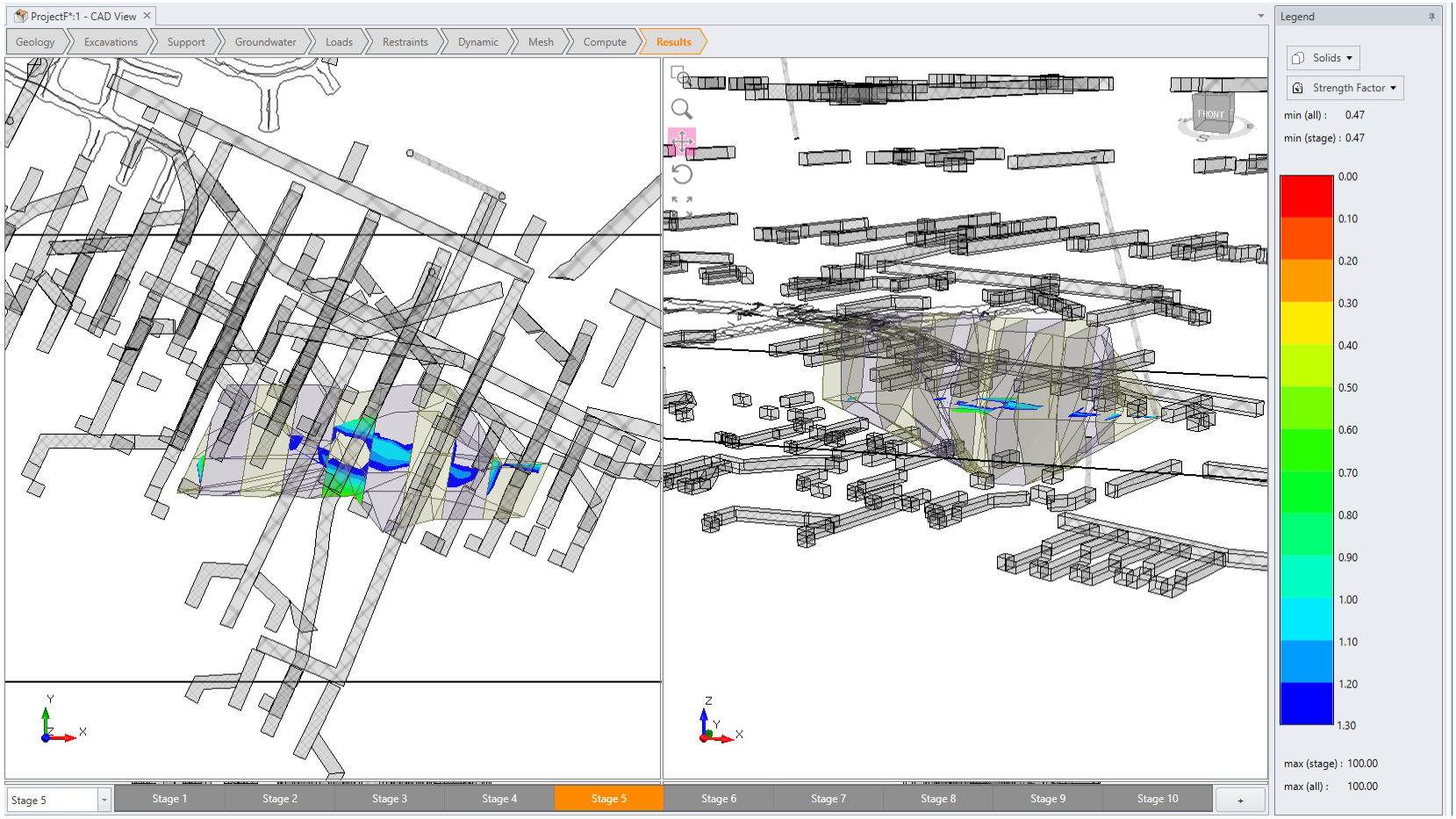
Notes:
1. The Hoek-Brown failure criteria have been estimated assuming a disturbance factor ('D') of 0.8 for all units.
2. GSI is calculated from median rock mass parameters for each unit, where GSI = RMR '76.
3. Unit weights are based on average results of specific gravity testing when possible.
4. The Hoek-Brown curves have been derived using a sigma3 max. for a tunnel depth of 650 m.


ProjectF:1 - CAD View
Geology
Excavations
Support
Groundwater
Loads
Restraints
Dynamic
Mesh
Compute
Results
N
W
TOP
E
S
Stage 1
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6
Stage 7
Stage 8
Stage 9
Stage 10

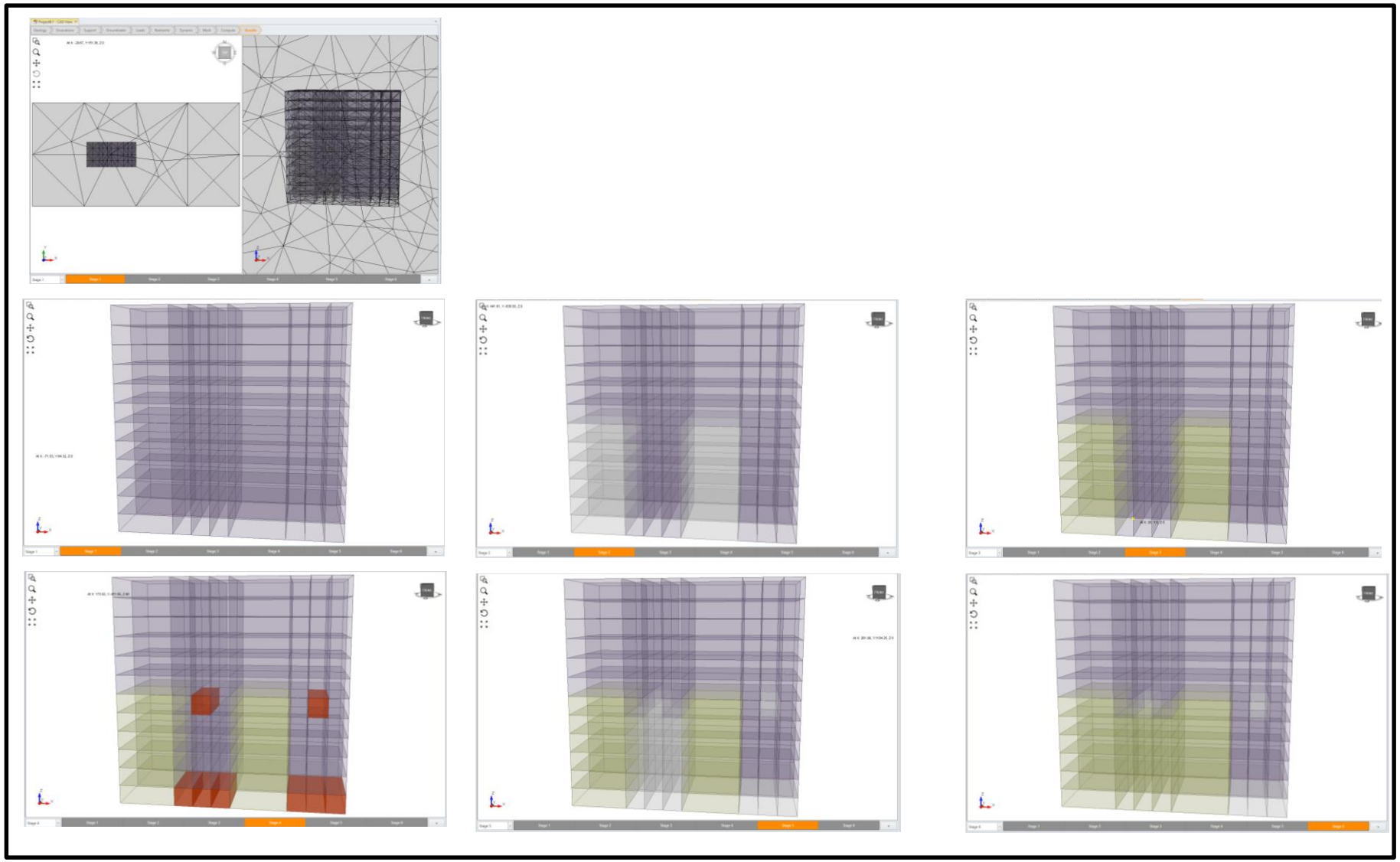

ProjectF*:1 - CAD View
Geology
Excavations
Support
Groundwater
Loads
Restraints
Dynamic
Mesh
Compute
Results
N
W
TOP
E
S
Y
Z
X
Z
Y
X
Legend
Solids
Sigma 1 Effective
min (all) : -26.32 kPa
min (stage) : -12.84 kPa
-1000.00
3000.00
7000.00
11000.00
15000.00
19000.00
23000.00
27000.00
31000.00
35000.00
39000.00
40000.00
max (stage) : 33094.64 kPa
max (all) : 39474.97 kPa
Stage 5
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Stage 6
Stage 7
Stage 8
Stage 9
Stage 10

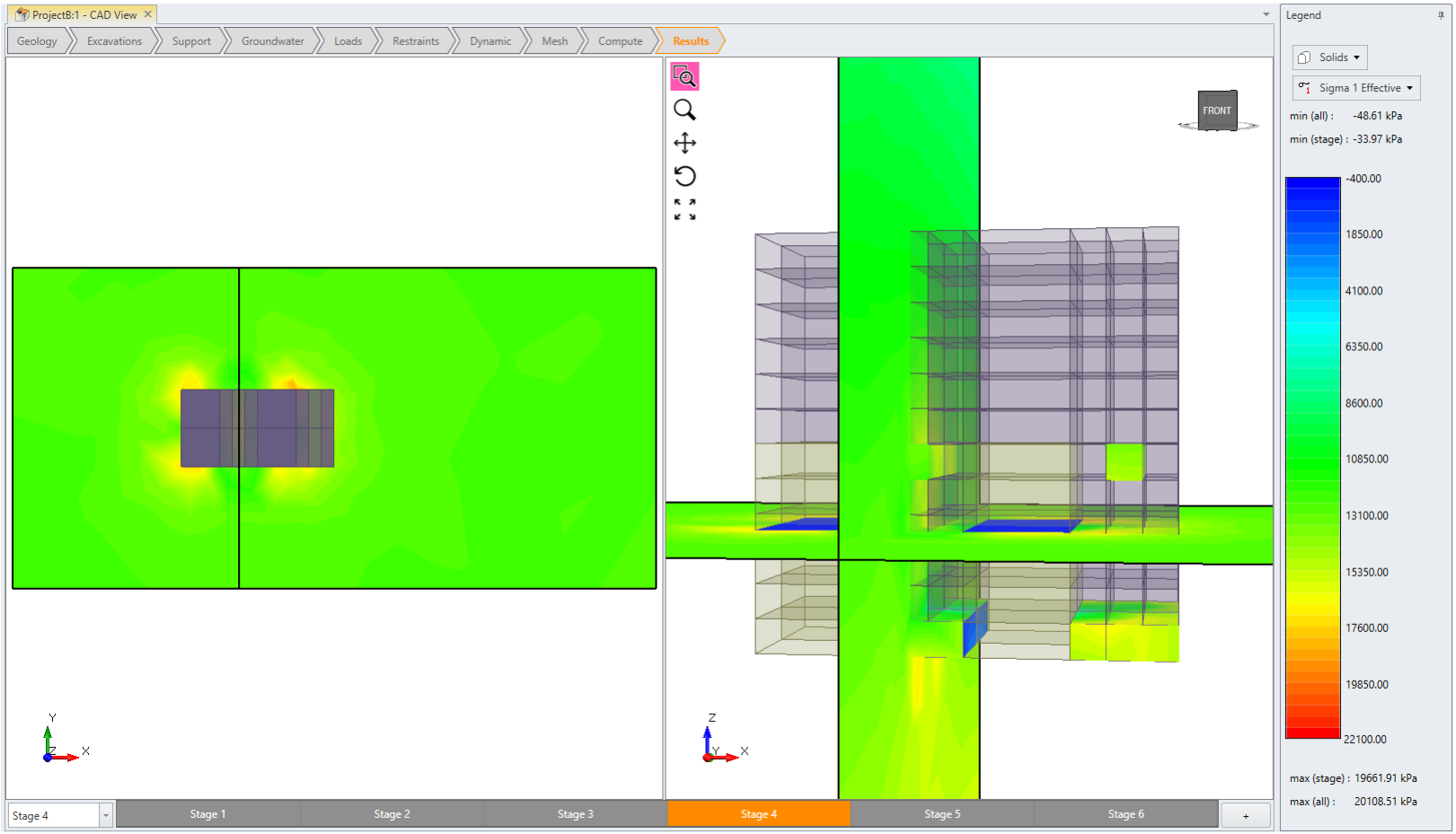


Project:	Subject:
Brucejack Project – Geotechnical Assessment of Secondary Stopes Project Number: 1008030	1220L-1290L – Stage 5 Tot. Displ.
	Date: 1/19/2019 Page 24

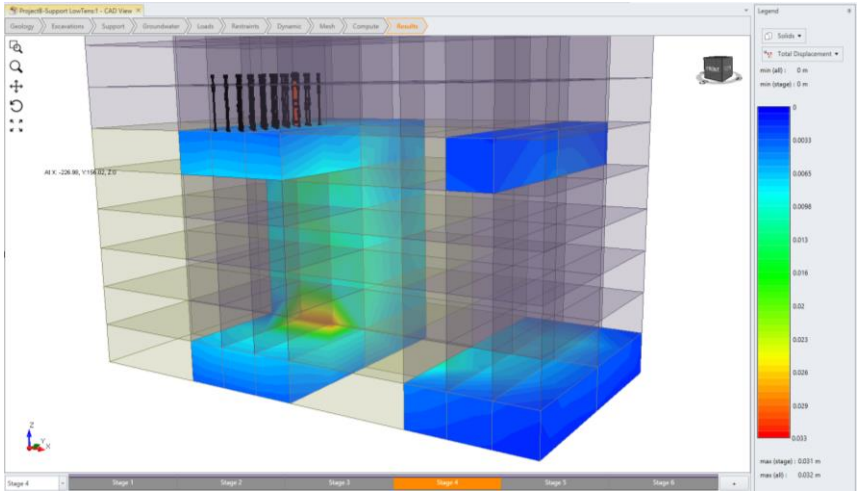


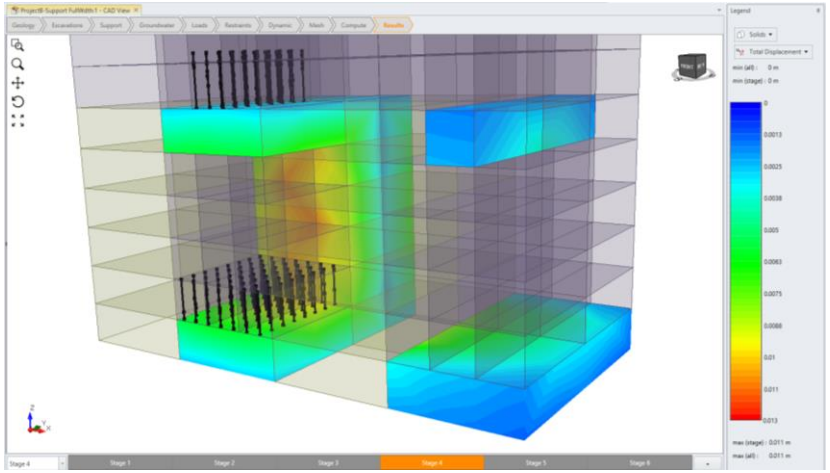
Project:	Subject:
Brucejack Project – Geotechnical Assessment of Secondary Stopes Project Number: 1008030	1220L-1290L – Stage 5 Str. Factor
	Date: 1/19/2019 Page 25





Project:	Subject:
Brucejack Project – Geotechnical Assessment of Secondary Stopes Project Number: 1008030	BJ Secondary Stoping Conceptual RS3 Stress Assessment and Ground Support Model – Stage 4 Sig1
	Date: 1/19/2019 Page 27





- Results form the models indicate that at current and near-term planned depths mining of the Brucejack orebody is unlikely to induce rock-bursting or cause un-manageable yield (or failure) within proposed sill, rib, or cross cut pillars. Standard empirical and analytical analysis techniques demonstrate that the proposed mine and pillar geometries are feasible and are likely to be stable.

- Preliminary stress analyses corroborate this, as well as highlight areas within the mine where elevated (but not un-manageable) stress conditions are anticipated as a result of mining activities. As expected, these tend to concentrate at various stages of the mining cycle, particularly within pillars and zone abutments. These and other locations of geotechnical interest should be monitored closely as mining progresses, with step-wise increases to ground surveillance and monitoring programs as required, as determined by pre-defined event-triggers and responsive actions specified in the project's Ground Control Management Plan.

- RS3 analyses are considered suitable for studying the evolution of mining-induced stresses, but are not considered suitably calibrated to estimate precise magnitudes of stress, strain, or infer absolute degrees of rock mass damage resulting from progressively failing / yielding rock (i.e. progressively micro-cracking, spalling, non-recoverable plastic deformation, and, in extreme cases, rock-bursting).

- The models' limited capacity arises from the current level of knowledge (or lack thereof) regarding the local geometry, in-situ stress conditions, local and intermediate-scale structural features and geotechnical 'zoning', etc. All of these can significantly constrain the extent to which the model can be used to accurately predict local and global rock mass behaviour during mine life.

- However, the model results can be reviewed with the goal of highlighting areas where stress is concentrating, where stress shadows (loss of confinement, or relaxation) are occurring, and where standoff distances or pillar thicknesses are not sufficient to isolate a critical openings from significant mining-induced stress changes.

- Typical results are presented in the figures above, illustrating maximum principal effective stresses 'Sigma 1', total displacements for various sequence phases, strength factors etc. As anticipated, at current depths the results indicate moderately increased loads in the 'secondary' stopes that serve as rib pillars during the primary stoping phase, as well as slightly increased loading in the rib pillars separating the cross cuts. Other mining steps indicate stresses concentrating in the sill region as mining progresses upwards, similar to that described in the excerpt provided. Analogous models run at deeper depths indicate a predicable increase in stress influences on stability.

Further RS3 model results are included in an appended slide package for review and discussion.

- The current design sill pillar thickness is 30 m. The numerical modelling analysis shows some relaxation in larger stope hanging walls, and stress concentrations in sill pillars within areas of the mine with denser stoping. The model shows that the bottom-up sequence concentrates stress in both VOK Zone sill pillars. Yielding is likely to occur prior to recovering the entire sill pillar, and therefore achievable sill pillar recovery may be less than 100%.

- The rib pillars between the open stoping blocks are intended to give temporary support to the mining block until the primary stopes are backfilled and the pillar can be recovered in the form of a secondary stope. Analyses of "conservative / low strength cases" indicates that *higher pillar load to UCS ratios may develop with increasing depths, within the pillar cores, resulting in an increased potential for progressive pillar damage, such as pillar cracking and or surface spalling, as Load to UCS ratios approach and exceed 0.5.*]

- If such a case arises, a number of mitigative measures could be used to remedy potential rib pillar deterioration, including increased localized reinforcement of the pillars with bolts, screen, straps and / or shotcrete (where accessible), or alternatively, a change in the local excavation geometry and /or mining sequence.

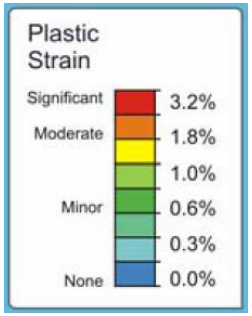
Common Damage Scale

The RS3 stress assessment results include the maximum shear strain predicted throughout the modeled zone.

It is notable that the indicated strain is substantially below the 2% to 3% typically required for the onset of significant ground deterioration.

The Common Damage Scale (Beck and Duplancic, 2005) presents a useful empirically-tested correlation of modeled plastic strain vs expected rock mass damage.

	Class	Description
	Very Significant	Drive surface heavily deformed, drill holes crushed, support visibly loaded. → Substantial rehabilitation required to prevent frequent falls of ground
	Significant	Any or all of: Buckling, dilation of existing structure or induced fractures, failed corners and brows, hole problems. Bulking of the mesh is present in some areas. → "Spot" rehabilitation required to maintain access, more substantial rehabilitation required for drill and blast activity etc. Hole problems develop
	Moderate	Shearing on existing structure, visible yield. Frequent scats in the mesh, or material may be spalling under mesh. → Rehabilitation required only when intense activity will be undertaken in the area (ie drill and blast). Drive still safe for travel. Holes show more frequent signs of damage, sometimes requiring re-drilling.
	Minor	Minor signs of strain or displacement on persistent structures, some occasional scats in mesh. → No rehabilitation required.
	None	Blast damage/virgin stress damage only → Primary support controls drive surface



Paste Backfill

Primary backfilling material, with high-strength (1.1 MPa) used in the lower portion of primary and secondary stopes on the sill level where paste will be undercut during sill excavation

Regular strength (400 kPa) used in primary stopes where vertical paste re-exposure will occur during secondary stope extraction

Low strength (200 kPa) paste or unconsolidated waste rock used to backfill secondary stopes that will not be re-exposed by adjacent mining.

Paste Backfill QA QC

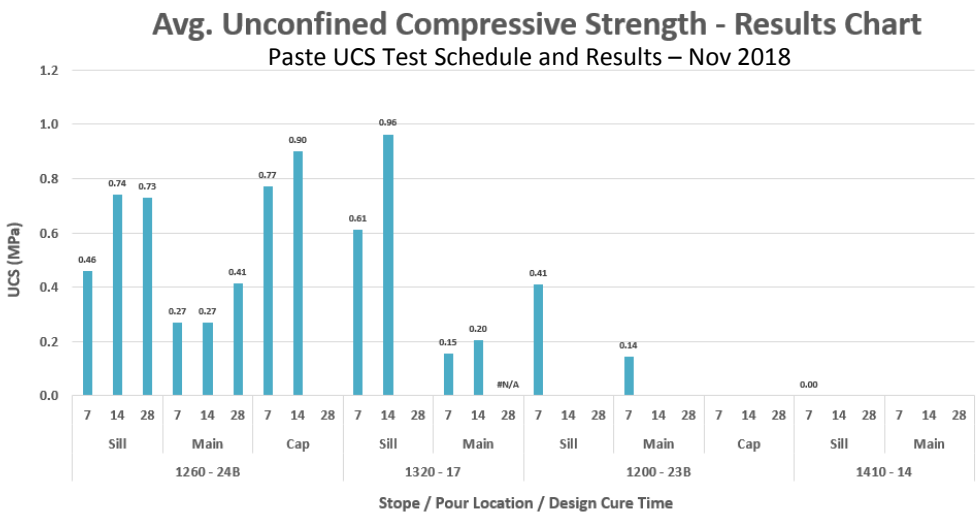
A Quality Control Quality Assurance for paste has been implemented which was broadly reviewed by BGC. During the December 2018 site visit

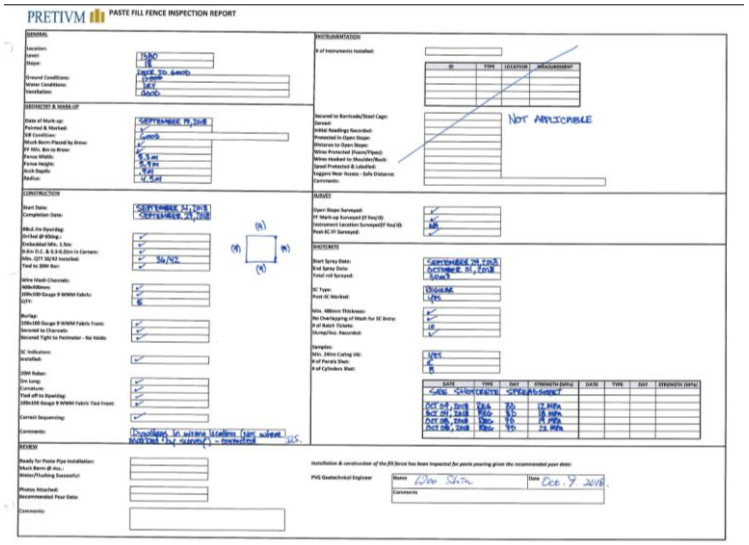
Data suggests a wide range of strength results from sample test results, with mean values generally achieving design standards. Additional data is required from now fully commissioned paste plant to establish long term quality trends.

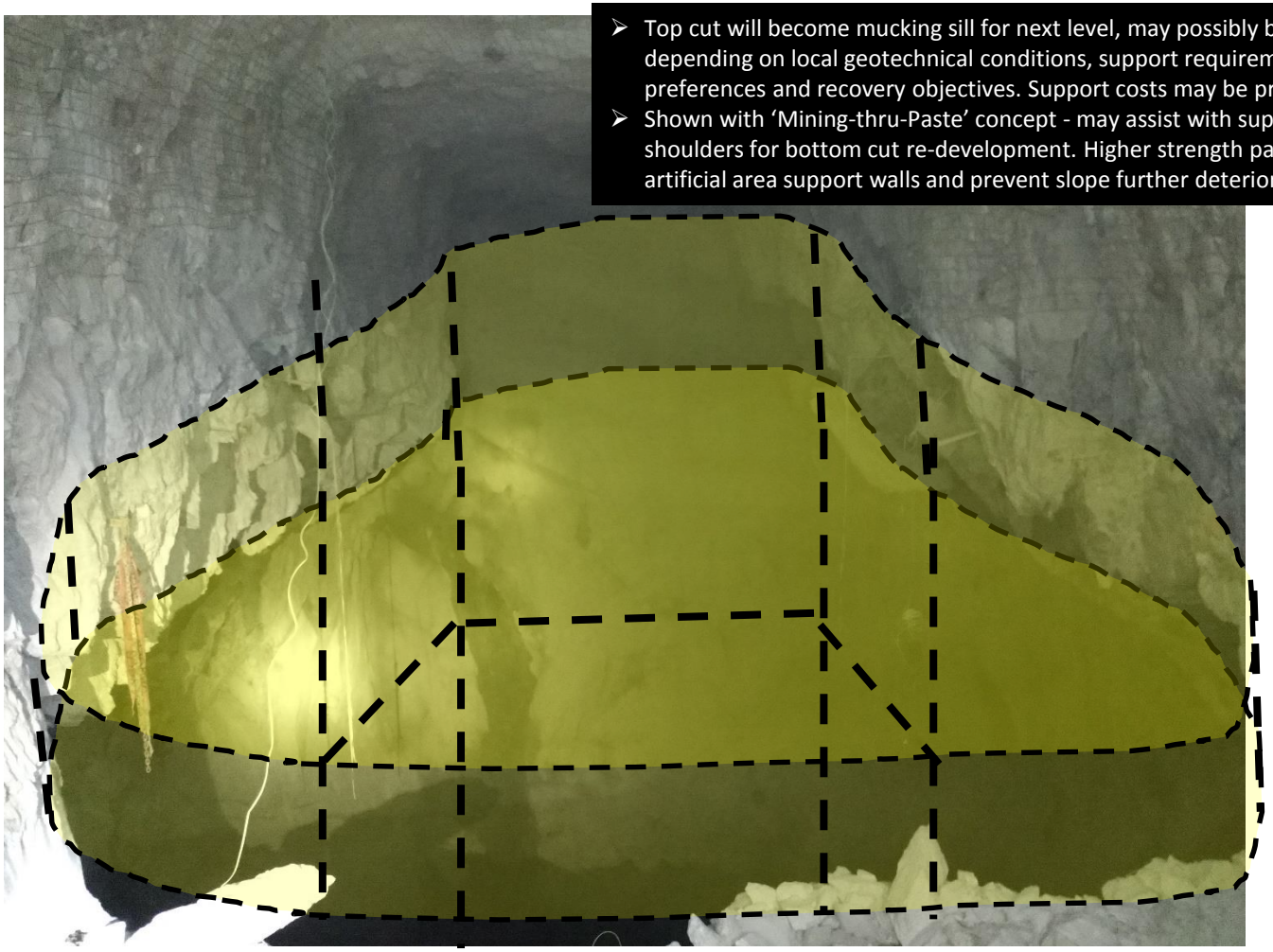
Uncertainties remain regarding the assessment of paste fill exposures for various stoping configurations and the impact of paste strengths of overall stability, particularly for dimensions that approach the larger range of those contemplated as part of the mine design (e.g.. 30 m high x 30-plus metres long x 15 m wide).

Confirmation and on-going coordination with the project paste design engineers (AMC) is recommended, particularly as secondary stopes are now being developed.

Paste may possibly be used as a local stabilizer for stope shoulders, by overfilling and 'mining thru paste' to re-establish stable and controlled access for bottom cut development following blasting. The mining practicalities, paste strength requirements and possible advantages of this approach should be investigated.







- Top cut will become mucking sill for next level, may possibly be slashed full width depending on local geotechnical conditions, support requirements, mining preferences and recovery objectives. Support costs may be prohibitive.
- Shown with 'Mining-thru-Paste' concept - may assist with support of stope shoulders for bottom cut re-development. Higher strength paste used to provide artificial area support walls and prevent slope further deterioration.

Geotechnical Monitoring at Brucejack

An observational 'mine and monitor' risk management system will be employed at Brucejack, as part of the GCMP. Similar to the current state of practice for monitoring in underground mines in North America, Brucejack's planned ground monitoring system includes, progressively :

- Visual geotechnical inspections of mine workings
- Tape extensometer stations
- **CMS and monitoring prisms , rectified and reconciled to the mine coordinate system**
- **Vibrating wire and / or manual crackmeters**
- **Time domain reflectrometry (TDR) cables in excavation walls**
- **Multi-point borehole extensometers (MPBX) in pillars and walls**
- **Borehole stress meters**
- **Spatially Accurate 3D Mine Model as contiguous solids**
- **In-situ Stress Testing and Micro-seismic systems** , as appropriate

(items for advancement highlighted in blue, for discussion / consideration)

The various hardware systems noted above should be augmented with an appropriate suite of software to provide near real-time visualization, displacement calculations, monitoring, and warnings for the geotechnical and operations staff of the mine. Of particular significance will be the excavations near and within the Brucejack Fault Zone, the underground crusher chamber, and crown, rib, and sill pillars.

Regular visual geotechnical inspections of all mine workings are to completed by Pretium and / or their contractors

Deformation monitoring of critical stope walls, pillars, and infrastructure excavations such as shops, service bays, crusher chambers, primary developments, main access ramps, ventilation infrastructure etc., should be initiated as mining progresses. This monitoring is required to:

- Maintain safe operational practices for personnel and equipment
- Provide warning of rock mass instability
- Provide geotechnical information for designs to assist in making subsequent modifications, should they be required, to achieve the desired rock mass performance.
- If field observations and performance data indicate the progressive development of un-anticipated / anomalous / elevated stress conditions (similar to those noted in the 'Common Damage Scale'), or growing uncertainties with respect to Pretium's understanding of evolving stress conditions, monitoring programs and related instrumentation will be progressively upgraded until the necessary levels of surveillance are achieved and maintained.

MPBX

(Multi-Point Borehole Extensometer)

Typically has ~five or more anchor points and an integrated electronic readout head.

Specifications

Length: up to 100 m

Diameter: 33 mm

Weight: 0.5 kg/m

Borehole diameter: 50 mm minimum

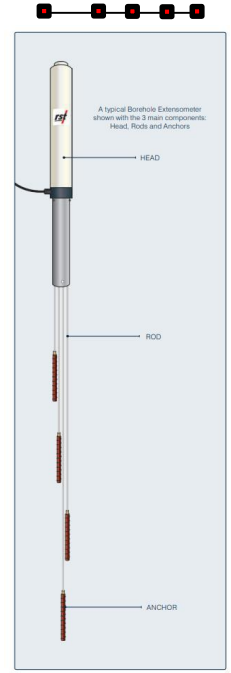
Applications

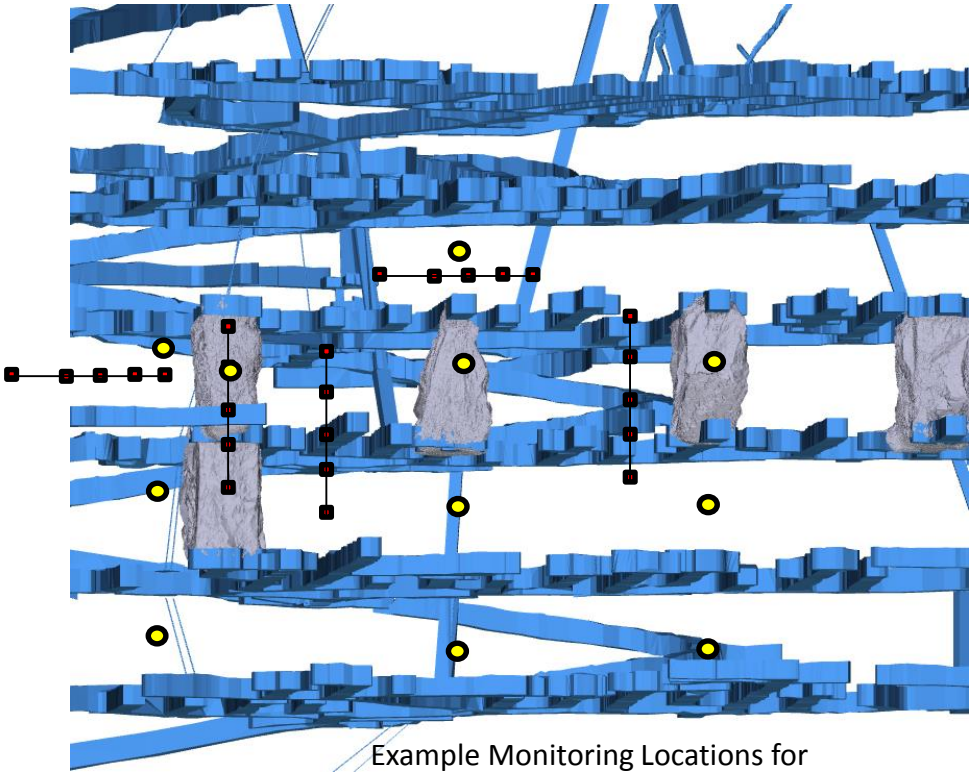
Monitoring of underground excavations including walls and backs of mining drifts

Surface crown-pillar monitoring

Backfill monitoring in underground mines

Tunnels and dams on surface





Example Monitoring Locations for Current 1220 L to 1290 L Stoping Zone

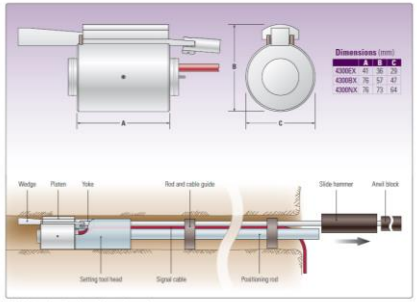
Stress Cell

Operating Principle

The stressmeter consists essentially of a high strength steel proving ring wedged tightly across one diameter of a borehole drilled into the rock. The distortion of the proving ring, caused by changing rock stresses, is measured by means of a vibrating wire. Changes in rock stress cause changes in the resonant frequency of vibration of the tensioned wire, and the two are related by means of calibration data supplied with each stressmeter.

• Model 4300 installation in hard rock

• Model 4300 installation in soft rock, using a soft rock shoe and soft rock platen.



• Model 4300 details and installation tool assembly.

RECOMMENDATIONS

- **Mining of Secondary Stopes should be limited to a 5-m wide top cut. General case stability analyses indicated a cross drift to allow for parallel drilling is unlikely to adversely impact stope stability vs. a full width slash.**
- Due to adverse orientation of some of the discontinuity sets in the Brucejack rock mass, there will remain some residual risk for rock fall in the full width undercuts despite the installation of the ground support summarized in this memo.
- The risk for that rock fall increases where the discontinuities are persistent (greater than half of the cross-cut span) and closely spaced (less than half of the cross-cut span). The existing geotechnical database is insufficient to predict where these more persistent and/or closely spaced discontinuities may occur, therefore thorough geotechnical inspections and routine scaling of the workings throughout the development cycle should be carried out to help mitigate the residual risk.
- When poorer quality rock masses and/or persistent structure(s) are encountered, customized support designs which address local conditions are required. Additional support may include simple modifications such as reducing the spacing on the Super Swellex, or more complex solutions targeting specific zones or features.
- Underground mining personnel will need to assess if underground rock mass conditions closely match the assumed conditions. Should different or atypical conditions be encountered, then the design supplied herein may not be appropriate or valid.
- Mucking level brows of full width undercuts should be regularly inspected by qualified geotechnical staff and mining supervisors for signs of rock mass damage, raveling, and failure within the back and ribs. All support (short and long) should be installed in timely manner (ideally “in-cycle”) and subject to a rigorous QA/ QC program.
- Rehabilitation of damaged zones of rock within full width undercuts should be carried out as soon as practical.
- It is recommended that all standard ground support designs be reviewed and updated annually, as additional operational experience, structural data, stress regime data, and excavation performance data becomes available.
- Consider modifying the standard ground support for full-width undercuts. Longer length and higher-capacity support than the 4.8 m SuperSwellex is required to achieve design FOS if persistent geologic structure intersects the stope. Analysis completed as part of this assessment indicates that 6 to 15 m long 0.7 inch diameter double-strand bulbed cables (or equivalent ~ 50 ton element) on a 1.0 to 1.5 m by 1.0 to 1.5 m staggered pattern may be required achieve design FOS’s for some of the larger wedges potentially formed by persistent geologic structure. In these cases full widths cuts may well be preferentially / selectively avoided.
- Review production blast designs with the intent to minimize blast-induced damage in the rock mass.
- Consider reducing the stope lengths and access options, locations of backfill placement , particularly when persistent and adversely oriented structures are mapped in the stope cross-cuts.
- Paste may possibly be used as a local stabilizer for stope shoulders, by overfilling and ‘mining thru paste’ to re-establish stable and controlled access for bottom cut development following blasting. The mining practicalities, paste strength requirements and possible advantages of this approach should be investigated.

Limitations

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We trust the enclosed meets your needs at this time. If you have any questions or comments, please don't hesitate to contact us.

Yours sincerely,

BGC ENGINEERING INC.
per:

J. Roland Tosney, M.Sc., P.Eng.
Senior Mining Geotechnical Engineer

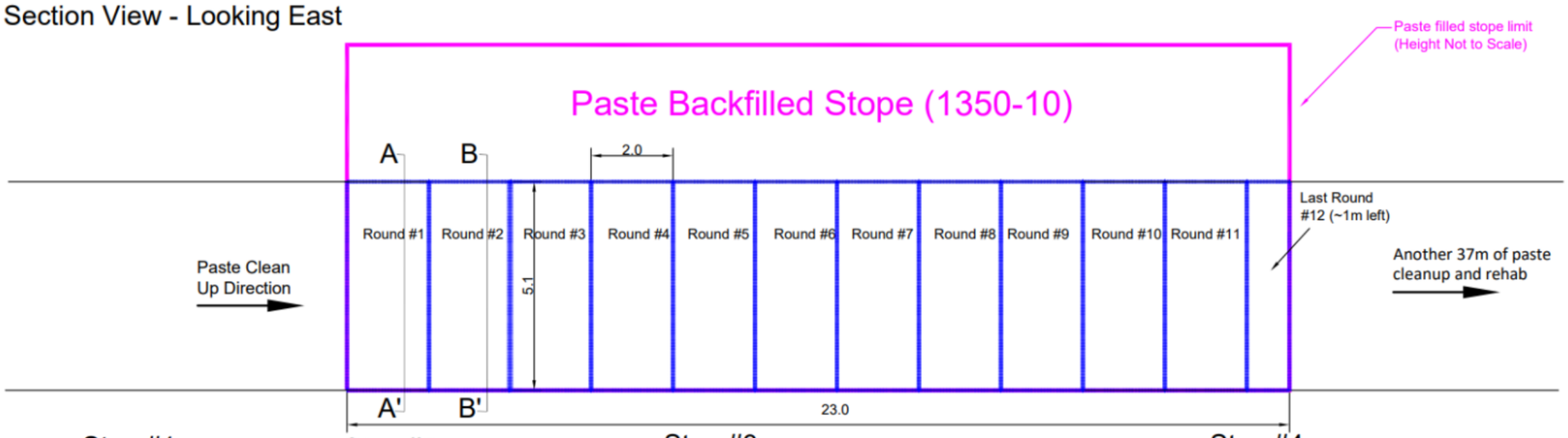
Reviewed by:
C. Schmid, M.Sc., P.Eng.
Senior Geotechnical Engineer

Appendix O

Ground support system- development into paste backfill

SUPPORT PLAN FOR PASTE BREAKTHROUGH

Section View - Looking East



Step #1

1. Excavate 2m of paste at the full dimensions of 5.2mW by 5.1mH.

Step #2:

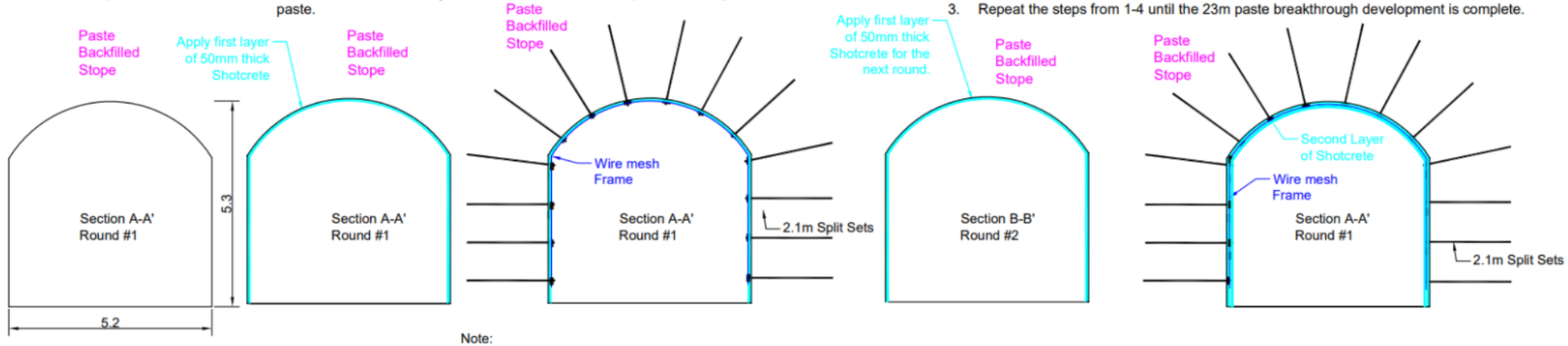
1. Apply the initial layer of 50mm thick shotcrete from sill to sill to cover the first round of exposed paste.

Step #3:

1. Wait for 6 hours to let shotcrete to cure;
2. Install Wire Mesh Screen and 2.1m split sets with 1.0m by 1.0m spacing.

Step #4:

1. Excavate 2m of paste for the next round;
2. Apply initial layer to the current round and 2nd layer to the previous round of 50mm thick shotcrete;
3. Repeat the steps from 1-4 until the 23m paste breakthrough development is complete.



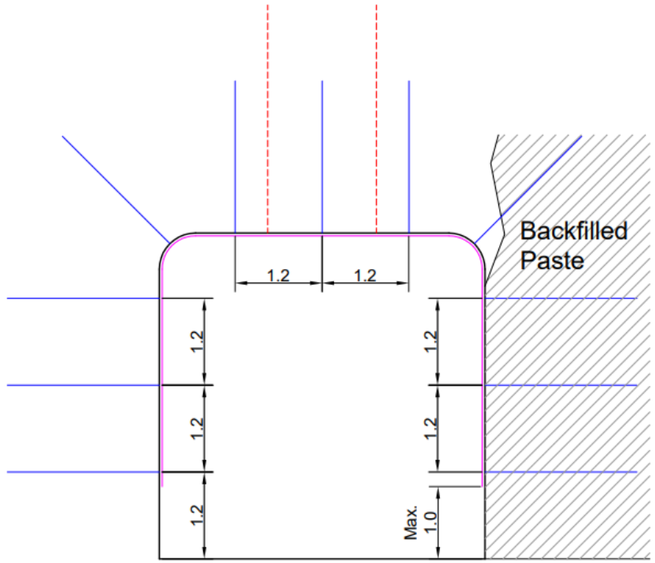
Note:
1. Drift is to be excavated with arch back. The straight wall height is to be 4m before curve starts.
2. 2.1 m long Splitsets are to be installed at 1m by 1m pattern as shown in the section view
3. Shotcrete curing time is 6 hours before working underneath.
4. When second layer of shotcrete is applied, screen, bolts plate are to be fully covered.

Plan View 0 1.0 2.0 3.0 4.0 5.0
Scale in Metres

PRETIVM	J:\EngineeringGeotechnical\Additional Ground Support Drawing\1350-10 Paste Breakthrough Support Plan 20200421	Ground Support Plan	
Brucejack GoldMine		1350-10 Paste Breakthrough Support Plan	
		Date: April 21, 2020	

SUPPORT PLAN FOR MINE BESIDE PASTE

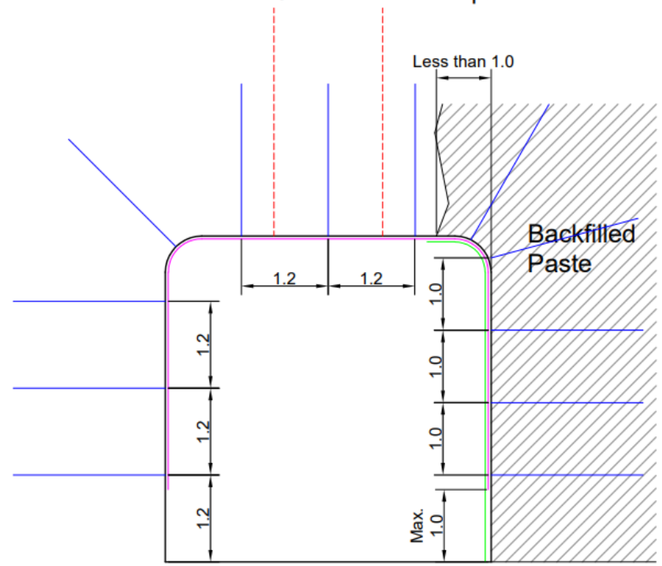
Drift with Paste Wall Exposure



Advance (m)		3.6 m (2.0m as required by Geotech Eng)
Rock Bolt	Back	2.1m Long Split Set (1.2m by 1.2m spacing)
	Wall (Rock)	2.1m Long Split Set (1.2m by 1.2m spacing) down to maximum 1.2m from Sill
	Wall (Paste)	2.1m Long Split Set (1.2m by 1.2m spacing) down to maximum 1.2m from Sill
Wire Mesh		Back & Walls - Down to maximum 1.0m from Sill
Shotcrete	Pre - SC	as Required depends on Paste Condition
	Post - SC	N/A
Secondary Long Support		4.9m Long Connectables to the Back as Required

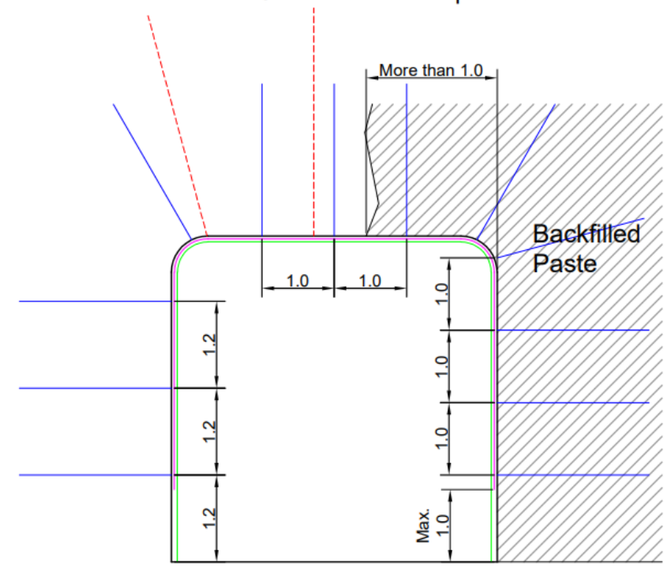
Drift with Paste Wall/Back Exposure

Less than 1.0m Paste Back Exposure



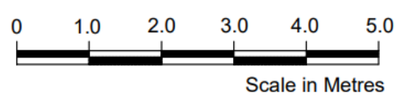
Advance (m)		2.0 m
Rock Bolt	Back	2.1m Long Split Set (1.0m by 1.0m spacing)
	Wall (Rock)	2.1m Long Split Set (1.2m by 1.2m spacing) down to maximum 1.2m from Sill
	Wall (Paste)	2.1m Long Split Set (1.0m by 1.0m spacing) down to maximum 1.2m from Sill
Wire Mesh		Back & Walls - Down to maximum 1.0m from Sill
Shotcrete	Pre - SC	as Required depends on Paste Condition
	Post - SC	Paste Exposure (Min. 50mm)
Secondary Long Support		4.9m Long Connectables to the Back as Required

More than 1.0m Paste Back Exposure



Advance (m)		2.0m
Rock Bolt	Back	2.1m Long Split Set (1.0m by 1.0m spacing)
	Wall (Rock)	2.1m Long Split Set (1.2m by 1.2m spacing) down to maximum 1.2m from Sill
	Wall (Paste)	2.1m Long Split Set (1.0m by 1.0m spacing) down to maximum 1.2m from Sill
Wire Mesh		Back & Walls - Down to maximum 1.0m from Sill
Shotcrete	Pre - SC	Paste Exposure (Min. 50mm)
	Post - SC	Sill to Sill (Min. 50mm)
Secondary Long Support		4.9m Long Connectables to the Back as Required

Plan View



Note:

1. Shotcrete curing time is 6 hours before working underneath.
2. When second layer of shotcrete is applied, screen, bolts plate are to be fully covered.
3. Drift with more than 1m of paste exposure at the back will be considered as a drift break through and applied same support plan.

PRETIVM

Brucejack GoldMine

J:\Engineering\Geotechnical\Additional Ground Support Drawing\Mine Beside Paste Backfill

Ground Support Plan

Mine beside Paste Backfill

Date: February 19, 2022

Supporting Information

BRUCEJACK GOLD MINE

Ground Control Management Plan

I. Brucejack Ground Support Product Specifications and Installation Guidelines

I-A. Cable Bolt Installation

I-B. Cable Bolt Specification

I-C. Resin Rebar Bolt Specification

I-D. DYWIDAG Threadbar Specification

I-E. Connectable Swellex Specification

I-F. Split Set Bolt Specification

I-G. Mesh, Straps, and Plate Washers Specifications

I-H. Shotcrete Mix Designs

I-A. Cable Bolt Installation Guidelines

14.5.3 Cable installation

The left hand drawing in Figure 14.14 shows the traditional method of grouting a cable in an uphole. This method will be called the 'breather tube method'. The grout, usually having a water/cement ratio ≥ 0.4, is injected into the bottom of the hole through a large diameter tube, typically 19 mm diameter. The air is bled through a smaller diameter tube which extends to the end of the hole and which is taped onto the cable. Both tubes and the cable are sealed into the bottom of the hole by means of a plug of cotton waste or of quick setting mortar. As shown, the direction of grout travel is upwards in the hole and this tends to favour a grout column which is devoid of air gaps since any slump in the grout tends to fill these gaps.

Apart from the difficulty of sealing the collar of the hole, the main problem with this system is that it is difficult to detect when the hole is full of grout. Typically, the hole is judged to be full when air ceases to flow from the bleed tube. This may occur prematurely if air is vented into an open joint along the hole. In addition, a void the size of the bleed tube is likely to be left in the grout column. Therefore, it is preferable to stop grouting the borehole only when grout returns along the bleed tube. However, a viscous grout will not flow down a 9 mm bleed tube and so a larger tube is required.

An alternative method, called the 'grout tube method' is illustrated in the right hand drawing in Figure 14.14. In this case a large diameter grout injection tube extends to the end of the hole and is taped onto the cable. The cable and tube are held in place in the hole by a wooden wedge inserted into the hole collar. Note that care has to be taken to avoid compressing the grout tube between the wedge and the cable. Grout is injected to the top of the hole and is pumped down the hole until it appears at the hole collar. If a watery grout appears first at the collar of the hole, grout pumping is continued until a consistently thick grout is observed.

Provided that a very viscous mix is used (0.3 to 0.35 water/cement ratio), the grout will have to be pumped into the hole and there is little danger of slump voids being formed. However, a higher water/cement ratio mix will almost certainly result in air voids in the grout column as a result of slumping of the grout. The principal advantage of this method is that it is fairly obvious when the hole is full of grout and this, together with the smaller number of components required, makes the method attractive when compared with the traditional method for grouting plain strand cables. In addition, the thicker grout used in this method is not likely to flow into fractures in the rock, preferring instead the path of least flow resistance towards the borehole collar.

The procedure used for grouting downholes is similar to the grout tube method, described above, without the wooden wedge in the borehole collar. The grout tube may be taped to the cable or retracted slowly from the bottom of the hole as grouting progresses. It is important to ensure that the withdrawal rate does not exceed the rate of filling the hole so the air voids are not introduced. This is achieved by applying, by hand, a slight downward force to resist the upward force applied to the tube by the rising grout column. Grout of any consistency is suitable for this method but the best range for plain strand cables is between 0.3 and 0.4 water/cement ratio.

Modified cables, such as birdcage, ferruled or bulbed strand, should be grouted using a 0.4 water/cement ratio mix to ensure that the grout is fluid enough to fill the cage structure of these cables. Therefore, the breather tube method must be used for

these types of cables, since the grout flow characteristics required by the grout tube method is limited to grouts in the range of 0.3 to 0.35 water/cement ratio.

One of the most critical components in a cable installation is the grout column. Every possible care must be taken to ensure that the column contains as few air voids as possible. In the breather tube method, a large diameter breather tube will allow the return of grout as well as air. When using the grout tube method in upholes, a 0.3 to 0.35 water/cement ration grout will ensure that pumping is required to cause the grout column to flow, and this will avoid slumping of the grout in the borehole. A grout with a water/cement ratio of less than 0.3 should be avoided, since it will tend to form encapsulated air voids as it flows around the cable.

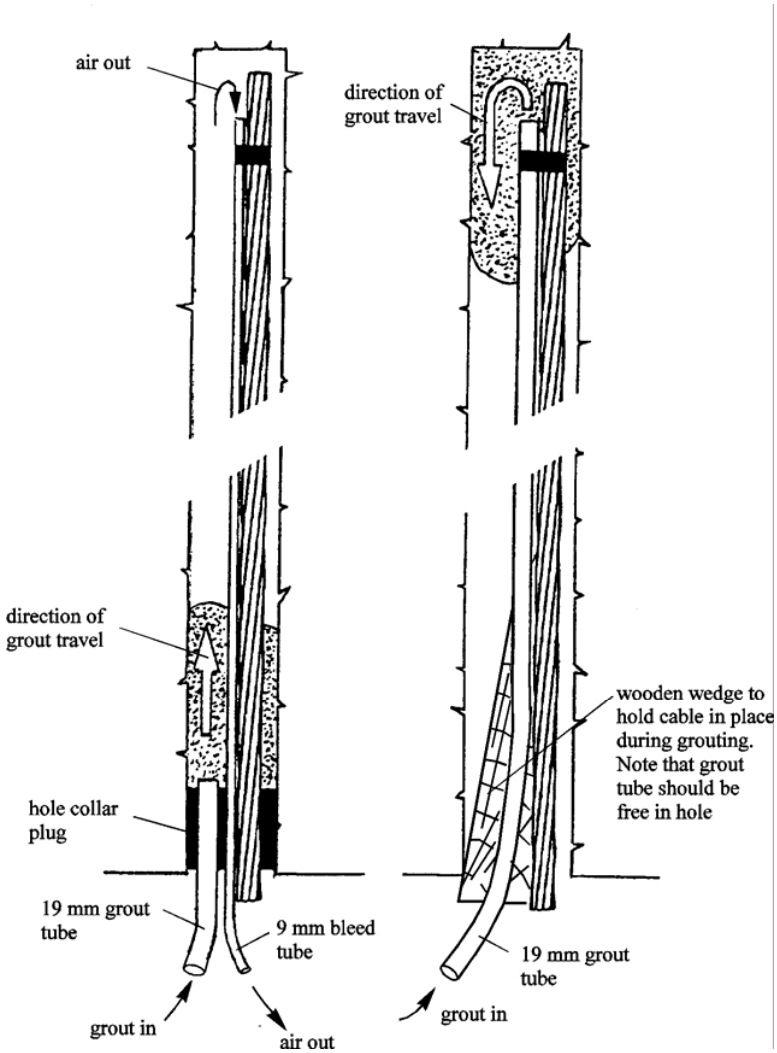
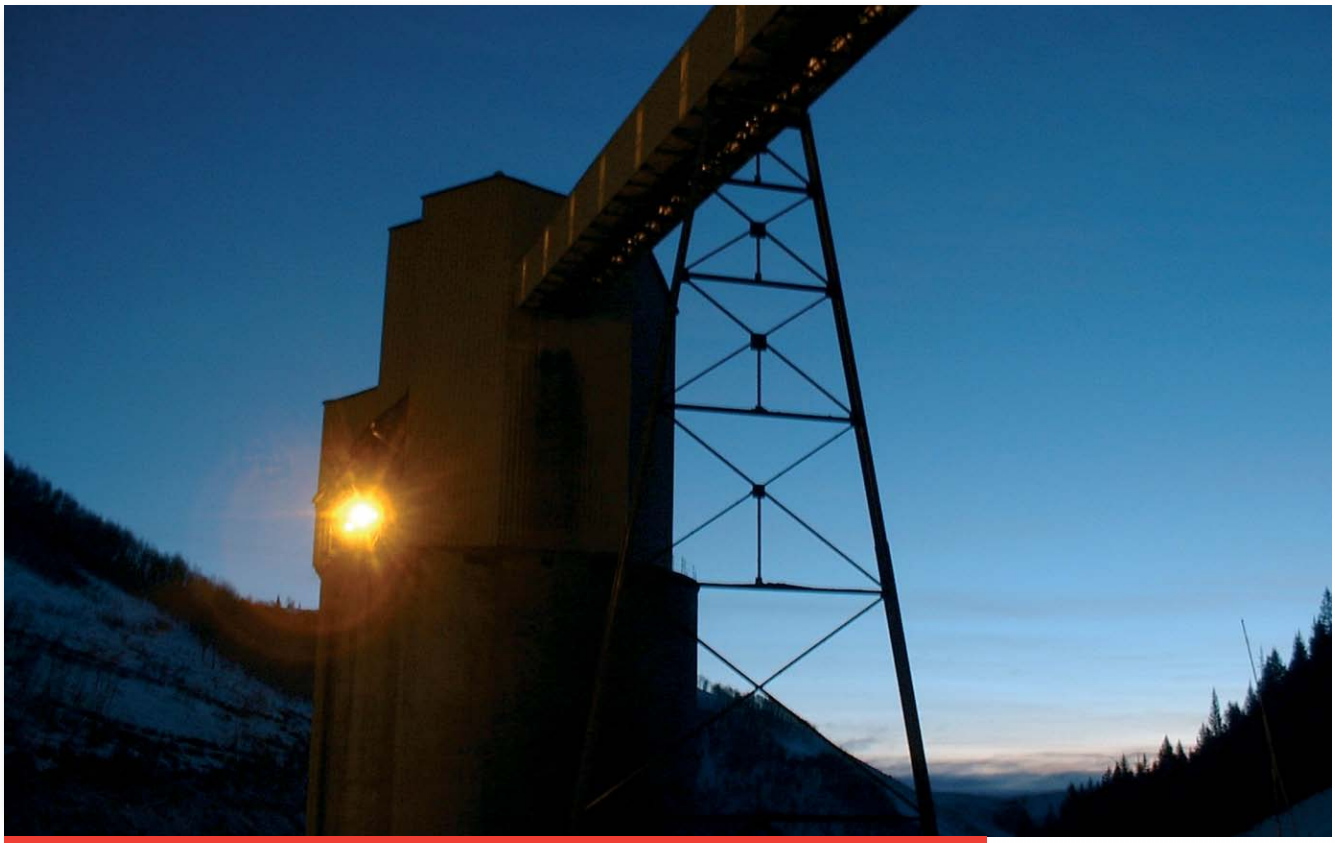


Figure 14.14: Alternative methods for grouting cables in upholes.

I-B. Cable Bolt Specification

DYWIDAG-SYSTEMS INTERNATIONAL

Ground Support Catalogue



Mining & Tunneling Division

www.dsigroundsupport.com

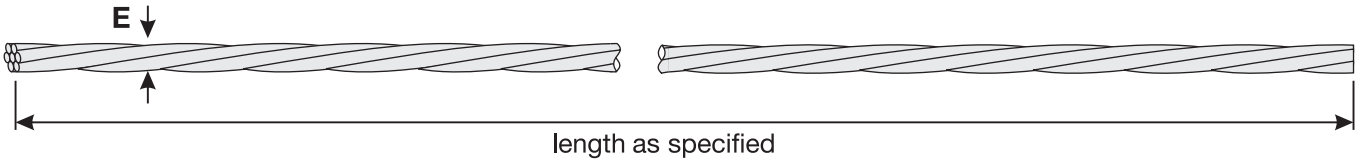
Section 2

	Section
Friction Stabilizers & Expandable Bolts	1
Cable Bolts	**2**
Dywidag Threadbar	3
Mechanical Rockbolts, Extension Bolts, Stelpipe Bolts	4
Rebar Rock Bolts	5
Specialty Bolts	6
Fibreglass Bolts	7
Trusses & Slings	8
Resins and Cement Cartridges	9
Mesh, Straps, & Plate Washers	10
Eyebolts, Scaling Bars, & Utility Hangers	11
Tools & Hardware	12
Lattice Girders	13
High Performance Grouts & Application Equipment	14
Drilling Fluids	15
Miscellaneous	16

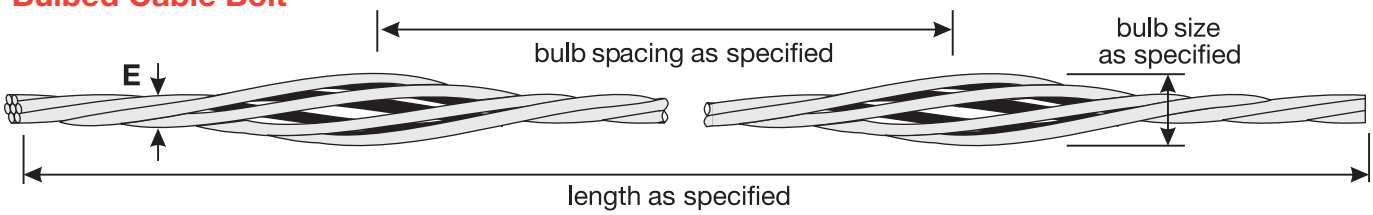
Cable Bolts (Plain & Bulb)

0.5", 0.6" and 0.7"

Plain Cable Bolt



Bulbed Cable Bolt



Dimensions

	0.5" Cable Bolt	0.6" Cable Bolt	0.7" Cable Bolt
E Strand Diameter	0.500" $^{+0.026"}_{-0.006"}$ 12.70 mm $^{+0.66\ mm}_{-0.15\ mm}$	0.600" $^{+0.026"}_{-0.006"}$ 15.24 mm $^{+0.66\ mm}_{-0.15\ mm}$	0.700" $^{+0.026"}_{-0.006"}$ 17.78 mm $^{+0.66\ mm}_{-0.15\ mm}$

Physical Properties

	0.5" Cable Bolt	0.6" Cable Bolt	0.7" Cable Bolt
Product	uncoated 7 wire low relaxation strand		
Grade	270 K - 270,000 psi (1860 MPa) ultimate strength		
Breaking strength, min.	41,300 lbs (183.7 kN)	58,600 lbs (260.7 kN)	76,200 lbs (339 kN)
1% extension under load, min.	37,170 lbs (165.3 kN)	52,740 lbs (234.6 kN)	68,600 lbs (305.1 kN)
Elongation in 24 inch (610 mm)	3.5% minimum		
Relaxation after 1000 hrs	maximum 2.5% with initial load = 70% breaking strength maximum 3.5% with initial load = 80% breaking strength		
Specification	ASTM A416, CSA G279-75, CSA G279-M1985		

Construction Details

	0.5" Cable Bolt	0.6" Cable Bolt	0.7" Cable Bolt
Construction	1 center wire & 6 outer wires		
Steel area	nom. 0.153 in^2 (98.7 mm^2)	nom. 0.217 in^2 (140 mm^2)	nom. 0.304 in^2 (196 mm^2)
Standing pitch	12-16 x diameter		
Weight per 1000 ft	520 lbs	740 lbs	1110 lbs
Weight per 1000 m	775 kg	1102 kg	1654 kg
Difference in wire size (center - outer)	min. 0.003" (0.076 mm)	min. 0.004" (0.102 mm)	min. 0.005" (0.127 mm)

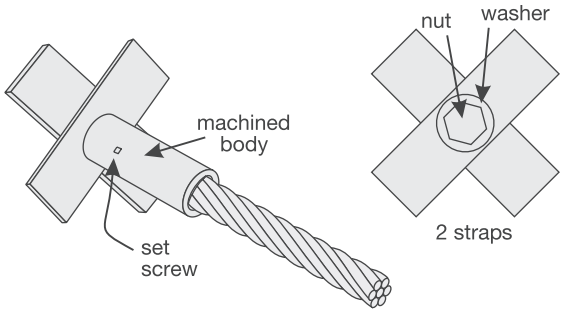
Galvanized cable bolts available on request

Installation Accessories

Cable Bolts

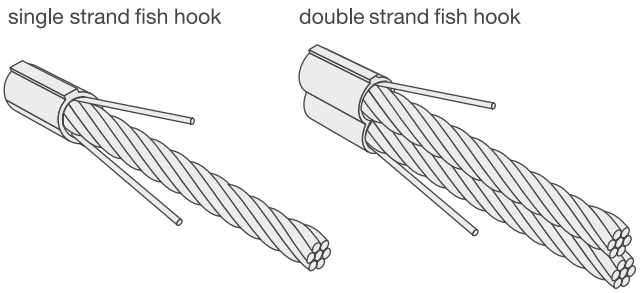
End Holding Device - conventional style

- to hold cable bolt prior to grouting
- 2 straps ¾" x 2¾" (19 mm x 70 mm)
- suitable for 2" (51 mm) to 2.5" (64 mm) hole
- can be ordered separately and site installed
- if factory ordered, straps removed for shipping
- not available for double cable bolts



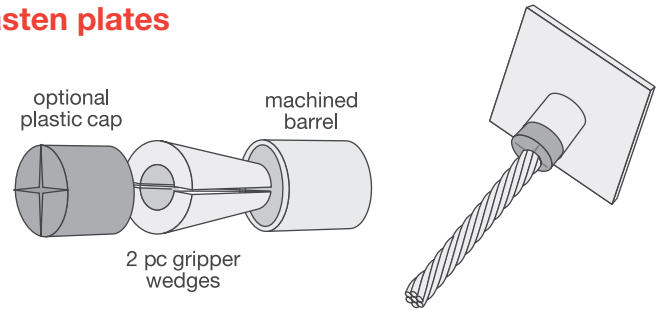
End Holding Device - fish hook style

- hooks swaged on with steel tubing
- hooks can be bent out to accommodate any hole size
- for single or double cable bolts
- fitting holds double cables together



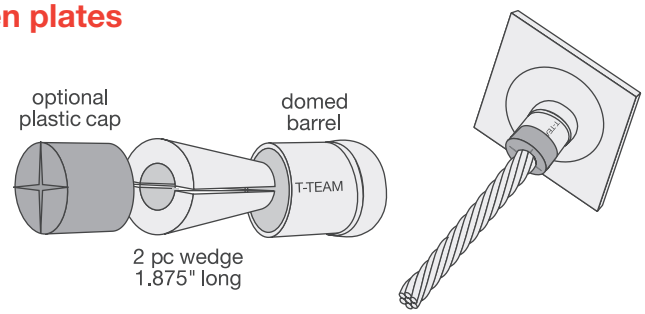
0.5", 0.6" & 0.7" Machined Cable Grip - to fasten plates

- rated for full load of cable bolt
- Ø 1¼" (32 mm) for 0.5" cable bolts
- Ø 1½" (38 mm) for 0.6" cable bolts
- c/w 2 part gripper wedges
- available galvanized
- optional plastic cap to secure wedges during shipping



0.6" & 0.7" Cast Domed Cable Grip - to fasten plates

- rated for full load of cable bolt
- Ø 2" (51 mm) domed face
- c/w 2 part gripper wedges
- wedges available with or without groove & retaining spring
- available galvanized
- optional plastic cap to secure wedges during shipping

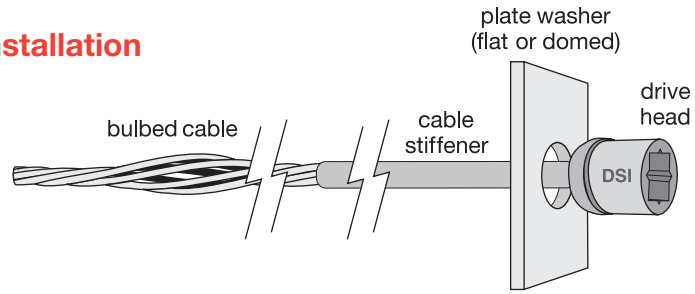


Installation Accessories

Cable Bolts

Passive Spinnable Cable Bolt - for resin installation

- 0.6" & 0.7" cable available
- resin anchored
- bulbs provide resin mixing and anchoring
- accepts 1⅛" square or hex male spinner
- available plain or galvanized
- cable available in any length
- factory assembled



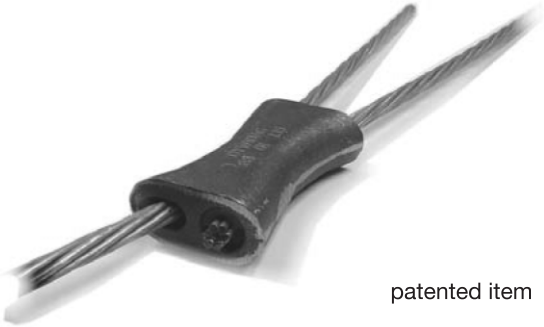
patented item

Grout and Breather Tubing

- ¾" ID x ⅞" OD black poly tubing (400' roll)
- ¾" ID x ⅞" OD high density grout tubing (400' roll)
- ½" ID x ⅝" OD regular poly tubing (400' roll)
- ⅜" ID x ½" OD high density poly tubing (500' roll)
- black poly tubing rated for 100 psi
- yellow high density tubing rated for 200 psi

0.6" & 0.7" Dogbone Cable Coupler

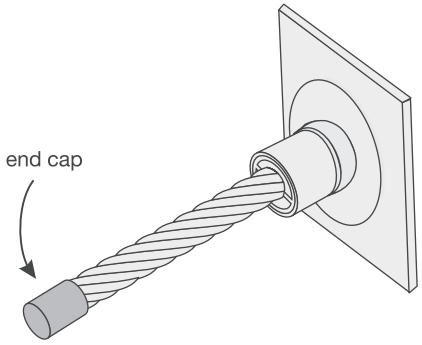
- rated for full load of cable bolt
- used to join cables for slings or trusses
- used to wrap failing pillars
- requires 2 sets of wedges (included)



patented item

0.6" Cable Safety End Cap Grip

- for 0.6" cable bolts
- made from durable vinyl
- protects workers from sharp ends of cable



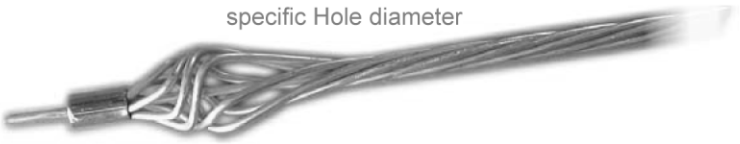
Cable Bolt

0.6" or 0.7" Passive and Tensionable

Cable Diameter	0.6" gr270	0.7" gr270
Weight	0.74 lbs/ft	1.11 lbs/ft
Bore Hole Diameter	1" to 1.375"	1" to 1.375"
Cross Sectional Area	140mm^2	196mm^2
Ultimate Load [1000lbs]	58.6	76.2
Yield Load [1000lbs]	46	68.6
Min. Elongation in 2ft	3.5%	3.5%
Typical plate	gr6 w/ 1$^3/_8$" hole	Grade 6

Also available are 0.5", 0.62" and 0.9" upon request.

- 270 ksi, low relaxation cable per ASTM A416.
- Supplied in any length, black or galvanized cable.
- Point anchored active bolt, tensioned after installation utilizing the hydraulic tensioning jack.
- Point-anchored passive bolt with pre-seated head. Wedge barrel shaped to accept 1⅛" hex or square male spinner.
- Several options for anchoring in the resin are available: The bulbed cable bolt is designed for point-anchoring in resin. It may also be fully grouted with slow speed resin, or cement grouts. Bulbing is an effective means to center the bolt in the drill hole, to mix the resin and to develop bond for anchoring the bolt.
- The Bond head is an additional bulb that can be formed on the end of the cable bolt.
- Bulbs are provided to fit hole sizes:
  - 1" hole: strip cage
  - 1⅜" hole: plunge bulb
  - 1¾" hole: bond head

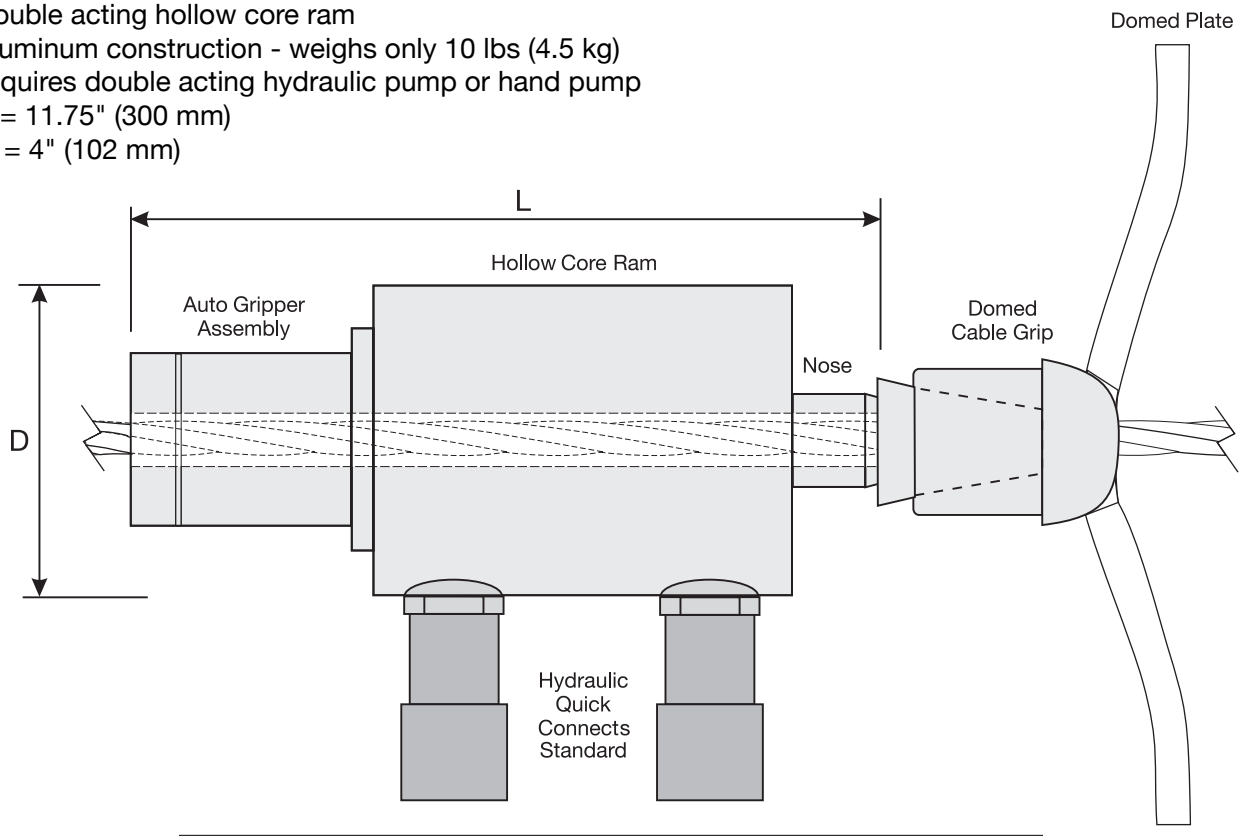


CBJ-1 Cable Bolt Tensioning Jack

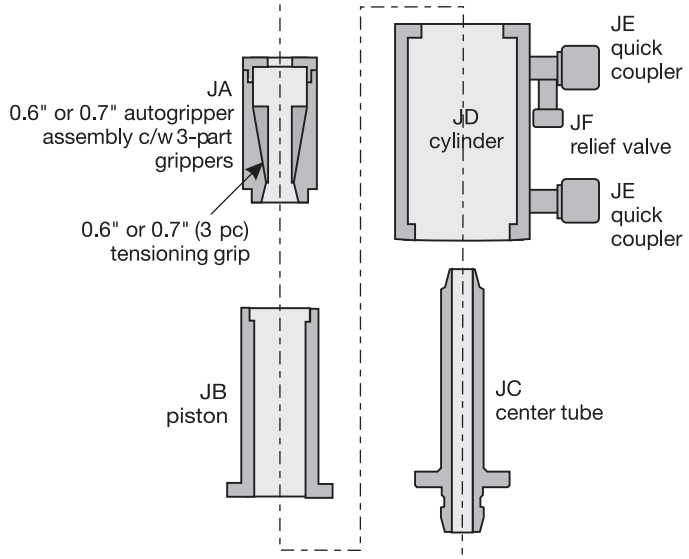
For installation of bearing plates

Specifications

- for 0.6" (15.2 mm) or 0.7" (17.8 mm) cable bolts
- maximum load 25 ton @ 10,000 psi (225 kN @ 70 MPa)
- stroke = 3" (75 mm)
- double acting hollow core ram
- aluminum construction - weighs only 10 lbs (4.5 kg)
- requires double acting hydraulic pump or hand pump
- L = 11.75" (300 mm)
- D = 4" (102 mm)



Parts



Seal Kit includes:

1 - 2.25" AN wiper
1 - 2.25" x 2.75" x 3.75" rod seal
1 - 1.25" x 1.75" x 0.250" rod seal
1 - 2.31" O-ring
1 - 2.875" T-seal

Cable Tensioner Mark2

For tensioning cables and installing plates

Specifications

A light weight and unique way for pre-loading cable bolts, the DSI Cable Tensioner Mark2 grips the end of the cable bolt and tensions it, leaving only a short tail protruding from the bearing plate (approx. 6 inch). The Cable Tensioner is a single hydraulic ram driven by an air/hydraulic pump or by machine hydraulics.

- The jack weighs 25 lbs. The entire kit (jack and pump) weighs 51lbs.
- Two grip handles allow for operation by one person.
- Unit locks on the cable, until lanyard is pulled to release spring loaded grippers.
- Can be configured for all cable bolts, from 0.6" to 0.7" and the DSI 0.9" HITEN cable bolt.
- Capacity: 48,500 lbs
- Bleed off: 15% i.e. cable lock-off load is 85% of pulling force due to seating loss. (for a typical 12ft bolt)

Operation

Install the plate and wedge barrel with wedge on the end of the cable bolt.

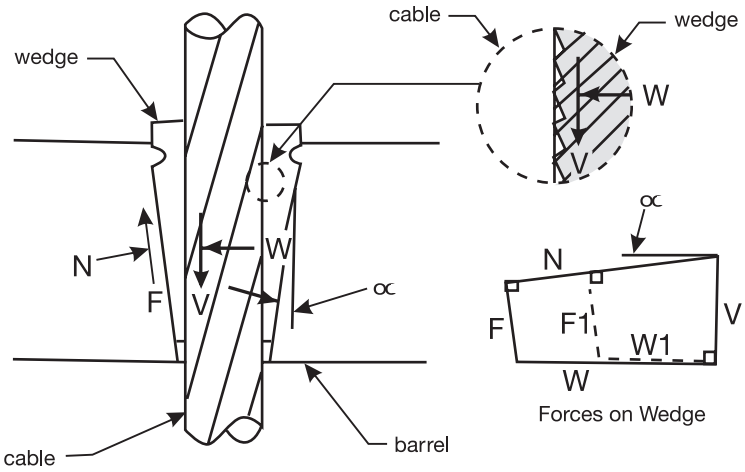
Push the Cable Tensioner on. It will self-lock onto the cable.

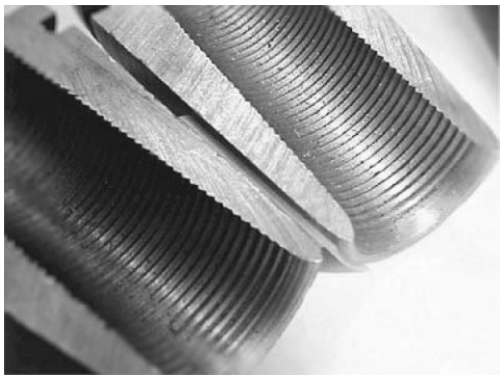
Tension bolt to the desired load per hydraulic gage included with the unit.

After stressing, the Cable Tensioner is easily removed by pulling on the lanyard to release the internal grippers.

The Wedge Anchorage of the Cable Bolt

The anchorage of most cable bolts consists of a wedge barrel and a 2- or 3-part wedge. The wedge segments grip the cable by means of tooth shaped threads which are forced into the surface of the cable wires.

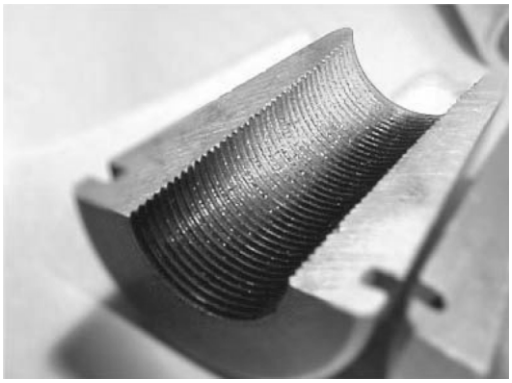




The clamping force W is highly dependent on the friction between wedge and wedge hole. For normal friction conditions, the clamping force W is more than 4 times the cable pulling force V and it adjusts with the pulling force V.

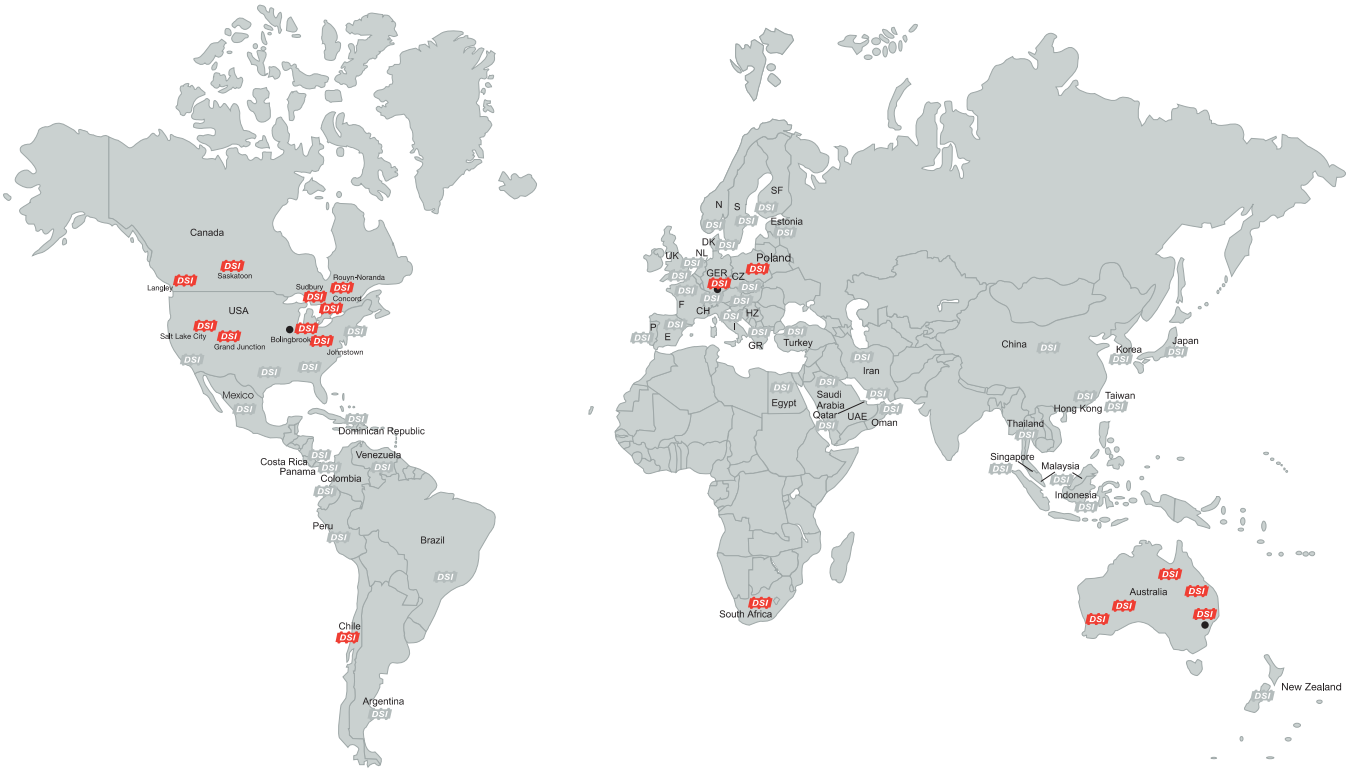
Warning: If friction increases (due to corrosion), a larger F will reduce the clamping force. As V increases all other forces can only increase if the wedge can seat deeper into the barrel. If the wedge is restrained to do so (i.e. by corrosion or dirt-accumulation), the clamping force can not increase with the pulling force causing slippage when the load on the cable bolt gradually increases during service life.

To avoid slippages during use, it is important that the cable bolt is fully stressed at time of installation to a force equal to 0.5 Fu. (ie. 50% of the capacity of the cable)



When a wedge is properly seated, radial cracks may develop indicating adequate seating.

The wedge can be supplied with a rubber O-ring or a metal spring ring holding the wedge segments together.



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DSI

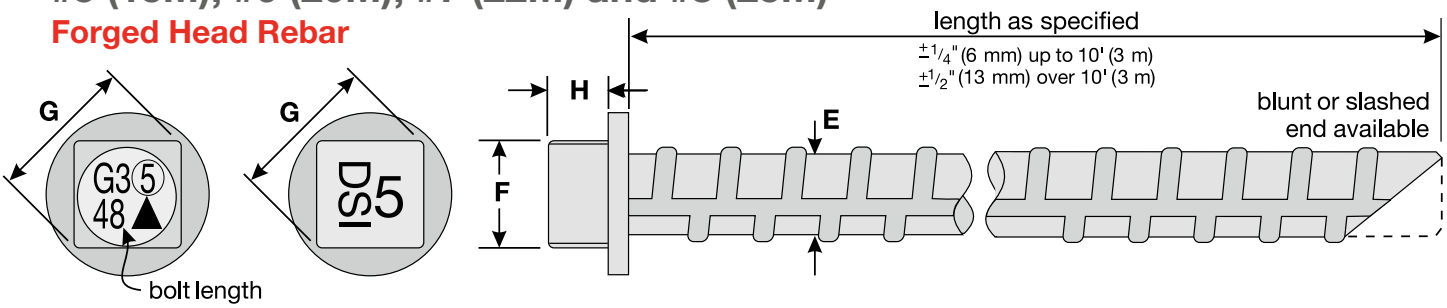
DYWIDAG-SYSTEMS
INTERNATIONAL

I-C. Resin Rebar Bolt Specifications

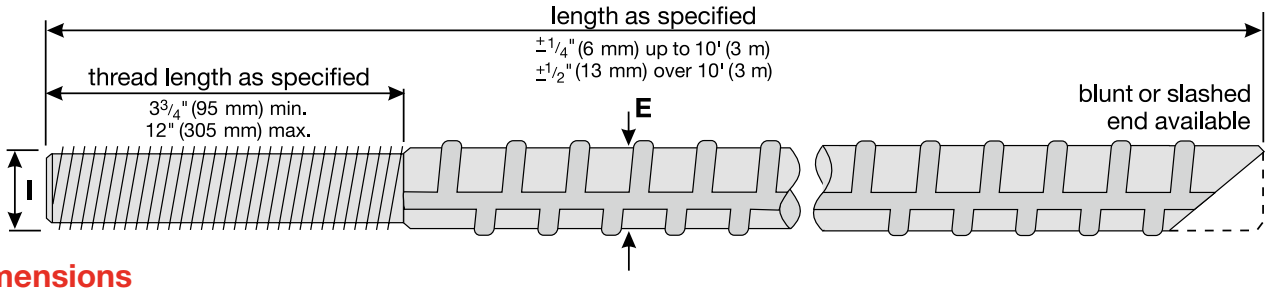
Rebar Rock Bolts (Forged Head & Threaded)

#5 (15M), #6 (20M), #7 (22M) and #8 (25M)

Forged Head Rebar



Threaded Rebar



Dimensions

	#5 (15M)	#6 (20M)	#7 (22M)	#8 (25M)
Nominal Bar Size **E**	0.625" (16 mm)	0.750" (19.5 mm)	0.875" (22.2 mm)	1.0" (25.2 mm)
Head Across Flats **F**	1.088" to 1.125" (27.64 mm to 28.58 mm)			
Head Across Corners **G**	1.425" to 1.591" (36.19 mm to 40.41 mm)			
Head Height, min. **H**	0.40" (10.2 mm)			
Thread Size (left and right) **I**	5/8"- 11 UNC	3/4"- 10 UNC	7/8"- 9 UNC	1"- 8 UNC

Technical Data - Forged Head - Grade 60

	#5 (15M)	#6 (20M)	#7 (22M)	#8 (25M)
Yield Strength, min.	18,600 lbs (80 kN)	26,400 lbs (120 kN)	36,100 lbs (155 kN)	47,100 lbs (200 kN)
Tensile Strength, min.	27,600 lbs (121 kN)	39,600 lbs (180 kN)	54,100 lbs (232 kN)	70,600 lbs (300 kN)
Elongation in 8" (200mm)	9% minimum			

Technical Data - Threaded - Grade 60

	5/8" - 11 UNC	3/4" - 10 UNC	7/8" - 9 UNC	1" - 8 UNC
Yield Strength, min.	13,600 lbs (60.5 kN)	20,000 lbs (89 kN)	27,700 lbs (123.2 kN)	36,400 lbs (161.9 kN)
Tensile Strength, min.	20,300 lbs (90.3 kN)	30,100 lbs (133.9 kN)	41,600 lbs (185 kN)	54,500 lbs (242.4 kN)
Elongation in 8" (200 mm)	9% minimum			

Notes: USA - manufactured to ASTM F432 and ASTM A615 specifications; bolts MSHA approved
Canada - manufactured to ASTM F432, CSA M430 and CSA G30.18M specifications
Grade 40 & 75 available where applicable. Notched rebar optional for bending.

Installation Accessories

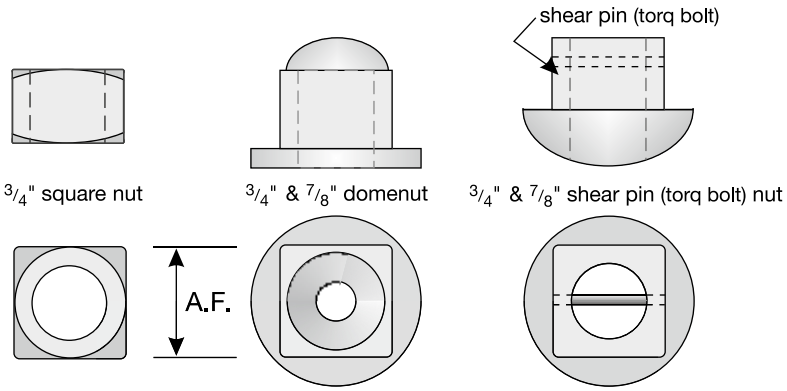
Rebar Rock Bolts

Nuts

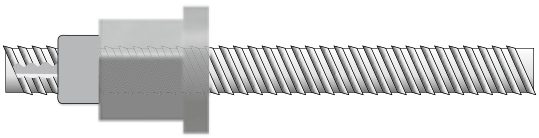
Domenuts
- for ¾" thread A.F. = 1 ⅛" square
- for ⅞" thread A.F. = 1⅛" square
- for 1" thread A.F. = 1 ⅝" hex

Plain Nuts - used with pinched thread
- for ¾" thread A.F. = 1⅛" square
- for ⅞" thread A.F. = 1⅛" square with flange
- for 1" thread A.F. = 1⅝" hex

Torq Bolts - system available
- for ¾" and ⅞" thread A.F. = 1⅛" square



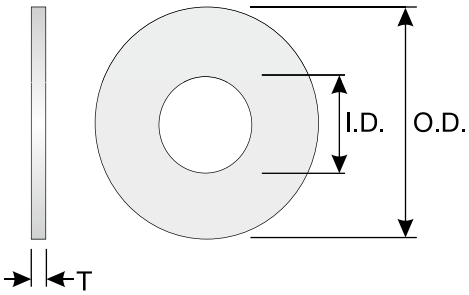
Resin Mixing System "crimped thread"



Reverse Spin Reverse Drive

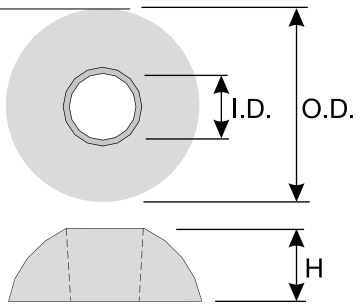
Hardened Round Washers

- to ASTM F436 specifications
- for ¾" thread:
  I.D. = 13⁄16", O.D. = 1 15⁄32", T = 0.122" to 0.177"
- for ⅞" thread:
  I.D. = 15⁄16", O.D. = 1¾", T = 0.136" to 0.177"
- for 1" thread:
  I.D. = 1⅛", O.D. = 2", T = 0.136" to 0.177"



Spherical Seat (Compensation) Washers

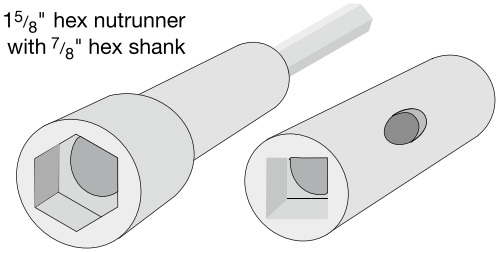
- ductile iron ASTM A536 Gr. 65-45-12
- for ¾" thread:
  I.D. = 13⁄16", O.D. = 2", H = 13⁄16" (model TSW-4)
  I.D. = 15⁄16", O.D. = 2", H = ½" (model TSW)
- for ⅞" & 1" thread:
  I.D. = 1 1⁄16", O.D. = 2", H = ½" (model TSW-1)



Installation Tools - for Stopers/Jacklegs

Forged Head Rebar Driver (Dollie)
- 1 ⅛" square driver
- available with ⅞" hex socket or 3 ¼" long hex shank

Threaded Rebar Nutrunners
- 1⅛" square nutrunner (for ¾" & ⅞" bolts)
- 1⅝" hex nutrunner (for 1" bolts)
- available with ⅞" hex socket or 3¼" long hex shank



1 1/8" square nutrunner
with 7/8" hex socket
and optional ejector hole
for domenut "caps"

Rope thread and T-thread drivers and nutrunners available on request

I-D. Thread Bar Resin Anchored Rock Bolts

DYWIDAG-SYSTEMS INTERNATIONAL

DYWIDAG Threadbar Resin Anchored Rock Bolts

Lafayette Bluff Tunnel, U.S. Highway 61, Minnesota

DYWIDAG Threadbar Resin Anchored Rock Bolts

Resin bolts, bonded to rock or concrete by a fast curing polyester resin grout, are used extensively for slope stabilization, tie backs, tie downs, and rock bolts. The resin grout develops a bond superior to that developed by cement grout. Fast gelling resin allows transfer of load to the rock formation within minutes after installing the bolt.

DYWIDAG THREADBAR® provides a simple, economical, and rugged solution to both tensioned and non-tensioned rock bolts and rock anchors when installed with resin grout. Threadbar for prestressing, conforming to ASTM A722, is available in 1" (26 mm), 1¼" (32 mm), and 1⅜" (36 mm) nominal diameter. Threadbar for reinforcing, conforming to ASTM A615, is available in grades 60 and 75 for sizes #6 through #8, grade 75 for sizes #9 through #18, and grade 80 for 63 mm bar.

Dywidag Threadbar for prestressing and reinforcing have a continuous pattern of threadlike deformations along their entire length. More durable that machined threads, the deformations allow anchorages and couplers to thread onto a Threadbar at any point.

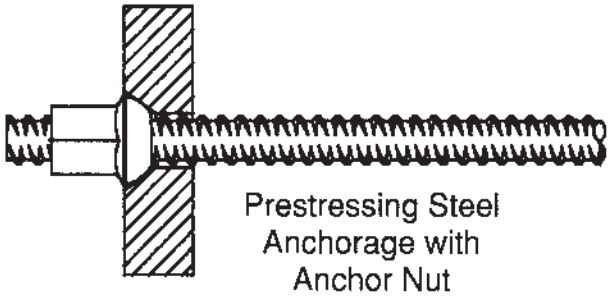
The rolled-in Dywidag thread pattern has no effect on the overall strength or effective area of the Threadbar. Conventional rebar and other steels have a reduction of 25% to 35% lin effective area when machined threads are applied.

The strength of Dywidag Threadbar anchorages and couplers, for prestressing, exceed the requirements of ACI 318. Test reports are available for the main components of the system. Anchorages and couplers for reinforcing Threadbar develop 100% of the ultimate nominal strength of the bar.

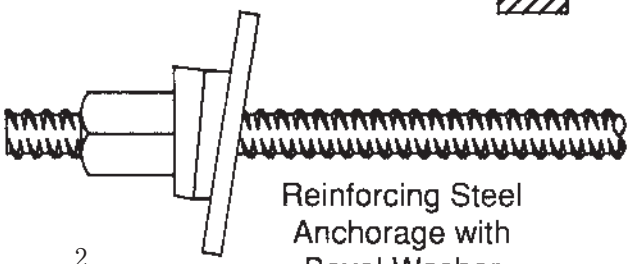
Available in mill lengths to 60', Dywidag Threadbar may be cut to specified lengths before being shipped to the job site or, where circumstances warrant, Threadbars may be shipped in mill lengths for field cutting with a portable friction or band saw.

Threadbars may be coupled to facilitate installation in confined areas of to allow removal of prebolted overcast and resetting of anchors. Dywidag Threadbar anchors can be extended into a structure or function as a form tie.

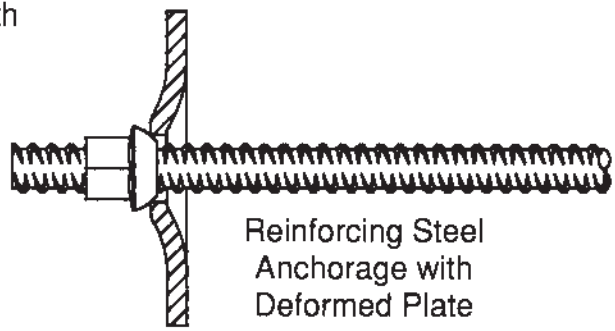
Dywidag Threadbars are used extensively for rock anchors because of their versatility, strength, performance characteristics, and off-the-shelf availability of most components.



Prestressing Steel Anchorage with Anchor Nut



Reinforcing Steel Anchorage with Bevel Washer



Reinforcing Steel Anchorage with Deformed Plate

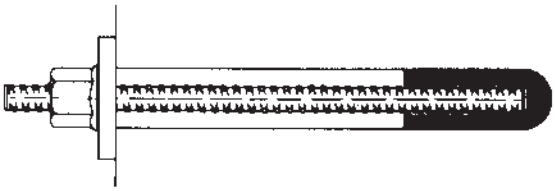
The components of the DYWIDAG THREADBAR® system are manufactured in the United States and Canada by DYWIDAG-Systems International.

Polyester resin is packaged in cartridge form and is available in various diameters and gel times. The cartridge consists of a heat sealed tube of polyester film containing both the resin and the catalyst, which are separated by a barrier which prevents chemical interaction. The resin cartridges are placed in the bore hole before the Threadbar is inserted. The resin gels after the components are mixed during the installation of the Dywidag Threadbar.

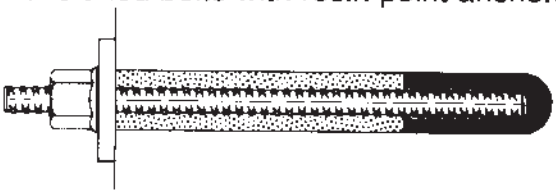
Resin anchored rock bolts are installed in all types of rock of concrete. Track drills, tire mounted drills, jacklegs or storrpers may be used to both drill the hole and install the Dywidag bolt.

Dywidag resin anchors are used where expansion shells are inappropriate. The resin anchorage length is easily adjusted to fit the varying rock conditions. Resin anchored Dywidag rock bolts may be installed in bore holes located at any angle above or below the horizontal.

Tension bolts with resin point anchorage are used to apply a compressive force across layered rock strata. Tension bolts may be applied using fast setting resin as the point anchorage in conjunction with slow setting resin as a corrosion protection for the free stressing length. Bolt tension is applied after the fast setting resin has cured but before the slow setting resin cures. Untensioned dowels are fully encapsulated with resin and rely on movement of the rock strata to load the bolts.



Tensioned bolts with resin point anchorage.



Tensioned bolts fully resin anchored and grouted.

Untensioned dowels fully resin grouted.

Prestressing Steel
Wedge Washer
Assembly

Resin Cartridge

Some important notes concerning the safe handling of high strength steel for prestressed concrete:

1. Do not damage surface of bar.
2. Do not weld or burn so that sparks or hot slag will touch any portion of bar which will be under stress.
3. Do not use any part of bar as a ground connection for welding.
4. Do not use bar that has been kinked or contains a sharp bend.

Disregard of these instructions may cause failure of material during stressing.

DYWIDAG THREADBAR® Products

Prestressing Steel Properties ASTM A722

THREADBAR® Designation			Cross Section Area		Ultimate Strength (f_{pu} A_{PS})		Nominal Weight		Maximum THREADBAR® Diameter		Coupler Length		Coupler Diameter		Anchor Nut Extension		Hex Nut Length		Hex Nut Width	
	in	mm	in²	mm²	kips	kN	lbs/ft	kg/m	b (in)	(mm)	c (in)	(mm)	b (in)	(mm)	e (in)	(mm)	a (in)	(mm)	d (in)	(mm)
Grade 150	1	26	0.85	548	127.5	564	3.01	4.48	1.20	30.5	6.25	158.8	2.00	50.8	1.88	47.6	2.63	66.7	1.75	44.5
	1¼	32	1.25	806	187.5	830	4.39	6.54	1.46	37.1	6.75	171.5	2.38	60.3	2.50	63.5	2.88	73.0	2.25	57.2
	1⅜	36	1.58	1018	237.0	1049	5.56	8.28	1.63	41.4	8.75	222.3	2.75	69.9	2.75	69.9	3.88	98.4	2.38	60.3
Grade 160	1	26	0.85	548	136.0	603	3.01	4.48	1.20	30.5	6.25	158.8	2.00	50.8	1.88	47.6	2.63	66.7	1.75	44.5
	1¼	32	1.25	806	200.0	887	4.39	6.54	1.46	37.1	6.75	171.5	2.38	60.3	2.50	63.5	2.88	73.0	2.25	57.2
	1⅜	36	1.58	1018	252.8	1120	5.56	8.28	1.63	41.4	8.75	222.3	2.75	69.9	2.75	69.9	3.88	98.4	2.38	60.3

"p" is the minimum threadbar protrusion to accomodate prestressing, proof loading, or coupling, "p" = 1/2 c + 1/2" (12.7 mm)
* Couplers and nuts develop 100% of guaranteed ultimate strength

Resin Anchors using DYWIDAG prestressing steel may be proof stressed to 80% of the guaranteed ultimate strength of the prestressing steel. Lock off force should not exceed 70% of the guaranteed ultimate strength of the prestressing steel

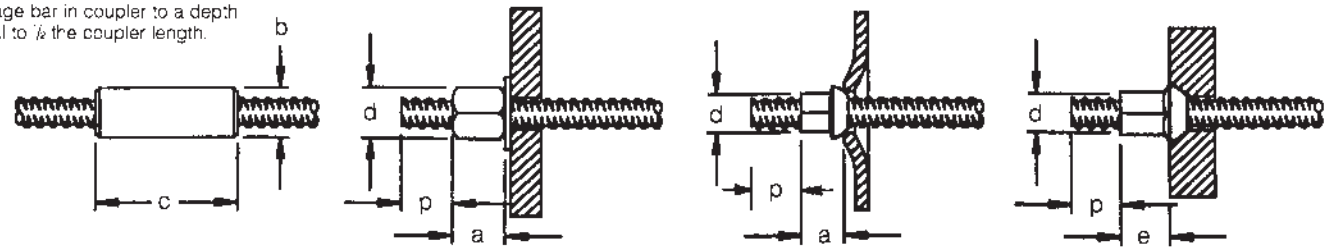
Reinforcing Steel Properties ASTM A615 (Grade 60 & 75) CAN/CSA (G30 18-M1982)

THREADBAR® Designation			Yield Stress		Cross Section Area		Maximum Yield Strength		Nomial Weight		THREADBAR® Diameter		Coupler Length		Coupler Diameter		Nut Length		Nut Width[2]	
	in-lb	mm	ksi	MPa	in²	mm²	kips	kN	lbs/lf	kg/m	in	mm	c (in)	(mm)	b (in)	(mm)	a (in)	(mm)	d (in)	(mm)
Grade 60	#6	19	60	414	0.44	284	26.4	118	1.50	2.24	0.86	21.8	2.86	72.5	1.22	30.9	1.30	32.9	1.16	29.5
	#7	22	60	414	0.60	387	36.0	160	2.04	3.04	0.99	25.1	3.40	86.4	1.41	35.7	1.55	39.4	1.34	34.0
	#8	25	60	414	0.79	510	47.4	211	2.67	3.98	1.12	28.4	3.69	93.8	1.59	40.4	1.66	42.2	1.52	38.5
Grade 75	#6	19	75	517	0.44	284	33.0	147	1.50	2.24	0.86	21.8	3.12	79.2	1.22	30.9	1.43	36.2	1.16	29.5
	#7	22	75	517	0.60	387	45.0	200	2.04	3.04	0.99	25.1	3.73	94.6	1.41	35.7	1.71	43.4	1.34	34.0
	#8	25	75	517	0.79	510	59.3	264	2.67	3.98	1.12	28.4	4.03	102.4	1.59	40.4	1.84	46.6	1.52	38.5
	#9	29	75	517	1.00	645	75.0	333	3.40	5.06	1.26	32.0	5.02	127.5	1.79	45.5	2.30	58.4	1.71	43.3
	#10	32	75	517	1.27	819	95.3	423	4.30	6.41	1.43	36.3	5.70	144.8	2.02	51.2	2.56	65.0	1.92	48.8
	#11	36	75	517	1.56	1006	117.0	520	5.31	7.91	1.61	40.9	6.37	161.8	2.25	57.0	2.88	73.0	2.14	54.4
	#14	43	75	517	2.25	1452	168.8	751	7.65	11.39	1.86	47.2	7.82	198.6	2.55	64.8	3.55	90.2	2.52	64.0
	#18	57	75	517	4.00	2581	300.0	1335	13.60	20.24	2.50	63.5	9.35	237.5	3.50	88.9	4.23	107.4	3.34	84.8
	63 mm[1]		80	552	4.91	3168	392.8	1747	16.70	24.65	2.72	69.1	9.68	245.7	3.86	98.0	4.50	114.3	3.67	93.2

All couplers and hex nuts develop 100% of the nominal ultimate strength of the bar
[1] 63 mm bars and hardware available in grade 60 material only
[2] Measured across flats

Resin anchors using DYWIDAG reinforcing steel may be proof stressed to 90% of the guaranteed yield strength of the reinforcing steel. The final working force varies with the application and function of the anchors.

Engage bar in coupler to a depth equal to ½ the coupler length.



Coupler | Plate Anchorage with Hex Nut | Anchor Nut & Deformed Plate | Anchor Nut & Bearing Plate

DYWIDAG Resin Anchor Design

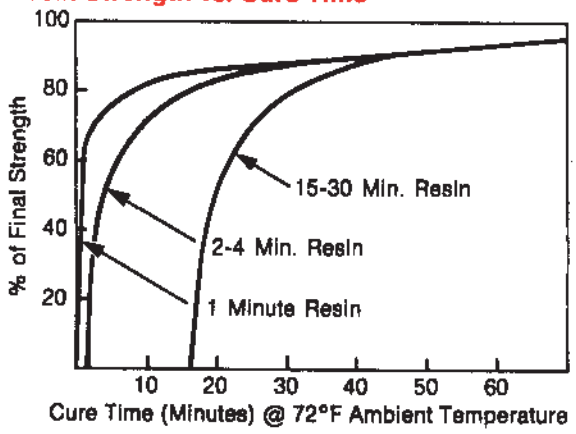
Dywidag Threadbar reinforcing steel is intended for use in relatively low strength rock bolt and rock dowel applications. Dywidag Threadbar prestressing steel is intended for use in high strength applications to permit the maximum design load in each bore hole. The use of prestressing steel may allow a reduction in the number of bolts in the pattern and thus usually reduces drilling costs.

After drilling, each bore hole must be cleaned with either air or water before the resin cartridge is installed. Standing or flowing water does not affect the resin but may cause deterioration of the hole.

The bore hole and cartridge diameter must be compatible with the diameter of the threadbar specified. Bore hole diameters other than those suggested by the Resin Yield Chart may be used under special conditions. For these applications, testing may be necessary to demonstrate that the tools and procedures selected will sufficiently mix the resin with the catalyst.

Anchor plates vary in size and thickness depending upon the function and the bearing conditions. Bevel washers, flat washers or anchor nuts are required for Dywidag reinforcing steel. Wedge washers may be used with prestressing threadbars where the plate is not perpendicular to the threadbar.

Resin Strength vs. Cure Time



Dywidag Threadbars may be stressed to proof load an anchor or to induce a permanent load. The continuous threadlike deformations simplify stressing. Stressing is accomplished using a center hole hydraulic jack, torque wrench or air wrench.

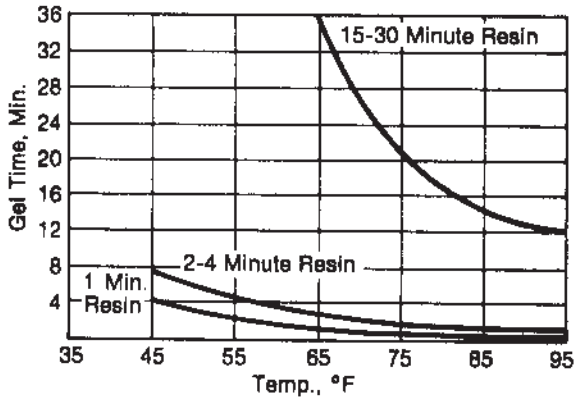
The anchorage length varies with the structure of the rock formation. The properties of the polyester resin do not govern the design of the bond zone length.

All design assumptions should be verified by field tests.

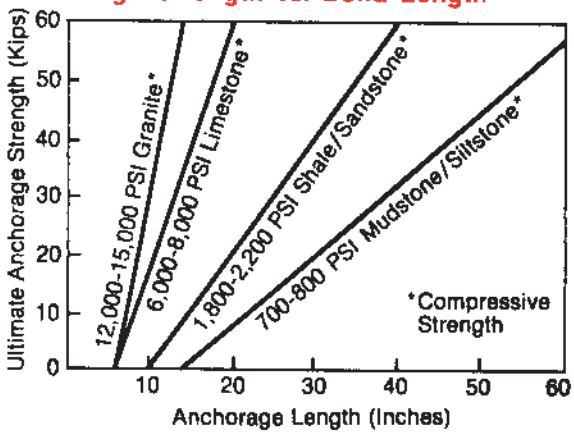
Polyester resin grout is unaffected by blasting and provides a corrosion protection equal to cement grout. Resin is unaffected by fresh water, salt water, mild alkalies and mild acids.

The resin gel time and cure time are temperature sensitive. To insure proper behavior, the ambient temperature of the rock, or concrete must be monitored.

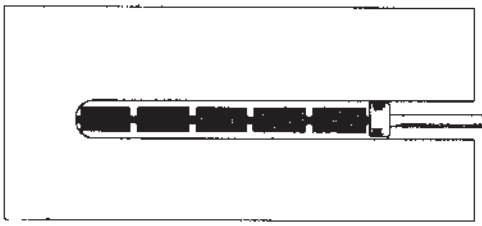
Gel Time vs. Temperature



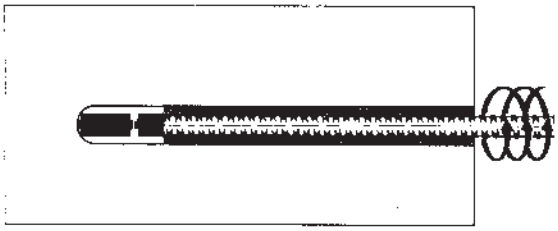
Anchorage Strength vs. Bond Length



DYWIDAG Resin Anchor Installation

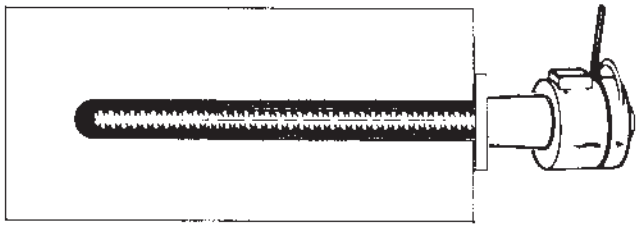


Drill and clean hole.
Drill smallest diameter hole which is compatible with the bolt and cartridge diameter selected.



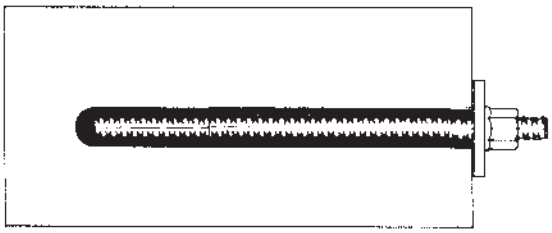
Insert Resin Cartridges.
Use fast setting resin for bond length. If full encapsulation is desired, use slow setting resin or cement grout in the upper length to accommodate stressing.

Insert DYWIDAG Threadbar.
Spin bar with drill tool at about 100 rpm. Advance threadbar through cartridges while spinning. Spin for 30 to 60 seconds after reaching the bottom of the hole. Total spinning time should not exceed gel time.



Mount bearing plate and secure plate with anchor nut.
Wedge washers are required when anchor plate is not perpendicular to bolt.

Stress after resin has cured (when required).
Setting time varies from 1 to 20 minutes depending upon temperature and the resin type used. Apply tension with hydraulic jack, torque wrench or air wrench.



Monitor bolt tension.
The bolt tension is monitored by reading the pressure gauge where the hydraulic jack is utilized. Where torque or air wrench is utilized, the bolt tension is monitored by developing a tension-torque relationship curve for the specific application.

Resin Yield Chart*

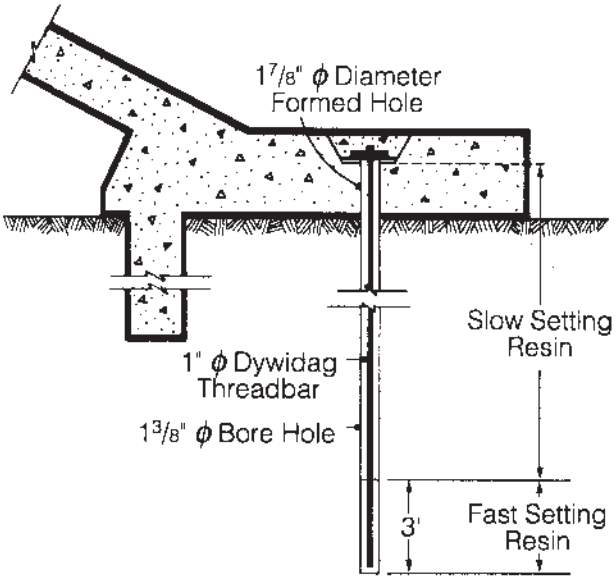
ASTM A 615 THREADBAR Size Designation	ASTM A 722 Nominal THREADBAR Diameter		Hole Diameter													
			1	1¼	1⅜	1½	1⅝	1½	1⅝	1¾	1⅞	2	2¼	2	2¼	in
			26	32	36	38	42	38	42	45	48	51	58	51	58	mm
			Cartridge Diameter													
			15/16	1⅛	1¼	1¼	1¼	1⅜	1⅜	1 9/16	1 9/16	1 9/16	1 9/16	1¾	1¾	in
	in	mm	23	32	32	32	32	36	36	40	40	40	40	45	45	mm
#6			1.87	1.22												
#7				1.52	1.41			1.27								
#8	1	26		2.16	1.78	1.27		1.52	1.16	1.19						
#9						1.61	1.15	1.94	1.38	1.37						
#10	1¼	32					1.47		1.76	1.65	1.30			1.28		
#11	1⅜	36								2.12	1.53	1.21		1.52	1.00	

*Ratio of resin column length after insertion of Dywidag Threadbar to resin column length before inserting Dywidag Threadbar. Resin yield chart information provided by Celtite, Inc.

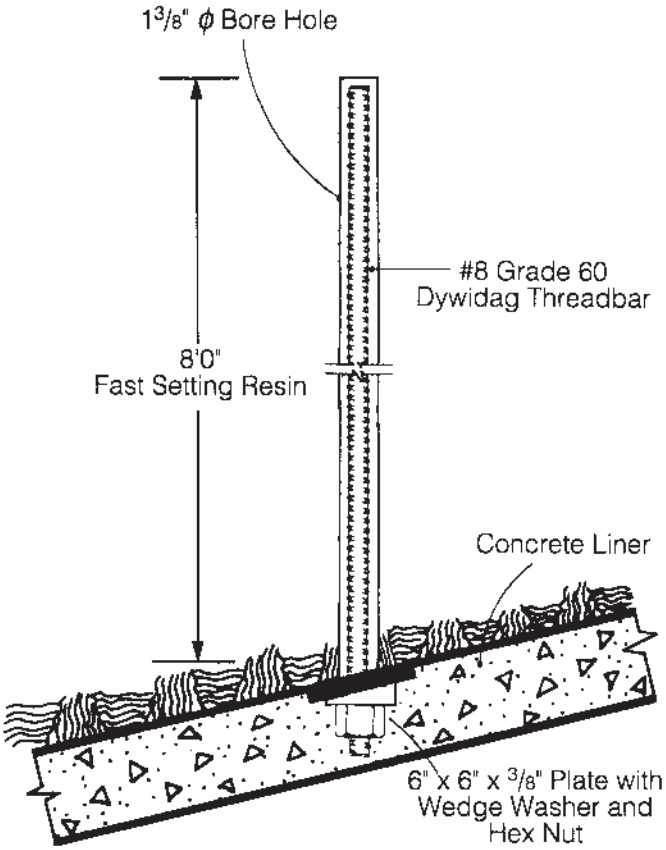
Yields are calculated; no waste or allowance for over drilling is included. Site trials should be conducted to determine actual resin requirements.

Example: When using 1" (26 mm) Dywidag Threadbar in 1½" (38 mm) diameter hole with 1¼" (32 mm) diameter resin cartridge, resin yield multiplier is 1.27. A 12" (305 mm) resin column yields 15" (381 mm) of resin after the insertion of the Dywidag Threadbar.

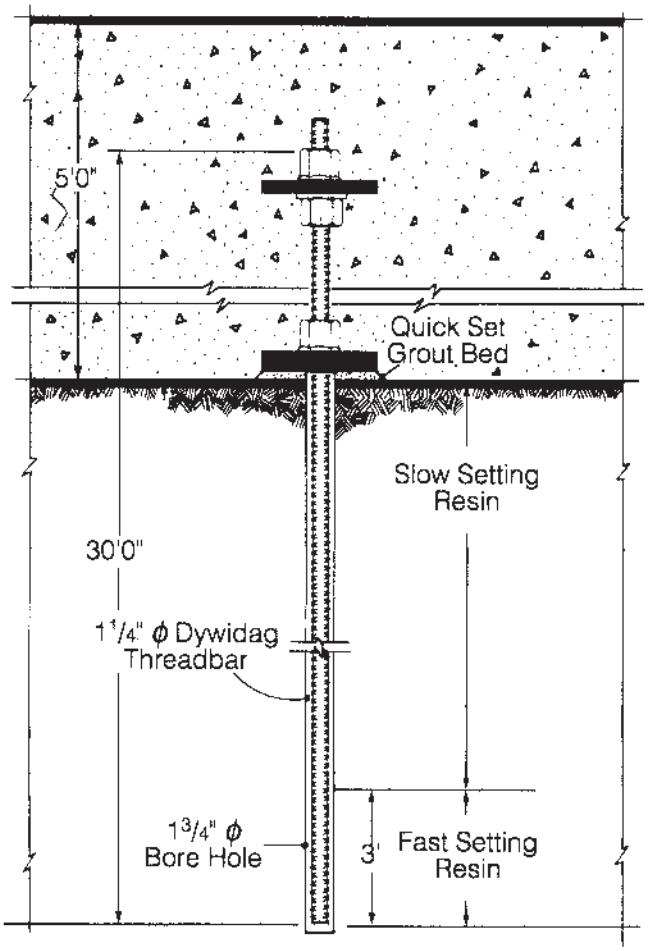
DYWIDAG Resin Anchor Applications



Toe Slab Rock Anchors. R.D. Bailey Lake Dam. Guyandot River, West Virginia. U.S. Army Corps of Engineers, Huntington District. 1" ϕ Grade 150 Dywidag Threadbars.

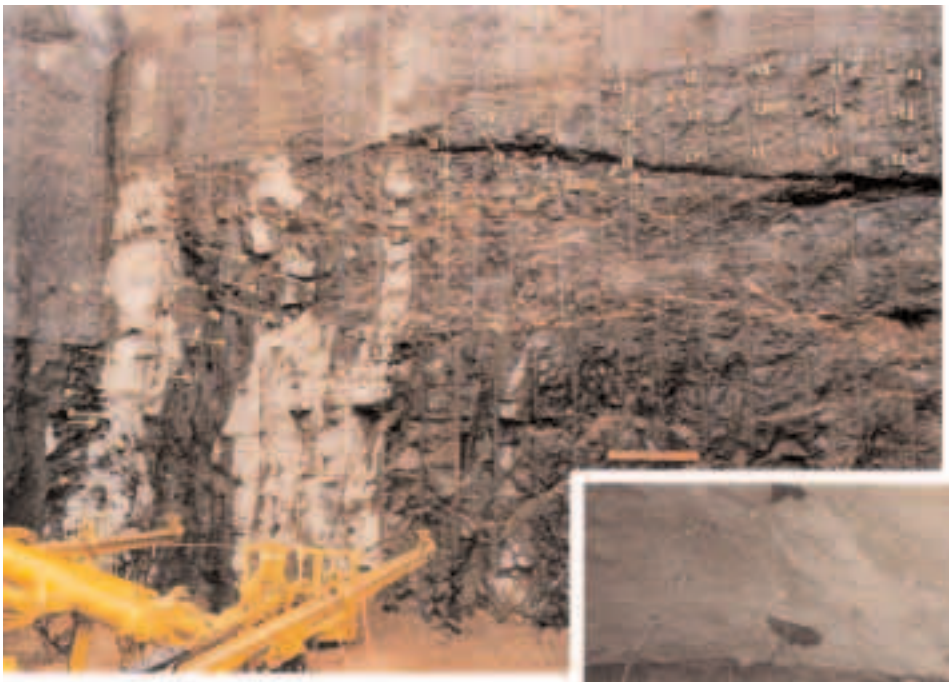


Roof Bolts in Diversion Tunnel. Paintsville Lake Dam, Kentucky. U.S. Army Corps of Engineers, Huntington District. #8 Grade 60 Dywidag Threadbars.



Stilling Basin Rock Anchors. Smithland Dam, Ohio River. U.S. Army Corps of Engineers, Nashville District. 1 1/4" ϕ Grade 150 Dywidag Threadbars.

DSI reserves the right to change the design or details of its products without notice. Specific information for job details and drawings should be obtained from your DSI Sales Engineer.



Portal and open cut face of Lafayette Bluff tunnel stabilized by 1,076 twenty foot long epoxy coated #11 Threadbar bolts.

3,214 #11 epoxy coated, resin anchored Threadbar bolts together with shotcrete form reinforced rock arch inside tunnel.

I-E. Swellex Bolt Specifications

Swellex connectable bolts
– long support

Swellex connectable rock bolt is an ingenious system. It is a true alternative as long secondary support to secure potentially unstable areas or to control dilution while boosting productivity. By simply connecting two, three or more specially adapted Swellex rock bolt segments, you create a custom-made long rock bolt, able to penetrate deep to stable rock.

Immediate support

It is ideal as secondary reinforcement in difficult areas, as long anchors in stopes for dilution control or where other long anchors have problems with excessive water.

Quick installation

No curing time! No special crew! Recent tests have shown up to four fold increased productivity when compared to manually and semi-mechanized installed cable bolts.

Peace of mind

By reaching recommended expansion pressure you are assured of a perfect installation on the entire length of the bolt irrespectively of presence of water in the hole.

Swellex connectables

General Information	Swellex Pm 24C
Minimum breaking load	240 kN
Minimum yielding load	200 kN
Minimum elongation	10%
Expansion pressure	300 bar

I-F. Split Set Stabilizers

INTERNATIONAL ROLLFORMS, INC.
SPLIT SET®

SPLIT SET® Stabilizers SS-33

Specifications and performance

The Split Set stabilizer is a slotted steel tube, with one end tapered for easy insertion into a drill hole. The other end has a welded ring flange to hold the bearing plate.

The stabilizer is inserted into a hole slightly smaller in diameter than the tube, using a simple driver tool fitted to the drill. As the tube enters, its diameter is compressed and the slot partially closes. This exerts radial forces along the length of contact with the rock, providing the friction which holds the rock together. The driving force of the drill actively loads the bearing plate against the rock.

International Rollforms' Split Sets feature a <u>patented</u> "Ring Indexing" feature. This allows for determining the length of an installed Split Set.

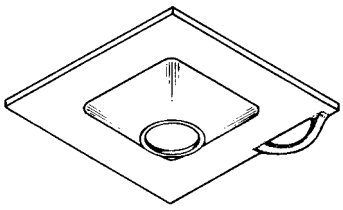
Tubes and plates are available standard or galvanized, made in accordance with ASTM F 432-95 where applicable. Code stampings on the tube show its size, date and place of manufacture, and heat lot of steel.

Model SS-33 Split Set stabilizers are 1.3 in. (33 mm) in diameter.

Stabilizers are packaged 6 per pack and 300 per pallet.

Also see Utility Hangers on page 2.

SS-33 tube		Standard			Galvanized		
Length Inches	(mm)	Weight Lb.	(kg)	Comm No.	Weight Lb.	(kg)	Comm No.
30	(762)	2.7	(1.2)	90322835	2.9	(1.3)	90322850
36	(914)	3.2	(1.4)	72237936	3.4	(1.5)	90321688
42	(1067)	3.7	(1.7)	90322843	4.0	(1.8)	90322868
48	(1219)	4.3	(2.0)	72237944	4.6	(2.1)	90321696
60	(1524)	5.3	(2.4)	72237951	5.7	(2.6)	90321704
66	(1676)	5.8	(2.6)	90321316	6.2	(2.8)	90321712
69	(1753)	6.1	(2.8)	90322264	6.5	(3.0)	90322512
72	(1829)	6.4	(2.9)	72237969	6.8	(3.1)	90321720
84	(2134)	7.4	(3.4)	72237977	7.9	(3.6)	90321738
96	(2438)	8.4	(3.8)	72237985	9.0	(4.1)	90321746



SS-33 domed plate		Standard			Galvanized		
Dimensions Inches	(mm)	Weight Lb.	(kg)	Comm. No.	Weight Lb.	(kg)	Comm. No.
6 x 6 x 0.16	(150 x 150 x 4)	1.6	(0.7)	90320250	1.7	(0.8)	90322447

Domed bearing plate

Split Set domed bearing plates uniquely combine high strength with light weight, and are integral parts of the Split Set system. International Rollforms plates meet ASTM F 432-95 standards where applicable, providing a load capacity of 10 tons (9.1 metric tons) with minimal deflection.

INTERNATIONAL ROLLFORMS, INC.
SPLIT SET®

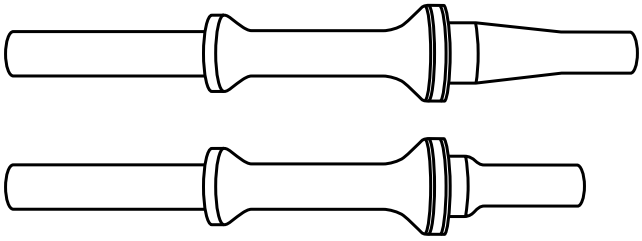
Installing the SS-33 stabilizer

The SS-33 tube has a nominal outside diameter of 1.3 inches (33 mm). The length chosen should be the same as with other types of rock bolts, and installed with the same spacing.

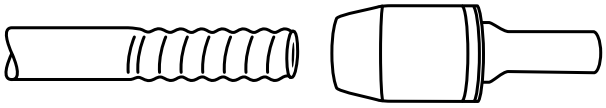
The stabilizer is installed with the same drill used to make the hole. Split Set stabilizers are commonly installed with jacklegs, stopers, jumbos and automatic bolting machines. Almost any hydraulic drill, or any percussive air drill with a bore of 2-5/8 inches (66 mm) and operating at 90 psig (6 bar), will have sufficient impact.

SS-33 drivers Standard	Shank size Inches	(mm)	Weight Lb.	(kg)	Comm. No.
Short-nose	7/8 x 4-1/4	(22 x 108)	2.5	(1.1)	72243405
Long-nose	7/8 x 4-1/4	(22 x 108)	2.8	(1.3)	90324518

SS-33 drivers Rope-threaded	Steel size Inches	(mm)	Weight Lb.	(kg)	Comm. No.
Short-nose	1	(25)	1.9	(0.9)	90321019
Long-nose	1	(25)	2.2	(1.0)	90325507



Typical long-nose and short-nose drivers



Typical rope-threaded driver

SS-33 driver tools

A simple driver tool adapts the drill for easy stabilizer insertion. One end fits the tube; the other fits the drill chuck or drill steel.

All genuine Split Set driver tools are made of high-strength heat-treated alloy steel, designed for long life, and precision-made for the proper fit.

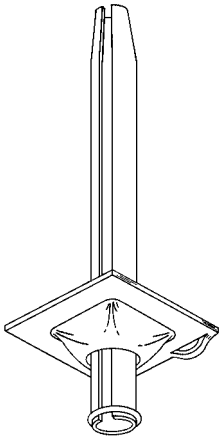
For jackleg or stoper insertion, a long-nose or short-nose driver tool may be used. The short-nose tool is also used for driving an SS-33 Split Set utility hanger inside an installed SS-33 Split Set stabilizer.

Rope-threaded drivers are available to fit drill steel for jumbos and bolters, and for long reach with jacklegs and stopers.

SS-33 utility hangers

Split Set utility hangers are available in 18 and 24-inch (46 and 61-cm) tube lengths to support light loads such as cables, vent tubing, and pipes.

Also, utility hangers can be driven inside installed Split Set stabilizers, by aligning the hanger slot with that of the stabilizer. This permits easier installation of mesh, after the ground is secured by the stabilizers.



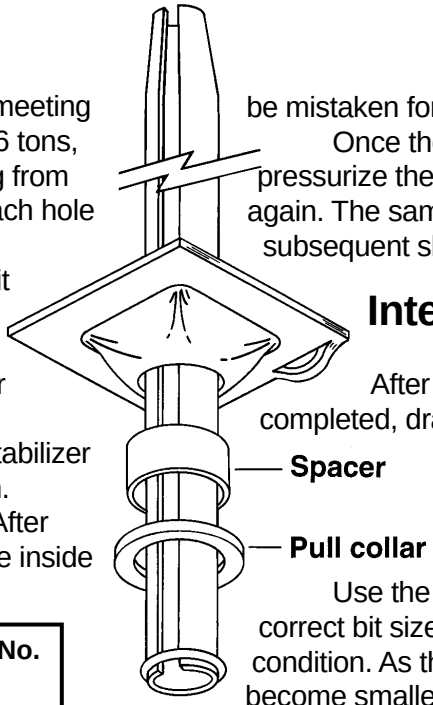
SS-33 utility hangers					
Length In.	(mm)	Weight Lb.	(kg)	Comm No.	
Standard					
18	(457)	1.7	(0.8)	90321076	
24	(610)	2.2	(1.0)	90321324	
Galvanized					
18	(457)	1.8	(0.8)	90321662	
24	(610)	2.3	(1.0)	90321670	

SS-33 installation and pull testing

Bit selection and drilling

To select the correct drill bit diameter for meeting the recommended initial anchorage of 3 to 6 tons, drill several holes with bit diameters ranging from 1-3/16 to 1-5/16 inch (30 to 33 mm). Drill each hole at least 2 inches (5 cm) longer than the bolt length. Number each hole and record the bit size. (In soft ground, a bit may drill a hole larger than its diameter. In hard abrasive ground, the hole may be the same diameter as the bit.)

Drive into each hole an SS-33 Split Set stabilizer fitted with a pull collar and spacer as shown. Record the driving time for each stabilizer. After insertion, observe the amount of slot closure inside each stabilizer.



SS-33 pull collar and spacer set	Weight lb.	Weight (kg)	Comm. No.
	0.4	(0.2)	90320888

To determine anchorage, perform a pull test (page 4). Align the pull tester with the stabilizer, and pressurize it until the stabilizer slips in the hole.

Watch to be sure that it is actually the stabilizer that has slipped. When building up the pull load on the stabilizer, various adjustments may occur such as realignment of the tester housing, bearing plate settling, or localized rock crushing. These must not be mistaken for tube slippage.

Once the bolt has slipped in the hole, pressurize the tester pump until the bolt slips again. The same pull load should cause subsequent slippage.

Interpreting test data

After the above pull tests are completed, draw two graphs:

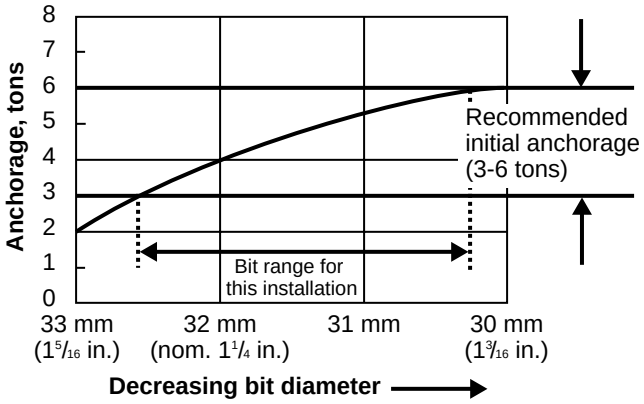
(a) Anchorage versus bit diameter.

(b) Anchorage versus driving time.

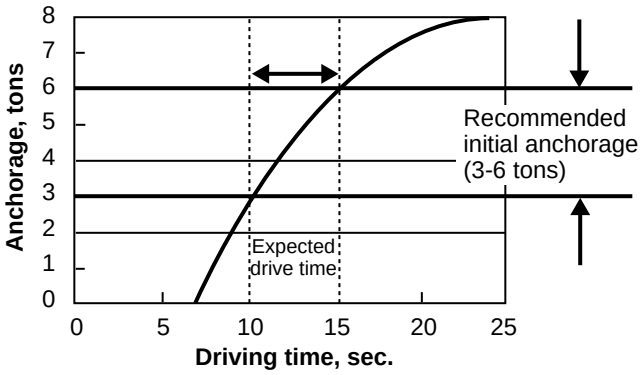
Use the first graph to determine the correct bit size for your particular ground condition. As the bit wears, the hole will become smaller and friction will increase until the bit is replaced or the drill can't drive the bolt completely.

Use the second graph to establish correct driving time required for this ground and bolt length. With a given bit, drill, bolt length, rock characteristic and constant pressure, insertion time will be proportional to initial anchorage.

It's important to establish this data for use in later spot checks, to assure that proper installation techniques are still being used.



(a) Anchorage versus bit diameter



(b) Anchorage versus driving time

SS-33 pull tester			
Description	Weight Lb.	(kg)	Comm. No.
Pull tester assembly	27.6	(12.5)	90320904
Mechanical portion	11.9	(5.4)	90321290
Hydraulic portion	15.7	(7.1)	90321415
Hydraulic parts			
Cylinder	7.0	(3.2)	90320177
Gage	1.5	(0.7)	90320193
Pump	5.0	(2.3)	90320169
Hydraulic hose	2.0	(0.9)	90320185
Gage adapter	0.2	(0.1)	90320201
Mechanical parts			
Claw	3.3	(1.5)	90320896
Housing	5.5	(2.5)	72233422
Bushing	1.0	(0.5)	72233430
Spindle	1.8	(0.8)	72233414
Hex nut	0.3	(0.1)	95084778

SS-33 pull test equipment

The pull tester consists of two assemblies: the hydraulic portion which includes the cylinder, gage, pump, hose and adapter; and the mechanical portion which includes the claw, housing, U-shaped bushing, spindle and nut.

With the bushing removed, the claw can be slid over the pull collar which has been installed with the stabilizer. When the housing and cylinder are raised, the bushing can be inserted between the nut and the cylinder. The nut is then tightened to take up slack.

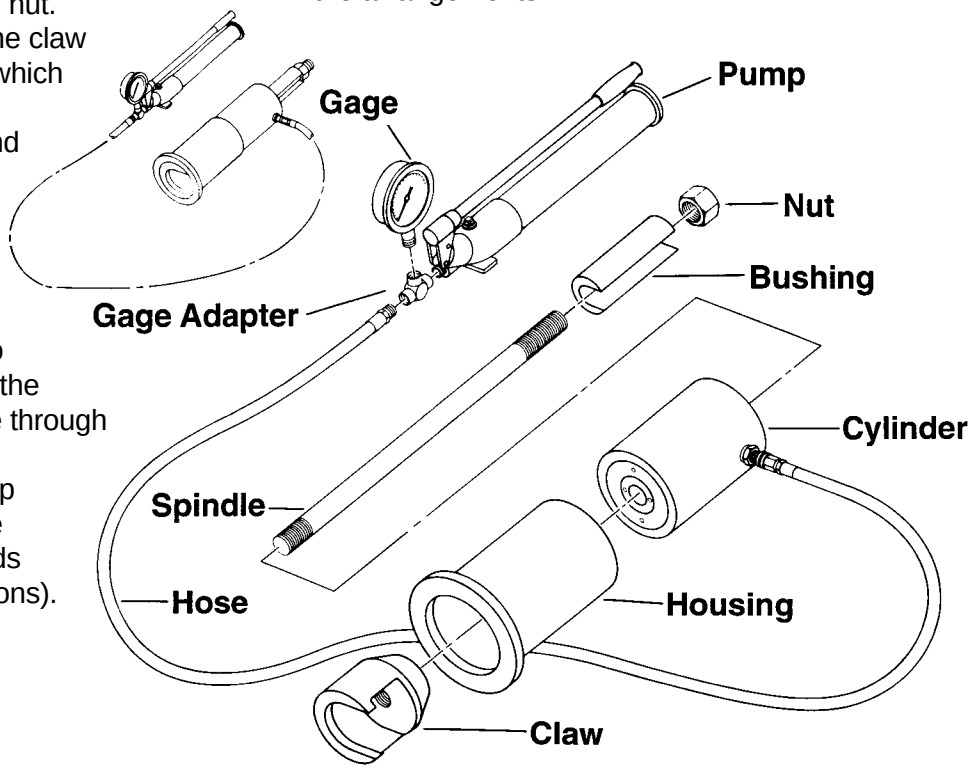
The pump is then actuated to raise cylinder pressure, pulling the stabilizer slightly out of the hole through the bearing plate.

Maximum gage reading at slip indicates the holding force. The device can be used for slip loads up to 12 US tons (10.9 metric tons).

Application Engineering Service

The Split Set stabilizer is a unique rock stabilization and support system.
It interacts with the rock differently from other rock bolts. For this reason, the Split Set Group offers a free application engineering service to assist you in the selection of the proper Split Set configuration for your needs. We will also assist in determining the best way to use your existing equipment for the job, the best drilling procedure, and appropriate tools and accessories for your equipment and space limitations.

We urge you to take advantage of this service. Our sales representative will be pleased to make the arrangements.



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SPLIT SET® Stabilizers SS-39

Specifications and performance

The Split Set stabilizer is a slotted steel tube, with one end tapered for easy insertion into a drill hole. The other end has a welded ring flange to hold the bearing plate.

The stabilizer is inserted into a hole slightly smaller in diameter than the tube, using a simple driver tool fitted to the drill. As the tube enters, its diameter is compressed and the slot partially closes. This exerts radial forces along the length of contact with the rock, providing the friction which holds the rock together. The driving force of the drill actively loads the bearing plate against the rock.

International Rollforms' Split Sets feature a patented "Ring Indexing" feature. This allows for determining the length of an installed Split Set.

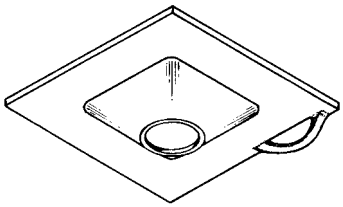
Tubes and plates are available standard or galvanized, made in accordance with ASTM F 432-95 where applicable. Code stampings on the tube show its size, date and place of manufacture, and heat lot of steel.

Model SS-39 Split Set stabilizers are 1.5 in. (39 mm) in diameter.

Stabilizers up to 96 in. (2438 mm) are packaged 6 per pack and 300 per pallet. Longer stabilizers are three-packed 150 per pallet.

Also see Utility Hangers on page 2.

SS-39 tube		Standard			Galvanized		
Length Inches	(mm)	Weight Lb.	(kg)	Comm No.	Weight Lb.	(kg)	Comm No.
30	(762)	3.1	(1.4)	90320235	3.3	(1.5)	90322454
36	(914)	3.7	(1.7)	72243447	3.9	(1.8)	90321423
42	(1067)	4.3	(2.0)	90321332	4.6	(2.2)	90322462
48	(1219)	4.9	(2.2)	72243454	5.2	(2.4)	90321225
60	(1524)	6.1	(2.7)	72225287	6.5	(3.0)	90321233
66	(1676)	6.7	(3.0)	90320664	7.2	(3.3)	90322082
72	(1829)	7.3	(3.3)	72221310	7.8	(3.6)	90321241
84	(2134)	8.5	(3.9)	72236128	9.1	(4.1)	90321449
96	(2438)	9.7	(4.4)	72243462	10.4	(4.7)	90321258
108	(2743)	10.9	(5.0)	90320656	11.7	(5.3)	90322421
120	(3048)	12.1	(5.5)	90320649	13.0	(5.9)	90322439



SS-39 domed plate		Standard			Galvanized		
Dimensions Inches	(mm)	Weight Lb.	(kg)	Comm. No.	Weight Lb.	(kg)	Comm. No.
6 x 6 x 0.16	(150 x 150 x 4)	1.6	(0.7)	90320243	1.7	(0.8)	90321274

Domed bearing plate

Split Set domed bearing plates uniquely combine high strength with light weight, and are integral parts of the Split Set system. International Rollforms plates meet ASTM F 432 standards where applicable, providing a load capacity of 10 tons (9.1 metric tons) with minimal deflection.

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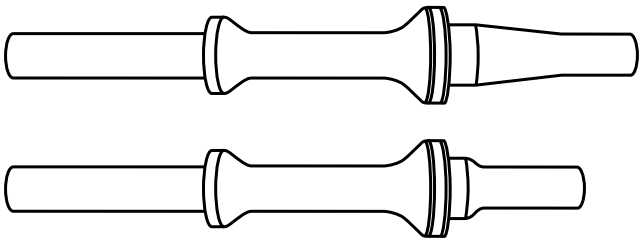
Installing the SS-39 stabilizer

The SS-39 tube has a nominal outside diameter of 1.5 inches (39 mm). The length chosen should be the same as with other types of rock bolts, and installed with the same spacing.

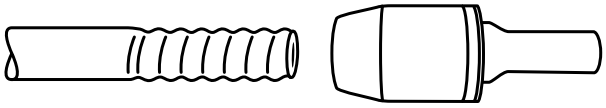
The stabilizer is installed with the same drill used to make the hole. Split Set stabilizers are commonly installed with jacklegs, stopers, jumbos and automatic bolting machines. Almost any hydraulic drill, or any percussive air drill with a bore of 2-5/8 inches (66 mm) and operating at 90 psig (6 bar), will have sufficient impact.

SS-39 drivers Standard	Shank size Inches	(mm)	Weight Lb.	(kg)	Comm. No.
Short-nose	7/8 x 4-1/4	(22 x 108)	2.9	(1.3)	72243363
Short-nose	1 x 4-1/4	(25 x 108)	3.1	(1.4)	72243389
Long-nose	7/8 x 4-1/4	(22 x 108)	3.2	(1.5)	90325481
Long-nose	1 x 4-1/4	(25 x 108)	3.4	(1.6)	90324740

SS-39 drivers Rope-threaded	Steel size Inches	(mm)	Weight Lb.	(kg)	Comm. No.
	1	(25)	2.5	(1.1)	90320607
	1-1/4	(32)	2.2	(1.0)	90320029
	1-1/2	(28)	1.9	(0.9)	90320615



Typical long-nose and short-nose drivers



Typical rope-threaded driver

SS-39 driver tools

A simple driver tool adapts the drill for easy stabilizer insertion. One end fits the tube; the other fits the drill chuck or drill steel.

All genuine Split Set driver tools are made of high-strength heat-treated alloy steel, designed for long life, and precision-made for the proper fit.

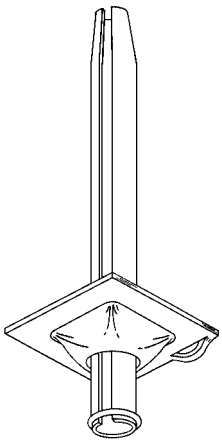
For jackleg or stoper insertion, a long-nose or short-nose driver tool may be used. The short-nose tool is also used for driving an SS-39 Split Set utility hanger inside an installed SS-39 Split Set stabilizer.

Rope-threaded drivers are available to fit drill steel for jumbos and bolters, and for long reach with jacklegs and stopers.

SS-39 utility hangers

Split Set utility hangers are available in 18 and 24-inch (46 and 61-cm) tube lengths to support light loads such as cables, vent tubing, and pipes.

Also, utility hangers can be driven inside installed Split Set stabilizers, by aligning the hanger slot with that of the stabilizer. This permits easier installation of mesh, after the ground is secured by the stabilizers.



SS-39 utility hangers					
Length In.	(mm)	Weight Lb.	(kg)	Comm No.	
Standard					
18	(457)	1.9	(0.8)	90320631	
24	(610)	2.5	(1.1)	90321506	
Galvanized					
18	(457)	2.0	(0.9)	90321431	
24	(610)	2.7	(1.2)	90321654	

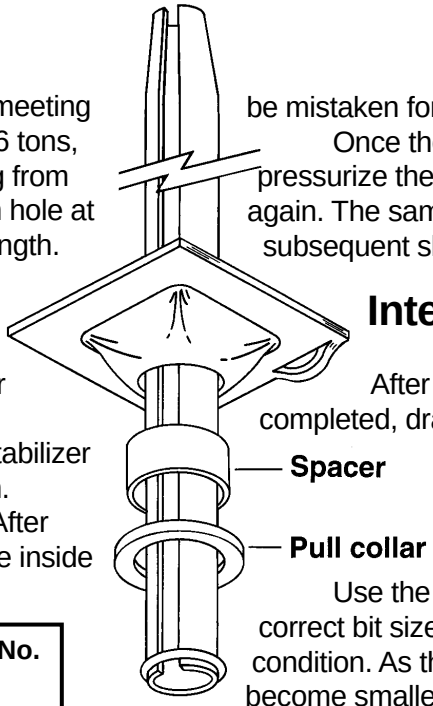
SS-39 installation and pull testing

Bit selection and drilling

To select the correct drill bit diameter for meeting the recommended initial anchorage of 3 to 6 tons, drill several holes with bit diameters ranging from 1-3/8 to 1-1/2 inch (35 to 38 mm). Drill each hole at least 2 inches (5 cm) longer than the bolt length. Number each hole and record the bit size.

In soft ground, a bit may drill a hole larger than its diameter. In hard abrasive ground, the hole may be the same diameter as the bit.)

Drive into each hole an SS-39 Split Set stabilizer fitted with a pull collar and spacer as shown. Record the driving time for each stabilizer. After insertion, observe the amount of slot closure inside each stabilizer.



SS-39 pull collar and spacer set	Weight lb.	(kg)	Comm. No.
	0.4	(0.2)	90320854

To determine anchorage, perform a pull test (page 4). Align the pull tester with the stabilizer, and pressurize it until the stabilizer slips in the hole.

Watch to be sure that it is actually the stabilizer that has slipped. (When building up the pull load on the stabilizer, various adjustments may occur such as realignment of the tester housing, bearing plate settling, or localized rock crushing. These must not be mistaken for tube slippage.)

Once the bolt has slipped in the hole, pressurize the tester pump until the bolt slips again. The same pull load should cause subsequent slippage.

Interpreting test data

After the above pull tests are completed, draw two graphs:

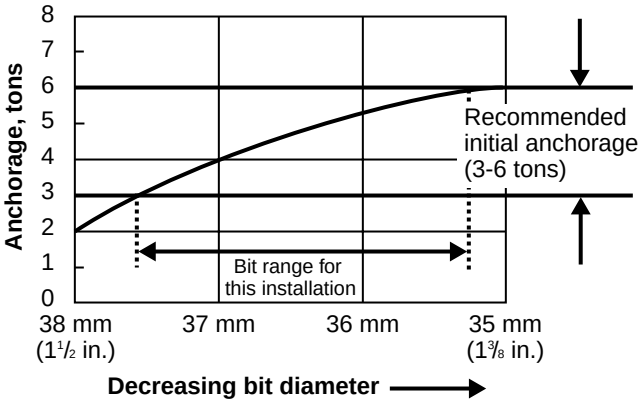
(a) Anchorage versus bit diameter.

(b) Anchorage versus driving time.

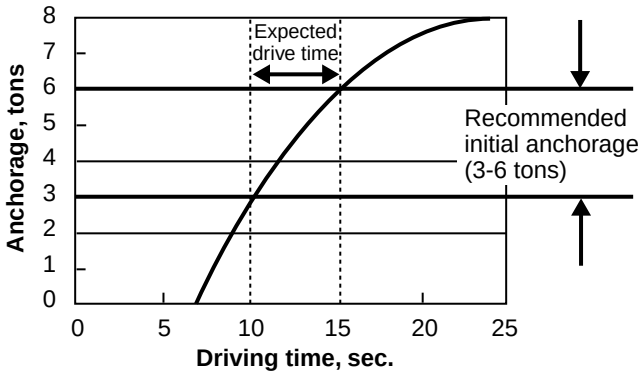
Use the first graph to determine the correct bit size for your particular ground condition. As the bit wears, the hole will become smaller and friction will increase until the bit is replaced or the drill can't drive the bolt completely.

Use the second graph to establish correct driving time required for this ground and bolt length. With a given bit, drill, bolt length, rock characteristic and constant pressure, insertion time will be proportional to initial anchorage.

It's important to establish this data for use in later spot checks, to assure that proper installation techniques are still being used.



(a) Anchorage versus bit diameter



(b) Anchorage versus driving time

SS-39 pull tester			
Description	Weight Lb.	(kg)	Comm. No.
Pull tester assembly	27.6	(12.5)	72233398
Mechanical portion	11.9	(5.4)	90321282
Hydraulic portion	15.7	(7.1)	90321415
Hydraulic parts			
Cylinder	7.0	(3.2)	90320177
Gage	1.5	(0.7)	90320193
Pump	5.0	(2.3)	90320169
Hydraulic hose	2.0	(0.9)	90320185
Gage adapter	0.2	(0.1)	90320201
Mechanical parts			
Claw	3.3	(1.5)	72233406
Housing	5.5	(2.5)	72233422
Bushing	1.0	(0.5)	72233430
Spindle	1.8	(0.8)	72233414
Hex nut	0.3	(0.1)	95084778

SS-39 pull test equipment

The pull tester consists of two assemblies: the hydraulic portion which includes the cylinder, gage, pump, hose and adapter; and the mechanical portion which includes the claw, housing, U-shaped bushing, spindle and nut.

With the bushing removed, the claw can be slid over the pull collar which has been installed with the stabilizer. When the housing and cylinder are raised, the bushing can be inserted between the nut and the cylinder. The nut is then tightened to take up slack.

The pump is then actuated to raise cylinder pressure, pulling the stabilizer slightly out of the hole through the bearing plate.

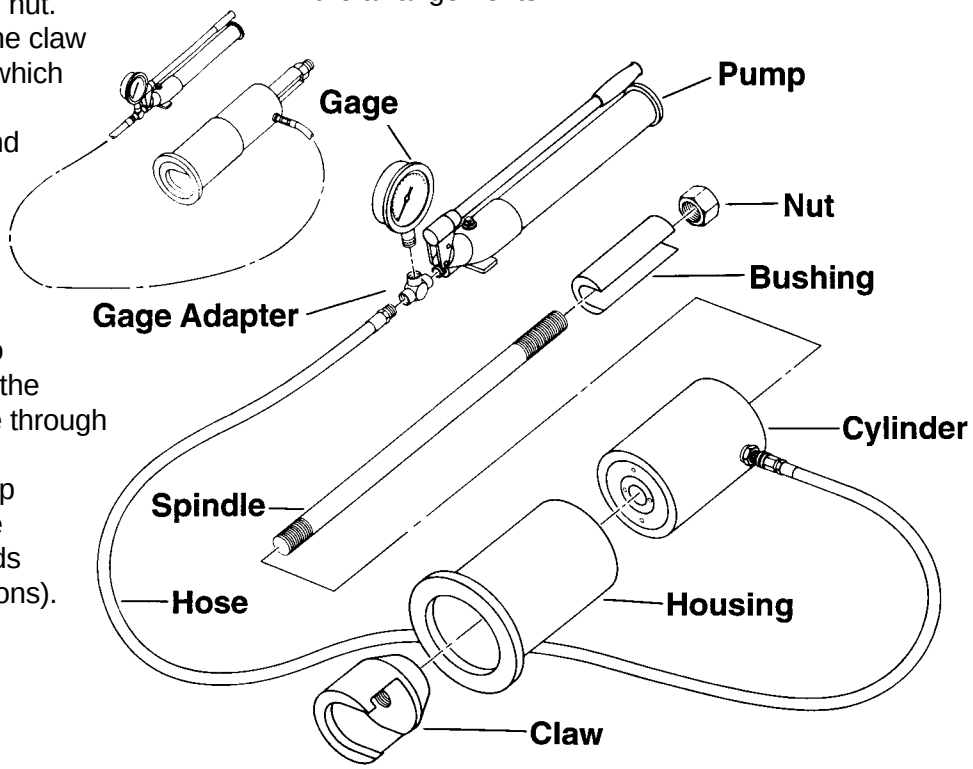
Maximum gage reading at slip indicates the holding force. The device can be used for slip loads up to 12 US tons (10.9 metric tons).

Application Engineering Service

The Split Set stabilizer is a unique rock stabilization and support system.

It interacts with the rock differently from other rock bolts. For this reason, the Split Set Group offers a free application engineering service to assist you in the selection of the proper Split Set configuration for your needs. We will also assist in determining the best way to use your existing equipment for the job, the best drilling procedure, and appropriate tools and accessories for your equipment and space limitations.

We urge you to take advantage of this service. Our sales representative will be pleased to make the arrangements.



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SPLIT SET® Stabilizers SS-46

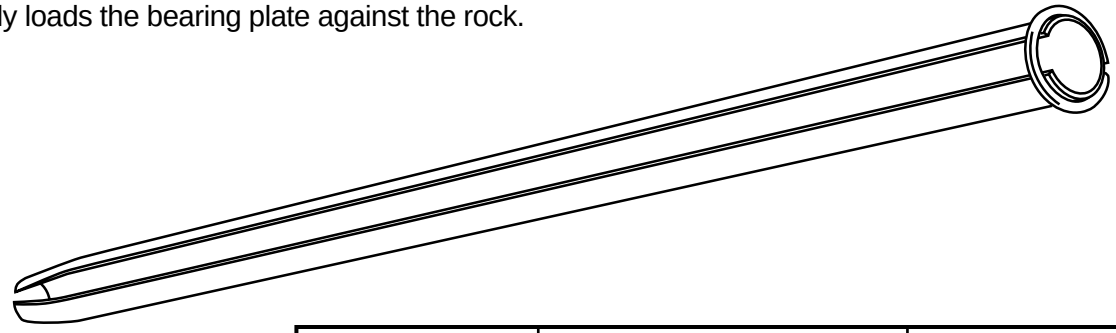
Specifications and performance

The Split Set stabilizer is a slotted steel tube, with one end tapered for easy insertion into a drill hole. The other end has a welded ring flange to hold the bearing plate.

The stabilizer is inserted into a hole slightly smaller in diameter than the tube, using a simple driver tool fitted to the drill. As the tube enters, its diameter is compressed and the slot partially closes. This exerts radial forces along the length of contact with the rock, providing the friction which holds the rock together. The driving force of the drill actively loads the bearing plate against the rock.

International Rollforms' Split Sets feature a patented "Ring Indexing" feature. This allows for determining the length of an installed Split Set.

Tubes and plates are available standard or galvanized, made in accordance with ASTM F 432-95 where applicable. Code stampings on the tube show its size, date and place of manufacture, and heat lot of steel.



Model SS-46 Split Set stabilizers are 1.8 in. (46 mm) in diameter.

SS-46 stabilizers are typically packaged 150 per pallet.

Also see Utility Hangers on page 2.

SS-46 tube		Standard			Galvanized		
Length Inches	(mm)	Weight Lb.	(kg)	Comm. No.	Weight Lb.	(kg)	Comm. No.
36	(914)	5.7	(2.6)	90322470	6.0	(2.7)	90322660
42	(1067)	6.6	(3.0)	90322777	6.9	(3.1)	90322785
48	(1219)	7.6	(3.5)	90322769	7.9	(3.6)	90322751
60	(1524)	9.4	(4.3)	90321811	9.9	(4.5)	90322330
72	(1829)	11.3	(5.1)	90321522	11.8	(5.4)	90322348
78	(1981)	12.2	(5.5)	90322132	12.8	(5.8)	90322678
84	(2134)	13.1	(6.0)	90321530	13.8	(6.3)	90321753
90	(2286)	14.1	(6.4)	90322140	14.8	(6.7)	90322686
96	(2438)	15.0	(6.8)	90321548	15.7	(7.1)	90321761
102	(2591)	15.9	(7.2)	90322157	16.7	(7.6)	90322694
108	(2743)	16.8	(7.6)	90321555	17.7	(8.0)	90321779
114	(2896)	17.8	(8.1)	90322165	18.7	(8.5)	90322702
120	(3048)	18.7	(8.5)	90321563	19.6	(8.9)	90321787
126	(3200)	19.6	(8.9)	90322173	20.6	(9.4)	90322710
132	(3353)	20.6	(9.4)	90322306	21.6	(9.8)	90322355
138	(3505)	21.5	(9.8)	90322181	22.6	(10.3)	90322728
144	(3658)	22.4	(10.2)	90322314	23.5	(10.7)	90322363

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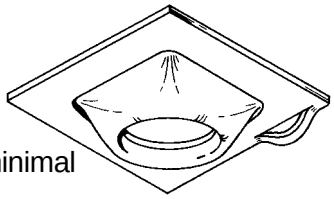
SS-46 plate	Standard		Galvanized	
Dimensions Inches (mm)	Weight Lb. (kg)	Comm. No.	Weight Lb. (kg)	Comm. No.
Domed plate				
6 x 6 x 0.16 (150 x 150 x 4)	1.7 (0.8)	90324575	1.8 (0.8)	90322389
Domed plate, *Australian version*				
6 x 6 x 0.16 (150 x 150 x 4)	1.7 (0.8)	90322280	1.8 (0.8)	90322371

Domed bearing plate

Split Set domed bearing plates uniquely combine high strength with light weight, and are integral parts of the Split Set system. Plates meet ASTM F-432-95 standards for Grade 3 plates where applicable, providing a load capacity of 15 tons (13.7 metric tons) with minimal deflection.



Domed bearing plate

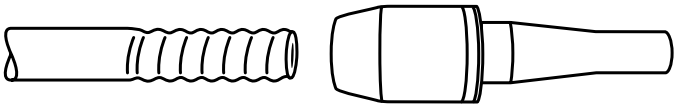
Installing the SS-46 stabilizer

The SS-46 tube has a nominal outside diameter of 1.8 inches (46 mm). The length chosen should be the same as with other types of rock bolts, and installed with the same spacing.

The stabilizer is installed with the same drill used to make the hole. Model SS-46 Split Set stabilizers are commonly installed with jumbos. Almost any mounted percussive or hydraulic drill will have sufficient impact power for installing SS-46 stabilizers.

SS-46 drivers	Thread size Inches (mm)	Weight Lb. (kg)	Comm. No.
	1-1/4 (32)	4.4 (2.0)	90322448
	1-1/2 (38)	4.4 (2.0)	90322496
	T-38 (38)	5.0 (2.3)	90322587

Special tools are available on request.



Typical rope-threaded driver

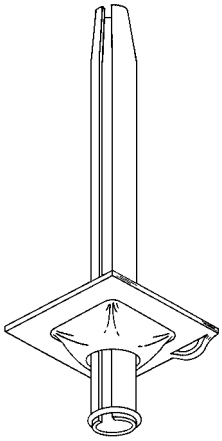
SS-46 driver tools

A simple driver tool adapts the drill for easy stabilizer insertion. One end fits the tube; the other fits the rope-threaded drill steel.

All genuine Split Set driver tools are made of high-strength heat-treated alloy steel, designed for long life, and precision-made for the proper fit.

SS-46 utility hangers

Split Set utility hangers are available in 18 and 24-inch (46 and 61-cm) tube lengths to support light loads such as cables, vent tubing, and pipes.



SS-46 utility hangers		
Length In. (mm)	Weight Lb. (kg)	Comm. No.
Standard		
18 (457)	3.0 (1.4)	90322561
24 (610)	3.9 (1.8)	90322579
Galvanized		
18 (457)	3.1 (1.4)	90322645
24 (610)	4.1 (1.9)	90322652

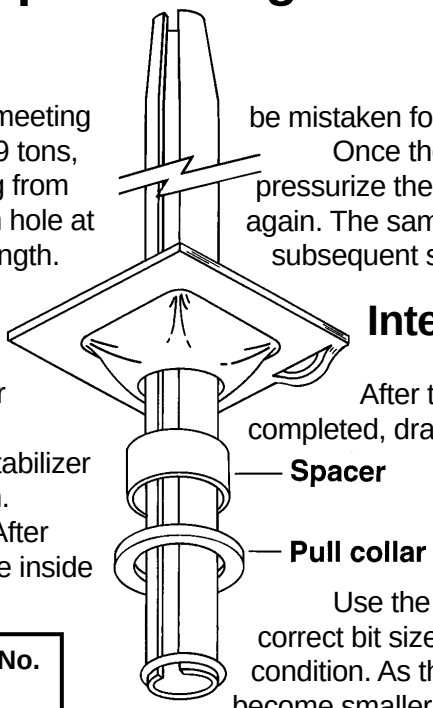
SS-46 installation and pull testing

Bit selection and drilling

To select the correct drill bit diameter for meeting the recommended initial anchorage of 6 to 9 tons, drill several holes with bit diameters ranging from 1-5/8 to 1-3/4 inch (41 to 45 mm). Drill each hole at least 2 inches (5 cm) longer than the bolt length. Number each hole and record the bit size.

In soft ground, a bit may drill a hole larger than its diameter. In hard abrasive ground, the hole may be the same diameter as the bit.

Drive into each hole an SS-46 Split Set stabilizer fitted with a pull collar and spacer as shown. Record the driving time for each stabilizer. After insertion, observe the amount of slot closure inside each stabilizer.



SS-46 pull collar and spacer set	Weight lb.	Weight (kg)	Comm. No.
	0.5	(0.2)	90321647

To determine anchorage, perform a pull test (page 4). Align the pull tester with the stabilizer, and pressurize it until the stabilizer slips in the hole.

Watch to be sure that it is actually the stabilizer that has slipped. (When building up the pull load on the stabilizer, various adjustments may occur such as realignment of the tester housing, bearing plate settling, or localized rock crushing. These must not be mistaken for tube slippage.)

Once the bolt has slipped in the hole, pressurize the tester pump until the bolt slips again. The same pull load should cause subsequent slippage.

Interpreting test data

After the above pull tests are completed, draw two graphs:

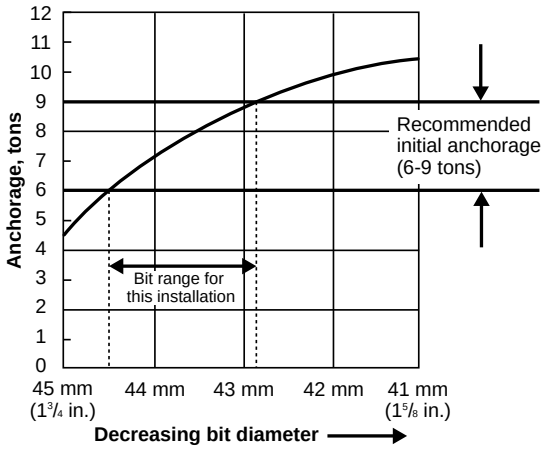
(a) Anchorage versus bit diameter.

(b) Anchorage versus driving time.

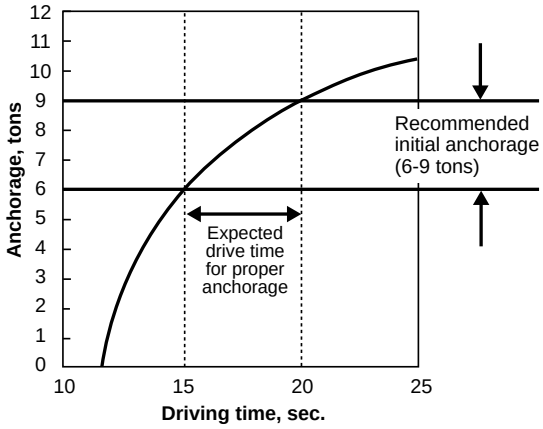
Use the first graph to determine the correct bit size for your particular ground condition. As the bit wears, the hole will become smaller and friction will increase until the bit is replaced or the drill can't drive the bolt completely.

Use the second graph to establish correct driving time required for this ground and bolt length. With a given bit, drill, bolt length, rock characteristic and constant pressure, insertion time will be proportional to initial anchorage.

It's important to establish this data for use in later spot checks, to assure that proper installation techniques are still being used.



(a) Anchorage versus bit diameter



(b) Anchorage versus driving time

SS-46 pull tester			
Description	**Weight Lb.**	**(kg)**	**Comm No.**
Pull tester assembly	**49.0**	**(22.3)**	**90321597**
Mechanical portion	**15.0**	**(6.8)**	**90321902**
Hydraulic portion	**34.0**	**(15.5)**	**90321910**
Hydraulic parts			
Cylinder	**17.5**	**(8.0)**	**90321852**
Gage	**1.3**	**(0.6)**	**90321860**
Pump	**10.5**	**(4.8)**	**90321878**
Hydraulic hose	**4.3**	**(2.0)**	**90321886**
Gage adapter	**0.4**	**(0.2)**	**90321894**
Mechanical parts			
Claw	**3.4**	**(1.5)**	**90321605**
Housing	**6.5**	**(3.0)**	**90321613**
Bushing	**1.3**	**(0.6)**	**90321837**
Spindle	**3.4**	**(1.5)**	**90321845**
Hex nut	**0.4**	**(0.2)**	**95084711**

SS-46 pull test equipment

The pull tester consists of two assemblies: the hydraulic portion which includes the cylinder, gage, pump, hose and adapter; and the mechanical portion which includes the claw, housing, U-shaped bushing, spindle and nut.

With the bushing removed, the claw can be slid over the pull collar which has been installed with the stabilizer. When the housing and cylinder are raised, the bushing can be inserted between the nut and the cylinder. The nut is then tightened to take up slack.

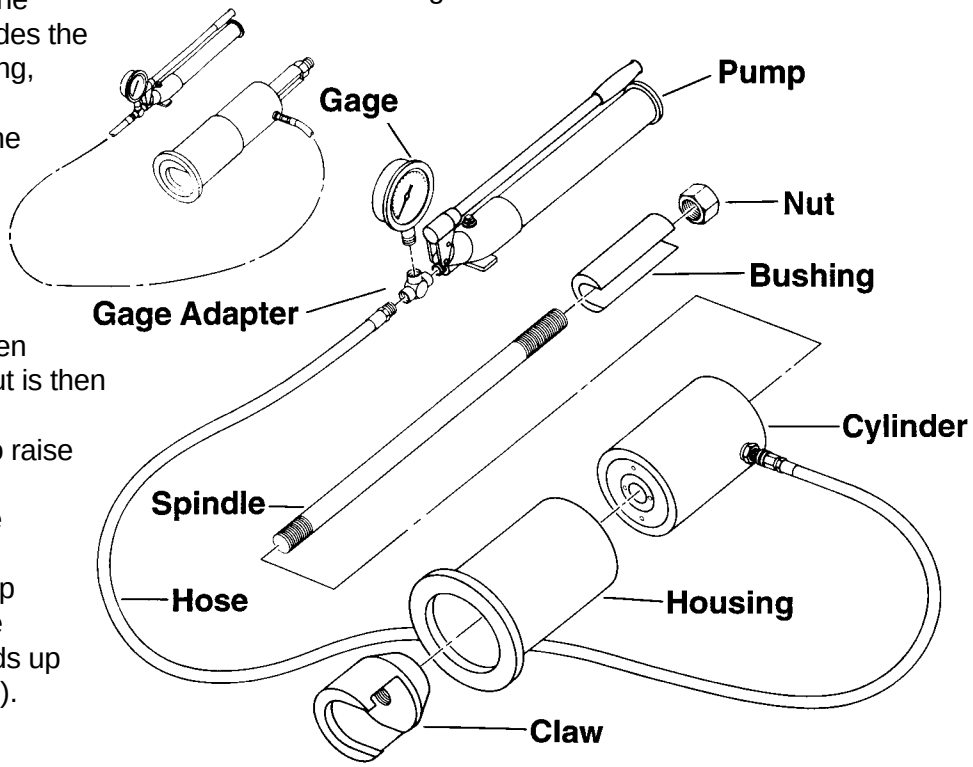
The pump is then actuated to raise cylinder pressure, pulling the stabilizer slightly out of the hole through the bearing plate.

Maximum gage reading at slip indicates the holding force. The device can be used for slip loads up to 20 US tons (18.2 metric tons).

Application Engineering Service

The Split Set stabilizer is a unique rock stabilization and support system.
It interacts with the rock differently from other rock bolts. For this reason, the Split Set Group offers a free application engineering service to assist you in the selection of the proper Split Set configuration for your needs. We will also assist in determining the best way to use your existing equipment for the job, the best drilling procedure, and appropriate tools and accessories for your equipment and space limitations.

We urge you to take advantage of this service. Our sales representative will be pleased to make the arrangements.



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SPLIT SET®

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I-G. Mesh, Straps, and Plate Washers Specifications

DYWIDAG-SYSTEMS INTERNATIONAL

Mining and Tunneling Products Catalogue

Mesh, Straps & Plate Washers

www.dsiunderground.com

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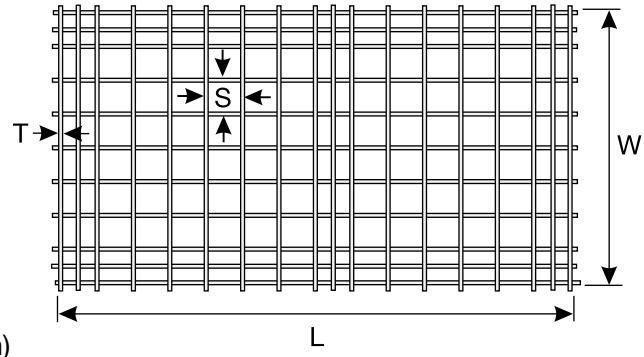
Mesh

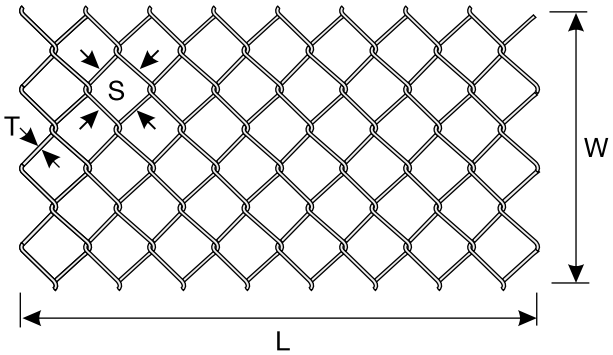
Welded Wire Mesh

- to ASTM A185 specifications
- wire to ASTM A82 specs (75,000 psi tensile)
- minimum weld shear strength (lbs) = 35,000 x wire cross sectional area (in^2)
- ends flush cut for safer handling
- available galvanized
- T = 4 (0.232"), 6 (0.192"), 8 (0.160"), 9 (0.144") and 10 (.0128") gauge
- W = 48" to 96" wide
- L = 48" to 24' long sheet or to 100' long roll
- S = 4" x 4" spacing typical but variable (as shown)



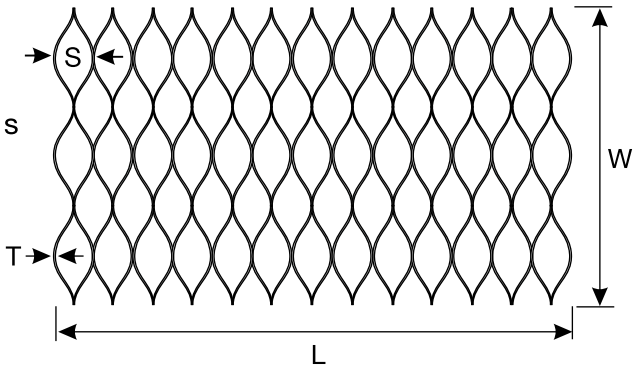
Chainlink Mesh (Frost Fencing)

- galvanized to ASTM A392 specifications
- T = 6 (0.192"), 9 (0.144"), 11 (0.120") and 12 (0.106") gauge
- W = 4', 5', 6', 7', 8' and 10' wide
- L = rolls 25', 50' and 100' long
- S = 2", 2½" and 3" opening size



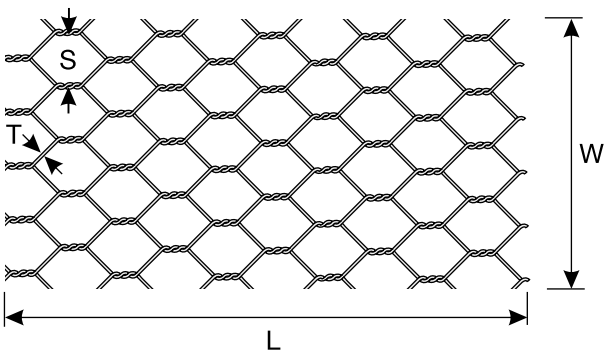
Expanded Metal Mesh

- carbon steel to ASTM A1011 specifications
- up to 4x stronger than welded wire mesh at joints
- available galvanized
- T = 12 gauge (0.106")
- W = 4', 5' and 6'
- L = 4' to 10'
- S = 3" x 6" opening size



Gabion Mesh

- to ASTM A975 specifications
- galvanized
- weight = 0.365 lbs/ft^2
- T = 11 gauge (0.120")
- W = 2m (79") or 3m (118")
- L = 30m (99')
- S = 3.25" x 4.5" opening size

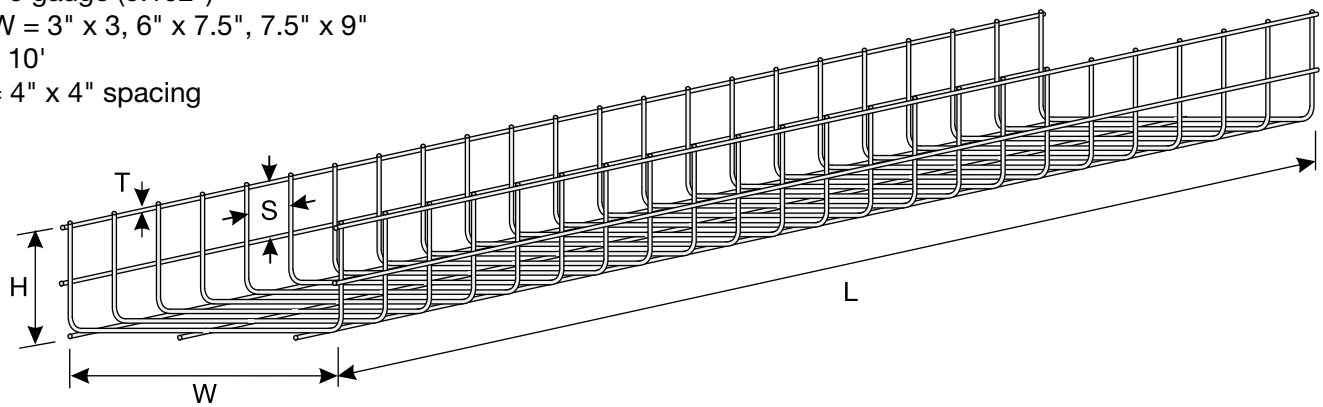


Custom sizes available on request

Formed Mesh

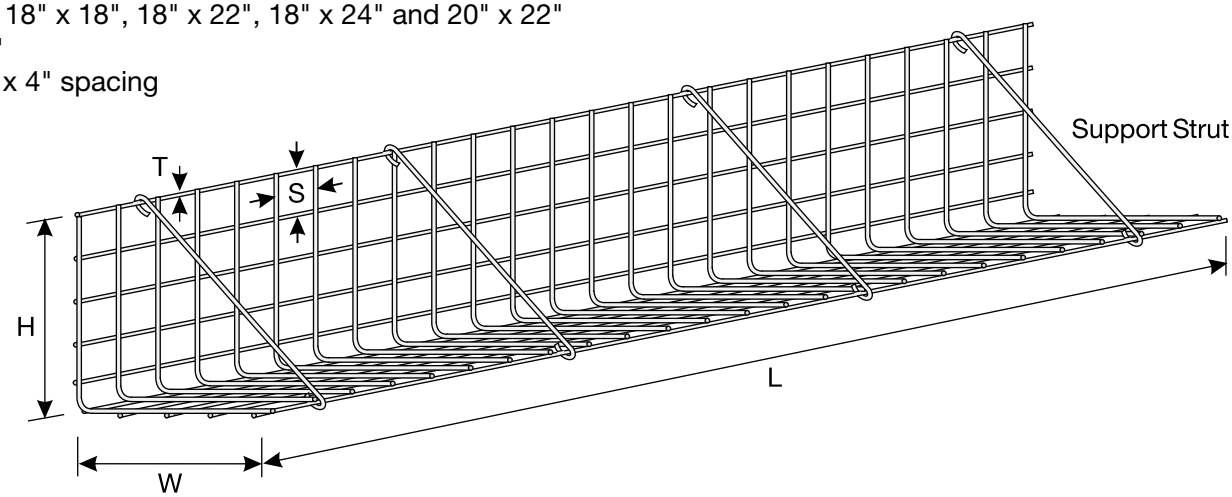
Mesh Channels
For construction of shotcrete barricades and fill fences

- mesh to ASTM A185 specifications
- wire strand to ASTM A82 specifications (75,000 psi tensile minimum)
- minimum weld shear strength (lbs) = 35,000 x wire cross sectional area (in^2)
- ends flush cut for safer handling
- T = 6 gauge (0.192")
- H/W = 3" x 3, 6" x 7.5", 7.5" x 9"
- L = 10'
- S = 4" x 4" spacing



Mesh Retainers
For construction of soil retaining walls

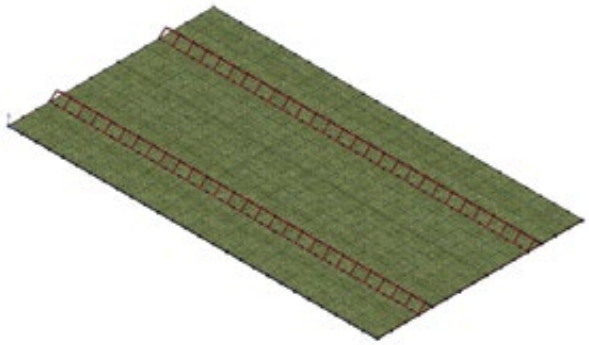
- mesh to ASTM A185 specifications
- wire strand to ASTM A82 specifications (75,000 psi tensile minimum)
- minimum weld shear strength (lbs) = 35,000 x wire cross sectional area (in^2)
- ends flush cut for safer handling
- available galvanized
- support struts hold mesh at 80° angle
- T = mesh and support struts 4 gauge (0.225")
- H/W = 18" x 18", 18" x 22", 18" x 24" and 20" x 22"
- L = 10'
- S = 4" x 4" spacing



Custom sizes available on request

Shotcrete Mesh Panels

Shotcrete Mesh Panels are constructed with black or galvanized mesh and burlap cloth. Stiffeners are incorporated for three-dimensionable stability. The panels can be various sizes depending on application. They are lightweight and can be cut-to-shape with small bolt-cutters. When Shotcrete is applied to the panels, the result is a durable wall, which is resilient to close proximity blasting.



Advantages

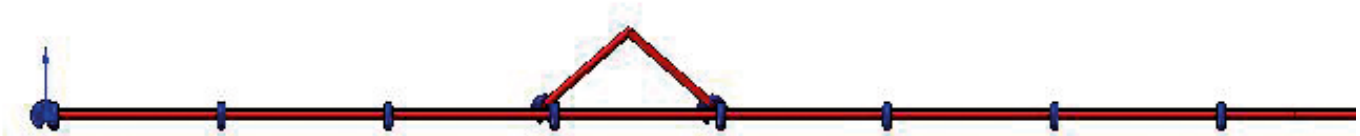
- Fast and easy to erect
- Non-corrosive if galvanized mesh is used.
- Concussion-resistant

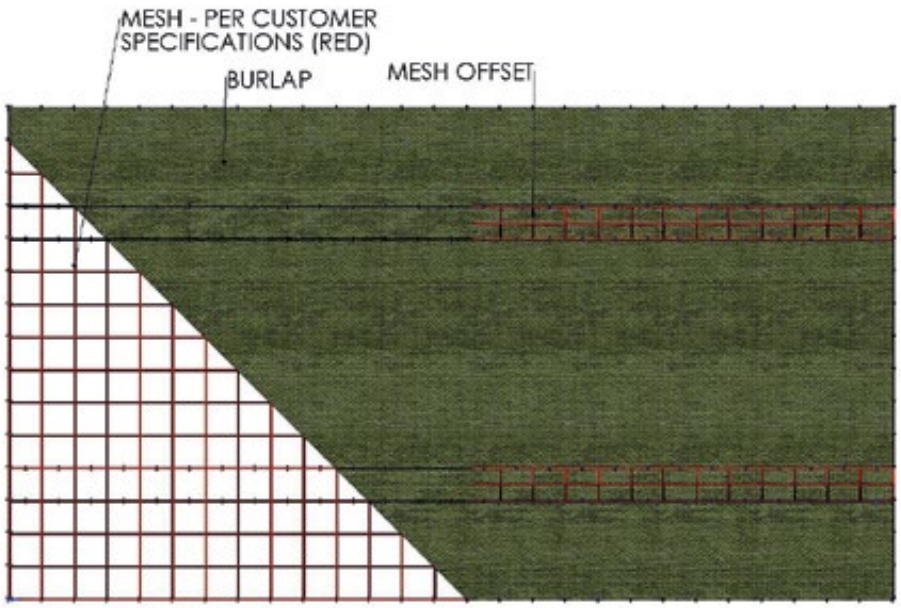
Uses

- Construction of walls for lunchrooms
- Utility rooms
- Building bulkheads
- Protective wall for shaft areas

Installation

- Install grouted dowels on 2-4' centers around perimeter of proposed wall
- Tie 1/2" rebar to the dowels and form a grid of approximately 2-3' squares
- Tie the Shotecrete Mesh Panel forms to the rebar grid using tie wire. The rib stiffener of the panel is then tied to the rebar. The panels must be butted together and wire tied about every foot. Panels can be easily trimmed to conform to tunnel of drift irregularities using ordinary bolt-cutters.
- Apply Shotcrete through rebar grid.
- Can also be attached to existing beams on structures.

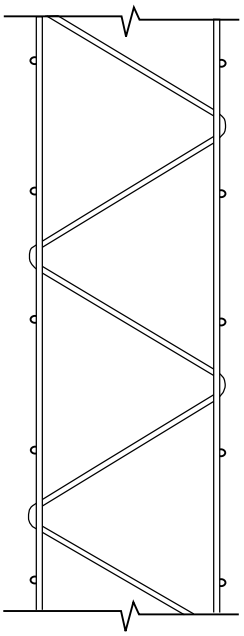




‘Gun Quip’ Wall & Support System

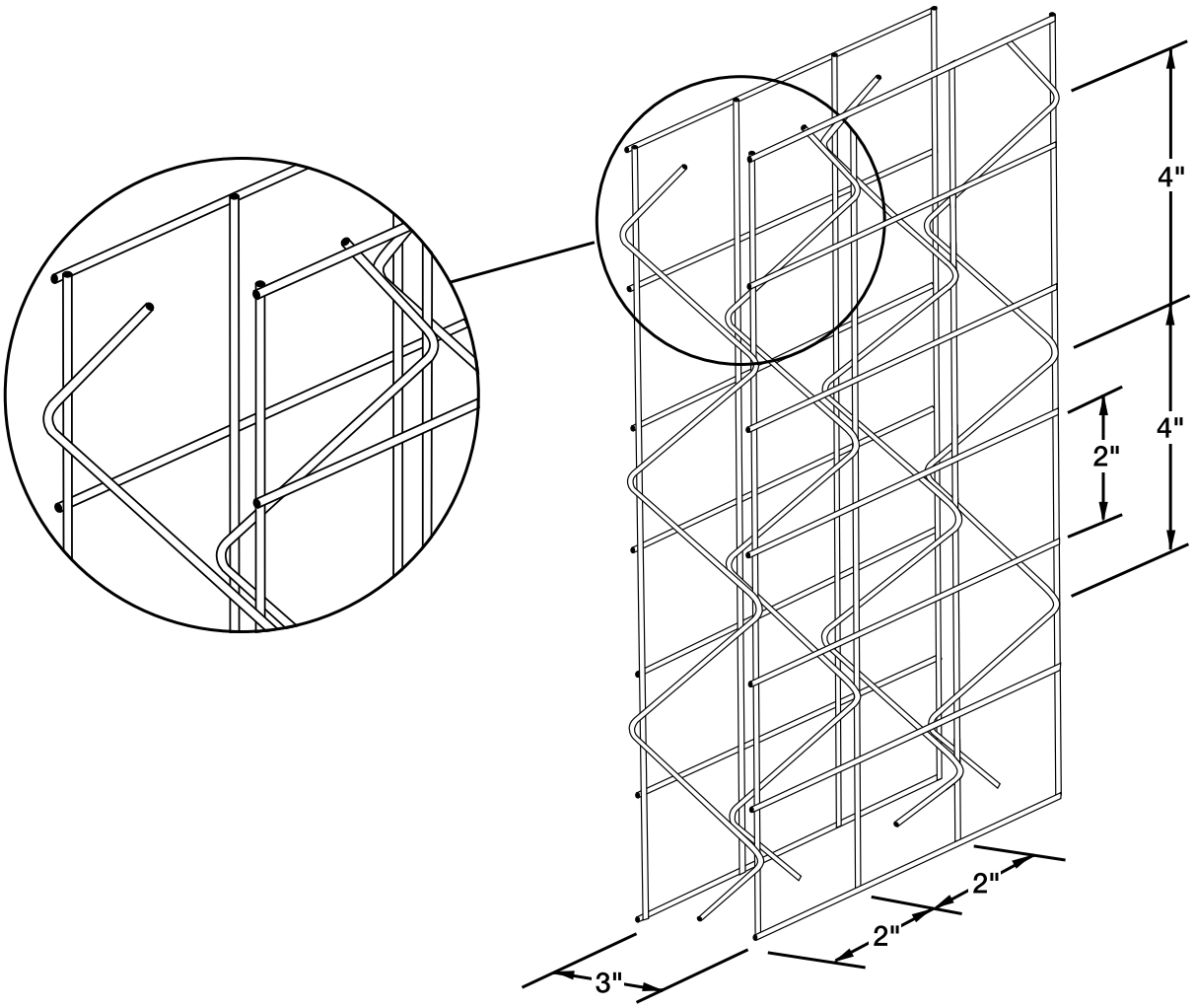
- Shotcrete panel
- ventilation walls - temporary or permanent.
- fireproof underground work shops and offices.
- provides rock support with rock bolt installation
- protective reinforcing around elevators and shafts.
- extra protection on walls and roofs near expensive machinery or electrical substations.
- comes complete with backing or plain
- manufactured under ASTM A02

panel side view



Technical wire specifications

- ASTM 510 wire composition
- ASTM A82
- wire size 14 gauge (WO.5)
- nominal diameter - wire diameter
  0.080" (2.032 mm). Specify wire diameter.
  0.081" +.001" (2.0574 mm + .0254 mm)
- Tensile
  maximum: 130,000 psi (896 MPa)
  minimum: 110,000 psi (758 MPa)



Polymesh

DYWIDAG Polymesh is comprised of high tenacity yarns, woven into a stable interlocking grid structure and then coated with PVC for protection during installation.

Polymesh is used for longwall recovery mats as well as rib and roof control. Longwall recovery mats are fabricated and assembled to mine-specifications.

- Light weight - reduces cost and handling time.
- No sharp edges, reducing injury hazard associated with chain link and welded wire.
- Conforms easily to the roof or ribs due to the multifilament yarn design.
- Stronger than other polymer grids: Since the longitudinal and transverse members are crossed and independent, there is less ripping out at the intersections than with other polymer grids.
- Both FRAS and Non-FRAS available (FRAS - Fire Resistant and Anti-Static))

Polymesh is available in rolls made to custom length. The typical roll lengths are 30 m, 50 m and 100 m.The width also can be customized to specific needs but common are 1.25 m and 2.5 m with 5 m being the maximum width.

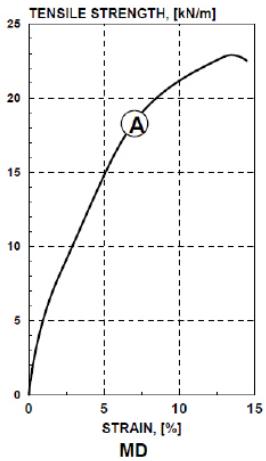
DSI Grades	Tensile strength (ASTM-D4595)					Minimum aperture size		Weight (ASTM-D5261)	
	MD	XMD	MD	XMD	ultimate				
	at 2% strain[1]		ultimate						
All Polyester	lbs/ft		kN/m		elongation	inch	mm	oz/yd²	g/m²
55/55	440	440	55	55	18×23%	1.30	33	12	375
55/55	440	440	55	55	18×23%	2.40	60	12	375
80/80	650	650	80	80	18×23%	1.25	31	15	500
80/80	650	650	80	80	18×23%	2.40	60	15	500
200/80	1,600	650	200	80	18×23%	1.25	31	23	780
200/200	1,600	1,600	200	200	18×23%	1.05	26	38	1288

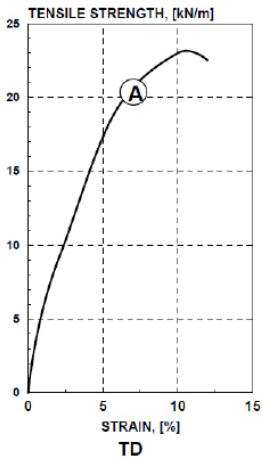
MD = machine direction, XMD = Cross Machine Direction
[1] 2% strain is equivalent to 10" convergence given 10ft unsupported span during shield recovery.

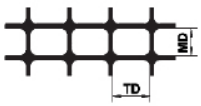
Polymer Mining Grid

DSI Polymer Mining Grid is an alternative to weld wire mesh products and can be used as a supplemental support structure between roof/rib bolts in any underground mining and or tunneling operation.

It is corrosion resistant and is especially applicable to any screening project when it will need to be "mined through" such as for pillar wrapping or for pilot tunnels. It is also especially useful in corrosive environments.







GEOGRID D TYPE

A = MG270 SAMPLE

Physical Properties

Physical Characteristics	Test Methods	Data
Structure		Bi-Oriented Geogrids
Mesh Type		Rectangular Apertures
Standard Color		White
Polymer Type		Polypropylene
Carbon Black Content	ASTM D4218	No
Flame Retardant	ISO 9705	Yes
Packaging	ISO 10320	Rolls in Polyethylene bags with I.D. labels.

Dimensions

Dimensional Characteristics	Test Method	Unit	FR 270	Notes
Aperture MD		mm	59.5	b,d
Aperture TD		mm	56.5	b,d
Mass Per Unit Area	ISO 9864	g/m²	270	b
Roll Width		m	4.0	b
Roll Length		m	25.0	b
Roll Diameter		m	0.3	b
Roll Volume		m³	0.4	b
Gross Roll Weight		kg	61.0	b

Technical Data

Technical Characteristics	Test Method	Unit	FR 270		Notes
			MD	TD	
Peak Tensile Strength	ISO 10319	kN/m	20.0	20.0	a,c,d
Yield Point Elongation	ISO 10319	%	13.0	10.0	b,c,d

Notes:

a) 95% lower confidence limit values, IS) 2602

b) Typical values

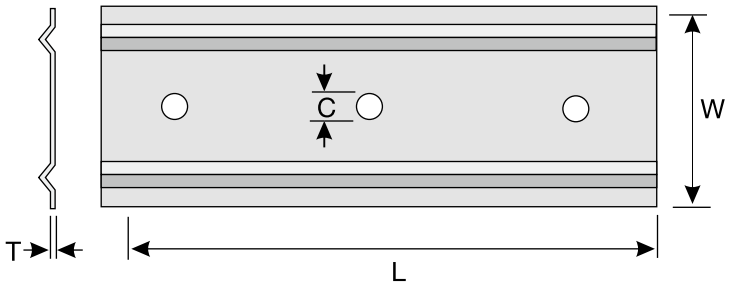
c) Tests performed using extensometers

d) MD: machine direction (longitude to the roll)
TD: transversal direction (across roll width)

Straps (Mats)

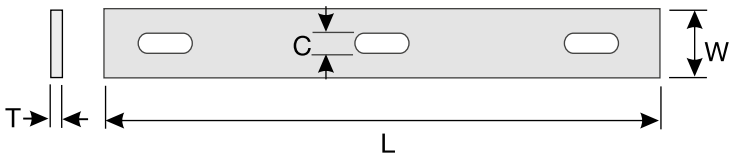
W-Strap (Mat)

- T = 12, 14, 16 gauge
- W = 5" to 13"
- L = 54" to 240"
- C = hole size/spacing to customer specs



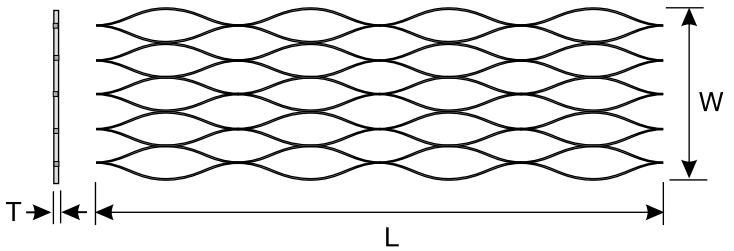
Rock Bolt Strap

- A36 material (36,000 psi yield)
- T = 12 gauge to ¼"
- W = 4" to 8"
- L = 48" to 120"
- C = hole/slot size/spacing to spec



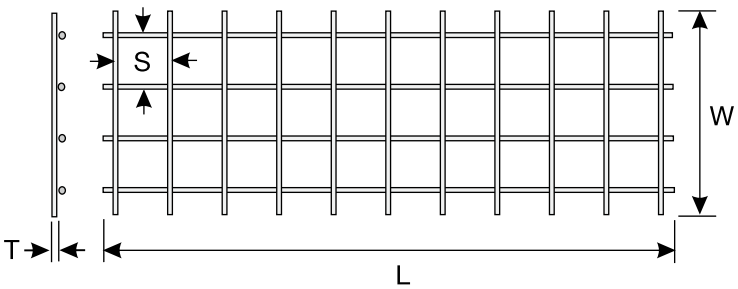
Expanded Metal Mesh Strap

- 1008 material (30,000 psi yield)
- T = 8 gauge (0.164")
- W = 15"
- L = 88.5"
- deburred for safer handling



Welded Wire Mesh Strap

- to ASTM A185 specifications
- T = % gauge (0.306")
- W = 12"
- L = 84" and 108"
- S = 4" x 4" spacing



Custom sizes and/or galvanizing available on request

Roof Channel

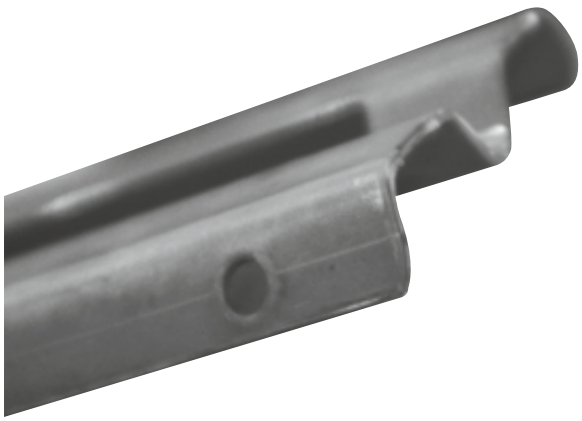
Description

- 2 material grades - A36 and 65000psi minimum yield
- Length and hole spacing - to customer specifications
- Width - nominal 5-1/2 inches
- Thickness
  T-2 - minimum 0.100 inc
  T-3 - minimum 0.125 inch
  T-4 - minimum 0.145 inch
  T-5 - minimum 0.165 inch

Design Features

a) holes punched on the sides for hanging cables and ventilation materials

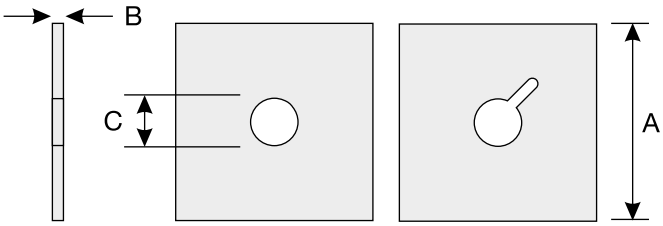
b) channel ends have the corners rounded - such reducing sharp corners and prevent cuts to the miners hands and backs in low coal



Bearing Plates (washers)

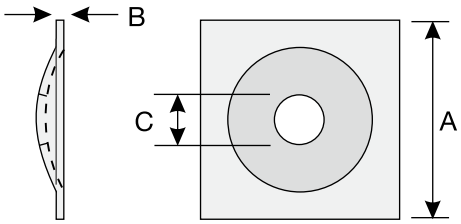
Flat Plate - for General Use

- minimum A-36 material (36,000 psi yield)
- A = 4" to 12" square
- B = ⅛" to 1½" thick
- C = hole diameter as required
- bent corner, grout slots & keyholes available



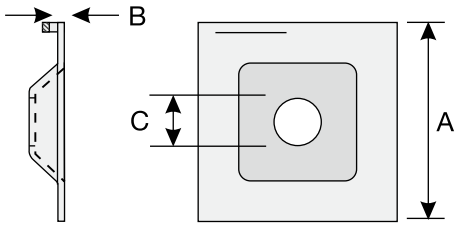
Domed Plate - Use with Anchornuts, Cable Grips or Spherical Seat Washers

- minimum A-36 material (36,000 psi yield)
- A = 5", 6", 8" and 12" square (rect 4" x 6")
- B = ¼" or ⅜" thick
- C = hole diameter as required



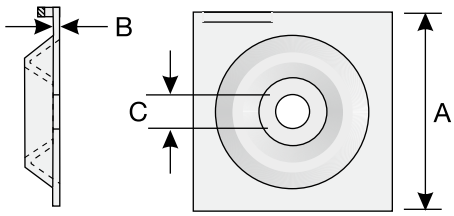
Friction Bolt Plate - for Use with Friction Stabilizers

- minimum A-36 material (36,000 psi yield)
- A = 6" square
- B = FB-33 & FB-39: 3/16" thick; FB-46: ¼" thick
- C = FB-33: 36mm (1 7/16") diameter
  FB-39: 41mm (1 ⅝") diameter
  FB-46: 48mm (2") diameter



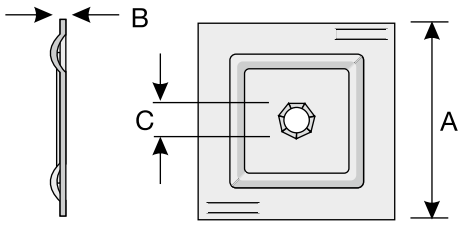
Embossed Plate (Donut plate)

- minimum A-36 material (36,000 psi yield)
- A = 6" and 8" square
- C = 13/16" to 1⅛"
- available in Gr. 2 or Gr. 3 rating



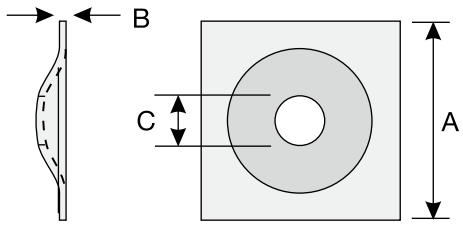
Push-on-Plate - for installing Screen/Mesh (Threaded Bolts and OMEGA-BOLT® Rockbolts)

- heat treated to HRC 45 minimum
- A = 5" square
- B = 0.068" thick
- C = ⅝", ¾" and ⅞" available
- magnetic installation tool available



T-Dome Plate - for use with T-Dome Rock Bolts

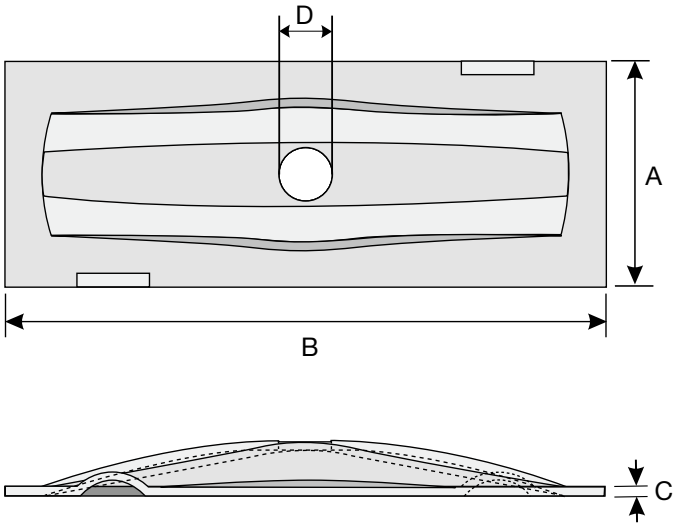
- minimum A-36 material (36,000 psi yield)
- A = 4", 5" & 6" square
- B = ¼" thick
- C = ⅞" diameter



6" and larger plates meet or exceed ASTM F432 Grade 2 specifications for deflection
Custom sizes and/or galvanizing available upon request

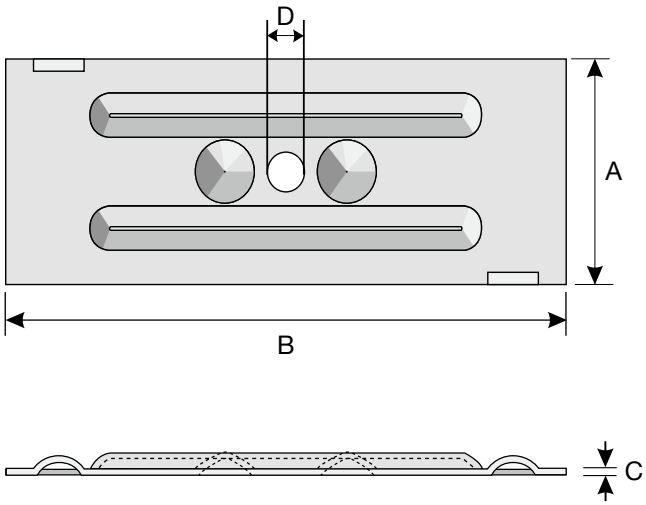
Conventional Header Plate

- minimum A-36 material (36,000 psi yield)
- A = 6"
- B = 10" and 16"
- C = grade 2 and 3
- D = hole diameter as required



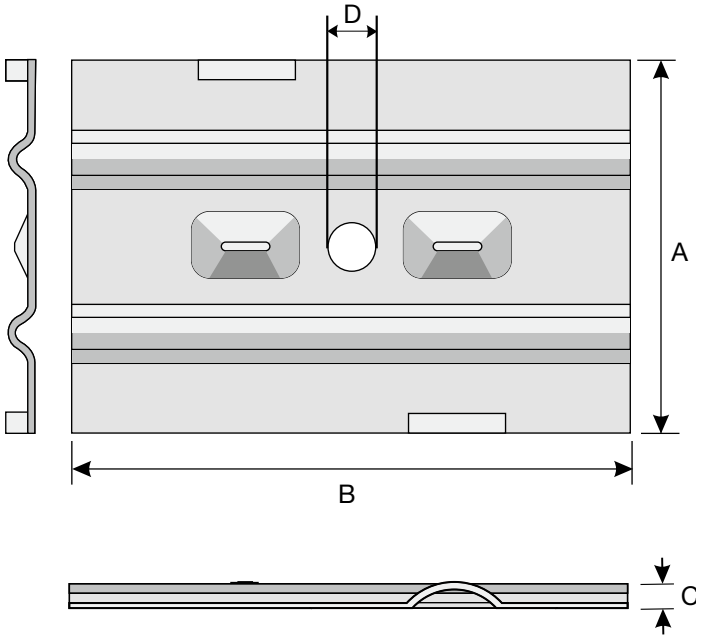
Low Profile Header Plate

- minimum A-36 material (36,000 psi yield)
- A = 6"
- B = 16"
- C = grade 2 and 3
- D = hole diameter as required



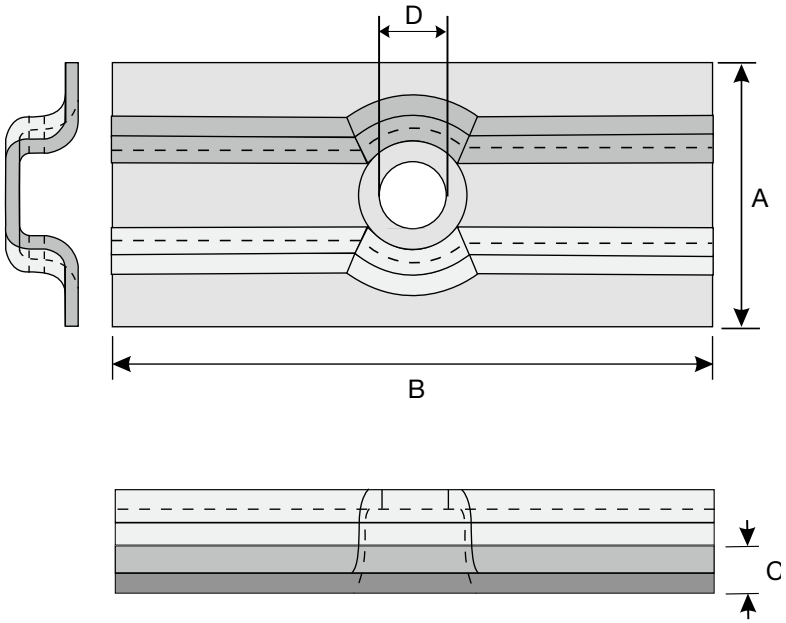
8 x 12 Header Plate

- minimum A-36 material (36,000 psi yield)
- A = 8"
- B = 12"
- C = grade 2 or grade 3
- D = hole diameter as required

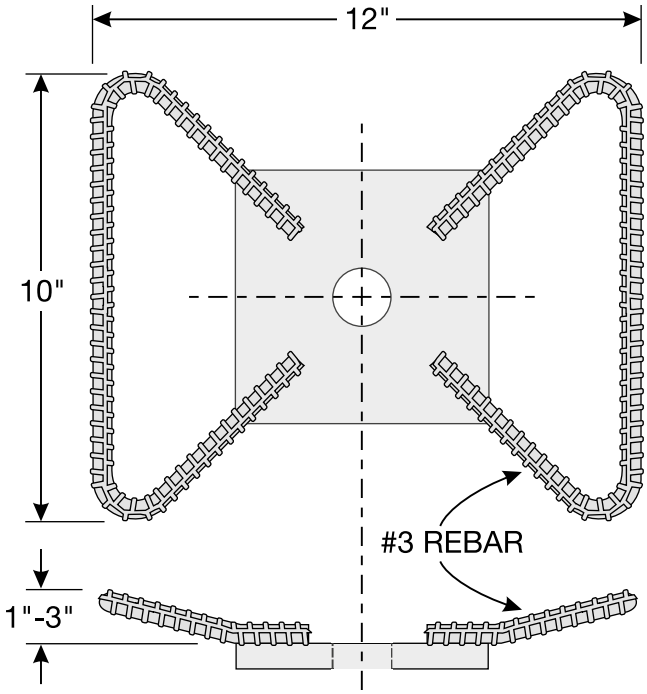


T-Channel Plate

- minimum A-36 material (36,000 psi yield)
- A = 4"
- B = 9"
- C = grade 2 and 3
- D = hole diameter as required



Shotcrete (Spider) Plate (Black & Galvanized)



Description

DSI shotcrete anchor plates are constructed specifically for use with rock bolts and shotcrete. Reinforcing bar is custom bent and welded to conventional rock bolt anchor plates.

Plates are 5" x 5" x ¼", 6" x 6" x ¼" or ⅜". Hole size can be from ⅞" to 1½". Rise on spider can be made to any height required for depth of shotcrete.

Advantages

- Fast and easy to use.
- Greatly improves “punching” shear of shotcrete.
- Provides enlarged bearing area for higher load carrying capacity.

Where to Use

Any areas where bolting precedes shotcreting, especially in poor rock conditions, where improved bearing capacity of the ground support is desirable.

Dimensions	Center Hole	Form	Weight
5" × 5" × 1/4"	1.2"	Flat	4.5 lbs
6" × 6" × 1/4"	1.2"	Flat	6.4 lbs
5" × 5" × 3/8"	1.2"	Flat	9.6 lbs

Custom sizes available upon request

Installation

1. Install DSI shotcrete plates in the same manner as conventional plates.
2. Apply shotcrete to the rock surfaces and ensure the plates and rebar wings are embedded at least 38 mm (1½").

Materials

Plate material Grade A-36 (36,000 psi) meets or exceeds ASTM F432 deflection criteria. Rebar meets ASTM A-615 and CSA G30.18M specs.

Butterfly Plate

Length x Width	Thickness	Hole Diameter	Net weight black	Net weight galv.
300 × 278 mm 12 × 11 inch	1.9 mm	50 mm = 2 inch	2.87 lbs	2.95 lbs
400 × 278 mm 15.75 × 11 inch	1.9 mm	50 mm = 2 inch	3.73 lbs	3.83 lbs

The butterfly plate is a light-weight plate with a large surface area. It is used as an intermediate plate to increase the surface coverage of a bolt.

- DSI Butterfly plates feature both longitudinal and transverse V-shaped deformations for added strength and greater ability to conform to irregularities in the rock surface.
- The deformed design renders a greater strength, placing the perimeter of the Butterfly Plate in tension.
- User friendly rounded corners.
- Can be used with both flat and domed plates (up to 150mm, 6 in^2)
- Butterfly plates are can be placed directly to the rock surface or used with Welded Steel Mesh.
- Butterfly plates are supplied with slots for supporting of light service lines.
- Corrosion protection may be provided by hot-dip galvanizing the finished plate or by using pre-galvanized material.

Product Code(s)	
12 × 12" black	BUTT300S USA
12 × 12" galv.	BUTT300GS USA
12 × 16" black	BUTT400SWA
12 × 16" galv.	BUTT400GS

Packaging

Butterfly Plates are tied with wire clips and palletized.

Surface Control Plates

23" and 19"

General Information

- the 23" diameter is "special" order
- the 19" diameter is stock production
- all plates have the "rolled edge" to provide for safe handling
- large diameter plates for surface control
- these plates are to be used in conjunction with a roof bolt and roof plate

23" Description

- 23" diameter with a 1⅜" center hole
- available in a variety of mill thicknesses from 0.022" to 0.050" cold rolled or coated steel

19" Description

- 19" diameter with a 1" center hole
- 19" diameter with a 1⅜" center hole
- available in a variety of mill thicknesses from 0.022" to 0.050" cold rolled or coated steel

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ITALY
JAPAN
KOREA
LEBANON
LUXEMBOURG
MALAYSIA
MEXICO
NETHERLANDS
NORWAY
OMAN
PANAMA
PARAGUAY
PERU
POLAND
PORTUGAL
QATAR
RUSSIA
SAUDI ARABIA
SINGAPORE
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Table 15.1: Typical steel fibre reinforced silica fume shotcrete mix designs (After Wood, 1992)

Components	Dry mix		Wet mix	
	kg./m^3	% dry materials	kg./m^3	% wet materials
Cement	420	19.0	420	18.1
Silica fume additive	50	2.2	40	1.7
Blended aggregate	1,670	75.5	1,600	68.9
Steel fibres	60	2.7	60	2.6
Accelerator	13	0.6	13	0.6
Superplasticizer	-	-	6 litres	0.3
Water reducer	-	-	2 litres	0.1
Air entraining admixture	-	-	if required	
Water	controlled at nozzle		180	7.7
Total	2,213	100	2,321	100

I-H. Shotcrete Mix Design

II. Current Mining Contractor Safety and Ground Control Documentation

II-A. Sample Job Hazard Analysis Form

II-B. Sample Weekly Safety Report

II-C. Procon Scaling Examination & Signoff Training Quiz

II-D. Procon Safe Operating Procedures for Raise Climber Raising

II-E. Sample Task Observation Form

II-F. Sample Planned Inspection Form

II-G. Procon Safety Handbook Table of Contents

II-H. Procon Six Point Safety Plan Form and Risk Assessment Forms

II-A. Sample Job Hazard Analysis Form

ProconSAFE

JOB HAZARD ANALYSIS

JOB BEING ANALYSED:	
FACILITY / SITE:	Brucejack #484
DEPARTMENT:	
TEAM LEADER:	
DATE:	
REVIEW DATE:	
Required Personal Protective Equipment:	

List Associated Procedures/Work Instructions or Temporary Work Instruction:

Step	Describe Job Step	Hazards/Potential Incidents	Risk Control Methods Required
	List the natural steps of the job (not too broad and not too fine).	What can happen at each step? Use the following checklist. Can an employee be struck by / caught on / contacted by / struck against / contact with / caught between?	Describe how defined hazards can be managed or removed. Consider elimination / substitution, engineering controls, administrative controls, personal protective equipment.
1			

ProconSAFE

Step	Describe Job Step	Hazards/Potential Incidents	Risk Control Methods Required
	List the natural steps of the job (not too broad and not too fine).	What can happen at each step? Use the following checklist. Can an employee be struck by / caught on / contacted by / struck against / contact with / caught between?	Describe how defined hazards can be managed or removed. Consider elimination / substitution, engineering controls, administrative controls, personal protective equipment.

ProconSAFE

Formal JHA Leader Name: _____

Signature: _____

Team Member:

_____
_____
_____
_____
_____
_____
_____
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Signature:

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II-B. Sample Weekly Safety Report

ProconSAFE

WEEKLY SAFETY REPORT

Project: ___Brucejack Project (Job #484)_____ Week Ending: ____Feb 4, 2018_____

Safety Officer: ___Chris Koebel / John Hovdebo / Nigel Holmes / Jeff DePiero

	Week End	Month End	Y.T.D.	Comments
First Aid	1	1	4	Worker got Hypothermia
Medical Aid			0	
Lost Time			0	
Near Miss			3	
Equip Damage	1	1	9	Cracked screen on remote stand for solo
Environmental			0	

Inspections Completed: _25__ Total Days no LTI: _132_

SAFETY TRAINING:

# Orientations	Names
3	**Luc O'Rielly, Ryan Hudon, Bob Harnum**
# Equipment Sign-Offs	
3	**Jason Hann (1), Randolph Whitedeer (1), Kurt Mroch (1)**
Emergency Services Training (i.e. Mine Rescue, First Aid, Fire Drills…) – Name & Type of Training	
Mine Rescue Training – Kevin Grant	

DAILY TOOL BOX TOPICS:

DATE	D/S Topic	N/S Topic
Jan 29, 2018	Platform Safety	Platform Safety
Jan 30, 2018	Overexertion	Overexertion
Jan 31, 2018	Errors that cause Incidents	Errors that cause Incidents
Feb 1, 2018	Importance of Signs	Importance of Signs
Feb 2, 2018	3 Right's	3 Right's
Feb 3, 2018	Safe Work Habits	Safe Work Habits

Weekly Safety Meeting Date: _____Feb 4, 2018_____

Topic: **Occupational Hygiene Presentation** _

II-C. Procon Scaling Examination & Signoff Training Quiz

Check Scaling Sign Off Sheet

Brucejack Mine

Shift: _____
Month: _____
Level/Heading: _____

Note: By signing the employee agrees that the heading has been check scaled and to the best of his knowledge is safe for travel

Employee Name (print)	Employee Signature	Date
Surpervisor Name (print)	**Supervisor Signature**	**Date**

Comments/Feedback from Crew

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Scaling Examination Task Assessment

Trainee: _____ _____
(Print Name) (Signature)

Location: _____ **Date:** _____

1. The Legislation states that during scaling operations:

(a) Secondary work in the area may continue as usual.
(b) No other work activity shall be conducted in that worksite that may hinder or interfere with the scaling procedure.
(c) Only facemen and rockbolters are required to scale because they are the ones first in contact with fresh rock surfaces.
(d) A scooptram is the best device for sounding ground because it can hit the rock much harder than a scaling bar.

2. While scaling:

(a) Ear muffs and plugs must be worn to protect the worker's hearing from the sound of nearby loud equipment.
(b) Only ear muffs should be worn.
(c) No loud equipment should be running; as these impair the worker's ability to properly sound the rock.
(d) Only ear plugs should be worn.

3. Safety glasses, head, hand, and foot protection:

(a) Should not be worn, as they impair the worker's ability to sound the rock.
(b) Should be worn at all times while scaling.
(c) Are intended for those working in the forestry industry and do not apply to miners.
(d) Make the worker look silly and are not intended to be used.

4. Making and keeping the underground workplace safe from loose by scaling:

(a) Is the responsibility of the mine manager, mine captain and shift bosses.
(b) Is an activity to occupy workers when there's nothing else to do?
(c) Is a waste of time?
(d) Is a necessary and ongoing task and the responsibility of all people working underground?

5. Areas that are secured with rock bolts or screening:

(a) Are permanently safe from loose and never require scaling.
(b) Only require scaling once every five years or after a large rock burst.
(c) Must be inspected and scaled, just like any other area.
(d) Only need to be scaled if your shifter tells you to.

6. A scaling bar should be:

(a) Of the proper length to safely reach the rock being scaled.
(b) In good condition: straight and not too dull.
(c) Any one that you can find. Size and condition don't matter; they all work the same way.
(d) answers (a) and (b)

7. Ground should be scaled.

(a) From good ground to bad.
(b) From the bottom up.
(c) As quickly as possible.
(d) Only if you have time

8. A safe retreat must be maintained while scaling.

(a) Only if practical to do so.
(b) But is not required if worker has more than two years' experience.
(c) During night shift.
(d) At all times. This allows the worker to move out of the way if loose falls or throws scaling bar towards him/her.

9. When scaling, a *safe bed* for loose to fall on.

(a) Refers to an area where material scaled down can safely fall and not roll or slide onto the worker or cause any other injury or damage. A safe bed should be recognized before scaling down any piece of loose.
(b) Is a made-up word that is used to trick new miners? Most experienced miners know that there's no such thing and just laugh when you talk about it.
(c) Is only required when scaling from a scissor-lift or other elevated platform.
(d) Is another way of saying *a bench in a lunchroom*?

10. Pieces of loose which cannot be safely scaled down.

(a) Probably will never fall, and can be left as they are.
(b) Must be chiseled down with a stoper.
(c) Are never found at the Brucejack Project, and so are not of any concern to those writing this test.
(d) Must be roped off to prevent access, and must be reported to supervision so that arrangements can be made to secure the ground by other means such as blasting.

11. Loose ground can always be recognized by.

(a) Glancing at it as you drive underneath.
(b) Labels which are painted on by the engineering department.
(c) The 'drummy' sound it emits when struck directly and firmly with the end of a scaling bar, contrasted by the high-pitch 'ting' sound of a scaling bar striking solid ground.
(d) Checking geology drawings of the area and using these to identify any problems with the rock.

12. Scaling bars of proper length and in good condition must be kept.

(a) Easily accessible while in the work area, and at the entrance to the work area at the end of the shift.
(b) At the shaft station so that they will not be lost or damaged.
(c) In as best condition as possible by minimizing usage.
(d) For special jobs only, such as prying large machine parts from each other, or for use by the millwrights in the crusher.

Mark_____/12

Date: _____ **Training Hours:** _____

Instructor: _____ **Signature:** _____

ProconSAFE

TASK OBSERVATION

Trainee: _____ _____
(Print Name) (Signature)

Location: _____ **Date:** _____

SCALING AND INSPECTION	***Initial each item as evaluated***	
Checks entrance way to work place.	yes _____	no _____
Observes five point safety system.	yes _____	no _____
Wears proper protective equipment.	yes _____	no _____
Selects proper length of scaling bar.	yes _____	no _____
Checks condition of scaling bar.	yes _____	no _____
Sounds the ground and understands the difference between bad/good.	yes _____	no _____
Holds the bar in the proper position (side of body).	yes _____	no _____
Ensures that he/she has a clear space behind for retreat.	yes _____	no _____
Ensures that scaled material will not fall on him/her.	yes _____	no _____
Ensures that the scaled material has a safe bed to fall on.	yes _____	no _____
Proceeds from good ground to bad.	yes _____	no _____
Shows an interest in working productively.	yes _____	no _____
Demonstrates a positive attitude towards safety.	yes _____	no _____

Employee is competent to do this task safely yes_____ no _____

Supervisor/Trainer's Name: _____ **Date:** _____

Employee received training Supervisor/Trainer's Signature: _____

II-D. Procon Safe Operating Procedures for Raise Climber Raising

SUBJECT: ALIMAK RAISE MINING BRUCEJACK UND-DRI-004		PROJECT: BRUCEJACK
EFFECTIVE DATE: JUNE 11, 2017	REVISION DATE: JUNE 26, 2020	PREPARDED / REVISED BY: JASON LI / NIGEL HOLMES

PURPOSE

To establish mandatory requirements for safe and responsible working standards for Alimak Raise Mining. This standard was created to provide consistent and safe operating procedures, for all employees and supervisors, and to comply with Procon Mining and Tunnelling standards, and relevant provincial/territorial mining regulations.

SCOPE

All activities related to Alimak Raise Mining. This includes set up, advancement and emergency procedures.

This procedure applies to all employees, including independent contractors of Procon Mining and Tunnelling.

PERSONAL PROTECTIVE EQUIPMENT

This includes hardhat with reflective stripes, steel toed boots, safety glasses, reflective stripes on outer wear, W65 self-rescuer, 5-point harness, lanyards (self-retracting lifelines), gloves and double hearing protection.

TOOLS AND EQUIPMENT

All gear related to Alimak raise mining: Rails spacer etc., ground support, survey equipment, raise laser, paint, scaling bar, low frequency 2 way radios for communication, glow sticks, air horn, and Ocencos.

RESPONSIBILITY

Site Superintendent is responsible for:

- Ensuring personnel comply with this procedure and that it is maintained.

Mine Supervisors are responsible for:

- Implementing this procedure.

All Alimak Raise Miners are responsible for:

- Being aware of and practicing this procedure, in addition to satisfying themselves of the following:

Have I done my pre-operational check?

Is my equipment/machine in good working condition?

What could fall or roll onto me?

Do I have a clear view of the area?

Is my ventilation sufficient?

Have I checked my work areas for other workers?

Is it safe to start drilling?

Site Safety Coordinator is responsible for:

- Monitoring the implementation of this procedure.

PROCEDURE

- Miners will get prints from Engineering/Survey.
- Check status of work done on previous shift.
- Proceed to Alimak nest to assess work area and perform pre-op inspections on Alimak.
- Ensure that adequate ventilation is provided to all workers in raise/headings. The supervisor will check at the start of every shift for gases and again during the shift.

1.0 ALIMAK MINING

1.1. Setup and Operating

- Only personnel trained and authorized are permitted to setup, maintain, and operate the raise climber.
- Ensure all guide rails have been adequately installed to the rock face and raise climber has been assembled correctly and is properly installed onto the guide rails.
- Check all hose reels are secured anchored and check all fittings/connections/whip-checks. Remove all oil off fittings/connections.
- Inspect all fittings/connections at the automatic air/water central to ensure all is in proper working condition. Check oil level in lubricator.
- Ensure all pathways are clear of obstructions and guide rails are clear of any debris.
- Install and extend guide rails as mining progresses; Ensuring proper expanding bolts are utilized (If poor ground is encountered, utilize longer expanding bolts). Spacers are to be used when the distance between the guide rail and rock face are more than 4” (100mm).
- Ensure trap-door and cage door are closed properly before ascending or descending in the cage. Personnel are to only be transported in the cage; unless maintenance is required on the guide rails.
- Ensure proper signage is in place at the bottom of the raise/workings (“Men Working Above”)

1.2. Scaling/Face Prep

- Proper face preparation and scaling shall be done prior to start of work and after every round.
- Scaling of the face and walls shall be done from under the safety roof on the working platform.
- Wash/clean misfires/bootlegs free and clear of explosives with a non-sparking copper blow pipe.
- Scaling bars of proper length shall be used

1.3. Drilling

- Inspect and check all equipment, hoses, fittings/connections are in good working condition.
- Check air and water lines are flowing freely and clear of obstructions.
- Ensure the stoper/jackleg footing is secure
-

1.4. Loading

- Only personnel trained and authorized as per BC regulations are permitted to handle explosives.
- Remove any materials or equipment that are not being used in the loading of explosives.
- The vehicle used to transport explosives shall meet the British Columbia HSRC requirements listed in 8.4.2 (Vehicle Requirements) and 8.4.3 (Transport of Detonator).
- There will be no smoking while handling, transporting and loading explosives.
- Ensure ventilation is sufficient.
- Clean out and measure all holes to be loaded; mark and have holes re-drilled as required.
- Explosives (daybox) shall only be transported on the raise climber when the face is ready to be loaded.
- If any explosives are believed to be defective, DO NOT USE. Remove from area for proper disposal and contact supervisor.
- Using a proper loading rod, place the booster (as required) and detonator at the designated location in the hole and fill with packaged emulsion (ensuring to adequate tamp each stick of emulsion to ensure hole is filled).
- Once loading has been completed, the blast may now be tied as per the design. Ensure all connections are secure and clear of any water or debris.

1.5. Clearing Gases

- Blasting gases must be cleared from the workings following a blast and prior to resuming work in the raise.
- Access to the automatic header must be maintained in a fresh-air area.

- Open all bypass lines for both water and air to allow a mist to form at the face. The resulting positive pressure will wash and force gases down the raise.
- Check gas levels. Continue to clear gases if gases levels have not reached a safe working level.
- Once gases have cleared, close all bypass valves at the central and notify Shifter once gases have cleared noting the time.

1.6. Scaling/Face Prep

- Following a blast, the fresh face and walls must be scaled of any loose prior to extending the guide rails to reach the face with the raise climber.
- Final scaling of the face and walls must be done under the safety roof. If the distance between the platform and rock wall exceeds 150mm (6”) safety wire and safety railing must be installed.
- Do not scale any large pieces of loose onto the working platform.

1.7. Installing Ground Support

- Ensure to have the latest ground support requirement plans for the raise
- Check to have the correct and competent drill bits, rock bolts, screen, pins, etc. A minimum length of 600mm (3 feet) shall be installed for each round.

2.0 EMERGENCY RESPONSE FOR ALIMAK

- Two (2) Ocencos to be carried with Alimak crew at all times.
- Raise crew will notify if an emergency is occurring by dropping glow sticks.
- One (1) of the two-way radios will be with Alimak crew at all times and the second radio will be located in the nest. Location of the nearest Femco must be noted by the Alimak crew.
- If there is an emergency in the mine and contact with the Alimak crew is required, turn the air off/on/off/on/off slowly in 5 second intervals to let workers know someone is trying to contact them. Then blast the air horn which will signal the Alimak crew to pick up the 2-way radio. (Both low frequency radio and air horn will be located in the nest).
- Communicate with Alimak crew what the problem is.
- **Turn air back on so raise miners can retreat back to nest.**
- A remote activated stench system will be set up at the raise to alert workers of a Code 1 emergency.
- Alicab will be located in a safe and secure area readily available and operational if needed.

2.1 ALI-CAB RESCUE PROCEDURE

In the event that the raise climber breaks down and workers cannot get back to the nest the following procedures must be followed:

- The crew will contact shiftboss or mechanical via Femco.
- Explain the situation and what type of assistance is required (personal injury, mechanical)
- The crew will be advised that personnel and equipment will be travelling up the raise to provide assistance via Femco or radio.
- Mine personnel trained in the operation of the Ali-cab will report to the raise
- Mechanic will remove the stop block to allow the Ali-cab to travel up the raise.
- Install 1" air hose to the header of the Ali-cab (stored in the marked crate)
- Take 2 extra Ocenco's up on the Ali-cab.
- Test run the unit. If all is functioning correctly, load the required tools, parts or emergency equipment onto the Ali-cab and proceed up the raise.
- Upon reaching the disabled climber, contact workers and begin to access the climber.
- Once the necessary repairs have been completed and the raise climber is operational, both units shall return to the nest and a thorough mechanical inspection must be completed.
- If it is a medical emergency, secure scene and make area safe. Treat life threatening injuries and bring injured worker down to nest for transport to surface.

All government mine regulations and company standards must be followed.

The Procon Shift Supervisor and the Procon Project Manager are responsible for implementing and enforcing this procedure. All Procon personnel are to follow this procedure.

REFERENCES AND RELATED DOCUMENTS

- Procon Safety Handbook – UND-DRI-002 (Face Mark up Alimak)
- Procon Safety Handbook – UND-DRI-004 (Alimak Survey)
- Procon Safety Handbook – UND-DRI-005 (Drilling with Jackleg)
- Procon Safety Handbook – UND-DRI-006 (Drilling with Stoper)
- Procon Safety Handbook – UND-DRI-007 (Raise Climber)
- BC HSRC, Part 4, 4.13 (Raise Climbers)

Reviewed By	Print Name	Signature	Date
Pretium Engineer	[redacted]		
Pretivm Mine Captain			
Pretivm Superintendent			
Mine Manager			
Procon Superintendent			
Procon Safety			
Procon Engineer			
Procon Maintenance Coordinator or Designate			
Procon Regional Manager			

REVISION CONTROL SHEET

DATE	Rev. No	NATURE OF CHANGE	PAGE INSERTED, REPLACED, REVISED OR CANCELLED
June 26/20	1	Adjusted emergency response for Alimak	Page 4 - 2
June 26/20	1	Added remote stench on compressed air at Alimak	Page 4 - 2
June 26/20	1	Added Ali-Cab Rescue Procedure	Page 5 – 2.1

II-E. Sample Task Observation Form

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Procon Work Observations (from 6 Point Safety Cards) Weekly Report

Week of September 8-14, 2013

Number of work Observations Completed:
(Requirement is *1 per day* for Supervisors and Safety Officers, *2 per week* for Superintendents)

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	Sept 8/13	Sept 9/13	Sept 10/13	Sept 11/13	Sept 12/13	Sept 13/13	Sept 14/13
Superintendents							
Neil Kraft				2	1	2	1
Roy Edvardsen	1						
Shift Boss							
Bill Cowin			1		1	2	1
Fred Glasgow				1	1		1
Peter Girard	1	1					
Dave Green	1	1					
Master Mechanics							
Barry Pennell	1	1					
Kevin Curtis				1	1	1	1
Safety Officer							
Tom Davidson			1	1	1	1	1
Bill Gerbig	1	1					
YELLOW = Personnel On Site							

II-F. Sample Planned Inspection Form

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PLANNED INSPECTION

Inspection Performed By: Rod Wood Title: Shifter

Site: Brucejack Project (Job #484) Date: Feb 9/18 Shift: **D/S** **N/S**

1. This inspection will be performed **once per rotation** by each of the following personnel:
   - Front Line Supervisor: Shift Boss, Supervisor, Master Mechanic, or Lead Hand, both dayshift and nightshift

2. Place a check mark in the appropriate box in the "Ratings Columns" opposite the area / item being evaluated. If the area / item "Requires Action" classify the identified hazard & allocate sequential hazard letter, either A, B or C. (see table below for letter classifications)

3. Any item requiring "Immediate Action" must be dealt with immediately without delay.

4. After the Inspection form is completed; the form is to be forwarded to the Corporate Safety Office in Burnaby, BC via email - burnabysafety@procongroup.net or fax – 604.291.8292

Hazard Class

A - Any condition/practice likely to cause permanent disability of life/body part and/or loss of structure, equipment, or material.

B – Any condition/practice likely to cause serious injury/illness or property damage that is disruptive but less severe than class "A".

C – Any condition/practice likely to cause non-disabling injury/illness or non-disruptive property damage.

RATINGS COLUMN

Priority Guide **A-** Require immediate action. **B-** Requires action within 3 days **C-** Requires action within 15 days		Not Applicable	Requires Action	Acceptable	Excellent	Class A,B,C
1. Workplace Entrance						
A	Housekeeping		✓			
B	Warning signs in place (brake test before entering portal)			✓		
C	Road Conditions (surface portal entrance)			✓		
D	Warning Signs in place, clean and legible			✓		
E	Seasonal hazards removed/maintained (snow, ice)			✓		
2. Decline Roadway Conditions - General						
A	Ramp roadway conditions (excess muck, boulders on the ramp)			✓		
B	Ground conditions – Visual inspection			✓		
C	Services hung correctly – (from eyebolts utilizing chain)			✓		
D	Ventilation is adequate – Correct distance to face (15 meters)			✓		

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Priority Guide **A-** Requires Immediate Action **B-** Requires action within 3 days **C-** Requires action within 15 days		Not Applicable	Requires Action	Acceptable	Excellent	Class A,B,C
3. SAFEmap Six Point Cards – min. of 10 if applicable to be viewed at time of inspection						
A	Workers have cards available				✓	
B	Six Point Safety Plan is adequately filled out			✓		
C	Risk is identified, Calculated and Risk Level established			✓		
D	Substandard Condition reported / documented (if any)			✓		
E	Procon Work Observation Report completed by Inspector			✓		
4. Mobile Equipment						
A	Pre- Operational Checks performed			✓		
B	Hour Meter readings noted			✓		
C	Defects Identified and Documented			✓		
D	Operator Acknowledgement completed			✓		
E	Brake Tests performed by Operator (demonstrated Brake Test)			✓		
5. Refuge Chamber Weekly Inspections						
A	Air Supply (mine air and O2 Bottles present and operational)			✓		
B	Mine Plans in place and are up to date (no more than 30 days)			✓		
C	Fresh Water – min. of 30 litres		✓			
D	Emergency Equipment – First Aid Kit, Stretcher, etc.			✓		
E	Communication System - Available / Functional			✓		
F	Carbon Dioxide Curtains			✓		
G	Emergency Food / Rations			✓		
H	Chemical Toilet			✓		
I	Doors close and latches securely			✓		
J	Refuge Station Procedures and O2 distribution documents			✓		
K	Refuge Station Log Book (present and updated weekly)			✓		
6. Regulatory Checks and Inspection Items						
A	Worker Training Records (Current and Complete)			✓		
B	Supervisor, Blasting and First Aid Certificates			✓		
C	Operator Log Books completed by operator as required			✓		
D	Emergency Warning Systems (Stench Gas – expiry date)			✓		
E	Carbon Monoxide Detectors (in place and operational)			✓		
F	Training Matrix (current and accurate)			✓		
G	OHSC Representative List - posted and up to date			✓		
H	OHSC Meeting Minutes – posted and current			✓		
I	Ministry Inspection sheets posted			✓		
7. Mine Rescue and Fire Fighting Equipment						
A	Current Mine Rescue and Fire Fighting personnel lists posted					
B	Adequate number of trained personnel as required by regulation					
C	Mine Rescue room in order, tidy, items secure					
D	Mine Rescue Apparatus station tested within required dates					
E	Suitable supply of: Oxygen Bottles, Ice Moulds, Draegersorb, etc					
F	Training being performed as scheduled					

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Priority Guide **A-** Requires Immediate Action **B-** Requires action within 3 days **C-** Requires action within 15 days		Not Applicable	Requires Action	Acceptable	Excellent	Class A,B,C
8. Emergency Escape Routes (if applicable)						
A	Appropriate Signage posted – clear and legible			✓		
B	Doors and Hatches – easily opened, clear of obstructions			✓		
C	Ladders and Landings – Condition? Landings clear of debris?			✓		
D	Ground Conditions – Collar and Hanging Wall			✓		
E	Ladders Extended Past Landing a minimum of One Meter			✓		
F	Areas of Potential Fall Hazards are identified and barricaded			✓		
9. General Housekeeping						
A	Overall Condition of the Workplace			✓		
B	Overall Condition of Storage Areas			✓		
C	Appropriate Signage and Barricades			✓		
D	Fire Hazards Identified or Guarded			✓		
E	No Accumulation of Flammable Refuse			✓		
10. Explosive Magazines and Day Boxes						
A	Appropriate Signage displayed – clear and legible			✓		
B	Explosive Log Books - present and current as per Ministry Regs.			✓		
C	Day Boxes – Explosives and Dets, no more than 24 hr supply			✓		
D	Main Magazines – Inventory must not to exceed allowable limits			✓		
E	Explosive Transportation – Appropriate signs, Non static Liner			✓		
F	Blasting Lines – Hung properly, away from pipe and elect cables			✓		
11. Ground Control						
A	Scaling Bars in all Headings – active or inactive			✓		
B	Adequate Ground Control installed as per client standards			✓		
C	Unsupported Ground – Cleary identified and barricaded			✓		
D	Check Scale program - in effect and documented			✓		
E	Loose Rock cradled in screen, remove and repair			✓		
F	Workers installing Ground Support are adequately trained			✓		
G	Open Holes are clearly identified and barricaded			✓		
H	Pillars – inspected for unravelling or formation of cracks			✓		
I	Shotcreted areas inspected for cracks and failures			✓		
J	Damaged or Loose Screen – repaired or reported			✓		
K	Ground Control Log – Present at Shifters Office			✓		
12. Electrical Installations						
A	Installed as directed in the relevant Provincial or Territorial Reg.					
B	Adequate signage and personnel barriers installed					
C	Housekeeping – clear path of entry, no accumulation of materials					
D	Cables hung as required – clear of any conductive material					
E	Fire Extinguishers of adequate size and type present					
F	Electrical Installations barricaded to prevent vehicle contact					
G	Elevated pad to prevent possibility of water accumulation					
H	Sub Stations are grounded to sill in a minimum of four points					
I	Suitable Illumination					

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Priority Guide **A-** Requires Immediate Action **B-** Requires action within 3 days **C-** Requires action within 15 days		Not Applicable	Requires Action	Acceptable	Excellent	Class A,B,C
13. Surface Buildings and Services						
A	Fuel Distribution Areas – Signage, cleanliness, organization			✓		
B	Oil Storage Facilities – Signage, cleanliness, organization			✓		
C	Surface Shops - cleanliness, organization, hazards identified			✓		
D	Warehousing/Storage areas– Signage, cleanliness, organization			✓		
E	Material Storage - adequate			✓		
F	Entrances and Exits – clearly marked			✓		
G	Lighting – sufficient lighting of the work areas			✓		
H	Fire Extinguishers – sufficient number, tagged and dated			✓		
I	Office Complex – cleanliness, organization			✓		
J	Toilet Facilities – Gender specific, cleanliness, organization			✓		
K	Dry Area – Clean Side, cleanliness, organization			✓		
L	Dry Area - Dirty Side, cleanliness, organization			✓		
M	Laundry Facilities – Available? cleanliness, organization			✓		

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PLANNED INSPECTION – ACTION ITEMS

Inspection Performed By: Rod Wood Title: Shifter

Site: Brucejack Project (Job #484) Date: Feb 9/18 Shift: D/S N/S

Items that are identified during the inspection process that require attention are transferred to the Action Item Sheet. Identify the item by writing the corresponding identification number and letter from the inspection checklist in to the designated column below. Then transfer the Hazard Class to the designated column and explain the hazard.

Item # (i.e. 8C)	Hazard Class (A, B, C)	Give a brief description outlining the concern you have identified	Responsibility Assigned	Date By:	Date Corrected	Super -visor Initial
1	A	Old vent on ground	Rod Wood	Feb 10 2018	Feb 10 2018	RW
5	C	No water in 1335 Refuge	Rod Wood	Feb 9 2018	Feb 9 2018	RW

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Procon
Mining & Tunnelling Ltd.

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Six Point Safety Plan

	EMPLOYEE			SUPERVISOR
1. **Situation:** Check entrance, work area, travel ways	OK	?	No	☐
2. **Arrangements** Check equipment, conditions, tools	OK	?	No	☐
3. **Fellow (employee)** Check people, compliance, risk-taking	OK	?	No	☐
4. **Encourage** Supervisor discuss Risks, Topic	OK	?	No	☐
5. **Today** Safe rest of shift? Other risks in shift?	OK	?	No	☐
6. **Yes** Final check Risks Overlooked, Underestimated, Ignored, Rewarded?				☐

Time 1: _____ Time 2: _____

Risk Finder

PLEASE PRINT CLEARLY

Name	
Date	
Time	
Task	
Where	
Risks noted	
Action taken	
Sign Supervisor	
Sign Superintendent	

Were you injured or are you aware of any incidents? ☐ Yes ☐ No

RISK calculator

Likelihood

- Almost Certain
- Likely
- Possible
- Heard of
- Unlikely
- Almost Impossible

Exposure

- Seldom
- Quarterly
- Monthly
- Weekly
- Daily
- Continuous

Result

- Fatalities
- Serious (LTI)
- Medical
- First Aid

RISK level

9 Refer to Manager
8 Ask a Specialist
7 Discuss with Supervisor
6 Ask a Co Worker
5 Change The Conditions
4 Do the Job Differently
3 Apply Safety Checks
2 Be More Cautious
1 Proceed with Usual Caution

II-H. Procon Six Point Safety Plan Form and Risk Assessment Forms

PROCON SUBSTANDARD CONDITION REPORT

Use this section to report conditions that can potentially cause a loss and to report events that under slightly different circumstances could have resulted in injury, equipment damage, or harm to the environment.

Location: _____

Describe Substandard Condition: _____

_____

_____

_____

What actions did you take?: _____

Is further action required?: _____

Comments: _____

_____

_____

_____

SHIFT REPORT

Work to be performed: _____

_____

_____

_____

Equipment Unit #/Location: _____

Pre-Op inspection complete and recorded in the vehicle log book?: ☐ Yes

Work completed: _____

_____

_____

Equipment Unit #/Location: _____

Pre-Op inspection complete and recorded in the vehicle log book?: ☐ Yes

Work Completed: _____

_____

_____

Employee: _____

PROCON WORK OBSERVATION REPORT

This section is to be used by the Supervisor when observing the employee at work:

Task observed: _____

Is person wearing the required PPE?	Yes ☐	No ☐
Is person using the proper tools/following procedure?	Yes ☐	No ☐
Is the person in the proper position for the task?	Yes ☐	No ☐
Is the person aware of the other tasks being performed nearby?	Yes ☐	No ☐
Is the entrance and travelway to the workplace in good order?	Yes ☐	No ☐
Is housekeeping in good order?	Yes ☐	No ☐
Are the tools and equipment being used in good order?	Yes ☐	No ☐
Is the person using proper techniques/devices/equipment?	Yes ☐	No ☐
Does the person have the proper attitude to work safely?	Yes ☐	No ☐
How does the person respond to corrective suggestions?	Positive ☐	Negative ☐

Additional Comments: _____

_____

_____

_____

_____

_____

_____

_____

Employee: _____

Supervisor: _____

III. Pretium Safety and Ground Control Documentation

III-A. SOP Underground Incident Command Plan

III-B. Rock Bolt Anchor Pull Test Data Sheet

III-C. Sample Geotechnical Inspection Memos

III-A. Pretium Underground Mine Emergency Response Plan

PRETIVM		BJ-OHS-SOP-008 Underground Incident Command Plan	
Owner: ERT Coordinators	**Approver**: H&S Manager	**Revision Number**: 6.0	**Creation Date**: 05/15/2017 **Revision Date**: 04/20/2020

Objective

The Underground Incident Command Plan will describe the actions taken by personnel in the event of any underground issue, emergency, or crisis to ensure:

- Our people are protected against injury or loss of life;
- The potential for asset loss is mitigated;
- Our reputation is protected;
- Damage to the natural and social environment is minimized;
- The community's interests are considered;
- Business continuity and recovery are assured; and
- Legal issues are considered.

In the event of a crisis we must be able to:

- Manage the crisis effectively and professionally, so that we may provide the necessary support and care to all involved personnel, protect the environment, and minimize the impact on our operations and business;
- Help the news media focus on known facts and our positive actions;
- Maintain public and shareholder confidence in our ability to effectively manage the crisis situation; and
- Continue to run the business effectively and efficiently during the course of the crisis.
- This manual has been designed to establish an effective management structure and process that will be readily prepared to support the Underground Incident Command Team, Emergency Response Teams, and Incident Management Teams in dealing with the crisis and to manage the associated sensitive communications issues in the first few critical hours of a crisis situation and the business continuity support thereafter.

If we can achieve these objectives, we will meet our goal of protecting and caring for the people impacted by our activities, as well as protecting the environment and our company's assets. We will also maintain the company's reputation during the crisis and our ability to inspire public confidence in our operations in the future.

Scope

The Underground Incident Command Plan describes the actions to be taken by personnel in the event of an emergency or crisis at the Brucejack Mine Site.

Health, Safety & Reclamation Code of BC

- 3.7.1 – Mine Emergency Response Plan
- 3.7.2 – Mine Rescue, Underground
- 3.4.2 (1)(i) safe work procedures, emergency response plan

Definitions

- MERP – Mine Emergency Response Plan
- PPE – Personal Protective Equipment

Background

Underground Incident Command Plan Context

The Underground Incident Command Plan will describe the actions taken by personnel in the event of any underground issue, emergency, or crisis to ensure:

- Our people are protected against injury or loss of life;
- The potential for asset loss is mitigated;
- Our reputation is protected;
- Damage to the natural and social environment is minimized;
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- Help the news media focus on known facts and our positive actions;
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- Continue to run the business effectively and efficiently during the course of the crisis.

This manual has been designed to establish an effective management structure and process that will be readily prepared to support the Underground Incident Command Team, Emergency Response Teams, and Incident Management Teams in dealing with the crisis and to manage the associated sensitive communications issues in the first few critical hours of a crisis situation and the business continuity support thereafter.

If we can achieve these objectives, we will meet our goal of protecting and caring for the people impacted by our activities, as well as protecting the environment and our company's assets. We will also maintain the company's reputation during the crisis and our ability to inspire public confidence in our operations in the future.

Underground Incident Command Plan Reviews and Updates

Reviews of the Underground Incident Command Plan should occur annually, and/or:

- Whenever enhancements have been identified during the normal course of business;
- Following a Brucejack incident/issue, to incorporate any lessons learnt;
- Whenever any lessons have been learnt from other sources (i.e. mock emergencies or desktop exercises);
- After an employee change which would have a significant effect on an emergency-related team's capability;
- Whenever details on stakeholder contact lists change; and
- After an organizational restructure.

Initial Emergency Actions

At any time, a worker may witness an incident and/or be called upon to assist with an underground emergency. Therefore, it is important that all workers at BruceJack Mine know and understand these initial emergency response procedures.

Declaring an Underground Emergency

CODE ONE – CODE ONE – CODE ONE on surface radio **Channel 2 Repeater 1 U/G radio Channel 1 (All Dispatch), FEMCO phone** or phone call to Dispatch **108** will initiate an emergency. The radio call is received

by Dispatch, at which time they will activate the Emergency Response Team (ERT). All areas at the Brucejack Gold Mine must stand down until told otherwise. Supervisors are responsible for ensuring no one is working in their area. All vehicles will go to the nearest pull out and remain there until instructed by Dispatch.

Refer to BJ-OHS-SOP-004 (Stench Gas Release) for instructions and locations to release the stench. Mill control room operator will be asked to release the stench in the VOK Portal and West Zone Portal.

ALL THE EMERGENCY PROCEDURES IN THIS

MANUAL ASSUME THE CALL HAS

BEEN INITIATED

It is critical to respond to any issue in an appropriate and timely manner to ensure it is resolved as soon as possible, and escalation to crisis level is avoided. When considering the level of activation, it is better to over-react and rapidly de-escalate. It is easier and usually more effective to scale down an over-reaction than it is to ramp-up an under-reaction.

Emergency Response Team (ERT) The Emergency Response Team acts quickly to ensure an effective immediate response to any Underground issue, emergency, or crisis.

The Emergency Response Team:

- Protects human life – provides appropriate medical response and mitigates life threatening situations while minimizing impacts on the environment and operations.
- Is responsible in responding to any level of underground emergency:
  - Fire;
  - Industrial emergencies;
  - Medical emergencies;
  - Technical rescue;
  - Chemical/environmental spills;
  - Mud rush/In rush of water; and
  - Natural disasters.
- Supports the Underground Incident Command Team during and after the initial response.

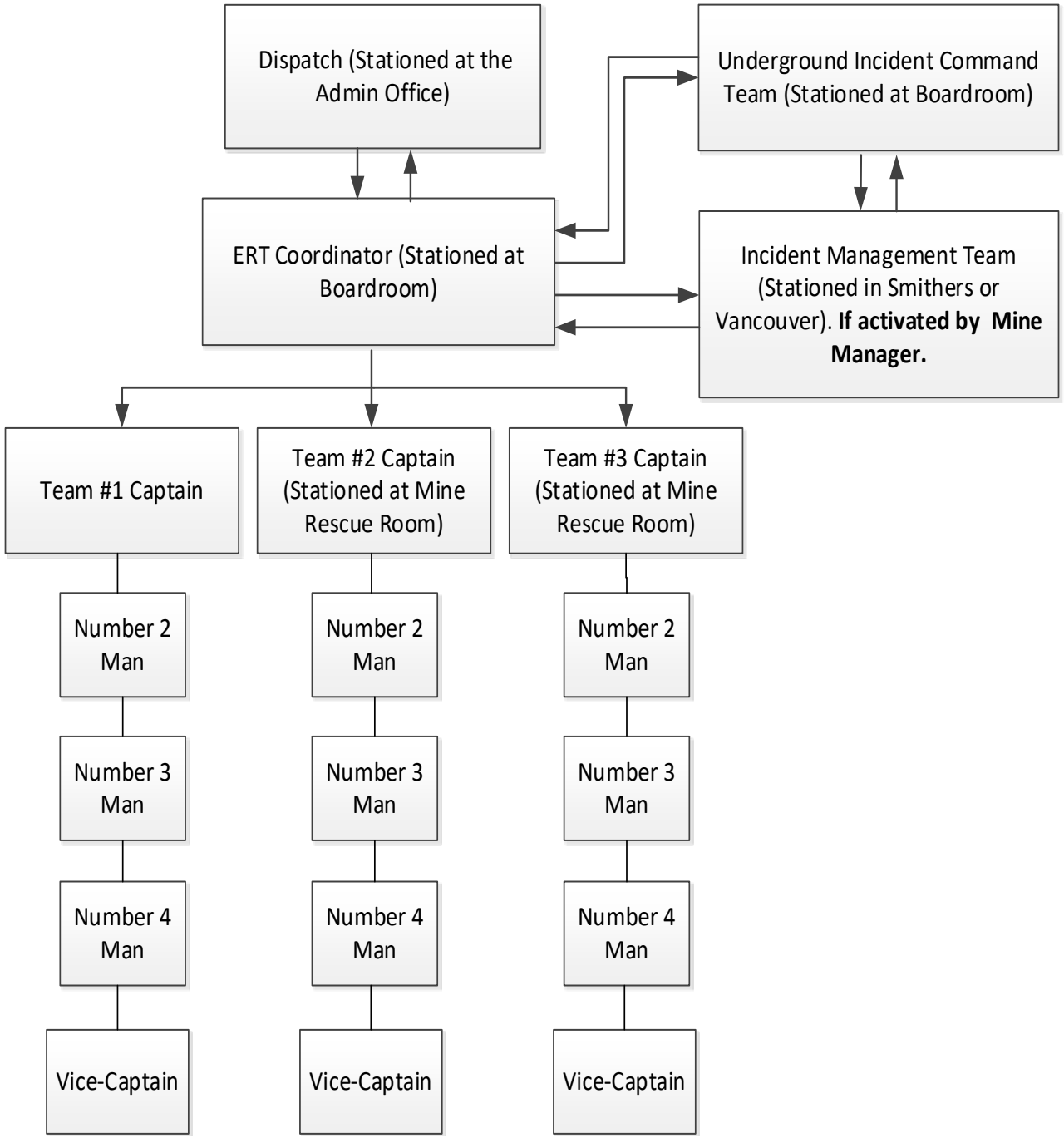
Underground emergencies requiring the ERT can be divided into two main categories; Toxic atmosphere (CCBA required) and non-toxic atmosphere (no CCBA required).

Toxic Atmosphere - A closed-circuit breathing apparatus (CCBA) is required and five ERT members constitute one Team. The ERT Coordinator remains on surface in the Control Room and the team of five complete the rescue work. The ERT Coordinator is the liaison person between the Team Captain and the Underground Incident Command Team. The ERT Coordinator is the sole individual responsible for the operation and direction of the Team(s).

- The Team of five (Team 1) is only allowed to enter the Underground Operations once they have tagged-in, received their brief from the ERT Coordinator, and Team 2 is physically in the mine rescue room.

Non-toxic Atmosphere – As many ERT members and equipment as required will respond to the scene.

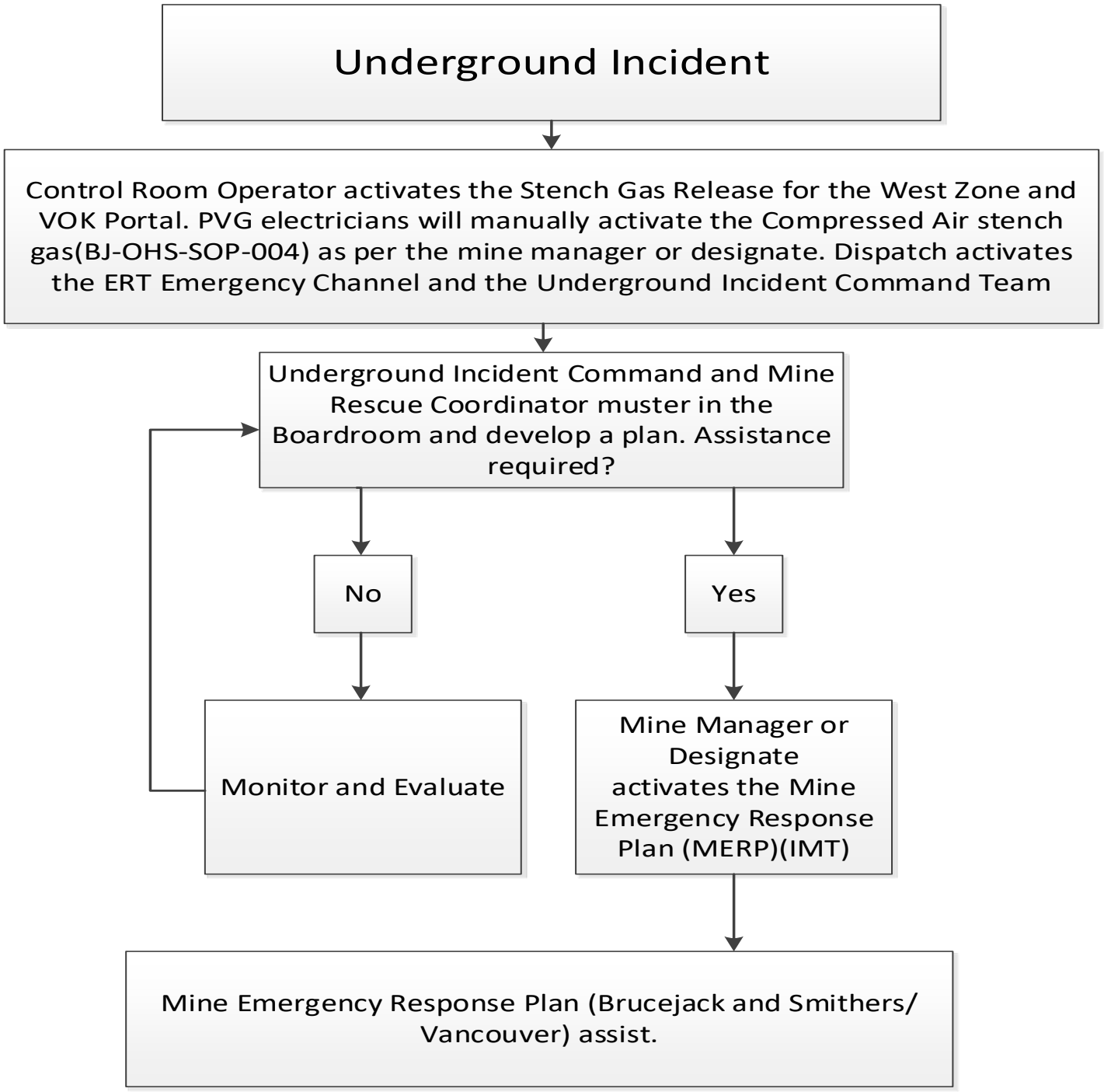
Communication Flow (Incident Command Structure)



Underground Incident Command Activation

As soon as a significant Underground incident, crisis, or emergency is declared, Dispatch will activate the Underground Incident Command Communication System. The Underground Incident Command Team will muster in the Boardroom.

The activation process in an emergency is shown in the Incident Communication Flowchart (see below).



Activation of Mutual Assistance

In response to an emergency, the ERT Coordinator and the Incident Management Team (IMT) Leader will consider the need to request additional resources. The New Gold Mine from Kamloops may be called if necessary to assist in an emergency.

New Gold Mine Kamloops

- Call (250) 377-2770 Health and Safety Manager and state that the call is a mutual aid request for the Mine Manager (or designate)
- If a message is taken for relay (after hours) to the designated person, provide a telephone number that is guaranteed to be answered by the Operations Manager (IMT).

Only the Incident Management Team (IMT) Leader can formally request mutual aid.

Initial Actions

The first person to arrive at the Control Room is to commence preparing the room for the Underground Incident Command Team. As soon as the Underground Incident Command Team convenes, an initial team briefing should be held.

The Incident Commander facilitates the initial briefing. The objectives of this initial meeting are to:

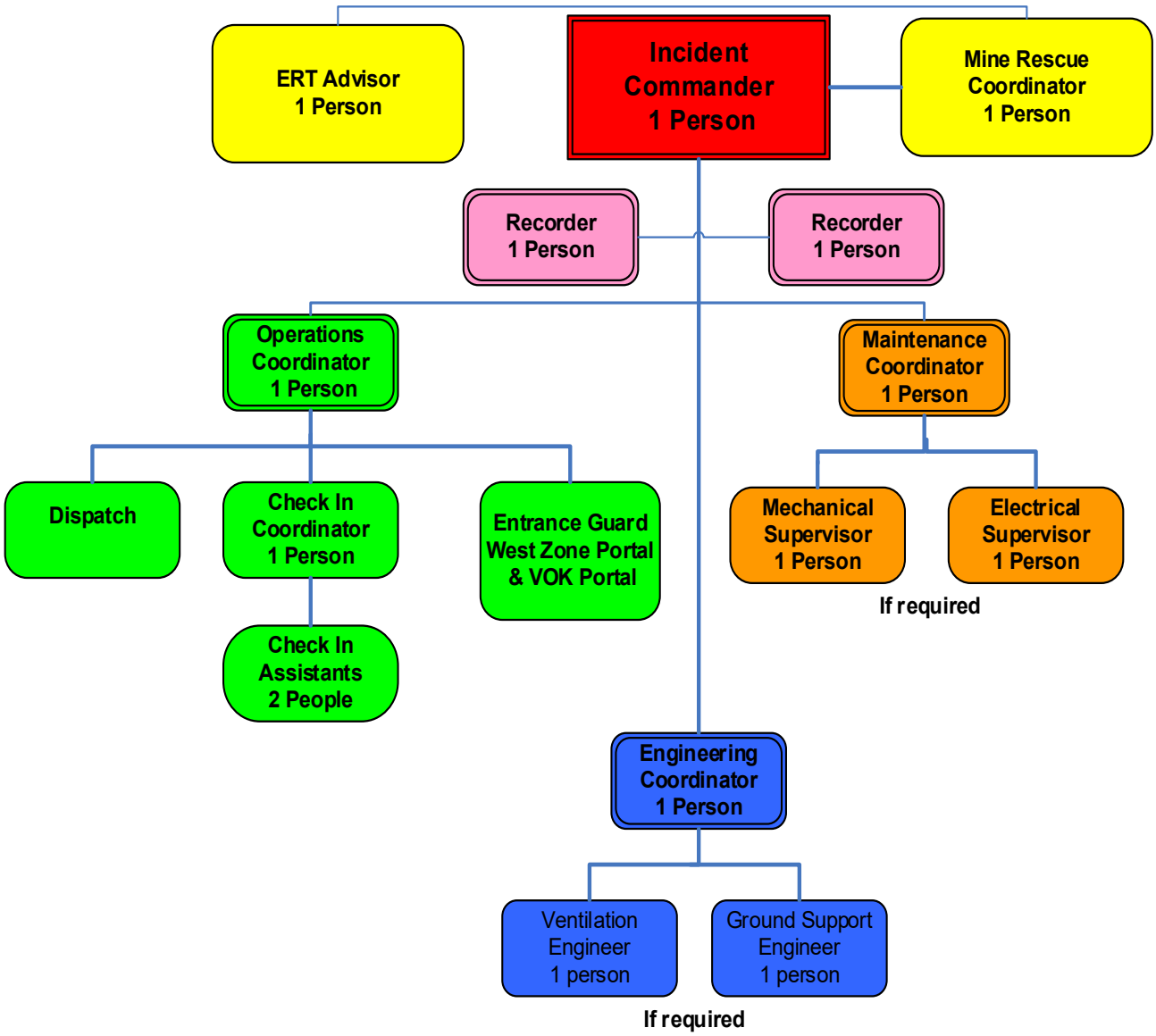
- Introduce members and ensure understanding of their respective roles/responsibilities;
- Review key assignments;
- Brief members on the incident;
- Identify on-scene assistance needed by ERT;
- Identify issues;
- Provide objectives and establish priorities;
- Task members;
- Plan for the worst-case scenario; and
- Identify triggers to recognise escalation towards worst-case scenario;

All Underground Incident Command Team members should commence and maintain an ‘Individual Actions Log’ from activation until the completion of the post-crisis review. The individual actions log (hardcopy) is located in the applicable duty card manila envelope in the Control Room.

Underground Incident Command Team

In addition to Underground Incident Command Team members knowing and understanding their primary roles and responsibilities, it is important that they are familiar with all Underground Incident Command Team roles and responsibilities, as they may be required to fulfil these roles at any time (particularly during the early stage of activation).

Underground Incident Command Structure



The duty card checklist system helps to ensure an effective and timely response to a crisis by guiding team members through the specific activities required of their role on the Underground Incident Command Team. The duty card checklists also enable other employees to replace a designated team member when they are unavailable. Duty card checklists, for each role, are located on the wall in the Control Room in manila envelopes and within this manual.

Key Appointments

It is important to note that the Underground Incident Command structure is only a guide to the functions that may be required to effectively respond to an emergency. Depending on the incident's severity, some groups may only require one appointment to be filled, or may require multiple appointments fulfilling the same role. Similarly, if the situation deteriorates, then the Underground Incident Command structure may require supplementation or, conversely, if the situation improves, then elements of the structure may be 'stood down'.

Incident Commander (Duty Card Checklist #1)

The Incident Commander is responsible for management and decision making in relation to incident assessment and the on-going management of the Underground emergency response. The Incident Commander is the final decision maker in plan development, analysis, selection and execution.

Mine Rescue Coordinator/ERT Coordinator (Duty Card Checklist #2)

The Mine Rescue Coordinator is the ERT Coordinator or delegate senior ERT member and their primary duty is to synchronise the Emergency Response Team(s). The Mine Rescue Coordinator manages and coordinates the ERT while providing quality control and coordination with the Underground Incident Command Team.

The deployment and direction of the Emergency Response Teams is the sole responsibility of the Mine Rescue Coordinator and the proper chain of command must be followed.

Group Coordinators

Group Coordinators provide subject matter expertise to the Incident Commander in decision-making and provide the conduit for the Incident Commander to execute emergency response action plans. The Group Coordinators (Operations, Engineering, and Maintenance Coordinator) are responsible for forming task-oriented teams (if required) and managing those teams to support the overall Underground Incident Command response effort.

ERT Advisor/ Safety (Duty Card Checklist #3)

The ERT Advisor will direct teams from the fire hall and communicate with the ERT Coordinator in the Incident Command Room.

Operations Coordinator (Duty Card Checklist #4)

The Operations Coordinator manages the tasking and application of resources to resolve a crisis or emergency. This is achieved through the management of emergency response activities and by the development and implementation of an appropriate response plan. The Operations Group is led by the Operations Coordinator (Duty Card Checklist #3). The Operations Group includes:

- Underground Dispatch (Duty Card Checklist #7);
- Check-in Coordinator (Duty Card Checklist #8);
- Two (2) Check-in Assistants (Duty Card Checklist #9);
- Two (2) Entrance Guards (Duty Card Checklist #10).

The Operations Group's tasks are to:

- Determine the location and condition of all personnel Underground;
- Verify and ensure proper emergency notification has been activated (Stench, Radio);
- Maintain the communication link between the Dispatch, ERT, and the Underground Incident Command;
- Ensure the Incident Commander has complete situational understanding of an emergency event;
- Maintain records of all actions taken, activities and information;
- Ensure no personnel enter the underground operations;
- Provide subject matter expertise appropriate to the nature of the emergency to the Incident Commander; and
- Advise the Incident Commander of plan options, and assist the Incident Commander in decision making;

Engineering Coordinator (Duty Card Checklist #5)

The Engineering Coordinator is responsible for providing technical assistance to the Incident Commander. If required, the Engineering Coordinator can request a Ventilation Engineer, Ground Support Engineer, or other onsite subject matter expert.

The Engineering Coordinator tasks are to:

- Support the Incident Commander in managing the crisis;
- Provide copies of current ventilation plans. Review plans (utilizing overhead projector) showing mining areas, ventilation flows and controls, refuge stations, escape ways, explosives magazines, etc;
- Inform the Underground Incident Command Team of draw point locations where pre-loading of emulsion and/or ANFO exists;
- Provide technical assistance to the Incident Commander; and
- Maintain records of all actions taken, activities, and information.

Maintenance Coordinator (Duty Card Checklist #6)

The Maintenance Coordinator is responsible for providing any maintenance related issues to the Incident Commander. If required, the Maintenance Coordinator can request a Mechanical Supervisor, Electrical Supervisor, or other onsite subject matter expert.

The Maintenance Coordinator tasks are to:

- Support the Incident Commander in managing the crisis;
- Under the direction of the Incident Commander, identify and work to remedy any maintenance related issues;
- Provide technical assistance to the Incident Commander; and
- Maintain personal records of all actions taken, activities, and information.

Two Recorders (Duty Card Checklist #7)

The Recorder reports to the Incident Commander and is responsible for recording key information and events.

- Record key incident information on the status boards;
- Manage the flow of hard copy information and retain copies for a permanent log;
- Alert other Underground Incident Command members to major changes, issues and outstanding actions;
- Take digital photos of status boards before they are updated;
- Proactively monitor all communications and record pertinent points as they arise; and
- Document all personal actions and decisions in an individual log
- Second recorder will stay with dispatch and record all pertinent information and assist dispatch as necessary

Post Incident:

- Assist with the collection and filing of all documentation from all groups.

Technical and Administrative Support

In the event of an emergency, the Underground Incident Command Team can draw upon the support of employees to provide administrative and technical support and expertise as necessary. The type and scale of the emergency will determine the support required.

Underground Incident Command Team Training

Underground Incident Command Training will be provided for new members joining the team and desktop scenarios will be conducted quarterly.

Underground Incident Management Room

The Control Room is the focal point of the Underground Incident Management Team's emergency response. It is important that the Control Room is well-equipped and organised so the team is best positioned for effective decision-making, able to achieve optimal information sharing, and achieve the best possible outcomes in emergency response.

Activation Pack

The activation pack is a pre-prepared hard plastic case containing stationary supplies, notepads, and other items required upon Underground Incident Command activation. This pack is designed to assist members in fulfilling their duties and responsibilities. If items are used from the pack, team members must notify the ERT Coordinator to refill the contents.

Status Boards

During a crisis, a great deal of information is gathered by the Underground Incident Command Team. In order to accurately capture, display and record this information, standardised status boards located in the Control Room are available for use. These hard copy status boards are rolled up and located in the Control room. The status boards include: Incident Status Board, Event Log, Issues and Actions, and Casualty Information Board.

It is the responsibility of the Recorder to record the information on a status board if appropriate.

Management

The ERT Coordinator is in charge of the management of the Control Room. This responsibility commences well before the occurrence of an emergency event. The ERT Coordinator/ ERT Advisor is responsible for ensuring that the Control Room is stocked with the appropriate duty cards, status boards, copies of the Underground Emergency Response Plan, and other relevant collateral. Additionally, the Engineering Coordinator should monitor the serviceability of IT equipment, communications systems, and room amenity systems.

On standing down the Underground Incident Command Team (Code One is over), the ERT Coordinator is responsible for refurbishing all pre-prepared materials, such as duty cards and checklists, for use in a future event.

Managing Communication

Context

Throughout the period of emergency response, the Underground Incident Command Team is in control of the situation and actions that are occurring Underground and affecting Underground Operations. The success of the response will be determined by the way the Incident Commander manages information, plans, and executes with the direction of the Underground Incident Command Team.

Effective communication in a crisis is critical. An uncoordinated, ineffective response could not only damage the reputation of Pretivm Resources and the Brucejack Mine but also the future viability of the business.

The Incident Management Team (IMT) will manage communication with internal and external stakeholders, not the Underground Incident Command Team.

General Enquires

In the event that Incident Command Team Members or other employees are contacted by someone requesting information or comment about the incident, they should:

- Inform the person that they are not an authorised spokesperson, and as such, they are not in a position to comment.

Standing Down the Response

The Underground Emergency response ends when the ERT Coordinator states 'The Code One is Over' and the transmission is relayed through Dispatch.

Once the emergency response has ended, the Incident Commander will stand down the Underground Incident Command Team and return the Mine to normal operations. In their place, a Mine recovery team may be

required to take control of any Brucejack business recovery effort. On standing down the Underground Incident Command Team, the Incident Commander should detail the state of the business, the work achieved and the intent for the way forward.

Debriefing and Counseling

Debriefing is the process of drawing out lessons learned and imparting advice for improvement to and from engaged staff and priority stakeholders after an event. The Recorder will record the minutes and the information will be passed on to the ERT Coordinator.

Counselling is the provision of personal support and management to people who are exposed to potentially stressful environments or situations. This process is managed by the Human Resources Department (IMT) who may be supported by specialist external providers.

Appendix A – Underground Incident Command Team Personnel

POSITION	PRIMARY	ALTERNATE
INCIDENT COMMANDER	Darryl Ukrainetz (302) Ron Koebel (151)	Paul Nesbitt (383) Ray Swanson (378)
MINE RESCUE COORDINATOR	Travis Murphy (217) Tom Cheveldave (167)	Joel Ashburner (117) Matt McManus (144) Stephanie Nicholls (197)
ERT ADVISOR	Peter Devolder (166) David Elliot (253)	Chris Koebel (431) Nigel Holmes (431)
RECORDER #1	Amissa Funk (339) Susanne Fleming (202) Brock Roadhouse (375) Anthony D. (283)	Koral Bloomfield (131) Christine Daniels (212) Allison Buchhorn (275) Angeline Nyce (264)
RECORDER #2	Nicole Swain (423) Vicki Thistle (340)	Koral Bloomfield (131) Christine Daniels (212) Angeline Nyce (264) Allison Buchhorn (275)
DISPATCH	Cei Sullivan (135), Dispatch (108) Ashley Neuls (326), Jolene Seinen (136)	Joan Good (108) Cassie Ofner (108)
OPERATIONS GROUP		
OPERATIONS COORDINATOR	Les Wentzell (427) Wayne Coles (427)	Jason Li (435), Kevin Grant (435), Jeremiah McFee, Rick Coffill (331), Dean Hynes (236) Gord McDermid (238)
CHECK-IN COORDINATOR	Mike Boem (303) Blaine Eagle (382)	Shannon Dennis (441) Andre Moncion (467) Dave Hodges (323)
CHECK-IN ASSISTANTS	Paulette Wentzell (185) Linda Lamprecht (185)	Fabricio Barrionuevo, Steven Russell Rick Coffill (423)
ENTRANCE GUARDS	Procon employees (Mechanics, Electricians)	
ENGINEERING GROUP		
ENGINEERING COORDINATOR	Tahir Mahmood (262), Daniel Avar (448)	Doug Vis (297) Baoyao Tang (224)
VENTILATION ENGINEER	Paulo Bermudez Gomez *(227)* Mauricio Figueroa (290)	Lyle M. (125) George F. (127) Daniel Avar, Tahir Mahmood (262)
MAINTENANCE GROUP		
MAINTENANCE COORDINATOR	Bill McGill (273), Darren Storm (376), Jarrett Burns (472) Doug Furlinger (343), Lloyd Sturge (252)	John Sheehan (446) David Archibald (270)

INCIDENT COMMANDER DUTY CARD

INCIDENT COMMANDER - **Checklist**		
☐	1)	In the event that there is an Underground CODE 1 **fire** emergency, it is critical that the Underground Emergency warning system is activated without delay, and that the accounting for personnel begins. These Three Actions must be taken FIRST before the Underground Incident Command Team musters: • Ensure the Main fan (WZ and VOK) Stench Gas has been released: • Only if required, have the electricians manually release the stench in the compressed airlines • Ensure Code One was called on all channels (Dispatch is responsible for this action); • Secure the UG tag-in board by placing a guard at the board. Non-fire emergencies require Code One call, and radio message to clear the ramp to the scene.
☐	2)	Ensure the Underground Incident Command Team positions are fulfilled: Operations Coordinator; Engineering Coordinator; Maintenance Coordinator; and Recorders. Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) – 455 Tagboard – 675 U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699 Survey office (Check in – Alternate) – 484 Firehall – 444
☐	3)	Obtain a verbal briefing outlining the incident from the relevant Underground Team Captain and/or ERT Advisor (ext 444 Fire Hall).
☐	4)	Conduct an initial team brief and detail initial response priorities to the Underground Incident Command Team.
☐	5)	Start an individual log, document all personal actions and decisions. Ensure the Recorder has posted the status boards and is recording relevant information.
☐	6)	If the fire is in a heading with charged explosives (Operations Coordinator will confirm) and communicate this with the ERT Coordinator. The ERT Coordinator will instruct the ERT not to

		fight the fire.
☐	7)	In consultation with ERT Coordinator decide on a response plan for the Mine Rescue Team and whether or not to activate the Incident Management Team. Ventilation cannot be changed until the mine manager has approved changes and all personnel are accounted for. As well, everyone must be made aware of the ventilation change.
☐	8)	Determine staging areas for the extra people and traffic that are in the area effected by the code one.
☐	9)	Follow up and monitor assigned responsibilities.
☐	10)	Consult with ERT Coordinator and Mechanical Supervisor to determine if a mechanical inspection of any mobile equipment involved is required prior to calling the Code One over.
☐	11)	In consultation with the ERT Coordinator, decide when the incident is over. The ERT Coordinator will make arrangements for the “Code One Over” message to be relayed and broadcast. Dispatch will receive confirmation from the Incident Commander prior to broadcasting “Code one over”
☐	12)	Ensure all relevant information is entered in Incident Commander Log sheet.
☐	13)	At the conclusion of the incident, sign the Incident Commander log sheets.

Post Incident - **Checklist**		
☐	1)	Ensure the ERT Coordinator replenishes the Duty Card Packets.
☐	2)	Debrief the Underground Incident Command Team and provide feedback.
☐	3)	Confirm recommended changes to the Underground Incident Command Manual and other relevant documents have been completed (ERT Coordinator is responsible).

ERT COORDINATOR DUTY CARD

ERT Coordinator - Checklist		
☐	1)	Coordinate with Incident Commander and Underground Incident Command Team to plan the Mine Rescue Teams actions while underground. Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) – 455 Tagboard – 675 U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699 Survey office (Check in – Alternate) – 484 Firehall - 444
☐	2)	Brief Mine Rescue Team 1 on incident and plan of action. When Team 2 is travelling to Underground, Team 1 will get under air. Once Team 2 enters the Underground surface building, Team 1 can commence with their rescue operation.
☐	3)	Record all actions and orders given to Mine Rescue Team in your action log. Record the time Team 1 enters the underground in the ERT Coordinator Logbook (Approximately 1 bar for every 1 minute Underground with the BG4). Check in every 15mins and record all air supply levels of the team.
☐	4)	Maintain contact with Mine Rescue Team while underground and provide direction as required. Always follow the Mine Rescue Principals in order: Safety of the team; Safety of the trapped/injured; Protection of mine property; Rehabilitation of mine property.
☐	5)	Consult with Incident Commander and Mechanical Supervisor to determine if a mechanical inspection is required prior to calling the Code One over.
☐	6)	Check with Incident Command on areas underground where pre-loading of emulsion explosives are located. **NOTE: Under no circumstances will the Mine Rescue Team fight fires in a heading with charged explosives**
☐	7)	Contact Incident Command to relay 'The Code One is over' once the final Team is finished.
☐	8)	Replenish incident command cards

Post Incident- Checklist		
☐	1)	Debrief with ERT members at the Fire Hall.
☐	2)	Follow-up with Incident Commander and Engineering Coordinator on the Underground Incident Command Team debrief. Gather notes and action items.

ERT ADVISOR DUTY CARD

ERT Advisor - Checklist		
☐	1)	Gather cap lamps, tag-in cards, and W65's for incoming teams.
☐	2)	Report to Dispatch (108) or ADMIN CH 1 (ERT CHANNEL) when ERT arrives at the Fire Hall (both Team 1 and 2).
☐	3)	Brief Mine Rescue Team 1 on incident and plan of action. When Team 2 is travelling to Underground, Team 1 will get under air. Once Team 2 enters the Underground surface building, Team 1 can commence with their rescue operation.
☐	4)	Contact ERT Coordinator via Channel 1 (ERT Channel) Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) – 455 Tagboard – 675 U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699 Survey office (Check in – Alternate) – 484 Firehall - 444
Post Incident- Checklist		
☐	1)	Debrief with ERT members at the Fire Hall.
☐	2)	Follow-up with Incident Commander and Engineering Coordinator on the Underground Incident Command Team debrief. Gather notes and action items.
☐	3)	Collect all information from rescue and make any necessary changes to procedure.

OPERATIONS COORDINATOR DUTY CARD

Operations Coordinator - Checklist		
☐	1)	Record all relevant information in the Operations Coordinator log sheet.
☐	2)	Oversee all immediate needs of the Incident Commander.
☐	3)	Assign the following responsibilities: Check-in Coordinator – Name: Mine Entrance Guards – Names: West Zone portal guard: VOK portal guard: Office Entrance Guard(security) – Name: Door guard: Transportation Coordinator (not required unless operation is extensive) Transportation Coordinator name:
☐	4)	Confirm with ERT Coordinator to ensure the Underground Mine Rescue Team has been notified and all necessary radio calls have been made.
☐	5)	If applicable, barricade or post guards at the incident area to prevent any unauthorized access and remove all non-essential personnel.
☐	6)	Brief and keep the Incident Commander informed. This communication must include any area that has the potential for explosives.
☐	7)	Monitor assigned responsibilities.
☐	8)	Sign the Operations Coordinator log sheet and return to Recorder when emergency is over.

Post Incident - Checklist		
☐	1)	Participate in the post crisis review
☐	2)	Evaluate the effectiveness of the Underground Incident Management Team during the response and implement any necessary changes to the room or associated procedures

ENGINEERING COORDINATOR DUTY CARD

Engineering Coordinator - Checklist		
☐	1)	Set up personal work station. Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) – 455 Tagboard – 675 U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699 Survey office (Check in – Alternate) – 484 Firehall - 444
☐	2)	Enter all relevant information on the Engineering Coordinator log Sheet.
☐	3)	Assign a Ventilation Engineer and provide instructions and support throughout the incident.
☐	4)	Provide copy of current ventilation plans. Review plans showing mining areas, ventilation flows and controls, refuge stations, escape ways, explosives magazines, etc.
☐	5)	Provide technical assistance to the Incident Commander.
☐	6)	Ensure main surface fans are operating as required.
☐	7)	Follow up and monitor all assigned responsibilities.
☐	8)	Sign the Engineering Coordinator log sheet and return to the Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups. Pass the information onto the ERT Advisor.
☐	2)	Participate in the post-crisis debrief.
☐	3)	Ensure allocated post-crisis follow-up actions are completed.

MAINTENANCE COORDINATOR DUTY CARD

Maintenance Coordinator - Checklist		
☐	1)	Assign Mechanical Supervisor and Electrical Supervisor, if required: Name of Mechanical Supervisor: Name of Electrical Supervisor:
☐	2)	Confirm that Stench at the main fans has been released (by radio). Only if required , check to make sure the stench gas has been released in the compressed lines.
☐	3)	Report to Incident Commander that stench has been released.
☐	4)	Under the direction of the Incident Commander, identify and work to remedy any maintenance related issues.
☐	5)	Discuss with the ERT Coordinator the need to have a mechanic inspect equipment involved in the incident prior to calling the Code One over.
☐	6)	Record relevant information in the Maintenance Coordinator log sheet.
☐	7)	Sign the Maintenance Coordinator log sheet and return to Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Participate in the post crisis review
☐	2)	Evaluate the effectiveness of the Underground Incident Management Team during the response and implement any necessary changes to the room or associated procedures
☐	3)	Provide a list of what equipment is locked out and/or need repair.

RECORDER DUTY CARD #1

Recorder - Checklist		
☐	1)	Set up personal work station and start recorder.
☐	2)	Record key incident information on the event log and/or the status boards (rolled up poster sheets located in the auxiliary room). This must include times.
☐	3)	Update the status boards and manage administrative functions.
☐	4)	Manage the flow of hard copy information and retain copies for the permanent log.
☐	5)	Assist the Incident Commander in record keeping.
☐	6)	Alert team members of major changes, issues and outstanding actions.
☐	7)	Take digital photos of status boards before they are updated.
☐	8)	Proactively monitor all communications and record pertinent points as they arise.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups.
☐	2)	Participate in the IMT post-crisis interview.
☐	3)	Assist with refurbishing the Incident Management Room back to a ready state.

RECORDER DUTY CARD #2

Recorder - Checklist		
☐	1)	Set up personal work station.
☐	2)	Record key incident information on the event log. This must include times.
☐	3)	Assist Dispatch in all aspects.
☐	4)	Manage the flow of hard copy information and retain copies for the permanent log.
☐	5)	Record all pertinent information from radio and telephone communication
☐	6)	Alert team members of major changes, issues and outstanding actions.
☐	7)	Take digital photos of information received
☐	8)	Proactively monitor all communications and record pertinent points as they arise.
Post Incident - Checklist		
☐	1)	Assist with the collection and filing of all documentation from all groups.
☐	2)	Participate in the IMT post-crisis interview.
☐	3)	Assist with refurbishing the Incident Management Room back to a ready state.

DISPATCH DUTY CARD

Dispatch - Checklist		
☐	1)	If an underground emergency is called on any UG channel, immediately relay the message without delay to Senior Management as per site extensions. Ch2 days Event: _____ Location of Event: _____ Person Reporting Event: _____ Injuries: _____ Required Phone Numbers: Main Camp Boardroom (UGIC) – 640 Boardroom (IMT) – 455 Tagboard – 675 U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699 Survey office (Check in – Alternate) – 484 Firehall - 444
☐	2)	If it is a medical emergency, inform all personnel on all underground channels to clear all ramps to the incident scene.
☐	3)	Monitor channel “all dispatch” and record any information in the Dispatch logbook.
☐	4)	If calls are received from a refuge station to report people present tell the caller that someone will contact them shortly. If the caller has information regarding the emergency record on log sheet. Relay information to Operations Coordinator.
☐	5)	Relay relevant information received from the UG channels to the Operations Coordinator.
☐	6)	When requested, provide any information on the location of personnel or equipment to the Operations Coordinator.
☐	7)	Record relevant information on Dispatch log sheet.
Post Incident - Checklist		
☐	1)	Participate in the IMT post-crisis interview

CHECK-IN COORDINATOR DUTY CARD

Check-In Coordinator - Checklist		
☐	1)	Start your Check In Coordinator log sheet. Required Phone Numbers: Boardroom – 640, Boardroom (IMT) – 455, Tagboard – 675, U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699, Survey office (Check in – Alternate) – 484, Firehall - 444
☐	2)	Designate the West Zone shop area and VOK Portal entrance as the muster area.
☐	3)	Assign one of the people mustering to direct, supervise & monitor personnel in the muster area. Instruct them to ensure all personnel remain in the muster area. Name: _____ Assign one Tag Board Check-In Assistant to oversee/guard the tag board. Instruct them not to let anyone remove a tag from the board until all workers are accounted for and the Check-In Coordinator has given approval. Tag board check in assistant:_____
☐	4)	Install the TAG BOARD “NO ENTRY” BARRICADES around the tag board to prevent persons from entering the TAG BOARD area.
☐	5)	Assign two Refuge Station Check-In Assistants. Designate each person specific refuge stations. Distribute refuge station records accordingly.
☐	6)	Delegate two Check-In Assistants to sit in the Shifter’s office to start call ins. Refuge Station Check-In Assistants #1: Refuge Station Check-In Assistants #2: Ensure the Check-In Assistants have their appropriate Refuge Station Check-In sheets (#1 and #2). The refuge stations are split up between Assistants to increase efficiency.
☐	7)	Monitor and direct the activities of the Check-In Assistants and UG Office muster area.
☐	8)	Provide a list of personnel accounted and unaccounted for and any Refuge Stations that were not contacted to the Operations Coordinator
☐	9)	Inform Operations Coordinator when all personnel are accounted for.
☐	10)	Release persons in the UG Offices muster area once the Code One is over.
☐	11)	Ensure all relevant information is entered in Check-In Coordinator log sheet, sign, then give to the recorder.
Post Incident - Checklist		
☐	1)	Participate in the IMT post-crisis interview

CHECK-IN ASSISTANT DUTY CARD

Check In Assistant - Checklist		
☐	1)	Use the REFUGE STATION RECORD sheets to phone all assigned refuge stations and record the name, employer/company name, refuge location, and condition of all personnel. Repeat the names to the refuge station attendant for verification. Ensure to include the refuge station attendant name. If a refuge station cannot be contacted by phone inform the Check-In Coordinator who will provide a radio. Attempt to contact the refuge station on radio channel 1, 2, and 3. Use a separate sheet for each refuge station and circle the refuge station location at the top of the sheet. Required Phone Numbers: Boardroom – 640, Boardroom (IMT) – 455, Tagboard – 675, U/G refuge 1335 – 676 Safety Training Room (IMT Alternate) – 699, Survey office (Check in – Alternate) – 484, Firehall - 444
☐	2)	After all refuge stations have been contacted once, take the REFUGE STATION RECORD to the tag board and read the names one at a time to the Tag Board Check in Assistants. The Tag Board Check in Assistant will flip the tags as you read them. The Refuge Station Check in Assistant will mark an X in the column on the REFUGE STATION RECORD beside the person's name to indicate their tag has been flipped. Once all names have been read from the Refuge Station Check in Assistants list, compile a list of people not accounted for and notify the Check-In Coordinator.
☐	3)	Return to designated office and contact all the refuge stations again for any new arrivals. Repeat process at tag board of confirming names and flipping tags.
☐	4)	Provide a list of personnel unaccounted-for to the Check-In Coordinator.
☐	5)	Follow all directions from the Check In Coordinator.
☐	6)	Record all relevant information in the Refuge Station Check in Assistants Log sheet
☐	7)	Sign the Refuge Station Check in Assistant's Log sheet and return all paperwork to Recorder when emergency is over.
Post Incident - Checklist		
☐	1)	Attend the incident post-crisis review

ENTRANCE GUARD DUTY CARD

Entrance Guards - Checklist		
☐	1)	There are two locations that need to be guarded: West Zone Portal; VOK Portal; The Operations Coordinator will brief the two individuals with all pertinent information.
☐	2)	Obtain communications radio (Channel 2 RPT 1) and proceed to your designated location.
☐	3)	Record all relevant information in the Entrance Guard log sheet.
☐	4)	Position yourself, or vehicle: West Zone Portal - In a location that allows visual surveillance of the portal without being exposed to mine exhaust flow. VOK Portal - In a location that allows visual surveillance of the portal without being exposed to mine exhaust flow.
☐	5)	Stop anyone: West Zone Portal – Who attempts to enter the mine via the West Zone Portal. Contact Operations Coordinator to advise. VOK Portal – Who attempts to enter the mine via the VOK Portal. Contact Operations Coordinator to advise.
☐	6)	Identify anyone who exits the mine via the West Zone or VOK Portal. Contact the Operations Coordinator (Channel 2) to request transportation or first aid treatment of personnel exiting the mine.
☐	7)	Follow all directions from the Operations Coordinator.
☐	8)	Duties are not relieved until the Operations Coordinator instructs you to leave your post.
☐	9)	Sign the entrance guard log sheet and return to Underground Incident Command Team when emergency is over.

Appendix B - Response Procedures

Protocols

The aim of the following protocols is to describe the issues/actions to be considered during a particular type of Underground Emergency. Many of these actions are the responsibility of the Underground Incident Command Team and/or the Incident Management Team (IMT). All incidents are different and these generic protocols will have to be adapted accordingly. It is the role of the Incident Commander to agree the optimum way to manage and respond to any incident to save and safeguard life, protect the environment, and minimize damage property.

Major Underground Explosion

BUSINESS ISSUES

- Safety of personnel;
- Evacuation, reception, support of personnel;
- Infrastructure impacts; and
- Company image/reputation;

IMMEDIATE ACTIONS

The ERT Coordinator will ensure the following is completed:

- Team 1 (five ERT members) will conduct a bench test of their BG4 breathing apparatus at the ERT hall and prepare the underground ambulance for response.
- Team 2 (five ERT members) will conduct a bench test and be backup for Team 1. Team 2 will respond in the rescue truck.
- Team 3 (five ERT members) will standby and backup Team 2 if dispatched.

Teams must have a full back-up Team before responding to major unexpected explosions.

MAINTAINING THE RESPONSE

- Underground Incident Command Team assembles and emergency duty card checklist system is implemented;
- The Incident Management Team (IMT) will be contacted and respond to this type of emergency. Mine Manager makes the call;
- Medic prepares to receive casualties and ambulance and other vehicles capable of transporting injured.
- Important information required if achievable from initial reports, area supervision, drawings and/or from refuge station witnesses:
    - Are there any injuries and number of people not accounted for?
    - The source and location of the explosion if known.
    - Are there any hazards in the area (open holes, explosives, fuel, vehicles not secured, equipment parked on an incline, fire beyond control, air lines, power cables, electrical sources)?
    - Location and status of auxiliary fans and mine services.
- The Underground Incident Command Team obtains adequate information from all possible resources on the nature of the incident;

- The safety of the ERT is number one priority and the first consideration is the route of travel and when and where to report back;
- If possible the team should always be directed to travel in the best air or on the intake side of the explosion and potential fire;
- The ERT Coordinator, with input from the Underground Incident Command Team, is to complete the initial response plan;
- Team 1 receives directions from the ERT Coordinator. Team 1 tags-in and is on standby until given the go ahead to enter the mine from the ERT Coordinator.

Team 1 explores the mine and reports back information as required to the ERT Coordinator.

- Key information (signs of smoke or fire, gas readings, ventilation direction/speed, personnel encountered and injuries;
- Information is transmitted by Team 1 and gathered by the Underground Incident Command Team for continued review of response requirements.

If a fire has been ignited by the explosion and the fire can be easily extinguished, the ERT will extinguish the fire. The casualties in the area will be treated and transported to a refuge.

If the fire is beyond control of the team and there are casualties in the area, the injured will be evacuated prior to extinguishing the fire.

If the fire is not extinguished in Team 1's time frame, Team 2 will be deployed to continue the work.

- This will require Team 3 to bench and prepare to be Team 2's back up. Team 1 will clean up and rest.
- The three teams can cycle two (2) hour shifts under CCBA.
- Once it has been determined that the fire extends beyond 6 hours, the Incident Management Team will activate mutual assistance.

Once the fire is out and patients are taken to safe area and treated, the Underground Incident Command Team will derive a plan to check all areas of the mine to ensure that the smoke is clear and safe to evacuate the people from the refuge stations to surface.

- Derive plan to check all effected ventilation areas;
- Fire watch stationed at fire location ensuring it stays out (CCBA required);
- ERT completes all checks and safety routes as required;
- Underground Incident Command gives approval to release refuge station occupants and to report to surface.

Gas tests will be conducted behind any seals to determine that there are no longer signs of combustion before tearing down and rehabilitation of the affected area.

- Underground Incident Command requests gas sampling from ERT under CCBA until all signs of combustion are no longer present;
- Once safe, request ERT to remove seals under CCBA and vent out smoke;
- Tape off area for incident investigation;
- Equipment salvaged and area rehabilitated.

Equipment/Personnel Down Open Hole

IMMEDIATE ACTIONS

The ERT Coordinator will ensure the following is completed:

- ERT respond with mine rescue vehicle and underground ambulance;
- ERT will tag-in and respond underground;

- ERT Coordinator will be on scene and in communication with the Underground Incident Command Team via radio.

MAINTAINING THE RESPONSE

Important information required from initial reports, area supervision, mine plans, and or from eye witnesses:

- Number of personnel involved;
- Location and depth of fall;
- Equipment involved;
- Any other known hazards;
- Obtains adequate information from all possible resources on the nature of the incident and commence a response plan; and
- Underground Incident Command Team may requests a radio message sent out to have all underground personnel report to refuge stations for a head count and stand by for assistance.

Rescue methods from the top of the hole:

- Lower rescuer(s) and basket utilizing MPD system with 540 safety belay. If patient is uninjured, lift with harness. If the patient is injured, utilize basket. Anchor could be ground supports, scoop bucket or any other suitable available anchor.
- If the hole is small in diameter, utilize tripod system.

Rescue from the bottom:

- Requires mucking out and pulling with LHD equipment to get the victim out. Utilize rope and rigging horizontally to pull patient out;
- May require vehicle extrication tools to cut and lift materials out of the way.

Precautions to consider:

- Loose materials around the open hole;
- Loose on the walls and back above the open hole. (Clear all loose before entering the hole and without knocking materials down onto patient on descent);
- Wedged equipment in the hole begins to fall further. (Rescuers and victims attached to safety lines at all times).

The ERT Coordinator and designated senior mining person on scene will coordinate with the Underground Incident Command Team to support, remove materials, and equipment for the rescue of trapped person(s).

Once the area is safe to proceed ERT members will extract victims utilizing rescue tools and equipment as required. Once rescued, the casualties will be transported to the Medic's clinic.

Ground Fall (Personnel Trapped or Missing)

IMMEDIATE ACTIONS

The ERT Coordinator will ensure the following is completed:

- ERT respond with rescue truck and underground ambulance;
- ERT will tag-in and respond underground; and
- ERT Coordinator will be on scene and in communication with the Underground Incident Command Team via radio.

MAINTAINING THE RESPONSE

Important information required from initial reports, area supervision, mine plans, and or from eye witnesses:

- Number of personnel involved;
- Location and size of ground fall;
- Equipment involved (buried, pinned, stuck); and

- Any other known hazards;

This type of incident may require an assessment in the field involving the ERT Coordinator, Underground Ground Support Engineer, Shift Supervision, and/or Senior Mine Personnel to determine requirements at the scene. The area will be required to be made safe before responding.

Depending on the extent of the ground fall, the rescue could take a relatively short period of time with minimal equipment (rescue airbags) or several hours/days (requiring ground support and removal of several tons of material). If the fall is extensive, a designated Senior Mining Engineer on scene will coordinate with the Underground Incident Command Team, mining operations, and rescue teams to support, remove materials, and equipment for the rescue of trapped person(s).

- Once the area is safe to proceed ERT members will extract victims utilizing rescue tools and equipment as required; and
- Once rescued the victims will be handed over to the Medic.

Injured Underground Personnel

IMMEDIATE ACTIONS

The ERT Coordinator will ensure the following is completed:

- Location of the incident is safe from toxic hazards (i.e. oxygen depletion, gases, etc.). This will be conducted with a MX4 gas detector;
- ERT respond with underground ambulance and rescue truck;
- ERT tags-in and enters portal to scene without delay;
- ERT on scene. ERT Coordinator will be on scene and in communication with the Underground Incident Command Team via radio.
- Extrication and treatment completed;
- ERT transports injured to medic's Clinic;
- Incident scene taped off for incident investigation.

MAINTAINING THE RESPONSE

Investigation required and hazards eliminated before work commences.

Underground Fire (Fixed or Mobile)

BUSINESS ISSUES

- Safety of personnel;
- Evacuation, reception, support of personnel;
- Infrastructure impacts; and
- Company image and reputation.

IMMEDIATE ACTIONS

The ERT Coordinator will ensure the following is completed:

- Team 1 (five ERT members) will conduct a bench test of their BG4 breathing apparatus at the ERT hall and prepare the rescue truck for response.
- Team 2 (five ERT members) will conduct a bench test and be backup for Team 1. Team 2 will respond in the UG ambulance.
- Team 3 (five ERT members) will standby and backup team 2 if dispatched.

Teams must have a full backup Team before responding to any toxic atmosphere emergency.

MAINTAINING THE RESPONSE

- Underground Incident Command Team assembles and emergency duty card system is implemented;

- If the event is serious, the Incident Management Team will be contacted and respond to the emergency.
- Medics prepare to receive casualties and ambulance and other vehicles capable of transporting injured.
- Important information required (area supervision, information from refuge station witnesses);
- Are there any injuries and number of people not accounted for?
- The source and location of the fire if known;
- Are there any hazards in the area (open holes, explosives, fuel, vehicle not secured, unit parked on an incline, fire beyond control, air lines, power cables, electrical sources);
- Location and status of auxiliary fans and mine services;

The Underground Incident Command Team utilizes the duty card checklist system and gathers all available and pertinent information to aid in an initial response plan for the ERT.

- The safety of the team is number one priority and the first consideration is the route of travel and when and where to report back;
- If possible the team should always be directed to travel in the best air or on the intake side of the fire;
- The ERT Coordinator with input from the Underground Incident Command Team will complete the initial response plan; and
- Team 1 receives directions from the ERT Coordinator. Team 1 tags-in and is on standby until given the go ahead to enter the mine from the ERT Coordinator.

Team 1 explores the mine and reports back information as required to the ERT Coordinator.

- Key information (signs of smoke or fire, gas readings, ventilation direction/speed, personnel encountered and injuries); and
- Information is transmitted by Team 1 and gathered by the Underground Incident Command Team for continued review of response requirements.

If the fire is beyond control of the team, a plan of attack will be planned and agreed upon by the Underground Incident Command Team and ERT Coordinator.

Precautions when fighting mobile equipment or fixed structure fires:

- Burning tires may explode (If this is the case the team must retreat out of the area until the tires have exploded);
- Service airlines may burst. Teams will be required to maintain distance from service air lines;
- Energized power cables, transformers, substations, etc (power may be required to be turned off at the heading or substation);
- Poor visibility for ERT members. Teams may not be able to safely advance towards the fire if on the exhaust side;
- Hydraulic oil, diesel fuel, and motor oil on the equipment; and
- Loose created by the fire or if located in an unsupported area.

Methods of directly fighting the fire:

- Utilize hand held fire extinguishers;
- Utilize mine water services and water hose;
- Seal off the heading with muck and burlap to create a seal. Seal intake first if ventilation flows through;
- Erect light seal and fill with foam using high expansion foam generator; and
- If everyone is accountable and safe in refuge stations let fire burn out on its own. If the fire is beyond control of the team and there are casualties in the area the injured will be evacuated prior to extinguishing the fire.

If the fire is not extinguished in Team 1's time frame, Team 2 will be deployed to continue the work.

- This will require Team #3 to bench and prepare to be Team #2 backup. Team #1 will clean up and rest;
- The three teams can cycle 2 hour shifts under CCBA;
- Once it has been determined that the fire extends beyond 6 hours, the Incident Management Team will activate mutual assistance;

Once fire is out and patients are taken to safe area and treated, the Underground Incident Command Team will derive a plan to check all areas of the mine to ensure that the smoke is clear and safe to evacuate the people from the refuge stations to surface.

- Derive plan to check all effected ventilation areas;
- Fire watch stationed at fire location ensuring it stays out (CCBA required);
- ERT completes all checks and safety routes as required;
- ERT verifies all routes are safe to travel;
- Underground Incident Command gives approval to release refuge station occupants and to report to surface.

Gas tests will be conducted behind any seals to determine that there are no longer signs of combustion before tearing down and rehabilitation of the affected area.

- Underground Incident Command request gas sampling from ERT under CCBA until all signs of combustion are no longer present;
- Once safe, request ERT to remove seals under CCBA;
- Ventilate smoke (all personnel accounted for) ;
- Tape off area for incident investigation;
- Equipment salvaged and area rehabilitated.

Mud Rush or In Rush of Water

IMMEDIATE ACTIONS

Ensure all Underground employees are notified.

Important information required from initial reports, area supervision, Geotechnical services, and/or from eye witnesses:

- Is it safe to enter the mine and look for missing people?
- Is the mud rush contained to the level?
- At what rate is the water rising and last known elevation level?
- How many people are missing and last known location(s); and
- Any other known hazards.

Underground Incident Command obtains adequate information from all possible resources on the nature of the flooding and commences a response plan.

The ERT Coordinator will ensure the following is completed:

- ERT respond with mine rescue vehicle and underground ambulance to the portal area.

MAINTAINING THE RESPONSE

This type of incident requires careful assessments of dangers that may be encountered by rescue teams should people be unaccounted for and or are in need of help to evacuate the mine.

- ERT Coordinator and Underground Incident Command Team reviews rescue plan and makes final decision on route of travel and response;
- ERT Coordinator gives permission for Team 1 to enter and explore the mine for missing workers. Team 1 is only allowed to enter the Underground Operations once they have tagged-in, received their brief from the ERT Coordinator, and Team 2 is physically ready as backup;

- Mine rescue teams explore mine by safest route and reports conditions encountered on way to last known location of missing worker(s) provided it is safe to do so;
- Trapped or missing personnel extricated and transported to surface as soon as possible;
- ERT transports injured to First Aid room.

Vehicle/Equipment Interaction

IMMEDIATE ACTIONS

The ERT Coordinator will determine if there is a possibility of fire through communication with the caller or dispatch. If fire is present, the ERT will respond as Appendix 3.5 Underground Fire (Fixed or Mobile). If there is no possibility of fire, the ERT Coordinator will ensure the following is completed:

- ERT respond with underground ambulance and mine rescue vehicle;
- ERT tags-in and enters portal to scene without delay;
- ERT on scene. ERT Coordinator will be on scene and in communication with the Underground Incident Command Team via radio;
- Extrication and treatment completed;
- ERT transports injured to first aid room; and
- Incident scene taped off for incident investigation.

MAINTAINING THE RESPONSE

Other equipment that may be required in the event of mobile equipment/vehicle interaction:

- Scoop tram to remove muck if haulage truck involved, assist in a lift, or pull away equipment to reach victims;
- Loader with forks or basket;
- Maintenance vehicle with cutting torch to remove or cut away enforced steel that may be trapping victims.

Revisions

Revisions

DATE	CHANGES	SIGNATURE	PAGE #
10/23/2018	Updated wording in Duty Cards from Mine Rescue Coordinator to ERT Coordinator		13-25
10/23/2018	Updated the Personnel Structure. Also added phone extensions.		12
03/05/2019	Updated personnel structure.		12
06/09/2019	Updated personnel structure.		12
04/22/2020	Updated personnel structure.	Peter Devolder	12
04/25/2020	Change the wording from ERT to Mine Rescue	Peter Devolder	13-25

Approval Signatures Record

REVIEWER ROLE	NAME	SIGNATURE	DATE
Mine Manager or Designate	[redacted]		
Health and Safety Manager or Designate			
Mine Captain			
Chief Engineer or Designate			
Mill Superintendent or Designate			
Maintenance Manager or Designate			
Mine Rescue Coordinator or Designate			
Procon Superintendent			
Dispatch			
ERT Coordinator/ Advisor			
JOHSC Co-Chair			

III-B. Rock Bolt Anchor Pull Test Data Sheet

Pull Test Form - Brucejack Mine

Date: 15-Oct-22
Test Conducted By: Louigi Sanchez Badillo and Sahad Nooruddin
Bolt Type and Length: 2.4m #7 Rebar
All distances are approximate

Location:	1050 - 20
Ground Condition:	Good/Blocky

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 2m from face of 20-ELAT13
2	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 4m from face of 20-ELAT13
3	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 2m from face of 20-ELAT13
4	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 4m from face of 20-ELAT13
5	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, across from 20-ELAT13
6	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, across from 20-ELAT13
7	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, across from 20-ELAT13
8	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, across from 20-ELAT13
9	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, 5m from 20-ELAT13
10	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, 10m from 20-ELAT13

Pull Test Form - Brucejack Mine

Date: 18-Oct-22
Test Conducted By: Louigi Sanchez Badillo and Sahad Nooruddin
Bolt Type and Length: 2.4m #7 Rebar
All distances are approximate

Location:	1130 N
Ground Condition:	Good/Blocky

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 15m from face
2	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 17m from face
3	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 19m from face
4	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 20m from face
5	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 16m from face
6	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 18m from face
7	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 22m from face
8	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 24m from face
9	RR	35	3600	10.0	Pass	Wall	West Wall 1.5m from sill, 5m from N DB 13E face

Pull Test Form - Brucejack Mine

Date: 17-Dec-22
Test Conducted By: Cody Stewart and Timothy Williams
Bolt Type and Length: 2.4m #7 Rebar
All distances are approximate

Location:	FZ 1380 - 8 E
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	3600	10.0	Pass	Wall	10m from face. North wall. 1.5m above sill
2	RR	35	3600	10.0	Pass	Wall	20m from face. North wall. 2m above sill
3	RR	35	3600	10.0	Pass	Wall	42m from face. South wall. 1.5m above sill
4	RR	35	3600	10.0	Pass	Wall	41m from face. North wall. 1.5m above sill
5	RR	35	3600	10.0	Pass	Wall	3m from RE4977. South wall. 1.8m above sill

Pull Test Form - Brucejack Mine

Date: 18-Dec-22
Test Conducted By: Cody Stewart and Timothy Williams
Bolt Type and Length: 2.4m #7 Rebar
All distances are approximate

Location:	WZ 1130 N
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	3600	10.0	Pass	Wall	2m S of RE5078. East wall. 2m above sill
2	RR	35	3600	10.0	Pass	Wall	5m N of RE5078. West wall. 1.5m above sill.
3	RR	35	3600	10.0	Pass	Wall	14m N of RE4731. West wall. 1.5m above sill.
4	RR	35	3600	10.0	Pass	Wall	12m N of RE4731. East wall. 1.5m above sill.
5	RR	35	3600	10.0	Pass	Wall	8m N of RE4731. East wall. 1.5m above sill.
6	RR	35	3600	10.0	Pass	Wall	8m N of RE4731. West wall. 1.5m above sill.
7	RR	35	3600	10.0	Pass	Wall	2m N of RE4731. West wall. 1.5m above sill.
8	RR	35	3600	10.0	Pass	Wall	At RE4731. West wall. 1.5m above sill.
9	RR	35	3600	10.0	Pass	Wall	8m S of RE4729. East wall. 1.5m above sill.
10	RR	35	3600	10.0	Pass	Wall	6m S of RE4729. East wall. 1.5m above sill.
11	RR	35	3600	10.0	Pass	Wall	6m S of RE4729. West wall. 1.5m above sill.

Pull Test Form - Brucejack Mine

Date: 07-Jan-23
Test Conducted By: Louigi Sanchez Badillo and Sahad Nooruddin
Bolt Type and Length: 2.4m #7 Rebar
All distances are approximate

Location:	1290-15 ELAT24
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 3m from face
2	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 5m from face
3	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 3m from face
4	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 6m from face
5	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 12m from face
6	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 15m from face
7	RR	35	3600	10.0	Pass	Wall	North Wall 1.5m from sill, 17m from face

Pull Test Form - Brucejack Mine

Date: 11-Jan-23
Test Conducted By: Louigi Sanchez Badillo and Sahad Nooruddin
Bolt Type and Length: 2.1m 39mm Split Sets & 2.4m #7 Rebar
All distances are approximate

Location:	1350-39
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	SS	37	2200	6.0	Pass	Wall	East Wall 1.5m from sill, 10m from face
2	SS	37	2200	6.0	Pass	Wall	West Wall 1.5m from sill, 12m from face
3	SS	37	2200	6.0	Pass	Wall	East Wall 1.5m from sill, 18m from face
4	SS	37	2200	6.0	Pass	Wall	East Wall 1.5m from sill, 25m from face
5	SS	37	2200	6.0	Pass	Wall	East Wall 1.5m from sill, 26m from face
6	SS	37	2200	6.0	Pass	Wall	East Wall 1.5m from sill, 28m from face

Location:	1290-15 ELAT24
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 19m from face
2	RR	35	3600	10.0	Pass	Wall	South Wall 1.5m from sill, 21m from face

Pull Test Form - Brucejack Mine

Date: 17-Jan-23
Test Conducted By: Louigi Sanchez Badillo and Timothy Williams
Bolt Type and Length: 2.4m #7 Rebar
All distances are approximate

Location:	WZ 1130 N
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	35	2800	10.0	Pass	Wall	North Wall 1.5m from sill, 3m from face
2	RR	35	2800	10.0	Pass	Wall	North Wall 1.5m from sill, 4m from face
3	RR	35	2800	10.0	Pass	Wall	North Wall 1.5m from sill, 6m from face
4	RR	35	2800	10.0	Pass	Wall	North Wall 1.5m from sill, 8m from face
5	RR	35	2800	10.0	Pass	Wall	North Wall 2.0m from sill, 9m from face
6	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 3m from face
7	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 5m from face
8	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 7m from face
9	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 9m from face
10	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 10m from face
11	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 11m from face
12	RR	35	2800	10.0	Pass	Wall	North Wall 1.5m from sill, 15m from face
13	RR	35	2800	10.0	Pass	Wall	North Wall 1.5m from sill, 16m from face
14	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 17m from face
15	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 19m from face
16	RR	35	2800	10.0	Pass	Wall	South Wall 1.5m from sill, 21m from face

Pull Test Form - Brucejack Mine

Date: 11-Feb-23
Test Conducted By: Gord Hannigan & Sahad Nooruddin
Bolt Type and Length: 2.1m 39mm Split Sets
All distances are approximate

Location:	FZ 1350-21 S LAT 20
Ground Condition:	Good

No.	Bolt Type	Bit Dia. (mm)	Pull Load		Test Results	Location (B/W)	Comments: All bolts painted with a 'P' or 'F' in Blue or Pink
			psi	Tons			
1	RR	37	1700	6.0	Pass	Wall	West Wall 1.5m from sill, 1m south of DS1
2	RR	37	1700	6.0	Pass	Wall	West Wall 1.5m from sill, 7m south of DS1
3	RR	37	1700	6.0	Pass	Wall	East Wall 1.5m from sill, 6m south of DS1

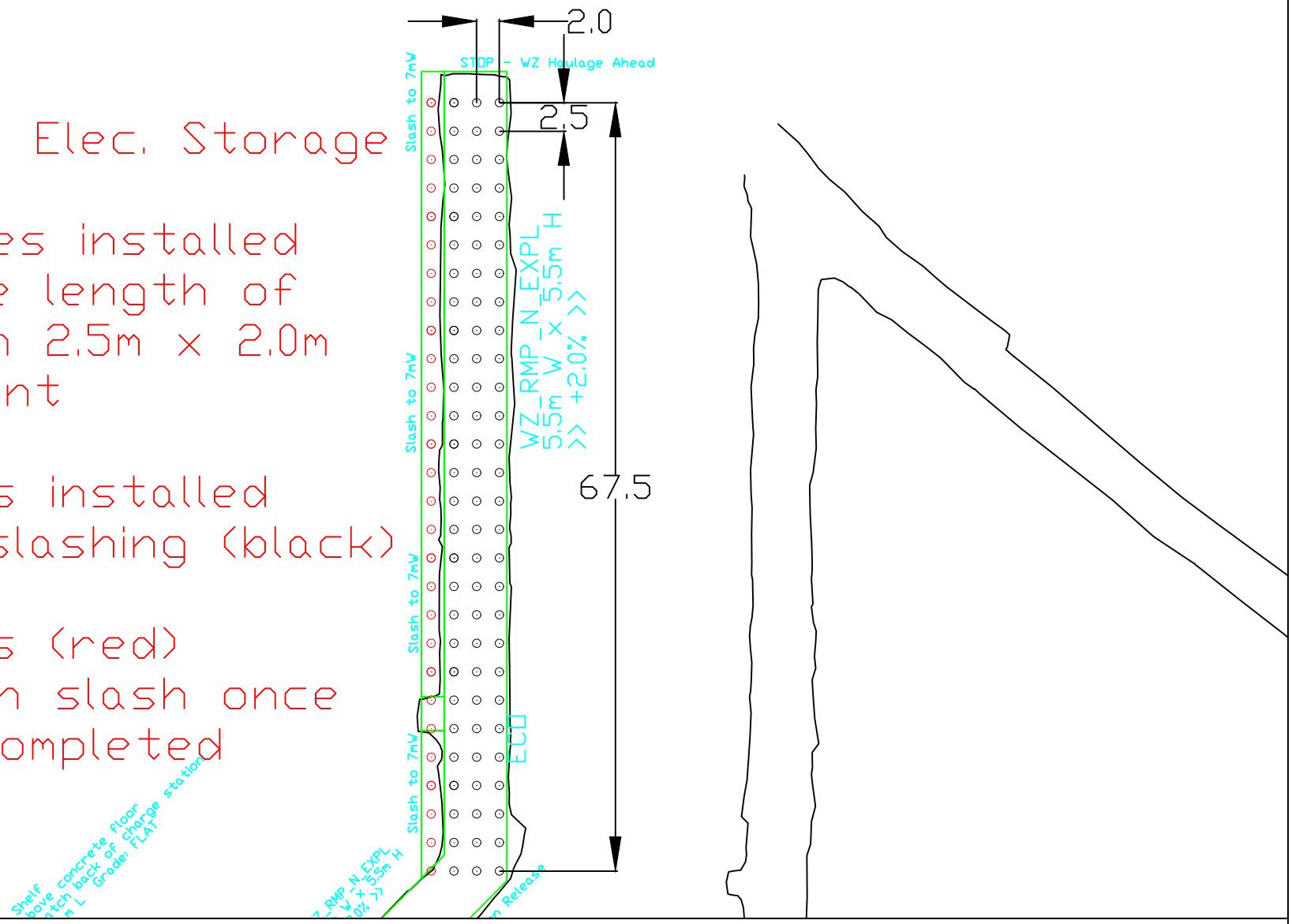
III-C. Sample Geotechnical Inspection Memos

Permanent Elec. Storage

-6 m cables installed for entire length of storage in 2.5m x 2.0m arrangement

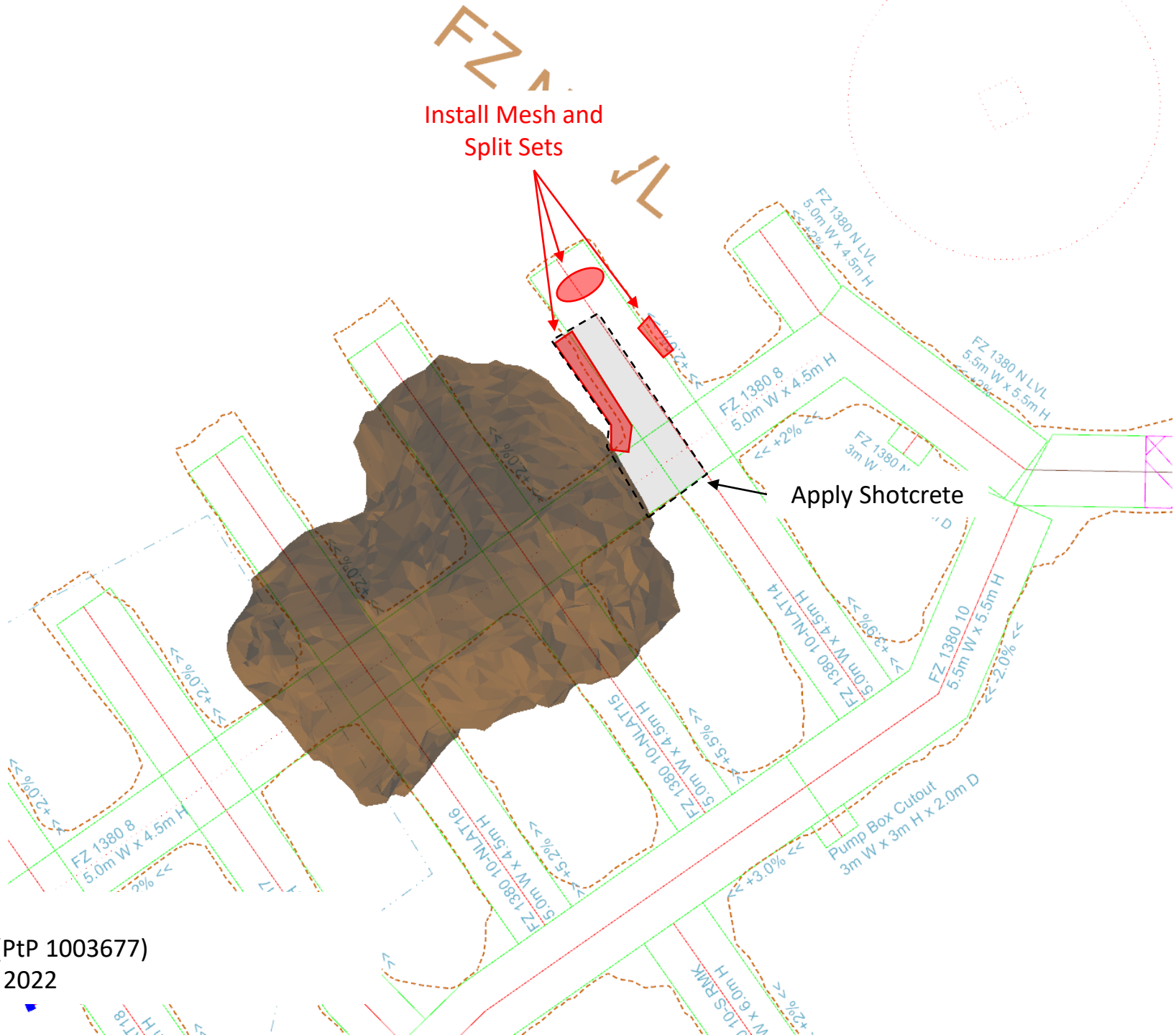
-84 cables installed prior to slashing (black)

-28 cables (red) installed in slash once slashing completed



Elec Storage WZ	1320 WZ	Drawn by Matt B
		Date 12-Sep-22
		Checked by Caitlin Scinocca
		Drawing 20220912 GIM - Elec Storage

NEWCREST MINING LIMITED



FZ 1380 10 – NLAT 14 GIM

Issued By: Caitlin Scinocca (PtP 1003677)

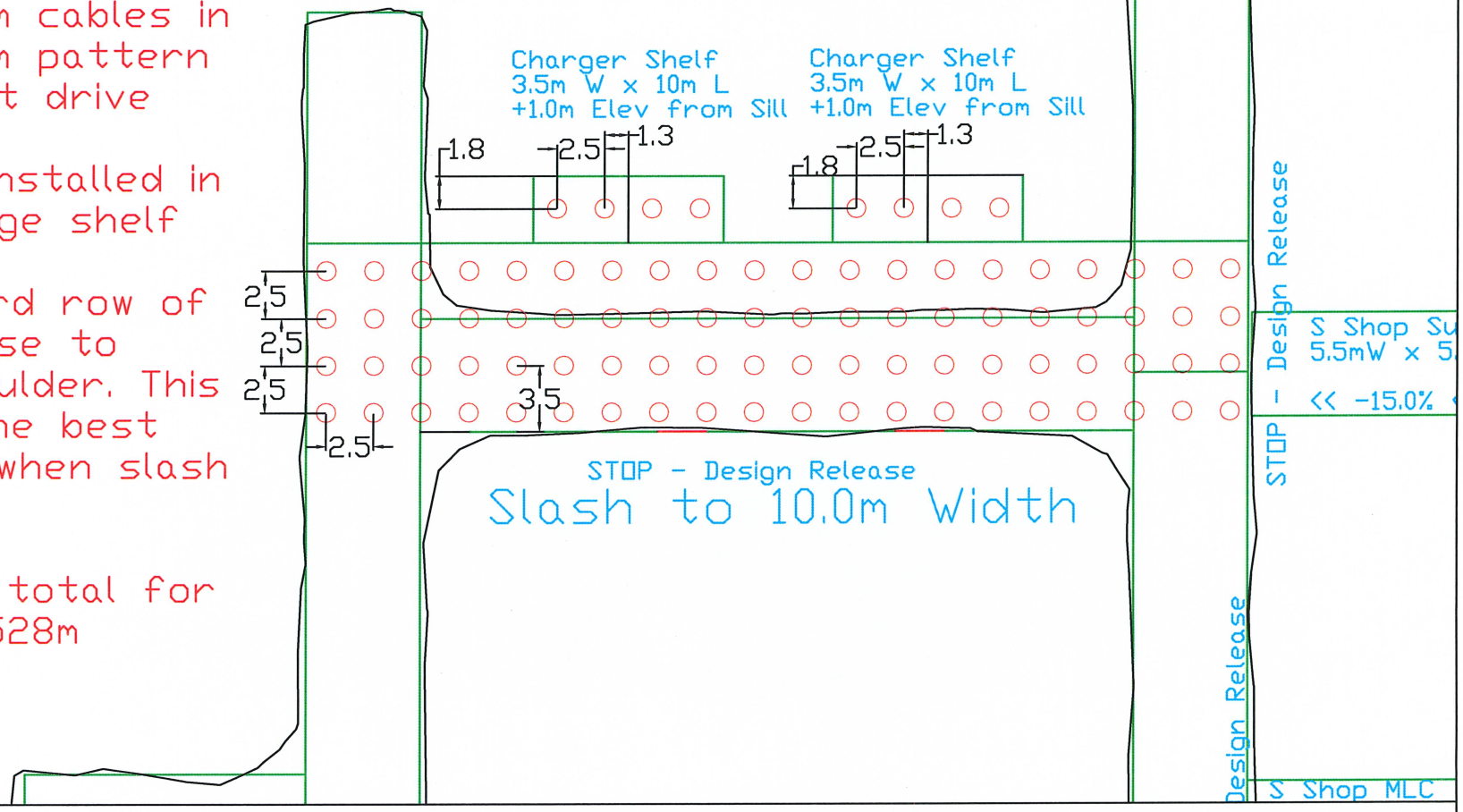
Issued Date: December 31, 2022

Install 6 m cables in 2.5m x 2.5m pattern throughout drive

4 cables installed in each charge shelf

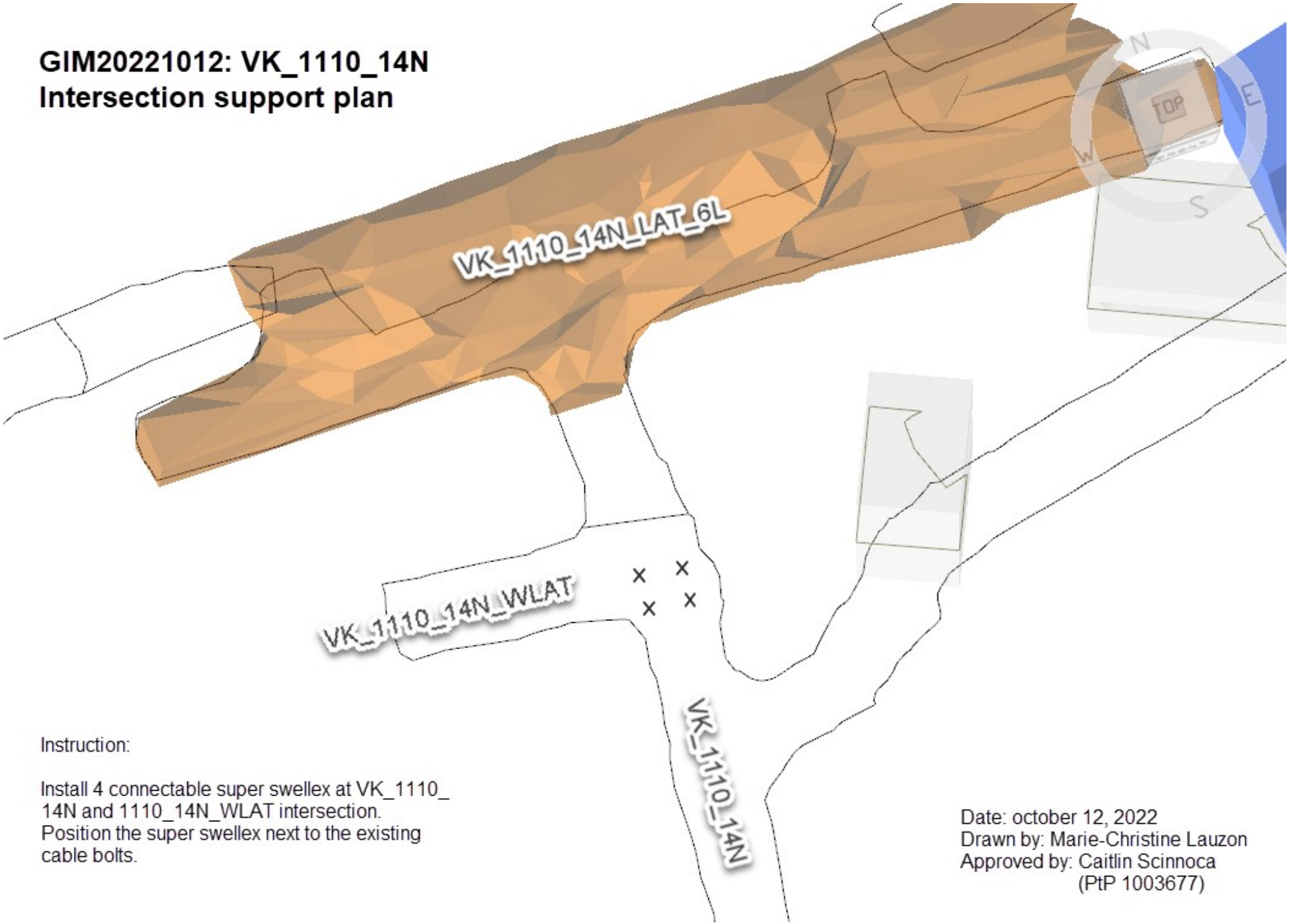
install third row of cables close to north shoulder. This will give the best coverage when slash is taken

88 cables total for total of 528m drilling



1335 Charge Bay Slashing	1335	Drawn by Matt B	NEWCREST MINING LIMITED
		Date 4-Oct-22	
		Checked by WS (Proj: 1003677)	
		Drawing Charge Bay Cutout	

GIM20221012: VK_1110_14N
Intersection support plan



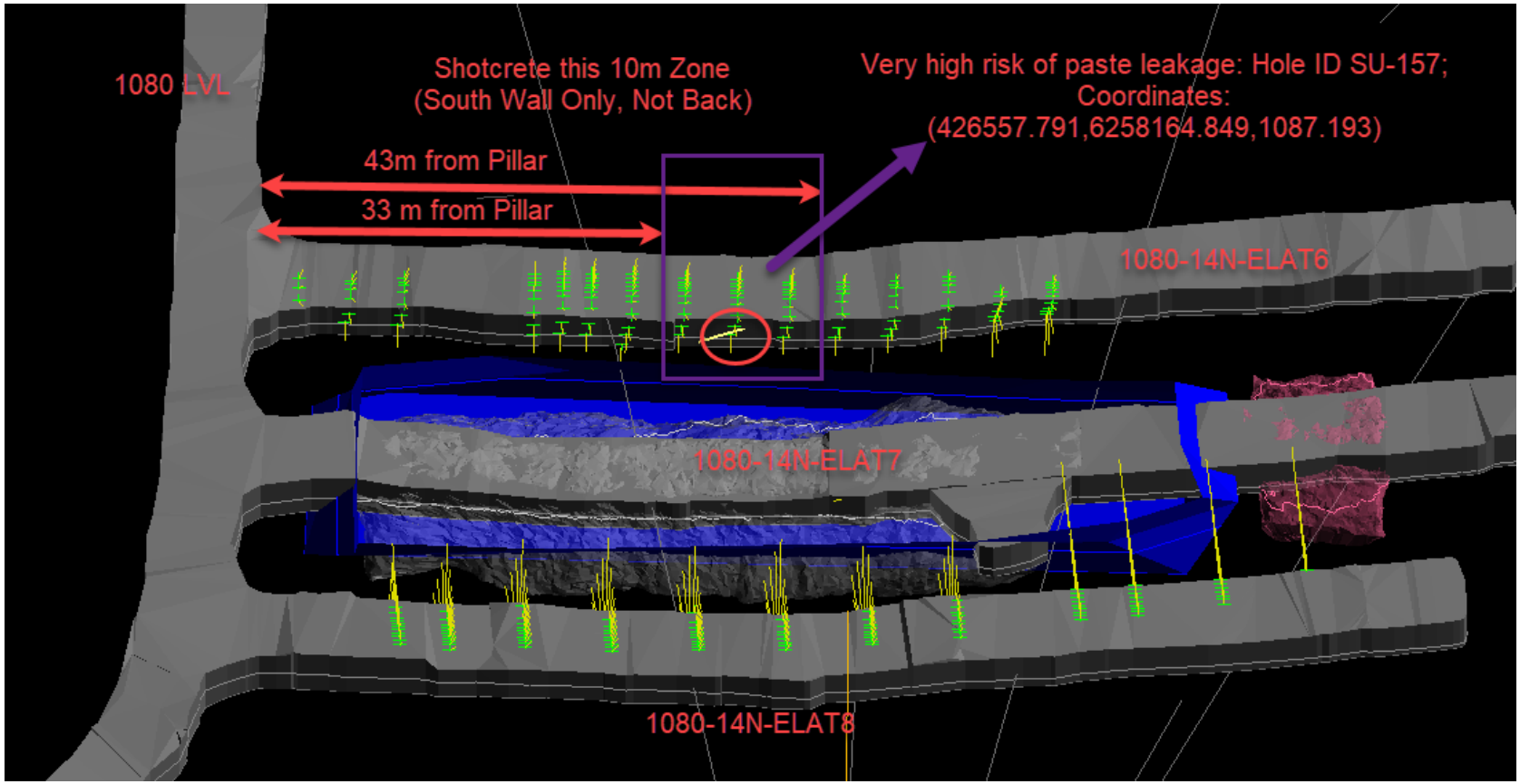
Instruction:

Install 4 connectable super swellex at VK_1110_14N and 1110_14N_WLAT intersection. Position the super swellex next to the existing cable bolts.

Date: october 12, 2022
Drawn by: Marie-Christine Lauzon
Approved by: Caitlin Scinnoca
(PtP 1003677)

GIM20220822: VK_1080_14N_ELAT6 Drift

- Visual inspection&search for surface hole, SU-157, which intersects **1080-14N-ELAT7** stope and **1080-14N-ELAT6 drift** has been conducted, and we were not able to locate it among lots of RC/production holes surrounding and baggy screens on the south wall.
- In order to prevent paste leakage when pasting **1080-14N-ELAT7**, shotcrete the south side wall of ELAT6 drift (only 10m zone as shown below) will be required.
- The shotcrete zone will be 10m wide. Survey, please mark up the line 33m from the access pillar and the other one is 43m from pillar.
- Only shotcrete the south wall. Do NOT shotcrete the back.



GIM20221113 - VK_1470_XC21-ELAT
Long support instructions for wide opening

Date: Novermber 13, 2022
Drawn by: Marie-Christine Lauzon
Approved by: Caitlin Scinnoca

INSTRUCTIONS:

1. Install 5 rows of connectables super swellex

    2.5m spacing between rows
    2.0m spacing between bolts

21 connectables will be required to support the wide opening

Appendix 9-2-5. Mountain Goat Management Plan

BRUCEJACK MINE

Mountain Goat Management Plan

January 2023

NEWCREST

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

PRETIUM RESOURCES INC.

A member of the Newcrest Group of companies

BRUCEJACK MINE

Mountain Goat Management Plan

Date: January 2023

Pretium Resources Inc.
Suite 2300 Four Bentall Centre
PO Box 49334
Vancouver, BC
Canada V7X 1L4
T: (604) 558-1784

VERSION CONTROL

Revision #	Date Released	Amendment
1	April 2017	
2	June 2020	Address comments from Nisga'a Lisims Government; update to avalanche control measures (Wyssen Towers); update to helicopter management
3	January 2023	Document format updated to NCM Brucejack template.

BRUCJEACK MINE
Mountain Goat Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BC	British Columbia
BC ILMB	British Columbia Integrated Land Management Bureau
BC MOE	British Columbia Ministry of Environment
BC MFLNRORD	Ministry of Forests, Lands, Natural Resource Operations and Rural Development
BC *Wildlife Act* (1996)	The main provincial law for protecting wildlife, endangered species, and wildlife habitat. The Act has a number of provisions for protecting, managing, and purchasing habitat areas as well as protecting endangered and threatened species. The Act is administered by the Ministry of Environment.
BJAR	Brucejack Access Road
BMP	Best management practices
EA	Environmental assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
FRPA	*Forest Regulation and Protection Act* (2002)
GWM	General Wildlife Measure
LRMP	Land and Resource Management Plan
MGMP	Mountain Goat Management Plan
Pretium	Pretium Resources Inc.
RACS	Remote avalanche control system
RSA	Regional Study Area
SOP	Standard operating procedure
SU	Survey Unit
SRMP	Sustainable Resource Management Plan
UWR	Ungulate Winter Range
VC	Valued Component

WHA	Wildlife Habitat Area: mapped areas that are necessary to meet the habitat requirements of an Identified Wildlife species under the Identified Wildlife Management Strategy. WHAs designate habitats in which activities are managed to minimize their effect on the Identified Wildlife for which the area was established.
WAC	Wildlife Advisory Committee

1 PURPOSE

1.1 INTRODUCTION

This Mountain Goat Management Plan (MGMP) describes actions that are intended to mitigate potential effects on mountain goats during the Construction, Operations, Closure and Post-closure phases of the Brucejack Mine (the Mine), owned and operated by Pretium Resources Inc. (Pretium). It focuses on the management recommended for legislated Ungulate Winter Range (UWR), high quality summer habitat, unique areas (mineral licks; kidding areas), and areas of known persistent use within the wildlife Regional Study Area (RSA) particularly on the Mine footprint components and activities (Rescan 2013a). Unless otherwise indicated, measures described in the MGMP apply to all components for the life of the Mine. This plan is designed to be adaptive, effective, and achievable in both the short and long term, and will incorporate the activity details as they are developed with the Mine.

1.2 BACKGROUND INFORMATION

Mountain goat populations were surveyed in the RSA during the summers of 2010 and 2012, and the winters of 2011 and 2013, following provincial standards for aerial surveys standards (RIC 2002). These surveys reported 286 mountain goats in the RSA (Rescan 2013a). Furthermore, mountain goats were surveyed in 2017 following provincial standards for aerial survey standard during the summer and 298 goats were observed (ERM 2017). The mountain goat surveys in 2022 yielded detections of 325 goats in 84 groups from 12 survey unit (SU) areas (ERM 2023). Mountain goats were observed in all SUs including areas where no individuals were detected during the 2017 survey period (ERM 2023).

For winter habitat in the Brucejack area, aerial surveys indicate that, mountain goats prefer subalpine forest stands that provide a diverse range of arboreal and rooted plant forage adjacent to escape terrain. Tree and shrub cover on steep, rocky ledges offer thermal advantage during sunny weather (solar radiation) and during inclement stormy weather by providing cover from snow. Goats also prefer southerly aspects because snow accumulation tends to be lower and food can be found more readily (Wilson 2005). Natal and kidding habitats are generally smaller pockets of habitat located within and near winter ranges (Mountain Goat Management Team 2010, p. 11).

During summer, mountain goats move to higher elevations to exploit the newly emerged high-quality vegetation. Areas with abundant early seral stage vegetation (e.g., grasses and herbs) are preferred by mountain goats. Mountain goats also seek higher elevation habitat as it provides thermal relief during the warmest periods of summer. Mineral licks at various elevations receive annual use and are important for the local mountain goat population. They are used primarily during the summer to compensate for mineral deficiencies or imbalances in goats' diets (Ayotte, Parker, and Gillingham 2008).

The majority of goats recorded during baseline studies (Rescan 2013a) were observed in mid-elevation habitat generally below the treeline along the Bowser River and close to Bowser Lake in the winter, and in high-elevation habitat above the treeline near peaks associated with Sulphurets Creek, in the summer. These areas also have UWRs that were occupied by wintering goats in 2012. See maps in Appendix A.

The nearest occupied high quality mountain goat habitat to Mine infrastructure is beyond 3 km west of the Brucejack Mine Site on either side of Sulphurets Creek, well away from any mining activities. High quality mountain goat habitat was defined in the environmental assessment for the Mine as high, medium–high, and medium-rated habitat derived from habitat suitability modeling (Rescan 2013b). Baseline surveys indicated that the majority of goat observations occur in this high quality goat habitat (Rescan 2013a). Other areas of occupied high-quality mountain goat habitat within the Mine area include an area 1 km north of the Brucejack Access Road (BJAR) approximately mid-way between Knipple Lake and the Mine, and an area along the mountains north of Bowser Lake, beyond 3 km from the BJAR. Additionally, the nearest identified kidding habitat to Mine infrastructure is west of the Knipple Glacier, approximately 1 km away from the Knipple Glacier Access Road crossing. No mineral licks have been found near Mine infrastructure (see maps in Appendix A).

2 PERFORMANCE OBJECTIVES

The overall performance objectives of the MGMP are to:

- prevent disturbance and habitat loss to goats within designated and candidate UWR during the winter and within high-rated summer habitat during the kidding period;
- manage disturbance due to aircraft and helicopters through avoidance where possible and minimization where it cannot be avoided; and
- manage incidental mortality of mountain goats due to avalanche control procedures through pre-avalanche control surveys, herding of goats from avalanche paths, and delaying avalanche controls until goats clear the area.

This document provided direction for environmental managers mainly during the Construction phase of the Mine but also is applicable to the Operations, Closure and Post-closure phases. Mine-related activities of relevance to this MGMP include the construction of mining infrastructure, transmission line, camps and other early-stage facilities and activities associated with helicopter use, and avalanche control during all Mine phases.

3 SCOPE

The MGMP is applicable to Construction, Operations, Closure and Post-closure activities that require Mine-specific mitigation and monitoring. The MGMP provides the environmental personnel and construction crews with information that can be used to coordinate activities and avoid negative effects on mountain goats where possible and to mitigate effects where unavoidable. Site-specific mitigation and monitoring will be addressed through the following measures (Table 3-1):

1. Clearing Management for Mountain Goats (Section 5.1)
2. Aircraft and Helicopter Management for Mountain Goats (Section 5.2)
3. Avalanche Management for Mountain Goats (Section 5.3)

Table 3-1. Summary of Mitigation Measures Applicable to Mine Phases and Components

Mitigation Measure	Mine Phase	Mine Component
Clearing Management	Construction	Transmission Line
Aircraft and Helicopter Management	Construction; Operations	All Components
Avalanche Management	Construction; Operations; Closure	Mine Site, Access Road, Transmission Line

4 RELEVANT LEGISLATION, REGULATIONS, AND PERMITS

Mountain goats are protected legislatively by the provincial *Wildlife Act* (1996) and guidance for habitat management is provided by the provincial *Forest Regulation and Protection Act* (FRPA; 2002). Under the FRPA, areas that are important or critical to ungulates and sensitive wildlife may be designated as Ungulate Winter Ranges (UWRs) or Wildlife Habitat Areas (WHAs), and General Wildlife Measures (GWMs) may be used to manage forest and range practices for protection and conservation of the species (Mountain Goat Management Team 2010).

General Wildlife Measures established for UWRs and WHAs include regulations for primary forestry activity (defined under the Forest Planning and Practices Regulation to include tree clearing and access structure [road/trail] construction/maintenance), such as prohibiting road construction, timber harvesting or silviculture treatments within established buffers around UWR and/or WHA boundaries unless an exemption is provided. Schedule 1 - GWM order # U-6-002 identifies management measures and actions that can be carried out in the UWR in the Nass Timber Supply Area, Upper Portion of the Ningunsaw and Unuk watersheds within the Mine RSA.

The relevant best management practices that guided the development of this plan are summarized in the *Management Plan for the Mountain Goat in British Columbia* and *A Compendium of Wildlife Guidelines for Industrial Development Projects in the North Area, British Columbia* (Mountain Goat Management Team 2010; BC MFLNRO 2014). Procedures and protocols of the best management practices were incorporated in the clearing, aircraft and helicopter, and avalanche management actions for mountain goats in the following sections.

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

This section identifies the management and mitigation measures to facilitate protection of mountain goats as per the BC Mountain Goat Management team guidelines and GWM order #U-6-002 (Mountain Goat Management Team 2010). This includes consideration for clearing and pre-clearing surveys, and air-based activities. In addition, avalanche management is considered due to the potential of incidental mortality caused by avalanche control procedures.

5.1 CLEARING MANAGEMENT FOR MOUNTAIN GOATS

Most Construction Phase clearing for the Mine was completed between September 5 and November 1, 2015, within the timing window that is outside of periods identified as being sensitive for mountain goats. The southern-most section of the transmission line, as well as the preferred Bulk Emulsion Site are not within or in proximity to UWR habitat and were cleared in 2016 when it is snow-free. Clearing of the Knipple Transfer Area was also completed during autumn 2015, along with most of the clearing for the Bowser Aerodrome and camps, and locations where additional clearing was needed along the lower BJAR (km 0-58). Minor additional clearing for the Bowser Aerodrome and BJAR (mainly borrow locations) may be done later; however, these sites are not within or in proximity to UWR habitat. No clearing is needed at the Mine Site, as it is above treeline. Clearing management as described in the following section will therefore only be relevant in the unlikely event that additional clearing needs are identified for the Mine in the future.

Mitigation activities are determined by habitat type, season and the number of goats observed. If any winter clearing is planned in future, pre-clearing surveys will be conducted during winter when ground-based Mine activities are within 500 m of UWR habitat (Rescan 2013a, 2013b). If clearing is required within a UWR or within 500 m of UWR habitat during the sensitive period, an exemption permit application will be submitted by a Registered Professional Biologist. Work requiring helicopter or aircraft support will be conducted as described in Section 5.2, Aircraft and Helicopter Management.

All actions regarding mountain goat clearing management will be directed by qualified environmental personnel (either staff or consultant) with appropriate experience with ungulates in BC. The objective for surveys will be to conduct them as close to clearing as possible, with a maximum of 72 hours before clearing. The pre-clearing survey will survey for goats out to 2-3 km from the proposed clearing site, covering the area of mountainside defined by drainages unlikely to be crossed by goats. If a particular block of mountain side does not have goats, then the clearing teams are free to clear within 72 hours. If goats are found within 1.5 km of the clearing site: 1) a further pre-clearing survey will be conducted, 2) the site will be surveyed as the crews are being put out, or 3) the clearing schedule will be altered to clear that site later, following another pre-clearing survey. If the pre-clearing is conducted within 24 hours of clearing, and the area within 500 m of the clearing site is clear of goats, clearing can continue as planned. Vegetation clearing will be halted if goats are observed within 500 m of the clearing area during sensitive timing periods (i.e., winter – November 1 to June 14 for all goats, and May 1 to July 15 for goats with kids) until animals are outside the recommended threshold distance of 500 m.

If goats with kids are observed, additional surveys will be conducted, and mitigation implemented. Note that kidding is assumed to occur at mid to high elevation generally up-slope during the winter or

spring and goats are at high elevation during the summer or fall months. Table 5.1-1 summarizes the timing, habitat, triggers, and mitigation activities.

Table 5.1-1. Mitigation Activities for Mountain Goats during Vegetation Clearing

Timing	Habitat	Mitigation Activities
Winter (November 1 to April 30)	UWRs	The preferred option is to avoid activities within 500 m of UWR habitat during winter. If clearing is planned in these areas during winter, then conduct pre-clearing surveys and apply for an exemption permit. If goats are observed within a 500 m buffer of clearing, pause work until goats have moved outside of this buffer.
Summer (May 1 to July 15)	High-quality Summer Habitat – Kidding Areas	If goats with kids are observed between May 1 and July 15 within a 500 m buffer during clearing activities, pause work until goats have moved off. Avoid clearing activities within 2 km of confirmed natal/kidding areas. Pre-clearing surveys may also be conducted less than 72 hours prior to activity.
Spring/Fall (April to November	High-quality Summer Habitat – Mineral Licks	Avoid destruction of mineral licks. Minimize disturbance within 100 m of licks.
All Year	All Habitats	Vehicles accessing the Mine will be required to give the right of way to mountain goats observed on the road.

5.2 AIRCRAFT MANAGEMENT FOR MOUNTAIN GOATS

Mountain goats are potentially sensitive to noise and disturbance from development, particularly to helicopter disturbance, as well as other aircraft. Goats are vulnerable to disturbance during:

- winter (November 1 to April 30) in the low elevation forested areas that goats use during winter in designated UWRs; and
- kidding period (May 1 to July 15) in the high elevation alpine areas that goats use during kidding, summer, and fall.

The guidelines proposed by the province do not differentiate between types of helicopters. However, research and professional experience indicate that goats react at different distances to different types of aircraft. Goats typically react more strongly to larger, multi-rotor aircraft (e.g., Vertol, Chinook) that are louder than other helicopters, and larger helicopters with only two blades (e.g., Bell 205) that produce a distinct blade slap noise when descending (ERM unpublished data).

In contrast, goats typically react less strongly to smaller, multi-blade helicopters such as the Eurocopter A-star, which produces a “whine” rather than a blade slap sound. Choosing the appropriate helicopter should reduce the potential for disturbance to mountain goats at the site and allow the helicopters some small leeway in flying closer to goats if the circumstances require it (e.g., low ceiling).

During primary forest activities [i.e., clearing and access structure (road/trail) construction], mountain goat mitigation related to aircraft includes:

- As recommended by the province, maintaining 2 km horizontal setback from mountain goats where feasible and weather permitting. Also, maintaining 500 m vertical separation between helicopters and mountain goat habitat, weather permitting.
- Educating pilots as to the importance of avoiding and not flying towards mountain goats, particularly during important periods of the year such as kidding and winter.
- Disseminating established flight paths for camps and construction areas to all new pilots.

There is a general set of helicopter "behaviours" which, if followed, can significantly reduce the potential for mountain ungulates to be disturbed by helicopters. Goats typically have little defence against predators, except fleeing to escape terrain and they likely perceive helicopters as a predation risk. Thus, it is important to understand and have the helicopter "behave" in a way that does not startle or trigger this predation response.

General recommendations for pilots include:

- Avoid overflights of occupied goat habitat whenever possible (below suggested elevations of 500 m), including avoiding "flightseeing".
- If flying a helicopter that produces a heavy "blade slap" noise, avoid inducing this noise when overflying or adjacent to occupied goat habitat.
- If a pilot is aware that goats are on the opposite side of a ridge or mountain, avoid surprising goats by flying low over the ridge and suddenly appearing above them.
- Avoid triggering a goat's "chase response" by avoiding flying directly at goats. Helicopters flying tangentially to goats are perceived less as potential predators.
- Goats can become habituated to helicopters if the helicopters operate in a predictable and non-threatening manner. Wherever possible, use the same routes and elevations to and from camps and drills.
- Use topographic barriers to separate helicopters from mountain goats.
- Keep helicopters below mountain goats if feasible.
- Helicopters can drop off specialized work crews in goat habitat, but only when goats are not present within 500 m.

In the balance between operability and reducing disturbance to goats, for aircraft activities pilots are instructed to maintain the largest separation feasible from mountain goats. The ideal situation is >2 km. In some cases, it may not be possible to maintain >2 km separation with goats given that certain valleys may be less than 2 km wide, and seasonal low clouds may force helicopters into the bottom of valleys. Pilots avoid flying within 500 m of goats, even if that means that certain valleys are unpassable on certain days with low cloud. Pilots minimize any flights in the range of 500-1,500 m, to those that are absolutely necessary. Pilots do not conduct crew "tours" near goats. There are allowances for different topographies given the fact that the average width of valleys in NW BC is 1.5-2.5 km wide. Flight paths that consider observed goat use and occupation of habitat within the RSA are provided in

Appendix A. Air traffic is encouraged to use these paths to minimize disturbance during sensitive periods.

5.3 AVALANCHE MANAGEMENT FOR MOUNTAIN GOATS

5.3.1 Management Activities

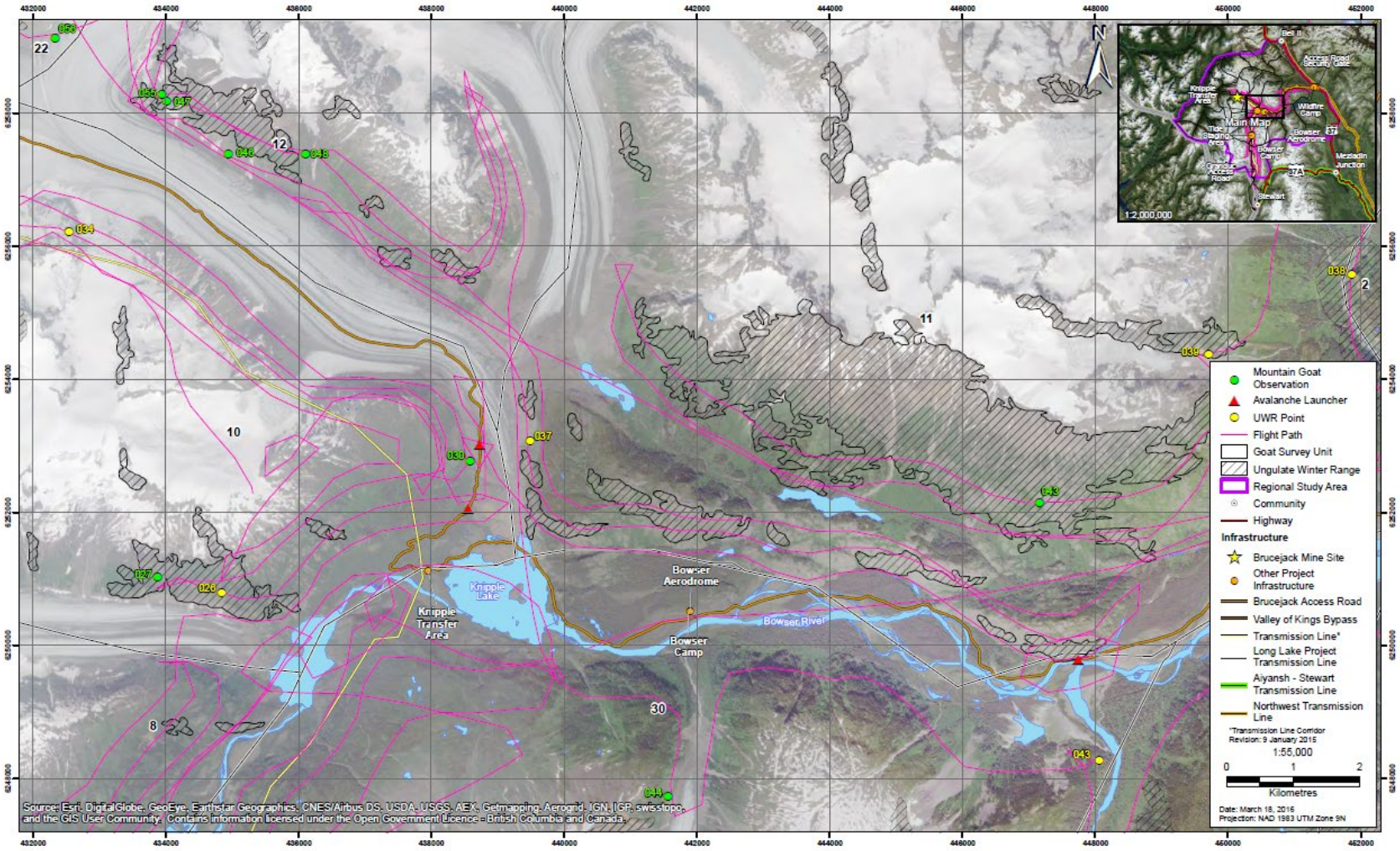
Avalanche management is conducted in the winter during all Mine phases. Mountain goats occupy alpine areas with steep, rocky cliffs during the summer. During winter, mountain goats can occupy low elevation forested areas on southern slopes as well as habitat in or below areas prone to avalanches, including alpine areas above the BJAR, near Knipple Lake, and along the Knipple Glacier (Figure 5.3-1 and Appendix A). Avalanche management activities include management to avoid mortality or abandonment of habitats by mountain goats due to control induced avalanches.

Avalanche management procedures typically use helicopter deployment of explosives (Pretium 2018a, 2018b). This procedure requires the avalanche area to be clear and visible prior to deployment. However, Remote Avalanche Control System (RACS) concussive devices that are built into the start zone of avalanche tracks can be deployed during or after snow events and at night.

Mitigation activities to limit risks to mountain goats are primarily based on conducting surveys for goats prior to initiating avalanche control and pausing control activities until goats have cleared avalanche paths. Mitigation activities depend on the choice of avalanche control. Three methods of avalanche control are currently used for the Mine; each has an associated survey protocol to ensure the site is clear of people or wildlife prior to detonation. These include:

1. Hand-based blasting is conducted predominantly at the base of the avalanche path using case charges which consist of a high explosive suspended on a bamboo pole tripod and remotely detonated. These are placed on or slightly above the BJAR. Ski-touring and throwing hand charges may also be employed up slope from the road: prior to conducting hand-based blasting the crew conducts visual confirmation the site is clear of people or wildlife along avalanche path and start zone. If goats are present, blasting will be delayed until they have left the area. Air horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins. If this is required, then a General Wildlife Permit application will be submitted to BC MFLNRORD.
2. Helicopter-based blasting is conducted at the top of avalanche paths and most often to be used in spring to clean up sites. It includes dropping of explosive charges out of the helicopter to initiate and avalanche from above: prior to conducting helicopter-based blasting, there is a detailed sweep of the slope to determine where best to place targets ensuring a thorough survey of the path and surrounding area for hazards and goats. If the area and area immediately adjacent (within 100 m) to the avalanche path is clear, blasting will proceed. If not, goats will be herded away to a safe distance before blasting begins if possible. If terrain and snow conditions preclude herding goats away from the area, blasting will be delayed until goats clear the area.

Figure 5.3-1
Location of RACS Units



PRETIVM

Proj # 0194150-0008 | GIS # BJP-23-223c

Over the past four winters during which helicopter-based blasting has been conducted for avalanche control at the Mine and along the BJAR, no mountain goats have been observed within or in proximity to the avalanche control sites at the time control was being conducted. Pre-blast visual inspections have been conducted as part of standard procedure to ensure that the areas are clear of both personnel and wildlife, including mountain goats.

3. In-place RACS concussive devices, of which Pretium uses two different systems, were installed at three of the most problematic sites along the BJAR. These devices may be operated remotely during any weather and are used to initiate avalanches at the top of the path. During clear weather, a ground-based survey of the avalanche track is conducted from a safe location using a spotting scope or similar device. Site-specific details are described in Section 6.1.3. If goats are observed and safety is not compromised, then blasting will occur once mountain goats move out of the avalanche area. Air horns or other suitable sounding devices may be used to herd goats away to a safe distance before blasting begins. If blasting is planned during obscured conditions with low lying cloud or fog, heavy snowfall or wind events, pre-blast surveys may not be feasible.

As some approaches to mountain goat deterrence may be novel, all avalanche management activities considered will be documented and summarized in an annual report. The results of avalanche mitigation activities will be used in an adaptive management approach to inform future actions. Documentation will include:

- Survey methods and results;
- Any mitigation required – deferring the avalanche control or use of air horns; and
- Results of avalanche control.

Details of the avalanche control methodology were included in the Licence of Occupation applications submitted by Pretium to BC MFLNRORD, which were subsequently approved.

5.3.2 Risk to Mountain Goats from Avalanche Control Measures

This section evaluates the risk to mountain goats resulting from avalanche control measures at a site level using field data on the locations of proposed avalanche control measures, goat habitat, and goat occupancy collected during 2015. There are several avalanche zones identified along the BJAR and near the mine site. Avalanche control measures in all areas follow the mitigation and adaptive management approach described in Section 5.3.1.

Within each of the zones there are areas that are managed for avalanches; these include areas along the BJAR at 2 km, 30 km, 44 km, 56 km, 58 km, 59 km, and the area around the Brucejack Camp. While the event frequency and size of avalanches vary, of the areas requiring most consistent avalanche control, the areas at the Brucejack Camp, 56 km, and 2 km are not identified as key goat winter habitat, and goats were not observed at any of these locations during inventory (Rescan 2011). Slopes above the BJAR at 30 km are near a UWR, however goats were not identified in this area during inventory. The UWR is at the top of the avalanche zone, and control measures are only expected to be associated with the lower slope above the road. Consequently, goats are not expected to occupy this area when avalanche control is required.

Risk to goats from avalanche control at the Brucejack Mine Site, 56 km, 30 km, and 2 km is considered very low. Directed monitoring for goats is not proposed for these sites beyond the scanning protocol that currently occurs for avalanche control using helicopter-based or hand-based blasting described in section 5.3.1. If, for exceptional circumstances, goats are observed within avalanche tracks planned for blasting, avalanche control will be halted until the goats have cleared the area. If required, noise will be used to herd goats out of the danger area as described in Section 5.3.1. The response of goats to noise will be documented (Section 5.3.1).

Avalanche control at 44 km and 58 km is the most likely to provide a risk to mountain goat. The 59 km site has also been assessed for risk to mountain goat. All three methods of control may potentially be used at these sites, however, the ground-based RACS represent the avalanche control of greatest consequence to goats in size of area, potential goat occupancy, and frequency of use. The RACS are remotely fired with a charge of compressed oxygen and propane, Gasex®, or 4 kg explosive charge dropped from Wyssen Towers to initiate an avalanche. The RACS used to manage avalanche hazards will be installed at three key locations along the Brucejack Access Road. The Gazex® is permanently fixed at the top of the avalanche paths at 44 km, while Wyssen Towers are installed at the top of avalanche paths at 58 km and 59 km (Figure 5.3-1). A monitoring plan has been identified for use with RACS avalanche control in these areas and it can be extended to include all methods of avalanche control at these problematic sites.

To evaluate the potential risk to mountain goats at these three sites from the installation of the RACS and other avalanche control systems, a field survey was carried out in May 2015 (June 17, 2015, Wildlife Trip Report). The survey was conducted, in part, to evaluate the likelihood that goats would occupy the areas slated for avalanche control. The risk to goats was evaluated based on the results of this survey combined with the information available from habitat suitability mapping, spatial distribution of habitat, and the anticipated goat use. Locations at 44 km and 58 km were identified as potentially supporting use, while goat winter use at km 59 is not anticipated. The risk to mountain goats from avalanche control at these three sites was qualitatively evaluated based on professional judgement of habitat suitability and potential occupancy during the winter. The habitat value, and therefore likelihood of habitat uses and risk to goats, was referenced to a local benchmark; the UWR unit on the north side of Bowser Lake which supports substantial goat numbers (12 observed in the winter 2011 survey at this location). This UWR is located at Anderson Mountain approximately 5 km away from the 10 km marker on the Brucejack Access Road, along Wildfire Creek, and is not expected to be disturbed by Mine-related activities.

The Gazex® RACS unit at 44 km is at the edge of a large UWR complex that has potential to support several goats. This avalanche control site is at the lower, south, and eastern edge of the complex, and while goats may occupy the site during winter, there is habitat of higher quality and greater connectivity north of the site. Within the UWR, goats were observed in May 2015 (waypoint 043, Figure 5.3-1) up slope on the mountain within the UWR. Goats were observed in a favourable area of green vegetation near the large UWR polygon during the May 2015 reconnaissance. The 2011 winter ungulate surveys (Rescan 2011), did not detect goats in this area, but identified a total of 14 goats to the north and west of the 44 km UWR polygon unit. The RACS unit will affect a large area downslope from the UWR polygon unit (Plate 5.3-1). Considering the isolation of this unit at the periphery of a larger more suitable complex, the probability of it being occupied by goats during avalanche control is low and with monitoring, risk to goats is predicted as Low as well. The 44 km avalanche control area was checked for presence of mountain goats and other wildlife as part of standard pre-blast procedures during

blasting that occurred over the past four winters; no mountain goats were observed within the blast areas.

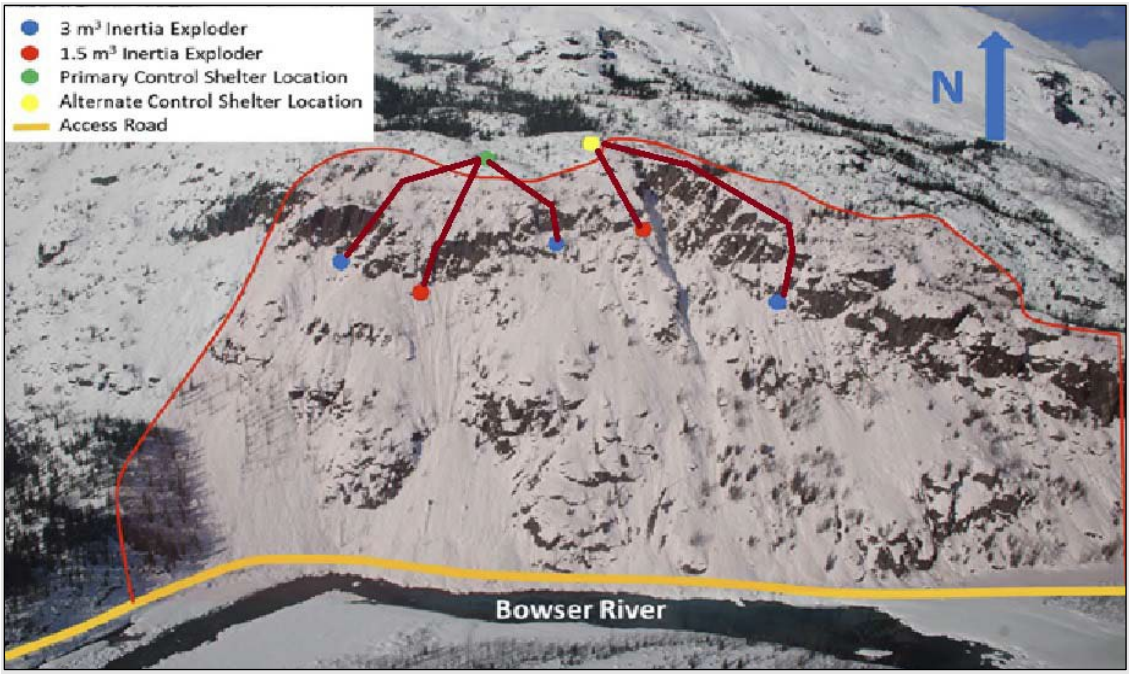


Plate 5.3-1. Location of RACS unit exploders at 44 km site.

The first Wyssen RACS site is comprised of one tower located at 58 km at the southern end of the Knipple Glacier portion of the BJAR. One mountain goat was observed at this location during the May 2015 reconnaissance, and goats with kids had been recorded near this site in 2011 prior to July 1 as recorded in the July 14, 2011, Vegetation and Wildlife Critical Review trip report. No goats were observed during winter 2011 survey near this location (Rescan 2011) and the survey unit associated with the site only had one goat observed during the winter 2011 surveys. The habitat was assessed as high-quality winter habitat as it supports vegetation including conifer cover and shrubs adjacent to escape terrain. The area potentially affected by the RACS is at the lower elevation of the suitable habitat, where escape terrain is becoming fragmented, and connectivity to more contiguous habitat is reduced in winter (Figure 5.3-2). Considering the location at the edge of habitat and no documented winter use, it has a low probability of being occupied by goats during avalanche control, and risk to goats is predicted as Low with monitoring. As with the 44 km area, km 58 was also checked for mountain goat presence prior to blasting over the past four winters and no goats were observed within the avalanche zone.

The second Wyssen RACS site is comprised of 11 towers located between 59 and 60 km and was assessed as low-quality winter habitat for goats. This site is in area recently exposed as the Knipple Glacier receded and has virtually no vegetation cover that would provide winter forage to goats. Its value as escape terrain is also marginal as it is small and surrounded by more gently rolling topography (Figure 5.3-2), and only a small, low elevation area will be impacted by the RACS. No goats were observed near this site during the 2011 winter inventory (Rescan 2011) and only one goat was observed in survey unit (SU) 10. The probability of this site being used during winter by goats is very low and risk to goats is predicted as Very Low. No goats have been observed at this location during previous avalanche blasting activities.

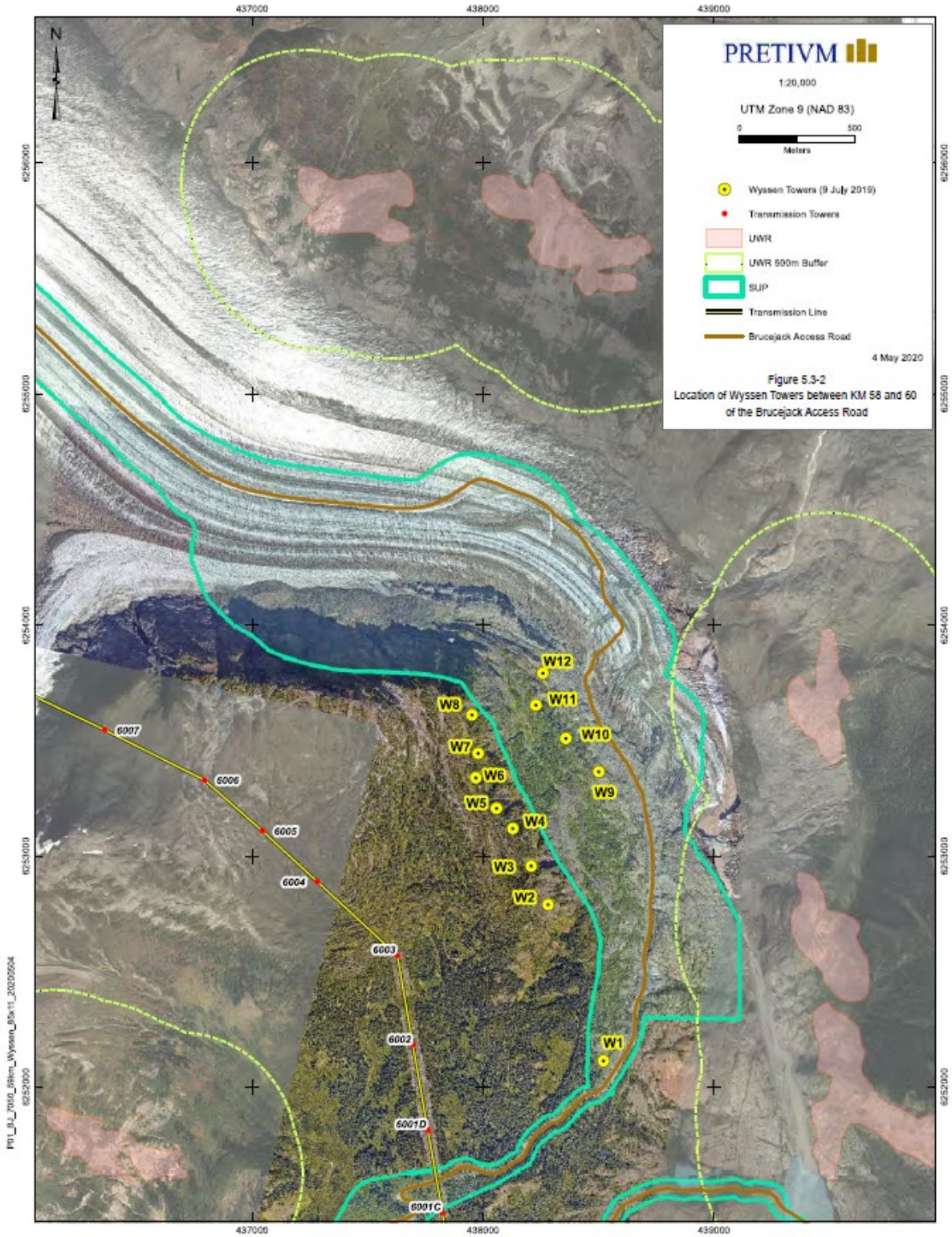


Figure 5.3-2. Location of Wyssen Towers between Km 58 and 60 of the Brucejack Access Road

6 ENVIRONMENTAL MONITORING

6.1 PERFORMANCE MONITORING

6.1.1 Clearing Monitoring

Any additional pre-clearing surveys will be completed by consultants or environmental staff (preferably Registered Professional Biologists) with appropriate experience and/or training with mountain goats in BC. As described in Section 5.1 however, almost all planned clearing has been completed to date and any further clearing required in sensitive areas will occur between September 5 and November 1, outside of the sensitive periods for mountain goats.

Monitoring frequency may be triggered during vegetation clearing but not during normal operations thereafter. Monitoring will occur for clearing activities that will occur in winter (November 1 until April 30) within 500 m the mountain goat UWR. The objective for surveys will be to conduct them as close to clearing as possible, with a maximum of 72 hours before clearing. The pre-clearing survey will survey for goats out to 2-3 km from the proposed clearing site, covering the area of mountainside defined by drainages unlikely to be crossed by goats. If a particular block of mountain side does not have goats, then the clearing teams are free to clear within 72 hours. If goats are found within 1.5 km of the clearing site, then: 1) a further pre-clearing survey will be conducted, 2) the site will be surveyed as the crews are being put out, or 3) the clearing schedule will be altered to clear that site later, following another pre-clearing survey. If the pre-clearing is conducted within 24 hours of clearing, and the area within 500 m of the clearing site is clear of goats, then clearing can continue as planned.

Ground surveys may be used to supplement helicopter-based surveys if topography requires, and weather and work safety allows it. Flight scheduling for monitoring will be conducted by a Registered Professional Biologist with appropriate experience and/or training with mountain goats in BC.

6.1.2 Aircraft Monitoring

Pilots are asked to report incidental observations of goats as part of the incidental wildlife reporting program as discussed in the Wildlife Monitoring Plan (Pretium 2023). Employees who feel that pilots have flown too close to goats are encouraged to report this to Brucejack Logistics or environmental staff.

6.1.3 Avalanche Monitoring

Monitoring during avalanche control activities is conducted to minimize potential mountain goat mortality during avalanche control measures.

Avalanche control monitoring information collected include:

- Location;
- Date;
- Time;

- Personnel;
- Methods and results of pre-control surveys;
- Mitigation actions including;
  - all wildlife herding actions and other mitigative measures,
  - wildlife response,
  - subsequent rationale for decision regarding blasting (including decision not to trigger an avalanche);
- Any blasting activity undertaken; and
- Notes on results.

As listed above, the monitoring measures include visual surveys before avalanche control is initiated to the extent feasible, mitigation efforts and their effects, decision making, and avalanche control results. The avalanche control results include post-control surveys to evaluate if any goat mortality has occurred. The RACS units located at 44 km, 58 km and 59 km along the BJAR have been predicted as having a Low (44 km and 58 km) or Very Low (59 km) risk to goats. Surveys conducted in May 2015 identified varied risks at each location considering connectivity of habitat, habitat quality and spatial distribution of habitat and goats.

The site at 44 km includes a large area of slope that tails out over the BJAR and into the Bowser River. This control is initiated by six Gazex® RACS exploders. The initiation zone is in the low elevation portion of a UWR polygon that has been identified as potentially used by goats. When feasible – i.e., when avalanche control is to be conducted during clear weather conditions – spotting for mountain goats (and moose at the tail out) will be conducted from the ground with a spotting scope (or similar device) prior to detonation of exploders. Spotting will be conducted from 44.4 km. The observer will be in communication by radio and give the all clear when there are no goats within 100 m of the “Slasher” avalanche path

The site at 58 km includes a relatively short run and small area at the bottom of the slope that can be initiated by a Wyssen Tower RACS exploder. The site is expected to have a Low risk to goats and can be observed on the ground by a monitor with a spotting scope prior to detonation. Spotting for 58 km will be done from the causeway across the Bowser River, as there is no safe location with good visibility closer to the 58 km site. The observer will be in communication by radio and give the all clear when no goats are observed in openings within 500 m from the blast location.

The sites between 59 and 60 km include a large area of slope that tails out over the BJAR at several locations and is managed by 11 Wyssen Tower RACS exploders. The area is predicted to have a Very Low risk to goats as such no monitoring is proposed.

Monitoring for mortalities will occur as a check by environmental staff in the spring, with mortality evidenced by signs of goats or as signs of scavenging by predators or birds. Monitoring will be implemented if evidence of goat use is identified through the course of development.

6.2 WORK PLANNING AND SCHEDULE

The mitigation and management measures for mountain goats that will be implemented to eliminate or minimize adverse effects will occur throughout the various Mine phases.

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance Reporting

Compliance reporting will be subject to EA Certificate conditions, and *Mines Act* permit conditions.

Compliance reporting for a wildlife permit used to herd mountain goats away from avalanche paths, if needed, will be reported separately to BC MFLNRORD as detailed in the permit.

The results of monitoring and mitigation are reported to the Wildlife Advisory Committee (WAC).

7.1.2 External/Internal Reporting

All personnel are encouraged to report wildlife observations made anywhere within the Mine. Information collected during monitoring activities, including incidental observations, is summarized in the daily wildlife monitoring log.

7.1.3 Incident Reporting

Incident reporting includes observations of mountain goats during pre-clearing surveys, mountain goat encounters with aircraft/helicopters not following appropriate mitigation measures, and wildlife interactions with avalanche mitigation actions. In addition, any mortality and/or encounters during vegetation clearing surveys, or other mortality events, are reported.

7.2 RECORD KEEPING/TRACKING

7.2.1 Monitoring Results

Information collected during monitoring activities includes the effort that the monitor has put into surveying (start and end times), as well as documenting information on goat observations including time of observation, physical condition, age, sex (if possible) and number of goats. Notes on behaviour and response to the activity will also be recorded, as will observations of other sensitive wildlife incidentally observed.

7.2.2 Continuous Improvement, Follow up, and Adaptive Management

Mitigation measures will continuously be improved by recording incidents involving mountain goats and following up on these incidences and implementing adaptive management when or if current mitigation measures are ineffective.

8 REFERENCES

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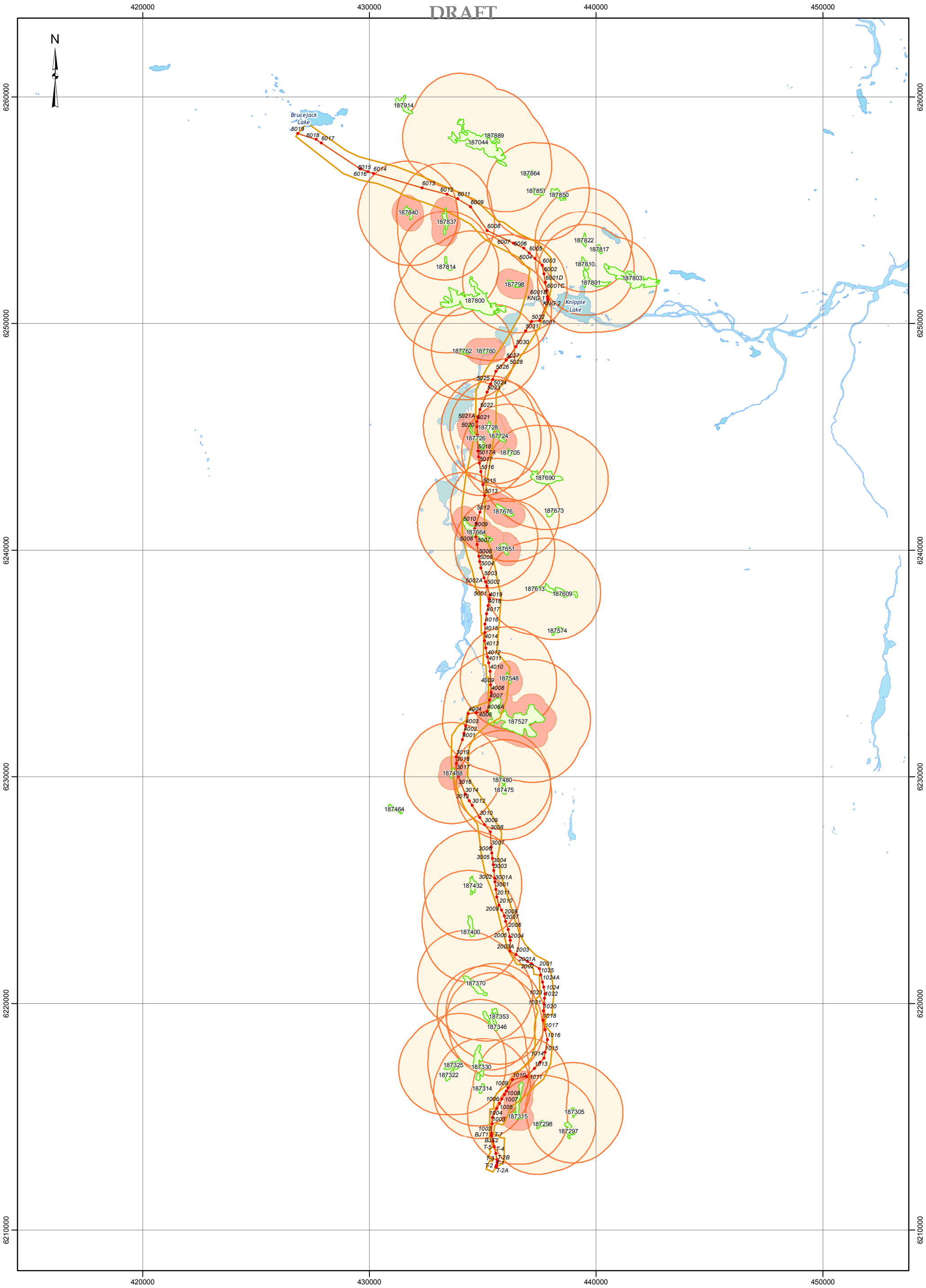
Appendix A

Figures and Maps

DRAFT



Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Transmission Line Corridor (as of 9 Jan 2015)
- Mountain Goats Along Transmission Line
- 2 Km Buffer
- 500m Buffer

0 1 2 4 6 8
Kilometers

PRETIVM

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Brucejack Project

1600–570 Granville St.
Vancouver, BC V6C 3P1
Canada
(604) 558–1784

Mountain Goats Along Transmission Line

PROJECTION: UTM Zone 9 (NAD 83)

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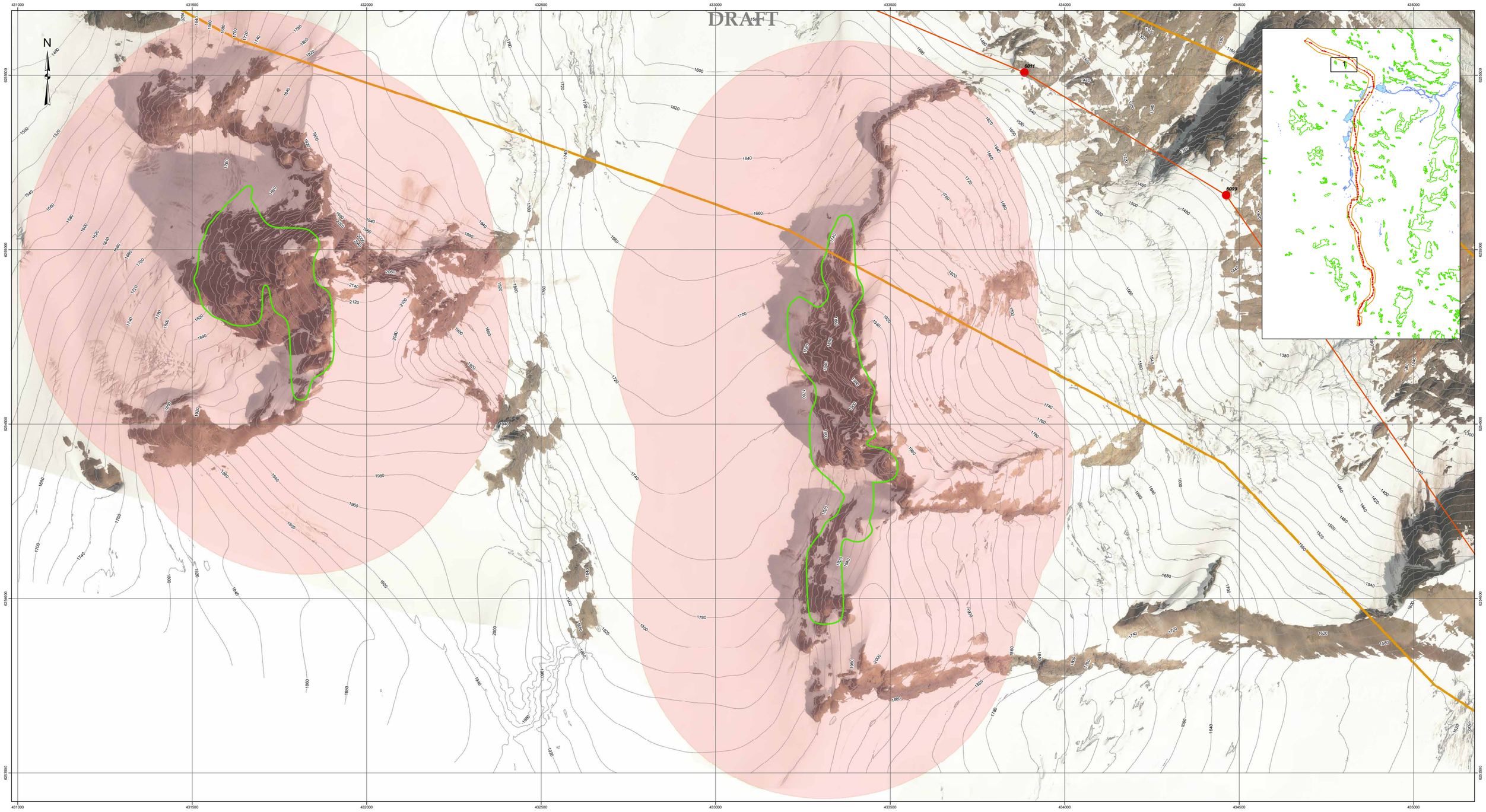

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundry Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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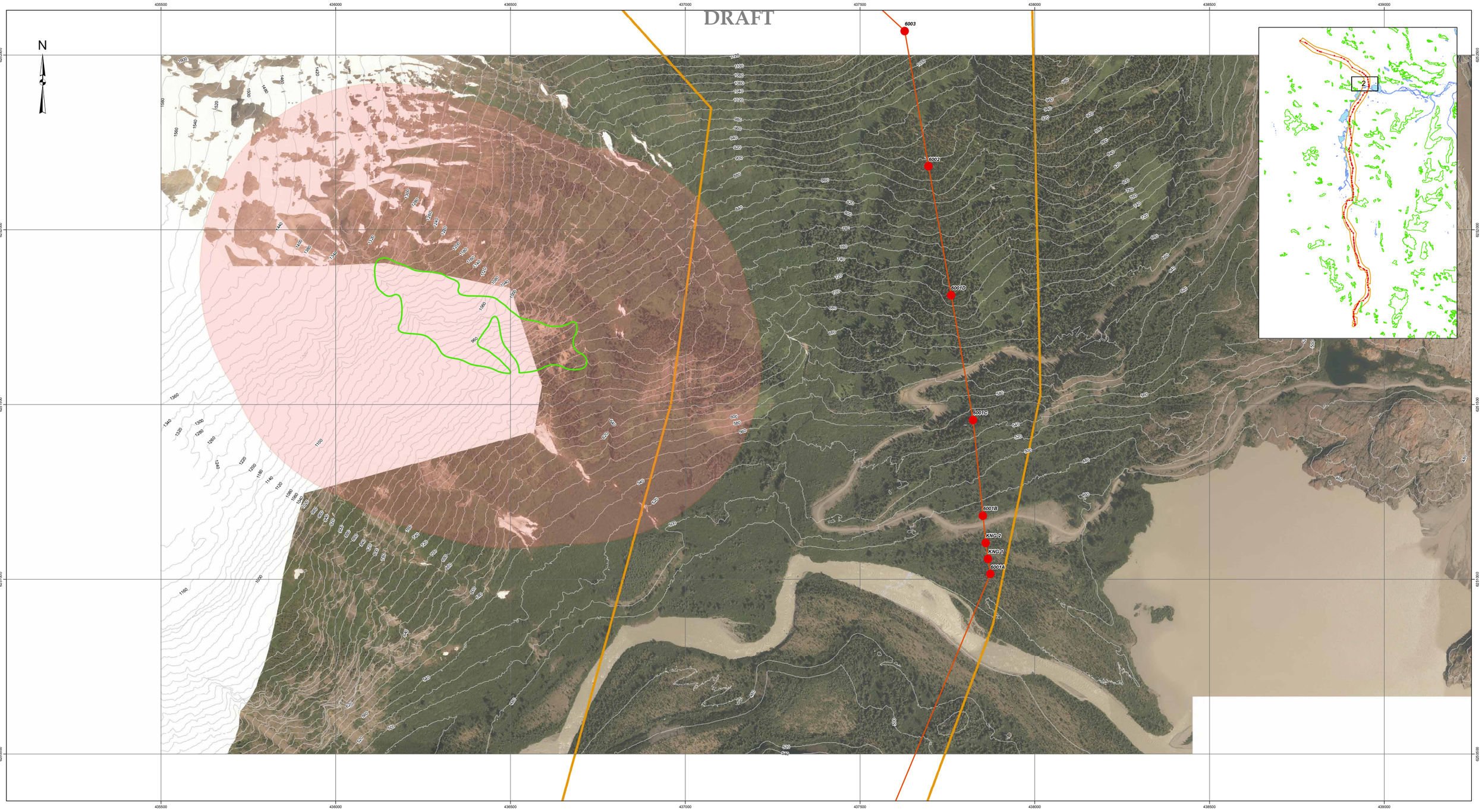

Legend

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- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

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Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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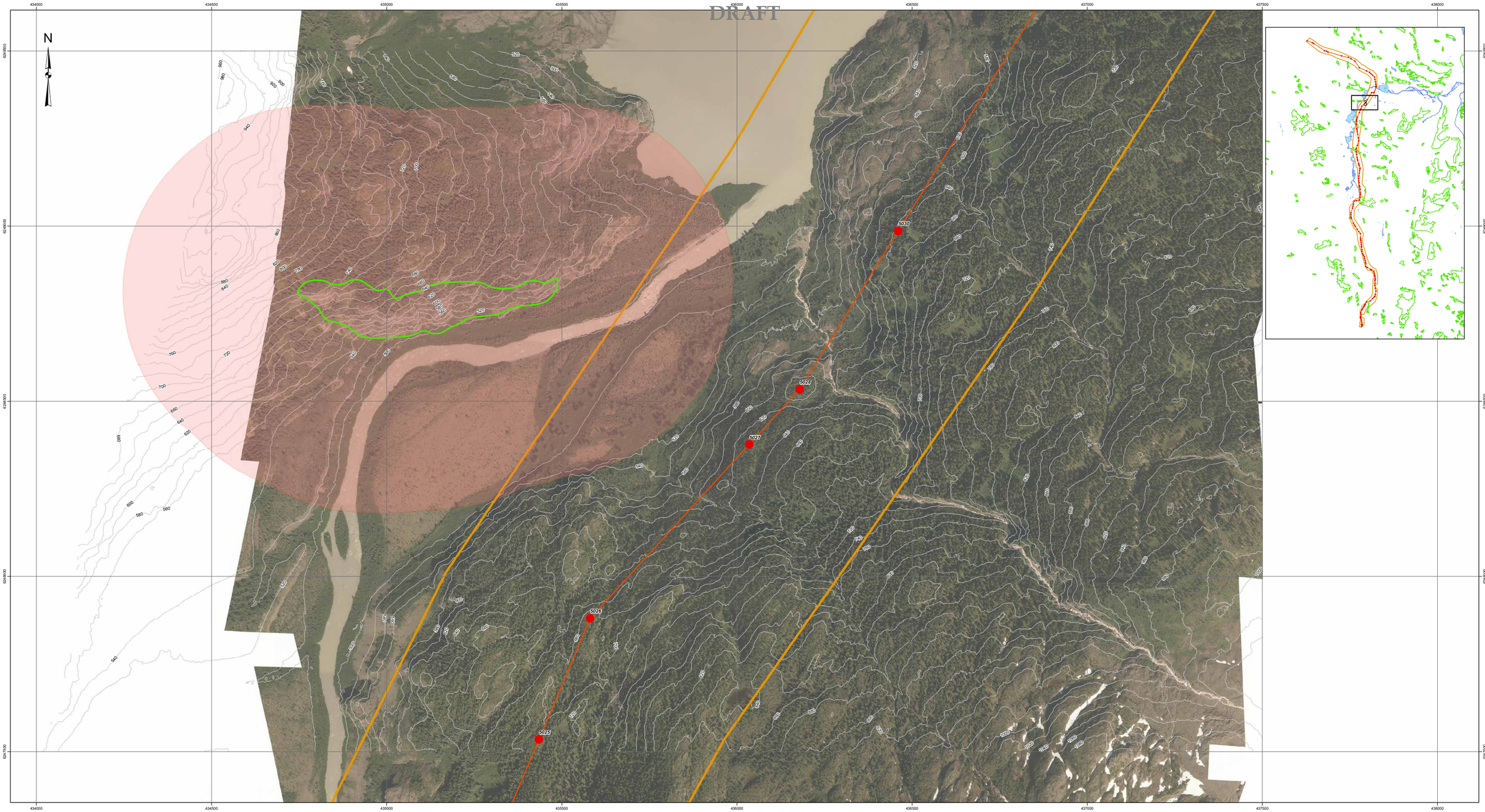

Legend

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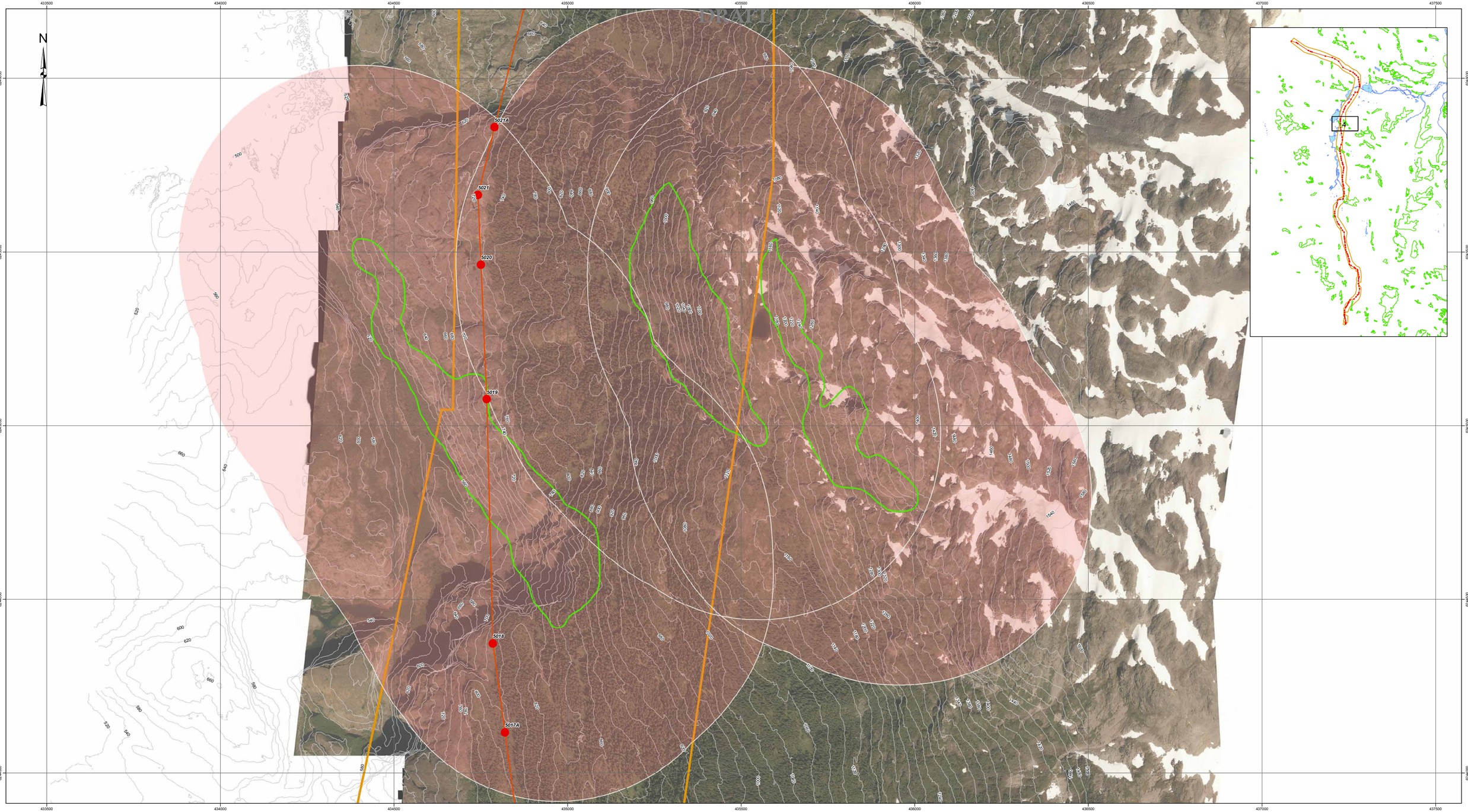

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PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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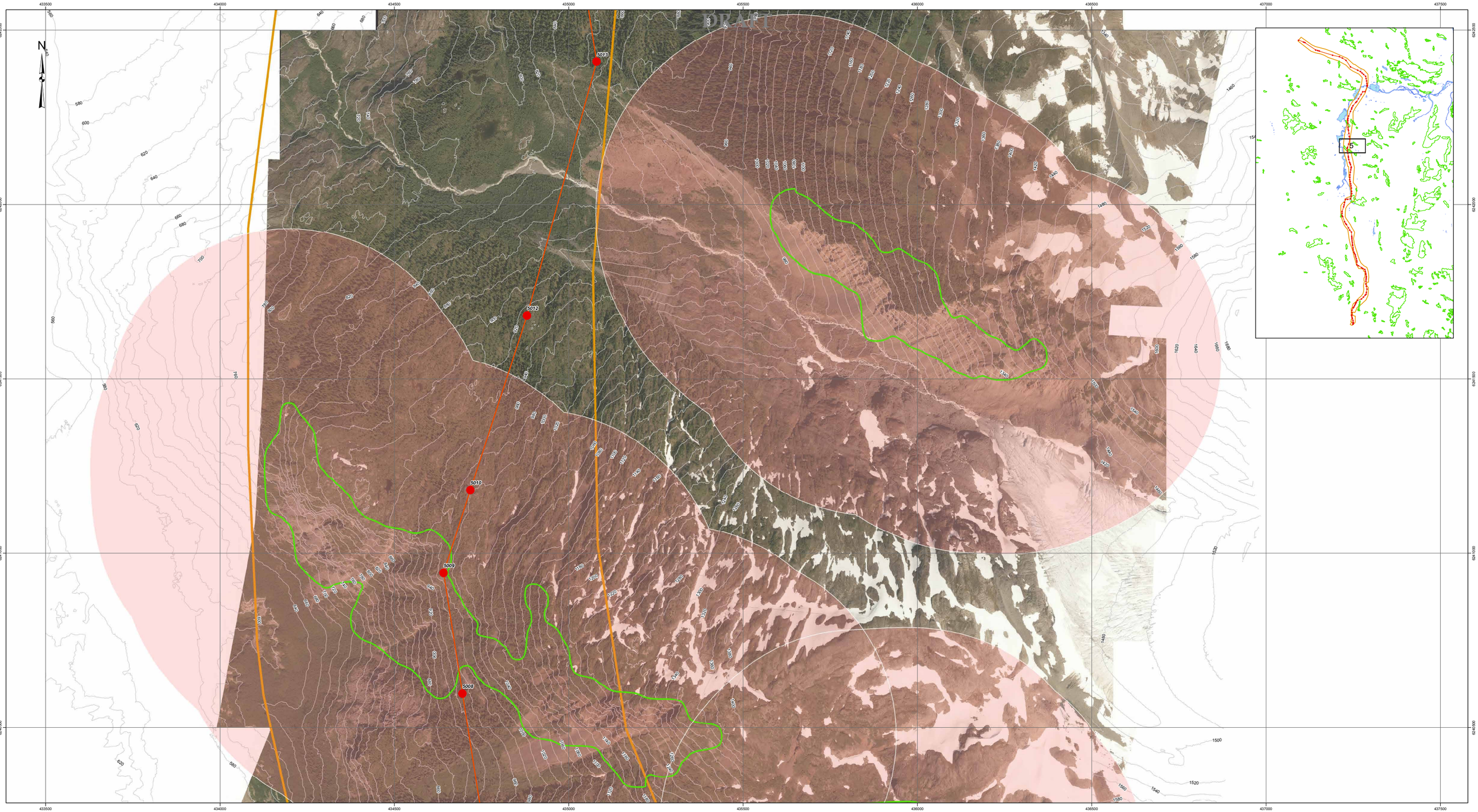

Legend

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Mountain Goat Area Along Transmission Line
with 500m Buffer

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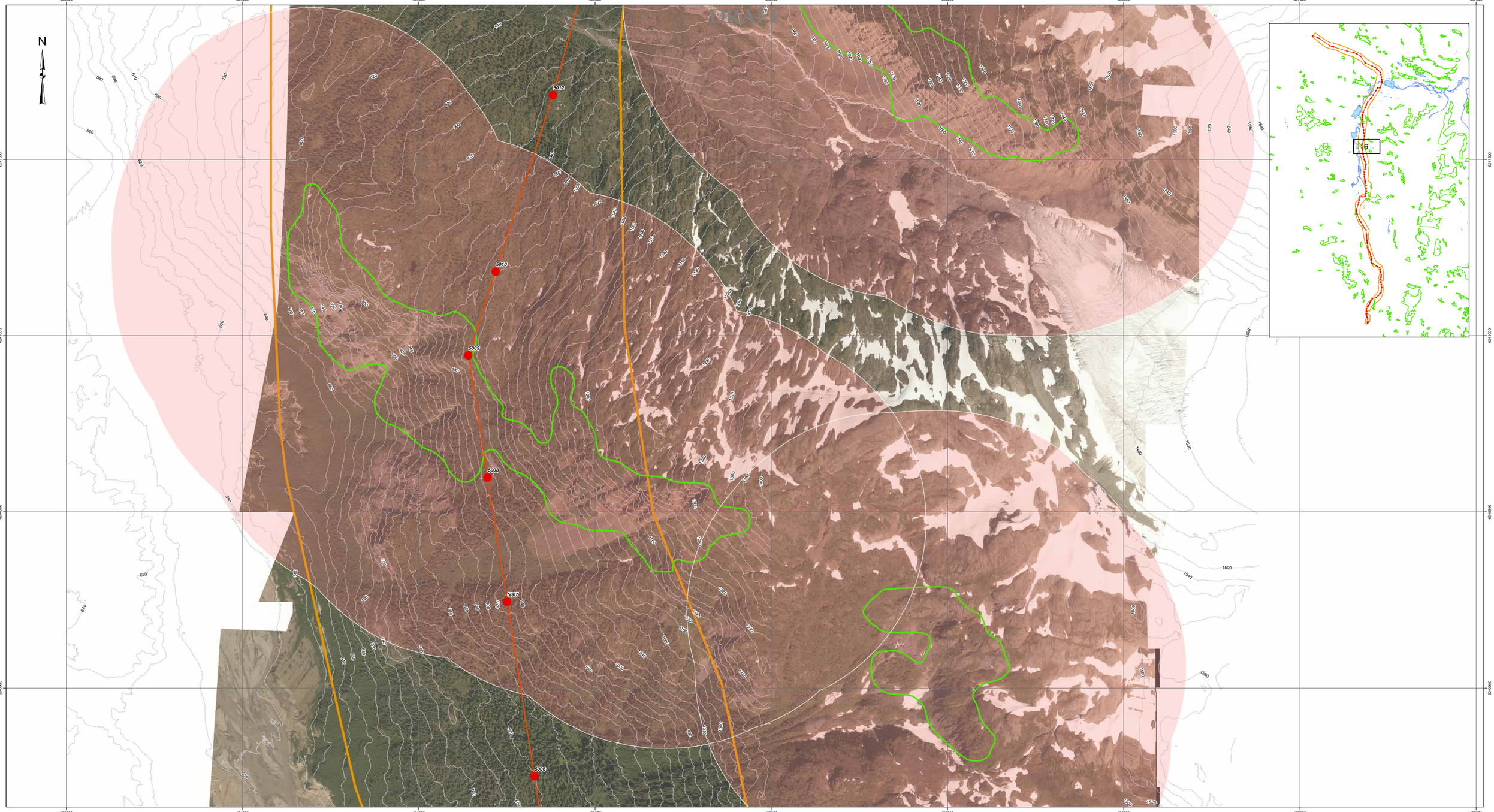

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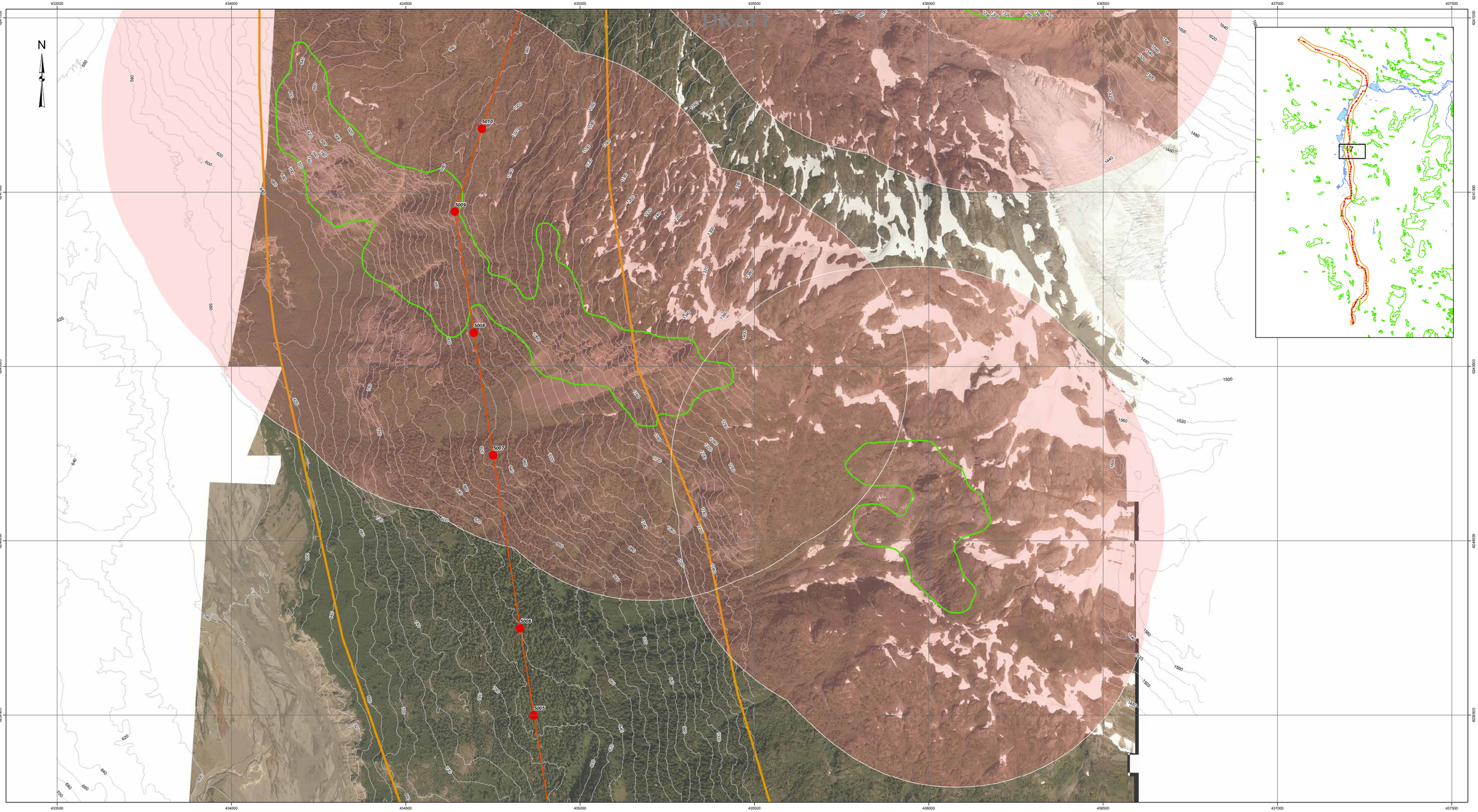

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with 500m Buffer

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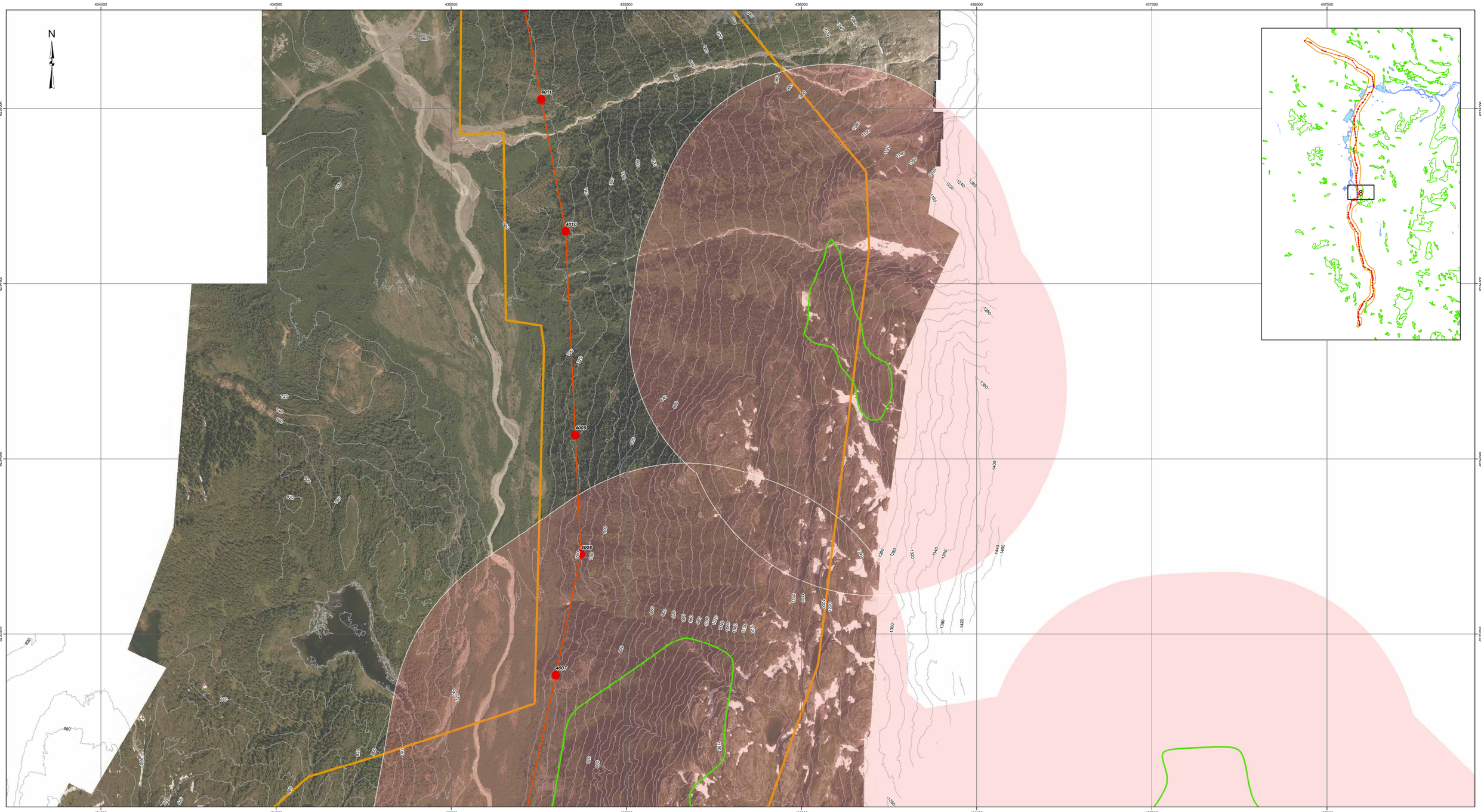

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Brucejack Project

Mountain Goat Area Along Transmission Line

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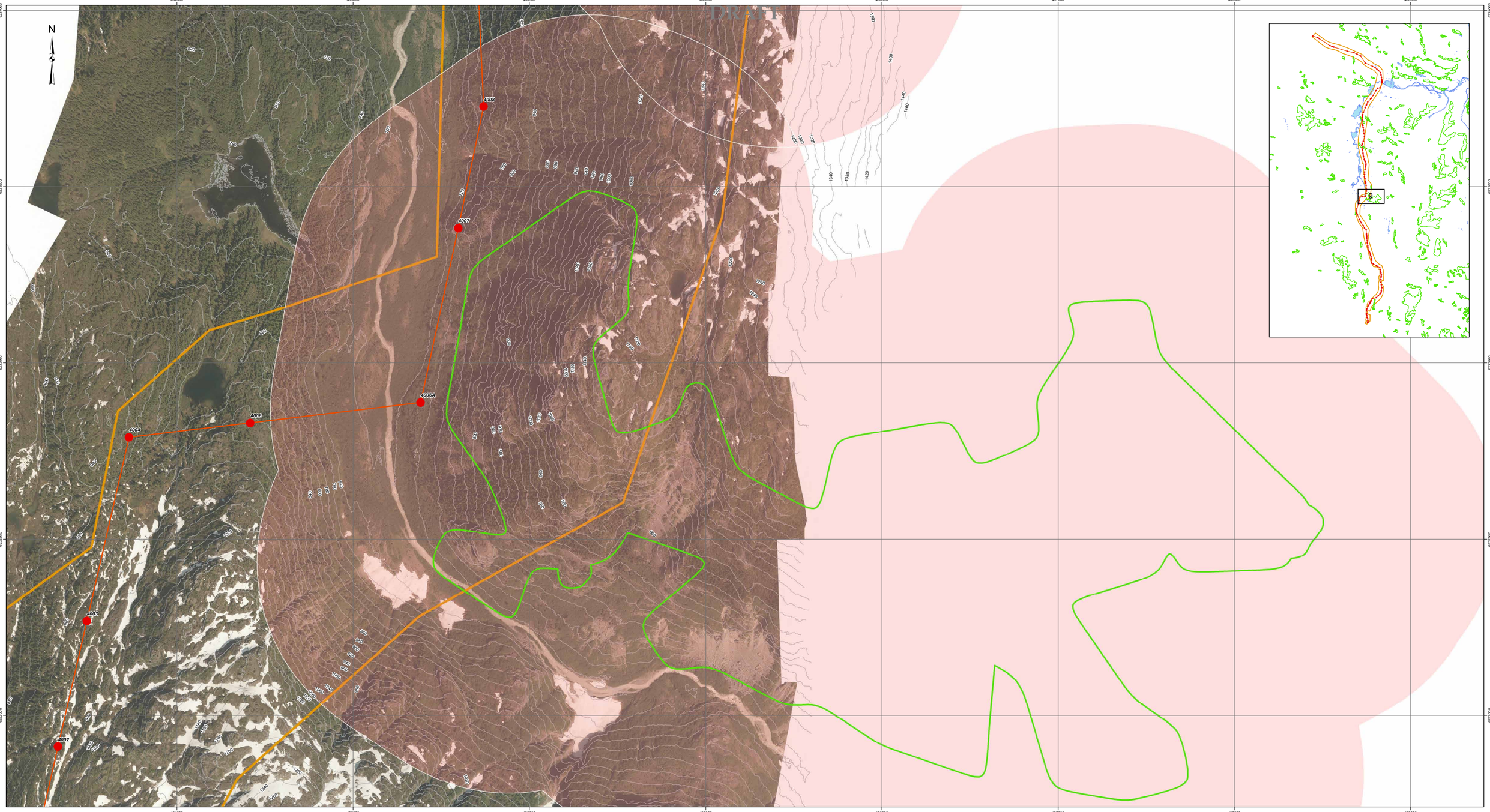

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Canada
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Brucejack Project

Mountain Goat Area Along Transmission Line

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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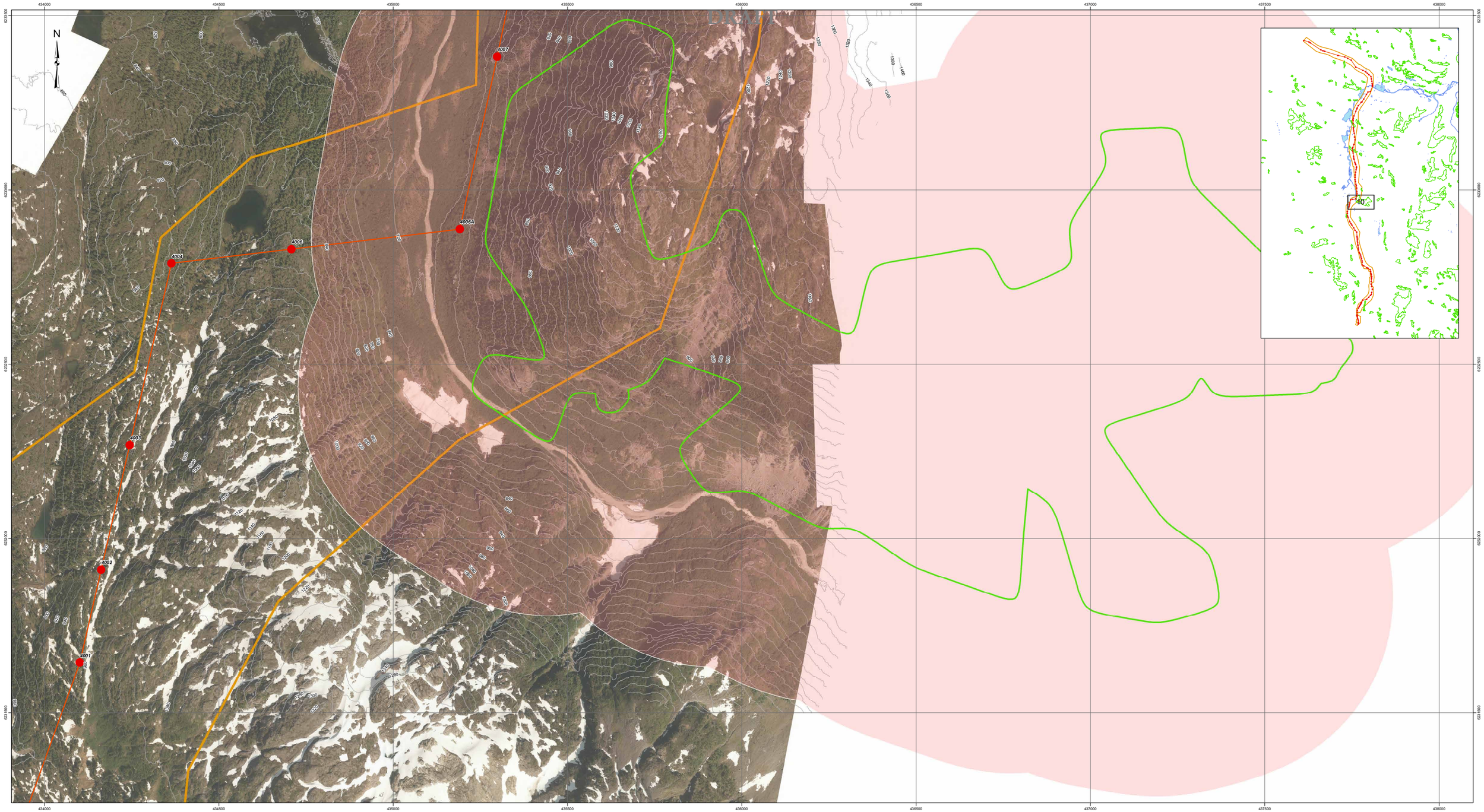

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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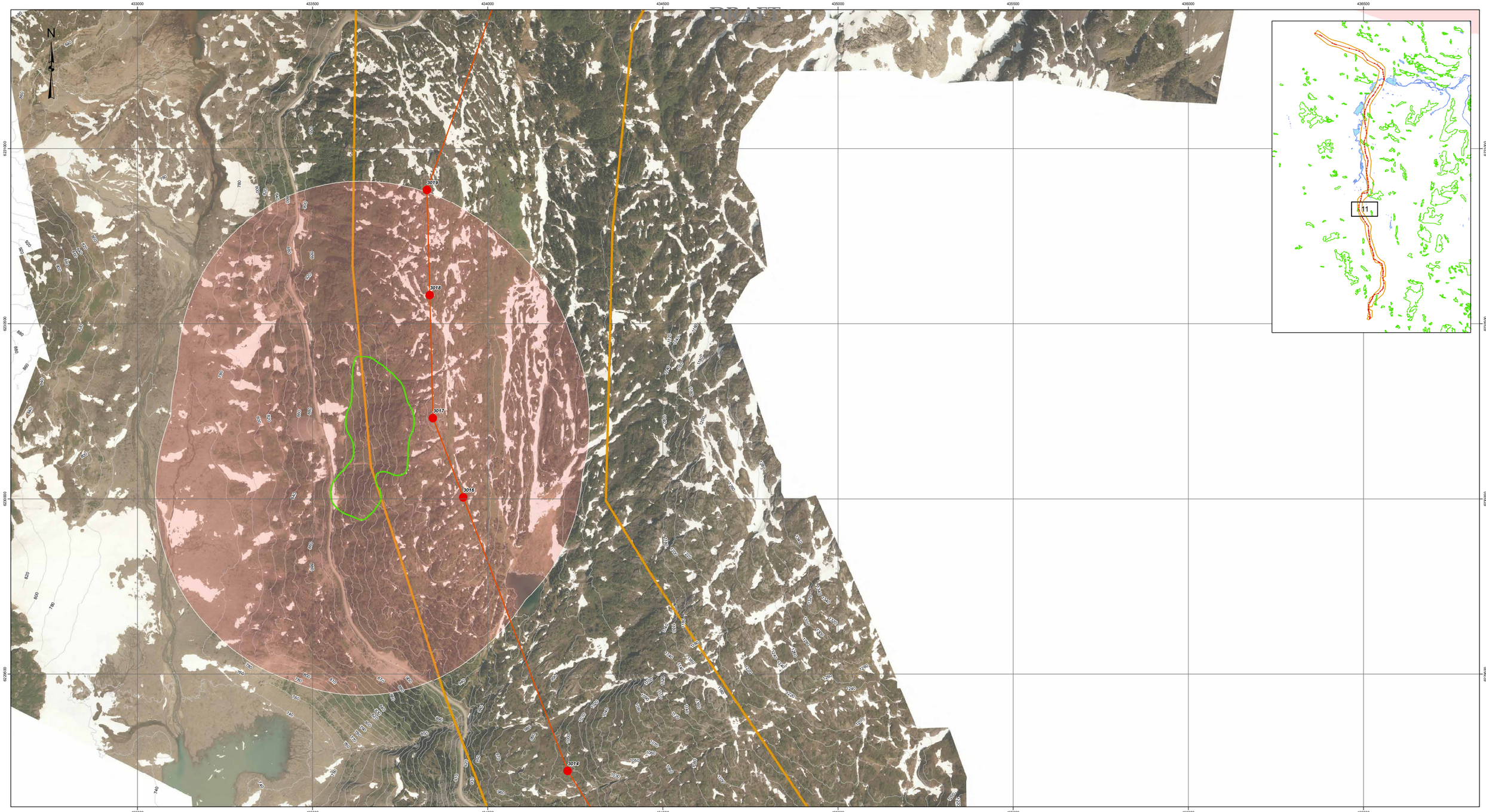

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Brucejack Project

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with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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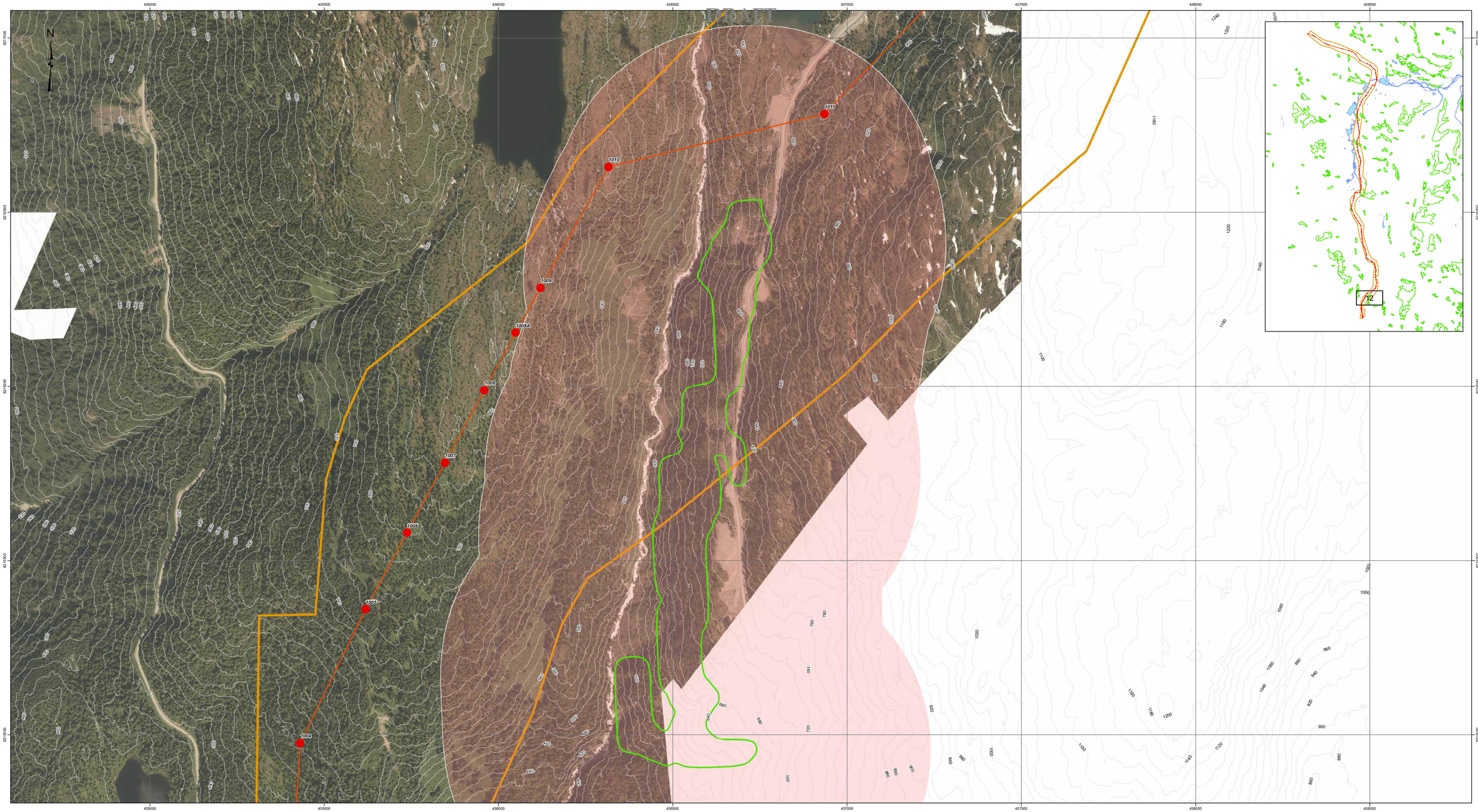

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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PROJECTION: UTM Zone 9 (NAD 83)

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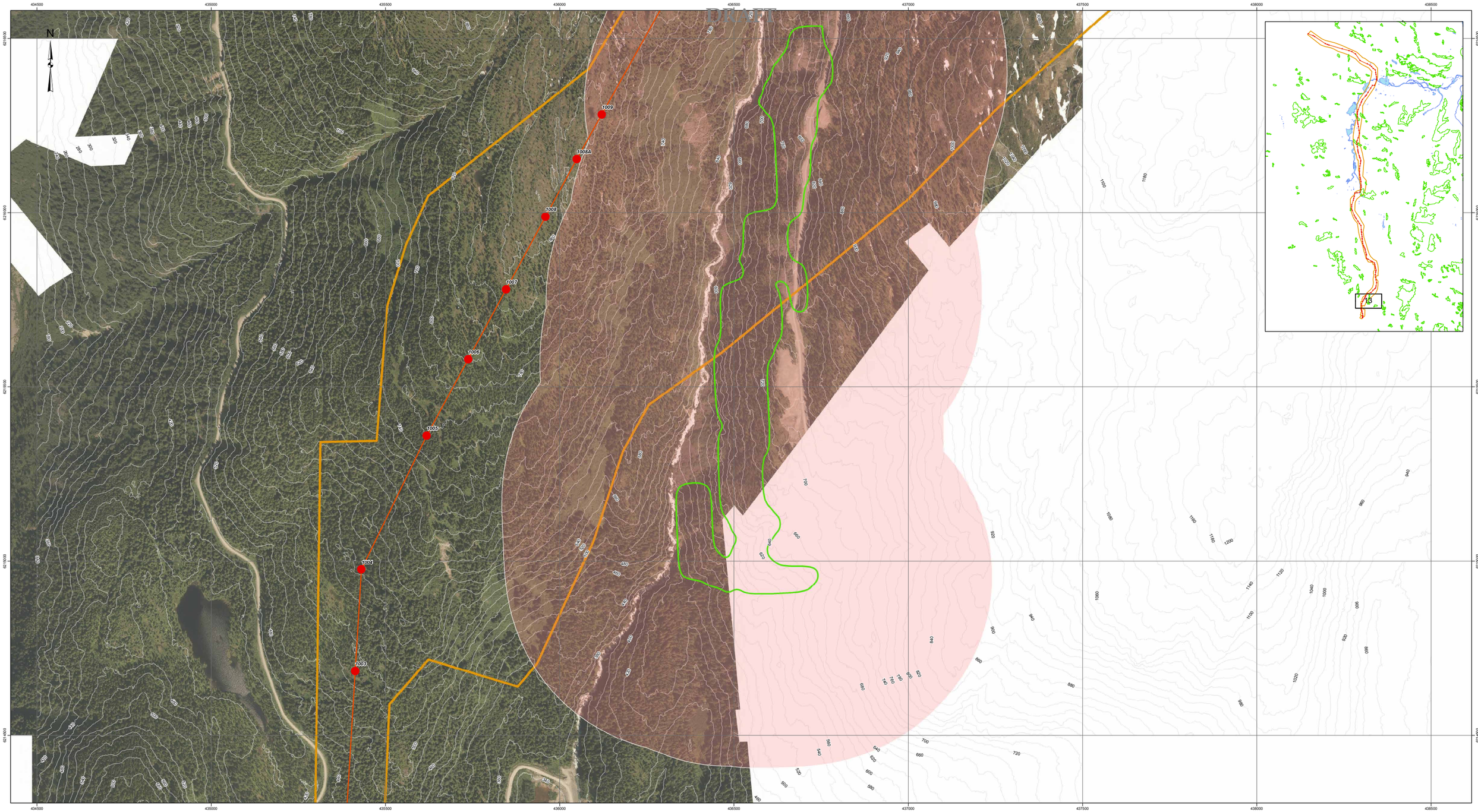

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Mountain Goat Boundaries
- Mountain Goat Boundary Buffer (500m)
- Transmission Line Corridor (as of 9 Jan 2015)

0 75 150 300 450 600
Meters

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PRETIUM RESOURCES INC.
Brucejack Project

Mountain Goat Area Along Transmission Line
with 500m Buffer

PROJECT NO:	FILE:	PROJECTION:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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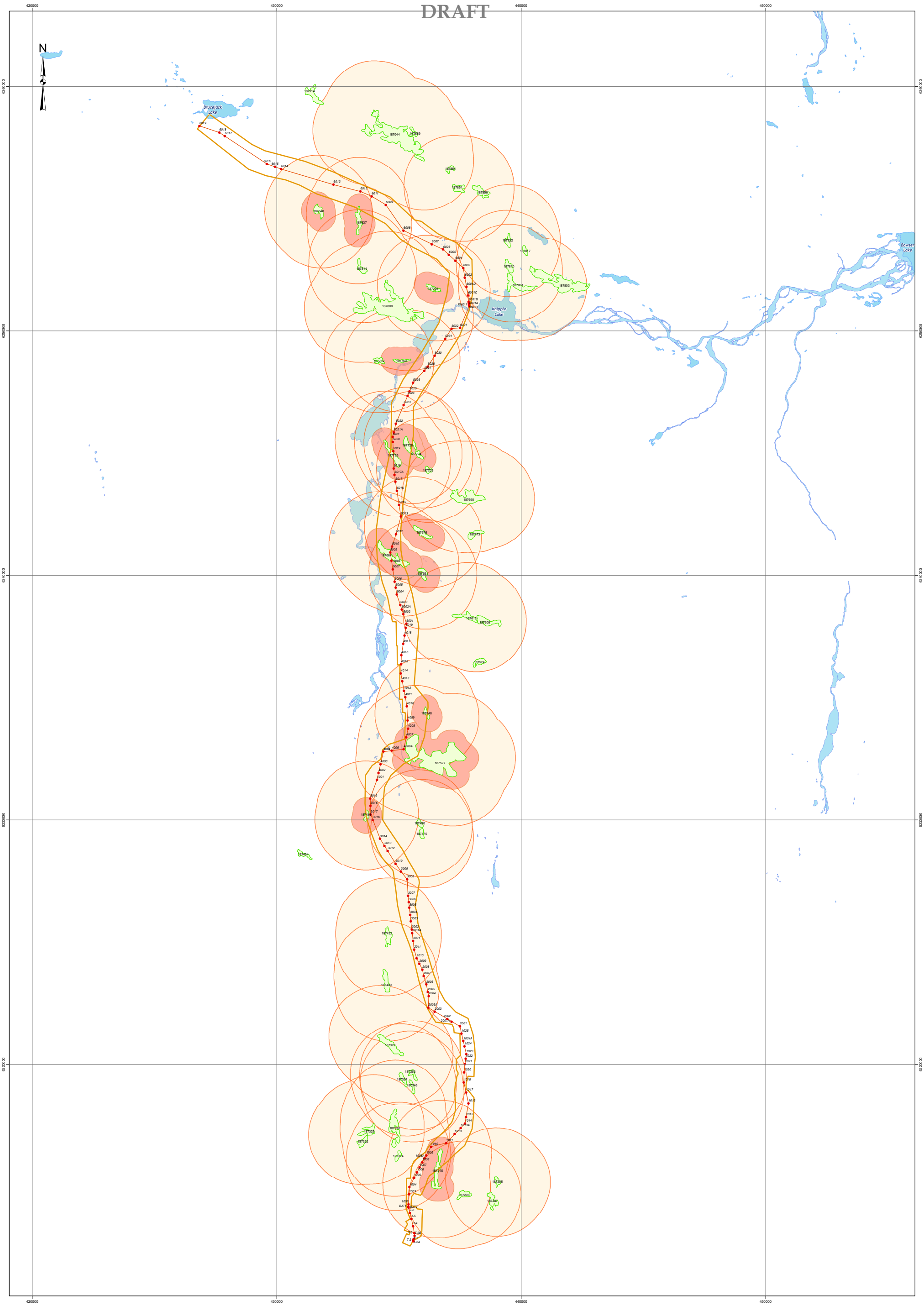

Legend

- Transmission Tower (as of 13 Jan 2015)
- Transmission Line (as of 13 Jan 2015)
- Transmission Line Corridor (as of 9 Jan 2015)
- Mountain Goats Along Transmission Line
- 2 Km Buffer
- 500m Buffer

0 0.75 1.5 3 4.5 6
Kilometers

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Brucejack Project

Mountain Goats Along Transmission Line

PROJECTION: UTM Zone 9 (NAD 83)

PROJECT NO:	FILE:	REV:	SCALE:	DATE:	DOCUMENT:	FIGURE #:
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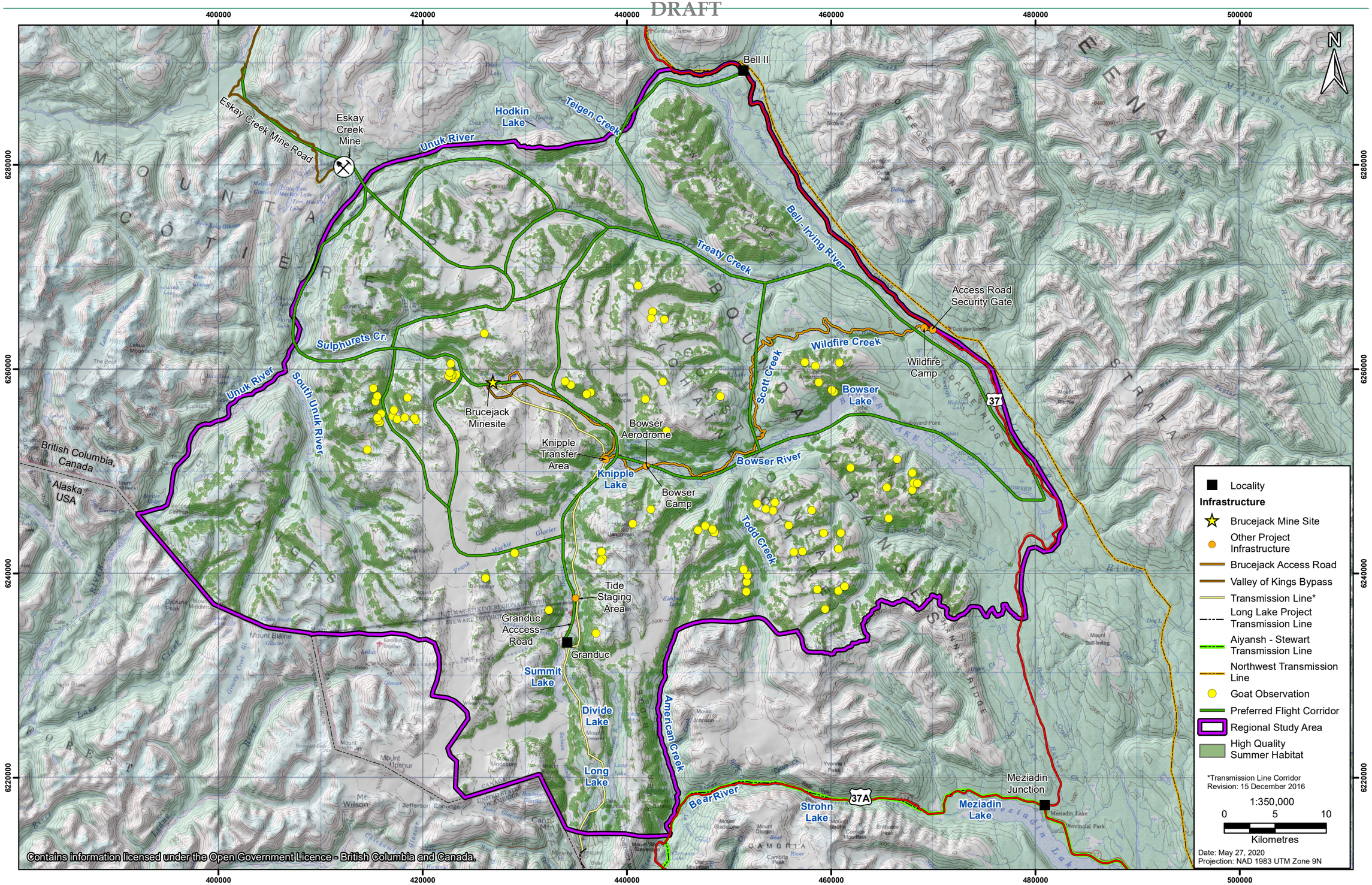

Helicopters and Mountain Goats at Brucejack

Appendix 9-2-6. Nitrogen Management Plan

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Nitrogen Management Plan

March 2023

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Nitrogen Management Plan

Revision 5

Date: 2023-03-31

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VERSION CONTROL

Revision #	Date Released	Author	Approval	Amendment
0	Nov 16, 2015	Patrick Mueller, Lorax	-	Replacement for the Nitrite Management Plan
1 - Draft	July 29, 2016	Patrick Mueller, Lorax	Lyle Morgenthaler, Pretium	Document reorganization
1 - Final	November 10, 2016	Patrick Mueller, Lorax	Lyle Morgenthaler, Pretium	Update N loading rate and mine water plot
2 – Draft	March 27, 2019	Patrick Mueller, Lorax Colleen Atherton, Pretium	Lyle Morgenthaler, Pretium	Align NMP with MOE Guidance; Update monitoring procedures, benchmarks and monitoring metrics based on operational data
3 - Final	July 27, 2020	Patrick Mueller, Lorax Colleen Atherton, Pretium	Lyle Morgenthaler, Pretium	Update production blasting methods; add surface blasting source control procedures; update Sections 4, 5, 6, 7, 8 and 9 to reflect current practice
4 – Final	March 17, 2022	Nathan Glas, Pretium Patrick Mueller, Lorax	Robin McCall, Pretium	Annual Review with updates to monitoring results, waste rock deposition practices, ore blasting practices and training conducted. New sections for audit results and conclusions were added.
5 – Final	March 1, 2023	Nathan Glas, Pretium Patrick Mueller, Lorax	Torence Sandhals, Pretium	Annual review with updates to monitoring results, powder factor monitoring practices and associated blasting procedures, along with mine water loading rate procedure update.

AUTHORSHIP

This Nitrogen Management Plan (NMP), revision 5, was updated from revision 4 by Nathan Glas, M.A.Sc., P.Geo. Pretium Resources Incorporated (Pretium) with input and review by Patrick Mueller, B.Sc., P.Chem of Lorax Environmental Services Limited (Lorax), the acting qualified professional (QP) for this plan. Revision 5 provides updated details surrounding:

- Changes to drilling equipment and data management practices that have resulted to changes in how the development and production powder factors (PF) are calculated;
- Changes to procedure for monitoring nitrogen (N) Loading from waste rock deposition by incorporating a 2 year averaging period to obtain more representative and normalized results;
- A summary of NMP monitoring results to the end of 2022;

Prepared by:

Mar 23, 2023

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Mar 15, 2023

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AN	Ammonium Nitrate
ANFO	Ammonium Nitrate Fuel Oil
ENV	BC Ministry of Environment and Climate Change Strategy (formerly MOE)
BJAR	Brucejack Access Road
CWP	Contact Water Pond
EBR	Electro-biochemical Reactor
EMA	*Environmental Management Act*
EMLI	Ministry of Energy, Mines and Low Carbon Innovation
EMS	Environmental Management System
IX	Ion Exchange
MA	*Mines Act*
MBBR	Moving Bed Biofilm Reactor
MDMER	Metal and Diamond Mining Effluent Regulations
MEMPR	Ministry of Energy, Mines and Petroleum Resources (formerly MEM)
MERP	Mine Emergency Response Plan
MOE	Ministry of Environment
N	Nitrogen
NMP	Nitrogen Management Plan
NPAG	Not Potentially Acid Generating
OMS	Operations Maintenance and Surveillance
PAG	Potentially Acid Generating
PF	Powder Factor (kg explosive / tonne rock)
QA/QC	Quality Assurance/ Quality Control
STP	Sewage Treatment Plant
WRTSF	Waste Rock and Tailings Storage Facility
WTP	Water Treatment Plant
WZ	West Zone

1 PURPOSE

The purpose of this Nitrogen Management Plan (NMP) is to provide guidance for Pretium Resources Inc. (Pretium), a member of the Newcrest Group of companies, regarding minimization and management of the release of soluble nitrogen compounds (ammonia, nitrite and nitrate) associated with explosives at the Brucejack Mine (Brucejack or the Mine). This plan aims to: 1) describe potential sources and pathways of nitrogen; 2) document the potential risk to the environment; 3) describe the monitoring plan for ensuring that the environmental risks are minimized; 4) outline the management triggers for implementing mitigation should it be necessary; and, 5) outline potential mitigation and timelines for implementation.

2 SCOPE

This NMP is intended to provide guidance to Pretium on nitrogen management and applies to all individuals working for or on behalf of Pretium, including employees and contractors who have a role and/or accountability for the development, implementation and maintenance of this NMP.

This NMP has been developed in accordance with applicable legislation, regulations and guidelines. Environmental protection is a requirement of both the BC *Mines Act* (1996) and the Health, Safety and Reclamation Code for Mines in British Columbia (EMLI, 2021). The movement, storage, use and disposal of explosives at mines in BC are regulated pursuant to Part 8 of the Code. Discharge is authorized under section 120 (3) of the BC *Environmental Management Act* (2003) and is administered by the BC Ministry of Environment and Climate Change Strategy (ENV) under Effluent Permit 107835 (PE-107835). Discharge limits for ammonia, nitrite and nitrate are regulated at the outlet of the Waste Rock and Tailings Storage Facility (WRTSF) and are summarized in Table 2-1.

Table 2-1: Effluent Permit PE-107835 discharge limits for Nitrogen (N) compounds at BJ 3.10.

Parameter	Discharge Limit (mg-N/L)
Ammonia	4.0
Nitrite	0.24
Nitrate	11.5

The following Federal and Provincial legislation, regulations and guidance documents are relevant for nitrogen management, the handling of explosives and the discharge of effluent from mining operations:

- Federal *Explosives Act* (R.S.C., 1985, c. E-17);
- Federal *Explosives Regulations* (SOR/2013-211);
- Federal *Fisheries Act* (R.S.C., 1985, c. F-14, as amended) Sections 34(2), 36(3), 36(5) and 38(9);
- Federal *Metal and Diamond Mining Effluent Regulations* (MDMER; SOR/2002-222);

- Health, Safety and Reclamation Code for Mines in British Columbia (EMLI, 2021);
- BC *Mines Act* Permit M-243 Section D.1 (EMLI, 2022);
- BC *Environmental Management Act* Effluent Permit 107835 Conditions 1.1 and 3.2 (ENV, 2022);
- BC *Municipal Wastewater Regulation* (Reg. 87/2012) domestic wastewater;
- BC *Spill Reporting Regulation (*BC Reg. 187/2017); and,
- BC Guidance on Preparing Nitrogen Management Plans for Mines using Ammonium Nitrate Fuel Oil Products for Blasting (ENV, 2018)

Field sampling and laboratory testing are undertaken according to procedures outlined in the following:

- *British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emission, Water, Wastewater, Soil, Sediment and Biological Samples* (ENV, 2020a; and,
- *British Columbia Laboratory Manual* (ENV, 2020b).

3 INTRODUCTION

Pretium owns and operates the Brucejack Mine located in northwest British Columbia approximately 65 km NNW of Stewart by air. Brucejack is an underground gold mine with related surface infrastructure including a mill, mine water treatment plant (WTP), subaqueous waste rock and thickened tailings slurry deposition sites, accommodations, transmission line and off-site infrastructure (Figure 3-1). Commercial production was achieved July 2017 and the planned operating life of the mine is approximately 14 years at an annual ore production of 1.387 Mt (3,800 tpd) as described in Lorax (2020).

The BC Environmental Assessment Office issued BC Environmental Assessment Certificate #M15-01 on March 26, 2015. During the next five months Pretium applied for, and received *Mines Act* Permit M-243 and *Environmental Management Act* Permit for discharge of effluent (PE-107835) based on an annual ore production of 0.99 Mt. The *Mines Act* and *Environmental Management Act* permits were amended in December 2018 following an application for increased ore production of 1.387 Mt (3,800 tpd) and have most recently been amended in November 2022 to reflect expansion of the Permitted Mine Area (PMA) and June 2022 to update sewage treatment plant authorizations and amend nomenclature from Brucejack Gold Mine to Brucejack Mine, respectively.

Over the life of the mine, underground excavation will total approximately 5.3 Mt of waste rock and 18.5 Mt of ore, mined at a 3800 tpd production rate in accordance with the *Mines Act* permit (EMLI, 2021). Nitrogen residues are exported from blasted rock on the blasted rock surfaces and in contact water (Pommen, 1983; Wiber *et al*., 1991; Forsyth *et al.*, 1995). The release of nitrogen (N) compounds from blasting is directly related to the quantity of explosives used for blasting a tonne of rock. Blasting residuals associated with rock excavation can mobilize from the following:

- To mine water from blasted rock surfaces through contact with groundwater and water used for dust suppression;
- To mill process water from ore surfaces;
- To mine water from paste backfill bleed water and waste rock backfill seepage;
- To the WRTSF through waste rock and tailings deposition;
- To the WRTSF though discharge of treated WTP and sewage treatment plant (STP) effluent;
- To the WRTSF through NPAG quarry runoff and rock used for road surfacing.

Elevated concentrations of ammonia, nitrite and nitrate in Brucejack Creek may be harmful to aquatic resources. Although fish are not present in Brucejack Creek, insects (e.g., mayflies) are present. The discharge limits for ammonia, nitrite and nitrate specified in PE-107835 are protective of these organisms.

The following sections summarize sources of nitrogen compounds, material and water management, the NMP monitoring programs and results, and N source control procedures implemented at Brucejack. This plan will be routinely updated as relevant information becomes available and management practices are refined.

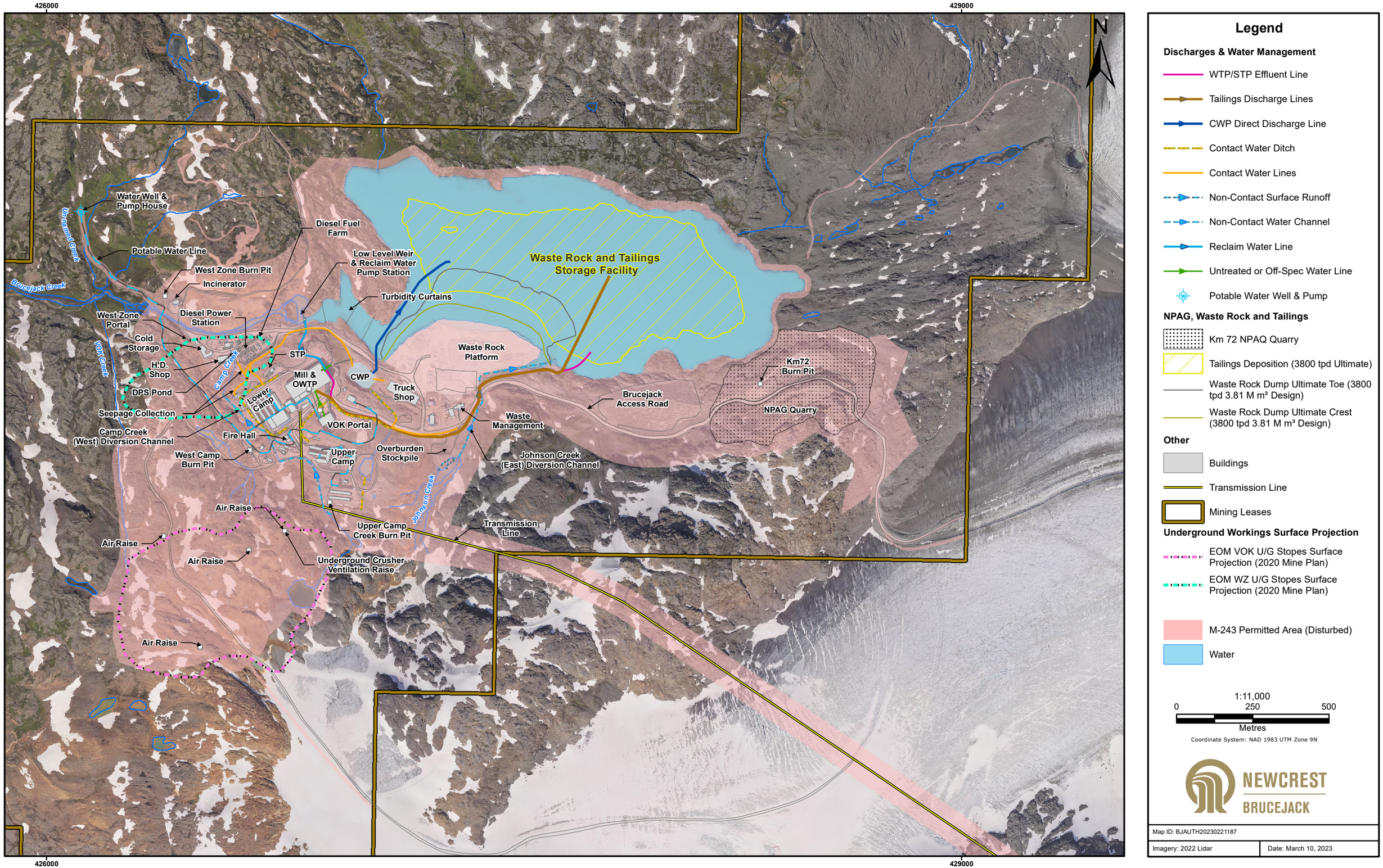


Figure 3-1 Mine Site General Arrangement and Detailed Infrastructure Plan - End of 2022

4 NITROGEN SOURCES AND CONTROL PROCEDURES

4.1 Explosives Products and Hazard Classes

Explosives residues are a widely recognized source of ammonia, nitrite and nitrate in contact water and blasted rock surfaces (Pommen, 1983; Ferguson and Leask, 1988; Wiber, 1991; Forsyth, 1995; Cameron *et al*., 2007; Morin, 2009; Bailey *et al*., 2013; Mueller, 2015; Sidenko, 2018). Nitrogen constitutes approximately 25% of the ammonia nitrate (AN) based explosive product used at Brucejack, apportioned almost equally between ammonia and nitrate as N, while nitrite is an oxidation product of the explosion reaction. Treated domestic wastewater is also a source of ammonia and nitrate, however this represents a small proportion of the nitrogen load discharged to the WRTSF therefore N source control measures are focussed on explosives use. Water soluble nitrogen compounds are transported to the aquatic environment downstream of the mine through discharge from the WRTSF at station BJ 3.10.

Nitrogen residues are exported from blasted rock on the blasted rock surfaces and in the contact water. The release of N compounds from blasting is directly related to the quantity of explosives used for blasting a tonne of rock (also known as a powder factor, or PF) and the blasting method used. Blasting conditions (and PF) vary on a daily basis and are therefore evaluated over longer periods (*i.e.,* monthly).

The primary explosive used for underground blasting at Brucejack is the following AN-emulsion product:

- TITAN® 7000 sensitized bulk emulsion manufactured by Dyno Nobel; DOT hazard shipping description: explosive, blasting, type E 1.5D II, UN0332.

Packaged AN-emulsion explosives are also used for small areas and include:

- Dyno® AP detonator sensitive water-resistant emulsion explosives packaged in plastic. DOT hazard shipping description: explosive, blasting, type E, 1.1D, UN 0241 II;

- DynoSplit® nitroglycerin dynamite packaged in rigid paper cartridges. DOT hazard shipping description: explosive, blasting, type A, 1.1D, UN 0081 II.

The primary explosives used for surface blasting at Brucejack include:

- Dyno® Blastex booster sensitive, water-resistant, packaged emulsion explosive. DOT hazard shipping description: explosive, blasting, type E, 1.5D, UN 0332 II.

Detonators and Boosters used for underground and surface blasting include:

- Dyno TROJAN® SPARTAN® detonator sensitive cast boosters, high density, high energy molecular explosives. DOT hazard shipping description: boosters, 1.1D, UN 0042.

4.2 Explosives Transport, Storage and Blasting Procedures

The majority of explosives used at Brucejack are employed in the excavation of waste rock and ore in the underground mine. A limited volume of explosives are used at the mine site for quarrying NPAG rock for road surfacing and building foundations. Additional blasting is conducted for NPAG quarry excavation along the Brucejack access road (BJAR) to generate material for road construction and maintenance.

Procedures to minimize transfer of nitrogen to the environment are required at all locations where explosives are used. Considerations for nitrogen source control are included in Appendix A and Appendix B for surface blasting and underground blasting, respectively. Explosives use within the M-243 permit area is restricted to water insensitive products such as bulk and packaged AN-emulsion. Due to typically dry conditions and limited excavation volumes, ANFO products are permitted at NPAG quarry sites along the BJAR, however, at this stage they have not been utilized.

Health and safety and explosives handling practices are the responsibility of the blasting contractor and are described in the SOPs prepared and controlled by the blasting contractor. Pretium requires that the blasting contractor health and safety practices comply with the regulatory requirements outlined in Section 2.

Explosives are stored in restricted areas that are secure and locked and access is limited to authorized personnel only. Bulk emulsion and packaged emulsion products are stored in magazines and are used first-in, first-out to prevent degradation from storage. Spoiled emulsion explosives are deposited into the designated waste tote and returned to the supplier.

Blasting is used to excavate underground drifts and stopes, and for surface excavation at NPAG quarries. Blast hole patterns are designed by Mine Engineers and field fit as needed to excavate a specific volume of rock. Adjustments are made based on visual observation of rock fragmentation. Explosives are loaded with boosters and detonators and detonator tie in is conducted just prior to a blast.

Development blasting methods are used to advance drifts and access tunnels for underground mining operations. The blasts are conducted with a short hole pattern of 60 to 80 horizontal holes to a depth of 2.8 to 4.2 m with an open square blast face typically 5.5 by 5.5 m in dimension. Small diameter boreholes (51 mm) are drilled for loading explosives and the explosives use rate (powder factor or PF) for development blasting is high relative to other blasting methods used at Brucejack.

Ore is excavated at Brucejack via longitudinal or transverse open stoping production blasting methods. Stopes are excavated by advancing drifts at 30 m intervals. Longholes (101.6 mm diameter) are then drilled from the top or bottom drift in a parallel or radiating fan pattern. Stopes are typically 30 m high and 15 m wide, and the length of the stope varies depending on the mine plan. The initial blast in a stope, termed the slot, requires a higher PF than the remaining blasts; therefore, smaller stopes will generate higher PFs. Overall, the production PF is significantly lower than for development blasting. Blast holes were previously drilled by Sandvik Solo top-hammer drills that produced 3.5 inch holes. However, in 2021 ITH drills were commissioned and these produce a 4 inch hole that increases the amount of explosives used for each blast compared to the smaller 3.5 inch blast holes. The Mine completed the transition to ITH drills during 2022. Although the blast hole spacing has been updated for the ITH drills, the revised blast patterns yield a higher emulsion to blasted rock ratio over the

previous 3.5 inch holes and associated blast patterns, and this is reflected in the 2021 and 2022 Production PF monitoring results.

Surface blasting at the km 72 NPAG Quarry is conducted using packaged AN-emulsion. Surface blasting at quarries along the BJAR (*e.g.,* at km 59 NPAG Quarry) may also use ANFO if dry blasting conditions are present within the quarry. The km 72 and km 59 NPAG Quarries are a source of rock for fill material and road surfacing, with the km 72 NPAG Quarry providing material for the Brucejack Site and the km 59 NPAG Quarry providing material for the Brucejack Access Road. Blast holes are drilled down from the surface to a depth and over an area specified in the blast pattern design prepared by the mine engineer. The powder factors for surface blasting are generally lower than for underground blasting. Similar to nitrogen audits of underground blasting procedures, surface blasting nitrogen audits were initiated in 2022, with one completed at the km 72 NPAG Quarry.

The following protocols for underground blasting practices are prepared and used by the mining contractor, Procon Mining and Tunnelling Ltd. (2008):

- Brucejack-UND-EXP-001 Central and Remote Blasting
- Brucejack-UND-EXP-002 Underground Longhole Explosives Loading
- Brucejack-UND-EXP-003 Re-Entering the Workplace After Blasting
- Brucejack-UND-EXP-004 Loading a Development Round
- Brucejack-UND-EXP-005 Disposing Waste Explosives
- Brucejack-UND-EXP-007 Blasting Oversize – Remote Stope Muck
- Brucejack-UND-EXP-008 Blasting Oversize Muck During Shift
- Brucejack-UND-EXP-009 Transporting & Receiving Explosives
- Brucejack-UND-EXP-010 Transferring Emulsion Underground
- Brucejack-UND-EXP-011 Receiving and Transporting Emulsion ISO Container with A64 Getman Hauler

4.3 Source Control

Source control is generally recognized as an effective strategy for N mitigation and this is implemented at Brucejack Mine through the use of best practices for explosive handling and blasting, as well as domestic wastewater management. Explosives are the primary source of N in Brucejack Mine discharges. Nitrogen source control is achieved through good explosives handling and spill clean-up procedures. Considerations for N source control are summarized in Table 4-1 and are reviewed during regular inspections to evaluate implementation. Additional source control considerations for surface quarrying and underground mining are provided in Appendix A and Appendix B, respectively.

Table 4-1: Nitrogen Control Measures for Explosives Use

Activity	Nitrogen Control Considerations
Explosive Selection	• Select water-resistant explosives appropriate for site conditions (e.g., AN-emulsion)

Blast pattern design	• Design patterns to achieve desired fragmentation with minimum explosives use
Blast hole loading	• Dewater blast holes • Use packaged explosive for flowing holes • Minimize the loaded pattern “sleep” time (the elapsed time between explosives loading and detonation) • Clean up all spilled explosives
Water management	• Divert water away from blast holes and/or contact surfaces
Disposal	• Detonate with regular blasting • Collect and ship off-site for disposal

4.4 Nitrogen Cycling

Nitrogen from explosives residues may be present as ammonia (defined as NH_3, NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-). The relative distribution of nitrogen between ammonia, nitrite and nitrate in the WRTSF can shift due to naturally occurring nitrogen cycling processes. Nitrification reactions in the natural environment are mediated by nitrifying organisms that are ubiquitous in groundwater, lakes and streams (Ward et al., 2011; Ward, 2013) and in cold water environments (Small et al., 2013; Clevinger, 2013). Empirical observations from Brucejack monitoring data indicate nitrification processes that convert ammonia to nitrate are active in the WRTSF. Nitrate is the dominant N containing species at the WRTSF outlet and typically accounts for > 98% of the total nitrogen exported from the WRTSF. Nitrification processes are expected to control the nitrogen species distribution in the WRTSF discharge throughout mining and closure. The processes that control nitrogen cycling in the WRTSF are discussed in detail in Appendix C.

5 MATERIAL MANAGEMENT

5.1 Blasting

Development and Production blasting, using the methods described in Section 4.2, generate blasted rock at the blast location (*i.e.*, muck piles). Water is sprayed onto the muck pile at the blast site for dust suppression following each blast. Monitoring data indicate that some of N loads on the blasted rock are transferred to mine water at the blast location. However, the majority of the N containing residues remain on the blasted ore and waste surfaces. The annual tonnages blasted, and explosives used for Development and Production blasting are provided in Table 5-1.

Table 5-1: Annual Development and Production Blasting Tonnage and Explosives Use

Year	Development Blasting (t)	Development Explosives Use (kg)	Production Blasting (t)	Production Explosives Use (kg)
2015	225,226	319,433	-	-
2016	768,238	1,374,220	-	-
2017	675,264	1,141,313	440,839	346,209
2018	651,531	1,135,531	825,464	687,485
2019	779,124	1,356,416	1,115,052	983,046
2020	941,543	1,541,517	1,092,670	932,722
2021	893,734	1,695,208	1,026,936	1,018,560
2022	789,731	1,578,750	1,001,966	1,129,722

5.2 Waste Excavation and Deposition to WRTSF or Backfill

Waste rock at Brucejack is managed via subaqueous deposition either as backfill in portions of the underground mine that will ultimately be flooded upon closure, or deposited in the WRTSF. Waste rock destined for WRTSF deposition is transported to the surface via scoop and underground haul truck where it is temporarily deposited near the portal before being transferred to the waste rock deposition platform by a surface haul truck. Waste rock is either directly deposited on the waste dump pad for deposition to the WRTSF, or temporarily stored in a stockpile until such time that it can be deposited. Waste can be stockpiled for several reasons, such as during winter months when the lake is frozen, during turnover when deposition is halted, and during maintenance or other activities occurring on the waste dump pad that preclude waste deposition. Waste rock deposited in the WRTSF builds up and eventually forms the waste rock deposition platform where some waste rock extends to or above the normal WRTSF water level. This subaerially exposed PAG waste rock is periodically replaced with either NPAG material or freshly excavated PAG waste rock, or left with a 1 m water cover, such that surface-deposited PAG waste rock is ultimately subaqueously deposited with a minimum 1 m water cover within the allowable two-year exposure period. On July 11, 2022 waste deposition was halted due to increased settlement rates on the dump pad. On July 16, 2022 the waste pad experienced a failure, at which point deposition was halted from mid-July to mid-August to allow for geotechnical stability evaluations to be undertaken before continued waste deposition could occur.

Prior to May 2021, waste transferred to the WRTSF was segregated into two waste streams: 8 inch minus and 8 inch plus. The 8 inch minus material was deposited into the WRTSF using a stacker. Material larger than 8 inches was placed into the WRTSF by bailing with a backhoe. The volume of waste rock placed in the WRTSF was estimated using backhoe bucket loads fed to the stacker and truck counts of oversize material removed for bailing. In May 2021, the use of a remote-controlled dozer was initiated, which allowed all material to be pushed into the WRTSF using one methodology. The volume of waste rock placed in the WRTSF is now tracked using truck loads. The stacker has been dismantled and decommissioned, but there is still the ability to bail material in the future as required. The temporary waste stockpile at the end of 2022 was approximately 232,460 m^3.

For 2022, deposition did not occur from January through April or in December, deposition volumes were higher and consistent from May through mid-July, with a deposition gap from mid-July to mid-August, followed by lower but consistent deposition from mid-August to late October and low and intermittent deposition through later November. The annual waste rock excavation and deposition quantities for 2020-2022, and planned through 2032 are shown in Table 5-2 (Lorax, 2020).

Table 5-2: Annual Waste Excavation and Deposition Schedule from 2020 through 2032.

Year	Waste Excavation [1] (kt)	Waste Delivered to WRTSF [1] (kt)	Waste Deposition to Backfill [1] (kt)
2020	761	720	41
2021	1,011	804	207
2022	850	626	224
2023	*486*	*46*	*439*
2024	*392*	*199*	*193*
2025	*389*	*85*	*305*
2026	*315*	*121*	*195*
2027	*264*	*149*	*115*
2028	*44*	*13*	*31*

2029	*36*	*1*	*35*
2030	*35*	*6*	*29*
2031	*7*	*2*	*5*
2032	*4*	*4*	*0*

[1] 2020-2022 are actual values, whereas 2023 through 2032 are projected values provided by Pretium for the 2020 water quality model update (Lorax, 2020).

5.3 Ore Processing

Ore is excavated at Brucejack using production blasting methods described in Section 4.2 via longitudinal or transverse open stoping. A portion of ore, typically less than 15%, is generated during development blasting for excavation of drifts. Following blasting, ore is transferred to the underground crusher via remote scoop and rock truck. Crushed ore is transferred to the surge bin within the mill via conveyor and from there is directed to the SAG mill for grinding. Process water is also directed to the SAG mill and monitoring data suggest that most or all the soluble N species on ore surfaces are transferred to process water in the SAG mill. The annual ore production quantities for 2020-2022, and planned through 2032 are shown in Table 5-3 (Lorax, 2020).

Table 5-3: Annual Ore Production Schedule

Year	Ore Production [1] (kt)
2020	1,309
2021	1,383
2022	1,254
2023	*1,386*
2024	*1,388*
2025	*1,388*
2026	*1,388*
2027	*1,180*
2028	*1,180*
2029	*902*
2030	*801*
2031	*561*
2032	*189*

[1] 2020-2022 are actual values, whereas 2023 through 2032 are projected values provided by Pretium for the 2020 water quality model update (Lorax, 2020).

5.4 Tailings Deposition to WRTSF or Paste Backfill

Tailings are managed via subaqueous deposition at depth in the WRTSF or placed as cemented paste backfill in the underground mine. Nitrogen species are water soluble and the primary method of transmission of N from tailings to the WRTSF is via the liquid fraction (*i.e.,* supernatant) of the tailings slurry. Tailings supernatant is composed of mill process water that has been influenced by N loading from WTP effluent and ore. During the winter, the primary discharge of water to the WRTSF typically occurs in the form of tailings supernatant discharged with the tailings slurry.

Monitoring of backfilled stopes indicates that limited water is released during and after backfilling and therefore cemented paste backfill is not expected to contribute a significant N load to mine water. The annual tailings deposition quantities for 2020-2022, and planned through 2032 are summarized in Table 5-4 (Lorax, 2020).

Table 5-4: Annual Schedule for Tailings Deposition to the WRTSF and Paste Backfill

Year	Tailings Deposition to WRTSF [1] (dry kt)	Tailings Deposition to Paste Backfill [1] (dry kt)
2020	797	432
2021	900	406
2022	804	379
2023	*982*	*328*
2024	*882*	*440*
2025	*929*	*389*
2026	*877*	*442*
2027	*722*	*400*
2028	*669*	*450*
2029	*508*	*349*
2030	*461*	*300*
2031	*297*	*231*
2032	*87*	*89*

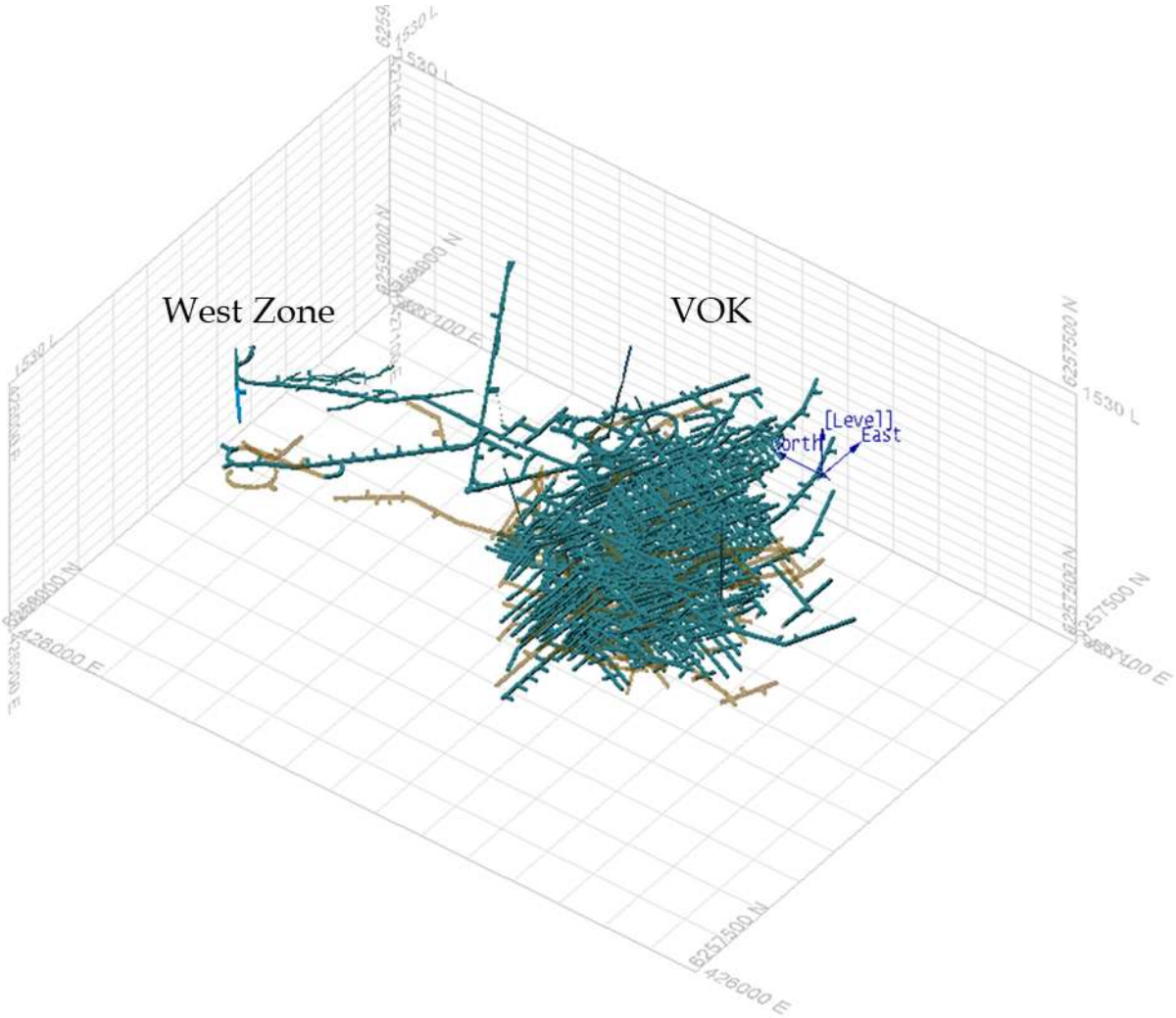
[1] 2020-2022 are actual values, whereas 2023 through 2032 are projected values provided by Pretium for the 2020 water quality model update (Lorax, 2020).

6 WATER MANAGEMENT

6.1 Underground Water Management

Mine dewatering is conducted to allow excavation of new workings, with water directed to the WTP for treatment prior to discharge. The historic West Zone (WZ) workings will remain flooded below approximately 1275 m asl until development of the WZ commences. A cross section of the underground workings at the end of 2022 are shown colour-coded in Figure 6-1 and the conceptual water management schematic is given in Figure 6-2.

Water drains from the upper levels of the workings and is pumped from the lower levels to the 1300 level sump and from there to the WTP for treatment (Figure 6-2). Sumps and pipelines are used to manage and convey water, and driving surfaces are covered with construction aggregate (3/4” or 3” screened quarry crush).


West Zone
VOK
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East
1530 L
6257500 N
426000 E

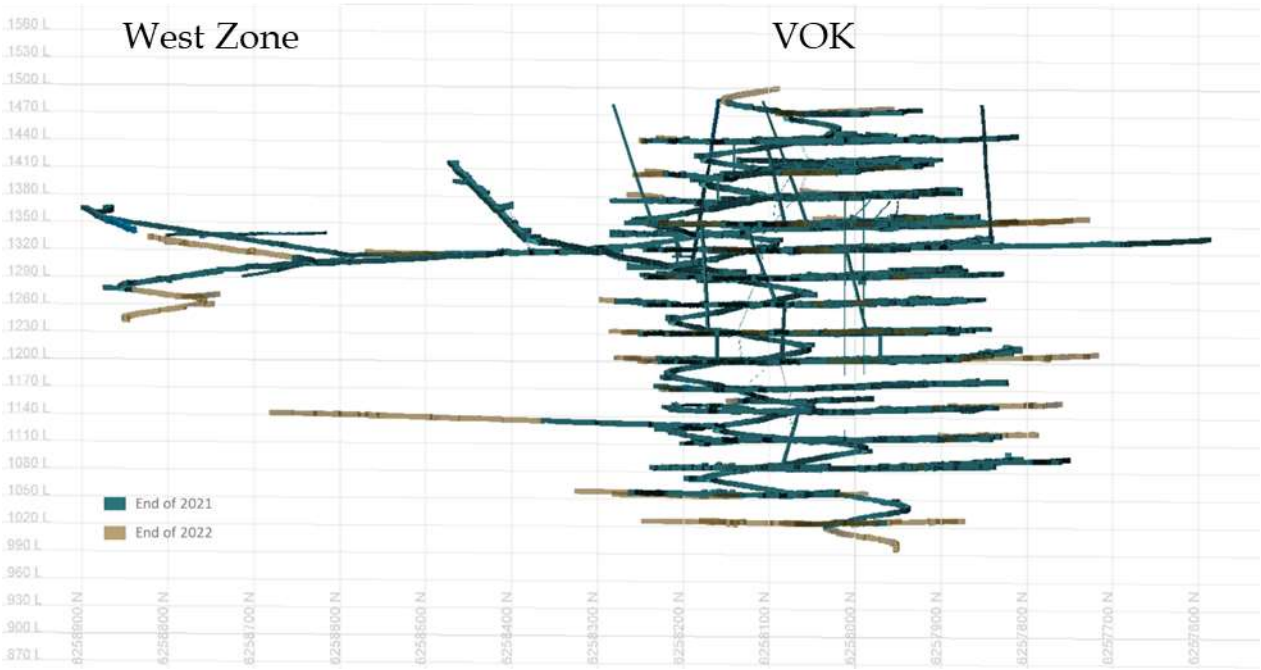

Figure 6-1: Schematics showing the extent of the underground workings. Top: 3-dimensional view; Bottom: cross-sectional view. Blue indicates workings excavated prior to 2022 whereas gold indicates workings excavated in 2022.

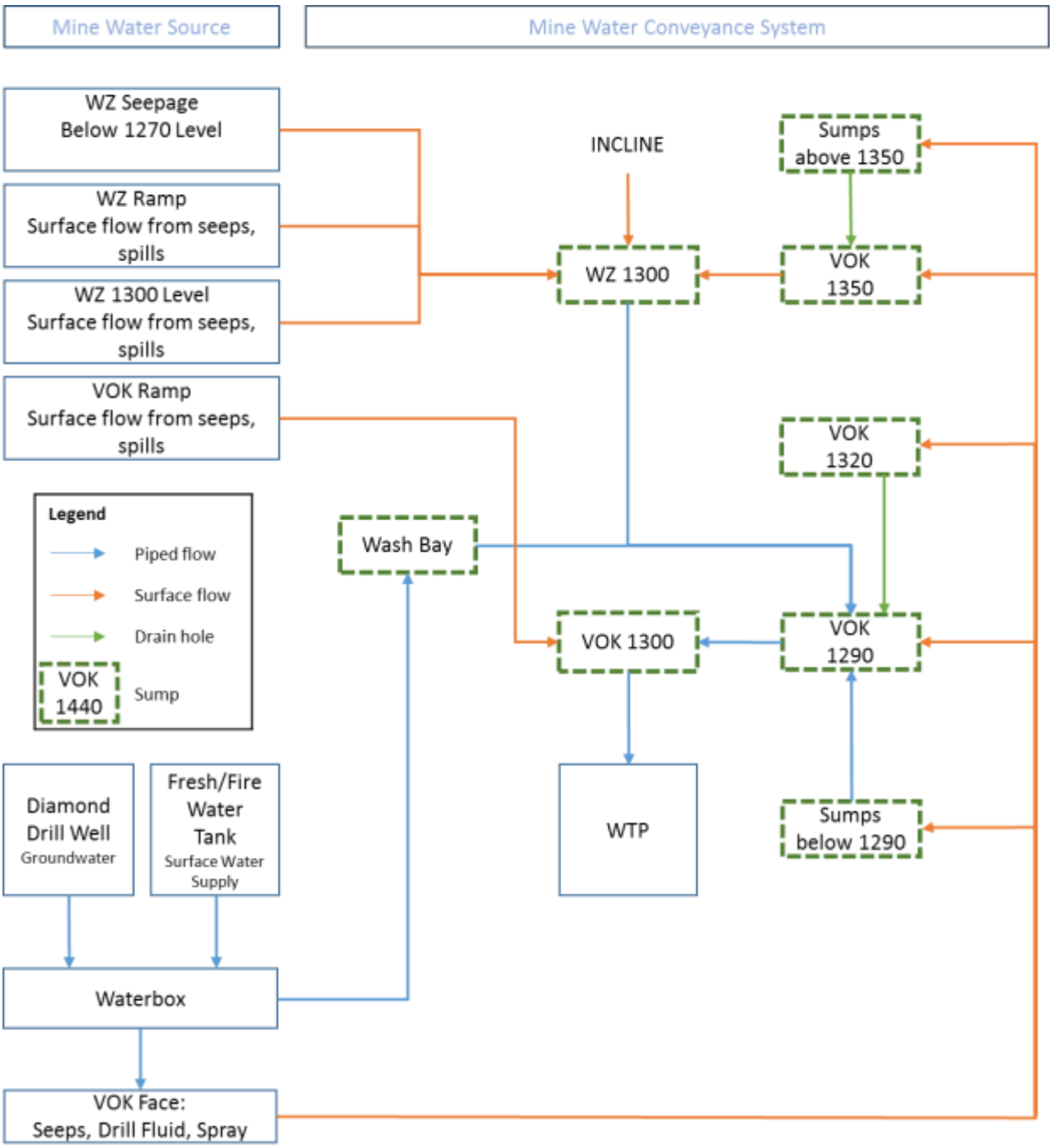

Figure 6-2: Conceptual diagram of the underground water management system on December 31, 2022.

6.2 Surface Water Management

Site surface runoff from the contact water management area is directed to the CWP and water levels within the CWP are managed as described in the Water Management Operations Maintenance and Surveillance (OMS) Manual (Pretium, 2020). Inputs to the CWP include surface runoff collected via the contact water management system and surplus WTP effluent recirculated to the CWP for water storage. Water withdrawn from the CWP is directed to the WTP for treatment.

Inputs to the WRTSF come in the form of treated effluent from the STP and WTP, along with water as a component of tailings. Additionally, water can enter the WRTSF through waste rock deposited to the WRTSF, where water can be retained either as snow or water within waste rock pore space. Non-contact water can also naturally flow into the WRTSF. A schematic of the site water balance is provided in Figure 6-3.

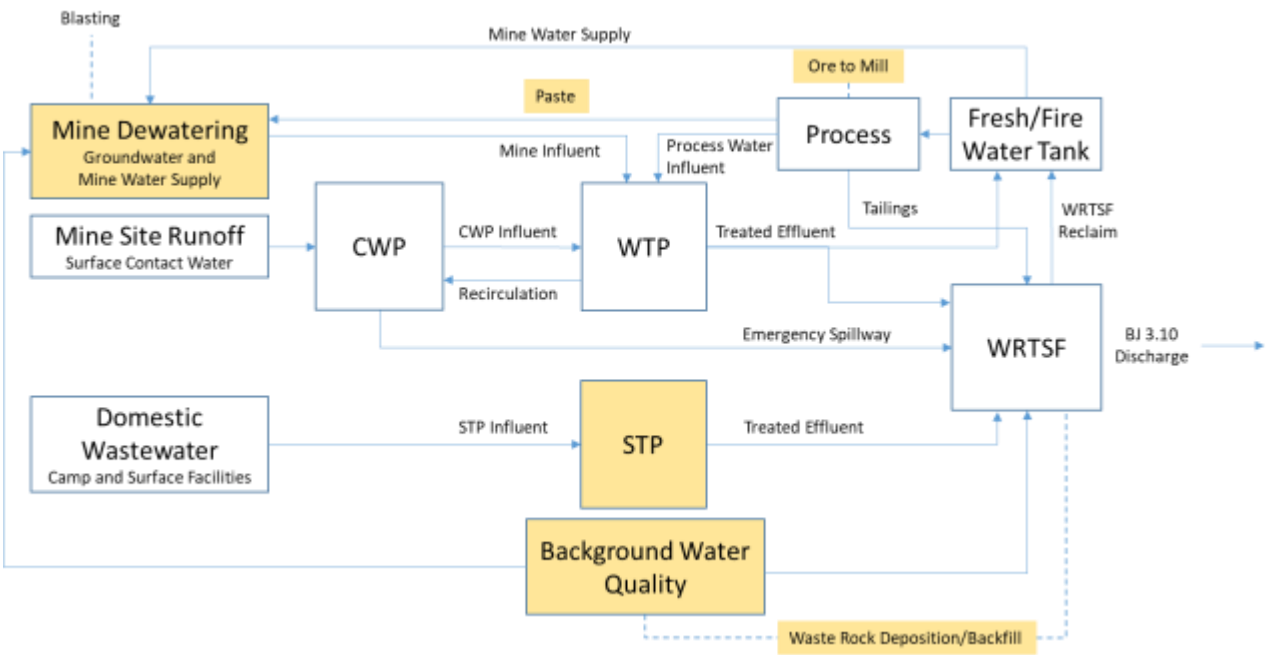

Figure 6-3: Site water balance schematic, with water quality model N source terms highlighted.

6.3 Water Treatment Plant (WTP) and Sewage Treatment Plant (STP)

The Water Treatment Plant (WTP) is located within the mill building and is designed to treat TSS and dissolved metals, however ammonia, nitrite and nitrate are not removed by the treatment process. The WTP receives water from mine dewatering, the CWP and from the mill (Figure 6-3). The treated WTP effluent is recycled to the fresh/fire water tank for mill and mine water supply, and to the CWP for storage and future recycling. Surplus treated effluent is discharged to the WRTSF by pipeline to the deep water of the WRTSF. Treated effluent from the WTP represents the cumulative effects of N transmission to mine water, process water and surface runoff, and treated WTP effluent was discharged to the WRTSF at an average of 914 m^3/day in 2022, with the majority of discharges occurring between late May and late November.

Domestic wastewater from the camp and other surface facilities is directed by pipelines to the STP, which consists of two parallel treatment streams. Treated domestic wastewater effluent is discharged by pipeline to the deep waters of the WRTSF. A schematic of water conveyance to and from the STP is shown in Figure 6-3. The STP discharged an average of 88 m^3/day in 2022.

7 WATER QUALITY PREDICTIONS

The Brucejack water quality model (Lorax, 2020) predicts water quality at various locations in the Brucejack water management system, at the WRTSF outlet (B 3.10) and in Brucejack Creek (BJ 2.62). The projected site water balance, life of mine schedules for mining, milling and waste deposition, and loading rates for each source of ammonia, nitrite and nitrate are combined in the model to generate water quality predictions at the modelled locations. Source terms are prepared to model base case and upper case scenarios; the base case represents the expected water quality whereas the upper case represents a scenario with poor nitrogen source control. The water quality model source terms for ammonia, nitrite and nitrate are empirically derived from monitoring records for explosives consumption, ore and waste production, water quality and flows for the 2015 through 2019 operational period.

Explosives-related nitrogen species are currently introduced to the WRTSF from waste rock deposition, tailings slurry discharge, WTP effluent, STP effluent, NPAG Quarry rock contact water and mine site surface runoff (Figure 6-3). Although the dominant inputs to the WRTSF are from the waste rock, tailings slurry and WTP effluent, source terms are developed and modelled for all known inputs of nitrogen to the WRTSF including background and STP loadings. However, N loads from background and treated domestic wastewater input are minimal and are not further reviewed in the NMP. The input of N from explosives will cease at Closure when blasting stops and mine flooding occurs. It is expected that the soluble N species will be released to the flooded mine pool from walls, floors and backfill to mine water during mine flooding.

The water quality model predictions for ammonia, nitrite and nitrate concentrations in site waters are based on excavation, deposition, N loading rate and water balance assumptions. Comparison of measured values to model assumptions is important to maintain confidence in the water quality predictions for N species. The water quality model source terms for mine water, waste rock and ore are presented and compared to monitoring results in Section 8.4 through Section 8.6. The predicted and measured water quality of discharge from the WRTSF are discussed in Section 8.7.

8 NITROGEN MONITORING PROGRAMS AND RESULTS

8.1 Overview

The NMP uses data from various ongoing water quality and flow monitoring programs as well as mining and milling records for nitrogen source control monitoring. Audits of blasting practices are conducted at underground and surface blasting locations to regularly review the N source control procedures that are used for explosives handling and blasting. Ammonia, nitrite, nitrate and total nitrogen are measured in all water quality samples collected for NMP monitoring. The monitoring and auditing programs are summarized as follows:

- **Blasting Quantities and Explosives Use Records:** Underground blasting is conducted daily for mine development and ore production. Records are kept for explosives use and tonnage blasted. These records are used for explosives use monitoring and are combined with derived N loads to calculate N loading rates for blasted rock to mine water, waste rock and ore.

- **Km 72 NPAG quarry:** Nitrogen contributions to the WRTSF from NPAG quarry blasting are monitored in surface water samples that are periodically collected from pooled water or runoff in the vicinity of the quarry. The N concentrations in runoff from the NPAG quarry are low: water from two samples collected in August and September of 2022 contained <0.030 and 0.095 mg-N/L total nitrogen, respectively, similar to the concentrations observed in 2020 and 2021 and indicating quarry blasting is a minor influence on the N species concentrations in the WRTSF.

- **Surface water quality monitoring**: Water quality monitoring includes water quality and flow monitoring at several locations of interest for N management. These stations include surface contact water runoff into the CWP, Mine Water, CWP Water, Process Water, WTP Effluent and the WRTSF outlet (BJ 3.10). Monitoring of the fresh/fire water tank was added in 2020 to monitor the water supply to the mine. Concentrations at the WRTSF outlet (BJ 3.10) are compared to management triggers and discharge limits. Samples are collected in accordance with the procedures described in BJ-ENV-SOP-035 - Water Treatment Plant Sampling and BJ-ENV-SOP-021 – Water Quality Sampling for Compliance Site BJ 3.10. The N species concentrations and flows measured for mine dewatering, and WRTSF discharge, are used to derive N loading rates for blasted rock to mine water, and to determine a WTP effluent point load for calculation of the waste rock N loading rate to the WRTSF.

- **Water column monitoring:** Water column sampling is periodically conducted at BJ 35, located near the deepest area of the WRTSF. Water column samples are collected at approximately 10 to 15 m intervals and field parameters are measured *in situ* using submersible sensors according to Brucejack sampling procedures described in BJ-ENV-SOP-059 - Open Water Lake Monitoring and Sampling. Water column profiles are also collected using a CTD that measures temperature, conductivity, pH, dissolved oxygen and turbidity. Sampling intervals are typically aligned with turnover events and conducted approximately mid- month January, April, July and September, with additional sampling completed as required. The water column N species concentrations and lake volume-elevation curve are used to calculate the N inventory in the WRTSF for the determination of the waste rock N loading rate to the WRTSF.

- **Underground mine walls**: Nitrogen residues are expected to accumulate on mine walls during mining and be released to mine water during mine closure when the mine is flooded. The build up of nitrogen residues is monitored annually at several underground stations as part of the mine wall station monitoring program, as described in BJ-ENV-SOP-038 – Mine Wall Station Water Quality Sampling. The monitoring data are used for water quality modelling of nitrogen release from mine walls to mine water during Closure.

- **Paste backfill bleed water:** Paste backfill is expected to release a limited quantity of water (bleed water) at the time of placement in the underground mine. Paste bleed water monitoring is conducted at two stopes per year and includes monitoring of nitrogen compounds, as

described in BJ-ENV-SOP-011 – Underground Chromium Sample Collection. These data are collected and used to derive a source term for modelling the transfer of nitrogen from paste bleed water to mine water.

- **Ore processing and tailings discharge:** The contribution of N from ore processing is monitored at two locations: the SAG mill, where water quality can be monitored at both the inlet and the outlet, and tailings supernatant. SAG mill monitoring data are used to derive an ore N loading rate that represents the transmission of N from ore to process water. Quantities of N transferred from tailings to the WRTSF are determined from the tailings supernatant water quality and discharge volumes and are used to determine a point load for the derivation of the waste rock N loading rate to the WRTSF. The procedures for collecting tailings supernatant and samples from the SAG mill are described in Brucejack sampling procedures BJ-ENV-SOP-007 – Tailings Grab Sample Collection and BJ-ENV-SOP-41 – SAG Mill Sampling, respectively.

- **STP discharge monitoring:** Treated domestic effluent is monitored at the STP discharge for flow and N species. These data are used to derive N source terms for STP discharge and to calculate a point load for the determination of the waste rock N loading rate to the WRTSF.

- **N source control audits:** Routine internal audits are conducted for N source control. The frequency of underground NMP audits, typically monthly, is adjusted as needed in response to previous audit findings and monitoring metrics. The surface blasting audit program was implemented in 2022 and will be conducted annually for each year that surface blasting is conducted. The audit checklists provided in Appendix E are used for evaluation of surface and underground blasting and explosives handling practices. Audit reports are maintained, and corrective actions are identified for implementation and follow-up.

The data and records collected through the monitoring programs outlined in Section 8.1 are analyzed and used to derive metrics for evaluating N source control. These metrics are compared to trigger values to determine when further investigation or action are warranted. A monthly time step is used for most metrics. Waste rock deposition metrics are prepared approximately quarterly. The full set of monitoring results for N species along with other parameters are presented on an annual basis in the Brucejack Mine Annual Report. The formulas used to calculate the NMP metrics are described in Appendix D.

8.2 Explosives Use

Loading rates for N from explosives are dependent on blasting efficiency, which varies depending on the method of excavation, and the type of rock that is blasted. Blasting efficiency can be measured using the powder factor (PF) which is the quantity of explosives used to blast a tonne of rock. Over the long term (> 12 months) the PF is generally stable; however, the PF can vary over monthly periods due to normal variations in blasting conditions. Significant and sustained increases in PF may indicate a N source control issue that will lead to an increase in the N loading rates from blasted rock; therefore, management triggers have been established for PF monitoring to trigger investigation of N source control procedures as described in Section 9.4.

Mining is conducted for access tunnels (development drifts) and for ore excavation (production stopes). Different blasting methods are employed for development drifts and ore stopes as described in Section 4.2, however similar approaches are used for N source control based on the considerations described in Appendix B. Management triggers were previously established at the 90th percentile of monthly PF values from the June 2017 through December 2018 period (0.88 and 1.75 kg/t, for production and development blasting, respectively). Improvements to blasting and recordkeeping methods that have been progressively implemented since mid-2020 have resulted in calculated PF values that are higher in 2021 and 2022, compared to the June 2017 through December 2020 period, and are generally greater than the PF trigger values. However, a corresponding increasing trend for the N loading rates to mine water, and on ore and waste is not observed indicating the change in PF values did not alter the amount of N exported to the WRTSF. Therefore, from January 2023 onwards, management triggers are not applied to the PF monitoring results. The establishment of new trigger values will be evaluated once sufficient monitoring data are collected. A breakdown of the PF monitoring results is provided below.

Monthly records indicate relatively consistent Production PF values from June 2017 through December 2020 that were occasionally above the trigger value of 0.88 kg/t. as shown in Figure 8-1. Production PF was elevated above the trigger value from May to November 2019 due to drilling modifications which required re-optimization of the blast pattern design to improve blasting efficiency and return the production PF to below the trigger level. Almost all of the Production PF values for 2021 and 2022 were above the currently suspended trigger value (0.88 kg/t).

The increase in Production PF is attributed to a modification of the method used to calculate stope volumes, and to changes in the blast hole dimensions. Previously, the stope volume calculation assumed the blast extended one meter beyond the end of the blast holes. Starting in July 2020, stope volume calculations did not extend beyond the blast holes, resulting in smaller blasted volume estimates for stopes. This change results in a higher calculated PF compared to the methods in use when the current (0.88 kg/t) management trigger was established. The calculated PF for production blasting has increased in 2021 and 2022 relative to 2017-2020. This increase is due to the use of larger diameter blast holes, as described in Section 4.2, which lead to an increase in the explosives usage rate.

Updates to the Development explosives use recordkeeping practices were implemented in 2021 and again in 2023. Prior to 2021, Development PF was derived using metered and calculated values recorded on daily blasting reports. In 2021, the recording methodology was modified to use the annual explosives quantities invoiced by Dyno and the annual tonnage blasted, expressed as a monthly average value. In 2023, the derivation procedure was further revised and the monthly Development PF values for 2021 and 2022 were recalculated. The updated procedure uses a correction factor derived from the ratio of explosives delivered (corrected for production usage) and the reported development usage on an annual basis. The explosives amounts recorded on daily blasting reports are multiplied by the correction factor (*i.e.*, 1.11 and 1.10, for 2021 and 2022, respectively*)* and the resulting values are used to derive the monthly Development PF values. This method proportionately increases the PF value compared to using the unscaled emulsion use records. Therefore, in order to maintain inter-comparability of the Development PF values, the 2021 and 2022 average scaling factor (*i.e.,* 1.105) was retroactively applied to the PF values that were previously reported for the 2017 through 2020 period. The revised Development PF values for the June 2017 through December 2022 period are plotted in Figure 8-1 and show an increased number of trigger exceedances. Overall, an increasing

Development PF trend is observed with values generally higher in 2022 than in prior years. Additional monitoring data will be collected and assessed prior to establishing an updated trigger value.

As an outcome of training sessions completed in 2021, tracking of the frequency and quantity of non-detonated explosives in the muck was initiated and was evaluated as a possible metric that may indicate N source control issues. The tracking program is still ongoing and is qualitatively utilized by underground personnel to identify issues related to poor source control practices, however, it was found to have no discernable correlation to observed N species concentrations at BJ 3.10 or variations in PF. With this in mind, tracking of this metric was suspended in relation to the NMP.

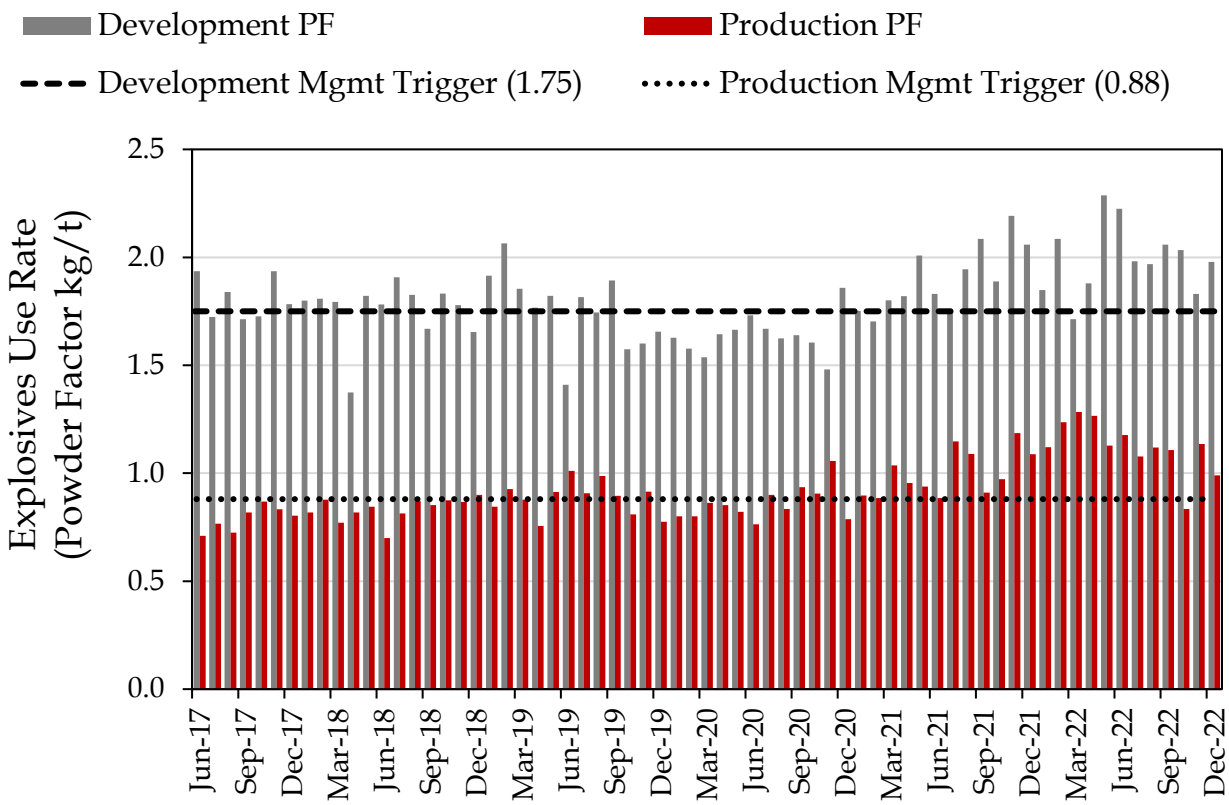

Figure 8-1: Powder factor (PF) for underground development and production blasting compared to management trigger values.

8.3 Blasted Rock Excavation and Deposition to the WRTSF

The Lorax (2020) water quality predictions are based on the planned excavation, milling and deposition schedules to the WRTSF. Table 5-1, Table 5-2, Table 5-3, and Table 5-4 show ore and waste excavation, waste deposition to the WRTSF, and tailings deposition to the WRTSF. The tables present 2020-2022 actual values, alongside 2023 to 2032 modelled values, allowing for comparison of actual quantities to the model assumptions moving into the future.

8.4 Mine Water

Nitrogen residues are transferred from blasted rock to mine contact water through the infiltration of groundwater into the mine, through spraying down muck piles for dust suppression and flush water from the mill after pasting a stope. Nitrogen loads originating from WTP treated effluent and the WRTSF reclaim water are also transferred to mine water via the mine water supply. Data used to calculate the N loading rate for blasted rock to mine water include mine water N species concentrations, mine dewatering flows (measured at WTP influent station) and blasted tonnes of ore and waste. The calculated mine water N load is corrected to subtract the loads contributed from the mine water supply. The corrected N loads still include N originating from paste backfill operations. However, the contributions from backfilled paste are difficult to accurately quantify and due to very low contact flows are considered minor, therefore the corrected mine water N load is conservatively assumed to originate entirely from blasted rock. The measured N loading rate is compared to the water quality model base case and upper case source terms. Calculation of the N loading rate to mine water is described in Appendix D.

The N loading rate from blasted rock to mine water fluctuated from 0.012 to 0.046 kg-N/t on a monthly basis from June 2017 through December 2022 and typically remained between the base case and upper case modelled rates (0.022 to 0.033 kg-N/t, Figure 8-2). The observed monthly loading rates are corrected for contributions from the water supply (Fresh/Fire Water) from September 2020 onwards. The N load from the water supply is subtracted by accounting for the T-N concentration and the volume of water that is transported underground on a monthly basis. The loading rates used for the water quality model were derived using monitoring data from January 2015 through July 2017 (Lorax, 2018 and 2020), before significant recycling of N through the mine water supply commenced.

In June and August of 2021, the monthly loading rates exceeded 0.04 kg-N/t. This increase is inferred to be related to the intersection of the Windy Fault underground. This fault was intersected by various stopes and along the West Zone Ramp. The Windy Fault produced significant amounts of water during the period of June to August, both along the West Zone Ramp and at several faces, which could have resulted in increased transfer of N from blast residues to mine water during these months. Similar increases were observed between 2015 and 2017 due to equipment issues that resulted in loss of non-detonated explosives to mine water when fault structures were intersected at faces. Active water production made the loading of faces difficult and increased associated emulsion spillage and waste. Loading rates for 2022 largely stayed within the bounds of the base case and upper case modelled rates, with three exceptions. Investigations have not yet identified specific causation, but review is ongoing.

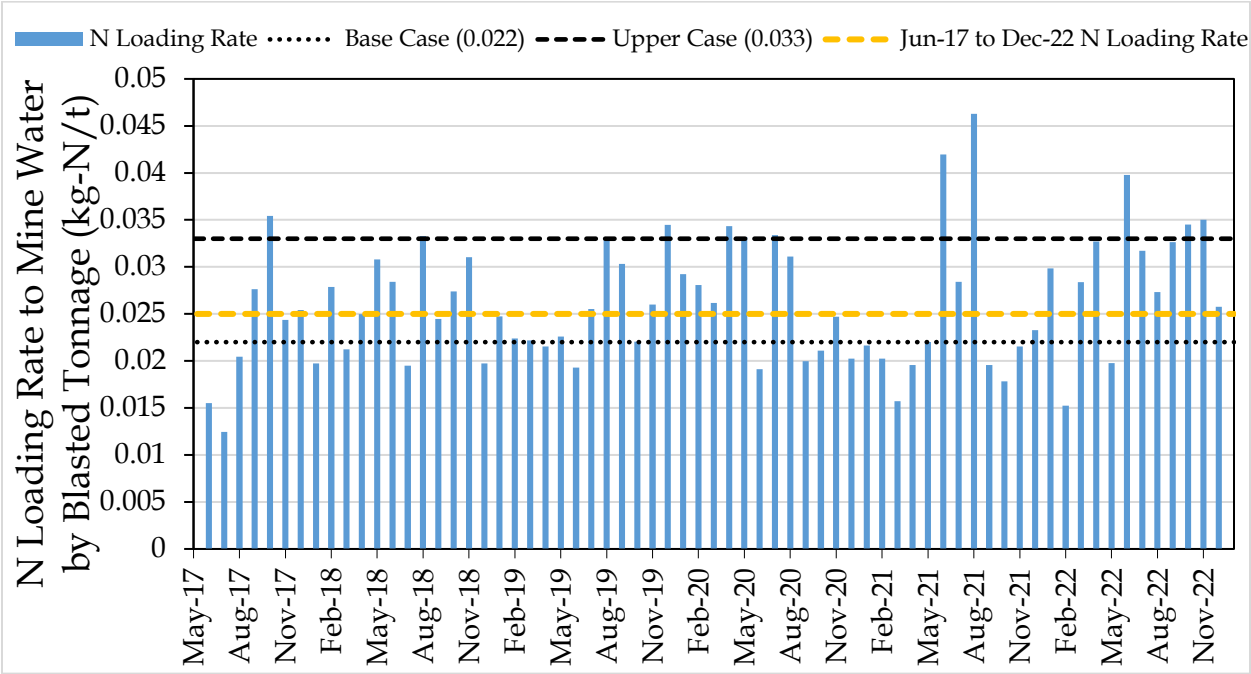

Figure 8-2: Monthly nitrogen (N) loading rate to mine water from blasted rock (ore and waste) compared to water quality model assumptions and the cumulative loading rate for the June 2017 through December 2022 period.

8.5 Ore and Tailings

Ore is moved from stopes to the underground crusher for processing and delivered to the mill hopper by conveyor. Minimal water contact with ore occurs until it is directed to the SAG Mill for grinding. The N loads from ore are exported from the mill in WTP effluent, tailings and ore concentrate. The N loading rate from ore to process water is determined using the SAG influent and effluent water quality, the SAG water feed rate and the SAG ore feed rate as described in Appendix D and is compared to the water quality model base case and upper case source terms.

The water quality model base case and upper case ore N loading rates (0.028 and 0.054 kg-N/t) are derived from the 75th and 90th percentiles of a high frequency (*i.e.,* weekly) monitoring dataset collected June through September 2017 (Lorax, 2018 and 2020). The ore N loading rate was measured weekly from June through October 2017, and monthly thereafter through December 2022, and is plotted in Figure 8-3. Weekly values are compiled and plotted as monthly average values for the June through October 2017 period. The N loading rates are generally below the base case model assumption of 0.028 kg-N/t, with a median loading rate of 0.022 kg-N/t for the values plotted in Figure 8-3 (June 2017 through December 2022).

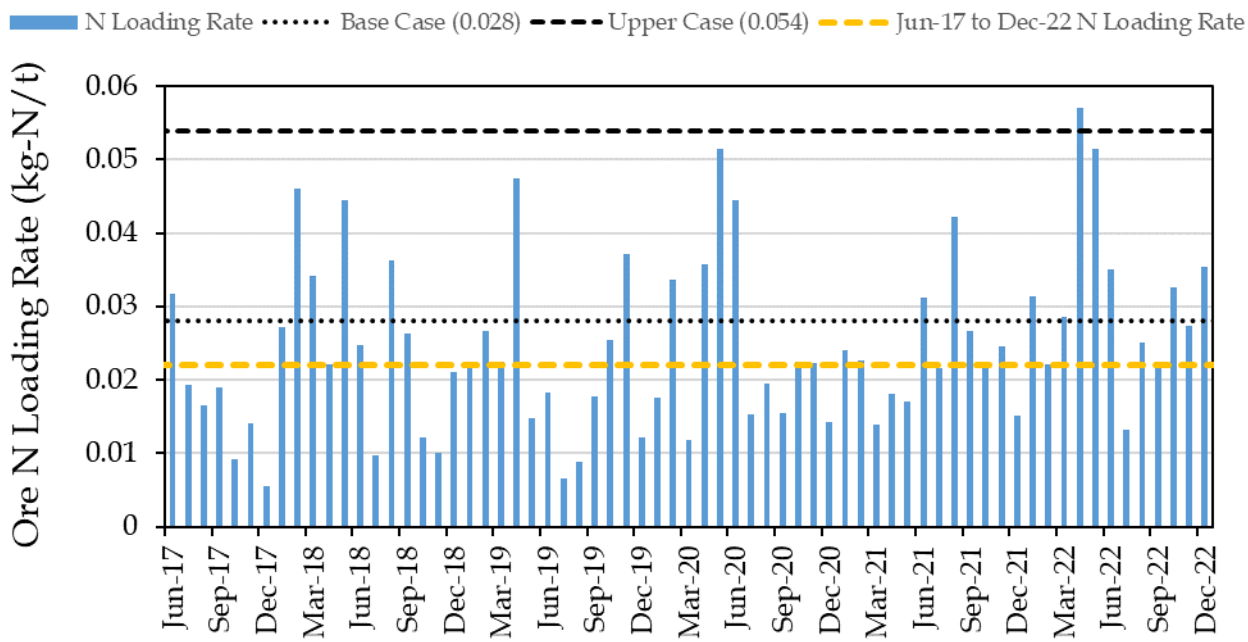

Figure 8-3: Nitrogen (N) loading rate from ore to process water compared to the period median value and the water quality model loading rate assumptions for ore.

Mill tailings are discharged to the WRTSF or backfilled to the mine as cemented paste backfill. The N loading rate from tailings to the WRTSF is monitored using monthly tailings supernatant samples and flow data as described in Appendix D. The monthly N loading rate in tailings during the period from June 2017 through December 2022 ranged from 0.020 to 0.100 kg-N/dry t as shown in Figure 8-4. The cumulative N loading rate of 0.053 kg N/dry t is derived from the cumulative N load and tailings tonnage discharged over the June 2017 to December 2022 period. The water quality model predicts N species concentrations in tailings supernatant based on N inputs from mine water and ore; therefore, a tailings N loading rate is not currently used for modelling. Monitoring of the tailings N load rate is conducted to aid with N source control investigations and for comparison to the loading rates for mine water and waste.

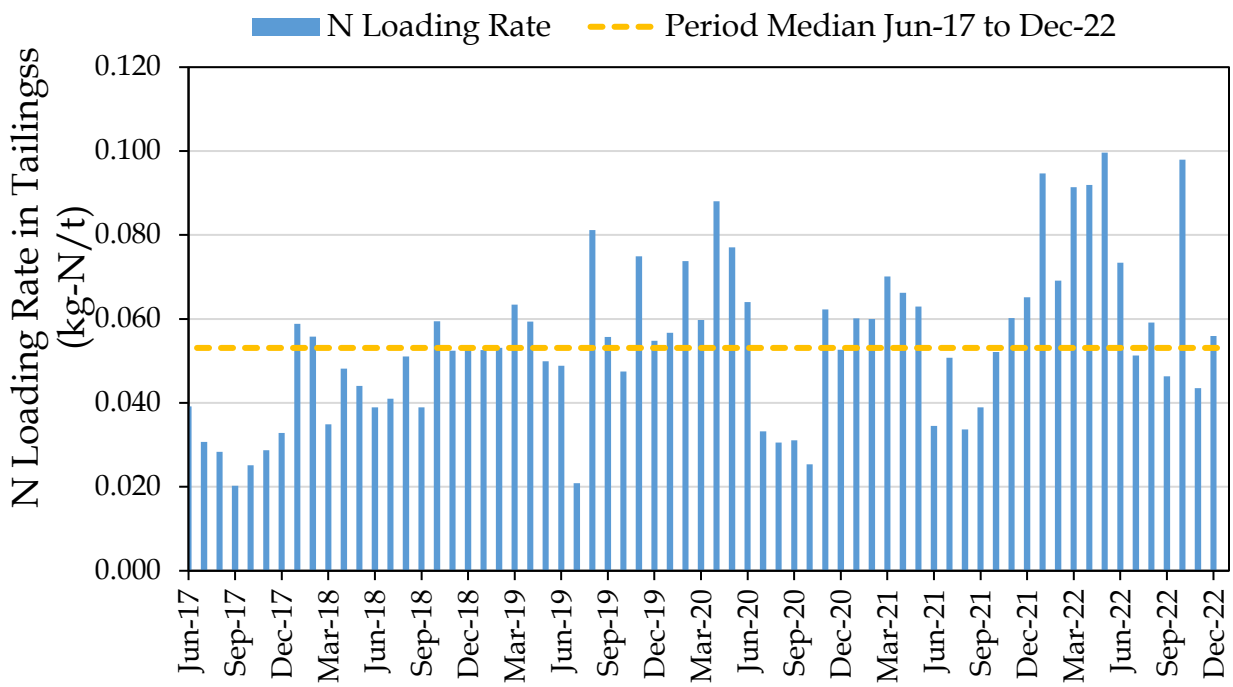

Figure 8-4: Nitrogen (N) loading rate in tailings supernatant compared to the cumulative loading rate for the June 2017 through December 2022 period.

8.6 Waste Rock

Nitrogen residues on waste rock are transferred to the WRTSF primarily during sub-aqueous deposition. Waste rock is removed from the underground for disposal in the WRTSF where it is assumed to instantaneously release 100% of the N load to the WRTSF water at the time of deposition. As mine development proceeds, some waste rock will be retained in the underground mine as backfill, where the N load will be transmitted to mine water. Estimates of N transmitted to the WRTSF via waste rock deposition are made by subtracting N contributions from measurable point sources (*e.g.,* WTP effluent, tailings and STP effluent) from the change in N inventory derived from water column samples and N exported via BJ 3.10 as described in Appendix D. With this version of the NMP the method used to derive the N load loads on waste rock is modified to extend the averaging period from approximately three months to 24 months as described below.

The base case and upper case modelled N loading rates for waste rock are derived from January 2015 through July 2017 monitoring data (Lorax, 2018 and 2020) using approximately quarterly averaging periods. The previous version of this NMP noted that this approach was generating a wide range of values (*i.e.,* 0.008 to 0.295 kg-N/t) for the late 2018 through 2021 dataset. The averaging calculations were modified to use a two year averaging period to smooth out the loading rate fluctuations. The loading rate is assigned to the last year in the two year period. Utilizing a longer time period yields N loading rates for 2017 through 2022 that are similar to, but also generally lower than the base case and upper case loading rates developed from the January 2015 through July 2017 data, as shown in (Figure 8-5). The derivation method for this loading metric will be periodically re-evaluated moving forward. Overall, the N loading rates for waste show a declining trend from 2017-2018.

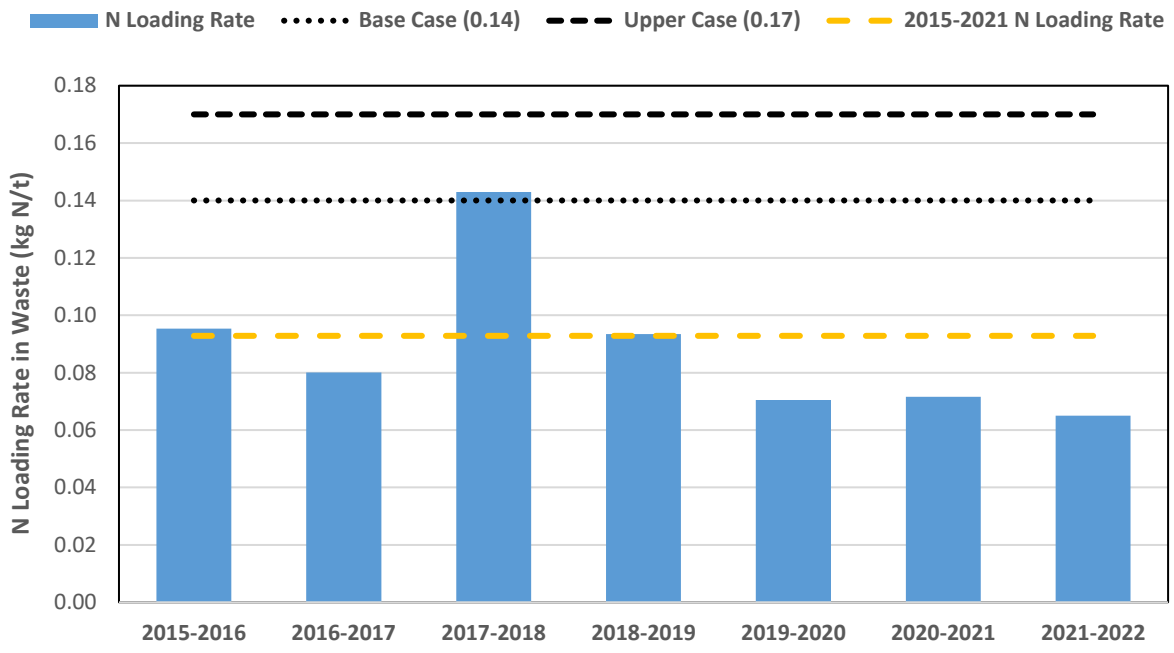

Figure 8-5: Nitrogen (N) loading rate for the transfer of N from waste rock to the WRTSF compared to water quality model loading rates.

8.7 WRTSF

The WRTSF discharges at BJ 3.10 and receives all Brucejack contact waters, as well as waste rock and tailings deposited in the WRTSF. Tailings, WTP and STP effluent are discharged by pipeline at depth into the WRTSF, whereas waste rock is deposited from the waste rock deposition platform. Vertical mixing of WRTSF waters is limited during the open water and ice covered seasons due to thermal stratification of the water column; however, mixing of the water column occurs during turnover events. Waste rock deposition is expected to promote limited vertical mixing by drawing surface water to depth during deposition.

Spring turnover events follow the melting of ice on the WRTSF. Vertical mixing typically occurs through most of the water column as cold surface water warms and sinks when maximum density is attained at ~4°C. As surface water becomes more buoyant with increasing temperature, stratification establishes a surface and deep water layer that do not mix until temperatures cool in the fall. When autumn surface water temperatures return to ~4°C, almost full vertical mixing reoccurs until surface waters cool to become sufficiently buoyant once again. Wind driven mixing contributes to this seasonal mixing process, termed turnover, and the effect of wind driven mixing tends to be stronger in fall. Deposition of a thickened tailings slurry at the bottom of the WRTSF has resulted in an additional stratified bottom layer, which resists mixing due to the density effect of the suspended solid load contributed by tailings deposition.

From 2015 through 2020, turnover was observed in spring and fall. However, since 2021, turnover has only been observed in the fall. This has led to sub-oxic conditions (i.e. dissolved oxygen below

1 mg/L) in the deeper waters during summer, from 10 to 30 m below the surface to the bottom of the water column. If the absence of spring turnover becomes a permanent feature of the WRTSF then sub-oxic conditions at depth are expected to develop annually, from late spring through to autumn turnover in October or November. The development of sub-oxic zones may influence nitrogen cycling processes within the water column, and monitoring data will continue to be evaluated for changes in the nitrogen cycling trends within the water column.

Varying inputs to the water column, *e.g.*, tailings discharge at depth, and the effects of stratification can result in variable concentrations of N species throughout the water column with higher concentrations at depth compared to surface. Variability of up to two orders of magnitude have been observed for NH_3 concentrations within the WRTSF. Over time, tailings and waste deposition will reduce the WRTSF water column depth and volume. A WRTSF volume-elevation curve has been developed and is updated based on bathymetric surveys that are conducted approximately annually. The volume-elevation curve estimates the volume of water associated with the water quality at a specific depth in order to calculate the N inventory in the WRTSF as per Appendix D.

Overall, the N inventory in the WRTSF has increased during mining; with a general leveling off beginning in 2019. Some seasonal decreases that are associated with freshet flows or autumn rains observed from 2018 onwards. A summary of the N inventory measurement in the WRTSF from January 2014 through October 2022 is presented in Figure 8-6.

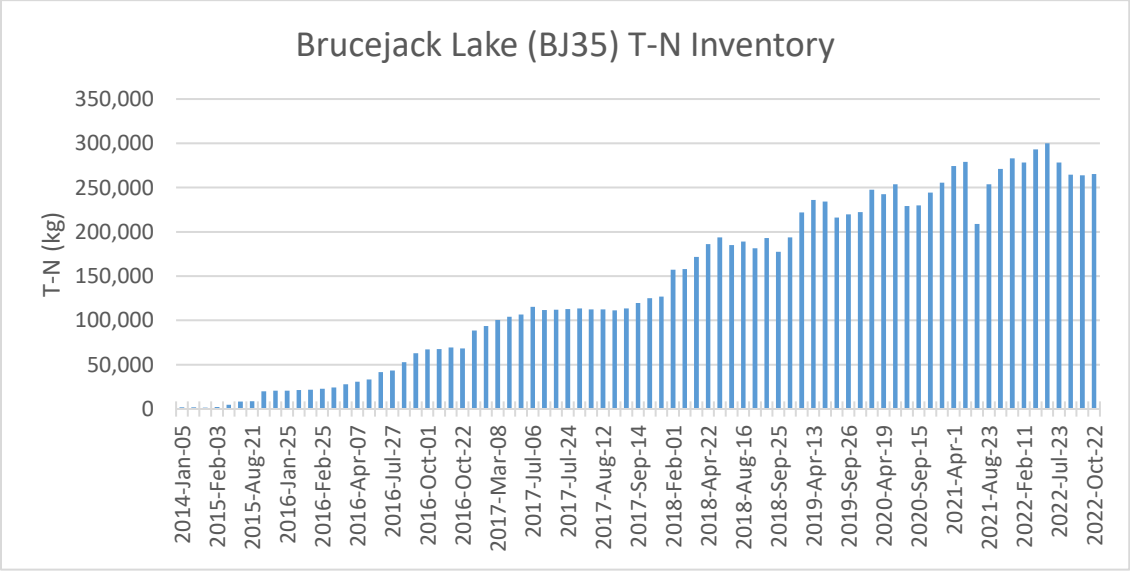

Figure 8-6: Summary of total N inventory in the WRTSF.

Weekly samples are collected from compliance point BJ 3.10 in accordance with Condition 1.1 and Appendix A of Effluent Permit PE-107835. The permit specified discharge limits for ammonia, nitrite and nitrate are presented in Table 2-1 and Figure 8-7. Discharge limits were initially established when PE-107835 was issued on August 31, 2015 and were revised in the amended permits issued on March 31, 2017 and December 14, 2018 (Table 8-1). Management triggers were implemented in March 2019 with version 2 of the NMP and are discussed in Section 9.4. In revision 3 of the NMP the nitrate

management trigger was revised from 8 to 10 mg-N/L, which is approximately equal to the base case predicted maximum value (Figure 8-7, bottom plot).

Table 8-1: Effluent Permit PE-107835 discharge limits for N compounds at BJ 3.10 over time.

Parameter	August 31, 2015 Discharge Limit (mg-N/L)	March 31, 2017 Discharge Limit (mg-N/L)	December 14, 2018 Discharge Limit (mg-N/L)
Ammonia	1.0	1.0	4.0
Nitrite	0.075	0.240	0.240
Nitrate	3.0	11.5	11.5

Ammonia and nitrite concentrations at BJ 3.10 are below discharge limits, base case water quality predictions and NMP management triggers as shown in Figure 8-7. Nitrate concentrations have been tracking the base case predicted values and were generally stable in 2022 except when seasonal low concentrations are typically observed in June following the onset of spring freshet. One nitrate value (10.2 mg/L) on May 16, 2022 was observed to be above the NMP management trigger. The associated duplicate that was collected on May 16, 2022 was below the trigger value (9.9 mg/L) and follow up samples from the following week were both below the NMP management trigger and showed a decreasing trend. It was determined that this was an isolated occurrence. Ammonia and nitrite are well below base case predictions and fluctuate seasonally, and the accumulation of both parameters is typically observed from approximately November to February, followed by declining concentrations from approximately March through June. The seasonal increase in the concentrations of these parameters is associated with fall turnover of the water column that is speculated to result in a temporary interruption of the natural microbial nitrification processes in the WRTSF. Ammonia and nitrite predictions model a no nitrification endpoint for the WRTSF. However, observed concentrations of these parameters are well below the base case predictions thereby providing indirect evidence that naturally occurring processes in the WRTSF are converting ammonia and nitrite to nitrate.

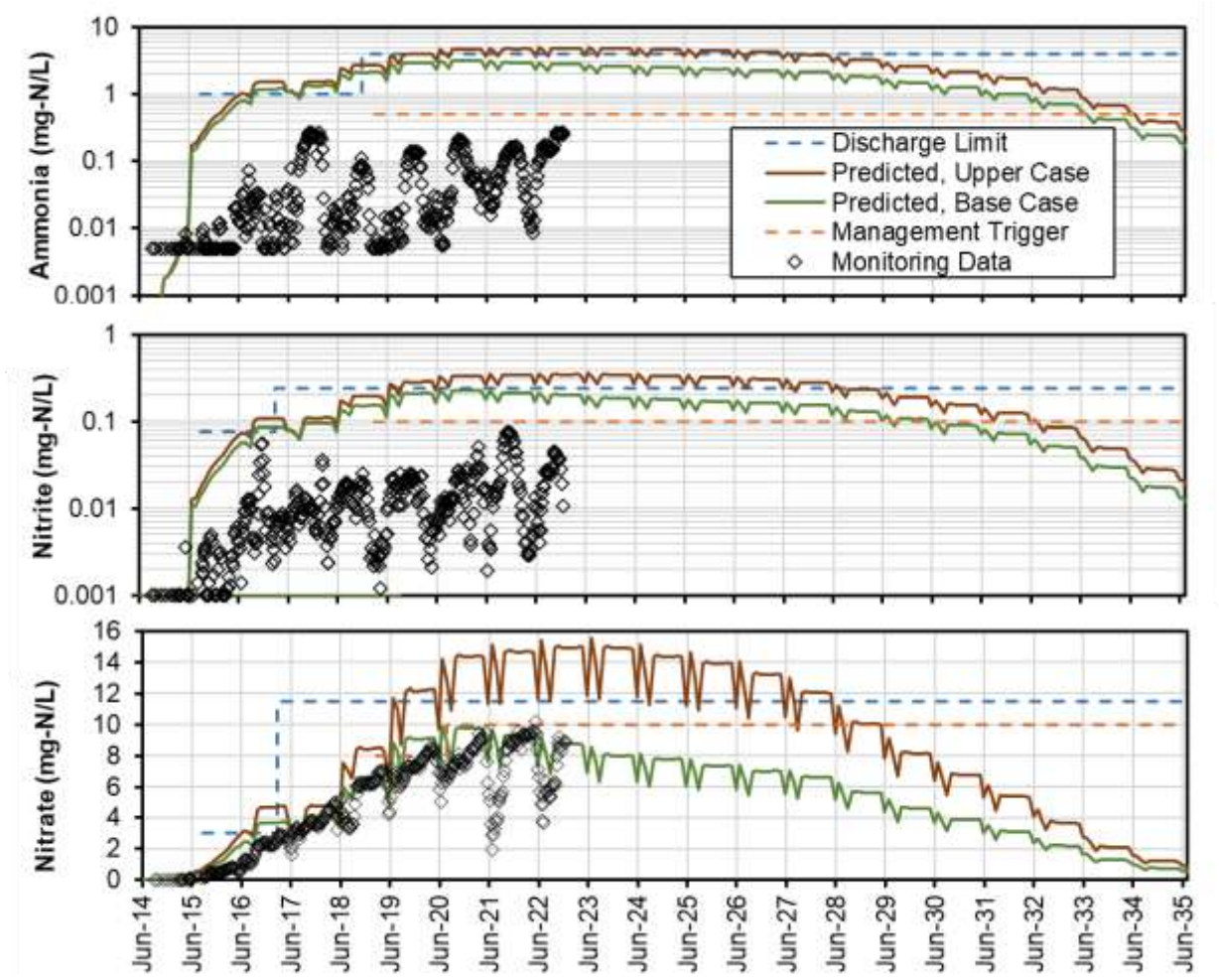

Figure 8-7: Results of BJ 3.10 water quality monitoring compared discharge limits, water quality model predictions and management trigger values.

8.8 Nitrogen Source Control Audits

Nitrogen source control audits were generally conducted underground at a quarterly frequency in 2016 and a monthly frequency since February 2017 with a total of 77 audits completed to the end of December 2022 (Table 8-2). Typical issues corresponded to excessive emulsion spillage at the face, deteriorated explosive/emulsion labelling, poor loading or handling, poor housekeeping, or other spills noted in the area. Issues were typically addressed at the time of the audit, or mitigation requirements were developed and followed up with crews on subsequent audits to ensure deficiencies were rectified. Generally, there has been a decrease in major and minor deficiencies from 2016 to present. Surface blasting audits were implemented in 2022, with one audit completed, and no issues observed.

Overall, the audits completed in 2022 noted good adherence to N source control procedures for explosives handling and blasting at underground excavations. Several areas for improvement were occasionally identified, including; emulsion spillage observed at the blast face, inadequate housekeeping, and excessive loading of blast pattern. These deficiencies were addressed by modifying procedures, providing training to blasting personnel and conducting follow-up audits to

ensure the effective implementation of corrective actions. Generally, discussions were had with the blast crew during explosives loading such that emulsion spillage could be cleaned up at the time, housekeeping could be addressed, and inadequate loading practices could be rectified in real time.

Table 8-2: A summary of nitrogen (N) source control audits completed each year since 2016 indicating the number of source control non-conformances that were identified and addressed.

Year	Audits Completed	Issues Observed	Issues Corrected
2016	4	7	7
2017	14	11	11
2018	11	3	3
2019	12	5	5
2020	12	10	10
2021	12	4	4
2022	12	7	7

9 NITROGEN MANAGEMENT

9.1 Overview

Management of N at Brucejack includes procedures for explosives use, best practices for N source control, water quality monitoring and regular audits of blasting practices. The monitoring data are evaluated and if the results are above a trigger level further investigation is undertaken to inform management decisions for the implementation of mitigation needed to meet discharge limits at BJ 3.10. Collectively, the following activities are conducted to support N management at Brucejack:

- Training of mine and environmental staff;
- Implementing best practices for explosives use and domestic wastewater management;
- Evaluation of options for treatment of N species;
- Monitoring, recordkeeping, auditing and program reviews;
- Using management triggers to initiate management response to ensure discharge limits are met at BJ 3.10; and
- Implementing corrective actions to address non-conformances and follow-up to evaluate effectiveness.

The monitoring programs developed for N species are described in Section 8. The other key elements of N management at Brucejack are described in the following sections.

9.2 Training

Personnel and contractors involved with explosives use at Brucejack Mine are trained by Pretium to understand best blasting practices, the environmental impacts of explosive use and methods for minimizing those impacts. Performance evaluation and follow-up training is provided to relevant personnel to support implementation of best practices.

In 2021 the Environmental Department provided NMP training to the Geology and Technical Services Departments that reviewed N source control procedures for underground blasting. In 2023, there are plans to present similar presentations to all underground workers regarding the Nitrogen Management Plan and Source Control Procedures to ensure all individuals are aware of the importance of reducing excess emulsion and explosive use and to clearly identify how they can contribute to reducing this problem on site.

The Pretium Environmental Department, in partnership with Lorax presented Nitrogen Prediction and Management at Brucejack Mine at the BC MEND Metal Leaching/Acid Rock Drainage 28th Annual Workshop in December of 2021 (Mueller & Fredrickson, 2021). Participation in industry workshops and conferences provides opportunity to learn from industry peers and for sharing N management experience gained at Brucejack Mine.

9.3 Treatment

Treatment for nitrite was periodically implemented during the Exploration and Construction phases of Brucejack Mine (late-2014 through May 2017). A nitrite discharge limit for WTP effluent was specified in Approval 106251 which was in effect from September 3, 2014 through August 30, 2015, and in EP- 107835 from August 31, 2015 though March 30, 2017. The WTP effluent was discharged to Brucejack Creek late October 2014 through December 23, 2015. From December 24, 2015 and onwards, the WTP effluent has been discharged to the deep waters of the WRTSF.

Monitoring data collected in 2016 indicated that nitrite was being removed within the WRTSF by natural processes indicating treatment of the WTP effluent was not necessary to meet discharge limits at the WRTSF outlet (BJ 3.10). Brucejack Mine applied for permit amendments in 2016 that included the request to remove the nitrite discharge limit for WTP effluent on the basis that the nitrite concentrations were being controlled by processes in the WRTSF. The March 31, 2017 amendment to PE-107835 does not specify a nitrite limit for WTP effluent. However, discharge limits for ammonia, nitrite and nitrate continue to be applied at BJ 3.10, the final discharge location.

The WTP commissioned in late 2014, during Exploration, was configured to treat for nitrite using hydrogen peroxide. The treatment of nitrite using this method was ineffective and residual concentrations of the oxidant caused *Ceriodaphnia* toxicity test failures in the WTP effluent. Therefore, this treatment method was abandoned and a nitrite source control program was implemented to control nitrite concentrations in mine water.

A new nitrite treatment system was procured by Brucejack Mine and treatment using sodium hypochlorite was commissioned mid-2015 for the Construction WTP, and was effective at removing nitrite from the influent waters. The system was activated from November 11th through December 23rd, 2015, and February 6th through May 3rd, 2016. Ammonia was incidentally treated as well and, due to

the high ammonia concentration relative to nitrite, significantly more hypochlorite reagent was consumed than the amount required to treat for nitrite only.

Therefore, in 2016, the Construction WTP was upgraded to use ozone which targeted the treatment of nitrite only. The switch to ozone eliminated the unnecessary use of reagents to treat nitrite compared to the hypochlorite process, noting that ammonia was not treated by the ozone process. Monitoring data indicate the ozone system was activated from September 16th through December 1st, 2016, and effectively treated nitrite during this period.

The Operations WTP in use since mid-2017 does not treat nitrite and all N species pass through the WTP untreated. The base-case water quality predictions (Lorax, 2020) indicate that all N species are expected to remain below WRTSF discharge limits assuming that good N source control procedures are continuously implemented. Therefore, N source control is selected as the primary mitigation for N compounds during Operations and treatment is considered a secondary option.

In consideration of upper-case predictions that indicate nitrate may exceed discharge limits, Pretium previously undertook a review of nitrate treatment technologies (Lorax, 2017). Three technologies were identified for further evaluation and possible implementation, should future monitoring data indicate the nitrate discharge limit is likely to be exceeded:

- Moving bed biofilm reactor (MBBR): MBBRs utilize an attached growth process, in which microorganisms form as biofilms on inert packing media and are used to treat nitrate. An MBBR bench test for nitrate treatment was undertaken in early 2015. The results indicate that Brucejack mine water can be treated for nitrate using this technology.

- Electro-biochemical reactor (EBR): EBRs supplement the biological nitrate reduction process by supplying electrons to the reactor using an applied voltage, in addition to nutrients required to sustain the biofilm.

- Ion exchange (IX): for IX, ions in solution adsorb onto the surface of a solid material (resin) achieving high nitrate removal efficiencies.

Further evaluation to support the selection of treatment technologies will be conducted if ongoing NMP monitoring data, or changes to the mine schedules, indicate treatment will be required to meet discharge limits for ammonia, nitrite or nitrate at BJ 3.10, the WRTSF outlet.

9.4 Nitrogen Management Triggers

Threshold trigger values are used to initiate investigation and corrective action for N source control or mitigation. Nitrogen management trigger levels have been defined for powder factors (PF) (development and production blasting) and N species concentrations at BJ 3.10 (Table 9-1). Note that the PF trigger values are not currently applied due to changes in Production blasting methods and Development recordkeeping, as described in Section 8.2. The trigger levels were derived from operational data and water quality model predictions. If monitoring metrics are below the trigger values, then N source control measures are considered to be effective and N species concentrations at BJ 3.10 are expected to remain well below regulated discharge levels. Temporary upset conditions may occasionally result in a short term trigger exceedance. If a trigger exceedance is observed, then the

Mine Manager and Environment Manager are notified, and a management investigation and response is initiated.

Table 9-1: Trigger values for nitrogen management

Monitoring Metric	Trigger Value
Powder factor, development blasting (kg/t)	1.75 [1]
Powder factor, production blasting (kg/t)	0.88 [1]
BJ 3.10 ammonia (mg-N/L)	0.50
BJ 3.10 nitrite (mg-N/L)	0.10
BJ 3.10 nitrate (mg-N/L)	10

[1] The PF trigger values are not currently applied due to changes in Production blasting methods and Development recordkeeping, as described in Section 8.2

A significant increase in the powder factor may alter N loading rates from blasted rock to contact water. The variation in monthly values is typically small, therefore, the 90th percentile values of the monthly development and production PF values from the June 2017 to December 2018 period were selected as trigger values to flag possible excessive explosives use. As discussed in Section 8.2, the Production and Development PF values have been generally above the trigger levels in 2021 and 2022. The PF trigger levels will be re-derived once a sufficiently large data set for statistical evaluation is obtained.

Trigger values at BJ 3.10 have been set at concentrations considered to identify significant changes in nitrification processes and N loadings that may influence future water quality at BJ 3.10. The concentrations of N species at BJ 3.10 are influenced by N loads input to the WRTSF and the N species conversions that occur in the WRTSF. Monitoring data indicate that nitrate is the dominant N species at BJ 3.10, generally accounting for more than 98% of the N measured in the discharge. Therefore, based on trends in monitoring data, trigger values for ammonia and nitrite have been conservatively set at 0.5 and 0.1 mg-N/L, respectively, to indicate possible changes to the natural nitrification processes that are active within the WRTSF.

The observed concentrations for nitrate are at base case levels (Figure 8-7). Prior to 2020, the nitrate trigger value was set to 8 mg-N/L although predictions indicated concentrations would reach 10 mg-N/L. The trigger value was exceeded in 2020, and a review of monitoring data indicated nitrate was closely tracking base case predictions for the WRTSF outlet, therefore the trigger value was reset to 10 mg-N/L, the maximum predicted base case concentration (Lorax, 2020), and well below the 11.5 mg-N/L discharge limit for nitrate.

In the event of a trigger level exceedance, Pretium will follow the steps outlined in the trigger response flow chart shown in Figure 9-1. The initial response to the management trigger exceedance is an investigation to identify root cause and corrective action. The investigation will be conducted as described in Section 9.5. Following the investigation, appropriate mitigation measures will be identified and implemented, as necessary. The efficacy of the mitigation will be evaluated based on follow up monitoring results.

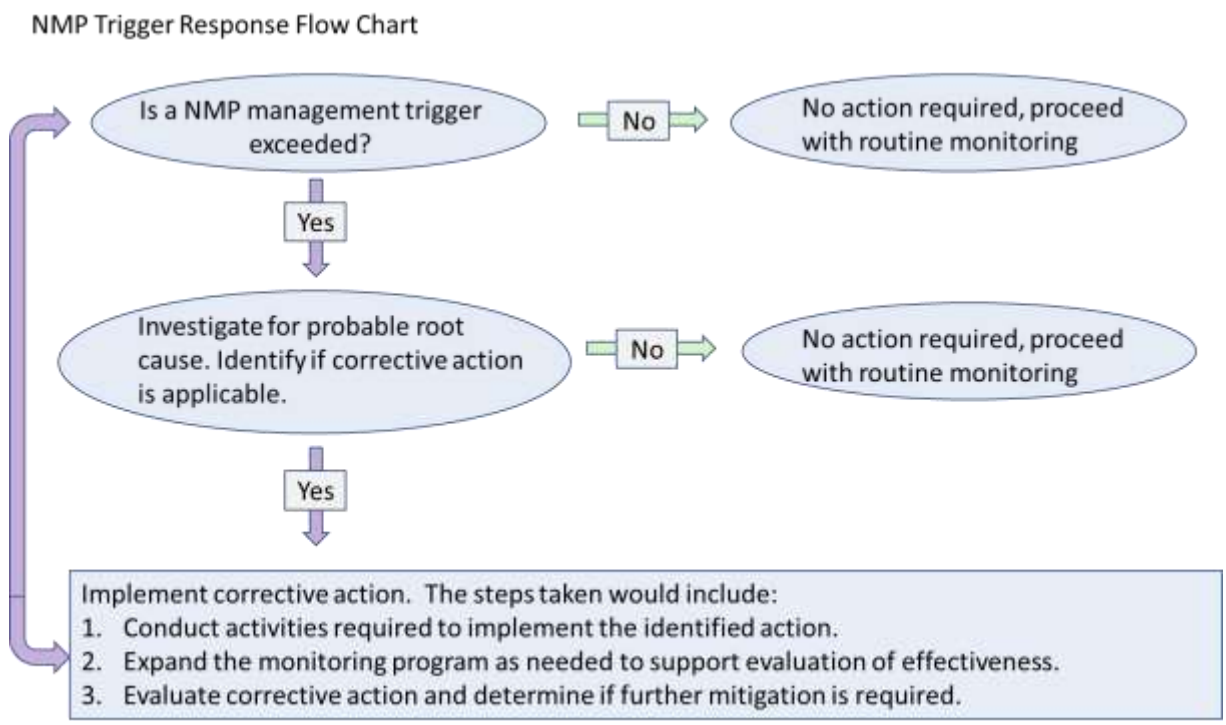

Figure 9-1: Schematic of the NMP trigger response process that is activated when management trigger exceedances are observed.

9.5 Investigation and Corrective Action

In the event that monitoring results indicate a management trigger value is exceeded, an investigation will be carried out to identify the root cause of the exceedance. The investigation may include, but will not necessarily be limited to, the following:

1. Verification of results through collection of additional samples to be analyzed for total nitrogen, ammonia, nitrite and nitrate, where applicable.

2. Determining the potential cause(s) based on indications in the monitoring data and in consultation with mine staff to determine if routine operations or extraordinary circumstances resulted in the elevated N.

3. A visual inspection of the underground mine to determine possible sources of N.

4. Expansion of the monitoring program to identify the source of elevated N, if warranted.

5. An assessment of the severity of the occurrence and likelihood of recurrence.

6. Recommendations for immediate source control and ongoing mitigation.

A review of the investigation will be prepared by Pretium Environment staff. The review may include, but will not necessarily be limited to, the following information:

- A description of the triggering incident;
- A description of the investigation that was undertaken;
- An assessment of the root cause;
- Recommended action; and,
- A summary of the source control measures that were implemented.

Corrective actions will be implemented in accordance with this plan and reviewed for effectiveness. If further improvements are necessary, these will be tracked with the original incident file. The Environmental Manager is responsible for ensuring that the corrective actions are tracked until an incident is considered to have been addressed. Relevant records are summarized for annual reporting.

9.6 Emergency Procedures and Response

A Mine Emergency Response Plan (MERP) has been developed by Pretium in accordance with the Health Safety and Reclamation Code for Mines in British Columbia (EMLI 2021). This MERP outlines response procedures in the event of a variety of incidences including spills of hazardous substances and unplanned explosions. Emergencies will be immediately communicated to the Pretium emergency response coordinator and response plans and activities will be coordinated by Pretium.

9.7 Roles and Responsibilities

This NMP applies to all individuals working for, or on behalf of, Pretium including employees and contractors who have a role and/or accountability for the use of explosives and the development, implementation or maintenance of this NMP.

The Mine Manager is responsible for nitrogen management and source control at Brucejack. The Mine Manager works with Mine Operations and the Environment Manager to ensure appropriate N source control procedures are identified and implemented. Underground mining personnel are responsible to implement approved procedures and corrective actions for explosives handling and N source control, and to prepare the blast and waste disposal records outlined in this NMP. Environment Department staff conduct explosives use audits, collect and evaluate monitoring data to detect trends in nitrogen export arising from explosives use, and prepare internal and external summary reports of the NMP metrics and trends.

The tracking and reporting relevant to N management are summarized in Table 9-2. Regulatory reporting of NMP monitoring is not required. However, the records must be maintained and provided for regulatory review if requested. A summary of the NMP monitoring data is provided on an annual basis in the Brucejack Mine Annual Report.

Table 9-2: Summary of NMP Monitoring and Reporting

Review/Report	What is monitored
Blast Report (Daily)	Drilling/blasting records for a given pattern • Hole depth, explosives use, blasted volume/advance • Other activities (*i.e.,* shotcrete, water management, spills, etc.)
Waste Disposal Report (Daily)	Waste rock placement records • Underground rock volumes deposited to the WRTSF
WTP Report (Daily)	Daily performance and effluent quality • report on key performance metrics for WTP operation • metrics include nitrite monitoring
WTP Summary Review (Monthly)	Monthly performance review • Year to date summary of reagent usage, influent and effluent volumes, and internal water quality results
NMP Quarterly Review (Quarterly)	Year to date summary of NMP metrics • Informal internal review summarizing N loading rates, PF, BJ 3.10 results, external laboratory results for influent and effluent and blast audit findings • Comparison of modelled to actual quantities for excavation, as well as the deposition of waste and tailings to the WRTSF. • Flag emerging issues • Update progress on past issues
Annual Report	Annual summary of NMP monitoring metrics, N source control and loading rates • Annual summary of NMP monitoring data • Mine water, waste rock, ore, tailings, WTP Effluent and BJ 3.10 • Included in the annual water quality report

9.8 Management Review

The overall implementation and effectiveness of the NMP is reviewed quarterly by the Mine Manager and Environment Manager, with the review led by the staff Hydrogeologist/Hydrogeochemist. Reviews include monitoring records, nitrogen audits and an overall evaluation of the implementation of the NMP. Action items arising from the review process are assigned to the appropriate individuals and tracked for future evaluation.

10 CONCLUSIONS

Nitrogen Source Control Practices implemented at the Brucejack Mine have thus far kept Nitrogen levels at, or below, expected values. This version (version 5) of the Nitrogen Management Plan provides updated data for 2022, as well as detailing Nitrogen Management Plan changes, updates and best practices underway and planned for Brucejack Mine. Some of these activities included:

- Changes to drilling equipment and data management practices that have resulted to changes in how the development and production PFs are calculated;
- Changes to procedure for monitoring nitrogen (N) Loading from waste rock deposition by incorporating a 2 year averaging period to obtain more representative and normalized results; and

- Conducting N surface source control audit results within the NMP to summarize audit findings and corrective actions.

In terms of performance, recent data continues to illustrate good N source control, with:

- Nitrogen loading rates to mine water and ore that are in line with expected values; and,
- Water quality measurements of Nitrogen species at BJ 3.10 aligned with, or below expected values and permit conditions.

Planned improvements to N source control procedures in 2023 include:

- Continued training through presenting the NMP and Source Control Measures to the entire underground workforce in 2023; and
- Updating management trigger values for the Development and Production PFs based on changes to stope volume calculations, drilling methodology/equipment, blast pattern design and on-site reporting methods coupled with continued data evaluation.

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APPENDIX A – SURFACE BLASTING N SOURCE CONTROL CONSIDERATIONS

Surface Blasting Explosives Use - Nitrogen Source Control Considerations [1]	
Explosives quality, storage and record keeping	- Explosives shall be manufacturer certified, stored according to manufacturer specifications, and be used prior to the expiry date. - Explosives certificates and/or test results shall be provided to Pretium.
Pattern design and record keeping	- Blast pattern design must use minimum quantity of explosives required to meet fragmentation objectives. - Pattern as-built design, explosives type and quantity, detonator type, booster type and placement, volume of rock blasted, miss holes, incompletely detonated holes, and presence of water shall be recorded for each blast. - These records shall be provided to Pretium within 24 hours of each blast.
Wet site conditions	- Water must be directed away from boreholes. - Dewater wet boreholes prior to loading. - Use explosives appropriate for wet conditions (i.e., emulsion) when water is present in the pattern or boreholes.
Powder column contamination	- Procedures must be implemented that prevent water, sediment and drill cuttings from entering the blast hole at any time.
Fractures and voids	- Decking and stemming can be used to isolate fractures and voids.
Stemming materials	- Stemming material should be angular coarse crush with a size approximately 1/5th to 1/8th of the blast hole diameter. - Drill cuttings may not be used for stemming.
Spills and record keeping	- The date, time, explosives type and quantity of all spills shall be recorded and reported to Pretium immediately. - Water shall not be used to wash away spilled explosives. - All spilled explosives shall be collected.
Disposal	- Waste explosives must be returned to manufacturer for disposal or detonated during a blast.

[1] Adapted from: Brucejack Mine Project Nitrogen Management Plan Revision 1, November 10, 2016.

APPENDIX B - UNDERGROUND BLASTING N SOURCE CONTROL CONSIDERATIONS

There are numerous considerations for underground blasting that may either enhance or reduce explosive consumption efficiency. Outlined below are typical considerations for improving explosive consumption efficiency and reducing the amount of residual nitrogen compounds available for waterborne export from the mine site.

Consideration	Description
Pattern design	The blast pattern should be designed to meet rock fragmentation objectives considering specific pattern geometry and geo-mechanical rock properties. The PF target is based on the minimum amount of explosive required to meet the fragmentation objectives.
Wet site conditions	The presence of water in the blast face creates challenging blast conditions that affect the amount of nitrogen released to the environment. Explosives appropriate for wet conditions must be used (i.e., AN-emulsion).
Explosive quality	Poor explosive quality (i.e., out of specification composition) may cause inefficient consumption, and in extreme cases failure to detonate, leading to poor blast performance and increased residue of nitrogen compounds.
Powder column contamination	This occurs when water or sediment (i.e., drill hole cuttings) are mixed into the powder column during blast hole loading. Sediment and water can cause bridging when one part of the powder column is separated from the remaining powder column, thereby preventing propagation of the explosion reaction through the column.
Fractures and voids	Loading explosives into boreholes with fractured rock or voids will result in explosives loading of empty spaces adjacent to the blast hole. Explosives connected to the powder column but confined to small spaces will deflagrate leading to the formation of yellow/orange smoke (nitrous oxides).
Detonation Failure	The powder column will not detonate if the detonator and booster are outside of the explosive or if the detonator chord is cut prior to detonation.
Spills	Spills can occur at the blast face due to leakage from the blast hole or by dripping out of the hose as the hose is moved between blast holes. All spills must be removed prior to blasting. Waste explosive must be collected before and after detonation to minimize N loss to the adit water and muck pile.

APPENDIX C – NITROGEN CONVERSION PROCESSES

1 PURPOSE

This appendix provides an overview of the nitrogen cycle, highlighting the key microbially-mediated nitrogen (N) conversion reactions and the reactions associated with N-based explosives. This overview is followed by a summary of water quality observations in the Waste Rock and Tailings Storage Facility (WRTSF) which are used to assess nitrogen conversion processes currently active in the WRTSF. Together this information is used to inform N management decisions at the Brucejack Mine (Brucejack).

2 NITROGEN REACTIONS IN THE ENVIRONMENT

2.1 Overview

In aqueous systems, nitrogen is stable as ammonia (as NH_3 or NH_4^+), nitrite (NO_2^-) and nitrate (NO_3^-) as well as dissolved nitrogen gas (N_2). The relative distribution of nitrogen between ammonia, nitrite and nitrate can shift according to the reduction-oxidation (redox) conditions of the water. Under oxidizing conditions, characterized by the presence of dissolved oxygen (oxic), nitrate is favoured. Whereas under reducing conditions, when dissolved oxygen is absent (anoxic), ammonia and nitrogen gas are favoured as shown in Figure 2-1.

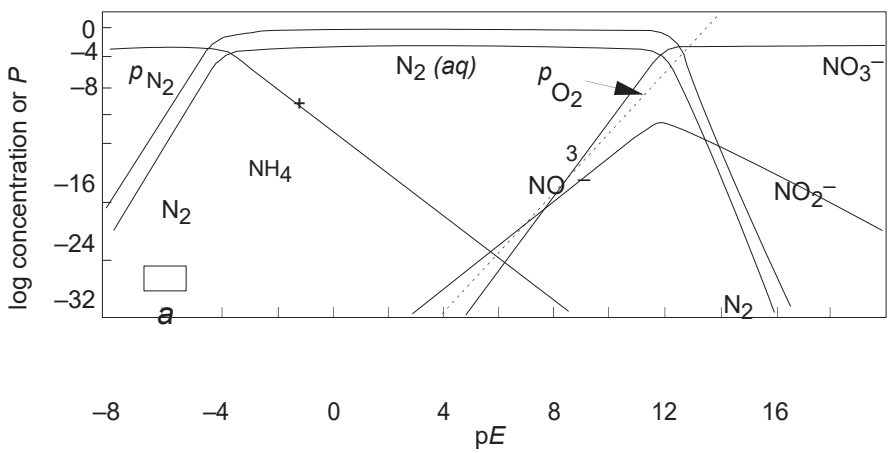

Figure 2-1: Distribution of nitrogen species based on the reduction-oxidation potential (p*E*) of the aqueous system. Oxidizing conditions (positive p*E*) favour NO_3^- as the dominant N species, whereas reducing conditions (negative p*E*) favour conversion of NO_3^- to NH_3 and N_2. (Image credit: Stumm W. And Morgan J.J., 1981. Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters, second edition).

The distribution of nitrogen species in the environment is also regulated by micro-organisms which convert nitrogen through various processes. These processes include nitrogen fixation, ammonification, nitrification, denitrification, anammox and dissimilatory nitrate reduction to ammonia (DNRA) (Figure 2-2). Together these processes and the associated chemical reactions (Table 2-1) comprise the N biogeochemical cycle which recycles nitrogen throughout the atmosphere and hydrosphere.

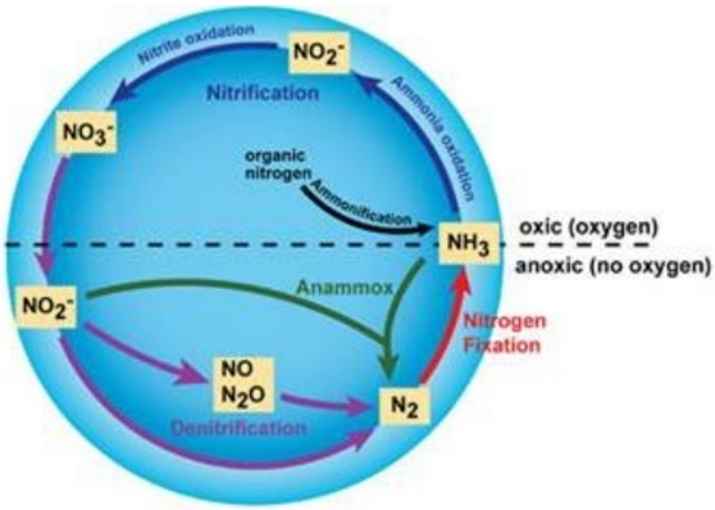

Figure 2-2: The microbially-mediated nitrogen biogeochemical cycle showing the inter-relationship between ammonification, nitrification, denitrification, annamox and dissimilatory nitrate reduction to ammonia (DNRA) processes. (Image credit: Bernhard, A. (2010) The Nitrogen Cycle: Processes, Players, and Human Impact. Nature Education Knowledge 3(10):25).

Table 2-1: Nitrogen cycling processes and corresponding chemical reactions.

Nitrogen Cycling Process	Chemical Reaction
Ammonia oxidation	$NH_3 + O_2 \rightarrow NO_2^- + 3H^+$
Ammonification	$N_2 + 8H^+ + 6e^- \rightarrow 2NH_4^+$
Ammonium nitrate dissolution	$NH_4\ NO_3 \rightarrow NH_4^+ + NO_3^-$
Anammox	$NH_4^+ + NO_2^- \rightarrow N_2 + 2H_2O$
Denitrification	$5\{CH_2O\} + 4NO_3^- + 4H^+ \rightarrow 5CO_2 + 2N_2 + 7H_2O$
Dissimilatory nitrate reduction to ammonia (DNRA)	$2\{CH_2O\} + NO_3^- + 2H^+ \rightarrow 2CO_2 + NH_4^+ + H_2O$
Nitrification	$2NH_3 + 3O_2 \rightarrow 2NO_3^- + 6H^+$
Nitrite oxidation	$2NO_2^- + 2O_2 \rightarrow 2NO_3^-$

Nitrogen in the form of ammonia and nitrate is often the limiting element for plant growth. Nitrogen gas is relatively inert and unreactive; however, certain organisms have adapted to convert nitrogen gas to ammonia through the nitrogen fixation process. Once nitrogen has been "fixed", it is available to be assimilated by plants and can be converted into organic forms such as amino acids and proteins.

As organisms die, microbial decomposition produces ammonia through the ammonification process. Conversely, nitrification is the process by which organisms convert ammonia to nitrite and nitrite to nitrate. Nitrification is favoured under oxic (i.e., presence of oxygen) conditions. Nitrate is converted back into nitrogen gas under anoxic to suboxic conditions when denitrification processes convert nitrate to nitrogen gas with nitrite as an intermediary product. Simultaneous anaerobic ammonium oxidation (anammox) processes can occur that combine ammonia and nitrite to nitrogen gas. These conditions are also conducive to DNRA processes that produce ammonia.

The discussion in following sections provides additional details on the nitrification and denitrification processes since these processes are most relevant to N in the WRTSF.

2.2 Nitrification (Oxidation) Reactions

Nitrification reactions in the natural environment (Table 2-2) are mediated by nitrifying organisms that are ubiquitous in groundwater, lakes and streams (Ward 2013; Ward *et al.*, 2011). These reactions typically occur under circum-neutral oxidizing conditions with the reaction rates for conversion of ammonia to nitrite and nitrite to nitrate increasing with increasing temperature and ammonia concentration.

Although the conversion rates are expected to be slower in cold-water systems, studies have shown that nitrification is active in cold-water northern lakes (Small *et al.*, 2013; Clevinger, 2013). The WRTSF is deep cold-water, circum-neutral and oxic throughout the water column. The entire water volume is exchanged over approximately 12 to 18 months. Conditions are conducive for the growth of nitrifying organisms throughout the water column, and the long residence time allows time for nitrification to occur. Based on observations of water quality, ammonia and nitrite oxidation processes are inferred to be active in the WRTSF throughout the water column (see Section 4).

Table 2-2: Key environmental factors influencing nitrification processes in cold water lakes

Environmental Factor	Description
Temperature	• In general, microbial growth rates and nitrification rates decrease with temperature; • Nitrification has been observed in lakes at 1 to 2 degrees C.
pH	• pH influences substrate and nutrient availability, affecting microbial growth rates; o low pH converts NO_2^- to HNO_2; HCO_3^- to H_2CO_3; o high pH converts NH_4^+ to NH_3; HCO_3^- to CO_3^{2-}. • Nitrification occurs over a range of pH, although circum-neutral conditions are favoured nitrification has been observed to occur as low as pH 3
Dissolved oxygen	• Oxygen is required for microbial growth • Below 0.5 mg-O_2/L dissolved oxygen there is little or no nitrification; • Nitrification consumes oxygen: o NH_4^+ to NO_2^-: 3.4 mg-O_2/L per mg-N/L; • NO_2^- to NO_3^-: 1.1 mg-O_2/L per mg-N/L.
Light	• Nitrifying bacteria are photosensitive and inhibited by ultraviolet light
Phosphorous	• Phosphorus is required for microbial growth; • Trace levels are sufficient to sustain nitrification in low nutrient lakes.
Substrate (Ammonia and Nitrite)	• Substrate is required for microbial growth; • Ammonia and nitrite oxidation rates are dependent on microbe populations; • Increase in substrate stimulates microbial growth and increases the nitrification rate; • Lack of substrate limits microbial growth, reducing the nitrification rate.
Chemicals	• High levels of heavy metals, inorganic and organic compounds may reduce microbial growth;

Note: Information compiled from: Bollmann *et al,* 2002; Kaplan *et al.*, 2000; Jeschke *et al.*, 2013, Clevinger, 2013; Small *et al.*, 2013; Anthonisen *et al.*, 1976.

Nitrification reactions in the WRTSF are expected to proceed throughout life of mine; however, nitrifying organisms are sensitive to environmental conditions and thus it is critical for monitoring data to be collected on a regular basis to assess any changes in these conditions. The interruption of nitrification processes can lead to accumulation of NH_3 or NO_2^-, or both. Some of the key environmental factors influencing nitrification processes are summarized in Table 2-2.

2.3 Denitrification and Reduction Processes

Denitrification processes are mediated by organisms that use ammonia, nitrite and nitrate as an energy sources and require organic carbon as a source of electrons for the reduction reactions. These conversion processes occur in anoxic or suboxic waters, and under mildly reducing to mildly oxidizing conditions. Other organisms mediate other conversions that can occur under these conditions such as conversion of nitrate to ammonia (DNRA), or ammonia to nitrogen gas (Anammox). The chemical equations for these processes are presented in Table 2-1, above.

Conditions that would support the growth of denitrifying, DNRA or Anammox organisms are not expected to occur in the WRTSF; however, should suboxic or anoxic zones develop and persist, the accumulation of ammonia may occur due to the interruption of nitrification processes. Denitrification and other nitrogen conversion processes could also occur within these zones leading to conversion of nitrate to nitrogen gas or ammonia, or both, as well as conversion of ammonia and nitrite to nitrogen gas.

3 NITROGEN FROM EXPLOSIVES

Ammonia and nitrate constitute the primary reactive ingredients in mining explosives. When detonated, the ammonia and nitrate combine to form nitrogen and other gases in an explosive reaction. Significant quantities of explosives are consumed during active mining and blasting residues can release nitrogen compounds to contact waters. In the ideal ammonium nitrate explosion reaction only gaseous nitrogen, oxygen and water are produced:

$$NH_4^+ + NO_3^- \rightarrow N_2 + 2H_2O + \frac{1}{2}O_2$$

However, in practice the explosion reaction converts less than 100% of the nitrogen to nitrogen gas with the remaining amounts as other nitrogen containing gases (*e.g.*, ammonia, nitrous oxides) that condense on blasted surfaces, ultimately entering contact water as ammonia, nitrite and nitrate.

4 NITROGEN MONITORING RESULTS FOR THE WRTSF

4.1 Monitoring Program

Water quality and flows are routinely monitored for mine dewatering and WRTSF discharge. Additional site investigations were conducted in 2016 through 2018 to characterize water quality throughout the water column. The water quality data indicate that microbially-mediated nitrification processes are active in the WRTSF, with higher proportions of nitrate observed in water from the

outlet as compared to mine water discharged to the WRTSF. The following sections summarize the data collected for mine water, the water column (BJ 35) and the WRTSF outlet (BJ 3.10).

4.2 Mine Water

During and after blasting, explosives residues are transferred to mine water from spraying and water accumulations in muck piles (blasted rock) on the mine floor. The blasted waste rock is then excavated and deposited in the WRTSF. Mine water is considered a proxy for the distribution of nitrogen species on waste rock surfaces, although this is complicated by recycling of treated WTP effluent to the underground mine for dust suppression.

Mining rates increased significantly in early 2016, therefore data from the 2016 to 2018 period were evaluated. As expected, concentrations of ammonia, nitrite and nitrate in mine water have increased in tandem with mining rate increases (Figure 4-1). From 2016 through 2018, nitrate ranged from approximately 5 to 60 mg-N/L. Ammonia and nitrite ranged from approximately 2 to 25 mg-N/L, and 0.5 to 6 mg-N/L, respectively.

The distribution of nitrogen species is shown in Figure 4-2. Overall, the proportional distributions of nitrate, ammonia and nitrite were relatively stable during the 2016 to 2018 period (approximately 70%, 25% and 5%, respectively). The monitoring data indicate the majority of the nitrogen added through waste rock deposition is in the form of nitrate with a significant proportion also present as ammonia.

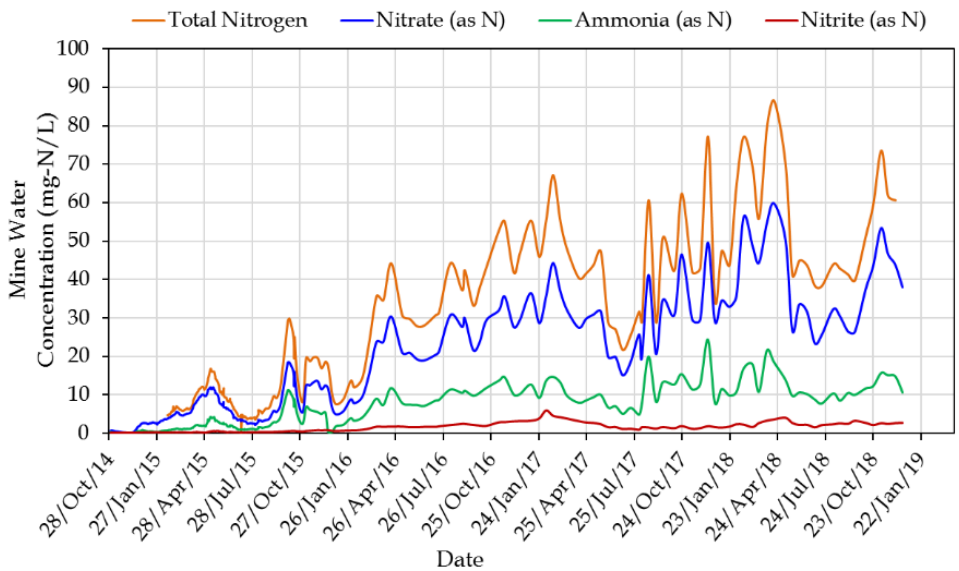

Figure 4-1: Mine water concentrations of total nitrogen, nitrate, ammonia and nitrite from October 2014 through November 2018.

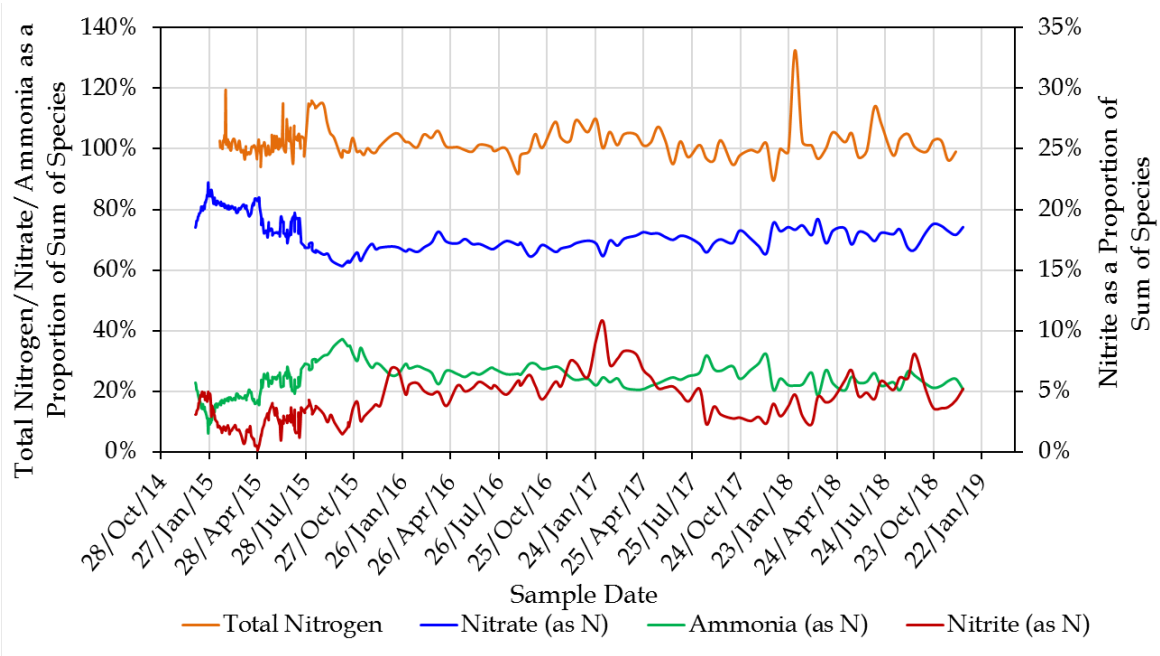

Figure 4-2: Proportional distribution of N in the form of nitrate, ammonia and nitrite in mine water from October 2014 through November 2018.

4.3 WRTSF Water Column (BJ 35)

The WRTSF water quality was periodically studied from 2016 to 2018 at station BJ 35, which is located in the vicinity of the deepest area of the WRTSF. Field parameters throughout the water column at this station were monitored using a profiling CTD configured with depth, temperature, pH, conductivity, dissolved oxygen and turbidity sensors. Water quality grab samples were collected annually in September with a Niskin grab sampler at variable depth intervals spanning 2 m below the surface to the bottom. The nitrogen species data are summarized and discussed below.

Based on the data sets acquired between 2016 and 2018, the WRTSF is stratified in September with two distinct layers. The surface layer is warm (approximately 6 to 9 °C) with variable depths ranging from approximately 5 to 15 m below the surface (Figure 4-3). The temperature of the cooler deep layer was generally uniform to the bottom (approximately 3.5 to 5.5 °C). The stratification of the WRTSF at this time of year is reflected in the shift in temperature, conductivity and dissolved oxygen concentrations that mark the depth boundary between the surface and deep layers (Figure 4-3).

The WRTSF water column was oxic during the study period but showed variable saturation levels from year to year. In September 2016 and 2017 dissolved oxygen saturation levels ranged from approximately 40% to 80% throughout the water column. In 2018 the dissolved oxygen levels were at approximately 80% saturation in the surface layer but ranged from approximately 5% to 20% saturation in the deep layer, lower than previous years. The decline in dissolved oxygen saturation is attributed to the temporary suspension of waste rock deposition for several months prior to monitoring in September 2018. Waste rock deposition is thought to pull oxygenated surface waters to depth as the waste rock descends through the water column, providing a continuous supply of oxic

water from the surface layer to the deep layer during waste rock deposition, which typically occurs continuously between the natural turnover mixing periods that occur twice annually (typically in June and September).

In all data sets, the concentration of nitrogen species generally decreased from the bottom to the surface, as shown in Figure 4-4, and stratification is reflected in the shift in nitrogen species concentrations between the surface and deep layers of the WRTSF. This observation is consistent with the expectation that inputs of nitrogen species from tailings and waste rock will initially accumulate at depth, due to the density induced by the TSS associated with these discharges, before slowly mixing upwards in the water column.

Nitrogen is dominantly present as nitrate, the nitrification end-member. Nitrate concentrations ranged from approximately 2 to 4 mg-N/L in the surface layer and from approximately 2 to 8 mg-N/L in the deep layer. In 2017 and 2018, ammonia concentrations showed a wide range from surface to depth, from approximately 0.01 to 0.65 mg-N. The lower ammonia concentrations at shallower depths relative to the bottom are attributed to nitrification processes that convert ammonia to nitrate as the bottom waters mix upwards. Nitrite concentrations, ranging from 0.005 to 0.025 mg-N/L, were relatively low at all measured intervals, indicating that ammonia oxidation is likely the rate limiting step for nitrification in the WRTSF.

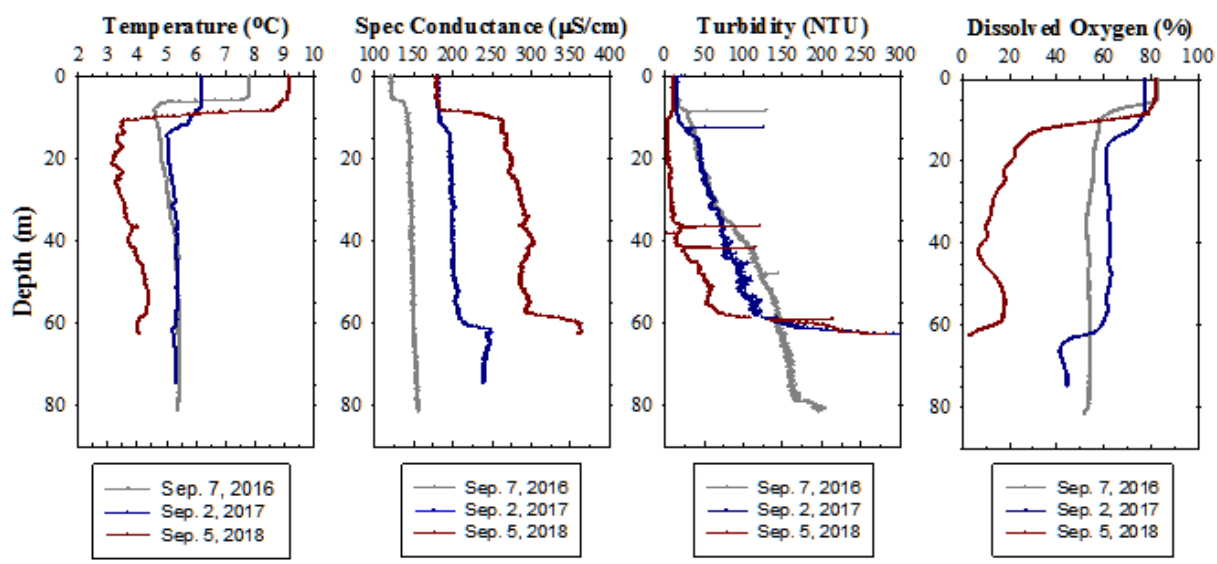

Figure 4-3: Water column temperature, conductivity, turbidity and dissolved oxygen measured with a profiling CTD each September from 2016 through 2018.

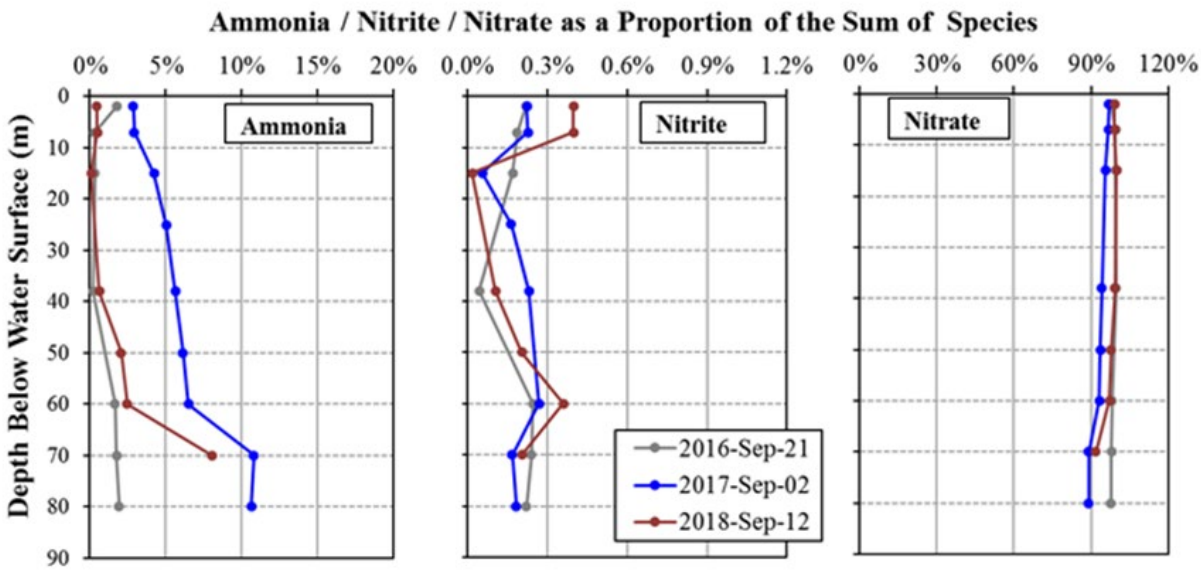

Figure 4-4: Proportional distribution of ammonia, nitrite and nitrate measured in water column grab samples collected at specific depths each September from 2016 through 2018 (indicated by the plot symbols).

4.4 WRTSF Outlet (BJ 3.10)

Nitrogen at the BJ 3.10 is dominantly present as nitrate (typically >95% of all N present) with the balance present as ammonia and nitrite (Figure 4-5). Assuming that the mine water N distribution is representative of all N inputs to the WRTSF, with approximately 70% of N in the form of nitrate, then the observed enrichment of nitrate at BJ 3.10 may be attributed to nitrification processes in the WRTSF.

From August 2017 through February 2018 the proportion of N as ammonia increased from less than 1% to approximately 7% of all N at BJ 3.10. It is speculated environmental conditions were influenced by the discharge of tailings which began July 2017. This new discharge may have led to a temporary interruption of nitrification processes while the nitrifying organisms acclimatized to a slight change in conditions prior to resuming growth.

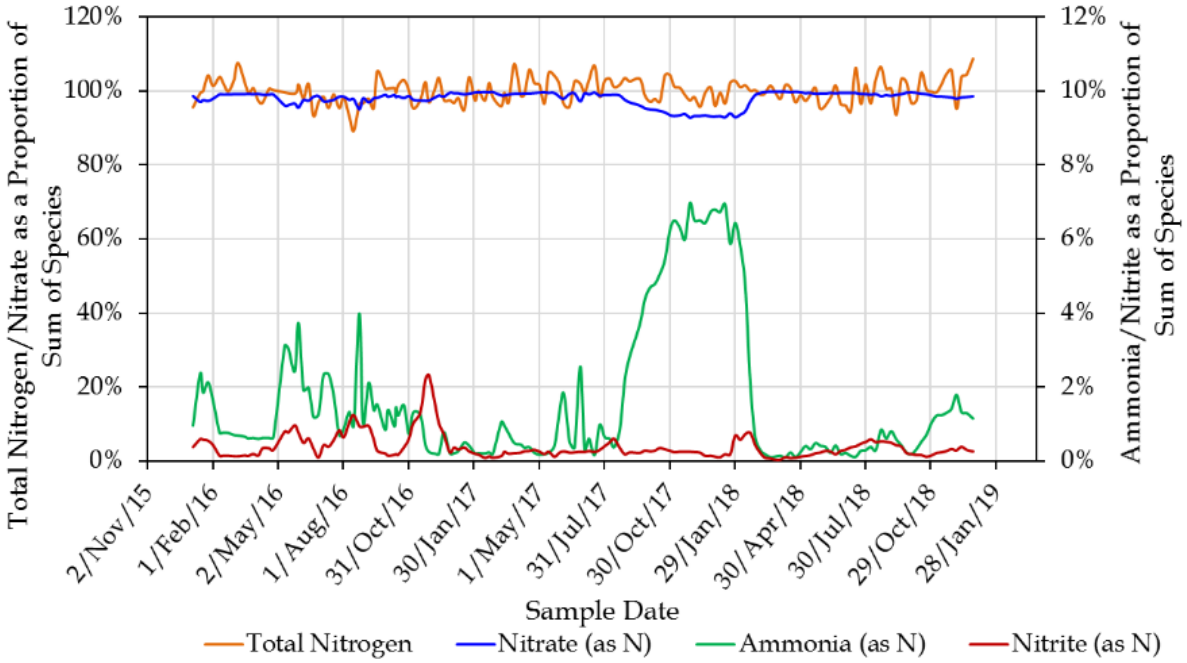

Figure 4-5: Proportional distribution of N in the form of nitrate, ammonia and nitrite at the BJ 3.10 from January 2016 through November 2018.

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APPENDIX D - PREPARATION OF NMP METRICS

1 INTRODUCTION

The calculations used to derive Nitrogen Management Plan (NMP) metrics from monitoring data and records are described below. The NMP metrics should be updated on a monthly basis, including updates to plots used for NMP performance monitoring, similar to those presented in Section 7 of the NMP. Explosives use, nitrogen loading rates and nitrogen speciation are derived and compared to trigger values. Additional metrics not described below are derived as needed to aid with investigations or reporting.

2 EXPLOSIVES USE

Explosives use rates are monitored to evaluate source control measures. Good N source control is achieved when explosives use is similar to design values. Explosives use is monitored by calculating the powder factor (PF), which is equivalent to the amount of explosives (kg) used to blast a tonne of rock. Waste rock and ore blasted, and explosives use for each, are recorded on a daily basis by blasting crews and mine engineers. A monthly powder factor plot for ore (production) and waste (development) blasting is prepared, similar to NMP Figure 8-1.

3 MINE WATER

Nitrogen loads are transferred to mine water after a blast, therefore monitoring mine water N loading can indicate if excessive explosives loss is occurring during blasting. The total nitrogen (T-N) water quality parameter provides a non-specific measure of inorganic and organically bound N and is used with mine dewatering flows to estimate monthly N loads in mine water, per Equation 1.

Equation 1: $N = C_{mw} * Q_{mw} * 0.001 - C_{fw} * Q_{fw} * 0.001$

where:

N = Monthly N load (kg-N)
C_{mw} = Monthly average mine water T-N concentration (mg/L)
Q_{mw} = Monthly mine water volume (m^3)
C_{fw} = Fire/fresh water tank T-N concentration (mg/L)
Q_{fw} = Monthly flow directed from the fire/fresh water tank to the water box (m^3)

The monthly mine water loading rates are determined using the monthly N load (N) and the total tonnage of ore and waste rock blasted for the month, per Equation 2. A monthly loading rate plot is similar to NMP Figure 8-2 is updated.

Equation 2: $LR_N = \frac{N}{T}$

where:

LR_N = Monthly N loading rate per tonne of blasted rock (kg-N/t)
N = Monthly N load (kg-N)
T = Monthly blasted rock tonnage (t)

4 ORE

Ore is first processed in the SAG mill. At this stage water is added and the resulting slurry is ground to reduce the ore particle size. Nitrogen species are assumed to transfer entirely from the ore to the water in the slurry. The N loading rate for ore can be derived from water quality and flow data collected at the SAG mill.

The N load attributable to ore is derived from SAG mill water quality data, and instantaneous ore and process water feed rates. The change in the process water T-N concentration is calculated for each sampling event, as per Equation 4:

Equation 3: $\Delta C_N = C_{N-SAG\ Mill\ Discharge} - C_{N-SAG\ Mill\ Influent}$

where:

Δ CN = Change in T-N concentration (mg/L)
$C_{N\text{-}SAG\ Mill\ Discharge}$ = T-N concentration of SAG Mill discharge (mg/L)
$C_{N\text{-}SAG\ Mill\ Influent}$ = T-N concentration of SAG Mill influent (mg/L)

The SAG Mill influent feed rate (m^3/hr), ore feed rate (t/hr) and ΔC_N are used to calculate an instantaneous N load from ore using Equation 4 to calculate the ore N loading rate, and the ore N loading rate plot similar to NMP Figure 8-3 is updated.

Equation 4: $LR_{Ore} = \Delta C_N * 0.001 * \frac{FR_{pw}}{FR_{ore}}$

where:

LR_{Ore} = Loading rate per tonne of ore
Δ CN = Change in T-N concentration (mg/L)
FR_{ow} = Process water feed rate (m^3/hr)
FR_{ore} = Ore feed rate (t/hr)

5 TAILINGS

Tailings are discharged to the WRTSF bottom and N loads from tailings to the WRTSF are monitored. Tailings discharge flows and supernatant T-N concentration is used to estimate monthly N loads in tailings per Equation 5, and the N loading rate for tailings using Equation 2. The tailings N loading rate plot similar to NMP Figure 8-4 is updated.

Equation 5: $N = C_{SN} * Q_{SN} * 0.001$

where:

N = Monthly N load (kg-N)
C_{SN} = Tailings T-N concentration (mg/L)
Q_{SN} = Monthly supernatant volume (m^3)

6 WTP EFFLUENT

WTP effluent contains N loads transferred from all sources within the mill, the underground mine and the contact water system. WTP effluent accumulates N as it is recirculated during low flow months, when effluent is retained for use in ore processing and underground dust suppression. Concentrations of T-N in WTP effluent is used with WTP discharge flows to the WRTSF per Equation 5.

7 NITROGEN SPECIATION AND CONCENTRATION AT BJ 3.10

The concentrations and relative proportions of N species (ammonia, nitrite and nitrate) are monitored at BJ 3.10. The concentrations are compared to trigger values and discharge limits and plots similar to those in NMP Figure 8-7 are updated. The relative proportions of N species in mine water, tailings supernatant and at the WRTSF outlet (BJ 3.10) are derived by dividing the parameter concentration (as mg-N/L) by the sum of NH_3, NO_2^- and NO_3^- (as mg-N/L) and converting the ratio to a percentage. The proportion of T-N is compared to the sum of the N species to confirm that the N budget in the mine water is balanced. Monthly average T-N concentration at BJ 3.10 is used with BJ 3.10 discharge data to calculate the mass of N exported from the WRTSF per Equation 5.

8 WASTE ROCK

The N load from waste rock is back-calculated from the measured WRTSF N inventory and the N loads attributable to WTP effluent, STP Effluent and tailings. The waste rock N loading rate is back-calculated for the waste rock added to the WRTSF during the deposition period.

The WRTSF N inventory is derived from mass calculations for layers defined by the depth of each sample. The layer volume is estimated from a theoretical fill curve calculated from annual bathymetry surveys of the WRTSF. The layer volume and the corresponding T-N concentration are used in Equation 5 to calculate the N mass in each layer and the total WRTSF N inventory. The N exported from BJ 3.10, as described in Section 8, is added to the WRTSF inventory, and the previous N inventory is subtracted to derive the N load added to the WRTSF during the current period.

The N load terms are combined in Equation 6 to calculate the N load from waste rock. The N contributions from background input and NPAG quarry runoff are not measured and are therefore conservatively included the waste rock N load term.

Equation 3: $N_W = N_I + N_D - N_{WTP} - N_{STP} - N_T$

where:

N_W = N load (kg) attributed to waste rock
N_I = N inventory (kg) in the WRTSF
N_D = N load (kg) measured in the WRTSF discharge
N_{WTP} = N load (kg) measured in the WTP effluent
N_{STP} = N load (kg) measured in the STP effluent (treated domestic wastewater)
N_T = N load (kg) measured in tailings

The period waste rock N loading rate is determined using the period N load (N_w) and the total tonnage of waste rock placed in the WRTSF during the period, per Equation 2. The period loading rate plot similar to NMP Figure 8-5 is updated.

APPENDIX E – NMP AUDIT CHECKLISTS FOR SURFACE AND UNDERGROUND BLASTING

Brucejack Project Environmental Inspection Form
Underground and Surface Nitrogen Source Audit

Part 1 - Site Description	
Date and Time:	Inspector(s):
Site Name:	Location/Co-ordinates:
Site Location: •	
Part 2 - Site Assessment	
• Activity:	
Findings: Emulsion Magazine Loop: Development Loading: Production Loading:	
Samples Taken:	
Part 3 - Mitigation Requirements	
Mitigation Required:	
Part 4 - Monitoring Requirements	
Follow-up Monitoring:	
Monitoring Frequency:	
Reporting Requirements:	

Site Name:
Date:
Photo 1:
Photo 2:
Photo 3:
Photo 4:
Photo 5:
Photo 6:
Photo 7:
Photo 8:
Photo 9:
Photo 10:
Photo 11:

Appendix 9-2-7. Refuse Incinerator Management Plan

NEWCREST

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Refuse Incinerator Management Plan

February 2023

PRETIUM RESOURCES INC.
A member of the Newcrest Group of companies

BRUCEJACK MINE

Refuse Incinerator Management Plan

Date: February 2023

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VERSION CONTROL

Revision #	Date Released	Amendment
0	August 2016	Original
1	March 2020	Updated to reflect current permits, regulations and practices
2	February 2023	Minor change to ash disposal location. Document format updated to NCM Brucejack template.

ACKNOWLEDGEMENTS

This Refuse Incinerator Management Plan (RIMP) was prepared by Pretium Resources Inc. The report was written by Leilah Tate, P. Geo.; reviewed by Max Holtby. P. Geo., Sylvia Van Zalingen, P.Ag. and William Witte, P. Eng.; and updated by Torence Sandals, MSc., P.Ag, Jason Gabora and Travis Beebe. Updates were provided in 2023 by John Sheehan and reviewed by Torence Sandhals M.Sc, P.Ag.

BRUCEJACK MINE
Refuse Incinerator Management Plan

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Appendix B Knipple Incinerator Installation, Operation and Maintenance Manual (excluding Section 8)
Appendix C Chain of Custody Record for Waste Oil Analysis (Maxxam)

GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

EMA	*Environmental Management Act*
EWS	Eco Waste Solutions
HWR	*Hazardous Waste Regulation*
IOMM	Installation Operation and Maintenance Manual
KTA	Knipple Transfer Area
PLC	Programmable Logic Controller
Pretium	Pretium Resources Inc.
RIMP	Refuse Incinerator Management Plan
SOP	Standard Operating Procedure

1 PURPOSE

Environmental Management Act (EMA) Air Permit 107025 (PA-107025) authorizes Pretium Resources Inc. (Pretium) to operate two auxiliary fuel fired refuse incinerators throughout the life of the Brucejack Mine. The incinerators are operated in accordance with the Refuse Incinerator Management Plan (RIMP), as per Sections 11.7.7 and 4.5 of PA-107025. The purpose of this management plan is to provide direction on and methods for:

- measures to avoid potential wildlife attraction to the refuse incinerator area;
- a sampling and analysis plan for the waste oil burned;
- a tracking system to document the types and amounts of waste incinerated;
- a performance monitoring component including temperature readings; and
- an operational component describing how the operators will be trained and operate the refuse incinerators.

2 PERFORMANCE OBJECTIVES

The objectives of the RIMP are to manage and operate the incinerators for optimal performance and to track and monitor data and information required to comply with the conditions in PA-107025 for the Brucejack Mine.

3 SCOPE

The RIMP applies to the incinerator located at Brucejack Mine and the incinerator located at the Knipple Transfer Area (KTA), during all phases of the mine, until no longer required and facilities are decommissioned.

4 RELEVANT LEGISLATION, REGULATIONS AND EAC CONDITIONS

4.1 APPROVALS

Pretium is currently authorized to discharge contaminants to the air and ash to the ground from incinerators operated as part of the Brucejack Mine as per PA-107025 issued on January 9, 2014 (amended March 27, 2018 and July 8, 2021).

4.2 RELEVANT ENVIRONMENTAL ASSESSMENT CERTIFICATE CONDITIONS

Pretium was granted an Environmental Assessment Certificate (#M15-01) on March 26, 2015 that include a series of conditions associated with the Certificate. There are no conditions in the EAC that are required to be addressed within this plan.

4.3 RELEVANT DECISION STATEMENT CONDITIONS

Pretium was granted approval to proceed with the Brucejack Mine by the Government of Canada on July 30, 2015 in a Decision Statement that includes a series of conditions. There are no conditions in the Decision Statement that are required to be address within this plan.

4.4 RELEVANT LEGISLATION

Waste oil used to fuel the incinerators is analyzed quarterly and meets the specifications defined in Section 41(5) of Hazardous Waste Regulation (*HWR*) under the *EMA*.

4.5 ASSOCIATED MANAGEMENT PLANS

Management plans that support the activities associated with the RIMP include:

- Waste Management Plan;
- Wildlife Management Plan;
- Air Quality Management Plan; and
- Spill Response Plan.

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

5.1 INCINERATOR OPERATION

Optimal operation and performance of the incinerators is achieved through:

- management of the incineration process by trained personnel;
- operating the incinerator as per Section 6: Operating Instructions of the Installation, Operation and Maintenance Manual (IOMM) (Appendix A (Brucejack) & B (Knipple));
- incinerating acceptable waste products only, as defined in the permit and by the supplier ECO Waste Solutions (EWS) and for quantities as per the permit and the design of the incinerator; and,
- performing required maintenance as per Section 7: Maintenance Instructions of the Installation, Operation and Maintenance Manual.

5.1.1 Operator Responsibilities

It is the operator's role and responsibility to protect the environment by:

- complying with authorized discharge limits and operating practices specified in the permit to operate;
- minimizing emissions of particulate matter, HCl, toxic metals, carbon monoxide and organic compounds through proper incineration;
- operating the incinerator to generate high quality ash that is sterile (free of pathogens) and can be disposed of as per the permit;
- minimizing particulate matter emissions from ash handling;
- disposing of ash properly by sending it to the permitted disposal site; and
- performing regular maintenance inspections to identify deficiencies.

5.1.2 Operator Training

The incinerators are operated by individuals who have received training from the supplier, EWS. Operator qualifications include an aptitude for performing required equipment maintenance and operating the digital control panel. As the need for additional operators arises, they will be trained in-house by experienced operators. Future training by EWS will be supplied as required.

5.1.3 Waste Stream

Waste stream composition and quantity are important for the incinerator to operate properly. The solid waste material generated at the Brucejack Mine is typical of mixed camp non-hazardous solid waste consisting primarily of food-waste, kitchen waste including packaging, cardboard, wood waste and general refuse. The list of acceptable wastes as outlined in Section 5.1 of the Waste Management Plan, and also included in Section 6 of the Brucejack Installation, Operations and Maintenance Manual (Appendix A), is based upon guidance provided by EWS, and is supported by the waste segregation plan described in Section 5.2.4 of the Waste Management Plan. Waste is sorted at the source distinguishing waste designated for incinerator feed from other waste types. Waste is then transported directly to the incinerator or to the waste handling facility.

The following wastes will be limited in quantity:

- As per Section 1.7.5 of PA-107025 oil contaminated rags containing less than 3% of oil by weight may be incinerated provided they do not exceed 0.2% of the total waste incinerated per year;
- As per Section 1.7.6 of PA-107025 sewage sludge will be dewatered to a minimum of 25-30% solids content and comprise no more than 20% of the batch by weight; and
- As per operation specifications, kitchen grease and kitchen oils will be incinerated in limited quantities (up to a 2 ½ gallon pail) per batch.

The types of waste for each batch are weighed, using the scale that is housed within the incinerator building, and recorded. This prevents overloading the incinerator and promotes optimization of the waste feed characteristics for each batch, thereby contributing to effective and complete combustion.

The volume of waste per batch that each incinerator is design for is as follows:

- Brucejack Mine Site (Model: ECO M2TN WO): 1513 kg/batch/day plus up to 20 L/hour of waste oil.
- KTA (Model: CA100WO): 182 kg/batch; 364 kg per day plus up to 19 L/hour (5 gal/hour) of waste oil.

The incinerators were designed for the type and volume of waste mentioned above, and only those waste types and volumes are processed in the incinerator to maintain incinerator efficiency. Inappropriate materials including, but not limited to, reactive/explosive chemicals and items containing heavy metals, are not processed in the incinerator.

Waste oil used to fire the incinerators is collected at the source (i.e., maintenance facilities) in either containers less than 230 L capacity or in totes, which are transported to the incinerator and oil transferred to the incinerator waste oil tanks. Totes are either double-walled (i.e., Lube Pro totes with secondary containment built in) or placed in secondary containment when not in transport. Waste oil is burned as the first fuel of choice whenever available.

5.1.4 Optimal Operation

Section 6 of the Installation, Operation and Maintenance Manuals (Appendices A & B) provides Operation Instructions for each of the two incinerator types. Hard copies of these manuals are located at each incinerator facility.

Optimal operation of the incinerator depends on several factors, such as: composition and quantity of the waste, incinerator loading method and the temperature within the Secondary Chamber. The Secondary Chamber controls the temperature at 1000°C (1832°F), using a thermocouple, which constantly measures the temperature inside the chamber. The temperature readings are monitored by the system's programmable logic controller (PLC) and the PLC initiates operational changes such as increasing or decreasing the speed of the Secondary Chamber Blower and the output of the Secondary Chamber Burner.

Dewatered sewage sludge (bio solids) may be transported to the incinerator in sealed 20 kg to 25 kg heavy duty and combustible plastic bags. The sealed bags may be loaded into the primary incinerator chamber onto a layer of other solid camp wastes. The sewage sludge proportion does not exceed 20% of the batch by weight.

The solid waste, oily rags (if available), kitchen grease and dewatered sewage sludge are co-mingled to ensure that any wet low heat value waste is mixed with the other drier materials.

5.1.4.1 Sewage Sludge Handling

A prime rotary fan press is used to dewater the sewage sludge to a minimum of 25-30% solids content. The press, designed by FilterBoxx, is built to achieve the 25-30% solids content. A screw conveyor/feeder system is used to load the dewatered sewage sludge into reinforced plastic bags. Sludge contained in sealed bags may be transported to the incinerator, weighed and loaded into the incinerator at the appropriate time.

5.1.5 Incinerator Maintenance

Maintenance instructions for each incinerator are outlined in Section 7 of the Installation, Operation and Maintenance Manuals. Summary tables of preventative maintenance instructions are broken out into daily, weekly, monthly, quarterly, annual and 24-60-month maintenance procedures. Maintenance is performed by the operator or appropriate specialists.

5.1.6 Disposal of Ash

Adequately burned ash may be disposed of in the salvaged soil stockpile located at the KTA as per PA-107025. No large chunks of unburned waste material (other than metals or glass) should remain in the ash. Metals and glass that may be present after incineration, due to being missed in pre-segregation and sorting, will be removed prior to disposal. By following the manufacturer's operating

specifications, residual incinerator ash will be inert and non-toxic. The incinerator operator is responsible for efficient operation of the incinerator and a well- separated end-product.

Ash and waste residue from the incinerator are cooled and placed into tote for offsite disposal by 360 Environmental Solutions Ltd. or buried on site. Any runoff that might enter a burial site will be diverted away to prevent contact.

5.2 WILDLIFE PROTECTION

At the KTA, the incinerator building and waste handling facility building are enclosed within an electrified fence. At the Brucejack Mine, neither the building housing, the incinerator or the waste handling facility are planned to be fenced unless warranted.

Additional measures to minimize wildlife attractants are described in Section 5.2.5 of the Waste Management Plan and in Section 5.5 of the Wildlife Management Plan.

The onsite incinerators minimize the storage duration of kitchen wastes with burns scheduled either daily or every other day, depending on the number of people on site.

6 ENVIRONMENTAL MONITORING

6.1 PERFORMANCE MONITORING – TEMPERATURE

The integrated PLC in the Main Control Panel automatically monitors the entire incineration process and some system inputs are recorded and logged for record-keeping purposes, including temperature and pressure. Data can be transferred to storage by using the USB flash memory installed in the back of the HMI. Data from the incinerator that is logged automatically on the HMI will be manually retrieved from the HMI by the operator to create a record of temperature and pressure for reporting and inspection as required by PA-107025.

6.2 WASTE OIL ANALYSIS

Waste oil samples are collected and analyzed at a certified laboratory, as per Section 5.2 of PA-107025. Results are compared against the specifications defined in Section 41(5) of the *HWR* under the *EMA*.

HWR Section 41(5): A person must not, without approval, use waste oil as a fuel unless it meets the following specifications:

Table 6.2-1. Allowable metal and PCB concentrations in waste oil use as a fuel

Waste Oil Specifications for Use as a Fuel	
Column I Parameter	Column III Allowable Level for Fuel in Uses Other than for Cement Kilns
total arsenic	5.0 mg/L maximum
total cadmium	2.0 mg/L maximum
total organic halogens (as Cl)	1,500 mg/L maximum
total chromium	10 mg/L maximum
total lead	50 mg/L maximum
total polychlorinated biphenyls (PCB)	3.0 mg/L maximum

Samples are collected from the 1,000 L totes and other containers (less than 230 L) that are used to collect and transport waste oil. The Chain of Custody Record presented in Appendix C is used to record sampling events.

As per Section 5.2 of PA-107025, the frequency of the analyses is quarterly. Sample frequency may be reduced to annual provided Pretium demonstrates consistency in four consecutive quarterly results and that the content meets the requirements specified in Sections 1.7.4 (i.e. Section 41(5) of the *HWR* under the *EMA*). Should the annual results fail, Pretium must return to performing quarterly analyses.

6.3 SEWAGE SLUDGE ANALYSIS

Although sewage sludge solids are currently transported offsite for disposal, sludge may be incinerated provided Sections 1.7.6 and 5.2 of PA-107025 are met. Should sludge disposal via incineration be resumed, sludge samples will be collected quarterly to verify the PA-107025 criteria of 25-30% solid content is met. Upon demonstration that four consecutive quarterly results meet the requirements specified in Section 1.7.6, sample frequency will be reduced to annually. Should an annual result fail, Pretium will return to conducting quarterly analyses. Sludge samples are collected from the discharge hopper of the screw feeder while the transfer bags are being filled.

6.4 WORK PLANNING AND SCHEDULE

Monitoring frequency for temperature and pressure, waste oil and sewage sludge are outlined in Table 6.4-1.

Table 6.4-1. Monitoring Schedule

Monitoring	Frequency
Temperature & Pressure	Continuous
Waste Oil	Quarterly*
Sewage Sludge	Quarterly*

*Frequency may be reduced to annually as per Section 5.2 of PA-107025

7 REPORTING AND RECORDING

7.1 REPORTING

7.1.1 Compliance Reporting

7.1.1.1 Environmental Management Act Permit Reporting

Section 5.2.5 and 5.9 of PA-107025 require an annual assessment report be submitted to the BC Ministry of Environment. The report will include, but is not necessarily limited to, the following:

- summary of any non-compliance with the permit and remedial and preventative actions undertaken; include the copy of the Annual Status Report Form;
- summary of air quality and meteorological monitoring data obtained during the reporting period and interpretation of such data,
- summary of equipment performance monitoring data including continuous temperature and pressure recordings for the incinerators;
- summary of inspection and maintenance activities of the authorized works;
- results of analyses of waste oil used as fuel for the incinerators;
- results of lab analyses of sewage sludge for solids content;
- mass and percentage of sewage sludge per each batch of incineration;
- any new information or proposed changes relating to the authorized sources;
- summary of waste streams subject to incineration and open burning including annual quantification and waste storage methods.
- occurrences or observations of wildlife (medium and large carnivores) accessing waste, ash, or the incinerator area at the site; incidents of killing bears on the mine site due to potential concerns related to human-bear interactions; and mitigation measures taken;
- a statement regarding progress in reducing the waste stream, in accordance with the hierarchy of reduce, reuse and recycle principles.

The report will be submitted on or before March 31st of each year for the previous year's operations. Copies of this report will be sent to the Tsetsaut/Skii km Lax Ha First Nation, the Tahltan Central Council and Nisga'a Lisims Government.

7.1.2 External / Internal Reporting

Currently there are no other external/internal reporting requirements (i.e., reporting to advisory group or annual environmental report) identified for this management plan.

7.2 RECORD KEEPING / TRACKING

7.2.1 Waste Quantity and Composition

Wastes appropriate for incineration are sorted by type and weighed at the incinerator to assure the proper feed composition. The incinerator operators maintain a log of the waste composition and quantity for each batch incinerated. These records are kept at each facility and are made readily available in the event of an inspection.

7.2.2 Temperature and Pressure

Temperature and pressure data from the incinerator is logged automatically on the Human Machine Interface (HMI) and manually retrieved from the HMI by the operator to create a record. Data is downloaded weekly.

7.2.3 Monitoring Results

Pretium will assume the responsibility of data management and record-keeping of monitoring results. Data will be entered into suitable electronic databases and have quality control checks completed upon receipt of results. Data will be entered in a format and program that allows for comparison between quarters and will be stored in a single file format for each type of monitoring activity. Monitoring data will be stored for the life of the mine and be made available for review upon request.

The Chain of Custody Record form presented in Appendix C will create a record of sampling events.

7.2.4 Continuous Improvement, Follow-up, and Adaptive Management

If monitoring data are found to be out of compliance with permit conditions, adaptive management options will be assessed prior to implementation. The need for any corrective actions to reduce on-site emissions or install additional control measures will be determined on a case-by-case basis. Any modifications made to the plan, or any of the associated plans, will be communicated to regulatory authorities and First Nations where applicable.

7.2.5 Incident Response Records

Incident response records will be stored for a minimum of five years and made available for review upon request.

7.2.6 Permit Database and Amendments

The following permits related to refuse incineration are currently held for the Project:

- Environmental Management Act (2003) - Air Discharge Permit 107025 (amended July 22, 2015, July 12, 2016, November 5, 2017, March 27, 2018, and July 8, 2021).

Additional permit and permit amendments will be added on an as-needed basis.

8 REFERENCES

2003. *Environmental Management Act*, SBC. C. 53.

ECO Waste Solutions. February 2016. *ECO M2TN Installation, Operation and Maintenance Manual*. Document Number BRJ-IOM-ECOM2TN. Prepared for the Brucejack Project.

ECO Waste Solutions. February 2016. *CA 100WO Installation, Operation and Maintenance Manual*. Prepared for the Brucejack Project.

Appendix A

Brucejack Incinerator Installation, Operation and Maintenance Manual (excluding Section 8)

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 1

CONTACT PERSONNEL

ECO M2TN WO

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Email: info@ecosolutions.com
Web: www.ecosolutions.com

ECO WASTE SOLUTIONS

Project Name: Brucejack
PO: 177421-PG040 Incinerators
EWS Project # 15-2MS-B

Incinerator ECO M2TN WO Tag No.3242-IN-001

CONTACT INFORMATION		
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Toll Free	1-866-326-2876	
Fax	905-634-0831	
email	info@ecosolutions.com	
Personnel Contact	**Job Title**	**Email**
Sandra Marshall	**Customer Service Manager**	smarshall@ecosolutions.com
If Sandra Marshall can't be reached try below contacts:		
James Anderson	Technician	janderson@ecosolutions.com
Joe Coutinho	Instrumentation & Installation Specialist	jcoutinho@ecosolutions.com

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 2

GENERAL DESCRIPTION

ECO M2TN WO

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Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

General Description - Thermal Oxidation Concept

The **ECO M2TN WO** Incinerator system consists of a **Primary Chamber** and a **Secondary Chamber** (also known as the Afterburner). Both chambers are vessels constructed of steel with a special insulating liner known as refractory.

The **Primary Chamber** has a front door for loading of waste material and for the removal of residual ash.

The waste is loaded into the **Primary Chamber** until it is ¾ full. Once ¾ full the **Primary Chamber** is sealed and the combustion cycle begins. This type of system is known as *batch-fed* processing.

Primary Chamber

To begin the process of burning the solid waste, the **Primary Chamber Burner** is used to elevate the temperature of the **Primary Chamber** to ignite the waste. Once the **Primary Chamber** reaches a temperature of 650-850 ^{o}C (1200-1560 ^{o}F), by using a **Thermocouple** to measure the temperature of the **Primary Chamber**, the burn process becomes self-fuelling and the burner will shut off. To save fuel and control temperatures, only when the energy contained within the waste is depleted, will the burner periodically turn on.

The **Primary Chamber** operates under *controlled temperature* conditions. The amount of heat released, from the burning of the waste, is controlled by limiting the air into the **Primary Chamber** to less than what is required to complete combustion. This is described as *starved air* conditions. With controlled air and temperature the waste is dried, heated and burned thereby releasing moisture and volatile components. The non-volatile, combustible portion of the waste is burned in the **Primary Chamber** to provide heat while the non-combustible portion accumulates as ash. These conditions ensure that the waste is allowed to fully combust and is rendered sterile. In the end, the waste volume is reduced by over 90%.

Remaining in the **Primary Chamber** are non-combustibles, such as metal and glass, and carbonaceous residue. The incoming air, subjecting the non-combustibles to high temperatures, further burns the carbonaceous residue. The result is an oxidized ash product.

Controlling the gas velocity through the system is an important factor in limiting pollution. The gases flowing from the **Primary Chamber** are a result of the interaction of the air with the waste during the controlled burning process. Both the quantity and velocity of the gas product vary according to chamber temperature conditions and the type of waste being burned. The integrated controls for the **Primary** and **Secondary Chamber** act to minimize peaking activity thus controlling pollution automatically.

The combustion gases released in the **Primary Chamber** then pass into the **Secondary Chamber** through a turbulent mixing zone where ignition takes place and additional combustion air is provided to complete the burning process.

Secondary Chamber

As waste burns in the **Primary Chamber**, gases containing the products of combustion are pulled continuously into the high temperature zone of the **Secondary Chamber** where the oxidation reaction of the combustible products is completed.

The **Secondary Chamber** controls the temperature at 1000°C (1832 ^{o}F), using a **Thermocouple,** which constantly measures the temperature inside the chamber. The temperature readings are monitored by the system's PLC and the PLC will initiate operational changes such as increasing or decreasing the speed of the **Secondary Chamber Blower** and the output of the **Secondary Chamber Burner**.

The **Secondary Chamber Blower** air is introduced into the **Secondary Chamber** by an air ring manifold that surrounds the **Secondary Chamber**. The manifold has small air jets called tweers that open into the **Secondary Chamber** at the side walls and create a powerful vortex of excess air to mix the incoming gases and ensure complete combustion. The flow of air is tightly managed by the control system using a Variable Frequency Drive (VFD) to control the speed of the fan and modulating motors on the blower inlet dampers.

The **Secondary Chamber Blower** is extremely important as it creates the turbulence required to mix the gases and oxygenate them. This fosters the high efficiency combustion required to break hydrocarbon chains into carbon dioxide and water vapour. It also acts to cool the **Primary Chamber** and prevent temperature overruns.

Secondary Chamber Burner is similar to the burner used in the **Primary Chamber** except that it has a much higher output and it is self-modulated over a broad range for very precise temperature control.

The **Secondary Chamber** is sized to allow two seconds of retention time. This is the time that the gases from the **Primary Chamber** are retained in the **Secondary Chamber** before they exit to the next stage. Two seconds of retention is considered to be ideal to destroy any harmful organic hydrocarbons produced from the **Primary Chamber**.

Protecting the Environment

Why Incinerate

As society becomes more environmentally conscious, environmental regulations on the proper disposal of waste has become more stringent. As a result, incineration has become an environmentally responsible and socially acceptable alternative for handling waste at the point of need. However, incineration does not eliminate the need to landfill waste but it does reduce the amount of waste that must be placed in landfills.

Primary Advantages of incineration are:

- It greatly reduces the weight and volume of waste material that must be disposed of in landfills
- It destroys organic materials that may be harmful or that may be degradable to harmful materials in landfills

- The incinerator sterilizes the waste; that is, the high temperatures in incinerators can destroy any pathogens that may be in infectious waste materials
- The incinerator destroys animal or human pathological wastes that the general public finds objectionable to handle or see.

Environmental Concerns

The general public will not accept incineration as an option for treating waste of any kind, if they do not believe that it is safe environmentally. The primary concerns are about air pollutants produced by the incinerator and the toxicity of the residual ash.

Air Pollutants of Concern

Particulate matter may be defined as fine liquid or solid matter such as dust, smoke, mist, or fumes found in the gaseous emissions from the incinerator. Particulate matter emissions may have a dark or light color. Particulate matter emissions can be described in terms of opacity. Opacity is the degree to which light is obscured by a polluted gas (a clear window has 0 percent opacity while black paper has 100 percent opacity). Opacity may be measured with the naked eye or using an opacity monitor. Particulate matter is a problem because it can cause or aggravate respiratory problems in humans. It also creates aesthetic problems since it is readily noticed and is a nuisance because of soiling of exposed surfaces on houses and cars.

Hydrochloric HCl acid is generated when polyvinyl chloride (PVC) plastic (usually clear plastic) material is burned in the incinerator. The appearance of a white plume or cloud a short distance above the stack indicates that HCl is condensing. The major concerns about HCl are that it causes respiratory problems in humans, contributes to acid rain problems, and causes material damage to metals and concrete.

Toxic metals include cadmium, arsenic, beryllium, chromium, nickel, lead, and mercury. These metals may be found in municipal wastes. These metals are known to be hazardous to human health.

Organic compounds are compounds that contain primarily carbon and hydrogen and may also contain other elements such as oxygen, nitrogen, and chlorine in smaller amounts. Some organic compounds are known to cause or are suspected of causing cancer and are considered hazardous air pollutants. The public's primary concern is related to dioxin and furan emissions, but other organic compounds such as benzene and vinyl chloride may be emitted.

Carbon Monoxide (CO) also is generated during combustion if the combustor is not operated properly. (Your automobile generates some amount of CO.) CO is toxic to humans if concentrations are high enough, and it also is an indicator of combustion quality.

Solid Waste Ash Quality

One of the major objectives of incineration is to generate a high quality ash for land disposal. All pathogens should be destroyed, and almost all organic material should be completely burned. Ideally, no large chunks of unburned waste material (other than metals or glass) should remain in the waste. A measure of ash quality is "burnout," which is the percentage of organic material remaining in the waste. For example, a burnout of 95 percent means that the ash can contain only 5 percent organics. Adequately burned and quenched ash may be disposed of in a

sanitary (municipal) landfill. The ash should be stored in covered containers or kept wet prior to transport to the landfill to prevent 'fugitive \ emissions.' Individual landfills may have requirements that must be followed in order for your waste to be accepted. You should familiarize yourself with these requirements to prevent refusal of the waste.

The Operator – Your Role

It is the operator's role and responsibility to protect the environment by:

1. Complying with all emission limits and operating practices specified in the permit to operate.
2. Minimizing emissions of particulate matter, HCl, toxic metals, carbon monoxide, and organic compounds through proper incinerator;
3. Operating the incinerator to generate high quality ash that is sterile and can be disposed of in landfills;
4. Minimizing particulate matter emissions from ash handling;
5. Disposing of ash properly by sending it to appropriate disposal sites; and
6. Performing the regular maintenance inspections to catch any operational problems early.

Basic Combustion Principles

The Combustion Process

Combustion of MSW is a chemical reaction. In the incinerator, organic materials and oxygen react rapidly and violently to produce combustion gases and energy in the form of heat and light.

$$\text{Organic Solid Material + Oxygen} \xrightarrow[\text{Heat}]{} \text{Combustion Gas + Solid Residue + Energy(Heat)}$$

For the reaction to begin and to keep going, all three elements - organic material, oxygen, and heat-must be present. The organic material used in the reaction comes from two sources, waste and auxiliary fuel. Some organic material is contained in most solid waste types. Depending on the fraction of organics and the specific organic composition, the waste may be adequate to sustain combustion. Auxiliary fuel may be used to maintain combustion if the waste material does not contain enough organic material to maintain high temperatures. The combustion reaction between the organic material and oxygen that causes the organics to burn will occur only after the temperature of the organic material is raised to the point that combustion can begin.

Energy in the form of heat is required to raise the temperatures of the incinerator chamber and organic material and O_2. Initially, this energy usually is supplied by the pilot and auxiliary fuel burners. After the system is in full operation, the energy released from the burning waste often is adequate to maintain these high temperatures.

Fate of Combustion Air

The oxygen needed for the combustion reaction is supplied by the ambient combustion air. Combustion air is supplied to the combustion chambers through air ports by a forced draft fan,

by an induced draft fan, or by natural draft. In general, this air contains about 21 percent oxygen (O_2) and 79 percent nitrogen (N_2), so about 21 percent of the total combustion air fed to the incinerator is oxygen that is available to react with the organic material in the waste and fuel. The nitrogen passes through the chamber mostly unreacted; some nitrogen oxides are formed.

Oxygen Reaction

Solid waste contains two types of organic materials

1. Volatile Matter
2. Fixed Carbon

These two types of materials are involved in distinct types of combustion reactions, and the operating variables that control the two types of reaction are different.

Volatile matter is that portion of the waste that is vaporized (or evaporated) when the waste is heated. Combustion occurs after the material becomes a gas. The combustion variables that influence this reaction are gas temperature, residence time, and mixing.

- A minimum temperature is needed to start and sustain the chemical reaction.
- Residence time is the length of time, generally measured in seconds that the combustion gas spends in the high temperature combustion chamber. The residence time must be long enough for the reaction to be completed before it leaves the high temperature zone.
- Turbulent mixing of the volatile matter and combustion air is required to ensure that the organic material and oxygen are well mixed.

Fixed carbon is the nonvolatile organic portion of the waste. The combustion reaction is a solid-phase reaction that occurs in the primary chamber (although some materials may burn in suspension). Key operating parameters are temperature and solids retention time.

- The solids retention time is the length of time that the waste remains in the primary chamber.

Products of complete combustion are:

- Carbon dioxide
- Water

An example of volatile waste is backyard charcoal grill with starting fluid. The starting fluid is highly volatile. When put on the charcoal and ignited with a match, it rapidly volatilizes and burns. The charcoal contains less volatile matter and burns slowly as a fixed carbon bed.

Operating Factors Related to Combustion

The three operating factors that have the greatest effects on the combustion reaction are:

- Combustion airflow rate and distribution,
- Operating temperatures, and
- Waste feed rate and characteristics.

These three factors are all related. Controlling them controls the combustion reaction. The two key questions about combustion air are:

- How much combustion air is needed to sustain the combustion reaction?
- What happens if there is too much or too little combustion air?

Stoichiometric Air

In the chemical reaction between organic materials and oxygen, the amount of oxygen required under ideal or "perfect" conditions to burn all of the organic materials with no oxygen left over is the stoichiometric (or theoretical)-oxygen level. The amount of combustion air associated with that oxygen level is called the stoichiometric air level. At stoichiometric air level the combustion gas would contain no oxygen because it would all be used in the combustion reaction.

Substoichiometric Air

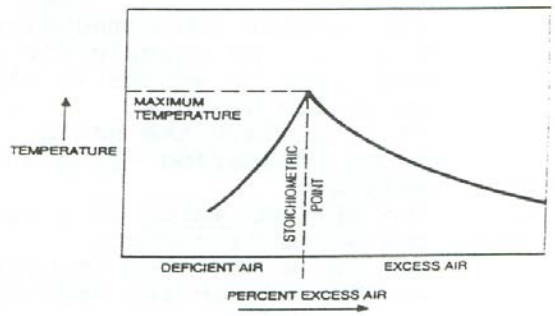
Airflows less than those required at stoichiometric levels are called deficient air or substoichiometric starved-air levels. Under starved-air conditions, the combustion gas would again contain no oxygen, but organics also would remain because combustion is not complete.

Excess Air

Air flows greater than those required at stoichiometric levels are called excess-air levels. Typically an incinerator operates with an overall 140 to 200 percent excess air level. That is, the incinerator operates with one and one-half to two times more air than required at stoichiometric levels. Excess air is used to assure that enough oxygen is available for complete combustion.

Control of Temperature as a Function of Air Level

Maximum combustion temperatures are always attained at stoichiometric conditions. As the amount of excess air is increased above the stoichiometric point, the temperature in the incinerator drops because energy is used to heat the combustion air. If the amount of combustion air is too great, the temperature drops below “good combustion temperature," and undesirable combustion products are generated as a result of incomplete combustion. As the amount of excess air is decreased, the combustion temperature increases until it becomes maximum at the stoichiometric point. Below the stoichiometric point, the temperature decreases because complete combustion has not occurred.



CONTROL OF TEMPERATURE AS A FUNCTION OF EXCESS AIR

The relationship of how combustion air level can affect temperature has just been shown. Temperature also plays an important role in the combustion of waste. Temperatures need to be maintained at levels high enough to ensure pathogen destruction and to sustain the combustion reaction. However, temperatures that are too high also cause problems. Continuous exposure of the combustor refractory to high temperatures is generally not desirable because it can cause the ash to fuse and can cause damage to the refractory.

Waste Characteristics

The primary characteristics of the waste that affect the combustion reaction are:

- The heating value
- The moisture content
- The chlorine content

Different wastes have different heating values and moisture contents. They will affect the combustion process.

The HEATING VALUE of a waste is a measure of the energy released when the waste is burned. It is measured in units of Btu/lb (J/kg). A heating value of about 5,000 Btu/lb (11.6×10^{-6} J/kg) or greater is needed to sustain combustion. Wastes with lower heating values can be burned but they will not maintain adequate temperature without the addition of auxiliary fuel. The heating value of the waste can be used to calculate total heat input to the incinerator where:

Heat Input (Btu/h) = Feed Rate (lb/h) x Heating Value (Btu/lb)

Heat input to the incinerator will affect temperature. More heat input yields higher temperature. Heat input also will affect air requirements; more air is required (1 SCF/100 Btu).

MOISTURE is evaporated from the waste as the temperature of the waste is raised in the combustion chamber. It passes through the incinerator, unchanged, as water vapor. Evaporation of moisture uses energy and reduces the temperature in the combustion chamber.

CHLORINE in plastics or solvents in the waste feed will react to form hydrochloric acid (HCl). This HCl can be an emission problem. It can create corrosion problems of the equipment downstream from the incinerator.

The heating value (Btu value) and moisture varies widely. Compare plastics (high Btu, no moisture) to Beddings, shavings, etc. to Anatomical

Summary of Key Operation Factors Affecting Combustion

1. Key factors are interrelated.
2. Air quality/distribution
3. Sufficient air for complete reaction
4. Distributed to promote mixing
5. Mixing
6. Assure contact of oxygen and organics
7. Temperature

8. High enough to sustain combustion
9. High enough to have complete reaction
10. Residence/retention time
11. Sufficient time to allow reaction to complete

Waste characteristics also are important

- Heating value
- Measure of energy released
- Heat input determines air required
- Moisture content
- Requires energy to vaporize water
- Chlorine content
- Affects HCl emissions

Products of Combustion Reaction

Complete Combustion

The primary products of waste incineration are:

- Combustion gases
- Solid residue (ash)
- Energy

The primary objectives of the combustion process are to generate an ash residue that is sterile (free of pathogens) and does not contain unburned, recognizable wastes; and to minimize air pollutants in the combustion gas stream.

The organic materials that enter the incinerator with the waste and fuel are primarily made up of carbon, hydrogen, and oxygen. Ideally, these organic materials react with oxygen in the combustion gas to form carbon dioxide and water vapor. The chemical reaction for this ideal situation is

$$\text{Organics} + O_2 + \text{Heat} \longrightarrow CO_2 + H_2O + \text{Heat}$$
(C, H, 0)

This ideal reaction represents complete combustion.

Incomplete Combustion

However, this ideal reaction does not occur in operating waste combustion systems. Factors that lead to a less than ideal reaction are poor mixing, too little combustion air, and low temperatures. Under those conditions products of incomplete combustion are emitted with the stack gases. The most common product of incomplete combustion is CO. Another product of incomplete combustion that often is emitted under poor mixing conditions or high temperature, low excess air conditions, is elemental carbon (or soot). The soot particles are very fine and generally result in high opacity at the combustion stack. Other products of incomplete combustion that cause concern because of their health impacts are hazardous organic

compounds such as benzene, dioxins, and furans. Although these compounds are not found in the waste, under incomplete combustion conditions they can be formed as intermediate combustion products.

The waste feed also includes inorganic materials; generally, they are not involved in the combustion reaction. The inorganic materials in the waste feed (ash) are either retained in the ash or are emitted as particulate matter in the combustion gas. Air velocities in the combustion bed are controlled to reduce the amount of inorganic material entrained (picked up by) the combustion gas and emitted with the combustion gas. If combustion is not complete, organics will remain in ash; this is typical…it is atypical to have 100 percent combustion of ash bed. Under poor conditions (low temperature, low turbulence in ash bed) the ash may have pathogens present, the ash may not be sterilized.

Combustion Indicators

The following indicators can be used to monitor combustion quality.

Opacity

The opacity of the combustion gas stream is a measure of the degree to which the stack gas plume blocks light.

- High opacities indicate high emissions.
- Opacity is primarily caused by noncombustible ash or uncombusted carbon (soot) in the flue gas.
- High opacities can indicate poor mixing or low levels of combustion air.
- High opacities also may be generated by high levels of HCl emissions or poor burner operation in the secondary chamber.

If a large amount of water vapor is present in the combustion gas, the water can condense when it cools as it leaves the stack forming a dense white "steam plume." This is not an indicator of poor combustion and should not be confused with a black or white smoke plume caused by soot or acid gases. Opacity can be visually determined by a person or measured by an instrument.

Other indicators which provide information about combustion conditions are measurements of the combustion gas oxygen and CO levels. However, these measurements require instruments and most facilities do not have those instruments.

Ash Quality

Visual appearance of ash can be an indicator of combustion problems. If an incinerator is operating properly, little organic material will remain in the ash. Whitish gray ash indicates better burnout and less carbon than black. The extent of organics combustion can be measured by the quantity of combustible materials remaining in the ash. Noted increases in combustibles in the ash indicate a combustion problem which may include bed temperatures that are too low, improper distribution of combustion air in the bed, or insufficient waste retention times.

ECO WASTE SOLUTIONS

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SECTION 3

PHOTOS OF THE INCINERATOR

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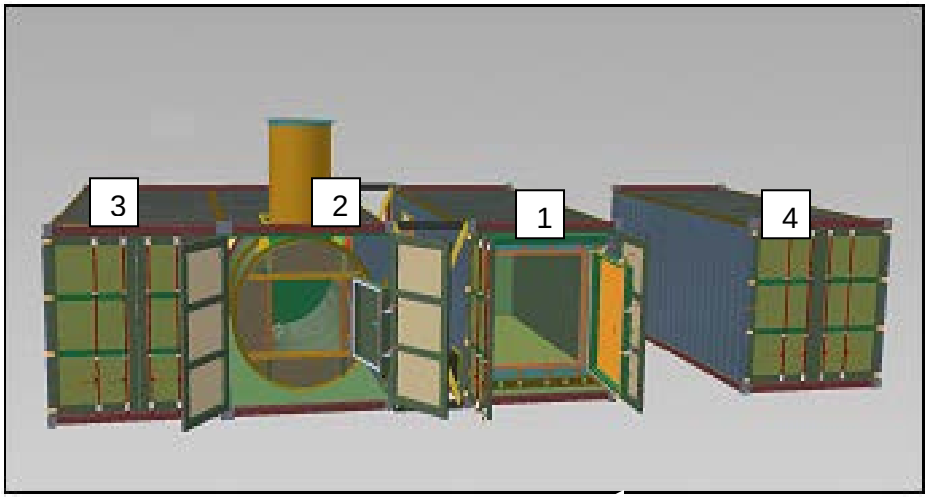
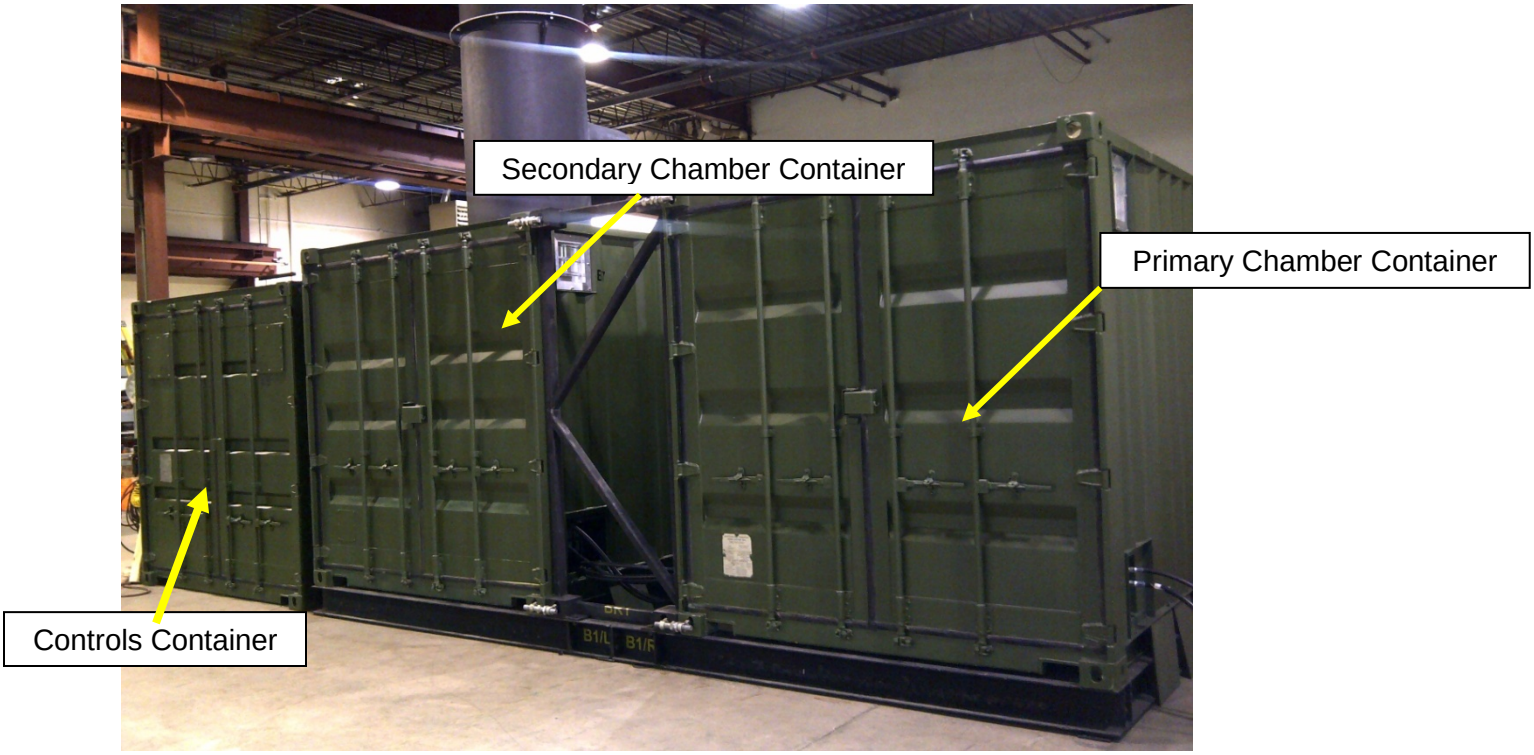
ECO M Model Incinerator Containers

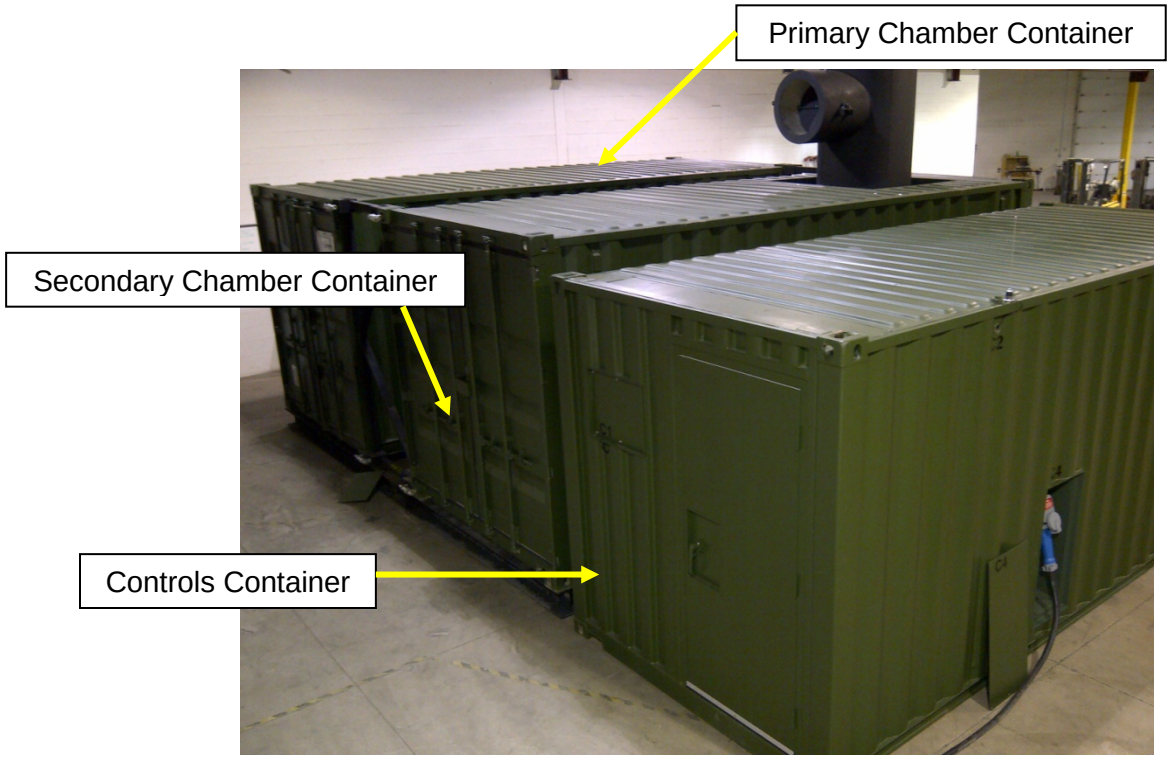


View of the EWS Mobile Incinerator Containers for reference only
(Left to right: Container 3 - Controls Container, Container 2 - Secondary Chamber Container, Container 1 - Primary Chamber Container, Container 4 – Waste Storage Container (to be attached to the front of container 1))



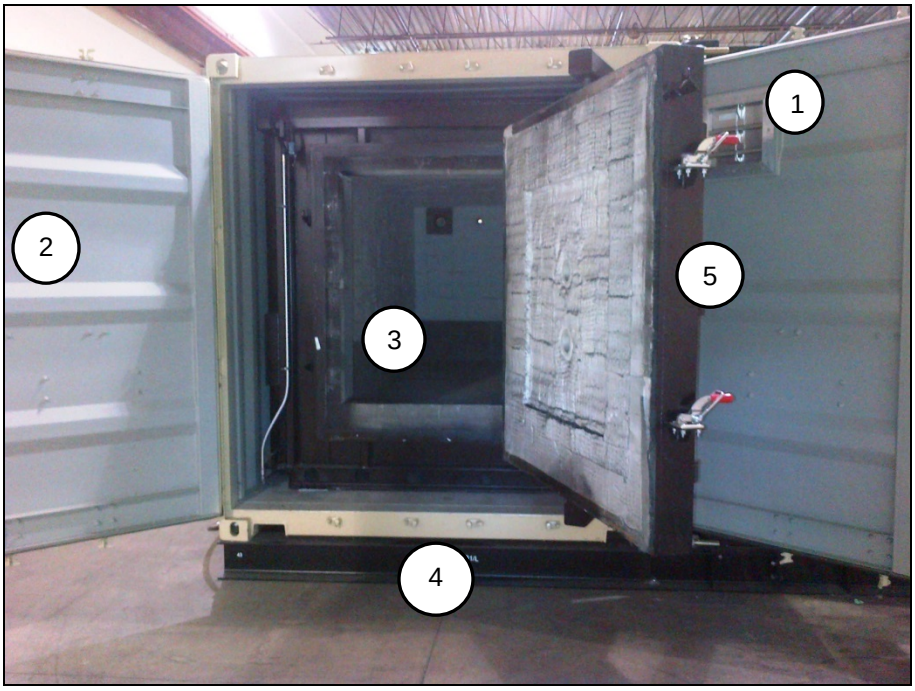
Front View (sample picture)

ECO WASTE SOLUTIONS



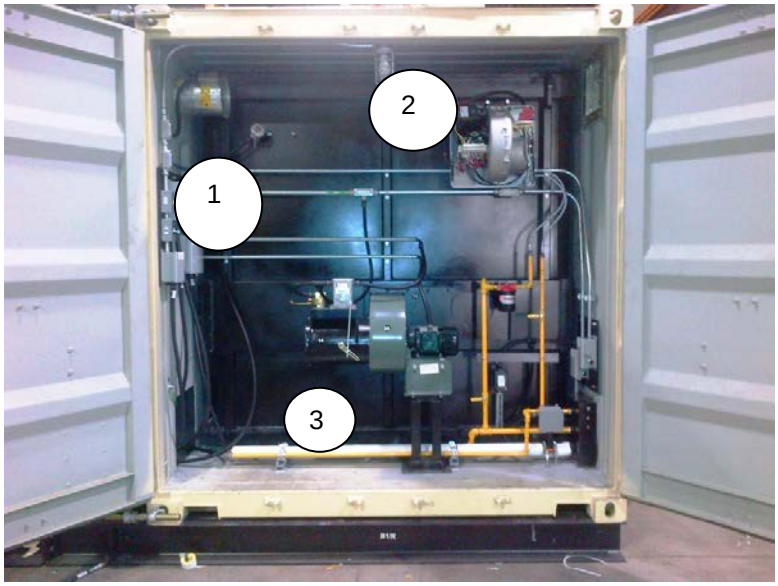
Rear View (sample picture)

ECO M Model Incinerator Primary Chamber Front View



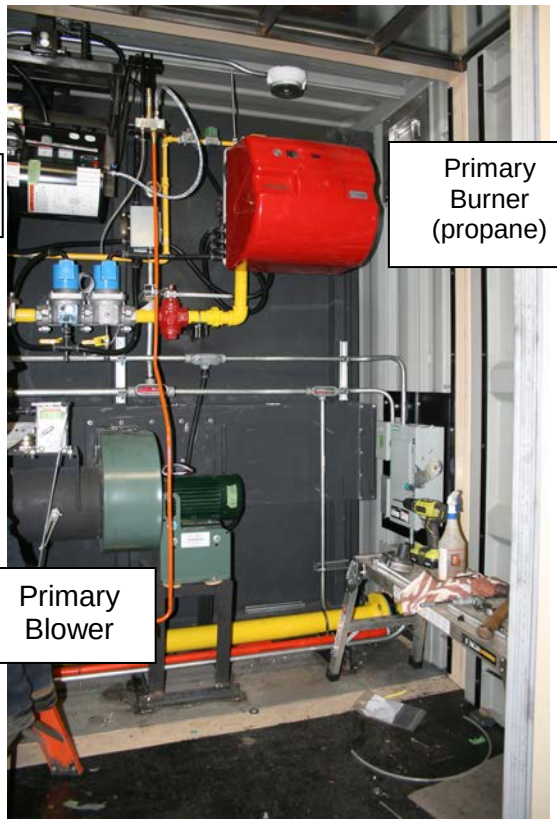
1. Louver
2. Container door
3. Opening for loading
4. Base frame
5. Toggle clamps

ECO M Model Incinerator Primary Chamber Rear View



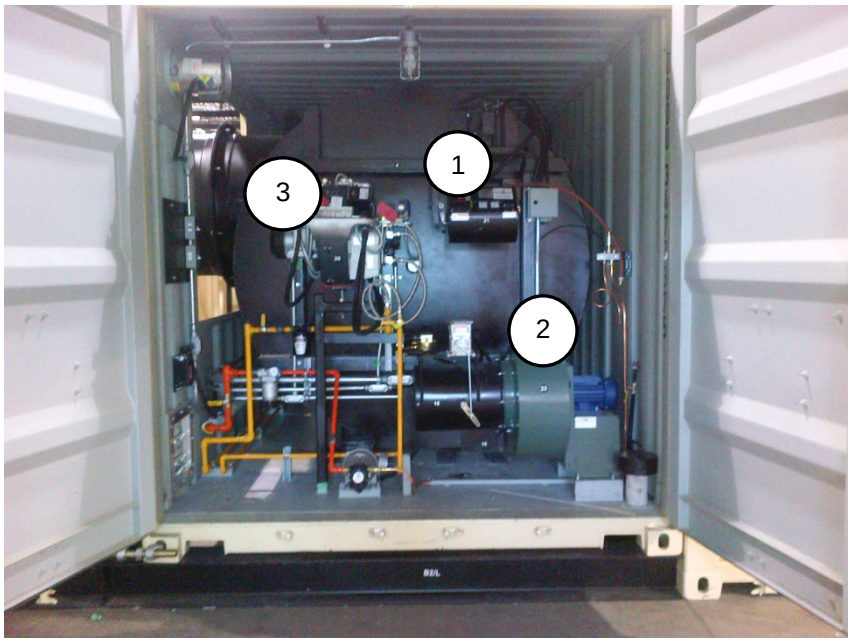
1. Thermocouple
2. Burner
3. Primary Chamber Blower/Cooling Fan

Sample picture



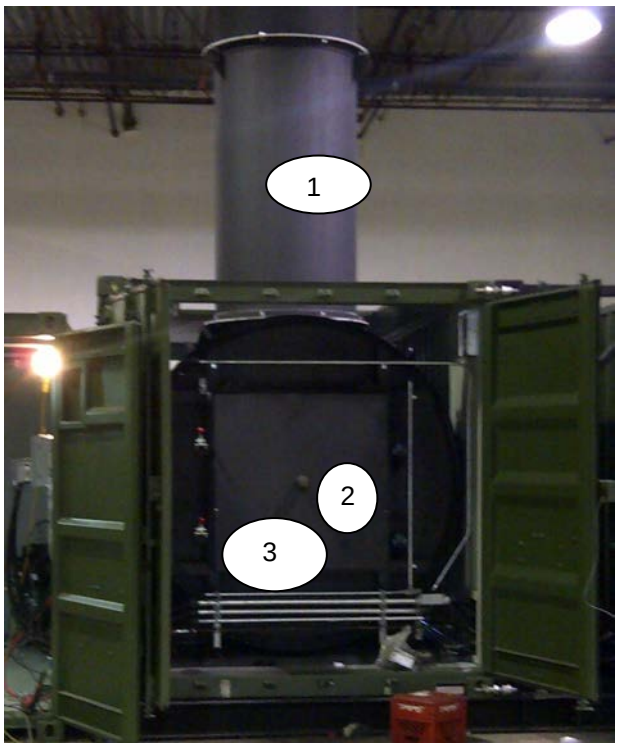
Actual Eco M2TN

ECO M Model Incinerator Secondary Chamber Front View



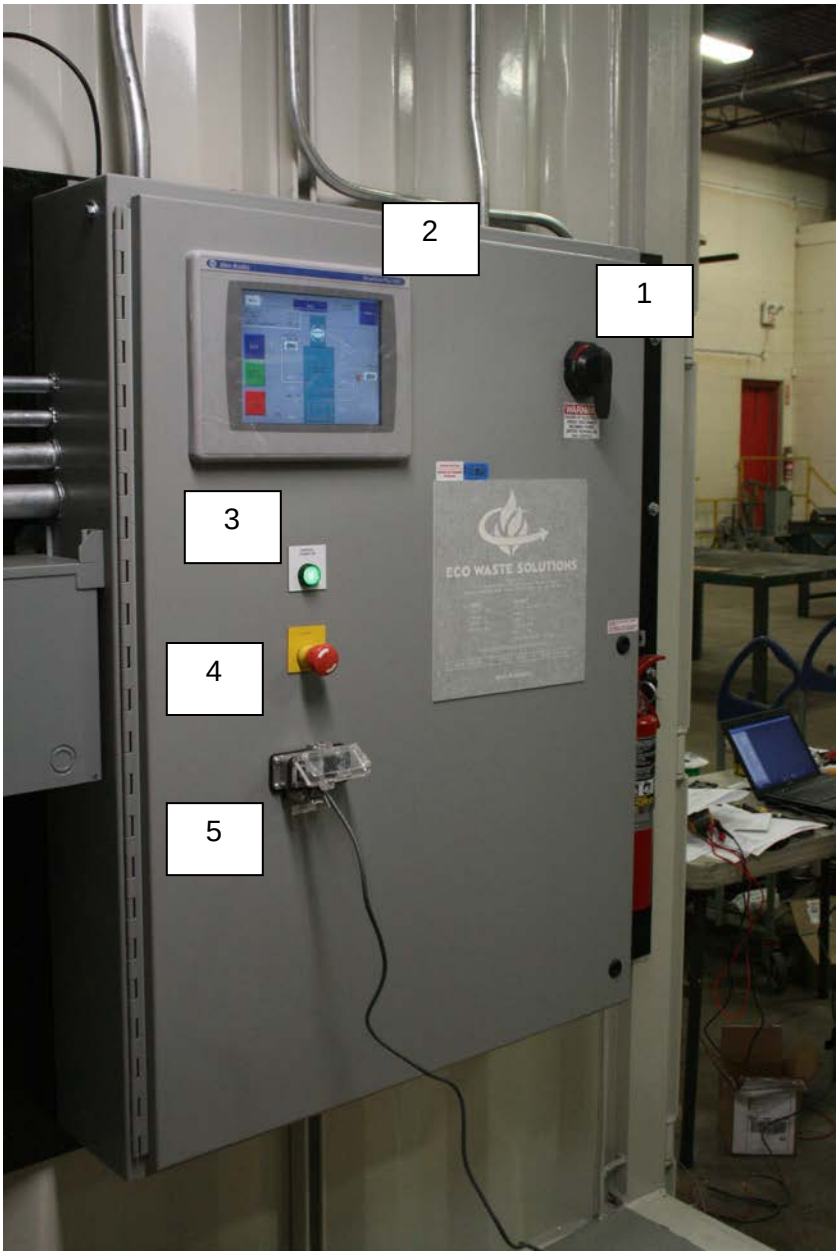
1. Waste Oil Burner
2. Secondary Chamber Blower/Fan
3. Secondary Chamber Burner (Propane-fired)

ECO M Secondary Chamber Rear View



1. Stack
2. Secondary Chamber View Port
3. Secondary Chamber Access Door

Main Control Panel



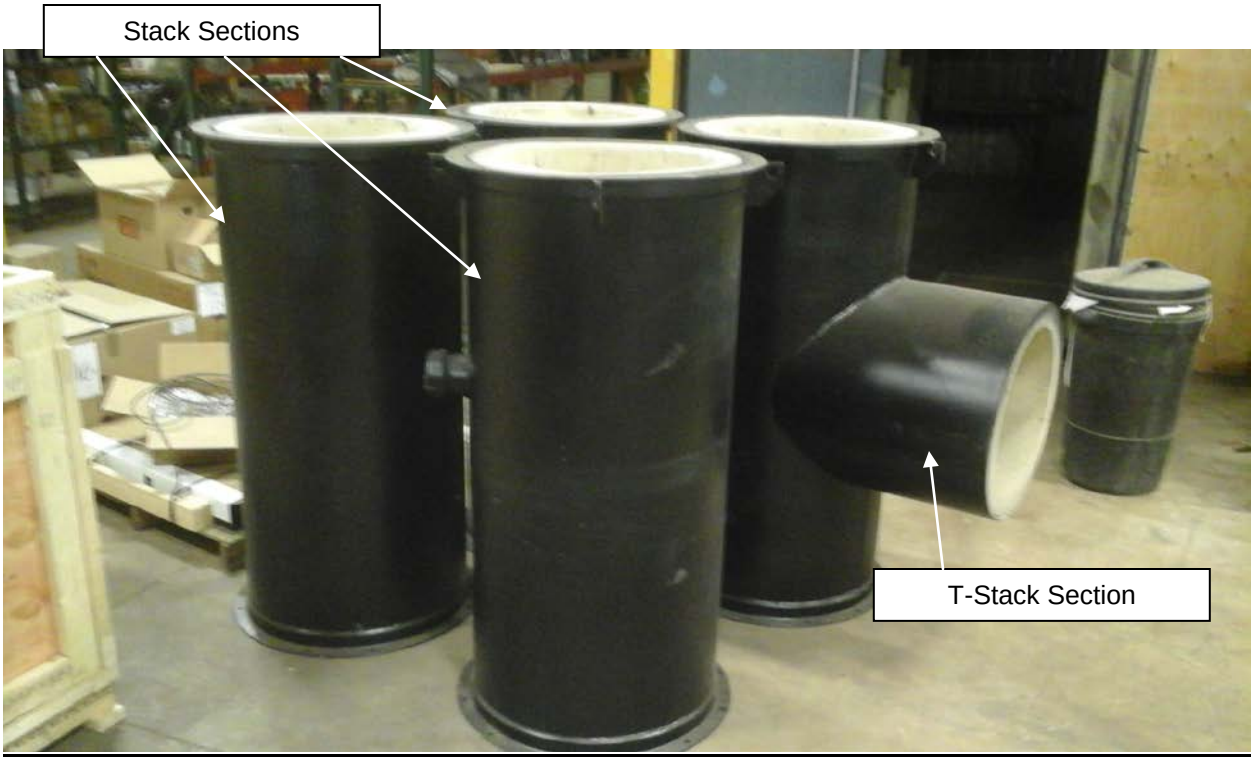
Main Control Panel (as built)

1. **Main Disconnect Switch**
2. **HMI**
3. **Control Power ON**
4. **Emergency Stop Push Button**
5. **USB Port**

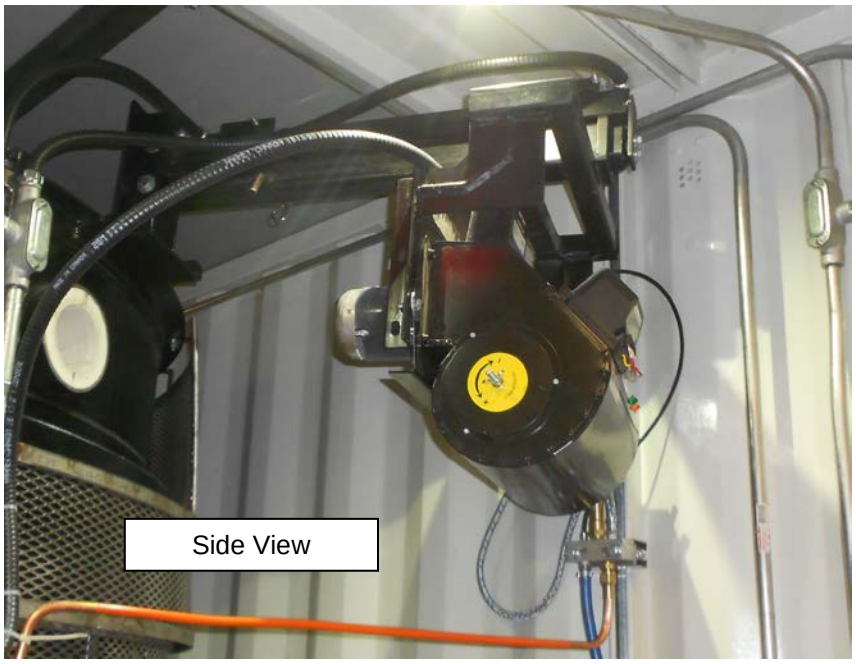
Thermocouple, Viewport and Limit Switch

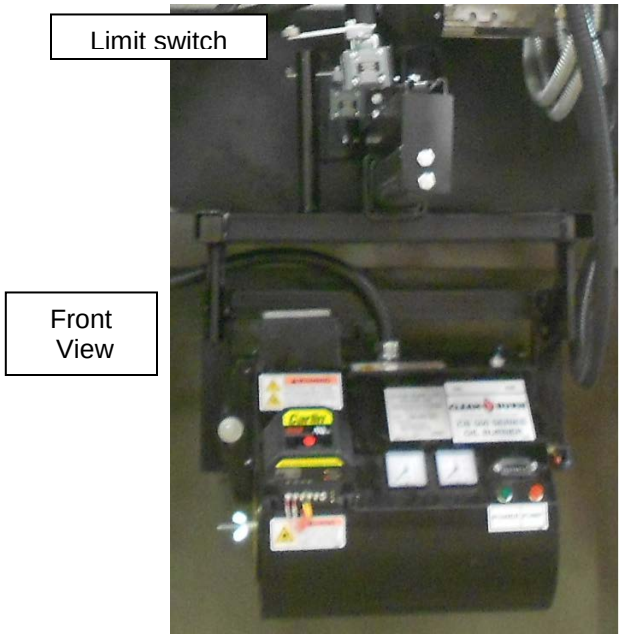
Note: These are sample photos

T-Stack and Stack Sections



Waste Oil Burner





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SECTION 4

INDEX OF DRAWINGS

ECO M2TNWO

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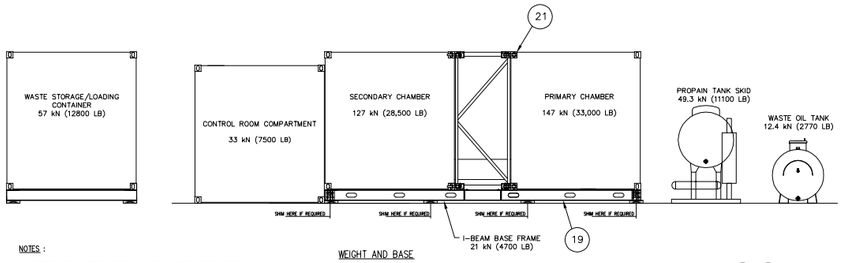


WEIGHT AND BASE

NOTES :

1. SUPPORT FRAME CONTINUOUSLY ON FIRMLY COMPACTED DENSE GRANULAR PAD.
2. TIMBER BLOCKING MAY BE REQUIRED ON SOFT SURFACE.
3. IF REQUIRED, PLACE SOLID SHIMS WHERE SHOWN, FRAME TO BE LEVEL WITHIN ±5 mm BEFORE POSITIONING CONTAINERS.
4. SHIMS TO BE WOOD BLOCKS 50 X 250 X 300 LONG (2 X 10 X 12"), IN COMBINATION WITH PLYWOOD AS REQUIRED.
5. MAX. SHIM HEIGHT 100mm (4")
6. FOR RE-LEVELING, LIFT AT ALL SUPPORT ZONES TO PREVENT DISTORTION.
7. CUSTOMER TO LOCATE PROPANE TANK AND WASTE OIL TANK ACCORDING TO LOCAL CODES.

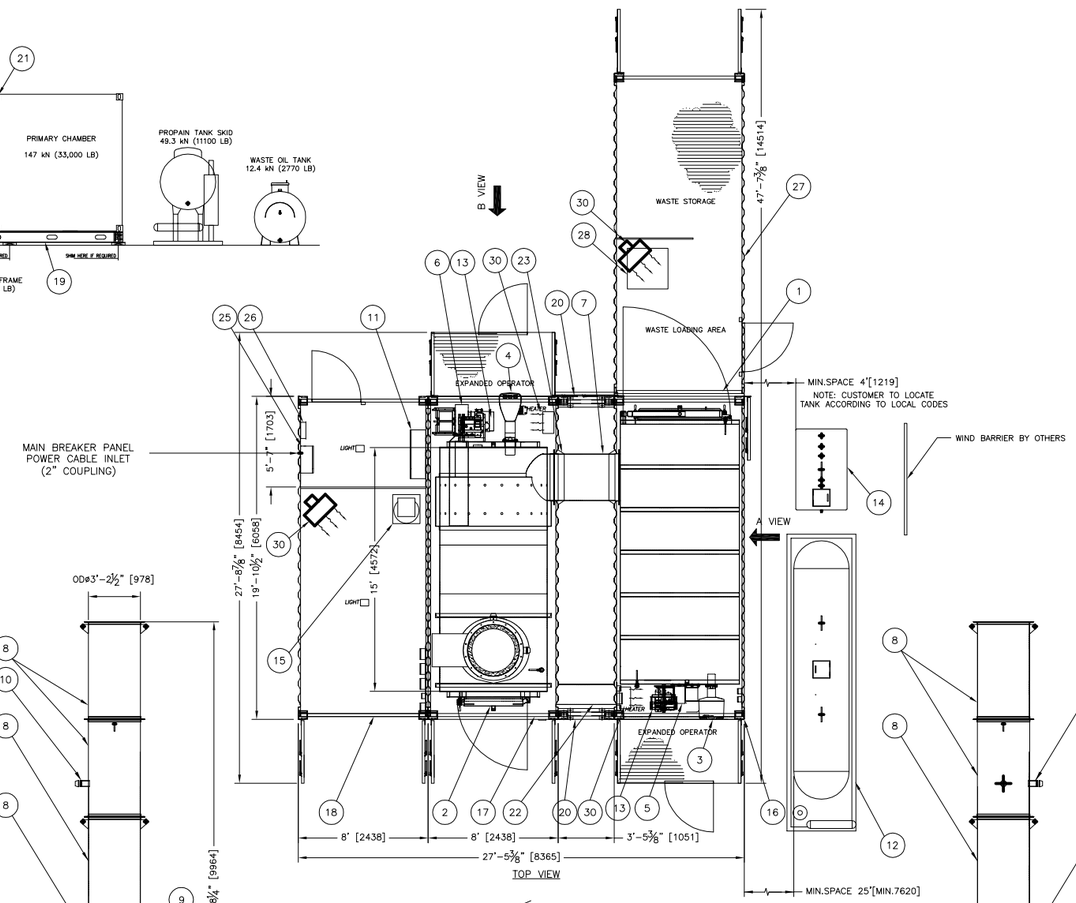
Equipment Design Assumptions

Waste Type	Waste Processing Capacity	Total Moisture Content	Average Density	Average Heat Value
Mixed Solid Camp Waste material	2000 kg/batch 4410 lb/hour	Up to 35%	192 kg/m³ 12 lbs/ft³	13 MJ/kg 5600 BTU/lb

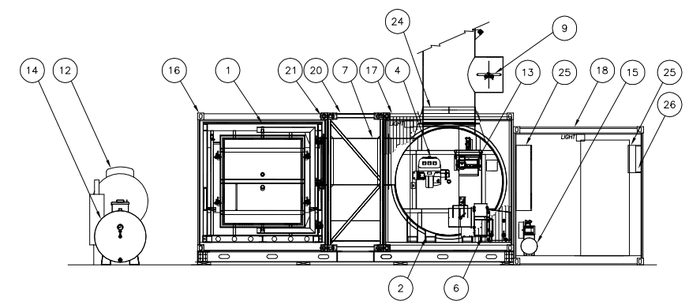
PROPRIETARY INFORMATION

BILL OF MATERIAL

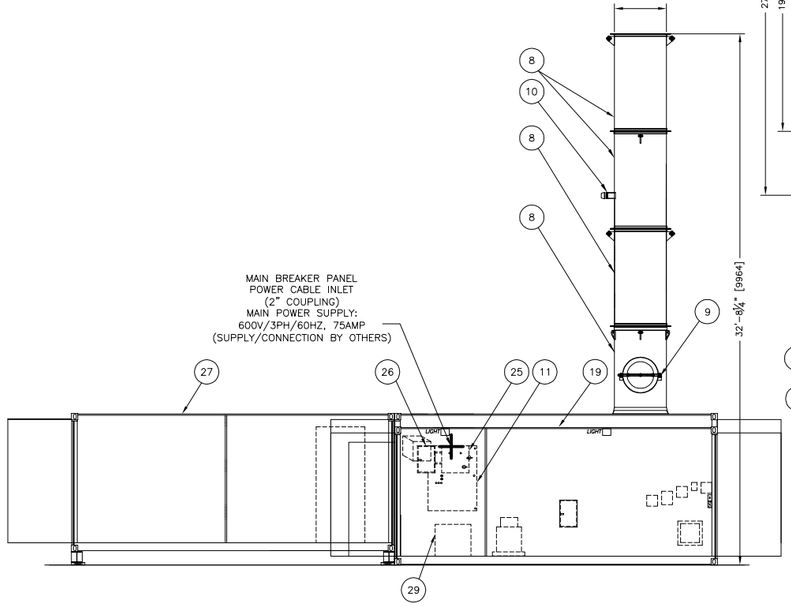
ITM.	QTY.	DESCRIPTION
1	1	PRIMARY CHAMBER
2	1	SECONDARY CHAMBER
3	1	PRIMARY BURNER
4	1	SECONDARY BURNER
5	1	PRIMARY BLOWER ASSEMBLY
6	1	SECONDARY BLOWER ASSEMBLY
7	1	BREECH ASSEMBLY
8	4	STACK SECTIONS
9	1	BAROMETRIC DAMPER ASSEMBLY
10	2	AIR EMISSIONS TEST PORTS
11	1	MAIN CONTROL PANEL
12	1	PROPANE TANK SKID
13	2	WASTE OIL BURNER
14	1	WASTE OIL TANK
15	1	AIR COMPRESSOR
16	1	PRIMARY CHAMBER CONTAINER
17	1	SECONDARY CHAMBER CONTAINER
18	1	CONTROL PANEL CONTAINER
19	1	I-BEAM BASE FRAME ASSEMBLY
20	2	CONTAINER SPACER
21	8	UNIVERSAL BRIDGE CLAMP
22	1	UTILITY CONDUIT (PRIMARY CONTAINER TO SECONDARY CONTAINER)
23	4	BREECH STORM COLLAR
24	2	STACK FLASHING (C/W STORM COLLARS)
25	1	MAIN DISCONNECT
26	1	AUXILIARY POWER BREAKER PANEL
27	1	WASTE STORAGE AND LOADING AREA
28	1	WEIGHT SCALE
29	1	TRANSFORMER
30	4	SPACE HEATER



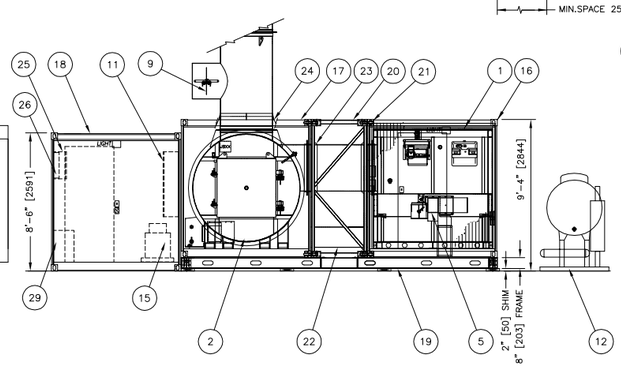
TOP VIEW



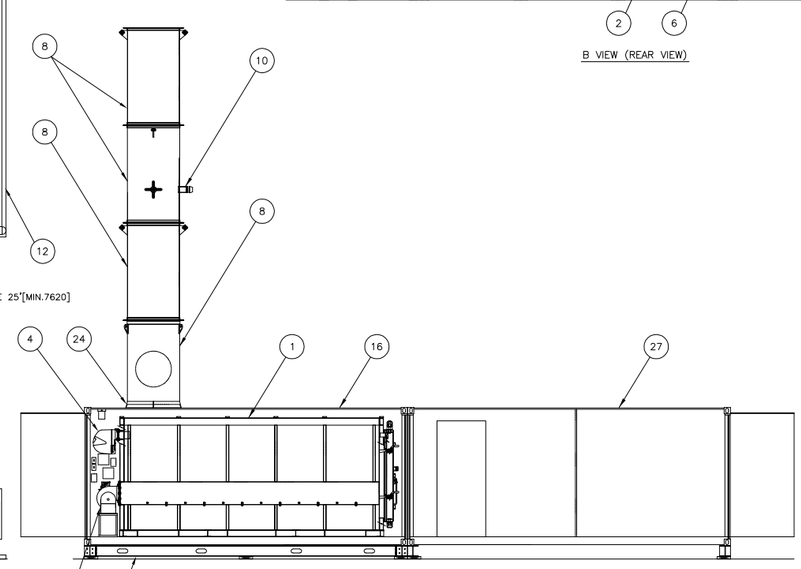
B VIEW (REAR VIEW)



LEFT ELEVATION VIEW



ELEVATION VIEW



A VIEW (RIGHT ELEVATION)

SUPPLIER DOC. NUMBER: BRJ-ELD-ECOM2TN

REV.	DATE	DESCRIPTION	BY	APPROVED
B	11/23/2015	ADDED TWO OPERATING ROOMS	–	

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DRAWN: J.X. DATE: MAY-06-2015
CHECKED: KD DATE: MAY-08-2015

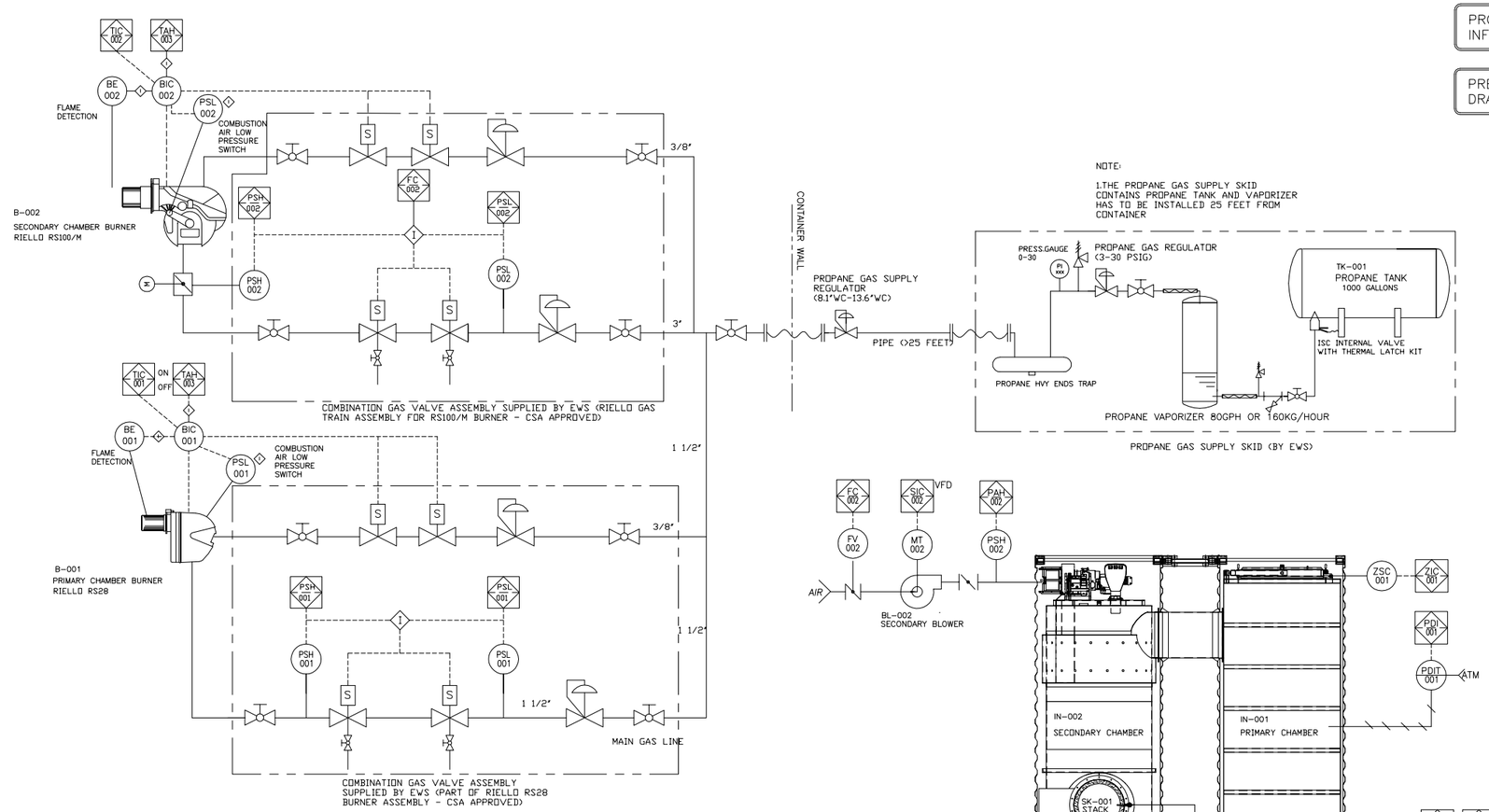
ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-P6040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001
SCALE: 1:45
JOB NO. 15-2MS
TITLE: GENERAL ARRANGEMENT ECO M2TNWO MOBILE
P.1_OF_1
THIRD ANGLE
DWG. NO. ECO M2TNWO-00
REV. B

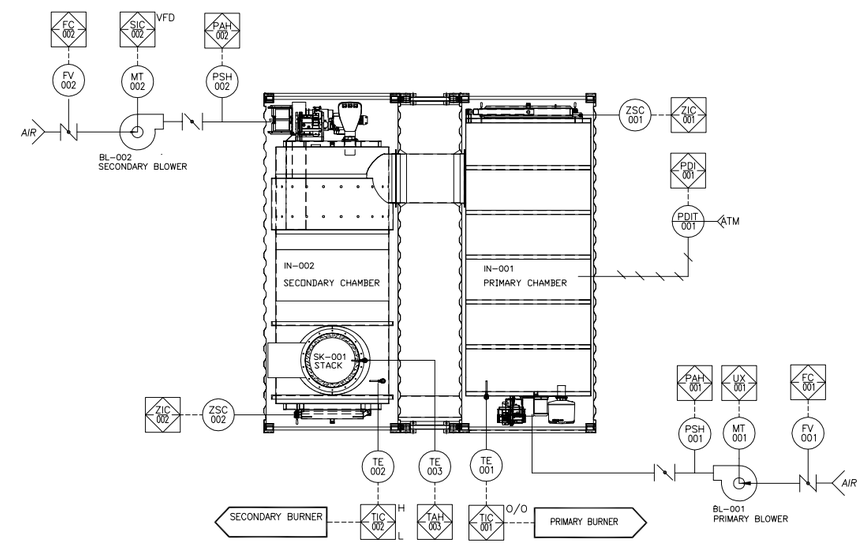
BLK ID.	SYMBOL & DESCRIPTION		BLK ID.	SYMBOL & DESCRIPTION	
EBLWS001	SUPPLY PIPING		EBLWS025	BALL VALVE	
EBLWS002	AIR PIPING		EBLWS026	CHECK VALVE	
EBLWS003	FLEX PIPING		EBLWS027	FUEL FILTER	
EBLWS004	UNION		EBLWS028	PUMP	
EBLWS005	PLC I/O		EBLWS029	IMMERSION HEATER	
EBLWS006	ZS	LIMIT SWITCH	EBLWS016	UX	MULTIVARIABLE CONVERT
EBLWS007	PSL	PRESSURE SWITCH LOW	EBLWS017	SIC	VFD
EBLWS008	MT	MOTOR	EBLWS018	PI	PRESSURE INDICATOR
EBLWS009	ZE	MODUTROL MOTOR	EBLWS019	ZY	SOLENOID COIL
EBLWS010	TIC	TEMPERATURE CONTROLLER	EBLWS020	BIC	BURNER INDICATING CONTROLLER
EBLWS011	LSL	LEVEL SWITCH LOW	EBLWS021	TAH	TEMPERATURE ALARM HIGH
EBLWS012	I	INTERLOCK	EBLWS022	PDI	PRESSURE DIFFERENCE INDICATOR
EBLWS013	TE	THERMOCOUPLE	EBLWS023	BE	FLAME DETECTION
EBLWS015	ZI	POSITION INDICATOR	EBLWS024	IS	ELECTRICAL SWITCH

PROPRIETARY INFORMATION

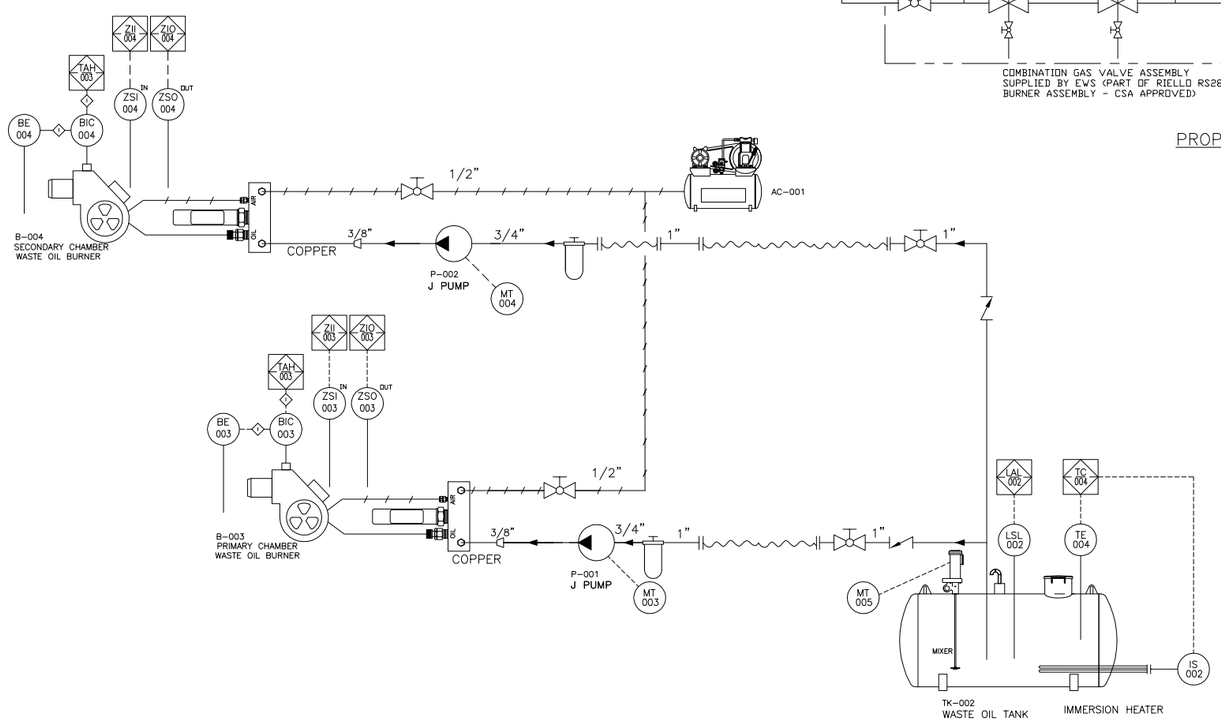
PRELIMINARY DRAWING



PROPANE GAS PIPING DIAGRAM



INCINERATOR INSTRUMENTATION DIAGRAM
TOP VIEW



WASTE OIL PIPING DIAGRAM

SUPPLIER DOC. NUMBER: BRJ-P&ID-ECOM2TN

REV.	DATE	DESCRIPTION	BY	APPROVED
A	-	-	-	-

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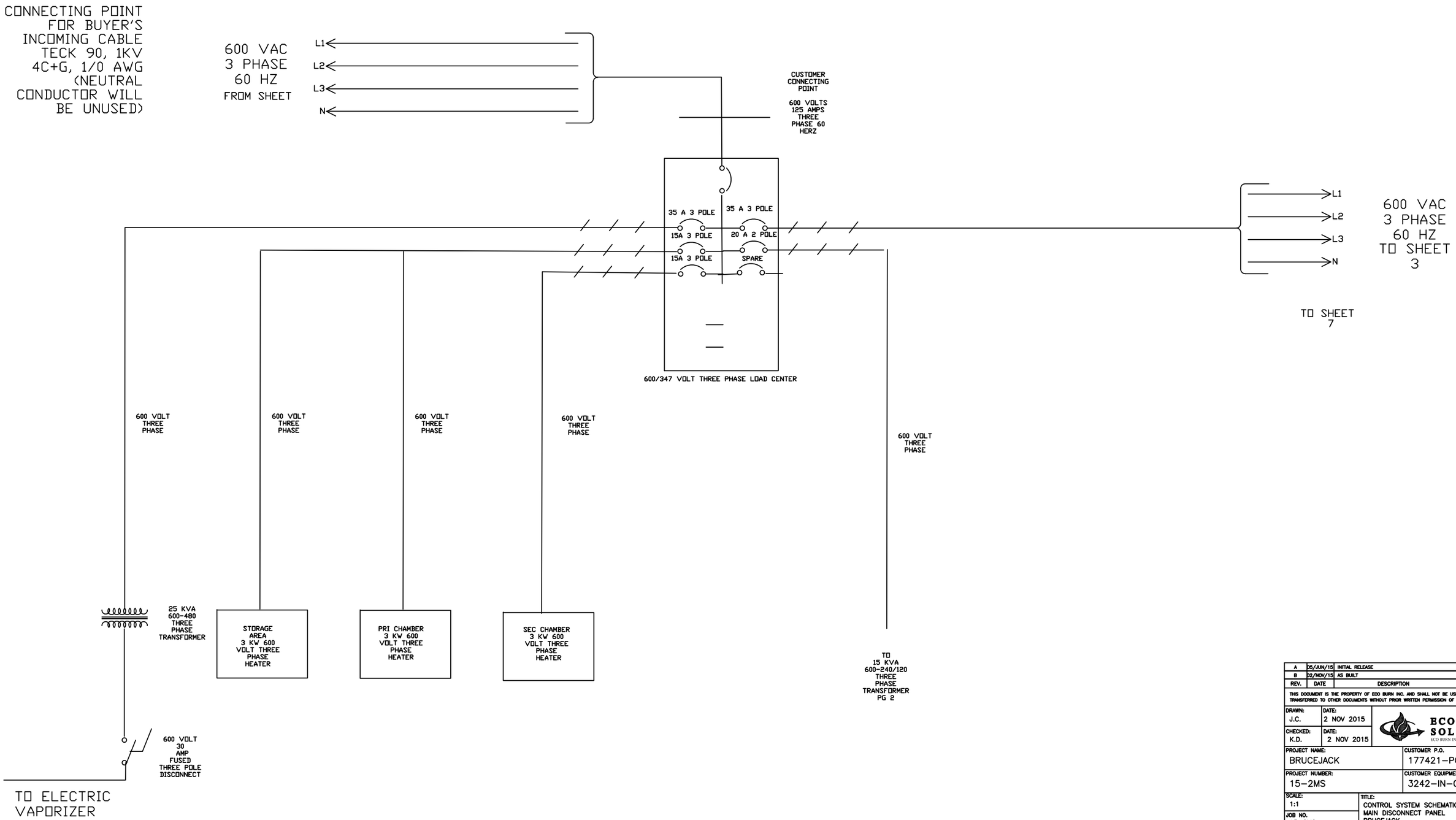
DRAWN: JX	DATE: 20-MAY-2015	ECO WASTE SOLUTIONS ECO BURN INC.
CHECKED: KD	DATE: 21-MAY-2015	
PROJECT NAME: BRUCEJACK		CUSTOMER P.O. 177421-P6040
PROJECT NUMBER: 15-2MS		CUSTOMER EQUIPMENT. # 3242-IN-001
SCALE: NONE	TITLE: PIPING & INSTRUMENTATION DIAGRAM ECO M2TN WO MOBILE	P.1_OF_1
JOB NO. 15-2MS		
THIRD ANGLE	DWG. NO. ECO M2TNWO-01	REV. A



REV.	DATE	DESCRIPTION	BY	APPROVED
A	05/JUN/15	INITIAL RELEASE	J.C.	K.D.
B	02/NOV/15	AS BUILT	JC	KD

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DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

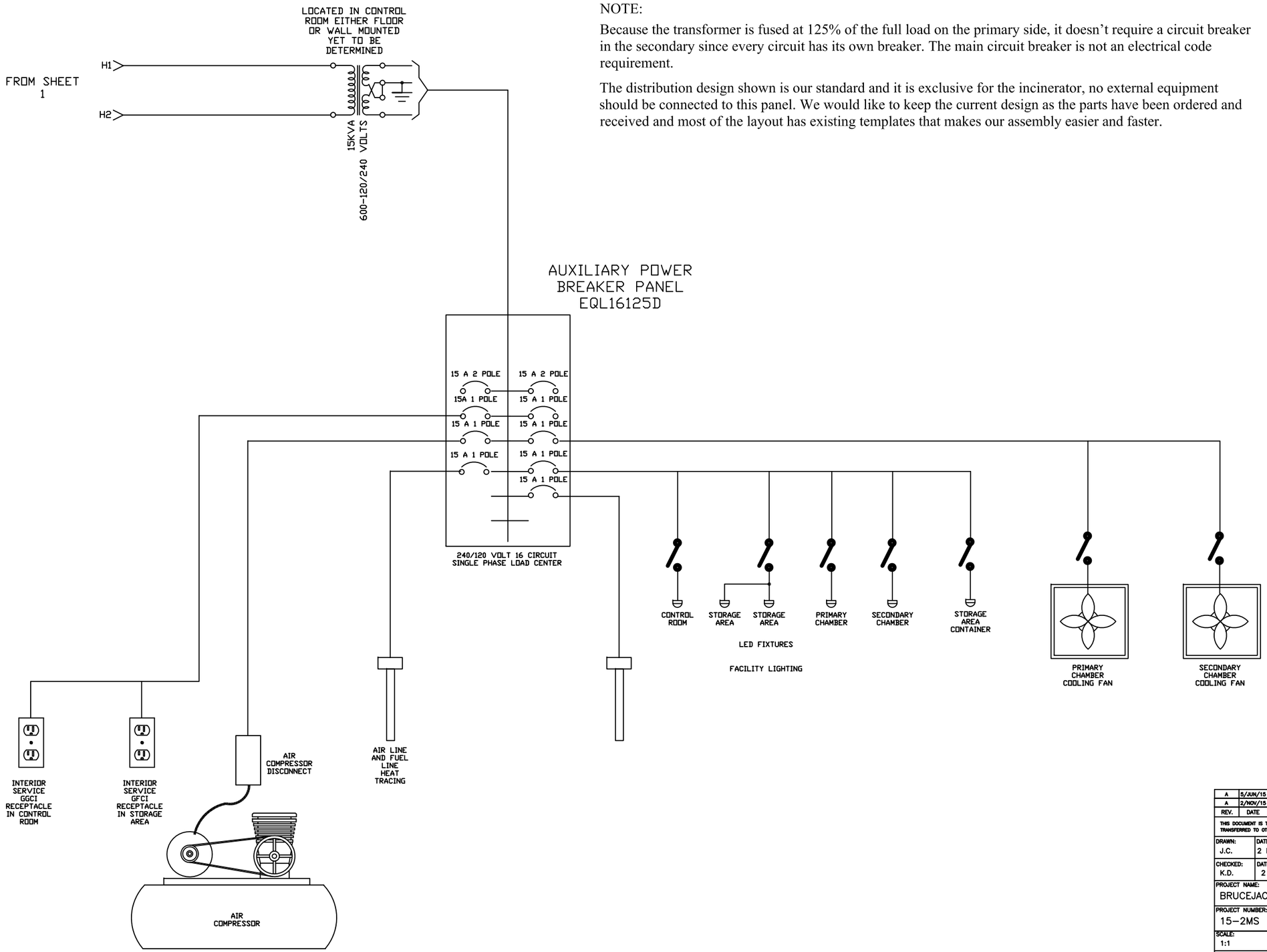
ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS MAIN DISCONNECT PANEL BRUCEJACK
SH 1 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-1
REV. B

NOTE:

Because the transformer is fused at 125% of the full load on the primary side, it doesn't require a circuit breaker in the secondary since every circuit has its own breaker. The main circuit breaker is not an electrical code requirement.

The distribution design shown is our standard and it is exclusive for the incinerator, no external equipment should be connected to this panel. We would like to keep the current design as the parts have been ordered and received and most of the layout has existing templates that makes our assembly easier and faster.



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
A	2/NOV/15	AS BUILT	JC	KD

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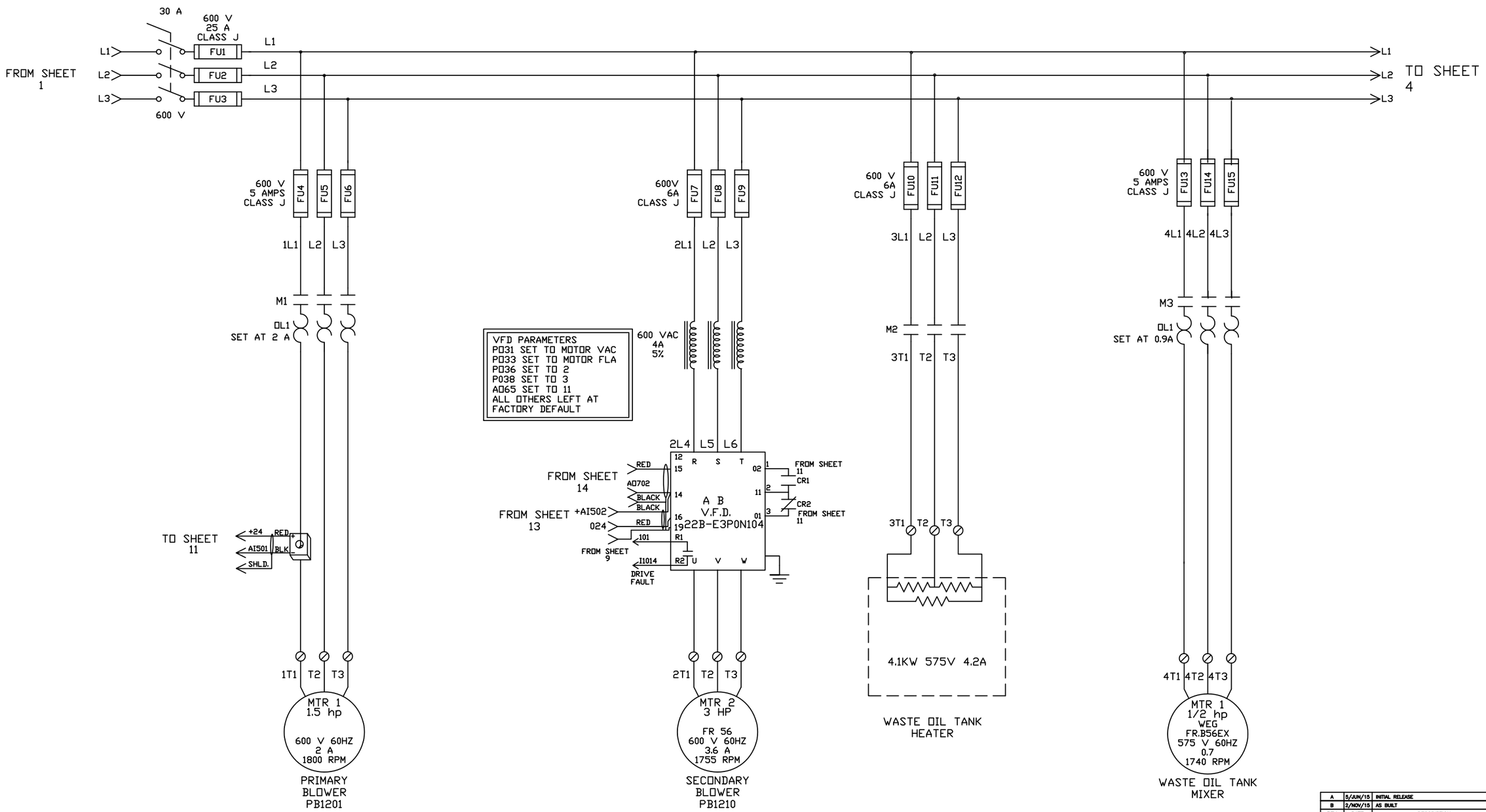
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: SINGLE LINE SCHEMATIC AUXILIARY POWER BRUCEJACK
SH 2 OF 13
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-2
REV. A



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
B	2/NOV/15	AS BUILT	JC	KD

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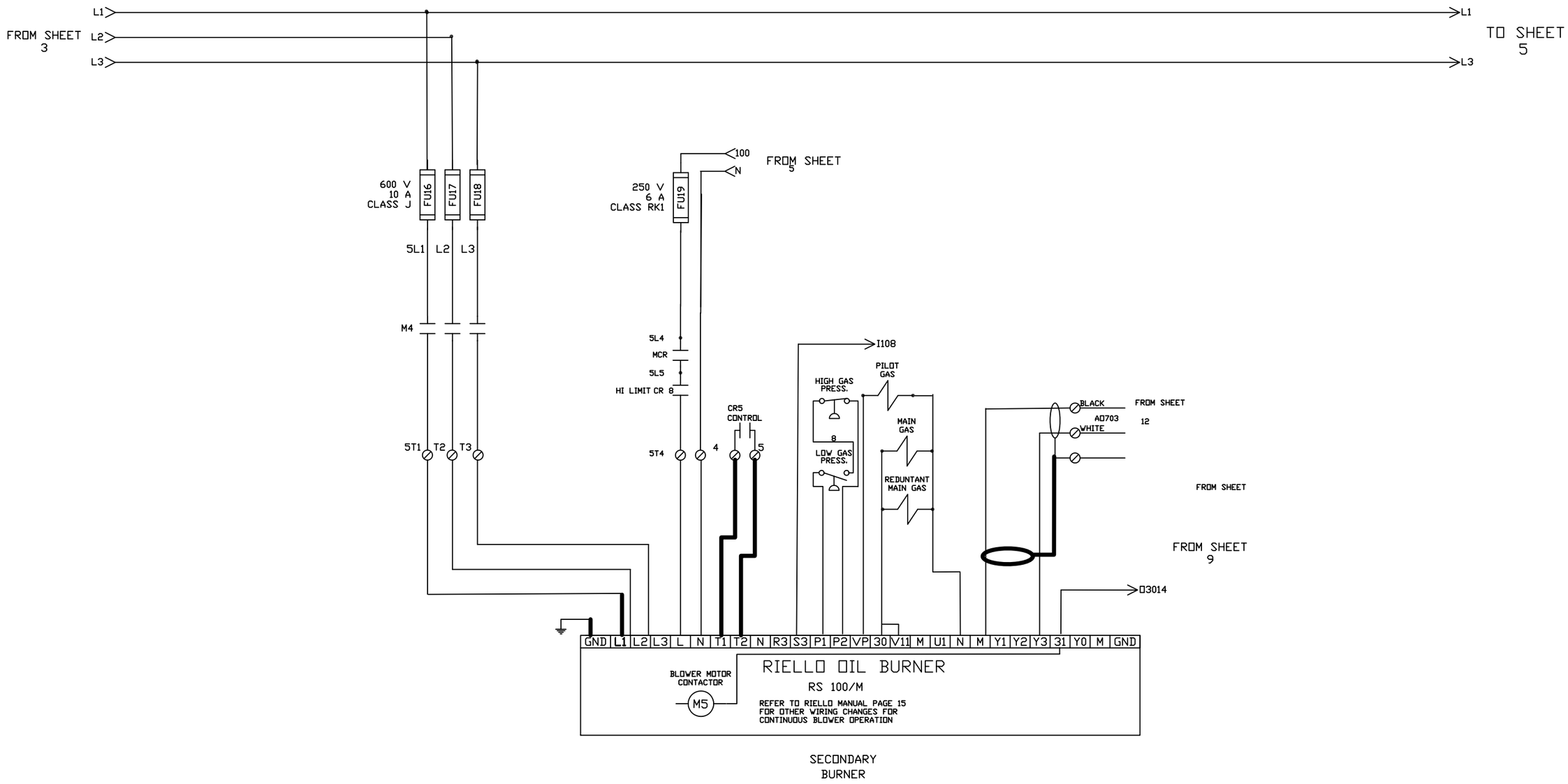
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS PRIMARY AND SECONDARY BLOWERS BRUCEJACK
SH. 3 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-3
REV. B



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
B	2/NOV/15	INITIAL RELEASE	JC	KD

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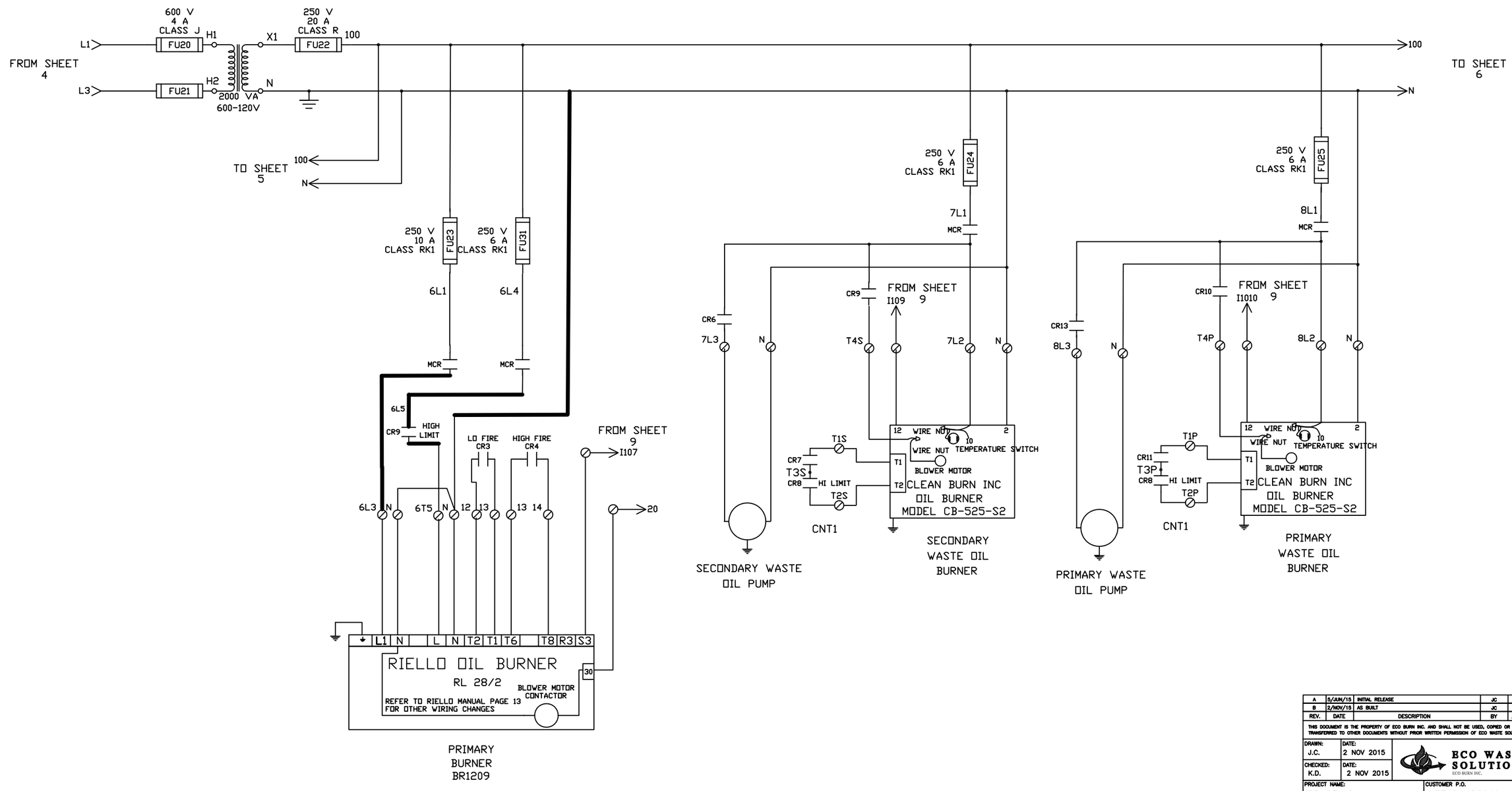
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS SECONDARY BURNER BRUCEJACK
SH 4 OF 13
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-4
REV. B



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
B	2/NOV/15	AS BUILT	JC	KM

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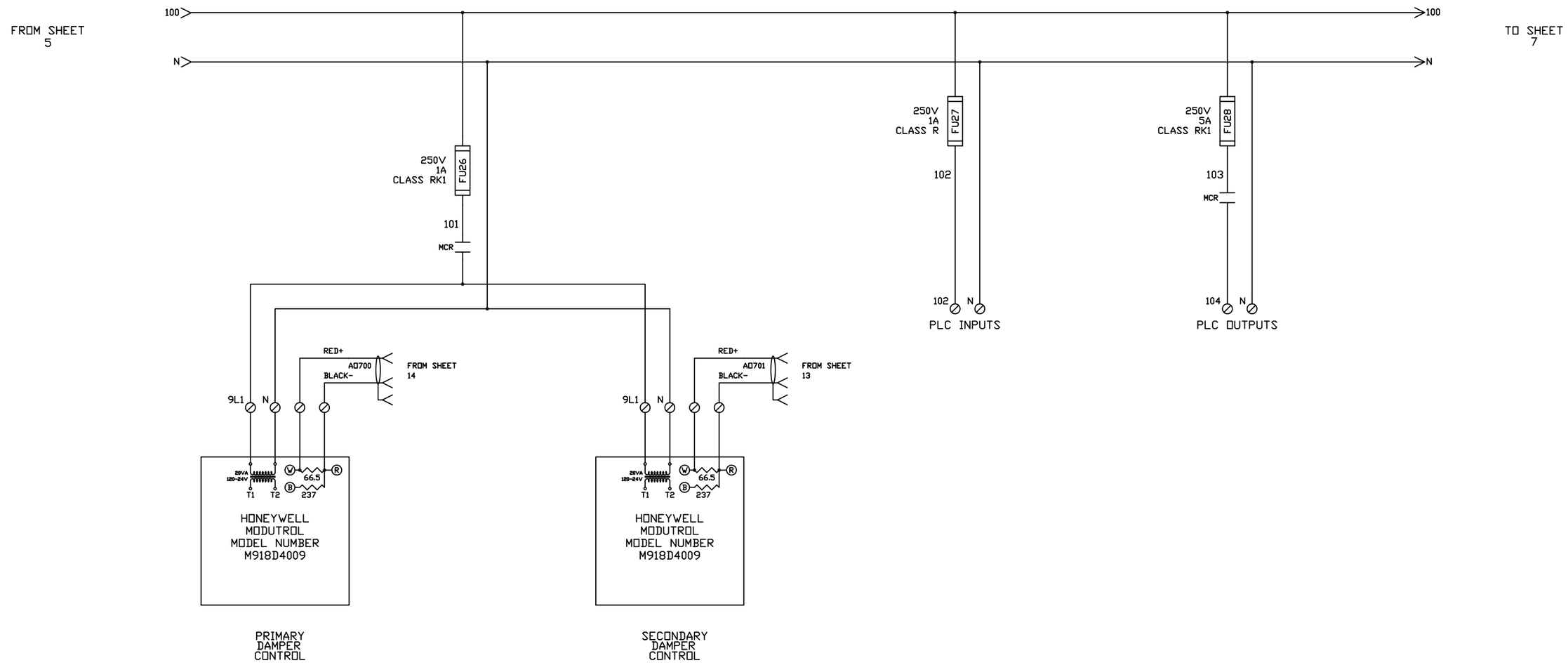
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS PRIMARY AND WASTE OIL BURNERS BRUCEJACK
SH 5 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-5
REV. B



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
B	2/NOV/15	AS BUILT	JC	KD

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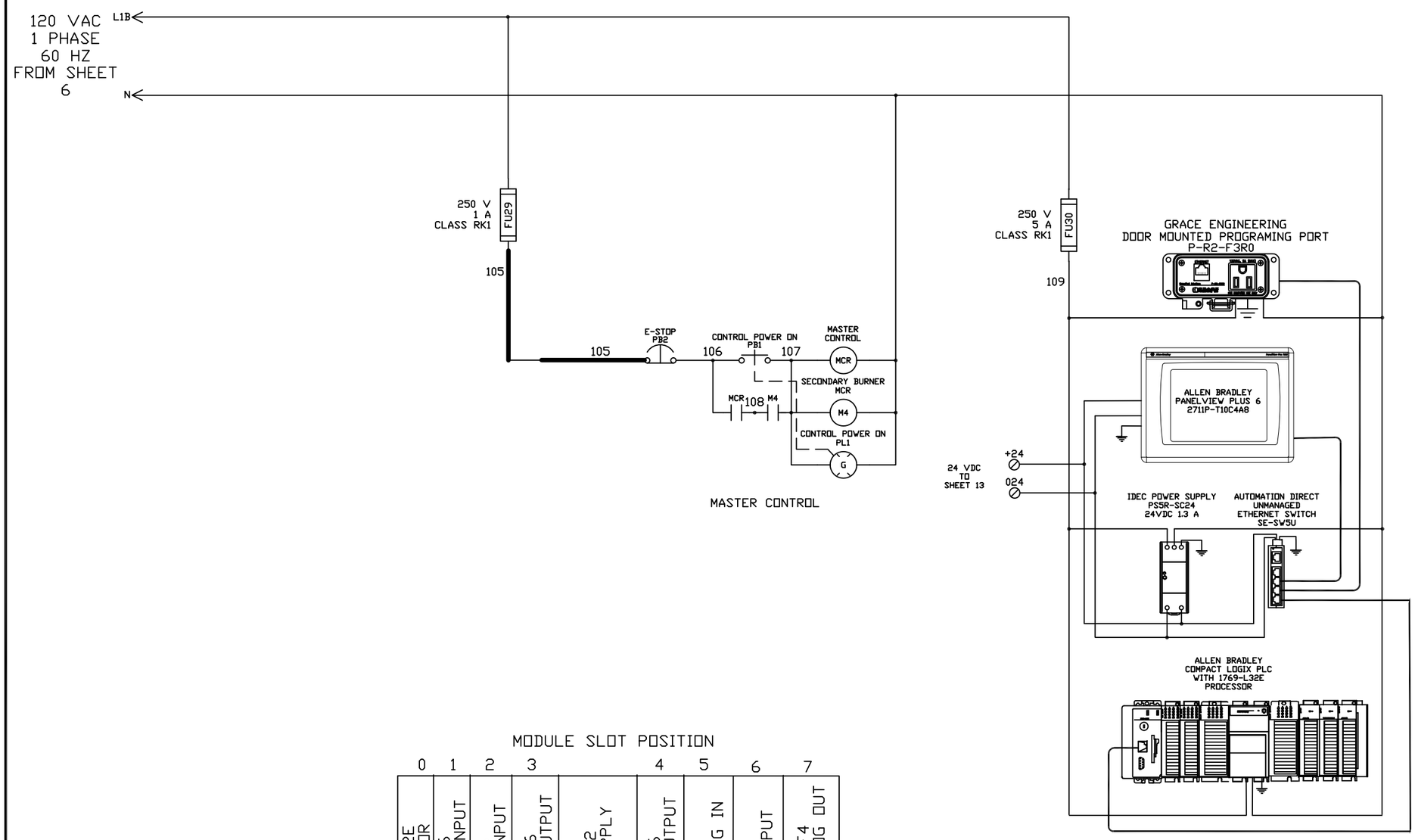
DRAWN: J.C. DATE: 5 JUN 2015
CHECKED: K.D. DATE: 5 JUN 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS DAMPERS BRUCEJACK
SH. 6 OF 13
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-6
REV. A



MODULE SLOT POSITION

0	1	2	3		4	5	6	7
1769-L32E PROCESSOR	1769-IA16 16 PT. AC INPUT	1769-IA16 16 PT. AC INPUT	1769-OA16 16 PT AC OUTPUT	1769-PA2 POWER SUPPLY	1769-OA16 16 PT AC OUTPUT	1769-IF4 4 CH. ANALOG IN	1769-IT6 6 CH. TC INPUT	1769-OF4 4 CH. ANALOG OUT

REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
B	2/NOV/15	AS BUILT	JC	KD

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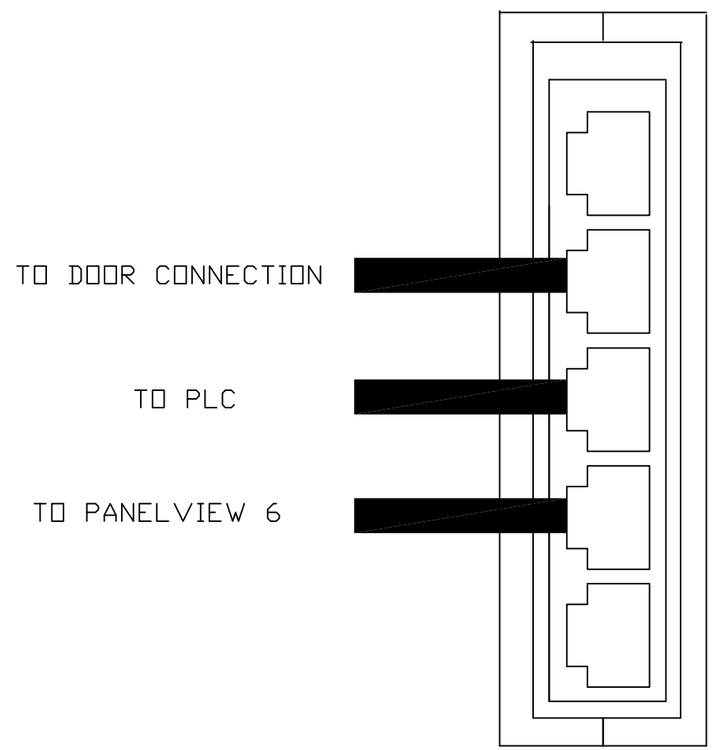
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS MCR, PLC AND HMI BRUCEJACK
SH 7 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-7
REV. B

UNMANAGED ETHERNET
SWITCH
SE-SW5U



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/JUN/15	INITIAL RELEASE	JC	KD
B	2/NOV/15	AS BUILT	JC	KD

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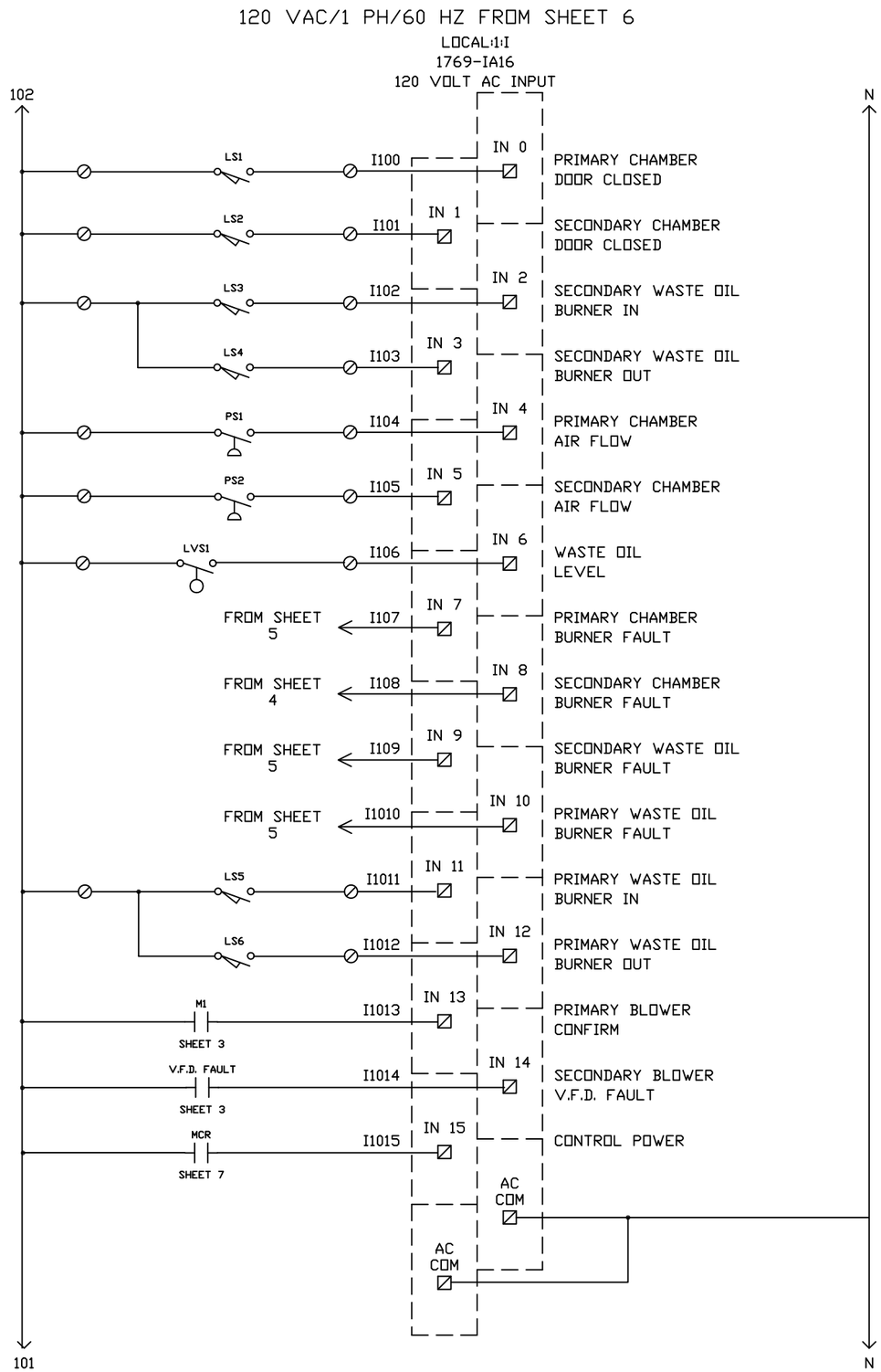
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS
PLC DIGITAL INPUTS
BRUCEJACK
SH 8 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-8
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/6/2015	INITAL RELEASE	JC	KD
B	2/11/2015	AS BUILT	JC	KD

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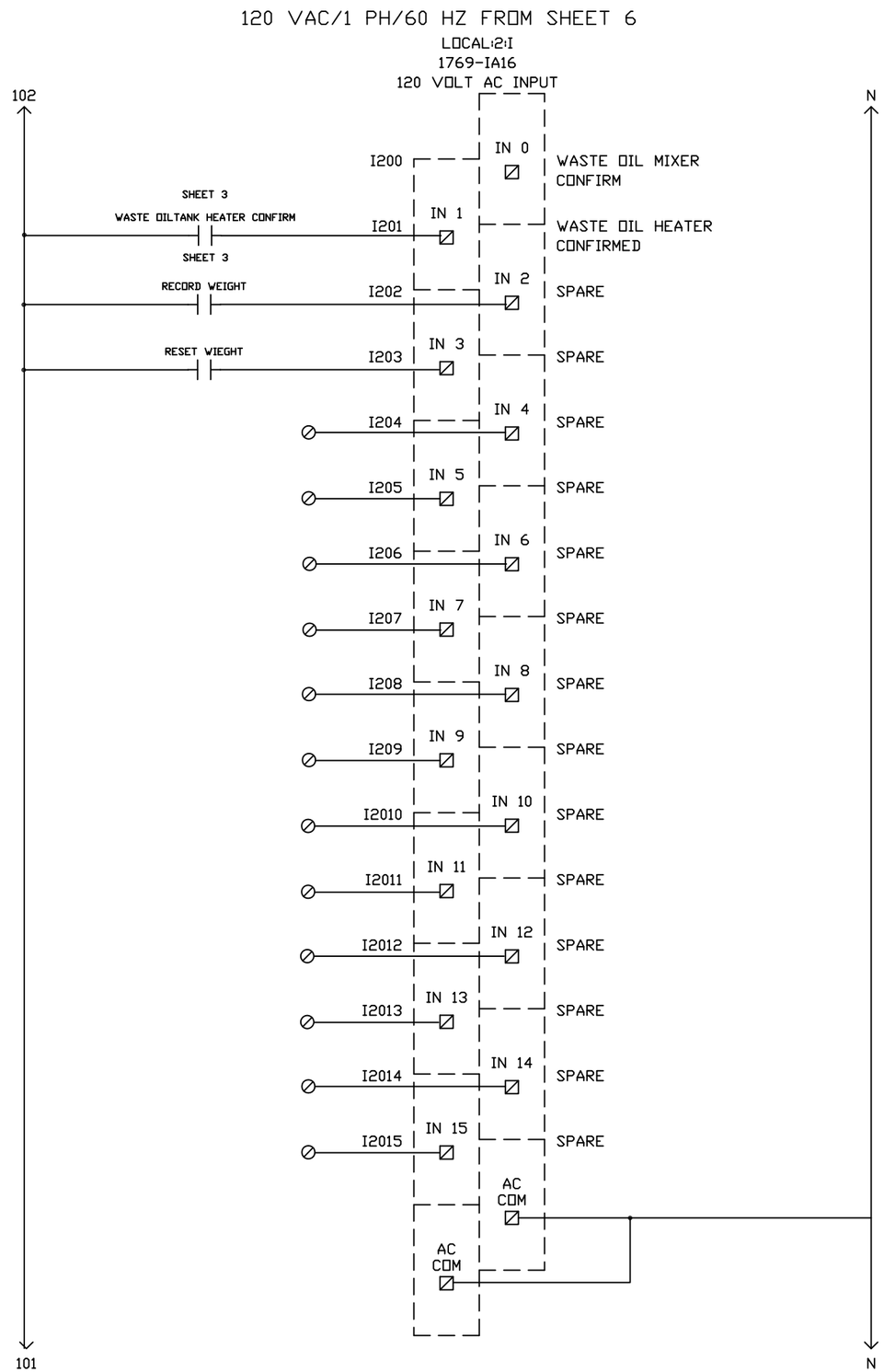
DRAWN: J.C> DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS PLC DIGITAL INPUTS BRUCEJACK
SH 9 OF 15
THIRD ANGLE
DWG. NO. ECO-M2TN1PWO-10A-9
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/6/2015	INITIAL RELEASE	JC	KD
B	5/11/2015	AS BUILT	JC	KD

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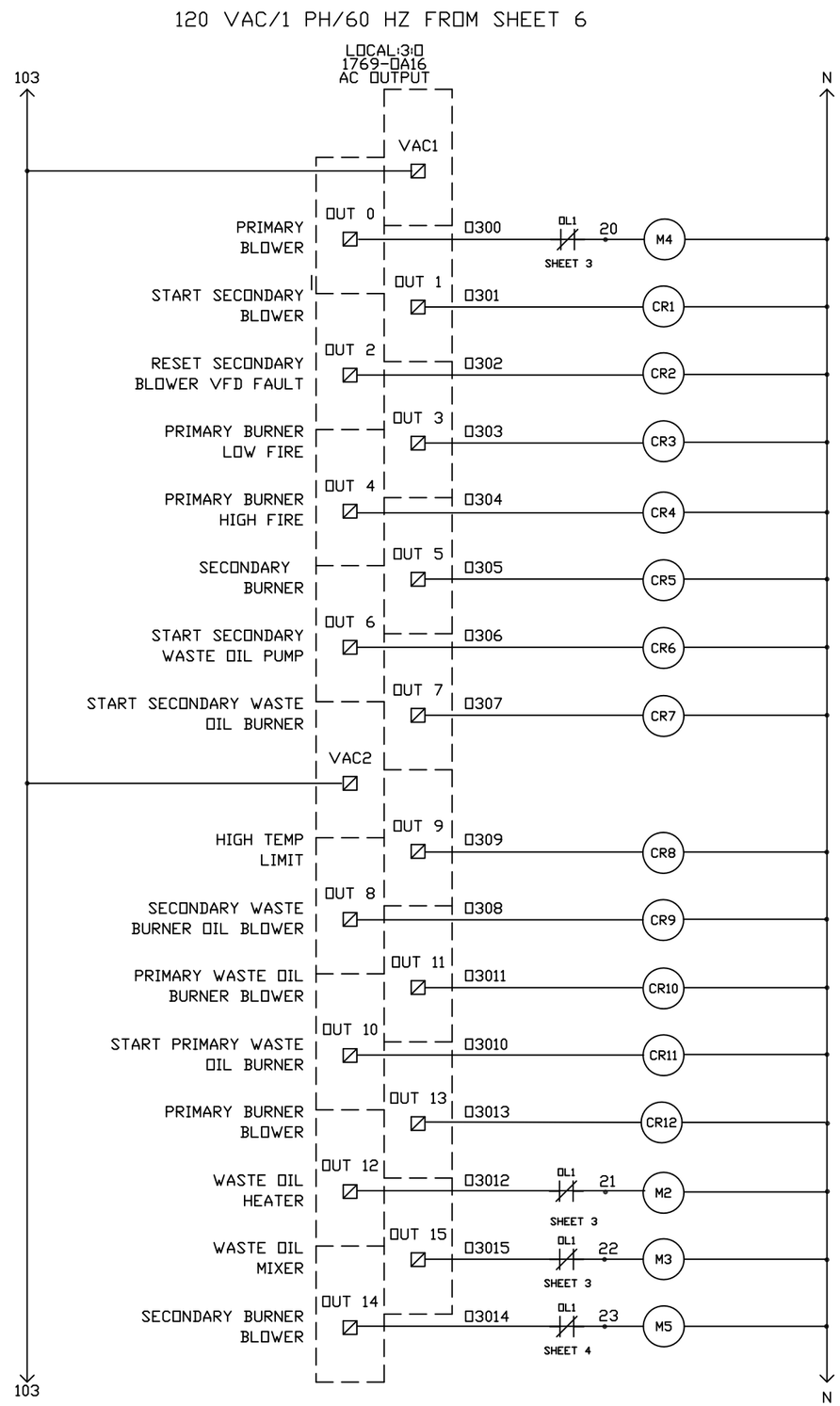
DRAWN: J.C> DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO

SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS
PLC DIGITAL INPUTS
BRUCEJACK
SH 10 OF 14
THIRD ANGLE
DWG. NO. ECO-M2TN1PWO-10A-10
REV. A



REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/8/15	INITIAL RELEASE	JC	KD
B	5/11/15	AS BUILT	JC	KD

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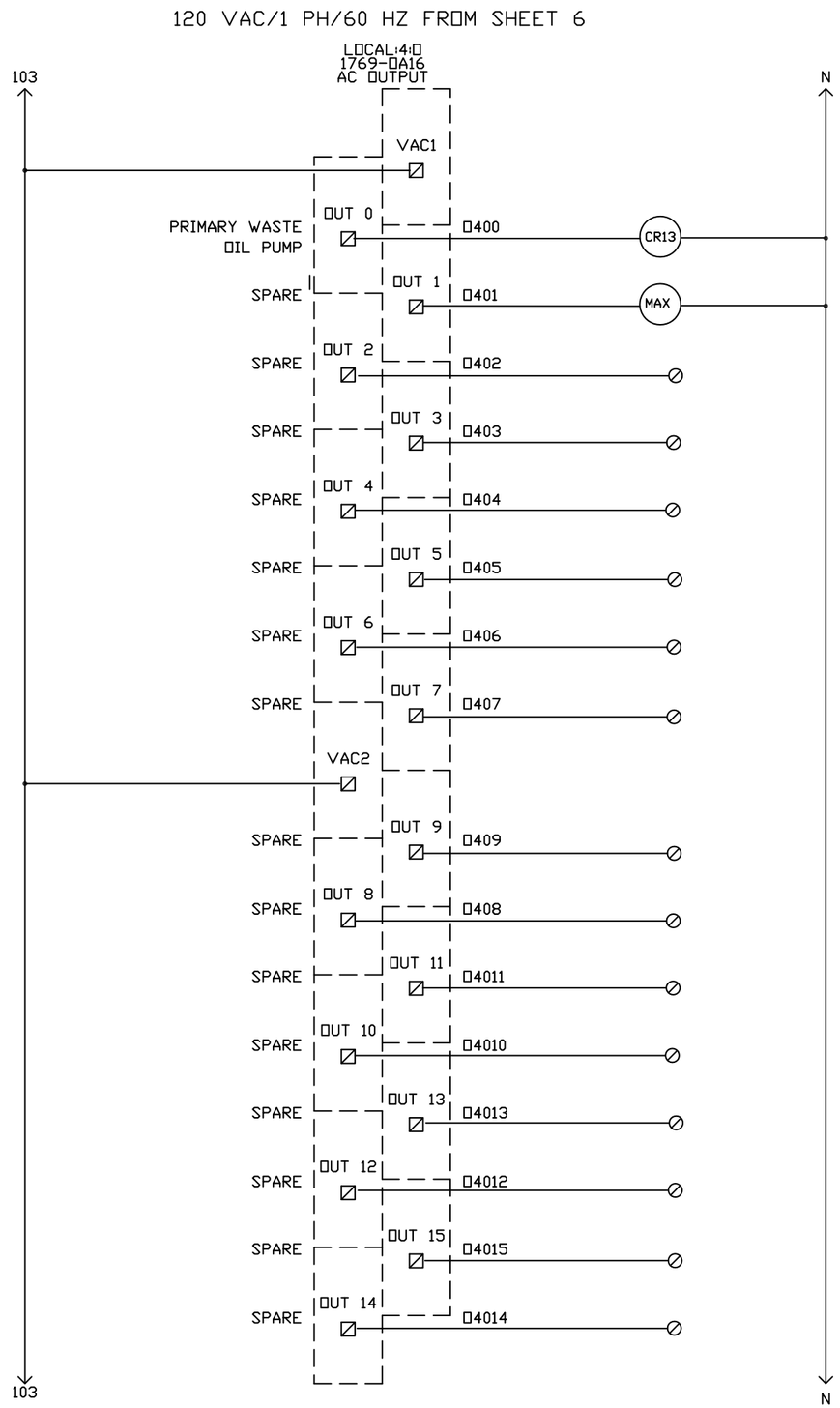
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: 15-2MS
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: BRUCEJACK
CUSTOMER EQUIPMENT # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 13-2MS
TITLE: CONTROL SYSTEM SCHEMATICS
PLC DIGITAL OUTPUTS
BRUCEJACK
SH 11 OF 14
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-11
REV. B



REV.	DATE	DESCRIPTION	BY	APPROVED
A	3/6/15	INITIAL RELEASE	JC	KD
B	2/11/15	INITIAL RELEASE	JC	KD

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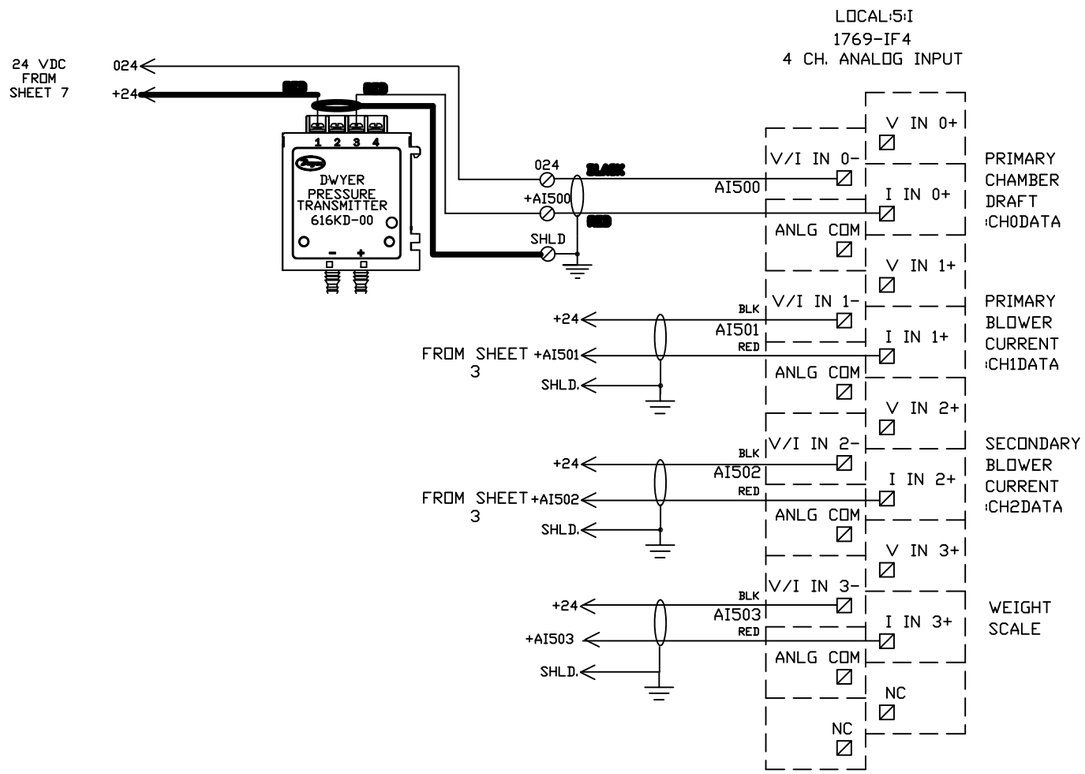
DRAWN: J.C. DATE: 2 NOV 2015
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: 15-2MS
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: BRUCEJACK
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 13-2MS
TITLE: CONTROL SYSTEM SCHEMATICS
PLC DIGITAL OUTPUTS
BRUCEJACK
SH 12 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-12
REV. B



NOTES

1 SHIELDS GROUNDED AT PLC END ONLY

2 JUMPER UNUSED INPUTS

REV.	DATE	DESCRIPTION	BY	APPROVED
A	5/8/15	INITIAL RELEASE	JC	KD
B	2/11/15	INITIAL RELEASE	JC	KD

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DRAWN: J.C. DATE: 2 NOV 2015

CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK

CUSTOMER P.O. 177421-PG040

PROJECT NUMBER: 15-2MS

CUSTOMER EQUIPMENT. # 3242-IN-001-ECO

SCALE: 1:1

JOB NO. 15-2MS

TITLE: CONTROL SYSTEM SCHEMATICS
PLC ANALOG INPUTS
BRUCEJACK

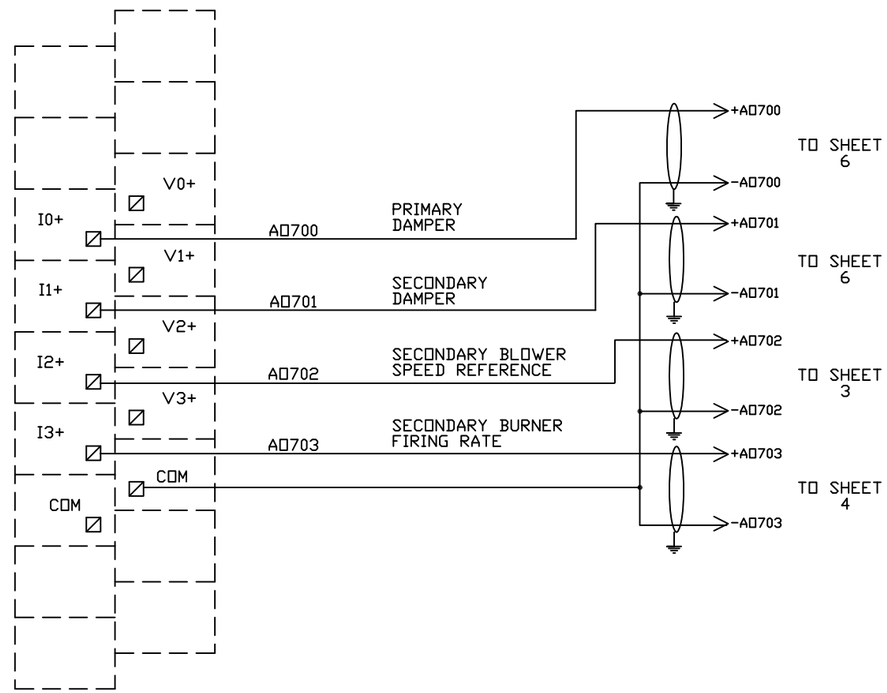
SH 13 OF 15

THIRD ANGLE

DWG. NO. ECOM2TN1PWO-10A-13

REV. B

LOCAL:7:0
1769-OF4
4 CH. ANALOG OUTPUT



NOTES

1 SHIELDS GROUNDED AT PLC END ONLY

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A	5/6/15	INITIAL RELEASE	JC	KD
B	5/11/15	AS BUILT	JC	KD

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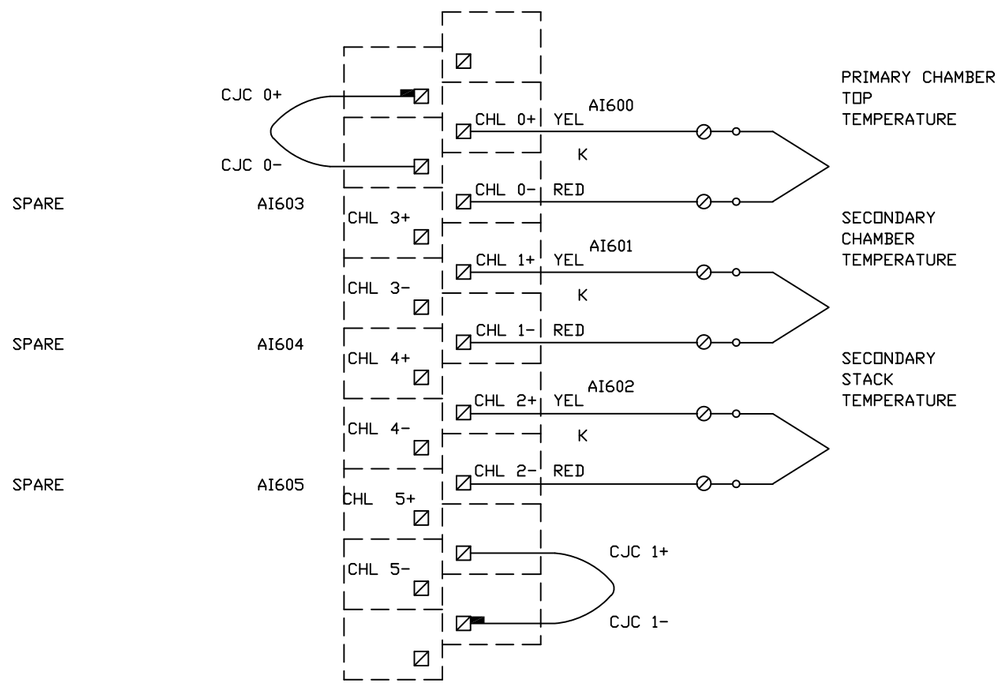
CHECKED: K.D. DATE: 2 NOV 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: CONTROL SYSTEM SCHEMATICS
PLC ANALOG OUTPUTS
BRUCEJACK
SH 14 OF 15
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10A-14
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	

LOCAL:6:I
1769-IT6
ANALOG INPUT,6CHS(THERMOCOUPLE/MV)



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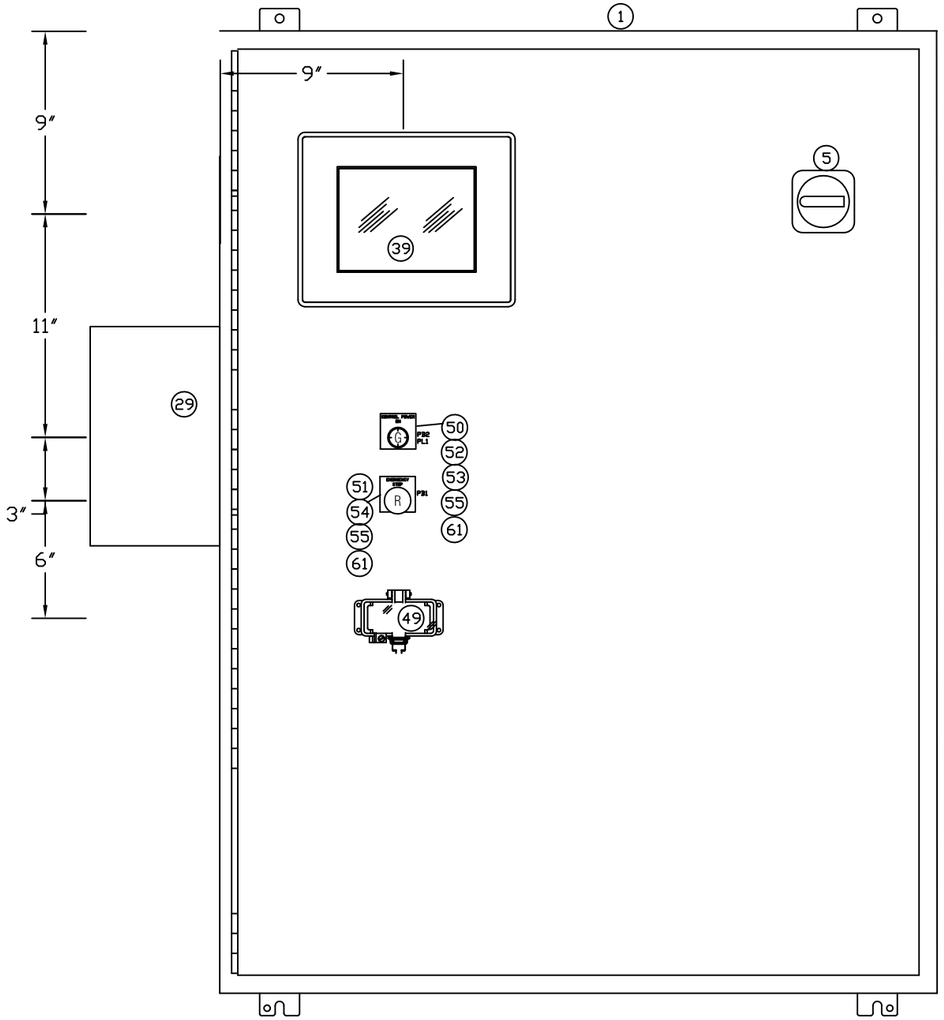
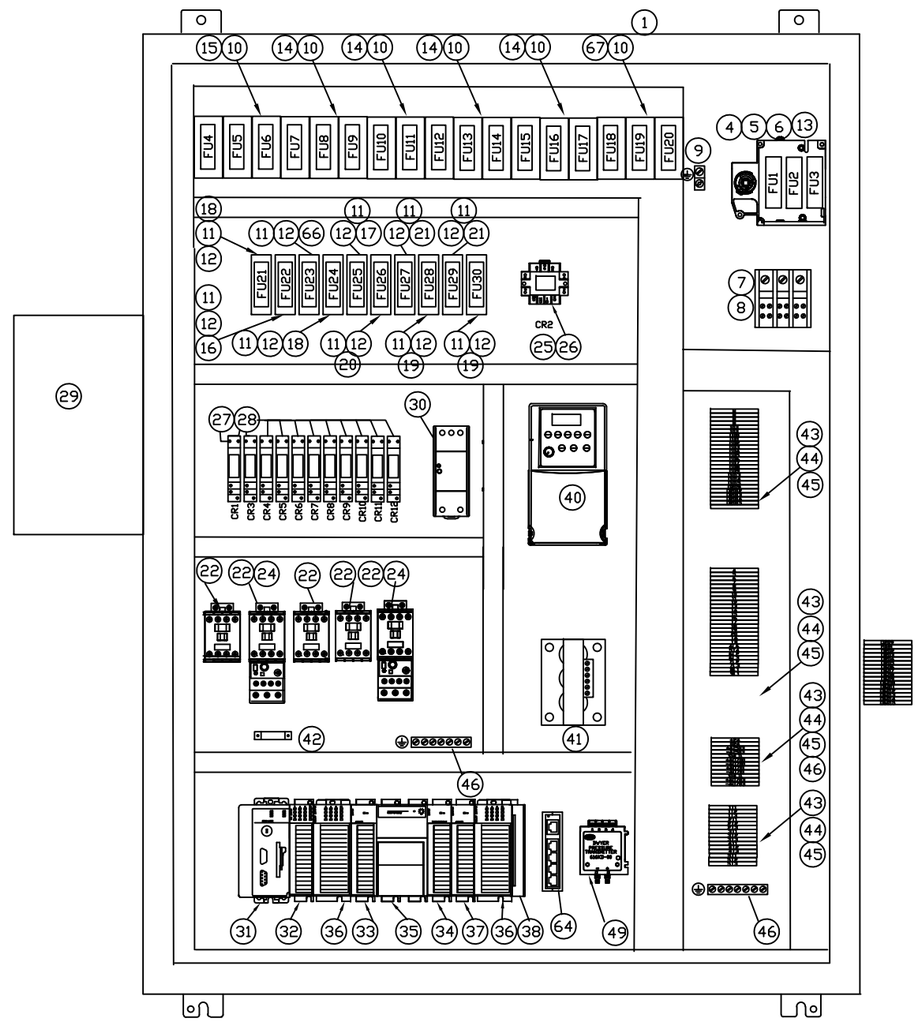
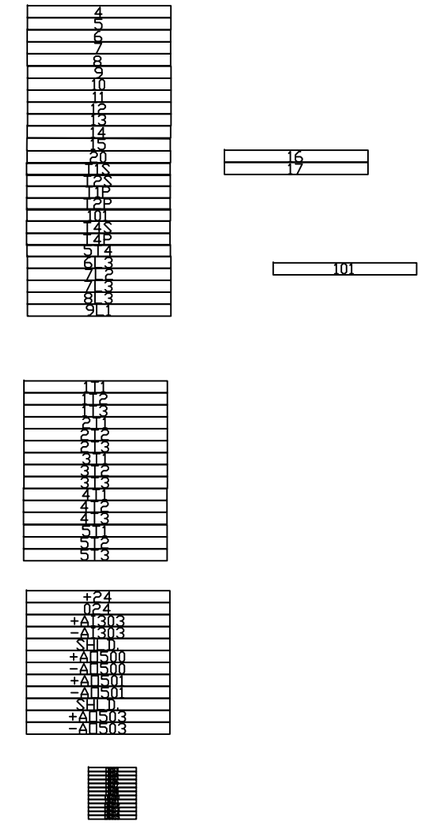
CHECKED: K.D.	DATE: 5 JUNE 2015	
PROJECT NAME: BRUCEJACK		CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS		CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1	TITLE: CONTROL SYSTEM SCHEMATICS PLC ANALOG INPUTS THERMOCOUPLES	SH 15 OF 15
JOB NO. 15-2MS		
THIRD ANGLE	DWG. NO. GKP-ECO-M1TN1PWOS-10A-15	REV. A







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ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O.: 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. #: 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: PANEL LAYOUT MARY RIVER
SH 1 OF 2
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10B-1
REV. A

ITEM	MANUFACTURE	PART NUMBER	Description	QUANTITY
1	Ralston	N12-483610	NEMA 12 enclosure 48Hx36Wx10D	1
2	Ralston	V-GP-202008	NEMA 12 enclosure 20Hx20Wx8D	1
3	Ralston	V-2020	Inner panel for V-GP-202008	1
7	Allen-Bradley	194R-J30-1753	IEC 30 amp 600 volt rotary disconnect	1
8	Allen-Bradley	194R-J60-1753	IEC60 amp 600 volt rotary disconnect	1
9	Allen-Bradley	194R-PY	Disconnect operating handle	2
10	Allen-Bradley	194R-S1	Operating shaft	2
11	Allen-Bradley	1492-PD3141	175 amp power distribution block	3
12	Allen-Bradley	1492-PBC1	Power block cover	3
13	Panduit	LAM1/0-14-QY	Ground lug	4
14	Cooper-Bussman	JT60030	600 volt 30 amp 1 pole class J fuse block	13
15	Cooper-Bussman	CHCC3DU	600 volt 30 amp 3 pole class CC fuse block	1
16	Cooper-Bussman	H25030-1CR	250 volt 30 amp 1 pole class RK1 fuse block	10
17	Cooper-Bussman	LPJ-60SP	600 volt 60 amp class J fuse	3
18	Cooper-Bussman	LPJ-20SP	600 volt 20 amp class J fuse	5
19	Cooper-Bussman	LPJ-6SP	600 volt 6 amp class J fuse	6
20	Cooper-Bussman	LPJ-5SP	600 volt 5 amp class J fuse	3
21	Cooper-Bussman	LPJ-4SP	600 volt 4 amp class J fuse	2
22	Cooper-Bussman	LPCC-1/2	600 volt 1/2 amp class CC fuse	3
23	Cooper-Bussman	LPNRK-20SP	250 volt 20 amp class RK1 fuse	1
24	Cooper-Bussman	LPNRK-10SP	250 volt 10 amp class RK1 fuse	1
25	Cooper-Bussman	LPNRK-6SP	250 volt 6 amp class RK1 fuse	3
26	Cooper-Bussman	LPNRK-5SP	250 volt 5 amp class RK1 fuse	2
27	Cooper-Bussman	LPNRK-1SP	250 volt 1 amp class RK1 fuse	3
28	Allen-Bradley	100-C09D10	9 amp IEC contactor 120 VAC coil	3
29	Allen-Bradley	100-FA40	4 N.O. top mount auxilary contact	1
30	Allen-Bradley	193-EECB	IEC solid state overload relay range 1.0- 5 a	1
31	Allen-Bradley	700-HA33A1	3PDT 11 pin tube based relay 120 VAC coil	1
32	Allen-Bradley	700-HN126	11 pin tube based relay base	1
33	Allen-Bradley	700-HK36A1	16 amp SPDT slim line relay 120 VAC coil	8
34	Allen-Bradley	700-HN121	Base slim line relay	8
35	Rex Manufacturing	CS2000JA/C4/C4	600 to 120 VAC 2000 VA transformer	1
36	Rex Manufacturing	CS25JA/C4/C5	600 to 120 VAC 25 VA transformer	1
37	Siemens	3UG4512-1BR20	Phase sequence relay	1
38	Idec	PS5R-SC24	24 VDC 1.3 amp switching power supply	1
39	Allen-Bradley	1756-A10	10 slot rack	1
40	Allen-Bradley	1756-PA72	120 vac supply 10 amp power supply	1
41	Allen-Bradley	1756-L61	Compact Logix processor	1
42	Allen-Bradley	1756-ENBT	Ethernet module	1
43	Allen-Bradley	1756-IA16	16 point 120 vac input module	1
44	Allen-Bradley	1756-OA16	16 point AC output module	1
45	Allen-Bradley	1756-IF8	8 channel analog input module	1
46	Allen-Bradley	1756-IT6I	6 channel thermocouple input module	1
47	Allen-Bradley	1756-OF4	8 channel analog output module	1
48	Allen-Bradley	1756-TBNH	20 position screw clamp RTB	4
49	Allen-Bradley	1756-TBCH	36 pin cage clamp RTB	1
50	Allen-Bradley	1756-N2	Slot filler	3
51	Allen-Bradley	2711P-T10C4A8	HMI with 10" colour touch screen	1
52	Cisco Systems	SF302-08MP	8 Port managed ethernet switch	1
53	Automation Direct	ACT005-42L-F	5 amp to 4-20ma current transducer	1
54	Allen-Bradley	22B-E3P0N104	600 volt 2 H.P. V.F.D.	1
55	Rex Manufacturing	3PR0004C5H	600 volt 4 amp line reactor	1
57	Allen-Bradley	1492-J3	IEC 600 volt 20 amp terminal block	A/R
58	Allen-Bradley	1492-EBJ3	End barrier	12
59	Allen-Bradley	1492-EAJ35	End Anchor	18
60	Allen-Bradley	1492-JG4	Grounding block	3
61	Allen-Bradley	1492-CJJ5-10	Center jumper	A/R
63	Wiedmuller	1018790000	Ethernet bulk head feed through connector	3
65	Allen-Bradley	800FP-LF3	Green illuminated push button operator	1
68	Allen-Bradley	800FP-P3	Green pilot light operator	1
69	Allen-Bradley	800FP-P4	Red pilot light operator	1
70	Allen-Bradley	800FP-MT44	Emergency stop push button operator	1
71	Allen-Bradley	800F-N5G	Green integrated led module 120 vac	2
72	Allen-Bradley	800F-N5R	Red integrated led module 120 vac	1
73	Allen-Bradley	800F-X10	N.O. contact block	1
74	Allen-Bradley	800F-X01	N.C. contact block	1
75	Allen-Bradley	800F-ALP	Mounting latch	4
76	Ilsco	N174A	Copper ground bar	4"
77	Panduit	C1LG6	1 inch light gray duct cover	12'
78	Panduit	G1x3LG6	1 by 3 inch light grey duct	12'
79	Panduit	C2LG6	2 inch light grey duct cover	18'
80	Panduit	G2x3LG6	2 by 3 inch light grey duct	18'
81			lamacoid label for 22mm push button	4
83	Siemens	EQL16125D	3 wire 240 vac 125 A loadcenter	1
84	Siemens	Q115	15 A sirgle pole breaker	7
85	Siemens	Q215	15 A two pole breaker with common trip	2
86	Siemens	Q230	30 A two pole breaker with common trip	1
87	Wiedmuller	7940084720	15 A duplex din-rail receptacle	1
88	Bussman	FNM-1/4	1/4 amp 250 volt class M fuses	1

NOTE:

During the bidding EWS took an exception to H349000/TX001 S26 00 50 Basic Electric Requirements:

4.2 Motor Control Centres EWS standard supply is a single control panel which includes starters, Class J fuses for short circuit protection, IEC Contactors, solid state overloads. Alarms are shown on LCD. EWS has one control transformer to supply all of the control power required in the control panel.

NOTE: A/R STANDS FOR AS REQUIRED.

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A	5/6/15	INITIAL RELEASE	JC	KD

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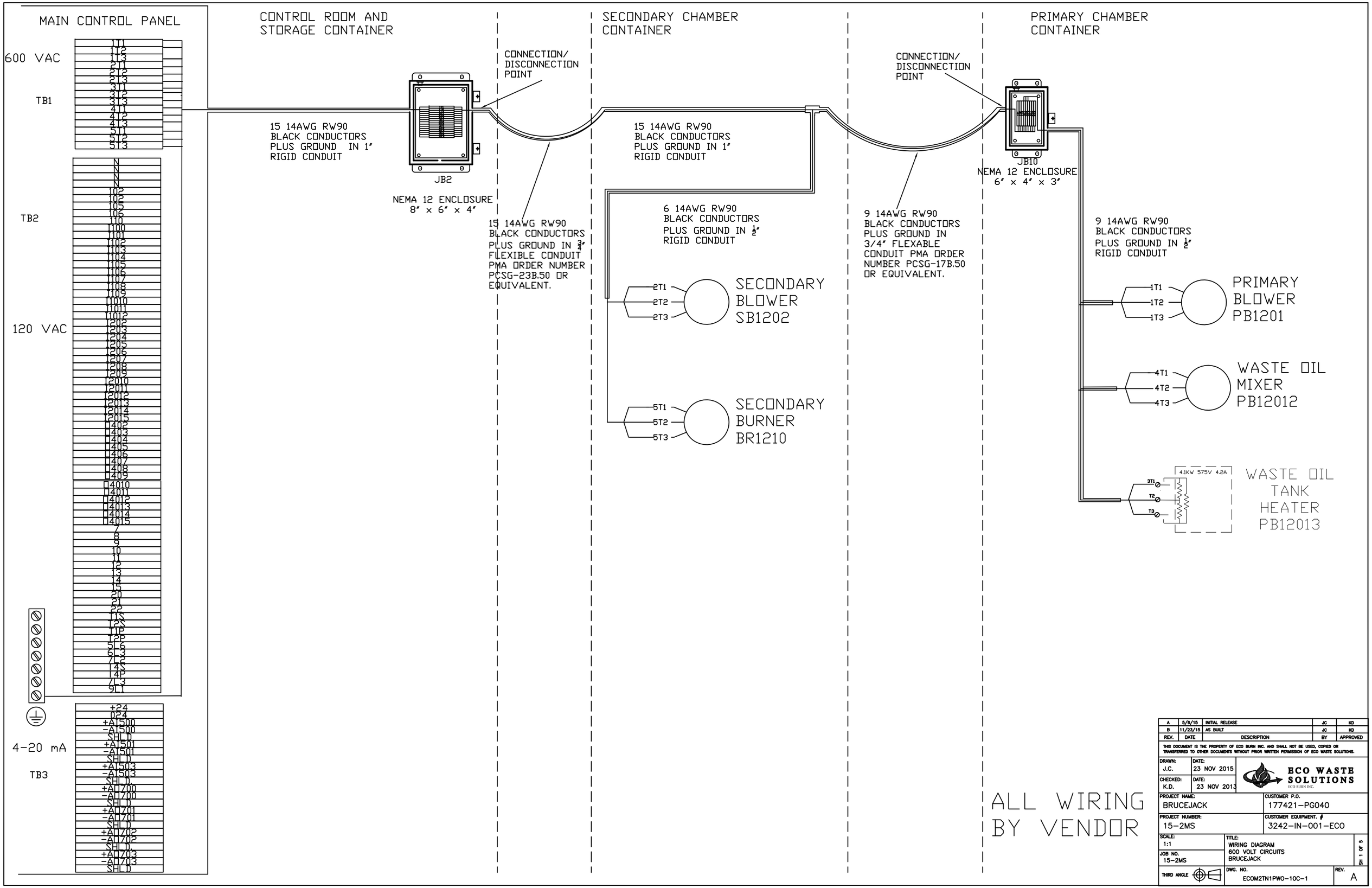
CHECKED: K.D. DATE: 5 JUNE 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: PANEL BILL OF MATERIAL BRUCEJACK
SH 2 OF 2
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10B-2
REV. A



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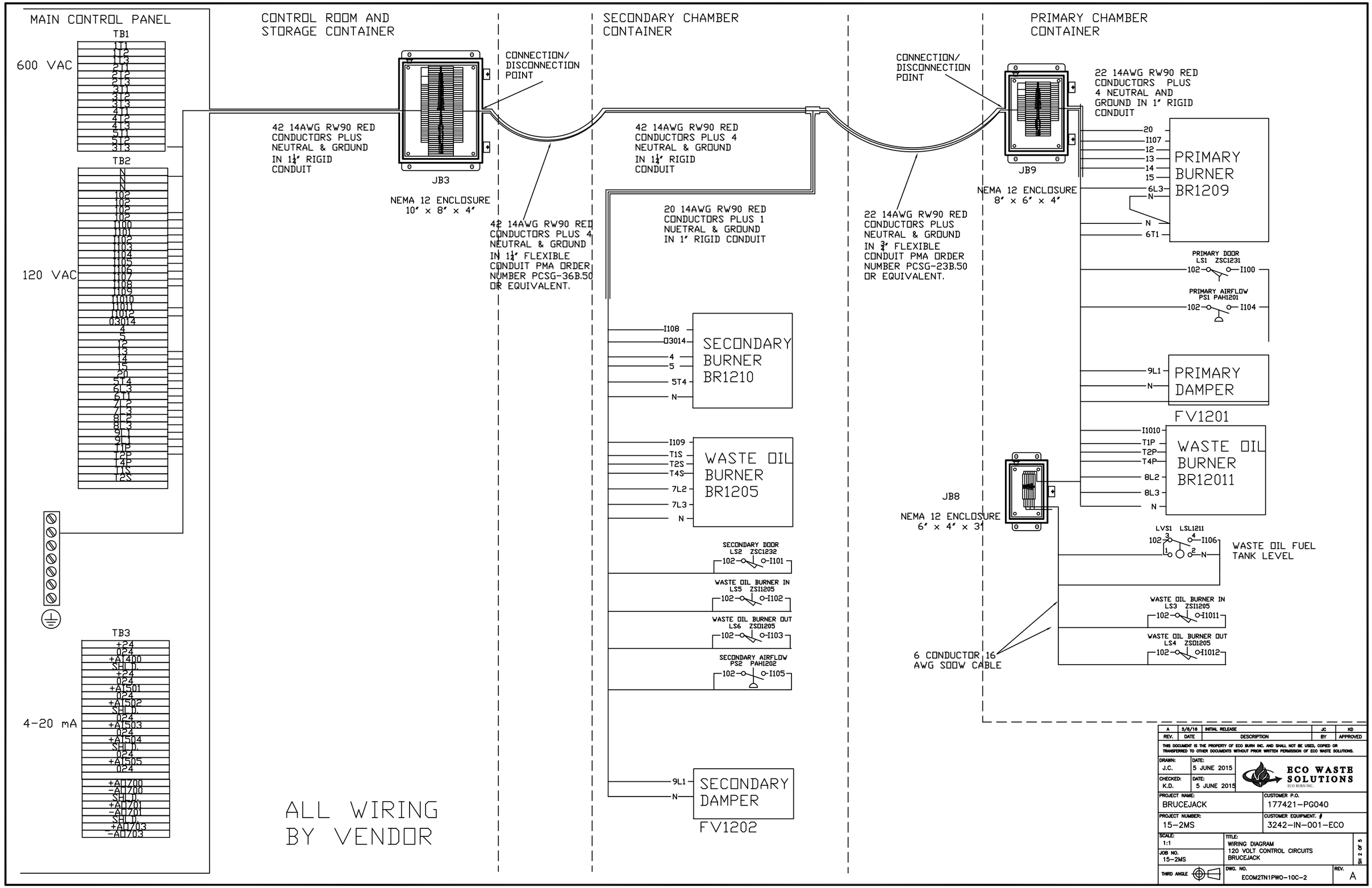
CHECKED: K.D. DATE: 23 NOV 2013

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM
600 VOLT CIRCUITS
BRUCEJACK
SH 1 OF 5
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10C-1
REV. A



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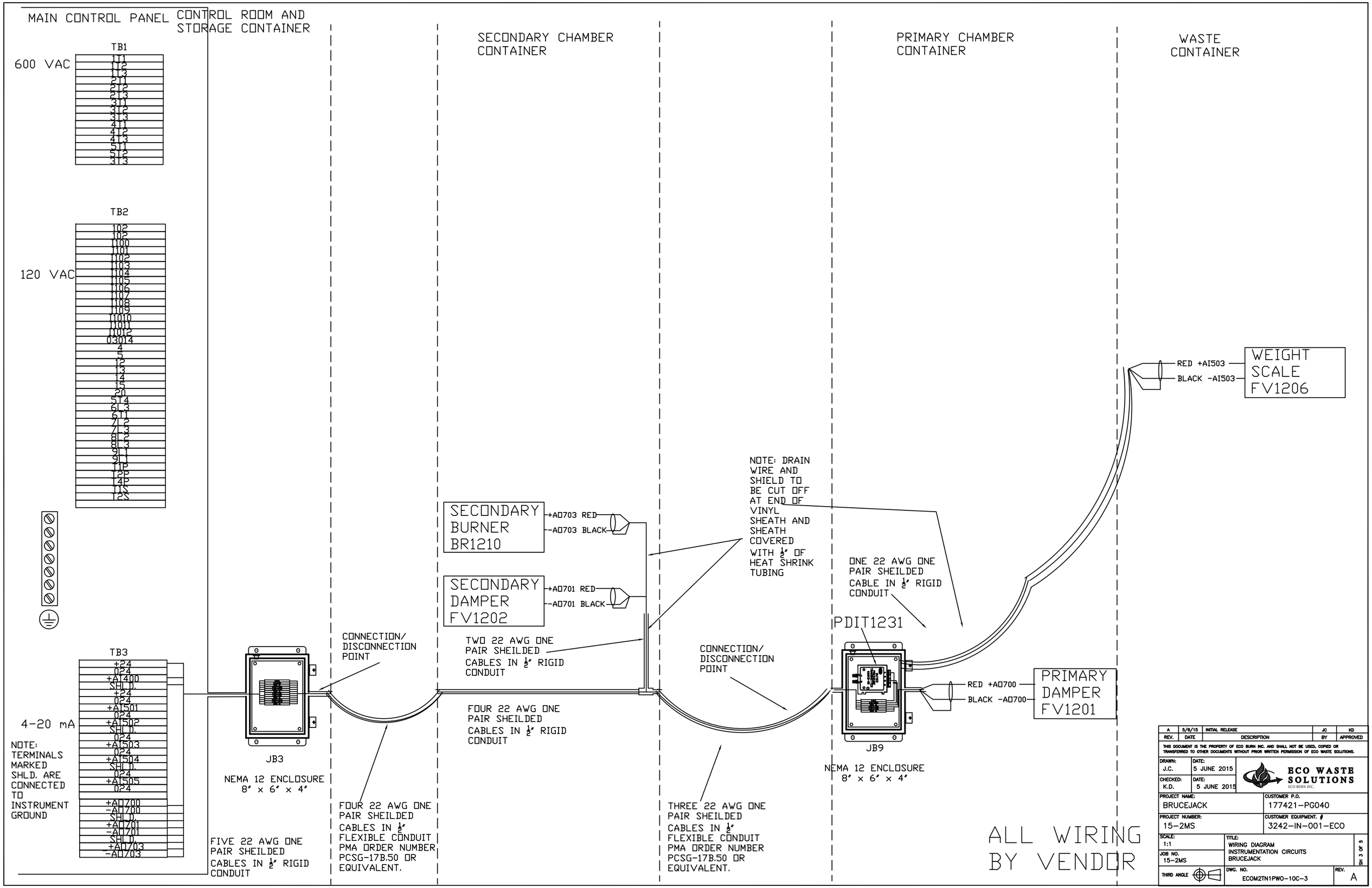
CHECKED: K.D. DATE: 5 JUNE 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT: # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM 120 VOLT CONTROL CIRCUITS BRUCEJACK
SH. 2 OF 5
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10C-2
REV. A



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A	5/6/15	INITIAL RELEASE	JC	KD

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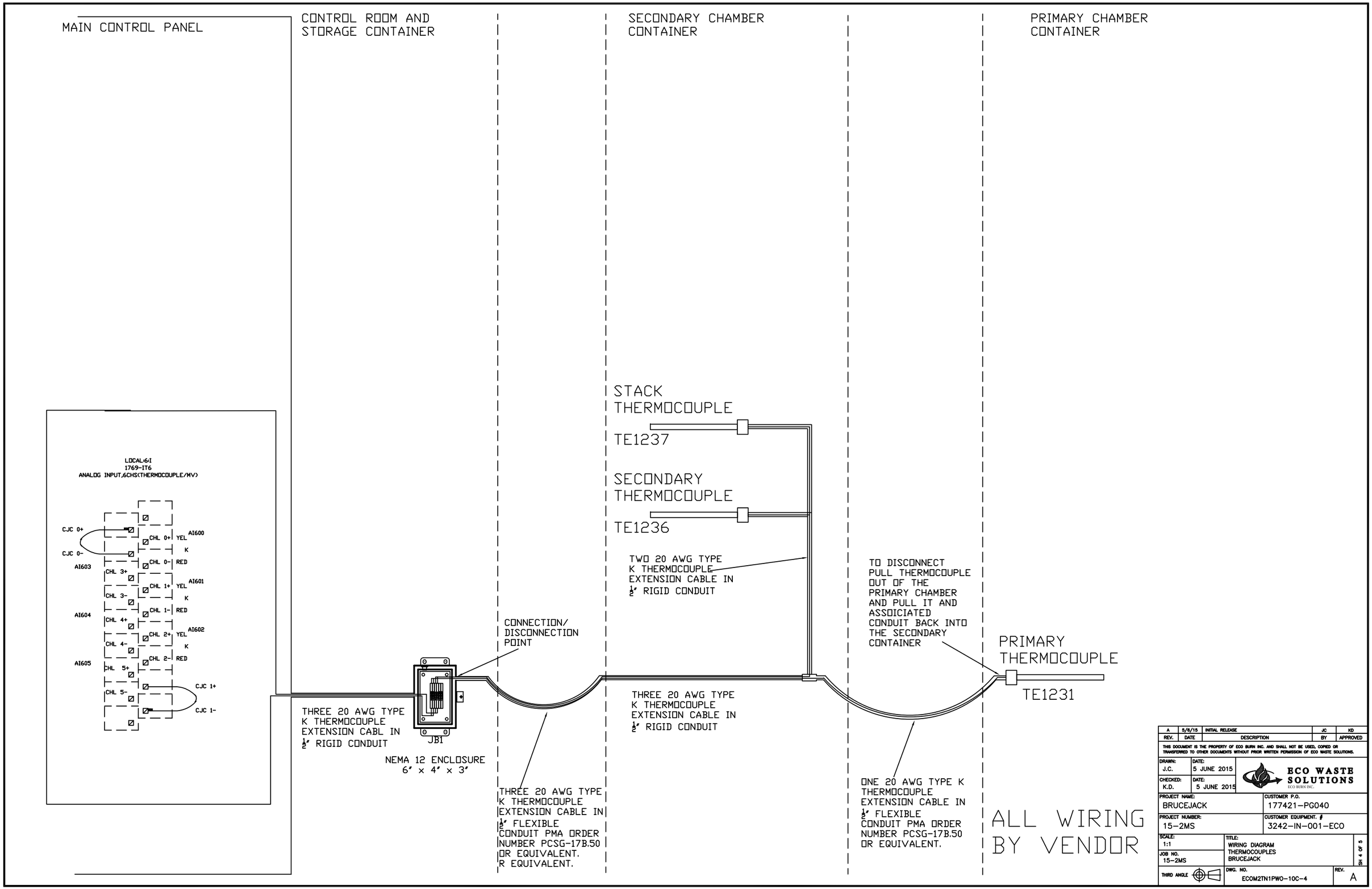
CHECKED: K.D. DATE: 5 JUNE 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM INSTRUMENTATION CIRCUITS BRUCEJACK
SH 3 OF 5
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10C-3
REV. A


MAIN CONTROL PANEL
CONTROL ROOM AND STORAGE CONTAINER
SECONDARY CHAMBER CONTAINER
PRIMARY CHAMBER CONTAINER
LOCAL:6:I
1769-IT6
ANALOG INPUT,6CHS(THERMOCOUPLE/MV)
CJC 0+
CJC 0-
AI603
CHL 3+
CHL 3-
AI604
CHL 4+
CHL 4-
AI605
CHL 5+
CHL 5-
CHL 0+ YEL
K
CHL 0- RED
AI600
CHL 1+ YEL
K
CHL 1- RED
AI601
CHL 2+ YEL
K
CHL 2- RED
AI602
CJC 1+
CJC 1-
THREE 20 AWG TYPE K THERMOCOUPLE EXTENSION CABL IN ½" RIGID CONDUIT
JB1
NEMA 12 ENCLOSURE 6" x 4" x 3"
CONNECTION/ DISCONNECTION POINT
THREE 20 AWG TYPE K THERMOCOUPLE EXTENSION CABLE IN ½" FLEXIBLE CONDUIT PMA ORDER NUMBER PCSG-17B.50 OR EQUIVALENT. R EQUIVALENT.
STACK THERMOCOUPLE
TE1237
SECONDARY THERMOCOUPLE
TE1236
TWO 20 AWG TYPE K THERMOCOUPLE EXTENSION CABLE IN ½" RIGID CONDUIT
THREE 20 AWG TYPE K THERMOCOUPLE EXTENSION CABLE IN ½" RIGID CONDUIT
TO DISCONNECT PULL THERMOCOUPLE OUT OF THE PRIMARY CHAMBER AND PULL IT AND ASSOICIATED CONDUIT BACK INTO THE SECONDARY CONTAINER
ONE 20 AWG TYPE K THERMOCOUPLE EXTENSION CABLE IN ½" FLEXIBLE CONDUIT PMA ORDER NUMBER PCSG-17B.50 OR EQUIVALENT.
PRIMARY THERMOCOUPLE
TE1231
ALL WIRING BY VENDOR
A 5/8/15 INITIAL RELEASE JC KD
REV. DATE DESCRIPTION BY APPROVED
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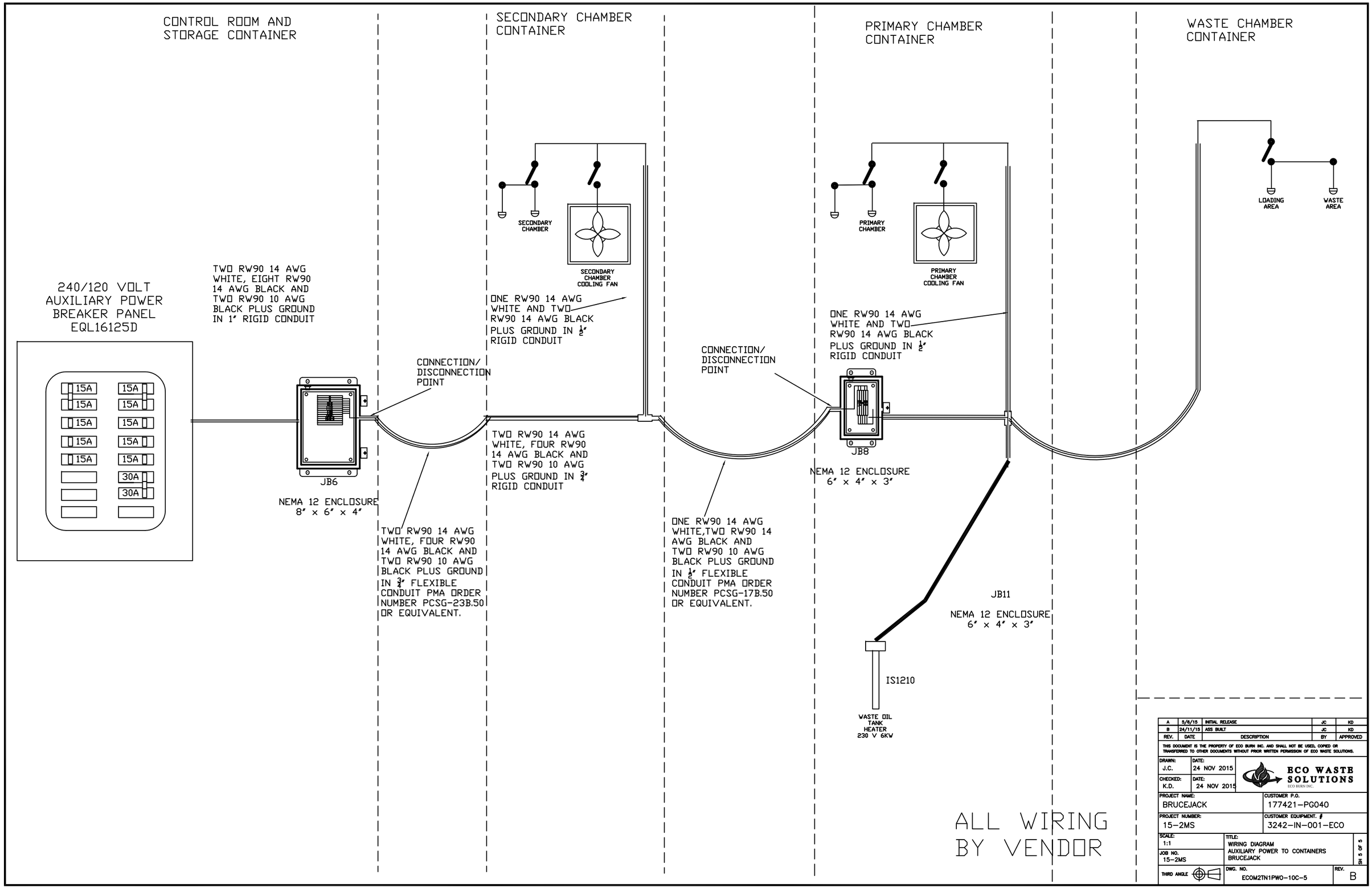
ECO WASTE SOLUTIONS
ECO BURN INC.
PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM THERMOCOUPLES BRUCEJACK
SH 4 OF 5
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10C-4
REV. A



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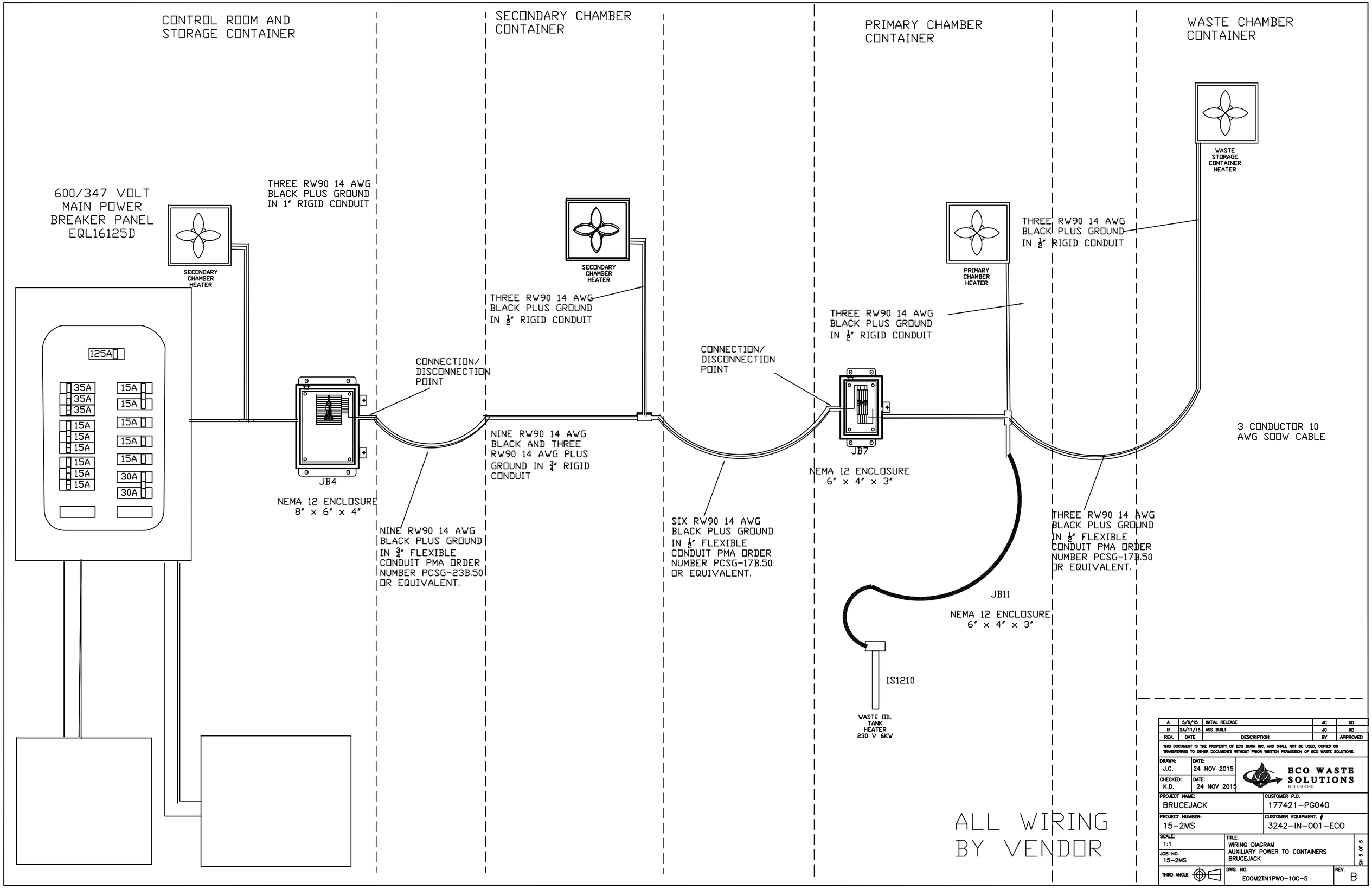
ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM AUXILIARY POWER TO CONTAINERS BRUCEJACK
SH. 5 OF 5
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10C-5
REV. B



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ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 3242-IN-001-ECO
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM AUXILIARY POWER TO CONTAINERS BRUCEJACK
SH 5 OF 5
THIRD ANGLE
DWG. NO. ECOM2TN1PWO-10C-5
REV. B

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 5

ASSEMBLY & INSTALLATION PROCEDURES

ECO M2TNWO

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

ECO WASTE SOLUTIONS

GENERAL ASSEMBLY & INSTALLATION INFORMATION

The **EWS Mobile Incinerator** is assembled with interconnections and external components to be mounted as required. Please review (section 4 on this manual) the Equipment Layout ECOM2TNWO-GA-rB and Piping ECO-M2TNWO P&ID prior to assembly.

Customer Responsibility

Provide all foundation work of packed gravel under the base frame and tanks. Provide electrical wiring between Main Disconnect Panel, Control Panel and Junction boxes. Connect provided electrical cables from Junction box associated Equipment as per Electrical wiring drawings where necessary. All electrical work is to be performed by Certified Electrician.

NOTE

a. **Fuel tanks should be out of the way and protected using bollards against accidental impact of mobile equipment (e.g. trucks, etc.)**

b. Foundation requirements between pads to be determined by customer

c. Specific location of incinerator to be determined by customer and site restrictions

- Install I-beams, spacers and equipment using a crane, forklift, come-a-longs, hydraulic jacks/hand-pumps, etc. Installation to be performed by qualified trades as per local code.
- Provide all utility services including connections to the equipment including fuel, electrical, air, etc. using basic hand tools. Installation of all Services to be performed by qualified local trades, as per local code.
- Provide proper protection of all equipment from accidental damage or vandalism (bollards, exterior lighting, etc).
- Perform any touch up painting and cleanup of equipment after assembly.
- Locate the fuel tank as per Equipment Layout to ensure maximum positive supply pressure on the suction side.
- Obtain any and all construction, operating and environmental permits and other approvals as may be required in the area of jurisdiction where the equipment is being deployed and operated prior to installation. EWS will assist in supplying technical information required for these permits to the customer as it relates to EWS equipment.
- Maintain ample space around all equipment for maintenance, cleaning and safety considerations. A suggested provision would be to provide a minimum of 1.83 meters from all major equipment surfaces and edges. Always allow proper space for the swing radius of the chamber doors including vehicular traffic.

NOTE

Do not scale drawings: If certain dimensions are required which are not shown on drawings, EWS should be contacted for the required dimension. EWS will not be responsible for any dimensional conflicts resulting from dimensions not shown on a

certified drawing. Do not use general sales literature or other general equipment submittals for construction, assembly and/or erection, unless so indicated.
Please note that some of the diagrams and/or photos in this MANUAL are conceptual in nature and may not be exact representations of the equipment purchased.

Preparation Prior to Assembly & Installation

Electrical & Fuel Availability

The electrical supply required is 600 VAC, 60 Hz, 3 phases. Connect power supply to Main Disconnect Panel (supplied by EWS) as per Supplied Electrical drawings in Section 4 of this manual.

DO NOT CONNECT THE EXTERNAL POWER SUPPLY TO THE EWS MOBILE INCINERATOR UNTIL ALL INTERNAL ELECTRICAL CONNECTIONS ARE COMPLETE AND THE SYSTEM IS COMPLETELY ASSEMBLED.

The fuel supply connections are located on the Secondary Chamber Container. Connect the flexible fuel supply lines to the fuel tank(s) located externally. There are fuel lines between the containers for fuel distribution which are to be connected before the external hook-ups and connections are made.

DO NOT CONNECT THE EXTERNAL FUEL SUPPLY TO THE EWS MOBILE INCINERATOR UNTIL ALL INTERNAL FUEL CONNECTIONS ARE COMPLETE AND THE SYSTEM IS COMPLETELY ASSEMBLED.

Assembly & Installation Overview

Specialized Tools and Equipment for Assembly and Installation

The complete assembly of the **EWS Mobile Incinerator** will require 2-3 full time qualified personnel for 2 days. The following list identifies the tools and equipment required to be supplied by the customer in order to proceed with the assembly:

- Crane
- Forklift
- Boom Lift, Scissor Lift and/or Scaffolding
- Steel Shims
- Ladder (12')
- Come-along
- Hydraulic Jack/pump
- Level
- Erection Wrench / Alignment bar

- Container Clamp 2”-Wrench
- Sling
- I-beam Clamp

The following list identifies the consumable items to proceed with the assembly:

- Anti-Seize Compound (Generic Graphite-Based Anti-Seize Compound)
- Gasket Spray-on Adhesive (Generic Spray-On Contact Cement)

Assembly Overview

The following general steps are the order in which the **EWS Mobile Incinerator** Package needs to be installed. Each step is detailed in the subsequent section.

ORDER OF ASSEMBLY (and detailed in following Section)

1) I-Beam & Spacer Base Structure (Base Frame Structure)
2) Connections Between Primary and Secondary Chamber Containers
3) T-Stack Section on Secondary Chamber Container
4) Internal Component Connections
5) Internal Connections
6) External Connections

NOTE

Important Notes to Consider Prior to and During Assembly

- Lifting lugs are provided on the stacks, and major accessories, and should be used in setting these units into position.
- Do not allow lifting chains or cables to put loads on piping, or mounting flanges as they may be damaged.
- Avoid dragging lifting gear across painted surfaces.
- When placing the system into position, be careful not to subject the refractory to mechanical shock, which may result in refractory damage.

Assembly Instructions

I-BEAM & SPACER BASE STRUCTURE (Base Frame Structure)

NOTE

For all fasteners used in assembly use regular-grade anti-seize spray to ensure that fasteners will be easily removed when disassembly is required.

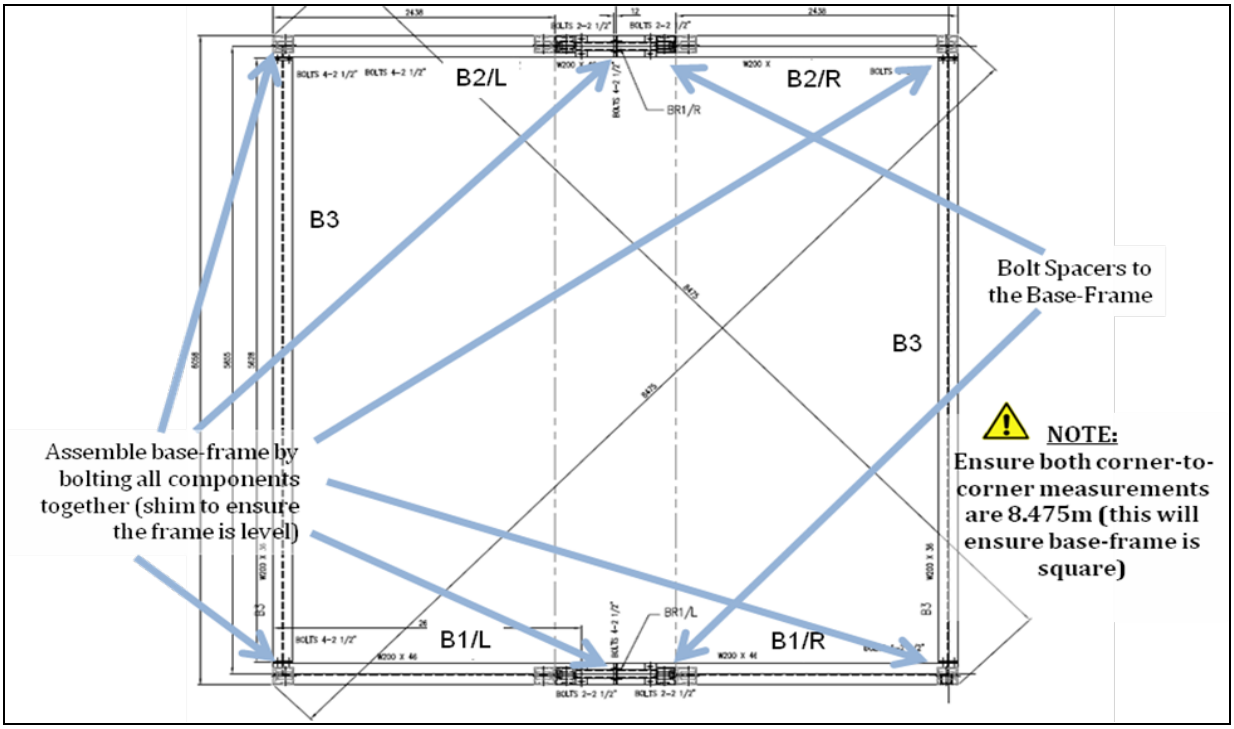
NOTE

Do not fully torque bolts during initial assembly.

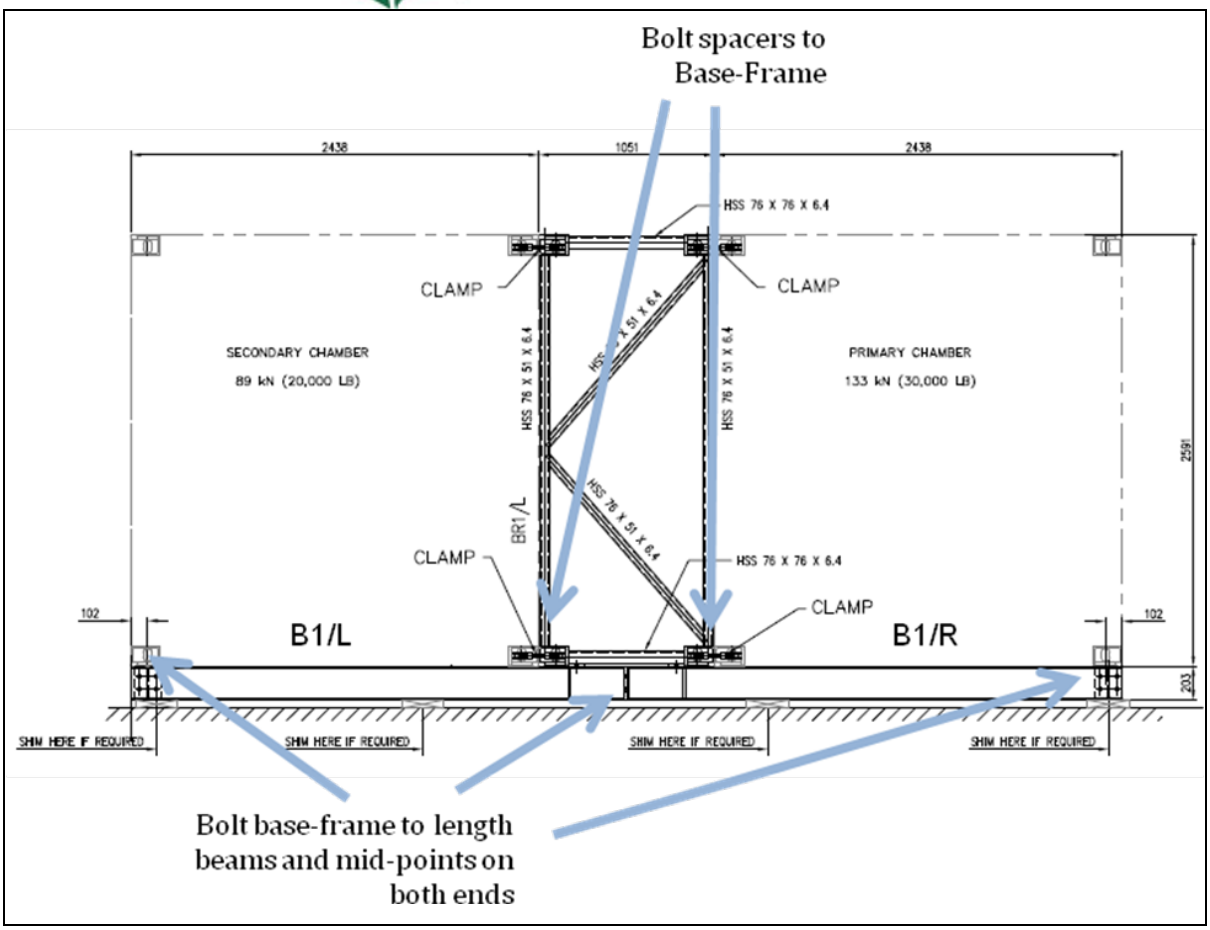
Correct Clamp Installation

When installing the clamps, install in such a manner that the installer pulls back on the wrench when tightening the clamp. From the installer's perspective, the smaller nut would then be located on the right of the large nut. If it is installed the other way, or during removal, a lift-truck or other lifting device will need to be employed for safety reasons.

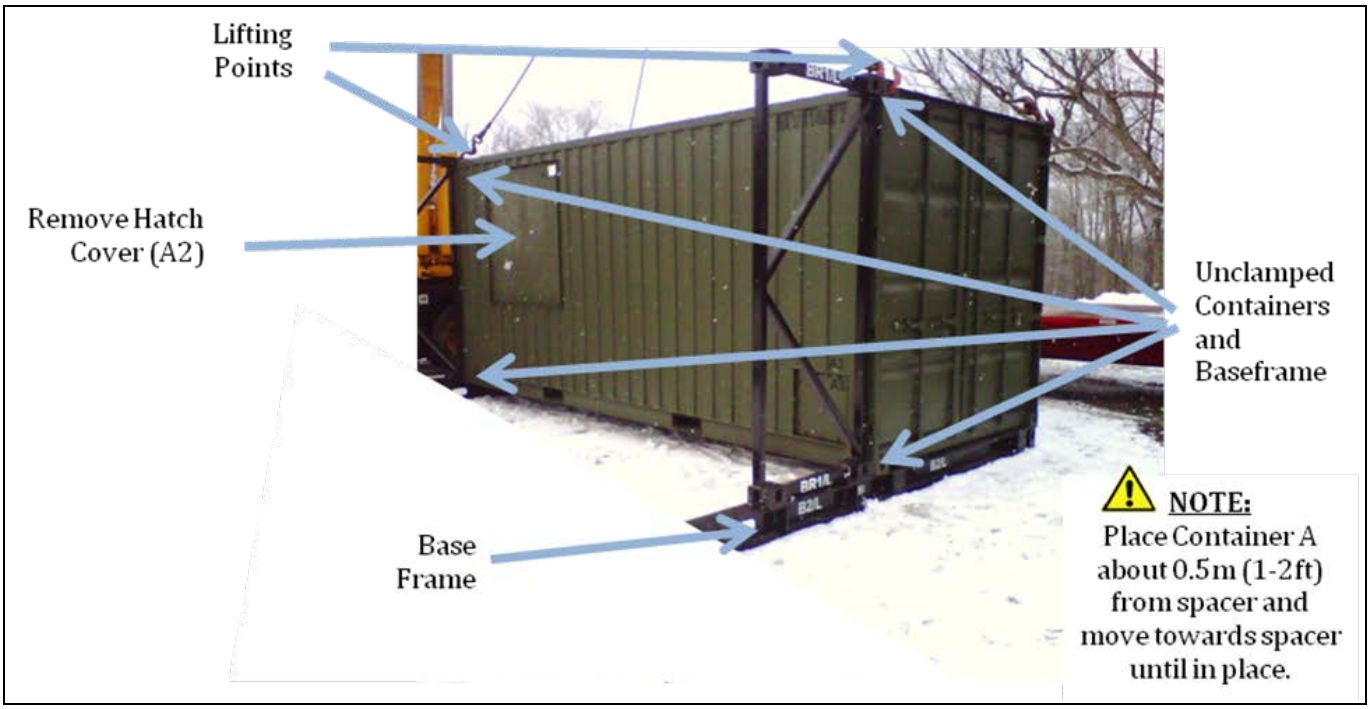
Failure to follow the above instructions poses a safety hazard to an installer situated on top of the Primary Container as they would need to push forward to tighten or loosen the clamp.



ECO WASTE SOLUTIONS



CONNECTIONS BETWEEN PRIMARY AND SECONDARY CHAMBER CONTAINERS



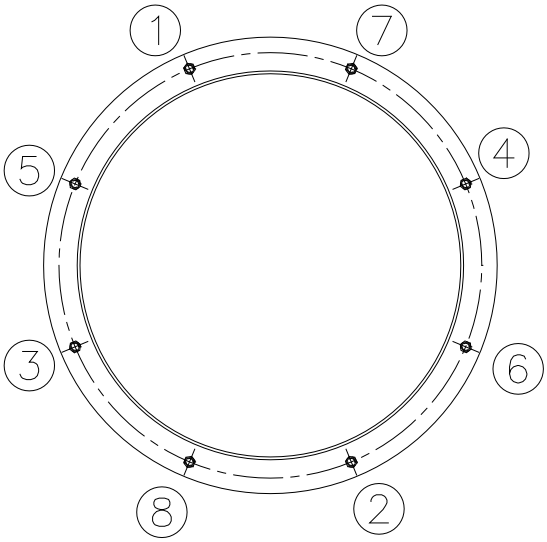
ECO WASTE SOLUTIONS

Gasket adhesive spray being applied

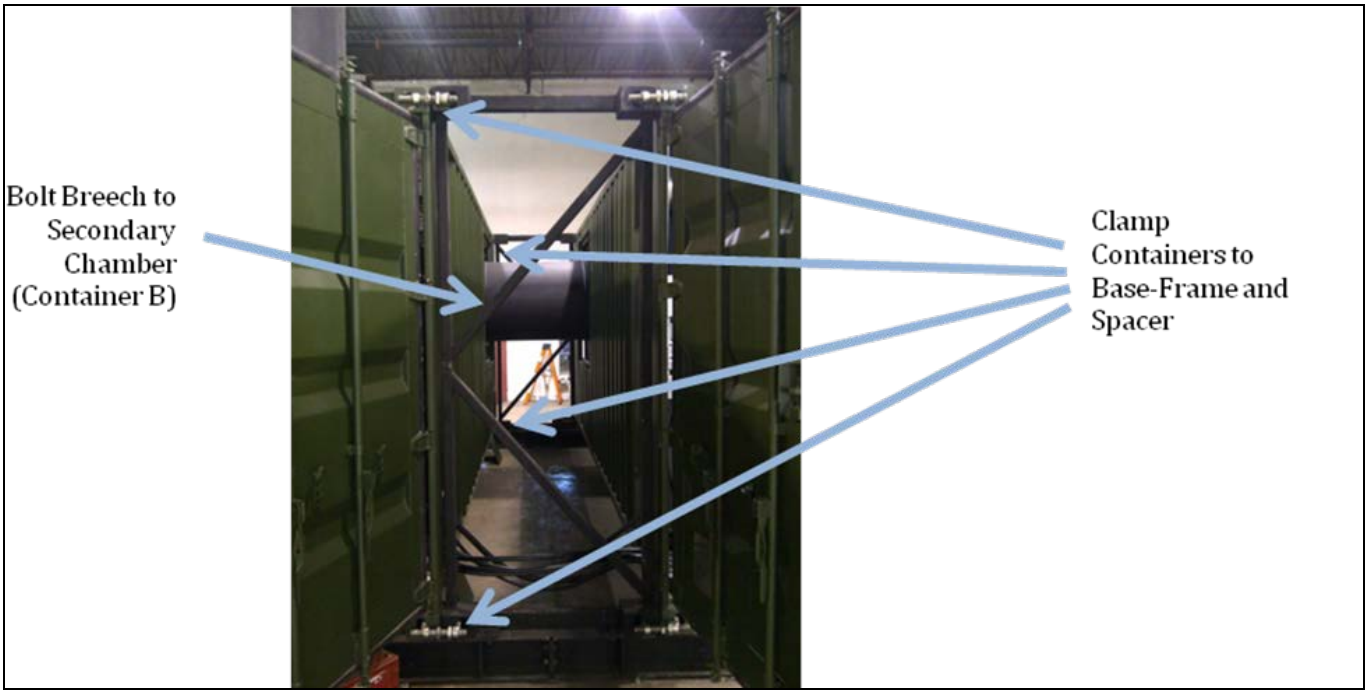
Correctly Installed Gasket

NOTE

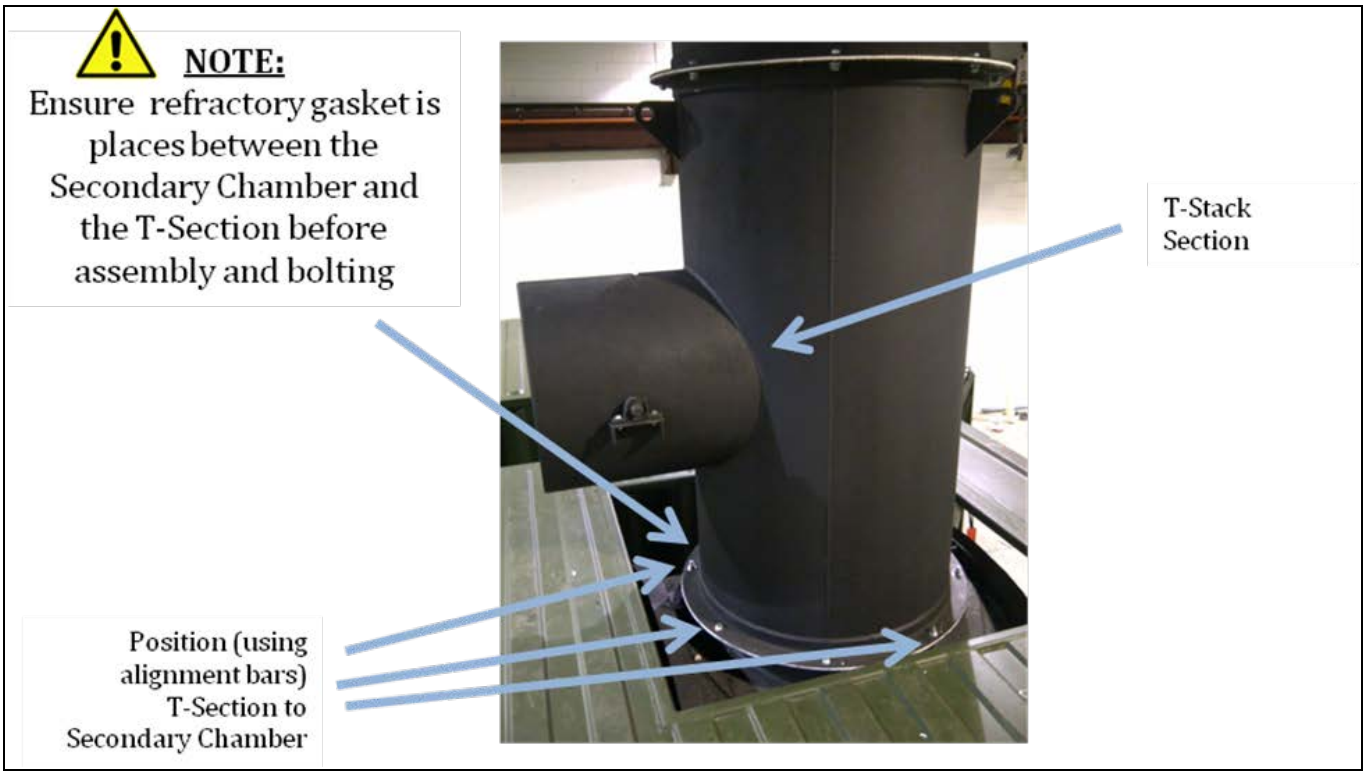
Once breech flanges are aligned and together bolt flanges together using the numerical order described in the pattern below.


1
7
5
4
3
6
8
2

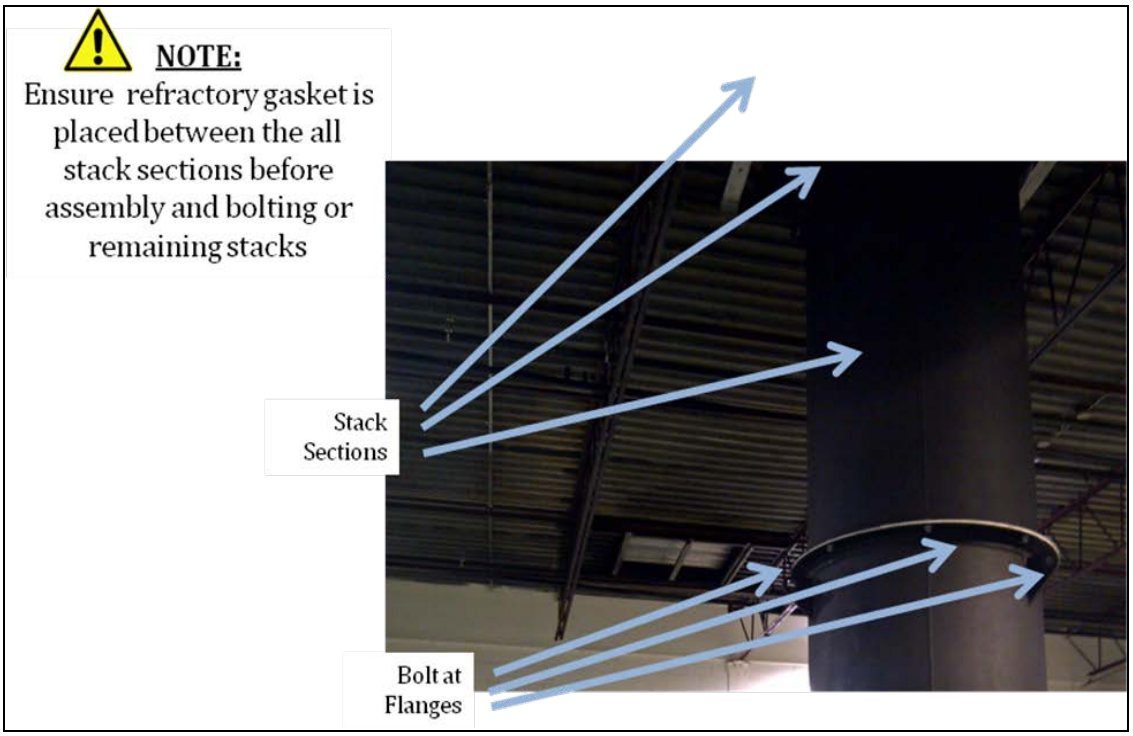
Lifting Points
Container B (Secondary Chamber Container)
Move in this direction
Base Frame
Once in place, clamp Container B to Spacer
NOTE:
Place Container B about 0.5m (1-2ft) from spacer and move towards spacer until in place.



T-STACK SECTION AND SECONDARY CHAMBER CONTAINER



T-Stack and Stack Sections



NOTE

Each flange hole requires (1) bolt, (2) flat washers, (1) lock Washer and a Nut. Hard ware provided by EWS.

Install stack gaskets between stack sections.

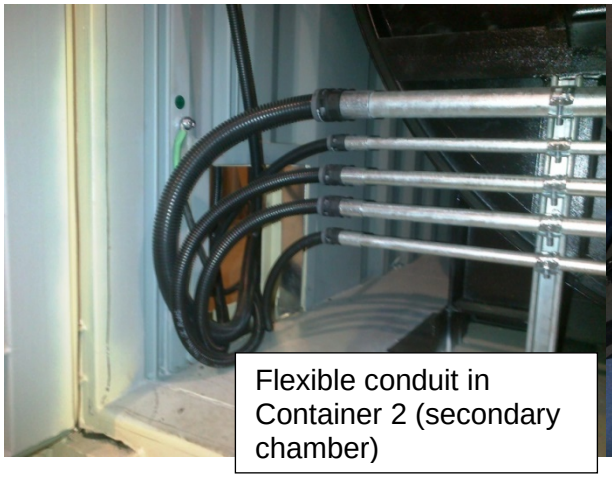
Install refractory-lined *T-Stack Section* on top of the *Secondary Chamber* using the hardware provided. Then install the next three *Stack Sections* as per the drawing using hardware provided.

ECO WASTE SOLUTIONS

T-Stack and Stack Sections

This is a Sample Photo only of Erection of the Stack Sections

INTERNAL COMPONENT CONNECTIONS –



Flexible conduit in Container 2 (secondary chamber)

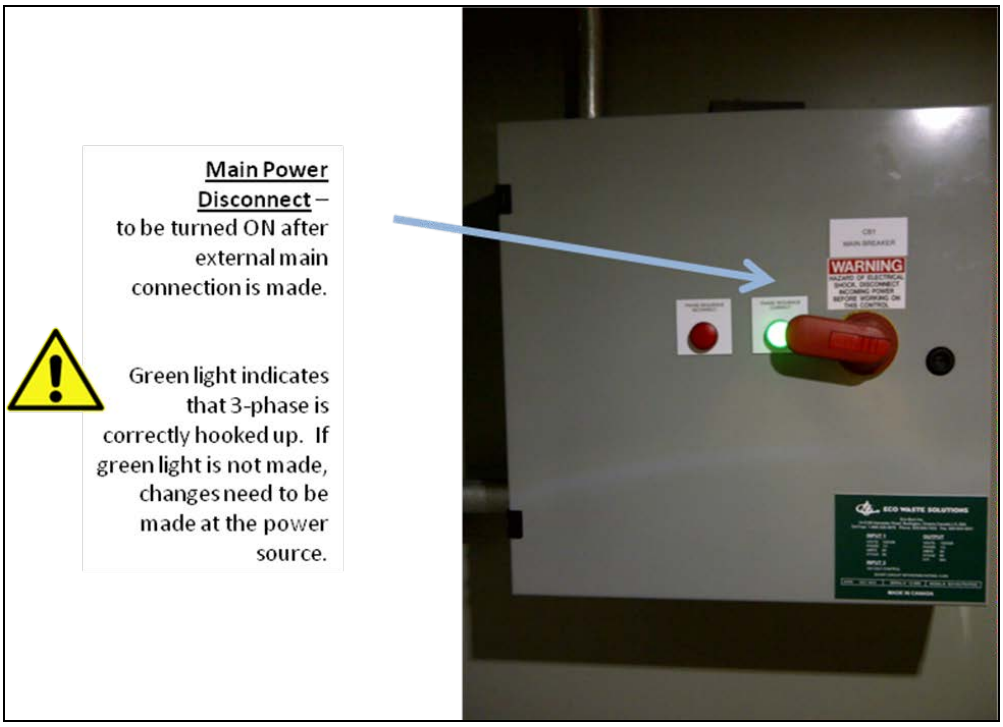
Feed flexible conduit from Secondary Container to Primary Container through utility duct into corresponding Junction boxes in Primary Container.

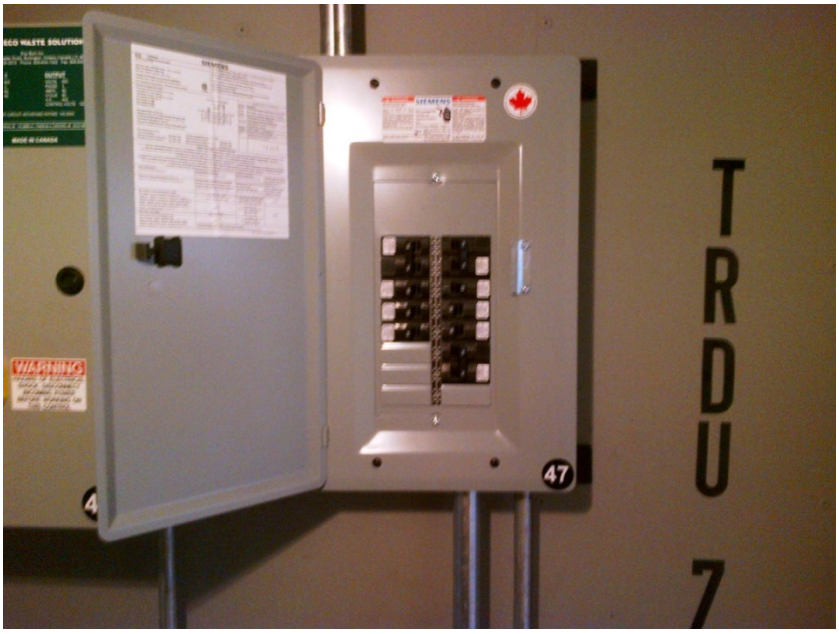
5 Junction Boxes located in Primary Chamber Container.

Connect each flexible conduit to the correspondent Junction Box (i.e. JB1 conduit with JB1 box) wire the terminal block inside the junction box following the labels on both the wires and the terminal block

DO NOT CONNECT THE ELECTRICAL UNLESS THE MAIN SUPPLY FROM THE SITE HAS BEEN INTERRUPTED AND THE INCINERATOR BREAKERS ARE IN THE OFF POSITION

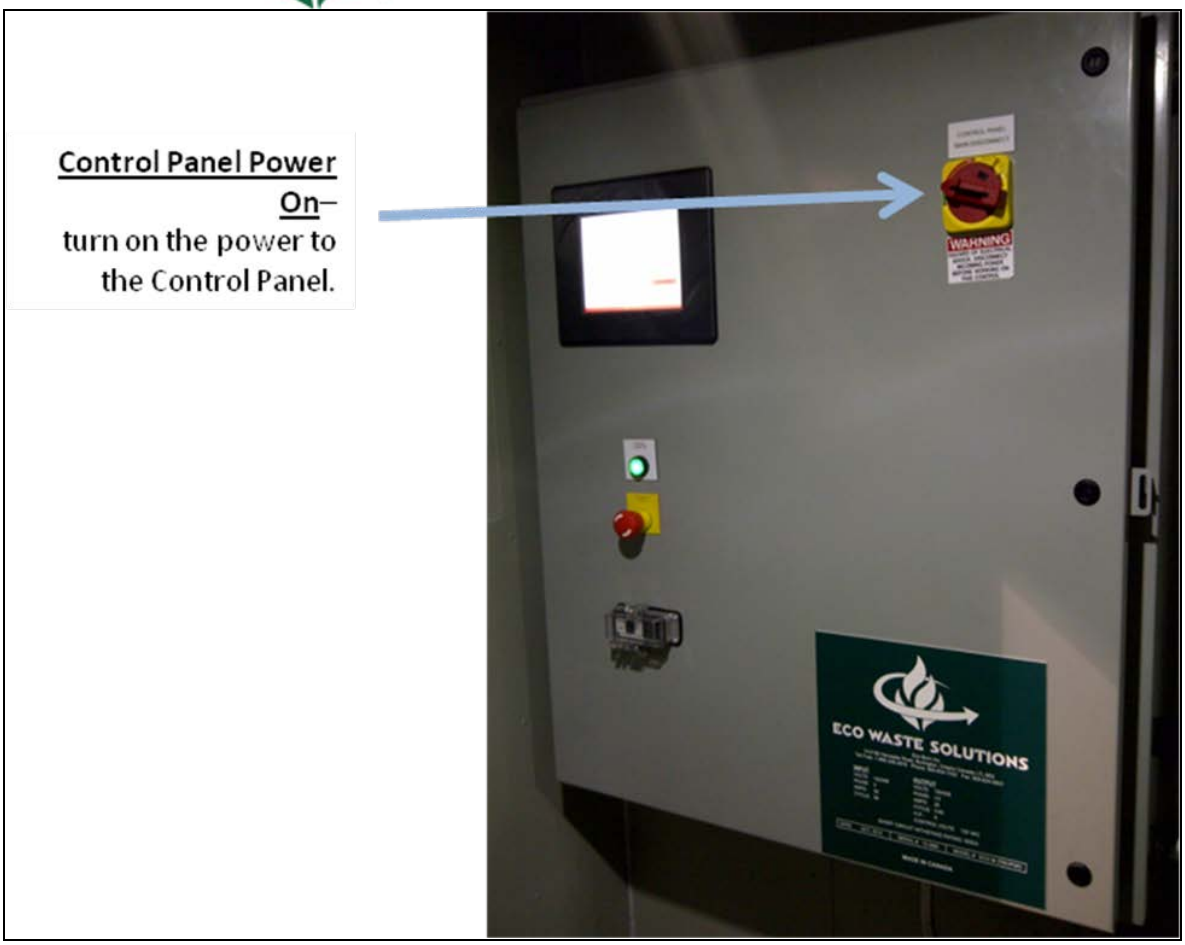
Feed the 600v 60Hz power into the bottom of the Main Disconnect Panel. After the Main Disconnect Panel, Control panel and junctions boxes have been connected, the main supply from the site can be turned on now.





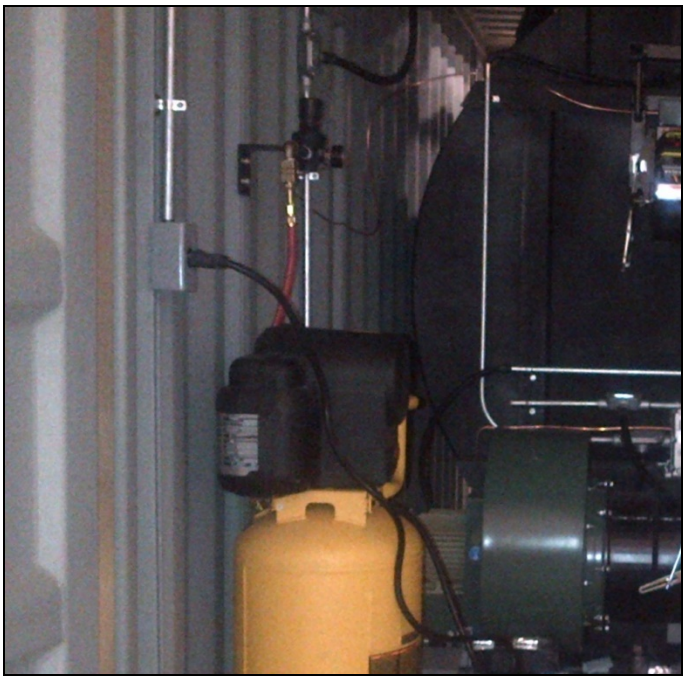
Switch on all incinerator breakers in the Breaker Panel

ECO WASTE SOLUTIONS



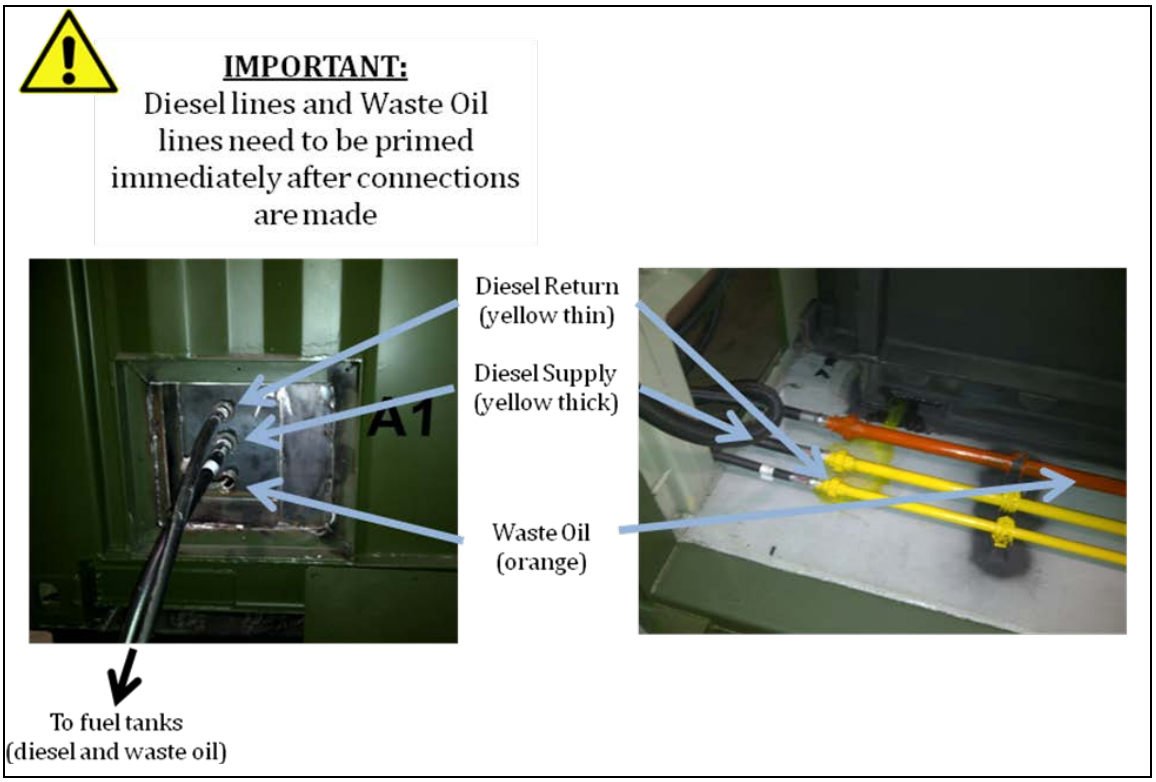
ECO WASTE SOLUTIONS

INTERNAL CONNECTIONS



Compressed air quick connect for Waste Oil Burner

Connect the air hose from the Waste oil Burner to the quick connect fitting

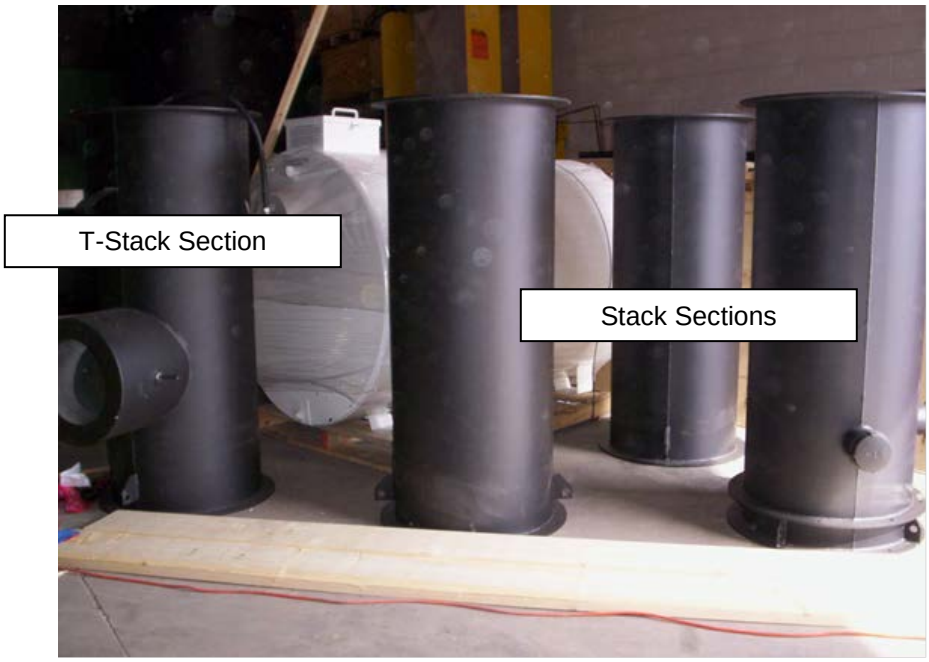


Feed wires for the tanks' level sensors and waste oil tank heater from the tanks through the opening beside the hose adaptors and connect to the junction boxes

Step 6: T-Stack and Stack Sections

Install stack gaskets between stack sections.

Install refractory-lined *T-Stack Section* on top of the *Secondary Chamber* using the hardware provided. Then install the next three *Stack Sections* as per the drawing using hardware provided.



T-Stack and Stack Sections

Propane Gas and Waste Oil Connections

<u>Reference</u>: Drawing ECOM2TNWO-GA-rB General Arrangement (GA)
Drawing ECOM2TNWO-P&ID

The Propane gas tank and evaporator are pre-assembled on a skid; the gas trains for the burners are pre-assembled to be installed in the building. The connection from the heavy ends trap in the tank skid to the building, including the low pressure regulator for the burners' gas train has to be carried on-site (by client's qualified contractors). There must be a proper clearance according to local regulations from the tank/evaporator skid to the containers. The complete propane installation has to be inspected and approved by the local authority (client's scope).

Propane Skid

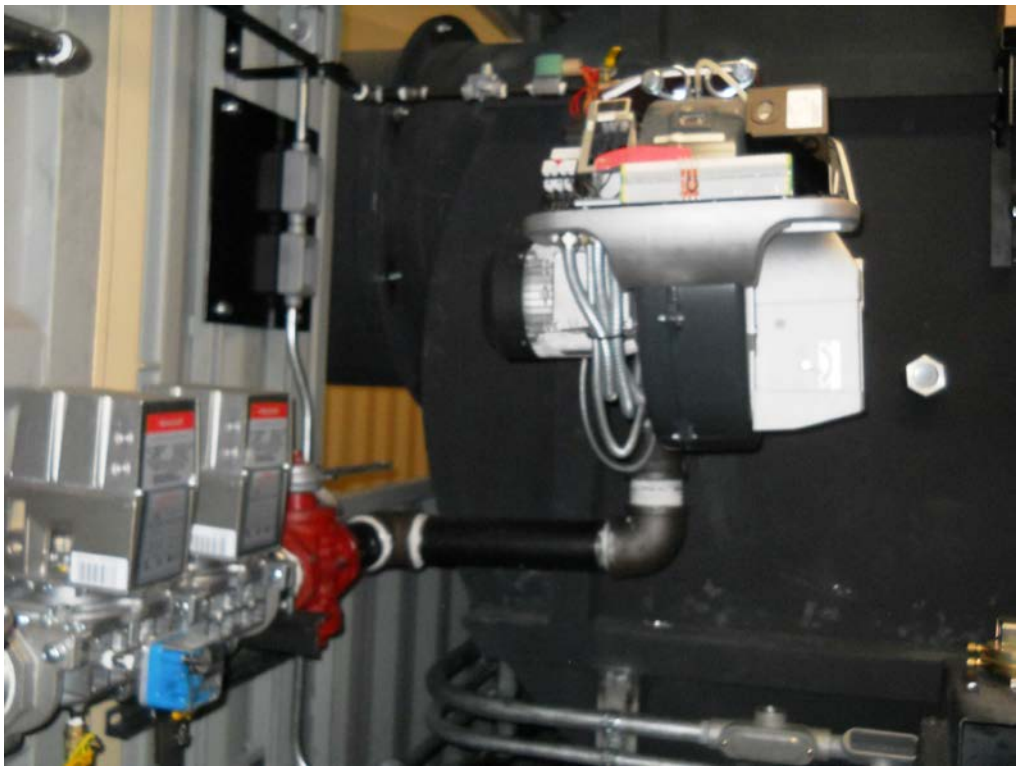
The propane gas trains required more space than the space available inside the closed containers. To accommodate the extended propane gas train an extension room is formed using the open container doors in the Primary and Secondary chamber at eh burners' end. The roof, floor and end wall with a man door are supplied for assembly on-site

Propane Gas train extension room (Primary and Secondary containers)

Propane Burner, Waste Oil Burner and Gas Train Primary Chamber

ECO WASTE SOLUTIONS

Propane Burner Gas Train Secondary Chamber



Propane Burner Secondary Chamber

NOTE All Propane Gas connections to be done by a certified technician and should satisfy all local codes (all lines to be pressured tested), including the distance between the incinerator system and the tank.

Step 16: Electrical Connections
Reference: Electrical Drawings provided

NOTE All electrical connections, terminations and conduit installation to be done by a certified electrician and should satisfy all local codes.

Most of the internal wiring of the incinerator was completed at the factory and dismounted for shipping.

The wiring necessary on-site (by client's contactors) is:

- From the *power source* to the *Main Control Panel*
- From the incinerator's building to the propane vaporizer
- From the *Main Control Panel* to components Junction Box
- From the breaker box to the propane vaporizer
- From the *Main Control Panel* to the waste oil tank

Step 17: Start-Up

NOTE **CAUTION**: Do not attempt to place the equipment into operation until an EWS Service Technician has checked out all equipment and interlocks.

Upon completion of mechanical erection, interconnection of equipment and provisions of utilities as described above, arrangements should be made with the EWS field service department for scheduling of a service technician for initial start-up.

An EWS representative must perform start-up of all incinerator systems unless specifically arranged otherwise in writing by EWS.

Attempts to start-up incinerator systems by the buyer without prior written approval may result in revocation of all expressed or implied warranties.

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 6

OPERATING INSTRUCTIONS

ECO M 2TNWO

Corporate Office:

Eco Waste Solutions

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Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

Important Information

Proper operating and maintenance procedures must be followed in order for the ECO Model Incinerator system to perform at maximum efficiency.

Do not attempt to start or operate this equipment until this Operator Manual is read thoroughly and is understood.

The equipment has been designed with many safety features, however, like all thermal processes; this equipment is not free from the inherent hazards of high temperature processes.

Safety procedures and precautions must be followed at ALL times during operation.

There are safety procedures outlined in this Manual, however, no amount of written instruction can replace good judgment and safe operating practices.

Responsibility for the safe operation and maintenance of the equipment supplied rests solely on those operating it.

There are many engineered features incorporated into the ECO Model Incinerator system to free the operator of repetitive chores. They do not, however, relieve the operator of maintenance responsibilities. In order to maximize the operating life of the equipment, it is strongly recommended that the maintenance procedures, be followed diligently. It is advisable to keep an equipment log for recording maintenance activities along with unusual operation.

NOTE

In the event that the equipment is not operating in the normal manner, contact Eco Waste Solutions immediately at (905) 634-7022. It is important to report problems as soon as they are noticed to minimize damage that faulty operation could cause.

Design Specification Criteria

The **ECO M2TNWO** incinerator system was designed specifically for the **Brucejack** project under **Eco Waste Solutions (EWS)** proposal **PRB-ECO M2TN** presented on July 8, 2014 and based on information provided by Pretivm Resources Ltd.

The **Brucejack Project** is a gold mine located 65 km north of Stewart in northwestern, BC; the EWS team designed an incinerator with the following criteria in mind.

Waste Description

The solid waste material generated at this site is described as mainly camp and kitchen waste.

EWS assumed that the waste material is typical of mixed camp waste, non-hazardous solid waste consisting of food-waste, kitchen waste including packaging, cardboard, wood waste, and general refuse.

In addition, there will be some dewatered sewage treatment sludge. All of the solid waste materials will be available each day and will be processed as a mixture.

Important Notes

- Sewage sludge must be dewatered (equipment provided by others) to a minimum of 25-30% solid content prior to loading into the incinerator proposed herein
- Dewatered sewage sludge will be added onto a layer of other solid camp wastes and will comprise no more than 20% of the batch by weight. It will be loaded into the Primary chamber by utilizing a shovel (provided by others)
- Kitchen grease and kitchen oils should be in limited quantities (up to a 2 ½ gallon pail) per batch
- The solid waste, oil rags (if available), kitchen grease and dewatered sewage sludge will need to be co-mingled to ensure that any wet low heat value waste is mixed with the other drier materials
- Regardless of recycling programs that may or may not be in place at site, it is assumed that the solid camp waste will include some plastic packaging and containers. This waste is expected to be bagged or stored in skips/bins around the mine operation then brought to the incinerator by truck.
- Inappropriate materials including, but not limited to, reactive/explosive chemicals and items containing heavy metals will not be processed in the incinerator proposed herein.

Acceptable Waste-Streams

The **Eco Waste Solutions Waste Oxidizer** can process a range of waste materials. The following list has some of the potential waste streams that can be effectively processed in our system. This list is only a guide and should not be assumed to be an exhaustive list of materials. Please contact EWS for more details.

ECO WASTE SOLUTIONS

Acceptable Waste Materials Suitable for Processing in Eco Waste Solutions Technology

Solid Waste	Description	Origin
Food Waste	Food, food packaging and containers, plastic and paper waste from food preparation	Kitchen and dining areas
Domestic waste	General refuse such as paper, plastics, cans, bottles, cardboard, newsprint	Dormitory areas, recreation facilities, office areas, warehouse, plant and production facilities
Packaging	Cardboard boxes, paper, plastic containers, plastic film, Styrofoam, poly-weave bags	Inbound supplies to all work areas.
Wood waste	Skids, pallets, crates, including wood materials contaminated with chemical residues from Cyanide or explosives	Construction activity, inbound supplies, reagent and chemical packaging.
Absorbents	Rags, wipes, spill cleanup materials	From all work areas
Filters – Air and Fluid	Filters coated with fine particles and trapped solids, saturated with water or fluids (glycol, lube oils, fuel)	From water treatment facility, or generated at point of maintenance of vehicles, machinery and equipment
Medical Waste	Bandages, dressings, gloves, swabs, syringes, sharps	Medical clinic or first aid centre
Tires & Rubbers	Tires, belts, hoses	From vehicles and equipment maintenance shop
Waste Oil	**Description**	**Origin**
Used Oils	Used lubricating and hydraulic oils, including synthetics	From vehicles and equipment maintenance shop
Semi-solid Waste	**Description**	**Origin**
Sewage sludge	Dry filter cakes	From sewage treatment plant dewatering equipment
Kitchen grease, oils	Solid kitchen fats, grease, used cooking oil	Kitchen grease traps, fryers

1. Dewatered sewage sludge and kitchen grease can be comingled with waste – restrictions apply.

Unacceptable Waste-Streams

The following is a list of some of the waste-streams that should not be processed in the Eco Waste Oxidizer. This list is only a guide and should not be assumed to be an exhaustive list of materials. Please contact EWS for more details and to discuss your specific waste processing requirements.

A waste and procurement audit is highly recommended and encouraged to ensure that all sources of heavy metals are identified and diverted to other disposal methods. Small amounts of materials containing heavy metals may be acceptable if air pollution control equipment specially designed for metals removal is included with the package.

Unacceptable Waste Materials - NOT Suitable for Processing in Eco Waste Solutions Technology

Solid Waste	Description	Origin
Bulky Materials	Automotive or heavy equipment parts such as engine blocks and transmissions	From vehicles and equipment maintenance shop
Non-Combustible Materials	Drywall, asbestos, bricks, concrete, soils	Construction activity
Radioactive Materials	Smoke detectors, laboratory wastes	From Buildings, laboratories
Potentially Explosive Materials	Aerosol spray cans, large propane tanks, other pressurized vessels. Actual explosives	From warehouse, plant and production facilities
Heavy Metals	Items containing lead, mercury, cadmium, for example: batteries, electronic devices, fittings, old pipe work, fluorescent light bulbs, electrical switches, thermometers, PVC plastics, aluminum solder, photovoltaic cells	From maintenance activities, operations and construction activities
Liquid Waste	**Description**	**Origin**
High Alkaline or High Acid Materials	By-products of industrial processes, unrefined fuels	From warehouse, plant and production facilities

Waste Quantity

According to **Pretivm,** there will be three camps during construction and one during operation. For the two-year construction phase, the camps will house 550 people. Once in operation, the camp will decrease to 330 people for the anticipated 24+ years operation of the mine.

Pretivm provided EWS with a detailed list of waste materials (table below). Some of the waste material has been deemed unacceptable and are highlighted in red font, but the majority of the waste streams are acceptable and will be processed accordingly in the incinerator.

ECO WASTE SOLUTIONS

Catalog	Material	Quantity			
		Supply		Waste	
Fluids/Oils/Fuels	Lubricants	1,038	L/yr	830	L/yr
	Grease	200	L/yr	160	L/yr
	Solvent	100	L/yr	80	L/yr
	Glycol	tbd			
	Engine Oils	15,000	L/yr	12000	L/yr
	Waste Hydr Oil	18,000	L/yr	14400	L/yr
	Waste Trans Fluid	300	L/yr	240	L/yr
	Brake Oil	30,000	L/yr	24000	L/yr
	Engine Cool	3,000	L/yr	2400	L/yr
	Axel Oil	11,000	L/yr	8800	L/yr
	Jet Fuel	10,000	L/yr	-	L/yr
Camp	Cleaning Supplies, including bleach, dishwashing powder, soaps, laundry detergent	4	t/yr	-	t/yr
	General Camp Waste, including bottles, cans and cups		t/yr	200	t/yr?
	Waste Foods		t/yr	60	t/yr
	Propane - Kitchen	3,500	gal/yr	-	gal/yr
Others	Plastic Drums		pieces/yr	150	pieces/yr
	Tote Bags		t/yr	23	t/yr
	Cardboard Boxes		t/yr	30	t/yr
	Woods/Pallets		t/yr	20	t/yr
	Fluorescent tubes/bulbs		pieces/yr	100	pieces/yr
	Batteries		pieces/yr	800	pieces/yr
	Printer/ Copier Toner Cartridges		pieces/yr	40	pieces/yr
	Paints		L/yr	250	L/yr
	HDPE Pipes		m/yr	1,700	m/yr
	Air Hose		m/yr	500	m/yr
	1" Water Hose		m/yr	500	m/yr
	Paint Cans		pieces/yr	3,500	pieces/yr
	Hydraulic Hose		m/yr	800	m/yr
	1200 mm Vent Bag		m/yr	1,000	m/yr
	Filters				
	- Fuel Filter	800	piece/yr	800	piece/yr
	- Air Filter	800	piece/yr	800	piece/yr
	- Hydraulic Oil Return Filter	300	piece/yr	300	piece/yr
	- Brake Hydraulic Oil Return Filte	600	piece/yr	600	piece/yr
	- AC Filter	600	piece/yr	600	piece/yr
	- Transmission Oil Filter	300	piece/yr	300	piece/yr
	- Oil Filters	800	piece/yr	800	piece/yr
	Sewage Sludge		t/yr	15	t/yr
	Tailings *		t/yr	821,455	t/yr
	Waste Rocks *		t/yr	198,591	t/yr
	Sludge from Water Treatment Pla		t/yr	1500-3000?	t/yr TBD

It is important to note that the waste materials and corresponding volumes (as seen in the table) is based on a population of 330 people only (not 550, which is the higher population, during the construction phase). Pretivm advises us that they were only able to provide us with a **partial list**, of waste materials, at this time.

Based on the table, EWS performed calculations to determine the total volume of acceptable solid waste generated at the camps, including their waste characteristics (total moisture content, average waste density and average heat value). See table 1 below:

Table 1: EWS Calculations of Waste Volume & Waste Characteristics

Solid waste Mixed With Sewage Sludege												
Waste Category	% of Total MSW Stream	kg/year	Condition	As-Received Heat Value,HHV	Heat Value Percentage,HHV	H_2O content		Ash Content		Bulk Density	Specific Volume	
				Btu/lb	Btu/lb	% Wt	Percentage	% Wt	Percentage	Lb/ft^3	ft^3/lb	Percentage(ft^3/lb)
General Camp Waste	61.3%	*200000*	*Solid*	*6500*	*3984*	*30%*	*18.39%*	*5%*	*3.06%*	*10.00*	*0.100*	0.06
Waste Foods	18.4%	*60000*	*Solid*	*3000*	*552*	*55%*	*10.11%*	*15%*	*2.76%*	*18.00*	*0.056*	0.01
Cardboard Boxes	9.2%	*30000*	*Solid*	*6400*	*588*	*15%*	*1.38%*	*6%*	*0.55%*	*18.00*	*0.056*	0.01
Woods/Pallets	6.1%	*20000*	*Solid*	*7000*	*429*	*23%*	*1.41%*	*7%*	*0.43%*	*35.00*	*0.029*	0.00
HDPE Pipes	0.1%	*340*	*Solid*	*13200*	*14*	*4%*	*0.00%*	*1%*	*0.00%*	*2.00*	*0.500*	0.00
Air Hose	0.0%	*100*	*Solid*	*13200*	*4*	*4%*	*0.00%*	*1%*	*0.00%*	*2.00*	*0.500*	0.00
1" Water Hose	0.0%	*100*	*Solid*	*13200*	*4*	*4%*	*0.00%*	*1%*	*0.00%*	*2.00*	*0.500*	0.00
Hydraulic Hose	0.0%	*160*	*Solid*	*13200*	*6*	*4%*	*0.00%*	*1%*	*0.00%*	*2.00*	*0.500*	0.00
1200 mm Vent Bag	0.1%	*200*	*Solid*	*8700*	*5*	*10%*	*0.01%*	*3%*	*0.00%*	*10.00*	*0.100*	0.00
- Fuel Filter	0.0%	*80*	*Solid*	*14100*	*3*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
- Air Filter	0.0%	*80*	*Solid*	*14100*	*3*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
- Hydraulic Oil Return Filter	0.0%	*30*	*Solid*	*14100*	*1*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
- Brake Hydraulic Oil Return Filter	0.0%	*60*	*Solid*	*14100*	*3*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
- AC Filter	0.0%	*60*	*Solid*	*14100*	*3*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
- Transmission Oil Filter	0.0%	*30*	*Solid*	*14100*	*1*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
- Oil Filters	0.0%	*80*	*Solid*	*14100*	*3*	*5%*	*0.00%*	*5%*	*0.00%*	*3.00*	*0.333*	0.00
Sewage Sludge	4.6%	*15000*	*Semi-Solid*	*1000*	*46*	*80%*	*3.68%*	*10%*	*0.46%*	*50.00*	*0.020*	0.00
TOTAL	***100.0%***	***326320.00***	***Solid***	***5651***		***35.0%***		***7.3%***		***12.369***	***0.081***	

To summarize the table above, EWS has prepared this table below:

Table 2: Summary of EWS Calculations of Waste Assumptions

Waste Description	Annual Waste Volume Generated	Daily Waste Volume Generated	Total Moisture Content	Average Waste Density	Average Heat Value
Mixed Solid Camp Waste Material	~330,000 kg	~894 kg	Up to 35%	12 lbs/ft^3	5600 BTU/lb

Based on the table, EWS performed calculations to determine the total volume of acceptable waste oils generated at the camps, including their waste characteristics (total moisture content and average heat value). See table 1 below:

Table 3: EWS Calculations of Waste Oils

Catalog	Material	Waste Quantity	Unit
Fluids/Oils/Fuels	Lubricants	830	L/yr
	Engine Oils	12000	L/yr
	Waste Hydr Oil	14400	L/yr
	Waste Trans Fluid	240	L/yr
	Brake Oil	24000	L/yr
	Axel Oil	8800	L/yr
	Total	60270	L/yr
	Flow Rate Daily	231	L/Day @ 5 days/week
	Flow Rate Hourly	38	L/Hr @ 6 hr/day
		10	GPH
	Assuming HHV	125000	Btu/Gallon
	Heat Output	1271023	Btu/Hr
	Air Capacity	12710	SCFH

To summarize the table above, EWS has prepared this table below:

Table 4: Summary of EWS Calculations

Waste Description	Annual Waste Oil Volume Generated	Daily Waste Oil Volume Generated	Total Moisture Content	Average Waste Density	Average Heat Value
Waste Oils	~60,270 L	~231 L	Up to 5%	n/a	12,5000 BTU/lb

However, as Pretivm indicated that this list was based on only 330 people and not 550 and that it was only a **partial list** of waste materials generated at the mining camps, EWS resorts to past experience working with mining clients in remote locations to determine the appropriate sizing of the incinerator package for the **Brucejack Project.**

To calculate the **solid waste generation** daily rate at any given mine site, EWS typically uses a per capita waste generation rate or “rule of thumb” of 2 kg per person per day.

Also, EWS uses an industry standard per capita waste generation rate of 0.75 kg to calculate the amount of **dewatered sewage sludge** produced on any given day at the mine site.

Please see table below for more information:

Table 5: EWS Per Capita Waste Generation Rates

Waste Material Description	Per Capita Waste Generation Rate
Mixed Solid Camp Waste	2.0 kg
Dewatered Sewage Sludge	0.75 kg
Total Mixed Waste Material Per Capita Waste Generation Rate	**2.75 kg**

It is assumed that the **waste oils** generated will not be affected by the size of the camp population and therefore believe that the waste oils generated at the mine site will remain the same as calculated in **Table 3: EWS Calculations of Waste Oils** and summarized in **Table 4: Summary of EWS Calculations.**

Therefore, based on this rule of thumb for solid waste, EWS calculates that approximately **1513 kg** of solid mixed waste material will be generated per day during the construction phase and up to **908 kg** per day during the operation phase. Please see table below for EWS calculations:

Table 6: EWS Calculated Daily Waste Generation by Project Phase

Project Phase	Population	Total Per Capita Waste Generation Rate	Total Daily Waste Generation Rate
Construction Phase	550	2.75 kg	1513 kg/day
Operation Phase	330	2.75 kg	908 kg/day

EWS Waste Assumptions

To compare, based on EWS past experience working with remote mine sites, the table below summarizes EWS typical waste assumptions which is very similar to the waste characteristics calculated in **Table 2: Summary of EWS Calculations of Waste Assumptions.**

Table 7: EWS Waste Characteristic Assumptions

Description	Total Moisture Content	Average Waste Density Range	Average Heat Value
Mixed Solid Camp Waste Material	Up to 45%	10-15 lbs/ft^3 160-240 kg/m^3	5000 BTU/lb 11655 KJ/kg

Addressing Waste Oil

To address the need of disposing waste oils generated at site, the ECO M2TNWO has two (2) **Waste Oil Burner (WOB) Packages**

These WOBs can dispose of the acceptable waste oils available on site and function as a fuel source to operate the incinerator system, in lieu of propane. This packaged burner will not only dispose of the waste oils in an environmentally sound manner, but it will also decrease the daily operating costs of the waste incinerator system.

To address the need of disposing any waste oils generated at site a **Waste Oil Burner (WOB) Package,** has been integrated as part of the incinerator system to dispose of up to 20 L/hr of waste oil

Waste Oil Specifications

•Each Waste Oil burner is designed to burn up to 10 L/hr of the following fuels:

Used crankcase oil up to 50 SAE
Used transmission fluid
Used hydraulic oils
#2 fuel oil
#4 fuel oil
#5 fuel oil

NOTE: Used oils may contain other substances, including gasoline, which may hinder performance.

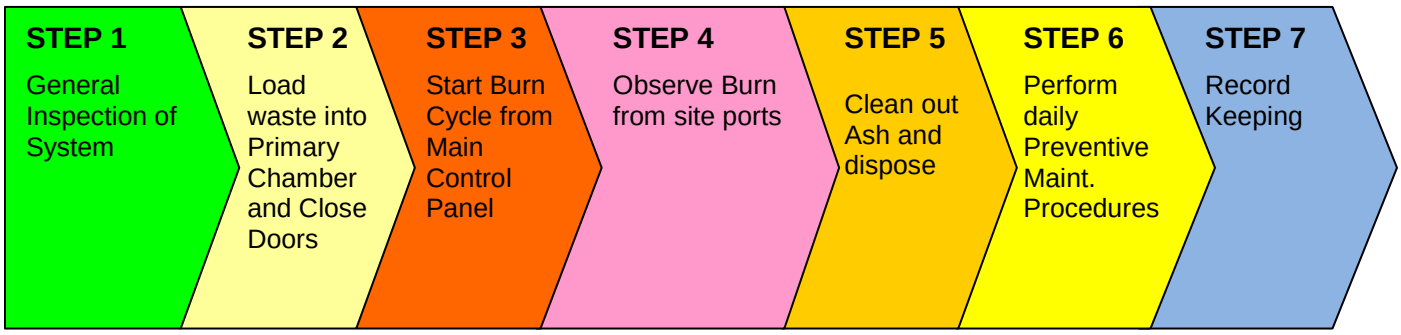
• Hazardous wastes, such as chlorinated solvents, are NOT to be mixed with your used oil

NOTE

This incinerator was only designed for the type of waste and amount of waste mentioned above. It is important that the waste quantities and characteristics described above are processed in the incinerator. Otherwise, the incinerator system will not operate properly.

General Operating Overview

The operation of the **ECO M2TN WO Waste Incinerator** follows 7 general steps that take place over a 12-hour period.



Although all 7 steps are critical in the general operation of the incinerator system, this section of the manual focuses on **Step 1, Step 3** and **Step 4** and how to start the system and monitor it during operation.

This section will also cover **Step 7** on how to use the historical charts, store incinerator data, and access incinerator historical information for record keeping purposes.

Monitoring and Data Acquisition System

Overview

The **PLC** automatically monitors the entire process and some system inputs are recorded and logged for record-keeping purposes and also allows for historical trending of key operating conditions.

The integrated **PLC** in the Main Control Panel monitors and records the following:

1. Temperature sensors
2. Differential pressure sensors with transmitter (draft)
3. Monitoring of burner faults
4. Fan amperage monitoring via current transducer and VFD
5. Door position interlock monitoring
6. High temperature limit and interlock
7. Damper positions

All data can be transferred to storage by using the USB flash memory installed in the back of the HMI

Data Logging

Data from the Incinerator is logged automatically on the HMI and will need to be manually retrieved from the HMI.

Using Historical Charts

Accessing Historical Information

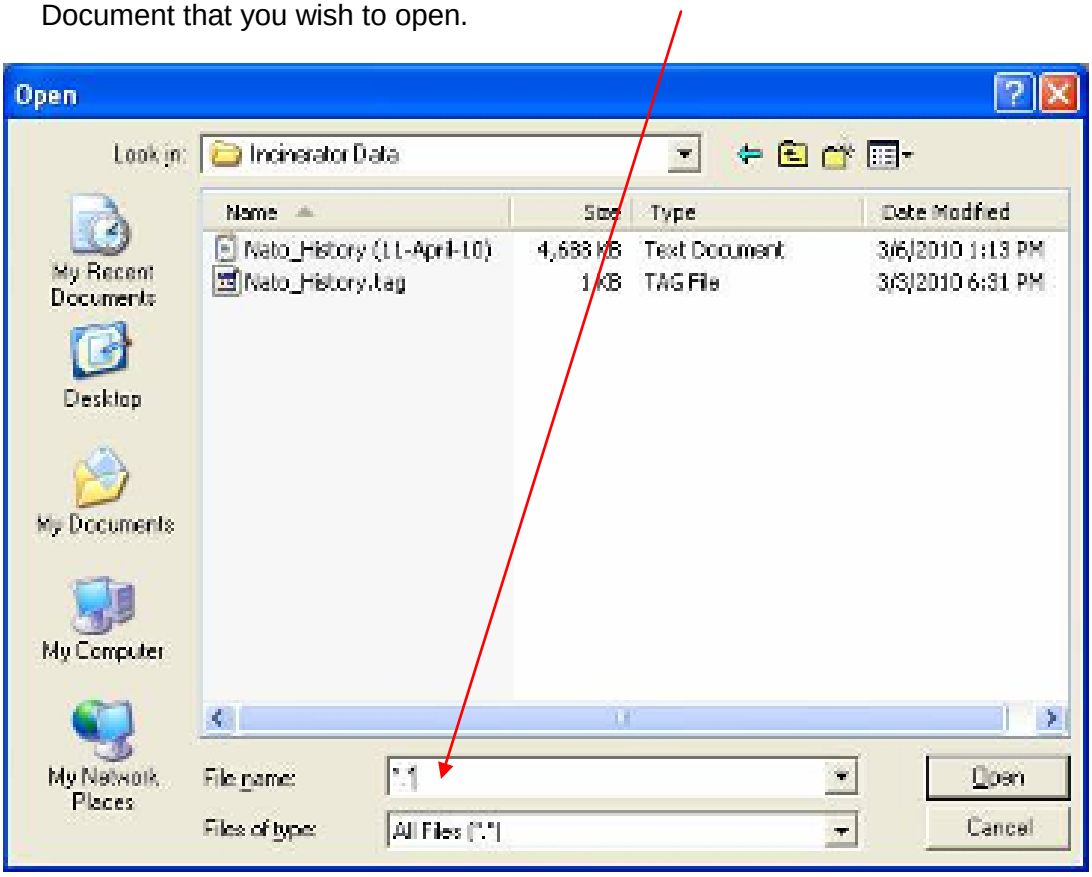
a. It is recommended that a dedicated folder be set on the destination computer that is used for storing data from the Incinerator Package (e.g. “Incinerator Data”)

b. Copy the data file “**RSView Enterprise Viewer.EXE”** from the USB Flash Memory (extracted from the back of HMI, in the panel) to this dedicated directory. Only has to be done the first time

c. Copy and rename the text file with the date to easily access previous week’s information.

d. To open data, double click on the RSView Enterprise Viewer application. From the File menu select Open. Make sure you are searching in the folder containing the historical data files.

e. In the Open dialogue box, in the File Name type **“ *.* ”** to view all files. Click on the specific Text Document that you wish to open.



f. Once the data is open, it will look similar to the following:

RSView Enterprise File Viewer - [List View - Nato_History (11-April-10)]

File Tools View Window Help

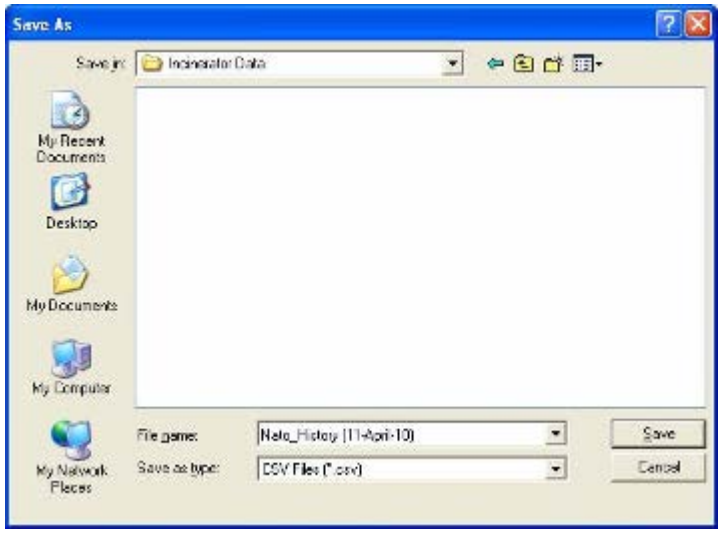
Date	Time	Millm	Marker	TagIndex	Status	Value
3/5/2010	05:52:30	687		6		212.00000000
3/5/2010	05:52:30	687		7		37.00000000
3/5/2010	05:52:30	687		8		44.00000000
3/5/2010	05:52:30	687		9		10.19964886
3/5/2010	05:52:30	687		10		249.00000000
3/5/2010	05:53:30	694		0		6.63999987
3/5/2010	05:53:30	694		1		0.03000000
3/5/2010	05:53:30	694		2		0.14000000
3/5/2010	05:53:30	694		3		43.00000000
3/5/2010	05:53:30	694		4		-0.08000000
3/5/2010	05:53:30	694		5		21.00000000
3/5/2010	05:53:30	694		6		209.00000000
3/5/2010	05:53:30	694		7		37.00000000
3/5/2010	05:53:30	694		8		44.00000000
3/5/2010	05:53:30	694		9		10.17622456
3/5/2010	05:53:30	694		10		251.00000000
3/5/2010	05:54:30	690		0		7.44000006
3/5/2010	05:54:30	690		1		0.03000000
3/5/2010	05:54:30	690		2		1.39999998
3/5/2010	05:54:30	690		3		42.00000000
3/5/2010	05:54:30	690		4		0.00000000
3/5/2010	05:54:30	690		5		21.00000000
3/5/2010	05:54:30	690		6		207.00000000
3/5/2010	05:54:30	690		7		36.00000000
3/5/2010	05:54:30	690		8		43.00000000
3/5/2010	05:54:30	690		9		10.20361614
3/5/2010	05:54:30	690		10		252.00000000
3/5/2010	05:55:30	688		0		8.65999985
3/5/2010	05:55:30	688		1		0.03000000
3/5/2010	05:55:30	688		2		-0.69000000
3/5/2010	05:55:30	688		3		40.00000000
3/5/2010	05:55:30	688		4		-0.08000000
3/5/2010	05:55:30	688		5		21.00000000
3/5/2010	05:55:30	688		6		206.00000000
3/5/2010	05:55:30	688		7		35.00000000

Total record number: 44022 Selected record:

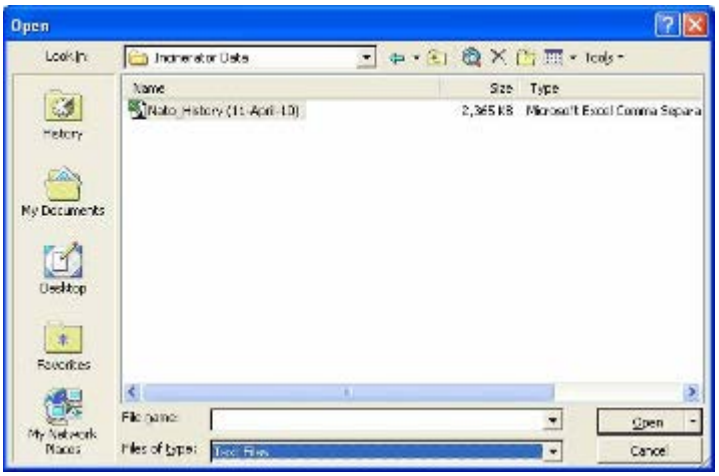
Ready

Saving Data to Excel

a. To save the data in a Microsoft Excel format – with the data open (as above) from the File menu select Save As and select the directory where you wish to save the file. Make sure you have a logical name in the File Name field (it will default to the same file name as the TXT file you have opened). Make sure CSV is selected in the "Save as Type" drop down box and select the Save button.



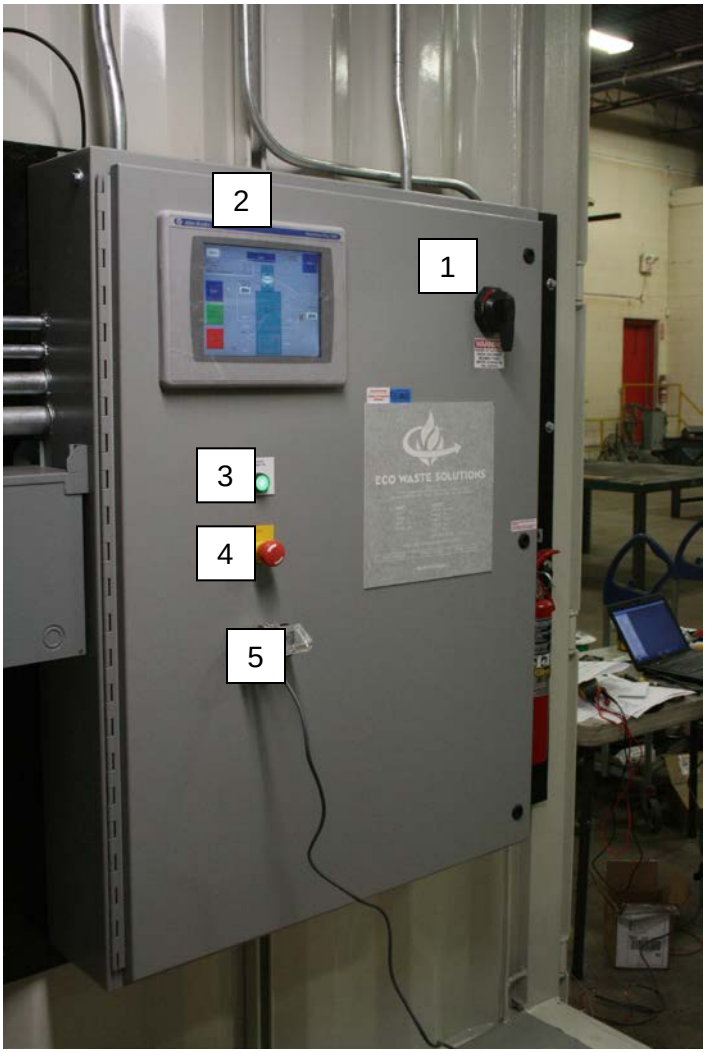
b. To view the file in Microsoft Excel, open the Excel application and from the File menu, select Open and then make sure that "Files of Type" is on "Text Files"



c. Choose the file you wish to open and select "Open" from the dialogue box. The file is now open in Excel.

HMI Operator Interface

Main Control Panel Components



Number	Name	Purpose
1	**Main Disconnect Switch**	Isolates the incinerator from its source of electric power.
2	**HMI Operator Interface**	Displays various screens reflecting system performance.
3	**Control Power ON**	1. Green light indicates the control power in the panel is on. 2. Pushing it if the **Emergency-Stop** is out will turn on the control power.
4	**Emergency Stop Pushbutton**	Stops the cycle if it is on and disables any possibility of starting it.
5	**Programming Port**	Allows access to PLC and HMI

The HMI Operator Interface

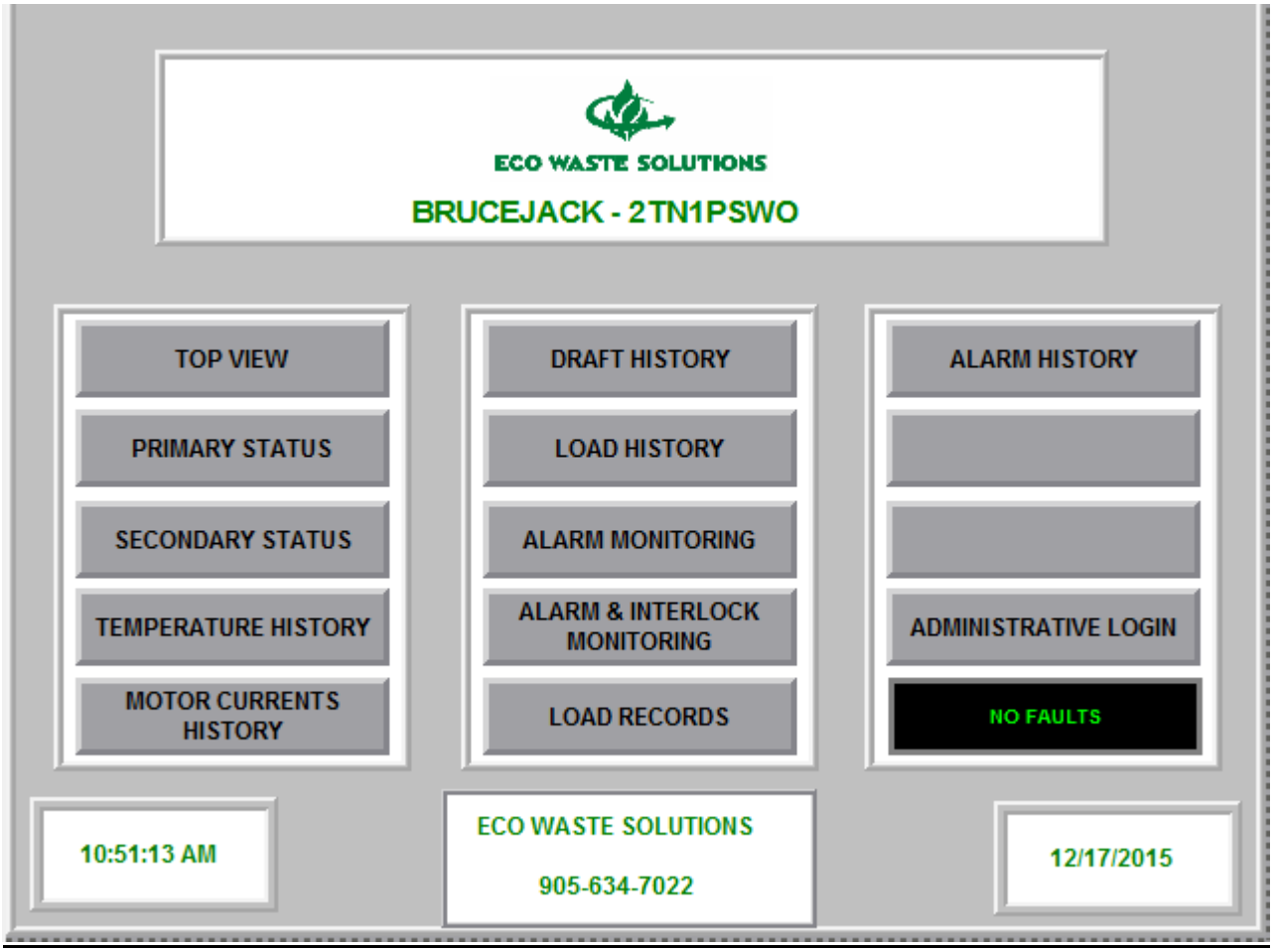
The **HMI Operator Interface** controls the operation of the incinerator directly from the **Main Control Panel.**

The **Main Menu** screen displays all the available options for viewing the system in operation.

The **HMI** has a touch-screen and items can be selected by touching them on the screen.

Main Menu

The first screen the operator will view is the **Main Menu** (see below).



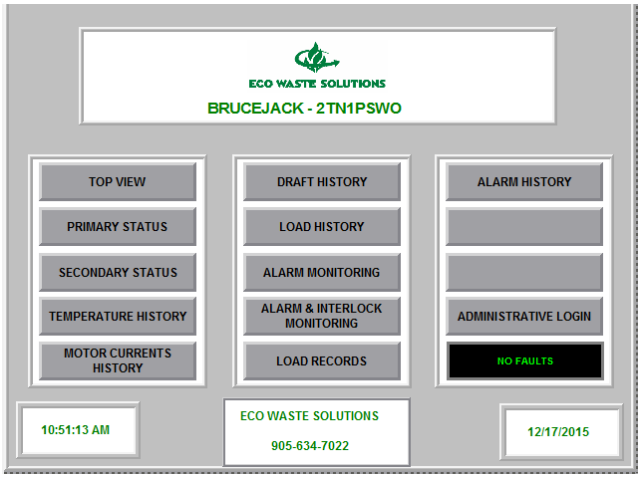
Front View

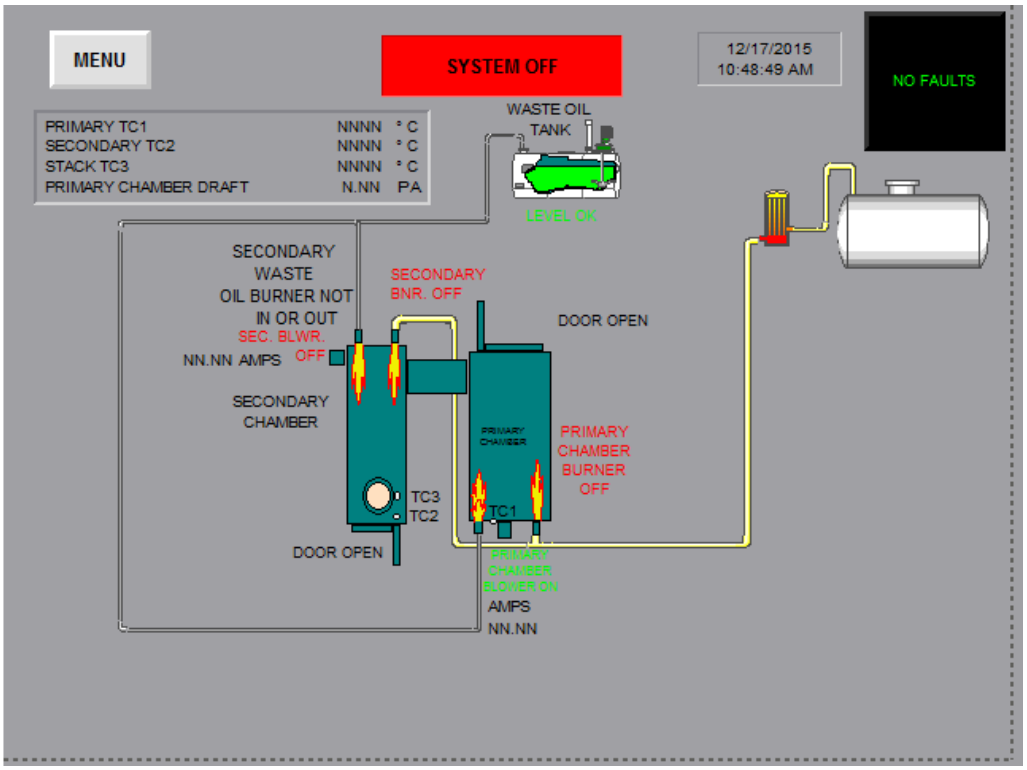
When the ***Top View*** button is selected, an overview of the incinerator and related components is displayed. This shows key temperatures, flows, and other indicators of what is happening in the process in a real-time basis.

NOTE

The system will not start if there are alarms or faults present.

At any time, touch **Main Menu** to go back to the main screen.





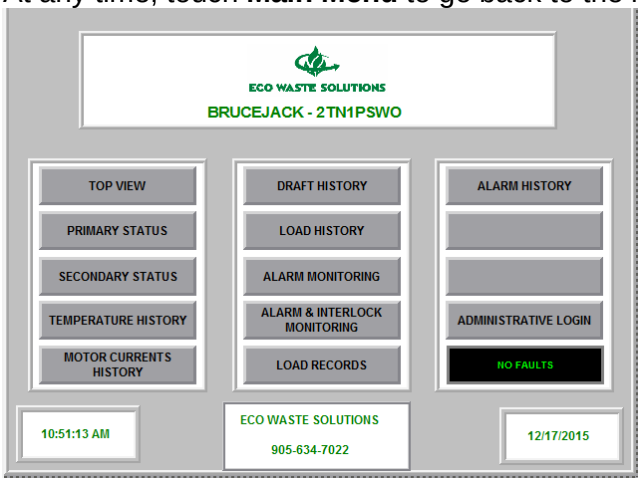
Primary and Secondary Status

When the ***Primary Status*** **or Secondary Status** button is selected from the **Main Menu,** a screen will display the status of all the operating parameters of the Primary Chamber or Secondary Chamber accordingly, such as the temperatures and the time remaining in the cycle, as well as displaying other informational items such as status of the door and blowers, etc.

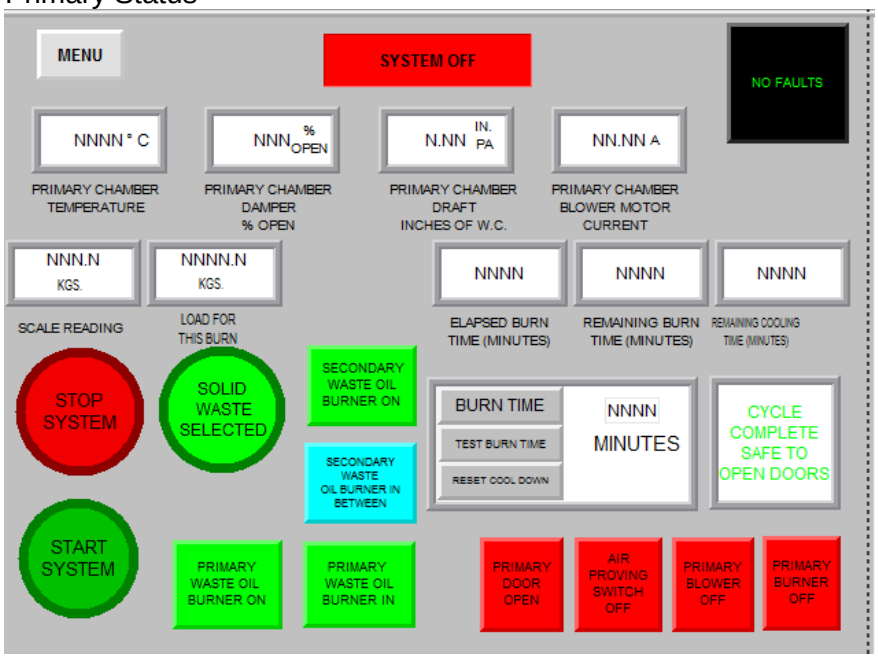
On the Primary Status screen, the operator can change the burn time of the cycle by selecting “BURN TIME” and entering a time (in minutes), to either prolong the burn time, or decrease the burn time depending on the waste mixture; for example a very wet batch of garbage will take more time to burn than a dryer waste.

In this Primary Status screen the burning of waste oil can be selected and where system is started

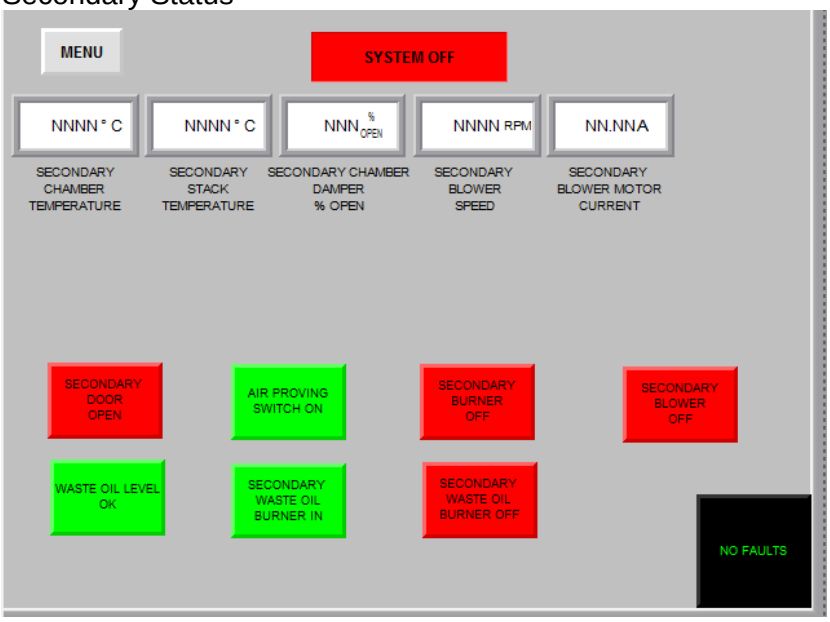
At any time, touch **Main Menu** to go back to the main screen.



Primary Status



Secondary Status

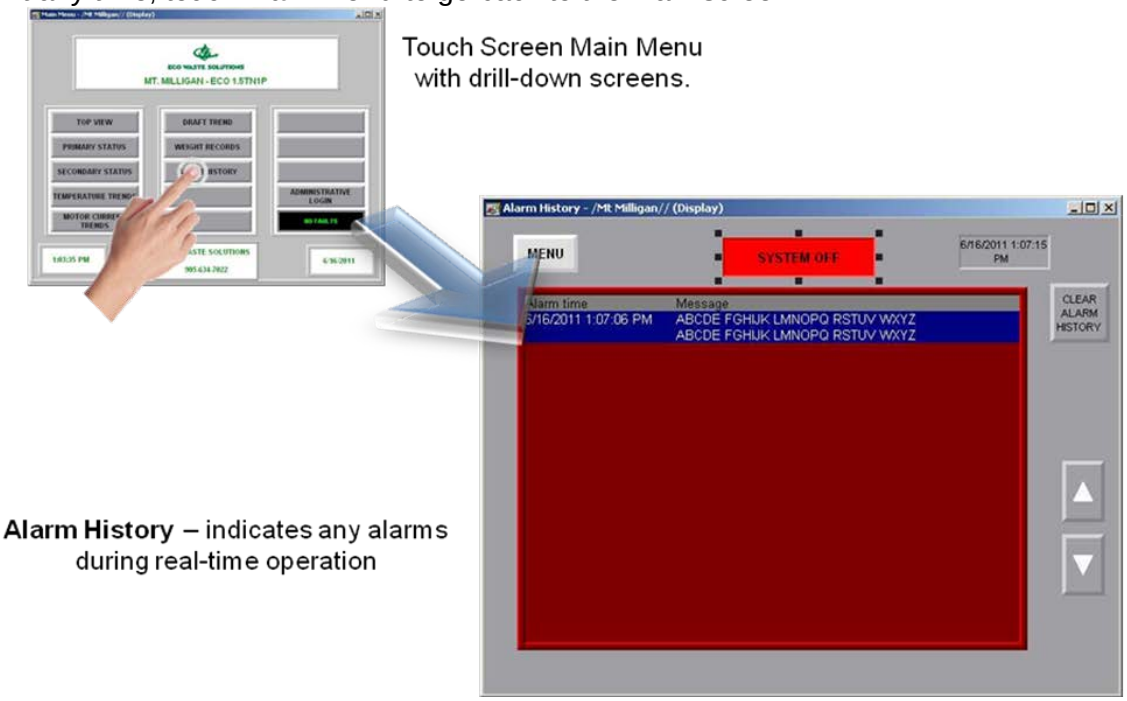


Alarm History

When the ***Alarm History*** button is selected a screen will display the last 128 faults with the date & time of occurrence.

The operator can press the *CLEAR ALARM HISTORY* to clear all of the faults, if they wish to. This does not affect the record-keeping feature of the system.

At any time, touch **Main Menu** to go back to the main screen.



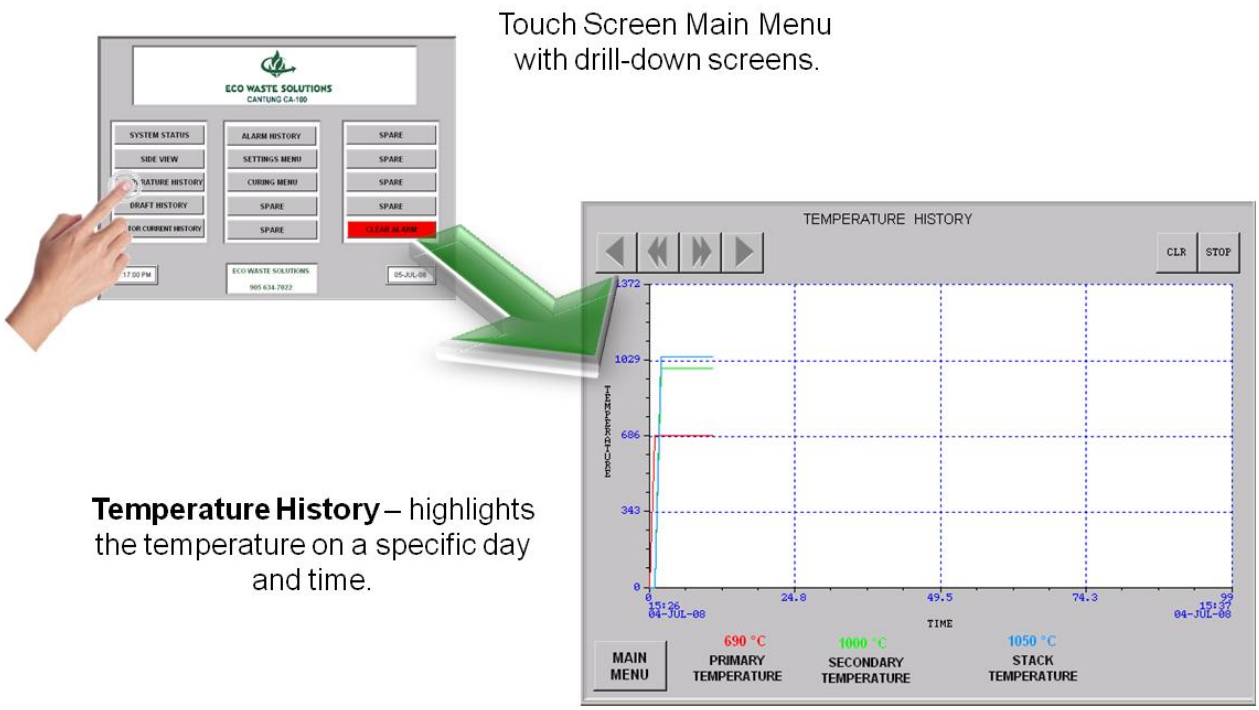
Overview of Historical Charts

The **HMI** operator interface monitors and records (every minute) critical operating parameters of the incinerator system like the temperature, motors, draft, load weights and alarms. Each operating parameter has its own graphic display for the operator to view, at any given time. Each display can easily be selected from the **Main Menu** of the **HMI**. The display will show the specific data collected from previous burn cycles.

This **Incinerator Data** is important for regulatory purposes and for general operating purposes.

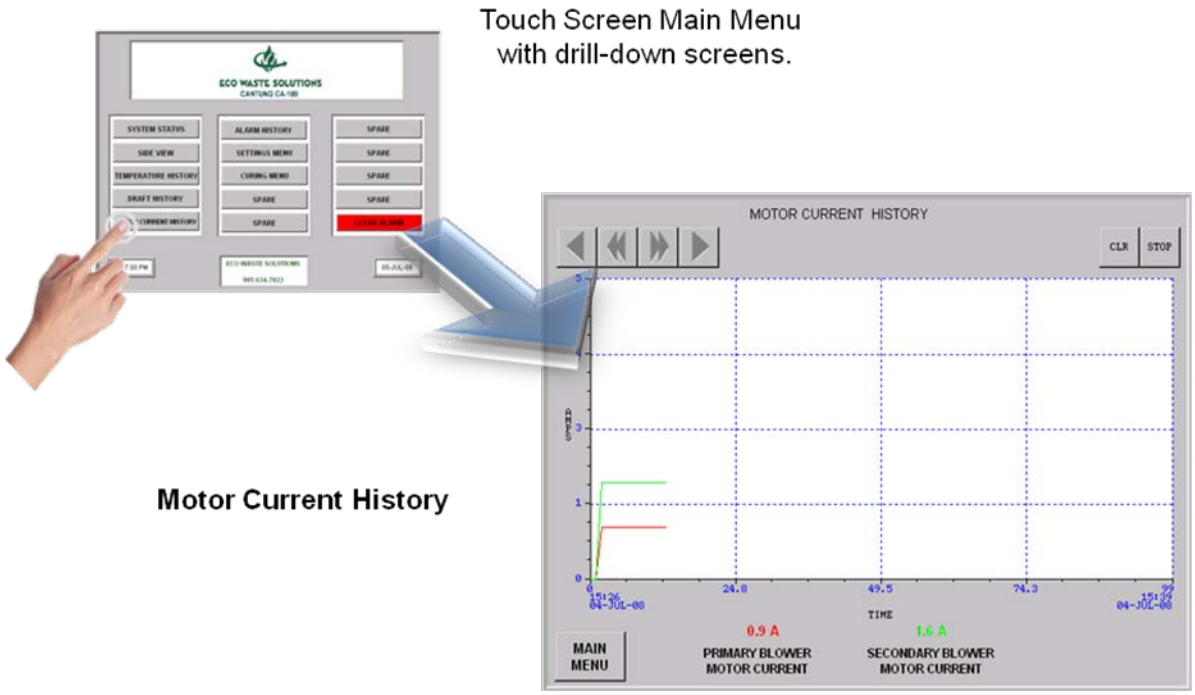
Temperature History

For example, when the ***Temperature History*** button is selected, the screen will display the trend in temperature during the operation of the system, include date & time of occurrence of that specific temperature.



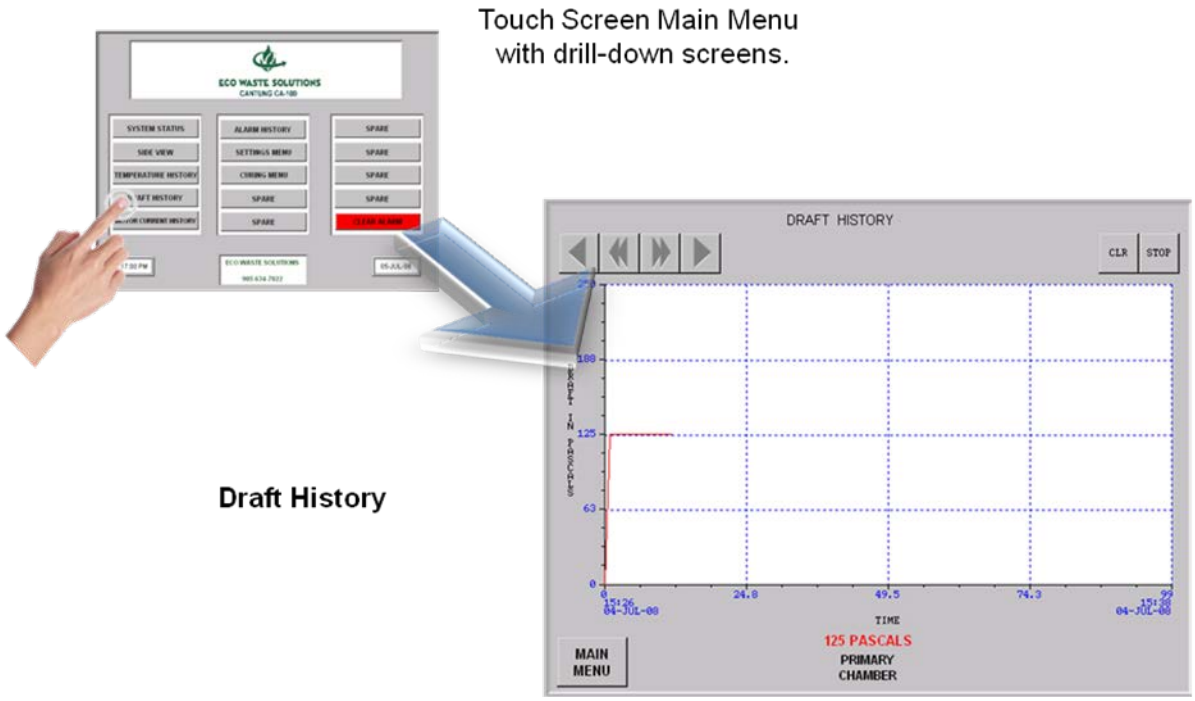
Motor Currents History

When the ***Motor Currents History*** is selected a screen will display the motor currents from the Primary Burner and the Secondary Burner, in AMPS, during the operation of the system, including date & time of occurrence of that specific motor current.



Draft History

When the ***Draft History*** button is selected a screen will display the draft during the operation of the system, include date & time of occurrence of that specific draft trend.



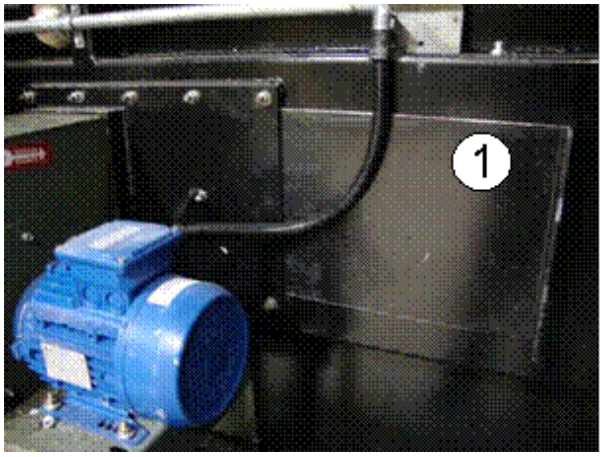
Standard Daily Operating Procedures

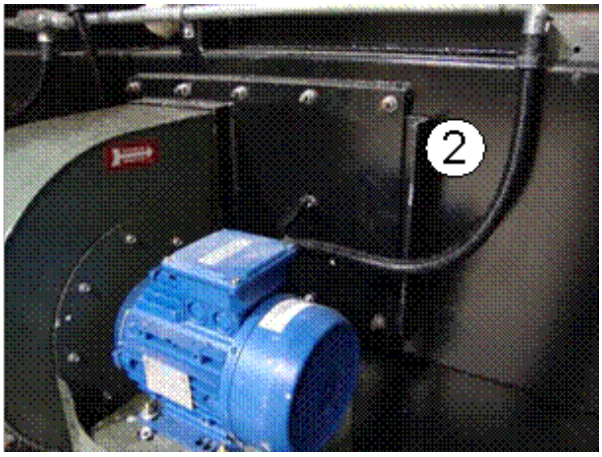
Daily Circular Inspection

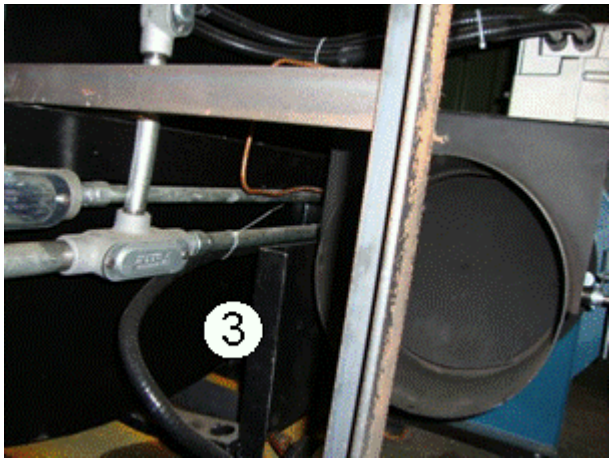
1. Check that all valves leading to the burners are open
2. Check that the slide gates on the blowers are open
3. Check waste oil valves from tank to burner are open and lines leak free
4. Check that all circuit breakers are in the “ON” position
    - In the main breaker panel
    - For the propane skid, check the circuit breaker in the primary container to ensure the vaporizer has power. The vaporizer should feel warm to the touch
5. Fix any items found incorrect.

Incinerator Daily Start up

1. Ensure that manual slide gates for each blower are in the open position for free airflow into the **Primary and Secondary Chambers**

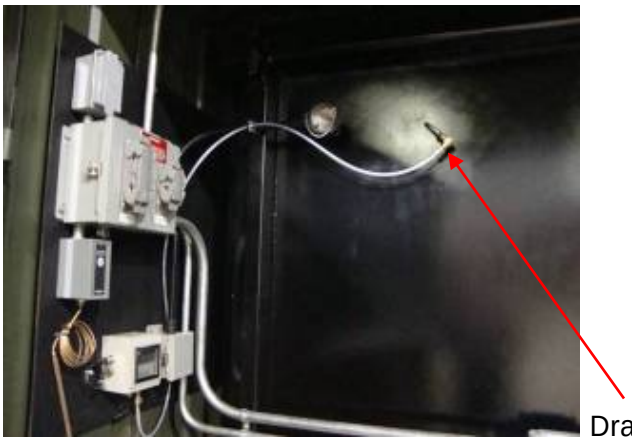






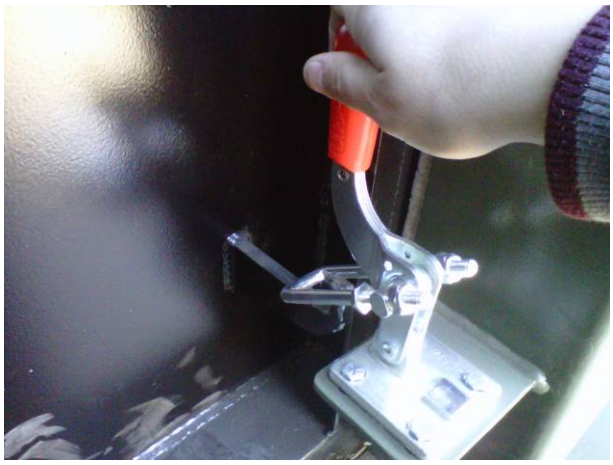
1. Primary Chamber blower Manual Slide Gate Open Position
2. Primary Chamber blower Manual Slide Gate Closed Position
3. Secondary Chamber blower Manual Slide Gate Open

2. If propane odour is noticed, visually inspect the burner piping to ensure that there are no gas leaks.
3. Ensure the draft gauge connection is tight and sealed. This is tubing located in the back of the **Primary Chamber.**



Draft Gauge Hose connection

4. Unlatch clamps on the **Primary Chamber** door, open and secure in the open position



5. Ensure the Primary Chamber floor is cool (less than 50°C). Remove all the ash from the previous burn and store ash in ash bins.

If the floor is hotter than this temperature the waste may spontaneously catch on fire during loading.

6. Tips for loading. The following loading procedure will decrease burn time and allow for more uniform burn.
   a. Load the less dense waste first
   b. Load dry waste first. Placing wet waste near the top of the Primary Chamber allows moisture to evaporate early in the cycle.

c. Place waste on the weigh scale, once the waste is on the weigh scale the Operator has to push the RECORD WEIGHT (black button) on the Weigh Scale Push-Button Station. By pressing this button, the weight value of that particular load of waste is sent to the PLC and the weight is recorded. At this time, the MAXIMUM WEIGHT (green button) will flash green once to show that the weight has been logged.

d. Then, the operator must take the waste and load it into the Primary Chamber.

e. The operator returns to the weigh scale with some more waste and repeats Steps c and d. This entire procedure is repeated until the maximum load weight for the Primary Chamber is reached. The PLC will indicate this to the operator when the MAXIMUM WEIGHT (green light) comes on and remains on. This indicates that the maximum weight permitted, in this case, the incinerator is designed for a maximum of 2,000 kg of waste material.

f. The Primary Chambers are loaded, and the incinerator is ready to start.

NOTE

No more waste should be loaded into the Primary Chamber after the load has reached the maximum weight, or in the case of lower density waste, the chamber is ¾ full (the burner requires open space in front of it to allow for a proper flame)

NOTE

Do not throw the waste towards the sides of the Primary Chamber. Doing so will damage the ceramic fiber refractory.

NOTE

Load only the waste stream that the system has been designed for. DO NOT load a lot of high BTU rated waste for one burn (i.e. do not load three (3) 5 gallon pails of bacon grease or wood only). Doing so will result in excessive temperatures in the system reducing the life of the refractory.

NOTE

Do not load the Primary Chamber above its rated capacity by weight or above the burner opening.

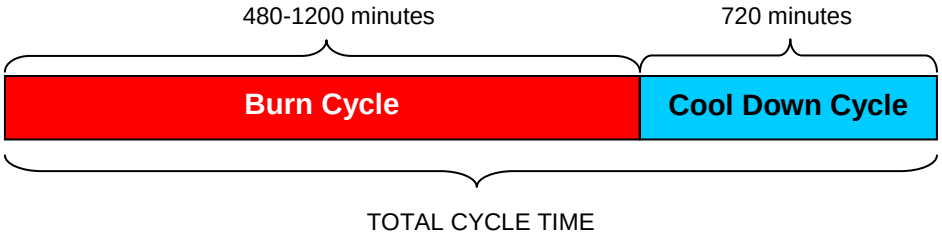
7. Lock the **Primary Chamber** Door and ensure all latches are properly engaged.
8. Proceed to the **Main Control Panel.**

NOTE

The burn time will be set to the previous burn, if you wish to change the set time, proceed to the System Status screen and click on the BURN TIME button. The minimum number of minutes you can enter is 180 (3 hours). When you have finished, the time will be displayed in minutes beside the BURN TIME button

NOTE

The burn time value (in minutes) determines the length of the burn cycle before cool down cycle starts.



9. Check that the primary door shows closed on the **HMI SYSTEM STATUS** screen or the **HMI PRIMARY STATUS** screen**.**

   Check that no alarms are displayed. The **HMI** will display any faults, which need to be cleared before the system can start.

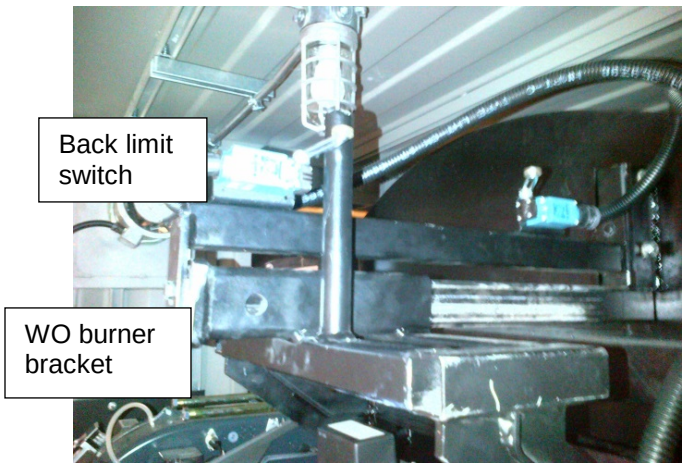
10. Check that the EMERGENCY STOP BUTTON is out.

11. Check that the **green control light is illuminated.**

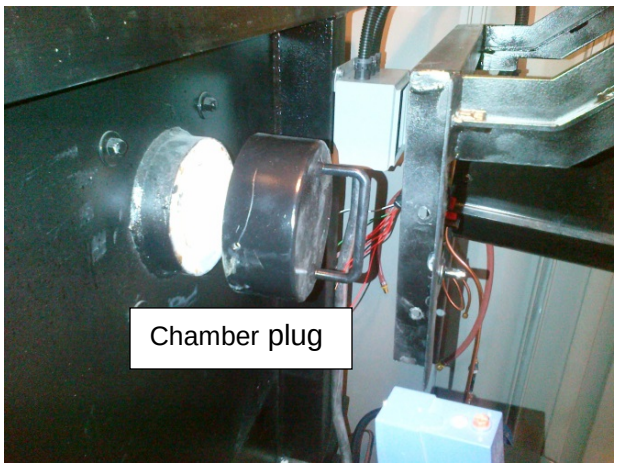
    Do not use this incinerator to burn waste oil only. Always burn a complete load of solid waste when burning waste oil

12. On the **HMI** Primary Status Screen make sure to select the proper combination of Solid Waste, plus any combination of: no Waste Oil, Primary and and/or Secondary Waste Oil.

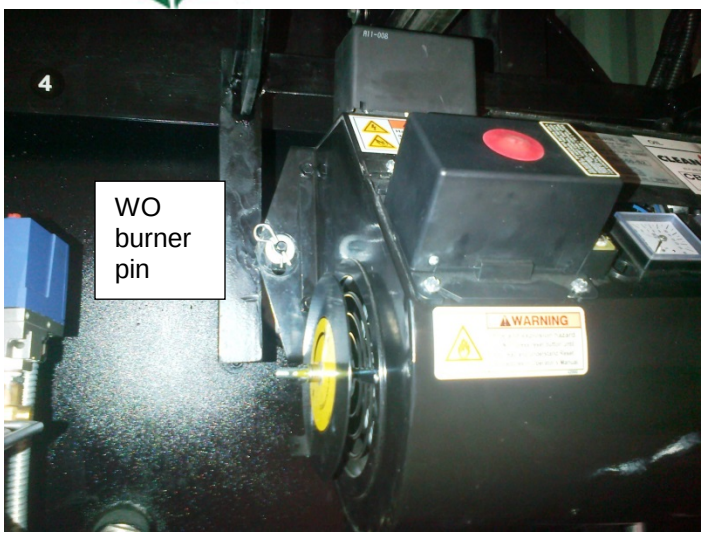
    a. Waste Oil System Off: Ensure the Waste Oil burners are pulled out and the Limit switches are made. The HMI Primary Status will show burners are out. ***Make sure to put the PLUGS into the opening of the waste oil burner in each chamber***.



Waste oil all the way out limit switch made

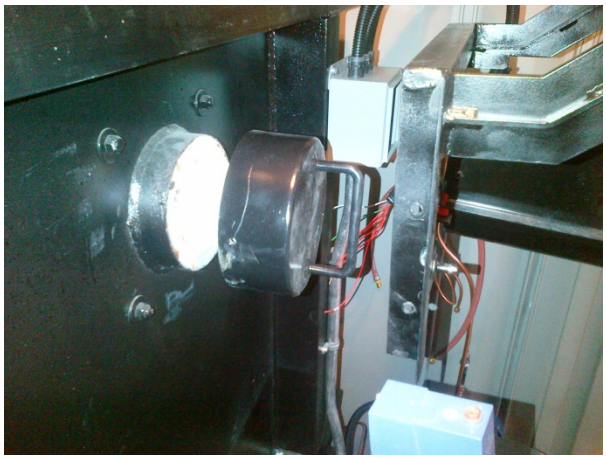


Chamber plug being installed

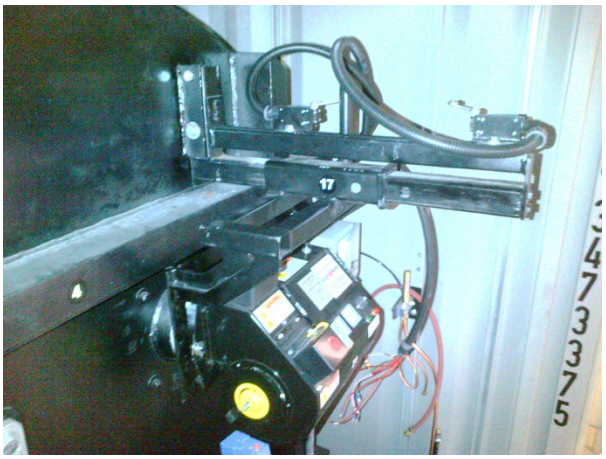


Waste oil burner secured with pin

b. WASTE OIL SYSTEM ON: Ensure the plug is removed from opening from the chamber or chambers where waste oil is going to be used, and push the Waste Oil Burner all the way in, making contact with the Limit Switch in, the HMI Primary Status will show which burner is in. Primary, Secondary or both



Remove plug



Push all the way in until front limit switch is made

13. On the **HMI** Primary Status Screen press the “START SYSTEM” button. The following steps will automatically take place, controlled by the **Main Control Panel**:

    a. Waste Oils System Off

        I. The **Primary Blower and Secondary Blower** will purge the system for 2 minutes.

        II. The **Secondary Burner** will purge for safety, and upon completion will ignite.

        III. Once the **Secondary Chamber** temperature reaches 1000°C, the **Primary Burner** will purge for safety and upon completion will ignite.

IV. The burn time will start counting down when the temperature in the **Primary Chambers** reaches 427°C.

b. Waste Oil System On

I. The **Primary Blower and Secondary Blower** will purge the system for 2 minutes.

II. The **Secondary Burner** and **Waste Oil Burner** will purge for safety, and upon completion they will ignite.

III. Once the **Secondary Chamber** temperature reaches 1000°C, the **Primary Burner** on will purge for safety and upon completion will ignite.

IV. The burn time will start counting down when the temperature in the **Primary Chambers** reaches 427°C.

NOTE The Main Control System will maintain proper operating conditions for the ECO M2TN WO.

14. During the system start-up, it is recommended to monitor its operation. The barometric damper on the T-stack helps control the draft through the system, recommended draft is between 20-30 Pa (displayed in Top View and Primary Status screens). Draft readings above 30 Pa result in gases traveling at high speed inside the system; reduce the draft by opening the damper (using the chain attached to the damper). Ensuring the draft stays within the recommended values, will maintain the system running an efficient burn, proper fuel consumption, clean emissions, etc.

After the burn cycle is completed the system will enter the cool-down cycle and the following things will occur:

- Primary Chamber & Secondary Chamber burners OFF
- Secondary Chamber Blower OFF
- Primary Modutrol 100% open
- Primary Blower ON

Once fully cooled and the temperature is below 50°C, proceed to the **Primary Chamber Clean Out Procedures**

Primary Chamber Clean Out Procedures

Operators responsible for loading and cleaning out incinerators should wear appropriate protective equipment, including eye protection, dust masks, heavy gloves and safety shoes with puncture-proof toes and soles to avoid injury.

Although the ash from the system is considered sterile and will not contain microorganisms, it may contain a quantity of sharp objects, such as broken glass and other sharps which may not be fully destroyed in the burning process, and may thus still pose a hazard to persons who clean out the ash and residues. Also removing the ash does create dust particles in the air. Dust should not be inhaled. The operator must wear dust protection safety gear.

Please follow these steps when the cycle is complete:

1. When the internal temperature of the **Primary Chamber** has cooled to less than 50°C, lock out the power to the system on the **Main Control Panel** by moving the main disconnect to the “OFF” position.
2. Unlock all door latches on the access door to the **Primary Chamber.**

3. While standing in front of the **Primary Chamber** door, slowly open the door to allow clear entry. Secure **Primary Chamber** Door in the OPEN position.
4. Clean the **Primary Chamber** by using ash handling tool(s) and proper safety equipment (not provided).
5. Inspect the interior of the **Primary Chamber** for wear and inspect around the door seals to ensure the door will maintain a tight seal upon closure.
6. Check the air inlet holes and remove any obstructions if necessary.
7. Inspect the door seals to ensure there are no gaps between the door gasket and the door jamb.
8. Close the **Primary Chamber** access door by clamping each latch until it is tight.
9. Clean the inspection **View Port** (glass) with a mild soap and water. To clean the view port, unscrew it by hand and re-tighten by hand.

In Case of Emergency

1. Go to manual Slide Gates on the **Primary Chamber**, located just after the blower and close them all the way. This will help to put the fire out in the **Primary Chamber** out.
2. Check alarms to see what the problem is.
3. Do not open the door of the **Primary Chamber** unless the temperature inside the chamber is below 50°C.
4. Call a certified technician to fix the problem and/or consult with **Eco Waste Solutions Customer Service Department at 905.634.7022, toll free 1-866-326-2876.**

Start Up After Power Failure

1. Once the power is restored turn breaker (main disconnect) back on.
2. The Operator Interface and PLC will begin a boot up procedure. Wait until the **HMI** on the **Main Control Panel** has booted up before turning the control power to the panel back on by pressing the Control Power ON button.
3. When the power is restored to the **Main Control Panel**, the button should illuminate.
4. If the system was interrupted during a burn cycle, on the **HMI SYSTEM STATUS** screen press the "**START BURN**" button to restart the system. If the system was interrupted during cool-down cycle, it will resume the cycle where it left off.
5. Ensure the propane vaporizer circuit breaker is "ON" and check if any of the propane pressure switches require reset at the burner valve train and at the top of the vaporizer.

Dealing with Warning and Faults

Troubleshooting

The burn cycle will not start if one of the following conditions exists:

1. The system still is in “cool-down” cycle. Wait until the “cool down” cycle is complete.
2. There is a fault in the system as indicated on the **HMI**.
3. Loss of power due to any one or more of the following:

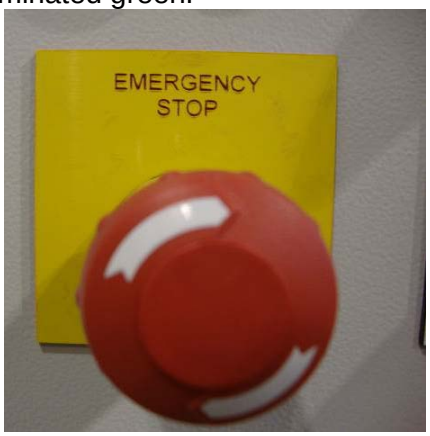
- The main disconnect (see image) is off or there is no electrical power. Turn on the disconnect switch or check why there is no power.

Power is OFF in this position

Power is ON in this position

- An open circuit breaker or blown fuse. Check the breakers and fuses, replace any that are defective.

- The EMERGENCY STOP is pushed in. Twist the EMERGENCY STOP button to unlock, and then push the CONTROL POWER ON button. The CONTROL POWER BUTTON should now be illuminated green.

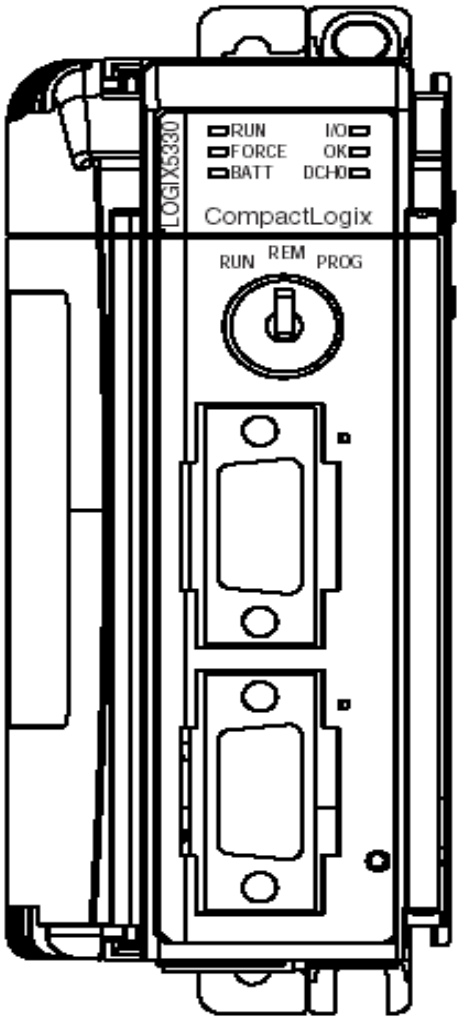


4. If on the Main Control Panel HMI the **Primary Chamber** door is not closed, the door has not been shut properly. Adjust the limit switch lever arm if necessary. Check the limit switch and that the wiring is in working order.

5. If fuel pressure is low, system will not start. This is an indication the vaporizer is not “ON”

6. If fuel pressure is high, the pressure switches will trip. The pressure switched will have to be reset and if they trip again the propane regulators will have to be checked.

PLC Processor Problem



- Check the run light on the PLC processor. If it is on the PLC it is ready.
- “OK LIGHT” is green = Controller is OK.
- “OK LIGHT” is Red Flashing = this is a recoverable fault, check the PLC processor. This fault is very unlikely to occur.
- OK LIGHT is Red = this is a non-recoverable controller fault. Cycle Power. The OK LED should change to flashing red. If LED remains solid red, replace the PLC. This fault is very unlikely to occur.
- DCHO light is green = this indicates the PLC processor has lost the program. The PLC is equipped with a flash card that will automatically load the program back onto the PLC.

ECO WASTE SOLUTIONS

Possible Problems, Causes and Solutions

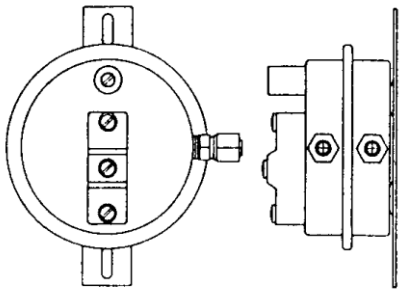
Problem	Causes	Solutions
Blower Fails to start	Over load tripped, blown fuse	Turn power off. Open Panel and reset overload. Check fuse and replace.
	Motor starters or contactor coil is burnt out	Locate contactor for Blower and visually observe if the contactor is pulled in. Use a volt meter to check for voltage across the coil If there is voltage across the coil and the contactor is not pulled in, replace the contactor.
Secondary Burner won't ignite	Bad Electrodes	Refer to Maintenance Section of this manual.
	Fuel Pressure fault	Ensure there is enough fuel in the tank Reset pressure switches on burner fuel train Reset vaporizer switch (on top of vaporizer) Ensure vaporizer is turned ON
	Fuel Line Leak	If propane odor is noticed, close all valves, tighten any fittings or replace leaking piping.
	Door Switch not making contact	Make sure main door is closed and latched shut. Make sure limit switch is hitting striker plate.
	Burner main switch is turned off	Turn switch on.
	Burner alarm has been tripped	Acknowledge burn alarm and then hit the reset button on control panel.
	Bad Thermocouple	Replace thermocouple.
Primary Burner won't ignite	Bad Electrode	Refer to Maintenance Section of this manual.
	Fuel Pressure Fault	Ensure there is enough fuel in the tank Reset pressure switches on burner fuel train
	Fuel Line Leak	If propane odor is noticed, close all valves, tighten any fittings or replace leaking piping.

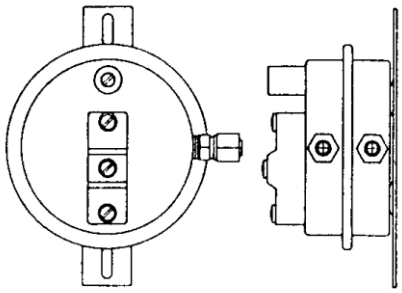
Problem	Causes	Solutions
	Door Switch not making contact or broken	Make sure main door is closed and latched shut. Make sure limit switch is hitting striker plate.
	Secondary temperature not at 1000°C	Wait until Secondary temperature is at 1000°C and try again.
	Burner main switch is turned off	Turn switch on.
	Burner alarm has been tripped	Acknowledge burn alarm and then hit the reset button on control panel.
Persistent Black Smoke	Insufficient air supply to Secondary Chamber to completely consume emissions	Check to ensure combustion air blower/damper assembly is operating properly.
	Secondary Chamber is not hot enough.	Check that the Secondary temperature is operating at required temperature set point.
	Secondary Chamber is not hot enough.	Too much draft, open barometric damper.
	Overloading or loading highly volatile material	Decrease load size on next batch (confirm by weighing), ensure the waste mix is correct.
	Burner failure	Check burner operation – if no flame or a poor flame is visible through the flame view port adjust air/fuel ratio.
	Operation at too high a Primary Chamber temperature	Check/decrease primary chamber combustion air.
Smoke coming out of Primary	Too much air	Check dampers on primary blower.
	Too much volatile material loaded	Decrease load size on next batch to ensure the waste mix is correct.
	Low draft	Close the barometric damper in the t-stack section
	Primary Chamber temperature too high	Waste loaded may not be a good mix of heat value .
Too much fuel usage	Too much secondary combustion air	Check/reduce secondary combustion air.
	Too much air infiltration	Reduce air flow by adjusting the damper.
	Fuel leakage	Check fuel trains and burners for fuel leakage.

Problem	Causes	Solutions
	Wet waste	Spread wet waste with other waste through several loads – do not charge all of the wet waste at one time.
	Excessive draft	Check/reduce draft – check door seals and other seals for leakage adjust damper.
	Burner setting too high	Check air/fuel mix.
Incomplete burnout/poor ash quality	Build-up around air holes – clogged with ash from previous burn	Check around air holes and clean.
	Poor draft	Draft should be -0.25-0.06 KPa (or 1.0-0.25"W.C).
	Too much wet waste – overloading system	Spread wet waste with other waste through several loads – do not charge all of the wet waste at one time.
	Insufficient burn time	Allow longer burn time period.
Waste Oil Burner		
System will not start when Solid is selected	Waste Oil burner is inserted into the Secondary Chamber	Remove Waste Oil burner assembly from the Secondary Chamber. And place the plug into the port
System will not start when Solid and Waste Oil are selected	Waste Oil burner is not inserted into the Secondary Chamber	Remove the plug from the port and insert the Waste Oil burner assembly into the Secondary Chamber.

Possible Alarms (Faults)

#	ALARM (System Fault)	SOLUTION
1	The Primary Chamber Thermocouple is faulted	See corrective maintenance procedures. Section 7 on this manual
2	The Secondary Chamber thermocouple is faulted	See corrective maintenance procedures. Section 7 on this manual
3	The Secondary Stack Thermocouple is faulted	See corrective maintenance procedures. Section 7 on this manual

#	ALARM (System Fault)	SOLUTION
4	The primary burner is faulted	The primary burner has failed to light when it received a signal telling it to start. To reset the burner, press the reset button located on the Burner. Ensure the vaporizer is ON, the pressure switches are not tripped and all valves from tank to burner are open If this does not start the burner, refer to Supplier Catalogue (Riello Burner) Section 8 of this manual.
5	The secondary burner is faulted	The secondary burner has failed to light when it received a signal telling it to start. To reset the burner, press the reset button located on the Burner. Ensure the vaporizer is ON, the pressure switches are not tripped and all valves from tank to burner are open If this does not start the burner refer to Supplier Catalogue (Riello Burner) Section 8 of this manual.
6	The system has shut down due to primary blower low air flow. 	Visually examine the primary blower for any obstructions that may be causing low air flow. Check slide gate located between Primary chamber and blower, ensure it is open. Check damper assembly, ensuring modutrol crank arm is still connected and that butterfly damper is open, allowing air flow. Air proving switch may be defective. Refer to Section 6 of this manual. There are two ports on the air flow switch marked V and P. Ensure the inlet tube is attached to the port marked “P” for pressure. V stands for vacuum. Ensure the “V” port is open to atmosphere and is not blocked. If no air restriction is observed (i.e. blockage in the tube) change the air proving switch. Refer to Section 7 of this manual.

#	ALARM (System Fault)	SOLUTION
7	The primary blower motor overload is tripped.	Turn power off on Control panel by turning the Main Disconnect to the OFF position. Reset overload.
8	The system has shut down due to secondary blower low air flow. 	Visually examine the Secondary Blower for any obstructions that may be causing low air flow. . Check slide gate located between Secondary chamber and blower, ensure it is open. Check damper assembly, ensuring Modutrol crank arm is still connected and that butterfly damper is open, allowing air flow. Air flow switch may be defective. Refer to Section 6 of this manual. There are two ports on the air flow switch marked V and P. Ensure the inlet tube is attached to the port marked “P” for pressure. V stands for vacuum. Ensure the “V” port is open to atmosphere and is not blocked. If no air restriction is observed (i.e. blockage in the tube) change the air proving switch. Refer to Section 7 of this manual.
9	The Secondary blower variable frequency drive is faulted.	Push fault reset button on the HMI If fault persist check the error code on the variable frequency drive and check manual for troubleshooting alarm.
10	The Waste oil tank is low	This is a warning which will appear for 5 seconds if you try and start the system when solid and waste oil is selected, the system will not start. Add waste oil to the tank and the alarm should reset itself.
11	The Waste oil burner is not all the way in.	Check that the burner is all the way in. Check the limit switch arm and wiring.
12	The Waste Oil burner is not all the way out.	Check that the burner is all the way out and connecting with the limit switch. Check the limit switch arm and wiring.

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 7

MAINTENANCE INSTRUCTIONS

ECO M2TNWO

Corporate Office:

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Web: www.ecosolutions.com

ECO WASTE SOLUTIONS

MAINTENANCE INSTRUCTIONS

SUMMARY OF PREVENTIVE MAINTENANCE INSTRUCTIONS

IF APPLICABLE: The air compressor pump is shipped with break-in oil which should be changed after the first 8 hours of operation.

Daily Maintenance

Freq.	Routine	Component	Description
Daily	Inspection & Cleaning	Burners	Inspect fuel lines for leaks.
Daily	Inspection & Cleaning	Refractory	Check inside the Chambers for shrinkage or any exposed metal.

Weekly Maintenance

Routine	Component	Description
Inspection & Cleaning	Blowers and Assembly	Modutrol crank arm connected to damper.
Inspection & Cleaning	Blowers and Assembly	Slide gates are open.
Inspection & Cleaning	Burners	Secondary Burner maintenence
Inspection & Cleaning	Waste Oil Burner Filter	Clean the canister filter
Inspection & Cleaning	Air compressor	Check air filter
Inspection & Cleaning	Air compressor	Pull ring on safety valve and allow the ring to snap back to normal position (Check for free operation of the safety valve)
Inspection & Cleaning	Thermocouples	Remove and clean thermocouples as necessary – inspect for damage. Replace if necessary.

Monthly Maintenance

Routine	Component	Description
Inspection & Cleaning	Blowers and Assembly	Check the fan wheel for any wear or corrosion, as either can cause catastrophic failures
Inspection & Cleaning	Refractory	Check the refractory in the Secondary Chamber for shrinkage, anything greater than 1.2cm should be patched (i.e. gaps between modules exposing metal surface)
Inspection & Cleaning	Waste Oil	Visually check all electrical components
Inspection & Cleaning	Waste Oil	Remove heater element from casing and inspect for build-up. Clean any deposits. When reinstalling the heater element always ensure the bundle will be restarted immersed. **NEVER** use the inline oil heater dry
Inspection & Cleaning	Air compressor	Check all fasteners for proper tightness.

Quarterly Maintenance

Routine	Component	Description
Inspection & Cleaning	Refractory	Inspect door gasket for damage or heat damage. Replace segments, if necessary. Doors must close tightly and securely.
Inspection & Cleaning	Refractory	Check all refractory for damage. Patch or replace as needed. Patch if modules show a little gap and replace modules if the modules have shrunk excessively (greater than 1”)
Inspection & Cleaning	Paint	Maintain paint exterior to protect metal from heat damage

Yearly Maintenance

Routine	Component	Description
Detailed Maintenance	Refractory	Replace door gasket
Inspection & Cleaning	Electrical	Check the limit switch

24 to 60 Months

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Periodicity	Routine	Component	Description
24 Monthly	Detailed Maintenance	Refractory	Replace the door sills on Primary Chamber
24 Monthly	Detailed Maintenance	Refractory	Replace the door sills on Secondary Chamber
60 monthly	Detailed Maintenance	Refractory	Relining of Secondary Chamber.
60 monthly	Detailed Maintenance	Refractory	First stack section to be relined.
60 monthly	Detailed Maintenance	Fuel Tanks	Inspect Fuel tanks

PREVENTIVE MAINTENANCE INSTRUCTIONS

Instruction Classification

Each component is associated with an identification number, see table below:

System Component	Identification number
Primary Blower	01-001
Secondary Blower	02-001
Primary Burner	01-002
Secondary Burner	02-002
Refractory	05-001
Waste Oil Burner	02-003
Air Compressor	03-001
Main Control Panel	03-010
Paint	05-003
Electrical	05-004
Limit Switch	05-005

To differentiate if the instruction is weekly, monthly, quarterly or yearly, the above identification number will be followed by a letter:

Daily: D
Weekly: W
Monthly: M
Quarterly: Q
Yearly: Y

For example**, 01-001.Q.01** Primary blower assembly quarterly instruction number 1.

ECO WASTE SOLUTIONS

Zero Mechanical State & Lock Out Instructions

Proper maintenance of the equipment is essential to ensure long term, reliable operation of the EWS model Incinerator. The preventive maintenance instructions are outlined in this section of the Facility Manual.

NOTE
The warranty will become void if proper maintenance is not performed as instructed.

Safety

During maintenance of the EWS mobile incinerator, it is very important to be aware of special hazards. Two safety programs are described in the following sections:

1. Zero Mechanical State
2. Power Lock Out Instructions

Failure to comply with these instructions during maintenance could result in injury or death. The responsibility for implementation of a comprehensive safety program rests with the operating staff and supervision. The safety instructions in this Facility Manual should be considered only as a starting point for the safety program at site.

ACCIDENTS CAN BE PREVENTED
A CAREFUL WORKER IS THE BEST SAFETY DEVICE

Zero Mechanical State

Zero Mechanical State (ZMS) exists when the possibility of an unexpected mechanical movement has been eliminated. During maintenance, it is mandatory to totally deactivate the incinerator so that there is no possibility of an unexpected machine movement. Power lock-out, described in the next section, is commonly used for this purpose. Most machines are powered by electrical, hydraulic or pneumatic drives. Energy may be stored in a shutdown machine in various ways: Air pressure in a cylinder, hydraulic fluid stored in pressurized hoses, or machine members whose weight can generate fluid pressure. Therefore, just cutting off the electrical power may not be enough to neutralize all power sources. Certain maintenance instructions at site should require ZMS condition as a matter of course.

Zero Mechanical State (ZMS) Checklist

1. Every electrical power source to the incinerator must be cut off and locked out (to prevent others who may not be aware of maintenance work from turning the power back on inadvertently).
2. Ensure that the mechanical potential energy of the incinerator is at its lowest practical value so that opening of pipe, tubing, hose or actuation of any valve will not produce an unexpected movement that could cause injury.

3. Check that there is no pressurized fluid (air, oil, gas or other) trapped in the incinerator lines, cylinders or other components. This will ensure that there will be no incinerator motion when a valve is actuated.

4. Secure loose or freely moving parts so that there is no possibility of accidental movement.

Power Lock Out Instructions

Unexpected operation of electrical equipment started by automatic or manual remote control may cause injuries to persons who happen to be nearby. For this reason, when repair work is to be done on motors or other electrical equipment the circuit should be opened at the switch box and the switch pad locked in the OFF position. Tag the switch with a lock out tag indicating who must be contacted before the power is turned back on again.

BECAUSE OF THE SEVERE CONSEQUENCES, INCLUDING DEATH, OF NOT PROPERLY LOCKING OUT ELECTRICITY SUPPLIES DURING MAINTENANCE, THE SUPERVISOR SHOULD ENSURE THAT THERE IS ONLY 1 KEY FOR THE LOCK USED TO LOCK OUT THE POWER SUPPLY.

For identification, locks may be color coded to indicate different crews or shifts.

The Supervisor should maintain the master key and list of key numbers, and should keep an extra key to each lock for his department. The master key should not be loaned out under any circumstances.

No matter what method is used to lock out power, strict discipline and constant supervision should be employed during any equipment maintenance work.

Power Lock Out Checklist

1. Alert the operator of the equipment.

2. Before starting the work on an engine, motor, line shaft or other power transmission equipment or power-driven machine, make sure it cannot be set in motion without your knowledge.

3. Place your own padlock on the control switch, lever, or valve, even if someone has locked the control panel before you. You will not be protected unless you put your own padlock on it. (Another maintenance person could remove their lock and then someone else could start the equipment if they were not aware of maintenance work being done.)

When you are finished working, remove your own padlock. Never permit someone else to remove it for you. Be sure you are not exposing someone else to danger by removing your padlock

Daily Instructions

Primary & Secondary Chamber Burners: (01-002.D & 02-002.D)

Do not store flammable or hazardous materials in the vicinity of fuel burning appliances.

Improper installation, adjustment, alteration, service or maintenance can cause property damage, personal injury or death.

Burner shall be installed and maintained in accordance with manufacturer's requirements as outlined in the Burner manual, local codes and authorities having jurisdiction.

INSTRUCTION 01/02-002.D.02: INSPECTING THE FUEL LINES

1. Visually inspect all fuel lines to the Primary and Secondary Burner as well as to the Waste Oil burner for any leaks.

2. If any leaks are observed tighten or replace the piping section where the leak is occurring

Refractory: (05-001.D)

When working with the refractory make sure you use the proper tools; wear goggles, approved dust mask and gloves

INSTRUCTION 05-001.D.01: INSPECTING THE REFRACTORY

Ensure power is locked out.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

1. Open Primary Chamber door by unlatching all clamps.

2. Tie-off door to open position to ensure that it will not close unintentionally.

3. Enter Primary Chamber and check the refractory for shrinkage, any gap between the modules greater than 2.5 cm should be patched with the blanket refractory

4. Check for any exposed metal between the modules, if metal is exposed make sure to patch area with blanket material (PN: 501803) or new module (PN: 433026) (*CMI 4.4.2/05-001A & 4.4.2/05-001B)*Weekly Instructions

Primary & Secondary Chamber Blowers: (01-001.W & 02-001.W)

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

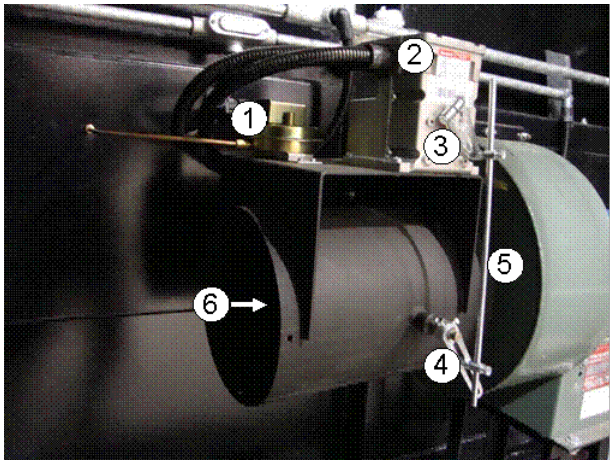
A fan can windmill despite removal of all electrical power therefore, take extra care when working with fans in the system.

The rotating assembly should be blocked securely before attempting maintenance of any kind.

INSTRUCTION 01/02-001.W.01: DAMPER CRANK ARM

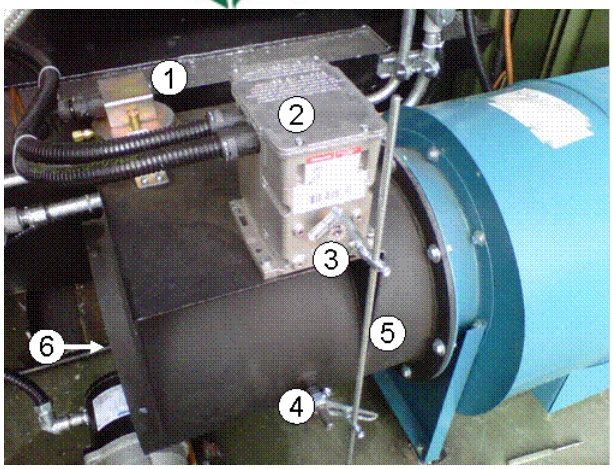
Check to see that the damper crank arm is connected to the damper and the rod.

Ensure mechanical linkage on damper is tight, if loose tighten with wrench.



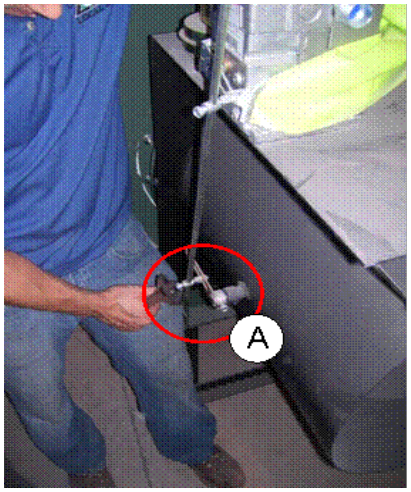
PRIMARY BLOWER

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper



SECONDARY BLOWER

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper



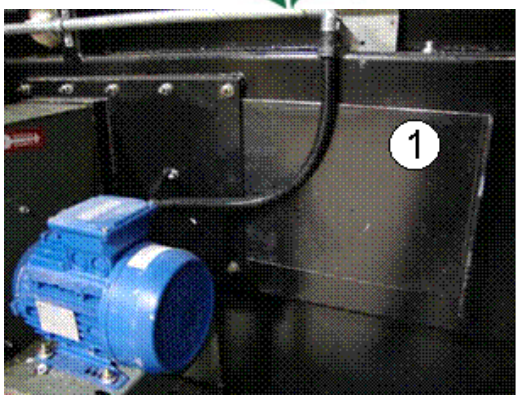
A. Damper Crank arm and connection to Damper and Rod

INSTRUCTION 01/02-001.W.02: SLIDE GATES

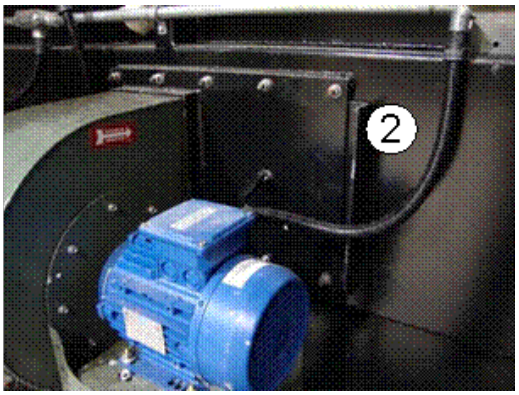
Check to see if slide gates move freely.

1. Move slide gate in and out to ensure free movement. If sticking, use lubricant to loosen. Lubricant should be rated for a high temperature (>150°F) application.

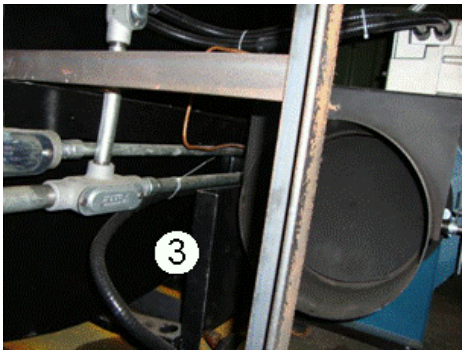
2. Gates must be opened to allow under fire air to enter the chamber. They should only be closed to reduce air in abnormal operating conditions.



1. Sample Primary Chamber Slide Gate Open



2. Sample Primary Chamber Slide Gate Closed



3. Sample Secondary Chamber Slide gate Open

Primary & Secondary Chamber Burners: (01-002.W & 02-002.W)

Do not store flammable or hazardous materials in the vicinity of fuel burning appliances.

Improper installation, adjustment, alteration, service or maintenance can cause property damage, personal injury or death.

Burner shall be installed and maintained in accordance with manufacturer's requirements as outlined in the Burner manual, local codes and authorities having jurisdiction.

Switch off the electrical power. Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.* Cover must be removed to perform maintenance on burners.

ECO WASTE SOLUTIONS

INSTRUCTION 01/02-002.W.02: PRIMARY & SECONDARY BURNER MAINTENENCE

Refer to Burners manuals in section 8 of this manual

Primary Burner: Riello RS 28/M
Secondary Burner: Riello RS 100/M

Air Compressor: (03-001.W)

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. This air compressor is not designed, intended or approved for breathing air. Compressed air should not be used for breathing air application.

HAZARDOUS VOLTAGE. Can cause serious injury or death. Disconnect power and bleed pressure from the tank before servicing.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing.

HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

HIGH PRESSURE AIR. Bypassing, modifying or removing safety/relief valves can cause serious injury or death. Do not bypass, modify or remove safety/relief valves. Do not direct the air stream at body. Rusted tanks can cause explosion and severe injury or death. Drain tank before each use. Drain valve located at bottom of tank.

RISK OF BURSTING. Use only suitable air handling parts acceptable for pressure of not less than the maximum allowable working pressure of the machine.

INSTRUCTION 03-001.W.02: INSPECTING AIR FILTERS IN AIR COMPRESSOR

Refer to Husky Compressor manual Model HLA3706056 in section 8 of this manual

INSTRUCTION 03-001.W.03: CLEANING COMPRESSOR & CHECKING SAFETY VALVE

Cleaning

A dirty compressor will cause abnormally high temperature and result in oil carbonization on valve components.

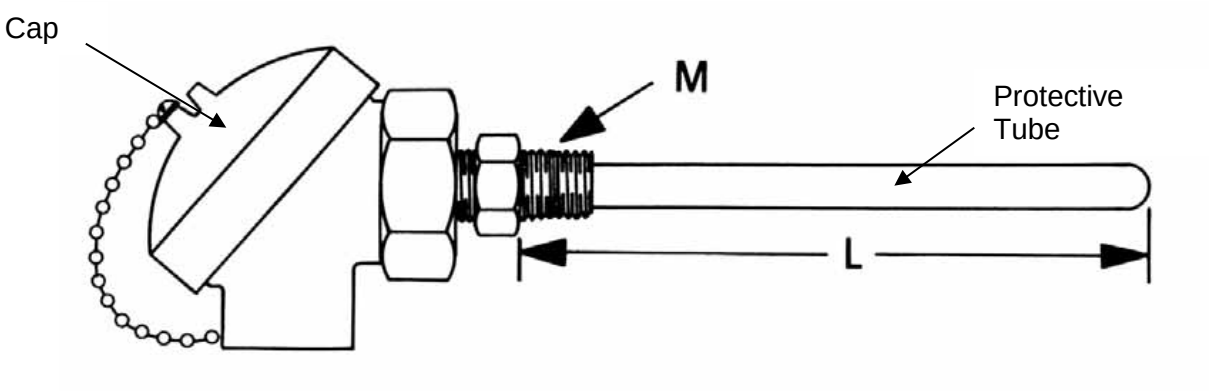
Clean all external parts of the compressor with compressed air. Concentrate the cleaning on the external fins where dirt can accumulate as cooling air is forced across them.

Refer to to Husky Compressor manual Model HLA3706056 in section 8 of this manual for:

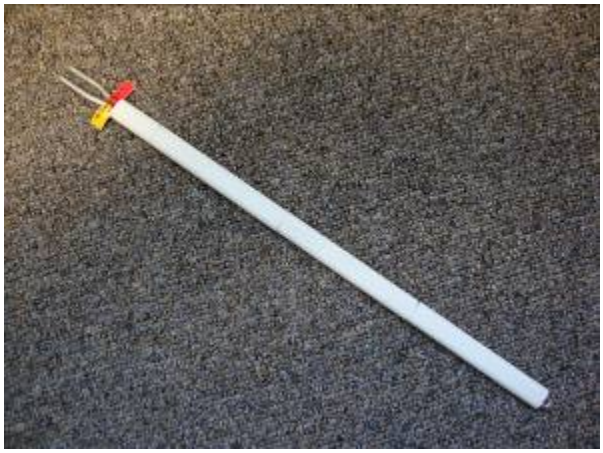
Checking Safety Valve
Draning the Tank

Thermocouple: (05-002.W)

When working with electrical components, ensure lock out instructions are being followed.



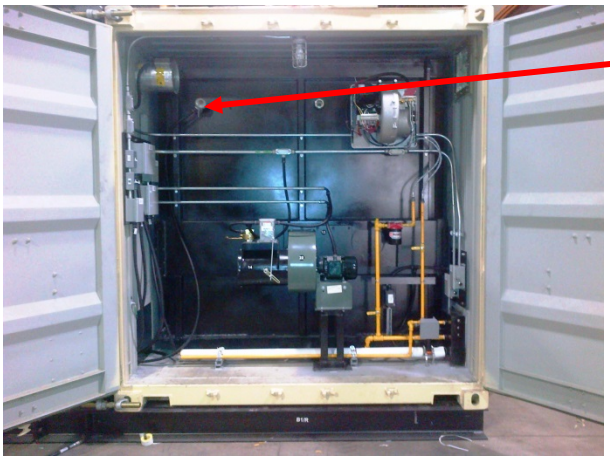
Thermocouple Assembly


Thermocouple Element

ECO WASTE SOLUTIONS

INSTRUCTION 05-002.W.01: INSPECT THERMOCOUPLE FOR DAMAGE

Turn main power to the system off - Remove thermocouple and visually inspect for damage. If damaged, see *CMI 4.4.1/05-002A*



1. Primary Thermocouple (TC1)

2. Secondary Thermocouple (TC2) on Secondary Chamber Container

3. T-stack thermocouple (TC3not shown)

Monthly Instructions

Primary & Secondary Chamber Blowers: (01-001.M & 02-001.M)

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

INSTRUCTION 01/02-001.M.01: CHECK FAN WHEEL

1. Check the fan wheel for any wear or corrosion, as either can cause catastrophic failures, if left in operation.
2. The wheel can be accessed one of two ways.
   a. Remove the blower assembly from the unit and look down the outlet of the blower.
   b. Remove the damper assembly from the inlet of the blower and inspect by looking through the inlet of the blower.
3. Check also for the build-up of material which can cause unbalance resulting in vibration, bearing wear and serious safety hazards.
4. Clean the wheel as required.
5. If replacement is necessary follow these steps:
   a. Remove damper assembly from the unit
   b. Remove the blower assembly
   c. Remove the blower housing around the wheel
   d. Loosen all set screws that are located on the wheel.
   e. A puller may be required if the wheel hasn't been removed for some time.
   f. Ensure the shaft "key" is installed on the shaft before installing the new wheel.
   g. When installing a new wheel, the wheel should be positioned in the housing with the correct spacing between the edge of the inlet cone and the wheel. The wheel to cone clearance on the Primary Blower is 0.3175 cm.
   h. Ensure that the wheel is installed securely before reassembling the blower assembly.
   i. Install the blower assembly
   j. Install the damper assembly

ECO WASTE SOLUTIONS

INSTRUCTION 05-001.M.01: INSPECT REFRACTORY

1. Ensure power is locked out.
2. Open Primary Chamber door.
3. Fasten door open, ensuring it will not close by its own weight.
4. Enter Primary Chamber and check the refractory for shrinkage, any gaps between the modules greater than 2.5 cm should be patched.
5. Fix gaps with supplied blanket by stuffing material into opening. (See *CMI 4.4.2/05-001A)*
6. Check for any exposed metal, if metal is exposed make sure to patch area with blanket material or new module. (See *CMI 4.4.2/05-001A* & *4.4.2/05-001B)*
7. Pay special attention to areas where the junction boxes are located, as any excessive heat may melt the wires within the box.
8. While inside the Primary Chamber using a flashlight check the status of the Dome and the center piece which consist of 3 holes.

Some cracking is normal, however if pieces are missing or have fallen out, (See *CMI 4.4.2/05-001E)*

Waste Oil Burner: (02-003.M)

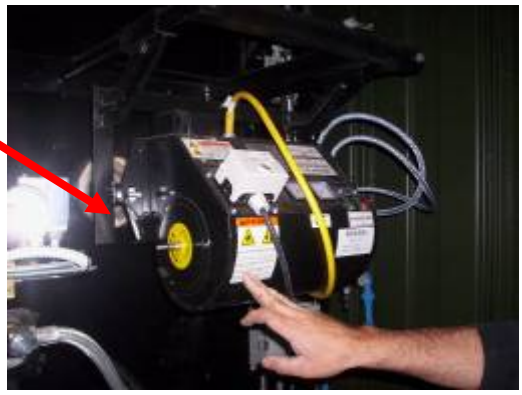
Failure to maintain and / or improper servicing by unqualified personnel will adversely affect the proper, safe operation of your burner, will reduce the service life of your burner and will void your warranty

INSTRUCTION 02-003.M.01: INSPECT ELECTRICAL COMPONENTS

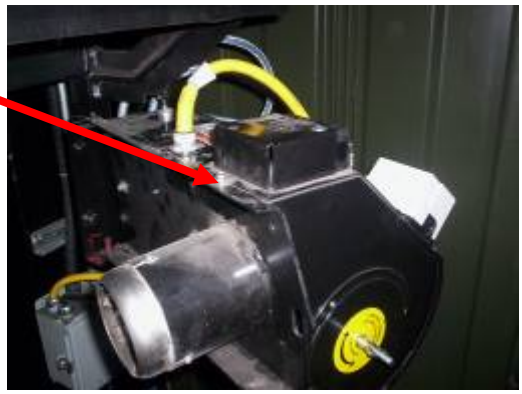
1. Check all electrical components for any heat damage.
2. If heat damage is observed remove and replace.

ECO WASTE SOLUTIONS

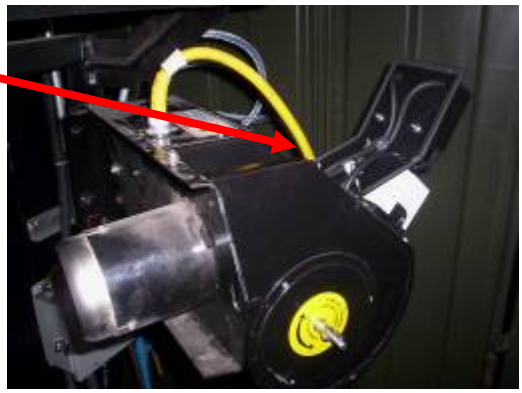
1. Slide out burner
2. Undo Bolt



3. Loosen Bolt



4. Open hinged hatch to access front components



INSTRUCTION 02-003.M.02: INSPECT HEATER ELEMENT

1. Remove heater element from casing and inspect for build-up

2. Clean any deposits.

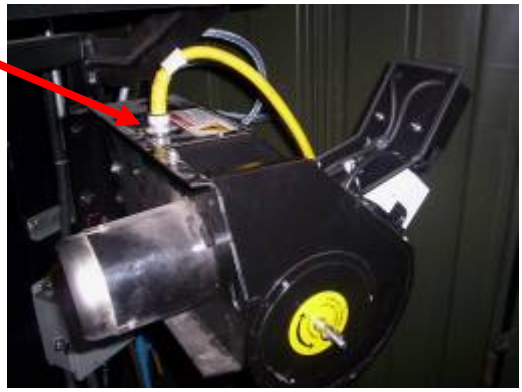
3. If damaged, heater element needs to be replaced. Removal involves the following steps:
    a. Remove all electrical connections attached to the heater block identified in Picture #3 below.
    b. Remove all the bolts attaching the heater to the burner housing.
    c. Remove all fuel line connections.

d. Remove the heater element and install the new one. (PN: 33173)
e. Reinstall the heater block.

4. When reinstalling the heater element always ensure the element will be restarted immersed.

NEVER use the inline heater dry

1. Unscrew (yellow) electrical connection



2. Remove cover screw

3. Open hatch cover to expose heater element

Air Compressor: (03-001.M)

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. This air compressor is not designed, intended or approved for

breathing air. Compressed air should not be used for breathing air application unless treated in accordance with all applicable codes and regulations.

HAZARDOUS VOLTAGE. Can cause serious injury or death. Disconnect power and bleed pressure from the tank before servicing. Compressor must be connected to properly grounded circuit. Do not operate compressor in wet conditions. Store indoors.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing. Lockout/Tagout machine.

HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing.

HIGH PRESSURE AIR. Bypassing, modifying or removing safety/relief valves can cause serious injury or death. Do not bypass, modify or remove safety/relief valves. Do not direct air-stream at body. Rusted tanks can cause explosion and severe injury or death. Drain tank before each use. Drain valve located at bottom of tank.

RISK OF BURSTING. Use only suitable air handling parts acceptable for pressure of not less than the maximum allowable working pressure of the machine.

INSTRUCTION 03-001.M.01: CHECK FASTENERS FOR TIGHTNESS

1. Check all fasteners for tightness (tighten as required).

2. Check the safety valve manually, by pulling ring or lever, to make sure that it is not stuck. Allow the ring to snap back to normal position

Quarterly Instructions

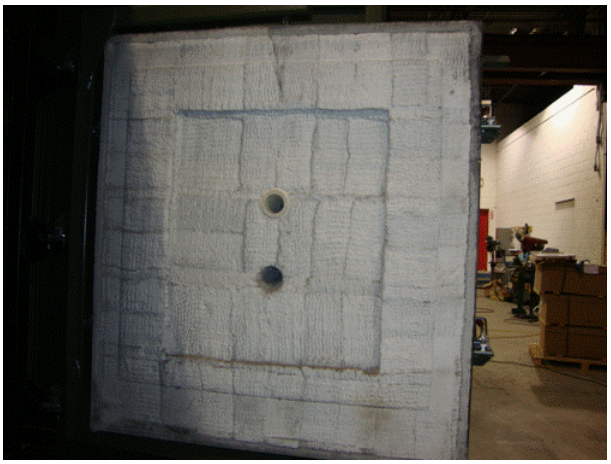
Refractory: (05-001.Q)

When working with the refractory make sure you use the proper tools; wear goggles, dust mask and gloves

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

INSTRUCTION 05-001.Q.01: INSPECT DOOR GASKETS

1. Open Primary Chamber door.
2. Fasten door open, ensuring the door will not close on its own.
3. Inspect door gasket for damage.
4. Replace any damaged segments of door gasket (PN: 462007) if necessary. Cut out the damaged section and replace with new door gasket. See *CMI 4.4.2/05-001C*.
5. Doors must close tightly and securely, ensuring a good seal.



Sample Primary Door (refractory lined)

1. Primary Door Gasket

ECO WASTE SOLUTIONS

INSTRUCTION 05-001.Q.02: INSPECT REFRACTORY FOR SHRINKAGE

1. Ensure power is locked out.
2. Open Primary Chamber door.
3. Fasten door open, ensuring they will not close on their own.
4. Enter Primary Chamber and check the refractory for shrinkage, anything greater than 2.54 cm should be patched.
5. Check to make sure the anchoring of the modules is still strong and intact, if any modules seem loose replace complete module with new module.

A. REMOVAL: Remove existing Module (physically pull away existing refractory from underlying Module Anchor).

B. Remove welded stud from steel casing (cut with hack saw or other device between Module Anchor and Furnace Casing/Shell).

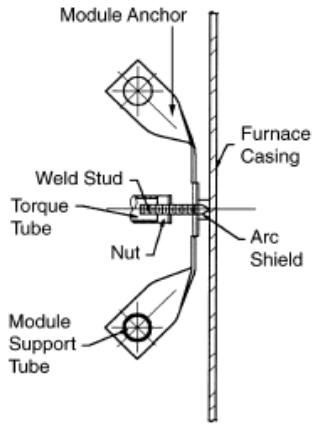


Figure 1: Side view of the Weld Loc Module

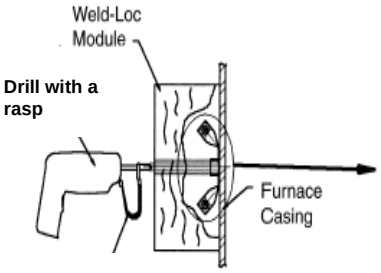


Figure 2: Stud Gun with rasp and Torque Tube.

A. INSTALLATION: Once the new module (PN: 433026) is in place take the stud gun (PN: ECO-STUD) with rasp to the Torque Tube and drill into place.

B. Once it has tightened the Torque Tube should come off with the drill.

Paint: (05-003.Q)

Ensure proper ventilation and proper equipment is being used when using any paint product.

INSTRUCTION 05-003.Q.01: INSPECT AND MAINTAIN EXTERIOR PAINT

1. Maintain paint exterior to protect metal from heat and corrosion damage. This includes all components in the system including containers and incinerator components.

2. If discoloration is noted and painting needs to be performed, on areas where paint will be applied, you must do a light sanding before application.

3. Follow paint manufacturer's application instructions which will include surface preparation, priming and painting.

Paint Specifications:

Incinerator Paint: This is the paint coated directly on the incinerator shell. This includes the following components:

1. Primary Chamber
2. Secondary Chamber
3. Hot Stack Section (Black)

Finish needs to be able to withstand temperatures in the 650-750°F (340-400°C) range.

Parts: There are no paint specifications for each individual component. This is left up to the discretion of the customer.

Yearly Instructions

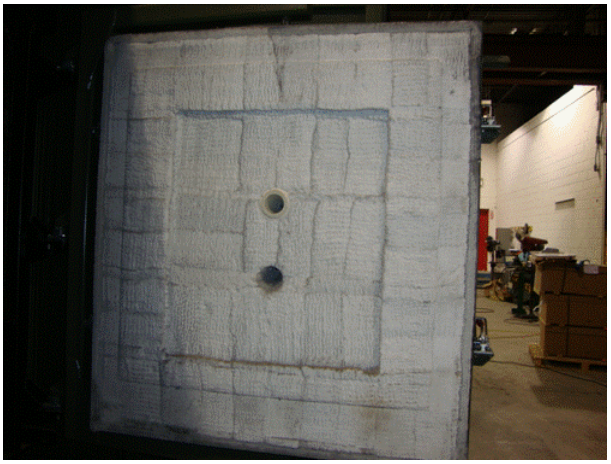
Refractory: (05-001.Y)

When working with the refractory make sure you use the proper tools; wear goggles, dust mask and gloves

INSTRUCTION 05-001.Y.01:
CHECK DOOR GASKET ALONG PRIMARY CHAMBER DOOR

1. If required replace the door gasket. The gasket can last over 2 years but will depend on the careful use by the operator when loading and unloading.

2. Remove the damaged section of door gasket from door and reinstall new gasket (PN: 462007)



Sample Primary Door (refractory lined)

Primary Door Gasket

Electrical: (05-004.Y)

When working with electrical components ensure lock out instructions are being followed

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

ECO WASTE SOLUTIONS

INSTRUCTION 05-004.Y.01: CHECK LIMIT SWITCHES

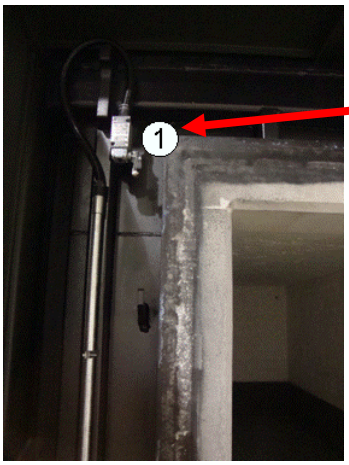
NOTA System must not be running or in cool down to perform this inspection.

1. Open Primary Chamber door and check top view screen on the HMI Panel view to ensure that it indicates door is open.

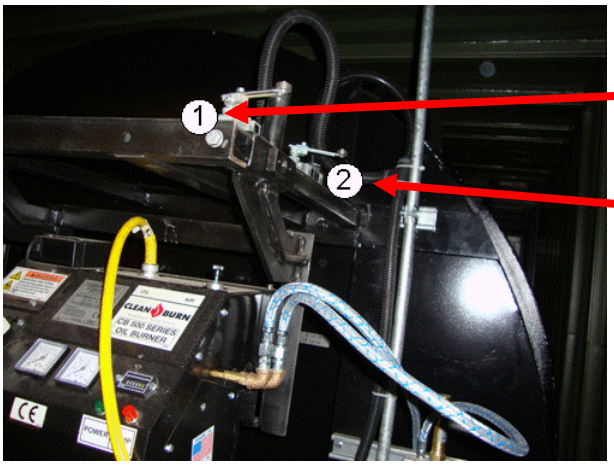
2. Close Primary Chamber door and check top view screen on the HMI Panel View to ensure that it indicates door is closed.

3. All limit switches located on the unit are checked this way.

4. Replace limit switches (PN: 802T-APE) if necessary.

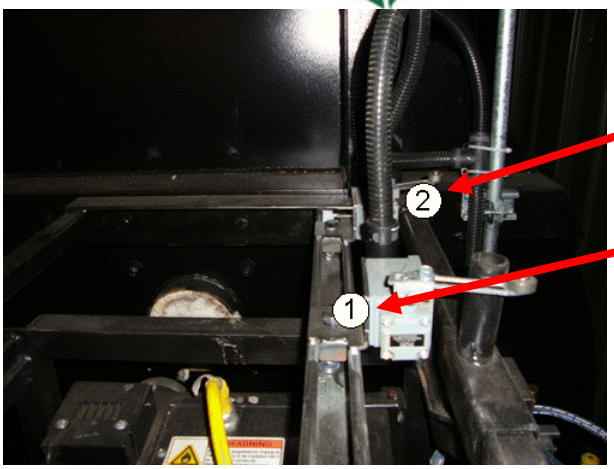


Primary Chamber Limit Switch



Waste Oil Burner Out Limit Switch

Waste Oil Burner In Limit Switch



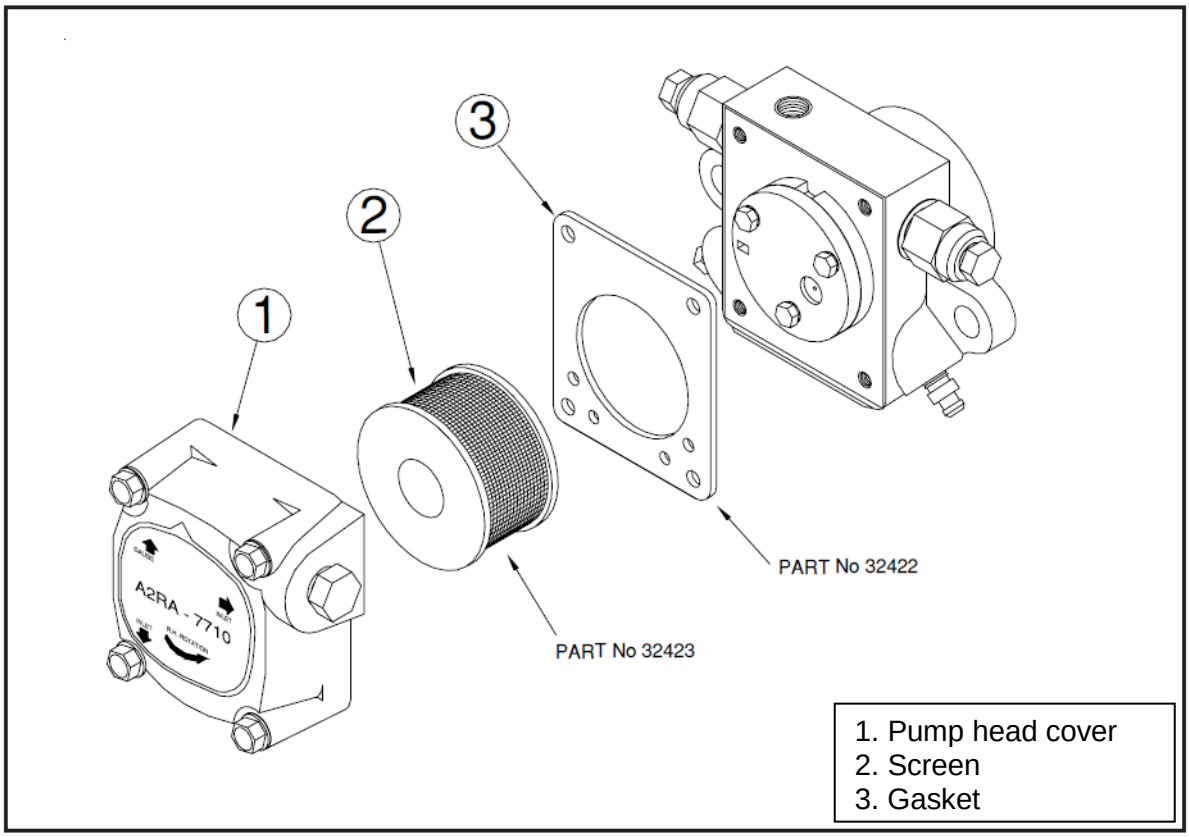
Waste Oil Burner In Limit Switch

Waste Oil Burner Out Limit Switch

Waste Oil Burner: (02-003.Y)

Failure to maintain and / or improper servicing by unqualified personnel will adversely affect the proper, safe operation of your burner, will reduce the service life of your burner and will void your warranty

INSTRUCTION 02-003.Y.01: SERVICING THE METERING PUMP



1. Remove the pump head cover.
2. Remove the screen and wash it.
3. Remove and discard the used gasket.
4. Install a new gasket.
5. Replace the screen and pump head cover.

For more detail, refer to OEM Waste Oil Burner Manual

Corrective Maintenance Instructions (CMI)

The following instructions relate to the replacement or correction (fixing) of components of the EWS Mobile Incinerator Package.

These Corrective Instructions are grouped in this section by the following:

4.4.1 General Corrective Maintenance Instructions
4.4.2 Refractory Corrective Maintenance Instructions
4.4.3 Primary & Secondary Burner Corrective Maintenance Instructions
4.4.4 Primary & Secondary Blower Corrective Maintenance Instructions
4.4.5 Waste Oil Burner Corrective Maintenance Instructions
4.4.6 Main Control Panel Corrective Maintenance Instructions

As per the *Preventive Maintenance Instructions Manual*, the following table is utilized to identify the components of the system that require corrective maintenance.

System Component		**Identification number**	
Thermocouple		**05-002**	
	Replacing Thermocouple		4.4.1/05-002A
Limit Switch		**05-005**	
	Limit Switch Replacement		4.4.1/05-005A
Refractory		**05-001**	
	Wall Refractory: Gaps between the Modules		4.4.2/05-001A
	Wall Refractory: Replacement of the Modules		4.4.2/05-001B
	Door Gasket		4.4.2/05-001C
	Castable Refractory		4.4.2/05-001D
	Temporary Repair of Castable		4.4.2/05-001E
Primary Blower		**01-001**	
	Air Proving Switch Replacement		4.4.4/01-001A
	Damper Calibration		4.4.4/01-001B
	Modutrol Resistor Replacement		4.4.4/01-001C
	Damper Crank Arm Replacement		4.4.4/01-001D
	Motor Replacement		4.4.4/01-001E
	Modutrol Motor & Transformer Replacement		4.4.4/01-001F
Secondary Blower		**02-001**	
	Air Proving Switch Replacement		4.4.4/02-001A
	Damper Calibration		4.4.4/02-001B
	Modutrol Resistor Replacement		4.4.4/02-001C
	Damper Crank Arm Replacement		4.4.4/02-001D
	Motor Replacement		4.4.4/02-001E
	Modutrol Motor & Transformer Replacement		4.4.4/02-001F
Waste Oil Burner		**02-003**	
	Waste Oil Burner		4.4.5/02-003A
	Waste Oil Burner Parts Replacement		4.4.5/02-003B
	Waste Oil Burner J-Pump Replacement		4.4.5/02-003C
Main Control Panel		**03-010**	
	Main Control Panel		4.4.6/03-010A
	Reboot PLC		4.4.6/03-010B

LIMIT SWITCH REPLACEMENT (4.4.1/05-005A)

1. Loosen the 2 screws holding the limit switch in place.
2. Remove limit switch, replace with a new one (PN: 802T-APE).
3. Take arm off of old body and mount to new.
4. Tighten the 2 screws holding the limit switch body.

REPLACING THERMOCOUPLE (4.4.1/05-002A)

The thermocouple will require routine replacement. The environment inside the incinerator will erode the protection tube to the point of failure. If the element is exposed to this environment it will be destroyed and will need to be replaced.

1. Unscrew thermocouple lid and remove wires.
2. Remove protection tube. To aid with this a vise and a pipe wrench will be needed.
3. Remove element and replace with new element (PN: TK-K08B-0100-S) and protection tube (PN: TA-A427A-K08B-010).

4. Reinstall on incinerator.

5. After installation turn power back on. Observe the temperature reading of the thermocouple you were just working on. If the wires were installed incorrectly the temperature will read the opposite temperature. (I.e. 20°C would read as -20°C). If this is the case open the thermocouple housing and switch the wires.

Refractory Corrective Maintenance Instructions

When working with the refractory make sure you use the proper tools; wear goggles, dust mask and gloves

WALL REFRACTORY: GAPS BETWEEN THE MODULES (4.4.2/05-001A)

The ceramic block refractory will shrink over time exposing the exterior metal shell. These gaps need to be filled in with ceramic refractory blanket.

1. Identify gaps in the chamber that are larger than 1” in width between the modules or if you can see exterior shell.

2. With a Utility knife cut a length of ceramic blanket (PN: 501803) that will fit in the gap between the modules.

3. Stuff the blanket into the space with a straight edge or ruler.

WALL REFRACTORY: REPLACEMENT OF MODULES (4.4.2/05-001B)

Excessive damage to a section of refractory may necessitate the replacement of modules in the incinerator. Such damage is largely due to mechanical wear. The following diagram walks through the removal and installation of new modules.

A. REMOVAL: Remove existing Module (physically pull away existing refractory from underlying Module Anchor)

B. Remove welded stud from steel casing (cut with hack saw or other device between Module Anchor and Furnace Casing/Shell)

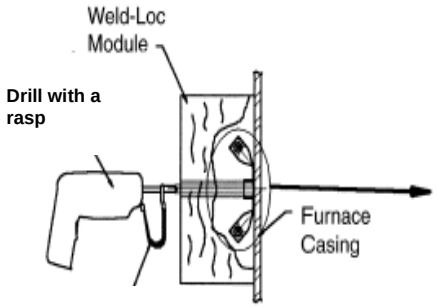


Figure 2: Stud Gun with rasp and Torque Tube (part of module assembly).

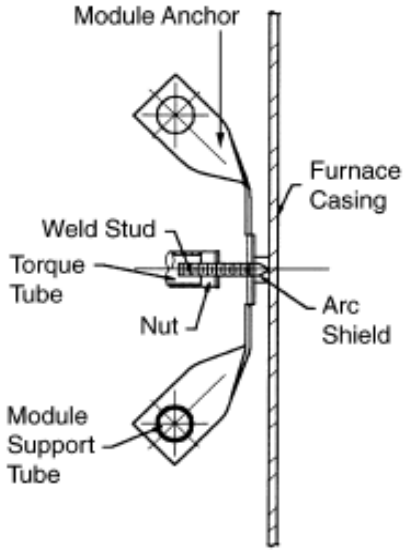


Figure 1: Side view of the Weld Loc Module

C. INSTALLATION: Once the new module is in place take the stud gun with rasp to the Torque Tube and drill into place.

D. Once it has tightened the Torque Tube should come off with the drill.

DOOR GASKET REFRACTORY (4.4.2/05-001C)

The door gasket will degrade over time and will need to be replaced. The bottom of the door will see more degradation due to the waste burning in that vicinity.

1. Identify the damaged section of gasket that will need to be removed
2. With a utility knife cut out the section that needs to be replaced.
3. A new piece of gasket (PN: 462007) will need to be cut the same length as the removed piece.
4. With contact cement coat the gasket on one side and the door section and install.

CASTABLE REFRACTORY (4.4.2/05-001D)

Operators will notice that the castable refractory will show signs of minor cracking. The minor cracking is normal. Large sections of castable should not separate from the rest of the monolithic cast. Such occurrences are largely due to a sudden impact from machinery or dropping of the units themselves. Mortar is supplied to help with a temporary repair while a permanent repair is resolved.

TEMPORARY REPAIR OF CASTABLE (4.4.2/05-001E)

1. Find the pieces of castable refractory that have separated.
2. Clean both the pieces of refractory and the area where the separation occurred.
3. Spread an even amount of high temperature mortar (PN: 452036) on the pieces and the area of separation.
4. Put the pieces back where they originated and support as necessary for a minimum of an hour while the mortar cures.

LEVEL SWITCH REPLACEMENT (4.4.3/01-002G & 02-002G)

The level switch is located in the Waste Oil Tank.

NOTE

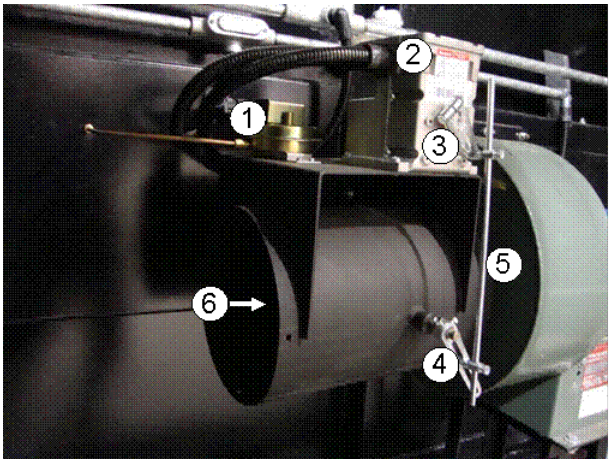
Tank does not have to be emptied to replace.

1. Unplug the level switch.
2. Disconnect the cord and remove the level switch.
3. Replace level switch (PN: FS301-01) and reconnect the cord.
4. Plug in the level switch.

Primary & Secondary Blower Corrective Maintenance Instructions

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

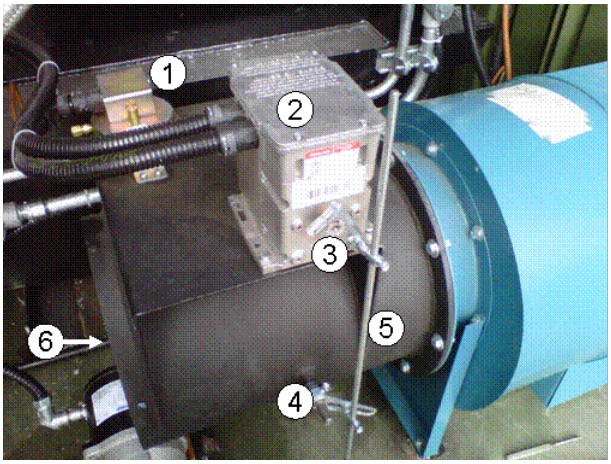
Primary Blower Assemblies are not a commonly repaired part on the incinerator. Parts within this assembly will need to be repaired or replaced. They are outlined below.



Primary Blower

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper

Secondary Blower Assemblies are not a commonly repaired part on the incinerator. Parts within this assembly will need to be repaired or replaced. They are outlined below.



Secondary Blower

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper

AIR PROVING SWITCH REPLACEMENT (4.4.4/01-001A & 02-001A)

1. Ensure all power is locked out.
2. Remove wiring from switch.
3. Remove tubing from switch.
4. Unscrew screws at the two locations and remove switch.
5. Reinstall new switch (PN: SML8221210034) complete with tubing and wiring and then retighten.
6. Turn power back on.

DAMPER CALIBRATION (4.4.4/01-001B & 02-001B)

Sometimes the damper linkage will slip when the connections become loose (Items 3,4,5 in the Secondary Blower photo) In order to ensure that the linkage is correctly calibrated the operator will need to look at the display screen on the control panel while the unit is in operation

1. Read the %Open value on the control panel operator interface for the Primary Blower.
2. During operation the damper is factory preset to be 0% open, or fully closed.
3. Look inside the damper (Item 6) and ensure that the linkage is completely closed.
4. If it is, then this maintenance is complete.
5. Should the damper be open even a small percentage the linkages are to be loosened and the damper adjusted to be completely closed, and then retighten.

MODUTROL RESISTOR REPLACEMENT (4.4.4/01-001C & 02-001C)

The Modutrol resistors are located inside the top lid of the Modutrol motor. Remove the lid to the Modutrol motor by unscrewing the top four (4) screws. The connection between the control panel and the Modutrol is made with a small white connector with 3 terminals. Jumpered between these terminals is the resistors.

Remove and replace the resistors one at a time to ensure the correct resistors are replaced. You identify the correct resistor by examining the color band on the center node of the resistor. Replace like resistors.

DAMPER CRANK ARM REPLACEMENT (4.4.4/01-001D & 02-001D)

The crank arm will only need to be replaced if the arm is damaged due to misuse. Identify the damper crank arm (Item #4 in the picture on the previous page).

Identify the location of the linkage on the rod and the damper arm with a marker, so the new crank arm will be in the same spot when reinstalled. Remove the connections to the crank arm and replace with the new one (PN: 26026G) and ensure it is in the same spot as the old one.

MOTOR REPLACEMENT (4.4.4/01-001E & 02-001E)

Information on replacing the motor can be found in the OEM manual New York Blower, Installation, Maintenance and Operating, IM-160 Junior Fans.

MODUTROL MOTOR & TRANSFORMER REPLACEMENT (4.4.4/01-001F & 02-001F)

To replace the Modutrol motor all power to the system need to be off as you will need to expose electrical connections. First get the new motor and orientate the motor in the same direction as the old motor. Identify where the conduit is connected on the old motor and punch the connector holes for the new motor.

Removal

1. Remove all electrical terminations and remove the transformer.
2. Install the transformer in the new Modutrol motor.
3. Remove all conduit connections on the motor.
4. Remove the damper arm and linkage from the motor.
5. Unbolt the motor from the damper, and ensure all nuts and bolts are kept for the new motor install

Install

1. Bolt the new motor in the same orientation as the old motor.
2. Install the damper arm and linkage to the motor
3. Install all conduit connections

Terminate all electrical connections the same as the old motor.

REPLACE THE BLOWER CONTACTOR 4.4.4/01-001G

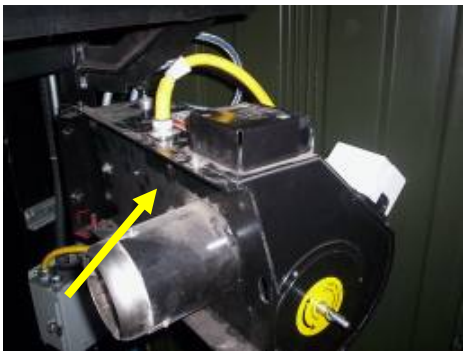
1. Turn Main Disconnect Switch into the OFF position.
2. Open Panel.
3. Remove the wires.
4. Pull the retaining clip up.
5. Tilt contactor forward and remove.
6. To reinstall tilt new contactor until it clicks back in.
7. Pull the retaining clip back down to lock.
8. Reinstall wires.
9. Close panel.
10. Turn power back on.

Waste Oil Burner Corrective Maintenance Instructions

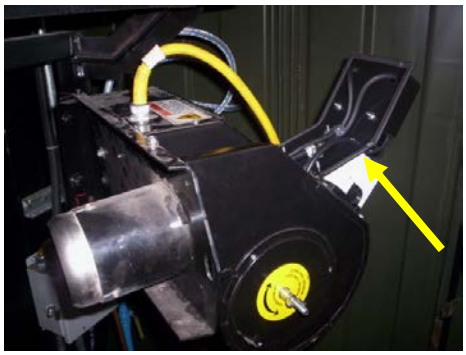
Failure to maintain and/or improper servicing by unqualified personnel will adversely affect the efficient and safe operation of your burner, will reduce the service life and will void your warranty.

WASTE OIL BURNER HEATER ELEMENT CLEANING / REPLACEMENT (4.4.5/02-003A)

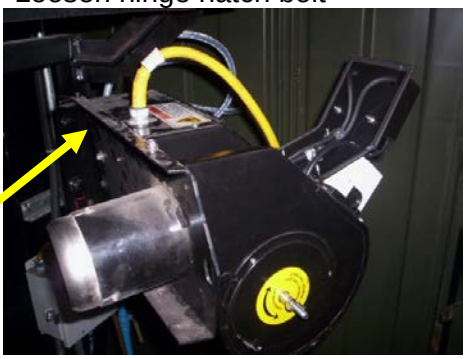
Slide out burner undo bolt



Loosen hinge hatch bolt



Open hinged hatch to access front components



Unscrew (yellow) electrical connection

Remove Cover Screw

Open hatch cover to expose heater element

Remove heater element from casing and inspect for build-up.

Clean any deposits.

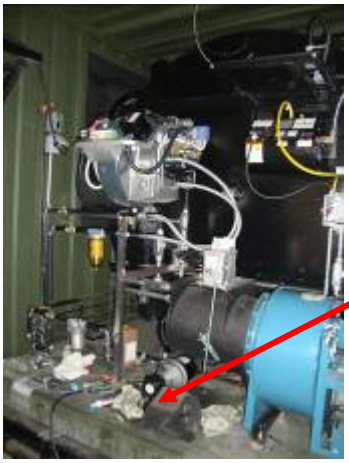
When reinstalling the heater element (PN: 33173) always ensure the element will be restarted immersed in waste oil. A dry element while in operation will reduce the life of the element.

WASTE OIL BURNER PARTS REPLACEMENT (4.4.5/02-003B)

The waste oil burner has the following parts that may need replacing:

Part Description	Part #	Description of replacement
Primary Control	33391	Locate remove and reinstall new one
Igniters Transformer	33189	Locate remove and reinstall new one
CAD Cell	33116	Locate remove and reinstall new one
Fan Squirrel Cage	31113	Locate remove and reinstall new one
Blower Motor	33337	Locate remove and reinstall new one
Retention Head	11427	Locate remove and reinstall new one
Air Pressure switch	33057	Locate remove and reinstall new one
Heater Block	26090	Locate remove and reinstall new one
Air / Oil Solenoid	32322	Locate remove and reinstall new one

WASTE OIL BURNER J-PUMP REPLACEMENT (4.4.5/02-003C)



Waste Oil Burner Pump (J-Pump) Sample location

Removing the pump requires the power to be off to the system. When this is done complete the following step:

1. Open the junction box on the side of the motor of the pump. Disconnect the electrical connections and remove the conduit connection
2. With fuel containment cloth remove the waste oil connection from the pump inlet and outlet.
3. Unbolt the pump. Remove from the chamber

Install the new pump by reversing the above steps.

MAIN CONTROL PANEL (4.4.6/03-010A)

All control panel diagnostics are to be completed by certified or trained technicians. Electrical drawings / diagrams are provided to aid electricians with any diagnostics.

REBOOT PLC (4.4.6/03-010B)

Turn Main Disconnect to the off position on the front of the Control Panel. Turn the main disconnect back on.

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 8

SUPPLIER CATALOGUES

CA 100WO

(This section will be completed with OEM manuals)

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

Appendix B

Knipple Incinerator Installation, Operation and Maintenance Manual (excluding Section 8)

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 1

CONTACT PERSONNEL

CA 100WO

Corporate Office:

Eco Waste Solutions
5195 Harvester Road, Unit 14
Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831
Email: info@ecosolutions.com
Web: www.ecosolutions.com

ECO WASTE SOLUTIONS

Project Name: Brucejack
PO: 177421-PG040 Incinerators
EWS Project # 15-2MS-A

Incinerator CA 100WO Tag No.6128-IN-001

CONTACT INFORMATION		
Eco Waste Solutions	14-5195 Harvester Road Burlington, Ontario, Canada L7L 6E9	
Phone	905-634-7022	
Toll Free	1-866-326-2876	
Fax	905-634-0831	
email	info@ecosolutions.com	
Personnel Contact	**Job Title**	**Email**
Sandra Marshall	**Customer Service Manager**	smarshall@ecosolutions.com
If Sandra Marshall can't be reached try below contacts:		
James Anderson	Technician	janderson@ecosolutions.com
Joe Coutinho	Instrumentation & Installation Specialist	jcoutinho@ecosolutions.com

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 2

GENERAL DESCRIPTION

CA100WO

Corporate Office:

Eco Waste Solutions
5195 Harvester Road, Unit 14
Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831
Email: info@ecosolutions.com
Web: www.ecosolutions.com

General Description - Thermal Oxidation Concept

The **CA100WO** Incinerator system consists of a **Primary Chamber** and a **Secondary Chamber** (also known as the Afterburner). Both chambers are vessels constructed of steel with a special insulating liner known as refractory.

The **Primary Chamber** has a front door for loading of waste material and for the removal of residual ash.

The waste is loaded into the **Primary Chamber** until it is ¾ full. Once ¾ full the **Primary Chamber** is sealed and the combustion cycle begins. This type of system is known as *batch-fed* processing.

Primary Chamber

To begin the process of burning the solid waste, the **Primary Chamber Burner** is used to elevate the temperature of the **Primary Chamber** to ignite the waste. Once the **Primary Chamber** reaches a temperature of 650-850 ^{o}C (1200-1560 ^{o}F), by using a **Thermocouple** to measure the temperature of the **Primary Chamber**, the burn process becomes self-fuelling and the burner will shut off. To save fuel and control temperatures, only when the energy contained within the waste is depleted, will the burner periodically turn on.

The **Primary Chamber** operates under *controlled temperature* conditions. The amount of heat released, from the burning of the waste, is controlled by limiting the air into the **Primary Chamber** to less than what is required to complete combustion. This is described as *starved air* conditions. With controlled air and temperature the waste is dried, heated and burned thereby releasing moisture and volatile components. The non-volatile, combustible portion of the waste is burned in the **Primary Chamber** to provide heat while the non-combustible portion accumulates as ash. These conditions ensure that the waste is allowed to fully combust and is rendered sterile. In the end, the waste volume is reduced by over 90%.

Remaining in the **Primary Chamber** are non-combustibles, such as metal and glass, and carbonaceous residue. The incoming air, subjecting the non-combustibles to high temperatures, further burns the carbonaceous residue. The result is an oxidized ash product.

Controlling the gas velocity through the system is an important factor in limiting pollution. The gases flowing from the **Primary Chamber** are a result of the interaction of the air with the waste during the controlled burning process. Both the quantity and velocity of the gas product vary according to chamber temperature conditions and the type of waste being burned. The integrated controls for the **Primary** and **Secondary Chamber** act to minimize peaking activity thus controlling pollution automatically.

The combustion gases released in the **Primary Chamber** then pass into the **Secondary Chamber** through a turbulent mixing zone where ignition takes place and additional combustion air is provided to complete the burning process.

Secondary Chamber

As waste burns in the **Primary Chamber**, gases containing the products of combustion are pulled continuously into the high temperature zone of the **Secondary Chamber** where the oxidation reaction of the combustible products is completed.

The **Secondary Chamber** controls the temperature at 1000°C (1832 ^{o}F), using a **Thermocouple,** which constantly measures the temperature inside the chamber. The temperature readings are monitored by the system's PLC and the PLC will initiate operational changes such as increasing or decreasing the speed of the **Secondary Chamber Blower** and the output of the **Secondary Chamber Burner**.

The **Secondary Chamber Blower** air is introduced into the **Secondary Chamber** by an air ring manifold that surrounds the **Secondary Chamber**. The manifold has small air jets called tweers that open into the **Secondary Chamber** at the side walls and create a powerful vortex of excess air to mix the incoming gases and ensure complete combustion. The flow of air is tightly managed by the control system using a Variable Frequency Drive (VFD) to control the speed of the fan and modulating motors on the blower inlet dampers.

The **Secondary Chamber Blower** is extremely important as it creates the turbulence required to mix the gases and oxygenate them. This fosters the high efficiency combustion required to break hydrocarbon chains into carbon dioxide and water vapour. It also acts to cool the **Primary Chamber** and prevent temperature overruns.

Secondary Chamber Burner is similar to the burner used in the **Primary Chamber** except that it has a much higher output and it is self-modulated over a broad range for very precise temperature control.

The **Secondary Chamber** is sized to allow two seconds of retention time. This is the time that the gases from the **Primary Chamber** are retained in the **Secondary Chamber** before they exit to the next stage. Two seconds of retention is considered to be ideal to destroy any harmful organic hydrocarbons produced from the **Primary Chamber**.

Protecting the Environment

Why Incinerate

As society becomes more environmentally conscious, environmental regulations on the proper disposal of waste has become more stringent. As a result, incineration has become an environmentally responsible and socially acceptable alternative for handling waste at the point of need. However, incineration does not eliminate the need to landfill waste but it does reduce the amount of waste that must be placed in landfills.

Primary Advantages of incineration are:

- It greatly reduces the weight and volume of waste material that must be disposed of in landfills
- It destroys organic materials that may be harmful or that may be degradable to harmful materials in landfills
- The incinerator sterilizes the waste; that is, the high temperatures in incinerators can destroy any pathogens that may be in infectious waste materials
- The incinerator destroys animal or human pathological wastes that the general public finds objectionable to handle or see.

Environmental Concerns

The general public will not accept incineration as an option for treating waste of any kind, if they do not believe that it is safe environmentally. The primary concerns are about air pollutants produced by the incinerator and the toxicity of the residual ash.

Air Pollutants of Concern

Particulate matter may be defined as fine liquid or solid matter such as dust, smoke, mist, or fumes found in the gaseous emissions from the incinerator. Particulate matter emissions may have a dark or light color. Particulate matter emissions can be described in terms of opacity. Opacity is the degree to which light is obscured by a polluted gas (a clear window has 0 percent opacity while black paper has 100 percent opacity). Opacity may be measured with the naked eye or using an opacity monitor. Particulate matter is a problem because it can cause or aggravate respiratory problems in humans. It also creates aesthetic problems since it is readily noticed and is a nuisance because of soiling of exposed surfaces on houses and cars.

Hydrochloric HCl acid is generated when polyvinyl chloride (PVC) plastic (usually clear plastic) material is burned in the incinerator. The appearance of a white plume or cloud a short distance above the stack indicates that HCl is condensing. The major concerns about HCl are that it causes respiratory problems in humans, contributes to acid rain problems, and causes material damage to metals and concrete.

Toxic metals include cadmium, arsenic, beryllium, chromium, nickel, lead, and mercury. These metals may be found in municipal wastes. These metals are known to be hazardous to human health.

Organic compounds are compounds that contain primarily carbon and hydrogen and may also contain other elements such as oxygen, nitrogen, and chlorine in smaller amounts. Some organic compounds are known to cause or are suspected of causing cancer and are considered hazardous air pollutants. The public's primary concern is related to dioxin and furan emissions, but other organic compounds such as benzene and vinyl chloride may be emitted.

Carbon Monoxide (CO) also is generated during combustion if the combustor is not operated properly. (Your automobile generates some amount of CO.) CO is toxic to humans if concentrations are high enough, and it also is an indicator of combustion quality.

Solid Waste Ash Quality

One of the major objectives of incineration is to generate a high quality ash for land disposal. All pathogens should be destroyed, and almost all organic material should be completely burned. Ideally, no large chunks of unburned waste material (other than metals or glass) should remain in the waste. A measure of ash quality is "burnout," which is the percentage of organic material remaining in the waste. For example, a burnout of 95 percent means that the ash can contain only 5 percent organics. Adequately burned and quenched ash may be disposed of in a sanitary (municipal) landfill. The ash should be stored in covered containers or kept wet prior to transport to the landfill to prevent 'fugitive \ emissions.' Individual landfills may have requirements that must be followed in order for your waste to be accepted. You should familiarize yourself with these requirements to prevent refusal of the waste.

The Operator – Your Role

It is the operator's role and responsibility to protect the environment by:

1. Complying with all emission limits and operating practices specified in the permit to operate.
2. Minimizing emissions of particulate matter, HCl, toxic metals, carbon monoxide, and organic compounds through proper incinerator;
3. Operating the incinerator to generate high quality ash that is sterile and can be disposed of in landfills;
4. Minimizing particulate matter emissions from ash handling;
5. Disposing of ash properly by sending it to appropriate disposal sites; and
6. Performing the regular maintenance inspections to catch any operational problems early.

Basic Combustion Principles

The Combustion Process

Combustion of MSW is a chemical reaction. In the incinerator, organic materials and oxygen react rapidly and violently to produce combustion gases and energy in the form of heat and light.

$$\text{Organic Solid Material + Oxygen} \xrightarrow[\text{Heat}]{} \text{Combustion Gas + Solid Residue + Energy(Heat)}$$

For the reaction to begin and to keep going, all three elements - organic material, oxygen, and heat-must be present. The organic material used in the reaction comes from two sources, waste and auxiliary fuel. Some organic material is contained in most solid waste types. Depending on the fraction of organics and the specific organic composition, the waste may be adequate to sustain combustion. Auxiliary fuel may be used to maintain combustion if the waste material does not contain enough organic material to maintain high temperatures. The combustion reaction between the organic material and oxygen that causes the organics to burn will occur only after the temperature of the organic material is raised to the point that combustion can begin.

Energy in the form of heat is required to raise the temperatures of the incinerator chamber and organic material and O_2. Initially, this energy usually is supplied by the pilot and auxiliary fuel burners. After the system is in full operation, the energy released from the burning waste often is adequate to maintain these high temperatures.

Fate of Combustion Air

The oxygen needed for the combustion reaction is supplied by the ambient combustion air. Combustion air is supplied to the combustion chambers through air ports by a forced draft fan, by an induced draft fan, or by natural draft. In general, this air contains about 21 percent oxygen (O_2) and 79 percent nitrogen (N_2), so about 21 percent of the total combustion air fed to the incinerator is oxygen that is available to react with the organic material in the waste and fuel. The nitrogen passes through the chamber mostly unreacted; some nitrogen oxides are formed.

Oxygen Reaction

Solid waste contains two types of organic materials

1. Volatile Matter
2. Fixed Carbon

These two types of materials are involved in distinct types of combustion reactions, and the operating variables that control the two types of reaction are different.

Volatile matter is that portion of the waste that is vaporized (or evaporated) when the waste is heated. Combustion occurs after the material becomes a gas. The combustion variables that influence this reaction are gas temperature, residence time, and mixing.

- A minimum temperature is needed to start and sustain the chemical reaction.
- Residence time is the length of time, generally measured in seconds that the combustion gas spends in the high temperature combustion chamber. The residence time must be long enough for the reaction to be completed before it leaves the high temperature zone.
- Turbulent mixing of the volatile matter and combustion air is required to ensure that the organic material and oxygen are well mixed.

Fixed carbon is the nonvolatile organic portion of the waste. The combustion reaction is a solid-phase reaction that occurs in the primary chamber (although some materials may burn in suspension). Key operating parameters are temperature and solids retention time.

- The solids retention time is the length of time that the waste remains in the primary chamber.

Products of complete combustion are:
- Carbon dioxide
- Water

One example of volatile waste is backyard charcoal grill with starting fluid. The starting fluid is highly volatile. When put on the charcoal and ignited with a match, it rapidly volatilizes and burns. The charcoal contains less volatile matter and primarily burns slowly as a fixed carbon bed.

Operating Factors Related to Combustion

The three operating factors that have the greatest effects on the combustion reaction are:

- Combustion airflow rate and distribution,
- Operating temperatures, and
- Waste feed rate and characteristics.

These three factors are all related. Controlling them controls the combustion reaction. The two key questions about combustion air are:

- How much combustion air is needed to sustain the combustion reaction?
- What happens if there is too much or too little combustion air?

Stoichiometric Air

In the chemical reaction between organic materials and oxygen, the amount of oxygen required under ideal or "perfect" conditions to burn all of the organic materials with no oxygen left over is called the stoichiometric (or theoretical)-oxygen level. The amount of combustion air associated with that oxygen level is called the stoichiometric air level. At stoichiometric air level the combustion gas would contain no oxygen because it would all be used in the combustion reaction.

Substoichiometric Air

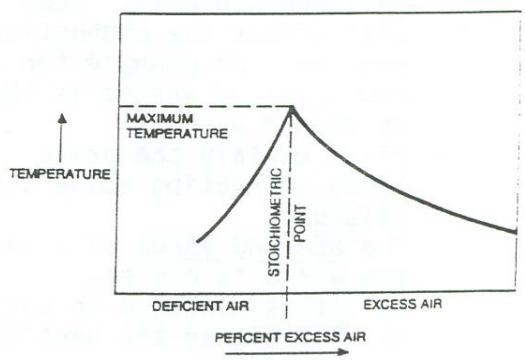
Airflows less than those required at stoichiometric levels are called deficient air or substoichiometric starved-air levels. Under starved-air conditions, the combustion gas would again contain no oxygen, but organics also would remain because combustion is not complete.

Excess Air

Air flows greater than those required at stoichiometric levels are called excess-air levels. Typically an incinerator operates with an overall 140 to 200 percent excess air level. That is, the incinerator operates with one and one-half to two times more air than required at stoichiometric levels. Excess air is used to assure that enough oxygen is available for complete combustion.

Control of Temperature as a Function of Air Level

Maximum combustion temperatures are always attained at stoichiometric conditions. As the amount of excess air is increased above the stoichiometric point, the temperature in the incinerator drops because energy is used to heat the combustion air. If the amount of combustion air is too great, the temperature drops below “good combustion temperature," and undesirable combustion products are generated as a result of incomplete combustion. As the amount of excess air is decreased, the combustion temperature increases until it becomes maximum at the stoichiometric point. Below the stoichiometric point, the temperature decreases because complete combustion has not occurred.



CONTROL OF TEMPERATURE AS A FUNCTION OF EXCESS AIR

The relationship of how combustion air level can affect temperature has just been shown. Temperature also plays an important role in the combustion of waste. Temperatures need to be maintained at levels high enough to ensure pathogen destruction and to sustain the combustion reaction. However, temperatures that are too high also cause problems. Continuous exposure of the combustor refractory to high temperatures is generally not desirable because it can cause the ash to fuse and can cause damage to the refractory.

Waste Characteristics

The primary characteristics of the waste that affect the combustion reaction are:

- The heating value

- The moisture content
- The chlorine content

Different wastes have different heating values and moisture contents. They will affect the combustion process.

The HEATING VALUE of a waste is a measure of the energy released when the waste is burned. It is measured in units of Btu/lb (J/kg). A heating value of about 5,000 Btu/lb (11.6×10^{-6} J/kg) or greater is needed to sustain combustion. Wastes with lower heating values can be burned but they will not maintain adequate temperature without the addition of auxiliary fuel. The heating value of the waste can be used to calculate total heat input to the incinerator where:

Heat Input (Btu/h) = Feed Rate (lb/h) x Heating Value (Btu/lb)

Heat input to the incinerator will affect temperature. More heat input yields higher temperature. Heat input also will affect air requirements; more air is required (1 SCF/100 Btu).

MOISTURE is evaporated from the waste as the temperature of the waste is raised in the combustion chamber. It passes through the incinerator, unchanged, as water vapor. Evaporation of moisture uses energy and reduces the temperature in the combustion chamber.

CHLORINE in plastics or solvents in the waste feed will react to form hydrochloric acid (HCl). This HCl can be an emission problem. It can create corrosion problems of the equipment downstream from the incinerator.

The heating value (Btu value) and moisture varies widely. Compare plastics (high Btu, no moisture) to Beddings, shavings, etc. to Anatomical

Summary of Key Operation Factors Affecting Combustion

1. Key factors are interrelated.
2. Air quality/distribution
3. Sufficient air for complete reaction
4. Distributed to promote mixing
5. Mixing
6. Assure contact of oxygen and organics
7. Temperature
8. High enough to sustain combustion
9. High enough to have complete reaction
10. Residence/retention time
11. Sufficient time to allow reaction to complete

Waste characteristics also are important

- Heating value
- Measure of energy released
- Heat input determines air required
- Moisture content
- Requires energy to vaporize water
- Chlorine content

- Affects HCl emissions

Products of Combustion Reaction

Complete Combustion

The primary products of waste incineration are:

- Combustion gases
- Solid residue (ash)
- Energy

The primary objectives of the combustion process are to generate an ash residue that is sterile (free of pathogens) and does not contain unburned, recognizable wastes; and to minimize air pollutants in the combustion gas stream.

The organic materials that enter the incinerator with the waste and fuel are primarily made up of carbon, hydrogen, and oxygen. Ideally, these organic materials react with oxygen in the combustion gas to form carbon dioxide and water vapor. The chemical reaction for this ideal situation is

$$\text{Organics} + O_2 + \text{Heat} \longrightarrow CO_2 + H_2O + \text{Heat}$$
(C, H, 0)

This ideal reaction represents complete combustion.

Incomplete Combustion

However, this ideal reaction does not occur in operating waste combustion systems. Factors that lead to a less than ideal reaction are poor mixing, too little combustion air, and low temperatures. Under those conditions products of incomplete combustion are emitted with the stack gases. The most common product of incomplete combustion is CO. Another product of incomplete combustion that often is emitted under poor mixing conditions or high temperature, low excess air conditions, is elemental carbon (or soot). The soot particles are very fine and generally result in high opacity at the combustion stack. Other products of incomplete combustion that cause concern because of their health impacts are hazardous organic compounds such as benzene, dioxins, and furans. Although these compounds are not found in the waste, under incomplete combustion conditions they can be formed as intermediate combustion products.

The waste feed also includes inorganic materials; generally, they are not involved in the combustion reaction. The inorganic materials in the waste feed (ash) are either retained in the ash or are emitted as particulate matter in the combustion gas. Air velocities in the combustion bed are controlled to reduce the amount of inorganic material entrained (picked up by) the combustion gas and emitted with the combustion gas. If combustion is not complete, organics will remain in ash; this is typical…it is atypical to have 100 percent combustion of ash bed. Under poor conditions (low temperature, low turbulence in ash bed) the ash may have pathogens present, the ash may not be sterilized.

Combustion Indicators

The following indicators can be used to monitor combustion quality.

Opacity

The opacity of the combustion gas stream is a measure of the degree to which the stack gas plume blocks light.

- High opacities indicate high emissions.
- Opacity is primarily caused by noncombustible ash or uncombusted carbon (soot) in the flue gas.
- High opacities can indicate poor mixing or low levels of combustion air.
- High opacities also may be generated by high levels of HCl emissions or poor burner operation in the secondary chamber.

If a large amount of water vapor is present in the combustion gas, the water can condense when it cools as it leaves the stack forming a dense white "steam plume." This is not an indicator of poor combustion and should not be confused with a black or white smoke plume caused by soot or acid gases. Opacity can be visually determined by a person or measured by an instrument.

Other indicators which provide information about combustion conditions are measurements of the combustion gas oxygen and CO levels. However, these measurements require instruments and most facilities do not have those instruments.

Ash Quality

Visual appearance of ash can be an indicator of combustion problems. If an incinerator is operating properly, little organic material will remain in the ash. Whitish gray ash indicates better burnout and less carbon than black. The extent of organics combustion can be measured by the quantity of combustible materials remaining in the ash. Noted increases in combustibles in the ash indicate a combustion problem which may include bed temperatures that are too low, improper distribution of combustion air in the bed, or insufficient waste retention times.

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 3

PHOTOS OF THE INCINERATOR

CA100WO

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

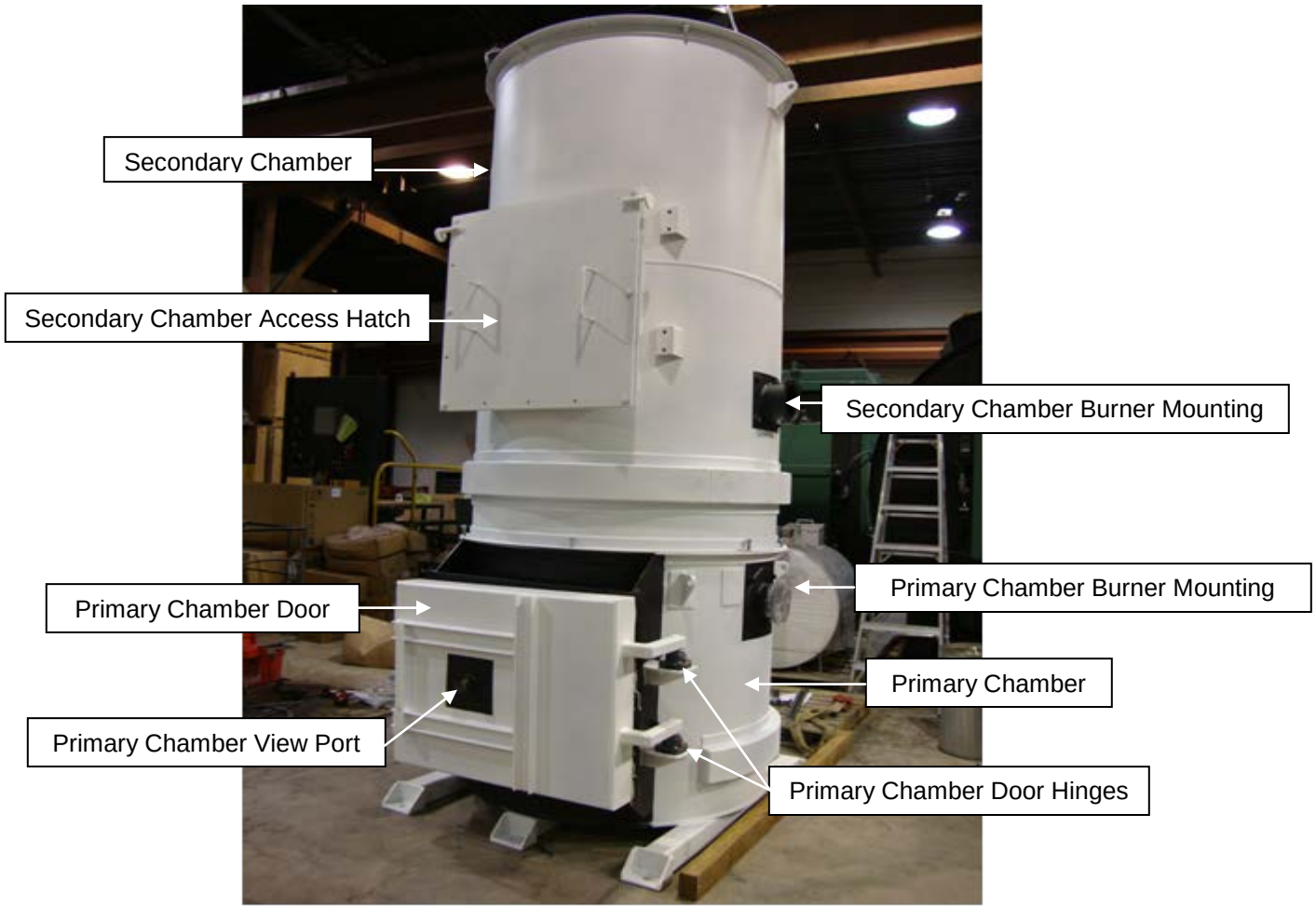
Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

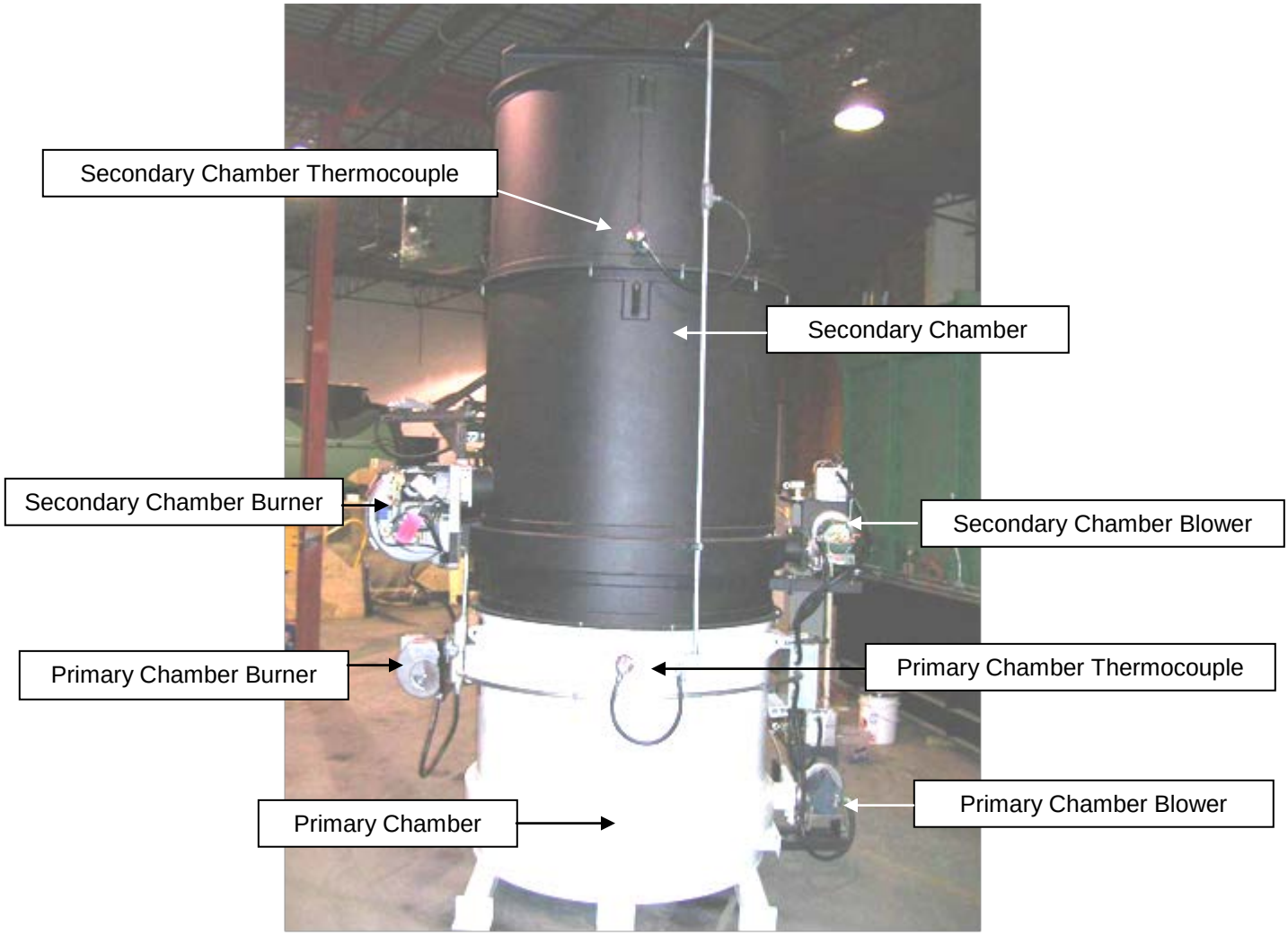
Web: www.ecosolutions.com

CA Model Incinerator Front View



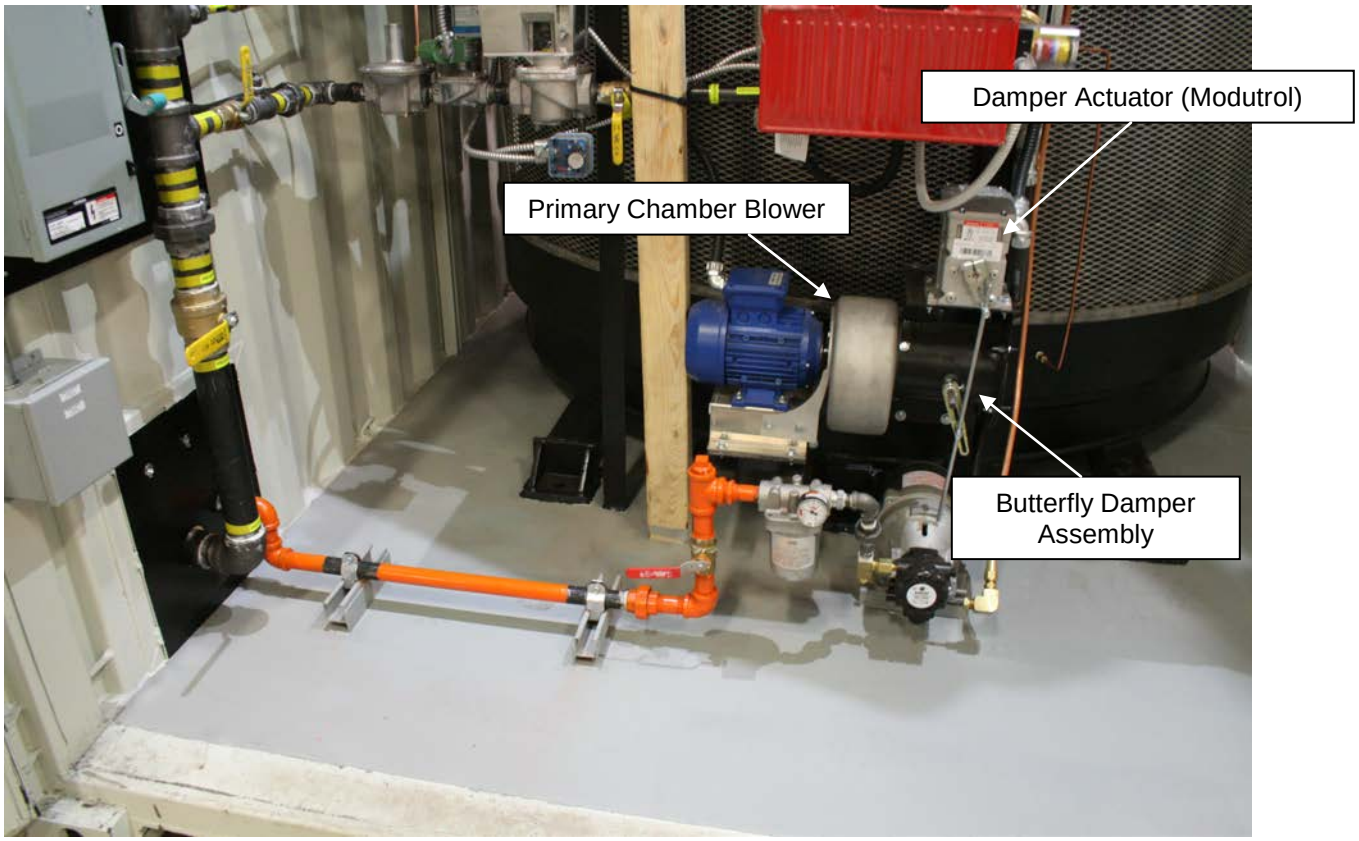
CA Model Incinerator – Front View
(Sample photos for reference only)

CA Model Incinerator Rear View



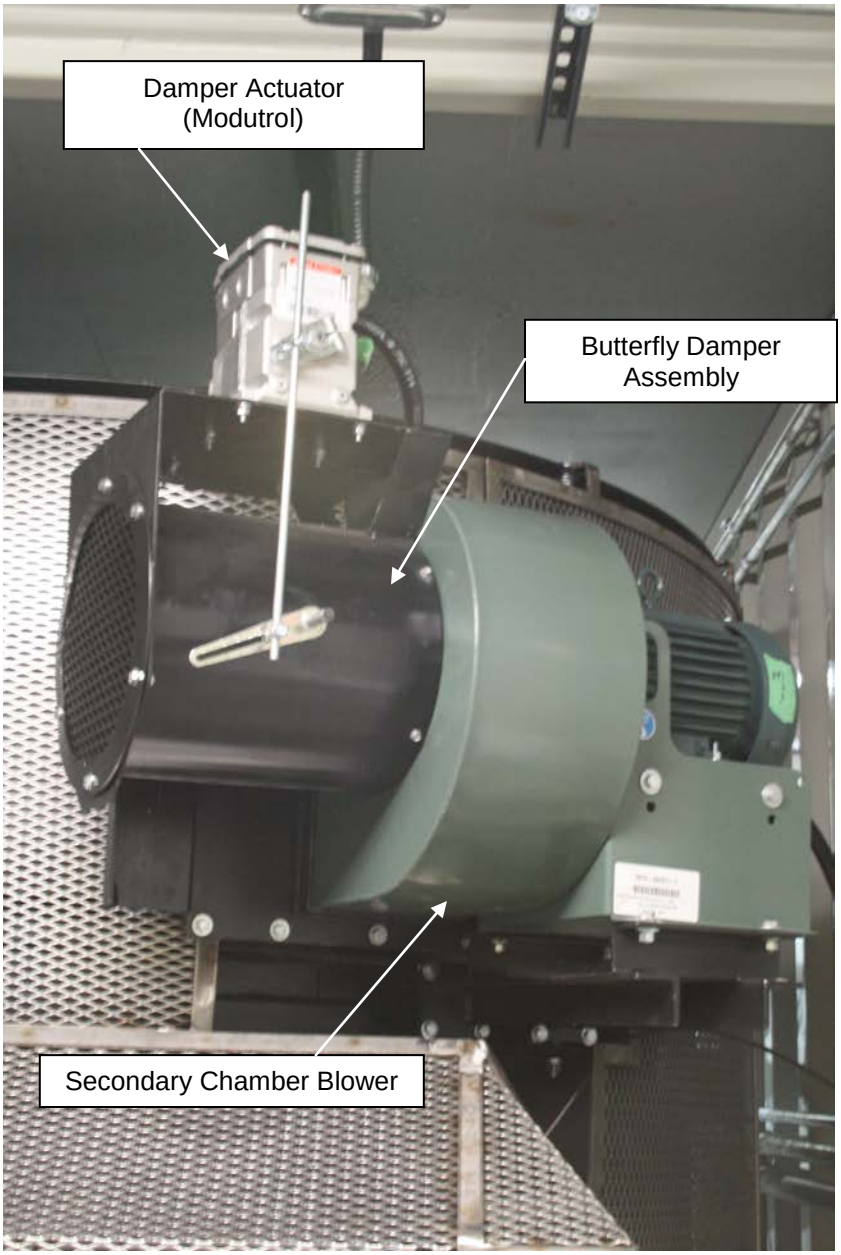
CA Model Incinerator – Rear View
(Sample photos for reference only)

Primary Chamber Blower



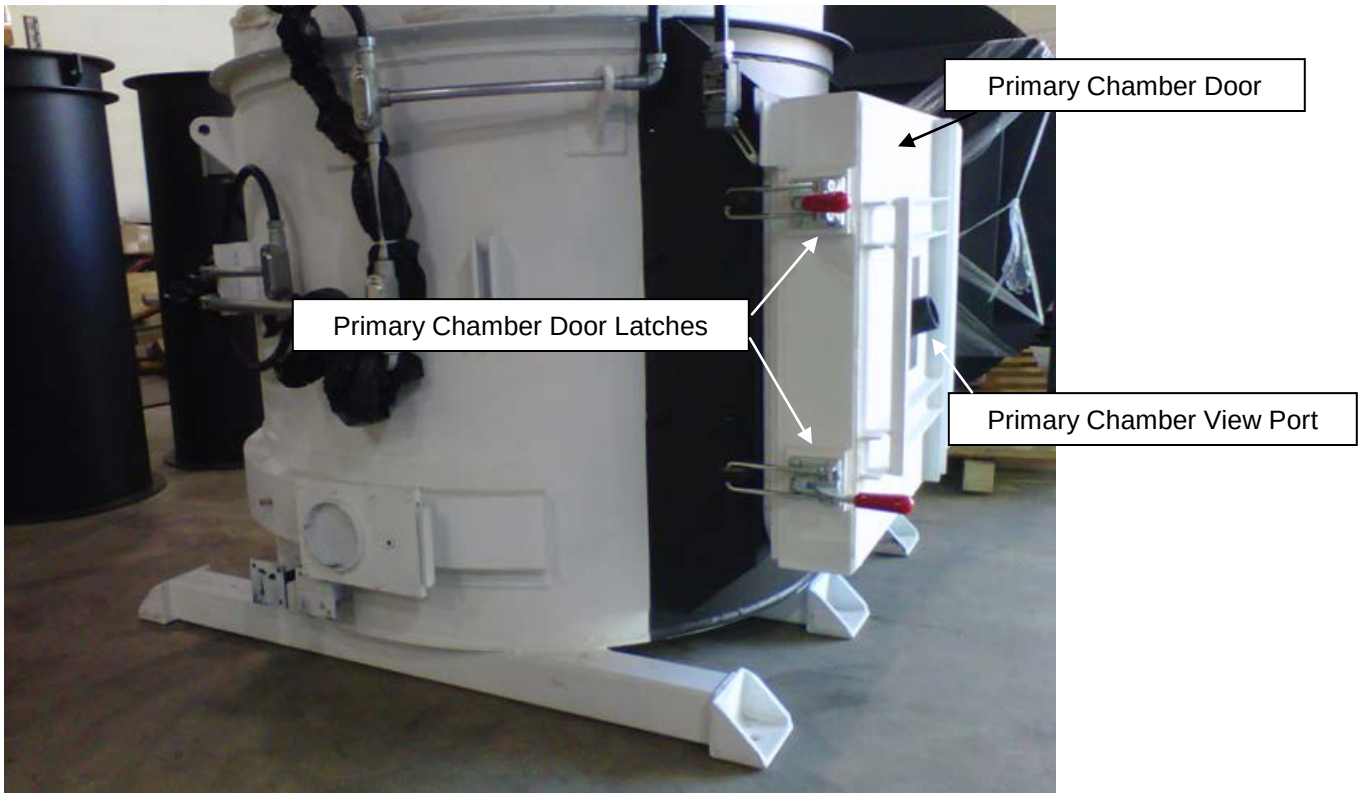
Primary Chamber Blower
(Sample photos for reference only)

Secondary Chamber Blower



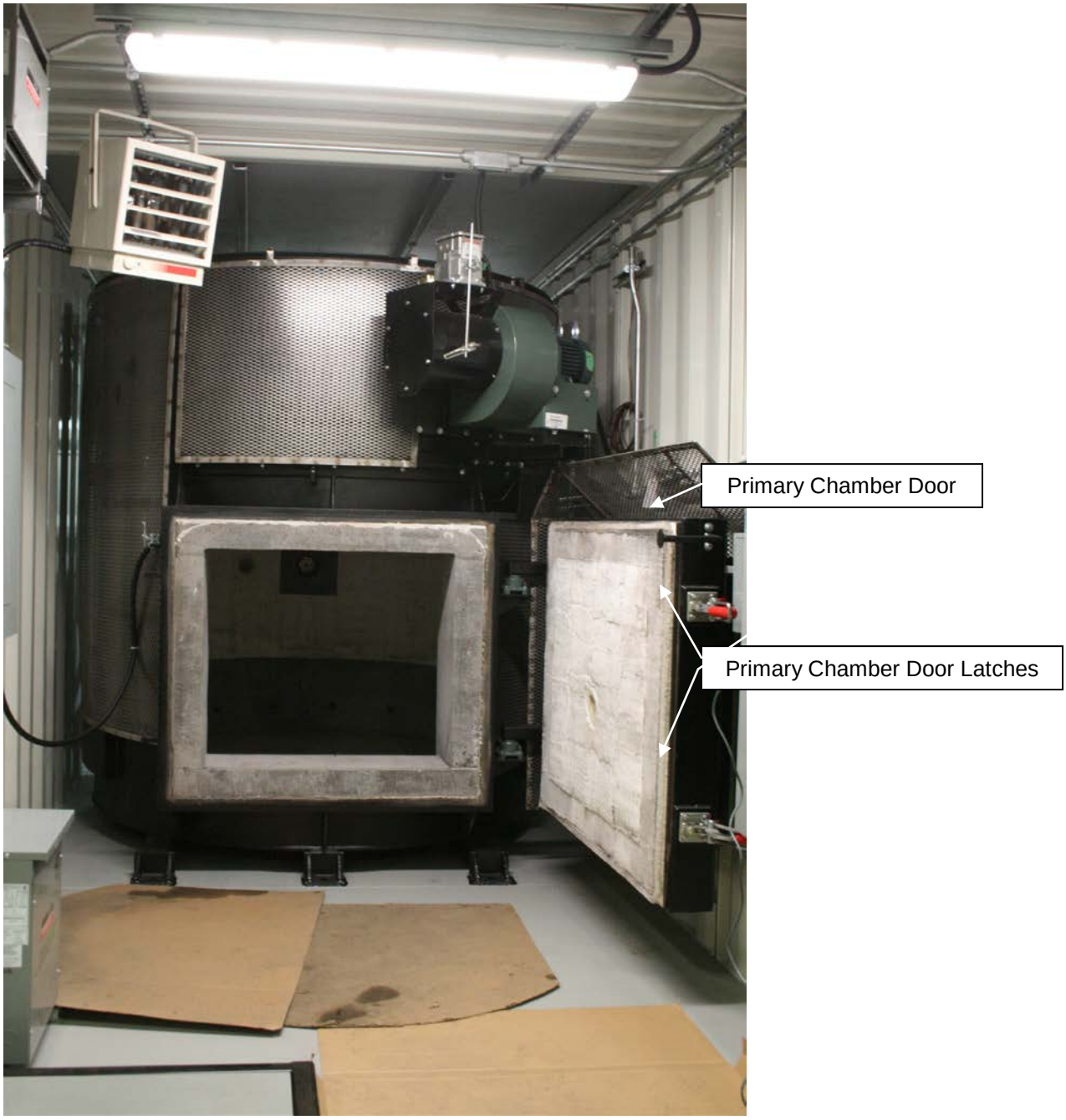
Secondary Chamber Blower
(Sample photos for reference only)

Primary Chamber (Side View)



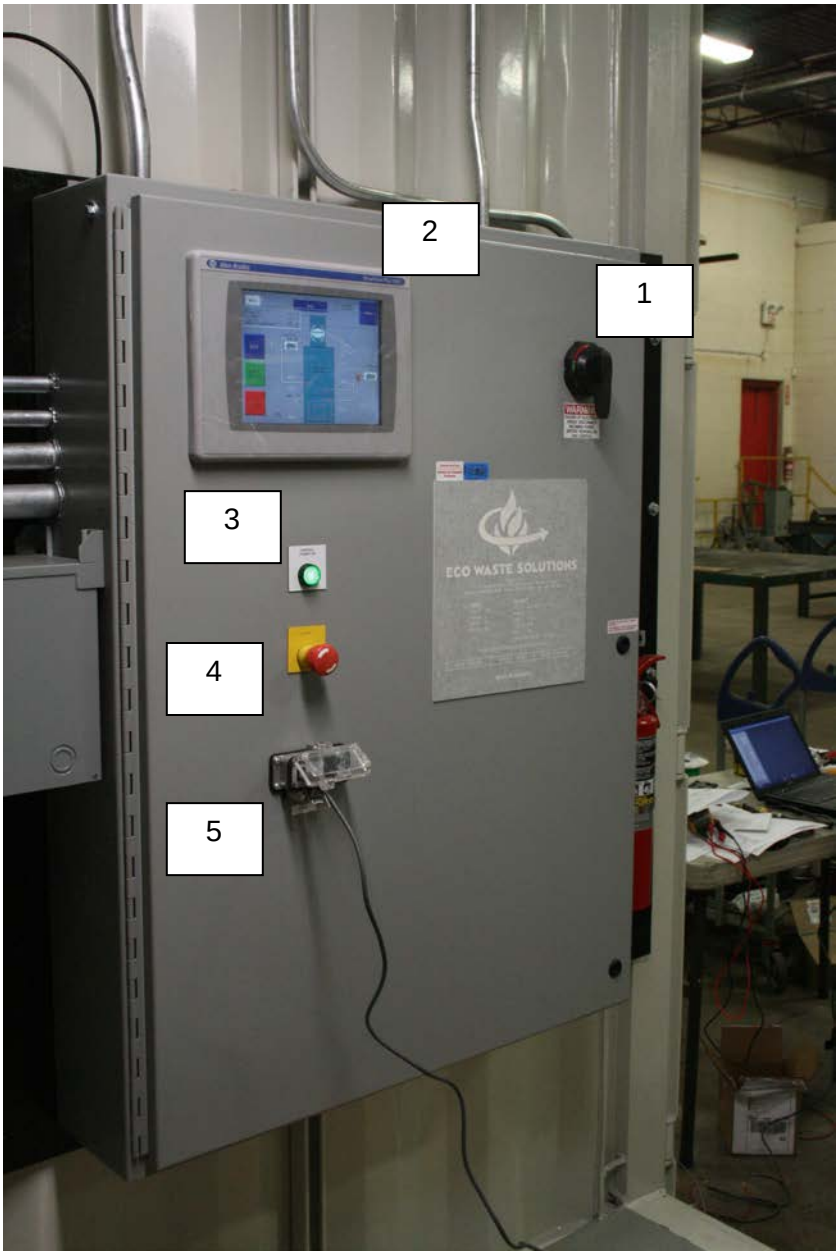
Primary Chamber Side View
(Sample photos for reference only)

Primary Chamber Open (Front View)



Primary Chamber Open
(Sample photos for reference only)

Main Control Panel



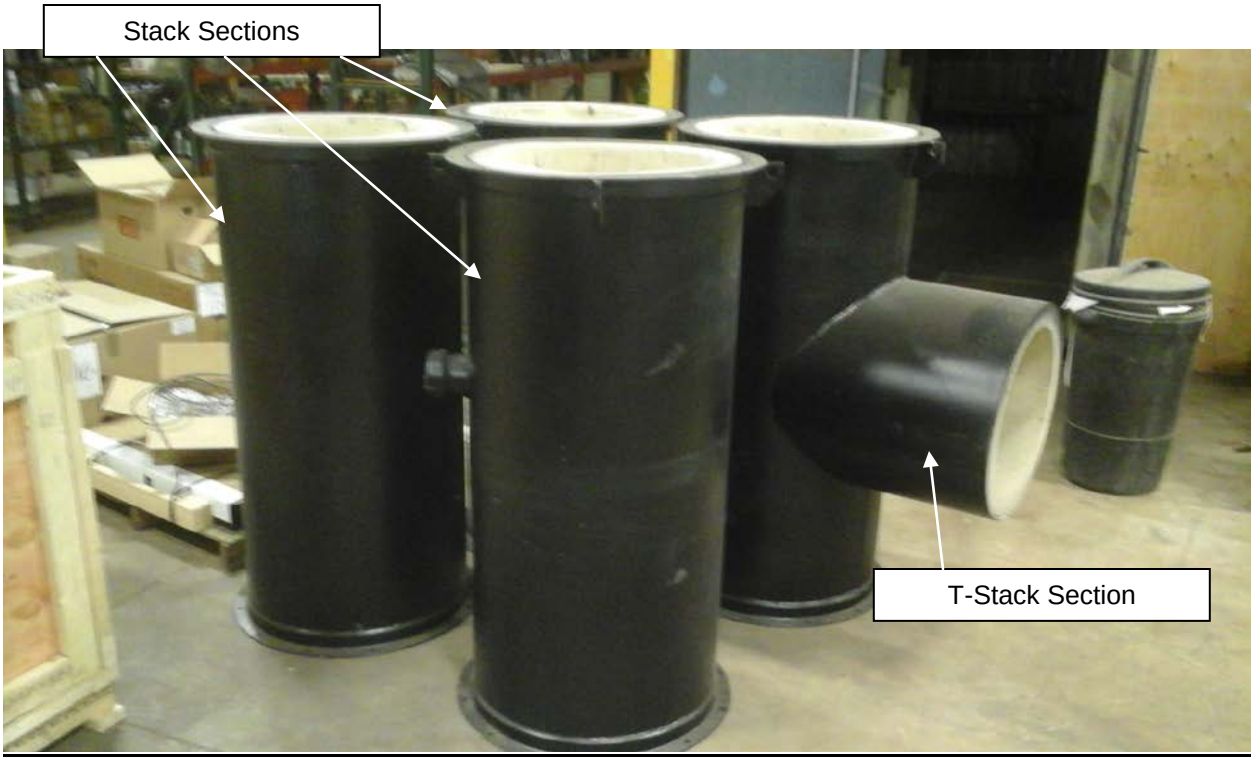
Main Control Panel (as built)

1. **Main Disconnect Switch**
2. **HMI**
3. **Control Power ON**
4. **Emergency Stop Push Button**
5. **USB Port**

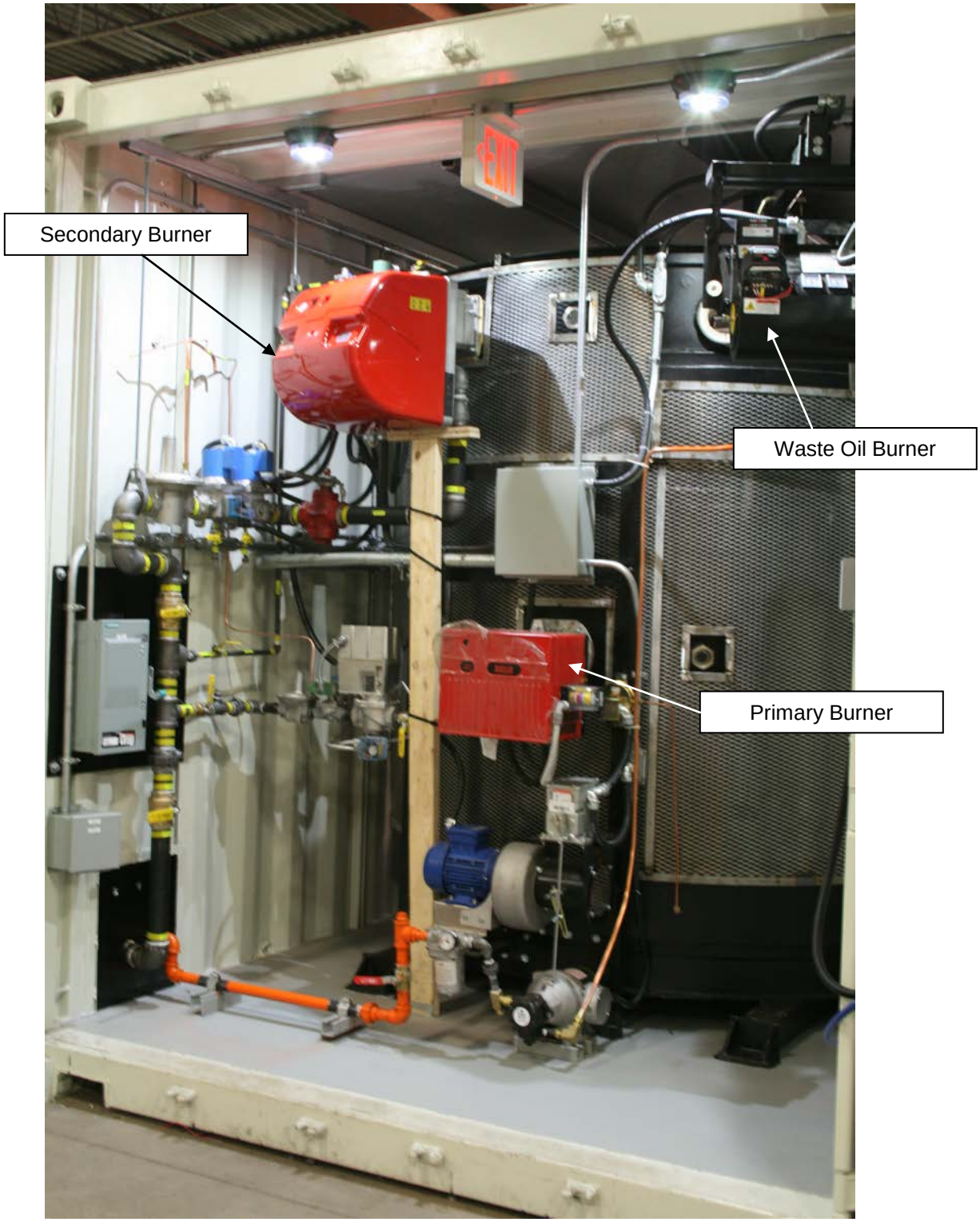
Thermocouple, Viewport and Limit Switch

Note: These are sample photos

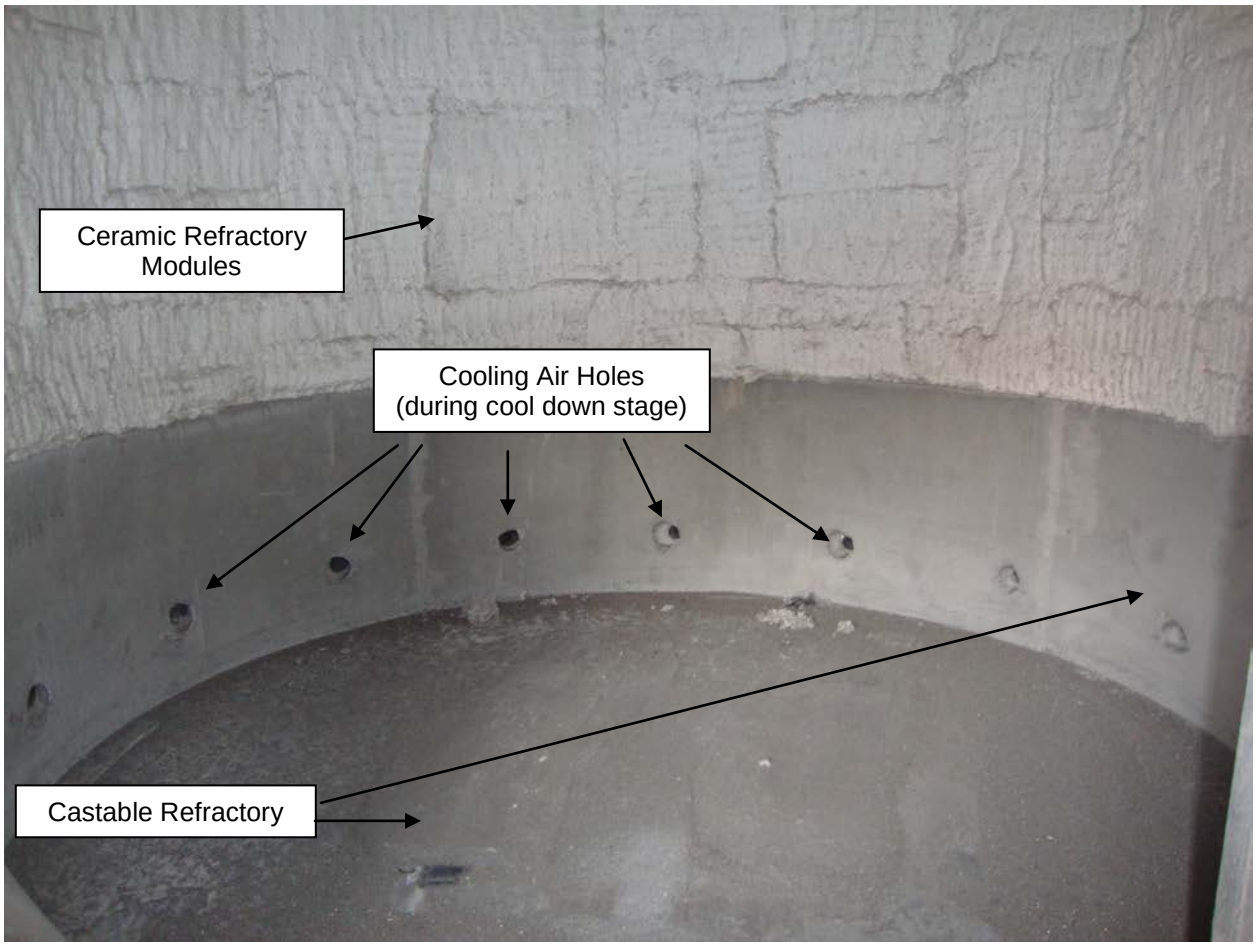
T-Stack and Stack Sections



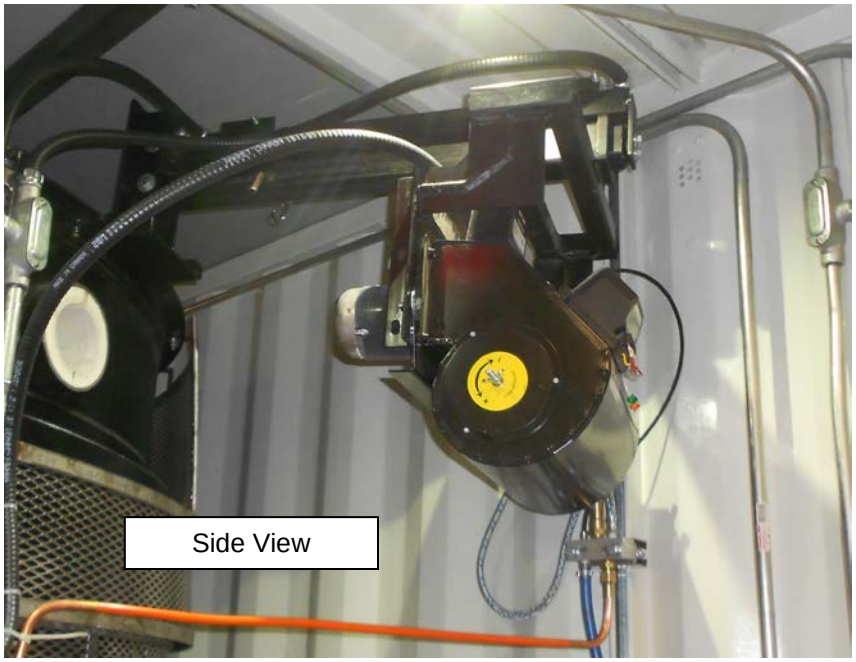
Burners

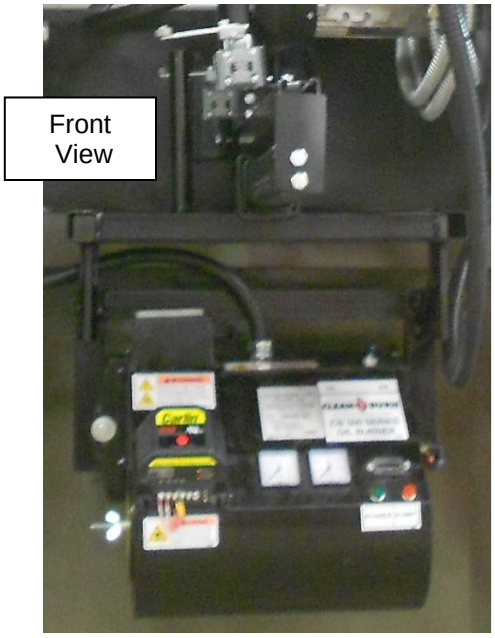


Primary Chamber (Inside)



Waste Oil Burner





PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 4

INDEX OF DRAWINGS

CA 100WO

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

NOTES:

CUSTOMER TO LOCATE PROPANE TANK AND WASTE OIL TANK ACCORDING TO LOCAL CODES

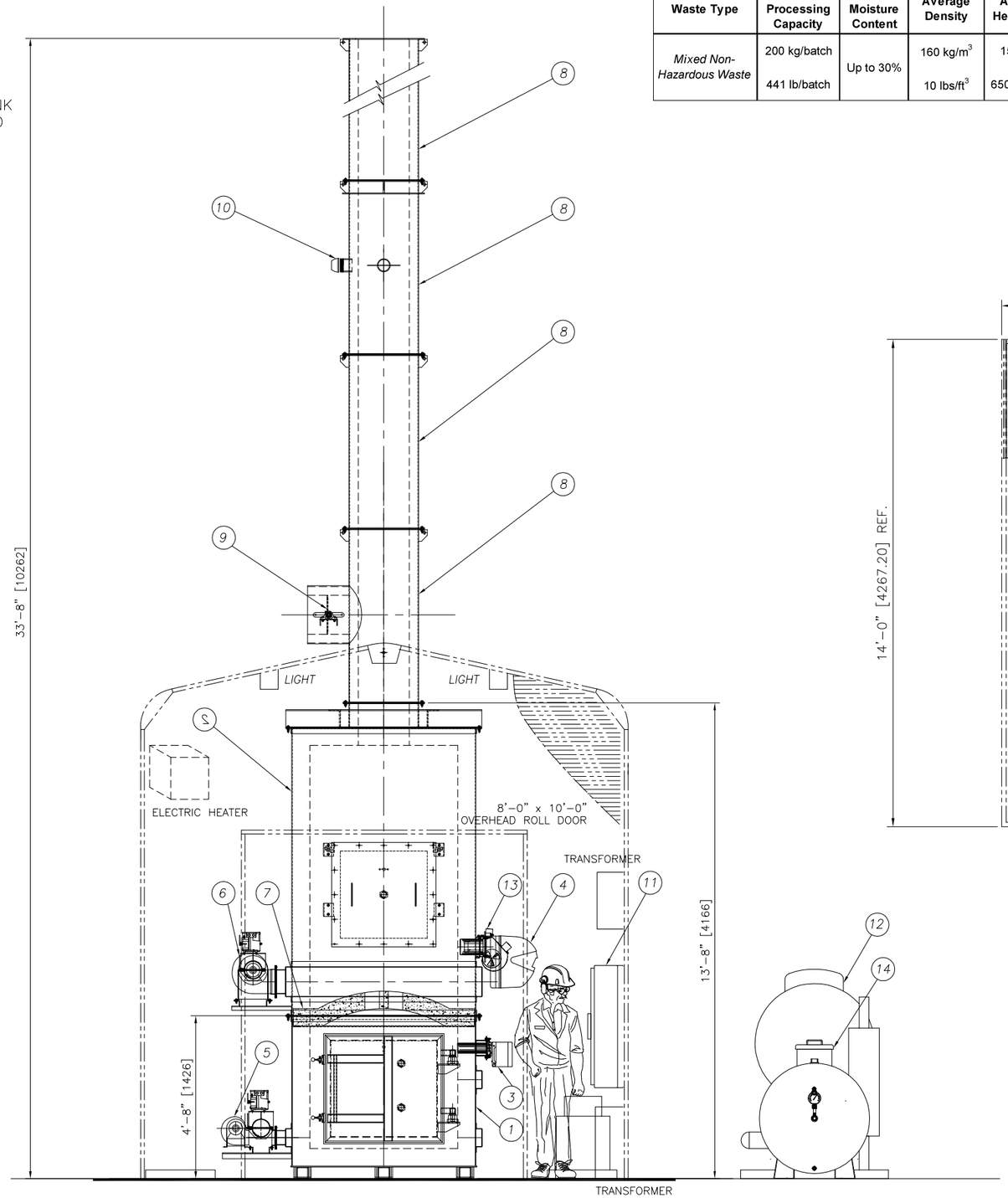
Equipment Design Assumptions

Waste Type	Waste Processing Capacity	Total Moisture Content	Average Density	Average Heat Value
Mixed Non-Hazardous Waste	200 kg/batch 441 lb/batch	Up to 30%	160 kg/m^3 10 lbs/ft^3	15 MJ/kg 6500 BTU/lb

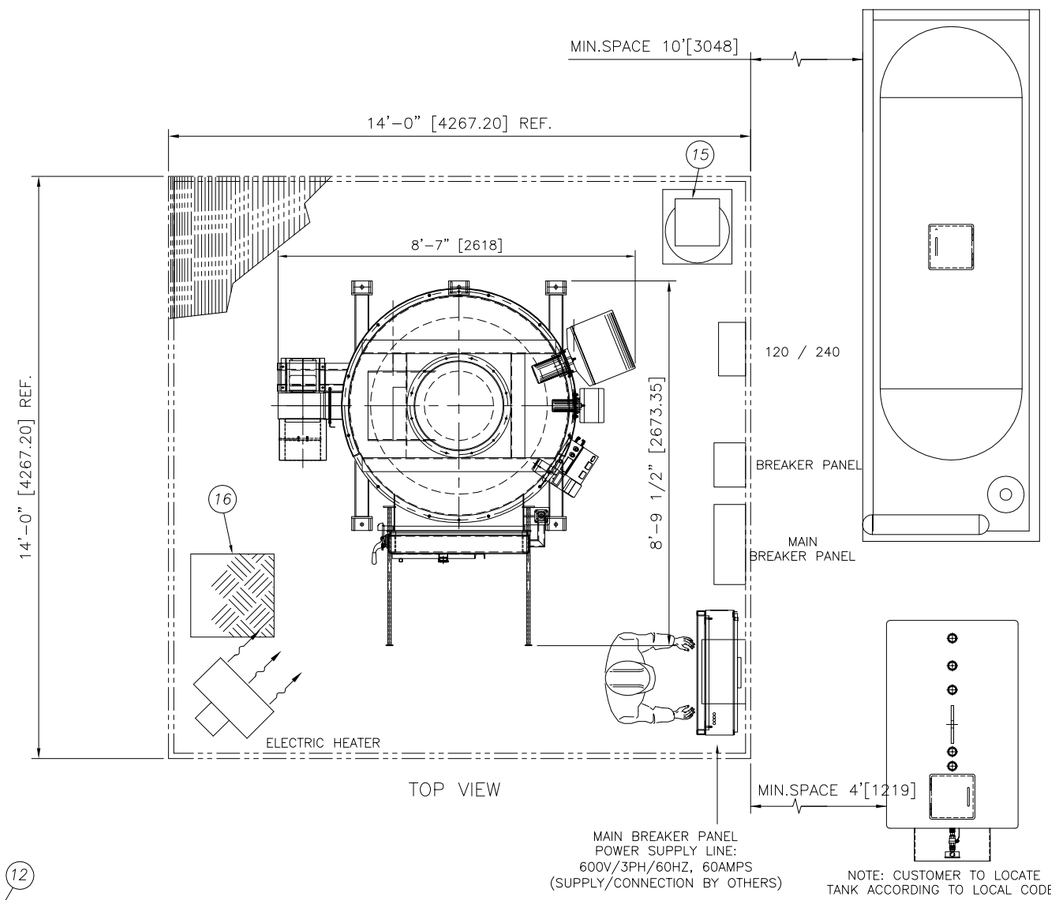
PROPRIETARY INFORMATION

BILL OF MATERIAL

ITM.	QTY.	DESCRIPTION	WEIGHT lbs(kg)
1	1	PRIMARY CHAMBER	4100(1860)
2	1	SECONDARY CHAMBER	12680(5752)
3	1	PRIMARY BURNER	30(14)
4	1	SECONDARY BURNER	90(41)
5	1	PRIMARY BLOWER ASSEMBLY	40(18)
6	1	SECONDARY BLOWER ASSEMBLY	70(32)
7	1	PRIMARY CHAMBER DOME	950(431)
8	4	STACK SECTIONS	1020(463) x4
9	1	BAROMETRIC DAMPER ASSEMBLY	110(50)
10	2	AIR EMISSIONS TEST PORTS	–
11	1	MAIN CONTROL PANEL	300(136)
12	1	PROPANE TANK SKID	–
13	1	WASTE OIL BURNER	50(22)
14	1	WASTE OIL TANK	510(231)
15	1	AIR COMPRESSOR	265(120)
16	1	ABOVE GROUND SCALE	–



FRONT ELEVATION



TOP VIEW

SUPPLIER DOC. NUMBER: BRJ–ELD–CA100

REV.	DATE	DESCRIPTION	BY	APPROVED
B	18-NOV-2015	AS BUILT	JX	KD

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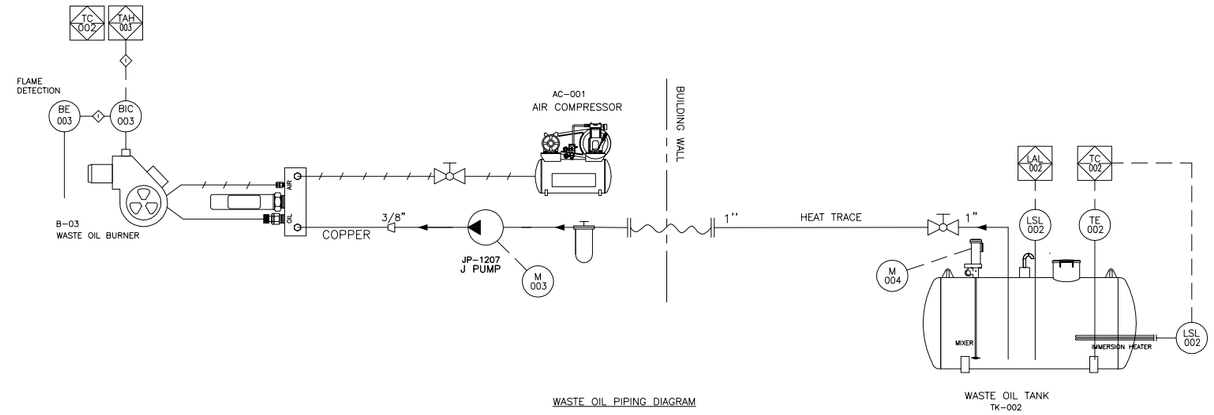
DRAWN: J.X.	DATE: MAY–07–2015	ECO WASTE SOLUTIONS ECO BURN INC.
CHECKED: KD	DATE: MAY–08–2015	
PROJECT NAME: BRUCEJACK		CUSTOMER P.O. 177421–P6040
PROJECT NUMBER: 15–2MS		CUSTOMER EQUIPMENT. # 6128–IN–001
SCALE: NONE	TITLE: GENERAL ARRANGEMENT CA–100 WO	P.1_OF_1
JOB NO. 15–2MS		
THIRD ANGLE	DWG. NO. CA 100 WO–00	REV. B

LEGEND

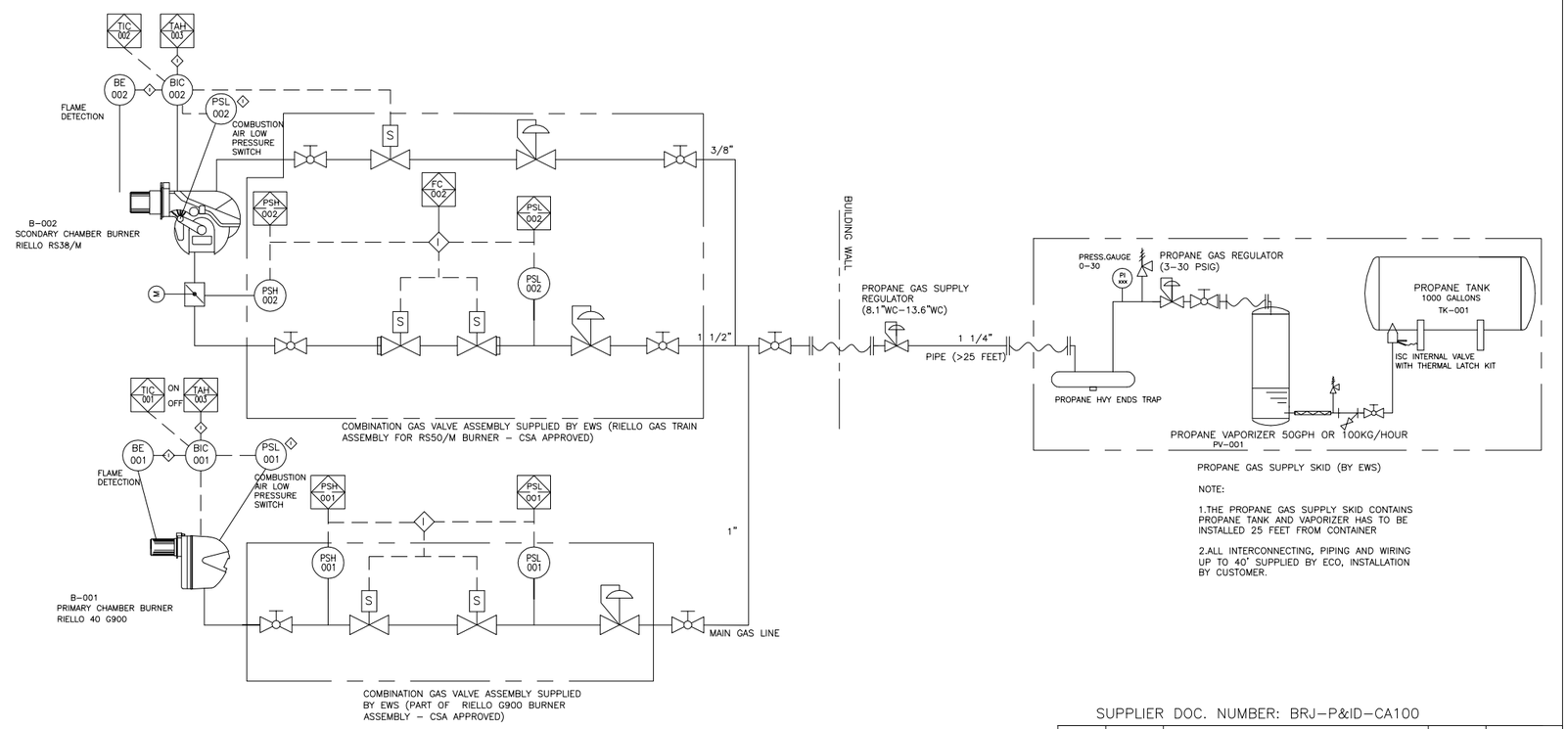
BLK ID.	GENERAL INSTRUMENT OR FUNCTION SYMBOLS	BLK ID.	SYMBOL & DESCRIPTION
EBLWS001	PIPING	EBLWS015	SHUT OFF VALVE
EBLWS002	AIR SUPPLY PIPING	EBLWS016	OIL FILTER
EBLWS003	SAFETY RELIEF VALVE	EBLWS017	STRAINER
EBLWS004	PRESSURE REGULATOR	EBLWS018	MANUAL GATE DAMPER
EBLWS005	PLC I/O	EBLWS019	SOLENOID VALVE
EBLWS006	PUMP	EBLWS020	BLOWER
EBLWS021	PROPANE HEAVY ENDS TRAP	EBLWS022	FLEX PIPING

EBLWS006	ZX	PROXIMITY SWITCH	EBLWS016	AIT	CONTINUOUS EMISSION MONITOR
EBLWS007	PSL	PRESSURE SWITCH LOW	EBLWS017	AAH	CEM ANALYSIS
EBLWS008	M	MOTOR	EBLWS018	PI	PRESSURE INDICATOR
EBLWS009	ZM	MODUTROL SERVOMOTOR	EBLWS019	SS	SAFETY LOCK SOLENOID SWITCH
EBLWS010	TIC	TEMPERATURE CONTROLLER	EBLWS020	BIC	BURNER INDICATING CONTROLLER
EBLWS011	LSL	LEVEL SWITCH LOW	EBLWS021	UA	MULTIVARIABLE ALARM
EBLWS012	I	INTERLOCK	EBLWS022	EH	IMMERSION HEATER
EBLWS013	TE	THERMOCOUPLE	EBLWS023	SC	POSITION CONTROL
EBLWS014	ZS	LIMIT SWITCH	EBLWS024	BE	FLAME DETECTION
EBLWS015	ZI	POSITION INDICATOR			

PROPRIETARY INFORMATION



WASTE OIL PIPING DIAGRAM



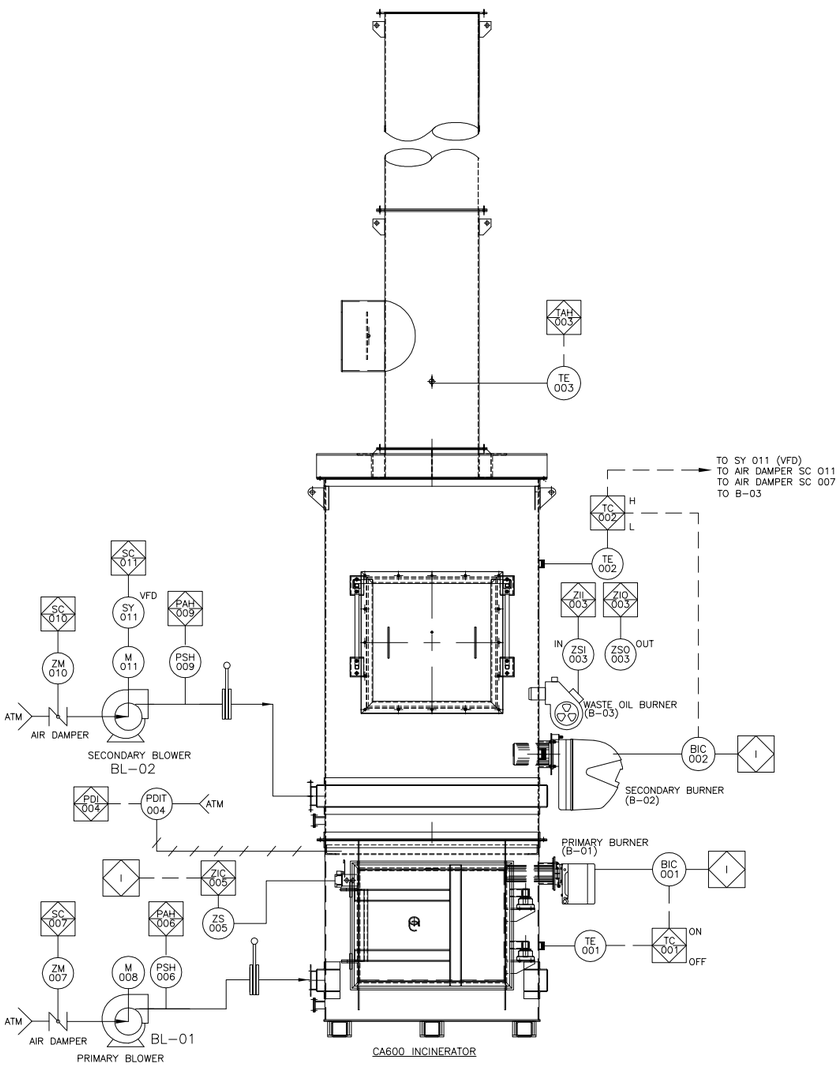
PROPANE GAS PIPING DIAGRAM

PROPANE GAS SUPPLY SKID (BY EWS)

NOTE:

1.THE PROPANE GAS SUPPLY SKID CONTAINS PROPANE TANK AND VAPORIZER HAS TO BE INSTALLED 25 FEET FROM CONTAINER

2.ALL INTERCONNECTING, PIPING AND WIRING UP TO 40' SUPPLIED BY ECO, INSTALLATION BY CUSTOMER.



CA600 INCINERATOR

SUPPLIER DOC. NUMBER: BRJ-P&ID-CA100

REV.	DATE	DESCRIPTION	BY	APPROVED
A	-	-	-	-

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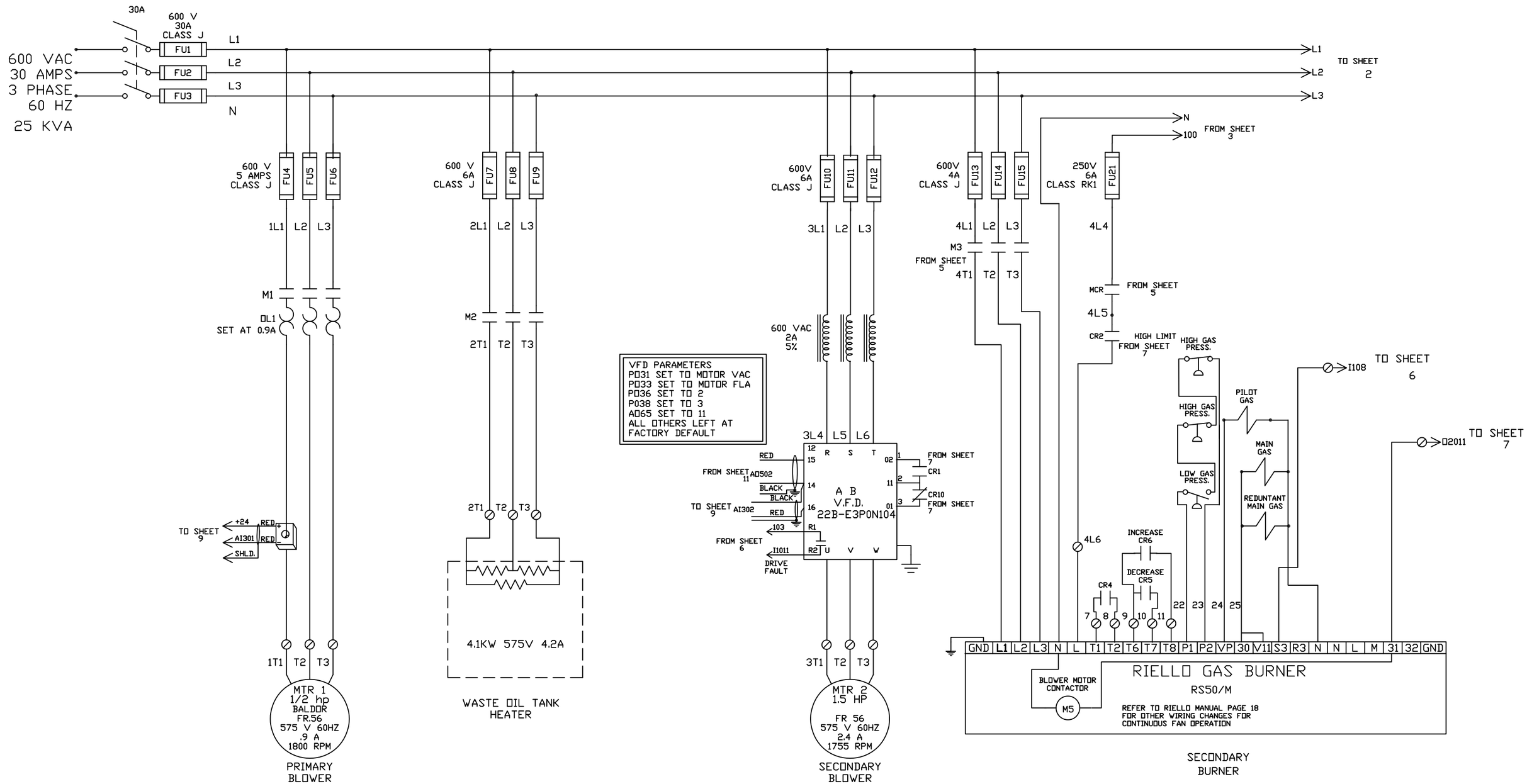
DRAWN: JX	DATE: 20-MAY-2015
CHECKED: KD	DATE: 21-MAY-2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK	CUSTOMER P.O. 177421-P6040
PROJECT NUMBER: 15-2MS	CUSTOMER EQUIPMENT. # 6128-IN-001
SCALE: NONE	TITLE: PIPING & INSTRUMENTATION DIAGRAM ECO CA100 WO INCINERATOR
JOB NO. 15-2MS	P.1_OF_1
THIRD ANGLE	DWG. NO. CA-100 WO-01
	REV. A

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



REV.	DATE	DESCRIPTION	BY	APPROVED
A	22/MAY/15	INITIAL RELEASE	J.C.	K.D.
B	30/OCT/15	AS BUILT	J.C.	K.D.

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DRAWN: J.C. DATE: 30 OCT 2015
CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 1 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-1
REV. B

BILL OF MATERIAL			
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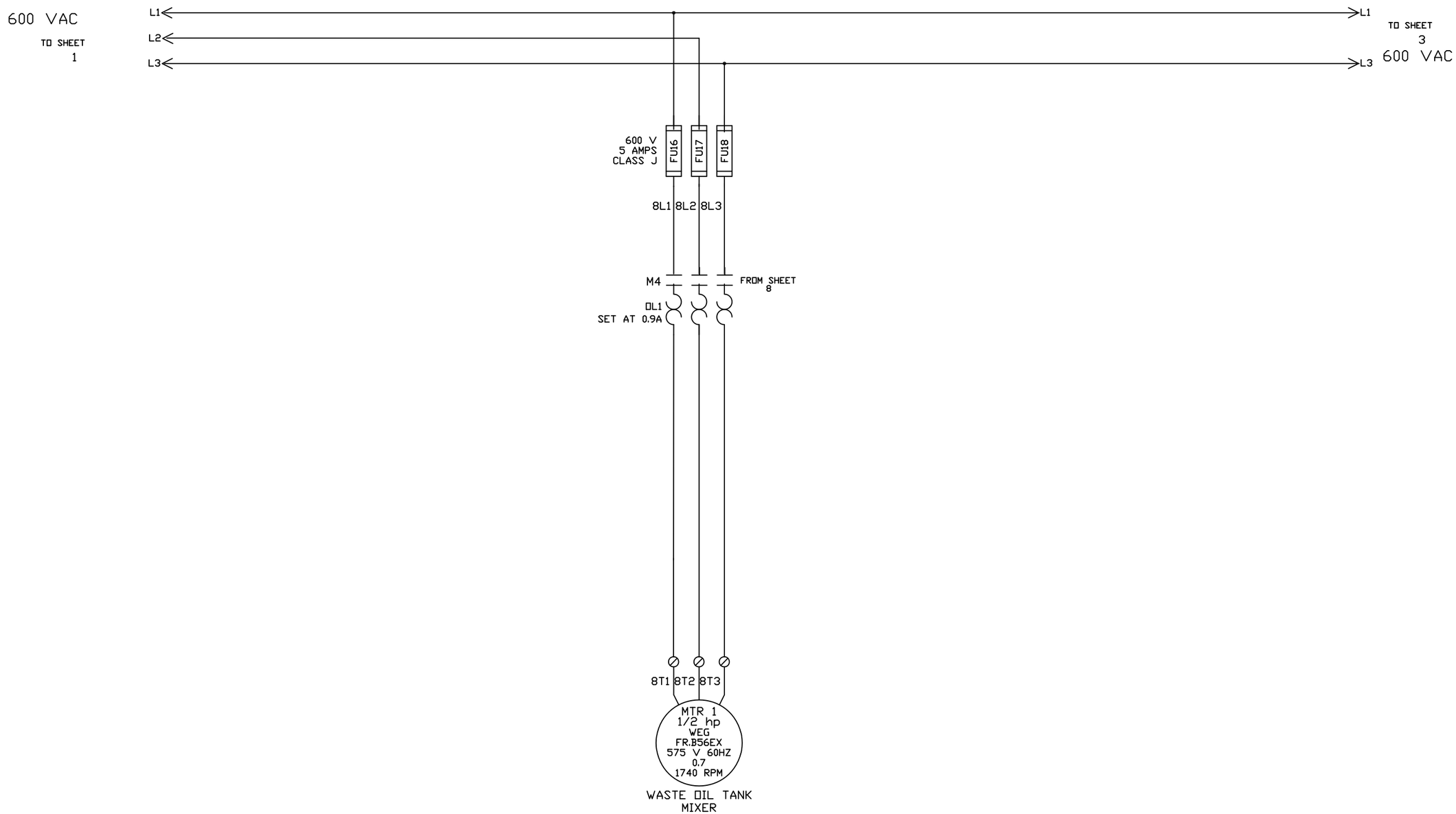

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ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 2 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-2
REV. B

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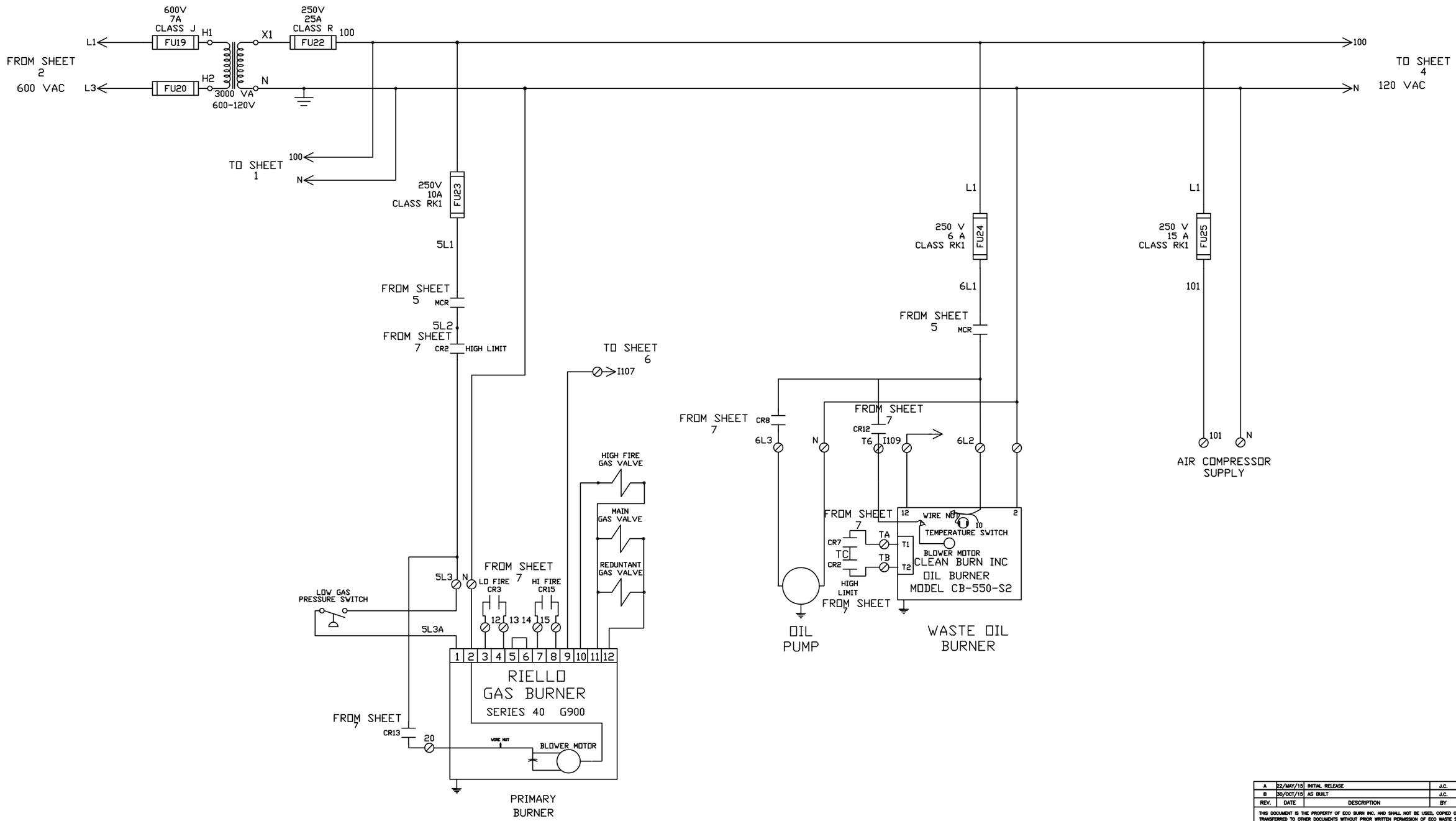

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CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 3 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-3
REV. B

BILL OF MATERIAL			
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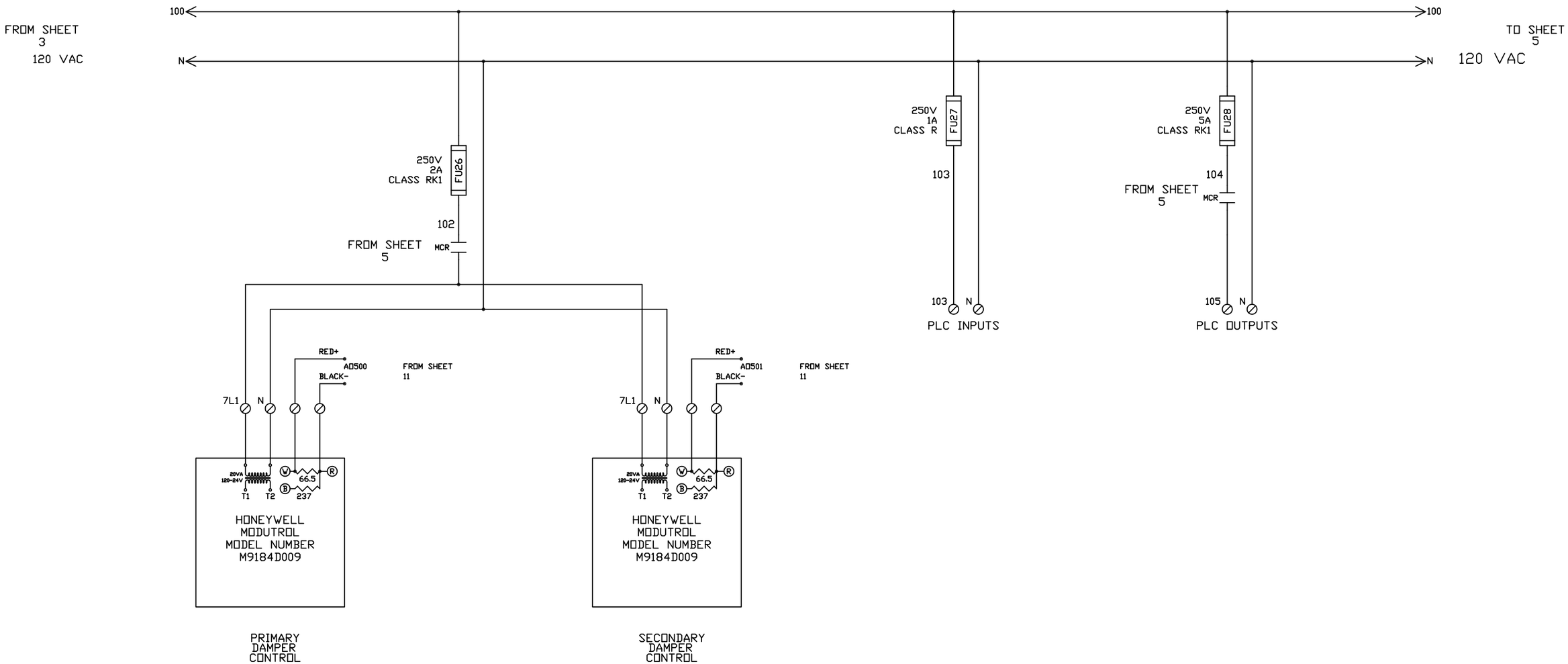

REV.	DATE	DESCRIPTION	BY	APPROVED
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B	30/OCT/15	AS BUILT	J.C.	K.D.

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DRAWN: J.C. DATE: 22 MAY 2015
CHECKED: K.D. DATE: 22 MAY 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 4 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-4
REV. B

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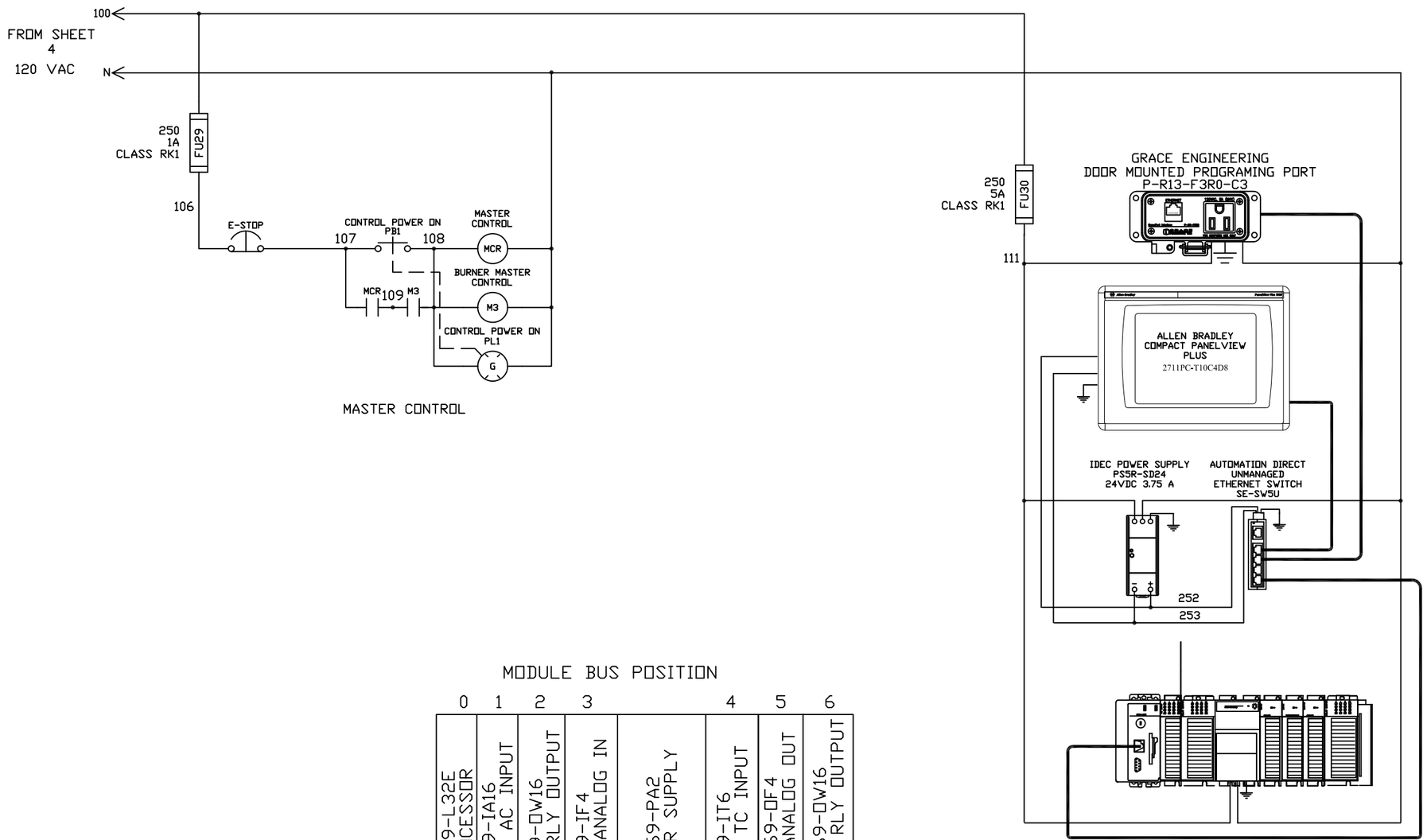

MODULE BUS POSITION

0	1	2	3	4	5	6
1769-L32E PROCESSOR	1769-IA16 16 PT. AC INPUT	1769-OW16 16 PT RLY OUTPUT	1769-IF4 4 CH. ANALOG IN	1769-PA2 POWER SUPPLY	1769-IT6 6 CH. TC INPUT	1769-OF4 4 CH. ANALOG OUT	1769-OW16 16 PT RLY OUTPUT

REV.	DATE	DESCRIPTION	BY	APPROVED
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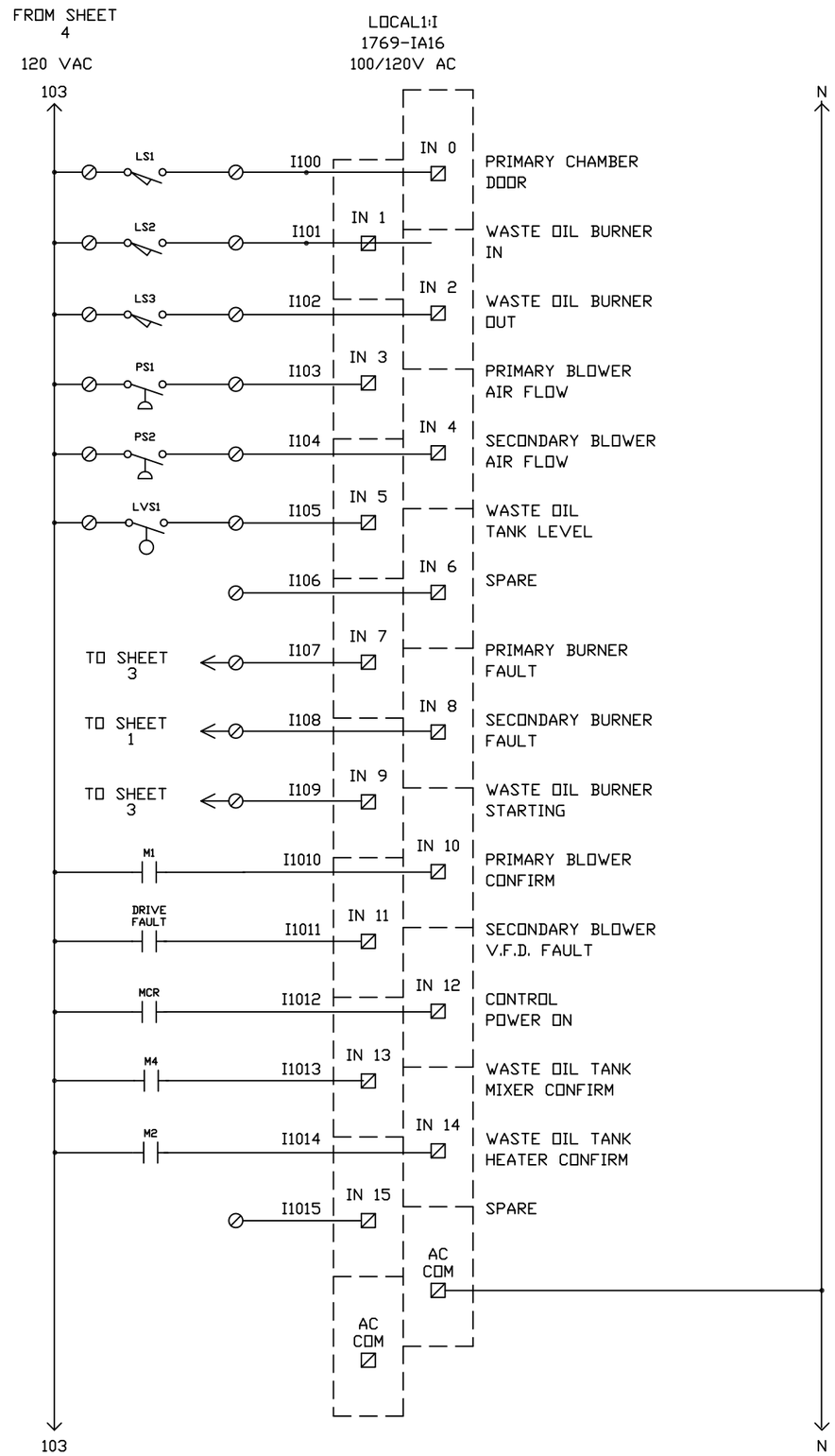
ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 5 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-5
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



REV.	DATE	DESCRIPTION	BY	APPROVED
A	22/MAY/15	INITIAL RELEASE	J.C.	K.D.
B	30/OCT/15	AS BUILT	J.C.	K.D.

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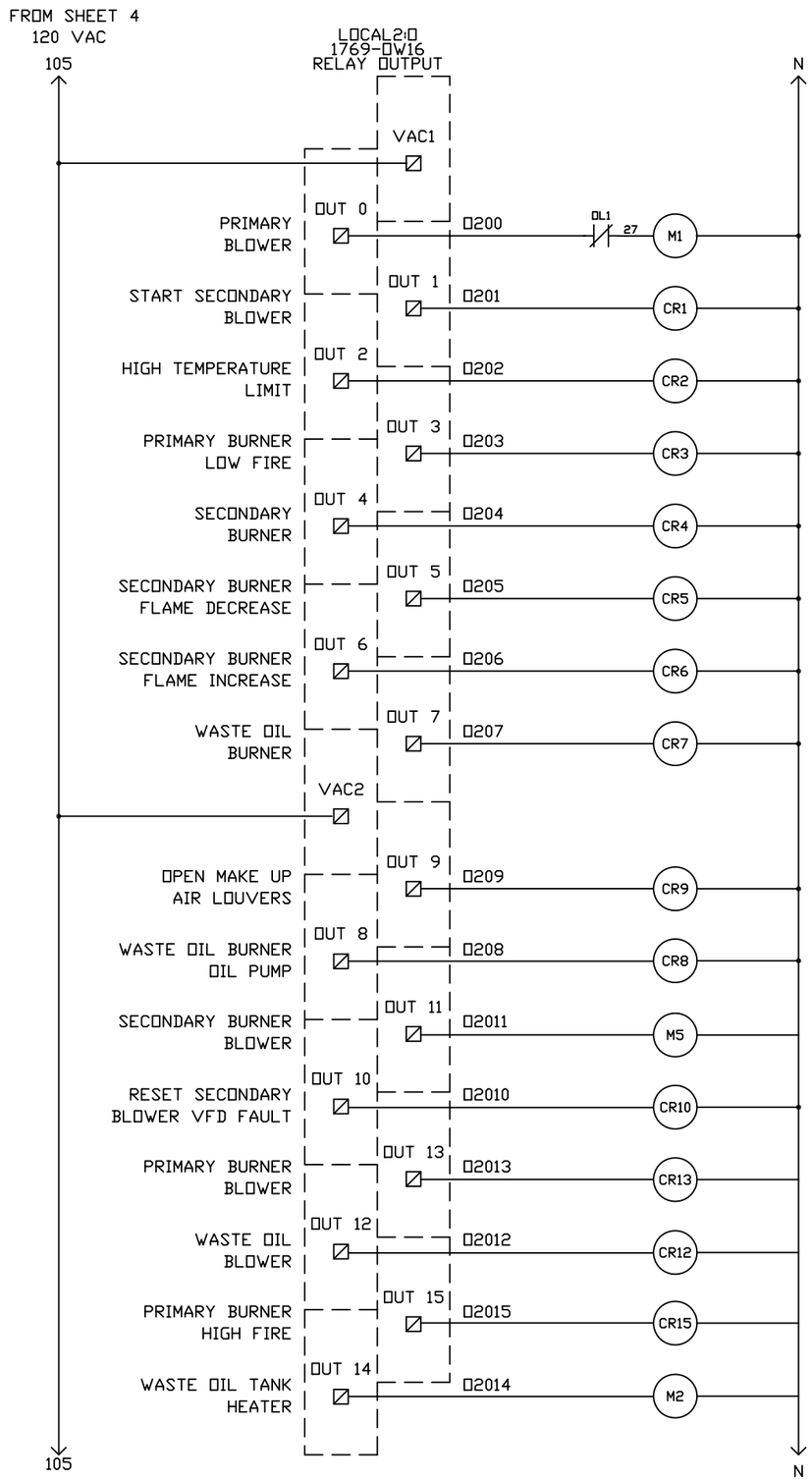
DRAWN: J.C. DATE: 30 OCT 2015
CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O.: 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. #: 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 6 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-6
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



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B	30/OCT/15	AS BUILT	J.C.	K.D.

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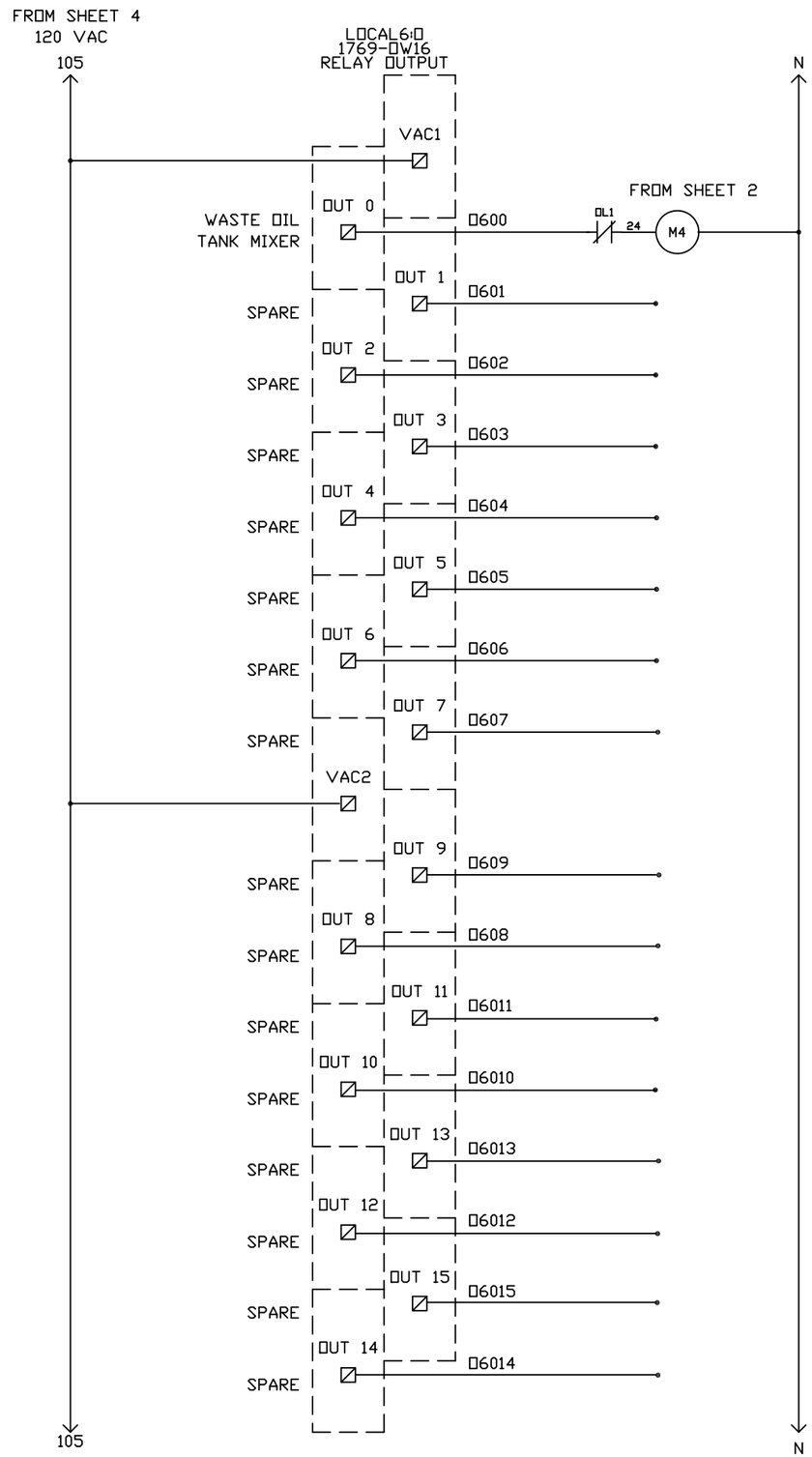
ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 7 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-7
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



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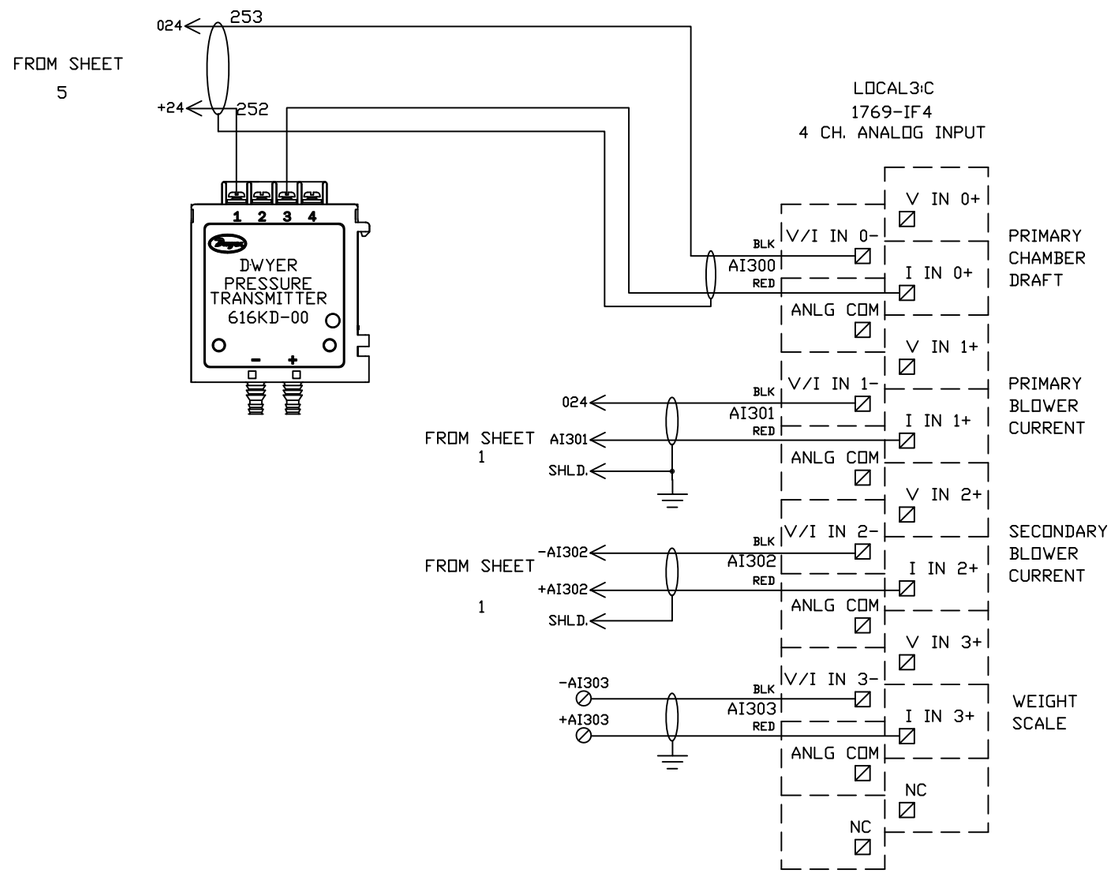
CHECKED: K.D. DATE: 30/OCT/2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRUCEJACK
SH 8 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-8
REV. A

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



REV.	DATE	DESCRIPTION	BY	APPROVED
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B	30/OCT/15	AS BUILT	J.C.	K.M.

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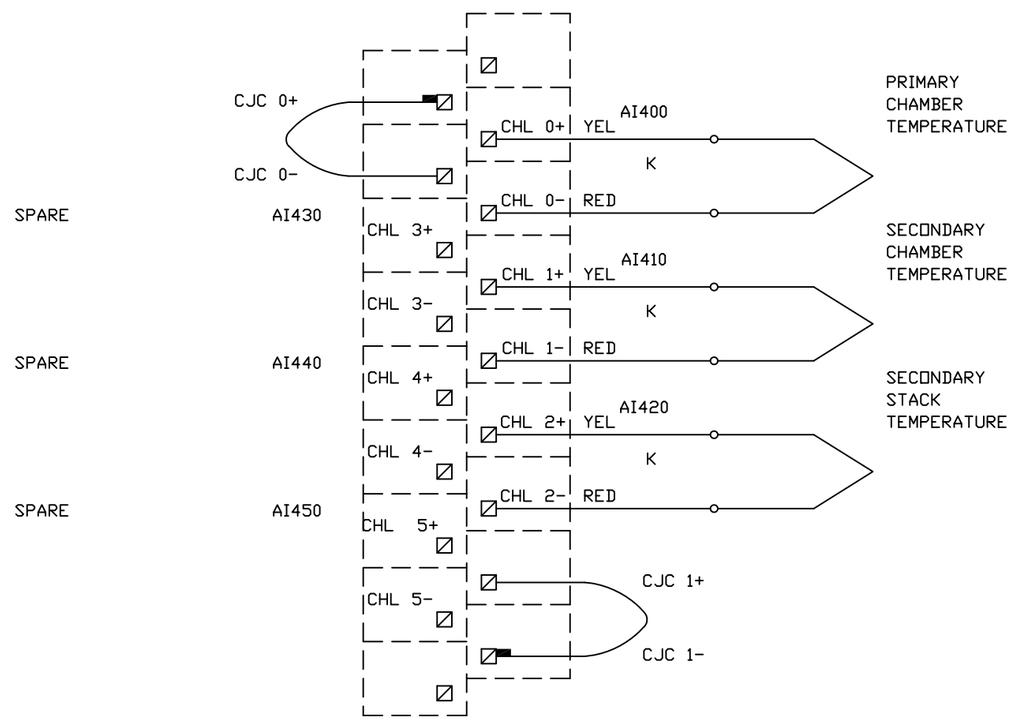
DRAWN: J.C. DATE: 30 OCT 2015
CHECKED: K.M. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O.: 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. #: 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS MAIN POWER BRFUCEJACK
SH 9 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-9
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	

LOCAL4:C
1769-IT6
ANALOG INPUT, 6CHS(THERMOCOUPLE/MV)



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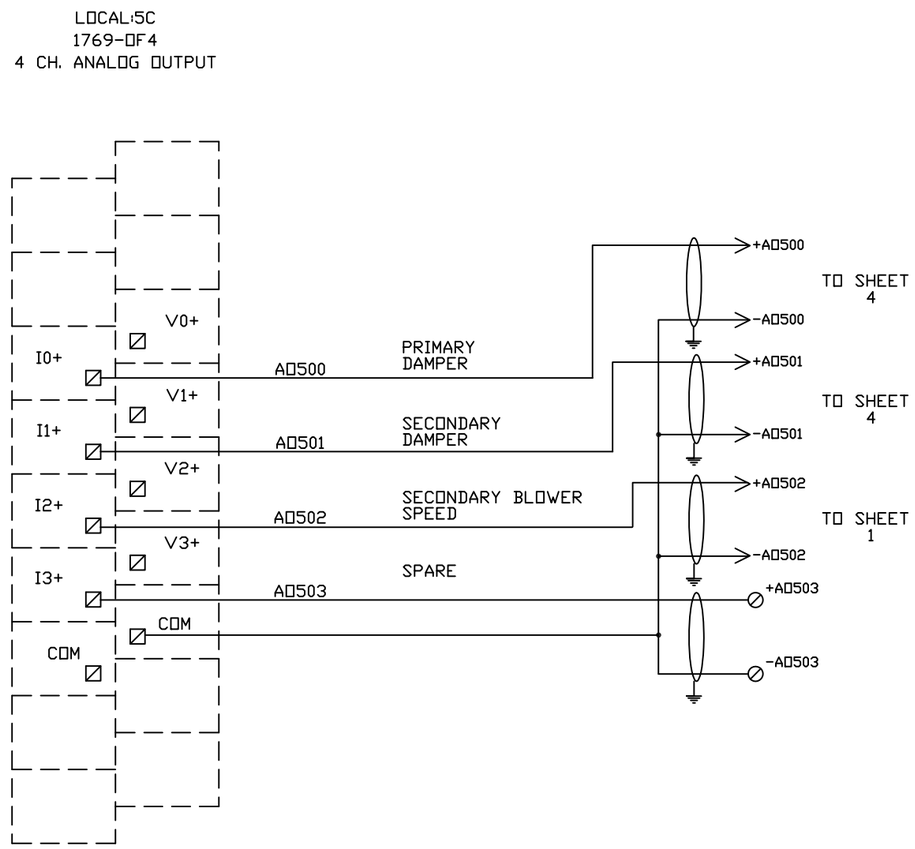
DRAWN: J.C. DATE: 30 OCT 2015
CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS
ANALOG INPUTS-THERMOCOUPLES
BRUCEJACK
SH 10 OF 11
THIRD ANGLE
DWG. NO. CA-100WO-10A-10
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	



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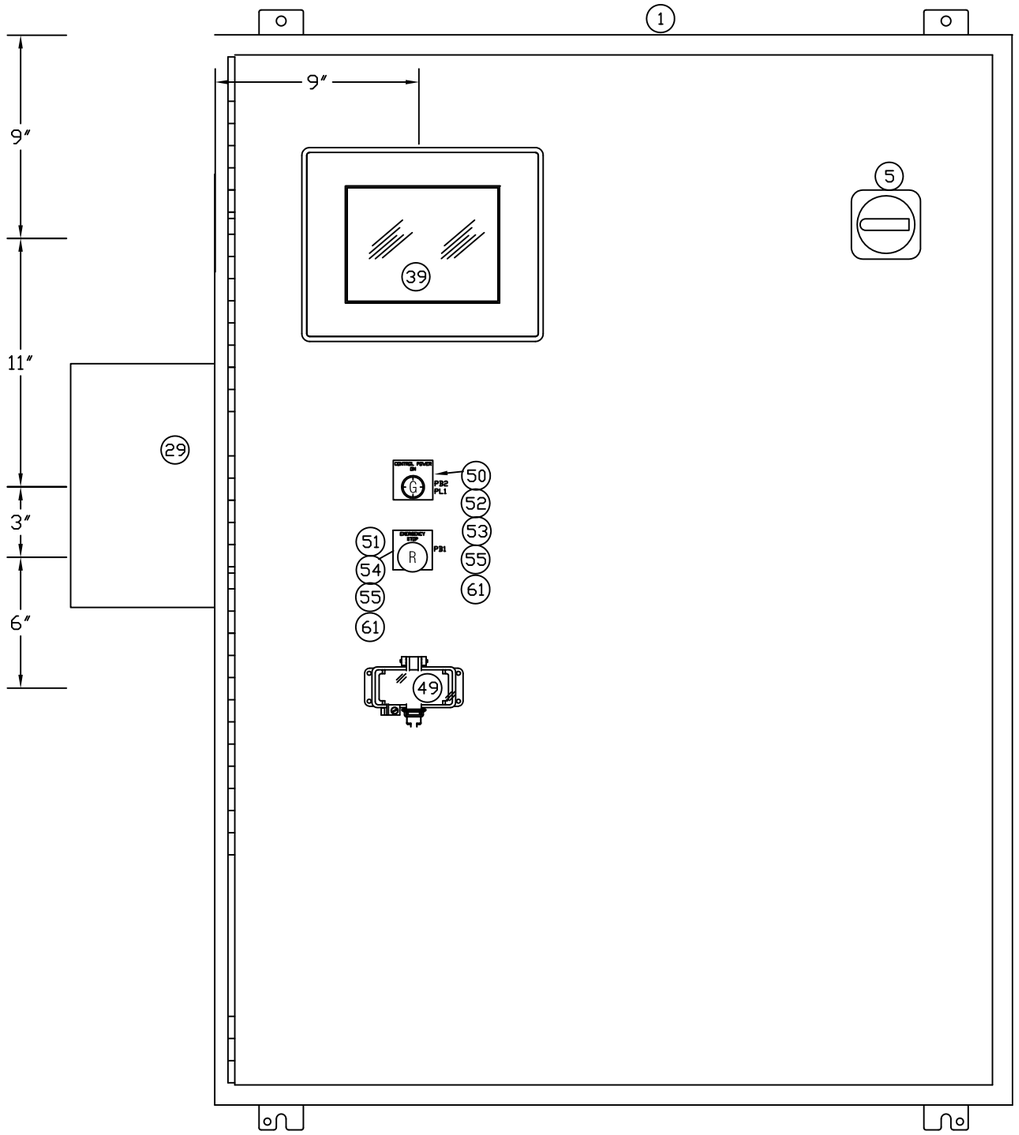
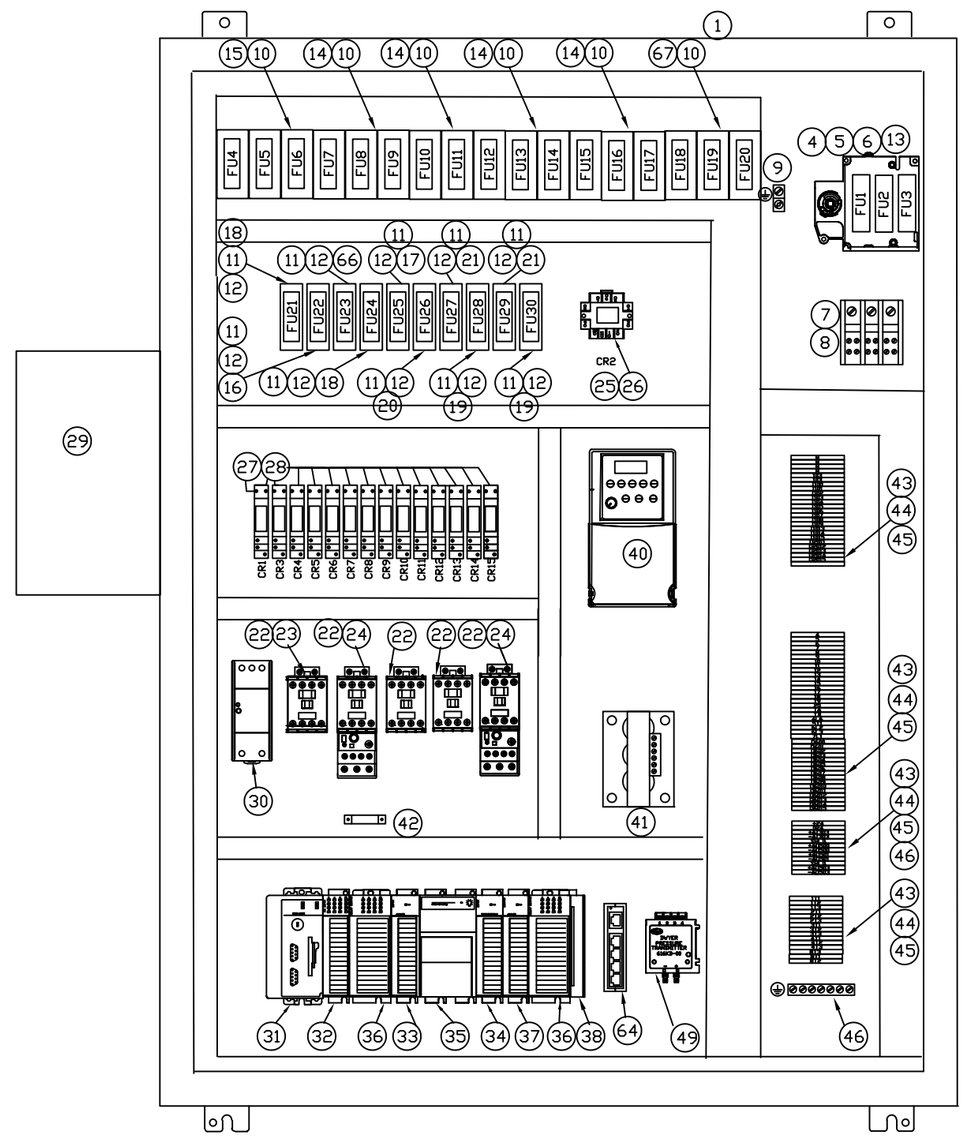
CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: ELECTRICAL SCHEMATICS ANALOG OUTPUTS BRUCEJACK
SH 11 OF 11
THIRD ANGLE
DWG. NO. CA-600WO-10A-11
REV. B





BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	

N
N
N
N
103
103
I100
I101
I102
I103
I104
I105
I106
I107
I108
I109
I113
I114
I115
I2011
I2012
I2013
I2014
I2015
I600
I601
I602
I603
I604
I605
I606
I607
I608
I609
I6010
I6011
I6012
I6013
I6014
I6015
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L8
L9
101
4L6
5L1
6L2
6L3
7L1
1L2
1L3
2L2
2L3
3L1
3L2
3L3
4L1
4L2
4L3
8L1
8L2
8L3
+24
024
+AI303
-AI303
SHLD
+AI500
-AI500
+AI501
-AI501
SHLD
+AI503
-AI503

REV.	DATE	DESCRIPTION	BY	APPROVED
A	22/MAY/15	INITIAL RELEASE	J.C.	K.D.
B	30/OCT/15	AS BUILT	J.C.	K.D.

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DRAWN: J.C. DATE: 30 OCT 2015
CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: MAIN CONTROL PANEL PANEL LAYOUT BRUCEJACK
SH 1 OF 2
THIRD ANGLE
DWG. NO. CA-100WO-10B-1
REV. B

ITEM	MANUFACTURE	PART NUMBER	Description	QUANTITY
1	Ralston	N12-483608	NEMA 12 enclosure 48Hx36Wx08D	1
2	Ralston	V-GP-202008	NEMA 12 enclosure 20Hx20Wx08D	1
3				1
4	Allen-Bradley	194R-J30-1753	IEC 30 amp 600 volt rotary disconnect	1
5	Allen-Bradley	194R-PB	Disconnect operating handle	1
6	Allen-Bradley	194R-S2	Operating shaft	1
7	Allen-Bradley	1492-PD3141	175 amp power distribution block	1
8	Allen-Bradley	1492-PBC1	Power block cover	1
9	Panduit	LAM6-14-QY	Ground lug	1
10	Cooper-Bussman	JT60030	600 volt 30 amp 1 pole class J fuse block	17
11	Cooper-Bussman	SAMI-9N	Non-indicating Fuse cover for RK1 Fuse	10
12	Cooper-Bussman	H25030-1CR	250 volt 30 amp 1 pole class RK1 fuse block	10
13	Cooper-Bussman	LPJ-30SP	600 volt 30 amp class J fuse	3
14	Cooper-Bussman	LPJ-6SP	600 volt 6 amp class J fuse	6
15	Cooper-Bussman	LPJ-5SP	600 volt 5 amp class J fuse	3
16	Cooper-Bussman	LPNRK-25SP	250 volt 25 amp class RK1 fuse	1
17	Cooper-Bussman	LPNRK-15SP	250 volt 15 amp class RK1 fuse	1
18	Cooper-Bussman	LPNRK-6SP	250 volt 6 amp class RK1 fuse	2
19	Cooper-Bussman	LPNRK-5SP	250 volt 5 amp class RK1 fuse	2
20	Cooper-Bussman	LPNRK-2SP	250 volt 2 amp class RK1 fuse	1
21	Cooper-Bussman	LPNRK-1SP	250 volt 1 amp class RK1 fuse	2
22	Allen-Bradley	100-C09D10	9 amp IEC contactor 120 VAC coil	5
23	Allen-Bradley	100-FA40	4 N.O. top mount auxilary contact	1
24	Allen-Bradley	193-EECB	IEC solid state overload relay range 0.2- 5 a	2
25	Allen-Bradley	700-HA33A1	3PDT 11 pin tube based relay 120 VAC coil	1
26	Allen-Bradley	700-HN126	11 pin tube based relay base	1
27	Allen-Bradley	700-HK36A1	16 amp SPDT slim line relay 120 VAC coil	12
28	Allen-Bradley	700-HN121	Base slim line relay	12
29	Hammond	C1F003PES	600 to 120 VAC 3000 VA transformer	1
30	Idec	PS5R-SD24	24 VDC 1.3 amp switching power supply	1
31	Allen-Bradley	1769-L32E	Compact Logix processor	1
32	Allen-Bradley	1769-IA16	16 point 120 vac input module	1
33	Allen-Bradley	1769-IF4	4 channel analog input module	1
34	Allen-Bradley	1769-IT6	6 channel thermocouple input module	1
35	Allen-Bradley	1769-PA2	120 vac supply 2 amp power supply	1
36	Allen-Bradley	1769-OW16	16 point relay output module	2
37	Allen-Bradley	1769-OF4	4 channel analog output module	1
38	Allen-Bradley	1769-ECR	Right end cap	1
39	Allen-Bradley	2711PC-T10C4D8	HMI with 10" colour touch screen	1
40	Allen-Bradley	22B-E3P0N104	600 volt 2 H.P. V.F.D.	1
41	Rex Manufacturing	3PR0002C3H	600 volt 2 amp line reactor	1
42	Automation Direct	ACT005-42I-F	5 amp to 4-20ma current transducer	1
43	Allen-Bradley	1492-J3	IEC 600 volt 20 amp terminal block	100
44	Allen-Bradley	1492-EBJ3	End barrier	8
45	Allen-Bradley	1492-EAJ35	End Anchor	15
46	Allen-Bradley	1492-JG2Q	Grounding block	8
47	Allen-Bradley	1492-CJJ5-10	Center jumper	4
48	Allen-Bradley	1492-DR5	Din rail	3
49	Grace Engineering	P-R13-F3R0-C3 (ETHERNET)	PLC Programing Port	1
49	Dywer	616KD-00	0-1" H2O draft transmitter	1
50	Allen-Bradley	800FP-LF3	Green illuminated push button operator	1
51	Allen-Bradley	800FP-MT44	Emergency stop push button operator	1
52	Allen-Bradley	800F-N5G	Green integrated led module	1
53	Allen-Bradley	800F-X10	N.O. contact block	1
54	Allen-Bradley	800F-X01	N.C. contact block	1
55	Allen-Bradley	800F-ALP	Mounting latch	2
56	Ilsco	N174A	Copper ground bar	0
57	Panduit	C1LG6	I inch light gray duct cover	18
58	Panduit	G1x3LG6	1 by 3 inch light grey duct	18
59	Panduit	C2LG6	2 inch light grey duct cover	18
60	Panduit	G2x3LG6	2 by 3 inch light grey duct	18
61			lamacoid label for 22mm push button	2
62	Allen-Bradley	802T-AP	Limit switch	3
63	Allen-Bradley	802T-W2B	Limit switch lever	3
64	Automation Direct	SE-SW5U	5 port unmanged ethernet switch	1
65	Cooper-Bussman	LPJ-4SP	600 volt 4 amp class J fuse	3
66	Cooper-Bussman	LPNRK-10SP	250 volt 10 amp class RK1 fuse	1
67	Cooper-Bussman	LPJ-7SP	600 volt 7 amp class J fuse	2
68	Siemens	AECBJXN001-INT	P2 18C 125A 347/600V 3PH4W	1
69	Siemens	AECBJXN002-INT	P1 18C 125A 120/240V 1PH3W	1
70	Siemens	B32	P1/P2 ENCLOSURE TYPE 1 (5.75X20X32)	1
71	Siemens	S32B	P1/P2 SURFACE TRIM 20X32	8
72	Siemens	BQD6315	Low Tab Breaker 15 A 347/600V	1
73	Siemens	BQD6320	Low Tab Breaker 20 A 347/600V	1
74	Siemens	BQD6220	Low Tab Breaker 20 A 347/600V	1
75	Siemens	BQD6335	Low Tab Breaker 35 A 347/600V	1
76	Siemens	SIB32	Box Assembly C1 5.75X20X32	1
77	Siemens	S32B	Surface Trim	1
78	Siemens	E32B	Flush Trim	1
79	Siemens	ID361	IND Duty switch Fused 30A	1
80		FLSR-025ID	600V Class R Time Delay	3
81	Rex Manufacturing	RC9JC	9 KVA 600-240 volts 3 phase transformer	1
82	Rex Manufacturing	SC15JK	600-240/120 volt 15 KVA transformer	1
83	Siemens	MBKBL12100	MAIN SUBFEED KIT	1

BILL OF MATERIAL

ITM.	QTY.	DESCRIPTION	PART #
		SEE SHEET 1 FOR BOM	

REV.	DATE	DESCRIPTION	BY	APPROVED
A	22/MAY/15	INITIAL RELEASE	J.C.	K.D.
B	30/OCT/15	AS BUILT	J.C.	K.D.

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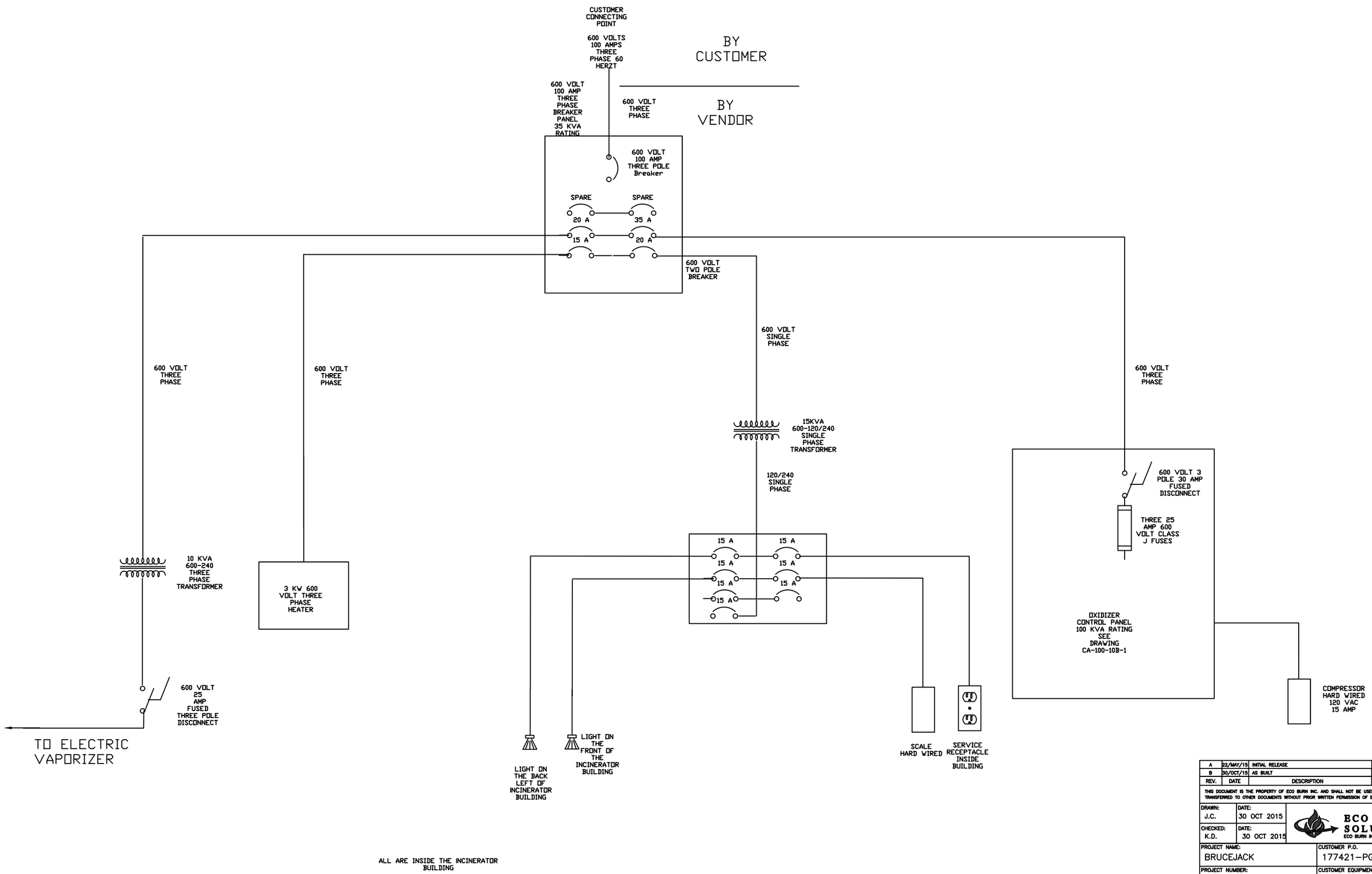
DRAWN: J.C. DATE: 30 OCT 2015
CHECKED: K.D. DATE: 30 OCT 2015

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421–PG040
PROJECT NUMBER: 15–2MS
CUSTOMER EQUIPMENT. # 6128–IN–001–CA
SCALE: 1:1
JOB NO. 15–2MS
TITLE: MAIN CONTROL PANEL BILL OF MATERIAL BRUCEJACK
SH. 2 OF 2
THIRD ANGLE
DWG. NO. CA–100WO–10B–2
REV. B



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DRAWN: J.C. DATE: 30 OCT 2015
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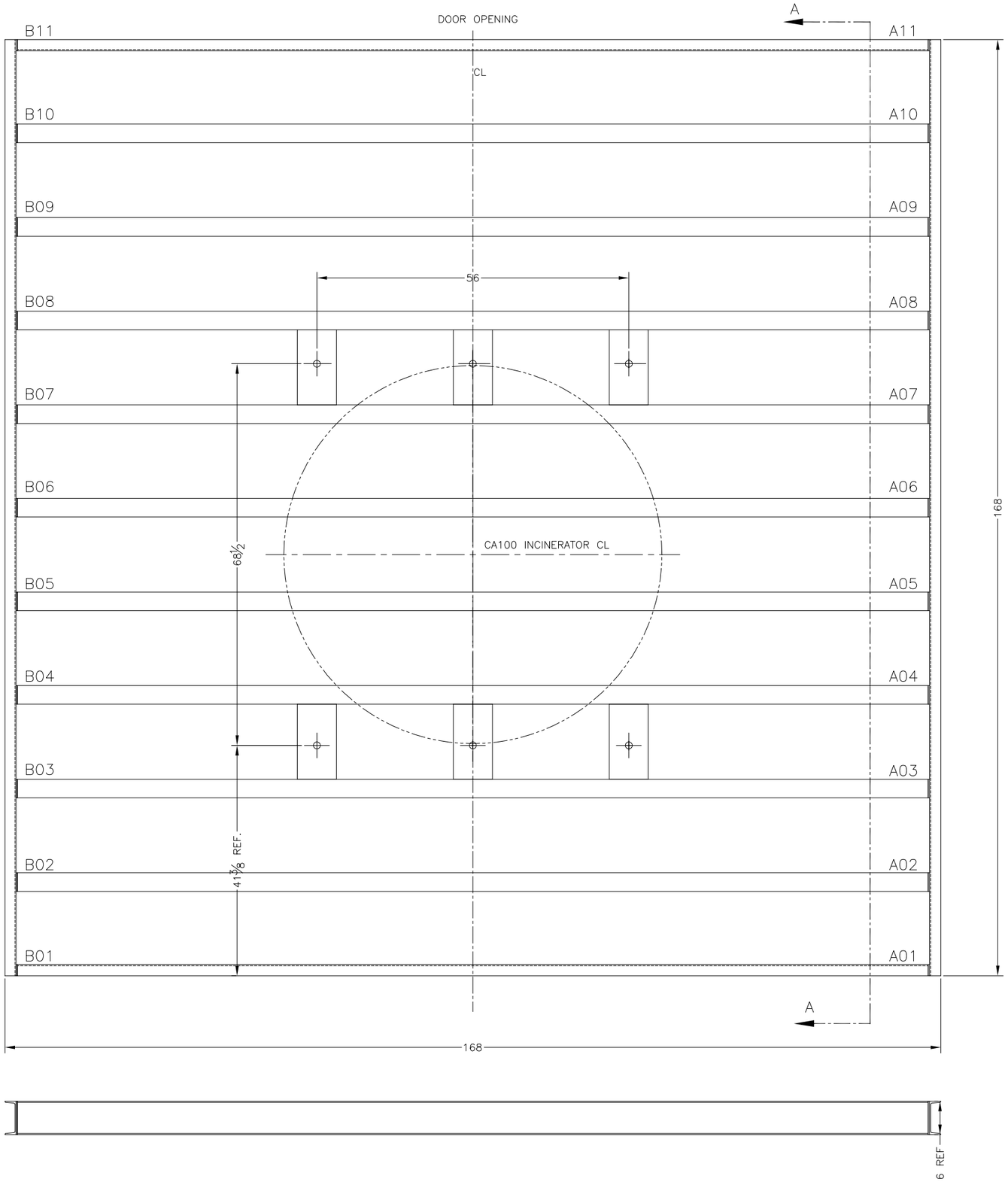
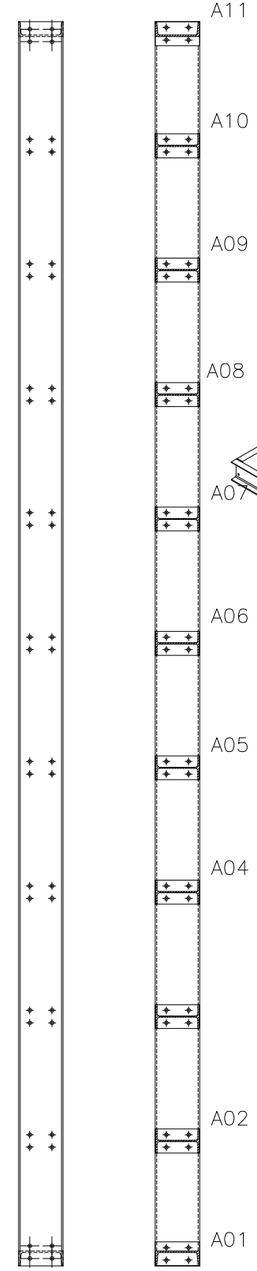
ECO WASTE SOLUTIONS
ECO BURN INC.

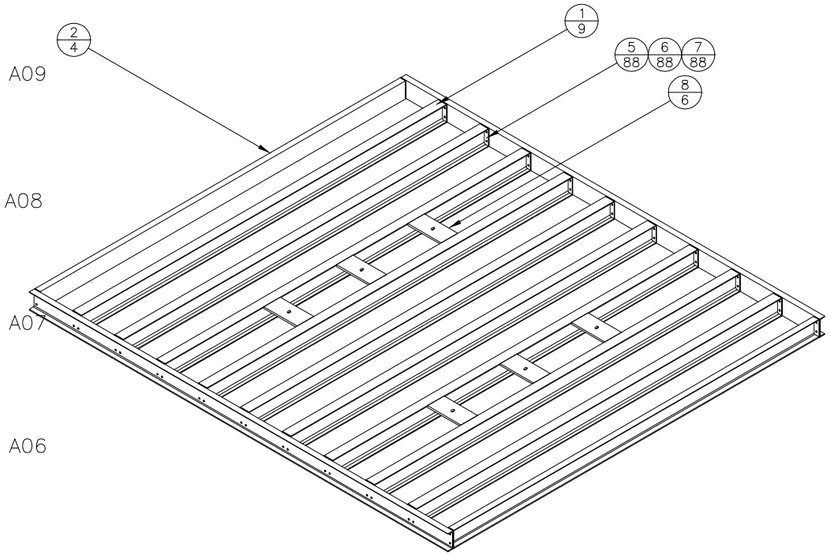
PROJECT NAME: BRUCEJACK
CUSTOMER P.O. 177421-PG040
PROJECT NUMBER: 15-2MS
CUSTOMER EQUIPMENT. # 6128-IN-001-CA
SCALE: 1:1
JOB NO. 15-2MS
TITLE: WIRING DIAGRAM MAIN CONTAINER BRUCEJACK
SH 1 OF 1
THIRD ANGLE
DWG. NO. CA-100WO-10C-1
REV. B

BILL OF MATERIAL			
ITM.	QTY.	DESCRIPTION	PART #
1	9	I-BEAM – S6 X 12.5, L 163 1/2"	
2	4	CHANNEL – C6 X 8.2, L 163 1/2" X2, 168" X2.	
3	22	MOUNTING PLATE, THK 0.25"	
4	1	FLOOR PLATE – 0.25 STEEL CHECKER PLATE, SEE SHEET 2 FOR DETAILS	
5	88	HEX HEAD CAP SCREW, 1/2-13 UNC-2A X 1.5 LG	
6	88	HEX NUT, 1/2-13 UNC-2B	
7	88	WASHER, FLAT – 1/2 NOM	
8	8	INCINERATOR FOOT PLATE	

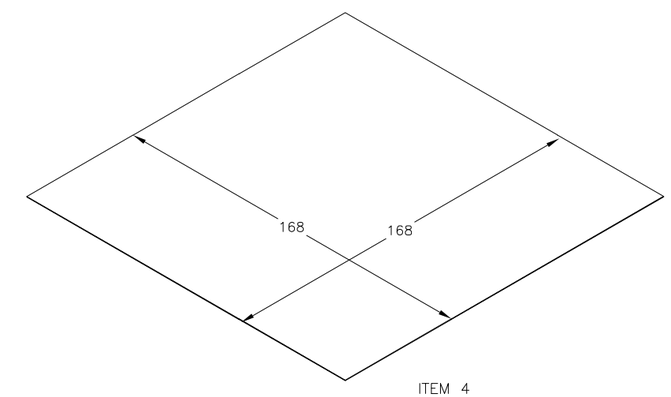




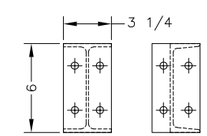
SECTION A–A



ARRANGE COMPONENTS AS SHOWN AND BOLT TOGETHER WITH HARDWARE PROVIDED



ITEM 4
ARRANGE FLOOR PLATE SECTIONS
AND WELD IN POSITION
ON FLOOR FRAME
SEE SHEET 2 FOR HOLE DETAILS



ITEM 3
MOUNTING PLATES
WELDED TO STRUCTURAL SHAPES
SCALE 1:5

REV.	DATE	DESCRIPTION	BY	APPROVED
	NOV-18-2015	ADDED 6 FOOT PLATES		

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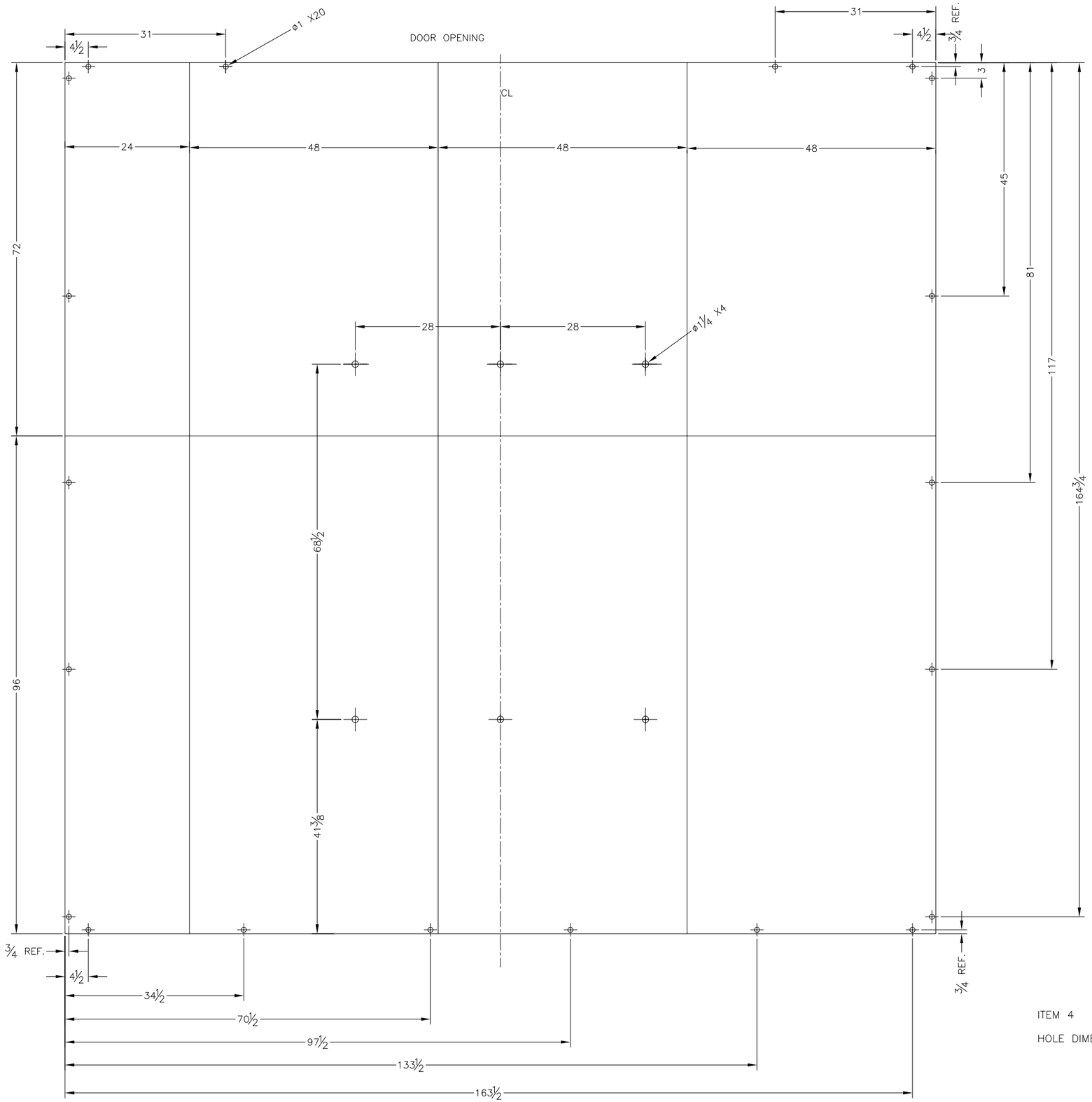
DRAWN: JX
DATE: 16 OCT 14
CHECKED:
DATE:

ECO WASTE SOLUTIONS
ECO BURN INC.

PROJECT NAME: BruceJack
CUSTOMER P.O.
PROJECT NUMBER: – –
CUSTOMER EQUIPMENT. #: –
SCALE: 1:10
JOB NO. –
TITLE: FLOOR FRAME ASSEMBLY
SH 1 OF 2
THIRD ANGLE
DWG. NO. BUILDING FLOOR
REV. –



ITEM 4

HOLE DIMENSIONS

REV.	DATE	DESCRIPTION	BY	APPROVED
	NOV-18-2015	ADDED 6 FOOT PLATES		

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DRAWN: JX	DATE: 16 OCT 14	ECO WASTE SOLUTIONS ECO BURN INC.
CHECKED:	DATE:	
PROJECT NAME: BruceJack		CUSTOMER P.O.
PROJECT NUMBER: — —		CUSTOMER EQUIPMENT. # —
SCALE: 1:10	TITLE: FLOOR FRAME ASSEMBLY DETAIL ITEM 4: CHECK PLATE	SH 2 OF 2
JOB NO. —		
THIRD ANGLE	DWG. NO. CHECK PLATE	REV. —

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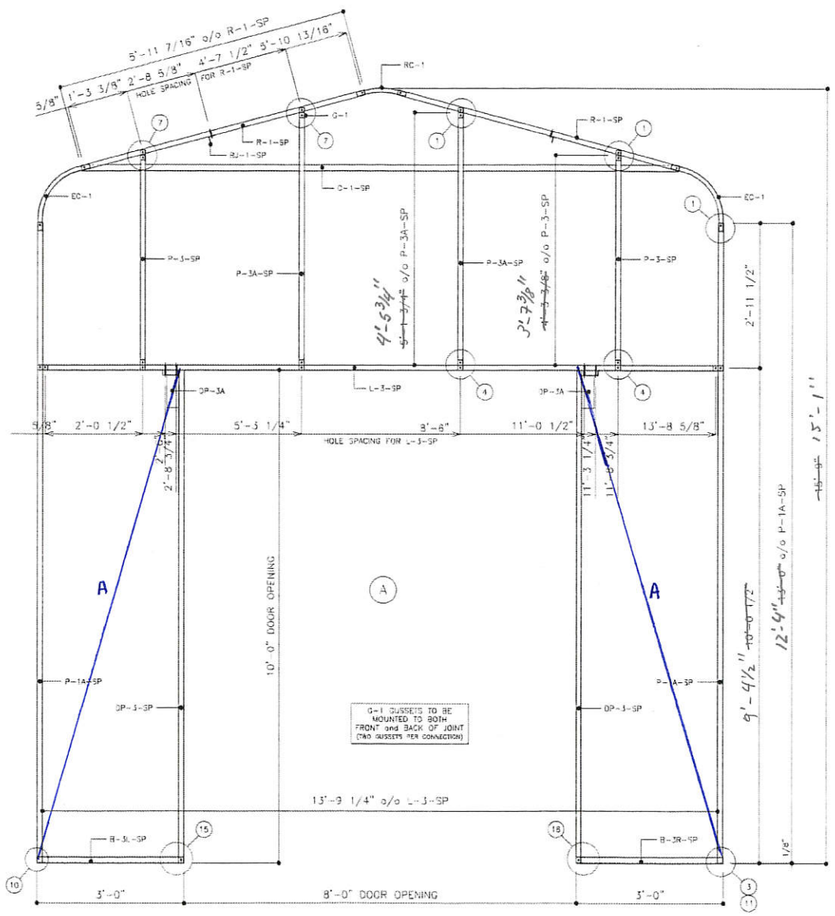
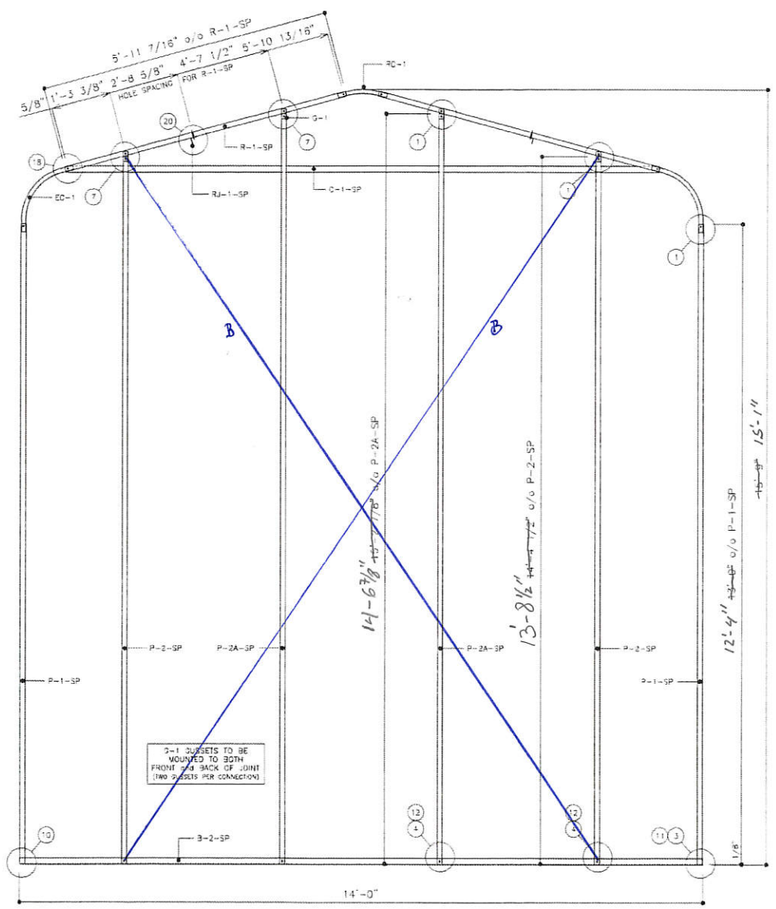
Additional wall bracing (in blue)			
Description	Code	Length	Qty
Front wall (door side walls)	A	9'-10"	2
Back wall	B	16'-9"	2
Side walls (not shown)	C	15'-10"	4

DOOR SCHEDULE				
	DESCRIPTION	R.S.O.	REMARKS	QTY
A	8'-0" x 10'-0" OVERHEAD STEEL ROLL DOOR	96" x 120"	OVERHEAD DOOR SERIES 770 SS, NON INSULATED, PREFINISHED 26ga ROLL-FORMED STEEL CURTAIN, 18ga GALVANIZED STEEL GUIDES, BULB STYLE BOTTOM SEAL, MANUAL PUSH UP CENTER HANDLE, LOCK: RIGHT SIDE, TWO BOLT DOUBLE SHACKLE or CYLINDER LOCK,	1

MATERIAL SCHEDULE	
PARTS	DESCRIPTION
GUSSET PLATES	FLAT STEEL 1.25 x 2.5 x 16ga
POSTS, RAFTERS and LINTELS	HSS 1.25" x 1.25" x .100"
BASE ANGLES, COLLAR TIES and CONTINUOUS RAFTER BRIDGING	STEEL ANGLE 1.5" x 1.5" x .125"
RIDGE CONNECTORS and GABLE WALL EAVE CONNECTORS	HSS 1" x 1" x .125"
INTERMEDIATE RIB EAVE CONNECTORS	HSS 1.5" x 1.5" x .100"



A 2 END WALL FRAMING
SCALE: 3/4"=1'-0"



B 2 END WALL FRAMING
SCALE: 3/4"=1'-0"

Canadian Portable Structures Ltd
4400 Corporate Drive, Burlington, Ontario, Canada L7L 5R5
PHONE: (905) 335-2500 or 1-800-236-4295 (4277)
FAX: (905) 335-1492 or on the World Wide Web.
Internet address: http://www.cdnportable.com
E-mail: info@cdnportable.com

SUBCONTRACTORS MUST VERIFY ALL DIMENSIONS AND DETAILS

ECO WASTE SOLUTIONS
ECO BURN Inc
Knipple, British Columbia

14' x 14' ELLIPTA
STORAGE SHELTER

No	Date	By	Revisions

Drawn by	Date	Checked by	Sales Rep
T.B.	MAY 29 2015	P.R.	P.R.

Scale	Quantity	Job Number	Sheet
3/4"=1'-0"	ONE	E15-1045	2 of 2

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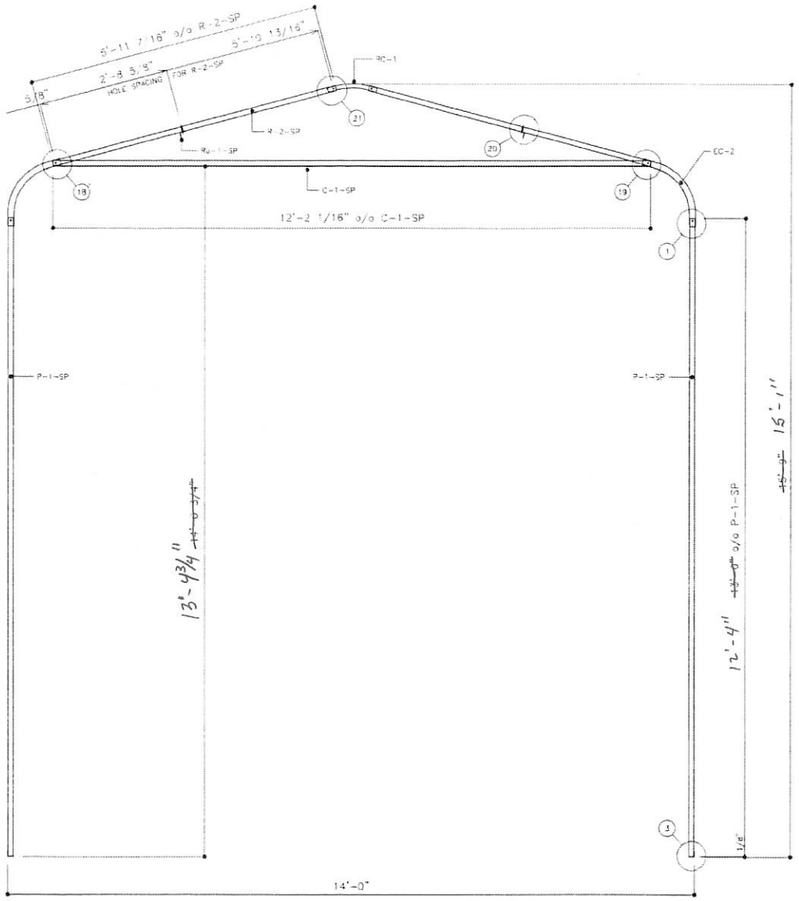
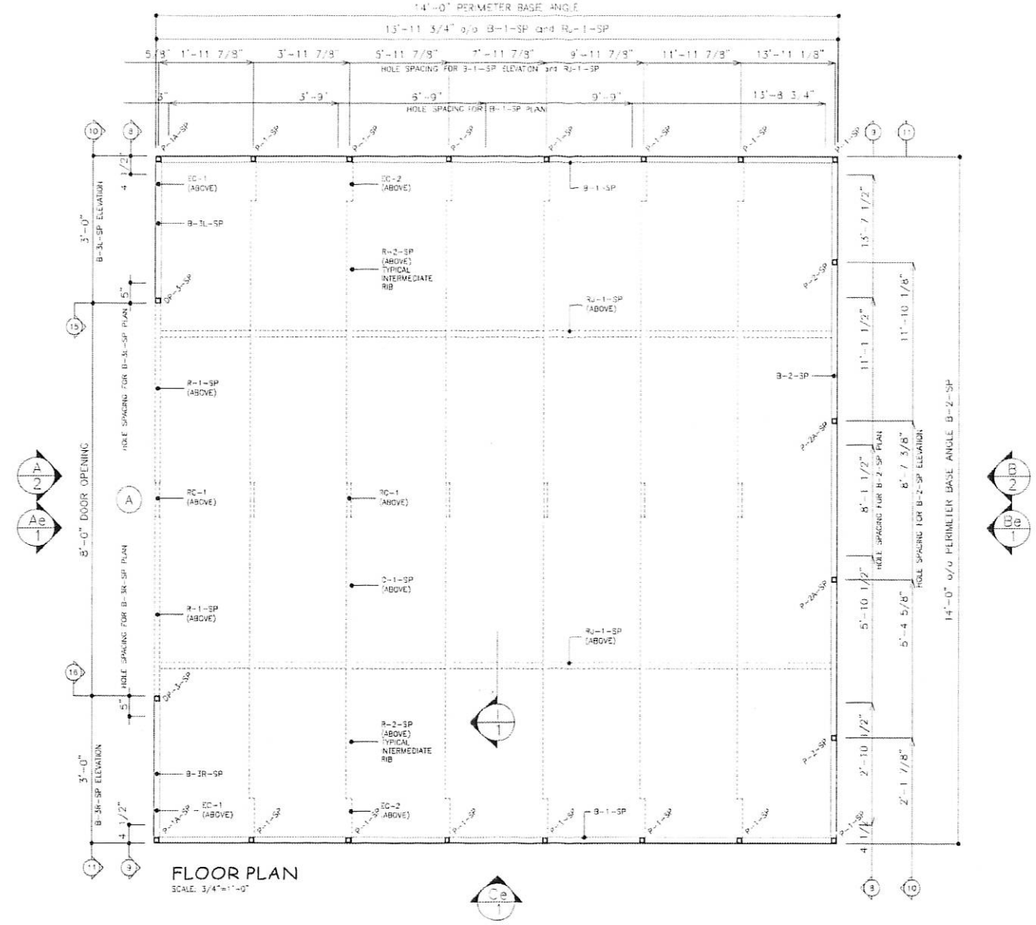


I / 1 INTERMEDIATE RIB FRAMING
SCALE: 3/4"=1'-0"



FLOOR PLAN
SCALE: 3/4"=1'-0"

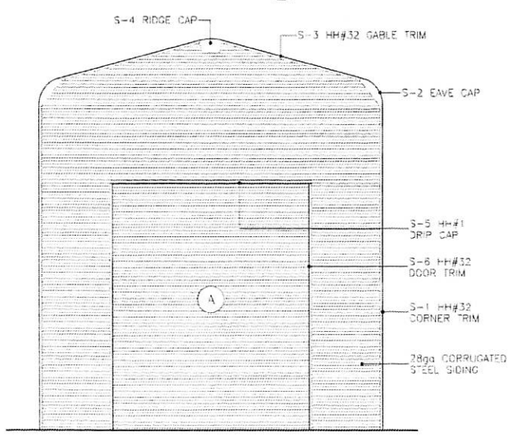
STRUCTURAL NOTES

1. ROOF DESIGN LIVE LOAD (1/50) = 35 psf (1.68 KPa) – By Design NO ALLOWANCE HAS BEEN MADE FOR EXTRA SNOW ACCUMULATION (SEE NOTE BELOW).

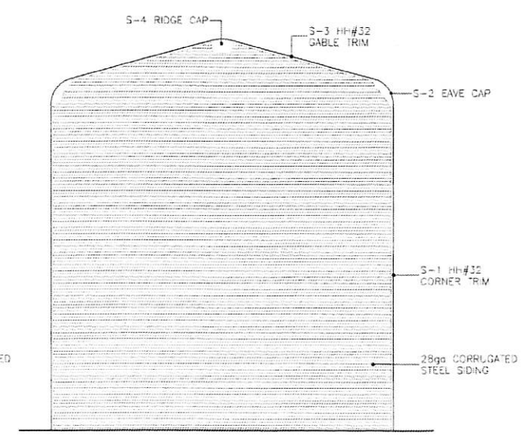
   HOURLY WIND DESIGN PRESSURE (1/50) = 7.2 psf (0.36 KPa)

   OWNER SHALL NOTE THAT BUILDING IS DESIGNED FOR ABOVE LOADING. SOME SITES MAY HAVE ADDITIONAL STRUCTURAL REQUIREMENTS DUE TO SITE SPECIFIC WIND and SNOW CONDITIONS. NOTE: SNOW ACCUMULATION MUST BE CONSIDERED WHEN PLACING BUILDING NEAR A TALLER EXISTING BUILDING.

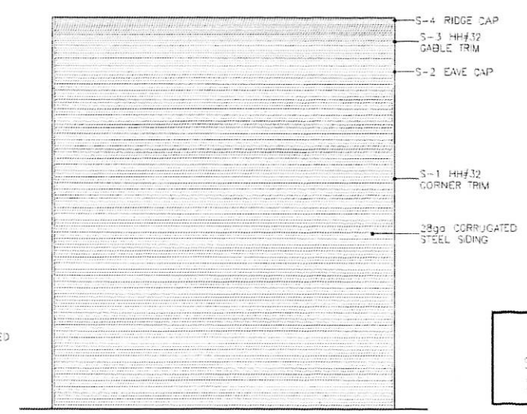
2. BUILDING TO BE SUPPORTED ON EXISTING CONCRETE SLAB CAPABLE OF MINIMUM 250 psf BEARING CAPACITY. OWNER TO VERIFY.



Ae / 1 ELEVATION
SCALE: 3/8"=1'-0"



Be / 1 ELEVATION
SCALE: 3/8"=1'-0"



Ce / 1 ELEVATION
SCALE: 3/8"=1'-0"

DELIVERY and INSTALLATION NOTE

THIS ELLIPTA STORAGE BUILDING WILL BE SHIPPED IN KIT FORM AND WILL BE INSTALLED ON SITE BY CUSTOMER

COLOURS
SIDING – Colour to be Selected
DOOR – Colour to be Selected

Canadian Portable Structures Ltd
4498 Cowichan Drive, Burlington, Ontario, Canada L7L 5H1
PHONE: (905) 335-1492 or (800) 263-2271
FAX: (905) 335-1492 or on the World Wide Web
Internet address: http://www.cdnportable.com
E-mail: info@cdnportable.com

SUBCONTRACTORS MUST VERIFY ALL STRUCTURAL DIMENSIONS AND DETAILS

ECO WASTE SOLUTIONS
ECO BURN Inc
Knipple, British Columbia

14' x 14' ELLIPTA
STORAGE SHELTER

No	Date	By	Revisions

Drawn by	Date	Checked by	Status Rev
T.B.	MAY 29 2015	P.R.	P.R.

Scale	Quantity	Job Number	Sheet
3/4"=1'-0"	ONE	E15-1045	1 of 2

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ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 5

ASSEMBLY & INSTALLATION PROCEDURES

CA 100WO

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

Introduction

The unit will require assembly in the field. Consult Eco Waste Solutions (EWS) for component weights so that properly sized cranes are available at the site for unloading and erecting.

This incinerator has been knocked down for packaging and transportation inside 20' shipping containers.

Lifting lugs are provided on stacks, and major accessories. These lugs should be used in setting the pieces into position. Do not attach lifting chains or cables to piping or mounting flanges as they may be damaged. Avoid dragging lifting gear across painted surfaces as this will cause damage to the high temperature paint. When placing the incinerator into position be extremely careful not to subject the refractory to mechanical shock as this may result in refractory damage.

Additional utility connections are as follows and some instructions follow at the end of this section:

- Electrical
- Propane Gas

Incinerator Assembly and Installation Procedures

Assembly of CA 100WO Incinerator System

Reference: Drawing: CA 100 WO 00 General Arrangement (GA)

Step 1: Foundation for building
The incinerator's building and related components must be installed on a level concrete pad or compacted gravel pad. It is recommended that appropriate consultation with civil engineers and/or architects is taken before designing an appropriate foundation.

Please refer to EWS supplied drawings BUILDING FLOOR.

Preparation of 14'x14' floor to accommodate CA-100 WO

- Set up and bolt C-channel and I-Beams together using lettered markings as a guide

Install (weld) the provided ¼ "check plate for floor surfaces.

Once the building floor is installed with the checkered plate welded on the appropriate foundation, the primary chamber and the secondary chamber can be placed on the building floor.

Step 2: Primary Chamber

The location of the *Primary Chamber* is already determined in the building floor. Set *Primary Chamber* into position. Shim with steel shim plates until level. Install anchor bolts in all six (6) locations on the base.

Primary Chamber

Step 3: Insulating Blanket

Install the provided insulating blanket along top edge of Primary dome.

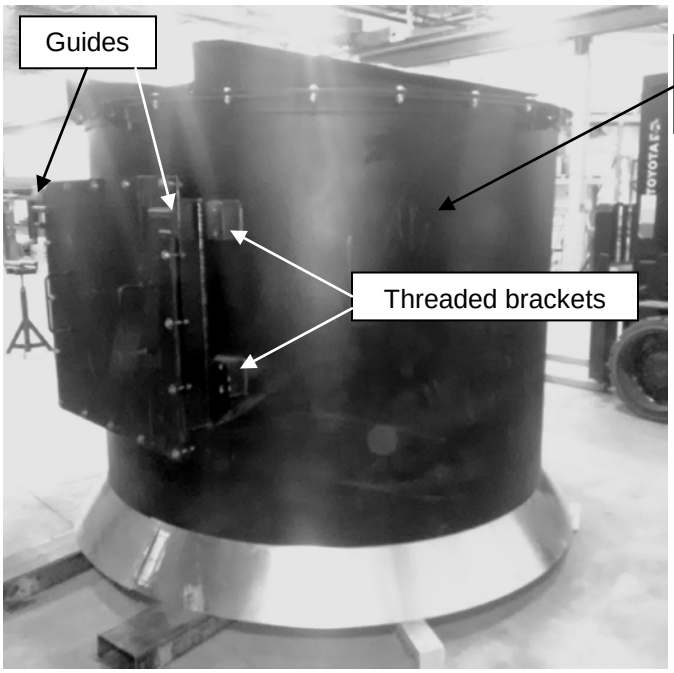
Dome Side/Top

Dome: Top View

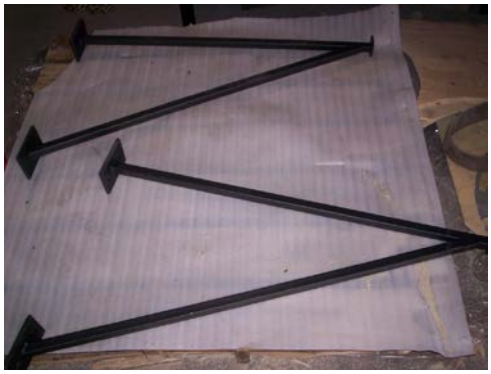
Dome: Side View

Step 4: Secondary Chamber Door

With the door attached to the secondary chamber, disassemble the guides attached to the door. These guides will ride on the rails shipped loose



Rails



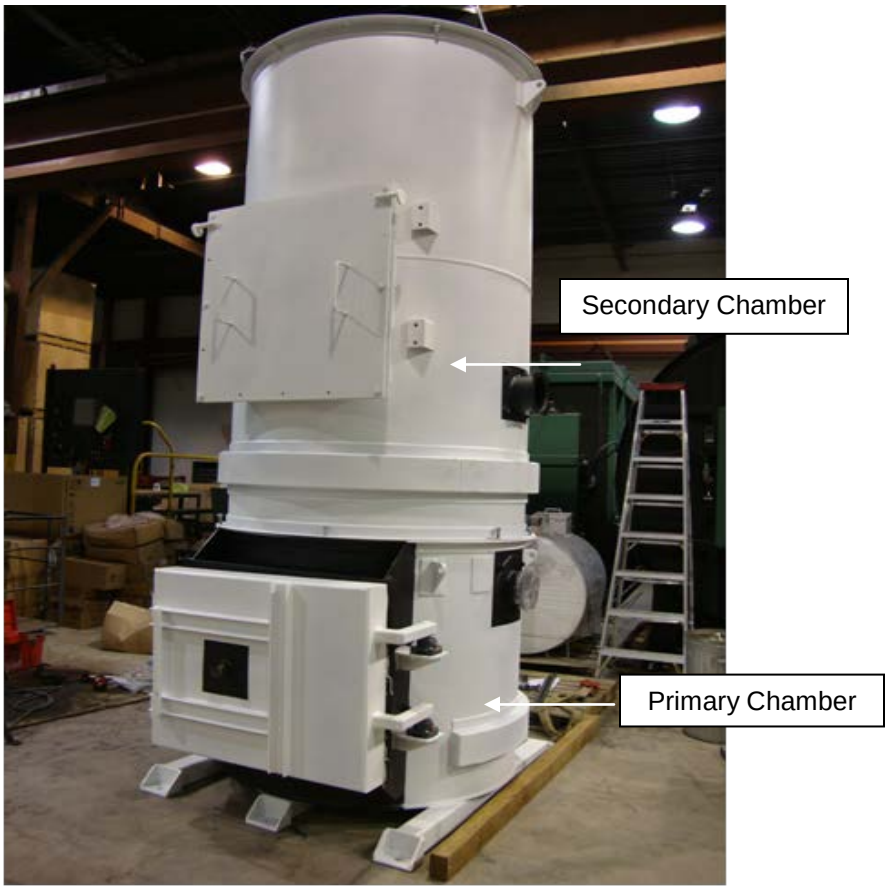
Install the rails to the secondary chamber using the pre-installed threaded Brackets

This secondary chamber door can only be opened when the incinerator is cold and for maintenance purposes.

Step 5: Secondary Chamber

Install the *Secondary Chamber* aligned (see below) with the *Primary Chamber* as per the installation drawings. Lower *Secondary Chamber* slowly onto *Primary Chamber* compressing the insulating blanket between the *Primary* and the *Secondary* Chambers. Align bolt holes and bolt together using hardware provided.

At this point, the CA 100WO Model Incinerator should look as follows:



Step 6: T-Stack and Stack Sections

Install stack gaskets between stack sections.

Install refractory-lined *T-Stack Section* on top of the *Secondary Chamber* using the hardware provided. Then install the next three *Stack Sections* as per the drawing using hardware provided.

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T-Stack and Stack Sections

This is a Sample Photo <u>only</u> of Erection of the Stack Sections

Step 7: Building Assembly

At this point EWS recommends the erection of the building around the CA-100WO as per '*Ellipta Assembly Instructions'* in O&M Manual.

- Sheet metal siding panels will require clipping to fit around stack. Weld two piece ring flange to T-Stack just above roof line.
- Attach flashing provided between ring flange and building roof.

Collar installed to stack section

Flashing sections to be installed over the collar and attached to the building roof

Step 8: Primary Chamber Burner

Have a licensed gas fitter, install *Primary Chamber Burner* and gasket in Primary Burner port using the hardware provided.

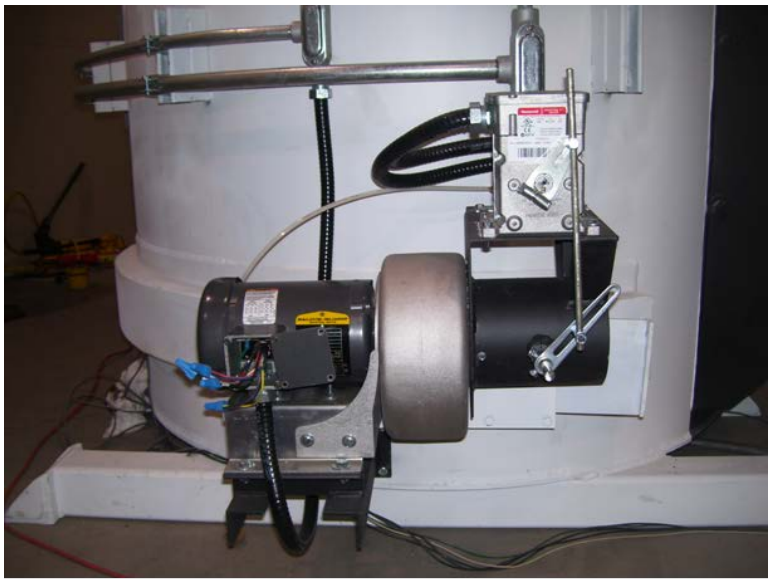
Step 9: Secondary Chamber Burner

Have a licensed gas fitter; install *Secondary Chamber Burner* and gasket in secondary burner port using the hardware provided.

Step 10: Primary Chamber Blower

Install the *Primary Chamber Blower* mount frame using the hardware provided.

Install the *Primary Chamber Blower Assembly* including motor and damper on top of the mount frame using the hardware provided.



Primary Chamber Blower

Step 11: Secondary Chamber Blower

Install the *Secondary Chamber Blower* mount frame using the hardware provided.

Install the *Secondary Chamber Blower Assembly* including motor and damper on top of the mount frame using the hardware provided.

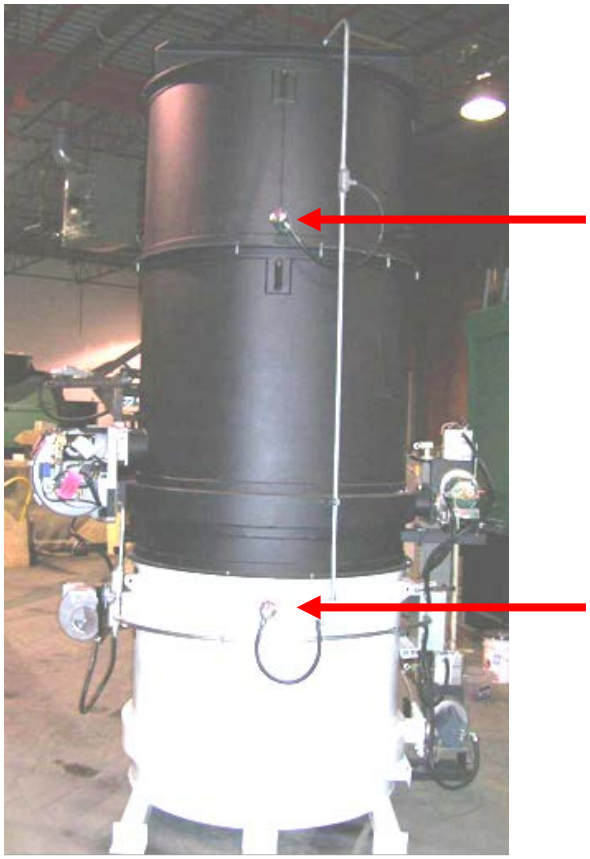
Secondary Chamber Blower

Step 12: Thermocouples

Install the three (3) ¾" *Thermocouples* at positions indicated in red below in Primary Chamber, Secondary Chamber and T-Stack (not shown in picture).

NOTE When wiring the thermocouples there must be no splices between the Main Control Panel and the thermocouple. Use the thermocouple wire provided.

On the Thermocouples the red wire is NEGATIVE and the Yellow is POSITIVE.



Step 13: Viewports

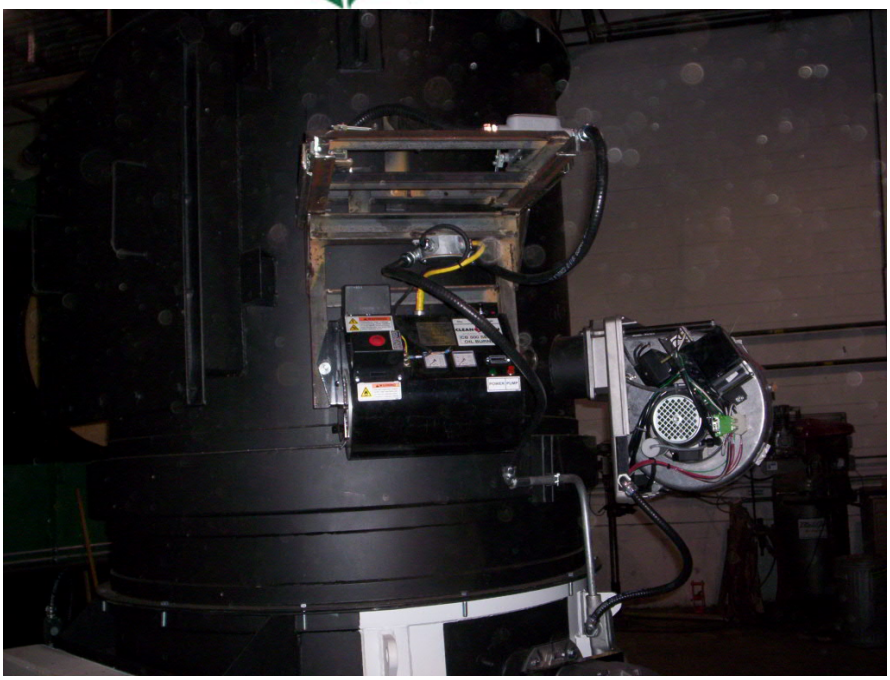
Install three (3) 2" threaded *viewports* at positions indicated in red below on the *Primary Chamber* door, the right hand side of the *Secondary Chamber* burner and on the right hand side of the *Primary Chamber* burner.

NOTE The viewports should be hand tightened only, do NOT over tighten.

Step 14: Waste Oil Burner

Refer to Clean Burn OEM manuals

- Mount the waste oil burner slide frame assembly onto the lower section of the Secondary with hardware provided.
- Mount the waste oil burner (Clean Burn) on the slide frame assembly on the red bracket.



Accumulator Block

Step 15 Propane Gas and Waste Oil Connections

<u>Reference</u>: Drawing CA 100-WO-00 General Arrangement (GA)
Drawing CA 100-WO-01 P&ID

The Propane gas tank and evaporator are pre-assembled on a skid; the gas trains for the burners are pre-assembled to be installed in the building. The connection from the heavy ends trap in the tank skid to the building, including the low pressure regulator for the burners' gas train has to be carried on-site (by client's qualified contractors). There must be a proper clearance according to local regulations from the tank/evaporator skid to the building . The complete propane installation has to be inspected and approved by the local authority (client's scope).

Propane Skid

Propane Burners gas Train

NOTE All Propane Gas connections to be done by a certified technician and should satisfy all local codes (all lines to be pressured tested), including the distance between the incinerator system and the tank.

Step 16: Electrical Connections
Reference: Electrical Drawings provided

NOTE All electrical connections, terminations and conduit installation to be done by a certified electrician and should satisfy all local codes.

Most of the internal wiring of the incinerator was completed at the factory and dismounted for shipping.

The wiring necessary on-site (by client's contactors) is:

- From the *power source* to the *Main Control Panel*
- From the incinerator's building to the propane vaporizer
- From the *Main Control Panel* to components Junction Box
- From the breaker box to the propane vaporizer
- From the *Main Control Panel* to the waste oil tank

Step 17: Start-Up

NOTE **CAUTION**: Do not attempt to place the equipment into operation until an EWS Service Technician has checked out all equipment and interlocks.

Upon completion of mechanical erection, interconnection of equipment and provisions of utilities as described above, arrangements should be made with the EWS field service department for scheduling of a service technician for initial start-up.

An EWS representative must perform start-up of all incinerator systems unless specifically arranged otherwise in writing by EWS.

Attempts to start-up incinerator systems by the buyer without prior written approval may result in revocation of all expressed or implied warranties.

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 6

OPERATING INSTRUCTIONS

CA 100WO

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

Important Information

Proper operating and maintenance procedures must be followed in order for the CA Model Incinerator system to perform at maximum efficiency.

Do not attempt to start or operate this equipment until this Operator Manual is read thoroughly and is understood.

The equipment has been designed with many safety features, however, like all thermal processes; this equipment is not free from the inherent hazards of high temperature processes.

Safety procedures and precautions must be followed at ALL times during operation.

There are safety procedures outlined in this Manual, however, no amount of written instruction can replace good judgment and safe operating practices.

Responsibility for the safe operation and maintenance of the equipment supplied rests solely on those operating it.

There are many engineered features incorporated into the CA Model Incinerator system to free the operator of repetitive chores. They do not, however, relieve the operator of maintenance responsibilities. In order to maximize the operating life of the equipment, it is strongly recommended that the maintenance procedures, be followed diligently. It is advisable to keep an equipment log for recording maintenance activities along with unusual operation.

NOTE

In the event that the equipment is not operating in the normal manner, contact Eco Waste Solutions immediately at (905) 634-7022. It is important to report problems as soon as they are noticed to minimize damage that faulty operation could cause.

Design Specification Criteria

The **CA100WO** incinerator system was designed specifically for the **Brucejack** project under **Eco Waste Solutions (EWS)** proposal **PRB-CA 100** presented on December 3, 2014 and based on information provided by Pretivm Resources Ltd.

The **Brucejack Project** is a gold mine located 65 km north of Stewart in northwestern, BC; the EWS team designed an incinerator with the following criteria in mind.

Waste Description

The solid waste material generated at this mine camp is described as mainly camp and kitchen waste.

EWS assumes that the waste material is typical of mixed camp waste, non-hazardous solid waste consisting of food-waste, kitchen waste including packaging, cardboard, wood waste, and general refuse.

- Inappropriate materials including, but not limited to, reactive/explosive chemicals and items containing heavy metals will not be processed in the incinerator proposed herein.

Project

The **Brucejack Project** is a gold mine located 65 km north of Stewart in northwestern, BC.

Waste Description

This Ca100 WO incinerator is required to process camp waste as follows:

CA 100 Incinerator Package

	CA 100
Maximum Incinerator Processing Rate	182 kg/batch
Hours of operation	Burn Cycle 3-5 hours, Cool-Down Cycle 4 hours
Maximum Waste processed in 24 hours (operated twice per day only)	364 kg per day (over 2 batches)

To address the need of disposing any waste oils generated at site a **Waste Oil Burner (WOB) Package,** has been integrated as part of the incinerator system to dispose of up to 5gal/hr of waste oil

ECO WASTE SOLUTIONS

EWS Waste Assumptions

In addition to daily waste generation rates, one of the most critical assumptions to be made in planning a waste management/incineration disposal system is the estimation of the waste density. With batch incinerators in particular, waste density is critical to determining the size of the incineration system.

We have based our assumptions upon our experience but should site specific data be available, it should be considered in the design assumptions.

Description	Total Moisture Content	Density	Higher Heat Value
Mixed Solid Waste	Up to 40%	10-15 lbs/ft^3 160-240 kg/m^3	6,500 BTU/lb 15,150 KJ/kg

Waste Oil Specifications

- The Waste Oil burner is designed to burn up to 5 gal/hr of the following fuels:

Used crankcase oil up to 50 SAE
Used transmission fluid
Used hydraulic oils
#2 fuel oil
#4 fuel oil
#5 fuel oil

NOTE: Used oils may contain other substances, including gasoline, which may hinder performance.

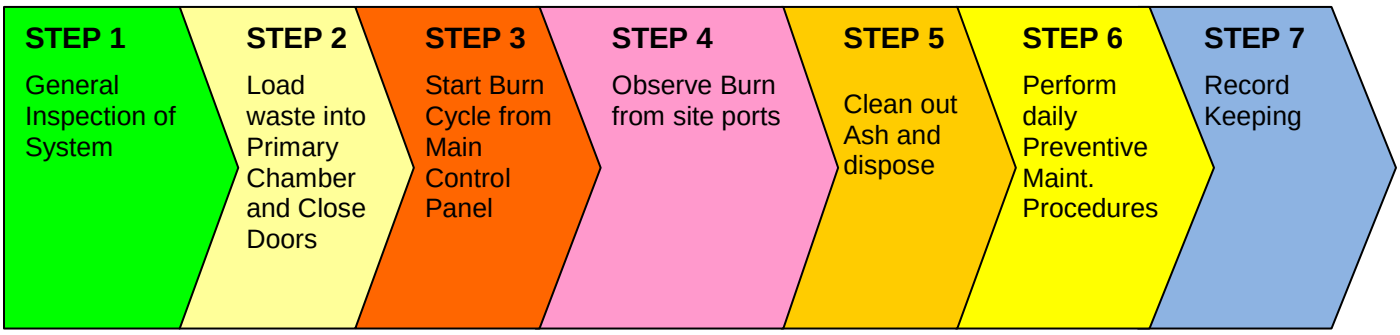
- Hazardous wastes, such as chlorinated solvents, are NOT to be mixed with your used oil

NOTE

This incinerator was only designed for the type of waste and amount of waste mentioned above. It is important that the waste quantities and characteristics described above are processed in the incinerator. Otherwise, the incinerator system will not operate properly.

General Operating Overview

The operation of the **CA 100WO Waste Incinerator** follows 7 general steps that take place over a 12-hour period.



Although all 7 steps are critical in the general operation of the incinerator system, this section of the manual focuses on **Step 1, Step 3** and **Step 4** and how to start the system and monitor it during operation.

This section will also cover **Step 7** on how to use the historical charts, store incinerator data, and access incinerator historical information for record keeping purposes.

Monitoring and Data Acquisition System

Overview

The **PLC** automatically monitors the entire process and some system inputs are recorded and logged for record-keeping purposes and also allows for historical trending of key operating conditions.

The integrated **PLC** in the Main Control Panel monitors and records the following:

1. Temperature sensors
2. Differential pressure sensors with transmitter (draft)
3. Monitoring of burner faults
4. Fan amperage monitoring via current transducer and VFD
5. Door position interlock monitoring
6. High temperature limit and interlock
7. Damper positions

All data can be transferred to storage by using the USB flash memory installed in the back of the HMI

Data Logging

Data from the Incinerator is logged automatically on the HMI and will need to be manually retrieved from the HMI.

Using Historical Charts

Accessing Historical Information

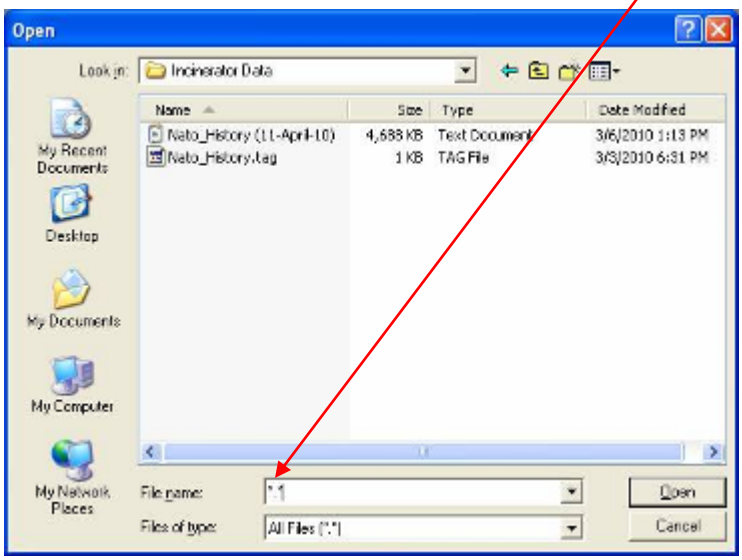
a. It is recommended that a dedicated folder be set on the destination computer that is used for storing data from the Incinerator Package (e.g. “Incinerator Data”)

b. Copy the data file “**RSView Enterprise Viewer.EXE”** from the USB Flash Memory (extracted from the back of HMI, in the panel) to this dedicated directory and rename the file with the date to easily access previous week’s information.

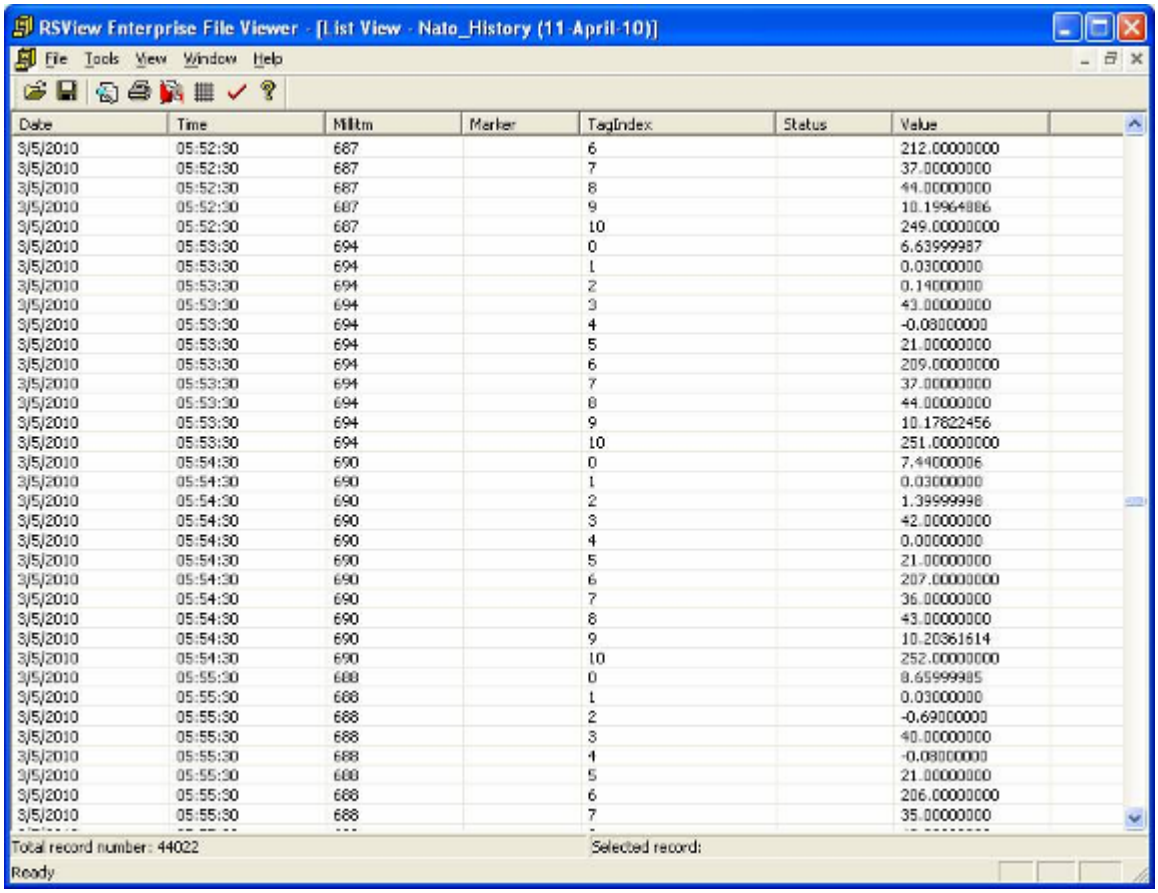
c. **“”**.

d. To open data, double click on the RSView Enterprise Viewer application. From the File menu select Open. Make sure you are searching in the folder containing the historical data files.

e. In the Open dialogue box, in the File Name type “***.***” to view all files. Click on the specific Text Document that you wish to open.



f. Once the data is open, it will look similar to the following:



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3/5/2010	05:52:30	687		10		249.00000000
3/5/2010	05:53:30	694		0		6.63999987
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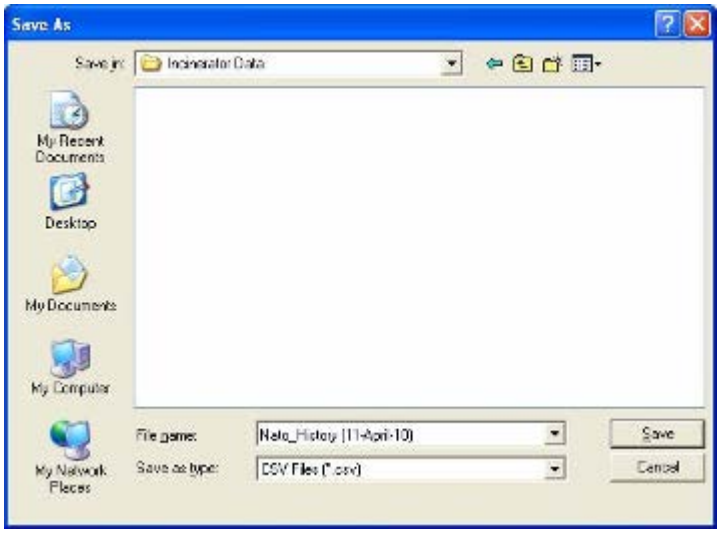
3/5/2010	05:53:30	694		2		0.14000000
3/5/2010	05:53:30	694		3		43.00000000
3/5/2010	05:53:30	694		4		-0.08000000
3/5/2010	05:53:30	694		5		21.00000000
3/5/2010	05:53:30	694		6		209.00000000
3/5/2010	05:53:30	694		7		37.00000000
3/5/2010	05:53:30	694		8		44.00000000
3/5/2010	05:53:30	694		9		10.17822456
3/5/2010	05:53:30	694		10		251.00000000
3/5/2010	05:54:30	690		0		7.44000006
3/5/2010	05:54:30	690		1		0.03000000
3/5/2010	05:54:30	690		2		1.39999998
3/5/2010	05:54:30	690		3		42.00000000
3/5/2010	05:54:30	690		4		0.00000000
3/5/2010	05:54:30	690		5		21.00000000
3/5/2010	05:54:30	690		6		207.00000000
3/5/2010	05:54:30	690		7		36.00000000
3/5/2010	05:54:30	690		8		43.00000000
3/5/2010	05:54:30	690		9		10.20361614
3/5/2010	05:54:30	690		10		252.00000000
3/5/2010	05:55:30	688		0		8.65999985
3/5/2010	05:55:30	688		1		0.03000000
3/5/2010	05:55:30	688		2		-0.69000000
3/5/2010	05:55:30	688		3		40.00000000
3/5/2010	05:55:30	688		4		-0.08000000
3/5/2010	05:55:30	688		5		21.00000000
3/5/2010	05:55:30	688		6		206.00000000
3/5/2010	05:55:30	688		7		35.00000000

Saving Data to Excel

a. To save the data in a Microsoft Excel format – with the data open (as above) from the File menu select Save As and select the directory where you wish to save the file. Make sure you have a logical name in the File Name field (it will default to the same file name as the TXT file you have opened). Make sure CSV is selected in the "Save as Type" drop down box and select the Save button.

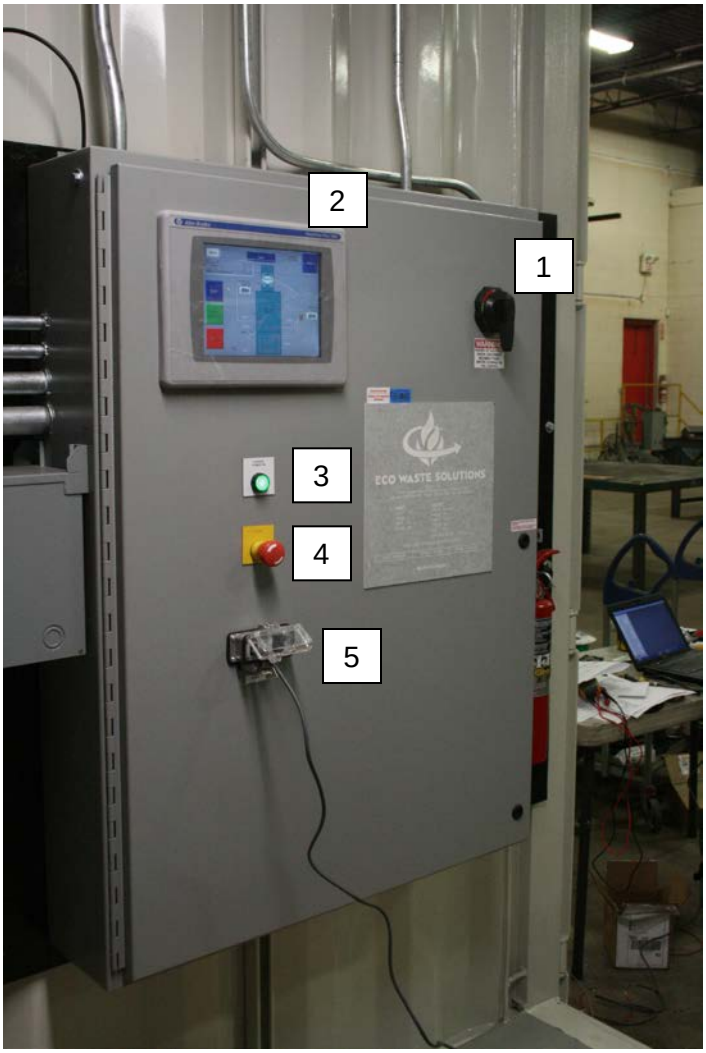


b. To view the file in Microsoft Excel, open the Excel application and from the File menu, select Open and then make sure that "Files of Type" is on "Text Files"

c. Choose the file you wish to open and select "Open" from the dialogue box. The file is now open in Excel.

HMI Operator Interface

Main Control Panel Components



Number	Name	Purpose
1	**Main Disconnect Switch**	Isolates the incinerator from its source of electric power.
2	**HMI Operator Interface**	Displays various screens reflecting system performance.
3	**Control Power ON**	1. Green light indicates the control power in the panel is on. 2. Pushing it if the **Emergency-Stop** is out will turn on the control power.
4	**Emergency Stop Pushbutton**	Stops the cycle if it is on and disables any possibility of starting it.
5	**USB Port**	Allows access to PLC and HMI

The HMI Operator Interface

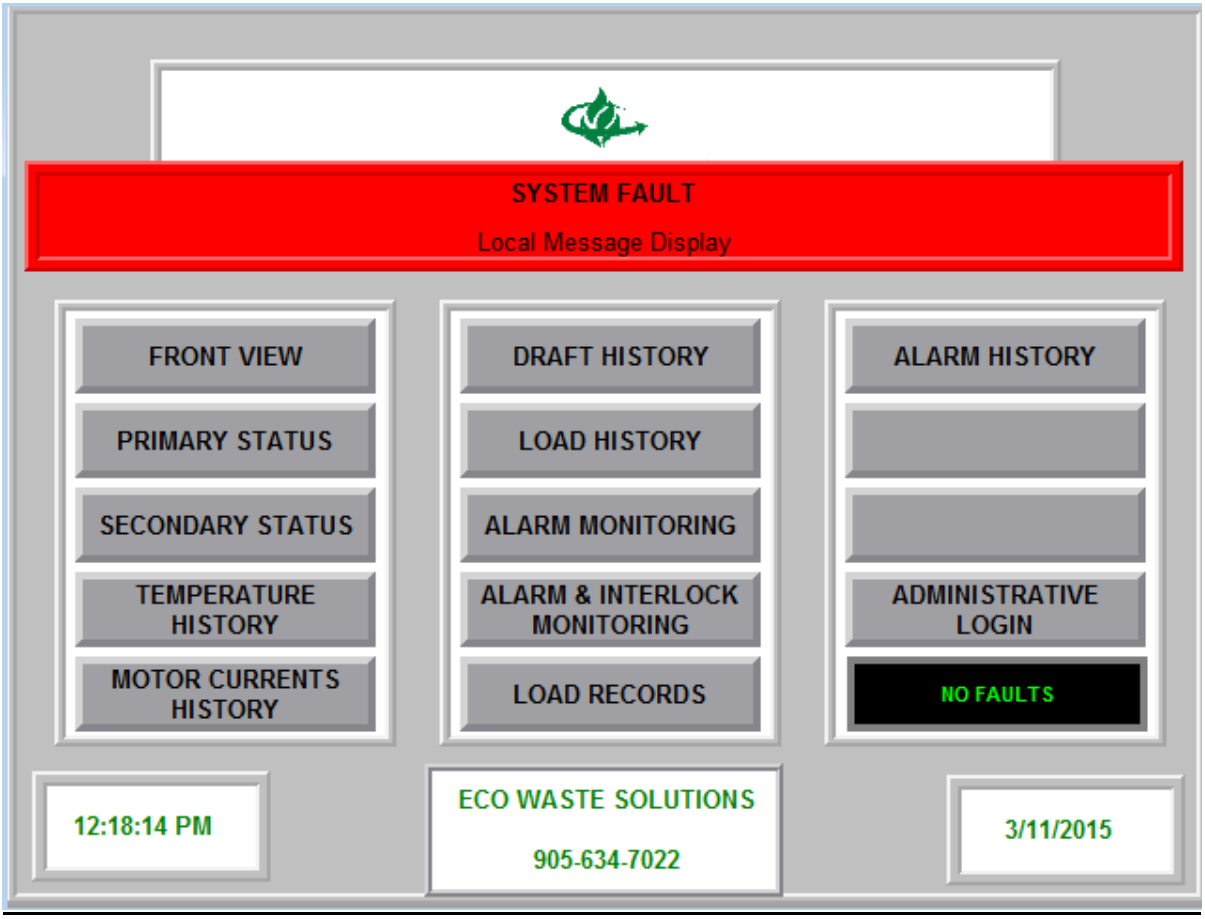
The **HMI Operator Interface** controls the operation of the incinerator directly from the **Main Control Panel.**

The **Main Menu** screen displays all the available options for viewing the system in operation.

The **HMI** has a touch-screen and items can be selected by touching them on the screen.

Main Menu

The first screen the operator will view is the **Main Menu** (see below).



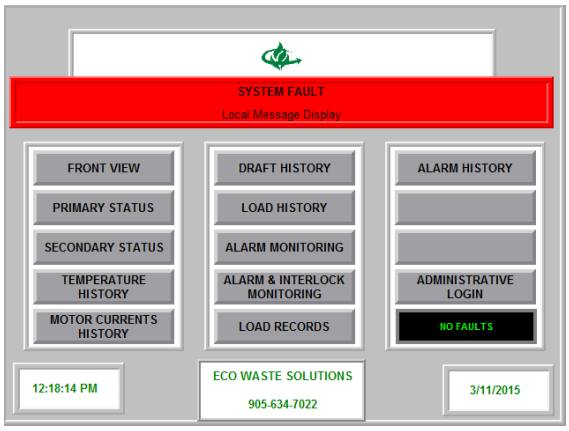
Front View

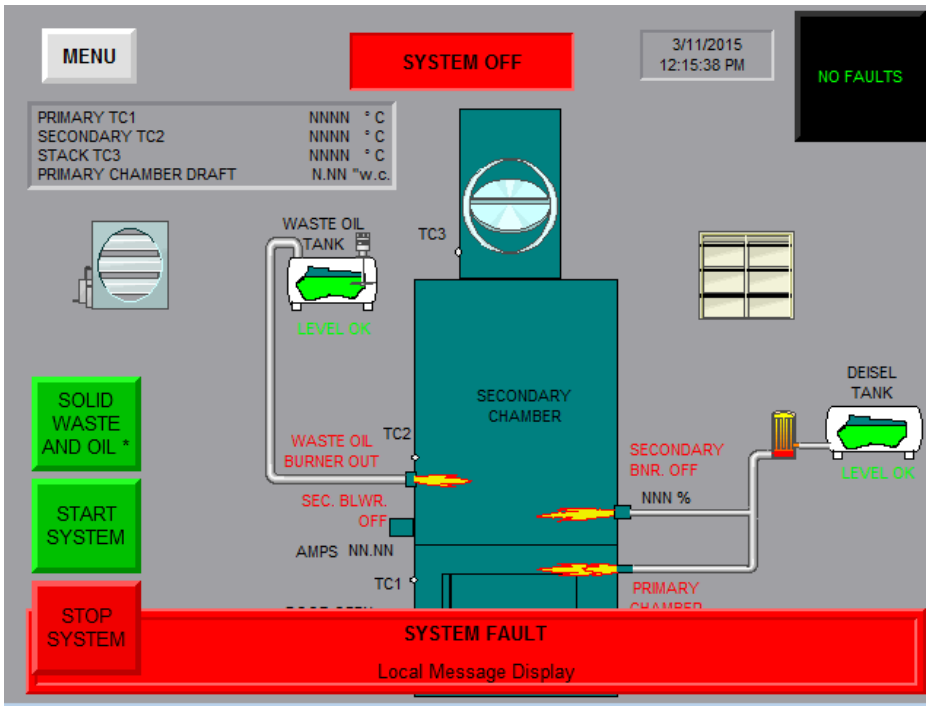
When the ***Front View*** button is selected, an overview of the incinerator and related components is displayed. This shows key temperatures, flows, and other indicators of what is happening in the process in a real-time basis.

NOTE

The system will not start if there are alarms or faults present.

At any time, touch **Main Menu** to go back to the main screen.



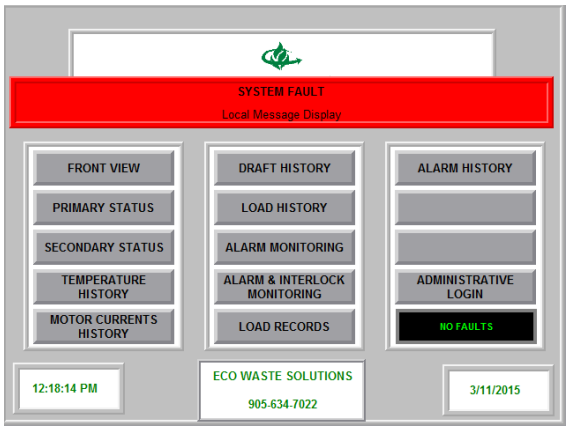


Primary and Secondary Status

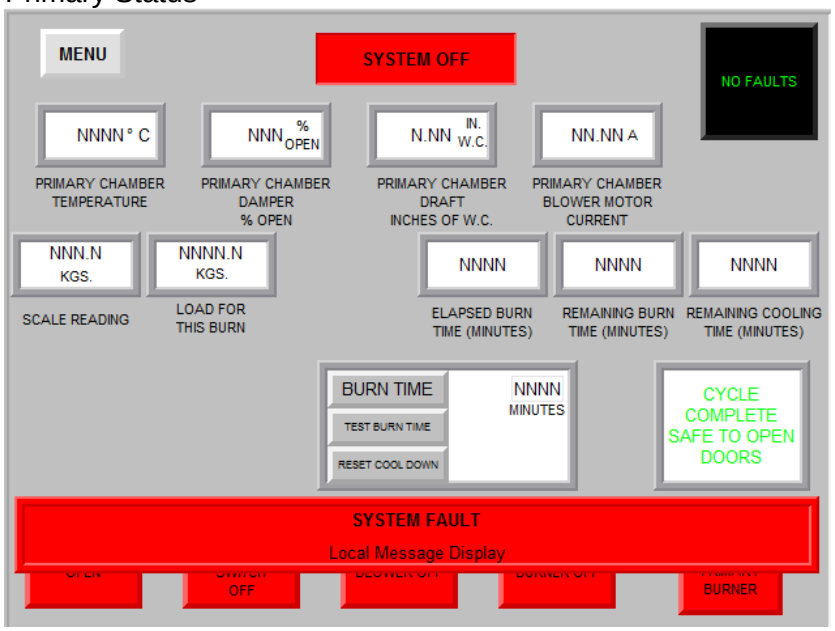
When the ***Primary Status* or Secondary Status** button is selected from the **Main Menu,** a screen will display the status of all the operating parameters of the Primary Chamber or Secondary Chamber accordingly, such as the temperatures and the time remaining in the cycle, as well as displaying other informational items such as status of the door and blowers, etc.

The operator can change the burn time of the cycle by selecting “BURN TIME” and entering a time (in minutes). The operator may do this over time to either prolong the burn time, or decrease the burn time depending on the waste mixture; for example a very wet batch of garbage will take more time to burn than a dryer batch of waste.

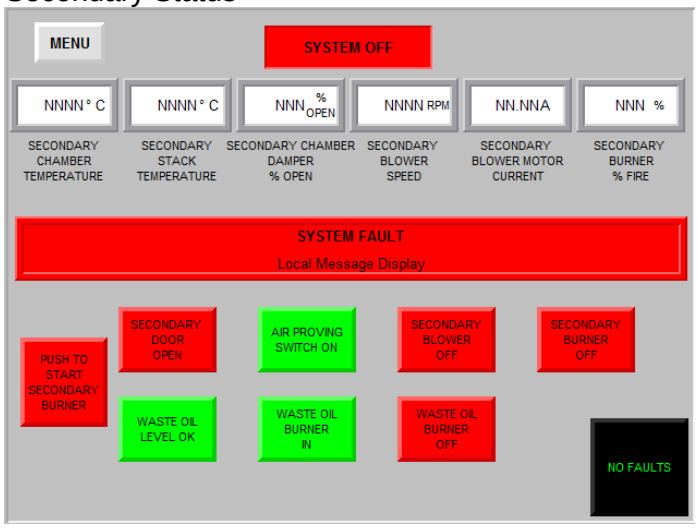
At any time, touch **Main Menu** to go back to the main screen.



Primary Status



Secondary Status

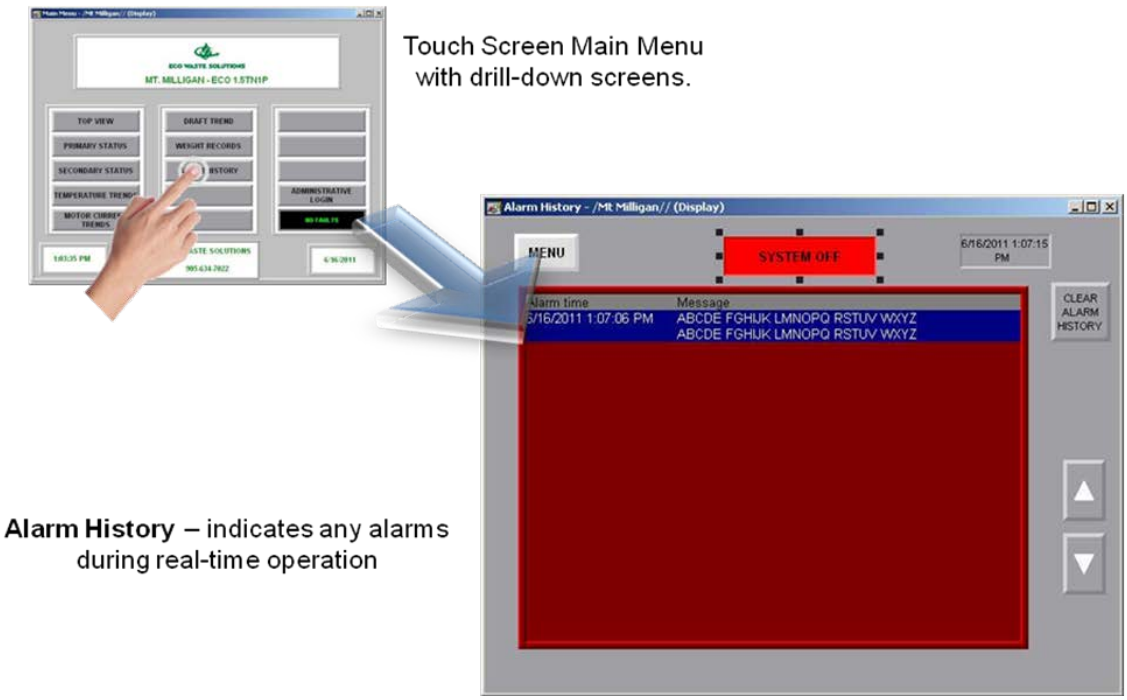


Alarm History

When the ***Alarm History*** button is selected a screen will display the last 128 faults with the date & time of occurrence.

The operator can press the *CLEAR ALARM HISTORY* to clear all of the faults, if they wish to. This does not affect the record-keeping feature of the system.

At any time, touch **Main Menu** to go back to the main screen.



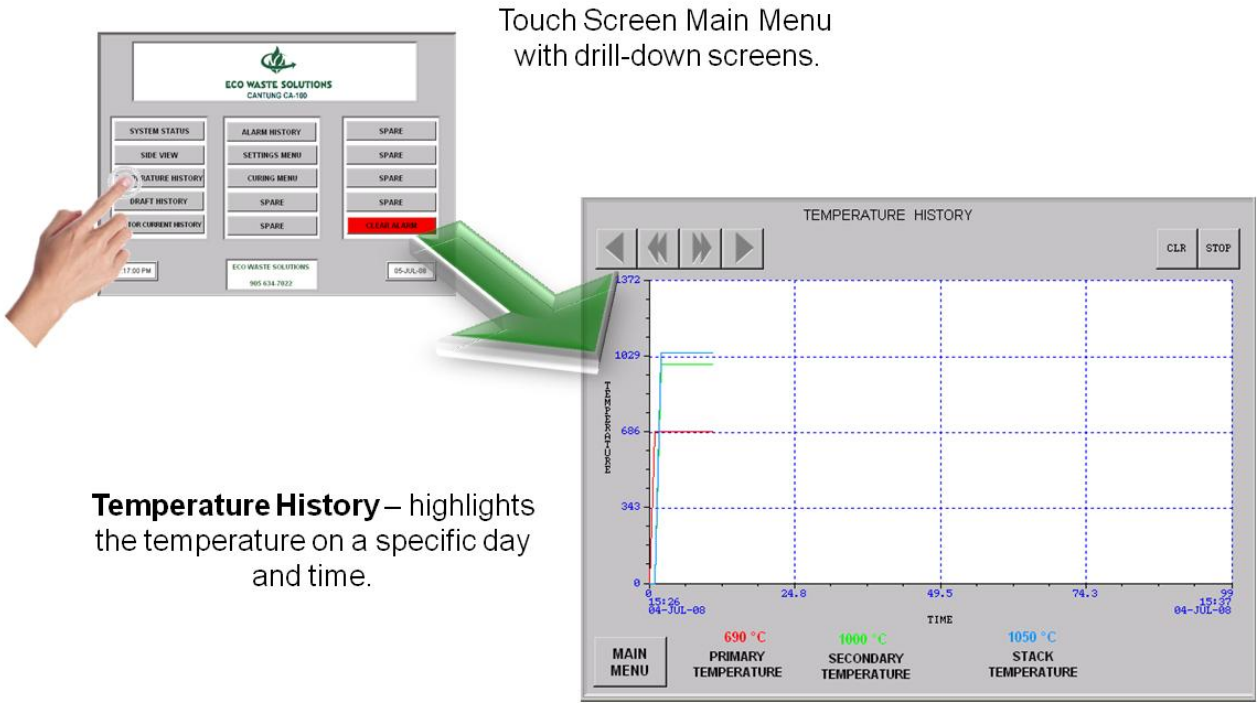
Overview of Historical Charts

The **HMI** operator interface monitors and records (every minute) critical operating parameters of the incinerator system like the temperature, motors, draft, load weights and alarms. Each operating parameter has its own graphic display for the operator to view, at any given time. Each display can easily be selected from the **Main Menu** of the **HMI**. The display will show the specific data collected from previous burn cycles.

This **Incinerator Data** is important for regulatory purposes and for general operating purposes.

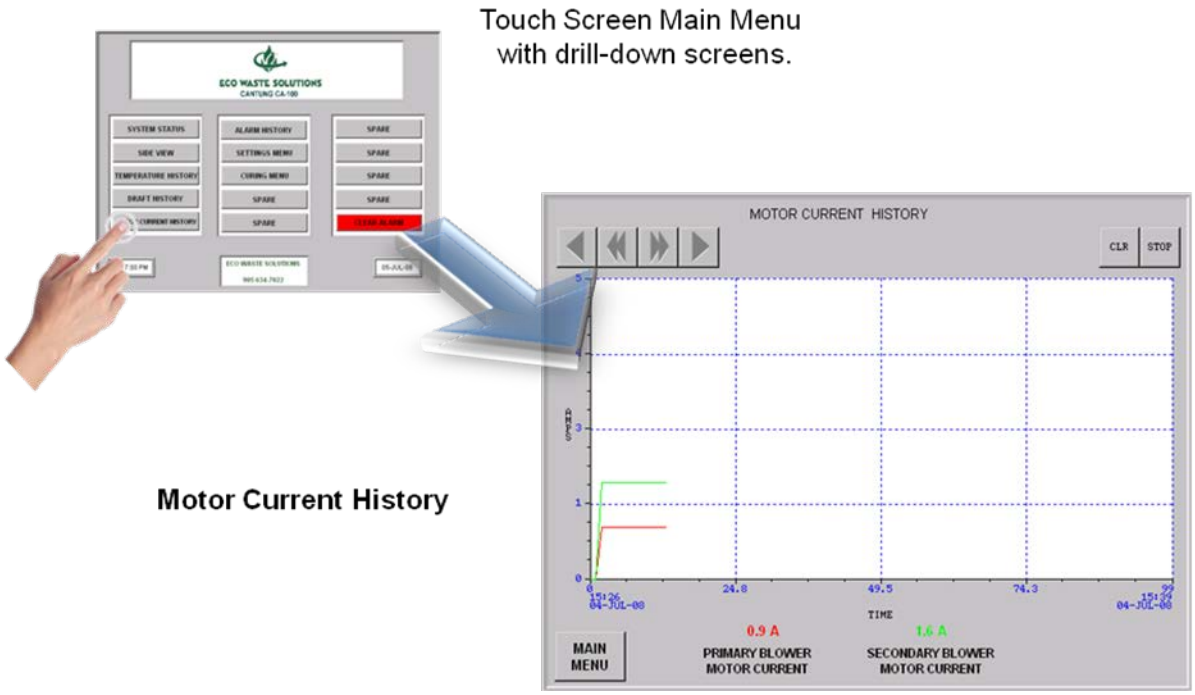
Temperature History

For example, when the ***Temperature History*** button is selected, the screen will display the trend in temperature during the operation of the system, include date & time of occurrence of that specific temperature.



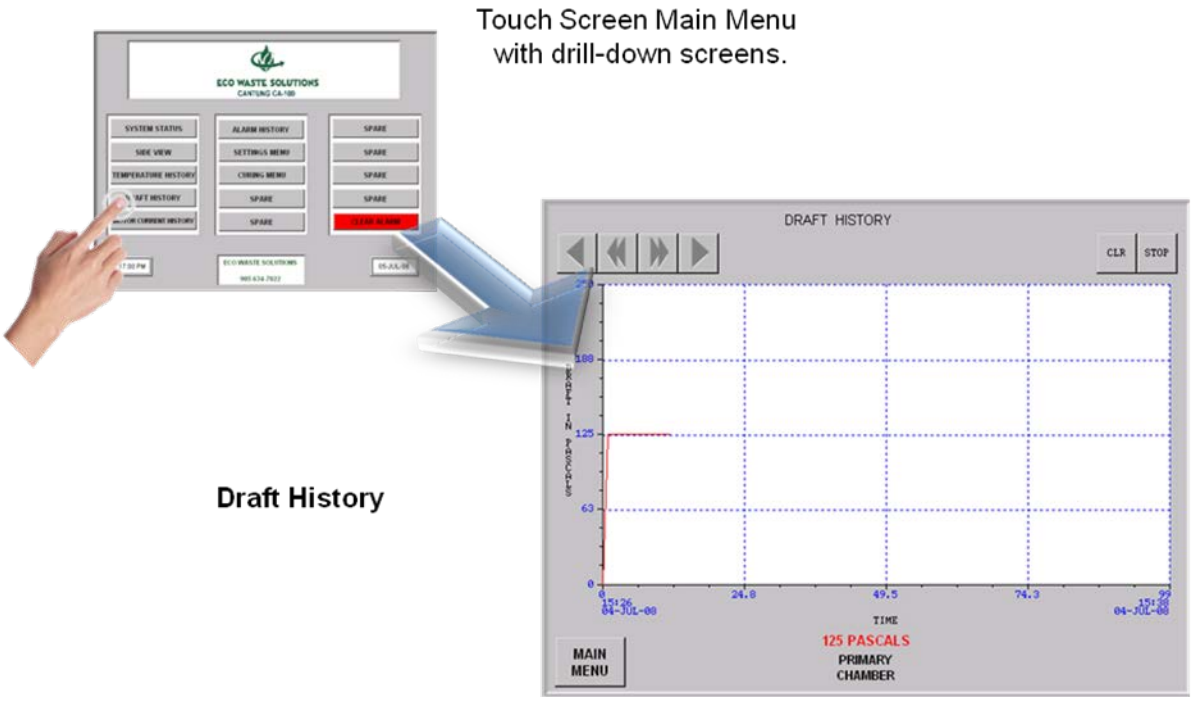
Motor Currents History

When the ***Motor Currents History*** is selected a screen will display the motor currents from the Primary Burner and the Secondary Burner, in AMPS, during the operation of the system, including date & time of occurrence of that specific motor current.



Draft History

When the ***Draft History*** button is selected a screen will display the draft during the operation of the system, include date & time of occurrence of that specific draft trend.



Standard Daily Operating Procedures

Daily Circular Inspection

1. Check that all valves leading to the burners are open
2. Check that the slide gates on the blowers are open
3. Check waste oil valves from tank to burner are open and lines leak free
4. Check that all circuit breakers are in the “ON” position
    - In the main breaker panel
    - For the propane skid, check the circuit breaker at the back of the building to ensure the vaporizer has power. The vaporizer should feel warm to the touch
5. Fix any items found incorrect.

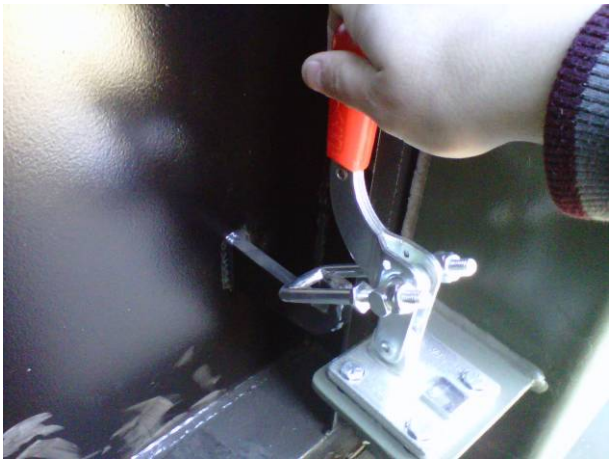
Incinerator Daily Start up

1. Ensure that manual slide gates for each blower are in the open position for free airflow into the **Primary and Secondary Chambers**

Primary Chamber Blower Manual Slide Gate Open

Secondary Chamber Blower Manual Slide Gate Open

2. If propane odour is noticed, visually inspect the burner piping to ensure that there are no gas leaks.
3. Ensure the draft gauge connection is tight and sealed. This is tubing located in the back of the **Primary Chamber.**
4. Unlatch clamps on the **Primary Chamber** door, open and secure in the open position



5. Ensure the Primary Chamber floor is cool (less than 50°C). Remove all the ash from the previous burn and store ash in ash bins.

If the floor is hotter than this temperature the waste may spontaneously catch on fire during loading.

6. Tips for loading. The following loading procedure will decrease burn time and allow for more uniform burn.
   a. Load the less dense waste first
   b. Load dry waste first. Placing wet waste near the top of the Primary Chamber allows moisture to evaporate early in the cycle.
   c. Place waste on the weigh scale, the operator has to manually record the waste weight being loaded to the CA 100 model incinerator
   d. Then, the operator must take the waste and load it into the Primary Chamber.
   e. The operator returns to the weigh scale with some more waste and repeats Steps c and d. This entire procedure is repeated until the maximum load weight is reached, in this case 182kg per load cycle

NOTE

No more waste should be loaded into the Primary Chamber after the load has reached the maximum weight, or in the case of lower density waste, the chamber is ¾ full (the burner requires open space in front of it to allow for a proper flame)

NOTE

Do not throw the waste towards the sides of the Primary Chamber. Doing so will damage the ceramic fiber refractory.

NOTE

Load only the waste stream that the system has been designed for. DO NOT load a lot of high BTU rated waste for one burn (i.e. do not load three (3) 5 gallon pails of bacon grease or wood only). Doing so will result in excessive temperatures in the system reducing the life of the refractory.

NOTE

Do not load the Primary Chamber above its rated capacity by weight or above the burner opening.

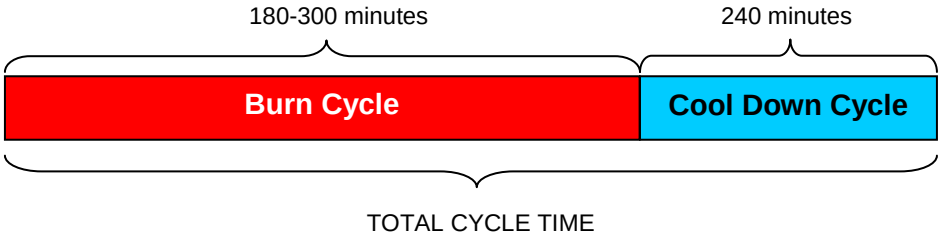
7. Lock the **Primary Chamber** Door and ensure all latches are properly engaged.
8. Proceed to the **Main Control Panel.**

NOTE

The burn time will be set to the previous burn, if you wish to change the set time, proceed to the System Status screen and click on the BURN TIME button. The minimum number of minutes you can enter is 180 (3 hours). When you have finished, the time will be displayed in minutes beside the BURN TIME button

NOTE

The burn time value (in minutes) determines the length of the burn cycle before cool down cycle starts.

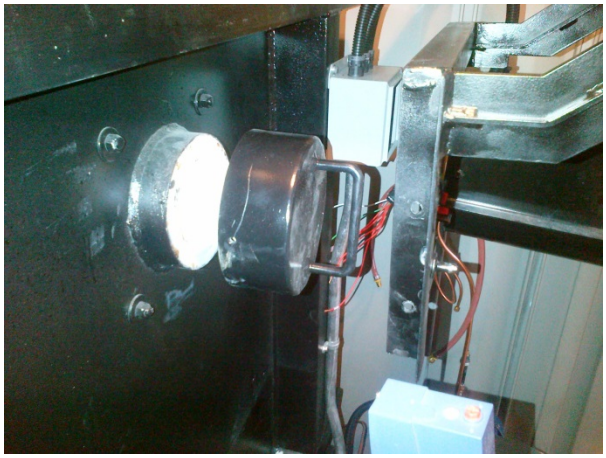


9. Check that the primary door shows closed on the **HMI SYSTEM STATUS** screen or the **HMI FRONT VIEW** screen**.**

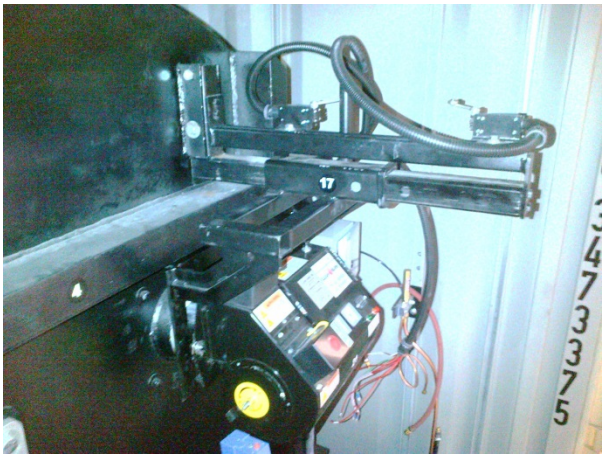
   Check that no alarms are displayed. The **HMI** will display any faults, which need to be cleared before the system can start.
10. Check that the EMERGENCY STOP BUTTON is out.
11. Check that the **green control light is illuminated.**

Do not use this incinerator to burn waste oil only. Always burn a complete load of solid waste when burning waste oil

12. On the **HMI** System Status Screen make sure to select Solid Waste or Solid Waste and Waste oil (System Mode)
    a. SOLID WASTE SELECTED: Ensure the Waste Oil burner is pulled out and the Limit switch is made. ABB HMI Side View will show burner is out. ***Make sure to put the PLUG into the opening of the Secondary Chamber***.
    b. SOLID WASTE AND WASTE OIL SELECTED: Ensure the plug is removed from opening and push the Waste Oil Burner all the way in, making connection with the Limit Switch in, the HMI Side View will show burner is in.



Remove plug



Push all the way in until front limit switch is made

13. On the **HMI** Primary Status Screen press the “START SYSTEM” button. The following steps will automatically take place, controlled by the **Main Control Panel**:
    a. SOLID WASTE SELECTED
        I. The **Primary Blower and Secondary Blower** will purge the system for 2 minutes.
        II. The **Secondary Burner** will purge for safety, and upon completion will ignite.
        III. Once the **Secondary Chamber** temperature reaches 1000°C, the **Primary Burner** will purge for safety and upon completion will ignite.
        IV. The burn time will start counting down when the temperature in the **Primary Chambers** reaches 427°C.
    b. SOLID WASTE AND WASTE OIL SELECTED
        I. The **Primary Blower and Secondary Blower** will purge the system for 2 minutes.

ECO WASTE SOLUTIONS

II. The **Secondary Burner** and **Waste Oil Burner** will purge for safety, and upon completion they will ignite.

III. Once the **Secondary Chamber** temperature reaches 1000°C, the **Primary Burner** on will purge for safety and upon completion will ignite.

IV. The burn time will start counting down when the temperature in the **Primary Chambers** reaches 427°C.

NOTE

The Main Control Panel System will maintain proper operating conditions for the CA100WO.

After the burn cycle is completed the system will enter the cool-down cycle and the following things will occur:

- Primary Chamber & Secondary Chamber burners OFF
- Secondary Chamber Blower OFF
- Primary Modutrol 100% open
- Primary Blower ON

Once fully cooled and the temperature is below 50°C, proceed to the **Primary Chamber Clean Out Procedures**.

Primary Chamber Clean Out Procedures

Operators responsible for loading and cleaning out incinerators should wear appropriate protective equipment, including eye protection, dust masks, heavy gloves and safety shoes with puncture-proof toes and soles to avoid injury.

Although the ash from the system is considered sterile and will not contain microorganisms, it may contain a quantity of sharp objects, such as broken glass and other sharps which may not be fully destroyed in the burning process, and may thus still pose a hazard to persons who clean out the ash and residues. Also removing the ash does create dust particles in the air. Dust should not be inhaled. The operator must wear dust protection safety gear.

Please follow these steps when the cycle is complete:

1. When the internal temperature of the **Primary Chamber** has cooled to less than 50°C, lock out the power to the system on the **Main Control Panel** by moving the main disconnect to the “OFF” position.
2. Unlock all door latches on the access door to the **Primary Chamber.**
3. While standing in front of the **Primary Chamber** door, slowly open the door to allow clear entry. Secure **Primary Chamber** Door in the OPEN position.

4. Clean the **Primary Chamber** by using ash handling tool(s) and proper safety equipment (not provided).
5. Inspect the interior of the **Primary Chamber** for wear and inspect around the door seals to ensure the door will maintain a tight seal upon closure.
6. Check the air inlet holes and remove any obstructions if necessary.
7. Inspect the door seals to ensure there are no gaps between the door gasket and the door jamb.
8. Close the **Primary Chamber** access door by clamping each latch until it is tight.
9. Clean the inspection **View Port** (glass) with a mild soap and water. To clean the view port, unscrew it by hand and re-tighten by hand.

In Case of Emergency

1. Go to manual Slide Gates on the **Primary Chamber**, located just after the blower and close them all the way. This will help to put the fire out in the **Primary Chamber** out.
2. Check alarms to see what the problem is.
3. Do not open the door of the **Primary Chamber** unless the temperature inside the chamber is below 50°C.
4. Call a certified technician to fix the problem and/or consult with **Eco Waste Solutions Customer Service Department at 905.634.7022, toll free 1-866-326-2876.**

Start Up After Power Failure

1. Once the power is restored turn breaker (main disconnect) back on.
2. The Operator Interface and PLC will begin a boot up procedure. Wait until the **HMI** on the **Main Control Panel** has booted up before turning the control power to the panel back on by pressing the Control Power ON button.
3. When the power is restored to the **Main Control Panel**, the button should illuminate.
4. If the system was interrupted during a burn cycle, on the **HMI SYSTEM STATUS** screen press the "**START BURN**" button to restart the system. If the system was interrupted during cool-down cycle, it will resume the cycle where it left off.
5. Ensure the propane vaporizer circuit breaker is "ON" and check if any of the propane pressure switches require reset at the burner valve train and at the top of the vaporizer.

Dealing with Warning and Faults

Troubleshooting

The burn cycle will not start if one of the following conditions exists:

1. The system still is in “cool-down” cycle. Wait until the “cool down” cycle is complete.
2. There is a fault in the system as indicated on the **HMI**.
3. Loss of power due to any one or more of the following:
    - The main disconnect (see image) is off or there is no electrical power. Turn on the disconnect switch or check why there is no power.

Power is OFF in this position

Power is ON in this position

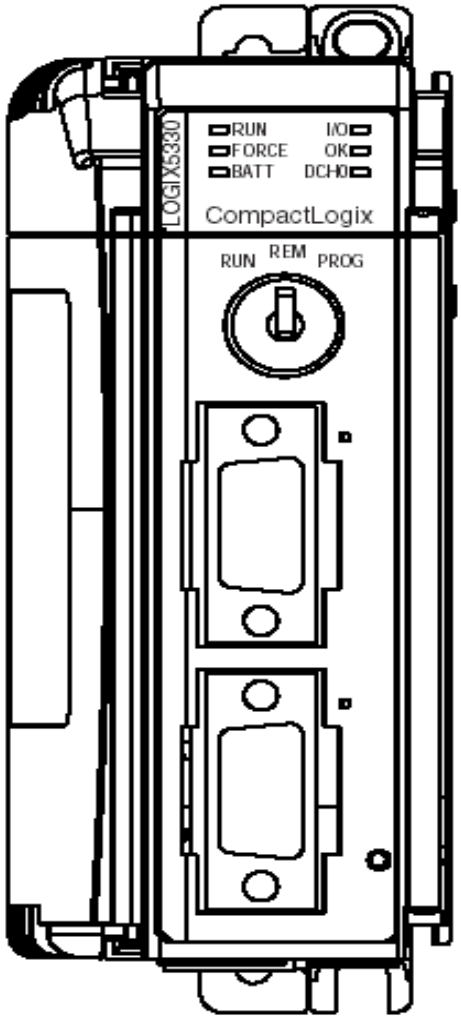
- An open circuit breaker or blown fuse. Check the breakers and fuses, replace any that are defective.
- The EMERGENCY STOP is pushed in. Twist the EMERGENCY STOP button to unlock, and then push the CONTROL POWER ON button. The CONTROL POWER BUTTON should now be illuminated green.

4. If on the Main Control Panel HMI the **Primary Chamber** door is not closed, the door has not been shut properly. Adjust the limit switch lever arm if necessary. Check the limit switch and that the wiring is in working order.

5. If fuel pressure is low, system will not start. This is an indication the vaporizer is not “ON”

6. If fuel pressure is high, the pressure switches will trip. The pressure switched will have to be reset and if they trip again the propane regulators will have to be checked.

PLC Processor Problem



- Check the run light on the PLC processor. If it is on the PLC it is ready.
- “OK LIGHT” is green = Controller is OK.
- “OK LIGHT” is Red Flashing = this is a recoverable fault, check the PLC processor. This fault is very unlikely to occur.
- OK LIGHT is Red = this is a non-recoverable controller fault. Cycle Power. The OK LED should change to flashing red. If LED remains solid red, replace the PLC. This fault is very unlikely to occur.
- DCHO light is green = this indicates the PLC processor has lost the program. The PLC is equipped with a flash card that will automatically load the program back onto the PLC.

ECO WASTE SOLUTIONS

Possible Problems, Causes and Solutions

Problem	Causes	Solutions
Blower Fails to start	Over load tripped, blown fuse	Turn power off. Open Panel and reset overload. Check fuse and replace.
	Motor starters or contactor coil is burnt out	Locate contactor for Blower and visually observe if the contactor is pulled in. Use a volt meter to check for voltage across the coil If there is voltage across the coil and the contactor is not pulled in, replace the contactor.
Secondary Burner won't ignite	Bad Electrodes	Refer to Maintenance Section of this manual.
	Fuel Pressure fault	Ensure there is enough fuel in the tank Reset pressure switches on burner fuel train Reset vaporizer switch (on top of vaporizer) Ensure vaporizer is turned ON
	Fuel Line Leak	If propane odor is noticed, close all valves, tighten any fittings or replace leaking piping.
	Door Switch not making contact	Make sure main door is closed and latched shut. Make sure limit switch is hitting striker plate.
	Burner main switch is turned off	Turn switch on.
	Burner alarm has been tripped	Acknowledge burn alarm and then hit the reset button on control panel.
	Bad Thermocouple	Replace thermocouple.
Primary Burner won't ignite	Bad Electrode	Refer to Maintenance Section of this manual.
	Fuel Pressure Fault	Ensure there is enough fuel in the tank Reset pressure switches on burner fuel train
	Fuel Line Leak	If propane odor is noticed, close all valves, tighten any fittings or replace leaking piping.

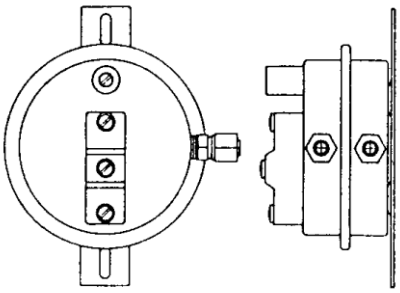
ECO WASTE SOLUTIONS

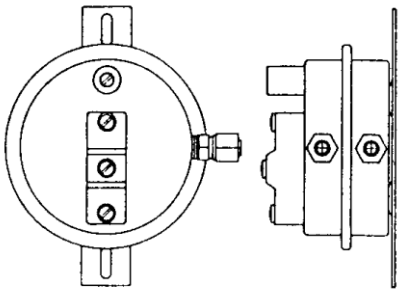
Problem	Causes	Solutions
	Door Switch not making contact or broken	Make sure main door is closed and latched shut. Make sure limit switch is hitting striker plate.
	Secondary temperature not at 1000°C	Wait until Secondary temperature is at 1000°C and try again.
	Burner main switch is turned off	Turn switch on.
	Burner alarm has been tripped	Acknowledge burn alarm and then hit the reset button on control panel.
Persistent Black Smoke	Insufficient air supply to Secondary Chamber to completely consume emissions	Check to ensure combustion air blower/damper assembly is operating properly.
	Secondary Chamber is not hot enough.	Check that the Secondary temperature is operating at required temperature set point.
	Secondary Chamber is not hot enough.	Too much draft, open barometric damper.
	Overloading or loading highly volatile material	Decrease load size on next batch (confirm by weighing), ensure the waste mix is correct.
	Burner failure	Check burner operation – if no flame or a poor flame is visible through the flame view port adjust air/fuel ratio.
	Operation at too high a Primary Chamber temperature	Check/decrease primary chamber combustion air.
Smoke coming out of Primary	Too much air	Check dampers on primary blower.
	Too much volatile material loaded	Decrease load size on next batch to ensure the waste mix is correct.
	Low draft	Close the barometric damper in the t-stack section
	Primary Chamber temperature too high	Waste loaded may not be a good mix of heat value .
Too much fuel usage	Too much secondary combustion air	Check/reduce secondary combustion air.
	Too much air infiltration	Reduce air flow by adjusting the damper.
	Fuel leakage	Check fuel trains and burners for fuel leakage.

Problem	Causes	Solutions
	Wet waste	Spread wet waste with other waste through several loads – do not charge all of the wet waste at one time.
	Excessive draft	Check/reduce draft – check door seals and other seals for leakage adjust damper.
	Burner setting too high	Check air/fuel mix.
Incomplete burnout/poor ash quality	Build-up around air holes – clogged with ash from previous burn	Check around air holes and clean.
	Poor draft	Draft should be -0.25-0.06 KPa (or 1.0-0.25"W.C).
	Too much wet waste – overloading system	Spread wet waste with other waste through several loads – do not charge all of the wet waste at one time.
	Insufficient burn time	Allow longer burn time period.
Waste Oil Burner		
System will not start when Solid is selected	Waste Oil burner is inserted into the Secondary Chamber	Remove Waste Oil burner assembly from the Secondary Chamber. And place the plug into the port
System will not start when Solid and Waste Oil are selected	Waste Oil burner is not inserted into the Secondary Chamber	Remove the plug from the port and insert the Waste Oil burner assembly into the Secondary Chamber.

Possible Alarms (Faults)

#	ALARM (System Fault)	SOLUTION
1	The Primary Chamber Thermocouple is faulted	See corrective maintenance procedures. Section 7 on this manual
2	The Secondary Chamber thermocouple is faulted	See corrective maintenance procedures. Section 7 on this manual
3	The Secondary Stack Thermocouple is faulted	See corrective maintenance procedures. Section 7 on this manual

#	ALARM (System Fault)	SOLUTION
4	The primary burner is faulted	The primary burner has failed to light when it received a signal telling it to start. To reset the burner, press the reset button located on the Burner. Ensure the vaporizer is ON, the pressure switches are not tripped and all valves from tank to burner are open If this does not start the burner, refer to Supplier Catalogue (Riello Burner) Section 8 of this manual.
5	The secondary burner is faulted	The secondary burner has failed to light when it received a signal telling it to start. To reset the burner, press the reset button located on the Burner. Ensure the vaporizer is ON, the pressure switches are not tripped and all valves from tank to burner are open If this does not start the burner refer to Supplier Catalogue (Riello Burner) Section 8 of this manual.
6	The system has shut down due to primary blower low air flow. 	Visually examine the primary blower for any obstructions that may be causing low air flow. Check slide gate located between Primary chamber and blower, ensure it is open. Check damper assembly, ensuring modutrol crank arm is still connected and that butterfly damper is open, allowing air flow. Air proving switch may be defective. Refer to Section 6 of this manual. There are two ports on the air flow switch marked V and P. Ensure the inlet tube is attached to the port marked “P” for pressure. V stands for vacuum. Ensure the “V” port is open to atmosphere and is not blocked. If no air restriction is observed (i.e. blockage in the tube) change the air proving switch. Refer to Section 7 of this manual.

#	ALARM (System Fault)	SOLUTION
7	The primary blower motor overload is tripped.	Turn power off on Control panel by turning the Main Disconnect to the OFF position. Reset overload.
8	The system has shut down due to secondary blower low air flow. 	Visually examine the Secondary Blower for any obstructions that may be causing low air flow. . Check slide gate located between Secondary chamber and blower, ensure it is open. Check damper assembly, ensuring Modutrol crank arm is still connected and that butterfly damper is open, allowing air flow. Air flow switch may be defective. Refer to Section 6 of this manual. There are two ports on the air flow switch marked V and P. Ensure the inlet tube is attached to the port marked “P” for pressure. V stands for vacuum. Ensure the “V” port is open to atmosphere and is not blocked. If no air restriction is observed (i.e. blockage in the tube) change the air proving switch. Refer to Section 7 of this manual.
9	The Secondary blower variable frequency drive is faulted.	Push fault reset button on the HMI If fault persist check the error code on the variable frequency drive and check manual for troubleshooting alarm.
10	The Waste oil tank is low	This is a warning which will appear for 5 seconds if you try and start the system when solid and waste oil is selected, the system will not start. Add waste oil to the tank and the alarm should reset itself.
11	The Waste oil burner is not all the way in.	Check that the burner is all the way in. Check the limit switch arm and wiring.
12	The Waste Oil burner is not all the way out.	Check that the burner is all the way out and connecting with the limit switch. Check the limit switch arm and wiring.

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 7

MAINTENANCE INSTRUCTIONS

CA 100WO

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ECO WASTE SOLUTIONS

MAINTENANCE INSTRUCTIONS

SUMMARY OF PREVENTIVE MAINTENANCE INSTRUCTIONS

IF APPLICABLE: The air compressor pump is shipped with break-in oil which should be changed after the first 8 hours of operation.

Daily Maintenance

Freq.	Routine	Component	Description
Daily	Inspection & Cleaning	Burners	Inspect fuel lines for leaks.
Daily	Inspection & Cleaning	Refractory	Check inside the Chambers for shrinkage or any exposed metal.

Weekly Maintenance

Routine	Component	Description
Inspection & Cleaning	Blowers and Assembly	Modutrol crank arm connected to damper.
Inspection & Cleaning	Blowers and Assembly	Slide gates are open.
Inspection & Cleaning	Burners	Secondary Burner maintenence
Inspection & Cleaning	Waste Oil Burner Filter	Clean the canister filter
Inspection & Cleaning	Air compressor	Check air filter
Inspection & Cleaning	Air compressor	Pull ring on safety valve and allow the ring to snap back to normal position (Check for free operation of the safety valve)
Inspection & Cleaning	Thermocouples	Remove and clean thermocouples as necessary – inspect for damage. Replace if necessary.

ECO WASTE SOLUTIONS

Monthly Maintenance

Routine	Component	Description
Inspection & Cleaning	Blowers and Assembly	Check the fan wheel for any wear or corrosion, as either can cause catastrophic failures
Inspection & Cleaning	Refractory	Check the refractory in the Secondary Chamber for shrinkage, anything greater than 1.2cm should be patched (i.e. gaps between modules exposing metal surface)
Inspection & Cleaning	Waste Oil	Visually check all electrical components
Inspection & Cleaning	Waste Oil	Remove heater element from casing and inspect for build-up. Clean any deposits. When reinstalling the heater element always ensure the bundle will be restarted immersed. **NEVER** use the inline oil heater dry
Inspection & Cleaning	Air compressor	Check all fasteners for proper tightness.

Quarterly Maintenance

Routine	Component	Description
Inspection & Cleaning	Blowers and Assembly	Lubricate all bearings – lubrication intervals depend on operating speed (RPM). Clean cooling fan on motors.
Inspection & Cleaning	Refractory	Inspect door gasket for damage or heat damage. Replace segments, if necessary. Doors must close tightly and securely.
Inspection & Cleaning	Refractory	Check all refractory for damage. Patch or replace as needed. Patch if modules show a little gap and replace modules if the modules have shrunk excessively (greater than 1”)
Inspection & Cleaning	Paint	Maintain paint exterior to protect metal from heat damage

Yearly Maintenance

Routine	Component	Description
Detailed Maintenance	Refractory	Replace door gasket
Inspection & Cleaning	Electrical	Check the limit switch

24 to 60 Months

.

Periodicity	Routine	Component	Description
24 Monthly	Detailed Maintenance	Refractory	Replace the door sills on Primary Chamber
24 Monthly	Detailed Maintenance	Refractory	Replace the door sills on Secondary Chamber
60 monthly	Detailed Maintenance	Refractory	Relining of Secondary Chamber.
60 monthly	Detailed Maintenance	Refractory	First stack section to be relined.
60 monthly	Detailed Maintenance	Fuel Tanks	Inspect Fuel tanks

ECO WASTE SOLUTIONS

PREVENTIVE MAINTENANCE INSTRUCTIONS

Instruction Classification

Each component is associated with an identification number, see table below:

System Component	Identification number
Primary Blower	01-001
Secondary Blower	02-001
Primary Burner	01-002
Secondary Burner	02-002
Refractory	05-001
Waste Oil Burner	02-003
Air Compressor	03-001
Main Control Panel	03-010
Paint	05-003
Electrical	05-004
Limit Switch	05-005

To differentiate if the instruction is weekly, monthly, quarterly or yearly, the above identification number will be followed by a letter:

Daily: D
Weekly: W
Monthly: M
Quarterly: Q
Yearly: Y

For example**, 01-001.Q.01** Primary blower assembly quarterly instruction number 1.

Zero Mechanical State & Lock Out Instructions

Proper maintenance of the equipment is essential to ensure long term, reliable operation of the EWS model Incinerator. The preventive maintenance instructions are outlined in this section of the Facility Manual.

NOTE

The warranty will become void if proper maintenance is not performed as instructed.

Safety

During maintenance of the EWS mobile incinerator, it is very important to be aware of special hazards. Two safety programs are described in the following sections:

1. Zero Mechanical State
2. Power Lock Out Instructions

Failure to comply with these instructions during maintenance could result in injury or death. The responsibility for implementation of a comprehensive safety program rests with the operating staff and supervision. The safety instructions in this Facility Manual should be considered only as a starting point for the safety program at site.

ACCIDENTS CAN BE PREVENTED
A CAREFUL WORKER IS THE BEST SAFETY DEVICE

Zero Mechanical State

Zero Mechanical State (ZMS) exists when the possibility of an unexpected mechanical movement has been eliminated. During maintenance, it is mandatory to totally deactivate the incinerator so that there is no possibility of an unexpected machine movement. Power lock-out, described in the next section, is commonly used for this purpose. Most machines are powered by electrical, hydraulic or pneumatic drives. Energy may be stored in a shutdown machine in various ways: Air pressure in a cylinder, hydraulic fluid stored in pressurized hoses, or machine members whose weight can generate fluid pressure. Therefore, just cutting off the electrical power may not be enough to neutralize all power sources. Certain maintenance instructions at site should require ZMS condition as a matter of course.

Zero Mechanical State (ZMS) Checklist

1. Every electrical power source to the incinerator must be cut off and locked out (to prevent others who may not be aware of maintenance work from turning the power back on inadvertently).
2. Ensure that the mechanical potential energy of the incinerator is at its lowest practical value so that opening of pipe, tubing, hose or actuation of any valve will not produce an unexpected movement that could cause injury.

3. Check that there is no pressurized fluid (air, oil, gas or other) trapped in the incinerator lines, cylinders or other components. This will ensure that there will be no incinerator motion when a valve is actuated.

4. Secure loose or freely moving parts so that there is no possibility of accidental movement.

Power Lock Out Instructions

Unexpected operation of electrical equipment started by automatic or manual remote control may cause injuries to persons who happen to be nearby. For this reason, when repair work is to be done on motors or other electrical equipment the circuit should be opened at the switch box and the switch pad locked in the OFF position. Tag the switch with a lock out tag indicating who must be contacted before the power is turned back on again.

BECAUSE OF THE SEVERE CONSEQUENCES, INCLUDING DEATH, OF NOT PROPERLY LOCKING OUT ELECTRICITY SUPPLIES DURING MAINTENANCE, THE SUPERVISOR SHOULD ENSURE THAT THERE IS ONLY 1 KEY FOR THE LOCK USED TO LOCK OUT THE POWER SUPPLY.

For identification, locks may be color coded to indicate different crews or shifts.

The Supervisor should maintain the master key and list of key numbers, and should keep an extra key to each lock for his department. The master key should not be loaned out under any circumstances.

No matter what method is used to lock out power, strict discipline and constant supervision should be employed during any equipment maintenance work.

Power Lock Out Checklist

1. Alert the operator of the equipment.

2. Before starting the work on an engine, motor, line shaft or other power transmission equipment or power-driven machine, make sure it cannot be set in motion without your knowledge.

3. Place your own padlock on the control switch, lever, or valve, even if someone has locked the control panel before you. You will not be protected unless you put your own padlock on it. (Another maintenance person could remove their lock and then someone else could start the equipment if they were not aware of maintenance work being done.)

When you are finished working, remove your own padlock. Never permit someone else to remove it for you. Be sure you are not exposing someone else to danger by removing your padlock

Daily Instructions

Primary & Secondary Chamber Burners: (01-002.D & 02-002.D)

Do not store flammable or hazardous materials in the vicinity of fuel burning appliances.

Improper installation, adjustment, alteration, service or maintenance can cause property damage, personal injury or death.

Burner shall be installed and maintained in accordance with manufacturer's requirements as outlined in the Burner manual, local codes and authorities having jurisdiction.

INSTRUCTION 01/02-002.D.02: INSPECTING THE FUEL LINES

1. Visually inspect all fuel lines to the Primary and Secondary Burner as well as to the Waste Oil burner for any leaks.

2. If any leaks are observed tighten or replace the piping section where the leak is occurring

Refractory: (05-001.D)

When working with the refractory make sure you use the proper tools; wear goggles, approved dust mask and gloves

INSTRUCTION 05-001.D.01: INSPECTING THE REFRACTORY

Ensure power is locked out.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

1. Open Primary Chamber door by unlatching all clamps.

2. Tie-off door to open position to ensure that it will not close unintentionally.

3. Enter Primary Chamber and check the refractory for shrinkage, any gap between the modules greater than 2.5 cm should be patched with the blanket refractory

4. Check for any exposed metal between the modules, if metal is exposed make sure to patch area with blanket material (PN: 501803) or new module (PN: 433026) (*CMI 4.4.2/05-001A & 4.4.2/05-001B)*Weekly Instructions

Primary & Secondary Chamber Blowers: (01-001.W & 02-001.W)

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

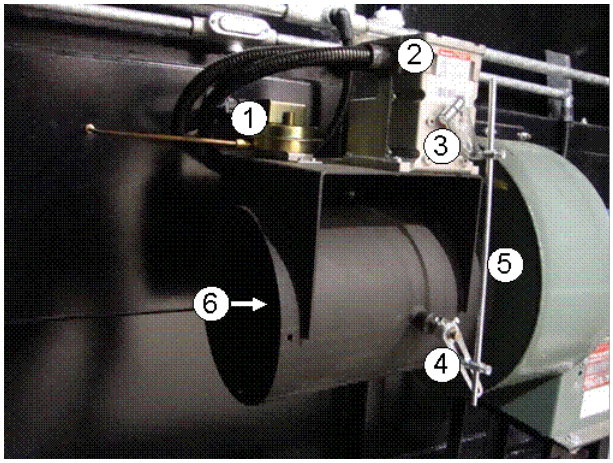
A fan can windmill despite removal of all electrical power therefore, take extra care when working with fans in the system.

The rotating assembly should be blocked securely before attempting maintenance of any kind.

INSTRUCTION 01/02-001.W.01: DAMPER CRANK ARM

Check to see that the damper crank arm is connected to the damper and the rod.

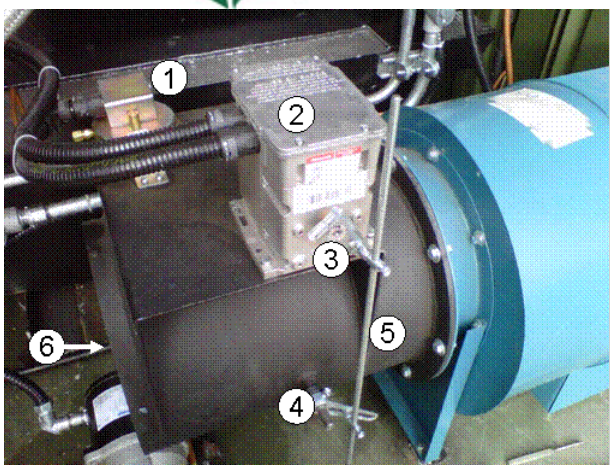
Ensure mechanical linkage on damper is tight, if loose tighten with wrench.



PRIMARY BLOWER

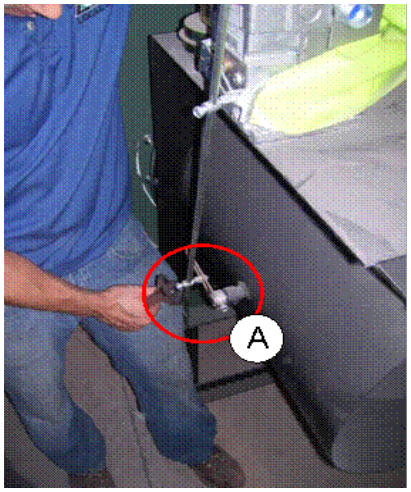
1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper

ECO WASTE SOLUTIONS



SECONDARY BLOWER

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper



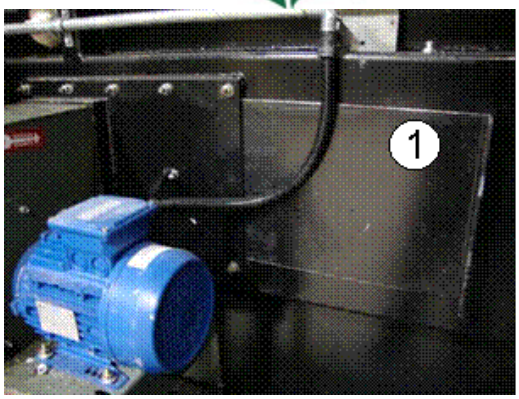
A. Damper Crank arm and connection to Damper and Rod

INSTRUCTION 01/02-001.W.02: SLIDE GATES

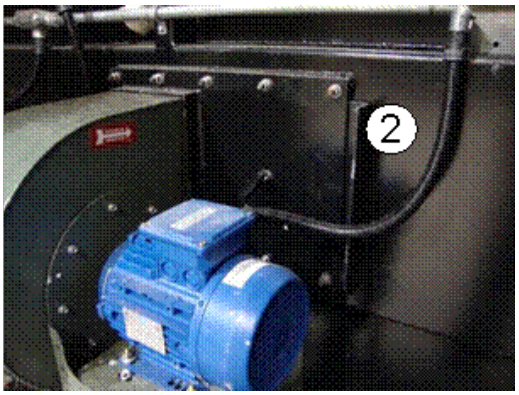
Check to see if slide gates move freely.

1. Move slide gate in and out to ensure free movement. If sticking, use lubricant to loosen. Lubricant should be rated for a high temperature (>150°F) application.

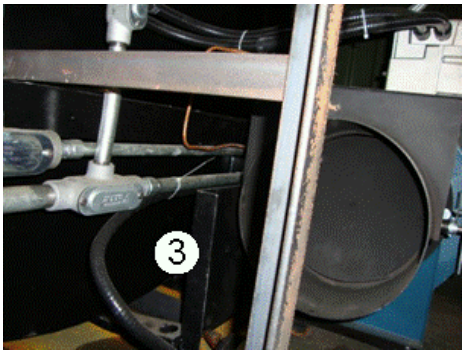
2. Gates must be opened to allow under fire air to enter the chamber. They should only be closed to reduce air in abnormal operating conditions.



1. Sample Primary Chamber Slide Gate Open



2. Sample Primary Chamber Slide Gate Closed



3. Sample Secondary Chamber Slide gate Open

Primary & Secondary Chamber Burners: (01-002.W & 02-002.W)

Do not store flammable or hazardous materials in the vicinity of fuel burning appliances.

Improper installation, adjustment, alteration, service or maintenance can cause property damage, personal injury or death.

Burner shall be installed and maintained in accordance with manufacturer's requirements as outlined in the Burner manual, local codes and authorities having jurisdiction.

Switch off the electrical power. Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.* Cover must be removed to perform maintenance on burners.

ECO WASTE SOLUTIONS

INSTRUCTION 01/02-002.W.02: PRIMARY & SECONDARY BURNER MAINTENENCE

Refer to Burners manuals in section 8 of this manual

Primary Burner: Riello 40 Model G900
Secondary Burner: Riello RS 38/M

Air Compressor: (03-001.W)

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. This air compressor is not designed, intended or approved for breathing air. Compressed air should not be used for breathing air application.

HAZARDOUS VOLTAGE. Can cause serious injury or death. Disconnect power and bleed pressure from the tank before servicing.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing.

HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing. Do not touch hot compressor or tubing.

HIGH PRESSURE AIR. Bypassing, modifying or removing safety/relief valves can cause serious injury or death. Do not bypass, modify or remove safety/relief valves. Do not direct the air stream at body. Rusted tanks can cause explosion and severe injury or death. Drain tank before each use. Drain valve located at bottom of tank.

RISK OF BURSTING. Use only suitable air handling parts acceptable for pressure of not less than the maximum allowable working pressure of the machine.

INSTRUCTION 03-001.W.02: INSPECTING AIR FILTERS IN AIR COMPRESSOR

Refer to Dewalt Compressor manual Model D55168 in section 8 of this manual

INSTRUCTION 03-001.W.03: CLEANING COMPRESSOR & CHECKING SAFETY VALVE

Cleaning

A dirty compressor will cause abnormally high temperature and result in oil carbonization on valve components.

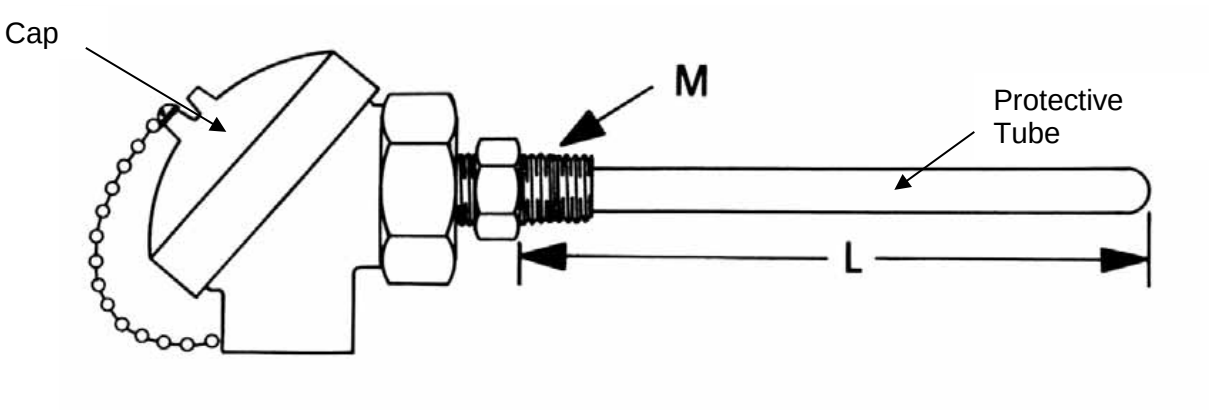
Clean all external parts of the compressor with compressed air. Concentrate the cleaning on the external fins where dirt can accumulate as cooling air is forced across them.

Refer to Dewalt Compressor manual Model D55168 in section 8 of this manual for:

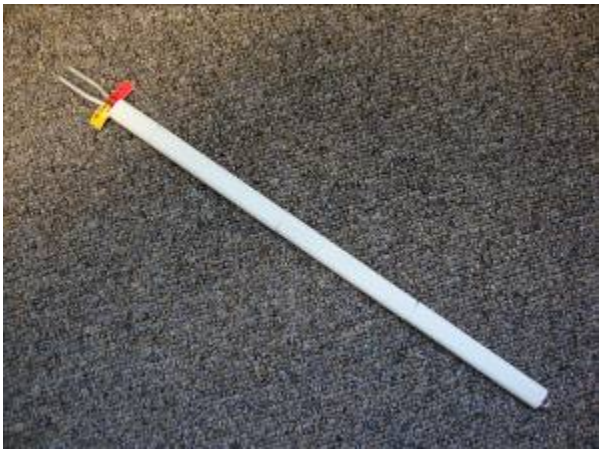
Checking Safety Valve
Draning Air Tank

Thermocouple: (05-002.W)

When working with electrical components, ensure lock out instructions are being followed.



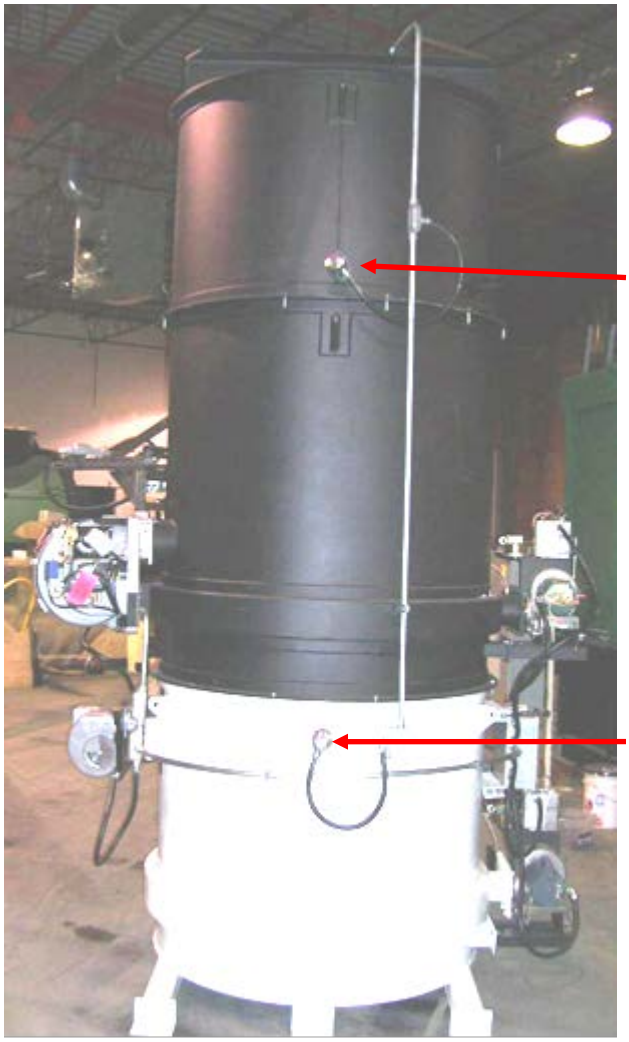
Thermocouple Assembly


Thermocouple Element

ECO WASTE SOLUTIONS

INSTRUCTION 05-002.W.01: INSPECT THERMOCOUPLE FOR DAMAGE

Turn main power to the system off - Remove thermocouple and visually inspect for damage. If damaged, see *CMI 4.4.1/05-002A*



1. Secondary Thermocouple (TC2) on Secondary Chamber Container
2. Primary Thermocouple (TC1)
3. Stack Thermocouple (TC3) not shown

ECO WASTE SOLUTIONS

Monthly Instructions

Primary & Secondary Chamber Blowers: (01-001.M & 02-001.M)

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

INSTRUCTION 01/02-001.M.01: CHECK FAN WHEEL

1. Check the fan wheel for any wear or corrosion, as either can cause catastrophic failures, if left in operation.
2. The wheel can be accessed one of two ways.
   a. Remove the blower assembly from the unit and look down the outlet of the blower.
   b. Remove the damper assembly from the inlet of the blower and inspect by looking through the inlet of the blower.
3. Check also for the build-up of material which can cause unbalance resulting in vibration, bearing wear and serious safety hazards.
4. Clean the wheel as required.
5. If replacement is necessary follow these steps:
   a. Remove damper assembly from the unit
   b. Remove the blower assembly
   c. Remove the blower housing around the wheel
   d. Loosen all set screws that are located on the wheel.
   e. A puller may be required if the wheel hasn't been removed for some time.
   f. Ensure the shaft "key" is installed on the shaft before installing the new wheel.
   g. When installing a new wheel, the wheel should be positioned in the housing with the correct spacing between the edge of the inlet cone and the wheel. The wheel to cone clearance on the Primary Blower is 0.3175 cm.
   h. Ensure that the wheel is installed securely before reassembling the blower assembly.
   i. Install the blower assembly
   j. Install the damper assembly

ECO WASTE SOLUTIONS

INSTRUCTION 05-001.M.01: INSPECT REFRACTORY

1. Ensure power is locked out.
2. Open Primary Chamber door.
3. Fasten door open, ensuring it will not close by its own weight.
4. Enter Primary Chamber and check the refractory for shrinkage, any gaps between the modules greater than 2.5 cm should be patched.
5. Fix gaps with supplied blanket by stuffing material into opening. (See *CMI 4.4.2/05-001A)*
6. Check for any exposed metal, if metal is exposed make sure to patch area with blanket material or new module. (See *CMI 4.4.2/05-001A* & *4.4.2/05-001B)*
7. Pay special attention to areas where the junction boxes are located, as any excessive heat may melt the wires within the box.
8. While inside the Primary Chamber using a flashlight check the status of the Dome and the center piece which consist of 3 holes.

Some cracking is normal, however if pieces are missing or have fallen out, (See *CMI 4.4.2/05-001E)*

Waste Oil Burner: (02-003.M)

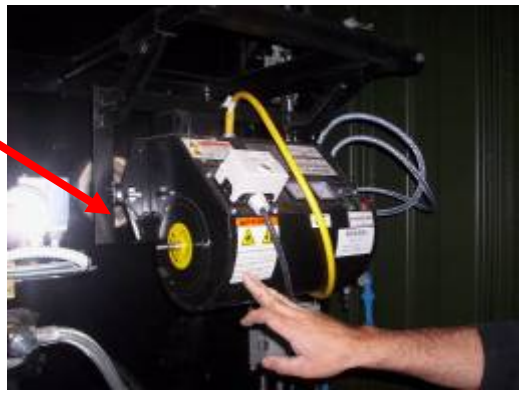
Failure to maintain and / or improper servicing by unqualified personnel will adversely affect the proper, safe operation of your burner, will reduce the service life of your burner and will void your warranty

INSTRUCTION 02-003.M.01: INSPECT ELECTRICAL COMPONENTS

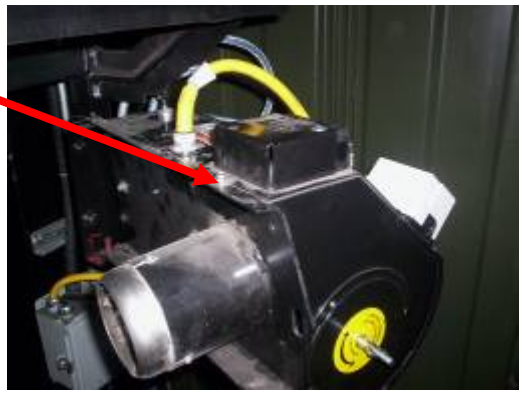
1. Check all electrical components for any heat damage.
2. If heat damage is observed remove and replace.

ECO WASTE SOLUTIONS

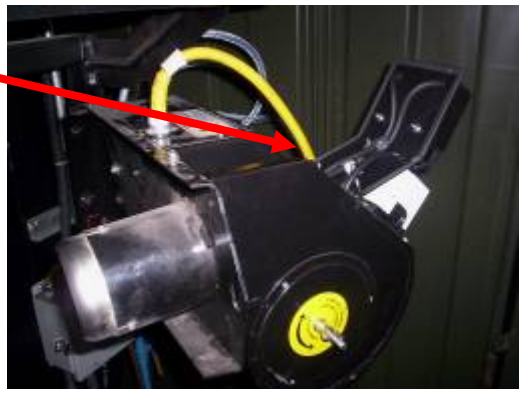
1. Slide out burner
2. Undo Bolt



3. Loosen Bolt



4. Open hinged hatch to access front components



INSTRUCTION 02-003.M.02: INSPECT HEATER ELEMENT

1. Remove heater element from casing and inspect for build-up

2. Clean any deposits.

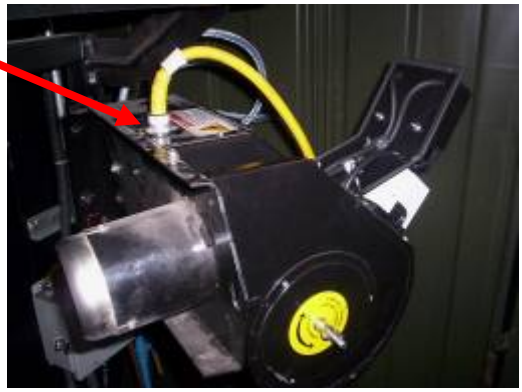
3. If damaged, heater element needs to be replaced. Removal involves the following steps:
    a. Remove all electrical connections attached to the heater block identified in Picture #3 below.
    b. Remove all the bolts attaching the heater to the burner housing.
    c. Remove all fuel line connections.

d. Remove the heater element and install the new one. (PN: 33173)
e. Reinstall the heater block.

4. When reinstalling the heater element always ensure the element will be restarted immersed.

NEVER use the inline heater dry

1. Unscrew (yellow) electrical connection



2. Remove cover screw

3. Open hatch cover to expose heater element

Air Compressor: (03-001.M)

INTAKE AIR. Can contain carbon monoxide or other contaminants. Will cause serious injury or death. This air compressor is not designed, intended or approved for

breathing air. Compressed air should not be used for breathing air application unless treated in accordance with all applicable codes and regulations.

HAZARDOUS VOLTAGE. Can cause serious injury or death. Disconnect power and bleed pressure from the tank before servicing. Compressor must be connected to properly grounded circuit. Do not operate compressor in wet conditions. Store indoors.

MOVING PARTS. Can cause serious injury. Do not operate with guards removed. Machine may start automatically. Disconnect power before servicing. Lockout/Tagout machine.

HOT SURFACES. Can cause serious injury. Do not touch. Allow to cool before servicing.

HIGH PRESSURE AIR. Bypassing, modifying or removing safety/relief valves can cause serious injury or death. Do not bypass, modify or remove safety/relief valves. Do not direct air-stream at body. Rusted tanks can cause explosion and severe injury or death. Drain tank before each use. Drain valve located at bottom of tank.

RISK OF BURSTING. Use only suitable air handling parts acceptable for pressure of not less than the maximum allowable working pressure of the machine.

INSTRUCTION 03-001.M.01: CHECK FASTENERS FOR TIGHTNESS

1. Check all fasteners for tightness (tighten as required).

2. Check the safety valve manually, by pulling ring or lever, to make sure that it is not stuck. Allow the ring to snap back to normal position

Quarterly Instructions

Primary & Secondary Chamber Blowers: (01-001.Q & 02-001.Q)

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

INSTRUCTION 01/02-001.Q.01: LUBRICATE BEARINGS

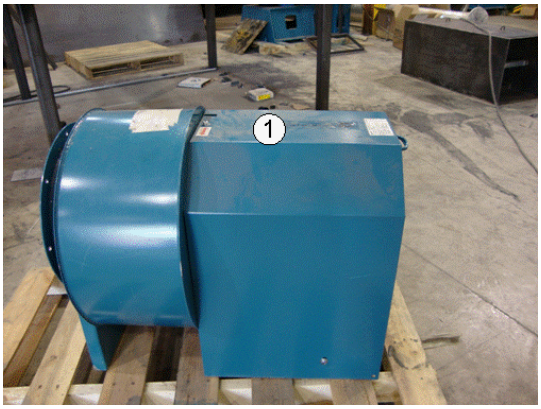
1. Lubricate the bearings, but do not over lubricate.

2. Bearings are completely filled with grease at the factory; they may run at an elevated temperature during initial operation. Surface temperatures may reach 180°F and grease may bleed from the bearing seals. This is normal and no attempt should be made to replace lost grease. Bearing surface temperatures will decrease when the internal grease quantity reaches a normal operating level.

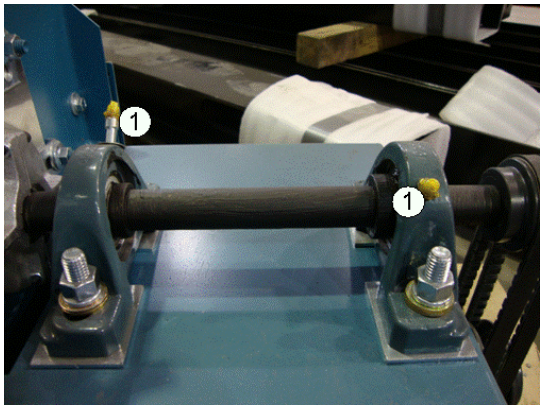
3. Bearings should be lubricated with premium quality lithium-based grease conforming to NLGI Grade 2. Examples are:

   Mobil - Mobilgrease XHP
   Texaco - Premium RB
   Chevron - Amolith #2
   Shell - Alvania #2

4. Add grease to the bearing via the grease nipple while running the fan or rotating the shaft by hand. Be sure all guards are in place if lubrication is performed while the fan is operating. Add just enough grease to cause a slight purging at the seals. Do not over lubricate.



1. Sample Secondary Blower Cover



1. Sample Grease Nipples

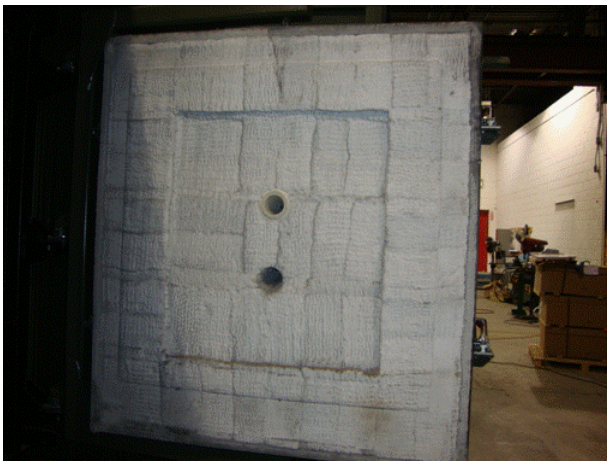
Refractory: (05-001.Q)

When working with the refractory make sure you use the proper tools; wear goggles, dust mask and gloves

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

INSTRUCTION 05-001.Q.01: INSPECT DOOR GASKETS

1. Open Primary Chamber door.
2. Fasten door open, ensuring the door will not close on its own.
3. Inspect door gasket for damage.
4. Replace any damaged segments of door gasket (PN: 462007) if necessary. Cut out the damaged section and replace with new door gasket. See *CMI 4.4.2/05-001C*.
5. Doors must close tightly and securely, ensuring a good seal.



Sample Primary Door (refractory lined)

1. Primary Door Gasket

ECO WASTE SOLUTIONS

INSTRUCTION 05-001.Q.02: INSPECT REFRACTORY FOR SHRINKAGE

1. Ensure power is locked out.
2. Open Primary Chamber door.
3. Fasten door open, ensuring they will not close on their own.
4. Enter Primary Chamber and check the refractory for shrinkage, anything greater than 2.54 cm should be patched.
5. Check to make sure the anchoring of the modules is still strong and intact, if any modules seem loose replace complete module with new module.

A. REMOVAL: Remove existing Module (physically pull away existing refractory from underlying Module Anchor).

B. Remove welded stud from steel casing (cut with hack saw or other device between Module Anchor and Furnace Casing/Shell).

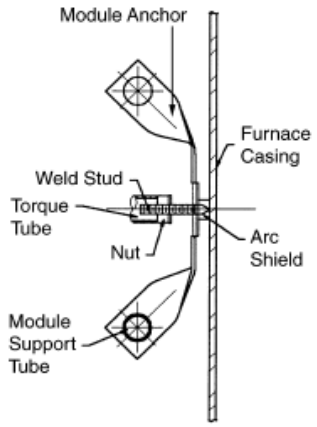


Figure 1: Side view of the Weld Loc Module

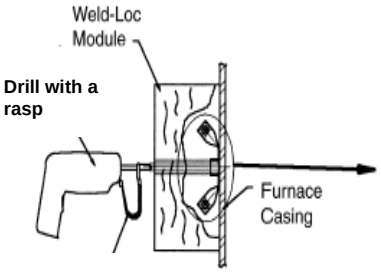


Figure 2: Stud Gun with rasp and Torque Tube.

A. INSTALLATION: Once the new module (PN: 433026) is in place take the stud gun (PN: ECO-STUD) with rasp to the Torque Tube and drill into place.

B. Once it has tightened the Torque Tube should come off with the drill.

ECO WASTE SOLUTIONS

Paint: (05-003.Q)

Ensure proper ventilation and proper equipment is being used when using any paint product.

INSTRUCTION 05-003.Q.01: INSPECT AND MAINTAIN EXTERIOR PAINT

1. Maintain paint exterior to protect metal from heat and corrosion damage. This includes all components in the system including containers and incinerator components.

2. If discoloration is noted and painting needs to be performed, on areas where paint will be applied, you must do a light sanding before application.

3. Follow paint manufacturer's application instructions which will include surface preparation, priming and painting.

Paint Specifications:

Incinerator Paint: This is the paint coated directly on the incinerator shell. This includes the following components:

1. Primary Chamber
2. Secondary Chamber
3. Hot Stack Section (Black)

Finish needs to be able to withstand temperatures in the 650-750°F (340-400°C) range.

Parts: There are no paint specifications for each individual component. This is left up to the discretion of the customer.

Yearly Instructions

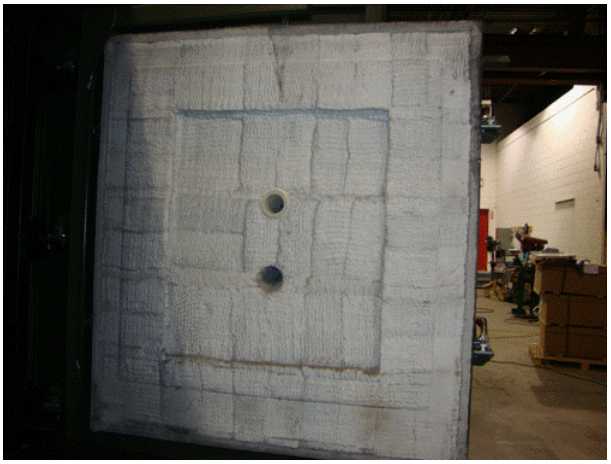
Refractory: (05-001.Y)

When working with the refractory make sure you use the proper tools; wear goggles, dust mask and gloves

INSTRUCTION 05-001.Y.01:
CHECK DOOR GASKET ALONG PRIMARY CHAMBER DOOR

1. If required replace the door gasket. The gasket can last over 2 years but will depend on the careful use by the operator when loading and unloading.

2. Remove the damaged section of door gasket from door and reinstall new gasket (PN: 462007)



Sample Primary Door (refractory lined)

Primary Door Gasket

Electrical: (05-004.Y)

When working with electrical components ensure lock out instructions are being followed

Please follow all instructions outlined in *Zero Mechanical State & Lock Out Instructions.*

ECO WASTE SOLUTIONS

INSTRUCTION 05-004.Y.01: CHECK LIMIT SWITCHES

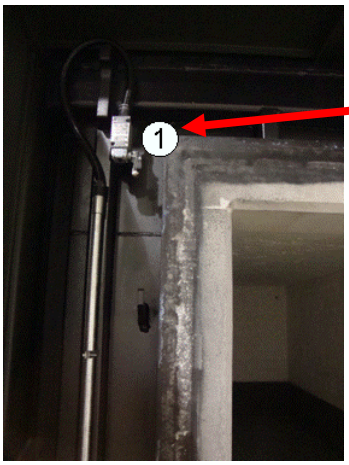
NOTA System must not be running or in cool down to perform this inspection.

1. Open Primary Chamber door and check top view screen on the HMI Panel view to ensure that it indicates door is open.

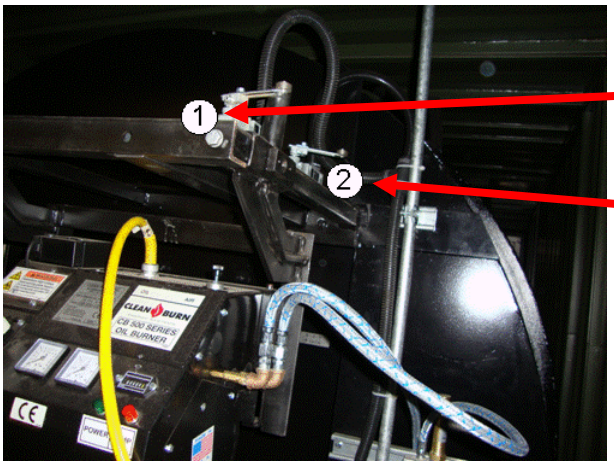
2. Close Primary Chamber door and check top view screen on the HMI Panel View to ensure that it indicates door is closed.

3. All limit switches located on the unit are checked this way.

4. Replace limit switches (PN: 802T-APE) if necessary.

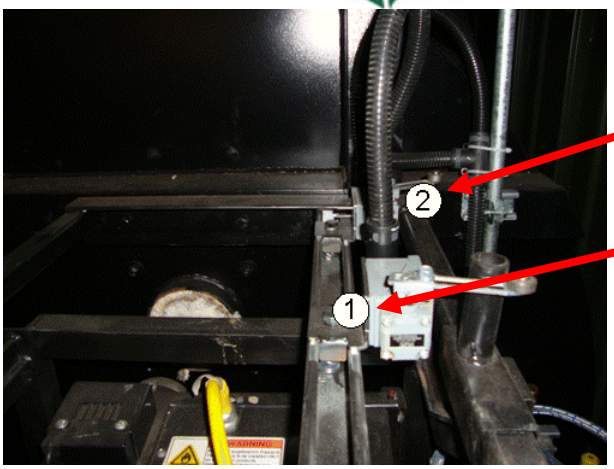


Primary Chamber Limit Switch



Waste Oil Burner Out Limit Switch

Waste Oil Burner In Limit Switch



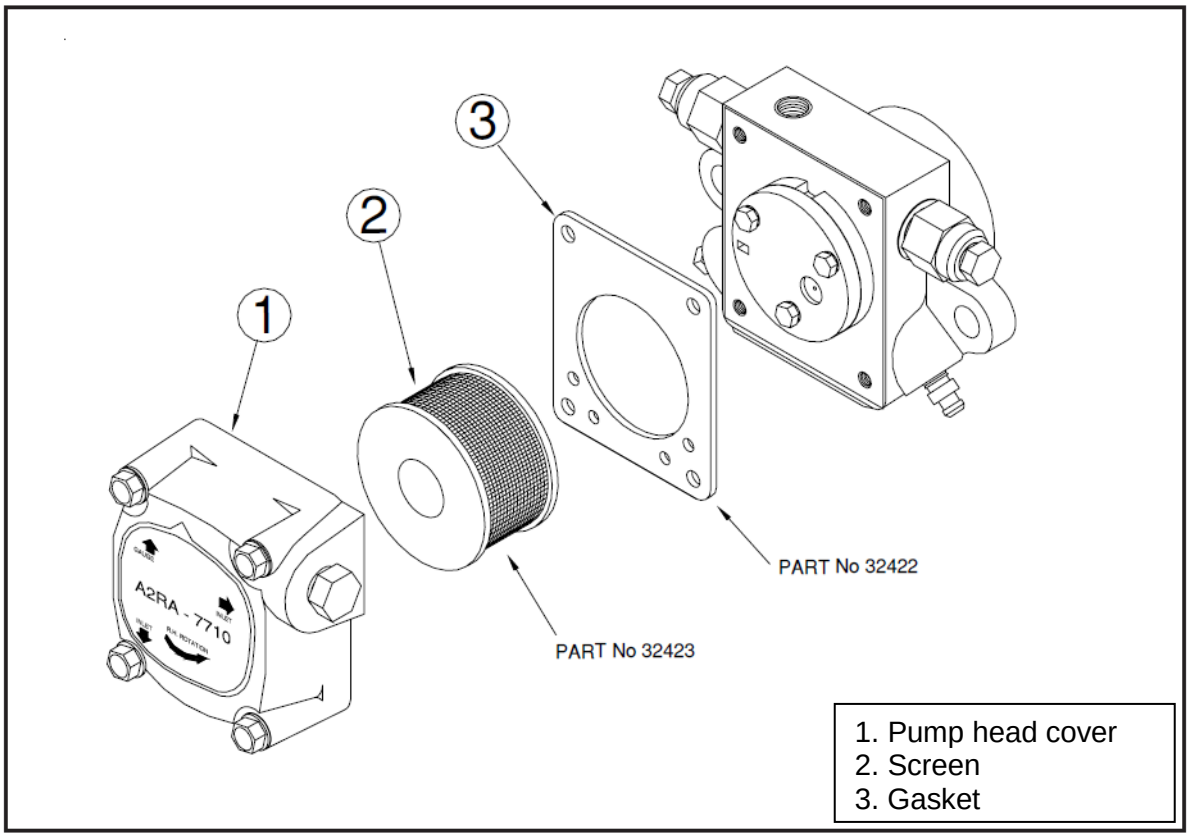
Waste Oil Burner In Limit Switch

Waste Oil Burner Out Limit Switch

Waste Oil Burner: (02-003.Y)

Failure to maintain and / or improper servicing by unqualified personnel will adversely affect the proper, safe operation of your burner, will reduce the service life of your burner and will void your warranty

INSTRUCTION 02-003.Y.01: SERVICING THE METERING PUMP



1. Remove the pump head cover.
2. Remove the screen and wash it.
3. Remove and discard the used gasket.
4. Install a new gasket.
5. Replace the screen and pump head cover.

For more detail, refer to OEM Waste Oil Burner Manual

Corrective Maintenance Instructions (CMI)

The following instructions relate to the replacement or correction (fixing) of components of the EWS Mobile Incinerator Package.

These Corrective Instructions are grouped in this section by the following:

4.4.1 General Corrective Maintenance Instructions
4.4.2 Refractory Corrective Maintenance Instructions
4.4.3 Primary & Secondary Burner Corrective Maintenance Instructions
4.4.4 Primary & Secondary Blower Corrective Maintenance Instructions
4.4.5 Waste Oil Burner Corrective Maintenance Instructions
4.4.6 Main Control Panel Corrective Maintenance Instructions

As per the *Preventive Maintenance Instructions Manual*, the following table is utilized to identify the components of the system that require corrective maintenance.

System Component		**Identification number**	
Primary Burner		**01-002**	
	Replacing Fuel Filter		4.4.1/01-002A
Secondary Burner		**02-002**	
	Replacing Fuel Filter		4.4.1/02-002A
Thermocouple		**05-002**	
	Replacing Thermocouple		4.4.1/05-002A
Limit Switch		**05-005**	
	Limit Switch Replacement		4.4.1/05-005A
Refractory		**05-001**	
	Wall Refractory: Gaps between the Modules		4.4.2/05-001A
	Wall Refractory: Replacement of the Modules		4.4.2/05-001B
	Door Gasket		4.4.2/05-001C
	Castable Refractory		4.4.2/05-001D
	Temporary Repair of Castable		4.4.2/05-001E
Primary Blower		**01-001**	
	Air Proving Switch Replacement		4.4.4/01-001A
	Damper Calibration		4.4.4/01-001B
	Modutrol Resistor Replacement		4.4.4/01-001C
	Damper Crank Arm Replacement		4.4.4/01-001D
	Motor Replacement		4.4.4/01-001E
	Modutrol Motor & Transformer Replacement		4.4.4/01-001F
Secondary Blower		**02-001**	
	Air Proving Switch Replacement		4.4.4/02-001A
	Damper Calibration		4.4.4/02-001B
	Modutrol Resistor Replacement		4.4.4/02-001C
	Damper Crank Arm Replacement		4.4.4/02-001D
	Motor Replacement		4.4.4/02-001E
	Modutrol Motor & Transformer Replacement		4.4.4/02-001F
Waste Oil Burner		**02-003**	
	Waste Oil Burner		4.4.5/02-003A
	Waste Oil Burner Parts Replacement		4.4.5/02-003B

	Waste Oil Burner J-Pump Replacement		4.4.5/02-003C
Main Control Panel		**03-010**	
	Main Control Panel		4.4.6/03-010A
	Reboot PLC		4.4.6/03-010B

General Corrective Maintenance Instructions

LIMIT SWITCH REPLACEMENT (4.4.1/05-005A)

1. Loosen the 2 screws holding the limit switch in place.
2. Remove limit switch, replace with a new one (PN: 802T-APE).
3. Take arm off of old body and mount to new.
4. Tighten the 2 screws holding the limit switch body.

REPLACING THERMOCOUPLE (4.4.1/05-002A)

The thermocouple will require routine replacement. The environment inside the incinerator will erode the protection tube to the point of failure. If the element is exposed to this environment it will be destroyed and will need to be replaced.

1. Unscrew thermocouple lid and remove wires.
2. Remove protection tube. To aid with this a vise and a pipe wrench will be needed.
3. Remove element and replace with new element (PN: TK-K08B-0100-S) and protection tube (PN: TA-A427A-K08B-010).

4. Reinstall on incinerator.

5. After installation turn power back on. Observe the temperature reading of the thermocouple you were just working on. If the wires were installed incorrectly the temperature will read the opposite temperature. (I.e. 20°C would read as -20°C). If this is the case open the thermocouple housing and switch the wires.

Refractory Corrective Maintenance Instructions

When working with the refractory make sure you use the proper tools; wear goggles, dust mask and gloves

WALL REFRACTORY: GAPS BETWEEN THE MODULES (4.4.2/05-001A)

The ceramic block refractory will shrink over time exposing the exterior metal shell. These gaps need to be filled in with ceramic refractory blanket.

1. Identify gaps in the chamber that are larger than 1” in width between the modules or if you can see exterior shell.

2. With a Utility knife cut a length of ceramic blanket (PN: 501803) that will fit in the gap between the modules.

3. Stuff the blanket into the space with a straight edge or ruler.

WALL REFRACTORY: REPLACEMENT OF MODULES (4.4.2/05-001B)

Excessive damage to a section of refractory may necessitate the replacement of modules in the incinerator. Such damage is largely due to mechanical wear. The following diagram walks through the removal and installation of new modules.

A. REMOVAL: Remove existing Module (physically pull away existing refractory from underlying Module Anchor)

B. Remove welded stud from steel casing (cut with hack saw or other device between Module Anchor and Furnace Casing/Shell)

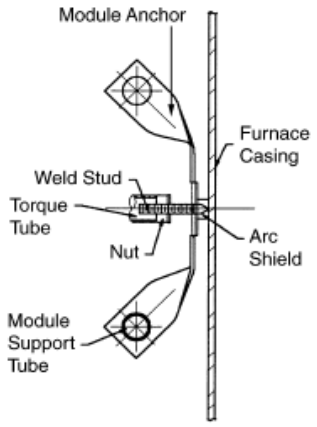


Figure 1: Side view of the Weld Loc Module

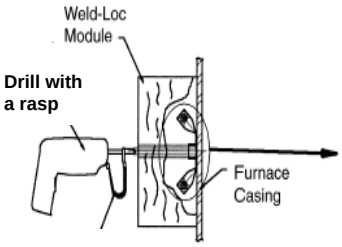


Figure 2: Stud Gun with rasp and Torque Tube (part of module assembly).

C. INSTALLATION: Once the new module is in place take the stud gun with rasp to the Torque Tube and drill into place.

D. Once it has tightened the Torque Tube should come off with the drill.

DOOR GASKET REFRACTORY (4.4.2/05-001C)

The door gasket will degrade over time and will need to be replaced. The bottom of the door will see more degradation due to the waste burning in that vicinity.

1. Identify the damaged section of gasket that will need to be removed
2. With a utility knife cut out the section that needs to be replaced.
3. A new piece of gasket (PN: 462007) will need to be cut the same length as the removed piece.
4. With contact cement coat the gasket on one side and the door section and install.

CASTABLE REFRACTORY (4.4.2/05-001D)

Operators will notice that the castable refractory will show signs of minor cracking. The minor cracking is normal. Large sections of castable should not separate from the rest of the monolithic cast. Such occurrences are largely due to a sudden impact from machinery or dropping of the units themselves. Mortar is supplied to help with a temporary repair while a permanent repair is resolved.

TEMPORARY REPAIR OF CASTABLE (4.4.2/05-001E)

1. Find the pieces of castable refractory that have separated.
2. Clean both the pieces of refractory and the area where the separation occurred.
3. Spread an even amount of high temperature mortar (PN: 452036) on the pieces and the area of separation.
4. Put the pieces back where they originated and support as necessary for a minimum of an hour while the mortar cures.

LEVEL SWITCH REPLACEMENT (4.4.3/01-002G & 02-002G)

The level switch is located in the Waste Oil Tanks.

NOTE

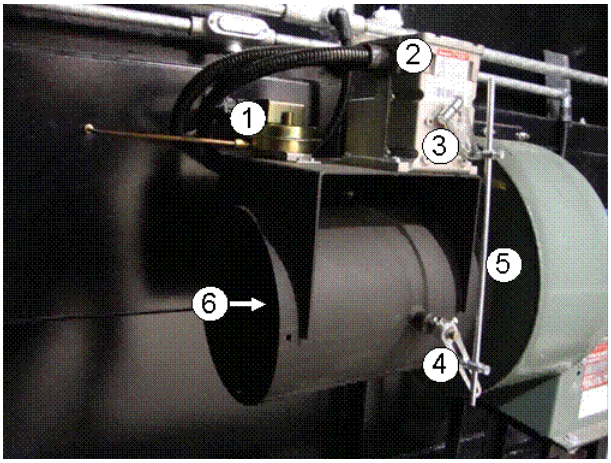
Tank does not have to be emptied to replace.

1. Unplug the level switch.
2. Disconnect the cord and remove the level switch.
3. Replace level switch (PN: FS301-01) and reconnect the cord.
4. Plug in the level switch.

Primary & Secondary Blower Corrective Maintenance Instructions

Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked. In many cases, a fan can windmill despite removal of all electrical power. The rotating assembly should be blocked securely before attempting maintenance of any kind.

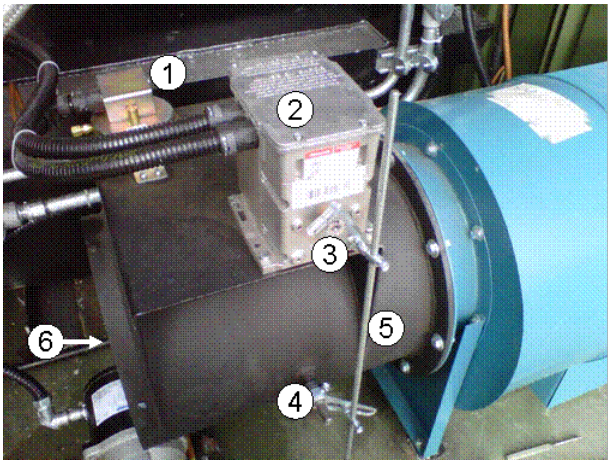
Primary Blower Assemblies are not a commonly repaired part on the incinerator. Parts within this assembly will need to be repaired or replaced. They are outlined below.



Primary Blower

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper

Secondary Blower Assemblies are not a commonly repaired part on the incinerator. Parts within this assembly will need to be repaired or replaced. They are outlined below.



Secondary Blower

1. Air Proving Switch
2. Modutrol Motor
3. Motor Crank Arm
4. Damper Crank Arm
5. Rod
6. Damper

AIR PROVING SWITCH REPLACEMENT (4.4.4/01-001A & 02-001A)

1. Ensure all power is locked out.
2. Remove wiring from switch.
3. Remove tubing from switch.
4. Unscrew screws at the two locations and remove switch.
5. Reinstall new switch (PN: SML8221210034) complete with tubing and wiring and then retighten.
6. Turn power back on.

DAMPER CALIBRATION (4.4.4/01-001B & 02-001B)

Sometimes the damper linkage will slip when the connections become loose (Items 3,4,5 in the Secondary Blower photo) In order to ensure that the linkage is correctly calibrated the operator will need to look at the display screen on the control panel while the unit is in operation

1. Read the %Open value on the control panel operator interface for the Primary Blower.
2. During operation the damper is factory preset to be 0% open, or fully closed.
3. Look inside the damper (Item 6) and ensure that the linkage is completely closed.
4. If it is, then this maintenance is complete.
5. Should the damper be open even a small percentage the linkages are to be loosened and the damper adjusted to be completely closed, and then retighten.

MODUTROL RESISTOR REPLACEMENT (4.4.4/01-001C & 02-001C)

The Modutrol resistors are located inside the top lid of the Modutrol motor. Remove the lid to the Modutrol motor by unscrewing the top four (4) screws. The connection between the control panel and the Modutrol is made with a small white connector with 3 terminals. Jumpered between these terminals is the resistors.

Remove and replace the resistors one at a time to ensure the correct resistors are replaced. You identify the correct resistor by examining the color band on the center node of the resistor. Replace like resistors.

DAMPER CRANK ARM REPLACEMENT (4.4.4/01-001D & 02-001D)

The crank arm will only need to be replaced if the arm is damaged due to misuse. Identify the damper crank arm (Item #4 in the picture on the previous page).

Identify the location of the linkage on the rod and the damper arm with a marker, so the new crank arm will be in the same spot when reinstalled. Remove the connections to the crank arm and replace with the new one (PN: 26026G) and ensure it is in the same spot as the old one.

MOTOR REPLACEMENT (4.4.4/01-001E & 02-001E)

Information on replacing the motor can be found in the OEM manual New York Blower, Installation, Maintenance and Operating, IM-160 Junior Fans.

MODUTROL MOTOR & TRANSFORMER REPLACEMENT (4.4.4/01-001F & 02-001F)

To replace the Modutrol motor all power to the system need to be off as you will need to expose electrical connections. First get the new motor and orientate the motor in the same direction as the old motor. Identify where the conduit is connected on the old motor and punch the connector holes for the new motor.

Removal

1. Remove all electrical terminations and remove the transformer.
2. Install the transformer in the new Modutrol motor.
3. Remove all conduit connections on the motor.
4. Remove the damper arm and linkage from the motor.
5. Unbolt the motor from the damper, and ensure all nuts and bolts are kept for the new motor install

Install

1. Bolt the new motor in the same orientation as the old motor.
2. Install the damper arm and linkage to the motor
3. Install all conduit connections

Terminate all electrical connections the same as the old motor.

REPLACE THE BLOWER CONTACTOR 4.4.4/01-001G

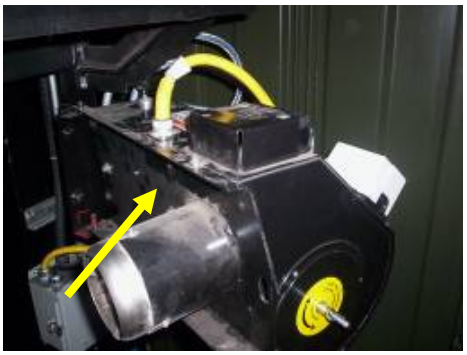
1. Turn Main Disconnect Switch into the OFF position.
2. Open Panel.
3. Remove the wires.
4. Pull the retaining clip up.
5. Tilt contactor forward and remove.
6. To reinstall tilt new contactor until it clicks back in.
7. Pull the retaining clip back down to lock.
8. Reinstall wires.
9. Close panel.
10. Turn power back on.

Waste Oil Burner Corrective Maintenance Instructions

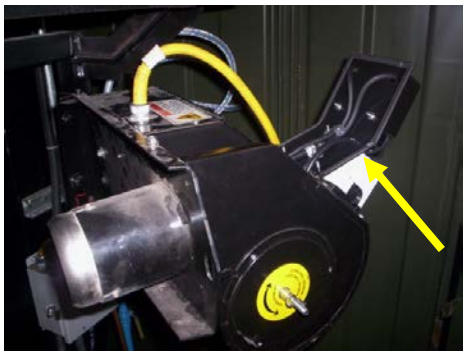
Failure to maintain and/or improper servicing by unqualified personnel will adversely affect the efficient and safe operation of your burner, will reduce the service life and will void your warranty.

WASTE OIL BURNER HEATER ELEMENT CLEANING / REPLACEMENT (4.4.5/02-003A)

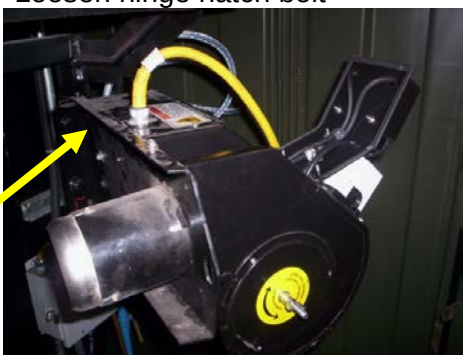
Slide out burner undo bolt



Loosen hinge hatch bolt



Open hinged hatch to access front components



Unscrew (yellow) electrical connection

Remove Cover Screw

Open hatch cover to expose heater element

Remove heater element from casing and inspect for build-up.

Clean any deposits.

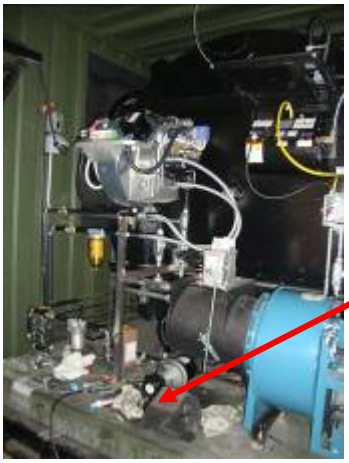
When reinstalling the heater element (PN: 33173) always ensure the element will be restarted immersed in waste oil. A dry element while in operation will reduce the life of the element.

WASTE OIL BURNER PARTS REPLACEMENT (4.4.5/02-003B)

The waste oil burner has the following parts that may need replacing:

Part Description	Part #	Description of replacement
Primary Control	33391	Locate remove and reinstall new one
Igniters Transformer	33189	Locate remove and reinstall new one
CAD Cell	33116	Locate remove and reinstall new one
Fan Squirrel Cage	31113	Locate remove and reinstall new one
Blower Motor	33337	Locate remove and reinstall new one
Retention Head	11427	Locate remove and reinstall new one
Air Pressure switch	33057	Locate remove and reinstall new one
Heater Block	26090	Locate remove and reinstall new one
Air / Oil Solenoid	32322	Locate remove and reinstall new one

WASTE OIL BURNER J-PUMP REPLACEMENT (4.4.5/02-003C)



Waste Oil Burner Pump (J-Pump) Sample location

Removing the pump requires the power to be off to the system. When this is done complete the following step:

1. Open the junction box on the side of the motor of the pump. Disconnect the electrical connections and remove the conduit connection
2. With fuel containment cloth remove the waste oil connection from the pump inlet and outlet.
3. Unbolt the pump. Remove from the chamber

Install the new pump by reversing the above steps.

MAIN CONTROL PANEL (4.4.6/03-010A)

All control panel diagnostics are to be completed by certified or trained technicians. Electrical drawings / diagrams are provided to aid electricians with any diagnostics.

REBOOT PLC (4.4.6/03-010B)

Turn Main Disconnect to the off position on the front of the Control Panel. Turn the main disconnect back on.

Project Name: Brucejack
PO: 177421-PG040 Incinerat
Tag No.6128-IN-001

ECO WASTE SOLUTIONS

Spare Part Packages

Commissioning	Quantity	Part #
Insulation		
Module Refractory (6 per box)	12	433026
Blanket Refractory (50 sq ft per box)	50	502614
Super 3000 Mortar	1	452036
Primary Burner - G900		
Electrode Assembly	2	3006706
Ionization Assembly	2	3020209
High Voltage Leads	9	3002461
Ionization Leads	2	3007310
Secondary Burner - RS 38/M		
Electrode	2	3013136
High Temperature Leads (pkg of 10)	1	3012995
Fuses		
Fuses	1	LPJ-30SP
Fuses	2	LPJ-6SP
Fuses	2	LPJ-5SP
Fuses	1	LPNRK-25SP
Fuses	1	LPNRK-15SP
Fuses	1	LPNRK-6SP
Fuses	1	LPNRK-5SP
Fuses	1	LPNRK-2SP
Fuses	1	LPNRK-1SP
Fuses	1	LPJ-4SP
Fuses	1	LPNRK-10SP
Fuses	1	LPJ-7SP
Miscellaneous		
Type K Thermocouple element	2	TK-K08B-010.0-000
Inconel Protection Tube 10"	2	MP-60140-08-10.0
Air Proving Switch	1	SML8221210034

Special Tools	Quantity	Part #
Stud Gun	1	STMOD
Incinerator Clean Out Kit	1	ECSS2344

Project Name: Brucejack
PO: 177421-PG040 Incinerat
Tag No.6128-IN-001

ECO WASTE SOLUTIONS

Spare Part Packages

Operating Spares	Quantity	Part #
Insulation		
Module Refractory (6 per box)	48	433026
Door Gasket	50	462007
Primary Burner - G900 Propane		
Control Box	2	3013072
High Voltage Leads	10	3002461
Ionization Leads (pkg of 10)	1	3007310
Mounting Gasket	2	3005852
Transformer - Ignition	2	3002462
Electrode Assembly	2	3006706
Ionization Assembly	2	3020209
Secondary Burner - RS38/M Propane		
Electrode	2	3013136
HT Leads (pkg of 10)	1	3012995
Disc	2	3012998
Probe	2	3012174
Probe Lead (pkg of 10)	1	3003848
Spring	8	3003879
Spring Lever	2	3012064
Control Box	1	3012955(C5830008)
Transformer	1	3012956
Servomotor	1	3013008
Air Pressure Switch	1	3012948
Fuses		
Fuses	3	LPJ-30SP
Fuses	9	LPJ-6SP
Fuses	6	LPJ-5SP
Fuses	1	LPNRK-25SP
Fuses	1	LPNRK-15SP
Fuses	2	LPNRK-6SP
Fuses	2	LPNRK-5SP
Fuses	1	LPNRK-2SP
Fuses	2	LPNRK-1SP
Fuses	3	LPJ-4SP
Fuses	1	LPNRK-10SP
Fuses	2	LPJ-7SP
Starters		
9 Amp IEC Contactor	1	100-C09D10
Auxiliary Contact Block	1	100-FA40
Overloads		
1.6-5.0 Amp Overload	1	193-EECB
Relays		
Relay	1	700-HK36A1

Operating Spares continued	Quantity	Part #
PLC		
Input Cards - AC	1	1769-IA16
Output Cards - Relay	1	1769-OW16
Analog Input Card	1	1769-IF4
6 Input TC Card	1	1769-IT6
Analog Output	1	1769-OF4
Miscellaneous		
Type K Thermocouple element	5	TK-K08B-010.0-000
Inconel Protection Tube 10"	5	MP-60140-08-10.0
Pressure Transmiter	1	616KD-00
Air Proving Switch	2	SML8221210034
Modutrol	1	M9184D4009
Resistor Kit	1	A4-20ma
Modutrol Transformers	1	50017460-001

Capital	Quantity	Part #
Capital spares		
Primary Burner		
Primary Propane Burner	1	C8559254
Secondary Burner		
Secondary Propane Burner Kit		
Includes: Burner	1	C9522351
Propane Conversion Kit RS 38/M	1	3010271
Installation of R-Series Propane Kit	1	C7005526
Gas Train 1 1/2" Mod 8"	1	C8316012
Power Supply	1	1769-PA2
Processor	1	1769-L32E
24 VDC 1.2 Amp Power Supply	1	PS5R-SC24
Frequency Drive	1	22B-E3P0N104

ECO WASTE SOLUTIONS

PRETIVM - AMEC

BRUCEJACK PROJECT

SECTION 8

SUPPLIER CATALOGUES

CA 100WO

(This section will be completed with OEM manuals)

Corporate Office:

Eco Waste Solutions

5195 Harvester Road, Unit 14

Burlington, ON, Canada L7L 6E9

Tel: 905-634-7022 Fax: 905-634-0831

Email: info@ecosolutions.com

Web: www.ecosolutions.com

Appendix C

Chain of Custody Record for Waste Oil Analysis (Maxxam)

Maxxam

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5 Ph: (604) 734-7276 Fax: (604) 731-2386, Toll Free: (800) 665-8566

CHAIN OF CUSTODY RECORD

Click here to get the COC number

Maxxam Job #: **COC #:** Page: of

Invoice To: Require Report? Yes ☑ No ☐

Company Name:	Pretium Exploration Inc.
Contact Name:	M Holtby
Address:	1600 - 570 Granville St
	Vancouver PC: V6C 3P1
Phone / Fax#:	Ph: 604-558-1784 Fax: 604-558-1784
E-mail	invoices@pretivm.com

Report To:

Company Name:	SAME
Contact Name:	
Address:	
	PC:
Phone / Fax#:	Ph: Fax:
E-mail	mholtby@pretivm.com

PO #:	
Quotation #:	
Project # :	
Proj. Name:	Brucejack
Location:	
Sampled by:	

REGULATORY REQUIREMENTS:

- ☐ CSR
- ☐ CCME
- ☐ BC Water Quality
- ☑ Other Waste oil
- ☐ DRINKING WATER

SERVICE REQUESTED:

- ◉ Regular Turn Around Time (TAT) (5 days for most tests)
- **RUSH** (Please contact the lab) ○ 1 Day ○ 2 Day ○ 3 Day

Date Required:

SPECIAL INSTRUCTIONS:

Return Cooler ☑ **Ship Sample Bottles (please specify)** ☑

ANALYSIS REQUESTED

	Sample Identification	Lab Identification (Lab Use Only)	Sample Type	Date/Time(24hr) Sampled	Pick a **Volatile package** from list	Pick a **Hydrocarbon pkg** from list	Pick a **DW package** from list	Pick a **Salinity package** from list	Pick a **Leachate package** from list	Pick a **THM package** from list			Pick a **Metals pkg in tissue** from list	Pick a **Metals pkg in water** from list	Dissolved Metals (DM) Field Filtered? Y N	Dissolved Metals (DM) Field Acidified? Y N	Total Metals Field Acidified? Y N	Total As, Cd, Cr, Pb		Overwrite with **Inorganic test(s)**-UF	Overwrite with **Inorganic test(s)**-UF	Overwrite with **Inorganic test(s)**-PA	Overwrite with **Inorganic test(s)**-PE	Overwrite with **Inorganic test(s)**-PC	Organic halogens as Chlorine	PCB	Overwrite with **Micro test(s)** here	Overwrite with **Air or IH test(s)** here	Overwrite with **Toxicity test(s)** here	**HOLD**	**Number of Containers**	**Samples are from a Drinking Water Source?** YES ☐ NO ☐	**Does source supply multiple households?** YES ☐ NO ☐
1																		√							√	√							
2																		√							√	√							
3																		√							√	√							
4																		√							√	√							
5																																	
6																																	
7																																	
8																																	
9																																	
10																																	
11																																	
12																																	

Print name and sign			Print name and sign				Laboratory Use Only			
***Relinquished By:**	Date (yy/mm/dd):	Time (24 hr):	**Received by :**	Date (yy/mm/dd):	Time (24 hr):	Time Sensitive ☐	Temperature on Receipt (°C)	**Custody Seal**	Yes	No
							A) B) C)	Present?	☐	☐
							Just sampled & rec'd on ice: ☐	Intact?	☐	☐

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORDS. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

Appendix 9-2-8. Subsidence Monitoring and Management Plan

Subsidence Monitoring and Management Plan – Brucejack

Brucejack Mine - Version 01

Prepared for

NCM - Brucejack

SRK Consulting (Canada) Inc.
1CP026.003
July 2020

Subsidence Monitoring and Management Plan

July 2020

Reviews and updates of this document are a collaborative effort between SRK Consulting (Canada) Inc. and Brucejack Mine

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Project No: 1CP026.003
File Name: Brucejack_Subsidence_Monitoring and Management Plan_2CP0023.003_20200709

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Version Control

Version	Prepared By	Primary Author(s)	Comments / Changes
Ver. 0: June 2020	SRK Consulting (Canada) Inc	Tim Coleman	Initial document
Ver.1 : Feb 18 2023	NCM - Brucejack	Dinesh Devathasan	-Update on monitoring, -updated mining zones and 2023 updates to monitoring methods -Updated Pretivm Resources name to NCM Brucejack where required

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Appendix A: Preliminary Assessment of Subsidence Potential at the Brucejack Project

Appendix B: SRK Brucejack Subsidence Monitoring and Management Plan Memo

Acronyms and Abbreviations

The following acronyms and abbreviations are used throughout this Subsidence Monitoring and Management Plan.

SMMP	Subsidence Monitoring and Management Plan
VOK	Valley of the Kings
LiDAR	Light detection and ranging
AMP	Adaptive Management Plan
UAV	Unmanned Areal Vehicles
InSAR	Interferometric Synthetic Aperture Radar
WZ	West Zone
BZ	Bridge Zone
WRD	Waste Rock Dump

1 Introduction

1.1 Purpose

Pretium Resources Inc. (Pretivm) – now NCM (Newcrest Mining) Brucejack, retained SRK Consulting (Canada) Inc. (SRK) to prepare a Subsidence Monitoring and Management Plan (referenced here in as the SMMP or the Plan) for Brucejack Mine as per *Mines Act* Permit M-243 Condition D.13.

The enclosed SMMP has evaluated the effectiveness of subsidence controls to provide an early warning of surface expression that may result in changes to terrestrial or aquatic values. Subsequently, this plan includes adaptive management measures for monitoring subsidence and developing mitigation measures as needed.

1.2 Mining Method Overview

The underground mine comprises of several ore zones: Valley of the Kings (VOK) zone, the West zone (WZ) , Bridge Zone (BZ) , Fault Zone (FZ) , Galena Hill (GH) and Office Porphyry (OFP) . The mine began commercial operation in July 2017 with production from the VOK zone. There has been no production to date in the West zone. The FZ and OFP are new zones that commenced mining in 2020. GH is on track for production in mid-year 2023. The mining method at Brucejack is long-hole stoping; a combination of longitudinal and transverse mining is used depending on the width and orientation of the mineralized zones. The mine employs an overhand primary/secondary stoping method with cemented tailings pastefill used to backfill stopes after mining.

Predominantly, the underground development at Brucejack measures 5.5 m wide by 5.5 m high, with an increase in height to 6 m on the main ramp and crossover drives. In ore development, crosscuts are 5 m wide and 5 m high. Where stopes are to be mined, the undercut is sometimes slashed out to a total width of 15 m.

Underground developments are supported by installation of cable bolts in the upper stopes to reinforce the crown pillar and backfilling with waste rock and cemented tailings backfill upon completion. These supported mining methods have a reduced subsidence impact when compared with alternative unsupported methods.

Brucejack Mine's current permitted production rate is 3,800 tonnes per day and the mine has an anticipated mine life of 14 years.

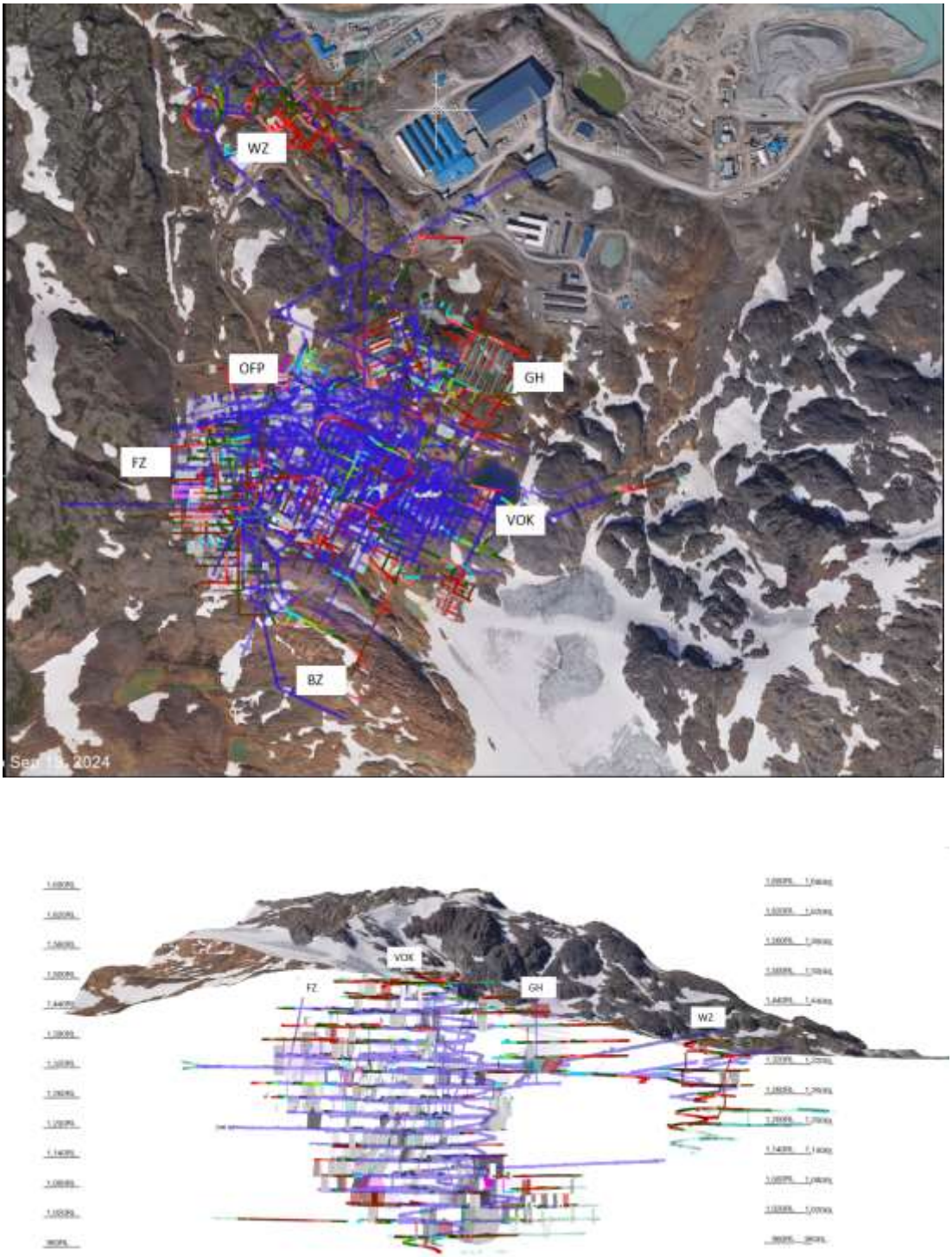

Figure 1-1: Plan View (top) and Oblique View looking West (bottom) of the VOK/ GH/ WZ/ FZ

1.3 Geology Overview

The Brucejack gold-silver deposit is located in the Sulphurets gold-silver-copper mining camp. The deposit is interpreted as a deformed porphyry-related gold-silver epithermal deposit. High-grade gold-silver mineralization occurs as coarse aggregates of electrum and silver sulfosalts that are hosted in steeply dipping and predominantly west to northwest-trending quartz-carbonate vein stockwork and breccia zones within a broader halo of clay alteration and low-grade mineralization.

Mineralized veins and stockwork zones appear to have utilized lithological contacts and pre-existing structures. Epithermal veins are largely discordant to the penetrative foliation of the altered host rock, suggesting that mineralization postdates a fabric-forming event. Mineralized zones were tilted, thrusted, and sheared during Cretaceous compressional deformation.

The Brucejack Ground Control Management Plan (GCMP) classifies the rock mass into a number of “geotechnical units” based on characterization of the rock mass and the presence of major geological structures (Pretivm, 2020).

The geotechnical units in the VOK zone, described in BGC’s review of underground geotechnical units (BGC, 2019), are listed in order of increasing competence:

- The weathered zone comprises near-surface rocks.
- The Fault Zone unit comprises rock identified as fault-disturbed rock. It is strong, with good RQD values (75% - 90%) and close discontinuity spacing.
- Rock mass Domain 1 includes the Volcano-sedimentary Facies (argillite portion) geological unit; it very strong, with good RQD values, and moderate discontinuity spacing.
- Rock mass Domain 2 includes the Bridge Zone Porphyry, Office Porphyry, and Silicified Rock geological units; these are strong, with excellent RQD values (>90%), and moderate discontinuity spacing.
- Rock mass Domain 3 includes the Volcaniclastics, Volcano-sedimentary Facies (sandstone-conglomerate portion), S3-Trans, and ANDX units; these are strong, with excellent RQD values, and wide discontinuity spacing.

1.4 Subsidence Mechanisms Overview

Subsidence is an inevitable consequence of the extraction of minerals, liquid, or gas from beneath the ground surface. The surface expression may be of a small magnitude and localized or extend over large areas. Subsidence may occur immediately with mining or may be delayed by many years. Geology and mining methods are the main variables that dictate the magnitude of impact of subsidence and cannot be ignored.

The study of mining induced subsidence has predominantly been in connection with the mining of extensive tabular mineral deposits, such as coal and potash, through either longwall or room and pillar mining.

The effects of subsidence are not limited to the vertical displacement of the ground surface but include the total of all surface effects that are associated with the extraction of minerals. There are essentially three potential surface subsidence effects of underground mining:

- **Trough subsidence** – generally associated with the extraction of relatively flat tabular orebodies. The ground disturbance associated with the trough is generally greater than the extent of the underground workings. Cracks or fissures may be formed at the edges of the subsidence trough and reflect tensile or shear stresses in the ground surface. This is considered to be unlikely at Brucejack Mine.
- **Collapse subsidence** – caused by the failure of the strata between the underground excavations and the ground surface. The ground disturbance associated with collapse type subsidence can vary in magnitude from a zone around an individual stope (i.e., chimney subsidence) to large areas of a mine (i.e., plug failure). Collapse type subsidence generally exhibits at surface as a sinkhole or conical depression. Cracks or fissures may be formed around the depression or sinkhole. The supported mining method employed at Brucejack Mine means that this is unlikely to occur.

- **Plug failure** – generally controlled by weak, continuous geological structures in the overlying rock mass or can be initiated by the large-scale failure of pillars, either rock or backfill pillars or a combination of both. Plug subsidence is generally controlled by one or more major structural features, such as a fault or dyke, which provides a continuous plane of weakness or where the shear strength of the rock mass is overcome at a critical stage of mining or through the failure of regional mine support such as pillars or backfill. Structural geology studies conducted on the Brucejack deposit have not identified continuous features that might act as the failure surfaces for a plug type failure.

BGC Engineering Inc. completed a preliminary assessment of the potential for subsidence at the Brucejack Mine site considering the subsidence failure mechanisms listed above. This report is attached in Appendix A.

2023 Update:

SRK was consulted in 2020 to provide a second opinion on BGC's findings (Appendix B) . It was found that BGC's approach was based of analytical, empirical, and numerical analysis. SRK supplemented this with the Betournay method, which examines the likelihood of progressive UG failure. The worst-case scenario where a caving failure ceases is because of caved material occupying available void. This is related to stope dimensions, unfilled volume, and bulking factor of overlying rock mass.

The current 2022 GCMP recommends a 15m crown pillar consisting of competent rock and 10m stope strike length. Even if the stopes cannot be tight filled and a 5m unfilled gap was left in the stopes, the maximum self-mining height is also estimated at about 5m, likely due to bulking factors. This is roughly a third of the crown pillar recommended and no ground disturbance should be noticeable. The crown pillar may also be increased to 20-25m for initial stopes until stope performance (Cavity monitoring scans) are performed to monitor overbreak and back failure.

2 Subsidence Monitoring Plan

The topography, mountainous terrain, and seasonal snow and ice cover at the Brucejack Mine pose unique challenges to the development of an appropriate subsidence monitoring plan as the surfaces being monitored for subsidence are under snow cover for extended periods of the year. Furthermore, the supported mining methods employed underground, discussed in Section 1.2, drastically reduce the magnitude of subsidence effects below the level of detection without the use of precision levelling survey techniques.

Subsidence monitoring plans typically include combinations of:

- Ground-based precision surveys
- Visual observations
- Aerial and satellite photogrammetry and LiDAR, and
- Deformation sensing instrumentation.

The following is a practical subsidence monitoring plan that takes into consideration the potential subsidence mechanisms, discussed in Section 1.4, as well as challenges related to accessibility on the steep mountainous terrain and extended periods that the site is under snow cover. If subsidence is observed, an adaptive management plan (AMP) will be initiated to further monitor deformations (Section 3).

2.1 Levelling Surveys

Brucejack will establish a series of levelling monitoring points in both the main VOK zone and the West zone. These surveys will serve to provide a calibration/check on the potential deformation detected by other monitoring methods. These precision levelling surveys will be completed annually in late summer, when snow cover is at it's lowest, and will be limited to those areas in which safe personnel access is possible.

Establishing stable reference survey monuments that have the capability to survive the significant seasonal processes that occur in alpine environments subjected to high snowfall is not practical. Therefore, the broader application of this monitoring technique, beyond an initial survey to establish a baseline for the site, is best suited as an adaptive management strategy to monitor localized subsidence if surface deformations are observed.

2023 update:

Brucejack has been trialing localized GNSS radio transmitters at the WRD. These beacons will be able to provide real time feedback with up to 6 months of battery life. Mounts are currently being made to increase data accuracy from +/- 20mm to +/- 10 mm , a reasonable deviation given the shifting weather conditions and the overall displacement that would be observed in a subsidence event.

The beacons will be implemented at the centroid of the zones as they come within 30m of the crown pillar. Above ground mounts are currently being designed so the pelican cases housing the beacons are not buried by snow – which can affect reading accuracy.

Once the reliability of these beacons can be proven with regular ground-based survey's on the WRD, they could start implementation on the zones identified in Figure 2-1.

2.2 Annual Photogrammetry

Environmental conditions at the Brucejack Mine result in few days in which cloud cover is low enough for photogrammetry to be used as a routine monitoring tool. This is further compounded by the requirement for specialist equipment and operators to be available on site at precisely the right time. Where weather, visibility, and snow free conditions allow, Brucejack will endeavour to complete an annual low elevation survey of terrestrial surfaces above underground mining areas (Figure 2-1). Unmanned Areal Vehicles (UAV) or “Drones” will be used to capture photographs for comparison of surface deformations between subsequent annual photogrammetry surveys if conditions permit.

2023 Update:

Brucejack has invested in a Matrice 300 RTK drone capable of real time surveys and photo overlays. The flights will be conducted when snow has cleared over the identified mining horizons. Since no mining is taking place this year within the 15m crown pillar, a general flight will be performed rather than detailed zone mapping with 2m contour level spacing. This will continue year over year until a zone approaches 30m within the crown pillar
If a zone does commence mining within 30m of the crown pillar, a more detailed flight will be undertaken with 1m contour intervals for the mining zones listed in Figure 2-1

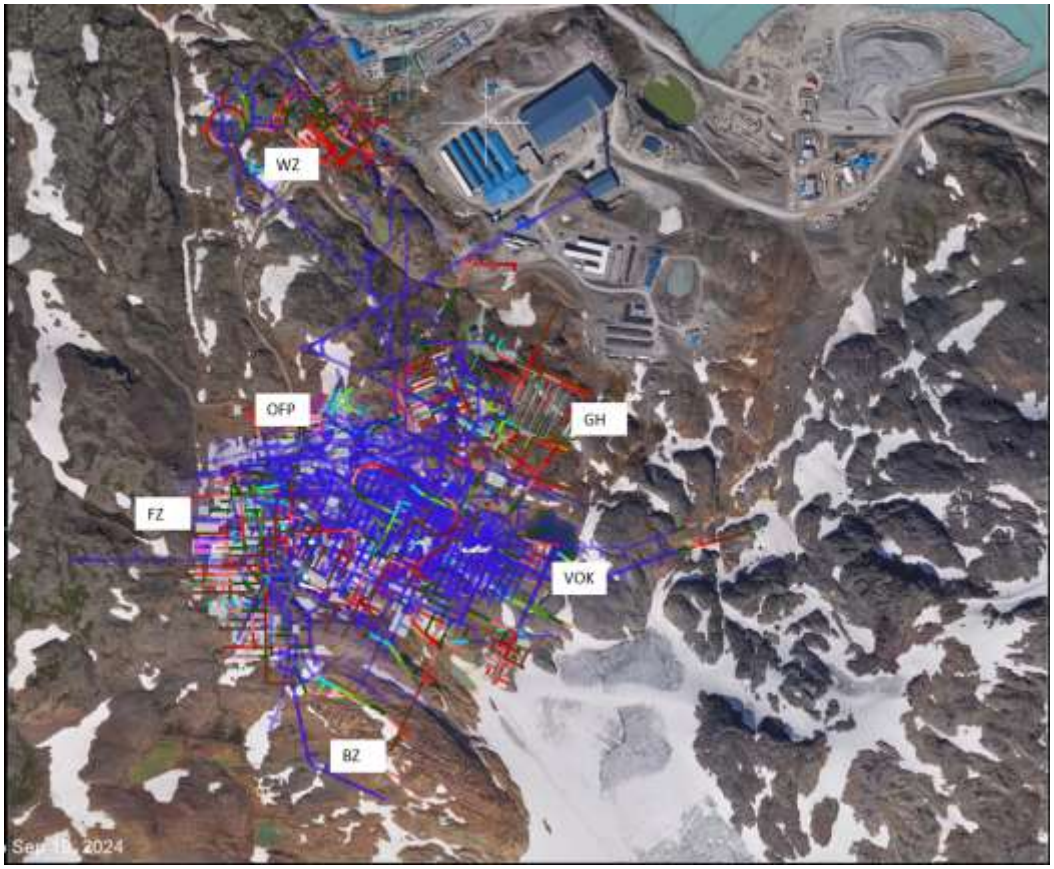

Figure 2-1: Photogrammetry location showing the relationship between mining areas and surface features

2.3 Remote Sensing Alternatives

2.3.1 InSAR

InSAR uses radar images taken from a low earth orbiting satellite. Subsequent images are compared to produce an interferogram which can be used to determine ground displacement. The bare rock surfaces of the terrain around the Brucejack Mine site provide excellent reflectors for the radar data suggesting that the InSAR method could be the ideal solution for monitoring ground deformation. Measurement precision is typically in the order of 1 cm with a 1 m by 1 m pixel size. In ideal conditions, precision can be as good as 1 mm. InSAR satellite interferometry is not required as a part of the subsidence monitoring plan; however, it is a technology that can be explored to determine if it is a candidate for use at the mine site.

Brucejack and the Brucejack technical team will approach one of the InSAR service providers to determine whether the mine's location and aspect is amenable to the use of InSAR data. Should InSAR be deemed suitable for use at the Brucejack Mine site the SMMP will be updated to include the use of InSAR in the monitoring plan.

2023 Update:

Brucejack will not be undertaking inSAR imagery. Given the highly erosive environment from snowpack movement and wind erosion, 1mm accuracy will not yield more information, and in fact prove to have more noise in the data. The +/- 10mm results from GNSS beacons will be sufficient, along with visual confirmation with photogrammetry.

2.3.2 LiDAR

LiDAR surveys are not required as a part of the subsidence monitoring plan. However, in 2019 Brucejack obtained a comprehensive LiDAR scan of the mine area. This 2019 scan data can be used as a basis for comparing observational information when future survey data becomes available.

2023 update:

Lidar will not be used as a standard, but will be referenced if no other leveling survey or photogrammetry results

2.4 Reporting

An annual subsidence monitoring report will be prepared by a qualified person to support submission of Brucejack's Annual Reports to the British Columbia Ministry of Energy and Mines. The report will review the location of mining activities, proximity to the crown pillars, and summarize the annual photogrammetry data in relation to any surface subsidence observed since the previous annual subsidence monitoring report. The use of GNSS remote beacons will also supplement the photogrammetry data and a cumulative elevation displacement chart will be shown year over year. The report will detail location and magnitude of subsidence and any adaptive management activities that were triggered to further monitor deformation.

Remote sensing technology is rapidly developing. High resolution survey technologies that are considered as cost prohibitive and data intensive today are rapidly being refined and scaled for commercial uses. A key component of the annual report is to review and update the SMMP annually to ensure that it is up to date and that the most appropriate available technologies are used for monitoring subsidence at this mine site.

3 Adaptive Management Plan

An AMP for subsidence monitoring would be triggered if subsidence is observed on the ground surface. Also, if a concern is raised that underground mining will induce a surface subsidence.

When triggered, the AMP will include the following steps:

1. **Ensure the safety of workers:** This may include the egress of underground miners and cordoning off surface mining infrastructure in a zone of potential subsidence influence. If the subsidence immediately threatens worker safety, a "Stop Work Order" should be placed on immediate work areas and staff removed from the area and reported to appropriate authorities.
2. **Evaluate magnitudes and extents:** Brucejack's geotechnical engineers will evaluate the subsidence and geology to determine the risk potential that the subsidence will impact surface infrastructure, the work areas for staff and the environment.
3. **Monitoring:** A localized precision levelling monitoring programme will be developed by Brucejack's geotechnical engineers to monitor deformations. Typically, this will include installing survey monuments within the observed subsidence and peripherally, around the perimeter immediately outside of the area. The geotechnical engineers will determine the locations of surveys and the frequency of the measurements.
4. **Documentation:** Brucejack's geotechnical engineers will document the subsidence and deformation survey data that should be included in the Annual Subsidence Report.
5. **Revise the Mining Methods:** Based on the evaluation completed by Brucejack's geotechnical engineers, it may be necessary to revise the mining methods in order to limit future events.

6. **Update the Subsidence Monitoring and Management Plan:** Based on the evaluation completed by Brucejack's geotechnical engineers, it may be necessary to revise the SMMP.

4 Summary

A review of the site-specific conditions and factors affecting the potential for surface subsidence at the Brucejack Mine indicate a very low probability that noticeable subsidence at surface will occur. The two potential subsidence mechanisms identified for a mine of this nature are an unravelling progressive crown pillar failure and plug failure. Both of these potential mechanisms are mitigated by the mining practices used at this mine. These mining practices include the tight placement of cemented pastefill in the mined-out stopes and the installation of cable bolts in the upper stopes to reinforce the crown pillar.

Periodic high precision leveling surveys will be performed in the crown pillar and adjacent areas to provide broader assessment of potential ground movement.

Remote sensing technology is rapidly developing. High resolution survey technologies that are considered as cost prohibitive and data intensive today are rapidly being refined and scaled for commercial uses. It is important to review and update this SMMP annually to ensure that monitoring practices are evaluated to the latest technologies.

This report, Subsidence Monitoring and Management Plan, was prepared by:

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Consultant , Mining Rock Mechanics

and

Tim Coleman, PEng BEng(Hons) ACSM MSc DIC
Principal Consultant, Mining Rock Mechanics

Revised by Dinesh Devathasan, P.Eng

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D. DEVATHASAN # 48422

Chief Mine Engineer, Brucejack operations

~~Feb 19~~ 2023
Feb 30th

Attachments:
Appendix A: Preliminary Assessment of Subsidence Potential at the Brucejack Mine Site
Appendix B: SRK Subsidence Monitoring and Management Plan Memo

Disclaimer- SRK Consulting (Canada) Inc. has prepared this document for Pretium Resources Inc. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

5 References

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Brucejack Subsidence Monitoring and Management Plan Memo (2023)

Appendix A: Preliminary Assessment of Subsidence Potential at the Brucejack Mine Site

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October 10, 2013
Project No.: 1008-010
Document: BJ-2013-11

Ian Chang, Vice President, Project Development
Pretium Resources Inc.
#1600 – 570 Granville Street
Vancouver, B.C., V6C 3P1

Dear Mr. Chang,

Re: Preliminary Assessment of Subsidence Potential for the Brucejack Project - FINAL

1.0 INTRODUCTION

BGC Engineering Inc. (BGC) is pleased to provide you with the following preliminary assessment regarding the potential for surface subsidence due to excavation of the proposed Brucejack Project mine workings.

This discussion is intended to support the Environmental Assessment (EA) phase of the project, currently being undertaken by Pretium and their environmental consultant Rescan.

A review of the site specific conditions and factors affecting the potential for subsidence at the Brucejack property indicates a very low probability that significant subsidence will occur.

2.0 BACKGROUND

2.1. Definition of Subsidence

Subsidence is a natural and man-made phenomena associated with a variety of processes including compaction of natural sediments, groundwater dewatering, wetting, melting of permafrost, liquefaction and crustal deformation, withdrawal of petroleum and geothermal fluids, and mining of coal, limestone, salt, and metallic ores. Most subsidence is either created or accelerated by human activity.

Mine subsidence can be defined as ground surface movements that occur due to the collapse of overlying or adjacent strata into mined out voids, which expresses itself in cracks, fissures, step fractures, pits or sinkholes, troughs, or sags.

Subsidence is an inevitable consequence of underground mining – it may be virtually undetectable, of significant magnitude but localized, or gradual, continuous and extensive over very large areas. Subsidence may occur immediately following mining, or be delayed for decades due to a variety of factors.

2.2. Subsidence Mechanisms and Controlling Factors

(Note: The following discussion is sourced primarily from SME, 1986; Marcus, 1997).

A number of geologic and mining parameters can affect the magnitude and extent of subsidence. These include the thickness of extracted materials; overlying mining areas; depth of mining; dip of mining zone; competence and nature of mined and surrounding rock masses; near surface geology; structural characteristics and geologic discontinuities; faults, fractures and lineaments; in-situ stresses; degree of extraction; surface topography; groundwater (including water elevation and fluctuation); method of mining; rate of advance; backfilling; and time.

These factors have been recognized and examined in detail in the literature. Included below is a brief discussion of some of those factors, with particular emphasis on those that are more typical of hard-rock mining-related subsidence.

- Ore Thickness: There is a direct relationship between the thickness of the extracted materials and the amount of surface subsidence that may result, making it an important factor in subsidence predictions. A greater ore thickness generally results in a greater amount of surface subsidence.
- Multiple Ore Zones: Where multiple mining horizons exist, subsidence which occurs in one area increases the likelihood of similar events in other areas, because the strata have been disturbed.
- Ore Zone Depth: A general consensus among industry experts is that subsidence is often *independent* of depth, refuting the previously held notion that surface subsidence can be prevented by leaving sufficient thicknesses of overburden. While this may prolong the time period before subsidence effects are observed at the surface, the possibility for subsidence is generally not changed. Bulking / swelling of material failing into mined out voids may impact the magnitude of subsidence, but will not prevent it entirely, regardless of depth.
- Dip of Ore Zone: Where the mining horizon is inclined, subsidence becomes skewed and mitigation measures such as pillars become less effective.
- Competence of Mine Floors and Roofs / Stope Footwalls and Hanging walls: The competence of mine excavation surfaces is critical in the initiation of subsidence events, since they propagate from these areas. Weak poor quality rock permits the fall of overlying strata, and may compact more easily, resulting in a greater likelihood and severity of subsidence. Conversely, **good quality rock around the periphery of an excavation limits the failure of overlying strata, resulting in a lower likelihood and severity subsidence.**
- Nature of Overlying Rock and Overburden: The strength of the overlying strata above the mining horizon is a factor in the timing and extent of subsidence.
- Surface and Near-Surface Geology: Surface and near-surface soils and unconsolidated materials tend to emphasize subsidence effects, because they behave in an inconsistent manner. They are an important factor relative to hydrologic

impacts of subsidence because they affect the exchange of surface water and groundwater.

- Geologic Discontinuities: **Faults, folds, and other inconsistencies in the overlying and surrounding strata may increase subsidence potential.** The disturbance of equilibrium forces by mining can trigger movement along a fault plane. Faults may also weaken the overlying strata and trigger subsidence in materials that may otherwise show desirable properties. Subsidence effects related to faulting may be localized about the fault structure, or may occur as increased subsidence magnitudes over a more regional area. Joints and fissures in the strata also affect subsidence but on a smaller scale.
- Degree of Extraction: The amount of pillar support is directly related to the timing and extent of subsidence. Lower extraction ratios result in greater thicknesses of pillars, which tends to delay and decrease subsidence. As the amount of pillar support is decreased, either by mine design or as a result of pillar extraction, subsidence occurs more rapidly and extensively. Complete removal of pillars without backfill is almost always followed by subsidence, with surface manifestations being a function of upward propagation to the surface.
- Surface Topography: Sloping ground like hillsides tends to emphasize the surface manifestation of subsidence, while it is less accentuated on flatter ground and in valleys.
- Groundwater: Drainage gradients may be altered by disturbance of the strata around mine areas. Rocks may become weakened by saturation, and erosion patterns could change. Where surface water is present, it may migrate more easily to fractures and fissures in the strata and into the mine area and may induce subsidence. Subsidence may also occur as a result of dewatering to facilitate underground mining in some rock types.
- Mining Method: The extent and magnitude of subsidence is dependent on the mining method(s) used to extract the ore. **The inclusion of appropriately designed crown, sill, and rib pillars into the geometry may significantly limit the effective extent and magnitude of subsidence.**
- Backfilling: **Partial or complete mine backfilling reduces subsidence and is dependent upon the type and extent of backfilling. However, it is important to note that backfilling does not necessarily eliminate subsidence entirely.**
- Time: The amount of subsidence has been observed as a direct function of time. Surface effects are delayed in room-and-pillar mining for some time, unless the pillars are removed. In block caving mines, surface effects are often noticeable soon after the initiation of caving.

As noted above, the geologic configuration of an ore deposit directly influences the nature and magnitude of potential surface subsidence. Shallow mining operations within flat layers of relatively weak sedimentary or evaporite deposits (e.g. coal, salt, potash) typically represent the most unfavorable configuration in terms of subsidence magnitudes and zone of

influence. In contrast, vein-type deposits typically have relatively limited ore thicknesses, are relatively steeply dipping, and typically have a strong host rock mass. **The principal risks for the safety of people and property located at surface above vein-type deposits is often concentrated above crown pillars and represents a relatively limited zone of influence at surface.**

The potential for mine induced subsidence is strongly related to the mining method and resultant mine geometry. The selection of the mining method mainly depends on the configuration of the deposit (e.g. size, depth, extent, orientation). Stope mining techniques like those proposed for the Brucejack Project, combined with the development of adits, drifts, and shafts, have historically been the most prolific form of hard-rock metals mining and has been done at both large and small scales. Stope mining is applicable to most vein-type ore bodies typical of base and precious metals deposits. The subsidence created by stope mining is usually the result of unintended cave-ins, inadequate support, pillar robbing, mining too close to the surface, and eventual collapse of the workings over time as the inevitable consolidation of the strata takes place. **Most often subsidence occurring as a result of stope mining techniques is limited to the hanging wall side of underlying stopes. In many cases, the degree of surface subsidence that occurs from stope mining is both isolated and relatively minor.** However, in some cases, particularly where extensive mining by this technique has been employed (e.g. Butte Mine, Montana; Hollinger Mine, Ontario), the resulting subsidence can result in significant surface impacts.

Subsidence above underground mines can be categorized into two distinct types: continuous and discontinuous. Continuous subsidence is characterized by a usually slow, smooth, and flexible readjustment of the ground surface that has no abrupt changes. This well-known and generally well understood phenomenon induces topographical depressions without major failures, leading to a dish-shaped feature on surface. In most cases the maximum amplitude in the centre of the depression is on a decimetric to metric scale. Continuous subsidence typically occurs in mining operations within flat layers of relatively weak sedimentary or evaporite deposits (e.g. coal, salt, potash).

Discontinuous subsidence is characterized by the gradual to sudden appearance of a generally irregularly-shaped depression or collapse crater at surface, resulting in localized large surface displacements, on the order of metres to tens of metres. Subsidence resulting from failures or caving of stopes is commonly discontinuous. As shown in Figure 2-1, failure modes that result in discontinuous subsidence include plug failures, progressive block raveling due to lack of adequate confinement / in-situ stress, de-stratification, chimneying disintegration, and block caving.

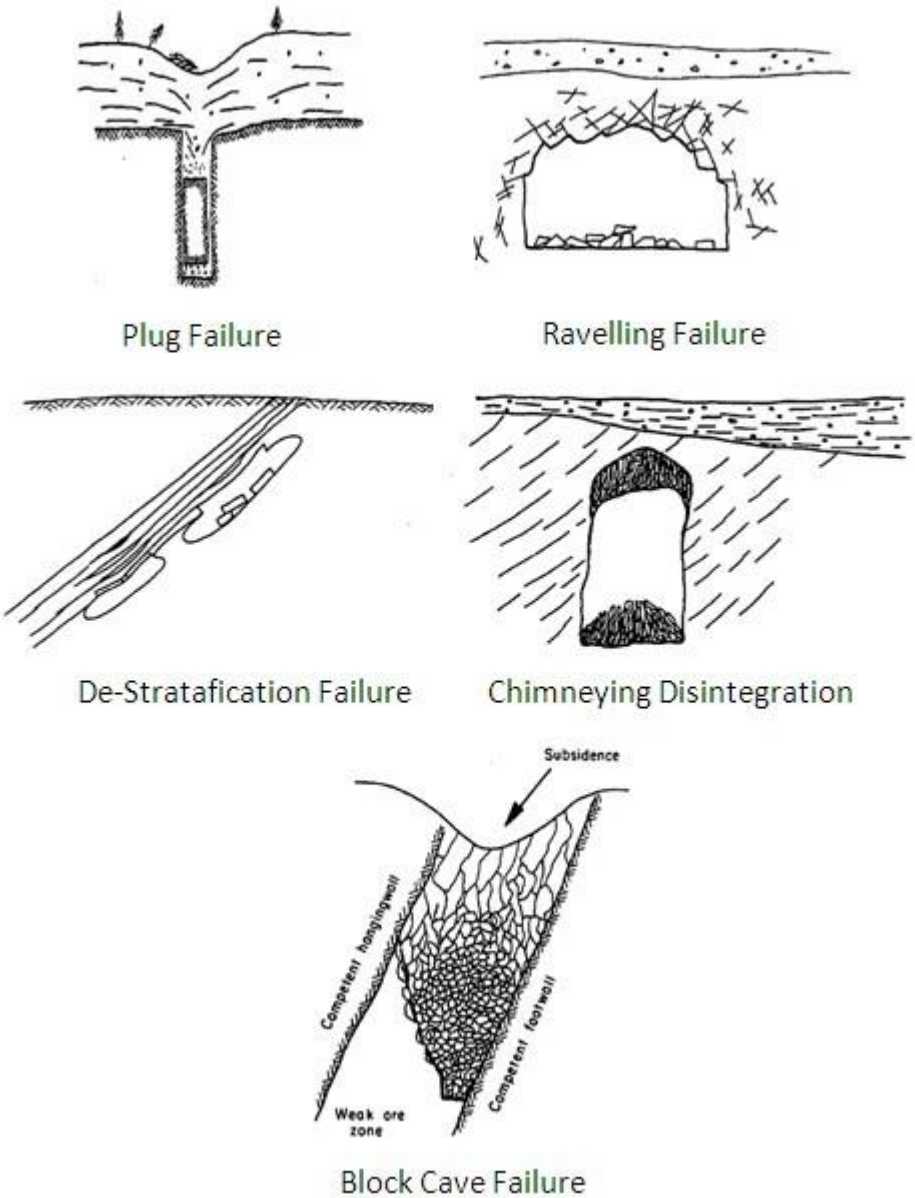

Figure 2-1. Common Failure Mechanisms of Shallow Stopes in Hard Rock Mines (after Bétournay, 1995)

The deposit and rock mass properties also have a significant influence on subsidence potential. Displacements within the rock mass at the periphery of underground workings can be discontinuous, sudden, and irregular. **A strong rock mass above vein-type deposit mine workings will tend to prevent any underground instabilities progressing towards the surface if the mining depth is sufficient.**

Active mine stability is generally studied for short-term projects. In contrast, subsidence can occur over very long time scales (i.e. decades to centuries). Time is therefore a fundamental factor in subsidence development. Time related factors effecting subsidence include the long term reduction in rock strength due to micro-fracturing under continuous loading conditions.

Some rock types are very sensitive to this effect (salt, gypsum, clay) while some exhibit less sensitivity (granite, quartzite). Strength reductions typically range from 20% to 50%, based on laboratory testing. The ageing of a rock mass also can affect its long term strength characteristics. Ageing is a chemical process that modifies the rock mass properties due to imposed variations in environmental conditions. In particular, the introduction of changes to the water and oxygen can have a significant impact of the quality and competency of a rock mass over time.

2.3. Subsidence Monitoring

Subsidence monitoring should be carried out over the life of the mine, including post-closure. Pre-mining high-resolution topographic surveys are useful in establishing base case conditions to be evaluated against as mining progresses.

Subsidence monitoring measurements are based upon a survey of the vertical and horizontal displacements that take place at known reference points on the ground surface. A variety of specific methods may be used depending on the objectives, site, density of monitoring points, duration and cost. Automatic data acquisition systems have been utilized and are gaining acceptance. The actual range of subsidence varies between a few feet to as much as several hundred feet vertically; horizontal displacement may occur as well. It is important in monitoring subsidence that full coordinates (x, y, z) are measured in order to track the progress of ground movements.

2.4. Subsidence Mitigation

Post-mining stabilization techniques to mitigate subsidence include backfilling, grouting, excavation and fill placement, and blasting. The extent to which post-mining stabilization techniques can be relied on to mitigate subsidence damage is uncertain, as they require assessment of long-term stability. Current analytical and empirical methods to predict the very long-term stability characteristics of mining districts need significant improvement. This is particularly the case for vein / stope mining methods.

3.0 GEOTECHNICAL CONDITIONS AT THE BRUCEJACK PROPERTY

This section presents a summary of the geotechnical conditions and geologic structure within the footprint of the proposed Brucejack Project excavations, and summarizes the geotechnical model used to assess the potential for surface subsidence. Work completed for the current study focuses on the Brucejack Project's West Zone (WZ) and Valley of Kings (VOK) mineralized zones. The discussion below is sourced largely from BGC (2013).

3.1. Overburden

The overburden in the area of Brucejack Project consists of a veneer of well-graded glacial till over bedrock. Grain size varies from sand to gravel, with some silt and clay, and variable quantities of cobbles and boulders. Clasts are subrounded to rounded, and color varies from

orangey brown to grey. Overburden thickness varies but is generally less than 5 m and often less than 1 m. A thin (often less than 0.5 m, but occasionally up to 3.0 m) layer of sandy organics overlies the overburden.

3.2. Rock Mass Conditions

For the purposes of this study, the rock mass has been categorized as “fresh rock” or “weathered rock”. The near-surface weathered rock mass is distinguished from the underlying fresh rock by an increased fracture frequency and a slightly higher degree of alteration characterized by iron oxide staining on joint surfaces (Photograph 1). The interface depth between weathered and fresh rock is estimated to range between 10 and 50 m, based on core logging and underground mapping of existing workings.

Photograph 1. Typical Weathered Rock Zone (Outlined in Red)

The fresh rock at Brucejack has an average Geological Strength Index (GSI) rating that typically ranges from 70 to 85, and average unconfined compressive strength (UCS) of approximately 100 MPa. The fresh rock is classified using standard terminology as 'Good' to 'Very Good' and 'Strong to Very Strong'. The weathered rock at Brucejack has an average GSI ranging from 60 to 65, and an average UCS of 40 to 50 MPa. The weathered rock is classified as 'Good' and 'Medium Strong'. Additional details on the geotechnical properties for Brucejack rock mass can be found in BGC (2013).

3.3. Geologic Structure

3.3.1. Major Faults and Regional Structure

The Brucejack Project area includes a number of major faults and corresponding surface lineaments. These are summarized in BGC (2013), and on Table 2-1.

The major regional lineaments near the Brucejack Project are the Brucejack Fault lineament, the Upper Treaty Glacier lineament and the Treaty Creek lineament.

The Brucejack Fault Zone truncates several site-scale faults at the western extent of the Brucejack Project, and thus has been interpreted as post-dating site-scale deformation events. Structural orientations parallel to the inferred Brucejack Fault lineament were commonly observed in downhole structural measurements across the property. All interpreted structural domains include sets oriented along the Brucejack Fault Zone with dips ranging from 56˚ to vertical.

The Upper Treaty Glacier lineament is a prominent high angle topographic lineament north of the Brucejack Project area. Although not associated with a specific fault set, similarities in regional topography and drainages make it likely that parallel structures will be prevalent throughout the study area. The Upper Treaty Glacier lineament appears in drill hole and underground mapping data in the northern regions of the property, and appears locally as a moderately strong shear and joint set.

The Treaty Creek lineament strikes east-southeast and extends north to the Iskut River Fault. The lineament marks the contact between the Hazleton Group and Bowser Lake Group rocks to the north of the property, and is a common orientation for valleys and drainages in the region. It is expected that lineament-parallel steep structures will be prevalent throughout the study area.

The level of knowledge with respect to site-scale faulting is greater for the WZ than the VOK. The VOK mineralized zone is bound to the west by the Brucejack Fault Zone, is surrounded to the north and south by northeasterly-trending fault traces, and is crossed by a southeasterly-plunging syncline. Oriented core measurements from a geotechnical drill hole drilled less than 100 m away from, and parallel to, the Brucejack Fault Zone showed significantly higher variability than other geotechnical drill holes in the VOK, indicating a potential zone of fault-related structural disturbance in the westerly extents of the mineralization.

Table 2-1. Major Geologic Structure in the Brucejack Project Area (BGC, 2013)

Scale	Structure	Strike (°)	Dip (°)	Orientation Source
Regional	Treaty Creek Lineament	291 or 111	-	ERSi, 2010
	Upper Treaty Glacier Lineament	310 or 130	-	ERSi, 2010
	Brucejack Fault Lineament	355	-	ERSi, 2010
		176	60-90	Newhawk, 1990
		356	60	Margolis, 1993
Site	Lancaster Fault	330	74	BGC Mapping, 2012
		023	80-85	Newhawk, 1990
	Sutcliffe Fault	036	86	Newhawk, 1990
		038	73	BGC Mapping, 2012
	Jaz Fault	204	40	BGC Mapping, 2012
		191	-	Newhawk, 1990
	Zorzi Fault	212	74	BGC Mapping, 2012
		200	-	Newhawk, 1990
	Babics Fault	141	83	BGC Mapping, 2012
		125	-	Newhawk, 1990
		122	75	Roach, 1991
	Ryne Fault	246	71	BGC Mapping, 2012
		213	-	Newhawk, 1990
	Maddux Fault	059	69	BGC Mapping, 2012 - 1350 Level Ore Drive
		048	73	BGC Mapping, 2012 - Ramp-Exploration Drift Intersection
		020	72	Roach, 1991
		020	-	Newhawk, 1990
	Not My Fault	312	-	Newhawk, 1990
	Kovacic Fault	124	-	Newhawk, 1990
	SW Fault	151	-	Newhawk, 1990
	Bruce Fault	291	60-70	Newhawk, 1990, SSR NI 43-101
	Wobbegone Fault	237	-	Newhawk, 1990
	Grace Shear Zone	321	-	Newhawk, 1990

3.3.2. Structural Domains and Design Discontinuity Sets

Structural domains for the Brucejack Project have been previously defined in BGC (2013). In general, the geologic structure across the property is highly variable in both dip and dip direction. Dominant fabrics include moderately to steeply-dipping southeast-striking structures, moderately-dipping southwest to northwest-striking structures, moderately to

steeply-dipping easterly-striking shear sets, and vertical north to north-northwest striking structures. Shallowly dipping (<20˚) sets are less common but have been identified due to their potential for adverse failure geometries in the backs of underground excavations. Vein-parallel structures, including faults, should be assumed to be present in the walls of the stopes.

4.0 MINING METHOD AND PROPOSED CROWN PILLAR

The Brucejack Project Feasibility Study mine plan is shown in plan view in Figure 4-1 and in isometric view in Figure 4-2. The total width of the mining footprint will range from 650 m (east to west) to 1125 m (north to south). This footprint area includes both the Valley of Kings and West Zone proposed underground workings, and the main access decline between them. Topography varies considerably in the project area, but the estimated maximum depth of mining is approximately 600 m below ground surface. Dewatering is currently proposed to occur through a sump and pump system as mining proceeds (i.e. no dewatering wells are planned).

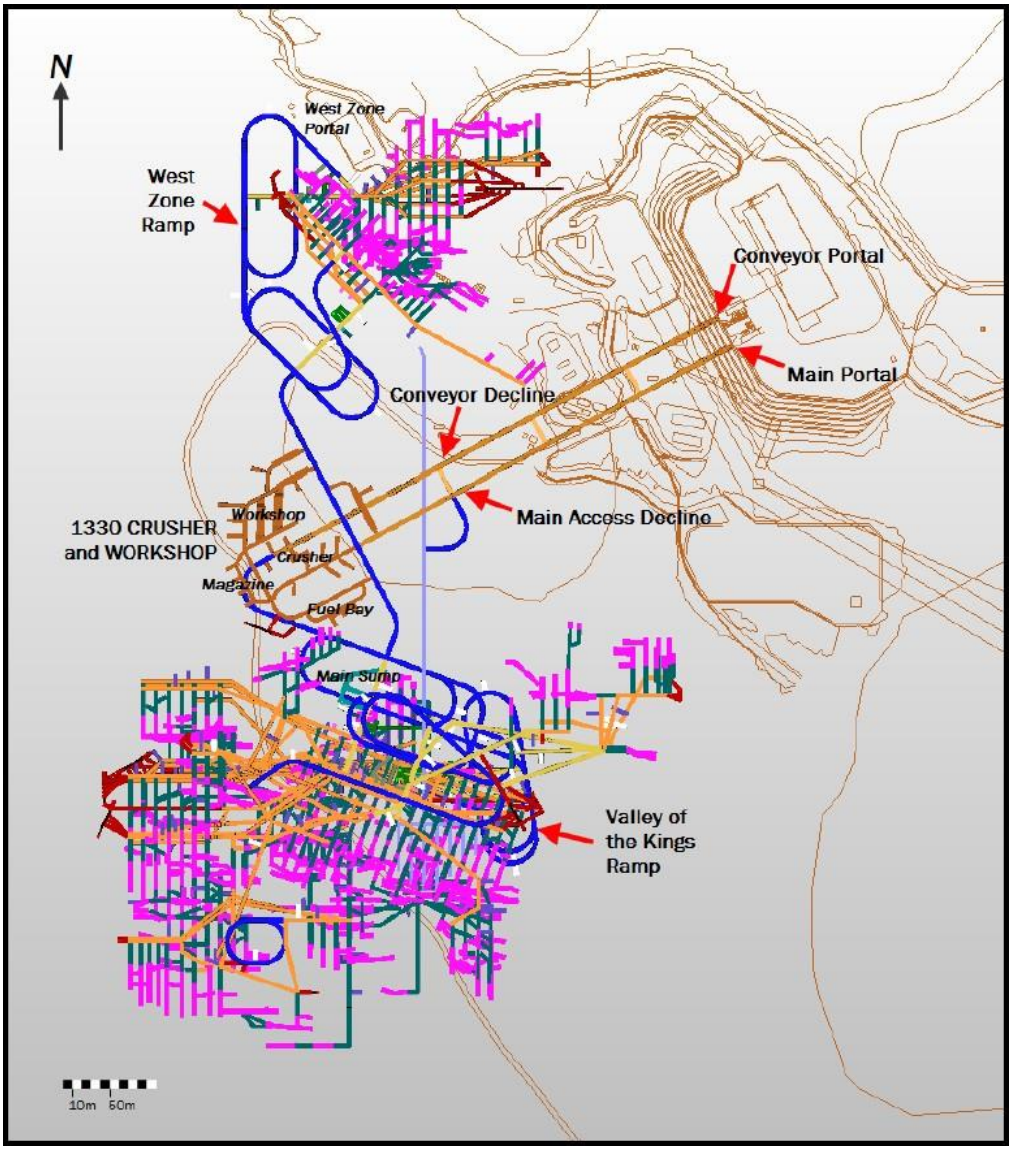

Figure 4-1. Mine Development and Infrastructure, Plan View (Tetra Tech, 2013)

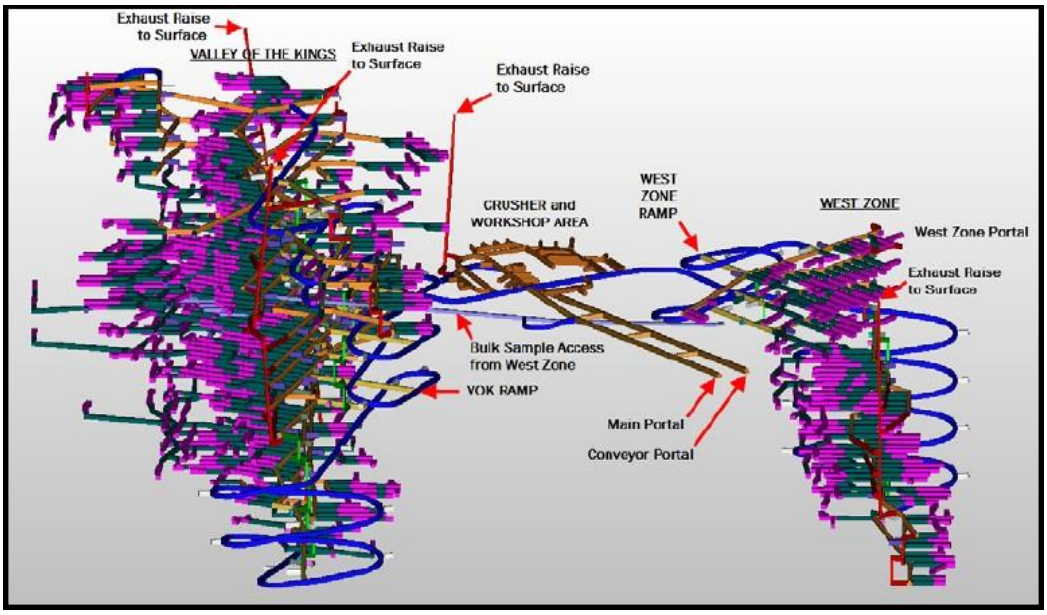

Figure 4-2. Mine Development and Infrastructure, Isometric View (Tetra Tech, 2013)

The proposed underground mine design supports the extraction of 2,700 t/d of ore through a combination of transverse 'Long Hole Open Stoping' (LHOS) and longitudinal LHOS. Paste backfilling of stopes is integral to the mine plan to maximize orebody recovery and mining productivity. Sublevels will be accessed from the main ramps on a 30 m vertical interval that is defined by the planned stoping heights (Figure 4-3).

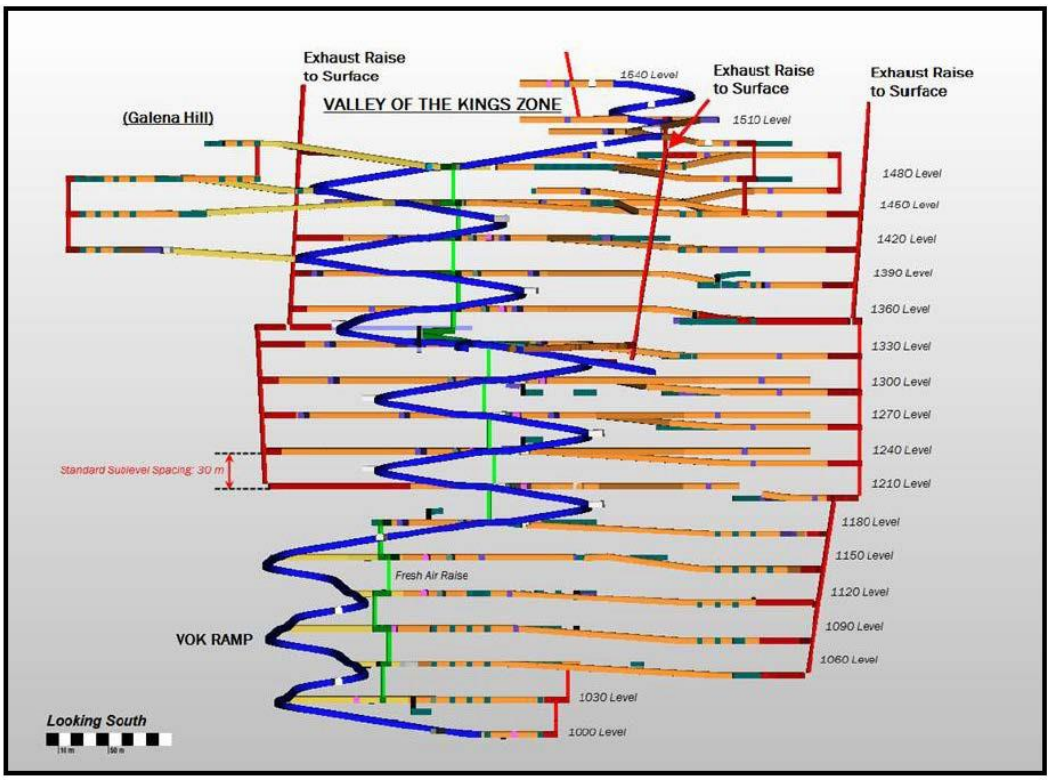

Figure 4-3. Mine Development and Infrastructure, VOK Long Section (Tetra Tech, 2013)

Level development will follow the general strike of the various lenses (Figure 4-4), providing access to the mineralized zones in a manner that promotes transverse mining wherever possible. Level development will generally be in the hanging wall, with hanging wall drives typically including excavations for sumps, refuges, transformers, remucks, paste fill line, and raise accesses. Stope access crosscuts will be on 15 m spacings, with the exception of those levels where sill extraction or near-surface weathered ore will be recovered in smaller units that are designed on 10 m spacings.

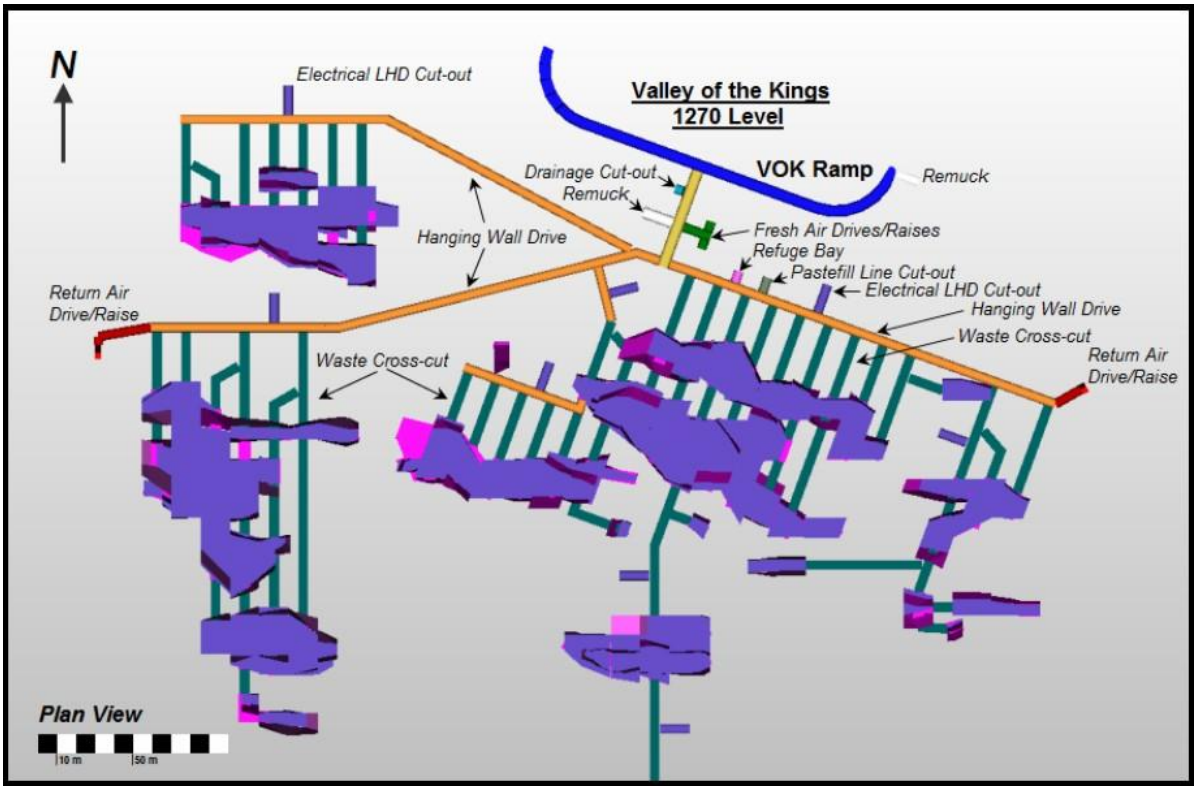

Figure 4-4. Mine Development and Infrastructure, VOK 1270 Level (Tetra Tech, 2013)

Transverse LHOS is a non-entry method, with remote mucking of blasted ore required once the drawpoint brow is open to the extent where the operator may be exposed to uncontrolled sloughing from the stope cavity. Once emptied of ore, the stope will be remotely surveyed with cavity monitoring equipment. A barricade will be constructed in the drawpoint and the stope backfilled to just below the floor elevation of the top level. Crushed aggregate or ROM waste may be spread over the fill surface to reduce backfill dilution and increase trafficability of mucking equipment for the next lift of the stope.

The primary means of backfilling at the property will be paste fill, which will be generated from unclassified mill tailings mixed with adequate cementitious binder to meet the strength requirements. Regular strength paste fill is commonly required where there will be re-exposure of vertical stope walls. Stopes that will not be re-exposed by adjacent mining are proposed to be backfilled with unconsolidated waste and/or by paste fill with sufficient binder to remove any risk of future liquefaction (low-strength paste fill). High-strength paste fill will be required in the lower portion of all primary and secondary stopes that will be undercut by sill extraction from below.

The minimum recommended crown pillar thickness for the Brucejack mine is 15 m, determined using a number of industry standard geotechnical methods and techniques (BGC, 2013). The maximum recommended transverse stope span is 10 m for all stopes immediately below the crown pillar. Transverse stopes immediately below the crown must be

tight-filled as much as practicable to reduce the potential for crown pillar collapse. The crown pillars are also to be supported with 5.0 m long single strand bulbed cable bolts on 2.5 m spacing, to assist with enhancing stability conditions and preventing the onset of subsidence mechanisms.

5.0 POTENTIAL FOR SURFACE SUBSIDENCE AT THE BRUCEJACK PROJECT

A preliminary review of the site specific conditions and factors affecting the potential for subsidence at the Brucejack Project indicates a very low probability that significant subsidence will occur. This conclusion is based primarily on the following facts:

- Because the overburden is thin (< 5 m) and generally has a low clay content, dewatering of the project area is not anticipated to cause consolidation and subsidence in the overburden.
- The rock mass at Brucejack is classified as Good to Very Good and Medium Strong to Strong, using industry standard classification systems. Rock of this quality around the periphery of an excavation limits the failure of overlying strata, resulting in a lower likelihood and severity of subsidence.
- The Brucejack deposit is a steeply-dipping vein-type deposit. The principal risks for the safety of people and property located at surface above vein-type deposits is often concentrated above crown pillars and represents a relatively limited zone of influence at surface.
- The proposed mine footprint, while substantial, is not on the scale of other vein-type mining districts where significant subsidence has typically been recorded (e.g. tens to hundreds of hectares vs. thousands to tens of thousands of hectares).
- The proposed mining method of long hole open stoping with complete paste backfilling significantly reduces post-mining void volumes. Most often subsidence occurring as a result of stope mining techniques is limited to the hanging wall side of underlying stopes. In many cases, the degree of surface subsidence that occurs from stope mining is both isolated and relatively minor. Complete mine backfilling further reduces subsidence potential, often to virtually undetectable levels.
- To improve near-surface stability conditions at the Brucejack Project, a minimum recommended crown pillar thickness of 15 m has been determined using a number of industry standard geotechnical methods and techniques. The crown pillars are also to be supported with cable bolts to assist with enhancing stability conditions and preventing the onset of subsidence mechanisms.

Notwithstanding the above, the presence of a number of significant regional geologic structures in the Brucejack Project area may negatively influence rock mass stability and increase the potential for mining induced subsidence. Continuous subsidence monitoring and

further study of these structures will improve the level of understanding with respect to this potential.

6.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of Pretium Resources Inc. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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We trust the above satisfies your requirements at this time. Should you have any questions or comments, please do not hesitate to contact us.

Yours sincerely,

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Appendix B: SRK Subsidence Monitoring and Management Plan Memo

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Memo

To:	Sylvia Van Zalingen, Lyle Morgenthaler, and George Friesen	**Client:**	Pretium Resources Inc.
From:	Tim Coleman	**Project No:**	1CP026.003
Cc:	Baoyao Tang and Woo Shin	**Date:**	October 26, 2023
Subject:	Subsidence Monitoring and Management Plan		

1 Introduction

Pretium Resources Inc. (Pretium) retained SRK Consulting (Canada) Inc. (SRK) to prepare a Subsidence Monitoring and Management Plan (referenced here in as the SMMP or the Plan) for Brucejack Gold Mine as per *Mines Act* Permit M-243 Condition D.13.

Subsidence is an inevitable consequence of the extraction of minerals, liquid, or gas from beneath the ground surface. The surface expression may be of a small magnitude and localised or extend over large areas. Subsidence may occur immediately with mining or may be delayed by many years. Geology and mining methods are the main variables that dictate the magnitude of impact of subsidence and cannot be ignored.

The enclosed SMMP has evaluated the effectiveness of subsidence controls to provide an early warning of surface expression that may result in changes to terrestrial or aquatic values. Subsequently, this plan includes adaptive management measures for monitoring subsidence and developing mitigation measures as needed.

1.1 Mining Method

The underground mine comprises two main ore zones: Valley of the Kings (VOK) zone, and the West zone (Figure 1-1). The mine began commercial operation in July 2017 with production from the VOK zone. There has been no production to date in the West zone. The mining method at Brucejack is long-hole stoping; a combination of longitudinal and transverse mining is used depending on the width and orientation of the mineralized zones. The mine employs an overhand primary/secondary stoping method with cemented tailings pastefill used to backfill stopes after mining.

Predominantly, the underground development at Brucejack measures 5.5 m wide by 5.5 m high, with an increase in height to 6 m on the main ramp and crossover drives. In ore development, crosscuts are 5 m wide and 5 m high. Where stopes are to be mined, the undercut is slashed out to a total width of 15 m.

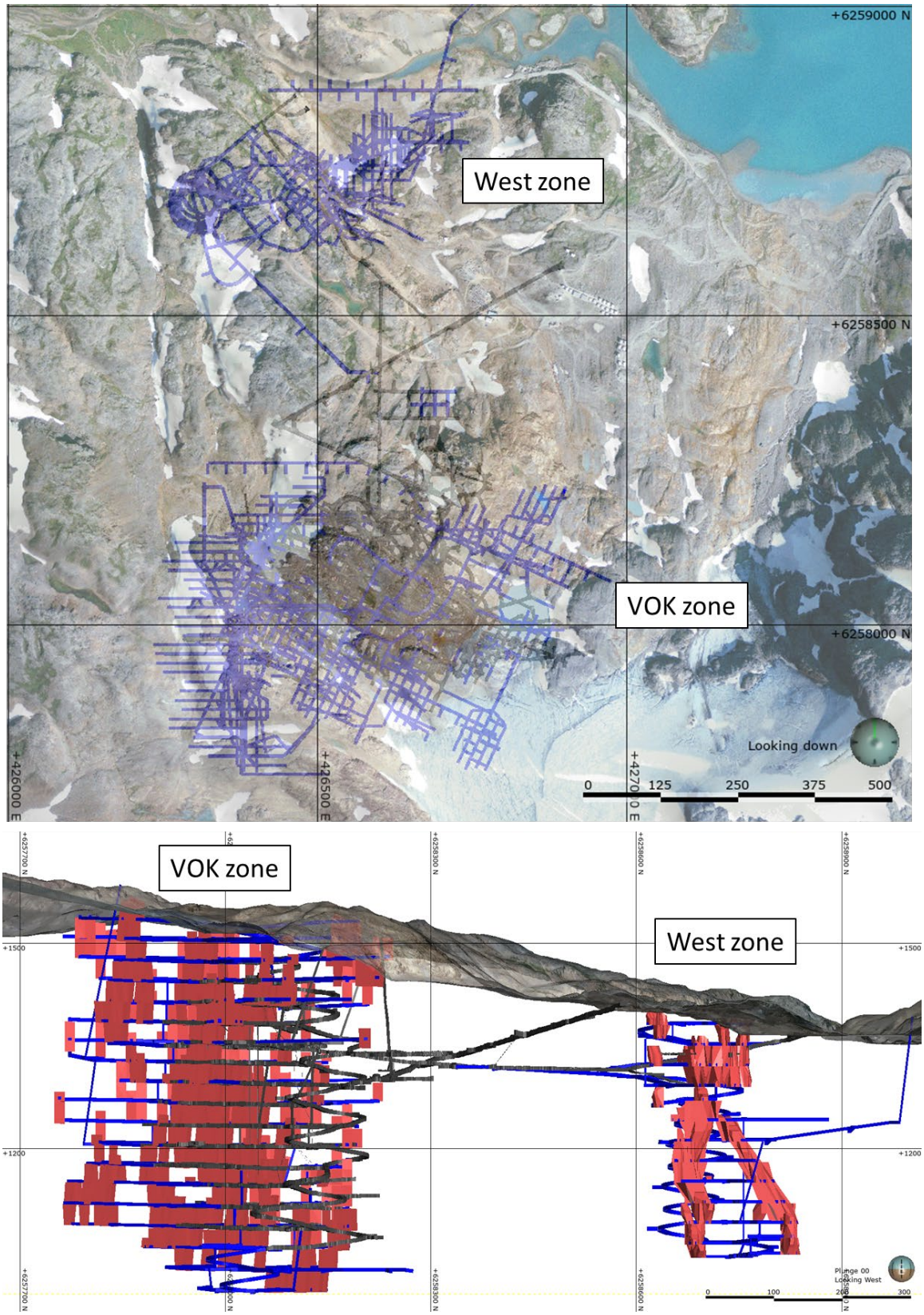

Figure 1-1: Plan View (top) and Oblique View looking West of the VOK and West zones

Underground developments are supported by installation of cable bolts in the upper stopes to reinforce the crown pillar and backfilling with waste rock and cemented tailings backfill upon completion. Supported mining methods, as such have a reduced subsidence impact when compared with alternative unsupported methods.

The mine's current production rate is approximately 3,800 tonnes per day and has an anticipated mine life of 14 years.

1.2 Geology

The Brucejack gold-silver deposit is located in the Sulphurets gold-silver-copper mining camp. The deposit is interpreted as a deformed porphyry-related gold-silver epithermal deposit. High-grade gold-silver mineralization occurs as coarse aggregates of electrum and silver sulfosalts that are hosted in steeply dipping and predominantly west- to northwest-trending quartz-carbonate vein stockwork and breccia zones within a broader halo of clay alteration and low-grade mineralization.

Mineralized veins and stockwork zones appear to have utilized lithological contacts and pre-existing structures. Epithermal veins are largely discordant to the penetrative foliation of the altered host rock, suggesting that mineralization postdates a fabric-forming event. Mineralized zones were tilted, thrusted, and sheared during Cretaceous compressional deformation.

The Brucejack Ground Control Management Plan (GCMP) classifies the rock mass into a number of "geotechnical units" based on characterization of the rock mass and the presence of major geological structures (Pretivm, 2020).

The geotechnical units in the VOK zone, described in BGC's review of underground geotechnical units (BGC, 2019), are listed in order of increasing competence:

- The weathered zone comprises near-surface rocks.
- The Fault Zone unit comprises rock identified as fault-disturbed rock. It is strong, with good RQD values (75% - 90%), and close discontinuity spacing.
- Rock mass Domain 1 includes the Volcano-sedimentary Facies (argillite portion) geological unit; it very strong, with good RQD values, and moderate discontinuity spacing.
- Rock mass Domain 2 includes the Bridge Zone Porphyry, Office Porphyry, and Silicified Rock geological units; these are strong, with excellent RQD values (>90%), and moderate discontinuity spacing.
- Rock mass Domain 3 includes the Volcaniclastics, Volcano-sedimentary Facies (sandstone-conglomerate portion), S3-Trans and ANDX units; these are strong, with excellent RQD values, and wide discontinuity spacing.

2 Subsidence

The study of mining induced subsidence has predominantly been in connection with the mining of extensive tabular mineral deposits, such as coal and potash, through either longwall or room and pillar mining.

The effects of subsidence are not limited to the vertical displacement of the ground surface but include the total of all surface effects that are associated with the extraction of minerals.

There are essentially three potential surface subsidence effects of underground mining:

- **Trough subsidence** – generally associated with the extraction of relatively flat tabular orebodies. The ground disturbance associated with the trough is generally greater than the extent of the underground workings. Cracks or fissures may be formed at the edges of the subsidence trough and reflect tensile or shear stresses in the ground surface. This is considered to be unlikely at the Brucejack Mine.
- **Collapse subsidence** – caused by the failure of the strata between the underground excavations and the ground surface. The ground disturbance associated with collapse type subsidence can vary in magnitude from a zone around an individual stope (i.e., chimney subsidence) to large areas of a mine (i.e., plug failure). Collapse type subsidence generally exhibits at surface as a sinkhole or conical depression. Cracks or fissures may be formed around the depression or sinkhole.
- **Plug failure** – generally controlled by weak, continuous geological structures in the overlying rock mass or can be initiated by the large-scale failure of pillars, either rock or backfill pillars or a combination of both. Plug subsidence is generally controlled by one or more major structural features, such as a fault or dyke, which provides a continuous plane of weakness or where the shear strength of the rock mass is overcome at a critical stage of mining or through the failure of regional mine support such as pillars or backfill. Structural geology studies conducted on the Brucejack deposit have not identified continuous features that might act as the failure surfaces for a plug type failure.

2.1 Subsidence Assessment

The conventional approach to assessing subsidence effects over metal mines is to consider the stability of the crown pillar formed between the upper limit of mineral extraction and the ground surface. The initial crown pillar stability assessment was conducted by BGC Engineering Inc. (BGC) and described in the original Brucejack Mine Feasibility Study (BGC, 2013). The approach used by BGC in their assessment comprised analytical, empirical and numerical methods.

In order to supplement the approaches used in the initial crown pillar assessment, SRK used an alternate approach. The approach described by Bétournay (2004), examines the effects of the proposed excavations on the overlying rock to identify the portion of the rockmass that can be mobilized and the likelihood of this resulting in failure through to surface.

The Bétournay methodology is based upon the assumption that failure of underground openings is progressive and will not stop until the following is achieved:

- There is a significant improvement in rock mass properties;
- The effective span is reduced by the support provided by the failed rock;
- A stable rock arch is formed; and/or
- The space available for failed rock to occupy is insufficient with the result that the failure chokes off.

The method proposed by Bétournay (2004) utilises the technique that Janelid and Kvapil (1966) proposed for the design of sub-level caving operations. This empirical method calculates the volume of rock that is mobilized when collapse of the stope back occurs and caving is initiated. The caving process can be halted by many factors such as increased rock strength, natural arching of the roof span, and caving hang ups but in the worst-case scenario, the cave will continue until the space available for the caved material to occupy has been completely filled.

The volume of rock that fails into any given excavation is related to stope dimensions, the unfilled volume and the bulking factor of the overlying rock mass. This volume of rock can be defined by the draw cone, or ellipsoid represented in Figure 2-1, and the volume of rock in which movement takes place is defined by the limit ellipsoid. If the ground surface lies within the radius of the draw cone, then complete failure through to ground surface will occur. If the ground surface lies within the radius of the limit ellipsoid, then subsidence of the ground surface can be expected.

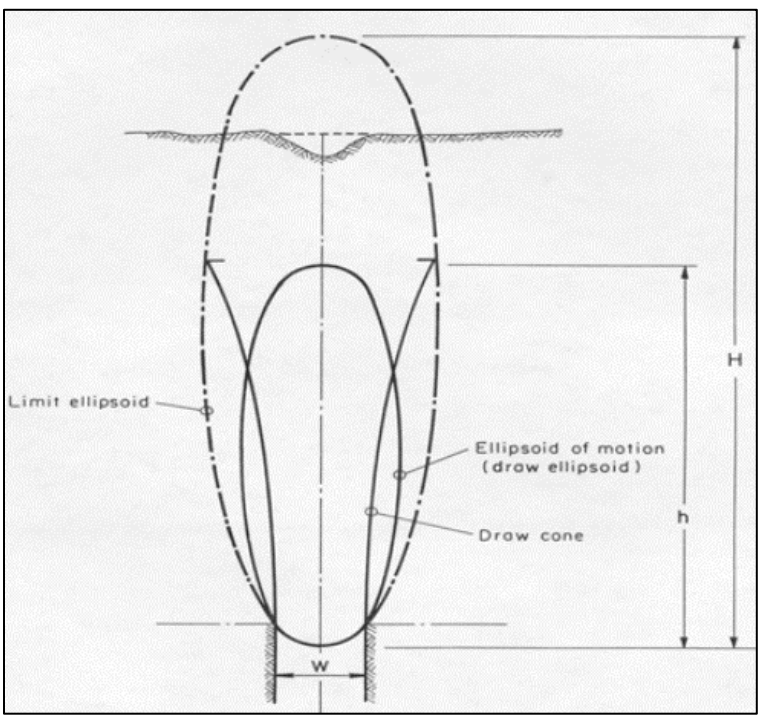

Figure 2-1: Diagram illustrating the effects on ground surface of the draw and limit ellipsoids, Bétournay (2004)

SRK considered a single stope and the footprint of each of the continuous stoping blocks in the main mining zones (the VOK and West zone). An example of the footprint dimensions considered, is shown in Figure 2-2. Although the mine design calls for tight cemented pastefill to the back of the stopes, the assessment adopted a conservative approach and assumed that a 5 m unfilled gap was left above the backfilled stope.

For all the scenarios considered, the unravelling progressive failure described by Bétournay (2004) becomes self limiting with the limit ellipsoid height being less than 5 m for all cases. As this is a third of the design crown pillar thickness, no disturbance would be expected to be noticeable at the ground surface.

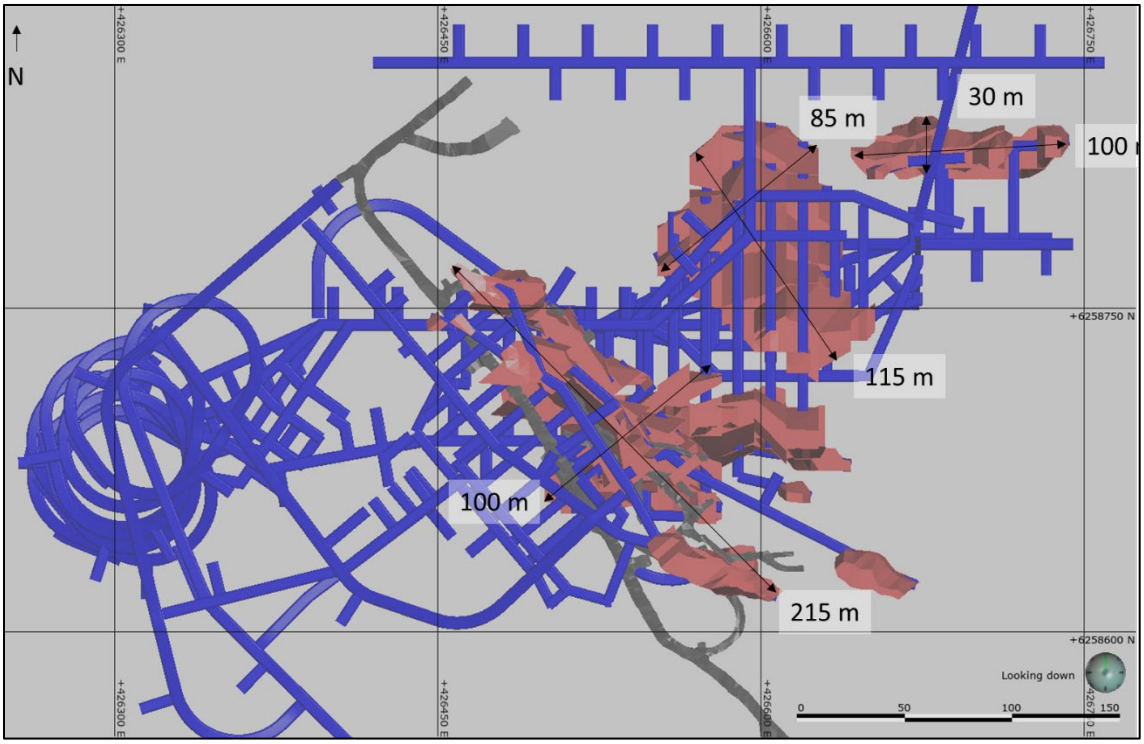

Figure 2-2: Crown pillar footprint dimensions for the West zone

3 Monitoring Plan

Subsidence monitoring plans typically include combinations of visual observations, aerial and satellite photogrammetry and LiDAR, ground-based precision surveys and deformation sensing instrumentation. The topography, mountainous terrain and seasonal snow and ice cover at the Brucejack Mine pose unique challenges to the development of an appropriate subsidence monitoring plan. as the surfaces being monitored for subsidence are under snow cover for extended periods of the year. Furthermore, the supported mining methods employed underground, drastically reduce the magnitude of subsidence effects below the level of detection without the use of precision levelling survey techniques.

The following is a practical subsidence monitoring plan that takes into consideration challenges related to accessibility on the steep mountainous terrain and extended periods that the site is under snow cover. If subsidence is observed, an adaptive management plan (AMP) will be initiated to further monitor deformations (Section 4).

3.1 Annual Photogrammetry

During snow free conditions, Pretivm will complete annual low elevation survey of terrestrial surfaces above underground mining areas (Figure 4.1). Unmanned Areal Vehicles (UAV) or “Drones” are to be used to capture photographs for comparison of surface deformations between subsequent annual photogrammetry surveys.

InSAR satellite interferometry uses radar images taken from a low earth orbiting satellite. Subsequent images are compared to produce an interferogram which can be used to determine ground displacement. The bare rock surfaces of the terrain around the Brucejack Mine site provide excellent reflectors for the radar data suggesting that the InSAR method could be the ideal solution for monitoring ground deformation. Measurement precision is typically in the order of 1 cm with a 1 m by 1 m pixel size. In ideal conditions, precision can be as good as 1 mm.

SRK suggests that Pretivm and the Brucejack technical team approach one of the InSAR service providers to determine whether the mine’s location and aspect is amenable to the use of this approach.

3.2 LiDAR

The price point for LiDAR data comes at a much higher cost than photogrammetry and InSAR. It would be unrealistic to require annual LiDAR surveys to monitor subsidence. In 2019, Pretivm obtained a comprehensive LiDAR scan of the mine area. This data can be used as a basis for comparison when future survey data becomes available.

3.3 Precision Levelling Survey

The implementation of a precision levelling monitoring programme would require the installation of stable reference survey monuments that have the capability to survive the significant seasonal processes that occur in alpine environments subjected to high snowfall. These precision levelling surveys would have to be completed in late summer when snow cover is at it’s lowest and would be limited to those areas in which safe personnel access would be possible.

Although the levelling method provides the greatest precision (sub-millimetre measurements are possible), the limits on areal coverage resulting from the terrain and the challenge of maintaining reference survey monuments, means this method is not the most applicable for broad site-wide subsidence monitoring. SRK suggest that a single levelling traverse is established on the long axis of the main VOK and another traverse along the long axis of the West Zone ore zone. These would serve to provide a calibration/check on the potential deformation detected by other monitoring methods. Broader application of this monitoring technique is best suited as an

adaptive management strategy to monitor localized subsidence if surface deformations are observed.

3.4 Reporting

An annual subsidence monitoring report will be prepared by a qualified person to support submission of Pretivm's Annual Reports to the British Columbia Ministry of Energy and Mines. The report will review the location of mining activities, the mined geology, and summarize the annual photogrammetry data in relation to any surface subsidence observed since the previous annual subsidence monitoring report. The report will detail location and magnitude of subsidence and any adaptive management activities that were triggered to further monitor deformation.

A key component of the annual report is to review and update the SMMP to ensure that it is kept up to date and that the best available technologies are used for monitoring subsidence at this mine site.

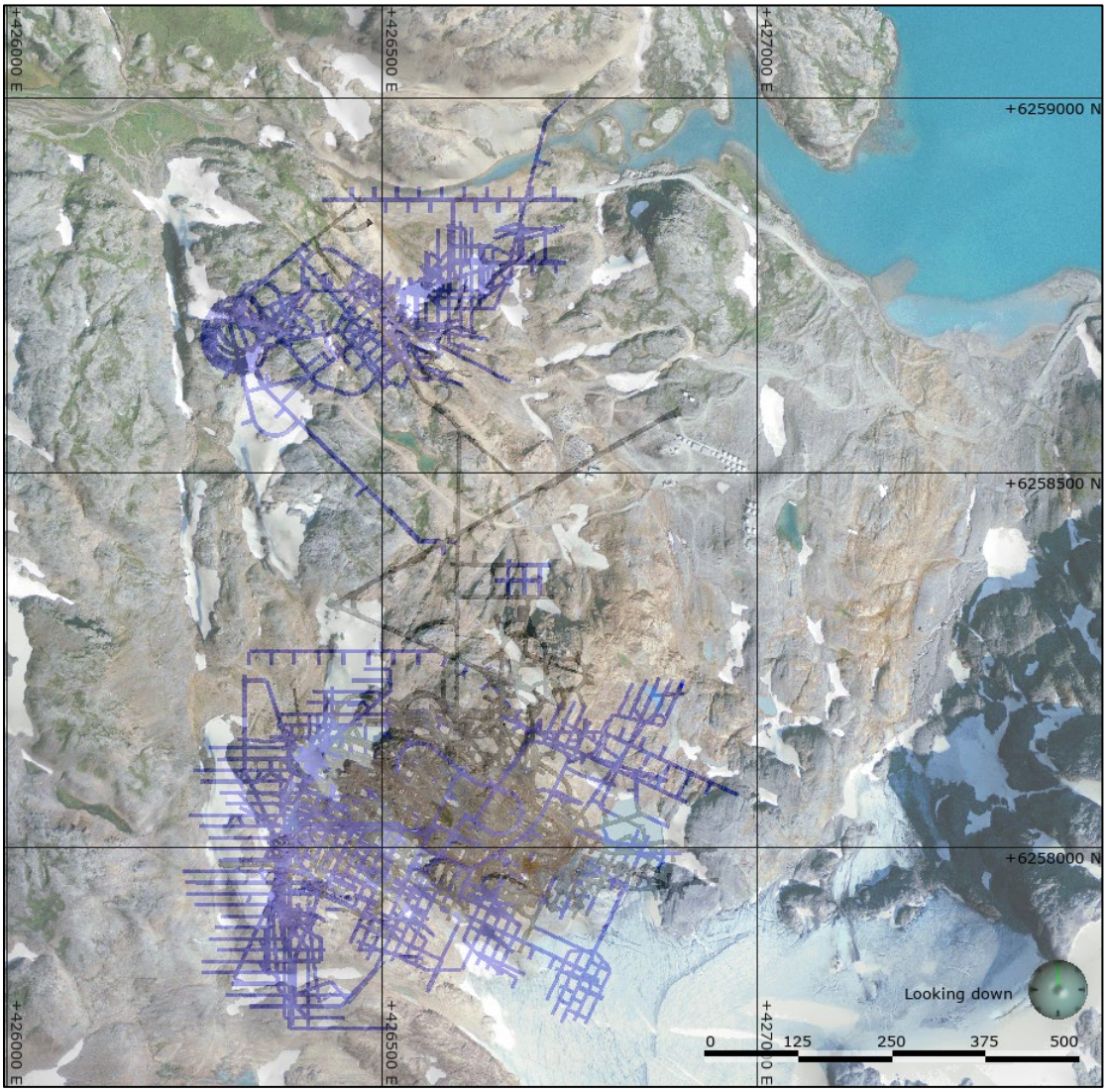

Figure 3-1: Relationship of current and planned underground excavations and surface features

4 Adaptive Management Plan

An AMP for subsidence monitoring would be triggered if subsidence is observed on the ground surface. Also, if a concern is raised that underground mining will induce a surface subsidence.

When triggered, the AMP will include the following steps:

1) **Ensure the safety of workers:** This may include the egress of underground miners and cordoning off surface mining infrastructure in a zone of potential subsidence influence. If the subsidence immediately threatens worker safety, a “Stop Work Order” should be placed on immediate work areas and staff removed from the area and reported to appropriate authorities.

2) **Evaluate magnitudes and extents:** Pretivm’s geotechnical engineers will evaluate the subsidence and geology to determine the risk potential that the subsidence will impact surface infrastructure, the work areas for staff and the environment.

3) **Monitoring:** A localized precision levelling monitoring programme will be developed by Pretivm’s geotechnical engineers to monitor deformations. Typically, this will include installing survey monuments within the observed subsidence and peripherally, around the perimeter immediately outside of the area. The geotechnical engineers will determine the locations of surveys and the frequency of the measurements.

4) **Documentation:** Pretivm’s geotechnical engineers will document the subsidence and deformation survey data that should be included in the Annual Subsidence Report.

5) **Revise the Mining Methods:** Based on the evaluation completed by Pretivm’s geotechnical engineers, it may be necessary to revise the mining methods in order to limit future events.

5 Summary

A review of the site-specific conditions and factors affecting the potential for subsidence at the Brucejack Mine indicate a very low probability that noticeable subsidence at surface will occur. The two potential subsidence mechanisms identified for a mine of this nature are an unravelling progressive crown pillar failure and plug failure. Both of these potential mechanisms are mitigated by the mining practices used at this mine. These mining practices include the tight placement of cemented pastefill in the mined-out stopes and the installation of cable bolts in the upper stopes, to reinforce the crown pillar.

Periodic high precision leveling surveys are strongly recommended in the crown pillar and adjacent areas to provide broader assessment of potential ground movement. There is potential to use InSAR or LiDAR surveys to accomplish this. The benefit of utilising satellite InSAR measurements is that radar images from the past can be used to gain a better understanding of historic deformation. The use of InSAR data could help in the planning and optimisation of other monitoring methods and placement of survey instruments.

Remote sensing technology is rapidly developing. High resolution survey technologies that are considered as cost prohibitive and data intensive, are rapidly being refined. It is important to review and update this SMMP to ensure that monitoring practices are evaluated to the latest technologies.

SRK Consulting (Canada) Inc.

6/10/23

PROFESSIONAL PROVINCE OF T. J. COLEMAN # 46105 BRITISH COLUMBIA ENGINEER

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

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Appendix 9-2-9. Surface Erosion Prevention and Sediment Control Plan

PRETIVM

BRUCEJACK GOLD MINE PROJECT

Surface Erosion Prevention and Sediment Control Management Plan

Date: March 2015

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VERSION CONTROL

Revision #	Date Released	Approved By	Amendment
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BRUCEJACK GOLD MINE PROJECT

Surface Erosion Prevention and Sediment Control Management Plan

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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

BC	British Columbia
BC MEMPR	British Columbia Ministry of Mining, Energy and Petroleum Resources
BC MOE	British Columbia Ministry of Environment
BC MOF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Land and Air Protection
BCWQG	British Columbia Water Quality Guidelines
BGC	BGC Engineering Inc.
BMP	Best management practice
CWP	Contact water pond
DFO	Fisheries and Oceans Canada
Ecosection	Ecosections are areas with minor physiographic and macroclimatic or oceanographic variations.
EPCM	Engineering Procurement and Construction Manager
EPSC	Erosion prevention and sediment control
NPAG	Not potentially acid generating
NTU	Nephelometric turbidity units
PAG	Potentially acid generating
Positive Drainage	Drainage that directs water away from the structure
Project	Brucejack Gold Mine Project
RECP	Rolled erosion control product
Rescan	Rescan Environmental Services Ltd. (now ERM Consultants Canada Ltd.)
RMA	Riparian Management Area
SEPSC Management Plan	Surface Erosion Prevention and Sediment Control Management Plan

TSFA	Terrain Stability Field Assessment
TSS	Total suspended solid
WTP	Water treatment plant

LIMITATIONS OF REPORT

This Plan is intended to guide construction activities in order to minimize erosion and sedimentation at the Brucejack Gold Mine Project site. This is not an assessment of terrain stability nor is it an assessment of the design of the structures and facilities themselves. The contents of this report are based on the information available at the time it was produced and on the judgement of ERM Consultants Canada Ltd. (ERM) staff. The evaluation presented here will not be substituted for on-site inspection of conditions. Evaluation of potential erosion and sediment delivery must be conducted on site in conjunction with construction activities.

1 PURPOSE

This Surface Erosion Prevention and Sediment Control Management Plan (the SEPSC Management Plan) provides guidance for erosion prevention and sediment control (EPSC) measures to be used during the Construction and Operations phases of the Brucejack Gold Mine Project (the Project; Figure 1-1). The intention is that this Plan informs the development of site-specific EPSC plans and can help to estimate the effort required for EPSC activities during the Construction phase, when the majority of erosion and sediment issues are expected to occur.

For the purposes of this Plan, erosion control refers to those measures that aim to reduce the amount of soil that is detached by water or wind. Erosion control measures include, but are not limited to, re-vegetation, the use of mulches and rolled erosion control products (RECPs), soil bioengineering, slope breaks, surface roughening and terracing, buffer strips, and timing of construction. The primary goal of erosion control is to stabilize sediment, preventing its release from the source.

Whereas erosion control is proactive, sediment control refers to reactive, remedial measures that aim to collect and retain sediment that has already been detached and mobilized. The main purpose of sediment control is to prevent sediment from entering waterways. Measures of sediment control include, but are not limited to, sediment fences, check dams, wattles and fascines, berms and earth dikes, and sediment retention pools. Some of these measures, such as check dams, wattles, and fascines, can function as both prevention erosion and sediment control. For example, a check dam used as a slope break will slow water, simultaneously reducing surface erosion and promoting sediment deposition.

Figure 1-1

Brucejack Gold Mine Project: Location and Major Components

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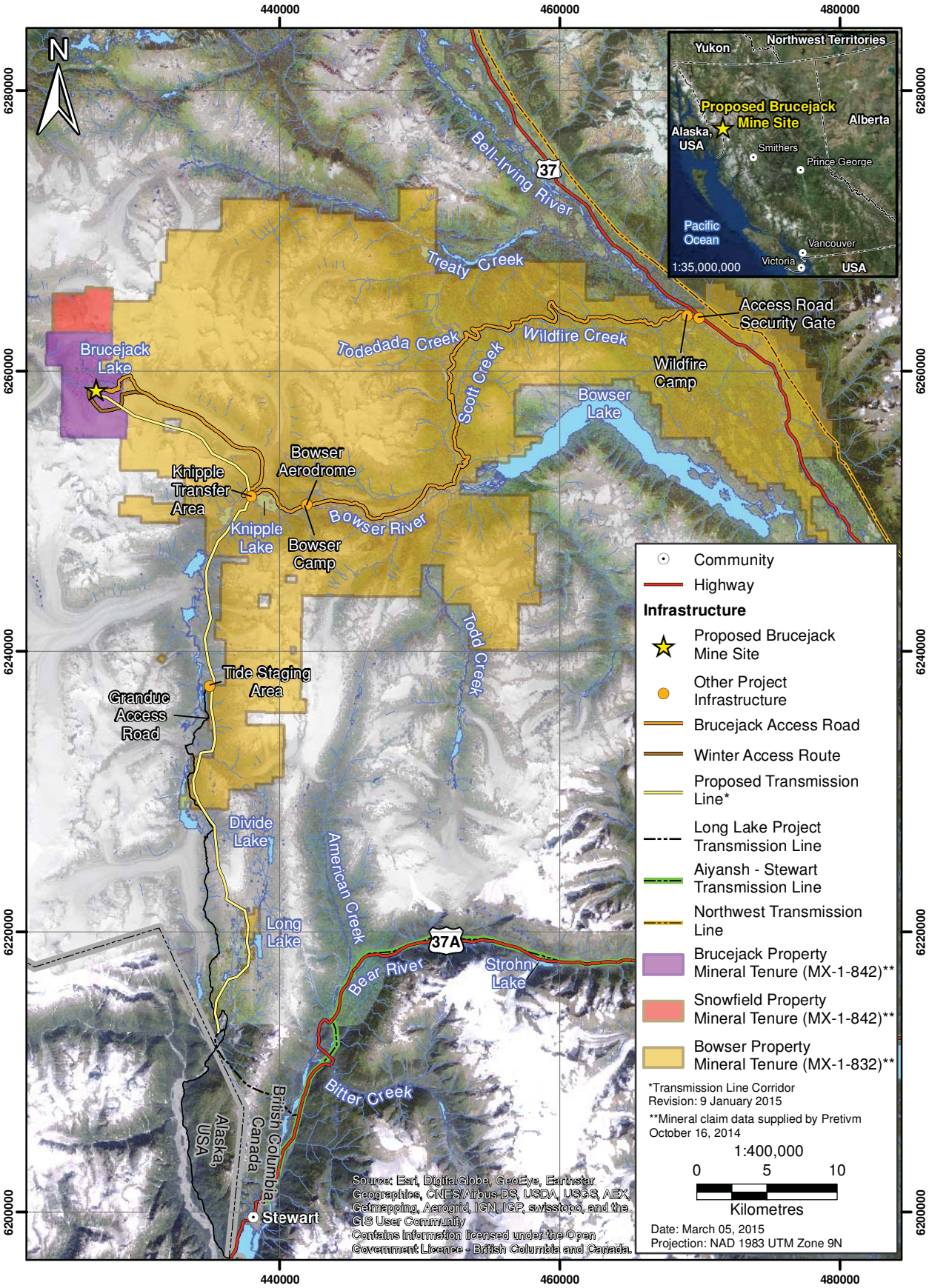


2 PERFORMANCE OBJECTIVES

The SEPSC Management Plan provides guidance for achieving the following performance objectives during the Construction phase of the Project:

- ongoing compliance with regulatory commitments, guidelines, and objectives;
- implementation of environmental protection measures in a timely, effective, and cost-efficient manner;
- integration of EPSC management activities with other management and monitoring programs;
- interception and diversion of non-contact water away from work areas using ditches, berms, or other diversion structures to prevent erosion and sedimentation; and
- descriptions of typical best management practices (BMPs) for several expected activities during the Construction and Operations phases.

3 SCOPE

This Plan is applicable to the Construction phase in the following Project areas:

- Brucejack Access Road;
- Mine Site;
- not potentially acid-generating (NPAG) Quarry;
- Mine Site gravel borrow sources and other borrows;
- Knipple Transfer Area;
- Bowser Aerodrome;
- Bowser Camp; and
- Brucejack Transmission Line and Tide Staging Area.

The potential construction activities in these areas have been reviewed to determine the potential sites of erosion and sediment delivery to watercourses. Vulnerable sites typically requiring EPSCs include:

- stream and wetland crossings;
- spoil areas;
- borrow areas;
- sensitive soils (e.g., unconsolidated morainal materials);
- cut-and-fill construction; and
- ditches.

4 RELEVANT LEGISLATION AND REGULATIONS

Relevant federal and provincial legislation and regulations include the following.

- British Columbia (BC) *Environmental Management Act* (2003). Regulates the discharge of air contaminants, liquid effluent, and refuse into the environment, and regulates the management of hazardous wastes.
- BC *Mines Act* (1996a). Provides guidance and approvals for all activities related to the Project, including exploration, development, operations, closure, and reclamation.
- *Health, Safety, and Reclamation Code for Mines in British Columbia* (BC MEMPR 2008). Under the *Mines Act* (1996a), requires the proponent to provide:
  - designs and details for water management structures, water storage, and water treatment facilities;
  - the source, use, and water balance for any water required during Operations;
  - a plan for erosion control and sediment retention; and
  - a reclamation plan.
- *Fisheries Act* (1985b). The *Fisheries Act* was amended in 2012. The changes to the *Fisheries Act* include a prohibition against causing *serious harm to fish* that are part of or support a commercial, recreational, or Aboriginal fishery (Section 35); provisions for flow and passage (Sections 20 and 21); and a framework for regulatory decision-making (Sections 6 and 6.1). Section 36, the key pollution prevention provision, prohibits the deposit of harmful substances into waters frequented by fish, unless authorized by regulations under the *Fisheries Act* or other federal legislation.
- Metal Mining Effluent Regulations (SOR/2002-222). Environmental monitoring and surveillance programs of effluent discharges are requirements of the Metal Mining Effluent Regulations pursuant to the *Fisheries Act*.
- *Canada Water Act* (1985a). Provides the framework for joint federal-provincial management of Canada's water resources.
- BC *Water Act* (1996b). Administers the allocation and management of surface waters in BC. It is the primary legislation for regulating surface water diversion, storage, use, and management of water quality. Approvals and licences under provincial water acts are required to authorize the construction of works for the purposes of diverting, storing, or using water, or causing changes in and about a stream for any purpose.
- *Navigation Protection Act* (1985d). Regulates works that interfere with navigation built in, on, over, under, through, or across navigable waters in Canada.
- *International River Improvements Act* (1985c). Enacted to ensure Canada meets its obligations under the *Boundary Waters Treaty* of 1909. The intent of the treaty is to ensure that Canada's water resources in international waters are developed and used in the best national interest.

Under the Act, a permit is required if the construction of the Project changes the natural flow of an international river (i.e., the Unuk River).

- BC *Forest and Range Practices Act* (2002). Requires that road construction adheres to codes provided in the Forest Service Road Use Regulation (BC Reg. 70/2004), which focuses extensively on erosion prevention.

The following documents were used as primary sources for mitigation and management measures:

- *Water and Air Baseline Monitoring Guidance Document for Mine Proponents* (BC MOE 2012);
- *Forest Practices Code of British Columbia Forest Road Engineering Guidebook* (BC MOF 2002);
- *Forest Management on Fans* (Wilford, Sakals, and Innes 2005);
- *Operational Statement for Overhead Line Construction* (DFO 2007 [Appendix A]); and
- *Operational Statement for Maintenance of Riparian Vegetation in Existing Rights-of-Way* (DFO 2007 [Appendix B]).

It should be noted that the DFO operational statements have been super ceded by 'Measures to Avoid Causing Harm to Fish and Fish Habitat' (http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html). The included operational statements are relevant tools that can be used in developing site specific mitigations and management measures to comply with the *Fisheries Act* as per by 'Measures to Avoid Causing Harm to Fish and Fish Habitat'.

5 ENVIRONMENTAL PROTECTION AND MANAGEMENT

This section provides an overview of general environmental protection plans and resources that can be applied to specific surface EPSC issues at the Project.

5.1 EROSION PREVENTION AND SEDIMENT CONTROL PLANNING

Erosion control measures are practices that aim to reduce the amount of soil that is detached by wind or water. Erosion control measures include, but are not limited to, re-vegetation, the use of mulches and RECPs, bio engineering, slope breaks, surface roughening and terracing, and timing of construction. The primary goal of erosion control is to stabilize soils, preventing them from becoming detached from the source and re-deposited as sediment elsewhere.

Sediment prevention is the reactive remedial measures that aim to collect and retain sediment that has already been detached and mobilized. The main purpose of sediment prevention is to prevent sediment from entering waterways. Measures of sediment prevention include, but are not limited to, sediment fences, check dams, wattles and fascines, berms and earth dikes, and sediment retention ponds. Some of these structures, such as fascines and wattles, can function both as erosion control and sediment prevention. For example, a check dam used as a slope break will slow water, simultaneously reducing surface erosion and promoting sediment deposition.

5.1.1 Site-Specific Plans and Engineered Designs

Implementation of the SEPSC Management Plan will require an ability to adapt to changing site conditions, and perhaps modifications to construction plans. Prior to beginning construction at a specific site, the Environmental Monitor will collaborate with construction personnel on site to develop a site-specific plan that identifies any soil-disturbing activities. The plan will consider all ground-cover disturbance activities planned for the site and the proposed BMPs associated with each activity, using this SEPSC Management Plan for guidance. The site-specific plan will be flexible and adaptable. All construction personnel working at the site will be advised of the plan's goals and their responsibilities in order to implement the plan successfully.

A kick-off field visit will be conducted for each construction site to determine if a site-specific plan will be required. The field visit will consist of an on-site assessment by the construction managers and environmental monitors. At each construction site, any key areas will be identified prior to beginning work. These include:

- areas requiring protective measures, such as riparian management areas (RMAs);
- upslope locations where runoff could enter the site and potential routes for diverting the runoff around, or routing it through, the site; and
- highly erodible areas (e.g., steep slopes, unconsolidated morainal material).

Prior to beginning work, the work boundaries at each site will be identified and flagged to confine construction activities within the designated boundaries. Based on information gathered during the site assessment, a supply of EPSC materials such as culverts, riprap geotextiles, and sediment fencing will be provided at the site for immediate use to avoid construction delays.

5.1.2 Response and Contingency Plans

Implementations of BMPs are the key to preventing erosion and controlling sediment on a construction site. Proper and timely implementations of BMPs are often sufficient to meet total suspended solids (TSS) concentrations in runoff at levels that meet guideline criteria (Section 7.2).

Management for EPSC at the Project will be active and adaptive, incorporating ongoing inspection, maintenance, and re-evaluation of the effectiveness of the implemented BMPs. During emergencies, such as extreme precipitation events, it is extremely important that contingency measures are in place, to be implemented if required.

The structure of this SEPSC Management Plan reflects a hierarchy of responses to potential erosion and sediment transport events resulting from construction. BMPs and a corresponding inspection, maintenance, and monitoring program constitute the basis of EPSC planning. If the results of monitoring indicate that the BMPs on a site are not adequate to meet adjacent stream water quality objectives, the first step is an assessment of current BMPs to confirm that they are installed correctly and functioning as intended. The next step is reassessment of the existing BMPs to evaluate whether they are appropriately sized for the contributing drainage area and to determine whether more frequent maintenance or an alternative or additional BMP may be required.

As a contingency measure, installation of sediment retention structures has been considered in the event that reassessment and correction of existing BMPs do not achieve a sufficient reduction in TSS levels. Sediment retention structures are a form of BMP, but they are addressed independently in this report (Appendices C, D, and E) because in many cases their design, installation, and operation require additional considerations. Numerous size and design options exist depending on site-specific requirements, ranging from small sediment pools or traps to detain local runoff (e.g., at culvert inlets) to large sediment ponds requiring engineered design.

Sediment control ponds are a contingency measure for managing surface runoff from clearing, grubbing, and other surface construction activities. Some pond capacity will be available at the Mine Site for emergency storm water management or where BMPs are not effective in preventing erosion or controlling detached sediment. Discharge from the ponds will be monitored for compliance with BC Water Quality Guidelines (BCWQGs) for TSS concentrations.

5.1.3 Site Resources for Erosion Prevention and Sediment Control

A supply of EPSC equipment and materials will be maintained in locations that are easily identifiable and accessible to construction sites in the Project area. These EPSC supplies will include materials for routine BMP maintenance and repair as well as contingency supplies to be used in the event of an emergency. Supplies may include, but are not limited to:

- geotextile, polyethylene sheeting, and/or other forms of RECPs;
- shovels and other hand tools;
- tarps;
- sediment fencing;
- piping;
- approved grass seed and spreader;
- stakes and signage;
- crushed and washed NPAG gravel or rock riprap;
- mulching materials such as bark, straw, or sawdust;
- sandbags (filled with clean sand, or with a clean sand source readily available); and
- portable water pumps and hoses.

The on-site supply of EPSC materials will be regularly inventoried, and materials that are used up will be promptly replaced, as determined by the Construction Management Team.

5.2 EROSION PREVENTION AND SEDIMENT CONTROL BEST MANAGEMENT PRACTICES

Erosion and sediment production can be minimized on a site through the implementation of BMPs, both prior to, during, and immediately following Construction. This section contains an overview of the EPSC BMPs generally applicable to activities that have been identified to occur during Project Construction. A detailed summary table and typical drawings are included in Appendices C, D, and E.

5.3 EROSION PREVENTION AND SEDIMENT CONTROL– TYPICAL CONSTRUCTION ACTIVITIES

5.3.1 Work in or near Streams

Stream crossing upgrades are not anticipated during the Construction phase; however, controls at road crossings may need to be installed as there may be potential for increased sediment delivery to streams at these locations. Construction near stream channels will adhere to all applicable legislation and guidelines (e.g., Appendices A and B) to minimize disturbance to stream banks and riparian habitat. For work within riparian areas, consideration will be given to salvaging rooted shrubs and maintaining as much vegetation as feasible.

While stream crossing construction in not anticipated, if it were to occur, it will be scheduled for dry or low water periods, whenever feasible. Surface Water Hydrology baseline reports (Rescan 2011a, 2013a, 2014) may be consulted for general seasonal discharge variability of creeks related to the Project.

Fording may be permitted in creeks that are classified as non-fish bearing, where fish habitat is not located within 250 m of the proposed ford, and where creek substrate is not likely to cause significant sediment production. This information on designated fish habitat in the Project can be confirmed by referring to the Fish and Fish Habitat Baseline Reports (Rescan 2011b, 2012, 2013b). If fording is considered, clean logs or large rocks will be placed in the creek such that machine tracks or tires do not contact moving water and such that banks are not disturbed. Any material placed in the creek will be removed once the fording is complete. Fording creeks will be limited to one crossing per machine and will only be considered a temporary measure. When fording is required for more than one week, a temporary crossing will be installed.

Work in or near streams will adhere to the guidelines in the *Riparian Management Area Guidebook* (BC MOF 1995) and the *Standards and Best Practices for Instream Works* (BC MWLAP 2004). An additional resource is the interactive BC Ministry of Environment Instream Works website (BC MOE 2011).

If there are work activities not currently planned in and around fish bearing waters, such as stream crossings along the Brucejack Access Road, an authorization to cause *serious harm to fish* will be applied for from Fisheries and Oceans Canada (DFO) before proceeding. A site-specific EPSC plan including all instream works will be completed, in addition to the permitting requirements. Guidance for site-specific plans for work in fish-bearing streams may be found in the *Fish-Stream Crossing Guidebook* (BC MOF 2012).

5.3.2 Cut and Fill Construction

Cut and fill construction is also known as side cast or partial bench construction. This will be the most common building technique used during upgrades along the Brucejack Access Road. These cut and fill slopes are also the design elements of the road that have the highest surface erosion potential.

Cuts may be excavated out of steep hillslopes with poor soils that cannot support side casting, as in the case of full bench construction. Fills constructed by side casting in steep terrain have the potential to over steepen slopes. In areas where side casting is unsuitable, the road design will consider end-hauling cut material to a designated spoil site.

Cuts and fills will be re-vegetated as soon as feasible after construction is complete. During construction, the use of mulches or mats in conjunction with seeding may be required to minimize erosion prior to the establishment of new vegetation.

Steep sections of the road will be constructed using full bench construction. This type of construction uses only a cut and is preferred where the slope is too steep to support a fill. This method is often used in conjunction with steep rocky terrain. These areas have a low surface erosion potential when constructed in rock.

5.3.3 Construction in Sensitive Soils

Soil sensitivity to erosion depends primarily on grain size (BC MOF 1993). Fine-grained material such as fine sands and silts are the most erodible. Clay is also erodible; however, clays exhibit cohesion such that the individual clay particles can be difficult to detach, providing erosion

resistance. The erodibility of surficial materials is heightened in areas where the materials are deposited in a thin veneer over bedrock.

Organic materials that are intact on the soil surface provide a measure of erosion resistance by protecting the soil from rain splash and runoff erosion. However, once disturbed, organic materials are highly susceptible to erosion and entrainment due to their large proportion of fine-grained materials. Once removed from the soil surface, organic materials must be handled carefully during earth-disturbing construction activities. Organic soils are generally found in gently sloping to flat areas (e.g., wetlands), decreasing the chances of detachment and entrainment by runoff.

The length of time required to settle particles of entrained sediment is directly related to grain size. The selection of appropriate sediment control measures also depends in part on grain size. The smaller the particle, the more difficult it is to remove from suspension. Coarse particles do not require long settling times and are therefore relatively easy to remove from suspension. Sediment fences are suitable for retaining coarse particles, but they do not function well for retaining fine-textured soils. Fine sands and silt particles are considerably more difficult to retain than coarser sands, requiring slower water velocities and a longer retention time. Removal of fine-grained particles from entrainment is often only feasible with berms, earth dikes, or sediment retention basins (smaller pools or larger ponds). The removal of clay particles from entrainment generally requires large settling ponds, which are unfeasible along the Brucejack Access Road corridor. Although smaller sediment retention pools will help to remove fine particles from suspension, they are not likely to settle clays. This emphasizes the importance of preventing erosion of fine grained materials at the source to avoid expensive and elaborate sediment control systems.

Construction in sensitive materials will be conducted during periods of dry weather whenever feasible. Where materials are deposited in veneers, removal of the sediment from the bedrock will reduce the likelihood of erosion. Organic soils, along with other sensitive fine-grained materials, will be excavated wherever feasible as a first step to site development. The excavated materials will be removed to a stable spoil location and stored for future reclamation activities. Re-vegetation and stabilization of sensitive sites will be prioritized as soon as construction in these areas is complete. Identification of sensitive soils will be done by the Environmental Monitor on site.

5.3.4 Construction-induced Slope Failure

Construction-induced slope failure can occur in unstable terrain, during periods of heavy rainfall, or anywhere that road construction creates excess disturbance to a hillslope. Work in sensitive or potentially unstable areas will not be conducted during heavy rainfall or otherwise adverse weather. Adverse weather conditions that may trigger a stop work order are outlined in Section 5.3.7.

Geohazard risk assessment and terrain stability field assessment (TSFA) documents will be consulted prior to beginning construction, in particular along the Brucejack Access Road.

Installation of gabions or retaining walls may be needed to reduce excavation, contain bank material, or prevent slope failure. The significance of observed seepage zones may dictate the

application of other measures, as prescribed by the on-site engineer, to reduce the likelihood of slope failure during construction.

5.3.5 Clearing

Clearing and grubbing activities expose large quantities of soil, leaving it highly susceptible to erosion. To minimize erosion during clearing and grubbing, the following measures will be implemented.

- Prior to beginning work, perimeter sediment control measures will be established at the downslope edges of the site and along any streams or waterbodies. The type and configuration of sediment control measures will vary depending on specific site characteristics and may include sediment fences, temporary or permanent diversion ditches, and earth or straw bale dikes.
- Work will begin at the top of the construction footprint and move downslope in order to maintain a buffer of vegetation.
- Machine operators will work along slope contours whenever feasible to reduce the potential for channelization and gullying on the slope.
- Soil will only be stripped from areas that will be required to be disturbed to support construction. The width of clearings for any site access will be kept to a minimum.
- Understory vegetation and ground cover will be retained wherever feasible, such as in areas that are only subject to temporary disturbance.
- In areas with exposed soil where construction will be inactive for an extended period of time, temporary covers such as brush, RECPs, or polyethylene sheeting may be used as a protective measure.
- Whenever feasible, clearing and grubbing work will be conducted in dry weather, and work will be temporarily halted during periods of extreme or sustained heavy precipitation.
- As the site is cleared, slope length can be minimized by installing slope breaks such as straw wattles or brush berms. Slopes will be textured or terraced to reduce runoff velocity and volume.
- Topsoil that is removed from a site will be stockpiled for future use in site reclamation. BMPs for stockpiles are described in Section 5.3.12.
- Depending on site characteristics, temporary diversion ditches may be required to collect runoff from areas upslope of the construction works. Flow in these ditches will be directed to stable, vegetated, level areas where the water can infiltrate into the ground. Ditches susceptible to erosion may be lined with geotextiles or riprap.
- Ground surface protection will be concentrated on exposed and steep slopes around the edges of the site, close to drainage channels and at any obvious drainage features.
- Supplemental approaches such as mulching, topsoiling, and/or hydroseeding/hydromulching may be used in conjunction with seeding depending on specific site requirements. Live wattles and fascines may be used as a form of re-vegetation.

5.3.6 Snow Handling

Where construction is carried out in areas with snow cover, proper handling of cleared snow is required. Large amounts of topsoil or organic matter can be entrained during snow removal activities. As this snow melts, fine materials can be transported with the meltwater. To prevent the delivery of fine materials into stream channels, snow will be piled in undisturbed areas with low slopes at a minimum of 30 metres from any waterway. Sediment fencing or berms may be placed around snow piles to trap sediment and prevent erosion if deemed necessary.

5.3.7 Adverse Weather Shutdown Triggers

The potential for surface erosion during periods of severe weather may facilitate shutdown / stop work orders of construction activities. Stop work orders will be based on safety concerns, environmental effects, and protection of Project infrastructure. Stop work orders can be initiated by the Environmental Monitor(s), Environmental Coordinator, Environmental Manager, Health and Safety Manager, Construction Manager(s), or Mine Manager.

Triggers resulting from adverse weather that may cause a shutdown include:

- periods of very high rainfall or extended periods of high rainfall;
- indicators of erosion and instability are encountered;
- unsafe conditions may exist or environmental damage may occur; and
- soils are visibly soft or muddy and associated sediment-laden waters or sediment are flowing towards watercourses or where such conditions are reasonably anticipated to develop.

Traffic restrictions will be put in place in areas that are subject to shut down of construction activities.

Construction activities that may need to be shut down prior to a forecasted maximum rainfall include:

- subgrade construction on slopes over 50% or where naturally occurring slope failures occur;
- bridge or culvert construction;
- work near fish bearing waters;
- work in areas of sensitive soils;
- work near landslides or unstable terrain;
- areas with significant amounts of groundwater seepage; and
- any work designated in the SECSP Plan as requiring dry weather only.

5.3.8 Overlanding Floodplains and Alluvial Fans

Floodplains and alluvial fans are areas of concern during Construction phase activities because they may be subject to flooding during periods of high flow, and because close proximity to streams shortens the distance that sediment-laden water travels from the site to the stream, allowing for direct delivery of sediment into the waterway. Construction in floodplains and fans will be scheduled for dry periods, to the extent feasible. During construction, areas of bare ground will be covered with brush or RECPs if deemed necessary. Slopes on floodplains and fans will be stabilized with riprap armouring. After construction is complete, re-vegetation will take place as soon as feasible. There is limited topsoil inherently available for reclamation in these areas so re-vegetation will be challenging. The selection of plants and planting methods that may be used for re-vegetation will be researched as per the Reclamation and Closure Plan.

5.3.9 Steep Slopes

Slopes greatly increase the potential for erosion if soil or erodible materials are present in sufficient volumes. Runoff velocities and erosion generally increase in proportion to slope steepness. Construction on soil-mantled slopes at moderate to extreme steepness (greater than 26%), as defined by the British Columbia Terrain Classification System (Howes and Kenk 1997) requires special care in the form of diversion measures, slope drains, and slope stabilization measures.

Construction-induced slope failure can occur in unstable terrain, during periods of heavy rainfall, or anywhere that construction creates excess disturbance to a hillslope that is not bedrock. Work in potentially unstable areas will not be conducted during heavy rainfall or otherwise adverse weather. Adverse weather conditions that may trigger a stop work order are outlined in Section 5.3.7.

Geohazard risk assessment and TSFA documents will be consulted prior to beginning construction.

The following are BMPs for steep slopes.

- Maintaining a buffer strip of natural vegetation at the base of a slope is a highly effective method for erosion control and may reduce the need for additional EPSC measures.
- Diversion ditches (temporary or permanent, depending on construction plans and site requirements), earth dikes, or a combination of ditches and dikes can be used to divert runoff from the face of exposed slopes. Temporary diversions must remain in place until slopes have been permanently re-stabilized.
- Flow in diversion ditches will be directed to stable, vegetated, level areas where the water can infiltrate into the soil. Alternately, flows may be directed to a sediment pool or pond. Ditches susceptible to erosion will be lined with geotextiles or NPAG rock.
- Slope drains (temporary or permanent, depending on construction plans and site requirements) may be used alone or in conjunction with diversion ditches. Temporary slope drains may be pipes made of corrugated metal, chlorinated polyvinyl chloride, high-density polyethylene, or other suitable material. Permanent slope drains may be blasted channels in

rock. The inlet and outlet of slope drains will be protected (e.g., using an energy dissipator) to prevent erosion and undercutting.

- Areas cleared to construct a slope drain will be re-vegetated and stabilized. Runoff from slope drains will be directed to stable, level, vegetated areas or to a sediment pool or pond.
- Gabions or retaining walls may be required as permanent measures to stabilize slopes, particularly for slopes that are too steep to establish and retain vegetation. These structures will be designed by a professional engineer.
- Stabilization of slopes will be prioritized as soon as construction in these areas is complete. In areas where re-vegetation is feasible, hydroseeding and hydromulching are effective methods for steep slopes and do not require the seedbed preparation, which may be impractical in steep areas.
- Length and gradient of slopes can be minimized by installing slope breaks, such as terraces or berms. General recommendations for spacing of slope breaks are given in Table 5.3-1.

Table 5.3-1. Recommended Spacing for Slope Breaks

	Slope Gradient	Slope Break Spacing (m)
Steep slopes	2:1 (50%)	6
	3:1 (33%)	11
	4:1 (25%)	14
Long slopes	15-25%	15
	10-15%	24
	6-10%	38
	3-6%	61
	<3%	91

Source: BC MEMNG (2002).

5.3.10 Ditches and Non-contact Water Diversions

5.3.10.1 Ditches

Erosion in gullies and ditches constructed in erodible soils or on steep slopes will be controlled by armouring with vegetation, riprap, geotextiles, or other means to protect the soils and reduce flow velocities. Temporary mitigation for ditch erosion may include check dams constructed with brush or logs. Rock check dams will provide a more durable, permanent method of preventing ditch erosion. In rare instances, temporary ditches constructed in fine soils will be lined with geotextiles to avoid erosion.

Ditchlines will be re-vegetated along with all other exposed soils along the road. Regular inspection of ditches will be conducted to check that associated cuts are not slumping into the ditches and vegetation is established. Inspection will also be conducted to check that catch basins and culverts

remain clear. Ditch stabilization measures that are disturbed by grading or other road maintenance activities will be repaired immediately or removed if no longer required.

Ditchlines at the Mine Site will be directed initially (prior to completion of Phase 1 of the Contact Water Pond [CWP]) to sumps which will be pumped to the water treatment plant (WTP). When directing ditch flow to stable, vegetated, level areas, consideration is given to confirming water can infiltrate into the soil and not cause further erosion. In the case of the NPAG Quarry, the quarry floor will be configured to slope inward to act as a settling basin. Water will be withdrawn (pumped) from the top of this settling basin and directed downslope, where it will drain to Brucejack Lake (BGC 2015).

5.3.10.2 Non-contact Water Diversions

Non-contact water diversions will be installed to prevent non-contact water from entering a work area. Diversion channels will be constructed to the west of the Operations Camp and the south and east sides of the laydown area. These channels will typically follow access roads or the base of rock cuts. A geotextile liner will be used as necessary with riprap to prevent erosion damage to the channel if the scour velocity is exceeded. The diversion channels will discharge directly to Brucejack Creek or Brucejack Lake. Where deemed necessary, geotechnical recommendations will be followed for diversion stability, such as maximum slope angles, rock bolting, and shotcrete. The stability of side slopes will be further addressed as required, by lining protection (riprap or high-density polyethylene lining as warranted by flow velocities).

Further information regarding the design of non-contact water diversions can be found in the Water Management Plan (BGC 2015).

5.3.11 Road Surfaces

Erosion from the road surface will be minimized by proper road design and construction, as well as regular maintenance. Maintenance will include grading and replacement of surface material as required to avoid washboarding, potholes, and puddling of surface water. Surfaces will be capped with appropriate material if erosion problems persist. Roads will be graded to produce a crown, and in-slope or out-slope will be undertaken to avoid puddling. Grader operators will be instructed not to blade material into stream channels or ditches.

Runoff from the roadway will be collected in drainage structures and ditches and directed through the use of ditch blocks into culverts. Inlet basins and settling pools will be constructed at the culvert inlet where necessary to capture fine sediment washed into ditches from cut slopes or the roadway. These structures, especially settling pools, will be maintained regularly to clean out sediment. Low flows of sediment-laden runoff may be directed to vegetated areas. Sediment-laden water will not be directed into natural streams or into areas that drain immediately into natural streams.

5.3.12 Spoil Sites

Soil will be removed from construction sites and stabilized in an appropriate location. Due to long transportation distances, the use of the Brucejack Access Road for transporting construction spoil

materials for use in future site reclamation may be unfeasible. Therefore, the spoil sites associated with road construction will be permanently stabilized, rather than temporarily stockpiled. Spoil sites will be located in the road right-of-way in accordance with standard forest road engineering practices. Spoil materials will not be placed on sensitive soils or in environmentally sensitive areas. Disposal sites will be planned in advance of construction and will be sufficiently stable to support the material, have very low potential for erosion to a stream, and have little or no impact on other forest resource values. Whenever feasible, disposal sites will be constructed in permanent locations to minimize the disturbance and re-handling of material.

As soon as feasible, spoil piles will be graded and seeded to prevent wind and water erosion and to initiate long-term stabilization. If immediate re-vegetation is seasonally unfeasible, materials will be protected by a temporary cover such as RECPs or polyethylene sheeting, as required. Woody debris from cleared sites may be used as a reclamation material, as it creates protected microsites to promote germination and adds organic matter and nutrients. Cover soil will be roughened in order to promote seed catch and germination and to control erosion. Until spoil piles are stabilized by vegetative cover, temporary perimeter sediment controls (e.g., sediment fencing, berms) will be installed around the piles. These temporary measures will be inspected regularly and removed when they are determined to be no longer necessary.

5.3.13 Borrow Sites

Organic and fine-grained soils removed from borrow sites will be stockpiled for use in future reclamation. All borrow sites will be re-sloped to a stable configuration and re-vegetated or otherwise reclaimed after construction is complete.

Perimeter ditches or berms will be placed upslope of the borrow area prior to the start of construction to divert fresh or non-contact water from entering the area where feasible. Should borrow areas sit idle for extended periods, protection of erodible materials by temporary covers such as RECPs or polyethylene sheeting will be considered. At borrow sites, where water from screening and washing activities produces sediment-laden water, this water will be detained on site to reduce suspended sediment prior to discharge from the area.

5.3.14 Contact Water and Settling Ponds

5.3.14.1 Contact Water Pond

The contact water ditches will direct contact water to the CWP, which is sized to contain runoff from the 24-hour, 200-year return period rain-on-snow event (~ 50,000 m^3). The contained water will be pumped to the permanent WTP.

The CWP will be constructed on bedrock with the exception of the north side where an embankment will be required. The combination of bedrock and a liner will minimize seepage from the pond. Construction will start with the installation of sediment control measures such as diversion ditches and silt fences, followed by stripping of any topsoil and overburden, and excavation of bedrock by ripping or drilling and blasting with removal to Brucejack Lake.

Details of the CWP design can be found in the Water Management Plan (BGC 2015).

5.3.14.2 Sediment Ponds / Traps

Sediment ponds are designed to collect and store sediment for extended periods of time. The retention time provided by their relatively large size allows ponds to be capable of settling and retaining smaller grain sizes than sediment traps or swales. Sediment ponds may be temporary or permanent structures and require design by a professional engineer. Sediment ponds are most effective when used in conjunction with other BMPs and will not be used as a stand-alone measure for sediment control.

Small, temporary ponding areas referred to as sediment pools or sediment traps may be used to manage localized overland flow. These structures do not require design by a professional engineer, but they have limited capacity to retain small particles and are only suitable for relatively small contributing drainage areas (less than 1.2 ha). The simplest application of sediment pools is in conjunction with cross drain culverts, where they can be easily constructed by widening and levelling a portion of the drainage ditch that routes flow to the culvert. Sediment pools with gravel outlets may also be installed at the perimeter of construction sites, formed by excavation and/or by constructing an earthen embankment.

Sediment pools will be monitored and maintained on a regular basis until the site is permanently stabilized. Sediment will be periodically removed and stockpiled in a designated location. After site stabilization, pools or traps will be removed and disturbed soil areas resulting from removal will be stabilized.

5.3.15 Concrete Placement

During construction of concrete foundations or pads controlling run-off from the work site, the following is required (BC MOE 2014):

- prevent release of deleterious substances, including sediment, and ensure that all works involving the use of concrete, cement, mortars, and/or other Portland cement or lime-containing construction materials will not deposit (directly or indirectly) sediments, debris, concrete, leachate concrete fines, wash or contact water into or about any watercourse;
- cast-in-place concrete must remain isolated from water inside sealed formed structures until cured (approximately 48 to 72 hours), as concrete leachate is highly toxic to fish and other aquatic life;
- when working in areas near surface water, make available a carbon dioxide (CO_2) tank with regulator, hose, and gas diffuser during concrete work to neutralize pH levels should a spill occur. Staff must be trained in its proper use;
- provide containment facilities for wash-down water from concrete delivery trucks, concrete pumping equipment, and other tools and equipment;

- prevent any water that contacts deleterious uncured or partly cured concrete (during activities like exposed aggregate wash-off, wet curing, or equipment washing) from directly or indirectly entering any watercourse or storm water system;
- isolate and hold any water that contacts uncured or partly cured concrete until the pH is between 6.5 and 8.0 pH units and the turbidity is less than 25 nephelometric turbidity units (NTU), measured to an accuracy of +/- 2 NTU;
- if works are being undertaken in stream, monitor pH frequently in the watercourse immediately downstream of the isolated worksite until the works are completed. Emergency measures should be implemented if downstream pH has changed more than 1.0 pH unit, measured to an accuracy of +/- 0.2 pH units from the background level, or is below 6.0 or above 9.0 pH units; and
- immediately report any spills of sediments, debris, concrete fines, wash, or contact water of reportable quantities.

6 CONSTRUCTION AREA EROSION PREVENTION AND SEDIMENT CONTROLS

This section describes the construction activities that may require EPSC measures within specific infrastructure areas. Management objectives and measures (Appendix C) together with reference to typical BMPs (Appendix D and E) are provided.

6.1 BRUCEJACK ACCESS ROAD

The existing access road was constructed as a temporary, all-season exploration access road that commences at km 216 on Highway 37 and continues westward to Brucejack Lake, a distance of 73 km. There are four access road sections described below (km 0 is located at the intersection with Highway 37):

- Section 1 - km 0 to 35 - road completed in 2011 to 2013;
- Section 2 - km 35 to 59 - road existing prior to 2011;
- Section 3 - km 59 to 71 - Knipple Glacier Road; and
- Section 4 - km 71 to 75.3 - Lakeshore Drive.

The entire length of the access road is referred to as the Brucejack Access Road. The all-weather gravel sections 1 and 2 are collectively referred to as the Lower Brucejack Access Road.

Near Highway 37, the Brucejack Access Road crosses through the Nass Basin Ecosection, a basin of low relief encircled by sharply rising mountains that includes the Boundary Ranges to the west and the Skeena Mountains to the east. Bedrock underlying this basin is predominantly volcanic and sedimentary, and the relief is more subdued than that found in other adjacent ecosections. The soils and rock materials in the area of the Brucejack Access Road are generally considered NPAG (Chapter 5 of ERM Rescan 2014).

A number of geohazard types have been identified along the Brucejack Access Road, including debris and snow avalanche, flood, and rockfall (Table 6.1-1). These locations will be monitored as necessary and mitigation applied where appropriate as per the Geohazards Management Plan.

Table 6.1-1. Geohazard Types Identified along the Brucejack Access Road

Access Road Segment	Road km Reference (+/- 50 m)	Hazard Type
Wildfire Creek (0 to 17 km)	2.3 to 2.7	Debris avalanche
Scott Creek (17 to 35 km)	30 to 31.5	Snow avalanche
	33.8 to 34.2	Debris flow

(continued)

Table 6.1-1. Geohazard Types Identified along the Brucejack Access Road (completed)

Access Road Segment	Road km Reference (+/- 50 m)	Hazard Type
Bowser River to Knipple Glacier (35 to 59 km)	36.6 to 36.7	Flood
	38.0 to 38.3	Flood
	39.5 to 40.0	Snow avalanche
	41.0 to 45.4	Flood
	43.7 to 44.2	Snow avalanche
	45.2	Snow avalanche
	45.3 to45.4	Rock fall impact
	47.8 to 51.8	Flood
	52.0 to 54.0	Flood
	54.8 to 55.8	Snow avalanche
	55.7 to 56.7	Snow avalanche
	57.7 to 58.0	Rockfall
	57.8 to 59.3	Snow avalanche
	58.7 to 59.0	Rockfall
Brucejack Lake	71.2 to 71.3	Rockfall
	72.1 to 72.5	Rockfall
	71.7 to 73.0	Snow avalanche

6.1.1 Description of Works – Construction

Road access to the Brucejack Mine Site will be via the existing 73-km-long exploration access road from Highway 37 (Figure 6.1-1), which will be upgraded to allow for construction and operational traffic. The Brucejack Access Road refers to the entire length of the road and includes the segments of Lakeshore Drive, the Knipple Transfer Area, and the Mine Site. The upgrades to the Brucejack Access Road to accommodate mine traffic (Brucejack Access Road Upgrade Prescription, Cypress Forest Consultants Ltd. 2014) will include minor re-alignments of the sharper curves, reductions of the steeper grades, short sections of double lanes for pull-out areas, widening in areas of reduced visibility, and additional surfacing of some sections; however, it is not anticipated that any upgrades to stream crossings will be required.

The Brucejack Access Road begins at about km 216 on Highway 37, crosses the Bell-Irving River on a single-span bridge and follows the valley of Wildfire Creek to Scott Creek drainage, passes Todedada Lake in the Todedada Creek Valley and proceeds over the pass to follow Scott Creek in the Bowser Valley, which it follows to the toe of the Knipple Glacier. A constructed ramp allows tracked vehicles to access the glacier, which is traversed for about 12 km to its apex near Brucejack Lake where a further 2 km of road leads to the Brucejack Mine Site.

The Brucejack Access Road will have a 5-m stabilized road width and a 40 km/hour design speed. To meet the standards laid out in the *Forest Road Engineering Guidebook* (BC MOF 2002) the road will have:

- a 95-m minimum stopping site distance;
- a minimum horizontal curve radius of 65 m;
- vertical curve values (K values) of 9.6 for crest curves and 8.5 for sag curves;
- favourable grades of 12% (14% for pitches less than 150 m); and
- adverse grades of 8% (10% for pitches less than 100 m).

To address safe two-way traffic along the Brucejack Access Road, the road width will be widened to 10 m (double lane) in locations with sight distances below the minimum site stopping distance of 95 m (blind vertical and horizontal curves).

The section of the Brucejack Access Road from km 71 to 75.3, referred to as Lakeshore Drive (Figure 6.1-2), descends off the Knipple Glacier and traverses open rock and gravels on the south side of Brucejack Lake to the Brucejack Mine Site. Lakeshore Drive will be realigned to address concerns identified with respect to:

- improved gradients for accessing the Knipple Glacier road;
- improved road way that reduces high, steep drop-offs;
- reduced geohazard risk due to the increased distance from avalanche slopes;
- reduced geohazard risk due to the existing Lakeshore Drive acting as a catch bench for falling rocks; and
- access to construction sand and gravel sources.

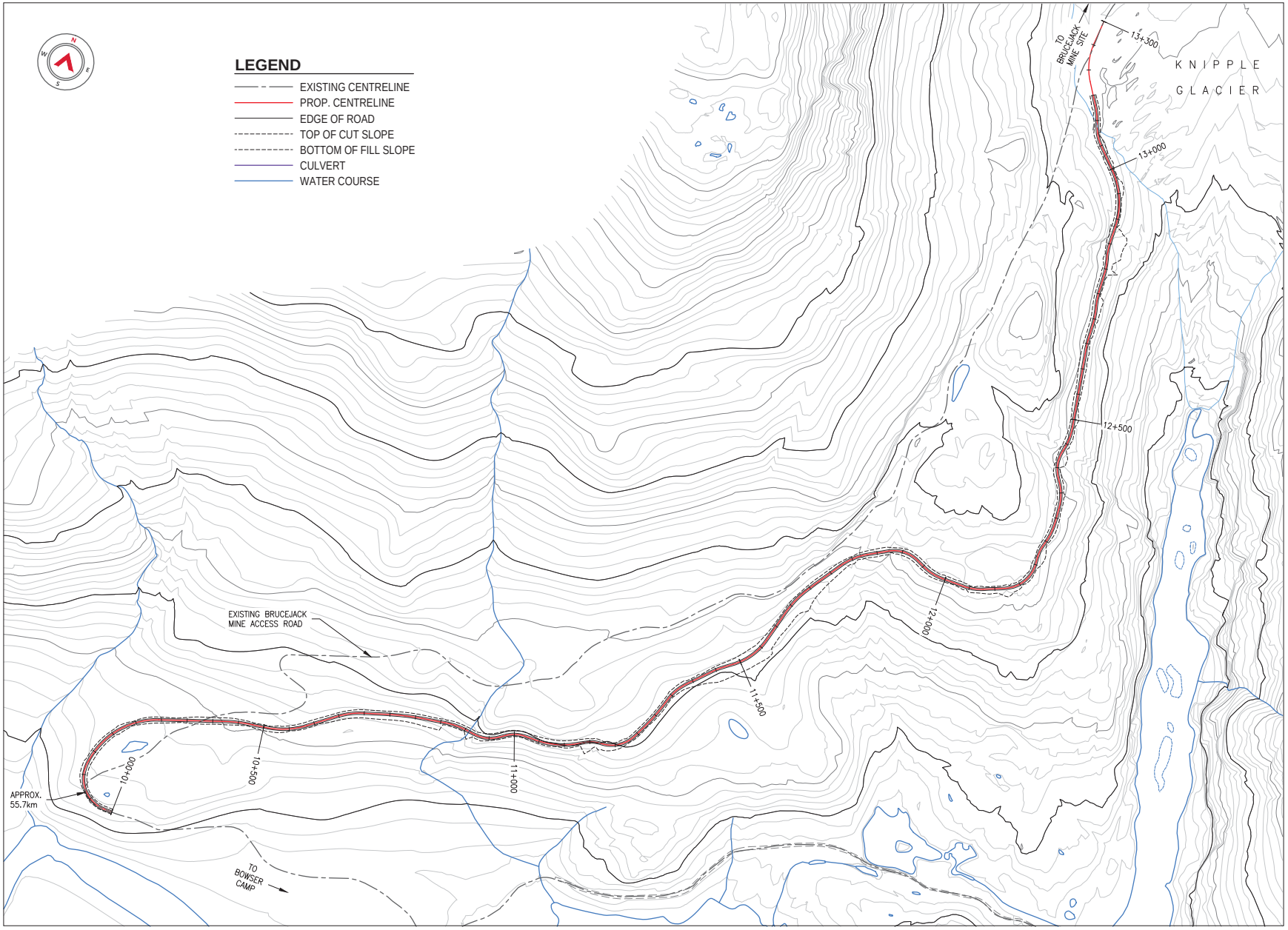
The realignment starts at approximately km 71 and travels in a northern direction. The section from approximately km 71.25 to 72.75 is on the Knipple Glacier. From km 72.75, the route travels westerly for approximately 1 km to 73.75 km; this section transects through the gravel borrow sources required for the Project. From km 73.75, the route continues in a westerly direction along the southern shore of Brucejack Lake to connect back to the existing Lakeshore Drive at approximately km 75.25.

The realignment consists of two segments with differing road design specifications. The segment from 71 km to approximately 73.76 km is a single lane road with a 5-m-wide running surface with pullouts at intervals that provide safe passage for opposing traffic. The road will support the transport of materials and supplies required for construction of the Project site and the long-term operations of the Project. Cross drain culverts will be installed where required to maintain natural drainage patterns.

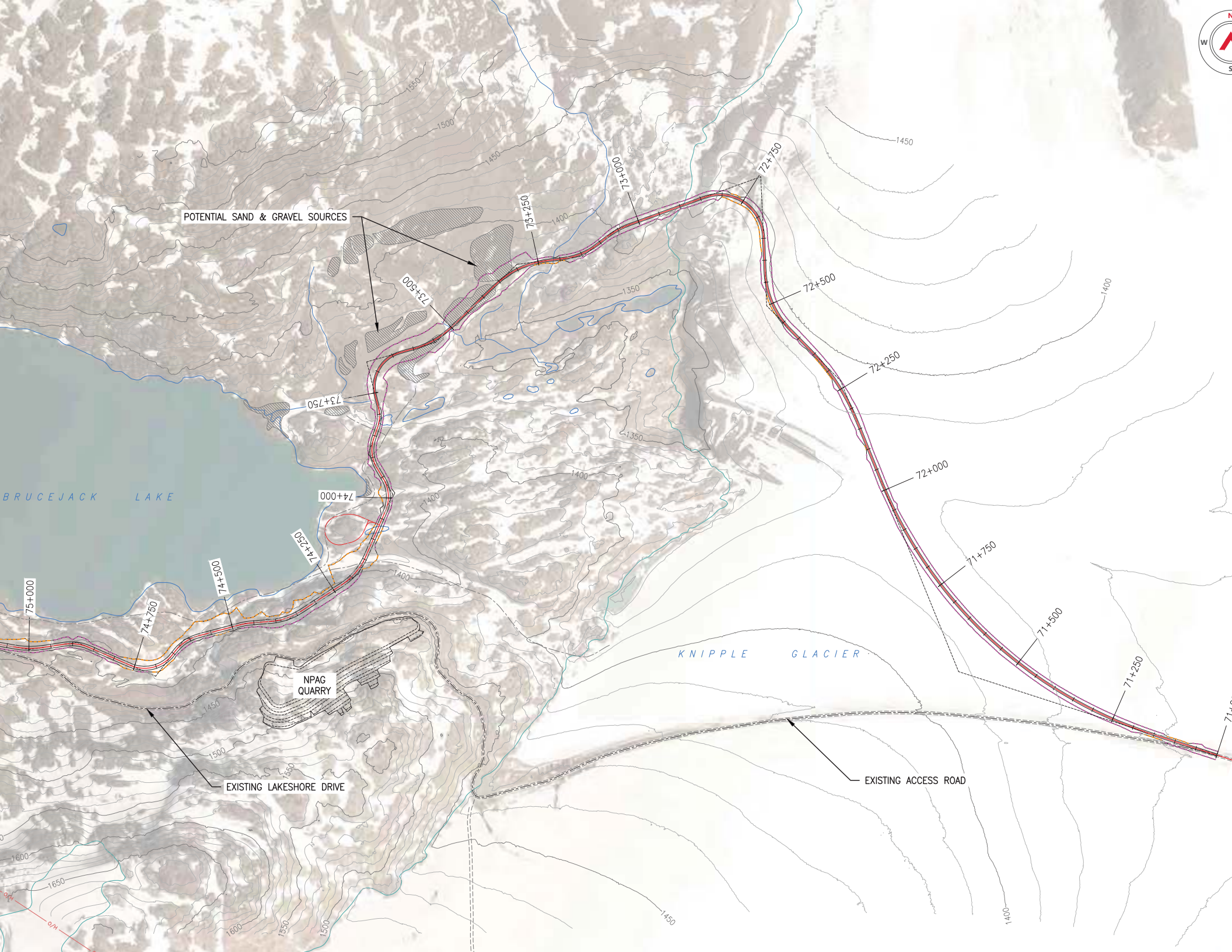
The segment or road from km 73.76 to 75.25 is designed to a similar standard as for a mine haul road as defined in the *Mines Act* (1996a). The road has a running surface of 9 m, which supports the safe passage of 30-tonne articulated rock trucks. The road will also support the transportation of materials and supplies required for construction of the Project site and the long-term operations of the mine, as well as the transport of waste rock from the Mine Site to the proposed contingency East Subaqueous Waste Rock Deposition Site at the eastern end of Brucejack Lake.

Figure 6.1-1
Access Road Alignment

PRETIVM



Source: Allnorth (2012).


POTENTIAL SAND & GRAVEL SOURCES
BRUCEJACK LAKE
KNIPPLE GLACIER
NPAG QUARRY
EXISTING LAKESHORE DRIVE
EXISTING ACCESS ROAD
75+000
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74+500
74+250
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6.1.2 *Erosion Prevention and Sediment Control – Implementation and Operation Measures*

The Brucejack Access Road construction and improvement work will follow the objectives of the practices presented in the *Forest Road Engineering Guidebook* (BC MOF 2002). Road and diversion ditch construction has the potential to generate surface erosion and deliver sediment yield to waterways. Maintenance will be conducted to prevent or minimize landslide risk and to provide for continuous, efficient, and controlled water drainage.

Management measures for EPSC during construction and maintenance of the Brucejack Access Road are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.1-2 provides a summary of the expected access road construction activities with applicable management measures and BMPs. Some applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis.

Table 6.1-2. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to Road Construction / Upgrading and Maintenance

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Stream crossings/road adjacent to streams	Prevent sediment from entering streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Maintain ditches, cross-drain culverts, and other structures so they do not discharge water directly into streams. • Minimize disturbance to riparian vegetation. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Handle excavated material on streambanks carefully. • Limit construction to dry weather periods when feasible. • Use armour/riprap in areas where bank erosion is likely. • Inspect EPSC measures after any runoff-producing rain event. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where bank stabilization required. • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when they are no longer necessary.	1, 4-10, 14, 16-19, 21-24

(continued)

Table 6.1-2. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to Road Construction / Upgrading and Maintenance (continued)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Overland floodplains and alluvial fans	Prevent erosion of slopes in floodplains, fans and, on sensitive soils	**Short Term** • Avoid construction in sensitive soils whenever feasible. • If construction in sensitive soils is required, cover bare ground at temporarily inactive sites with brush or RECPs. • Install armour/riprap along fills. • Limit construction to dry weather periods when feasible. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-10, 14
Cut and fill construction	Maintain slope stability by preventing over-steepening, prevent sediment from entering streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Limit construction to dry weather periods when feasible. • Consider end hauling in steep areas to avoid sliver fills and over steepening of slopes. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-10, 14, 19, 21-24
Ditches	Prevent erosion, maintain stability of ditch structures and armouring	**Short Term** • Armour with vegetation, riprap, RECPs, or other suitable means. • Use check dams to slow runoff velocity. **Long Term** • Immediately re-stabilize if disturbed by grading or other road maintenance. • Conduct re-vegetation in conjunction with mulching and/or erosion mats, as required. • Inspect and maintain EPSC measures.	1, 4-10, 13-14, 16, 17, 20-24

(continued)

Table 6.1-2. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to Road Construction / Upgrading and Maintenance (continued)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Road surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Adhere to proper road construction guidelines, including maintaining an appropriate depth and type of surfacing material. • Use water bars as a temporary measure until ditches and culverts can be installed or repaired. **Long Term** • Grade and replace surface material as required. • Inspect and maintain EPSC measures.	2, 11, 20, 22, 24
Construction in sensitive soils	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Remove veneers from bedrock within road prism to remove likelihood of erosion. • Limit construction to dry weather periods when feasible. • Consider end hauling in steep areas to avoid sliver fills and over steepening of slopes. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-8, 21-24
Spoil sites	Prevent sediment from entering streams/waterways, maintain long-term site stability	**Short Term** • Install perimeter sediment control (e.g., berms, sediment fencing) around soil disposal / stockpile sites. • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible as required. **Long Term** • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when no longer necessary. • Monitor for successful re-vegetation .	1, 2, 4-10, 21-23

(continued)

Table 6.1-2. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to Road Construction / Upgrading and Maintenance (completed)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Borrow sites	Prevent sediment from entering streams/waterways, maintain site stability	**Short Term** • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Re-slope to stable configuration after closure. • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible as required. **Long Term** • Monitor for successful re-vegetation.	1, 2, 4-12, 21-23
Construction induced slope failure	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Consult TSFAs and geohazard risk assessments prior to beginning construction. • Conduct work in sensitive or potentially unstable areas in dry weather. • Identify seepage zones and other locations of potential failure prior to beginning construction. • Install retaining wall structures or gabions where necessary. **Long Term** • Inspect and maintain retaining walls.	1, 17, 18
Snow handling	Prevent delivery of fine sediment from meltwater to streams/waterways	**Short Term** • Pile snow in undisturbed areas with low slopes a minimum of 30 m from any waterway. • Minimize the amount of sediment mixed with snow during snow removal and transport, where feasible. • Install sediment controls (e.g., silt fences, berms) around snow piles containing a large amount of soil or organic matter.	1, 21-24
Adverse weather	Mitigate the potential for surface erosion during periods of severe weather	**Short Term** • Make all personnel aware of adverse weather shutdown conditions. • Conduct construction activities in sensitive areas (e.g., adjacent to streams/waterways, areas with high erosion potential) during dry weather. • Stop work before soils are visibly soft or muddy and associated silty waters or sediment are flowing toward watercourses, or where such conditions are reasonably anticipated to develop.	1

Note: For "Applicable BMP Numbers," refer to Appendix D.

Clearing and excavation leave exposed soils susceptible to erosion. The roads and ditches have the potential to intercept surface water flow at cuts, which can result in an increase in surface water runoff over the construction site. Additionally, roads and ditches may cross streams which will receive sediment if proper sediment controls are not in place and maintained. Given that these are linear infrastructure developments, space is limited within the proposed construction footprints for ponds or other large sediment control measures.

It is anticipated that all planned Project roads will be required throughout the life of mine. In the currently unforeseen circumstance of any road or road section no longer being required before mine closure, it will be deactivated and reclaimed in accordance with the Reclamation and Closure Plan (Chapter 5).

Standard EPSC BMPs will be implemented during construction along the entire length of the Brucejack Access Road, as required. Applicable management practices may include:

- using standard forest road engineering practices and procedures as described in the *BC Forest Road Engineering Guidebook* (BC MOF 2002);
- beginning construction activity in each road segment, where feasible, at the top of the slope and working down to the lowest slope;
- minimizing the slope length of each segment cleared by installing slope breaks. Slope breaks will be retained throughout the construction process or until no longer required;
- excavating small, temporary diversion ditches to collect runoff from areas upslope of the road excavation and direct it away from areas susceptible to erosion. Ditches constructed in erodible soils will be lined with an appropriate geotextile and covered with riprap armouring where ditch bottoms are susceptible to erosion;
- adverse weather conditions that may trigger a stop work order are described in Section 5.3.7;
- covering exposed slopes with a layer of branches or brush if earthworks are not scheduled to begin soon after clearing and grubbing;
- excavating catch basins around the inlet of culverts to trap coarse material that is transported in drainage ditches; and
- avoiding discharging from cross-drain culverts directly into streams. Unless they are in use as part of a stream crossing, culverts will discharge onto rock or another stable energy dissipater and then diffuse flow into established forest or wetland vegetation.

Following construction, exposed cut and fill slopes will be re-vegetated as soon as feasible. The use of temporary cover (e.g., RECP) will be considered if re-vegetation is not immediately feasible. Based on field observations, existing sumps or basins that reduce flow velocity appear to be successful in capturing silt and fine sand particles. This suggests that this type of sediment control approach will be effective along the Brucejack Access Road. Culverts will be inspected to maintain suitable sump capacity where appropriate. Regular monitoring and maintenance will be carried out to remove accumulated sediment.

6.2 MINE SITE

Non-vegetated and sparsely vegetated ecosystems dominate the Brucejack Mine Site. Ice and rock are the dominant surficial materials. Non-vegetated ecosystems include glaciers, permanent snow/ice, lakes, and ponds. Patches of snow, névé, and firn persist late into the year. Sparsely vegetated ecosystems include rock outcrops, talus, and moraine.

Vegetation community development in the Brucejack Mine Site Area is influenced by the recent deposition of the soil parent material, excessive snow pack, wind, and cold temperatures. The area is subject to the effects of frost and wind which give rise to a characteristic low plant cover. Soils are either absent or exist as thin veneers, often derived from *in-situ* bedrock weathering, remnant glacial till, and colluvium. Thin annual snowpack leads to active freeze–thaw cycles that push plants out of the soil.

6.2.1 Surface Infrastructure and Construction Activities

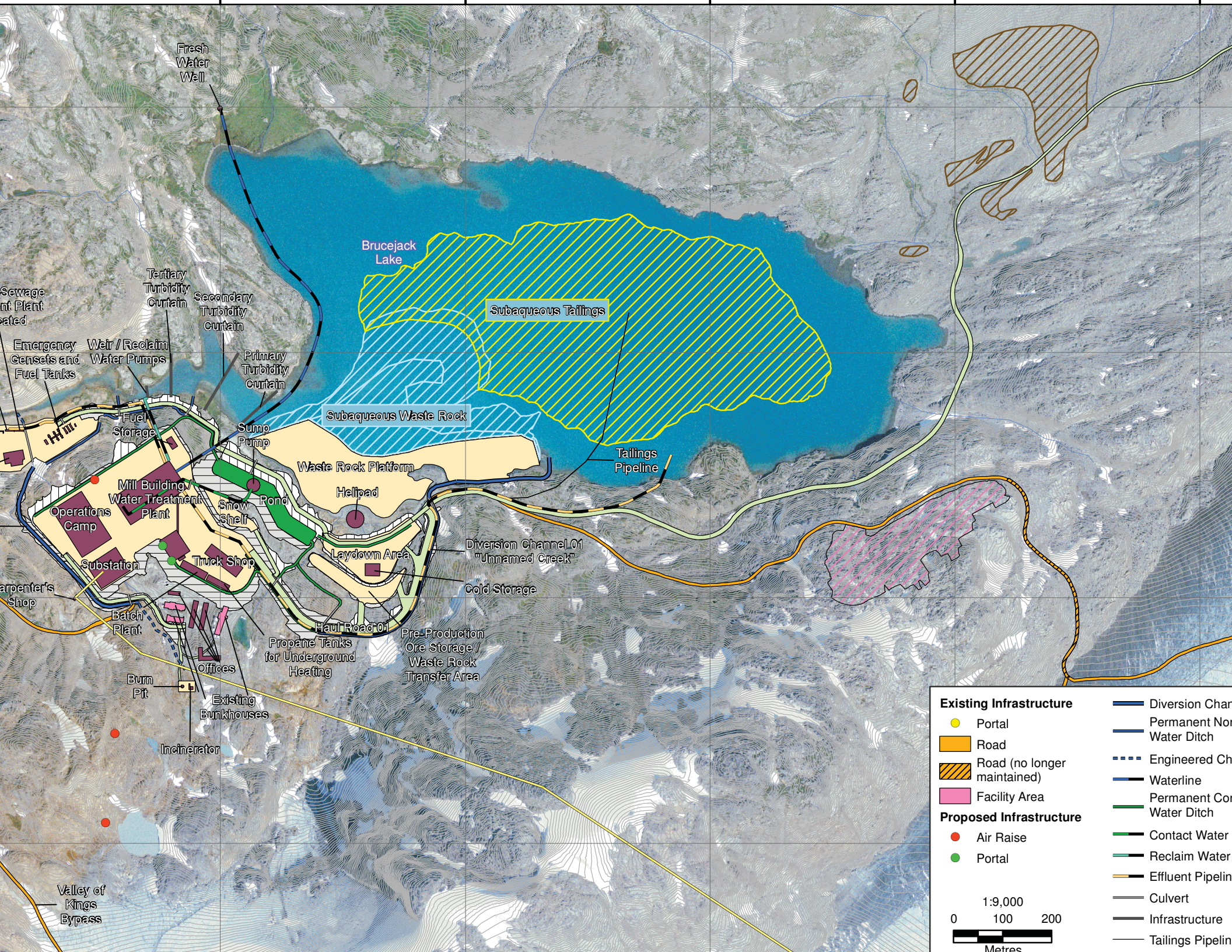
6.2.1.1 Surface Infrastructure

Surface infrastructure at the Mine Site (Figure 6.2-1) will include:

- camp facilities – expansion of existing facilities including an additional mine dry, bunkhouse, kitchen, sewage and administration facilities;
- ancillary buildings including a concrete batch plant, the mill and truck shop, substation and generator buildings, explosive storage facilities, metallurgical lab, fuel storage facility, an incinerator, and the tailings pipeline;
- an underground portal and related facilities such as the crushed ore conveyor;
- a lined waste rock storage facility; and
- a WTP (Construction WTP) close to the existing exploration mine WTP. This plant will be operational before development of the underground mine.

Site preparation and construction activities will include:

- development of the surface water management system, including contact and non-contact water ditches and the CWP, and implementation of other EPSC measures;
- a general earthworks program including rock cuts, pad development for mine infrastructure, and grading; and
- salvage of any available overburden materials and stockpiling for reclamation where feasible as there are limited developed soils on the Brucejack Mine Site.


Fresh Water Well
Brucejack Lake
Subaqueous Tailings
Subaqueous Waste Rock
Tertiary Turbidity Curtain
Secondary Turbidity Curtain
Primary Turbidity Curtain
Sewage nt Plant eated
Emergency Gensets and Fuel Tanks
Weir / Reclaim Water Pumps
Fuel Storage
Sump Pump
Waste Rock Platform
Helipad
Tailings Pipeline
Mill Building/ Water Treatment Plant
Operations Camp
Snow Shelf
Pond
Substation
Truck Shop
Laydown Area
Diversion Channel 01 "Unnamed Creek"
Cold Storage
arpenter's Shop
Batch Plant
Haul Road 01
Pre-Production Ore Storage / Waste Rock Transfer Area
Propane Tanks for Underground Heating
Offices
Burn Pit
Existing Bunkhouses
Incinerator
Valley of Kings Bypass
Existing Infrastructure
Portal
Road
Road (no longer maintained)
Facility Area
Proposed Infrastructure
Air Raise
Portal
Diversion Chan
Permanent Nor Water Ditch
Engineered Ch
Waterline
Permanent Co Water Ditch
Contact Water
Reclaim Water
Effluent Pipelin
Culvert
Infrastructure
Tailings Pipelin
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Metres

6.2.2 *Erosion Prevention and Sediment Control– Implementation and Operation Measures*

Upgradient, non-contact surface flow will be diverted around the Mine Site. Existing drainage courses will be preserved as much as feasible as this typically leads to the most economical drainage design.

The Mine Site will be positively drained at all times and all contact water generated from within the Mine Site will be directed to a CWP. Water contained in the CWP will be pumped to the mine WTP for treatment prior to use or discharge.

Designed drainage systems are based on the 200-year storm event. As construction progresses, for each area disturbed, the storm drainage will be managed by temporary (or permanent) swales, ditches, sumps, pumps, and hoses/pipes. In areas of PAG rock, the contact water will be pumped directly to the Construction WTP using the temporary sumps, pumps, hoses, and pipes. The water may also be pumped indirectly to the Construction WTP by way of the Phase 1 CWP and sump pump. In areas of NPAG rock, drainage does not have to go to the CWP or WTP. This drainage will be directed to Brucejack Lake or Brucejack Creek. Basic storm water BMPs such as silt fences and poly cover to prevent erosion will be employed when appropriate. Additional information regarding storm water is found in the Water Management Plan.

Management measures for EPSC during construction and maintenance of the Mine Site are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.2-1 provides a summary of the expected Mine Site construction activities with applicable management measures and BMPs. Some applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis.

Table 6.2-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant for the Mine Site

Management Area	Management Objectives	Recommended Measures	Applicable BMP Numbers
Spoil sites	Prevent sediment from entering streams/waterways, maintain long-term site stability	**Short Term** • Install perimeter sediment control (e.g., berms, sediment fencing) around soil disposal sites. • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Grade and re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately possible. **Long Term** • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when no longer necessary. • Monitor for successful re-vegetation.	1, 2, 4-10, 21-23

(continued)

Table 6.2-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant for the Mine Site (continued)

Management Area	Management Objectives	Recommended Measures	Applicable BMP Numbers
Roads and surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Adhere to proper road construction guidelines, including maintaining an appropriate depth and type of surfacing material. • Use water bars as a temporary measure until ditches and culverts can be installed or repaired. **Long Term** • Grade and replace surface material as required. • Inspect and maintain EPSC measures.	2, 11, 20, 22, 24
Construction in sensitive soils	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Remove veneers from bedrock within road prism to remove likelihood of erosion. • Limit construction to dry weather periods when possible. • Consider end hauling in steep areas to avoid sliver fills and over steepening of slopes. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-12, 14, 21-24
Spoil sites	Prevent sediment from entering streams/waterways, maintain long-term site stability	**Short Term** • Install perimeter sediment control (e.g., berms, sediment fencing) around soil disposal sites. • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately possible. **Long Term** • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when no longer necessary. • Monitor for successful re-vegetation.	1, 2, 4-12, 21-23

(continued)

Table 6.2-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant for the Mine Site (completed)

Management Area	Management Objectives	Recommended Measures	Applicable BMP Numbers
Cut and fill construction	Maintain slope stability by preventing over-steepening, prevent sediment from entering streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Limit construction to dry weather periods when possible. • Consider end hauling in steep areas to avoid sliver fills and over steepening of slopes. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-10, 14, 19, 21-24
Borrow sites	Prevent sediment from entering streams/waterways, maintain site stability	**Short Term** • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Re-slope to stable configuration after closure. • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately possible. **Long Term** • Monitor for successful re-vegetation.	1, 2, 4-12, 21-23
Construction induced slope failure	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Consult TSFAs and geohazard risk assessments prior to beginning construction. • Conduct work in sensitive or potentially unstable areas in dry weather. • Identify seepage zones and other locations of potential failure prior to beginning construction. • Install retaining wall structures where necessary. **Long Term** • Inspect and maintain retaining walls.	1, 17, 18
Settling Basin	Prevent erosion and delivery of sediment into streams/waterways, maintain sediment removal efficiency in pond	**Short Term** • Monitor efficiency of basin. **Long Term** • Dredge basin to maintain sediment removal efficiency. • Maintain access road to basin.	

Note: For "Applicable BMP Numbers," refer to Appendix D.

6.3 NPAG QUARRY

6.3.1 Description of Works – Construction

An NPAG Quarry (area = 4 ha) will be developed in NPAG rock, about 1,600 m east of the mill building, southeast of Brucejack Lake (Figure 6.3-1), to provide construction fill as required. The quarry bedrock is volcanic porphyry and has been classified as NPAG (BGC 2014). The rock will be mined at the quarry site using conventional drill and blast methods. A crusher will be located at the quarry site. Approximately 740,000 m^3 of rock will be excavated from the quarry and hauled along existing Lakeshore Drive that follows the south shore of Brucejack Lake to the Mine Site.

Slope design parameters include an average bench face angle of 65°, a maximum bench height of 15 m, minimum bench widths ranging from 9 to 10 m, and a maximum overall height of 75 m (BGC 2014). The overall angle of the NPAG Quarry will be controlled by the bench geometry, and will be dependent on the number of benches utilized. Based on the maximum overall slope height considered, overall slope angles will range from 45 to 47°.

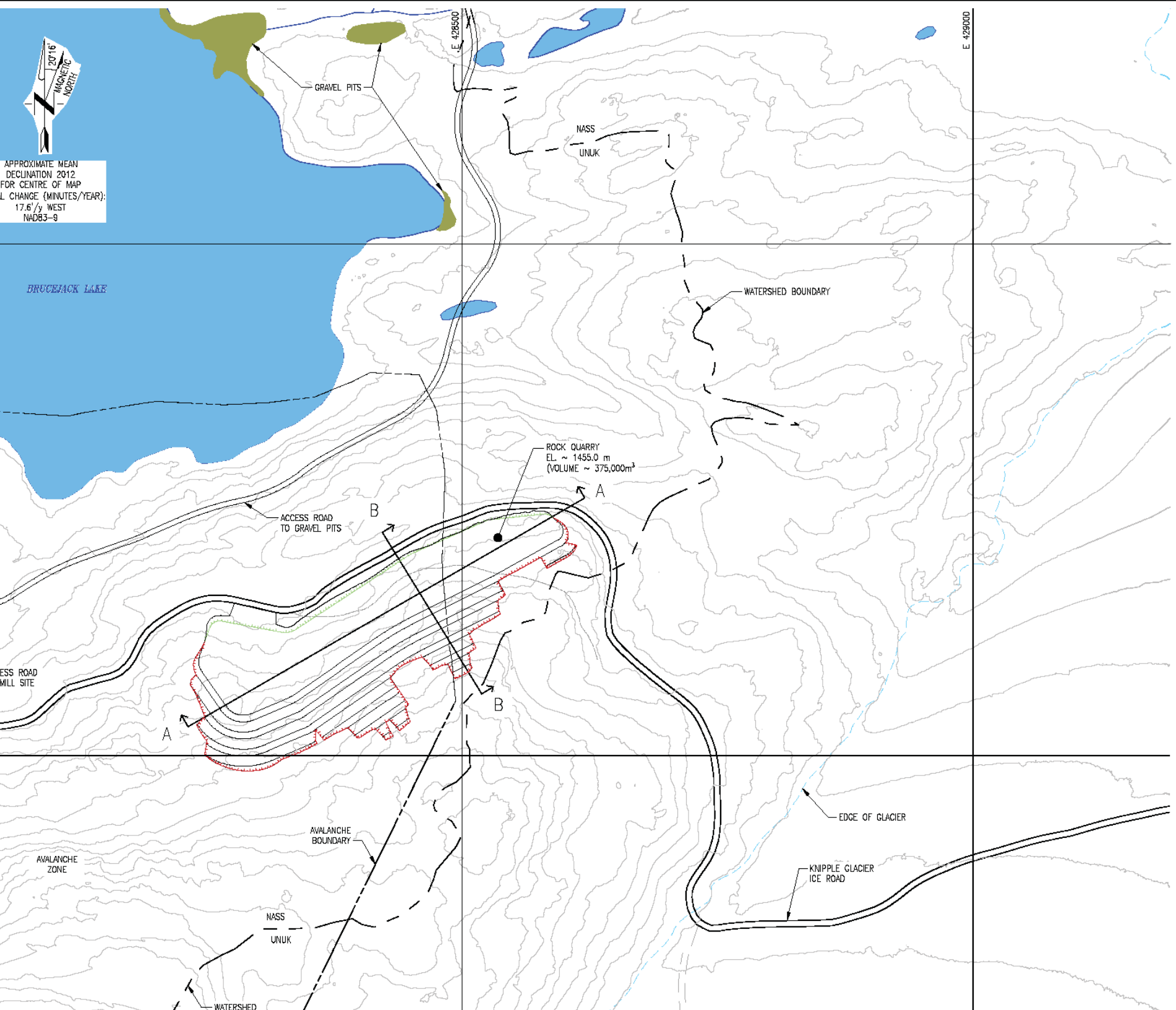
All surface drainage from the quarry site will be to Brucejack Lake, which will act as a settling basin, as well as providing dilution capacity. The NPAG Quarry floor will be configured to slope inward to act as a settling basin. Water will be withdrawn (pumped) from the top of this settling basin and directed downslope, where it will drain to Brucejack Lake. There is an approximate 200-m buffer between Brucejack Lake and the quarry. During periods that the NPAG Quarry is not active, the quarry floor will be allowed to fill and overtop (BGC 2015).

6.3.2 Erosion Prevention and Sediment Control – Implementation and Operation Measures

Management measures for EPSC during construction and maintenance of the NPAG Quarry are provide below. Selecting the appropriate measure is critical to achieving the management objective during a specific construction activity. Table 6.3-1 provides a summary of the expected NPAG Quarry construction activities with applicable management measures and BMPs. Some applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis.

Drainage during construction will be managed as follows.

- A diversion channel is not envisaged for this temporary quarry as it is deemed impractical at this rocky and steep site.
- As construction progresses, storm drainage will be managed by temporary (or permanent) swales and ditches. The drainage will be directed to current outlet drainage patterns. Basic storm water BMPs such as the installation of silt fences to prevent erosion may be employed where appropriate.
- Flows down-gradient of the site will follow existing drainage paths to Brucejack Lake, some 200 m away. As noted above, these drainage paths may be treated with storm water BMPs such as silt fences if required.



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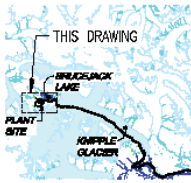

Table 6.3-1. Applicable Erosion Prevention and Sediment Control Best Management Practices (BMPs) Relevant to the NPAG Quarry

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Ditches	Prevent erosion, maintain stability of ditch structures and armouring	**Short Term** • Armour with riprap, RECPs, or other means. • Use check dams to slow runoff velocity. **Long Term** • Immediately re-stabilize if disturbed by grading or other road maintenance. • Install erosion mats. • Inspect and maintain EPSC measures.	1, 4-9, 12-13, 24
Settling Basin	Prevent erosion and delivery of sediment into streams/waterways, maintain sediment removal efficiency in basin	**Short Term** • Monitor effectiveness of basin. **Long Term** • Dredge basin to maintain sediment removal efficiency. • Maintain access road to basin.	24
Road surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Adhere to proper road construction guidelines, including maintaining an appropriate depth and type of surfacing material. • Use water bars as a temporary measure until ditches and culverts can be installed or repaired. **Long Term** • Grade and replace surface material as required. • Inspect and maintain EPSC measures.	2, 11, 20, 22, 24

Note: See Section 6.1 for a detailed description of road surface erosion control
Note: For "Applicable BMP Numbers," refer to Appendix D.

6.4 GRAVEL BORROW SOURCES AT MINE SITE

Along with the NPAG Quarry, additional areas will be developed to provide an NPAG aggregate source.

These gravel borrow sources, located on southeast corner of Brucejack Lake near the NPAG Quarry (Figure 6.4-1), will be developed using a front-end loader and haul trucks. Drilling and blasting will not be required to develop these gravel sources. Gravel will be used primarily in concrete, but at times may also be used for structural backfill and road cap. Table 6.4-1 presents the location and general description of the samples taken from each site.

The gravel source was sampled and tests concluding that the gravel is NPAG.

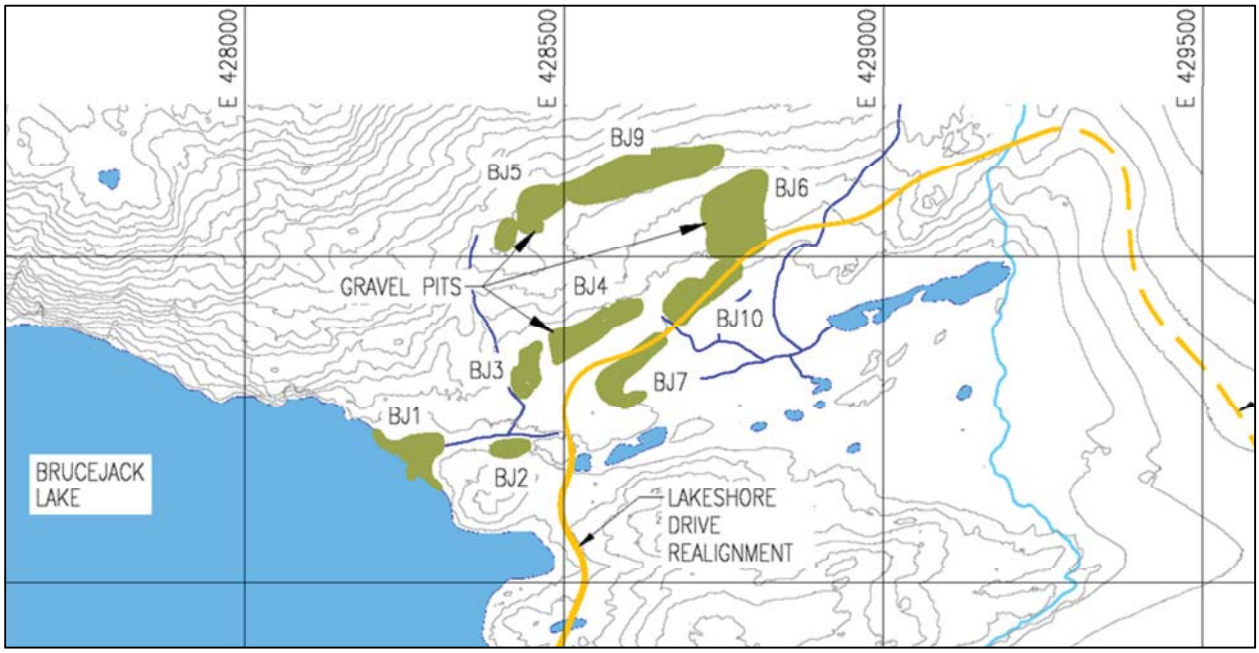

Figure 6.4-1. Location of Gravel Borrow Sources and Test Areas

Table 6.4-1. Location and Description of Borrow Samples

Site Number	Easting NAD83	Northing NAD83	Description
BJ1	428266	6259175	1:1 sand gravel ratio; gravels are fine with a thin layer of 1/2" gravel covering the surface exposure; only 30 - 50 cm of material before hitting the water table.
BJ2	428419	6259212	1:1 sand gravel ratio; fine gravels; thin layer of 1 - 2" gravel on surface exposure, local pieces > 3"
BJ3	428454	6259321	Sand-dominated zone, 2:1 ratio; 1 – 3 m thick; 1 - 2" gravel covering the surface, with rare cobble and boulder ranging up to 1 m
BJ4	428579	6259401	1:4 sand gravel ratio; overburden is 2 – 4 m thick, cut by surrounding creeks; gravels are pea size, with 20 - 30% ½ - 1" component; surface exposure is dominated by 1 - 2" material, with lesser 3 - 4" material
BJ5	428470	6259574	Gravel dominated bed, 1:5; sands are coarser as are the gravels (typically ¼ - 1/2" size), with occasional > 3" piece picked up by the shovels (~3 per pail); this bed is 6 m thick at the south end, and only 2 m thick at the top end, as it is underlain southerly dipping outcrop, and also cut by creek in the middle; surface exposure covered by 2 - 6" material
BJ6	428743	6259585	1:4 sand gravel ratio; sands are coarse; beds are over 8m thick locally; surface exposure covered mainly by 2 - 4" material
BJ7	428573	6259295	Sand Pit; 2:1 ratio; surface exposure covered by 1/4" - 1" gravel; difficult to estimate the thickness of the bed, but it is at least 2m thick
BJ8	428486	6259042	Sandy beach, 2:1 ratio; small area to collect material from, so likely not ideal; fine sands and gravels; surface exposure covered by 1/4" gravel
BJ9	428864	6259617	Gravel with minor, coarse sands, 4:1 (gravel:sand); material 40% < 5mm, 40% 5 – 10 mm, 20% > 10mm; extensive glaciofluvial terraces cover an area ~ 200 m X 60 m; sediment thickness will vary over area

(continued)

Table 6.4-1. Location and Description of Borrow Samples (completed)

Site Number	Easting NAD83	Northing NAD83	Description
BJ10	428711	6259435	Sandy gravels, ~ 2:1 (gravel:sand); material: 50% < 5 mm, 40% 5 – 10 mm, 10% > 10 mm; extensive glaciofluvial terraces covering an area ~ 170 m X 50 m, however, till intercepted 30 – 50 cm deep within sample pit indicating that glacialfluvial sediments may only form layer over till here; thickness of glacialffluvial sediments will vary within area, intersection of till beds of varied thickness, interbedded with glacialfluvial sediments, can be expected when excavating; extensive glaciofluvial terraces covering area ~. 170 m X 60 m

6.4.1 Description of Works – Construction

The gravel processing operation required to produce concrete aggregates will involve excavation and stockpiling of natural gravel deposits. A front-end loader will feed the gravel from the stockpile into the feed hopper of a screening plant. The vibrating screens will separate the unwanted fraction of grain sizes to produce a product with the required gradation. The screen plant will also be fitted with spray bars which will wash the fine silt particles from the rock and sand as it passes through the screens. The silt-laden water will drop through the screens and be channeled to a sump which will provide retention time to allow the fines to settle. A pump will decant water from the sump and recycle it back to the screening plant. During initial start-up of the operation, water will be drawn from the lake to run the spray bars, until the sump has been filled up. Once the sump is full, only make-up water will be required to replace the water that seeps out of the sump into the underlying soils. The silt accumulating on the bottom of the sump will "blind" the underlying soils and reduce loss of water from the cycle, which will serve to minimize the required volume of make-up water. Access to the gravel borrow sources will be off the realignment of Lakeshore Drive.

Gravel will be used extensively during the Construction phase, then may be required periodically throughout Operations for road bed maintenance. Therefore, access to the gravel source will remain in place until end of mine life.

6.4.2 Erosion Control and Sediment Prevention – Implementation and Operation Measures

Management measures for erosion prevention and sedimentation control during construction and maintenance of the gravel borrow sources are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.4-2 provides a summary of the expected aggregate quarries construction activities with applicable management measures and BMPs. All applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis.

6.5 KNIPPLE TRANSFER AREA

The Knipple Transfer Area is located along the Brucejack Access Road approximately 5 km west of the Bowser Aerodrome. It is in a relatively flat terraced area located above historical flood levels of Bowser Creek. The site has been previously used as a camp. Although not generally subject to geohazards, there is some risk of snow avalanche at this site.

Table 6.4-2. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to the Aggregate Quarries at Mine Site

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Ditches	Prevent erosion, maintain stability of ditch structures and armouring	**Short Term** • Armour with riprap, RECPs, or other means. • Use check dams to slow runoff velocity. **Long Term** • Immediately re-stabilize if disturbed by grading or other road maintenance. • Install erosion mats. • Inspect and maintain EPSC measures.	1, 4-9, 12-13, 24
Road surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Adhere to proper road construction guidelines, including maintaining an appropriate depth and type of surfacing material. • Use water bars as a temporary measure until ditches and culverts can be installed or repaired. **Long Term** • Grade and replace surface material as required. • Inspect and maintain EPSC measures.	2, 11, 20, 22, 24

Note: See Section 6.1 for a detailed description of road surface erosion control
Note: For "Applicable BMP Numbers," refer to Appendix D.

6.5.1 Description of Works – Construction

The Knipple Transfer Area will be located west of Knipple Lake, about 55 km by road from Highway 37 and 18 km from the Brucejack Mine Site. The Knipple Transfer Area will include a camp, maintenance and emergency vehicle building, fuel dispensing system, helipad, and laydown area as shown in Figure 6.5-1. It will occupy a development footprint of about 5 ha. All deliveries to and from the Brucejack Mine Site will report to this facility.

6.5.2 Erosion Prevention and Sediment Control – Implementation and Operation Measures

Management measures for EPSC during construction and maintenance of the Knipple Transfer Area are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.5-1 provides a summary of the expected construction activities with applicable management measures and BMPs. Some applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis.

An interception ditch will be constructed along the northern edge of the Knipple Transfer Area to direct any intercepted non-contact water toward Knipple Lake. This will help keep the construction site dry and minimize sediment loading in site drainage. The ditch will be armour protected with riprap underlain with geotextile as needed for erosion protection (BGC 2015).

Figure 6.5-1
Knipple Transfer Area Layout

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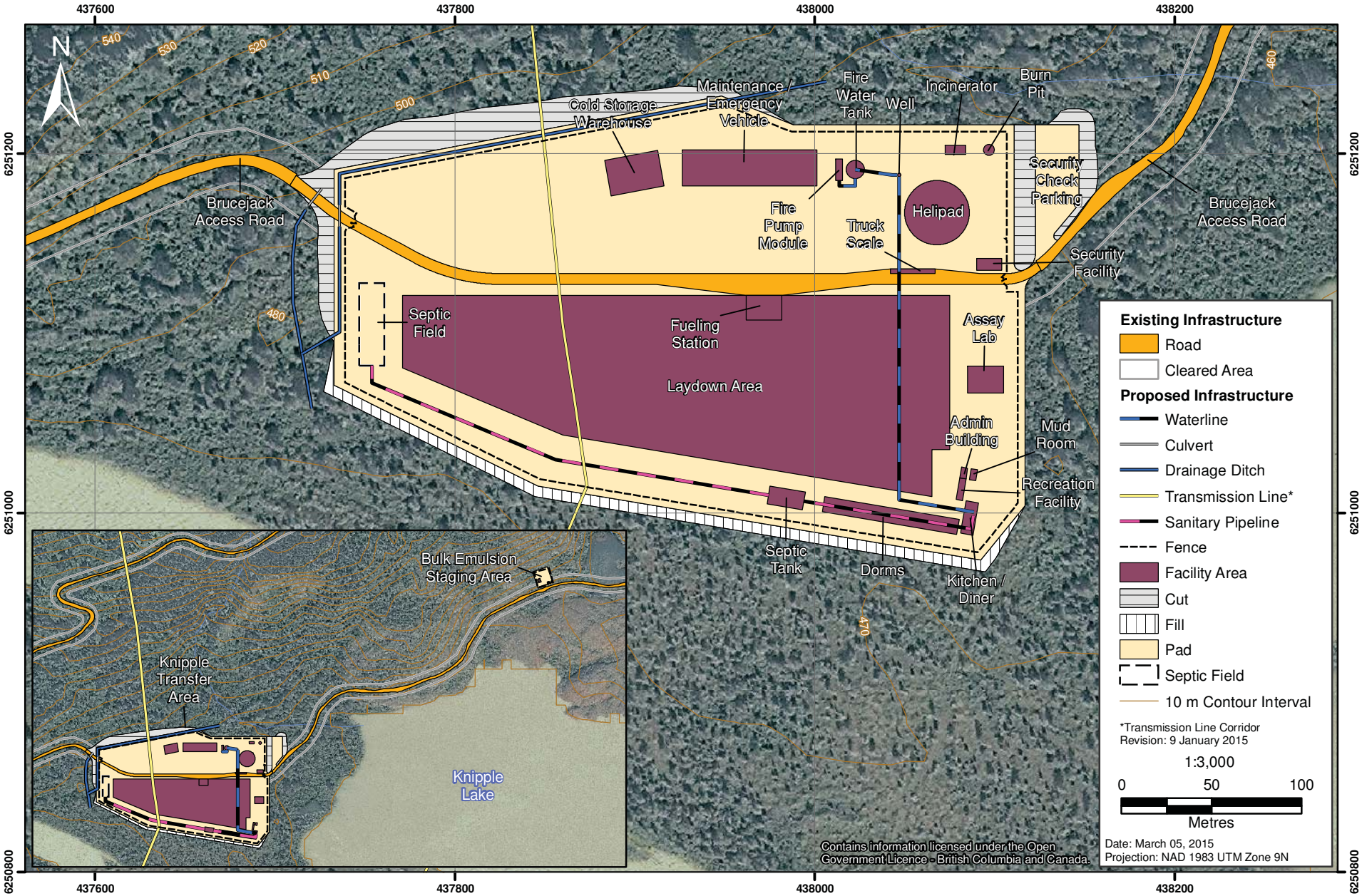

Table 6.5-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to the Knipple Transfer Area

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Ditches	Prevent erosion, maintain stability of ditch structures and armouring	**Short Term** • Armour with vegetation, riprap, RECPs, or other means. • Use check dams to slow runoff velocity. **Long Term** • Immediately re-stabilize if disturbed by grading or other road maintenance. • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Inspect and maintain EPSC measures. • Pile snow and ice in undisturbed areas with low slopes and a minimum of 30 m from any waterway. • Minimize the amount of sediment mixed with snow and ice during snow removal and transport. • Install sediment controls (e.g., silt fences, berms) around snow piles containing a large amount of soil or organic matter.	1, 4-9, 12-13, 24
Sumps	Prevent erosion and delivery of sediment into streams/waterways, maintain sediment removal efficiency in pond	**Short Term** • Monitor efficiency of sumps and remaining freeboard to achieve efficient sediment deposition. **Long Term** • Dredge sump to maintain sediment removal efficiency • Maintain access road to basin.	

Note: For "Applicable BMP Numbers," refer to Appendix D.

Runoff from the Knipple Transfer Area development site is expected to be minimal due to its small surface extent (5.4 ha) and relatively coarse textured substrate; however, temporary water management features such as sumps and ditches will be used during construction as part of the BMPs (Table 6.5-1).

6.6 BOWSER AERODROME

Regular chartered flights will transport mine personnel to and from the Project site from the point of origin to an aerodrome to be located west of Bowser Lake. In inclement weather conditions where aircraft are unable to fly, personnel will be bused from Terrace to the Knipple Transfer Area. Transport from both the Bowser Aerodrome and Knipple Transfer Area to / from the Brucejack Mine Site will be by vehicles equipped for glacier travel.

6.6.1 *Description of Works – Construction*

The new aerodrome will be constructed at the site of a historical gravel airstrip, which will be improved and expanded to provide a safe and maintainable facility for the chartered air traffic. The Bowser Aerodrome is shown in Figure 6.6-1. A small hill about 450 m west of the proposed aerodrome maybe excavated to reduce the impacts of the hill on the take-off approach surface areas. Samples collected from the Bowser Aerodrome area were NPAG.

The runway, taxiway, and apron surface will be granular and suitable for turbo-prop aircraft. The runway will be 1,524 m long and 30 m wide. The runway will include a 7.5-m graded area along each runway edge and a 60-m-long graded area beyond each runway end. The taxiway will be constructed to a width of 18 m with a 6-m-wide graded area along each edge. The aircraft parking apron has been sized to allow two Dash 8 sized aircraft to manoeuver and park. The overall footprint of the aerodrome will be about 10 ha.

A level area will be available for helicopter landing if required.

A pre-fabricated ATCO-type trailer Air Terminal Building will be located adjacent to the apron. The Air Terminal Building will be equipped with sufficient windows to view the aerodrome and surrounding area. The building will be mounted on piles to protect it from the possibility of floods.

6.6.2 *Erosion Control and Sediment Prevention – Implementation and Operation Measures*

Management measures for EPSC during construction and maintenance of the Bowser Aerodrome are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.6-1 provides a summary of the expected Bowser Aerodrome construction activities with applicable management measures and BMPs to meet these objectives. Some applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis.

Permanent drainage ditches will be located along the north and south sides of the runway, and will drain at approximately 0.5% grade to the river (BGC 2015).

Drainage during construction will be managed as follows.

- For the main runway / apron site, the ditches on the north and south sides of the runway will be installed. This will help keep the construction site dry and minimize sediment loading in site drainage, though as above this site generally drains rapidly to ground.
- For water flowing down-gradient of the runway ditches, the water may follow its existing drainage paths to the Bowser River.
- As earthworks construction progresses through the aerodrome site, the storm drainage will be managed by swales, ditches, and sumps.

Figure 6.6-1
Bowser Aerodrome

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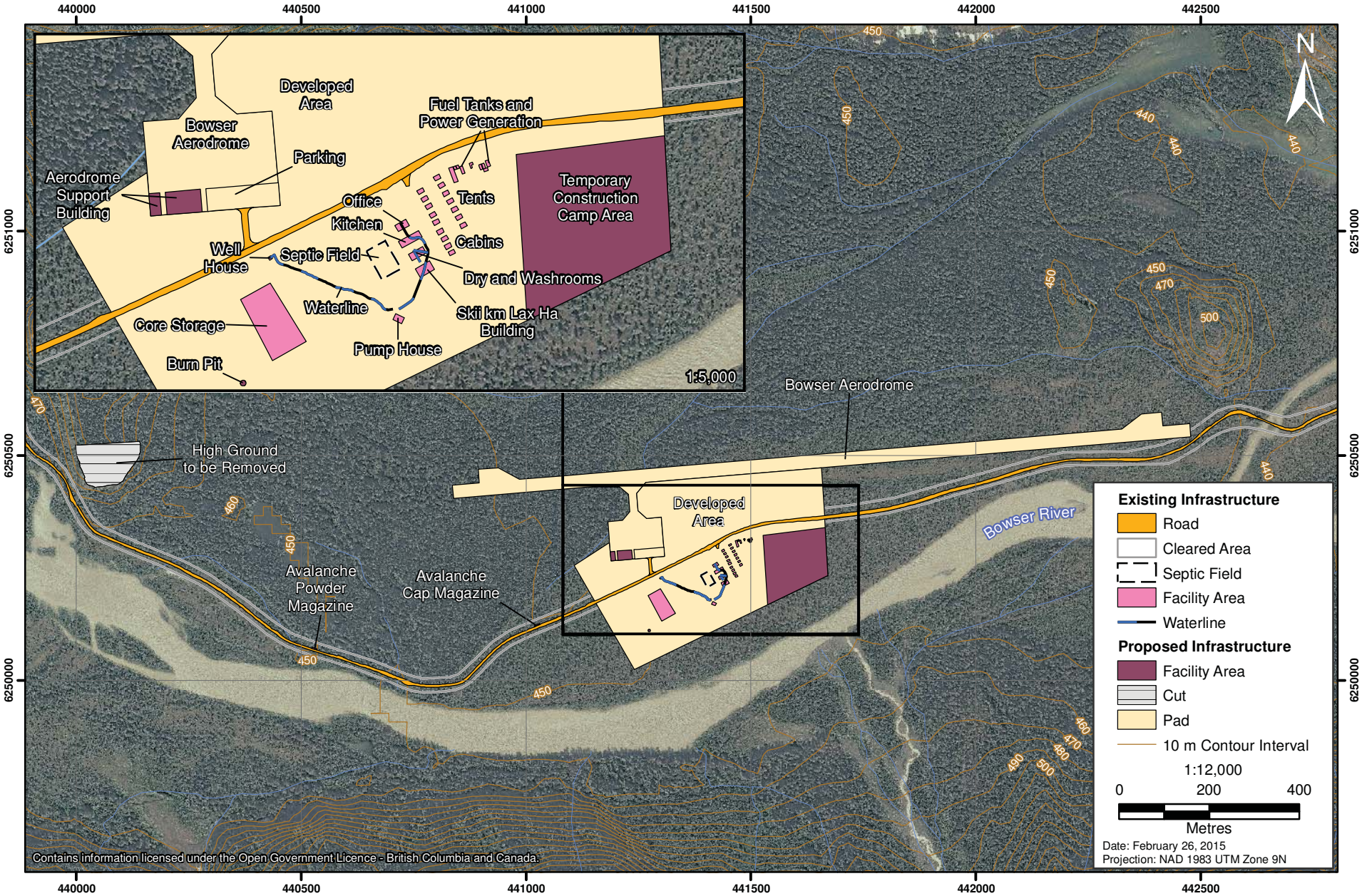

Table 6.6-1. Applicable Erosion Control and Sediment Prevention Best Management Practices Relevant to the Bowser Aerodrome

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Overland floodplains and alluvial fans	Prevent erosion of slopes in floodplains, fans and, on sensitive soils	**Short Term** • Avoid construction in sensitive soils whenever feasible. • If construction in sensitive soils is required, cover bare ground at temporarily inactive sites with brush or RECPs. • Install armour/riprap along fills. • Limit construction to dry weather periods when feasible. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-10, 14, 21-24
Ditches	Prevent erosion, maintain stability of ditch structures and armouring	**Short Term** • Armour with vegetation, riprap, RECPs, or other means. • Use check dams to slow runoff velocity. **Long Term** • Immediately re-stabilize if disturbed by grading or other road maintenance. • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Inspect and maintain EPSC measures.	1, 4-10, 13-14, 16, 17, 20-22, 24
Spoil sites	Prevent sediment from entering streams/waterways, maintain long-term site stability	**Short Term** • Install perimeter sediment control (e.g., berms, sediment fencing) around soil disposal sites. • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible. **Long Term** • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when no longer necessary. • Monitor for successful re-vegetation.	1, 2, 4-10, 21-23

(continued)

Table 6.6-1. Applicable Erosion Control and Sediment Prevention Best Management Practices Relevant to the Bowser Aerodrome (completed)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Runway and road surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Adhere to proper road construction guidelines, including maintaining an appropriate depth and type of surfacing material. • Use water bars as a temporary measure until ditches and culverts can be installed or repaired. **Long Term** • Grade and replace surface material as required. • Inspect and maintain EPSC measures.	11, 17-18, 20, 22, 24
Snow handling	Prevent delivery of fine sediment from meltwater to streams/waterways	**Short Term** • Pile snow in undisturbed areas with low slopes a minimum of 30 m from any waterway. • Minimize the amount of sediment mixed with snow during snow removal and transport, where feasible. • Install sediment controls (e.g., silt fences, berms) around snow piles containing a large amount of soil or organic matter.	1, 21-24
Concrete Placement	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Control runoff from the in and out of the area through the use of sediment fencing, berms and ditches. • Control runoff from the in and out of the area through the use of sediment fencing, berms and ditches.	11, 21 22, 24
Settling Basins and Sumps	Prevent erosion and delivery of sediment into streams/waterways, maintain sediment removal efficiency in basin/sump	**Short Term** • Monitor efficiency of basin/sump **Long Term** • Dredge basin to maintain sediment removal efficiency • Maintain access road to basin/sump	

Note: See Section 6.1 for a detailed description of runway and road surface erosion control
Note: For "Applicable BMP Numbers," refer to Appendix D.

The drainage at the excavation to remove the high ground within the west approach will follow storm water BMPs. This will include diverting drainage around the site if required, and use of other BMPs.

6.7 BOWSER CAMP

The existing Bowser Camp includes a kitchen and dormitories, and can accommodate 30 people.

6.7.1 Description of Works – Construction

An area will be cleared at the existing Bowser Camp to accommodate a temporary 100-man camp to support construction of the Brucejack Transmission Line and a laydown area. Figure 6.7-1 shows this area in relation to the Bowser Aerodrome.

Figure 6.7-1
Bowser Camp Arrangement

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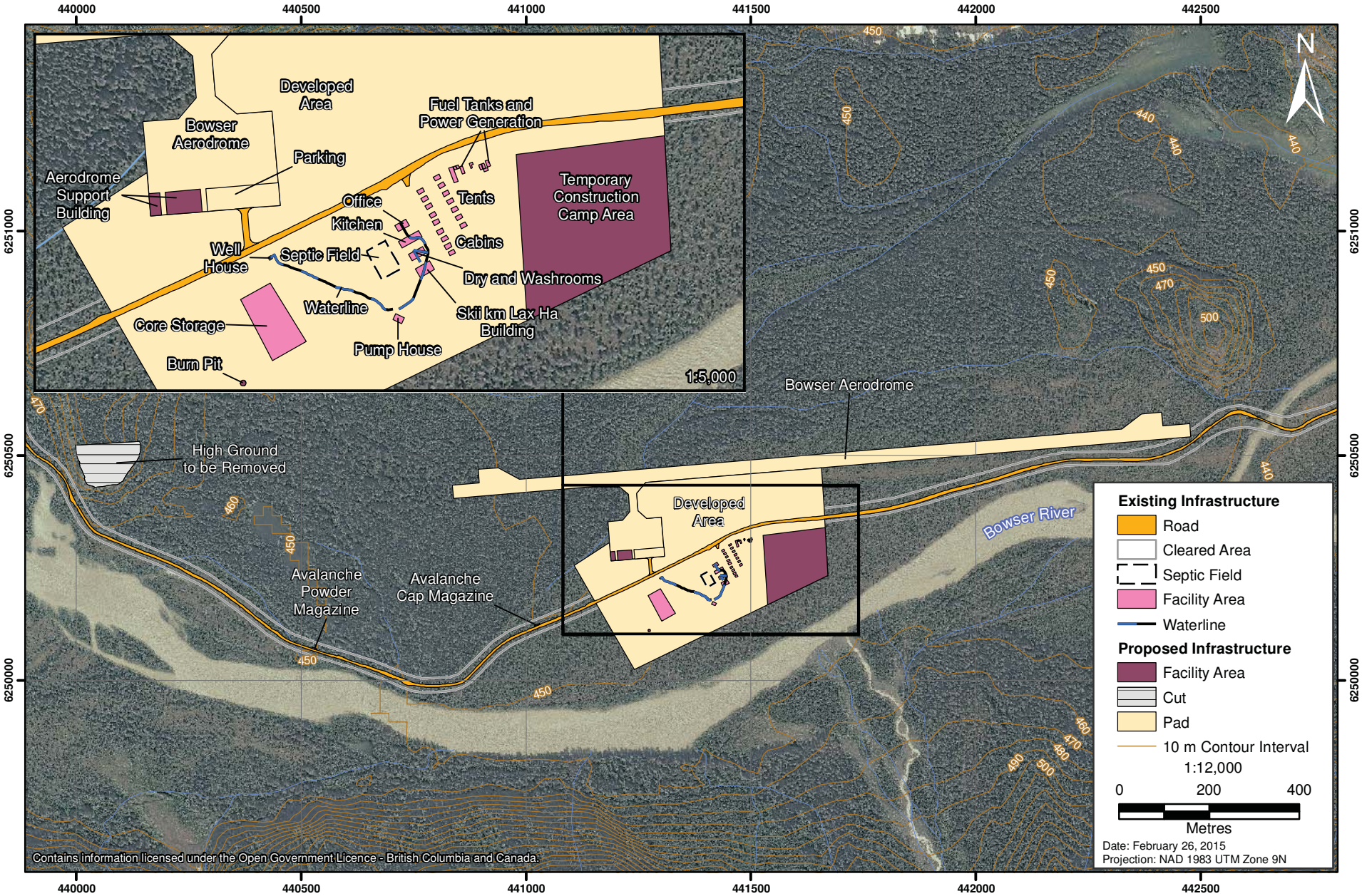

6.7.2 Erosion Prevention and Sediment Control – Implementation and Operation Measures

Management measures for EPSC during construction and maintenance of the Bowser Camp are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.7-1 provides a summary of the expected Bowser Camp construction activities with applicable measures and BMPs. Some applicable BMPs may not be identified in this table and will be selected on a site-specific basis.

Table 6.7-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to Bowser Camp

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Cut and fill construction	Maintain slope stability by preventing over-steepening, prevent sediment from entering streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Limit construction to dry weather periods when feasible. • Consider end hauling in steep areas to avoid sliver fills and over steepening of slopes. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-10, 14, 19, 21-24
Spoil sites	Prevent sediment from entering streams/waterways, maintain long-term site stability	**Short Term** • Install perimeter sediment control (e.g., berms, sediment fencing) around soil disposal sites. • Maximize distance from streams/waterways. • Avoid steep slopes or otherwise unstable sites. • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible. **Long Term** • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when no longer necessary. • Monitor for successful re-vegetation.	1, 2, 4-10, 21-23

(continued)

Table 6.7-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to Bowser Camp (completed)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Ditches	Prevent erosion, maintain stability of ditch structures and armouring	**Short Term** • Armour with vegetation, riprap, RECPs, or other means. • Use check dams to slow runoff velocity. **Long Term** • Immediately re-stabilize if disturbed by grading or other road maintenance. • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Inspect and maintain EPSC measures.	1, 4-9, 12-13, 24
Road surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Adhere to proper road construction guidelines, including maintaining an appropriate depth and type of surfacing material. • Use water bars as a temporary measure until ditches and culverts can be installed or repaired. **Long Term** • Grade and replace surface material as required. • Inspect and maintain EPSC measures.	2, 11, 20, 22, 24
Construction in sensitive soils	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Remove veneers from bedrock within road prism to remove likelihood of erosion. • Limit construction to dry weather periods when feasible. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-12, 14, 21-24
Snow handling	Prevent delivery of fine sediment from meltwater to streams/waterways	**Short Term** • Pile snow in undisturbed areas with low slopes a minimum of 30 m from any waterway. • Minimize the amount of sediment mixed with snow during snow removal and transport, where feasible. • Install sediment controls (e.g., silt fences, berms) around snow piles containing a large amount of soil or organic matter.	1, 21-24

Note: See Section 6.1 for a detailed description of road surface erosion control
Note: For "Applicable BMP Numbers," refer to Appendix D.

6.8 BRUCEJACK TRANSMISSION LINE

The Brucejack Transmission Line alignment will follow bedrock-dominated terrain that is characterized by gentle to moderate slopes, bedrock hummocks, and discrete debris flow/snow avalanche tracks.

6.8.1 Description of Works – Construction

The overall power requirements for the Project will be approximately 20 megawatts. The Project will be powered by electricity from the BC Hydro grid. The proposed transmission line route is from the Long Lake Hydro Substation to the Mine Site (Figure 6.8-1).

Starting at the Long Lake transmission line west of the Hydro Substation, the Brucejack Transmission Line will follow the bedrock slopes on the east side of the Salmon Glacier to the terminus of the Knipple Glacier. From the Knipple Glacier, the preferred transmission line route will generally follow the upper crest of the bedrock slope south of the glacier to the Mine Site. Large towers will facilitate spanning the snowfields in the area.

No new roads are anticipated to be required to support construction of the Brucejack Transmission Line. The Granduc Access Road and existing mineral exploration trails will provide access and staging areas for much of the southern portion of the alignment. Staging for portions of the alignment north of the Granduc mill site will be from the Tide Staging Area, Bowser Camp laydown, and the Knipple Transfer Area. Tower emplacement and conductor stringing will be conducted by helicopter.

6.8.1.1 Tide Staging Area

The Tide Staging Area is located near the site of the historical Granduc Mine and airstrip. It is a relatively small area which will further be cleared to increase the size for use as a short-term staging area for equipment and materials associated with the construction of the Brucejack Transmission Line.

6.8.2 Erosion Control and Sediment Prevention – Implementation and Operation Measures

Management measures for EPSC during construction and maintenance of the Brucejack Transmission Line are provided below. Selecting the appropriate measure is critical to achieve the management objective during a specific construction activity. Table 6.8-1 provides a summary of the expected Brucejack Transmission Line construction activities with applicable management measures and BMPs. Some applicable BMPs may not be identified in this table and will be selected on a site-specific, as-needed basis. BMPs specific to riparian protection can be found in Appendix B.

Brucejack Transmission Line construction is anticipated to have minimal implications for water management as construction by use of helicopters rather than by use of land vehicles is planned. Should there be a need to work in and around water during construction of the Brucejack Transmission Line, Section 6.1 – Brucejack Access Road, will be referred to for direction regarding EPSC.

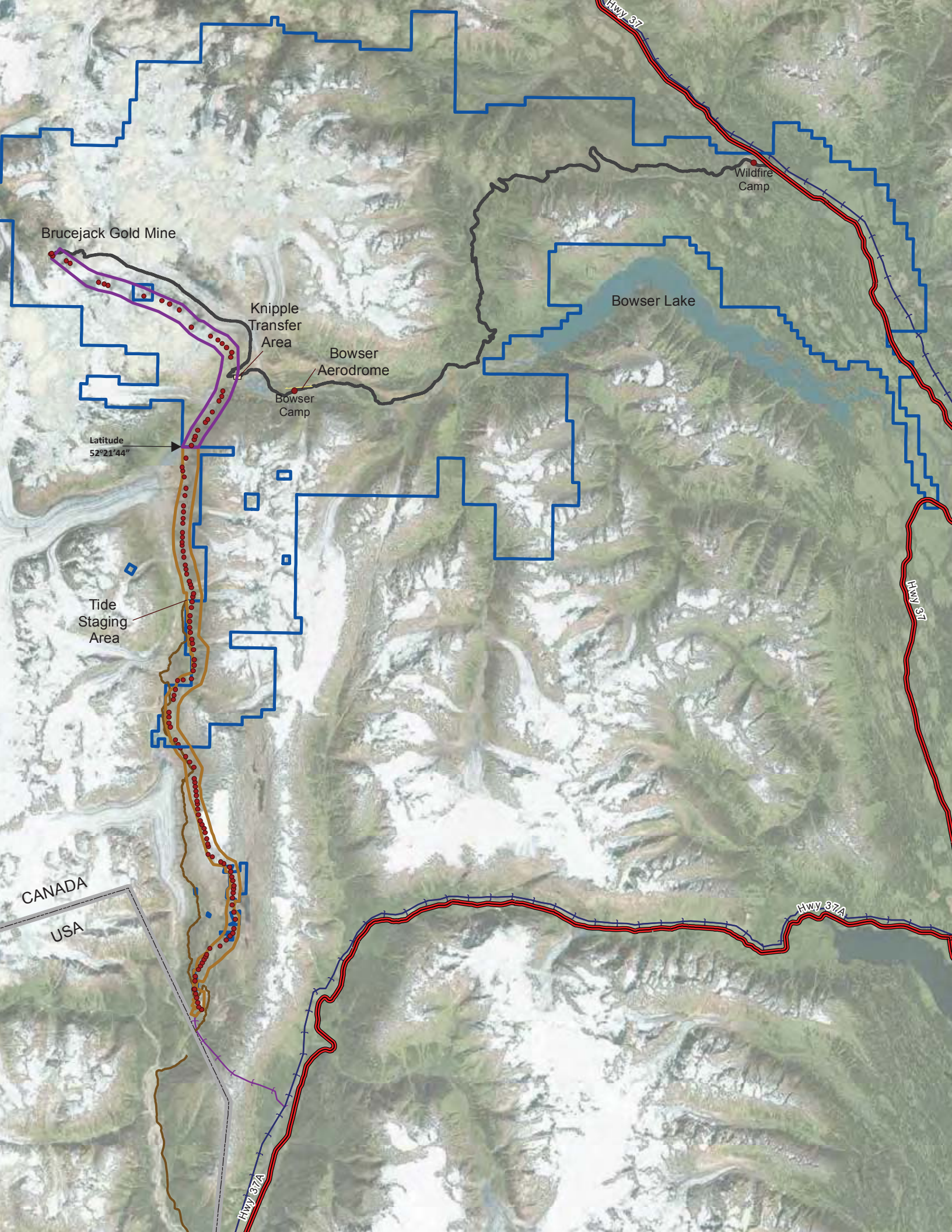
Hwy 37
Wildfire Camp
Brucejack Gold Mine
Bowser Lake
Knipple Transfer Area
Bowser Aerodrome
Bowser Camp
Latitude 52°21'44"
Tide Staging Area
Hwy 37
CANADA
USA
Hwy 37A
Hwy 37A

Table 6.8-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to the Transmission Line

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Road surface erosion	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term road surface stability	**Short Term** • Monitoring of road surface erosion to be done and response coordinated with operators of Granduc Road. • Adhere to proper road construction guidelines for any necessary upgrades, including maintaining an appropriate depth and type of surfacing material.	2, 11, 20, 22, 24
Clearing	Prevent erosion and delivery of sediment into streams/waterways, maintain long-term site stability	**Short Term** • Minimize removal of vegetation and disturbance to soil (leave in place) to extent possible, yet still meets engineered design specs. • Install perimeter sediment control (e.g., berms, sediment fencing) around clearing site as needed. **Long Term** • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when no longer necessary. • Monitor for successful re-vegetation and soil.	1, 2, 4-10, 21-23
Stream crossings	Prevent sediment from entering streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Minimize disturbance to riparian vegetation. • Limit construction to dry weather periods when feasible. • Use armour/riprap in areas where bank erosion is likely. • Inspect EPSC measures after any runoff-producing rain event. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where bank stabilization required. • Inspect and maintain EPSC measures and remove temporary measures (e.g., sediment fencing) when they are no longer necessary.	1, 4-10, 14, 16-19, 21-24

(continued)

Table 6.8-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to the Transmission Line (continued)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Construction in sensitive soils	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. • Cover bare ground at temporarily inactive sites with brush or RECPs. • Remove veneers from bedrock within road prism to remove likelihood of erosion. • Limit construction to dry weather periods when feasible. • Consider end hauling in steep areas to avoid sliver fills and over steepening of slopes. **Long Term** • Conduct re-vegetation in conjunction with mulching and/or erosion mats. • Use live wattles or fascines where stabilization required. • Inspect and maintain EPSC measures.	1, 4-12, 14, 21-24
Equipment and Staging Areas	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Minimize the footprint and install sediment controls (e.g., sediment fences, berms) between staging site and waterways. • Avoid steep slopes or otherwise unstable sites. • Grade traffic area and maintain berms and ditches. **Long Term** • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible.	1, 2, 4-12, 21-24
Steep Slopes	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Avoid constructing or exposing very steep slopes. Create slope breaks through terracing and add texture on slopes where feasible. • Stabilize slopes (is. live wattles/fascines, RECPs, riprap armouring, gabions, retaining walls). • Maintain proper drainage through the use of slope drains. Construct cross drains and ditches if necessary. **Long Term** • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible.	1-12, 14-15, 17-20

(continued)

Table 6.8-1. Applicable Erosion Prevention and Sediment Control Best Management Practices Relevant to the Transmission Line (continued)

Activity	Management Objectives	Management Measures	Applicable BMP Numbers
Anchor Drilling	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Prior to starting work, install sediment controls (e.g., sediment fences, berms) between construction works and waterways. **Long Term** • Re-vegetate as soon as feasible and use temporary covers (e.g., RECPs, polyethylene sheeting) if re-vegetation is not immediately feasible.	1, 4-12, 21-24
Concrete Placement	Prevent erosion and delivery of sediment into streams/waterways	**Short Term** • Control runoff from the in and out of the area through the use of sediment fencing, berms and ditches to contain concrete wash.	11, 21 22, 24

Note: See Section 6.1 for a detailed description of road surface erosion control
Note: For "Applicable BMP Numbers," refer to Appendix D.

7 ENVIRONMENTAL MONITORING

An Erosion Prevention and Sediment Control Monitoring Program will be implemented at the initiation of construction activities. The monitoring program will focus on inspection and maintenance of structures related to EPSC management, with an emphasis on adaptive management to quickly evaluate and respond to changing conditions and requirements. The key objectives of the Erosion Prevention and Sediment Control Monitoring Program are:

- to assess the performance of water management structures and systems; and
- to identify and promptly address areas where maintenance, upgrades, modifications, or additional mitigation measures are necessary.

The following plans have additional mitigation and management measures relevant to EPSC:

- Aquatic Effects Monitoring Plan;
- Vegetation Management Plan;
- Emergency Response Plan;
- Traffic Management Plan; and
- Water Management Plan.

The Environmental Manager will be responsible for overseeing the Erosion Prevention and Sediment Control Monitoring Program, maintaining inspection and maintenance records, ensuring monitoring reporting, and providing guidance on any modifications to the program.

7.1 PERFORMANCE MONITORING

Trained environmental personnel will be employed as Environmental Monitors and Technicians. The environmental personnel will inspect, evaluate, and report on the effectiveness of EPSC management strategies and mitigation measures, with respect to regulatory permits, approvals, and authorizations. Under the supervision of the Environmental Manager, the environmental personnel will have the responsibility of confirming that EPSC measures are properly implemented. The Environmental Manager, along with others, will have the authority to stop work if conditions are not met or if, in their technical opinion, the continuation of work will lead to non-compliance. Site workers will report incidents that may result in erosion, structural or functional failure, culvert debris accumulation, or similar occurrences to the Environmental Department.

Site personnel will be encouraged to communicate any concerns related to erosion and sedimentation, improper site drainage, contaminant releases, and debris or snow jams in drainage-ways and at stream crossings to their supervisor.

The Environmental Monitors and Construction Management Team, where appropriate, will conduct visual inspections and assessments of EPSC structures on an ongoing basis as part of general site management. On active work sites, these informal visual inspections will be augmented by formal, regularly scheduled inspections to be performed by Environmental Monitors such that each site is visited on a monthly basis or more often as dictated by site conditions. In frozen conditions, formal inspection frequency may be reduced. Inspections of all sites will be conducted within 24 hours of rainfall events greater than 100 mm in a 24-hour period as per the Water Management Plan.

EPSC structures will be maintained during construction by the Contractor. Maintenance procedures will include prompt attention to potential ditch or culvert blockage or failure, or outside seepage, because such problems could lead to structure failure and sediment transport. Maintenance will also include routine removal of accumulated sediment from ditches and retention structures.

EPSC monitoring variables and their monitoring frequency are outlined in Table 7.1-1. Monitoring frequency may be increased based on the results of the Aquatic Effects Monitoring Plan and other relevant monitoring results. Inspection criteria may be modified on a site-by-site basis or as conditions require.

Table 7.1-1. Erosion Prevention and Sediment Control Monitoring Variables, Frequency, and Expected Targets

Monitoring Variable	Monitoring Frequency	Targets
Performance of EPSC structures and systems (e.g., diversion ditches, sumps)	Monthly[1] or after high rainfall/runoff[2] events	Functioning as intended
Site and Brucejack Access Road drainages	Monthly[1] or after high rainfall/runoff[2] events	Positive drainage maintained at all times; no ponding
Inventory of on-site supply of EPSC materials	Ongoing[3]	Sufficient supply is always available on site

[1]*Frequency may be decreased during winter when ground is frozen*
[2]*Combined rainfall and snowmelt runoff events (rain-on-snow events) pose the most significant risk to water management structures and systems. Surveys of EPSC structures prior to winter break-up are required to assess functionality and potential maintenance requirements (e.g., removal of excess snow/ice from ditches and basins, repair or replacement of blocked/frozen culverts and pipes).*
[3]*Materials will be replaced immediately after use, if identified by the Construction Management Team as necessary. Inventory checked at a minimum of monthly.*

7.2 WATER QUALITY (TOTAL SUSPENDED SOLIDS, TOTAL DISSOLVED SOLIDS, AND TURBIDITY MANAGEMENT)

The BC Ministry of Environment's Environmental Protection Division administers the *Environmental Management Act* (2003) by setting criteria to define when "sediment yield" becomes a "pollutant" (Clark et al. 2012). Provincial water quality guideline documents provide targets of acceptable levels of sediment in water that are typically used when determining the performance of control measures when undertaking in-stream works and works that may result in a sediment release to a water course (*Ambient Water Quality Guidelines (Criteria) for Turbidity, Suspended and Benthic Sediments;* BC MOE 2001).

The hydrological regime is an important determinant of water quality in the Project area. Typically local streams experience a low flow period between November and April. Higher flows typically occur between May and October associated with freshet, summer glacial melt, and fall heavy rain events. The hydrological regime affects water quality in two ways: 1) increased discharge during freshet, glacial melt, and heavy rainfall events dilutes concentrations of total dissolved solids; and 2) increased sediment load and transport during high flow periods leads to increased concentrations of TSS.

Embankment condition and evidence of sediment transport into watercourses will be assessed at, for example, water diversion channels, drainage ditches, pools, and waterway crossings along roads. The waterbodies adjacent to construction sites will be visually inspected for introduced sediment. Water sampling and/or turbidity testing may also be carried out if discolouration occurs. Regular inspection of areas releasing sediment will be carried out until sediment is no longer released.

Any sites determined to require ongoing monitoring will document, as appropriate, GPS coordinates, erosion type, rainfall intensity, and the extent of the affected area, as well as existing control measures and assessment of their performance. Identified sites will be regularly checked for ongoing evidence of erosion, particularly after high rainfall events, until erosion is no longer a concern. Targeted field measurements, such as turbidity, will be taken as appropriate. Monitoring results may be used to trigger an appropriate adaptive management response.

7.3 CONTINGENCY RESPONSES

In the event that TSS concentrations exceed the BCWQGs or measured background levels, taken upstream of the discharge point at the time of discharge, the Environmental Monitor will immediately stop related work and notify the Environmental Coordinator. The Environmental Coordinator, in consultation with the Mine Manager, will have the authority to require that other mitigation and emergency sediment control measures be carried out depending on the severity of the situation.

A supply of environmental contingency material and equipment will be available on site as described in Section 5.1.3.

During and after an exceedance event, additional turbidity and TSS samples will be taken at key locations, including the entry point to the affected waterway and the corresponding background site until conditions return to baseline or within the BCWQG. Exceedances require the completion of an environmental incident report (described in Section 8.1).

8 REPORTING AND RECORDING

8.1 REPORTING

8.1.1 Compliance Reporting (As per Permit Conditions)

The Environmental Manager will ultimately be responsible for reporting on observations and monitoring results (Table 8.1-1). Reporting of environmental monitoring data will be conducted in accordance with permit and approval conditions. Regulatory requirements are anticipated to entail formal annual reports, including disclosure of issues of non-compliance.

Table 8.1-1. Erosion Prevention and Sediment Control Reporting Requirements, Frequency, and Responsibilities

Report Type	Frequency	Reporting Responsibilities	Submitted to
Annual report	Annually	Environmental Manager	Mine Manager, regulatory authorities
Environmental incident report	As soon as feasible after occurrence	Initial notification by attending manager	Environmental Manager, regulatory authorities

8.1.2 Internal Reporting

The Environmental Monitor will document all site inspections, field observations, and photos using a Daily Monitoring Form (Appendix F). Information recorded will include the work site, time, date, weather conditions, current site activity, list of water management practices or structures being utilized, key observations (challenges and successes), incidents or non-compliance issues, plus any follow-up that was implemented. This information will be summarized into a weekly (Appendix G) and, if required, monthly internal Environmental Monitoring Summary report.

Any formal documents and reports will follow version-control procedures to ensure they are approved before use and the internal and external users are accessing the most current information.

8.1.3 Incident Reporting

Environmental incidents will be communicated by the individual who detects an incident to their supervisor and to the Environmental Coordinator.

Incident and non-compliance reports will be prepared by the Environmental Monitor for distribution to the Project management and any applicable regulatory agencies. An example of an incident report is provided in Appendix H showing the nature and type of data that will be recorded. Key information includes:

- location, cause, and nature of the incident;
- environmental or Project features affected (e.g., road, watercourse, forest land, infrastructure) ;

- time, extent, and magnitude/quantity of material or area affected;
- response and actions to control the incident;
- any follow-up tasks required, mitigation/remediation/corrective actions, or additional sampling needs;
- notifications of the incident and communication within and outside the Project Team; and
- photographs, GPS location, and a map may be included for clarification and understanding of proximity risks.

Environmental incidents during construction can be grouped into two categories based upon impact magnitude and complexity. Minor incidents have no permanent or long-term impact on the environment and are generally small scale in nature with simple remedies. Major environmental incidents are infrequent; can have widespread, permanent, or lethal/toxic impacts; are complex to resolve; and may require extensive remediation or cleanup resources.

Minor incidents with little consequence to the environment will be reported within 24 hours to the Environmental Monitor. Examples of minor incidents include non-compliance with recommended Standard Operating Procedures, lack of spill cleanup equipment, and non-compliance with flagging of sensitive areas. Cleanup and remediation of the incident will be performed by the Contractor, in consultation with the Environmental Monitor, to address the causes, potential impacts, and long-term risks. The Environmental Monitor, with the assistance of the Contractor's Supervisors, will complete an Environmental Incident Report Form (Appendix H) within 48 hours, detailing the root causes, consequence(s), impacts, remediation approach, corrective recommendations, and any photos or maps. The Contractor's Environmental Manager, Environmental Monitor, and Site Supervisor will review and sign-off on the incident report and provide copies to the Engineering Procurement and Construction Manager (EPCM)/Owner's Environmental Manager with 48 hours. Minor issues are generally expected to be resolved immediately and generally no follow-up is required once addressed.

Major incidents are those with the potential to cause permanent, widespread, lethal, or cumulative impacts; a pollution release to the environment; a contravention of legislation and/or permit conditions; or a risk to human health and safety. These incidents are rare, but are more complex and resource intensive to remediate than minor incidents. Examples of major incidents include a major sediment release into a stream and damage to fish habitat or critical wildlife habitat.

Major incidents must be reported immediately to the Environmental Monitor and upward to the Mine Manager. The Mine Manager will contact applicable regulatory agencies. The Contractor must immediately respond to control, contain, and minimize any impact on the environment or risk to people. The Environmental Incident Report Form (Appendix H) will be completed, within the same day as the occurrence, by the Environmental Monitor with the assistance of the Contractor's Supervisor. The Environmental Incident Report Form will detail the root causes, consequence, impacts, and remediation approach for the incident, as well as any recommendations, photos, or maps.

The Environmental Monitor, EPCM representative, and Pretivm's Construction and Environmental Managers will conduct an immediate investigation and site visit to prepare a Major Incident Report

and provide copies to the EPCM and Pretivm management within 24 hours. External agency and First Nation/stakeholder notification may be required and will be conducted by the Mine Manager. Control of a major incident may require assistance from external agencies (e.g., sediment discharge into a sensitive area), in which case Pretivm will coordinate the response. Extensive follow-up, sampling of the environment, and remediation may be required during or after a major incident.

8.2 RECORD KEEPING / TRACKING

8.2.1 Monitoring Results

Environmental Monitors will maintain a daily log of site conditions, construction and mitigation activities, turbidity and TSS readings, upcoming activities and issues, and any other relevant communications and observations on compliance. Any incidents, unusual occurrences, or sampling results will be documented. The information compiled in the daily log will be supplemented with photographs and GPS waypoints as necessary.

Environmental Monitors will record, transcribe, and store all field data, photographs, and results from lab analyses in an information management system.

8.2.2 Audits Results

Any audit findings resulting from government site visits or communications from external agencies will be shared with the contractors to promote compliance and continuous improvement.

8.2.3 Continuous Improvement, Follow-up, and Adaptive Management

Adaptive management is a process for continually improving management practices by learning from the outcomes of operational approaches (e.g., Bunnell et al. 2009; BC MOF 2013). To be effectively implemented, it will require a prompt response to field observations of changing environmental conditions and limitations or deficiencies in existing water management structures. Adaptive management is therefore an ongoing process of monitoring, maintenance, and reassessment.

Adaptive management enables a cost- and time-effective hierarchical response to potential environmental issues when properly implemented. If the results of monitoring indicate that management measures are not adequately meeting performance objectives, the inadequacies will be promptly identified and addressed. The adaptive management approach promotes proactive measures, with the caveat that contingency plans and materials will be in place prior to the initiation of work so that additional measures can be quickly implemented if needed.

8.2.4 Documentation Responsibilities

Documents generated by the Environmental Monitor during planning and construction will include daily inspection forms, weekly/monthly summary reports, field sampling forms, incident reports, and stop work orders. Contractors will be expected to contribute factual information and review

relevant documents produced by the Environmental Monitor and, if discrepancies are found, work to clarify facts.

Contractors will provide their staff with appropriate construction documentation (designs, drawings, maps, contract specifications, environmental plans, etc.) to ensure work is appropriately planned and executed. Contractors will be responsible for documenting, photographing any environmental mitigation activities/plans, field visits, field fit plans, spill response, Requests for Information, environmental observations, and communications with the Project Team around environmental incidents, mitigation, and planning. Contractors will be expected to share environmental information, plans, and construction schedules with the Project Team and Environmental Monitor to implement effective compliance assessment, coordination, and problem solving. Contractors must keep accurate records of the location and nature of any incidents, non-compliance events, responses and mitigation measures implemented, as well as photo documentation of works adjacent to environmentally sensitive areas (e.g., culvert/bridge installations, clearing along buffers, spill cleanup, incidents) in the event an Environmental Monitor is not on site to observe work.

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Appendix A

DFO Operational Statement for Overhead Line Construction

OVERHEAD LINE CONSTRUCTION

Fisheries and Oceans Canada
Ontario Operational Statement

Version 3.0

Overhead lines are constructed for electrical or telecommunication transmission across many watercourses that range in size from small streams and ponds to large rivers, lakes and reservoirs. This Operational Statement applies to selective removal of vegetation along the right-of-way to provide for installation and safe operation of overhead lines, and passage of equipment and materials across the water body.

Although fish habitat occurs throughout a water system, it is the riparian habitat that is most sensitive to overhead line construction. Riparian vegetation occurs adjacent to the watercourse and directly contributes to fish habitat by providing shade, cover, and spawning and food production areas. It is important to design and build your overhead line project to meet your needs while also protecting riparian areas. Potential impacts to fish and fish habitat include excessive loss of riparian vegetation, erosion and sedimentation resulting from bank disturbance and loss of plant root systems, rutting and compaction of stream substrate at crossing sites, and disruption of sensitive fish life stages.

Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat across Canada. Under the *Fisheries Act* no one may carry out a work or undertaking that will cause the harmful alteration, disruption or destruction (HADD) of fish habitat unless it has been authorized by DFO. By following the conditions and measures set out below you will be in compliance with subsection 35(1) of the *Fisheries Act*.

The purpose of this Operational Statement is to describe the conditions under which it is applicable to your project and the measures to incorporate into your project in order to avoid negative impacts to fish habitat. You may proceed with your overhead line project without a DFO review when you meet the following conditions:

- it does not require the construction or placement of any temporary or permanent structures (e.g. islands, poles, crib works, etc.) below the ordinary high water mark (HWM) (see definition below), and
- you incorporate the *Measures to Protect Fish and Fish Habitat when Constructing Overhead Lines* listed below in this Operational Statement.

If you cannot meet all of the conditions listed above and cannot incorporate all of the measures listed below then your project may result in a violation of subsection 35(1) of the *Fisheries Act* and you could be subject to enforcement action. In this case, you should contact your Conservation Authority, or the DFO office in your area (see Ontario DFO office list) or Parks Canada if the project is located within its jurisdiction, including the Trent-Severn Waterway and the Rideau Canal, if you wish to obtain an opinion on the possible options you should consider to avoid contravention of the *Fisheries Act.*

You are required to respect all municipal, provincial or federal legislation that applies to the work being carried out in relation to this Operational Statement. The activities undertaken in this Operational Statement must also comply with the *Species at Risk Act* (**www.sararegistry.gc.ca**). If you have questions regarding this Operational Statement, please contact one of the agencies listed above.

We ask that you notify DFO, preferably 10 working days before starting your work by filling out and sending the Ontario Operational Statement notification form (**www.dfo-mpo.gc.ca/regions/central/habitat/os-eo/prov-terr/index_e.htm**) to the DFO office in your area. This information is requested in order to evaluate the effectiveness of the work carried out in relation to this Operational Statement.

Measures to Protect Fish and Fish Habitat when Constructing Overhead Lines

1. Installing overhead lines under frozen conditions is preferable in all situations. On wet terrains (e.g., bogs), lines should be installed under frozen conditions, where possible, or using aerial methods (i.e., helicopter).

2. Design and construct approaches so that they are perpendicular to the watercourse wherever possible to minimize loss or disturbance to riparian vegetation.

3. Avoid building structures on meander bends, braided streams, alluvial fans, active floodplains or any other area that is inherently unstable and may result in erosion and scouring of the stream bed or overhead line structures.

3.1. Wherever possible, locate all temporary or permanent structures, such as poles, sufficiently above the HWM to prevent erosion.

4. While this Operational Statement does not cover the clearing of riparian vegetation, the removal of select plants may be necessary to accommodate the overhead line. This removal

should be kept to a minimum and within the road or utility right-of-way.

5. Machinery fording the watercourse to bring equipment required for construction to the opposite side is limited to a one-time event (over and back) and should occur only if an existing crossing at another location is not available or practical to use. A *Temporary Stream Crossing* Operational Statement is also available.

- **5.1.** If minor rutting is likely to occur, stream bank and bed protection methods (e.g., swamp mats, pads) should be used provided they do not constrict flows or block fish passage.
- **5.2.** Grading of the stream banks for the approaches should not occur.
- **5.3.** If the stream bed and banks are steep and highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation is likely to occur as a result of equipment fording, then a temporary crossing structure or other practice should be used to protect these areas.
- **5.4.** Time the one-time fording to prevent disruption to sensitive fish life stages by adhering to appropriate fisheries timing windows (see the *Ontario In-Water Construction Timing Windows*).
- **5.5.** Fording should occur under low flow conditions and not when flows are elevated due to local rain events or seasonal flooding.

6. Operate machinery on land and in a manner that minimizes disturbance to the banks of the watercourse.

- **6.1.** Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks.
- **6.2.** Wash, refuel and service machinery and store fuel and other materials for the machinery away from the water to prevent any deleterious substance from entering the water.
- **6.3.** Keep an emergency spill kit on site in case of fluid leaks or spills from machinery.
- **6.4.** Restore banks to original condition if any disturbance occurs.

7. Install effective sediment and erosion control measures before starting work to prevent entry of sediment into the watercourse. Inspect them regularly during the course of construction and make all necessary repairs if any damage occurs.

- **7.1.** Avoid work during wet, rainy conditions or use alternative techniques such as aerial methods (i.e., helicopter) to install overhead lines.

8. Stabilize any waste materials removed from the work site to prevent them from entering the watercourse. This could include covering spoil piles with biodegradable mats or tarps or planting them with grass or shrubs.

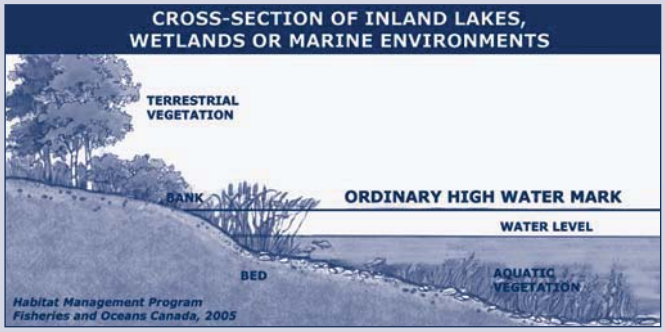
9. Vegetate any disturbed areas by planting and seeding preferably with native trees, shrubs or grasses and cover such areas with mulch to prevent erosion and to help seeds germinate. If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring.

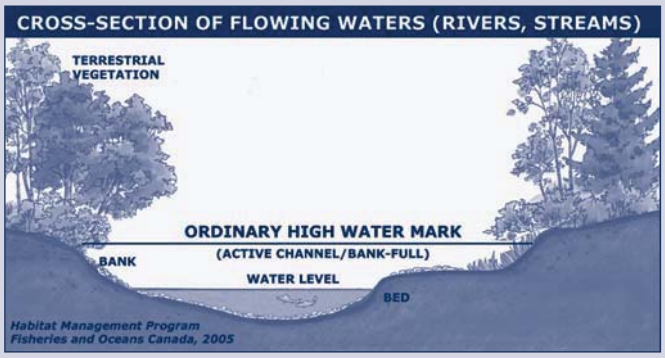
- **9.1.** Maintain effective sediment and erosion control measures until re-vegetation of disturbed areas is achieved.

Definition:

Ordinary high water mark (HWM) – The usual or average level to which a body of water rises at its highest point and remains for sufficient time so as to change the characteristics of the land. In flowing waters (rivers, streams) this refers to the "active channel/bank-full level" which is often the 1:2 year flood flow return level. In inland lakes, wetlands or marine environments it refers to those parts of the water body bed and banks that are frequently flooded by water so as to leave a mark on the land and where the natural vegetation changes from predominately aquatic vegetation to terrestrial vegetation (excepting water tolerant species). For reservoirs this refers to normal high operating levels (Full Supply Level).

For the Great Lakes this refers to the 80th percentile elevation above chart datum as described in DFO's *Fish Habitat and Determining the High Water Mark on Lakes*.





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http://www.dfo-mpo.gc.ca/oceans-habitat/habitat/modernizing-moderniser/epmp-pmpe/index_f.asp

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Appendix B

DFO Operational Statement for Maintenance of Riparian Vegetation in Existing Rights-of-Way

MAINTENANCE OF RIPARIAN VEGETATION IN EXISTING RIGHTS-OF-WAY

Fisheries and Oceans Canada
Pacific Region Operational Statement

Version 3.0

Rights-of-way are areas of land devoted to providing transportation corridors (e.g., highways, railways) or utilities (e.g., pipelines, power lines, water lines) that often intersect waterways. Vegetation is closely managed in these areas to prevent disruption to transportation or utilities (e.g., circuit outages, fires) and to ensure personal safety. Maintenance activities involving the removal or alteration of riparian vegetation in the right-of-way corridor may negatively affect fish habitat when improperly executed. This Operational Statement applies only to existing rights-of-way at the location where they intersect and cross a water body.

Riparian areas are the vegetated areas adjacent to a water body and directly contribute to fish habitat by providing shade, cover and food production areas. Riparian areas are also important because they stabilize stream banks and shorelines. In order to minimize disturbance to fish habitat and prevent bank erosion, it is important to retain as much riparian vegetation as possible, especially the vegetation directly adjacent to the watercourse, in the right-of-way corridor.

Activities carried out to maintain riparian vegetation in existing rights-of-way can negatively impact fish and fish habitat by causing excessive loss of riparian vegetation, erosion and sedimentation, disturbance to the banks and the bottom of the water body from use of heavy equipment, and introduction of deleterious substances as a result of inadequate containment of spoil piles and improper maintenance of equipment.

Fisheries and Oceans Canada (DFO) is responsible for protecting fish and fish habitat across Canada. Under the *Fisheries Act* no one may carry out a work or undertaking that will cause the harmful alteration, disruption or destruction (HADD) of fish habitat unless it has been authorized by DFO. By following the conditions and measures set out below you will be in compliance with subsection 35(1) of the *Fisheries Act*.

The purpose of this Operational Statement is to describe the conditions under which it is applicable to your project and the measures to be incorporated into your project in order to avoid negative impacts to fish habitat. You may proceed with your right-of-way maintenance project without a DFO review when you meet the following conditions:

- the work involves the maintenance of vegetation in an **existing** active right-of-way for a transportation or utility corridor and not construction of a new right-of-way or reactivation of an old right-of-way,
- it is an existing right-of-way at the location where it intersects and crosses a water body, the right-of-way is perpendicular or near perpendicular to the water body,
- it does not include complete removal of vegetation adjacent to the water body,
- it involves the use of vegetative maintenance techniques that allow the root system to stay intact, to help bind the soil and encourage rapid colonization of low-growing plant species,
- the maintenance activities are not currently covered by an existing DFO approved management plan, an approved work practice or according to the conditions of a previous government review, and
- you incorporate the *Measures to Protect Fish and Fish Habitat when Maintaining Rights-of-way in Riparian Areas* listed below in this Operational Statement.

If you cannot meet all of the conditions listed above and cannot incorporate all of the measures listed below then your project may result in the violation of subsection 35(1) of the *Fisheries Act* and you could be subject to enforcement action. In this case, you should contact the DFO office in your area if you wish to obtain DFO's opinion on the possible options you should consider to avoid contravention of the *Fisheries Act*.

You are required to comply with all municipal, provincial, territorial and/or federal legislation that applies to the work being carried out in relation to this Operational Statement. In British Columbia, please contact the Water Stewardship Division, Ministry of Environment (**http://www.env.gov.bc.ca/wsd/water_rights/licence_application/section9/index.html**) for information the Provincial *Water Regulation* notification requirements when planning to conduct maintenance of riparian vegetation in existing rights-of-ways in or around BC waters.

The activities undertaken in this Operational Statement must also comply with the *Species at Risk Act* (**http://www.speciesatrisk.gc.ca**). For general information on aquatic SARA species visit the following web site: **http://www.dfo-mpo.gc.ca/species-especes/actMeans/actMeans_criticalHabit_factsheet_e.asp** and/or contact DFO by email at **SARA@pac.dfo-mpo.gc.ca**.

If you have questions regarding this Operational Statement, please refer to the list of **Frequently Asked Questions** (**http://www-heb.pac.dfo-mpo.gc.ca/decisionsupport/os/os-faq_e.htm**) or contact DFO Regional Headquarters at 1-866-845-6776.

Please notify DFO 10 working days before starting your work by filling out and sending the Pacific Region Operational Statement **notification form** directly to DFO Regional Headquarters. This information is requested in order to evaluate the effectiveness of the work carried out in relation to this Operational Statement. It is recommended that you keep a copy of the Operational

Statement at the work site to demonstrate to Habitat and Fishery Officer staff that the conditions and measures, as outlined in the OS, are being followed.

Area of Application
This Operational Statement applies to the province of British Columbia and Yukon Territory freshwater systems only.

Measures to Protect Fish and Fish Habitat when Maintaining Riparian Vegetation in Rights-of-way

1. While this Operational Statement does not cover the complete clearing of riparian vegetation, the alteration (e.g., topping and pruning) of select plants may be necessary to meet operational and safety needs.

2. Combined maintenance activities (e.g., mowing, brushing, topping, slashing, etc.) will affect no more than one third (1/3) of the total woody vegetation, such as trees and shrubs, in the right-of-way within 30 metres of the **high water mark** (**http://www-heb.pac.dfo-mpo.gc.ca/decisionsupport/os/definitions_e.htm**) in any given year.

3. When practicable, alter riparian vegetation in the right-of-way by hand. If machinery must be used, operate machinery on land (above the **HWM**) and in a manner that minimizes disturbance to the banks of the water body.

- **3.1.** Machinery is to arrive on site in a clean condition and is to be maintained free of fluid leaks, invasive species and noxious weeds.
- **3.2.** Wash, refuel and service and store fuel and other materials for the machinery, which include hand tools, at locations away from the water to prevent any deleterious substance from entering the water body.
- **3.3.** Keep an emergency spill kit on site in case of fluid leaks or spills from machinery.
- **3.4.** Restore banks to original condition if any disturbance occurs.

4. Machinery fording the watercourse to bring equipment required for maintenance to the opposite side is limited to a one-time event (over and back) and should occur only if an existing crossing at another location is not available or practical to use. A *Temporary Ford Stream Crossings* Operational Statement is also available.

- **4.1.** To exercise this option, the stream bed at the fording site must be comprised of stable gravel or bedrock and the stream banks must be low and stable.
- **4.2.** If minor rutting is likely to occur, stream bank and bed protection methods (e.g., swamp mats, pads) should be used provided they do not constrict flows or block fish passage.
- **4.3.** Grading of the stream banks for the approaches is not permitted.
- **4.4.** If the stream bed and banks are steep and highly erodible (e.g., dominated by organic materials and silts) and erosion and degradation are likely to occur as a result of equipment fording, then a temporary crossing structure or other practice should be used to protect these areas.
- **4.5.** The one-time fording should prevent disruption to sensitive fish life stages by adhering to appropriate fisheries **timing windows** (**http://www-heb.pac.dfo-mpo.gc.ca/decisionsupport/os/timing_e.htm**) .
- **4.6.** Fording should occur under low flow conditions and not when flows are elevated due to local rain events or seasonal flooding.

5. When altering a tree that is located on the bank of a water body, ensure that the root structure and stability are maintained.

6. Stabilize any waste materials removed from the work site to prevent them from entering the water body. This could include covering spoil piles with biodegradable mats or tarps. All long-term storage of waste materials should be kept outside of the riparian area.

7. Vegetate any disturbed areas by planting and seeding with native trees, shrubs or grasses and cover such areas with mulch to prevent erosion and to help seeds germinate. All seeding and/or planting trees should follow the DFO guidance on **Riparian Revegetation** (**http://www-heb.pac.dfo-mpo.gc.ca/decisionsupport/os/riparian-reveg_e.htm**). If there is insufficient time remaining in the growing season, the site should be stabilized (e.g., cover exposed areas with erosion control blankets to keep the soil in place and prevent erosion) and vegetated the following spring.

- **7.1.** Maintain effective sediment and erosion control measures until re-vegetation of disturbed areas is achieved.

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Appendix C

Best Management Practices (BMPs) for Erosion Prevention and Sediment Control

1 BEST MANAGEMENT PRACTICES FOR EROSION PREVENTION AND SEDIMENT CONTROL

For successful erosion prevention and sediment control (EPSC), erosion prevention measures must be the primary control implemented on a construction site. Erosion prevention is proactive source control. By preventing the initial detachment and transport of sediment, erosion prevention minimizes the cost and effort associated with sediment control. Successful erosion prevention measures will reduce or eliminate the need for sediment control measures.

1.1 BEST MANAGEMENT PRACTICES FOR EROSION PREVENTION AND SEDIMENT CONTROL

While erosion prevention aims to prevent the initial detachment and entrainment of material, sediment control is a secondary, non-source control with the objective of collecting and retaining sediment some distance away from its source. Erosion prevention will always be the first objective, because the need for sediment control is reduced if minimal erosion is occurring. Although initial costs for sediment controls may be cheaper than initial costs for erosion controls, sediment controls may have higher long-term costs because they require ongoing maintenance and are less effective than erosion controls.

The key goal of sediment control is to decrease surface water flow velocities to prevent delivery of entrained material into waterways. Limiting the energy of runoff by slowing water movement reduces erosion and promotes deposition of entrained particles.

Given the environmental conditions in the Project area – high rainfall and runoff, erodible soils, and steep slopes – some degree of soil erosion is likely to occur even with comprehensive erosion management. Sediment control measures are required to capture eroded material before it is released to waterways. In order to limit disturbance associated with land clearing along the Brucejack Access Road, no large sediment ponds will be prescribed during construction. In general, sediment ponds are not feasible along linear infrastructure projects. However, smaller sediment retention pools or traps may be useful for localized, site-specific applications (e.g., culvert inlets).

The general erosion prevention measures are divided into three main categories:

- soil stabilization and protection;
- minimization of runoff velocity; and
- minimization of runoff volume.

1.1.1 Sediment Retention

Sediment control is ideally used only to manage the residual, minimal sediment production that occurs after effective erosion prevention controls have been implemented. Sediment control

structures slow runoff velocity by forcing runoff to pool. This allows materials to settle out of suspension. Sediment control is most effective at retaining larger particles (e.g., sand and coarse silt). Its effectiveness at retention decreases as the particle size decreases. Sediment controls are most effective at retaining sediment when runoff sediment concentrations, velocity, and volume are low. Therefore, sediment control effectiveness is lowest when the need for it is greatest (i.e., during periods of heavy precipitation).

Common measures for slowing runoff include sediment fences, berms, earth dikes, and sediment retention pools/traps. Some erosion prevention measures may provide minimal sediment control as a secondary function. These include slope roughening and terracing, wattles, fascines, check dams, and gabions. Additionally, maintaining vegetative buffer zones at the perimeter of construction sites and along streambanks is a highly effective and inexpensive method of preventing sedimentation. Vegetative buffers are particularly important when construction takes place near streams.

Regular inspection and maintenance of sediment control structures is essential, not only so they remain functional but also to remove the accumulated sediment that they trap and impound. Failure of a sediment control structure containing a large accumulation of impounded sediment can cause rapid delivery of significant quantities of sediment to streams, potentially creating a severe impact to water quality. Most sediment control structures (with the exception of large sediment retention basins, which are not feasible for access road construction) are only temporary measures to prevent sediment transport while construction is ongoing, or post-construction before the site is stabilized (i.e., prior to vegetation establishment).

1.1.2 Soil Stabilization and Protection

Exposed soils erode more quickly than soils that are covered or bound together by vegetation. Therefore, a fundamental goal of erosion prevention is to minimize the amount of time that bare soil is exposed to the elements.

1.1.2.1 Vegetation

Vegetation is the most cost-effective, long-term surface erosion prevention method. It helps to maintain the quality of the soil structure and protects the soil from rainsplash impact. Hence, natural vegetation will be left in place for as long as feasible during construction. Although it may be necessary to remove large standing vegetation such as shrubs and trees, ground cover plants will be retained, where feasible.

When construction activities are complete in an area, slopes with exposed soils will be re-vegetated as soon as feasible to prevent surface erosion. Most erosion occurs in the first year when soils are exposed, during and immediately following construction. Throughout the first few years following construction there will likely be significant re-vegetation work required as the cuts and fills stabilize. Re-vegetation will also be considered in ditchlines to ensure that permanent ditches remain stable. Spot seeding to fill in gaps in vegetation is an effective way to minimize the scope of potential problems.

Best management practices (BMPs) such as surface texturing, mulching, and application of topsoil can be used in conjunction with seeding to promote vegetation germination and growth and

enhance the effectiveness of re-vegetation efforts. Following construction, disturbed areas will be re-sloped to a stable configuration and seeded with an approved rapidly establishing, weed-free native seed mix by broadcast seeding or hydroseeding. The soils will be assessed for fertility prior to seeding and a fertilizer applied where required. Where feasible, native plants removed from the construction site will be salvaged for use at adjacent sites where construction is completed. Bioengineering with willows and plantings of other shrubs may be used where additional stabilization is required.

Mulching and application of topsoil are recommended in conjunction with re-vegetation efforts to add protection after seed and fertilizer have been applied, but prior to vegetation establishment. Organic matter provided by mulch and topsoil has high nutrient- and moisture-holding capacities and helps to protect seeds prior to germination and growth. Local and natural materials will be used whenever feasible. Straw, wood chips, and green mulch (produced by shredding slash and other vegetation) are effective mulches and may be highly cost-efficient if materials are locally abundant. Application of topsoil can also make use of local materials, as topsoil stripped from a construction site can be reapplied once construction is complete. Topsoil application is particularly useful in areas where the soil is nutrient deficient or shallow.

1.1.2.2 Temporary Covers

At sites that are temporarily inactive, or when the seasonal timing of construction is not conducive to re-seeding, slopes will be covered with brush material, rolled erosion control products (RECPs), or polyethylene sheeting, where required. The material protects the soil from rainsplash erosion and can be easily removed when activity resumes at the site.

1.1.2.3 Slope, Ditch, and Outlet Protection

Slopes, ditches, outlets, and other areas which receive concentrated flow are highly susceptible to erosion. Gabions, retaining walls, and riprap armouring can be used to protect these areas. Gabions and retaining walls are durable and effective for relatively high slopes. Construction of gabions and retaining walls is often expensive and labour intensive, but they provide long-lasting slope stabilization in extreme conditions.

Rock armouring or riprap can be used to line slopes or outlets, protecting against erosion by stabilizing soil and dissipating runoff energy. It is easily installed and effective in highly erodible soils, but it will be applied in conjunction with other erosion prevention measures, including an underlay of geotextile or gravel to prevent displacement of finer materials.

These protective measures will be used in conjunction with runoff control BMPs (discussed below), not as a stand-alone erosion prevention approach.

1.1.3 Minimization of Runoff Velocity

When flow velocities are decreased, the erosive power of water is reduced. Minimizing runoff velocity limits rill and channel erosion. Additionally, lower runoff velocity promotes the deposition of entrained material as close as feasible to its source, thereby reducing the amount of sediment that is transported into waterways.

1.1.3.1 Slope Length

Slope length is the distance along a slope where water may flow unimpeded. As slope length and steepness increase, runoff velocity increases. Slope length will be limited by installing slope breaks that can redirect or absorb surface water energy. Steeper slopes require shorter lengths to minimize runoff velocity. As a general rule, erosion hazard exists if slope length for a given gradient exceeds the maximum figures given in Table 1.1-1. Additionally, shorter slope lengths may be required in order to enhance the functionality of specific EPSC measures (e.g., maximum allowable slope lengths contributing runoff to sediment fences, listed in Appendix E SEPSCP). Common slope breaks include sediment fences, rock or brush berms, wattles, fascines, and drainage ditches. It is important that slope breaks are installed properly and maintained so that they do not cause erosion by concentrating and channelizing flow.

Table 1.1-1. Maximum Slope Length as a Function of Slope Gradient

Slope Gradient (%)	Maximum Slope Length (m)
0 - 7	100
7 - 15	50
> 15	25

Source: GVSDD (1999) and ID DEQ (2005).

Flow velocity reduction in ditches is particularly important, because channelized flow can quickly pick up speed and energy to become a major erosive force. Check dams reduce gradient in ditches, thereby slowing the velocity of concentrated flow and triggering the deposition of the transported sediment. Check dams are relatively simple and inexpensive to construct, and can generally be made from locally available material such as rocks or brush. At the outlets of ditches or other areas with channelized flow (such as slope drains or culverts), energy dissipators are useful to slow flow velocity and dissipate flow energy.

Culvert installation can limit slope length and runoff velocity if culverts are extended along steep downslope areas. Water that would otherwise flow across the slope face can therefore be routed through the culvert and discharged where the gradient has lessened. Corrugated metal pipes may be more effective in slowing water velocity than culvert pipes with smooth interior walls.

On road surfaces, water bars and rolling dips can be used to minimize slope length and slow runoff velocity. Although these structures are easy to install and maintain, they require proper installation and regular maintenance to remain functional. As with slope breaks, improperly constructed and maintained water bars and rolling dips have the potential to cause erosion by concentrating flow or directing runoff onto unstable fill slopes.

1.1.3.2 Slope Configuration

Roughening or terracing through the construction of furrows or steps along a contour produces unevenness on exposed slopes. This decreases erosion potential by reducing flow velocities, trapping sediment, and increasing infiltration. Roughening the soil also promotes vegetation establishment following seeding.

1.1.3.3 Construction Sequencing

When clearing a site, working from the top of the slope to the bottom maintains the largest buffer zone between the disturbed areas and the receiving environment below. Hillslope runoff from the construction site will pass through the vegetated zone before entering the receiving environment, resulting in a decrease in overland flow velocity and an increase in sediment deposition.

1.1.4 Minimization of Runoff Volume

The key aims of erosion prevention measures in this category are to prevent upslope runoff entering a site, to decrease the likelihood of runoff being generated on the site and to minimize the volume of sediment-laden water requiring treatment in a sedimentation pond or other sediment control structure.

1.1.4.1 Soil Drainage

Soil drainage will be implemented prior to the commencement of construction activities. Draining the soil opens up pore space, thereby enhancing infiltration capacity and minimizing the generation of overland flow. Improved soil structure in well-drained soils helps to minimize erosion caused by heavy machinery during construction activities. Drainage can be achieved through the construction of temporary or permanent ditches. Where feasible, ditches will be installed in advance of construction on the rest of the site. Ditch configuration and spacing are dependent upon local drainage conditions and site access.

Pipe slope drains are often used in conjunction with ditches that direct runoff along the top of cut and fill slopes. Slope drains can provide effective temporary or permanent erosion prevention, but will always be used in conjunction with other erosion prevention measures such as armouring of the outlet.

1.1.4.2 Runoff Diversion

Diverting runoff from upslope of the construction site minimizes the amount of water flowing through the construction site. This limits the potential for generation of overland flow and for concentration of flow paths. Decreasing flow through the site also reduces the amount of eroded material that is generated from the site, therefore reducing the need for sediment control structures such as retention pools or traps.

A series of diversion ditches may be constructed on the upslope end of a construction site to capture and divert runoff. Diversion ditches are most effective when paired with other erosion prevention measures, such as rock armour and pipe slope drains.

1.1.4.3 Inclement Weather

To minimize the impact of large rain events, which can generate large amounts of runoff and subsequent erosion, major ground breaking activities and land clearing will be avoided during periods of high and sustained rainfall. A list of adverse weather shutdown triggers has been developed for construction activities.

Appendix D

Recommended Best Management Practices (BMPs) for the Brucejack Gold Mine Project

Erosion Prevention/ Sediment Control	Applications					Comments	
	Slopes	Ditches and Channels	Flat Areas	Borrow and Stockpile Areas	Road Surfaces	Advantages	Limitations
E/S	x	x	x	x	x	• Proactive and cost-effective • Identifies major construction and land disturbing activities and prescribes effective erosion prevention and sediment control practices prior to the start of construction • Focus on effective, cost-efficient erosion prevention controls rather than higher cost, less effective sediment controls	• Presumptive and subject to uncertainty • Only effective if construction procedures and control practices are regularly assessed and m conditions
E/S	x		x	x		• Roughens slope surface to reduce erosion potential and sediment production • Suitable for most soil types except very loose soils • Reduces runoff velocity and increases infiltration rates • May trap sediment laden runoff • Promotes vegetation development • Can be applied on slopes with a maximum gradient of 2H:1V • Inexpensive and easy to apply, can be implemented using commonly available heavy construction equipment • Provides temporary erosion prevention and sediment control (EPSC) benefits on sites that are not immediately topsoiled, mulched, or re-vegetated	• Unsuitable for loose soils • Not practical for steep slopes (limits dozer op • Provides limited sediment and erosion contro control measure • Limited application on slopes steeper than 2H • Most effective when combined with other EPS • Must be re-established after heavy rains
E/S	x			x		• Reduce erosion damage by capturing surface runoff and directing it to a stable outlet at a speed that minimizes erosion • Effective for slopes up to 50% • Can be implemented using commonly available heavy construction equipment	• Unsuitable for excessively steep slopes (> 50% • May cause sloughing if water infiltrates soil • Will need to be designed by qualified professi • Stable runoff outlets (e.g., vegetated areas) mu
E	x		x	x		• Organic mulches (e.g., compost, straw, wood chips) are a useful temporary measure to protect slopes for short periods and can be applied in conjunction with seeding • Inorganic mulches (e.g., gravel or rock blankets) can provide permanent erosion prevention • Inexpensive and easy to apply • Prevents soil particle detachment, decreases runoff velocity, promotes infiltration into soil, and prevents surface crusting and soil compaction • Promotes plant germination and growth	• Application on steep slopes may be difficult • Inorganic mulches may prevent the establishn • May deplete available nitrogen • Organic mulches have a limited functional life • Certain mulches (e.g., straw) can be easily blo runoff • Certain mulches may not be available or may • Most effective when combined with other EPS texturing/roughening)
E	x		x	x		• Provides suitable growth medium for vegetation on slopes 2H:1V and flatter • Useful in areas where soil is nutrient deficient or too shallow to provide adequate rooting depth for the growth of the desired vegetation • Topsoil stripped from a construction site can be reapplied • Optimizes performance of seeding and re-vegetation methods	• Limited to slopes 2H:1V and flatter • Applicability and cost-effectiveness are subjec available equipment; importing topsoil can in • Application is seasonally limited; topsoil will frozen or extremely wet • Will not be used as a stand-alone method, effe combined with associated erosion prevention

Erosion Prevention/ Sediment Control	Applications					Comments	
	Slopes	Ditches and Channels	Flat Areas	Borrow and Stockpile Areas	Road Surfaces	Advantages	Limitations
E	x	x	x	x		• Temporary seeding can be used on disturbed soils that require interim erosion prevention controls • Permanent seeding can be used to provide effective post-construction erosion prevention on disturbed bare soil that has been graded to final contour • Inexpensive • Effectiveness increases with time as vegetation develops • Increases the erosion prevention performance of other methods (e.g., organic mulches, straw wattles) by decreasing runoff volume and velocity	• May require periodic maintenance (e.g., fertili • Seeding may be difficult on steep slopes (mos • Seasonal limitations on seeding effectiveness • Freshly seeded areas are susceptible to erosion requiring temporary erosion prevention meas • Will be combined with other methods (e.g., sl topsoiling, mulching) to optimize performanc
E	x	x	x	x		• Effective for establishing a vegetation cover, especially where seedbed preparation is impractical • Can be used on an irregular soil surface • Large rocks, stones, roots and other large materials do not need to be removed from site • Can be used on steep or inaccessible slopes where other seeding and mulching methods may be impractical or unsafe • Hydromulching is relatively low cost compared to other mulching methods or rolled erosion control products (RECPs)	• Requires specialized equipment to mix and ap • Not practical where equipment cannot access • Areas where application has not been success applications • Not a fail-safe method; must be combined wit performance
E/S	x	x	x	x		• Establishes vegetative cover and root mat • Reduces flow velocities on vegetative surface • May trap sediment laden runoff • Grows stronger with time as root structure develops	• May be labour intensive to install • Re-vegetated areas are subject to erosion until • Watering may be required until plants are esta
E	x	x	x	x		• Provide immediate, effective temporary erosion prevention to bare soil or topsoiled surfaces where need for erosion protection is high • Provide immediate, effective temporary or permanent erosion prevention in a constructed ditch • Can be more uniform and longer lasting than mulch • Wide range of commercially available products allows for use across a range of slope and soil conditions • Prevents soil particle detachment, decreases runoff velocity, promotes infiltration into soil, and prevents surface crusting and soil compaction • Promotes plant germination and growth • Hand installation, does not require specialized equipment • Suitable for remote sites	• Installation may be labour intensive, proper si RECP onto soil correctly • Temporary RECP blankets require removal pr activities • Unsuitable for rocky slopes • Performance is dependent upon successful ve • Limited functional life (6 months to 3 years) • Cannot be installed on frozen ground, may be accumulation • Must not be used as a stand-alone erosion pre • Prone to failure if subjected to concentrated ru

Erosion evention/ ediment Control	Applications					Comments	
	Slopes	Ditches and Channels	Flat Areas	Borrow and Stockpile Areas	Road Surfaces	Advantages	Limitations
E	x	x	x	x		• Can provide highly effective temporary erosion prevention • Provides immediate effective prevention of erosion during rain events, short periods of inactivity or emergency spill response • Inexpensive, readily available in varying widths	• Must be installed by hand • Requires frequent inspection and maintenanc • Other mulch materials may be just as effective • Not effective as a long-term erosion preventio • Susceptible to displacement by water or wind • Concentrates runoff, increasing erosion poten receiving water source • Sediment-laden runoff must be directed into s as a sediment retention pond
E	x			x	x	• Can provide temporary or permanent post-construction runoff control • Can be used to collect and divert sheet flow or runoff at the top of a slope to reduce downslope erosion potential • Temporary ditches can be easily incorporated with permanent project drainage systems • Relatively easy to design and construct • Inexpensive, can be implemented using commonly available heavy construction equipment	• Must be sized for expected flows; professiona will convey large volumes of water or high ve • Riprap spillway and/or permeable outlet may • Channel lining (e.g., riprap) may be required • Sediment-laden runoff must be directed into s as a sediment retention pond • Regular inspection and maintenance required in ditches • Most effective when combined with other EPS
E	x		x	x		• Can be easily decommissioned or relocated as construction progresses • Relatively easy to design and construct • Inexpensive, can be implemented using readily available heavy construction equipment • Can be used to help keep work sites dry by intercepting overland flow upslope of an active work area • Can be used at crest of cut and fill slopes to intercept and prevent runoff over slope • Increases the erosion prevention performance of other best management practices (BMPs; e.g., RECPs on slopes, straw wattles, mulch) • Can be constructed easily and quickly using commonly available construction equipment • Can be used in conjunction with berms	• Geotechnical design required for fill heights i • May not be suitable for all soil types or sites • Limited to small catchment areas ≤ 2 ha • Riprap spillway and/or permeable outlet may • Channel lining (e.g., riprap) may be required • Sediment-laden runoff must be directed into s as a sediment retention pond • Regular inspection and maintenance required in ditches • Must not be used as a stand-alone erosion pre

Erosion Prevention/ Sediment Control	Applications					Comments	
	Slopes	Ditches and Channels	Flat Areas	Borrow and Stockpile Areas	Road Surfaces	Advantages	Limitations
E/S	x	x				• Slow runoff velocity by reducing gradient in ditches, decreasing the potential for erosion • Provide limited sediment capture and storage as a secondary benefit • Cheaper than gabion or armouring entire channel • Easily constructed using materials and equipment found on most construction sites	• Require extensive maintenance after high flow • Susceptible to failure if water undermines or c • Only provides partial sediment control; sand a detention time is too short to allow fine sedim • Limited functional life (6 months to 1 year) • May require design by qualified professional f velocities • Not to be used as a stand-alone erosion preve • Must not be used in natural watercourses • Rock check dams are more stable and effectiv
E	x	x				• Riprap used as slope lining protects against erosion by dissipating runoff energy • Riprap used as outlet lining protects against erosion by reducing the speed of concentrated flows and minimizing scouring • Durable, long lasting, flexible and low maintenance • Effective in ditches with higher flow velocities (2 to 5 m/s) • Effective for slopes up to 40% • Suitable for ditches or outlets in easily eroded soils • Easily constructed using heavy equipment • More effective than check dam structures in preventing erosion	• May be expensive compared to check dams; c available rock and rock transport and handlin • Rock must meet specification for gradation (si angularity • Must be combined with a non-woven geotexti prevent entrainment and displacement of fine underlying soil layer • Will need to be designed and specified by a qu • Must not be used as a stand-alone erosion pre • Must not be used in natural watercourses
E	x					• Often used in conjunction with diversion berms/ditches that collect and direct runoff along the top of cut and fill slopes • Effective erosion prevention measure prior to slope stabilization or before permanent drainage structures are ready for use • Can provide effective temporary or permanent erosion prevention, depending on circumstances and conduit material used • Relatively inexpensive, can be constructed using readily available materials • Depending on construction materials, may be easily disassembled and relocated as construction progresses	• Must be sized appropriately to accommodate • Erosion can occur at inlet/outlet if protection armouring) is not incorporated into design • Failure can result in severe gully erosion • Unsuitable for drainage areas > 4 ha • Sediment-laden runoff must be directed into s as a sediment retention pond • Must not be used as a stand-alone erosion pre

Erosion Prevention/ Sediment Control	Applications					Comments	
	Slopes	Ditches and Channels	Flat Areas	Borrow and Stockpile Areas	Road Surfaces	Advantages	Limitations
E	x	x				• Slows runoff velocity and dissipates flow energy in relatively short distances • Use at outlets of slope drains, culverts, conduits or channels with significant flow • Can be constructed using heavy equipment found on most construction sites • Usually constructed from angular rock, which may be readily available	• Small diameter rocks/stones can be easily dis • Grouted riprap armouring may break up due heaves, or settlement • May be expensive if riprap materials or concr • May require design by qualified professional velocities • Rock must meet specification for gradation (si angularity • After flowing over dissipator, runoff must be area or into a non-erodible ditch • Severe erosion may occur if a portion of the di • Must not be used as a stand-alone erosion pre
E	x	x			x	• Rectangular wire-mesh cages that are filled with rock and wired together, forming a protective but permeable structure for slope stabilization • Durable, long lasting, and low maintenance • Effective for slopes up to 40% • May be less expensive than riprap • Suitable for resisting high flow velocity	• Construction and installation may be labour i • Extra costs associated with gabion basket mat • Wire used for baskets may wear off quickly in loads
E	x				x	• Provide long-term slope protection or stabilization under extreme conditions • Effective for slopes up to 67%	• May be damaged by freeze-thaw cycles • Require design by qualified professional • Relatively expensive and labour intensive to i
E/S	x					• Inexpensive, easy to install by hand • Function well in freeze-thaw conditions • Can be used on slopes too steep for silt fences or straw bale barriers (up to 1H:1V) • Provide grade breaks and reduce erosion by decreasing runoff velocity • May trap sediment laden runoff • Can be combined with live staking as a bioengineering control	• Installation is labour intensive • Not appropriate for EPSC in concentrated flo • Short functional life (1 to 2 years) • Most effective when combined with other EPS to provide long term erosion prevention)
E		x			x	• Minimize the volume and velocity of road surface runoff • Minimize slope length and potential for erosion • Can be constructed easily and quickly using commonly available construction equipment • Easy to maintain	• Require maintenance to remain functional; eff fill with sediment and vehicle traffic degrades • Will cause erosion if runoff is directed onto u • Can direct sediment into watercourses if locat • Most effective when combined with other EPS

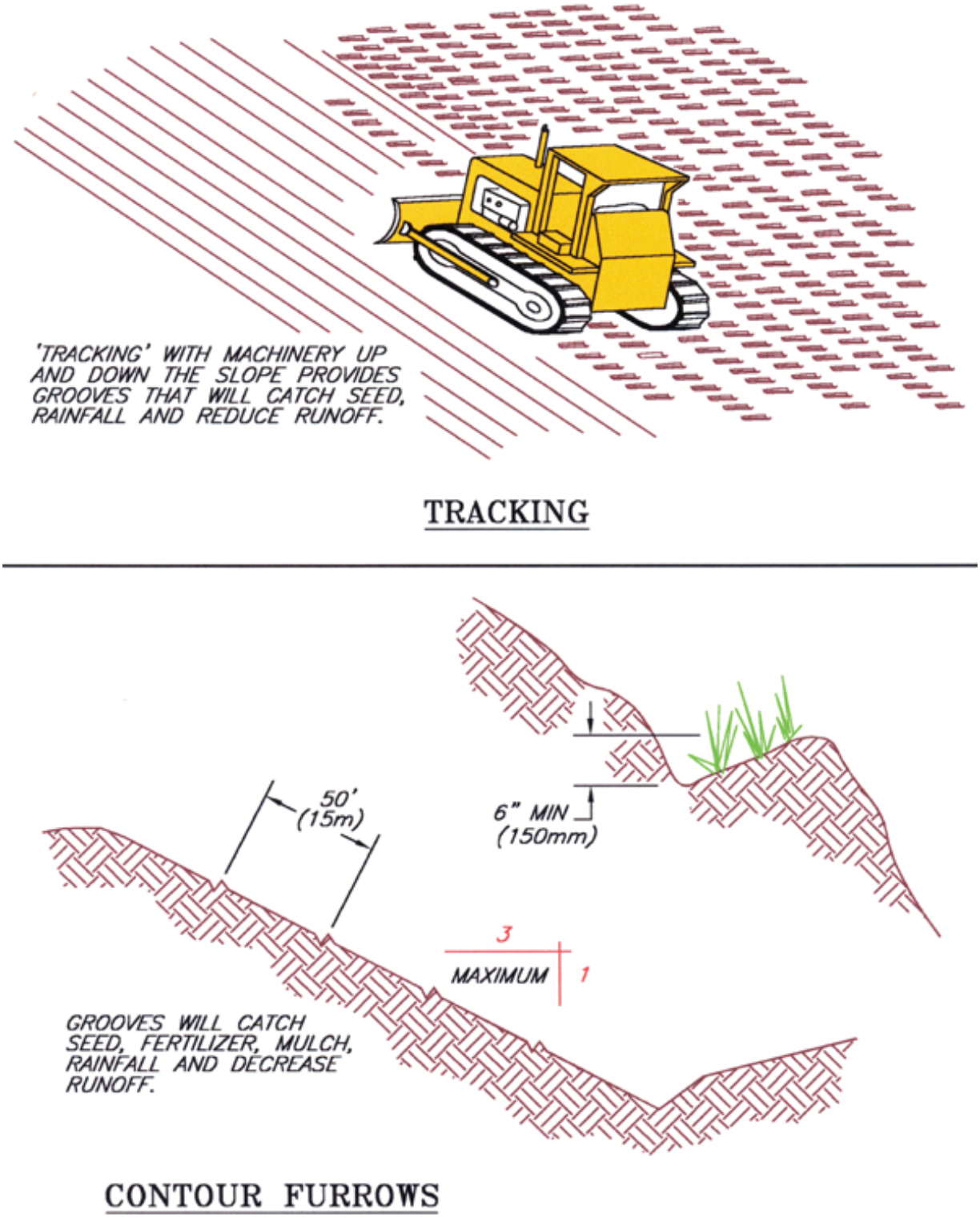
Erosion Prevention/ Sediment Control	Applications					Comments	
	Slopes	Ditches and Channels	Flat Areas	Borrow and Stockpile Areas	Road Surfaces	Advantages	Limitations
S	x	x	x	x		• Force low volume overland flow to pool so that suspended sediment can drop out of suspension • Inexpensive • Trap sediment laden runoff • Easy to install, easily replaced if damaged • Readily available	• Must not be installed in or across defined drai • May fail in high runoff events; not for use at lo expected to occur • Limited to locations where adequate space is a • Susceptible to damage, short functional life (a • Inappropriate sediment control for fine textur • Installation can be difficult in compacted or ro dense ground-covering vegetation • Retained sediment must be removed and fenc maintained on a regular basis • Combine with erosion prevention measures to
S	x	x	x	x	x	• Force low volume overland flow to pool so that suspended sediment can drop out of suspension • Easily replaced if damaged • Can be constructed from fill materials that may be readily available on the work site • Provide perimeter sediment control around active construction site or stockpile • Can be used in conjunction with, or instead of, diversion ditches	• Must not be installed in or across defined drai • May fail in high runoff events; not for use at lo expected to occur • Improper installation will concentrate runoff a erosion under or around ends of berm • Retained sediment must be removed and berm maintained on a regular basis • Combine with erosion prevention measures to
S	x		x	x		• Force low volume overland flow to pool so that suspended sediment can drop out of suspension • May provide effective sediment control for coarse soils • Easily replaced if damaged • Can be constructed from fill materials that may be on a work site or readily available to the work site • Provides perimeter sediment control around active construction site or stockpile	• Must not be installed in or across defined drai • May fail in high runoff events; not for use at lo expected to occur • Improper installation will concentrate runoff a erosion under or around ends of dike • Retained sediment must be removed and dike on a regular basis • Combine with erosion prevention measures to
S	x	x	x	x	x	• Collect and store sediment that is generated from active construction sites or sites that have not yet been stabilized by vegetation • Can be used at cross-drain culvert inlets to reduce sediment loads in road surface runoff • Can be easily installed along linear infrastructure and do not require design by a qualified professional, unlike larger sediment ponds	• May only partially retain suspended sediment pass directly through most pools/traps • Efficiency decreases as pools fill with sedimen accumulated sediment • May require specialized materials or structure structures for outlets) • Only suitable for relatively small contributing • Combine with erosion prevention measures to
			x	x	x	• Controls erosion at the source and prevents sediment transport	• May need to be applied multiple times per da humidity and the amount of traffic on the surf • Some dust suppressants may be deleterious su courses • Requires specialized equipment to apply to th

Appendix E

BMP Drawings

Figure A.C-1

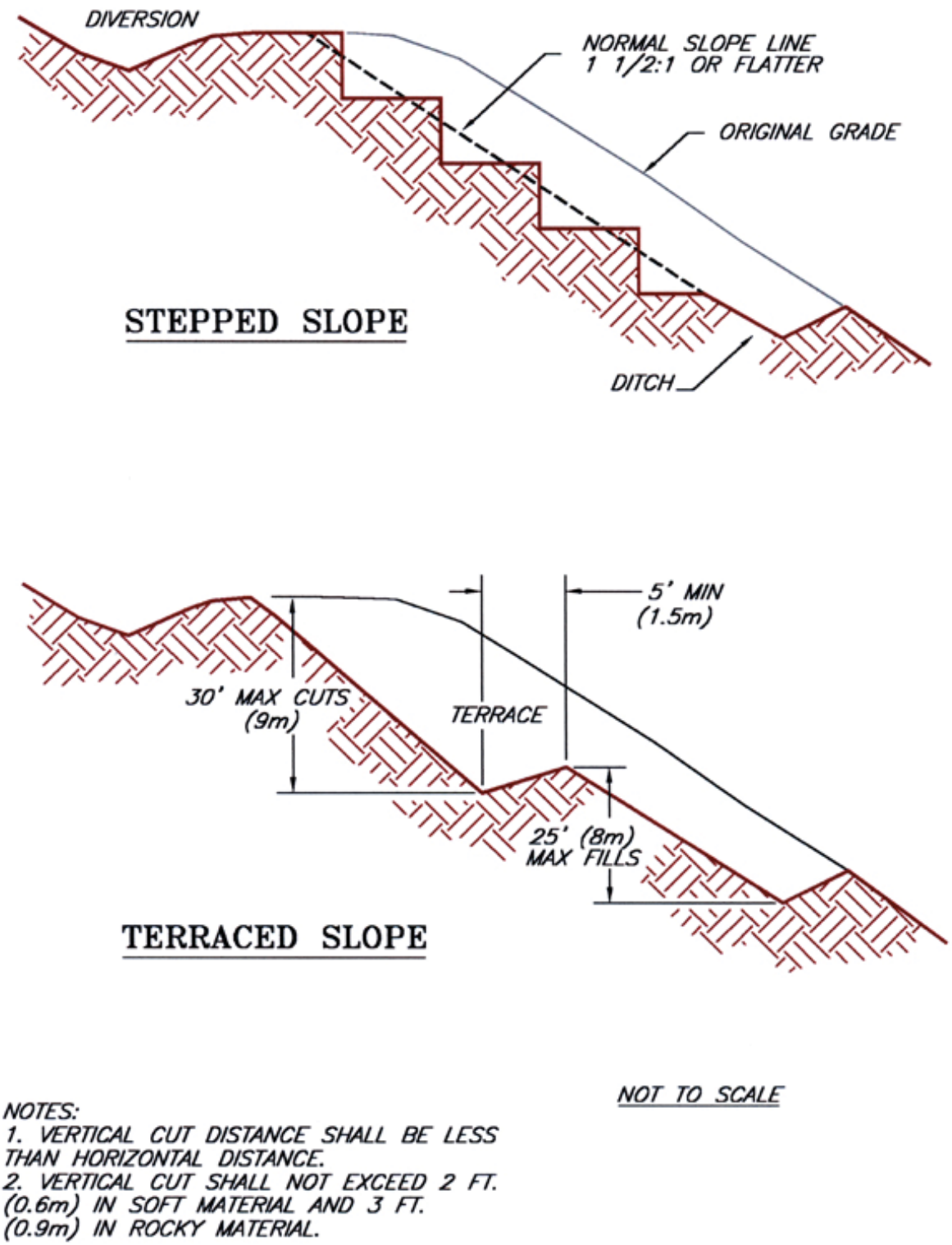
Schematic Diagram of Surface Roughening



Source: John McCullah (1994)

Figure A.C-2

Schematic Diagram of Slope Terracing



Source: John McCullan (1994)

Figure A.C-3

Straw Mulch Installation

'TRACKING' WITH MACHINERY ON SANDY SOIL PROVIDES ROUGHENING WITHOUT UNDUE COMPACTION.

STRAW ANCHORING

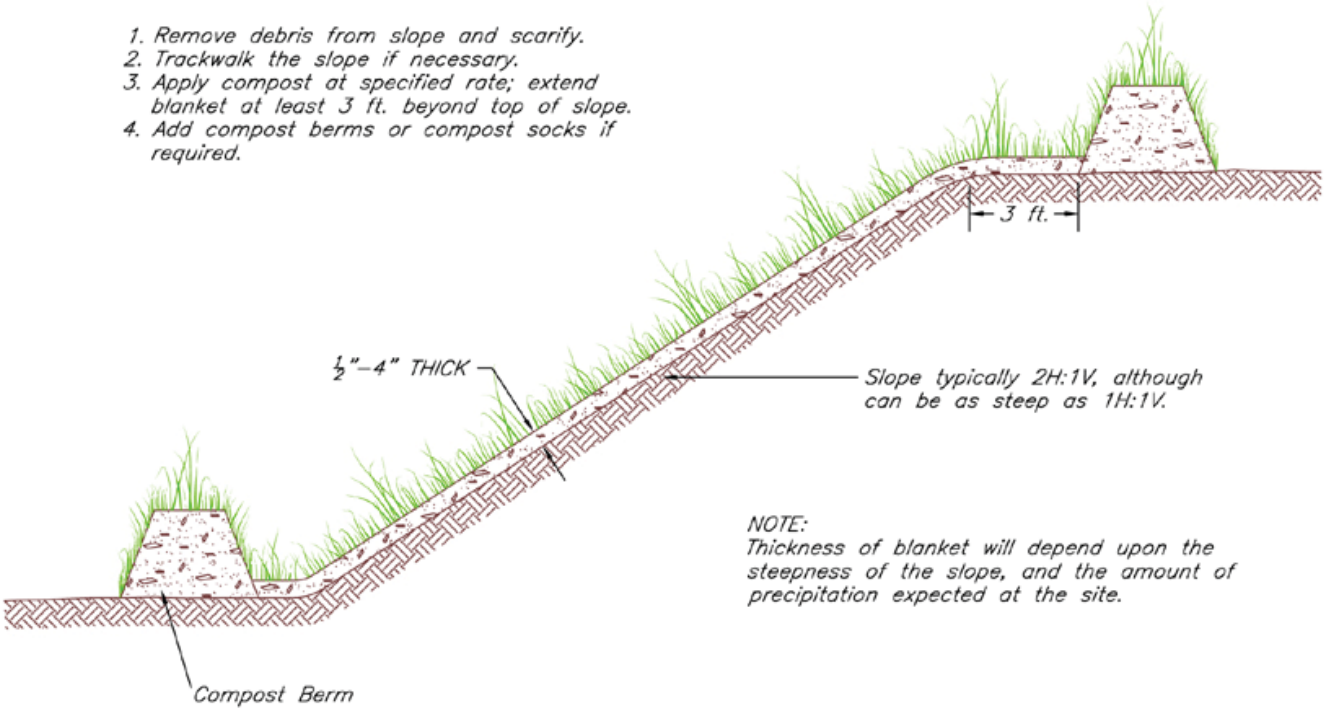
NOTES:

1. ROUGHEN SLOPE WITH BULLDOZER
2. BROADCAST SEED AND FERTILIZER.
3. SPREAD STRAW MULCH 3" (76mm) THICK. (2 1/2 TONS PER ACRE)
4. PUNCH STRAW MULCH INTO SLOPE BY RUNNING BULLDOZER UP AND DOWN SLOPE.

Source: John McCullah (1994)

Figure A.C-4

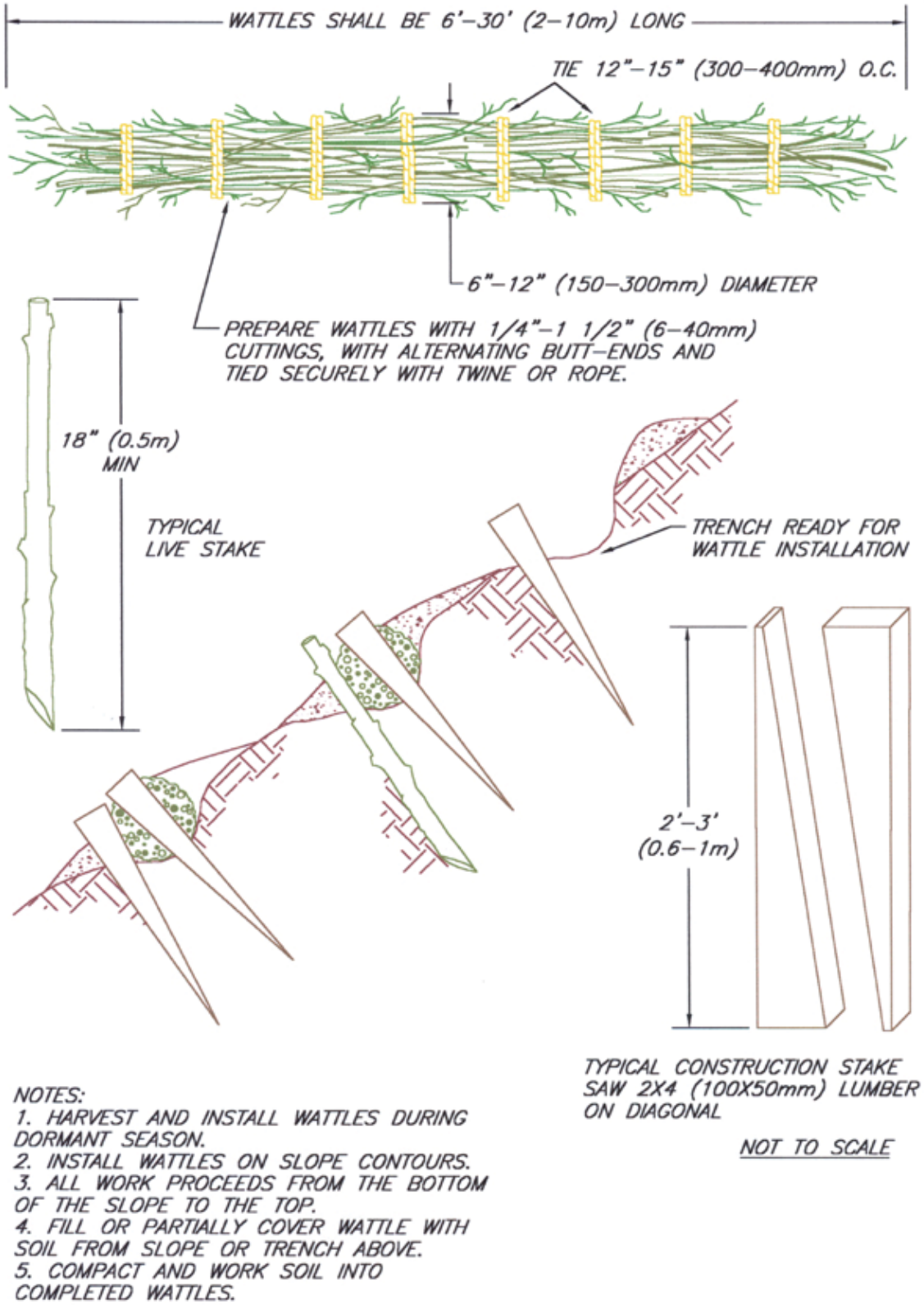
Compost Blanket Mulch Installation



Source: John McCullah (1994)

Figure A.C-5

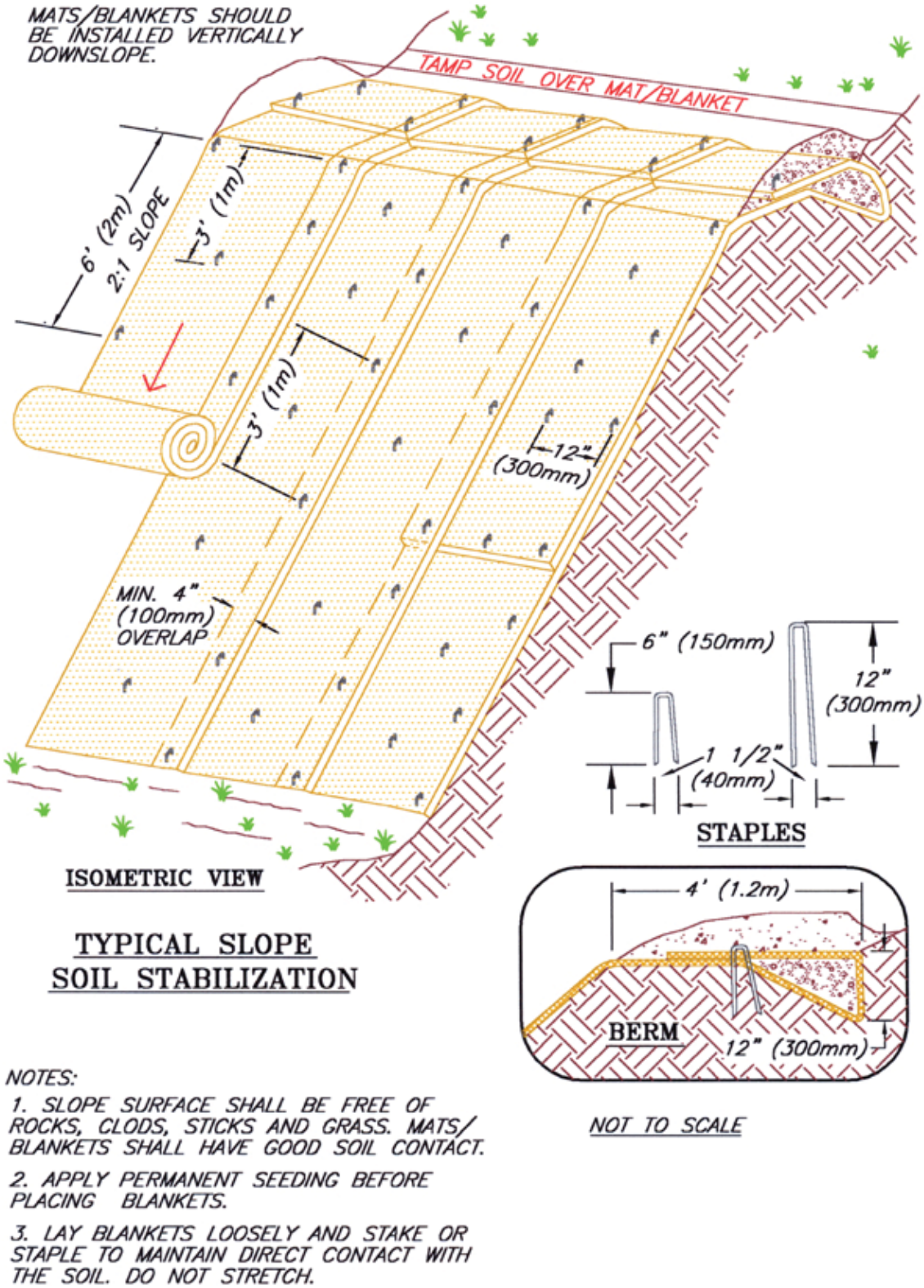
Wattle (Live Fascine) Installation



Source: John McCullah (1994)

Figure A.C-6

Installation of Rolled Erosion Control Products (RECPs) on Slopes



TYPICAL SLOPE SOIL STABILIZATION

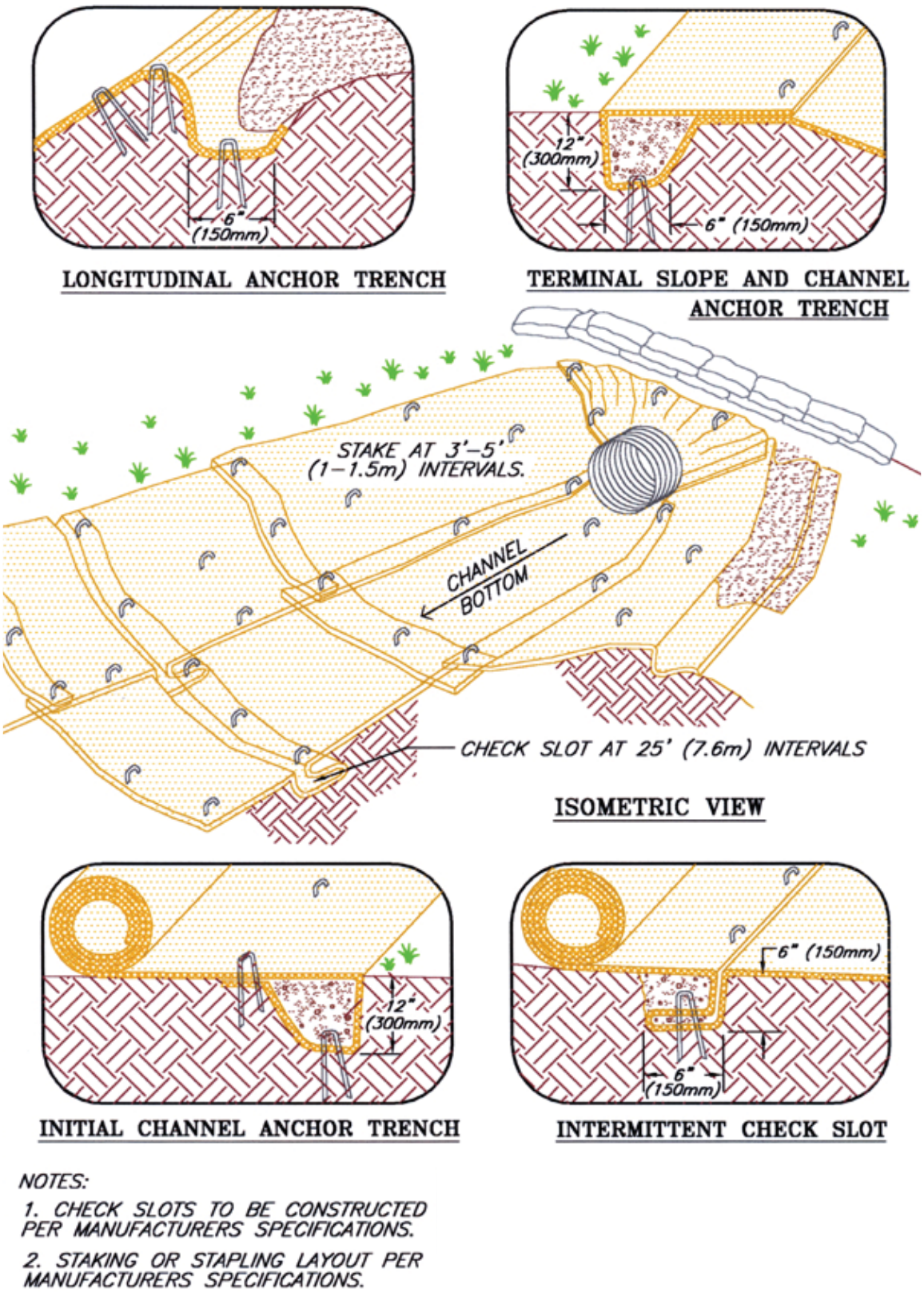
NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS. MATS/BLANKETS SHALL HAVE GOOD SOIL CONTACT.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS.
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

Source: John McCullah (1994)

Figure A.C-7

Installation of Rolled Erosion Control Products (RECPs) in Ditches



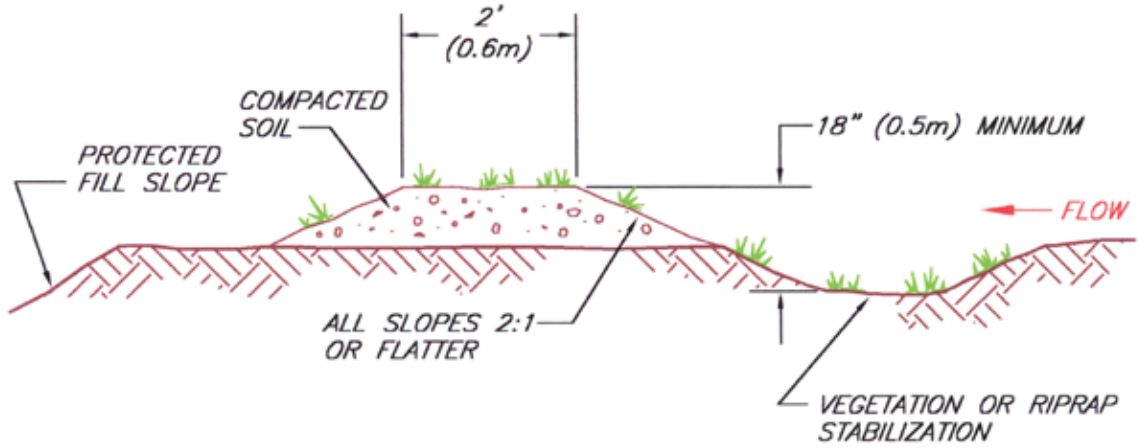
NOTES:

1. CHECK SLOTS TO BE CONSTRUCTED PER MANUFACTURERS SPECIFICATIONS.
2. STAKING OR STAPLING LAYOUT PER MANUFACTURERS SPECIFICATIONS.

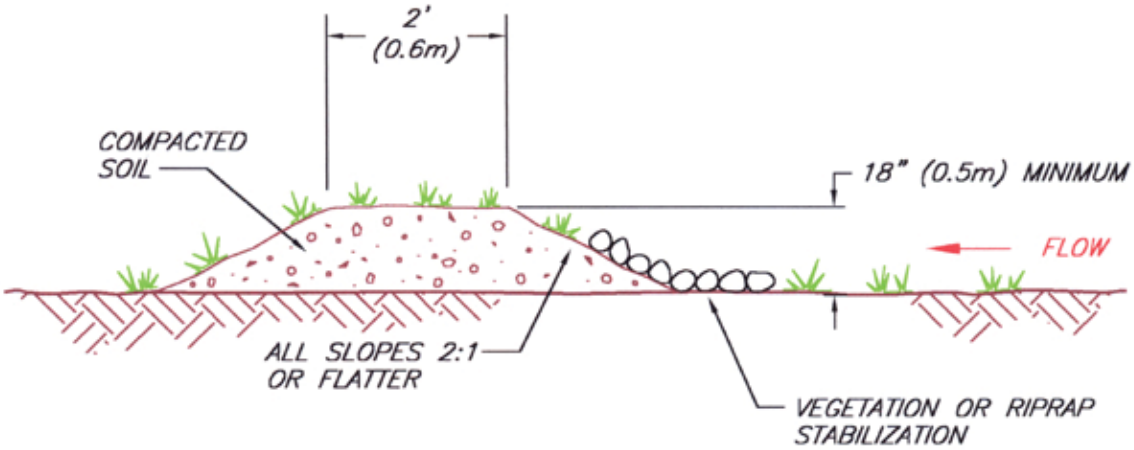
Source: John McCullah (1994)

Figure A.C-8

Schematic Diagram of Temporary Diversion Ditch and Dike



TYPICAL FILL DIVERSION



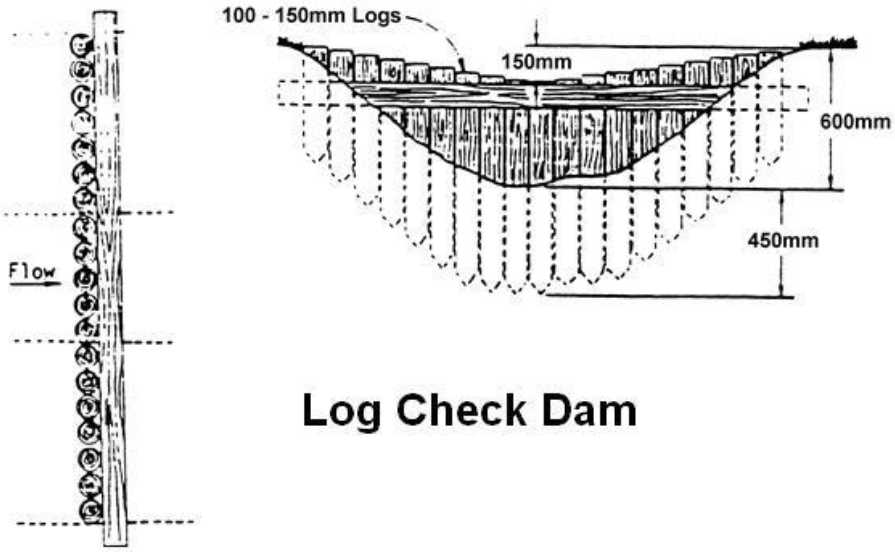
TYPICAL TEMPORARY DIVERSION DIKE

NOTES:
1. THE CHANNEL BEHIND THE DIKE SHALL HAVE POSITIVE GRADE TO A STABILIZED OUTLET.
2. THE DIKE SHALL BE ADEQUATELY COMPACTED TO PREVENT FAILURE.
3. THE DIKE SHALL BE STABILIZED WITH TEMPORARY OR PERMANENT SEEDING OR RIPRAP.

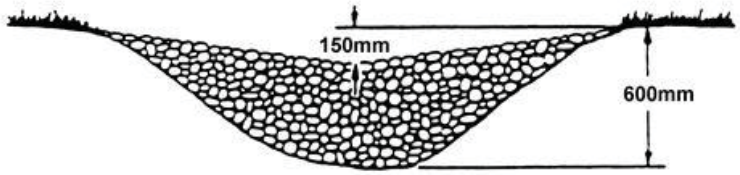
Source: John McCullah (1994)

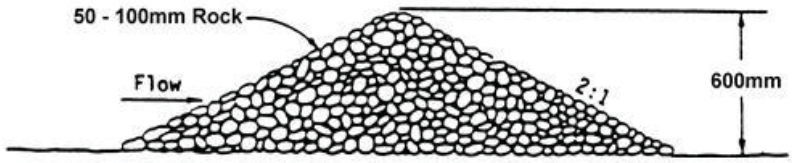
Figure A.C-9

Log and Rock Check Dam Installation

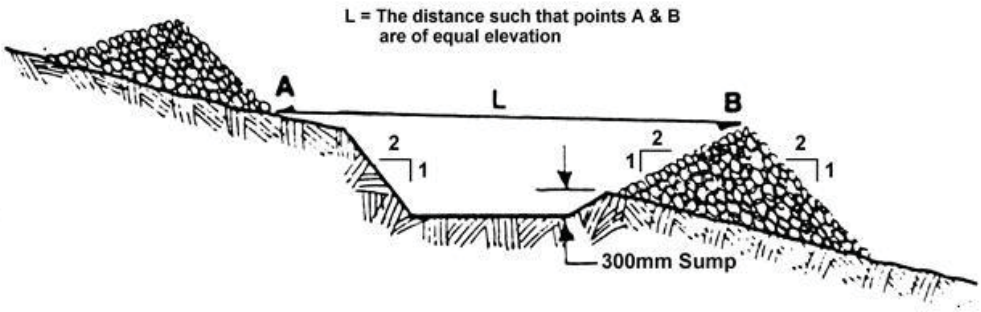


Log Check Dam





Rock Check Dam



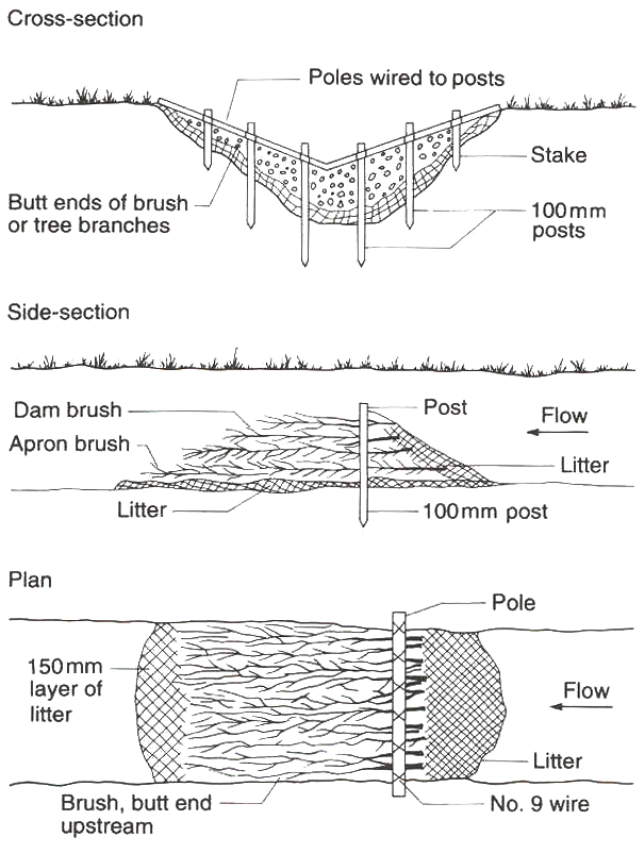
Check Dam Spacing

Source: GVRD Best Management Practices Guide for Stormwater

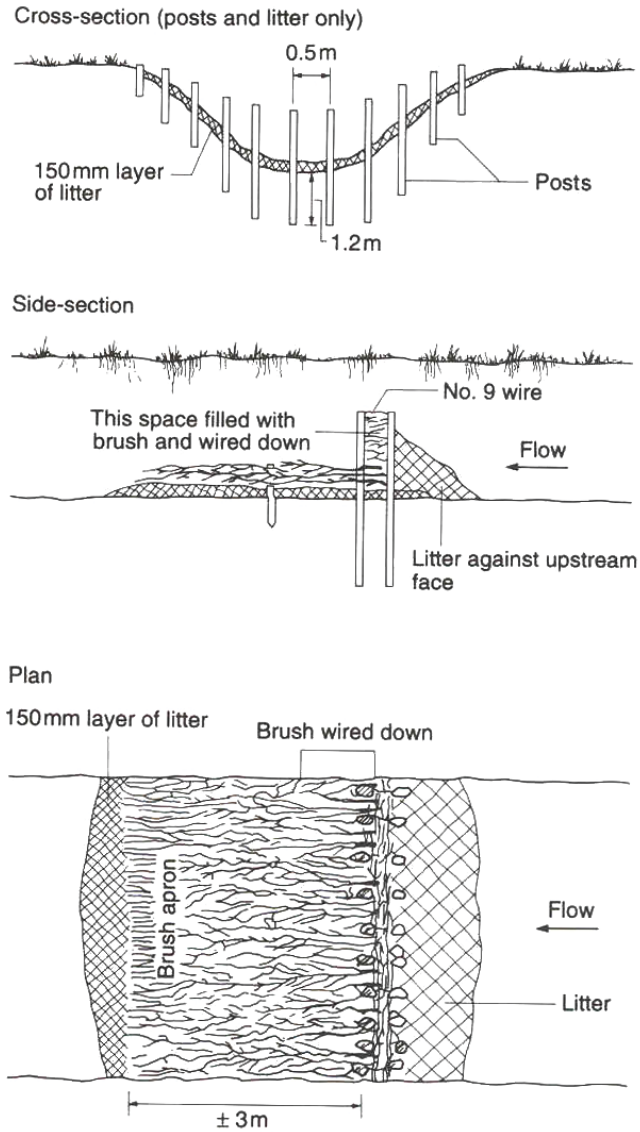
Figure A.C-10

Brush Check Dam Installation

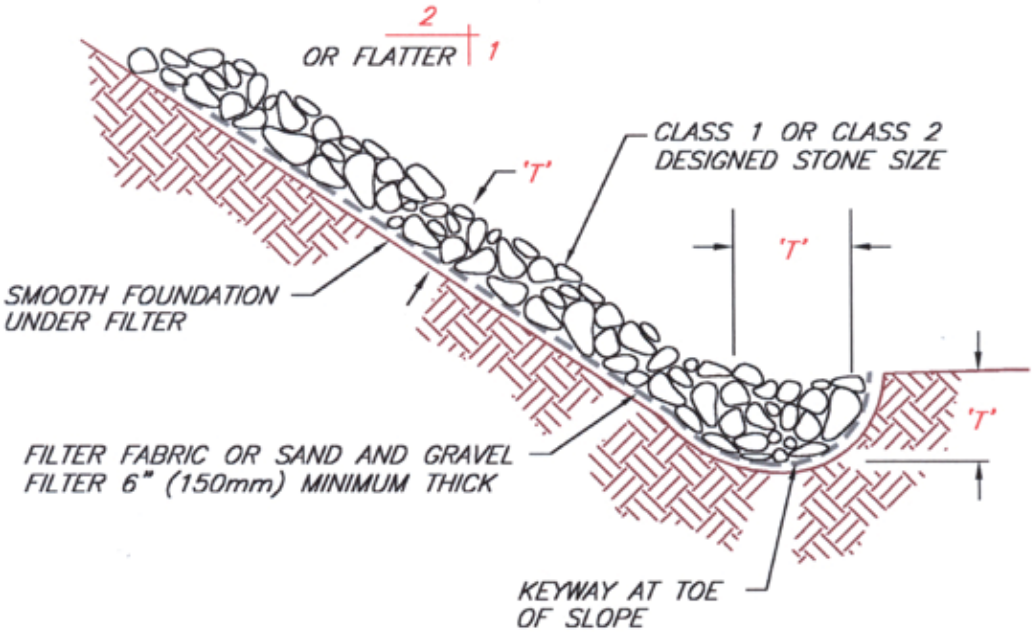
Single-fence Brush Dam



Doube-fence Brush Dam



Source: Gray and Leiser (1982), in Morgan (1995)



TYPICAL SECTION

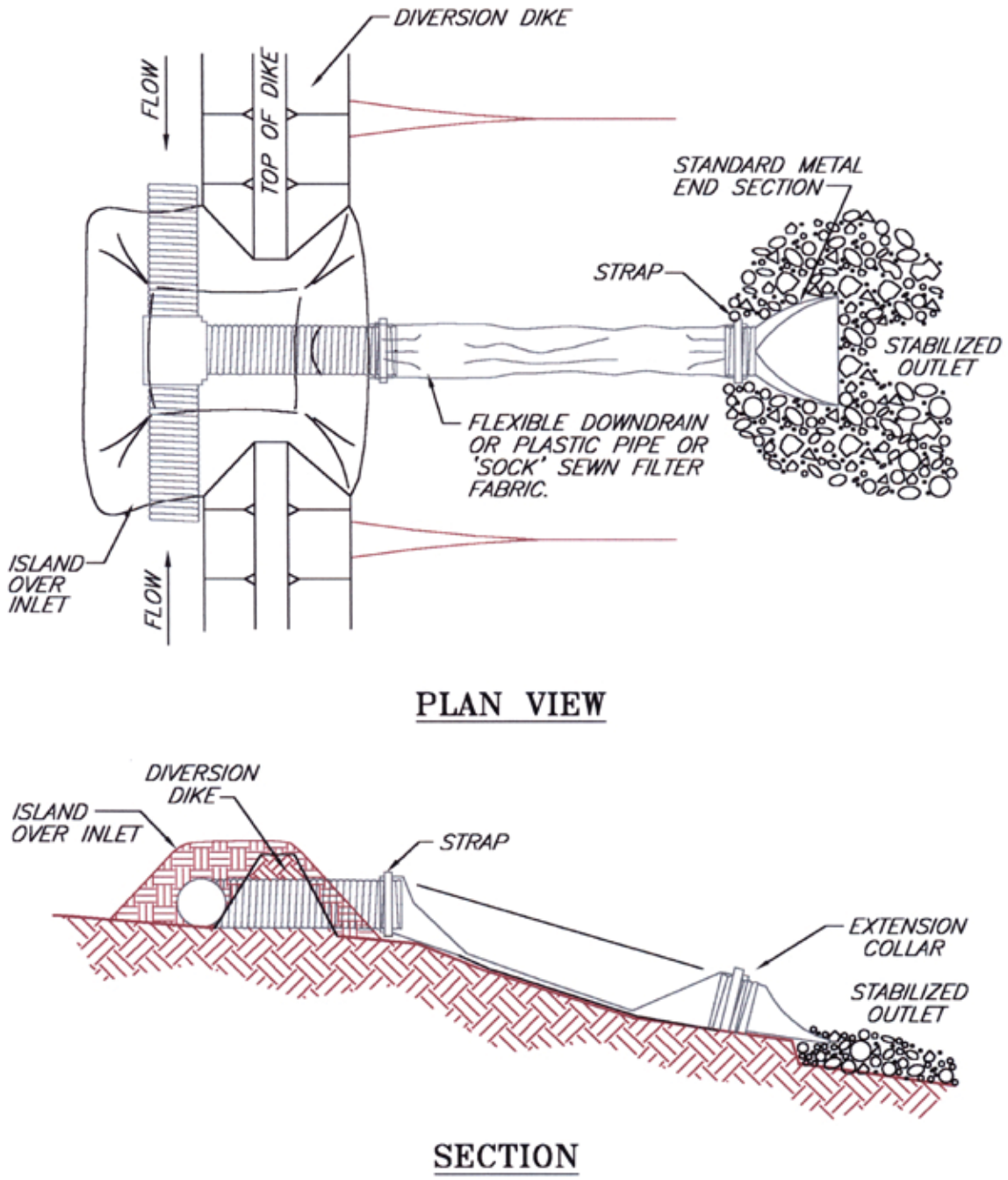
NOTE:
'T' = THICKNESS: THICKNESS SHALL BE DETERMINED BY THE ENGINEER.

MINIMUM THICKNESS SHALL BE 1.5x THE MAXIMUM STONE DIAMETER, NEVER LESS THAN 6" (150mm).

Source: John McCullah (1994)

Figure A.C-12

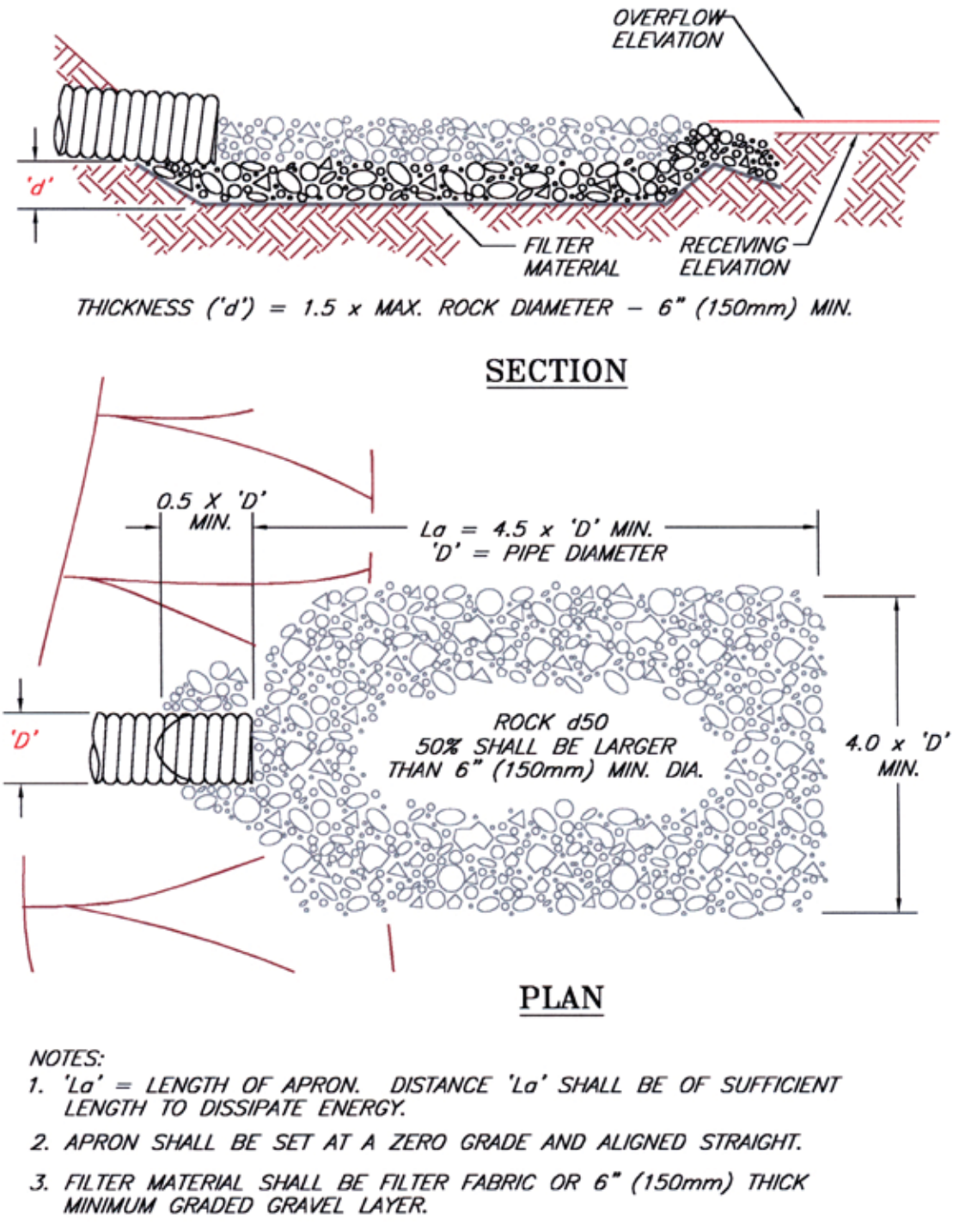
Slope Drain Installation



Source: John McCullah (1994)

Figure A.C-13

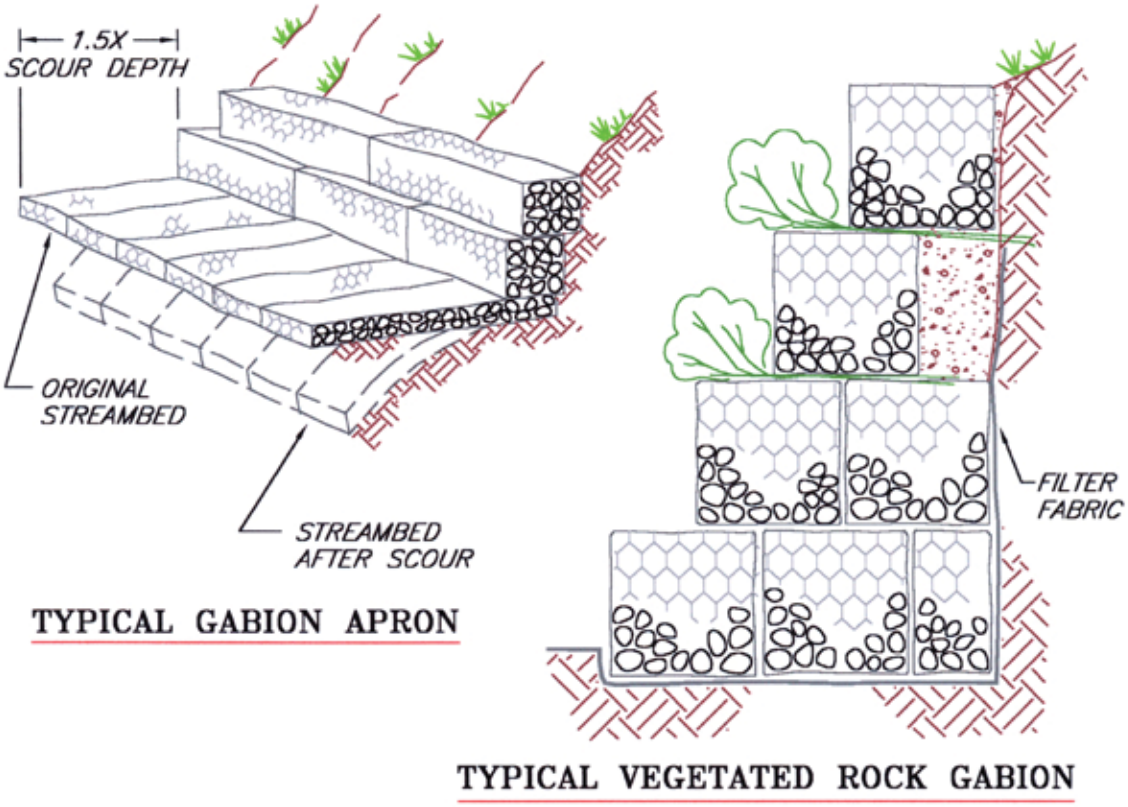
Installation of Energy Dissipator at Outlet

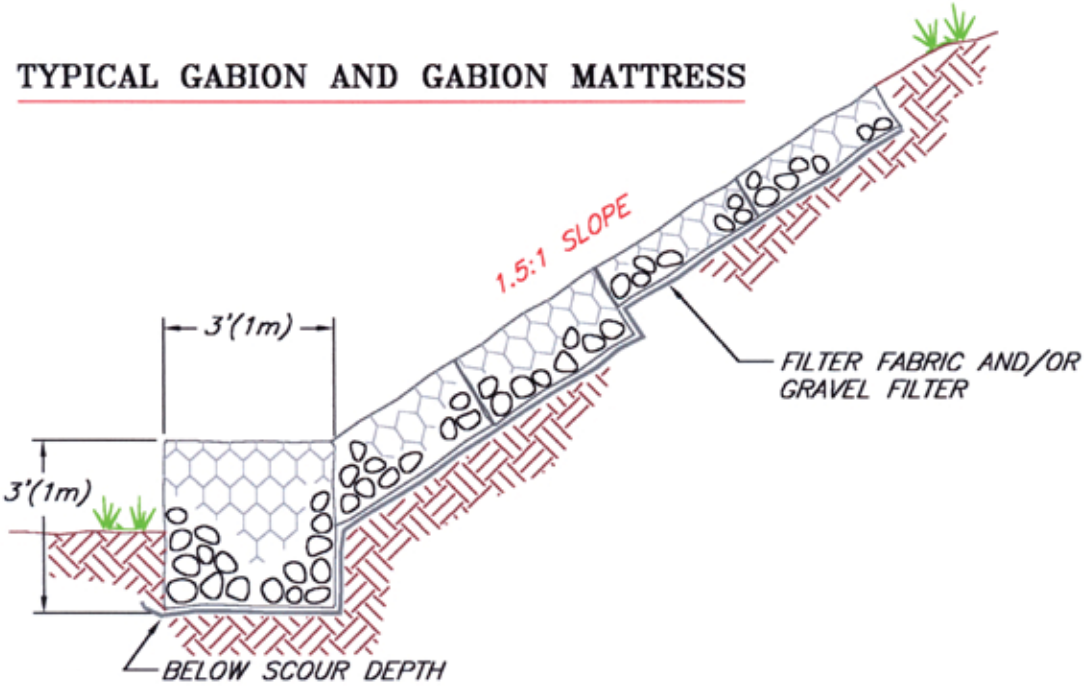


NOTES:

1. 'La' = LENGTH OF APRON. DISTANCE 'La' SHALL BE OF SUFFICIENT LENGTH TO DISSIPATE ENERGY.
2. APRON SHALL BE SET AT A ZERO GRADE AND ALIGNED STRAIGHT.
3. FILTER MATERIAL SHALL BE FILTER FABRIC OR 6" (150mm) THICK MINIMUM GRADED GRAVEL LAYER.

Source: John McCullah (1994)

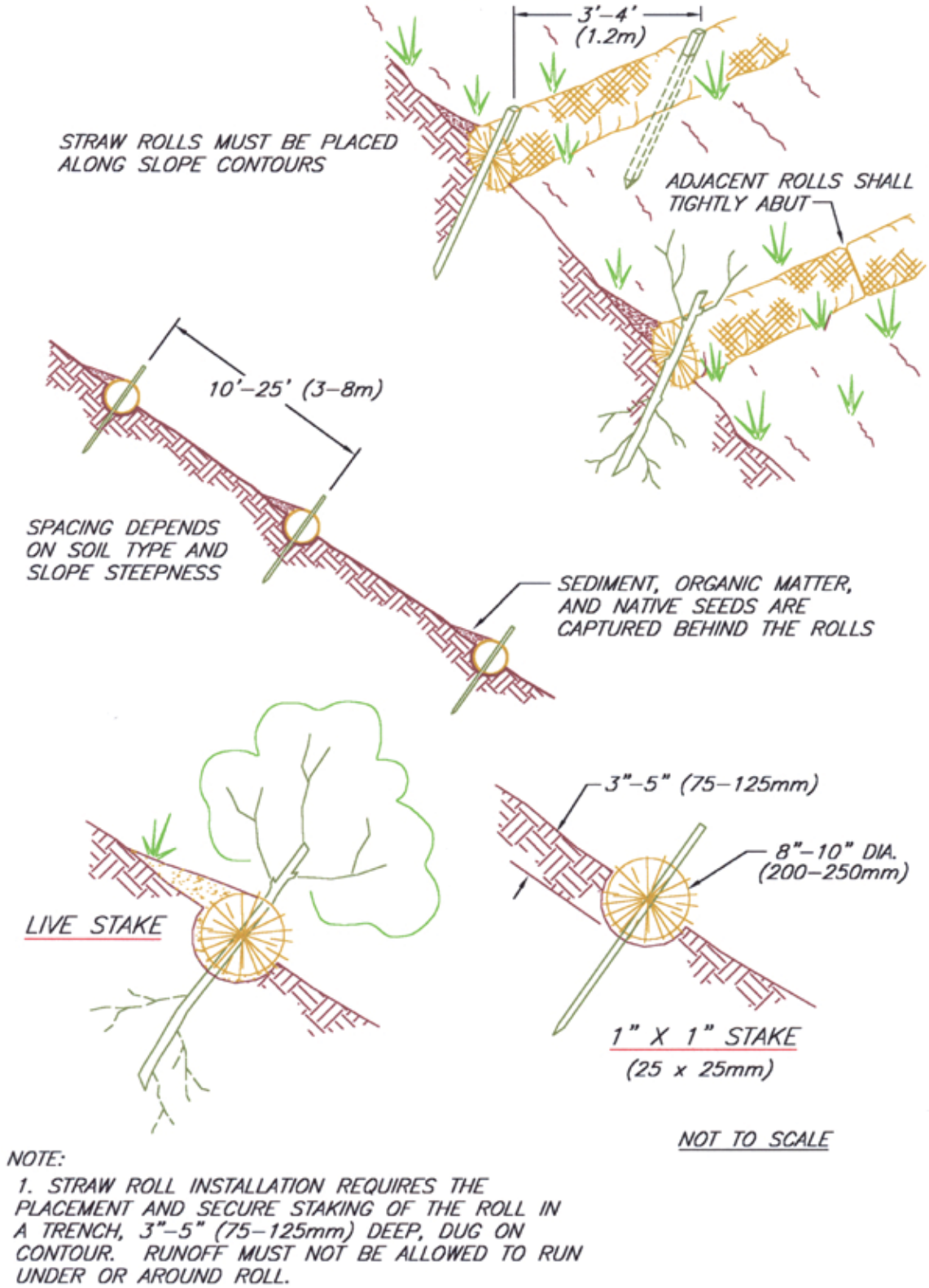




Source: John McCullah (1994)

Figure A.C-15

Straw Roll or Wattle Installation



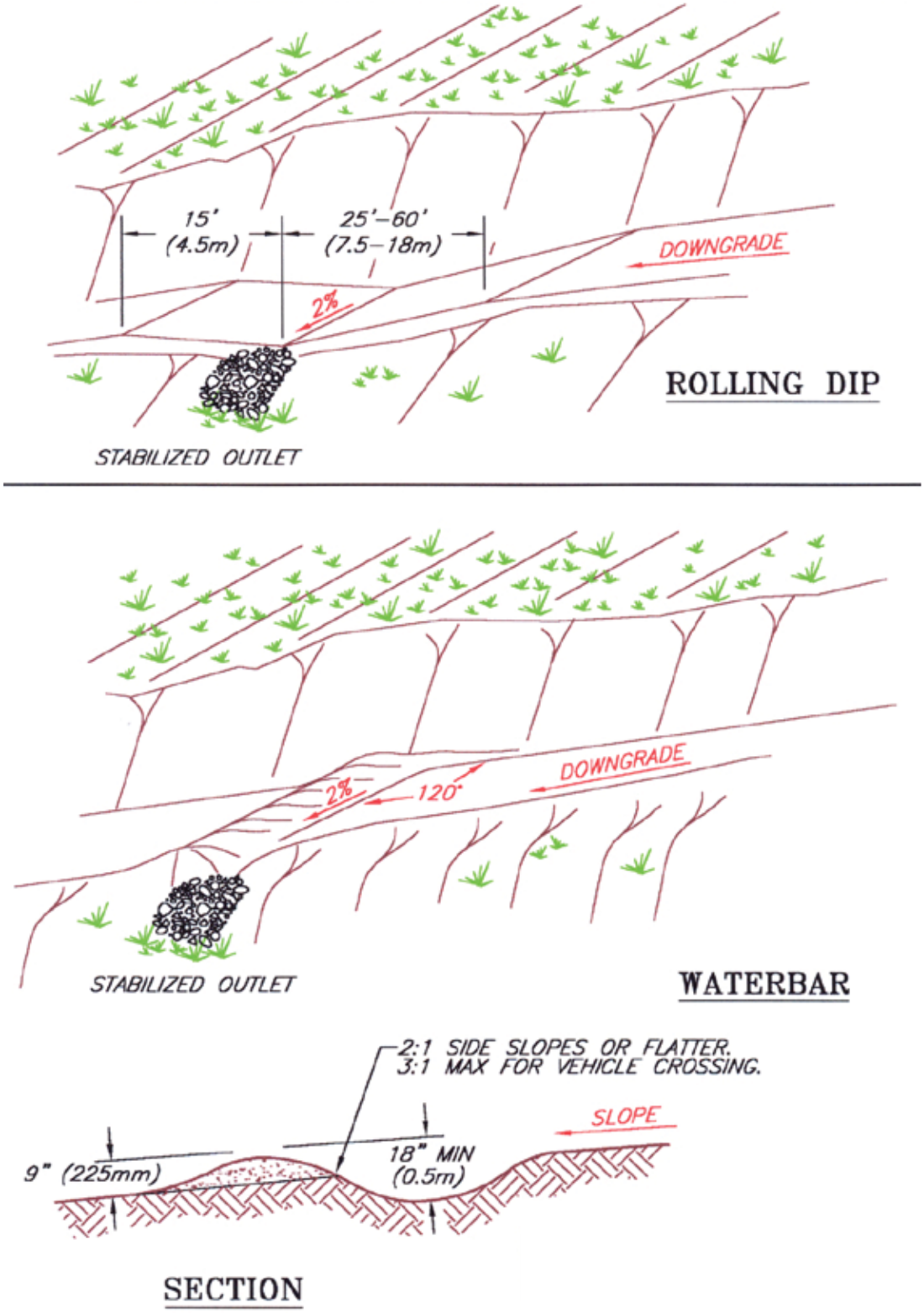
NOTE:

1. STRAW ROLL INSTALLATION REQUIRES THE PLACEMENT AND SECURE STAKING OF THE ROLL IN A TRENCH, 3"–5" (75–125mm) DEEP, DUG ON CONTOUR. RUNOFF MUST NOT BE ALLOWED TO RUN UNDER OR AROUND ROLL.

Source: John McCullah (1994)

Figure A.C-16

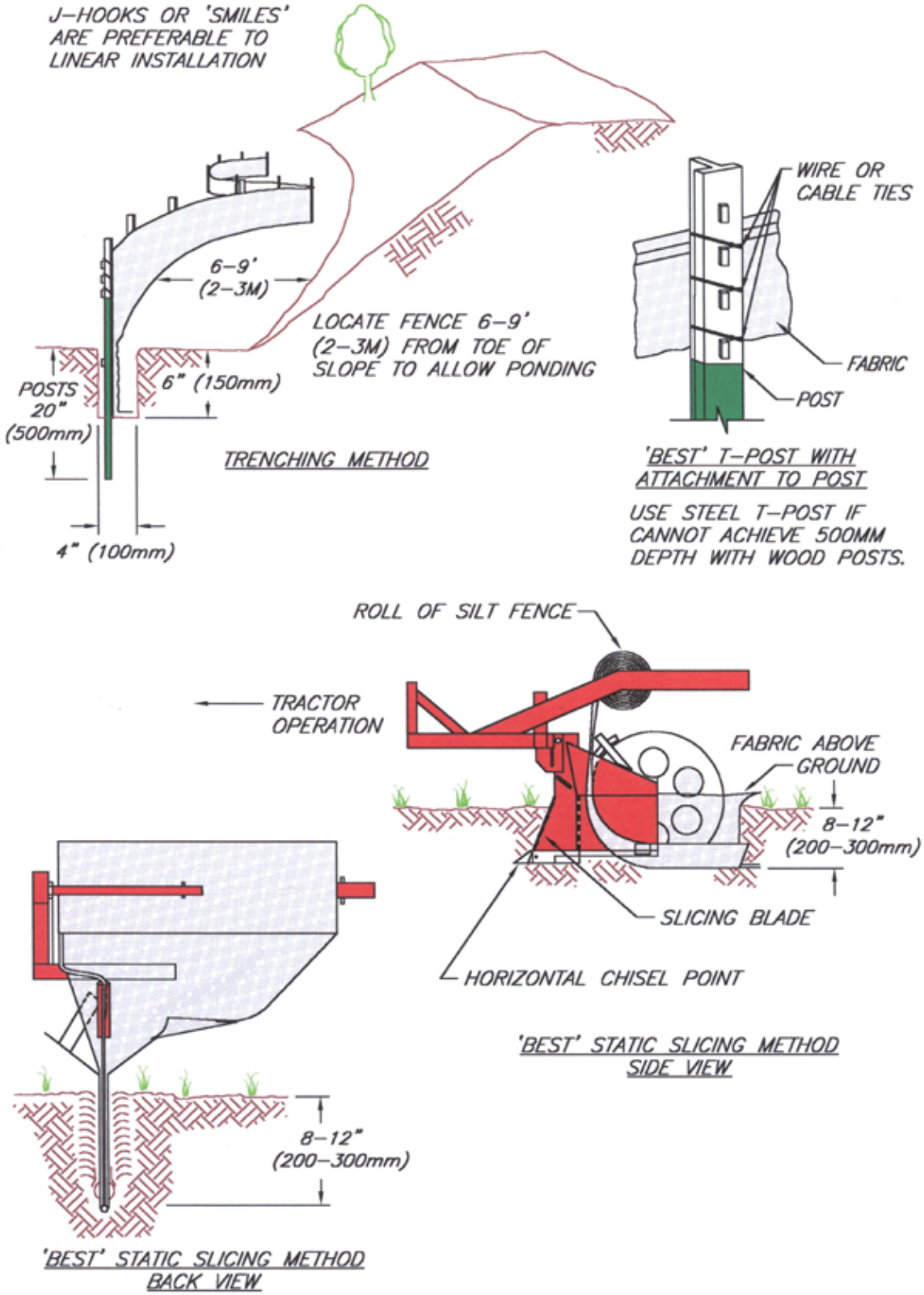
Schematic Diagram of Rolling Dip and Waterbar



Source: John McCullah (1994)

Figure A.C-17

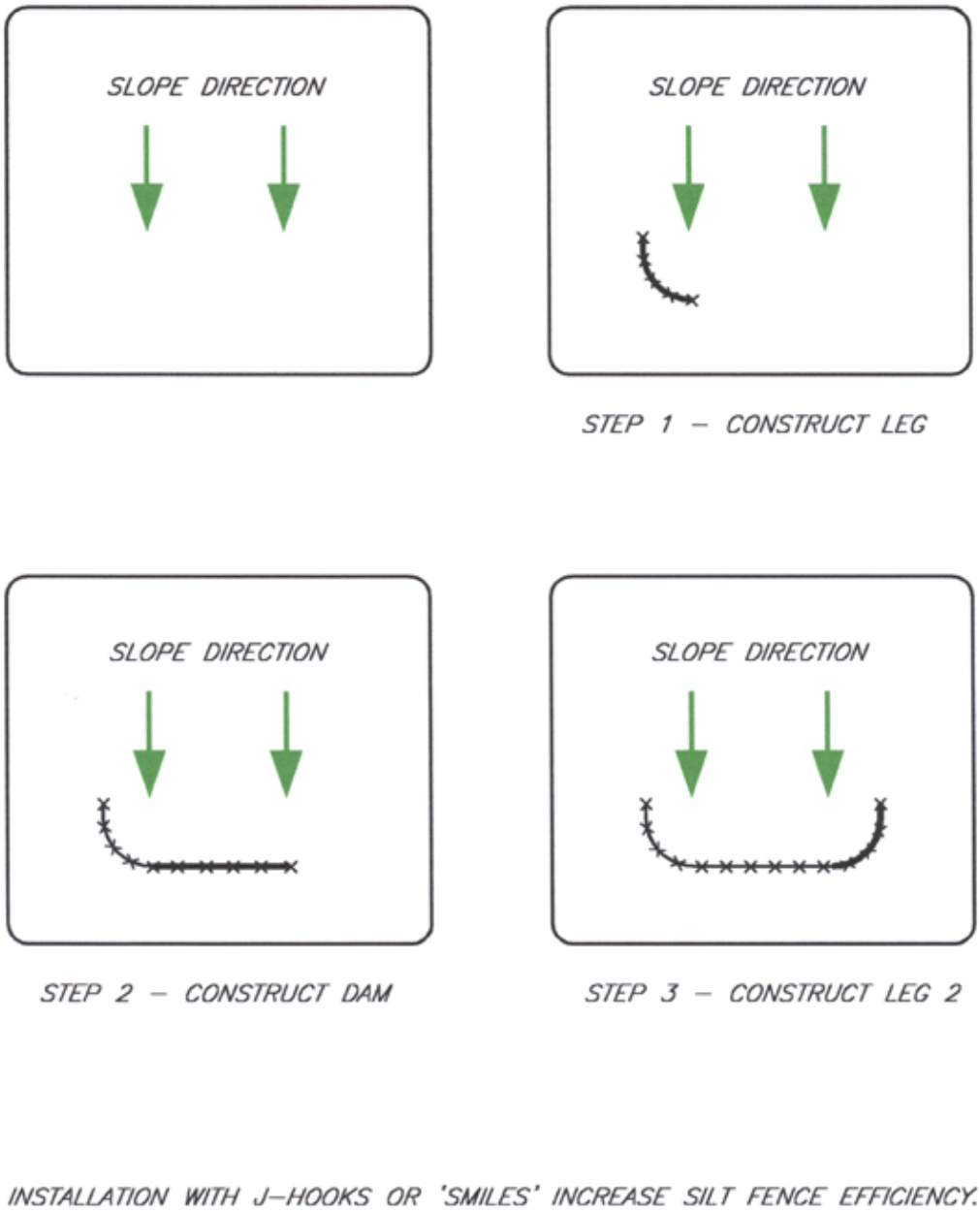
Sediment Fence Installation



Source: John McCullah (1994)

Figure A.C-18

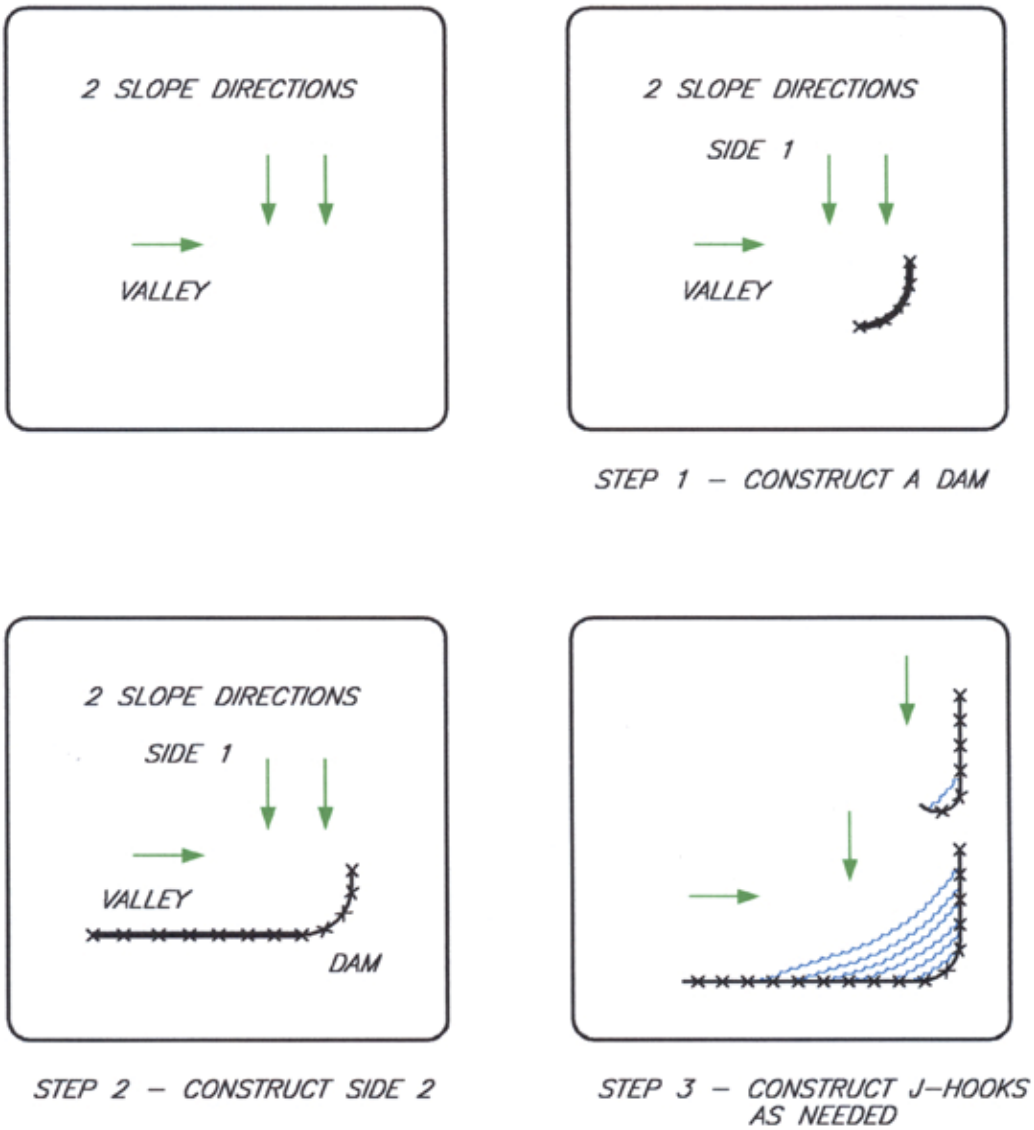
Typical Sediment Fence Placement for One Slope



Source: John McCullah (1994)

Figure A.C-19

Typical Sediment Fence Placement for Two Slopes

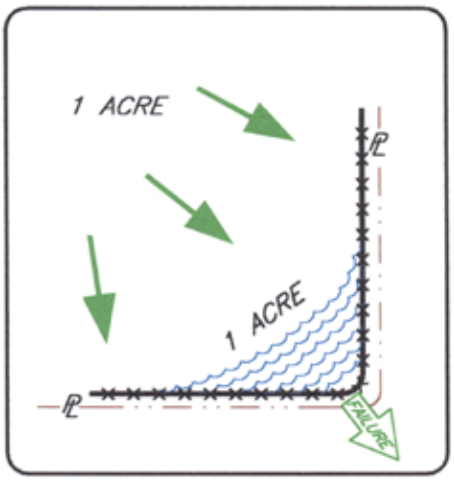


INSTALLATION WITH J–HOOKS WILL INCREASE SILT FENCE EFFICIENCY AND REDUCE EROSION–CAUSING FAILURES.

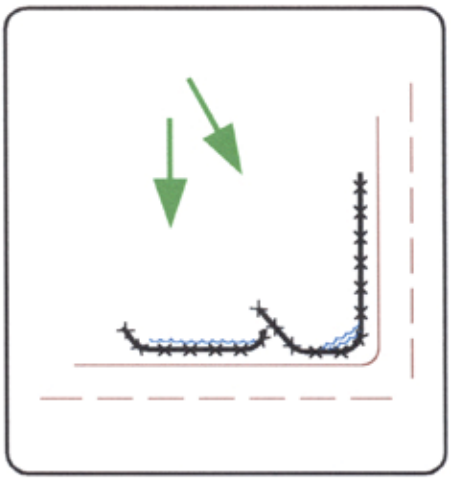
Source: John McCullah (1994)

Figure A.C-20

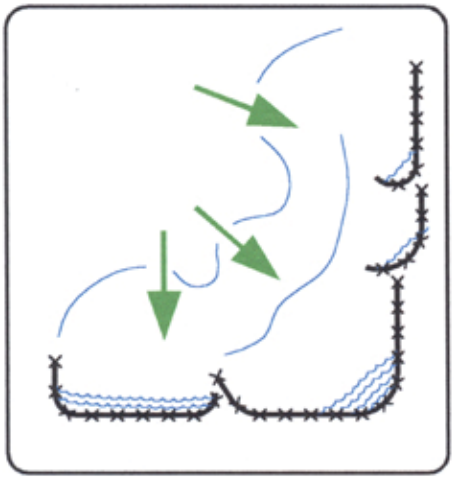
Sediment Fence Placement for Perimeter Control

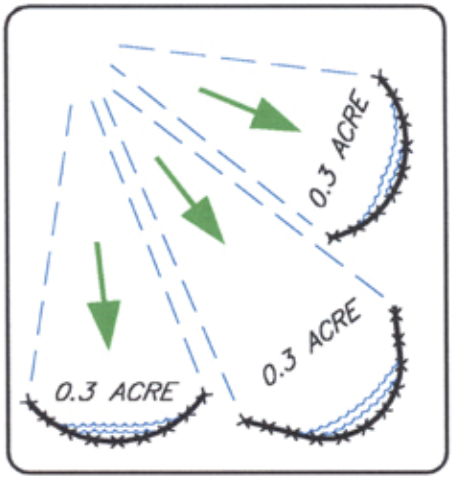


Incorrect – Do Not layout "perimeter control" silt fences along property lines. All sediment laden runoff will concentrate and overwhelm the system.



Correct – Install J–hooks



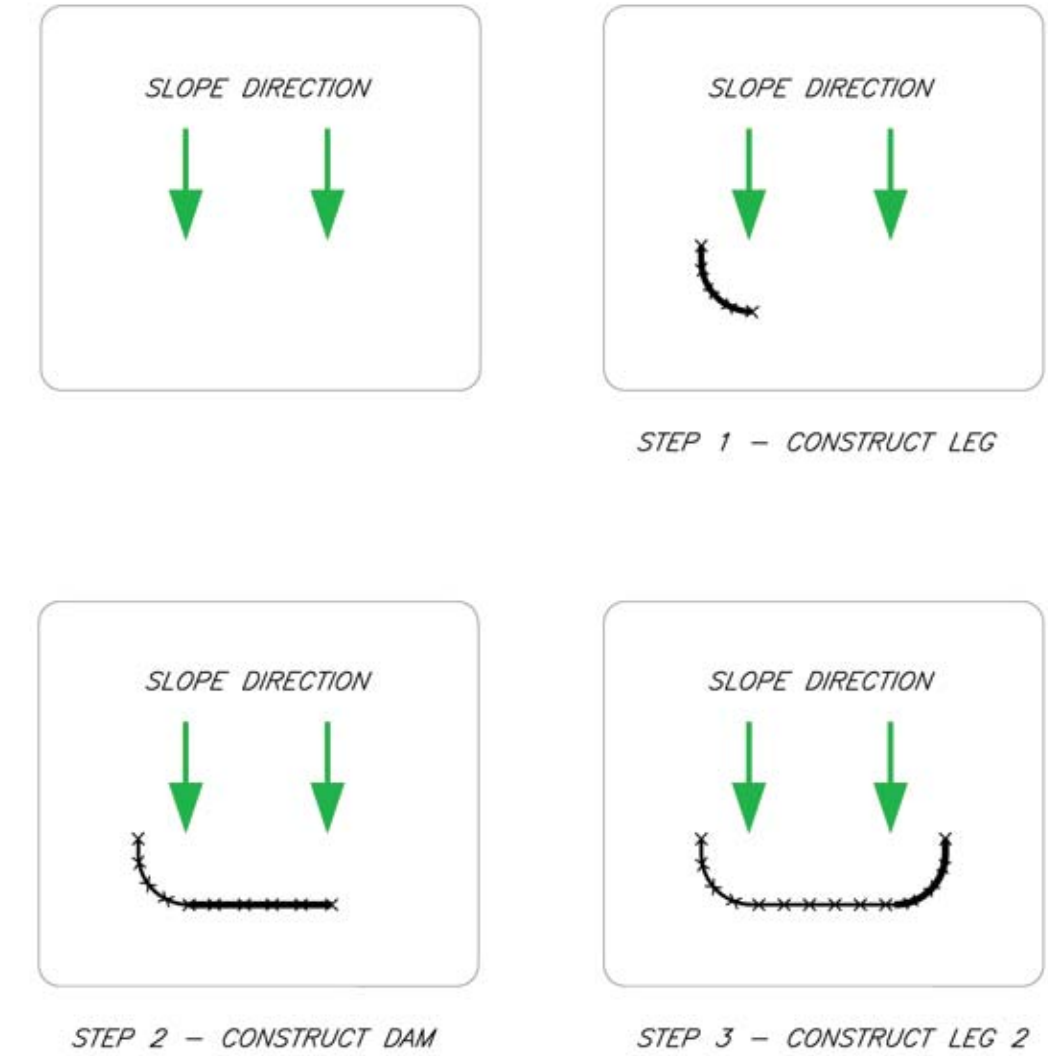


Discreet segments of silt fence, installed with J–hooks or 'smiles' will be much more effective.

Source: John McCullah (1994)

Figure A.C-21

Typical Compost Berm Placement for One Slope

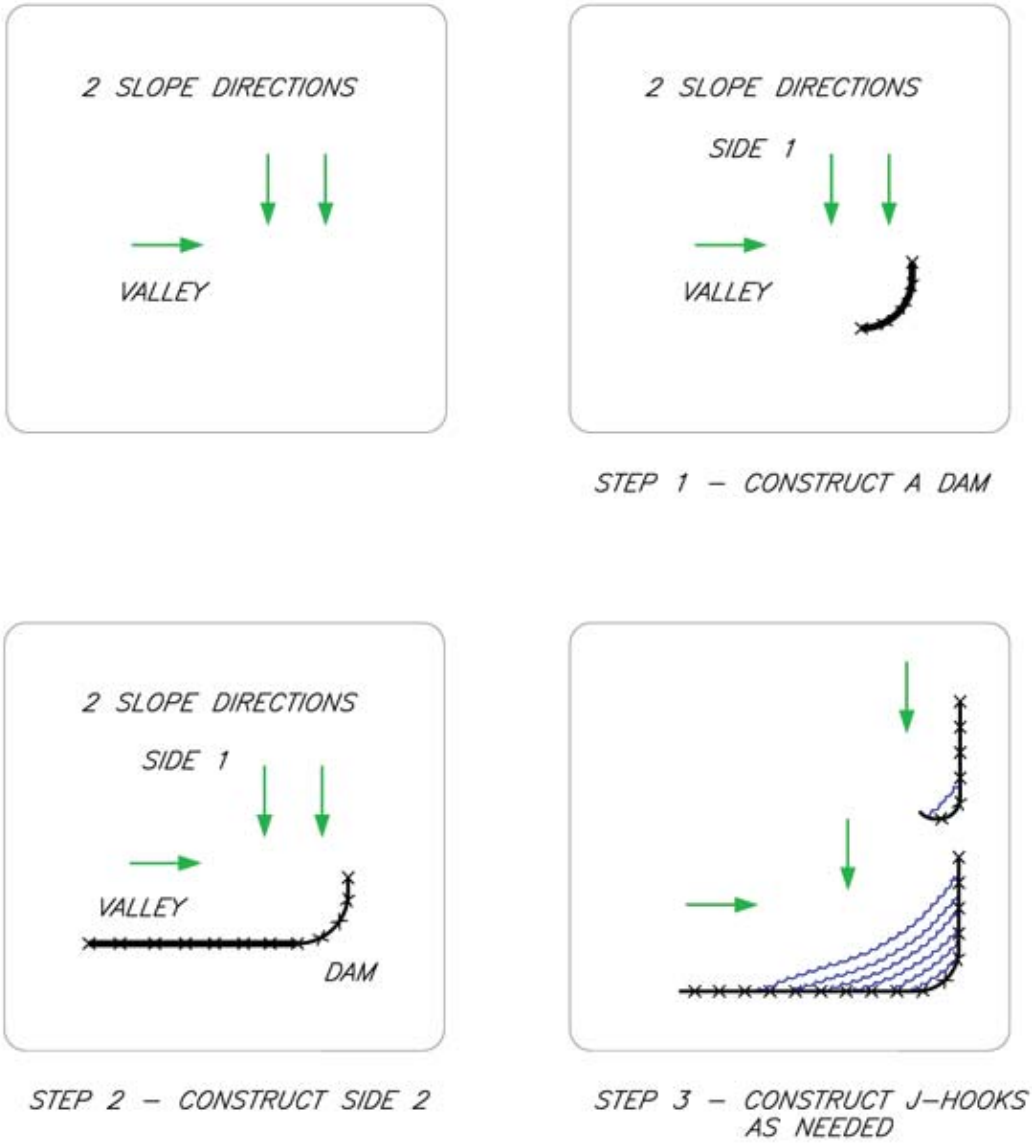


INSTALLATION WITH J–HOOKS OR 'SMILES' INCREASE COMPOST BERM EFFICIENCY.

Source: John McCullah (1994)

Figure A.C-22

Typical Compost Berm Placement for Two Slopes

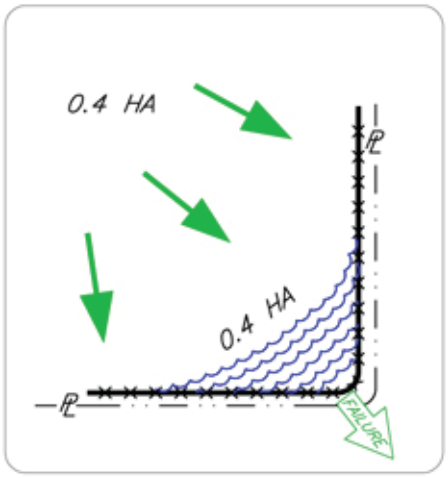


INSTALLATION WITH J–HOOKS WILL INCREASE COMPOST BERM EFFICIENCY AND REDUCE EROSION–CAUSING FAILURES.

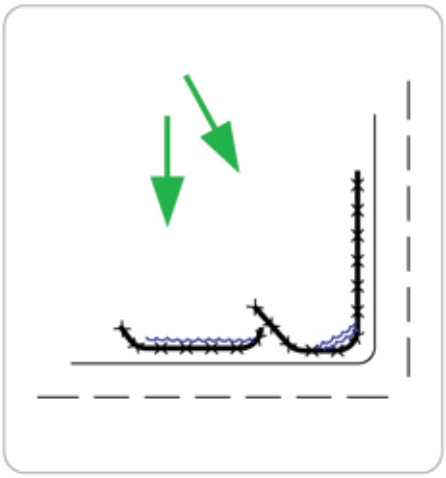
Source: John McCullah (1994)

Figure A.C-23

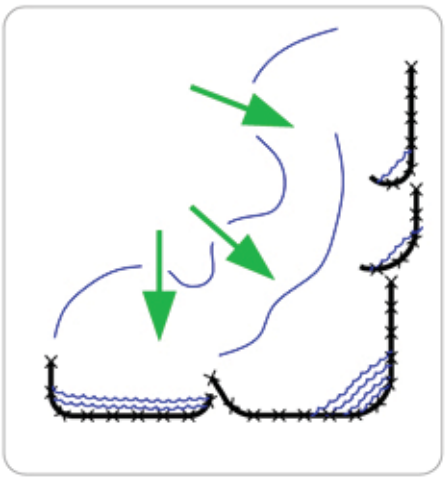
Compost Berm Placement for Perimeter Control

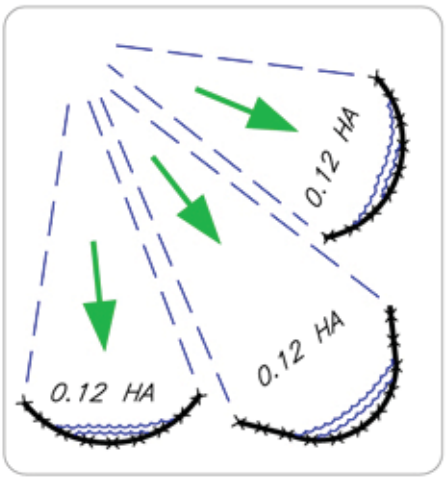


Incorrect – Do Not layout "perimeter control" compost berms along property lines. All sediment laden runoff will concentrate and overwhelm the system.



Correct – Install J–hooks



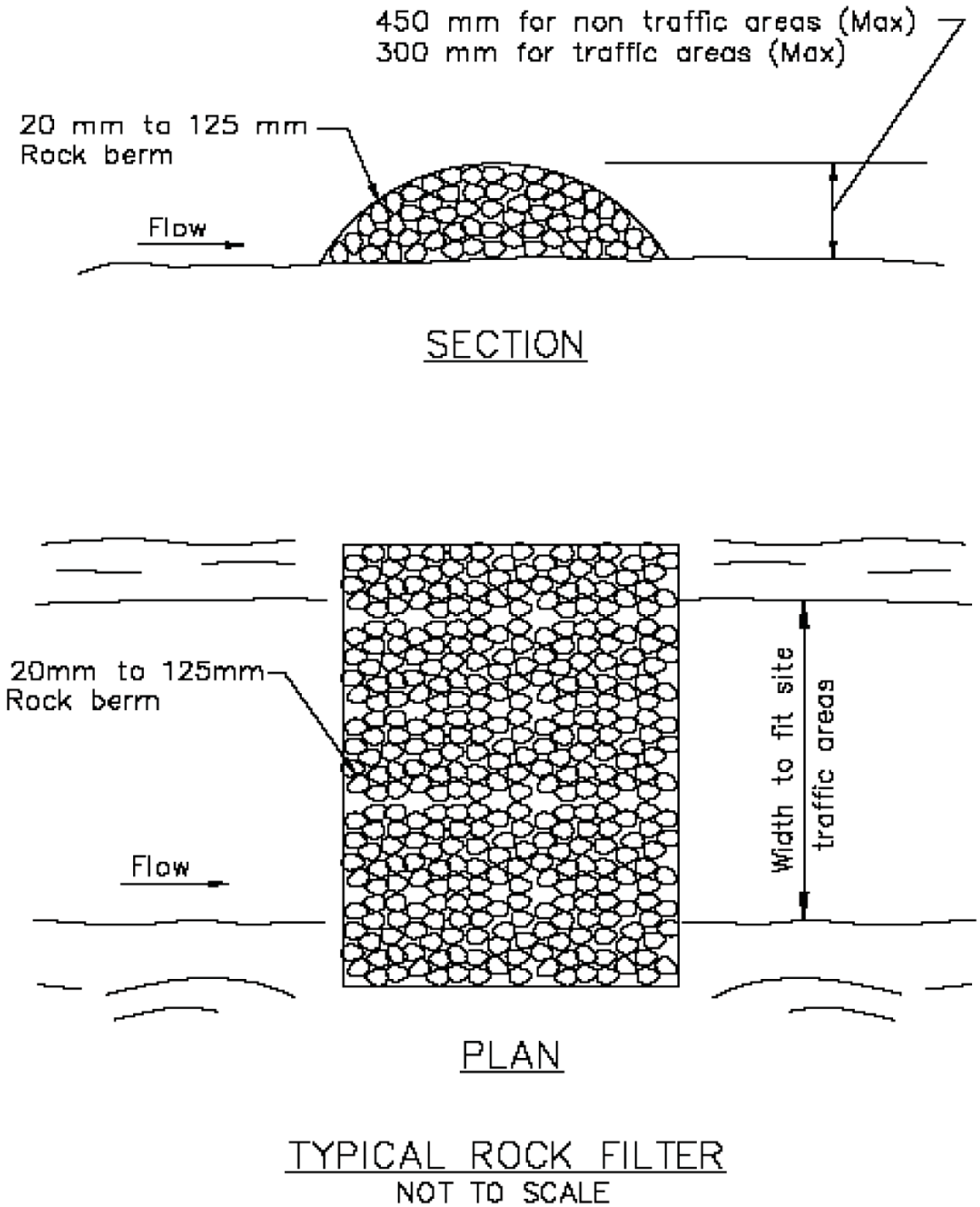


Discreet segments of compost berms, installed with J–hooks or 'smiles' will be much more effective.

Source: John McCullah (1994)

Figure A.C-24

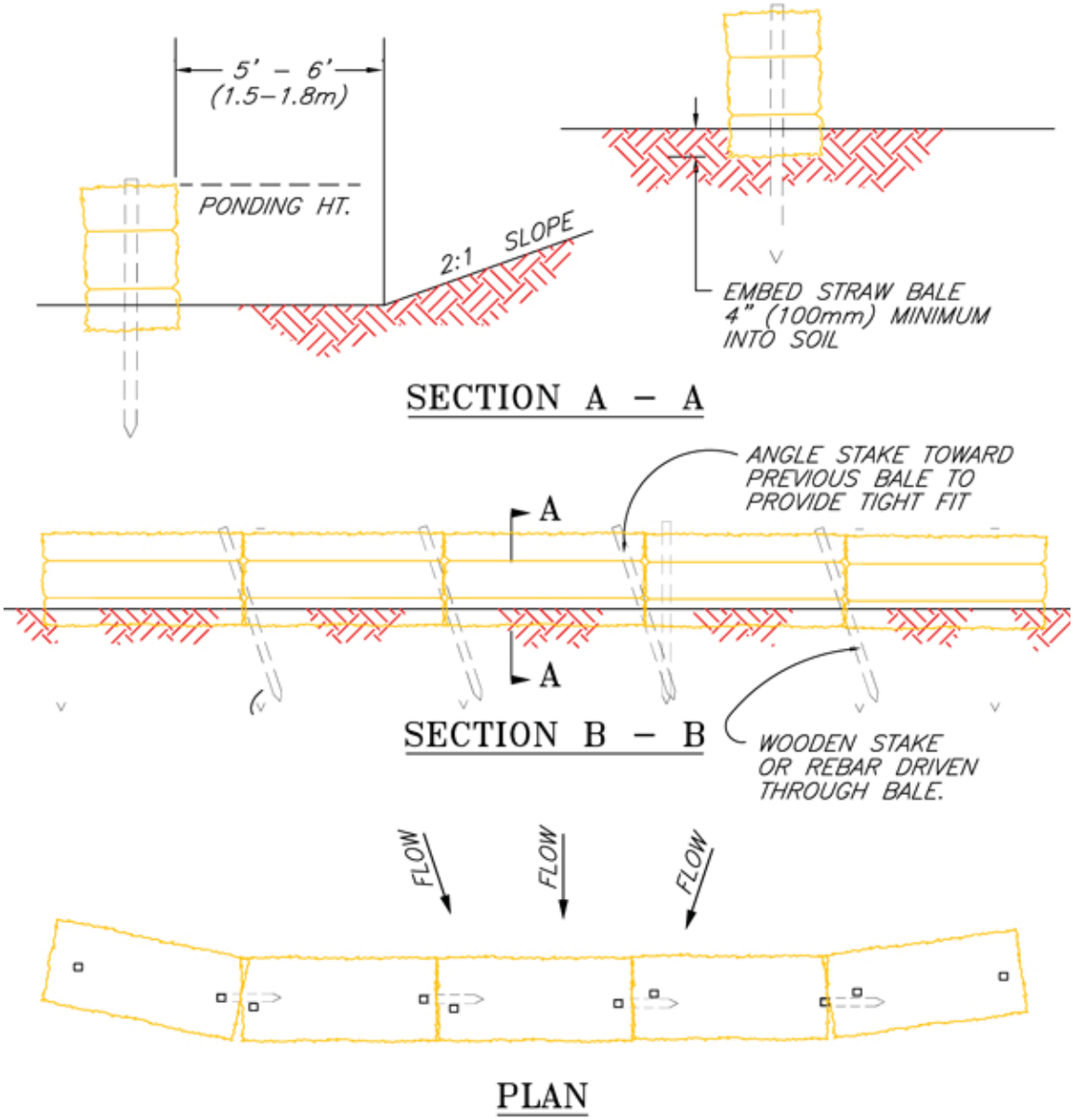
Schematic Diagram of Rock Berm



Source: Virginia Erosion and Sediment Control Handbook (1992)

Figure A.C-25

Straw Bale Dike Installation



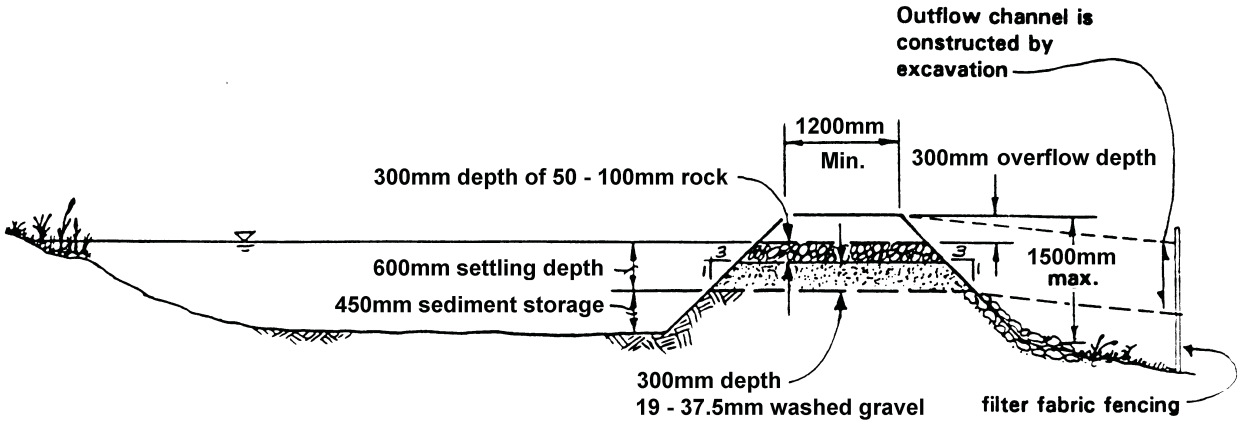
NOTES:

1. THE STRAW BALES SHALL BE PLACED ON SLOPE CONTOUR.
2. BALES TO BE PLACED IN A ROW WITH THE ENDS TIGHTLY ABUTTING.
3. KEY IN BALES TO PREVENT EROSION OR FLOW UNDER BALES.

Source: John McCullah (1994)

Figure A.C-26

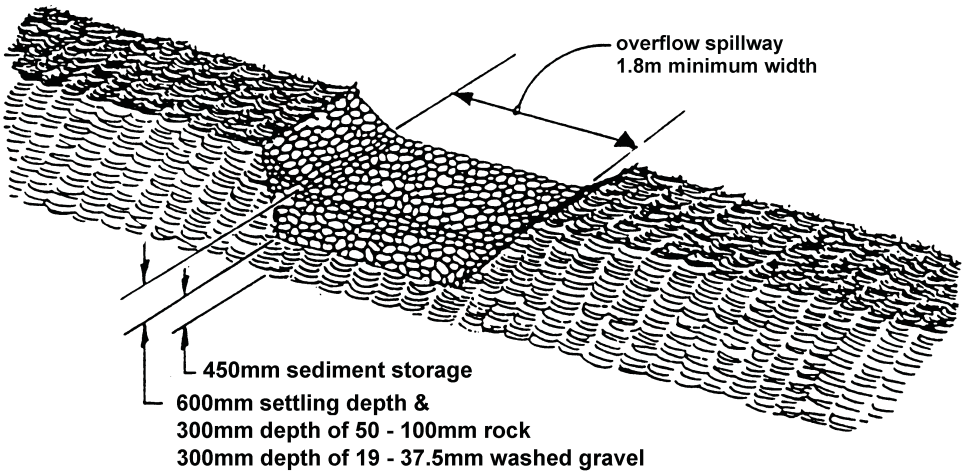
Schematic Diagram of Sediment Retention Trap



CROSS SECTION

NO SCALE

note: may be constructed by excavation or by building a berm



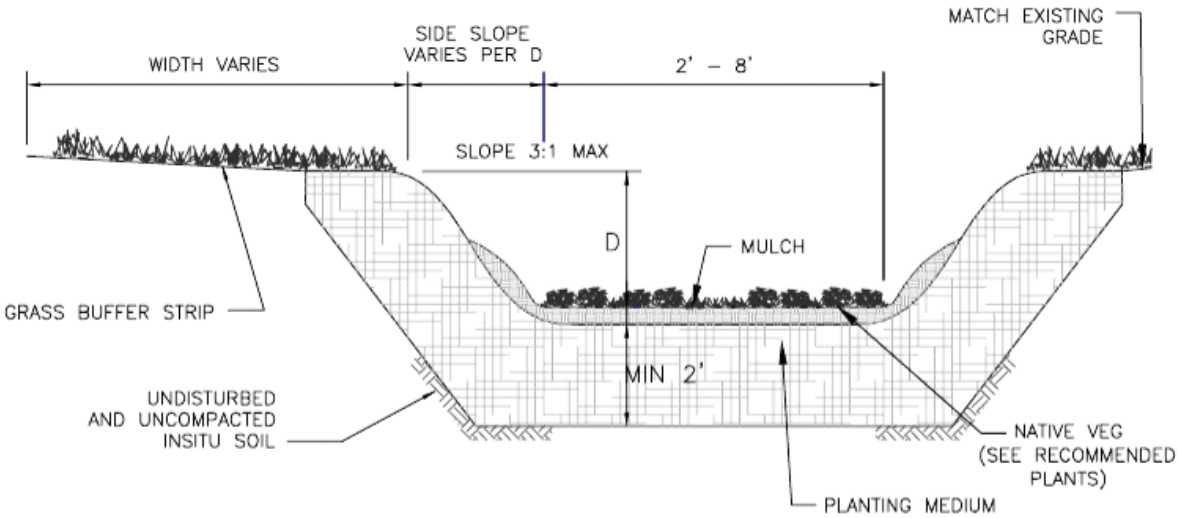
SEDIMENT TRAP OUTLET

NO SCALE

Source: GVSDD (1999).

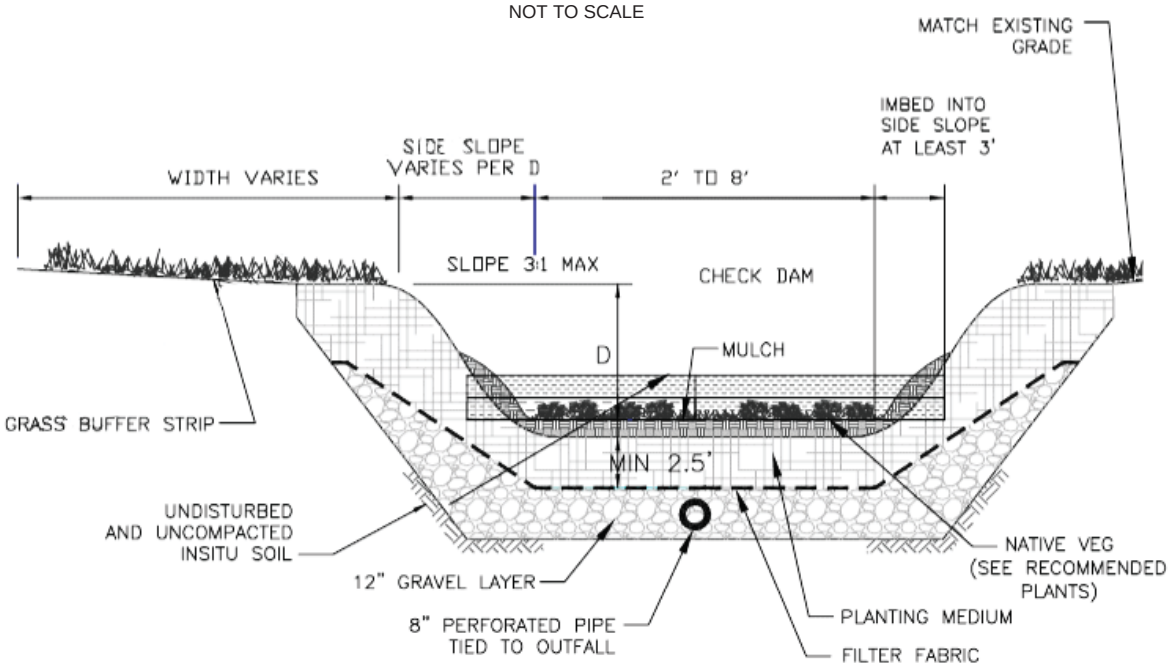
Figure A.C-27

Schematic Diagrams of Dry and Wet Sediment Retention Swales



TYPICAL WET SWALE CROSS-SECTION

NOT TO SCALE



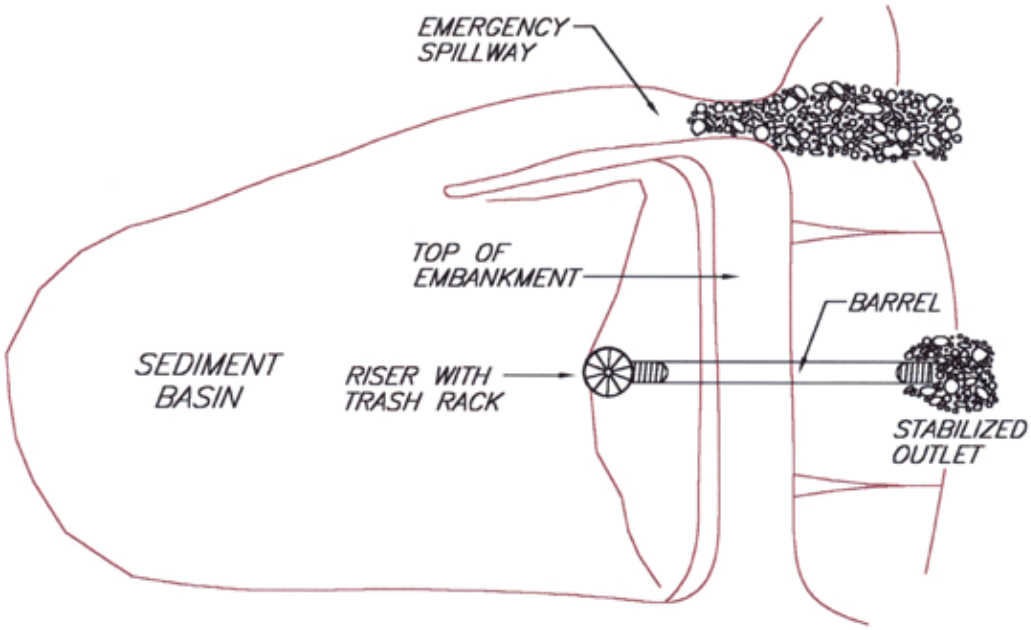
TYPICAL DRY SWALE CROSS-SECTION (WITH CHECKDAM)

NOT TO SCALE

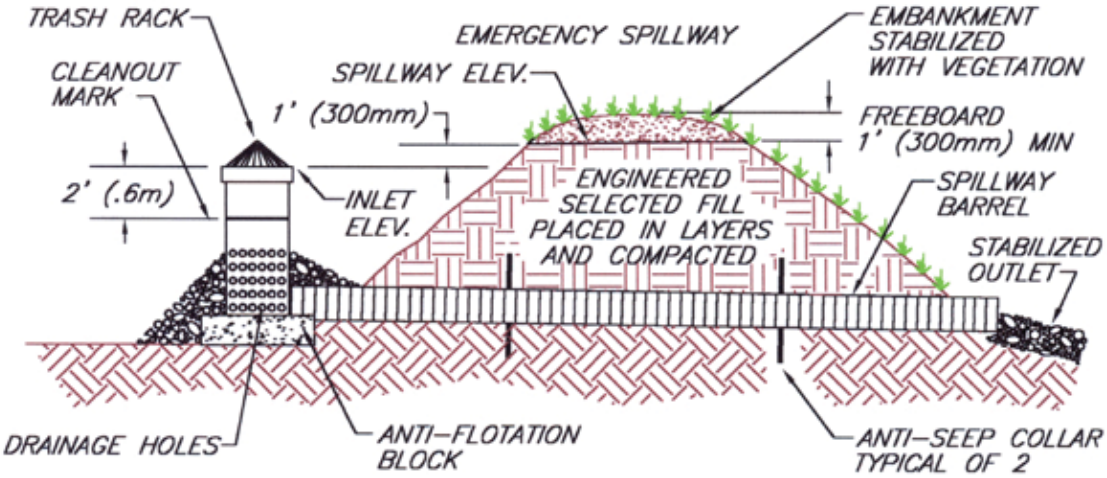
Source: MN PCA (2008)

Figure A.C-28

Schematic Diagram of Sediment Retention Basin



PLAN

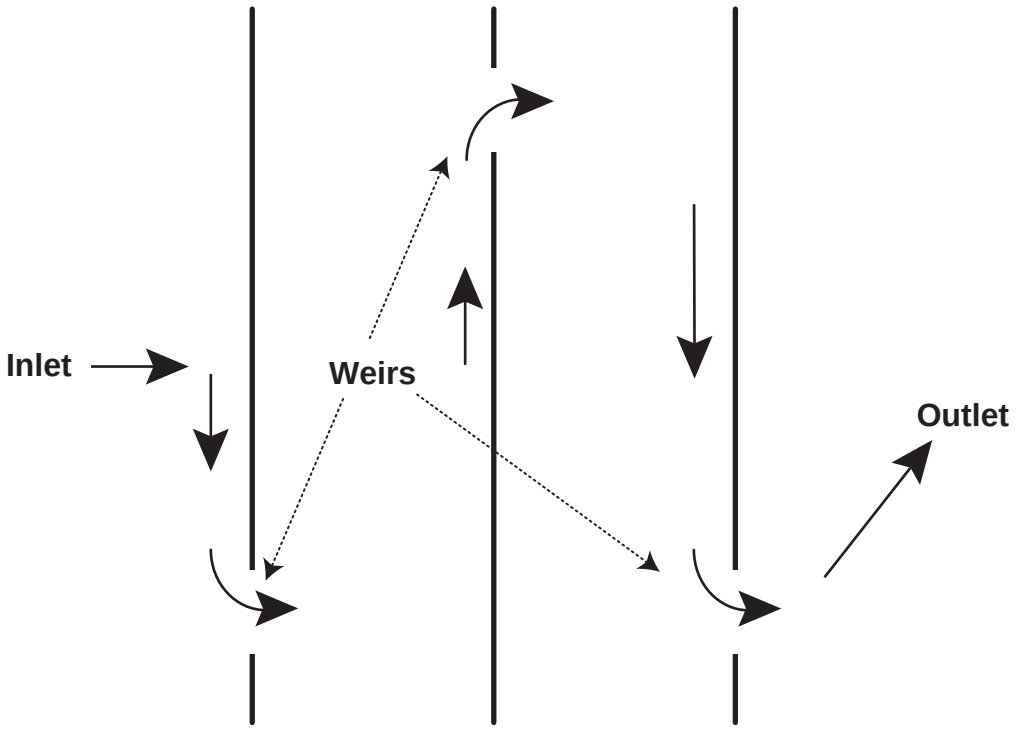


SECTION

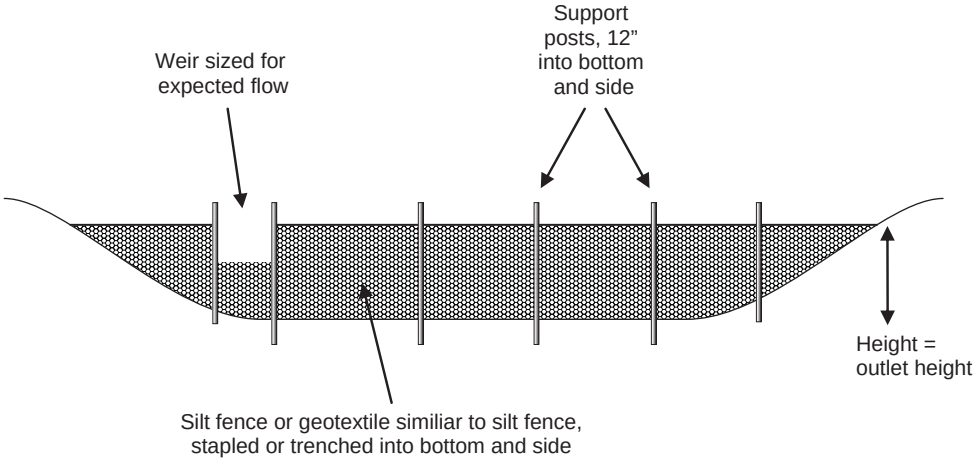
Source: John McCullah (1994)

Figure A.C-29

Typical Sediment Pond Solid Baffle Installation



Baffles lengthen the flow path of the water and allow more basin to be used for sedimentation.

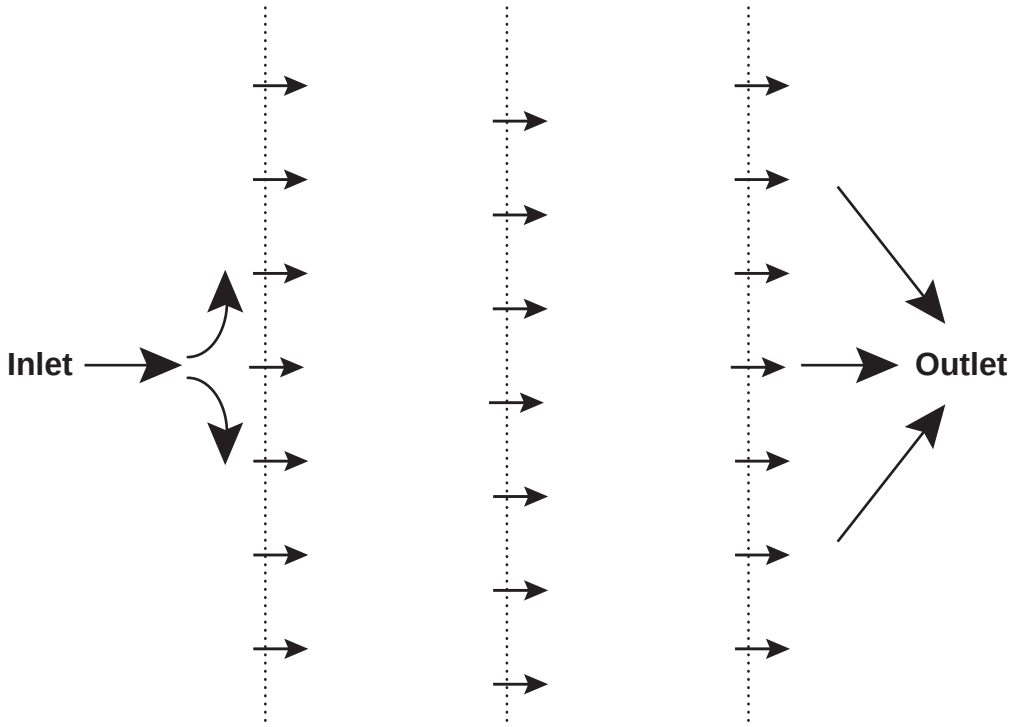


Cross section of silt fence baffle in a sediment basin.
Typically, the weir is cut 1 foot deep and the width of the weir is adjusted for expected flows.

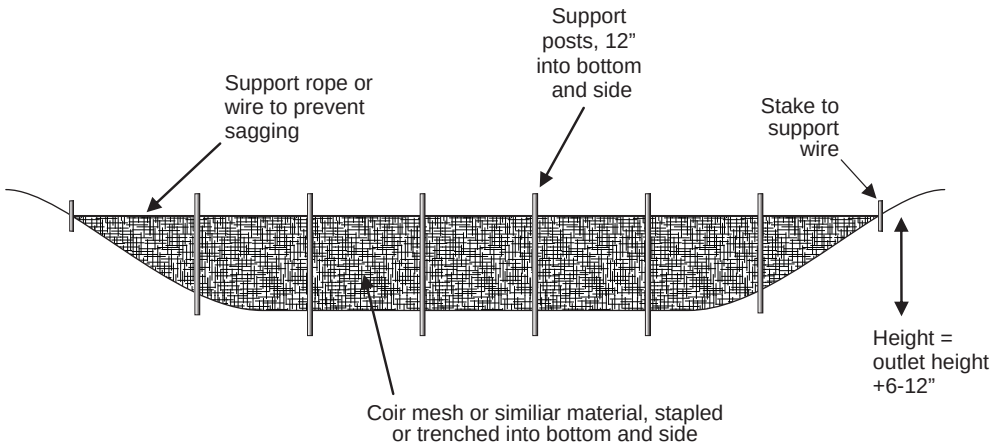
Source: North Carolina State University (2005).

Figure A.C-30

Typical Sediment Pond Porous Baffle Installation



Porous baffles in a sediment basin. The flow is divided evenly across the basin to reduce flow rates and turbulence, resulting in greater sediment retention.



Cross section of a porous baffle in a sediment basin.
Note that there is no weir because the water flows through the baffle material.

Source: North Carolina State University (2005).

Appendix F

Daily Monitoring Form

DAILY ENVIRONMENTAL INSPECTION FORM PROJECT:			Log No.: _____
Date:	___/___/_____	**Arrival time:** ___:___	**Departure time:** ___:___
Chainage:	**Start - End:**	**Weather:**	**H:** **L:**
Map Numbers:		**ENVIRONMENTAL FEATURES AT RISK**	
Environmental Coordinator:		**Environmental sensitivities present?**	☐ Yes ☐ No
Environmental Monitor:			
CONTRACTOR INFORMATION		☐ Raptor nesting	☐ Fish-bearing stream
Company/Foreman:		☐ Harlequin duck	☐ Wetland
Activity:		☐ Breeding waterfowl	☐ Potential toad breeding area
		☐ Marten	☐ Potential toad migration area
		☐ Moose	☐ Goat – summer
		☐ Marmot	☐ Goat – winter
Company/Foreman:		☐ Rare plant	☐ Grizzly bear – spring
Activity:		☐ Sensitive soils	☐ Grizzly bear – summer
		☐ Rare ecosystem	☐ Grizzly bear – fall
		☐ Environmentally sensitive area	☐ Other Bird Nest
			☐ Other (describe):
Company/Foreman:			
Activity:		**Forms attached?**	☐ Yes (list on page 2) ☐ No
		Actions taken?	☐ Yes ☐ No
		Recommendations:	

DESCRIPTION OF WORKING OR DAILY ACTIVITIES: (Daily synopsis – use additional sheet if necessary)

Environmental Incident?	☐ Yes ☐ No	**Incident Report Attached:**	☐ Yes ☐ No
Stop Work Order issued?	☐ Yes ☐ No	**Stop Work Order Report Attached:**	☐ Yes ☐ No
Summary:	(full details should be provided in the Stop Work Order report)		

Notification:		**Date:**	___/___/_____	**Time:**	___:___ am pm

(clearly identify who has been notified of the incident)

WASTE MANAGEMENT

Overall site cleanliness	☐ Adequate	☐ Inadequate		
Waste materials adequately contained:	☐ Yes	☐ No		
Slash disposal:	☐ Burning	☐ Burying	☐ Chipping	☐ Other (_____)

Action required?	☐ Yes ☐ No	**Action taken?**	☐ Yes ☐ No

Details:

FUEL AND OIL MANAGEMENT			Log no. _____
Machinery:	☐ No leaks	☐ Minor leaks	☐ Major leaks
Details:			
Fuel stations	Clearly identified?	☐ Yes	☐ No
Fuel storage	☐ Clean, no spills	☐ Obvious signs of spills	
Fuel containment	☐ Contained	☐ Not contained	
Spill response plan	☐ On-site, accessible	☐ Not on site	☐ Not accessible
Spill response equip.	☐ On-site, accessible	☐ Not on site	☐ Not accessible
Sorbent pads	☐ On-site, accessible	☐ Not on site	☐ Not accessible
Oil boom	☐ On-site, accessible	☐ Not on site	☐ Not accessible
Spill containment	☐ On-site, accessible	☐ Not on site	☐ Not accessible
Sensitive zones:	Clearly identified?	☐ Yes ☐ No	Sign of disturbance? ☐ Yes ☐ No
Action required?	☐ Yes	☐ No	
Action taken?	☐ Yes	☐ No	
Details:			

EROSION, SEDIMENT AND RUNOFF MANAGEMENT				
Applicable?	☐ Yes ☐ No	(i.e. is construction occurring in an area that requires EPSC management?)		
Silt laden H_2O present?	☐ Yes ☐ No	Sedimentation pond in use? ☐ Yes ☐ No (if yes, see sedimentation pond guidelines in Erosion and Sediment Control Guidelines)		
Pumps	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Silt fencing	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Straw bales	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Straw (loose)	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Plastic tarps	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Erosion blankets	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Geo-textiles	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Filter fabric	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Seed mix	☐ On-site, accessible	☐ Not on site	☐ Not accessible	☐ N/A
Established sediment control mechanisms intact and functional?			☐ Yes	☐ No
Established water management mechanisms intact and functional?			☐ Yes	☐ No
Action required?	☐ Yes	☐ No		
Action taken?	☐ Yes	☐ No		
Details:				

SAMPLING SUMMARY				ATTACHED FORMS
Fish	☐ Yes	☐ No	Form #	☐ Water quality
Water quality				☐ Fish-bearing stream detailed site information
Turbidity	☐ Yes	☐ No	Form #	☐ Wildlife sighting
Conductivity	☐ Yes	☐ No	Form #	☐ Toad observation
pH	☐ Yes	☐ No	Form #	☐ Archaeological chance find
TSS	☐ Yes	☐ No	Form #	☐ ARD sampling
ARD	☐ Yes	☐ No	Form #	☐ Other (_____)
Other (_____)	☐ Yes	☐ No	Form #	

Details reported in this Daily Environmental Inspection Log are accurate and reflective of the conditions observed on ____/____/_____ (date).

_____ _____

(Environmental Monitor Name and Signature) (Contractor Name and signature)

DESCRIPTION OF DAILY ACTIVITIES (Continued)	**Log No: _____**

PHOTO DOCUMENTATION FORM		**Log No: _____**
Environmental Coordinator:		Date:
Environmental Monitor:		Camera:
PHOTO NO.	TIME	DESCRIPTION

Appendix G

Weekly Monitoring Report Form

Weekly Environmental Monitoring Summary Report

Date:	**Week:**
To:	**From:**
Cc: see distribution list at end	**Weekly Report #:**
Project Component: (e.g. Brucejack Access Road, Brucejack Mine Site, etc.)	**Specific Location:** (e.g. km XX to XX; diversion ditch A)

A) SUMMARY OF CONSTRUCTION ACTIVITIES

Provide overview of the nature and scope of construction activities, weather, and other factors that provide the reader with a quick grasp of the Project component being monitored, environmental performance, and any issues encountered during the past week. Divide out by Project component and further divide by location along Project component if necessary.

Meetings

Summarize meeting issues and outcomes including environmental orientation training, environmental plans (EPP, CEMP) content and intent, archaeological features and monitoring, pre-clearing survey findings, work windows, reporting requirements, buffers, and permits.

B) SUMMARY OF ENVIRONMENTAL MONITORING ACTIVITIES

Communication

Summarize any pertinent communication between Environmental Monitors, Contractor, Pretivm, or regulatory agencies.

Environmental Orientation Training

Summarize any training delivered and orientations including participants.

On-site Environmental Inspections and Findings

Describe any inspections, locations, on-site presence of Environmental Monitors, key findings, and overall scope of activity for the week. Provide photos and descriptions of challenging or successful activities. Ensure reader quickly obtains understanding of the scope, complexity of monitoring relative to the scale of activity, and nature of the environmental issues at the site. Comment on follow-up from previous issues and close out any issues. Note data collection activities for the week and locations, if in addition to the established ongoing monitoring program.

Erosion Prevention and Sediment Control

Water Quality

Spill Prevention and Emergency Response

Wildlife Interaction Summary

Waste Management

Air Quality and Noise Management

Heritage Resource Protection

C) INCIDENT SUMMARY

Summarize the nature, issue, contractor performance/actions, and outcomes of any environmental incidents. Describe impacts, remediation, and follow-up measures and notification to agencies/parties.

Prepare a tracking table which assigns a unique number to each event for week-to-week follow-up until closure.

D) EMERGENCY/UPCOMING ISSUES

Provide advance awareness and comments on upcoming issues for the following week.

E) ATTACHMENTS

Daily Environmental Monitoring Inspection Forms, Incident Reports, Photos.

Weekly Report Distribution:
Person X, Pretivm
Person Y, Construction Contactor
Person Z, Safety Officer and email address
Environmental Monitor (onsite) and email address
EPCM Contractor
Etc.

Appendix H

Environmental Incident Form

Initial Spill or Incident Report

Project Area:	Date:
Contractor/Subcontractor:	Day: S M T W Th F S
Weather:	Temperature
Wind: Precip:	High: Low:
GPS Coordinates:	Strip Map Attached? -

A. Cause / Nature of Spill or Incident	
Nature of incident	
Cause of spill or incident	
Contributing events leading up to the spill or incident	
Magnitude of spill (volume of area affected) or incident (number of people and/or equipment involved, etc.)	
Amount released to the environment outside of containment	
Duration of event	

B. Affected Area	
Aquatic resources affected	
Terrestrial resources affected	
Cultural resources affected	
Social resources affected	
Additional comments	

C. Actions Taken

Actions to control spill or incident	
Actions to contain spill / incident or manage incident receptors	
Actions taken to clean up the spill	

D. Additional Proposed Remedial or Corrective Actions Recommended

By Whom:	Description:

E. Communications

Date / Time	Contacts name and company / agency	Details of communication

F. Samples Collected

Type:	Where and how:

G. Other Information	
Who owns assets involved	
Nearest town	
Additional comments	
Photographs	

EM	(Print Name)	(Signature and Date)
Contractor	(Print Name)	(Signature and Date)

Appendix 9-2-10. Ventilation Plan

Production Ventilation Plan

Brucejack Mine

Date: February 11, 2022

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1 Introduction

The Brucejack Project is a high-grade gold mine located 65 km north of Stewart in northwestern British Columbia, Canada. The project is 100% owned by Pretium Resources Inc. (Pretivm). The mining method selected for Brucejack is Long Hole Open Stoping (LHOS) with cemented paste backfill, currently mined at a rate of 3,800 tonnes of ore per day (tpd).

Pre-production development commenced in the third quarter of 2015 with commercial production commencing in the third quarter of 2017. In late 2017, Pretivm applied to increase the production rate to 3,800 tpd.

The following describes the ventilation plan to support the 3,800 tpd production rate. This scenario represents the peak ventilation demand for the mine.

To ensure adequate ventilation for production operations, airflow requirements were estimated and simulations were run using Ventsim Visual 4.

2 Ventilation requirements

The total ventilation requirements for the 3,800 tpd production rate and drive are based on the airflow required for the diesel powered mobile equipment fleet, underground fixed facilities and a leakage and balancing factor. The airflow requirements for underground fixed facilities are unchanged as no new facilities are planned.

2.1 Mobile equipment

The airflow required for the mobile diesel equipment follows the ventilation requirements of the Health, Safety and Reclamation Code for Mines in British Columbia, Section 4.6.1 (3). Therefore a minimum of 0.06 $m^3/s/kW$ of operating diesel engine power is used.

Required ventilation quantities are estimated based on the current diesel equipment fleet as well as the additional equipment planned to support the increased production and exploration drive development.

The mining contractor is supplying the bulk of the underground mobile equipment. Every engine operating underground is CANMET certified.

Utilization factors are applied to each piece of equipment, given in Table 2-1.

Table 2-1 below shows the mobile equipment fleet with engine power, utilizations and the required ventilation volume. Note the fleet sizes and utilizations shown represent the maximum anticipated to meet full production.

Table 2-1 Mobile equipment ventilation requirements 2022

Equipment	Qty	Utilization	Engine Operating Time	kW	HSRC Requirements	
					Ventilation required per unit (m^3/s)	Required Ventilation (m^3/s)
Normet Boomtruck	1	45%	100%	63	3.8	1.7
Timberjack M40 Scissorlift	3	27%	100%	63	3.8	3.1
JCC Boom Truck	1	22%	100%	63	3.8	0.8
Marcotte Emulsion Loader M40	1	20%	100%	143	8.6	1.7
A64 GETMAN WATER TRUCK	1	71%	100%	127	7.6	5.4
JS Manufacturing SLX 5000 Scissorlift	1	10%	100%	74.6	4.5	0.4
KUBOTA RTVX1100C	1	40%	100%	18.7	1.1	0.4
Sparta USL5000 ScissorLift	1	27%	100%	148	8.9	2.4
KUBOTA RTVX1100C	2	40%	100%	18.7	1.1	0.9
A64 GETMAN MANCARRIER	2	25%	100%	129	7.7	3.9
SPARTA UBT24000 UNDERGROUND BOOM TRUCK	1	22%	100%	150	9.0	2.0
SPARTA USL5000 SCISSORLIFT	1	27%	100%	110	6.6	1.8
KUBOTA RTVX1100C	17	40%	100%	18.7	1.1	7.6
Jeffery Man Carrier	1	40%	100%	73	4.4	1.8
Utimec MF500 carrier	2	20%	100%	110	6.6	2.6
Normet Spraymec	1	7%	25%	110	6.6	0.1
Himec 9810BA Bulk Emulsion Loader	1	22%	100%	73	4.4	1.0
Jeffery Man Carrier	1	40%	100%	73	4.4	1.8
Jeffrey Flatdeck/BoomTruck	2	65%	100%	73	4.4	5.7
Jeffrey Lube Truck	1	70%	100%	73	4.4	3.1
10 Person Jeffery Mancarrier	1	40%	100%	73	4.4	1.8
Jeffery Boomtruck (beat Mechanics)	1	40%	100%	74	4.4	1.8
Jeffrey Mechanics Truck	1	45%	100%	73	4.4	2.0
Marcotte Emulsion Loader (drift rounds)	1	20%	100%	143	8.6	1.7
CAT 120k grader	1	15%	100%	73	4.4	0.7
415 Emulsion Toe Loader Carrier	1	2%	100%	128	7.7	0.2
Atlas COPCO MT2000 Truck - has not been used	0					
CAT AD30 Underground Truck	12	65%	100%	305	18.3	142.7
JLG G1255 Telehandler	1	60%	100%	93.3	5.6	3.4
CAT Skidsteer	1	10%	100%	71	4.3	0.4
JLG G1255A Telehandler	1	60%	100%	125	7.5	4.5
JLG G1255A Telehandler	2	60%	100%	97	5.8	7.0

Equipment	Qty	Utilization	Engine Operating Time	kW	HSRC Requirements	
					Ventilation required per unit (m^3/s)	Required Ventilation (m^3/s)
Maclean Bolter	3	100%	10%	112	6.7	2.0
Maclean Bolter	1	100%	10%	112	6.7	0.7
Tamrock DS310C Bolter	1	100%	15%	93.3	5.6	0.8
Sandvik DL 310 LH Drill (SOLO 66 & SOLO 68)	2	100%	2%	93.3	5.6	0.2
Cubex Aries LH Drill (ARIES 69)	1	100%	2%	110	6.6	0.1
Maclean Bolter	2	100%	10%	112	6.7	1.3
Sandvik DU311 TVK (ORION)	1	100%	2%	58	3.5	0.1
Sandvik DU421 Longhole Drill	1	100%	2%	55.8	3.3	0.1
Tamrock D07S 2 Boom Jumbo	2	100%	15%	110	6.6	2.0
TAMROCK Axera 7-260 2 BOOM JUMBO	0	100%	7%	110	6.6	0.0
EPIROC M2C 2 BOOM JUMBO	1	100%	10%	120	7.2	0.7
EPIROC M2C 2 BOOM JUMBO	1	100%	10%	120	7.2	0.7
JS220 Scooptram (2yd)	1	40%	100%	93.3	5.6	2.2
CAT R1700G SCOOPTRAM 8 YD	0	69%	100%	241	14.5	0.0
CAT R2900G SCOOPTRAM 10YD	1	64%	100%	305	18.3	11.7
ELPHINSTONE R1600G SCOOPTRAM	0	25%	100%	208	12.5	0.0
CAT R1700G SCOOPTRAM 8 YD	1	69%	100%	263	15.8	10.9
CAT R2900G SCOOPTRAM 10YD	0	64%	100%	305	18.3	0.0
CAT R2900G SCOOPTRAM 10YD	1	64%	100%	305	18.3	11.7
CAT R1700G SCOOPTRAM 8 YD	1	69%	100%	263	15.8	10.9
CAT R1700K SCOOPTRAM 8 YD	4	69%	100%	257	15.4	42.6
Sandvik DU411 LH Drill (R019)	2	100%	2%	130	7.8	0.3
Sandvik DU411 LH Drill (RC DRILLS)	3	100%	2%	130	7.8	0.5
A64 GETMAN CARRIER FOR DYNO TOE LOADER	1	25%	100%	129	7.7	1.9
A64 GETMAN EMULSION HAULER	1	25%	100%	127	7.6	1.9
Maclean MEM-955 Blockholer	1	1%	100%	105	6.3	0.1
Toyota (Engineering)	9	12%	100%	95	5.7	6.3
Toyota (Mill)	5	12%	100%	95	5.7	3.5
KUBOTA UTV (RTVX1100C?)	1	40%	100%	18.7	1.1	0.4
Manitou MLT625 Telehandler	1	60%	100%	55.4	3.3	2.0
JLG 6036 TELEHANDLER SKYTRACK 6036	1	10%	100%	55	3.3	0.3
Kubota Minemaster Loader	1	60%	100%	34.3	2.1	1.2
JLG 1055A Telehandler	2	30%	100%	97	5.8	3.5
Toyota Landcruiser	4	12%	100%	95	5.7	2.8
Minecat UT99 - Man Carrier	1	10%	100%	73.8	4.4	0.4

Equipment	Qty	Utilization	Engine Operating Time	kW	HSRC Requirements	
					Ventilation required per unit (m^3/s)	Required Ventilation (m^3/s)
Minecat MC100G - Telehandler	1	10%	100%	73.8	4.4	0.4
Fixed Facilities	1	100%	100%		56	37.7
						376.3
						413.9

As shown in Table 2-1, the total estimated airflow required for the mobile equipment fleet is 376.3 m^3/s.

2.2 Fixed facilities

The Brucejack mine design includes the following underground fixed facilities:

- Crusher
- Magazine
- Conveyor sacrificial belt level

All fixed facility locations are near a major mine intake route. Some intake air is diverted through these areas to provide ventilation. This airflow will report directly to Vent Exhaust Raise 2 (VR-2) (refer to Figure 3-1). This arrangement prevents air pollutants and dust produced in this area from being introduced into the mine primary circuit.

The airflow allowance for each area is described in greater detail below.

2.2.1 Crusher tipple and truck loop

Primary airflow must be provided through the crusher tipple level and within the truck loop to transport dust and dilute diesel emissions from trucks dumping at the tipple and travelling within the truck loop.

The largest diesel powered piece of equipment entering the tipple area is a 30-tonne, 305 kW truck. To satisfy the DEE dilution requirements for the truck, 18 m^3/s is required in each of the two legs of the truck loop. This airflow will also remove the dust generated in the tipple area and is exhausted down to the sacrificial belt conveyor level via a raise and exhaust fan. The raise is located on the opposite side of the rock-breaker cab to pull dusty air away from the operator and report to the VR-2 exhaust raise. A dust suppression system in the form of water sprays at the grizzly area is included.

2.2.2 Magazine

The magazine is a loop located off the east leg of the truck loop. Fresh air for this area is drawn from the 1335 level of the main VOK ramp. The airflow pattern through the magazine is intended to provide a single pass flow of air through the magazine and exhaust down the crusher exhaust raise to VR-2. The airflow through the magazine is approximately 7.5 m^3/s, sufficient to maintain a minimum velocity of 0.3 m/s.

Fire doors at the entry and exit points are included. In the event of a fire in the magazine loop, the doors would automatically close and contain the smoke within. A man-door is adjacent to each fire door.

2.2.3 Fuel bay and underground workshop

There is a fuel bay loop developed located at the north end of the truck loop. The fuel bay is currently inactive with no refueling infrastructure installed. The development for an underground shop is currently incomplete and no servicing facilities are in place.

If the fuel the bay and workshop are completed in the future, an appropriate airflow allowance will be provided.

2.2.4 Sacrificial belt level

The sacrificial conveyor between the lower main conveyor and the crusher is ventilated with air from the lower main conveyor decline. Approximately 12.5 m^3/s is drawn from the lower main conveyor decline and exhausted through a roll-up door regulating the air to VR-2.

The sacrificial conveyor regulator is part of the recommended smoke management strategy in the event of a fire along the conveyor ramp. In the event of conveyor fire, the door will be automatically fully opened for all ventilation air from the main conveyor declines to be diverted to the exhaust VR-2.

The total airflow allowance for the currently active fixed facilities is approximately 55 m^3/s.

2.3 Leakage and balancing

All mines experience leakage and balancing inefficiencies. The magnitude of these inefficiencies is dependent on a number of factors and typically ranges from 10% to 50% of total mine air flows. Being a new mine, leakage can be towards to the lower end of this range and has allowed a 10% addition to the total airflow requirements of this mine.

Regular monitoring and maintenance of all ventilation controls will be undertaken to reduce leakage.

2.4 Total airflow requirement

The total airflow requirement for the Brucejack mine during 3,800 tpd production is as follows:

- Diesel equipment - 338.6 m^3/s
- Fixed facilities – 55 m^3/s
- Leakage and balancing (10%) - 39 m^3/s
- **Total – 413.9 m^3/s**

3 Ventilation circuit

The Brucejack ventilation system is designed as a push system - the primary fans are located on surface, at the conveyor ramp and the West Zone portals.

Intake connections to the surface will consist of the West Zone ramp and the conveyor ramp. These two intake airways provide sufficient ventilation capacity to support steady state mining operations. To ensure the temperature of the air does not enter the mine below the freezing point, mine air heaters are fitted in front of the primary fans.

The VOK production ramp is connected to the intake ramps to deliver fresh air to the active production levels. An escape-way ladder system is installed in fresh air raises in parallel with the production ramp.

Fresh air travels from the production ramp, along the footwall drives and exhausted to return air raises located at the extremities of the level. Regulators are installed at the raise connections to distribute the required volume of air to the level. An appropriately designed auxiliary fan and duct system force fresh air from the footwall drives to active stope faces.

The underground fixed facilities have a dedicated return air raise (VR-2) to eliminate the introduction of dust and other unwanted contaminants into the production areas. The volume of air flowing through the crusher and workshop areas is controlled with a combination of fan and regulators.

Figure 3-1 shows an isometric view of the Brucejack ventilation system with airflows and velocities in key airways. This ventilation configuration represents the stage of the mine life chosen for primary fan selection.

Figure 3-1 Brucejack ventilation system - looking east

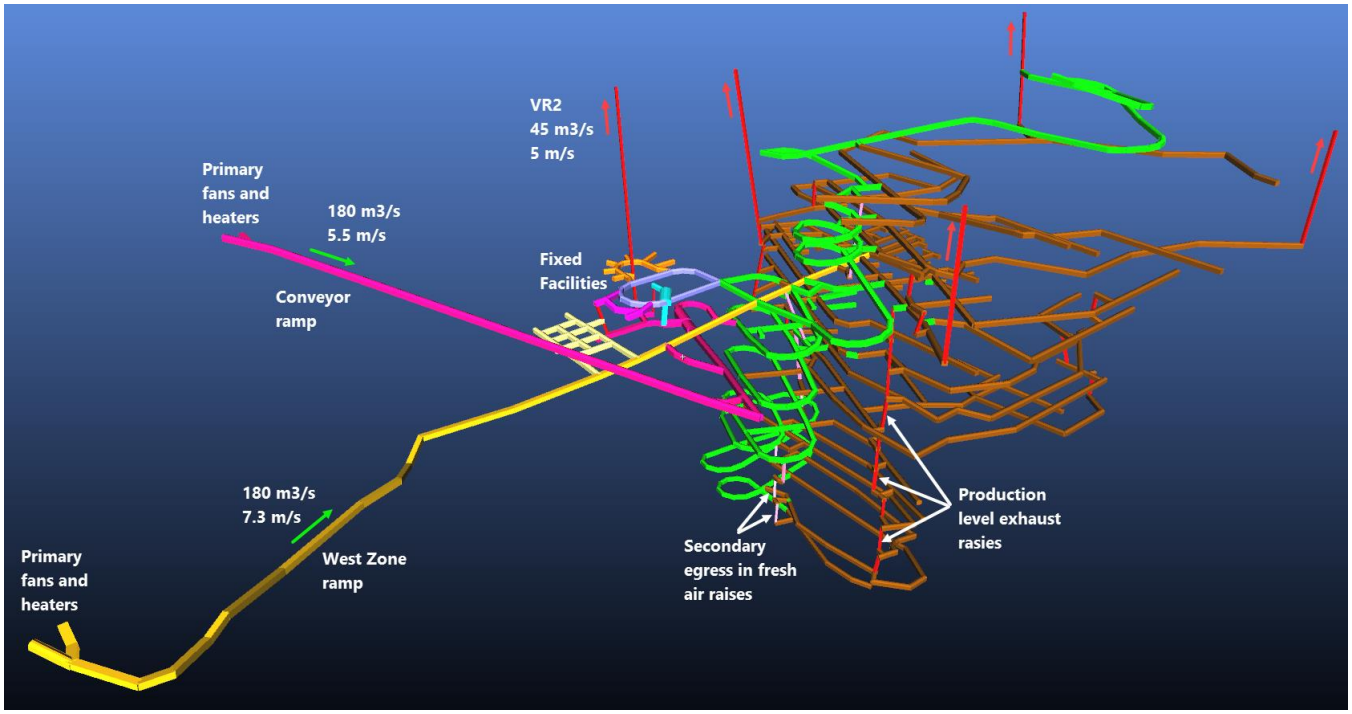
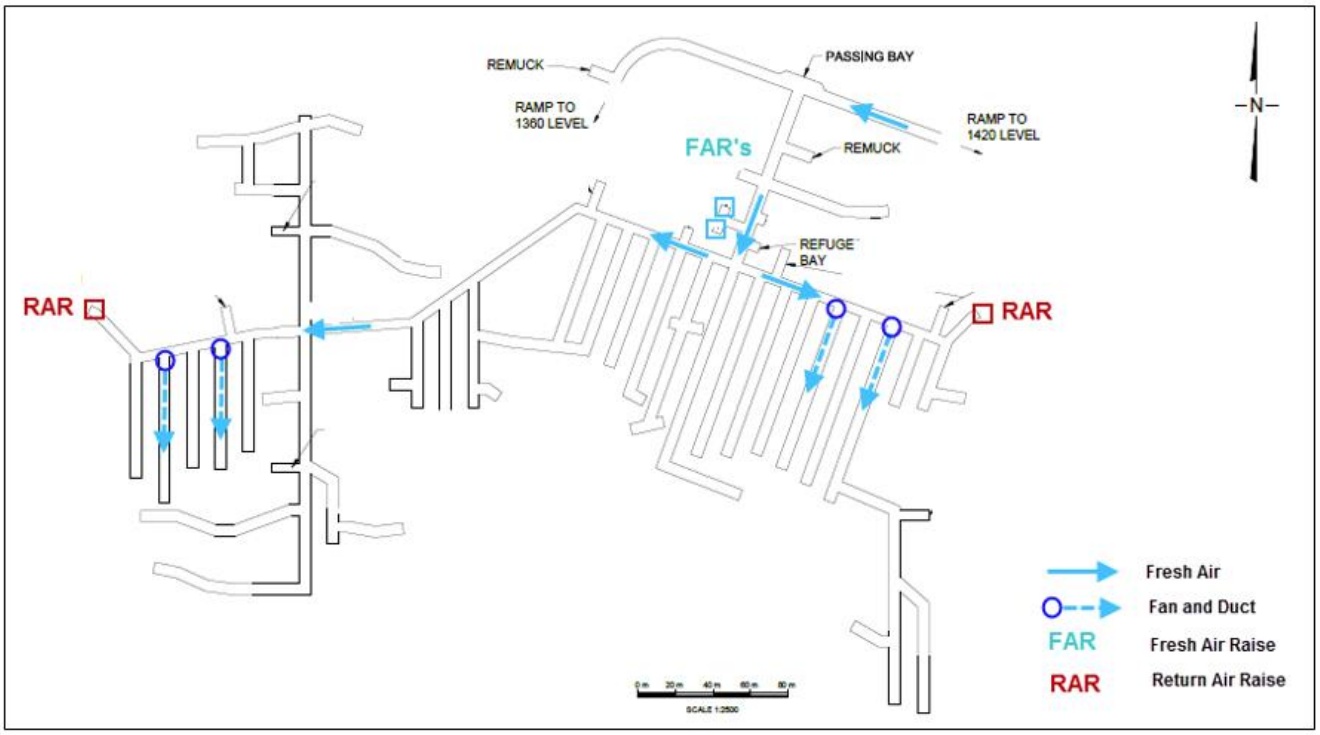


Figure 3-2 shows an isometric view of the ventilation arrangement for the fixed facilities area. The arrows show the airflow direction of travel.

Figure 3-2 Fixed facilities ventilation arrangement

Figure 3-3 shows a plan view of a typical production level.

Figure 3-3 Typical production level



4 Primary fans

Ventilation modelling was undertaken for the purposes of appropriate primary fan selection during the feasibility study phase. Over the life of mine there are a large number of settings for the ventilation circuit, depending on the type of activities and their location throughout the mine. The modelled scenario attempts to reflect the peak primary fan duties that could be reasonably expected. This scenario involves development occurring in conjunction with full production in the upper, middle and lower mining blocks of the VOK (as shown in Figure 3-1 above).

The primary fan duties is as shown in Table 4-1.

Table 4-1 Primary fan duty

Description	Specification
Duty	Two each @ 229 m^3/s @ 1,625 Pa
Fan Diameter	2.4 m
Type	Horizontal mount axial mine fan
Configuration	Two forcing fans, each connected with ducting to the WZ access decline and the VOK conveyor decline

Description	Specification
Voltage	575 V
Fan Motor	600 kW at 1180 rpm, variable frequency drive capability

The fans are controlled from surface and include a complete package of airflow, pressure and vibration monitoring capability. The fans and motors are also capable of reversal, providing ~ 60% of the forward flow.

5 Mine air heating

A mine air heating system is included for the Brucejack operation. The target intake air temperature will approximately 2°C. At the Brucejack mine, the primary purposes of this is to:

- minimize the potential that ice can accumulate on the roadbed of either the main decline or the conveyor decline,
- protect water pipes and other infrastructure in those main intakes, and to protect these drifts from freeze/thaw cycles.

Additionally, heating the intake air can offer a modest increase to the comfort of the mine workers, who may be exposed outside of equipment cabs.

During the 3,800 tpd production phase, 413.9 m^3/s of air will require heating when the surface temperature is near freezing. Mine air heating is provided for with a hybrid heating system. Primary heating is electrical resistance heaters with a direct fired propane system to provide heating at peak times when the electric system capacity is exceeded. The mine air heating system is installed at both intake portals.

The specifications of the heating system is shown below in Table 5-1.

Table 5-1 Heating system key specifications

Overall heater data	
Airflow through each heater	229 m^3/s
Total heat load (each heater)	7 MW (electric and propane heater)
Winter Design Entering Dry Bulb Temp.	-34°C
Winter Design Leaving Dry Bulb Temp.	+2°C
Electric heater data	
Heating capacity/heater	2 MW
Coil type/Material	80% nickel, 20% chromium, Grade A resistance wire
Power supply (V/Ph/Hz)	600/3/60
Propane heater data	
Heating capacity / heater	5 MW

Burner material	Aluminum casting and stainless Wings
Fuel flow required (Per Burner / Total)	97 Nm3/hr / 193 Nm3/hr
Burner Control	4-20 mA fully modulating

A carbon monoxide detection system is included for both heaters. The detector will shut down all the heater units in the event of CO concentrations exceeding 25 ppm. As per Health, Safety and Reclamation Code for Mines in British Columbia regulation 4.4.19 (3), the sensor are installed approximately 15 m downstream of the heated air manifold to allow sufficient air mixing.

6 Emergency preparedness

6.1 Refuge chambers

A permanent refuge station designed for emergency refuge of 40 persons is located near the truck loop on 1,335 level. It acts as lunch room during non-emergencies. The refuge chamber is provided by MineARC and the major components of the system include:

- Secondary oxygen supply – medical grade oxygen cache, sized to provide O_2 at a minimum rate of 0.5L per occupant, per minute, for duration of refuge.
- Third source of breathable air – sodium chlorate O_2 candle.
- Carbon dioxide removal – CO_2 removal system capable of removing no less than 24 L CO_2 per person, per hour, for the duration of the refuge, in order to maintain levels at less than 1%.
- Carbon monoxide removal – CO removal system capable of maintaining levels below the maximum exposure limit of 25 ppm.
- Cooling & dehumidifying – a cooling system with a nominal capacity of 130 watts per person, to mitigate heat loads of occupants and additional heat sources, with the ability to dehumidify the chamber interior.
- Atmospheric monitoring – ability to monitor levels of oxygen, carbon dioxide and carbon monoxide within the chamber and outside the chamber during emergency.
- Emergency food and water rations
- UPS battery backup
- Inverter charging system
- Vent Doors / Airlock
- Compressed air management

Compressed air sourced from surface compressors provide compressed air to the chamber. If the compressed air line is compromised during an emergency, the refuge chamber is capable of supporting up to 40 people for up to 72 hours.

Portable MineARC refuge chambers are also installed for personnel working in outlying areas of the mine where secondary means of escape has not been established. They are relocated relative to the active working areas to be within the average walking pace duration of a personal self-rescuer device, within approximately 750 m. Brucejack has for four, 16-person and one 12-person MineARC refuge chambers underground. These portable chambers in combination with the permanent chamber are sufficient for the maximum number of anticipated personnel working underground each shift.

The portable chambers contain the same features and performance of the permanent chamber. A compressed air line from surface compressors is reticulated to each portable refuge chamber.

6.2 Fire modelling

Extensive fire modelling of numerous fire scenarios was undertaken as part of the emergency preparedness for the Brucejack mine. The fire modelling was completed by external consultants, AMEC Foster Wheeler – the report can be found in Appendix B.

Five cases were simulated that represent six scenarios including: VOK conveyor decline fire, WZ access decline fire, WZ ramp fire, VOK ramp fire, and a production level fire. Stench gas distribution was also modelled. As an outcome of these models, countermeasures and evacuation routes were recommended and subsequently adopted as part of the emergency planning.

6.3 Conveyor decline

Brucejack mine uses the conveyor ramp as a main ventilation intake to the VOK mine workings. Under normal conditions, the ventilation intake air flows down both the upper and lower conveyor legs. When the airflow passes the sacrificial transfer conveyor, a small portion is drawn off to ventilate the transfer conveyor at the bottom of the crusher chamber. The remaining air flows into the main production ramp at about the 1290 m level.

This arrangement places a risk to the VOK district below the 1335 m level in the event of a fire along the conveyor decline. Mine fire modelling was completed by external consultants (AMEC Foster Wheeler). Part of this study included establishing the best strategy to implement in the unlikely event of conveyor belt fire.

Based on these simulations, the response to a conveyor fire is:

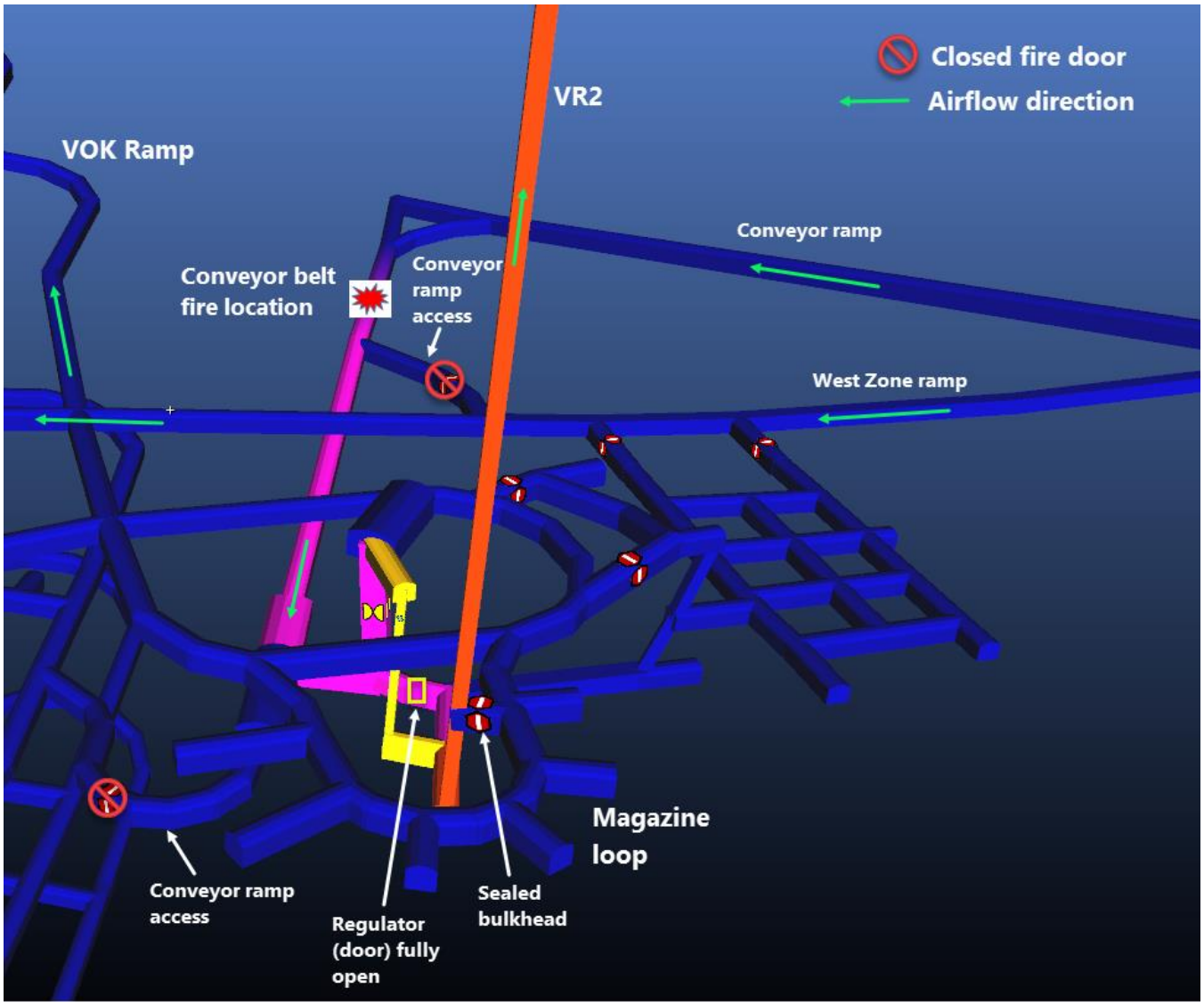
- Close the fire doors in the conveyor access ramps

- Fully open the regulator that exhausts the sacrificial conveyor area to VR2.
- The VOK conveyor portal fan is slowed down to 50% of its steady state speed.

The fire detection system installed at Brucejack is capable of automatically performing the closure of the appropriate fire doors.

This procedure is shown in Figure 6-1. The colored drifts shown the areas affected by fire contaminants.

Figure 6-1 Conveyor fire procedure



This approach does not materially impact the flow of air that would be perceived by the underground workers, which should help avoid confusion during the evacuation process.

To reduce the risk of a conveyor fire, the conveyor belting is fire retardant. The Brucejack mine includes an extensive fire detection system for the conveyance system including the crusher and transfer stations and the VOK portal building. In the unlikely event of a conveyor fire, the system will automatically implement the closure of the required fire doors.

The entire conveyor system is also provided with firefighting equipment in the form of high flow/extended discharge Red Line type fire extinguishers. To maximize the efficacy of these extinguishers a high sensitivity smoke detection in the VOK Portal (downstream of the main fan), transfer station, and crusher station is included.

In addition, standpipe systems are installed at the crusher station, transfer Station and VOK portal building where pulleys create a greater source of friction and potential ignition.

Further details of these systems can be found in Appendix A.

6.4 Stench

A stench gas system is installed at the primary fresh air intakes at the West Zone and conveyor ramp portals. In the event of a mine-wide emergency requiring evacuation, if the mine's ventilation system remains functioning and intact, a stench warning system is capable of alerting the workforce of the necessity to evacuate or travel to the nearest place of refuge.

Stench gas modelling was undertaken as part of the fire modelling work completed by the external consultants. Modelling indicates that after releasing stench at both portals, stench is distributed to the fixed facilities, crusher, and a portion of the VOK production ramp. After ten minutes, all of the likely active areas of the mine have been alerted; however, areas that are not under active production or development activities will not be reached by this time.

Radio communication is an additional key component of the emergency alert protocol.

6.5 Underground fire detection and protection

The Brucejack mine includes an extensive fire detection and protection system. The system includes high sensitivity smoke detection, fire alarms and fire suppression at the following facilities.

- VOK portal building

- Conveyor ramps and transfer station
- Permanent refuge station
- Crusher
- Substation
- Paste plant booster station

High sensitivity smoke detection (Vesada) systems are located in key areas to initiate fire alarms and automatically close the required fire doors. The fire alarms will initiate the manual control of the conveyor systems and primary fans. The detailed design of these systems is provided by Tyco Integrated Fire and Security and can be found in Appendix A.

6.6 Mobile equipment fire protection

All mobile equipment operating underground will carry at least one appropriately sized fire extinguisher. The equipment is also furnished with both manual and automatically actuated fire suppression system.

6.7 Escape plan

The Brucejack mine has two independent and separate accesses to surface – the West Zone portal and the conveyor ramp portal. Both ramps are primary fresh air intakes and act as the egress routes to surface.

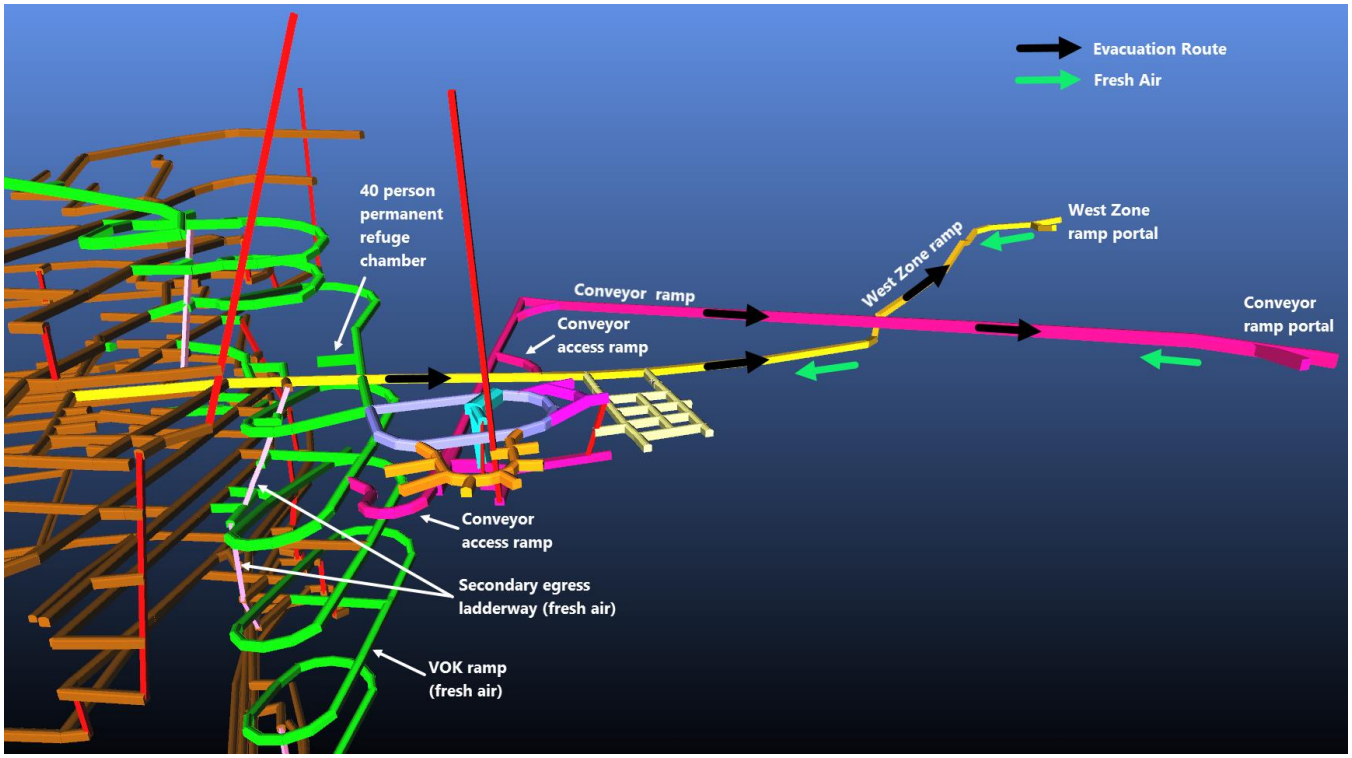
In the event of a mine emergency, personnel are to report to surface or the nearest refuge chamber.

For personnel working in the VOK production areas, the route of escape is to the VOK ramp, the West Zone ramp, and out the West Zone portal. Level to level secondary egress is provided for in the VOK area with an escape way ladder system located in the fresh air raises connecting the levels. An alternate escape route is to surface via the conveyor ramp. The lower conveyor ramp has two access points; from the VOK ramp at 1290 Level and the West Zone ramp connection at the 1335 Level.

Escape route maps are to be posted in the refuge stations and in other conspicuous areas of the mine.

Figure 6-2 shows an overview of the mine escape routes and the location of the permanent refuge station. Also shown is the fresh air flow direction. The portable chambers will be relocated as required as the mining locations evolve over the life of mine.

Figure 6-2 Escape plan



Appendix A – Brucejack Underground Fire Protection Design Criteria

Brucejack Underground Fire Protection Design Criteria

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Document No.		Rev F	April 20, 2016

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Regulatory Baseline & Reference Documents

Regulatory Baseline
The following documents have been considered as both applicable and enforceable for the purposes of this Design Criteria

A. BC Building Code 2012 Edition
B. Health Safety and Reclamation Code for Mines in British Columbia 2008 Edition
C. BC Fire Code 2012 Edition
D. WorkSafe BC Part 22 Underground Workings
E. ULC S-524 M2006– Fire Alarm Installation Standard
F. CSA Standard CAN/CSA-M424.2-M90, Non-Rail-Bound Diesel-Powered Machines for Use in Non-Gassy Underground Mines
G. NFPA 10 - Fire Extinguishers
H. NFPA 13 – Fire Protection (Sprinklers)
I. NFPA 14 - Standpipes
J. NFPA 20 – Fire pumps

Non Enforceable Reference Documents
Other documents that are considered non enforceable but having applicability for good practice have also been considered for the purposes of this Design Criteria. These documents are:

A. NFPA 122 Standard for Fire Prevention and Control in Metal/Non Metal Mining – 2010 Edition
B. NFPA 2001 – Clean Agent Suppression
C. NFPA 15 – Transformer protection
D. NFPA 16 – Foam Protection
E. FM Standards – Where Applicable

General Document Structure

For each area or hazard underground at Brucejack, the following is described:

Key Factors – The underlying factors that lead to the developed design criteria

Identified Hazards – Elements within this building (or sub portion of a building) that constitute a risk to people, assets, or productivity.

Fire Alarm Coverage – Description of the extent to Fire Alarm coverage for this area.

Fire Suppression Coverage - Description of the extents of Standpipe, Sprinkler, Fire Extinguishers, Foam and Clean Agent for this area.

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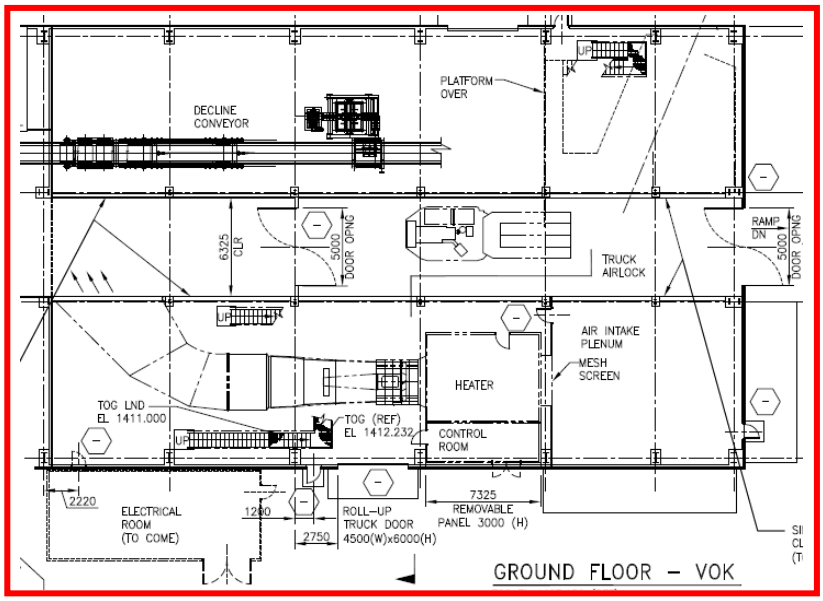
Brucejack Site – VOK Portal Bldg / Mine Underground Heater Bldg



1.1 Key Factors

- Occupancy type F3
- Non-combustible construction
- Critical egress point for underground
- Onsite Fire Department

1.2 Identified Hazards

- Flammable gas
- Surface air pollution (smoke)

1.3 Fire Alarm – Coverage

Provide a fire alarm control panel that directly communicates with site wide fire alarm network complete with audible/visual notification device coverage and manual pull stations at all exits. Pull stations in non-heated areas will be installed in Nema 4 enclosures. Smoke detection will be provided at the top of any enclosed stairwells. Sprinkler flow and tampers shall be monitored by the fire alarm system and the valve room shall be monitored for low temperature detection to alert of any risk of freezing.

High sensitivity smoke detection shall be provided on downstream side of underground air supply fan to provide protection against any smoke drawn from the surface.

Process Interface shutdowns will be provided in the event of Portal Building Fire to:

- Shutdown Portal Fan
- Shutdown Conveyor

In addition to the interlocks described above, additional High Sensitivity Smoke Detection points shall be installed at the Transfer Station and Crusher Station, see the Conveyor section for further detail on how these interlocks shall interact with the VOK Fan logic.

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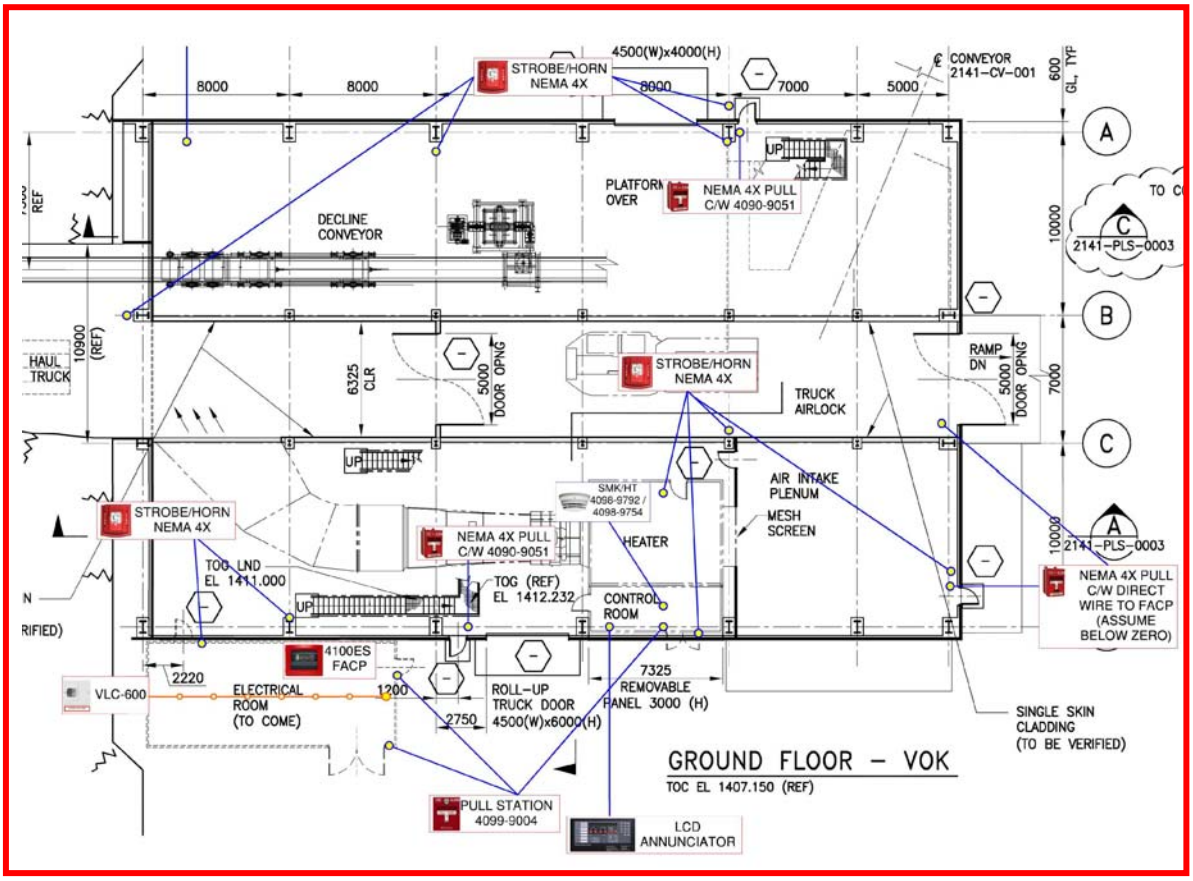

1.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

Standpipe and Fire Extinguisher coverage shall be provided throughout the VOK Portal building in accordance with BCBC 2012 and NFPA 14 (Standpipe) and NFPA 10 (Fire Extinguishers). Automatic sprinkler coverage will be provided for the conveyor pulley area. See additional pertinent details below:

- Class 1 standpipe system shall be installed in VOK PORTAL BUILDING to facilitate effective firefighting capabilities. The wet zone valve will be fed from the fire water 8" main (by others). Fire Hose Cabinets shall be located at exits and other locations where required due to overall distance considerations. Cabinets shall be placed at each platform level to facilitate firefighting of large equipment.
- Fire extinguishers shall be placed within the standpipe cabinets and throughout the building as required.

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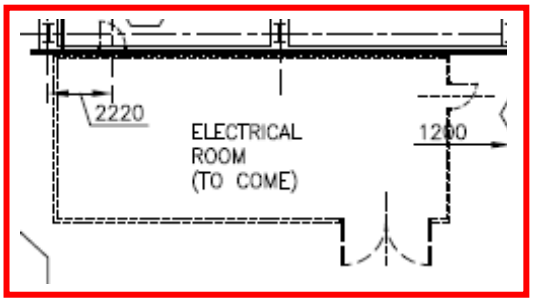
Brucejack Site – VOK Portal Electrical Rooms



2.1 Key Factors

- Occupancy type F3
- Non-combustible construction
- 2 Hour Fire Rating Separating Electrical Room from VOK Building
- Local Fire Department

2.2 Identified Hazards

- Electrical Equipment / Cabling (insulation)

2.3 Fire Alarm – Coverage

Provide air sampling based Vesda system that directly communicates with the fire alarm system. The system shall provide multiple levels of early detection (despite the high air flows anticipated in this room for cooling) to draw attention to an issue prior to evacuating the building or releasing any potential suppression system.

2.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

Sprinkler coverage is not recommended in this room as it can damage sensitive electrical equipment. The electrical room is to be separated from the VOK Building with a 2 Hour Fire Rating, allowing for compliance to BC Building code without providing sprinklers.

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Underground – Conveyor Tunnels / Transfer Station

3.1 Key Factors

- Fire Retardant Belt (as required by HSRC)
- Local Fire Department

3.2 Identified Hazards

- Conveyor belt
- Electrical cables (insulation)
- Motors
- Bearings (friction source)

3.3 Fire Alarm – Coverage

Any sprinkler flow and tampers will be monitored with addressable inputs connected to the closest fire alarm panel. The underground transfer station and the conveyor area at/near the bottom of the crusher conveyor feed sprinkler devices shall be monitored by the substation or the underground crusher panels as appropriate.

Audible visuals shall be located near any areas of sprinkler coverage. In the event a flow of water is detected the fire alarm system shall shut down the conveyor(s), to limit the spread of fire and enhance the efficacy of the Red Line high flow fire extinguishers. In addition, high sensitivity smoke detection (Vesda) at the Transfer Station and at the Crusher will detect smoke produced by a conveyor belt fire and allow for the following interlock logic:

1) Fire Door closure direct from the Fire Alarm system by local addressable (Fire Alarm) relay
2) Integration (Modbus or similar) with the mine airflow system to slow the standard 5m/sec rate down to allow for maximum efficacy of the Red Line high flow fire extinguishers.
3) Integration (Modbus or similar) with the mine process control system to stop conveyer immediately.

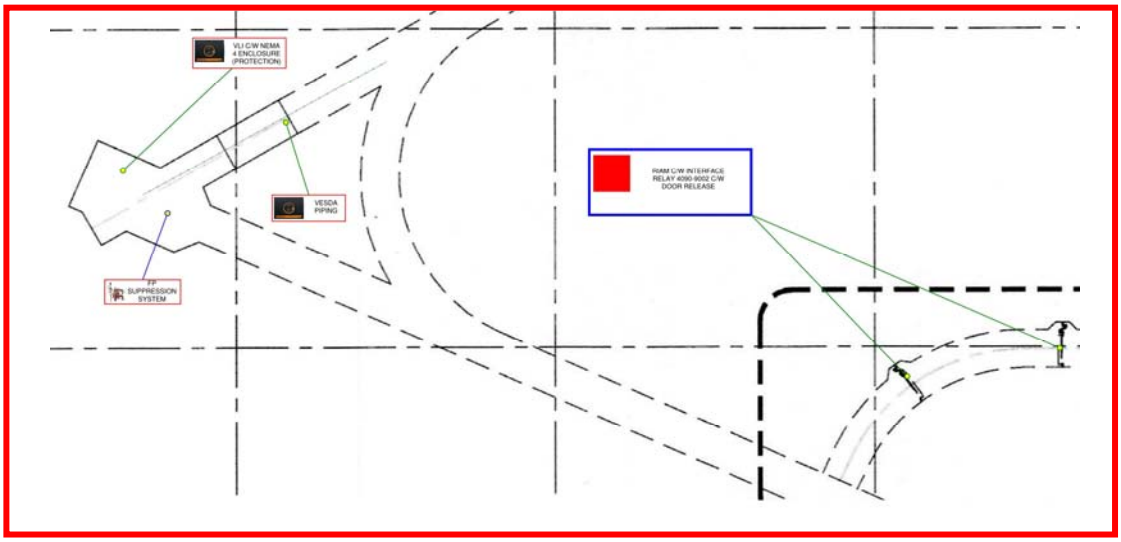
These same Vesda systems, along with the additional Vesda unit in the Vok Building (just downstream of the supply fan) will be integrated with the VOK building mine airflow system to determine when the fire is likely coming from within the VOK building itself. Specifically:

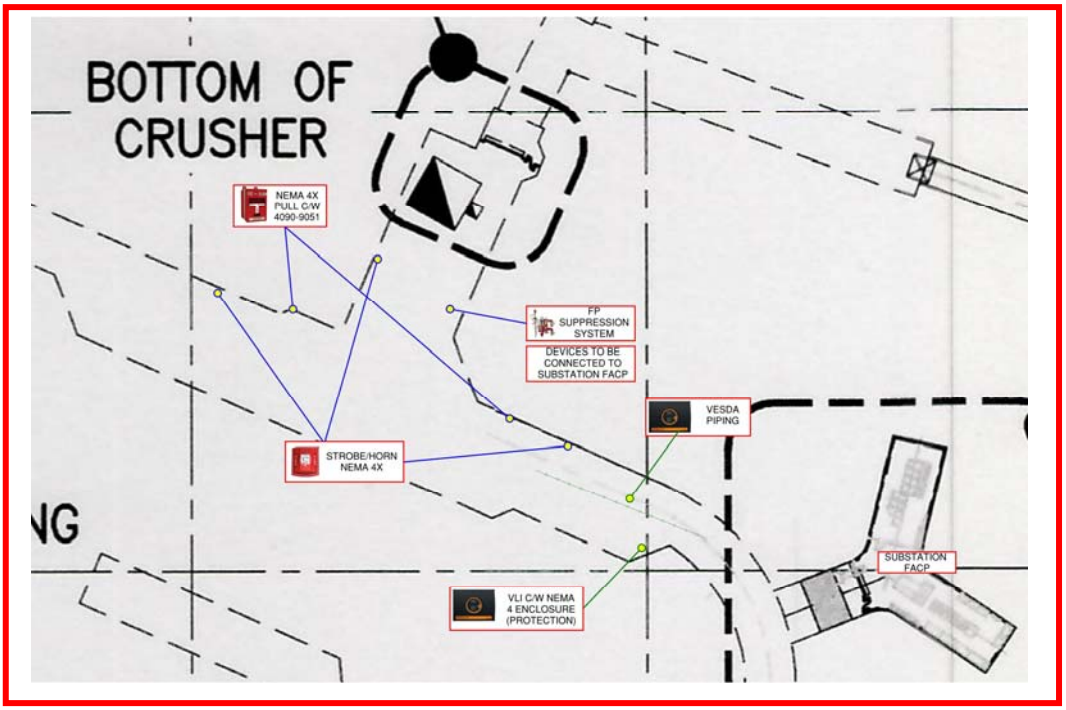
A) First alarm (chronologically), and high values from the VOK Vesda plus second alarm (chronologically) and lower values from the Transfer Station and Crusher Vesda likely indicate a VOK fire (or VOK drawing smoke from another surface fire).
B) A reverse of the above where the first alarm and higher values come from either the Transfer Station or the Crusher likely indicate a conveyor fire where the VOK air supply Shall be maintained but at a slower rate than the standard 5m/s.

These process interlock conditions shall be discussed further with the owner/operator and refined prior to implementation however the base design is that fire alarm will control the doors directly where mine airflow and conveyor systems will be a case of fire alarm notifying those systems for final control.

See Images Overleaf:

"ALL CONTENT HEREIN IS TO BE CONSIDERED INTELLECTUAL PROPERTY AND/OR TRADE SECRETS OF PRETIVM/TYCO AND IS TO BE UTILIZED FOR THE SUPPORT OF THE BRUCEJACK PROJECT. ANY OTHER USE IS PROHIBITED"





3.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

Automatic sprinkler protection shall be provided for the conveyor tail and head pulleys, plus the transfer station. Detailed design shall be in accordance with the FM requirements detailed below.

4. Protect important production belt conveyors running in tunnels or passageways which are accessible for manual fire fighting with automatic sprinklers over drive motors, end pulleys, or other known or common friction or ignition points or sources. Extend sprinklers 50 ft (15 m) beyond in both directions and space at10 ft (3 m) intervals on lines. Design sprinkler activation to sound an alarm at a constantly attended location and shutdown the conveyor system..*

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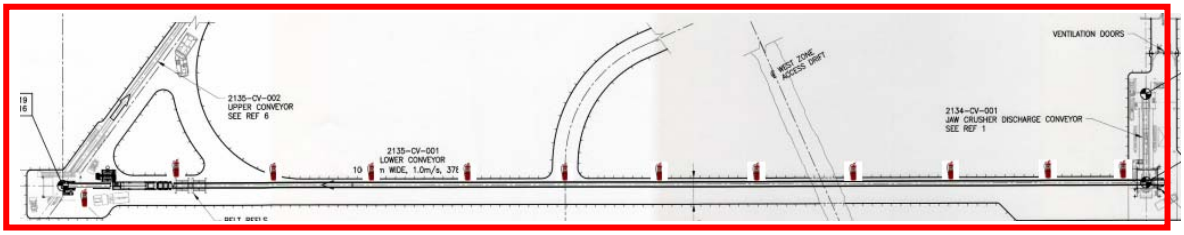
The entire conveyor system shall be provided with firefighting equipment in the form of high flow/extended discharge, cartridge operated Red Line type fire extinguishers. To maximize the efficacy of these extinguishers the high sensitivity smoke detection in the Vok Portal (downstream of supply fan), Transfer Station, and Crusher Station points shall be interlocked with the supply air as described in the preceding fire alarm section.



In addition, standpipe systems shall be installed at the Crusher Station, Transfer Station and VOK Portal building where pulleys create a greater source of friction and potential ignition.

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Underground – Fuel Bay and Oil & Grease Storage

4.1 Key Factors

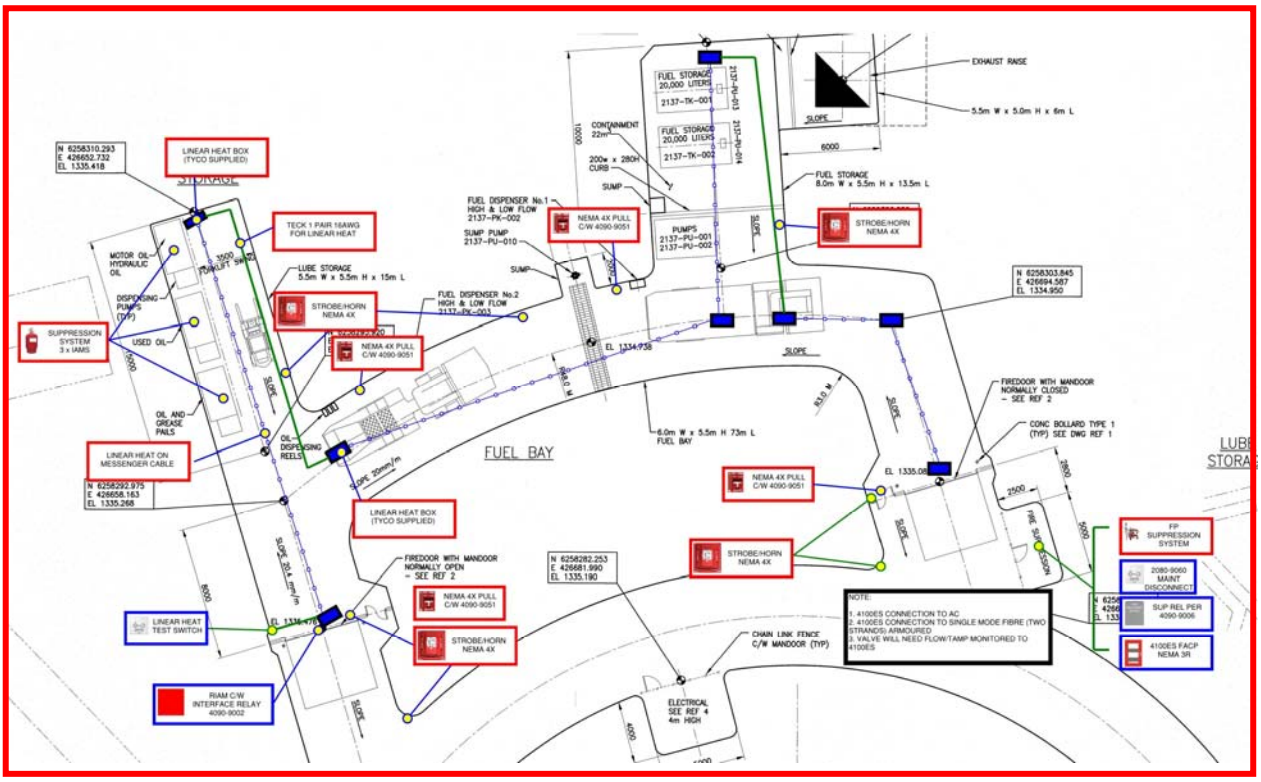
- Local (Surface) Fire Department Response

4.2 Identified Hazards

- Fuel Hazard & Ignition risk (vehicle)
- Restricted access for fire fighting

4.3 Fire Alarm – Coverage

Provide a fire alarm control panel connected to the underground/site wide fire alarm network. Pull stations and audible/visual coverage shall be provided throughout this area. Flammable fluid hazards shall be monitored with linear heat detection zones including supervision and control of the fire suppression system. A means to manually release each hazard both from within this area and outside of this area will be provided.



4.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

Provide an AFF foam fire suppression system for the entire fuel bay area up to the fire doors at either end of the bay. Containment shall be provided by sloping & grading in combination with an appropriately sized sump with an oil/water separator. The foam fire suppression system shall be automatically activated and also be equipped with manual activation points both within and outside of the fuel bay area.

Fire doors shall be interfaced with the fire detection/suppression system to close automatically in the event of fire. This interface means shall be by direct fire alarm relay.

See coverage image overleaf:

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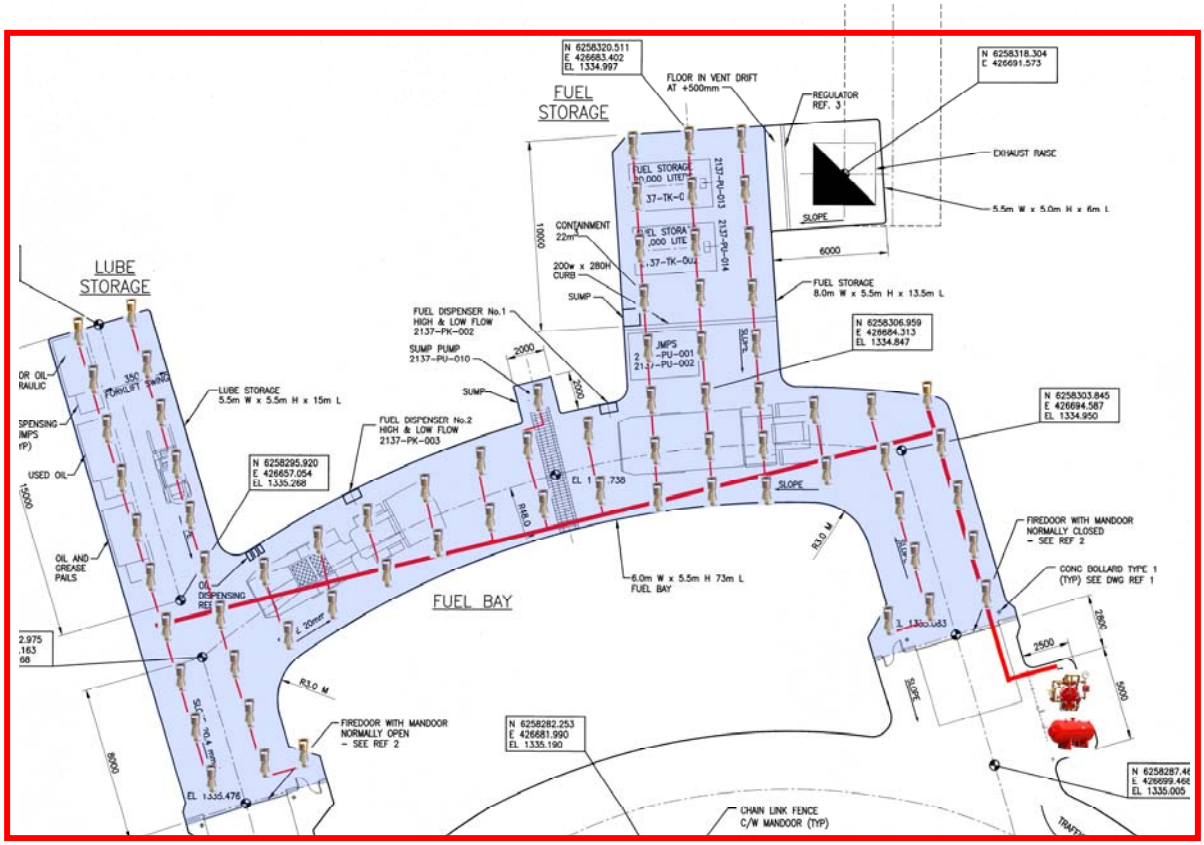

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Underground – Refuge / Lunch Room

5.1 Key Factors

- Local Fire Department (Surface)
- Limited combustible load (limited storage)

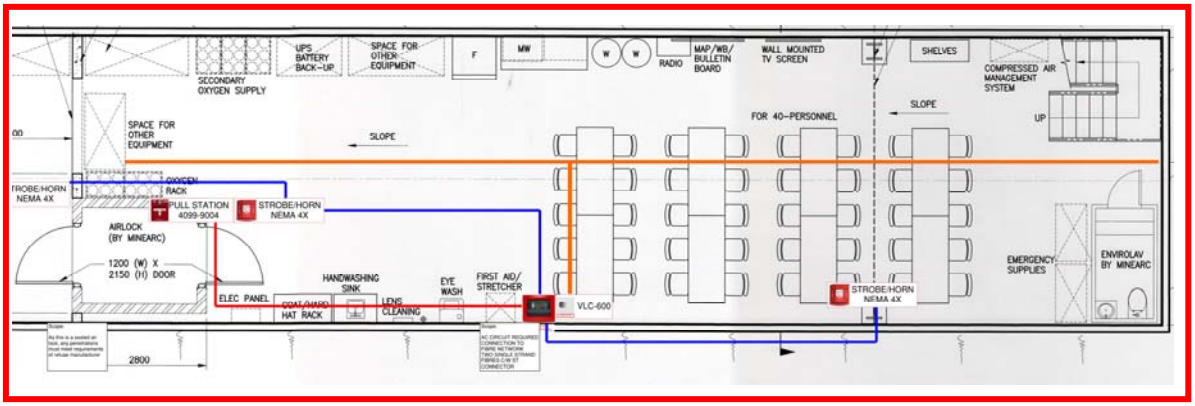
5.2 Identified Hazards

- Class A materials
- Ignition sources, cooking equipment

5.3 Fire Alarm – Coverage

A fire alarm control panel that directly communicates with site wide fire alarm network c/w audible/visual coverage and manual pull stations at exit.

The fire alarm system shall also include smoke detection to provide early warning of an incipient fire. To accommodate the high ceiling a Vesda type air sampling system shall be utilized.



5.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

All fire extinguishers in the Underground – Refuge/Lunch Room will be spaced no further than 75 ft travel, they will be 20lb Stored Pressure 10A;120B;C Dry Chemical Extinguisher charged with ABC Powder.

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Underground – Truck Shop/ Warehouse

6.1 Key Factors

- Non-combustible construction
- Local Fire Department (Surface)

6.2 Identified Hazards

- Vehicles
- Maintenance equipment
- Ignition sources (welding, grinding, etc.)

6.3 Fire Alarm – Coverage

Coverage considered under this Design Criteria is confined to the initial site build out which is through the two entry doors and up to the first cross cut. The image below shows the whole service garage area including the future cross cuts that will be created in future phases of truck shop expansion. Fire Alarm coverage is detailed as for the first cross cut only at this time.

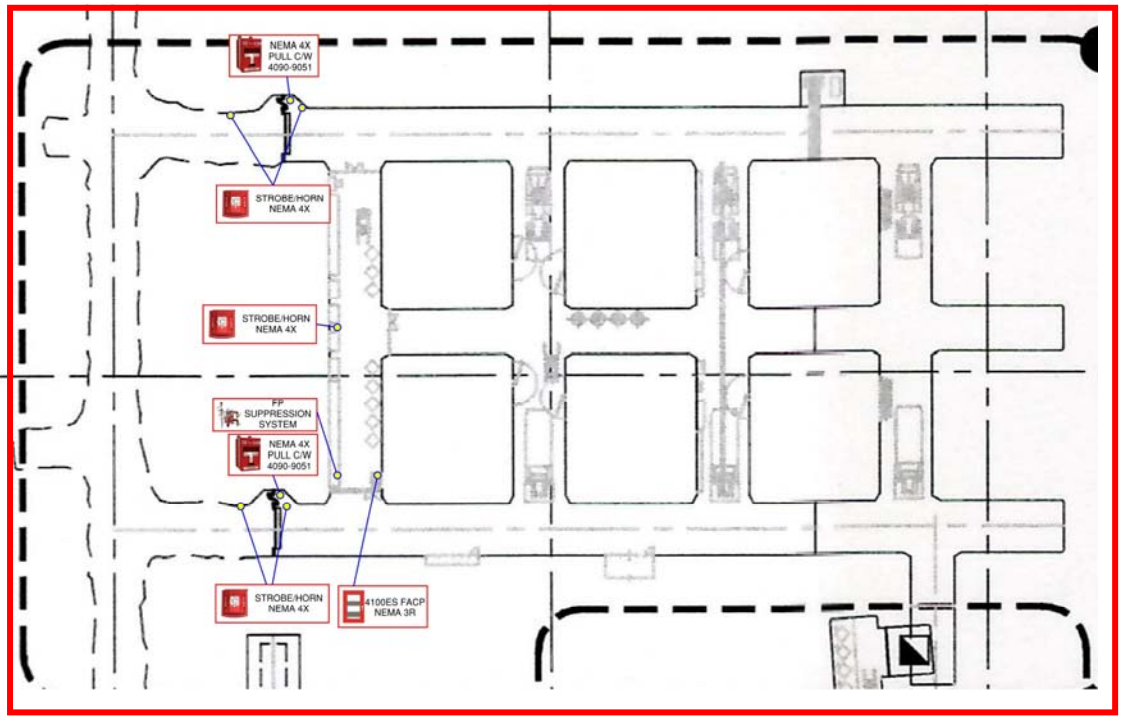
Provide a fire alarm control panel connected to the underground/site wide fire alarm fiber network. Including Nema 4 enclosures for pulls stations, audible/visual notification devices and sprinkler supervision.

6.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

The area of coverage included in this design criteria is the same as that referred to in section 29.4 above (from the two entry doors, through to the first cross cut only).

Provide a wet type automatic sprinkler system based on FM Global Datasheet 7-12 Section 2.4.7

1. Where the ceiling of the bay above the mobile equipment is 60 feet (18 m) or less provide standard wet or dry pipe automatic sprinklers on a system designed to provide 0.45 gpm/ft2 (18 mm/min) over 5000 ft2 (12 mm/min over 460 m2) (wet pipe) or 8000 ft2 (740 m 2)(dry pipe) using 165°F (75°C) heads.



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Underground – Crusher/Rock Breaker

7.1 Key Factors

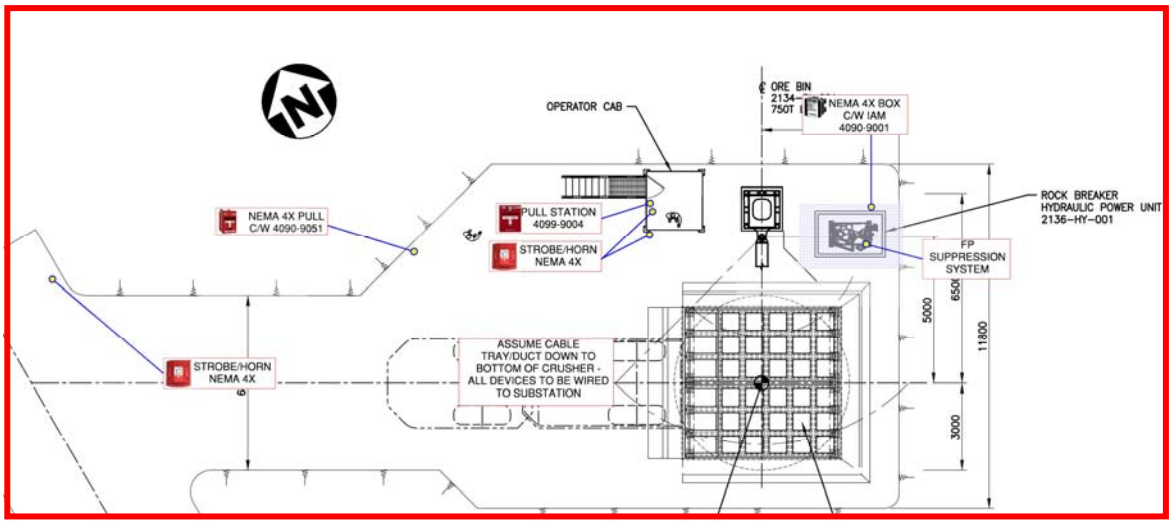
- Non-combustible construction
- Local Fire Department (Surface_

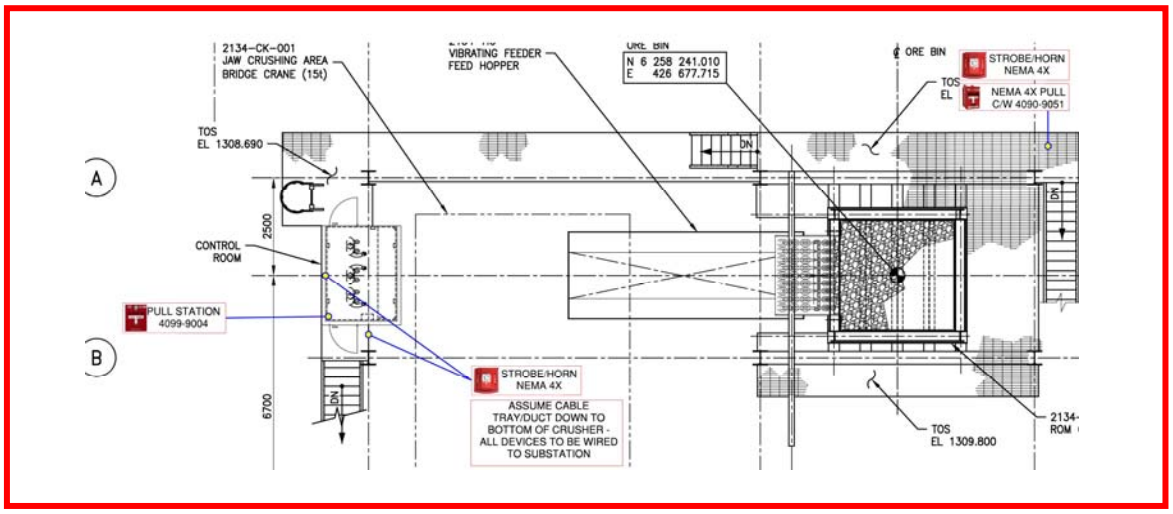
7.2 Identified Hazards

- Lube Oil Unit
- Conveyor
- Electrical Equipment / Motors

7.3 Fire Alarm – Coverage

Provide a fire alarm control panel that directly communicates with site wide fire alarm network c/w audible/visual coverage for inside the control room and general Crusher area. Provide a pull station at the control room exit and at the area near the Crusher. Supervise sprinkler system for valve isolation and water flow. Interface to the process control system for shutdown upon fire system activation.





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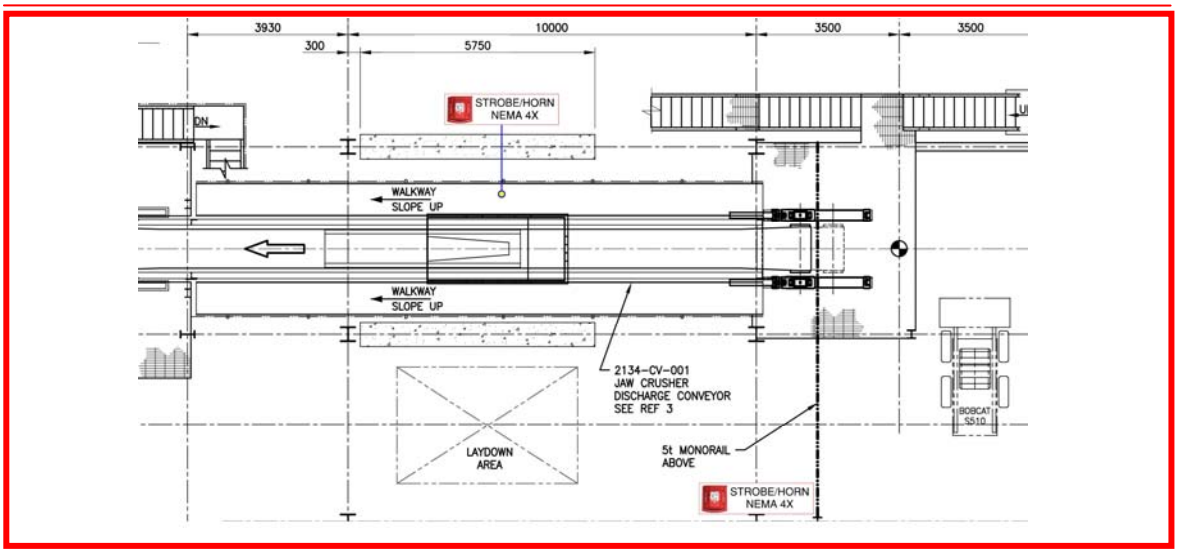

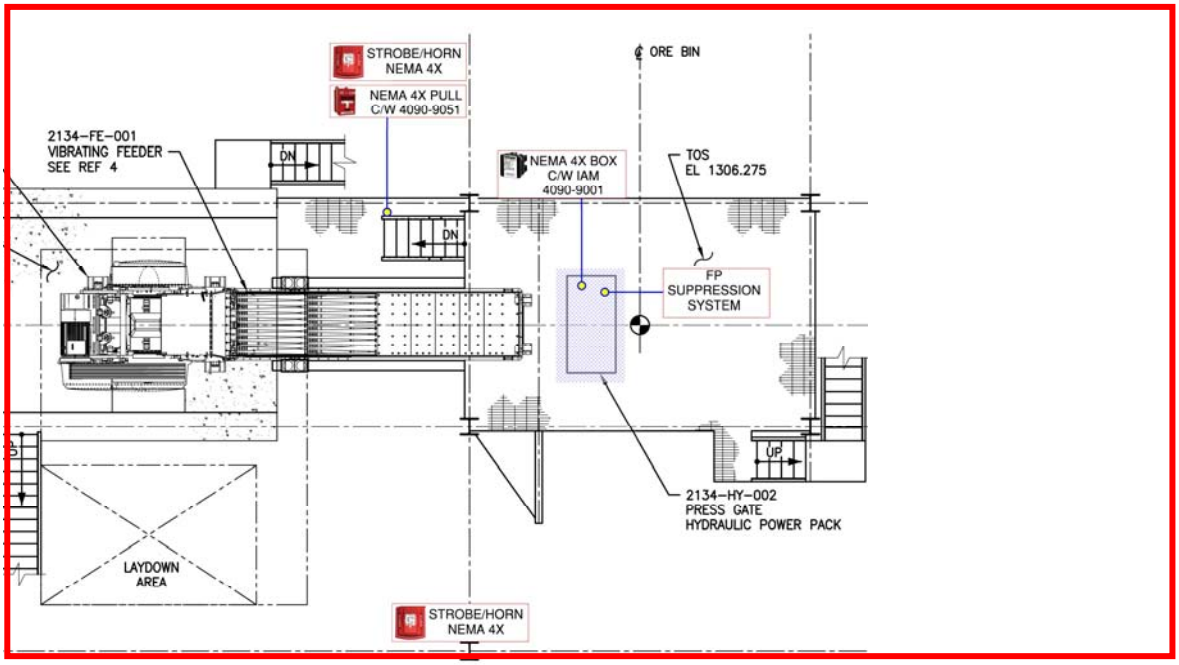

7.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

The Jaw Crusher discharge conveyor shall be protected with an automatic sprinkler system along it's complete length. The main conveyor pulley area shall also be protected with an automatic sprinkler system.

Hydraulic lube units shall be protected with an automatically activated wet chemical LVS type fire suppression system.

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Underground – Substation

8.1 Key Factors

- Non-combustible construction
- Local Fire Department (Surface)
- Dry type transformers

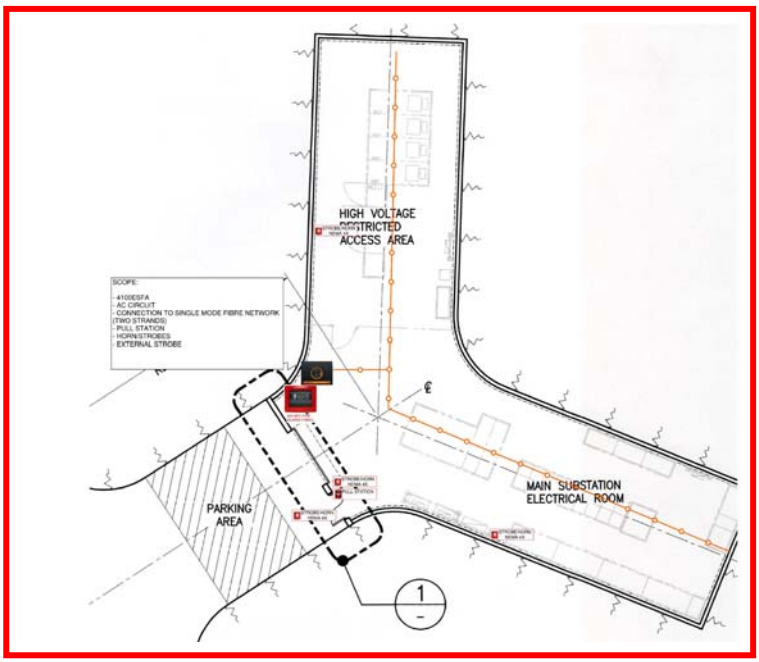
8.2 Identified Hazards

- Restricted access (underground enclosure with one entry point)
- Cable/Insulation

8.3 Fire Alarm – Coverage

Provide a fire alarm control panel that directly communicates with site wide fire alarm network c/w audible/visual coverage and manual pull station at exit. Utilize an air sampling based Vesda type smoke detection system for effective sensing of smoke in the incipient stages in this high air change environment.

Monitor and control the Inergen Clean Agent system including the use of uniquely colored (blue) strobes located inside & outside of this room. These strobes shall indicate the system either has or will be released. Provide means to manually release the system, means to delay the release of the system (abort), monitor/control of suppression system and associated HVAC/damper controls to achieve the required pressure relief and agent containment parameters.



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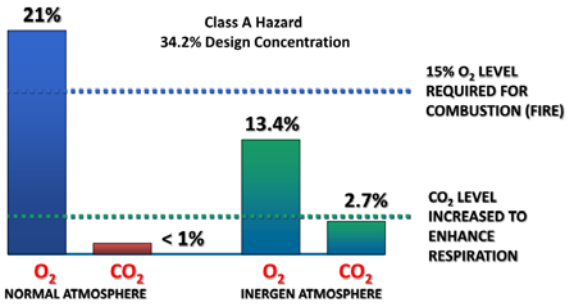
8.4 Standpipe, Sprinkler, Fire Extinguishers – Coverage

Provide an automatic Inergen Clean Agent/Inert Gas fire suppression system in a total flooding application for the main substation enclosure. This system shall comply with the HRSC requirements noted below and shall be rated and considered safe for occupied spaces.

3.10.2 Fire extinguishers which are capable of giving off or generating poisonous gas when operated shall not be allowed below ground and in confined spaces.



Portable fire extinguishers shall NOT be CO_2 type anywhere underground as they are considered a poisonous gas pursuant to HRSC *3.10.2* above. Instead Clean Guard type FE13-13lb (for ABC fires) extinguishers shall be provided in the main substation.

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Paste Plant Booster Pumps

9.1 Key Factors

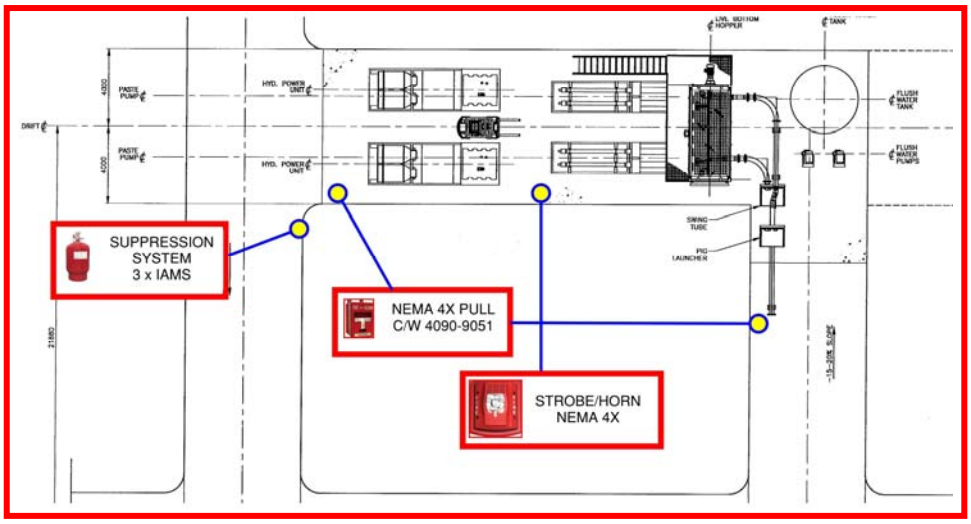
- Over 10L Flammable Fluid

9.2 Identified Hazards

- Hydraulic Unit

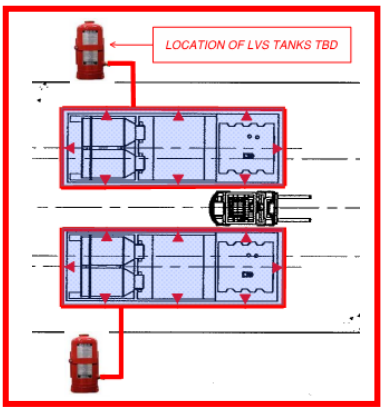
9.3 Fire Alarm – Coverage

Fire alarm coverage shall be provided to facilitate the automatic wet chemical fire suppression system. Refer to image below:



9.4 Standpipe, Sprinkler, Fire Extinguishers – Code Determination

Provide an automatic wet chemical LVS type fire suppresion system for the booster pumps, monitored and controlled by the fire alarm system.



Provide 40-B:C sized fire extinguishers at this location.

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Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART

Project Address

Electrical - Fire Alarm Only

Discipline

The undersigned also undertakes to notify the *authority having jurisdiction* in writing as soon as possible if the undersigned's contract for *field review* is terminated at any time during construction.

I certify that I am a *registered professional* as defined in the British Columbia Building Code.

Martin J. Coles

Registered Professional of Record's Name (Print)

135 - 13900 Maycrest Way

Address (Print)

Richmond, BC

604 242 0083

Phone No.

PROFESSIONAL PROVINCE OF M. COLES ENGINEER

(Professional's Seal and Signature)

December 19, 2016

Date

(If the *Registered Professional of Record* is a member of a firm, complete the following.)

I am a member of the firm Jensen Hughes Consulting Canada Ltd.
and I sign this letter on behalf of the firm.

(Print name of firm)

Note: The above letter must be signed by a *registered professional of record,* who is a *registered professional* . The British Columbia Building Code defines a *registered professional* to mean

(a) a person who is registered or licensed to practise as an architect under the Architects Act, or
(b) a person who is registered or licensed to practise as a professional engineer under the Engineers and Geoscientists Act.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

SCHEDULE B

Forming Part of Subsection 2.2.7, Div. C of the British Columbia Building Code

Building Permit No.
(for *authority having jurisdiction's* use)

ASSURANCE OF PROFESSIONAL DESIGN ~~AND COMMITMENT FOR FIELD REVIEW~~ GY

Notes: (i) This letter must be submitted prior to the commencement of construction activities of the components identified below. A separate letter must be submitted by each *registered professional of record.*
(ii) This letter is endorsed by: Architectural Institute of B.C., Association of Professional Engineers and Geoscientists of B.C., Building Officials' Association of B.C., and Union of B.C. Municipalities.
(iii) In this letter the words in italics have the same meaning as in the British Columbia Building Code.

To: The *authority having jurisdiction*

REGIONAL DISTRICT OF KITIMAT-STIKINE
Name of Jurisdiction (Print)

Re: BRUCEJACK GOLD MINE
Name of Project (Print)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART, BC
Address of Project (Print)

The undersigned hereby gives assurance that the design of the
(Initial those of the items listed below that apply to this *registered professional of record.* All the disciplines will not necessarily be employed on every project.)

_____ **ARCHITECTURAL**
_____ **STRUCTURAL**
GY ✓ **MECHANICAL**
GY ✓ **PLUMBING**
GY ✓ **FIRE SUPPRESSION SYSTEMS**
_____ **ELECTRICAL**
_____ **GEOTECHNICAL — temporary**
_____ **GEOTECHNICAL — permanent**

PROFESSIONAL PROVINCE X. W. YANG #34669 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

25 NOV 2016
Date

components of the plans and supporting documents prepared by this *registered professional of record* in support of the application for the *building* permit as outlined below substantially comply with the B.C. Building Code and other applicable enactments respecting safety except for construction safety aspects.

~~The undersigned hereby undertakes to be responsible for *field reviews* of the above referenced components during construction, as indicated on the "SUMMARY OF DESIGN AND FIELD REVIEW REQUIREMENTS" below.~~ GY

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART,
Project Address

BUILDING SERVICES
Discipline

~~The undersigned also undertakes to notify the *authority having jurisdiction* in writing as soon as possible if the undersigned's contract for *field review* is terminated at any time during construction.~~ GY

I certify that I am a *registered professional* as defined in the British Columbia Building Code.

XING WEI YANG
Registered Professional of Record's Name (Print)

8379 13TH AVE BURNABY
Address (Print)

604 664 4606

Phone No.

PROFESSIONAL PROVINCE OF X. W. YANG #34669 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

25 Nov 2016
Date

(If the *Registered Professional of Record* is a member of a firm, complete the following.)

I am a member of the firm Amec Foster Wheeler
and I sign this letter on behalf of the firm. (Print name of firm)

Note: The above letter must be signed by a *registered professional of record*, who is a *registered professional* . The British Columbia Building Code defines a *registered professional* to mean

(a) a person who is registered or licensed to practise as an architect under the Architects Act, or
(b) a person who is registered or licensed to practise as a professional engineer under the Engineers and Geoscientists Act.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for authority having jurisdiction's use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART,
Project Address

BULDING SERVICES
Discipline

SUMMARY OF DESIGN ~~AND FIELD REVIEW REQUIREMENTS~~ GY

(Initial applicable discipline below and cross out and initial only those items not applicable to the project.)

_____ **ARCHITECTURAL**

1.1 Fire resisting assemblies
1.2 *Fire separations* and their continuity
1.3 *Closures*, including tightness and operation
1.4 Egress systems, including *access to exit* within *suites* and *floor areas*
1.5 Performance and physical safety features (guardrails, handrails, etc.)
1.6 Structural capacity of architectural components, including anchorage and seismic restraint
1.7 Sound control
1.8 Landscaping, screening and site grading
1.9 Provisions for fire fighting access
1.10 *Access* requirements for *persons with disabilities*
1.11 Elevating devices
1.12 Functional testing of architecturally related fire emergency systems and devices
1.13 Development Permit and conditions therein
1.14 Interior signage, including acceptable materials, dimensions and locations
1.15 Review of all applicable shop drawings
1.16 Interior and exterior finishes
1.17 Dampproofing and/or waterproofing of walls and slabs below *grade*
1.18 Roofing and flashings
1.19 Wall cladding systems
1.20 Condensation control and cavity ventilation
1.21 Exterior glazing
1.22 Integration of building envelope components
1.23 Environmental separation requirements (Part 5)
1.24 Building Envelope, Part 10/ASHRAE or NECB Requirements

PROFESSIONAL PROVINCE OF X. W. YANG #34669 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

25 Nov 2016
Date

_____ **STRUCTURAL**

2.1 Structural capacity of structural components of the *building*, including anchorage and seismic restraint
2.2 Structural aspects of *deep foundations*
2.3 Review of all applicable shop drawings
2.4 Structural aspects of unbonded post-tensioned concrete design and construction

GY ✓ **MECHANICAL**

3.1 HVAC systems and devices, including high *building* requirements where applicable
3.2 *Fire dampers* at required *fire separations*
3.3 Continuity of *fire separations* at HVAC penetrations
3.4 Functional testing of mechanically related fire emergency systems and devices
3.5 Maintenance manuals for mechanical systems
GY ~~3.6 Structural capacity of mechanical components, including anchorage and seismic restraint~~
3.7 Review of all applicable shop drawings
~~3.8 Mechanical Systems, Part 10/ASHRAE or NECB Requirements~~

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for authority having jurisdiction's use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART,
Project Address

BUILDING SERVICES
Discipline

GY ✓ **PLUMBING**

~~4.1 Roof drainage systems~~ GY
~~4.2 Site and foundation drainage systems~~ GY
4.3 *Plumbing systems* and devices
4.4 Continuity of *fire separations* at plumbing penetrations
4.5 Functional testing of plumbing related fire emergency systems and devices
4.6 Maintenance manuals for *plumbing systems*
~~4.7 Structural capacity of plumbing components, including anchorage and seismic restraint~~ GY
4.8 Review of all applicable shop drawings
~~4.9 Plumbing Systems, Part 10/ASHRAE or NECB Requirements~~

GY ✓ **FIRE SUPPRESSION SYSTEMS**

5.1 Suppression system classification for type of *occupancy*
~~5.2 Design coverage, including concealed or special areas~~ GY
5.3 ~~Compatibility and location of electrical supervision, ancillary alarm and control devices~~ GY
5.4 ~~Evaluation of the capacity of city (municipal) water supply versus system demands and domestic demand, including pumping devices where necessary~~ GY
5.5 ~~Qualification of welder, quality of welds and material~~ GY
5.6 Review of all applicable shop drawings
5.7 ~~Acceptance testing for "Contractor's Material and Test Certificate" as per NFPA Standards~~ GY
5.8 ~~Maintenance program and manual for suppression systems~~ GY
5.9 ~~Structural capacity of sprinkler components, including anchorage and seismic restraint~~ GY
5.10 For partial systems — confirm sprinklers are installed in all areas where required
5.11 Fire Department connections and hydrant locations
5.12 Fire hose standpipes
5.13 Freeze protection measures for fire suppression systems
5.14 ~~Functional testing of fire suppression systems and devices~~

_____ **ELECTRICAL**

6.1 Electrical systems and devices, including high building requirements where applicable
6.2 Continuity of *fire separations* at electrical penetrations
6.3 Functional testing of electrical related fire emergency systems and devices
6.4 Electrical systems and devices maintenance manuals
6.5 Structural capacity of electrical components, including anchorage and seismic restraint
6.6 Clearances from *buildings* of all electrical utility equipment
6.7 Fire protection of wiring for emergency systems
6.8 Review of all applicable shop drawings
6.9 Electrical Systems, Part 10/ASHRAE or NECB requirements

_____ **GEOTECHNICAL — Temporary**

7.1 *Excavation*
7.2 Shoring
7.3 Underpinning
7.4 Temporary construction dewatering

_____ **GEOTECHNICAL — Permanent**

8.1 Bearing capacity of the soil
8.2 Geotechnical aspects of deep *foundations*
8.3 Compaction of engineered fill
8.4 Structural considerations of soil, including slope stability and seismic loading
8.5 Backfill
8.6 Permanent dewatering
8.7 Permanent underpinning

PROFESSIONAL PROVINCE OF X. W. YANG #34669 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

25 NOV 2016
Date

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BRITISH COLUMBIA BUILDING CODE

SCHEDULE C-B

Forming Part of Subsection 2.2.7, Division C of the British Columbia Building Code

Building Permit No.
(for authority having jurisdiction's use)

ASSURANCE OF PROFESSIONAL FIELD REVIEW AND COMPLIANCE

Notes: (i) This letter must be submitted after completion of the project but prior to final inspection by the *authority having jurisdiction*. A separate letter must be submitted by each *registered professional of record*.
(ii) This letter is endorsed by: Architectural Institute of B.C., Association of Professional Engineers and Geoscientists of B.C., Building Officials' Association of B.C., and Union of B.C. Municipalities.
(iii) In this letter the words in italics have the same meaning as in the British Columbia Building Code.

To: The *authority having jurisdiction*
Regional District of Kitimat - Stikine
Name of Jurisdiction (Print)

Re: Fire Protection - Fire Water Mains Only
Discipline (e.g. Architectural, etc.) (Print)

Brucejack Gold Mine
Name of Project (Print)

BrackJack, 65 kilometers North of Steward, BC
Address of Project (Print)

(Each *registered professional of record* shall complete the following:)

Gary Xing Wei Yang
Name (Print)

400- 11 Dunsmuir St, Vancouver, BC, V6B 5W3
Address (Print)

604 664 4606
Phone No.

PROFESSIONAL PROVINCE OF X. W. YANG # 34669 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

AUG 16/2017

Date

I hereby give assurance that

(a) I have fulfilled my obligations for *field review* as outlined in Subsection 2.2.7, Division C of the British Columbia Building Code and in the previously submitted Schedule B, "ASSURANCE OF PROFESSIONAL DESIGN AND COMMITMENT FOR FIELD REVIEW", and
(b) those components of the project opposite my initials in Schedule B substantially comply in all material respects with
  (i) the applicable requirements of the B.C. Building Code and other applicable enactments respecting safety, not including construction safety aspects, and
  (ii) the plans and supporting documents submitted in support of the application for the *building* permit,
(c) I am a *registered professional of record* as defined in the British Columbia Building Code.

(If the *registered professional of record* is a member of a firm, complete the following:)

I am a member of the firm Amec Foster Wheeler Americas Ltd.
and I sign this letter on behalf of the firm. (Print name of firm)

Note: The above letter must be signed by a *registered professional of record*, who is a *registered professional*. The British Columbia Building Code defines a *registered professional* to mean
(a) a person who is registered or licensed to practise as an architect under the Architects Act, or
(b) a person who is registered or licensed to practise as a professional engineer under the Engineers and Geoscientists Act.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

SCHEDULE B

Forming Part of Subsection 2.2.7, Div. C of the British Columbia Building Code

Building Permit No.
(for *authority having jurisdiction's* use)

ASSURANCE OF PROFESSIONAL DESIGN AND COMMITMENT FOR FIELD REVIEW

Notes: (i) This letter must be submitted prior to the commencement of construction activities of the components identified below. A separate letter must be submitted by each *registered professional of record*.
(ii) This letter is endorsed by: Architectural Institute of B.C., Association of Professional Engineers and Geoscientists of B.C., Building Officials' Association of B.C., and Union of B.C. Municipalities.
(iii) In this letter the words in italics have the same meaning as in the British Columbia Building Code.

To: The *authority having jurisdiction*

REGIONAL DISTRICT OF KITIMAT-STIKINE
Name of Jurisdiction (Print)

Re: BRUCEJACK GOLD MINE
Name of Project (Print)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART, BC
Address of Project (Print)

The undersigned hereby gives assurance that the design of the
(Initial those of the items listed below that apply to this *registered professional of record*. All the disciplines will not necessarily be employed on every project.)

_____ **ARCHITECTURAL**
_____ **STRUCTURAL**
_____ **MECHANICAL**
_____ **PLUMBING**
_____ **FIRE SUPPRESSION SYSTEMS**
MC **ELECTRICAL** - Fire Alarm Only
_____ **GEOTECHNICAL — temporary**
_____ **GEOTECHNICAL — permanent**

PROFESSIONAL PROVINCE OF M. COLES #39367 BRITISH COLUMBIA ENGINEER 19 DEC 2016

(Professional's Seal and Signature)

December 19, 2016
Date

components of the plans and supporting documents prepared by this *registered professional of record* in support of the application for the *building* permit as outlined below substantially comply with the B.C. Building Code and other applicable enactments respecting safety except for construction safety aspects.

The undersigned hereby undertakes to be responsible for *field reviews* of the above referenced components during construction, as indicated on the "SUMMARY OF DESIGN AND FIELD REVIEW REQUIREMENTS" below.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART
Project Address

Electrical - Fire Alarm Only
Discipline

PLUMBING

4.1 Roof *drainage systems*
4.2 Site and foundation *drainage systems*
4.3 *Plumbing systems* and devices
4.4 Continuity of *fire separations* at plumbing penetrations
4.5 Functional testing of plumbing related fire emergency systems and devices
4.6 Maintenance manuals for *plumbing systems*
4.7 Structural capacity of plumbing components, including anchorage and seismic restraint
4.8 Review of all applicable shop drawings
4.9 Plumbing Systems, Part 10/ASHRAE or NECB Requirements

FIRE SUPPRESSION SYSTEMS

5.1 Suppression system classification for type of *occupancy*
5.2 Design coverage, including concealed or special areas
5.3 Compatibility and location of electrical supervision, ancillary alarm and control devices
5.4 Evaluation of the capacity of city (municipal) water supply versus system demands and domestic demand, including pumping devices where necessary
5.5 Qualification of welder, quality of welds and material
5.6 Review of all applicable shop drawings
5.7 Acceptance testing for "Contractor's Material and Test Certificate" as per NFPA Standards
5.8 Maintenance program and manual for suppression systems
5.9 Structural capacity of sprinkler components, including anchorage and seismic restraint
5.10 For partial systems — confirm sprinklers are installed in all areas where required
5.11 Fire Department connections and hydrant locations
5.12 Fire hose standpipes
5.13 Freeze protection measures for fire suppression systems
5.14 Functional testing of fire suppression systems and devices

NE **ELECTRICAL** - Fire Alarm Only

6.1 Electrical systems and devices, including high building requirements where applicable
6.2 Continuity of *fire separations* at electrical penetrations
6.3 Functional testing of electrical related fire emergency systems and devices
6.4 Electrical systems and devices maintenance manuals
6.5 Structural capacity of electrical components, including anchorage and seismic restraint
6.6 Clearances from *buildings* of all electrical utility equipment
6.7 Fire protection of wiring for emergency systems
6.8 Review of all applicable shop drawings
6.9 Electrical Systems, Part 10/ASHRAE or NECB requirements

GEOTECHNICAL — Temporary

7.1 *Excavation*
7.2 Shoring
7.3 Underpinning
7.4 Temporary construction dewatering

GEOTECHNICAL — Permanent

8.1 Bearing capacity of the soil
8.2 Geotechnical aspects of deep *foundations*
8.3 Compaction of engineered fill
8.4 Structural considerations of soil, including slope stability and seismic loading
8.5 Backfill
8.6 Permanent dewatering
8.7 Permanent underpinning

PROFESSIONAL PROVINCE OF M. COLES # 39367 BRITISH COLUMBIA ENGINEER
19 Dec 2016

(Professional's Seal and Signature)

December 19, 2016
Date

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART
Project Address

FIRE SUPPRESSION SYSTEMS
Discipline

PLUMBING

4.1 Roof *drainage systems*
4.2 Site and foundation *drainage systems*
4.3 *Plumbing systems* and devices
4.4 Continuity of *fire separations* at plumbing penetrations
4.5 Functional testing of plumbing related fire emergency systems and devices
4.6 Maintenance manuals for *plumbing systems*
4.7 Structural capacity of plumbing components, including anchorage and seismic restraint
4.8 Review of all applicable shop drawings
4.9 Plumbing Systems, Part 10/ASHRAE or NECB Requirements

CA

FIRE SUPPRESSION SYSTEMS

5.1 Suppression system classification for type of *occupancy*
5.2 Design coverage, including concealed or special areas
5.3 Compatibility and location of electrical supervision, ancillary alarm and control devices
5.4 Evaluation of the capacity of city (municipal) water supply versus system demands and domestic demand, including pumping devices where necessary
5.5 Qualification of welder, quality of welds and material
5.6 Review of all applicable shop drawings
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5.14 Functional testing of fire suppression systems and devices

ELECTRICAL

6.1 Electrical systems and devices, including high building requirements where applicable
6.2 Continuity of *fire separations* at electrical penetrations
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6.5 Structural capacity of electrical components, including anchorage and seismic restraint
6.6 Clearances from *buildings* of all electrical utility equipment
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GEOTECHNICAL — Temporary

7.1 *Excavation*
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8.1 Bearing capacity of the soil
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8.4 Structural considerations of soil, including slope stability and seismic loading
8.5 Backfill
8.6 Permanent dewatering
8.7 Permanent underpinning

PROFESSIONAL PROVINCE OF C. C. B. ANDERSON # 41238 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

2016-12-19
Date

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART

Project Address

FIRE SUPPRESSION SYSTEMS

Discipline

SUMMARY OF DESIGN AND FIELD REVIEW REQUIREMENTS

(Initial applicable discipline below and cross out and initial only those items not applicable to the project.)

ARCHITECTURAL

1.1 Fire resisting assemblies
1.2 *Fire separations* and their continuity
1.3 *Closures*, including tightness and operation
1.4 Egress systems, including *access to exit* within *suites* and *floor areas*
1.5 Performance and physical safety features (guardrails, handrails, etc.)
1.6 Structural capacity of architectural components, including anchorage and seismic restraint
1.7 Sound control
1.8 Landscaping, screening and site grading
1.9 Provisions for fire fighting access
1.10 *Access* requirements for *persons with disabilities*
1.11 Elevating devices
1.12 Functional testing of architecturally related fire emergency systems and devices
1.13 Development Permit and conditions therein
1.14 Interior signage, including acceptable materials, dimensions and locations
1.15 Review of all applicable shop drawings
1.16 Interior and exterior finishes
1.17 Dampproofing and/or waterproofing of walls and slabs below *grade*
1.18 Roofing and flashings
1.19 Wall cladding systems
1.20 Condensation control and cavity ventilation
1.21 Exterior glazing
1.22 Integration of building envelope components
1.23 Environmental separation requirements (Part 5)
1.24 Building Envelope, Part 10/ASHRAE or NECB Requirements

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA
C. C. B. ANDERSON
41238

(Professional's Seal and Signature)

2016-12-19

Date

STRUCTURAL

2.1 Structural capacity of structural components of the *building*, including anchorage and seismic restraint
2.2 Structural aspects of *deep foundations*
2.3 Review of all applicable shop drawings
2.4 Structural aspects of unbonded post-tensioned concrete design and construction

MECHANICAL

3.1 HVAC systems and devices, including high *building* requirements where applicable
3.2 *Fire dampers* at required *fire separations*
3.3 Continuity of *fire separations* at HVAC penetrations
3.4 Functional testing of mechanically related fire emergency systems and devices
3.5 Maintenance manuals for mechanical systems
3.6 Structural capacity of mechanical components, including anchorage and seismic restraint
3.7 Review of all applicable shop drawings
3.8 Mechanical Systems, Part 10/ASHRAE or NECB Requirements

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

SCHEDULE C-B

Forming Part of Subsection 2.2.7, Division C of the British Columbia Building Code

Building Permit No.
(for *authority having jurisdiction's* use)

ASSURANCE OF PROFESSIONAL FIELD REVIEW AND COMPLIANCE

Notes: (i) This letter must be submitted after completion of the project but prior to final inspection by the *authority having jurisdiction*. A separate letter must be submitted by each *registered professional of record*.
(ii) This letter is endorsed by: Architectural Institute of B.C., Association of Professional Engineers and Geoscientists of B.C., Building Officials' Association of B.C., and Union of B.C. Municipalities.
(iii) In this letter the words in italics have the same meaning as in the British Columbia Building Code.

To: The *authority having jurisdiction*
REGIONAL DISTRICT OF KITIMAT-STIKINE
Name of Jurisdiction (Print)

Re: FIRE SUPPRESSION
Discipline (e.g. Architectural, etc.) (Print)

BRUCEJACK GOLD MINE
Name of Project (Print)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART, BC
Address of Project (Print)

(Each *registered professional of record* shall complete the following:)

CHRISTOPHER ANDERSON
Name (Print)

135-13900 MAYCREST WAY
Address (Print)

RICHMOND, BC, V6V 3E2

604-295-3431
Phone No.

PROFESSIONAL PROVINCE OF C. C. B. ANDERSON #41288 BRITISH COLUMBIA ENGINEER 2017-10-05

(Professional's Seal and Signature)

2017-10-05
Date

I hereby give assurance that

(a) I have fulfilled my obligations for *field review* as outlined in Subsection 2.2.7, Division C of the British Columbia Building Code and in the previously submitted Schedule B, "ASSURANCE OF PROFESSIONAL DESIGN AND COMMITMENT FOR FIELD REVIEW", and
(b) those components of the project opposite my initials in Schedule B substantially comply in all material respects with
  (i) the applicable requirements of the B.C. Building Code and other applicable enactments respecting safety, not including construction safety aspects, and
  (ii) the plans and supporting documents submitted in support of the application for the *building* permit,
(c) I am a *registered professional of record* as defined in the British Columbia Building Code.

(If the *registered professional of record* is a member of a firm, complete the following:)

I am a member of the firm JENSEN HUGHES CONSULTING CANADA LTD.
and I sign this letter on behalf of the firm. (Print name of firm)

Note: The above letter must be signed by a *registered professional of record*, who is a *registered professional* . The British Columbia Building Code defines a *registered professional* to mean
(a) a person who is registered or licensed to practise as an architect under the Architects Act, or
(b) a person who is registered or licensed to practise as a professional engineer under the Engineers and Geoscientists Act.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART

Project Address

FIRE SUPPRESSION SYSTEMS

Discipline

The undersigned also undertakes to notify the *authority having jurisdiction* in writing as soon as possible if the undersigned's contract for *field review* is terminated at any time during construction.

I certify that I am a *registered professional* as defined in the British Columbia Building Code.

CHRISTOPHER ANDERSON

Registered Professional of Record's Name (Print)

135-13900 MAYCREST WAY

Address (Print)

RICHMOND, BC, V6V 3E2

604-295-3431

Phone No.

PROFESSIONAL PROVINCE OF C. C. B. ANDERSON # 41238 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

2016-12-19

Date

(If the *Registered Professional of Record* is a member of a firm, complete the following.)

I am a member of the firm JENSEN HUGHES CONSULTING CANADA LTD.
and I sign this letter on behalf of the firm.

(Print name of firm)

Note: The above letter must be signed by a *registered professional of record*, who is a *registered professional* . The British Columbia Building Code defines a *registered professional* to mean

(a) a person who is registered or licensed to practise as an architect under the Architects Act, or
(b) a person who is registered or licensed to practise as a professional engineer under the Engineers and Geoscientists Act.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

SCHEDULE B

Forming Part of Subsection 2.2.7, Div. C of the British Columbia Building Code

Building Permit No.
(for *authority having jurisdiction's* use)

ASSURANCE OF PROFESSIONAL DESIGN AND COMMITMENT FOR FIELD REVIEW

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(iii) In this letter the words in italics have the same meaning as in the British Columbia Building Code.

To: The *authority having jurisdiction*

REGIONAL DISTRICT OF KITIMAT-STIKINE
Name of Jurisdiction (Print)

Re: BRUCEJACK GOLD MINE
Name of Project (Print)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART, BC
Address of Project (Print)

The undersigned hereby gives assurance that the design of the
(Initial those of the items listed below that apply to this *registered professional of record*. All the disciplines will not necessarily be employed on every project.)

_____ **ARCHITECTURAL**
_____ **STRUCTURAL**
_____ **MECHANICAL**
_____ **PLUMBING**
CA **FIRE SUPPRESSION SYSTEMS**
_____ **ELECTRICAL**
_____ **GEOTECHNICAL — temporary**
_____ **GEOTECHNICAL — permanent**

PROFESSIONAL PROVINCE OF C. C. B. ANDERSON # 41238 BRITISH COLUMBIA ENGINEER

(Professional's Seal and Signature)

2016 12-19
Date

components of the plans and supporting documents prepared by this *registered professional of record* in support of the application for the *building* permit as outlined below substantially comply with the B.C. Building Code and other applicable enactments respecting safety except for construction safety aspects.

The undersigned hereby undertakes to be responsible for *field reviews* of the above referenced components during construction, as indicated on the "SUMMARY OF DESIGN AND FIELD REVIEW REQUIREMENTS" below.

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Schedule B - *Continued*

Building Permit No.
(for *authority having jurisdiction's* use)

BRUCEJACK, 65 KILOMETERS NORTH OF STEWART
Project Address

Electrical - Fire Alarm Only
Discipline

SUMMARY OF DESIGN AND FIELD REVIEW REQUIREMENTS

(Initial applicable discipline below and cross out and initial only those items not applicable to the project.)

ARCHITECTURAL

1.1 Fire resisting assemblies
1.2 *Fire separations* and their continuity
1.3 *Closures*, including tightness and operation
1.4 Egress systems, including *access to exit* within *suites* and *floor areas*
1.5 Performance and physical safety features (guardrails, handrails, etc.)
1.6 Structural capacity of architectural components, including anchorage and seismic restraint
1.7 Sound control
1.8 Landscaping, screening and site grading
1.9 Provisions for fire fighting access
1.10 *Access* requirements for *persons with disabilities*
1.11 Elevating devices
1.12 Functional testing of architecturally related fire emergency systems and devices
1.13 Development Permit and conditions therein
1.14 Interior signage, including acceptable materials, dimensions and locations
1.15 Review of all applicable shop drawings
1.16 Interior and exterior finishes
1.17 Dampproofing and/or waterproofing of walls and slabs below *grade*
1.18 Roofing and flashings
1.19 Wall cladding systems
1.20 Condensation control and cavity ventilation
1.21 Exterior glazing
1.22 Integration of building envelope components
1.23 Environmental separation requirements (Part 5)
1.24 Building Envelope, Part 10/ASHRAE or NECB Requirements

PROFESSIONAL PROVINCE OF M. COLES # 39367 BRITISH COLUMBIA ENGINEER
19 Dec 2016

(Professional's Seal and Signature)

December 19, 2016
Date

STRUCTURAL

2.1 Structural capacity of structural components of the *building*, including anchorage and seismic restraint
2.2 Structural aspects of *deep foundations*
2.3 Review of all applicable shop drawings
2.4 Structural aspects of unbonded post-tensioned concrete design and construction

MECHANICAL

3.1 HVAC systems and devices, including high *building* requirements where applicable
3.2 *Fire dampers* at required *fire separations*
3.3 Continuity of *fire separations* at HVAC penetrations
3.4 Functional testing of mechanically related fire emergency systems and devices
3.5 Maintenance manuals for mechanical systems
3.6 Structural capacity of mechanical components, including anchorage and seismic restraint
3.7 Review of all applicable shop drawings
3.8 Mechanical Systems, Part 10/ASHRAE or NECB Requirements

CRP's Initials

BRITISH COLUMBIA BUILDING CODE

Appendix B – Underground Fire Modelling

PRETIVM

amec foster wheeler

BRUCEJACK PROJECT
Stewart, BC
BRUCEJACK FIRE STUDY
Revision A

177421

27 August 2018

Document Number: 177421-0000-DJ00-RPT-0002

Important Notice

This report was prepared exclusively for Pretium Exploration Inc. by Amec Foster Wheeler. The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Pretium Resources Inc. only, subject to the terms and conditions of its contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

Prepared by: Ian M. Loomis

Reviewed by: William Bagnell

Approved by: Sean Lynn

Engineer's Seal

COLORADO LICENSED
IAN MORTON LOOMIS
48674
8/28/2018
PROFESSIONAL ENGINEER

Engineer's Seal

PROFESSIONAL
PROVINCE OF
W. R. A. BAGNELL
47923
BRITISH COLUMBIA
ENGINEER
11-12-2018

Brucejack Fire Simulations Report

Disclaimer

1) The effective date of this document is 21 August 2015.
2) This document has been prepared from mine ventilation system models adapted, from previous Feasibility Studies (prepared by others), by Ian M. Loomis and mine fire simulations conducted under his direction by Felipe Fernández and Alfonso Ovalle of AMEC International Ingenieria y Construcción Limitada (Amec Foster Wheeler).
3) The process and results were the topic of several meetings between Amec Foster Wheeler and Pretium personnel.
4) This material in this document has been reviewed by George Zazzi, Pretium, with comments as of the effective date incorporated into the text.
5) The basis and results presented in the report are based on the available knowledge of the proposed mine layout and mine ventilation system at the time that the study was undertaken (March 2015 through August 2015).
6) A connection beween the West Zone Access ramp and the VOK conveyor Decline is not included in this study since the modelers were not advised of this potential until after completion of the study. This has potential effects on an extension of Case1 that includes WZ and Case 3 – WZ Ramp Fire
7) The analysis are based on general and limited expectations of fire behavior as carried out by conventional mine ventilation simulations.
8) To my knowledge, no testing or field simulation had been done to verify the results.
9) The results are intended as guidance for the specific fire management cases addressed and are not, to my knowledge, backed by physical testing. Thus, this is not to be considered as a general response plan nor is this a design document.
10) I have not visited the mine site to verify the recommended/necessary fire detection systems and response relative to these recommendations.

Ian M. Loomis

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Figure 2-44: Flow Chart of Case 5 Response 2-77

1.0 INTRODUCTION

Using the ventilation models current at the time of the effort, several mine fire scenarios were considered and evaluated for the purpose of determining the likely areas/districts of the mine to be impacted by the particular cases and to assess/recommend courses of action to assist in mitigation of the spread of the smoke, heat, and other products of combustion. A key consideration in the recommendations, both as a response to a fire and as normal operating practice, is the maintenance of personnel normal egress and emergency escapeways. Since the Brucejack does not have a dedicated fresh air intake system (both intakes are used for haulage and equipment access), fires in the primary intakes warrant the consideration that immediate reversal of airflow, under the effect of the respective main fan, is a viable approach to quickly and efficiently clear the mine downstream of the fire. The approach of immediately reversing airflow is contradictory to generally established mining practice of obtaining full account of all personnel before making changes to the ventilation system and should, therefore, be taken with and under the advice of the mine's safety manager.

The spread of stench gas, as an alarm system, was analyzed for both zones at their respective period of initial stoping. The results indicate that, consistent with routine practice, the use of stench gas should be limited to use as secondary alarm system (this approach is within the mine operational plan) . The primary alarm should be through the mine communication system using radios, information display panels, light boards, etc. to ensure that as much information as possible can be sent to personnel working underground.

Conveyor belt and mobile equipment fires are considered here in cases where standard fire prevention and/fire control systems are assumed to have failed. Normal fire prevention and control methods within the Brucejack operational plan account for the use of a fire rated conveyor belt and the specification of on-board fire extinguishers on heavy mobile equipment.

The effects of several mine fire scenarios were considered as a part of this study. Overall, seven cases were simulated that represent six scenarios including: stench gas distribution for both VOK and WZ areas, VOK conveyor decline fire, WZ access decline fire, WZ ramp fire, VOK ramp fire, and a production level fire. As an outcome of these models, countermeasures and evacuation routes are also proposed.

1.1 Study Content

Two different stages of the mine were considered for the fire simulations: i) intial VOK-stoping and ii) initial WZ-stoping. The following scenarios were considered:

- Stench gas distribution

- VOK Conveyor Decline Conveyor Belt Fire
- WZ Access Decline Truck Fire
- WZ Ramp Truck Fire
- VOK Ramp Truck Fire
- Generic Production Level Equipment fire

Countermeasures and evacuation routes are considered and proposed for each of the fire scenarios.

1.2 Conclusions and Recommendations

The use of Stench Gas as an alarm system was analyzed for both stages considered. Certain recommendations for implementation are provided that may enhance the effectiveness and speed of response to this technique. It is recommended that the use of Stench Gas be limited to a secondary warning system. Potential alternatives and primary alarm systems are discussed in the stench gas section.

Table 1-1 lists the respective initial countermeasures and escape routes proposed based on the five fire scenarios considered. More detailed and advanced countermeasures are addressed in respective detail in following sections.

Table 1-1: Mine Fire Modelling and Recommended Countermeasures and Evacuation

Brucejack Project Fire Cases Simulated					
Case	Location	Stage	Fire Source	Countermeasures	Evacuation Route
1	VOK Conveyor Decline	Initial WZ-Stoping	Conveyor belt	Plan 1 Reverse the VOK Main Fan	Escapeway raises and WZ access decline
				Plan 2 Close the fire door to the production Ramp Fully open regulator/drive-through door at the exhaust of the jaw crusher conveyor area to VR-2 Exhaust regulators from other fixed facilities (crusher, truck loop) must be equipped with backflow preventers. Magazine fire doors closed VOK conveyor portal fan slowed to 50% of operating speed.	
2	WZ Access Decline	Initial WZ-Stoping	Truck	The WZ Portal main fan must be stopped. The access doors to the fixed facility must be closed. Open airlock(s) between the WZ and VOK Open Airlock at WZ portal	No clear escape route available from the VOK area, personnel must head to the closest refuge Escapeway raises are may not be suitable for use.
3	WZ Production Ramp	Initial WZ-Stoping	Truck	Maintain airlock(s) between WZ and VOK closed. Stop the WZ Main Fan Start WZ Main Fan in reverse rotation	
4	VOK Production Ramp	Initial VOK-Stoping	Truck	Plan1 - If the fire is in the upper or lower sections of the ramp, the ventilation system will operate normally.	Escapeway raises and WZ access decline If not able to reach the WZ access decline, personnel must head to the nearest refuge
				Plan 2 – Fire in the middle section of the ramp Reverse VOK Main Fan to clear crusher Close door at lower conveyor/production ramp Open door from transfer conveyor to VR-2 Airlock(s) between VOK and WZ remain closed.	
5	Production Level	Initial VOK-Stoping	LHD	Ventilation system will operate in normal configuration	

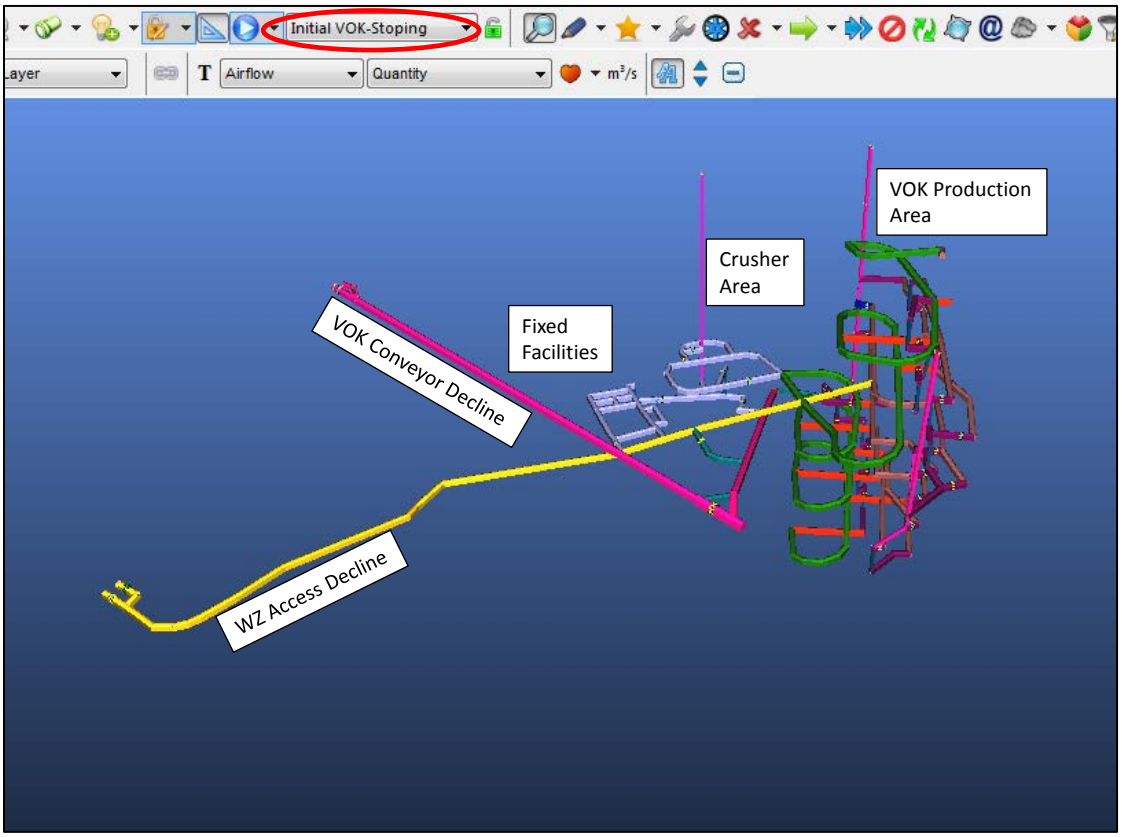
2.0 FIRE MODELING AND RESULTS

2.1 Scenario Analysis

For this study, two stench gas distribution and five fire scenarios were analyzed. As appropriate, these were considered at the stage of initial stoping in the VOK or the initial stoping in the WZ.

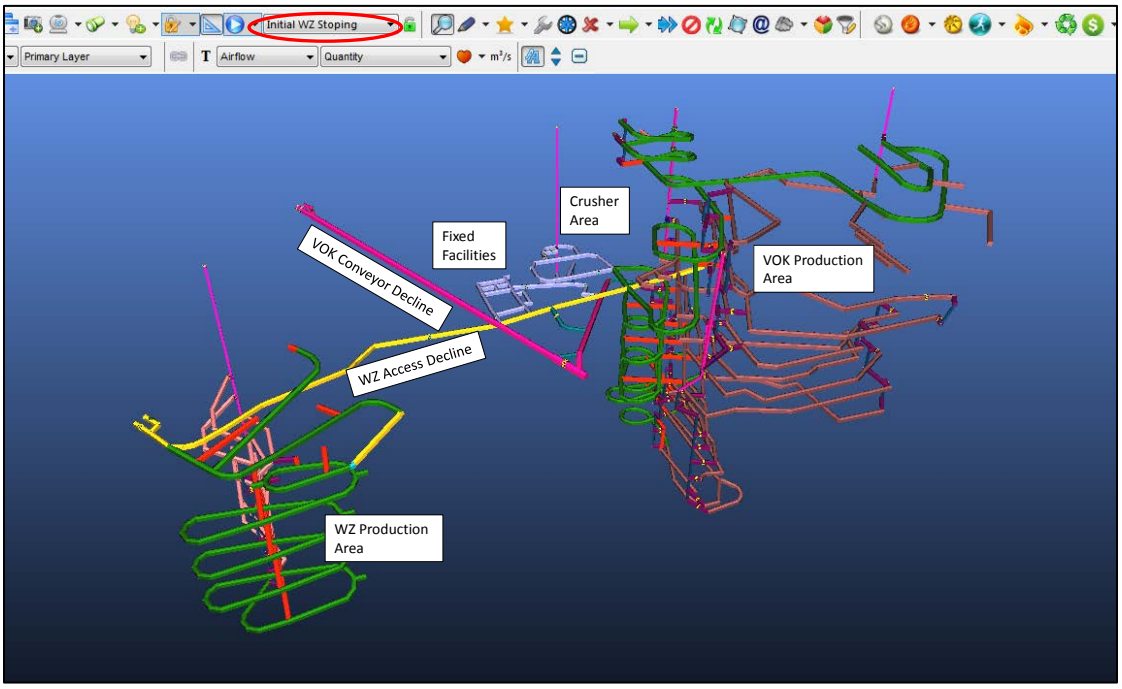
The layout of the mine at the beginning of stoping in the VOK is shown in Figure 2-1.

Figure 2-1: Initial VOK Stoping Stage



The layout of the mine at the beginning of stoping in the WZ is shown in Figure 2-2.

Figure 2-2: Initial WZ Stoping Stage



2.2 Stench Distribution Cases

As a component of a mine's alarm system, stench gas (typically either methyl- or ethyl-mercaptan) is used to alert personnel working underground of an emergency requiring evacuation. This gas is generally injected into the mine ventilation system at the intake portals, which at the Brucejack Mine include both the VOK Conveyor Decline Portal and the WZ Portal entrance.

The time based stench gas distribution through the mine was considered for both the initial stoping at the VOK and at the WZ by applying a "contaminant" source at the respective portals. A time-step model was then run to determine the overall effectiveness of the stench gas distribution and the time required to spread throughout the mine.

2.2.1 Initial VOK Stoping Stage

In a stench gas release alarm, the gas will be released at both portals, so that the gas is distributed to all of the existing mine facilities. The distribution at five minutes after the release is shown in Figure 2-3, which shows distribution to the fixed facilities, crusher, and a portion of the VOK production ramp.

Figure 2-3: Stench Gas Spread after Five Minutes, Initial VOK Stoping

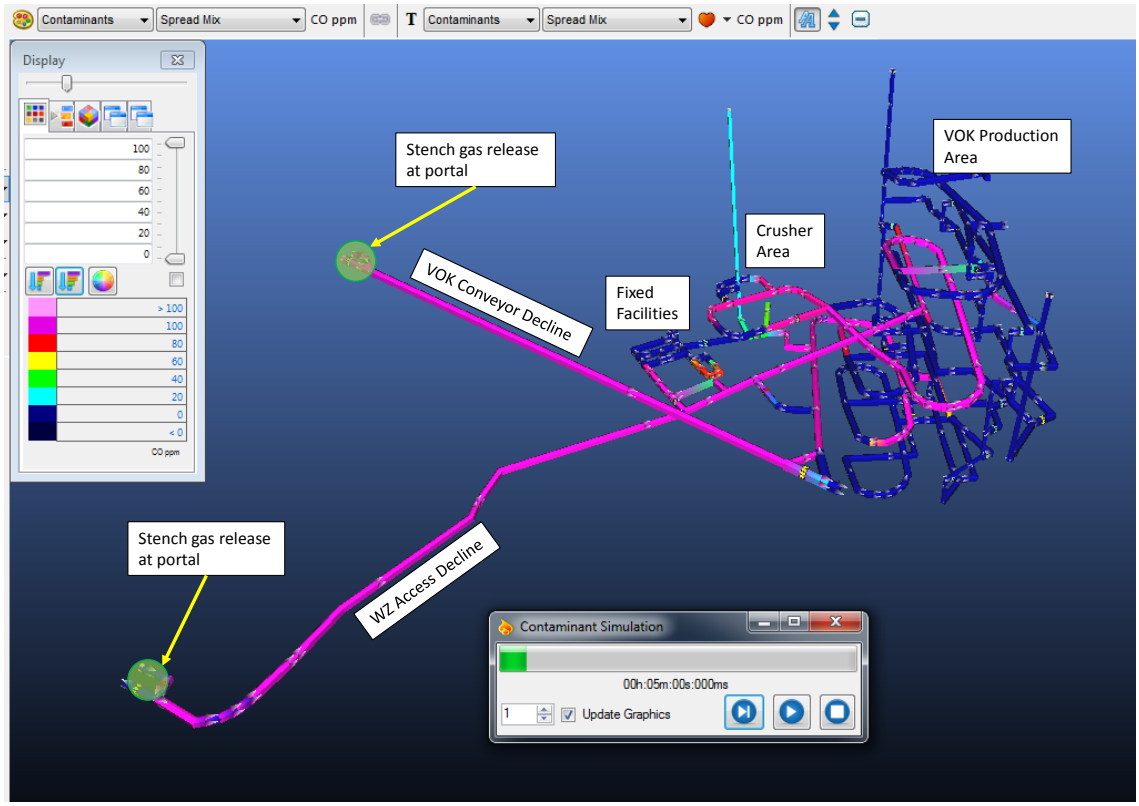
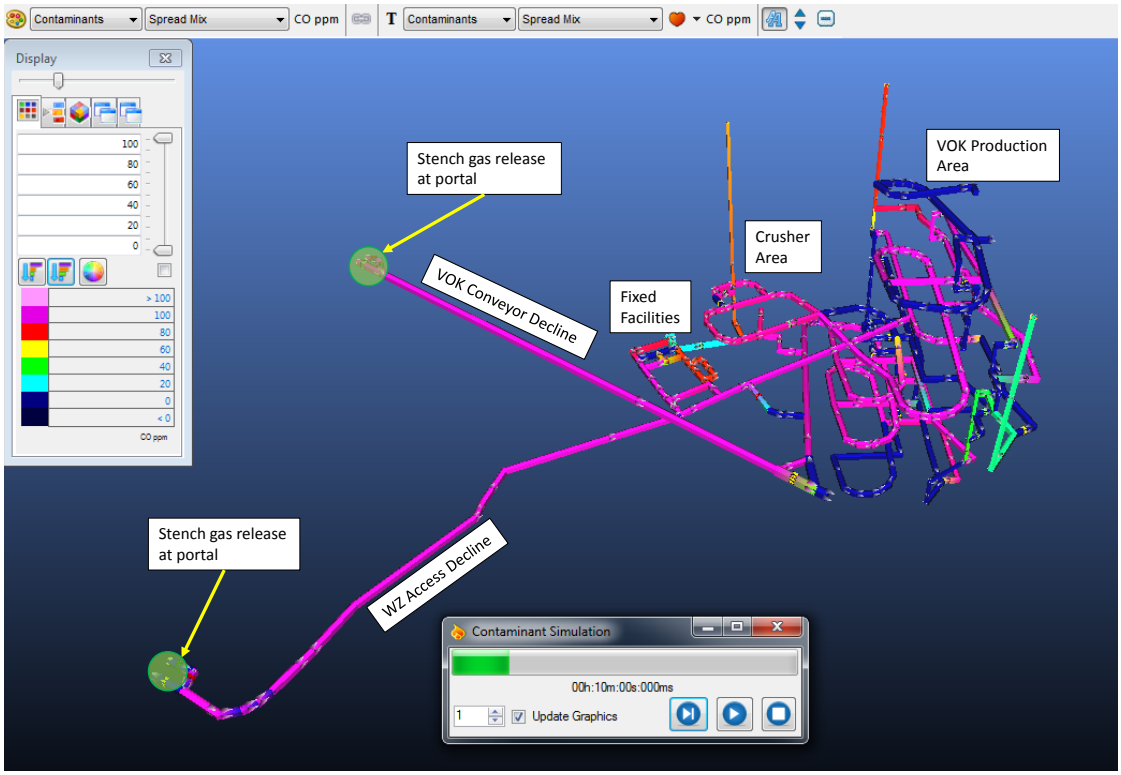


Figure 2-4 shows the distribution at 10 minutes after the initial release. By this time, all of the active areas of the mine have been alerted; however, areas that are not under active production or development activities will not be reached by this time.

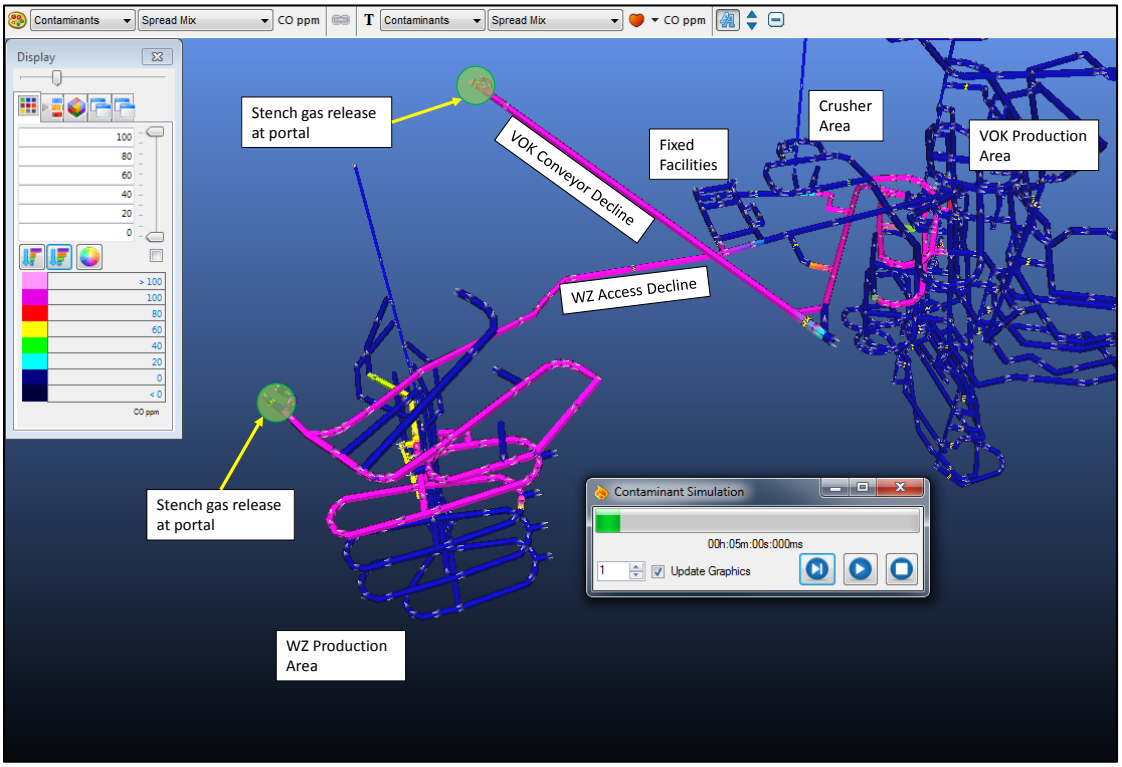
Figure 2-4: Stench Gas Spread after 10 minutes, Initial VOK Stoping



2.2.2 Initial WZ Stoping Stage

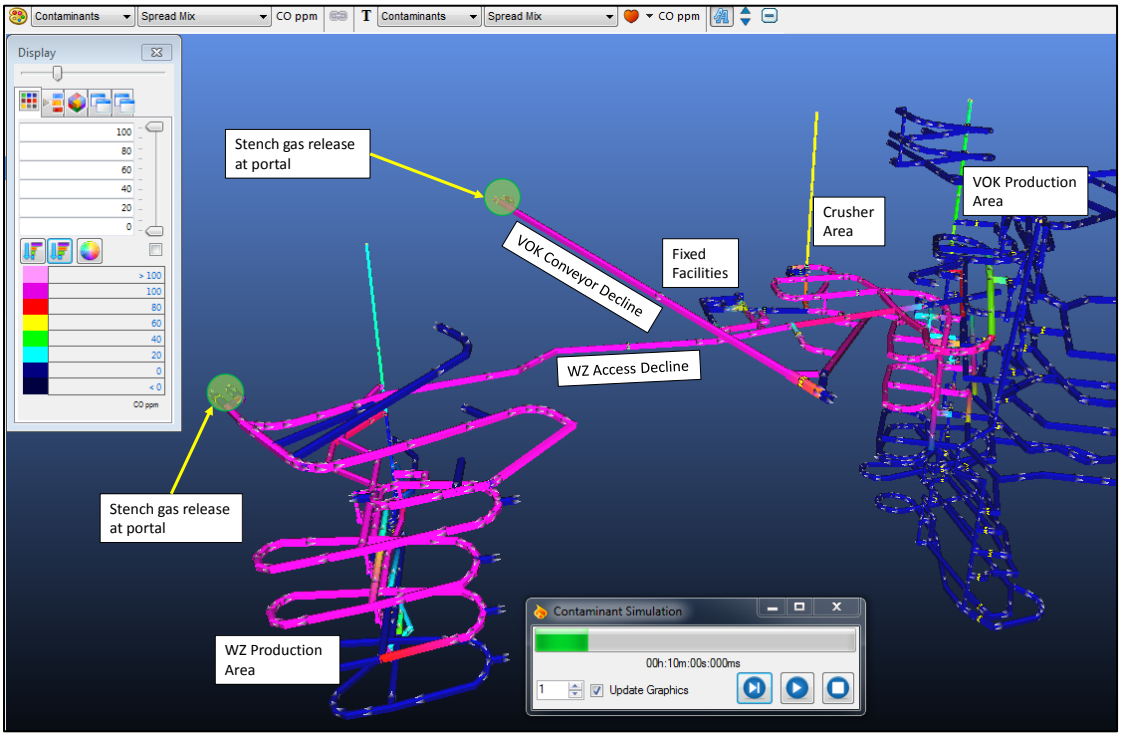
When stoping begins in the WZ, there will be two ventilation circuits that are separated by an airlock. The VOK Conveyor Decline Portal will provide the majority of the intake air to the VOK and the WZ Portal will provide air to the WZ. Figure 2-5 shows the estimated distribution of stench gas five minutes after the initial release. Under these conditions, the stench gas is just beginning to arrive at the mine fixed facilities, crusher, and production levels on the VOK side and is reaching the upper production levels in the WZ.

Figure 2-5: Stench Gas Spread after Five Minutes, Initial WZ Stoping



After 10 minutes, the stench gas is beginning to spread through the central production levels in the VOK and is beginning to reach the lower production levels at the WZ. This is shown in Figure 2-6.

Figure 2-6: Stench Gas Spread after 10 Minutes, Initial WZ Stoping



Analysis

The distribution of stench gas through the mine is limited by the mine ventilation system. It is, therefore, recommended for use only as a backup alarm system. An alarm system consisting of the Wi-Fi Radio application (already within the mine operational plan), information panels/light boards, and other schemes should be provided to more quickly spread information relating to a mine emergency.

These simulations show that there is limited distribution of the stench gas to the production and development headings 10 minutes after the initial gas release. It is, therefore, recommended that the Brucejack Mine consider adding stench gas release points deeper within the mine, such as at a major intersection of the ventilation systems (i.e., the intersection of the two main declines and the ramps to ensure that the stench gets to the ramps and in parallel intake raise) to more quickly affect an alert in the mine.

2.3 Mine Fire Cases

2.3.1 VOK Conveyor Decline Fire

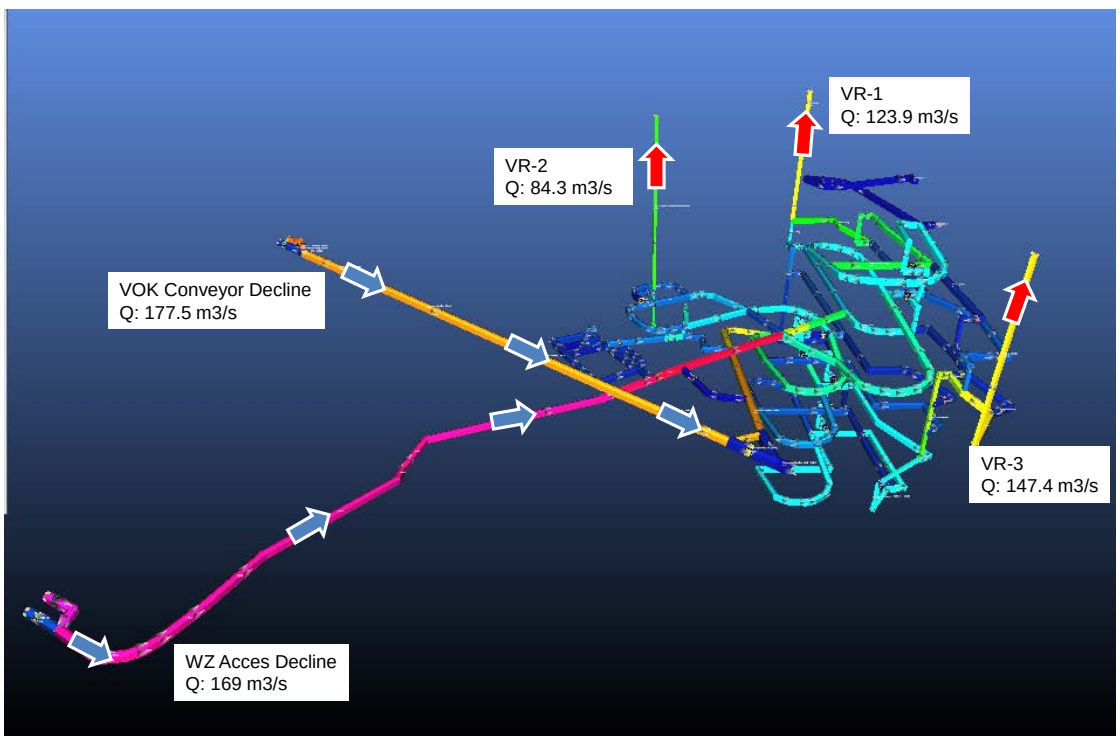
The case of a fire on the conveyor belt in the conveyor decline was studied as the initial fire case, and a separate technical memo was prepared (#M90177-CD-00-MEM-003). The fuel for the fire was considered to be the conveyor belt of the upper conveyor. The effects of this fire scenario were considered for both the initial stoping at VOK and initial stoping at WZ.

Note that the mine operational plan calls for a fire rated belt to inhibit initiation or sustain combustion as associated with that rating.

Initial Stoping in VOK

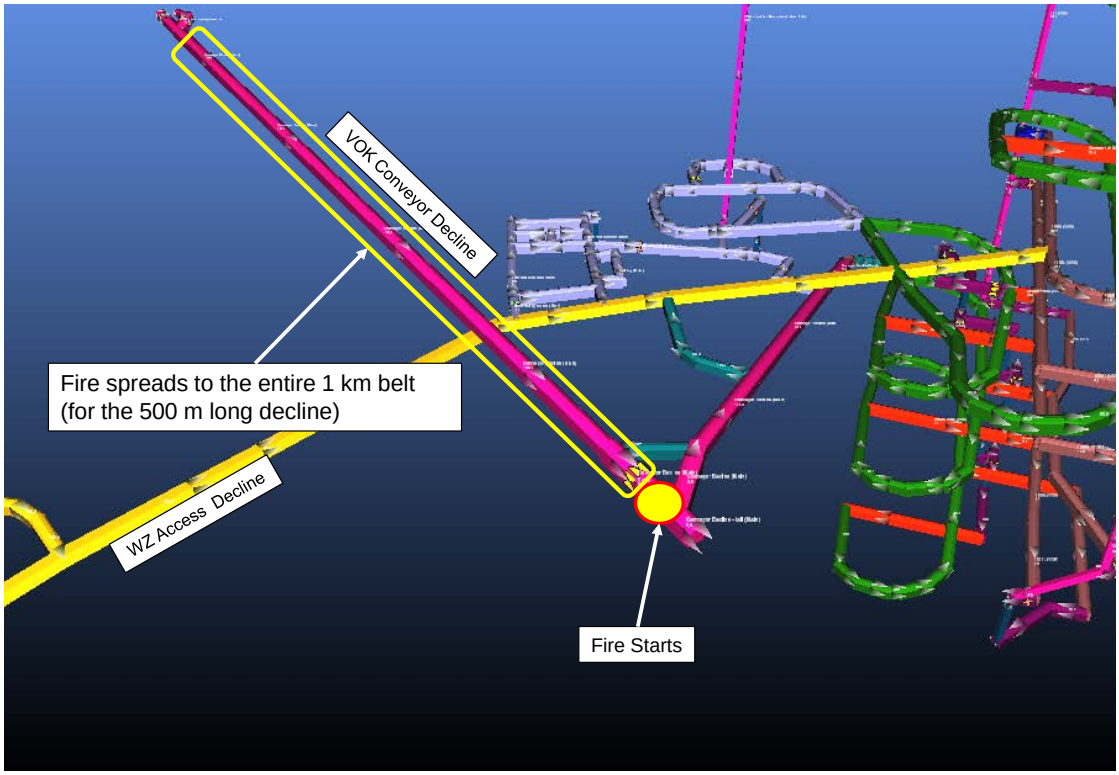
Based on the results of ventilation modeling, the intake ventilation in this case consists of 177.5 m^3/s in the VOK Conveyor Decline Portal and 169 m^3/s from the WZ Access Portal. The starting point for this scenario is shown in Figure 2-7.

Figure 2-7: Main Ventilation System Flow at Initial VOK Stoping



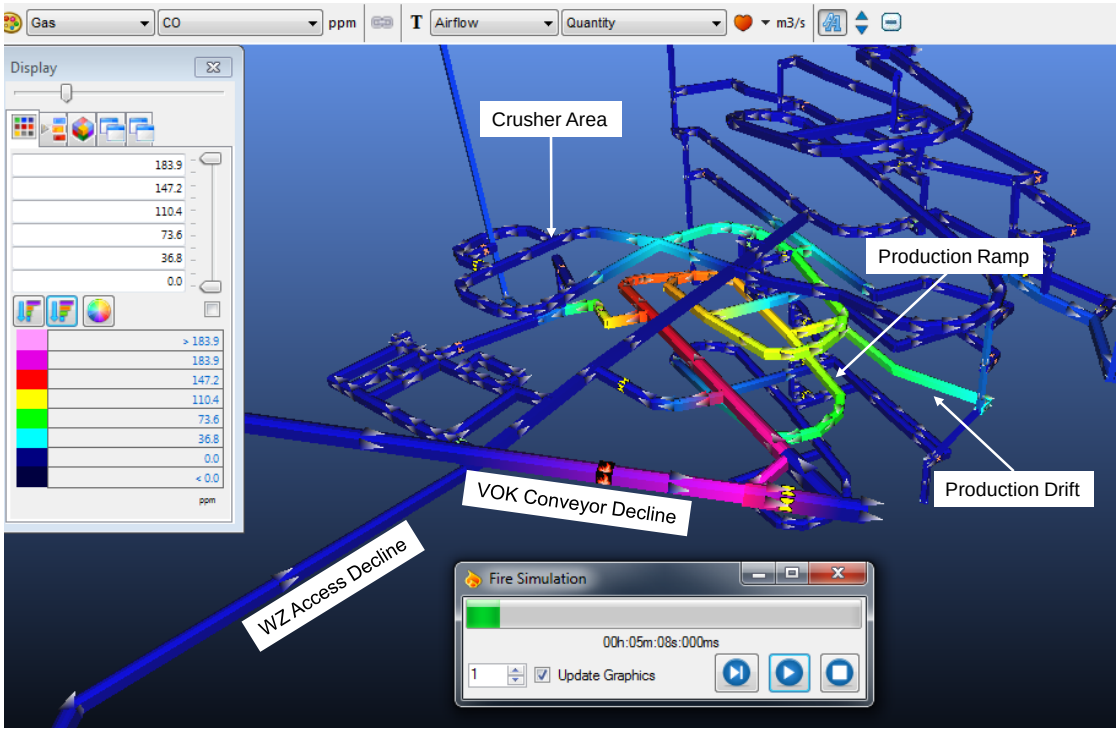
In this scenario, it is assumed that: a conveyor belt fire starts at the lower end (transfer station) of the upper conveyor, the fuel load is limited to the one km long belt, the spread rate will be 1 m/min, and that the belt is empty. This is shown in Figure 2-8.

Figure 2-8: Fire and Fuel Source on the VOK Conveyor Decline



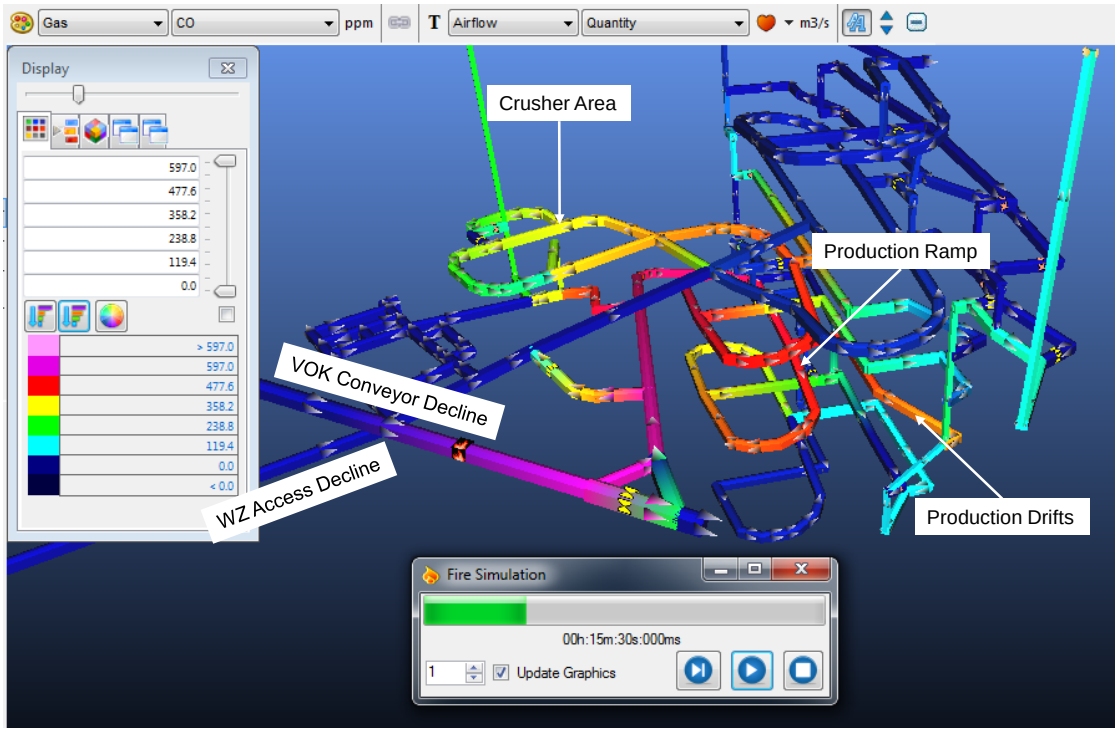
Without controls (unmitigated) the products of combustion (POCs) reach the crusher area, the production ramp and some production levels within five minutes (Figure 2-9).

Figure 2-9: Spread of POCs, Five Minutes after Fire Starts



By 15 minutes after the fire starts, the POCs completely inundate the crusher area and the lower portion of the active production zone (Figure 2-10). The escapeway raises are not impacted at this point, since they receive their intake directly from the WZ access (assuming that the airlock in the "dog-leg" drift is closed).

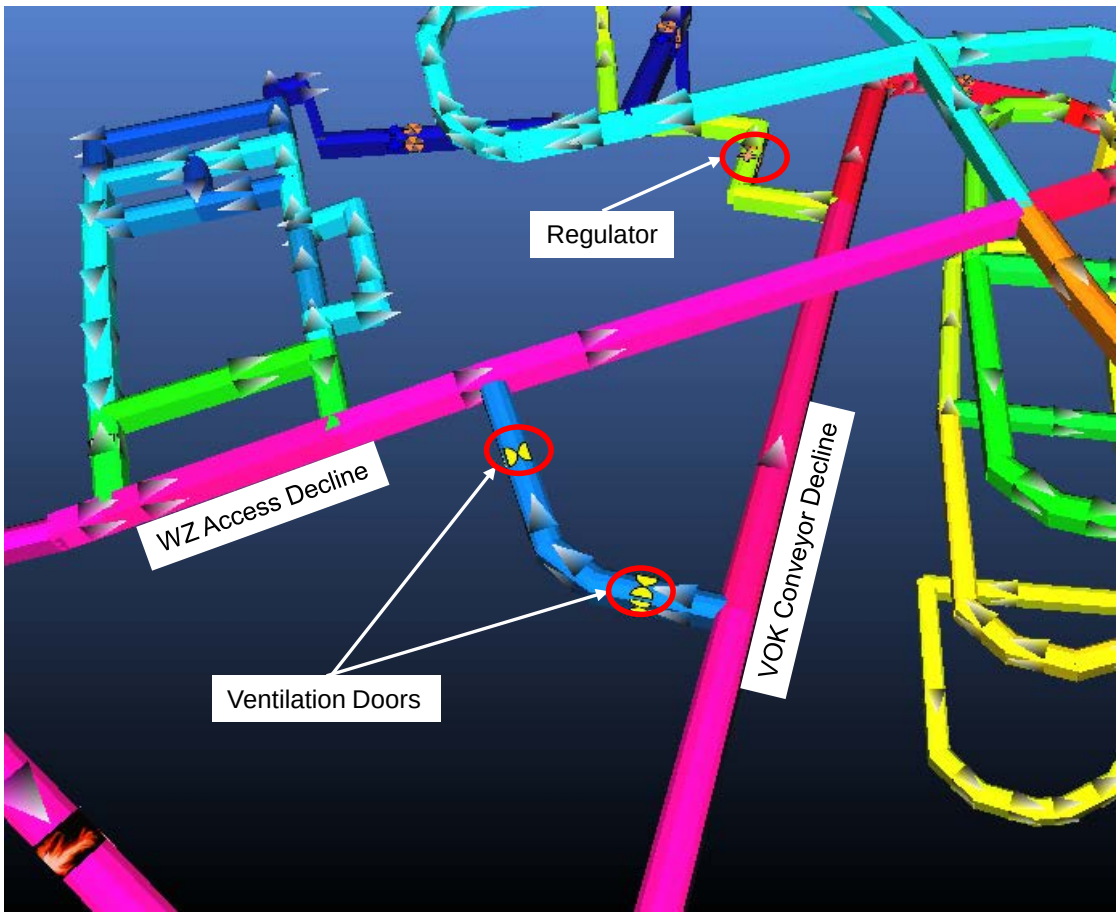
Figure 2-10: Conveyor Fire, Spread of POCs, 15 Minutes



These results suggest a couple of modifications: install a normally closed airlock in the "dog-leg" connection between the WZ access decline and the lower flight of the conveyor; execute a procedure to fully open the exhaust regulator between the jaw crusher discharge conveyor and VR-2. These are illustrated in Figure 2-11.

A viable alternative to the normally closed airlock in the "dog-leg" is the normally open fire activated door in the mine operational plan.

Figure 2-11: Recommended Modifications to the Ventilation System



Countermeasure implementation:

Plan 1 – Reverse VOK Conveyor Decline Main Fan

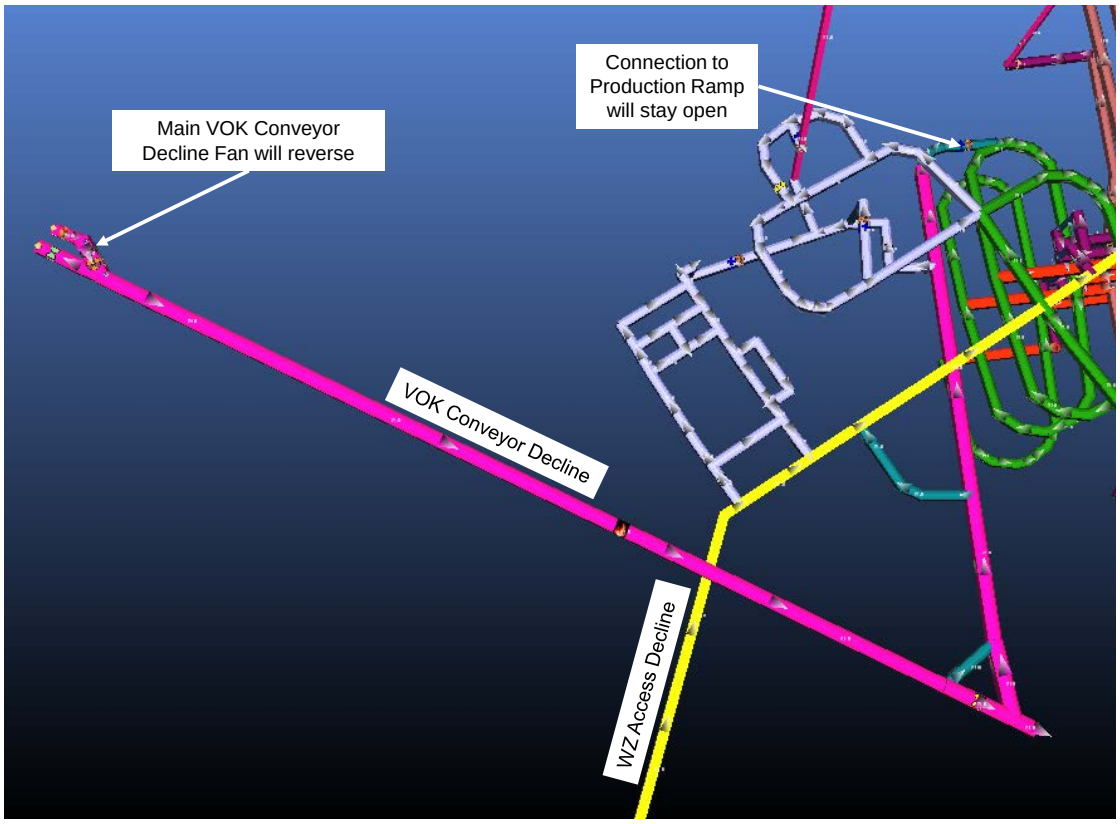
This approach consists of only reversing the VOK conveyor decline main fan. There is a timeline that needs to be considered:

- Response Time – This is the time between the fire starting, an alarm sounding and countermeasures being implemented. It is estimated that the minimum will be between three and five minutes given the systems for the detection of smoke, CO, and/or elevated temperatures.
- Fan stop – assuming that the main fan is equipped with a break, the time to de-energize and stop the forward rotation of the fan is estimated at two to three minutes.
- Fan start in reverse – once the forward rotation of the fan is stopped, it is estimated that it will take between one and two minutes to bring the fan back to full speed in the reverse direction. Once the fan is operating in reverse, it is assumed that the airflow efficiency is 50% of the forward case.

Thus, the minimum time to implement the air flow reversal scheme will be between 6 and 10 minutes.

The layout of this approach is shown in Figure 2-12.

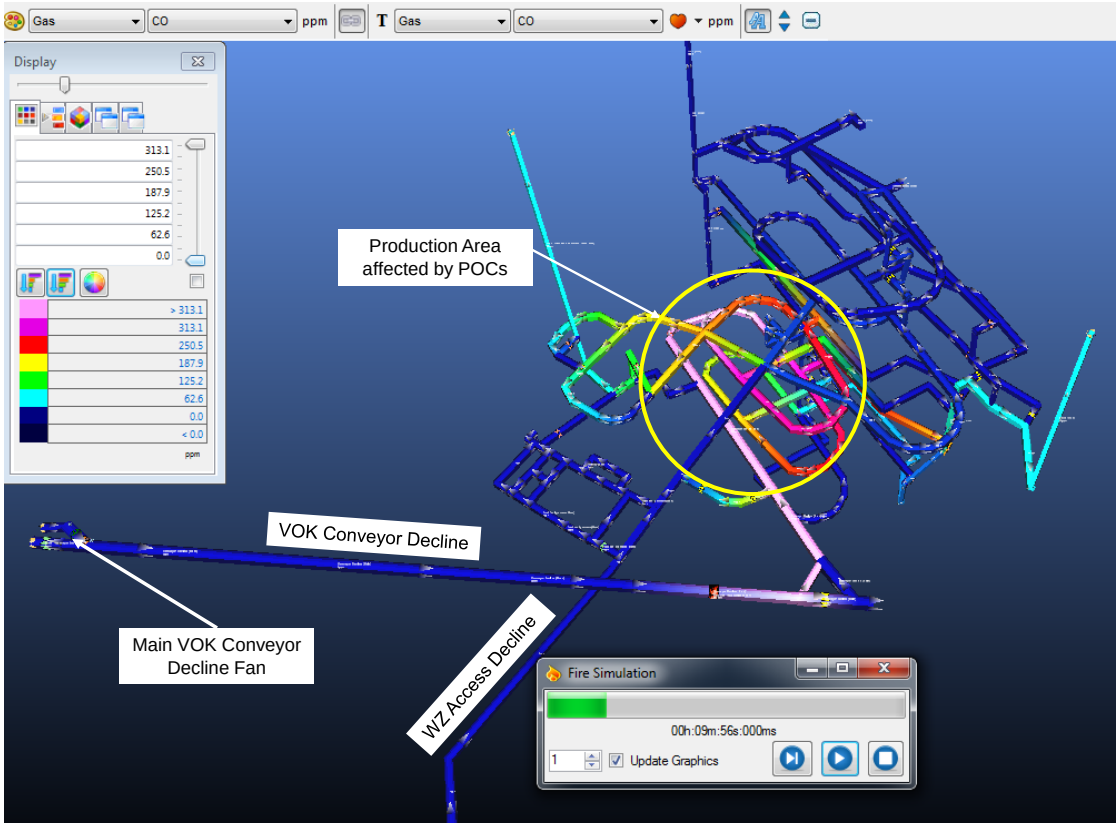
Figure 2-12: Single Countermeasure Approach



Implementation:

The estimated conditions in the mine 10 minutes after the fire starts are shown in Figure 2-13. By this time, POCs have entered into the VOK production ramp and the crusher facilities area.

Figure 2-13: Conditions 10 Minutes after Fire Starts



Once the fan reversal is implemented, the POCs begin to be extracted from the mine through the VOK Conveyor Portal. This clears the production ramp and allows evacuation of personnel through the WZ access. This condition is shown in Figure 2-14.

During the airflow reversal, it is estimated that the air temperature through the fan will rise to approximately 46°C within the first hour. This is below the estimated temperature that could begin to cause damage to the fan (60–70°C dry bulb). This is predicted to provide at least one hour of operation of the fan in reverse in order to implement a general mine evacuation.

Figure 2-14: Effect of Reversing the VOK Conveyor Portal Fan, 20 Minutes after Fire Starts

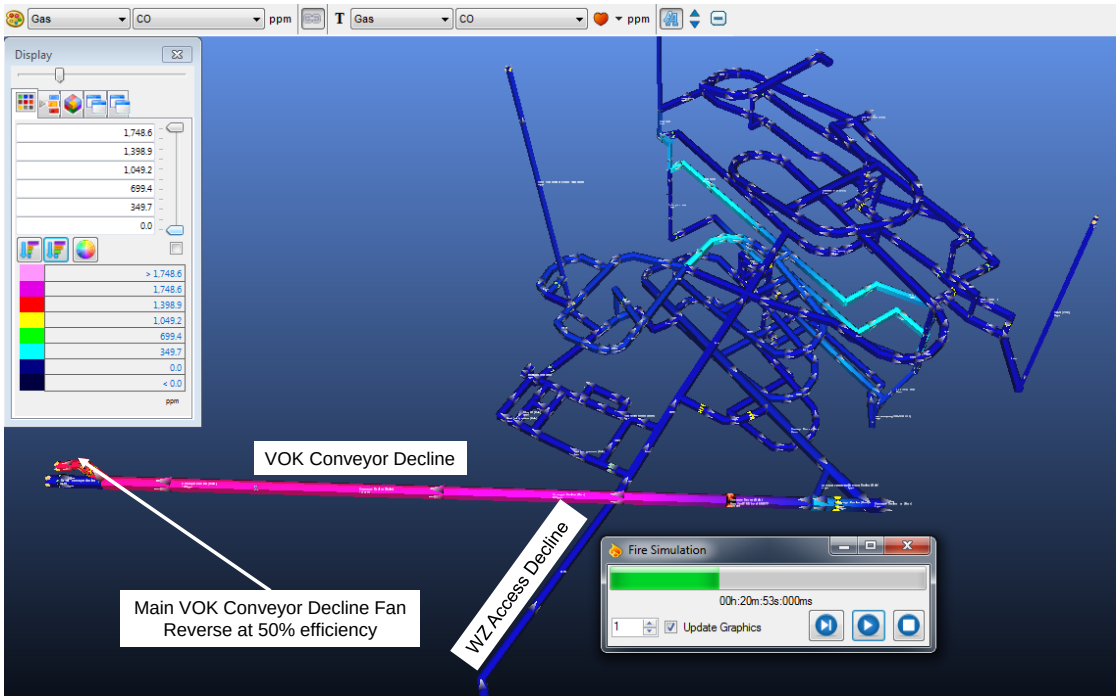
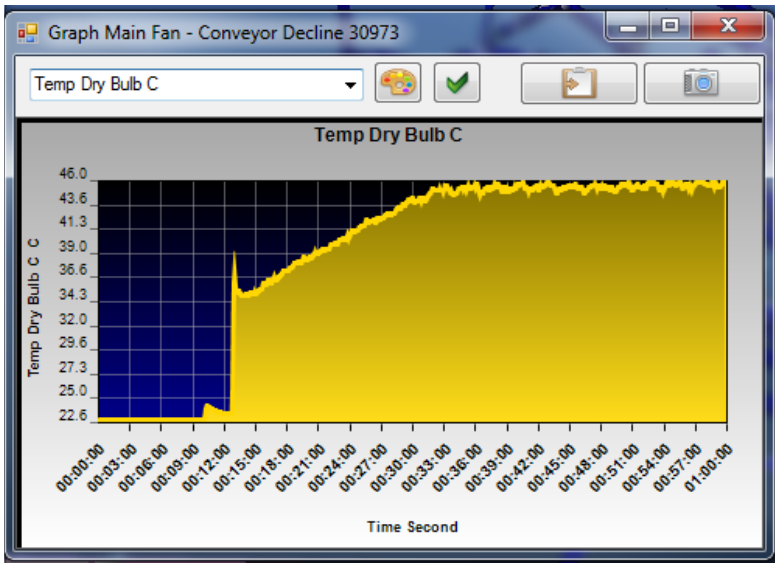
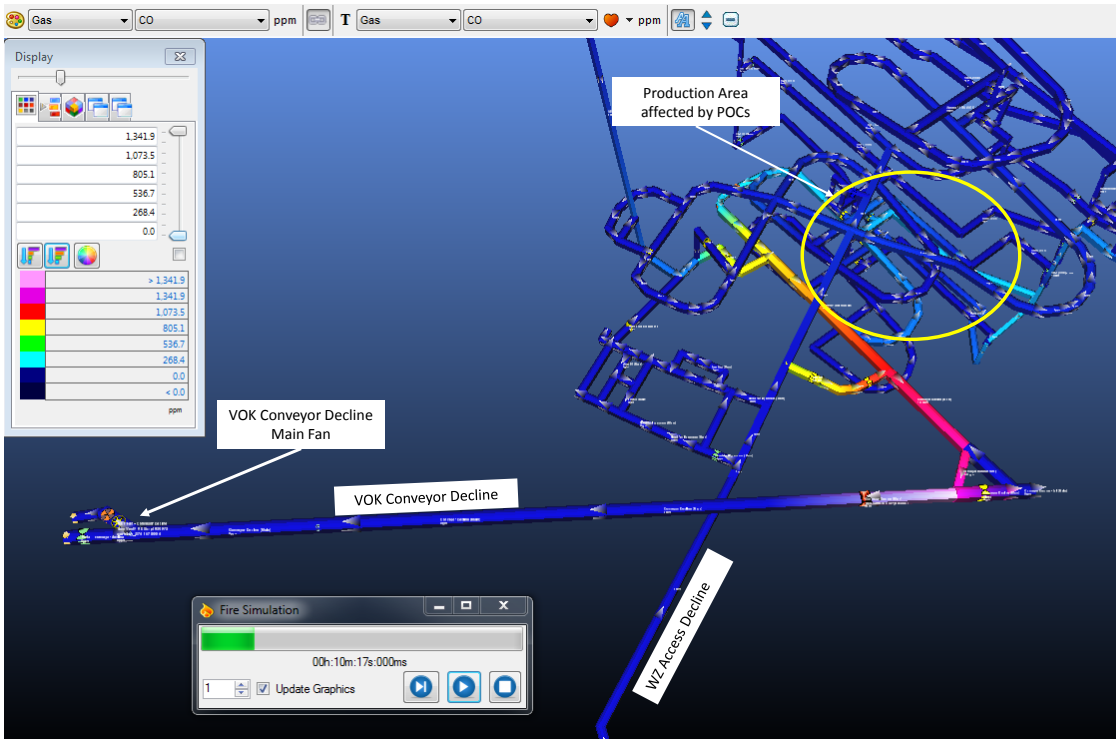


Figure 2-15: Predicted Temperature Rise at the VOC Conveyor Main Fan



As an additional feature to the approach, use of a fire door between the tail of the lower conveyor and the VOK production ramp should be considered. This reduces the response time and decreases the quantity of POCs entering the production areas (Figure 2-16).

Figure 2-16: POC Spread after 10 Minutes, with Augmentation by Closing Fire Door



This approach, however, results in the VOK conveyor main fan entering a stalled operating condition placing the fan at risk of structural failure. If this approach is considered, reducing the fan speed to 50% should be considered.

Plan 2 – Combined Countermeasures

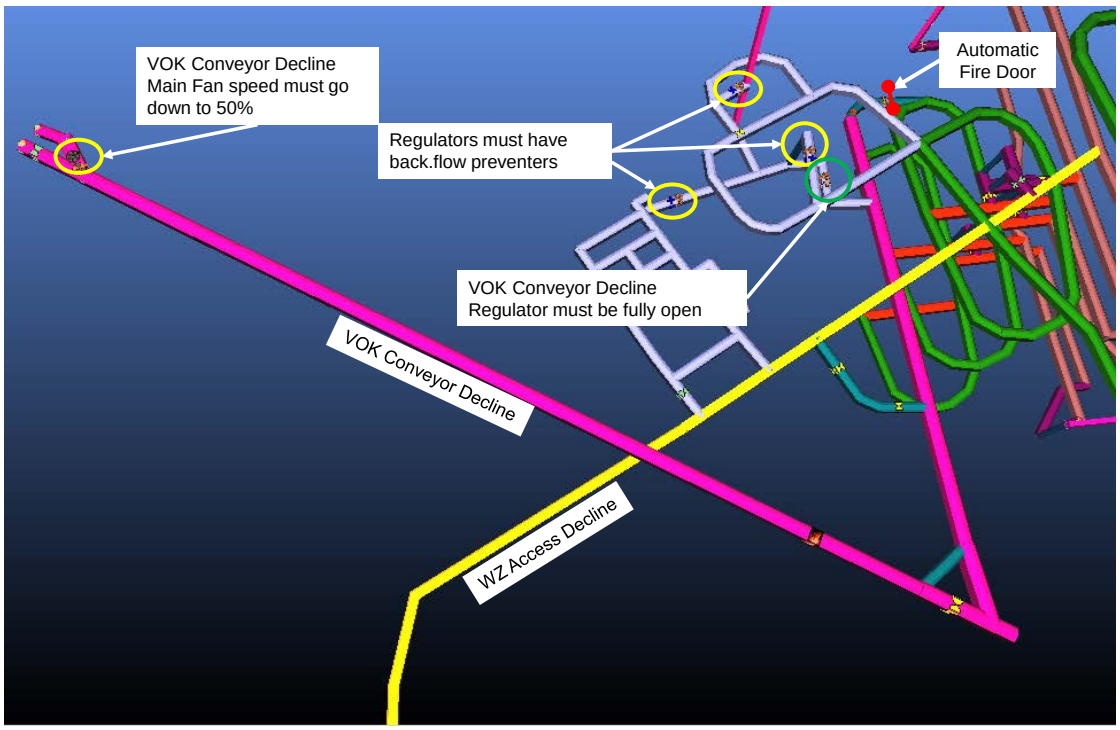
This plan considers the effect of reducing the forward speed of the conveyor decline main fan and diverting the conveyor decline airflow to VR-2. This involves the following requirements and sequence of events:

- Fire detection systems (CO, smoke, and thermal) must be installed along the entire conveyor system to ensure a rapid response to a fire.
- A fire door must be installed in the connection between the lower VOK conveyor decline to the production ramp. This door must be actuated in response to the fire detection systems along the conveyor system.

- The exhaust access door from the jaw crusher discharge conveyor towards VR-2 must have fail-open controller that opens the door (5 m by 5 m), so that all of the conveyor decline ventilation can be diverted to VR-2.
- Exhaust regulators from other fixed facilities (shop, crusher tip, and magazine) must close when the jaw crusher discharge conveyor regulator is opened. It is recommended that these regulators also be equipped with back-flow preventers to ensure that POCs are not force backwards to the fixed facilities. Note: back flow preventors at these locations are reported to be in the mine operational plan to above automatic controls on the regulators.
- The VOK Conveyor Portal main fan speed must be reduced to 50% in the forward direction.

These features are illustrated in Figure 2-17.

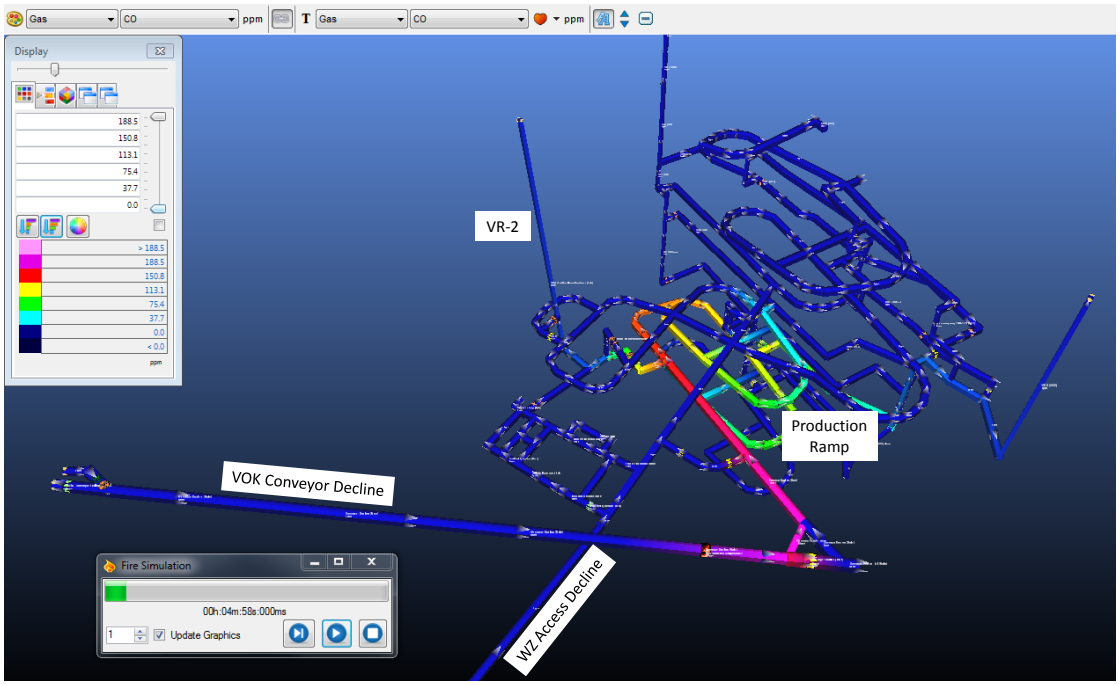
Figure 2-17: Countermeasures to Isolate the VOC Conveyor Decline



Implementation:

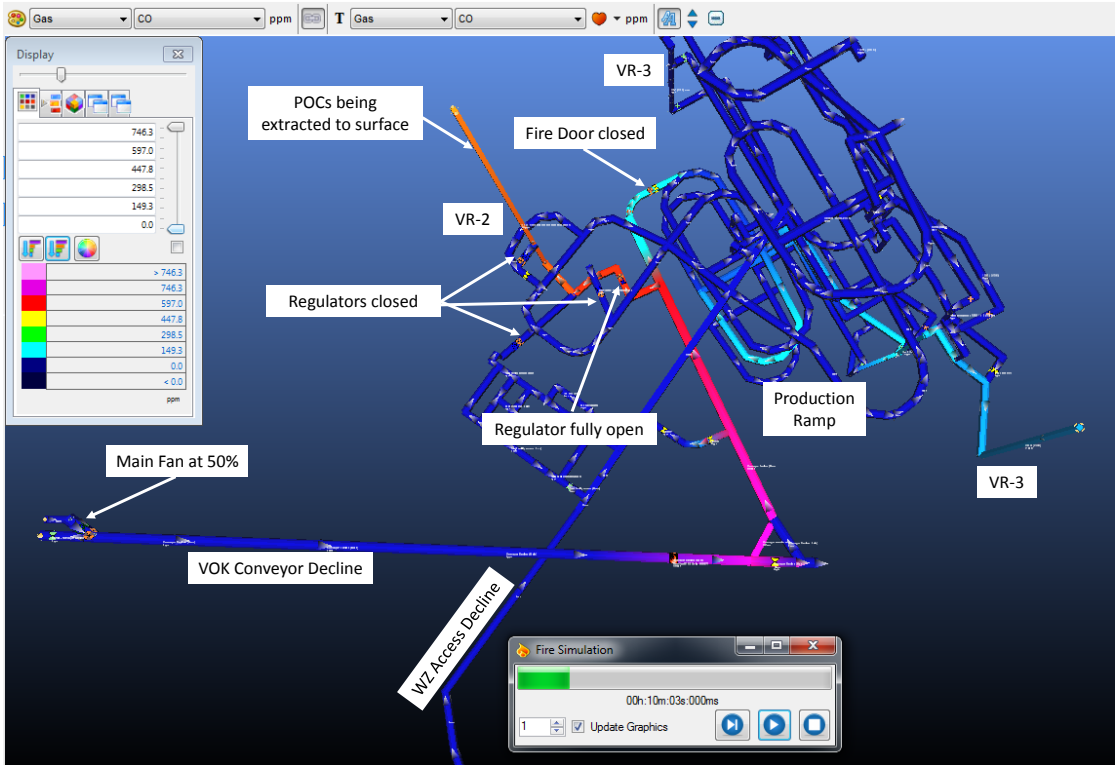
This approach considers that it will take approximately five minutes for the POCs to reach the lower portion of the production ramp and to reach the crusher area (Figure 2-18). This is the point in time that it is assumed these countermeasures can be implemented; completion of the changeover is assume to occur by 10 minutes.

Figure 2-18: Conveyor Fire Simulation, CO Spread after Five Minutes



Ten minutes after the fire starts, it is assumed that the countermeasures are fully implemented. The production ramp area is cleared by exhausting the POCs through VR-1 and VR-3. The POCs within the VOC conveyor decline are directed through the jaw crusher discharge regulator to VR-2 (Figure 2-19).

Figure 2-19: Alternate Countermeasure System, POC Spread at 10 Minutes

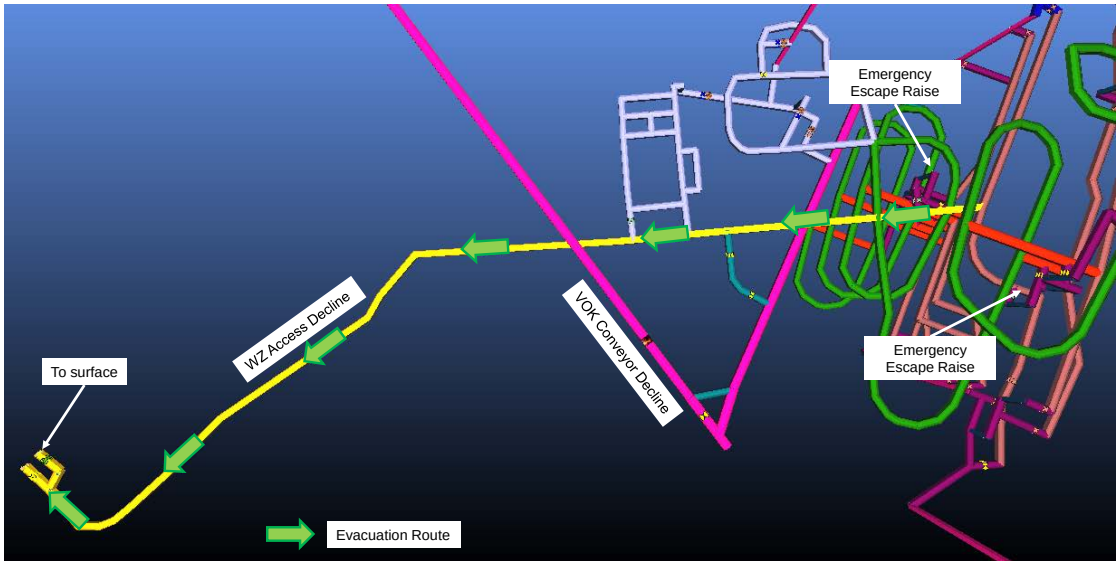


Effects of This Approach

During normal operation, the development ventilation/escapeway raises receive fresh air from the WZ access decline; if that source is maintained clear, then personnel can use the raises to bypass the POCs in the production ramp. In order to maintain that separation of intake airflow, it is recommended that the isolation airlock in the "dog-leg" connection be maintained normally closed. This is predicted to provide sufficient isolation that the WZ access decline can serve as the primary egress (Figure 2-20).

For normal operations purposes, a remotely activated, single, normally-open door may be preferred in the"dog-leg" rather than the normally closed airlock. This can be considered a viable alternative with the door closing as part of the fire response sequence.

Figure 2-20: Evacuation Route



Based on these simulations, the recommended response to this scenario is:

- Close the fire door to the production ramp.
- If normally-open door is used in the "dog-leg" - close this fire door.
- Fully open the regulator/drive-through door at the exhaust of the jaw crusher discharge conveyor area to VR-2.
- The exhaust regulators from the other fixed facilities (crusher, truck loop) must be equipped with backflow preventers. Magazine fire doors closed.
- The VOK conveyor portal fan must be slowed down to 50% of its rated full speed.

- Proper maintenance and calibration of the fire detection system along the conveyor belt is critical.

This approach does not materially impact the flow of air that would be perceived by the underground workers, which should help avoid confusion during the evacuation process.

Initial Stoping WZ

The general layout of the mine at the time of initial stoping in the WZ is shown in Figure 2-21. The airlock shown in the WZ access decline creates an effective barrier to the spread of the fire POCs to the WZ production area.

Figure 2-21: Conveyor Belt Fire Scenario, Initial WZ Stoping

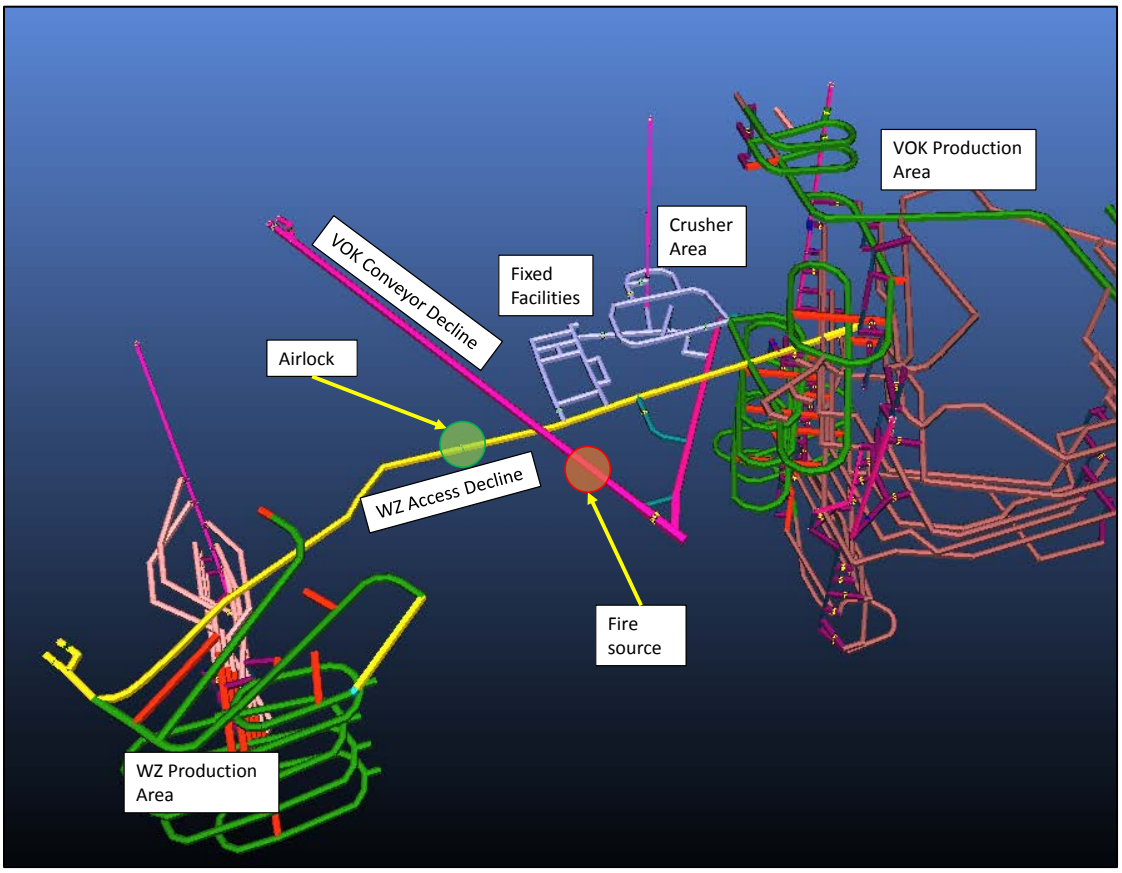


Figure 2-22 illustrates the spread of the fire POCs five minutes after initiation by which time the POCs have reached the VOK production ramp and the crusher areas. By 10 minutes, the fire POCs have inundated the crusher area and are spreading through the VOK production ramp (Figure 2-23).

Figure 2-22: Conveyor Belt Fire, POC Spread after Five Minutes, Initial WZ Stoping

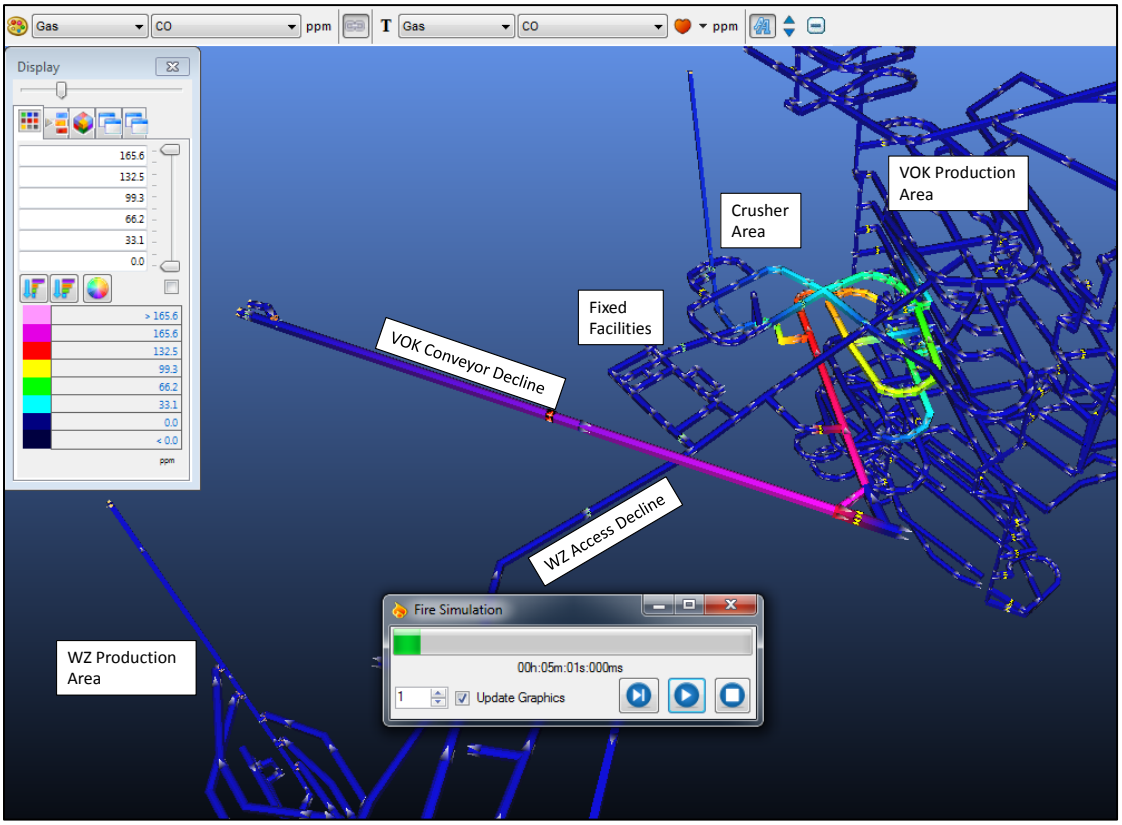
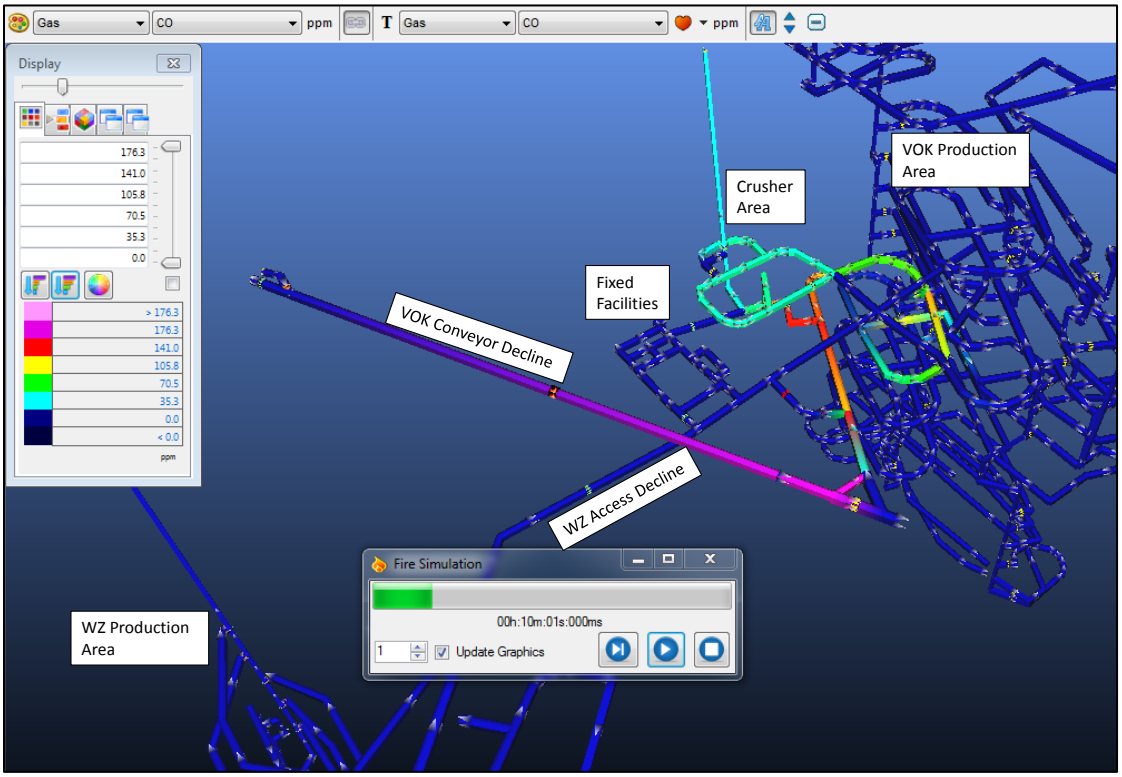


Figure 2-23: Conveyor Belt Fire, POC Spread after 10 Minutes, Initial WZ Stoping



As a means to control the POC spread through the mine, a procedure to reverse the VOK main fan was recommended for the VOK only case above. To cause a faster response when the WZ in is production in the mine for diverting the POCs from the conveyor fire, it is also recommended to implement the following countermeasures: close the fire door that connects the conveyor decline to the production ramp; stop the VOK Conveyor Portal main fan; open the airlock in the WZ exploration access decline. The fire door can be closed immediately after the fire has been detected to prevent the spread of POCs into the VOK production ramp (this would occur approximately five minutes after the fire's initiation). At the same time, the fire door is closed the VOK Conveyor Portal main fan must be stopped.

A secure evacuation route is predicted by opening the WZ exploration access decline airlock, so that the WZ Portal fan is providing forced airflow through the VOK (Figure 2-24).

Figure 2-24: Conveyor Belt Fire, POC Spread after 10 Minutes with Countermeasures

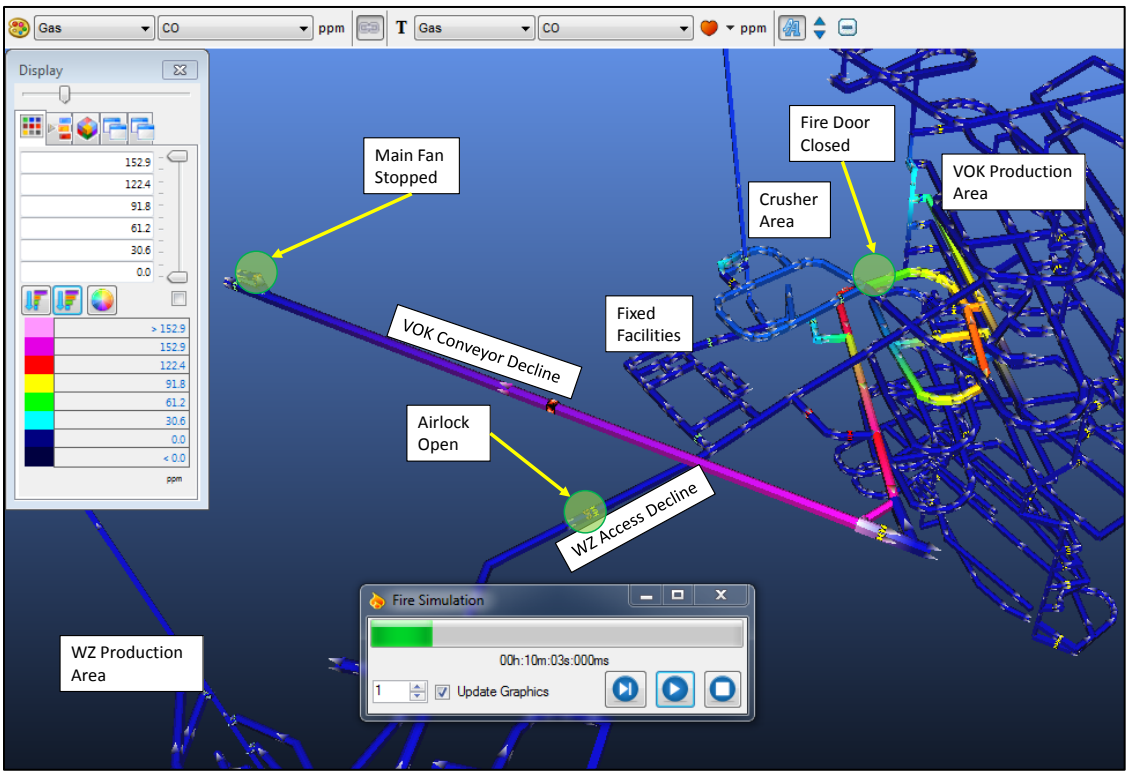
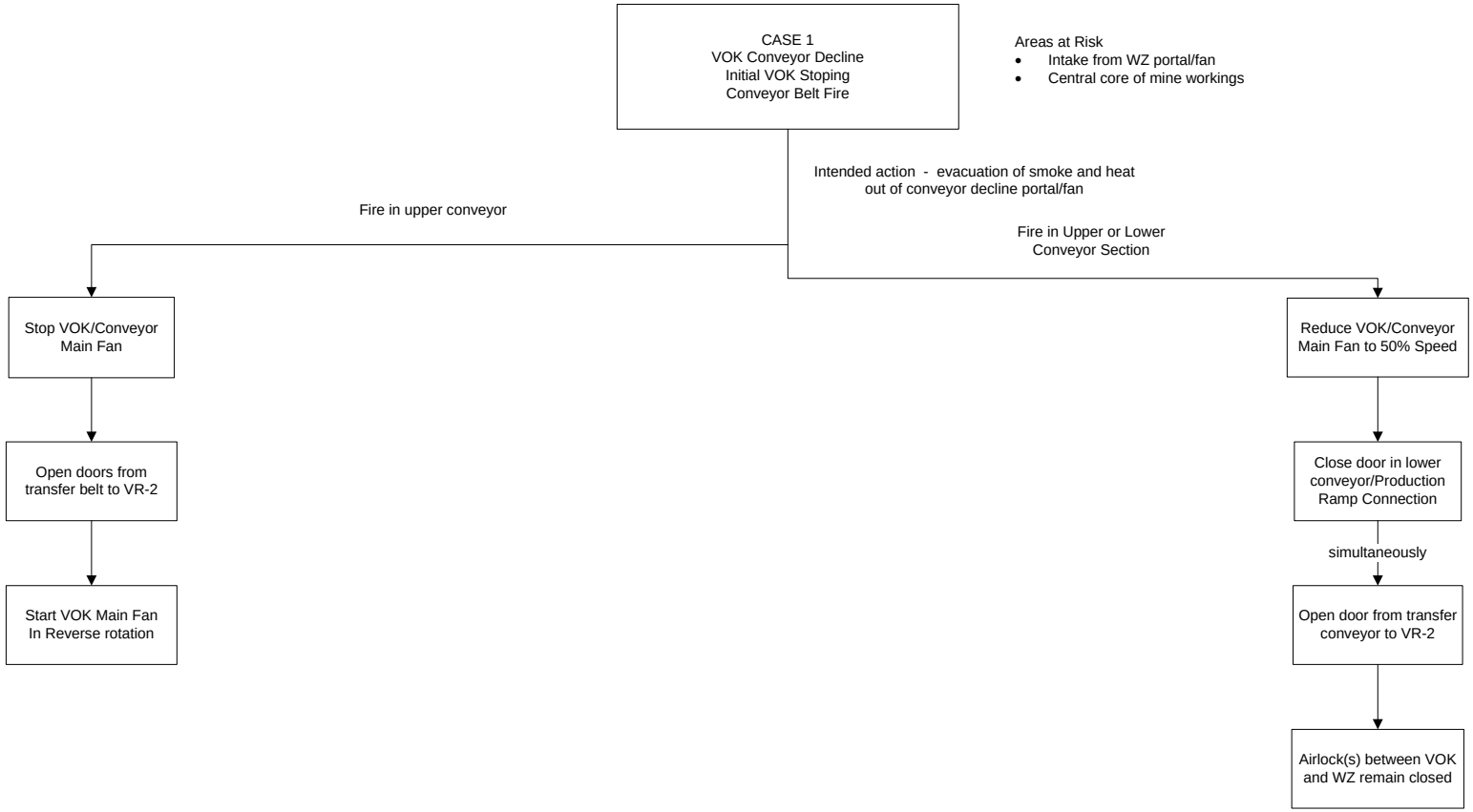


Figure 2-25: Flow Chart Case 1 Response



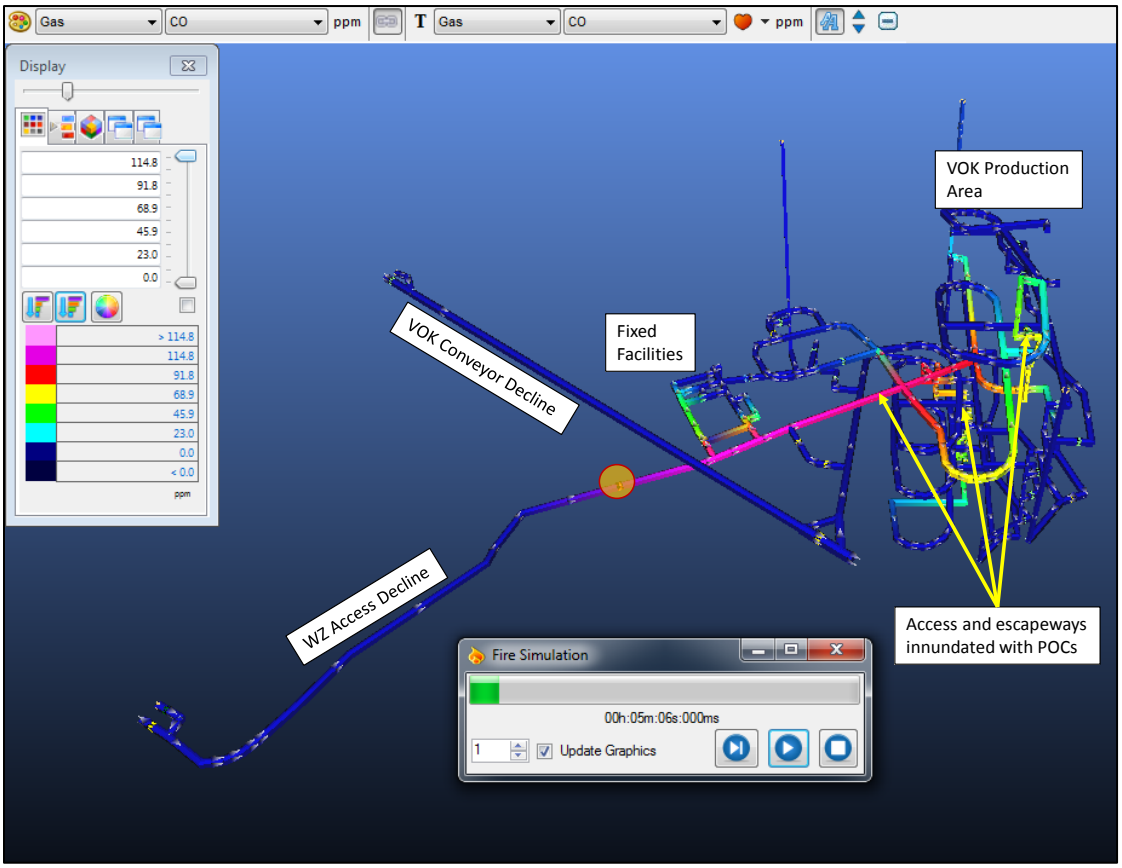
2.3.2 Truck Fire in the WZ Access Decline

This fire case assumes that a haulage truck is burning in the WZ exploration/access decline between the WZ and the VOK. The initial status is that the mine is operating under normal conditions at the time of the fire (Figure 2-26).

Figure 2-26: WZ Access Decline, fire source location, initial VOK stoping

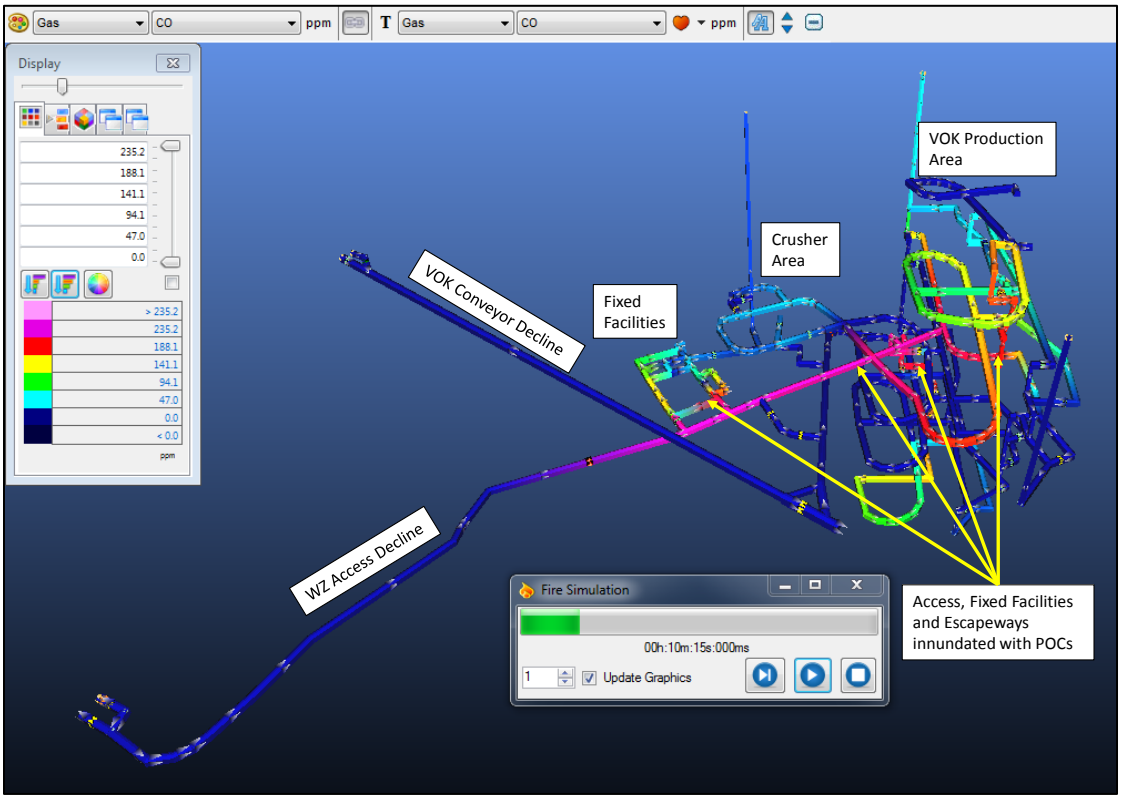
Because the WZ access decline is a major intake drift, the POCs spread quickly and inundate the VOK production levels (Figure 2-27). Because the access decline intake air flows directly to the development ventilation intake raises, the POCS will quickly spread that development headings. Furthermore, since the POCs will also enter to the ramp system, both the primary (decline) and secondary (intake raises) will be impacted. Since both the primary and secondary escapeways may be affected in this scenario, personnel should have the option to seek refuge on their production levels.

Figure 2-27: WZ Access Decline Fire, POC Spread after Five Minutes, Initial VOK Stoping



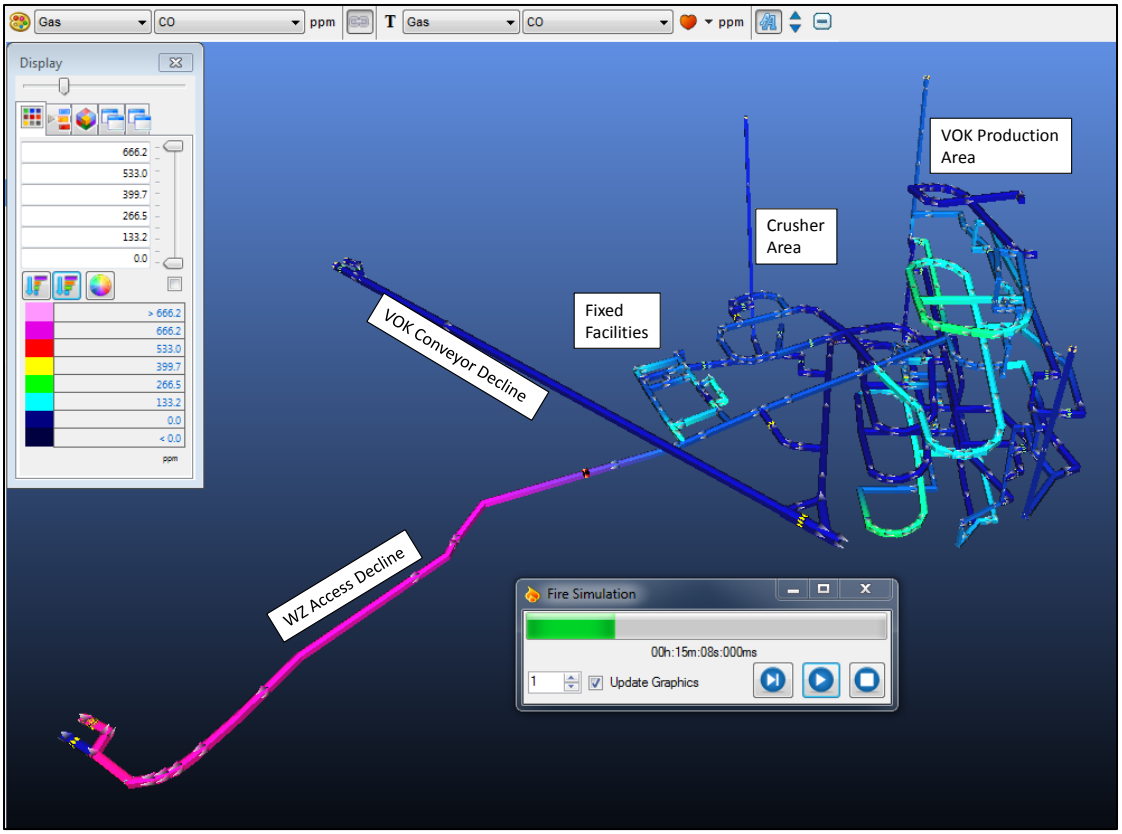
As in the conveyor fire case, a reversal of flow through the WZ Portal fan may limit the spread of POCs through the underground. However, due to the time required for the reversal to be initiated and implemented, it is still expected that POCs would reach production levels (Figure 2-28).

Figure 2-28: WZ Access Decline Fire, POC Spread after 10 Minutes, Initial VOK Stoping



The effect of the reversal on the distribution of POCs, five minutes after the reversal is implemented (Figure 2-29).

Figure 2-29: WZ Access Decline Fire, POC Spread after 15 Minutes with Fan Reversal



Steps that can be considered for controlling or limiting the impact of a fire in the WZ access/exploration decline include: installing a normally open fire door in the decline at the intersection to the VOK production ramps, implementation of a procedure to stop the WZ Portal main fan, and providing fire rated doors at the entrances to the fixed facility areas (already provided for). These are indicated and shown in Figure 2-30.

Figure 2-30: WZ Access Decline Fire, POC Spread 10 Minutes after Fire Door Activation

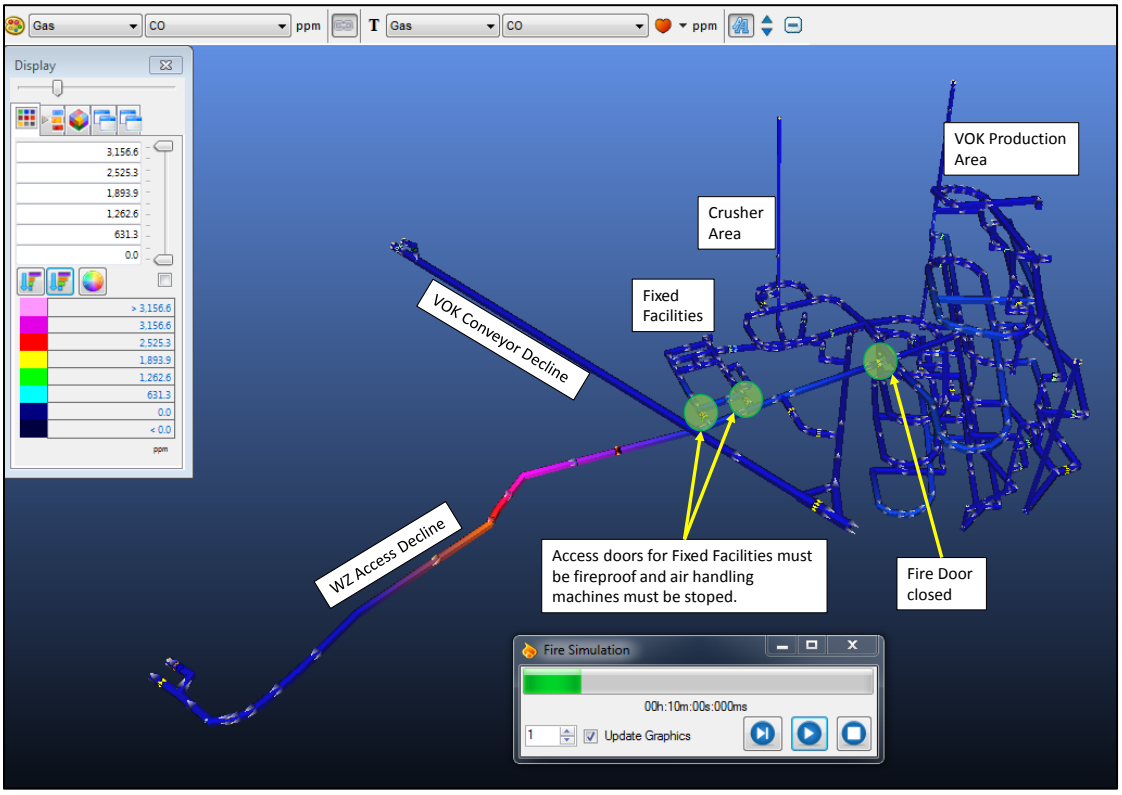
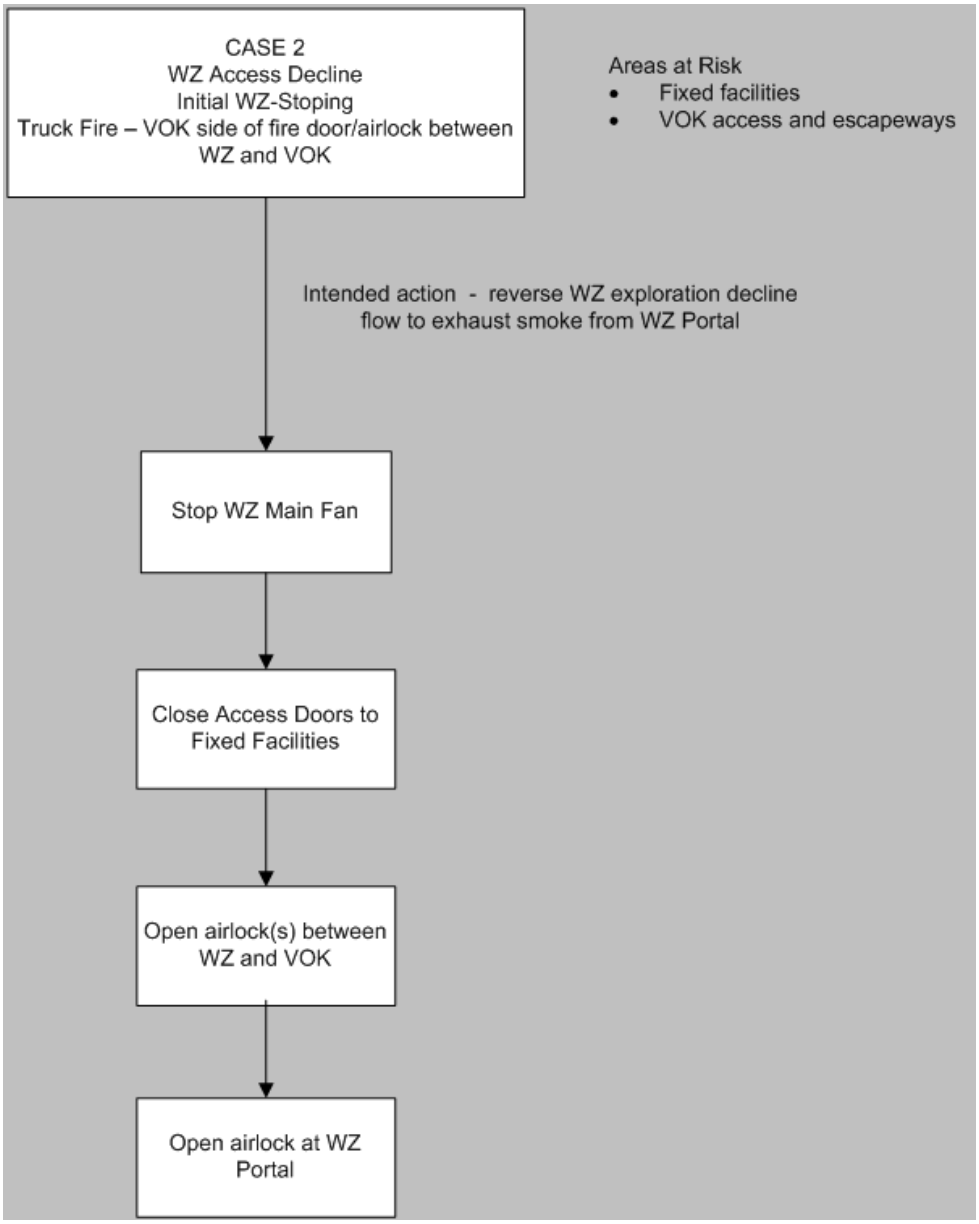


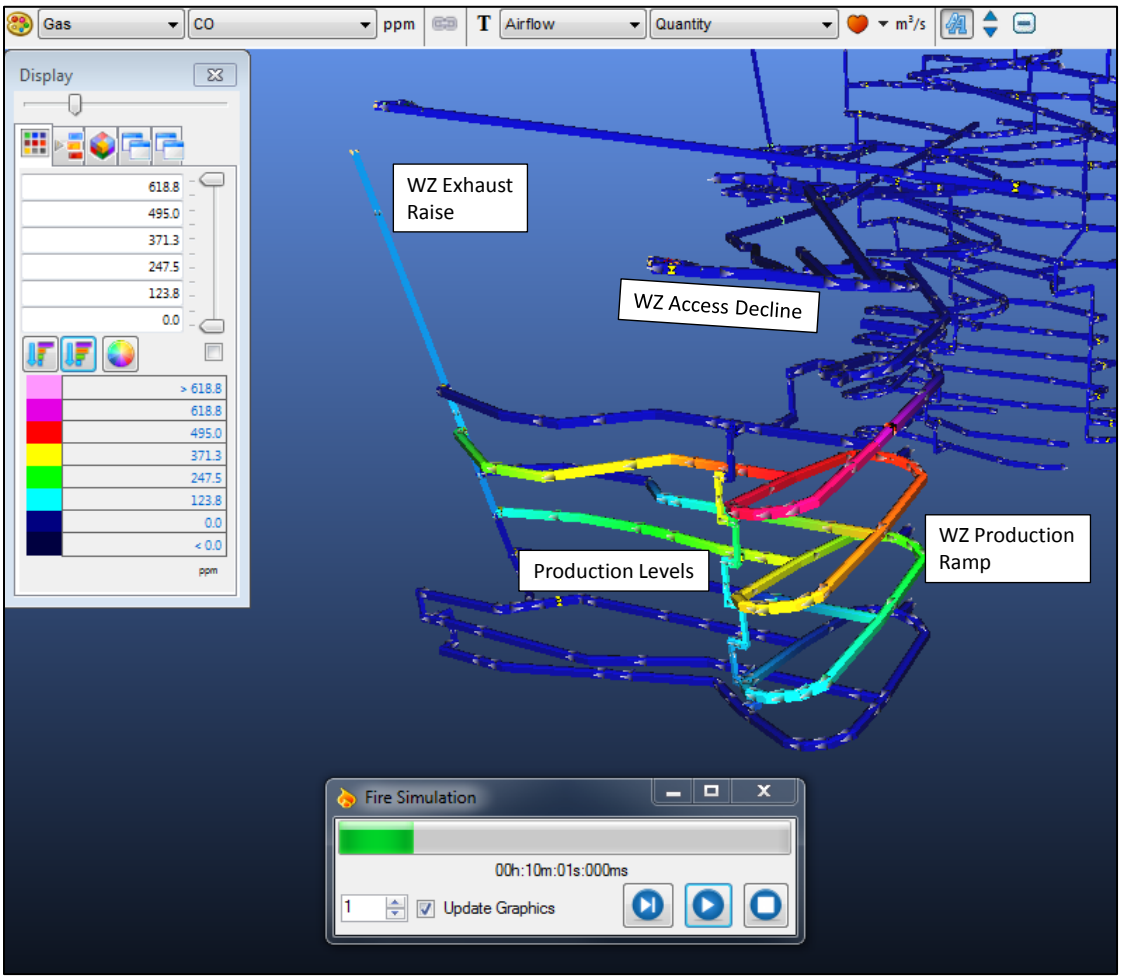
Figure 2-31: Flow Chart of Case 2 Response



2.3.3 Truck Fire in WZ Production Ramp

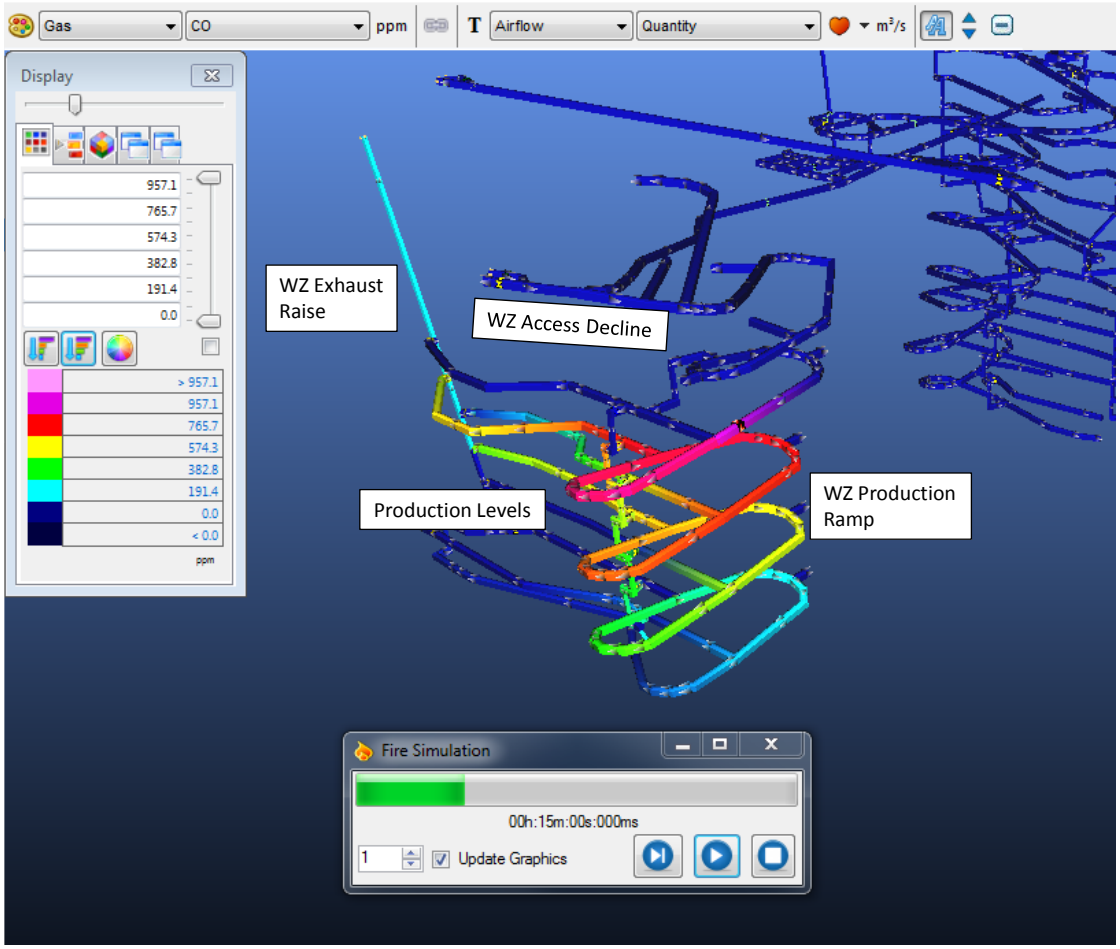
In this scenario, at the beginning of stoping in the WZ, a haul truck fire is considered in the upper section of the WZ production ramp. In this case, by 10 minutes after the fire starts, the POCs have inundated several upper levels and have reached the surface through the WZ exhaust raise. Additionally, due to the source of air into the development ventilation/escapeway raise, that raise is also affected by the spread of POCs (Figure 2-32).

Figure 2-32: WZ Ramp fire, POC spread after 10 minutes, Initial WZ Stoping



By 15 minutes after the fire starts, the POCs have reached to lowest level of the WZ and in the escapeway raise (Figure 2-33). Under these conditions, personnel would need to rely on refuges on each production level.

Figure 2-33: WZ Ramp Fire, POC Spread after 15 Minutes, Initial WZ Stoping



Since it is not practical to locate a fire control door on the production ramp or in the production access drifts, an option to reverse the main fan needs to be considered to keep the levels clear of POCs. The case of implementing a reversal of the main fan is shown in Figure 2-34, which is taken 15 minutes after the fire begins and 5 minutes after the reversal of the main fan is completed.

Figure 2-34: WZ Ramp Fire, POC Spread after 15 Minutes with Main Fan Reversal

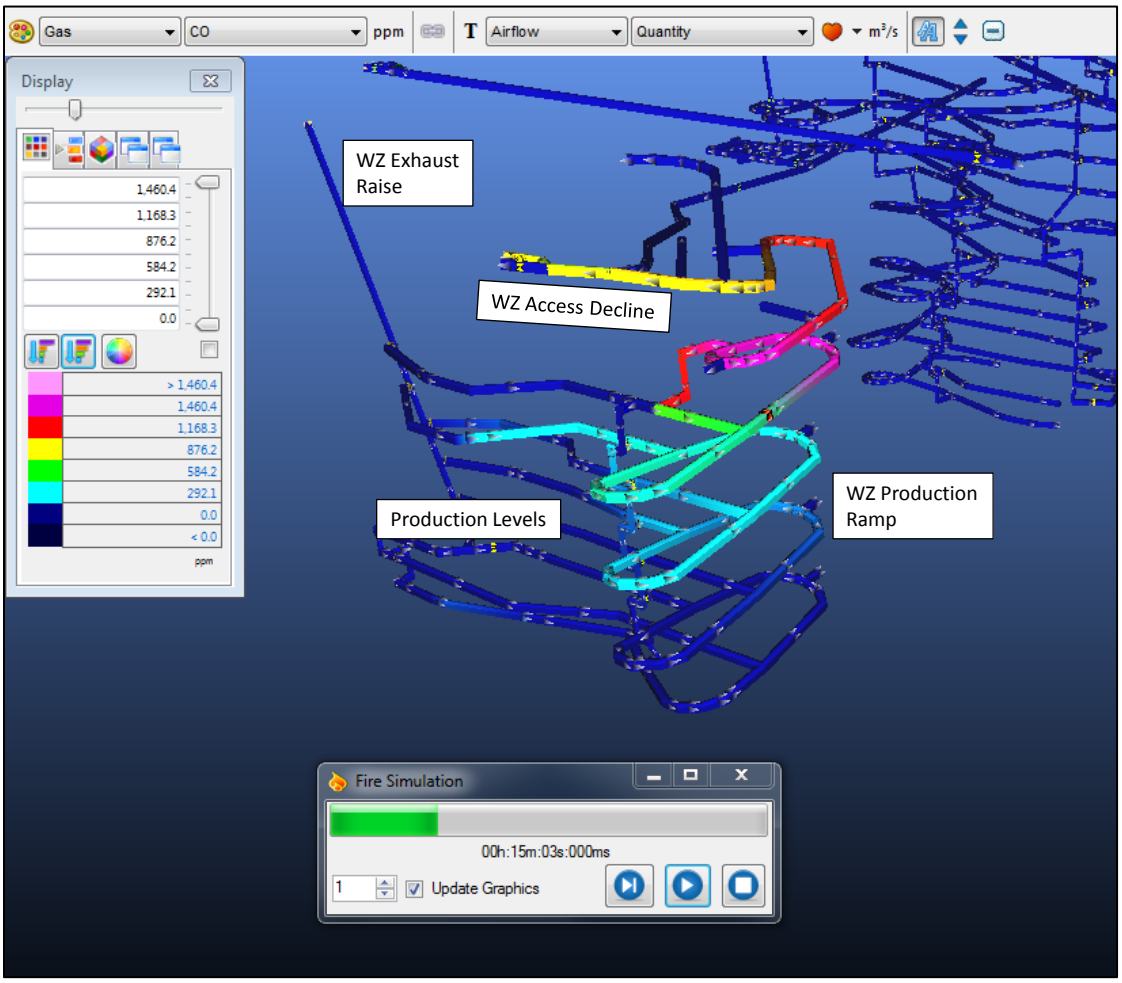
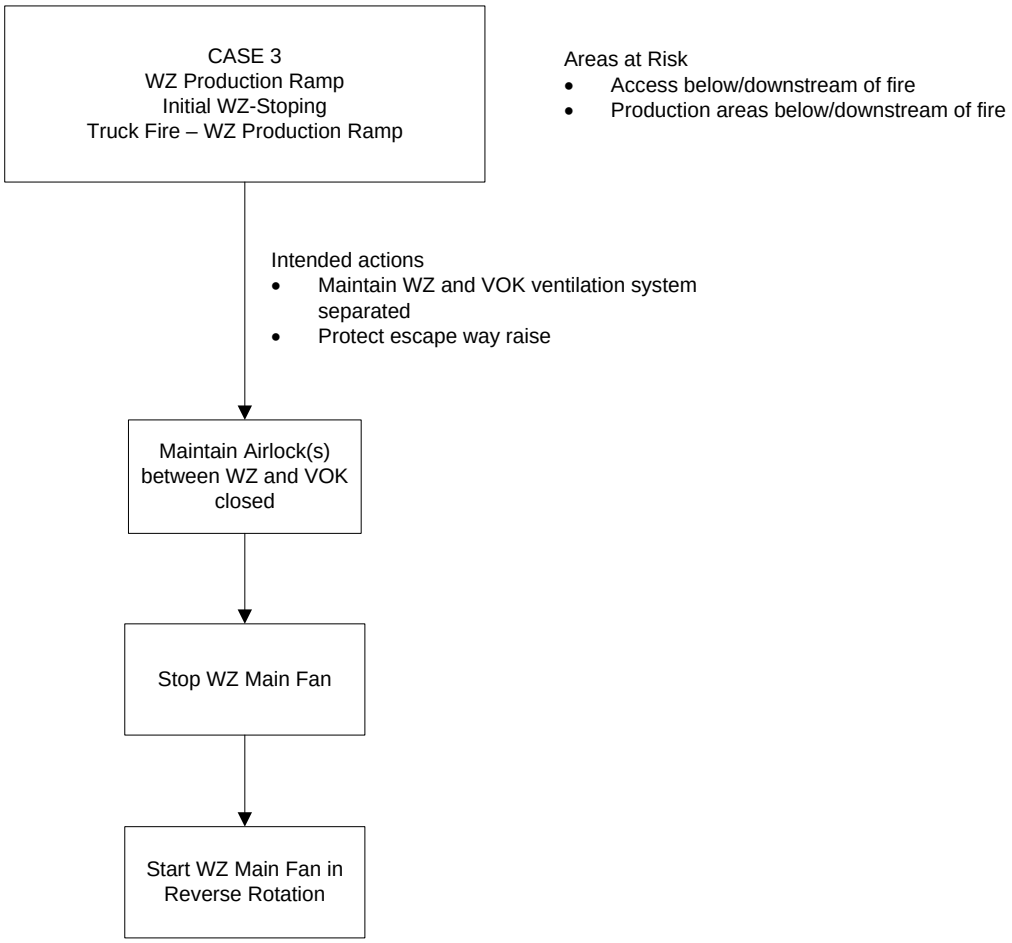


Figure 2-35: Flow Chart of Case 3 Response



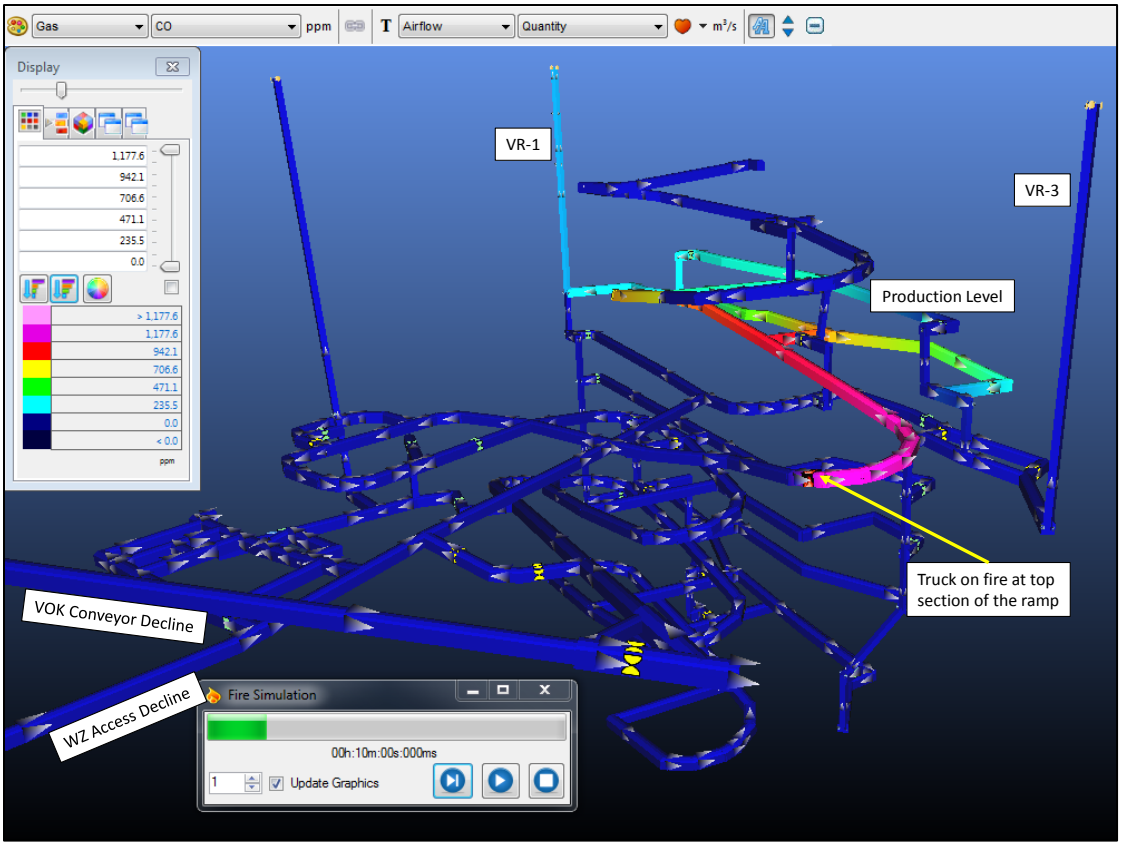
2.3.4 Truck Fire in VOK Production Ramp

Due to the variety of conditions and airflow patterns associated with the VOK production ramp, a truck fire is considered at three locations along the ramp: upper portion of the ramp, lower portion of the ramp, and in the middle portion of the ramp. Each of these cases is discussed separately.

Fire in the Upper VOK Production Ramp

Figure 2-36 shows the event of a truck fire in the upper portion of the VOK production ramp. In this event, the POCs move across an active production level and then are exhausted through an exhaust raise. The escapeway raise system remains clear in this scenario and can be used by personnel to by-pass the fire in the ramp.

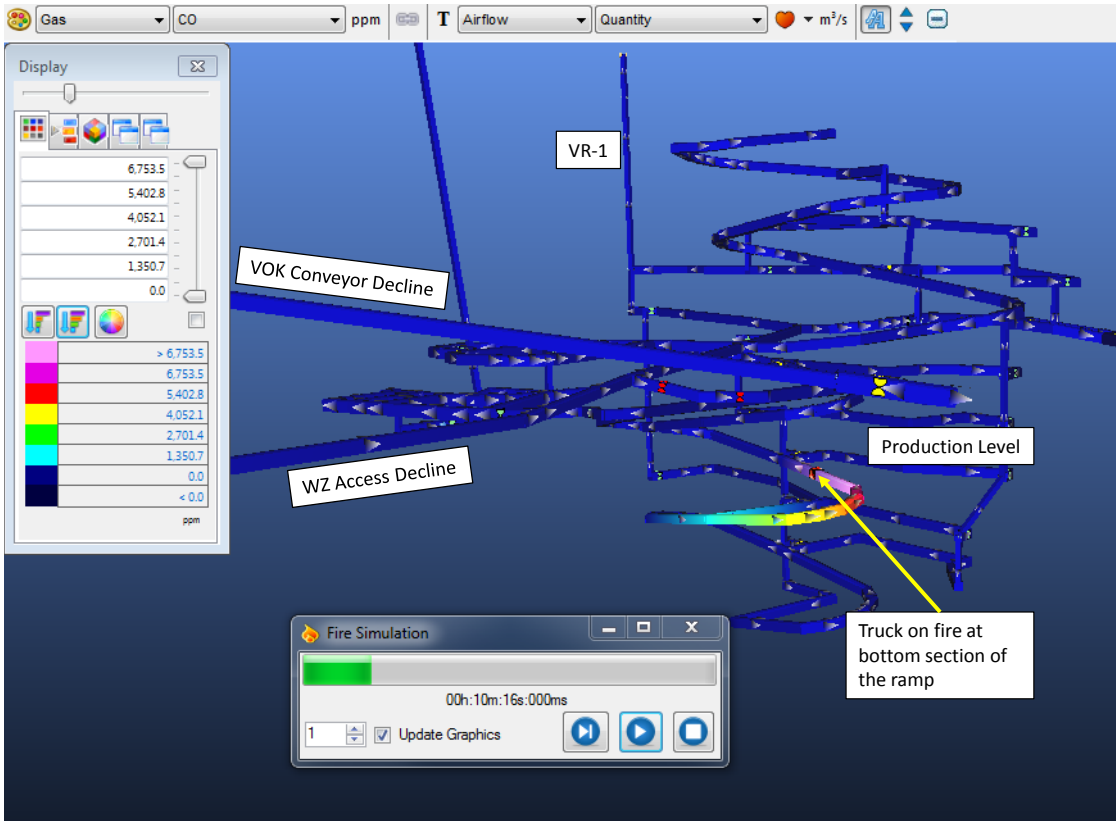
Figure 2-36: Upper VOK Ramp Fire, POC Spread after 10 Minutes



Fire in the Lower VOK Production Ramp

Figure 2-37 shows the event of a truck fire in the lower portion of the VOK production ramp. The POCs move across an active production level to the exhaust raises. The escapeway raise system remains clear in this scenario and can be used by personnel to by-pass the fire in the ramp.

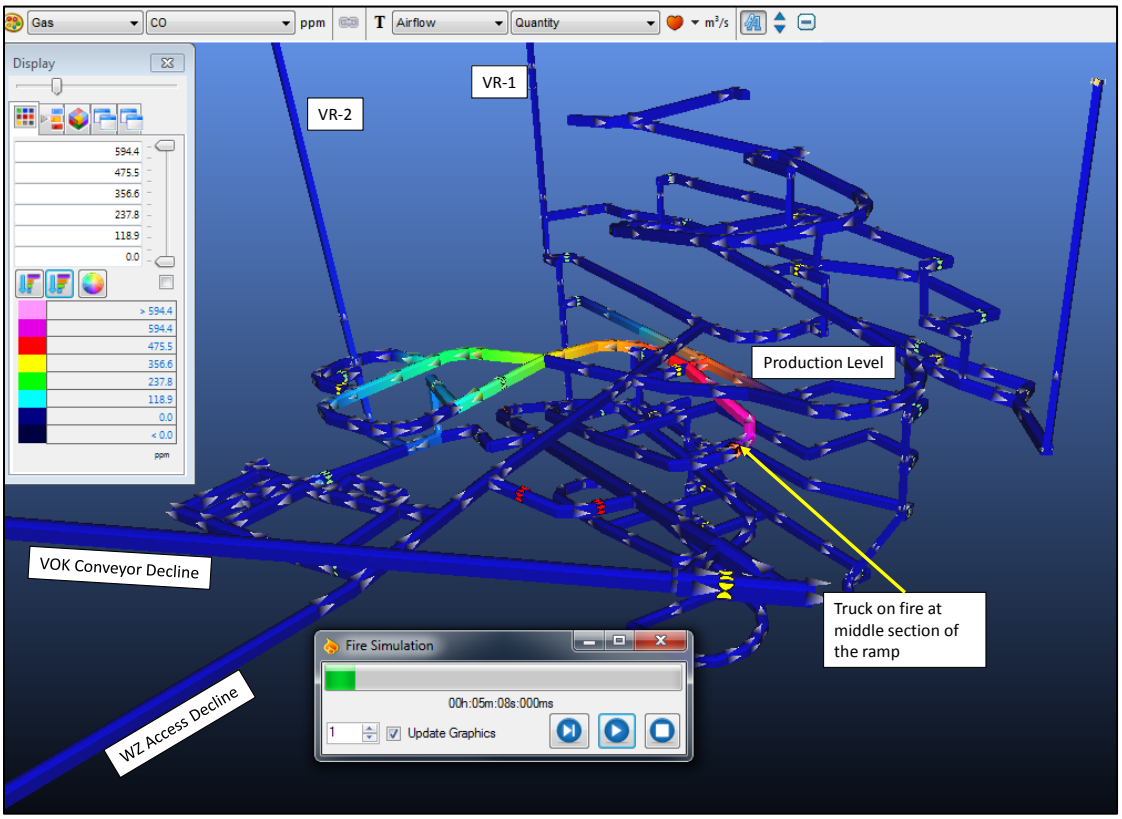
Figure 2-37: Lower WZ Ramp Fire, POC Spread after 10 Minutes



Fire in the Middle Portion of the VOK Ramp

Figure 2-38 shows the event of a truck fire in the middle portion of the VOK production ramp. In this scenario, the crusher/truck loop will be impacted by the spreading POCs. Within five minutes of the fire starting, the crusher/truck loop and active production levels are being impacted by the fire.

Figure 2-38: Middle WZ Ramp Fire, POC Spread after Five Minutes



By 10 minutes after the start of the fire, the crusher/truck loop and the nearest active production level are inundated as shown in Figure 2-39. The analysis indicates that reversing the airflow through the conveyor portal main fan is a prudent action to exhaust contaminants from the mine. The predicted conditions 20 minutes after the start of the fire and 10 minutes after reversing the main fan are shown in Figure 2-40. Within the production area, the escapeway raises are predicted to remain clear allowing personnel to escape via the WZ access; however, personnel in the crusher area may need to use the nearest refuge chamber/station.

Figure 2-39: Middle WZ Ramp Fire, POC Spread after 10 Minutes

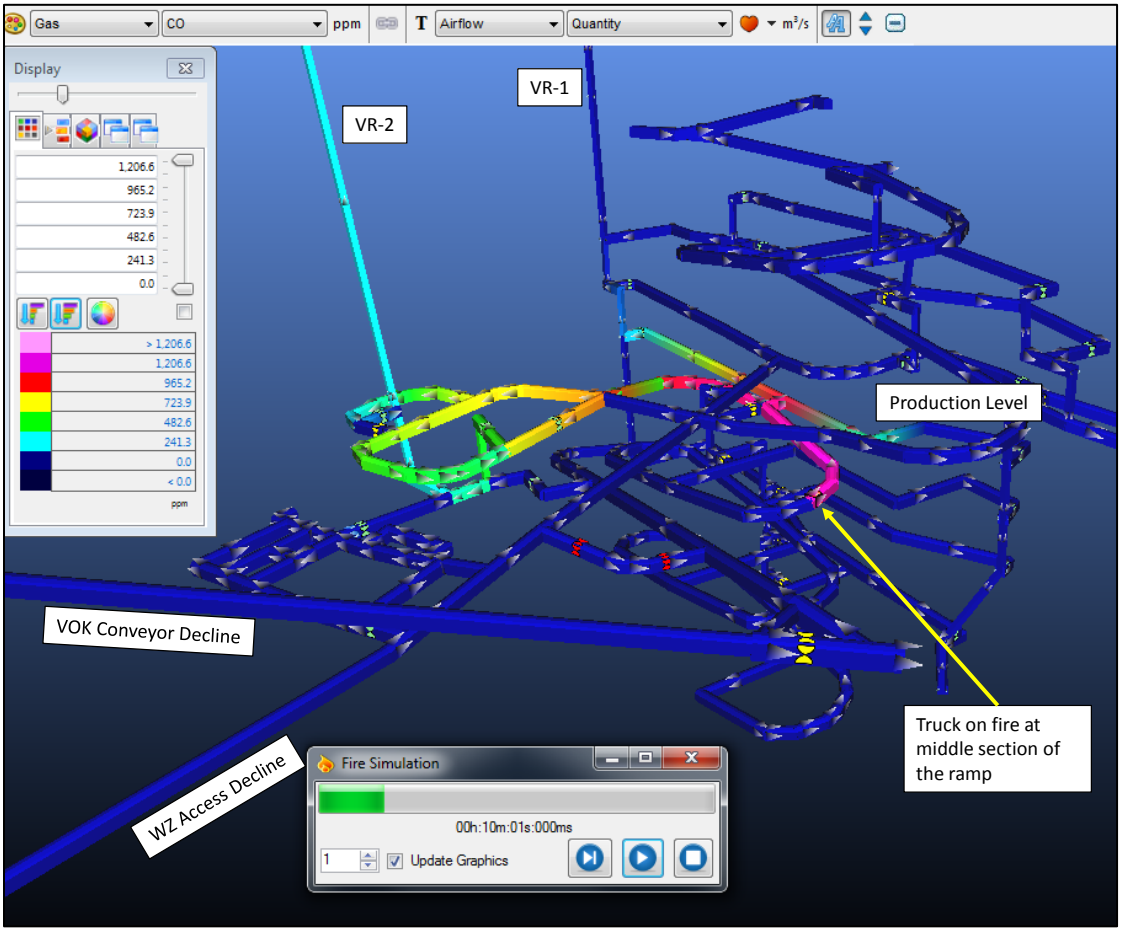


Figure 2-40: Middle WZ Ramp Fire, POC Spread after 20 Minutes with Fan Reversal

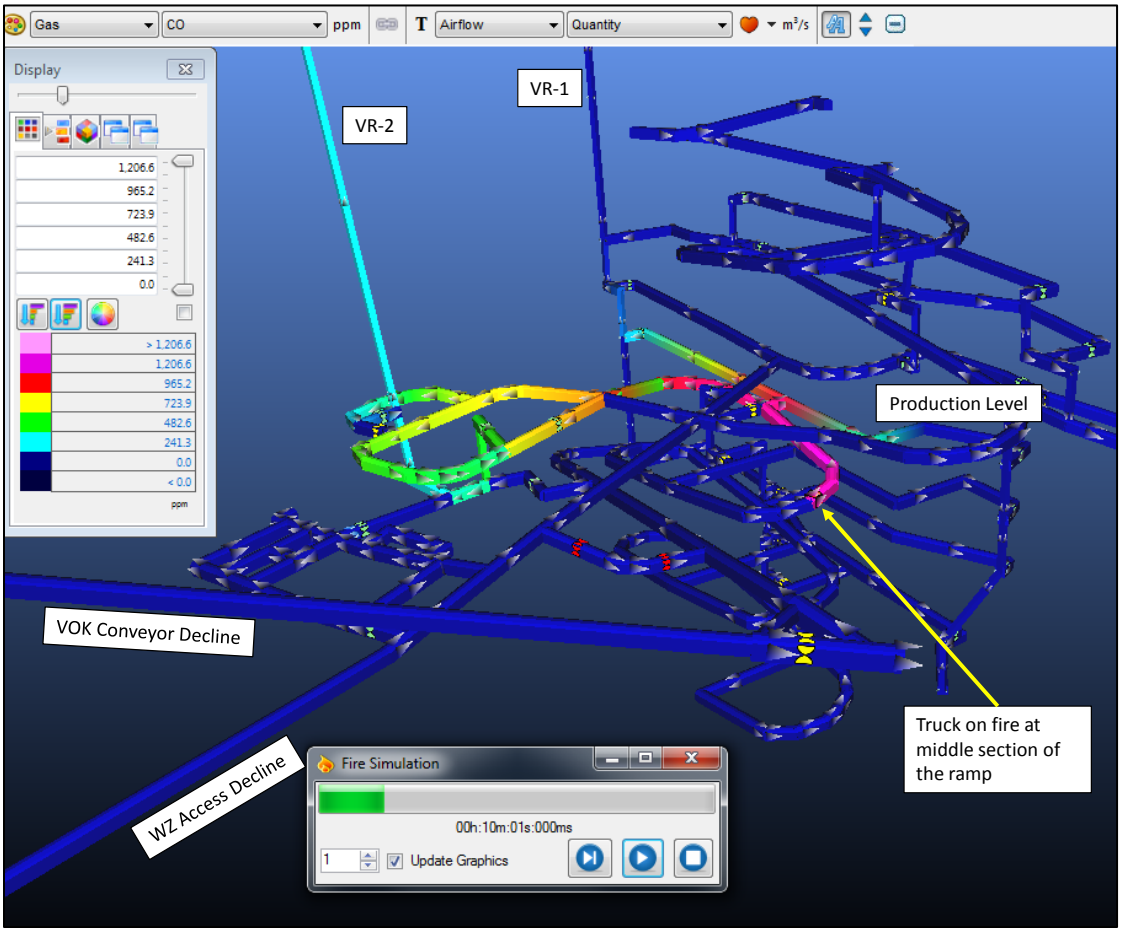
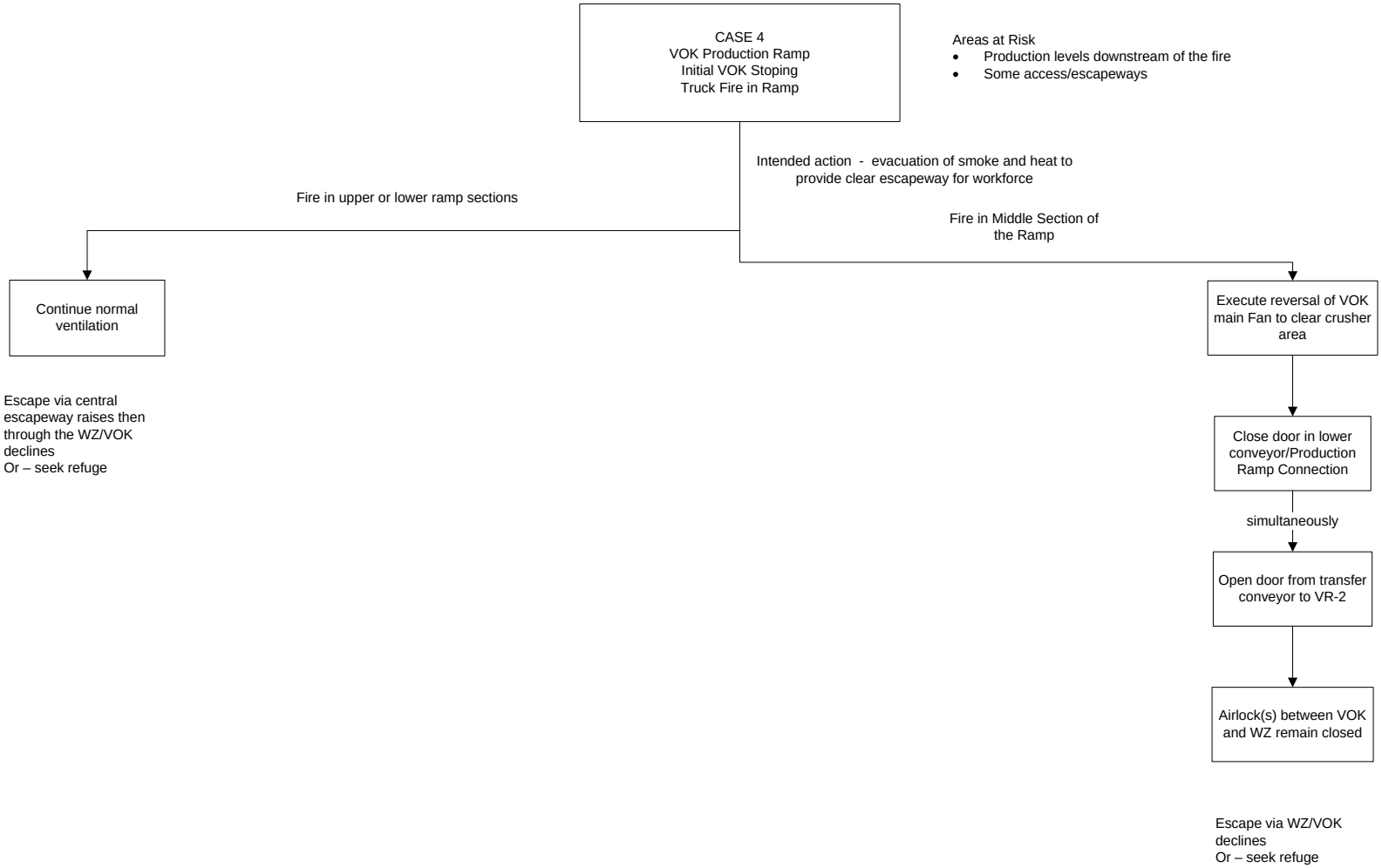


Figure 2-41: Flow Chart of Case 4 Response



2.3.5 Production Level Fire

The event of a Loader (LHD) fire on typical production level is shown in Figure 2-42. In this scenario, it is predicted that the POCs will be carried across the level to the main exhaust raise system. The effect of the fire on airflow across the level is shown in Figure 2-43. This illustrates that although there is some throttling effect due to the fire, the airflow remains towards the exhaust and does not reverse towards the production ramp.

Figure 2-42: VOK Production Level, LHD Fire, POC Spread after Five Minutes

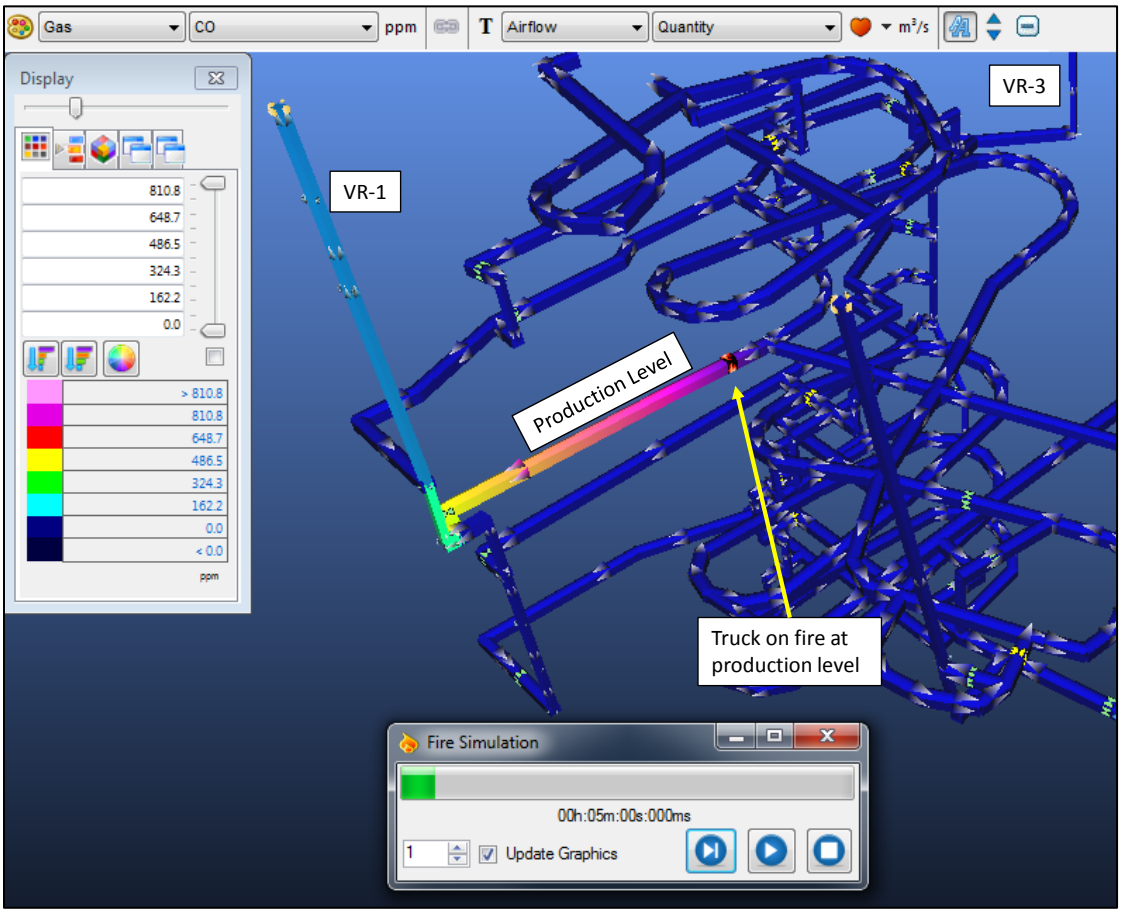


Figure 2-43: VOK Production Level, LHD Fire, Throttling of Airflow to Level

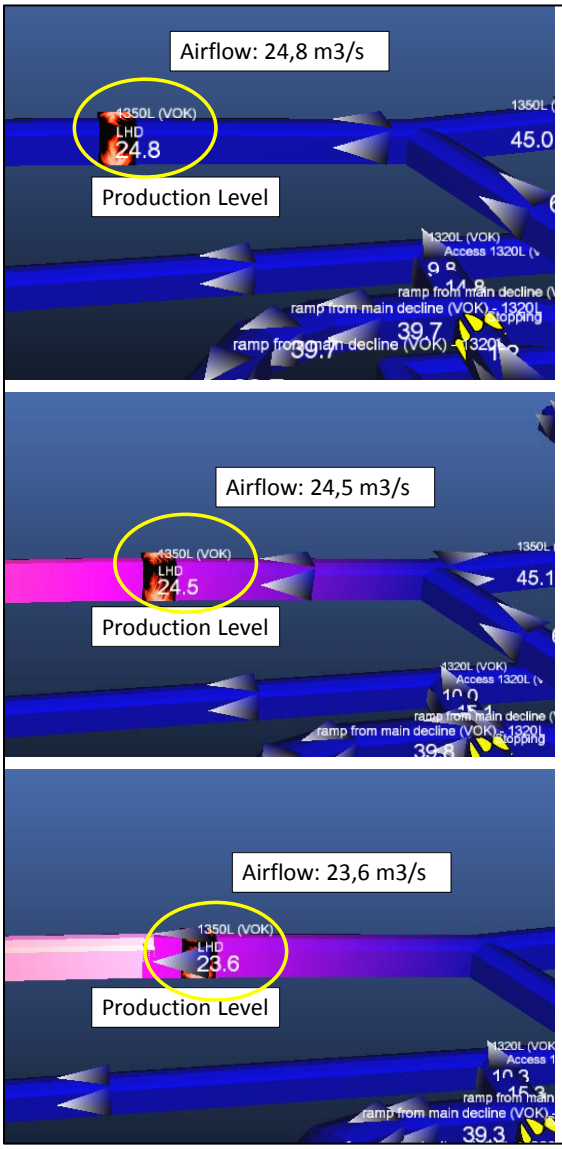
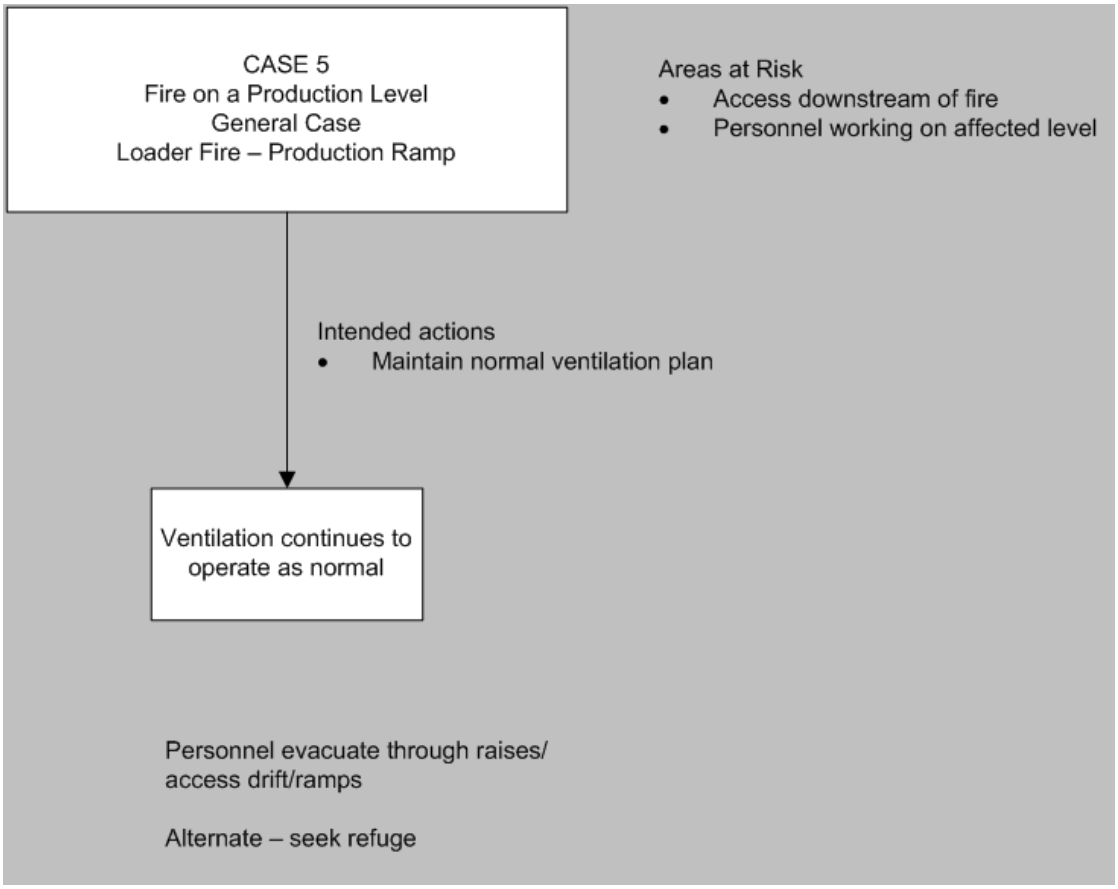


Figure 2-44: Flow Chart of Case 5 Response



Chapter 10 Appendix

Appendix 10-1: ENV Declarations Forms

Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

A qualified professional [1] providing services to either the Ministry of Environment and Climate Change Strategy ("ministry"), or to a regulated person for the purpose of obtaining an authorization from the ministry, or pursuant to a requirement imposed under the *Environmental Management Act,* the *Integrated Pest Management Act* or the *Park Act* has a real or perceived conflict of interest when the qualified professional, or their relatives, close associates or personal friends have a financial or other interest in the outcome of the work being performed.

A real or perceived conflict of interest occurs when a qualified professional has

a) an ownership interest in the regulated person's business;

b) an opportunity to influence a decision that leads to financial benefits from the regulated person or their business other than a standard fee for service (e.g. bonuses, stock options, other profit sharing arrangements);

c) a personal or professional interest in a specific outcome;

d) the promise of a long term or ongoing business relationship with the regulated person, that is contingent upon a specific outcome of work;

e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I Alison Shaw, as a member of Engineers and Geoscientists BC declare

Select one of the following:

☒ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

This conflict of interest disclosure statement is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Signature:

X _____

Print name: Alison Shaw

Date: February 28, 2023

Witnessed by:

X _____

Print name: Meghan Goertzen

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

Ministry of Environment and Climate Change Strategy

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional Alison Shaw

   Title Senior Geochemist

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: Engineers and Geoscientists BC Registration # 47412

3. Brief description of professional services:

   Authored Appendix 5-3 (Brucejack Mine: 4950 tpd Water Quality Model Report) and contributed to sections 2.1, 2.3, 2.4, 5 and 7.

This declaration of competency is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X Alison Shaw

Print Name: Alison Shaw

Witnessed by:

X Meghan Goertzen

Print Name: Meghan Goertzen

Date signed: February 28, 2023

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

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A real or perceived conflict of interest occurs when a qualified professional has

a) an ownership interest in the regulated person's business;

b) an opportunity to influence a decision that leads to financial benefits from the regulated person or their business other than a standard fee for service (e.g. bonuses, stock options, other profit sharing arrangements);

c) a personal or professional interest in a specific outcome;

d) the promise of a long term or ongoing business relationship with the regulated person, that is contingent upon a specific outcome of work;

e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I **Brett DeHay-Turner**, as a member of **EGBC** declare

Select one of the following:

☐ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this _____.

I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to _____, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☒ Real or perceived conflict of interest

Description and nature of conflict(s):

I am employed by Newcrest Mining Ltd.

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

Continue to uphold EGBC's Code of Ethics that is required under the Professional Governance Act, S.B.C. 2018, p. 47

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

This conflict of interest disclosure statement is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Signature:

X _____

Print name: Brett DeHay-Turner

Date: March 13 2023

Witnessed by:

X Laura Fredrickson

Print name: Laura Fredrickson

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

Ministry of Environment and Climate Change Strategy

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional Brett DeHay-Turner

   Title Regional Environmental Scientist - Senior Hydrogeochemist

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: EGBC Registration # 217846

3. Brief description of professional services:

   Industry: Mining

   Areas of Practice: Hydrogeology and Geochemistry

This declaration of competency is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Brett DeHay-Turner

Witnessed by:

X Laura Fredrickson

Print Name: Laura Fredrickson

Date signed: March 13 2023

[1] *Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

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b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

Ministry of
Environment and
Climate Change Strategy

Conflict of Interest Disclosure Statement

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Declaration

I Colin Fraser, as a member of Engineers and Geoscientists BC declare

Select one of the following:

☒ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of
Environment and
Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X _____

Print name: Colin Fraser

Date: February 28, 2023

Witnessed by:

X _____

Print name: Alison Shaw

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) *is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and*

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Ministry of
Environment and
Climate Change Strategy

BRITISH COLUMBIA

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional Colin Fraser

   Title Senior Hydrologist

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: EGBC Registration # 36348

3. Brief description of professional services:

   - climate, hydrology, water balance studies

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Colin Fraser

Date signed: Feb 28, 2023

Witnessed by:

X

Print Name: Meghan Goertzen

[1] *Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) *is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and*

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

Ministry of
Environment and
Climate Change Strategy

BRITISH COLUMBIA

Conflict of Interest Disclosure Statement

A qualified professional [1] providing services to either the Ministry of Environment and Climate Change Strategy ("ministry"), or to a regulated person for the purpose of obtaining an authorization from the ministry, or pursuant to a requirement imposed under the *Environmental Management Act,* the *Integrated Pest Management Act* or the *Park Act* has a real or perceived conflict of interest when the qualified professional, or their relatives, close associates or personal friends have a financial or other interest in the outcome of the work being performed.

A real or perceived conflict of interest occurs when a qualified professional has

a) an ownership interest in the regulated person's business;

b) an opportunity to influence a decision that leads to financial benefits from the regulated person or their business other than a standard fee for service (e.g. bonuses, stock options, other profit sharing arrangements);

c) a personal or professional interest in a specific outcome;

d) the promise of a long term or ongoing business relationship with the regulated person, that is contingent upon a specific outcome of work;

e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I Dinesh Devatharan (Print First and Last Name), as a member of EGBC (Print Name of Professional Association)
declare

Select one of the following:

☐ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this _____ (application/project/work/etc.).
I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to _____ (Insert Ministry Contact Name), erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☑ Real or perceived conflict of interest

Description and nature of conflict(s):
work at Bruejack

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:
Ensure information submitted is within scope of professional knowledge and is based off sound judgement

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X

Print name: Dinesh Devathasan

Date: Oct 30th 2023

Witnessed by:

X Laura Fredrickson

Print name: Laura Fredrickson

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a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

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Ministry of Environment and Climate Change Strategy

BRITISH COLUMBIA

Declaration of Competency

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1. Name of Qualified Professional Dinesh Devathasan

   Title Chief Mine Engineer

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: EGBC Registration # 168792

3. Brief description of professional services:

   Review submission for 4950 tpd application in sections 3.5.1.5.1, 3.5.1.5.2, 3.5.5 and 3.5.6

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Dinesh Devathasan

Date signed: Oct 30th 2023

Witnessed by:

X Laura Fredrickson

Print Name: Laura Fredrickson

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Ministry of Environment and Climate Change Strategy

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e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I Jane May, as a member of Engineers and Geoscientists BC declare

Select one of the following:

☒ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

BRITISH COLUMBIA | Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

x Jane May

Print name: Jane May

Date: Feb. 28, 2023

Witnessed by:

x [1]

Print name: Derek May

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

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BRITISH COLUMBIA | Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional: Jane May

   Title: Chemical Engineer

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: EGBC Registration # 54903

3. Brief description of professional services:
   Author of "Brucejack Mine: WRTSF Best Achievable Technology Assessment" Report and Section 5.6.2 of the Brucejack Mine 4950 tpd Joint M-243/PE-107835 Amendments Application.

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

x Jane May

Print Name: Jane May

Date signed: Feb. 28, 2023

Witnessed by:

x

Print Name: Derek May

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Ministry of Environment and Climate Change Strategy

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Declaration

I Krystle Batiuk, as a member of Alberta Society of Professional Biologist declare

Select one of the following:

☑ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X Krystle Batiuk

Print name: Krystle Batiuk

Date: March 10, 2023

Witnessed by:

X Laura Fredrickson

Print name: Laura Fredrickson

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1. Name of Qualified Professional Krystle Batiuk

   Title Senior Consultant

2. Are you a registered member of a professional association in B.C.? ☐ Yes ☑ No

   Name of Association: Alberta Society of Professional Biologist Registration # 1820

3. Brief description of professional services:

   Regulatory lead, environmental assessment specialist

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

x Krystle Batiuk

Print Name: Krystle Batiuk

Witnessed by:

x Laura Fredrickson

Print Name: Laura Fredrickson

Date signed: March 10, 2023

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Ministry of Environment and Climate Change Strategy

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Declaration

I Laura-Lee Findlater, as a member of Engineers and Geoscientists BC declare

Select one of the following:

☑ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X L Findlater

Print name: Laura-Lee Findlater

Witnessed by:

X Alison Shaw

Print name: Alison Shaw

Date: February 28, 2023

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Ministry of Environment and Climate Change Strategy

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1. Name of Qualified Professional Laura-Lee Findlater

   Title Senior Hydrogeologist

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: Engineers and Geoscientists BC Registration # 38298

3. Brief description of professional services:

   Authored Appendix 5-1 (Brucejack Mine: 4950 tpd Groundwater Model Report) and contributed to sections 2.6.2, 2.7.2, 4.6.3, 5.3, 7.2.2 and Section 12.3 of Appendix 4-1

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

x L Findlater

Print Name: Laura-Lee Findlater

Witnessed by:

x Alison Shaw

Print Name: Alison Shaw

Date signed: February 28, 2023

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

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Declaration

I Michael Yakimchuk (Print First and Last Name), as a member of Engineers & Geoscientists British Columbia (Print Name of Professional Association) declare

Select one of the following:

☑ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Application (application/project/work/etc.).
I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson (Insert Ministry Contact Name), erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☑ Real or perceived conflict of interest

Description and nature of conflict(s):
My employment status may be a potential source of a conflict of interest

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

Continue to uphold EGBC's Code of Ethics that is required under the
Professional Governance Act, S.B.C 2018, p. 47>

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X

Print name: Michael Yakimchuk

Date: March 9th, 2023

Witnessed by:

X Laura Fredrickson

Print name: Laura Fredrickson

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1. Name of Qualified Professional Michael Yakimchuk

   Title Mill Manager

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: Engineers & Geoscientists British Columbia Registration # 55100

3. Brief description of professional services:

   Manager responsible for Mill Operations and Maintenance.
   Technical oversight and verification has been provided for this project.

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Michael Yakimchuk

Witnessed by:

X Laura Fredrickson

Print Name: Laura Fredrickson

Date signed: March 9th, 2023

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BRITISH COLUMBIA | Ministry of Environment and Climate Change Strategy

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Declaration

I **Nicolas Scarcelli-Casciola**, as a member of **EGBC**

declare

Select one of the following:

☐ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this _____.

I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to _____, erring on the side of caution.

Ministry of
Environment and
Climate Change Strategy

☑ Real or perceived conflict of interest

Description and nature of conflict(s):
I am employed by Newcrest Mining Ltd.

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:
Continue to uphold EGBC's code of conduct and ethics under Professional governance act S.B.C 2018 p.47

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

This conflict of interest disclosure statement is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Signature:
X

Print name: Nicolas Scarcelli-Cascioli

Date: 2023-03-17

Witnessed by:
X

Print name: Brett DeHaney-Turner

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) *is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and*

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

Ministry of Environment and Climate Change Strategy

BRITISH COLUMBIA

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional Nicolas Scarcelli-Casciola

   Title Mine Planning Manager at Newcrest

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: EGBC Registration # 212628

3. Brief description of professional services:

   Oversaw the generation of the LOM for the 4950tpd joint application (Bluejack Mine 4950tpd Joint Amendments Application)

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Nicolas Scarcelli-Casciola

Witnessed by:

X

Print Name: Brett DeHay-Turner

Date signed: March 13th/22

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

A qualified professional [1] providing services to either the Ministry of Environment and Climate Change Strategy ("ministry"), or to a regulated person for the purpose of obtaining an authorization from the ministry, or pursuant to a requirement imposed under the *Environmental Management Act,* the *Integrated Pest Management Act* or the *Park Act* has a real or perceived conflict of interest when the qualified professional, or their relatives, close associates or personal friends have a financial or other interest in the outcome of the work being performed.

A real or perceived conflict of interest occurs when a qualified professional has

a) an ownership interest in the regulated person's business;

b) an opportunity to influence a decision that leads to financial benefits from the regulated person or their business other than a standard fee for service (e.g. bonuses, stock options, other profit sharing arrangements);

c) a personal or professional interest in a specific outcome;

d) the promise of a long term or ongoing business relationship with the regulated person, that is contingent upon a specific outcome of work;

e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I Patrick Mueller, as a member of Association of the Chemical Profession of British Columbia declare

Select one of the following:

☒ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature: **X** _____

Print name: Patrick Mueller

Date: February 28, 2023

Witnessed by: **X** _____

Print name: Susana Ahumada

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

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Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Patrick Mueller

   Title Environmental Chemist

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: ACPBC Registration # 2008135

3. Brief description of professional services:
   Developed water quality model source terms for nitrogen compounds and water treatment plant effluent. Author of Sections 3.5 and 3.8 of the Water Quality Model Report and Section 5.6.1 of the 4950 tpd Joint Amendments Application.

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature: X

Print Name: Patrick Mueller

Witnessed by: X

Print Name: Susana Ahumada

Date signed: February 28, 2023

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

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d) the promise of a long term or ongoing business relationship with the regulated person, that is contingent upon a specific outcome of work;

e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I Rhonda Netzel (Print First and Last Name), as a member of EGBC (Name of Professional Association) declare

Select one of the following:

☑ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application (Project Name). I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson (Ministry Contact Name), erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X _____

Print name: Rhonda Netzel

Date: 9-Mar-2023

Witnessed by:

X _____

Print name: Laura Fredrickson

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Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Rhonda Netzel

   Title Sr. Electrical Engineer

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: EGBC Registration # 19998

3. Brief description of professional services:

   Electrical Engineering Consultant to Brucejack Mine. Author and review section on Power Supply Distribution.

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Rhonda Netzel

Witnessed by:

X

Print Name: Laura Fredrickson

Date signed: 10-Mar-23

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

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Declaration

I Robert Goldblatt, as a member of College of Applied Biologists of BC declare

Select one of the following:

☒ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☐ Real or perceived conflict of interest

Description and nature of conflict(s):

_____

_____

_____

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

_____

_____

_____

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X R. Goldblatt

Print name: Robert Goldblatt

Date: March 3, 2023

Witnessed by:

X Alison Shaw

Print name: Alison Shaw

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Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Robert Goldblatt

   Title Senior Aquatic Biologist

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: College of Applied Biologists of BC Registration # 3372

3. Brief description of professional services:

   Authored Section 5 of Appendix 5-3 (Brucejack Mine: 4950 tpd Water Quality Model Report) & Ch.6, contributed to writing Ch.5, & reviewer of subsections of Ch.2 and Ch. 7.

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature: R. Goldblatt

X

Print Name: Robert Goldblatt

Witnessed by: Alison Shaw

X

Print Name: Alison Shaw

Date signed: March 3, 2023

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

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Declaration

I Sylvia Van Zalingen (Print First and Last Name), as a member of BC Institute of Agrologists (Print Name of Professional Association) declare

Select one of the following:

☐ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this 4950 tpd Joint M-243/PE-107835 Amendments Application (application/project/contract/etc) I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson (Insert Ministry Contact Name), erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☒ Real or perceived conflict of interest

Description and nature of conflict(s):
I am an employee of the applicant and permittee - Pretium Resources Inc., and my position/role is to manage the preparation of permit applications and permittee components of review processes for same, with the objective of obtaining permits required for Brucejack Mine operations.

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:
This form is included/disclosed in the 4950 tpd Joint Application. I will continue to abide by the BC Insitute of Agrologists Bylaw Sections 93 to 98 for standards of conduct and competence, including adherence to the Code of Ethics. The reclamation liability cost estimate for the Brucejack Mine has been prepared by WSP.
Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:
Type text here
X Sylvia Van Zalingen

Witnessed by:
X

Print name: Sylvia Van Zalingen

Print name: Brett DeHay-Turner

Date: March 17, 2023

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Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Sylvia Van Zalingen

   Title Manager, Permitting

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: BC Institute of Agrologists Registration # 827

3. Brief description of professional services:

   Reclamation and closure planning

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature: Type text here

X Sylvia Van Zalingen

Print Name: Sylvia Van Zalingen

Witnessed by:

X

Print Name: Brett DeHay-Turner

Date signed: March 17, 2023

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Ministry of Environment and Climate Change Strategy

Conflict of Interest Disclosure Statement

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Declaration

I Woo Shin, as a member of **Engineers and Geoscientists BC** declare

Select one of the following:

☐ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this Brucejack Mine 4950 tpd Joint Amendments Application. I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to Todd Adamsson, erring on the side of caution.

Ministry of Environment and Climate Change Strategy

☑ Real or perceived conflict of interest

Description and nature of conflict(s):
I am employed by Newcrest Mining Ltd.

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:
Continue to uphold EGBC's Code of Ethics that is required under the Professional Governance Act, S.B.C 2018, p. 47

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

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Signature:

X _____

Print name: Woo Shin

Date: Mar. 9, 2023

Witnessed by:

X Laura Fredrickson

Print name: Laura Fredrickson

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Ministry of Environment and Climate Change Strategy

Declaration of Competency

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1. Name of Qualified Professional Woo Shin

   Title Sr. Geotechnical Engineer

2. Are you a registered member of a professional association in B.C.? ☑ Yes ☐ No

   Name of Association: Engineers and Geoscientists BC Registration # 43539

3. Brief description of professional services:

   Ground control for underground mine activities and surface waste rock dump slope stability control

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Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature:

X

Print Name: Woo Shin

Witnessed by:

X Laura Fredrickson

Print Name: Laura Fredrickson

Date signed: March 9, 2023

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Ministry of Environment and Climate Change Strategy

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d) the promise of a long term or ongoing business relationship with the regulated person, that is contingent upon a specific outcome of work;

e) a spouse or other family member who will benefit from a specific outcome; or

f) any other interest that could be perceived as a threat to the independence or objectivity of the qualified professional in performing a duty or function.

Qualified professionals who work under ministry legislation must take care in the conduct of their work that potential conflicts of interest within their control are avoided or mitigated. Precise rules in conflict of interest are not possible and professionals must rely on guidance of their professional associations, their common sense, conscience and sense of personal integrity.

Declaration

I **Xavier Pinto Gregori**, as a member of **Engineers and Geoscientists of British Columbia** declare

Select one of the following:

☐ Absence from conflict of interest

Other than the standard fee I will receive for my professional services, I have no financial or other interest in the outcome of this _____

I further declare that should a conflict of interest arise in the future during the course of this work, I will fully disclose the circumstances in writing and without delay to _____, erring on the side of caution.

*

Ministry of Environment and Climate Change Strategy

☒ Real or perceived conflict of interest

Description and nature of conflict(s):

I am an employee of Newcrest Mining Ltd.

I will maintain my objectivity, conducting my work in accordance with my Code of Ethics and standards of practice.

In addition, I will take the following steps to mitigate the real or perceived conflict(s) I have disclosed, to ensure the public interest remains paramount:

I will continue to abide by the Code of Ethics
set in the Bylaws of Engineers and Geoscientists BC. February 28, 2023.,
Pursuant to the Professional Governance Act. S.B.C. 2018, c.47

Further, I acknowledge that this disclosure may be interpreted as a threat to my independence and will be considered by the statutory decision maker accordingly.

This conflict of interest disclosure statement is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Signature: Xavier Pinto Gregori Digitally signed by Xavier Pinto Gregori Date: 2023.03.17 13:03:31 -07'00'

X

Witnessed by:

X Laura Fredrickson

Print name: Xavier Pinto Gregori

Print name: Laura Fredrickson

Date: March 17, 2023

[1]*Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*

Ministry of Environment and Climate Change Strategy

Declaration of Competency

The Ministry of Environment and Climate Change Strategy relies on the work, advice, recommendations and in some cases decision making of qualified professionals[1], under government's professional reliance regime. With this comes an assumption that professionals who undertake work in relation to ministry legislation, regulations and codes of practice have the knowledge, experience and objectivity necessary to fulfill this role.

1. Name of Qualified Professional Xavier Pinto Gregori

   Title Senior Hydrologist

2. Are you a registered member of a professional association in B.C.? ☒ Yes ☐ No

   Name of Association: Engineers and Geoscientists BC Registration # 44973

3. Brief description of professional services:

   Management of hyrometric and meteorologic monitoring programs for the Brucejack Mine

This declaration of competency is collected under section 26(c) of the *Freedom of Information and Protection of Privacy Act* for the purposes of increasing government transparency and ensuring professional ethics and accountability. By signing and submitting this statement you consent to its publication and its disclosure outside of Canada. This consent is valid from the date submitted and cannot be revoked. If you have any questions about the collection, use or disclosure of your personal information please contact the Ministry of Environment and Climate Change Strategy Headquarters Office at 1-800-663-7867.

Declaration

I am a qualified professional with the knowledge, skills and experience to provide expert information, advice and/or recommendations in relation to the specific work described above.

Signature: Xavier Pinto

X

Print Name: Xavier Pinto Gregori

Witnessed by: Laura Fredrickson

X

Print Name: Laura Fredrickson

Date signed: March 14, 2023

[1] *Qualified Professional, in relation to a duty or function under ministry legislation, means an individual who*

a) is registered in British Columbia with a professional association, is acting under that organization's code of ethics, and is subject to disciplinary action by that association, and

b) *through suitable education, experience, accreditation and knowledge, may reasonably be relied on to provide advice within his or her area of expertise, which area of expertise is applicable to the duty or function.*